LIGHT UNFLAVORED MESONS
$(S = C = B = 0)$

For $l = 1$ ($\pi$, $b$, $\rho$, $a$): $u\bar{d}$, $(u\bar{u} - d\bar{d})/\sqrt{2}$, $d\bar{u}$; for $l = 0$ ($\eta$, $\eta'$, $h$, $h'$, $\omega$, $\phi$, $f$, $f'$): $c_1(u\bar{u} + d\bar{d}) + c_2(s\bar{s})$

$\pi^\pm$

$I^G(J^P) = 1^-(0^-)$

Mass $m = 139.57018 \pm 0.00035$ MeV  \( S = 1.2 \)
Mean life $\tau = (2.6033 \pm 0.0005) \times 10^{-8}$ s \( S = 1.2 \)
$ct = 7.8045$ m

$\pi^\pm \rightarrow \ell^\pm \nu_\ell \gamma$ form factors \( [a] \)

$F_V = 0.0254 \pm 0.0017$
$F_A = 0.0119 \pm 0.0001$
$F_V$ slope parameter $a = 0.10 \pm 0.06$
$R = 0.059 \pm 0.009$

$\pi^-$ modes are charge conjugates of the modes below.

For decay limits to particles which are not established, see the section on Searches for Axions and Other Very Light Bosons.

<table>
<thead>
<tr>
<th>$\pi^+$ DECAY MODES</th>
<th>Fraction $\left( \Gamma_i/\Gamma \right)$</th>
<th>Confidence level $(\text{MeV/c})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu^+ \nu_\mu$</td>
<td>[b] ( (99.98770 \pm 0.00004) % )</td>
<td>30</td>
</tr>
<tr>
<td>$\mu^+ \nu_\mu \gamma$</td>
<td>[c] ( (2.00 \pm 0.25) \times 10^{-4} )</td>
<td>30</td>
</tr>
<tr>
<td>$e^+ \nu_e$</td>
<td>[b] ( (1.230 \pm 0.004) \times 10^{-4} )</td>
<td>70</td>
</tr>
<tr>
<td>$e^+ \nu_e \gamma$</td>
<td>[c] ( (7.39 \pm 0.05) \times 10^{-7} )</td>
<td>70</td>
</tr>
<tr>
<td>$e^+ \nu_e \pi^0$</td>
<td>( (1.036 \pm 0.006) \times 10^{-8} )</td>
<td>4</td>
</tr>
<tr>
<td>$e^+ \nu_e e^+ e^-$</td>
<td>( (3.2 \pm 0.5) \times 10^{-9} )</td>
<td>70</td>
</tr>
<tr>
<td>$e^+ \nu_e \nu \bar{\nu}$</td>
<td>&lt; 5 ( \times 10^{-6} ) 90%</td>
<td>70</td>
</tr>
</tbody>
</table>

Lepton Family number \( (LF) \) or Lepton number \( (L) \) violating modes

| $\mu^+ \nu_e$ | $L$ | \( [d] < 1.5 \) \( \times 10^{-3} \) 90% | 30 |
| $\mu^+ \nu_e$ | $LF$ | \( [d] < 8.0 \) \( \times 10^{-3} \) 90% | 30 |
| $\mu^- e^+ e^+ \nu$ | $LF$ | \( < 1.6 \) \( \times 10^{-6} \) 90% | 30 |

$\pi^0$

$I^G(J^{PC}) = 1^-(0^-)$

Mass $m = 134.9766 \pm 0.0006$ MeV \( S = 1.1 \)
$\rho_{\pi^0} - m_{\pi^0} = 4.5936 \pm 0.0005$ MeV
Mean life $\tau = (8.52 \pm 0.18) \times 10^{-17}$ s \( S = 1.2 \)
$ct = 25.5$ nm
For decay limits to particles which are not established, see the appropriate Search sections (\(A^0\) (axion) and Other Light Boson (\(X^0\)) Searches, etc.).

### \(\pi^0\) Decay Modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>Confidence level</th>
<th>Scale factor/(\rho) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2\gamma)</td>
<td>((98.823 \pm 0.034))%</td>
<td>S=1.5</td>
<td>67</td>
</tr>
<tr>
<td>(e^+e^-\gamma)</td>
<td>((1.174 \pm 0.035))%</td>
<td>S=1.5</td>
<td>67</td>
</tr>
<tr>
<td>(\gamma)</td>
<td>((1.82 \pm 0.29)) \times 10^{-9}</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>(e^+e^+e^-e^-)</td>
<td>((3.34 \pm 0.16)) \times 10^{-5}</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>(e^+e^-)</td>
<td>((6.46 \pm 0.33)) \times 10^{-8}</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>(4\gamma)</td>
<td>&lt; 2 \times 10^{-8} \text{ CL=90%}</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>(\nu)</td>
<td>([e] &lt; 2.7 \times 10^{-7} \text{ CL=90%} )</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>(\nu_e\bar{\nu}_e)</td>
<td>&lt; 1.7 \times 10^{-6} \text{ CL=90%}</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>(\nu\mu\bar{\nu}_\mu)</td>
<td>&lt; 1.6 \times 10^{-6} \text{ CL=90%}</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>(\nu\tau\bar{\nu}_\tau)</td>
<td>&lt; 2.1 \times 10^{-6} \text{ CL=90%}</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>(\gamma)</td>
<td>&lt; 6 \times 10^{-4} \text{ CL=90%}</td>
<td>67</td>
<td></td>
</tr>
</tbody>
</table>

**Charge conjugation (\(C\)) or Lepton Family number (\(LF\)) violating modes**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>Confidence level</th>
<th>Scale factor/(\rho) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(3\gamma)</td>
<td>(C &lt; 3.1 \times 10^{-8} \text{ CL=90%} )</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>(\mu^+e^-)</td>
<td>(LF &lt; 3.8 \times 10^{-10} \text{ CL=90%} )</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>(\mu^-e^+)</td>
<td>(LF &lt; 3.4 \times 10^{-9} \text{ CL=90%} )</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>(\mu^+e^- + \mu^-e^+)</td>
<td>(LF &lt; 3.6 \times 10^{-10} \text{ CL=90%} )</td>
<td>26</td>
<td></td>
</tr>
</tbody>
</table>

### \(\eta\)

\[ j^G(j^{PC}) = 0^+(0^-) \]

- Mass \(m = 547.862 \pm 0.018\) MeV
- Full width \(\Gamma = 1.31 \pm 0.05\) keV

**\(C\)-nonconserving decay parameters**

- \(\pi^+\pi^-\pi^0\) left-right asymmetry = \((0.09^{+0.11}_{-0.12}) \times 10^{-2}\)
- \(\pi^+\pi^-\pi^0\) sextant asymmetry = \((0.12^{+0.10}_{-0.11}) \times 10^{-2}\)
- \(\pi^+\pi^-\pi^0\) quadrant asymmetry = \((-0.09 \pm 0.09) \times 10^{-2}\)
- \(\pi^+\pi^-\gamma\) left-right asymmetry = \((0.9 \pm 0.4) \times 10^{-2}\)
- \(\pi^+\pi^-\gamma\) \(\beta\) (\(D\)-wave) = \(-0.02 \pm 0.07\) \((S = 1.3)\)

**\(CP\)-nonconserving decay parameters**

- \(\pi^+\pi^-e^+e^-\) decay-plane asymmetry \(A_\phi = (-0.6 \pm 3.1) \times 10^{-2}\)

**Dalitz plot parameter**

\(\pi^0\pi^0\) \(\alpha = -0.0315 \pm 0.0015\)

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URL: http://pdg.lbl.gov
## η DECAY MODES

<table>
<thead>
<tr>
<th>Mode</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>Scale factor/Confidence level</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neutral modes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$2\gamma$</td>
<td>(72.12±0.34) %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$3\pi^0$</td>
<td>(39.41±0.20) %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\pi^0\gamma$</td>
<td>(2.7±0.5)×10$^{-4}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\pi^0\gamma$</td>
<td>&lt; 1.2 × 10$^{-4}$</td>
<td>CL=90%</td>
<td>274</td>
</tr>
<tr>
<td>invisible</td>
<td>&lt; 1.0 × 10$^{-4}$</td>
<td>CL=90%</td>
<td></td>
</tr>
<tr>
<td><strong>Charged modes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\pi^+\pi^−\pi^0$</td>
<td>(28.10±0.34) %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\pi^+\pi^−\gamma$</td>
<td>(22.92±0.28) %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$e^+e^−\gamma$</td>
<td>(6.9±0.4)×10$^{-3}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\mu^+\mu^−\gamma$</td>
<td>(3.1±0.4)×10$^{-4}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$e^+e^−$</td>
<td>&lt; 5.6 × 10$^{-4}$</td>
<td>CL=90%</td>
<td>274</td>
</tr>
<tr>
<td>$\mu^+\mu^−$</td>
<td>(5.8±0.8)×10$^{-6}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$2e^+2e^−$</td>
<td>(2.40±0.22)×10$^{-5}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\pi^+\pi^−e^+e^−(\gamma)$</td>
<td>(2.68±0.11)×10$^{-4}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$e^+e^−\mu^+\mu^−$</td>
<td>&lt; 1.6 × 10$^{-4}$</td>
<td>CL=90%</td>
<td>253</td>
</tr>
<tr>
<td>$2\mu^+\mu^−$</td>
<td>&lt; 3.6 × 10$^{-4}$</td>
<td>CL=90%</td>
<td>161</td>
</tr>
<tr>
<td>$\mu^+\mu^−\pi^+\pi^−$</td>
<td>&lt; 3.6 × 10$^{-4}$</td>
<td>CL=90%</td>
<td>113</td>
</tr>
<tr>
<td>$\pi^+\pi^−\pi^0\gamma$</td>
<td>&lt; 1.7 × 10$^{-4}$</td>
<td>CL=90%</td>
<td>256</td>
</tr>
<tr>
<td>$\pi^+\pi^−2\gamma$</td>
<td>&lt; 2.1 × 10$^{-3}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\pi^0\mu^+\mu^−$</td>
<td>&lt; 3 × 10$^{-6}$</td>
<td>CL=90%</td>
<td>210</td>
</tr>
</tbody>
</table>

### Charge conjugation (C), Parity (P), Charge conjugation × Parity (CP), or Lepton Family number (LF) violating modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>C/P/CP</th>
<th>Scale factor/Confidence level</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi^0\gamma$</td>
<td>C</td>
<td>&lt; 9 × 10$^{-5}$</td>
<td>CL=90%</td>
</tr>
<tr>
<td>$\pi^+\pi^−$</td>
<td>P,CP</td>
<td>&lt; 1.3 × 10$^{-5}$</td>
<td>CL=90%</td>
</tr>
<tr>
<td>$2\pi^0$</td>
<td>P,CP</td>
<td>&lt; 3.5 × 10$^{-4}$</td>
<td>CL=90%</td>
</tr>
<tr>
<td>$2\pi^0\gamma$</td>
<td>C</td>
<td>&lt; 5 × 10$^{-4}$</td>
<td>CL=90%</td>
</tr>
<tr>
<td>$3\pi^0\gamma$</td>
<td>C</td>
<td>&lt; 6 × 10$^{-5}$</td>
<td>CL=90%</td>
</tr>
<tr>
<td>$3\gamma$</td>
<td>C</td>
<td>&lt; 1.6 × 10$^{-5}$</td>
<td>CL=90%</td>
</tr>
<tr>
<td>$4\pi^0$</td>
<td>P,CP</td>
<td>&lt; 6.9 × 10$^{-7}$</td>
<td>CL=90%</td>
</tr>
<tr>
<td>$\pi^0e^+e^−$</td>
<td>C [f]</td>
<td>&lt; 4 × 10$^{-5}$</td>
<td>CL=90%</td>
</tr>
<tr>
<td>$\pi^0\mu^+\mu^−$</td>
<td>C [f]</td>
<td>&lt; 5 × 10$^{-6}$</td>
<td>CL=90%</td>
</tr>
<tr>
<td>$\mu^+e^−\mu^−e^+$</td>
<td>LF</td>
<td>&lt; 6 × 10$^{-6}$</td>
<td>CL=90%</td>
</tr>
</tbody>
</table>
\[ f_0(500) \text{ or } \sigma \left[ g \right] \text{ was } f_0(600) \]

\[ iG(j^{PC}) = 0^+(0++) \]

Mass \( m = (400-550) \text{ MeV} \)
Full width \( \Gamma = (400-700) \text{ MeV} \)

**\( f_0(500) \) DECAY MODES**

<table>
<thead>
<tr>
<th>Fraction ( \Gamma_i/\Gamma )</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \pi\pi )</td>
<td>dominant</td>
</tr>
<tr>
<td>( \gamma\gamma )</td>
<td>seen</td>
</tr>
</tbody>
</table>

\[ \rho(770) \left[ h \right] \]

\[ iG(j^{PC}) = 1^+(1--) \]

Mass \( m = 775.26 \pm 0.25 \text{ MeV} \)
Full width \( \Gamma = 149.1 \pm 0.8 \text{ MeV} \)
\( \Gamma_{ee} = 7.04 \pm 0.06 \text{ keV} \)

**\( \rho(770) \) DECAY MODES**

<table>
<thead>
<tr>
<th>Fraction ( \Gamma_i/\Gamma )</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \pi^\pm \gamma )</td>
<td>~ 100%</td>
</tr>
</tbody>
</table>

\( \rho(770)^\pm \) decays

| \( \pi^\pm \eta \) | \( 6 \times 10^{-3} \) | 152 |
| \( \pi^\pm \pi^+\pi^-\pi^0 \) | \( 2.0 \times 10^{-3} \) | 254 |

\( \rho(770)^0 \) decays

| \( \pi^+\pi^-\gamma \) | \( 9.9 \times 10^{-3} \) | 362 |
| \( \pi^0\gamma \) | \( 6.0 \times 10^{-4} \) | 376 |
| \( \eta\gamma \) | \( 3.00 \times 10^{-4} \) | 194 |
| \( \pi^0\pi^0\gamma \) | \( 4.5 \times 10^{-5} \) | 363 |
| \( \mu^+\mu^- \) [1] | \( 4.55 \pm 0.28 \times 10^{-5} \) | 373 |
| \( e^+e^- \) [1] | \( 4.72 \pm 0.05 \times 10^{-5} \) | 388 |
| \( \pi^+\pi^-\pi^0 \) | \( 1.01\pm0.54 \pm0.30 \pm0.34 \times 10^{-7} \) | 323 |
| \( \pi^+\pi^-\pi^+\pi^- \) | \( 1.8 \times 10^{-5} \) | 251 |
| \( \pi^+\pi^-\pi^0\pi^0 \) | \( 1.6 \times 10^{-5} \) | 257 |
| \( \pi^0e^+e^- \) | \( 1.2 \times 10^{-5} \) | 376 |

\( \omega(782) \)

\[ iG(j^{PC}) = 0^-(1--) \]

Mass \( m = 782.65 \pm 0.12 \text{ MeV} \) \( (S = 1.9) \)
Full width \( \Gamma = 8.49 \pm 0.08 \text{ MeV} \)
\( \Gamma_{ee} = 0.60 \pm 0.02 \text{ keV} \)

HTTP://PDG.LBL.GOV Page 4 Created: 8/25/2014 17:06
### Scale factor/\( \rho \) (MeV/c) Fraction (\( \Gamma_i/\Gamma \)) Confidence level

<table>
<thead>
<tr>
<th>Decay Modes</th>
<th>( \frac{\Gamma_i}{\Gamma} )</th>
<th>Scale factor/( \rho ) (MeV/c)</th>
<th>Confidence level</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \pi^+ \pi^- \pi^0 )</td>
<td>(89.2 ± 0.7) %</td>
<td>327</td>
<td></td>
</tr>
<tr>
<td>( \pi^0 \gamma )</td>
<td>(8.28 ± 0.28) %</td>
<td>S=2.1</td>
<td>380</td>
</tr>
<tr>
<td>( \pi^+ \pi^- )</td>
<td>(1.53 ± 0.11) %</td>
<td>S=1.2</td>
<td>366</td>
</tr>
<tr>
<td>Neutrals (excluding ( \pi^0 \gamma ))</td>
<td>(8 ± 8) × 10^{-3}</td>
<td>S=1.1</td>
<td></td>
</tr>
<tr>
<td>( \eta \gamma )</td>
<td>(4.6 ± 0.4) × 10^{-4}</td>
<td>S=1.1</td>
<td>200</td>
</tr>
<tr>
<td>( \pi^0 e^+ e^- )</td>
<td>(7.7 ± 0.6) × 10^{-4}</td>
<td>S=1.3</td>
<td></td>
</tr>
<tr>
<td>( \pi^0 \mu^+ \mu^- )</td>
<td>(1.3 ± 0.4) × 10^{-4}</td>
<td>S=2.1</td>
<td>349</td>
</tr>
<tr>
<td>( e^+ e^- )</td>
<td>(7.28 ± 0.14) × 10^{-5}</td>
<td>S=1.3</td>
<td>391</td>
</tr>
<tr>
<td>( \pi^+ \pi^- \pi^0 \pi^0 )</td>
<td>&lt; 2 × 10^{-4}</td>
<td>CL=90%</td>
<td>262</td>
</tr>
<tr>
<td>( \pi^+ \pi^- \gamma )</td>
<td>&lt; 3.6 × 10^{-3}</td>
<td>CL=95%</td>
<td>366</td>
</tr>
<tr>
<td>( \pi^+ \pi^- \pi^+ \pi^- )</td>
<td>&lt; 1 × 10^{-3}</td>
<td>CL=90%</td>
<td>256</td>
</tr>
<tr>
<td>( \eta \pi^0 \gamma )</td>
<td>&lt; 3.3 × 10^{-5}</td>
<td>CL=90%</td>
<td>162</td>
</tr>
<tr>
<td>( \mu^+ \mu^- )</td>
<td>(9.0 ± 3.1) × 10^{-5}</td>
<td>S=2.1</td>
<td>377</td>
</tr>
<tr>
<td>( 3\gamma )</td>
<td>&lt; 1.9 × 10^{-4}</td>
<td>CL=95%</td>
<td>391</td>
</tr>
</tbody>
</table>

#### Charge conjugation (C) violating modes

<table>
<thead>
<tr>
<th>Decay Modes</th>
<th>Scale factor/( \rho ) (MeV/c)</th>
<th>Confidence level</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \eta \pi^0 )</td>
<td>( &lt; 2.1 ) × 10^{-4}</td>
<td>CL=90%</td>
</tr>
<tr>
<td>( \eta \pi^0 )</td>
<td>( &lt; 2.1 ) × 10^{-4}</td>
<td>CL=90%</td>
</tr>
<tr>
<td>( \eta \pi^0 )</td>
<td>( &lt; 2.3 ) × 10^{-4}</td>
<td>CL=90%</td>
</tr>
</tbody>
</table>

---

### \( \eta'(958) \)

\( iG(J^{PC}) = 0^+(0^-+) \)

Mass \( m = 957.78 ± 0.06 \) MeV
Full width \( \Gamma = 0.198 ± 0.009 \) MeV

#### \( \eta'(958) \) DECAY MODES

<table>
<thead>
<tr>
<th>Decay Modes</th>
<th>( \frac{\Gamma_i}{\Gamma} )</th>
<th>Confidence level (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \pi^+ \pi^- \eta )</td>
<td>(42.9 ± 0.7) %</td>
<td>232</td>
</tr>
<tr>
<td>( \rho^0 \gamma ) (including non-resonant)</td>
<td>(29.1 ± 0.5) %</td>
<td>165</td>
</tr>
<tr>
<td>( \pi^0 \rho^- \eta )</td>
<td>(22.2 ± 0.8) %</td>
<td>239</td>
</tr>
<tr>
<td>( \omega \gamma )</td>
<td>(2.75 ± 0.23) %</td>
<td>159</td>
</tr>
<tr>
<td>( \gamma \gamma )</td>
<td>(2.20 ± 0.08) %</td>
<td>479</td>
</tr>
<tr>
<td>( 3\pi^0 )</td>
<td>(2.14 ± 0.20) × 10^{-3}</td>
<td>430</td>
</tr>
<tr>
<td>( \mu^+ \mu^- \gamma )</td>
<td>(1.08 ± 0.27) × 10^{-4}</td>
<td>467</td>
</tr>
<tr>
<td>( \pi^+ \pi^- \mu^+ \mu^- )</td>
<td>&lt; 2.9 × 10^{-5}</td>
<td>CL=90%</td>
</tr>
<tr>
<td>( \pi^+ \pi^- \pi^0 )</td>
<td>(3.8 ± 0.4) × 10^{-3}</td>
<td>428</td>
</tr>
<tr>
<td>( \pi^0 \rho^- )</td>
<td>&lt; 4 %</td>
<td>CL=90%</td>
</tr>
<tr>
<td>( 2(\pi^+ \pi^-) )</td>
<td>&lt; 2.4 × 10^{-4}</td>
<td>CL=90%</td>
</tr>
</tbody>
</table>

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\[ \pi^+ \pi^- 2\pi^0 \quad < 2.5 \times 10^{-3} \quad 90\% \quad 376 \]

\[ 2(\pi^+ \pi^-) \text{ neutrals} \quad < 1 \quad \% \quad 95\% \quad - \]

\[ 2(\pi^+ \pi^-)\pi^0 \quad < 1.9 \times 10^{-3} \quad 90\% \quad 298 \]

\[ 2(\pi^+ \pi^-)2\pi^0 \quad < 1 \quad \% \quad 95\% \quad 197 \]

\[ 3(\pi^+ \pi^-) \quad < 3.1 \times 10^{-5} \quad 90\% \quad 189 \]

\[ \pi^+ \pi^- e^+ e^- \quad (2.4 \pm 1.3) \times 10^{-3} \quad 458 \]

\[ \pi^+ e^- \nu_e + \text{c.c.} \quad < 2.1 \times 10^{-4} \quad 90\% \quad 469 \]

\[ e^+ e^- \quad < 2.1 \times 10^{-7} \quad 90\% \quad 479 \]

\[ \text{invisible} \quad < 5 \times 10^{-4} \quad 90\% \quad - \]

**Charge conjugation (C), Parity (P), Lepton family number (LF) violating modes**

<table>
<thead>
<tr>
<th>( \pi^+ \pi^- )</th>
<th>( P,CP )</th>
<th>&lt; 6 ( \times 10^{-5} )</th>
<th>90%</th>
<th>458</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \pi^0 \pi^0 )</td>
<td>( P,CP )</td>
<td>&lt; 4 ( \times 10^{-4} )</td>
<td>90%</td>
<td>459</td>
</tr>
<tr>
<td>( \pi^0 e^+ e^- )</td>
<td>( C ) ( [f] )</td>
<td>&lt; 1.4 ( \times 10^{-3} )</td>
<td>90%</td>
<td>469</td>
</tr>
<tr>
<td>( \eta e^+ e^- )</td>
<td>( C ) ( [f] )</td>
<td>&lt; 2.4 ( \times 10^{-3} )</td>
<td>90%</td>
<td>322</td>
</tr>
<tr>
<td>( 3\gamma )</td>
<td>( C ) ( [f] )</td>
<td>&lt; 1.0 ( \times 10^{-4} )</td>
<td>90%</td>
<td>479</td>
</tr>
<tr>
<td>( \mu^+ \mu^- \pi^0 )</td>
<td>( C ) ( [f] )</td>
<td>&lt; 6.0 ( \times 10^{-5} )</td>
<td>90%</td>
<td>445</td>
</tr>
<tr>
<td>( \mu^+ \mu^- \eta )</td>
<td>( C ) ( [f] )</td>
<td>&lt; 1.5 ( \times 10^{-5} )</td>
<td>90%</td>
<td>273</td>
</tr>
<tr>
<td>( e \mu )</td>
<td>( LF )</td>
<td>&lt; 4.7 ( \times 10^{-4} )</td>
<td>90%</td>
<td>473</td>
</tr>
</tbody>
</table>

**\( f_0(980) \)**

\[ i^G (J^{PC}) = 0^+(0^-) \]

Mass \( m = 990 \pm 20 \text{ MeV} \)

Full width \( \Gamma = 40 \text{ to } 100 \text{ MeV} \)

<table>
<thead>
<tr>
<th>( f_0(980) ) \text{ DECA Y MODES}</th>
<th>( \Gamma_i/\Gamma )</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \pi \pi )</td>
<td>dominant</td>
<td>476</td>
</tr>
<tr>
<td>( K \overline{K} )</td>
<td>seen</td>
<td>36</td>
</tr>
<tr>
<td>( \gamma \gamma )</td>
<td>seen</td>
<td>495</td>
</tr>
</tbody>
</table>
\(a_0(980)\) \([\jmath]\)

\[
\mathcal{I}^G(J^{PC}) = 1^- (0^+ +)
\]

Mass \(m = 980 \pm 20\) MeV
Full width \(\Gamma = 50\) to 100 MeV

\(a_0(980)\) DECAY MODES

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>Scale factor/Confidence level</th>
<th>(p) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\eta\pi)</td>
<td>dominant</td>
<td></td>
<td>319</td>
</tr>
<tr>
<td>(K\bar{K})</td>
<td>seen</td>
<td></td>
<td>(\dagger)</td>
</tr>
<tr>
<td>(\gamma\gamma)</td>
<td>seen</td>
<td></td>
<td>490</td>
</tr>
</tbody>
</table>

\(\phi(1020)\)

\[
\mathcal{I}^G(J^{PC}) = 0^- (1^--)
\]

Mass \(m = 1019.461 \pm 0.019\) MeV \((S = 1.1)\)
Full width \(\Gamma = 4.266 \pm 0.031\) MeV \((S = 1.2)\)

\(\phi(1020)\) DECAY MODES

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>Scale factor/Confidence level</th>
<th>(p) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(K^+K^-)</td>
<td>(48.9 \pm 0.5) %</td>
<td>S=1.1</td>
<td>127</td>
</tr>
<tr>
<td>(K^0_L\bar{K}^0_S)</td>
<td>(34.2 \pm 0.4) %</td>
<td>S=1.1</td>
<td>110</td>
</tr>
<tr>
<td>(\rho\pi^+\pi^-\pi^0)</td>
<td>(15.32 \pm 0.32) %</td>
<td>S=1.1</td>
<td>363</td>
</tr>
<tr>
<td>(\eta\gamma)</td>
<td>(1.309 \pm 0.024) %</td>
<td>S=1.2</td>
<td>501</td>
</tr>
<tr>
<td>(\pi^0\gamma)</td>
<td>(1.27 \pm 0.06) \times 10^{-3}</td>
<td></td>
<td>510</td>
</tr>
<tr>
<td>(\ell^+\ell^-)</td>
<td></td>
<td></td>
<td>510</td>
</tr>
<tr>
<td>(e^+e^-)</td>
<td>(2.954 \pm 0.030) \times 10^{-4}</td>
<td>S=1.1</td>
<td>510</td>
</tr>
<tr>
<td>(\mu^+\mu^-)</td>
<td>(2.87 \pm 0.19) \times 10^{-4}</td>
<td></td>
<td>499</td>
</tr>
<tr>
<td>(\eta e^+e^-)</td>
<td>(1.15 \pm 0.10) \times 10^{-4}</td>
<td></td>
<td>363</td>
</tr>
<tr>
<td>(\pi^+\pi^-)</td>
<td>(7.4 \pm 1.3) \times 10^{-5}</td>
<td></td>
<td>490</td>
</tr>
<tr>
<td>(\omega\pi^0)</td>
<td>(4.7 \pm 0.5) \times 10^{-5}</td>
<td></td>
<td>172</td>
</tr>
<tr>
<td>(\omega\gamma)</td>
<td>&lt; 5 %</td>
<td>CL=84%</td>
<td>209</td>
</tr>
<tr>
<td>(\rho\gamma)</td>
<td>&lt; 1.2 \times 10^{-5}</td>
<td>CL=90%</td>
<td>215</td>
</tr>
<tr>
<td>(\pi^+\pi^-\gamma)</td>
<td>(4.1 \pm 1.3) \times 10^{-5}</td>
<td></td>
<td>490</td>
</tr>
<tr>
<td>(f_0(980)\gamma)</td>
<td>(3.22 \pm 0.19) \times 10^{-4}</td>
<td>S=1.1</td>
<td>29</td>
</tr>
<tr>
<td>(\pi^0\pi^0\gamma)</td>
<td>(1.13 \pm 0.06) \times 10^{-4}</td>
<td></td>
<td>492</td>
</tr>
<tr>
<td>(\pi^+\pi^-\pi^+\pi^-)</td>
<td>(4.0 \pm 2.8) \times 10^{-6}</td>
<td></td>
<td>410</td>
</tr>
<tr>
<td>(\pi^0\pi^+\pi^-\pi^0)</td>
<td>&lt; 4.6 \times 10^{-6}</td>
<td>CL=90%</td>
<td>342</td>
</tr>
<tr>
<td>(\pi^0 e^+e^-)</td>
<td>(1.12 \pm 0.28) \times 10^{-5}</td>
<td></td>
<td>501</td>
</tr>
<tr>
<td>(\pi^0\eta\gamma)</td>
<td>(7.27 \pm 0.30) \times 10^{-5}</td>
<td>S=1.5</td>
<td>346</td>
</tr>
<tr>
<td>(a_0(980)\gamma)</td>
<td>(7.6 \pm 0.6) \times 10^{-5}</td>
<td></td>
<td>39</td>
</tr>
<tr>
<td>(K^0\bar{K}^0\gamma)</td>
<td>&lt; 1.9 \times 10^{-8}</td>
<td>CL=90%</td>
<td>110</td>
</tr>
<tr>
<td>(\eta'(958)\gamma)</td>
<td>(6.25 \pm 0.21) \times 10^{-5}</td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>(\eta\pi^0\pi^0\gamma)</td>
<td>&lt; 2 \times 10^{-5}</td>
<td>CL=90%</td>
<td>293</td>
</tr>
</tbody>
</table>

HTTP://PDG.LBL.GOV Page 7 Created: 8/25/2014 17:06
\( \mu^+ \mu^- \gamma \)
\[(1.4 \pm 0.5) \times 10^{-5} \]
\(499\)

\(\rho \gamma \gamma\)
\(<1.2 \times 10^{-4}\) CL=90%
\(215\)

\(\eta \pi^+ \pi^-\)
\(<1.8 \times 10^{-5}\) CL=90%
\(288\)

\(\eta \mu^+ \mu^-\)
\(<9.4 \times 10^{-6}\) CL=90%
\(321\)

\(\eta U \rightarrow \eta e^+ e^-\)
\(<1 \times 10^{-6}\) CL=90%
\(-\)

<table>
<thead>
<tr>
<th>Lepton Family number (LF) violating modes</th>
</tr>
</thead>
</table>
| \(e^\pm \mu^\mp\) LF \(<2\) \(\times 10^{-6}\) CL=90%
| 504 |

<table>
<thead>
<tr>
<th>(h_1(1170))</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i^G(J^{PC}) = 0^-(1^- -))</td>
</tr>
</tbody>
</table>

Mass \(m = 1170 \pm 20\) MeV
Full width \(\Gamma = 360 \pm 40\) MeV

<table>
<thead>
<tr>
<th>(h_1(1170)) DECA Y MODES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraction ((\Gamma_i/\Gamma))</td>
</tr>
<tr>
<td>(\rho \pi) seen</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(b_1(1235))</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i^G(J^{PC}) = 1^+(1^- -))</td>
</tr>
</tbody>
</table>

Mass \(m = 1229.5 \pm 3.2\) MeV \((S = 1.6)\)
Full width \(\Gamma = 142 \pm 9\) MeV \((S = 1.2)\)

<table>
<thead>
<tr>
<th>(b_1(1235)) DECA Y MODES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraction ((\Gamma_i/\Gamma))</td>
</tr>
<tr>
<td>(\omega \pi) dominant</td>
</tr>
<tr>
<td>([D/S) amplitude ratio = 0.277 \pm 0.027]</td>
</tr>
<tr>
<td>(\pi^\pm \gamma) ((1.6 \pm 0.4) \times 10^{-3})</td>
</tr>
<tr>
<td>(\eta \rho) seen</td>
</tr>
<tr>
<td>(\pi^+ \pi^+ \pi^- \pi^0)</td>
</tr>
<tr>
<td>(K^*(892)^\pm K^\mp) seen</td>
</tr>
<tr>
<td>(K^0 S K^0 S \pi^\pm)</td>
</tr>
<tr>
<td>(K^0 S K^0 S \pi^\pm)</td>
</tr>
<tr>
<td>(\phi \pi)</td>
</tr>
</tbody>
</table>
\(a_1(1260)^{[k]}\)

\[ i^G(J^PC) = 1^-(1^+ +) \]

Mass \(m = 1230 \pm 40\) MeV \([l]\)
Full width \(\Gamma = 250\) to \(600\) MeV

\[a_1(1260)\) DECAY MODES\]

| \((\rho\pi)\) S-wave | seen |  |
| \((\rho\pi)\) D-wave | seen |  |
| \((\rho(1450)\pi)\) S-wave | seen |  |
| \((\rho(1450)\pi)\) D-wave | seen |  |
| \(\sigma\pi\) | seen |  |
| \(f_0(980)\pi\) | not seen | 179 |
| \(f_0(1370)\pi\) | seen |  |
| \(f_2(1270)\pi\) | seen |  |
| \(K\overline{K}^*(892) + \) c.c. | seen |  |
| \(\pi\gamma\) | seen | 608 |

\(f_2(1270)\)

\[ i^G(J^PC) = 0^+(2^+ +) \]

Mass \(m = 1275.1 \pm 1.2\) MeV \((S = 1.1)\)
Full width \(\Gamma = 185.1^{+2.9}_{-2.4}\) MeV \((S = 1.5)\)

\[f_2(1270)\) DECAY MODES\]

| \(\pi\pi\) | \((84.8^{+2.4}_{-1.2})\) % | \(S=1.2\) | 623 |
| \(\pi^+\pi^- 2\pi^0\) | \((7.1^{+1.4}_{-2.7})\) % | \(S=1.3\) | 562 |
| \(K\overline{K}\) | \((4.6 \pm 0.4)\) % | \(S=2.8\) | 403 |
| \(2\pi^+ 2\pi^-\) | \((2.8 \pm 0.4)\) % | \(S=1.2\) | 559 |
| \(\eta\eta\) | \((4.0 \pm 0.8) \times 10^{-3}\) | \(S=2.1\) | 326 |
| \(4\pi^0\) | \((3.0 \pm 1.0) \times 10^{-3}\) | \(S=2.1\) | 564 |
| \(\gamma\gamma\) | \((1.64 \pm 0.19) \times 10^{-5}\) | \(S=1.9\) | 638 |
| \(\eta\pi\pi\) | \(< \) \(8 \times 10^{-3}\) | \(CL=95\%\) | 477 |
| \(K^0\overline{K}^-\pi^+ +\) c.c. | \(< \) \(3.4 \times 10^{-3}\) | \(CL=95\%\) | 293 |
| \(e^+e^-\) | \(< \) \(6 \times 10^{-10}\) | \(CL=90\%\) | 638 |

\(f_1(1285)\)

\[ i^G(J^PC) = 0^+(1^+ +) \]

Mass \(m = 1281.9 \pm 0.5\) MeV \((S = 1.8)\)
Full width \(\Gamma = 24.2 \pm 1.1\) MeV \((S = 1.3)\)

**f_1(1285) DECA Y MODES**

<table>
<thead>
<tr>
<th>Decay Modes</th>
<th>Fraction (Γ_i/Γ)</th>
<th>Scale factor/ Confidence level</th>
<th>p (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4π</td>
<td>(33.1 ± 2.1) %</td>
<td>S=1.3</td>
<td>568</td>
</tr>
<tr>
<td>π^0 π^+ π^-</td>
<td>(22.0 ± 1.4) %</td>
<td>S=1.3</td>
<td>566</td>
</tr>
<tr>
<td>2π^+ 2π^-</td>
<td>(11.0 ± 0.7) %</td>
<td>S=1.3</td>
<td>563</td>
</tr>
<tr>
<td>ρ^0 π^+ π^-</td>
<td>(11.0 ± 0.7) %</td>
<td>S=1.3</td>
<td>336</td>
</tr>
<tr>
<td>ρ^0 ρ^0</td>
<td>seen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4π^0</td>
<td>&lt; 7 × 10^{-4}</td>
<td>CL=90%</td>
<td>568</td>
</tr>
<tr>
<td>ηπ^+ π^-</td>
<td>(35 ± 15) %</td>
<td></td>
<td>479</td>
</tr>
<tr>
<td>ηπ π</td>
<td>(52.4 ± 1.9) %</td>
<td>S=1.2</td>
<td>482</td>
</tr>
<tr>
<td>a_0(980)π</td>
<td>[ignoring a_0(980) → K K]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ηπ π</td>
<td>(36 ± 7) %</td>
<td></td>
<td>238</td>
</tr>
<tr>
<td>K K^+</td>
<td>(9.0 ± 0.4) %</td>
<td>S=1.1</td>
<td>308</td>
</tr>
<tr>
<td>K K^±(892)</td>
<td>not seen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>π^+ π^- π^0</td>
<td>(3.0 ± 0.9) × 10^{-3}</td>
<td></td>
<td>603</td>
</tr>
<tr>
<td>ρ ± ρ^±</td>
<td>&lt; 3.1 × 10^{-3}</td>
<td>CL=95%</td>
<td>390</td>
</tr>
<tr>
<td>γ ρ^0</td>
<td>(5.5 ± 1.3) %</td>
<td>S=2.8</td>
<td>407</td>
</tr>
<tr>
<td>φ γ</td>
<td>(7.4 ± 2.6) × 10^{-4}</td>
<td></td>
<td>236</td>
</tr>
</tbody>
</table>

**η(1295)**

\[ j^G (jPC) = 0^+(0-+) \]

Mass \( m = 1294 ± 4 \text{ MeV} \) \( (S = 1.6) \)

Full width \( \Gamma = 55 ± 5 \text{ MeV} \)

**η(1295) DECAY MODES**

<table>
<thead>
<tr>
<th>Decay Modes</th>
<th>Fraction (Γ_i/Γ)</th>
<th>p (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ηπ^+ π^-</td>
<td>seen</td>
<td>487</td>
</tr>
<tr>
<td>a_0(980)π</td>
<td>seen</td>
<td>248</td>
</tr>
<tr>
<td>ηπ^0 π^0</td>
<td>seen</td>
<td>490</td>
</tr>
<tr>
<td>η(ππ) S-wave</td>
<td>seen</td>
<td>−</td>
</tr>
</tbody>
</table>

**π(1300)**

\[ j^G (jPC) = 1^-(0-+) \]

Mass \( m = 1300 ± 100 \text{ MeV} \)

Full width \( \Gamma = 200 \) to \( 600 \text{ MeV} \)
### π(1300) DECAY MODES

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho \pi$</td>
<td>seen</td>
<td>404</td>
</tr>
<tr>
<td>$\pi(\pi\pi)$ s-wave</td>
<td>seen</td>
<td>-</td>
</tr>
</tbody>
</table>

### $a_2(1320)$

$J^G(J^{PC}) = 1^- (2^{++})$

Mass $m = 1318.3^{+0.5}_{-0.6}$ MeV ($S = 1.2$)

Full width $\Gamma = 107 \pm 5$ MeV

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>Scale factor/Confidence level</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3\pi$</td>
<td>$(70.1 \pm 2.7 %)$</td>
<td>S=1.2</td>
<td>624</td>
</tr>
<tr>
<td>$\eta \pi$</td>
<td>$(14.5 \pm 1.2 %)$</td>
<td></td>
<td>535</td>
</tr>
<tr>
<td>$\omega \pi \pi$</td>
<td>$(10.6 \pm 3.2 %)$</td>
<td>S=1.3</td>
<td>366</td>
</tr>
<tr>
<td>$K \bar{K}$</td>
<td>$(4.9 \pm 0.8 %)$</td>
<td></td>
<td>437</td>
</tr>
<tr>
<td>$\eta'(958)\pi$</td>
<td>$(5.3 \pm 0.9 %) \times 10^{-3}$</td>
<td></td>
<td>288</td>
</tr>
<tr>
<td>$\pi^\pm \gamma$</td>
<td>$(2.68 \pm 0.31) \times 10^{-3}$</td>
<td></td>
<td>652</td>
</tr>
<tr>
<td>$\gamma \gamma$</td>
<td>$(9.4 \pm 0.7) \times 10^{-6}$</td>
<td></td>
<td>659</td>
</tr>
<tr>
<td>$e^+ e^-$</td>
<td>$&lt; 5 \times 10^{-9}$ CL=90%</td>
<td></td>
<td>659</td>
</tr>
</tbody>
</table>

### $f_0(1370)$

$J^G(J^{PC}) = 0^+(0^{++})$

Mass $m = 1200$ to $1500$ MeV

Full width $\Gamma = 200$ to $500$ MeV

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi \pi$</td>
<td>seen</td>
<td>672</td>
</tr>
<tr>
<td>$4\pi$</td>
<td>seen</td>
<td>617</td>
</tr>
<tr>
<td>$4\pi^0$</td>
<td>seen</td>
<td>617</td>
</tr>
<tr>
<td>$2\pi^+ 2\pi^-$</td>
<td>seen</td>
<td>612</td>
</tr>
<tr>
<td>$\pi^+ \pi^- 2\pi^0$</td>
<td>seen</td>
<td>615</td>
</tr>
<tr>
<td>$\rho \rho$</td>
<td>dominant</td>
<td>†</td>
</tr>
<tr>
<td>$2(\pi\pi)$ s-wave</td>
<td>seen</td>
<td>†</td>
</tr>
<tr>
<td>$\pi(1300)\pi$</td>
<td>seen</td>
<td>†</td>
</tr>
<tr>
<td>$a_1(1260)\pi$</td>
<td>seen</td>
<td>35</td>
</tr>
<tr>
<td>$\eta \eta$</td>
<td>seen</td>
<td>411</td>
</tr>
<tr>
<td>$K \bar{K}$</td>
<td>seen</td>
<td>475</td>
</tr>
<tr>
<td>$K \bar{K} n \pi$</td>
<td>not seen</td>
<td>†</td>
</tr>
<tr>
<td>$6\pi$</td>
<td>not seen</td>
<td>508</td>
</tr>
</tbody>
</table>
ωω not seen
γγ seen 685
e+e− not seen 685

\[ \pi_1(1400) \] [\textsuperscript{[n]} \]
\[ i^G(J^{PC}) = 1^-(1^-+) \]

Mass \( m = 1354 \pm 25 \text{ MeV} \) \((S = 1.8)\)
Full width \( \Gamma = 330 \pm 35 \text{ MeV} \)

\[ \pi_1(1400) \text{ DECAY MODES} \]
\[ \frac{\Gamma_i}{\Gamma} \] \( p \) (MeV/c)
\[ \eta \pi^0 \] seen 557
\[ \eta \pi^- \] seen 556

\[ \eta(1405) \] [\textsuperscript{[o]} \]
\[ i^G(J^{PC}) = 0^+(0^-+) \]

Mass \( m = 1408.8 \pm 1.8 \text{ MeV} \) \([\textsuperscript{l}]\) \((S = 2.1)\)
Full width \( \Gamma = 51.0 \pm 2.9 \text{ MeV} \) \([\textsuperscript{l}]\) \((S = 1.8)\)

\[ \eta(1405) \text{ DECAY MODES} \]
\[ \frac{\Gamma_i}{\Gamma} \] \( p \) (MeV/c)
\[ K\bar{K} \pi \] seen 424
\[ \eta \pi \pi \] seen 562
\[ a_0(980) \pi \] seen 345
\[ \eta(\pi \pi) \text{s-wave} \] seen -
\[ f_0(980) \eta \] seen 99.85% 
\[ 4\pi \] seen 639
\[ \rho \rho \] seen 491
\[ \rho^0 \gamma \] seen 123
\[ K^*(892) K \] seen 

\[ f_1(1420) \] [\textsuperscript{[p]} \]
\[ i^G(J^{PC}) = 0^+(1^+++) \]

Mass \( m = 1426.4 \pm 0.9 \text{ MeV} \) \((S = 1.1)\)
Full width \( \Gamma = 54.9 \pm 2.6 \text{ MeV} \)

\[ f_1(1420) \text{ DECAY MODES} \]
\[ \frac{\Gamma_i}{\Gamma} \] \( p \) (MeV/c)
\[ K\bar{K} \pi \] dominant 438
\[ K\bar{K}^*(892) + \text{c.c.} \] dominant 163
\[ \eta \pi \pi \] possibly seen 573
\[ \phi \gamma \] seen 349
$\omega(1420)$ \([q]\)

$I^G(J^{PC}) = 0^-(1^{--})$

Mass $m = (1400–1450)\text{ MeV}$
Full width $\Gamma = (180–250)\text{ MeV}$

<table>
<thead>
<tr>
<th>$\omega(1420)$ DECAY MODES</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho \pi$</td>
<td>dominant</td>
<td>486</td>
</tr>
<tr>
<td>$\omega \pi \pi$</td>
<td>seen</td>
<td>444</td>
</tr>
<tr>
<td>$b_1(1235) \pi$</td>
<td>seen</td>
<td>125</td>
</tr>
<tr>
<td>$e^+ e^-$</td>
<td>seen</td>
<td>710</td>
</tr>
</tbody>
</table>

$a_0(1450)$ \([l]\)

$I^G(J^{PC}) = 1^-(0^{++})$

Mass $m = 1474 \pm 19\text{ MeV}$
Full width $\Gamma = 265 \pm 13\text{ MeV}$

<table>
<thead>
<tr>
<th>$a_0(1450)$ DECAY MODES</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi \eta$</td>
<td>seen</td>
<td>627</td>
</tr>
<tr>
<td>$\pi \eta'(958)$</td>
<td>seen</td>
<td>410</td>
</tr>
<tr>
<td>$K \bar{K}$</td>
<td>seen</td>
<td>547</td>
</tr>
<tr>
<td>$\omega \pi \pi$</td>
<td>seen</td>
<td>484</td>
</tr>
<tr>
<td>$a_0(980) \pi \pi$</td>
<td>seen</td>
<td>342</td>
</tr>
<tr>
<td>$\gamma \gamma$</td>
<td>see</td>
<td>737</td>
</tr>
</tbody>
</table>

$\rho(1450)$ \([r]\)

$I^G(J^{PC}) = 1^+(1^{--})$

Mass $m = 1465 \pm 25\text{ MeV} \[l]\$
Full width $\Gamma = 400 \pm 60\text{ MeV} \[l]\$

<table>
<thead>
<tr>
<th>$\rho(1450)$ DECAY MODES</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi \pi$</td>
<td>seen</td>
<td>720</td>
</tr>
<tr>
<td>$4\pi$</td>
<td>seen</td>
<td>669</td>
</tr>
<tr>
<td>$e^+ e^-$</td>
<td>seen</td>
<td>732</td>
</tr>
<tr>
<td>$\eta \rho$</td>
<td>possibly seen</td>
<td>311</td>
</tr>
<tr>
<td>$a_2(1320) \pi$</td>
<td>not seen</td>
<td>54</td>
</tr>
<tr>
<td>$K \bar{K}$</td>
<td>not seen</td>
<td>541</td>
</tr>
<tr>
<td>$K \bar{K}^*(892) + c.c.$</td>
<td>possibly seen</td>
<td>229</td>
</tr>
<tr>
<td>$\eta \gamma$</td>
<td>possibly seen</td>
<td>630</td>
</tr>
</tbody>
</table>
$f_0(500)\gamma$ not seen --
$f_0(980)\gamma$ not seen 398
$f_0(1370)\gamma$ not seen 92
$f_2(1270)\gamma$ not seen 178

$\eta(1475)$ \cite{a}

\[ iG(J^{PC}) = 0^+(0^-+) \]

Mass $m = 1476 \pm 4$ MeV ($S = 1.3$)
Full width $\Gamma = 85 \pm 9$ MeV ($S = 1.5$)

$\eta(1475)$ DECAY MODES

<table>
<thead>
<tr>
<th>Decay Modes</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>Scale Factor ($\rho$) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K\bar{K}\pi$</td>
<td>dominant</td>
<td></td>
</tr>
<tr>
<td>$K\bar{K}^*(892)+$ c.c.</td>
<td>seen</td>
<td>477</td>
</tr>
<tr>
<td>$a_0(980)\pi$</td>
<td>seen</td>
<td>245</td>
</tr>
<tr>
<td>$\gamma\gamma$</td>
<td>seen</td>
<td>396</td>
</tr>
</tbody>
</table>

$f_0(1500)$ \cite{n}

\[ iG(J^{PC}) = 0^+(0^+) \]

Mass $m = 1505 \pm 6$ MeV ($S = 1.3$)
Full width $\Gamma = 109 \pm 7$ MeV

$f_0(1500)$ DECAY MODES

<table>
<thead>
<tr>
<th>Decay Modes</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>Scale Factor ($\rho$) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi\pi$</td>
<td>(34.9\pm2.3) %</td>
<td>1.2</td>
</tr>
<tr>
<td>$\pi^+\pi^-$</td>
<td>seen</td>
<td>741</td>
</tr>
<tr>
<td>$2\pi^0$</td>
<td>seen</td>
<td>740</td>
</tr>
<tr>
<td>$4\pi$</td>
<td>(49.5\pm3.3) %</td>
<td>1.2</td>
</tr>
<tr>
<td>$4\pi^0$</td>
<td>seen</td>
<td>691</td>
</tr>
<tr>
<td>$2\pi^+2\pi^-$</td>
<td>seen</td>
<td>687</td>
</tr>
<tr>
<td>$2(\pi\pi)s$-wave</td>
<td>seen</td>
<td>$\rho$</td>
</tr>
<tr>
<td>$\rho\rho$</td>
<td>seen</td>
<td>$\gamma\gamma$</td>
</tr>
<tr>
<td>$\pi(1300)\pi$</td>
<td>seen</td>
<td>144</td>
</tr>
<tr>
<td>$a_1(1260)\pi$</td>
<td>seen</td>
<td>218</td>
</tr>
<tr>
<td>$\eta\eta'$</td>
<td>(5.1\pm0.9) %</td>
<td>1.4</td>
</tr>
<tr>
<td>$\eta\eta'(958)$</td>
<td>(1.9\pm0.8) %</td>
<td>1.7</td>
</tr>
<tr>
<td>$K\bar{K}$</td>
<td>(8.6\pm1.0) %</td>
<td>1.1</td>
</tr>
<tr>
<td>$\gamma\gamma$</td>
<td>not seen</td>
<td>753</td>
</tr>
</tbody>
</table>
**f'_2(1525)**

\[ i^G (JPC) = 0^+(2^+ +) \]

Mass \( m = 1525 \pm 5 \text{ MeV} \)
Full width \( \Gamma = 73^{+6}_{-5} \text{ MeV} \)

<table>
<thead>
<tr>
<th>( f'_2(1525) ) DECAY MODES</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( K\bar{K} )</td>
<td>(88.7 ± 2.2 ) %</td>
<td>581</td>
</tr>
<tr>
<td>( \eta\eta )</td>
<td>(10.4 ± 2.2 ) %</td>
<td>530</td>
</tr>
<tr>
<td>( \pi\pi )</td>
<td>( 8.2 ±1.5 ) \times 10^{-3}</td>
<td>750</td>
</tr>
<tr>
<td>( \gamma\gamma )</td>
<td>( 1.10±0.14) \times 10^{-6}</td>
<td>763</td>
</tr>
</tbody>
</table>

**\pi_1(1600) \ [n]**

\[ i^G (JPC) = 1^-(1^- +) \]

Mass \( m = 1662^{+8}_{-9} \text{ MeV} \)
Full width \( \Gamma = 241 \pm 40 \text{ MeV} \) (S = 1.4)

<table>
<thead>
<tr>
<th>( \pi_1(1600) ) DECAY MODES</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \pi\pi\pi )</td>
<td>not seen</td>
<td>803</td>
</tr>
<tr>
<td>( \rho^0\pi^- )</td>
<td>not seen</td>
<td>641</td>
</tr>
<tr>
<td>( f_2(1270)\pi^- )</td>
<td>not seen</td>
<td>318</td>
</tr>
<tr>
<td>( b_1(1235)\pi )</td>
<td>seen</td>
<td>357</td>
</tr>
<tr>
<td>( \eta'(958)\pi^- )</td>
<td>seen</td>
<td>543</td>
</tr>
<tr>
<td>( f_1(1285)\pi )</td>
<td>seen</td>
<td>314</td>
</tr>
</tbody>
</table>

**\eta_2(1645)**

\[ i^G (JPC) = 0^+(2^- +) \]

Mass \( m = 1617 \pm 5 \text{ MeV} \)
Full width \( \Gamma = 181 \pm 11 \text{ MeV} \)

<table>
<thead>
<tr>
<th>( \eta_2(1645) ) DECAY MODES</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( a_2(1320)\pi )</td>
<td>seen</td>
<td>242</td>
</tr>
<tr>
<td>( K\bar{K}\pi )</td>
<td>seen</td>
<td>580</td>
</tr>
<tr>
<td>( K^+\bar{K} )</td>
<td>seen</td>
<td>404</td>
</tr>
<tr>
<td>( \eta\pi^+\pi^- )</td>
<td>seen</td>
<td>685</td>
</tr>
<tr>
<td>( a_0(980)\pi )</td>
<td>seen</td>
<td>499</td>
</tr>
<tr>
<td>( f_2(1270)\eta )</td>
<td>not seen</td>
<td>†</td>
</tr>
</tbody>
</table>
**ω(1650) [s]**

\[ i^G(J^{PC}) = 0^-(1^{--}) \]

Mass \( m = 1670 \pm 30 \) MeV  
Full width \( \Gamma = 315 \pm 35 \) MeV

<table>
<thead>
<tr>
<th>( \omega(1650) ) DECAY MODES</th>
<th>Fraction ( (\Gamma_i/\Gamma) )</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \rho \pi )</td>
<td>seen</td>
<td>647</td>
</tr>
<tr>
<td>( \omega \pi \pi )</td>
<td>seen</td>
<td>617</td>
</tr>
<tr>
<td>( \omega \eta )</td>
<td>seen</td>
<td>500</td>
</tr>
<tr>
<td>( e^+e^- )</td>
<td>seen</td>
<td>835</td>
</tr>
</tbody>
</table>

**ω(1650) DECA Y MODES**

<table>
<thead>
<tr>
<th>( \omega_3(1670) )</th>
<th>( i^G(J^{PC}) = 0^-(3^{--}) )</th>
</tr>
</thead>
</table>

Mass \( m = 1667 \pm 4 \) MeV  
Full width \( \Gamma = 168 \pm 10 \) MeV [l]

<table>
<thead>
<tr>
<th>( \omega_3(1670) ) DECAY MODES</th>
<th>Fraction ( (\Gamma_i/\Gamma) )</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \rho \pi )</td>
<td>seen</td>
<td>645</td>
</tr>
<tr>
<td>( \omega \pi \pi )</td>
<td>seen</td>
<td>615</td>
</tr>
<tr>
<td>( b_1(1235) \pi )</td>
<td>possibly seen</td>
<td>361</td>
</tr>
</tbody>
</table>

**ω3(1670) DECA Y MODES**

<table>
<thead>
<tr>
<th>( \pi_2(1670) )</th>
<th>( i^G(J^{PC}) = 1^-(2^{-+}) )</th>
</tr>
</thead>
</table>

Mass \( m = 1672.2 \pm 3.0 \) MeV [l] \( (S = 1.4) \)  
Full width \( \Gamma = 260 \pm 9 \) MeV [l] \( (S = 1.2) \)

<table>
<thead>
<tr>
<th>( \pi_2(1670) ) DECAY MODES</th>
<th>Fraction ( (\Gamma_i/\Gamma) )</th>
<th>Confidence level ( (\text{MeV/c}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 3\pi )</td>
<td>( (95.8 \pm 1.4) ) %</td>
<td>809</td>
</tr>
<tr>
<td>( f_2(1270) \pi )</td>
<td>( (56.3 \pm 3.2) ) %</td>
<td>329</td>
</tr>
<tr>
<td>( \rho \pi )</td>
<td>( (31 \pm 4) ) %</td>
<td>648</td>
</tr>
<tr>
<td>( \sigma \pi )</td>
<td>( (10.9 \pm 3.4) ) %</td>
<td>–</td>
</tr>
<tr>
<td>( (\pi \pi) S\text{-wave} )</td>
<td>( (8.7 \pm 3.4) ) %</td>
<td>–</td>
</tr>
<tr>
<td>( K K^*(892) + \text{c.c.} )</td>
<td>( (4.2 \pm 1.4) ) %</td>
<td>455</td>
</tr>
<tr>
<td>( \omega \rho )</td>
<td>( (2.7 \pm 1.1) ) %</td>
<td>304</td>
</tr>
<tr>
<td>( \gamma \gamma )</td>
<td>( &lt; 2.8 \times 10^{-7} )</td>
<td>90% 836</td>
</tr>
<tr>
<td>( \rho(1450) \pi )</td>
<td>( &lt; 3.6 \times 10^{-3} )</td>
<td>97.7% 147</td>
</tr>
<tr>
<td>( b_1(1235) \pi )</td>
<td>( &lt; 1.9 \times 10^{-3} )</td>
<td>97.7% 365</td>
</tr>
<tr>
<td>( f_1(1285) \pi )</td>
<td>possibly seen</td>
<td>323</td>
</tr>
<tr>
<td>( a_2(1320) \pi )</td>
<td>not seen</td>
<td>292</td>
</tr>
</tbody>
</table>

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**φ(1680)**

\[ i^G (J^P C) = 0^- (1^- -) \]

Mass \( m = 1680 \pm 20 \text{ MeV} \)

Full width \( \Gamma = 150 \pm 50 \text{ MeV} \)

<table>
<thead>
<tr>
<th>Decay Modes</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( K K^* (892) + \text{c.c.} )</td>
<td>dominant</td>
<td>462</td>
</tr>
<tr>
<td>( K^0 K \pi )</td>
<td>seen</td>
<td>621</td>
</tr>
<tr>
<td>( K \bar{K} )</td>
<td>seen</td>
<td>680</td>
</tr>
<tr>
<td>( e^+ e^- )</td>
<td>seen</td>
<td>840</td>
</tr>
<tr>
<td>( \omega \pi \pi )</td>
<td>not seen</td>
<td>623</td>
</tr>
<tr>
<td>( K^+ K^- \pi^+ \pi^- )</td>
<td>seen</td>
<td>544</td>
</tr>
</tbody>
</table>

**ρ(1690)**

\[ i^G (J^P C) = 1^+ (3^- -) \]

Mass \( m = 1688.8 \pm 2.1 \text{ MeV} \)

Full width \( \Gamma = 161 \pm 10 \text{ MeV} \) \( (S = 1.5) \)

| Decay Modes | Fraction \((\Gamma_i/\Gamma)\) | Scale factor \( p \) (MeV/c) |
|-------------|-------------------------------|----------------|---|
| \( 4\pi \) | (71.1 ± 1.9 )% | 790 |
| \( \pi^+ \pi^- \pi^+ \pi^- \) | (67 ± 22 )% | 787 |
| \( \omega \pi \) | (16 ± 6 )% | 655 |
| \( \pi \pi \) | (23.6 ± 1.3 )% | 834 |
| \( K \bar{K} \) | (3.8 ± 1.2 )% | 629 |
| \( K K^* \) | (1.58± 0.26)% | 1.2 | 685 |
| \( \eta \pi^+ \pi^- \) | seen | 727 |
| \( \rho(770) \eta \) | seen | 520 |
| \( \pi \pi \rho \) | seen | 633 |
| \( a_2(1320) \pi \) | seen | 307 |
| \( \rho \rho \) | seen | 335 |

**ρ(1700)**

\[ i^G (J^P C) = 1^+ (1^- -) \]

Mass \( m = 1720 \pm 20 \text{ MeV} \) \( (\eta \rho^0 \text{ and } \pi^+ \pi^- \text{ modes}) \)

Full width \( \Gamma = 250 \pm 100 \text{ MeV} \) \( (\eta \rho^0 \text{ and } \pi^+ \pi^- \text{ modes}) \)

<table>
<thead>
<tr>
<th>Decay Modes</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 2(\pi^+ \pi^-) )</td>
<td>large</td>
<td>803</td>
</tr>
<tr>
<td>( \rho \pi \pi )</td>
<td>dominant</td>
<td>653</td>
</tr>
<tr>
<td>( \rho^0 \pi^+ \pi^- )</td>
<td>large</td>
<td>651</td>
</tr>
</tbody>
</table>
\begin{align*}
\rho^{\pm} \pi^{\mp} \pi^{0} & \quad \text{large} & 652 \\
a_1(1260) \pi & \quad \text{seen} & 404 \\
h_1(1170) \pi & \quad \text{seen} & 447 \\
\pi(1300) \pi & \quad \text{seen} & 349 \\
\rho \rho & \quad \text{seen} & 372 \\
\pi^{+} \pi^{-} & \quad \text{seen} & 849 \\
\pi \pi & \quad \text{seen} & 849 \\
K \overline{K}(892) + \text{c.c.} & \quad \text{seen} & 496 \\
\eta \rho & \quad \text{seen} & 545 \\
a_2(1320) \pi & \quad \text{not seen} & 334 \\
K \overline{K} & \quad \text{seen} & 704 \\
e^{+} e^{-} & \quad \text{seen} & 860 \\
\pi^{0} \omega & \quad \text{seen} & 674 \\
\end{align*}

\begin{tabular}{|c|c|c|}
\hline
\textbf{f_0(1710)} & $I^G(J^{PC}) = 0^{+}(0^{++})$ & \\
\hline
Mass $m = 1722^{+6}_{-5}$ MeV & $(S = 1.6)$ & \\
Full width $\Gamma = 135 \pm 7$ MeV & $(S = 1.1)$ & \\
\hline
\end{tabular}

\begin{tabular}{|c|c|c|}
\hline
\textbf{f_0(1710) DECAY MODES} & Fraction ($\Gamma_i/\Gamma$) & $p$ (MeV/c) \\
\hline
K \overline{K} & \text{seen} & 705 \\
\eta \eta & \text{seen} & 664 \\
\pi \pi & \text{seen} & 850 \\
\omega \omega & \text{seen} & 358 \\
\hline
\end{tabular}

\begin{align*}
\pi(1800) & \quad I^G(J^{PC}) = 1^{−}(0^{−+}) \\
\text{Mass} & \quad m = 1812 \pm 12$ MeV $(S = 2.3)$ \\
\text{Full width} & \quad \Gamma = 208 \pm 12$ MeV \\
\hline
\textbf{\pi(1800) DECAY MODES} & Fraction ($\Gamma_i/\Gamma$) & $p$ (MeV/c) \\
\hline
\pi^{+} \pi^{-} \pi^{-} & \text{seen} & 879 \\
f_0(500) \pi^{-} & \text{seen} & \_ \_ \\
f_0(980) \pi^{-} & \text{seen} & 625 \\
f_0(1370) \pi^{-} & \text{seen} & 368 \\
f_0(1500) \pi^{-} & \text{not seen} & 250 \\
\rho \pi^{-} & \text{not seen} & 732 \\
\eta \eta \pi^{-} & \text{seen} & 661 \\
a_0(980) \eta & \text{seen} & 473 \\
\hline
\end{tabular}
\[ a_2(1320) \eta \quad \text{not seen} \]
\[ f_2(1270) \pi \quad \text{not seen} \]
\[ f_0(1370) \pi^- \quad \text{not seen} \]
\[ f_0(1500) \pi^- \quad \text{seen} \]
\[ \eta \eta' (958) \pi^- \quad \text{seen} \]
\[ K_0^*(1430) K^- \quad \text{seen} \]
\[ K^*(892) K^- \quad \text{not seen} \]

\[ \phi_3(1850) \]
\[ i^G (JPC) = 0^-(3^- -) \]

Mass \( m = 1854 \pm 7 \text{ MeV} \)
Full width \( \Gamma = 87^{+28}_{-23} \text{ MeV} \quad (S = 1.2) \)

\[ \phi_3(1850) \text{ DECAY MODES} \quad \begin{array}{ccc}
K \overline{K} & \text{seen} & 785 \\
K \overline{K}^* (892) + \text{c.c.} & \text{seen} & 602
\end{array} \]

\[ \pi_2(1880) \]
\[ i^G (JPC) = 1^-(2 - +) \]

Mass \( m = 1895 \pm 16 \text{ MeV} \)
Full width \( \Gamma = 235 \pm 34 \text{ MeV} \)

\[ f_2(1950) \]
\[ i^G (JPC) = 0^+(2 + +) \]

Mass \( m = 1944 \pm 12 \text{ MeV} \quad (S = 1.5) \)
Full width \( \Gamma = 472 \pm 18 \text{ MeV} \)

\[ f_2(1950) \text{ DECAY MODES} \quad \begin{array}{ccc}
K^* (892) \overline{K}^* (892) & \text{seen} & 387 \\
\pi^+ \pi^- & \text{seen} & 962 \\
\pi^0 \pi^0 & \text{seen} & 963 \\
4\pi & \text{seen} & 925 \\
\eta \eta & \text{seen} & 803 \\
K \overline{K} & \text{seen} & 837 \\
\gamma \gamma & \text{seen} & 972 \\
\rho \overline{\rho} & \text{seen} & 254
\end{array} \]
$f_2(2010)$

\[ iG(J^{PC}) = 0^+(2^{-+}) \]

Mass $m = 2011^{+60}_{-80}$ MeV  
Full width $\Gamma = 202 \pm 60$ MeV

<table>
<thead>
<tr>
<th>$f_2(2010)$ DECAY MODES</th>
<th>Fraction $(\Gamma_i/\Gamma)$</th>
<th>$\rho$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi\phi$</td>
<td>seen</td>
<td>$\uparrow$</td>
</tr>
<tr>
<td>$K\bar{K}$</td>
<td>seen</td>
<td>876</td>
</tr>
</tbody>
</table>

$a_4(2040)$

\[ iG(J^{PC}) = 1^-(4^{++}) \]

Mass $m = 1996^{+10}_{-9}$ MeV  ($S = 1.1$)  
Full width $\Gamma = 255^{+28}_{-24}$ MeV  ($S = 1.3$)

<table>
<thead>
<tr>
<th>$a_4(2040)$ DECAY MODES</th>
<th>Fraction $(\Gamma_i/\Gamma)$</th>
<th>$\rho$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K\bar{K}$</td>
<td>seen</td>
<td>868</td>
</tr>
<tr>
<td>$\pi^+\pi^-\pi^0$</td>
<td>seen</td>
<td>974</td>
</tr>
<tr>
<td>$\rho\pi$</td>
<td>seen</td>
<td>841</td>
</tr>
<tr>
<td>$f_2(1270)\pi$</td>
<td>seen</td>
<td>580</td>
</tr>
<tr>
<td>$\omega\pi^-\pi^0$</td>
<td>seen</td>
<td>819</td>
</tr>
<tr>
<td>$\omega\rho$</td>
<td>seen</td>
<td>624</td>
</tr>
<tr>
<td>$\eta\pi^0$</td>
<td>seen</td>
<td>918</td>
</tr>
<tr>
<td>$\eta'(958)\pi$</td>
<td>seen</td>
<td>761</td>
</tr>
</tbody>
</table>

$f_2(2050)$

\[ iG(J^{PC}) = 0^+(4^{++}) \]

Mass $m = 2018 \pm 11$ MeV  ($S = 2.1$)  
Full width $\Gamma = 237 \pm 18$ MeV  ($S = 1.9$)

<table>
<thead>
<tr>
<th>$f_2(2050)$ DECAY MODES</th>
<th>Fraction $(\Gamma_i/\Gamma)$</th>
<th>$\rho$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\omega\omega$</td>
<td>seen</td>
<td>637</td>
</tr>
<tr>
<td>$\pi\pi$</td>
<td>$(17.0 \pm 1.5)%$</td>
<td>1000</td>
</tr>
<tr>
<td>$K\bar{K}$</td>
<td>$(6.8^{+3.4}_{-1.8}) \times 10^{-3}$</td>
<td>880</td>
</tr>
<tr>
<td>$\eta\eta$</td>
<td>$(2.1 \pm 0.8) \times 10^{-3}$</td>
<td>848</td>
</tr>
<tr>
<td>$4\pi^0$</td>
<td>&lt; 1.2%</td>
<td>964</td>
</tr>
<tr>
<td>$a_2(1320)\pi$</td>
<td>seen</td>
<td>567</td>
</tr>
</tbody>
</table>
\[ \phi(2170) \]

\[ j^G J^{PC} = 0^- (1^- -) \]

Mass \( m = 2175 \pm 15 \text{ MeV} \) \((S = 1.6)\)
Full width \( \Gamma = 61 \pm 18 \text{ MeV} \)

\text{\phi(2170) DECA Y MODES}

<table>
<thead>
<tr>
<th>Decays</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( e^+ e^- )</td>
<td>seen</td>
<td>1087</td>
</tr>
<tr>
<td>( \phi f_0(980) )</td>
<td>seen</td>
<td>416</td>
</tr>
<tr>
<td>( K^+ K^- f_0(980) \to )</td>
<td>seen</td>
<td></td>
</tr>
<tr>
<td>( K^+ K^- \pi^+ \pi^- )</td>
<td>seen</td>
<td></td>
</tr>
<tr>
<td>( K^+ K^- f_0(980) \to K^+ K^- \pi^0 \pi^0 )</td>
<td>seen</td>
<td></td>
</tr>
<tr>
<td>( K^* f_0(980) \to K^+ K^- \pi^0 \pi^0 )</td>
<td>not seen</td>
<td>770</td>
</tr>
<tr>
<td>( K^* (892)^0 K^* (892)^0 )</td>
<td>not seen</td>
<td>622</td>
</tr>
</tbody>
</table>

\[ f_2(2300) \]

\[ j^G J^{PC} = 0^+ (2^++ \) \]

Mass \( m = 2297 \pm 28 \text{ MeV} \)
Full width \( \Gamma = 149 \pm 40 \text{ MeV} \)

\text{f_2(2300) DECA Y MODES}

<table>
<thead>
<tr>
<th>Decays</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \phi \phi )</td>
<td>seen</td>
<td>529</td>
</tr>
<tr>
<td>( K K )</td>
<td>seen</td>
<td>1037</td>
</tr>
<tr>
<td>( \gamma \gamma )</td>
<td>seen</td>
<td>1149</td>
</tr>
</tbody>
</table>

\[ f_2(2340) \]

\[ j^G J^{PC} = 0^+ (2^++ \) \]

Mass \( m = 2339 \pm 60 \text{ MeV} \)
Full width \( \Gamma = 319^{+80}_{-70} \text{ MeV} \)

\text{f_2(2340) DECA Y MODES}

<table>
<thead>
<tr>
<th>Decays</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \phi \phi )</td>
<td>seen</td>
<td>573</td>
</tr>
<tr>
<td>( \eta \eta )</td>
<td>seen</td>
<td>1033</td>
</tr>
</tbody>
</table>
\[ K^\pm = u\bar{s}, \ K^0 = d\bar{s}, \ K^0 = d, \ K^- = \bar{u}s, \ \text{similarly for } K^*\text{'s} \]

\[ I(J^P) = \frac{1}{2}(0^-) \]

Mass \( m = 493.677 \pm 0.016 \text{ MeV} \) \( (S = 2.8) \)
Mean life \( \tau = (1.2380 \pm 0.0021) \times 10^{-8} \text{ s} \) \( (S = 1.9) \)
\( c\tau = 3.712 \text{ m} \)

**Slope parameter \( g \)** [v]

(See Particle Listings for quadratic coefficients and alternative parametrization related to \( \pi\pi \) scattering)

\[ K^\pm \rightarrow \pi^+\pi^- \quad g = -0.21134 \pm 0.00017 \]
\[ K^\pm \rightarrow \pi^0\pi^0 \quad g = 0.626 \pm 0.007 \]

\[ (g^+ - g^-) / (g^+ + g^-) = (-1.5 \pm 2.2) \times 10^{-4} \]

\[ (g^- - g^-) / (g^+ + g^-) = (1.8 \pm 1.8) \times 10^{-4} \]

**\( K^\pm \) decay form factors** [a,x]

Assuming \( \mu-e \) universality

\[ \lambda_+(K^{+\mu3}) = \lambda_+(K^{+e3}) = (2.97 \pm 0.05) \times 10^{-2} \]
\[ \lambda_0(K^{+\mu3}) = (1.95 \pm 0.12) \times 10^{-2} \]

Not assuming \( \mu-e \) universality

\[ \lambda_+(K^{+e3}) = (2.98 \pm 0.05) \times 10^{-2} \]
\[ \lambda_+(K^{+\mu3}) = (2.96 \pm 0.17) \times 10^{-2} \]
\[ \lambda_0(K^{+\mu3}) = (1.96 \pm 0.13) \times 10^{-2} \]

**\( K^{+\mu3} \) form factor quadratic fit**

\[ \lambda_1'(K^{+\mu3}) \text{ linear coeff. } = (2.49 \pm 0.17) \times 10^{-2} \]
\[ \lambda_2'(K^{+\mu3}) \text{ quadratic coeff. } = (0.19 \pm 0.09) \times 10^{-2} \]

\[ K^{+e3} \quad |f_S/f_+| = (-0.3^{+0.8}_{-0.7}) \times 10^{-2} \]
\[ K^{+e3} \quad |f_T/f_+| = (-1.2 \pm 2.3) \times 10^{-2} \]
\[ K^{+\mu3} \quad |f_S/f_+| = (0.2 \pm 0.6) \times 10^{-2} \]
\[ K^{+\mu3} \quad |f_T/f_+| = (-0.1 \pm 0.7) \times 10^{-2} \]

\[ K^+ \rightarrow e^+\nu_e \gamma \quad |F_A + F_V| = 0.133 \pm 0.008 \quad (S = 1.3) \]
\[ K^+ \rightarrow \mu^+\nu_\mu \gamma \quad |F_A + F_V| = 0.165 \pm 0.013 \]
\[ K^+ \rightarrow e^+\nu_e \gamma \quad |F_A - F_V| < 0.49 \]
\[ K^+ \rightarrow \mu^+\nu_\mu \gamma \quad |F_A - F_V| = -0.24 \text{ to } 0.04, \ CL = 90\% \]
Charge Radius
\[ \langle r \rangle = 0.560 \pm 0.031 \text{ fm} \]

**CP violation parameters**

\[ \Delta(K_{\pi ee}) = ( -2.2 \pm 1.6 ) \times 10^{-2} \]
\[ \Delta(K_{\pi \mu \mu}) = 0.010 \pm 0.023 \]
\[ \Delta(K_{\pi \pi \gamma}) = ( 0.0 \pm 1.2 ) \times 10^{-3} \]
\[ A_{FB}(K_{\pi \mu \mu}) = \frac{\Gamma(\cos(\theta_{K_{\mu}}) > 0) - \Gamma(\cos(\theta_{K_{\mu}}) < 0)}{\Gamma(\cos(\theta_{K_{\mu}}) > 0) + \Gamma(\cos(\theta_{K_{\mu}}) < 0)} < 2.3 \times 10^{-2}, \text{ CL} = 90\% \]

**T violation parameters**

\[ K^+ \rightarrow \pi^0 \mu^+ \nu_\mu \quad P_T = ( -1.7 \pm 2.5 ) \times 10^{-3} \]
\[ K^+ \rightarrow \mu^+ \nu_\mu \gamma \quad P_T = ( -0.6 \pm 1.9 ) \times 10^{-2} \]
\[ K^+ \rightarrow \pi^0 \mu^+ \nu_\mu \quad \text{Im}(\xi) = -0.006 \pm 0.008 \]

\( K^- \) modes are charge conjugates of the modes below.

### K⁺ Decay Modes

<table>
<thead>
<tr>
<th>Decay Modes</th>
<th>Fraction (( \Gamma_j / \Gamma ))</th>
<th>Scale Factor/Confidence level(MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leptonic and semileptonic modes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e⁺νₑ</td>
<td>( 1.581±0.007 ) \times 10⁻⁵</td>
<td>247</td>
</tr>
<tr>
<td>μ⁺ν_μ</td>
<td>( 63.55 \pm 0.11 ) %</td>
<td>S=1.2 236</td>
</tr>
<tr>
<td>π⁰e⁺νₑ</td>
<td>( 5.07 \pm 0.04 ) %</td>
<td>S=2.1 228</td>
</tr>
<tr>
<td>Called ( K_{\pi^0 e^+}^+ )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>π⁺π⁻e⁺νₑ</td>
<td>( 2.2 \ ±0.4 ) \times 10⁻⁵</td>
<td>206</td>
</tr>
<tr>
<td>π⁺π⁻μ⁺ν_μ</td>
<td>( 4.254 \ ±0.032 ) \times 10⁻⁵</td>
<td>203</td>
</tr>
<tr>
<td>π⁺π⁻π⁺π⁻μ⁺ν_μ</td>
<td>( 1.4 \ ±0.9 ) \times 10⁻⁵</td>
<td>151</td>
</tr>
<tr>
<td>π⁺π⁻π⁰π⁰e⁺νₑ</td>
<td>&lt; 3.5 \times 10⁻⁶</td>
<td>135</td>
</tr>
<tr>
<td>Hadronic modes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>π⁺π⁰</td>
<td>( 20.66 \ ±0.08 ) %</td>
<td>S=1.2 205</td>
</tr>
<tr>
<td>π⁺π⁰π⁰</td>
<td>( 1.761 \ ±0.022 ) %</td>
<td>S=1.1 133</td>
</tr>
<tr>
<td>π⁺π⁺π⁻</td>
<td>( 5.59 \ ±0.04 ) %</td>
<td>S=1.3 125</td>
</tr>
<tr>
<td>Leptonic and semileptonic modes with photons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>μ⁺ν_μγ</td>
<td>[ν;z] ( 6.2 \ ±0.8 ) \times 10⁻³</td>
<td>236</td>
</tr>
<tr>
<td>μ⁺ν_μγ(SD⁺)</td>
<td>[a,aa] ( 1.33 \ ±0.22 ) \times 10⁻⁵</td>
<td>–</td>
</tr>
<tr>
<td>μ⁺ν_μγ(SD⁺INT)</td>
<td>[a,aa] &lt; 2.7 \times 10⁻⁵</td>
<td>CL=90% –</td>
</tr>
<tr>
<td>μ⁺ν_μγ(SD⁻ + SD⁻INT)</td>
<td>[a,aa] &lt; 2.6 \times 10⁻⁴</td>
<td>CL=90% –</td>
</tr>
<tr>
<td>Decay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$e^+ \nu_e \gamma$</td>
<td>$9.4 \pm 0.4 \times 10^{-6}$</td>
<td>247</td>
</tr>
<tr>
<td>$\pi^0 e^+ \nu_e \gamma$</td>
<td>$2.56 \pm 0.16 \times 10^{-4}$</td>
<td>228</td>
</tr>
<tr>
<td>$\pi^0 e^+ \nu_e \gamma$</td>
<td>$2.56 \pm 0.16 \times 10^{-4}$</td>
<td>228</td>
</tr>
<tr>
<td>$\pi^0 \mu^+ \nu_\mu \gamma$</td>
<td>$1.25 \pm 0.25 \times 10^{-5}$</td>
<td>215</td>
</tr>
<tr>
<td>$\pi^0 \pi^0 e^+ \nu_e \gamma$</td>
<td>$&lt; 5 \times 10^{-6}$</td>
<td>206</td>
</tr>
</tbody>
</table>

Hadronic modes with photons or $\ell\ell$ pairs

<table>
<thead>
<tr>
<th>Decay</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi^+ \pi^0 \gamma$ (INT)</td>
</tr>
<tr>
<td>$\pi^+ \pi^0 \gamma$ (DE)</td>
</tr>
<tr>
<td>$\pi^+ \pi^0 \pi^0 \gamma$</td>
</tr>
<tr>
<td>$\pi^+ \pi^+ \pi^- \gamma$</td>
</tr>
<tr>
<td>$\pi^+ \gamma \gamma$</td>
</tr>
<tr>
<td>$\pi^+ 3\gamma$</td>
</tr>
<tr>
<td>$\pi^+ e^+ e^- \gamma$</td>
</tr>
</tbody>
</table>

Leptonic modes with $\ell\ell$ pairs

<table>
<thead>
<tr>
<th>Decay</th>
</tr>
</thead>
<tbody>
<tr>
<td>$e^+ \nu_e \nu_\nu$</td>
</tr>
<tr>
<td>$\mu^+ \nu_\mu \nu_\nu$</td>
</tr>
<tr>
<td>$e^+ \nu_e e^+ e^-$</td>
</tr>
<tr>
<td>$\mu^+ \nu_\mu e^+ e^-$</td>
</tr>
<tr>
<td>$e^+ \nu_\nu \mu^+ \mu^-$</td>
</tr>
<tr>
<td>$\mu^+ \nu_\mu \mu^+ \mu^-$</td>
</tr>
</tbody>
</table>

Lepton Family number ($LF$), Lepton number ($L$), $\Delta S = \Delta Q$ ($SQ$) violating modes, or $\Delta S = 1$ weak neutral current ($S1$) modes

<table>
<thead>
<tr>
<th>Decay</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi^+ \pi^+ e^- \nu_e$</td>
</tr>
<tr>
<td>$\pi^+ \pi^+ \mu^- \nu_\mu$</td>
</tr>
<tr>
<td>$\pi^+ \pi^+ e^-$</td>
</tr>
<tr>
<td>$\pi^+ \mu^+ \mu^-$</td>
</tr>
<tr>
<td>$\pi^+ \nu_\nu$</td>
</tr>
<tr>
<td>$\pi^+ \pi^0 \nu_\nu$</td>
</tr>
<tr>
<td>$\mu^- \nu e^+ e^+$</td>
</tr>
<tr>
<td>$\mu^+ \nu_\nu$</td>
</tr>
<tr>
<td>$\pi^+ \mu^+ e^-$</td>
</tr>
<tr>
<td>$\pi^+ \mu^- e^+$</td>
</tr>
<tr>
<td>$\pi^- \mu^+ e^+$</td>
</tr>
<tr>
<td>$\pi^- e^+ e^+$</td>
</tr>
<tr>
<td>$\pi^- \mu^+ \mu^+$</td>
</tr>
<tr>
<td>$\mu^+ \nu_\nu$</td>
</tr>
<tr>
<td>$\pi^0 e^+ \nu_e$</td>
</tr>
<tr>
<td>$\pi^+ \gamma$</td>
</tr>
</tbody>
</table>
\[ \mathbf{K^0} \]

\[ I(J^P) = \frac{1}{2}(0^-) \]

50% \( K_S \), 50% \( K_L \)

Mass \( m = 497.614 \pm 0.024 \) MeV \( (S = 1.6) \)

\[ m_{K^0} - m_{K^+} = 3.937 \pm 0.028 \) MeV \( (S = 1.8) \)

\[ \text{Mean Square Charge Radius} \]

\[ \langle r^2 \rangle = -0.077 \pm 0.010 \) fm^2 \]

\[ \text{T-violation parameters in } K^0-\bar{K}^0 \text{ mixing} \]

Asymmetry \( A_T \) in \( K^0-\bar{K}^0 \) mixing = \( (6.6 \pm 1.6) \times 10^{-3} \)

\[ \text{CPT-violation parameters} \]

Re \( \delta = (2.5 \pm 2.3) \times 10^{-4} \)

Im \( \delta = (-1.5 \pm 1.6) \times 10^{-5} \)

Re(\( y \)), \( K_{e3} \) parameter = \( (0.4 \pm 2.5) \times 10^{-3} \)

Re(\( x_- \)), \( K_{e3} \) parameter = \( (-2.9 \pm 2.0) \times 10^{-3} \)

\[ |m_{K^0} - m_{\bar{K}^0}| / m_{\text{average}} < 6 \times 10^{-19}, \text{CL = 90\%} \]

\( (\Gamma_{K^0} - \Gamma_{\bar{K}^0})/m_{\text{average}} = (8 \pm 8) \times 10^{-18} \)

\[ \text{Tests of } \Delta S = \Delta Q \]

Re(\( x_+ \)), \( K_{e3} \) parameter = \( (-0.9 \pm 3.0) \times 10^{-3} \)

\[ \mathbf{K^0_S} \]

\[ I(J^P) = \frac{1}{2}(0^-) \]

Mean life \( \tau = (0.8954 \pm 0.0004) \times 10^{-10} \) s \( (S = 1.1) \)

Assuming CPT

Mean life \( \tau = (0.89564 \pm 0.00033) \times 10^{-10} \) s \( (S = 1.1) \)

Not assuming CPT

\[ c\tau = 2.6844 \text{ cm} \]

Assuming CPT

\[ \text{CP-violation parameters} \]

\[ \text{Im}(\eta_{+0}) = -0.002 \pm 0.009 \]

\[ \text{Im}(\eta_{000}) = (-0.1 \pm 1.6) \times 10^{-2} \]

\[ |\eta_{000}| = |A(K^0_S \to 3\pi^0)/A(K^0_L \to 3\pi^0)| < 0.0088, \text{CL = 90\%} \]

\( CP \) asymmetry \( A \) in \( \pi^+\pi^- e^+e^- = (-0.4 \pm 0.8)\% \)
\( K_S^0 \) \textbf{DECAY MODES}  

\begin{tabular}{|c|c|c|c|}
\hline
\textbf{Mode} & \textbf{Fraction (\( \Gamma_i / \Gamma \))} & \textbf{Scale factor/} & \textbf{Confidence level (MeV/c)} \\
\hline
\textbf{Hadronic modes} & & & \\
\( \pi^0 \pi^0 \) & (30.69 \pm 0.05) \% & & 209 \\
\( \pi^+ \pi^- \) & (69.20 \pm 0.05) \% & & 206 \\
\( \pi^+ \pi^- \pi^0 \) & (3.5 \pm 0.1) \times 10^{-7} & & 133 \\
\hline
\textbf{Modes with photons or \( \ell \bar{\ell} \) pairs} & & & \\
\( \pi^+ \pi^- \gamma \) & [z,ff] & (1.79 \pm 0.05) \times 10^{-3} & 206 \\
\( \pi^+ \pi^- e^+ e^- \) & [z,ff] & (4.79 \pm 0.15) \times 10^{-5} & 206 \\
\( \pi^0 \gamma \gamma \) & [ff] & (4.9 \pm 1.8) \times 10^{-8} & 231 \\
\( \gamma \gamma \) & & (2.63 \pm 0.17) \times 10^{-6} & S = 3.0 \\
\hline
\textbf{Semileptonic modes} & & & \\
\( \pi^\pm e^\mp \nu_e \) & [gg] & (7.04 \pm 0.08) \times 10^{-4} & 229 \\
\hline
\end{tabular} 

\textbf{\( CP \) violating (\( CP \)) and \( \Delta S = 1 \) weak neutral current (S1) modes}  

\begin{tabular}{|c|c|c|c|c|}
\hline
\textbf{Mode} & \textbf{CP} & \textbf{S1} & \textbf{S1} & \\
\hline
\( 3 \pi^0 \) & & & &  \\
\( \mu^+ \mu^- \) & < 2.6 & < 9 & < 9 & 139 \\
\( e^+ e^- \) & < 9 & < 9 & < 9 & 225 \\
\( \pi^0 e^+ e^- \) & [ff] & (3.0 \pm 1.5) \times 10^{-9} & & 230 \\
\( \pi^0 \mu^+ \mu^- \) & [ff] & (2.9 \pm 1.5) \times 10^{-9} & & 177 \\
\hline
\end{tabular} 

\( m_{K_L} - m_{K_S} \)  

\begin{align*}
&= (0.5293 \pm 0.0009) \times 10^{10} \, \text{f s}^{-1} \quad (S = 1.3) \quad \text{Assuming } \text{CPT} \\
&= (3.484 \pm 0.006) \times 10^{-12} \, \text{MeV} \quad \text{Assuming } \text{CPT} \\
&= (0.5289 \pm 0.0010) \times 10^{10} \, \text{f s}^{-1} \quad \text{Not assuming } \text{CPT} \\
&\text{Mean life } \tau = (5.116 \pm 0.021) \times 10^{-8} \, \text{s} \quad (S = 1.1) \\
&\tau = 15.34 \, \text{m}
\end{align*}

\textbf{Slope parameter } \( g \) \([v]\)  

(See Particle Listings for other linear and quadratic coefficients)  

\begin{align*}
K^0_L &\rightarrow \pi^+ \pi^- \pi^0: \ g = 0.678 \pm 0.008 \quad (S = 1.5) \\
K^0_L &\rightarrow \pi^0 \pi^0 \pi^0: \ h = (+0.59 \pm 0.20 \pm 1.16) \times 10^{-3}
\end{align*}

\textbf{\( K_L \) decay form factors} \([x]\)  

Linear parametrization assuming \( \mu-e \) universality  

\begin{align*}
\lambda_\pi(K^0_{\mu3}) &= \lambda_\pi(K^0_{e3}) = (2.82 \pm 0.04) \times 10^{-2} \quad (S = 1.1) \\
\lambda_0(K^0_{\mu3}) &= (1.38 \pm 0.18) \times 10^{-2} \quad (S = 2.2)
\end{align*}
Quadratic parametrization assuming $\mu$-$e$ universality

\[ \lambda'_+(K_{\mu 3}^0) = \lambda'_+(K_{e 3}^0) = (2.40 \pm 0.12) \times 10^{-2} \]  
(S = 1.2)

\[ \lambda''_+(K_{\mu 3}^0) = \lambda''_+(K_{e 3}^0) = (0.20 \pm 0.05) \times 10^{-2} \]  
(S = 1.2)

\[ \lambda_0(K_{\mu 3}^0) = (1.16 \pm 0.09) \times 10^{-2} \]  
(S = 1.2)

Pole parametrization assuming $\mu$-$e$ universality

\[ M^\mu_V (K_{\mu 3}^0) = M^e_V (K_{e 3}^0) = 878 \pm 6 \text{ MeV} \]  
(S = 1.1)

\[ M^\mu_S (K_{\mu 3}^0) = 1252 \pm 90 \text{ MeV} \]  
(S = 2.6)

Dispersive parametrization assuming $\mu$-$e$ universality

\[ \lambda_+ = (0.251 \pm 0.006) \times 10^{-1} \]  
(S = 1.5)

\[ \ln(C) = (1.75 \pm 0.18) \times 10^{-1} \]  
(S = 2.0)

\[ K_{e 3}^0 |f_3/f_+| = (1.5^{+1.4}_{-1.6}) \times 10^{-2} \]

\[ K_{e 3}^0 |f_T/f_+| = (5^{+4}_{-5}) \times 10^{-2} \]

\[ K_{\mu 3}^0 |f_T/f_+| = (12 \pm 12) \times 10^{-2} \]

\[ K_L \rightarrow \ell^+ \ell^- \gamma, K_L \rightarrow \ell^+ \ell^- \ell'^+ \ell'^-: \alpha_{K^*} = -0.205 \pm 0.022 \]  
(S = 1.8)

\[ K_L^0 \rightarrow \ell^+ \ell^- \gamma, K_L^0 \rightarrow \ell^+ \ell^- \ell'^+ \ell'^-: \alpha_{DIP} = -1.69 \pm 0.08 \]  
(S = 1.7)

\[ K_L \rightarrow \pi^+ \pi^- e^+ e^-: a_1/a_2 = -0.737 \pm 0.014 \text{ GeV}^2 \]

\[ K_L \rightarrow \pi^0 2\gamma: \quad a_V = -0.43 \pm 0.06 \]  
(S = 1.5)

**CP-violation parameters [ee]**

\[ A_L = (0.332 \pm 0.006)\% \]

\[ |\eta_{00}| = (2.220 \pm 0.011) \times 10^{-3} \]  
(S = 1.8)

\[ |\eta_{+-}| = (2.232 \pm 0.011) \times 10^{-3} \]  
(S = 1.8)

\[ |\epsilon| = (2.228 \pm 0.011) \times 10^{-3} \]  
(S = 1.8)

\[ |\eta_{00}/\eta_{+-}| = 0.9950 \pm 0.0007 [hh] \]  
(S = 1.6)

\[ \text{Re}(\epsilon'/\epsilon) = (1.66 \pm 0.23) \times 10^{-3} [hh] \]  
(S = 1.6)

Assuming $CPT$

\[ \phi_{+-} = (43.51 \pm 0.05)^\circ \]  
(S = 1.2)

\[ \phi_{00} = (43.52 \pm 0.05)^\circ \]  
(S = 1.3)

\[ \phi_\epsilon = \phi_{SW} = (43.52 \pm 0.05)^\circ \]  
(S = 1.2)

\[ \text{Im}(\epsilon'/\epsilon) = -\left(\phi_{00} - \phi_{+-}\right)/3 = (0.002 \pm 0.005)^\circ \]  
(S = 1.7)
Not assuming \( CPT \)
\[
\phi_{+-} = (43.4 \pm 0.5)^\circ \quad (S = 1.2) \\
\phi_{00} = (43.7 \pm 0.6)^\circ \quad (S = 1.2) \\
\phi_c = (43.5 \pm 0.5)^\circ \quad (S = 1.3)
\]
\( CPT \) asymmetry \( A \) in \( K_L^0 \to \pi^+ \pi^- e^+ e^- = (13.7 \pm 1.5)\% \\
\beta_{CP} \) from \( K_L^0 \to e^+ e^- e^+ e^- = -0.19 \pm 0.07 \\
\gamma_{CP} \) from \( K_L^0 \to e^+ e^- e^+ e^- = 0.01 \pm 0.11 \quad (S = 1.6) \\
\( f \) for \( K_L^0 \to \pi^+ \pi^- \pi^0 = 0.0012 \pm 0.0008 \\
\( \gamma'_{+\gamma} \) for \( K_L^0 \to \pi^+ \pi^- \gamma < 0.21, CL = 90\% \)

\( T \)-violation parameters
\[
\Im(\xi) \text{ in } K_{\mu 3}^0 = -0.007 \pm 0.026
\]

\( CPT \) invariance tests
\[
\phi_{00} - \phi_{+-} = (0.34 \pm 0.32)^\circ \\
\Re(\frac{2}{3} \eta_{+-} + \frac{1}{3} \eta_{00} - \frac{A_f}{2}) = (-3 \pm 35) \times 10^{-6}
\]
\( \Delta S = -\Delta Q \) in \( K_{e3}^0 \) decay
\[
\Re x = -0.002 \pm 0.006 \\
\Im x = 0.0012 \pm 0.0021
\]

\[
\begin{array}{llll}
\text{\( K_L^0 \) decay modes} & \text{Fraction (\( \Gamma_i/\Gamma \))} & \text{Scale factor/}\quad \rho & \text{Confidence level (MeV/c)} \\
\hline
\text{Semileptonic modes} & & & \\
\pi^\pm e^\mp \nu_e & [gg] & (40.55 \pm 0.11) \% & S=1.7 & 229 \\
\text{Called } K_{e3}^0. & & & \\
\pi^\pm \mu^\mp \nu_\mu & [gg] & (27.04 \pm 0.07) \% & S=1.1 & 216 \\
\text{Called } K_{\mu 3}^0. & & & \\
(\pi \mu \text{ atom}) \nu & & (1.05 \pm 0.11) \times 10^{-7} & 188 \\
\pi^0 \bar{\pi}^0 e^+ e^- & [gg] & (5.20 \pm 0.11) \times 10^{-5} & 207 \\
\pi^\pm e^\mp \nu e^+ e^- & [gg] & (1.26 \pm 0.04) \times 10^{-5} & 229 \\
\hline
\text{Hadronic modes, including Charge conjugation x Parity Violating (CPV) modes} & & & \\
3\pi^0 & & (19.52 \pm 0.12) \% & S=1.6 & 139 \\
\pi^+ \pi^- \pi^0 & & (12.54 \pm 0.05) \% & 133 \\
\pi^+ \pi^- & \text{CPV} & [ii] & (1.967 \pm 0.010) \times 10^{-3} & S=1.5 & 206 \\
\pi^0 \pi^0 & \text{CPV} & & (8.64 \pm 0.06) \times 10^{-4} & S=1.8 & 209 \\
\end{array}
\]
### Semileptonic modes with photons

<table>
<thead>
<tr>
<th>Process</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi^+ e^- \nu_e \gamma$</td>
<td>$(3.79 \pm 0.06) \times 10^{-3}$</td>
</tr>
<tr>
<td>$\pi^+ \mu^- \nu_\mu \gamma$</td>
<td>$(5.65 \pm 0.23) \times 10^{-4}$</td>
</tr>
</tbody>
</table>

### Hadronic modes with photons or $\ell\ell$ pairs

<table>
<thead>
<tr>
<th>Process</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi^+ \pi^- \gamma$</td>
<td>$&lt; 2.43 \times 10^{-7}$ CL=90%</td>
</tr>
<tr>
<td>$\pi^0 \pi^0 \gamma$</td>
<td>$&lt; 0.20 \times 10^{-7}$ S=2.8</td>
</tr>
<tr>
<td>$\pi^+ \pi^- \gamma (DE)$</td>
<td>$(2.84 \pm 0.11) \times 10^{-5}$ S=2.0</td>
</tr>
<tr>
<td>$\pi^0 \gamma e^+ e^-$</td>
<td>$(1.273 \pm 0.033) \times 10^{-6}$</td>
</tr>
<tr>
<td></td>
<td>$(1.62 \pm 0.17) \times 10^{-8}$</td>
</tr>
</tbody>
</table>

### Other modes with photons or $\ell\ell$ pairs

<table>
<thead>
<tr>
<th>Process</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma^2$</td>
<td>$(5.47 \pm 0.04) \times 10^{-4}$ S=1.1</td>
</tr>
<tr>
<td>$\gamma^3$</td>
<td>$&lt; 7.4 \times 10^{-8}$ CL=90%</td>
</tr>
<tr>
<td>$\mu^+ \mu^- \gamma$</td>
<td>$(9.4 \pm 0.4) \times 10^{-6}$ S=2.0</td>
</tr>
<tr>
<td>$\mu^+ \mu^-\gamma\gamma$</td>
<td>$(3.59 \pm 0.11) \times 10^{-7}$ S=1.3</td>
</tr>
<tr>
<td>$e^+ e^-\gamma\gamma$</td>
<td>$(5.95 \pm 0.33) \times 10^{-7}$</td>
</tr>
<tr>
<td>$\mu^+ \mu^-\gamma\gamma$</td>
<td>$(1.0 \pm 0.8) \times 10^{-8}$</td>
</tr>
</tbody>
</table>

### Charge conjugation $\times$ Parity ($CP$) or Lepton Family number ($LF$) violating modes, or $\Delta S = 1$ weak neutral current ($S1$) modes

<table>
<thead>
<tr>
<th>Process</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu^+ \mu^-$</td>
<td>$(6.84 \pm 0.11) \times 10^{-9}$</td>
</tr>
<tr>
<td>$e^+ e^-$</td>
<td>$(9 \pm 6) \times 10^{-12}$</td>
</tr>
<tr>
<td>$\pi^+ \pi^- e^+ e^-$</td>
<td>$(3.11 \pm 0.19) \times 10^{-7}$</td>
</tr>
<tr>
<td>$\pi^0 \pi^0 e^+ e^-$</td>
<td>$&lt; 6.6 \times 10^{-9}$ CL=90%</td>
</tr>
<tr>
<td>$\mu^+ \mu^- e^+ e^-$</td>
<td>$&lt; 9.2 \times 10^{-11}$ CL=90%</td>
</tr>
<tr>
<td>$e^+ e^- e^+ e^-$</td>
<td>$(2.69 \pm 0.27) \times 10^{-9}$</td>
</tr>
<tr>
<td>$\pi^0 \mu^+ \mu^-$</td>
<td>$&lt; 3.56 \times 10^{-8}$</td>
</tr>
<tr>
<td>$\pi^0 e^+ e^-$</td>
<td>$&lt; 3.8 \times 10^{-10}$ CL=90%</td>
</tr>
<tr>
<td>$\pi^0 \nu \bar{\nu}$</td>
<td>$&lt; 2.8 \times 10^{-10}$ CL=90%</td>
</tr>
<tr>
<td>$\pi^0 \nu \bar{\nu}$</td>
<td>$&lt; 2.6 \times 10^{-8}$ CL=90%</td>
</tr>
<tr>
<td>$\pi^0 \nu \bar{\nu}$</td>
<td>$&lt; 8.1 \times 10^{-7}$ CL=90%</td>
</tr>
<tr>
<td>$e^\mp \mu^\pm$</td>
<td>$&lt; 4.7 \times 10^{-12}$ CL=90%</td>
</tr>
<tr>
<td>$e^\pm e^\mp \mu^\pm \mu^\mp$</td>
<td>$&lt; 4.12 \times 10^{-11}$ CL=90%</td>
</tr>
<tr>
<td>$\pi^0 \mu^\pm \mu^\mp$</td>
<td>$&lt; 7.6 \times 10^{-11}$ CL=90%</td>
</tr>
<tr>
<td>$\pi^0 \pi^0 \mu^\pm e^\mp$</td>
<td>$&lt; 1.7 \times 10^{-10}$ CL=90%</td>
</tr>
</tbody>
</table>
### $K^*(892)$

\[ I(J^P) = \frac{1}{2}(1^-) \]

- $K^*(892)^\pm$ hadroproduced mass $m = 891.66 \pm 0.26$ MeV
- $K^*(892)^\pm$ in $\tau$ decays mass $m = 895.5 \pm 0.8$ MeV
- $K^*(892)^0$ mass $m = 895.81 \pm 0.19$ MeV ($S = 1.4$)
- $K^*(892)^\pm$ hadroproduced full width $\Gamma = 50.8 \pm 0.9$ MeV
- $K^*(892)^\pm$ in $\tau$ decays full width $\Gamma = 46.2 \pm 1.3$ MeV
- $K^*(892)^0$ full width $\Gamma = 47.4 \pm 0.6$ MeV ($S = 2.2$)

### $K^*(892)$ Decay Modes

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>Confidence Level (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K \pi$</td>
<td>$\sim$ 100%</td>
<td>289</td>
</tr>
<tr>
<td>$K^0 \gamma$</td>
<td>$(2.46 \pm 0.21) \times 10^{-3}$</td>
<td>307</td>
</tr>
<tr>
<td>$K^{\pm} \gamma$</td>
<td>$(9.9 \pm 0.9) \times 10^{-4}$</td>
<td>309</td>
</tr>
<tr>
<td>$K \pi \pi$</td>
<td>$&lt; 7 \times 10^{-4}$</td>
<td>95% 223</td>
</tr>
</tbody>
</table>

### $K_1(1270)$

\[ I(J^P) = \frac{1}{2}(1^-) \]

Mass $m = 1272 \pm 7$ MeV [$l$]

Full width $\Gamma = 90 \pm 20$ MeV [$l$]

#### $K_1(1270)$ Decay Modes

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K \rho$</td>
<td>$(42 \pm 6)$%</td>
<td>46</td>
</tr>
<tr>
<td>$K_0'(1430) \pi$</td>
<td>$(28 \pm 4)$%</td>
<td>†</td>
</tr>
<tr>
<td>$K^*(892) \pi$</td>
<td>$(16 \pm 5)$%</td>
<td>302</td>
</tr>
<tr>
<td>$K \omega$</td>
<td>$(11.0 \pm 2.0)$%</td>
<td>†</td>
</tr>
<tr>
<td>$K f_0(1370)$</td>
<td>$(3.0 \pm 2.0)$%</td>
<td>†</td>
</tr>
<tr>
<td>$\gamma K^0$</td>
<td>seen</td>
<td>539</td>
</tr>
</tbody>
</table>

### $K_1(1400)$

\[ I(J^P) = \frac{1}{2}(1^-) \]

Mass $m = 1403 \pm 7$ MeV

Full width $\Gamma = 174 \pm 13$ MeV ($S = 1.6$)

#### $K_1(1400)$ Decay Modes

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K^*(892) \pi$</td>
<td>$(94 \pm 6)$%</td>
<td>402</td>
</tr>
<tr>
<td>$K \rho$</td>
<td>$(3.0 \pm 3.0)$%</td>
<td>293</td>
</tr>
<tr>
<td>$K f_0(1370)$</td>
<td>$(2.0 \pm 2.0)$%</td>
<td>†</td>
</tr>
<tr>
<td>$K \omega$</td>
<td>$(1.0 \pm 1.0)$%</td>
<td>284</td>
</tr>
<tr>
<td>$K_0^*(1430) \pi$</td>
<td>not seen</td>
<td>†</td>
</tr>
<tr>
<td>$\gamma K^0$</td>
<td>seen</td>
<td>613</td>
</tr>
</tbody>
</table>
\( K^*(1410) \)

\[ I(J^P) = \frac{1}{2}(1^-) \]

Mass \( m = 1414 \pm 15 \text{ MeV} \) \( (S = 1.3) \)
Full width \( \Gamma = 232 \pm 21 \text{ MeV} \) \( (S = 1.1) \)

### \( K^*(1410) \) Decay Modes

<table>
<thead>
<tr>
<th>Decay Mode ( K^*(892) \pi )</th>
<th>Fraction ( \Gamma_i/\Gamma )</th>
<th>Confidence level</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( K \pi )</td>
<td>( 6.6 \pm 1.3 ) %</td>
<td>95%</td>
<td>612</td>
</tr>
<tr>
<td>( K \rho )</td>
<td>&lt; 7 %</td>
<td>95%</td>
<td>305</td>
</tr>
<tr>
<td>( \gamma K^0 )</td>
<td>seen</td>
<td></td>
<td>619</td>
</tr>
</tbody>
</table>

\( K_0^*(1430) \)

\[ I(J^P) = \frac{1}{2}(0^+) \]

Mass \( m = 1425 \pm 50 \text{ MeV} \)
Full width \( \Gamma = 270 \pm 80 \text{ MeV} \)

### \( K_0^*(1430) \) Decay Modes

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ( \Gamma_i/\Gamma )</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( K \pi )</td>
<td>(93\pm10) %</td>
<td>619</td>
</tr>
</tbody>
</table>

\( K_2^*(1430) \)

\[ I(J^P) = \frac{1}{2}(2^+) \]

\( K^*_2(1430) \)

\( m = 1425.6 \pm 1.5 \text{ MeV} \) \( (S = 1.1) \)
\( K^*_2(1430)^0 \)

Mass \( m = 1432.4 \pm 1.3 \text{ MeV} \)
Full width \( \Gamma = 98.5 \pm 2.7 \text{ MeV} \) \( (S = 1.1) \)
Full width \( \Gamma = 109 \pm 5 \text{ MeV} \) \( (S = 1.9) \)

### \( K_2^*(1430) \) Decay Modes

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ( \Gamma_i/\Gamma )</th>
<th>Scale factor/Confidence level</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( K \pi )</td>
<td>(49.9\pm1.2) %</td>
<td>619</td>
<td></td>
</tr>
<tr>
<td>( K^*(892) \pi )</td>
<td>(24.7\pm1.5) %</td>
<td>419</td>
<td></td>
</tr>
<tr>
<td>( K^*(892) \pi \pi )</td>
<td>(13.4\pm2.2) %</td>
<td>372</td>
<td></td>
</tr>
<tr>
<td>( K \rho )</td>
<td>(8.7\pm0.8) %</td>
<td>S=1.2</td>
<td>318</td>
</tr>
<tr>
<td>( K \omega )</td>
<td>(2.9\pm0.8) %</td>
<td>311</td>
<td></td>
</tr>
<tr>
<td>( K^+ \gamma )</td>
<td>(2.4\pm0.5) \times 10^{-3}</td>
<td>S=1.1</td>
<td>627</td>
</tr>
<tr>
<td>( K \eta )</td>
<td>(1.5\pm3.4) \times 10^{-3}</td>
<td>S=1.3</td>
<td>486</td>
</tr>
<tr>
<td>( K \omega \pi )</td>
<td>&lt; 7.2 \times 10^{-4}</td>
<td>CL=95%</td>
<td>100</td>
</tr>
<tr>
<td>( K^0 \gamma )</td>
<td>&lt; 9 \times 10^{-4}</td>
<td>CL=90%</td>
<td>626</td>
</tr>
</tbody>
</table>
**K*(1680)**

\[ I(J^P) = \frac{1}{2}(1^-) \]

Mass \( m = 1717 \pm 27 \text{ MeV} \) \((S = 1.4)\)
Full width \( \Gamma = 322 \pm 110 \text{ MeV} \) \((S = 4.2)\)

<table>
<thead>
<tr>
<th>K*(1680) DECAY MODES</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( K\pi )</td>
<td>((38.7\pm2.5)) %</td>
<td>781</td>
</tr>
<tr>
<td>( K\rho )</td>
<td>((31.4\pm5.0)%)</td>
<td>571</td>
</tr>
<tr>
<td>( K^*(892)\pi )</td>
<td>((29.9\pm2.2)%)</td>
<td>618</td>
</tr>
</tbody>
</table>

**K2(1770)**

\[ I(J^P) = \frac{1}{2}(2^-) \]

Mass \( m = 1773 \pm 8 \text{ MeV} \)
Full width \( \Gamma = 186 \pm 14 \text{ MeV} \)

<table>
<thead>
<tr>
<th>K2(1770) DECAY MODES</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( K\pi\pi )</td>
<td>dominant</td>
<td>794</td>
</tr>
<tr>
<td>( K_x^*(1430)\pi )</td>
<td></td>
<td>288</td>
</tr>
<tr>
<td>( K^*(892)\pi )</td>
<td>seen</td>
<td>654</td>
</tr>
<tr>
<td>( Kf_2(1270) )</td>
<td>seen</td>
<td>55</td>
</tr>
<tr>
<td>( K\phi )</td>
<td>seen</td>
<td>441</td>
</tr>
<tr>
<td>( K\omega )</td>
<td>seen</td>
<td>607</td>
</tr>
</tbody>
</table>

**K3(1780)**

\[ I(J^P) = \frac{1}{2}(3^-) \]

Mass \( m = 1776 \pm 7 \text{ MeV} \) \((S = 1.1)\)
Full width \( \Gamma = 159 \pm 21 \text{ MeV} \) \((S = 1.3)\)

<table>
<thead>
<tr>
<th>K3(1780) DECAY MODES</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>Confidence level ( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( K\rho )</td>
<td>((31 \pm 9)%)</td>
<td>((31 \pm 9)%)</td>
</tr>
<tr>
<td>( K^*(892)\pi )</td>
<td>((20 \pm 5)%)</td>
<td>((20 \pm 5)%)</td>
</tr>
<tr>
<td>( K\pi )</td>
<td>((18.8\pm1.0)%)</td>
<td>((18.8\pm1.0)%)</td>
</tr>
<tr>
<td>( K\eta )</td>
<td>((30 \pm 13)%)</td>
<td>((30 \pm 13)%)</td>
</tr>
<tr>
<td>( K_{2}^*(1430)\pi )</td>
<td>(&lt;16%)</td>
<td>(&lt;16%)</td>
</tr>
</tbody>
</table>
$K_2(1820)$ \[pp\]

\[I(J^P) = \frac{1}{2}(2^-)\]

Mass \( m = 1816 \pm 13 \text{ MeV} \)
Full width \( \Gamma = 276 \pm 35 \text{ MeV} \)

**$K_2(1820)$ DECAY MODES**

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K_2(1430)\pi$</td>
<td>seen</td>
<td>327</td>
</tr>
<tr>
<td>$K^*(892)\pi$</td>
<td>seen</td>
<td>681</td>
</tr>
<tr>
<td>$K f_2(1270)$</td>
<td>seen</td>
<td>186</td>
</tr>
<tr>
<td>$K \omega$</td>
<td>seen</td>
<td>638</td>
</tr>
</tbody>
</table>

$K^*_4(2045)$

\[I(J^P) = \frac{1}{2}(4^+)\]

Mass \( m = 2045 \pm 9 \text{ MeV} \) \( (S = 1.1) \)
Full width \( \Gamma = 198 \pm 30 \text{ MeV} \)

**$K^*_4(2045)$ DECAY MODES**

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K \pi$</td>
<td>(9.9\pm1.2) %</td>
<td>958</td>
</tr>
<tr>
<td>$K^*(892)\pi\pi$</td>
<td>(9\pm5) %</td>
<td>802</td>
</tr>
<tr>
<td>$K^*(892)\pi\pi\pi$</td>
<td>(7\pm5) %</td>
<td>768</td>
</tr>
<tr>
<td>$\rho K \pi$</td>
<td>(5.7\pm3.2) %</td>
<td>741</td>
</tr>
<tr>
<td>$\omega K \pi$</td>
<td>(5.0\pm3.0) %</td>
<td>738</td>
</tr>
<tr>
<td>$\phi K \pi$</td>
<td>(2.8\pm1.4) %</td>
<td>594</td>
</tr>
<tr>
<td>$\phi K^*(892)$</td>
<td>(1.4\pm0.7) %</td>
<td>363</td>
</tr>
</tbody>
</table>

**CHARMED MESONS**

\((C = \pm 1)\)

\[D^+ = c\bar{d}, D^0 = c\bar{u}, \overline{D^0} = \bar{u}c, D^- = \bar{c}d, \text{ similarly for } D^*\text{'s}\]

$D^\pm$

\[I(J^P) = \frac{1}{2}(0^-)\]

Mass \( m = 1869.61 \pm 0.10 \text{ MeV} \) \( (S = 1.1) \)
Mean life \( \tau = (1040 \pm 7) \times 10^{-15} \text{ s} \)
\( c\tau = 311.8 \mu \text{m} \)

$c$-quark decays

\[
\begin{align*}
\Gamma(c \to \ell^+ \text{ anything})/\Gamma(c \to \text{ anything}) &= 0.096 \pm 0.004 \ [qq] \\
\Gamma(c \to D^*(2010)^+ \text{ anything})/\Gamma(c \to \text{ anything}) &= 0.255 \pm 0.017
\end{align*}
\]
**CP-violation decay-rate asymmetries**

\begin{align*}
A_{CP}(\mu^\pm \nu) &= (8 \pm 8)\% \\
A_{CP}(K_S^0 \pi^\pm) &= (-0.41 \pm 0.09)\% \\
A_{CP}(K^\mp 2\pi^\pm) &= (-0.1 \pm 1.0)\% \\
A_{CP}(K^\mp \pi^\mp \pi^0) &= (1.0 \pm 1.3)\% \\
A_{CP}(K_S^0 \pi^\pm \pi^0) &= (0.3 \pm 0.9)\% \\
A_{CP}(K_S^0 \pi^\pm \pi^-) &= (0.1 \pm 1.3)\% \\
A_{CP}(\pi^\pm \pi^0) &= (2.9 \pm 2.9)\% \\
A_{CP}(\pi^\pm \eta) &= (1.0 \pm 1.5)\% \quad (S = 1.4) \\
A_{CP}(\pi^\pm \eta'(958)) &= (-0.5 \pm 1.2)\% \quad (S = 1.1) \\
A_{CP}(K_S^0 K^\pm) &= (-0.11 \pm 0.25)\% \\
A_{CP}(K^+ K^- \pi^\pm) &= (0.36 \pm 0.29)\% \\
A_{CP}(K^\pm K^*) &= (-0.3 \pm 0.4)\% \\
A_{CP}(\phi \pi^+) &= (0.09 \pm 0.19)\% \quad (S = 1.2) \\
A_{CP}(K^\pm K_0^*(1430)^0) &= (8^{+7}_{-6})\% \\
A_{CP}(K^\pm K_2^*(1430)^0) &= (43^{+29}_{-26})\% \\
A_{CP}(K^\pm K_0^*(800)) &= (-12^{+18}_{-13})\% \\
A_{CP}(a_0(1450)^0 \pi^\pm) &= (-19^{+14}_{-16})\% \\
A_{CP}(\phi(1680) \pi^+) &= (-9 \pm 26)\% \\
A_{CP}(\pi^+ \pi^- \pi^\pm) &= (-2 \pm 4)\% \\
A_{CP}(K_S^0 K^\pm \pi^+ \pi^-) &= (-4 \pm 7)\% \\
A_{CP}(K^\pm \pi^0) &= (-4 \pm 11)\% \\
\end{align*}

**T-violation decay-rate asymmetry**

\[ A_T(K_S^0 K^\pm \pi^+ \pi^-) = (-12 \pm 11) \times 10^{-3} \quad [r] \]

**D^+ form factors**

\begin{align*}
&f_+(0) | V_{cs} | \text{ in } K^0 \ell^+ \nu \ell = 0.707 \pm 0.013 \\
r_1 = a_1/a_0 \text{ in } K^0 \ell^+ \nu \ell = -1.7 \pm 0.5 \\
r_2 = a_2/a_0 \text{ in } K^0 \ell^+ \nu \ell = -14 \pm 11 \\
f_+(0) | V_{cd} | \text{ in } \pi^0 \ell^+ \nu \ell = 0.146 \pm 0.007 \\
r_1 = a_1/a_0 \text{ in } \pi^0 \ell^+ \nu \ell = -1.4 \pm 0.9 \\
r_2 = a_2/a_0 \text{ in } \pi^0 \ell^+ \nu \ell = -4 \pm 5 \\
f_+(0) | V_{cd} | \text{ in } D^+ \rightarrow \eta e^+ \nu e = 0.086 \pm 0.006 \\
r_1 = a_1/a_0 \text{ in } D^+ \rightarrow \eta e^+ \nu e = -1.8 \pm 2.2 \\
r_v = V(0)/A_1(0) \text{ in } D^+, D^0 \rightarrow \rho e^+ \nu e = 1.48 \pm 0.16 \\
r_2 = A_2(0)/A_1(0) \text{ in } D^+, D^0 \rightarrow \rho e^+ \nu e = 0.83 \pm 0.12 \\
r_v = V(0)/A_1(0) \text{ in } K^*(892)^0 \ell^+ \nu \ell = 1.51 \pm 0.07 \quad (S = 2.2) \\
r_2 = A_2(0)/A_1(0) \text{ in } K^*(892)^0 \ell^+ \nu \ell = 0.807 \pm 0.025 \\
r_3 = A_3(0)/A_1(0) \text{ in } K^*(892)^0 \ell^+ \nu \ell = 0.0 \pm 0.4 \\
\Gamma_L/\Gamma_T \text{ in } K^*(892)^0 \ell^+ \nu \ell = 1.13 \pm 0.08 \\
\Gamma_+/(\Gamma_+ + \Gamma_-) \text{ in } K^*(892)^0 \ell^+ \nu \ell = 0.22 \pm 0.06 \quad (S = 1.6) \\
\end{align*}
Most decay modes (other than the semileptonic modes) that involve a neutral $K$ meson are now given as $K_S^0$ modes, not as $\bar{K}^0$ modes. Nearly always it is a $K_S^0$ that is measured, and interference between Cabibbo-allowed and doubly Cabibbo-suppressed modes can invalidate the assumption that $2\Gamma(K_S^0) = \Gamma(\bar{K}^0)$.

<table>
<thead>
<tr>
<th>$D^+$ DECAY MODES</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>Scale factor/Confidence level</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inclusive modes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$e^+ \nu_e$ semileptonic</td>
<td>$(16.07\pm0.30)$ %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\mu^+ \nu_\mu$</td>
<td>$(17.6 \pm 3.2 )$ %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$K^- \nu_e$</td>
<td>$(25.7 \pm 1.4 )$ %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\bar{K}^0 \nu_e + K^0 \nu_e$</td>
<td>$(61 \pm 5 )$ %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$K^+ \nu_e$</td>
<td>$(5.9 \pm 0.8 )$ %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$K^*(892)^- \nu_e$</td>
<td>$(6 \pm 5 )$ %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\bar{K}^*(892)^0 \nu_e$</td>
<td>$(23 \pm 5 )$ %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$K^*(892)^0 \nu_e$</td>
<td>$&lt; 6.6$ %</td>
<td>CL=90%</td>
<td></td>
</tr>
<tr>
<td>$\eta \nu_e$</td>
<td>$(6.3 \pm 0.7 )$ %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\eta' \nu_e$</td>
<td>$(1.04\pm0.18)$ %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\phi \nu_e$</td>
<td>$(1.03\pm0.12)$ %</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Leptonic and semileptonic modes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$e^+ \nu_e$</td>
<td>$&lt; 8.8 \times 10^{-6}$</td>
<td>CL=90%</td>
<td>935</td>
</tr>
<tr>
<td>$\mu^+ \nu_\mu$</td>
<td>$3.82\pm0.33 \times 10^{-4}$</td>
<td></td>
<td>932</td>
</tr>
<tr>
<td>$\tau^+ \nu_\tau$</td>
<td>$&lt; 1.2 \times 10^{-3}$</td>
<td>CL=90%</td>
<td>90</td>
</tr>
<tr>
<td>$\bar{K}^0 e^+ \nu_e$</td>
<td>$(8.83\pm0.22)$ %</td>
<td></td>
<td>869</td>
</tr>
<tr>
<td>$\bar{K}^0 \mu^+ \nu_\mu$</td>
<td>$(9.2 \pm 0.6 )$ %</td>
<td></td>
<td>865</td>
</tr>
<tr>
<td>$K^- \pi^+ e^+ \nu_e$</td>
<td>$(4.00\pm0.10)$ %</td>
<td></td>
<td>864</td>
</tr>
<tr>
<td>$\bar{K}^<em>(892)^0 e^+ \nu_e$, $\bar{K}^</em>(892)^0 \rightarrow K^- \pi^+$</td>
<td>$(3.68\pm0.10)$ %</td>
<td></td>
<td>722</td>
</tr>
<tr>
<td>$(K^- \pi^+)_S$ wave $e^+ \nu_e$</td>
<td>$(2.32\pm0.10) \times 10^{-3}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\bar{K}^<em>(1410)^0 e^+ \nu_e$, $\bar{K}^</em>(1410)^0 \rightarrow K^- \pi^+$</td>
<td>$&lt; 6 \times 10^{-3}$</td>
<td>CL=90%</td>
<td></td>
</tr>
<tr>
<td>$\bar{K}^<em>_2(1430)^0 e^+ \nu_e$, $\bar{K}^</em>_2(1430)^0 \rightarrow K^- \pi^+$</td>
<td>$&lt; 5 \times 10^{-4}$</td>
<td>CL=90%</td>
<td></td>
</tr>
<tr>
<td>$K^- \pi^+ e^+ \nu_e$ nonresonant</td>
<td>$&lt; 7 \times 10^{-3}$</td>
<td>CL=90%</td>
<td>864</td>
</tr>
<tr>
<td>$K^- \pi^+ \mu^+ \nu_\mu$</td>
<td>$(3.8 \pm 0.4 )$ %</td>
<td></td>
<td>851</td>
</tr>
<tr>
<td>$\bar{K}^*(892)^0 \mu^+ \nu_\mu$</td>
<td>$(3.52\pm0.10)$ %</td>
<td></td>
<td>717</td>
</tr>
<tr>
<td>$K^- \pi^+ \mu^+ \nu_\mu$ nonresonant</td>
<td>$(2.0 \pm 0.5 ) \times 10^{-3}$</td>
<td></td>
<td>851</td>
</tr>
<tr>
<td>$K^- \pi^0 \mu^+ \nu_\mu$</td>
<td>$&lt; 1.6 \times 10^{-3}$</td>
<td>CL=90%</td>
<td>825</td>
</tr>
<tr>
<td>$\pi^0 e^+ \nu_e$</td>
<td>$(4.05\pm0.18) \times 10^{-3}$</td>
<td></td>
<td>930</td>
</tr>
<tr>
<td>$\eta e^+ \nu_e$</td>
<td>$(1.14\pm0.10) \times 10^{-3}$</td>
<td></td>
<td>855</td>
</tr>
</tbody>
</table>
\[ \rho^0 e^+ \nu_e \quad (2.18^{+0.17}_{-0.25}) \times 10^{-3} \quad 774 \]
\[ \rho^0 \mu^+ \nu_\mu \quad (2.4 \pm 0.4) \times 10^{-3} \quad 770 \]
\[ \omega e^+ \nu_e \quad (1.82 \pm 0.19) \times 10^{-3} \quad 771 \]
\[ \eta'(958) e^+ \nu_e \quad (2.2 \pm 0.5) \times 10^{-4} \quad 689 \]
\[ \phi e^+ \nu_e \quad < 9 \times 10^{-5} \quad \text{CL}=90\% \quad 657 \]

Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

\[ \overline{K}^*(892)^0 e^+ \nu_e \quad (5.52 \pm 0.15) \% \quad 722 \]
\[ \overline{K}^*(892)^0 \mu^+ \nu_\mu \quad (5.28 \pm 0.15) \% \quad 717 \]
\[ \overline{K}^*_0(1430)^0 \mu^+ \nu_\mu \quad < 2.4 \times 10^{-4} \quad \text{CL}=90\% \quad 380 \]
\[ \overline{K}^*(1680)^0 \mu^+ \nu_\mu \quad < 1.5 \times 10^{-3} \quad \text{CL}=90\% \quad 105 \]

**Hadronic modes with a \( \overline{K} \) or \( \overline{K} K \overline{K} \)**

\[ K^0_S \pi^+ \quad (1.47 \pm 0.07) \% \quad S=2.0 \quad 863 \]
\[ K^0_L \pi^+ \quad (1.46 \pm 0.05) \% \quad 863 \]
\[ K^- 2\pi^+ \quad [ss] \quad (9.13 \pm 0.19) \% \quad 846 \]
\[ (K^- \pi^+)_{s-wave} \pi^+ \quad (7.32 \pm 0.19) \% \quad 846 \]
\[ K^0_L(1430)^0 \pi^+, \quad [tt] \quad (1.21 \pm 0.06) \% \quad 382 \]
\[ K^0_S(1430)^0 \pi^+ \quad (1.01 \pm 0.11) \% \quad 714 \]
\[ K^*(892)^0 \pi^+ \quad \overline{K}^*_0(1430)^0 \pi^+, \quad \overline{K}^* \rightarrow K^- \pi^+ \]
\[ K^*(1410)^0 \pi^+, \quad \overline{K}^* \rightarrow \text{not seen} \quad 381 \]
\[ K^*_2(1430)^0 \pi^+, \quad [tt] \quad (2.2 \pm 0.7 ) \times 10^{-4} \quad 371 \]
\[ K^*(1680)^0 \pi^+, \quad [tt] \quad (2.1 \pm 1.1 ) \times 10^{-4} \quad 58 \]
\[ K^- (2\pi^+)_{l=2} \quad (1.41 \pm 0.26) \% \quad - \]
\[ K^0_S^+ \pi_0 \quad [ss] \quad (6.99 \pm 0.27) \% \quad 845 \]
\[ K^0_S^0 \rho^+ \quad (4.8 \pm 1.0 ) \% \quad 677 \]
\[ K^*(892)^0 \pi^+, \quad \overline{K}^*(892)^0 \rightarrow K^0_S \pi_0 \quad (1.3 \pm 0.6) \% \quad 714 \]
\[ K^0_S \pi^+ \pi^0 \quad \text{nonresonant} \quad (9 \pm 7 ) \times 10^{-3} \quad 845 \]
\[ K^- 2\pi^+ \pi^0 \quad [uu] \quad (5.99 \pm 0.18) \% \quad 816 \]
\[ K^0_S 2\pi^+ \pi^- \quad [uu] \quad (3.12 \pm 0.11) \% \quad 814 \]
\[ K^- 3\pi^+ \pi^- \quad [ss] \quad (5.6 \pm 0.5 ) \times 10^{-3} \quad S=1.1 \quad 772 \]
\[ K^*(892)^0 2\pi^+ \pi^-, \quad (1.2 \pm 0.4 ) \times 10^{-3} \quad 645 \]
\[ K^*(892)^0 \rho^0 \pi^+, \quad (2.2 \pm 0.4 ) \times 10^{-3} \quad 239 \]
\[ K^*(892)^0 \rightarrow K^- \pi^+ \quad [\nu \nu] \quad (9.0 \pm 1.8 ) \times 10^{-3} \quad \dag \]
\[ K^- \rho^0 2\pi^+ \]
\[ K^- 3\pi^+ \pi^- \text{ nonresonant} \]
\[ K^+ 2K^0_S \]
\[ K^+ K^- K^0_S \pi^+ \]

\[ \begin{array}{ll}
\pi^+ \pi^0 & (1.19 \pm 0.06) \times 10^{-3} \\
2\pi^+ \pi^- & (3.18 \pm 0.18) \times 10^{-3} \\
\rho^0 \pi^+ & (8.1 \pm 1.5) \times 10^{-4} \\
\pi^+ (\pi^+ \pi^-)_{s-wave} & (1.78 \pm 0.16) \times 10^{-3} \\
\pi^+ (\pi^+ \pi^-)_{s-wave} & (1.34 \pm 0.12) \times 10^{-3} \\
f_0(980) \pi^+ & (1.52 \pm 0.33) \times 10^{-4} \\
f_0(980) \rightarrow \pi^+ \pi^- & (8 \pm 4) \times 10^{-5} \\
f_0(1370) \pi^+ & (4.9 \pm 0.9) \times 10^{-4} \\
f_0(1370) \rightarrow \pi^+ \pi^- & < 8 \times 10^{-5} \text{ CL=95\%} \\
\rho(1450)^0 \pi^+ & (1.1 \pm 0.4) \times 10^{-4} \\
f_0(1500) \pi^+ & < 5 \times 10^{-5} \text{ CL=95\%} \\
f_0(1710) \pi^+ & < 6 \times 10^{-5} \text{ CL=95\%} \\
f_0(1790) \pi^+ & < 1.2 \times 10^{-4} \text{ CL=95\%} \\
\pi^+ 2\pi^0 & < 1.1 \times 10^{-4} \text{ CL=95\%} \\
2\pi^+ \pi^- \pi^0 & (4.6 \pm 0.4) \times 10^{-3} \\
\eta \pi^+ & (3.53 \pm 0.21) \times 10^{-3} \\
\eta \pi^+ \pi^0 & (1.38 \pm 0.35) \times 10^{-3} \\
\omega \pi^+ & < 3 \times 10^{-4} \text{ CL=90\%} \\
\eta'(958) \pi^+ & (4.67 \pm 0.29) \times 10^{-3} \\
\eta'(958) \pi^+ \pi^0 & (1.6 \pm 0.5) \times 10^{-3} \\
\end{array} \]

Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

\[ \eta \pi^+ \pi^0 \]
\[ \omega \pi^+ \]
\[ \eta'(958) \pi^+ \]
\[ \eta'(958) \pi^+ \pi^0 \]
Hadronic modes with a $K\bar{K}$ pair

$K^+ K^-\pi^+$  
$\phi\pi^+, \phi \rightarrow K^+ K^-$  
$K^+ K^-(892)^0, K^-(892)^0 \rightarrow \pi^-\pi^-$  
$K^+ K^-(1430)^0, K^-(1430)^0 \rightarrow \pi^-\pi^-$  
$K^+ K^0_2(1430)^0, \bar{K}^*_2 \rightarrow K^-\pi^+$  
$K^+ K^0_0(800), \bar{K}^*_0 \rightarrow K^-\pi^+$  
$K^+ K^0_0(1450)\pi^+\pi^-, a_0(1450)\pi^+\pi^- \rightarrow K^+ K^-\pi^+$  
$\phi(1680)\pi^+, \phi \rightarrow K^+ K^-\pi^+$  

$K^+ K^-\pi^+$ nonresonant  
$K^+ K^0_0\pi^-\pi^-$  
$K^0_0 K^- 2\pi^+$  
$K^+ K^- 2\pi^+\pi^-$

A few poorly measured branching fractions:

$\phi\pi^+\pi^0$  
$\phi\rho^+$  
$K^+ K^-\pi^+\pi^0$ non-$\phi$  
$K^*(892)^+ K^0_S$

Doubly Cabibbo-suppressed modes

$K^+\pi^0$  
$K^+\eta$  
$K^+\eta'(958)$  
$K^+\pi^+\pi^-$  
$K^+\rho^0$  
$K^*(892)^0\pi^+, K^*(892)^0 \rightarrow K^+\pi^-$  
$K^+ f_0(980), f_0(980) \rightarrow \pi^+\pi^-$  
$K^*_2(1430)^0\pi^+, K^*_2(1430)^0 \rightarrow K^+\pi^-$  
$K^+\pi^+\pi^-$ nonresonant  
$2K^+ K^-$

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\[ \Delta C = 1 \text{ weak neutral current (CI) modes, or} \]

Lepton Family number (LF) or Lepton number (L) violating modes

\[
\begin{align*}
\pi^+ e^+ e^- & \quad CI & < 1.1 \times 10^{-6} & \text{CL}=90\% & 930 \\
\pi^+ \phi, \phi \to e^+ e^- & \quad [\text{xx}] & (1.7^{+1.4}_{-0.9}) \times 10^{-6} & - \\
\pi^+ \mu^+ \mu^- & \quad CI & < 7.3 \times 10^{-8} & \text{CL}=90\% & 918 \\
\rho^+ \mu^+ \mu^- & \quad CI & < 5.6 \times 10^{-4} & \text{CL}=90\% & 757 \\
K^+ e^+ e^- & \quad LF & < 1.0 \times 10^{-6} & \text{CL}=90\% & 870 \\
K^+ \mu^+ \mu^- & \quad LF & < 4.3 \times 10^{-6} & \text{CL}=90\% & 856 \\
\pi^+ e^+ \mu^- & \quad LF & < 2.9 \times 10^{-6} & \text{CL}=90\% & 927 \\
\pi^+ e^- \mu^+ & \quad LF & < 3.6 \times 10^{-6} & \text{CL}=90\% & 927 \\
K^+ e^+ \mu^- & \quad LF & < 1.2 \times 10^{-6} & \text{CL}=90\% & 866 \\
K^+ \mu^- \mu^+ & \quad LF & < 2.8 \times 10^{-6} & \text{CL}=90\% & 866 \\
\pi^- 2e^+ & \quad L & < 1.1 \times 10^{-6} & \text{CL}=90\% & 930 \\
\pi^- 2\mu^+ & \quad L & < 2.2 \times 10^{-8} & \text{CL}=90\% & 918 \\
\pi^- e^+ \mu^+ & \quad L & < 2.0 \times 10^{-6} & \text{CL}=90\% & 927 \\
\rho^- 2\mu^+ & \quad L & < 5.6 \times 10^{-4} & \text{CL}=90\% & 757 \\
K^- 2e^+ & \quad L & < 9 \times 10^{-7} & \text{CL}=90\% & 870 \\
K^- 2\mu^+ & \quad L & < 1.0 \times 10^{-5} & \text{CL}=90\% & 856 \\
K^- e^- \mu^+ & \quad L & < 1.9 \times 10^{-6} & \text{CL}=90\% & 866 \\
K^*(892)^- 2\mu^+ & \quad L & < 8.5 \times 10^{-4} & \text{CL}=90\% & 703
\end{align*}
\]

\[ D^0 \]

\[ I(J^P) = \frac{1}{2}(0^-) \]

Mass \( m = 1864.84 \pm 0.07 \) MeV \( (S = 1.1) \)

Mean life \( \tau = (410.1 \pm 1.5) \times 10^{-15} \) s

\[
\begin{align*}
cr & = 122.9 \ \mu\text{m} \\
|m_{D^0_1} - m_{D^0_2}| & = (0.95^{+0.41}_{-0.44}) \times 10^{10} \ \hbar \ \text{s}^{-1} \\
(\Gamma_{D^0_1} - \Gamma_{D^0_2})/\Gamma & = 2\gamma = (1.29^{+0.14}_{-0.18}) \times 10^{-2} \\
|q/p| & = 0.92^{+0.12}_{-0.09} \\
A_R & = (-0.125 \pm 0.526) \times 10^{-3} \\
K^+ \pi^- \text{ relative strong phase: } \cos \delta & = 0.81^{+0.23}_{-0.19} \\
K^- \pi^+ \pi^0 \text{ coherence factor } R_{K\pi \pi^0} & = 0.78^{+0.11}_{-0.25} \\
K^- \pi^+ \pi^0 \text{ average relative strong phase } \delta_{K\pi \pi^0} & = (239^{+32}_{-28})^\circ \\
K^- 2\pi^+ \text{ coherence factor } R_{K3\pi} & = 0.36^{+0.24}_{-0.30} \\
K^- 2\pi^+ \text{ average relative strong phase } \delta_{K3\pi} & = (118^{+60}_{-50})^\circ \\
K_S^0 K^+ \pi^- \text{ coherence factor } R_{K_S^0 K\pi} & = 0.73 \pm 0.08 \\
K_S^0 K^+ \pi^- \text{ average relative strong phase } \delta_{K_S^0 K\pi} & = (8 \pm 15)^\circ \\
K^* K \text{ coherence factor } R_{K* K} & = 1.00 \pm 0.16 \\
K^* K \text{ average relative strong phase } \delta_{K* K} & = (26 \pm 16)^\circ
\end{align*}
\]
**CP-violation decay-rate asymmetries (labeled by the $D^0$ decay)**

\[
A_{CP}(K^+ K^-) = (-0.21 \pm 0.17)\%
\]

\[
A_{CP}(2K_S^0) = (-23 \pm 19)\%
\]

\[
A_{CP}(\pi^+ \pi^-) = (0.22 \pm 0.21)\%
\]

\[
A_{CP}(2\pi^0) = (0 \pm 5)\%
\]

\[
A_{CP}(\pi^+ \pi^- \pi^0) = (0.3 \pm 0.4)\%
\]

\[
A_{CP}(\rho(770)^+ \pi^- \rightarrow \pi^+ \pi^- \pi^0) = (1.2 \pm 0.9)\% \quad [\text{zz}]
\]

\[
A_{CP}(\rho(770)^0 \pi^- \rightarrow \pi^+ \pi^- \pi^0) = (-3.1 \pm 3.0)\% \quad [\text{zz}]
\]

\[
A_{CP}(\rho(770)^- \pi^+ \rightarrow \pi^+ \pi^- \pi^0) = (-1.0 \pm 1.7)\% \quad [\text{zz}]
\]

\[
A_{CP}(\rho(1450)^+ \pi^- \rightarrow \pi^+ \pi^- \pi^0) = (0 \pm 70)\% \quad [\text{zz}]
\]

\[
A_{CP}(\rho(1450)^0 \pi^- \rightarrow \pi^+ \pi^- \pi^0) = (-20 \pm 40)\% \quad [\text{zz}]
\]

\[
A_{CP}(\rho(1450)^- \pi^+ \rightarrow \pi^+ \pi^- \pi^0) = (6 \pm 9)\% \quad [\text{zz}]
\]

\[
A_{CP}(\rho(1700)^+ \pi^- \rightarrow \pi^+ \pi^- \pi^0) = (-5 \pm 14)\% \quad [\text{zz}]
\]

\[
A_{CP}(\rho(1700)^0 \pi^- \rightarrow \pi^+ \pi^- \pi^0) = (13 \pm 9)\% \quad [\text{zz}]
\]

\[
A_{CP}(\rho(1700)^- \pi^+ \rightarrow \pi^+ \pi^- \pi^0) = (8 \pm 11)\% \quad [\text{zz}]
\]

\[
A_{CP}(f_0(980) \pi^0 \rightarrow \pi^+ \pi^- \pi^0) = (0 \pm 35)\% \quad [\text{zz}]
\]

\[
A_{CP}(f_0(1370) \pi^0 \rightarrow \pi^+ \pi^- \pi^0) = (25 \pm 18)\% \quad [\text{zz}]
\]

\[
A_{CP}(f_0(1500) \pi^0 \rightarrow \pi^+ \pi^- \pi^0) = (0 \pm 18)\% \quad [\text{zz}]
\]

\[
A_{CP}(f_0(1710) \pi^0 \rightarrow \pi^+ \pi^- \pi^0) = (0 \pm 24)\% \quad [\text{zz}]
\]

\[
A_{CP}(f_2(1270) \pi^0 \rightarrow \pi^+ \pi^- \pi^0) = (-4 \pm 6)\% \quad [\text{zz}]
\]

\[
A_{CP}(\sigma(400) \pi^0 \rightarrow \pi^+ \pi^- \pi^0) = (6 \pm 8)\% \quad [\text{zz}]
\]

\[
A_{CP}(\text{nonresonant } \pi^+ \pi^- \pi^0) = (-13 \pm 23)\% \quad [\text{zz}]
\]

\[
A_{CP}(2\pi^+ 2\pi^-)
\]

\[
A_{CP}(K^+ K^- \pi^0) = (-1.0 \pm 1.7)\%
\]

\[
A_{CP}(K^+(892)^+ K^- \rightarrow K^+ K^- \pi^0) = (-0.9 \pm 1.3)\% \quad [\text{zz}]
\]

\[
A_{CP}(K^+(1410)^+ K^- \rightarrow K^+ K^- \pi^0) = (-21 \pm 24)\% \quad [\text{zz}]
\]

\[
A_{CP}((K^+ \pi^0)_{s-wave} K^- \rightarrow K^+ K^- \pi^0) = (7 \pm 15)\% \quad [\text{zz}]
\]

\[
A_{CP}(\phi(1020) \pi^0 \rightarrow K^+ K^- \pi^0) = (1.1 \pm 2.2)\% \quad [\text{zz}]
\]

\[
A_{CP}(f_0(980) \pi^0 \rightarrow K^+ K^- \pi^0) = (-3 \pm 19)\% \quad [\text{zz}]
\]

\[
A_{CP}(a_0(980)^0 \pi^0 \rightarrow K^+ K^- \pi^0) = (-5 \pm 16)\% \quad [\text{zz}]
\]

\[
A_{CP}(f_2'(1525) \pi^0 \rightarrow K^+ K^- \pi^0) = (0 \pm 160)\% \quad [\text{zz}]
\]

\[
A_{CP}(K^+(892)^- K^+ \rightarrow K^+ K^- \pi^0) = (-5 \pm 4)\% \quad [\text{zz}]
\]

\[
A_{CP}(K^+(1410)^- K^+ \rightarrow K^+ K^- \pi^0) = (-17 \pm 29)\% \quad [\text{zz}]
\]

\[
A_{CP}((K^- \pi^0)_{s-wave} K^+ \rightarrow K^+ K^- \pi^0) = (-10 \pm 40)\% \quad [\text{zz}]
\]

\[
A_{CP}(K^0 S \pi^0) = (-0.27 \pm 0.21)\%
\]

\[
A_{CP}(K^0 S \eta) = (0.5 \pm 0.5)\%
\]

\[
A_{CP}(K^0 S \eta') = (1.0 \pm 0.7)\%
\]

\[
A_{CP}(K^0 S \phi) = (-3 \pm 9)\%
\]

\[
A_{CP}(K^- \pi^+) = (0.1 \pm 0.7)\%
\]

\[
A_{CP}(K^+ \pi^-) = (0.0 \pm 1.6)\%
\]
\[ A_{CP}(K^-\pi^+\pi^0) = (0.2 \pm 0.9)\% \]
\[ A_{CP}(K^+\pi^-\pi^0) = (0 \pm 5)\% \]
\[ A_{CP}(K_S^0\pi^+\pi^-) = (-0.1 \pm 0.8)\% \]
\[ A_{CP}(K^*(892)^-\pi^+ \rightarrow K_S^0\pi^+\pi^-) = (0.4 \pm 0.5)\% \]
\[ A_{CP}(K^*(892)^+\pi^- \rightarrow K_S^0\pi^+\pi^-) = (1 \pm 6)\% \]
\[ A_{CP}(K^0\rho^0 \rightarrow K_S^0\pi^+\pi^-) = (-0.1 \pm 0.5)\% \]
\[ A_{CP}(K^0\omega \rightarrow K_S^0\pi^+\pi^-) = (-13 \pm 7)\% \]
\[ A_{CP}(K^0f_0(980) \rightarrow K_S^0\pi^+\pi^-) = (-0.4 \pm 2.7)\% \]
\[ A_{CP}(K^0f_2(1270) \rightarrow K_S^0\pi^+\pi^-) = (-4 \pm 5)\% \]
\[ A_{CP}(K^0f_0(1370) \rightarrow K_S^0\pi^+\pi^-) = (-1 \pm 9)\% \]
\[ A_{CP}(K^0\rho^0(1450) \rightarrow K_S^0\pi^+\pi^-) = (-4 \pm 10)\% \]
\[ A_{CP}(K^0f_0(600) \rightarrow K_S^0\pi^+\pi^-) = (-3 \pm 5)\% \]
\[ A_{CP}(K^*(1410)^-\pi^+ \rightarrow K_S^0\pi^+\pi^-) = (-2 \pm 9)\% \]
\[ A_{CP}(K_0^*(1430)^-\pi^+ \rightarrow K_S^0\pi^+\pi^-) = (4 \pm 4)\% \]
\[ A_{CP}(K_0^*(1430)^+\pi^- \rightarrow K_S^0\pi^+\pi^-) = (12 \pm 15)\% \]
\[ A_{CP}(K_2^*(1430)^-\pi^+ \rightarrow K_S^0\pi^+\pi^-) = (3 \pm 6)\% \]
\[ A_{CP}(K_2^*(1430)^+\pi^- \rightarrow K_S^0\pi^+\pi^-) = (-10 \pm 32)\% \]
\[ A_{CP}(K^*(1680)^-\pi^+ \rightarrow K_S^0\pi^+\pi^-) \]
\[ A_{CP}(K^-\pi^+\pi^+\pi^-) = (0.7 \pm 1.0)\% \]
\[ A_{CP}(K^+\pi^-\pi^+\pi^-) = (-2 \pm 4)\% \]
\[ A_{CP}(K^+\pi^+\pi^+\pi^-) = (-8 \pm 7)\% \]
\[ A_{CP}(K^*_1(1270)^+K^- \rightarrow K^*^0\pi^+K^-) = (-1 \pm 10)\% \]
\[ A_{CP}(K^*_1(1270)^-K^+ \rightarrow K^*^0\pi^-K^+) = (-10 \pm 32)\% \]
\[ A_{CP}(K^*_1(1270)^+K^- \rightarrow \rho^0K^+K^-) = (-7 \pm 17)\% \]
\[ A_{CP}(K^*_1(1270)^-K^+ \rightarrow \rho^0K^-K^+) = (10 \pm 13)\% \]
\[ A_{CP}(K^*(1410)^+K^- \rightarrow K^*^0\pi^+K^-) = (-20 \pm 17)\% \]
\[ A_{CP}(K^*(1410)^-K^+ \rightarrow \overline{K}^*^0\pi^-K^+) = (-1 \pm 14)\% \]
\[ A_{CP}(K^*^0\overline{K}^*^0 \text{S-wave}) = (10 \pm 14)\% \]
\[ A_{CP}(\phi\rho^0 \text{S-wave}) = (-3 \pm 5)\% \]
\[ A_{CP}(\phi\rho^0 \text{D-wave}) = (-37 \pm 19)\% \]
\[ A_{CP}(\phi (\pi^+\pi^-)_{S\text{-wave}}) = (-9 \pm 10)\% \]
\[ A_{CP}((K^-\pi^+)_{P\text{-wave}} (K^+\pi^-)_{S\text{-wave}}) = (3 \pm 11)\% \]

**CP-violation asymmetry difference**
\[ \Delta A_{CP} = A_{CP}(K^+K^-) - A_{CP}(\pi^+\pi^-) = (-0.46 \pm 0.25)\% \quad (S = 1.8) \]

**T-violation decay-rate asymmetry**
\[ A_T(K^+K^-\pi^+\pi^-) = (1 \pm 7) \times 10^{-3} \, [\text{rr}] \]

**CPT-violation decay-rate asymmetry**
\[ A_{CP}(K^{\mp}\pi^{\pm}) = 0.008 \pm 0.008 \]
Form factors

\[ r_V \equiv \frac{V(0)}{A_1(0)} \text{ in } D^0 \to K^+(892)^- \ell^+ \nu_\ell = 1.7 \pm 0.8 \]
\[ r_2 \equiv \frac{A_2(0)}{A_1(0)} \text{ in } D^0 \to K^+(892)^- \ell^+ \nu_\ell = 0.9 \pm 0.4 \]
\[ f_+(0) \text{ in } D^0 \to K^- \ell^+ \nu_\ell = 0.727 \pm 0.011 \]
\[ f_+(0) \left| V_{cs} \right| \text{ in } D^0 \to K^- \ell^+ \nu_\ell = 0.726 \pm 0.009 \]
\[ r_1 \equiv a_1/a_0 \text{ in } D^0 \to K^- \ell^+ \nu_\ell = -2.65 \pm 0.35 \]
\[ r_2 \equiv a_1/a_0 \text{ in } D^0 \to K^- \ell^+ \nu_\ell = 13 \pm 9 \]
\[ f_+(0) \left| V_{cd} \right| \text{ in } D^0 \to \pi^- \ell^+ \nu_\ell = 0.152 \pm 0.005 \]
\[ r_1 \equiv a_1/a_0 \text{ in } D^0 \to \pi^- \ell^+ \nu_\ell = -2.8 \pm 0.5 \]
\[ r_2 \equiv a_1/a_0 \text{ in } D^0 \to \pi^- \ell^+ \nu_\ell = 6 \pm 3.0 \]

Most decay modes (other than the semileptonic modes) that involve a neutral K meson are now given as \( K^0_S \) modes, not as \( K^0 \) modes. Nearly always it is a \( K^0_S \) that is measured, and interference between Cabibbo-allowed and doubly Cabibbo-suppressed modes can invalidate the assumption that \( 2 \Gamma(K^0_S) = \Gamma(K^0) \).

### D⁰ Decay Modes

<table>
<thead>
<tr>
<th>Scale factor/ ( p )</th>
<th>Confidence level (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topological modes</strong></td>
<td></td>
</tr>
<tr>
<td>0-prongs ([aaa])</td>
<td>(15 (\pm) 6) %</td>
</tr>
<tr>
<td>2-prongs ([bbb])</td>
<td>(70 (\pm) 6) %</td>
</tr>
<tr>
<td>4-prongs ([ccc])</td>
<td>(14.5 (\pm) 0.5) %</td>
</tr>
<tr>
<td>6-prongs ([ddd])</td>
<td>(6.4 (\pm) 1.3) (\times) 10⁻⁴</td>
</tr>
<tr>
<td><strong>Inclusive modes</strong></td>
<td></td>
</tr>
<tr>
<td>( e^+ \text{ anything} ) ([ddd])</td>
<td>(6.49 (\pm) 0.11) %</td>
</tr>
<tr>
<td>( \mu^+ \text{ anything} )</td>
<td>(6.7 (\pm) 0.6) %</td>
</tr>
<tr>
<td>( K^- \text{ anything} )</td>
<td>(54.7 (\pm) 2.8) %</td>
</tr>
<tr>
<td>( \bar{K}^0 \text{ anything} + K^0 \text{ anything} )</td>
<td>(47 (\pm) 4) %</td>
</tr>
<tr>
<td>( K^+ \text{ anything} )</td>
<td>(3.4 (\pm) 0.4) %</td>
</tr>
<tr>
<td>( K^+(892)^- \text{ anything} )</td>
<td>(15 (\pm) 9) %</td>
</tr>
<tr>
<td>( \bar{K}^*(892)^0 \text{ anything} )</td>
<td>(9 (\pm) 4) %</td>
</tr>
<tr>
<td>( K^*(892)^+ \text{ anything} )</td>
<td>(&lt; 3.6) %</td>
</tr>
<tr>
<td>( K^*(892)^0 \text{ anything} )</td>
<td>(2.8 (\pm) 1.3) %</td>
</tr>
<tr>
<td>( \eta \text{ anything} )</td>
<td>(9.5 (\pm) 0.9) %</td>
</tr>
<tr>
<td>( \eta' \text{ anything} )</td>
<td>(2.48 (\pm) 0.27) %</td>
</tr>
<tr>
<td>( \phi \text{ anything} )</td>
<td>(1.05 (\pm) 0.11) %</td>
</tr>
</tbody>
</table>
Semileptonic modes

\begin{align*}
K^- e^+ \nu_e & \quad (3.55 \pm 0.05 \%) \quad S=1.2 \quad 867 \\
K^- \mu^+ \nu_\mu & \quad (3.31 \pm 0.13 \%) \quad 864 \\
K^*(892)^- e^+ \nu_e & \quad (2.16 \pm 0.16 \%) \quad 719 \\
K^*(892)^- \mu^+ \nu_\mu & \quad (1.91 \pm 0.24 \%) \quad 714 \\
K^- \pi^0 e^+ \nu_e & \quad (1.6 \pm 1.3 \%) \quad 861 \\
\bar{\kappa}^0 \pi^- e^+ \nu_e & \quad (2.7 \pm 0.9 \%) \quad 860 \\
K^- \pi^+ \pi^- e^+ \nu_e & \quad (2.8 \pm 1.4 \times 10^{-4}) \quad 843 \\
K_1(1270)^- e^+ \nu_e & \quad (7.6 \pm 4.0 \times 10^{-4}) \quad 498 \\
K^- \pi^+ \pi^- \mu^+ \nu_\mu & \quad < 1.2 \times 10^{-3} \quad CL=90\% \quad 821 \\
\left(\bar{K}^*(892)\pi\right)^- \mu^+ \nu_\mu & \quad < 1.4 \times 10^{-3} \quad CL=90\% \quad 692 \\
\pi^- e^+ \nu_e & \quad (2.89 \pm 0.08 \times 10^{-3}) \quad S=1.1 \quad 927 \\
\pi^- \mu^+ \nu_\mu & \quad (2.37 \pm 0.24 \times 10^{-3}) \quad 924 \\
\rho^- e^+ \nu_e & \quad (1.77 \pm 0.16 \times 10^{-3}) \quad 771 \\
\end{align*}

Hadronic modes with one \(\kappa\)

\begin{align*}
K^- \pi^+ & \quad (3.88 \pm 0.05 \%) \quad S=1.1 \quad 861 \\
K^+ \pi^- & \quad (1.380 \pm 0.028 \times 10^{-4}) \quad 861 \\
K_S^0 \pi^0 & \quad (1.19 \pm 0.04 \%) \quad 860 \\
K_L^0 \pi^0 & \quad (10.0 \pm 0.7 \times 10^{-3}) \quad 860 \\
K_S^0 \pi^+ \pi^- & \quad [ss] \quad (2.83 \pm 0.20 \%) \quad S=1.1 \quad 842 \\
K_S^0 \rho^0 & \quad (6.3 \pm 0.7 \times 10^{-3}) \quad 674 \\
K_S^0 \omega, \omega \rightarrow \pi^+ \pi^- & \quad (2.1 \pm 0.6 \times 10^{-4}) \quad 670 \\
K_S^0 (\pi^+ \pi^-)_{S\text{-wave}} & \quad (3.4 \pm 0.8 \times 10^{-3}) \quad 842 \\
K_S^0 f_0(980), & \quad f_0(980) \rightarrow \pi^+ \pi^- \\
& \quad (1.22 \pm 0.40 \times 10^{-3}) \quad 549 \\
K_S^0 f_0(1370), & \quad f_0(1370) \rightarrow \pi^+ \pi^- \\
& \quad (2.8 \pm 0.9 \times 10^{-3}) \quad \dagger \\
K_S^0 f_2(1270), & \quad f_2(1270) \rightarrow \pi^+ \pi^- \\
& \quad (9 \pm 10 \times 10^{-5}) \quad 262 \\
K^*(892)^- \pi^+ & \quad (1.66 \pm 0.15 \%) \quad 711 \\
K^*(892)^- \rightarrow K_S^0 \pi^- \\
K_S^0(1430)^- \pi^+ & \quad (2.70 \pm 0.40 \times 10^{-3}) \quad 378 \\
K_S^0(1430)^- \rightarrow K_S^0 \pi^- \\
K_S^0(1430)^- \pi^+ & \quad (3.4 \pm 1.9 \times 10^{-4}) \quad 367 \\
K_S^0(1430)^- \rightarrow K_S^0 \pi^- \\
K^*(1680)^- \pi^+ & \quad (4 \pm 4 \times 10^{-4}) \quad 46 \\
K^*(1680)^- \rightarrow K_S^0 \pi^- \\
\end{align*}
$K^*(892)^+ \pi^-$, $K^*(892)^+ \rightarrow K^0_S \pi^+$
$K^*_0(1430)^+ \pi^-$, $K^*_0(1430)^+ \rightarrow K^0_S \pi^+$
$K^*_2(1430)^+ \pi^-$, $K^*_2(1430)^+ \rightarrow K^0_S \pi^+$
$K^0_S \pi^+ \pi^-$ nonresonant

Citation: K.A. Olive et al. (Particle Data Group), Chin. Phys. C38, 090001 (2014) (URL: http://pdg.lbl.gov)

| Process | $|S\rangle$ | $|S\rangle$ | Width | $\Delta |S\rangle$ | $\Delta |S\rangle$ | $\Delta |S\rangle$ |
|---------|------------|------------|-------|---------------|---------------|---------------|
| $K^- \pi^+ \pi^0$ | [ss] | $(13.9 \pm 0.5)$% | $S=1.7$ | | | |
| $K^- \rho^+$ | | | | | | |
| $K^- \rho(1700)^+$, $\rho(1700)^+ \rightarrow \pi^+ \pi^0$ | | | | | | |
| $K^*(892)^- \pi^+$, $K^*(892)^- \rightarrow K^- \pi^0$ | | | | | | |
| $\overline{K}^*(892)^0 \pi^0$, $\overline{K}^*(892)^0 \rightarrow K^- \pi^+$ | | | | | | |
| $K^*_0(1430)^- \pi^+$, $K^*_0(1430)^- \rightarrow K^- \pi^0$ | | | | | | |
| $\overline{K}^*_0(1430)^0 \pi^0$, $\overline{K}^*_0(1430)^0 \rightarrow K^- \pi^+$ | | | | | | |
| $K^*(1680)^- \pi^+$, $K^*(1680)^- \rightarrow K^- \pi^0$ | | | | | | |
| $K^- \pi^+ \pi^0$ nonresonant | | | | | | |
| $K^0_S 2\pi^0$ | | | | | | |
| $K^*_0(2\pi^0)$-S-wave | | | | | | |
| $\overline{K}^*(892)^0 \pi^0$, $\overline{K}^*(892)^0 \rightarrow K^0_S \pi^0$ | | | | | | |
| $\overline{K}^*(1430)^0 \pi^0$, $\overline{K}^* \rightarrow K^0_S \pi^0$ | | | | | | |
| $K^0_S \pi^-$ nonresonant | | | | | | |
| $K^0_S 2\pi^0$ | | | | | | |
| $K^*_0(2\pi^0)$-S-wave | | | | | | |
| $\overline{K}^*(892)^0 \pi^0$, $\overline{K}^*(892)^0 \rightarrow K^0_S \pi^0$ | | | | | | |
| $\overline{K}^*(1430)^0 \pi^0$, $\overline{K}^* \rightarrow K^0_S \pi^0$ | | | | | | |
| $K^0_S \pi^-$ nonresonant | | | | | | |
| $K^- 2\pi^+$ | [ss] | $(8.08 \pm 0.21)$% | $S=1.3$ | | | |
| $K^- \pi^+ \rho^0$ total | | | | | | |
| $K^- \pi^+ \rho^0$ 3-body | | | | | | |
| $K^*-\rho(892)^0 \pi^+$, $K^*-\rho(892)^0 \rightarrow K^- \pi^+$ | | | | | | |
| $K^- a_1(1260)^+$, $a_1(1260)^+ \rightarrow 2\pi^+ \pi^-$ | | | | | | |

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\[ \bar{K}^*(892)^0 \pi^+ \pi^- \text{ total,} \quad (1.6 \pm 0.4)\% \]
\[ \bar{K}^*(892)^0 \rightarrow K^- \pi^+ \quad 685 \]
\[ \bar{K}^*(892)^0 \pi^+ \pi^- 3\text{-body,} \quad (9.9 \pm 2.3) \times 10^{-3} \]
\[ \bar{K}^*(892)^0 \rightarrow K^- \pi^+ \quad 685 \]
\[ K_1(1270)^- \pi^+ \quad [\text{ff}f] \quad (2.9 \pm 0.3) \times 10^{-3} \quad 484 \]
\[ K_1(1270)^- \rightarrow K^- \pi^+ \pi^- \quad 685 \]
\[ K^- 2\pi^+ \pi^- \quad (1.88 \pm 0.26)\% \quad 813 \]
\[ K_S^0 \pi^+ \pi^- \quad [\text{ggg}] \quad (5.2 \pm 0.6)\% \quad 813 \]
\[ K_S^0 \eta, \eta \rightarrow \pi^+ \pi^- \pi^0 \quad (1.02 \pm 0.09) \times 10^{-3} \quad 772 \]
\[ K_S^0 \omega, \omega \rightarrow \pi^+ \pi^- \pi^0 \quad (9.9 \pm 0.5) \times 10^{-3} \quad 670 \]
\[ K^- 2\pi^+ \pi^- \pi^0 \quad (4.2 \pm 0.4)\% \quad 771 \]
\[ \bar{K}^*(892)^0 \pi^+ \pi^- \pi^0, \quad 643 \]
\[ K^- \pi^+ \omega, \omega \rightarrow \pi^+ \pi^- \pi^0 \quad (2.7 \pm 0.5)\% \quad 605 \]
\[ \bar{K}^*(892)^0 \omega, \quad (6.5 \pm 3.0) \times 10^{-3} \quad 410 \]
\[ K_S^0 \eta \pi^0 \quad (5.5 \pm 1.1) \times 10^{-3} \quad 721 \]
\[ K_S^0 a_0(980), a_0(980) \rightarrow \eta \pi^0 \quad (6.5 \pm 2.0) \times 10^{-3} \quad - \]
\[ \bar{K}^*(892)^0 \eta, \quad \bar{K}^*(892)^0 \rightarrow \quad (1.6 \pm 0.5) \times 10^{-3} \quad - \]
\[ K_S^0 \pi^0 \quad \]
\[ K_S^0 2\pi^+ \pi^- \quad (2.69 \pm 0.31) \times 10^{-3} \quad 768 \]
\[ K_S^0 \rho^0 \pi^+ \pi^-, \quad \text{no} \bar{K}^*(892)^- \quad (1.1 \pm 0.7) \times 10^{-3} \quad - \]
\[ K^*(892)^- 2\pi^+ \pi^- \quad (5 \pm 8) \times 10^{-4} \quad 642 \]
\[ K^*(892)^- \rightarrow K_S^0 \pi^-, \quad \text{no} \rho^0 \quad 768 \]
\[ K^*(892)^- \rho^0 \pi^+, \quad (1.6 \pm 0.6) \times 10^{-3} \quad 230 \]
\[ K^*(892)^- \rightarrow K_S^0 \pi^- \quad 768 \]
\[ K_S^0 2\pi^+ 2\pi^- \quad \text{nonresonant} \quad < 1.2 \times 10^{-3} \quad \text{CL}=90\% \quad 768 \]
\[ K^- 3\pi^+ 2\pi^- \quad (2.2 \pm 0.6) \times 10^{-4} \quad 713 \]

Fractions of many of the following modes with resonances have already appeared above as submodes of particular charged-particle modes. (Modes for which there are only upper limits and \( \bar{K}^*(892)^0 \rho \) submodes only appear below.)

\[ K_S^0 \eta \quad (4.79 \pm 0.30) \times 10^{-3} \quad 772 \]
\[ K_S^0 \omega \quad (1.11 \pm 0.06)\% \quad 670 \]
\[ K_S^0 \eta'(958) \quad (9.4 \pm 0.5) \times 10^{-3} \quad 565 \]
\[ K^- a_1(1260)^+ \quad (7.8 \pm 1.1)\% \quad 327 \]
\[ K^- a_2(1320)^+ \quad < 2 \times 10^{-3} \quad \text{CL}=90\% \quad 198 \]
\[ \bar{K}^*(892)^0 \pi^+ \pi^- \text{ total} \quad (2.4 \pm 0.5)\% \quad 685 \]
\[ \bar{K}^*(892)^0 \pi^+ \pi^- 3\text{-body} \quad (1.48 \pm 0.34)\% \quad 685 \]
\[ \bar{K}^*(892)^0 \rho^0 \quad (1.58 \pm 0.34)\% \quad 417 \]
\( K^+(892)^0 \rho^0 \) transverse  ( 1.7 ± 0.6 ) %  417
\( K^+(892)^0 \rho^0 \) S-wave  ( 3.0 ± 0.6 ) %  417
\( K^+(892)^0 \rho^0 \) S-wave long.  < 3 \( \times 10^{-3} \) CL=90%  417
\( K^+(892)^0 \rho^0 \) P-wave  < 3 \( \times 10^{-3} \) CL=90%  417
\( K^+(892)^0 \rho^0 \) D-wave  ( 2.1 ± 0.6 ) %  417
\( K_1(1270)^- \pi^+ \)  [HF]  ( 1.6 ± 0.8 ) %  484
\( K_1(1400)^- \pi^+ \)  < 1.2 %  CL=90%  386
\( K^+(892)^0 \pi^+ \pi^- \pi^0 \)  ( 1.9 ± 0.9 ) %  643
\( K^- \pi^+ \omega \)  ( 3.0 ± 0.6 ) %  605
\( K^+(892)^0 \omega \)  ( 1.1 ± 0.5 ) %  410
\( K^- \pi^+ \eta'(958) \)  ( 7.5 ± 1.9 ) \( \times 10^{-3} \)  479
\( \bar{K}^+(892)^0 \eta'(958) \)  < 1.1 \( \times 10^{-3} \) CL=90%  119

### Hadronic modes with three \( K^\prime s \)

\( K_S^0 K^+ K^- \)  ( 4.47 ± 0.34 ) \( \times 10^{-3} \)  544
\( K_S^0 a_0(980)^0, a_0^0 \rightarrow K^+ K^- \)  ( 3.0 ± 0.4 ) \( \times 10^{-3} \)  –
\( K^- a_0(980)^+, a_0^+ \rightarrow K^+ K_S^0 \)  ( 6.0 ± 1.8 ) \( \times 10^{-4} \)  –
\( K_0^0 f_0(980)^-, a_0^- \rightarrow \bar{K}^- K_S^0 \)  < 1.1 \( \times 10^{-4} \) CL=95%  –
\( K_S^0 f_0(1370), f_0 \rightarrow K^+ K^- \)  < 9 \( \times 10^{-5} \) CL=95%  –
\( 3 K_S^0 \)  ( 9.1 ± 1.3 ) \( \times 10^{-4} \)  539
\( K^+ 2 K^- \pi^+ \)  ( 2.21 ± 0.31 ) \( \times 10^{-4} \)  434
\( K^+ K^- \bar{K}^*(892)^0 \),
\( \bar{K}^*(892)^0 \rightarrow K^- \pi^+ \)  ( 4.4 ± 1.7 ) \( \times 10^{-5} \)  †
\( K^- \pi^+ \phi, \phi \rightarrow K^+ K^- \)  ( 4.0 ± 1.7 ) \( \times 10^{-5} \)  422
\( \phi \bar{K}^*(892)^0 \),
\( \phi \rightarrow K^+ K^- \),
\( \bar{K}^*(892)^0 \rightarrow K^- \pi^+ \)  ( 1.06 ± 0.20 ) \( \times 10^{-4} \)  †
\( K^+ 2 K^- \pi^+ \) nonresonant  ( 3.3 ± 1.5 ) \( \times 10^{-5} \)  434
\( 2 K_S^0 K^\pm \pi^\mp \)  ( 6.0 ± 1.3 ) \( \times 10^{-4} \)  427

### Pionic modes

\( \pi^+ \pi^- \)  ( 1.402± 0.026 ) \( \times 10^{-3} \) S=1.1  922
\( 2 \pi^0 \)  ( 8.20 ± 0.35 ) \( \times 10^{-4} \)  923
\( \pi^+ \pi^- \pi^0 \)  ( 1.43 ± 0.06 ) %  S=1.9  907
\( \rho^+ \pi^- \)  ( 9.8 ± 0.4 ) \( \times 10^{-3} \)  764
\( \rho^0 \pi^0 \)  ( 3.72 ± 0.22 ) \( \times 10^{-3} \)  764
\( \rho^- \pi^+ \)  ( 4.96 ± 0.24 ) \( \times 10^{-3} \)  764
\( \rho(1450)^+ \pi^-, \rho(1450)^+ \rightarrow \pi^+ \pi^0 \)  ( 1.6 ± 2.0 ) \( \times 10^{-5} \)  –
\( \rho(1450)^0 \pi^0, \rho(1450)^0 \rightarrow \pi^+ \pi^- \)  ( 4.3 ± 1.9 ) \( \times 10^{-5} \)  –
\( \rho(1450)^- \pi^+, \rho(1450)^- \rightarrow \pi^- \pi^0 \)  ( 2.6 ± 0.4 ) \( \times 10^{-4} \)  –
\( \rho(1700)^{+} \pi^{-}, \rho(1700)^{+} \rightarrow (5.9 \pm 1.4) \times 10^{-4} \)

\( \rho(1700)^{0} \pi^{0}, \rho(1700)^{0} \rightarrow (7.2 \pm 1.7) \times 10^{-4} \)

\( \rho(1700)^{-} \pi^{+}, \rho(1700)^{-} \rightarrow (4.6 \pm 1.1) \times 10^{-4} \)

\( f_{0}(980) \pi^{0}, f_{0}(980) \rightarrow (3.6 \pm 0.8) \times 10^{-5} \)

\( f_{0}(500) \pi^{0}, f_{0}(500) \rightarrow (1.18 \pm 0.21) \times 10^{-4} \)

\( f_{0}(1370) \pi^{0}, f_{0}(1370) \rightarrow (5.3 \pm 2.1) \times 10^{-5} \)

\( f_{0}(1500) \pi^{0}, f_{0}(1500) \rightarrow (5.6 \pm 1.5) \times 10^{-5} \)

\( f_{0}(1710) \pi^{0}, f_{0}(1710) \rightarrow (4.4 \pm 1.5) \times 10^{-5} \)

\( f_{2}(1270) \pi^{0}, f_{2}(1270) \rightarrow (1.89 \pm 0.20) \times 10^{-4} \)

\( \pi^{+} \pi^{-} \pi^{0} \text{ nonresonant} \)

\( 3\pi^{0} (1.20 \pm 0.35) \times 10^{-4} \)

\( 2\pi^{+} 2\pi^{-} < 3.5 \times 10^{-4} \text{ CL}=90\% \)

\( a_{1}(1260)^{+} \pi^{-}, a_{1}^{+} \rightarrow (4.45 \pm 0.31) \times 10^{-3} \)

\( 2\pi^{+} \pi^{-} \text{ total} \)

\( a_{1}(1260)^{+} \pi^{-}, a_{1}^{+} \rightarrow (3.21 \pm 0.25) \times 10^{-3} \)

\( \rho^{0} \pi^{+} \text{ S-wave} \)

\( a_{1}(1260)^{+} \pi^{-}, a_{1}^{+} \rightarrow (1.9 \pm 0.5) \times 10^{-4} \)

\( \rho^{0} \pi^{+} \text{ D-wave} \)

\( a_{1}(1260)^{+} \pi^{-}, a_{1}^{+} \rightarrow (6.2 \pm 0.7) \times 10^{-4} \)

\( \sigma \pi^{+} \)

\( 2\rho^{0} \text{ total} \)

\( 2\rho^{0}, \text{ parallel helicities} \)

\( 2\rho^{0}, \text{ perpendicular helicities} \)

\( 2\rho^{0}, \text{ longitudinal helicities} \)

\( \text{Resonant} (\pi^{+} \pi^{-}) \pi^{+} \pi^{-} \)

\( \text{3-body total} \)

\( f_{0}(980) \pi^{+} \pi^{-}, f_{0} \rightarrow (1.8 \pm 0.5) \times 10^{-4} \)

\( f_{2}(1270) \pi^{+} \pi^{-}, f_{2} \rightarrow (3.6 \pm 0.6) \times 10^{-4} \)

\( \pi^{+} \pi^{-} 2\pi^{0} \)

\( \eta \pi^{0} \)

\( \omega \pi^{0} \)

\( 2\pi^{+} 2\pi^{-} \pi^{0} \)

\( \eta \pi^{+} \pi^{-} \)
\[
\begin{align*}
\omega \pi^+ \pi^- & \quad \text{[hhh] } (1.6 \pm 0.5) \times 10^{-3} \quad 738 \\
3\pi^+ 3\pi^- & \quad (4.2 \pm 1.2) \times 10^{-4} \quad 795 \\
\eta'(958) \pi^0 & \quad (9.0 \pm 1.4) \times 10^{-4} \quad 678 \\
\eta'(958) \pi^+ \pi^- & \quad (4.5 \pm 1.7) \times 10^{-4} \quad 650 \\
2\eta & \quad (1.67 \pm 0.20) \times 10^{-3} \quad 754 \\
\eta \eta'(958) & \quad (1.05 \pm 0.26) \times 10^{-3} \quad 537 \\
\end{align*}
\]

**Hadronic modes with a \( K\bar{K} \) pair**

\[
\begin{align*}
K^+ K^- & \quad (3.96 \pm 0.08) \times 10^{-3} \quad S=1.4 \quad 791 \\
2K^0_S & \quad (1.7 \pm 0.4) \times 10^{-4} \quad S=2.5 \quad 789 \\
K^0_S K^- \pi^+ & \quad (3.5 \pm 0.5) \times 10^{-3} \quad S=1.2 \quad 739 \\
\bar{K}^+(892)0 K^0_S, \bar{K}^+0 & \to < 5 \times 10^{-4} \quad \text{CL}=90\% \quad 608 \\
K^0_S K^+ \pi^- & \quad (2.1 \pm 0.4) \times 10^{-3} \quad S=1.3 \quad 739 \\
K^+(892)0 K^0_S, K^+0 & \to < 1.8 \times 10^{-4} \quad \text{CL}=90\% \quad 608 \\
K^+ K^- \pi^+ & \quad (3.29 \pm 0.14) \times 10^{-3} \quad 743 \\
K^+(892)^+ K^-, K^+(892)^+ & \to (1.46 \pm 0.07) \times 10^{-3} \quad - \\
K^+ \pi^0 & \quad (5.2 \pm 0.4) \times 10^{-4} \quad - \\
K^+ \pi^0, K^*(892)^0 & \to (2.34 \pm 0.17) \times 10^{-3} \quad 743 \\
(K^+ \pi^0)_S^{-, -} & \to (1.3 \pm 0.4) \times 10^{-4} \quad 743 \\
f_0(980) \pi^0, f_0 & \to K^+ K^- & (3.5 \pm 0.6) \times 10^{-4} & - \\
\phi \pi^0, \phi & \to K^+ K^- & (6.4 \pm 0.4) \times 10^{-4} & - \\
2K^0_S \pi^0 & \to < 5.9 \times 10^{-4} \quad 740 \\
K^+ K^- \pi^+ \pi^- & \quad (2.43 \pm 0.12) \times 10^{-3} \quad 677 \\
\phi (\pi^+ \pi^-)_S^{-, -} & \to (2.50 \pm 0.33) \times 10^{-4} \quad 614 \\
(\phi \rho^0)_S^{-, -} & \to K^+ K^- & (9.3 \pm 1.2) \times 10^{-4} & 250 \\
(\phi \rho^0)_D^{-, -} & \to K^+ K^- & (8.3 \pm 2.3) \times 10^{-5} & - \\
(K^*0 \bar{K}^0)_S^{-, -} & \to K^+0 & (1.48 \pm 0.30) \times 10^{-4} & - \\
K^+ \pi^+ & \quad (2.6 \pm 0.5) \times 10^{-4} \quad - \\
(K^+ \pi^-)_S^{-, -} & \to K^+0 & - \\
K^0_1(1270)^+ K^- & \quad (1.8 \pm 0.5) \times 10^{-4} \quad - \\
K^0_1(1270)^+ & \to K^0 \pi^+ & (1.14 \pm 0.26) \times 10^{-4} \quad - \\
K^0_1(1270)^+ K^- & \quad (1.11 \pm 0.26) \times 10^{-4} \quad - \\
K^0_1(1270)^+ & \to \rho^0 K^+ & (2.2 \pm 1.2) \times 10^{-5} \quad - \\
K^0_1(1270)^0 K^- & \quad (1.46 \pm 0.25) \times 10^{-4} \quad - \\
K^0_1(1270)^0 & \to \rho^0 K^- & (1.02 \pm 0.26) \times 10^{-4} \quad - \\
\end{align*}
\]
\[ K^*(1410)^- K^+ \]
\[ K^*(1410)^- \to \overline{K}^{*0} \pi^- \]
\[ 2K_S^0 \pi^+ \pi^- \]
\[ K_S^0 K^- 2\pi^+ \pi^- \]
\[ K^+ K^- \pi^+ \pi^- \pi^0 \]

Other \( K \overline{K} X \) modes. They include all decay modes of the \( \phi, \eta, \) and \( \omega \).
\[ \phi \eta \]
\[ \phi \omega \]

Radiative modes
\[ \phi^0 \gamma \]
\[ \omega \gamma \]
\[ \phi \gamma \]
\[ \overline{K}^*(892)^0 \gamma \]

Doubly Cabibbo suppressed (DC) modes or \( \Delta C = 2 \) forbidden via mixing (C2M) modes
\[ K^+ \ell^+ \nu_\ell \text{ via } D^0 \]
\[ K^+ \text{ or } K^*(892)^+ e^- \nu_e \text{ via } D^0 \]
\[ K^+ \pi^- \text{ via DCS} \]
\[ K^+ \pi^- \text{ via } D^0 \]
\[ K_S^0 \pi^+ \pi^- \text{ in } D^0 \to D^0 \]
\[ K^*(892)^+ \pi^- , \text{ via } D^0 \]
\[ K_0^*(1430)^+ \pi^- , \text{ via } D^0 \]
\[ K_S^0 \pi^+ \pi^- \text{ via } D^0 \]
\[ K^+ \pi^- \pi^0 \text{ via } D^0 \]
\[ K^+ \pi^- 2\pi^- \text{ via } D^0 \]

\( \Delta C = 1 \) weak neutral current (C1) modes,
Lepton Family number (LF) violating modes,
Lepton (L) or Baryon (B) number violating modes
\[ \gamma \gamma \]
\[ e^+ e^- \]
\[ \mu^+ \mu^- \]
\[ \pi^0 e^+ e^- \]
\[ \pi^0 \mu^+ \mu^- \]
<table>
<thead>
<tr>
<th>Process</th>
<th>C1</th>
<th>&lt; Value &gt;</th>
<th>&lt; Error &gt;</th>
<th>CL</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\eta e^+e^-$</td>
<td>C1</td>
<td>&lt; 1.1</td>
<td>$10^{-4}$</td>
<td>CL=90%</td>
<td>852</td>
</tr>
<tr>
<td>$\eta\mu^+\mu^-$</td>
<td>C1</td>
<td>5.3</td>
<td>$10^{-4}$</td>
<td>CL=90%</td>
<td>838</td>
</tr>
<tr>
<td>$\pi^+\pi^- e^+e^-$</td>
<td>C1</td>
<td>&lt; 3.73</td>
<td>$10^{-4}$</td>
<td>CL=90%</td>
<td>922</td>
</tr>
<tr>
<td>$\rho^0 e^+e^-$</td>
<td>C1</td>
<td>&lt; 1.0</td>
<td>$10^{-4}$</td>
<td>CL=90%</td>
<td>771</td>
</tr>
<tr>
<td>$\pi^+\pi^- \mu^+\mu^-$</td>
<td>C1</td>
<td>&lt; 5.5</td>
<td>$10^{-7}$</td>
<td>CL=90%</td>
<td>894</td>
</tr>
<tr>
<td>$\rho^0 \mu^+\mu^-$</td>
<td>C1</td>
<td>&lt; 2.2</td>
<td>$10^{-5}$</td>
<td>CL=90%</td>
<td>754</td>
</tr>
<tr>
<td>$\omega e^+e^-$</td>
<td>C1</td>
<td>&lt; 1.8</td>
<td>$10^{-4}$</td>
<td>CL=90%</td>
<td>768</td>
</tr>
<tr>
<td>$\omega\mu^+\mu^-$</td>
<td>C1</td>
<td>&lt; 8.3</td>
<td>$10^{-4}$</td>
<td>CL=90%</td>
<td>751</td>
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<tr>
<td>$K^- K^+ e^+e^-$</td>
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<td>791</td>
</tr>
<tr>
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<td>$10^{-5}$</td>
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<tr>
<td>$K^- K^+ \mu^+\mu^-$</td>
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<td>&lt; 3.3</td>
<td>$10^{-5}$</td>
<td>CL=90%</td>
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</tr>
<tr>
<td>$\phi\mu^+\mu^-$</td>
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<tr>
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<tr>
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</tr>
<tr>
<td>$\pi^+\pi^- \pi^0 \mu^+\mu^-$</td>
<td>C1</td>
<td>&lt; 8.1</td>
<td>$10^{-4}$</td>
<td>CL=90%</td>
<td>863</td>
</tr>
<tr>
<td>$\mu^\pm e^\mp$</td>
<td>LF</td>
<td>[gg]</td>
<td>2.6</td>
<td>$10^{-7}$</td>
<td>CL=90%</td>
</tr>
<tr>
<td>$\pi^0 e^\pm \mu^\mp$</td>
<td>LF</td>
<td>[gg]</td>
<td>8.6</td>
<td>$10^{-5}$</td>
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</tr>
<tr>
<td>$\eta e^\pm \mu^\mp$</td>
<td>LF</td>
<td>[gg]</td>
<td>1.0</td>
<td>$10^{-4}$</td>
<td>CL=90%</td>
</tr>
<tr>
<td>$\pi^+\pi^- e^\pm \mu^\mp$</td>
<td>LF</td>
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<td>1.5</td>
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<tr>
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<tr>
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<td>[gg]</td>
<td>3.4</td>
<td>$10^{-5}$</td>
<td>CL=90%</td>
</tr>
<tr>
<td>$K^*0(892) e^\pm \mu^\mp$</td>
<td>LF</td>
<td>[gg]</td>
<td>1.0</td>
<td>$10^{-4}$</td>
<td>CL=90%</td>
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<tr>
<td>$K^- \pi^+ e^\pm \mu^\mp$</td>
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<td>5.53</td>
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<tr>
<td>$2\pi^- 2e^+ + c.c.$</td>
<td>L</td>
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</tr>
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<td>$10^{-4}$</td>
<td>CL=90%</td>
<td>829</td>
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<tr>
<td>$2K^- 2e^+ + c.c.$</td>
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<td>&lt; 1.52</td>
<td>$10^{-4}$</td>
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<td>$2K^- 2\mu^+ + c.c.$</td>
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<td>&lt; 9.4</td>
<td>$10^{-5}$</td>
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<tr>
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<td>&lt; 7.9</td>
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<tr>
<td>$p e^-$</td>
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<td>[iii]</td>
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<tr>
<td>$\bar{p} e^+$</td>
<td>LB</td>
<td>[iii]</td>
<td>&lt; 1.1</td>
<td>$10^{-5}$</td>
<td>CL=90%</td>
</tr>
</tbody>
</table>
**D*(2007)⁰**

\[ I(J^P) = \frac{1}{2}(1^-) \]

I, J, P need confirmation.

Mass \( m = 2006.96 \pm 0.10 \text{ MeV} \)

\[ m_{D^*(0)} - m_{D^0} = 142.12 \pm 0.07 \text{ MeV} \]

Full width \( \Gamma < 2.1 \text{ MeV}, \text{ CL} = 90\% \)

\( D^*(2007)^0 \) modes are charge conjugates of modes below.

<table>
<thead>
<tr>
<th><em><em>D</em>(2007)⁰ DECAY MODES</em>*</th>
<th>Fraction (( \Gamma_i/\Gamma ))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( D^0 \pi^0 )</td>
<td>( 61.9 \pm 2.9 ) %</td>
<td>43</td>
</tr>
<tr>
<td>( D^0 \gamma )</td>
<td>( 38.1 \pm 2.9 ) %</td>
<td>137</td>
</tr>
</tbody>
</table>

**D*(2010)±**

\[ I(J^P) = \frac{1}{2}(1^-) \]

I, J, P need confirmation.

Mass \( m = 2010.26 \pm 0.07 \text{ MeV} \quad (S = 1.1) \)

\[ m_{D^*(2010)^+} - m_{D^+} = 140.66 \pm 0.08 \text{ MeV} \]

\[ m_{D^*(2010)^+} - m_{D^0} = 145.4257 \pm 0.0017 \text{ MeV} \]

Full width \( \Gamma = 83.4 \pm 1.8 \text{ keV} \)

\( D^*(2010)^- \) modes are charge conjugates of the modes below.

<table>
<thead>
<tr>
<th><em><em>D</em>(2010)± DECAY MODES</em>*</th>
<th>Fraction (( \Gamma_i/\Gamma ))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( D^0 \pi^+ )</td>
<td>( 67.7 \pm 0.5 ) %</td>
<td>39</td>
</tr>
<tr>
<td>( D^+ \pi^0 )</td>
<td>( 30.7 \pm 0.5 ) %</td>
<td>38</td>
</tr>
<tr>
<td>( D^+ \gamma )</td>
<td>( 1.6 \pm 0.4 ) %</td>
<td>136</td>
</tr>
</tbody>
</table>

**D₀⁺(2400)⁰**

\[ I(J^P) = \frac{1}{2}(0^+) \]

Mass \( m = 2318 \pm 29 \text{ MeV} \quad (S = 1.7) \)

Full width \( \Gamma = 267 \pm 40 \text{ MeV} \)

<table>
<thead>
<tr>
<th><strong>D₀⁺(2400)⁰ DECAY MODES</strong></th>
<th>Fraction (( \Gamma_i/\Gamma ))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( D^+ \pi^- )</td>
<td>seen</td>
<td>385</td>
</tr>
</tbody>
</table>

**D₁(2420)⁰**

\[ I(J^P) = \frac{1}{2}(1^+) \]

I needs confirmation.

Mass \( m = 2421.4 \pm 0.6 \text{ MeV} \quad (S = 1.2) \)

\[ m_{D_1^0} - m_{D_{1^+}} = 411.1 \pm 0.6 \quad (S = 1.2) \]

Full width \( \Gamma = 27.4 \pm 2.5 \text{ MeV} \quad (S = 2.3) \)
$D_1(2420)^0$ modes are charge conjugates of modes below.

### $D_1(2420)^0$ DECAY MODES

<table>
<thead>
<tr>
<th>Decay</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D^*(2010)^+\pi^-$</td>
<td>seen</td>
<td>354</td>
</tr>
<tr>
<td>$D^0\pi^+\pi^-$</td>
<td>seen</td>
<td>425</td>
</tr>
<tr>
<td>$D^+\pi^-$</td>
<td>not seen</td>
<td>473</td>
</tr>
<tr>
<td>$D^{*0}\pi^+\pi^-$</td>
<td>not seen</td>
<td>280</td>
</tr>
</tbody>
</table>

$D_2^*(2460)^0$ modes are charge conjugates of modes below.

### $D_2^*(2460)^0$ DECAY MODES

<table>
<thead>
<tr>
<th>Decay</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D^0\pi^+\pi^-$</td>
<td>seen</td>
<td>507</td>
</tr>
<tr>
<td>$D^*(2010)^+\pi^-$</td>
<td>seen</td>
<td>391</td>
</tr>
<tr>
<td>$D^0\pi^+\pi^-$</td>
<td>not seen</td>
<td>463</td>
</tr>
<tr>
<td>$D^{*0}\pi^+\pi^-$</td>
<td>not seen</td>
<td>326</td>
</tr>
</tbody>
</table>

$J^P = 2^+$ assignment strongly favored.

Mass $m = 2462.6 \pm 0.6$ MeV \ ($S = 1.2$)  
$m_{D_2^0} - m_{D^+} = 593.0 \pm 0.6$ MeV \ ($S = 1.2$)  
$m_{D_2^0} - m_{D^{*+}} = 452.3 \pm 0.6$ MeV \ ($S = 1.2$)  
Full width $\Gamma = 49.0 \pm 1.3$ MeV \ ($S = 1.5$)

$D_2^*(2460)^0$ modes are charge conjugates of modes below.

### $D_2^*(2460)^0$ DECAY MODES

<table>
<thead>
<tr>
<th>Decay</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D^0\pi^+$</td>
<td>seen</td>
<td>512</td>
</tr>
<tr>
<td>$D^{*0}\pi^+$</td>
<td>seen</td>
<td>395</td>
</tr>
<tr>
<td>$D^+\pi^+\pi^-$</td>
<td>not seen</td>
<td>461</td>
</tr>
<tr>
<td>$D^{*+}\pi^+\pi^-$</td>
<td>not seen</td>
<td>324</td>
</tr>
</tbody>
</table>

$D_2^*(2460)^\pm$ modes are charge conjugates of modes below.

### $D_2^*(2460)^\pm$ DECAY MODES

<table>
<thead>
<tr>
<th>Decay</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D^0\pi^+$</td>
<td>seen</td>
<td>512</td>
</tr>
<tr>
<td>$D^{*0}\pi^+$</td>
<td>seen</td>
<td>395</td>
</tr>
<tr>
<td>$D^+\pi^+\pi^-$</td>
<td>not seen</td>
<td>461</td>
</tr>
<tr>
<td>$D^{*+}\pi^+\pi^-$</td>
<td>not seen</td>
<td>324</td>
</tr>
</tbody>
</table>
CHARMED, STRANGE MESONS
(C = S = ±1)

\[ D_s^+ = c\bar{s}, \, D_s^- = \bar{c}s, \text{ similarly for } D_s^* \text{'s} \]

\[ I(J^P) = 0(0^-) \]

Mass \( m = 1968.30 \pm 0.11 \) MeV \((S = 1.1)\)
\[ m_{D_s^\pm} - m_{D_s^0} = 98.69 \pm 0.05 \text{ MeV} \]
Mean life \( \tau = (500 \pm 7 \times 10^{-15}) \text{ s} \) \((S = 1.3)\)
\[ c\tau = 149.9 \mu\text{m} \]

**CP-violating decay-rate asymmetries**
\[ A_{CP}(\mu^\pm \nu) = (5 \pm 6)\% \]
\[ A_{CP}(K^\pm K^0_S) = (0.08 \pm 0.26)\% \]
\[ A_{CP}(K^+ K^- \pi^\pm) = (-0.5 \pm 0.9)\% \]
\[ A_{CP}(K^\pm K^0_S \pi^0) = (-2 \pm 6)\% \]
\[ A_{CP}(2K^0_S \pi^\pm) = (3 \pm 5)\% \]
\[ A_{CP}(K^+ K^- \pi^\pm \pi^0) = (0.0 \pm 3.0)\% \]
\[ A_{CP}(K^\pm K^0_S \pi^+ \pi^-) = (-6 \pm 5)\% \]
\[ A_{CP}(K^0_S K^\mp 2\pi^\pm) = (4.1 \pm 2.8)\% \]
\[ A_{CP}(\pi^+ \pi^- \pi^\pm) = (-0.7 \pm 3.1)\% \]
\[ A_{CP}(\pi^\pm \eta) = (1.1 \pm 3.1)\% \]
\[ A_{CP}(\pi^\pm \eta') = (-2.2 \pm 2.3)\% \]
\[ A_{CP}(\eta \pi^\pm \pi^0) = (-1 \pm 4)\% \]
\[ A_{CP}(\eta' \pi^\pm \pi^0) = (0 \pm 8)\% \]
\[ A_{CP}(K^\pm \pi^0) = (-27 \pm 24)\% \]
\[ A_{CP}(K^0_S \pi^\pm) = (1.2 \pm 1.0)\% \text{ (S = 1.3)} \]
\[ A_{CP}(K^\pm \pi^+ \pi^-) = (4 \pm 5)\% \]
\[ A_{CP}(K^\pm \eta) = (9 \pm 15)\% \]
\[ A_{CP}(K^\pm \eta/(958)) = (6 \pm 19)\% \]

**T-violating decay-rate asymmetry**
\[ A_T(K^0_S K^\pm \pi^+ \pi^-) = (-14 \pm 8 \times 10^{-3}) \text{ [\tau]} \]

**\( D_s^+ \to \phi \ell^+ \nu_\ell \) form factors**
\[ r_2 = 0.84 \pm 0.11 \text{ (S = 2.4)} \]
\[ r_\nu = 1.80 \pm 0.08 \]
\[ \Gamma_L/\Gamma_T = 0.72 \pm 0.18 \]
Unless otherwise noted, the branching fractions for modes with a resonance in the final state include all the decay modes of the resonance. $D_s^-$ modes are charge conjugates of the modes below.

### $D_s^+$ Decay Modes

<table>
<thead>
<tr>
<th>$\Gamma_i/\Gamma$</th>
<th>Confidence level (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inclusive modes</strong></td>
<td></td>
</tr>
<tr>
<td>$e^+\nu_e$</td>
<td>$&lt; 8.3 \times 10^{-5}$ CL=90% 984</td>
</tr>
<tr>
<td>$\mu^+\nu_\mu$</td>
<td>$(5.56\pm0.25) \times 10^{-3}$ 981</td>
</tr>
<tr>
<td>$\tau^+\nu_\tau$</td>
<td>$(5.54\pm0.24)$ 182</td>
</tr>
<tr>
<td>$K^+K^- e^+\nu_e$</td>
<td>— 851</td>
</tr>
<tr>
<td>$\phi e^+\nu_e$</td>
<td>[ooo] $(2.49\pm0.14)$ % 720</td>
</tr>
<tr>
<td>$\eta e^+\nu_e + \eta' (958) e^+\nu_e$</td>
<td>[ooo] $(3.66\pm0.37)$ % 908</td>
</tr>
<tr>
<td>$\eta e^+\nu_e$</td>
<td>[ooo] $(2.67\pm0.29)$ % S=1.1 751</td>
</tr>
<tr>
<td>$\eta' (958) e^+\nu_e$</td>
<td>[ooo] $(9.9\pm2.3) \times 10^{-3}$ 751</td>
</tr>
<tr>
<td>$\omega e^+\nu_e$</td>
<td>[ppp] $&lt; 2.0 \times 10^{-3}$ CL=90% 829</td>
</tr>
<tr>
<td>$K^0 e^+\nu_e$</td>
<td>$(3.7\pm1.0) \times 10^{-3}$ 921</td>
</tr>
<tr>
<td>$K^*(892)^0 e^+\nu_e$</td>
<td>[ooo] $(1.8\pm0.7) \times 10^{-3}$ 782</td>
</tr>
<tr>
<td>$f_0(980) e^+\nu_e$, $f_0 \rightarrow \pi^+\pi^-$</td>
<td>$&lt; 2.0 \pm 0.32 \pm 10^{-3}$ 782</td>
</tr>
</tbody>
</table>

### Leptonic and semileptonic modes

<table>
<thead>
<tr>
<th>$\Gamma_i/\Gamma$</th>
<th>Confidence level (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi^+$ anything</td>
<td>$(119.3 \pm 1.4)$ % 921</td>
</tr>
<tr>
<td>$\pi^-$ anything</td>
<td>$(43.2 \pm 0.9)$ % 921</td>
</tr>
<tr>
<td>$\pi^0$ anything</td>
<td>$(123 \pm 7)$ % 921</td>
</tr>
<tr>
<td>$K^-$ anything</td>
<td>$(18.7 \pm 0.5)$ % 921</td>
</tr>
<tr>
<td>$K^+$ anything</td>
<td>$(28.9 \pm 0.7)$ % 921</td>
</tr>
<tr>
<td>$K^0_S$ anything</td>
<td>$(19.0 \pm 1.1)$ % 921</td>
</tr>
<tr>
<td>$\eta_f$ anything</td>
<td>[fff] $(29.9 \pm 2.8)$ % 921</td>
</tr>
<tr>
<td>$\omega$ anything</td>
<td>$(6.1 \pm 1.4)$ % 921</td>
</tr>
<tr>
<td>$\eta'$ anything</td>
<td>[nnn] $(11.7 \pm 1.8)$ % 921</td>
</tr>
<tr>
<td>$\phi$ anything</td>
<td>$(15.7 \pm 1.0)$ % 921</td>
</tr>
<tr>
<td>$K^+ K^- \rightarrow e^+\nu_e$</td>
<td>$(15.8 \pm 0.7)$ % 921</td>
</tr>
<tr>
<td>$K^0_S K^+ \rightarrow e^+\nu_e$</td>
<td>$(5.8 \pm 0.5)$ % 921</td>
</tr>
<tr>
<td>$K^0_S K^- \rightarrow e^+\nu_e$</td>
<td>$(1.9 \pm 0.4)$ % 921</td>
</tr>
<tr>
<td>$2K^0_S$ anything</td>
<td>$(1.70 \pm 0.32)$ % 921</td>
</tr>
<tr>
<td>$2K^+$ anything</td>
<td>$&lt; 2.6 \times 10^{-3}$ CL=90% 921</td>
</tr>
<tr>
<td>$2K^-$ anything</td>
<td>$&lt; 6 \times 10^{-4}$ CL=90% 921</td>
</tr>
</tbody>
</table>
Hadronic modes with a $K\bar{K}$ pair

$$K^+ K^0_S$$

$$K^+ \bar{K}^0$$

$$K^+ K^- \pi^+$$

$$\phi \pi^+$$

$$\phi \pi^+, \phi \rightarrow K^+ K^-$$

$$K^+ \bar{K}^0 (892)^0, \bar{K}^*0 \rightarrow$$

$$K^- \pi^+$$

$$f_0(980) \pi^+, f_0 \rightarrow K^+ K^-$$

$$f_0(1370) \pi^+, f_0 \rightarrow K^+ K^-$$

$$f_0(1710) \pi^+, f_0 \rightarrow K^+ K^-$$

$$K^+ \bar{K}^0 (1430)^0, \bar{K}^0 \rightarrow$$

$$K^- \pi^+$$

$$K^+ K^0_S \pi^0$$

$$2K^0_S \pi^+$$

$$K^0 \bar{K}^0 \pi^+$$

$$K^* (892)^+ \bar{K}^0$$

$$K^+ K^- \pi^+ \pi^0$$

$$\phi \rho^+$$

$$K^0_S K^- 2\pi^+$$

$$K^*(892)^+ \bar{K}^* (892)^0$$

$$K^+ K^0_S \pi^+ \pi^-$$

$$K^+ K^- 2\pi^+ \pi^-$$

$$\phi 2\pi^+ \pi^-$$

$$K^+ K^- \rho^0 \pi^+ \text{non-}\phi$$

$$\phi \rho^0 \pi^+, \phi \rightarrow K^+ K^-$$

$$\phi a_1(1260)^+, \phi \rightarrow$$

$$K^+ K^-, a_1^+ \rightarrow \rho^0 \pi^+$$

$$K^+ K^- 2\pi^+ \pi^- \text{nonresonant}$$

$$2K^0_S \pi^+ \pi^-$$

Hadronic modes without $K$'s

$$\pi^+ \pi^0$$

$$2\pi^+ \pi^-$$

$$\rho^0 \pi^+$$

$$\pi^+ (\pi^+ \pi^-)_{\text{s-wave}}$$

$$f_2(1270) \pi^+, f_2 \rightarrow \pi^+ \pi^-$$

$$\rho(1450)^0 \pi^+, \rho^0 \rightarrow \pi^+ \pi^-$$

$$\pi^+ 2\pi^0$$

$$2\pi^+ \pi^- \pi^0$$

$$\eta \pi^+$$

$$\omega \pi^+$$

$$3\pi^+ 2\pi^-$$
\[2\pi^+\pi^- 2\pi^0\]
\[\eta\rho^+\] [ooo] ( 8.9 \ ± \ 0.8 \ ) \ % \ 724
\[\eta\pi^+\pi^0\] ( 9.2 \ ± \ 1.2 \ ) \ % \ 885
\[\omega\pi^+\pi^0\] [ooo] ( 2.8 \ ± \ 0.7 \ ) \ % \ 802
\[3\pi^+2\pi^-\pi^0\] [ooo] ( 4.9 \ ± \ 3.2 \ ) \ % \ 856
\[\omega\pi^+\pi^-\] [ooo] ( 1.6 \ ± \ 0.5 \ ) \ % \ 766
\[\eta'(958)\pi^+\] [nnn,ooo] ( 3.94 \ ± \ 0.25 \ ) \ % \ 743
\[3\pi^+2\pi^-2\pi^0\] — \ 803
\[\omega\eta\pi^+\] [ooo] < 2.13 \ % \ CL=90% \ 654
\[\eta'(958)\rho^+\] [nnn,ooo] ( 12.5 \ ± \ 2.2 \ ) \ % \ 465
\[\eta'(958)\pi^+\pi^0\] ( 5.6 \ ± \ 0.8 \ ) \ % \ 720

**Modes with one or three K’s**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Branching</th>
</tr>
</thead>
<tbody>
<tr>
<td>(K^+\pi^0)</td>
<td>( 6.3 \ ± \ 2.1 \ ) \ \times \ 10^{-4}</td>
</tr>
<tr>
<td>(K^0\pi^+)</td>
<td>( 1.21 \ ± \ 0.06 \ ) \ \times \ 10^{-3}</td>
</tr>
<tr>
<td>(K^+\eta)</td>
<td>[ooo] ( 1.76 \ ± \ 0.35 \ ) \ \times \ 10^{-5}</td>
</tr>
<tr>
<td>(K^+\omega)</td>
<td>[ooo] &lt; 2.4 \ \times \ 10^{-3} \ CL=90%</td>
</tr>
<tr>
<td>(K^+\eta'(958))</td>
<td>[ooo] ( 1.8 \ ± \ 0.6 \ ) \ \times \ 10^{-3}</td>
</tr>
<tr>
<td>(K^+\pi^+\pi^-)</td>
<td>[ooo] ( 6.5 \ ± \ 0.4 \ ) \ \times \ 10^{-3}</td>
</tr>
<tr>
<td>(K^+\rho^0)</td>
<td>( 2.5 \ ± \ 0.4 \ ) \ \times \ 10^{-3}</td>
</tr>
<tr>
<td>(K^+\rho(1450)^0, \rho^0 \rightarrow \pi^+\pi^-)</td>
<td>( 6.9 \ ± \ 2.4 \ ) \ \times \ 10^{-4}</td>
</tr>
<tr>
<td>(K^*(892)^0\pi^+, K^*0 \rightarrow)</td>
<td>( 1.41 \ ± \ 0.24 \ ) \ \times \ 10^{-3}</td>
</tr>
<tr>
<td>(K^*(1410)^0\pi^+, K^*0 \rightarrow)</td>
<td>( 1.23 \ ± \ 0.28 \ ) \ \times \ 10^{-3}</td>
</tr>
<tr>
<td>(K^*(1430)^0\pi^+, K^*0 \rightarrow)</td>
<td>( 5.0 \ ± \ 3.5 \ ) \ \times \ 10^{-4}</td>
</tr>
<tr>
<td>(K^+\pi^+\pi^-) nonresonant</td>
<td>( 1.04 \ ± \ 0.34 \ ) \ \times \ 10^{-3}</td>
</tr>
<tr>
<td>(K^0\pi^+\pi^0)</td>
<td>( 1.00 \ ± \ 0.18 \ ) \ %</td>
</tr>
<tr>
<td>(K^0\pi^-\pi^-)</td>
<td>( 3.0 \ ± \ 1.1 \ ) \ \times \ 10^{-3}</td>
</tr>
<tr>
<td>(K^+\omega\pi^0)</td>
<td>[ooo] &lt; 8.2 \ \times \ 10^{-3} \ CL=90%</td>
</tr>
<tr>
<td>(K^+\omega\pi^+\pi^-)</td>
<td>[ooo] &lt; 5.4 \ \times \ 10^{-3} \ CL=90%</td>
</tr>
<tr>
<td>(K^+\omega\eta)</td>
<td>[ooo] &lt; 7.9 \ \times \ 10^{-3} \ CL=90%</td>
</tr>
<tr>
<td>(2K^+K^-)</td>
<td>( 2.16 \ ± \ 0.21 \ ) \ \times \ 10^{-4}</td>
</tr>
<tr>
<td>(\phi K^+, \phi \rightarrow K^+K^-)</td>
<td>( 8.8 \ ± \ 2.0 \ ) \ \times \ 10^{-5}</td>
</tr>
</tbody>
</table>

**Doubly Cabibbo-suppressed modes**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Branching</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2K^+\pi^-)</td>
<td>( 1.26 \ ± \ 0.13 \ ) \ \times \ 10^{-4}</td>
</tr>
<tr>
<td>(K^+K^*(892)^0, K^*0 \rightarrow)</td>
<td>( 5.9 \ ± \ 3.4 \ ) \ \times \ 10^{-5}</td>
</tr>
</tbody>
</table>

**Baryon-antibaryon mode**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Branching</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\rho\bar{\pi})</td>
<td>( 1.3 \ ± \ 0.4 \ ) \ \times \ 10^{-3}</td>
</tr>
</tbody>
</table>
$\Delta C = 1$ weak neutral current (CI) modes,
Lepton family number (LF), or
Lepton number (L) violating modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>$[\mu\gamma]$</th>
<th>$\times 10^{-5}$</th>
<th>CL</th>
<th>MeV</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi^+ e^+ e^-$</td>
<td>$\leq 1.3$</td>
<td></td>
<td>979</td>
<td></td>
</tr>
<tr>
<td>$\pi^+ \phi, \phi \rightarrow e^+ e^-$</td>
<td>$[\mu\mu]$</td>
<td>$\leq 4.1$</td>
<td>968</td>
<td></td>
</tr>
<tr>
<td>$K^+ e^+ e^-$</td>
<td>$C1$</td>
<td>$\leq 2.1$</td>
<td>909</td>
<td></td>
</tr>
<tr>
<td>$K^+ (892)^+ \mu^+ \mu^-$</td>
<td>$C1$</td>
<td>$\leq 1.4$</td>
<td>765</td>
<td>765</td>
</tr>
<tr>
<td>$\pi^+ e^+ \mu^-$</td>
<td>$LF$</td>
<td>$\leq 2.0$</td>
<td>976</td>
<td></td>
</tr>
<tr>
<td>$\pi^+ e^- \mu^+$</td>
<td>$LF$</td>
<td>$\leq 1.4$</td>
<td>919</td>
<td></td>
</tr>
<tr>
<td>$\pi^- e^+ \mu^+$</td>
<td>$LF$</td>
<td>$\leq 1.2$</td>
<td>919</td>
<td></td>
</tr>
<tr>
<td>$\pi^- e^- \mu^+$</td>
<td>$L$</td>
<td>$\leq 4.1$</td>
<td>979</td>
<td></td>
</tr>
<tr>
<td>$\pi^- 2\mu^+$</td>
<td>$L$</td>
<td>$\leq 1.2$</td>
<td>968</td>
<td></td>
</tr>
<tr>
<td>$\pi^- e^+ \mu^+$</td>
<td>$L$</td>
<td>$\leq 8.4$</td>
<td>976</td>
<td></td>
</tr>
<tr>
<td>$K^- 2\mu^+$</td>
<td>$L$</td>
<td>$\leq 5.2$</td>
<td>922</td>
<td></td>
</tr>
<tr>
<td>$K^- e^+ \mu^+$</td>
<td>$L$</td>
<td>$\leq 6.1$</td>
<td>919</td>
<td></td>
</tr>
<tr>
<td>$K^* (892)^- 2\mu^+$</td>
<td>$L$</td>
<td>$\leq 1.4$</td>
<td>765</td>
<td></td>
</tr>
</tbody>
</table>

$D_s^{*\pm}$

$I(J^P) = 0(?)$

$J^P$ is natural, width and decay modes consistent with $1^-$.  

Mass $m = 2112.1 \pm 0.4$ MeV  
$\Delta m_{D_s^{*\pm}} - m_{D_s^{*\pm}} = 143.8 \pm 0.4$ MeV  
Full width $\Gamma < 1.9$ MeV, CL = 90%

$D_s^{*\pm}$ modes are charge conjugates of the modes below.

$D_s^{**+}$ DECAY MODES

<table>
<thead>
<tr>
<th>Mode</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>$\rho$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_s^{*+} \gamma$</td>
<td>($94.2 \pm 0.7$) %</td>
<td>139</td>
</tr>
<tr>
<td>$D_s^{*+} \pi^0$</td>
<td>($5.8 \pm 0.7$) %</td>
<td>48</td>
</tr>
</tbody>
</table>

$D_{s0}^{*}(2317)^\pm$

$I(J^P) = 0(0^+)$

$J, P$ need confirmation.

$J^P$ is natural, low mass consistent with $0^+$.

Mass $m = 2317.7 \pm 0.6$ MeV ($S = 1.1$)  
$\Delta m_{D_{s0}^{*}(2317)^\pm} - m_{D_{s0}^{*}} = 349.4 \pm 0.6$ MeV ($S = 1.1$)  
Full width $\Gamma < 3.8$ MeV, CL = 95%
$D_s^*(2317)^-$ modes are charge conjugates of modes below.

### $D_s^0(2317)^\pm$ DECAY MODES

<table>
<thead>
<tr>
<th>Mode</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>$\rho$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_s^+ \pi^0$</td>
<td>seen</td>
<td>298</td>
</tr>
<tr>
<td>$D_s^+ \pi^0 \pi^0$</td>
<td>not seen</td>
<td>205</td>
</tr>
</tbody>
</table>

### $D_s(2460)^\pm$

$I(J^P) = 0(1^+)$

Mass $m = 2459.5 \pm 0.6$ MeV (S = 1.1)

$m_{D_s(2460)^\pm} - m_{D_s^+} = 347.3 \pm 0.7$ MeV (S = 1.2)

$m_{D_s(2460)^\pm} - m_{D_s^0} = 491.2 \pm 0.6$ MeV (S = 1.1)

Full width $\Gamma < 3.5$ MeV, CL = 95%

$D_s(2460)^-$ modes are charge conjugates of the modes below.

### $D_s(2460)^+$ DECAY MODES

<table>
<thead>
<tr>
<th>Mode</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>$\rho$ (MeV/c)</th>
<th>Confidence level</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_s^{++} \pi^0$</td>
<td>(48 $\pm$ 11) %</td>
<td>297</td>
<td></td>
</tr>
<tr>
<td>$D_s^+ \gamma$</td>
<td>(18 $\pm$ 4) %</td>
<td>442</td>
<td></td>
</tr>
<tr>
<td>$D_s^{++} \pi^+ \pi^-$</td>
<td>(4.3$\pm$1.3) %</td>
<td>363</td>
<td>S=1.1</td>
</tr>
<tr>
<td>$D_s^{++} \gamma$</td>
<td>&lt; 8 %</td>
<td>323</td>
<td>CL=90%</td>
</tr>
<tr>
<td>$D_s^0(2317)^+ \gamma$</td>
<td>(3.7$\pm$5.0) %</td>
<td>138</td>
<td></td>
</tr>
</tbody>
</table>

### $D_s(2536)^\pm$

$I(J^P) = 0(1^+)$

$J, P$ need confirmation.

Mass $m = 2535.10 \pm 0.08$ MeV (S = 1.1)

Full width $\Gamma = 0.92 \pm 0.05$ MeV

$D_s(2536)^-$ modes are charge conjugates of the modes below.

### $D_s(2536)^+$ DECAY MODES

<table>
<thead>
<tr>
<th>Mode</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>$\rho$ (MeV/c)</th>
<th>Confidence level</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_s^*(2010)^+ K^0$</td>
<td>0.85 $\pm$ 0.12</td>
<td>149</td>
<td></td>
</tr>
<tr>
<td>$(D_s^*(2010)^+ K^0)_{S-wave}$</td>
<td>0.61 $\pm$ 0.09</td>
<td>149</td>
<td></td>
</tr>
<tr>
<td>$D_s^+ \pi^- K^+$</td>
<td>0.028$\pm$0.005</td>
<td>176</td>
<td></td>
</tr>
<tr>
<td>$D_s^*(2007)^0 K^+$</td>
<td>DEFINED AS 1</td>
<td>167</td>
<td></td>
</tr>
<tr>
<td>$D_s^0 K^0$</td>
<td>&lt;0.34</td>
<td>381</td>
<td>90%</td>
</tr>
<tr>
<td>$D_s^+ K^+$</td>
<td>&lt;0.12</td>
<td>391</td>
<td>90%</td>
</tr>
<tr>
<td>$D_s^{++} \gamma$</td>
<td>possibly seen</td>
<td>388</td>
<td></td>
</tr>
<tr>
<td>$D_s^+ \pi^+ \pi^-$</td>
<td>seen</td>
<td>437</td>
<td></td>
</tr>
</tbody>
</table>
\( D_{s2}^{*}(2573) \)

\[ I(J^P) = 0(?) \]

\( J^P \) is natural, width and decay modes consistent with \( 2^+ \).

\[ \begin{align*}
\text{Mass } m &= 2571.9 \pm 0.8 \text{ MeV} \\
\text{Full width } \Gamma &= 17 \pm 4 \text{ MeV} \quad (S = 1.3)
\end{align*} \]

\( D_{s2}^{*}(2573)^- \) modes are charge conjugates of the modes below.

\[ D_{s2}^{*}(2573)^+ \text{ DECAY MODES} \]

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( D^0 K^+ )</td>
<td>seen</td>
<td>434</td>
</tr>
<tr>
<td>( D^*(2007)^0 K^+ )</td>
<td>not seen</td>
<td>243</td>
</tr>
</tbody>
</table>

\[ D_{s1}(2700)^\pm \]

\[ I(J^P) = 0(1^-) \]

\[ \begin{align*}
\text{Mass } m &= 2709 \pm 4 \text{ MeV} \\
\text{Full width } \Gamma &= 117 \pm 13 \text{ MeV}
\end{align*} \]

\[ \begin{align*}
\text{BOTTOM MESONS} \\
(B = \pm 1)
\end{align*} \]

\[ B^+ = u \bar{b}, B^0 = d \bar{b}, \overline{B^0} = \bar{d} b, B^- = \bar{u} b, \quad \text{similarly for } B^{*+}'s \]

\[ B\text{-particle organization} \]

Many measurements of \( B \) decays involve admixtures of \( B \) hadrons. Previously we arbitrarily included such admixtures in the \( B^{\pm} \) section, but because of their importance we have created two new sections: "\( B^{\pm}/B^0 \) Admixture" for \( \Upsilon(4S) \) results and "\( B^{\pm}/B^0/B^0_s/b\)-baryon Admixture" for results at higher energies. Most inclusive decay branching fractions and \( \chi_b \) at high energy are found in the Admixture sections. \( B^0-\overline{B^0} \) mixing data are found in the \( B^0 \) section, while \( B^0_s-\overline{B^0_s} \) mixing data and \( B-\overline{B} \) mixing data for an \( B^0/B^0_s \) admixture are found in the \( B^0_s \) section. \( CP \)-violation data are found in...
the $B^\pm$, $B^0$, and $B^\pm B^0$ Admixture sections. $b$-baryons are
found near the end of the Baryon section.

The organization of the $B$ sections is now as follows, where
bullets indicate particle sections and brackets indicate re-
views.

- $B^\pm$
  - mass, mean life, $CP$ violation, branching fractions
- $B^0$
  - mass, mean life, $B^0$-$\overline{B}^0$ mixing, $CP$ violation,
  branching fractions
- $B^\pm B^0$ Admixtures
  - $CP$ violation, branching fractions
- $B^\pm/\overline{B}^0/\overline{B}^0_s/b$-baryon Admixtures
  - mean life, production fractions, branching fractions
- $B^*$
  - mass
- $B_1(5721)^0$
  - mass
- $B_2^*(5747)^0$
  - mass
- $B_s^0$
  - mass, mean life, $B_s^0-\overline{B}_s^0$ mixing, $CP$ violation,
  branching fractions
- $B_s^*$
  - mass
- $B_{s1}(5830)^0$
  - mass
- $B_{s2}^*(5840)^0$
  - mass
- $B_c^\pm$
  - mass, mean life, branching fractions

At the end of Baryon Listings:

- $\Lambda_b$
  - mass, mean life, branching fractions
- $\Lambda_b(5912)^0$
mass, mean life
- $\Lambda_b(5920)^0$

mass, mean life
- $\Sigma_b$

mass
- $\Sigma_b^*$

mass
- $\Xi_b^0, \Xi_b^-$

mass, mean life, branching fractions
- $\Xi_b(5945)^0$

mass, mean life
- $\Omega_b^-$

mass, branching fractions
- $b$-baryon Admixture

mean life, branching fractions

\[
B^\pm \quad I(J^P) = \frac{1}{2}(0^-)
\]

$I, J, P$ need confirmation. Quantum numbers shown are quark-model predictions.

Mass $m_{B^\pm} = 5279.26 \pm 0.17$ MeV
Mean life $\tau_{B^\pm} = (1.638 \pm 0.004) \times 10^{-12}$ s

$ct = 491.1 \mu$m

**CP violation**

\[
\begin{align*}
A_{CP}(B^+ &\to J/\psi(1S)K^+) = 0.003 \pm 0.006 \quad (S = 1.8) \\
A_{CP}(B^+ &\to J/\psi(1S)\pi^+) = (0.1 \pm 2.8) \times 10^{-2} \quad (S = 1.2) \\
A_{CP}(B^+ &\to J/\psi \rho^+) = -0.11 \pm 0.14 \\
A_{CP}(B^+ &\to J/\psi K^*(892)^+) = -0.048 \pm 0.033 \\
A_{CP}(B^+ &\to J/\psi K^*) = -0.02 \pm 0.10 \quad (S = 2.0) \\
A_{CP}(B^+ &\to \eta_c K^+) = 0.03 \pm 0.06 \\
A_{CP}(B^+ &\to \eta_c K^*) = -0.024 \pm 0.023 \\
A_{CP}(B^+ &\to \psi(2S)K^+) = 0.08 \pm 0.21 \\
A_{CP}(B^+ &\to \psi(2S)K^*) = 0.07 \pm 0.18 \\
A_{CP}(B^+ &\to \chi_{c1}(1P)\pi^+) = -0.20 \pm 0.18 \quad (S = 1.5) \\
A_{CP}(B^+ &\to \chi_{c0} K^+) = -0.009 \pm 0.033 \\
A_{CP}(B^+ &\to \chi_{c1} K^*) = 0.5 \pm 0.5 \\
A_{CP}(B^+ &\to D^0\pi^+) = -0.007 \pm 0.007
\end{align*}
\]
\[ A_{CP}(B^+ \rightarrow D_{CP(+1)} \pi^+) = 0.035 \pm 0.024 \]
\[ A_{CP}(B^+ \rightarrow D_{CP(-1)} \pi^+) = 0.017 \pm 0.026 \]
\[ A_{CP}([K^+ \pi^+ \pi^-]_D \pi^+) = 0.13 \pm 0.10 \]
\[ A_{CP}(B^+ \rightarrow \overline{D}^0 K^+) = 0.01 \pm 0.05 \ (S = 2.1) \]
\[ A_{CP}([K^+ \pi^+ \pi^-]_D K^+) = -0.42 \pm 0.22 \]
\[ \tau_B(B^+ \rightarrow D^0 K^+) = 0.096 \pm 0.008 \]
\[ \delta_B(B^+ \rightarrow D^0 K^+) = (115 \pm 13)^\circ \]
\[ \tau_B(B^+ \rightarrow \overline{D}^0 K^{**+}) = 0.17 \pm 0.11 \ (S = 2.3) \]
\[ \delta_B(B^+ \rightarrow D^0 K^{**+}) = (155 \pm 70)^\circ \ (S = 2.0) \]
\[ A_{CP}(B^+ \rightarrow [K^- \pi^+]_D K^+) = -0.58 \pm 0.21 \]
\[ A_{CP}(B^+ \rightarrow [K^- \pi^+ \pi^0]_D K^+) = 0.41 \pm 0.30 \]
\[ A_{CP}(B^+ \rightarrow [K^- \pi^+]_D K^*(892)^+) = -0.3 \pm 0.5 \]
\[ A_{CP}(B^+ \rightarrow [K^- \pi^+]_D \pi^+) = 0.00 \pm 0.09 \]
\[ A_{CP}(B^+ \rightarrow [K^- \pi^+ \pi^0]_D \pi^+) = 0.16 \pm 0.27 \]
\[ A_{CP}(B^+ \rightarrow [K^- \pi^+]_D \pi^+) = -0.09 \pm 0.27 \]
\[ A_{CP}(B^+ \rightarrow [K^- \pi^+]_D \gamma \pi^+) = -0.7 \pm 0.6 \]
\[ A_{CP}(B^+ \rightarrow [K^- \pi^+]_D \gamma K^+) = 0.8 \pm 0.4 \]
\[ A_{CP}(B^+ \rightarrow [K^- \pi^+]_D \gamma K^+) = 0.4 \pm 1.0 \]
\[ A_{CP}(B^+ \rightarrow [\pi^+ \pi^- \pi^0]_D K^+) = -0.02 \pm 0.15 \]
\[ A_{CP}(B^+ \rightarrow D_{CP(+1)} K^+) = 0.170 \pm 0.033 \ (S = 1.2) \]
\[ A_{ADS}(B^+ \rightarrow D K^+) = -0.52 \pm 0.15 \]
\[ A_{ADS}(B^+ \rightarrow D \pi^+) = 0.14 \pm 0.06 \]
\[ A_{CP}(B^+ \rightarrow D_{CP(-1)} K^+) = -0.10 \pm 0.07 \]
\[ A_{CP}(B^+ \rightarrow \overline{D}^* \pi^+) = -0.014 \pm 0.015 \]
\[ A_{CP}(B^+ \rightarrow (D^{*+}_{CP(+1)})^0 \pi^+) = -0.02 \pm 0.05 \]
\[ A_{CP}(B^+ \rightarrow (D^{*+}_{CP(-1)})^0 \pi^+) = -0.09 \pm 0.05 \]
\[ A_{CP}(B^+ \rightarrow D^{*0} K^+) = -0.07 \pm 0.04 \]
\[ \tau_B^*(B^+ \rightarrow D^{*0} K^+) = 0.114_{-0.040}^{+0.023} \ (S = 1.2) \]
\[ \delta_B^*(B^+ \rightarrow D^{*0} K^+) = (310_{-28}^{+22})^\circ \ (S = 1.3) \]
\[ A_{CP}(B^+ \rightarrow D^{*0}_{CP(+1)} K^+) = -0.12 \pm 0.08 \]
\[ A_{CP}(B^+ \rightarrow D^{*0}_{CP(-1)} K^+) = 0.07 \pm 0.10 \]
\[ A_{CP}(B^+ \rightarrow D^{*0}_{CP(+1)} K^*(892)^+) = 0.09 \pm 0.14 \]
\[ A_{CP}(B^+ \rightarrow D^{*0}_{CP(-1)} K^*(892)^+) = -0.23 \pm 0.22 \]
\[ A_{CP}(B^+ \rightarrow D^s \phi) = 0.0 \pm 0.4 \]
\[ A_{CP}(B^+ \rightarrow D^{**} \overline{D}^{*0}) = -0.15 \pm 0.11 \]
\[ A_{CP}(B^+ \rightarrow D^{**} \overline{D}^0) = -0.06 \pm 0.13 \]
\[ A_{CP}(B^+ \rightarrow D^* \overline{D}^{*0}) = 0.13 \pm 0.18 \]
\[ A_{CP}(B^+ \rightarrow D^* \overline{D}^0) = -0.03 \pm 0.07 \]
\[ A_{CP}(B^+ \rightarrow K^0_s \pi^+) = -0.017 \pm 0.016 \]
\[ A_{CP}(B^+ \rightarrow K^+ \pi^0) = 0.037 \pm 0.021 \]
\[ A_{CP}(B^+ \rightarrow \eta' K^+) = 0.013 \pm 0.017 \]
\[ A_{CP}(B^+ \rightarrow \eta' K^*(892)^+) = -0.26 \pm 0.27 \]
\[ A_{CP}(B^+ \rightarrow \eta' K^*_0(1430)^+) = 0.06 \pm 0.20 \]
\[ A_{CP}(B^+ \rightarrow \eta' K^*_2(1430)^+) = 0.15 \pm 0.13 \]
\[ A_{CP}(B^+ \rightarrow \eta K^+) = -0.37 \pm 0.08 \]
\[ A_{CP}(B^+ \rightarrow \eta K^*(892)^+) = 0.02 \pm 0.06 \]
\[ A_{CP}(B^+ \rightarrow \eta K^*_0(1430)^+) = 0.05 \pm 0.13 \]
\[ A_{CP}(B^+ \rightarrow \eta K^*_2(1430)^+) = -0.45 \pm 0.30 \]
\[ A_{CP}(B^+ \rightarrow \omega K^+) = 0.02 \pm 0.05 \]
\[ A_{CP}(B^+ \rightarrow \omega K^{*+}) = 0.29 \pm 0.35 \]
\[ A_{CP}(B^+ \rightarrow \omega (K\pi)_{0}^{*+}) = -0.10 \pm 0.09 \]
\[ A_{CP}(B^+ \rightarrow \omega K^*_2(1430)^+) = 0.14 \pm 0.15 \]
\[ A_{CP}(B^+ \rightarrow K^{*0} \pi^+) = -0.04 \pm 0.09 \ (S = 2.1) \]
\[ A_{CP}(B^+ \rightarrow K^*(892)^+ \pi^0) = -0.06 \pm 0.24 \]
\[ A_{CP}(B^+ \rightarrow K^+ \pi^- \pi^+) = 0.033 \pm 0.010 \]
\[ A_{CP}(B^+ \rightarrow K^+ K^- K^+ \text{nonresonant}) = 0.06 \pm 0.05 \]
\[ A_{CP}(B^+ \rightarrow f(980)^0 K^+) = -0.08 \pm 0.09 \]
\[ A_{CP}(B^+ \rightarrow f_2(1270) K^+) = -0.68_{-0.17}^{+0.19} \]
\[ A_{CP}(B^+ \rightarrow f_0(1500) K^+) = 0.28 \pm 0.30 \]
\[ A_{CP}(B^+ \rightarrow f'_2(1525)^0 K^+) = -0.08_{-0.04}^{+0.05} \]
\[ A_{CP}(B^+ \rightarrow \rho^0 K^+) = 0.37 \pm 0.10 \]
\[ A_{CP}(B^+ \rightarrow K^*_0(1430)^0 \pi^+) = 0.055 \pm 0.033 \]
\[ A_{CP}(B^+ \rightarrow K^*_2(1430)^0 \pi^+) = 0.05_{-0.24}^{+0.29} \]
\[ A_{CP}(B^+ \rightarrow K^+ \pi^0 \pi^0) = -0.06 \pm 0.07 \]
\[ A_{CP}(B^+ \rightarrow K^0 \rho^+ ) = -0.12 \pm 0.17 \]
\[ A_{CP}(B^+ \rightarrow K^{*+} \pi^+ \pi^-) = 0.07 \pm 0.08 \]
\[ A_{CP}(B^+ \rightarrow \rho^0 K^*(892)^+) = 0.31 \pm 0.13 \]
\[ A_{CP}(B^+ \rightarrow K^*(892)^+ f_0(980)) = -0.15 \pm 0.12 \]
\[ A_{CP}(B^+ \rightarrow a_1^+ K^0) = 0.12 \pm 0.11 \]
\[ A_{CP}(B^+ \rightarrow b_1^+ K^0) = -0.03 \pm 0.15 \]
\[ A_{CP}(B^+ \rightarrow K^*(892)^0 \rho^+) = -0.01 \pm 0.16 \]
\[ A_{CP}(B^+ \rightarrow b_0^+ K^+) = -0.46 \pm 0.20 \]
\[ A_{CP}(B^+ \rightarrow K_0^0 K^+) = 0.04 \pm 0.14 \]
\[ A_{CP}(B^+ \rightarrow K_0^0 K^-) = -0.21 \pm 0.14 \]
\[ A_{CP}(B^+ \rightarrow K^+ K_0^0 K_0^0) = 0.04_{-0.05}^{+0.04} \]
\[ A_{CP}(B^+ \rightarrow K^+ K^- \pi^+) = -0.12 \pm 0.05 \ (S = 1.2) \]
\[ A_{CP}(B^+ \rightarrow K^+ K^- K^+) = -0.036 \pm 0.012 \ (S = 1.1) \]
\[ A_{CP}(B^+ \rightarrow \phi K^+) = 0.04 \pm 0.04 \ (S = 2.1) \]
\[ A_{CP}(B^+ \rightarrow X_0(1550) K^+) = -0.04 \pm 0.07 \]
\[ A_{CP}(B^+ \rightarrow K^{*+} K^+ K^-) = 0.11 \pm 0.09 \]
$A_{CP}(B^+ \to \phi K^*(892)^+) = -0.01 \pm 0.08$
$A_{CP}(B^+ \to \phi (K\pi)_0^{*+}) = 0.04 \pm 0.16$
$A_{CP}(B^+ \to \phi K_1(1270)^+) = 0.15 \pm 0.20$
$A_{CP}(B^+ \to \phi K_2^*(1430)^+) = -0.23 \pm 0.20$
$A_{CP}(B^+ \to K^+ \phi \phi) = -0.10 \pm 0.08$
$A_{CP}(B^+ \to K^+[\phi \phi]_{\eta_c}) = 0.09 \pm 0.10$
$A_{CP}(B^+ \to K^*(892)^+\gamma) = 0.018 \pm 0.029$
$A_{CP}(B^+ \to \eta K^+\gamma) = -0.12 \pm 0.07$
$A_{CP}(B^+ \to \phi K^+\gamma) = -0.13 \pm 0.11 \ (S = 1.1)$
$A_{CP}(B^+ \to \rho^+\gamma) = -0.11 \pm 0.33$
$A_{CP}(B^+ \to \pi^+\pi^0) = 0.03 \pm 0.04$
$A_{CP}(B^+ \to \pi^+\pi^-\pi^+) = 0.105 \pm 0.029 \ (S = 1.3)$
$A_{CP}(B^+ \to \rho^0\pi^+) = 0.18^{+0.09}_{-0.17}$
$A_{CP}(B^+ \to f_2(1270)\pi^+) = 0.41 \pm 0.30$
$A_{CP}(B^+ \to \rho^0(1450)\pi^+) = -0.11^{+0.04}_{-0.05}$
$A_{CP}(B^+ \to f_0(1370)\pi^+) = 0.72 \pm 0.22$
$A_{CP}(B^+ \to \pi^+\pi^-\pi^+ \text{ nonresonant}) = -0.14^{+0.23}_{-0.16}$
$A_{CP}(B^+ \to \rho^+\pi^0) = 0.02 \pm 0.11$
$A_{CP}(B^+ \to \rho^+\rho^0) = -0.05 \pm 0.05$
$A_{CP}(B^+ \to \omega\pi^+) = -0.04 \pm 0.06$
$A_{CP}(B^+ \to \omega\rho^+) = -0.20 \pm 0.09$
$A_{CP}(B^+ \to \eta\pi^+) = -0.14 \pm 0.07 \ (S = 1.4)$
$A_{CP}(B^+ \to \eta\rho^+) = 0.11 \pm 0.11$
$A_{CP}(B^+ \to \eta'\pi^+) = 0.06 \pm 0.16$
$A_{CP}(B^+ \to \eta'\rho^+) = 0.26 \pm 0.17$
$A_{CP}(B^+ \to b_0^0\pi^+) = 0.05 \pm 0.16$
$A_{CP}(B^+ \to p\bar{p}\pi^+) = 0.00 \pm 0.04$
$A_{CP}(B^+ \to p\pi K^+) = -0.08 \pm 0.04 \ (S = 1.1)$
$A_{CP}(B^+ \to p\pi K^*(892)^+) = 0.21 \pm 0.16 \ (S = 1.4)$
$A_{CP}(B^+ \to p\pi\pi^+) = 0.17 \pm 0.17$
$A_{CP}(B^+ \to p\pi\pi^0) = 0.01 \pm 0.17$
$A_{CP}(B^+ \to K^+\ell^+\ell^-) = -0.02 \pm 0.08$
$A_{CP}(B^+ \to K^+e^+e^-) = 0.14 \pm 0.14$
$A_{CP}(B^+ \to K^+\mu^+\mu^-) = -0.003 \pm 0.033$
$A_{CP}(B^+ \to K^{*+}\ell^+\ell^-) = -0.09 \pm 0.14$
$A_{CP}(B^+ \to K^*e^+e^-) = -0.14 \pm 0.23$
$A_{CP}(B^+ \to K^*\mu^+\mu^-) = -0.12 \pm 0.24$
\[\gamma(B^+ \to D^{(*)0}K^{(*)+}) = (73^{+17}_{-9})^\circ\]
$B^-$ modes are charge conjugates of the modes below. Modes which do not identify the charge state of the $B$ are listed in the $B^\pm/B^0$ ADMIXTURE section.

The branching fractions listed below assume 50% $B^0 \bar{B}^0$ and 50% $B^+B^-$ production at the $T(4S)$. We have attempted to bring older measurements up to date by rescaling their assumed $T(4S)$ production ratio to 50:50 and their assumed $D$, $D_s$, $D^*$, and $\psi$ branching ratios to current values whenever this would affect our averages and best limits significantly.

Indentation is used to indicate a subchannel of a previous reaction. All resonant subchannels have been corrected for resonance branching fractions to the final state so the sum of the subchannel branching fractions can exceed that of the final state.

For inclusive branching fractions, e.g., $B \rightarrow D^\pm$ anything, the values usually are multiplicities, not branching fractions. They can be greater than one.

### $B^+$ DECAY MODES

<table>
<thead>
<tr>
<th>Mode</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>Scale factor/p</th>
<th>Confidence level (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ell^+ \nu_\ell$ anything</td>
<td>[sss]</td>
<td>(10.99 ± 0.28 ) %</td>
<td>-</td>
</tr>
<tr>
<td>$e^+ \nu_e X_c$</td>
<td></td>
<td>(10.8 ± 0.4 ) %</td>
<td>-</td>
</tr>
<tr>
<td>$D \ell^+ \nu_\ell$ anything</td>
<td></td>
<td>(9.8 ± 0.7 ) %</td>
<td>-</td>
</tr>
<tr>
<td>$\bar{D}^0 \ell^+ \nu_\ell$</td>
<td>[sss]</td>
<td>(2.27 ± 0.11 ) %</td>
<td>2310</td>
</tr>
<tr>
<td>$\bar{D}^0 \tau^+ \nu_\tau$</td>
<td></td>
<td>(7.7 ± 2.5 ) × 10^{-3}</td>
<td>1911</td>
</tr>
<tr>
<td>$\bar{D}^*(2007)^0 \ell^+ \nu_\ell$</td>
<td>[sss]</td>
<td>(5.69 ± 0.19 ) %</td>
<td>2258</td>
</tr>
<tr>
<td>$\bar{D}^*(2007)^0 \tau^+ \nu_\tau$</td>
<td></td>
<td>(1.88 ± 0.20 ) %</td>
<td>1839</td>
</tr>
<tr>
<td>$D^- \pi^+ \ell^+ \nu_\ell$</td>
<td></td>
<td>(4.2 ± 0.5 ) × 10^{-3}</td>
<td>2306</td>
</tr>
<tr>
<td>$\bar{D}^0(2420)^0 \ell^+ \nu_\ell$, $\bar{D}^0 \rightarrow$</td>
<td></td>
<td>(2.5 ± 0.5 ) × 10^{-3}</td>
<td>-</td>
</tr>
<tr>
<td>$D^- \pi^+ \ell^+ \nu_\ell$, $\bar{D}^0 \rightarrow$</td>
<td></td>
<td>(1.53 ± 0.16 ) × 10^{-3}</td>
<td>2065</td>
</tr>
<tr>
<td>$D^{(*)} n \pi^+ \ell^+ \nu_\ell$ (n ≥ 1)</td>
<td></td>
<td>(1.87 ± 0.26 ) %</td>
<td>-</td>
</tr>
<tr>
<td>$D^{*-} \pi^+ \ell^+ \nu_\ell$</td>
<td></td>
<td>(6.1 ± 0.6 ) × 10^{-3}</td>
<td>2254</td>
</tr>
<tr>
<td>$\bar{D}<em>1(2420)^0 \ell^+ \nu</em>\ell$, $\bar{D}_1^0 \rightarrow$</td>
<td></td>
<td>(3.03 ± 0.20 ) × 10^{-3}</td>
<td>2084</td>
</tr>
<tr>
<td>$D^{*-} \pi^+ \ell^+ \nu_\ell$, $\bar{D}_1^0 \rightarrow$</td>
<td></td>
<td>(2.7 ± 0.6 ) × 10^{-3}</td>
<td>-</td>
</tr>
<tr>
<td>$\bar{D}<em>2(2460)^0 \ell^+ \nu</em>\ell$, $\bar{D}_2^0 \rightarrow$</td>
<td></td>
<td>(1.01 ± 0.24 ) × 10^{-3}</td>
<td>S=2.0 2065</td>
</tr>
<tr>
<td>$D^{(*)-} K^+ \ell^+ \nu_\ell$</td>
<td></td>
<td>(6.1 ± 1.0 ) × 10^{-4}</td>
<td>-</td>
</tr>
<tr>
<td>$D^- K^+ \ell^+ \nu_\ell$</td>
<td></td>
<td>(3.0 ± 1.4 ) × 10^{-4}</td>
<td>2242</td>
</tr>
<tr>
<td>$D^{*-} K^+ \ell^+ \nu_\ell$</td>
<td></td>
<td>(2.9 ± 1.9 ) × 10^{-4}</td>
<td>2185</td>
</tr>
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</table>
\[
\begin{align*}
\pi^0 \ell^+ \nu_\ell & \quad \text{(7.80 ± 0.27)} \times 10^{-5} \quad 2638 \\
\eta \ell^+ \nu_\ell & \quad \text{(3.8 ± 0.6)} \times 10^{-5} \quad 2611 \\
\eta' \ell^+ \nu_\ell & \quad \text{(2.3 ± 0.8)} \times 10^{-5} \quad 2553 \\
\omega \ell^+ \nu_\ell & \quad \text{[sss]} \quad \text{[1.19 ± 0.09]} \times 10^{-4} \quad 2582 \\
\rho^0 \ell^+ \nu_\ell & \quad \text{[sss]} \quad \text{[1.58 ± 0.11]} \times 10^{-4} \quad 2583 \\
p\bar{p} \ell^+ \nu_\ell & \quad \text{[5.8 ± 2.6]} \times 10^{-6} \quad 2467 \\
p\bar{p} \mu^+ \nu_\mu & \quad \text{(8.2 ± 4.0)} \times 10^{-6} \quad 2467 \\
e^+ \nu_e & \quad \text{< 8.5 \times 10^{-6}} \quad \text{CL=90\%} \quad 2446 \\
\mu^+ \nu_\mu & \quad \text{< 9.8 \times 10^{-7}} \quad \text{CL=90\%} \quad 2640 \\
\tau^+ \nu_\tau & \quad \text{< 1.0 \times 10^{-6}} \quad \text{CL=90\%} \quad 2639 \\
\ell^+ \nu_\ell \gamma & \quad \text{< 1.14 ± 0.27 \times 10^{-4}} \quad \text{S=1.3 \quad 2341} \\
e^+ \nu_e \gamma & \quad \text{< 1.56 \times 10^{-5}} \quad \text{CL=90\%} \quad 2640 \\
\mu^+ \nu_\mu \gamma & \quad \text{< 1.7 \times 10^{-5}} \quad \text{CL=90\%} \quad 2640 \\
\end{align*}
\]

**Inclusive modes**

\[
\begin{align*}
D^0 X & \quad \text{(8.6 ± 0.7)} \% \quad - \\
\bar{D}^0 X & \quad \text{(7.9 ± 4)} \% \quad - \\
D^+ X & \quad \text{(2.5 ± 0.5)} \% \quad - \\
D^- X & \quad \text{(9.9 ± 1.2)} \% \quad - \\
D_s^+ X & \quad \text{(7.9 ± 1.4)} \% \quad - \\
D_s^- X & \quad \text{(1.10 ± 0.40)} \% \quad - \\
Λ_c^+ X & \quad \text{(2.1 ± 0.9)} \% \quad - \\
\bar{Λ}_c^+ X & \quad \text{(2.8 ± 1.1)} \% \quad - \\
\bar{τ} X & \quad \text{(97 ± 4)} \% \quad - \\
c X & \quad \text{(23.4 ± 2.2)} \% \quad - \\
c / τ X & \quad \text{(120 ± 6)} \% \quad - \\
\end{align*}
\]

**D, D*, or Ds modes**

\[
\begin{align*}
\bar{D}^0 \pi^+ & \quad \text{(4.81 ± 0.15)} \times 10^{-3} \quad 2308 \\
D_{CP(+1)} \pi^+ & \quad \text{[ttt]} \quad \text{(2.20 ± 0.24)} \times 10^{-3} \quad - \\
D_{CP(-1)} \pi^+ & \quad \text{[ttt]} \quad \text{(2.1 ± 0.4)} \times 10^{-3} \quad - \\
\bar{D}^0 K^+ & \quad \text{(1.34 ± 0.18)} \% \quad 2237 \\
D_{CP(+1)} K^+ & \quad \text{[ttt]} \quad \text{(1.92 ± 0.14)} \times 10^{-4} \quad - \\
D_{CP(-1)} K^+ & \quad \text{[ttt]} \quad \text{(2.00 ± 0.19)} \times 10^{-4} \quad - \\
[K^- \pi^+]_D K^+ & \quad \text{< 2.8 \times 10^{-7}} \quad \text{CL=90\%} \quad - \\
[K^+ \pi^-]_D K^+ & \quad \text{< 1.8 \times 10^{-5}} \quad \text{CL=90\%} \quad - \\
[K^- \pi^+]_D \pi^+ & \quad \text{[ttt]} \quad \text{(6.3 ± 1.1)} \times 10^{-7} \quad - \\
[K^+ \pi^-]_D \pi^+ & \quad \text{(1.68 ± 0.31)} \times 10^{-4} \quad - \\
\end{align*}
\]
\[ [\pi^+ \pi^- \pi^0]_{D/K^-} \]
\[ D^0 K^*(892)^+ \]
\[ D_{CP}^{(-1)} K^*(892)^+ \]
\[ D_{CP}^{(+1)} K^*(892)^+ \]
\[ D^0 K^+ \pi^+ \pi^- \]
\[ D^0 K^+ K^0 \]
\[ D^0 K^+ \bar{K}^0(892) \]
\[ D^0 \pi^+ \pi^+ \pi^- \]
\[ D^0 \pi^+ \pi^+ \pi^- \text{ nonresonant} \]
\[ D^0 \pi^+ \rho^0 \]
\[ D^0 a_1(1260)^+ \]
\[ D^0 \omega \pi^+ \]
\[ D^*(2010)^- \pi^+ \pi^+ \]
\[ D_1(2420)^0 \pi^+ \]
\[ D^*(2010)^- \pi^+ \pi^+ \]
\[ D^+ K^0 \]
\[ D^+ K^*^0 \]
\[ D^+ \bar{K}^*^0 \]
\[ D^*(2007)^0 \pi^+ \]
\[ D_{CP}^{(1+1)} \pi^+ \]
\[ D_{CP}^{(-1)} \pi^+ \]
\[ D^*(2007)^0 \omega \pi^+ \]
\[ D^*(2007)^0 \rho^0 \]
\[ D^*(2007)^0 K^+ \]
\[ D_{CP}^{(1+1)} K^+ \]
\[ D_{CP}^{(-1)} K^+ \]
\[ D^*(2007)^0 K^*(892)^+ \]
\[ D^*(2007)^0 K^+ \bar{K}^0 \]
\[ D^*(2007)^0 K^+ K^*(892)^0 \]
\[ D^*(2007)^0 \pi^+ \pi^- \pi^- \]
\[ D^*(2007)^0 a_1(1260)^+ \]
\[ D^*(2007)^0 \pi^- \pi^- \pi^- \pi^0 \]
\[ D^*(2010)^0 \pi^+ \pi^- \]
\[ D^*(2010)^0 K^0 \]
\[ D^*(2010)^- \pi^+ \pi^- \pi^- \pi^- \]
\[ D^*(2010)^- \pi^+ \pi^- \pi^- \pi^- \]
\[ D^*(2010)^- \pi^+ \pi^- \pi^- \pi^- \]
\[ D^*(2010)^- \pi^+ \pi^- \pi^- \pi^- \]
\[ D^*(2010)^- \pi^+ \pi^- \pi^- \pi^- \]

\[ \chi^2 / NDF = 1 / 1 \]

\[ \text{Citation: K.A. Olive et al. (Particle Data Group), Chin. Phys. C38, 090001 (2014) (URL: http://pdg.lbl.gov)} \]
\begin{align*}
\overline{D_1}(2420)^0 \pi^+ \times B(\overline{D}_1^0) & \rightarrow \quad (2.3 \pm 1.0) \times 10^{-4} \quad 2081 \\
\overline{D}_2(2462)^0 \pi^+ & \times B(\overline{D}_2^*) \rightarrow D^- \pi^+ \\
\overline{D}_2(2462)^0 \pi^+ \times B(\overline{D}_2^0) & \rightarrow \quad (2.3 \pm 1.1) \times 10^{-4} \quad - \\
\overline{D}_2(2462)^0 \pi^+ & \times B(\overline{D}_2^0) \rightarrow < 1.7 \times 10^{-4} \quad \text{CL}=90\% \quad - \\
\overline{D}_2(2462)^0 \pi^+ \times B(\overline{D}_2^0) & \rightarrow \quad (2.2 \pm 1.1) \times 10^{-4} \quad - \\
\overline{D}^*(2010)^0 & \pi^+ \times B(\overline{D}_2^0) \rightarrow \quad (6.4 \pm 1.4) \times 10^{-4} \quad 2128 \\
\overline{D}^*_1(2400)^0 & \pi^+ \times B(\overline{D}_1^0) \rightarrow \quad (6.8 \pm 1.5) \times 10^{-4} \quad - \\
\overline{D}^*_1(2421)^0 & \pi^+ \times B(\overline{D}_1^0) \rightarrow D^* \pi^+ \\
\overline{D}^*_2(2462)^0 & \pi^+ \times B(\overline{D}_2^0) \rightarrow \quad (1.8 \pm 0.5) \times 10^{-4} \quad - \\
\overline{D}^*_1(2427)^0 & \pi^+ \times B(\overline{D}_1^0) \rightarrow \quad (5.0 \pm 1.2) \times 10^{-4} \quad - \\
\overline{D}_1(2420)^0 & \pi^+ \times B(\overline{D}_1^0) \rightarrow < 6 \times 10^{-6} \quad \text{CL}=90\% \quad 2081 \\
\overline{D}^*_0 & \rho^+ \times B(\overline{D}_1^0) \rightarrow \quad < 1.4 \times 10^{-3} \quad \text{CL}=90\% \quad 1996 \\
\overline{D}^*_2(2460)^0 & \pi^+ \times B(\overline{D}_2^0) \rightarrow \quad < 1.3 \times 10^{-3} \quad \text{CL}=90\% \quad 2062 \\
\overline{D}^*_2(2460)^0 & \pi^+ \times B(\overline{D}_2^0) \rightarrow \quad < 2.2 \times 10^{-5} \quad \text{CL}=90\% \quad 2062 \\
\overline{D}^*_3(2460)^0 & \rho^+ < 4.7 \times 10^{-3} \quad \text{CL}=90\% \quad 1976 \\
\overline{D}_5^0 & D_s^+ < 9.0 \pm 0.9 \times 10^{-3} \quad 1815 \\
D_{s0}(2317)^+ & \overline{D}^0 \times \quad (7.3 \pm 2.2 \pm 1.7) \times 10^{-4} \quad 1605 \\
B(D_{s0}(2317)^+ \rightarrow D_s^+ \pi^0) & \quad < 7.6 \times 10^{-4} \quad \text{CL}=90\% \quad 1605 \\
D_{s0}(2317)^+ & \overline{D}^0 \times \quad (9 \pm 7) \times 10^{-4} \quad 1511 \\
B(D_{s0}(2317)^+ \rightarrow D_s^+ \gamma) & \quad (9 \pm 7) \times 10^{-4} \quad 1511 \\
D_{s0}(2317)^+ & \overline{D}^*(2007)^0 \times \quad (10 \pm 5) \times 10^{-4} \quad 1511 \\
B(D_{s0}(2317)^+ \rightarrow D_s^+ \pi^0) & \quad < 3.1 \times 10^{-3} \quad - \\
D_{s,J}(2457)^+ & \overline{D}^0 \times \quad (4.6 \pm 1.3 \pm 1.1) \times 10^{-4} \quad - \\
B(D_{s,J}(2457)^+ \rightarrow D_s^+ \gamma) & \quad < 2.2 \times 10^{-4} \quad \text{CL}=90\% \quad - \\
D_{s,J}(2457)^+ & \overline{D}^0 \times \quad < 2.7 \times 10^{-4} \quad \text{CL}=90\% \quad - \\
B(D_{s,J}(2457)^+ \rightarrow D_s^+ \pi^0) & \quad < 2.7 \times 10^{-4} \quad \text{CL}=90\% \quad -
\end{align*}
<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_{sJ}(2457)^+ \mathcal{B}^0 \times $</td>
<td>$&lt; 9.8 \times 10^{-4}$ CL=90%</td>
</tr>
<tr>
<td>$B(D_{sJ}(2457)^+ \to D_s^+ \gamma)$</td>
<td></td>
</tr>
<tr>
<td>$D_{sJ}(2457)^+ \mathcal{B}^*(2007)^0 \times $</td>
<td>$(1.20 \pm 0.30 %)$</td>
</tr>
<tr>
<td>$B(D_{sJ}(2457)^+ \to D_s^+ \gamma)$</td>
<td></td>
</tr>
<tr>
<td>$\mathcal{B}^0 D_{s1}(2536)^+ \times $</td>
<td>$(4.0 \pm 1.0 \times 10^{-4}$</td>
</tr>
<tr>
<td>$B(D_{s1}(2536)^+ \to D_s^+ K^0)$</td>
<td></td>
</tr>
<tr>
<td>$\mathcal{B}^* (2007)^0 D_{s1}(2536)^+ \times $</td>
<td>$(5.5 \pm 1.6 \times 10^{-4}$</td>
</tr>
<tr>
<td>$B(D_{s1}(2536)^+ \to D_s^+ K^0)$</td>
<td></td>
</tr>
<tr>
<td>$\mathcal{B}^0 D_{s1}(2536)^+ \times $</td>
<td>$(2.3 \pm 1.1 \times 10^{-4}$</td>
</tr>
<tr>
<td>$B(D_{s1}(2536)^+ \to D_s^+ K^0)$</td>
<td></td>
</tr>
<tr>
<td>$\mathcal{B}^0 D_{sJ}(2700)^+ \times $</td>
<td>$(1.13 \pm 0.26 \times 10^{-3}$</td>
</tr>
<tr>
<td>$B(D_{sJ}(2700)^+ \to D^0 K^+)$</td>
<td></td>
</tr>
<tr>
<td>$\mathcal{B}^*(2007)^0 D_{s1}(2536)^+ \times $</td>
<td>$(3.9 \pm 2.6 \times 10^{-4}$</td>
</tr>
<tr>
<td>$B(D_{s1}(2536)^+ \to D_s^+ K^0)$</td>
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<td>$\mathcal{B}^*(2007)^0 D_{sJ}(2573)^+ \times $</td>
<td>$&lt; 2 \times 10^{-4}$ CL=90%</td>
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<tr>
<td>$B(D_{sJ}(2573)^+ \to D^0 K^+)$</td>
<td></td>
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<td>$\mathcal{B}^* (2007)^0 D_{sJ}(2573)^+ \times $</td>
<td>$&lt; 5 \times 10^{-4}$ CL=90%</td>
</tr>
<tr>
<td>$B(D_{sJ}(2573)^+ \to D^0 K^+)$</td>
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</tr>
<tr>
<td>$\mathcal{B}^0 D^+_s$</td>
<td>$(7.6 \pm 1.6 \times 10^{-3}$</td>
</tr>
<tr>
<td>$\mathcal{B}^*(2007)^0 D_s^+$</td>
<td>$(8.2 \pm 1.7 \times 10^{-3}$</td>
</tr>
<tr>
<td>$\mathcal{B}^*(2007)^0 D^+_s$</td>
<td>$(1.71 \pm 0.24 %)$</td>
</tr>
<tr>
<td>$D^{(*)}_s \mathcal{B}^{**0}$</td>
<td>$(2.7 \pm 1.2 %)$</td>
</tr>
<tr>
<td>$\mathcal{B}^* (2007)^0 D^*(2010)^+$</td>
<td>$(8.1 \pm 1.7 \times 10^{-4}$</td>
</tr>
<tr>
<td>$\mathcal{B}^0 D^*(2010)^+$</td>
<td>$&lt; 1.30 %$ CL=90%</td>
</tr>
<tr>
<td>$\mathcal{B}^*(2007)^0 D^+(2010)^+$</td>
<td>$&lt; 1.30 %$ CL=90%</td>
</tr>
<tr>
<td>$\mathcal{B}^0 D^*(2010)^+$</td>
<td>$1734$</td>
</tr>
<tr>
<td>$\mathcal{B}^0 D^+$</td>
<td>$1737$</td>
</tr>
<tr>
<td>$\mathcal{B}^0 D^+ K^0$</td>
<td>$1651$</td>
</tr>
<tr>
<td>$D^+ \mathcal{B}^*(2007)^0$</td>
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<tr>
<td>$\mathcal{B}^*(2007)^0 D^+ K^0$</td>
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<tr>
<td>$D^+(2010)^+ K^0$</td>
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<td>$\mathcal{B}^*(2007)^0 D^+(2010)^+ K^0$</td>
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<td>$\mathcal{B}^*(2007)^0 D^+(2010)^+ K^0$</td>
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</tr>
<tr>
<td>$\mathcal{B}^*(2007)^0 D^+(2010)^+ K^0$</td>
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</tr>
<tr>
<td>$\mathcal{B}^*(2007)^0 D^0 K^0$</td>
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</tr>
<tr>
<td>$\mathcal{B}^*(2007)^0 D^0 K^0$</td>
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</tr>
<tr>
<td>$\mathcal{B}^*(2007)^0 D^0 K^0$</td>
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</tr>
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<td>$\mathcal{B}^*(2007)^0 D^0 K^0$</td>
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<td>$\mathcal{B}^*(2007)^0 D^0 K^0$</td>
<td>$1481$</td>
</tr>
<tr>
<td>$\mathcal{B}^*(2007)^0 D^0 K^0$</td>
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</tr>
</tbody>
</table>
\[ \bar{D}^*(2007)^0 D^*(2007)^0 K^+ \]  
\( D^- D^+ K^+ \)  
\( D^- D^*(2010)^+ K^+ \)  
\( D^*(2010)^- D^+ K^+ \)  
\( D^*(2010)^- D^*(2010)^+ K^+ \)  
\( (\bar{D} + D^*) (D + D^*) K \)  
\( 1.12 \pm 0.13 \) \% \hspace{1cm} 1368

\[ D_s^+ \pi^0 \]  
\( D_s^+ \pi^0 \)  
\( D_s^+ \eta \)  
\( D_s^+ \eta \)  
\( D_s^+ \rho^0 \)  
\( D_s^+ \omega \)  
\( D_s^+ \omega \)  
\( D_s^+ a_1(1260)^0 \)  
\( D_s^- a_1(1260)^0 \)  
\( 1.7 \pm 1.2 \) \% \hspace{1cm} 2141

<table>
<thead>
<tr>
<th>Particle</th>
<th>Value</th>
<th>CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>( D^+ \phi )</td>
<td>( &lt; 2.6 \times 10^{-4} )</td>
<td>CL=90% 2215</td>
</tr>
<tr>
<td>( D_s^+ \phi )</td>
<td>( &lt; 1.2 \times 10^{-5} )</td>
<td>CL=90% 2079</td>
</tr>
<tr>
<td>( D_s^+ K^0 )</td>
<td>( &lt; 8 \times 10^{-4} )</td>
<td>CL=90% 2242</td>
</tr>
<tr>
<td>( D_s^+ K^*(892)^0 )</td>
<td>( &lt; 4.4 \times 10^{-4} )</td>
<td>CL=90% 2172</td>
</tr>
<tr>
<td>( D_s^- K^* )</td>
<td>( &lt; 3.5 \times 10^{-4} )</td>
<td>CL=90% 2172</td>
</tr>
<tr>
<td>( D_s^+ K^*(892)^0 )</td>
<td>( &lt; 3.5 \times 10^{-4} )</td>
<td>CL=90% 2112</td>
</tr>
<tr>
<td>( D_s^- \pi^+ K^+ )</td>
<td>( &lt; 5 \times 10^{-3} )</td>
<td>CL=90% 2138</td>
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<tr>
<td>( D_s^- \pi^+ K^*(892)^+ )</td>
<td>( &lt; 7 \times 10^{-3} )</td>
<td>CL=90% 2076</td>
</tr>
<tr>
<td>( D_s^- K^+ K^+ )</td>
<td>( &lt; 3.4 \times 10^{-6} )</td>
<td>CL=90% 1401</td>
</tr>
<tr>
<td>( h_c(1P) K^+ ), ( h_c \rightarrow J/\psi \pi^+ \pi^- )</td>
<td>( &lt; 3.4 \times 10^{-6} )</td>
<td>CL=90% 1401</td>
</tr>
<tr>
<td>( X(3872) K^+ )</td>
<td>( &lt; 3.2 \times 10^{-4} )</td>
<td>CL=90% 1141</td>
</tr>
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</table>

**Charmonium modes**

<table>
<thead>
<tr>
<th>Particle</th>
<th>Value</th>
<th>CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \eta_c K^+ )</td>
<td>( &lt; 9.6 \pm 1.1 \times 10^{-4} )</td>
<td>CL=90% 1751</td>
</tr>
<tr>
<td>( \eta_c K^+, \eta_c \rightarrow K_S^0 K^+ \pi^\pm )</td>
<td>( &lt; 2.7 \pm 0.6 \times 10^{-5} )</td>
<td>CL=90% 1912</td>
</tr>
<tr>
<td>( \eta_c K^*(892)^+ )</td>
<td>( &lt; 3.4 \pm 0.5 \times 10^{-4} )</td>
<td>CL=90% 1646</td>
</tr>
<tr>
<td>( \eta_c(2S) K^+ )</td>
<td>( &lt; 1.06 \times 10^{-7} )</td>
<td>CL=90% 1401</td>
</tr>
<tr>
<td>( \eta_c(2S) K^+, \eta_c \rightarrow \rho \bar{\rho} )</td>
<td>( &lt; 1.06 \times 10^{-7} )</td>
<td>CL=90% 1401</td>
</tr>
<tr>
<td>( \eta_c(2S) K^+, \eta_c \rightarrow K_S^0 K^+ \pi^\pm )</td>
<td>( &lt; 3.4 \times 10^{-6} )</td>
<td>CL=90% 1401</td>
</tr>
<tr>
<td>( h_c(1P) K^+ ), ( h_c \rightarrow J/\psi \pi^+ \pi^- )</td>
<td>( &lt; 3.4 \times 10^{-6} )</td>
<td>CL=90% 1401</td>
</tr>
<tr>
<td>( X(3872) K^+ )</td>
<td>( &lt; 3.2 \times 10^{-4} )</td>
<td>CL=90% 1141</td>
</tr>
</tbody>
</table>
\[
\begin{array}{lcl}
X(3872)K^+, X \to p\bar{p} & < & 1.7 \times 10^{-8} \text{ CL}=95\% \quad - \\
X(3872)K^+, X \to J/\psi \pi^+\pi^- & ( & 8.6 \pm 0.8 ) \times 10^{-6} \quad 1141 \\
X(3872)K^+, X \to J/\psi \gamma & ( & 2.1 \pm 0.4 ) \times 10^{-6} \text{ S}=1.1 \quad 1141 \\
X(3872)K^+, X \to \psi(2S)\gamma & ( & 4 \pm 4 ) \times 10^{-6} \text{ S}=2.5 \quad 1141 \\
X(3872)K^+, X \to \psi(1S)\eta & ( & 7.7 \pm 0.3 ) \times 10^{-6} \text{ CL}=90\% \quad 1141 \\
X(3872)K^+, X \to D^0\bar{D}^0 & < & 6.0 \times 10^{-5} \text{ CL}=90\% \quad 1141 \\
X(3872)K^+, X \to D^+D^- & < & 4.0 \times 10^{-5} \text{ CL}=90\% \quad 1141 \\
X(3872)K^+, X \to \psi(1S)\pi^0 & ( & 1.0 \pm 0.4 ) \times 10^{-4} \quad 1141 \\
X(3872)K^+, X \to \bar{D}^0D^0 & ( & 8.5 \pm 2.6 ) \times 10^{-5} \text{ S}=1.4 \quad 1141 \\
X(3872)K^+(892)^+, X \to j/\psi & < & 4.8 \times 10^{-6} \text{ CL}=90\% \quad 939 \\
X(3872)K^+(892)^+, X \to \psi(2S)\gamma & < & 2.8 \times 10^{-5} \text{ CL}=90\% \quad 939 \\
X(3872)^+K^0, X^+ \to [\gamma \gamma \gamma] & < & 6.1 \times 10^{-6} \text{ CL}=90\% \quad - \\
X(3872)^+K^0, X^+ \to j/\psi \pi^0 & < & 1.5 \times 10^{-5} \text{ CL}=95\% \quad - \\
X(3872)^+K^0, X^+ \to j/\psi \pi^0 & < & 4.7 \times 10^{-5} \text{ CL}=95\% \quad - \\
X(4260)^0K^+, X^0 \to j/\psi \pi^+\pi^- & < & 2.9 \times 10^{-5} \text{ CL}=95\% \quad - \\
\chi_c(2P)K^+, X^0 \to j/\psi \gamma & < & 1.4 \times 10^{-5} \text{ CL}=90\% \quad - \\
X(3930)^0K^+, X^0 \to j/\psi \gamma & < & 2.5 \times 10^{-6} \text{ CL}=90\% \quad - \\
J/\psi(1S)K^+ & ( & 1.027 \pm 0.031 ) \times 10^{-3} \quad 1683 \\
J/\psi(1S)K^+ \pi^+\pi^- & ( & 8.1 \pm 1.3 ) \times 10^{-4} \text{ S}=2.5 \quad 1612 \\
\chi_c(2P)K^+, \chi_c0 \to p\bar{p} & < & 7.1 \times 10^{-8} \text{ CL}=95\% \quad - \\
J/\psi(1S)K^+(892)^+ & ( & 1.44 \pm 0.08 ) \times 10^{-3} \quad 1571 \\
J/\psi(1S)K^{(1270)}^+ & ( & 1.8 \pm 0.5 ) \times 10^{-3} \quad 1390 \\
J/\psi(1S)K^{(1400)}^+ & < & 5 \times 10^{-4} \text{ CL}=90\% \quad 1308 \\
J/\psi(1S)\eta^0K^+ & ( & 1.08 \pm 0.33 ) \times 10^{-4} \quad 1510 \\
J/\psi(1S)\eta^0K^+ & < & 8.8 \times 10^{-5} \text{ CL}=90\% \quad 1273 \\
J/\psi(1S)\phi K^+ & ( & 5.2 \pm 1.7 ) \times 10^{-5} \text{ S}=1.2 \quad 1227 \\
X(4140)K^+, X \to j/\psi(1S)\phi & ( & 10 \pm 5 ) \times 10^{-6} \quad - \\
X(4274)K^+, X \to j/\psi(1S)\phi & < & 4 \times 10^{-6} \text{ CL}=90\% \quad - \\
\end{array}
\]
\begin{align*}
\psi(1S) & \psi(1S) \pi^+ \pi^0 \text{ nonresonant} & < 7.3 \times 10^{-6} & \text{CL}=90\% & 1717 \\
\psi(1S) & \psi(1S) a_1(1260)^+ & < 1.2 \times 10^{-3} & \text{CL}=90\% & 1415 \\
\psi(1S) & \psi(1S) J^+ & < 5.0 \times 10^{-7} & \text{CL}=90\% & 643 \\
\psi(2S) & \psi(2S) \pi^+ & (2.44 \pm 0.30) \times 10^{-5} & 1347 \\
\psi(2S) & \psi(2S) K^+ & (6.27 \pm 0.24) \times 10^{-4} & 1284 \\
\psi(2S) & \psi(2S) K^+(892)^+ & (6.7 \pm 1.4) \times 10^{-4} & S=1.3 & 1115 \\
\psi(3770) & \psi(3770) K^+ & (4.9 \pm 1.3) \times 10^{-4} & 1218 \\
\psi(3770) & \psi(3770) K^+ & (1.6 \pm 0.4) \times 10^{-4} & S=1.1 & 1218 \\
\chi_{c0} & \chi_{c0} & < 1 \times 10^{-7} & \text{CL}=90\% & 1531 \\
\chi_{c0} & \chi_{c0} K^*(892)^+ & < 2.1 \times 10^{-4} & \text{CL}=90\% & 1341 \\
\chi_{c2} & \chi_{c2} \pi^+ & < 1 \times 10^{-7} & \text{CL}=90\% & 1437 \\
\chi_{c2} & \chi_{c2} K^+ & (1.1 \pm 0.4) \times 10^{-5} & 1379 \\
\chi_{c1} & \chi_{c1} K^*(892)^+ & < 1.2 \times 10^{-4} & \text{CL}=90\% & 1227 \\
\chi_{c1} & \chi_{c1} (1P) \pi^+ & (2.2 \pm 0.5) \times 10^{-5} & 1468 \\
\chi_{c1} & \chi_{c1} (1P) K^+ & (4.79 \pm 0.23) \times 10^{-4} & 1412 \\
h_c & h_c K^*(892)^+ & (3.0 \pm 0.6) \times 10^{-4} & S=1.1 & 1265 \\
h_c & h_c (1P) K^+ & < 3.8 \times 10^{-5} & 1401 \\
h_c & h_c (1P) K^+, h_c \to p\bar{p} & < 6.4 \times 10^{-8} & \text{CL}=95\% & - \\
K^0 & K^0 \pi^+ & (2.37 \pm 0.08) \times 10^{-5} & 2614 \\
K^+ & K^+ \pi^0 & (1.29 \pm 0.05) \times 10^{-5} & 2615 \\
\eta' & \eta' K^+ & (7.06 \pm 0.25) \times 10^{-5} & 2528 \\
\eta' & \eta' K^*(892)^+ & (4.8 \pm 1.8) \times 10^{-6} & 2472 \\
\eta' & \eta' K_0^*(1430)^+ & (5.2 \pm 2.1) \times 10^{-6} & - \\
\eta' & \eta' K_2^*(1430)^+ & (2.8 \pm 0.5) \times 10^{-5} & 2346 \\
\eta & \eta K^+ & (2.4 \pm 0.4) \times 10^{-6} & S=1.7 & 2588 \\
\eta & \eta K^*(892)^+ & (1.93 \pm 0.16) \times 10^{-5} & 2534 \\
\eta & \eta K_0^*(1430)^+ & (1.8 \pm 0.4) \times 10^{-5} & - \\
\eta & \eta K_2^*(1430)^+ & (9.1 \pm 3.0) \times 10^{-6} & 2414 \\
\eta(1295) & \eta(1295) K^+ \times B(\eta(1295) \to \eta \pi \pi) & (2.9 \pm 0.8 \pm 0.7) \times 10^{-6} & 2455
\end{align*}
\[ \eta(1405)K^+ \times B(\eta(1405) \rightarrow \eta \pi \pi) < 1.3 \times 10^{-6} \text{ CL=90\% 2425} \]

\[ \eta(1405)K^+ \times B(\eta(1405) \rightarrow K^* K) < 1.2 \times 10^{-6} \text{ CL=90\% 2425} \]

\[ \eta(1475)K^+ \times B(\eta(1475) \rightarrow K^* K) \]

\[ f_1(1285)K^+ < 2.0 \times 10^{-6} \text{ CL=90\% 2458} \]

\[ f_1(1420)K^+ \times B(f_1(1420) \rightarrow \eta \pi \pi) < 2.9 \times 10^{-6} \text{ CL=90\% 2420} \]

\[ f_1(1420)K^+ \times B(f_1(1420) \rightarrow K^* K) < 4.1 \times 10^{-6} \text{ CL=90\% 2420} \]

\[ \phi(1680)K^+ \times B(\phi(1680) \rightarrow K^* K) < 3.4 \times 10^{-6} \text{ CL=90\% 2344} \]

\[ f_0(1500)K^+ ( 3.7 \pm 2.2 ) \times 10^{-6} 2398 \]

\[ \omega K^+ ( 6.7 \pm 0.8 ) \times 10^{-6} 2557 \]

\[ \omega K^*(892)^+ < 7.4 \times 10^{-6} \text{ CL=90\% 2503} \]

\[ \omega(\kappa_\pi)^+ ( 2.8 \pm 0.4 ) \times 10^{-5} - \]

\[ \omega K_0^*(1430)^+ ( 2.4 \pm 0.5 ) \times 10^{-5} - \]

\[ \omega K_2^*(1430)^+ ( 2.1 \pm 0.4 ) \times 10^{-5} 2380 \]

\[ a_0(980)^+ K^0 \times B(a_0(980)^+ \rightarrow \eta \pi^+) < 3.9 \times 10^{-6} \text{ CL=90\% -} \]

\[ a_0(980)^0 K^+ \times B(a_0(980)^0 \rightarrow \eta \pi^0) < 2.5 \times 10^{-6} \text{ CL=90\% -} \]

\[ K^*(892)^0 \pi^+ ( 1.01 \pm 0.09 ) \times 10^{-5} 2562 \]

\[ K^*(892)^+ \pi^0 ( 8.2 \pm 1.9 ) \times 10^{-6} 2563 \]

\[ K^+ \pi^- \pi^+ \text{ nonresonant (1.63} \pm 0.21 \pm 0.15 \times 10^{-5} 2609 \]

\[ \omega(782)K^+ ( 6 \pm 9 ) \times 10^{-6} 2557 \]

\[ K^+ f_0(980) \times B(f_0(980) \rightarrow \pi^+ \pi^-) ( 9.4 \pm 1.0 \pm 1.2 ) \times 10^{-6} 2522 \]

\[ f_2(1270)^0 K^+ ( 1.07 \pm 0.27 ) \times 10^{-6} - \]

\[ f_0(1370)^0 K^+ \times B(f_0(1370)^0 \rightarrow \pi^+ \pi^-) < 1.07 \times 10^{-5} \text{ CL=90\% -} \]

\[ \rho^0(1450)K^+ \times B(\rho^0(1450) \rightarrow \pi^+ \pi^-) < 1.17 \times 10^{-5} \text{ CL=90\% -} \]

\[ f_2'(1525)K^+ \times B(f_2'(1525) \rightarrow \pi^+ \pi^-) < 3.4 \times 10^{-6} \text{ CL=90\% 2392} \]

\[ K^+ \rho^0 ( 3.7 \pm 0.5 ) \times 10^{-6} 2559 \]

\[ K_0^*(1430)^0 \pi^+ ( 4.5 \pm 0.9 \pm 0.7 ) \times 10^{-5} \text{ S=1.5 2445} \]

\[ K_2^*(1430)^0 \pi^+ ( 5.6 \pm 2.2 \pm 1.5 ) \times 10^{-6} 2445 \]

\[ K^*(1410)^0 \pi^+ < 4.5 \times 10^{-5} \text{ CL=90\% 2448} \]
\begin{align*}
K^+(1680)^0 & \rightarrow \pi^+ \\
K^+ & \pi^0 \pi^0 \\
f_0(980) K^+ & \rightarrow \pi^0 \pi^0 \\
K^- & \pi^+ \pi^+ \\
K^- & \pi^+ \pi^+ \text{ nonresonant} \\
K_1(1270)^0 & \rightarrow \pi^+ \\
K_1(1400)^0 & \rightarrow \pi^+ \\
K^0 & \pi^+ \pi^0 \\
K^0 & \rho^+ \\
K^+(892)^+ & \pi^+ \pi^- \\
K^+(892)^+ & \rho^0 \\
K^+(892)^+ & f_0(980) \\
a_1^+ K^0 & \rightarrow \omega \pi^+ \\
b_1^+ K^0 & \rightarrow \omega \pi^0 \\
K^*(892)^0 & \rightarrow \rho^+ \\
K_1(1400)^0 & \rightarrow \rho^0 \\
K^0 S(1430)^0 & \rightarrow \rho^0 \\
K^+ & \rightarrow \omega \pi^0 \\
K^0 K^0 & \rightarrow \omega \pi^+ \\
f_0(980) K^+ & \rightarrow K^0 S K^0 \\
f_0(1710) K^+ & \rightarrow K^0 S K^0 \\
K^+ & K^0 S K^0 \text{ nonresonant} \\
K^+ K^0 S K^0 & \rightarrow \pi^+ \\
K^+ & \rightarrow \pi^+ \\
K^+ & \rightarrow \pi^+ \text{ nonresonant} \\
K^+ K^* & \rightarrow (892)^0 \\
K^+ & \rightarrow (1430)^0 \\
K^+ & \rightarrow \pi^- \\
K^+ & \rightarrow \pi^- \text{ nonresonant} \\
f_2'(1525) K^+ & \rightarrow \pi^- \\
K^{**} & \rightarrow \pi^+ K^- \\
K^*(892)^+ & K^*(892)^0 \\
K^{**} K^+ & \rightarrow \pi^- \\
K^+ & \rightarrow K^- K^+ \\
K^+ & \rightarrow K^- K^+ \text{ nonresonant} \\
f_0(980) K^+ & \rightarrow K^+ K^- \\
\end{align*}
\[
\begin{align*}
a_2(1320)K^+ & \times B(a_2(1320) \to K^+K^-) < 1.1 \times 10^{-6} \text{ CL=90}\% 2449 \\
X_0(1550)K^+ & \times B(X_0(1550) \to K^+K^-) (4.3 \pm 0.7) \times 10^{-6} - \\
\phi(1680)K^+ & \times B(\phi(1680) \to K^+K^-) < 8 \times 10^{-7} \text{ CL=90}\% 2344 \\
f_0(1710)K^+ & \times B(f_0(1710) \to K^+K^-) (1.1 \pm 0.6) \times 10^{-6} 2330 \\
K^+K^- & \text{ nonresonant} (2.38 \pm 0.28) \times 10^{-5} 2523 \\
K^+(892)^+K^+K^- & (3.6 \pm 0.5) \times 10^{-5} 2466 \\
K^+(892)^+\phi & (10.0 \pm 2.0) \times 10^{-6} S=1.7 2460 \\
\phi(K\pi)^+_0 & (8.3 \pm 1.6) \times 10^{-6} - \\
\phi K_1(1270)^+ & (6.1 \pm 1.9) \times 10^{-6} 2375 \\
\phi K_1(1400)^+ & < 3.2 \times 10^{-6} \text{ CL=90}\% 2339 \\
\phi K^+(1410)^+ & < 4.3 \times 10^{-6} \text{ CL=90}\% - \\
\phi K_0^*(1430)^+ & (7.0 \pm 1.6) \times 10^{-6} - \\
\phi K_2^*(1430)^+ & (8.4 \pm 2.1) \times 10^{-6} 2333 \\
\phi K_2^*(1770)^+ & < 1.50 \times 10^{-5} \text{ CL=90}\% - \\
\phi K_2(1820)^+ & < 1.63 \times 10^{-5} \text{ CL=90}\% - \\
a_1^+ & < 3.6 \times 10^{-6} \text{ CL=90}\% - \\
K^+\phi\phi & (5.0 \pm 1.2) \times 10^{-6} S=2.3 2306 \\
\eta'\eta'K^+ & < 2.5 \times 10^{-5} \text{ CL=90}\% 2338 \\
\omega\phi K^+ & < 1.9 \times 10^{-6} \text{ CL=90}\% 2374 \\
X(1812)K^+ & \times B(X \to \omega\phi) < 3.2 \times 10^{-7} \text{ CL=90}\% - \\
K^+(892)^+\gamma & (4.21 \pm 0.18) \times 10^{-5} 2564 \\
K_1(1270)^+\gamma & (4.3 \pm 1.3) \times 10^{-5} 2486 \\
\eta K^+\gamma & (7.9 \pm 0.9) \times 10^{-6} 2588 \\
\eta'K^+\gamma & (2.9 \pm 1.0) \times 10^{-6} 2528 \\
\phi K^+\gamma & (2.7 \pm 0.4) \times 10^{-6} S=1.2 2516 \\
K^+\pi^\pm\pi^+\gamma & (2.76 \pm 0.22) \times 10^{-5} S=1.2 2609 \\
K^+(892)0^0\pi^+\gamma & (2.0 \pm 0.7) \times 10^{-5} 2562 \\
K^+\rho^0\gamma & < 2.0 \times 10^{-5} \text{ CL=90}\% 2559 \\
K^+\pi^-\pi^+\gamma & < 9.2 \times 10^{-6} \text{ CL=90}\% 2609 \\
K^0\pi^+\pi^0\gamma & (4.6 \pm 0.5) \times 10^{-5} 2609 \\
K_1(1400)^+\gamma & < 1.5 \times 10^{-5} \text{ CL=90}\% 2453 \\
K_2^*(1430)^+\gamma & (1.4 \pm 0.4) \times 10^{-5} 2447 \\
K^+(1680)^+\gamma & < 1.9 \times 10^{-3} \text{ CL=90}\% 2360 \\
K_3^*(1780)^+\gamma & < 3.9 \times 10^{-5} \text{ CL=90}\% 2341 \\
K_4^*(2045)^+\gamma & < 9.9 \times 10^{-3} \text{ CL=90}\% 2244 \\
\end{align*}
\]
### Light unflavored meson modes

| Reaction                                      | 
|-----------------------------------------------|-----------------------------------------------|
| $\rho^+\gamma$                                | $(9.8 \pm 2.5) \times 10^{-7}$                | 2583 |
| $\pi^+\pi^0$                                  | $(5.5 \pm 0.4) \times 10^{-6}$                | 2636 |
| $\pi^+\pi^+\pi^-$                             | $(1.52 \pm 0.14) \times 10^{-5}$              | 2630 |
| $\rho^0\pi^+$                                 | $(8.3 \pm 1.2) \times 10^{-6}$                | 2581 |
| $\pi^+ f_0(980)$, $f_0 \to \pi^+\pi^-$       | $<1.5 \times 10^{-6}$                         | 2545 |
| $\pi^+ f_2(1270)$                             | $(1.6 \pm 0.7) \times 10^{-6}$                | 2484 |
| $\rho(1450)^0 \rho i^+, \rho^0 \to \pi^+\pi^-$| $(1.4 \pm 0.6) \times 10^{-6}$                | 2434 |
| $f_0(1370)\pi^+,$ $f_0 \to \pi^+\pi^-$        | $<4.0 \times 10^{-6}$                         | 2460 |
| $f_0(500)\pi^+, f_0 \to \pi^+\pi^-$           | $<4.1 \times 10^{-6}$                         | 2630 |
| $\pi^+\pi^-\pi^+\pi^-$ nonresonant           | $(5.3 \pm 1.5) \times 10^{-6}$                | 2630 |
| $\pi^+\pi^0\pi^0$                            | $<8.9 \times 10^{-4}$                         | 2631 |
| $\rho^+\pi^0$                                 | $(1.09 \pm 0.14) \times 10^{-5}$              | 2581 |
| $\pi^+\pi^-\pi^+\pi^0$                       | $<4.0 \times 10^{-3}$                         | 2622 |
| $\rho^+\rho^0$                                | $(2.40 \pm 0.19) \times 10^{-5}$              | 2523 |
| $\rho^+ f_0(980)$, $f_0 \to \pi^+\pi^-$      | $<2.0 \times 10^{-6}$                         | 2486 |
| $a_1(1260)^+\pi^0$                            | $(2.6 \pm 0.7) \times 10^{-5}$                | 2494 |
| $a_1(1260)^0\pi^+$                            | $(2.0 \pm 0.6) \times 10^{-5}$                | 2494 |
| $\omega\pi^+$                                 | $(6.9 \pm 0.5) \times 10^{-6}$                | 2580 |
| $\omega\rho^+$                                | $(1.59 \pm 0.21) \times 10^{-5}$              | 2522 |
| $\eta\pi^+$                                   | $(4.02 \pm 0.27) \times 10^{-6}$              | 2609 |
| $\eta\rho^+$                                  | $(7.0 \pm 2.9) \times 10^{-6}$                | 2553 |
| $\eta'\pi^+$                                  | $(2.7 \pm 0.9) \times 10^{-6}$                | 2551 |
| $\eta'\rho^+$                                 | $(9.7 \pm 2.2) \times 10^{-6}$                | 2492 |
| $\phi\pi^+$                                   | $<1.5 \times 10^{-7}$                         | 2539 |
| $\phi\rho^+$                                  | $<3.0 \times 10^{-6}$                         | 2480 |
| $a_0(980)^0\pi^+$                              | $<5.8 \times 10^{-6}$                         | 2480 |
| $a_0(980)^+\pi^0$, $a_0^- \to \eta\pi^0$      | $<1.4 \times 10^{-6}$                         | 2480 |
| $\pi^+\pi^+\pi^-\pi^-$                       | $<8.6 \times 10^{-4}$                         | 2608 |
| $\rho^0 a_1(1260)^+$                           | $<6.2 \times 10^{-4}$                         | 2433 |
| $\rho^0 a_2(1320)^+$                           | $<7.2 \times 10^{-4}$                         | 2410 |
| $b_1^0\pi^+$, $b_1^+ \to \omega\pi^0$        | $(6.7 \pm 2.0) \times 10^{-6}$                |        |
| $b_1^+\pi^0$, $b_1^+ \to \omega\pi^+$        | $<3.3 \times 10^{-6}$                         | 2480 |
| $\pi^+\pi^+\pi^-\pi^-\pi^0$                 | $<6.3 \times 10^{-3}$                         | 2592 |
| $b_1^+\rho^0$, $b_1^+ \to \omega\pi^+$       | $<5.2 \times 10^{-6}$                         | 2480 |
| $a_1(1260)^+ a_1(1260)^0$                     | $<1.3 \times 10^{-6}$                         | 2336 |
| $b_1^0\rho^+$                                  | $<3.3 \times 10^{-6}$                         | 2480 |

Citation: K.A. Olive et al. (Particle Data Group), Chin. Phys. C38, 090001 (2014) (URL: http://pdg.lbl.gov)
Charged particle \((h^\pm)\) modes

\[ h^+ \pi^0 = \kappa^\pm \text{ or } \pi^\pm \]

\[ \omega h^+ \]

\[ h^+ \chi(0) \text{ (Familon)} \]

Baryon modes

\[ p \bar{\rho} \pi^+ \]

\[ p \bar{\rho} \pi^+ \text{ nonresonant} \]

\[ p \bar{\rho} \kappa^+ \]

\[ \Theta(1710)^{++} \bar{\rho}, \ \Theta^{++} \rightarrow [zzz] \]

\[ f_j(2220) K^+ \rightarrow p \bar{\rho} \]

\[ p \bar{\Lambda}(1520) \]

\[ p \bar{\rho} \kappa^+ \text{ nonresonant} \]

\[ p \bar{\rho} \kappa^* (892)^+ \]

\[ f_j(2220) K^{*',+} \rightarrow p \bar{\rho} \]

\[ p \bar{\Lambda} \]

\[ p \bar{\Lambda} \gamma \]

\[ p \bar{\Lambda} \pi^0 \]

\[ p \Sigma(1385)^0 \]

\[ \Delta^+ \bar{\Lambda} \]

\[ p \Sigma \gamma \]

\[ p \bar{\Lambda} \pi^+ \pi^- \]

\[ p \bar{\Lambda} \rho^0 \]

\[ p \bar{\Lambda}_2(1270) \]

\[ \Lambda \bar{\Lambda} \pi^+ \]

\[ \Lambda \bar{\Lambda} K^+ \]

\[ \Lambda \bar{\Lambda} K^{*+} \]

\[ \bar{\Lambda}^0 \rho \]

\[ \Delta^++ \bar{\rho} \]

\[ D^+ \rho \bar{\rho} \]

\[ D^*(2010)^+ \rho \bar{\rho} \]

\[ \bar{D}^0 \rho \bar{\rho} \pi^+ \]

\[ \bar{D}^*0 \rho \bar{\rho} \pi^+ \]

\[ D^- \rho \bar{\rho} \pi^+ \pi^- \]

\[ D^{**} \rho \bar{\rho} \pi^+ \pi^- \]

\[ p \bar{\Lambda}^0 \bar{D}^0 \]

\[ p \bar{\Lambda}^0 \bar{D}^* (2007)^0 \]

\[ \bar{\Lambda}^- c \rho \pi^+ \]
\[ \Lambda^{-}_c \Delta(1232) \]  
\[ \Lambda^{-}_c \Delta_X(1600) \]  
\[ \Lambda^{-}_c \Delta_X(2420) \]  
\[ (\Lambda^{-}_c \rho)_{\pi^+} \]  
\[ \Sigma^+(2520) \rho \]  
\[ \Sigma^+(2800) \rho \]  
\[ \Lambda^+_c p^{\pi^+}\pi^0 \]  
\[ \Lambda^+_c p^{\pi^+}\pi^+\pi^- \]  
\[ \Lambda^+_c p^{\pi^+}\pi^+\pi^- \]  
\[ (\Lambda^+_c K^+) \]  
\[ \Sigma^+(2555) \rho \]  
\[ \Sigma^+(2555) p^{\pi^+} \]  
\[ \Sigma^+(2555) p^{\pi^+} \]  
\[ \Lambda^+_c(2593) / \Lambda^+_c(2625) p^{\pi^+} \]  
\[ \Xi^0 \Lambda^+_c \rightarrow \Xi^0 \pi^- \]  
\[ \Xi^0 \Lambda^+_c \rightarrow \Lambda K^+ \pi^- \]  

**Lepton Family number (LF) or Lepton number (L) or Baryon number (B) violating modes, or/and \( \Delta B = 1 \) weak neutral current \( (B1) \) modes**

\[ \pi^+ \ell^+ \ell^- \quad B1 \quad + \quad 4.9 \quad \times 10^{-8} \quad \text{CL}=90\% \quad 2638 \]
\[ \pi^+ e^+ e^- \quad B1 \quad < \quad 8.0 \quad \times 10^{-8} \quad \text{CL}=90\% \quad 2638 \]
\[ \pi^+ \mu^+ \mu^- \quad B1 \quad < \quad 5.5 \quad \times 10^{-8} \quad \text{CL}=90\% \quad 2634 \]
\[ \pi^+ \nu \bar{\nu} \quad B1 \quad < \quad 9.8 \quad \times 10^{-5} \quad \text{CL}=90\% \quad 2638 \]
\[ \pi^- \ell^+ \ell^- \quad B1 \quad \text{[sss]} \quad ( \quad 4.51 \quad \pm 0.23 \quad ) \quad \times 10^{-7} \quad \text{S}=1.1 \quad 2617 \]
\[ \pi^- e^+ e^- \quad B1 \quad \text{[sss]} \quad ( \quad 5.5 \quad \pm 0.7 \quad ) \quad \times 10^{-7} \quad \text{S}=1.1 \quad 2617 \]
\[ \pi^- \mu^+ \mu^- \quad B1 \quad \text{[sss]} \quad ( \quad 4.49 \quad \pm 0.23 \quad ) \quad \times 10^{-7} \quad \text{S}=1.1 \quad 2612 \]
\[ \psi(4040) \pi^+ \pi^- \quad B1 \quad \text{[sss]} \quad ( \quad 5.1 \quad \pm 2.7 \quad ) \quad \times 10^{-4} \quad \text{S}=1.1 \quad 2612 \]
\[ \psi(4160) \pi^+ \pi^- \quad B1 \quad \text{[sss]} \quad ( \quad 1.29 \quad \pm 0.21 \quad ) \quad \times 10^{-6} \quad \text{S}=1.1 \quad 2612 \]
\[ \psi(4040) \pi^+ \pi^- \quad B1 \quad \text{[sss]} \quad ( \quad 1.29 \quad \pm 0.21 \quad ) \quad \times 10^{-6} \quad \text{S}=1.1 \quad 2612 \]
\[ \psi(4160) \pi^+ \pi^- \quad B1 \quad \text{[sss]} \quad ( \quad 1.29 \quad \pm 0.21 \quad ) \quad \times 10^{-6} \quad \text{S}=1.1 \quad 2612 \]
\[ \psi(4040) \pi^+ \pi^- \quad B1 \quad \text{[sss]} \quad ( \quad 1.29 \quad \pm 0.21 \quad ) \quad \times 10^{-6} \quad \text{S}=1.1 \quad 2612 \]
\[ \psi(4160) \pi^+ \pi^- \quad B1 \quad \text{[sss]} \quad ( \quad 1.29 \quad \pm 0.21 \quad ) \quad \times 10^{-6} \quad \text{S}=1.1 \quad 2612 \]
\[ \psi(4040) \pi^+ \pi^- \quad B1 \quad \text{[sss]} \quad ( \quad 1.29 \quad \pm 0.21 \quad ) \quad \times 10^{-6} \quad \text{S}=1.1 \quad 2612 \]
\[ \psi(4160) \pi^+ \pi^- \quad B1 \quad \text{[sss]} \quad ( \quad 1.29 \quad \pm 0.21 \quad ) \quad \times 10^{-6} \quad \text{S}=1.1 \quad 2612 \]
\[ \psi(4040) \pi^+ \pi^- \quad B1 \quad \text{[sss]} \quad ( \quad 1.29 \quad \pm 0.21 \quad ) \quad \times 10^{-6} \quad \text{S}=1.1 \quad 2612 \]
\[ \psi(4160) \pi^+ \pi^- \quad B1 \quad \text{[sss]} \quad ( \quad 1.29 \quad \pm 0.21 \quad ) \quad \times 10^{-6} \quad \text{S}=1.1 \quad 2612 \]
\[ \psi(4040) \pi^+ \pi^- \quad B1 \quad \text{[sss]} \quad ( \quad 1.29 \quad \pm 0.21 \quad ) \quad \times 10^{-6} \quad \text{S}=1.1 \quad 2612 \]
\[ \psi(4160) \pi^+ \pi^- \quad B1 \quad \text{[sss]} \quad ( \quad 1.29 \quad \pm 0.21 \quad ) \quad \times 10^{-6} \quad \text{S}=1.1 \quad 2612 \]
\[ \psi(4040) \pi^+ \pi^- \quad B1 \quad \text{[sss]} \quad ( \quad 1.29 \quad \pm 0.21 \quad ) \quad \times 10^{-6} \quad \text{S}=1.1 \quad 2612 \]
\[ \psi(4160) \pi^+ \pi^- \quad B1 \quad \text{[sss]} \quad ( \quad 1.29 \quad \pm 0.21 \quad ) \quad \times 10^{-6} \quad \text{S}=1.1 \quad 2612 \]
\[ \psi(4040) \pi^+ \pi^- \quad B1 \quad \text{[sss]} \quad ( \quad 1.29 \quad \pm 0.21 \quad ) \quad \times 10^{-6} \quad \text{S}=1.1 \quad 2612 \]
\[ \psi(4160) \pi^+ \pi^- \quad B1 \quad \text{[sss]} \quad ( \quad 1.29 \quad \pm 0.21 \quad ) \quad \times 10^{-6} \quad \text{S}=1.1 \quad 2612 \]
\[
\begin{align*}
\pi^+ \mu^+ \mu^- & \quad LF \quad < \quad 7.2 \quad \times 10^{-5} \quad CL=90\% \quad 2333 \\
K^+ e^+ \mu^- & \quad LF \quad < \quad 9.1 \quad \times 10^{-8} \quad CL=90\% \quad 2615 \\
K^+ e^- \mu^+ & \quad LF \quad < \quad 1.3 \quad \times 10^{-7} \quad CL=90\% \quad 2615 \\
K^+ e^\pm \mu^\mp & \quad LF \quad < \quad 9.1 \quad \times 10^{-8} \quad CL=90\% \quad 2615 \\
K^+ e^+ \tau^- & \quad LF \quad < \quad 4.3 \quad \times 10^{-5} \quad CL=90\% \quad 2312 \\
K^+ e^- \tau^+ & \quad LF \quad < \quad 1.5 \quad \times 10^{-5} \quad CL=90\% \quad 2312 \\
K^+ \mu^+ \tau^- & \quad LF \quad < \quad 4.5 \quad \times 10^{-5} \quad CL=90\% \quad 2298 \\
K^+ \mu^- \tau^+ & \quad LF \quad < \quad 2.8 \quad \times 10^{-5} \quad CL=90\% \quad 2298 \\
K^+ \mu^\pm \tau^\mp & \quad LF \quad < \quad 4.8 \quad \times 10^{-5} \quad CL=90\% \quad 2298 \\
K^*(892)^+ e^+ \mu^- & \quad LF \quad < \quad 1.3 \quad \times 10^{-6} \quad CL=90\% \quad 2563 \\
K^*(892)^+ e^- \mu^+ & \quad LF \quad < \quad 9.9 \quad \times 10^{-7} \quad CL=90\% \quad 2563 \\
K^*(892)^+ e^\pm \mu^\mp & \quad LF \quad < \quad 1.4 \quad \times 10^{-6} \quad CL=90\% \quad 2563 \\
\pi^- e^+ e^+ & \quad L \quad < \quad 2.3 \quad \times 10^{-8} \quad CL=90\% \quad 2638 \\
\pi^- \mu^+ \mu^+ & \quad L \quad < \quad 1.3 \quad \times 10^{-8} \quad CL=95\% \quad 2634 \\
\pi^- e^+ \mu^+ & \quad L \quad < \quad 1.5 \quad \times 10^{-7} \quad CL=90\% \quad 2637 \\
\rho^- e^+ e^+ & \quad L \quad < \quad 1.7 \quad \times 10^{-7} \quad CL=90\% \quad 2583 \\
\rho^- \mu^+ \mu^+ & \quad L \quad < \quad 4.2 \quad \times 10^{-7} \quad CL=90\% \quad 2578 \\
\rho^- e^+ \mu^+ & \quad L \quad < \quad 4.7 \quad \times 10^{-7} \quad CL=90\% \quad 2582 \\
K^- e^+ e^+ & \quad L \quad < \quad 3.0 \quad \times 10^{-8} \quad CL=90\% \quad 2617 \\
K^- \mu^+ \mu^+ & \quad L \quad < \quad 4.1 \quad \times 10^{-8} \quad CL=90\% \quad 2612 \\
K^- e^+ \mu^+ & \quad L \quad < \quad 1.6 \quad \times 10^{-7} \quad CL=90\% \quad 2615 \\
K^*(892)^- e^+ e^+ & \quad L \quad < \quad 4.0 \quad \times 10^{-7} \quad CL=90\% \quad 2564 \\
K^*(892)^- \mu^+ \mu^+ & \quad L \quad < \quad 5.9 \quad \times 10^{-7} \quad CL=90\% \quad 2560 \\
K^*(892)^- e^+ \mu^+ & \quad L \quad < \quad 3.0 \quad \times 10^{-7} \quad CL=90\% \quad 2563 \\
D^- e^+ e^+ & \quad L \quad < \quad 2.6 \quad \times 10^{-6} \quad CL=90\% \quad 2309 \\
D^- e^+ \mu^+ & \quad L \quad < \quad 1.8 \quad \times 10^{-6} \quad CL=90\% \quad 2307 \\
D^- \mu^+ \mu^+ & \quad L \quad < \quad 6.9 \quad \times 10^{-7} \quad CL=95\% \quad 2303 \\
D^*^- \mu^+ \mu^+ & \quad L \quad < \quad 2.4 \quad \times 10^{-6} \quad CL=95\% \quad 2251 \\
D^- \mu^+ \mu^+ & \quad L \quad < \quad 5.8 \quad \times 10^{-7} \quad CL=95\% \quad 2267 \\
B^0 \pi^- \mu^+ \mu^+ & \quad L \quad < \quad 1.5 \quad \times 10^{-6} \quad CL=95\% \quad 2295 \\
\Lambda^0 \mu^+ & \quad L,B \quad < \quad 6 \quad \times 10^{-8} \quad CL=90\% \quad - \\
\Lambda^0 e^+ & \quad L,B \quad < \quad 3.2 \quad \times 10^{-8} \quad CL=90\% \quad - \\
\Xi^0 \mu^+ & \quad L,B \quad < \quad 6 \quad \times 10^{-8} \quad CL=90\% \quad - \\
\Xi^0 e^+ & \quad L,B \quad < \quad 8 \quad \times 10^{-8} \quad CL=90\% \quad -
\end{align*}
\]
\[ B^0 \]

\[ I(J^P) = \frac{1}{2}(0^-) \]

\( I, J, P \) need confirmation. Quantum numbers shown are quark-model predictions.

Mass \( m_{B^0} = 5279.58 \pm 0.17 \text{ MeV} \)

\( m_{B^0} - m_{B^+} = 0.32 \pm 0.06 \text{ MeV} \)

Mean life \( \tau_{B^0} = (1.519 \pm 0.005) \times 10^{-12} \text{ s} \)

\( c\tau = 455.4 \mu\text{m} \)

\( \tau_{B^+}/\tau_{B^0} = 1.076 \pm 0.004 \) (direct measurements)

**\( B^0-B^0 \) mixing parameters**

\( \chi_d = 0.1874 \pm 0.0018 \)

\( \Delta m_{B^0} = m_{B^0_H} - m_{B^0_L} = (0.510 \pm 0.003) \times 10^{12} \hbar \text{ s}^{-1} \)

\( = (3.337 \pm 0.033) \times 10^{-10} \text{ MeV} \)

\( \chi_d = \Delta m_{B^0}/\Gamma_{B^0} = 0.774 \pm 0.006 \)

\( \text{Re}(\lambda_{CP}/|\lambda_{CP}|) \text{ Re}(z) = 0.01 \pm 0.05 \)

\( \Delta \Gamma \text{ Re}(z) = -0.007 \pm 0.004 \)

\( \text{Re}(z) = (2 \pm 5) \times 10^{-2} \)

\( \text{Im}(z) = (-0.8 \pm 0.4) \times 10^{-2} \)

**\( CP \) violation parameters**

\( \text{Re}(\epsilon_{B^0})/(1+|\epsilon_{B^0}|^2) = (0.1 \pm 0.8) \times 10^{-3} \)

\( A_T/CP = 0.005 \pm 0.018 \)

\( A_{CP}(B^0 \to D^*(2010)^+D^-) = 0.037 \pm 0.034 \)

\( A_{CP}(B^0 \to [K^+K^-]_D K^*(892)^0) = -0.45 \pm 0.23 \)

\( A_{CP}(B^0 \to [K^+\pi^-]_D K^*(892)^0) = -0.08 \pm 0.08 \)

\( A_{CP}(B^0 \to K^+\pi^-) = -0.082 \pm 0.006 \)

\( A_{CP}(B^0 \to \eta' K^*(892)^0) = 0.02 \pm 0.23 \)

\( A_{CP}(B^0 \to \eta' K^0_0(1430)^0) = -0.19 \pm 0.17 \)

\( A_{CP}(B^0 \to \eta' K^0_2(1430)^0) = 0.14 \pm 0.18 \)

\( A_{CP}(B^0 \to \eta K^*(892)^0) = 0.19 \pm 0.05 \)

\( A_{CP}(B^0 \to \eta K^*_0(1430)^0) = 0.06 \pm 0.13 \)

\( A_{CP}(B^0 \to \eta K^*_2(1430)^0) = -0.07 \pm 0.19 \)

\( A_{CP}(B^0 \to b_1 K^+) = -0.07 \pm 0.12 \)

\( A_{CP}(B^0 \to \omega K^{*0}) = 0.45 \pm 0.25 \)

\( A_{CP}(B^0 \to \omega (K\pi)^*_{0}) = -0.07 \pm 0.09 \)

\( A_{CP}(B^0 \to \omega K^*_0(1430)^0) = -0.37 \pm 0.17 \)

\( A_{CP}(B^0 \to K^+\pi^-\pi^0) = (0 \pm 6) \times 10^{-2} \)

\( A_{CP}(B^0 \to \rho^- K^+) = 0.20 \pm 0.11 \)

\( A_{CP}(B^0 \to \rho(1450)^- K^+) = -0.10 \pm 0.33 \)

\( A_{CP}(B^0 \to \rho(1700)^- K^+) = -0.4 \pm 0.6 \)
\[ A_{CP}(B^0 \to K^+\pi^-\pi^0 \text{ nonresonant}) = 0.10 \pm 0.18 \]
\[ A_{CP}(B^0 \to K^0\pi^+\pi^-) = -0.01 \pm 0.05 \]
\[ A_{CP}(B^0 \to K^*(892)^+\pi^-) = -0.22 \pm 0.06 \]
\[ A_{CP}(B^0 \to (K\pi)_0^{*+}\pi^-) = 0.09 \pm 0.07 \]
\[ A_{CP}(B^0 \to (K\pi)_0^{*0}\pi^-) = -0.15 \pm 0.11 \]
\[ A_{CP}(B^0 \to K^{*0}\pi^-) = -0.15 \pm 0.13 \]
\[ A_{CP}(B^0 \to K^*(892)^0\pi^+\pi^-) = 0.07 \pm 0.05 \]
\[ A_{CP}(B^0 \to K^*(892)^0\rho^0) = -0.06 \pm 0.09 \]
\[ A_{CP}(B^0 \to K^{*0}f_0(980)) = 0.07 \pm 0.10 \]
\[ A_{CP}(B^0 \to K^{*+}\rho^-) = 0.21 \pm 0.15 \]
\[ A_{CP}(B^0 \to K^*(892)^0K^+K^-) = 0.01 \pm 0.05 \]
\[ A_{CP}(B^0 \to a_1^-K^+) = -0.16 \pm 0.12 \]
\[ A_{CP}(B^0 \to K^0 K^0) = -0.6 \pm 0.7 \]
\[ A_{CP}(B^0 \to K^*(892)^0\phi) = (0 \pm 4) \times 10^{-2} \]
\[ A_{CP}(B^0 \to K^*(892)^0K^-\pi^+) = 0.2 \pm 0.4 \]
\[ A_{CP}(B^0 \to \phi(K\pi)_0^{*0}) = 0.12 \pm 0.08 \]
\[ A_{CP}(B^0 \to \phi K^+_2(1430)^0) = -0.11 \pm 0.10 \]
\[ A_{CP}(B^0 \to K^*(892)^0\gamma) = -0.002 \pm 0.015 \]
\[ A_{CP}(B^0 \to K^+_2(1430)^0\gamma) = -0.08 \pm 0.15 \]
\[ A_{CP}(B^0 \to \rho^+\pi^-) = 0.13 \pm 0.06 \quad (S = 1.1) \]
\[ A_{CP}(B^0 \to \rho^-\pi^+) = -0.08 \pm 0.08 \]
\[ A_{CP}(B^0 \to a_1(1260)^\pm\pi^\mp) = -0.07 \pm 0.06 \]
\[ A_{CP}(B^0 \to b_1^-\pi^+) = -0.05 \pm 0.10 \]
\[ A_{CP}(B^0 \to \rho^+K^0 K^*(892)^0) = 0.05 \pm 0.12 \]
\[ A_{CP}(B^0 \to \rho^-\pi^0) = 0.04 \pm 0.07 \]
\[ A_{CP}(B^0 \to K^{*0}\ell^+\ell^-) = -0.05 \pm 0.10 \]
\[ A_{CP}(B^0 \to K^*e^+e^-) = -0.21 \pm 0.19 \]
\[ A_{CP}(B^0 \to K^{*0}\mu^+\mu^-) = -0.07 \pm 0.04 \]
\[ C_{D^+D^-}(B^0 \to D^*(2010)^-D^+) = -0.01 \pm 0.11 \]
\[ C_{D^0D^+D^-}(B^0 \to D^*(2010)^+D^-) = -0.72 \pm 0.15 \]
\[ C_{D^0D^+D^-}(B^0 \to D^*(2010)^+D^-) = 0.00 \pm 0.13 \quad (S = 1.3) \]
\[ C_{D^0D^+D^-}(B^0 \to D^*(2010)^+D^-) = -0.73 \pm 0.14 \]
\[ C_{D^0D^+D^-}(B^0 \to D^{**}D^{**}) = 0.01 \pm 0.09 \quad (S = 1.6) \]
\[ C_{D^0D^+D^-}(B^0 \to D^{**}D^{**}) = -0.59 \pm 0.14 \quad (S = 1.8) \]
\[ C_{D^0D^+D^-}(B^0 \to D^{**}D^{**}) = 0.00 \pm 0.10 \quad (S = 1.6) \]
\[ C_{D^0D^+D^-}(B^0 \to D^{**}D^{**}) = -0.73 \pm 0.09 \]
\[ C_{D^0D^+D^-}(B^0 \to D^{**}D^{**}) = 0.19 \pm 0.31 \]
\[ C_{D^0D^+D^-}(B^0 \to D^{**}D^{**}) = 0.1 \pm 1.6 \quad (S = 3.5) \]
\[ C_{D^0D^+D^-}(B^0 \to D^*(2010)^+D^*(2010)^-K^0_S) = 0.01 \pm 0.29 \]
\[ C_{D^0D^+D^-}(B^0 \to D^*(2010)^+D^*(2010)^-K^0_S) = 0.1 \pm 0.4 \]
\[ C_{D^0D^+D^-}(B^0 \to D^+D^-) = -0.46 \pm 0.21 \quad (S = 1.8) \]
\[ S_{D^+ D^-} (B^0 \to D^+ D^-) = -0.99^{+0.17}_{-0.14} \]
\[ C_{J/\psi(1S)}^0 (B^0 \to J/\psi(1S)\pi^0) = -0.13 \pm 0.13 \]
\[ S_{J/\psi(1S)\pi^0}^0 (B^0 \to J/\psi(1S)\pi^0) = -0.94 \pm 0.29 \] (S = 1.9)
\[ C_{D^+ h^0}^0 (B^0 \to D^{(*)}_h h^0) = -0.23 \pm 0.16 \]
\[ S_{D^+ h^0}^0 (B^0 \to D^{(*)}_h h^0) = -0.56 \pm 0.24 \]
\[ C_{K^0 \pi^0} (B^0 \to K^0 \pi^0) = 0.00 \pm 0.13 \] (S = 1.4)
\[ S_{K^0 h^0}^0 (B^0 \to K^0 h^0) = 0.58 \pm 0.17 \]
\[ C_{\eta'(958)K^0_S} (B^0 \to \eta'(958)K^0_S) = -0.04 \pm 0.20 \] (S = 2.5)
\[ S_{\eta'(958)K^0_S} (B^0 \to \eta'K^0_S) = 0.43 \pm 0.17 \] (S = 1.5)
\[ C_{\eta'K^0} (B^0 \to \eta'K^0) = -0.05 \pm 0.05 \]
\[ S_{\eta'K^0} (B^0 \to \eta'K^0) = 0.60 \pm 0.07 \]
\[ C_{\omega K^0_S}^0 (B^0 \to \omega K^0_S) = -0.30 \pm 0.28 \] (S = 1.6)
\[ S_{\omega K^0_S} (B^0 \to \omega K^0_S) = 0.43 \pm 0.24 \]
\[ C (B^0 \to K^0 \pi^0 \pi^0) = 0.2 \pm 0.5 \]
\[ S (B^0 \to K^0 \pi^0 \pi^0) = 0.7 \pm 0.7 \]
\[ C_{\rho^0 K^0_S} (B^0 \to \rho^0 K^0_S) = -0.04 \pm 0.20 \]
\[ S_{\rho^0 K^0_S} (B^0 \to \rho^0 K^0_S) = 0.50^{+0.17}_{-0.21} \]
\[ C_{f_0 K^0_S} (B^0 \to f_0(980)K^0_S) = 0.29 \pm 0.20 \]
\[ S_{f_0 K^0_S} (B^0 \to f_0(980)K^0_S) = -0.50 \pm 0.16 \]
\[ S_{f_2 K^0_S} (B^0 \to f_2(1270)K^0_S) = -0.5 \pm 0.5 \]
\[ C_{f_2 K^0_S} (B^0 \to f_2(1270)K^0_S) = 0.3 \pm 0.4 \]
\[ S_{f_2 K^0_S} (B^0 \to f_2(1270)K^0_S) = -0.2 \pm 0.5 \]
\[ C_{f_2 K^0_S} (B^0 \to f_2(1270)K^0_S) = 0.13 \pm 0.35 \]
\[ S_{K^0 \pi^+ \pi^-} (B^0 \to K^0 \pi^+ \pi^- \text{nonresonant}) = -0.01 \pm 0.33 \]
\[ C_{K^0 \pi^+ \pi^-} (B^0 \to K^0 \pi^+ \pi^- \text{nonresonant}) = 0.01 \pm 0.26 \]
\[ C_{K^0 K^0_S} (B^0 \to K^0 K^0_S) = 0.0 \pm 0.4 \] (S = 1.4)
\[ S_{K^0 K^0_S} (B^0 \to K^0 K^0_S) = -0.8 \pm 0.5 \]
\[ C_{K^+ K^- K^0_S} (B^0 \to K^+ K^- K^0_S \text{nonresonant}) = 0.06 \pm 0.08 \]
\[ S_{K^+ K^- K^0_S} (B^0 \to K^+ K^- K^0_S \text{nonresonant}) = -0.66 \pm 0.11 \]
\[ C_{K^+ K^- K^0_S} (B^0 \to K^+ K^- K^0_S \text{inclusive}) = 0.01 \pm 0.09 \]
\[ S_{K^+ K^- K^0_S} (B^0 \to K^+ K^- K^0_S \text{inclusive}) = -0.65 \pm 0.12 \]
\[ C_{\phi K^0_S} (B^0 \to \phi K^0_S) = 0.01 \pm 0.14 \]
$S_{\phi K^0_S}(B^0 \to \phi K^0_S)$ = 0.59 $\pm$ 0.14
$C_{K^0_S K^0_S K^0_S}(B^0 \to K^0_S K^0_S K^0_S)$ = -0.23 $\pm$ 0.14
$S_{K^0_S K^0_S K^0_S}(B^0 \to K^0_S K^0_S K^0_S)$ = -0.5 $\pm$ 0.6 $\quad$ ($S = 3.0$)
$C_{K^0_S \pi^0 \gamma}(B^0 \to K^0_S \pi^0 \gamma)$ = 0.36 $\pm$ 0.33
$S_{K^0_S \pi^0 \gamma}(B^0 \to K^0_S \pi^0 \gamma)$ = -0.8 $\pm$ 0.6
$C_{K^0 \gamma}(B^0 \to K^*(892)^0 \gamma)$ = -0.04 $\pm$ 0.16 $\quad$ ($S = 1.2$)
$S_{K^0 \gamma}(B^0 \to K^*(892)^0 \gamma)$ = -0.15 $\pm$ 0.22
$C_{\eta K^0 \gamma}(B^0 \to \eta K^0 \gamma)$ = -0.3 $\pm$ 0.4
$S_{\eta K^0 \gamma}(B^0 \to \eta K^0 \gamma)$ = -0.2 $\pm$ 0.5
$C_{K^0 \phi \gamma}(B^0 \to K^0 \phi \gamma)$ = -0.3 $\pm$ 0.6
$S_{K^0 \phi \gamma}(B^0 \to K^0 \phi \gamma)$ = 0.7$^{+0.7}_{-1.1}$
$C(B^0 \to K^0_S \rho^0 \gamma)$ = -0.05 $\pm$ 0.19
$S(B^0 \to K^0_S \rho^0 \gamma)$ = 0.11 $\pm$ 0.34
$C(B^0 \to \rho^0 \gamma)$ = 0.4 $\pm$ 0.5
$S(B^0 \to \rho^0 \gamma)$ = -0.8 $\pm$ 0.7
$C_{\pi \pi}(B^0 \to \pi^+ \pi^-)$ = -0.31 $\pm$ 0.05
$S_{\pi \pi}(B^0 \to \pi^+ \pi^-)$ = -0.67 $\pm$ 0.06
$C_{\pi^0 \pi^0}(B^0 \to \pi^0 \pi^0)$ = -0.43 $\pm$ 0.24
$C_{\rho \pi}(B^0 \to \rho^+ \pi^-)$ = -0.03 $\pm$ 0.07 $\quad$ ($S = 1.2$)
$S_{\rho \pi}(B^0 \to \rho^+ \pi^-)$ = 0.05 $\pm$ 0.07
$\Delta C_{\rho \pi}(B^0 \to \rho^+ \pi^-)$ = 0.27 $\pm$ 0.06
$\Delta S_{\rho \pi}(B^0 \to \rho^+ \pi^-)$ = 0.01 $\pm$ 0.08
$C_{\rho \rho}(B^0 \to \rho^0 \rho^0)$ = 0.27 $\pm$ 0.24
$S_{\rho \rho}(B^0 \to \rho^0 \rho^0)$ = -0.23 $\pm$ 0.34
$C_{a_1 \pi}(B^0 \to a_1(1260)^+ \pi^-)$ = -0.05 $\pm$ 0.11
$S_{a_1 \pi}(B^0 \to a_1(1260)^+ \pi^-)$ = -0.2 $\pm$ 0.4 $\quad$ ($S = 3.2$)
$\Delta C_{a_1 \pi}(B^0 \to a_1(1260)^+ \pi^-)$ = 0.43 $\pm$ 0.14 $\quad$ ($S = 1.3$)
$\Delta S_{a_1 \pi}(B^0 \to a_1(1260)^+ \pi^-)$ = -0.11 $\pm$ 0.12
$C(B^0 \to b^-_1 K^+)$ = -0.22 $\pm$ 0.24
$\Delta C(B^0 \to b^-_1 \pi^+)$ = -1.04 $\pm$ 0.24
$C_{\rho \rho}(B^0 \to \rho^0 \rho^0)$ = 0.2 $\pm$ 0.9
$S_{\rho \rho}(B^0 \to \rho^0 \rho^0)$ = 0.3 $\pm$ 0.7
$C_{\rho \rho}(B^0 \to \rho^+ \rho^-)$ = -0.05 $\pm$ 0.13
$S_{\rho \rho}(B^0 \to \rho^+ \rho^-)$ = -0.06 $\pm$ 0.17
$|\lambda_1 (B^0 \to J/\psi K^*(892)^0)| < 0.25$, CL = 95% $\quad$ $\cos 2\beta (B^0 \to J/\psi K^*(892)^0) = 1.7^{+0.7}_{-0.9} \quad$ ($S = 1.6$)
$\cos 2\beta (B^0 \to [K^0_S \pi^+ \pi^-]_{D(h)} h^0) = 1.0^{+0.6}_{-0.7} \quad$ ($S = 1.8$)
\( (S_+ + S_-)/2 \quad (B^0 \rightarrow D^{*-} \pi^+) = -0.039 \pm 0.011 \)
\( (S_- - S_+)/2 \quad (B^0 \rightarrow D^{*-} \pi^+) = -0.009 \pm 0.015 \)
\( (S_+ + S_-)/2 \quad (B^0 \rightarrow D^- \pi^+) = -0.046 \pm 0.023 \)
\( (S_- - S_+)/2 \quad (B^0 \rightarrow D^- \pi^+) = -0.022 \pm 0.021 \)
\( (S_+ + S_-)/2 \quad (B^0 \rightarrow D^- \rho^+) = -0.024 \pm 0.032 \)
\( (S_- - S_+)/2 \quad (B^0 \rightarrow D^- \rho^+) = -0.10 \pm 0.06 \)
\( C_{\eta_c K^0_S} (B^0 \rightarrow \eta_c K^0_S) = 0.08 \pm 0.13 \)
\( S_{\eta_c K^0_S} (B^0 \rightarrow \eta_c K^0_S) = 0.93 \pm 0.17 \)
\( C_{c \bar{c} K^{(*)} S} (B^0 \rightarrow c \bar{c} K^{(*)} S) = (0.5 \pm 1.7) \times 10^{-2} \)
\( \sin(2\beta) = 0.682 \pm 0.019 \)
\( C_{J/\psi(nS) K^0} (B^0 \rightarrow J/\psi(nS) K^0) = (0.5 \pm 2.0) \times 10^{-2} \)
\( S_{J/\psi(nS) K^0} (B^0 \rightarrow J/\psi(nS) K^0) = 0.676 \pm 0.021 \)
\( C_{J/\psi K^{*0}} (B^0 \rightarrow J/\psi K^{*0}) = 0.03 \pm 0.10 \)
\( S_{J/\psi K^{*0}} (B^0 \rightarrow J/\psi K^{*0}) = 0.60 \pm 0.25 \)
\( C_{\chi_{c0} K^0_S} (B^0 \rightarrow \chi_{c0} K^0_S) = -0.3^{+0.5}_{-0.4} \)
\( S_{\chi_{c0} K^0_S} (B^0 \rightarrow \chi_{c0} K^0_S) = -0.7 \pm 0.5 \)
\( C_{\chi_{c1} K^0_S} (B^0 \rightarrow \chi_{c1} K^0_S) = 0.06 \pm 0.07 \)
\( S_{\chi_{c1} K^0_S} (B^0 \rightarrow \chi_{c1} K^0_S) = 0.63 \pm 0.10 \)
\( \sin(2\beta_{\text{eff}})(B^0 \rightarrow \phi K^0) = 0.22 \pm 0.30 \)
\( \sin(2\beta_{\text{eff}})(B^0 \rightarrow \phi K^{*0}(1430)) = 0.97^{+0.03}_{-0.52} \)
\( \sin(2\beta_{\text{eff}})(B^0 \rightarrow K^+ K^- K^0_S) = 0.77^{+0.13}_{-0.12} \)
\( \sin(2\beta_{\text{eff}})(B^0 \rightarrow [K^0_S \pi^+ \pi^-]_{D^{(*)}} h^0) = 0.45 \pm 0.28 \)
\( |\lambda| (B^0 \rightarrow [K^0_S \pi^+ \pi^-]_{D^{(*)}} h^0) = 1.01 \pm 0.08 \)
\( \sin(2\beta + \gamma) > 0.40, \text{ CL = 90\%} \)
\( 2\beta + \gamma = (83 \pm 60)^\circ \)
\( \gamma(B^0 \rightarrow D^0 K^{*0}) = (162 \pm 60)^\circ \)
\( \alpha = (90 \pm 5)^\circ \)
$B^0$ modes are charge conjugates of the modes below. Reactions indicate the weak decay vertex and do not include mixing. Modes which do not identify the charge state of the $B$ are listed in the $B^+/B^0$ ADMIXTURE section.

The branching fractions listed below assume 50% $B^0\bar{B}^0$ and 50% $B^+B^−$ production at the $\Upsilon(4S)$. We have attempted to bring older measurements up to date by rescaling their assumed $\Upsilon(4S)$ production ratio to 50:50 and their assumed $D$, $D_s$, $D^*$, and $\psi$ branching ratios to current values whenever this would affect our averages and best limits significantly.

Indentation is used to indicate a subchannel of a previous reaction. All resonant subchannels have been corrected for resonance branching fractions to the final state so the sum of the subchannel branching fractions can exceed that of the final state.

For inclusive branching fractions, e.g., $B \to D^{\pm}$ anything, the values usually are multiplicities, not branching fractions. They can be greater than one.

<table>
<thead>
<tr>
<th>$B^0$ Decay Modes</th>
<th>Fraction ($\Gamma_f/\Gamma$)</th>
<th>Scale factor/Confidence level (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ell^+ \nu_\ell$ anything</td>
<td>[sss] (10.33 ± 0.28) %</td>
<td></td>
</tr>
<tr>
<td>$e^+ \nu_e \chi_c$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$D\ell^+ \nu_\ell$ anything</td>
<td>(10.1 ± 0.4) %</td>
<td></td>
</tr>
<tr>
<td>$D^- \ell^+ \nu_\ell$</td>
<td>[sss] (2.19 ± 0.12) %</td>
<td>2309</td>
</tr>
<tr>
<td>$D^- \tau^+ \nu_\tau$</td>
<td>(1.03 ± 0.22) %</td>
<td>1909</td>
</tr>
<tr>
<td>$D^*(2010)^- \ell^+ \nu_\ell$</td>
<td>[sss] (4.93 ± 0.11) %</td>
<td>2257</td>
</tr>
<tr>
<td>$D^*(2010)^- \tau^+ \nu_\tau$</td>
<td>(1.84 ± 0.22) %</td>
<td>1837</td>
</tr>
<tr>
<td>$D^0 \pi^- \ell^+ \nu_\ell$</td>
<td>(4.3 ± 0.6) $\times 10^{-3}$</td>
<td>2308</td>
</tr>
<tr>
<td>$D^0_{(2400)}^- \ell^+ \nu_\ell, D^*_0^- \to$</td>
<td>(3.0 ± 1.2) $\times 10^{-3}$</td>
<td>S=1.8</td>
</tr>
<tr>
<td>$D^0_{(2460)}^- \ell^+ \nu_\ell, D^*_2^- \to$</td>
<td>(1.21 ± 0.33) $\times 10^{-3}$</td>
<td>S=1.8 2065</td>
</tr>
<tr>
<td>$D^{(*)}<em>n \pi^+ \ell^+ \nu</em>\ell (n \geq 1)$</td>
<td>(2.3 ± 0.5) %</td>
<td></td>
</tr>
<tr>
<td>$D^{(*)}<em>n \pi^- \ell^+ \nu</em>\ell$</td>
<td>(4.9 ± 0.8) $\times 10^{-3}$</td>
<td>2256</td>
</tr>
<tr>
<td>$D_1(2420)^- \ell^+ \nu_\ell, D_1^- \to$</td>
<td>(2.80 ± 0.28) $\times 10^{-3}$</td>
<td></td>
</tr>
<tr>
<td>$D'<em>1(2430)^- \ell^+ \nu</em>\ell, D'_1^- \to$</td>
<td>(3.1 ± 0.9) $\times 10^{-3}$</td>
<td></td>
</tr>
<tr>
<td>$D^<em><em>2(2460)^- \ell^+ \nu</em>\ell, D^</em>_2^- \to$</td>
<td>(6.8 ± 1.2) $\times 10^{-4}$</td>
<td>2065</td>
</tr>
<tr>
<td>$\rho^- \ell^+ \nu_\ell$</td>
<td>[sss] (2.94 ± 0.21) $\times 10^{-4}$</td>
<td>2583</td>
</tr>
<tr>
<td>$\pi^- \ell^+ \nu_\ell$</td>
<td>[sss] (1.45 ± 0.05) $\times 10^{-4}$</td>
<td>2638</td>
</tr>
</tbody>
</table>
\begin{center}
\textbf{Inclusive modes}
\end{center}

\begin{itemize}
\item \( K^{\pm} \) anything (78 \pm 8 \%)\ 
\item \( D^0 X \) (8.1 \pm 1.5 \%)\ 
\item \( \bar{D}^0 X \) (47.4 \pm 2.8 \%)\ 
\item \( D^+ X \) < 3.9 \%  
\item \( D^- X \) (36.9 \pm 3.3 \%)\ 
\item \( D^+_s X \) (10.3 \pm 2.1 \%, \text{CL}=90\%)\ 
\item \( D^-_s X \) < 2.6 \%  
\item \( \Lambda^+_c X \) < 3.1 \%  
\item \( \overline{\Lambda}^-_c X \) (5.0 \pm 2.1 \%, \text{CL}=90\%)\ 
\item \( \tau X \) (95 \pm 5 \%)\ 
\item \( cX \) (24.6 \pm 3.1 \%)\ 
\item \( \overline{c}cX \) (119 \pm 6 \%)\ 
\end{itemize}

\begin{center}
\textbf{\( D, D^*, \) or \( D_s \) modes}
\end{center}

\begin{itemize}
\item \( D^- \pi^+ \) (2.68 \pm 0.13) \times 10^{-3}  
\item \( D^- \rho^+ \) (7.8 \pm 1.3) \times 10^{-3}  
\item \( D^- K^0 \pi^+ \) (4.9 \pm 0.9) \times 10^{-4}  
\item \( D^- K^* (892)^+ \) (4.5 \pm 0.7) \times 10^{-4}  
\item \( D^- \omega \pi^+ \) (2.8 \pm 0.6) \times 10^{-3}  
\item \( D^- K^+ \) (1.97 \pm 0.21) \times 10^{-4}  
\item \( D^- K^+ \pi^+ \pi^- \) (3.8 \pm 0.9) \times 10^{-4}  
\item \( D^- K^+ K^0 \) < 3.1 \%  
\item \( D^- K^+ K^* (892)^0 \) (8.8 \pm 1.9) \times 10^{-4}  
\item \( \bar{D}^0 \pi^+ \pi^- \) (8.4 \pm 0.9) \times 10^{-4}  
\item \( D^* (2010)^- \pi^+ \) (2.76 \pm 0.13) \times 10^{-3}  
\item \( \bar{D}^0 K^+ K^- \) (4.7 \pm 1.2) \times 10^{-5}  
\item \( D^- \pi^+ \pi^+ \pi^- \) (6.4 \pm 0.7) \times 10^{-3}  
\item \( (D^- \pi^+ \pi^+ \pi^-)\text{ nonresonant} \) (3.9 \pm 1.9) \times 10^{-3}  
\item \( D^- \pi^+ \rho^0 \) (1.1 \pm 1.0) \times 10^{-3}  
\item \( D^- a_1 (1260)^+ \) (6.0 \pm 3.3) \times 10^{-3}  
\item \( D^* (2010)^- \pi^+ \pi^0 \) (1.5 \pm 0.5) \%  
\item \( D^* (2010)^- \rho^+ \) (6.8 \pm 0.9) \times 10^{-3}  
\item \( D^* (2010)^- K^+ \) (2.14 \pm 0.16) \times 10^{-4}  
\item \( D^* (2010)^- K^0 \pi^+ \) (3.0 \pm 0.8) \times 10^{-4}  
\item \( D^* (2010)^- K^* (892)^+ \) (3.3 \pm 0.6) \times 10^{-4}  
\item \( D^* (2010)^- K^+ K^0 \) < 4.7 \%  
\item \( D^* (2010)^- K^+ K^* (892)^0 \) (1.29 \pm 0.33) \times 10^{-3}  
\item \( D^* (2010)^- \pi^+ \pi^+ \pi^- \) (7.0 \pm 0.8) \times 10^{-3}  
\item \( (D^* (2010)^- \pi^+ \pi^+ \pi^-)\text{ nonresonant} \) (0.0 \pm 2.5) \times 10^{-3}  
\item \( D^* (2010)^- \pi^+ \rho^0 \) (5.7 \pm 3.2) \times 10^{-3}  
\item \( D^* (2010)^- a_1 (1260)^+ \) (1.30 \pm 0.27) \%  
\end{itemize}
\( \bar{D}_1(2420)^0 \pi^- \pi^+ \rightarrow (1.4 \pm 0.4) \times 10^{-4} \)  
\( D^* \pi^- \)
\( D^*(2010)^- K^+ \pi^- \pi^+ \rightarrow (4.5 \pm 0.7) \times 10^{-4} \)  
\( D^*(2010)^- \pi^+ \pi^- \pi^- \rightarrow (1.76 \pm 0.27) \% \)  
\( D^{*-} 3\pi^+ 2\pi^- \rightarrow (4.7 \pm 0.9) \times 10^{-3} \)  
\( \bar{D}^*(2010)^- \omega \pi^+ \rightarrow (2.89 \pm 0.30) \times 10^{-3} \)  
\( D_1(2430)^0 \omega \times \rightarrow (4.1 \pm 1.6) \times 10^{-4} \)  
\( B(D_1(2430)^0 \rightarrow D^* \pi^+) \)
\( \bar{D}^{**-} \pi^- \)
\([xxx] \rightarrow (2.1 \pm 1.0) \times 10^{-3} \)  
\( D_1(2420)^- \pi^+ \times B(D_1^- \rightarrow D^- \pi^+ \pi^-) \)
\( D_1(2420)^- \pi^+ \times B(D_1^- \rightarrow D^* \pi^- \pi^-) \)
\( D_2^*(2460)^- \pi^+ \times B(D_2^*(2460)^- \rightarrow D^0 \pi^-) \)
\( D_0^*(2400)^- \pi^+ \times B(D_0^*(2400)^- \rightarrow D^0 \pi^-) \)
\( D_2^*(2460)^- \pi^+ \times B((D_2^*)^- \rightarrow D^* \pi^- \pi^-) \)
\( \bar{D}_2^*(2460)^- \rho^+ \)
\( D^0 \bar{D}^0 \)
\( D^{*0} \bar{D}^0 \)
\( D^- D^+ \)
\( D^{\pm} D^{*\mp} (CP\text{-}averaged) \)
\( D^- D_s^+ \)
\( D^*(2010)^- D_s^+ \)
\( D^- D_s^{**} \)
\( D^*(2010)^- D_s^{**} \)
\( D_{s0}(2317)^- K^+ \times B(D_{s0}(2317)^- \rightarrow D_s^- \pi^0) \)
\( D_{s0}(2317)^- \pi^+ \times B(D_{s0}(2317)^- \rightarrow D_s^- \pi^0) \)
\( D_{sJ}(2457)^- K^+ \times B(D_{sJ}(2457)^- \rightarrow D_s^- \pi^0) \)
\( D_{sJ}(2457)^- \pi^+ \times B(D_{sJ}(2457)^- \rightarrow D_s^- \pi^0) \)
\( D^- D_s^+ \)
\( D_s^- D_s^+ \)
\( D_s^{*-} D_s^{**} \)
\( D_s^{**} D_s^{**} \)
\[
D_{s0}(2317)^+ D^- \times 9.7 \pm 4.0 \times 10^{-4}
\]
\[
B(D_{s0}(2317)^+ \rightarrow D_s^+ \pi^0) 10^{-4}
\]
\[
D_{s0}(2317)^+ D^- \times 9.5 \times 10^{-4}
\]
\[
B(D_{s0}(2317)^+ \rightarrow D_s^+ \gamma) -
\]
\[
D_{s0}(2317)^+ D^*(2010)^- \times 1.5 \pm 0.6 \times 10^{-3}
\]
\[
B(D_{s0}(2317)^+ \rightarrow D_s^+ \pi^0) 1509
\]
\[
D_{sJ}(2457)^+ D^- 3.5 \pm 1.1 \times 10^{-3}
\]
\[
B(D_{sJ}(2457)^+ \rightarrow D_s^+ \gamma) -
\]
\[
D_{sJ}(2457)^+ D^- \times 6.0 \times 10^{-4}
\]
\[
B(D_{sJ}(2457)^+ \rightarrow D_s^+ \gamma) -
\]
\[
D_{sJ}(2457)^+ D^- \times 2.0 \times 10^{-4}
\]
\[
B(D_{sJ}(2457)^+ \rightarrow D_s^+ \pi^+ \pi^-) -
\]
\[
D_{sJ}(2457)^+ D^- \times 3.6 \times 10^{-4}
\]
\[
B(D_{sJ}(2457)^+ \rightarrow D_s^+ \pi^0) -
\]
\[
D^*(2010)^- D_{sJ}(2457)^+ 9.3 \pm 2.2 \times 10^{-3}
\]
\[
B(D_{sJ}(2457)^+ \rightarrow D_s^+ \gamma) -
\]
\[
D^*(2010)^- D_{sJ}(2457)^+ \times 2.3 \pm 0.9 \times 10^{-3}
\]
\[
B(D_{sJ}(2457)^+ \rightarrow D_s^+ \gamma) -
\]
\[
D^+ D_{s1}(2536)^- \times 2.8 \pm 0.7 \times 10^{-4}
\]
\[
B(D_{s1}(2536)^- \rightarrow D^0 K^+ + D^{**} K^0) 1444
\]
\[
D^- D_{s1}(2536)^+ \times 1.7 \pm 0.6 \times 10^{-4}
\]
\[
B(D_{s1}(2536)^+ \rightarrow D^0 K^+) 1444
\]
\[
D^- D_{s1}(2536)^+ \times 2.6 \pm 1.1 \times 10^{-4}
\]
\[
B(D_{s1}(2536)^+ \rightarrow D^{**} K^0) 1444
\]
\[
D^*(2010)^- D_{s1}(2536)^+ \times 5.0 \pm 1.4 \times 10^{-4}
\]
\[
B(D_{s1}(2536)^+ \rightarrow D^0 K^+ + D^{**} K^0) 1336
\]
\[
D^*(2010)^- D_{s1}(2536)^+ \times 3.3 \pm 1.1 \times 10^{-4}
\]
\[
B(D_{s1}(2536)^+ \rightarrow D^0 K^+) 1336
\]
\[
D^{**} D_{s1}(2536)^+ \times 5.0 \pm 1.7 \times 10^{-4}
\]
\[
B(D_{s1}(2536)^+ \rightarrow D^{**} K^0) 1336
\]
\[
D^- D_{sJ}(2573)^+ \times 1 \times 10^{-4}
\]
\[
B(D_{sJ}(2573)^+ \rightarrow D^0 K^+) 1414
\]
\[
D^*(2010)^- D_{sJ}(2573)^+ \times 2 \times 10^{-4}
\]
\[
B(D_{sJ}(2573)^+ \rightarrow D^0 K^+) 1304
\]
\[
D^+ \pi^- 7.8 \pm 1.4 \times 10^{-7}
\]

Citation: K.A. Olive et al. (Particle Data Group), Chin. Phys. C38, 090001 (2014) (URL: http://pdg.lbl.gov)
\[
\begin{array}{lll}
D_s^{\ast \pi^-} & (2.16 \pm 0.26) \times 10^{-5} & 2270 \\
D_s^{+ \pi^-} & (2.1 \pm 0.4) \times 10^{-5} & S=1.4 2215 \\
D_s^{+ \rho^-} & < 2.4 \times 10^{-5} & CL=90\% 2197 \\
D_s^{+ \rho^-} & (4.1 \pm 1.3) \times 10^{-5} & 2138 \\
D_s^{+ a_0} & < 1.9 \times 10^{-5} & CL=90\% - \\
D_s^{+ a_0} & < 3.6 \times 10^{-5} & CL=90\% - \\
D_s^{+ a_1(1260)^-} & < 2.1 \times 10^{-3} & CL=90\% 2080 \\
D_s^{+ a_1(1260)^-} & < 1.7 \times 10^{-3} & CL=90\% 2015 \\
D_s^{+ a_2} & < 1.9 \times 10^{-4} & CL=90\% - \\
D_s^{+ a_2} & < 2.0 \times 10^{-4} & CL=90\% - \\
D_s^- K^+ & (2.2 \pm 0.5) \times 10^{-5} & S=1.8 2242 \\
D_s^- K^*(892)^+ & (2.19 \pm 0.30) \times 10^{-5} & 2185 \\
D_s^- K^*(892)^+ & (3.5 \pm 1.0) \times 10^{-5} & 2172 \\
D_s^- K^*(892)^+ & (3.2 \pm 1.5) \times 10^{-5} & 2112 \\
D_s^- \pi^+ K^0 & (1.10 \pm 0.33) \times 10^{-4} & 2222 \\
D_s^- \pi^+ K^0 & < 1.10 \times 10^{-4} & CL=90\% 2164 \\
D_s^- K^+ \pi^+ \pi^- & (1.8 \pm 0.5) \times 10^{-4} & 2198 \\
D_s^- \pi^+ K^*(892)^0 & < 3.0 \times 10^{-3} & CL=90\% 2138 \\
D_s^- \pi^+ K^*(892)^0 & < 1.6 \times 10^{-3} & CL=90\% 2076 \\
D^0 K^0 & (5.2 \pm 0.7) \times 10^{-5} & 2280 \\
D^0 K^+ \pi^- & (8.8 \pm 1.7) \times 10^{-5} & 2261 \\
D^0 K^*(892)^0 & (4.2 \pm 0.6) \times 10^{-5} & 2213 \\
D^0 K^+ \pi^- & (1.8 \pm 0.5) \times 10^{-5} & 2029 \\
B(D_s^0(2460)^- \to D^0 \pi^-) & < 3.7 \times 10^{-5} & CL=90\% - \\
K^+ K^- & (5.8 \pm 1.8) \times 10^{-5} & - \\
D^0 \pi^0 & (2.63 \pm 0.14) \times 10^{-4} & 2308 \\
D^0 \rho^0 & (3.2 \pm 0.5) \times 10^{-4} & 2237 \\
D^0 f_2 & (1.2 \pm 0.4) \times 10^{-4} & - \\
D^0 \eta & (2.36 \pm 0.32) \times 10^{-4} & S=2.5 2274 \\
D^0 \eta' & (1.38 \pm 0.16) \times 10^{-4} & S=1.3 2198 \\
D^0 \omega & (2.53 \pm 0.16) \times 10^{-4} & 2235 \\
D^0 \phi & < 1.16 \times 10^{-5} & CL=90\% 2183 \\
D^0 K^+ \pi^- & (5.3 \pm 3.2) \times 10^{-6} & 2261 \\
D^0 K^*(892)^0 & < 1.1 \times 10^{-5} & CL=90\% 2213 \\
D^0 \rho^* & < 2.5 \times 10^{-5} & CL=90\% 2258 \\
D^0(2007)^0 \pi^0 & (2.2 \pm 0.6) \times 10^{-4} & S=2.6 2256 \\
D^0(2007)^0 \rho^0 & < 5.1 \times 10^{-4} & CL=90\% 2182 \\
D^0(2007)^0 \eta & (2.3 \pm 0.6) \times 10^{-4} & S=2.8 2220 \\
D^0(2007)^0 \eta' & (1.40 \pm 0.22) \times 10^{-4} & 2141 \\
D^0(2007)^0 \pi^+ \pi^- & (6.2 \pm 2.2) \times 10^{-4} & 2248 \\
\end{array}
\]
\( \bar{D}^*(2007)^0 K^0 \)  
\( \bar{D}^*(2007)^0 K^*(892)^0 \)  
\( D^*(2007)^0 K^0 \)  
\( D^*(2007)^0 K^*(892)^0 \)  
\( D^*(2010)^+ D^*(2010)^- \)  
\( \bar{D}^*(2007)^0 \)  
\( D^*(2010)^0 D^-(2007)^0 D^0 K^+ \)  
\( D^- D^0 K^+ \)  
\( D^- D^*(2007)^0 K^+ \)  
\( D^*(2010)^0 D^0 K^+ \)  
\( D^*(2010)^0 D^0 K^+ \)  
\( D^*(2010)^0 D^0 K^+ \)  
\( D^*(2010)^- D^*(2010)^+ K^0 \)  
\( D^* \to D_{s1}(2536)^+ \to B(D_{s1}(2536)^+ \to D^+ K^0) \)  
\( \bar{D}^0 D^0 K^0 \)  
\( D^*(2007)^0 K^0 \)  
\( \bar{D}^*(2007)^0 D^0 K^0 \)  
\( \bar{D}^*(2007)^0 D^*(2007)^0 K^0 \)  
\( (\bar{D} + \bar{D}^*) (D + D^*) K^0 \)  

\( \eta_c K^0 \)  
\( \eta_c K^*(892)^0 \)  
\( \eta_c (2S) K^* \)  
\( h_{c(1P)} K^* \)  
\( J/\psi(1S) K^0 \)  
\( J/\psi(1S) K^+ \)  
\( J/\psi(1S) K^+ \)  
\( J/\psi(1S) \eta K^0 \)  
\( J/\psi(1S) \eta' K^0 \)  
\( J/\psi(1S) \phi K^0 \)  
\( J/\psi(1S) \omega K^0 \)  
\( \chi_{c0}(3872) K^0 \times B(X \to J/\psi \omega) \)  
\( \chi_{c0}(2P), \chi_{c0} \to J/\psi \omega \)  
\( J/\psi(1S) K(1270)^0 \)  
\( J/\psi(1S) \pi^0 \)  
\( J/\psi(1S) \eta \)  
\( J/\psi(1S) \pi^+ \pi^- \)  

**Charmonium modes**

\( \eta_c K^0 \)  
\( \eta_c K^*(892)^0 \)  
\( \eta_c (2S) K^* \)  
\( h_{c(1P)} K^* \)  
\( J/\psi(1S) K^0 \)  
\( J/\psi(1S) K^+ \)  
\( J/\psi(1S) \eta K^0 \)  
\( J/\psi(1S) \eta' K^0 \)  
\( J/\psi(1S) \phi K^0 \)  
\( J/\psi(1S) \omega K^0 \)  
\( \chi_{c0}(3872) K^0 \times B(X \to J/\psi \omega) \)  
\( \chi_{c0}(2P), \chi_{c0} \to J/\psi \omega \)  
\( J/\psi(1S) K(1270)^0 \)  
\( J/\psi(1S) \pi^0 \)  
\( J/\psi(1S) \eta \)  
\( J/\psi(1S) \pi^+ \pi^- \)  

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\[
\begin{align*}
J/\psi(1S)\pi^+\pi^- \text{ nonresonant} &< 1.2 \times 10^{-5} \text{ CL=90\%} & 1716 \\
J/\psi(1S)f_0(500), f_0 \to \pi\pi & (6.5 \pm 2.6_{-1.1}^{+1.3}) \times 10^{-6} & - \\
J/\psi(1S)f_2 & (4.2 \pm 0.7) \times 10^{-6} & - \\
J/\psi(1S)p^0 & (2.58 \pm 0.21) \times 10^{-5} & 1612 \\
J/\psi(1S)f_0(980), f_0 \to \pi^+\pi^- & < 1.1 \times 10^{-6} \text{ CL=90\%} & - \\
J/\psi(1S)p(1450)^0, p^0 \to \pi\pi & (2.1 \pm 2.5_{-0.7}^{+0.5}) \times 10^{-6} & - \\
J/\psi(1S)\omega & (2.3 \pm 0.6) \times 10^{-5} & 1609 \\
J/\psi(1S)K^+K^- & (2.6 \pm 0.4) \times 10^{-6} & 1533 \\
J/\psi(1S)a_0(980), a_0 \to K^+K^- & (4.7 \pm 3.4) \times 10^{-7} & - \\
J/\psi(1S)\phi & < 1.9 \times 10^{-7} \text{ CL=90\%} & 1520 \\
J/\psi(1S)\eta'(958) & < 7.4 \times 10^{-6} \text{ CL=90\%} & 1546 \\
J/\psi(1S)K^0\pi^+\pi^- & (1.0 \pm 0.4) \times 10^{-3} & 1611 \\
J/\psi(1S)K^0p^0 & (5.4 \pm 3.0) \times 10^{-4} & 1390 \\
J/\psi(1S)K^+(892)^+\pi^- & (8 \pm 4) \times 10^{-4} & 1514 \\
J/\psi(1S)K^+(892)^0\pi^+\pi^- & (6.6 \pm 2.2) \times 10^{-4} & 1447 \\
X(3872)^-K^+ & < 5 \times 10^{-4} \text{ CL=90\%} & - \\
X(3872)^-K^+ \times [\psi(2S)\gamma^*] & < 4.2 \times 10^{-6} \text{ CL=90\%} & - \\
B(X(3872)^- \to J/\psi(1S)\pi^-\pi^0) & - \\
X(3872)^-K^0 \times B(X \to \pi\pi) & (4.3 \pm 1.3) \times 10^{-6} & 1140 \\
X(3872)^-K^0 \times B(X \to \pi\pi) & < 2.4 \times 10^{-6} \text{ CL=90\%} & 1140 \\
X(3872)^-K^0 \times B(X \to \psi(2S)\gamma) & < 2.8 \times 10^{-6} \text{ CL=90\%} & 940 \\
X(3872)^-K^0 \times B(X \to \psi(2S)\gamma) & < 4.4 \times 10^{-6} \text{ CL=90\%} & 940 \\
X(3872)^-K^0 \times B(X \to \psi(2S)\gamma) & (1.7 \pm 0.8) \times 10^{-4} & 1140 \\
X(3872)^-K^0 \times B(X \to \overline{D}^\ast D^0) & (1.2 \pm 0.4) \times 10^{-4} & 1140 \\
X(4430)^\pm K^+ \times B(X \to \psi(2S)\pi^\pm) & (6.0 \pm 3.0_{-2.4}^{+2.7}) \times 10^{-5} & 575 \\
X(4430)^\pm K^+ \times B(X \to \psi(2S)\pi^\pm) & < 4 \times 10^{-6} \text{ CL=95\%} & 575 \\
J/\psi(1S)p\pi^\pm & < 5.2 \times 10^{-7} \text{ CL=90\%} & 862 \\
J/\psi(1S)\gamma & < 1.6 \times 10^{-6} \text{ CL=90\%} & 1731 \\
J/\psi(1S)\overline{D}^0 & < 1.3 \times 10^{-5} \text{ CL=90\%} & 877 \\
\psi(2S)K^0 & (6.2 \pm 0.5) \times 10^{-4} & 1283 \\
\psi(3770)K^0 \times B(\psi \to \overline{D}^0 D^0) & < 1.23 \times 10^{-4} \text{ CL=90\%} & 1217
\end{align*}
\]
\[ \psi(3770) K^0 \times B(\psi \rightarrow D^- D^+) \quad < 1.88 \times 10^{-4} \quad \text{CL}=90\% \quad 1217 \]

\[ \psi(2S) \pi^+ \pi^- \]
\[ \psi(2S) K^+ \pi^- \]
\[ \psi(2S) K^+ (892)^0 \]
\[ \chi_{c0} K^0 \]
\[ \chi_{c0} K^* (892)^0 \]
\[ \chi_{c2} K^0 \]
\[ \chi_{c2} K^* (892)^0 \]
\[ \chi_{c1} K^0 \]
\[ \chi_{c1} K^* (892)^0 \]
\[ \chi_{c1} K^- \pi^+ \]
\[ \chi_{c1} K^+(892)^0 \]
\[ \chi_{c1} K^+(892)^0 \times B(X^+ \rightarrow \chi_{c1} \pi^+) \]
\[ X(4051)^+ K^- \times B(X^+ \rightarrow \chi_{c1} \pi^+) \]
\[ X(4248)^+ K^- \times B(X^+ \rightarrow \chi_{c1} \pi^+) \]

**K or K**\(^*\) **modes**

\[ K^+ \pi^- \quad (1.96 \pm 0.05) \times 10^{-5} \quad 2615 \]
\[ K^0 \pi^0 \quad (9.9 \pm 0.5) \times 10^{-6} \quad 2615 \]
\[ \eta' K^0 \quad (6.6 \pm 0.4) \times 10^{-5} \quad \text{S}=1.4 \quad 2528 \]
\[ \eta' K^* (892)^0 \quad (3.1 \pm 0.9) \times 10^{-6} \quad 2472 \]
\[ \eta' K_0^* (1430)^0 \quad (6.3 \pm 1.6) \times 10^{-6} \quad 2346 \]
\[ \eta' K_2^* (1430)^0 \quad (1.37 \pm 0.32) \times 10^{-5} \quad 2346 \]
\[ \eta K^0 \quad (1.23^{+0.27}_{-0.24}) \times 10^{-6} \quad 2587 \]
\[ \eta K^* (892)^0 \quad (1.59 \pm 0.10) \times 10^{-5} \quad 2534 \]
\[ \eta K_0^* (1430)^0 \quad (1.10 \pm 0.22) \times 10^{-5} \quad 2415 \]
\[ \eta K_2^* (1430)^0 \quad (9.6 \pm 2.1) \times 10^{-6} \quad 2414 \]
\[ \omega K^0 \quad (5.0 \pm 0.6) \times 10^{-6} \quad 2557 \]

\[ a_0 (980)^0 K^0 \times B(a_0 (980)^0 \rightarrow \eta \pi^0) \quad < 7.8 \times 10^{-6} \quad \text{CL}=90\% \quad - \]
\[ b_1^0 K^0 \times B(b_1^0 \rightarrow \omega \pi^0) \quad < 7.8 \times 10^{-6} \quad \text{CL}=90\% \quad - \]
\[ a_0 (980)^\pm K^\mp \times B(a_0 (980)^\pm \rightarrow \eta \pi^\pm) \quad < 1.9 \times 10^{-6} \quad \text{CL}=90\% \quad - \]
\[ b_1^- K^+ \times B(b_1^- \rightarrow \omega \pi^-) \quad (7.4 \pm 1.4) \times 10^{-6} \quad - \]
\[ b_1^0 K^* \times B(b_1^0 \rightarrow \omega \pi^0) \quad < 8.0 \times 10^{-6} \quad \text{CL}=90\% \quad - \]
\[ b_1^- K^+ \times B(b_1^- \rightarrow \omega \pi^-) \quad < 5.0 \times 10^{-6} \quad \text{CL}=90\% \quad - \]
\[ a_0 (1450)^\pm K^\mp \times B(a_0 (1450)^\pm \rightarrow \eta \pi^\pm) \quad < 3.1 \times 10^{-6} \quad \text{CL}=90\% \quad - \]
\[ K_S^0 X^0 \text{(Familon)} \quad < 5.3 \times 10^{-5} \quad \text{CL}=90\% \quad - \]
\[ \omega K^* (892)^0 \quad (2.0 \pm 0.5) \times 10^{-6} \quad 2503 \]
\[ \omega (K \pi)^0 \quad (1.84 \pm 0.25) \times 10^{-5} \quad - \]
\begin{itemize}
    \item \( \omega K_0^*(1430)^0 \)
    \( (1.60 \pm 0.34) \times 10^{-5} \)
    2380
    \item \( \omega K^*_2(1430)^0 \)
    \( (1.01 \pm 0.23) \times 10^{-5} \)
    2380
    \item \( \omega K^+ \pi^- \) nonresonant
    \( (5.1 \pm 1.0) \times 10^{-6} \)
    2542
    \item \( K^+ \pi^- \pi^0 \)
    \( (3.78 \pm 0.32) \times 10^{-5} \)
    2609
    \item \( K^+ \rho^- \)
    \( (7.0 \pm 0.9) \times 10^{-6} \)
    2559
    \item \( K^+ \rho(1450)^- \)
    \( (2.4 \pm 1.2) \times 10^{-6} \)
    –
    \item \( K^+ \rho(1700)^- \)
    \( (6 \pm 7) \times 10^{-7} \)
    –
    \item \( (K^+ \pi^- \pi^0) \) non-resonant
    \( (2.8 \pm 0.6) \times 10^{-6} \)
    –
    \item \( (K\pi)_0^+ \pi^- \times B((K\pi)_0^+ \rightarrow K^+ \pi^0) \)
    \( (3.4 \pm 0.5) \times 10^{-5} \)
    –
    \item \( (K\pi)_0^+ \pi^0 \times B((K\pi)_0^+ \rightarrow K^+ \pi^-) \)
    \( (8.6 \pm 1.7) \times 10^{-6} \)
    –
    \item \( K_2^*(1430)^0 \pi^0 \)
    \(<4.0 \times 10^{-6} \) 
    CL=90%
    2445
    \item \( K^*(1680)^0 \pi^0 \)
    \(<7.5 \times 10^{-6} \) 
    CL=90%
    2358
    \item \( K_\chi^0 \pi^0 \)
    \([bbaa]\)
    \( (6.1 \pm 1.6) \times 10^{-6} \)
    –
    \item \( K^0 \pi^+ \pi^- \)
    \( (6.5 \pm 0.8) \times 10^{-5} \)
    S=1.2
    2609
    \item \( K^0 \pi^+ \pi^- \) non-resonant
    \( (1.47 \pm 0.40) \times 10^{-5} \)
    S=2.1
    –
    \item \( K^0 \rho^0 \)
    \( (4.7 \pm 0.6) \times 10^{-6} \)
    2558
    \item \( K^+(892)^+ \pi^- \)
    \( (8.4 \pm 0.8) \times 10^{-6} \)
    2563
    \item \( K_0^*(1430)^+ \pi^- \)
    \( (3.3 \pm 0.7) \times 10^{-5} \)
    S=2.0
    –
    \item \( K_\chi^+ \pi^- \)
    \([bbaa]\)
    \( (5.1 \pm 1.6) \times 10^{-6} \)
    –
    \item \( K^+(1410)^+ \pi^- \times \)
    \( B(K^+(1410)^+ \rightarrow K^0 \pi^+) \)
    \(<3.8 \times 10^{-6} \)
    CL=90%
    –
    \item \( f_0(980) K^0 \times B(f_0(980) \rightarrow \pi^+ \pi^-) \)
    \( (7.0 \pm 0.9) \times 10^{-6} \)
    2522
    \item \( f_2(1270) K^0 \)
    \( (2.7 \pm 1.3) \times 10^{-6} \)
    2459
    \item \( f_\chi(1300) K^0 \times B(f_\chi \rightarrow \pi^+ \pi^-) \)
    \( (1.8 \pm 0.7) \times 10^{-6} \)
    –
    \item \( K^+(892)^0 \pi^0 \)
    \( (3.3 \pm 0.6) \times 10^{-6} \)
    2563
    \item \( K_2^*(1430)^+ \pi^- \)
    \(<6 \times 10^{-6} \) 
    CL=90%
    2445
    \item \( K^*(1680)^+ \pi^- \)
    \(<1.0 \times 10^{-5} \) 
    CL=90%
    2358
    \item \( K^+ \pi^- \pi^+ \pi^- \)
    \([ccaa]\)
    \( <2.3 \times 10^{-4} \)
    CL=90%
    2600
    \item \( \rho^0 K^+ \pi^- \)
    \( (2.8 \pm 0.7) \times 10^{-6} \)
    2543
    \item \( f_0(980) K^+ \pi^- \), \( f_0 \rightarrow \pi \pi \)
    \( (1.4 \pm 0.5) \times 10^{-6} \)
    2506
    \item \( K^+ \pi^- \pi^+ \pi^- \) nonresonant
    \( <2.1 \times 10^{-6} \) 
    CL=90%
    2600
    \item \( K^+(892)^0 \pi^+ \pi^- \)
    \( (5.5 \pm 0.5) \times 10^{-5} \)
    2557
    \item \( K^+(892)^0 \rho^0 \)
    \( (3.9 \pm 1.3) \times 10^{-6} \)
    S=1.9
    2504
    \item \( K^+(892)^0 f_0(980), \ f_0 \rightarrow \pi \pi \)
    \( (3.9 \pm 2.1) \times 10^{-6} \)
    S=3.9
    2466
    \item \( K_1(1270)^+ \pi^- \)
    \(<3.0 \times 10^{-5} \) 
    CL=90%
    2484
    \item \( K_1(1400)^+ \pi^- \)
    \(<2.7 \times 10^{-5} \) 
    CL=90%
    2451
    \item \( a_1(1260)^- K^+ \)
    \([ccaa]\)
    \( (1.6 \pm 0.4) \times 10^{-5} \)
    2471
\end{itemize}
\begin{align*}
  \bar{K}^0 &\rightarrow \pi^+ + \pi^- + \pi^0, \\
  \pi^+ &\rightarrow \text{nonresonant}, \\
  \phi &\rightarrow \text{nonresonant}.
\end{align*}
\[
\begin{align*}
\eta' \eta' & K^0 & < 3.1 \times 10^{-5} \text{ CL=90\%} & 2337 \\
\eta' K^0 & < 6.4 \times 10^{-6} \text{ CL=90\%} & 2528 \\
K^0 & < 1.3 \times 10^{-4} \text{ CL=90\%} & 2451 \\
K^+(950) \gamma & < 2.6 \times 10^{-6} \text{ CL=90\%} & 2615 \\
K^0 & < 1.95 \pm 0.22 \times 10^{-5} & 2609 \\
K^+ & < 4.1 \pm 0.4 \times 10^{-5} & 2609 \\
K^0(1270) & < 5.8 \times 10^{-5} \text{ CL=90\%} & 2486 \\
K^0(1400) & < 1.2 \times 10^{-5} \text{ CL=90\%} & 2453 \\
K^0(1430) & < 1.24 \pm 0.24 \times 10^{-5} & 2447 \\
K^0(1680) & < 2.0 \times 10^{-3} \text{ CL=90\%} & 2361 \\
K^0(1780) & < 8.3 \times 10^{-5} \text{ CL=90\%} & 2341 \\
K^0(2045) & < 4.3 \times 10^{-3} \text{ CL=90\%} & 2444 \\
\end{align*}
\]

**Light unflavored meson modes**

\[
\begin{align*}
\rho^0 & \times 10^{-7} & 2583 \\
\rho^0 & \times 10^{-8} \text{ CL=90\%} & 2582 \\
\omega & < 4.4 \pm 1.8 \times 10^{-7} & 2582 \\
\phi & < 8.5 \times 10^{-7} \text{ CL=90\%} & 2541 \\
\pi^+ & < 5.12 \pm 0.19 \times 10^{-6} & 2636 \\
\pi^0 & < 1.91 \pm 0.22 \times 10^{-6} & 2636 \\
\eta & < 1.5 \times 10^{-6} \text{ CL=90\%} & 2610 \\
\eta' & < 1.0 \times 10^{-6} \text{ CL=90\%} & 2582 \\
\eta' & < 1.7 \times 10^{-6} \text{ CL=90\%} & 2460 \\
\eta' & < 1.2 \times 10^{-6} \text{ CL=90\%} & 2523 \\
\eta' & < 1.3 \times 10^{-6} \text{ CL=90\%} & 2492 \\
\end{align*}
\]
\( \eta' f_0(980) \times B(f_0(980) \rightarrow \pi^+\pi^-) \)  
\( \eta\rho^0 \)  
\( \eta f_0(980) \times B(f_0(980) \rightarrow \pi^+\pi^-) \)  
\( \omega\eta \)  
\( \omega\eta' \)  
\( \omega\rho^0 \)  
\( \omega f_0(980) \times B(f_0(980) \rightarrow \pi^+\pi^-) \)  
\( \omega\omega \)  
\( \phi\pi^0 \)  
\( \phi\eta \)  
\( \phi\eta' \)  
\( \phi\rho^0 \)  
\( \phi f_0(980) \times B(f_0 \rightarrow \pi^+\pi^-) \)  
\( \phi\omega \)  
\( \phi\phi \)  
\( a_0(980)^\pm \times B(a_0(980)^\pm \rightarrow \eta\pi^\pm) \)  
\( a_0(1450)^\pm \times B(a_0(1450)^\pm \rightarrow \eta\pi^\pm) \)  
\( \rho^0\pi^0 \)  
\( \rho^\mp\pi^\pm \)  
\( \rho^0\pi^\pm \pi^- \pi^0 \)  
\( \rho^0\pi^\mp\pi^- \pi^+ \)  
\( \rho^0\rho^0 \)  
\( f_0(980)\pi^+\pi^- \)  
\( \rho^0 f_0(980) \times B(f_0(980) \rightarrow \pi^+\pi^-) \)  
\( f_0(980)f_0(980) \times B^2(f_0(980) \rightarrow \pi^+\pi^-) \)  
\( f_0(980)f_0(980) \times B(f_0 \rightarrow \pi^+\pi^-) \times B(f_0 \rightarrow K^+K^-) \)  
\( a_1(1260)^\mp\pi^\pm \)  
\( a_2(1320)^\mp\pi^\pm \)  
\( \pi^+\pi^-\pi^0\pi^0 \)  
\( \rho^+\rho^- \)  
\( a_1(1260)^0\pi^0 \)  
\( \omega\pi^0 \)  
\( \pi^+\pi^-\pi^-\pi^0 \)  
\( a_1(1260)^0\rho^- \)  

<table>
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<tr>
<th>Reaction</th>
<th>Value</th>
<th>Error</th>
<th>CL (%)</th>
<th>Units</th>
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<td>( a_1(1260)^0\rho^- )</td>
<td>&lt; 6.1</td>
<td>( 10^{-5} )</td>
<td>90</td>
<td>2433</td>
</tr>
</tbody>
</table>
\[
\begin{align*}
\text{a}_1(1260)^0 \rho^0 &< 2.4 \times 10^{-3} \text{ CL}=90\% \quad 2433 \\
b_1^+ \pi^\pm \times B(b_1^+ \to \omega \pi^\mp) &< (1.09 \pm 0.15) \times 10^{-5} \quad - \\
b_1^0 \pi^\pm \times B(b_1^0 \to \omega \pi^0) &< 1.9 \times 10^{-6} \text{ CL}=90\% \quad - \\
b_1^- \rho^+ \times B(b_1^- \to \omega \pi^-) &< 1.4 \times 10^{-6} \text{ CL}=90\% \quad - \\
b_1^0 \rho^0 \times B(b_1^0 \to \omega \pi^0) &< 3.4 \times 10^{-6} \text{ CL}=90\% \quad - \\
\pi^+ \pi^+ \pi^- \pi^- \pi^- &< 3.0 \times 10^{-3} \text{ CL}=90\% \quad 2592 \\
\text{a}_1(1260)^+ \text{a}_1(1260)^- \times B^2(a_1^+ \to 2\pi^+ \pi^-) &< (1.18 \pm 0.31) \times 10^{-5} \quad 2336 \\
\pi^+ \pi^+ \pi^- \pi^- \pi^- &< 1.1 \% \text{ CL}=90\% \quad 2572
\end{align*}
\]

**Baryon modes**

\[
\begin{align*}
p\bar{p} &< (1.5 \pm 0.7) \times 10^{-8} \quad 2467 \\
p\bar{p} \pi^+ \pi^- &< 2.5 \times 10^{-4} \text{ CL}=90\% \quad 2406 \\
p\bar{p} K^0 &< (2.66 \pm 0.32) \times 10^{-6} \quad 2347 \\
\Theta(1540)^+ \bar{p}, \Theta^+ \to p K_S^0 \quad [\text{f}a\text{a}] &< 5 \times 10^{-8} \text{ CL}=90\% \quad 2318 \\
f_j(2220) K^0, f_j \to p\bar{p} &< 4.5 \times 10^{-7} \text{ CL}=90\% \quad 2135 \\
p\bar{p} K^*(892)^0 &< (1.24^{+0.28}_{-0.25}) \times 10^{-6} \quad 2216 \\
f_j(2220) K^*_0, f_j \to p\bar{p} &< 1.5 \times 10^{-7} \text{ CL}=90\% \quad - \\
p\Lambda \pi^- &< (3.14 \pm 0.29) \times 10^{-6} \quad 2401 \\
p \Sigma^-(1385)^- &< 2.6 \times 10^{-7} \text{ CL}=90\% \quad 2363 \\
\Delta^0 \Lambda &< 9.3 \times 10^{-7} \text{ CL}=90\% \quad 2364 \\
p\Lambda K^- &< 8.2 \times 10^{-7} \text{ CL}=90\% \quad 2308 \\
p \Sigma^0 \pi^- &< 3.8 \times 10^{-6} \text{ CL}=90\% \quad 2383 \\
\Lambda \Lambda &< 3.2 \times 10^{-7} \text{ CL}=90\% \quad 2392 \\
\Lambda \Lambda K^0 &< (4.8 \pm 1.0) \times 10^{-6} \quad 2250 \\
\Lambda \Lambda K^*0 &< (2.5 \pm 0.9) \times 10^{-6} \quad 2098 \\
\Lambda \Lambda D^0 &< (1.1 \pm 0.6) \times 10^{-5} \quad 1661 \\
\Delta^0 \bar{\Delta}^0 &< 1.5 \times 10^{-3} \text{ CL}=90\% \quad 2335 \\
\Delta^+ \bar{\Delta}^-- &< 1.1 \times 10^{-4} \text{ CL}=90\% \quad 2335 \\
\bar{D}^0 p\bar{p} &< (1.04 \pm 0.07) \times 10^{-4} \quad 1863 \\
\bar{D}^- \bar{\Lambda} p &< (2.8 \pm 0.9) \times 10^{-5} \quad 1710 \\
\bar{D}^*(2007)^0 p\bar{p} &< (9.9 \pm 1.1) \times 10^{-5} \quad 1788 \\
D^*(2010)^- p\bar{\eta} &< (1.4 \pm 0.4) \times 10^{-3} \quad 1785 \\
D^- p\bar{p} \pi^+ &< (3.32 \pm 0.31) \times 10^{-4} \quad 1766 \\
D^*(2010)^- p\bar{p} \pi^+ &< (4.7 \pm 0.5) \times 10^{-4} \quad S=1.2 \quad 1707 \\
\bar{D}^0 p\bar{p} \pi^+ \pi^- &< (3.0 \pm 0.5) \times 10^{-4} \quad 1708 \\
\bar{D}^*0 p\bar{p} \pi^+ \pi^- &< (1.9 \pm 0.5) \times 10^{-4} \quad 1623 \\
\Theta_c p\pi^+, \Theta_c \to D^- p &< 9 \times 10^{-6} \text{ CL}=90\% \quad - \\
\Theta_c p\pi^+, \Theta_c \to D^*^- p &< 1.4 \times 10^{-5} \text{ CL}=90\% \quad - \\
\Sigma^- \Delta^+ &< 1.0 \times 10^{-3} \text{ CL}=90\% \quad 1839
\end{align*}
\]
\[ \Lambda^- p \pi^+ \pi^- \rightarrow (1.3 \pm 0.4) \times 10^{-3} \] 1934
\[ \Lambda^- p \rightarrow (2.0 \pm 0.4) \times 10^{-5} \] 2021
\[ \Lambda^- p \pi^0 \rightarrow (1.9 \pm 0.5) \times 10^{-4} \] 1982
\[ \Sigma_c(2455)^- p \rightarrow <3.0 \times 10^{-5} \] –
\[ \Lambda^- p \pi^+ \pi^- \pi^0 \rightarrow <5.07 \times 10^{-3} \text{ CL}=90\% \] 1882
\[ \Lambda^- p \pi^+ \pi^- \pi^+ \pi^- \rightarrow <2.74 \times 10^{-3} \text{ CL}=90\% \] 1821
\[ \Lambda^- p \pi^+ \pi^- \pi^+ \pi^- \] (1.17±0.23)×10^{-3} 1934
\[ \Sigma_c(2520)^- p \pi^+ \rightarrow (7.1 \pm 1.4) \times 10^{-4} \] 1934
\[ \Sigma_c(2520)^0 p \pi^- \rightarrow <3.1 \times 10^{-5} \text{ CL}=90\% \] 1860
\[ \Sigma_c(2455)^0 p \pi^- \rightarrow (1.04 \pm 0.22) \times 10^{-4} \] 1895
\[ \Sigma_c(2455)^0 N^0, \ N^0 \rightarrow \pi^- \] (8.0 ± 2.9) × 10^{-5} –
\[ \Lambda^- p K^+(892)^0 \pi^- \rightarrow <2.42 \times 10^{-5} \text{ CL}=90\% \] –
\[ \Lambda^- \Lambda K^+ \rightarrow (3.8 \pm 1.3) \times 10^{-5} \] 1767
\[ \Lambda^- \Lambda^+ \rightarrow <6.2 \times 10^{-5} \text{ CL}=90\% \] 1319
\[ \Lambda_c(2593)^- / \Lambda_c(2625)^- p \rightarrow <1.1 \times 10^{-4} \text{ CL}=90\% \] –
\[ \Xi_c^+ \Xi^- \rightarrow \Xi^+ \pi^- \pi^- \rightarrow (2.2 \pm 2.3) \times 10^{-5} \text{ S}=1.9 \] 1147
\[ \Lambda_c^+ \Lambda_c^- K^0 \rightarrow (5.4 \pm 3.2) \times 10^{-4} \] –

**Lepton Family number (LF) or Lepton number (L) or Baryon number (B) violating modes, or/and \( \Delta B = 1 \) weak neutral current (B1) modes**

\[ \gamma \gamma \rightarrow B1 \rightarrow 3.2 \times 10^{-7} \text{ CL}=90\% \] 2640
\[ e^+ e^- \rightarrow B1 \rightarrow 8.3 \times 10^{-8} \text{ CL}=90\% \] 2640
\[ e^+ e^- \gamma \rightarrow B1 \rightarrow 1.2 \times 10^{-7} \text{ CL}=90\% \] 2640
\[ \mu^+ \mu^- \rightarrow B1 \rightarrow 6.3 \times 10^{-10} \text{ CL}=90\% \] 2638
\[ \mu^+ \mu^- \gamma \rightarrow B1 \rightarrow 1.6 \times 10^{-7} \text{ CL}=90\% \] 2638
\[ \mu^+ \mu^- \mu^+ \mu^- \rightarrow 5.3 \times 10^{-9} \text{ CL}=90\% \] 2629
\[ SP, \ S \rightarrow \mu^+ \mu^-, \ \text{[ggaa]} \rightarrow 5.1 \times 10^{-9} \text{ CL}=90\% \] –
\[ \tau^+ \tau^- \rightarrow B1 \rightarrow 4.1 \times 10^{-3} \text{ CL}=90\% \] 1952
\[ \pi^0 \ell^+ \ell^- \rightarrow B1 \rightarrow 5.3 \times 10^{-8} \text{ CL}=90\% \] 2638
\[ \pi^0 e^+ e^- \rightarrow B1 \rightarrow 8.4 \times 10^{-8} \text{ CL}=90\% \] 2638
\[ \pi^0 \mu^+ \mu^- \rightarrow B1 \rightarrow 6.9 \times 10^{-8} \text{ CL}=90\% \] 2634
\[ \eta \ell^+ \ell^- \rightarrow <6.4 \times 10^{-8} \text{ CL}=90\% \] 2611
\[ \eta e^+ e^- \rightarrow <1.08 \times 10^{-7} \text{ CL}=90\% \] 2611
\[ \eta \mu^+ \mu^- \rightarrow <1.12 \times 10^{-7} \text{ CL}=90\% \] 2607
\[ \pi^0 \nu \bar{\nu} \rightarrow B1 \rightarrow 6.9 \times 10^{-5} \text{ CL}=90\% \] 2638
\[ K^0 \ell^+ \ell^- \quad B1 \quad [ss] \quad (3.1 \pm 0.8) \times 10^{-7} \quad 2616 \]
\[ K^0 e^+ e^- \quad B1 \quad (1.6 \pm 1.0) \times 10^{-7} \quad 2616 \]
\[ K^0 \mu^+ \mu^- \quad B1 \quad (3.4 \pm 0.5) \times 10^{-7} \quad 2612 \]
\[ K^0 \nu \bar{\nu} \quad B1 \quad < 4.9 \times 10^{-5} \quad \text{CL}=90\% \quad 2616 \]
\[ \rho^0 \nu \bar{\nu} \quad B1 \quad < 2.08 \times 10^{-4} \quad \text{CL}=90\% \quad 2583 \]
\[ K^*(892)^0 \ell^+ \ell^- \quad B1 \quad [ss] \quad (9.9 \pm 1.2) \times 10^{-7} \quad 2564 \]
\[ K^*(892)^0 e^+ e^- \quad B1 \quad (1.03 \pm 0.19) \times 10^{-6} \quad 2564 \]
\[ K^*(892)^0 \mu^+ \mu^- \quad B1 \quad (1.05 \pm 0.10) \times 10^{-6} \quad 2560 \]
\[ \phi \nu \bar{\nu} \quad B1 \quad < 5.5 \times 10^{-5} \quad \text{CL}=90\% \quad 2564 \]
\[ e^\pm \mu^\mp \quad LF \quad [gg] < 2.8 \times 10^{-9} \quad \text{CL}=90\% \quad 2639 \]
\[ \pi^0 e^\pm \mu^\mp \quad LF \quad < 1.4 \times 10^{-7} \quad \text{CL}=90\% \quad 2637 \]
\[ K^0 e^\pm \mu^\mp \quad LF \quad < 2.7 \times 10^{-7} \quad \text{CL}=90\% \quad 2615 \]
\[ K^*(892)^0 e^+ \mu^- \quad LF \quad < 5.3 \times 10^{-7} \quad \text{CL}=90\% \quad 2563 \]
\[ K^*(892)^0 e^- \mu^+ \quad LF \quad < 3.4 \times 10^{-7} \quad \text{CL}=90\% \quad 2563 \]
\[ K^*(892)^0 e^\pm \mu^\mp \quad LF \quad < 5.8 \times 10^{-7} \quad \text{CL}=90\% \quad 2563 \]
\[ e^\pm \tau^\mp \quad LF \quad [gg] < 2.8 \times 10^{-5} \quad \text{CL}=90\% \quad 2341 \]
\[ \mu^\pm \tau^\mp \quad LF \quad [gg] < 2.2 \times 10^{-5} \quad \text{CL}=90\% \quad 2339 \]
\[ \text{invisible} \quad B1 \quad < 2.4 \times 10^{-5} \quad \text{CL}=90\% \quad – \]
\[ \nu \bar{\nu} \gamma \quad B1 \quad < 1.7 \times 10^{-5} \quad \text{CL}=90\% \quad 2640 \]
\[ \Lambda_c^+ \mu^- \quad L,B \quad < 1.8 \times 10^{-6} \quad \text{CL}=90\% \quad 2143 \]
\[ \Lambda_c^+ e^- \quad L,B \quad < 5 \times 10^{-6} \quad \text{CL}=90\% \quad 2145 \]

\[ B^\pm / B^0 \text{ ADMIXTURE} \]

\[ \text{CP violation} \]
\[ A_{CP}(B \rightarrow K^*(892)\gamma) = -0.003 \pm 0.017 \]
\[ A_{CP}(b \rightarrow s\gamma) = -0.008 \pm 0.029 \]
\[ A_{CP}(b \rightarrow (s+d)\gamma) = -0.01 \pm 0.05 \]
\[ A_{CP}(B \rightarrow X_s\ell^+\ell^-) = -0.22 \pm 0.26 \]
\[ A_{CP}(B \rightarrow K^*\ell^+\ell^-) = -0.18 \pm 0.15 \]
\[ A_{CP}(B \rightarrow K^*\mu^+\mu^-) = -0.03 \pm 0.13 \]
\[ A_{CP}(B \rightarrow K^*\ell^+\ell^-) = -0.04 \pm 0.07 \]
\[ A_{CP}(B \rightarrow \eta \text{anything}) = -0.13^{+0.04}_{-0.05} \]
The branching fraction measurements are for an admixture of $B$ mesons at the $\Upsilon(4S)$. The values quoted assume that $B(\Upsilon(4S) \to B\overline{B}) = 100\%$.

For inclusive branching fractions, e.g., $B \to D^\pm$ anything, the treatment of multiple $D$’s in the final state must be defined. One possibility would be to count the number of events with one-or-more $D$’s and divide by the total number of $B$’s. Another possibility would be to count the total number of $D$’s and divide by the total number of $B$’s, which is the definition of average multiplicity. The two definitions are identical if only one $D$ is allowed in the final state. Even though the “one-or-more” definition seems sensible, for practical reasons inclusive branching fractions are almost always measured using the multiplicity definition. For heavy final state particles, authors call their results inclusive branching fractions while for light particles some authors call their results multiplicities. In the $B$ sections, we list all results as inclusive branching fractions, adopting a multiplicity definition. This means that inclusive branching fractions can exceed 100% and that inclusive partial widths can exceed total widths, just as inclusive cross sections can exceed total cross section.

$\overline{B}$ modes are charge conjugates of the modes below. Reactions indicate the weak decay vertex and do not include mixing.

### $B$ DECAY MODES

<table>
<thead>
<tr>
<th>Semileptonic and leptonic modes</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>Scale factor/Confidence level (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$e^+\nu_e$ anything</td>
<td>$[hhaa]$ (10.86 ± 0.16) %</td>
<td></td>
</tr>
<tr>
<td>$\overline{b}e^+\nu_e$ anything</td>
<td>$&lt; 5.9 \times 10^{-4}$ (CL=90%)</td>
<td></td>
</tr>
<tr>
<td>$\mu^+\nu_\mu$ anything</td>
<td>$[hhaa]$ (10.86 ± 0.16) %</td>
<td></td>
</tr>
<tr>
<td>$\ell^+\nu_\ell$ anything</td>
<td>$[sss,hhaa]$ (10.86 ± 0.16) %</td>
<td></td>
</tr>
<tr>
<td>$D^-\ell^+\nu_\ell$ anything</td>
<td>$[sss]$ (2.8 ± 0.9) %</td>
<td></td>
</tr>
<tr>
<td>$D^0\ell^+\nu_\ell$ anything</td>
<td>$[sss]$ (7.3 ± 1.5) %</td>
<td></td>
</tr>
<tr>
<td>$D^-\tau^+\nu_\tau$ anything</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$D^*\tau^+\nu_\tau$ anything</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$D^*\tau^+\nu_\tau$ anything</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$D^*\ell^+\nu_\ell$ anything</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$D^{**}\ell^+\nu_\ell$ anything</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$D^0(2420)\ell^+\nu_\ell$ anything</td>
<td>(3.8 ± 1.3) × 10^{-3} (S=2.4)</td>
<td></td>
</tr>
<tr>
<td>$D^-\pi^+\ell^+\nu_\ell$ anything</td>
<td>(2.6 ± 0.5) % (S=1.5)</td>
<td></td>
</tr>
<tr>
<td>$D^+\pi^-\ell^+\nu_\ell$ anything</td>
<td>(1.5 ± 0.6) %</td>
<td></td>
</tr>
<tr>
<td>$D^-\pi^+\ell^+\nu_\ell$ anything</td>
<td>(1.9 ± 0.4) %</td>
<td></td>
</tr>
<tr>
<td>$D^-\pi^+\ell^+\nu_\ell$ anything</td>
<td>(4.4 ± 1.6) × 10^{-3}</td>
<td></td>
</tr>
<tr>
<td>$D^-\pi^+\ell^+\nu_\ell$ anything</td>
<td>(1.00 ± 0.34) %</td>
<td></td>
</tr>
<tr>
<td>$D^*<em>s\ell^+\nu</em>\ell$ anything</td>
<td>$[sss] &lt; 7 \times 10^{-3}$ (CL=90%)</td>
<td></td>
</tr>
<tr>
<td>$D^*<em>s\ell^+\nu</em>\ell K^+$ anything</td>
<td>$[sss] &lt; 5 \times 10^{-3}$ (CL=90%)</td>
<td></td>
</tr>
<tr>
<td>$D^*<em>s\ell^+\nu</em>\ell K^0$ anything</td>
<td>$[sss] &lt; 7 \times 10^{-3}$ (CL=90%)</td>
<td></td>
</tr>
</tbody>
</table>
\[ X_c \ell^+ \nu_\ell \quad (10.65 \pm 0.16 \text{ ) \%} \\
X_u \ell^+ \nu_\ell \quad (2.14 \pm 0.31 \text{ ) } \times 10^{-3} \\
K^+ \ell^+ \nu_\ell \text{ anything } [\text{sss}] \quad (6.3 \pm 0.6 \text{ ) \%} \\
K^- \ell^+ \nu_\ell \text{ anything } [\text{sss}] \quad (10 \pm 4 \text{ ) } \times 10^{-3} \\
K^0 / \bar{K}^0 \ell^+ \nu_\ell \text{ anything } [\text{sss}] \quad (4.6 \pm 0.5 \text{ ) \%} \\

\textbf{D, D*, or D_s modes}

\[ D^\pm \text{ anything } \quad (23.7 \pm 1.3 \text{ ) \%} \\
D^0 / \bar{D}^0 \text{ anything } \quad (62.7 \pm 2.9 \text{ ) \%} \quad S=1.3 \\
D^*(2010)^\pm \text{ anything } \quad (22.5 \pm 1.5 \text{ ) \%} \\
D^*(2007)^0 \text{ anything } \quad (26.0 \pm 2.7 \text{ ) \%} \\
D_s^\pm \text{ anything } [\text{gg}] \quad (8.3 \pm 0.8 \text{ ) \%} \\
D_s^{*\pm} \text{ anything } \quad (6.3 \pm 1.0 \text{ ) \%} \\
D_s^{*\pm} \bar{\psi}(*) \quad (3.4 \pm 0.6 \text{ ) \%} \\
D^{(*)} \bar{\psi}(*) K^0 + [\text{gg,lla}] \quad (7.1 \pm 2.7 \text{ ) \%} \\
D^{(*)} \bar{\psi}(*) K^\pm \\
\]

\[ b \rightarrow c \tau s \quad (22 \pm 4 \text{ ) \%} \\
D_s^{(*)} \bar{\psi}(*) [\text{gg,lla}] \quad (3.9 \pm 0.4 \text{ ) \%} \\
D_s^* D^*(2010)^\pm [\text{gg}] < 5.9 \times 10^{-3} \quad \text{CL}=90\% \quad 1711 \\
D_s^* D^*(2010)^\pm + D^* D^\pm [\text{gg}] < 5.5 \times 10^{-3} \quad \text{CL}=90\% \\
D_s D^\pm [\text{gg}] < 3.1 \times 10^{-3} \quad \text{CL}=90\% \quad 1866 \\
D_s^{(*)} \bar{\psi}(*) X(n\pi^\pm) [\text{gg,lla}] \quad (9 \pm 5 \text{ ) \%} \\
D^*(2010)^\gamma < 1.1 \times 10^{-3} \quad \text{CL}=90\% \quad 2257 \\
D_s^+ \pi^-, D_s^+ \pi^-, D_s^+ \rho^-, [\text{gg}] < 4 \times 10^{-4} \quad \text{CL}=90\% \\
\]

\textbf{Charmonium modes}

\[ J/\psi(1S) \text{ anything } \quad (1.094\pm 0.032 \text{ ) \%} \quad S=1.1 \\
J/\psi(1S) \text{ (direct) anything } \quad (7.8 \pm 0.4 \text{ ) } \times 10^{-3} \quad S=1.1 \\
\psi(2S) \text{ anything } \quad (3.07 \pm 0.21 \text{ ) } \times 10^{-3} \\
\chi_{c1}(1P) \text{ anything } \quad (3.86 \pm 0.27 \text{ ) } \times 10^{-3} \\
\chi_{c1}(1P) \text{ (direct) anything } \quad (3.24 \pm 0.25 \text{ ) } \times 10^{-3} \\
\chi_{c2}(1P) \text{ anything } \quad (1.4 \pm 0.4 \text{ ) } \times 10^{-3} \quad S=1.9 \\
\chi_{c2}(1P) \text{ (direct) anything } \quad (1.65 \pm 0.31 \text{ ) } \times 10^{-3} \\
\eta_c(1S) \text{ anything } < 9 \times 10^{-3} \quad \text{CL}=90\% \\
K X(3872) \times B(X \rightarrow D^0 \bar{D}^0 \pi^0) < 1.2 \pm 0.4 \times 10^{-4} \quad 1141 \]
\[ K \times (3872) \times B(X \rightarrow D^{*0} D^0) \]
\[ K \times (3940) \times B(X \rightarrow D^{*0} D^0) \]
\[ K_{\chi c0}(2P), \chi c0 \rightarrow \omega J/\psi [nnaa] \]

### K or K* modes

- \( K^+ \) anything \([gg]\): \(78.9 \pm 2.5\)%
- \( K^+ \) anything: \(66 \pm 5\)%
- \( K^- \) anything: \(13 \pm 4\)%
- \( K^0/\bar{K}^0 \) anything \([gg]\): \(64 \pm 4\)%
- \( K^*(892) \) anything: \(18 \pm 6\)%
- \( K^*(892)^0/\bar{K}^*(892)^0 \) anything \([gg]\): \(14.6 \pm 2.6\)%
- \( K^*(892) \gamma \): \((4.2 \pm 0.6) \times 10^{-5}\)
- \( \eta K \gamma \): \((8.5 \pm 1.8) \times 10^{-6}\)
- \( K_{1}(1400) \gamma \): \(<1.27 \times 10^{-4}\) CL=90% 2453
- \( K_{2}^{*}(1430) \gamma \): \((1.7 \pm 0.6) \times 10^{-5}\)
- \( K_{2}(1770) \gamma \): \(<1.2 \times 10^{-3}\) CL=90% 2342
- \( K_{3}^{*}(1780) \gamma \): \(<3.7 \times 10^{-5}\) CL=90% 2341
- \( K_{4}^{*}(2045) \gamma \): \(<1.0 \times 10^{-3}\) CL=90% 2244
- \( K \eta' \): \((8.3 \pm 1.1) \times 10^{-5}\)
- \( K^*(892) \eta' \): \((4.1 \pm 1.1) \times 10^{-6}\)
- \( K \eta \): \(<5.2 \times 10^{-6}\) CL=90% 2588
- \( K^*(892) \eta \): \((1.8 \pm 0.5) \times 10^{-5}\)
- \( K \phi \): \((2.3 \pm 0.9) \times 10^{-6}\)
- \( \bar{B} \rightarrow \pi \gamma \): \((3.40 \pm 0.21) \times 10^{-4}\)
- \( \bar{B} \rightarrow \eta \gamma \): \((9.2 \pm 3.0) \times 10^{-6}\)
- \( \bar{B} \rightarrow \pi \text{gluon} \): \(<6.8\)% CL=90%
- \( \eta \) anything: \((2.6 \pm 0.5) \times 10^{-4}\)
- \( \eta' \) anything: \((4.2 \pm 0.9) \times 10^{-4}\)
- \( K^+ \) gluon (charmless): \(<1.87 \times 10^{-4}\) CL=90%
- \( K^0 \) gluon (charmless): \((1.9 \pm 0.7) \times 10^{-4}\)

### Light unflavored meson modes

- \( \rho \gamma \): \((1.39 \pm 0.25) \times 10^{-6}\) S=1.2 2583
- \( \rho/\omega \gamma \): \((1.30 \pm 0.23) \times 10^{-6}\) S=1.2
- \( \pi^\pm \) anything \([gg,ooaa]\): \((358 \pm 7)\)%
- \( \pi^0 \) anything: \((235 \pm 11)\)%
- \( \eta \) anything: \((17.6 \pm 1.6)\)%
- \( \rho^0 \) anything: \((21 \pm 5)\)%
- \( \omega \) anything: \(<81\)% CL=90%
\[
\phi \text{ anything} \quad (3.43 \pm 0.12) \%
\]
\[
\phi K^*(892) \quad < 2.2 \times 10^{-5} \text{ CL=90\%} \quad 2460
\]
\[
\pi^+ \text{ gluon (charmless)} \quad (3.7 \pm 0.8) \times 10^{-4} \quad -
\]

**Baryon modes**

\[
\Lambda_c^+ / \overline{\Lambda_c^-} \text{ anything} \quad (4.5 \pm 1.2) \%
\]
\[
\Lambda_c^- \text{ anything} \quad < 1.7 \% \quad \text{CL}=90\% \quad -
\]
\[
\Lambda_c^- \text{ anything} \quad < 9 \% \quad \text{CL}=90\% \quad -
\]
\[
\Lambda_c^- \ell^+ \text{ anything} \quad < 1.1 \times 10^{-3} \text{ CL=90\%} \quad -
\]
\[
\Lambda_c^- e^+ \text{ anything} \quad < 2.3 \times 10^{-3} \text{ CL=90\%} \quad -
\]
\[
\Lambda_c^- \mu^+ \text{ anything} \quad < -1.8 \times 10^{-3} \text{ CL=90\%} \quad -
\]
\[
\Lambda_c^- p \text{ anything} \quad (2.6 \pm 0.8) \%
\]
\[
\Lambda_c^- p e^+ \nu_e \quad < 1.0 \times 10^{-3} \text{ CL=90\%} \quad 2021
\]
\[
\Sigma_c^- \text{ anything} \quad (4.2 \pm 2.4) \times 10^{-3} \quad -
\]
\[
\Sigma_c^- \text{ anything} \quad < 9.6 \times 10^{-3} \text{ CL=90\%} \quad -
\]
\[
\Sigma_c^- \text{ anything} \quad (4.6 \pm 2.4) \times 10^{-3} \quad -
\]
\[
\Sigma_c^0 N(N = p \text{ or } n) \quad < 1.5 \times 10^{-3} \text{ CL=90\%} \quad 1938
\]
\[
\Xi_c^0 \text{ anything} \quad (1.93 \pm 0.30) \times 10^{-4} \quad S=1.1 \quad -
\]
\[
\times B(\Xi_c^0 \rightarrow \Xi^- \pi^+)
\]
\[
\Xi_c^+ \text{ anything} \quad (4.5 \pm 1.3) \times 10^{-4} \quad -
\]
\[
\times B(\Xi_c^+ \rightarrow \Xi^- \pi^+ \pi^+) \quad -
\]
\[
p/\overline{p} \text{ anything} \quad [gg] \quad (8.0 \pm 0.4) \% \quad -
\]
\[
p/\overline{p} \text{ (direct) anything} \quad [gg] \quad (5.5 \pm 0.5) \% \quad -
\]
\[
\Lambda/\overline{\Lambda} \text{ anything} \quad [gg] \quad (4.0 \pm 0.5) \% \quad -
\]
\[
\Xi^-/\Xi^+ \text{ anything} \quad [gg] \quad (2.7 \pm 0.6) \times 10^{-3} \quad -
\]
\[
baryons \text{ anything} \quad (6.8 \pm 0.6) \% \quad -
\]
\[
p\overline{p} \text{ anything} \quad (2.47 \pm 0.23) \% \quad -
\]
\[
\Lambda p/\overline{\Lambda} p \text{ anything} \quad [gg] \quad (2.5 \pm 0.4) \% \quad -
\]
\[
\Lambda/\overline{\Lambda} \text{ anything} \quad < 5 \times 10^{-3} \text{ CL=90\%} \quad -
\]

**Lepton Family number (LF) violating modes or \( \Delta B = 1 \) weak neutral current (B1) modes**

\[
s e^+ e^- \quad B1 \quad (4.7 \pm 1.3) \times 10^{-6} \quad -
\]
\[
s \mu^+ \mu^- \quad B1 \quad (4.3 \pm 1.2) \times 10^{-6} \quad -
\]
\[
s \ell^+ \ell^- \quad B1 \quad (4.5 \pm 1.0) \times 10^{-6} \quad -
\]
\[
\pi \ell^+ \ell^- \quad B1 \quad < 5.9 \times 10^{-8} \text{ CL=90\%} \quad 2638
\]
\[
\pi e^+ e^- \quad < 1.10 \times 10^{-7} \text{ CL=90\%} \quad 2638
\]
\[
\pi \mu^+ \mu^- \quad < 5.0 \times 10^{-8} \text{ CL=90\%} \quad 2634
\]
\[
K e^+ e^- \quad B1 \quad (4.4 \pm 0.6) \times 10^{-7} \quad 2617
\]
\[
K^*(892) e^+ e^- \quad B1 \quad (1.19 \pm 0.20) \times 10^{-6} \quad S=1.2 \quad 2564
\]
\[
K \mu^+ \mu^- \quad B1 \quad (4.4 \pm 0.4) \times 10^{-7} \quad 2612
\]
\[
K^*(892) \mu^+ \mu^- \quad B1 \quad (1.06 \pm 0.09) \times 10^{-6} \quad 2560
\]
These measurements are for an admixture of bottom particles at high energy (LHC, LEP, Tevatron, SpPs).

Mean life $\tau = (1.568 \pm 0.009) \times 10^{-12}$ s

Mean life $\tau = (1.72 \pm 0.10) \times 10^{-12}$ s Charged $b$-hadron admixture

Mean life $\tau = (1.58 \pm 0.14) \times 10^{-12}$ s Neutral $b$-hadron admixture

$\tau_{charged \ b-hadron}/\tau_{neutral \ b-hadron} = 1.09 \pm 0.13$

$|\Delta \tau_b|/\tau_{b,\overline{b}} = -0.001 \pm 0.014$

$\text{Re}(\epsilon_b) / (1 + |\epsilon_b|^2) = (1.2 \pm 0.4) \times 10^{-3}$

The branching fraction measurements are for an admixture of $B$ mesons and baryons at energies above the $\Upsilon(4S)$. Only the highest energy results (LHC, LEP, Tevatron, SpPs) are used in the branching fraction averages. In the following, we assume that the production fractions are the same at the LHC, LEP, and at the Tevatron.

For inclusive branching fractions, e.g., $B \rightarrow D^{\pm}$ anything, the values usually are multiplicities, not branching fractions. They can be greater than one.

The modes below are listed for a $\overline{b}$ initial state. $b$ modes are their charge conjugates. Reactions indicate the weak decay vertex and do not include mixing.

**PRODUCTION FRACTIONS**

The production fractions for weakly decaying $b$-hadrons at high energy have been calculated from the best values of mean lives, mixing parameters, and branching fractions in this edition by the Heavy Flavor Averaging Group (HFAG) as described in the note "$B^0-\overline{B^0}$ Mixing" in the $B^0$ Particle Listings. The production fractions in $b$-hadronic $Z$ decay or $p\overline{p}$ collisions at the Tevatron are also listed at the end of the section. Values assume $B(\overline{b} \rightarrow B^+) = B(\overline{b} \rightarrow B^0)$
\[ B(\mathcal{B} \to B^+) + B(\mathcal{B} \to B^0) + B(\mathcal{B} \to B^0_s) + B(b \to b\text{-baryon}) = 100\% \]

The correlation coefficients between production fractions are also reported:

\[
\begin{align*}
\text{cor}(B^0_s, b\text{-baryon}) &= -0.291 \\
\text{cor}(B^0_s, B^{\pm=0}) &= -0.083 \\
\text{cor}(b\text{-baryon}, B^{\pm=0}) &= -0.929.
\end{align*}
\]

Note these production fractions are not the conventional branching fractions of \( b \)-quark to a \( B \)-hadron, which may have considerable dependence on the initial and final state kinematic and production environment.

<table>
<thead>
<tr>
<th>( \mathcal{B} ) DECA Y MODES</th>
<th>Fraction ((\Gamma_{i}/\Gamma))</th>
<th>Scale factor/Confidence level</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( B^+ )</td>
<td>( 40.2 \pm 0.7 ) %</td>
<td>(-)</td>
<td>(-)</td>
</tr>
<tr>
<td>( B^0 )</td>
<td>( 40.2 \pm 0.7 ) %</td>
<td>(-)</td>
<td>(-)</td>
</tr>
<tr>
<td>( B^0_s )</td>
<td>( 10.5 \pm 0.6 ) %</td>
<td>(-)</td>
<td>(-)</td>
</tr>
<tr>
<td>( b\text{-baryon} )</td>
<td>( 9.2 \pm 1.5 ) %</td>
<td>(-)</td>
<td>(-)</td>
</tr>
</tbody>
</table>

**DECAY MODES**

**Semileptonic and leptonic modes**

\[ \nu \text{ anything} \]
\[ \ell^+ \nu_{\ell} \text{ anything} \]
\[ e^+ \nu_e \text{ anything} \]
\[ \mu^+ \nu_{\mu} \text{ anything} \]
\[ D^- \ell^+ \nu_{\ell} \text{ anything} \]
\[ D^- \pi^+ \ell^+ \nu_{\ell} \text{ anything} \]
\[ D^- \pi^- \ell^+ \nu_{\ell} \text{ anything} \]
\[ \overline{D}^0 \ell^+ \nu_{\ell} \text{ anything} \]
\[ \overline{D}^0 \pi^- \ell^+ \nu_{\ell} \text{ anything} \]
\[ \overline{D}^0 \pi^+ \ell^+ \nu_{\ell} \text{ anything} \]
\[ D^{*-} \ell^+ \nu_{\ell} \text{ anything} \]
\[ D^{*-} \pi^- \ell^+ \nu_{\ell} \text{ anything} \]
\[ D^{*-} \pi^+ \ell^+ \nu_{\ell} \text{ anything} \]
\[ \overline{D}^0_j \ell^+ \nu_{\ell} \text{ anything} \times [ss,ppa,aa] \]
\[ \text{B}(\overline{D}^0_j \to D^{*- \pi^-}) \]
\[ D^- \ell^+ \nu_{\ell} \text{ anything} \times [ss,ppa,aa] \]
\[ \text{B}(D^- \to D^0 \pi^-) \]
\[ \bar{D}_2^*(2460)^0 \ell^+ \nu_\ell \text{anything} \times B(\bar{D}_2^*(2460)^0 \rightarrow D^*\pi^+) < 1.4 \times 10^{-3} \text{ CL}=90\% \]

\[ D_2^*(2460)^- \ell^+ \nu_\ell \text{anything} \times B(D_2^*(2460)^- \rightarrow D^0\pi^-) \]
\[ (4.2 \pm 1.5) \times 10^{-3} \]

\[ \bar{D}_2^*(2460)^0 \ell^+ \nu_\ell \text{anything} \times B(\bar{D}_2^*(2460)^0 \rightarrow D^-\pi^+) \]
\[ (1.6 \pm 0.8) \times 10^{-3} \]

charmless \( \ell \bar{\nu}_\ell \)
\[ [ss] (1.7 \pm 0.5) \times 10^{-3} \]

\( \tau^+ \nu_\tau \) anything
\[ (2.41 \pm 0.23) \% \]

\( D^+\tau^- \nu_\tau \) anything
\[ (9 \pm 4) \times 10^{-3} \]

\( \bar{\tau} \rightarrow \ell^- \bar{\nu}_\ell \) anything
\[ [ss] (8.02 \pm 0.19) \% \]

\( c \rightarrow \ell^+ \nu \) anything
\[ (1.6 \pm 0.4) \% \]

Charmed meson and baryon modes

\( \bar{D}^0 \) anything
\[ (59.8 \pm 2.9) \% \]

\( D^0 D_s^\pm \) anything
\[ [gg] (9.1 \pm 4.0) \% \]

\( D^\mp D_s^\pm \) anything
\[ [gg] (4.0 \pm 2.3) \% \]

\( \bar{D}^0 D^0 \) anything
\[ [gg] (5.1 \pm 2.0) \% \]

\( D^0 D^\pm \) anything
\[ [gg] (2.7 \pm 1.8) \% \]

\( D^\pm D^\mp \) anything
\[ [gg] < 9 \times 10^{-3} \text{ CL}=90\% \]

\( D^- \) anything
\[ (23.3 \pm 1.7) \% \]

\( D^*(2010)^+ \) anything
\[ (17.3 \pm 2.0) \% \]

\( D_1(2420)^0 \) anything
\[ (5.0 \pm 1.5) \% \]

\( D^*(2010)^\mp D_s^\pm \) anything
\[ [gg] (3.3 \pm 1.6) \% \]

\( D^0 D^*(2010)^\pm \) anything
\[ [gg] (3.0 \pm 1.1) \% \]

\( D^*(2010)^\pm D^\mp \) anything
\[ [gg] (2.5 \pm 1.2) \% \]

\( D^*(2010)^\pm D^*(2010)^\mp \) anything
\[ [gg] (1.2 \pm 0.4) \% \]

\( \bar{D}D \) anything
\[ (10 \pm 11) \% \]

\( D_2^*(2460)^0 \) anything
\[ (4.7 \pm 2.7) \% \]

\( D_s^- \) anything
\[ (14.7 \pm 2.1) \% \]

\( D_s^+ \) anything
\[ (10.1 \pm 3.1) \% \]

\( \Lambda_c^+ \) anything
\[ (9.7 \pm 2.9) \% \]

\( \bar{\tau}/c \) anything
\[ [ooaa] (116.2 \pm 3.2) \% \]
Charmonium modes

\[ J/\psi (1S) \text{anything} \quad (1.16 \pm 0.10) \% \quad - \]
\[ \psi (2S) \text{anything} \quad (2.83 \pm 0.29) \times 10^{-3} \quad - \]
\[ \chi_{c1}(1P) \text{anything} \quad (1.4 \pm 0.4) \% \quad - \]

\[ K \text{ or } K^* \text{ modes} \]

\[ \Upsilon \gamma \quad (3.1 \pm 1.1) \times 10^{-4} \quad - \]
\[ \Upsilon \pi \nu \quad B1 \quad < 6.4 \times 10^{-4} \quad \text{CL=90}\% \quad - \]
\[ K^{\pm} \text{anything} \quad (74 \pm 6) \% \quad - \]
\[ K^0_S \text{anything} \quad (29.0 \pm 2.9) \% \quad - \]

Pion modes

\[ \pi^\pm \text{anything} \quad (397 \pm 21) \% \quad - \]
\[ \pi^0 \text{anything} \quad [ooaa] \quad (278 \pm 60) \% \quad - \]
\[ \phi \text{anything} \quad (2.82 \pm 0.23) \% \quad - \]

Baryon modes

\[ p/\overline{p} \text{anything} \quad (13.1 \pm 1.1) \% \quad - \]
\[ \Lambda/\overline{\Lambda} \text{anything} \quad (5.9 \pm 0.6) \% \quad - \]
\[ b \text{-baryon anything} \quad (10.2 \pm 2.8) \% \quad - \]

Other modes

charged anything \quad [ooaa] \quad (497 \pm 7) \% \quad -

hadron^+ hadron^- \quad (1.7 \pm 1.0) \times 10^{-5} \quad -

charmless \quad (7 \pm 21) \times 10^{-3} \quad -

\[ \Delta B = 1 \text{ weak neutral current (B1) modes} \]

\[ \mu^+ \mu^- \text{anything} \quad B1 \quad < 3.2 \times 10^{-4} \quad \text{CL=90}\% \quad - \]

\[ B^* \]

\[ I(J^P) = \frac{1}{2}(1^-) \]

\[ I, J, P \text{ need confirmation. Quantum numbers shown are quark-model predictions.} \]
\[ \text{Mass } m_{B^*} = 5325.2 \pm 0.4 \text{ MeV} \]
\[ m_{B^+} - m_B = 45.78 \pm 0.35 \text{ MeV} \]
\[ m_{B^{++}} - m_{B^+} = 45.0 \pm 0.4 \text{ MeV} \]

\[ B^* \text{ DECAY MODES} \]

<table>
<thead>
<tr>
<th>Fraction (\Gamma_i/\Gamma)</th>
<th>p (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>dominant</td>
<td>45</td>
</tr>
</tbody>
</table>

\[ B_1(5721)^0 \]

\[ I(J^P) = \frac{1}{2}(1^+) \]

\[ I, J, P \text{ need confirmation.} \]
\[ B_1(5721)^0 \text{ MASS } = 5723.5 \pm 2.0 \text{ MeV} \quad (S = 1.1) \]
\[ m_{B_1^0} - m_{B^+} = 444.3 \pm 2.0 \text{ MeV} \quad (S = 1.1) \]
\( B_1^{(5721)} \) \textbf{DECAY MODES}  
\begin{array}{lll} 
\ hpp & (\Gamma_i/\Gamma) & p \text{ (MeV/c)} \\
\ hpp & \text{dominant} & - \\
\end{array}

\[ \left[ B_2^*,(5747) \right]^0 \]

\( I(J^P) = \frac{1}{2} (2^+) \)
\( I, J, P \) need confirmation.

\( B_2^* (5747)^0 \) \text{MASS} = 5743 \pm 5 \text{ MeV} \quad (S = 2.9)

\( \text{Full width } \Gamma = 23^{+5}_{-11} \text{ MeV} \)
\( m_{B_2^0} - m_{B_1^0} = 19 \pm 6 \text{ MeV} \quad (S = 3.0) \)

\( B_2^* (5747)^0 \) \textbf{DECAY MODES}  
\begin{array}{lll} 
\ hpp & (\Gamma_i/\Gamma) & p \text{ (MeV/c)} \\
\ hpp & \text{dominant} & 424 \\
\ hpp & \text{dominant} & - \\
\end{array}

\textbf{BOTTOM, STRANGE MESONS}  
\(( B = \pm 1, S = \mp 1) \)

\( B_s^0 = s \bar{b}, \bar{B}_s^0 = \bar{s} b, \) similarly for \( B_s^* \)’s

\[ \left[ B_s^0 \right] \]

\( I(J^P) = 0(0^-) \)

\( I, J, P \) need confirmation. Quantum numbers shown are quark-model predictions.

\( \text{Mass } m_{B_s^0} = 5366.77 \pm 0.24 \text{ MeV} \)
\( m_{B_s^0} - m_B = 87.35 \pm 0.23 \text{ MeV} \)

\( \text{Mean life } \tau = (1.512 \pm 0.007) \times 10^{-12} \text{ s} \)
\( c\tau = 453.3 \text{ } \mu \text{m} \)

\( \Delta \Gamma_{B_s^0} = \Gamma_{B_s^{0L}} - \Gamma_{B_s^{0H}} = (0.091 \pm 0.008) \times 10^{12} \text{ s}^{-1} \)

\( B_s^0 - \bar{B}_s^0 \) \textbf{mixing parameters}  
\( \Delta m_{B_s^0} = m_{B_{sH}^0} - m_{B_{sL}^0} = (17.761 \pm 0.022) \times 10^{12} \text{ } \hbar \text{ s}^{-1} \)
\( = (1.1691 \pm 0.0014) \times 10^{-8} \text{ MeV} \)

\( \chi_s = \Delta m_{B_s^0}/\Gamma_{B_s^0} = 26.85 \pm 0.13 \)
\( \chi_s = 0.499311 \pm 0.000007 \)
\section*{CP violation parameters in $B_s^0$}

\begin{align*}
\Re(\epsilon_{B_s^0}) / (1 + |\epsilon_{B_s^0}|^2) &= (-1.9 \pm 1.0) \times 10^{-3} \\
C_{KK}(B_s^0 \to K^+ K^-) &= 0.14 \pm 0.11 \\
S_{KK}(B_s^0 \to K^+ K^-) &= 0.30 \pm 0.13 \\
CP\ Violation phase $\beta_s &= (0.0 \pm 3.5) \times 10^{-2} \\
A_{CP}(B_s \to \pi^+ K^-) &= 0.28 \pm 0.04 \\
A_{CP}(B_s^0 \to [K^+ K^-]_D K^*(892)^0) &= 0.04 \pm 0.16
\end{align*}

These branching fractions all scale with $B(\overline{B} \to B_s^0)$.

The branching fraction $B(B_s^0 \to D_s^- \ell^+ \nu_\ell\text{ anything})$ is not a pure measurement since the measured product branching fraction $B(\overline{B} \to B_s^0) \times B(B_s^0 \to D_s^- \ell^+ \nu_\ell\text{ anything})$ was used to determine $B(\overline{B} \to B_s^0)$, as described in the note on “$B^0$-$\overline{B}^0$ Mixing.”

For inclusive branching fractions, e.g., $B \to D^{\pm}\text{ anything}$, the values usually are multiplicities, not branching fractions. They can be greater than one.

### $B_s^0$ Decay Modes

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>Scale factor/Confidence level</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_s^-\text{ anything}$</td>
<td>(93 ± 25 )%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$\ell \nu_\ell X$</td>
<td>(10.5 ± 0.8 )%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$D_s^- \ell^+ \nu_\ell\text{ anything}$</td>
<td>[qqaa]</td>
<td>( 7.9 ± 2.4 )%</td>
<td>-</td>
</tr>
<tr>
<td>$D_{s1}(2536)^- \mu^+ \nu_\mu$, $D_{s1}^0 \to D_s^- K_S^0$</td>
<td>( 2.5 ± 0.7 ) × 10^{-3}</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$D_{s1}(2536)^- X \mu^+ \nu_\mu$, $D_{s1}^0 \to D_s^- K^+$</td>
<td>( 4.3 ± 1.7 ) × 10^{-3}</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$D_{s2}(2573)^- X \mu^+ \nu_\mu$, $D_{s2}^0 \to D_s^- K^+$</td>
<td>( 2.6 ± 1.2 ) × 10^{-3}</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$D_s^- \pi^+$</td>
<td>( 3.04 ± 0.23 ) × 10^{-3}</td>
<td>2320</td>
<td>-</td>
</tr>
<tr>
<td>$D_s^- \rho^+$</td>
<td>( 7.0 ± 1.5 ) × 10^{-3}</td>
<td>2249</td>
<td>-</td>
</tr>
<tr>
<td>$D_s^- \pi^+\pi^+\pi^-$</td>
<td>( 6.3 ± 1.1 ) × 10^{-3}</td>
<td>2301</td>
<td>-</td>
</tr>
<tr>
<td>$D_{s1}(2536)^- \pi^+$, $D_{s1}^0 \to D_s^- \pi^+\pi^-$</td>
<td>( 2.5 ± 0.8 ) × 10^{-5}</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$D_s^\mp K^\pm$</td>
<td>( 2.03± 0.28) × 10^{-4}</td>
<td>S=1.3</td>
<td>2293</td>
</tr>
<tr>
<td>$D_s^- K^+\pi^+\pi^-$</td>
<td>( 3.3 ± 0.7) × 10^{-4}</td>
<td>-</td>
<td>2249</td>
</tr>
<tr>
<td>$D_s^+ D_s^-$</td>
<td>( 4.4 ± 0.5 ) × 10^{-3}</td>
<td>1824</td>
<td>-</td>
</tr>
<tr>
<td>$D_s^- D^+$</td>
<td>( 3.6 ± 0.8 ) × 10^{-4}</td>
<td>1875</td>
<td>-</td>
</tr>
<tr>
<td>$D^+ D^-$</td>
<td>( 2.2 ± 0.6 ) × 10^{-4}</td>
<td>1925</td>
<td>-</td>
</tr>
<tr>
<td>$D^0\overline{D}^0$</td>
<td>( 1.9 ± 0.5) × 10^{-4}</td>
<td>-</td>
<td>1929</td>
</tr>
</tbody>
</table>
$D^+_s \pi^+$ 
$D^{*}_s \rho^+$ 
$D^{*+} D^{*-}_s + D^{*-} D^{*}_s$ 
$D^{*+} D^{*-}_s$ 
$D^{(*)+}_s D^{(*)-}_s$ 
$\overline{D}^0 K^+ \pi^+_s$ 
$\overline{D}^0 \overline{K^*}_{(892)}^0$ 
$\overline{D}^0 \phi$ 
$D^{*+} \pi^\pm$ 
$J/\psi (1S) \phi$ 
$J/\psi (1S) \pi^0$ 
$J/\psi (1S) \eta$ 
$J/\psi (1S) K^0_S$ 
$J/\psi (1S) K^+ K^-$ 
$J/\psi (1S) K^* (892)^0$ 
$J/\psi (1S) \eta'$ 
$J/\psi (1S) \pi^+ \pi^-$ 
$J/\psi (1S) f_0 (980)$, $f_0 \to$ 
$J/\psi (1S) f_0 (1370)$, $f_0 \to$ 
$J/\psi (1S) f_2 (1270)$, $f_2 \to$ 
$J/\psi (1S) \pi^+ \pi^-$ (nonresonant) 
$J/\psi (1S) K^+ K^-$ 
$J/\psi (1S) f'_2 (1525)$ 
$J/\psi (1S) p\overline{p}$ 
$\psi (2S) \eta$ 
$\psi (2S) \pi^+ \pi^-$ 
$\psi (2S) \phi$ 
$\chi_{c1} \phi$ 
$\pi^+ \pi^- \pi^0 \eta^0$ 
$\eta \pi^0$ 
$\eta \eta$ 
$\rho^0 \rho^0$ 
$\phi \rho^0$ 
$\phi \phi$ 
$\pi^+ K^-$ 
$K^+ K^-$ 
$K^0 \overline{K^0}$ 
$K^0 \pi^+ \pi^-$ 

$\begin{array}{ll}
  (2.0 \pm 0.5) \times 10^{-3} & 2265 \\
  (9.7 \pm 2.2) \times 10^{-3} & 2191 \\
  1.28 \pm 0.23 \% & S=1.2 1742 \\
  1.85 \pm 0.30 \% & 1655 \\
  (4.5 \pm 1.4) \% & - \\
  (9.9 \pm 1.5) \times 10^{-4} & 2312 \\
  (3.5 \pm 0.6) \times 10^{-4} & 2264 \\
  (4.2 \pm 1.9) \times 10^{-5} & 2242 \\
  (2.4 \pm 0.7) \times 10^{-5} & 2235 \\
  < 6.1 \times 10^{-6} & \text{CL=90\%} - \\
  (1.07 \pm 0.09) \times 10^{-3} & 1588 \\
  < 1.2 \times 10^{-3} & \text{CL=90\%} 1786 \\
  (4.0 \pm 0.7) \times 10^{-4} & 1733 \\
  (1.87 \pm 0.17) \times 10^{-5} & 1743 \\
  (4.4 \pm 0.9) \times 10^{-5} & 1637 \\
  (3.4 \pm 0.5) \times 10^{-4} & 1612 \\
  (2.12 \pm 0.19) \times 10^{-4} & 1775 \\
  (1.39 \pm 0.14) \times 10^{-4} & - \\
  (3.9 \pm 0.8 \pm 1.8) \times 10^{-5} & - \\
  (1.1 \pm 0.4 \pm 2.0 \pm 3.0) \times 10^{-4} & - \\
  (1.8 \pm 1.1 \pm 0.4 \pm 0.3) \times 10^{-5} & 1775 \\
  (7.9 \pm 0.7) \times 10^{-4} & 1601 \\
  (2.6 \pm 0.6 \pm 0.5 \pm 0.3) \times 10^{-4} & 1304 \\
  < 4.8 \times 10^{-6} & \text{CL=90\%} 982 \\
  (3.3 \pm 0.9 \pm 1.5 \pm 2.3) \times 10^{-4} & 1338 \\
  (7.2 \pm 1.2 \pm 2.3 \pm 3.4) \times 10^{-5} & 1397 \\
  (5.4 \pm 0.6 \pm 1.5 \pm 2.9) \times 10^{-4} & 1120 \\
  (2.02 \pm 0.30 \pm 0.50 \pm 0.60) \times 10^{-4} & 1274 \\
  (7.6 \pm 1.9 \pm 2.3 \pm 3.8) \times 10^{-7} & S=1.4 2680 \\
  < 2.1 \times 10^{-4} & \text{CL=90\%} 2680 \\
  < 1.0 \times 10^{-3} & \text{CL=90\%} 2654 \\
  < 1.5 \times 10^{-3} & \text{CL=90\%} 2627 \\
  < 3.20 \times 10^{-4} & \text{CL=90\%} 2569 \\
  < 6.17 \times 10^{-4} & \text{CL=90\%} 2526 \\
  (1.91 \pm 0.31 \pm 0.50 \pm 0.60) \times 10^{-5} & 2482 \\
  (5.5 \pm 0.6 \pm 1.0 \pm 1.5) \times 10^{-6} & 2659 \\
  (2.49 \pm 0.17 \pm 0.30 \pm 0.45) \times 10^{-5} & 2638 \\
  < 6.6 \times 10^{-5} & \text{CL=90\%} 2637 \\
  (1.9 \pm 0.5 \pm 1.0 \pm 1.5) \times 10^{-5} & 2653 \\
\end{array}
\[ K^0 K^{\pm} \pi^{\mp} \quad (9.7 \pm 1.7) \times 10^{-5} \quad 2622 \]
\[ K^0 K^+ K^- \quad < 4 \times 10^{-6} \quad \text{CL=90\%} \quad 2568 \]
\[ K^*(892)^0 \rho^0 \quad < 7.67 \times 10^{-4} \quad \text{CL=90\%} \quad 2550 \]
\[ K^*(892)^0 K^*(892)^0 \quad (2.8 \pm 0.7) \times 10^{-5} \quad 2531 \]
\[ \phi K^*(892)^0 \quad (1.13 \pm 0.30) \times 10^{-6} \quad 2507 \]
\[ \rho \bar{\rho} \quad (2.8 \pm 2.2_{-1.7}^{+2.2}) \times 10^{-8} \quad 2514 \]
\[ \Lambda_c^- \Lambda^+ \quad (3.6 \pm 1.6) \times 10^{-4} \quad \text{CL=90\%} \quad 2568 \]
\[ \gamma \gamma \quad B1 \quad < 8.7 \times 10^{-6} \quad \text{CL=90\%} \quad 2683 \]
\[ \phi \gamma \quad (3.6 \pm 0.4) \times 10^{-5} \quad 2587 \]

Lepton Family number (LF) violating modes or \( \Delta B = 1 \) weak neutral current (B1) modes

| \( \mu^+ \mu^- \) | B1 | \( (3.1 \pm 0.7) \times 10^{-9} \) | 2681 |
| \( e^+ e^- \) | B1 | \( < 2.8 \times 10^{-7} \) | 2683 |
| \( e^\pm \mu^\mp \) | LF, [gg] | \( < 1.1 \times 10^{-8} \) | 2682 |
| \( \mu^+ \mu^- \mu^+ \mu^- \) | [ggaa] | \( < 1.2 \times 10^{-8} \) | 2673 |
| \( \phi(1020) \mu^+ \mu^- \) | B1 | \( (7.6 \pm 1.5) \times 10^{-7} \) | 2582 |
| \( \phi \nu \bar{\nu} \) | B1 | \( < 5.4 \times 10^{-3} \) | 2587 |

**B**

\[ I(J^P) = 0(1^-) \]

I, J, P need confirmation. Quantum numbers shown are quark-model predictions.

\[ m = 5415.4^{+2.4}_{-2.1} \text{ MeV} \quad (S = 3.0) \]

\[ m_{B^+} - m_{B_s} = 48.7^{+2.3}_{-2.1} \text{ MeV} \quad (S = 2.8) \]

**B**

**B**

\[ I(J^P) = 0(1^-) \]

I, J, P need confirmation.

\[ m = 5828.7 \pm 0.4 \text{ MeV} \quad (S = 1.2) \]

\[ m_{B_{s1}^0} - m_{B_{s1}^{++}} = 504.41 \pm 0.25 \text{ MeV} \]

**B**

**B**

\[ I(J^P) = 0(1^-) \]

I, J, P need confirmation.
\( B_{s2}^{*}(5840)^0 \)

\[
I(J^P) = 0(2^+) \\
I, J, P \text{ need confirmation.}
\]

Mass \( m = 5839.96 \pm 0.20 \text{ MeV} \)

\[
m_{B_{s2}^{*0}} - m_{B_{s1}^0} = 10.5 \pm 0.6 \text{ MeV}
\]

Full width \( \Gamma = 1.6 \pm 0.5 \text{ MeV} \)

**\( B_{s2}^{*}(5840)^0 \) DECAY MODES**

<table>
<thead>
<tr>
<th>Mode</th>
<th>( \Gamma_i/\Gamma )</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( B^+ K^- )</td>
<td>dominant</td>
<td>253</td>
</tr>
</tbody>
</table>

**BOTTOM, CHARMED MESONS**

\((B = C = \pm 1)\)

\( B_c^+ = c\bar{b}, B_c^- = \tau b, \) similarly for \( B_c^* \)’s

\( B_c^{\pm} \)

\[
I(J^P) = 0(0^-) \\
I, J, P \text{ need confirmation.}
\]

Quantum numbers shown are quark-model predictions.

Mass \( m = 6.2756 \pm 0.0011 \text{ GeV} \)

Mean life \( \tau = (0.452 \pm 0.033) \times 10^{-12} \text{ s} \)

\( B_c^- \) modes are charge conjugates of the modes below.

**\( B_c^{\pm} \) DECAY MODES \times B(\bar{B} \to B_c)\**

<table>
<thead>
<tr>
<th>Mode</th>
<th>( \Gamma_i/\Gamma )</th>
<th>Confidence level (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( J/\psi(1S) \ell^+ \nu_\ell ) anything</td>
<td>( (5.2 \pm 2.4) \times 10^{-5} )</td>
<td>–</td>
</tr>
<tr>
<td>( J/\psi(1S) \pi^+ )</td>
<td>seen</td>
<td>2371</td>
</tr>
<tr>
<td>( J/\psi(1S) K^+ )</td>
<td>seen</td>
<td>2342</td>
</tr>
<tr>
<td>( J/\psi(1S) \pi^+ \pi^- )</td>
<td>seen</td>
<td>2351</td>
</tr>
<tr>
<td>( J/\psi(1S) a_1(1260) )</td>
<td>( &lt; 1.2 \times 10^{-3} ) 90%</td>
<td>2170</td>
</tr>
<tr>
<td>( J/\psi(1S) K^+ K^- \pi^+ )</td>
<td>seen</td>
<td>2203</td>
</tr>
<tr>
<td>( \psi(2S) \pi^+ )</td>
<td>seen</td>
<td>2052</td>
</tr>
<tr>
<td>( J/\psi(1S) D_s^{*+} )</td>
<td>seen</td>
<td>1822</td>
</tr>
<tr>
<td>( J/\psi(1S) D_s^{*+} )</td>
<td>seen</td>
<td>1728</td>
</tr>
</tbody>
</table>

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\begin{align*}
D^{*}(2010)^+ \bar{D}^0 &< 6.2 \times 10^{-3} \quad 90\% \quad 2467 \\
D^+ K^{*0} &< 0.20 \times 10^{-6} \quad 90\% \quad 2783 \\
D^+ \bar{K}^{*0} &< 0.16 \times 10^{-6} \quad 90\% \quad 2783 \\
D_s^+ K^{*0} &< 0.28 \times 10^{-6} \quad 90\% \quad 2752 \\
D_s^+ \bar{K}^{*0} &< 0.4 \times 10^{-6} \quad 90\% \quad 2752 \\
D_s^+ \phi &< 0.32 \times 10^{-6} \quad 90\% \quad 2728 \\
K^+ K^{*0} &< 4.6 \times 10^{-7} \quad 90\% \quad 3098 \\
B_s^0 \pi^+ / B(\bar{b} \rightarrow B_s) &\left( 2.37^{+0.37}_{-0.35} \right) \times 10^{-3} \
\end{align*}

\textbf{c\bar{c} MESONS}

\textbf{\(\eta_c(1S)\)} \hspace{1cm} iG(J^{PC}) = 0^+(0^-+)

\begin{align*}
\text{Mass} \quad m &= 2983.6 \pm 0.7 \text{ MeV} \quad (S = 1.3) \\
\text{Full width} \quad \Gamma &= 32.2 \pm 0.9 \text{ MeV}
\end{align*}

\begin{tabular}{llll}
\hline
\textbf{\(\eta_c(1S)\) DECAY MODES} & \textbf{Fraction (\(\Gamma_i/\Gamma\))} & \textbf{Confidence level (MeV/c)} \\
\hline
Decays involving hadronic resonances & & & \\
\hline
\(\eta'(958)\pi\pi\) & (4.1 \pm 1.7) \% & 1323 \\
\(\rho\rho\) & (1.8 \pm 0.5) \% & 1275 \\
\(K^*(892)^0 K^- \pi^+ + \text{ c.c.}\) & (2.0 \pm 0.7) \% & 1277 \\
\(K^*(892)\bar{K}^*(892)\) & (7.0 \pm 1.3) \times 10^{-3} & 1196 \\
\(K^*0 \bar{K}^*0 \pi^+ \pi^-\) & (1.1 \pm 0.5) \% & 1073 \\
\(\phi K^+ K^-\) & (2.9 \pm 1.4) \times 10^{-3} & 1104 \\
\(\phi \phi\) & (1.76 \pm 0.20) \times 10^{-3} & 1089 \\
\(\phi 2(\pi^+ \pi^-)\) & < 4 \times 10^{-3} \quad 90\% \quad 1251 \\
a_0(980)\pi & < 2 \% \quad 90\% \quad 1327 \\
a_2(1320)\pi & < 2 \% \quad 90\% \quad 1196 \\
\(K^*0(892)\bar{K}^+ + \text{ c.c.}\) & < 1.28 \% \quad 90\% \quad 1309 \\
f_2(1270)\eta & < 1.1 \% \quad 90\% \quad 1145 \\
\omega\omega & < 3.1 \times 10^{-3} \quad 90\% \quad 1270 \\
\omega\phi & < 1.7 \times 10^{-3} \quad 90\% \quad 1185 \\
f_2(1270)\phi_2(1270) & (9.8 \pm 2.5) \times 10^{-3} \quad 774 \\
f_2(1270)\phi_2'(1525) & (9.7 \pm 3.2) \times 10^{-3} \quad 513 
\end{tabular}

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Decays into stable hadrons

\[ \begin{align*}
K\bar{K}\pi & \quad (7.3 \pm 0.5)\% \\
\eta\pi^+\pi^- & \quad (1.7 \pm 0.5)\% \\
\eta 2(\pi^+\pi^-) & \quad (4.4 \pm 1.3)\% \\
K^+ K^- \pi^+\pi^- & \quad (6.9 \pm 1.1) \times 10^{-3} \\
K^+ K^- \pi^+\pi^- \pi^0 & \quad (3.5 \pm 0.6)\% \\
K^0 K^- \pi^+\pi^- \pi^+ + \text{c.c.} & \quad (5.6 \pm 1.5)\% \\
K^+ K^- 2(\pi^+\pi^-) & \quad (7.5 \pm 2.4) \times 10^{-3} \\
2(K^+ K^-) & \quad (1.47 \pm 0.31) \times 10^{-3} \\
\pi^+\pi^- \pi^0 & \quad (4.7 \pm 1.0)\% \\
2(\pi^+\pi^-) & \quad (9.7 \pm 1.2) \times 10^{-3} \\
2(\pi^+\pi^- \pi^0) & \quad (17.4 \pm 3.3)\% \\
3(\pi^+\pi^-) & \quad (1.8 \pm 0.4)\% \\
\rho\bar{\rho} & \quad (1.52 \pm 0.16) \times 10^{-3} \\
\rho\bar{\rho} \pi^0 & \quad (3.6 \pm 1.3) \times 10^{-3} \\
\Lambda\bar{\Lambda} & \quad (1.09 \pm 0.24) \times 10^{-3} \\
\Sigma^+ \Sigma^- & \quad (2.1 \pm 0.6) \times 10^{-3} \\
\Xi^- \Xi^+ & \quad (8.9 \pm 2.7) \times 10^{-4} \\
K\bar{K}\eta & \quad (10 \pm 5) \times 10^{-3} \\
\pi^+\pi^- \rho\bar{\rho} & \quad (5.3 \pm 1.8) \times 10^{-3}
\end{align*} \]

Radiative decays

\[ \gamma \gamma \quad (1.57 \pm 0.12) \times 10^{-4} \]

Charge conjugation (C), Parity (P), Lepton family number (LF) violating modes

<table>
<thead>
<tr>
<th>Decay</th>
<th>Scale factor/ Confidence level(MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>[\pi^+\pi^-]</td>
<td>[P,CP &lt; 1.1 \times 10^{-4} 90% 1485]</td>
</tr>
<tr>
<td>[\pi^0\pi^0]</td>
<td>[P,CP &lt; 3.5 \times 10^{-5} 90% 1486]</td>
</tr>
<tr>
<td>[K^+ K^-]</td>
<td>[P,CP &lt; 6 \times 10^{-4} 90% 1408]</td>
</tr>
<tr>
<td>[K^0 K^0]</td>
<td>[P,CP &lt; 3.1 \times 10^{-4} 90% 1406]</td>
</tr>
</tbody>
</table>

**J/ψ(1S)**

\[i^G (J^{PC}) = 0^- (1^- -)\]

Mass \(m = 3096.916 \pm 0.011\) MeV

Full width \(\Gamma = 92.9 \pm 2.8\) keV \((S = 1.1)\)

\(\Gamma_{ee} = 5.55 \pm 0.14 \pm 0.02\) keV

**J/ψ(1S) DECAY MODES**

<table>
<thead>
<tr>
<th>Decay</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
</tr>
</thead>
<tbody>
<tr>
<td>hadrons</td>
<td>((87.7 \pm 0.5)%)</td>
</tr>
<tr>
<td>virtual (\gamma \rightarrow) hadrons</td>
<td>((13.50 \pm 0.30)%)</td>
</tr>
<tr>
<td>(ggg)</td>
<td>((64.1 \pm 1.0)%)</td>
</tr>
<tr>
<td>(\gamma g g)</td>
<td>((8.8 \pm 1.1)%)</td>
</tr>
<tr>
<td>(e^+ e^-)</td>
<td>((5.971 \pm 0.032)%)</td>
</tr>
<tr>
<td>(e^+ e^- \gamma)</td>
<td>([r\alpha\alpha] (8.8 \pm 1.4) \times 10^{-3})</td>
</tr>
<tr>
<td>(\mu^+ \mu^-)</td>
<td>((5.961 \pm 0.033)%)</td>
</tr>
</tbody>
</table>

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Decays involving hadronic resonances

<table>
<thead>
<tr>
<th>Decay</th>
<th>Branching Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho \pi$</td>
<td>(1.69 ± 0.15)%</td>
</tr>
<tr>
<td>$\rho^0 \pi^0$</td>
<td>(5.6 ± 0.7) x 10^{-3}</td>
</tr>
<tr>
<td>$a_2(1320)\rho$</td>
<td>(1.09 ± 0.22)%</td>
</tr>
<tr>
<td>$\omega \pi^+ \pi^- \pi^- \pi^-$</td>
<td>(8.5 ± 3.4) x 10^{-3}</td>
</tr>
<tr>
<td>$\omega \pi^+ \pi^- \pi^0$</td>
<td>(4.0 ± 0.7) x 10^{-3}</td>
</tr>
<tr>
<td>$\omega \pi^+ \pi^-$</td>
<td>(8.6 ± 0.7) x 10^{-3}</td>
</tr>
<tr>
<td>$\omega f_2(1270)$</td>
<td>(4.3 ± 0.6) x 10^{-3}</td>
</tr>
<tr>
<td>$K^+(892)^0 \overline{K}^+(892)^0$</td>
<td>(2.3 ± 0.7) x 10^{-4}</td>
</tr>
<tr>
<td>$K^+(892)^0 \pm K^+(892)^\mp$</td>
<td>(1.00 ± 0.22)%</td>
</tr>
<tr>
<td>$K^+(892)^0 \pm K^+(800)^\mp$</td>
<td>(1.1 ± 1.0)%</td>
</tr>
<tr>
<td>$\eta K^+(892)^0 \overline{K}^+(892)^0$</td>
<td>(1.15 ± 0.26)%</td>
</tr>
<tr>
<td>$K^+(892)^0 \overline{K}^0(1430)^0 + c.c.$</td>
<td>(6.0 ± 0.6) x 10^{-3}</td>
</tr>
<tr>
<td>$K^+(892)^0 \overline{K}^0(1770)^0 + c.c.$</td>
<td>(6.9 ± 0.9) x 10^{-4}</td>
</tr>
<tr>
<td>$K^+(892)^0 \overline{K}^0 K^- \pi^+ + c.c.$</td>
<td></td>
</tr>
<tr>
<td>$\omega K^+(892)^0 \overline{K}^0 + c.c.$</td>
<td>(6.1 ± 0.9) x 10^{-3}</td>
</tr>
<tr>
<td>$K^+ K^+(892)^0 + c.c.$</td>
<td>(5.12 ± 0.30)%</td>
</tr>
<tr>
<td>$K^+ K^+(892)^0 + c.c.$</td>
<td>(1.97 ± 0.20)%</td>
</tr>
<tr>
<td>$K^+ K^+(892)^0 + c.c.$</td>
<td>(3.0 ± 0.4) x 10^{-3}</td>
</tr>
<tr>
<td>$K^+ K^+(892)^0 + c.c.$</td>
<td></td>
</tr>
<tr>
<td>$K^0 K^\mp \pi^+ + c.c.$</td>
<td></td>
</tr>
<tr>
<td>$K^0 \overline{K}^+ K^+(892)^0 + c.c.$</td>
<td>(4.39 ± 0.31)%</td>
</tr>
<tr>
<td>$K^0 \overline{K}^+(892)^0 + c.c.$</td>
<td>(3.2 ± 0.4) x 10^{-3}</td>
</tr>
<tr>
<td>$K^0 K^\mp \pi^+ + c.c.$</td>
<td></td>
</tr>
<tr>
<td>$K_1(1400)^0 \pm K^\mp$</td>
<td>(3.8 ± 1.4) x 10^{-3}</td>
</tr>
<tr>
<td>$K^0(892)^0 K^\mp + c.c.$</td>
<td>seen</td>
</tr>
<tr>
<td>$\omega \pi^0 \pi^0$</td>
<td>(3.4 ± 0.8) x 10^{-3}</td>
</tr>
<tr>
<td>$b_1(1235)^\pm \pi^\mp$</td>
<td>(3.0 ± 0.5) x 10^{-3}</td>
</tr>
<tr>
<td>$\omega K^\pm K_0^\mp \pi^\mp$</td>
<td>(3.4 ± 0.5) x 10^{-3}</td>
</tr>
<tr>
<td>$b_1(1235)^0 \pi^0$</td>
<td>(2.3 ± 0.6) x 10^{-3}</td>
</tr>
<tr>
<td>$\eta K^\pm K_0^\mp \pi^\mp$</td>
<td>(2.2 ± 0.4) x 10^{-3}</td>
</tr>
<tr>
<td>$\phi K^+(892)^0 \overline{K}^0 + c.c.$</td>
<td>(2.18 ± 0.23) x 10^{-3}</td>
</tr>
<tr>
<td>$\omega K \overline{K}$</td>
<td>(1.70 ± 0.32) x 10^{-3}</td>
</tr>
<tr>
<td>$\phi 2(\pi^+ \pi^-)$</td>
<td>(1.66 ± 0.23) x 10^{-3}</td>
</tr>
<tr>
<td>$\Delta(1232)^+ + \overline{p} \pi^-$</td>
<td>(1.6 ± 0.5) x 10^{-3}</td>
</tr>
<tr>
<td>$\omega \eta$</td>
<td>(1.74 ± 0.20) x 10^{-3}</td>
</tr>
<tr>
<td>$\phi K \overline{K}$</td>
<td>(1.83 ± 0.24) x 10^{-3}</td>
</tr>
<tr>
<td>$\phi f_0(1270)$</td>
<td>(3.6 ± 0.6) x 10^{-4}</td>
</tr>
<tr>
<td>$\phi f_2(1525)$</td>
<td>(8 ± 4) x 10^{-4}</td>
</tr>
</tbody>
</table>

Citation: K.A. Olive et al. (Particle Data Group), Chin. Phys. C38, 090001 (2014) (URL: http://pdg.lbl.gov)
\[
\begin{align*}
\phi \pi^+ \pi^- & \quad (9.4 \pm 0.9) \times 10^{-4} \quad S=1.2 \quad 1365 \\
\phi \pi^0 \pi^0 & \quad (5.6 \pm 1.6) \times 10^{-4} \quad 1366 \\
\phi K^+ K^- \pi^- & \quad (7.2 \pm 0.8) \times 10^{-4} \quad 1114 \\
\omega_1 (1420) & \quad (6.8 \pm 2.4) \times 10^{-4} \quad 1062 \\
\phi \eta & \quad (7.5 \pm 0.8) \times 10^{-4} \quad S=1.5 \quad 1320 \\
\Xi^0 \Xi^0 & \quad (1.20 \pm 0.24) \times 10^{-3} \quad 818 \\
\Xi (1530)^- & \quad (5.9 \pm 1.5) \times 10^{-4} \quad 600 \\
\rho K^- & \quad (5.1 \pm 3.2) \times 10^{-4} \quad 646 \\
\omega \pi^0 & \quad (4.5 \pm 0.5) \times 10^{-4} \quad S=1.4 \quad 1446 \\
\phi \eta (958) & \quad (4.0 \pm 0.7) \times 10^{-4} \quad S=2.1 \quad 1192 \\
\phi f_0 (980) & \quad (3.2 \pm 0.9) \times 10^{-4} \quad S=1.9 \quad 1178 \\
\phi f_0 (980) \rightarrow \phi \pi^+ \pi^- & \quad (1.8 \pm 0.4) \times 10^{-4} \quad 500 \\
\phi f_0 (980) \rightarrow \phi \pi^0 \pi^0 & \quad (1.7 \pm 0.7) \times 10^{-4} \quad 950 \\
\eta \phi f_0 (980) \rightarrow \eta \phi \pi^+ \pi^- & \quad (3.2 \pm 1.0) \times 10^{-4} \quad 1279 \\
\phi a_0 (980) \rightarrow \phi \eta \pi^0 & \quad (5 \pm 4) \times 10^{-6} \quad 1267 \\
\Xi (1530)^0 \Xi^0 (or \ c.c.) & \quad (3.2 \pm 1.4) \times 10^{-4} \quad 608 \\
\Sigma (1385)^- & \quad (3.1 \pm 0.5) \times 10^{-4} \quad 855 \\
\phi f_1 (1285) & \quad (2.6 \pm 0.5) \times 10^{-4} \quad S=1.1 \quad 1032 \\
\eta \pi^+ \pi^- & \quad (4.0 \pm 1.7) \times 10^{-4} \quad 1487 \\
\rho \eta & \quad (1.93 \pm 0.23) \times 10^{-4} \quad 1396 \\
\omega \eta (958) & \quad (1.82 \pm 0.21) \times 10^{-4} \quad 1279 \\
\omega f_0 (980) & \quad (1.4 \pm 0.5) \times 10^{-4} \quad 1267 \\
\rho \eta (958) & \quad (1.05 \pm 0.18) \times 10^{-4} \quad 1281 \\
a_2 (1320)^+ \pi^- & \quad [g g] < 4.3 \times 10^{-3} \quad CL=90\% \quad 1263 \\
K \kappa_s (1430) & \quad < 4.0 \times 10^{-3} \quad CL=90\% \quad 1159 \\
K_1 (1270)^+ & \quad < 3.0 \times 10^{-3} \quad CL=90\% \quad 1231 \\
K_2 (1430)^0 \kappa_s * (1430)^0 & \quad < 2.9 \times 10^{-3} \quad CL=90\% \quad 604 \\
\phi \pi^0 & \quad < 6.4 \times 10^{-6} \quad CL=90\% \quad 1377 \\
\phi \eta (1405) \rightarrow \phi \eta \pi^+ \pi^- & \quad < 2.5 \times 10^{-4} \quad CL=90\% \quad 946 \\
\omega f_2 (1525) & \quad < 2.2 \times 10^{-4} \quad CL=90\% \quad 1003 \\
\omega \chi (1835) & \quad < 3.9 \times 10^{-6} \quad CL=95\% \quad 1159 \\
\eta \phi (2170) & \quad < 2.52 \times 10^{-4} \quad CL=90\% \quad 1281 \\
\eta K^*(892)^0 & \quad CL=90\% \quad 912 \\
\Sigma (1385)^0 \pi^+ & \quad < 8.2 \times 10^{-6} \quad CL=90\% \quad 1100 \\
\Delta (1232)^+ & \quad < 1 \times 10^{-4} \quad CL=90\% \quad 1100 \\
\Lambda (1520) \pi^+ \rightarrow \gamma \Lambda \Lambda & \quad < 4.1 \times 10^{-6} \quad CL=90\% \quad 1100 \\
\Theta (1540) \Theta (1540) & \quad < 1.1 \times 10^{-5} \quad CL=90\% \quad 1100 \\
K_0^0 p K^- & \quad CL=90\% \quad 1100 \\
\Theta (1540) K^- \pi^0 & \quad < 2.1 \times 10^{-5} \quad CL=90\% \quad 1100 \\
\Theta (1540) K^0 \pi^0 & \quad < 1.6 \times 10^{-5} \quad CL=90\% \quad 1100 \\
\Theta (1540) K^+ n & \quad < 5.6 \times 10^{-5} \quad CL=90\% \quad 1100 \\
\Theta (1540) K^0 p & \quad < 1.1 \times 10^{-5} \quad CL=90\% \quad 1100 \\
\Lambda & \quad < 9 \times 10^{-5} \quad CL=90\% \quad 1032 \\
\end{align*}
\]
Decays into stable hadrons

<table>
<thead>
<tr>
<th>Decay</th>
<th>Rate (%)</th>
<th>S (%)</th>
<th>CL (%)</th>
<th>Value ± Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2(\pi^+ \pi^-)\pi^0$</td>
<td>(4.1 ± 0.5) %</td>
<td>S=2.4</td>
<td>1496</td>
<td></td>
</tr>
<tr>
<td>$3(\pi^+ \pi^-)\pi^0$</td>
<td>(2.9 ± 0.6) %</td>
<td></td>
<td>1433</td>
<td></td>
</tr>
<tr>
<td>$\pi^+ \pi^- \pi^0$</td>
<td>(2.11 ± 0.07) %</td>
<td>S=1.5</td>
<td>1533</td>
<td></td>
</tr>
<tr>
<td>$\pi^+ \pi^- \pi^0 K^+ K^-$</td>
<td>(1.79 ± 0.29) %</td>
<td>S=2.2</td>
<td>1368</td>
<td></td>
</tr>
<tr>
<td>$4(\pi^+ \pi^-)\pi^0$</td>
<td>(9.0 ± 3.0) x 10^{-3}</td>
<td></td>
<td>1345</td>
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<tr>
<td>$\pi^+ \pi^- K^+ K^-$</td>
<td>(6.6 ± 0.5) x 10^{-3}</td>
<td></td>
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<tr>
<td>$\pi^+ \pi^- K^+ K^- \eta$</td>
<td>(1.84 ± 0.28) x 10^{-3}</td>
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<tr>
<td>$\pi^0 \pi^0 K^+ K^-$</td>
<td>(2.45 ± 0.31) x 10^{-3}</td>
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<tr>
<td>$K \bar{K} \pi$</td>
<td>(6.1 ± 1.0) x 10^{-3}</td>
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<tr>
<td>$2(\pi^+ \pi^-)$</td>
<td>(3.57 ± 0.30) x 10^{-3}</td>
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<tr>
<td>$3(\pi^+ \pi^-)$</td>
<td>(4.3 ± 0.4) x 10^{-3}</td>
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<td>1466</td>
<td></td>
</tr>
<tr>
<td>$2(\pi^+ \pi^-)\pi^0$</td>
<td>(1.62 ± 0.21) %</td>
<td></td>
<td>1468</td>
<td></td>
</tr>
<tr>
<td>$2(\pi^+ \pi^-)\eta$</td>
<td>(2.29 ± 0.24) x 10^{-3}</td>
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<tr>
<td>$3(\pi^+ \pi^-)\eta$</td>
<td>(7.2 ± 1.5) x 10^{-4}</td>
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<tr>
<td>$p \bar{p}$</td>
<td>(2.12 ± 0.029) x 10^{-3}</td>
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<tr>
<td>$p \bar{p} \pi^0$</td>
<td>(1.19 ± 0.08) x 10^{-3}</td>
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<tr>
<td>$p \bar{p} \pi^+ \pi^-$</td>
<td>(6.0 ± 0.5) x 10^{-3}</td>
<td>S=1.3</td>
<td>1107</td>
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<tr>
<td>$p \bar{p} \pi^+ \pi^- \pi^0$</td>
<td>(2.3 ± 0.9) x 10^{-3}</td>
<td>S=1.9</td>
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<tr>
<td>$p \bar{p} \rho$</td>
<td>&lt; 3.1 x 10^{-4}</td>
<td>CL=90%</td>
<td>774</td>
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<tr>
<td>$p \bar{p} \omega$</td>
<td>(9.8 ± 1.0) x 10^{-4}</td>
<td>S=1.3</td>
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<tr>
<td>$p \bar{p} \eta (958)$</td>
<td>(2.1 ± 0.4) x 10^{-4}</td>
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<td>596</td>
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</tr>
<tr>
<td>$n \bar{n}$</td>
<td>(4 ± 4) x 10^{-3}</td>
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<td>1106</td>
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</tr>
<tr>
<td>$\Sigma^+ \bar{\Sigma}^-$</td>
<td>(1.50 ± 0.24) x 10^{-3}</td>
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<tr>
<td>$\Sigma^0 \bar{\Sigma}^0$</td>
<td>(1.29 ± 0.09) x 10^{-3}</td>
<td></td>
<td>988</td>
<td></td>
</tr>
<tr>
<td>$2(\pi^+ \pi^-) K^+ K^-$</td>
<td>(4.7 ± 0.7) x 10^{-3}</td>
<td>S=1.3</td>
<td>1320</td>
<td></td>
</tr>
<tr>
<td>$p \bar{p} \pi^-$</td>
<td>(2.12 ± 0.09) x 10^{-3}</td>
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<td>1174</td>
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</tr>
<tr>
<td>$n N(1440)$</td>
<td>seen</td>
<td></td>
<td>984</td>
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</tr>
<tr>
<td>$n N(1520)$</td>
<td>seen</td>
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<tr>
<td>$n N(1535)$</td>
<td>seen</td>
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<td>914</td>
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<tr>
<td>$\Xi^- \Xi^+$</td>
<td>(8.6 ± 1.1) x 10^{-4}</td>
<td>S=1.2</td>
<td>807</td>
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</tr>
<tr>
<td>$\Lambda \Lambda$</td>
<td>(1.61 ± 0.15) x 10^{-3}</td>
<td>S=1.9</td>
<td>1074</td>
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</tr>
<tr>
<td>$\Lambda \Sigma^- \pi^+$ (or c.c.)</td>
<td>[gg] (8.3 ± 0.7) x 10^{-4}</td>
<td>S=1.2</td>
<td>950</td>
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<tr>
<td>$p K^- \Lambda$</td>
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<tr>
<td>$2(K^+ K^-)$</td>
<td>(7.6 ± 0.9) x 10^{-4}</td>
<td></td>
<td>1131</td>
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<tr>
<td>$p K^- \Sigma^0$</td>
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<td>819</td>
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<tr>
<td>$K^+ K^- \Sigma^0$</td>
<td>(2.70 ± 0.17) x 10^{-4}</td>
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<td>1468</td>
<td></td>
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<tr>
<td>$K^0_S K^0 L$</td>
<td>(2.1 ± 0.4) x 10^{-4}</td>
<td>S=3.2</td>
<td>1466</td>
<td></td>
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<tr>
<td>$\Lambda \Lambda \pi^+ \pi^-$</td>
<td>(4.3 ± 1.0) x 10^{-3}</td>
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<tr>
<td>$\Lambda \Lambda \eta$</td>
<td>(1.62 ± 0.17) x 10^{-4}</td>
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<td>672</td>
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<tr>
<td>$\Lambda \Lambda \pi^0$</td>
<td>(3.8 ± 0.4) x 10^{-5}</td>
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<td>998</td>
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</tbody>
</table>
\[ \Lambda n K^0_S + \text{c.c.} \quad (6.5 \pm 1.1) \times 10^{-4} \quad 872 \]
\[ \pi^+ \pi^- \quad (1.47 \pm 0.14) \times 10^{-4} \quad 1542 \]
\[ \Lambda \Sigma^+ + \text{c.c.} \quad (2.83 \pm 0.23) \times 10^{-5} \quad 1034 \]
\[ K^0_S K^0_S \quad < 1 \times 10^{-6} \quad \text{CL}=95\% \quad 1466 \]

**Radiative decays**

\[
\begin{align*}
3\gamma & \quad (1.16 \pm 0.22) \times 10^{-5} \quad 1548 \\
4\gamma & \quad < 9 \times 10^{-6} \quad \text{CL}=90\% \quad 1548 \\
5\gamma & \quad < 1.5 \times 10^{-5} \quad \text{CL}=90\% \quad 1548 \\
4\eta & \quad (1.7 \pm 0.4) \% \quad S=1.6 \quad 111 \\
\gamma \eta(1S) & \quad (3.8 \pm 1.3 \pm 1.0) \times 10^{-6} \quad S=1.1 \quad – \\
\gamma \eta(1S) & \quad (8.3 \pm 3.1) \times 10^{-3} \quad 1518 \\
\gamma \pi^+ \pi^- 2\pi^0 & \quad (6.1 \pm 1.0) \times 10^{-3} \quad 1487 \\
\gamma \eta \pi \pi & \quad (6.2 \pm 2.4) \times 10^{-4} \quad – \\
\gamma \eta(1870) & \quad (2.8 \pm 0.6) \times 10^{-3} \quad S=1.6 \quad 1223 \\
\gamma \eta(1405/1475) & \quad \gamma K \bar{K} \pi \quad [o] \\
\gamma \eta(1405/1475) & \quad (7.8 \pm 2.0) \times 10^{-5} \quad S=1.8 \quad 1223 \\
\gamma \eta(1405/1475) & \quad \gamma \eta \pi^+ \pi^- \quad (3.0 \pm 0.5) \times 10^{-4} \quad – \\
\gamma \eta(1405/1475) & \quad \gamma \gamma \phi \quad < 8.2 \times 10^{-5} \quad \text{CL}=95\% \quad – \\
\gamma \rho \rho & \quad (4.5 \pm 0.8) \times 10^{-3} \quad 1340 \\
\gamma \rho \omega & \quad < 5.4 \times 10^{-4} \quad \text{CL}=90\% \quad 1338 \\
\gamma \rho \phi & \quad < 8.8 \times 10^{-5} \quad \text{CL}=90\% \quad 1258 \\
\gamma \eta(958) & \quad (5.15 \pm 0.16) \times 10^{-3} \quad S=1.2 \quad 1400 \\
\gamma 2\pi^+ 2\pi^- & \quad (2.8 \pm 0.5) \times 10^{-3} \quad S=1.9 \quad 1517 \\
\gamma f_2(1270) f_2(1270) & \quad (9.5 \pm 1.7) \times 10^{-4} \quad 879 \\
\gamma f_2(1270) f_2(1270) & \quad (8.2 \pm 1.9) \times 10^{-4} \quad – \\
\gamma K^+ K^- \pi^+ \pi^- & \quad (2.1 \pm 0.6) \times 10^{-3} \quad 1407 \\
\gamma f_2(2050) & \quad (2.7 \pm 0.7) \times 10^{-3} \quad 891 \\
\gamma \omega \omega & \quad (1.61 \pm 0.33) \times 10^{-3} \quad 1336 \\
\gamma \eta(1405/1475) & \quad \gamma \rho^0 \rho^0 \quad (1.7 \pm 0.4) \times 10^{-3} \quad S=1.3 \quad 1223 \\
\gamma f_2(1270) & \quad (1.43 \pm 0.11) \times 10^{-3} \quad 1286 \\
\gamma f_0(1710) & \quad \gamma K \bar{K} \quad (8.5 \pm 1.2 \pm 0.9) \times 10^{-4} \quad S=1.2 \quad 1075 \\
\gamma f_0(1710) & \quad \gamma \pi \pi \quad (4.0 \pm 1.0) \times 10^{-4} \quad – \\
\gamma f_0(1710) & \quad \gamma \omega \omega \quad (3.1 \pm 1.0) \times 10^{-4} \quad – \\
\gamma \eta & \quad (1.104 \pm 0.034) \times 10^{-3} \quad 1500 \\
\gamma f_1(1420) & \quad \gamma K \bar{K} \pi \quad (7.9 \pm 1.3) \times 10^{-4} \quad 1220 \\
\gamma f_1(1285) & \quad (6.1 \pm 0.8) \times 10^{-4} \quad 1283 \\
\gamma f_1(1510) & \quad \gamma \eta \pi^+ \pi^- \quad (4.5 \pm 1.2) \times 10^{-4} \quad – \\
\gamma f_2(1525) & \quad (4.5 \pm 0.7 \pm 0.4) \times 10^{-4} \quad 1173 \\
\gamma f_2(1640) & \quad \gamma \omega \omega \quad (2.8 \pm 1.8) \times 10^{-4} \quad – \\
\gamma f_2(1910) & \quad \gamma \omega \omega \quad (2.0 \pm 1.4) \times 10^{-4} \quad – \\
\gamma f_0(1800) & \quad \gamma \omega \phi \quad (2.5 \pm 0.6) \times 10^{-4} \quad – \\
\end{align*}
\]
\[ \gamma f_2(1950) \rightarrow \gamma K^*(892) \bar{K}^*(892) \]
\[ \gamma K^*(892) \bar{K}^*(892) \]
\[ \gamma \phi \phi \]
\[ \gamma \eta(2225) \]
\[ \gamma \eta(1760) \rightarrow \gamma \rho^0 \rho^0 \]
\[ \gamma \eta(1760) \rightarrow \gamma \omega \omega \]
\[ \gamma X(1835) \rightarrow \gamma \pi^+ \pi^- \pi^0 \]
\[ \gamma X(1835) \rightarrow \gamma \rho \bar{\rho} \]
\[ \gamma X(1840) \rightarrow \gamma 3(\pi^+ \pi^-) \]
\[ \gamma (K \bar{K}) \pi \] \[ J_{PC} = 0^{--} \]
\[ \gamma \eta' \]
\[ \gamma \eta \]
\[ \gamma \rho \bar{\rho} \pi^+ \pi^- \]
\[ \gamma \Lambda \bar{\Lambda} \]
\[ \gamma f_2(2220) \rightarrow \gamma \pi \pi \]
\[ \gamma f_2(2220) \rightarrow \gamma K \bar{K} \]
\[ \gamma f_2(2220) \rightarrow \gamma \rho \bar{\rho} \]
\[ \gamma f_0(1500) \]
\[ \gamma A \rightarrow \gamma \text{invisible} \]
\[ \gamma A^0 \rightarrow \gamma \mu^+ \mu^- \]

### Weak decays

- \[ D^- e^+ \nu_e + \text{c.c.} \]
- \[ \bar{D}^0 e^+ \bar{e}^- + \text{c.c.} \]
- \[ D_s^- e^+ \nu_e + \text{c.c.} \]
- \[ D^- \pi^+ + \text{c.c.} \]
- \[ \bar{D}^0 \bar{K}^0 + \text{c.c.} \]
- \[ D_s^- \pi^+ + \text{c.c.} \]

### Charge conjugation (C), Parity (P), Lepton Family number (LF) violating modes

- \[ \gamma \gamma \]
- \[ e^\pm \mu^\mp \]
- \[ e^\pm \tau^\mp \]
- \[ \mu^\pm \tau^\mp \]

### Other decays

- \[ \text{invisible} \]
\[ \chi_{c0}(1P) \]

\[ iG(J^{PC}) = 0^+(0^+ +) \]

Mass \( m = 3414.75 \pm 0.31 \text{ MeV} \)
Full width \( \Gamma = 10.5 \pm 0.6 \text{ MeV} \)

**\( \chi_{c0}(1P) \) DECAY MODES**

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ( (\Gamma_i/\Gamma) )</th>
<th>Scale factor/Confidence level</th>
<th>( \rho )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hadronic decays</strong></td>
<td></td>
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</tr>
<tr>
<td>( 2(\pi^+ \pi^-) )</td>
<td>( 2.24 \pm 0.18 %)</td>
<td>1679</td>
<td></td>
</tr>
<tr>
<td>( \rho^0 \pi^+ \pi^- )</td>
<td>( 8.7 \pm 2.8 \times 10^{-3} )</td>
<td>1607</td>
<td></td>
</tr>
<tr>
<td>( f_0(980) f_0(980) )</td>
<td>( 6.5 \pm 2.1 \times 10^{-4} )</td>
<td>1391</td>
<td></td>
</tr>
<tr>
<td>( \rho^+ \pi^- \pi^0 \pi^0 )</td>
<td>( 3.3 \pm 0.4 %)</td>
<td>1680</td>
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</tr>
<tr>
<td>( \rho^+ \pi^- \pi^0 + \text{c.c.} )</td>
<td>( 2.8 \pm 0.4 %)</td>
<td>1607</td>
<td></td>
</tr>
<tr>
<td>( 4\pi^0 )</td>
<td>( 3.2 \pm 0.4 \times 10^{-3} )</td>
<td>1681</td>
<td></td>
</tr>
<tr>
<td>( \pi^+ \pi^- K^+ K^- )</td>
<td>( 1.75 \pm 0.14 %)</td>
<td>1580</td>
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</tr>
<tr>
<td>( K_0^<em>(1430)^0 \overline{K}_0^</em>(1430)^0 \rightarrow \pi^+ \pi^- K^+ K^- )</td>
<td>( 9.6 \pm 3.5 \times 10^{-4} )</td>
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<tr>
<td>( K_0^<em>(1430)^0 \overline{K}_2^</em>(1430)^0 + \text{c.c.} \rightarrow \pi^+ \pi^- K^+ K^- )</td>
<td>( 7.8 \pm 1.9 \times 10^{-4} )</td>
<td>-</td>
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<tr>
<td>( K_1(1270)^+ K^- + \text{c.c.} \rightarrow \pi^+ \pi^- K^+ K^- )</td>
<td>( 6.1 \pm 1.9 \times 10^{-3} )</td>
<td>-</td>
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<tr>
<td>( K_1(1400)^+ K^- + \text{c.c.} \rightarrow \pi^+ \pi^- K^+ K^- )</td>
<td>(&lt; 2.6 \times 10^{-3} )</td>
<td>CL=90%</td>
<td>-</td>
</tr>
<tr>
<td>( f_0(980) f_0(980) )</td>
<td>( 1.6 \pm 1.0 \times 10^{-4} )</td>
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<td>( f_0(980) f_0(2200) )</td>
<td>( 7.8 \pm 2.0 \times 10^{-4} )</td>
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<tr>
<td>( f_0(1370) f_0(1370) )</td>
<td>( &lt; 2.7 \times 10^{-4} )</td>
<td>CL=90%</td>
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</tr>
<tr>
<td>( f_0(1370) f_0(1500) )</td>
<td>( &lt; 1.7 \times 10^{-4} )</td>
<td>CL=90%</td>
<td>920</td>
</tr>
<tr>
<td>( f_0(1370) f_0(1710) )</td>
<td>( 6.6 \pm 3.5 \times 10^{-4} )</td>
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<td>( f_0(1500) f_0(1370) )</td>
<td>( &lt; 1.3 \times 10^{-4} )</td>
<td>CL=90%</td>
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<tr>
<td>( f_0(1500) f_0(1500) )</td>
<td>( &lt; 5 \times 10^{-5} )</td>
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<tr>
<td>( f_0(1500) f_0(1710) )</td>
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<td>CL=90%</td>
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</tr>
<tr>
<td>( K^+ K^- \pi^+ \pi^- \pi^0 )</td>
<td>( 1.11 \pm 0.26 %)</td>
<td>1545</td>
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<tr>
<td>( K^+ K^- \pi^0 \pi^0 )</td>
<td>( 5.4 \pm 0.9 \times 10^{-3} )</td>
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<tr>
<td>( K^+ \pi^- \overline{K}^0 \pi^0 + \text{c.c.} )</td>
<td>( 2.44 \pm 0.33 %)</td>
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<tr>
<td>( \rho^+ K^- K^0 + \text{c.c.} )</td>
<td>( 1.18 \pm 0.21 %)</td>
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<tr>
<td>( K^*(892)^- K^+ \pi^0 \rightarrow K^+ \pi^- \overline{K}^0 \pi^0 + \text{c.c.} )</td>
<td>( 4.5 \pm 1.1 \times 10^{-3} )</td>
<td>-</td>
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<tr>
<td>( K_0^0 K_0^0 \pi^+ \pi^- )</td>
<td>( 5.6 \pm 1.0 \times 10^{-3} )</td>
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<tr>
<td>( K^+ K^- \eta \pi^0 )</td>
<td>( 3.0 \pm 0.7 \times 10^{-3} )</td>
<td>1468</td>
<td></td>
</tr>
<tr>
<td>( 3(\pi^+ \pi^-) )</td>
<td>( 1.20 \pm 0.18 %)</td>
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</tr>
<tr>
<td>( K^+ \overline{K}^*(892)^0 \pi^- + \text{c.c.} )</td>
<td>( 7.2 \pm 1.6 \times 10^{-3} )</td>
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<tr>
<td>( K^<em>(892)^0 \overline{K}^</em>(892)^0 )</td>
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<tr>
<td>Particle &amp; Branching</td>
<td>Branching Ratio &amp; Width</td>
<td>Measurement</td>
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</tr>
<tr>
<td>---------------------</td>
<td>------------------------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>$\pi^0 \eta$</td>
<td>$&lt; 1.8 \times 10^{-4}$</td>
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<td>$\pi^0 \eta'$</td>
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<tr>
<td>$\eta \eta'$</td>
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<tr>
<td>$\eta' \eta'$</td>
<td>$(1.96 \pm 0.21) \times 10^{-3}$</td>
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<tr>
<td>$\omega$</td>
<td>$(9.5 \pm 1.1) \times 10^{-4}$</td>
<td>1517</td>
<td></td>
</tr>
<tr>
<td>$K^+ K^-$</td>
<td>$(1.16 \pm 0.21) \times 10^{-4}$</td>
<td>1447</td>
<td></td>
</tr>
<tr>
<td>$K^0_S K^0_S$</td>
<td>$(5.91 \pm 0.32) \times 10^{-3}$</td>
<td>1634</td>
<td></td>
</tr>
<tr>
<td>$\pi^+ \pi^0 \eta$</td>
<td>$&lt; 1.9 \times 10^{-4}$</td>
<td>1651</td>
<td></td>
</tr>
<tr>
<td>$\pi^+ \pi^0 \eta'$</td>
<td>$&lt; 3.5 \times 10^{-4}$</td>
<td>1560</td>
<td></td>
</tr>
<tr>
<td>$\rho \rho \pi^0$</td>
<td>$(6.8 \pm 0.7) \times 10^{-4}$</td>
<td>S=1.3 1379</td>
<td></td>
</tr>
<tr>
<td>$\rho \rho \eta$</td>
<td>$(3.5 \pm 0.4) \times 10^{-4}$</td>
<td>1187</td>
<td></td>
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<tr>
<td>$\rho \rho \omega$</td>
<td>$(5.1 \pm 0.6) \times 10^{-4}$</td>
<td>1043</td>
<td></td>
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<tr>
<td>$\rho \rho \phi$</td>
<td>$(5.9 \pm 1.4) \times 10^{-5}$</td>
<td>876</td>
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<tr>
<td>$\rho \rho \pi^+ \pi^-$</td>
<td>$(2.1 \pm 0.7) \times 10^{-3}$</td>
<td>S=1.4 1320</td>
<td></td>
</tr>
<tr>
<td>$\rho \rho \pi^0 \pi^0$</td>
<td>$(1.02 \pm 0.27) \times 10^{-3}$</td>
<td>1324</td>
<td></td>
</tr>
<tr>
<td>$\rho \rho K^+ K^-$ (non-resonant)</td>
<td>$(1.19 \pm 0.26) \times 10^{-4}$</td>
<td>890</td>
<td></td>
</tr>
<tr>
<td>$\rho \rho K^0_S K^0_S$</td>
<td>$&lt; 8.8 \times 10^{-4}$</td>
<td>CL=90% 884</td>
<td></td>
</tr>
<tr>
<td>$\rho \rho \Lambda \Lambda$</td>
<td>$(1.24 \pm 0.11) \times 10^{-3}$</td>
<td>1376</td>
<td></td>
</tr>
<tr>
<td>$\rho \rho \Lambda \Lambda$</td>
<td>$(1.34 \pm 0.12) \times 10^{-3}$</td>
<td>1376</td>
<td></td>
</tr>
<tr>
<td>$\rho \rho \Lambda \Lambda$</td>
<td>$(2.29 \pm 0.21) \times 10^{-3}$</td>
<td>1321</td>
<td></td>
</tr>
<tr>
<td>$\rho \rho \Lambda \Lambda$</td>
<td>$(2.16 \pm 0.18) \times 10^{-3}$</td>
<td>1321</td>
<td></td>
</tr>
<tr>
<td>$\Lambda \Lambda$</td>
<td>$(3.21 \pm 0.25) \times 10^{-4}$</td>
<td>1292</td>
<td></td>
</tr>
<tr>
<td>$\Lambda \Lambda$</td>
<td>$(1.15 \pm 0.13) \times 10^{-3}$</td>
<td>1153</td>
<td></td>
</tr>
<tr>
<td>$\Sigma(1385)^+ \Lambda \pi^-$ (non-resonant)</td>
<td>$&lt; 5 \times 10^{-4}$</td>
<td>CL=90% 1153</td>
<td></td>
</tr>
<tr>
<td>$\Sigma(1385)^- \Lambda \pi^+$ (non-resonant)</td>
<td>$&lt; 5 \times 10^{-4}$</td>
<td>CL=90% 1083</td>
<td></td>
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<tr>
<td>$K^+ \rho \Lambda$ (non-resonant)</td>
<td>$(1.22 \pm 0.12) \times 10^{-3}$</td>
<td>S=1.3 1132</td>
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<td>$K^+ \rho \Lambda(1520)$ (non-resonant)</td>
<td>$(2.9 \pm 0.7) \times 10^{-4}$</td>
<td>858</td>
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<tr>
<td>$\Lambda(1520) \Lambda(1520)$</td>
<td>$(3.1 \pm 1.2) \times 10^{-4}$</td>
<td>779</td>
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<tr>
<td>$\Sigma^0 \Sigma^0$</td>
<td>$(4.4 \pm 0.4) \times 10^{-4}$</td>
<td>1222</td>
<td></td>
</tr>
<tr>
<td>$\Sigma^+ \Sigma^-$</td>
<td>$(3.9 \pm 0.7) \times 10^{-4}$</td>
<td>S=1.7 1225</td>
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<tr>
<td>$\Sigma(1385)^+ \Sigma(1385)^-$</td>
<td>$(1.6 \pm 0.6) \times 10^{-4}$</td>
<td>1001</td>
<td></td>
</tr>
</tbody>
</table>
$\Sigma(1385)^- \Sigma(1385)^+$  
$^{\Xi^0}_{\Xi^0}$  
$^{\Xi^-}_{\Xi^+}$  
$(2.3 \pm 0.6) \times 10^{-4}$  
$(3.1 \pm 0.8) \times 10^{-4}$  
$(4.7 \pm 0.7) \times 10^{-4}$  
1001  
1089  
1081

### Radiative decays

- $\gamma J/\psi(1S)$: $(1.27 \pm 0.06) \%$  
- $\gamma \rho^0$: $< 9 \times 10^{-6}$  
- $\gamma \omega$: $< 8 \times 10^{-6}$  
- $\gamma \phi$: $< 6 \times 10^{-6}$  
- $\gamma \gamma$: $(2.23 \pm 0.13) \times 10^{-4}$  

<table>
<thead>
<tr>
<th>$\chi_c(1P)$</th>
<th>$J^P (J^P_C)$ = 0$^+$ (1$^+$ + )</th>
</tr>
</thead>
<tbody>
<tr>
<td>mass</td>
<td>$m = 3510.66 \pm 0.07$ MeV (S = 1.5)</td>
</tr>
<tr>
<td>full width</td>
<td>$\Gamma = 0.84 \pm 0.04$ MeV</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$\chi_c(1P)$ decay modes</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>Confidence level</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3(\pi^+ \pi^-)$</td>
<td>$(5.8 \pm 1.4) \times 10^{-3}$</td>
<td>$\chi^0_S$ = 1.2</td>
<td>1683</td>
</tr>
<tr>
<td>$2(\pi^+ \pi^-)$</td>
<td>$(7.6 \pm 2.6) \times 10^{-3}$</td>
<td></td>
<td>1728</td>
</tr>
<tr>
<td>$\pi^+ \pi^- \pi^0 \pi^0$</td>
<td>$(1.22 \pm 0.16) %$</td>
<td></td>
<td>1729</td>
</tr>
<tr>
<td>$\rho^+ \pi^- \pi^0 + c.c.$</td>
<td>$(1.48 \pm 0.25) %$</td>
<td></td>
<td>1658</td>
</tr>
<tr>
<td>$\rho^0 \pi^+ \pi^-$</td>
<td>$(3.9 \pm 3.5) \times 10^{-3}$</td>
<td></td>
<td>1667</td>
</tr>
<tr>
<td>$4\pi^0$</td>
<td>$(5.5 \pm 0.8) \times 10^{-4}$</td>
<td></td>
<td>1729</td>
</tr>
<tr>
<td>$\eta \pi^0$</td>
<td>$(4.5 \pm 1.0) \times 10^{-3}$</td>
<td></td>
<td>1632</td>
</tr>
<tr>
<td>$K^+ K^- \pi^0 \pi^0$</td>
<td>$(1.14 \pm 0.28) \times 10^{-3}$</td>
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<td>1634</td>
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<tr>
<td>$K^+ \pi^- K^0 \pi^0 + c.c.$</td>
<td>$(8.7 \pm 1.4) \times 10^{-3}$</td>
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<td>1632</td>
</tr>
<tr>
<td>$\rho^- K^+ K^0 + c.c.$</td>
<td>$(5.1 \pm 1.2) \times 10^{-3}$</td>
<td></td>
<td>1514</td>
</tr>
<tr>
<td>$K^+(892) \pi^0 \pi^0 \rightarrow K^+ \pi^- K^0 \pi^0 + c.c.$</td>
<td>$(2.4 \pm 0.7) \times 10^{-3}$</td>
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<td>1514</td>
</tr>
<tr>
<td>$K^+ K^- \eta \pi^0$</td>
<td>$(1.14 \pm 0.35) \times 10^{-3}$</td>
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<td>1523</td>
</tr>
<tr>
<td>$\pi^+ \pi^- K_S^0 K_S^0$</td>
<td>$(7.0 \pm 3.0) \times 10^{-4}$</td>
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<td>1630</td>
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<tr>
<td>$K^+ K^- \eta$</td>
<td>$(3.2 \pm 1.0) \times 10^{-4}$</td>
<td></td>
<td>1566</td>
</tr>
<tr>
<td>$K^0 K^+ \pi^- + c.c.$</td>
<td>$(7.1 \pm 0.6) \times 10^{-3}$</td>
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<td>1661</td>
</tr>
<tr>
<td>$K^+(892) \pi^0 \eta + c.c.$</td>
<td>$(1.0 \pm 0.4) \times 10^{-3}$</td>
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<td>1602</td>
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<tr>
<td>$K^+(892)^+ \pi^- + c.c.$</td>
<td>$(1.5 \pm 0.7) \times 10^{-3}$</td>
<td></td>
<td>1602</td>
</tr>
<tr>
<td>$K_j^+(1430) \pi^0 + c.c.$</td>
<td>$&lt; 8 \times 10^{-4}$</td>
<td>$\chi^0_S$ =90%</td>
<td></td>
</tr>
<tr>
<td>$K^0 S K^+ \pi^- + c.c.$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$K_j^+(1430)^+ K^- + c.c.$</td>
<td>$&lt; 2.2 \times 10^{-3}$</td>
<td>$\chi^0_S$ =90%</td>
<td></td>
</tr>
<tr>
<td>$K^0 S K^+ \pi^- + c.c.$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$K^+ K^- \pi^0$</td>
<td>$(1.85 \pm 0.25) \times 10^{-3}$</td>
<td></td>
<td>1662</td>
</tr>
<tr>
<td>$\eta \pi^+ \pi^-$</td>
<td>$(4.9 \pm 0.5) \times 10^{-3}$</td>
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<td>1701</td>
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<tr>
<td>$a_0(980)^+ \pi^- + c.c.$</td>
<td>$(1.8 \pm 0.6) \times 10^{-3}$</td>
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<td>1701</td>
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</tbody>
</table>
\[
\begin{array}{l}
f_2(1270) \eta \\
\pi^+ \pi^- \eta' \\
\pi^0 f_0(980) \rightarrow \pi^0 \pi^+ \pi^- \\
K^+ K^* (892) \pi^- + \text{c.c.} \\
K^* (892) \pi^- \pi^- + \text{c.c.} \\
K^+ K^- K^0_S K^0_S \\
K^+ K^- K^+ K^- \\
K^+ K^- \phi \\
\omega \omega \\
\omega \phi \\
\phi \phi \\
p \bar{p} \\
p \bar{p} \pi^0 \\
p \bar{p} \eta \\
p \bar{p} \omega \\
p \bar{p} \phi \\
p \bar{p} \pi^+ \pi^- \\
p \bar{p} K^+ K^- \text{(non-resonant)} \\
p \bar{p} K^0_S K^0_S \\
p \bar{p} \pi^- \\
p \bar{n} \pi^+ \\
p \bar{n} \pi^- \pi^0 \\
p \bar{p} n \pi^+ \pi^0 \\
\Lambda \Lambda \\
\Lambda \Lambda \pi^+ \pi^- \text{(non-resonant)} \\
\Sigma(1385)^+ \Lambda \pi^- + \text{c.c.} \\
\Sigma(1385)^- \Lambda \pi^+ + \text{c.c.} \\
K^+ \bar{p} \Lambda \\
K^+ \bar{p} \Lambda (1520) + \text{c.c.} \\
\Lambda (1520) \Lambda (1520) \\
\Sigma^0 \Sigma^0 \\
\Sigma^+ \Sigma^- \\
\Sigma(1385)^+ \Sigma(1385)^- \\
\Sigma(1385)^- \Sigma(1385)^+ \\
\Xi^0 \Xi^0 \\
\Xi^- \Xi^+ \\
\pi^+ \pi^- + K^+ K^- \\
K^0_S K^0_S
\end{array}
\]

\[
\begin{array}{lcl}
(2.7 \pm 0.8) \times 10^{-3} & \text{CL=90%} & 1468 \\
(2.3 \pm 0.5) \times 10^{-3} & \text{CL=90%} & 1612 \\
< 6 \times 10^{-6} & \text{CL=90%} & \text{–} \\
(3.2 \pm 2.1) \times 10^{-3} & \text{CL=90%} & 1577 \\
(1.5 \pm 0.4) \times 10^{-3} & \text{CL=90%} & 1512 \\
< 4 \times 10^{-4} & \text{CL=90%} & 1390 \\
(5.5 \pm 1.1) \times 10^{-4} & \text{CL=90%} & 1393 \\
(4.2 \pm 1.6) \times 10^{-4} & \text{CL=90%} & 1440 \\
(5.8 \pm 0.7) \times 10^{-4} & \text{CL=90%} & 1571 \\
(2.1 \pm 0.6) \times 10^{-5} & \text{CL=90%} & 1503 \\
(4.2 \pm 0.5) \times 10^{-4} & \text{CL=90%} & 1429 \\
(7.72 \pm 0.35) \times 10^{-5} & \text{CL=90%} & 1484 \\
(1.59 \pm 0.19) \times 10^{-4} & \text{CL=90%} & 1438 \\
(1.48 \pm 0.25) \times 10^{-4} & \text{CL=90%} & 1254 \\
(2.16 \pm 0.31) \times 10^{-4} & \text{CL=90%} & 1117 \\
< 1.8 \times 10^{-5} & \text{CL=90%} & 962 \\
(5.0 \pm 1.9) \times 10^{-4} & \text{CL=90%} & 1381 \\
(1.30 \pm 0.23) \times 10^{-4} & \text{CL=90%} & 974 \\
< 4.5 \times 10^{-4} & \text{CL=90%} & 968 \\
(3.9 \pm 0.5) \times 10^{-4} & \text{CL=90%} & 1435 \\
(4.0 \pm 0.5) \times 10^{-4} & \text{CL=90%} & 1435 \\
(1.05 \pm 0.12) \times 10^{-3} & \text{CL=90%} & 1383 \\
(1.03 \pm 0.12) \times 10^{-3} & \text{CL=90%} & 1383 \\
(1.16 \pm 0.12) \times 10^{-4} & \text{CL=90%} & 1355 \\
(3.0 \pm 0.5) \times 10^{-4} & \text{CL=90%} & 1223 \\
(2.5 \pm 0.6) \times 10^{-4} & \text{CL=90%} & 1223 \\
< 1.3 \times 10^{-4} & \text{CL=90%} & 1157 \\
< 1.3 \times 10^{-4} & \text{CL=90%} & 1157 \\
(4.2 \pm 0.4) \times 10^{-4} & \text{S=1.1} & 1203 \\
(1.7 \pm 0.5) \times 10^{-4} & \text{CL=90%} & 950 \\
< 1.0 \times 10^{-4} & \text{CL=90%} & 879 \\
< 4 \times 10^{-5} & \text{CL=90%} & 1288 \\
< 6 \times 10^{-5} & \text{CL=90%} & 1291 \\
< 1.0 \times 10^{-4} & \text{CL=90%} & 1081 \\
< 5 \times 10^{-5} & \text{CL=90%} & 1081 \\
< 6 \times 10^{-5} & \text{CL=90%} & 1163 \\
(8.2 \pm 2.2) \times 10^{-5} & \text{CL=90%} & 1155 \\
< 2.1 \times 10^{-3} & \text{CL=90%} & 1683
\end{array}
\]
Radiative decays

\[ \gamma J/\psi(1S) \] \hspace{1cm} (33.9 \pm 1.2)\% \hspace{1cm} 389
\[ \gamma \rho^0 \] \hspace{1cm} (2.20 \pm 0.18) \times 10^{-4} \hspace{1cm} 1670
\[ \gamma \omega \] \hspace{1cm} (6.9 \pm 0.8) \times 10^{-5} \hspace{1cm} 1668
\[ \gamma \phi \] \hspace{1cm} (2.5 \pm 0.5) \times 10^{-5} \hspace{1cm} 1607

<table>
<thead>
<tr>
<th>[ h_c(1P) ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ J/\psi(1S) \pi \pi ]</td>
</tr>
<tr>
<td>not seen</td>
</tr>
<tr>
<td>[ \rho \pi ]</td>
</tr>
<tr>
<td>&lt; 1.5 \times 10^{-4}</td>
</tr>
<tr>
<td>90%</td>
</tr>
<tr>
<td>1492</td>
</tr>
<tr>
<td>[ \eta_c(1S) \gamma ]</td>
</tr>
<tr>
<td>(51 \pm 6)%</td>
</tr>
<tr>
<td>500</td>
</tr>
<tr>
<td>[ \pi^+ \pi^- \pi^0 ]</td>
</tr>
<tr>
<td>&lt; 2.2 \times 10^{-3}</td>
</tr>
<tr>
<td>1749</td>
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<tr>
<td>[ 2\pi^+ 2\pi^- \pi^0 ]</td>
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<tr>
<td>(2.2 \pm 0.8)%</td>
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<tr>
<td>1716</td>
</tr>
<tr>
<td>[ 3\pi^+ 3\pi^- \pi^0 ]</td>
</tr>
<tr>
<td>&lt; 2.9%</td>
</tr>
<tr>
<td>1661</td>
</tr>
</tbody>
</table>

\[ h_c(1P) \] \hspace{1cm} \[ j^G(j^{PC}) = ?(1 + -) \]

Mass \( m = 3525.38 \pm 0.11 \) MeV
Full width \( \Gamma = 0.7 \pm 0.4 \) MeV

\[ \chi_c(1P) \] \hspace{1cm} \[ j^G(j^{PC}) = 0^+(2 + +) \]

Mass \( m = 3556.20 \pm 0.09 \) MeV
Full width \( \Gamma = 1.93 \pm 0.11 \) MeV

\[ \chi_c(1P) \] \hspace{1cm} \[ j^G(j^{PC}) = 0^+(2 + +) \]

<table>
<thead>
<tr>
<th>[ \chi_c(1P) ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ 2(\pi^+ \pi^-) ]</td>
</tr>
<tr>
<td>(1.07 \pm 0.10)%</td>
</tr>
<tr>
<td>1751</td>
</tr>
<tr>
<td>[ \pi^+ \pi^- \pi^0 \pi^0 ]</td>
</tr>
<tr>
<td>(1.92 \pm 0.25)%</td>
</tr>
<tr>
<td>1752</td>
</tr>
<tr>
<td>[ \rho^+ \pi^- \pi^0 + \text{c.c.} ]</td>
</tr>
<tr>
<td>(2.3 \pm 0.4)%</td>
</tr>
<tr>
<td>1682</td>
</tr>
<tr>
<td>[ 4\pi^0 ]</td>
</tr>
<tr>
<td>(1.16 \pm 0.16) \times 10^{-3}</td>
</tr>
<tr>
<td>1752</td>
</tr>
<tr>
<td>[ K^+ K^- \pi^0 \pi^0 ]</td>
</tr>
<tr>
<td>(2.2 \pm 0.4) \times 10^{-3}</td>
</tr>
<tr>
<td>1658</td>
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<tr>
<td>[ K^+ \pi^- \bar{K}^0 \pi^0 + \text{c.c.} ]</td>
</tr>
<tr>
<td>(1.44 \pm 0.21)%</td>
</tr>
<tr>
<td>1657</td>
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<tr>
<td>[ \rho^- K^+ \bar{K}^0 + \text{c.c.} ]</td>
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<tr>
<td>(4.3 \pm 1.3) \times 10^{-3}</td>
</tr>
<tr>
<td>1540</td>
</tr>
<tr>
<td>[ K^+(892) ]</td>
</tr>
<tr>
<td>[ K^+ \pi^- \to K^- \pi^+ K^0 \pi^0 + \text{c.c.} ]</td>
</tr>
<tr>
<td>(3.1 \pm 0.8) \times 10^{-3}</td>
</tr>
<tr>
<td>-</td>
</tr>
<tr>
<td>[ K^+(892) ]</td>
</tr>
<tr>
<td>[ K^+ \pi^- \to K^- \pi^+ K^0 \pi^0 + \text{c.c.} ]</td>
</tr>
<tr>
<td>(4.0 \pm 0.9) \times 10^{-3}</td>
</tr>
<tr>
<td>-</td>
</tr>
<tr>
<td>[ K^+(892) ]</td>
</tr>
<tr>
<td>[ K^+ \pi^- \to K^- \pi^+ K^0 \pi^0 + \text{c.c.} ]</td>
</tr>
<tr>
<td>(3.9 \pm 0.9) \times 10^{-3}</td>
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<tr>
<td>-</td>
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<tr>
<td>[ K^+(892) ]</td>
</tr>
<tr>
<td>[ K^+ \pi^- \to K^- \pi^+ K^0 \pi^0 + \text{c.c.} ]</td>
</tr>
<tr>
<td>(3.1 \pm 0.8) \times 10^{-3}</td>
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<tr>
<td>-</td>
</tr>
</tbody>
</table>

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\[K^+ K^- \eta \pi^0\] 
\[K^+ K^- \pi^0 \pi^-\] 
\[K^+ K^- \pi^+ \pi^-\] 
\[K^+ K^- \pi^+ \pi^- \eta\] 
\[K^+ K^- (892)^0 \pi^- + \text{c.c.}\] 
\[K^+ (892)^0 K^*(892)^0\] 
\[3(\pi^+ \pi^-)\] 
\[\omega \omega\] 
\[\pi \pi\] 
\[\rho^0 \pi^+ \pi^-\] 
\[\pi^+ \pi^-\] 
\[\pi^+ \pi^- \eta\] 
\[\pi^+ \pi^- \eta'\] 
\[\eta\] 
\[K^+ K^-\] 
\[K^0 K^0\] 
\[K^+ K^- + \text{c.c.}\] 
\[K^+ K^- \eta\] 
\[\eta \eta'\] 
\[\eta' \eta'\] 
\[\pi^+ \pi^- K^0 S K^0 S\] 
\[K^+ K^- K^0 S K^0 S\] 
\[K^+ K^- K^+ K^-\] 
\[K^+ K^- \phi\] 
\[p \bar{p}\] 
\[p \bar{p} \pi^0\] 
\[p \bar{p} \eta\] 
\[p \bar{p} \omega\] 
\[p \bar{p} \phi\] 
\[p \bar{p} \pi^+ \pi^-\] 
\[p \bar{p} \pi^0 \pi^0\] 
\[p \bar{p} K^+ K^- \text{(non-resonant)}\] 
\[p \bar{p} K^0 S K^0 S\] 
\[p \bar{p} \pi^-\] 
\[p \bar{n} \pi^+\] 
\[p \bar{n} \pi^- \pi^0\] 
\[p \bar{n} \pi^+ \pi^0\] 
\[\Lambda \bar{\Lambda}\] 
\[\Lambda \bar{\Lambda} \pi^+ \pi^-\] 
\[\Lambda \bar{\Lambda} \pi^+ \pi^- \text{(non-resonant)}\] 
\[\Sigma (1385) \bar{\Lambda} \pi^- \text{+ c.c.}\] 
\[\Sigma (1385) \bar{\Lambda} \pi^+ \text{+ c.c.}\] 
\[K^+ \bar{p} \Lambda + \text{c.c.}\] 
\[K^+ \bar{p} \Lambda (1520) + \text{c.c.}\]
\[ \Lambda(1520) \bar{\Lambda}(1520) \]
\[ \Sigma^0 \bar{\Sigma}^0 \]
\[ \Sigma^+ \bar{\Sigma}^- \]
\[ \Sigma(1385)^+ \bar{\Sigma}(1385)^- \]
\[ \Sigma(1385)^- \bar{\Sigma}(1385)^+ \]
\[ \Xi^- \Xi^+ \]
\[ J/\psi(1S) \pi^+ \pi^- \pi^0 \]
\[ \eta_c(1S) \pi^+ \pi^- \]

\[ \Lambda(1520) \bar{\Lambda}(1520) \]
\[ \Sigma^0 \bar{\Sigma}^0 \]
\[ \Sigma^+ \bar{\Sigma}^- \]
\[ \Sigma(1385)^+ \bar{\Sigma}(1385)^- \]
\[ \Sigma(1385)^- \bar{\Sigma}(1385)^+ \]
\[ \Xi^- \Xi^+ \]
\[ J/\psi(1S) \pi^+ \pi^- \pi^0 \]
\[ \eta_c(1S) \pi^+ \pi^- \]

Radiative decays
\[ \gamma J/\psi(1S) \]
\[ \gamma \rho^0 \]
\[ \gamma \omega \]
\[ \gamma \phi \]
\[ \gamma \gamma \]

\[ \eta_c(2S) \]

Quantum numbers are quark model predictions.

Mass \( m = 3639.4 \pm 1.3 \text{ MeV} \quad (S = 1.2) \)

Full width \( \Gamma = 11.3^{+3.2}_{-2.9} \text{ MeV} \)

<table>
<thead>
<tr>
<th>( \eta_c(2S) ) DECA Y MODES</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>Confidence level (\Gamma_i/\Gamma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>hadrons</td>
<td>not seen</td>
<td>–</td>
</tr>
<tr>
<td>( K \bar{K} \pi )</td>
<td>( 1.9\pm1.2%)</td>
<td>1730</td>
</tr>
<tr>
<td>( 2\pi^+ 2\pi^- )</td>
<td>not seen</td>
<td>1793</td>
</tr>
<tr>
<td>( \rho^0 \rho^0 )</td>
<td>not seen</td>
<td>1646</td>
</tr>
<tr>
<td>( 3\pi^+ 3\pi^- )</td>
<td>not seen</td>
<td>1750</td>
</tr>
<tr>
<td>( K^+ K^- \pi^+ \pi^- )</td>
<td>not seen</td>
<td>1701</td>
</tr>
<tr>
<td>( K^{*0} \bar{K}^{*0} )</td>
<td>not seen</td>
<td>1586</td>
</tr>
<tr>
<td>( K^+ K^- \pi^+ \pi^- \pi^0 )</td>
<td>( 1.4\pm1.0%)</td>
<td>1668</td>
</tr>
<tr>
<td>( K^+ K^- 2\pi^+ 2\pi^- )</td>
<td>not seen</td>
<td>1628</td>
</tr>
<tr>
<td>( K_S^0 K^- 2\pi^+ \pi^- )</td>
<td>seen</td>
<td>1667</td>
</tr>
<tr>
<td>( 2K^+ 2K^- )</td>
<td>not seen</td>
<td>1571</td>
</tr>
<tr>
<td>( \phi \phi )</td>
<td>not seen</td>
<td>1507</td>
</tr>
<tr>
<td>( \rho \bar{\rho} )</td>
<td>&lt; 2.0 \times 10^{-3}</td>
<td>90% 1559</td>
</tr>
<tr>
<td>( \gamma \gamma )</td>
<td>( 1.9\pm1.3%)</td>
<td>1820</td>
</tr>
<tr>
<td>( \pi^+ \pi^- \eta )</td>
<td>not seen</td>
<td>1767</td>
</tr>
<tr>
<td>( \pi^+ \pi^- \eta' )</td>
<td>not seen</td>
<td>1681</td>
</tr>
<tr>
<td>( K^+ K^- \eta )</td>
<td>not seen</td>
<td>1638</td>
</tr>
<tr>
<td>( \pi^+ \pi^- \eta_c(1S) )</td>
<td>&lt; 25 %</td>
<td>90% 539</td>
</tr>
</tbody>
</table>
$$\psi(2S)$$

$$\psi(2S)$$

$$i^G (j^{PC}) = 0^-(1^{--})$$

Mass $$m = 3686.109^{+0.012}_{-0.014}$$ MeV

Full width $$\Gamma = 299 \pm 8$$ keV

$$\Gamma_{ee} = 2.36 \pm 0.04$$ keV

<table>
<thead>
<tr>
<th>$$\psi(2S)$$ DECAY MODES</th>
<th>Fraction $$(\Gamma_j/\Gamma)$$</th>
<th>Scale factor/Confidence level</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>hadrons</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>virtual $$\gamma \to$$ hadrons</td>
<td>(1.73 ± 0.14) %</td>
<td>S=1.5</td>
<td></td>
</tr>
<tr>
<td>$$\gamma\gamma$$</td>
<td>(10.6 ± 1.6) %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>light hadrons</td>
<td>(1.03 ± 0.29) %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$$e^+e^-$$</td>
<td>(7.89 ± 0.17) x 10^{-3}</td>
<td>1843</td>
<td></td>
</tr>
<tr>
<td>$$\mu^+\mu^-$$</td>
<td>(7.9 ± 0.9) x 10^{-3}</td>
<td>1840</td>
<td></td>
</tr>
<tr>
<td>$$\tau^+\tau^-$$</td>
<td>(3.1 ± 0.4) x 10^{-3}</td>
<td>490</td>
<td></td>
</tr>
</tbody>
</table>

Decays into $$J/\psi(1S)$$ and anything

- $$J/\psi(1S)$$ anything (60.9 ± 0.6) %
- $$J/\psi(1S)$$ neutrals (25.10 ± 0.33) %
- $$J/\psi(1S)$$ $$\pi^+\pi^-$$ (34.45 ± 0.30) %
- $$J/\psi(1S)$$ $$\pi^0\pi^0$$ (18.13 ± 0.31) %
- $$J/\psi(1S)$$ $$\eta$$ (3.36 ± 0.05) %
- $$J/\psi(1S)$$ $$\eta$$ (1.268 ± 0.032) x 10^{-3} 528

Hadronic decays

- $$\pi^0 h_c(1P)$$ (8.6 ± 1.3) x 10^{-4} 85
- $$3(\pi^+\pi^-)\pi^0$$ (3.5 ± 1.6) x 10^{-3} 1746
- $$2(\pi^+\pi^-)\pi^0$$ (2.9 ± 1.0) x 10^{-3} S=4.7 1799
- $$\rho\eta_{a2}(1320)$$ (2.6 ± 0.9) x 10^{-4} 1500
- $$\Delta^{++}\overline{\Delta}^{--}$$ (1.28 ± 0.35) x 10^{-4} 1371
- $$\Lambda\overline{\Lambda}\pi^0$$ < 2.9 x 10^{-6} CL=90% 1412
- $$\Lambda\overline{\Lambda}\eta$$ (2.5 ± 0.4) x 10^{-5} 1197
- $$\Lambda\eta K^+$$ (1.00 ± 0.14) x 10^{-4} 1327
- $$\Lambda\eta K^+\pi^+\pi^-$$ (1.8 ± 0.4) x 10^{-4} 1167
- $$\Lambda\overline{\Lambda}\pi^+\pi^-$$ (2.8 ± 0.6) x 10^{-4} 1346
- $$\Lambda\overline{\Lambda}$$ (2.8 ± 0.5) x 10^{-4} S=2.6 1467
- $$\Lambda\Sigma^+\pi^- +$$ c.c. (1.40 ± 0.13) x 10^{-4} 1376
- $$\Lambda\Sigma^-\pi^+ +$$ c.c. (1.54 ± 0.14) x 10^{-4} 1379
- $$\Sigma^0\overline{\rho}K^+ +$$ c.c. (1.67 ± 0.18) x 10^{-5} 1291
- $$\Sigma^+\Sigma^-$$ (2.6 ± 0.8) x 10^{-4} 1408
- $$\Sigma^0\Sigma^0$$ (2.2 ± 0.4) x 10^{-4} S=1.5 1405
- $$\Sigma(1385)^+\Sigma(1385)^-$$ (1.1 ± 0.4) x 10^{-4} 1218
- $$\Xi^-\Xi^+$$ (1.8 ± 0.6) x 10^{-4} S=2.8 1284
<table>
<thead>
<tr>
<th>reaction</th>
<th>$ \Xi^0 \Xi^0 $</th>
<th>$ \Xi(1530)^0 \Xi(1530)^0 $</th>
<th>$ \Omega^- \Omega^+ $</th>
<th>$ \pi^0 \rho \bar{\rho} $</th>
</tr>
</thead>
<tbody>
<tr>
<td>$ N(940) \bar{\pi} + \text{c.c.} \rightarrow \pi^0 \rho \bar{\rho} $</td>
<td>$(2.8 \pm 0.9) \times 10^{-4}$</td>
<td>$(5.2 \pm 3.2) \times 10^{-5}$</td>
<td>$(7.3 \pm 1.5) \times 10^{-5}$</td>
<td>$(6.6 \pm 1.8) \times 10^{-5}$</td>
</tr>
<tr>
<td>$ N(1440) \bar{\pi} + \text{c.c.} \rightarrow \pi^0 \rho \bar{\rho} $</td>
<td>$(7.3 \pm 1.7) \times 10^{-5}$</td>
<td>$&lt; 7.3 \times 10^{-5}$</td>
<td>$&lt; 7.3 \times 10^{-5}$</td>
<td>$(6.4 \pm 1.8) \times 10^{-5}$</td>
</tr>
<tr>
<td>$ N(1520) \bar{\pi} + \text{c.c.} \rightarrow \pi^0 \rho \bar{\rho} $</td>
<td>$(5.2 \pm 1.0) \times 10^{-5}$</td>
<td>$(6.4 \pm 2.3) \times 10^{-6}$</td>
<td>$(6.4 \pm 2.3) \times 10^{-6}$</td>
<td>$(2.6 \pm 1.2) \times 10^{-5}$</td>
</tr>
<tr>
<td>$ N(1535) \bar{\pi} + \text{c.c.} \rightarrow \pi^0 \rho \bar{\rho} $</td>
<td>$(2.5 \pm 1.0) \times 10^{-5}$</td>
<td>$(3.8 \pm 1.4) \times 10^{-5}$</td>
<td>$(3.8 \pm 1.4) \times 10^{-5}$</td>
<td>$(1.79 \pm 0.26) \times 10^{-5}$</td>
</tr>
<tr>
<td>$ N(1650) \bar{\pi} + \text{c.c.} \rightarrow \pi^0 \rho \bar{\rho} $</td>
<td>$(2.5 \pm 1.0) \times 10^{-5}$</td>
<td>$(3.8 \pm 1.4) \times 10^{-5}$</td>
<td>$(3.8 \pm 1.4) \times 10^{-5}$</td>
<td>$(1.79 \pm 0.26) \times 10^{-5}$</td>
</tr>
<tr>
<td>$ N(1720) \bar{\pi} + \text{c.c.} \rightarrow \pi^0 \rho \bar{\rho} $</td>
<td>$(1.53 \pm 0.07) \times 10^{-4}$</td>
<td>$(1.53 \pm 0.07) \times 10^{-4}$</td>
<td>$(1.53 \pm 0.07) \times 10^{-4}$</td>
<td>$(1.53 \pm 0.07) \times 10^{-4}$</td>
</tr>
<tr>
<td>$ N(2300) \bar{\pi} + \text{c.c.} \rightarrow \pi^0 \rho \bar{\rho} $</td>
<td>$(2.13 \pm 0.40) \times 10^{-5}$</td>
<td>$(2.13 \pm 0.40) \times 10^{-5}$</td>
<td>$(2.13 \pm 0.40) \times 10^{-5}$</td>
<td>$(2.13 \pm 0.40) \times 10^{-5}$</td>
</tr>
<tr>
<td>$ N(2570) \bar{\pi} + \text{c.c.} \rightarrow \pi^0 \rho \bar{\rho} $</td>
<td>$(1.11 \pm 0.4) \times 10^{-5}$</td>
<td>$(1.11 \pm 0.4) \times 10^{-5}$</td>
<td>$(1.11 \pm 0.4) \times 10^{-5}$</td>
<td>$(1.11 \pm 0.4) \times 10^{-5}$</td>
</tr>
<tr>
<td>$ 2 \rho \bar{\rho} $</td>
<td>$(3.2 \pm 0.7) \times 10^{-4}$</td>
<td>$(3.2 \pm 0.7) \times 10^{-4}$</td>
<td>$(3.2 \pm 0.7) \times 10^{-4}$</td>
<td>$(3.2 \pm 0.7) \times 10^{-4}$</td>
</tr>
<tr>
<td>$ \pi^0 f_0 (2100) \rightarrow \pi^0 \rho \bar{\rho} $</td>
<td>$(4.7 \pm 1.5) \times 10^{-3}$</td>
<td>$(4.7 \pm 1.5) \times 10^{-3}$</td>
<td>$(4.7 \pm 1.5) \times 10^{-3}$</td>
<td>$(4.7 \pm 1.5) \times 10^{-3}$</td>
</tr>
<tr>
<td>$ \rho \pi^0 \pi^0 $</td>
<td>$(6.0 \pm 0.4) \times 10^{-4}$</td>
<td>$(6.0 \pm 0.4) \times 10^{-4}$</td>
<td>$(6.0 \pm 0.4) \times 10^{-4}$</td>
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</tr>
<tr>
<td>$ \rho \pi^0 \pi^0 $</td>
<td>$(4.7 \pm 1.5) \times 10^{-3}$</td>
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<td>$(4.7 \pm 1.5) \times 10^{-3}$</td>
<td>$(4.7 \pm 1.5) \times 10^{-3}$</td>
</tr>
<tr>
<td>$ \rho \pi^+ \pi^- $</td>
<td>$(2.4 \pm 0.6) \times 10^{-4}$</td>
<td>$(2.4 \pm 0.6) \times 10^{-4}$</td>
<td>$(2.4 \pm 0.6) \times 10^{-4}$</td>
<td>$(2.4 \pm 0.6) \times 10^{-4}$</td>
</tr>
<tr>
<td>$ \rho \pi^+ \pi^- $</td>
<td>$(2.2 \pm 0.4) \times 10^{-4}$</td>
<td>$(2.2 \pm 0.4) \times 10^{-4}$</td>
<td>$(2.2 \pm 0.4) \times 10^{-4}$</td>
<td>$(2.2 \pm 0.4) \times 10^{-4}$</td>
</tr>
<tr>
<td>$ \phi \rho \bar{\rho} $</td>
<td>$(2.2 \pm 0.4) \times 10^{-4}$</td>
<td>$(2.2 \pm 0.4) \times 10^{-4}$</td>
<td>$(2.2 \pm 0.4) \times 10^{-4}$</td>
<td>$(2.2 \pm 0.4) \times 10^{-4}$</td>
</tr>
</tbody>
</table>

Citation: K.A. Olive et al. (Particle Data Group), Chin. Phys. C38, 090001 (2014) (URL: http://pdg.lbl.gov)
\[ K^+ \overline{K}^*(892)^0 \pi^- + \text{c.c.} \]  
\[ 2(\pi^+\pi^-) \]  
\[ \rho^0 \pi^+\pi^- \]  
\[ K^+ K^- \pi^+\pi^- \pi^0 \]  
\[ \omega f_0(1710) \rightarrow \omega K^+ K^- \]  
\[ K^*(892)^0 K^- \pi^+\pi^0 + \text{c.c.} \]  
\[ K^*(892)^+ K^- \pi^+\pi^- + \text{c.c.} \]  
\[ K^*(892)^+ K^- \rho^0 + \text{c.c.} \]  
\[ K^*(892)^0 K^- \rho^0 + \text{c.c.} \]  
\[ \eta K^+ K^- , \text{ no } \eta \phi \]  
\[ \omega K^+ K^- \]  
\[ \omega K^*(892)^+ K^- + \text{c.c.} \]  
\[ \omega K_s^*(1430)^+ K^- + \text{c.c.} \]  
\[ \omega K_s^*(892)^0 K^0 \]  
\[ \omega K_s^*(1430)^0 K^0 \]  
\[ \omega X(1440) \rightarrow \omega K^0_S K^- \pi^+ + \text{c.c.} \]  
\[ \omega X(1440) \rightarrow \omega K^+ K^- \pi^0 \]  
\[ \omega f_1(1285) \rightarrow \omega K^0_S K^- \pi^+ + \text{c.c.} \]  
\[ \omega f_1(1285) \rightarrow \omega K^+ K^- \pi^0 \]  
\[ 3(\pi^+\pi^-) \]  
\[ \rho \overline{\rho} \pi^+\pi^- \pi^0 \]  
\[ K^+ K^- \]  
\[ K^0_S K^0_L \]  
\[ \pi^+\pi^- \pi^0 \]  
\[ \rho(2150) \pi \rightarrow \pi^+\pi^- \pi^0 \]  
\[ \rho(770) \pi \rightarrow \pi^+\pi^- \pi^0 \]  
\[ \pi^+\pi^- \]  
\[ K_1(1400) \pm K^\mp \]  
\[ K_2^*(1430) \pm K^\mp \]  
\[ K^+ K^- \pi^0 \]  
\[ K^+ K^*(892)^- + \text{c.c.} \]  
\[ K^*(892)^0 \overline{K}^0 + \text{c.c.} \]  
\[ \phi \pi^+\pi^- \]  
\[ \phi f_0(980) \rightarrow \pi^+\pi^- \]  
\[ 2(K^+ K^-) \]  
\[ \phi K^+ K^- \]  
\[ 2(K^+ K^-) \pi^0 \]  
\[ \phi \eta \]  
\[ \phi \eta' \]  
\[ \omega \eta' \]  

Citation: K.A. Olive et al. (Particle Data Group), Chin. Phys. C38, 090001 (2014) (URL: http://pdg.lbl.gov)
\[ \omega \pi^0 \ ] (\ 2.1 \pm 0.6 \ ) \times 10^{-5} \quad 1757

\[ \rho \eta' \ ] (\ 1.9 \pm^{1.7}_{-1.2} \ ) \times 10^{-5} \quad 1625

\[ \rho \eta \ ] (\ 2.2 \pm 0.6 \ ) \times 10^{-5} \quad S=1.1 \quad 1717

\[ \omega \eta \ ] < 1.1 \times 10^{-5} \quad CL=90\% \quad 1715

\[ \phi \pi^0 \ ] < 4 \times 10^{-7} \quad CL=90\% \quad 1699

\[ \eta_c \pi^0 \pi^{-} \pi^0 \ ] < 1.0 \times 10^{-3} \quad CL=90\% \quad -

\[ p\bar{p} K^+ K^- \ ] (\ 2.7 \pm 0.7 \ ) \times 10^{-5} \quad 1118

\[ \Lambda n K^0_S + \text{c.c.} \ ] (\ 8.1 \pm 1.8 \ ) \times 10^{-5} \quad 1324

\[ \phi f'_2(1525) \ ] (\ 4.4 \pm 1.6 \ ) \times 10^{-5} \quad 1321

\[ \Theta(1540) \Theta(1540) \rightarrow \ ] < 8.8 \times 10^{-6} \quad CL=90\% \quad -

\[ K^0_S p K^- \pi^+ \pi^- \ ] < 1.0 \times 10^{-5} \quad CL=90\% \quad -

\[ \Theta(1540) K^- \pi \rightarrow K^0_S p K^- \pi \ ] < 7.0 \times 10^{-6} \quad CL=90\% \quad -

\[ \Theta(1540) K^0_S \bar{p} \rightarrow K^0_S \bar{p} K^+ n \ ] < 2.6 \times 10^{-5} \quad CL=90\% \quad -

\[ \Theta(1540) K^+ n \rightarrow K^0_S \bar{p} K^+ n \ ] < 6.0 \times 10^{-6} \quad CL=90\% \quad -

\[ K^0_S K^0_S \ ] < 4.6 \times 10^{-6} \quad 1775

\textbf{Radiative decays}

\[ \gamma \chi_{c0}(1P) \ ] (\ 9.99 \pm 0.27 \ ) \% \quad 261

\[ \gamma \chi_{c1}(1P) \ ] (\ 9.55 \pm 0.31 \ ) \% \quad 171

\[ \gamma \chi_{c2}(1P) \ ] (\ 9.11 \pm 0.31 \ ) \% \quad 128

\[ \gamma \eta_c(1S) \ ] (\ 3.4 \pm 0.5 \ ) \times 10^{-3} \quad S=1.3 \quad 636

\[ \gamma \eta_c(2S) \ ] (\ 7 \pm 5 \ ) \times 10^{-4} \quad 46

\[ \gamma \pi^0 \ ] (\ 1.6 \pm 0.4 \ ) \times 10^{-6} \quad 1841

\[ \gamma \eta'(958) \ ] (\ 1.23 \pm 0.06 \ ) \times 10^{-4} \quad 1719

\[ \gamma f_2(1270) \ ] (\ 2.1 \pm 0.4 \ ) \times 10^{-4} \quad 1623

\[ \gamma f_0(1710) \rightarrow \gamma \pi \pi \ ] (\ 3.0 \pm 1.3 \ ) \times 10^{-5} \quad -

\[ \gamma f_0(1710) \rightarrow \gamma K \bar{K} \ ] (\ 6.0 \pm 1.6 \ ) \times 10^{-5} \quad -

\[ \gamma \eta \pi^+ \pi^- \ ] (\ 8.7 \pm 2.1 \ ) \times 10^{-4} \quad 1791

\[ \gamma \eta(1405) \rightarrow \gamma K \bar{K} \pi \ ] < 9 \times 10^{-5} \quad CL=90\% \quad 1569

\[ \gamma \eta(1405) \rightarrow \eta \pi^+ \pi^- \ ] (\ 3.6 \pm 2.5 \ ) \times 10^{-5} \quad -

\[ \gamma \eta(1475) \rightarrow K \bar{K} \pi \ ] < 1.4 \times 10^{-4} \quad CL=90\% \quad -

\[ \gamma \eta(1475) \rightarrow \eta \pi^+ \pi^- \ ] < 8.8 \times 10^{-5} \quad CL=90\% \quad -

\[ \gamma (\pi^+ \pi^-) \ ] (\ 4.0 \pm 0.6 \ ) \times 10^{-4} \quad 1817

\[ \gamma K^*0 K^+ \pi^- + \text{c.c.} \ ] (\ 3.7 \pm 0.9 \ ) \times 10^{-4} \quad 1674

\[ \gamma K^*0 \bar{K}^0 \ ] (\ 2.4 \pm 0.7 \ ) \times 10^{-4} \quad 1613

\[ \gamma K^0_S K^+ \pi^- + \text{c.c.} \ ] (\ 2.6 \pm 0.5 \ ) \times 10^{-4} \quad 1753

\[ \gamma K^+ K^- \pi^+ \pi^- \ ] (\ 1.9 \pm 0.5 \ ) \times 10^{-4} \quad 1726

\[ \gamma p \bar{p} \ ] (\ 3.9 \pm 0.5 \ ) \times 10^{-5} \quad S=2.0 \quad 1586

\[ \gamma f_2(1950) \rightarrow \gamma p \bar{p} \ ] (\ 1.20 \pm 0.22 \ ) \times 10^{-5} \quad -

\[ \gamma f_2(2150) \rightarrow \gamma p \bar{p} \ ] (\ 7.2 \pm 1.8 \ ) \times 10^{-6} \quad -
\( \gamma X(1835) \rightarrow \gamma p\bar{p} \) 
\[ (4.6 \pm 1.8 \pm 4.0) \times 10^{-6} \]

\( \gamma X \rightarrow \gamma p\bar{p} \) \[ [\nu\nu\bar{a}] < 2 \times 10^{-6} \text{ CL=90\%} \]

\( \gamma \pi^+ \pi^- p\bar{p} \) \[ (2.8 \pm 1.4) \times 10^{-5} \]

\( 2(\pi^+ \pi^-) K^+ K^- \) \[ < 2.2 \times 10^{-4} \text{ CL=90\%} \]

\( 3(\pi^+ \pi^-) \) \[ < 1.7 \times 10^{-4} \text{ CL=90\%} \]

\( K^+ K^- K^+ K^- \) \[ < 4 \times 10^{-5} \text{ CL=90\%} \]

\( \gamma \gamma J/\psi \) \[ (3.1 \pm 1.0 \pm 1.2) \times 10^{-4} \]

\( \gamma \pi^+ \pi^- p\bar{p} \) \[ (4.6 \pm 1.8 \pm 4.0) \times 10^{-6} \]

\( \gamma X \rightarrow \gamma p\bar{p} \) \[ [\nu\nu\bar{a}] < 2 \times 10^{-6} \text{ CL=90\%} \]

\( \gamma \pi^+ \pi^- p\bar{p} \) \[ (2.8 \pm 1.4) \times 10^{-5} \]

\( 2(\pi^+ \pi^-) K^+ K^- \) \[ < 2.2 \times 10^{-4} \text{ CL=90\%} \]

\( 3(\pi^+ \pi^-) \) \[ < 1.7 \times 10^{-4} \text{ CL=90\%} \]

\( K^+ K^- K^+ K^- \) \[ < 4 \times 10^{-5} \text{ CL=90\%} \]

\( \gamma \gamma J/\psi \) \[ (3.1 \pm 1.0 \pm 1.2) \times 10^{-4} \]

\( \gamma \pi^+ \pi^- p\bar{p} \) \[ (4.6 \pm 1.8 \pm 4.0) \times 10^{-6} \]

\( \gamma X \rightarrow \gamma p\bar{p} \) \[ [\nu\nu\bar{a}] < 2 \times 10^{-6} \text{ CL=90\%} \]

\( \gamma \pi^+ \pi^- p\bar{p} \) \[ (2.8 \pm 1.4) \times 10^{-5} \]

\( 2(\pi^+ \pi^-) K^+ K^- \) \[ < 2.2 \times 10^{-4} \text{ CL=90\%} \]

\( 3(\pi^+ \pi^-) \) \[ < 1.7 \times 10^{-4} \text{ CL=90\%} \]

\( K^+ K^- K^+ K^- \) \[ < 4 \times 10^{-5} \text{ CL=90\%} \]

\( \gamma \gamma J/\psi \) \[ (3.1 \pm 1.0 \pm 1.2) \times 10^{-4} \]

\( \gamma \pi^+ \pi^- p\bar{p} \) \[ (4.6 \pm 1.8 \pm 4.0) \times 10^{-6} \]

\( \gamma X \rightarrow \gamma p\bar{p} \) \[ [\nu\nu\bar{a}] < 2 \times 10^{-6} \text{ CL=90\%} \]

\( \gamma \pi^+ \pi^- p\bar{p} \) \[ (2.8 \pm 1.4) \times 10^{-5} \]

\( 2(\pi^+ \pi^-) K^+ K^- \) \[ < 2.2 \times 10^{-4} \text{ CL=90\%} \]

\( 3(\pi^+ \pi^-) \) \[ < 1.7 \times 10^{-4} \text{ CL=90\%} \]

\( K^+ K^- K^+ K^- \) \[ < 4 \times 10^{-5} \text{ CL=90\%} \]

\( \gamma \gamma J/\psi \) \[ (3.1 \pm 1.0 \pm 1.2) \times 10^{-4} \]

\( \gamma \pi^+ \pi^- p\bar{p} \) \[ (4.6 \pm 1.8 \pm 4.0) \times 10^{-6} \]

\( \gamma X \rightarrow \gamma p\bar{p} \) \[ [\nu\nu\bar{a}] < 2 \times 10^{-6} \text{ CL=90\%} \]

\( \gamma \pi^+ \pi^- p\bar{p} \) \[ (2.8 \pm 1.4) \times 10^{-5} \]

\( 2(\pi^+ \pi^-) K^+ K^- \) \[ < 2.2 \times 10^{-4} \text{ CL=90\%} \]

\( 3(\pi^+ \pi^-) \) \[ < 1.7 \times 10^{-4} \text{ CL=90\%} \]

\( K^+ K^- K^+ K^- \) \[ < 4 \times 10^{-5} \text{ CL=90\%} \]

\( \gamma \gamma J/\psi \) \[ (3.1 \pm 1.0 \pm 1.2) \times 10^{-4} \]

\( \gamma \pi^+ \pi^- p\bar{p} \) \[ (4.6 \pm 1.8 \pm 4.0) \times 10^{-6} \]

\( \gamma X \rightarrow \gamma p\bar{p} \) \[ [\nu\nu\bar{a}] < 2 \times 10^{-6} \text{ CL=90\%} \]

\( \gamma \pi^+ \pi^- p\bar{p} \) \[ (2.8 \pm 1.4) \times 10^{-5} \]

\( 2(\pi^+ \pi^-) K^+ K^- \) \[ < 2.2 \times 10^{-4} \text{ CL=90\%} \]

\( 3(\pi^+ \pi^-) \) \[ < 1.7 \times 10^{-4} \text{ CL=90\%} \]

\( K^+ K^- K^+ K^- \) \[ < 4 \times 10^{-5} \text{ CL=90\%} \]

\( \gamma \gamma J/\psi \) \[ (3.1 \pm 1.0 \pm 1.2) \times 10^{-4} \]

\( \gamma \pi^+ \pi^- p\bar{p} \) \[ (4.6 \pm 1.8 \pm 4.0) \times 10^{-6} \]

\( \gamma X \rightarrow \gamma p\bar{p} \) \[ [\nu\nu\bar{a}] < 2 \times 10^{-6} \text{ CL=90\%} \]

\( \gamma \pi^+ \pi^- p\bar{p} \) \[ (2.8 \pm 1.4) \times 10^{-5} \]

\( 2(\pi^+ \pi^-) K^+ K^- \) \[ < 2.2 \times 10^{-4} \text{ CL=90\%} \]

\( 3(\pi^+ \pi^-) \) \[ < 1.7 \times 10^{-4} \text{ CL=90\%} \]

\( K^+ K^- K^+ K^- \) \[ < 4 \times 10^{-5} \text{ CL=90\%} \]

\( \gamma \gamma J/\psi \) \[ (3.1 \pm 1.0 \pm 1.2) \times 10^{-4} \]

\( \gamma \pi^+ \pi^- p\bar{p} \) \[ (4.6 \pm 1.8 \pm 4.0) \times 10^{-6} \]
\[\pi^+ \pi^- \pi^0 < 5 \times 10^{-6} \quad \mathrm{CL}=90\% \quad 1874\]

\[\rho \pi < 5 \times 10^{-6} \quad \mathrm{CL}=90\% \quad 1804\]

\[K^+(892)^+K^- + \text{c.c.} < 1.4 \times 10^{-5} \quad \mathrm{CL}=90\% \quad 1745\]

\[K^0(892)^0\bar{K}^0 + \text{c.c.} < 1.2 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1744\]

\[K^0_S K^0_L \]

\[2(\pi^+ \pi^-) < 1.12 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1861\]

\[2(\pi^+ \pi^-) \pi^0 < 1.06 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1843\]

\[\omega \pi^+ \pi^- < 6.0 \times 10^{-4} \quad \mathrm{CL}=90\% \quad 1794\]

\[3(\pi^+ \pi^-) < 9.1 \times 10^{-3} \quad 1819\]

\[3(\pi^+ \pi^-) \pi^0 < 1.37 \times 10^{-3} \quad 1792\]

\[3(\pi^+ \pi^-) 2\pi^0 < 11.74 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1760\]

\[\eta \pi^+ \pi^- < 1.24 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1836\]

\[\pi^+ \pi^- 2\pi^0 < 8.9 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1862\]

\[\rho^0 \pi^+ \pi^- < 6.9 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1796\]

\[\eta 3\pi < 1.34 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1824\]

\[\eta 2(\pi^+ \pi^-) < 2.43 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1804\]

\[\eta \rho^0 \pi^+ \pi^- < 1.45 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1708\]

\[\eta' 3\pi < 2.44 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1740\]

\[K^+ K^- \pi^+ \pi^- < 9.0 \times 10^{-4} \quad \mathrm{CL}=90\% \quad 1772\]

\[\phi \pi^+ \pi^- < 4.1 \times 10^{-4} \quad \mathrm{CL}=90\% \quad 1737\]

\[K^+ K^- 2\pi^0 < 4.2 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1774\]

\[4(\pi^+ \pi^-) < 1.67 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1757\]

\[4(\pi^+ \pi^-) \pi^0 < 3.06 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1720\]

\[\phi f_0(980) < 4.5 \times 10^{-4} \quad \mathrm{CL}=90\% \quad 1597\]

\[K^+ K^- \pi^+ \pi^- \pi^0 < 2.36 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1741\]

\[K^+ K^- \rho^0 \pi^0 < 8 \times 10^{-4} \quad \mathrm{CL}=90\% \quad 1624\]

\[K^+ K^- \rho^+ \pi^- < 1.46 \times 10^{-4} \quad \mathrm{CL}=90\% \quad 1622\]

\[\omega K^+ K^- < 3.4 \times 10^{-4} \quad \mathrm{CL}=90\% \quad 1664\]

\[\phi \pi^+ \pi^- \pi^0 < 3.8 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1722\]

\[K^{+0} K^- \pi^+ \pi^- \pi^0 + \text{c.c.} < 1.62 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1693\]

\[K^{++} K^- \pi^+ \pi^- + \text{c.c.} < 3.23 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1692\]

\[K^+ K^- \pi^+ \pi^- 2\pi^0 < 2.67 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1705\]

\[K^+ K^- 2(\pi^+ \pi^-) < 1.03 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1702\]

\[K^+ K^- 2(\pi^+ \pi^-) \pi^0 < 3.60 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1660\]

\[\eta K^+ K^- < 4.1 \times 10^{-4} \quad \mathrm{CL}=90\% \quad 1712\]

\[\eta K^+ K^- \pi^+ \pi^- < 1.24 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1624\]

\[\rho^0 K^+ K^- < 5.0 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1665\]

\[2(K^+ K^-) < 6.0 \times 10^{-4} \quad \mathrm{CL}=90\% \quad 1552\]

\[\phi K^+ K^- < 7.5 \times 10^{-4} \quad \mathrm{CL}=90\% \quad 1598\]

\[2(K^+ K^-) \pi^0 < 2.9 \times 10^{-4} \quad \mathrm{CL}=90\% \quad 1493\]

\[2(K^+ K^-) \pi^+ \pi^- < 3.2 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1425\]

\[K^0_S K^- \pi^+ \pi^- < 3.2 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1799\]

\[K^0_S K^- \pi^+ \pi^0 < 1.33 \times 10^{-3} \quad \mathrm{CL}=90\% \quad 1773\]
\$K_S^0 K^- \rho^+$ & \( < 6.6 \times 10^{-3} \) & CL=90\% & 1664 \\
\$K_S^0 K^- 2\pi^+ \pi^-$ & \( < 8.7 \times 10^{-3} \) & CL=90\% & 1739 \\
\$K_S^0 K^- \pi^+ \rho^0 \) & \( < 1.6 \) & \% & CL=90\% & 1621 \\
\$K_S^0 K^- \pi^+ \eta \) & \( < 1.3 \) & \% & CL=90\% & 1669 \\
\$K_S^0 K^- 2\pi^+ \pi^- \pi^0 \) & \( < 4.18 \) & \% & CL=90\% & 1703 \\
\$K_S^0 K^- 2\pi^+ \pi^- \eta \) & \( < 4.8 \) & \% & CL=90\% & 1570 \\
\$K_S^0 K^- \pi^+ 2(\pi^+ \pi^-) \) & \( < 1.22 \) & \% & CL=90\% & 1658 \\
\$K_S^0 K^- \pi^+ 2\pi^0 \) & \( < 2.65 \) & \% & CL=90\% & 1742 \\
\$K_S^0 K^- K^+ K^- \pi^+ \) & \( < 4.9 \times 10^{-3} \) & CL=90\% & 1490 \\
\$K_S^0 K^- K^+ K^- \pi^+ \pi^0 \) & \( < 3.0 \) & \% & CL=90\% & 1427 \\
\$K_S^0 K^- K^+ K^- \pi^+ \eta \) & \( < 2.2 \) & \% & CL=90\% & 1214 \\
\$K^*0 K^- \pi^+ + \text{c.c.} \) & \( < 9.7 \times 10^{-3} \) & CL=90\% & 1722 \\
\$p \bar{p} \pi^0 \) & \( < 1.2 \times 10^{-3} \) & & 1595 \\
\$p \bar{p} \pi^+ \pi^- \) & \( < 5.8 \times 10^{-4} \) & CL=90\% & 1544 \\
\$\Lambda \bar{\Lambda} \) & \( < 1.2 \times 10^{-4} \) & CL=90\% & 1521 \\
\$p \bar{p} \pi^+ \pi^- \pi^0 \) & \( < 1.85 \times 10^{-3} \) & CL=90\% & 1490 \\
\$\omega p \bar{p} \) & \( < 2.9 \times 10^{-4} \) & CL=90\% & 1309 \\
\$\Lambda \bar{\Lambda} \pi^0 \) & \( < 7 \times 10^{-5} \) & CL=90\% & 1469 \\
\$p \bar{p} 2(\pi^+ \pi^-) \) & \( < 2.6 \times 10^{-3} \) & CL=90\% & 1425 \\
\$\eta p \bar{p} \) & \( < 5.4 \times 10^{-4} \) & CL=90\% & 1430 \\
\$\eta p \bar{p} \pi^+ \pi^- \) & \( < 3.3 \times 10^{-3} \) & CL=90\% & 1284 \\
\$\rho^0 p \bar{p} \) & \( < 1.7 \times 10^{-3} \) & CL=90\% & 1313 \\
\$p \bar{p} K^+ K^- \) & \( < 3.2 \times 10^{-4} \) & CL=90\% & 1185 \\
\$\eta p \bar{p} K^+ K^- \) & \( < 6.9 \times 10^{-3} \) & CL=90\% & 736 \\
\$\pi^0 p \bar{p} K^+ K^- \) & \( < 1.2 \times 10^{-3} \) & CL=90\% & 1093 \\
\$\phi p \bar{p} \) & \( < 1.3 \times 10^{-4} \) & CL=90\% & 1178 \\
\$\Lambda \bar{\Lambda} \pi^+ \pi^- \) & \( < 2.5 \times 10^{-4} \) & CL=90\% & 1405 \\
\$\Lambda \bar{\Lambda} K^+ \) & \( < 2.8 \times 10^{-4} \) & CL=90\% & 1387 \\
\$\Lambda \bar{\Lambda} K^+ \pi^+ \pi^- \) & \( < 6.3 \times 10^{-4} \) & CL=90\% & 1234 \\
\$\Lambda \bar{\Lambda} \eta \) & \( < 1.9 \times 10^{-4} \) & CL=90\% & 1262 \\
\$\Sigma^+ \bar{\Sigma}^- \) & \( < 1.0 \times 10^{-4} \) & CL=90\% & 1464 \\
\$\Sigma^0 \bar{\Sigma}^0 \) & \( < 4 \times 10^{-5} \) & CL=90\% & 1462 \\
\$\Xi^+ \Xi^- \) & \( < 1.5 \times 10^{-4} \) & CL=90\% & \( - \) \\
\$\Xi^0 \Xi^0 \) & \( < 1.4 \times 10^{-4} \) & CL=90\% & 1353 \\

**Radiative decays**

\$\gamma \chi c2 \) & \( < 9 \times 10^{-4} \) & CL=90\% & 211 \\
\$\gamma \chi c1 \) & \(( 2.9 \pm 0.6 ) \times 10^{-3} \) & & 253 \\
\$\gamma \chi c0 \) & \(( 7.3 \pm 0.9 ) \times 10^{-3} \) & & 341 \\
\$\gamma \eta' \) & \( < 1.8 \times 10^{-4} \) & CL=90\% & 1765 \\
\$\gamma \eta \) & \( < 1.5 \times 10^{-4} \) & CL=90\% & 1847 \\
\$\gamma \pi^0 \) & \( < 2 \times 10^{-4} \) & CL=90\% & 1884
\( X(3872) \)

\[ i^G(J^PC) = 0^+(1^+ +) \]

Mass \( m = 3871.69 \pm 0.17 \text{ MeV} \)
\[ m_{X(3872)} - m_{J/\psi} = 775 \pm 4 \text{ MeV} \]
\[ m_{X(3872)} - m_{\psi(2S)} \]
Full width \( \Gamma < 1.2 \text{ MeV}, \text{ CL} = 90\% \)

<table>
<thead>
<tr>
<th>( X(3872) ) DECA Y MODES</th>
<th>Fraction (( \Gamma_i/\Gamma ))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \pi^+ \pi^- J/\psi(1S) )</td>
<td>&gt; 2.6 %</td>
<td>650</td>
</tr>
<tr>
<td>( \omega J/\psi(1S) )</td>
<td>&gt; 1.9 %</td>
<td>↑</td>
</tr>
<tr>
<td>( D^0 \bar{D}^0 \pi^0 )</td>
<td>&gt; 32 %</td>
<td>117</td>
</tr>
<tr>
<td>( \bar{D}^* \bar{D}^0 )</td>
<td>&gt; 24 %</td>
<td>↑</td>
</tr>
<tr>
<td>( \gamma J/\psi )</td>
<td>&gt; 6 \times 10^{-3}</td>
<td>697</td>
</tr>
<tr>
<td>( \gamma \psi(2S) )</td>
<td>[xxaa] &gt; 3.0 %</td>
<td>181</td>
</tr>
<tr>
<td>( \pi^+ \pi^- \eta_c(1S) )</td>
<td>not seen</td>
<td>746</td>
</tr>
<tr>
<td>( \rho \bar{\rho} )</td>
<td>not seen</td>
<td>1693</td>
</tr>
</tbody>
</table>

\( X(3900)^\pm \)

\[ i(J^P) = ?(1^+) \]

Mass \( m = 3888.7 \pm 3.4 \text{ MeV} \) \( (S = 1.3) \)
Full width \( \Gamma = 35 \pm 7 \text{ MeV} \)

<table>
<thead>
<tr>
<th>( X(3900)^\pm ) DECA Y MODES</th>
<th>Fraction (( \Gamma_i/\Gamma ))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( J/\psi \pi^\pm )</td>
<td>seen</td>
<td>700</td>
</tr>
<tr>
<td>( h_c \pi^\pm )</td>
<td>not seen</td>
<td>-</td>
</tr>
<tr>
<td>( (D \bar{D}^*)^\pm )</td>
<td>seen</td>
<td>-</td>
</tr>
</tbody>
</table>

\( \chi c_0(2P) \)

\[ i^G(J^PC) = 0^+(0^+++) \]

Mass \( m = 3918.4 \pm 1.9 \text{ MeV} \)
Full width \( \Gamma = 20 \pm 5 \text{ MeV} \) \( (S = 1.1) \)

<table>
<thead>
<tr>
<th>( \chi c_0(2P) ) DECA Y MODES</th>
<th>Fraction (( \Gamma_i/\Gamma ))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \omega J/\psi )</td>
<td>seen</td>
<td>222</td>
</tr>
<tr>
<td>( \pi^+ \pi^- \eta_c(1S) )</td>
<td>not seen</td>
<td>785</td>
</tr>
<tr>
<td>( K \bar{K} )</td>
<td>not seen</td>
<td>-</td>
</tr>
<tr>
<td>( \gamma \gamma )</td>
<td>seen</td>
<td>1959</td>
</tr>
</tbody>
</table>
\( \chi_c(2P) \)

\[ i^G(J^PC) = 0^+(2^++) \]

Mass \( m = 3927.2 \pm 2.6 \) MeV
Full width \( \Gamma = 24 \pm 6 \) MeV

### \( \chi_c(2P) \) Decay Modes

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction (( \Gamma_i/\Gamma ))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \gamma\gamma )</td>
<td>seen</td>
<td>1964</td>
</tr>
<tr>
<td>( D\bar{D} )</td>
<td>seen</td>
<td>615</td>
</tr>
<tr>
<td>( D^+D^- )</td>
<td>seen</td>
<td>600</td>
</tr>
<tr>
<td>( D^0\bar{D}^0 )</td>
<td>seen</td>
<td>615</td>
</tr>
<tr>
<td>( \pi^+\pi^-\eta_c(1S) )</td>
<td>not seen</td>
<td>792</td>
</tr>
<tr>
<td>( K\bar{K} )</td>
<td>not seen</td>
<td>1901</td>
</tr>
</tbody>
</table>

\( \psi(4040) \) \( [yyaa] \)

\[ i^G(J^PC) = 0^-(1^-) \]

Mass \( m = 4039 \pm 1 \) MeV
Full width \( \Gamma = 80 \pm 10 \) MeV
\( \Gamma_{ee} = 0.86 \pm 0.07 \) keV

Due to the complexity of the \( c\tau \) threshold region, in this listing, “seen” (”not seen”) means that a cross section for the mode in question has been measured at effective \( \sqrt{s} \) near this particle's central mass value, more (less) than \( 2\sigma \) above zero, without regard to any peaking behavior in \( \sqrt{s} \) or absence thereof. See mode listing(s) for details and references.

### \( \psi(4040) \) Decay Modes

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction (( \Gamma_i/\Gamma ))</th>
<th>Confidence level (( \Gamma_i/\Gamma ))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( e^+e^- )</td>
<td>( (1.07 \pm 0.16) \times 10^{-5} )</td>
<td></td>
<td>2019</td>
</tr>
<tr>
<td>( D\bar{D} )</td>
<td></td>
<td>seen</td>
<td>775</td>
</tr>
<tr>
<td>( D^0\bar{D}^0 )</td>
<td></td>
<td>seen</td>
<td>775</td>
</tr>
<tr>
<td>( D^+D^- )</td>
<td></td>
<td>seen</td>
<td>764</td>
</tr>
<tr>
<td>( D^*(2007)^0\bar{D}^0 + \text{c.c.} )</td>
<td></td>
<td>seen</td>
<td>569</td>
</tr>
<tr>
<td>( D^*(2010)^+D^- + \text{c.c.} )</td>
<td></td>
<td>seen</td>
<td>575</td>
</tr>
<tr>
<td>( D^<em>\bar{D}^</em> )</td>
<td></td>
<td>seen</td>
<td>561</td>
</tr>
<tr>
<td>( D^<em>(2007)^0\bar{D}^</em>(2007)^0 )</td>
<td></td>
<td>seen</td>
<td>193</td>
</tr>
<tr>
<td>( D^<em>(2010)^+D^</em>(2010)^- )</td>
<td></td>
<td>seen</td>
<td>193</td>
</tr>
<tr>
<td>( D^0D^-\pi^+ + \text{c.c. (excl.} )</td>
<td></td>
<td>not seen</td>
<td>–</td>
</tr>
<tr>
<td>( D^*(2007)^0\bar{D}^0 + \text{c.c.}, )</td>
<td></td>
<td>not seen</td>
<td>–</td>
</tr>
<tr>
<td>( D^*(2010)^+D^- + \text{c.c.)} )</td>
<td></td>
<td>not seen</td>
<td>–</td>
</tr>
<tr>
<td>( D\bar{D}^<em>\pi (\text{excl.} D^</em>\bar{D}^*) )</td>
<td></td>
<td>not seen</td>
<td>–</td>
</tr>
<tr>
<td>( D^0\bar{D}^*\pi^-\pi^+ + \text{c.c. (excl.} )</td>
<td></td>
<td>not seen</td>
<td>–</td>
</tr>
<tr>
<td>( D^<em>(2010)^+D^</em>(2010)^- )</td>
<td></td>
<td>seen</td>
<td>–</td>
</tr>
<tr>
<td>( D_s^+D_s^- )</td>
<td>seen</td>
<td>452</td>
<td></td>
</tr>
</tbody>
</table>
\[ \frac{\mathcal{C}}{\psi \pi^+ \pi^-} < 4 \times 10^{-3} \quad 90\% \quad 794 \]
\[ \frac{\mathcal{C}}{\psi \pi^0 \pi^0} < 2 \times 10^{-3} \quad 90\% \quad 797 \]
\[ \frac{\mathcal{C}}{\psi \eta} (5.2 \pm 0.7) \times 10^{-3} \quad 675 \]
\[ \frac{\mathcal{C}}{\psi \pi^0} < 2.8 \times 10^{-4} \quad 90\% \quad 823 \]
\[ \frac{\mathcal{C}}{\psi \pi^+ \pi^- \pi^0} < 2 \times 10^{-3} \quad 90\% \quad 746 \]
\[ \chi_1 \gamma < 1.1 \% \quad 90\% \quad 494 \]
\[ \chi_2 \gamma < 1.7 \% \quad 90\% \quad 454 \]
\[ \chi_1 \pi^+ \pi^- \pi^0 < 1.1 \% \quad 90\% \quad 306 \]
\[ \chi_2 \pi^+ \pi^- \pi^0 < 3.2 \% \quad 90\% \quad 233 \]
\[ h_c(1P) \pi^+ \pi^- < 3 \times 10^{-3} \quad 90\% \quad 403 \]
\[ \phi \pi^+ \pi^- < 3 \times 10^{-3} \quad 90\% \quad 1880 \]
\[ \Lambda \overline{\Lambda} \pi^+ \pi^- < 2.9 \times 10^{-4} \quad 90\% \quad 1578 \]
\[ \Lambda \overline{\Lambda} \pi^0 < 9 \times 10^{-5} \quad 90\% \quad 1636 \]
\[ \Lambda \overline{\Lambda} \eta < 3.0 \times 10^{-4} \quad 90\% \quad 1452 \]
\[ \Sigma^+ \Sigma^- < 1.3 \times 10^{-4} \quad 90\% \quad 1632 \]
\[ \Sigma^0 \Sigma^0 < 7 \times 10^{-5} \quad 90\% \quad 1630 \]
\[ \Xi^+ \Xi^- < 1.6 \times 10^{-4} \quad 90\% \quad 1533 \]
\[ \Xi^0 \Xi^0 < 1.8 \times 10^{-4} \quad 90\% \quad 1533 \]

**\(\psi(4160)\)** \[yyaa\]  

\[ i G(J^{PC}) = 0^-(1^-^-) \]

Mass \( m = 4191 \pm 5 \text{ MeV} \)  
Full width \( \Gamma = 70 \pm 10 \text{ MeV} \)  
\( \Gamma_{ee} = 0.48 \pm 0.22 \text{ keV} \)

Due to the complexity of the \( c \bar{c} \) threshold region, in this listing, “seen” (“not seen”) means that a cross section for the mode in question has been measured at effective \( \sqrt{s} \) near this particle’s central mass value, more (less) than \( 2\sigma \) above zero, without regard to any peaking behavior in \( \sqrt{s} \) or absence thereof. See mode listing(s) for details and references.

**\(\psi(4160)\) DECA Y MODES**  

<table>
<thead>
<tr>
<th>Mode</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>Confidence level ((\text{MeV/c}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>(e^+ e^-)</td>
<td>((6.9 \pm 3.3) \times 10^{-6})</td>
<td>2096</td>
</tr>
<tr>
<td>(\mu^+ \mu^-)</td>
<td>seen</td>
<td>2093</td>
</tr>
<tr>
<td>(D\overline{D})</td>
<td>seen</td>
<td>956</td>
</tr>
<tr>
<td>(D^0 \overline{D}^0)</td>
<td>seen</td>
<td>956</td>
</tr>
<tr>
<td>(D^+ D^-)</td>
<td>seen</td>
<td>947</td>
</tr>
<tr>
<td>(D^* D^{+ \text{c.c.}})</td>
<td>seen</td>
<td>798</td>
</tr>
<tr>
<td>(D^*(2007)^0 \overline{D}^0 + \text{c.c.})</td>
<td>seen</td>
<td>802</td>
</tr>
<tr>
<td>(D^*(2010)^+ D^- + \text{c.c.})</td>
<td>seen</td>
<td>792</td>
</tr>
<tr>
<td>(D^* \overline{D}^{*})</td>
<td>seen</td>
<td>592</td>
</tr>
<tr>
<td>(D^<em>(2007)^0 \overline{D}^</em> (2007)^0)</td>
<td>seen</td>
<td>603</td>
</tr>
<tr>
<td>(D^<em>(2010)^+ D^</em>(2010)^-)</td>
<td>seen</td>
<td>592</td>
</tr>
</tbody>
</table>
\[ D^0 D^- \pi^+ + c.c. \quad \text{(excl. not seen)} \]
\[ D^* \! (2007)^0 \overline{D}^0 + c.c., \quad \text{(excl. not seen)} \]
\[ D^*(2010)^+ D^- + c.c.) \quad \text{(excl. not seen)} \]
\[ D \overline{D}^* \pi + c.c. \quad \text{(excl. D}^* \overline{D}^* \text{ not seen)} \]
\[ D^0 D^* - \pi^+ + c.c. \quad \text{(excl. D}^* \overline{D}^* \text{ not seen)} \]
\[ D_s^+ D_s^- + c.c. \quad \text{(seen)} \]
\[ J/\psi \pi^+ \pi^- \quad < 3 \times 10^{-3} \quad 90\% \quad 919 \]
\[ J/\psi K^+ K^- \quad < 2 \times 10^{-3} \quad 90\% \quad 407 \]
\[ J/\psi \eta \quad < 8 \times 10^{-3} \quad 90\% \quad 821 \]
\[ J/\psi \eta' \quad < 5 \times 10^{-3} \quad 90\% \quad 457 \]
\[ J/\psi \pi^+ \pi^- \quad < 4 \times 10^{-3} \quad 90\% \quad 396 \]
\[ \chi_{c1} \gamma \quad < 7 \times 10^{-3} \quad 90\% \quad 625 \]
\[ \chi_{c2} \gamma \quad < 1.3 \% \quad 90\% \quad 587 \]
\[ \chi_{c1} \pi^+ \pi^- \pi^0 \quad < 2 \times 10^{-3} \quad 90\% \quad 496 \]
\[ \chi_{c2} \pi^+ \pi^- \pi^0 \quad < 8 \times 10^{-3} \quad 90\% \quad 445 \]
\[ h_c(1P) \pi^+ \pi^- \quad < 5 \times 10^{-3} \quad 90\% \quad 556 \]
\[ h_c(1P) \pi^0 \pi^0 \quad < 2 \times 10^{-3} \quad 90\% \quad 560 \]
\[ h_c(1P) \eta \quad < 2 \times 10^{-3} \quad 90\% \quad 348 \]
\[ h_c(1P) \pi^0 \quad < 4 \times 10^{-4} \quad 90\% \quad 600 \]
\[ \phi \pi^+ \pi^- \quad < 2 \times 10^{-3} \quad 90\% \quad 1961 \]

\[ X(4260) \quad J^G (J^{PC}) = ?(1^{--}) \]

Mass \[ m = 4251 \pm 9 \text{ MeV} \quad (S = 1.6) \]

Full width \[ \Gamma = 120 \pm 12 \text{ MeV} \quad (S = 1.1) \]

<table>
<thead>
<tr>
<th>X(4260) DECAY MODES</th>
<th>Fraction ( (\Gamma_i/\Gamma) )</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( J/\psi \pi^+ \pi^- )</td>
<td>seen</td>
<td>967</td>
</tr>
<tr>
<td>( J/\psi f_0(980), \ f_0(980) \to \pi^+ \pi^- )</td>
<td>seen</td>
<td>969</td>
</tr>
<tr>
<td>( X(3900) \pm \pi^\mp, \ X^\mp \to J/\psi \pi^\pm )</td>
<td>seen</td>
<td>512</td>
</tr>
<tr>
<td>( X(3872) \gamma )</td>
<td>seen</td>
<td>363</td>
</tr>
<tr>
<td>( J/\psi \eta )</td>
<td>not seen</td>
<td>876</td>
</tr>
<tr>
<td>( J/\psi \pi^0 )</td>
<td>not seen</td>
<td>991</td>
</tr>
<tr>
<td>( J/\psi \eta' )</td>
<td>not seen</td>
<td>552</td>
</tr>
<tr>
<td>( J/\psi \pi^+ \pi^- \pi^0 )</td>
<td>not seen</td>
<td>930</td>
</tr>
<tr>
<td>Particle</td>
<td>Status</td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>$J/\psi \eta \eta$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$\psi(2S)\pi^+\pi^-$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$\psi(2S)\eta$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$\chi_{c0}\omega$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$\chi_{c1}\gamma$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$\chi_{c1}\pi^+\pi^-\pi^0$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$\chi_{c2}\pi^+\pi^-\pi^0$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$h_c(1P)\pi^+\pi^-$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$\phi\pi^+\pi^-$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$\phi f_0(980) \to \phi\pi^+\pi^-$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$D \overline{D}$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$D^0\overline{D}^0$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$D^+D^-$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$D^<em>\overline{D}^</em> +c.c.$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$D^*(2007)^0\overline{D}^0 +c.c.$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$D^*(2010)^+D^- +c.c.$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$D^*(2007)^0\overline{D}^0 +c.c.$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$D^*(2010)^+D^- +c.c.$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$D^<em>\overline{D}^</em>$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$D^<em>(2007)^0\overline{D}^</em>(2007)^0$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$D^<em>(2010)^+D^</em>(2010)^-$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$D^0D^-\pi^+ +c.c.$ (excl. $D^<em>(2007)^0\overline{D}^0 +c.c.,D^</em>(2010)^+D^- +c.c.$)</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$D^0D^<em>(2007)^0 \overline{D}^</em>(2007)^0 +c.c.$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$D^0D^<em>(2010)^+D^</em>(2010)^-$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$D^<em>\overline{D}^</em>\pi$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$D^+_sD^-_s$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$D^+_sD^-_s+c.c.$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$D^+_sD^-_s$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$\rho\overline{\pi}$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$K^0\overline{K}^\pm\pi^\mp$</td>
<td>not seen</td>
<td></td>
</tr>
<tr>
<td>$K^+K^-\pi^0$</td>
<td>not seen</td>
<td></td>
</tr>
</tbody>
</table>

---

**$X(4360)$**

\[
J^G(J^{PC}) = ?(1--)
\]

$X(4360)$ MASS = 4361 ± 13 MeV

$X(4360)$ WIDTH = 74 ± 18 MeV

**$X(4360)$ DECAY MODES**

<table>
<thead>
<tr>
<th>Particle</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\psi(2S)\pi^+\pi^-$</td>
<td>seen</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Particle</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>$p$ (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\psi(2S)\pi^+\pi^-$</td>
<td>seen</td>
<td>567</td>
</tr>
</tbody>
</table>

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\( \psi(4415) \) \([\gamma\gamma a]\)

\[ iG(JPC) = 0^−(1^{−−}) \]

Mass \( m = 4421 \pm 4 \) MeV
Full width \( \Gamma = 62 \pm 20 \) MeV
\( \Gamma_{ee} = 0.58 \pm 0.07 \) keV

Due to the complexity of the \( c\bar{c} \) threshold region, in this listing, “seen” ("not seen") means that a cross section for the mode in question has been measured at effective \( \sqrt{s} \) near this particle’s central mass value, more (less) than 2\( \sigma \) above zero, without regard to any peaking behavior in \( \sqrt{s} \) or absence thereof. See mode listing(s) for details and references.

\begin{tabular}{|l|l|l|}
\hline
\psi(4415) DECA Y MODES & Fraction (\( \Gamma_i/\Gamma \)) & Confidence level (MeV/c) \\
\hline
\( D\bar{D} \) & not seen & 1187 \\
\( D^0 \bar{D}^0 \) & seen & 1187 \\
\( D^+ \bar{D}^- \) & seen & 1179 \\
\( D^* \bar{D} + \text{c.c.} \) & not seen & 1063 \\
\( D^*(2007)^0 \bar{D}^0 + \text{c.c.} \) & seen & 1066 \\
\( D^*(2010)^+ \bar{D}^- + \text{c.c.} \) & seen & 1059 \\
\( D^* \bar{D}^* \) & not seen & 919 \\
\( D^*(2007)^0 \bar{D}^*(2007)^0 + \text{c.c.} \) & seen & 927 \\
\( D^*(2010)^+ \bar{D}^*(2010)^- + \text{c.c.} \) & seen & 919 \\
\( D^0 D^- \pi^+ \) (excl. \( D^*(2007)^0 \bar{D}^0 + \text{c.c., D}^*(2010)^+ \bar{D}^- + \text{c.c.} \)) & < 2.3 \% & 90\% & - \\
\hline
\( X(4660) \) \( \pi^+ \pi^- \) & seen & 838 \\
\hline
\end{tabular}

\( X(4660) \) \( J^G(JPC) = ?^-(1^{--}) \)

\( X(4660) \) MASS = 4664 \( \pm 12 \) MeV
\( X(4660) \) WIDTH = 48 \( \pm 15 \) MeV

\begin{tabular}{|l|l|l|}
\hline
\( X(4660) \) DECA Y MODES & Fraction (\( \Gamma_i/\Gamma \)) & \( p \) (MeV/c) \\
\hline
\psi(2S) \pi^+ \pi^- & seen & 838 \\
\hline
\end{tabular}
### $b\bar{b}$ MESONS

#### $\Upsilon(1S)$

\[ iG(J^{PC}) = 0^-(1^{-+}) \]

Mass $m = 9460.30 \pm 0.26$ MeV \quad (S = 3.3)

Full width $\Gamma = 54.02 \pm 1.25$ keV

$\Gamma_{ee} = 1.340 \pm 0.018$ keV

#### $\Upsilon(1S)$ DECAY MODES

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>Confidence level ($%$)</th>
<th>Confidence level (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau^+\tau^-$</td>
<td>$2.60 \pm 0.10$</td>
<td>-</td>
<td>4384</td>
</tr>
<tr>
<td>$\eta^' (958)$ anything</td>
<td>$2.94 \pm 0.24$</td>
<td>-</td>
<td>4223</td>
</tr>
<tr>
<td>$J/\psi (1S)$ anything</td>
<td>$6.50 \pm 0.70 \times 10^{-4}$</td>
<td>-</td>
<td>1270</td>
</tr>
<tr>
<td>$\chi_{c0}$ anything</td>
<td>$&lt; 5 \times 10^{-3}$</td>
<td>90</td>
<td>-</td>
</tr>
<tr>
<td>$\chi_{c1}$ anything</td>
<td>$2.30 \pm 0.70 \times 10^{-4}$</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$\chi_{c2}$ anything</td>
<td>$3.40 \pm 1.00 \times 10^{-4}$</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$\psi (2S)$ anything</td>
<td>$2.70 \pm 0.90 \times 10^{-4}$</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$\rho \pi$</td>
<td>$3.68 \times 10^{-6}$</td>
<td>90</td>
<td>4697</td>
</tr>
<tr>
<td>$\omega \pi^0$</td>
<td>$3.90 \times 10^{-6}$</td>
<td>90</td>
<td>4636</td>
</tr>
<tr>
<td>$\pi^+\pi^-$</td>
<td>$&lt; 5 \times 10^{-4}$</td>
<td>90</td>
<td>4628</td>
</tr>
<tr>
<td>$K^+K^-$</td>
<td>$&lt; 5 \times 10^{-4}$</td>
<td>90</td>
<td>4604</td>
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<tr>
<td>$\rho \bar{\rho}$</td>
<td>$&lt; 5 \times 10^{-4}$</td>
<td>90</td>
<td>4636</td>
</tr>
<tr>
<td>$\pi^+\pi^-\pi^0$</td>
<td>$2.10 \pm 0.80 \times 10^{-6}$</td>
<td>-</td>
<td>4672</td>
</tr>
<tr>
<td>$\phi K^+K^-$</td>
<td>$2.40 \pm 0.50 \times 10^{-6}$</td>
<td>-</td>
<td>4622</td>
</tr>
<tr>
<td>$\omega \pi^+\pi^-$</td>
<td>$4.50 \pm 1.00 \times 10^{-6}$</td>
<td>-</td>
<td>4694</td>
</tr>
<tr>
<td>$K^*(892)^0 K^- \pi^+ + \text{c.c.}$</td>
<td>$4.40 \pm 0.80 \times 10^{-6}$</td>
<td>-</td>
<td>4667</td>
</tr>
<tr>
<td>$\phi f_2^I (1525)$</td>
<td>$1.63 \times 10^{-6}$</td>
<td>90</td>
<td>4549</td>
</tr>
<tr>
<td>$\omega f_2 (1270)$</td>
<td>$1.79 \times 10^{-6}$</td>
<td>90</td>
<td>4611</td>
</tr>
<tr>
<td>$\rho (770) a_2 (1320)$</td>
<td>$2.24 \times 10^{-6}$</td>
<td>90</td>
<td>4605</td>
</tr>
<tr>
<td>$K^*(892)^0 K_{2J}^0 (1430)^0 + \text{c.c.}$</td>
<td>$3.00 \pm 0.80 \times 10^{-6}$</td>
<td>-</td>
<td>4579</td>
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<tr>
<td>$K_1 (1270)^\pm K^\mp$</td>
<td>$2.41 \times 10^{-6}$</td>
<td>90</td>
<td>4631</td>
</tr>
<tr>
<td>$K_1 (1400)^\pm K^\mp$</td>
<td>$1.00 \pm 0.40 \times 10^{-6}$</td>
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<td>4613</td>
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<tr>
<td>$b_1 (1235)^\pm K^\mp$</td>
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<td>90</td>
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<tr>
<td>$\pi^+\pi^-\pi^0\pi^0$</td>
<td>$1.28 \pm 0.30 \times 10^{-5}$</td>
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</tr>
<tr>
<td>$K_0 S K^+\pi^- + \text{c.c.}$</td>
<td>$1.60 \pm 0.40 \times 10^{-6}$</td>
<td>-</td>
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<tr>
<td>$K^* (892)^0 K^0 + \text{c.c.}$</td>
<td>$2.90 \pm 0.90 \times 10^{-6}$</td>
<td>-</td>
<td>4675</td>
</tr>
</tbody>
</table>
\( K^*(892)^- K^+ \) c.c. & < 1.11 \times 10^{-6} & 90\% & 4675 \\
\( D^*(2010)^\pm \) anything & ( 2.52 \pm 0.20 ) \% & – & – \\
\( \overline{c} \) anything & ( 2.86 \pm 0.28 ) \times 10^{-5} & – & – \\
Sum of 100 exclusive modes & ( 1.200\pm0.017) \% & – & – \\

**Radiative decays**

<table>
<thead>
<tr>
<th>Decay</th>
<th>Branching</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \gamma \pi^+ \pi^- )</td>
<td>( 6.3 \pm 1.8 ) \times 10^{-5}</td>
<td>4728</td>
</tr>
<tr>
<td>( \gamma \pi^0 \pi^0 )</td>
<td>( 1.7 \pm 0.7 ) \times 10^{-5}</td>
<td>4728</td>
</tr>
<tr>
<td>( \gamma \pi^0 \eta )</td>
<td>&lt; 2.4 \times 10^{-6}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma K^+ K^- )</td>
<td>[zzaa] &amp; ( 1.14 \pm 0.13 ) \times 10^{-5}</td>
<td>4704</td>
</tr>
<tr>
<td>( \gamma p \overline{p} )</td>
<td>[aabb] &amp; &lt; 6 \times 10^{-6}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma 2h^+ 2h^- )</td>
<td>( 7.0 \pm 1.5 ) \times 10^{-4}</td>
<td>4720</td>
</tr>
<tr>
<td>( \gamma 3h^+ 3h^- )</td>
<td>( 5.4 \pm 2.0 ) \times 10^{-4}</td>
<td>4703</td>
</tr>
<tr>
<td>( \gamma 4h^+ 4h^- )</td>
<td>( 7.4 \pm 3.5 ) \times 10^{-4}</td>
<td>4679</td>
</tr>
<tr>
<td>( \gamma \pi^+ \pi^- K^+ K^- )</td>
<td>( 2.9 \pm 0.9 ) \times 10^{-4}</td>
<td>4686</td>
</tr>
<tr>
<td>( \gamma 2\pi^+ 2\pi^- )</td>
<td>( 2.5 \pm 0.9 ) \times 10^{-4}</td>
<td>4720</td>
</tr>
<tr>
<td>( \gamma 3\pi^+ 3\pi^- )</td>
<td>( 2.5 \pm 1.2 ) \times 10^{-4}</td>
<td>4703</td>
</tr>
<tr>
<td>( \gamma 2\pi^+ 2\pi^- K^+ K^- )</td>
<td>( 2.4 \pm 1.2 ) \times 10^{-4}</td>
<td>4658</td>
</tr>
<tr>
<td>( \gamma \pi^+ \pi^- \rho \overline{p} )</td>
<td>( 1.5 \pm 0.6 ) \times 10^{-4}</td>
<td>4604</td>
</tr>
<tr>
<td>( \gamma 2\pi^+ 2\pi^- \rho \overline{p} )</td>
<td>( 4 \pm 6 ) \times 10^{-5}</td>
<td>4563</td>
</tr>
<tr>
<td>( \gamma 2K^+ 2K^- )</td>
<td>( 2.0 \pm 2.0 ) \times 10^{-5}</td>
<td>4601</td>
</tr>
<tr>
<td>( \gamma \eta(958) )</td>
<td>&lt; 1.9 \times 10^{-6}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma \eta )</td>
<td>&lt; 1.0 \times 10^{-6}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma f_0(980) )</td>
<td>&lt; 3 \times 10^{-5}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma f_2^+(1525) )</td>
<td>( 3.8 \pm 0.9 ) \times 10^{-5}</td>
<td>4607</td>
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<tr>
<td>( \gamma f_2(1270) )</td>
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<td>4644</td>
</tr>
<tr>
<td>( \gamma \eta(1405) )</td>
<td>&lt; 8.2 \times 10^{-5}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma f_0(1500) )</td>
<td>&lt; 1.5 \times 10^{-5}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma f_0(1710) )</td>
<td>&lt; 2.6 \times 10^{-4}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma f_0(1710) \rightarrow \gamma K^+ K^- )</td>
<td>&lt; 7 \times 10^{-6}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma f_0(1710) \rightarrow \gamma \pi^0 \pi^0 )</td>
<td>&lt; 1.4 \times 10^{-6}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma f_0(1710) \rightarrow \gamma \eta \eta )</td>
<td>&lt; 1.8 \times 10^{-6}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma f_2(2050) )</td>
<td>&lt; 5.3 \times 10^{-5}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma f_0(2200) \rightarrow \gamma K^+ K^- )</td>
<td>&lt; 2 \times 10^{-4}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma f_0(2200) \rightarrow \gamma K^+ K^- )</td>
<td>&lt; 2 \times 10^{-7}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma f_0(2200) \rightarrow \gamma \pi^+ \pi^- )</td>
<td>&lt; 6 \times 10^{-7}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma f_0(2200) \rightarrow \gamma \rho \overline{p} )</td>
<td>&lt; 1.1 \times 10^{-6}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma \eta(2225) \rightarrow \gamma \phi \phi )</td>
<td>&lt; 3 \times 10^{-3}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma \eta(15S) )</td>
<td>&lt; 5.7 \times 10^{-5}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma \chi c 0 )</td>
<td>&lt; 6.5 \times 10^{-4}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma \chi c 1 )</td>
<td>&lt; 2.3 \times 10^{-5}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma \chi c 2 )</td>
<td>&lt; 7.6 \times 10^{-6}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma X(3872) \rightarrow \pi^+ \pi^- J/\psi )</td>
<td>&lt; 1.6 \times 10^{-6}</td>
<td>90%</td>
</tr>
<tr>
<td>( \gamma X(3872) \rightarrow \pi^+ \pi^- \pi^0 J/\psi )</td>
<td>&lt; 2.8 \times 10^{-6}</td>
<td>90%</td>
</tr>
</tbody>
</table>
\[ \gamma \chi_{c0}(2P) \rightarrow \omega \psi(2S) \quad \text{invisible} \quad < 3.0 \quad \times 10^{-6} \quad 90\% \quad - \]
\[ \gamma X(4140) \rightarrow \phi \psi(2S) \quad < 2.2 \quad \times 10^{-6} \quad 90\% \quad - \]
\[ \gamma X \quad [bbbb] < 4.5 \quad \times 10^{-6} \quad 90\% \quad - \]
\[ \gamma X \bar{X}(m_{X} < 3.1 \text{ GeV}) \quad [ccbb] < 1 \quad \times 10^{-3} \quad 90\% \quad - \]
\[ \gamma X \bar{X}(m_{X} < 4.5 \text{ GeV}) \quad [ddbb] < 2.4 \quad \times 10^{-4} \quad 90\% \quad - \]
\[ \gamma X \rightarrow \gamma + \geq 4 \text{ prongs} \quad [eebb] < 1.78 \quad \times 10^{-4} \quad 95\% \quad - \]
\[ \gamma a_{1}^{0} \rightarrow \gamma \mu^{+} \mu^{-} \quad [ffbb] < 9 \quad \times 10^{-6} \quad 90\% \quad - \]
\[ \gamma a_{1}^{0} \rightarrow \gamma \tau^{+} \tau^{-} \quad [zzaa] < 1.30 \quad \times 10^{-4} \quad 90\% \quad - \]
\[ \gamma a_{1}^{0} \rightarrow \gamma \gamma \quad [ggbb] < 1 \quad \% \quad 90\% \quad - \]
\[ \gamma a_{1}^{0} \rightarrow \gamma s \bar{s} \quad [ggbb] < 1 \quad \times 10^{-3} \quad 90\% \quad - \]

Lepton Family number (LF) violating modes

\[ \mu^{\pm} \tau^{\mp} \quad LF \quad < 6.0 \quad \times 10^{-6} \quad 95\% \quad 4563 \]

Other decays

\[ \chi_{b0}(1P) \quad [hhbb] \]
\[ J^{G}(J^{PC}) = 0^{+}(0^{++}) \]
\[ J \text{ needs confirmation.} \]

Mass \( m = 9859.44 \pm 0.42 \pm 0.31 \) MeV

\( \chi_{b0}(1P) \) DECAy MODES

<table>
<thead>
<tr>
<th>Decay MODES</th>
<th>Fraction (( \Gamma_{i}/\Gamma ))</th>
<th>Confidence level</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \gamma \ U(1S) )</td>
<td>( 1.76 \pm 0.35 ) %</td>
<td>90%</td>
<td>391</td>
</tr>
<tr>
<td>( D^{0} X )</td>
<td>&lt; 10.4</td>
<td>%</td>
<td>90%</td>
</tr>
<tr>
<td>( \pi^{+}\pi^{-} K^{+} K^{-} \pi^{0} )</td>
<td>&lt; 1.6</td>
<td>( \times 10^{-4} )</td>
<td>90%</td>
</tr>
<tr>
<td>( 2 \pi^{+}\pi^{-} K^{-} K^{0} )</td>
<td>&lt; 5</td>
<td>( \times 10^{-5} )</td>
<td>90%</td>
</tr>
<tr>
<td>( 2 \pi^{+}\pi^{-} K^{-} K^{0}_{S} 2 \pi^{0} )</td>
<td>&lt; 5</td>
<td>( \times 10^{-4} )</td>
<td>90%</td>
</tr>
<tr>
<td>( 2 \pi^{+} 2 \pi^{+} \pi^{-} 2 \pi^{-} )</td>
<td>&lt; 2.1</td>
<td>( \times 10^{-4} )</td>
<td>90%</td>
</tr>
<tr>
<td>( 2 \pi^{+} 2 \pi^{-} K^{+} K^{-} )</td>
<td>( 1.1 \pm 0.6 )</td>
<td>( \times 10^{-4} )</td>
<td>4861</td>
</tr>
<tr>
<td>( 2 \pi^{+} 2 \pi^{-} K^{+} K^{-} \pi^{0} )</td>
<td>&lt; 2.7</td>
<td>( \times 10^{-4} )</td>
<td>90%</td>
</tr>
<tr>
<td>( 2 \pi^{+} 2 \pi^{-} K^{+} K^{-} 2 \pi^{0} )</td>
<td>&lt; 5</td>
<td>( \times 10^{-4} )</td>
<td>90%</td>
</tr>
<tr>
<td>( 3 \pi^{+} 2 \pi^{-} K^{-} K^{0}_{S} \pi^{0} )</td>
<td>&lt; 1.6</td>
<td>( \times 10^{-4} )</td>
<td>90%</td>
</tr>
<tr>
<td>( 3 \pi^{+} 3 \pi^{-} )</td>
<td>&lt; 8</td>
<td>( \times 10^{-5} )</td>
<td>90%</td>
</tr>
<tr>
<td>( 3 \pi^{+} 3 \pi^{-} 2 \pi^{0} )</td>
<td>&lt; 6</td>
<td>( \times 10^{-4} )</td>
<td>90%</td>
</tr>
<tr>
<td>( 3 \pi^{+} 3 \pi^{-} K^{+} K^{-} )</td>
<td>( 2.4 \pm 1.2 )</td>
<td>( \times 10^{-4} )</td>
<td>4827</td>
</tr>
<tr>
<td>( 3 \pi^{+} 3 \pi^{-} K^{+} K^{-} \pi^{0} )</td>
<td>&lt; 1.0</td>
<td>( \times 10^{-3} )</td>
<td>90%</td>
</tr>
<tr>
<td>( 4 \pi^{+} 4 \pi^{-} )</td>
<td>&lt; 8</td>
<td>( \times 10^{-5} )</td>
<td>90%</td>
</tr>
<tr>
<td>( 4 \pi^{+} 4 \pi^{-} 2 \pi^{0} )</td>
<td>&lt; 2.1</td>
<td>( \times 10^{-3} )</td>
<td>90%</td>
</tr>
<tr>
<td>( J/\psi \ J/\psi )</td>
<td>&lt; 7</td>
<td>( \times 10^{-5} )</td>
<td>90%</td>
</tr>
<tr>
<td>( J/\psi \ J/\psi (2S) )</td>
<td>&lt; 1.2</td>
<td>( \times 10^{-4} )</td>
<td>90%</td>
</tr>
<tr>
<td>( \psi(2S) \ J/\psi(2S) )</td>
<td>&lt; 3.1</td>
<td>( \times 10^{-5} )</td>
<td>90%</td>
</tr>
</tbody>
</table>
$\chi_b(1P)$  

**[hhbb]**  

$iG(j^{PC}) = 0^+(1^+)$  

$J$ needs confirmation.  

Mass $m = 9892.78 \pm 0.26 \pm 0.31$ MeV

<table>
<thead>
<tr>
<th>Decay Modes</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>Confidence level (MeV/$c$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma \ U(1S)$</td>
<td>$(33.9\pm2.2)%$</td>
<td>423</td>
</tr>
<tr>
<td>$D^0 X$</td>
<td>$(12.6\pm2.2)%$</td>
<td>–</td>
</tr>
<tr>
<td>$\pi^+ \pi^- K^+ K^- \pi^0$</td>
<td>$(2.0\pm0.6) \times 10^{-4}$</td>
<td>4892</td>
</tr>
<tr>
<td>$2\pi^+ \pi^- K^0 S_0$</td>
<td>$(1.3\pm0.5) \times 10^{-4}$</td>
<td>4892</td>
</tr>
<tr>
<td>$2\pi^+ \pi^- K^- K^0 S_0$</td>
<td>$&lt; 6 \times 10^{-4}$</td>
<td>90% 4863</td>
</tr>
<tr>
<td>$\gamma J/\psi J/\psi$</td>
<td>$&lt; 2.7 \times 10^{-5}$</td>
<td>90% 3857</td>
</tr>
<tr>
<td>$\pi^+ 2\pi^- 2\pi^0$</td>
<td>$(8.0\pm2.5) \times 10^{-4}$</td>
<td>4921</td>
</tr>
<tr>
<td>$2\pi^+ 2\pi^- K^+ K^-$</td>
<td>$(1.5\pm0.5) \times 10^{-4}$</td>
<td>4878</td>
</tr>
<tr>
<td>$2\pi^+ 2\pi^- K^+ K^- \pi^0$</td>
<td>$(3.5\pm1.2) \times 10^{-4}$</td>
<td>4863</td>
</tr>
<tr>
<td>$2\pi^+ 2\pi^- K^+ K^- 2\pi^0$</td>
<td>$(8.6\pm3.2) \times 10^{-4}$</td>
<td>4845</td>
</tr>
<tr>
<td>$3\pi^+ 2\pi^- K^- K^0 S_0 \pi^0$</td>
<td>$(9.3\pm3.3) \times 10^{-4}$</td>
<td>4844</td>
</tr>
<tr>
<td>$3\pi^+ 3\pi^-$</td>
<td>$(1.9\pm0.6) \times 10^{-4}$</td>
<td>4921</td>
</tr>
<tr>
<td>$3\pi^+ 3\pi^- 2\pi^0$</td>
<td>$(1.7\pm0.5) \times 10^{-3}$</td>
<td>4908</td>
</tr>
<tr>
<td>$3\pi^+ 3\pi^- K^+ K^-$</td>
<td>$(2.6\pm0.8) \times 10^{-4}$</td>
<td>4844</td>
</tr>
<tr>
<td>$3\pi^+ 3\pi^- K^+ K^- \pi^0$</td>
<td>$(7.5\pm2.6) \times 10^{-4}$</td>
<td>4825</td>
</tr>
<tr>
<td>$4\pi^+ 4\pi^-$</td>
<td>$(2.6\pm0.9) \times 10^{-4}$</td>
<td>4897</td>
</tr>
<tr>
<td>$4\pi^+ 4\pi^- 2\pi^0$</td>
<td>$(1.4\pm0.6) \times 10^{-3}$</td>
<td>4867</td>
</tr>
</tbody>
</table>

$h_b(1P)$  

**[hhbb]**  

$iG(j^{PC}) = ?(1^-)$  

Mass $m = 9899.3 \pm 1.0$ MeV

<table>
<thead>
<tr>
<th>Decay Modes</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>$p$ (MeV/$c$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\eta_b(1S) \gamma$</td>
<td>$(49^{+8}_{-7})%$</td>
<td>489</td>
</tr>
</tbody>
</table>
\[ \chi_{b2}(1P) \ \ [hhbb] \]

\[ iG(J^{PC}) = 0^+(2^+ - -) \]

\[ J \] needs confirmation.

\[ \text{Mass } m = 9912.21 \pm 0.26 \pm 0.31 \text{ MeV} \]

<table>
<thead>
<tr>
<th>( \chi_{b2}(1P) ) DECAY MODES</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>Confidence level</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \gamma \ T(1S) ) ( \pi^+ \pi^- K^+ K^- \pi^0 )</td>
<td>((8 \pm 5) \times 10^{-5})</td>
<td>(4902)</td>
<td></td>
</tr>
<tr>
<td>( \gamma \ T(1S) ) ( \pi^+ \pi^- K^+ K^- \pi^0 )</td>
<td>((5.3 \pm 2.4) \times 10^{-4})</td>
<td>(4901)</td>
<td></td>
</tr>
<tr>
<td>( \gamma \ T(1S) ) ( \pi^+ \pi^- K^+ K^- \pi^0 )</td>
<td>((3.5 \pm 1.4) \times 10^{-4})</td>
<td>(4931)</td>
<td></td>
</tr>
<tr>
<td>( \gamma \ T(1S) ) ( \pi^+ \pi^- K^+ K^- \pi^0 )</td>
<td>((1.1 \pm 0.4) \times 10^{-4})</td>
<td>(4888)</td>
<td></td>
</tr>
<tr>
<td>( \gamma \ T(1S) ) ( \pi^+ \pi^- K^+ K^- \pi^0 )</td>
<td>((2.1 \pm 0.9) \times 10^{-4})</td>
<td>(4872)</td>
<td></td>
</tr>
<tr>
<td>( \gamma \ T(1S) ) ( \pi^+ \pi^- K^+ K^- \pi^0 )</td>
<td>((3.9 \pm 1.8) \times 10^{-4})</td>
<td>(4855)</td>
<td></td>
</tr>
<tr>
<td>( \gamma \ T(1S) ) ( \pi^+ \pi^- K^+ K^- \pi^0 )</td>
<td>((0.7 \pm 3.1) \times 10^{-4})</td>
<td>(4908)</td>
<td></td>
</tr>
<tr>
<td>( \gamma \ T(1S) ) ( \pi^+ \pi^- K^+ K^- \pi^0 )</td>
<td>((8 \pm 6) \times 10^{-4})</td>
<td>(4835)</td>
<td></td>
</tr>
<tr>
<td>( \gamma \ T(1S) ) ( \pi^+ \pi^- K^+ K^- \pi^0 )</td>
<td>((8 \pm 4) \times 10^{-4})</td>
<td>(4907)</td>
<td></td>
</tr>
<tr>
<td>( \gamma \ T(1S) ) ( \pi^+ \pi^- K^+ K^- \pi^0 )</td>
<td>((1.8 \pm 0.7) \times 10^{-3})</td>
<td>(4877)</td>
<td></td>
</tr>
<tr>
<td>( J/\psi J/\psi ) ( \pi^+ \pi^- )</td>
<td>((4 \times 10^{-5}) \times 10^{-5})</td>
<td>(3869)</td>
<td></td>
</tr>
<tr>
<td>( J/\psi J/\psi ) ( \pi^+ \pi^- )</td>
<td>((5 \times 10^{-5}) \times 10^{-5})</td>
<td>(3608)</td>
<td></td>
</tr>
<tr>
<td>( J/\psi J/\psi ) ( \pi^+ \pi^- )</td>
<td>((1.6 \times 10^{-5}) \times 10^{-5})</td>
<td>(3313)</td>
<td></td>
</tr>
</tbody>
</table>

\[ \Upsilon(2S) \]

\[ iG(J^{PC}) = 0^-(1^- - -) \]

\[ \text{Mass } m = 10023.26 \pm 0.31 \text{ MeV} \]

\[ \begin{align*}
   m \Upsilon(3S) - m \Upsilon(2S) &= 331.50 \pm 0.13 \text{ MeV} \\
   \text{Full width } \Gamma &= 31.98 \pm 2.63 \text{ keV} \\
   \Gamma_{ee} &= 0.612 \pm 0.011 \text{ keV}
\end{align*} \]

\[ \Upsilon(2S) \) DECAY MODES | Fraction \((\Gamma_i/\Gamma)\) | Confidence level | \( p \) (MeV/c) |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Upsilon(2S) ) ( \pi^+ \pi^- )</td>
<td>((17.85 \pm 0.26) %)</td>
<td>(475)</td>
<td></td>
</tr>
<tr>
<td>( \Upsilon(2S) ) ( \pi^+ \pi^- )</td>
<td>((8 \pm 6 \pm 8) %)</td>
<td>(480)</td>
<td></td>
</tr>
<tr>
<td>( \Upsilon(2S) ) ( \pi^+ \pi^- )</td>
<td>((2.0 \pm 0.21) %)</td>
<td>(4686)</td>
<td></td>
</tr>
<tr>
<td>( \Upsilon(2S) ) ( \pi^+ \pi^- )</td>
<td>((1.9 \pm 0.17) %)</td>
<td>(S=2.2)</td>
<td>(5011)</td>
</tr>
<tr>
<td>( \Upsilon(2S) ) ( \pi^+ \pi^- )</td>
<td>((1.9 \pm 0.16) %)</td>
<td>(5012)</td>
<td></td>
</tr>
<tr>
<td>( \Upsilon(2S) ) ( \pi^+ \pi^- )</td>
<td>((4 \times 10^{-5}) \times 10^{-5})</td>
<td>(CL=90%)</td>
<td>(531)</td>
</tr>
<tr>
<td>( \Upsilon(2S) ) ( \eta )</td>
<td>((2.9 \pm 0.4 \pm 10) \times 10^{-4})</td>
<td>(S=2.0)</td>
<td>(126)</td>
</tr>
<tr>
<td>( \Upsilon(2S) ) ( \pi^+ \pi^- )</td>
<td>((6 \times 10^{-3}) \times 10^{-3})</td>
<td>(CL=90%)</td>
<td>(4533)</td>
</tr>
</tbody>
</table>
hadrons

\[ \gamma \gamma \gamma \]
\[ \gamma \gamma \gamma \]
\[ \phi K^+ K^- \]
\[ \omega \pi^+ \pi^- \]
\[ K^*(892)^0 K^- \pi^+ + c.c. \]
\[ \phi f'_2(1525) \]
\[ \omega f_2(1270) \]
\[ \rho(770) a_2(1320) \]
\[ K^*(892)^0 \overline{K}_2^*(1430)^0 + c.c. \]
\[ K_1(1270)^\pm K^\mp \]
\[ K_1(1400)^\pm K^\mp \]
\[ b_1(1235)^\pm \pi^\mp \]
\[ \rho \pi \]
\[ \pi^+ \pi^- \pi^0 \]
\[ \omega \pi^0 \]
\[ \pi^+ \pi^- \pi^0 \pi^0 \]
\[ K^0_S K^+ \pi^- + c.c. \]
\[ K^*(892)^0 \overline{K}^0 + c.c. \]
\[ K^*(892)^- K^+ + c.c. \]

**Sum of 100 exclusive modes**

(94 \pm 11 \%)

(58.8 \pm 1.2 \%)

(8.8 \pm 1.1 \%)

(1.6 \pm 0.4 \times 10^{-6})

< 2.58 \times 10^{-6}

< 1.33 \times 10^{-6}

< 5.7 \times 10^{-7}

< 8.8 \times 10^{-7}

< 1.5 \pm 0.6 \times 10^{-6}

< 3.22 \times 10^{-6}

< 8.3 \times 10^{-7}

< 4.0 \times 10^{-7}

< 1.16 \times 10^{-6}

< 8.0 \times 10^{-7}

< 1.63 \times 10^{-6}

(1.30 \pm 0.28 \times 10^{-5})

(1.14 \pm 0.33 \times 10^{-6})

< 4.22 \times 10^{-6}

< 1.45 \times 10^{-6}

(2.90 \pm 0.30 \times 10^{-3})

---

**Radiative decays**

\[ \gamma \chi_{b1}(1P) \]
\[ \gamma \chi_{b2}(1P) \]
\[ \gamma \chi_{b0}(1P) \]
\[ \gamma f'_0(1710) \]
\[ \gamma f'_2(1525) \]
\[ \gamma f_2(1270) \]
\[ \gamma \eta_c(1S) \]
\[ \gamma \chi_0 \]
\[ \gamma \chi_1 \]
\[ \gamma \chi_2 \]
\[ \gamma X(3872) \rightarrow \pi^+ \pi^- J/\psi \]
\[ \gamma X(3872) \rightarrow \pi^+ \pi^- \pi^0 J/\psi \]
\[ \gamma \chi_{c0}(2P) \rightarrow \omega J/\psi \]
\[ \gamma X(4140) \rightarrow \phi J/\psi \]
\[ \gamma X(4350) \rightarrow \phi J/\psi \]
\[ \gamma \eta_b(1S) \]
\[ \gamma \eta_b(1S) \rightarrow \gamma \text{Sum of 26 exclusive modes} \]
\[ \gamma X \rightarrow \gamma \text{Sum of 26 exclusive modes} \]

(6.9 \pm 0.4 \%)

(7.15 \pm 0.35 \%)

(3.8 \pm 0.4 \%)

< 5.9 \times 10^{-4}

< 5.3 \times 10^{-4}

< 2.41 \times 10^{-4}

< 2.7 \times 10^{-5}

< 1.0 \times 10^{-4}

< 3.6 \times 10^{-6}

< 1.5 \times 10^{-5}

< 8 \times 10^{-7}

< 2.4 \times 10^{-6}

< 2.8 \times 10^{-6}

< 1.2 \times 10^{-6}

< 1.3 \times 10^{-6}

(3.9 \pm 1.5 \times 10^{-4})

< 3.7 \times 10^{-6}

< 4.9 \times 10^{-6}

130

110

162

4864

4896

4931

4568

4430

4397

4381

4977

606

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Citation: K.A. Olive et al. (Particle Data Group), Chin. Phys. C38, 090001 (2014) (URL: http://pdg.lbl.gov)
\( \gamma X \rightarrow \gamma + \geq 4 \) prongs \[\text{[iibb]} < 1.95 \times 10^{-4} \text{ CL=95%} \]
\( \gamma A^0 \rightarrow \gamma \) hadrons \[< 8 \times 10^{-5} \text{ CL=90%} \]
\( \gamma a_1^0 \rightarrow \gamma \mu^+ \mu^- \) \[< 8.3 \times 10^{-6} \text{ CL=90%} \]

### Lepton Family number (LF) violating modes

| \( e^\pm \tau^\mp \) | \( LF \) | \( < 3.2 \times 10^{-6} \) | CL=90% | 4854 |
| \( \mu^\pm \tau^\mp \) | \( LF \) | \( < 3.3 \times 10^{-6} \) | CL=90% | 4854 |

### \( \tau(1D) \)

\( iG(J^PC) = 0^-(2-\) \( \)

Mass \( m = 10163.7 \pm 1.4 \) MeV \( (S = 1.7) \)

#### \( \tau(1D) \) decay modes

| \( \gamma \gamma \tau(1S) \) | seen | 679 |
| \( \gamma \chi_{bJ}(1P) \) | seen | 300 |
| \( \eta \tau(1S) \) | not seen | 426 |
| \( \pi^+ \pi^- \tau(1S) \) | \( (6.6 \pm 1.6) \times 10^{-3} \) | 623 |

### \( \chi_{b0}(2P) \) \( [hhbb] \)

\( iG(J^PC) = 0^+(0++) \)

\( J \) needs confirmation.

Mass \( m = 10232.5 \pm 0.4 \pm 0.5 \) MeV

#### \( \chi_{b0}(2P) \) decay modes

| \( \gamma \tau(2S) \) | \( (4.6 \pm 2.1) \% \) | 207 |
| \( \gamma \tau(1S) \) | \( (9 \pm 6) \times 10^{-3} \) | 743 |
| \( D^0 X \) | < 8.2 \% | 90\% |  – |
| \( \pi^+ \pi^- K^+ K^- \pi^0 \) | < 3.4 \times 10^{-5} | 90\% | 5064 |
| \( 2\pi^+ \pi^- K^- K_S^0 \pi^0 \) | < 5 \times 10^{-5} | 90\% | 5063 |
| \( 2\pi^+ \pi^- K^- K_S^0 2\pi^0 \) | < 2.2 \times 10^{-4} | 90\% | 5036 |
| \( 2\pi^+ 2\pi^- 2\pi^0 \) | < 2.4 \times 10^{-4} | 90\% | 5092 |
| \( 2\pi^+ 2\pi^- K^- K^- \) | < 1.5 \times 10^{-4} | 90\% | 5050 |
| \( 2\pi^+ 2\pi^- K^+ K^- \pi^0 \) | < 2.2 \times 10^{-4} | 90\% | 5035 |
| \( 2\pi^+ 2\pi^- K^+ K^- 2\pi^0 \) | < 1.1 \times 10^{-3} | 90\% | 5019 |
| \( 3\pi^+ 2\pi^- K^- K_S^0 \pi^0 \) | < 7 \times 10^{-4} | 90\% | 5018 |
| \( 3\pi^+ 3\pi^- \) | < 7 \times 10^{-5} | 90\% | 5091 |
| \( 3\pi^+ 3\pi^- 2\pi^0 \) | < 1.2 \times 10^{-3} | 90\% | 5070 |
| \( 3\pi^+ 3\pi^- K^+ K^- \) | < 1.5 \times 10^{-4} | 90\% | 5017 |
| \( 3\pi^+ 3\pi^- K^+ K^- \pi^0 \) | < 7 \times 10^{-4} | 90\% | 4999 |
| \( 4\pi^+ 4\pi^- \) | < 1.7 \times 10^{-4} | 90\% | 5069 |
| \( 4\pi^+ 4\pi^- 2\pi^0 \) | < 6 \times 10^{-4} | 90\% | 5039 |
\[ \chi_{b1}(2P) \ [hhbb] \]

\[ iG(j^{PC}) = 0^+(1^++{)} \]

\[ J \text{ needs confirmation.} \]

Mass \( m = 10255.46 \pm 0.22 \pm 0.50 \text{ MeV} \)

\[ m_{\chi_{b1}(2P)} - m_{\chi_{b0}(2P)} = 23.5 \pm 1.0 \text{ MeV} \]

### \( \chi_{b1}(2P) \) DECAY MODES

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>Scale factor ((\text{MeV/c}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \omega \ \Upsilon(1S) )</td>
<td>( (1.63^{+0.40}_{-0.34}) % )</td>
<td>135</td>
</tr>
<tr>
<td>( \gamma \ \Upsilon(2S) )</td>
<td>( (19.9 \pm 1.9 ) % )</td>
<td>230</td>
</tr>
<tr>
<td>( \gamma \ \Upsilon(1S) )</td>
<td>( (9.2 \pm 0.8 ) % )</td>
<td>1.1 764</td>
</tr>
<tr>
<td>( \pi \pi \chi_{b1}(1P) )</td>
<td>( (9.1 \pm 1.3 ) \times 10^{-3} )</td>
<td>238</td>
</tr>
<tr>
<td>( D^0 X )</td>
<td>( (8.8 \pm 1.7 ) % )</td>
<td>–</td>
</tr>
<tr>
<td>( \pi^+ \pi^- K^+ K^- \pi^0 )</td>
<td>( (3.1 \pm 1.0 ) \times 10^{-4} )</td>
<td>5075</td>
</tr>
<tr>
<td>( 2\pi^+ \pi^- K^0 \pi^0 )</td>
<td>( (1.1 \pm 0.5 ) \times 10^{-4} )</td>
<td>5075</td>
</tr>
<tr>
<td>( 2\pi^+ 2\pi^- K^0 \pi^0 )</td>
<td>( (7.7 \pm 3.2 ) \times 10^{-4} )</td>
<td>5047</td>
</tr>
<tr>
<td>( 2\pi^+ 2\pi^- 2\pi^0 )</td>
<td>( (5.9 \pm 2.0 ) \times 10^{-4} )</td>
<td>5104</td>
</tr>
<tr>
<td>( 2\pi^+ 2\pi^- K^+ K^- )</td>
<td>( (10 \pm 4 ) \times 10^{-5} )</td>
<td>5062</td>
</tr>
<tr>
<td>( 2\pi^+ 2\pi^- K^+ K^- \pi^0 )</td>
<td>( (5.5 \pm 1.8 ) \times 10^{-4} )</td>
<td>5047</td>
</tr>
<tr>
<td>( 2\pi^+ 2\pi^- K^+ K^- 2\pi^0 )</td>
<td>( (10 \pm 4 ) \times 10^{-4} )</td>
<td>5030</td>
</tr>
<tr>
<td>( 3\pi^+ 2\pi^- K^0 \pi^0 )</td>
<td>( (6.7 \pm 2.6 ) \times 10^{-4} )</td>
<td>5029</td>
</tr>
<tr>
<td>( 3\pi^+ 3\pi^- )</td>
<td>( (1.2 \pm 0.4 ) \times 10^{-4} )</td>
<td>5130</td>
</tr>
<tr>
<td>( 3\pi^+ 3\pi^- 2\pi^0 )</td>
<td>( (1.2 \pm 0.4 ) \times 10^{-3} )</td>
<td>5081</td>
</tr>
<tr>
<td>( 3\pi^+ 3\pi^- K^+ K^- )</td>
<td>( (2.0 \pm 0.8 ) \times 10^{-4} )</td>
<td>5029</td>
</tr>
<tr>
<td>( 3\pi^+ 3\pi^- K^+ K^- \pi^0 )</td>
<td>( (6.1 \pm 2.2 ) \times 10^{-4} )</td>
<td>5011</td>
</tr>
<tr>
<td>( 4\pi^+ 4\pi^- )</td>
<td>( (1.7 \pm 0.6 ) \times 10^{-4} )</td>
<td>5080</td>
</tr>
<tr>
<td>( 4\pi^+ 4\pi^- 2\pi^0 )</td>
<td>( (1.9 \pm 0.7 ) \times 10^{-3} )</td>
<td>5051</td>
</tr>
</tbody>
</table>

\[ \chi_{b2}(2P) \ [hhbb] \]

\[ iG(j^{PC}) = 0^+(2^++{)} \]

\[ J \text{ needs confirmation.} \]

Mass \( m = 10268.65 \pm 0.22 \pm 0.50 \text{ MeV} \)

\[ m_{\chi_{b2}(2P)} - m_{\chi_{b1}(2P)} = 13.5 \pm 0.6 \text{ MeV} \]

### \( \chi_{b2}(2P) \) DECAY MODES

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ((\Gamma_i/\Gamma))</th>
<th>Scale factor/ Confidence level ((\text{MeV/c}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \omega \ \Upsilon(1S) )</td>
<td>( (1.10^{+0.34}_{-0.30}) % )</td>
<td>194</td>
</tr>
<tr>
<td>( \gamma \ \Upsilon(2S) )</td>
<td>( (10.6 \pm 2.6 ) % )</td>
<td>S=2.0 242</td>
</tr>
<tr>
<td>( \gamma \ \Upsilon(1S) )</td>
<td>( (7.0 \pm 0.7 ) % )</td>
<td>777</td>
</tr>
<tr>
<td>( \pi \pi \chi_{b2}(1P) )</td>
<td>( (5.1 \pm 0.9 ) \times 10^{-3} )</td>
<td>229</td>
</tr>
<tr>
<td>( D^0 X )</td>
<td>&lt; 2.4 %</td>
<td>CL=90% –</td>
</tr>
<tr>
<td>( \pi^+ \pi^- K^+ K^- \pi^0 )</td>
<td>&lt; 1.1 \times 10^{-4}</td>
<td>CL=90% 5082</td>
</tr>
<tr>
<td>( 2\pi^+ \pi^- K^+ K^0 \pi^0 )</td>
<td>&lt; 9 \times 10^{-5}</td>
<td>CL=90% 5082</td>
</tr>
</tbody>
</table>
\[ 2\pi^+\pi^- K^- K^0_S 2\pi^0 < 7 \times 10^{-4} \quad \text{CL}=90\% \quad 5054 \]
\[ 2\pi^+ 2\pi^- 2\pi^0 \quad (3.9 \pm 1.6) \times 10^{-4} \quad 5110 \]
\[ 2\pi^+ 2\pi^- K^+ K^- \quad (9 \pm 4) \times 10^{-5} \quad 5068 \]
\[ 2\pi^+ 2\pi^- K^+ K^0 \pi^- \quad (2.4 \pm 1.1) \times 10^{-4} \quad 5054 \]
\[ 2\pi^+ 2\pi^- K^+ K^- 2\pi^0 \quad (4.7 \pm 2.3) \times 10^{-4} \quad 5037 \]
\[ 3\pi^+ 2\pi^- K^- K^0_S 2\pi^0 < 4 \times 10^{-4} \quad \text{CL}=90\% \quad 5036 \]
\[ 3\pi^+ 3\pi^- \quad (9 \pm 4) \times 10^{-5} \quad 5110 \]
\[ 3\pi^+ 3\pi^- 2\pi^0 \quad (1.2 \pm 0.4) \times 10^{-3} \quad 5088 \]
\[ 3\pi^+ 3\pi^- K^+ K^- \quad (1.4 \pm 0.7) \times 10^{-4} \quad 5036 \]
\[ 3\pi^+ 3\pi^- K^+ K^- \pi^0 \quad (4.2 \pm 1.7) \times 10^{-4} \quad 5017 \]
\[ 4\pi^+ 4\pi^- \quad (9 \pm 5) \times 10^{-5} \quad 5087 \]
\[ 4\pi^+ 4\pi^- 2\pi^0 \quad (1.3 \pm 0.5) \times 10^{-3} \quad 5058 \]

\[ \Upsilon(3S) \]

\[ i G (j PC) = 0^- (1^- -) \]

Mass \( m = 10355.2 \pm 0.5 \text{ MeV} \)

\( m \Upsilon(3S) - m \Upsilon(2S) = 331.50 \pm 0.13 \text{ MeV} \)

Full width \( \Gamma = 20.32 \pm 1.85 \text{ keV} \)

\( \Gamma_{ee} = 0.443 \pm 0.008 \text{ keV} \)

<table>
<thead>
<tr>
<th>( \Upsilon(3S) ) DECAY MODES</th>
<th>Fraction ( (\Gamma_i/\Gamma) )</th>
<th>Scale factor/Confidence level</th>
<th>( \rho ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Upsilon(2S) ) anything</td>
<td>(10.6 \pm 0.8 \text{ %})</td>
<td></td>
<td>929</td>
</tr>
<tr>
<td>( \Upsilon(2S) \pi^+ \pi^- )</td>
<td>(2.82 \pm 0.18 \text{ %})</td>
<td>S=1.6</td>
<td>177</td>
</tr>
<tr>
<td>( \Upsilon(2S) \pi^0 \pi^0 )</td>
<td>(1.85 \pm 0.14 \text{ %})</td>
<td></td>
<td>190</td>
</tr>
<tr>
<td>( \Upsilon(2S) \gamma \gamma )</td>
<td>(5.0 \pm 0.7 \text{ %})</td>
<td></td>
<td>327</td>
</tr>
<tr>
<td>( \Upsilon(2S) \pi^0 \pi^0 )</td>
<td>&lt; 5.1 \times 10^{-4}</td>
<td>CL=90%</td>
<td>298</td>
</tr>
<tr>
<td>( \Upsilon(1S) \pi^+ \pi^- )</td>
<td>(4.37 \pm 0.08 \text{ %})</td>
<td></td>
<td>813</td>
</tr>
<tr>
<td>( \Upsilon(1S) \pi^0 \pi^0 )</td>
<td>(2.20 \pm 0.13 \text{ %})</td>
<td></td>
<td>816</td>
</tr>
<tr>
<td>( \Upsilon(1S) \eta )</td>
<td>&lt; 1 \times 10^{-4}</td>
<td>CL=90%</td>
<td>677</td>
</tr>
<tr>
<td>( \Upsilon(1S) \pi^0 \pi^0 )</td>
<td>&lt; 7 \times 10^{-5}</td>
<td>CL=90%</td>
<td>846</td>
</tr>
<tr>
<td>( h_b(1P) \pi^0 )</td>
<td>&lt; 1.2 \times 10^{-3}</td>
<td>CL=90%</td>
<td>426</td>
</tr>
<tr>
<td>( h_b(1P) \pi^0 \rightarrow \gamma \eta_b(1S) \pi^0 )</td>
<td>(4.3 \pm 1.4 \text{ %}) \times 10^{-4}</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>( h_b(1P) \pi^+ \pi^- )</td>
<td>&lt; 1.2 \times 10^{-4}</td>
<td>CL=90%</td>
<td>353</td>
</tr>
<tr>
<td>( \tau^+ \tau^- )</td>
<td>(2.29 \pm 0.30 \text{ %})</td>
<td></td>
<td>4863</td>
</tr>
<tr>
<td>( \mu^+ \mu^- )</td>
<td>(2.18 \pm 0.21 \text{ %})</td>
<td>S=2.1</td>
<td>5177</td>
</tr>
<tr>
<td>( e^+ e^- )</td>
<td>seen</td>
<td></td>
<td>5178</td>
</tr>
<tr>
<td>( gg g g )</td>
<td>(35.7 \pm 2.6 \text{ %})</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>( \gamma gg )</td>
<td>(9.7 \pm 1.8 \text{ %}) \times 10^{-3}</td>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

Citation: K.A. Olive et al. (Particle Data Group), Chin. Phys. C38, 090001 (2014) (URL: http://pdg.lbl.gov)
Radiative decays

\[ \gamma \chi_b(2P) \]  
(13.1 \pm 1.6) \% \hspace{1cm} S = 3.4 \hspace{1cm} 86

\[ \gamma \chi_b(1P) \]  
(12.6 \pm 1.2) \% \hspace{1cm} S = 2.4 \hspace{1cm} 99

\[ \gamma \chi_b(0P) \]  
(5.9 \pm 0.6) \% \hspace{1cm} S = 1.4 \hspace{1cm} 122

\[ \gamma \chi_b(1P) \]  
(9.9 \pm 1.3) \times 10^{-3} \hspace{1cm} S = 2.0 \hspace{1cm} 434

\[ \gamma A^0 \to \gamma \text{hadrons} \]  
< 8 \times 10^{-5} \hspace{1cm} CL = 90\% \hspace{1cm} –

\[ \gamma \chi_b(1P) \]  
(9 \pm 5) \times 10^{-4} \hspace{1cm} S = 1.9 \hspace{1cm} 452

\[ \gamma \chi_b(0P) \]  
(2.7 \pm 0.4) \times 10^{-3} \hspace{1cm} S = 1.9 \hspace{1cm} 484

\[ \gamma \eta_b(2S) \]  
(6.2 \pm 1.2) \times 10^{-4} \hspace{1cm} CL = 90\% \hspace{1cm} 350

\[ \gamma \eta_b(1S) \]  
(5.1 \pm 0.7) \times 10^{-4} \hspace{1cm} S = 1.9 \hspace{1cm} 913

\[ \gamma X \to \gamma + \geq 4 \text{prongs} \]  
[jjbb] < 2.2 \times 10^{-4} \hspace{1cm} CL = 95\% \hspace{1cm} –

\[ \gamma a^0 \to \gamma \mu^+ \mu^- \]  
< 5.5 \times 10^{-6} \hspace{1cm} CL = 90\% \hspace{1cm} –

\[ \gamma a_1^0 \to \gamma \tau^+ \tau^- \]  
[kkbb] < 1.6 \times 10^{-4} \hspace{1cm} CL = 90\% \hspace{1cm} –

Lepton Family number (LF) violating modes

\[ e^\pm \tau^\mp \]  
\[ LF \]  
< 4.2 \times 10^{-6} \hspace{1cm} CL = 90\% \hspace{1cm} 5025

\[ \mu^\pm \tau^\mp \]  
\[ LF \]  
< 3.1 \times 10^{-6} \hspace{1cm} CL = 90\% \hspace{1cm} 5025

\[ \Upsilon(3P) \]  
\[ \chi_b(3P) \]  
\[ I G(JPC) = \frac{1}{2}(-1-1) \]

Mass \( m = 10534 \pm 9 \) MeV

\[ \Upsilon(3P) \text{ DECA Y MODES} \]

<table>
<thead>
<tr>
<th>Fraction (( \Gamma_i/\Gamma ))</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Upsilon(1S) \gamma ) seen</td>
<td>1019</td>
</tr>
<tr>
<td>( \Upsilon(2S) \gamma ) seen</td>
<td>498</td>
</tr>
</tbody>
</table>

\[ \Upsilon(4S) \]  
or \( \Upsilon(10580) \)  
\[ \chi_b(3P) \]  
\[ I G(JPC) = 0^-(1--1) \]

Mass \( m = 10579.4 \pm 1.2 \) MeV

Full width \( \Gamma = 20.5 \pm 2.5 \) MeV

\( \Gamma_{ee} = 0.272 \pm 0.029 \) keV \( (S = 1.5) \)

\[ \Upsilon(4S) \text{ DECA Y MODES} \]

<table>
<thead>
<tr>
<th>Fraction (( \Gamma_i/\Gamma ))</th>
<th>Confidence level</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( B\overline{B} ) &gt; 96</td>
<td>%</td>
<td>95%</td>
</tr>
<tr>
<td>( B^+ B^- )</td>
<td>(51.4 \pm 0.6) %</td>
<td>332</td>
</tr>
<tr>
<td>( D_s^+ \text{anything + c.c.} )</td>
<td>(17.8 \pm 2.6) %</td>
<td>–</td>
</tr>
<tr>
<td>( B^0 \overline{B}^0 )</td>
<td>(48.6 \pm 0.6) %</td>
<td>327</td>
</tr>
<tr>
<td>( J/\psi K^0_S (J/\psi, \eta_c) K^0_S )</td>
<td>&lt; 4 \times 10^{-7}</td>
<td>90%</td>
</tr>
<tr>
<td>non- ( B\overline{B} )</td>
<td>&lt; 4 %</td>
<td>95%</td>
</tr>
<tr>
<td>( e^+ e^- )</td>
<td>(1.57 \pm 0.08) \times 10^{-5}</td>
<td>5290</td>
</tr>
<tr>
<td>( \rho^+ \rho^- )</td>
<td>&lt; 5.7 \times 10^{-6}</td>
<td>90%</td>
</tr>
</tbody>
</table>
\[ K^*(892)^0 \overline{K}^0 \quad < 2.0 \times 10^{-6} \quad 90\% \quad 5240 \]
\[ J/\psi(1S) \text{ anything} \quad < 1.9 \times 10^{-4} \quad 95\% \quad - \]
\[ D^{**} \text{ anything} + \text{ c.c.} \quad < 7.4 \quad \% \quad 90\% \quad 5099 \]
\[ \phi \text{ anything} \quad (7.1 \pm 0.6) \% \quad 5240 \]
\[ \phi \eta \quad < 1.8 \times 10^{-6} \quad 90\% \quad 5226 \]
\[ \phi \eta' \quad < 4.3 \times 10^{-6} \quad 90\% \quad 5196 \]
\[ \rho \eta \quad < 1.3 \times 10^{-6} \quad 90\% \quad 5247 \]
\[ \rho \eta' \quad < 2.5 \times 10^{-6} \quad 90\% \quad 5217 \]
\[ \Upsilon(1S) \text{ anything} \quad < 1.9 \times 10^{-4} \quad 95\% \quad - \]
\[ \Upsilon(1S) \pi^+ \pi^- \quad (8.1 \pm 0.6) \times 10^{-5} \quad 1026 \]
\[ \Upsilon(1S) \eta \quad (1.96 \pm 0.28) \times 10^{-4} \quad 924 \]
\[ \Upsilon(2S) \pi^+ \pi^- \quad (8.6 \pm 1.3) \times 10^{-5} \quad 468 \]
\[ h_b(1P) \pi^+ \pi^- \quad \text{not seen} \quad 600 \]
\[ \Delta' \text{ anything} \quad < 1.3 \times 10^{-5} \quad 90\% \quad - \]

\[ \Upsilon(10860) \quad \tag{1} \]

\[ iG(JPC) = 0^-(1^{--}) \]

Mass \( m = 10876 \pm 11 \text{ MeV} \)

Full width \( \Gamma = 55 \pm 28 \text{ MeV} \)

\( \Gamma_{ee} = 0.31 \pm 0.07 \text{ keV} \quad (S = 1.3) \)

\[
\text{\Upsilon(10860) DECAY MODES} \quad \begin{array}{ccc}
\text{Fraction (}\Gamma_i/\Gamma\text{)} & \text{Confidence level (MeV/c)} & \rho \\
\hline
B \overline{B} X & (76.2 \pm 2.7 \pm 4.0) \% & - \\
B B & (5.5 \pm 1.0) \% & 1303 \\
B \overline{B}^* + \text{ c.c.} & (13.7 \pm 1.6) \% & - \\
B^* \overline{B} & (38.1 \pm 3.4) \% & 1102 \\
B \overline{B}^{(*)} \pi & < 19.7 \% & 990 \\
B^* \overline{B} \pi & (0.0 \pm 1.2) \% & 990 \\
B^{*} \overline{B} \pi + B \overline{B}^{*} \pi & (7.3 \pm 2.3) \% & - \\
B^{*} \overline{B}^{*} \pi & (1.0 \pm 1.4) \% & 701 \\
B \overline{B} \pi \pi & < 8.9 \% & 90\% \quad 504 \\
B_s^{(*)} \overline{B}_s^{(*)} & (20.1 \pm 3.1) \% & 877 \\
B_s \overline{B}_s & (5 \pm 5) \times 10^{-3} \% & 877 \\
B_s \overline{B}_s^{*} + \text{ c.c.} & (1.35 \pm 0.32) \% & - \\
B_s^* \overline{B}_s^* & (17.6 \pm 2.7) \% & 495 \\
\text{no open-bottom} & (3.8 \pm 5.0 \pm 0.5) \% & - \\
\overline{e}^+ e^- & (5.6 \pm 3.1) \times 10^{-6} \% & 5438 \\
K^*(892)^0 \overline{K}^0 & < 1.0 \times 10^{-5} \% & 5390 \\
\Upsilon(1S) \pi^+ \pi^- & (5.3 \pm 0.6) \times 10^{-3} \% & 1297 \\
\Upsilon(2S) \pi^+ \pi^- & (7.8 \pm 1.3) \times 10^{-3} \% & 774 \\
\end{array}
\]

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\( \Upsilon(3S) \pi^+ \pi^- \quad (4.8 \pm 1.9) \times 10^{-3} \quad 429 \)

\( \Upsilon(1S) K^+ K^- \quad (6.1 \pm 1.8) \times 10^{-4} \quad 947 \)

\( h_b (1P) \pi^+ \pi^- \quad (3.5 \pm 1.0) \times 10^{-3} \quad 894 \)

\( h_b (2P) \pi^+ \pi^- \quad (6.0 \pm 2.1) \times 10^{-3} \quad 534 \)

**Inclusive Decays.**

These decay modes are submodes of one or more of the decay modes above.

\( \phi \) anything

\( (13.8 \pm 2.4) \% \)

\( D^0 \) anything + c.c.

\( (108 \pm 8) \% \)

\( D_s \) anything + c.c.

\( (46 \pm 6) \% \)

\( J/\psi \) anything

\( (2.06 \pm 0.21) \% \)

\( B^0 \) anything + c.c.

\( (77 \pm 8) \% \)

\( B^+ \) anything + c.c.

\( (72 \pm 6) \% \)

**\( \Upsilon(11020) \)**

\( \Gamma^G (JPC) = 0^{-}(1-\bar{1}) \)

- Mass \( m = 11019 \pm 8 \) MeV
- Full width \( \Gamma = 79 \pm 16 \) MeV
- \( \Gamma_{ee} = 0.130 \pm 0.030 \) keV

**\( \Upsilon(11020) \) Decay Modes**

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Fraction ( (\Gamma_i/\Gamma) )</th>
<th>( p ) (MeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( e^+ e^- )</td>
<td>( (1.6 \pm 0.5) \times 10^{-6} )</td>
<td>5510</td>
</tr>
</tbody>
</table>
NOTES

[a] See the “Note on $\pi^\pm \to \ell^\pm \nu \gamma$ and $K^\pm \to \ell^\pm \nu \gamma$ Form Factors” in the $\pi^\pm$ Particle Listings for definitions and details.

[b] Measurements of $\Gamma(e^+\nu_e)/\Gamma(\mu^+\nu_\mu)$ always include decays with $\gamma$’s, and measurements of $\Gamma(e^+\nu_e\gamma)$ and $\Gamma(\mu^+\nu_\mu\gamma)$ never include low-energy $\gamma$’s. Therefore, since no clean separation is possible, we consider the modes with $\gamma$’s to be subreactions of the modes without them, and let $[\Gamma(e^+\nu_e) + \Gamma(\mu^+\nu_\mu)]/\Gamma_{\text{total}} = 100\%$.

[c] See the $\pi^\pm$ Particle Listings for the energy limits used in this measurement; low-energy $\gamma$’s are not included.

[d] Derived from an analysis of neutrino-oscillation experiments.

[e] Astrophysical and cosmological arguments give limits of order $10^{-13}$; see the $\pi^0$ Particle Listings.

[f] C parity forbids this to occur as a single-photon process.

[g] See the “Note on scalar mesons” in the $f_0(500)$ Particle Listings. The interpretation of this entry as a particle is controversial.

[h] See the “Note on $\rho(770)$” in the $\rho(770)$ Particle Listings.

[i] The $\omega\rho$ interference is then due to $\omega\rho$ mixing only, and is expected to be small. If $e\mu$ universality holds, $\Gamma(\rho^0 \to \mu^+\mu^-) = \Gamma(\rho^0 \to e^+e^-) \times 0.99785$.

[j] See the “Note on scalar mesons” in the $f_0(500)$ Particle Listings.

[k] See the “Note on $a_1(1260)$” in the $a_1(1260)$ Particle Listings in PDG 06, Journal of Physics (generic for all A,B,E,G) G33 1 (2006).

[l] This is only an educated guess; the error given is larger than the error on the average of the published values. See the Particle Listings for details.

[n] See the “Note on non-$q\bar{q}$ mesons” in the Particle Listings in PDG 06, Journal of Physics (generic for all A,B,E,G) G33 1 (2006).

[o] See the “Note on the $\eta(1405)$” in the $\eta(1405)$ Particle Listings.

[p] See the “Note on the $f_1(1420)$” in the $\eta(1405)$ Particle Listings.

[q] See also the $\omega(1650)$ Particle Listings.

[r] See the “Note on the $\rho(1450)$ and the $\rho(1700)$” in the $\rho(1700)$ Particle Listings.

[s] See also the $\omega(1420)$ Particle Listings.

[t] See the “Note on $f_0(1710)$” in the $f_0(1710)$ Particle Listings in 2004 edition of Review of Particle Physics.

[u] See the note in the $K^\pm$ Particle Listings.
The definition of the slope parameter \( g \) of the \( K \rightarrow 3\pi \) Dalitz plot is as follows (see also “Note on Dalitz Plot Parameters for \( K \rightarrow 3\pi \) Decays” in the \( K^{\pm} \) Particle Listings):

\[
|M|^2 = 1 + g(s_3 - s_0)/m_{\pi^+}^2 + \cdots .
\]

For more details and definitions of parameters see the Particle Listings.

Most of this radiative mode, the low-momentum \( \gamma \) part, is also included in the parent mode listed without \( \gamma \)'s.

Structure-dependent part.

Direct-emission branching fraction.

Violates angular-momentum conservation.

Derived from measured values of \( \phi_{+\rightarrow}, \phi_{00}, |\eta|, |m_{K^0} - m_{\bar{K}^0}|, \) and \( \tau_{K^0_S} \), as described in the introduction to “Tests of Conservation Laws.”

The \( CP \)-violation parameters are defined as follows (see also “Note on \( CP \) Violation in \( K_S \rightarrow 3\pi \)” and “Note on \( CP \) Violation in \( K^0_L \) Decay” in the Particle Listings):

\[
\eta_{++} = |\eta_{++}|e^{i\phi_{++}} = \frac{A(K^0_L \rightarrow \pi^+\pi^-)}{A(K^0_S \rightarrow \pi^+\pi^-)} = \epsilon + \epsilon'
\]

\[
\eta_{00} = |\eta_{00}|e^{i\phi_{00}} = \frac{A(K^0_L \rightarrow \pi^0\pi^0)}{A(K^0_S \rightarrow \pi^0\pi^0)} = \epsilon - 2\epsilon'
\]

\[
\delta = \frac{\Gamma(K^0_L \rightarrow \pi^-\ell^+\nu) - \Gamma(K^0_L \rightarrow \pi^+\ell^-\nu)}{\Gamma(K^0_L \rightarrow \pi^-\ell^+\nu) + \Gamma(K^0_L \rightarrow \pi^+\ell^-\nu)} ,
\]

\[
\text{Im}(\eta_{+-0})^2 = \frac{\Gamma(K^0_S \rightarrow \pi^+\pi^-\pi^0) CP \text{ viol.}}{\Gamma(K^0_L \rightarrow \pi^0\pi^0\pi^0)} ,
\]

\[
\text{Im}(\eta_{000})^2 = \frac{\Gamma(K^0_S \rightarrow \pi^0\pi^0\pi^0)}{\Gamma(K^0_L \rightarrow \pi^0\pi^0\pi^0)} .
\]

where for the last two relations \( CPT \) is assumed valid, i.e., \( \text{Re}(\eta_{+-0}) \simeq 0 \) and \( \text{Re}(\eta_{000}) \simeq 0. \)

See the \( K^0_S \) Particle Listings for the energy limits used in this measurement.

The value is for the sum of the charge states or particle/antiparticle states indicated.

\( \text{Re}(\epsilon'/\epsilon) = \epsilon'/\epsilon \) to a very good approximation provided the phases satisfy \( CPT \) invariance.
This mode includes gammas from inner bremsstrahlung but not the direct emission mode $K_L^0 \rightarrow \pi^+ \pi^- \gamma$(DE).

See the $K_L^0$ Particle Listings for the energy limits used in this measurement.

Allowed by higher-order electroweak interactions.

Violates $CP$ in leading order. Test of direct $CP$ violation since the indirect $CP$-violating and $CP$-conserving contributions are expected to be suppressed.

See the “Note on $f_0(1370)$” in the $f_0(1370)$ Particle Listings and in the 1994 edition.

See the note in the $L(1770)$ Particle Listings in Reviews of Modern Physics 56 S1 (1984), p. S200. See also the “Note on $K_2(1770)$ and the $K_2(1820)$’’ in the $K_2(1770)$ Particle Listings.

See the “Note on $K_2(1770)$ and the $K_2(1820)$” in the $K_2(1770)$ Particle Listings.

This result applies to $Z^0 \rightarrow c \bar{c}$ decays only. Here $\ell^+$ is an average (not a sum) of $e^+$ and $\mu^+$ decays.

See the Particle Listings for the (complicated) definition of this quantity.

The branching fraction for this mode may differ from the sum of the submodes that contribute to it, due to interference effects. See the relevant papers in the Particle Listings.

These subfractions of the $K^- 2\pi^+$ mode are uncertain: see the Particle Listings.

Submodes of the $D^+ \rightarrow K^- 2\pi^+ \pi^0$ and $K^0_S 2\pi^+ \pi^-$ modes were studied by ANJOS 92C and COFFMAN 92B, but with at most 142 events for the first mode and 229 for the second – not enough for precise results. With nothing new for 18 years, we refer to our 2008 edition, Physics Letters B667 1 (2008), for those results.

The unseen decay modes of the resonances are included.

This is not a test for the $\Delta C=1$ weak neutral current, but leads to the $\pi^+ \ell^+\ell^-$ final state.

This mode is not a useful test for a $\Delta C=1$ weak neutral current because both quarks must change flavor in this decay.

In the 2010 Review, the values for these quantities were given using a measure of the asymmetry that was inconsistent with the usual definition.

This value is obtained by subtracting the branching fractions for 2-, 4- and 6-prongs from unity.

This is the sum of our $K^- 2\pi^+ \pi^-$, $K^- 2\pi^+ \pi^- \pi^0$, $\bar{K}^0 \pi^+ 2\pi^-$, $K^+ 2K^- \pi^+$, $2\pi^+ 2\pi^-$, $2\pi^+ 2\pi^- \pi^0$, $K^+ K^- \pi^+ \pi^-$, and $K^+ K^- \pi^+ \pi^- \pi^0$, branching fractions.
This is the sum of our $K^- 3\pi^+ 2\pi^- + 3\pi^+ 3\pi^-$ branching fractions.

The branching fractions for the $K^- e^+ \nu_e$, $K^*(892)^- e^+ \nu_e$, $\pi^- e^+ \nu_e$, and $\rho^- e^+ \nu_e$ modes add up to $6.19 \pm 0.17\%$.

This is a doubly Cabibbo-suppressed mode.

The two experiments measuring this fraction are in serious disagreement. See the Particle Listings.

Submodes of the $D^0 \to K^0_S \pi^+ \pi^- \pi^0$ mode with a $K^*$ and/or $\rho$ were studied by COFFMAN 92B, but with only 140 events. With nothing new for 18 years, we refer to our 2008 edition, Physics Letters B667 1 (2008), for those results.

This branching fraction includes all the decay modes of the resonance in the final state.

This limit is for either $D^0$ or $\bar{D}^0$ to $\rho e^-$.

This limit is for either $D^0$ or $\bar{D}^0$ to $\bar{\eta} e^+$.

This is the purely $e^+$ semileptonic branching fraction: the $e^+$ fraction from $\pi^+$ decays has been subtracted off. The sum of our (non-$\tau$) $e^+$ exclusive fractions — an $e^+ \nu_e$ with an $\eta$, $\eta'$, $\phi$, $K^0$, $K^{*0}$, or $f_0(980)$ — is $7.0 \pm 0.4\%$.

This fraction includes $\eta$ from $\eta'$ decays.

Two times (to include $\mu$ decays) the $\eta' e^+ \nu_e$ branching fraction, plus the $\eta' \pi^+$, $\eta' \rho^+$, and $\eta' K^+$ fractions, is $(18.6 \pm 2.3)\%$, which considerably exceeds the inclusive $\eta'$ fraction of $(11.7 \pm 1.8)\%$. Our best guess is that the $\eta' \rho^+$ fraction, $(12.5 \pm 2.2)\%$, is too large.

This branching fraction includes all the decay modes of the final-state resonance.

A test for $u\bar{u}$ or $d\bar{d}$ content in the $D_s^+$. Neither Cabibbo-favored nor Cabibbo-suppressed decays can contribute, and $\omega - \phi$ mixing is an unlikely explanation for any fraction above about $2 \times 10^{-4}$.

We decouple the $D_s^+ \to \phi \pi^+$ branching fraction obtained from mass projections (and used to get some of the other branching fractions) from the $D_s^+ \to \phi \pi^+$, $\phi \to K^+ K^-$ branching fraction obtained from the Dalitz-plot analysis of $D_s^+ \to K^+ K^- \pi^+$. That is, the ratio of these two branching fractions is not exactly the $\phi \to K^+ K^-$ branching fraction 0.491.

This is the average of a model-independent and a $K$-matrix parametrization of the $\pi^+ \pi^-$ $S$-wave and is a sum over several $f_0$ mesons.

An $\ell$ indicates an $e$ or a $\mu$ mode, not a sum over these modes.

An $CP(\pm 1)$ indicates the $CP=+1$ and $CP=-1$ eigenstates of the $D^0-\bar{D}^0$ system.

$D$ denotes $D^0$ or $\bar{D}^0$. 

HTTP://PDG.LBL.GOV
[vvv] $D_{CP}^{*0}$ decays into $D^0 \pi^0$ with the $D^0$ reconstructed in CP-even eigenstates $K^+ K^-$ and $\pi^+ \pi^-$. 

[xx] $D^{**}$ represents an excited state with mass $2.2 < M < 2.8 \text{ GeV}/c^2$. 

[yy] $X(3872)^+$ is a hypothetical charged partner of the $X(3872)$. 

[zz] $\Theta(1710)^{++}$ is a possible narrow pentaquark state and $G(2220)$ is a possible glueball resonance. 

[aaaa] $(\Lambda_c^- p)_s$ denotes a low-mass enhancement near $3.35 \text{ GeV}/c^2$. 

[bb] Stands for the possible candidates of $K^*(1410)$, $K'_0(1430)$ and $K''_0(1430)$. 

[ccaa] $B^0$ and $B^0_s$ contributions not separated. Limit is on weighted average of the two decay rates. 

[ddaa] This decay refers to the coherent sum of resonant and nonresonant $J^P = 0^+$ $K \pi$ components with $1.60 < m_{K\pi} < 2.15 \text{ GeV}/c^2$. 

[eeaa] $X(214)$ is a hypothetical particle of mass $214 \text{ MeV}/c^2$ reported by the HyperCP experiment, Physical Review Letters 94 (2005) 021801. 

[ffaa] $\Theta(1540)^+$ denotes a possible narrow pentaquark state. 

[ggaa] $X(3915)$ denotes a near-threshold enhancement in the $\omega J/\psi$ mass spectrum. 

[hhaa] These values are model dependent. 

[ii] Here “anything” means at least one particle observed. 

[jjaa] This is a $B(B^0 \rightarrow D^*^- \ell^+ \nu_\ell)$ value. 

[kkaa] $D^{**}$ stands for the sum of the $D(1^1P_1)$, $D(1^3P_0)$, $D(1{}^3P_1)$, $D(1{}^3P_2)$, $D(1{}^1S_0)$, and $D(2{}^1S_0)$ resonances. 

[llaa] $D^{(*)}\overline{D}^{(*)}$ stands for the sum of $D^* \overline{D}^*$, $D^* \overline{D}$, $D \overline{D}^*$, and $D \overline{D}$. 

[nnaa] $X(3915)$ denotes a near-threshold enhancement in the $\omega J/\psi$ mass spectrum. 

[ooaa] Inclusive branching fractions have a multiplicity definition and can be greater than 100%. 

[ppaa] $D_j$ represents an unresolved mixture of pseudoscalar and tensor $D^{**}$ ($P$-wave) states. 

[qqaa] Not a pure measurement. See note at head of $B_s^0$ Decay Modes. 

[rraa] For $E_\gamma > 100 \text{ MeV}$. 

[ssaa] Includes $p\bar{p} \pi^+ \pi^- \gamma$ and excludes $p\bar{p} \eta$, $p\bar{p} \omega$, $p\bar{p} \eta'$. 

[ttaa] For a narrow state $A$ with mass less than $960 \text{ MeV}$. 

[uu] For a narrow scalar or pseudoscalar $A^0$ with mass $0.21–3.0 \text{ GeV}$. 

[vvaa] For a narrow resonance in the range $2.2 < M(X) < 2.8 \text{ GeV}$. 

[xxaa] BHARDWAJ 11 does not observe this decay and presents a stronger 90% CL limit than this value. See measurements listings for details.
$J^{PC}$ known by production in $e^+ e^-$ via single photon annihilation. $I^G$ is not known; interpretation of this state as a single resonance is unclear because of the expectation of substantial threshold effects in this energy region.

$2m_\tau < M(\tau^+ \tau^-) < 9.2$ GeV

$2$ GeV $< m_{K^+ K^-} < 3$ GeV

$X =$ scalar with $m < 8.0$ GeV

$X \bar{X} =$ vectors with $m < 3.1$ GeV

$X$ and $\bar{X} =$ zero spin with $m < 4.5$ GeV

$1.5$ GeV $< m_X < 5.0$ GeV

$201$ MeV $< M(\mu^+ \mu^-) < 3565$ MeV

$0.5$ GeV $< m_X < 9.0$ GeV, where $m_X$ is the invariant mass of the hadronic final state.

Spectroscopic labeling for these states is theoretical, pending experimental information.

$1.5$ GeV $< m_X < 5.0$ GeV

$1.5$ GeV $< m_X < 5.0$ GeV

For $m_{\tau^+ \tau^-}$ in the ranges $4.03$–$9.52$ and $9.61$–$10.10$ GeV.