# $D_s^\pm$ was $F^\pm$

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

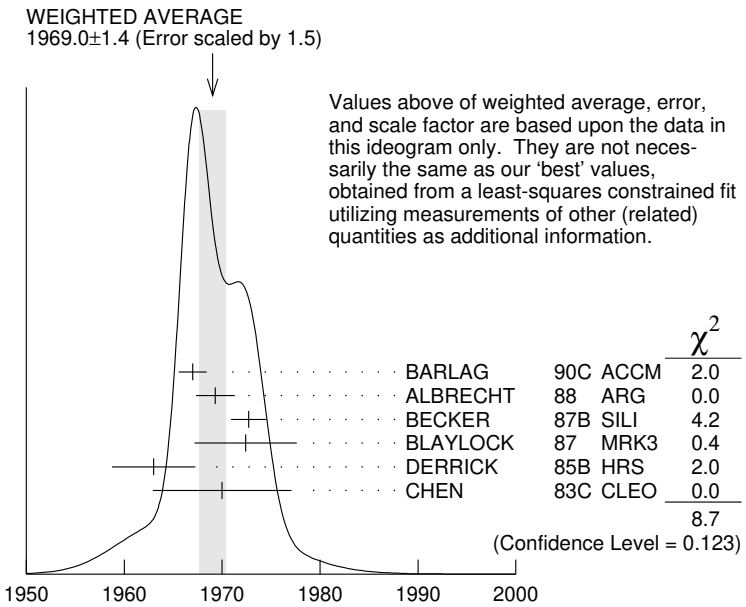
The angular distributions of the decays of the $\phi$ and $\overline{K}^*(892)^0$ in the $\phi\pi^+$ and $K^+\overline{K}^*(892)^0$ modes strongly indicate that the spin is zero. The parity given is that expected of a $c\overline{s}$ ground state.

## $D_s^\pm$ MASS

The fit includes $D^\pm$, $D^0$, $D_s^\pm$, $D^{*\pm}$, $D^{*0}$, and $D_s^{*\pm}$ mass and mass difference measurements. Measurements of the $D_s^\pm$ mass with an error greater than 10 MeV are omitted from the fit and average. A number of early measurements have been omitted altogether.

| *VALUE* (MeV) | *EVTS* | *DOCUMENT ID* | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **1968.1± 0.5 OUR NEW UNCHECKED FIT** Error includes scale factor of 1.1. [1968.5 ± 0.6 MeV OUR 2002 FIT Scale factor = 1.1] | | | | |
| **1969.0± 1.4 OUR AVERAGE** Error includes scale factor of 1.5. See the ideogram below. | | | | |
| 1967.0± 1.0± 1.0 | 54 | BARLAG | 90C ACCM | $\pi^-$ Cu 230 GeV |
| 1969.3± 1.4± 1.4 | | ALBRECHT | 88 ARG | $e^+e^-$ 9.4–10.6 GeV |
| 1972.7± 1.5± 1.0 | 21 | BECKER | 87B SILI | 200 GeV $\pi$,$K$,$p$ |
| 1972.4± 3.7± 3.7 | 27 | BLAYLOCK | 87 MRK3 | $e^+e^-$ 4.14 GeV |
| 1963 ± 3 ± 3 | 30 | DERRICK | 85B HRS | $e^+e^-$ 29 GeV |
| 1970 ± 5 ± 5 | 104 | CHEN | 83C CLEO | $e^+e^-$ 10.5 GeV |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 1968.3± 0.7± 0.7 | 290 | [1] ANJOS | 88 E691 | Photoproduction |
| 1980 ±15 | 6 | USHIDA | 86 EMUL | $\nu$ wideband |
| 1973.6± 2.6± 3.0 | 163 | ALBRECHT | 85D ARG | $e^+e^-$ 10 GeV |
| 1948 ±28 ±10 | 65 | AIHARA | 84D TPC | $e^+e^-$ 29 GeV |
| 1975 ± 9 ±10 | 49 | ALTHOFF | 84 TASS | $e^+e^-$ 14–25 GeV |
| 1975 ± 4 | 3 | BAILEY | 84 ACCM | hadron$^+$ Be $\rightarrow$ $\phi\pi^+$ X |

[1] ANJOS 88 enters the fit via $m_{D_s^\pm} - m_{D^\pm}$ (see below).




$D_s^{\pm}$ mass (MeV)

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## $m_{D_s^{\pm}} - m_{D^{\pm}}$

The fit includes $D^{\pm}$, $D^0$, $D_s^{\pm}$, $D^{*\pm}$, $D^{*0}$, and $D_s^{*\pm}$ mass and mass difference measurements.

| *VALUE* (MeV) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **98.68±0.28 OUR NEW UNCHECKED FIT** Error includes scale factor of 1.1. [99.2 ± 0.5 MeV OUR 2002 FIT Scale factor = 1.1] | | | | | |
| **98.64±0.27 OUR NEW AVERAGE** [99.2 ± 0.5 MeV OUR 2002 AVERAGE] | | | | | |
| 98.4 ±0.1 ±0.3 | 48k | AUBERT | 02G | BABR | $e^+e^- \approx \Upsilon(4S)$ |
| 99.5 ±0.6 ±0.3 | | BROWN | 94 | CLE2 | $e^+e^- \approx \Upsilon(4S)$ |
| 98.5 ±1.5 | 555 | CHEN | 89 | CLEO | $e^+e^-$ 10.5 GeV |
| 99.0 ±0.8 | 290 | ANJOS | 88 | E691 | Photoproduction |

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## $D_s^{\pm}$ MEAN LIFE

Measurements with an error greater than $100 \times 10^{-15}$ s or with fewer than 100 events have been omitted from the Listings.

| *VALUE* ($10^{-15}$ s) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **490 ± 9 OUR AVERAGE** Error includes scale factor of 1.1. | | | | | |
| 472.5±17.2± 6.6 | 760 | IORI | 01 | SELX | 600 GeV $\Sigma^-$, $\pi^-$, $p$ |
| 518 ±14 ± 7 | 1662 | AITALA | 99 | E791 | $\pi^-$ nucleus, 500 GeV |
| $486.3 \pm 15.0 \,^{+\ 4.9}_{-\ 5.1}$ | 2167 | [2] BONVICINI | 99 | CLE2 | $e^+e^- \approx \Upsilon(4S)$ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 475 | ±20 | ± 7 | 900 | FRABETTI | 93F | E687 | $\gamma$ Be, $\phi\pi^+$ |
| 500 | ±60 | ±30 | 104 | FRABETTI | 90 | E687 | $\gamma$ Be, $\phi\pi^+$ |
| 470 | ±40 | ±20 | 228 | RAAB | 88 | E691 | Photoproduction |

[2] BONVICINI 99 obtains 1.19 ± 0.04 for the ratio of $D_s^+$ to $D^0$ lifetimes.

## $D_s^+$ DECAY MODES

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.

| | Mode | | Fraction ($\Gamma_i/\Gamma$) | Scale factor/ Confidence level |
|---|---|---|---|---|
| | **Inclusive modes** | | | |
| $\Gamma_1$ | $K^-$ anything | | (13 $^{+14}_{-12}$ ) % | |
| $\Gamma_2$ | $\overline{K}^0$ anything + $K^0$ anything | | (39 ±28 ) % | |
| $\Gamma_3$ | $K^+$ anything | | (20 $^{+18}_{-14}$ ) % | |
| $\Gamma_4$ | non-$K\overline{K}$ anything | | (64 ±17 ) % | |
| $\Gamma_5$ | $e^+$ anything | | ( 8 $^{+\ 6}_{-\ 5}$ ) % | |
| $\Gamma_6$ | $\phi$ anything | | (18 $^{+15}_{-10}$ ) % | |
| | **Leptonic and semileptonic modes** | | | |
| $\Gamma_7$ | $\mu^+\nu_\mu$ | | ( 5.0 ± 1.9 ) $\times 10^{-3}$ | S=1.3 |
| $\Gamma_8$ | $\tau^+\nu_\tau$ | | ( 6.4 ± 1.5 ) % | |
| $\Gamma_9$ | $\phi\ell^+\nu_\ell$ | [a] | ( 2.0 ± 0.5 ) % | |
| $\Gamma_{10}$ | $\eta\ell^+\nu_\ell$ + $\eta'(958)\ell^+\nu_\ell$ | [a] | ( 3.4 ± 1.0 ) % | |
| $\Gamma_{11}$ | $\eta\ell^+\nu_\ell$ | [a] | ( 2.5 ± 0.7 ) % | |
| $\Gamma_{12}$ | $\eta'(958)\ell^+\nu_\ell$ | [a] | ( 8.9 ± 3.3 ) $\times 10^{-3}$ | |
| | **Hadronic modes with a $K\overline{K}$ pair (including from a $\phi$)** | | | |
| $\Gamma_{13}$ | $K^+\overline{K}^0$ | | ( 3.6 ± 1.1 ) % | |
| $\Gamma_{14}$ | $K^+K^-\pi^+$ | [b] | ( 4.4 ± 1.2 ) % | |
| $\Gamma_{15}$ | $\phi\pi^+$ | [c] | ( 3.6 ± 0.9 ) % | |
| $\Gamma_{16}$ | $K^+\overline{K}^*(892)^0$ | [c] | ( 3.3 ± 0.9 ) % | |
| $\Gamma_{17}$ | $f_0(980)\pi^+$ $\times$ B($f_0 \to K^+K^-$) | [d] | ( 4.9 ± 2.3 ) $\times 10^{-3}$ | |
| $\Gamma_{18}$ | $K^+\overline{K}_0^*(1430)^0$ | [c] | ( 7 ± 4 ) $\times 10^{-3}$ | |
| $\Gamma_{19}$ | $f_0(1710)\pi^+$ $\times$ B($f_0 \to K^+K^-$) | | | |
| $\Gamma_{20}$ | $K^+K^-\pi^+$ nonresonant | | ( 9 ± 4 ) $\times 10^{-3}$ | |
| $\Gamma_{21}$ | $K^0\overline{K}^0\pi^+$ | | — | |
| $\Gamma_{22}$ | $K^*(892)^+\overline{K}^0$ | [c] | ( 4.3 ± 1.4 ) % | |

| | | | | | |
|---|---|---|---|---|---|
| $\Gamma_{23}$ | $K^+ K^- \pi^+ \pi^0$ | | — | | |
| $\Gamma_{24}$ | $\phi \pi^+ \pi^0$ | [c] | ( 9 ± 5 ) | % | |
| $\Gamma_{25}$ | $\phi \rho^+$ | [c] | ( 6.7 ± 2.3 ) | % | |
| $\Gamma_{26}$ | $\phi \pi^+ \pi^0$ 3-body | [c] | < 2.6 | % | CL=90% |
| $\Gamma_{27}$ | $K^+ K^- \pi^+ \pi^0$ non-$\phi$ | | < 9 | % | CL=90% |
| $\Gamma_{28}$ | $K^+ \overline{K}^0 \pi^+ \pi^-$ | | ( 2.5 ± 0.9 ) | % | |
| $\Gamma_{29}$ | $K^0 K^- \pi^+ \pi^+$ | | ( 4.3 ± 1.5 ) | % | |
| $\Gamma_{30}$ | $K^*(892)^+ \overline{K}^*(892)^0$ | [c] | ( 5.8 ± 2.5 ) | % | |
| $\Gamma_{31}$ | $K^0 K^- \pi^+ \pi^+$ non-$K^{*+} \overline{K}^{*0}$ | | < 2.9 | % | CL=90% |
| $\Gamma_{32}$ | $K^+ K^- \pi^+ \pi^+ \pi^-$ | | ( 8.4 ± 3.3 ) | $\times 10^{-3}$ | |
| $\Gamma_{33}$ | $\phi \pi^+ \pi^+ \pi^-$ | [c] | ( 1.18± 0.35) | % | |

**Hadronic modes without $K$'s**

| | | | | | |
|---|---|---|---|---|---|
| $\Gamma_{34}$ | $\pi^+ \pi^+ \pi^-$ | | ( 1.01± 0.28) | % | S=1.1 |
| $\Gamma_{35}$ | $\rho^0 \pi^+$ | | < 7 | $\times 10^{-4}$ | CL=90% |
| $\Gamma_{36}$ | $f_0(980) \pi^+ \times$ B($f_0 \rightarrow \pi^+ \pi^-$) | [e] | ( 5.7 ± 1.7 ) | $\times 10^{-3}$ | |
| $\Gamma_{37}$ | $f_2(1270) \pi^+$ | [c] | ( 3.5 ± 1.2 ) | $\times 10^{-3}$ | |
| $\Gamma_{38}$ | $f_0(1370) \pi^+$ $\times$ B($f_0 \rightarrow \pi^+ \pi^-$) | [e] | ( 3.3 ± 1.2 ) | $\times 10^{-3}$ | |
| $\Gamma_{39}$ | $\rho(1450)^0 \pi^+$ $\times$ B($\rho^0 \rightarrow \pi^+ \pi^-$) | [e] | ( 4.4 ± 2.5 ) | $\times 10^{-4}$ | |
| $\Gamma_{40}$ | $f_0(1500) \pi^+$ $\times$ B($f_0 \rightarrow \pi^+ \pi^-$) | | | | |
| $\Gamma_{41}$ | $\pi^+ \pi^+ \pi^-$ nonresonant | | ( 5 ±22 ) | $\times 10^{-5}$ | |
| $\Gamma_{42}$ | $\pi^+ \pi^+ \pi^- \pi^0$ | | < 12 | % | CL=90% |
| $\Gamma_{43}$ | $\eta \pi^+$ | [c] | ( 1.7 ± 0.5 ) | % | |
| $\Gamma_{44}$ | $\omega \pi^+$ | [c] | ( 2.8 ± 1.1 ) | $\times 10^{-3}$ | |
| $\Gamma_{45}$ | $\pi^+ \pi^+ \pi^+ \pi^- \pi^-$ | | ( 7.0 ± 3.0 ) | $\times 10^{-3}$ | |
| $\Gamma_{46}$ | $\pi^+ \pi^+ \pi^- \pi^0 \pi^0$ | | — | | |
| $\Gamma_{47}$ | $\eta \rho^+$ | [c] | (10.8 ± 3.1 ) | % | |
| $\Gamma_{48}$ | $\eta \pi^+ \pi^0$ 3-body | [c] | < 4 | % | CL=90% |
| $\Gamma_{49}$ | $\pi^+ \pi^+ \pi^+ \pi^- \pi^- \pi^0$ | | ( 4.9 ± 3.2 ) | % | |
| $\Gamma_{50}$ | $\eta'(958) \pi^+$ | [c] | ( 3.9 ± 1.0 ) | % | |
| $\Gamma_{51}$ | $\pi^+ \pi^+ \pi^+ \pi^- \pi^- \pi^0 \pi^0$ | | — | | |
| $\Gamma_{52}$ | $\eta'(958) \rho^+$ | [c] | (10.1 ± 2.8 ) | % | |
| $\Gamma_{53}$ | $\eta'(958) \pi^+ \pi^0$ 3-body | [c] | < 1.4 | % | CL=90% |

**Modes with one or three $K$'s**

| | | | | | |
|---|---|---|---|---|---|
| $\Gamma_{54}$ | $K^0 \pi^+$ | | < 8 | $\times 10^{-3}$ | CL=90% |
| $\Gamma_{55}$ | $K^+ \pi^+ \pi^-$ | | ( 1.0 ± 0.4 ) | % | |
| $\Gamma_{56}$ | $K^+ \rho^0$ | | < 2.9 | $\times 10^{-3}$ | CL=90% |
| $\Gamma_{57}$ | $K^*(892)^0 \pi^+$ | [c] | ( 6.5 ± 2.8 ) | $\times 10^{-3}$ | |
| $\Gamma_{58}$ | $K^+ K^+ K^-$ | | ( 4.0 ± 1.7 ) | $\times 10^{-4}$ | |
| $\Gamma_{59}$ | $\phi K^+$ | [c] | < 5 | $\times 10^{-4}$ | CL=90% |

## $\Delta C = 1$ weak neutral current ($C1$) modes, Lepton family number ($LF$), or Lepton number ($L$) violating modes

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $\Gamma_{60}$ | $\pi^+ e^+ e^-$ | | [f] | $<$ | 2.7 | $\times 10^{-4}$ | CL=90% |
| $\Gamma_{61}$ | $\pi^+ \mu^+ \mu^-$ | | [f] | $<$ | 1.4 | $\times 10^{-4}$ | CL=90% |
| $\Gamma_{62}$ | $K^+ e^+ e^-$ | $C1$ | | $<$ | 1.6 | $\times 10^{-3}$ | CL=90% |
| $\Gamma_{63}$ | $K^+ \mu^+ \mu^-$ | $C1$ | | $<$ | 1.4 | $\times 10^{-4}$ | CL=90% |
| $\Gamma_{64}$ | $K^*(892)^+ \mu^+ \mu^-$ | $C1$ | | $<$ | 1.4 | $\times 10^{-3}$ | CL=90% |
| $\Gamma_{65}$ | $\pi^+ e^\pm \mu^\mp$ | $LF$ | [g] | $<$ | 6.1 | $\times 10^{-4}$ | CL=90% |
| $\Gamma_{66}$ | $K^+ e^\pm \mu^\mp$ | $LF$ | [g] | $<$ | 6.3 | $\times 10^{-4}$ | CL=90% |
| $\Gamma_{67}$ | $\pi^- e^+ e^+$ | $L$ | | $<$ | 6.9 | $\times 10^{-4}$ | CL=90% |
| $\Gamma_{68}$ | $\pi^- \mu^+ \mu^+$ | $L$ | | $<$ | 8.2 | $\times 10^{-5}$ | CL=90% |
| $\Gamma_{69}$ | $\pi^- e^+ \mu^+$ | $L$ | | $<$ | 7.3 | $\times 10^{-4}$ | CL=90% |
| $\Gamma_{70}$ | $K^- e^+ e^+$ | $L$ | | $<$ | 6.3 | $\times 10^{-4}$ | CL=90% |
| $\Gamma_{71}$ | $K^- \mu^+ \mu^+$ | $L$ | | $<$ | 1.8 | $\times 10^{-4}$ | CL=90% |
| $\Gamma_{72}$ | $K^- e^+ \mu^+$ | $L$ | | $<$ | 6.8 | $\times 10^{-4}$ | CL=90% |
| $\Gamma_{73}$ | $K^*(892)^- \mu^+ \mu^+$ | $L$ | | $<$ | 1.4 | $\times 10^{-3}$ | CL=90% |
| $\Gamma_{74}$ | A dummy mode used by the fit. | | | | (82 ± 5 )% | | |

[a] For now, we average together measurements of the $X e^+ \nu_e$ and $X \mu^+ \nu_\mu$ branching fractions. This is the *average*, not the *sum*.

[b] 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.

[c] This branching fraction includes all the decay modes of the final-state resonance.

[d] This value includes only $K^+ K^-$ decays of the intermediate resonance, because branching fractions of this resonance are not known.

[e] This value includes only $\pi^+ \pi^-$ decays of the intermediate resonance, because branching fractions of this resonance are not known.

[f] This mode is not a useful test for a $\Delta$C=1 weak neutral current because both quarks must change flavor in this decay.

[g] The value is for the sum of the charge states or particle/antiparticle states indicated.

## CONSTRAINED FIT INFORMATION

An overall fit to 12 branching ratios uses 24 measurements and one constraint to determine 9 parameters. The overall fit has a $\chi^2 = 13.0$ for 16 degrees of freedom.

The following *off-diagonal* array elements are the correlation coefficients $\langle \delta x_i \delta x_j \rangle / (\delta x_i \cdot \delta x_j)$, in percent, from the fit to the branching fractions, $x_i \equiv \Gamma_i/\Gamma_{\text{total}}$. The fit constrains the $x_i$ whose labels appear in this array to sum to one.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $x_9$ | 70 | | | | | | | |
| $x_{11}$ | 60 | 85 | | | | | | |
| $x_{12}$ | 45 | 64 | 54 | | | | | |
| $x_{14}$ | 66 | 88 | 75 | 56 | | | | |
| $x_{15}$ | 72 | 96 | 81 | 61 | 92 | | | |
| $x_{16}$ | 67 | 89 | 76 | 57 | 93 | 93 | | |
| $x_{34}$ | 63 | 84 | 72 | 54 | 86 | 88 | 84 | |
| $x_{74}$ | −73 | −96 | −86 | −66 | −96 | −98 | −96 | −89 |
| | $x_7$ | $x_9$ | $x_{11}$ | $x_{12}$ | $x_{14}$ | $x_{15}$ | $x_{16}$ | $x_{34}$ |

## $D_s^+$ BRANCHING RATIOS

A few older, now obsolete results have been omitted. They may be found in earlier editions.

### Inclusive modes

**$\Gamma(K^-\text{ anything})/\Gamma_{\text{total}}$** **$\Gamma_1/\Gamma$**

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| $0.13^{+0.14}_{-0.12} \pm 0.02$ | COFFMAN | 91 | MRK3 | $e^+e^-$ 4.14 GeV |

**$[\Gamma(\overline{K}^0\text{ anything}) + \Gamma(K^0\text{ anything})]/\Gamma_{\text{total}}$** **$\Gamma_2/\Gamma$**

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| $0.39^{+0.28}_{-0.27} \pm 0.04$ | COFFMAN | 91 | MRK3 | $e^+e^-$ 4.14 GeV |

**$\Gamma(K^+\text{ anything})/\Gamma_{\text{total}}$** **$\Gamma_3/\Gamma$**

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| $0.20^{+0.18}_{-0.13} \pm 0.04$ | COFFMAN | 91 | MRK3 | $e^+e^-$ 4.14 GeV |

**$\Gamma(\text{non-}K\overline{K}\text{ anything})/\Gamma_{\text{total}}$** **$\Gamma_4/\Gamma$**

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| $0.64 \pm 0.17 \pm 0.03$ | [3] COFFMAN | 91 | MRK3 | $e^+e^-$ 4.14 GeV |

[3] COFFMAN 91 uses the direct measurements of the kaon content to determine this non-$K\overline{K}$ fraction. This number implies that a large fraction of $D_s^+$ decays involve $\eta$, $\eta'$, and/or non-spectator decays.

### $\Gamma(e^+ \text{anything})/\Gamma_{\text{total}}$ $\Gamma_5/\Gamma$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| $\mathbf{0.077^{+0.057+0.024}_{-0.043-0.021}}$ | | BAI | 97 | BES | $e^+e^- \to D_s^+ D_s^-$ |

• • • We do not use the following data for averages, fits, limits, etc. • • •

| | | | | | |
|---|---|---|---|---|---|
| <0.20 | 90 | [4] BAI | 90 | MRK3 | $e^+e^-$ 4.14 GeV |

[4] Expressed as a value, the BAI 90 result is $\Gamma(e^+ \text{anything})/\Gamma_{\text{total}} = 0.05 \pm 0.05 \pm 0.02$.

### $\Gamma(\phi \text{ anything})/\Gamma_{\text{total}}$ $\Gamma_6/\Gamma$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| $\mathbf{0.178^{+0.151+0.006}_{-0.072-0.063}}$ | 3 | BAI | 98 | BES | $e^+e^- \to D_s^+ D_s^-$ |

## Leptonic and semileptonic modes

### $\Gamma(\mu^+\nu_\mu)/\Gamma_{\text{total}}$ $\Gamma_7/\Gamma$

See the "Note on Pseudoscalar-Meson Decay Constants" in the Listings for the $\pi^\pm$.

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $0.0068 \pm 0.0011 \pm 0.0018$ | 553 | [5] HEISTER | 02I | ALEP | $Z$ decays |
| $0.015\ ^{+0.013\ +0.003}_{-0.006\ -0.002}$ | 3 | [6] BAI | 95 | BES | $e^+e^- \to D_s^+ D_s^-$ |
| $0.004\ ^{+0.0018+0.0020}_{-0.0014-0.0019}$ | 8 | [7] AOKI | 93 | WA75 | $\pi^-$ emulsion 350 GeV |
| <0.03 | 0 | [8] AUBERT | 83 | SPEC | $\mu^+$ Fe, 250 GeV |

[5] This HEISTER 02I result is not actually an indepedent measurement of the absolute $\mu^+\nu_\mu$ branching fraction, but is in fact based on our $\phi\pi^+$ branching fraction of 3.6 ± 0.9%, so it cannot be included in our overall fit. HEISTER 02I combines its $D_s^+ \to \tau^+\nu_\tau$ and $\mu^+\nu_\mu$ branching fractions to get $f_{D_s} = (285 \pm 19 \pm 40)$ MeV.

[6] BAI 95 uses one actual $D_s^+ \to \mu^+\nu_\mu$ event together with two $D_s^+ \to \tau^+\nu_\tau$ events and assumes $\mu$-$\tau$ universality. This value of $\Gamma(\mu^+\nu_\mu)/\Gamma_{\text{total}}$ gives a pseudoscalar decay constant of $(430^{+150}_{-130} \pm 40)$ MeV.

[7] AOKI 93 assumes the ratio of production cross sections of the $D_s^+$ and $D^0$ is 0.27. The value of $\Gamma(\mu^+\nu_\mu)/\Gamma_{\text{total}}$ gives a pseudoscalar decay constant $f_{D_s} = (232 \pm 45 \pm 52)$ MeV.

[8] AUBERT 83 assume that the $D_s^\pm$ production rate is 20% of total charm production rate.

### $\Gamma(\mu^+\nu_\mu)/\Gamma(\phi\pi^+)$ $\Gamma_7/\Gamma_{15}$

See the "Note on Pseudoscalar-Meson Decay Constants" in the Listings for the $\pi^\pm$.

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.14 ±0.04 OUR NEW UNCHECKED FIT** Error includes scale factor of 1.4. [0.14 ± 0.04 OUR 2002 FIT Scale factor = 1.4] | | | | | |
| **0.19 ±0.04 OUR AVERAGE** | | | | | |
| 0.23 ±0.06 ±0.04 | 18 | [9] ALEXANDROV | 00 | BEAT | $\pi^-$ nucleus, 350 GeV |
| $0.173 \pm 0.023 \pm 0.035$ | 182 | [10] CHADA | 98 | CLE2 | $e^+e^- \approx \Upsilon(4S)$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $0.245 \pm 0.052 \pm 0.074$ | 39 | [11] ACOSTA | 94 | CLE2 | See CHADA 98 |

[9] ALEXANDROV 00 uses $f_D^2/f_{D_s}^2 = 0.82 \pm 0.09$ from a lattice-gauge-theory calculation to get the relative numbers of $D^+ \to \mu^+\nu_\mu$ and $D_s^+ \to \mu^+\nu_\mu$ events. The present result leads to $f_{D_s} = (323 \pm 44 \pm 36)$ MeV.

[10] CHADA 98 obtains $f_{D_s} = (280 \pm 19 \pm 28 \pm 34)$ MeV from this measurement, using $\Gamma(D_s^+ \to \phi\pi^+)/\Gamma(\text{total}) = 0.036 \pm 0.009$.

[11] ACOSTA 94 obtains $f_{D_s} = (344 \pm 37 \pm 52 \pm 42)$ MeV from this measurement, using $\Gamma(D_s^+ \to \phi\pi^+)/\Gamma(\text{total}) = 0.037 \pm 0.009$.

## $\Gamma(\mu^+\nu_\mu)/\Gamma(\phi\ell^+\nu_\ell)$ $\Gamma_7/\Gamma_9$

See the "Note on Pseudoscalar-Meson Decay Constants" in the Listings for the $\pi^\pm$.

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.25±0.07 OUR NEW UNCHECKED FIT** Error includes scale factor of 1.5. [0.25 ± 0.07 OUR 2002 FIT Scale factor = 1.4] | | | | | |
| **0.16±0.06±0.03** | 23 | [12] KODAMA | 96 | E653 | $\pi^-$ emulsion, 600 GeV |

[12] KODAMA 96 obtains $f_{D_s} = (194 \pm 35 \pm 20 \pm 14)$ MeV from this measurement, using $\Gamma(D_s^+ \to \phi\ell^+\nu)/\Gamma_{\text{total}} = 0.0188 \pm 0.0029$. The third error is from the uncertainty on $\phi\ell^+\nu_\ell$ branching fraction.

## $\Gamma(\tau^+\nu_\tau)/\Gamma_{\text{total}}$ $\Gamma_8/\Gamma$

See the "Note on Pseudoscalar-Meson Decay Constants" in the Listings for the $\pi^\pm$.

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.064 ±0.015 OUR AVERAGE** | | | | | |
| 0.0579±0.0077±0.0184 | 881 | [13] HEISTER | 02I | ALEP | $Z$ decays |
| 0.070 ±0.021 ±0.020 | 22 | [14] ABBIENDI | 01L | OPAL | $D_s^{*+} \to \gamma D_s^+$ from $Z$'s |
| 0.074 ±0.028 ±0.024 | 16 | [15] ACCIARRI | 97F | L3 | $D_s^{*+} \to \gamma D_s^+$ from $Z$'s |

[13] HEISTER 02I combines its $D_s^+ \to \tau^+\nu_\tau$ and $\mu^+\nu_\mu$ branching fractions to get $f_{D_s} = (285 \pm 19 \pm 40)$ MeV.

[14] This ABBIENDI 01L value gives a decay constant $f_{D_s}$ of $(286 \pm 44 \pm 41)$ MeV.

[15] The second ACCIARRI 97F error here combines in quadrature systematic (0.016) and normalization (0.018) errors. The branching fraction gives $f_{D_s} = (309 \pm 58 \pm 33 \pm 38)$ MeV.

## $\Gamma(\phi\ell^+\nu_\ell)/\Gamma(\phi\pi^+)$ $\Gamma_9/\Gamma_{15}$

For now, we average together measurements of the $\Gamma(\phi e^+\nu_e)/\Gamma(\phi\pi^+)$ and $\Gamma(\phi\mu^+\nu_\mu)/\Gamma(\phi\pi^+)$ ratios. See the end of the $D_s^+$ Listings for measurements of $D_s^+ \to \phi\ell^+\nu_\ell$ form-factor ratios.

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.55 ±0.04 OUR NEW UNCHECKED FIT** [0.56 ± 0.05 OUR 2002 FIT] | | | | | |
| **0.54 ±0.04 OUR NEW AVERAGE** [0.54 ± 0.05 OUR 2002 AVERAGE] | | | | | |
| 0.540±0.033±0.048 | 793 | [16] LINK | 02J | FOCS | $\gamma$ nucleus, ≈ 180 GeV |
| 0.54 ±0.05 ±0.04 | 367 | [17] BUTLER | 94 | CLE2 | $e^+e^- \approx \Upsilon(4S)$ |
| 0.58 ±0.17 ±0.07 | 97 | [18] FRABETTI | 93G | E687 | $\gamma$ Be $\overline{E}_\gamma$ = 220 GeV |
| 0.57 ±0.15 ±0.15 | 104 | [19] ALBRECHT | 91 | ARG | $e^+e^-$ ≈ 10.4 GeV |
| 0.49 ±0.10 $^{+0.10}_{-0.14}$ | 54 | [20] ALEXANDER | 90B | CLEO | $e^+e^-$ 10.5–11 GeV |

[16] LINK 02J measures the $\Gamma(\phi\mu^+\nu_\mu)/\Gamma(\phi\pi^+)$ ratio.

[17] BUTLER 94 uses both $\phi e^+\nu_e$ and $\phi\mu^+\nu_\mu$ events, and makes a phase-space adjustment to the latter to use them as $\phi e^+\nu_e$ events.

[18] FRABETTI 93G measures the $\Gamma(\phi\mu^+\nu_\mu)/\Gamma(\phi\pi^+)$ ratio.

[19] ALBRECHT 91 measures the $\Gamma(\phi e^+\nu_e)/\Gamma(\phi\pi^+)$ ratio.

[20] ALEXANDER 90B measures an average of the $\Gamma(\phi e^+\nu_e)/\Gamma(\phi\pi^+)$ and $\Gamma(\phi\mu^+\nu_\mu)/\Gamma(\phi\pi^+)$ ratios.

### $\Gamma(\eta\ell^+\nu_\ell)/\Gamma(\phi\ell^+\nu_\ell)$ $\Gamma_{11}/\Gamma_9$

Unseen decay modes of the $\eta$ and the $\phi$ are included.

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **1.27±0.19 OUR FIT** | | | | | |
| **1.24±0.12±0.15** | 440 | [21] BRANDENB... | 95 | CLE2 | $e^+e^-\approx\Upsilon(4S)$ |

[21] BRANDENBURG 95 uses both $e^+$ and $\mu^+$ events and makes a phase-space adjustment to use the $\mu^+$ events as $e^+$ events.

### $\Gamma(\eta'(958)\ell^+\nu_\ell)/\Gamma(\phi\ell^+\nu_\ell)$ $\Gamma_{12}/\Gamma_9$

Unseen decay modes of the resonances are included.

| VALUE | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **0.44±0.13 OUR FIT** | | | | | | |
| **0.43±0.11±0.07** | | 29 | [22] BRANDENB... | 95 | CLE2 | $e^+e^-\approx\Upsilon(4S)$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| <1.6 | 90 | | [23] KODAMA | 93B | E653 | $\pi^-$ emulsion 600 GeV |

[22] BRANDENBURG 95 uses both $e^+$ and $\mu^+$ events and makes a phase-space adjustment to use the $\mu^+$ events as $e^+$ events.

[23] KODAMA 93B uses $\mu^+$ events.

### $[\Gamma(\eta\ell^+\nu_\ell)+\Gamma(\eta'(958)\ell^+\nu_\ell)]/\Gamma(\phi\ell^+\nu_\ell)$ $\Gamma_{10}/\Gamma_9=(\Gamma_{11}+\Gamma_{12})/\Gamma_9$

Unseen decay modes of the resonances are included.

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **1.72±0.23 OUR FIT** | | | | | |
| **3.9 ±1.6** | 13 | [24] KODAMA | 93 | E653 | $\pi^-$ emulsion 600 GeV |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 1.67±0.17±0.17 | | [25] BRANDENB... | 95 | CLE2 | $e^+e^-\approx\Upsilon(4S)$ |

[24] KODAMA 93 uses $\mu^+$ events.

[25] This BRANDENBURG 95 data is redundant with data in previous blocks.

## Hadronic modes with a $K\overline{K}$ pair.

### $\Gamma(K^+\overline{K}^0)/\Gamma(\phi\pi^+)$ $\Gamma_{13}/\Gamma_{15}$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **1.01±0.16 OUR AVERAGE** | | | | | |
| 1.15±0.31±0.19 | 68 | ANJOS | 90C | E691 | $\gamma$ Be |
| 0.92±0.32±0.20 | | ADLER | 89B | MRK3 | $e^+e^-$ 4.14 GeV |
| 0.99±0.17±0.10 | | CHEN | 89 | CLEO | $e^+e^-$ 10 GeV |

## $\Gamma(\phi\pi^+)/\Gamma_{total}$ $\Gamma_{15}/\Gamma$

We now have model-independent measurements of this branching fraction, and so we no longer use the earlier, model-dependent results.

| VALUE | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **0.036 ±0.009 OUR FIT** | | | | | | |
| **0.036 ±0.009 OUR AVERAGE** | | | | | | |
| 0.0359 ±0.0077 ±0.0048 | | | [26] ARTUSO | 96 | CLE2 | $e^+e^-$ at $\Upsilon(4S)$ |
| 0.039 $^{+0.051}_{-0.019}$ $^{+0.018}_{-0.011}$ | | | [27] BAI | 95C | BES | $e^+e^-$ 4.03 GeV |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| 0.051 ±0.004 ±0.008 | | | [28] BUTLER | 94 | CLE2 | $e^+e^- \approx \Upsilon(4S)$ |
| <0.048 | 90 | | MUHEIM | 94 | | |
| 0.046 ±0.015 | | | [29] MUHEIM | 94 | | |
| 0.031 ±0.009 | | | [29] MUHEIM | 94 | | |
| 0.031 ±0.009 ±0.006 | | | [28] FRABETTI | 93G | E687 | $\gamma$ Be $\overline{E}_\gamma$ = 220 GeV |
| 0.024 ±0.010 | | | [28] ALBRECHT | 91 | ARG | $e^+e^- \approx$ 10.4 GeV |
| <0.041 | 90 | 0 | [27] ADLER | 90B | MRK3 | $e^+e^-$ 4.14 GeV |
| 0.031 ±0.006 $^{+0.011}_{-0.009}$ | | | [28] ALEXANDER | 90B | CLEO | $e^+e^-$ 10.5–11 GeV |
| 0.048 ±0.017 ±0.019 | | | [30] ALVAREZ | 90C | NA14 | Photoproduction |
| >0.034 | 90 | | [28] ANJOS | 90B | E691 | $\gamma$ Be, $\overline{E}_\gamma \approx$ 145 GeV |
| 0.02 ±0.01 | | 405 | [31] CHEN | 89 | CLEO | $e^+e^-$ 10 GeV |
| 0.033 ±0.016 ±0.010 | | 9 | [31] BRAUNSCH... | 87 | TASS | $e^+e^-$ 35–44 GeV |
| 0.033 ±0.011 | | 30 | [31] DERRICK | 85B | HRS | $e^+e^-$ 29 GeV |

[26] ARTUSO 96 uses partially reconstructed $\overline{B}^0 \to D^{*+} D_s^{*-}$ decays to get a model-independent value for $\Gamma(D_s^- \to \phi\pi^-)/\Gamma(D^0 \to K^-\pi^+)$ of 0.92 ± 0.20 ± 0.11.

[27] BAI 95C uses $e^+e^- \to D_s^+ D_s^-$ events in which one or both of the $D_s^\pm$ are observed to obtain the first model-independent measurement of the $D_s^+ \to \phi\pi^+$ branching fraction, without assumptions about $\sigma(D_s^\pm)$. However, with only two "doubly-tagged" events, the statistical error is very large. ADLER 90B used the same method to set a limit.

[28] BUTLER 94, FRABETTI 93G, ALBRECHT 91, ALEXANDER 90B, and ANJOS 90B measure the ratio $\Gamma(D_s^+ \to \phi\ell^+\nu_\ell)/\Gamma(D_s^+ \to \phi\pi^+)$, where $\ell$ = $e$ and/or $\mu$, and then use a theoretical calculation of the ratio of widths $\Gamma(D_s^+ \to \phi\ell^+\nu_\ell)/\Gamma(D^+ \to \overline{K}^{*0}\ell^+\nu)$. Not everyone uses the same value for this ratio.

[29] The two MUHEIM 94 values here are model-dependent calculations based on distinct data sets. The first uses measurements of the $D_2^*(2460)^0$ and $D_{s1}(2536)^+$, the second uses $B$-decay factorization and $\Gamma(D_s^+ \to \mu^+\nu_\mu)/\Gamma(D_s^+ \to \phi\ell^+\nu_\ell)$. A third calculation using the semileptonic width of $D_s^+ \to \phi\ell^+\nu_\ell$ is not independent of other results listed here. Note also the upper limit, based on the sum of established $D_s^+$ branching ratios.

[30] ALVAREZ 90C relies on the Lund model to estimate the ratio of $D_s^+$ to $D^+$ cross sections.

[31] Values based on crude estimates of the $D_s^\pm$ production level. DERRICK 85B errors are statistical only.

### $\Gamma(\phi\pi^+)/\Gamma(K^+K^-\pi^+)$ $\Gamma_{15}/\Gamma_{14}$

Unseen decay modes of the $\phi$ are included.

| VALUE | DOCUMENT ID | TECN | COMMENT |
|---|---|---|---|
| **0.81 ±0.08 OUR FIT** | | | |
| **0.807±0.067±0.096** | FRABETTI | 95B E687 | Dalitz plot analysis |

### $\Gamma(K^+\overline{K}^*(892)^0)/\Gamma(K^+K^-\pi^+)$ $\Gamma_{16}/\Gamma_{14}$

Unseen decay modes of the $\overline{K}^*(892)^0$ are included.

| VALUE | DOCUMENT ID | TECN | COMMENT |
|---|---|---|---|
| **0.75 ±0.07 OUR FIT** | | | |
| **0.717±0.069±0.060** | FRABETTI | 95B E687 | Dalitz plot analysis |

### $\Gamma(K^+\overline{K}^*(892)^0)/\Gamma(\phi\pi^+)$ $\Gamma_{16}/\Gamma_{15}$

Unseen decay modes of the resonances are included.

| VALUE | EVTS | DOCUMENT ID | TECN | COMMENT |
|---|---|---|---|---|
| **0.92±0.09 OUR FIT** | | | | |
| **0.95±0.10 OUR AVERAGE** | | | | |
| 0.85±0.34±0.20 | 9 | ALVAREZ | 90C NA14 | Photoproduction |
| 0.84±0.30±0.22 | | ADLER | 89B MRK3 | $e^+e^-$ 4.14 GeV |
| 1.05±0.17±0.12 | | CHEN | 89 CLEO | $e^+e^-$ 10 GeV |
| 0.87±0.13±0.05 | 117 | ANJOS | 88 E691 | Photoproduction |
| 1.44±0.37 | 87 | ALBRECHT | 87F ARG | $e^+e^-$ 10 GeV |

### $\Gamma(f_0(980)\pi^+ \times B(f_0 \to K^+K^-))/\Gamma(K^+K^-\pi^+)$ $\Gamma_{17}/\Gamma_{14}$

This includes only the $K^+K^-$ decays of the $f_0(980)$, because branching fractions of this resonance are not known.

| VALUE | DOCUMENT ID | TECN | COMMENT |
|---|---|---|---|
| **0.11±0.035±0.026** | FRABETTI | 95B E687 | Dalitz plot analysis |

### $\Gamma(f_0(1710)\pi^+ \times B(f_0 \to K^+K^-))/\Gamma(K^+K^-\pi^+)$ $\Gamma_{19}/\Gamma_{14}$

This includes only $K^+K^-$ decays of the $f_0(1710)$, because branching fractions of this resonance are not known.

| VALUE | DOCUMENT ID | TECN | COMMENT |
|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | |
| 0.034±0.023±0.035 | [32] FRABETTI | 95B E687 | Dalitz plot analysis |

[32] In other words, FRABETTI 95B doesn't see this resonance.

### $\Gamma(K^+\overline{K}_0^*(1430)^0)/\Gamma(K^+K^-\pi^+)$ $\Gamma_{18}/\Gamma_{14}$

Unseen decay modes of the $\overline{K}_0^*(1430)^0$ are included.

| VALUE | DOCUMENT ID | TECN | COMMENT |
|---|---|---|---|
| **0.150±0.052±0.052** | FRABETTI | 95B E687 | Dalitz plot analysis |

### $\Gamma(K^+K^-\pi^+ \text{nonresonant})/\Gamma(\phi\pi^+)$ $\Gamma_{20}/\Gamma_{15}$

| VALUE | EVTS | DOCUMENT ID | TECN | COMMENT |
|---|---|---|---|---|
| **0.25±0.07±0.05** | 48 | ANJOS | 88 E691 | Photoproduction |

### $\Gamma(K^*(892)^+\overline{K}^0)/\Gamma(\phi\pi^+)$ $\Gamma_{22}/\Gamma_{15}$

Unseen decay modes of the resonances are included.

| VALUE | DOCUMENT ID | TECN | COMMENT |
|---|---|---|---|
| **1.20±0.21±0.13** | CHEN | 89 CLEO | $e^+e^-$ 10 GeV |

### $\Gamma(K^*(892)^+\overline{K}^0)/\Gamma(K^+\overline{K}^0)$ $\Gamma_{22}/\Gamma_{13}$

Unseen decay modes of the $K^*(892)^+$ are included.

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| <0.9 | 90 | FRABETTI | 95 | E687 | $\gamma$ Be $\overline{E}_\gamma \approx 200$ GeV |

### $\Gamma(\phi\pi^+\pi^0)/\Gamma(\phi\pi^+)$ $\Gamma_{24}/\Gamma_{15}$

| VALUE | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **2.4±1.0±0.5** | | 11 | ANJOS | 89E | E691 | Photoproduction |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| <2.6 | 90 | | ALVAREZ | 90C | NA14 | Photoproduction |

### $\Gamma(\phi\rho^+)/\Gamma(\phi\pi^+)$ $\Gamma_{25}/\Gamma_{15}$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| $\mathbf{1.86\pm0.26^{+0.29}_{-0.40}}$ | 253 | AVERY | 92 | CLE2 | $e^+e^- \simeq 10.5$ GeV |

### $\Gamma(\phi\pi^+\pi^0\ 3\text{-body})/\Gamma(\phi\pi^+)$ $\Gamma_{26}/\Gamma_{15}$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<0.71** | 90 | DAOUDI | 92 | CLE2 | $e^+e^- \approx 10.5$ GeV |

### $\Gamma(K^+K^-\pi^+\pi^0\ \text{non-}\phi)/\Gamma(\phi\pi^+)$ $\Gamma_{27}/\Gamma_{15}$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<2.4** | 90 | ANJOS | 89E | E691 | Photoproduction |

### $\Gamma(K^+\overline{K}^0\pi^+\pi^-)/\Gamma(\phi\pi^+)$ $\Gamma_{28}/\Gamma_{15}$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| <0.77 | 90 | ALBRECHT | 92B | ARG | $e^+e^- \simeq 10.4$ GeV |

### $\Gamma(K^+\overline{K}^0\pi^+\pi^-)/\Gamma(K^0K^-\pi^+\pi^+)$ $\Gamma_{28}/\Gamma_{29}$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.586±0.052±0.043** | 476 | LINK | 01C | FOCS | $\gamma$ nucleus, $\overline{E}_\gamma \approx 180$ GeV |

### $\Gamma(K^0K^-\pi^+\pi^+)/\Gamma(\phi\pi^+)$ $\Gamma_{29}/\Gamma_{15}$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **1.2 ±0.2 ±0.2** | ALBRECHT | 92B | ARG | $e^+e^- \simeq 10.4$ GeV |

### $\Gamma(K^*(892)^+\overline{K}^*(892)^0)/\Gamma(\phi\pi^+)$ $\Gamma_{30}/\Gamma_{15}$

Unseen decay modes of the resonances are included.

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **1.6±0.4±0.4** | ALBRECHT | 92B | ARG | $e^+e^- \simeq 10.4$ GeV |

### $\Gamma(K^0K^-\pi^+\pi^+\ \text{non-}K^{*+}\overline{K}^{*0})/\Gamma(\phi\pi^+)$ $\Gamma_{31}/\Gamma_{15}$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<0.80** | 90 | ALBRECHT | 92B | ARG | $e^+e^- \simeq 10.4$ GeV |

### $\Gamma(K^+K^-\pi^+\pi^+\pi^-)/\Gamma(K^+K^-\pi^+)$ $\Gamma_{32}/\Gamma_{14}$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.188±0.036±0.040** | 75 | FRABETTI | 97C | E687 | $\gamma$ Be, $\overline{E}_\gamma \approx$ 200 GeV |

### $\Gamma(\phi\pi^+\pi^+\pi^-)/\Gamma(\phi\pi^+)$ $\Gamma_{33}/\Gamma_{15}$

| VALUE | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **0.33±0.06 OUR AVERAGE** | | | | | | |
| 0.28±0.06±0.01 | | 40 | FRABETTI | 97C | E687 | $\gamma$ Be, $\overline{E}_\gamma \approx$ 200 GeV |
| 0.58±0.21±0.10 | | 21 | FRABETTI | 92 | E687 | $\gamma$ Be |
| 0.42±0.13±0.07 | | 19 | ANJOS | 88 | E691 | Photoproduction |
| 1.11±0.37±0.28 | | 62 | ALBRECHT | 85D | ARG | $e^+e^-$ 10 GeV |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| <0.24 | 90 | | ALVAREZ | 90C | NA14 | Photoproduction |

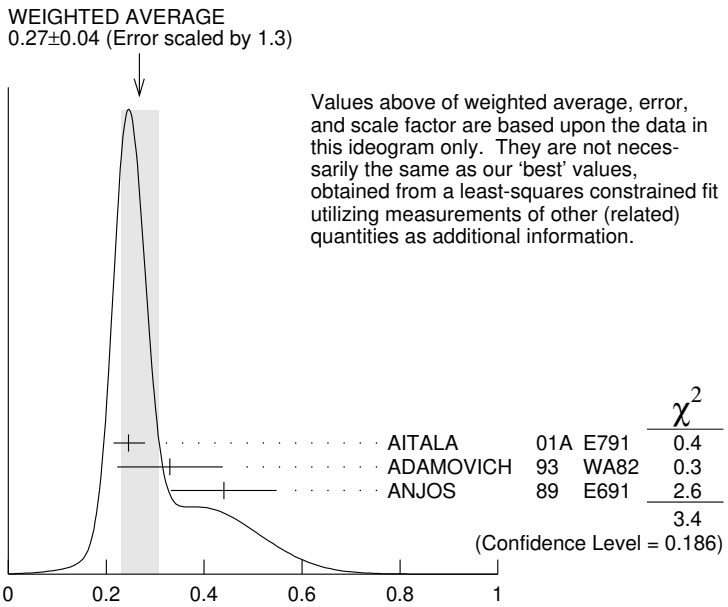
## Pionic modes

### $\Gamma(\pi^+\pi^+\pi^-)/\Gamma(K^+K^-\pi^+)$ $\Gamma_{34}/\Gamma_{14}$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.227±0.033 OUR FIT** | Error includes scale factor of 1.1. | | | | |
| **0.265±0.041±0.031** | 98 | FRABETTI | 97D | E687 | $\gamma$ Be $\approx$ 200 GeV |

### $\Gamma(\pi^+\pi^+\pi^-)/\Gamma(\phi\pi^+)$ $\Gamma_{34}/\Gamma_{15}$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.28 ±0.04 OUR FIT** | Error includes scale factor of 1.3. | | | | |
| **0.27 ±0.04 OUR AVERAGE** | Error includes scale factor of 1.3. See the ideogram below. | | | | |
| $0.245\pm0.028^{+0.019}_{-0.012}$ | 848 | AITALA | 01A | E791 | $\pi^-$ nucleus, 500 GeV |
| 0.33 ±0.10 ±0.04 | 29 | ADAMOVICH | 93 | WA82 | $\pi^-$ 340 GeV |
| 0.44 ±0.10 ±0.04 | 68 | ANJOS | 89 | E691 | Photoproduction |




$\Gamma\left(\pi^+\,\pi^+\,\pi^-\right)/\Gamma\left(\phi\,\pi^+\right)$

## $\Gamma(\rho^0\pi^+)/\Gamma(\pi^+\pi^+\pi^-)$ $\Gamma_{35}/\Gamma_{34}$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<0.073** | 90 | FRABETTI | 97D | E687 | $\gamma$ Be $\approx$ 200 GeV |

• • • We do not use the following data for averages, fits, limits, etc. • • •

| | | | | | |
|---|---|---|---|---|---|
| 0.058±0.023±0.037 | [33] | AITALA | 01A | E791 | $\pi^-$ nucleus, 500 GeV |

[33] This AITALA 01A result does not have enough statistical significance to prefer it to the FRABETTI 97D limit.

## $\Gamma(\rho^0\pi^+)/\Gamma(\phi\pi^+)$ $\Gamma_{35}/\Gamma_{15}$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|

• • • We do not use the following data for averages, fits, limits, etc. • • •

| | | | | | |
|---|---|---|---|---|---|
| <0.08 | 90 | ANJOS | 89 | E691 | Photoproduction |
| <0.22 | 90 | ALBRECHT | 87G | ARG | $e^+e^-$ 10 GeV |

## $\Gamma(f_0(980)\pi^+ \times B(f_0 \to \pi^+\pi^-))/\Gamma(\pi^+\pi^+\pi^-)$ $\Gamma_{36}/\Gamma_{34}$

This includes only the $\pi^+\pi^-$ decays of the $f_0(980)$, because branching fractions of this resonance are not known. In general, we favor the results of AITALA 01A over those of FRABETTI 97D (848 ± 44 events versus 98 ± 12).

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **0.565±0.043±0.047** | AITALA | 01A | E791 | $\pi^-$ nucleus, 500 GeV |

• • • We do not use the following data for averages, fits, limits, etc. • • •

| | | | | |
|---|---|---|---|---|
| 1.074±0.140±0.043 | FRABETTI | 97D | E687 | $\gamma$ Be $\approx$ 200 GeV |

### $\Gamma(f_0(980)\pi^+ \times B(f_0 \to \pi^+\pi^-))/\Gamma(\phi\pi^+)$ $\Gamma_{36}/\Gamma_{15}$

This includes only the $\pi^+\pi^-$ decays of the $f_0(980)$, because branching fractions of this resonance are not known.

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $0.28 \pm 0.10 \pm 0.03$ | ANJOS | 89 | E691 | Photoproduction |

### $\Gamma(f_2(1270)\pi^+)/\Gamma(\pi^+\pi^+\pi^-)$ $\Gamma_{37}/\Gamma_{34}$

Unseen decay modes of the $f_2(1270)$ are included.

In general, we favor the results of AITALA 01A over those of FRABETTI 97D ($848 \pm 44$ events versus $98 \pm 12$).

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **$0.349 \pm 0.059 \pm 0.011$** | [34] AITALA | 01A | E791 | $\pi^-$ nucleus, 500 GeV |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $0.22 \pm 0.10 \pm 0.03$ | FRABETTI | 97D | E687 | $\gamma$ Be $\approx$ 200 GeV |

[34] See AITALA 01A for the magnitude and phase of this amplitude relative to the $f_0(980)\pi^+$ amplitude.

### $\Gamma(f_0(1370)\pi^+ \times B(f_0 \to \pi^+\pi^-))/\Gamma(\pi^+\pi^+\pi^-)$ $\Gamma_{38}/\Gamma_{34}$

This includes only the $\pi^+\pi^-$ decays of the $f_0(1370)$, because branching fractions of this resonance are not known.

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **$0.324 \pm 0.077 \pm 0.017$** | [35] AITALA | 01A | E791 | $\pi^-$ nucleus, 500 GeV |

[35] See AITALA 01A for the magnitude and phase of this amplitude relative to the $f_0(980)\pi^+$ amplitude.

### $\Gamma(\rho(1450)^0\pi^+ \times B(\rho^0 \to \pi^+\pi^-))/\Gamma(\pi^+\pi^+\pi^-)$ $\Gamma_{39}/\Gamma_{34}$

This includes only the $\pi^+\pi^-$ decays of the $\rho(1450)^0$, because branching fractions of this resonance are not known.

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **$0.044 \pm 0.021 \pm 0.002$** | [36] AITALA | 01A | E791 | $\pi^-$ nucleus, 500 GeV |

[36] See AITALA 01A for the magnitude and phase of this amplitude relative to the $f_0(980)\pi^+$ amplitude.

### $\Gamma(f_0(1500)\pi^+ \times B(f_0 \to \pi^+\pi^-))/\Gamma(\pi^+\pi^+\pi^-)$ $\Gamma_{40}/\Gamma_{34}$

This includes only $\pi^+\pi^-$ decays of the $f_0(1500)$, because branching fractions of this resonance are not known. In general, we favor the results of AITALA 01A over those of FRABETTI 97D ($848 \pm 44$ events versus $98 \pm 12$).

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $0.274 \pm 0.114 \pm 0.019$ | [37] FRABETTI | 97D | E687 | $\gamma$ Be $\approx$ 200 GeV |

[37] FRABETTI 97D calls this mode $S(1475)\pi^+$, but finds the mass and width of this $S(1475)$ to be in excellent agreement with those of the $f_0(1500)$.

### $\Gamma(\pi^+\pi^+\pi^-$ nonresonant$)/\Gamma(\pi^+\pi^+\pi^-)$ $\Gamma_{41}/\Gamma_{34}$

In general, we favor the results of AITALA 01A over those of FRABETTI 97D (848 ± 44 events versus 98 ± 12).

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.005±0.014±0.017** | | AITALA | 01A | E791 | $\pi^-$ nucleus, 500 GeV |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| <0.269 | 90 | [38] FRABETTI | 97D | E687 | $\gamma$ Be ≈ 200 GeV |

[38] See FRABETTI 97D on the difficulty of disentangling the $f_0(1500)\pi^+$ and nonresonant modes.

### $\Gamma(\pi^+\pi^+\pi^-$ nonresonant$)/\Gamma(\phi\pi^+)$ $\Gamma_{41}/\Gamma_{15}$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 0.29±0.09±0.03 | ANJOS | 89 | E691 | Photoproduction |

### $\Gamma(\pi^+\pi^+\pi^-\pi^0)/\Gamma(\phi\pi^+)$ $\Gamma_{42}/\Gamma_{15}$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<3.3** | 90 | ANJOS | 89E | E691 | Photoproduction |

### $\Gamma(\eta\pi^+)/\Gamma(\phi\pi^+)$ $\Gamma_{43}/\Gamma_{15}$

Unseen decay modes of the resonances are included.

| VALUE | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **0.48±0.03±0.04** | | 920 | JESSOP | 98 | CLE2 | $e^+e^-$ ≈ $\Upsilon(4S)$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| 0.54±0.09±0.06 | | 165 | ALEXANDER | 92 | CLE2 | See JESSOP 98 |
| <1.5 | 90 | | ANJOS | 89E | E691 | Photoproduction |

### $\Gamma(\omega\pi^+)/\Gamma(\phi\pi^+)$ $\Gamma_{44}/\Gamma_{15}$

Unseen decay modes of the resonances are included.

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| <0.5 | 90 | ANJOS | 89E | E691 | Photoproduction |

### $\Gamma(\omega\pi^+)/\Gamma(\eta\pi^+)$ $\Gamma_{44}/\Gamma_{43}$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **0.16±0.04±0.03** | BALEST | 97 | CLE2 | $e^+e^-$ ≈ $\Upsilon(4S)$ |

### $\Gamma(\pi^+\pi^+\pi^+\pi^-\pi^-)/\Gamma(K^+K^-\pi^+)$ $\Gamma_{45}/\Gamma_{14}$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.158±0.042±0.031** | 37 | FRABETTI | 97C | E687 | $\gamma$ Be, $\overline{E}_\gamma$ ≈ 200 GeV |

### $\Gamma(\pi^+\pi^+\pi^+\pi^-\pi^-)/\Gamma(\phi\pi^+)$ $\Gamma_{45}/\Gamma_{15}$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| <0.29 | 90 | ANJOS | 89 | E691 | Photoproduction |

## $\Gamma(\eta\rho^+)/\Gamma(\phi\pi^+)$ $\Gamma_{47}/\Gamma_{15}$

Unseen decay modes of the resonances are included.

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$2.98\pm0.20\pm0.39$** | 447 | JESSOP | 98 | CLE2 | $e^+e^-\approx\ \Upsilon(4S)$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $2.86\pm0.38^{+0.36}_{-0.38}$ | 217 | AVERY | 92 | CLE2 | See JESSOP 98 |

## $\Gamma(\eta\pi^+\pi^0\text{3-body})/\Gamma(\phi\pi^+)$ $\Gamma_{48}/\Gamma_{15}$

Unseen decay modes of the resonances are included.

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<1.1** | 90 | JESSOP | 98 | CLE2 | $e^+e^-\approx\ \Upsilon(4S)$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| <0.82 | 90 | [39] DAOUDI | 92 | CLE2 | See JESSOP 98 |

[39] We use the JESSOP 98 limit, even though the DAOUDI 92 limit, from the same experiment but with a much smaller data sample, is more restrictive.

## $\Gamma(\pi^+\pi^+\pi^+\pi^-\pi^-\pi^0)/\Gamma_{\text{total}}$ $\Gamma_{49}/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **$0.049^{+0.033}_{-0.030}$** | BARLAG | 92C | ACCM | $\pi^-$ 230 GeV |

## $\Gamma(\eta'(958)\pi^+)/\Gamma(\phi\pi^+)$ $\Gamma_{50}/\Gamma_{15}$

Unseen decay modes of the resonances are included.

| VALUE | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **$1.08\pm0.09$ OUR AVERAGE** | | | | | | |
| $1.03\pm0.06\pm0.07$ | | 537 | JESSOP | 98 | CLE2 | $e^+e^-\approx\ \Upsilon(4S)$ |
| $2.5\ \pm1.0\ ^{+1.5}_{-0.4}$ | | 22 | ALVAREZ | 91 | NA14 | Photoproduction |
| $2.5\ \pm0.5\ \pm0.3$ | | 215 | ALBRECHT | 90D | ARG | $e^+e^-\approx 10.4$ GeV |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| $1.20\pm0.15\pm0.11$ | | 281 | ALEXANDER | 92 | CLE2 | See JESSOP 98 |
| <1.3 | 90 | | ANJOS | 91B | E691 | $\gamma$Be, $\overline{E}_\gamma\approx 145$ GeV |

## $\Gamma(\eta'(958)\rho^+)/\Gamma(\phi\pi^+)$ $\Gamma_{52}/\Gamma_{15}$

Unseen decay modes of the resonances are included.

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$2.78\pm0.28\pm0.30$** | 137 | JESSOP | 98 | CLE2 | $e^+e^-\approx\ \Upsilon(4S)$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $3.44\pm0.62^{+0.44}_{-0.46}$ | 68 | AVERY | 92 | CLE2 | See JESSOP 98 |

## $\Gamma(\eta'(958)\pi^+\pi^0\text{3-body})/\Gamma(\phi\pi^+)$ $\Gamma_{53}/\Gamma_{15}$

Unseen decay modes of the resonances are included.

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<0.4** | 90 | JESSOP | 98 | CLE2 | $e^+e^-\approx\ \Upsilon(4S)$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| <0.85 | 90 | DAOUDI | 92 | CLE2 | See JESSOP 98 |

## Modes with one or three $K$'s

### $\Gamma(K^0\pi^+)/\Gamma(\phi\pi^+)$ $\Gamma_{54}/\Gamma_{15}$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<0.21** | 90 | ADLER | 89B | MRK3 | $e^+e^-$ 4.14 GeV |

### $\Gamma(K^0\pi^+)/\Gamma(K^+\overline{K}^0)$ $\Gamma_{54}/\Gamma_{13}$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| <0.53 | 90 | FRABETTI | 95 | E687 | $\gamma$ Be $\overline{E}_\gamma \approx 200$ GeV |

### $\Gamma(K^+\pi^+\pi^-)/\Gamma(\phi\pi^+)$ $\Gamma_{55}/\Gamma_{15}$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.28±0.06±0.05** | 85 | FRABETTI | 95E | E687 | $\gamma$ Be, $\overline{E}_\gamma$= 220 GeV |

### $\Gamma(K^+\rho^0)/\Gamma(\phi\pi^+)$ $\Gamma_{56}/\Gamma_{15}$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<0.08** | 90 | FRABETTI | 95E | E687 | $\gamma$ Be, $\overline{E}_\gamma$= 220 GeV |

### $\Gamma(K^*(892)^0\pi^+)/\Gamma(\phi\pi^+)$ $\Gamma_{57}/\Gamma_{15}$

Unseen decay modes of the resonances are included.

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.18±0.05±0.04** | 25 | FRABETTI | 95E | E687 | $\gamma$ Be, $\overline{E}_\gamma$= 220 GeV |

### $\Gamma(K^+K^+K^-)/\Gamma(K^+K^-\pi^+)$ $\Gamma_{58}/\Gamma_{14}$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| $0.00895\pm0.00212^{+0.00224}_{-0.00231}$ | 31 | LINK | 02I | FOCS | $\gamma$ nucleus, $\approx$ 180 GeV |

### $\Gamma(K^+K^+K^-)/\Gamma(\phi\pi^+)$ $\Gamma_{58}/\Gamma_{15}$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| <0.016 | 90 | FRABETTI | 95F | E687 | $\gamma$ Be, $\overline{E}_\gamma \approx$ 220 GeV |

### $\Gamma(\phi K^+)/\Gamma(\phi\pi^+)$ $\Gamma_{59}/\Gamma_{15}$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<0.013** | 90 | FRABETTI | 95F | E687 | $\gamma$ Be, $\overline{E}_\gamma \approx$ 220 GeV |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| <0.071 | 90 | ANJOS | 92D | E691 | $\gamma$ Be, $\overline{E}_\gamma$ = 145 GeV |

## Rare or forbidden modes

### $\Gamma(\pi^+e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_{60}/\Gamma$

This mode is not a useful test for a $\Delta C$=1 weak neutral current because both quarks must change flavor in this decay.

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$<2.7\times10^{-4}$** | 90 | AITALA | 99G | E791 | $\pi^-$ $N$ 500 GeV |

### $\Gamma(\pi^+ \mu^+ \mu^-)/\Gamma_{total}$ $\Gamma_{61}/\Gamma$

This mode is not a useful test for a $\Delta C$=1 weak neutral current because both quarks must change flavor in this decay.

| VALUE | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **$<1.4 \times 10^{-4}$** | 90 | | AITALA | 99G | E791 | $\pi^-$ $N$ 500 GeV |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| $<4.3 \times 10^{-4}$ | 90 | 0 | KODAMA | 95 | E653 | $\pi^-$ emulsion 600 GeV |

### $\Gamma(K^+ e^+ e^-)/\Gamma_{total}$ $\Gamma_{62}/\Gamma$

A test for the $\Delta C$=1 weak neutral current. Allowed by higher-order electroweak interactions.

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$<1.6 \times 10^{-3}$** | 90 | AITALA | 99G | E791 | $\pi^-$ $N$ 500 GeV |

### $\Gamma(K^+ \mu^+ \mu^-)/\Gamma_{total}$ $\Gamma_{63}/\Gamma$

A test for the $\Delta C$=1 weak neutral current. Allowed by higher-order electroweak interactions.

| VALUE | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **$<1.4 \times 10^{-4}$** | 90 | | AITALA | 99G | E791 | $\pi^-$ $N$ 500 GeV |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| $<5.9 \times 10^{-4}$ | 90 | 0 | KODAMA | 95 | E653 | $\pi^-$ emulsion 600 GeV |

### $\Gamma(K^*(892)^+ \mu^+ \mu^-)/\Gamma_{total}$ $\Gamma_{64}/\Gamma$

A test for the $\Delta C$=1 weak neutral current. Allowed by higher-order electroweak interactions.

| VALUE | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **$<1.4 \times 10^{-3}$** | 90 | 0 | KODAMA | 95 | E653 | $\pi^-$ emulsion 600 GeV |

### $\Gamma(\pi^+ e^\pm \mu^\mp)/\Gamma_{total}$ $\Gamma_{65}/\Gamma$

A test of lepton-family-number conservation.

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$<6.1 \times 10^{-4}$** | 90 | AITALA | 99G | E791 | $\pi^-$ $N$ 500 GeV |

### $\Gamma(K^+ e^\pm \mu^\mp)/\Gamma_{total}$ $\Gamma_{66}/\Gamma$

A test of lepton-family-number conservation.

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$<6.3 \times 10^{-4}$** | 90 | AITALA | 99G | E791 | $\pi^-$ $N$ 500 GeV |

### $\Gamma(\pi^- e^+ e^+)/\Gamma_{total}$ $\Gamma_{67}/\Gamma$

A test of lepton-number conservation.

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$<6.9 \times 10^{-4}$** | 90 | AITALA | 99G | E791 | $\pi^-$ $N$ 500 GeV |

### $\Gamma(\pi^- \mu^+ \mu^+)/\Gamma_{total}$ $\Gamma_{68}/\Gamma$

A test of lepton-number conservation.

| VALUE | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **$<8.2 \times 10^{-5}$** | 90 | | AITALA | 99G | E791 | $\pi^-$ $N$ 500 GeV |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| $<4.3 \times 10^{-4}$ | 90 | 0 | KODAMA | 95 | E653 | $\pi^-$ emulsion 600 GeV |

### $\Gamma(\pi^- e^+ \mu^+)/\Gamma_{total}$ $\Gamma_{69}/\Gamma$

A test of lepton-number conservation.

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$<7.3 \times 10^{-4}$** | 90 | AITALA | 99G | E791 | $\pi^-$ $N$ 500 GeV |

### $\Gamma(K^- e^+ e^+)/\Gamma_{total}$ $\Gamma_{70}/\Gamma$

A test of lepton-number conservation.

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$<6.3 \times 10^{-4}$** | 90 | AITALA | 99G | E791 | $\pi^-$ $N$ 500 GeV |

### $\Gamma(K^- \mu^+ \mu^+)/\Gamma_{total}$ $\Gamma_{71}/\Gamma$

A test of lepton-number conservation.

| VALUE | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **$<1.8 \times 10^{-4}$** | 90 | | AITALA | 99G | E791 | $\pi^-$ $N$ 500 GeV |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| $<5.9 \times 10^{-4}$ | 90 | 0 | KODAMA | 95 | E653 | $\pi^-$ emulsion 600 GeV |

### $\Gamma(K^- e^+ \mu^+)/\Gamma_{total}$ $\Gamma_{72}/\Gamma$

A test of lepton-number conservation.

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$<6.8 \times 10^{-4}$** | 90 | AITALA | 99G | E791 | $\pi^-$ $N$ 500 GeV |

### $\Gamma(K^*(892)^- \mu^+ \mu^+)/\Gamma_{total}$ $\Gamma_{73}/\Gamma$

A test of lepton-number conservation.

| VALUE | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **$<1.4 \times 10^{-3}$** | 90 | 0 | KODAMA | 95 | E653 | $\pi^-$ emulsion 600 GeV |

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## $D_s^+ \to \phi \ell^+ \nu_\ell$ FORM FACTORS

### $r_2 \equiv A_2(0)/A_1(0)$ in $D_s^+ \to \phi \ell^+ \nu_\ell$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **1.60±0.24 OUR AVERAGE** | | | | | |
| 1.57±0.25±0.19 | 271 | AITALA | 99D | E791 | $\phi e^+ \nu_e$, $\phi \mu^+ \nu_\mu$ |
| 1.4 ±0.5 ±0.3 | 308 | AVERY | 94B | CLE2 | $\phi e^+ \nu_e$ |
| 1.1 ±0.8 ±0.1 | 90 | FRABETTI | 94F | E687 | $\phi \mu^+ \nu_\mu$ |
| $2.1\ ^{+0.6}_{-0.5}$ ±0.2 | 19 | KODAMA | 93 | E653 | $\phi \mu^+ \nu_\mu$ |

### $r_V \equiv V(0)/A_1(0)$ in $D_s^+ \to \phi \ell^+ \nu_\ell$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **1.92±0.32 OUR AVERAGE** | | | | | |
| 2.27±0.35±0.22 | 271 | AITALA | 99D | E791 | $\phi e^+ \nu_e$, $\phi \mu^+ \nu_\mu$ |
| 0.9 ±0.6 ±0.3 | 308 | AVERY | 94B | CLE2 | $\phi e^+ \nu_e$ |
| 1.8 ±0.9 ±0.2 | 90 | FRABETTI | 94F | E687 | $\phi \mu^+ \nu_\mu$ |
| $2.3\ ^{+1.1}_{-0.9}$ ±0.4 | 19 | KODAMA | 93 | E653 | $\phi \mu^+ \nu_\mu$ |

### $\Gamma_L/\Gamma_T$ in $D_s^+ \to \phi\ell^+\nu_\ell$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.72±0.18 OUR AVERAGE** | | | | | |
| 1.0 ±0.3 ±0.2 | 308 | AVERY | 94B | CLE2 | $\phi e^+\nu_e$ |
| 1.0 ±0.5 ±0.1 | 90 | [40] FRABETTI | 94F | E687 | $\phi\mu^+\nu_\mu$ |
| 0.54±0.21±0.10 | 19 | [40] KODAMA | 93 | E653 | $\phi\mu^+\nu_\mu$ |

[40] FRABETTI 94F and KODAMA 93 evaluate $\Gamma_L/\Gamma_T$ for a lepton mass of zero.

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