# $\Lambda_c(2593)^+$

$I(J^P) = 0(\frac{1}{2}^-)$ Status: ***

Seen in $\Lambda_c^+ \pi^+ \pi^-$ but not in $\Lambda_c^+ \pi^0$, so this is indeed an excited $\Lambda_c^+$ rather than a $\Sigma_c^+$. The $\Lambda_c^+ \pi^+ \pi^-$ mode is largely, and perhaps entirely, $\Sigma_c \pi$, which is just at threshold; thus (assuming, as has not yet been proven, that the $\Sigma_c$ has $J^P = 1/2^+$) the $J^P$ here is almost certainly $1/2^-$. This result is in accord with the theoretical expectation that this is the charm counterpart of the strange $\Lambda(1405)$.

## $\Lambda_c(2593)^+$ MASS

The mass is obtained from the $m_{\Lambda_c(2593)^+} - m_{\Lambda_c^+}$ mass-difference measurements below.

| *VALUE* (MeV) | *DOCUMENT ID* |
|---|---|
| **2593.9±0.8 OUR FIT** | |

## $m_{\Lambda_c(2593)^+} - m_{\Lambda_c^+}$

| *VALUE* (MeV) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **308.9±0.6 OUR FIT** Error includes scale factor of 1.1. | | | | | |
| **308.9±0.6 OUR AVERAGE** Error includes scale factor of 1.1. | | | | | |
| 309.7±0.9±0.4 | 19 | ALBRECHT | 97 | ARG | $e^+e^- \approx$ 10 GeV |
| 309.2±0.7±0.3 | 14 | [1] FRABETTI | 96 | E687 | $\gamma$ Be, $\overline{E}_\gamma \approx$ 220 GeV |
| 307.5±0.4±1.0 | 112 | [2] EDWARDS | 95 | CLE2 | $e^+e^- \approx$ 10.5 GeV |

[1] FRABETTI 96 claims a signal of 13.9 ± 4.5 events.

[2] EDWARDS 95 claims a signal of 112.5 ± 16.5 events in $\Lambda_c^+ \pi^+ \pi^-$.

## $\Lambda_c(2593)^+$ WIDTH

| *VALUE* (MeV) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **$3.6^{+2.0}_{-1.3}$ OUR AVERAGE** | | | | | |
| $2.9^{+2.9+1.8}_{-2.1-1.4}$ | 19 | ALBRECHT | 97 | ARG | $e^+e^- \approx$ 10 GeV |
| $3.9^{+1.4+2.0}_{-1.2-1.0}$ | 112 | EDWARDS | 95 | CLE2 | $e^+e^- \approx$ 10.5 GeV |

## $\Lambda_c(2593)^+$ DECAY MODES

$\Lambda_c^+ \pi\pi$ and its submode $\Sigma_c(2455)\pi$ — the latter just barely — are the only strong decays allowed to an excited $\Lambda_c^+$ having this mass; and the $\Lambda_c^+ \pi^+ \pi^-$ mode seems to be largely via $\Sigma_c^{++} \pi^-$ or $\Sigma_c^0 \pi^+$.

| | Mode | Fraction ($\Gamma_i/\Gamma$) |
|---|---|---|
| $\Gamma_1$ | $\Lambda_c^+ \pi^+ \pi^-$ | [a] $\approx$ 67 % |
| $\Gamma_2$ | $\Sigma_c(2455)^{++} \pi^-$ | 24 $\pm$ 7 % |
| $\Gamma_3$ | $\Sigma_c(2455)^0 \pi^+$ | 24 $\pm$ 7 % |
| $\Gamma_4$ | $\Lambda_c^+ \pi^+ \pi^-$ 3-body | 18 $\pm$ 10 % |
| $\Gamma_5$ | $\Lambda_c^+ \pi^0$ | not seen |
| $\Gamma_6$ | $\Lambda_c^+ \gamma$ | not seen |

[a] Assuming isospin conservation, so that the other third is $\Lambda_c^+ \pi^0 \pi^0$.

## $\Lambda_c(2593)^+$ BRANCHING RATIOS

### $\Gamma(\Sigma_c(2455)^{++}\pi^-)/\Gamma(\Lambda_c^+\pi^+\pi^-)$ $\Gamma_2/\Gamma_1$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **0.36±0.10 OUR AVERAGE** | | | | |
| 0.37±0.12±0.13 | ALBRECHT | 97 | ARG | $e^+e^-$ $\approx$ 10 GeV |
| 0.36±0.09±0.09 | EDWARDS | 95 | CLE2 | $e^+e^-$ $\approx$ 10.5 GeV |

### $\Gamma(\Sigma_c(2455)^0\pi^+)/\Gamma(\Lambda_c^+\pi^+\pi^-)$ $\Gamma_3/\Gamma_1$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **0.37±0.10 OUR AVERAGE** | | | | |
| 0.29±0.10±0.11 | ALBRECHT | 97 | ARG | $e^+e^-$ $\approx$ 10 GeV |
| 0.42±0.09±0.09 | EDWARDS | 95 | CLE2 | $e^+e^-$ $\approx$ 10.5 GeV |

### $[\Gamma(\Sigma_c(2455)^{++}\pi^-) + \Gamma(\Sigma_c(2455)^0\pi^+)]/\Gamma(\Lambda_c^+\pi^+\pi^-)$ $(\Gamma_2+\Gamma_3)/\Gamma_1$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $0.66^{+0.13}_{-0.16}\pm0.07$ | | ALBRECHT | 97 | ARG | $e^+e^-$ $\approx$ 10 GeV |
| >0.51 | 90 | [3] FRABETTI | 96 | E687 | $\gamma$ Be, $\overline{E}_\gamma \approx$ 220 GeV |

[3] The results of FRABETTI 96 are consistent with this ratio being 100%.

### $\Gamma(\Lambda_c^+\pi^0)/\Gamma(\Lambda_c^+\pi^+\pi^-)$ $\Gamma_5/\Gamma_1$

$\Lambda_c^+ \pi^0$ decay is forbidden by isospin conservation if this state is in fact a $\Lambda_c$.

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<3.53** | 90 | EDWARDS | 95 | CLE2 | $e^+e^-$ $\approx$ 10.5 GeV |

$\Gamma(\Lambda_c^+\gamma)/\Gamma(\Lambda_c^+\pi^+\pi^-)$ $\Gamma_6/\Gamma_1$

| *VALUE* | *CL%* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **<0.98** | 90 | EDWARDS | 95 | CLE2 | $e^+e^-\approx$ 10.5 GeV |

## $\Lambda_c(2593)^+$ REFERENCES


| | | | | |
|---|---|---|---|---|
| ALBRECHT | 97 | PL B402 207 | +Hamacher, Hofmann+ | (ARGUS Collab.) |
| FRABETTI | 96 | PL B365 461 | +Cheung, Cumalat+ | (FNAL E687 Collab.) |
| EDWARDS | 95 | PRL 74 3331 | +Ogg, Bellerive, Britton+ | (CLEO Collab.) |