# CHARMED BARYONS
# ($C = +1$)

$\Lambda_c^+ = udc$, $\Sigma_c^{++} = uuc$, $\Sigma_c^+ = udc$, $\Sigma_c^0 = ddc$,
$\Xi_c^+ = usc$, $\Xi_c^0 = dsc$, $\Omega_c^0 = ssc$

## $\Lambda_c^+$

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

$J$ is not well measured; $\frac{1}{2}$ is the quark-model prediction.

Mass $m = 2284.9 \pm 0.6$ MeV
Mean life $\tau = (0.206 \pm 0.012) \times 10^{-12}$ s
$c\tau = 61.8$ $\mu$m

**Decay asymmetry parameters**

| | |
|---|---|
| $\Lambda\pi^+$ | $\alpha = -0.98 \pm 0.19$ |
| $\Sigma^+\pi^0$ | $\alpha = -0.45 \pm 0.32$ |
| $\Lambda\ell^+\nu_\ell$ | $\alpha = -0.82^{+0.11}_{-0.07}$ |

Nearly all branching fractions of the $\Lambda_c^+$ are measured relative to the $pK^-\pi^+$ mode, but there are no model-independent measurements of this branching fraction. We explain how we arrive at our value of B($\Lambda_c^+ \to pK^-\pi^+$) in a Note at the beginning of the branching-ratio measurements in the Listings. When this branching fraction is eventually well determined, all the other branching fractions will slide up or down proportionally as the true value differs from the value we use here.

| $\Lambda_c^+$ DECAY MODES | | Fraction ($\Gamma_i/\Gamma$) | Scale factor/ Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|---|
| **Hadronic modes with a $p$ and one $\overline{K}$** | | | | |
| $p\overline{K}^0$ | | | ( 2.3 ± 0.6 ) % | 872 |
| $pK^-\pi^+$ | [$l$] | | ( 5.0 ± 1.3 ) % | 822 |
| $p\overline{K}^*(892)^0$ | [$m$] | | ( 1.6 ± 0.5 ) % | 681 |
| $\Delta(1232)^{++}K^-$ | | | ( 8.6 ± 3.0 ) $\times 10^{-3}$ | 709 |
| $\Lambda(1520)\pi^+$ | [$m$] | | ( 5.9 ± 2.1 ) $\times 10^{-3}$ | 626 |
| $pK^-\pi^+$ nonresonant | | | ( 2.8 ± 0.8 ) % | 822 |
| $p\overline{K}^0\pi^0$ | | | ( 3.3 ± 1.0 ) % | 822 |
| $p\overline{K}^0\eta$ | | | ( 1.2 ± 0.4 ) % | 567 |

| | | | | |
|---|---|---|---|---|
| $p\overline{K}^0\pi^+\pi^-$ | | ( 2.6 ± 0.7 ) % | | 753 |
| $pK^-\pi^+\pi^0$ | | ( 3.4 ± 1.0 ) % | | 758 |
| $pK^*(892)^-\pi^+$ | [m] | ( 1.1 ± 0.5 ) % | | 579 |
| $p(K^-\pi^+)_{\text{nonresonant}}\pi^0$ | | ( 3.6 ± 1.2 ) % | | 758 |
| $\Delta(1232)\overline{K}^*(892)$ | | seen | | 416 |
| $pK^-\pi^+\pi^+\pi^-$ | | ( 1.1 ± 0.8 ) $\times 10^{-3}$ | | 670 |
| $pK^-\pi^+\pi^0\pi^0$ | | ( 8 ± 4 ) $\times 10^{-3}$ | | 676 |
| $pK^-\pi^+\pi^0\pi^0\pi^0$ | | ( 5.0 ± 3.4 ) $\times 10^{-3}$ | | 573 |

## Hadronic modes with a $p$ and zero or two $K$'s

| | | | | |
|---|---|---|---|---|
| $p\pi^+\pi^-$ | | ( 3.5 ± 2.0 ) $\times 10^{-3}$ | | 926 |
| $pf_0(980)$ | [m] | ( 2.8 ± 1.9 ) $\times 10^{-3}$ | | 621 |
| $p\pi^+\pi^+\pi^-\pi^-$ | | ( 1.8 ± 1.2 ) $\times 10^{-3}$ | | 851 |
| $pK^+K^-$ | | ( 2.3 ± 0.9 ) $\times 10^{-3}$ | | 615 |
| $p\phi$ | [m] | ( 1.2 ± 0.5 ) $\times 10^{-3}$ | | 589 |

## Hadronic modes with a hyperon

| | | | | |
|---|---|---|---|---|
| $\Lambda\pi^+$ | | ( 9.0 ± 2.8 ) $\times 10^{-3}$ | | 863 |
| $\Lambda\pi^+\pi^0$ | | ( 3.6 ± 1.3 ) % | | 843 |
| $\Lambda\rho^+$ | | < 5 % | CL=95% | 638 |
| $\Lambda\pi^+\pi^+\pi^-$ | | ( 3.3 ± 1.0 ) % | | 806 |
| $\Lambda\pi^+\eta$ | | ( 1.8 ± 0.6 ) % | | 690 |
| $\Sigma(1385)^+\eta$ | [m] | ( 8.5 ± 3.3 ) $\times 10^{-3}$ | | 569 |
| $\Lambda K^+\overline{K}^0$ | | ( 6.0 ± 2.1 ) $\times 10^{-3}$ | | 441 |
| $\Sigma^0\pi^+$ | | ( 9.9 ± 3.2 ) $\times 10^{-3}$ | | 824 |
| $\Sigma^+\pi^0$ | | ( 1.00± 0.34) % | | 826 |
| $\Sigma^+\eta$ | | ( 5.5 ± 2.3 ) $\times 10^{-3}$ | | 712 |
| $\Sigma^+\pi^+\pi^-$ | | ( 3.4 ± 1.0 ) % | | 803 |
| $\Sigma^+\rho^0$ | | < 1.4 % | CL=95% | 578 |
| $\Sigma^-\pi^+\pi^+$ | | ( 1.8 ± 0.8 ) % | | 798 |
| $\Sigma^0\pi^+\pi^0$ | | ( 1.8 ± 0.8 ) % | | 802 |
| $\Sigma^0\pi^+\pi^+\pi^-$ | | ( 1.1 ± 0.4 ) % | | 762 |
| $\Sigma^+\pi^+\pi^-\pi^0$ | | — | | 766 |
| $\Sigma^+\omega$ | [m] | ( 2.7 ± 1.0 ) % | | 568 |
| $\Sigma^+\pi^+\pi^+\pi^-\pi^-$ | | ( 3.0 $^{+\ 4.1}_{-\ 2.1}$ ) $\times 10^{-3}$ | | 707 |
| $\Sigma^+K^+K^-$ | | ( 3.5 ± 1.2 ) $\times 10^{-3}$ | | 346 |
| $\Sigma^+\phi$ | [m] | ( 3.5 ± 1.7 ) $\times 10^{-3}$ | | 292 |
| $\Sigma^+K^+\pi^-$ | | ( 7 $^{+\ 6}_{-\ 4}$ ) $\times 10^{-3}$ | | 668 |
| $\Xi^0K^+$ | | ( 3.9 ± 1.4 ) $\times 10^{-3}$ | | 652 |
| $\Xi^-K^+\pi^+$ | | ( 4.9 ± 1.7 ) $\times 10^{-3}$ | | 564 |
| $\Xi(1530)^0K^+$ | [m] | ( 2.6 ± 1.0 ) $\times 10^{-3}$ | | 471 |

**Semileptonic modes**

| | | | | |
|---|---|---|---|---|
| $\Lambda\ell^+\nu_\ell$ | [n] | ( 2.0 ± 0.6 ) % | | – |
| $\Lambda e^+\nu_e$ | | ( 2.1 ± 0.6 ) % | | 870 |
| $\Lambda\mu^+\nu_\mu$ | | ( 2.0 ± 0.7 ) % | | 866 |

**Inclusive modes**

| | | | | |
|---|---|---|---|---|
| $e^+$ anything | | ( 4.5 ± 1.7 ) % | | – |
| $p e^+$ anything | | ( 1.8 ± 0.9 ) % | | – |
| $p$ anything | | (50 ±16 ) % | | – |
| $p$ anything (no $\Lambda$) | | (12 ±19 ) % | | – |
| $n$ anything | | (50 ±16 ) % | | – |
| $n$ anything (no $\Lambda$) | | (29 ±17 ) % | | – |
| $\Lambda$ anything | | (35 ±11 ) % | S=1.4 | – |
| $\Sigma^\pm$ anything | [o] | (10 ± 5 ) % | | – |

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

| | | | | | |
|---|---|---|---|---|---|
| $p\mu^+\mu^-$ | *C1* | < 3.4 | $\times 10^{-4}$ | CL=90% | 936 |
| $\Sigma^-\mu^+\mu^+$ | *L* | < 7.0 | $\times 10^{-4}$ | CL=90% | 811 |

## $\Lambda_c(2593)^+$

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

The spin-parity follows from the fact that $\Sigma_c(2455)\pi$ decays, with little available phase space, are dominant.

Mass $m = 2593.9 \pm 0.8$ MeV
$m - m_{\Lambda_c^+} = 308.9 \pm 0.6$ MeV (S = 1.1)
Full width $\Gamma = 3.6^{+2.0}_{-1.3}$ MeV

$\Lambda_c^+\pi\pi$ 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 submode seems to dominate.

| $\Lambda_c(2593)^+$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $\Lambda_c^+\pi^+\pi^-$ | [p] ≈ 67 % | 124 |
| $\Sigma_c(2455)^{++}\pi^-$ | 24 ± 7 % | 17 |
| $\Sigma_c(2455)^0\pi^+$ | 24 ± 7 % | 23 |
| $\Lambda_c^+\pi^+\pi^-$ 3-body | 18 ± 10 % | 124 |
| $\Lambda_c^+\pi^0$ | not seen | 261 |
| $\Lambda_c^+\gamma$ | not seen | 290 |

## $\Lambda_c(2625)^+$ $I(J^P) = 0(\frac{3}{2}^-)$

$J^P$ has not been measured; $\frac{3}{2}^-$ is the quark-model prediction.

Mass $m = 2626.6 \pm 0.8$ MeV (S = 1.2)
$m - m_{\Lambda_c^+} = 341.7 \pm 0.6$ MeV (S = 1.6)
Full width $\Gamma < 1.9$ MeV, CL = 90%

$\Lambda_c^+ \pi\pi$ and its submode $\Sigma(2455)\pi$ are the only strong decays allowed to an excited $\Lambda_c^+$ having this mass.

| $\Lambda_c(2625)^+$ DECAY MODES | | Fraction ($\Gamma_i/\Gamma$) | Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|---|
| $\Lambda_c^+ \pi^+ \pi^-$ | [$p$] | $\approx 67\%$ | | 184 |
| $\Sigma_c(2455)^{++}\pi^-$ | | <5 | 90% | 100 |
| $\Sigma_c(2455)^0\pi^+$ | | <5 | 90% | 101 |
| $\Lambda_c^+ \pi^+ \pi^-$ 3-body | | large | | 184 |
| $\Lambda_c^+ \pi^0$ | | not seen | | 293 |
| $\Lambda_c^+ \gamma$ | | not seen | | 319 |

## $\Sigma_c(2455)$ $I(J^P) = 1(\frac{1}{2}^+)$

$J^P$ has not been measured; $\frac{1}{2}^+$ is the quark-model prediction.

$\Sigma_c(2455)^{++}$ mass $m = 2452.8 \pm 0.6$ MeV
$\Sigma_c(2455)^+$ mass $m = 2453.6 \pm 0.9$ MeV
$\Sigma_c(2455)^0$ mass $m = 2452.2 \pm 0.6$ MeV
$m_{\Sigma_c^{++}} - m_{\Lambda_c^+} = 167.87 \pm 0.19$ MeV
$m_{\Sigma_c^+} - m_{\Lambda_c^+} = 168.7 \pm 0.6$ MeV
$m_{\Sigma_c^0} - m_{\Lambda_c^+} = 167.30 \pm 0.20$ MeV
$m_{\Sigma_c^{++}} - m_{\Sigma_c^0} = 0.57 \pm 0.23$ MeV
$m_{\Sigma_c^+} - m_{\Sigma_c^0} = 1.4 \pm 0.6$ MeV

$\Lambda_c^+ \pi$ is the only strong decay allowed to a $\Sigma_c$ having this mass.

| $\Sigma_c(2455)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $\Lambda_c^+ \pi$ | $\approx 100$ % | 90 |

## $\Sigma_c(2520)$

$I(J^P) = 1(\frac{3}{2}^+)$

$J^P$ has not been measured; $\frac{3}{2}^+$ is the quark-model prediction.

$\Sigma_c(2520)^{++}$ mass $m = 2519.4 \pm 1.5$ MeV
$\Sigma_c(2520)^0$ mass $m = 2517.5 \pm 1.4$ MeV
$m_{\Sigma_c(2520)^{++}} - m_{\Lambda_c^+} = 234.5 \pm 1.4$ MeV
$m_{\Sigma_c(2520)^0} - m_{\Lambda_c^+} = 232.6 \pm 1.3$ MeV
$m_{\Sigma_c(2520)^{++}} - m_{\Sigma_c(2520)^0} = 1.9 \pm 1.7$ MeV
$\Sigma_c(2520)^{++}$ full width $\Gamma = 18 \pm 5$ MeV
$\Sigma_c(2520)^0$ full width $\Gamma = 13 \pm 5$ MeV

$\Lambda_c^+ \pi$ is the only strong decay allowed to a $\Sigma_c$ having this mass.

| $\Sigma_c(2520)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $\Lambda_c^+ \pi$ | $\approx 100$ % | 180 |

## $\Xi_c^+$

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

$J^P$ has not been measured; $\frac{1}{2}^+$ is the quark-model prediction.

Mass $m = 2466.3 \pm 1.4$ MeV
Mean life $\tau = (0.33^{+0.06}_{-0.04}) \times 10^{-12}$ s
$c\tau = 98$ $\mu$m

No absolute branching fractions have been measured. The following are branching *ratios* relative to $\Xi^- \pi^+ \pi^+$.

| $\Xi_c^+$ DECAY MODES | | Fraction ($\Gamma_i/\Gamma$) | Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|---|
| $\Lambda K^- \pi^+ \pi^+$ | [$q$] | $0.58 \pm 0.18$ | | 785 |
| $\Lambda \overline{K}^*(892)^0 \pi^+$ | [$m,q$] | $<0.29$ | 90% | 603 |
| $\Sigma(1385)^+ K^- \pi^+$ | [$m,q$] | $<0.41$ | 90% | 677 |
| $\Sigma^+ K^- \pi^+$ | [$q$] | $1.18 \pm 0.31$ | | 809 |
| $\Sigma^+ \overline{K}^*(892)^0$ | [$m,q$] | $0.92 \pm 0.30$ | | 654 |
| $\Sigma^0 K^- \pi^+ \pi^+$ | [$q$] | $0.49 \pm 0.26$ | | 734 |

| | | | | |
|---|---|---|---|---|
| $\Xi^0\pi^+$ | [q] | $0.55\pm0.16$ | | 876 |
| $\Xi^-\pi^+\pi^+$ | [q] | $\equiv 1.0$ | | 850 |
| $\Xi(1530)^0\pi^+$ | [m,q] | $<0.2$ | 90% | 749 |
| $\Xi^0\pi^+\pi^0$ | [q] | $2.34\pm0.68$ | | 855 |
| $\Xi^0\pi^+\pi^+\pi^-$ | [q] | $1.74\pm0.50$ | | 817 |
| $\Xi^0 e^+\nu_e$ | [q] | $2.3\ ^{+0.7}_{-0.9}$ | | 883 |
| $pK^-\pi^+$ | [q] | $0.20\pm0.05$ | | – |

## $\Xi_c^0$

$$I(J^P) = \tfrac{1}{2}(\tfrac{1}{2}^+)$$

$J^P$ has not been measured; $\frac{1}{2}^+$ is the quark-model prediction.

Mass $m = 2471.8 \pm 1.4$ MeV

$m_{\Xi_c^0} - m_{\Xi_c^+} = 5.5 \pm 1.8$ MeV

Mean life $\tau = (0.098^{+0.023}_{-0.015}) \times 10^{-12}$ s

$c\tau = 29\ \mu$m

| $\Xi_c^0$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $\Lambda\overline{K}^0$ | seen | 907 |
| $\Lambda\overline{K}^0\pi^+\pi^-$ | seen | 788 |
| $\Lambda K^-\pi^+\pi^+\pi^-$ | seen | 704 |
| $\Xi^-\pi^+$ | seen | 876 |
| $\Xi^-\pi^+\pi^+\pi^-$ | seen | 817 |
| $pK^-\overline{K}^*(892)^0$ | seen | 408 |
| $\Omega^- K^+$ | seen | 523 |
| $\Xi^- e^+\nu_e$ | seen | 883 |
| $\Xi^-\ell^+$ anything | seen | – |

## $\Xi_c'^+$

$$I(J^P) = \tfrac{1}{2}(\tfrac{1}{2}^+)$$

$J^P$ has not been measured; $\frac{1}{2}^+$ is the quark-model prediction.

Mass $m = 2574.1 \pm 3.3$ MeV

$m_{\Xi_c'^+} - m_{\Xi_c^+} = 107.8 \pm 3.0$ MeV

The $\Xi_c'^+$–$\Xi_c^+$ mass difference is too small for any strong decay to occur.

| $\Xi_c'^+$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $\Xi_c^+\gamma$ | seen | 106 |

## $\Xi_c'^0$

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

$J^P$ has not been measured; $\frac{1}{2}^+$ is the quark-model prediction.

Mass $m = 2578.8 \pm 3.2$ MeV
$m_{\Xi_c'^0} - m_{\Xi_c^0} = 107.0 \pm 2.9$ MeV

The $\Xi_c'^0 - \Xi_c^0$ mass difference is too small for any strong decay to occur.

| $\Xi_c'^0$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $\Xi_c^0\gamma$ | seen | 105 |

## $\Xi_c(2645)$

$I(J^P) = \frac{1}{2}(\frac{3}{2}^+)$

$J^P$ has not been measured; $\frac{3}{2}^+$ is the quark-model prediction.

$\Xi_c(2645)^+$ mass $m = 2647.4 \pm 2.0$ MeV (S = 1.2)
$\Xi_c(2645)^0$ mass $m = 2644.5 \pm 1.8$ MeV
$m_{\Xi_c(2645)^+} - m_{\Xi_c^0} = 175.6 \pm 1.4$ MeV (S = 1.7)
$m_{\Xi_c(2645)^0} - m_{\Xi_c^+} = 178.2 \pm 1.1$ MeV
$\Xi_c(2645)^+$ full width $\Gamma < 3.1$ MeV, CL = 90%
$\Xi_c(2645)^0$ full width $\Gamma < 5.5$ MeV, CL = 90%

$\Xi_c\pi$ is the only strong decay allowed to a $\Xi_c$ resonance having this mass.

| $\Xi_c(2645)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $\Xi_c^0\pi^+$ | seen | 103 |
| $\Xi_c^+\pi^-$ | seen | 107 |

## $\Xi_c(2815)$

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

$J^P$ has not been measured; $\frac{3}{2}^-$ is the quark-model prediction.

$\Xi_c(2815)^+$ mass $m = 2814.9 \pm 1.8$ MeV
$\Xi_c(2815)^0$ mass $m = 2819.0 \pm 2.5$ MeV
$m_{\Xi_c(2815)^+} - m_{\Xi_c^+} = 348.6 \pm 1.2$ MeV
$m_{\Xi_c(2815)^0} - m_{\Xi_c^0} = 347.2 \pm 2.1$ MeV
$\Xi_c(2815)^+$ full width $\Gamma < 3.5$ MeV, CL = 90%
$\Xi_c(2815)^0$ full width $\Gamma < 6.5$ MeV, CL = 90%

The $\Xi_c\,\pi\,\pi$ modes are consistent with being entirely via $\Xi_c(2645)\,\pi$.

| $\Xi_c(2815)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $\Xi_c^+\,\pi^+\,\pi^-$ | seen | 196 |
| $\Xi_c^0\,\pi^+\,\pi^-$ | seen | 193 |

## $\Omega_c^0$

$$I(J^P) = 0(\tfrac{1}{2}^+)$$

$J^P$ has not been measured; $\frac{1}{2}^+$ is the quark-model prediction.

Mass $m = 2704 \pm 4$ MeV (S = 1.8)
Mean life $\tau = (0.064 \pm 0.020) \times 10^{-12}$ s
$c\tau = 19\ \mu$m

| $\Omega_c^0$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $\Sigma^+\,K^-\,K^-\,\pi^+$ | seen | 697 |
| $\Xi^-\,K^-\,\pi^+\,\pi^+$ | seen | 838 |
| $\Omega^-\,\pi^+$ | seen | 827 |
| $\Omega^-\,\pi^-\,\pi^+\,\pi^+$ | seen | 759 |