# Σ BARYONS
# $(S = -1, I = 1)$

$\Sigma^+ = uus, \quad \Sigma^0 = uds, \quad \Sigma^- = dds$

## $\Sigma^+$

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

Mass $m = 1189.37 \pm 0.07$ MeV   $(S = 2.2)$

Mean life $\tau = (0.8018 \pm 0.0026) \times 10^{-10}$ s

$\quad c\tau = 2.404$ cm

$(\tau_{\Sigma^+} - \tau_{\overline{\Sigma}^-}) / \tau_{\Sigma^+} = -0.0006 \pm 0.0012$

Magnetic moment $\mu = 2.458 \pm 0.010 \ \mu_N$   $(S = 2.1)$

$(\mu_{\Sigma^+} + \mu_{\overline{\Sigma}^-}) / \mu_{\Sigma^+} = 0.014 \pm 0.015$

$\Gamma(\Sigma^+ \to n\ell^+ \nu)/\Gamma(\Sigma^- \to n\ell^- \overline{\nu}) < 0.043$

### Decay parameters

| | |
|---|---|
| $p\pi^0$ | $\alpha_0 = -0.980^{+0.017}_{-0.015}$ |
| " | $\phi_0 = (36 \pm 34)°$ |
| " | $\gamma_0 = 0.16$ [a] |
| " | $\Delta_0 = (187 \pm 6)°$ [a] |
| $n\pi^+$ | $\alpha_+ = 0.068 \pm 0.013$ |
| " | $\phi_+ = (167 \pm 20)°$   $(S = 1.1)$ |
| " | $\gamma_+ = -0.97$ [a] |
| " | $\Delta_+ = (-73^{+133}_{-10})°$ [a] |
| $p\gamma$ | $\alpha_\gamma = -0.76 \pm 0.08$ |

| $\Sigma^+$ DECAY MODES | | Fraction $(\Gamma_i/\Gamma)$ | Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|---|
| $p\pi^0$ | | $(51.57 \pm 0.30)$ % | | 189 |
| $n\pi^+$ | | $(48.31 \pm 0.30)$ % | | 185 |
| $p\gamma$ | | $(1.23 \pm 0.05) \times 10^{-3}$ | | 225 |
| $n\pi^+ \gamma$ | [b] | $(4.5 \pm 0.5) \times 10^{-4}$ | | 185 |
| $\Lambda e^+ \nu_e$ | | $(2.0 \pm 0.5) \times 10^{-5}$ | | 71 |

### $\Delta S = \Delta Q$ ($SQ$) violating modes or $\Delta S = 1$ weak neutral current ($S1$) modes

| | | Fraction $(\Gamma_i/\Gamma)$ | | Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|---|---|
| $n e^+ \nu_e$ | $SQ$ | $< 5$ | $\times 10^{-6}$ | 90% | 224 |
| $n \mu^+ \nu_\mu$ | $SQ$ | $< 3.0$ | $\times 10^{-5}$ | 90% | 202 |
| $p e^+ e^-$ | $S1$ | $< 7$ | $\times 10^{-6}$ | | 225 |
| $p \mu^+ \mu^-$ | $S1$ | $(9^{+9}_{-8}) \times 10^{-8}$ | | | 121 |

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

Mass $m = 1192.642 \pm 0.024$ MeV
$m_{\Sigma^-} - m_{\Sigma^0} = 4.807 \pm 0.035$ MeV   (S = 1.1)
$m_{\Sigma^0} - m_\Lambda = 76.959 \pm 0.023$ MeV
Mean life $\tau = (7.4 \pm 0.7) \times 10^{-20}$ s
$\quad c\tau = 2.22 \times 10^{-11}$ m
Transition magnetic moment $\left|\mu_{\Sigma\Lambda}\right| = 1.61 \pm 0.08\ \mu_N$

| $\Sigma^0$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | Confidence level | $p$ (MeV/c) |
|---|---|---|---|
| $\Lambda\gamma$ | 100 % | | 74 |
| $\Lambda\gamma\gamma$ | < 3 % | 90% | 74 |
| $\Lambda e^+ e^-$ | [c]  $5 \times 10^{-3}$ | | 74 |

$\boxed{\Sigma^-}$ $\qquad\qquad I(J^P) = 1(\frac{1}{2}^+)$

Mass $m = 1197.449 \pm 0.030$ MeV   (S = 1.2)
$m_{\Sigma^-} - m_{\Sigma^+} = 8.08 \pm 0.08$ MeV   (S = 1.9)
$m_{\Sigma^-} - m_\Lambda = 81.766 \pm 0.030$ MeV   (S = 1.2)
Mean life $\tau = (1.479 \pm 0.011) \times 10^{-10}$ s   (S = 1.3)
$\quad c\tau = 4.434$ cm
Magnetic moment $\mu = -1.160 \pm 0.025\ \mu_N$   (S = 1.7)
$\Sigma^-$ charge radius $= 0.78 \pm 0.10$ fm

### Decay parameters

| | |
|---|---|
| $n\pi^-$ | $\alpha_- = -0.068 \pm 0.008$ |
| " | $\phi_- = (10 \pm 15)^\circ$ |
| " | $\gamma_- = 0.98$ [a] |
| " | $\Delta_- = (249^{+12}_{-120})^\circ$ [a] |
| $ne^-\overline{\nu}_e$ | $g_A/g_V = 0.340 \pm 0.017$ [d] |
| " | $f_2(0)/f_1(0) = 0.97 \pm 0.14$ |
| " | $D = 0.11 \pm 0.10$ |
| $\Lambda e^-\overline{\nu}_e$ | $g_V/g_A = 0.01 \pm 0.10$ [d]   (S = 1.5) |
| " | $g_{WM}/g_A = 2.4 \pm 1.7$ [d] |

| $\Sigma^-$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/c) |
|---|---|---|
| $n\pi^-$ | $(99.848 \pm 0.005)$ % | 193 |
| $n\pi^-\gamma$ | [b] $(\ 4.6\ \pm 0.6\ ) \times 10^{-4}$ | 193 |
| $ne^-\overline{\nu}_e$ | $(\ 1.017 \pm 0.034) \times 10^{-3}$ | 230 |
| $n\mu^-\overline{\nu}_\mu$ | $(\ 4.5\ \pm 0.4\ ) \times 10^{-4}$ | 210 |
| $\Lambda e^-\overline{\nu}_e$ | $(\ 5.73\ \pm 0.27\ ) \times 10^{-5}$ | 79 |

## $\Sigma(1385)\ 3/2^+$  $\qquad\qquad I(J^P) = 1(\frac{3}{2}^+)$

$\Sigma(1385)^+$ mass $m = 1382.80 \pm 0.35$ MeV  (S = 1.9)
$\Sigma(1385)^0$ mass $m = 1383.7 \pm 1.0$ MeV  (S = 1.4)
$\Sigma(1385)^-$ mass $m = 1387.2 \pm 0.5$ MeV  (S = 2.2)
$\Sigma(1385)^+$ full width $\Gamma = 36.0 \pm 0.7$ MeV
$\Sigma(1385)^0$ full width $\Gamma = 36 \pm 5$ MeV
$\Sigma(1385)^-$ full width $\Gamma = 39.4 \pm 2.1$ MeV  (S = 1.7)
Below $\overline{K}N$ threshold

| $\Sigma(1385)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | Confidence level | $p$ (MeV/$c$) |
|---|---|---|---|
| $\Lambda\pi$ | $(87.0 \pm 1.5)$ % | | 208 |
| $\Sigma\pi$ | $(11.7 \pm 1.5)$ % | | 129 |
| $\Lambda\gamma$ | $(1.25^{+0.13}_{-0.12})$ % | | 241 |
| $\Sigma^+\gamma$ | $(7.0 \pm 1.7) \times 10^{-3}$ | | 180 |
| $\Sigma^-\gamma$ | $< 2.4 \times 10^{-4}$ | 90% | 173 |

## $\Sigma(1660)\ 1/2^+$  $\qquad\qquad I(J^P) = 1(\frac{1}{2}^+)$

Mass $m = 1630$ to $1690$ ($\approx 1660$) MeV
Full width $\Gamma = 40$ to $200$ ($\approx 100$) MeV

| $\Sigma(1660)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $N\overline{K}$ | 10–30 % | 405 |
| $\Lambda\pi$ | seen | 440 |
| $\Sigma\pi$ | seen | 387 |

## $\Sigma(1670)\ 3/2^-$  $\qquad\qquad I(J^P) = 1(\frac{3}{2}^-)$

Mass $m = 1665$ to $1685$ ($\approx 1670$) MeV
Full width $\Gamma = 40$ to $80$ ($\approx 60$) MeV

| $\Sigma(1670)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $N\overline{K}$ | 7–13 % | 414 |
| $\Lambda\pi$ | 5–15 % | 448 |
| $\Sigma\pi$ | 30–60 % | 394 |

## $\boxed{\Sigma(1750)\ 1/2^-}$  $\qquad I(J^P) = 1(\frac{1}{2}^-)$

Mass $m = 1730$ to $1800$ ($\approx 1750$) MeV
Full width $\Gamma = 60$ to $160$ ($\approx 90$) MeV

| $\Sigma(1750)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $N\overline{K}$ | 10–40 % | 486 |
| $\Lambda\pi$ | seen | 507 |
| $\Sigma\pi$ | <8 % | 456 |
| $\Sigma\eta$ | 15–55 % | 98 |
| $N\overline{K}^*(892)$, S=1/2 | $(8\pm4)$ % | † |

## $\boxed{\Sigma(1775)\ 5/2^-}$  $\qquad I(J^P) = 1(\frac{5}{2}^-)$

Mass $m = 1770$ to $1780$ ($\approx 1775$) MeV
Full width $\Gamma = 105$ to $135$ ($\approx 120$) MeV

| $\Sigma(1775)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $N\overline{K}$ | 37–43% | 508 |
| $\Lambda\pi$ | 14–20% | 525 |
| $\Sigma\pi$ | 2–5% | 475 |
| $\Sigma(1385)\pi$ | 8–12% | 327 |
| $\Lambda(1520)\pi$, $P$-wave | 17–23% | 201 |

## $\boxed{\Sigma(1915)\ 5/2^+}$  $\qquad I(J^P) = 1(\frac{5}{2}^+)$

Mass $m = 1900$ to $1935$ ($\approx 1915$) MeV
Full width $\Gamma = 80$ to $160$ ($\approx 120$) MeV

| $\Sigma(1915)$ DECAY MODES | Fraction ($\Gamma_i/\Gamma$) | $p$ (MeV/$c$) |
|---|---|---|
| $N\overline{K}$ | 5–15 % | 618 |
| $\Lambda\pi$ | seen | 623 |
| $\Sigma\pi$ | seen | 577 |
| $\Sigma(1385)\pi$ | <5 % | 443 |

## $\Sigma(1940)\ 3/2^-$ $\qquad\qquad I(J^P) = 1(\frac{3}{2}^-)$

Mass $m = 1900$ to $1950$ ($\approx 1940$) MeV
Full width $\Gamma = 150$ to $300$ ($\approx 220$) MeV

| $\Sigma(1940)$ DECAY MODES | Fraction $(\Gamma_i/\Gamma)$ | $p$ (MeV/$c$) |
|---|---|---|
| $N\overline{K}$ | <20 % | 637 |
| $\Lambda\pi$ | seen | 640 |
| $\Sigma\pi$ | seen | 595 |
| $\Sigma(1385)\pi$ | seen | 463 |
| $\Lambda(1520)\pi$ | seen | 355 |
| $\Delta(1232)\overline{K}$ | seen | 410 |
| $N\overline{K}{}^*(892)$ | seen | 322 |

## $\Sigma(2030)\ 7/2^+$ $\qquad\qquad I(J^P) = 1(\frac{7}{2}^+)$

Mass $m = 2025$ to $2040$ ($\approx 2030$) MeV
Full width $\Gamma = 150$ to $200$ ($\approx 180$) MeV

| $\Sigma(2030)$ DECAY MODES | Fraction $(\Gamma_i/\Gamma)$ | $p$ (MeV/$c$) |
|---|---|---|
| $N\overline{K}$ | 17–23 % | 702 |
| $\Lambda\pi$ | 17–23 % | 700 |
| $\Sigma\pi$ | 5–10 % | 657 |
| $\Xi K$ | <2 % | 422 |
| $\Sigma(1385)\pi$ | 5–15 % | 532 |
| $\Lambda(1520)\pi$ | 10–20 % | 430 |
| $\Delta(1232)\overline{K}$ | 10–20 % | 498 |
| $N\overline{K}{}^*(892)$ | <5 % | 439 |

## $\Sigma(2250)$ $\qquad\qquad I(J^P) = 1(?^?)$

Mass $m = 2210$ to $2280$ ($\approx 2250$) MeV
Full width $\Gamma = 60$ to $150$ ($\approx 100$) MeV

| $\Sigma(2250)$ DECAY MODES | Fraction $(\Gamma_i/\Gamma)$ | $p$ (MeV/$c$) |
|---|---|---|
| $N\overline{K}$ | <10 % | 851 |
| $\Lambda\pi$ | seen | 842 |
| $\Sigma\pi$ | seen | 803 |

## NOTES

[a] The decay parameters $\gamma$ and $\Delta$ are calculated from $\alpha$ and $\phi$ using

$$\gamma = \sqrt{1-\alpha^2} \, \cos\phi \,, \qquad\qquad \tan\Delta = -\frac{1}{\alpha} \, \sqrt{1-\alpha^2} \, \sin\phi \,.$$

See the "Note on Baryon Decay Parameters" in the neutron Particle Listings.

[b] See the Listings for the pion momentum range used in this measurement.

[c] A theoretical value using QED.

[d] The parameters $g_A$, $g_V$, and $g_{WM}$ for semileptonic modes are defined by $\overline{B}_f[\gamma_\lambda(g_V + g_A\gamma_5) + i(g_{WM}/m_{B_i}) \, \sigma_{\lambda\nu} \, q^\nu]B_i$, and $\phi_{AV}$ is defined by $g_A/g_V = |g_A/g_V|e^{i\phi_{AV}}$. See the "Note on Baryon Decay Parameters" in the neutron Particle Listings.