

# Σ BARYONS

## (S = -1, I = 1)

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

Σ<sup>+</sup>

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

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

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

$c\tau = 2.404$  cm

$(\tau_{\Sigma^+} - \tau_{\Sigma^-}) / \tau_{\Sigma^+} = (-0.6 \pm 1.2) \times 10^{-3}$

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

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

### Decay parameters

$p\pi^0$        $\alpha_0 = -0.980^{+0.017}_{-0.015}$

"       $\phi_0 = (36 \pm 34)^\circ$

"       $\gamma_0 = 0.16$  [a]

"       $\Delta_0 = (187 \pm 6)^\circ$  [a]

$n\pi^+$        $\alpha_+ = 0.068 \pm 0.013$

"       $\phi_+ = (167 \pm 20)^\circ$  (S = 1.1)

"       $\gamma_+ = -0.97$  [a]

"       $\Delta_+ = (-73^{+133}_{-10})^\circ$  [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**

$ne^+\nu_e$	SQ	$< 5$	$\times 10^{-6}$	90%	224
$n\mu^+\nu_\mu$	SQ	$< 3.0$	$\times 10^{-5}$	90%	202
$pe^+e^-$	S1	$< 7$	$\times 10^{-6}$		225
$p\mu^+\mu^-$	S1	$(9 \pm 9)$	$\times 10^{-8}$		121

**$\Sigma^0$**

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

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

$c\tau = 2.22 \times 10^{-11}$  m

Transition magnetic moment  $|\mu_{\Sigma\Lambda}| = 1.61 \pm 0.08 \mu_N$

$\Sigma^0$ 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

**$\Sigma^-$**

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

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)

$c\tau = 4.434$  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]
"	$\Delta_- = (249_{-120}^{+12})^\circ$ [a]
$ne^- \bar{\nu}_e$	$g_A/g_V = 0.340 \pm 0.017$ [d]
"	$f_2(0)/f_1(0) = 0.97 \pm 0.14$
"	$D = 0.11 \pm 0.10$
$\Lambda e^- \bar{\nu}_e$	$g_V/g_A = 0.01 \pm 0.10$ [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
$ne^- \bar{\nu}_e$	$(1.017 \pm 0.034) \times 10^{-3}$	230
$n\mu^- \bar{\nu}_\mu$	$(4.5 \pm 0.4) \times 10^{-4}$	210
$\Lambda e^- \bar{\nu}_e$	$(5.73 \pm 0.27) \times 10^{-5}$	79

### $\Sigma(1385) P_{13}$

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

- $\Sigma(1385)^+$  mass  $m = 1382.8 \pm 0.4$  MeV (S = 2.0)
  - $\Sigma(1385)^0$  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  $\Gamma = 35.8 \pm 0.8$  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  $\bar{K}N$  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
$\Lambda\gamma$	$(1.3 \pm 0.4) \%$		241
$\Sigma^- \gamma$	$< 2.4 \times 10^{-4}$	90%	173

### $\Sigma(1660) P_{11}$

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

- Mass  $m = 1630$  to  $1690$  ( $\approx 1660$ ) MeV
- Full width  $\Gamma = 40$  to  $200$  ( $\approx 100$ ) MeV
- $p_{\text{beam}} = 0.72$  GeV/c  $4\pi\lambda^2 = 29.9$  mb

<b><math>\Sigma(1660)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\bar{K}$	10–30 %	405
$\Lambda\pi$	seen	440
$\Sigma\pi$	seen	387

**$\Sigma(1670) D_{13}$**

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

Mass  $m = 1665$  to  $1685$  ( $\approx 1670$ ) MeV

Full width  $\Gamma = 40$  to  $80$  ( $\approx 60$ ) MeV

$$p_{\text{beam}} = 0.74 \text{ GeV}/c \quad 4\pi\lambda^2 = 28.5 \text{ mb}$$

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

**$\Sigma(1750) S_{11}$**

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

Mass  $m = 1730$  to  $1800$  ( $\approx 1750$ ) MeV

Full width  $\Gamma = 60$  to  $160$  ( $\approx 90$ ) MeV

$$p_{\text{beam}} = 0.91 \text{ GeV}/c \quad 4\pi\lambda^2 = 20.7 \text{ mb}$$

<b><math>\Sigma(1750)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\bar{K}$	10–40 %	486
$\Lambda\pi$	seen	507
$\Sigma\pi$	<8 %	456
$\Sigma\eta$	15–55 %	98

**$\Sigma(1775) D_{15}$**

$$I(J^P) = 1\left(\frac{5}{2}^-\right)$$

Mass  $m = 1770$  to  $1780$  ( $\approx 1775$ ) MeV

Full width  $\Gamma = 105$  to  $135$  ( $\approx 120$ ) MeV

$$p_{\text{beam}} = 0.96 \text{ GeV}/c \quad 4\pi\lambda^2 = 19.0 \text{ mb}$$

<b><math>\Sigma(1775)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\bar{K}$	37–43%	508
$\Lambda\pi$	14–20%	525
$\Sigma\pi$	2–5%	475
$\Sigma(1385)\pi$	8–12%	327
$\Lambda(1520)\pi$	17–23%	201

### **$\Sigma(1915) F_{15}$**

$$I(J^P) = 1(\frac{5}{2}^+)$$

Mass  $m = 1900$  to  $1935$  ( $\approx 1915$ ) MeV

Full width  $\Gamma = 80$  to  $160$  ( $\approx 120$ ) MeV

$$p_{\text{beam}} = 1.26 \text{ GeV}/c \quad 4\pi\chi^2 = 12.8 \text{ mb}$$

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

### **$\Sigma(1940) D_{13}$**

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

Mass  $m = 1900$  to  $1950$  ( $\approx 1940$ ) MeV

Full width  $\Gamma = 150$  to  $300$  ( $\approx 220$ ) MeV

$$p_{\text{beam}} = 1.32 \text{ GeV}/c \quad 4\pi\chi^2 = 12.1 \text{ mb}$$

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

### **$\Sigma(2030) F_{17}$**

$$I(J^P) = 1(\frac{7}{2}^+)$$

Mass  $m = 2025$  to  $2040$  ( $\approx 2030$ ) MeV

Full width  $\Gamma = 150$  to  $200$  ( $\approx 180$ ) MeV

$$p_{\text{beam}} = 1.52 \text{ GeV}/c \quad 4\pi\chi^2 = 9.93 \text{ mb}$$

$\Sigma(2030)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\bar{K}$	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
$\Delta(1232)\bar{K}$	10–20 %	498
$N\bar{K}^*(892)$	<5 %	439

## $\Sigma(2250)$

$$I(J^P) = 1(?^?)$$

Mass  $m = 2210$  to  $2280$  ( $\approx 2250$ ) MeV

Full width  $\Gamma = 60$  to  $150$  ( $\approx 100$ ) MeV

$$p_{\text{beam}} = 2.04 \text{ GeV}/c \quad 4\pi\bar{\lambda}^2 = 6.76 \text{ mb}$$

$\Sigma(2250)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\bar{K}$	<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

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

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  $\bar{B}_f[\gamma_\lambda(g_V + g_A\gamma_5) + i(g_{WM}/m_{B_i})\sigma_{\lambda\nu}q^\nu]B_i$ , 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.