

# 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

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

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

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

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

### 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]

$p\gamma$        $\alpha_\gamma = -0.76 \pm 0.08$

Σ <sup>+</sup> DECAY MODES	Fraction (Γ <sub>i</sub> /Γ)	Confidence level	<sup>p</sup> (MeV/c)
$p\pi^0$	(51.57 ± 0.30) %		189
$n\pi^+$	(48.31 ± 0.30) %		185
$p\gamma$	( 1.23 ± 0.05 ) × 10 <sup>-3</sup>		225
$n\pi^+\gamma$	[b] ( 4.5 ± 0.5 ) × 10 <sup>-4</sup>		185
$\Lambda e^+\nu_e$	( 2.0 ± 0.5 ) × 10 <sup>-5</sup>		71

### ΔS = ΔQ (SQ) violating modes or ΔS = 1 weak neutral current (S1) modes

$ne^+\nu_e$	SQ	< 5	× 10 <sup>-6</sup>	90%	224
$n\mu^+\nu_\mu$	SQ	< 3.0	× 10 <sup>-5</sup>	90%	202
$pe^+e^-$	S1	< 7	× 10 <sup>-6</sup>		225
$p\mu^+\mu^-$	S1	( 2.4 <sup>+1.7</sup> <sub>-1.3</sub> )	× 10 <sup>-8</sup>		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) $m_{\Sigma^0} - m_{\Lambda} = 76.959 \pm 0.023$  MeVMean life  $\tau = (7.4 \pm 0.7) \times 10^{-20}$  s $c\tau = 2.22 \times 10^{-11}$  mTransition 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) $c\tau = 4.434$  cmMagnetic 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

**$\Sigma(1385) 3/2^+$**

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

$\Sigma(1385)^+$  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  $\bar{K}N$  threshold

<b><math>\Sigma(1385)</math> DECAY MODES</b>	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 <sup>+0.13</sup> <sub>-0.12</sub> ) %		241
$\Sigma^+\gamma$	( 7.0 $\pm$ 1.7 ) $\times 10^{-3}$		180
$\Sigma^-\gamma$	< 2.4 $\times 10^{-4}$	90%	173

**$\Sigma(1660) 1/2^+$**

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

Re(pole position) = 1585  $\pm$  20 MeV  
 $-2\text{Im}(\text{pole position}) = 290^{+140}_{-40}$  MeV  
 Mass  $m = 1640$  to 1680 ( $\approx 1660$ ) MeV  
 Full width  $\Gamma = 100$  to 300 ( $\approx 200$ ) MeV

<b><math>\Sigma(1660)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\bar{K}$	0.05 to 0.15 ( $\approx 010$ )	405
$\Lambda\pi$	(35 $\pm$ 12 ) %	440
$\Sigma\pi$	(37 $\pm$ 10 ) %	387
$\Sigma\sigma$	(20 $\pm$ 8 ) %	—
$\Lambda(1405)\pi$	( 4.0 $\pm$ 2.0 ) %	199

**$\Sigma(1670) 3/2^-$** 

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

Mass  $m = 1665$  to  $1685$  ( $\approx 1675$ ) MeVFull width  $\Gamma = 40$  to  $100$  ( $\approx 70$ ) MeV

<b><math>\Sigma(1670)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\bar{K}$	0.06 to 0.12	419
$\Lambda\pi$	5–15 %	452
$\Sigma\pi$	30–60 %	398
$\Sigma\sigma$	(7.0 $\pm$ 3.0) %	–

 **$\Sigma(1750) 1/2^-$** 

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

Mass  $m = 1700$  to  $1800$  ( $\approx 1750$ ) MeVFull width  $\Gamma = 100$  to  $200$  ( $\approx 150$ ) MeV

<b><math>\Sigma(1750)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\bar{K}$	0.06 to 0.12	486
$\Lambda\pi$	(14 $\pm$ 5) %	507
$\Sigma\pi$	(16 $\pm$ 4) %	456
$\Sigma\eta$	15–55 %	98
$\Sigma(1385)\pi$ , $D$ -wave	< 1 %	305
$\Lambda(1520)\pi$	(2.0 $\pm$ 1.0) %	175
$N\bar{K}^*(892)$ , $S=1/2$	(8 $\pm$ 4) %	†

 **$\Sigma(1775) 5/2^-$** 

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

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

<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
$\Lambda(1520)\pi$ , $P$ -wave	17–23%	202

**$\Sigma(1910) 3/2^-$** 

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

was  $\Sigma(1940)$ Full width  $\Gamma = 0.03 \pm 0.02$ Full width  $\Gamma = 0.16 \pm 0.04$ Full width  $\Gamma = 0.04 \pm 0.03$ Full width  $\Gamma = 0.01 \pm 0.01$ Full width  $\Gamma = 0.01 \pm 0.01$ Full width  $\Gamma = 0.03 \pm 0.01$ Full width  $\Gamma = 0.03 \pm 0.02$ Full width  $\Gamma = 0.02 \pm 0.01$ Full width  $\Gamma = 0.01 \pm 0.01$ Mass  $m = 1870$  to  $1950$  ( $\approx 1910$ ) MeVFull width  $\Gamma = 150$  to  $300$  ( $\approx 220$ ) MeV

<b><math>\Sigma(1910)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\bar{K}$	0.01 to 0.05 ( $\approx 0.02$ )	615
$\Lambda\pi$	( 6 $\pm$ 4 ) %	619
$\Sigma\pi$	(86 $\pm$ 21 ) %	574
$\Sigma(1385)\pi$	seen	439
$\Lambda(1520)\pi$	seen	329
$\Delta(1232)\bar{K}$	( 3.0 $\pm$ 1.0 ) %	377
$N\bar{K}^*(892)$	seen	274
$N\bar{K}^*(892)$ , $S=1/2$ , $D$ -wave	( 1.0 $\pm$ 1.0 ) %	274

 **$\Sigma(1915) 5/2^+$** 

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

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

<b><math>\Sigma(1915)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\bar{K}$	0.05 to 0.15	618
$\Lambda\pi$	( 6.0 $\pm$ 2.0 ) %	623
$\Sigma\pi$	(10.0 $\pm$ 2.0 ) %	577
$\Sigma(1385)\pi$ , $P$ -wave	( 2.0 $\pm$ 2.0 ) %	443
$\Sigma(1385)\pi$ , $F$ -wave	( 4.0 $\pm$ 2.0 ) %	443
$\Sigma(1385)\pi$	<5 %	443

$\Lambda(1520)\pi$ , <i>D</i> -wave	( 8.0 ± 2.0 ) %	334
$N\bar{K}^*(892)$ , <i>S</i> =1/2, <i>F</i> -wave	( 5.0 ± 3.0 ) %	282
$N\bar{K}^*(892)$ , <i>S</i> =3/2, <i>F</i> -wave	( 5.0 ± 2.0 ) %	282
$\Delta\bar{K}$ , <i>P</i> -wave	(16 ± 5 ) %	383
$\Delta\bar{K}$ , <i>F</i> -wave	( 5.0 ± 3.0 ) %	383

**$\Sigma(2030) 7/2^+$**

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

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

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

<b><math>\Sigma(2030)</math> DECAY MODES</b>	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
$\Sigma(1385)\pi$ , <i>F</i> -wave	( 1.0±1.0 ) %	532
$\Lambda(1520)\pi$	10–20 %	431
$\Delta(1232)\bar{K}$	10–20 %	498
$\Delta(1232)\bar{K}$ , <i>F</i> -wave	(15 ± 5 ) %	498
$\Delta(1232)\bar{K}$ , <i>H</i> -wave	( 1.0±1.0 ) %	498
$N\bar{K}^*(892)$	<5 %	439
$N\bar{K}^*(892)$ , <i>S</i> =3/2, <i>F</i> -wave	(14 ± 8 ) %	439

**$\Sigma(2250)$**

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

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

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

<b><math>\Sigma(2250)</math> DECAY MODES</b>	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.