N BARYONS
($S = 0$, $I = 1/2$)

p, $N^+ = uud$; n, $N^0 = udd$

p

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

Mass $m = 1.00727646681 \pm 0.00000000009$ u
Mass $m = 938.272046 \pm 0.000021$ MeV [a]
$|m_p - m_{\overline{p}}|/m_p < 2 \times 10^{-9}$, CL = 90% [b]
$|\frac{q_{\overline{p}}}{m_{\overline{p}}}|/(\frac{q_p}{m_p}) = 0.99999999991 \pm 0.00000000009$
$|q_p + q_{\overline{p}}|/e < 2 \times 10^{-9}$, CL = 90% [b]
$|q_p + q_e|/e < 1 \times 10^{-21}$ [c]
Magnetic moment $\mu = 2.792847356 \pm 0.000000023\ \mu_N$
$(\mu_p + \mu_{\overline{p}}) / \mu_p = (0 \pm 5) \times 10^{-6}$
Electric dipole moment $d < 0.54 \times 10^{-23}$ e cm
Electric polarizability $\alpha = (11.2 \pm 0.4) \times 10^{-4}$ fm^3
Magnetic polarizability $\beta = (2.5 \pm 0.4) \times 10^{-4}$ fm^3 (S = 1.2)
Charge radius, μp Lamb shift $= 0.84087 \pm 0.00039$ fm [d]
Charge radius, $e p$ CODATA value $= 0.8775 \pm 0.0051$ fm [d]
Magnetic radius $= 0.777 \pm 0.016$ fm
Mean life $\tau > 2.1 \times 10^{29}$ years, CL = 90% [e] ($p \rightarrow$ invisible mode)
Mean life $\tau > 10^{31}$ to 10^{33} years [e] (mode dependent)

See the "Note on Nucleon Decay" in our 1994 edition (Phys. Rev. **D50**, 1173) for a short review.

The "partial mean life" limits tabulated here are the limits on τ/B_i, where τ is the total mean life and B_i is the branching fraction for the mode in question. For N decays, p and n indicate proton and neutron partial lifetimes.

p DECAY MODES	Partial mean life (10^{30} years)	Confidence level	p (MeV/c)
Antilepton + meson			
$N \rightarrow e^+ \pi$	> 2000 (n), > 8200 (p)	90%	459
$N \rightarrow \mu^+ \pi$	> 1000 (n), > 6600 (p)	90%	453
$N \rightarrow \nu \pi$	> 112 (n), > 16 (p)	90%	459
$p \rightarrow e^+ \eta$	> 4200	90%	309
$p \rightarrow \mu^+ \eta$	> 1300	90%	297
$n \rightarrow \nu \eta$	> 158	90%	310
$N \rightarrow e^+ \rho$	> 217 (n), > 710 (p)	90%	149
$N \rightarrow \mu^+ \rho$	> 228 (n), > 160 (p)	90%	113

$N \to \nu \rho$	> 19 (n), > 162 (p)	90%	149
$p \to e^+ \omega$	> 320	90%	143
$p \to \mu^+ \omega$	> 780	90%	105
$n \to \nu \omega$	> 108	90%	144
$N \to e^+ K$	> 17 (n), > 1000 (p)	90%	339
$N \to \mu^+ K$	> 26 (n), > 1600 (p)	90%	329
$N \to \nu K$	> 86 (n), > 2300 (p)	90%	339
$n \to \nu K^0_S$	> 260	90%	338
$p \to e^+ K^*(892)^0$	> 84	90%	45
$N \to \nu K^*(892)$	> 78 (n), > 51 (p)	90%	45
Antilepton + mesons			
$p \to e^+ \pi^+ \pi^-$	> 82	90%	448
$p \to e^+ \pi^0 \pi^0$	> 147	90%	449
$n \to e^+ \pi^- \pi^0$	> 52	90%	449
$p \to \mu^+ \pi^+ \pi^-$	> 133	90%	425
$p \to \mu^+ \pi^0 \pi^0$	> 101	90%	427
$n \to \mu^+ \pi^- \pi^0$	> 74	90%	427
$n \to e^+ K^0 \pi^-$	> 18	90%	319
Lepton + meson			
$n \to e^- \pi^+$	> 65	90%	459
$n \to \mu^- \pi^+$	> 49	90%	453
$n \to e^- \rho^+$	> 62	90%	150
$n \to \mu^- \rho^+$	> 7	90%	115
$n \to e^- K^+$	> 32	90%	340
$n \to \mu^- K^+$	> 57	90%	330
Lepton + mesons			
$p \to e^- \pi^+ \pi^+$	> 30	90%	448
$n \to e^- \pi^+ \pi^0$	> 29	90%	449
$p \to \mu^- \pi^+ \pi^+$	> 17	90%	425
$n \to \mu^- \pi^+ \pi^0$	> 34	90%	427
$p \to e^- \pi^+ K^+$	> 75	90%	320
$p \to \mu^- \pi^+ K^+$	> 245	90%	279
Antilepton + photon(s)			
$p \to e^+ \gamma$	> 670	90%	469
$p \to \mu^+ \gamma$	> 478	90%	463
$n \to \nu \gamma$	> 28	90%	470
$p \to e^+ \gamma \gamma$	> 100	90%	469
$n \to \nu \gamma \gamma$	> 219	90%	470

Three (or more) leptons

$p \to e^+ e^+ e^-$	> 793	90%	469
$p \to e^+ \mu^+ \mu^-$	> 359	90%	457
$p \to e^+ \nu \nu$	> 17	90%	469
$n \to e^+ e^- \nu$	> 257	90%	470
$n \to \mu^+ e^- \nu$	> 83	90%	464
$n \to \mu^+ \mu^- \nu$	> 79	90%	458
$p \to \mu^+ e^+ e^-$	> 529	90%	463
$p \to \mu^+ \mu^+ \mu^-$	> 675	90%	439
$p \to \mu^+ \nu \nu$	> 21	90%	463
$p \to e^- \mu^+ \mu^+$	> 6	90%	457
$n \to 3\nu$	> 0.0005	90%	470

Inclusive modes

$N \to e^+$ anything	> 0.6 $(n,\ p)$	90%	–
$N \to \mu^+$ anything	> 12 $(n,\ p)$	90%	–
$N \to e^+ \pi^0$ anything	> 0.6 $(n,\ p)$	90%	–

$\Delta B = 2$ dinucleon modes

The following are lifetime limits per iron nucleus.

$pp \to \pi^+ \pi^+$	> 0.7	90%	–
$pn \to \pi^+ \pi^0$	> 2	90%	–
$nn \to \pi^+ \pi^-$	> 0.7	90%	–
$nn \to \pi^0 \pi^0$	> 3.4	90%	–
$pp \to e^+ e^+$	> 5.8	90%	–
$pp \to e^+ \mu^+$	> 3.6	90%	–
$pp \to \mu^+ \mu^+$	> 1.7	90%	–
$pn \to e^+ \overline{\nu}$	> 2.8	90%	–
$pn \to \mu^+ \overline{\nu}$	> 1.6	90%	–
$nn \to \nu_e \overline{\nu}_e$	> 1.4	90%	–
$nn \to \nu_\mu \overline{\nu}_\mu$	> 1.4	90%	–
$pn \to$ invisible	> 0.000021	90%	–
$pp \to$ invisible	> 0.00005	90%	–

$\overline{p}$ DECAY MODES

$\overline{p}$ DECAY MODES	Partial mean life (years)	Confidence level	p (MeV/c)
$\overline{p} \to e^- \gamma$	$> 7 \times 10^5$	90%	469
$\overline{p} \to \mu^- \gamma$	$> 5 \times 10^4$	90%	463
$\overline{p} \to e^- \pi^0$	$> 4 \times 10^5$	90%	459
$\overline{p} \to \mu^- \pi^0$	$> 5 \times 10^4$	90%	453
$\overline{p} \to e^- \eta$	$> 2 \times 10^4$	90%	309
$\overline{p} \to \mu^- \eta$	$> 8 \times 10^3$	90%	297

$\overline{p} \rightarrow e^- K^0_S$	> 900	90%	337
$\overline{p} \rightarrow \mu^- K^0_S$	$> 4 \times 10^3$	90%	326
$\overline{p} \rightarrow e^- K^0_L$	$> 9 \times 10^3$	90%	337
$\overline{p} \rightarrow \mu^- K^0_L$	$> 7 \times 10^3$	90%	326
$\overline{p} \rightarrow e^- \gamma\gamma$	$> 2 \times 10^4$	90%	469
$\overline{p} \rightarrow \mu^- \gamma\gamma$	$> 2 \times 10^4$	90%	463
$\overline{p} \rightarrow e^- \omega$	> 200	90%	143

n

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

Mass $m = 1.0086649160 \pm 0.0000000004$ u
Mass $m = 939.565379 \pm 0.000021$ MeV [a]
$(m_n - m_{\overline{n}})/\ m_n = (9 \pm 6) \times 10^{-5}$
$m_n - m_p = 1.2933322 \pm 0.0000004$ MeV
$= 0.00138844919(45)$ u
Mean life $\tau = 880.0 \pm 0.9$ s (S = 1.4)
$c\tau = 2.6381 \times 10^8$ km
Magnetic moment $\mu = -1.9130427 \pm 0.0000005\ \mu_N$
Electric dipole moment $d < 0.29 \times 10^{-25}$ e cm, CL = 90%
Mean-square charge radius $\langle r^2_n \rangle = -0.1161 \pm 0.0022$ fm^2 (S = 1.3)
Magnetic radius $\sqrt{\langle r^2_M \rangle} = 0.862^{+0.009}_{-0.008}$ fm
Electric polarizability $\alpha = (11.6 \pm 1.5) \times 10^{-4}$ fm^3
Magnetic polarizability $\beta = (3.7 \pm 2.0) \times 10^{-4}$ fm^3
Charge $q = (-0.2 \pm 0.8) \times 10^{-21}$ e
Mean $n\overline{n}$-oscillation time $> 8.6 \times 10^7$ s, CL = 90% (free n)
Mean $n\overline{n}$-oscillation time $> 1.3 \times 10^8$ s, CL = 90% [f] (bound n)
Mean nn'-oscillation time > 414 s, CL = 90% [g]

$p e^- \nu_e$ decay parameters [h]

$\lambda \equiv g_A\ /\ g_V = -1.2701 \pm 0.0025$ (S = 1.9)
$A = -0.1176 \pm 0.0011$ (S = 2.1)
$B = 0.9807 \pm 0.0030$
$C = -0.2377 \pm 0.0026$
$a = -0.103 \pm 0.004$
$\phi_{AV} = (180.017 \pm 0.026)^\circ$ [i]
$D = (-1.2 \pm 2.0) \times 10^{-4}$ [j]
$R = 0.004 \pm 0.013$ [j]

n DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$p e^- \overline{\nu}_e$		100 %		1
$p e^- \overline{\nu}_e \gamma$	[k]	(3.09±0.32) $\times 10^{-3}$		1
Charge conservation (Q) violating mode				
$p \nu_e \overline{\nu}_e$	Q	< 8 $\times 10^{-27}$	68%	1

N(1440) $1/2^+$

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

Breit-Wigner mass = 1420 to 1470 (≈ 1440) MeV
Breit-Wigner full width = 200 to 450 (≈ 300) MeV
$p_{\text{beam}} = 0.61$ GeV/c $4\pi\lambda\!\!\!^{-2} = 31.0$ mb
Re(pole position) = 1350 to 1380 (≈ 1365) MeV
−2Im(pole position) = 160 to 220 (≈ 190) MeV

N(1440) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	55–75 %	398
$N\eta$	(0.0±1.0) %	†
$N\pi\pi$	30–40 %	347
$\Delta\pi$	20–30 %	147
$\Delta(1232)\pi$, P-wave	15–30 %	147
$N\rho$	<8 %	†
$N\rho$, S=1/2, P-wave	(0.0±1.0) %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	10–20 %	–
$p\gamma$	0.035–0.048 %	414
$p\gamma$, helicity=1/2	0.035–0.048 %	414
$n\gamma$	0.02–0.04 %	413
$n\gamma$, helicity=1/2	0.02–0.04 %	413

N(1520) $3/2^-$

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

Breit-Wigner mass = 1515 to 1525 (≈ 1520) MeV
Breit-Wigner full width = 100 to 125 (≈ 115) MeV
$p_{\text{beam}} = 0.74$ GeV/c $4\pi\lambda\!\!\!^{-2} = 23.5$ mb
Re(pole position) = 1505 to 1515 (≈ 1510) MeV
−2Im(pole position) = 105 to 120 (≈ 110) MeV

***N*(1520) DECAY MODES**	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	55–65 %	457
$N\eta$	$(2.3\pm0.4)\times10^{-3}$	154
$N\pi\pi$	20–30 %	414
$\Delta\pi$	15–25 %	230
$\Delta(1232)\pi$, S-wave	10–20 %	230
$\Delta(1232)\pi$, D-wave	10–15 %	230
$N\rho$	15–25 %	†
$N\rho$, S=3/2, S-wave	(9.0 ± 1.0) %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	<8 %	–
$p\gamma$	0.31–0.52 %	470
$p\gamma$, helicity=1/2	0.01–0.02 %	470
$p\gamma$, helicity=3/2	0.30–0.50 %	470
$n\gamma$	0.30–0.53 %	470
$n\gamma$, helicity=1/2	0.04–0.10 %	470
$n\gamma$, helicity=3/2	0.25–0.45 %	470

N(1535) 1/2$^-$

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

Breit-Wigner mass = 1525 to 1545 (≈ 1535) MeV
Breit-Wigner full width = 125 to 175 (≈ 150) MeV
$p_{\text{beam}} = 0.76$ GeV/c $\quad 4\pi\lambda\!\!\!^-{}^2 = 22.5$ mb
Re(pole position) = 1490 to 1530 (≈ 1510) MeV
−2Im(pole position) = 90 to 250 (≈ 170) MeV

***N*(1535) DECAY MODES**	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	35–55 %	468
$N\eta$	(42 ± 10) %	186
$N\pi\pi$	1–10 %	426
$\Delta\pi$	<1 %	244
$\Delta(1232)\pi$, D-wave	0–4 %	244
$N\rho$	<4 %	†
$N\rho$, S=1/2, S-wave	(2.0 ± 1.0) %	†
$N\rho$, S=3/2, D-wave	(0.0 ± 1.0) %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	(2 ± 1) %	–
$N(1440)\pi$	(8 ± 3) %	†
$p\gamma$	0.15–0.30 %	481
$p\gamma$, helicity=1/2	0.15–0.30 %	481
$n\gamma$	0.01–0.25 %	480
$n\gamma$, helicity=1/2	0.01–0.25 %	480

N(1650) 1/2⁻

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

Breit-Wigner mass = 1645 to 1670 (≈ 1655) MeV
Breit-Wigner full width = 120 to 180 (≈ 150) MeV
$p_{\text{beam}} = 0.97$ GeV/c $4\pi\lambda\!\!\!^{-2} = 16.2$ mb
Re(pole position) = 1640 to 1670 (≈ 1655) MeV
−2Im(pole position) = 100 to 170 (≈ 135) MeV

N(1650) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	50–90 %	551
$N\eta$	5–15 %	354
ΛK	3–11 %	179
$N\pi\pi$	10–20 %	517
$\Delta\pi$	0–25 %	349
$\Delta(1232)\pi$, D-wave	0–25 %	349
$N\rho$	4–12 %	†
$N\rho$, S=1/2, S-wave	(1.0±1.0) %	†
$N\rho$, S=3/2, D-wave	(13.0±3.0) %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	<4 %	–
$N(1440)\pi$	<5 %	156
$p\gamma$	0.04–0.20 %	562
$p\gamma$, helicity=1/2	0.04–0.20 %	562
$n\gamma$	0.003–0.17 %	561
$n\gamma$, helicity=1/2	0.003–0.17 %	561

N(1675) 5/2⁻

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

Breit-Wigner mass = 1670 to 1680 (≈ 1675) MeV
Breit-Wigner full width = 130 to 165 (≈ 150) MeV
$p_{\text{beam}} = 1.01$ GeV/c $4\pi\lambda\!\!\!^{-2} = 15.4$ mb
Re(pole position) = 1655 to 1665 (≈ 1660) MeV
−2Im(pole position) = 125 to 150 (≈ 135) MeV

N(1675) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	35–45 %	564
$N\eta$	(0.0± 1.0) %	376
ΛK	<1 %	216
$N\pi\pi$	50–60 %	532
$\Delta\pi$	50–60 %	366
$\Delta(1232)\pi$, D-wave	(50 ±15) %	366
$N\rho$	< 1–3 %	†
$N\rho$, S=1/2, D-wave	(0.0± 1.0) %	†
$N\rho$, S=3/2, D-wave	(1.0± 1.0) %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	(7.0± 3.0) %	–
$p\gamma$	0–0.02 %	575
$p\gamma$, helicity=1/2	0–0.01 %	575
$p\gamma$, helicity=3/2	0–0.01 %	575
$n\gamma$	0–0.15 %	574
$n\gamma$, helicity=1/2	0–0.05 %	574
$n\gamma$, helicity=3/2	0–0.10 %	574

N(1680) 5/2$^+$

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

Breit-Wigner mass = 1680 to 1690 (≈ 1685) MeV
Breit-Wigner full width = 120 to 140 (≈ 130) MeV
$p_{\text{beam}} = 1.02$ GeV/c $\quad 4\pi\bar{\lambda}^2 = 15.0$ mb
Re(pole position) = 1665 to 1680 (≈ 1675) MeV
−2Im(pole position) = 110 to 135 (≈ 120) MeV

N(1680) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	65–70 %	571
$N\eta$	(0.0±1.0) %	386
$N\pi\pi$	30–40 %	539
$\Delta\pi$	5–15 %	374
$\Delta(1232)\pi$, P-wave	(10 ±5) %	374
$\Delta(1232)\pi$, F-wave	0–12 %	374
$N\rho$	3–15 %	†
$N\rho$, S=3/2, P-wave	<12;%	†
$N\rho$, S=3/2, F-wave	1–5 %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	(11 ±5) %	–
$p\gamma$	0.21–0.32 %	581
$p\gamma$, helicity=1/2	0.001–0.011 %	581

$p\gamma$, helicity=3/2	0.20–0.32 %	581
$n\gamma$	0.021–0.046 %	581
$n\gamma$, helicity=1/2	0.004–0.029 %	581
$n\gamma$, helicity=3/2	0.01–0.024 %	581

N(1700) 3/2$^-$

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

Breit-Wigner mass = 1650 to 1750 (≈ 1700) MeV
Breit-Wigner full width = 100 to 250 (≈ 150) MeV
$p_{\text{beam}} = 1.05$ GeV/c $4\pi\lambda\!\!\!^{-2} = 14.5$ mb
Re(pole position) = 1650 to 1750 (≈ 1700) MeV
−2Im(pole position) = 100 to 300 MeV

N(1700) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	(12 ±5) %	581
$N\eta$	(0.0±1.0) %	402
ΛK	< 3 %	255
$N\pi\pi$	85–95 %	550
$\Delta(1232)\pi$, S-wave	10–90 %	386
$\Delta(1232)\pi$, D-wave	< 20 %	386
$N\rho$	< 35 %	†
$N\rho$, S=3/2, S-wave	(7.0±1.0) %	†
$p\gamma$	0.01–0.05 %	591
$p\gamma$, helicity=1/2	0.0–0.024 %	591
$p\gamma$, helicity=3/2	0.002–0.026 %	591
$n\gamma$	0.01–0.13 %	590
$n\gamma$, helicity=1/2	0.0–0.09 %	590
$n\gamma$, helicity=3/2	0.01–0.05 %	590

N(1710) 1/2$^+$

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

Breit-Wigner mass = 1680 to 1740 (≈ 1710) MeV
Breit-Wigner full width = 50 to 250 (≈ 100) MeV
$p_{\text{beam}} = 1.07$ GeV/c $4\pi\lambda\!\!\!^{-2} = 14.2$ mb
Re(pole position) = 1670 to 1770 (≈ 1720) MeV
−2Im(pole position) = 80 to 380 (≈ 230) MeV

N(1710) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	5–20 %	588
$N\eta$	10–30 %	412
$N\omega$	(13.0±2.0) %	†
ΛK	5–25 %	269
$N\pi\pi$	40–90 %	557
$\Delta\pi$	15–40 %	394
$N\rho$	5–25 %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	10–40 %	–
$p\gamma$	0.002–0.08 %	598
$p\gamma$, helicity=1/2	0.002–0.08 %	598
$n\gamma$	0.0–0.02%	597
$n\gamma$, helicity=1/2	0.0–0.02%	597

N(1720) 3/2$^+$

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

Breit-Wigner mass = 1700 to 1750 (≈ 1720) MeV
Breit-Wigner full width = 150 to 400 (≈ 250) MeV
$p_{\text{beam}} = 1.09$ GeV/c $\quad 4\pi\lambda\!\!\!^{-2} = 13.9$ mb
Re(pole position) = 1660 to 1690 (≈ 1675) MeV
−2Im(pole position) = 150 to 400 (≈ 250) MeV

N(1720) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	(11± 3) %	594
$N\eta$	(4± 1) %	422
ΛK	1–15 %	283
$N\pi\pi$	>70 %	564
$\Delta(1232)\pi$, P-wave	(75±15) %	402
$N\rho$	70–85 %	74
$N\rho$, S=1/2, P-wave	large	74
$p\gamma$	0.05–0.25 %	604
$p\gamma$, helicity=1/2	0.05–0.15 %	604
$p\gamma$, helicity=3/2	0.002–0.16 %	604
$n\gamma$	0.0–0.016 %	603
$n\gamma$, helicity=1/2	0.0–0.01 %	603
$n\gamma$, helicity=3/2	0.0–0.015 %	603

N(1875) 3/2⁻

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

Breit-Wigner mass = 1820 to 1920 (≈ 1875) MeV
Breit-Wigner full width = 160 to 320 (≈ 220) MeV
Re(pole position) = 1800 to 1950 MeV
−2Im(pole position) = 150 to 250 MeV

N(1875) DECAY MODES	Fraction (Γ_i/Γ)	Scale factor	p (MeV/c)
$N\pi$	(12 ±10) %		695
$N\eta$	(3.5± 3.5) %	2.5	559
$N\omega$	(21 ± 7) %		371
ΣK	(7 ± 4) × 10^{-3}		384
$\Delta(1232)\pi$, S-wave	(40 ±10) %		520
$\Delta(1232)\pi$, D-wave	(17 ±10) %		520
$N\rho$, S=3/2, S-wave	(6 ± 6) %		379
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	(24 ±24) %		–
$p\gamma$	0.008–0.016 %		703
$p\gamma$, helicity=1/2	0.006–0.010 %		703
$p\gamma$, helicity=3/2	0.002–0.006 %		703

N(1900) 3/2⁺

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

Breit-Wigner mass ≈ 1900 MeV
Breit-Wigner full width ∼ 250 MeV
Re(pole position) = 1900 ± 30 MeV
−2Im(pole position) = $200^{+100}_{-\ 60}$ MeV

N(1900) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	∼ 10 %	710
$N\eta$	∼ 12 %	579
$N\omega$	(39 ±9) %	401
ΛK	0–10 %	477
ΣK	(5.0±2.0) %	410

N(2190) 7/2$^-$

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

Breit-Wigner mass = 2100 to 2200 (≈ 2190) MeV
Breit-Wigner full width = 300 to 700 (≈ 500) MeV
p_{beam} = 2.07 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 6.21 mb
Re(pole position) = 2050 to 2100 (≈ 2075) MeV
−2Im(pole position) = 400 to 520 (≈ 450) MeV

N(2190) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	10–20 %	888
$N\eta$	(0.0±1.0) %	791
$N\omega$	seen	676
ΛK	seen	712
$N\pi\pi$	seen	870
$N\rho$	seen	680
$p\gamma$	0.02–0.06 %	894
$p\gamma$, helicity=1/2	0.02–0.04 %	894
$p\gamma$, helicity=3/2	0.002–0.02 %	894

N(2220) 9/2$^+$

$I(J^P) = \frac{1}{2}(\frac{9}{2}^+)$

Breit-Wigner mass = 2200 to 2300 (≈ 2250) MeV
Breit-Wigner full width = 350 to 500 (≈ 400) MeV
p_{beam} = 2.21 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 5.74 mb
Re(pole position) = 2130 to 2200 (≈ 2170) MeV
−2Im(pole position) = 400 to 560 (≈ 480) MeV

N(2220) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	15–25 %	924

N(2250) 9/2$^-$

$I(J^P) = \frac{1}{2}(\frac{9}{2}^-)$

Breit-Wigner mass = 2200 to 2350 (≈ 2275) MeV
Breit-Wigner full width = 230 to 800 (≈ 500) MeV
p_{beam} = 2.27 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 5.56 mb
Re(pole position) = 2150 to 2250 (≈ 2200) MeV
−2Im(pole position) = 350 to 550 (≈ 450) MeV

N(2250) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	5–15 %	938

N(2600) 11/2$^-$

$I(J^P) = \frac{1}{2}(\frac{11}{2}^-)$

Breit-Wigner mass = 2550 to 2750 (≈ 2600) MeV
Breit-Wigner full width = 500 to 800 (≈ 650) MeV
$p_{\text{beam}} = 3.12$ GeV/c $4\pi\lambda\!\!\!^{-2} = 3.86$ mb

N(2600) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	5–10 %	1126

NOTES

[a] The masses of the p and n are most precisely known in u (unified atomic mass units). The conversion factor to MeV, 1 u = 931.494061(21) MeV, is less well known than are the masses in u.

[b] The $|m_p - m_{\overline{p}}|/m_p$ and $|q_p + q_{\overline{p}}|/e$ are not independent, and both use the more precise measurement of $|q_{\overline{p}}/m_{\overline{p}}|/(q_p/m_p)$.

[c] The limit is from neutrality-of-matter experiments; it assumes $q_n = q_p + q_e$. See also the charge of the neutron.

[d] The μp and $e p$ values for the charge radius are much too different to average them. The disagreement is not yet understood.

[e] The first limit is for $p \to$ anything or "disappearance" modes of a bound proton. The second entry, a rough range of limits, assumes the dominant decay modes are among those investigated. For antiprotons the best limit, inferred from the observation of cosmic ray $\overline{p}$'s is $\tau_{\overline{p}} > 10^7$ yr, the cosmic-ray storage time, but this limit depends on a number of assumptions. The best direct observation of stored antiprotons gives $\tau_{\overline{p}}/\text{B}(\overline{p} \to e^-\gamma) > 7 \times 10^5$ yr.

[f] There is some controversy about whether nuclear physics and model dependence complicate the analysis for bound neutrons (from which the best limit comes). The first limit here is from reactor experiments with free neutrons.

[g] Lee and Yang in 1956 proposed the existence of a mirror world in an attempt to restore global parity symmetry—thus a search for oscillations between the two worlds. Oscillations between the worlds would be maximal when the magnetic fields B and B' were equal. The limit for any B' in the range 0 to 12.5 μT is >12 s (95% CL).

[h] 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 ϕ_{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.

[*i*] Time-reversal invariance requires this to be 0° or 180°.

[*j*] This coefficient is zero if time invariance is not violated.

[*k*] This limit is for γ energies between 15 and 340 keV.