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 $m = 1.00727646688 \pm 0.00000000009$ u
Mass $m = 938.272081 \pm 0.000006$ MeV [a]
$\left|m_p - m_{\overline{p}}\right|/m_p < 7 \times 10^{-10}$, CL = 90% [b]
$\left|\frac{q_{\overline{p}}}{m_{\overline{p}}}\right|/(\frac{q_p}{m_p}) = 1.00000000000 \pm 0.00000000007$
$\left|q_p + q_{\overline{p}}\right|/e < 7 \times 10^{-10}$, CL = 90% [b]
$\left|q_p + q_e\right|/e < 1 \times 10^{-21}$ [c]
Magnetic moment $\mu = 2.7928473446 \pm 0.0000000008\ \mu_N$
$(\mu_p + \mu_{\overline{p}})\ /\ \mu_p = (0.3 \pm 0.8) \times 10^{-6}$
Electric dipole moment $d < 0.021 \times 10^{-23}$ 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 $= 0.8751 \pm 0.0061$ fm [d]
Magnetic radius $= 0.851 \pm 0.026$ fm [e]
Mean life $\tau > 2.1 \times 10^{29}$ years, CL = 90% [f] ($p \rightarrow$ invisible mode)
Mean life $\tau > 10^{31}$ to 10^{33} years [f] (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		
$N \rightarrow e^+ \pi$	> 5300 (n), > 16000 (p)	90%	459
$N \rightarrow \mu^+ \pi$	> 3500 (n), > 7700 (p)	90%	453
$N \rightarrow \nu \pi$	> 1100 (n), > 390 (p)	90%	459
$p \rightarrow e^+ \eta$	> 10000	90%	309
$p \rightarrow \mu^+ \eta$	> 4700	90%	297
$n \rightarrow \nu \eta$	> 158	90%	310
$N \rightarrow e^+ \rho$	> 217 (n), > 720 (p)	90%	149
$N \rightarrow \mu^+ \rho$	> 228 (n), > 570 (p)	90%	113

$N \to \nu\rho$	> 19 (n), > 162 (p)	90%	149
$p \to e^+\omega$	> 1600	90%	143
$p \to \mu^+\omega$	> 2800	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), > 5900 (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
$n \to \nu\gamma$	> 550	90%	470
$p \to e^+\gamma\gamma$	> 100	90%	469
$n \to \nu\gamma\gamma$	> 219	90%	470

Antilepton + single massless

$p \to e^+X$	> 790	90%	–
$p \to \mu^+X$	> 410	90%	–

Three (or more) leptons

$p \rightarrow e^+ e^+ e^-$	> 793	90%	469
$p \rightarrow e^+ \mu^+ \mu^-$	> 359	90%	457
$p \rightarrow e^+ \nu \nu$	> 170	90%	469
$n \rightarrow e^+ e^- \nu$	> 257	90%	470
$n \rightarrow \mu^+ e^- \nu$	> 83	90%	464
$n \rightarrow \mu^+ \mu^- \nu$	> 79	90%	458
$p \rightarrow \mu^+ e^+ e^-$	> 529	90%	463
$p \rightarrow \mu^+ \mu^+ \mu^-$	> 675	90%	439
$p \rightarrow \mu^+ \nu \nu$	> 220	90%	463
$p \rightarrow e^- \mu^+ \mu^+$	> 6	90%	457
$n \rightarrow 3\nu$	$> 5 \times 10^{-4}$	90%	470

Inclusive modes

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

$\Delta B = 2$ dinucleon modes

The following are lifetime limits per iron nucleus.

$p\,p \rightarrow \pi^+ \pi^+$	> 72.2	90%	–
$p\,n \rightarrow \pi^+ \pi^0$	> 170	90%	–
$n\,n \rightarrow \pi^+ \pi^-$	> 0.7	90%	–
$n\,n \rightarrow \pi^0 \pi^0$	> 404	90%	–
$p\,p \rightarrow K^+ K^+$	> 170	90%	–
$p\,p \rightarrow e^+ e^+$	> 5.8	90%	–
$p\,p \rightarrow e^+ \mu^+$	> 3.6	90%	–
$p\,p \rightarrow \mu^+ \mu^+$	> 1.7	90%	–
$p\,n \rightarrow e^+ \overline{\nu}$	> 260	90%	–
$p\,n \rightarrow \mu^+ \overline{\nu}$	> 200	90%	–
$p\,n \rightarrow \tau^+ \overline{\nu}_\tau$	> 29	90%	–
$n\,n \rightarrow \nu_e \overline{\nu}_e$	> 1.4	90%	–
$n\,n \rightarrow \nu_\mu \overline{\nu}_\mu$	> 1.4	90%	–
$p\,n \rightarrow$ invisible	$> 2.1 \times 10^{-5}$	90%	–
$p\,p \rightarrow$ invisible	$> 5 \times 10^{-5}$	90%	–

$\overline{p}$ DECAY MODES

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

$\overline{p} \to \mu^- \eta$	$> 8 \times 10^3$	90%	297
$\overline{p} \to e^- K^0_S$	> 900	90%	337
$\overline{p} \to \mu^- K^0_S$	$> 4 \times 10^3$	90%	326
$\overline{p} \to e^- K^0_L$	$> 9 \times 10^3$	90%	337
$\overline{p} \to \mu^- K^0_L$	$> 7 \times 10^3$	90%	326
$\overline{p} \to e^- \gamma\gamma$	$> 2 \times 10^4$	90%	469
$\overline{p} \to \mu^- \gamma\gamma$	$> 2 \times 10^4$	90%	463
$\overline{p} \to e^- \omega$	> 200	90%	143

n

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

Mass $m = 1.0086649159 \pm 0.0000000005$ u
Mass $m = 939.565413 \pm 0.000006$ MeV [a]
$(m_n - m_{\overline{n}})/m_n = (9 \pm 6) \times 10^{-5}$
$m_n - m_p = 1.2933321 \pm 0.0000005$ MeV
$= 0.00138844919(45)$ u
Mean life $\tau = 879.4 \pm 0.6$ s (S = 1.6)
$c\tau = 2.6362 \times 10^8$ km
Magnetic moment $\mu = -1.9130427 \pm 0.0000005\ \mu_N$
Electric dipole moment $d < 0.30 \times 10^{-25}\ e\,$cm, CL = 90%
Mean-square charge radius $\langle r_n^2 \rangle = -0.1161 \pm 0.0022$ fm^2 (S = 1.3)
Magnetic radius $\sqrt{\langle r_M^2 \rangle} = 0.864^{+0.009}_{-0.008}$ fm
Electric polarizability $\alpha = (11.8 \pm 1.1) \times 10^{-4}$ fm^3
Magnetic polarizability $\beta = (3.7 \pm 1.2) \times 10^{-4}$ 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 $> 2.7 \times 10^8$ s, CL = 90% [g] (bound n)
Mean nn'-oscillation time > 448 s, CL = 90% [h]

$pe^-\nu_e$ decay parameters [i]

$\lambda \equiv g_A / g_V = -1.2732 \pm 0.0023$ (S = 2.4)
$A = -0.1187 \pm 0.0010$ (S = 2.6)
$B = 0.9807 \pm 0.0030$
$C = -0.2377 \pm 0.0026$
$a = -0.1059 \pm 0.0028$
$\phi_{AV} = (180.017 \pm 0.026)^\circ$ [j]
$D = (-1.2 \pm 2.0) \times 10^{-4}$ [k]
$R = 0.004 \pm 0.013$ [k]

n DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$p e^- \overline{\nu}_e$		100 %		1
$p e^- \overline{\nu}_e \gamma$	[l]	(9.2±0.7) $\times 10^{-3}$		1
hydrogen-atom $\overline{\nu}_e$		< 2.7 $\times 10^{-3}$	95%	1.19
Charge conservation (Q) violating mode				
$p \nu_e \overline{\nu}_e$	Q	< 8 $\times 10^{-27}$	68%	1

N(1440) 1/2$^+$

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

Re(pole position) = 1360 to 1380 (≈ 1370) MeV
−2Im(pole position) = 160 to 190 (≈ 175) MeV
Breit-Wigner mass = 1410 to 1470 (≈ 1440) MeV
Breit-Wigner full width = 250 to 450 (≈ 350) MeV

N(1440) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	55–75 %	398
$N\eta$	<1 %	†
$N\pi\pi$	17–50 %	347
$\Delta(1232)\pi$, P-wave	6–27 %	147
$N\sigma$	11–23 %	–
$p\gamma$, helicity=1/2	0.035–0.048 %	414
$n\gamma$, helicity=1/2	0.02–0.04 %	413

N(1520) 3/2$^-$

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

Re(pole position) = 1505 to 1515 (≈ 1510) MeV
−2Im(pole position) = 105 to 120 (≈ 110) MeV
Breit-Wigner mass = 1510 to 1520 (≈ 1515) MeV
Breit-Wigner full width = 100 to 120 (≈ 110) MeV

N(1520) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	55–65 %	453
$N\eta$	0.07–0.09 %	142
$N\pi\pi$	25–35 %	410
$\Delta(1232)\pi$	22–34 %	225
$\Delta(1232)\pi$, S-wave	15–23 %	225
$\Delta(1232)\pi$, D-wave	7–11 %	225

$N\sigma$	< 2 %	–
$p\gamma$	0.31–0.52 %	467
$p\gamma$, helicity=1/2	0.01–0.02 %	467
$p\gamma$, helicity=3/2	0.30–0.50 %	467
$n\gamma$	0.30–0.53 %	466
$n\gamma$, helicity=1/2	0.04–0.10 %	466
$n\gamma$, helicity=3/2	0.25–0.45 %	466

N(1535) 1/2$^-$

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

Re(pole position) = 1500 to 1520 (≈ 1510) MeV
−2Im(pole position) = 110 to 150 (≈ 130) MeV
Breit-Wigner mass = 1515 to 1545 (≈ 1530) MeV
Breit-Wigner full width = 125 to 175 (≈ 150) MeV

***N*(1535) DECAY MODES**	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	32–52 %	464
$N\eta$	30–55 %	176
$N\pi\pi$	3–14 %	422
$\Delta(1232)\pi$, D-wave	1–4 %	240
$N\sigma$	2–10 %	–
$N(1440)\pi$	5–12 %	†
$p\gamma$, helicity=1/2	0.15–0.30 %	477
$n\gamma$, helicity=1/2	0.01–0.25 %	477

N(1650) 1/2$^-$

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

Re(pole position) = 1640 to 1670 (≈ 1655) MeV
−2Im(pole position) = 100 to 170 (≈ 135) MeV
Breit-Wigner mass = 1635 to 1665 (≈ 1650) MeV
Breit-Wigner full width = 100 to 150 (≈ 125) MeV

***N*(1650) DECAY MODES**	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	50–70 %	547
$N\eta$	15–35 %	348
ΛK	5–15 %	169
$N\pi\pi$	8–36 %	514
$\Delta(1232)\pi$, D-wave	6–18 %	345
$N\sigma$	2–18 %	–
$N(1440)\pi$	6–26 %	150

$p\gamma$, helicity=1/2	0.04–0.20 %	558
$n\gamma$, helicity=1/2	0.003–0.17 %	557

$N(1675)\ 5/2^-$

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

Re(pole position) = 1655 to 1665 (≈ 1660) MeV
−2Im(pole position) = 125 to 150 (≈ 135) MeV
Breit-Wigner mass = 1665 to 1680 (≈ 1675) MeV
Breit-Wigner full width = 130 to 160 (≈ 145) MeV

N(1675) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	38–42 %	564
$N\eta$	< 1 %	376
$N\pi\pi$	25–45 %	532
$\Delta(1232)\pi$, D-wave	23–37 %	366
$N\sigma$	3–7 %	–
$p\gamma$	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

$N(1680)\ 5/2^+$

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

Re(pole position) = 1665 to 1680 (≈ 1675) MeV
−2Im(pole position) = 110 to 135 (≈ 120) MeV
Breit-Wigner mass = 1680 to 1690 (≈ 1685) MeV
Breit-Wigner full width = 115 to 130 (≈ 120) MeV

N(1680) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	60–70 %	571
$N\eta$	<1 %	386
$N\pi\pi$	20–40 %	539
$\Delta(1232)\pi$	11–23 %	374
$\Delta(1232)\pi$, P-wave	4–10 %	374
$\Delta(1232)\pi$, F-wave	1–13 %	374
$N\sigma$	9–19 %	–
$p\gamma$	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

$N(1700)\ 3/2^-$

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

Re(pole position) = 1650 to 1750 (≈ 1700) MeV
-2Im(pole position) = 100 to 300 (≈ 200) MeV
Breit-Wigner mass = 1650 to 1800 (≈ 1720) MeV
Breit-Wigner full width = 100 to 300 (≈ 200) MeV

***N*(1700) DECAY MODES**	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	7–17 %	594
$N\eta$	seen	422
$N\omega$	10–34 %	†
$N\pi\pi$	60–90 %	564
$\Delta(1232)\pi$	55–85 %	402
$\Delta(1232)\pi$, S-wave	50–80 %	402
$\Delta(1232)\pi$, D-wave	4–14 %	402
$N(1440)\pi$	3–11 %	225
$N(1520)\pi$	<4 %	145
$N\rho$, S=3/2, S-wave	32–44 %	74
$N\sigma$	2–14 %	–
$p\gamma$	0.01–0.05 %	604
$p\gamma$, helicity=1/2	0.0–0.024 %	604
$p\gamma$, helicity=3/2	0.002–0.026 %	604
$n\gamma$	0.01–0.13 %	603
$n\gamma$, helicity=1/2	0.0–0.09 %	603
$n\gamma$, helicity=3/2	0.01–0.05 %	603

$N(1710)\ 1/2^+$

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

Re(pole position) = 1680 to 1720 (≈ 1700) MeV
-2Im(pole position) = 80 to 160 (≈ 120) MeV
Breit-Wigner mass = 1680 to 1740 (≈ 1710) MeV
Breit-Wigner full width = 80 to 200 (≈ 140) MeV

***N*(1710) DECAY MODES**	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	5–20 %	588
$N\eta$	10–50 %	412
$N\omega$	1–5 %	†
ΛK	5–25 %	269

ΣK	seen	138
$N\pi\pi$	seen	557
$\Delta(1232)\pi$, P-wave	3–9 %	394
$N(1535)\pi$	9–21 %	113
$N\rho$, S=1/2, P-wave	11–23 %	†
$p\gamma$, helicity=1/2	0.002–0.08 %	598
$n\gamma$, helicity=1/2	0.0–0.02%	597

$N(1720)$ 3/2$^+$

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

Re(pole position) = 1660 to 1690 ($\approx$ 1675) MeV
-2Im(pole position) = 150 to 400 ($\approx$ 250) MeV
Breit-Wigner mass = 1680 to 1750 ($\approx$ 1720) MeV
Breit-Wigner full width = 150 to 400 ($\approx$ 250) MeV

$N(1720)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	8–14 %	594
$N\eta$	1–5 %	422
$N\omega$	12–40 %	†
ΛK	4–5 %	283
$N\pi\pi$	50–90 %	564
$\Delta(1232)\pi$	47–89 %	402
$\Delta(1232)\pi$, P-wave	47–77 %	402
$\Delta(1232)\pi$, F-wave	<12 %	402
$N\rho$, S=1/2, P-wave	1–2 %	74
$N\sigma$	2–14 %	–
$N(1440)\pi$	<2 %	225
$N(1520)\pi$, S-wave	1–5 %	145
$p\gamma$	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$^-$

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

Re(pole position) = 1850 to 1950 ($\approx$ 1900) MeV
-2Im(pole position) = 100 to 220 ($\approx$ 160) MeV
Breit-Wigner mass = 1850 to 1920 ($\approx$ 1875) MeV
Breit-Wigner full width = 120 to 250 ($\approx$ 200) MeV

N(1875) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	3–11 %	695
$N\eta$	<1 %	559
$N\omega$	15–25 %	371
ΛK	seen	454
ΣK	seen	384
$N\pi\pi$		670
$\Delta(1232)\pi$	10–35 %	520
$\Delta(1232)\pi$, S-wave	7–21 %	520
$\Delta(1232)\pi$, D-wave	2–12 %	520
$N\rho$, S=3/2, S-wave	seen	379
$N\sigma$	30–60 %	–
$N(1440)\pi$	2–8 %	365
$N(1520)\pi$	<2 %	301
$p\gamma$	0.001–0.025 %	703
$p\gamma$, helicity=1/2	0.001–0.021 %	703
$p\gamma$, helicity=3/2	<0.003 %	703
$n\gamma$	<0.040 %	702
$n\gamma$, helicity=1/2	<0.007 %	702
$n\gamma$, helicity=3/2	<0.033 %	702

N(1880) 1/2$^+$

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

Re(pole position) = 1820 to 1900 (≈ 1860) MeV
−2Im(pole position) = 180 to 280 (≈ 230) MeV
Breit-Wigner mass = 1830 to 1930 (≈ 1880) MeV
Breit-Wigner full width = 200 to 400 (≈ 300) MeV

N(1880) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	3–9 %	698
$N\eta$	5–55 %	563
$N\omega$	12–28 %	377
ΛK	12–28 %	459
ΣK	10–24 %	389
$N\pi\pi$	30–80 %	673
$\Delta(1232)\pi$	18–42 %	524
$N\sigma$	10–40 %	539
$N(1535)\pi$	4–12 %	293
$N a_0(980)$	1–5 %	†

$\Lambda K^*(892)$	0.5–1 %	†
$p\gamma$, helicity=1/2	seen	706
$n\gamma$, helicity=1/2	0.002–0.63 %	705

$N(1895)$ $1/2^-$

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

Re(pole position) = 1890 to 1930 (≈ 1910) MeV
−2Im(pole position) = 80 to 140 (≈ 110) MeV
Breit-Wigner mass = 1870 to 1920 (≈ 1895) MeV
Breit-Wigner full width = 80 to 200 (≈ 120) MeV

***N*(1895) DECAY MODES**	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	2–18 %	707
$N\eta$	15–40 %	575
$N\eta'$	10–40 %	†
$N\omega$	16–40 %	395
ΛK	13–23 %	473
ΣK	6–20 %	405
$\Delta(1232)\pi$, D-wave	3–11 %	535
$N\rho$, S=1/2, S-wave	seen	403
$N\rho$, S=3/2, D-wave	3–12 %	403
$\Lambda K^*(892)$	4–9 %	†
$N\sigma$	seen	–
$N(1440)\pi$	1–4 %	382
$p\gamma$, helicity=1/2	0.01–0.06 %	715
$n\gamma$, helicity=1/2	0.003–0.05 %	715

$N(1900)$ $3/2^+$

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

Re(pole position) = 1900 to 1940 (≈ 1920) MeV
−2Im(pole position) = 100 to 200 (≈ 150) MeV
Breit-Wigner mass = 1890 to 1950 (≈ 1920) MeV
Breit-Wigner full width = 100 to 320 (≈ 200) MeV

***N*(1900) DECAY MODES**	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	1–20 %	723
$N\eta$	2–14 %	595
$N\eta'$	4–8 %	151
$N\omega$	7–13 %	424
ΛK	2–20 %	495
ΣK	3–7 %	431

$N\pi\pi$	40–80 %	699
$\Delta(1232)\pi$	30–70 %	553
$\Delta(1232)\pi$, P-wave	9–25 %	553
$\Delta(1232)\pi$, F-wave	21–45 %	553
$\Lambda K^*(892)$	$<$ 0.2 %	†
$N\sigma$	1–7 %	–
$N(1520)\pi$	7–23 %	341
$N(1535)\pi$	4–10 %	328
$p\gamma$	0.001–0.025 %	731
$p\gamma$, helicity=1/2	0.001–0.021 %	731
$p\gamma$, helicity=3/2	$<$0.003 %	731
$n\gamma$	$<$0.040 %	730
$n\gamma$, helicity=1/2	$<$0.007 %	730
$n\gamma$, helicity=3/2	$<$0.033 %	730

$N(2060)$ $5/2^-$

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

Re(pole position) = 2020 to 2130 (≈ 2070) MeV
−2Im(pole position) = 350 to 430 (≈ 400) MeV
Breit-Wigner mass = 2030 to 2200 (≈ 2100) MeV
Breit-Wigner full width = 300 to 450 (≈ 400) MeV

$N(2060)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	7–12 %	834
$N\eta$	2–6 %	729
$N\omega$	1–7 %	600
ΛK	seen	644
ΣK	1–5 %	593
$N\pi\pi$	7–19 %	814
$\Delta(1232)\pi$, D-wave	4–10 %	680
$N\rho$, S=1/2, P-wave	seen	605
$\Lambda K^*(892)$	0.3–1.3 %	307
$N\sigma$	3–9 %	–
$N(1440)\pi$	4–14 %	544
$N(1520)\pi$, P-wave	9–21 %	490
$N(1680)\pi$, S-wave	8–22 %	353
$p\gamma$	0.03–0.19 %	840
$p\gamma$, helicity=1/2	0.02–0.08 %	840
$p\gamma$, helicity=3/2	0.01–0.10 %	840
$n\gamma$	0.003–0.07 %	840
$n\gamma$, helicity=1/2	0.001–0.02 %	840
$n\gamma$, helicity=3/2	0.002–0.05 %	840

$N(2100)\ 1/2^+$

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

Re(pole position) = 2050 to 2150 (≈ 2100) MeV
−2Im(pole position) = 240 to 340 (≈ 300) MeV
Breit-Wigner mass = 2050 to 2150 (≈ 2100) MeV
Breit-Wigner full width = 200 to 320 (≈ 260) MeV

$N(2100)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	8–18 %	834
$N\eta$	seen	729
$N\eta'$	5–11 %	451
$N\omega$	10–25 %	600
ΛK	seen	644
$N\pi\pi$	20–40 %	814
$\Delta(1232)\pi$, P-wave	6–14 %	680
$N\rho$, S=1/2, P-wave	seen	605
$\Lambda K^*(892)$	3–11 %	307
$N\sigma$	14–26 %	–
$N(1535)\pi$	26–34 %	478
$N\gamma$, helicity=1/2	0.001–0.012 %	840

$N(2120)\ 3/2^-$

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

Re(pole position) = 2050 to 2150 (≈ 2100) MeV
−2Im(pole position) = 200 to 360 (≈ 280) MeV
Breit-Wigner mass = 2060 to 2160 (≈ 2120) MeV
Breit-Wigner full width = 260 to 360 (≈ 300) MeV

$N(2120)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	5–15 %	846
$N\eta'$	2–6 %	474
$N\omega$	4–20 %	617
$N\pi\pi$	50–95 %	827
$\Delta(1232)\pi$	40–90 %	693
$\Delta(1232)\pi$, S-wave	30–70 %	693
$\Delta(1232)\pi$, D-wave	8–32 %	693
$\Lambda K^*(892)$	$<$ 0.2 %	339
$N\sigma$	7–15 %	–
$N(1535)\pi$	7–23 %	494

$p\gamma$	0.16–2.1 %	852
$p\gamma$, helicity=1/2	0.07–0.80 %	852
$p\gamma$, helicity=3/2	0.09–1.3 %	852
$n\gamma$	0.04–0.72 %	852
$n\gamma$, helicity=1/2	0.04–0.60 %	852
$n\gamma$, helicity=3/2	0.001–0.12 %	852

N(2190) 7/2$^-$

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

Re(pole position) = 2050 to 2150 ($\approx$ 2100) MeV
-2Im(pole position) = 300 to 500 ($\approx$ 400) MeV
Breit-Wigner mass = 2140 to 2220 ($\approx$ 2180) MeV
Breit-Wigner full width = 300 to 500 ($\approx$ 400) MeV

***N*(2190) DECAY MODES**	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	10–20 %	882
$N\eta$	1–3 %	785
$N\omega$	8–20 %	667
$\Delta(1232)\pi$, D-wave	19–31 %	734
$N\rho$, S=3/2, D-wave	seen	672
$\Lambda K^*(892)$	0.2–0.8 %	423
$N\sigma$	3–9 %	–
$p\gamma$	0.014–0.077 %	888
$n\gamma$	<0.04 %	888
$n\gamma$, helicity=3/2	<0.03 %	888

N(2220) 9/2$^+$

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

Re(pole position) = 2130 to 2200 ($\approx$ 2170) MeV
-2Im(pole position) = 360 to 480 ($\approx$ 400) MeV
Breit-Wigner mass = 2200 to 2300 ($\approx$ 2250) MeV
Breit-Wigner full width = 350 to 500 ($\approx$ 400) MeV

***N*(2220) DECAY MODES**	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	15–30 %	924

N(2250) 9/2$^-$

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

Re(pole position) = 2150 to 2250 ($\approx$ 2200) MeV
-2Im(pole position) = 350 to 500 ($\approx$ 420) MeV
Breit-Wigner mass = 2250 to 2320 ($\approx$ 2280) MeV
Breit-Wigner full width = 300 to 600 ($\approx$ 500) MeV

N(2250) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	0.05 to 0.15 ($\approx$ 0.10)	941

N(2600) 11/2$^-$

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

Breit-Wigner mass = 2550 to 2750 ($\approx$ 2600) MeV
Breit-Wigner full width = 500 to 800 ($\approx$ 650) MeV

N(2600) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	3–8 %	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 $\left|m_p - m_{\overline{p}}\right|/m_p$ and $\left|q_p + q_{\overline{p}}\right|/e$ are not independent, and both use the more precise measurement of $\left|q_{\overline{p}}/m_{\overline{p}}\right|/(q_p/m_p)$.

[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] There is a lot of disagreement about the value of the proton magnetic charge radius. See the Listings.

[f] The first limit is for $p \rightarrow$ 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 $\tau_{\overline{p}}/\mathrm{B}(\overline{p} \rightarrow e^- \gamma) > 7 \times 10^5$ yr.

[g] 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.

[h] 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).

[*i*] 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 $g_A/g_V = \left|g_A/g_V\right|e^{i\phi_{AV}}$. See the "Note on Baryon Decay Parameters" in the neutron Particle Listings.

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

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

[*l*] This limit is for γ energies between 0.4 and 782 keV.