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]
$|m_p - m_{\overline{p}}|/m_p < 7 \times 10^{-10}$, CL = 90% [b]
$|\frac{q_{\overline{p}}}{m_{\overline{p}}}|/(\frac{q_p}{m_p}) = 0.99999999991 \pm 0.00000000009$
$|q_p + q_{\overline{p}}|/e < 7 \times 10^{-10}$, CL = 90% [b]
$|q_p + q_e|/e < 1 \times 10^{-21}$ [c]
Magnetic moment $\mu = 2.792847351 \pm 0.000000009$ μ_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 ± 0.00039 fm [d]
Charge radius, $e p$ CODATA value = 0.8751 ± 0.0061 fm [d]
Magnetic radius = 0.78 ± 0.04 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			
$N \rightarrow e^+ \pi$	> 2000 (n), > 8200 (p)	90%	459
$N \rightarrow \mu^+ \pi$	> 1000 (n), > 6600 (p)	90%	453
$N \rightarrow \nu \pi$	> 1100 (n), > 390 (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

$N \rightarrow \nu\rho$	> 19 (n), > 162 (p)	90%	149
$p \rightarrow e^{+}\omega$	> 320	90%	143
$p \rightarrow \mu^{+}\omega$	> 780	90%	105
$n \rightarrow \nu\omega$	> 108	90%	144
$N \rightarrow e^{+}K$	> 17 (n), > 1000 (p)	90%	339
$N \rightarrow \mu^{+}K$	> 26 (n), > 1600 (p)	90%	329
$N \rightarrow \nu K$	> 86 (n), > 5900 (p)	90%	339
$n \rightarrow \nu K^0_S$	> 260	90%	338
$p \rightarrow e^{+}K^{*}(892)^0$	> 84	90%	45
$N \rightarrow \nu K^{*}(892)$	> 78 (n), > 51 (p)	90%	45

Antilepton + mesons

$p \rightarrow e^{+}\pi^{+}\pi^{-}$	> 82	90%	448
$p \rightarrow e^{+}\pi^{0}\pi^{0}$	> 147	90%	449
$n \rightarrow e^{+}\pi^{-}\pi^{0}$	> 52	90%	449
$p \rightarrow \mu^{+}\pi^{+}\pi^{-}$	> 133	90%	425
$p \rightarrow \mu^{+}\pi^{0}\pi^{0}$	> 101	90%	427
$n \rightarrow \mu^{+}\pi^{-}\pi^{0}$	> 74	90%	427
$n \rightarrow e^{+}K^{0}\pi^{-}$	> 18	90%	319

Lepton + meson

$n \rightarrow e^{-}\pi^{+}$	> 65	90%	459
$n \rightarrow \mu^{-}\pi^{+}$	> 49	90%	453
$n \rightarrow e^{-}\rho^{+}$	> 62	90%	150
$n \rightarrow \mu^{-}\rho^{+}$	> 7	90%	115
$n \rightarrow e^{-}K^{+}$	> 32	90%	340
$n \rightarrow \mu^{-}K^{+}$	> 57	90%	330

Lepton + mesons

$p \rightarrow e^{-}\pi^{+}\pi^{+}$	> 30	90%	448
$n \rightarrow e^{-}\pi^{+}\pi^{0}$	> 29	90%	449
$p \rightarrow \mu^{-}\pi^{+}\pi^{+}$	> 17	90%	425
$n \rightarrow \mu^{-}\pi^{+}\pi^{0}$	> 34	90%	427
$p \rightarrow e^{-}\pi^{+}K^{+}$	> 75	90%	320
$p \rightarrow \mu^{-}\pi^{+}K^{+}$	> 245	90%	279

Antilepton + photon(s)

$p \rightarrow e^{+}\gamma$	> 670	90%	469
$p \rightarrow \mu^{+}\gamma$	> 478	90%	463
$n \rightarrow \nu\gamma$	> 550	90%	470
$p \rightarrow e^{+}\gamma\gamma$	> 100	90%	469
$n \rightarrow \nu\gamma\gamma$	> 219	90%	470

Antilepton + single massless

$p \rightarrow e^{+}X$	> 790	90%	–
$p \rightarrow \mu^{+}X$	> 410	90%	–

Three (or more) leptons

$p \to e^+ e^+ e^-$	> 793	90%	469
$p \to e^+ \mu^+ \mu^-$	> 359	90%	457
$p \to e^+ \nu \nu$	> 170	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
$p \to \mu^+ \nu \nu$	> 220	90%	463
$p \to e^- \mu^+ \mu^+$	> 6	90%	457
$n \to 3\nu$	$> 5 \times 10^{-4}$	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.

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

$\overline{p}$ DECAY MODES

$\overline{p}$ DECAY MODES	Partial mean life (years)	Confidence level	p (MeV/c)
$\overline{p} \to e^- \gamma$	$> 7 \times 10^5$	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
$\overline{p} \to e^- K^0_S$	> 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 $\qquad I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

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 $\tau = 880.2 \pm 1.0$ s (S = 1.9)
$c\tau = 2.6387 \times 10^8$ 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 $> 2.7 \times 10^8$ s, CL = 90% (free n)
Mean $n\overline{n}$-oscillation time $> 1.3 \times 10^8$ s, CL = 90% [g] (bound n)
Mean nn'-oscillation time > 414 s, CL = 90% [h]

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

$\lambda \equiv g_A\ /\ g_V = -1.2723 \pm 0.0023$ (S = 2.2)
$A = -0.1184 \pm 0.0010$ (S = 2.4)
$B = 0.9807 \pm 0.0030$
$C = -0.2377 \pm 0.0026$
$a = -0.103 \pm 0.004$
$\phi_{AV} = (180.017 \pm 0.026)^\circ$ [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
$\quad p e^- \overline{\nu}_e \gamma$	[l]	(3.09±0.32) × 10^{-3}		1
Charge conservation (Q) violating mode				
$p \nu_e \overline{\nu}_e$	Q	< 8 × 10^{-27}	68%	1

$N(1440)\ 1/2^+$

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

Breit-Wigner mass = 1410 to 1450 (≈ 1430) 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 %	391
$N\eta$	<1 %	†
$N\pi\pi$	25–50 %	338
$\quad \Delta(1232)\pi$	20–30 %	135
$\quad\quad \Delta(1232)\pi$, P-wave	13–27 %	135
$\quad N\sigma$	11–23 %	–
$p\gamma$, helicity=1/2	0.035–0.048 %	407
$n\gamma$, helicity=1/2	0.02–0.04 %	406

$N(1520)\ 3/2^-$

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

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 125 (≈ 115) MeV

***N*(1520) DECAY MODES**	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	55–65 %	453
$N\eta$	< 1 %	142
$N\pi\pi$	25–35 %	410
$\quad \Delta(1232)\pi$	22–34 %	225
$\quad\quad \Delta(1232)\pi$, S-wave	15–23 %	225
$\quad\quad \Delta(1232)\pi$, D-wave	7–11 %	225
$\quad N\sigma$	< 2 %	–
$p\gamma$	0.31–0.52 %	467
$\quad p\gamma$, helicity=1/2	0.01–0.02 %	467
$\quad p\gamma$, 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) = 1490 to 1530 (≈ 1510) MeV
-2Im(pole position) = 90 to 250 (≈ 170) MeV
Breit-Wigner mass = 1525 to 1545 (≈ 1535) MeV
Breit-Wigner full width = 125 to 175 (≈ 150) MeV

***N*(1535) DECAY MODES**	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	35–55 %	468
$N\eta$	32–52 %	186
$N\pi\pi$	3–14 %	426
$\Delta(1232)\pi$, *D*-wave	1–4 %	244
$N\sigma$	2–10 %	–
$N(1440)\pi$	5–12 %	†
$p\gamma$, helicity=1/2	0.15–0.30 %	481
$n\gamma$, helicity=1/2	0.01–0.25 %	480

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 = 1645 to 1670 (≈ 1655) MeV
Breit-Wigner full width = 110 to 170 (≈ 140) MeV

***N*(1650) DECAY MODES**	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	50–70 %	551
$N\eta$	14–22 %	354
ΛK	5–15 %	179
$N\pi\pi$	8–36 %	517
$\Delta(1232)\pi$, *D*-wave	6–18 %	349
$N\sigma$	2–18 %	–
$N(1440)\pi$	6–26 %	168
$p\gamma$, helicity=1/2	0.04–0.20 %	562
$n\gamma$, helicity=1/2	0.003–0.17 %	561

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

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

Re(pole position) = 1655 to 1665 ($\approx$ 1660) MeV
-2Im(pole position) = 125 to 150 ($\approx$ 135) MeV
Breit-Wigner mass = 1670 to 1680 ($\approx$ 1675) MeV
Breit-Wigner full width = 130 to 165 ($\approx$ 150) MeV

***N*(1675) DECAY MODES**	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	35–45 %	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 ($\approx$ 1675) MeV
-2Im(pole position) = 110 to 135 ($\approx$ 120) MeV
Breit-Wigner mass = 1680 to 1690 ($\approx$ 1685) MeV
Breit-Wigner full width = 120 to 140 ($\approx$ 130) MeV

***N*(1680) DECAY MODES**	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	65–70 %	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	7–13 %	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 ($\approx$ 1700) MeV
-2Im(pole position) = 100 to 300 MeV
Breit-Wigner mass = 1650 to 1750 ($\approx$ 1700) MeV
Breit-Wigner full width = 100 to 250 ($\approx$ 150) MeV

***N*(1700) DECAY MODES**	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	7–17 %	581
$N\eta$	seen	402
$N\pi\pi$	60–90 %	550
$\Delta(1232)\pi$	55–85 %	386
$\Delta(1232)\pi$, S-wave	50–80 %	386
$\Delta(1232)\pi$, D-wave	4–14 %	386
$N(1440)\pi$	3–11 %	215
$N(1520)\pi$	<4 %	120
$N\rho$, S=3/2, S-wave	seen	†
$N\sigma$	2–14 %	–
$p\gamma$	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

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

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

Re(pole position) = 1670 to 1770 ($\approx$ 1720) MeV
-2Im(pole position) = 80 to 380 ($\approx$ 230) MeV
Breit-Wigner mass = 1680 to 1740 ($\approx$ 1710) MeV
Breit-Wigner full width = 50 to 250 ($\approx$ 100) 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	seen	394
$N(1535)\pi$	9–21 %	106

$N\rho$, S=1/2, P-wave	seen	†
$p\gamma$, 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 (≈ 1675) MeV
−2Im(pole position) = 150 to 400 (≈ 250) MeV
Breit-Wigner mass = 1700 to 1750 (≈ 1720) MeV
Breit-Wigner full width = 150 to 400 (≈ 250) MeV

N(1720) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	8–14 %	594
$N\eta$	1–5 %	422
ΛK	4–5 %	283
$N\pi\pi$	50–90 %	564
$\Delta(1232)\pi$, P-wave	47–77 %	402
$\Delta(1232)\pi$, F-wave	<12 %	402
$N\rho$	70–85 %	74
$N\rho$, S=1/2, P-wave	seen	74
$N\sigma$	2–14 %	–
$N(1440)\pi$	<2 %	235
$N(1520)\pi$, 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) = 1800 to 1950 MeV
−2Im(pole position) = 150 to 250 MeV
Breit-Wigner mass = 1820 to 1920 (≈ 1875) MeV
Breit-Wigner full width = 250 ± 70 MeV

N(1875) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	2–14 %	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 %	373
$N(1520)\pi$	<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

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

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

Re(pole position) = 1900 to 1940 ($\approx$ 1920) MeV
-2Im(pole position) = 130 to 300 MeV
Breit-Wigner mass = 1900 $\pm$ 30 MeV
Breit-Wigner full width = 200 $\pm$ 50 MeV

N(1900) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	<10 %	710
$N\eta$	2–14 %	579
$N\omega$	7–13 %	401
ΛK	2–20 %	477
ΣK	3–7 %	410
$N\pi\pi$	40–80 %	686
$\Delta(1232)\pi$	30–70 %	539
$\Delta(1232)\pi$, P-wave	9–25 %	539
$\Delta(1232)\pi$, F-wave	21–45 %	539
$N\sigma$	1–7 %	–
$N(1520)\pi$	7–23 %	324
$N(1535)\pi$	4–10 %	306
$p\gamma$	0.001–0.025 %	718
$p\gamma$, helicity=1/2	0.001–0.021 %	718
$p\gamma$, helicity=3/2	<0.003 %	718
$n\gamma$	<0.040 %	718
$n\gamma$, helicity=1/2	<0.007 %	718
$n\gamma$, helicity=3/2	<0.033 %	718

$N(2190)\ 7/2^-$

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

Re(pole position) = 2050 to 2100 (≈ 2075) MeV
−2Im(pole position) = 400 to 520 (≈ 450) MeV
Breit-Wigner mass = 2100 to 2200 (≈ 2190) MeV
Breit-Wigner full width = 300 to 700 (≈ 500) MeV

N(2190) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	10–20 %	888
$N\eta$	seen	791
ΛK	0.2–0.8;%	712
$N\pi\pi$	22–80;%	870
$\Delta(1232)\pi$, D-wave	19–31 %	740
$N\rho$, S=3/2, D-wave	seen	680
$N\sigma$	3–9 %	–
$p\gamma$	0.014–0.077 %	894
$p\gamma$, helicity=1/2	0.013–0.062;%	894
$p\gamma$, helicity=3/2	0.001–0.014;%	894
$n\gamma$	<0.04 %	893
$n\gamma$, helicity=1/2	<0.01;%	893
$n\gamma$, helicity=3/2	<0.03 %	893

$N(2220)\ 9/2^+$

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

Re(pole position) = 2130 to 2200 (≈ 2170) MeV
−2Im(pole position) = 400 to 560 (≈ 480) MeV
Breit-Wigner mass = 2200 to 2300 (≈ 2250) MeV
Breit-Wigner full width = 350 to 500 (≈ 400) MeV

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

$N(2250)\ 9/2^-$

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

Re(pole position) = 2150 to 2250 (≈ 2200) MeV
−2Im(pole position) = 350 to 550 (≈ 450) MeV
Breit-Wigner mass = 2250 to 2320 (≈ 2280) MeV
Breit-Wigner full width = 300 to 600 (≈ 500) MeV

***N*(2250) DECAY MODES**	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	5–15 %	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)
$N\pi$	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 $\left|m_p - m_{\overline{p}}\right|/m_p$ 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 15 and 340 keV.