

Δ BARYONS

($S = 0, I = 3/2$)

$$\Delta^{++} = uuu, \quad \Delta^+ = uud, \quad \Delta^0 = udd, \quad \Delta^- = ddd$$

Δ(1232) 3/2⁺

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

Re(pole position) = 1209 to 1211 (≈ 1210) MeV

−2Im(pole position) = 98 to 102 (≈ 100) MeV

Breit-Wigner mass (mixed charges) = 1230 to 1234 (≈ 1232) MeV

Breit-Wigner full width (mixed charges) = 114 to 120 (≈ 117) MeV

| Δ(1232) DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|--------------------------|--------------------------------|-------------|
| $N\pi$ | 99.4 % | 229 |
| $N\gamma$ | 0.55–0.65 % | 259 |
| $N\gamma$, helicity=1/2 | 0.11–0.13 % | 259 |
| $N\gamma$, helicity=3/2 | 0.44–0.52 % | 259 |

Δ(1600) 3/2⁺

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

Re(pole position) = 1460 to 1560 (≈ 1510) MeV

−2Im(pole position) = 200 to 350 (≈ 275) MeV

Breit-Wigner mass = 1500 to 1700 (≈ 1600) MeV

Breit-Wigner full width = 220 to 420 (≈ 320) MeV

| Δ(1600) DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|--------------------------------|--------------------------------|-------------|
| $N\pi$ | 10–25 % | 513 |
| $N\pi\pi$ | 75–90 % | 477 |
| Δ(1232) π | 73–83 % | 303 |
| Δ(1232) π , <i>P</i> -wave | 72–82 % | 303 |
| Δ(1232) π , <i>F</i> -wave | <2 % | 303 |
| $N(1440)\pi$, <i>P</i> -wave | seen | 98 |
| $N\gamma$ | 0.001–0.035 % | 525 |
| $N\gamma$, helicity=1/2 | 0.0–0.02 % | 525 |
| $N\gamma$, helicity=3/2 | 0.001–0.015 % | 525 |

$\Delta(1620) 1/2^-$

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

Re(pole position) = 1590 to 1610 (≈ 1600) MeV $-2\text{Im}(\text{pole position}) = 120$ to 140 (≈ 130) MeVBreit-Wigner mass = 1600 to 1660 (≈ 1630) MeVBreit-Wigner full width = 130 to 150 (≈ 140) MeV

| $\Delta(1620)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|--|--------------------------------|-------------|
| $N\pi$ | 20–30 % | 534 |
| $N\pi\pi$ | 55–80 % | 499 |
| $\Delta(1232)\pi$, <i>D</i> -wave | 52–72 % | 328 |
| $N\rho$, $S=1/2$, <i>S</i> -wave | seen | † |
| $N\rho$, $S=3/2$, <i>D</i> -wave | seen | † |
| $N(1440)\pi$ | 3–9 % | 138 |
| $N\gamma$, helicity= $1/2$ | 0.03–0.10 % | 545 |

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

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

Re(pole position) = 1620 to 1680 (≈ 1650) MeV $-2\text{Im}(\text{pole position}) = 160$ to 300 (≈ 230) MeVBreit-Wigner mass = 1670 to 1750 (≈ 1700) MeVBreit-Wigner full width = 200 to 400 (≈ 300) MeV

| $\Delta(1700)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|--|--------------------------------|-------------|
| $N\pi$ | 10–20 % | 581 |
| $N\pi\pi$ | 10–55 % | 550 |
| $\Delta(1232)\pi$ | 10–50 % | 386 |
| $\Delta(1232)\pi$, <i>S</i> -wave | 5–35 % | 386 |
| $\Delta(1232)\pi$, <i>D</i> -wave | 4–16 % | 386 |
| $N\rho$, $S=3/2$, <i>S</i> -wave | seen | † |
| $N(1520)\pi$, <i>P</i> -wave | 1–5 % | 120 |
| $N(1535)\pi$ | 0.5–1.5 % | 90 |
| $\Delta(1232)\eta$ | 3–7 % | † |
| $N\gamma$ | 0.22–0.60 % | 591 |
| $N\gamma$, helicity= $1/2$ | 0.12–0.30 % | 591 |
| $N\gamma$, helicity= $3/2$ | 0.10–0.30 % | 591 |

$\Delta(1905) 5/2^+$

$$I(J^P) = \frac{3}{2}(\frac{5}{2}^+)$$

Re(pole position) = 1805 to 1835 (≈ 1820) MeV
 $-2\text{Im}(\text{pole position}) = 265$ to 300 (≈ 280) MeV
 Breit-Wigner mass = 1855 to 1910 (≈ 1880) MeV
 Breit-Wigner full width = 270 to 400 (≈ 330) MeV

| $\Delta(1905)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|--|--------------------------------|-------------|
| $N\pi$ | 9–15 % | 698 |
| $N\pi\pi$ | | 673 |
| $\Delta(1232)\pi$, P -wave | 23–43 % | 524 |
| $\Delta(1232)\pi$, F -wave | seen | 524 |
| $N\rho$, $S=3/2$, P -wave | seen | 385 |
| $N(1535)\pi$ | < 1 % | 288 |
| $N(1680)\pi$, P -wave | 5–15 % | 133 |
| $\Delta(1232)\eta$ | 2–6 % | 282 |
| $N\gamma$ | 0.012–0.036 % | 706 |
| $N\gamma$, helicity=1/2 | 0.002–0.006 % | 706 |
| $N\gamma$, helicity=3/2 | 0.01–0.03 % | 706 |

 $\Delta(1910) 1/2^+$

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

Re(pole position) = 1830 to 1880 (≈ 1855) MeV
 $-2\text{Im}(\text{pole position}) = 200$ to 500 (≈ 350) MeV
 Breit-Wigner mass = 1860 to 1910 (≈ 1890) MeV
 Breit-Wigner full width = 220 to 340 (≈ 280) MeV

| $\Delta(1910)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|--|--------------------------------|-------------|
| $N\pi$ | 15–30 % | 704 |
| ΣK | 4–14 % | 400 |
| $N\pi\pi$ | | 680 |
| $\Delta(1232)\pi$ | 34–66 % | 531 |
| $N(1440)\pi$ | 3–9 % | 386 |
| $\Delta(1232)\eta$ | 5–13 % | 296 |
| $N\gamma$, helicity=1/2 | 0.0–0.02 % | 712 |

 $\Delta(1920) 3/2^+$

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

Re(pole position) = 1850 to 1950 (≈ 1900) MeV
 $-2\text{Im}(\text{pole position}) = 200$ to 400 (≈ 300) MeV
 Breit-Wigner mass = 1900 to 1970 (≈ 1920) MeV
 Breit-Wigner full width = 180 to 300 (≈ 260) MeV

| $\Delta(1920)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|-------------------------------|--------------------------------|-------------|
| $N\pi$ | 5–20 % | 723 |
| ΣK | 2–6 % | 431 |
| $N\pi\pi$ | | 699 |
| $\Delta(1232)\pi$ | 50–90 % | 553 |
| $\Delta(1232)\pi$, P -wave | 8–28 % | 553 |
| $\Delta(1232)\pi$, F -wave | 44–72 % | 553 |
| $N(1440)\pi$, P -wave | <4 % | 411 |
| $N(1520)\pi$, S -wave | <5 % | 341 |
| $N(1535)\pi$ | <2 % | 324 |
| $N a_0(980)$ | seen | 41 |
| $\Delta(1232)\eta$ | 5–17 % | 336 |

 $\Delta(1930) 5/2^-$

$$I(J^P) = \frac{3}{2}(\frac{5}{2}^-)$$

Re(pole position) = 1840 to 1960 (\approx 1900) MeV
 $-2\text{Im}(\text{pole position}) = 175$ to 360 (\approx 270) MeV
 Breit-Wigner mass = 1900 to 2000 (\approx 1950) MeV
 Breit-Wigner full width = 220 to 500 (\approx 360) MeV

| $\Delta(1930)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\pi$ | 5–15 % | 742 |
| $N\gamma$ | 0.0–0.01 % | 749 |
| $N\gamma$, helicity=1/2 | 0.0–0.005 % | 749 |
| $N\gamma$, helicity=3/2 | 0.0–0.004 % | 749 |

 $\Delta(1950) 7/2^+$

$$I(J^P) = \frac{3}{2}(\frac{7}{2}^+)$$

Re(pole position) = 1870 to 1890 (\approx 1880) MeV
 $-2\text{Im}(\text{pole position}) = 220$ to 260 (\approx 240) MeV
 Breit-Wigner mass = 1915 to 1950 (\approx 1930) MeV
 Breit-Wigner full width = 235 to 335 (\approx 285) MeV

| $\Delta(1950)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|-------------------------------|--------------------------------|-------------|
| $N\pi$ | 35–45 % | 729 |
| ΣK | 0.3–0.5 % | 441 |
| $N\pi\pi$ | | 706 |
| $\Delta(1232)\pi$, F -wave | 1–9 % | 560 |
| $N(1680)\pi$, P -wave | 3–9 % | 191 |
| $\Delta(1232)\eta$ | < 1 % | 349 |

$\Delta(2420) 11/2^+$

$$I(J^P) = \frac{3}{2}(\frac{11}{2}^+)$$

Re(pole position) = 2260 to 2400 (≈ 2330) MeV

$-2\text{Im}(\text{pole position}) = 350$ to 750 (≈ 550) MeV

Breit-Wigner mass = 2300 to 2500 (≈ 2420) MeV

Breit-Wigner full width = 300 to 500 (≈ 400) MeV

| $\Delta(2420)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|--|--------------------------------|-------------|
| $N\pi$ | 5–15 % | 1023 |