

# Δ BARYONS

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

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

### Δ(1232) 3/2<sup>+</sup>

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

Re(pole position) = 1209 to 1211 ( $\approx 1210$ ) MeV

$-2\text{Im}(\text{pole position}) = 98$  to  $102$  ( $\approx 100$ ) MeV

Breit-Wigner mass (mixed charges) = 1230 to 1234 ( $\approx 1232$ ) MeV

Breit-Wigner full width (mixed charges) = 114 to 120 ( $\approx 117$ ) MeV

Δ(1232) DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (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<sup>+</sup>

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

Re(pole position) = 1460 to 1560 ( $\approx 1510$ ) MeV

$-2\text{Im}(\text{pole position}) = 200$  to  $350$  ( $\approx 275$ ) MeV

Breit-Wigner mass = 1500 to 1700 ( $\approx 1600$ ) MeV

Breit-Wigner full width = 220 to 420 ( $\approx 320$ ) MeV

Δ(1600) DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\pi$	10–25 %	513
$N\pi\pi$	75–90 %	477
Δ(1232) $\pi$	73–83 %	303
Δ(1232) $\pi$ , $P$ -wave	72–82 %	303
Δ(1232) $\pi$ , $F$ -wave	<2 %	303
$N(1440)\pi$ , $P$ -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 ( $\approx 1600$ ) MeV $-2\text{Im}(\text{pole position}) = 120$  to  $140$  ( $\approx 130$ ) MeVBreit-Wigner mass = 1600 to 1660 ( $\approx 1630$ ) MeVBreit-Wigner full width = 130 to 150 ( $\approx 140$ ) MeV

<b><math>\Delta(1620)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (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 ( $\approx 1650$ ) MeV $-2\text{Im}(\text{pole position}) = 160$  to  $300$  ( $\approx 230$ ) MeVBreit-Wigner mass = 1670 to 1750 ( $\approx 1700$ ) MeVBreit-Wigner full width = 200 to 400 ( $\approx 300$ ) MeV

<b><math>\Delta(1700)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (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 ( $\approx 1820$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 265$  to  $300$  ( $\approx 280$ ) MeV  
 Breit-Wigner mass = 1855 to 1910 ( $\approx 1880$ ) MeV  
 Breit-Wigner full width = 270 to 400 ( $\approx 330$ ) MeV

<b><math>\Delta(1905)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (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 ( $\approx 1855$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 200$  to  $500$  ( $\approx 350$ ) MeV  
 Breit-Wigner mass = 1860 to 1910 ( $\approx 1890$ ) MeV  
 Breit-Wigner full width = 220 to 340 ( $\approx 280$ ) MeV

<b><math>\Delta(1910)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\pi$	15–30 %	704
$\Sigma K$	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 ( $\approx 1900$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 200$  to  $400$  ( $\approx 300$ ) MeV  
 Breit-Wigner mass = 1900 to 1970 ( $\approx 1920$ ) MeV  
 Breit-Wigner full width = 180 to 300 ( $\approx 260$ ) MeV

$\Delta(1920)$ DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\pi$	5–20 %	723
$\Sigma K$	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 ( $\Gamma_i/\Gamma$ )	$p$ (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 ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\pi$	35–45 %	729
$\Sigma K$	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 ( $\approx 2330$ ) MeV $-2\text{Im}(\text{pole position}) = 350$  to 750 ( $\approx 550$ ) MeVBreit-Wigner mass = 2300 to 2500 ( $\approx 2420$ ) MeVBreit-Wigner full width = 300 to 500 ( $\approx 400$ ) MeV

<b><math>\Delta(2420)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\pi$	5–15 %	1023