

# Δ BARYONS

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

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

### Δ(1232) $P_{33}$

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

Breit-Wigner mass (mixed charges) = 1231 to 1233 ( $\approx 1232$ ) MeV

Breit-Wigner full width (mixed charges) = 116 to 120 ( $\approx 118$ ) MeV

$$p_{\text{beam}} = 0.30 \text{ GeV}/c \quad 4\pi\lambda^2 = 94.8 \text{ mb}$$

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

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

Δ(1232) DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\pi$	100 %	229
$N\gamma$	0.52–0.60 %	259
$N\gamma$ , helicity=1/2	0.11–0.13 %	259
$N\gamma$ , helicity=3/2	0.41–0.47 %	259

### Δ(1600) $P_{33}$

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

Breit-Wigner mass = 1550 to 1700 ( $\approx 1600$ ) MeV

Breit-Wigner full width = 250 to 450 ( $\approx 350$ ) MeV

$$p_{\text{beam}} = 0.87 \text{ GeV}/c \quad 4\pi\lambda^2 = 18.6 \text{ mb}$$

Re(pole position) = 1500 to 1700 ( $\approx 1600$ ) MeV

$-2\text{Im}(\text{pole position}) = 200$  to  $400$  ( $\approx 300$ ) MeV

Δ(1600) DECAY MODES	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\pi$	10–25 %	513
$N\pi\pi$	75–90 %	477
$\Delta\pi$	40–70 %	303
$N\rho$	<25 %	†
$N(1440)\pi$	10–35 %	82
$N\gamma$	0.001–0.02 %	525
$N\gamma$ , helicity=1/2	0.0–0.02 %	525
$N\gamma$ , helicity=3/2	0.001–0.005 %	525

**$\Delta(1620) S_{31}$**

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

Breit-Wigner mass = 1600 to 1660 ( $\approx 1630$ ) MeV  
 Breit-Wigner full width = 135 to 150 ( $\approx 145$ ) MeV  
 $p_{\text{beam}} = 0.93 \text{ GeV}/c$        $4\pi\lambda^2 = 17.2 \text{ mb}$   
 Re(pole position) = 1590 to 1610 ( $\approx 1600$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 115 \text{ to } 120$  ( $\approx 118$ ) MeV

<b><math>\Delta(1620)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\pi$	20–30 %	534
$N\pi\pi$	70–80 %	499
$\Delta\pi$	30–60 %	328
$N\rho$	7–25 %	†
$N\gamma$	0.004–0.044 %	545
$N\gamma$ , helicity=1/2	0.004–0.044 %	545

**$\Delta(1700) D_{33}$**

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

Breit-Wigner mass = 1670 to 1750 ( $\approx 1700$ ) MeV  
 Breit-Wigner full width = 200 to 400 ( $\approx 300$ ) MeV  
 $p_{\text{beam}} = 1.05 \text{ GeV}/c$        $4\pi\lambda^2 = 14.5 \text{ mb}$   
 Re(pole position) = 1620 to 1680 ( $\approx 1650$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 160 \text{ to } 240$  ( $\approx 200$ ) MeV

<b><math>\Delta(1700)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\pi$	10–20 %	581
$N\pi\pi$	80–90 %	550
$\Delta\pi$	30–60 %	386
$N\rho$	30–55 %	†
$N\gamma$	0.12–0.26 %	591
$N\gamma$ , helicity=1/2	0.08–0.16 %	591
$N\gamma$ , helicity=3/2	0.025–0.12 %	591

**$\Delta(1905) F_{35}$**

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

Breit-Wigner mass = 1865 to 1915 ( $\approx 1890$ ) MeV  
 Breit-Wigner full width = 270 to 400 ( $\approx 330$ ) MeV  
 $p_{\text{beam}} = 1.42 \text{ GeV}/c$        $4\pi\lambda^2 = 9.89 \text{ mb}$   
 Re(pole position) = 1825 to 1835 ( $\approx 1830$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 265 \text{ to } 300$  ( $\approx 280$ ) MeV

<b><math>\Delta(1905)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$\rho$ (MeV/c)
$N\pi$	0.09 to 0.15	704
$N\pi\pi$	85–95 %	680
$\Delta\pi$	<25 %	531
$N\rho$	>60 %	397
$N\gamma$	0.01–0.03 %	712
$N\gamma$ , helicity=1/2	0.0–0.1 %	712
$N\gamma$ , helicity=3/2	0.004–0.03 %	712

### **$\Delta(1910) P_{31}$**

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

Breit-Wigner mass = 1870 to 1920 ( $\approx 1910$ ) MeV  
 Breit-Wigner full width = 190 to 270 ( $\approx 250$ ) MeV  
 $p_{\text{beam}} = 1.46 \text{ GeV}/c$        $4\pi\lambda^2 = 9.54 \text{ mb}$   
 Re(pole position) = 1830 to 1880 ( $\approx 1855$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 200$  to 500 ( $\approx 350$ ) MeV

<b><math>\Delta(1910)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$\rho$ (MeV/c)
$N\pi$	15–30 %	717
$N\gamma$	0.0–0.2 %	725
$N\gamma$ , helicity=1/2	0.0–0.2 %	725

### **$\Delta(1920) P_{33}$**

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

Breit-Wigner mass = 1900 to 1970 ( $\approx 1920$ ) MeV  
 Breit-Wigner full width = 150 to 300 ( $\approx 200$ ) MeV  
 $p_{\text{beam}} = 1.48 \text{ GeV}/c$        $4\pi\lambda^2 = 9.37 \text{ mb}$   
 Re(pole position) = 1850 to 1950 ( $\approx 1900$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 200$  to 400 ( $\approx 300$ ) MeV

<b><math>\Delta(1920)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$\rho$ (MeV/c)
$N\pi$	5–20 %	723
$\Sigma K$	$(2.10 \pm 0.30) \%$	431

### **$\Delta(1930) D_{35}$**

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

Breit-Wigner mass = 1900 to 2020 ( $\approx 1960$ ) MeV  
 Breit-Wigner full width = 220 to 500 ( $\approx 360$ ) MeV  
 $p_{\text{beam}} = 1.56 \text{ GeV}/c$        $4\pi\lambda^2 = 8.76 \text{ mb}$   
 Re(pole position) = 1840 to 1960 ( $\approx 1900$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 175$  to 360 ( $\approx 270$ ) MeV

<b><math>\Delta(1930)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\pi$	0.05 to 0.15	748
$N\gamma$	0.0–0.02 %	755
$N\gamma$ , helicity=1/2	0.0–0.01 %	755
$N\gamma$ , helicity=3/2	0.0–0.01 %	755

### **$\Delta(1950) F_{37}$**

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

Breit-Wigner mass = 1915 to 1950 ( $\approx 1930$ ) MeV

Breit-Wigner full width = 235 to 335 ( $\approx 285$ ) MeV

$$p_{\text{beam}} = 1.50 \text{ GeV}/c \quad 4\pi\lambda^2 = 9.21 \text{ mb}$$

Re(pole position) = 1870 to 1890 ( $\approx 1880$ ) MeV

–2Im(pole position) = 220 to 260 ( $\approx 240$ ) MeV

<b><math>\Delta(1950)</math> DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	$p$ (MeV/c)
$N\pi$	0.35 to 0.45	729
$N\pi\pi$		706
$\Delta\pi$	20–30 %	560
$N\rho$	<10 %	442
$N\gamma$	0.08–0.13 %	737
$N\gamma$ , helicity=1/2	0.03–0.055 %	737
$N\gamma$ , helicity=3/2	0.05–0.075 %	737

### **$\Delta(2420) H_{3,11}$**

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

Breit-Wigner mass = 2300 to 2500 ( $\approx 2420$ ) MeV

Breit-Wigner full width = 300 to 500 ( $\approx 400$ ) MeV

$$p_{\text{beam}} = 2.64 \text{ GeV}/c \quad 4\pi\lambda^2 = 4.68 \text{ mb}$$

Re(pole position) = 2260 to 2400 ( $\approx 2330$ ) MeV

–2Im(pole position) = 350 to 750 ( $\approx 550$ ) MeV

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