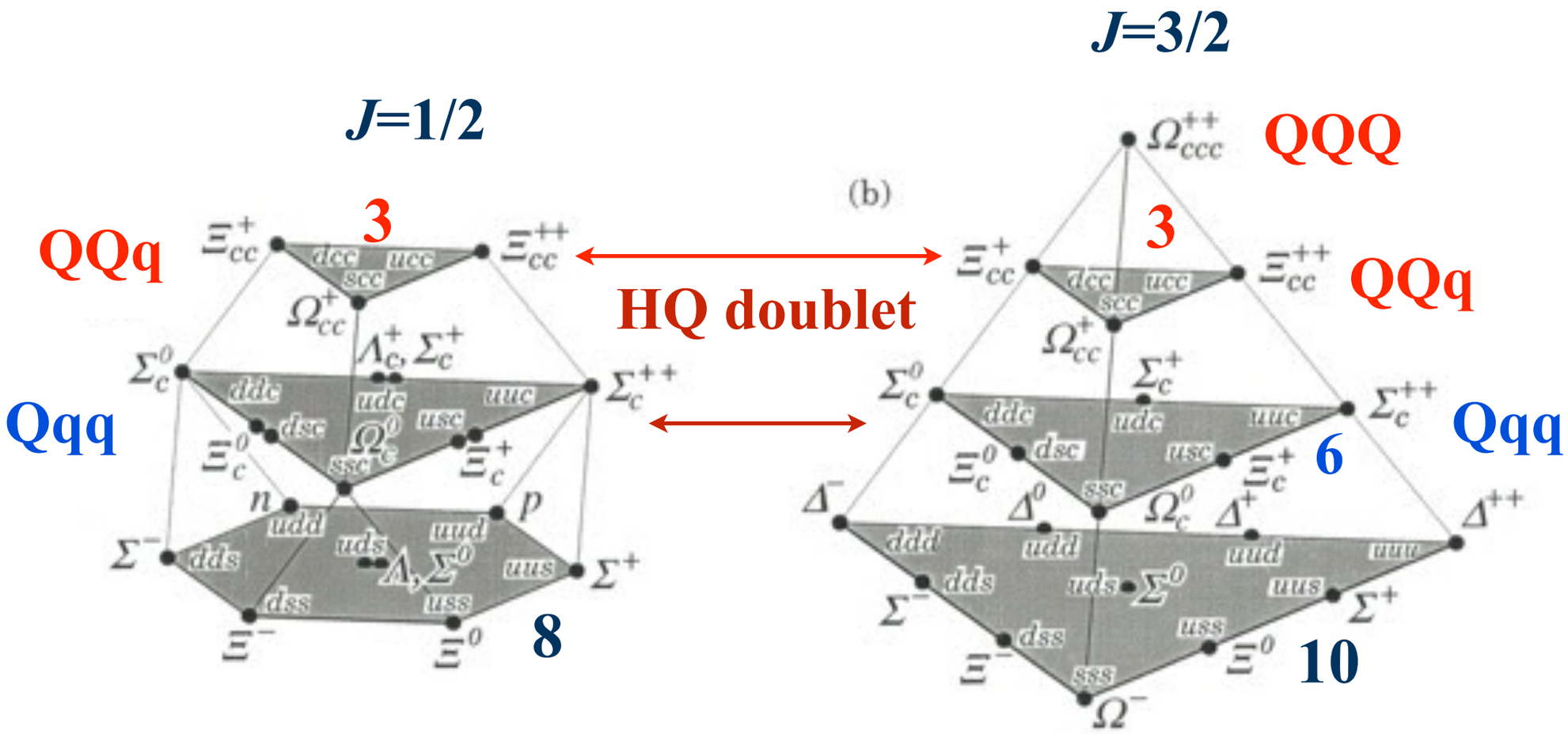
Ground states



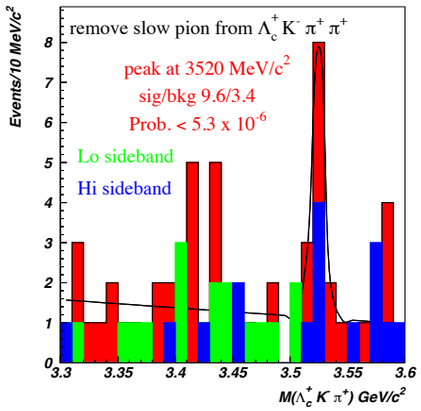
Oka 2/27/2014

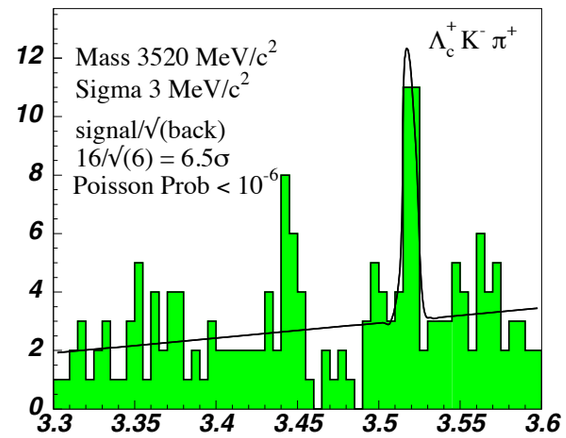
Double Charm Baryon(s) Ξ_{cc}

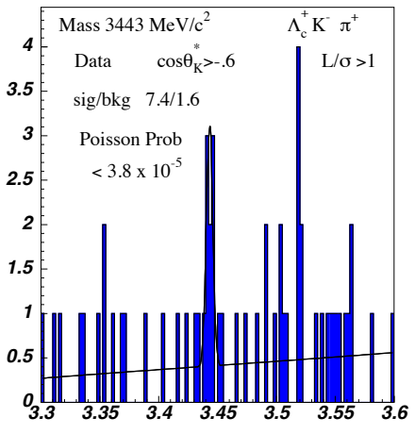
- **SELEX @ FNAL, fixed target experiment at Fermilab**
  Observed Ξ_{cc}^{+} in $\Lambda_c K\pi$ invariant mass spectrum in 2002.
  Further observations of two other states during 2002-2009.

Double Charm Baryon(s) Ξ_{cc}

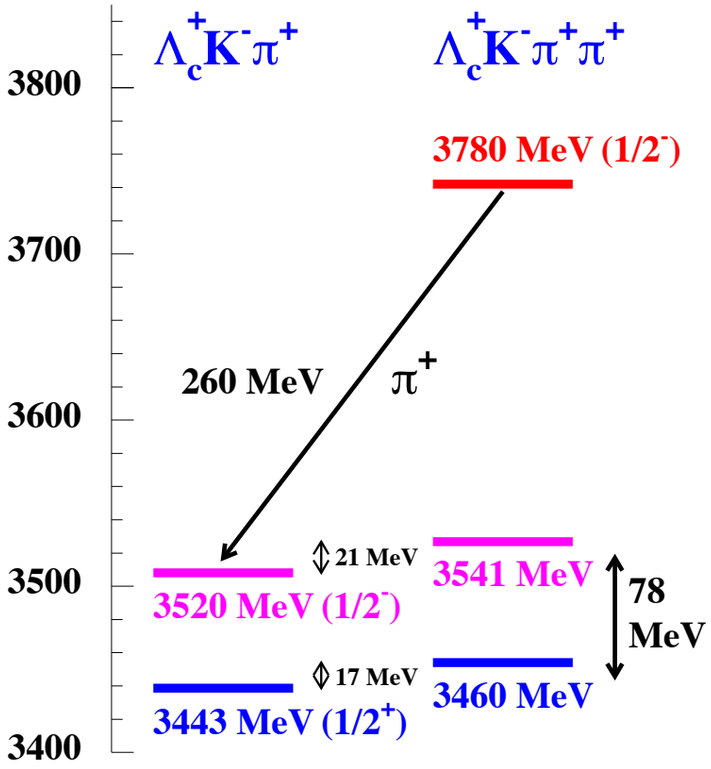
SELEX @ FNAL, fixed target experiment at Fermilab

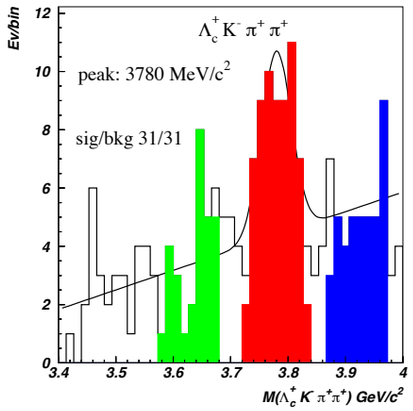


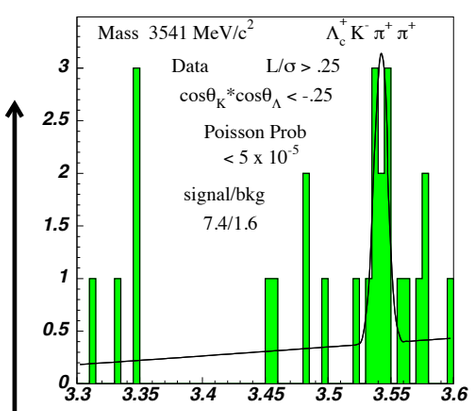


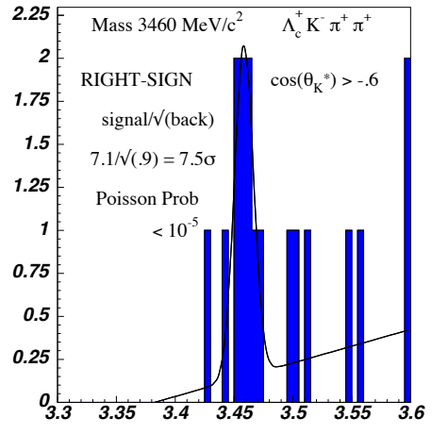


An exited state and a pair of isodoublets?









Oka 2/27/2014

Double Charm Baryon(s) Ξ_{cc}

- **SELEX @ FNAL, fixed target experiment at Fermilab**
  Observed Ξ_{cc}^{+} in $\Lambda_c K\pi$ invariant mass spectrum in 2002.
  Further observations of two other states during 2002-2009.
- **No evidence from Belle, FOCUS, BaBar**

LHCb: arXiv:1312.1601

Ξ_{cc}^{+} Search - Analysis Outline

- Search for particle in decay $\Xi_{cc}^{+} \to (\Lambda_c^+ \to p^+ K^- \pi^+) K^- \pi^+$
- Using $0.65 fb^{-1}$ of 2011 data at $\sqrt{s} = 7$ TeV
  Relevant triggers only online for half the year
- Measure production ratio relative to control $\Lambda_c^+ \to p^+ K^- \pi^+$:

$$R \equiv \frac{\sigma(\Xi_{cc}^{+})\mathcal{B}(\Xi_{cc}^{+} \to \Lambda_c^+ K^- \pi^+)}{\sigma(\Lambda_c^+)} = \frac{N_{signal}}{N_{control}} \frac{\epsilon_{control}}{\epsilon_{signal}}$$

  - Measured LHCb Λ_c^+ cross-section at $\sqrt{s} = 7 TeV \approx 230 \mu b$
    NUCL.PHYS.B871,1-20
  - Predicted LHC Ξ_{cc}^{+} cross-section at $\sqrt{s} = 14 TeV \approx (60 - 1800) nb$.
    At $\sqrt{s} = 7$ TeV expected to be roughly half this
- Assuming the following:

$$\mathcal{B}(\Xi_{cc}^{+} \to \Lambda_c^+ K^- \pi^+) \approx \mathcal{B}(\Lambda_c^+ \to p^+ K^- \pi^+) \approx 5\%$$

  expected value of R at LHCb is of order 10^{-5} to 10^{-4}
- Analysis performed with a blind approach.

$1/2^-$	$(70,1_1^-)$	$1/2\,N(1535)$	$\Lambda(1670)$	$\Sigma(1620)$	$\Xi(?)$	$\Lambda(1405)$
				$\Sigma(1560)^\dagger$		
$3/2^-$	$(70,1_1^-)$	$1/2\,N(1520)$	$\Lambda(1690)$	$\Sigma(1670)$	$\Xi(1820)$	$\Lambda(1520)$
$1/2^-$	$(70,1_1^-)$	$3/2\,N(1650)$	$\Lambda(1800)$	$\Sigma(1750)$	$\Xi(?)$	
				$\Sigma(1620)^\dagger$		
$3/2^-$	$(70,1_1^-)$	$3/2\,N(1700)$	$\Lambda(?)$	$\Sigma(1940)^\dagger$	$\Xi(?)$	
$5/2^-$	$(70,1_1^-)$	$3/2\,N(1675)$	$\Lambda(1830)$	$\Sigma(1775)$	$\Xi(1950)^\dagger$	

$1/2^-$	$(70,1_1^-)$	$1/2\,\Delta(1620)$	$\Sigma(1750)^\dagger$	$\Xi(?)$	$\Omega(?)$	
$3/2^-$	$(70,1_1^-)$	$1/2\,\Delta(1700)$	$\Sigma(?)$	$\Xi(?)$	$\Omega(?)$	

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Λ(sud)
(I=0)

$(j=2)_\rho$ Λ (1830) 5/2

Λ (1800) 1/2 $(j=0)_\rho$

1820
(3/2, 8)

$(S=3/2)_\rho$

$(j=1)_\rho$ Λ (1690) 3/2

Λ (1670) 1/2

1680
(1/2, 8)

$(j=1)_\lambda$ Λ (1520) 3/2

Λ (1405) 1/2

1480
(S=1/2, 1)

Σ (suu,sud,sdd)
(I=1)

$(j=1)_\rho$ Σ (2000) 1/2

Σ (1940) 3/2

1960
(1/2,10)

$(j=2)_\lambda$ Σ (1775) 5/2

Σ (1750) 1/2 $(j=0)_\lambda$

1770
(3/2, 8)

$(j=1)_\lambda$ Σ (1670) 3/2

Σ (1620) 1/2

1650
(S=1/2, 8)

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sud (I=0)	sqq (I=1)	ssq (I=1/2)	cud (I=0, 1)	csq (I=1/2)
Λ (1830) 5/2			Λ_c (2880) 5/2?	
Λ (1800) 1/2	Σ (2000) 1/2	?	Σ_c (2800) ?	
Λ (1690) 3/2	Σ (1940) 3/2	Ξ (2030) ?	?	?
Λ (1670) 1/2	Σ (1775) 5/2	Ξ (1950) ?		
Λ (1520) 3/2	Σ (1750) 1/2	Ξ (1820) 3/2	Λ_c (2625) 3/2	Ξ_c (2815) 3/2
Λ (1405) 1/2	Σ (1670) 3/2 Σ (1620) 1/2	Ξ (1690) ?	Λ_c (2595) 1/2	Ξ_c (2790) 1/2

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$$\sim V_{\rm ss} \sum_{i<j} (\vec{\sigma}_i \cdot \vec{\sigma}_j)\, \delta(\vec{r}_{ij})$$

SU(6)	ss interaction	known Λ (LS ave.)	known Σ (LS ave.)
1(1/2)	-9	1540	-
8(1/2)	-3	1680	1650
8(3/2)	+3	1820	1770
10(1/2)	+3	-	1770

$$\sim V_{\rm ss} \sum_{i<j} (\vec{\sigma}_i \cdot \vec{\sigma}_j)\, \delta(\vec{r}_{ij})$$

SU(6)	ss interaction	known Λ (LS ave.)	known Σ (LS ave.)
1(1/2)	-9	1540 → 1480	-
8(1/2)	-3	1680	1650
8(3/2)	+3	1820	1770
10(1/2)	+3	-	1770 → 1960