Charmed Baryons Spectroscopy

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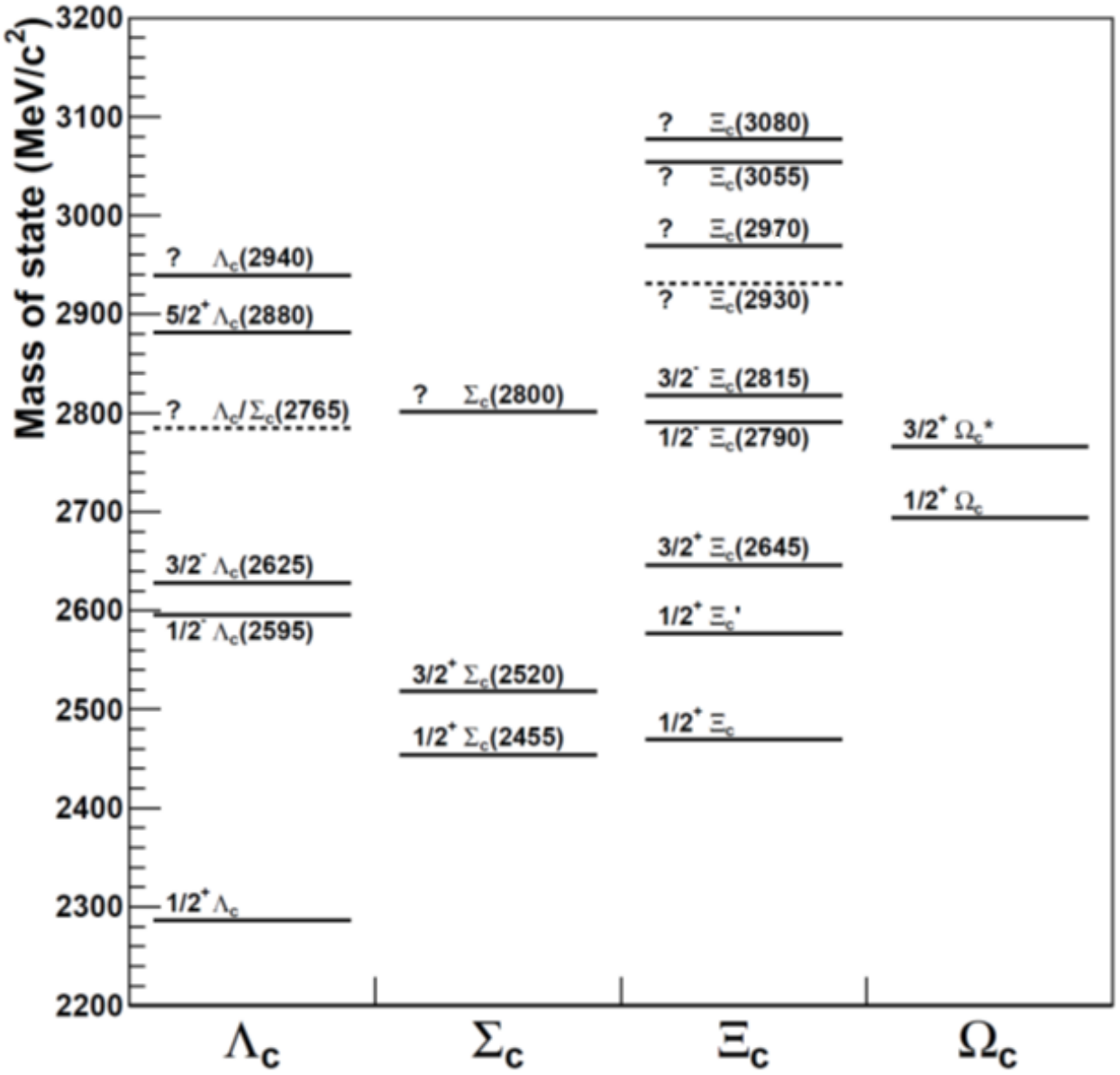
Known Charmed Baryon States



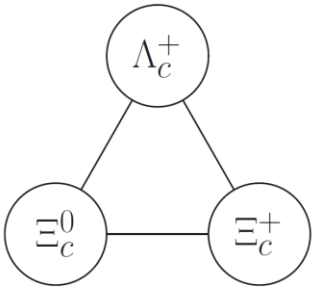
$\mathfrak{B}_c$ = c + diquark

Quark content of diquark:

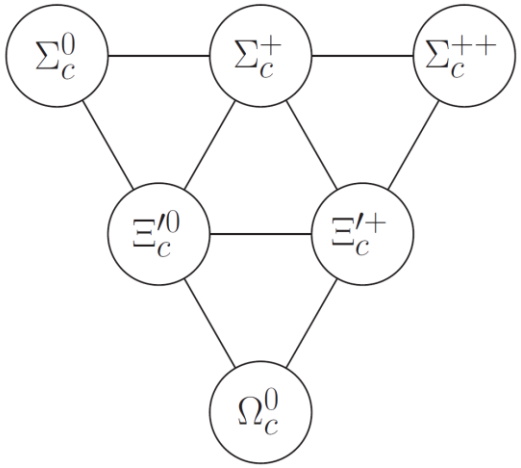
- qq with isospin 0 (flavor antisymmetric) — Λ_c **family**;
- qq with isospin 1 (flavor symmetric) — Σ_c **family**;
- qs with isospin $\frac{1}{2}$ — Ξ_c **family**;
- ss with isospin 0 (flavor symmetric) — Ω_c **family**.

Ground States

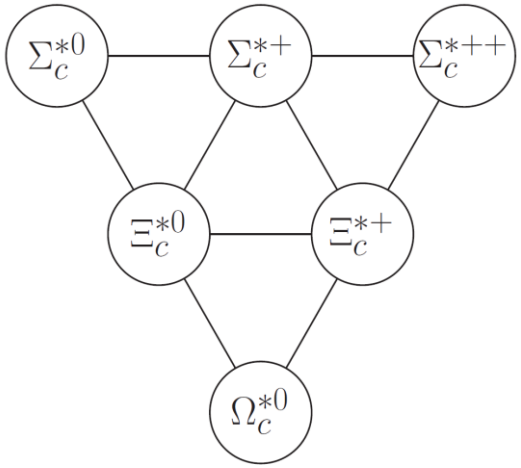
$j = 0, J^P = \frac{1}{2}^+$

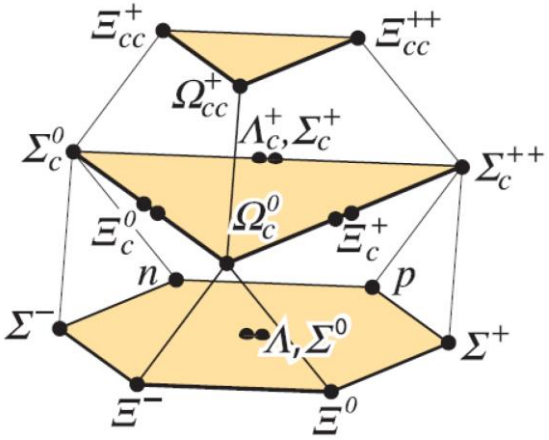


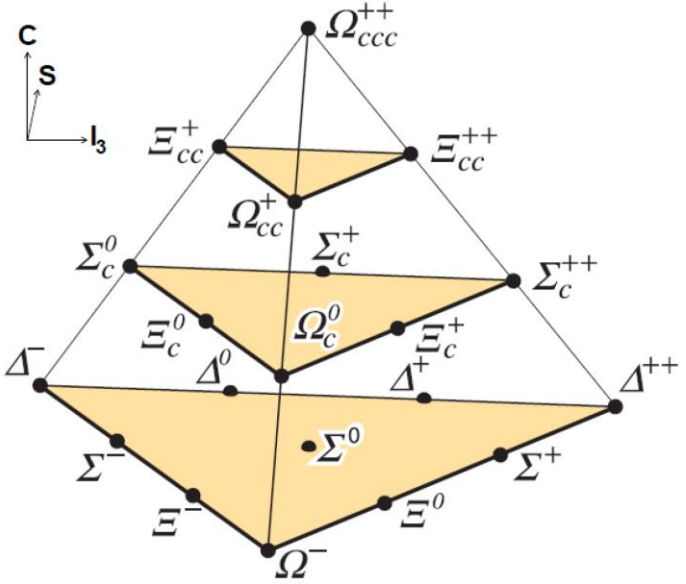
$j = 1, J^P = \frac{1}{2}^+$



$j = 1, J^P = \frac{3}{2}^+$



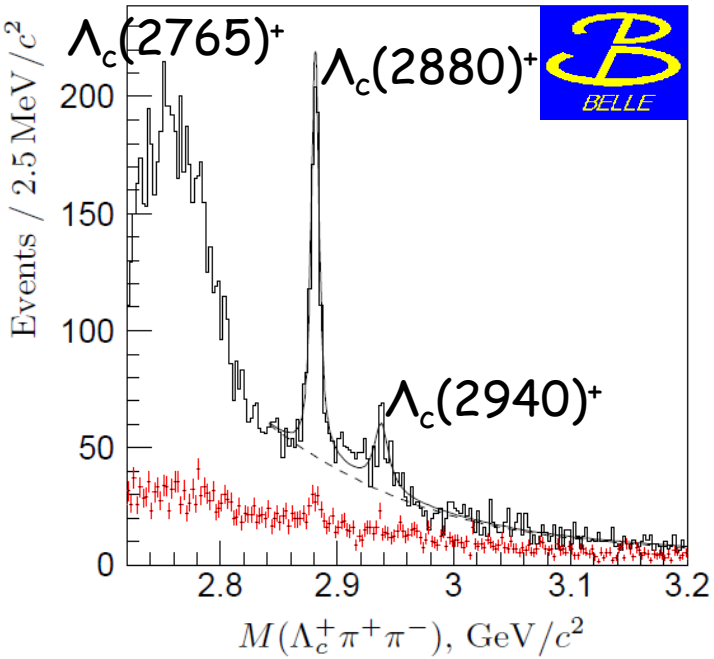




Λ_c Family

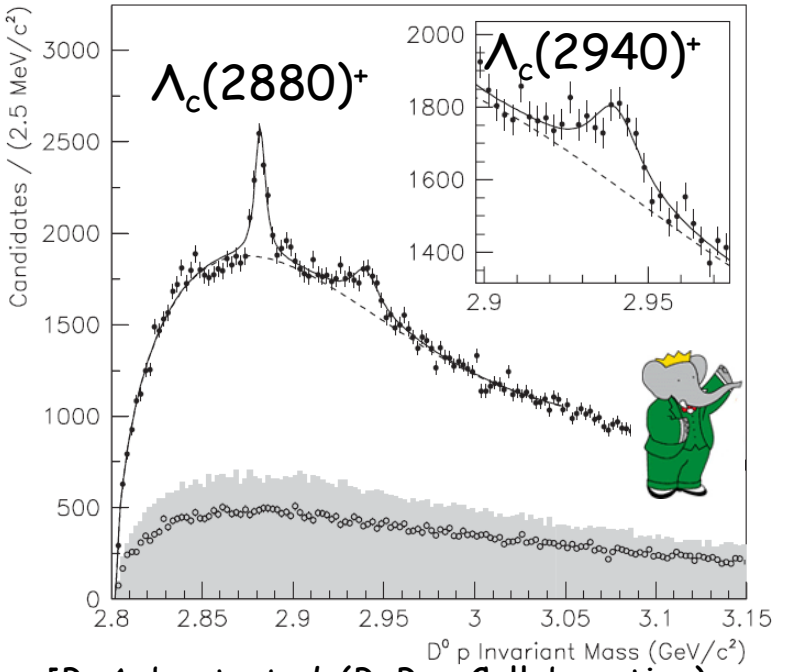
State	Decay mode	Mass, MeV/c^2	Width, MeV/c^2	J^P
$\Lambda_c(2595)^+$	$\Lambda_c^+\pi^+\pi^-$, $\Sigma_c\pi$	$2592,3 \pm 0,3$	$2,6 \pm 0,6$	$\frac{1}{2}^-$
$\Lambda_c(2625)^+$	$\Lambda_c^+\pi^+\pi^-$, $\Sigma_c\pi$	$2628,11 \pm 0,19$	$< 0,97$ @ 90% CL	$\frac{3}{2}^-$
$\Lambda_c(2765)^+$	$\Lambda_c^+\pi^+\pi^-$, $\Sigma_c\pi$	$2766,6 \pm 2,4$	~ 50	
$\Lambda_c(2880)^+$	$\Lambda_c^+\pi^+\pi^-$, $\Sigma_c\pi$, $\Sigma_c(2520)\pi$, D^0p	$2881,5 \pm 0,4$	$5,8 \pm 1,1$	$\frac{5}{2}^+$
$\Lambda_c(2940)^+$	D^0p, $\Sigma_c\pi$	$2939,3^{+1,4}_{-1,5}$	17^{+8}_{-6}	

$\Lambda_c \rightarrow \Sigma_c^{0,++}\pi^\pm$



[R. Mizuk *et al.* (Belle Collaboration), Phys. Rev. Lett. **98**, 262001 (2007)]

$\Lambda_c \rightarrow D^0p$

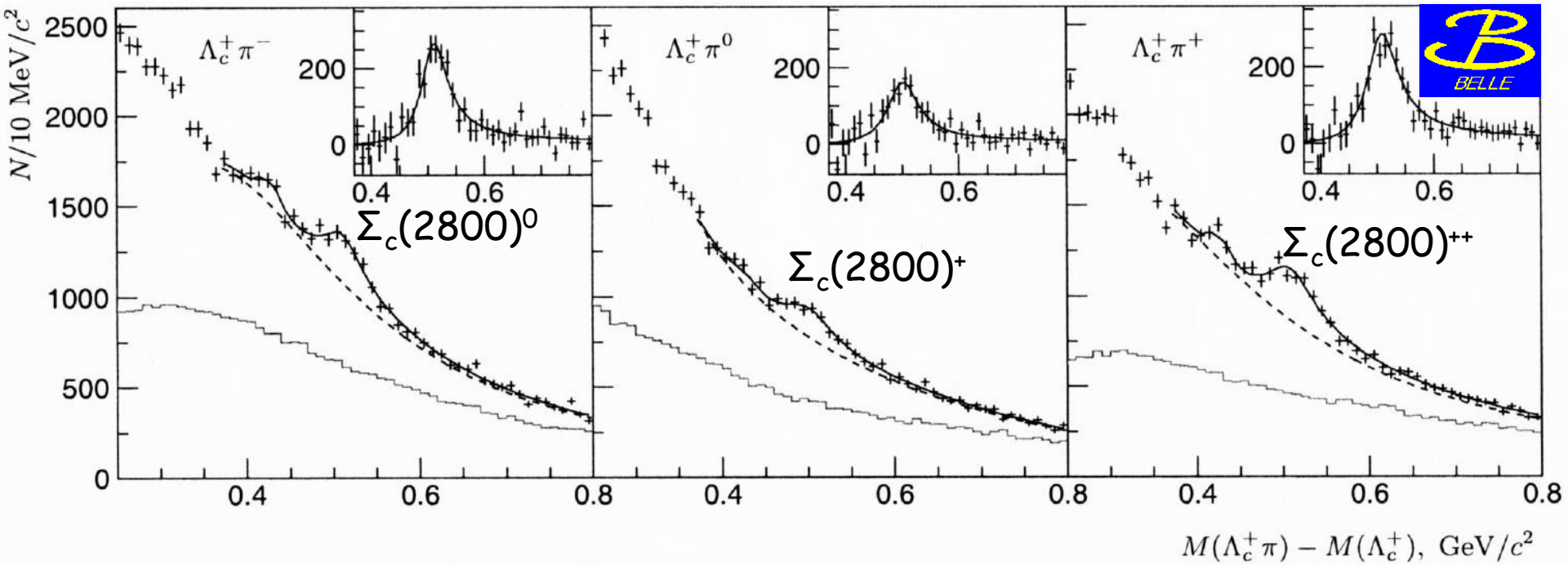


[B. Aubert *et al.* (BaBar Collaboration), Phys. Rev. Lett. **98**, 012001 (2007)]

Σ_c Family

State	Decay mode	Mass, MeV/c^2	Width, MeV/c^2	J^P
$\Sigma_c(2520)^{++}$	$\Lambda_c^+\pi^+$	$231,95^{+0,17}_{-0,12}$	$14,78^{+0,3}_{-0,4}$	$\frac{3}{2}^+$
$\Sigma_c(2520)^{+}$	$\Lambda_c^+\pi^0$	$231,0 \pm 2,3$	< 17 @ 90% CL	$\frac{3}{2}^+$
$\Sigma_c(2520)^{0}$	$\Lambda_c^+\pi^-$	$232,02^{+0,15}_{-0,14}$	$15,3^{+0,4}_{-0,5}$	$\frac{3}{2}^+$
$\Sigma_c(2800)^{++}$	$\Lambda_c^+\pi^+$	514^{+4}_{-6}	75^{+22}_{-17}	$\frac{3}{2}^-$
$\Sigma_c(2800)^{+}$	$\Lambda_c^+\pi^0$	505^{+14}_{-5}	62^{+60}_{-40}	$\frac{3}{2}^-$
$\Sigma_c(2800)^{0}$	$\Lambda_c^+\pi^-$	519^{+5}_{-7}	72^{+22}_{-15}	$\frac{3}{2}^-$

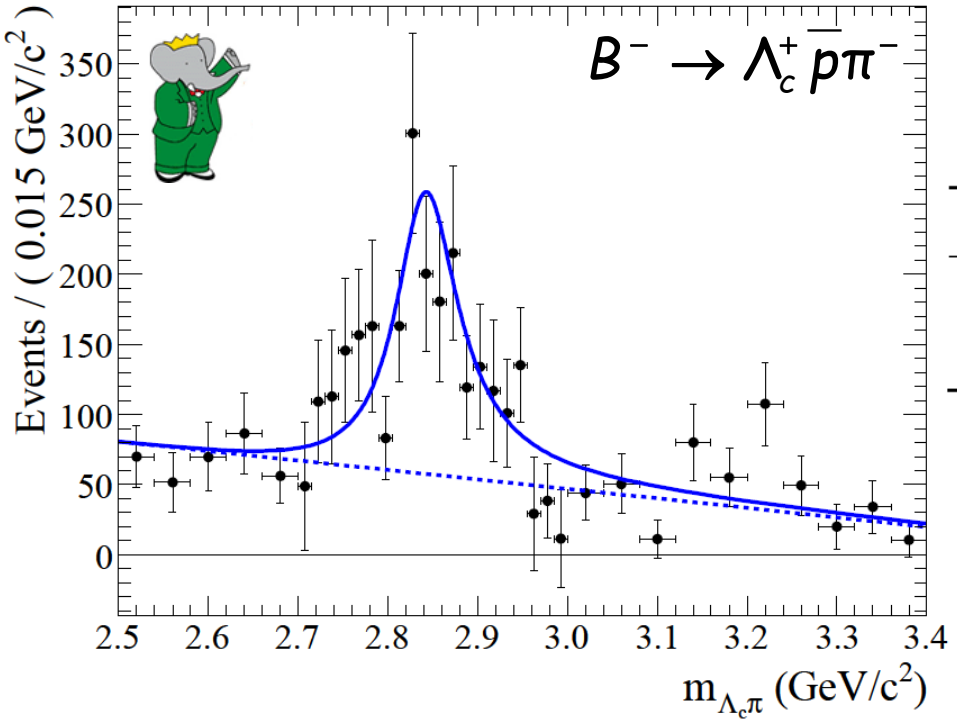
State	ΔM, MeV/c^2	Γ, MeV
$\Sigma_c(2800)^{0}$	$515.4^{+3.2+2.1}_{-3.1-6.0}$	61^{+18+22}_{-13-13}
$\Sigma_c(2800)^{+}$	$505.4^{+5.8+12.4}_{-4.6-\ 2.0}$	62^{+37+52}_{-23-38}
$\Sigma_c(2800)^{++}$	$514.5^{+3.4+2.8}_{-3.1-4.9}$	75^{+18+12}_{-13-11}



[R. Mizuk *et al.* (Belle Collaboration), Phys. Rev. Lett. **94**, 122002 (2005)]

Σ_c Family

State	Decay mode	Mass, MeV/c^2	Width, MeV/c^2	J^P
$\Sigma_c(2520)^{++}$	$\Lambda_c^+\pi^+$	$231,95^{+0,17}_{-0,12}$	$14,78^{+0,3}_{-0,4}$	$\frac{3}{2}^+$
$\Sigma_c(2520)^{+}$	$\Lambda_c^+\pi^0$	$231,0 \pm 2,3$	< 17 @ 90% CL	$\frac{3}{2}^+$
$\Sigma_c(2520)^{0}$	$\Lambda_c^+\pi^-$	$232,02^{+0,15}_{-0,14}$	$15,3^{+0,4}_{-0,5}$	$\frac{3}{2}^+$
$\Sigma_c(2800)^{++}$	$\Lambda_c^+\pi^+$	514^{+4}_{-6}	75^{+22}_{-17}	$\frac{3}{2}^-$
$\Sigma_c(2800)^{+}$	$\Lambda_c^+\pi^0$	505^{+14}_{-5}	62^{+60}_{-40}	$\frac{3}{2}^-$
$\Sigma_c(2800)^{0}$	$\Lambda_c^+\pi^-$	519^{+5}_{-7}	72^{+22}_{-15}	$\frac{3}{2}^-$



Fit Parameter	Value	PDG Value [8]
m_R (GeV/c^2)	2.846 ± 0.008	$2.802 \,^{+\,0.004}_{-\,0.007}$
Γ_R (MeV)	$86 \,^{+\,33}_{-\,22}$	$61 \,^{+\,28}_{-\,18}$

[B. Aubert *et al.* (BaBar Collaboration), Phys. Rev. D **78**, 112003 (2008)]

Ξ_c Family

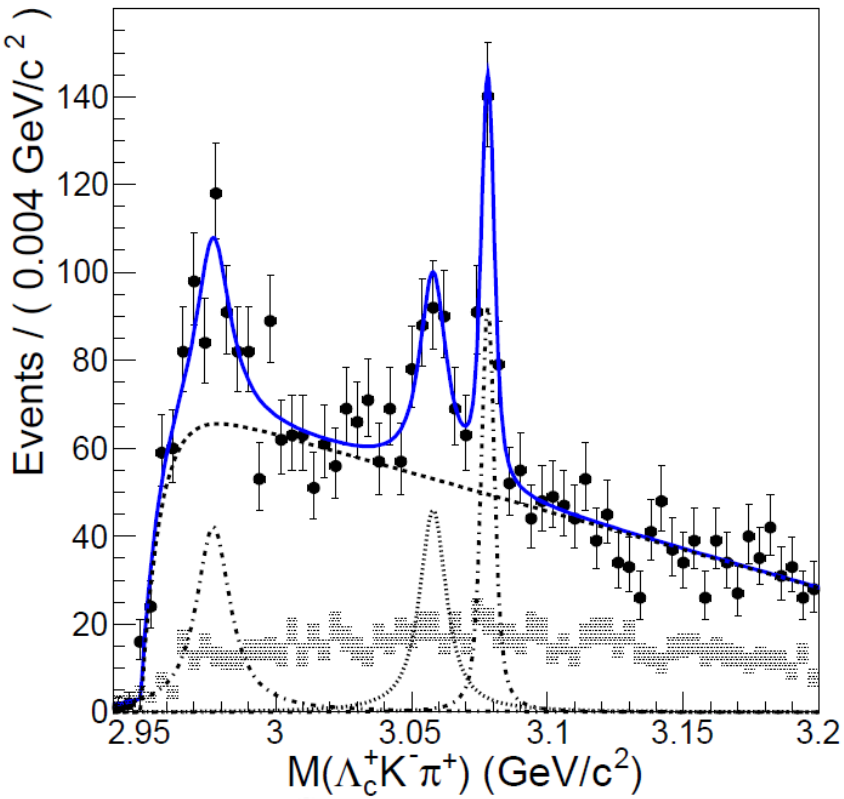
State	Decay mode	Mass, MeV/c^2	Width, MeV/c^2	J^P
$\Xi_c'^+$	$\Xi_c^+\gamma$	$2575,7 \pm 3,0$		$\frac{1}{2}^+$
$\Xi_c'^0$	$\Xi_c^0\gamma$	$2577,9 \pm 2,9$		$\frac{1}{2}^+$
$\Xi_c(2645)^+$	$\Xi_c^0\pi^+$	$2645,9 \pm 0,5$	$2,6 \pm 0,4$	$\frac{3}{2}^+$
$\Xi_c(2645)^0$	$\Xi_c^+\pi^-$	$2645,9 \pm 0,5$	$< 5,5$ @ 90% CL	$\frac{3}{2}^+$
$\Xi_c(2790)^+$	$\Xi_c'^0\pi^+$	$2789,1 \pm 3,2$	< 15 @ 90% CL	$\frac{1}{2}^-$
$\Xi_c(2790)^0$	$\Xi_c'^+\pi^-$	$2791,9 \pm 3,3$	< 12 @ 90% CL	$\frac{1}{2}^-$
$\Xi_c(2815)^+$	$\Xi_c^+\pi^+\pi^-$, $\Xi_c(2645)^0\pi^+$	$2816,6 \pm 0,9$	$< 3,5$ @ 90% CL	$\frac{3}{2}^-$
$\Xi_c(2815)^0$	$\Xi_c^0\pi^+\pi^-$, $\Xi_c(2645)^+\pi^-$	$2819,6 \pm 1,2$	$< 6,5$ @ 90% CL	$\frac{3}{2}^-$
$\Xi_c(2930)^0$	$\Lambda_c^+K^-$	2931 ± 6	36 ± 13	
$\Xi_c(2970)^+$	$\Lambda_c^+K^-\pi^+$, $\Sigma_c^{++}K^-$, $\Xi_c(2645)^0\pi^+$	$2970,7 \pm 2,2$	$17,9 \pm 3,5$	
$\Xi_c(2970)^0$	$\Xi_c(2645)^+\pi^-$	$2968,0 \pm 2,6$	20 ± 7	
$\Xi_c(3055)^+$	$\Sigma_c^{++}K^-$, ΛD^+	$3055,1 \pm 1,7$	11 ± 4	
$\Xi_c(3055)^0$	ΛD^0			
$\Xi_c(3080)^+$	$\Lambda_c^+K^-\pi^+$, $\Sigma_c^{++}K^-$, $\Sigma_c(2520)^{++}K^-$, ΛD^+	$3076,94 \pm 0,28$	$4,3 \pm 1,5$	
$\Xi_c(3080)^0$	$\Lambda_c^+K_S^0\pi^-$, $\Sigma_c^0K_S^0$, $\Sigma_c(2520)^0K_S^0$	$3079,9 \pm 1,4$	$5,6 \pm 2,2$	

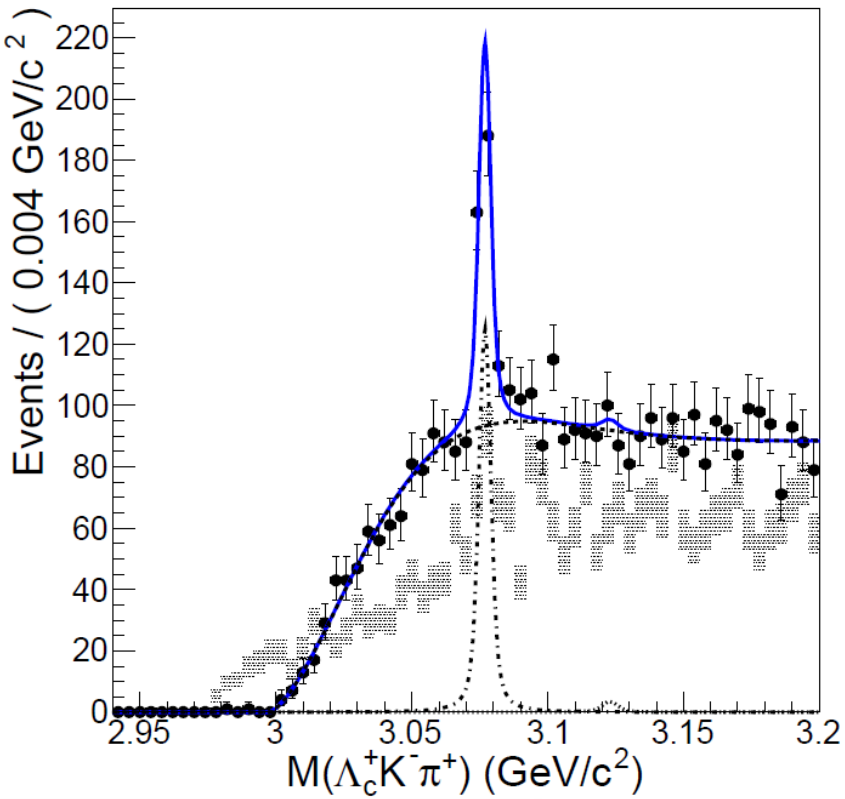
Ξ_c Family: Decays to Ξ_c

Particle	Yield	Mass	$M - M(\Xi_c)$	$M - M(\Xi_c')$	Width
$\Xi_c'^+$	7055 ± 211	$2578.4 \pm 0.1 \pm 0.4^{+0.3}_{-0.4}$	$110.5 \pm 0.1 \pm 0.4$		
PDG		2575.6 ± 3.0	107.8 ± 3.0		
$\Xi_c'^0$	11560 ± 276	$2579.2 \pm 0.1 \pm 0.4^{+0.3}_{-0.4}$	$108.3 \pm 0.1 \pm 0.4$		
PDG		2577.9 ± 2.9	107.0 ± 2.9		
$\Xi_c(2645)^+$	1260 ± 40	$2645.58 \pm 0.06 \pm 0.07^{+0.28}_{-0.40}$	$174.66 \pm 0.06 \pm 0.07$		$2.06 \pm 0.13 \pm 0.13$
PDG		2645.9 ± 0.5	175.0 ± 0.6		$2.6 \pm 0.2 \pm 0.4$
$\Xi_c(2645)^0$	975 ± 36	$2646.43 \pm 0.07 \pm 0.07^{+0.28}_{-0.40}$	$178.46 \pm 0.07 \pm 0.07$		$2.35 \pm 0.18 \pm 0.13$
PDG		2645.9 ± 0.5	178.0 ± 0.6		< 5.5
$\Xi_c(2790)^+$	2231 ± 103	$2791.6 \pm 0.2 \pm 0.1 \pm 0.4^{+0.3}_{-0.4}$	$320.7 \pm 0.2 \pm 0.1 \pm 0.4$	$213.2 \pm 0.2 \pm 0.1$	$8.9 \pm 0.6 \pm 0.8$
PDG		2789.8 ± 3.2	318.2 ± 3.2		< 15
$\Xi_c(2790)^0$	1241 ± 72	$2794.9 \pm 0.3 \pm 0.1 \pm 0.4^{+0.3}_{-0.4}$	$323.8 \pm 0.2 \pm 0.1 \pm 0.4$	$215.7 \pm 0.2 \pm 0.1$	$10.0 \pm 0.7 \pm 0.8$
PDG		2791.9 ± 3.3	324.0 ± 3.3		< 12
$\Xi_c(2815)^+$	941 ± 35	$2816.73 \pm 0.08 \pm 0.06^{+0.28}_{-0.40}$	$348.80 \pm 0.08 \pm 0.06$		$2.43 \pm 0.20 \pm 0.17$
PDG		2816.6 ± 0.9	348.7 ± 0.9		< 3.5
$\Xi_c(2815)^0$	1258 ± 40	$2820.20 \pm 0.08 \pm 0.07^{+0.28}_{-0.40}$	$349.35 \pm 0.08 \pm 0.07$		$2.54 \pm 0.18 \pm 0.17$
PDG		2819.6 ± 1.2	348.8 ± 1.2		< 6.5
$\Xi_c(2970)^+$	916 ± 55	$2966.0 \pm 0.8 \pm 0.2^{+0.3}_{-0.4}$	$498.1 \pm 0.8 \pm 0.2$		$28.1 \pm 2.4^{+1.0}_{-5.0}$
PDG		2970.7 ± 2.2			17.9 ± 3.5
$\Xi_c(2970)^0$	1443 ± 75	$2970.8 \pm 0.7 \pm 0.2^{+0.3}_{-0.4}$	$499.9 \pm 0.7 \pm 0.2$		$30.3 \pm 2.3^{+1.0}_{-1.8}$
PDG		$2968.0 \pm 2.6 \pm 0.5$			20 ± 7

[J. Yelton *et al.* (Belle Collaboration), arXiv: 1607.07123 [hep-ex], accepted by Phys. Rev. D]

Ξ_c Family: Decays to $\Lambda_c(\Sigma_c)$

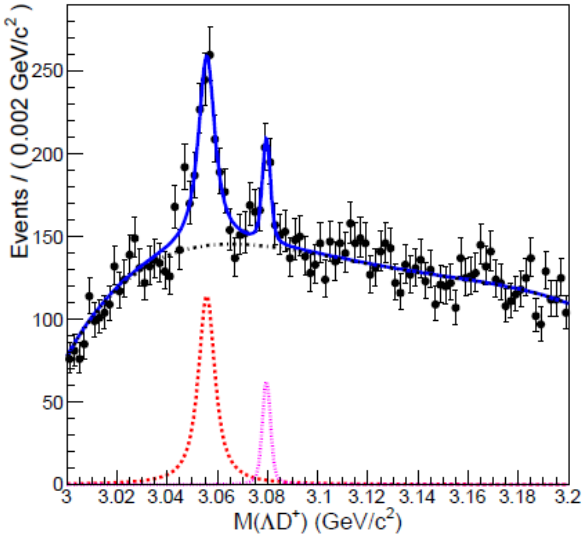




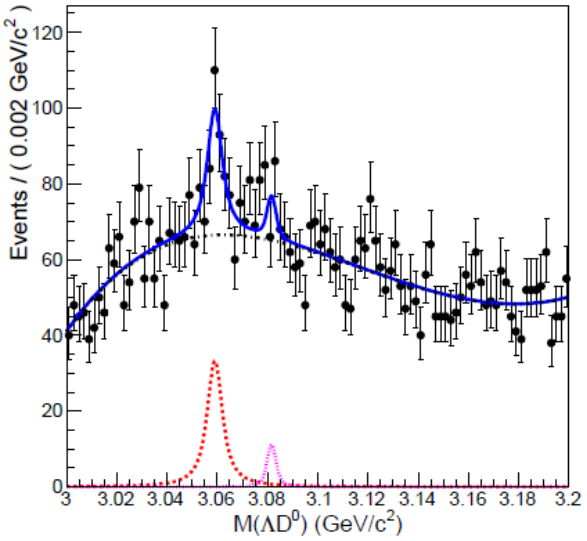
Particle	Mass (MeV/c^2)	Width (MeV/c^2)
$\Xi_c(2970)^+$	$2974.9 \pm 1.5 \pm 2.1$	$14.8 \pm 2.5 \pm 4.1$
$\Xi_c(3055)^+$	$3058.1 \pm 1.0 \pm 2.1$	$9.7 \pm 3.4 \pm 3.3$
$\Xi_c(3080)^+(\Sigma_c)$	$3077.9 \pm 0.4 \pm 0.7$	$3.2 \pm 1.3 \pm 1.3$
$\Xi_c(3080)^+(\Sigma_c^*)$	$3076.9 \pm 0.3 \pm 0.2$	$2.4 \pm 0.9 \pm 1.6$

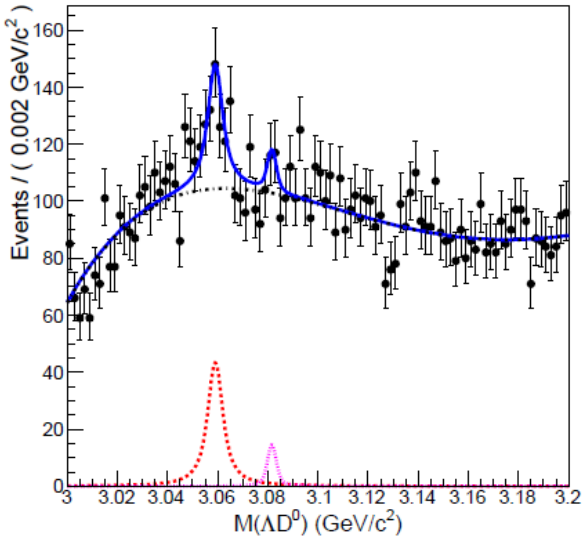
[Y. Kato, T.Iijima *et al.* (Belle Collaboration), Phys. Rev. D **89**, 052003 (2014)]

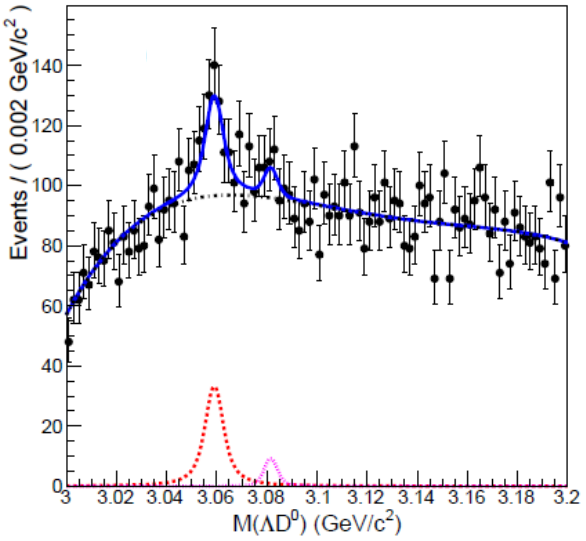
Ξ_c Family: Decays to ΛD



Resonance	Mass (MeV/c^2)	Width (MeV)	Significance (σ)
$\Xi_c(3055)^0$	$3059.0 \pm 0.5 \pm 0.6$	$6.4 \pm 2.1 \pm 1.1$	8.6
$\Xi_c(3055)^+$	$3055.8 \pm 0.4 \pm 0.2$	$7.0 \pm 1.2 \pm 1.5$	11.7
$\Xi_c(3080)^+$	$3079.6 \pm 0.4 \pm 0.1$	< 6.3	4.8

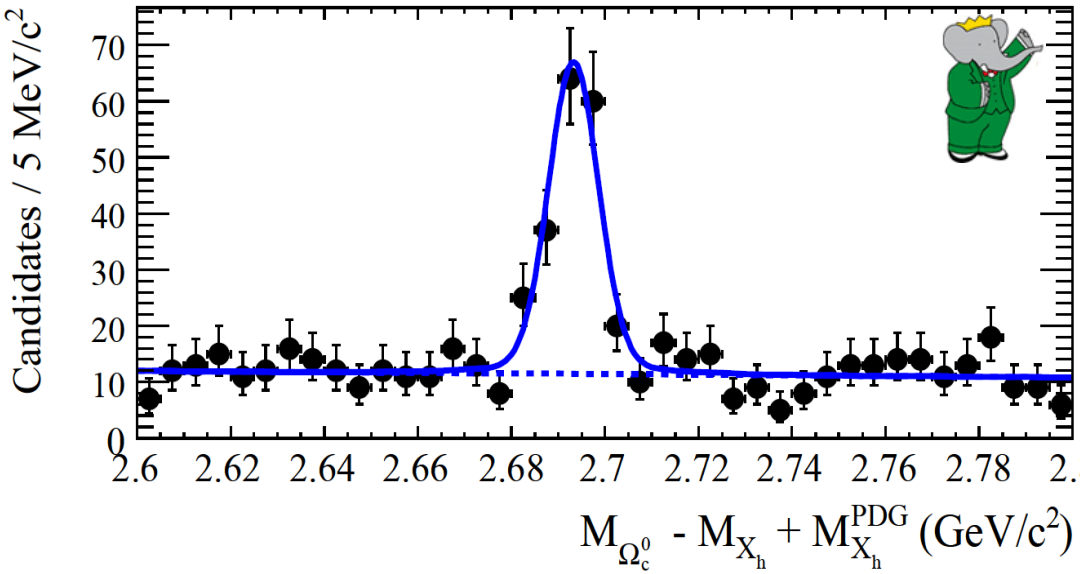






[Y.Kato, T.Iijima *et al.* (Belle Collaboration), Phys. Rev. D **94**, 032002 (2016)]

Ω_c Family

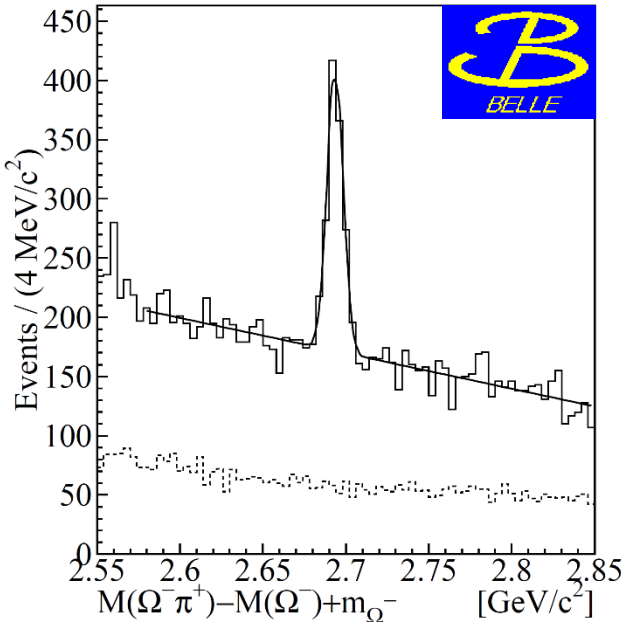


$$\Omega_c^0 = c\{ss\}$$

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

$$[2693.3 \pm 0.6(stat.)]\ MeV/c^2$$

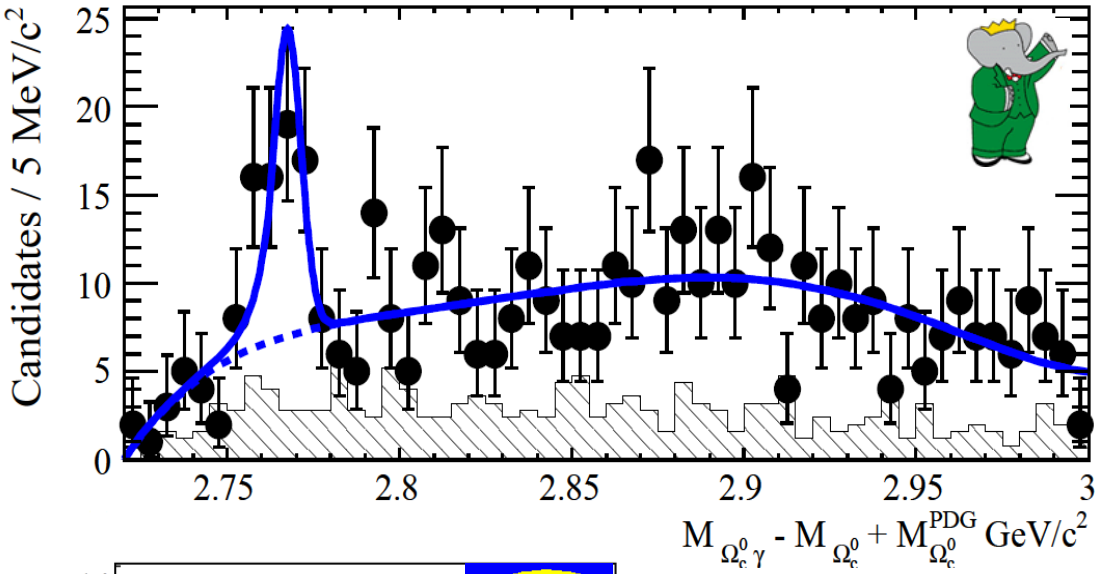
[B. Aubert *et al.* (BaBar Collaboration), Phys. Rev. Lett. **97**, 232001 (2006)]



$$m_{\Omega_c^0} = \left[2693.6 \pm 0.3(stat.)^{+1.8}_{-1.5}(syst.)\right]\ MeV/c^2$$

[E. Solovieva, R. Chistov *et al.* (Belle Collaboration), Phys. Lett. B **672**, 1 (2009)]

Ω_c Family

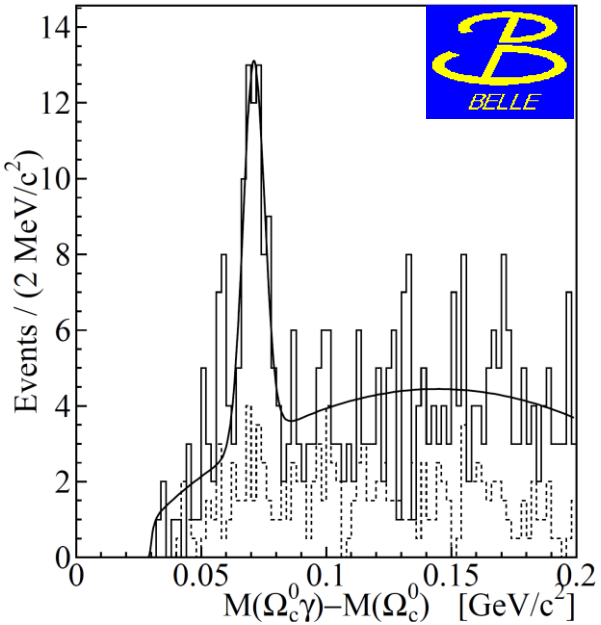


$$\Omega_c^{*0} = css$$

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

$$[70.8 \pm 1.0(stat.) \pm 1.1(syst.)]\ MeV/c^2$$

[B. Aubert *et al.* (BaBar Collaboration), Phys. Rev. Lett. **97**, 232001 (2006)]



$$\Delta m_{\Omega_c^0} = \left[70.7 \pm 0.9(stat.)^{+0.1}_{-0.9}(syst.)\right]\ MeV/c^2$$

[E. Solovieva, R. Chistov *et al.* (Belle Collaboration), Phys. Lett. B **672**, 1 (2009)]

Level Diagram