Charmed Baryon Decays and their asymmetries

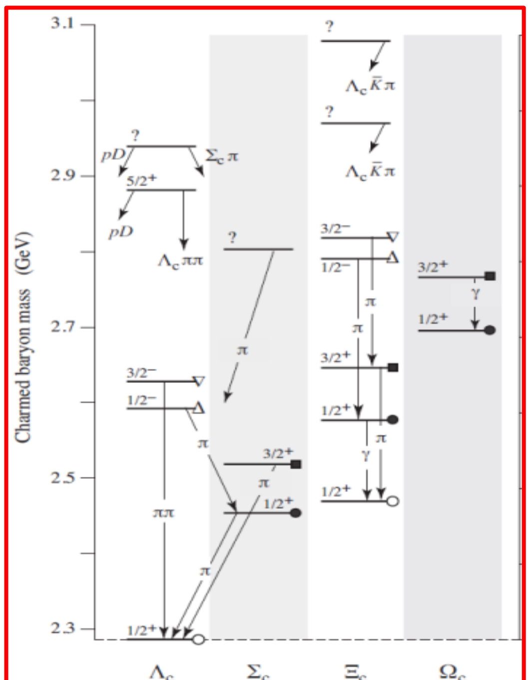
B.G. Cheon
(Hanyang Univ., Korea)
For the Belle collaboration

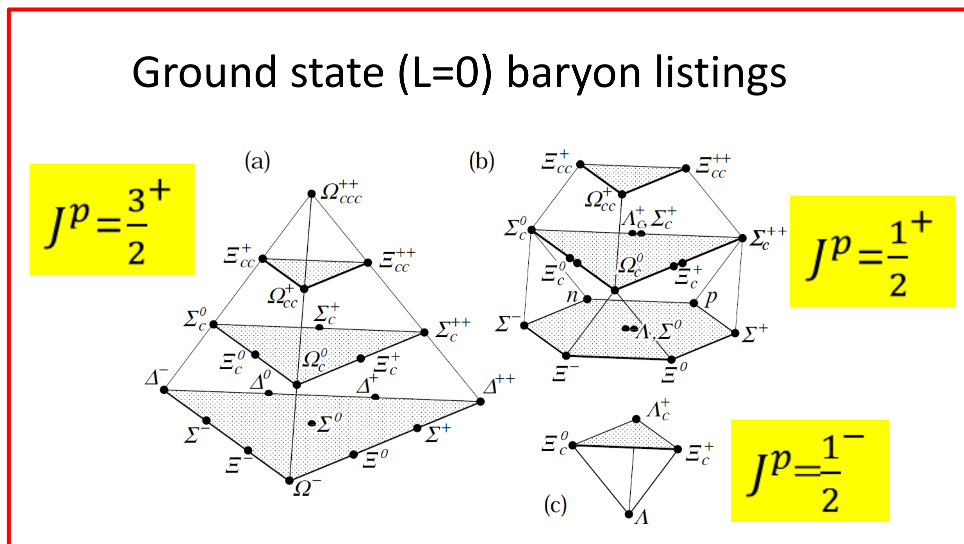
Charm2012, 14/May, Hawaii

Contents

Why charmed baryons?

- **Charmed baryon strong/EM decays provide lots of excited states.**
  - More orbital excitation states (Q+qq) than meson(Q+q).
  - Less phase space for decays and narrower states.
  - Established 17 charmed baryons up to date. (refer PDG).
  - Fruitful experimental results on excited states, but a few unpromoted states.
- **Charmed baryon weak decays are suitable to study decay dynamics.**
  - Still poor measurements in weak decays of Λ_c^+, Ξ_c^+, Ξ_c^0 , Ω_c^0
- **Theoretical predictions can be tested and motivated to new approaches.**





Strong/EM decays

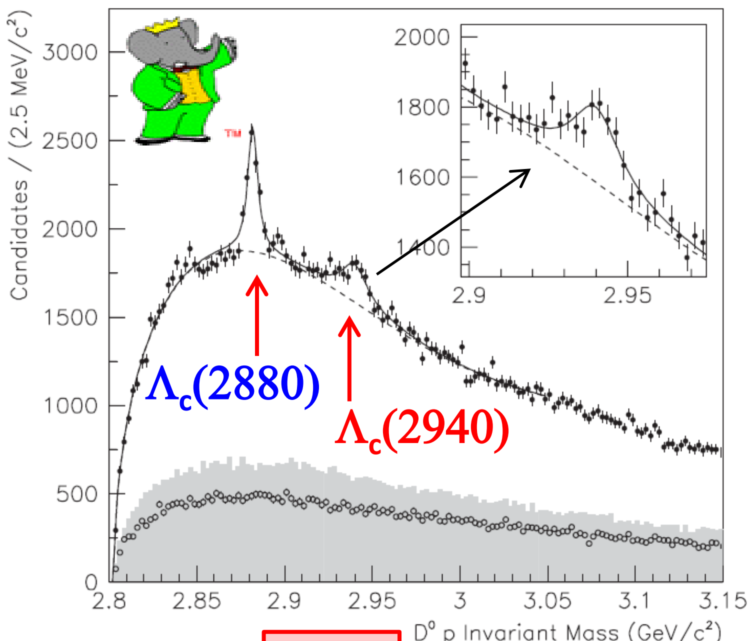
Λ_c-excitation family

Exp.	Mode	Mass (MeV/c^2)	Width (MeV)
CLEO	$\Lambda_c(2765)^+ \rightarrow \Lambda_c^+ \pi^+ \pi^-$	2766.6 ± 2.4	50
Belle	$\Lambda_c(2765)^+ \rightarrow \Sigma_c(2455)^0 \pi^+$	2761 ± 1	73 ± 5
CLEO	$\Lambda_c(2880)^+ \rightarrow \Sigma_c(2455)^0 \pi^+$	$2882 \pm 1 \pm 2$	$4 \pm 2 \pm 2$
BABAR	$\Lambda_c(2880)^+ \rightarrow D^0 p$	$2881.9 \pm 0.1 \pm 0.5$	$5.8 \pm 1.5 \pm 1.1$
Belle	$\Lambda_c(2880)^+ \rightarrow \Sigma_c(2455)^0 \pi^+$	$2881.2 \pm 0.2 \pm 0.4$	$5.8 \pm 0.7 \pm 1.1$
BABAR	$\Lambda_c(2940)^+ \rightarrow D^0 p$	$2939.8 \pm 1.3 \pm 1.0$	$17.5 \pm 5.2 \pm 5.9$
Belle	$\Lambda_c(2940)^+ \rightarrow \Sigma_c(2455)^0 \pi^+$	$2938.0 \pm 1.3\ ^{2.0}_{-4.0}$	$13\ ^{+8}_{-5}\ ^{+27}_{-7}$

- Good consistent among Belle, BaBar and CLEO measurements.
- Isospin singlets : $\Lambda_c(2880)^+$, $\Lambda_c(2940)^+$
  - Due to no isospin partners in D^+p @ Babar
  - Belle measured spin-parity of $\Lambda_c(2880)^+$
- $\Lambda_c(2940)^+$: 5MeV below D*p threshold
  - Exotics? hep-ph/0606015
  - Conventional baryon? PRD75,094017; JPG34, 961; PRD75, 094017 (2007)
- $\Lambda_c(2765)$: should be studied in more depth.

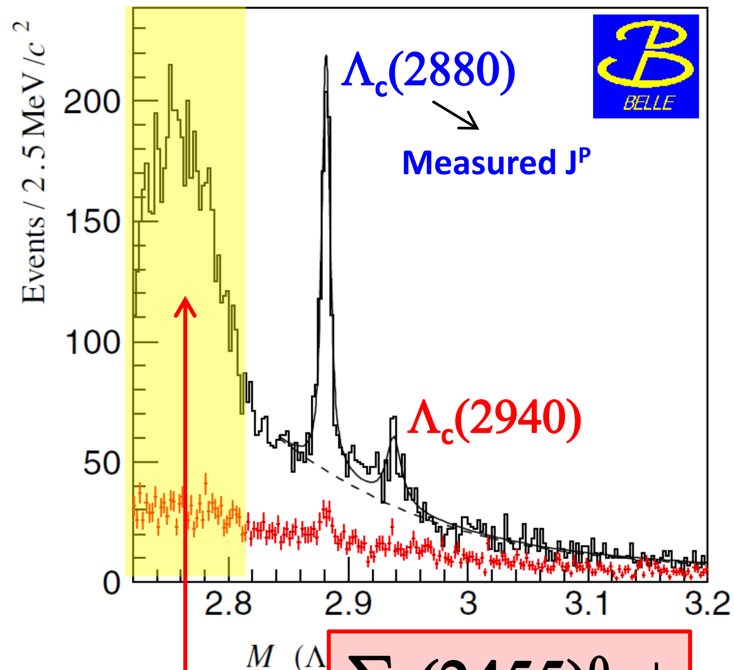
$\Lambda_c(2765) \rightarrow \Lambda_c^+ \pi^+ \pi^-$?

PRL 98, 012001 (2007) : BaBar



D^0p

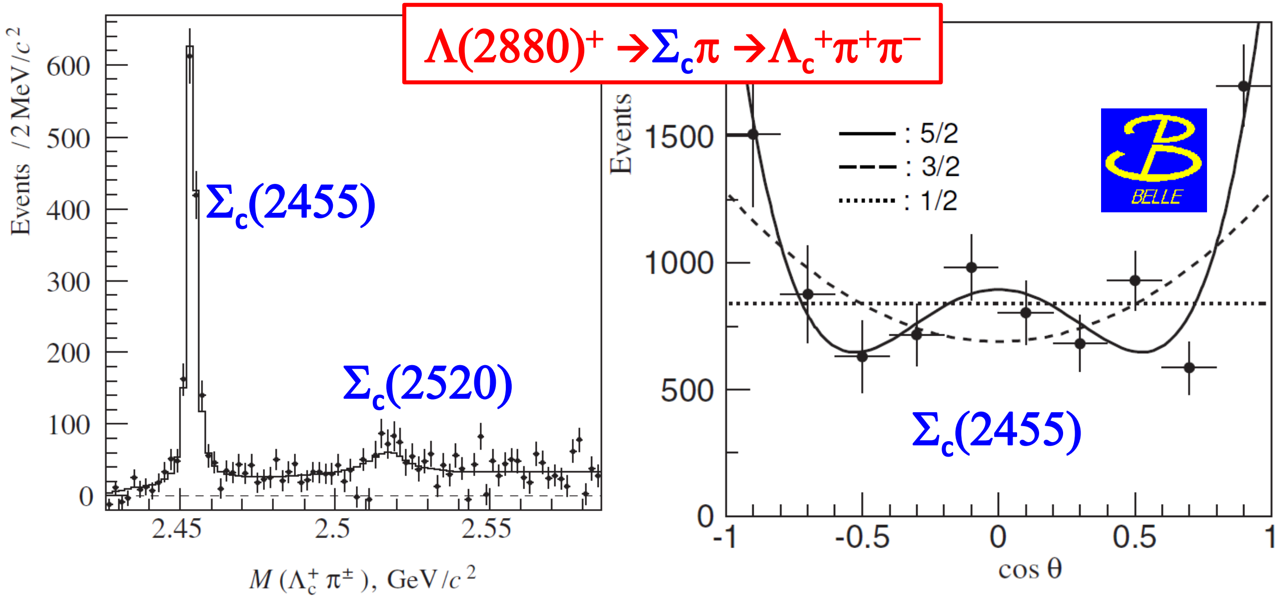
PRL 98, 262001 (2007) : Belle



$\Sigma_c(2455)^0\pi^+$

$\Lambda_c(2765)$?

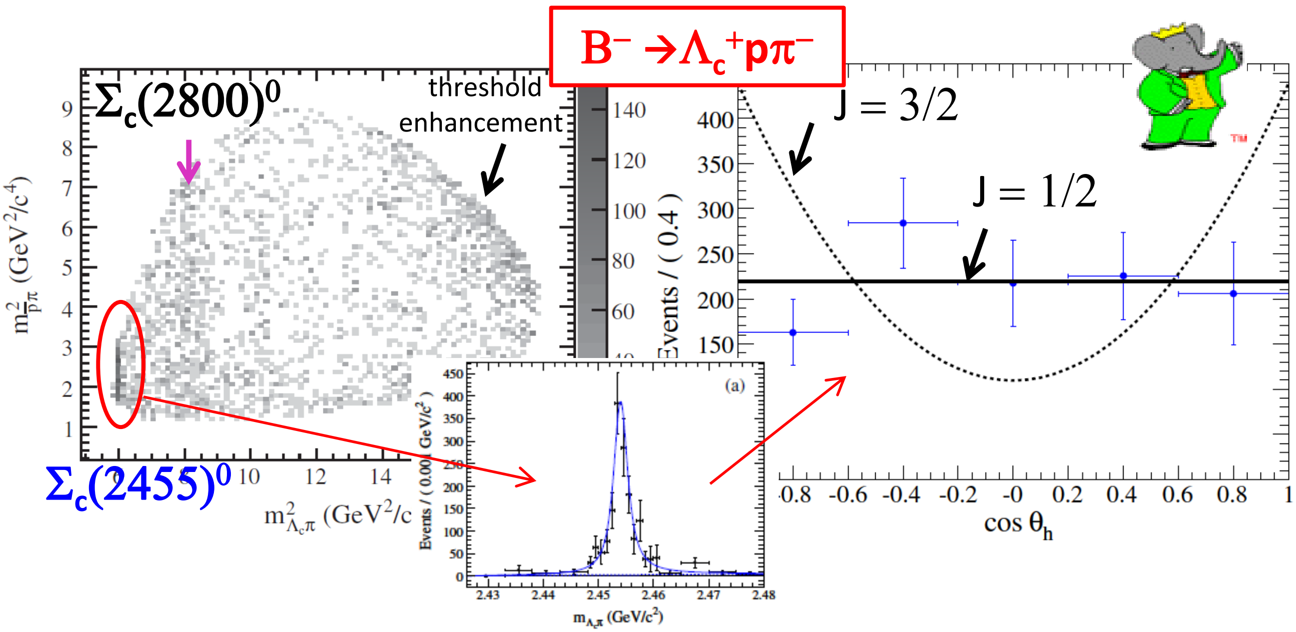
Spin-parity



PRL 98, 262001 (2007) : Belle

J^P [$\Lambda_c(2880)^+$]

- J = 5/2 favored
- $$R = \frac{\Gamma[\Sigma_c(2520)\pi]}{\Gamma[\Sigma_c(2455)\pi]}$$
  $$R = 0.23 \pm 0.06 \pm 0.03$$
- Heavy Quark Symmetry
  - $R = 1.4 : 5/2^-$
  - $R \sim 0.3 : 5/2^+$



PRD 78, 112003 (2008) : BaBar

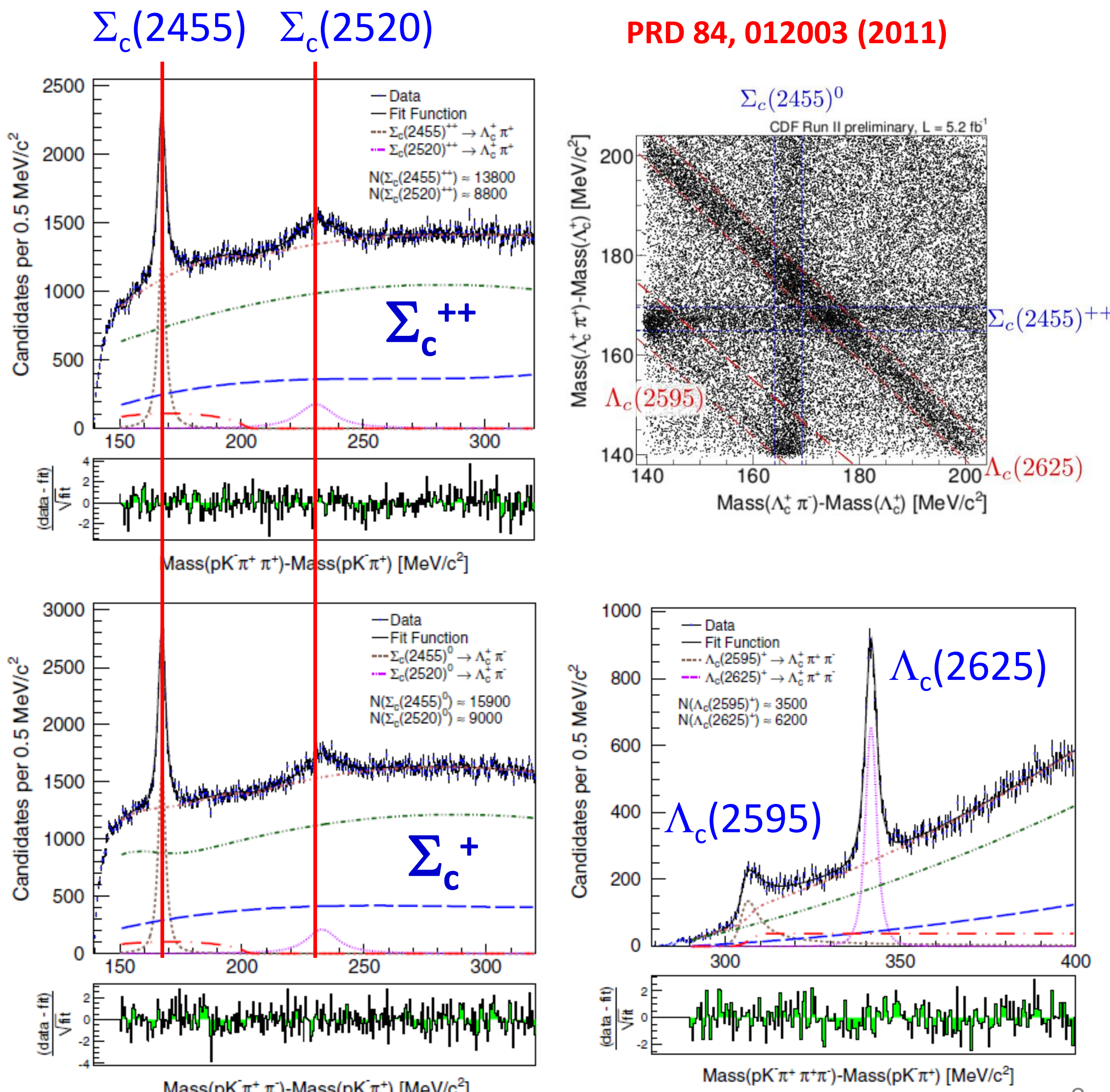
J^P [$\Sigma_c(2445)^0$]

- J = 1/2 favored

$\Sigma_c(2455)$, $\Sigma_c(2520)$, $\Lambda_c(2595)$, $\Lambda_c(2625)$

- $\Lambda_c^+(J^p = 1/2^+)$
  - only weak decay
- $\Sigma_c(2455)$ $(J^p = 1/2^+)$,
  $\Sigma_c(2520)$ $(J^p = 3/2^+)$
  - L=0 orbital excitations
  - Isospin triplets : $0, +, ++$
  - Strong decay to $\Lambda_c \pi$
- $\Lambda_c(2595)$ $(J^p = 1/2^-)$,
  $\Lambda_c(2625)$ $(J^p = 3/2^-)$
  - L=1 orbital excitations
  - Isospin singlets : $+$
  - Strong decay to $\Lambda_c \pi \pi$
  - $\Lambda_c(2595)$ S-wave res.
  - $\Lambda_c(2625)$ D-wave res.
  - Non-res. P-wave

PRD 84, 012003 (2011)

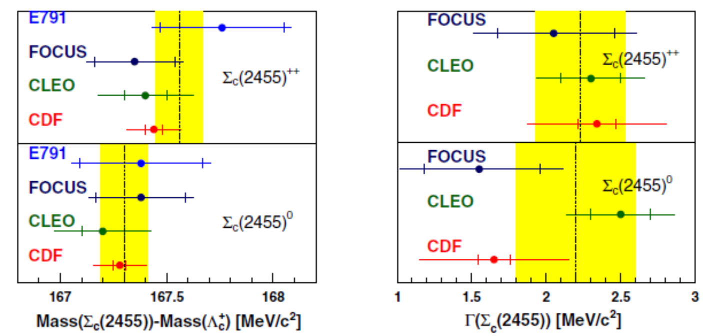


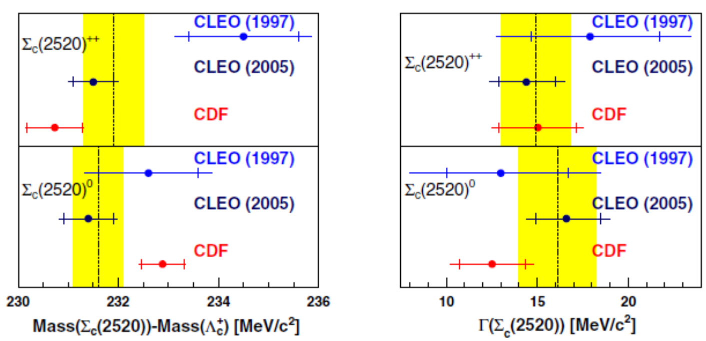
$\Sigma_c(2455)$, $\Sigma_c(2520)$, $\Lambda_c(2595)$, $\Lambda_c(2625)$

PRD 84, 012003 (2011)

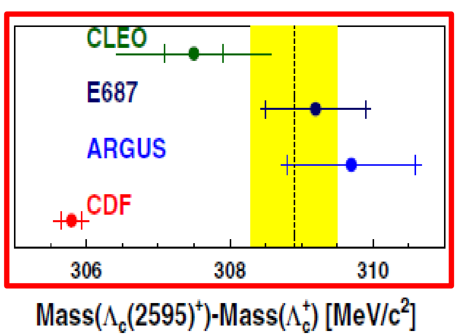
TABLE VIII. Measured resonance parameters, where the first uncertainty is statistical and the second is systematic.

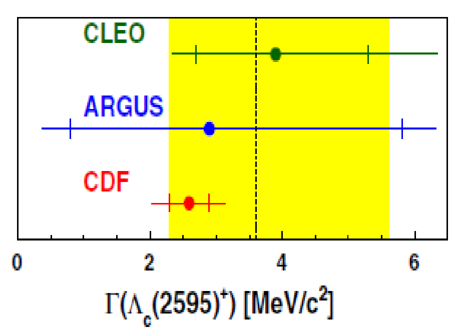
Hadron	ΔM [MeV/c^2]	Γ [MeV/c^2]
$\Sigma_c(2455)^{++}$	$167.44 \pm 0.04 \pm 0.12$	$2.34 \pm 0.13 \pm 0.45$
$\Sigma_c(2455)^{0}$	$167.28 \pm 0.03 \pm 0.12$	$1.65 \pm 0.11 \pm 0.49$
$\Sigma_c(2520)^{++}$	$230.73 \pm 0.56 \pm 0.16$	$15.03 \pm 2.12 \pm 1.36$
$\Sigma_c(2520)^{0}$	$232.88 \pm 0.43 \pm 0.16$	$12.51 \pm 1.82 \pm 1.37$
$\Lambda_c(2595)^{+}$	$305.79 \pm 0.14 \pm 0.20$	$h_2^2 = 0.36 \pm 0.04 \pm 0.07$
$\Lambda_c(2625)^{+}$	$341.65 \pm 0.04 \pm 0.12$	

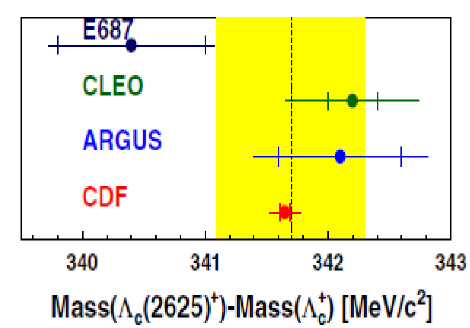




- Consistent with previous exp. results
- Considerable improvement in $\Lambda_c(2595)$, $\Lambda_c(2625)$
- Pion coupling constant (h_2) measured.
- Discrepancy in $\Lambda_c(2595)$ mass with previous results
  - Due to proper treatment of kinematical thresh. effect
  - Refer to PRD 67, 074033 (2003).







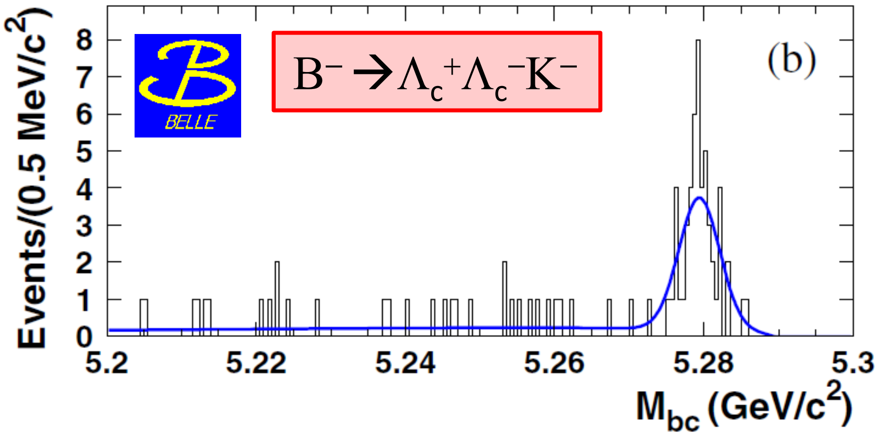
Ξ_c-excitation family

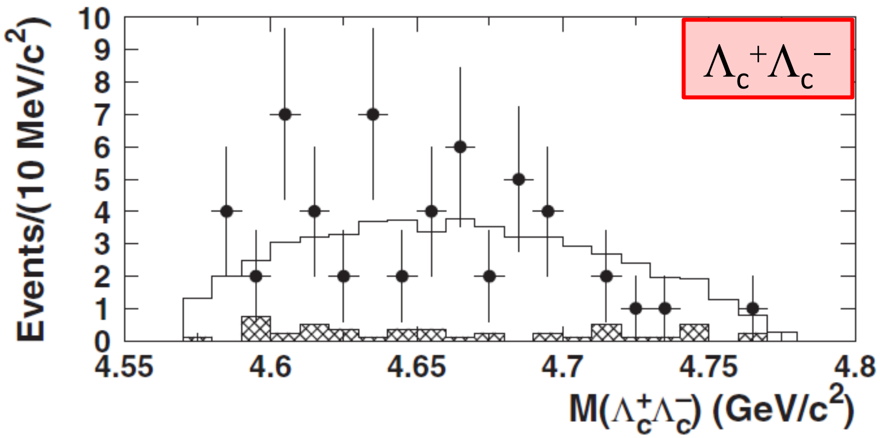
Exp.	Mode	Mass (MeV/c^2)	Width (MeV)	Sig.
BABAR	$\Xi_c(2930)^0 \to \Lambda_c^+ K^-$	$2931 \pm 3 \pm 5$	$36 \pm 7 \pm 1$	
Belle	$\Xi_c(2980)^+ \to \Xi_c(2645)^0 \pi^+$	$2967.7 \pm 2.3\ ^{+1.1}_{-1.2}$	$18 \pm 6 \pm 3$	$S = 7.3\sigma$
Belle	$\Xi_c(2980)^+ \to \Lambda_c^+ K^- \pi^+$	$2978.5 \pm 2.1 \pm 2.0$	$43.5 \pm 7.5 \pm 7.0$	$S = 5.7\sigma$
BABAR	$\Xi_c(2980)^+ \to \Lambda_c^+ K^- \pi^+$	$2978.5 \pm 2.1 \pm 2.0$	$43.5 \pm 7.5 \pm 7.0$	$S > 9\sigma$
Belle	$\Xi_c(2980)^0 \to \Xi_c(2645)^+ \pi^-$	$2965.7 \pm 2.4\ ^{+1.1}_{-1.2}$	$15 \pm 6 \pm 3$	$S = 6.1\sigma$
Belle	$\Xi_c(2980)^0 \to \Lambda_c^+ K_S \pi^-$	$2977.1 \pm 8.8 \pm 3.5$	43.5 (fixed)	$S = 1.5\sigma$
BABAR	$\Xi_c(2980)^0 \to \Lambda_c^+ K_S \pi^-$	$2972.9 \pm 4.4 \pm 1.6$	$31 \pm 7 \pm 8$	$S = 1.7\sigma$
BABAR	$\Xi_c(3055)^+ \to \Lambda_c^+ K^- \pi^+$	$3054.2 \pm 1.2 \pm 0.5$	$17 \pm 6 \pm 11$	$S = 6.4\sigma$
Belle	$\Xi_c(3077)^+ \to \Lambda_c^+ K^- \pi^+$	$3076.7 \pm 0.9 \pm 0.5$	$6.2 \pm 1.2 \pm 0.8$	$S = 9.2\sigma$
BABAR	$\Xi_c(3077)^+ \to \Lambda_c^+ K^- \pi^+$	$3077.0 \pm 0.4 \pm 0.2$	$5.5 \pm 1.3 \pm 0.6$	$S > 9\sigma$
Belle	$\Xi_c(3077)^0 \to \Lambda_c^+ K_S \pi^-$	$3082.8 \pm 1.8 \pm 1.5$	$5.2 \pm 3.1 \pm 1.8$	$S = 4.4\sigma$
BABAR	$\Xi_c(3077)^0 \to \Lambda_c^+ K_S \pi^-$	$3079.3 \pm 1.1 \pm 0.2$	$5.9 \pm 2.3 \pm 1.5$	$S = 4.5\sigma$
BABAR	$\Xi_c(3123)^+ \to \Lambda_c^+ K^- \pi^+$	$3122.9 \pm 1.3 \pm 0.3$	$4.4 \pm 3.4 \pm 1.7$	$S = 3.0\sigma$

- Good consistent between BaBar and Belle measurements.
- Isospin doublets : $\Xi_c(2980)$, $\Xi_c(3077)$
- $\Xi_c(2930)^+$, $\Xi_c(3055)^+$, $\Xi_c(3123)^+$: unpromoted states

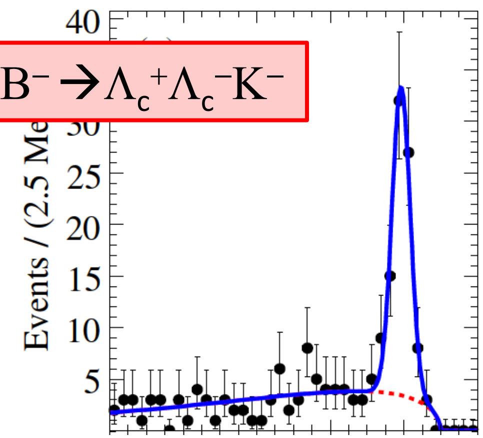
$\Xi_c(2930) \rightarrow \Lambda_c^+ K^-$?

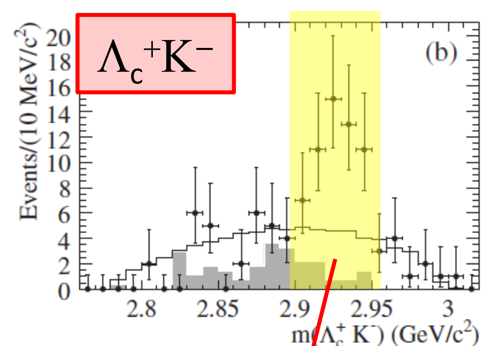
PRL 97, 202003 (2006) : Belle

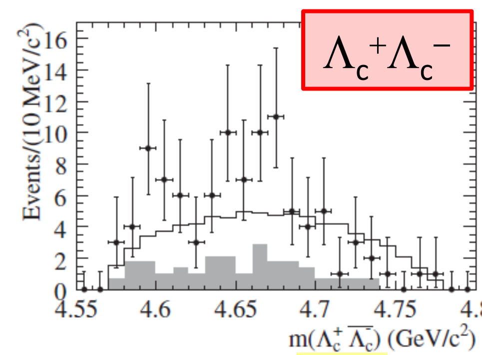




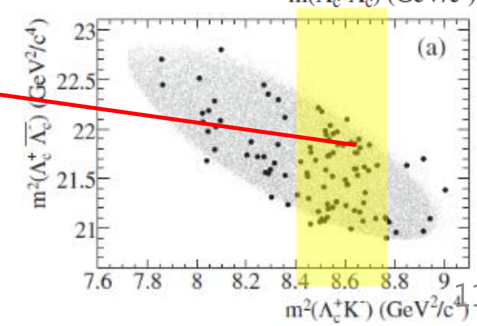
PRD 77, 031101 (2008) : BaBar







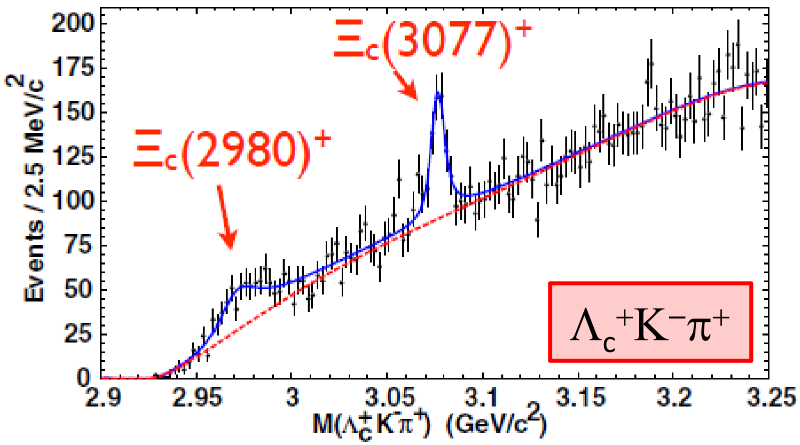
$\Xi_c(2930)$?

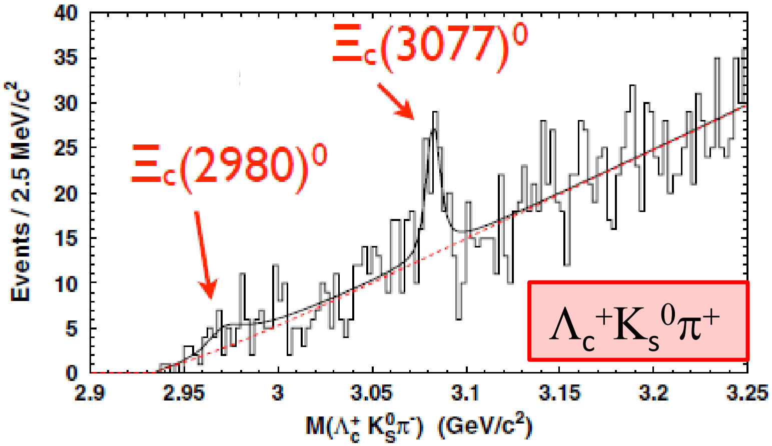


Single Ξ_c resonance χ^2 prob. 22%

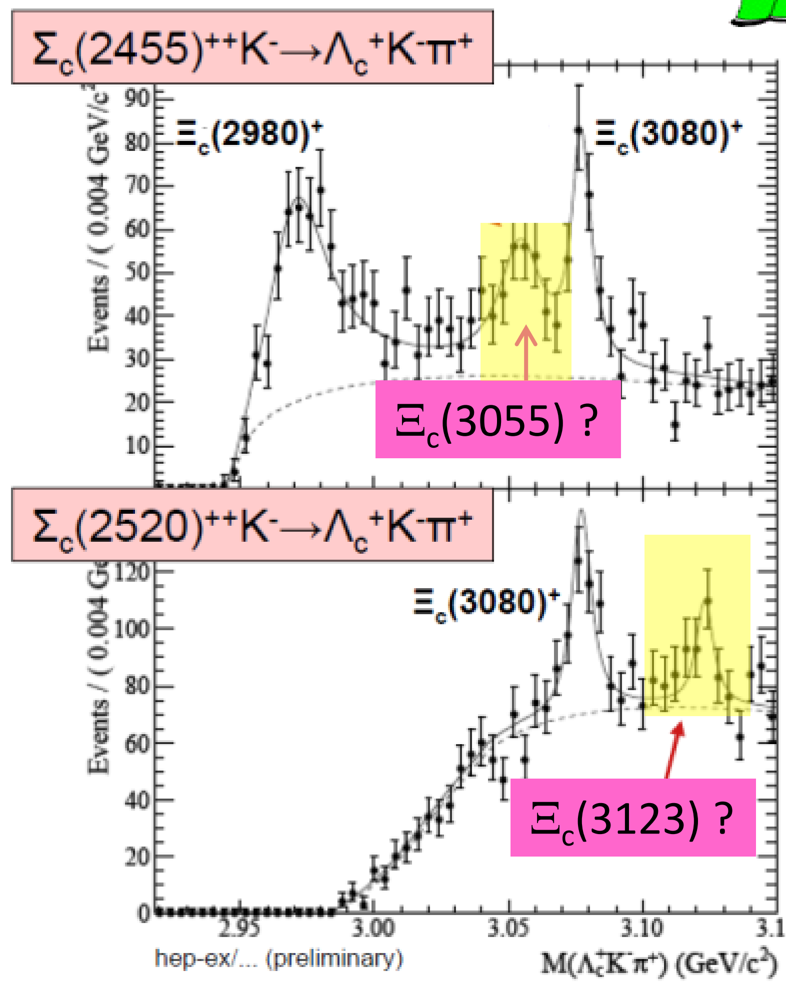
$\Xi_c(3055,3132) \rightarrow \Lambda_c^+ \bar{K} \pi^-$?

PRL 97, 162001 (2006) : Belle





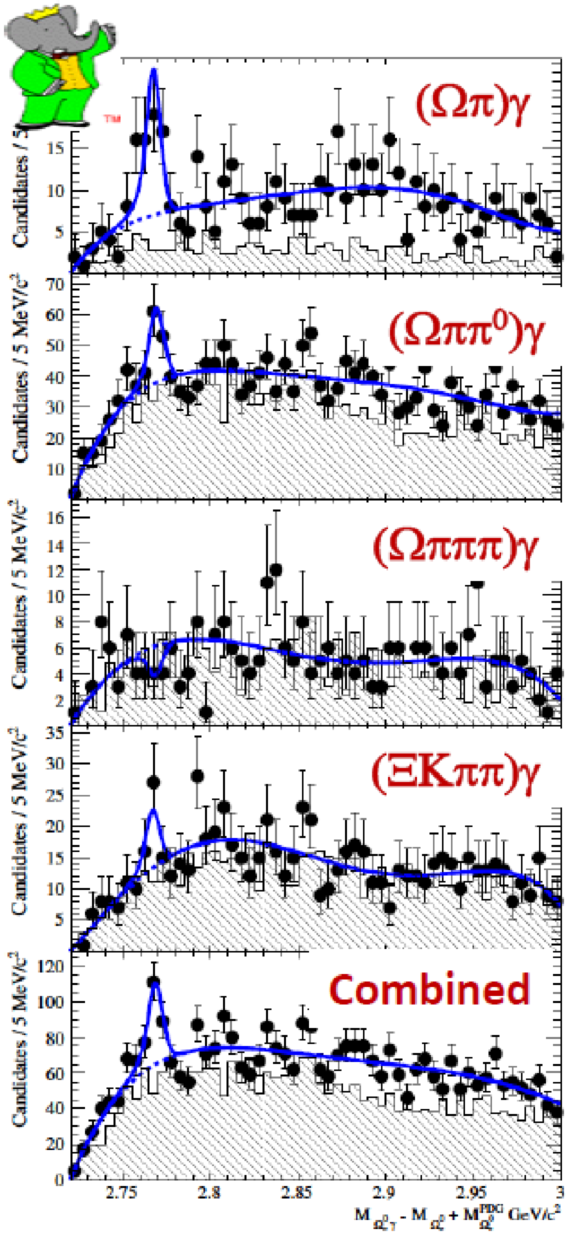
PRD 77, 012002 (2008) : BaBar

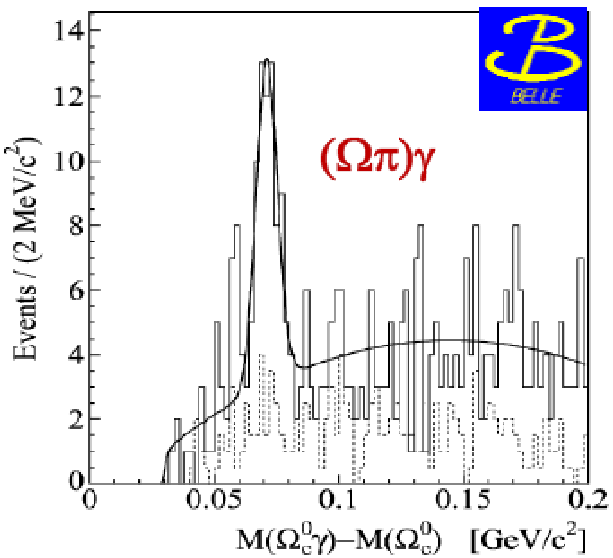


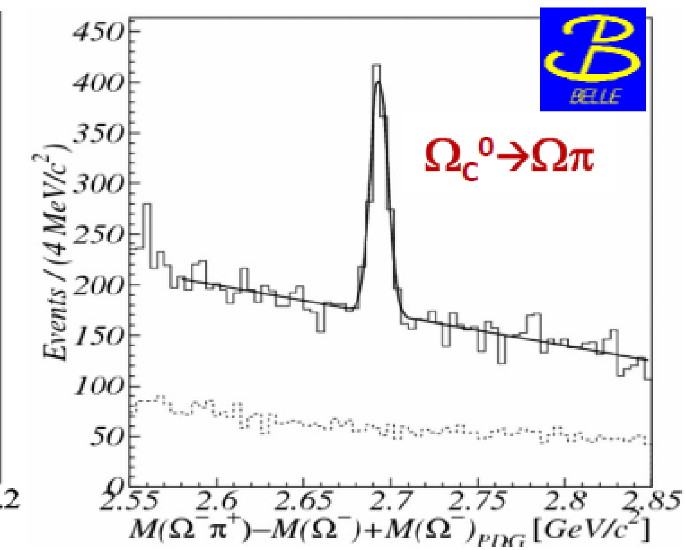
PRL 97, 232001 (2006) : BaBar
PRL 99, 062001 (2007) : BaBar

$\Omega_c^{0*} \rightarrow \Omega_c^0 \gamma$

PLB 672, 1 (2009) : Belle







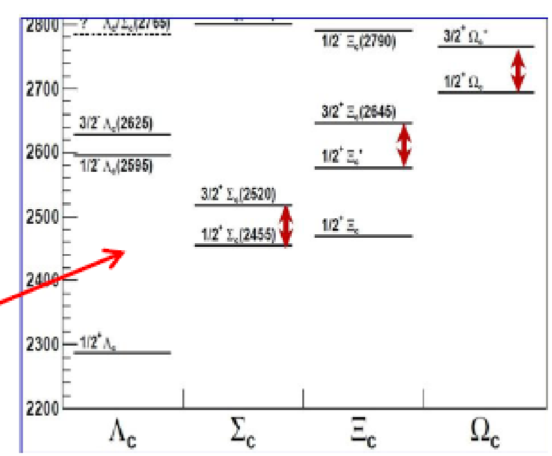
$$M_{\Omega_c^0} = \left(2693.6 \pm 0.3(\text{stat.})\,^{+1.8}_{-1.5}(\text{syst.})\right)\ \text{MeV}/c^2$$ **(Belle)**

Mass splitting $\Delta M = m(\Omega_c^{*0}) - m(\Omega_c^0)$:

BaBar: $\Delta M = 70.8 \pm 1.0 \pm 1.1\ \text{MeV}/c^2$

Belle: $\Delta M = 70.7 \pm 0.9^{+0.1}_{-0.9}\ \text{MeV}/c^2$

Consistent with
naïve mass splitting approach

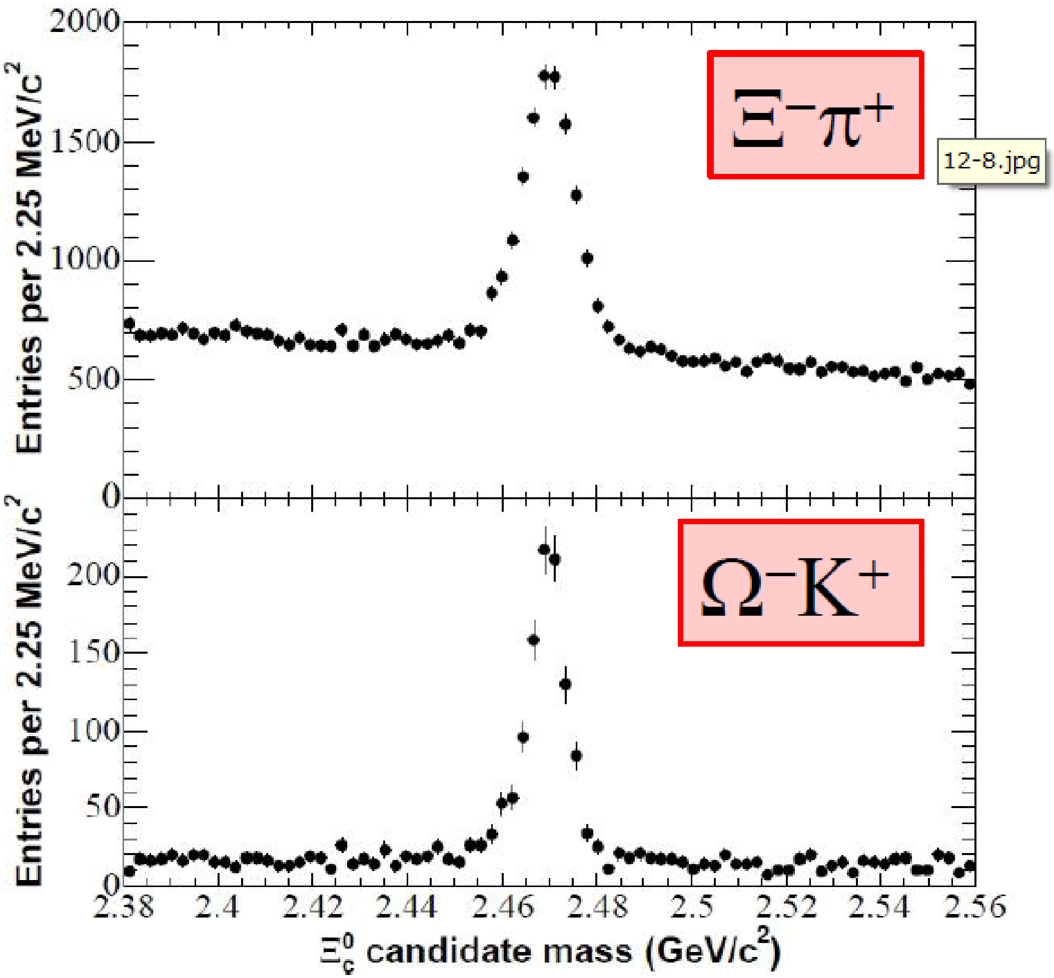


Weak decays

Updated results from Babar/Belle

Experiment	Baryon	Decay mode	Yield	Reference mode	$\mathcal{B}_{signal}/\mathcal{B}_{ref.}$
Belle		ΛK^+ (CS)	265 ± 25	$\Lambda\pi^+$	$0.074 \pm 0.010 \pm 0.012$
Belle		$\Sigma^0 K^+$ (CS)	75 ± 18	$\Sigma^0\pi^+$	$0.056 \pm 0.014 \pm 0.008$
BaBar		ΛK^+ (CS)	1162 ± 101	$\Lambda\pi^+$	$0.044 \pm 0.004 \pm 0.003$
BaBar		$\Sigma^0 K^+$ (CS)	366 ± 52	$\Sigma^0\pi^+$	$0.038 \pm 0.005 \pm 0.003$
BaBar		$\Lambda K^+\pi^+\pi^-$ (CS)	160 ± 62	$\Lambda\pi^+$	$<4.1 \times 10^{-2}$ 90% CL
BaBar		$\Sigma^0 K^+\pi^+\pi^-$ (CS)	21 ± 24	$\Sigma^0\pi^+$	$<2.0 \times 10^{-2}$ 90% CL
Belle		$\Sigma^+ K^+\pi^-$ (CS)	105 ± 24	$\Sigma^+\pi^+\pi^-$	$0.047 \pm 0.011 \pm 0.008$
Belle		$\Sigma^+ K^+ K^-$ (WE)	246 ± 20	$\Sigma^+\pi^+\pi^-$	$0.076 \pm 0.007 \pm 0.009$
Belle	Λ_c^+	$\Sigma^+\phi$ (WE)	129 ± 17	$\Sigma^+\pi^+\pi^-$	$0.085 \pm 0.012 \pm 0.012$
Belle		$\Xi(1690)^0(\to \Sigma^+ K^-)K^+$ (WE)	75 ± 16	$\Sigma^+\pi^+\pi^-$	$0.023 \pm 0.005 \pm 0.005$
Belle		$\Xi(1690)^0(\to \Lambda\bar{K}^0)K^+$ (WE)	93 ± 26	$\Lambda\bar{K}^0 K^+$	$0.26 \pm 0.08 \pm 0.03$
Belle		$\Sigma^+ K^+ K^-$ (non-res) (WE)	11 ± 16	$\Sigma^+\pi^+\pi^-$	< 0.018 @ 90% CL
Belle		pK^+K^- (CS)	676 ± 89	$pK^-\pi^+$	$0.014 \pm 0.002 \pm 0.002$
Belle		$p\phi$ (CS)	345 ± 43	$pK^-\pi^+$	$0.015 \pm 0.002 \pm 0.002$
Belle		pK^+K^- (non-ϕ)	344 ± 81	$pK^-\pi^+$	$0.007 \pm 0.002 \pm 0.002$
BaBar		$\Sigma^0\pi^+$ (CF)	32693 ± 324	$\Lambda\pi^+$	$0.977 \pm 0.015 \pm 0.051$
BaBar		$\Xi^- K^+\pi^+$ (CF)	2665 ± 84	$\Lambda\pi^+$	$0.480 \pm 0.016 \pm 0.039$
BaBar		$\Lambda\bar{K}^0 K^+$ (CF)	460 ± 30	$\Lambda\pi^+$	$0.395 \pm 0.026 \pm 0.036$
Belle	Ξ_c^+	$\Lambda K^-\pi^+\pi^+$	117 ± 55	$\Xi^-\pi^+\pi^+$	$0.32 \pm 0.03 \pm 0.02$
Belle		$pK_S^0K_S^0$	168 ± 27	$\Xi^-\pi^+\pi^+$	$0.087 \pm 0.016 \pm 0.014$
Belle		$pK^+K^+\pi^+$	1908 ± 62	$\Xi^-\pi^+$	$0.33 \pm 0.03 \pm 0.03$
Belle	Ξ_c^0	ΛK_S^0	465 ± 37	$\Xi^-\pi^+$	$0.21 \pm 0.02 \pm 0.02$
Belle		$\Lambda K^-\pi^+$	3268 ± 276	$\Xi^-\pi^+$	$1.07 \pm 0.12 \pm 0.07$
BaBar		$\Omega^- K^+$	≈ 650	$\Xi^-\pi^+$	$0.294 \pm 0.018 \pm 0.016$
BaBar		$\Omega^-\pi^+\pi^0$	64 ± 15	$\Omega^-\pi^+$	$1.27 \pm 0.31 \pm 0.11$
BaBar	Ω_c^0	$\Omega^-\pi^+\pi^+\pi^-$	25 ± 8	$\Omega^-\pi^+$	$0.28 \pm 0.09 \pm 0.01$
BaBar		$\Xi^- K^-\pi^+\pi^-$	45 ± 12	$\Omega^-\pi^+$	$0.46 \pm 0.13 \pm 0.03$

$\Xi_c^0 \to \Omega^- K^+$

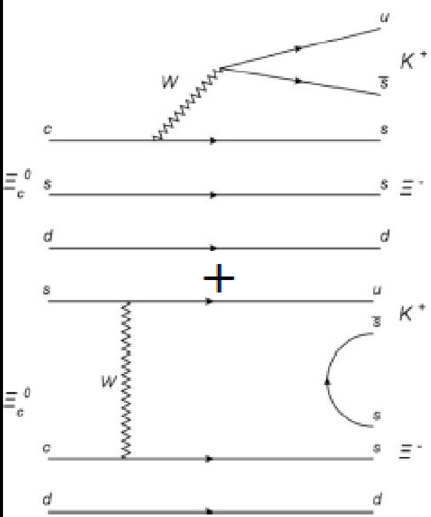


$$\frac{\mathcal{B}(\Xi_c^0 \to \Omega^- K^+)}{\mathcal{B}(\Xi_c^0 \to \Xi^- \pi^+)} = 0.294 \pm 0.018 \pm 0.016$$

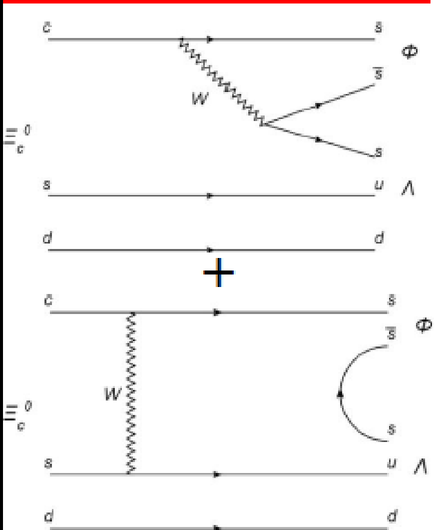
- Consistent with theoretical prediction: 0.32 (Korner & Kramer, 1992)

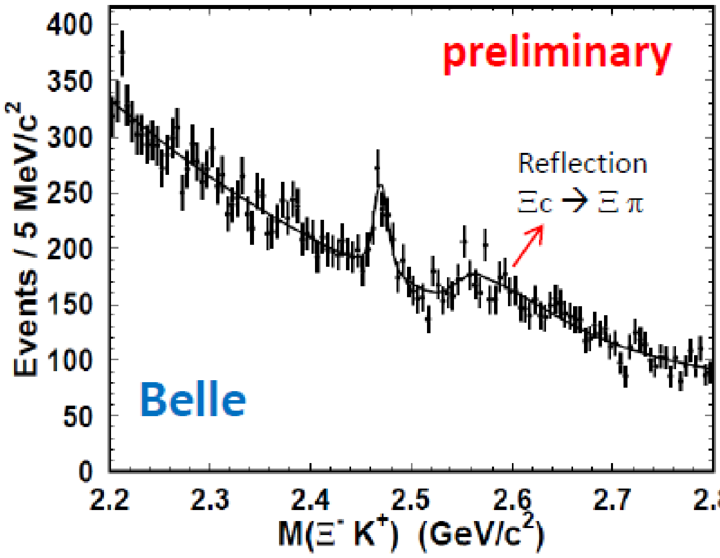
New Cabibbo-Suppressed Ξ_c^0 weak Decays

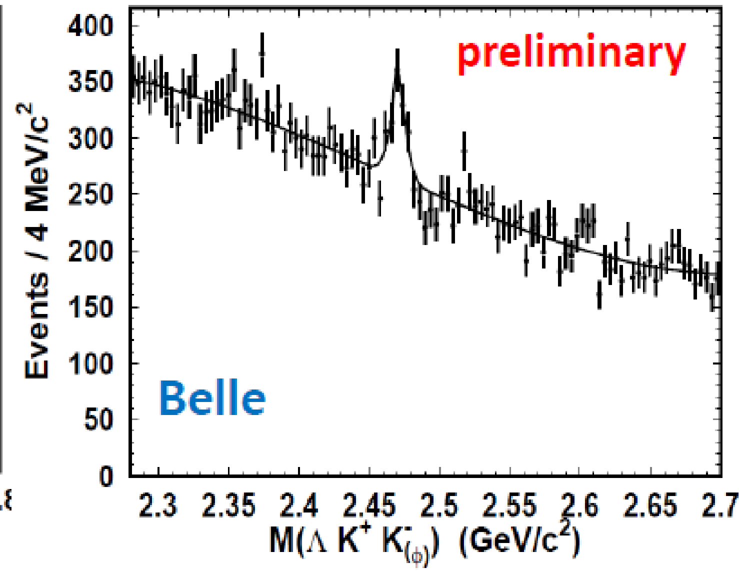
$\Xi_c^0 \to \Xi^- K^+$



$\Xi_c^0 \to \Lambda^0 \phi^0$







Mode	Yield	Efficiency (%)	$\frac{\mathcal{B}(\Xi_c^0 \to mode)}{\mathcal{B}(\Xi_c^0 \to \Xi^- \pi^+)}$ $(\times 10^{-2})$
$\Xi_c^0 \to \Xi^- K^+$	313.8 ± 57.8	4.47 ± 0.03	2.75 ± 0.51 ± 0.25
$\Xi_c^0 \to \Lambda^0 \phi$	315.8 ±53.7	3.60 ± 0.02	3.43 ± 0.58 ± 0.32
$\Xi_c^0 \to \Xi^- \pi^+$	15324 ± 262	6.00 ± 0.03	1

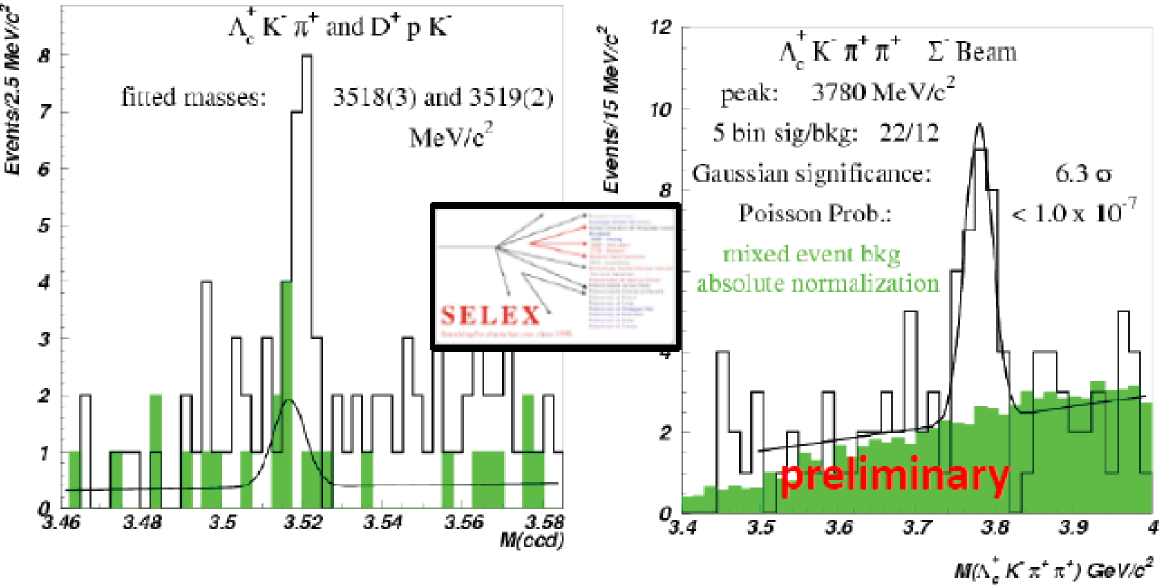
- **First** C.-S. mode observation in Ξ_c^0 weak decays.
- Used ~700/fb Υ(4S) on-resonance data sample.
- p*>3.0GeV/c to remove combinatorial BG.

Doubly charmed baryons

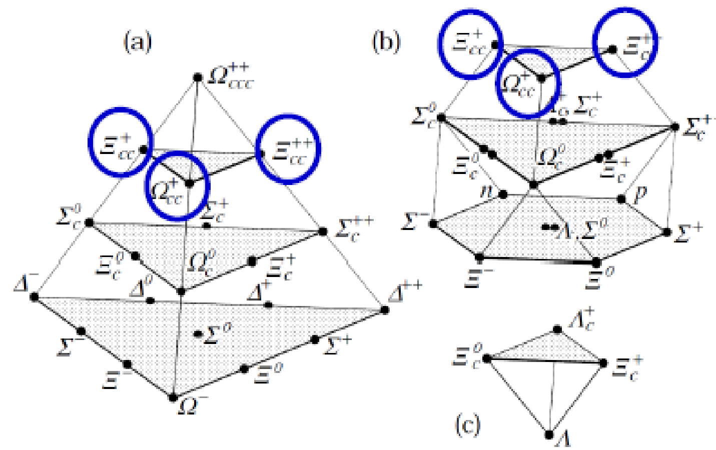
PRL 89, 112001 (2002) : SELEX
NPB proc. 115, 33 (2003) : FOCUS
PLB 628, 18 (2005) : SELEX
PRL 97, 162001 (2006) : Belle
PRD 74, 011103 (2006) : BaBar

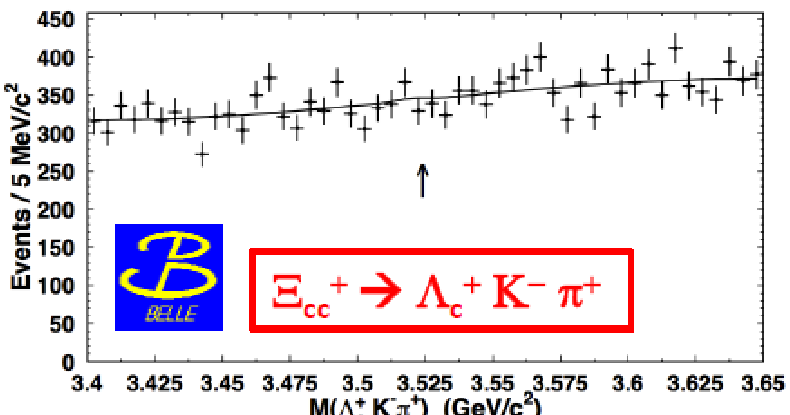
$\Xi_{cc}^{+} \rightarrow \Lambda_c^{+} K^{-} \pi^{+} + p\, D^{+} K^{-}$

$\Xi_{cc}^{++} \rightarrow \Lambda_c^{+} K^{-} \pi^{+} \pi^{+}$



{CCq}





- SELEX reported the observation of Ξ_{cc}^{+}
  - measured $m(\Xi_{cc}^{+})$ = 3518.7 (1.8) MeV/c^2
  - Theory : $m(\Xi_{cc}^{+})$ = ~ 3610 MeV/c^2
  - τ (measured) < τ (theory)
- No confirmed by FOCUS/Belle/BaBar

Experiment	Limit on $R_{\Xi_{cc}^+/\Lambda_c^+}$	Kinematic cuts
BABAR	6.9×10^{-4} @ 95% CL	—
BABAR	2.7×10^{-4} @ 95% CL	$p^* > 2.3$ GeV/c
Belle	1.5×10^{-4} @ 90% CL	$p^* > 2.5$ GeV/c
FOCUS	2.3×10^{-3} @ 90% CL	—

- LHCb under MC study in active.

Decay Asymmetry

Decay asymmetry

Predicted asymmetry parameter (α)

Decay	Körner, Krämer [56]	Xu, Kamal [60]	Cheng, Tseng [59]	Ivanov et al. [74]	Żenczykowski [73]	Sharma, Verma [72]	Expt. [3]
$\Lambda_c^+ \to \Lambda\pi^+$	−0.70	−0.67	−0.95	−0.95	−0.99	−0.99	-0.91 ± 0.15
$\Lambda_c^+ \to \Sigma^0\pi^+$	0.70	0.92	0.78	0.43	0.39	−0.31	
$\Lambda_c^+ \to \Sigma^+\pi^0$	0.71	0.92	0.78	0.43	0.39	−0.31	-0.45 ± 0.32
$\Lambda_c^+ \to \Sigma^+\eta$	0.33			0.55	0	−0.91	
$\Lambda_c^+ \to \Sigma^+\eta'$	−0.45			−0.05	−0.91	0.78	
$\Lambda_c^+ \to p\bar{K}^0$	−1.0	0.51	−0.49	−0.97	−0.66	−0.99	
$\Lambda_c^+ \to \Xi^0 K^+$	0	0		0	0	0	
$\Xi_c^+ \to \Sigma^+\bar{K}^0$	−1.0	0.24	−0.09	−0.99	1.00	0.54	
$\Xi_c^+ \to \Xi^0\pi^+$	−0.78	−0.81	−0.77	−1.0	1.00	−0.27	
$\Xi_c^0 \to \Lambda\bar{K}^0$	−0.76	1.0	−0.73	−0.75	−0.29	−0.79	
$\Xi_c^0 \to \Sigma^0\bar{K}^0$	−0.96	−0.99	−0.59	−0.55	−0.50	0.48	
$\Xi_c^0 \to \Sigma^+K^-$	0	0		0	0	0	
$\Xi_c^0 \to \Xi^0\pi^0$	0.92	0.92	−0.54	0.94	0.21	−0.80	
$\Xi_c^0 \to \Xi^0\eta$	−0.92			−1.0	−0.04	0.21	
$\Xi_c^0 \to \Xi^0\eta'$	−0.38			−0.32	−1.00	0.80	
$\Xi_c^0 \to \Xi^-\pi^+$	−0.38	−0.38	−0.99	−0.84	−0.79	−0.97	-0.6 ± 0.4
$\Omega_c^0 \to \Xi^0\bar{K}^0$	0.51		−0.93	−0.81			

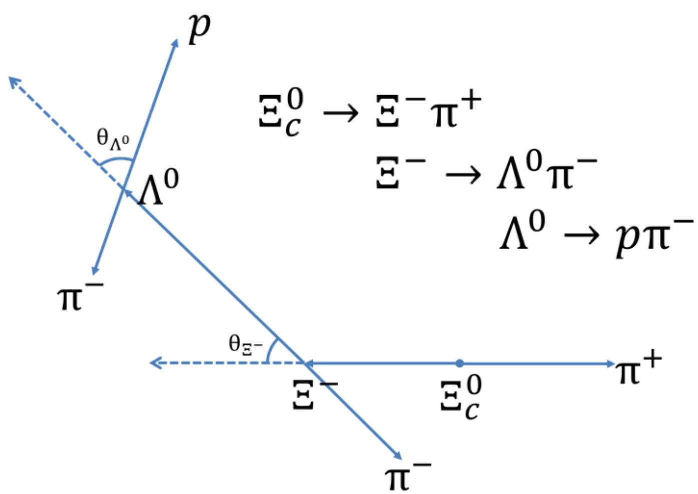
- Parity violation occurs in charm baryon decays due to existence of two orbital angular mom. decay amplitudes of opposite parity.
- The experimental observable is an asymmetry in the angular decay distribution due to interference between the two amplitudes.
- Many theoretical predictions have been made so that one can rule out some of them by measuring α.
- However, just few measurements available with large error so far.

Rather recent measurement(2006) by FOCUS:

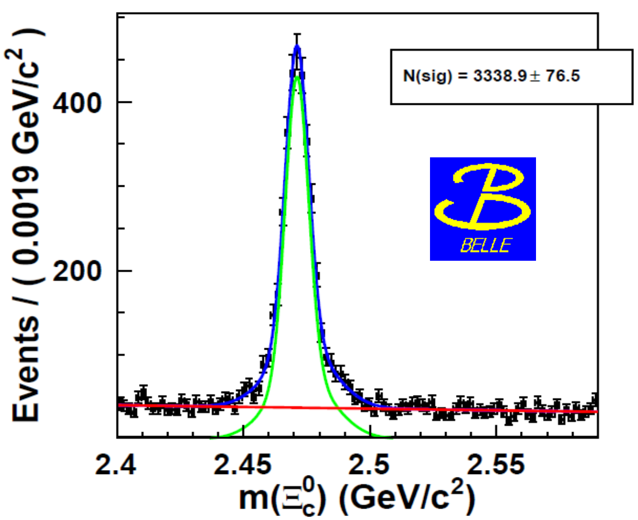
$$\alpha_{\Lambda_c^+} = -0.78 \pm 0.16 \pm 0.19(\Lambda_c^+ \to \Lambda^0\pi^+)$$

Under detail study @ Belle

$\Xi_c^0 \rightarrow \Xi^- \pi^+$ decay asymmetry



$$\frac{dN}{dcos\theta_{\Xi^-}} \propto 1 + \alpha_{\Xi_c^0}\alpha_{\Xi^-}cos\theta_{\Xi^-}$$



- Detail study with MC & control sample
  - N(sig) ~ 3K (off-resonance: 79/fb)
  - Cut optimization
  - α extraction procedure
- Expect ~30K signals (on-resonance data)
- Perform 2-D fit (M(Ξ_c^0) & $cos\theta_{\Xi^-}$)
  - $P_j^i = P_j(m(\Xi_c^0))^i \times P_j(cos\theta_{\Xi^-})^i$
  - $P_{sig}(cos\theta_{\Xi^-})^i = f(\varepsilon_{\Xi^-})^i \times f(\alpha_{\Xi_c^0}\alpha_{\Xi^-})^i$
  - $f(\varepsilon_{\Xi^-})$: efficiency correction
  - $f(\alpha_{\Xi_c^0}\alpha_{\Xi^-})$: our target
- Under systematic study
- Expected sensitivity:
  - $\delta\alpha \sim 3\%$ (stat.) (cf. CLEO : 0.6 ± 0.4)
- Extend to CPV measurement

CPV search

- CPV in baryonic decays has never been measured so far.
- Expected A_{CP} in the Standard Model is quite small.

$$A_{\mathrm{CP}} = \frac{\alpha + \bar{\alpha}}{\alpha - \bar{\alpha}} < \mathcal{O}(10^{-4})$$

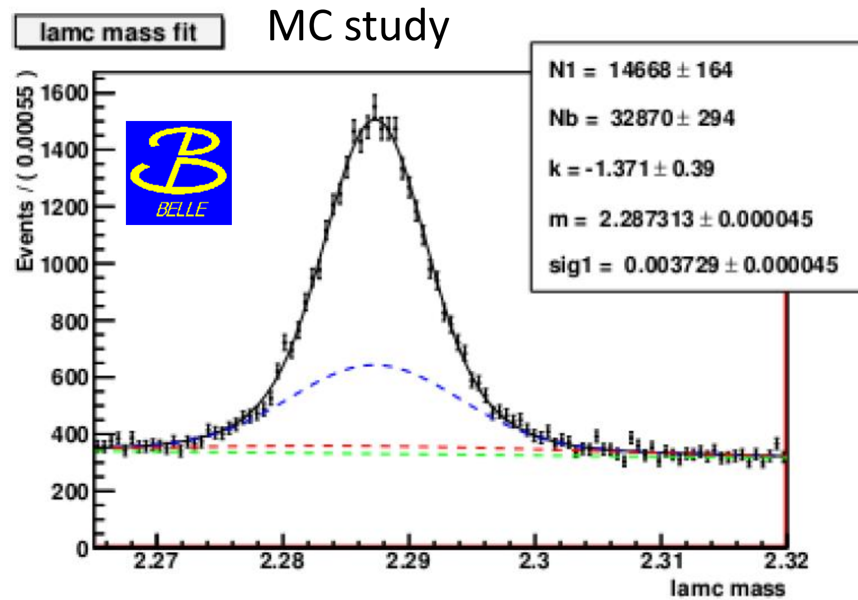
- Only FOCUS and CLEO made in charmed baryon decays.

Exp.	Mode	A_{CP}	
FOCUS	$\Lambda_c^+ \to \Lambda^0 \pi^+$	-0.07 $\pm$ 0.31	**PLB 634, 165 (2000)**
CLEO	$\Lambda_c^+ \to \Lambda^0 e^+ \nu_e$	0.00 $\pm$ 0.04	**PRL 94, 191801 (1994)**

- Better stat. & syst. sensitivities can be achieved in Belle.

CPV search at Belle

- Search mode : $\Lambda_c^+ \rightarrow \Lambda\, \pi^+$
- Basic strategy is blind analysis with MC sample at initial stage.
  - Kinematic reconstruction
  - Cut optimization
- Procedure of A_{CP} measurement is well established.
  - Measure signal yields in $\cos\theta_\Lambda$ bins.
  - Extract A_{CP} from measured α and α-bar
- Expected sensitivity
  - $\delta\alpha = \sim 0.5\%$ (stat.)
  - $\delta A_{CP} = \sim 7\%$ (stat.)



Summary

- Most of recent contributions done by **BaBar** and **Belle**.
- Good shape in measurement of strong/EM decays.
  - Need confirmation of unpromoted states.
- Still poor stage in measurement of weak decays.
  - Hope to see doubly charmed baryons in a few years.
  - Under study of decay asymmetry and CPV.
  - Need absolute BF measurements, model-indep. BF($\Lambda_c \rightarrow pK\pi$).
- Waiting for remarkable results from running/upcoming exp.

감사합니다!

Thank you