New charmed baryon results at BaBar

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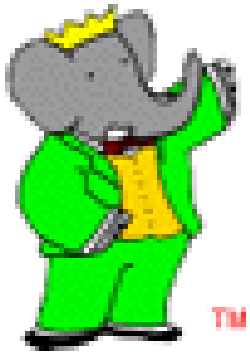
Representing The BaBar Collaboration

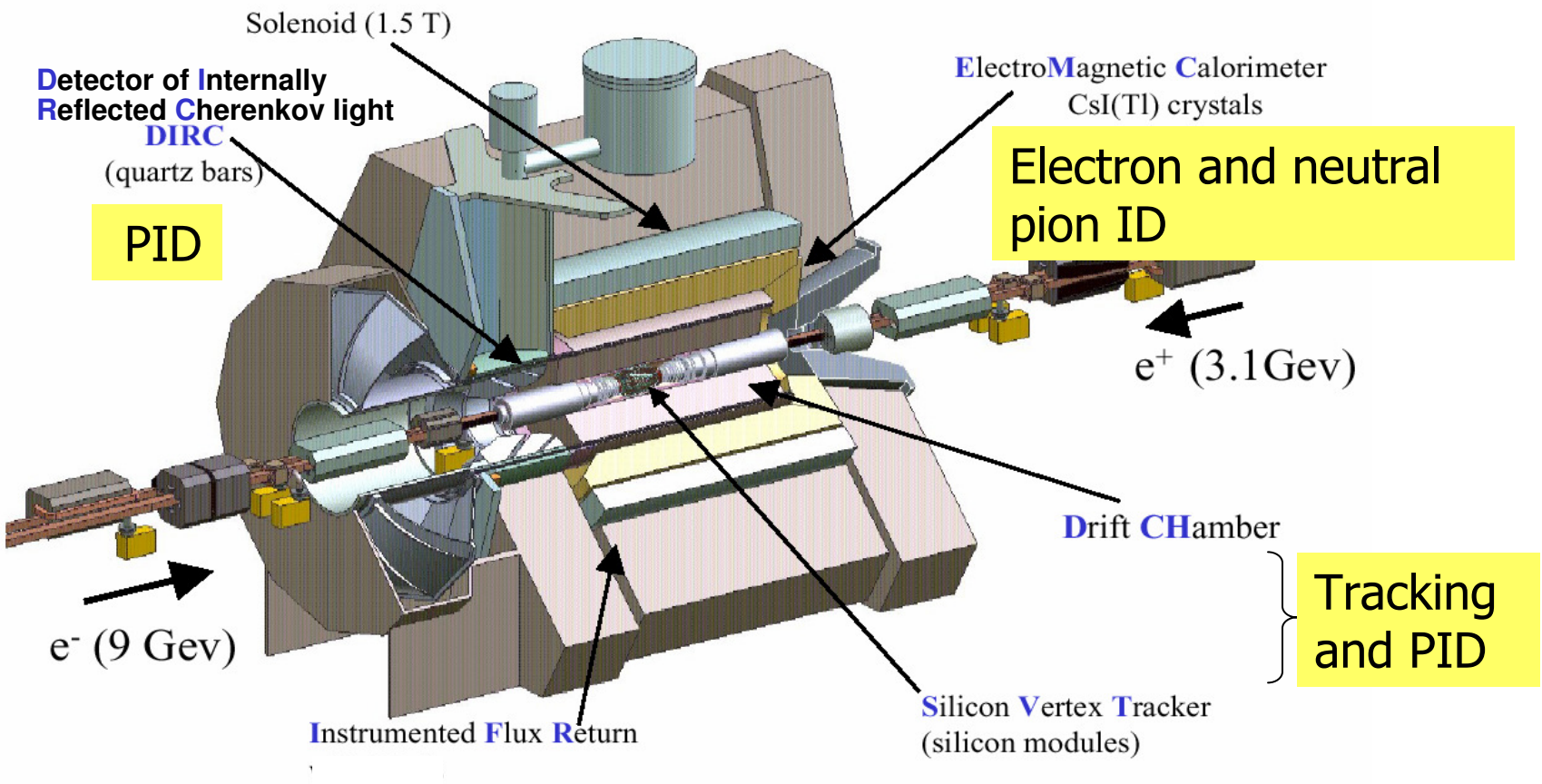


Charm 2007, Ithaca, August 2007

Outline of Topics

- First observation of $B \rightarrow \Omega_c^0 X$
- Discovery of Ω_c^{*0}
- Observation of $\Lambda_c(2940) \rightarrow D^0 p$
- Study of Excited Ξ_c resonances
- $e^+e^- \rightarrow \Lambda_c^+ \bar{\Lambda}_c^- X$

The BaBar Detector



SVT: 97% efficiency, 15 mm z hit resolution (inner layers, perp. tracks)

SVT+DCH: $\sigma(p_T)/p_T = 0.13\ \% \times p_T + 0.45\ \%$, $\sigma(z_0) = 65\mu m$ @ 1 GeV/c

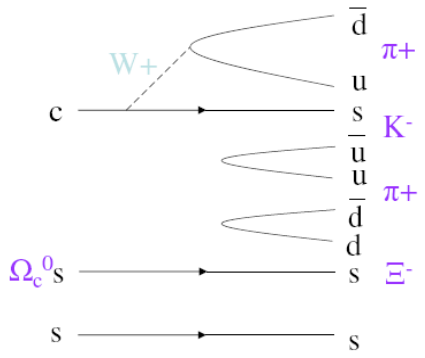
DIRC: K-π separation 4.2 σ @ 3.0 GeV/c → 2.5 σ @ 4.0 GeV/c

EMC: $\sigma_E/E = 2.3\ \% \cdot E^{-1/4} \oplus 1.9\ \%$

Study of $e^+e^- \to \Omega_c^0 X$

231 fb^{-1} Data

- Ω_c^0 is the css charmed baryon ground state



$\Omega_c^0 \to \Omega^-\pi^+$,
$\Omega^-\pi^+\pi^0$,
$\Omega^-\pi^+\pi^-\pi^+$,
$\Xi^-K^-\pi^+\pi^+$

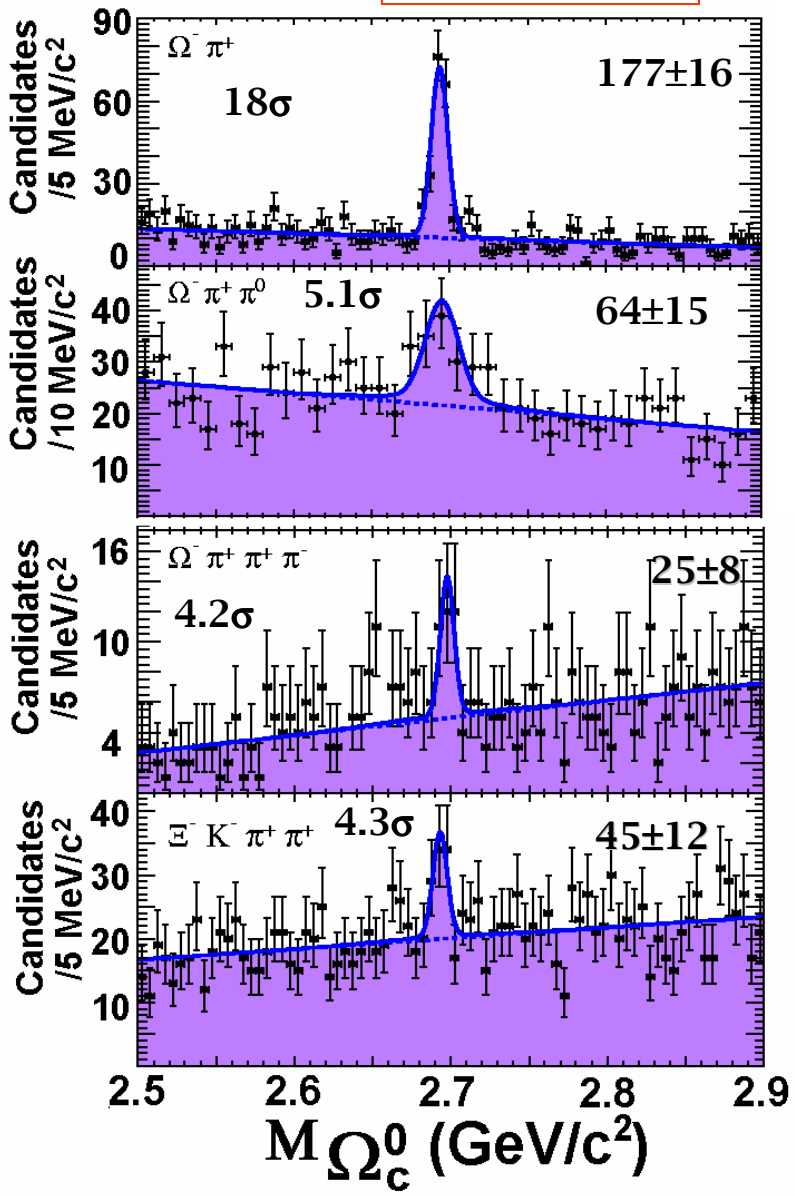
$$\frac{\mathcal{B}(\Omega_c^0 \to \Omega^-\pi^+\pi^0)}{\mathcal{B}(\Omega_c^0 \to \Omega^-\pi^+)} = 1.27 \pm 0.31 \pm 0.11$$

$$\frac{\mathcal{B}(\Omega_c^0 \to \Omega^-\pi^+\pi^+\pi^-)}{\mathcal{B}(\Omega_c^0 \to \Omega^-\pi^+)} = 0.28 \pm 0.09 \pm 0.01$$

$$\frac{\mathcal{B}(\Omega_c^0 \to \Xi^-K^-\pi^+\pi^+)}{\mathcal{B}(\Omega_c^0 \to \Omega^-\pi^+)} = 0.46 \pm 0.13 \pm 0.03$$

p*>2.4GeV/c

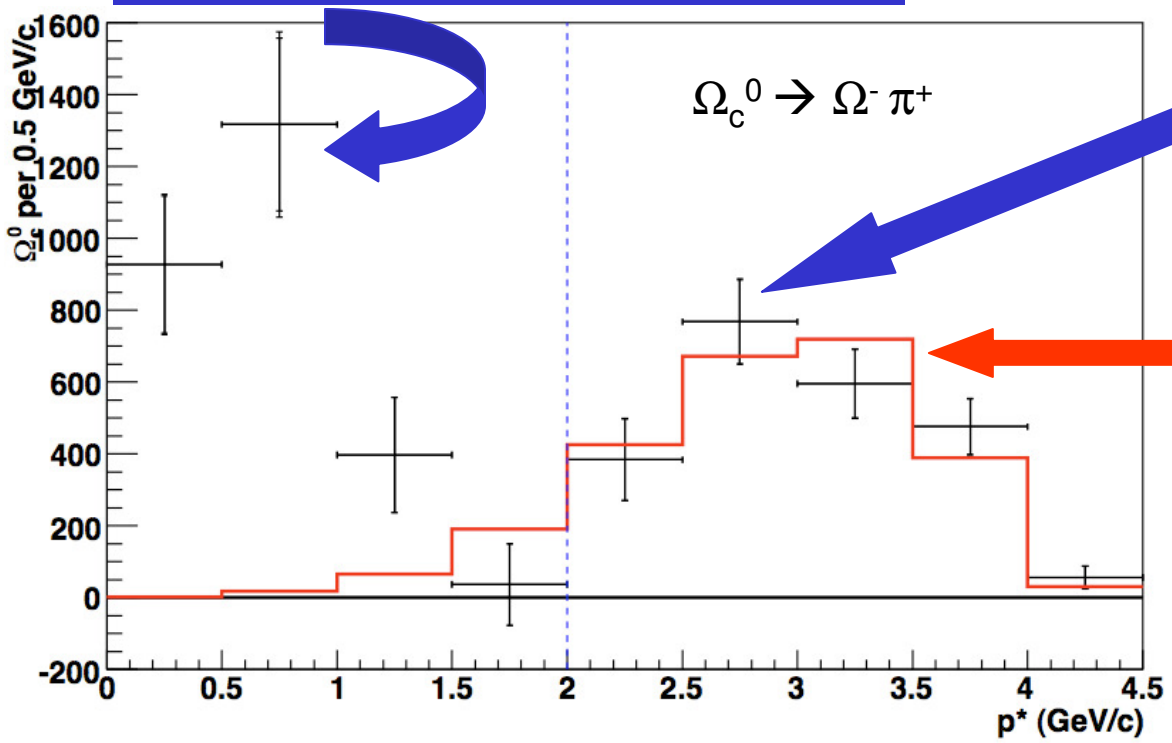
hep-ex/0703030, accepted by PRL



Production of Ω_c^0

231 fb^{-1} Data

First observation: $B \rightarrow \Omega_c^0 X$



$e^+e^- \rightarrow c\bar{c} \rightarrow \Omega_c^0 X$

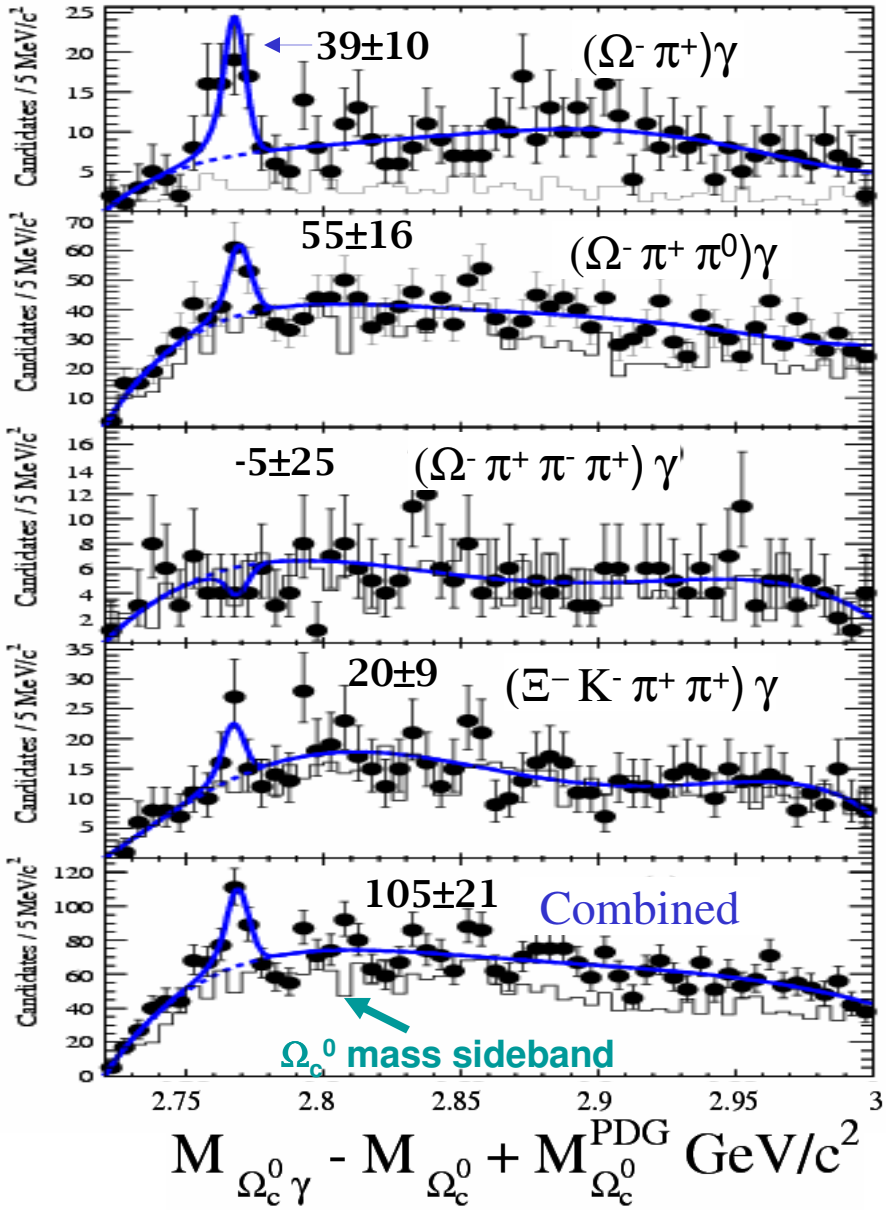
Bowler fragmentation Function (fit to data for $p^*>2$GeV)

Efficiency corrected p^* spectrum

$\mathcal{B}(B \rightarrow \Omega_c^0 X) \cdot \mathcal{B}(\Omega_c^0 \rightarrow \Omega^- \pi^+) = (5.2 \pm 0.9 \pm 0.05) \times 10^{-6}$ @ 2426 ± 414 events

$\sigma(e^+e^- \rightarrow \Omega_c^0 X) \cdot \mathcal{B}(\Omega_c^0 \rightarrow \Omega^- \pi^+) = (11.2 \pm 1.3 \pm 1.0)$ fb @ 2583 ± 289 events

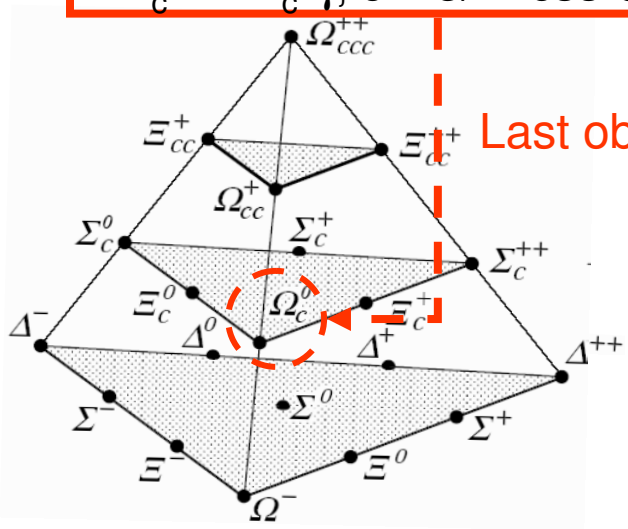
First observation of Ω_c^*



231 fb^{-1} Data

PRL 97:232001 (2006)

$\Omega_c^{*0} \rightarrow \Omega_c^0 \gamma$, $J^P = 3/2^+$ ccs baryon



Combined data give a 5.2σ signal significance

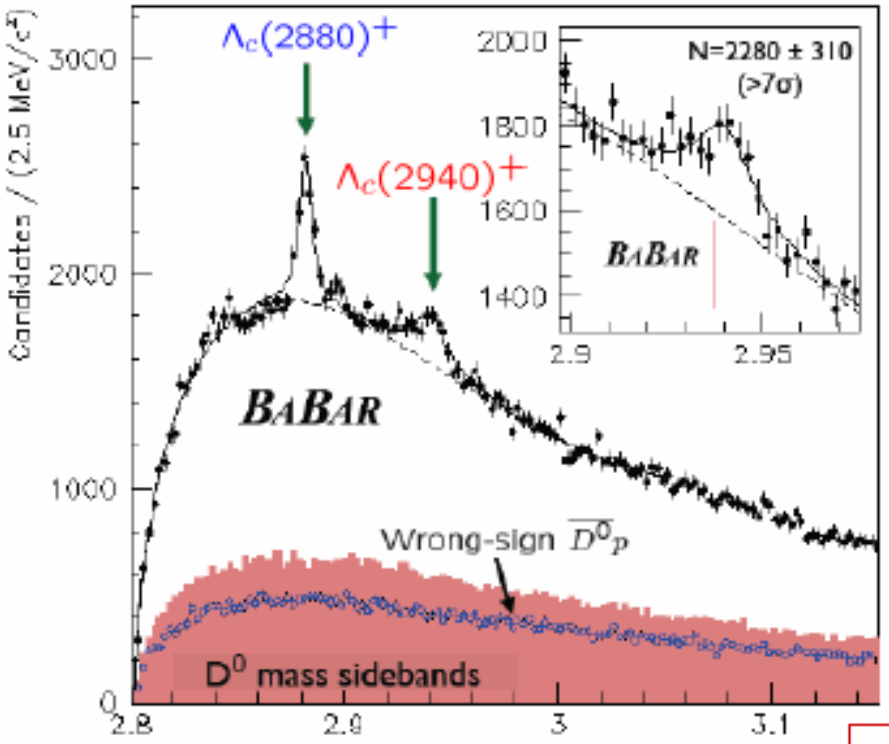
$$m(\Omega_c^{*0}) - m(\Omega_c^0) = 70.8 \pm 1.0 \pm 1.1 \text{MeV}/c^2$$

Predicted range: Δm= 50 – 94MeV/c²

$$\frac{\sigma(e^+e^- \rightarrow \Omega_c^{*0} X, x_p(\Omega_c^{*0}) > 0.5)}{\sigma(e^+e^- \rightarrow \Omega_c^0 X, x_p(\Omega_c^0) > 0.5)} = 1.01 \pm 0.23 \pm 0.11$$

Scaled momentum $x_p = p^*/p^*_{max}$

$\Lambda_c^+ \rightarrow D^0 p$



- First observation of charmed baryon decay to D meson and light baryon
- New Baryon state: $\Lambda_c(2940)$
- Is Λ_c (I=0) or Σ_c (I=1)?
  - no signal found in D^+p
    - → isospin =0
    - → both states are Λ_c not Σ_c

$$m(\Lambda_c(2880)^+) = 2881.9 \pm 0.1 \pm 0.5 \mathrm{MeV}/c^2$$
$$\Gamma(\Lambda_c(2880)^+) = 5.8 \pm 1.5 \pm 1.1 \mathrm{MeV}/c^2$$
$$m(\Lambda_c(2940)^+) = 2939.8 \pm 1.3 \pm 1.0 \mathrm{MeV}/c^2$$
$$\Gamma(\Lambda_c(2940)^+) = 17.5 \pm 5.2 \pm 5.9 \mathrm{MeV}/c^2$$

Data: 287fb^{-1}

PRL 98, 012001, 2007

Confirming Cleo result: m=2880.9±2.3MeV/c², Γ<8MeV at 90% CL

Study of Excited Ξ_c

- 384 fb^{-1} Data
- Six Ξ_c final states searched
  - $\Xi_c^{*+} \to \Lambda_c^+ K_s$
  - $\Xi_c^{*0} \to \Lambda_c^+ K^-$
  - $\Xi_c^{*0} \to \Lambda_c^+ K_s \pi^-$
  - $\Xi_c^{*+} \to \Lambda_c^+ K^- \pi^+$
  - $\Xi_c^{*+} \to \Lambda_c^+ K_s \pi^- \pi^+$
  - $\Xi_c^{*0} \to \Lambda_c^+ K^- \pi^+ \pi^-$

- 5 Λ_c^+ modes
  - $\Lambda_c^+ \to p K^- \pi^+$
  - $\Lambda_c^+ \to p K_s$
  - $\Lambda_c^+ \to p K_s \pi^- \pi^+$
  - $\Lambda_c^+ \to \Lambda^0 \pi^+$
  - $\Lambda_c^+ \to \Lambda^0 \pi^- \pi^+ \pi^+$

Significant signal

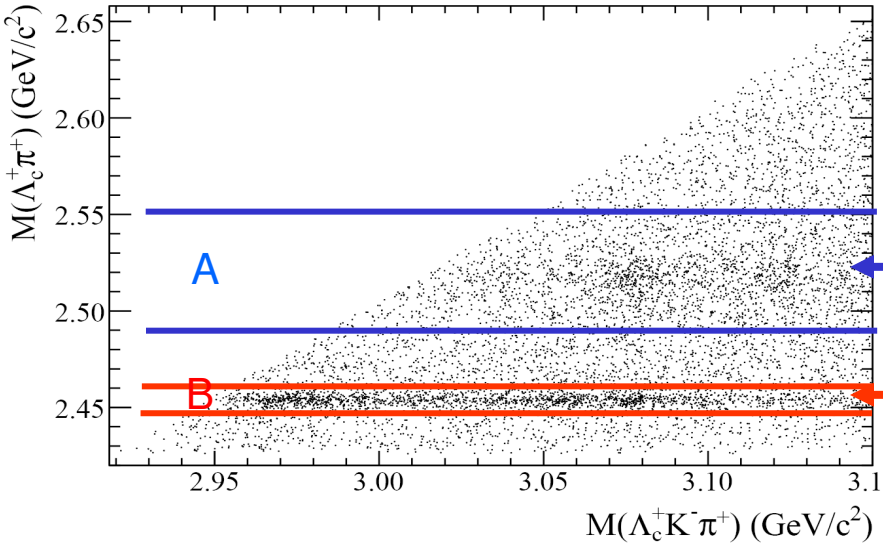
- Previous measurement by Belle (PRL 97, 162001, 2006)

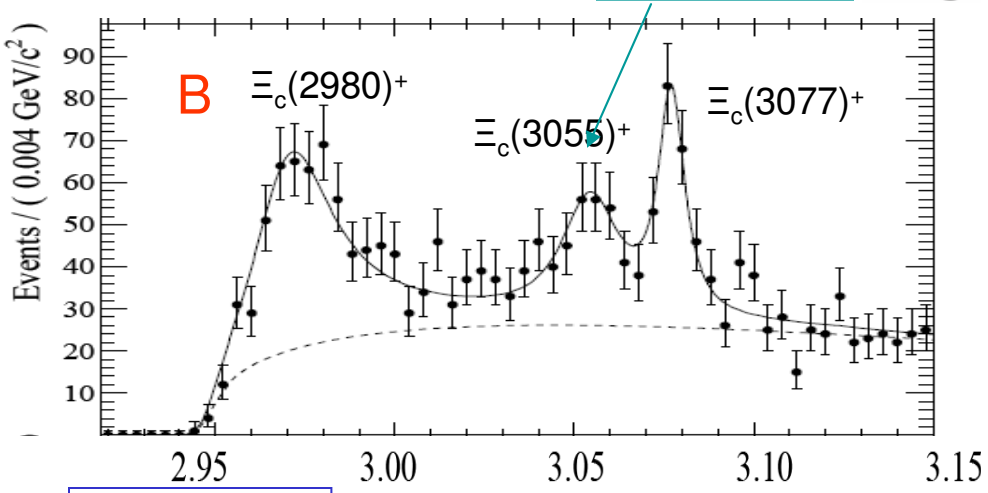
$\Xi_c(3077)^+$: 9.7σ	$\Xi_c(2980)^+$: 6.3σ
N=326.0 ± 39.6 events	N=405.3 ± 50.7 events
M=3076.7 ± 0.9 ± 0.5 MeV	M=2978.5 ± 2.1 ± 2.0 MeV
Γ=6.2 ± 1.2 ± 0.8 MeV	Γ=43.5 ± 7.5 ± 7.0 MeV

$\Xi_c^+ \to \Lambda_c^+ K^- \pi^+$

Preliminary

	$\Xi_c(3055)^+$	$\Xi_c(3123)^+$
Mass (MeV/c^2)	$3054.2 \pm 1.2 \pm 0.5$	$3122.9 \pm 1.3 \pm 0.3$
Width (MeV)	$17 \pm 6 \pm 11$	$4.4 \pm 3.4 \pm 1.7$
Yield	$218 \pm 53 \pm 79$	$101 \pm 34 \pm 9$
Significance	$6.4\,\sigma$	$3.6\,\sigma$ $(3.0\,\sigma)$

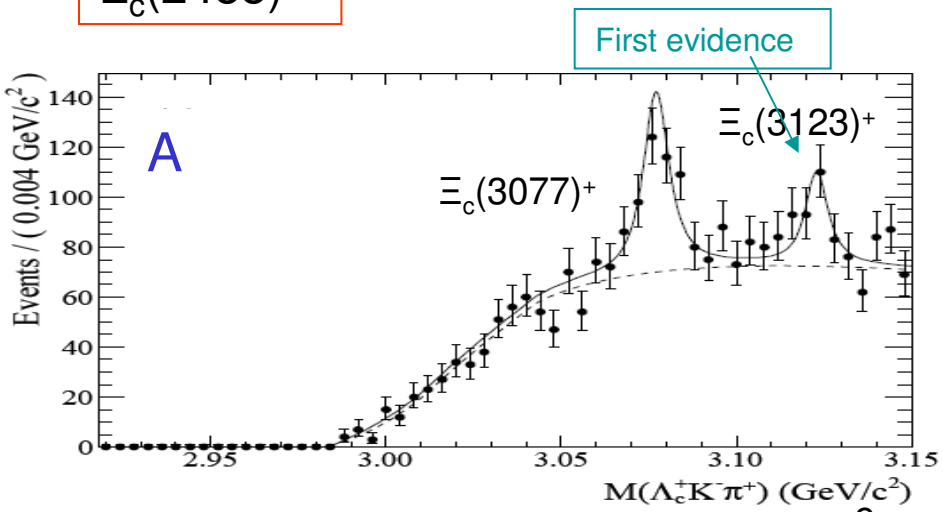




$\Sigma_c(2520)^{++}$

$\Sigma_c(2455)^{++}$

Ξ_c decay mostly through Σ_c



$m(\Xi_c(2980)^+) = 2969.3 \pm 2.2 \pm 1.7 \mathrm{MeV}/c^2$

10MeV/c^2 lower than Belle's

$\Xi_c^* \to$	$\Lambda_c^+ K^- \pi^+$
$\Xi_c(2980)$	$(11.8 \pm 3.4 \pm 2.2)$ fb
$\Xi_c(3055)$	$(2.2 \pm 1.2 \pm 0.7)$ fb
$\Xi_c(3077)$	$(8.1 \pm 1.2 \pm 0.8)$ fb
$\Xi_c(3123)$	$(1.6 \pm 0.6 \pm 0.2)$ fb

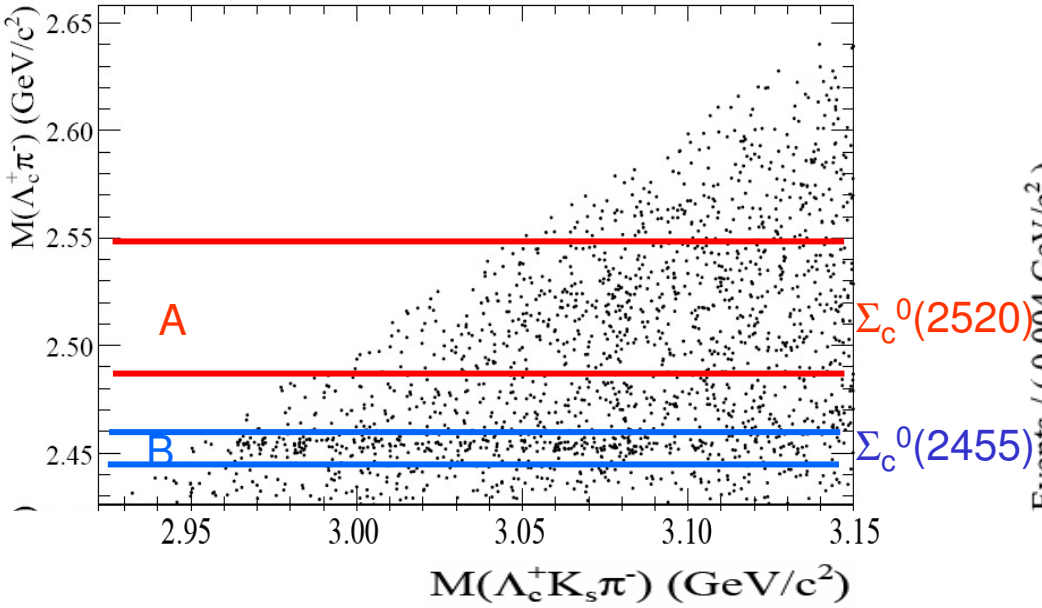
$\sigma(e^+e^- \to \Xi_c^* X)\mathcal{B}(\Xi_c^* \to \Lambda_c^+ K^-\pi^+)\mathcal{B}(\Lambda_c^+ \to pK^-\pi^+)$

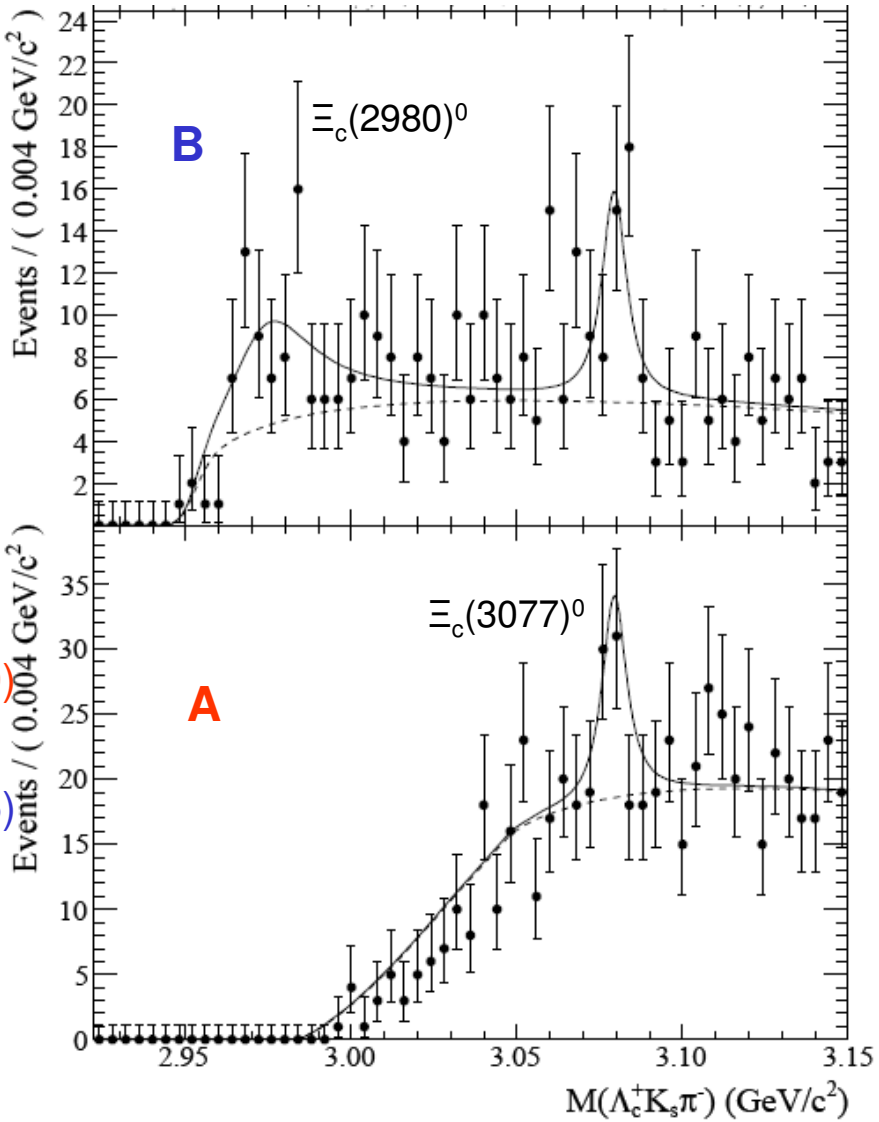
9

Preliminary

$\Xi_c^0 \to \Lambda_c^+ K_s \pi^-$

	Mass (MeV/c^2)	Width (MeV)	Yield	Significance
$\Xi_c(2970)^0$	$2972.9 \pm 4.4 \pm 1.6$	$31.4 \pm 6.5 \pm 8.2$	$67 \pm 33 \pm 29$	1.7σ
$\Xi_c(3077)^0$	$3079.3 \pm 1.1 \pm 0.2$	$5.9 \pm 2.3 \pm 1.5$	$90 \pm 22 \pm 15$	4.5σ





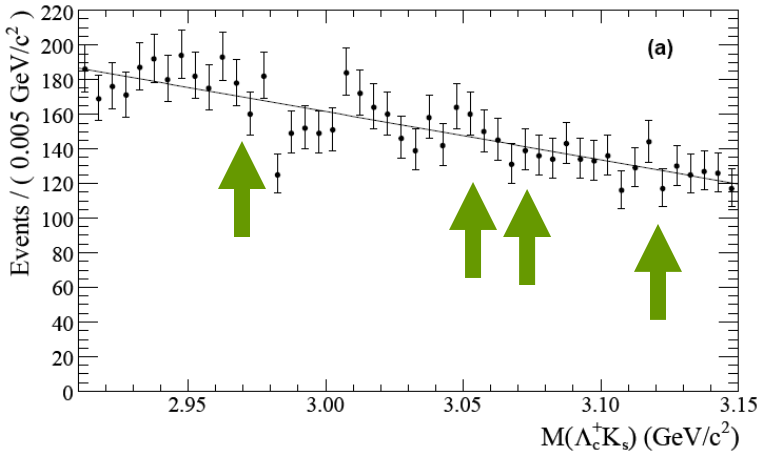
$\sigma(e^+e^- \to \Xi_c^* X)\mathcal{B}(\Xi_c^* \to \Lambda_c^+ \overline{K}^0 \pi^+)\mathcal{B}(\Lambda_c^+ \to pK^-\pi^+)$

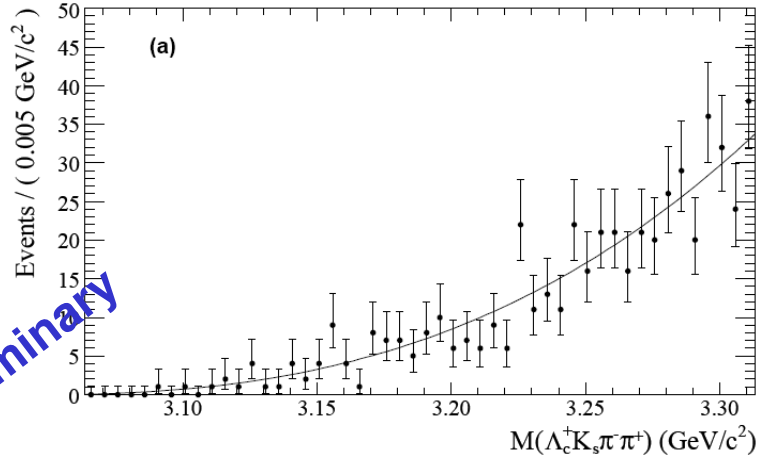
$\Xi_c^* \to$	$\Lambda_c^+ \overline{K}^0 \pi^-$
$\Xi_c(2980)$	< 15 fb
$\Xi_c(3055)$	< 7 fb
$\Xi_c(3077)$	$(6.2 \pm 2.1 \pm 1.5)$ fb
$\Xi_c(3123)$	< 1.4 fb

→ $\Xi_c^0(3055)$, $\Xi_c^0(3123)$ not seen since statistics is lower

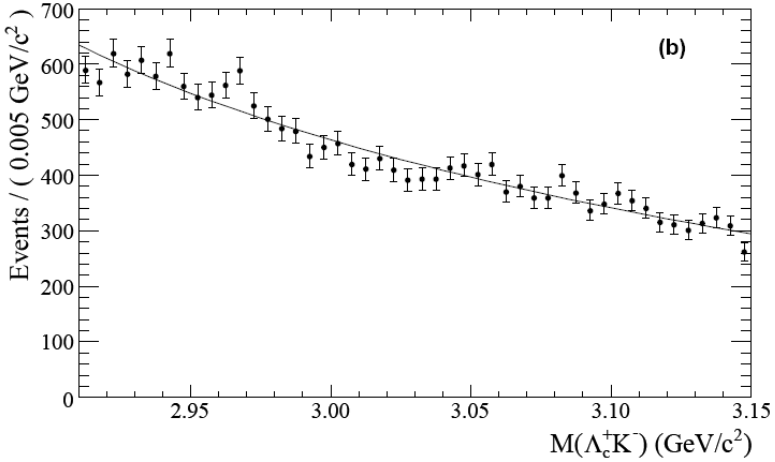
Two- and four-body Ξ_c decays

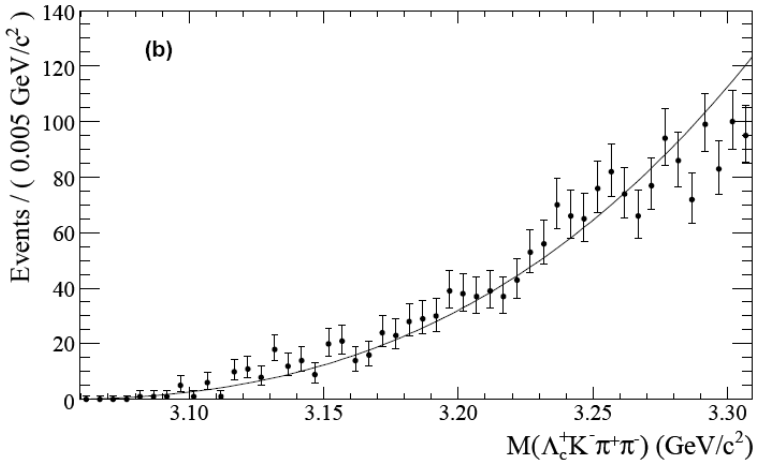
231 fb^{-1} Data





Preliminary





$\sigma(e^+e^- \to \Xi_c^* X)\mathcal{B}(\Xi_c^* \to Y)\mathcal{B}(\Lambda_c^+ \to pK^-\pi^+)$ ⇨

p*>2.9GeV, 90% CL

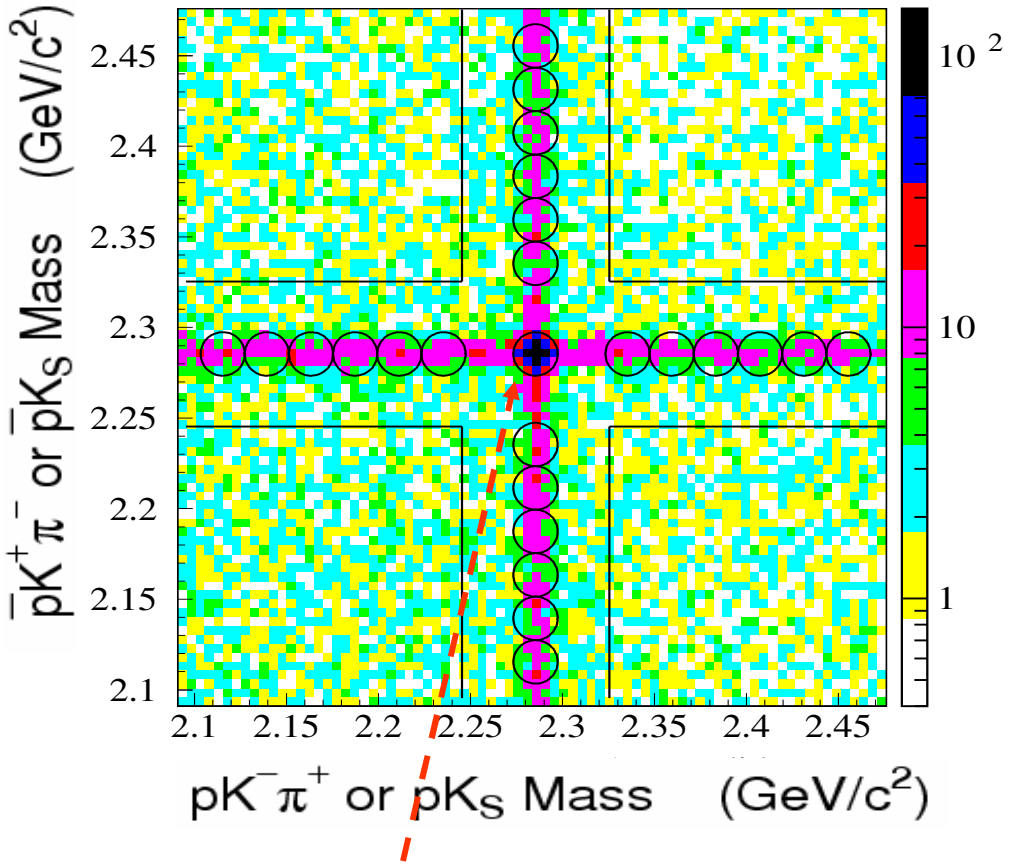
$\Xi_c^* \to$	$\Lambda_c^+\overline{K}^0$	$\Lambda_c^+K^-$	$\Lambda_c^+\overline{K}^0\pi^-\pi^+$	$\Lambda_c^+K^-\pi^+\pi^-$
$\Xi_c(2980)$	< 12 fb	< 10 fb	NA	NA
$\Xi_c(3055)$	< 9 fb	NO	NA	NA
$\Xi_c(3077)$	< 2.9 fb	< 1.2 fb	< 0.4 fb	< 0.1 fb
$\Xi_c(3123)$	< 2.7 fb	NO	< 1.4 fb	NO

Preliminary

$e+ e- \rightarrow \Lambda_c^+ \overline{\Lambda}_c^- + X$

Data: 220fb^{-1}

Correlated baryon-antibaryon production

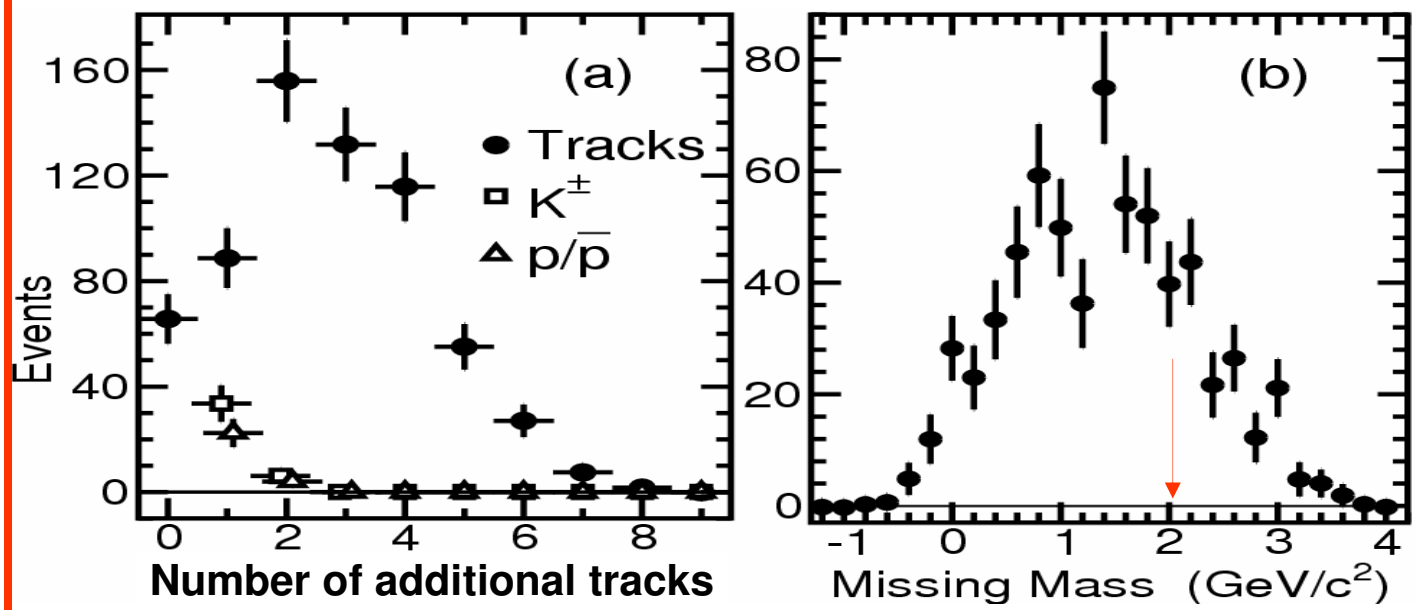


- 649±31 events with both Λ_c^+ and Λ_c^-
- The rate is 4 times higher than that expected from independently fragmenting jets

Preliminary

$e^+ e^- \rightarrow \Lambda_c^+ \Lambda_c^- + X$

Data: 220fb^{-1}



Background-subtracted events

- 4-baryon processes strongly suppressed
- ~4 extra mesons on average
- Very few 2-body or quasi-two-body events (e.g. e+e- $\rightarrow \Lambda_c^+ \Lambda_c^-$)
- Consistent with UCLA hadronization model , not JETSET or HERWIG

Summary

- Ω_c^0 decayed from B meson is observed for the first time

- New charmed baryons discovered: Ω_c^{*0} $\Lambda_c(2940)^+$ $\Xi_c(3055)^+$ $\Xi_c(3123)^+$

- Confirmation / Improvement of $\Xi_c(3077)^0$ $\Xi_c(3077)^+$ $\Xi_c(2980)^+$ $\Lambda_c(2880)^+$

- Charmed baryon pair production is measured in $c\bar{c}$ continuum events