B decays to baryonic final states and Ω_c^0 at Belle.

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on behalf of the **Belle Collaboration**

Outline

- Introduction
- Study of $\bar{B}^0 \to \Lambda_c^+ \bar{p} \pi^+ \pi^-$, $\Lambda_c^+ \bar{p}$, $B^- \to \Lambda_c^+ \bar{p} \pi^-$. Observation of $\bar{B}^0 \to \Sigma_c^{++} \bar{p} \pi^-$

  (BELLE-CONF-0238)
- Observation of $B^0 \to \bar{D}^{(*)0} p \bar{p}$ (BELLE-CONF-0222)
- Charmless Baryonic B Decays

  (BELLE-CONF-0224, -0237)
- Study of Ω_c^0 (BELLE-CONF-0253)
  - Ω_c^0 Mass Measurement using $\Omega_c^0 \to \Omega^- \pi^+$
  - Observation of Ω_c^0 Semileptonic Decay
- Summary

Introduction

Up to now only a few inclusive and exclusive B$\rightarrow$ $baryons$ modes have been studied experimentally:

- Exclusive modes:
  - $\bar{B}^0 \rightarrow \Lambda_c^+ \bar{p}\pi^+\pi^-$, $B^- \rightarrow \Lambda_c^+ \bar{p}\pi^-$ (CLEO-1997)
  - Searches for: $\bar{B}^0 \rightarrow \Lambda_c^+ \bar{p},\ p\bar{p},\ \Lambda\bar{\Lambda}$ and $B^+ \rightarrow p\bar{\Lambda}$ - no signals were found (CLEO-1997, 1998)
  - $B^0 \rightarrow D^{*-} p\bar{p}\pi^+$, $B^0 \rightarrow D^{*-} p\bar{n}$ (CLEO-2000)
- Inclusive modes:
  - $B \rightarrow \Lambda_c^+ X$ with large $\mathcal{B} = (6.4 \pm 1.1)\%$ (ARGUS-1988, CLEO-1992)
  - $B \rightarrow \Xi_c^{0,+} X$ (CLEO-1997)
  - The measured inclusive charmed baryon momentum spectra suggest the dominance of multibody final states.

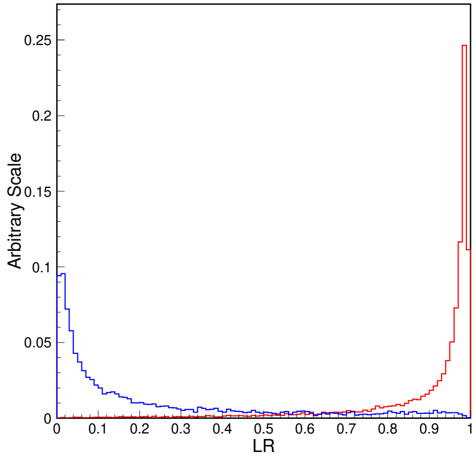
New measurements are needed to better understand $B \rightarrow baryons$ decays!

Introduction

5 of the 6 of Belle $B \to baryons$ results are based on the statistics of $\mathcal{L} = 31.9$ M $B\bar{B}$ and 1 on $\mathcal{L} = 65.4$ M $B\bar{B}$.

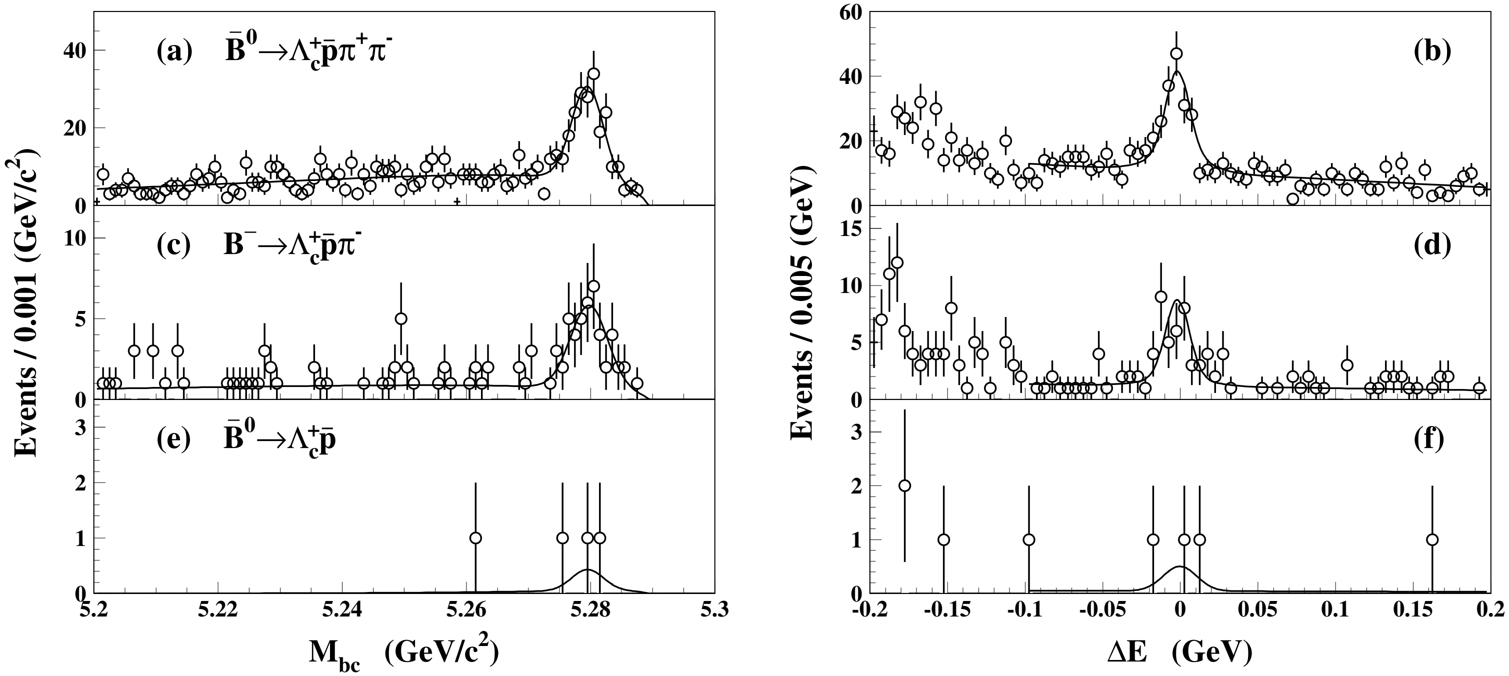
The common features of all $B \to baryons$ analyses are:

- particle ID: powerfull $p/K/\pi$ separation
- discriminate between jet-like continuum events and more spherical $B\bar{B}$:
  - Fox-Wolfram moments, $\cos(\theta_{thr})$, $\cos(\theta_B)$
  - combine into likelihoods for signal ($\mathcal{L}_S$) and background ($\mathcal{L}_B$)
  - cut at $\frac{\mathcal{L}_S}{\mathcal{L}_S + \mathcal{L}_B} > 0.6$ or 0.8



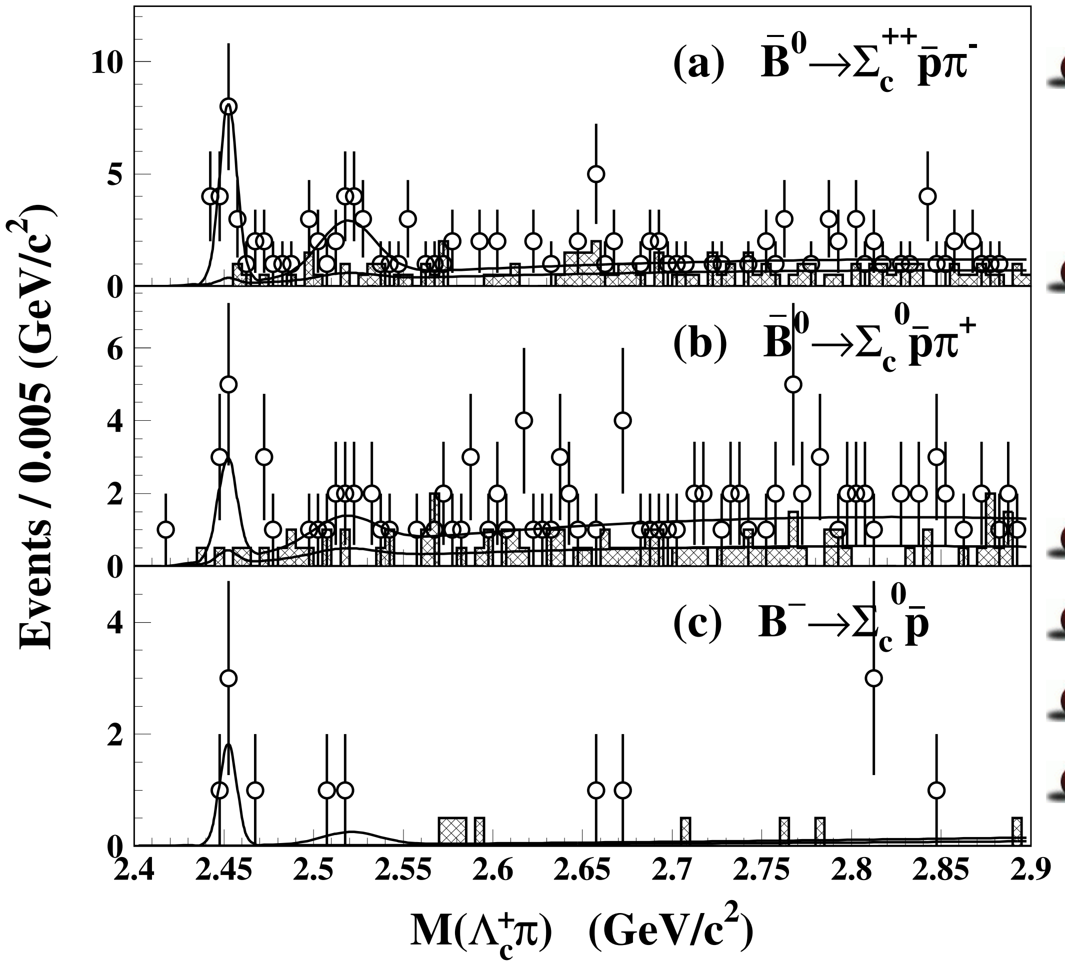
Study of $\bar{B}^0 \to \Lambda_c^+ \bar{p} \pi^+ \pi^-$, $\Lambda_c^+ \bar{p}$, $B^- \to \Lambda_c^+ \bar{p} \pi^-$

- Λ_c^+ reconstruction mode: $\Lambda_c^+ \to p K^- \pi^+$



- $\mathcal{B}(\bar{B}^0 \to \Lambda_c^+ \bar{p} \pi^+ \pi^-) = (11.04^{+1.22}_{-1.17} \pm 1.90 \pm 2.87) \times 10^{-4}$ (CLEO: $11.7^{+4.0}_{-3.7} \pm 2.7 \pm 3.0$)
- $\mathcal{B}(\bar{B}^- \to \Lambda_c^+ \bar{p} \pi^-) = (1.87^{+0.43}_{-0.40} \pm 0.27 \pm 0.49) \times 10^{-4}$ (CLEO: $5.5^{+2.0}_{-1.8} \pm 1.0 \pm 1.4$)
- $\mathcal{B}(\bar{B}^0 \to \Lambda_c^+ \bar{p}) < 0.34 \times 10^{-4}$ (CLEO: $< 1.85 \times 10^{-4}$@90% CL)

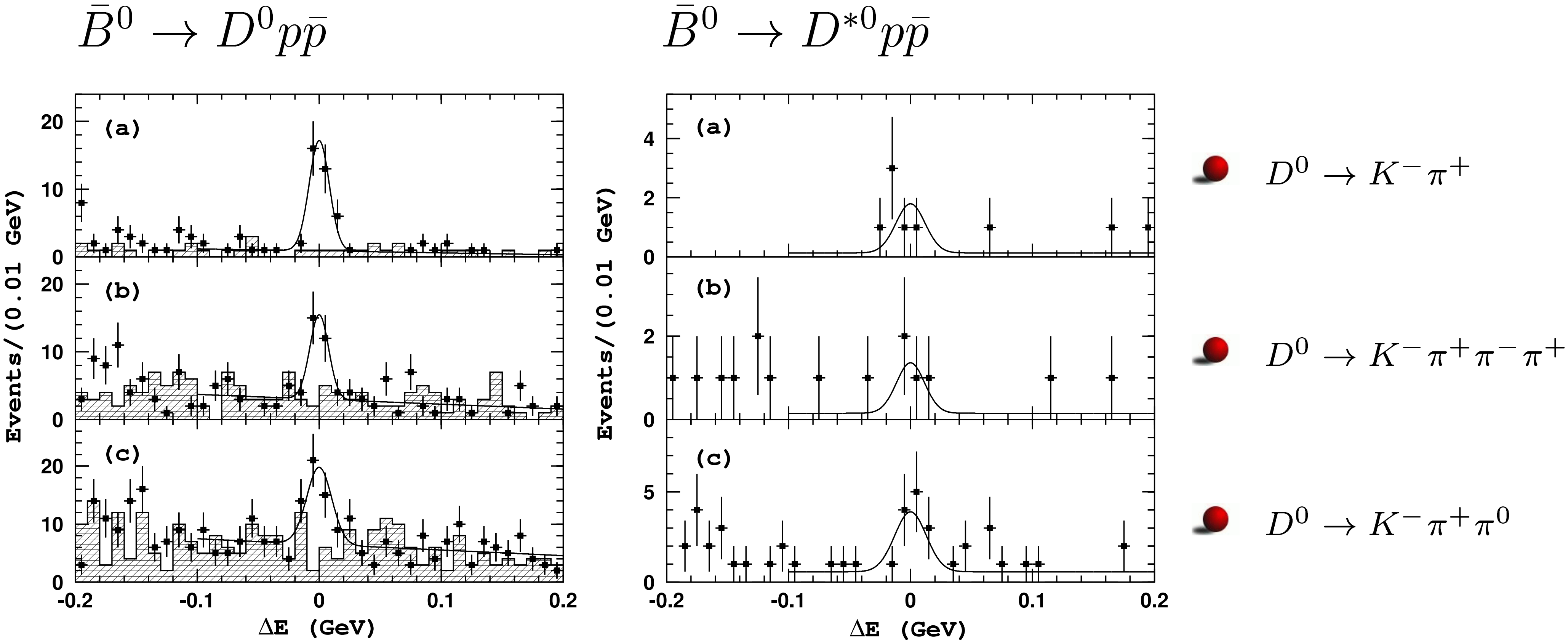
Observation of $\bar{B}^0 \to \Sigma_c^{++} \bar{p} \pi^-$



- $\mathcal{B}(\bar{B}^0 \to \Sigma_c^{++} \bar{p} \pi^-) =$ $(2.38^{+0.63}_{-0.55} \pm 0.41 \pm 0.62) \times 10^{-4}$ (5.3σ - first observation)
- $\mathcal{B}(\bar{B}^0 \to \Sigma_c^{++}(2520) \bar{p} \pi^-) =$ $(1.63^{+0.57}_{-0.51} \pm 0.28 \pm 0.42) \times 10^{-4}$ (3.5σ - evidence for the B decay to excited charmed baryon)
- $\mathcal{B}(\bar{B}^0 \to \Sigma_c^{0} \bar{p} \pi^+) < 1.59 \times 10^{-4}$
- $\mathcal{B}(\bar{B}^0 \to \Sigma_c^{0}(2520) \bar{p} \pi^+) < 1.21 \times 10^{-4}$
- $\mathcal{B}(B^- \to \Sigma_c^{0} \bar{p}) < 0.93 \times 10^{-4}$
- $\mathcal{B}(B^- \to \Sigma_c^{0}(2520) \bar{p}) < 0.46 \times 10^{-4}$

(all limits @ 90% CL)

Observation of $\bar{B}^0 \to D^{(*)0} p\bar{p}$

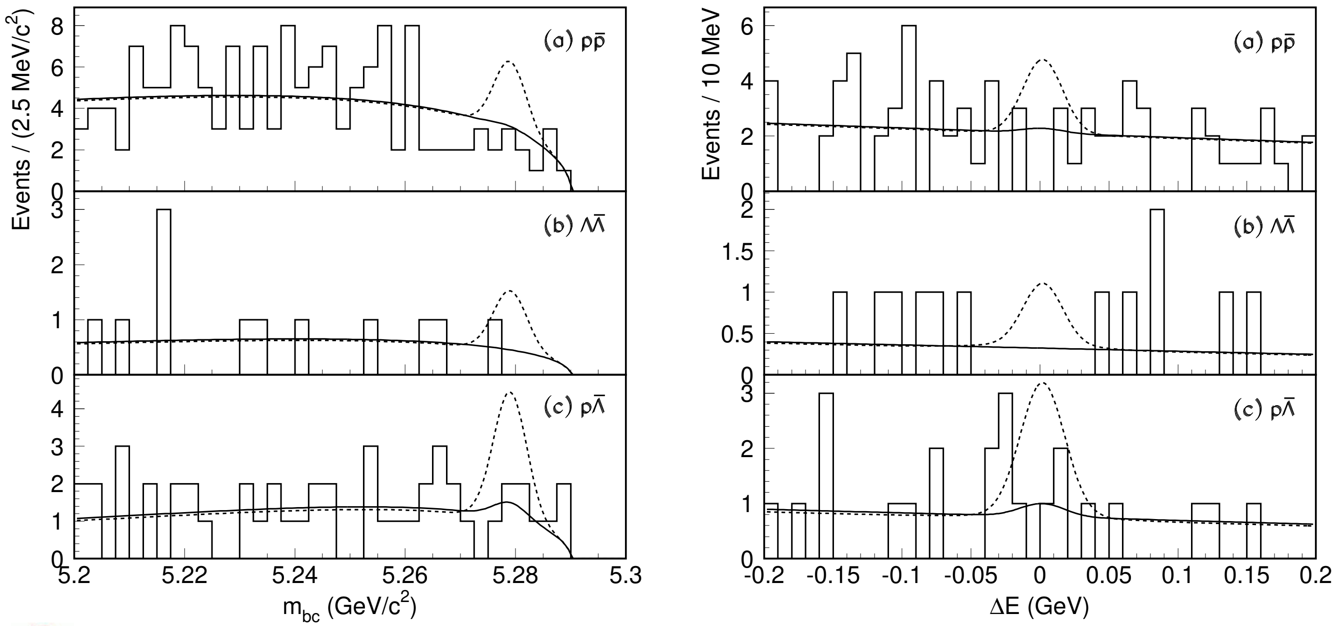


- $\mathcal{B}(\bar{B}^0 \to D^0 p\bar{p}) = (1.18 \pm 0.15 \pm 0.16) \times 10^{-4}$ with 12σ signficance
- $\mathcal{B}(\bar{B}^0 \to D^{*0} p\bar{p}) = (1.20^{+0.33}_{-0.29} \pm 0.21) \times 10^{-4}$ with 5.6σ signficance
- first observation of color-suppressed baryonic B decays

Charmless Baryonic B Decays (1)

Search for Charmless 2-body Baryonic B Decays

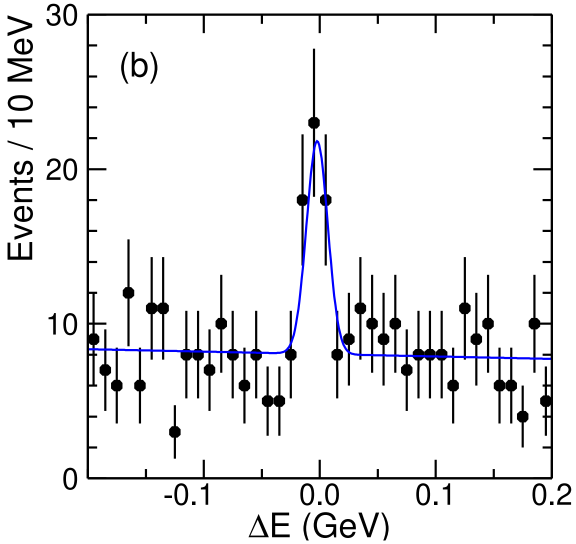
- $B^0 \to p\bar{p}$, $B^0 \to \Lambda\bar{\Lambda}$ and $B^+ \to p\bar{\Lambda}$
- In the SM, these decays are expected to proceed via $b \to u$ and $b \to s, d$.

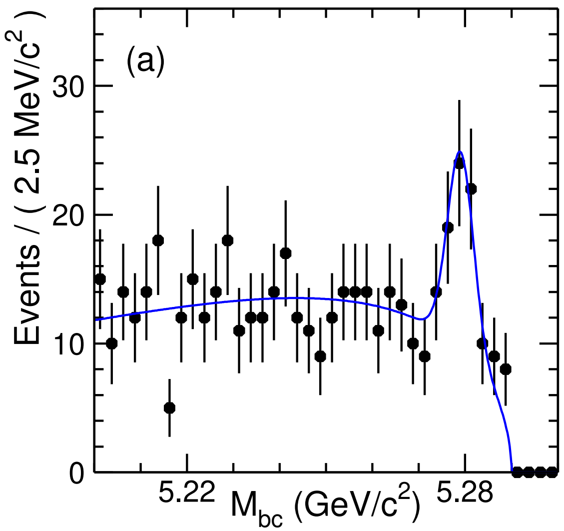


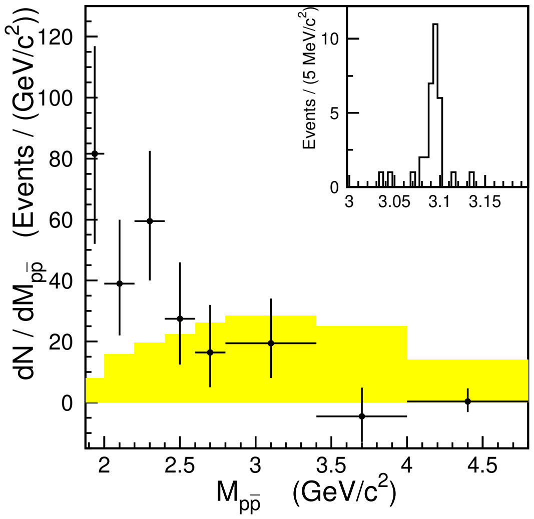
- $\mathcal{B}(B^0 \to p\bar{p}) < 1.2 \times 10^{-6}$ @90% CL (CLEO:$< 7.0 \times 10^{-6}$ @90% CL)
- $\mathcal{B}(B^0 \to \Lambda\bar{\Lambda}) < 1.0 \times 10^{-6}$ @90% CL (CLEO:$< 3.9 \times 10^{-6}$ @90% CL)
- $\mathcal{B}(B^+ \to p\bar{\Lambda}) < 2.2 \times 10^{-6}$ @90% CL (CLEO:$< 2.6 \times 10^{-6}$ @90% CL)

Charmless Baryonic B Decays (2)

Observation of $B^+ \to p\bar{p}K^+$



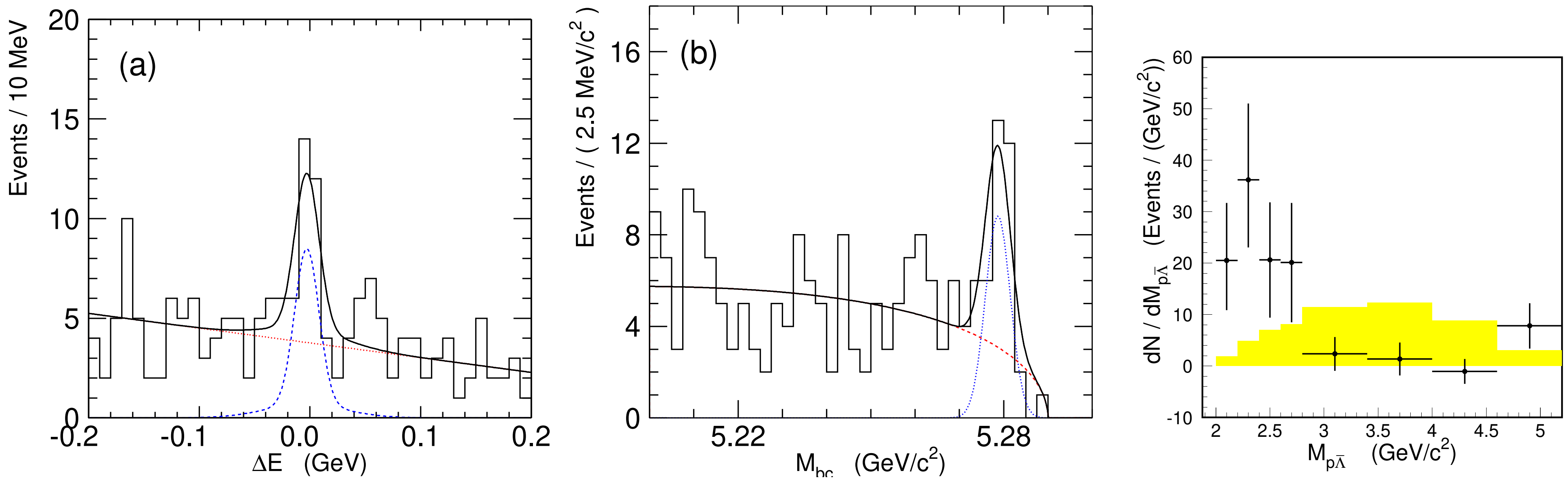




- signal yield: $42.8^{+10.0}_{-9.6}$ with a significance of 5.6σ,
  $\mathcal{B}(B^+ \to p\bar{p}K^+) = (4.3^{+1.1}_{-0.9} \pm 0.5) \times 10^{-6}$
- first observation of charmless baryonic B decay
- $p\bar{p}$ mass spectrum is inconsistent with phase space
- $\mathcal{B}(B^+ \to p\bar{p}K^0_s) < 7.2 \times 10^{-6}$@90% CL
- $\mathcal{B}(B^+ \to p\bar{p}\pi^+) < 3.7 \times 10^{-6}$@90% CL.

Charmless Baryonic B Decays (3)

Observation of $B^0 \to p\bar{\Lambda}\pi^-$ ($\mathcal{L} = 65.4$ M $B\bar{B}$)

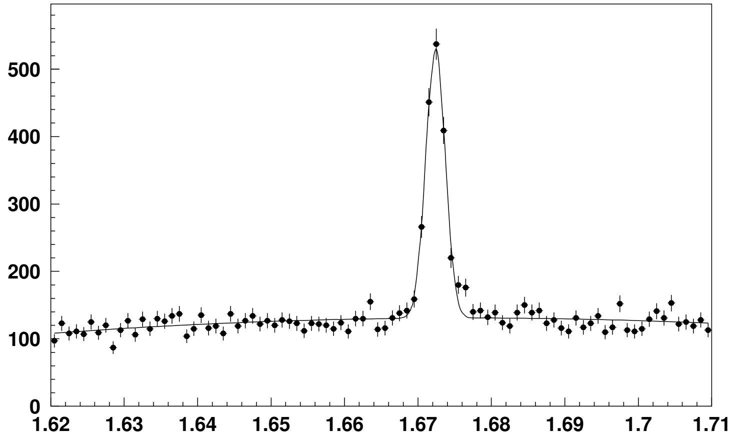


- signal yield: $28.2^{+7.6}_{-6.9}$ with a significance of 5.1σ, $\mathcal{B}(B^0 \to p\bar{\Lambda}\pi^-) = (3.56^{+0.86}_{-0.74} \pm 0.43) \times 10^{-6}$ (preliminary)
- first observation of charmless hyperonic B decay
- the observed $p\bar{\Lambda}$ mass distribution peaks at a low masses again
- $\mathcal{B}(B^0 \to p\bar{\Lambda}K^-) < 1.8 \times 10^{-6}$@90% CL (preliminary)
- $\mathcal{B}(B^0 \to p\bar{\Sigma}^0\pi^-) < 4.1 \times 10^{-6}$@90% CL. (preliminary)

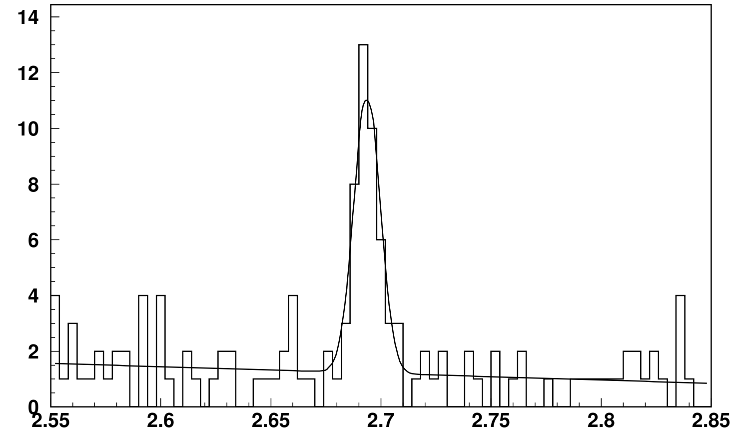
Ω_c^0 Mass Measurement using $\Omega_c^0 \to \Omega^- \pi^+$

The Ω_c^0 is the least well understand ground state charmed baryon

$\Omega^- \to \Lambda^0 K^-$



- Reconstruction steps:
- identify $\pi/K/p$
- reconstruct $\Lambda^0 \to p\pi^-$, reconstruct Λ^0-decay vertex
- reconstruct $\Omega^- \to \Lambda^0 K^-$ and Ω^--decay vertex
- 1311 ± 50 of inclusive $\Omega^- \to \Lambda^0 K^-$ events



$\Omega_c^0 \to \Omega^- \pi^+$

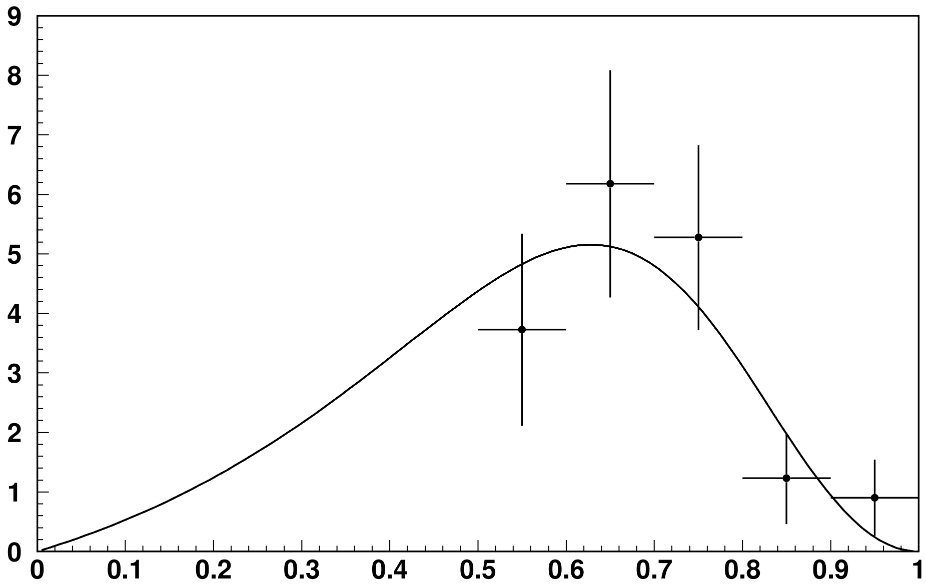
- $x_p(\Omega^- \pi^+) > 0.5$ - suppress combinatorial background
- Results:
- 37.6 ± 6.9 $\Omega_c^0 \to \Omega^- \pi^+$ events
- Belle preliminary: M(Ω_c^0) = $2693.7 \pm 1.3^{+1.1}_{-1.0}$ MeV
- CLEO (5 modes): M(Ω_c^0) = $2694.6 \pm 2.6 \pm 1.9$ MeV

Ω_c^0 Production Study

Belle preliminary: $\sigma(\Omega_c^0|x_p > 0.5) \times \mathcal{B}(\Omega_c^0 \to \Omega^-\pi^+) = 17.3 \pm 3.2 \pm 1.7$ fb

CLEO: $\sigma(\Omega_c^0|x_p > 0.5) \times \mathcal{B}(\Omega_c^0 \to \Omega^-\pi^+) = 11.3 \pm 3.9 \pm 2.0$ fb

x_p spectrum of Ω_c^0:



- Peterson *et al.* fragmentation function
  $$\frac{dN}{dx_p} \approx \frac{1}{x_p} \cdot \frac{1}{(1 - \frac{1}{x_p} - \frac{\epsilon_p}{1-x_p})^2}$$
  was used to fit the x_p spectrum
- BELLE preliminary:
  - $\epsilon_p = 0.22^{+0.13}_{-0.07} \pm 0.02$
  - $\sigma(\Omega_c^0) \times \mathcal{B}(\Omega_c^0 \to \Omega^-\pi^+) =$ $24.5^{+20.0}_{-10.7} \pm 3.4$ fb

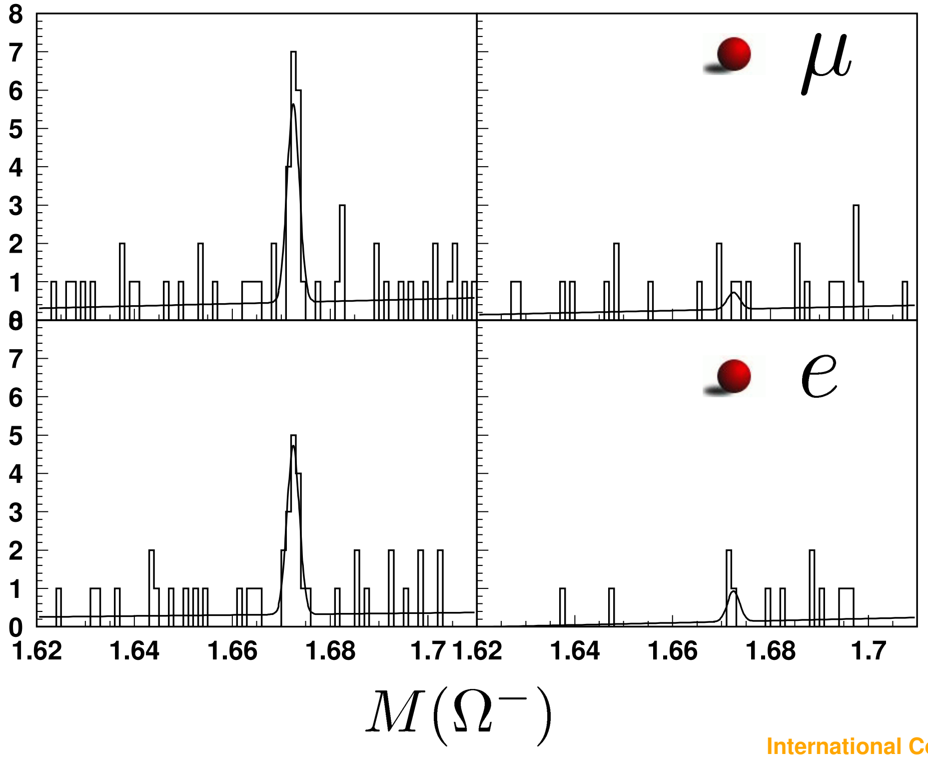
Observation of Ω_c^0 Semileptonic Decay (1)

CLEO observed 11.4 ± 3.8 $\Omega_c^0 \to \Omega^- e^+ \nu$ events

(last summer conference presentation)

Belle observes both $\Omega_c^0 \to \Omega^- e^+ \nu$ and $\Omega_c^0 \to \Omega^- \mu^+ \nu$:

Ω^- with right-sign lepton Ω^- with wrong-sign lepton



10.2 ± 4.6 signal $\Omega^- \mu^+$ events

12.8 ± 4.2 signal $\Omega^- e^+$ events

Observation of Ω_c^0 Semileptonic Decay (2)

After the efficiency correction Belle obtains (preliminary):

- $\sigma(\Omega_c^0|x_p > 0.5) \times \mathcal{B}(\Omega_c^0 \to \Omega^- \mu^+ \nu) = 20.1 \pm 9.0 \pm 2.7$ fb
- $\sigma(\Omega_c^0|x_p > 0.5) \times \mathcal{B}(\Omega_c^0 \to \Omega^- e^+ \nu) = 20.6 \pm 6.7 \pm 2.6$ fb
- weighted average:
  $\sigma(\Omega_c^0|x_p > 0.5) \times \mathcal{B}(\Omega_c^0 \to \Omega^- l^+ \nu) = 20.4 \pm 5.4 \pm 2.7$ fb

  - Belle preliminary: $\frac{\mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+)}{\mathcal{B}(\Omega_c^0 \to \Omega^- l^+ \nu)} = 0.83 \pm 0.28 \pm 0.14$
  - CLEO: $\frac{\mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+)}{\mathcal{B}(\Omega_c^0 \to \Omega^- l^+ \nu)} = 0.41 \pm 0.19 \pm 0.04$

Summary

Belle $B \to baryons$ results:

- study of exclusive B decays to charmed baryons: $\bar{B}^0 \to \Lambda_c^+ \bar{p}\pi^+\pi^-$, $\Lambda_c^+ \bar{p}$, $B^- \to \Lambda_c^+ \bar{p}\pi^-$ (results are consistent with CLEO)
- first observation of $\bar{B}^0 \to \Sigma_c^{++} \bar{p}\pi^-$ and evidence for $\bar{B}^0 \to \Sigma_c^{++}(2520)\bar{p}\pi^-$
- first observation of color-suppressed baryonic B decays: $\bar{B}^0 \to D^{(*)0} p\bar{p}$
- first observation of the charmless baryonic B decay $B^+ \to p\bar{p}K^+$
- first observation of the charmless hyperonic B decay $B^0 \to p\bar{\Lambda}\pi^-$
- many searches for other charmless baryonic and hyperonic B decays (first or improved upper limits)

Belle Ω_c^0 results:

- Ω_c^0 mass measurement and production study - consistent with CLEO
- observation of Ω_c^0 semileptonic decay: the ratio of hadronic and semileptonic $\mathcal{B}$'s is marginally consistent with CLEO