The study of charmed baryon at BESIII

Weimin Song (IHEP)

on behalf of BESIII Collaboration

Jinan Shandong, June 10th

Outline

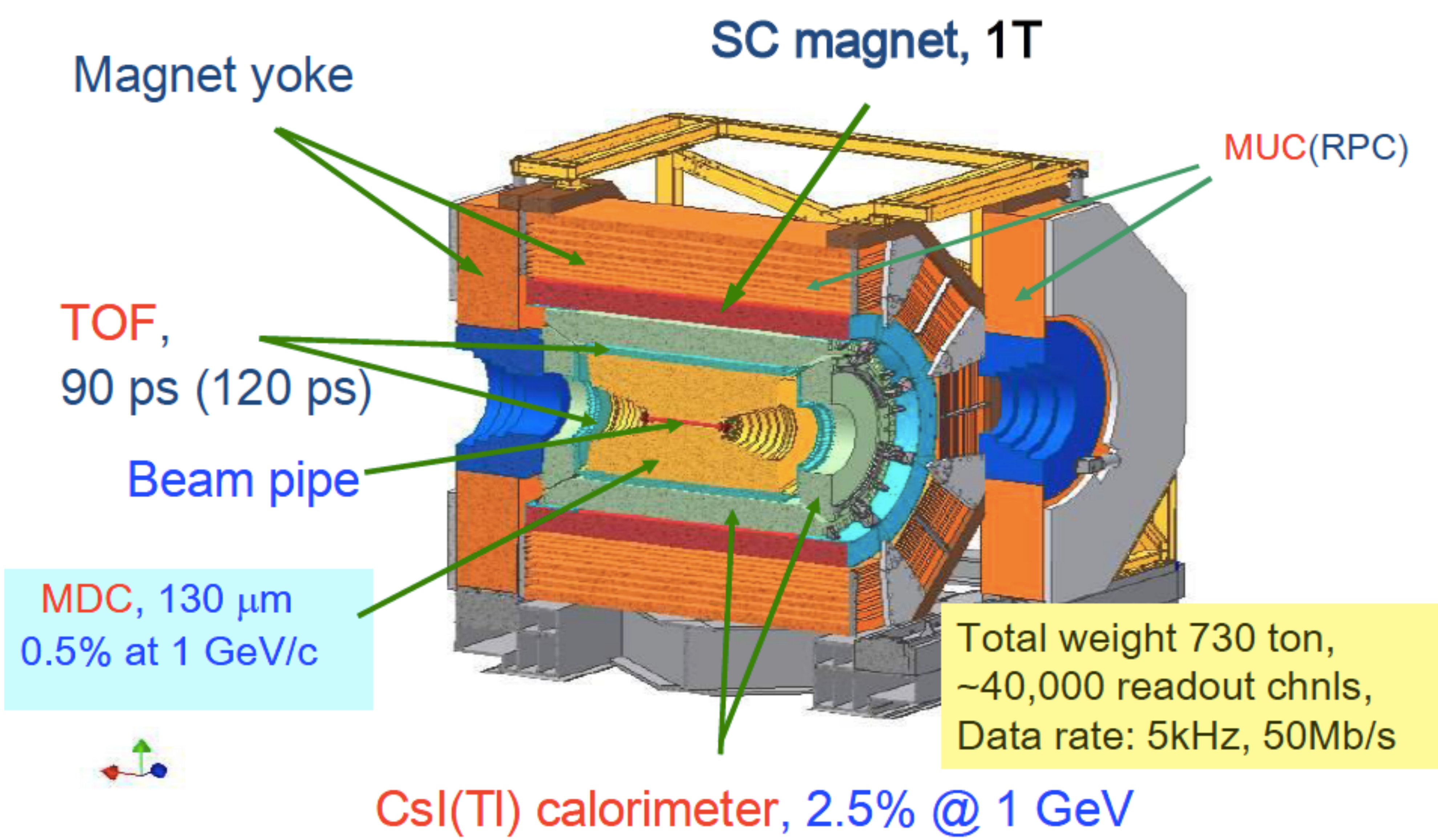
- Introduction
- $\Lambda^{\pm}_{c}$ production near the threshold
- $\Lambda^{\pm}_{c}$ branching ratio measurement
- Summary and prospect in the future

Introduction

Thanks to the effort of the accelerator people, the data with CMS of 4.6 GeV is available.

Introduction

BESIII Detector



CMS (MeV)	Lumi (pb^{-1})
4575	48
4580	8.5
4590	8.1
4600	567

Introduction

Λ_c^+ $\qquad I(J^P) = 0(\frac{1}{2}^+)$

J is not well measured; $\frac{1}{2}$ is the quark-model prediction.

Mass $m = 2286.46 \pm 0.14$ MeV
Mean life $\tau = (200 \pm 6) \times 10^{-15}$ s $\quad$ (S = 1.6)
$c\tau = 59.9\ \mu$m

The pair production threshold is 4573 MeV;
It is the ground state of charmed baryon;
There is almost no second vertex in the detector.

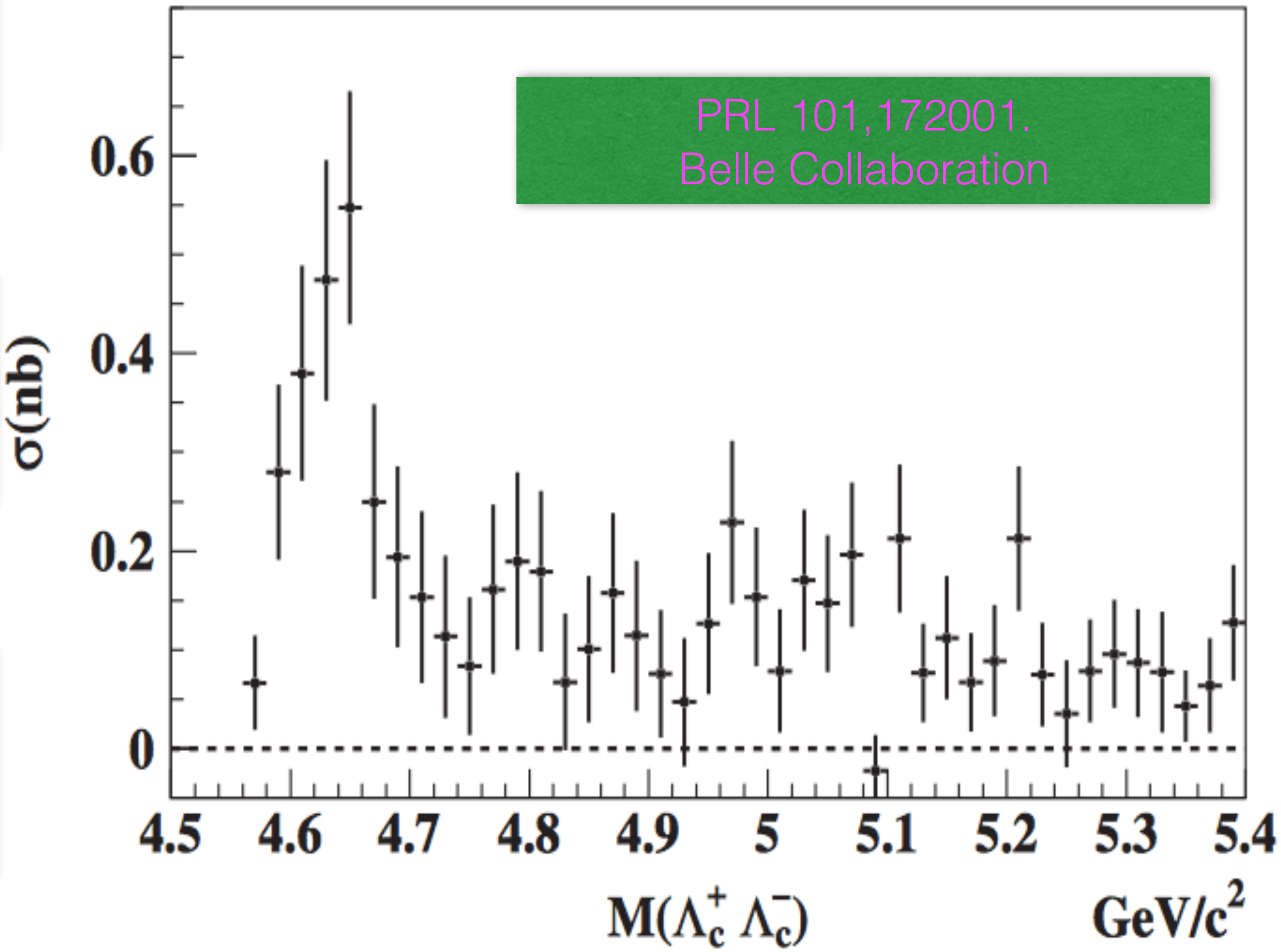
$\Lambda^{\pm}_{c}$ production near the threshold

Motivation

Y(4630) is observed by Belle in the $\Lambda^+_c \Lambda^-_c$ final state by ISR method , which maybe an exotic vector state

Whether Y(4630) is same as Y(4660) observed in the $\pi\pi\psi(2S)$ final state is still an open question.

The production cross section of $\Lambda^+_c \Lambda^-_c$ near the threshold is measured only in poor precision.



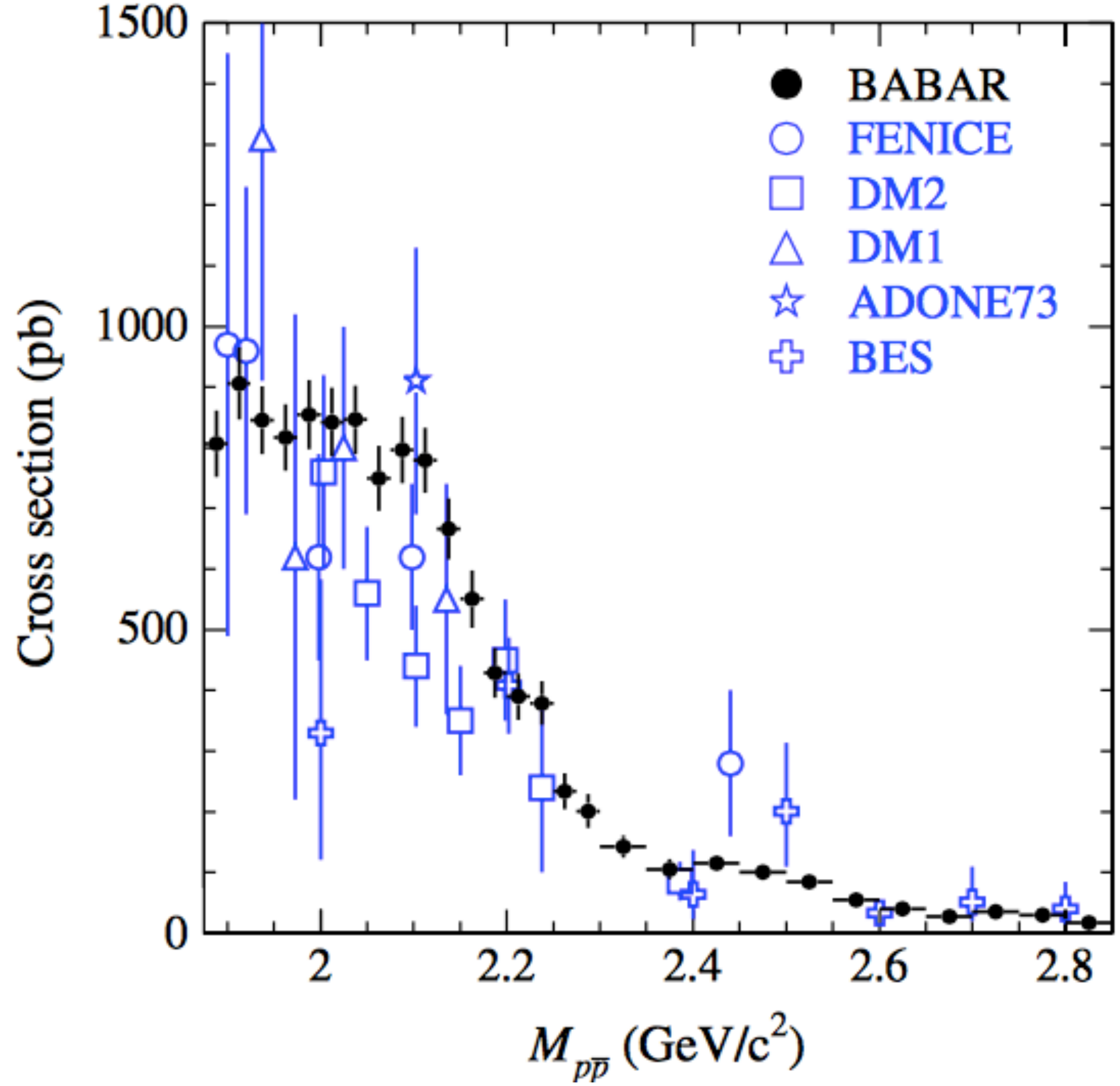
Motivation

The cross section enhancement is observed in $p\bar{p}$ final state, and one of the possible reason of this is the Coulomb interaction between the final state.

$$\sigma_{b\bar{b}}(q) = \frac{4\pi\alpha^2 C\beta}{3q^2}[|G_M(q)|^2 + \frac{1}{2\tau}|G_E(q)|^2]$$

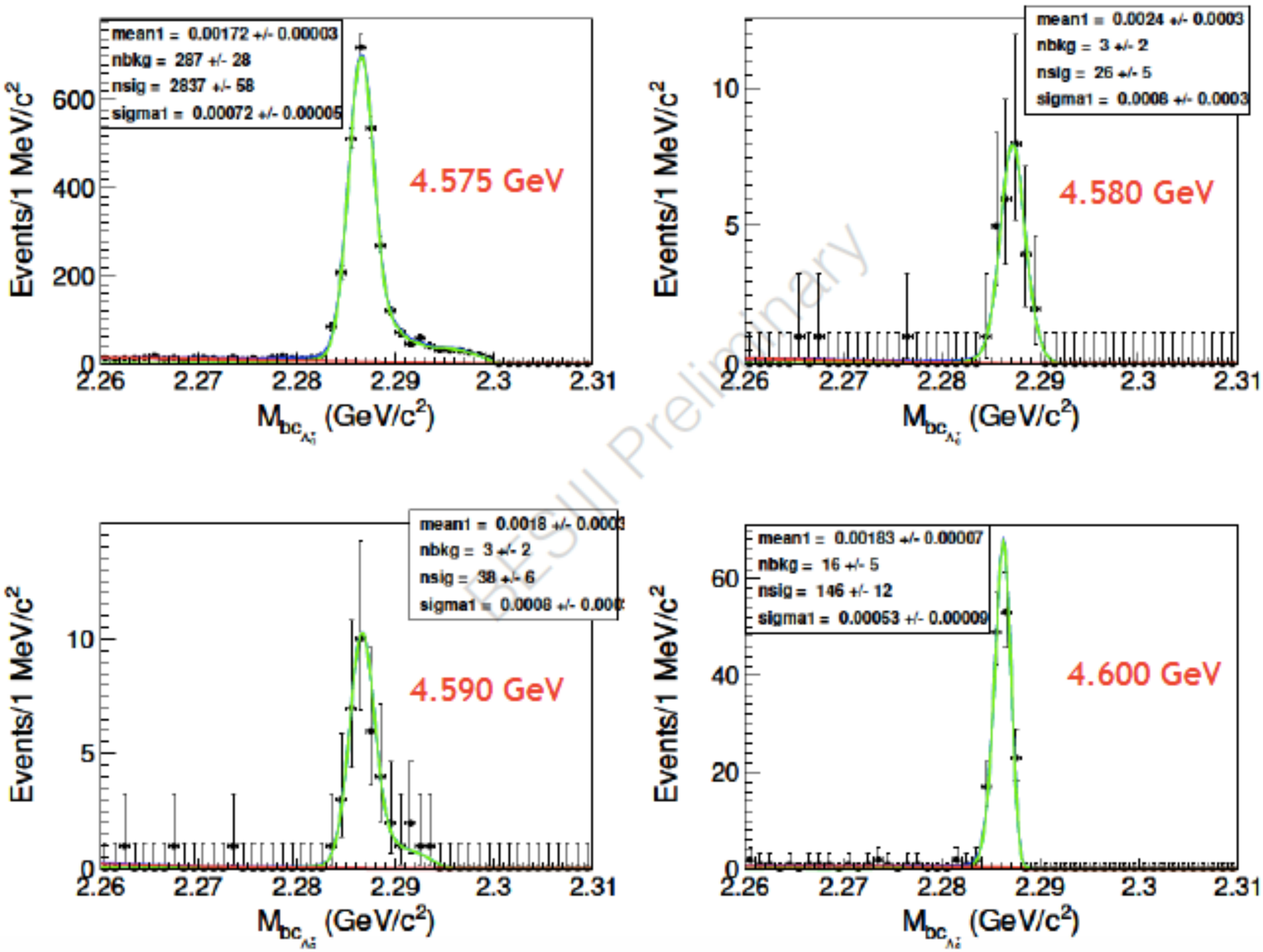
$$\beta = \sqrt{1-\frac{1}{\tau}} \qquad \tau = \frac{q^2}{4m_b^2}$$

$$C = \frac{\pi\alpha}{\beta} \bullet \frac{\sqrt{1-\beta^2}}{1-e^{-\pi\alpha/\beta}}$$



$$M_{bc} = \sqrt{E_{beam}^2 - |p_{\Lambda_c}|^2}$$

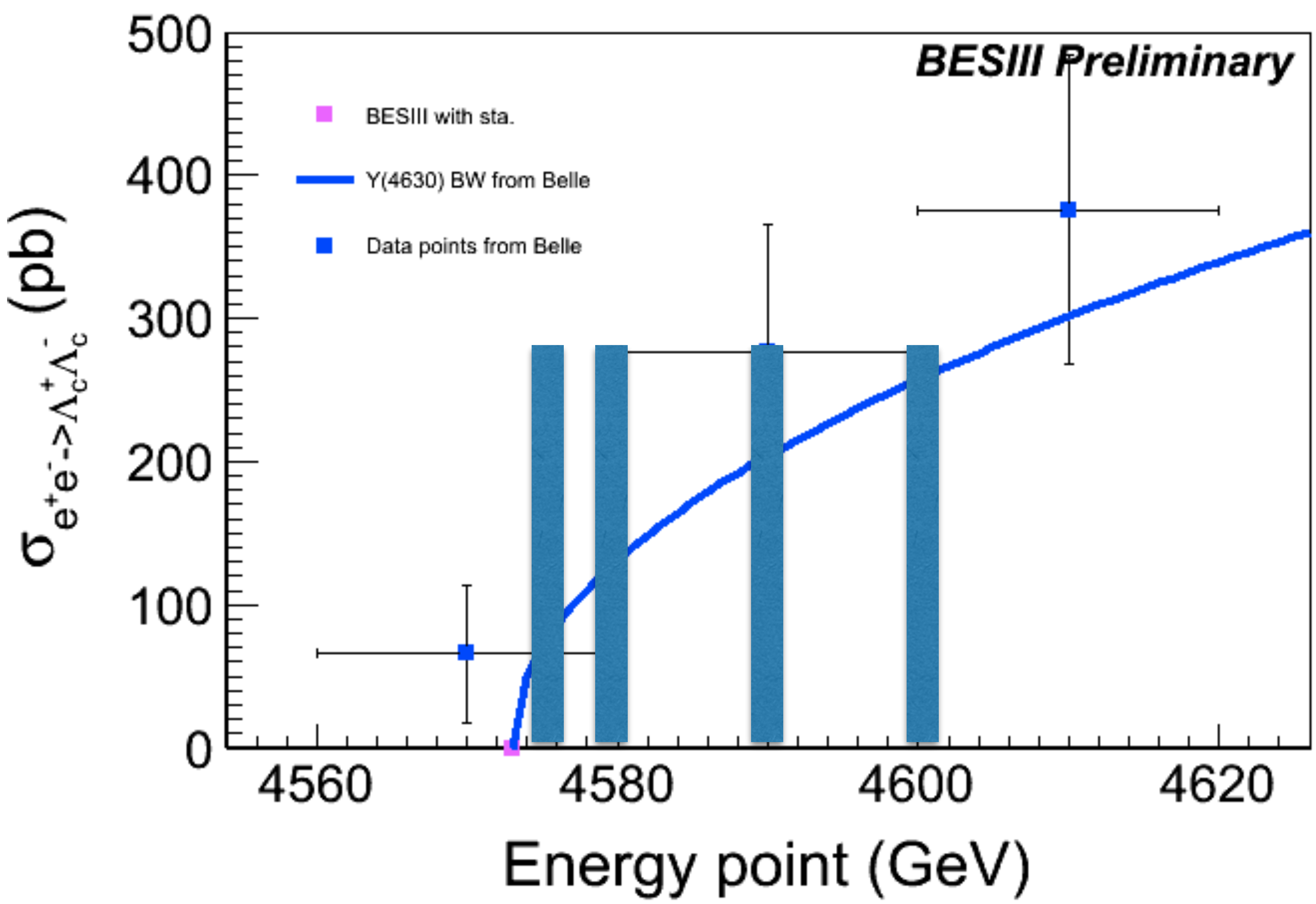
Fit the data: MC shape+Argus



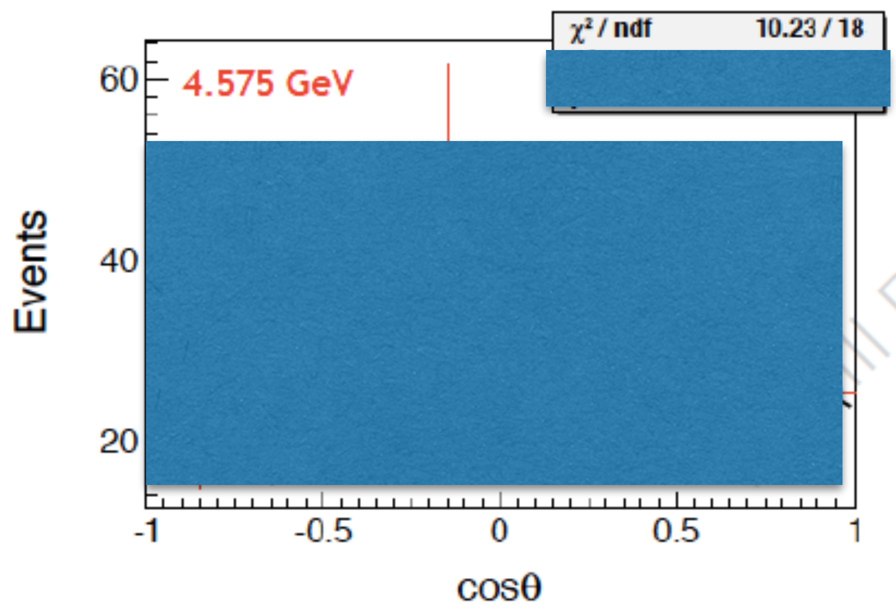
only the Λc->pKπ mode is used; and the charged conjugation mode is included.

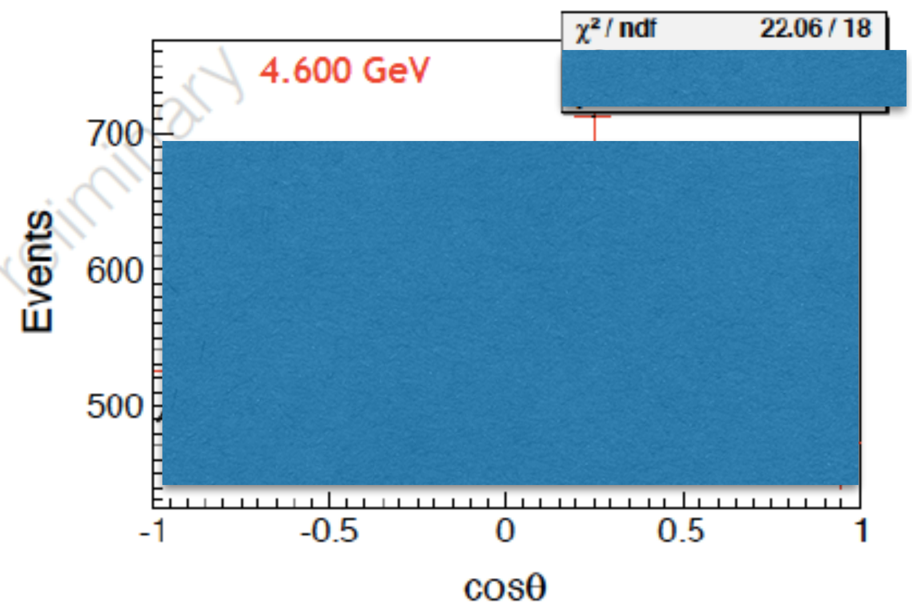
Cross section measurement

$$\sigma^{Born} = \frac{N^{obs.}}{L \cdot \varepsilon \cdot f_{VP} \cdot f_{ISR} \cdot BR}$$



Angular distribution measurement



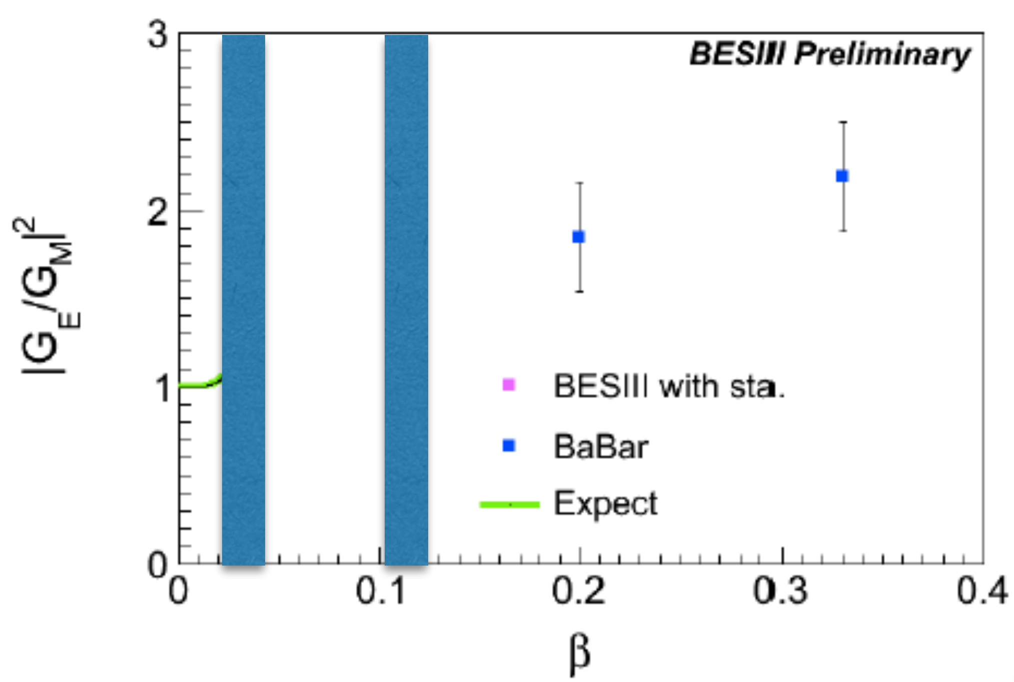


$$f(\cos\theta) = P1 \bullet (1 + P2\cos^2\theta)$$

- p2=α

$$|G_E/G_M|^2 = \tau(1-\alpha)/(1+\alpha)$$

$$\tau = \frac{q^2}{4m_b^2}$$



Discussion on the result

What will the cross section tell us if it can not be described by a naive BW function well near the charmed baryon production threshold?

What can we conclude if a large D-wave component or non-flat angular distribution is observed near the threshold?

$\Lambda^{\pm}_{c}$ absolute branching ratio measurement

Motivation

The branching fractions of the $\Lambda^{\pm}_{c}$ are measured in poor precision, and the results are all relative to pKπ mode; What is a pity, there is no direct branching fraction measurement for pKπ mode at all, until Belle published the result last year:

$$B(\Lambda_c^+ \to pK^-\pi^+) = (6.84 \pm 0.24^{+0.21}_{-0.27})\%$$

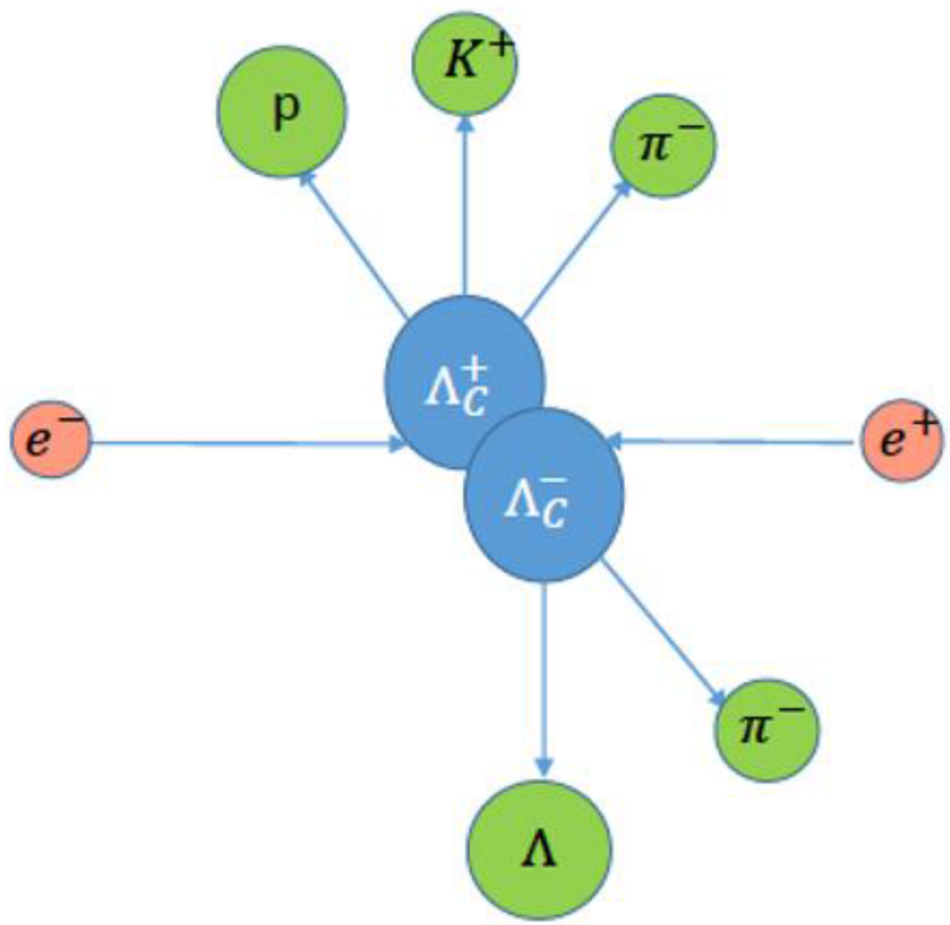
precision reaches to 4.7%

[PRL113(2014)042002]

The branching fraction measurement with the charmed baryon sample produced in electron-positron collision directly is easy and with lower background level.

Measurement method

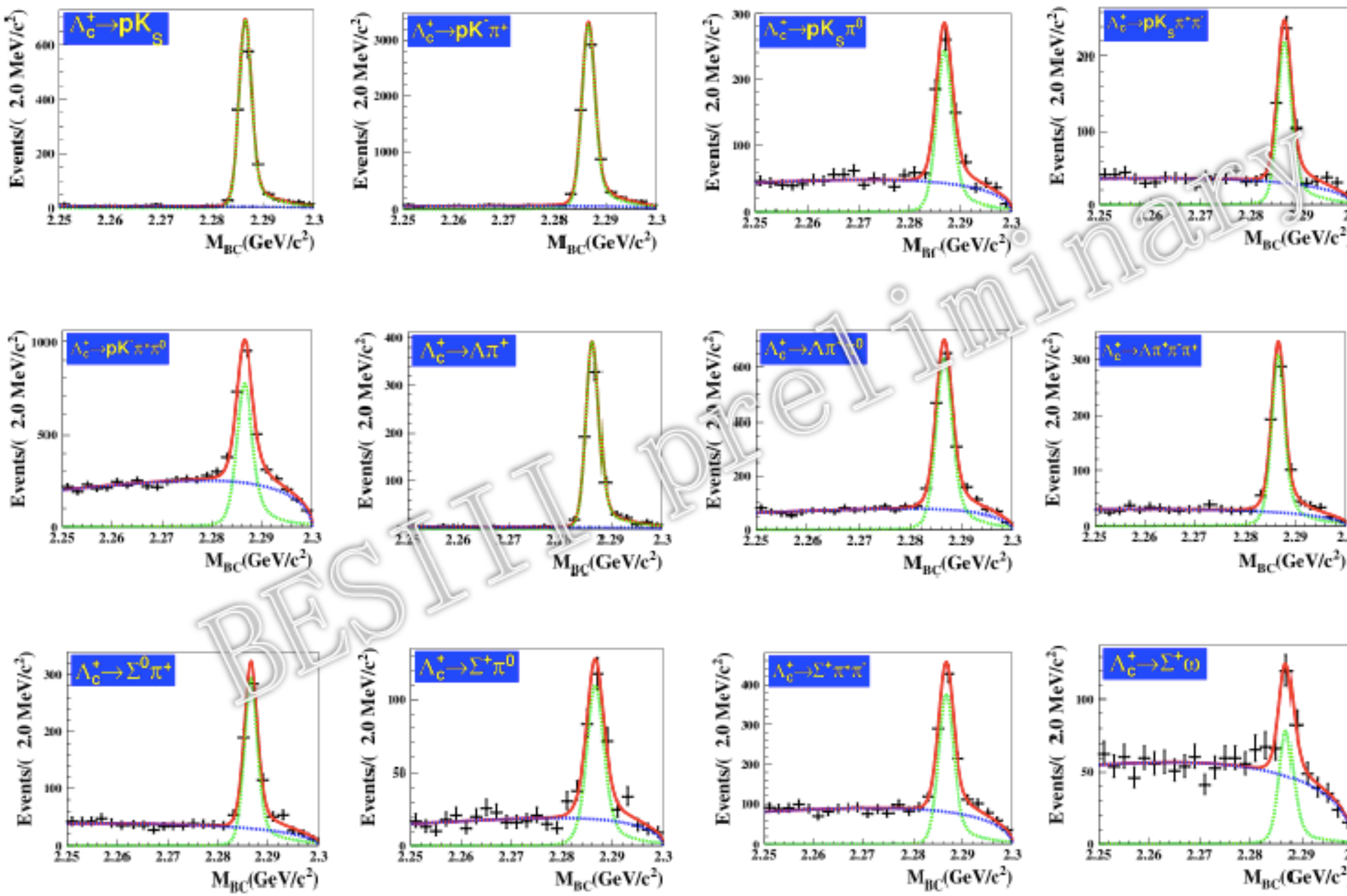
- ✓ ST yields $N_{i^+}^{ST} = N_{\Lambda_c^+\Lambda_c^-} \cdot \mathcal{B}_i \cdot \varepsilon_{i^+}^{ST}$
- ✓ DT yields $N_{i^+j^-}^{DT} = N_{\Lambda_c^+\Lambda_c^-} \cdot \mathcal{B}_i \cdot \mathcal{B}_j \cdot \varepsilon_{i^+j^-}^{DT}$



12 modes in total

modes
pK_S
$pK^-\pi^+$
$pK_S\pi^0$
$pK_S\pi^+\pi^-$
$pK^-\pi^+\pi^0$
$\Lambda\pi^+$
$\Lambda\pi^+\pi^0$
$\Lambda\pi^+\pi^-\pi^+$
$\Sigma^0\pi^+$
$\Sigma^+\pi^0$
$\Sigma^+\pi^+\pi^-$
$\Sigma^+\omega$

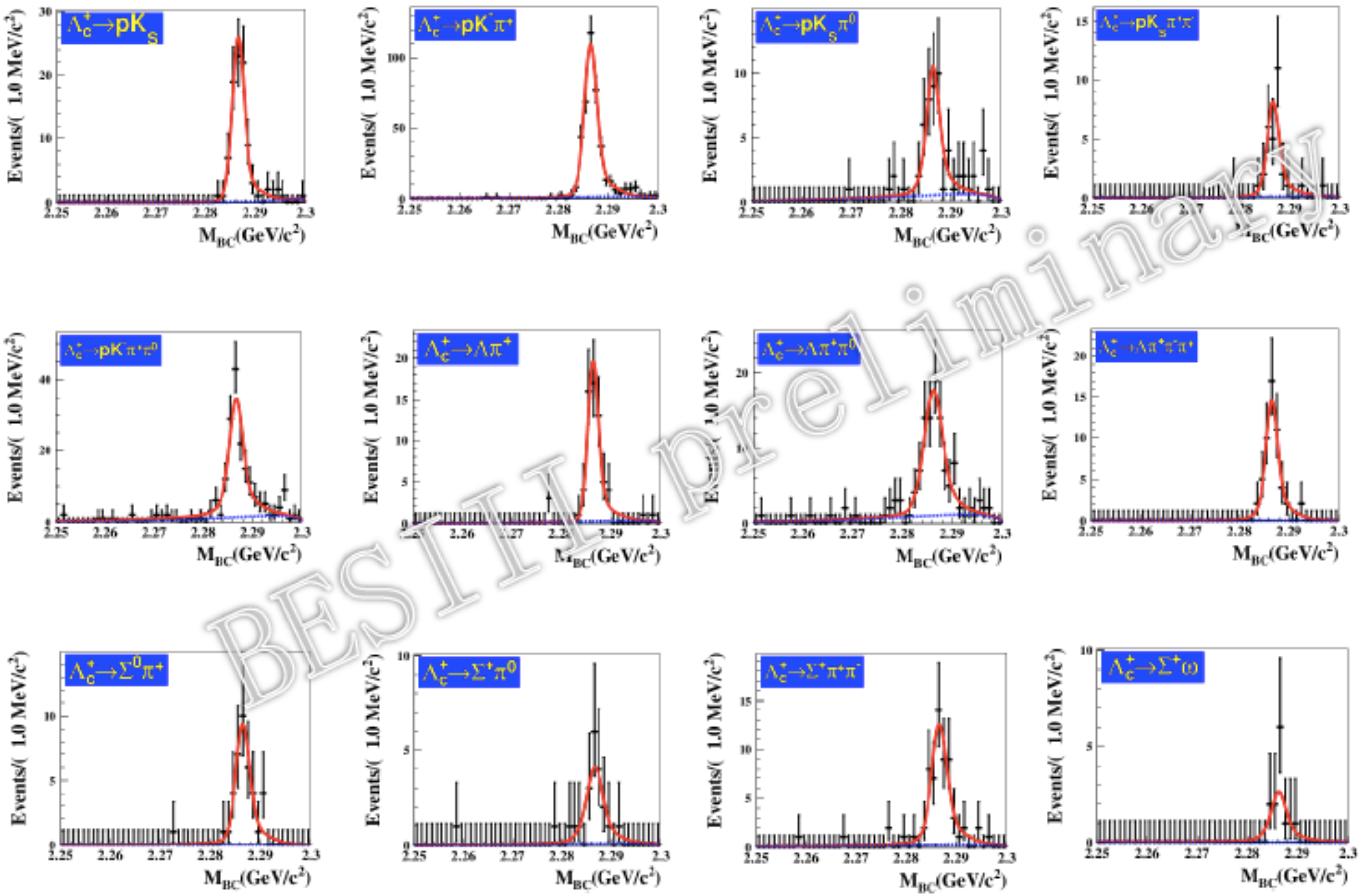
Single tag



data

modes	N_i^{ST}
pK_S	1243 ± 37
$pK^-\pi^+$	6308 ± 88
$pK_S\pi^0$	558 ± 33
$pK_S\pi^+\pi^-$	454 ± 28
$pK^-\pi^+\pi^0$	1849 ± 71
$\Lambda\pi^+$	706 ± 27
$\Lambda\pi^+\pi^0$	1497 ± 52
$\Lambda\pi^+\pi^-\pi^+$	609 ± 31
$\Sigma^0\pi^+$	586 ± 32
$\Sigma^+\pi^0$	271 ± 25
$\Sigma^+\pi^+\pi^-$	836 ± 43
$\Sigma^+\omega$	157 ± 22

Double tag



data

Decay modes	N_{-j}^{DT}
pK_S	89 ± 10
$pK^-\pi^+$	390 ± 21
$pK_S\pi^0$	40 ± 7
$pK_S\pi^+\pi^-$	29 ± 6
$pK^-\pi^+\pi^0$	148 ± 14
$\Lambda\pi^+$	59 ± 8
$\Lambda\pi^+\pi^0$	89 ± 11
$\Lambda\pi^+\pi^-\pi^+$	53 ± 7
$\Sigma^0\pi^+$	39 ± 6
$\Sigma^+\pi^0$	20 ± 5
$\Sigma^+\pi^+\pi^-$	56 ± 8
$\Sigma^+\omega$	13 ± 3

BESIII

Branching ratio result

- a least square global fitter: simultaneous fit to the all tag modes while constraining the total Λ_c pair number, taking into account the correlations

Chinese Phys. C 37 , 106201 (2013)

BESIII prel.

Decay modes	global fit $\mathcal{B}$	PDG $\mathcal{B}$	Belle $\mathcal{B}$
pK_S	1.48 ± 0.08	1.15 ± 0.30	
$pK^-\pi^+$	5.77 ± 0.27	5.0 ± 1.3	$6.84 \pm 0.24^{+0.21}_{-0.27}$
$pK_S\pi^0$	1.77 ± 0.12	1.65 ± 0.50	
$pK_S\pi^+\pi^-$	1.43 ± 0.10	1.30 ± 0.35	
$pK^-\pi^+\pi^0$	4.25 ± 0.22	3.4 ± 1.0	
$\Lambda\pi^+$	1.20 ± 0.07	1.07 ± 0.28	
$\Lambda\pi^+\pi^0$	6.70 ± 0.35	3.6 ± 1.3	
$\Lambda\pi^+\pi^-\pi^+$	3.67 ± 0.23	2.6 ± 0.7	
$\Sigma^0\pi^+$	1.28 ± 0.08	1.05 ± 0.28	
$\Sigma^+\pi^0$	1.18 ± 0.11	1.00 ± 0.34	
$\Sigma^+\pi^+\pi^-$	3.58 ± 0.22	3.6 ± 1.0	
$\Sigma^+\omega$	1.47 ± 0.18	2.7 ± 1.0	

only stat. errors

- ✓ **$B(pK^-\pi^+)$: BESIII precision comparable with Belle's result**
- ✓ **BESIII rate $B(pK^-\pi^+)$ is smaller**
- ✓ **Improved precisions of the other 11 modes significantly**

Summary and prospect

The charmed baryon can be produced in pair near the threshold;
Both the production cross section and decay branching ratios are being measured at BESIII;
More analysis about that charmed baryon, such as the quantum number, the asymmetry parameters, will be performed.

Thanks for your attention!