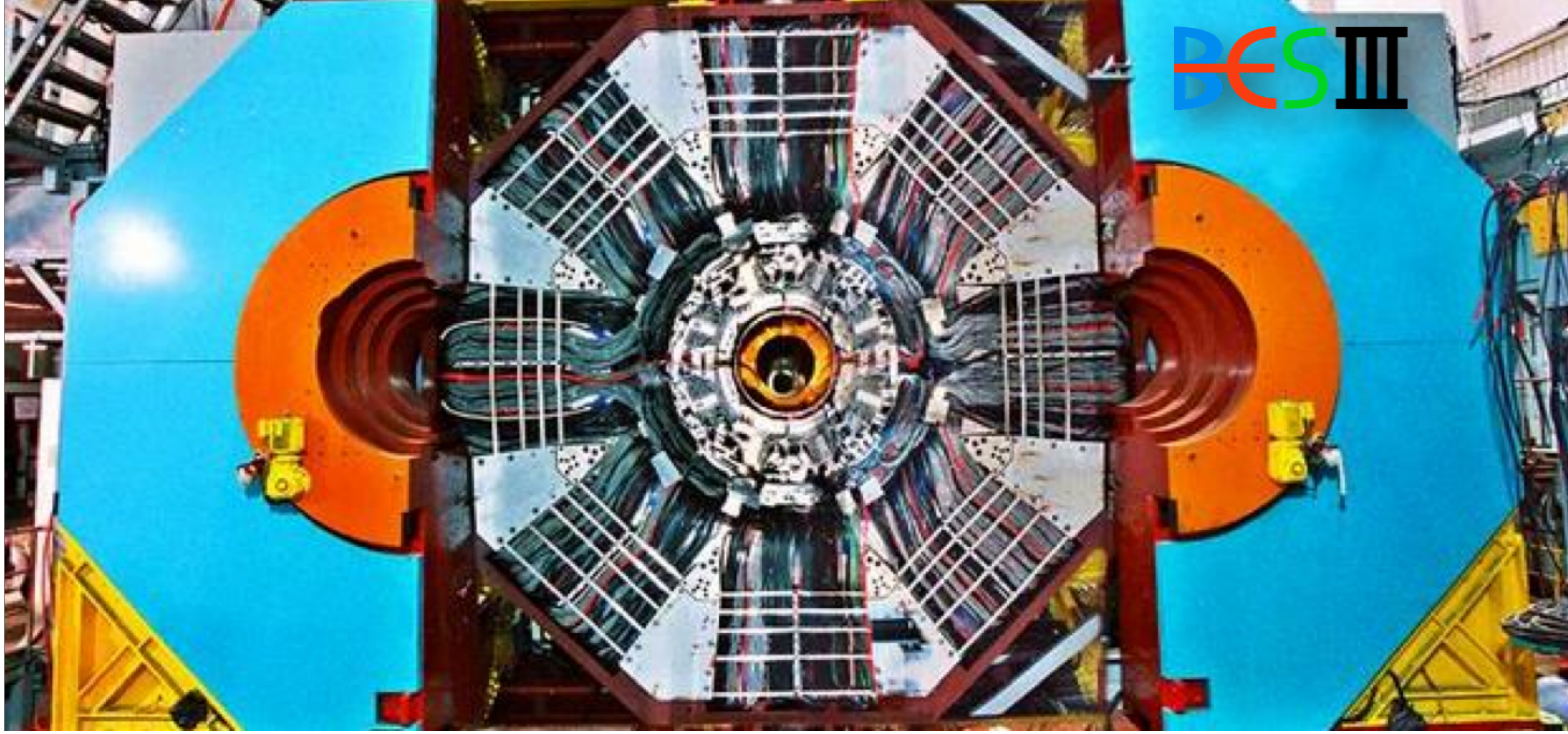


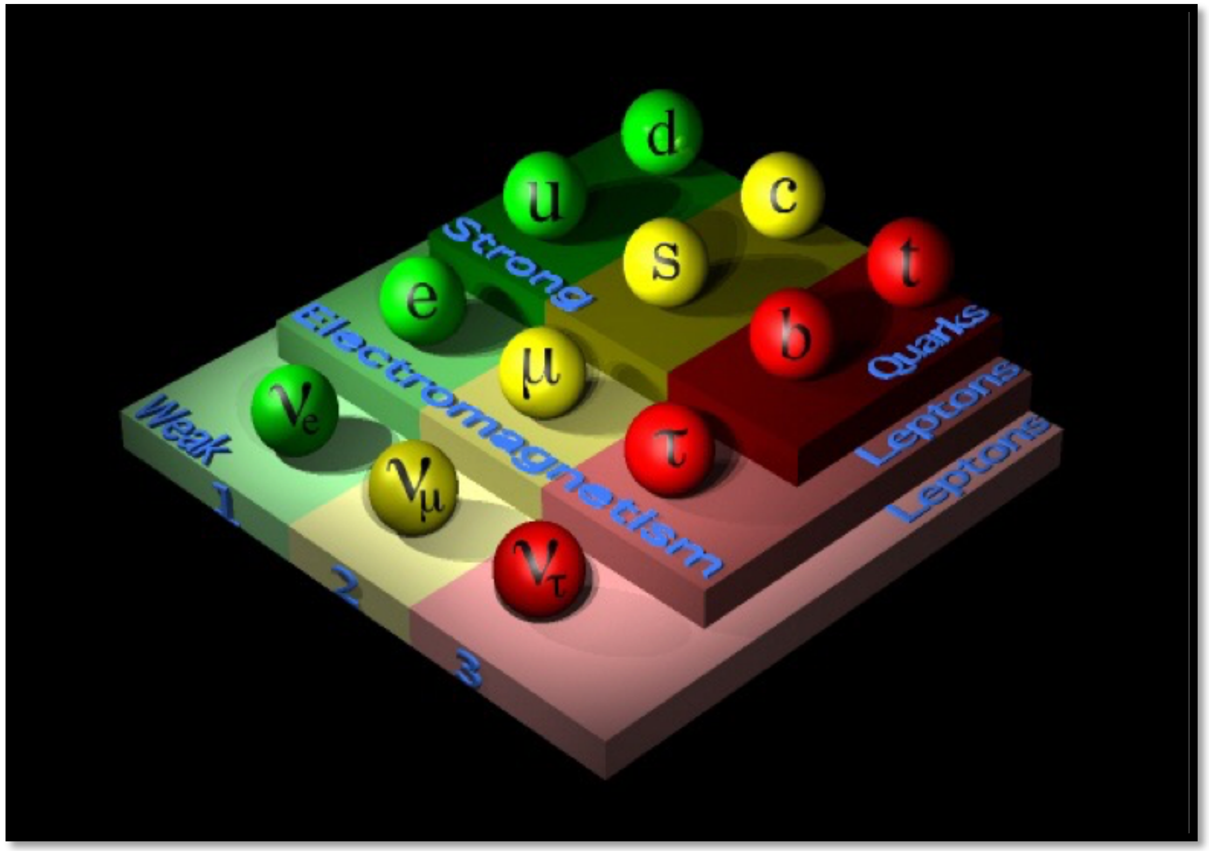
Studies on the charmed baryon Λ_c at BESIII

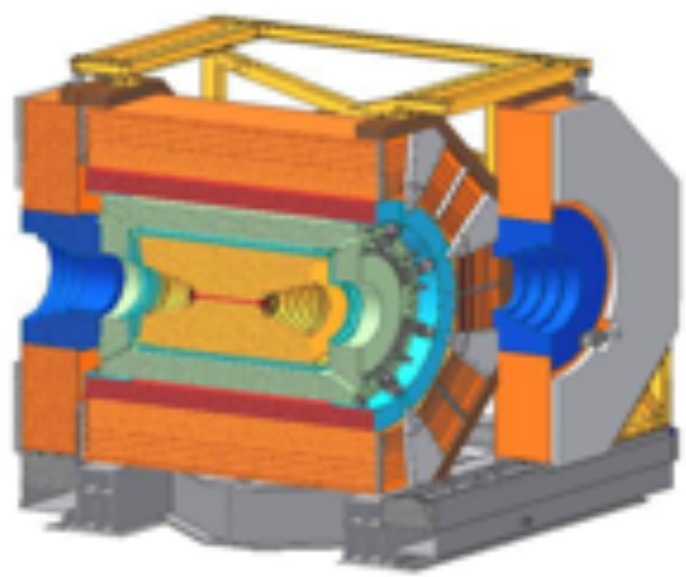
吕晓睿 (Lyu Xiao-Rui)
中国科学院大学 **(UCAS)**
(A member of the BESIII collaboration)

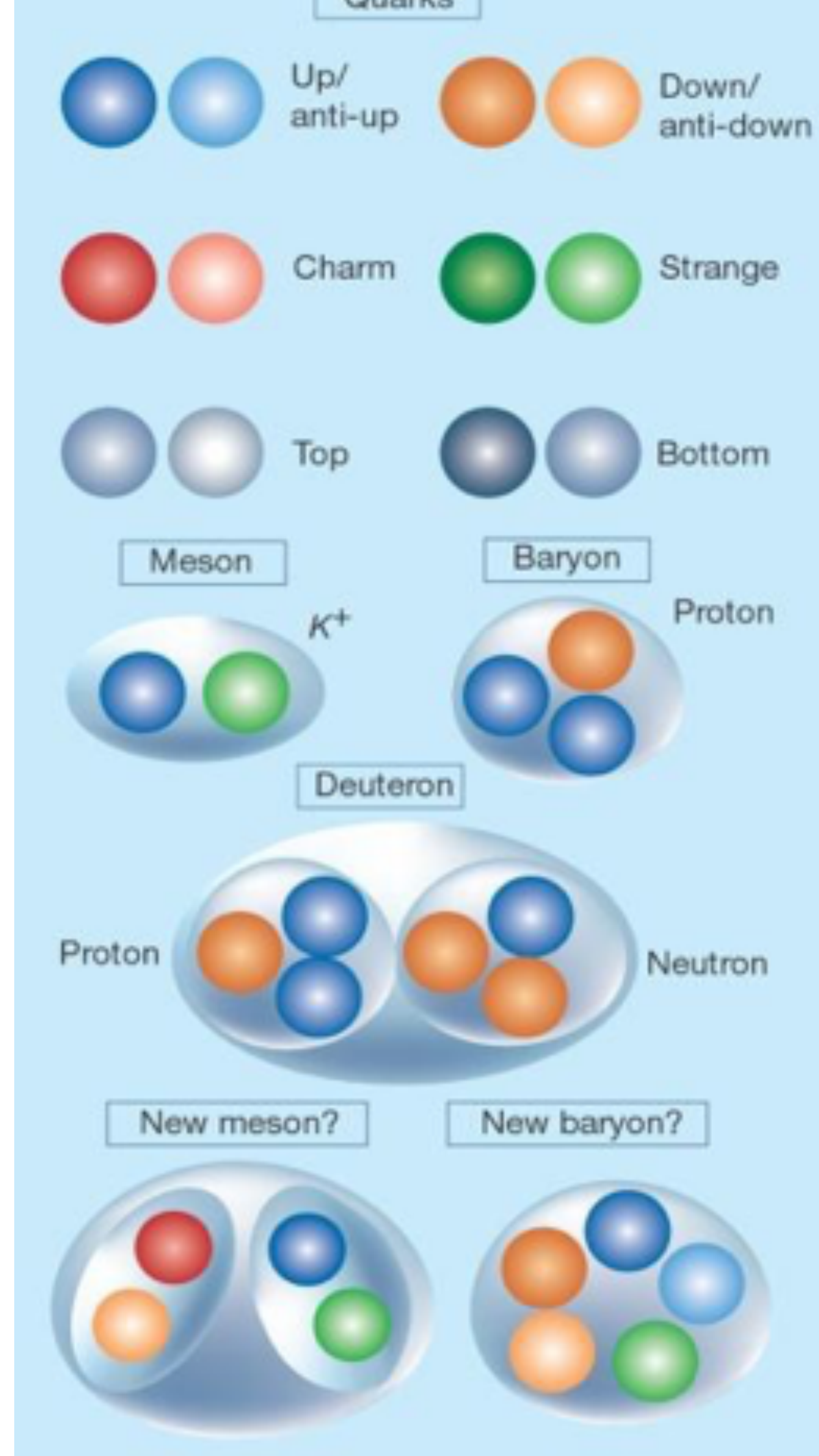
Outline

- **The lightest heavy baryon: Λ_c**
- **About the BESIII experiment**
- **Recent results on the Λ_c decays**
  - **the semi-leptonic decay $\Lambda_c^+ \to \Lambda e^+ \nu_e$**
  - **12 major hadronic decay rates, *esp*, pKπ**
  - **first observation of the decay involving the neutron**
- **Impacts and prospects**
- **Summary**

… the lego blocks of our matter-world!

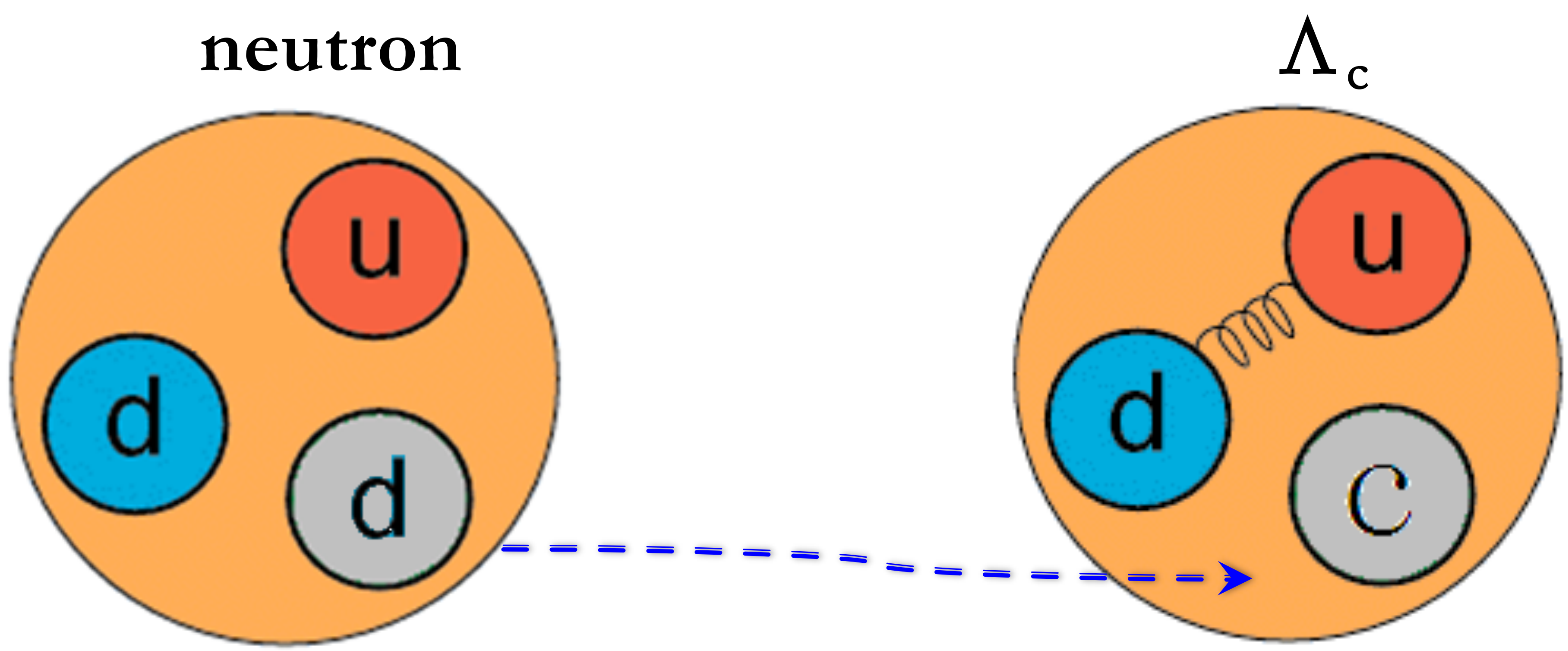






BESIII: a unique place to study the hadron structure below 3 GeV

Quark model picture:
a heavy quark (c) with an unexcited spin-zero diquark (u-d)

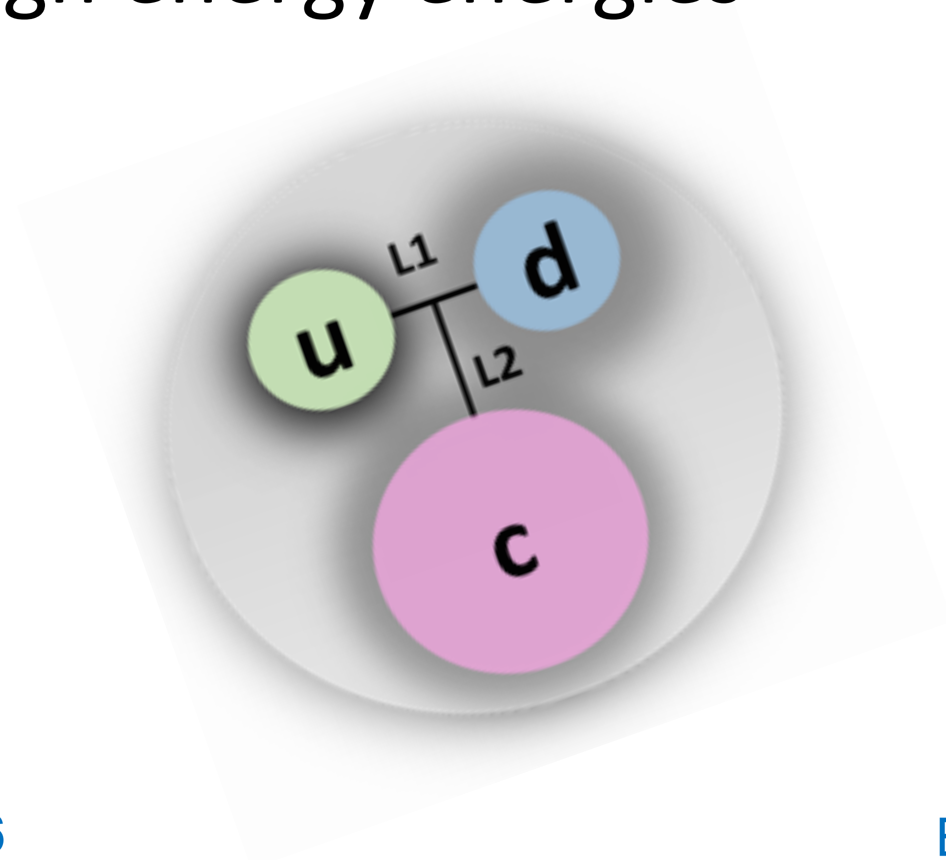


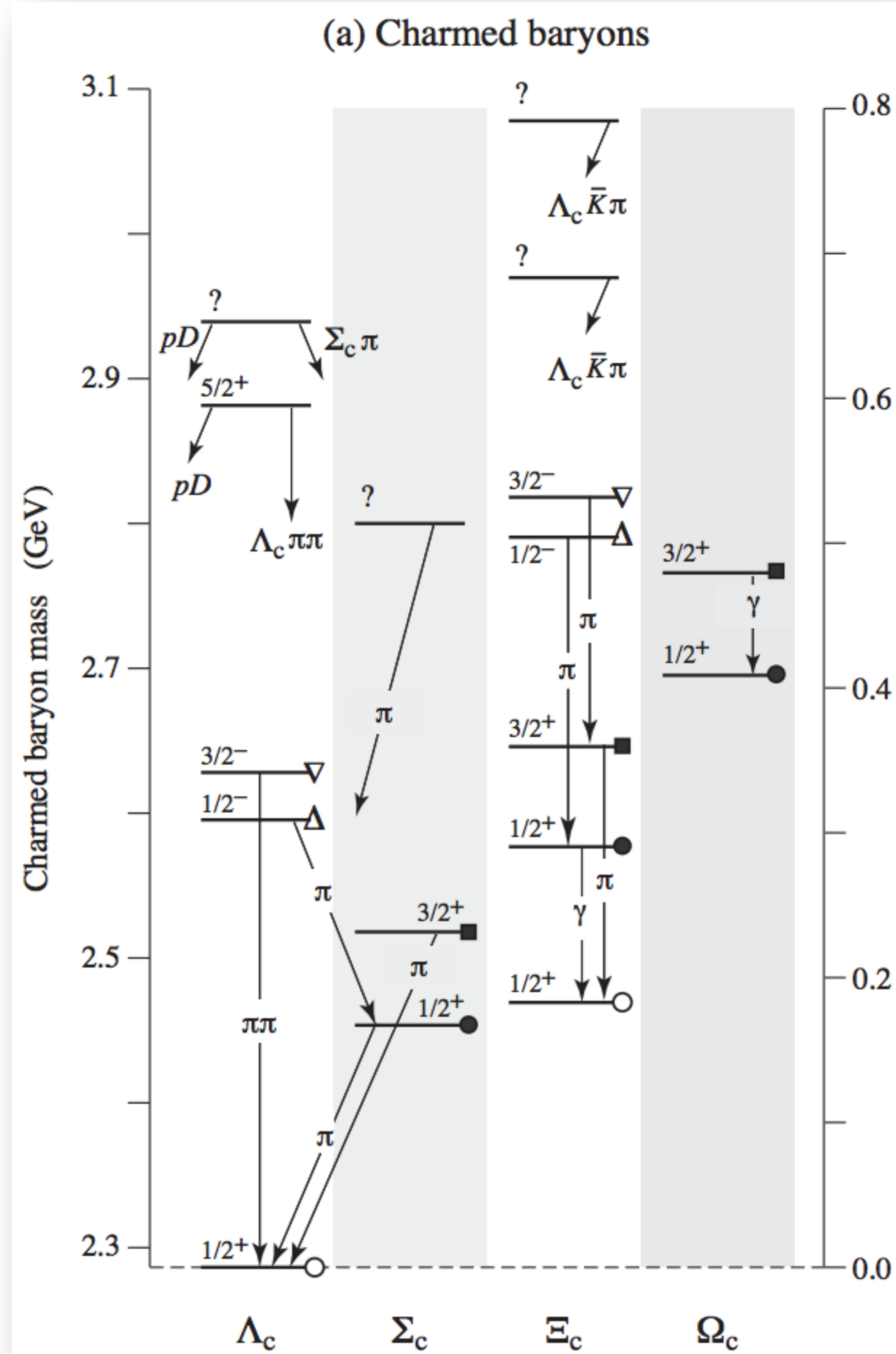
In some sense, more reliable prediction of heavy-light quark transition without dealing with light degrees of freedom that have net spin or isospin.

Λ_c^+ provides more powerful test on internal dynamics than D/Ds does

Λ_c^+ : cornerstone of charmed baryon spectroscopy

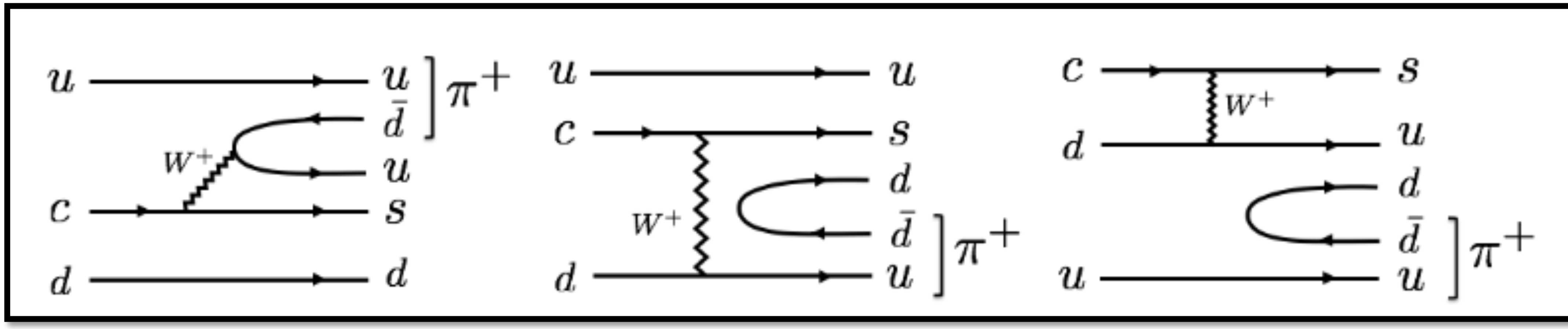
- The lightest charmed baryon
- Most of the charmed baryons will eventually decay to Λc
- The Λc is one of important tagging hadrons in c-quark counting in the productions at high energy energies





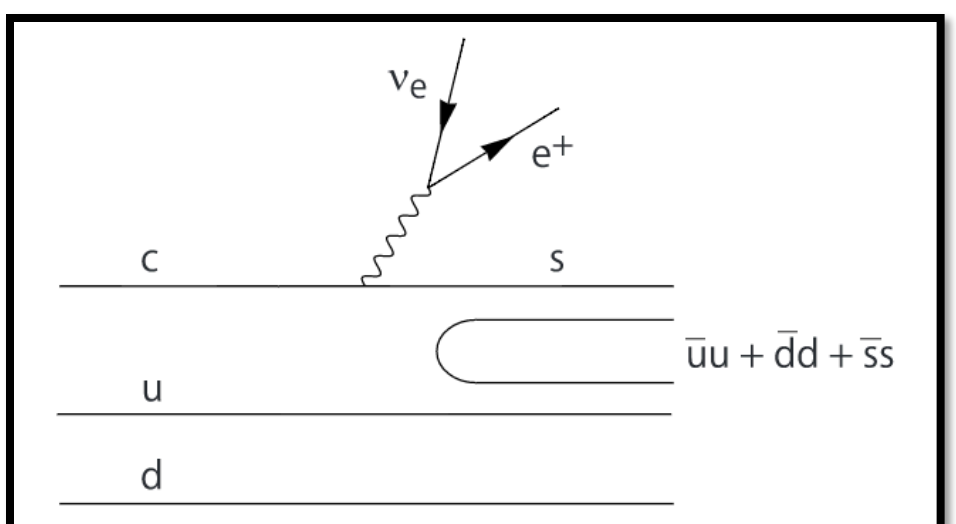
Λ_c^+ weak decays

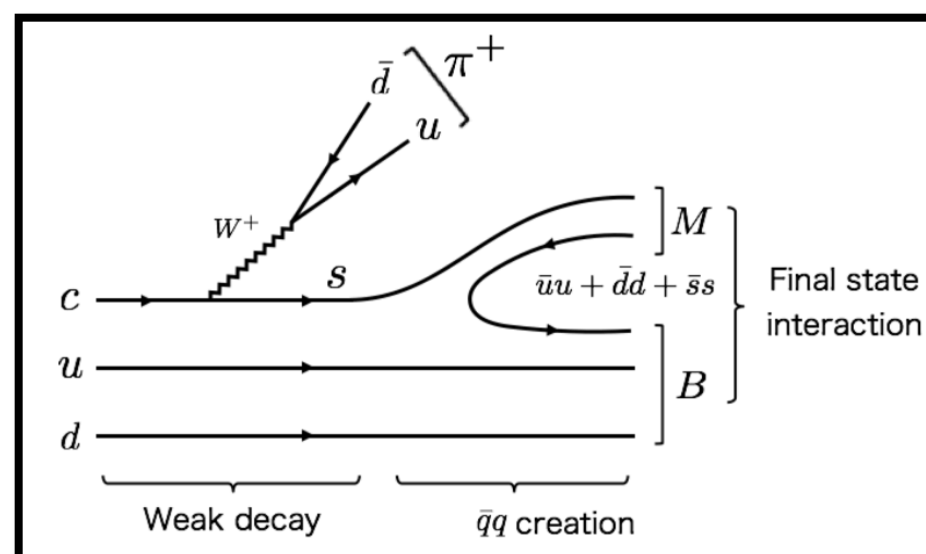
- Contrary to charmed meson, W-exchange contribution is important

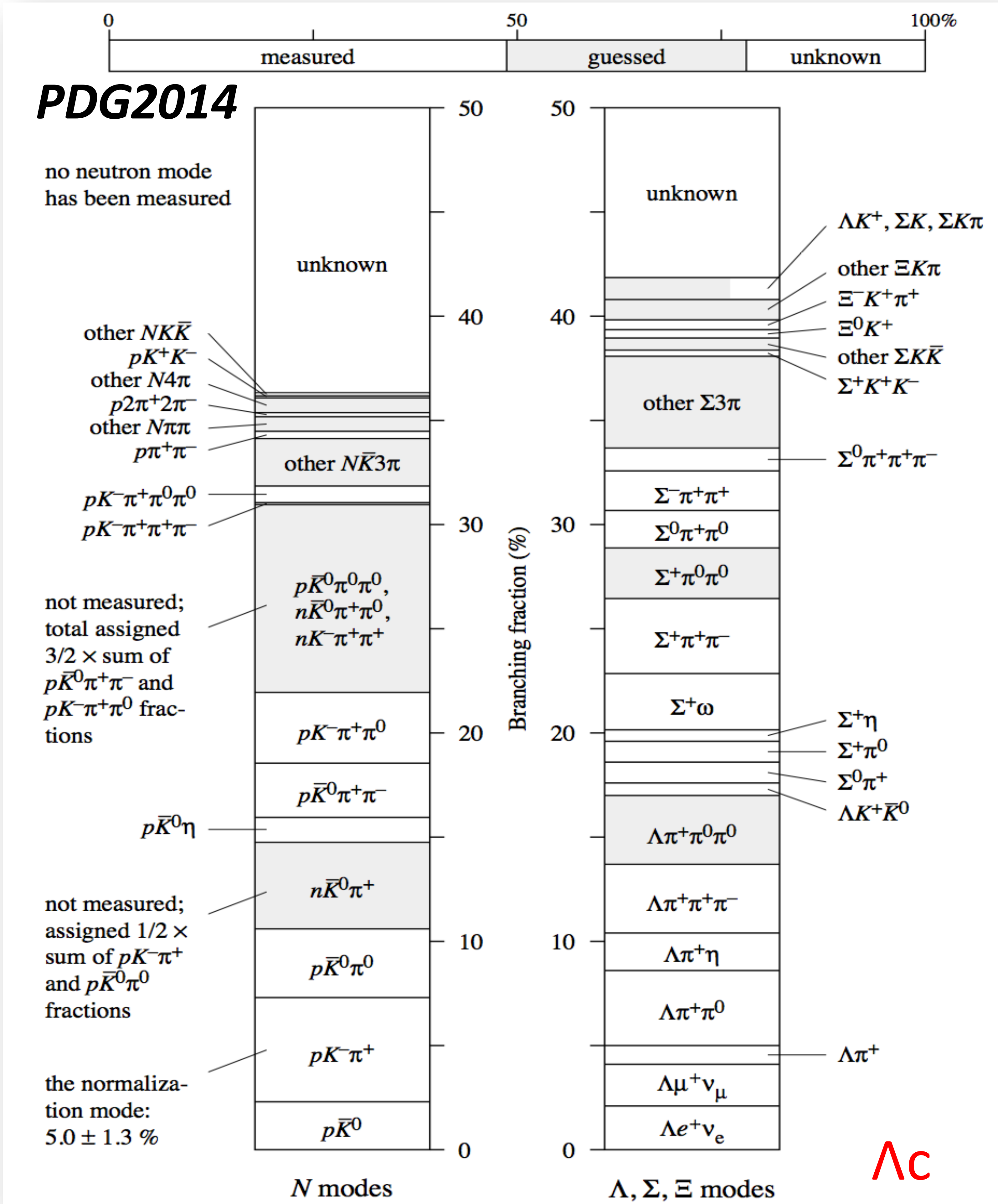


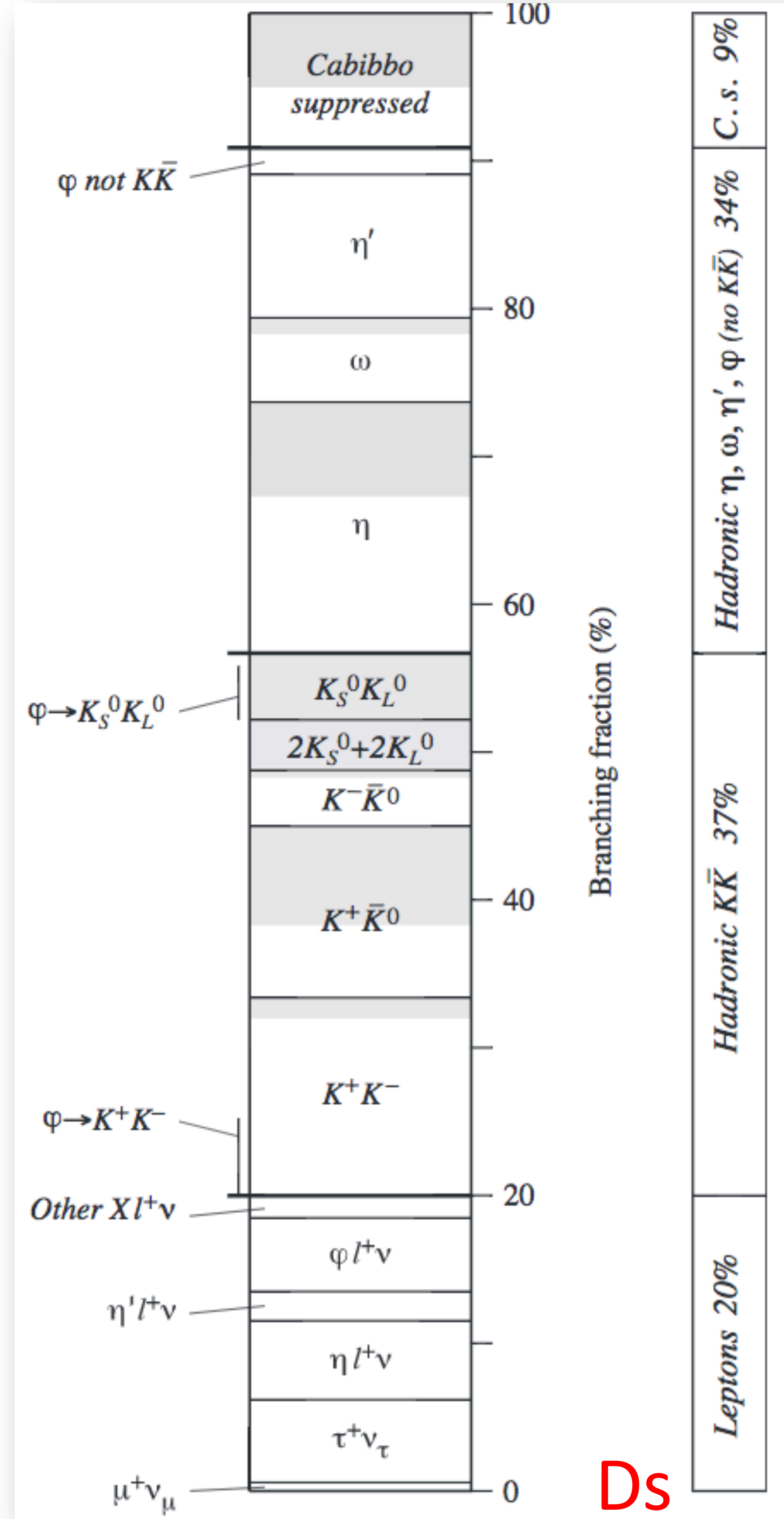
- The Λc weak decay acts as isospin filter
  - ✓ For example, Oset suggests to study the Λ(1405) through Λc→π Λ(1405) and Λ(1405) e *ν*, which filters isospin I=0 from contamination of the I=1

[Phys. Rev. C 92, 055204 (2015), Phys. Rev. D 93, 014021 (2016)]

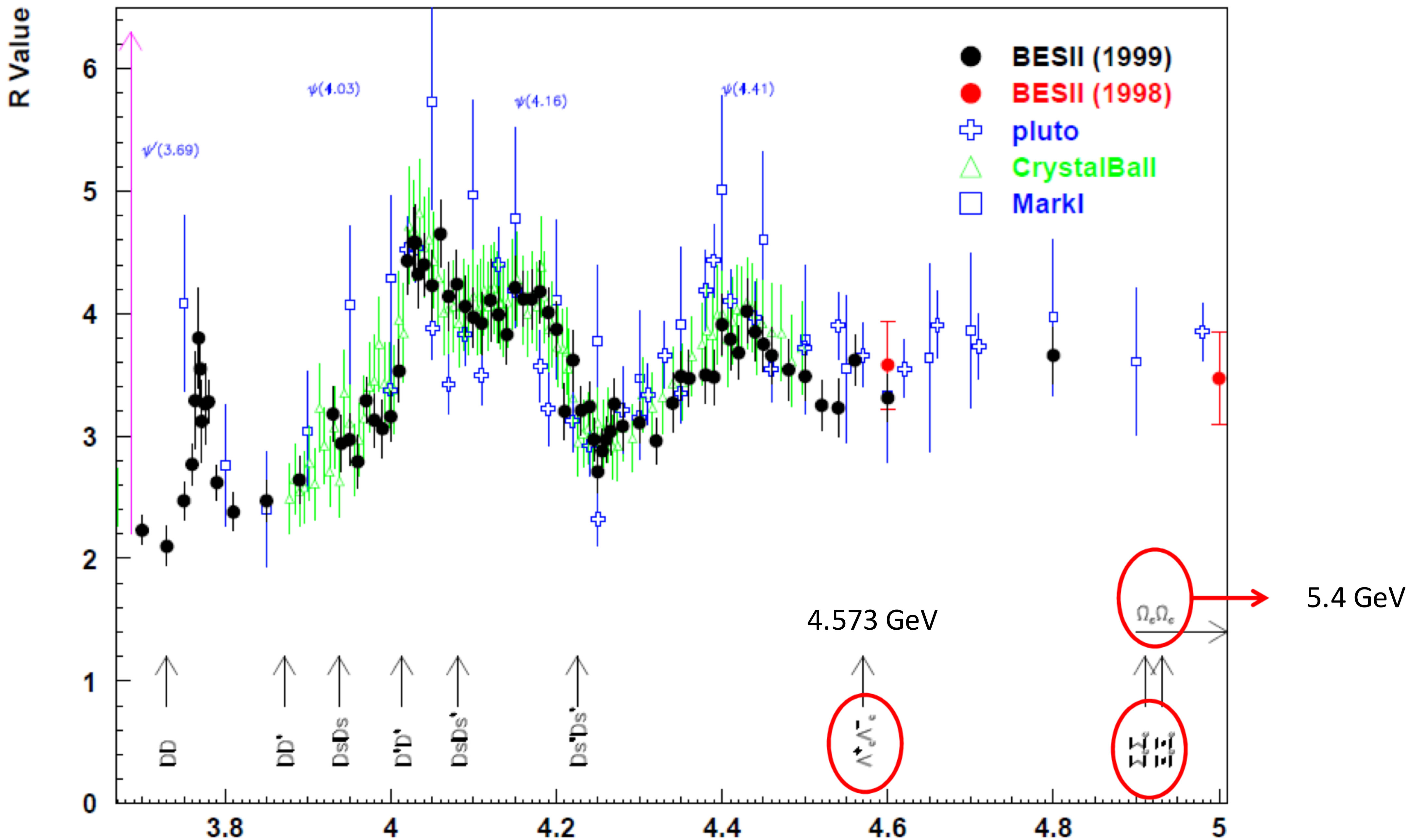





0
50
100%
measured
guessed
unknown
PDG2014
no neutron mode has been measured
unknown
other NKK̄
pK⁺K⁻
other N4π
p2π⁺2π⁻
other Nππ
pπ⁺π⁻
other NK̄3π
pK⁻π⁺π⁰π⁰
pK⁻π⁺π⁺π⁻
not measured; total assigned 3/2 × sum of pK̄⁰π⁺π⁻ and pK⁻π⁺π⁰ fractions
pK̄⁰π⁰π⁰, nK̄⁰π⁺π⁰, nK⁻π⁺π⁺
pK⁻π⁺π⁰
pK̄⁰π⁺π⁻
pK̄⁰η
nK̄⁰π⁺
not measured; assigned 1/2 × sum of pK⁻π⁺ and pK̄⁰π⁰ fractions
pK̄⁰π⁰
pK⁻π⁺
the normaliza-tion mode: 5.0 ± 1.3 %
pK̄⁰
N modes
50
40
30
20
10
0
Branching fraction (%)
unknown
ΛK⁺, ΣK, ΣKπ
other ΞKπ
Ξ⁻K⁺π⁺
Ξ⁰K⁺
other ΣKK̄
Σ⁺K⁺K⁻
other Σ3π
Σ⁰π⁺π⁺π⁻
Σ⁻π⁺π⁺
Σ⁰π⁺π⁰
Σ⁺π⁰π⁰
Σ⁺π⁺π⁻
Σ⁺ω
Σ⁺η
Σ⁺π⁰
Σ⁰π⁺
ΛK⁺K̄⁰
Λπ⁺π⁰π⁰
Λπ⁺π⁺π⁻
Λπ⁺η
Λπ⁺π⁰
Λπ⁺
Λμ⁺ν_μ
Λe⁺ν_e
Λ, Σ, Ξ modes
Λc


100
80
60
40
20
0
Cabibbo suppressed
φ not KK̄
η′
ω
η
φ→K_S⁰K_L⁰
K_S⁰K_L⁰
2K_S⁰+2K_L⁰
K⁻K̄⁰
K⁺K̄⁰
φ→K⁺K⁻
K⁺K⁻
Other X l⁺ν
φ l⁺ν
η′ l⁺ν
η l⁺ν
τ⁺ν_τ
μ⁺ν_μ
Branching fraction (%)
C. s. 9%
Hadronic η, ω, η′, φ (no KK̄) 34%
Hadronic KK̄ 37%
Leptons 20%
Ds

Charmed baryon thresholds



The BEPCII Collider

Beam energy: 1.0 – 2.3 GeV

Peak Luminosity:

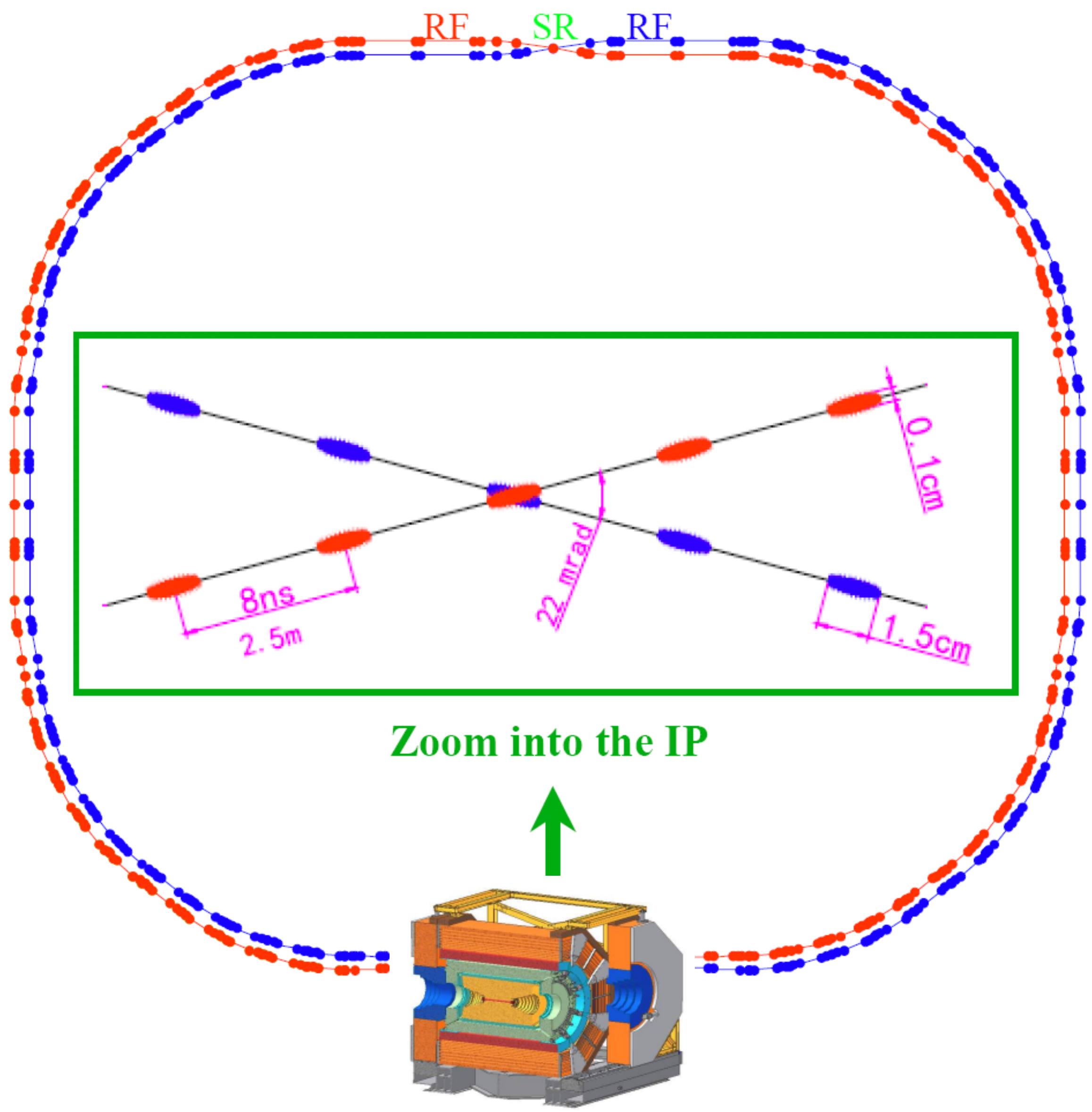
Design: 1×10^{33} cm^{-2}s^{-1}

Achieved: **1 x 10^{33} cm^{-2}s^{-1}**

Optimum energy: 1.89 GeV

Energy spread: 5.16×10^{-4}

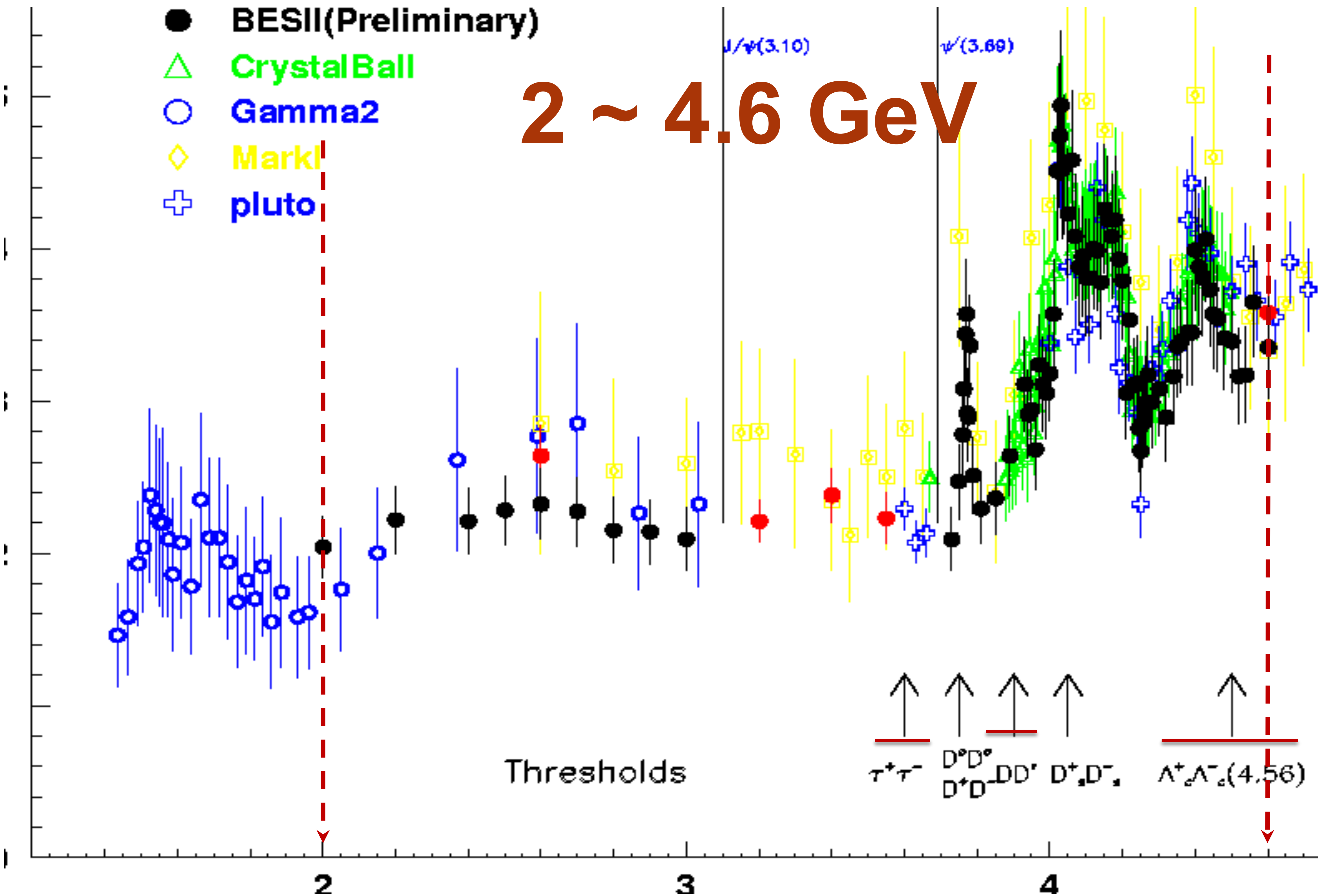
Circumference: 237 m



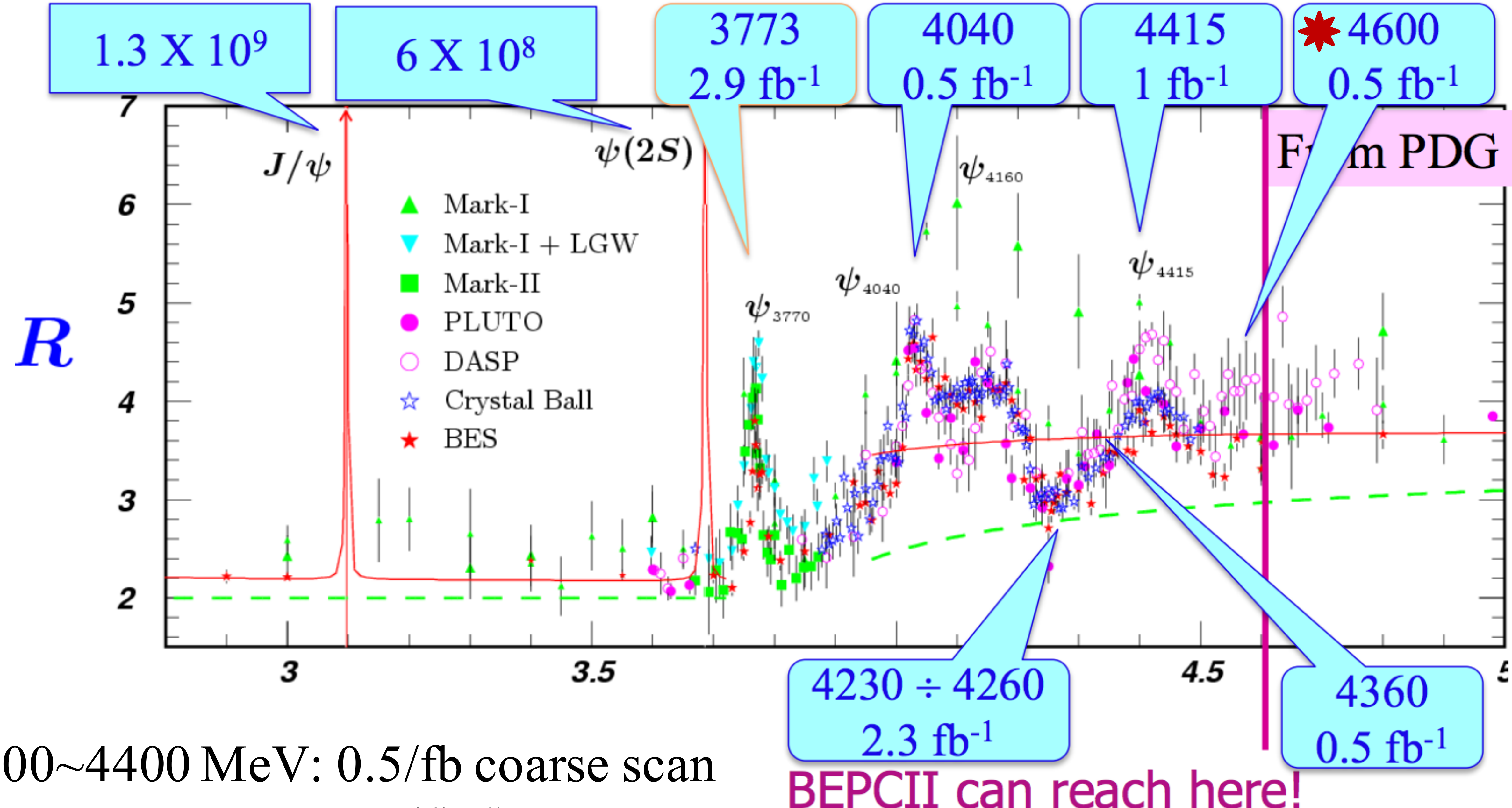
In 2015, BEPCII made successful test with top-up mode!

Beam energy measurement: Using Compton backscattering technique. Accuracy up to **5×10^{-5}**

Energies of the BEPCII Collider



BESIII data samples



- 4100~4400 MeV: 0.5/fb coarse scan
- 3850~4590 MeV: 0.5/fb fine scan
- In 2015, we finished energy scan at 2000~3000 MeV
- In 2016, we will take ~3/fb Ds data at 4180 MeV

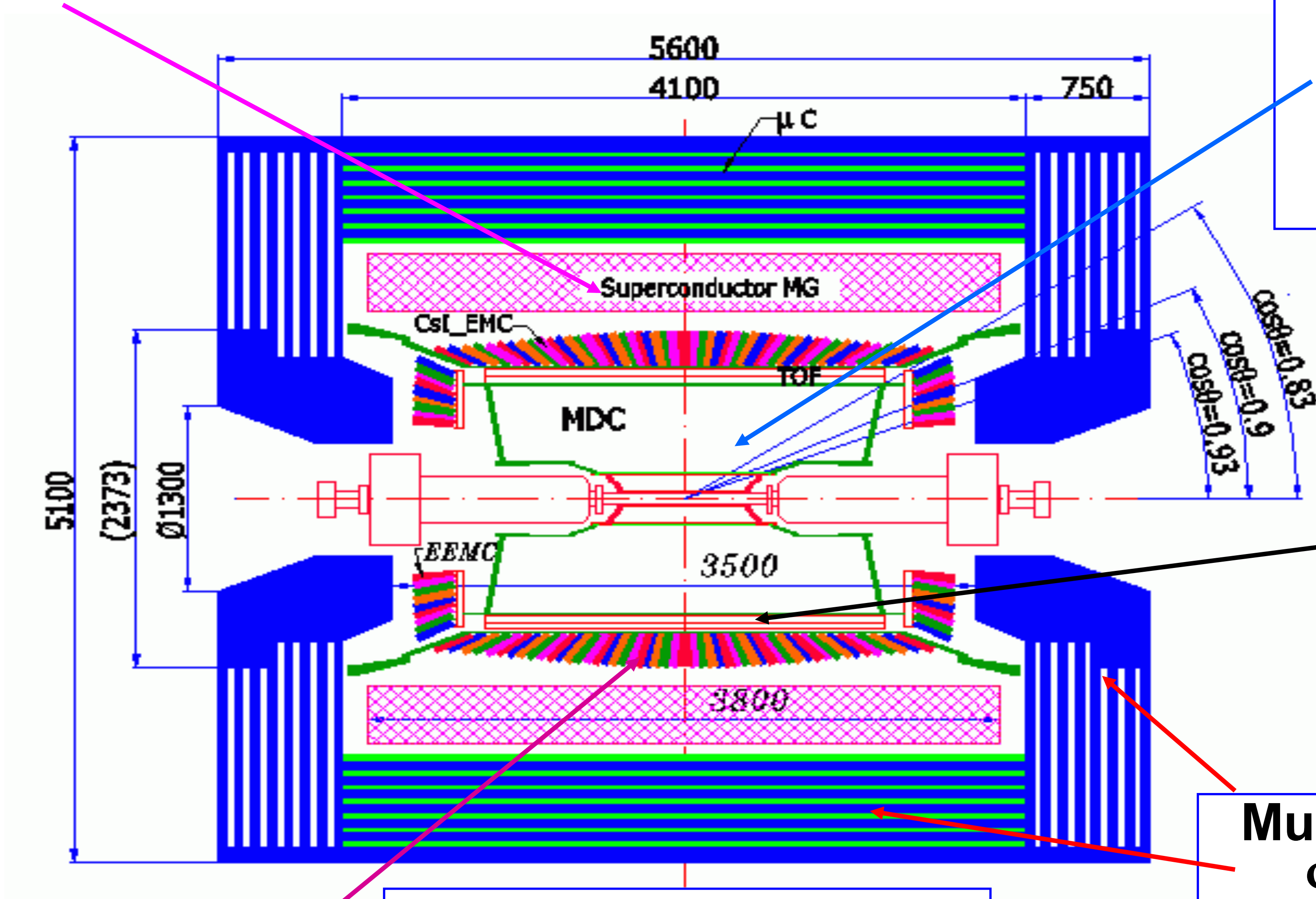
  (*about 5 times of CLEO-c data*)

Machine luminosity is optimal near ψ" peak

NIM A614, 345 (2010)

The BESIII Detector

Magnet: 1 T Super conducting



MDC: small cell & He gas
σ_{xy}=130 μm
s_p/p = 0.5% @1GeV
dE/dx=6%

TOF:
σ_T = 90 ps Barrel
110 ps Endcap

Muon ID: 8~9 layer RPC
$\sigma_{R\Phi}$=1.4 cm~1.7 cm

EMCAL: CsI crystal
$\Delta E/E$ = 2.5% @1 GeV
$\sigma_{\varphi,z}$ = 0.5~0.7 cm/$\sqrt{E}$

Data Acquisition:
Event rate = 3 kHz
Throughput ~ 50 MB/s

Trigger: Tracks & Showers
Pipelined; Latency = 6.4 μs

The new BESIII detector is hermetic for neutral and charged particle with excellent resolution, PID, and large coverage.

Data taking @4.6GeV proposed in 2013

Proposal of Studying the Charmed Bayron Λ_c^+ at BESIII

Guangshun Huang Hai-Bo Li <u>Xiao-Rui Lu</u> Wenbiao Yan
Changzheng Yuan Zhengguo Zhao Yangheng Zheng

Institute of High Energy Physics
University of Chinese Academy of Sciences
University of Science and Technology of China

BESIII physics and software workshop at Tsinghua University
2013.2.27-3.1

BESIII data taken

In 2014, BESIII took data above Λ_c pair threshold and run machine at 4.6GeV with excellent performance!
This is a marvelous achievement of BEPC!

available data set at BESIII

Energy(GeV)	lum.(1/pb)
4.575	~48
4.580	~8.5
4.590	~8.1
4.600	~567

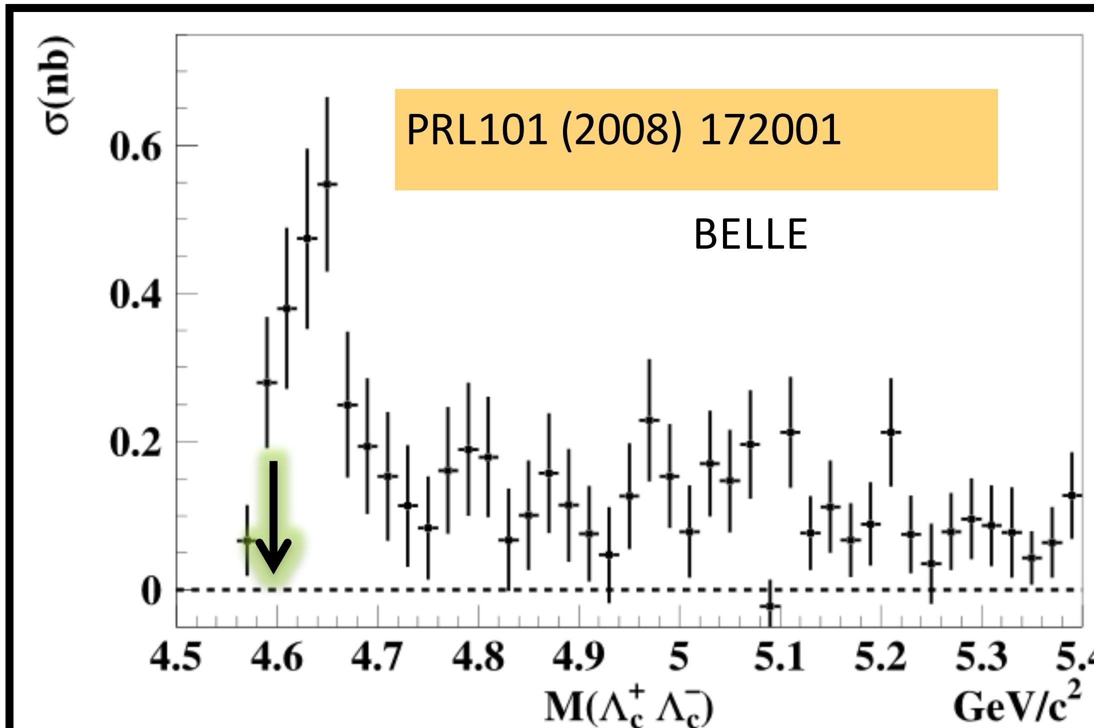


FIG. 4: The cross section for the exclusive process $e^+e^- \to \Lambda_c^+\Lambda_c^-$.

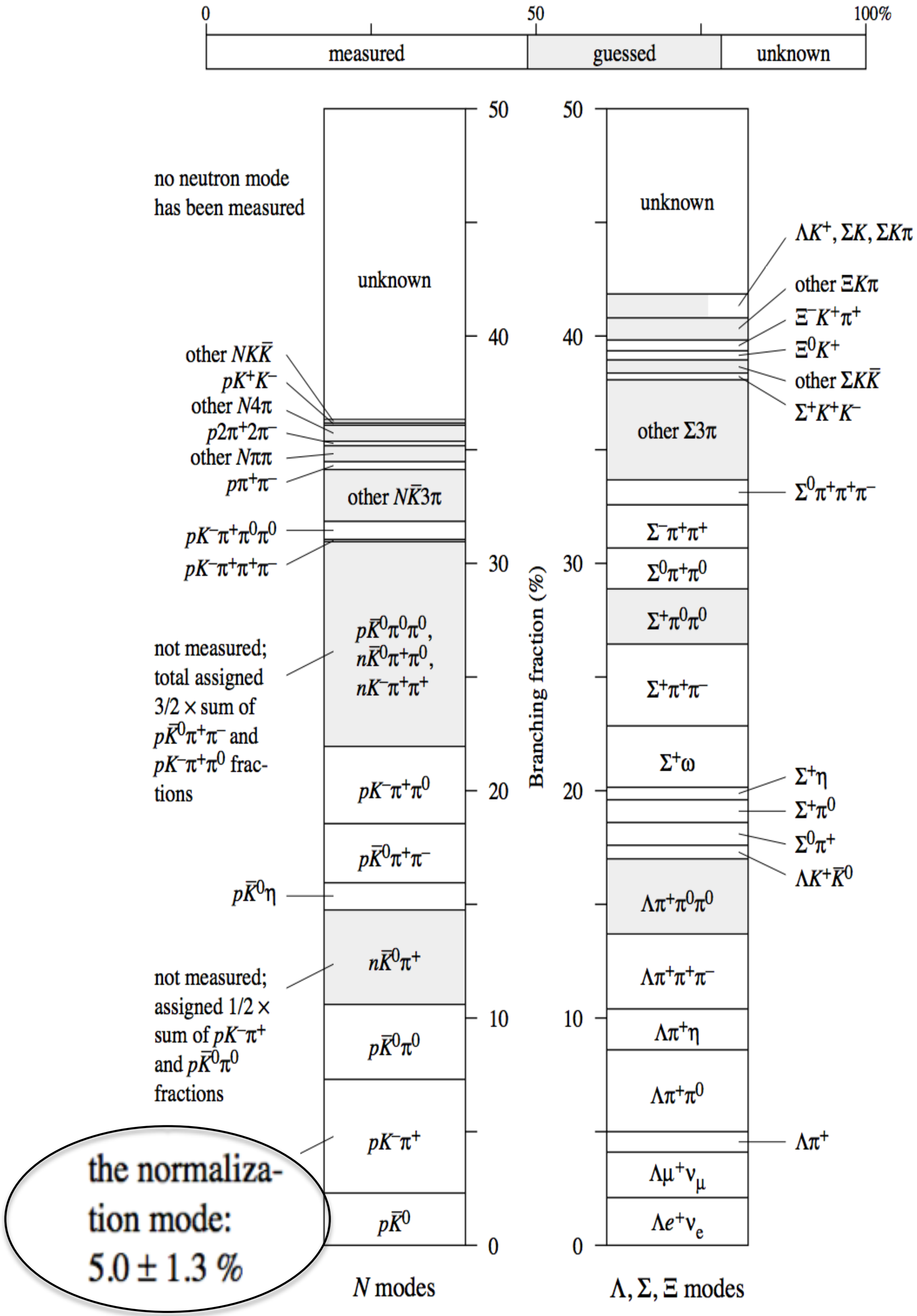
First time to systematically study charmed baryon at threshold!

Absolute BF's of Λ_c^+ hadronic decays

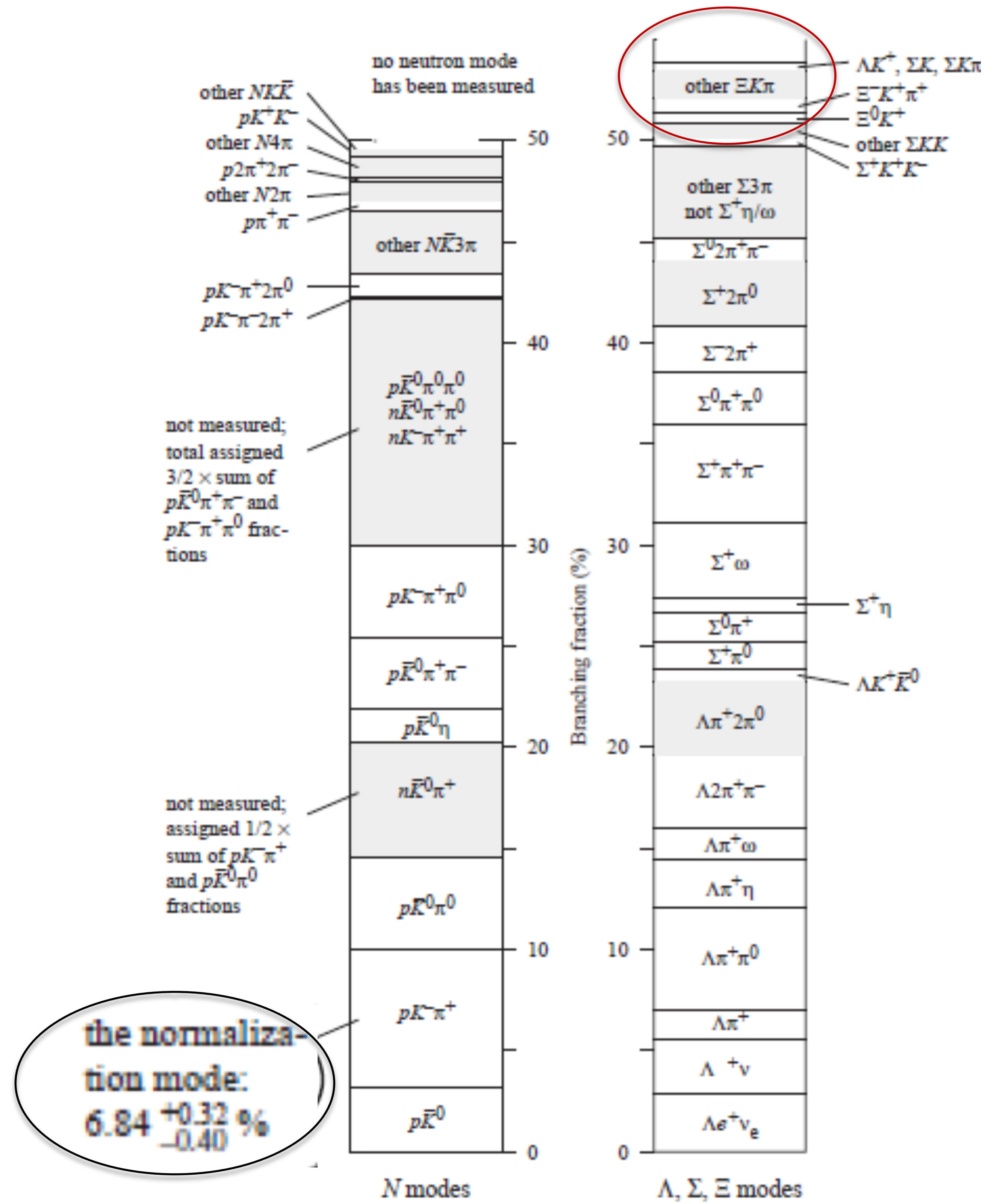
- Absolute branching fractions (BF) of Λ_c^+ decays are still not well determined since its discovery 30 years ago
  - BFs of all the decay modes (~85%) are measured relative to $\Lambda_c^+ \rightarrow pK^-\pi^+$
  - Charm counting ➔ test SM
  - However, no completely model-independent measurements of the absolute BF of $\Lambda_c^+ \rightarrow pK^-\pi^+$ (from Argus and CLEO very old results)
    uncertainties of BFs of Λ_c^+ decays are 25%~40% in PDG2014
- Until Belle's first "model-independent" measurement:
  $B(\Lambda_c^+ \rightarrow pK^-\pi^+) = (6.84 \pm 0.24^{+0.21}_{-0.27})\%$
  precision reaches to 4.7%
  [PRL113(2014)042002]
- However, measurement using the threshold pair-productions via e^+e^- annihilations is unique:
  the most simple and straightforward

Total BF overflow?

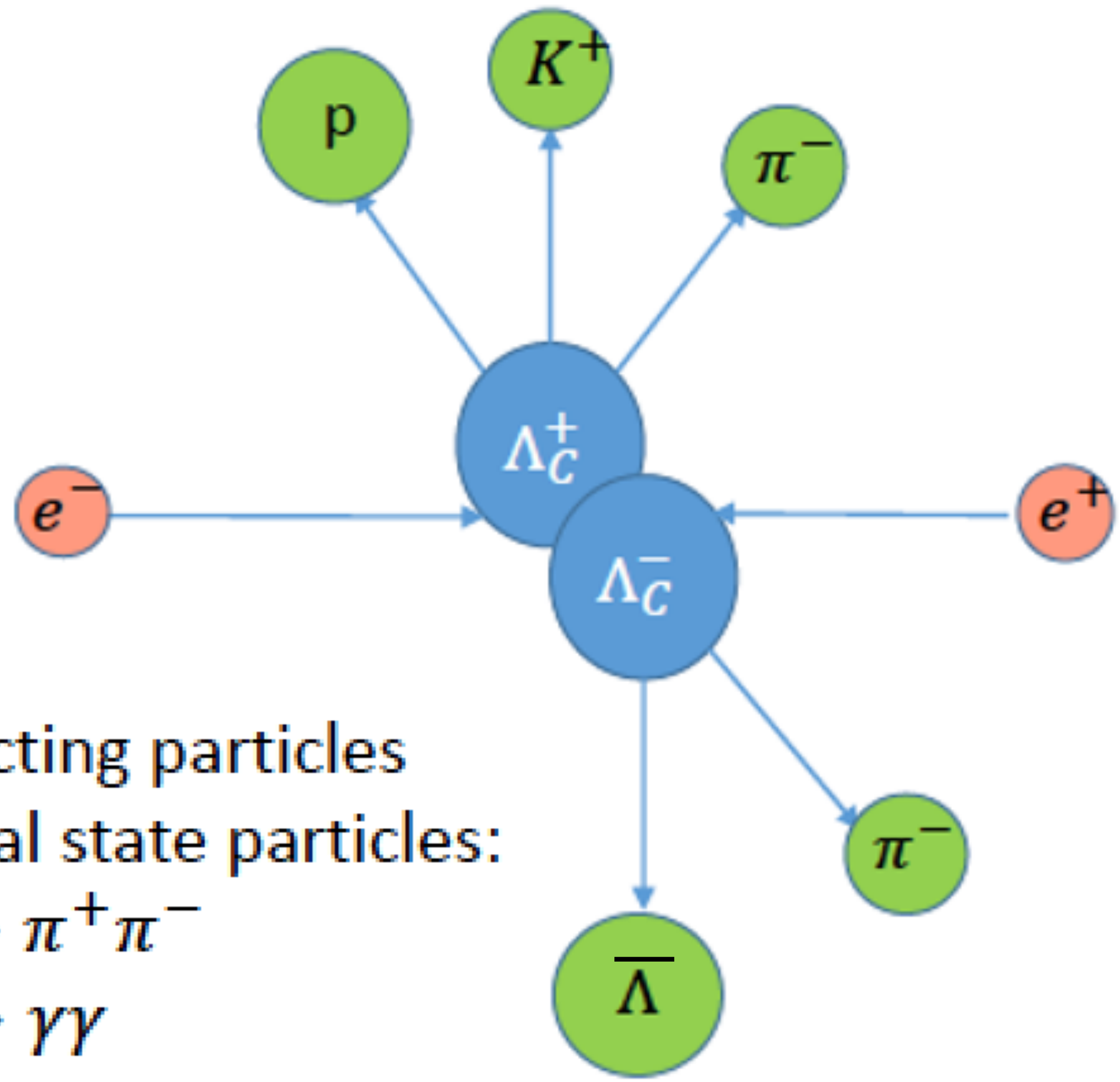
PDG2014



after adopting Belle's



Detection of Λ_c pairs



Constructing particles from final state particles:

- $K_S \to \pi^+\pi^-$
- $\pi^0 \to \gamma\gamma$
- $\Lambda \to p\pi^-$
- $\Sigma^0 \to \Lambda\gamma$
- $\Sigma^+ \to p\pi^0$
- $\omega \to \pi^+\pi^-\pi^0$

12 modes

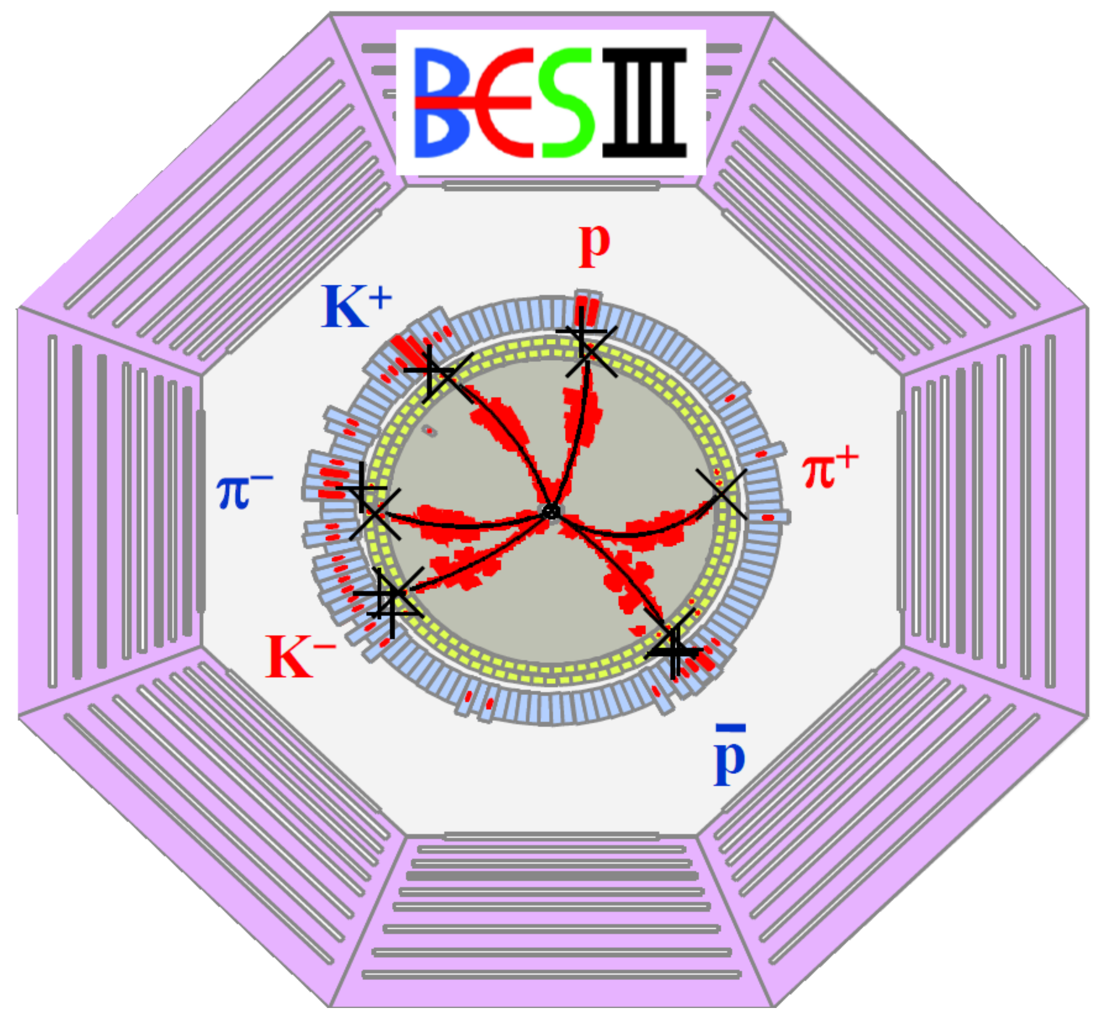
pK_S
$pK^-\pi^+$
$pK_S\pi^0$
$pK_S\pi^+\pi^-$
$pK^-\pi^+\pi^0$
$\Lambda\pi^+$
$\Lambda\pi^+\pi^0$
$\Lambda\pi^+\pi^-\pi^+$
$\Sigma^0\pi^+$
$\Sigma^+\pi^0$
$\Sigma^+\pi^+\pi^-$
$\Sigma^+\omega$

Single Tag (ST) and Double Tag (DT) method
单标记与双标记方法

- **Threshold production at 4.6GeV:**
  Λ_c are always in pairs
- **DT techniques: (partial-)reconstruct both Λ_c mesons**
- **Charm events at threshold are very clean**

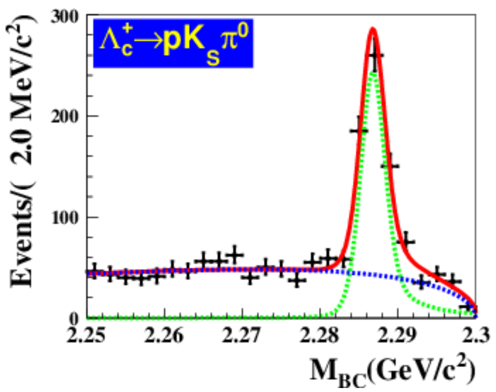
  - Ratio of signal to background is optimum
  - Lots of systematic uncertainties cancellation while applying DT method
  - We define an optimal invariant mass M_{BC}

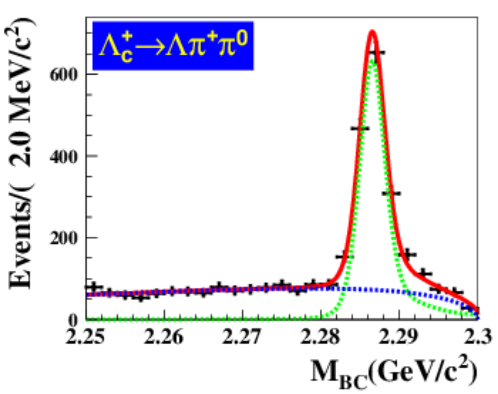
$$M_{BC}c^2 \equiv \sqrt{E_{beam}^2 - p^2c^2}$$

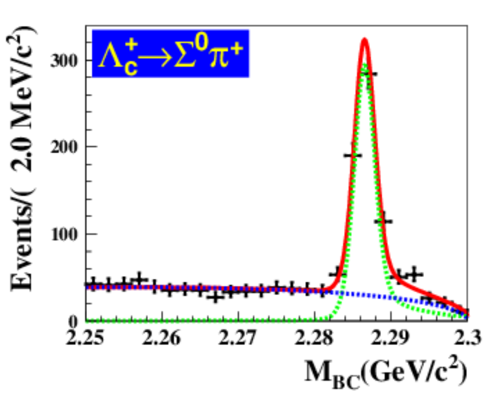


PRL 116, 052001 (2016)

$\Lambda_c^\pm$ yields in data

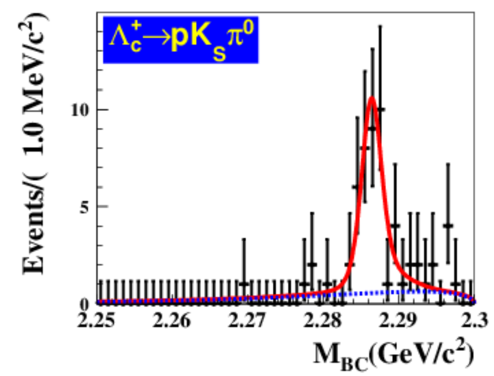


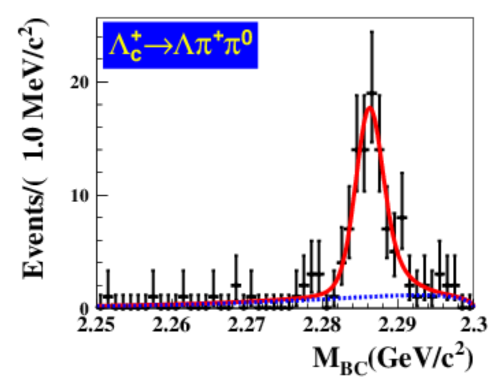


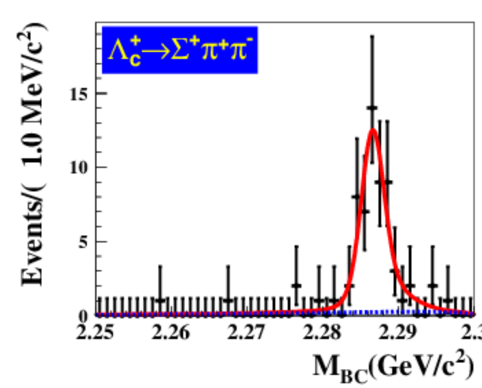


Single tags

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 tags

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

Very clean backgrounds

BESIII

Hadronic branching fraction results

PRL 116, 052001 (2016)

a least square global fitter: simultaneous fit to all the modes *[Chinese Phys. C37(2013)106201]*

Mode	This work (%)	PDG (%)	BELLE $\mathcal{B}$
pK_S^0	$1.52 \pm 0.08 \pm 0.03$	1.15 ± 0.30	
$pK^-\pi^+$	$5.84 \pm 0.27 \pm 0.23$	5.0 ± 1.3	$6.84 \pm 0.24^{+0.21}_{-0.27}$
$pK_S^0\pi^0$	$1.87 \pm 0.13 \pm 0.05$	1.65 ± 0.50	
$pK_S^0\pi^+\pi^-$	$1.53 \pm 0.11 \pm 0.09$	1.30 ± 0.35	
$pK^-\pi^+\pi^0$	$4.53 \pm 0.23 \pm 0.30$	3.4 ± 1.0	
$\Lambda\pi^+$	$1.24 \pm 0.07 \pm 0.03$	1.07 ± 0.28	
$\Lambda\pi^+\pi^0$	$7.01 \pm 0.37 \pm 0.19$	3.6 ± 1.3	
$\Lambda\pi^+\pi^-\pi^+$	$3.81 \pm 0.24 \pm 0.18$	2.6 ± 0.7	
$\Sigma^0\pi^+$	$1.27 \pm 0.08 \pm 0.03$	1.05 ± 0.28	
$\Sigma^+\pi^0$	$1.18 \pm 0.10 \pm 0.03$	1.00 ± 0.34	
$\Sigma^+\pi^+\pi^-$	$4.25 \pm 0.24 \pm 0.20$	3.6 ± 1.0	
$\Sigma^+\omega$	$1.56 \pm 0.20 \pm 0.07$	2.7 ± 1.0	

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

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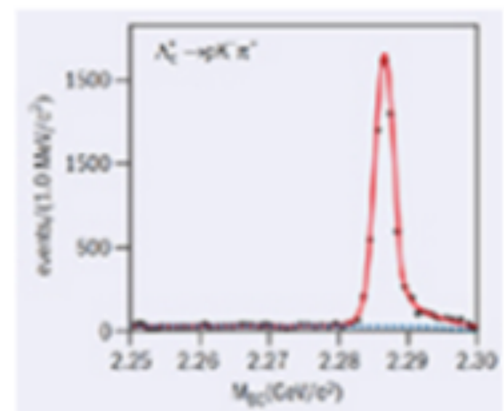
Mar 18, 2016

BESIII makes first direct measurement of the Λ_c at threshold

The charmed baryon, Λ_c, was first observed at Fermilab in 1976. Now, 40 years later, the Beijing Spectrometer (BESIII) experiment at the Beijing Electron–Positron Collider II (BEPCII) has measured the absolute branching fraction of $\Lambda^+_c \rightarrow pK^-\pi^+$ at threshold for the first time.



Beam-constrained mass distribution

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BF of $\Lambda_c^+ \rightarrow \Lambda e^+ \nu_e$

- $\Lambda_c^+ \to \Lambda e^+ \nu_e$ is a $c \to s l^+ \nu_l$ dominated process.
- Urgently needed for LQCD calculations.
- No direct absolute measurement for $\mathcal{B}(\Lambda_c^+ \to \Lambda e^+ \nu_e)$ available.

$$\mathcal{B}(\Lambda_c^+ \to \Lambda e^+ \nu_e) = (2.1 \pm 0.6)\% \qquad \text{PDG 2014}$$

scaling to (2.9±0.5)%, when taking the BELLE's B($pK^-\pi^+$)

However, this is not a direct measurement.

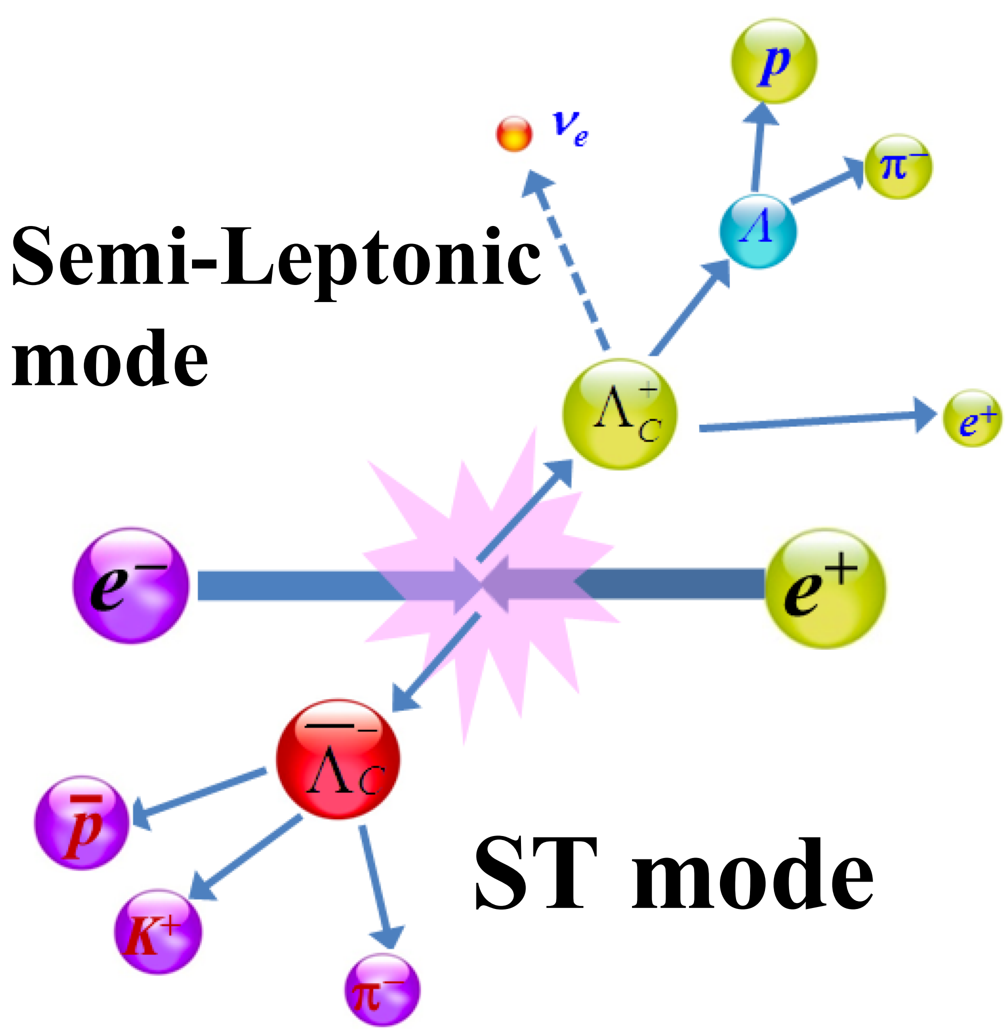
- Theoretical predications for branching fraction of $\Lambda_c^+ \to \Lambda e^+ \nu_e$ ranges from 1.4% to 9.2%.
- Thus, measuring $\mathcal{B}(\Lambda_c^+ \to \Lambda e^+ \nu_e)$ will provide very important experimental information for
  1) testing the theoretical predications for $\mathcal{B}(\Lambda_c^+ \to \Lambda e^+ \nu_e)$.
  2) calibrating the LQCD calculations.
  3) addition information for determining CKM elements.

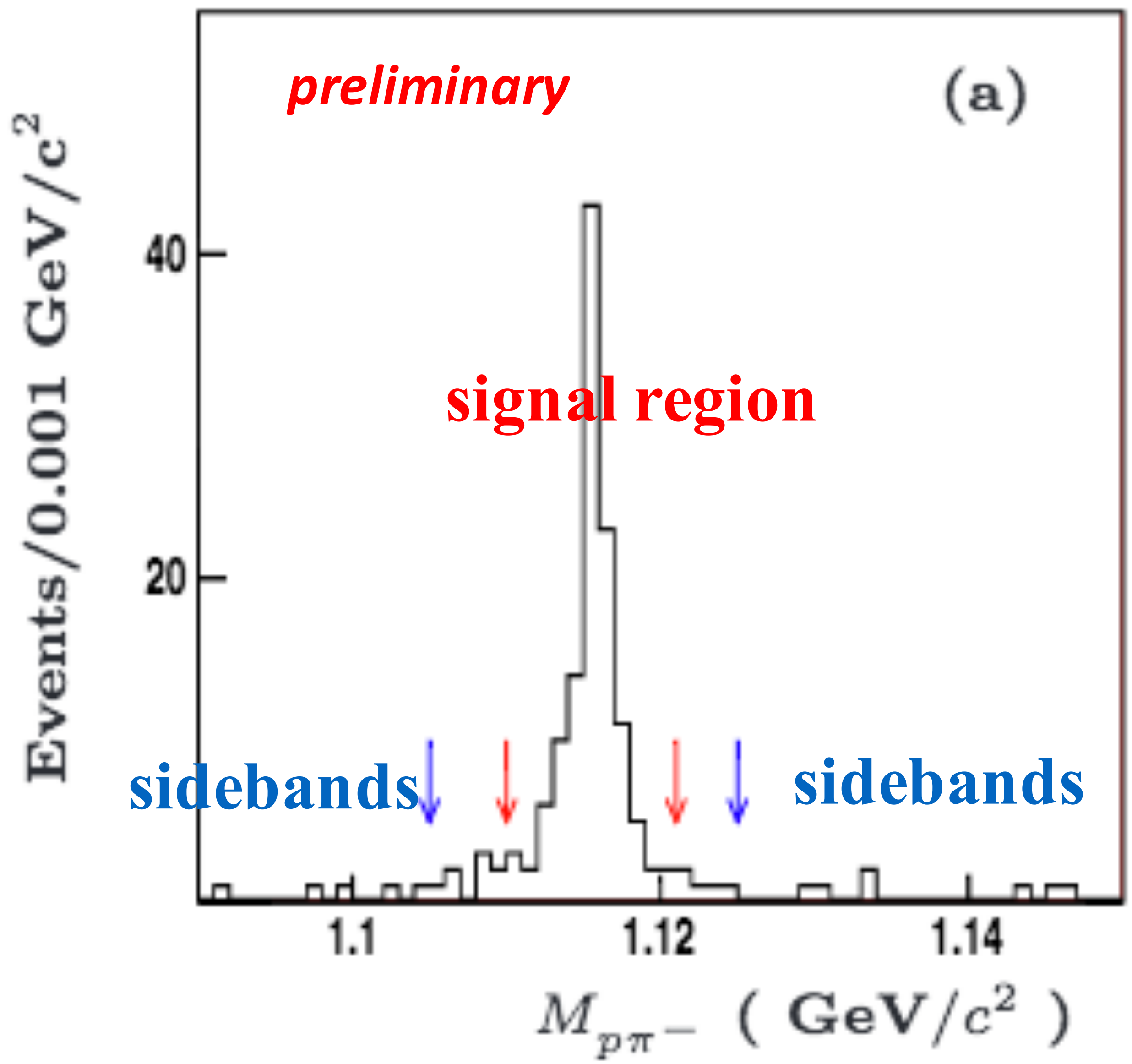
Candidate events for $\Lambda_c^+ \rightarrow \Lambda e^+ \nu_e$

11 ST modes are used, except $\Sigma^+\omega$

567/pb @ 4.6 GeV

We detect a p, π^- and e^+ among the remaining tracks from the ST Λ_c^- and require p and π^- are from Λ.





clean Λ peak

Results of $B(\Lambda_c^+ \to \Lambda e^+ \nu_e)$

PRL 115, 221805 (2015)

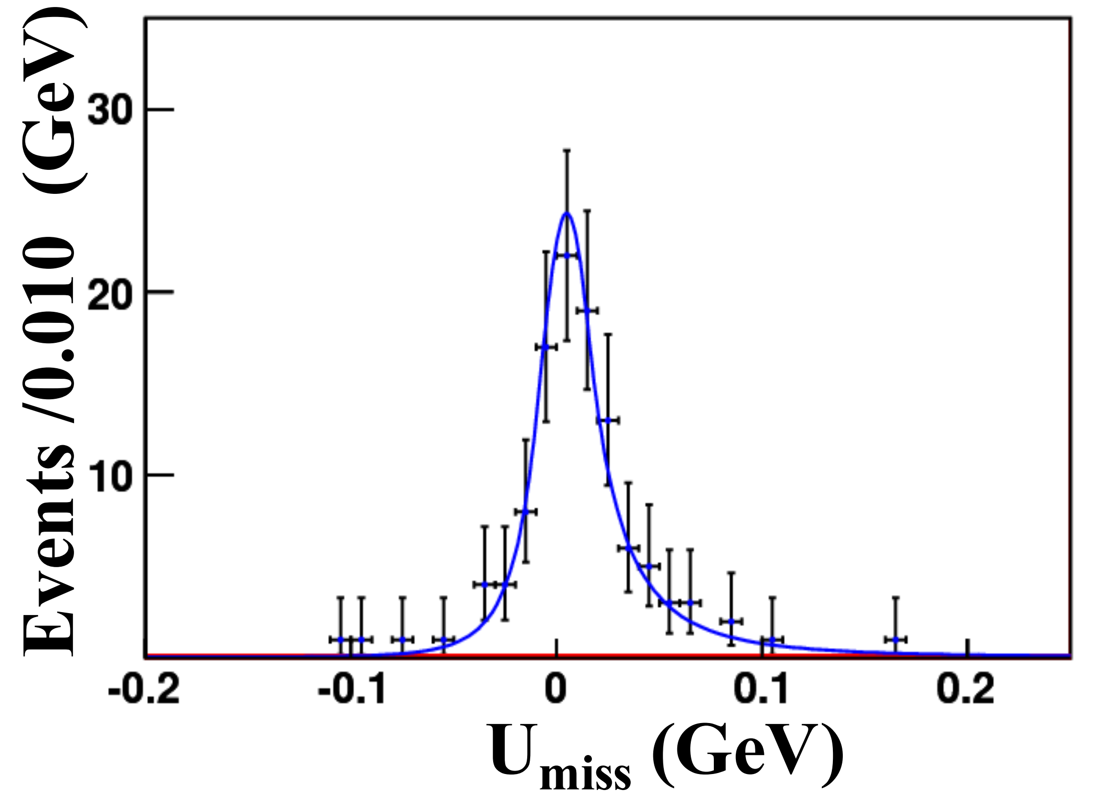
an optimized missing mass:

$$U_{\rm miss} = E_{\rm miss} - c|\vec{p}_{\rm miss}|$$

$$E_{\rm miss} = E_{\rm beam} - E_{K_S^0} - E_{\pi^+},$$

$$\vec{p}_{\rm miss} = \vec{p}_{\Lambda_c^+} - \vec{p}_{K_S^0} - \vec{p}_{\pi^+},$$

$$\vec{p}_{\Lambda_c^+} = -\hat{p}_{\rm tag}\sqrt{E_{\rm beam}^2 - m_{\Lambda_c^+}^2},$$



where $\hat{p}_{\rm tag}$ is the direction of the momentum of singly tagged $\bar{\Lambda}_c^-$;

$$B(\Lambda_c^+ \to \Lambda e^+ \nu_e) = (3.63 \pm 0.38 \pm 0.20)\%$$

scaled PDG
(2.9±0.5)%

- First absolute measurement!
- Statistics limited
- Best precision to date: twofold improvement

Comparison with predictions and PDG

Theoretical Models	predicated branching fraction for $\Lambda_c^+ \to \Lambda e^+ \nu_e$
MBM [1]	1.9%
NRQM [1]	2.6%
SU(4)-symmetry limit [2]	9.2%
RSQM [3]	4.4%
QCM [4]	5.62%
SQM [5]	1.96%
NRQM2 [6]	2.15%
NRQM3 [7]	1.42%
QCD SR1 [8]	$(3.0 \pm 0.9)\%$
QCD SR2 [9]	$(2.6 \pm 0.4)\%$
QCD SR3 [9]	$(5.8 \pm 1.5)\%$
STSR [10]	2.22% for $\Lambda_c^+ \to \Lambda l^+ \nu_l$
STNR [10]	1.58% for $\Lambda_c^+ \to \Lambda l^+ \nu_l$
HOSR [10]	4.72% for $\Lambda_c^+ \to \Lambda l^+ \nu_l$
HONR [10]	4.2% for $\Lambda_c^+ \to \Lambda l^+ \nu_l$
LCSRs [11]	$(3.0 \pm 0.3)\%$ for $\Lambda_c^+ \to \Lambda l^+ \nu_l$ (CZ-type)
PDG 2014 [14]	$(2.1 \pm 0.6)\%$
BESIII	$(3.62 \pm 0.38 \pm 0.20)\%$

Semileptonic Λ_c decay

$$\mathcal{B}(\Lambda_c^+ \to \Lambda e^+ \nu) = (3.63 \pm 0.38 \pm 0.20)\%$$ Phys.Rev.Lett. 115 (2015) 221805

$$\Gamma(\Lambda_c^+ \to \Lambda e^+ \nu) = (18.2 \pm 2.1) \times 10^{10} s^{-1}$$ BESIII

$$\boxed{\Gamma(\Lambda_c^+ \to X e^+ \nu) = (22.5 \pm 8.5) \times 10^{10} s^{-1}}$$

$$\Gamma(D^0 \to X e^+ \nu) = (15.84 \pm 0.27) \times 10^{10} s^{-1}$$ PDG2014

$$\Gamma(D^+ \to X e^+ \nu) = (15.45 \pm 0.29) \times 10^{10} s^{-1}$$

Data: $\frac{\Gamma(\Lambda_c^+ \to \Lambda e^+ \nu)}{\Gamma(D \to X e^+ \nu)} = 1.16 \pm 0.13$ $\frac{\Gamma(\Lambda_c^+ \to X e^+ \nu)}{\Gamma(D \to X e^+ \nu)} = 1.44 \pm 0.54$

Prediction: $\frac{\Gamma(\Lambda_c^+ \to X e^+ \nu)}{\Gamma(D \to X e^+ \nu)} = 1.20 \sim 1.67$

J. Rosner (2012)
Manohar, Wise(1994)
Gronau and Rosner(2011)

- **The inclusive Λc semileptonic decay rate ≈ Λc →Λlν rate?**
- **No evidence for semileptonic decay in the final states without Λ.**
- **Precise measurement of the inclusive Λc semileptonic is important.**
- **Search for other semileptonic modes, such as $pK^- e^+\nu_e$**

国际评价及后续工作

PRL审稿人意见

The article presents the first measurement of the absolute branching fraction for the semileptonic decay of the Lambda_c to Lambda e\nu. This sets of measurements are important for testing different non-perturbative theoretical models of heavy hadrons, and model-independent measurements like this one provide extremely valuable data. Moreover, this measurement provides important data to model the phenomenology of hadrons and which go on to be used in current and future collider experiments.

这是首次的绝对分支比测量。此项工作对检验重味强子的非微扰理论模型非常重要，并对未来的对撞机实验提供重要的数据。

Observation of $\Lambda_c^+ \rightarrow n K_S^0 \pi^+$

- ✓ The total measured branching fractions for Λ_c^+ decay is only about 60%. Searching for new decay modes are important for understanding the decay property of Λ_c^+.
- ✓ There is no measurements for Λ_c^+ decay into the final states containing neutron.
- ✓ DT method is used
- ✓ To confer the missing neutron, we define the variable M^2_{miss}

M^2_{miss} is calculated to extract the information of missing neutron

$$M^2_{\mathrm{miss}} = (p_{\Lambda_c^+} - p_{K_S^0} - p_{\pi^+})^2 = E^2_{\mathrm{miss}} - c^2|\vec{p}_{\mathrm{miss}}|^2.$$

In analysis,

$$E_{\mathrm{miss}} = E_{\mathrm{beam}} - E_{K_S^0} - E_{\pi^+},$$

$$\vec{p}_{\mathrm{miss}} = \vec{p}_{\Lambda_c^+} - \vec{p}_{K_S^0} - \vec{p}_{\pi^+},$$

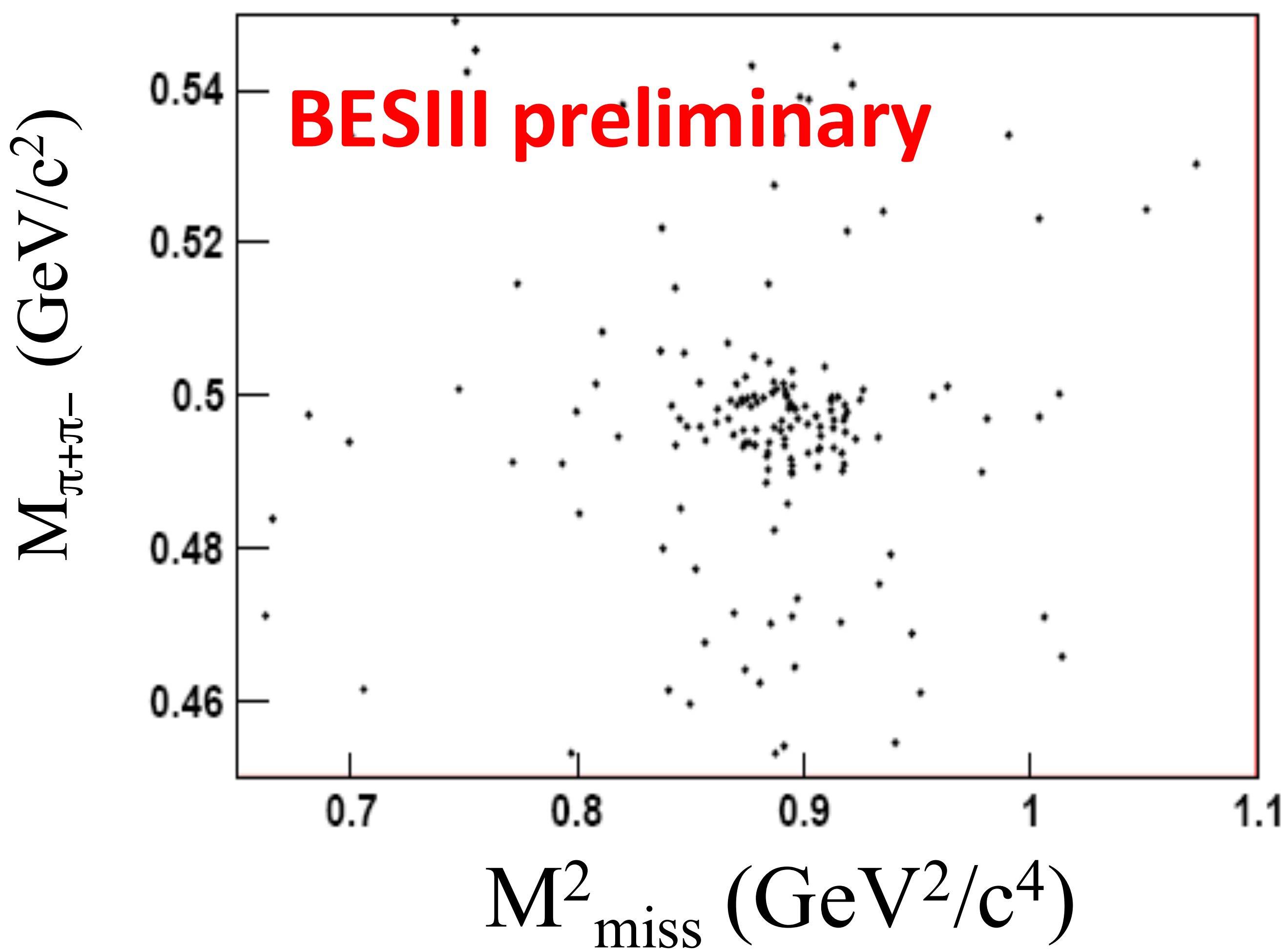
$$\boxed{\vec{p}_{\Lambda_c^+} = -\hat{p}_{\mathrm{tag}}\sqrt{E^2_{\mathrm{beam}} - m^2_{\Lambda_c^+}},}$$

An optimal way to improve resolution

where $\hat{p}_{\mathrm{tag}}$ is the direction of the momentum of singly tagged $\bar{\Lambda}_c^-$;

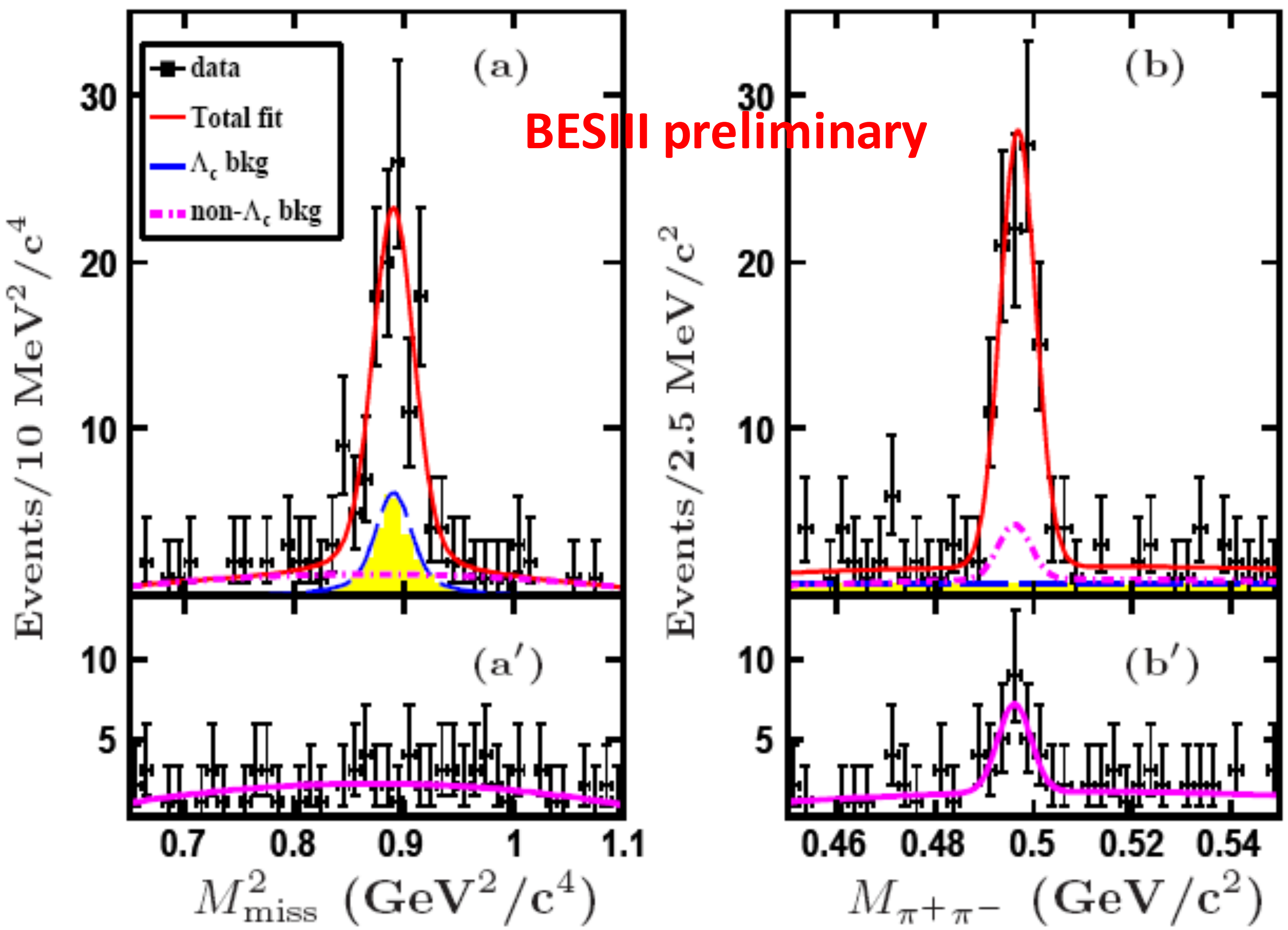
Observation of $\Lambda_c^+ \rightarrow nK_S^0\pi^+$

567/pb data @ 4.6 GeV



scatter plots $M_{\pi+\pi-}$ versus M^2_{miss}

Observation of $\Lambda_c^+ \rightarrow nK_S^0\pi^+$



Fit to M^2_{miss} and $M_{\pi+\pi}$ spectra in (a,b) Λ_c^- signal region and (a',b') Λ_c^- sideband region simultaneously.

83±11 net signal events

BESIII Preliminary results:

$$B[\Lambda_c^+ \rightarrow nK_S^0\pi^+]=(1.82\pm0.23\pm0.11)\%$$

First observation of Λ_C^+ decays to final states involving the neutron.

Experimental precision reaches of charmed hadrons

	golden mode	$\delta B/B$	SL	$\delta B/B$
D0	B(Kpi)=(3.88±0.05)%	1.3%	B(Kev)=(3.55±0.05)%	1.4%
D+	B(Kpipi)=(9.13±0.19)%	2.1%	B(K0ev)=(8.83±0.22)%	2.5%
Ds	B(Kkpi)=(5.39±0.21)%	3.9%	B(phiev)=(2.49±0.14)%	5.6%
Λ_c	B(pKpi)=(5.0±1.3)%(PDG2014) =(6.8±0.36)% (BELLE) =(5.84±0.35)% (BESIII)	26% 5.3% 6.0%	B(Λev)=(2.1±0.6)%(PDG2014) =(3.63±0.43)% (BESIII)	29% 12%

- **BESIII Λ_c data correspond to 567/pb taken in 2014**
- **We have chance to improve the precisions of Λ_c decay rates to the level of charmed mesons!**

More Λ_c data set ?

A combined data taking proposal of studying Λ_c^+

Proposal of precise study of the charmed baryon Λ_c^+ decays

Hai-Bo Li, Peirong Li, Lei Li, Xiao-Rui Lyu,
Haiping Peng, Yangheng Zheng

Analyticity Violation in $e^+e^- \to \Lambda_c \bar{\Lambda}_c$?
A request for
additional integrated luminosity at threshold

Rinaldo Baldini, Marco Maggiora, Guangshun Huang, RongGang Ping, Weimin Song, Weiping Wang, Liang Yan, Zhengguo Zhao, Xiaorong Zhou, Kai Zhu,
and the BESIII Italian Collaboration Team

BESIII collaboration meeting at SJTU 2015.6.14

We propose one year dedicated data taking at Λ_c threshold

0.5 M Λ_c^+ pairs

Precision Prospects

Push the precisions to the level of those of D/Ds mesons.

Hadronic decays

- PWA analysis of Cabbio-favored hadronic decays: light hadrons
- studies of the modes involving neutron particles

Semi-Leptonic decays :

- so far, only $\Lambda e^+\nu_e$ mode is measured; How about pK$^-$ $e^+\nu_e$?
- many more semi-leptonic modes can be established at BESIII!

	golden mode	δB/B	SL	δB/B
D0	B(Kpi)=(3.88±0.05)%	1.3%	B(K e v)=(3.55±0.05)%	1.4%
D+	B(Kpipi)=(9.13±0.19)%	2.1%	B(K0 e v)=(8.83±0.22)%	2.5%
Ds	B(Kkpi)=(5.39±0.21)%	3.9%	B(phi e v)=(2.49±0.14)%	5.6%
Λc	B(pKpi)=(5.0±1.3)% (PDG2014) =(6.8±0.36)% (BELLE) =(5.84±0.35)% (BESIII) **=(5.84±0.18)% (new BESIII)**	26% 5.3% 6.0% **3.0%**	B(Λev)=(2.1±0.6)%(PDG2014) =(3.63±0.43)% (BESIII) **=(3.63±0.20)% (new BESIII)**	29% 12% **5.4%**

You are welcome to join the effort!

Other Relevant Studies

- **$\boldsymbol{\Lambda_c^+}$ hadronic weak decays**
  - ✓ Two-body hadronic decays of Λ_c^+ are of great interest
  - ✓ Decay asymmetry parameters in Λ_c^+ two-body hadronic weak decays, such as $\Lambda_c^+ \to BP$ and $\Lambda_c^+ \to BV$
  - ✓ We can provide precise measurements on this observables (see next page)
- **search for $\boldsymbol{\Lambda_c^+}$ low rate decays and rare decays**
  - ✓ Weak radiative decay $\Lambda_c^+ \to \gamma \Sigma^+$; predictions of BF are 10^{-4} ~10^{-5}
    - ◆ Sensitivity with $0.5\,\mathrm{M}$ Λ_c^+ pairs gets to ~10^{-4}
  - ✓ FCNC, lepton number/family violation, baryon family violation ...
    - ◆ Sensitivity with $0.5\,\mathrm{M}$ Λ_c^+ pairs reaches to ~10^{-5}

Decay asymmetry in two-body decays

- first or improved measurements of decay asymmetry parameters the following modes $\Lambda_c^+ \to B(\frac{1}{2}^+)+P$

$$\frac{dW}{d\cos\theta} = \frac{1}{2}(1 + \alpha_{\Lambda_c}\alpha_B \cos\theta)$$

0.5 M Λ_c^+ pairs

Decay	Körner, Krämer [260]	Xu, Kamal [264]	Cheng, Tseng [263]	Ivanov et al. [278]	Żenczy-kowski[277]	Sharma, [276]	**PDG**	**δα**
$\Lambda_c^+ \to \Lambda\pi^+$	-0.70	-0.67	-0.95	-0.95	-0.99	-0.99	-0.91 ± 0.15	**0.10**
$\Lambda_c^+ \to \Sigma^0\pi^+$	0.70	0.92	0.78	0.43	0.39	-0.31		**0.10**
$\Lambda_c^+ \to \Sigma^+\pi^0$	0.71	0.92	0.78	0.43	0.39	-0.31	-0.45 ± 0.32	**0.20**
$\Lambda_c^+ \to \Sigma^+\eta$	0.33			0.55	0	-0.91		**0.25**
$\Lambda_c^+ \to pK^0$	-1.0	0.51	-0.49	-0.97	-0.66	-0.99		**0.05**

- Most of the modes involve photon or π^0 final states:
  - advantage for threshold measurement
- BESIII will provide rigid tests on the theoretical calculations

经过八年努力，终于在4月5日22:29实现对撞亮度 $1\times10^{33}cm^{-2}s^{-1}$，成功达到了BEPCII对撞亮度设计指标!

Summary

- BESIII also opens a new door for the charmed baryon Λ_c^+
  ➔**Precise study of Λc decays**
  stringent test on theoretical models
  - absolute branching fractions of Λ_c^+ decays suffers from large uncertainties since its discovery 30 years ago
  - For the first time, BES is able to precisely study its decays at threshold
  - BESIII took a data set of 567/pb and published several world-best results
- more potentials to reveal the nature of Λc dynamics
  - We are proposing to take a larger data set;
    a golden opportunity to thoroughly improve our knowledge on Λ_c decays
  - **Hadronic decays**
    PWA analysis of Cabbio-favored hadronic decays and studies of the modes involving the neutron
  - **Semi-Leptonic decays**
    many more semi-leptonic modes, like $pK^- e^+\nu_e$, can be established at BESIII!

Thank you!

谢谢大家！