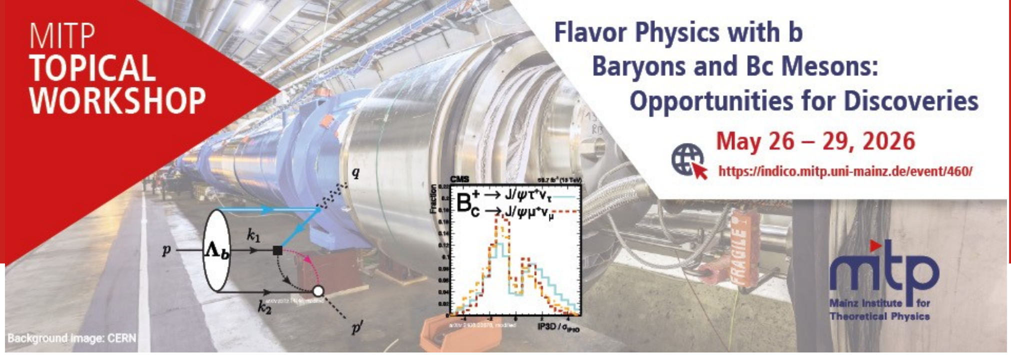


Excited charmed baryon at BESIII

G Mezzadri (INFN Ferrara) – gmezzadr@fe.infn.it
On behalf of the BESIII collaboration

27/05/2026, Mainz

Istituto Nazionale di Fisica Nucleare

Why charmed baryons are relevant today?

Typically, a bottom baryon will decay to a charmed baryon

- Most of the information are available only for Λ_c
- Scarse for other charmed baryon

Γ_{33}	$\Lambda_c^+ \pi^-$		$(4.9 \pm 0.4) \times 10^{-3}$	S=1.2
Γ_{34}	$\Lambda_c^+ K^-$		$(3.56 \pm 0.28) \times 10^{-4}$	S=1.2
Γ_{35}	$\Lambda_c^+ a_1(1260)^-$		seen	
Γ_{36}	$\Lambda_c^+ D^-$		$(4.6 \pm 0.6) \times 10^{-4}$	
Γ_{37}	$\Lambda_c^+ D_s^-$		(1.10 ± 0.10) %	
Γ_{38}	$\Lambda_c^+ D_s^{*-}$		(1.83 ± 0.18) %	
Γ_{39}	$\Lambda_c^+ \overline{D}^0 K^-$		$(2.13 \pm 0.20) \times 10^{-3}$	
Γ_{40}	$\Lambda_c^+ \overline{D}^{*0} K^-$		$(6.6 \pm 0.7) \times 10^{-3}$	
Γ_{41}	$\Lambda_c^+ \pi^+ \pi^- \pi^-$		$(7.6 \pm 1.1) \times 10^{-3}$	S=1.1
Γ_{42}	$\Lambda_c(2595)^+ \pi^-$, $\Lambda_c(2595)^+ \to \Lambda_c^+ \pi^+ \pi^-$		$(3.4 \pm 1.4) \times 10^{-4}$	
Γ_{43}	$\Lambda_c(2625)^+ \pi^-$, $\Lambda_c(2625)^+ \to \Lambda_c^+ \pi^+ \pi^-$		$(3.3 \pm 1.3) \times 10^{-4}$	
Γ_{44}	$\Sigma_c(2455)^0 \pi^+ \pi^-$, $\Sigma_c^0 \to \Lambda_c^+ \pi^-$		$(5.7 \pm 2.2) \times 10^{-4}$	
Γ_{45}	$\Sigma_c(2455)^{++} \pi^- \pi^-$, $\Sigma_c^{++} \to \Lambda_c^+ \pi^+$		$(3.2 \pm 1.5) \times 10^{-4}$	
Γ_{46}	$\Sigma_c(2455)^{++} D^- K^-$		$(6.0 \pm 0.8) \times 10^{-4}$	
Γ_{47}	$\Sigma_c(2455)^{++} D^{*-} K^-$		$(1.36 \pm 0.22) \times 10^{-3}$	
Γ_{48}	$\Sigma_c(2520)^{++} D^- K^-$		$(2.8 \pm 0.5) \times 10^{-4}$	
Γ_{49}	$\Sigma_c(2520)^{++} D^{*-} K^-$		$(5.4 \pm 1.1) \times 10^{-4}$	
Γ_{50}	$\Lambda_c^+ K^+ K^- \pi^-$		$(1.02 \pm 0.11) \times 10^{-3}$	
Γ_{51}	$\Lambda_c^+ p \overline{p} \pi^-$		$(2.63 \pm 0.27) \times 10^{-4}$	
Γ_{52}	$\Sigma_c(2455)^0 p \overline{p}$, $\Sigma_c^0 \to \Lambda_c^+ \pi^-$		$(2.3 \pm 0.5) \times 10^{-5}$	
Γ_{53}	$\Sigma_c(2520)^0 p \overline{p}$, $\Sigma_c(2520)^0 \to \Lambda_c^+ \pi^-$		$(3.1 \pm 0.7) \times 10^{-5}$	
Γ_{54}	$\Lambda K^0 2\pi^+ 2\pi^-$			
Γ_{55}	$\Lambda_c^+ \ell^- \overline{\nu}_\ell$ anything	[b]	(10.9 ± 2.2) %	
Γ_{56}	$\Lambda_c^+ \ell^- \overline{\nu}_\ell$		$(6.2 ^{+1.4}_{-1.3})$ %	

Λ_b decay modes

Why charmed baryons are relevant today?

- $\Lambda_c(2595)$ and $\Lambda_c(2625)$ are usually assigned as degenerate P-wave $J^P = 1/2^-$ and $J^P = 3/2^-$ partners
- CDF observed $\Lambda_b \to \Lambda_c\, \mu\nu$ decay rates
  - Higher probability of $\Lambda_c(2625)$
  - Contradicts Lattice QCD at larger q^2 (PRD 103, 094516 (2021), PRD 105, 054511 (2022))
  - Proposed dynamical structure for $\Lambda_c(2595)$ that sits close to $\Sigma_c\pi$ threshold, similar to $\Lambda(1405)$ and $\Lambda(1520)$
- LHCb has observed hadronic decays $\Lambda_c \to \Lambda_c\pi$ and reported similar decay rate (Phys. Rev. D 85, 092001 (2012))

Citation: S. Navas *et al.* (Particle Data Group), Phys. Rev. D **110**, 030001 (2024) and 2025 update

$\Lambda_c(2595)^+$

$I(J^P) = 0(\frac{1}{2}^-)$ Status: ∗∗∗

The $\Lambda_c^+\pi^+\pi^-$ mode is largely, and perhaps entirely, $\Sigma_c\pi$, which is just at threshold; since the Σ_c has $J^P = 1/2^+$, the J^P here is almost certainly $1/2^-$. This result is in accord with the theoretical expectation that this is the charm counterpart of the strange $\Lambda(1405)$.

$\Lambda_c(2595)^+$ MASS

The mass is obtained from the $\Lambda_c(2595)^+ - \Lambda_c^+$ mass-difference measurements below.

VALUE (MeV)	DOCUMENT ID
2592.25±0.28 OUR FIT	

$\Lambda_c(2595)^+ - \Lambda_c^+$ MASS DIFFERENCE

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
305.79±0.24 OUR FIT					
305.79±0.14±0.20	3.5k	AALTONEN	11H	CDF	$p\bar{p}$ at 1.96 TeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
305.6 ±0.3		[1] BLECHMAN	03		Threshold shift
309.7 ±0.9 ±0.4	19	ALBRECHT	97	ARG	$e^+e^- \approx$ 10 GeV
309.2 ±0.7 ±0.3	14 ± 4.5	FRABETTI	96	E687	γBe, $\overline{E}_\gamma \approx$ 220 GeV
307.5 ±0.4 ±1.0	112 ± 17	EDWARDS	95	CLE2	$e^+e^- \approx$ 10.5 GeV

[1] BLECHMAN 03 finds that a more sophisticated treatment than a simple Breit-Wigner for the proximity of the threshold of the dominant decay, $\Sigma_c(2455)\pi$, lowers the $\Lambda_c(2595)^+ - \Lambda_c^+$ mass difference by 2 or 3 MeV. The analysis of AALTONEN 11H bears this out.

$\Lambda_c(2595)^+$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
2.59±0.30±0.47	3.5k	[2] AALTONEN	11H	CDF	$p\bar{p}$ at 1.96 TeV

Citation: S. Navas *et al.* (Particle Data Group), Phys. Rev. D **110**, 030001 (2024) and 2025 update

$\Lambda_c(2625)^+$

$I(J^P) = 0(\frac{3}{2}^-)$ Status: ∗∗∗

The spin-parity has not been measured but is expected to be $3/2^-$: this is presumably the charm counterpart of the strange $\Lambda(1520)$.

$\Lambda_c(2625)^+$ MASS

The mass is obtained from the $\Lambda_c(2625)^+ - \Lambda_c^+$ mass-difference measurements below.

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
2628.00±0.15 OUR FIT					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2626.6 ±0.5 ±1.5	42 ± 9	ALBRECHT	93F	ARG	See ALBRECHT 97

$\Lambda_c(2625)^+ - \Lambda_c^+$ MASS DIFFERENCE

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
341.54 ±0.05 OUR FIT					
341.54 ±0.05 OUR AVERAGE					
341.518±0.006±0.049	30.3k	WANG	23	BELL	e^+e at/near $\Upsilon(4S)$
341.65 ±0.04 ±0.12	6.2k	AALTONEN	11H	CDF	$p\bar{p}$ at 1.96 TeV
342.1 ±0.5 ±0.5	51	ALBRECHT	97	ARG	$e^+e^- \approx$ 10 GeV
342.2 ±0.2 ±0.5	245	EDWARDS	95	CLE2	$e^+e^- \approx$ 10.5 GeV
340.4 ±0.6 ±0.3	40	FRABETTI	94	E687	γBe, $\overline{E}_\gamma$ = 220 GeV

$\Lambda_c(2625)^+$ WIDTH

VALUE (MeV)	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
<0.52	90	30.3k	WANG	23	BELL	e^+e at/near $\Upsilon(4S)$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<0.97	90	6.2k	AALTONEN	11H	CDF	$p\bar{p}$ at 1.96 TeV
<1.9	90	245 ± 19	EDWARDS	95	CLE2	$e^+e^- \approx$ 10.5 GeV
<3.2	90		ALBRECHT	93F	ARG	$e^+e^- \approx \Upsilon(4S)$

$\Lambda_c(2625)^+$ DECAY MODES

Why charmed baryons are relevant today?

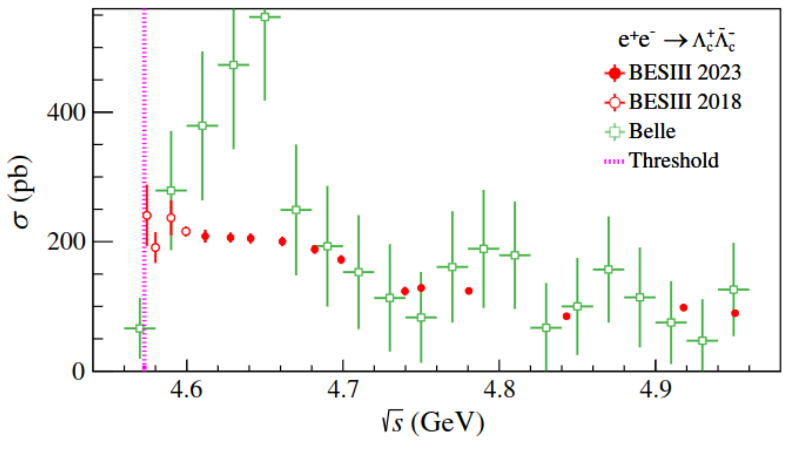
- Σ_c are the natural counterpart of Λ_c, with which share the same valence quarks
  - Σ_c have "bad" diquark $[ud]_{spin=1}$ that makes them heavier
  - Comparison with fully light hadrons

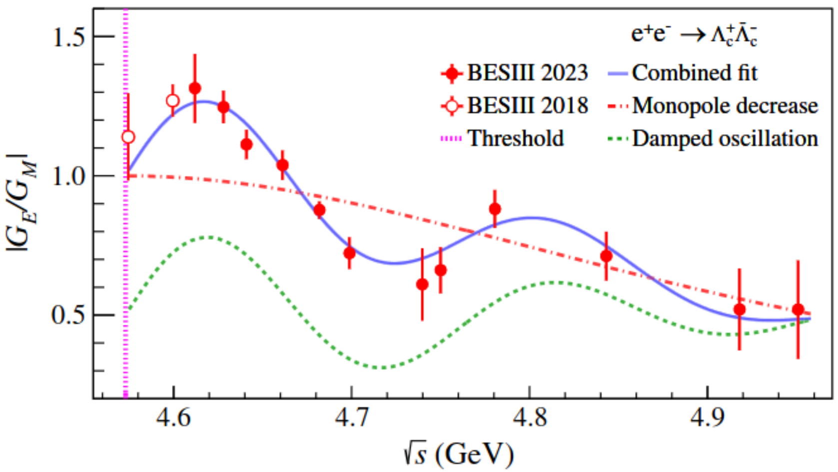
- Σ_c-Σ_c bound state is predicted with different models to describe the Σ_c-$\bar{\Sigma}_c$ interaction
  - However, no experimental data

Why charmed baryons are relevant today?

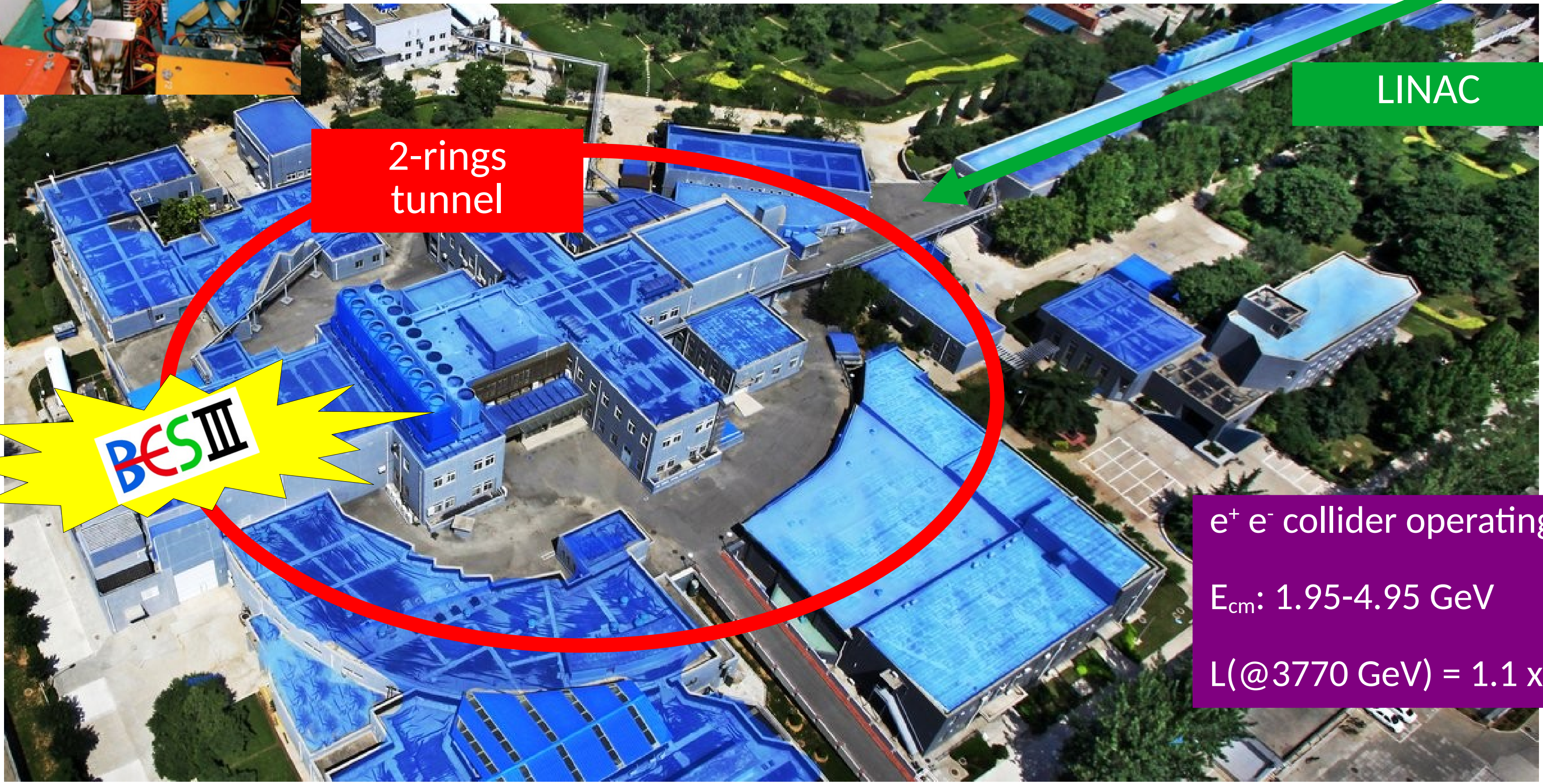
Even the Λ_c have still some limited knowledge:

- jump of cross section nearby threshold,
- oscillating behaviour of the G_E/G_M ratio,
- many unmeasured final states with neutrals
- …





BEPCII @ IHEP

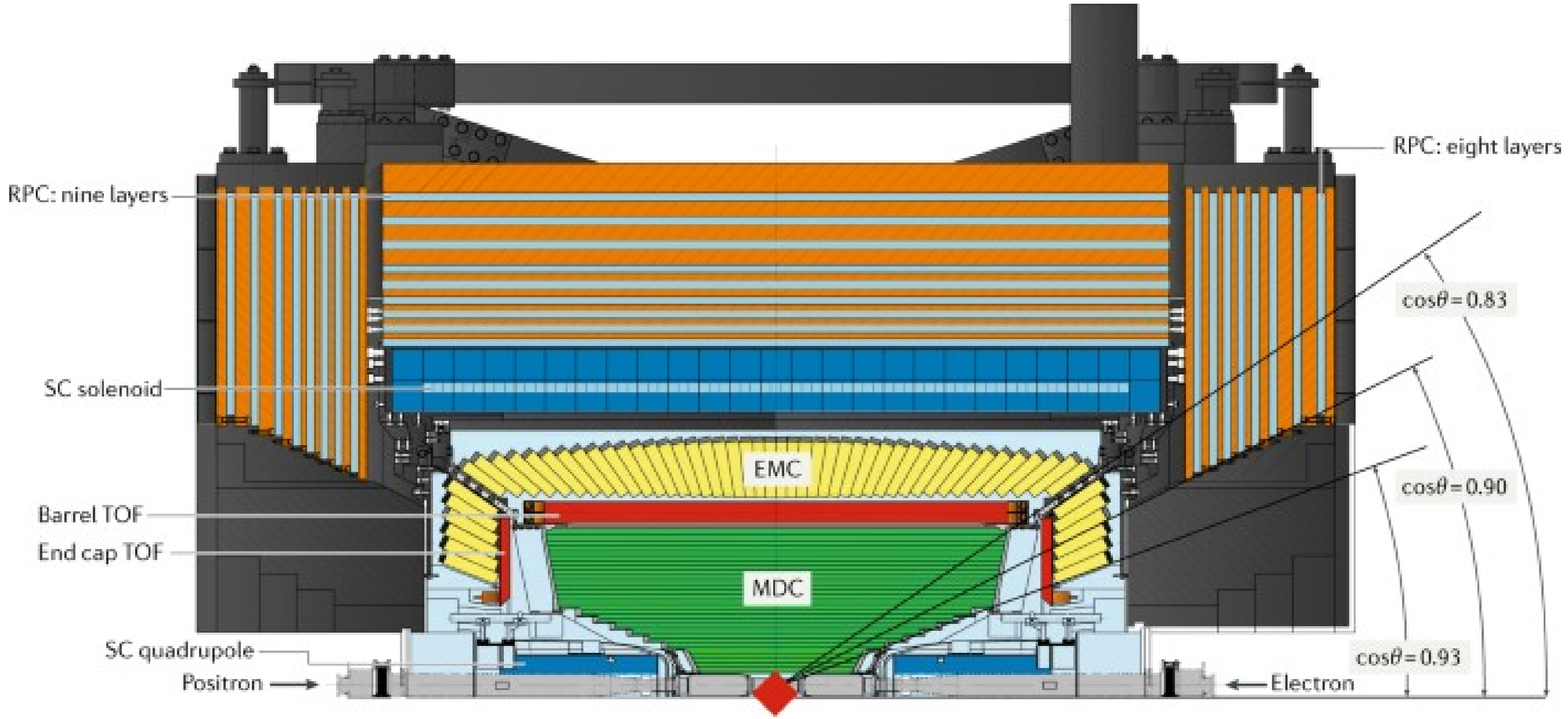


$e^+ e^-$ collider operating since 2009

E_{cm}: 1.95-4.95 GeV

L(@3770 GeV) = 1.1 x 10^{33} cm^{-2} s^{-1}

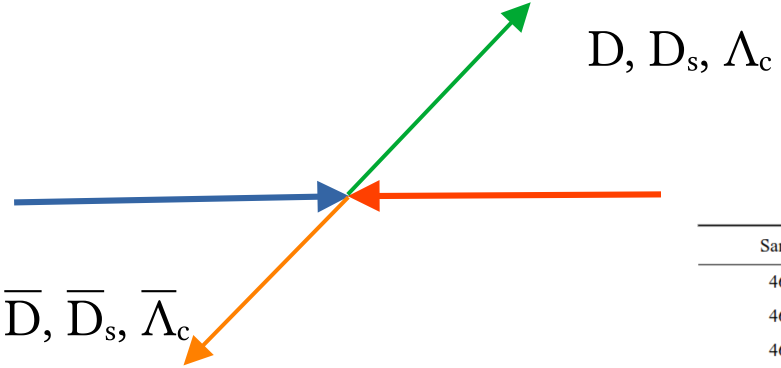
BESIII @ BEPCII



NIM A 614 (2010) 345-399

Studying charmed baryons at BESIII

Single or double-tag analyses:



Single tag: High efficiency, higher background

Double tag: excellent purity, lower efficiency

Unique samples of charmed baryons at thresholds!

$\Lambda_c\Lambda_c$ = 4.573 GeV
$\Lambda_c\Sigma_c$ = 4.739 GeV
$\Lambda_c\Lambda_c{}^*$= 4.878 GeV
$\Sigma_c\Sigma_c$ = 4.906 GeV
$\Xi_c\Xi_c$ = 4.934 GeV

Data samples

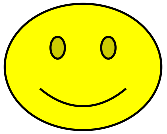
Sample	E_{cms}/MeV	$\mathscr{L}_{Bhabha}/pb^{-1}$	$\mathscr{L}_{di-photon}/pb^{-1}$	Ratio (%)
4610	4611.86±0.12±0.30	103.65±0.05±0.55	103.37±0.13	99.73±0.59
4620	4628.00±0.06±0.32	521.53±0.11±2.76	520.17±0.28	99.74±0.55
4640	4640.91±0.06±0.38	551.65±0.12±2.92	550.67±0.29	99.82±0.55
4660	4661.24±0.06±0.29	529.43±0.12±2.81	527.53±0.29	99.64±0.55
4680	4681.92±0.08±0.29	1667.39±0.21±8.84	1665.88±0.51	99.91±0.54
4700	4698.82±0.10±0.36	535.54±0.12±2.84	533.66±0.29	99.64±0.55
4740	4739.70±0.20±0.30	163.87±0.07±0.87	165.08±0.16	100.74±0.58
4750	4750.05±0.12±0.29	366.55±0.10±1.94	367.57±0.24	100.28±0.56
4780	4780.54±0.12±0.30	511.47±0.12±2.71	512.03±0.29	100.11±0.55
4840	4843.07±0.20±0.31	525.16±0.12±2.78	526.01±0.30	100.16±0.55
4920	4918.02±0.34±0.34	207.82±0.08±1.10	208.09±0.19	100.13±0.57
4950	4950.93±0.36±0.38	159.28±0.07±0.84	159.85±0.17	100.36±0.58

Chin. Phys. C 46, 113003 (2022)

Today's results

- Absolute BR of Λ_c hadronic decays – arXiv: 2601.01503 – accepted by JHEP
- Cross section of $\Sigma_c\Sigma_c$ and $\Sigma_c\Lambda_c$ – PRD 112 (2025) 9, 092017
- Cross section of $\Lambda_c\Lambda_c(2XXX)$ – PRD 109 (2024) 7, L071104
- $\Lambda_c(2xxx) \to \Lambda_c\pi\pi$ – PRD 109 (2024) 11, 112007

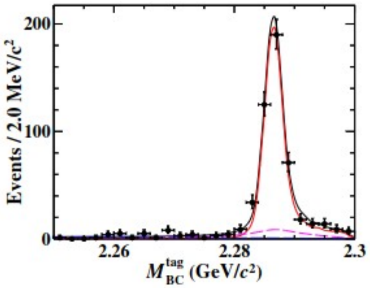
A huge list of Λ_c papers available at request

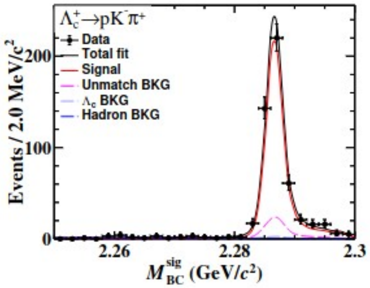


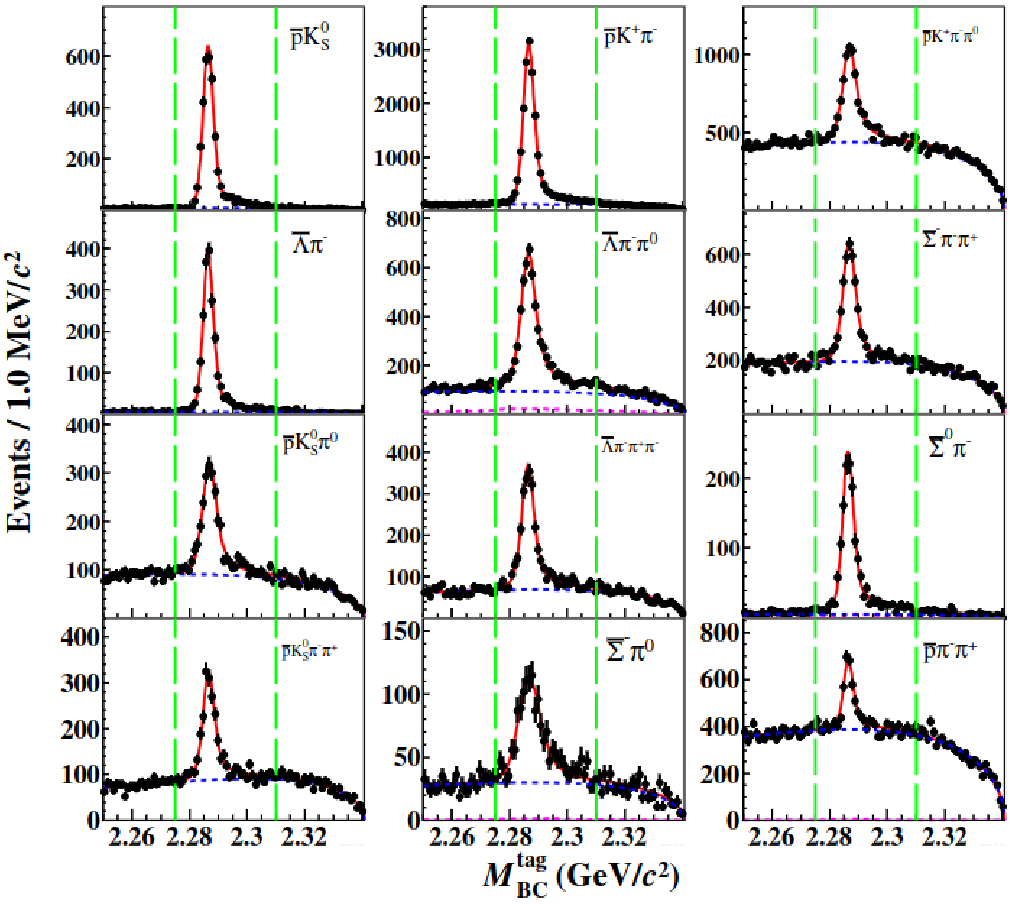
BR of hadronic Λ_c decays

arXiv: 2601.01503

- Improve precision of Λ_c crucial to pin down charmed baryons
- 7 Data sample from 4.6 to 4.698 GeV
- Study of 12 hadronic final states
  - First ST studies
  - Then DT measurements







arXiv: 2601.01503

BR of hadronic Λ_c decays

Global fit to extract branching ratios and yields for energy

Signal mode	Global fit	PDG
pK_S^0	$1.70 \pm 0.03 \pm 0.05$	1.59 ± 0.07
$pK^-\pi^+$	$6.61 \pm 0.11 \pm 0.12$	6.24 ± 0.28
$pK_S^0\pi^0$	$2.19 \pm 0.06 \pm 0.05$	1.96 ± 0.12
$pK_S^0\pi^+\pi^-$	$1.88 \pm 0.04 \pm 0.07$	1.59 ± 0.11
$pK^-\pi^+\pi^0$	$4.89 \pm 0.10 \pm 0.11$	4.43 ± 0.28
$\Lambda\pi^+$	$1.32 \pm 0.03 \pm 0.03$	1.29 ± 0.05
$\Lambda\pi^+\pi^0$	$6.67 \pm 0.13 \pm 0.10$	7.02 ± 0.35
$\Lambda\pi^+\pi^-\pi^+$	$4.09 \pm 0.09 \pm 0.10$	3.61 ± 0.26
$\Sigma^0\pi^+$	$1.45 \pm 0.03 \pm 0.03$	1.27 ± 0.06
$\Sigma^+\pi^0$	$1.37 \pm 0.04 \pm 0.03$	1.24 ± 0.09
$\Sigma^+\pi^+\pi^-$	$4.58 \pm 0.10 \pm 0.10$	4.47 ± 0.22
$p\pi^+\pi^-$	$0.50 \pm 0.02 \pm 0.01$	0.46 ± 0.03

$\sqrt{s}$(MeV)	$N_{\Lambda_c^+\bar{\Lambda}_c^-}(\times 10^3)$	σ(pb)	$\lvert G_{\rm eff}\rvert(\times 10^{-2})$
4599.53	$98.0 \pm 1.8 \pm 0.5$	$213.1 \pm 3.9 \pm 1.9$	$53.8 \pm 0.5 \pm 0.2$
4611.86	$17.7 \pm 0.5 \pm 0.1$	$211.5 \pm 6.0 \pm 2.0$	$49.5 \pm 0.7 \pm 0.2$
4628.00	$89.8 \pm 1.6 \pm 0.4$	$207.6 \pm 3.7 \pm 1.8$	$45.6 \pm 0.4 \pm 0.2$
4640.91	$96.1 \pm 1.9 \pm 0.5$	$206.5 \pm 4.1 \pm 1.9$	$43.5 \pm 0.4 \pm 0.2$
4661.24	$94.3 \pm 1.8 \pm 0.5$	$206.2 \pm 3.9 \pm 2.0$	$41.2 \pm 0.4 \pm 0.2$
4681.92	$284.3 \pm 4.9 \pm 1.3$	$192.0 \pm 3.3 \pm 1.8$	$38.1 \pm 0.4 \pm 0.2$
4698.82	$84.2 \pm 1.7 \pm 0.4$	$172.0 \pm 3.5 \pm 2.2$	$35.0 \pm 0.4 \pm 0.2$

$$|G_{\rm eff}| = \sqrt{\frac{\sigma}{\frac{\sigma_0}{3}(1+\frac{\kappa}{2})}},$$

Factor 2 or 3 better than previous measurements

PRD 112 (2025) 9, 092017

$e^+e^- \to \Sigma_c\Sigma_c$ and $e^+e^- \to \Sigma_c\Lambda_c$

Search for $e^+e^- \to \Sigma_c\Sigma_c$ (and excited states) crucial to understand the hadronization from e+e- → ccbar.

Isospin violating $e^+e^- \to \Sigma_c\Lambda_c$ can also provide information to diquark (ud) attachment

Dataset

$\sqrt{s}$ (MeV)	Luminosity (pb^{-1})
$4750.05 \pm 0.12 \pm 0.29$	$366.55 \pm 0.10 \pm 1.95$
$4780.54 \pm 0.12 \pm 0.30$	$511.47 \pm 0.12 \pm 2.72$
$4843.07 \pm 0.30 \pm 0.32$	$525.16 \pm 0.12 \pm 2.79$
$4918.02 \pm 0.34 \pm 0.34$	$207.82 \pm 0.08 \pm 1.10$
$4950.93 \pm 0.36 \pm 0.38$	$159.28 \pm 0.07 \pm 0.85$

Λ_c tagged via four hadronic modes (pKπ, pKs, Λπ, $\Sigma^0\pi$)

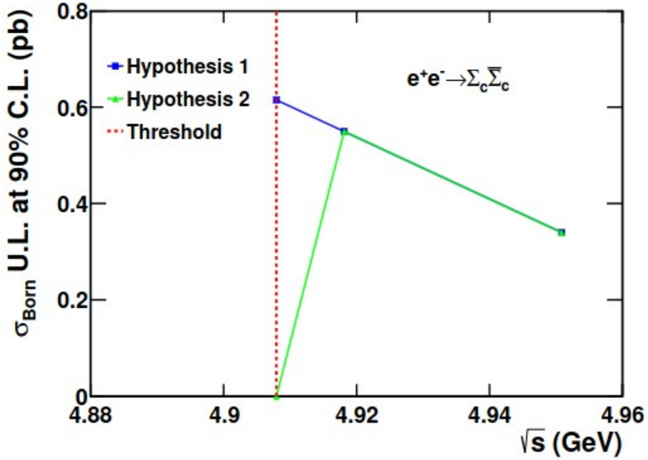
Σ_c reconstructed by adding to a Λ_c an additional pion

$\Sigma_c\Sigma_c$ cross section very complicated to be extracted due to Λ_c^* contributions.

Three dataset are extracted by the number of pions associated to Λ_c
Λ_c tag: 0 pions
$\Lambda_c\pi$ tag: 1 pion (any charge)
$\Lambda_c\pi\pi$ tag: 2 pions (any charge)

PRD 112 (2025) 9, 092017

$\Sigma_c\Sigma_c$ cross section



No signal found. Extracted upper limits with different lineshape hypotheses

At least 2 order of magnitude suppressed with respect to $e^+e^- \to \Lambda_c\Lambda_c$

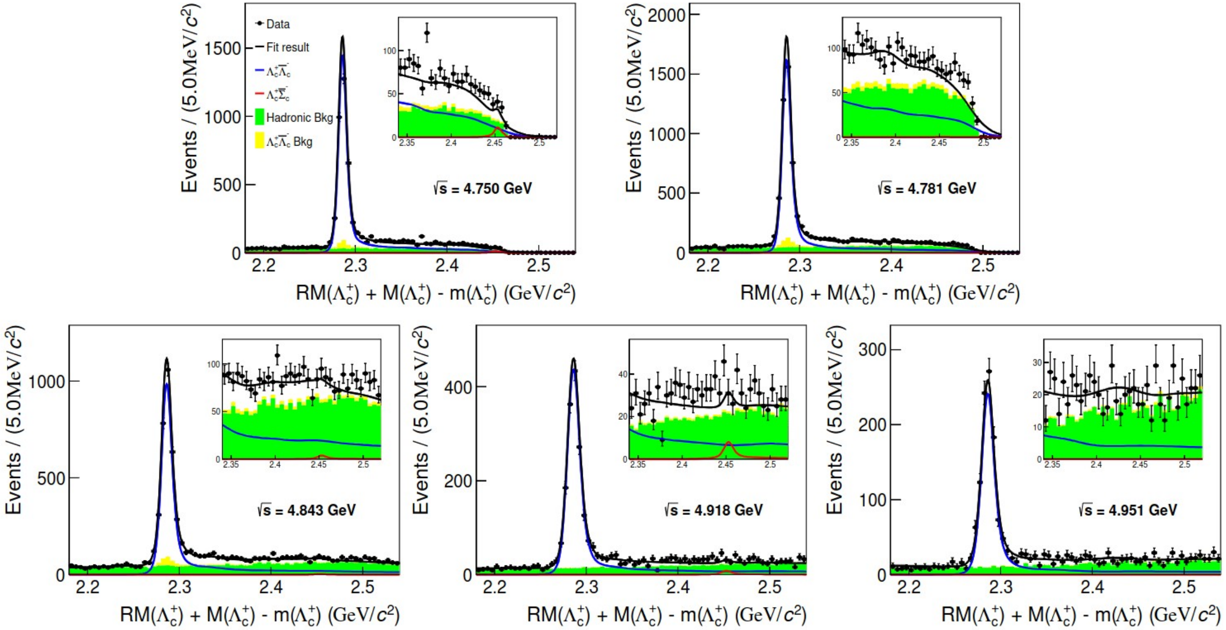
$\sqrt{s}$	f	baseline	Hypothesis 1	Hypothesis 2
4.918 GeV	f_{VP}	1.06	1.06	1.06
	f_{ISR}	0.96	0.68	0.58
	σ_{Born}	< 0.55 pb	< 0.61 pb	< 0.83 pb
4.951 GeV	f_{VP}	1.06	1.06	1.06
	f_{ISR}	0.96	0.81	0.79
	σ_{Born}	< 0.34 pb	< 0.39 pb	< 0.49 pb

Results aligns with Belle $e^+e^- \to \Lambda_c X$ (~141 pb) and $\Sigma_c X$ (~8 pb), where a similar suppression is observed. (Phys. Rev. D 97, 072005 (2018).)

However, measurement of $\Sigma_c X$ is ten times larger away from threshold. Reason to be investigated since not the same in light hadron case ($\Lambda\Lambda$ ~ 90 pb, $\Sigma\Sigma$ ~ 30 pb)

PRD 112 (2025) 9, 092017

$\Sigma_c \Lambda_c$ cross section



No signal observed at any energy

~1% magnitude wrt to $\Lambda_c\Lambda_c$ provides information about the magnitude of electromagnetic contribution in the production of charmed hadrons

$\sqrt{s}$	4.750 GeV	4.781 GeV	4.843 GeV	4.918 GeV	4.951 GeV
$R(\sigma)$ (%)	< 1.1	< 0.6	< 1.5	< 3.4	< 1.6
$\sigma_{\rm Born}(e^+e^- \to \Lambda_c^+\bar{\Lambda}_c^-)$ (pb)	$134 \pm 3 \pm 4$	$127 \pm 2 \pm 4$	$83 \pm 2 \pm 3$	$96 \pm 3 \pm 4$	$88 \pm 4 \pm 3$
$\sigma_{\rm Born}(e^+e^- \to \Lambda_c^+\bar{\Sigma}_c^-)$ (pb)	< 1.52	< 0.76	< 1.26	< 3.26	< 1.38

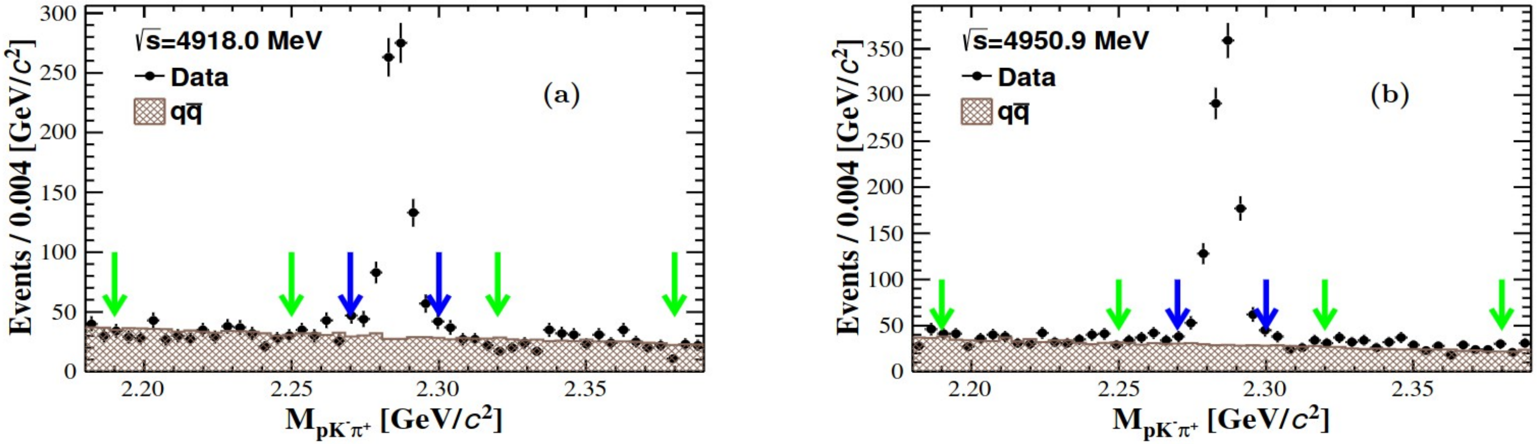
PRD 109 (2024) 7, L071104

$e^+ e^- \to \Lambda_c \Lambda_c(2xxx)$ cross section

No measurements of $\Lambda_c\Lambda_c(2595)$ and $\Lambda_c\Lambda_c(2625)$ cross section exists

BESIII can use the datasets above 4.9 GeV:
- ~208/pb @ 4918 MeV
- ~170/pb @ 4950 MeV

Analysis strategy:
- MC simulation of the prompt $\Lambda_c \to pK\pi$ and from the decay of the excited charmed baryon (via $\Lambda_c\pi\pi$)
- count all the events with $m_{pK\pi}$ > 2.5 GeV
- use sideband to account for background

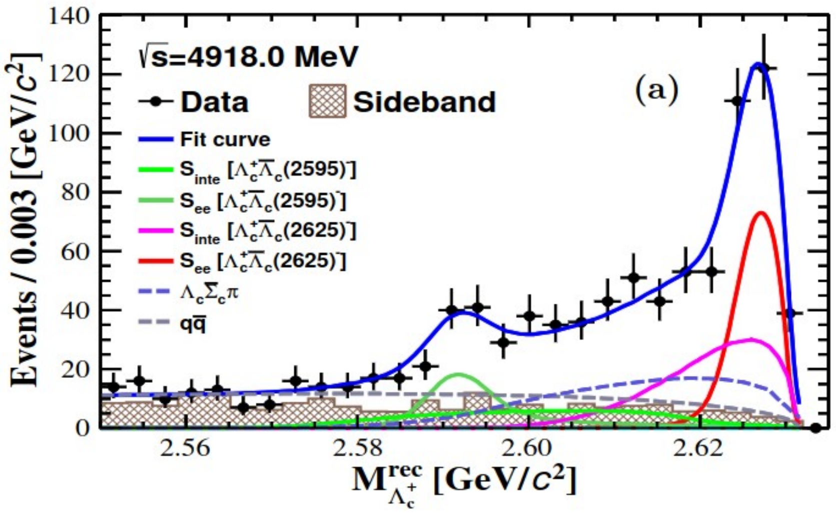


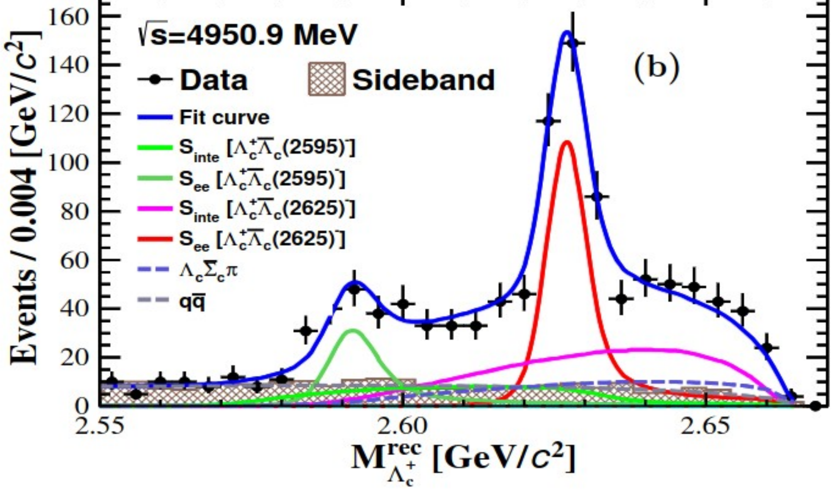
PRD 109 (2024) 7, L071104

$e^+ e^- \to \Lambda_c \Lambda_c(2xxx)$ cross section

Count the events in the Λ_c recoil mass:
S_{ee} are from prompt Λ_c
S_{inte} are Λ_c from excited baryon

$$N_{\rm obs} = N_{\rm sig}^{2595} + N_{\rm sig}^{2625} + N_{\rm bkg},$$

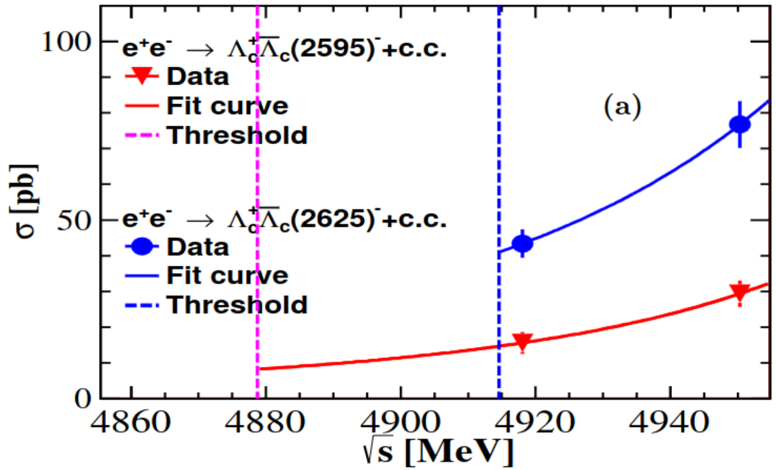




$$N_{\rm sig} = \sigma \mathcal{L} f_{\rm VP} f_{\rm ISR} \mathcal{B}(\varepsilon_{ee} + \varepsilon_{\rm inte}),$$

To extract born cross section, assuming no CP violation

$e^+ e^- \to \Lambda_c \Lambda_c(2xxx)$ cross section



$$\sigma(s) = \frac{C\beta}{s}\left(1 + \frac{2mm_*}{s}\right)\frac{c_0}{(s-c_1)^4[\pi^2 + \ln^2(\frac{s}{\Lambda^2_{\rm QCD}})]^2},$$

Lineshape used to estimate vacuum polarization and efficiency.

Non-zero cross section at threshold due to the Coulomb factor C

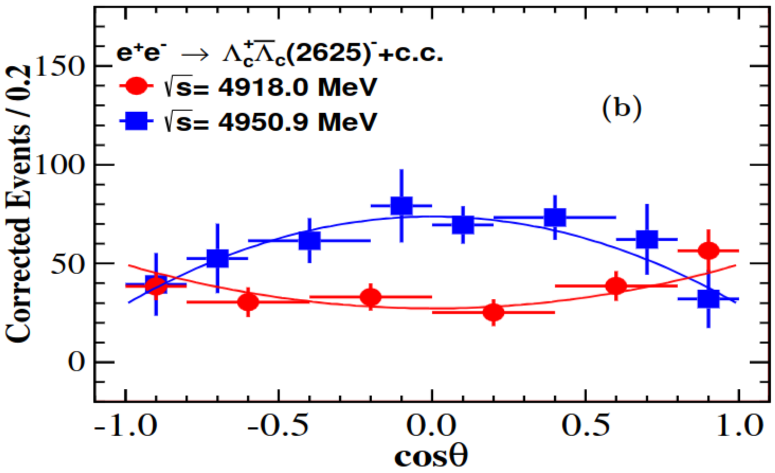
Signal process	$e^+e^- \to \Lambda_c^+\bar{\Lambda}_c(2595)^- + \text{c.c.}$		$e^+e^- \to \Lambda_c^+\bar{\Lambda}_c(2625)^- + \text{c.c.}$	
$\sqrt{s}$ (MeV)	4918.0	4950.9	4918.0	4950.9
$N_{\rm sig}$	148 ± 29	216 ± 27	311 ± 28	552 ± 47
σ (pb)	$15.6 \pm 3.1 \pm 0.9$	$29.4 \pm 3.7 \pm 2.4$	$43.4 \pm 4.0 \pm 4.1$	$76.8 \pm 6.5 \pm 4.2$

First ever measurement of these processes

Similar to Λ_b semileptonic decay!

$\Lambda_c(2625)$ form factor

For $\Lambda_c(2625)$, owing to larger statistics, it is possible to extract the $\alpha_{\Lambda c}$ parameter from angular distributions



This is also connected to ratio of form factors via

$$\frac{|G_E|^2 + 3|G_M|^2}{|G_C|^2} = \tau \cdot \frac{1+\alpha_{\Lambda_c}}{1-\alpha_{\Lambda_c}}$$

Sign flip very close to the pair production energy?

Signal process	$e^+e^- \to \Lambda_c^+\bar{\Lambda}_c(2595)^- +$ c.c.		$e^+e^- \to \Lambda_c^+\bar{\Lambda}_c(2625)^-$+c.c.	
$\sqrt{s}$ (MeV)	4918.0	4950.9	4918.0	4950.9
α_{Λ_c}	-	-	$0.82 \pm 0.56 \pm 0.02$	$-0.60 \pm 0.20 \pm 0.01$
$\sqrt{\|G_E\|^2 + 3\|G_M\|^2}/\|G_C\|$	-	-	$5.95 \pm 4.07 \pm 0.15$	$0.94 \pm 0.32 \pm 0.02$

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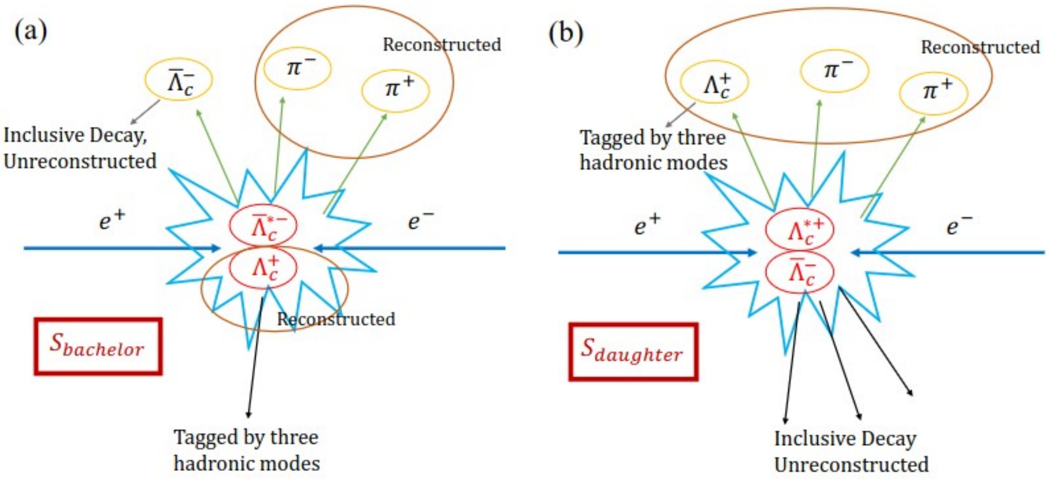
Absolute BR of $\Lambda_c(2625) \to \Lambda_c\pi\pi$

Studying dominant hadronic decays of excited charmed hadrons are crucial to understand their nature and provide experimental information to phenomenological models

Use $e^+e^- \to \Lambda_c\Lambda_c(2xxx)$ process, one Λ_c is tagged through 3 hadronic modes ($pK\pi$, pK_s, $\Lambda\pi^+$)

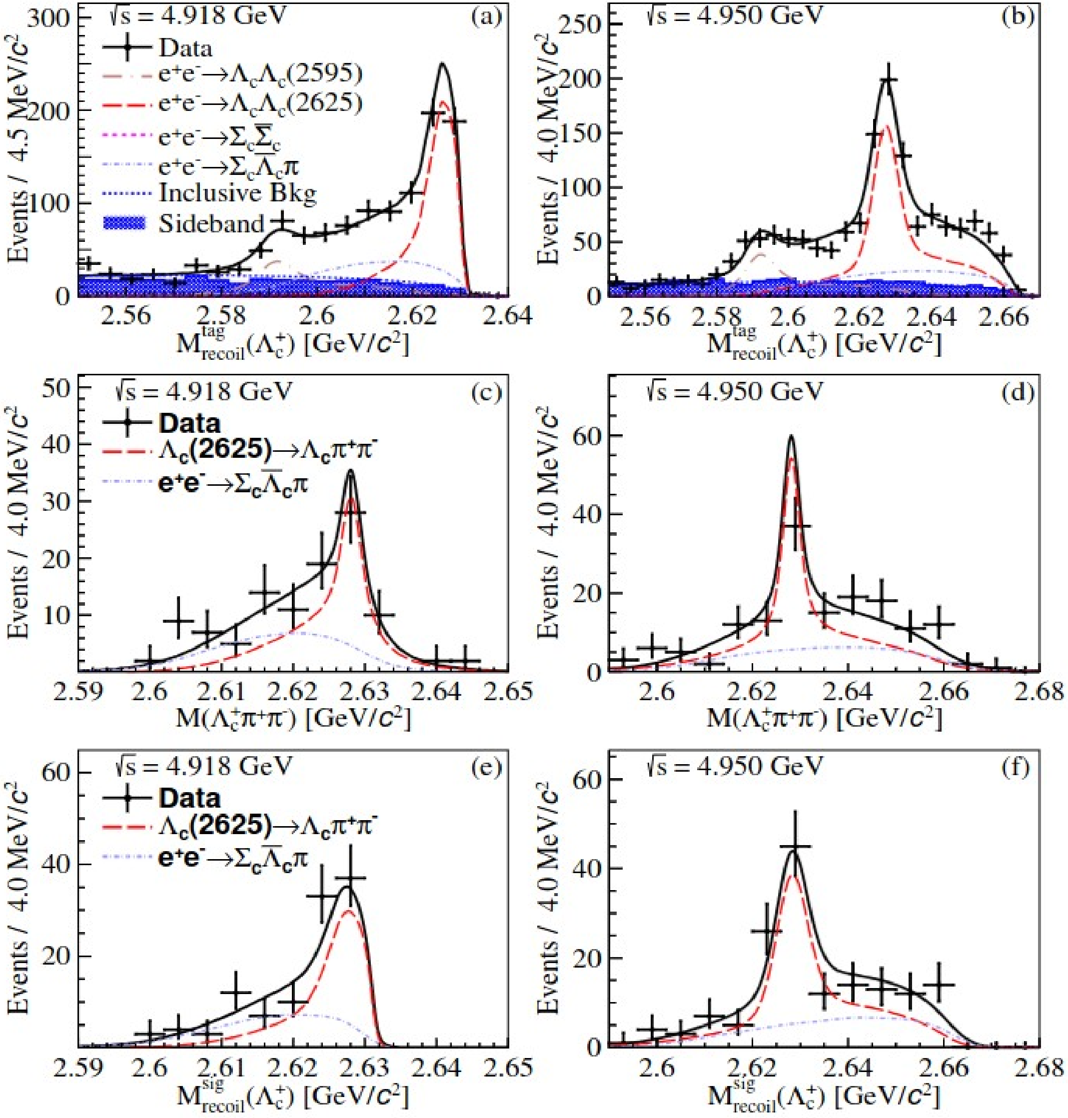


Partial reconstruction method:
Only Λ_c, π^-, π^+ are reconstructed

Best candidate is selected using

$$\Delta M = \sqrt{\left[2E_{\rm beam} - \left(\sum_i E_i\right)\right]^2 - \left(\sum_i \vec{p}_i\right)^2} - m_{\Lambda_c}^{\rm PDG},$$

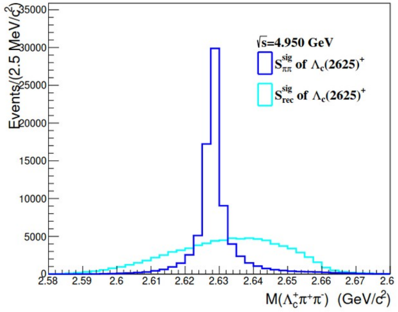
Absolute BR of $\Lambda_c(2625) \rightarrow \Lambda_c\pi\pi$

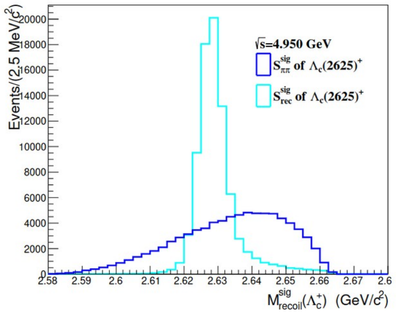


Tag mass to identify the Λ_c

We expect then two contributions:
- if Λ_c is prompt, a narrow Λ_c^* signal appears
- il Λ_c is from Λ_c^*, a wider Λ_c^* signal appears

We combine the shapes to extract the number of events





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Absolute BR of $\Lambda_c(2625) \to \Lambda_c\pi\pi$

Λ_c^+ decays		$pK^-\pi^+$	pK_S^0	$\Lambda\pi^+$
$\bar{\Lambda}_c^-\Lambda_c(2625)^+$	$\epsilon_{\rm tag}$ / %	46.6 (47.4)	50.0 (49.6)	38.3 (37.6)
	$\epsilon_{\rm sig}$ / %	14.6 (15.0)	16.1 (16.2)	12.0 (11.9)
	$N_{\rm tag}$		418.7 ± 34.4 (670.9 ± 55.6)	
	$N_{\rm sig}$		66.8 ± 6.6 (107.8 ± 10.6)	
	$\mathcal{B}$ / %		$50.7 \pm 5.0 \pm 4.9$	
$\bar{\Lambda}_c^-\Lambda_c(2595)^+$	$\epsilon_{\rm tag}$ / %	48.5 (48.8)	49.9 (49.0)	38.5 (37.8)
	$\epsilon_{\rm sig}$ / %	2.0 (2.5)	2.2 (2.7)	1.6 (2.1)
	$N_{\rm tag}$		135.2 ± 29.0 (210.3 ± 28.3)	
	$N_{\rm sig}$		< 4.2 (9.0)	
	$\mathcal{B}$ / %		< 80.8	

11.9σ significance for $\Lambda_c(2625) \to \Lambda_c\pi\pi$

No signal of $\Lambda_c(2595)$

BR lower than expected from theoretical prediction of isospin symmetry in the decay

Threshold effect in the decay of $\Lambda_c(2625)$ as in the decay of $\Lambda_c(2595)$?

This is the first absolute measurement of the process and can provide crucial element to HHChPT models and guide the discovery of other decays

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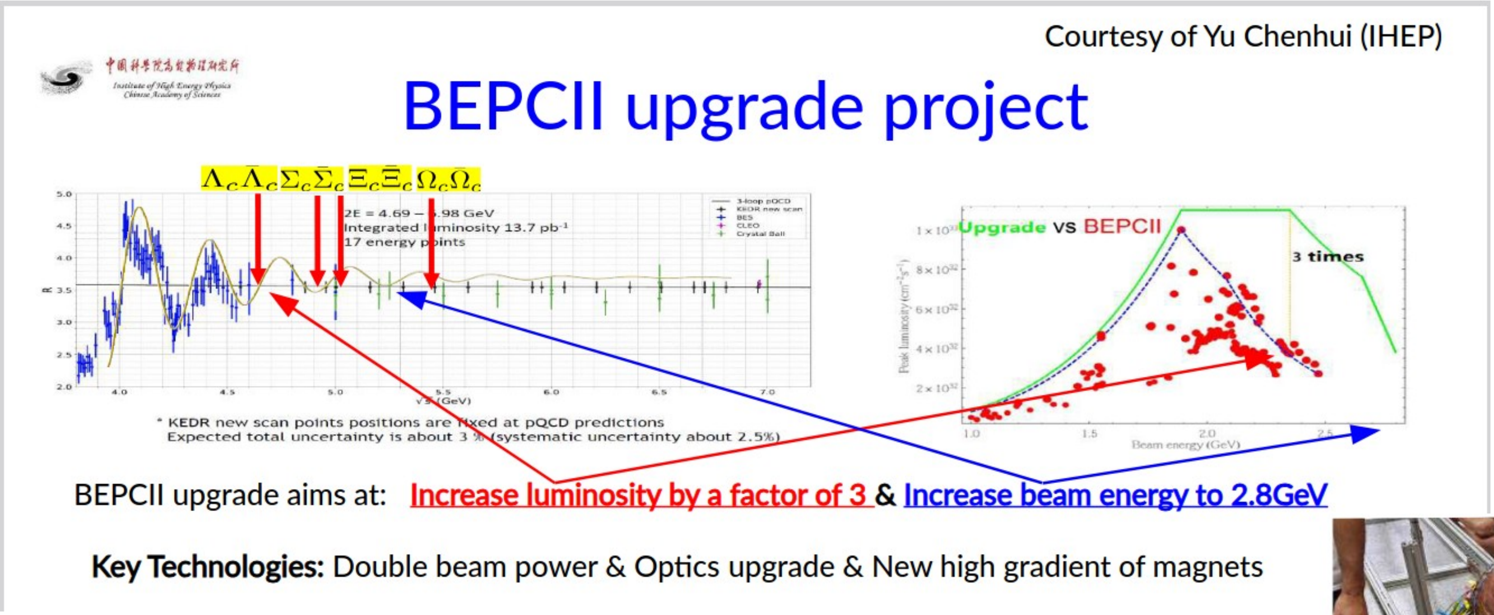
BESIII and BEPCII upgrades



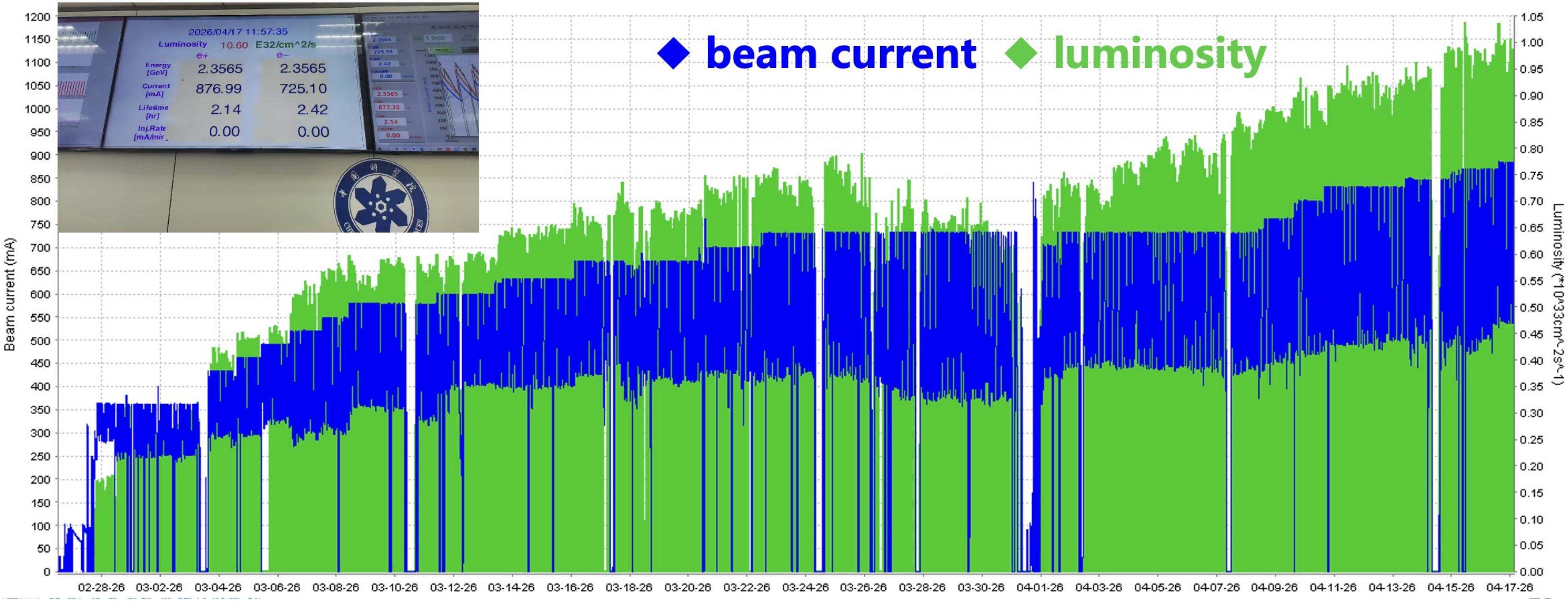
Upgrade started in 2024 and completed early 2025

Upgrade of machine (luminosity and center of mass energy)

Upgrade of the inner tracker: the new CGEM-IT

BESIII and BEPCII upgrades

The peak collision luminosity for online operation at a beam energy of 2.35 GeV has reached the designed $1.06\times10^{33}\ cm^{-2}s^{-1}$ (before the upgrade it is **$3.5\times 10^{32}cm^{-2}s^{-1}$**)



Summary and outlook

- (Excited) Charmed baryon are one of the cornerstones for the study of Lb
  - And are exciting by themselves!

- BESIII offers an unique look to study charmed baryons close to threshold
  - Cross section and absolute branching ratio are achievable!
  - Lower production cross sections but clean environment

- In 2024, BESIII upgraded the machine and the detector to expand its reach
  - Reached 1.1×10^{33} $cm^{-2}s^{-1}$ at 4.7 GeV, useful for charmed baryon
  - New inner tracker for better study of low momentum particles
  - New upgrade of center of energy scheduled in 2028

THANKS!

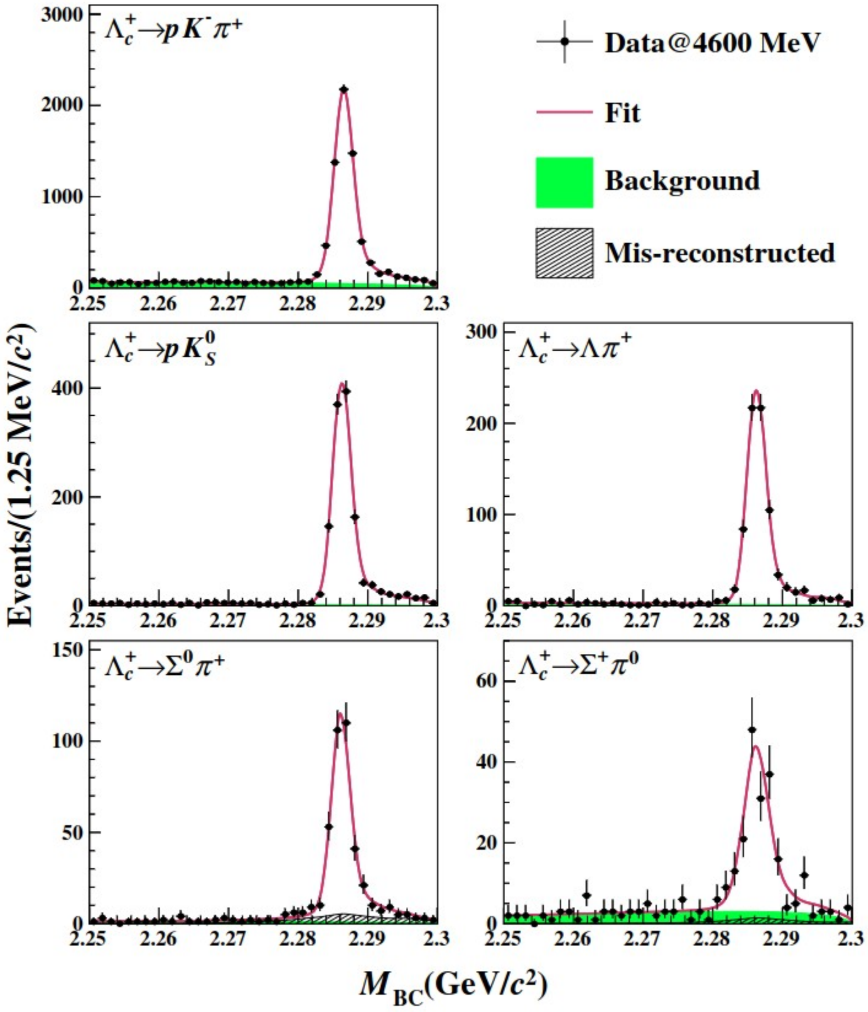
DANKE!

谢谢！

Additional material

ArXiv: 2508.11400

Λ_c polarization

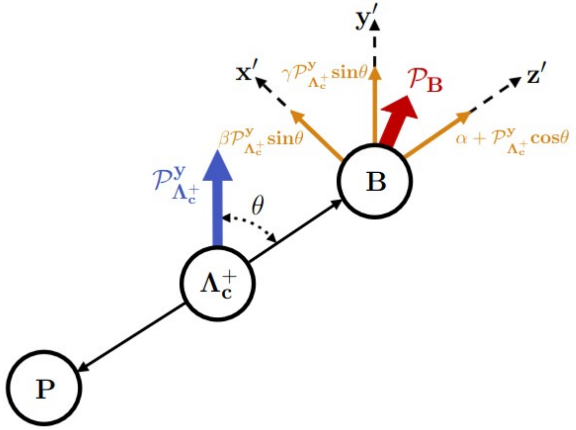


Complete extraction of many parameters from $e^+e^- \to \Lambda_c \Lambda_c$

4 two-body final states ($\Lambda\pi^+$, pK_s, $\Sigma^0\pi^+$, $\Sigma^+\pi^0$) and the golden channel $\Lambda_c \to pK\pi$ used

Using all dataset from 4.6 to 4.95 GeV, ~6.4/fb

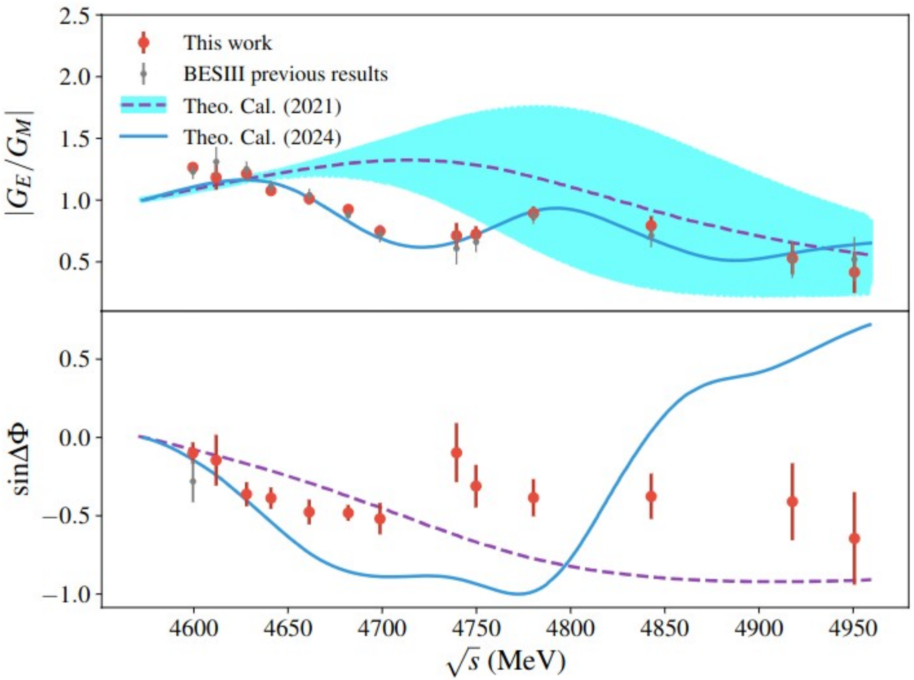
To extract polarization, full fit to helicity distribution



ArXiv: 2508.11400

Λ_c polarization

Extraction of cross section, |GE/GM| ratio and their relative phase

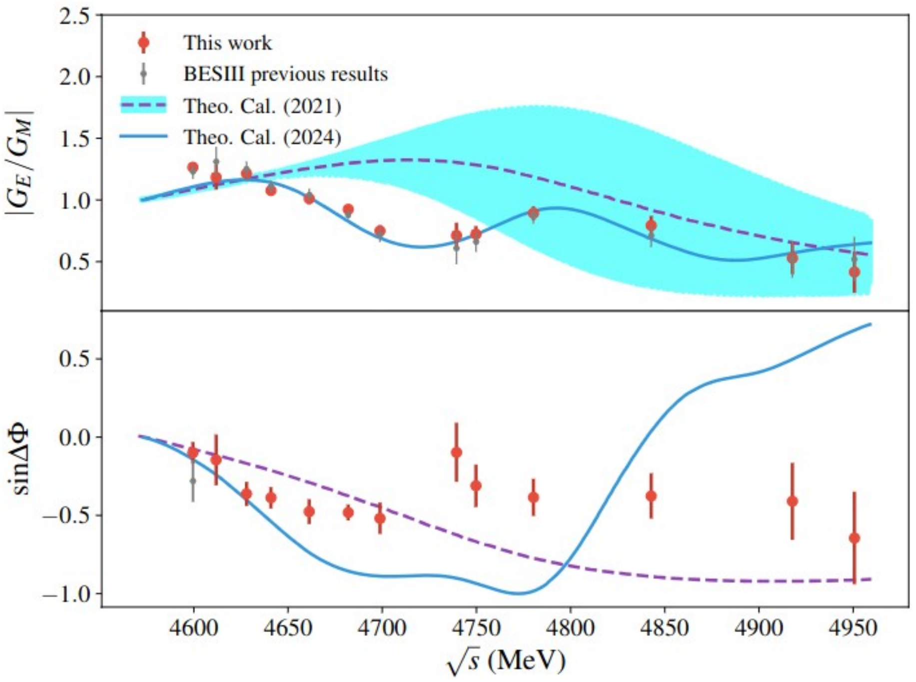


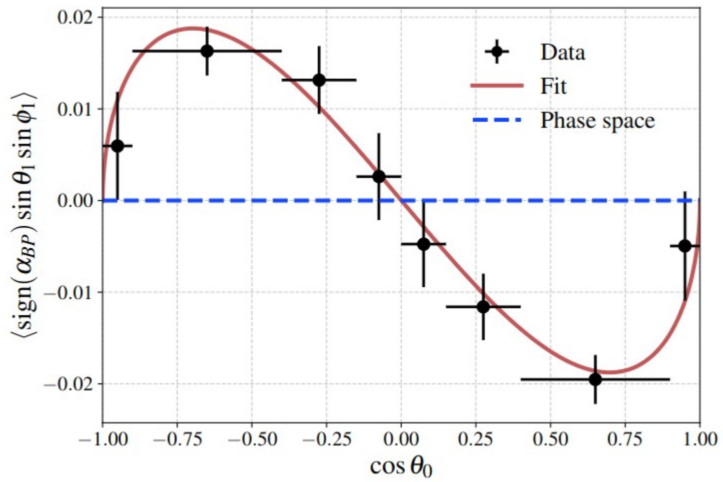
While theoretical models descibe well the ratio, still large discrepancies on the phase

ArXiv: 2508.11400

Λ_c polarization

Extraction of cross section, |GE/GM| ratio and their relative phase





Non-zero relative phase implies a net polarization, that shows dependence as a function of the Λ_c emission angle

While theoretical models descibe well the ratio, still large discrepancies on the phase

ArXiv: 2508.11400

Λ_c polarization

TABLE III. Results for α_0, $\Delta\Phi$, and transverse polarization of Λ_c^+ at 13 energy points, where the first uncertainties are statistical and the second are systematic. In the table, SL means the significance level of non-zero $\Delta\Phi$, σ represents the standard deviation, and $\mathcal{P}^{y,max}_{\Lambda_c^+}$ is the largest transverse polarization.

$\sqrt{s}$ [MeV]	α_0 in previous work [17, 82]	α_0 in this work	$\Delta\Phi$ [rad]	SL	$\mathcal{P}^{y,max}_{\Lambda_c^+}$
4600	$-0.20 \pm 0.04 \pm 0.02$	$-0.226 \pm 0.030 \pm 0.004$	$-0.100 \pm 0.069 \pm 0.009$	$2.2\ \sigma$	$-0.026 \pm 0.018 \pm 0.002$
4612	$-0.26 \pm 0.09 \pm 0.01$	$-0.160 \pm 0.083 \pm 0.004$	$-0.146 \pm 0.162 \pm 0.030$	$1.1\ \sigma$	$-0.038 \pm 0.042 \pm 0.008$
4628	$-0.21 \pm 0.04 \pm 0.01$	$-0.181 \pm 0.038 \pm 0.001$	$-0.371 \pm 0.082 \pm 0.012$	$6.8\ \sigma$	$-0.095 \pm 0.020 \pm 0.003$
4641	$-0.09 \pm 0.05 \pm 0.01$	$-0.060 \pm 0.039 \pm 0.003$	$-0.398 \pm 0.073 \pm 0.015$	$7.6\ \sigma$	$-0.099 \pm 0.017 \pm 0.004$
4661	$-0.02 \pm 0.05 \pm 0.01$	$0.008 \pm 0.044 \pm 0.003$	$-0.496 \pm 0.088 \pm 0.021$	$8.5\ \sigma$	$-0.119 \pm 0.019 \pm 0.005$
4682	$0.15 \pm 0.03 \pm 0.01$	$0.102 \pm 0.029 \pm 0.003$	$-0.502 \pm 0.054 \pm 0.021$	$14.1\ \sigma$	$-0.116 \pm 0.011 \pm 0.005$
4699	$0.34 \pm 0.07 \pm 0.01$	$0.305 \pm 0.055 \pm 0.010$	$-0.545 \pm 0.114 \pm 0.028$	$7.1\ \sigma$	$-0.112 \pm 0.021 \pm 0.007$
4740	$0.49 \pm 0.16 \pm 0.03$	$0.358 \pm 0.126 \pm 0.008$	$-0.097 \pm 0.190 \pm 0.016$	$0.4\ \sigma$	$-0.020 \pm 0.039 \pm 0.004$
4750	$0.42 \pm 0.10 \pm 0.01$	$0.347 \pm 0.079 \pm 0.004$	$-0.316 \pm 0.142 \pm 0.019$	$3.1\ \sigma$	$-0.065 \pm 0.029 \pm 0.005$
4781	$0.17 \pm 0.07 \pm 0.01$	$0.157 \pm 0.062 \pm 0.007$	$-0.395 \pm 0.126 \pm 0.028$	$5.1\ \sigma$	$-0.090 \pm 0.027 \pm 0.007$
4843	$0.38 \pm 0.10 \pm 0.01$	$0.282 \pm 0.089 \pm 0.019$	$-0.385 \pm 0.153 \pm 0.034$	$3.6\ \sigma$	$-0.082 \pm 0.031 \pm 0.008$
4918	$0.62 \pm 0.17 \pm 0.01$	$0.612 \pm 0.150 \pm 0.019$	$-0.423 \pm 0.272 \pm 0.024$	$1.9\ \sigma$	$-0.067 \pm 0.043 \pm 0.013$
4951	$0.63 \pm 0.21 \pm 0.01$	$0.744 \pm 0.179 \pm 0.007$	$-0.700 \pm 0.392 \pm 0.058$	$1.8\ \sigma$	$-0.086 \pm 0.050 \pm 0.030$

ArXiv: 2508.11400

Λ_c polarization

Comparison of angular distribution from theoretical calculation and experimental data