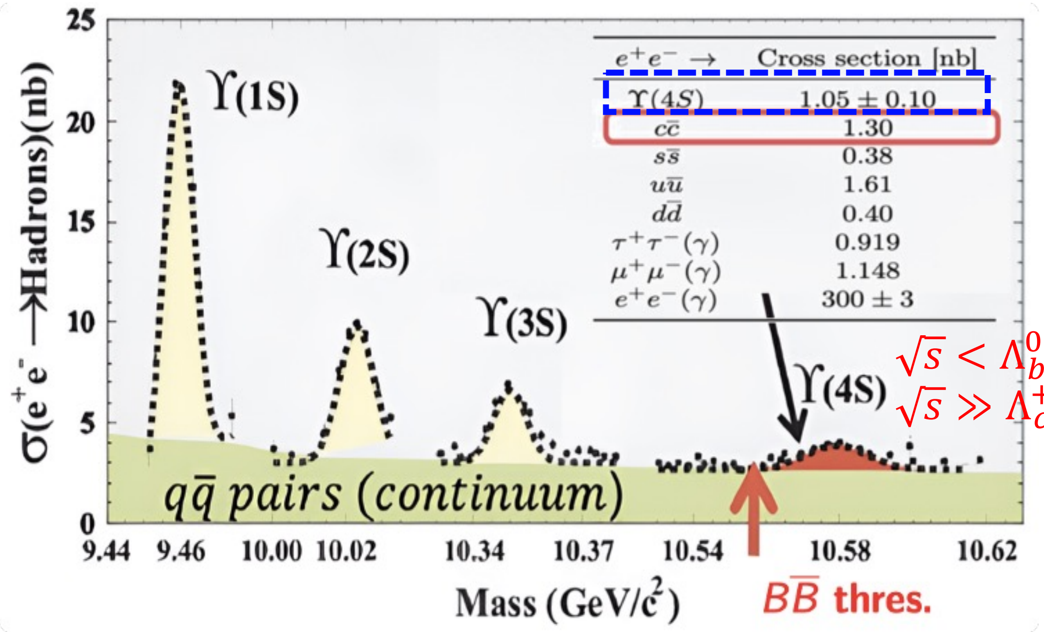
Belle II实验粲物理近期成果介绍

李龙科
lilongke@hunnu.edu.cn
湖南师范大学

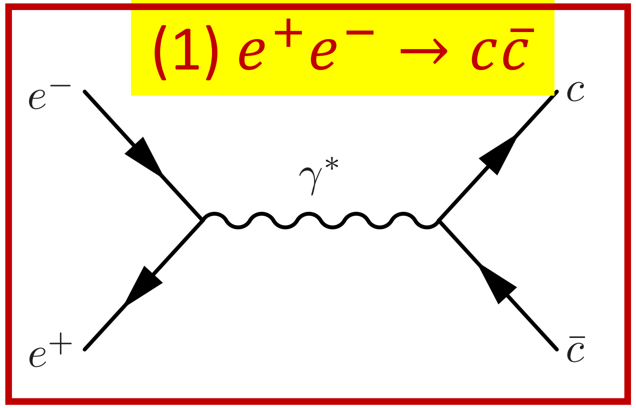
中国物理学会高能物理分会第十二届全国会员代表大会暨学术年会
2026年7月17日 @广州

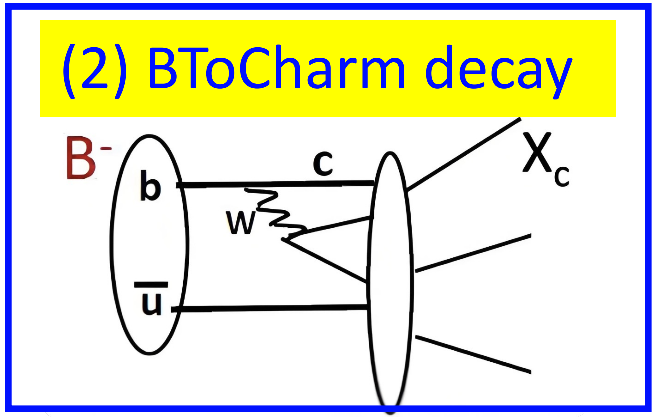
粲样本的产生

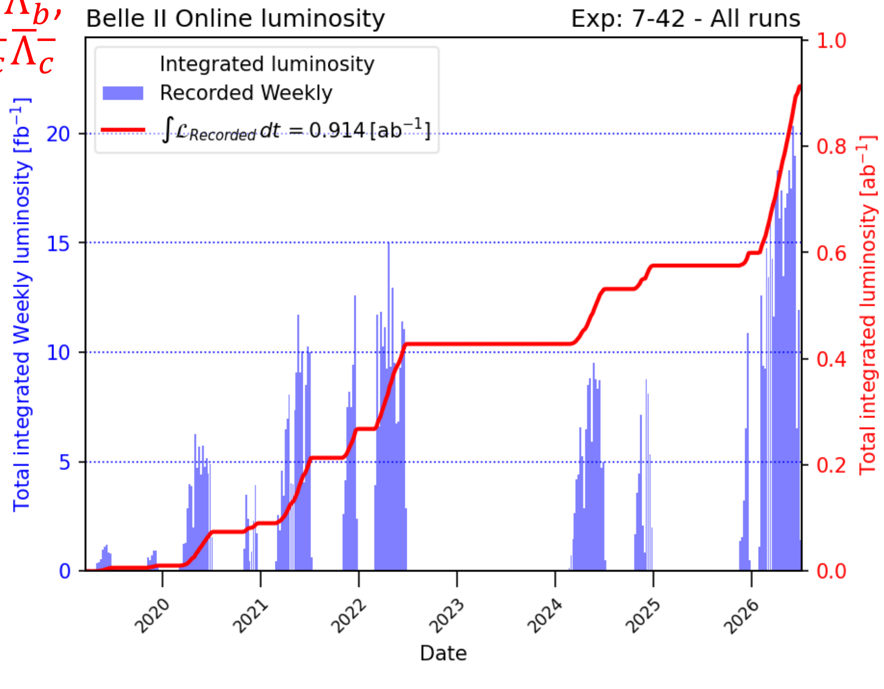
- SuperKEKB: 超级B/陶/粲工厂



$\sqrt{s} < \Lambda_b^0\bar{\Lambda}_b^0$;
$\sqrt{s} \gg \Lambda_c^+\bar{\Lambda}_c^-$







今年亮度快速上升，

单日采集数据翻番！

已积累粲样本量级：

$N(D^0) \sim O(10^9)$

$N(\Lambda_c^\pm) \sim O(10^8)$

- Belle II探测器的性能优势：

- 4π立体角：高接受度
- 顶点和径迹：高空间分辨率；高粒子鉴别能力
- 中性粒子和长寿命粒子：高重建效率

Belle-II实验粲物理成果

~20% of all physics publications

- Charm lifetimes:
  - $\tau(D^{0,+})$, PRL 127, 211801 (2021)
  - $\tau(\Lambda_c^+)$, PRL 130, 071802 (2023)
  - $\tau(\Omega_c^0)$, PRD 107, L031103 (2023)
  - $\tau(D_s^+)$, PRL 131, 171803 (2023)

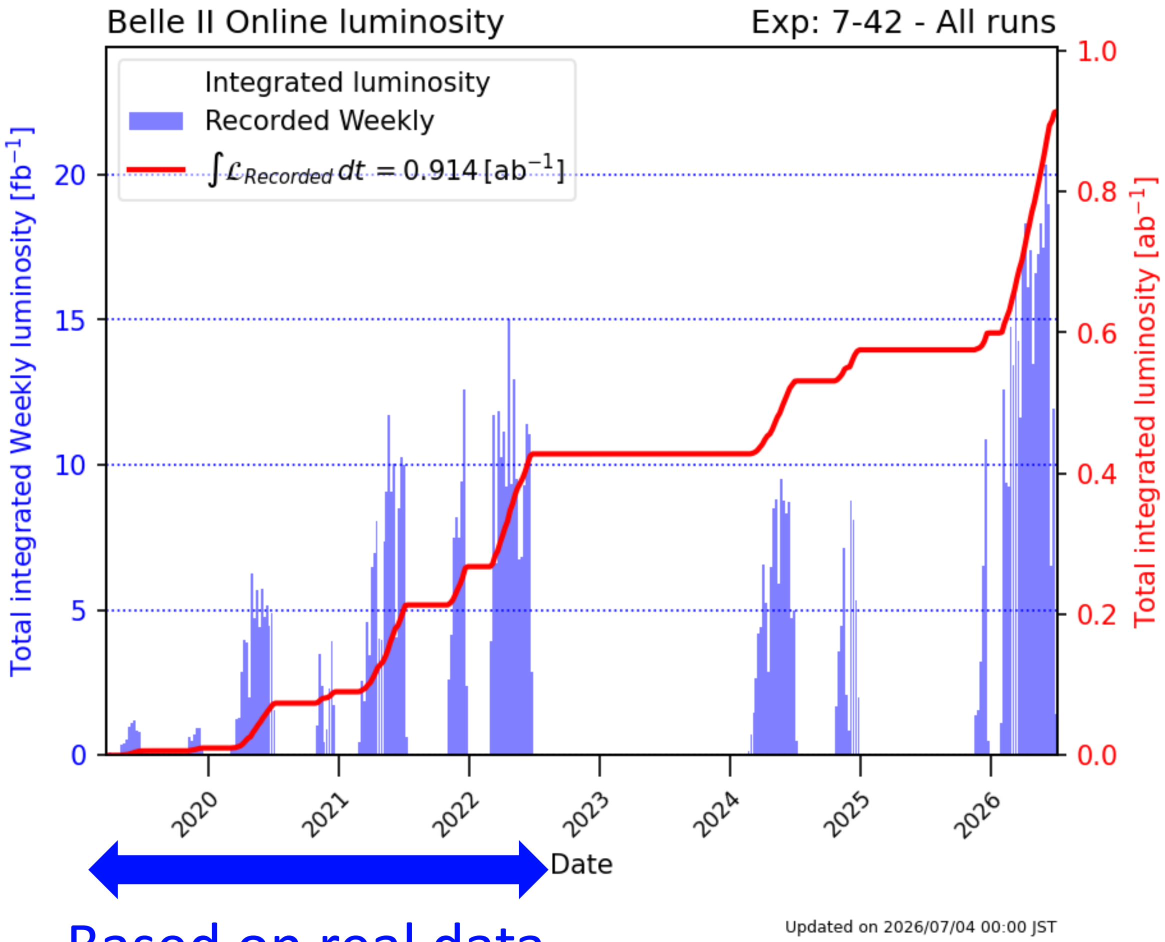
- Charmed baryon:
  - $\Xi_c^0 \to \Xi^0(\pi^0, \eta, \eta')$, JHEP 10 (2024) 045
  - $\Lambda_c^+ \to pK_S^0\pi^0$ (B1), PRD 112, 012013 (2025)
  - $\Xi_c^+ \to pK_S^0, \Lambda\pi^+, \Sigma^0\pi^+$, JHEP 03 (2025) 061
  - $\Xi_c^+ \to \Sigma^+K_S^0, \Xi^0\pi^+, \Xi^0K^+$, JHEP 08 (2025) 195
  - $\Xi_c^0 \to \Lambda(\pi^0, \eta, \eta')$, PRD 113, 032015 (2026)

- Charm CPV:
  - $D_{(s)}^+ \to K_S^0K^-\pi^+\pi^+$, JHEP 04 (2025) 036
  - $D^0 \to K_S^0K_S^0$ (D^{*+}), PRD 111, 012015 (2025)
  - $D^0 \to \pi^0\pi^0$, PRD 112, 012006 (2025)
  - $D^0 \to K_S^0K_S^0$ (CFT), PRD 112, 012017 (2025)
  - $D^+ \to \pi^+\pi^0$, PRD 112, L031101 (2025)
  - $D^0 \to \pi^+\pi^-\pi^0$, PRD 113, 052006 (2026)
  - $\Xi_c^+ \to \Sigma^+h^+h^-, \Lambda_c^+ \to ph^+h^-$, PRD 113, 032017 (2026)

- Charmed meson:
  - mixing in $D^0 \to K_S^0\pi^+\pi^-$, PRD 111, 112011 (2025)
  - $D^0 \to h^+h'^-e^+e^-$ (B1), PRD 112, L071101 (2025)
  - $D_{s0}(2317)^+ \to D_s^{*+}\gamma$, PRL 136, 241901 (2026)

近期粲物理结果介绍

- Study of radiative decay:
  - $D_{s0}(2317)^+ \to D_s^{*+}\gamma / D_s^+\pi^0$
- Study of charmed baryon:
  - $\Xi_c^0 \to \Lambda(\pi^0, \eta, \eta')$
- Search for charm CPV:
  - $D^0 \to K_S^0 K_S^0, \pi^+\pi^-\pi^0$
  - $\Xi_c^+ \to \Sigma^+ h^+ h^-, \Lambda_c^+ \to p h^+ h^-$

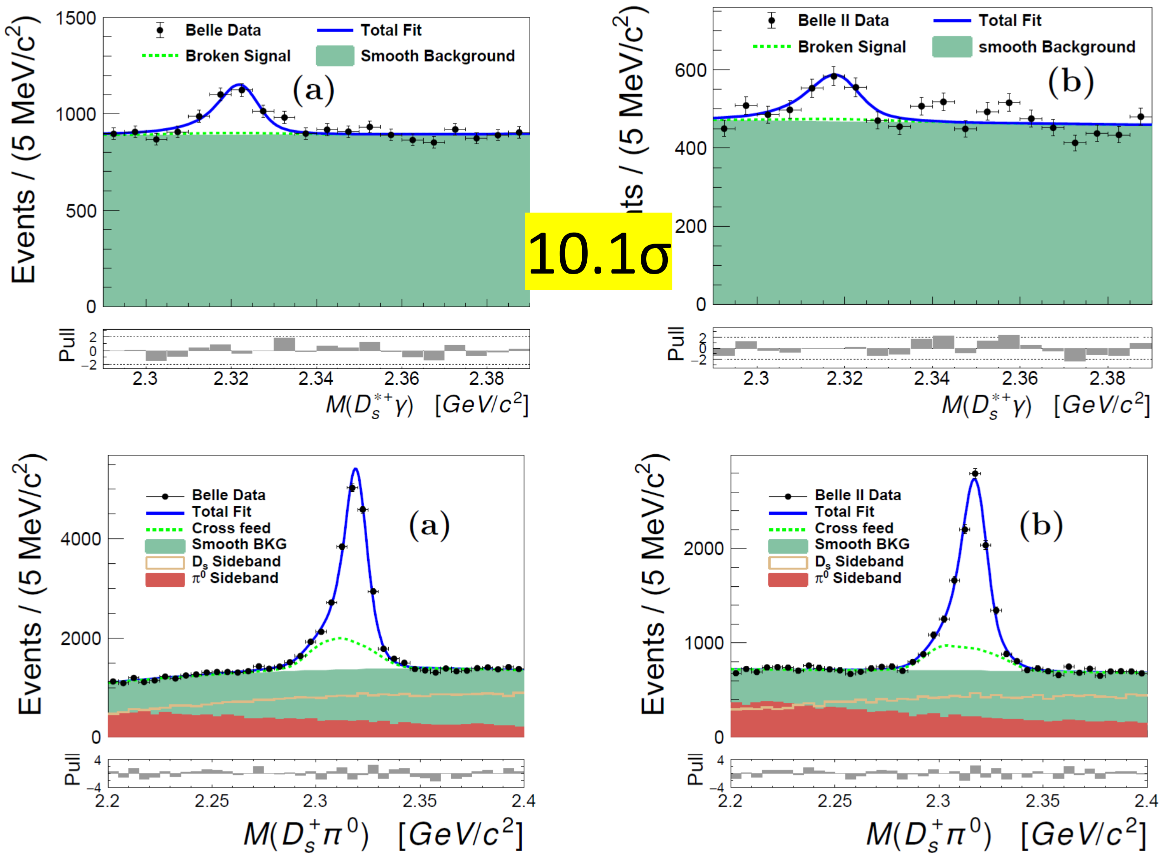


Based on real data before 2023 (≤428/fb)

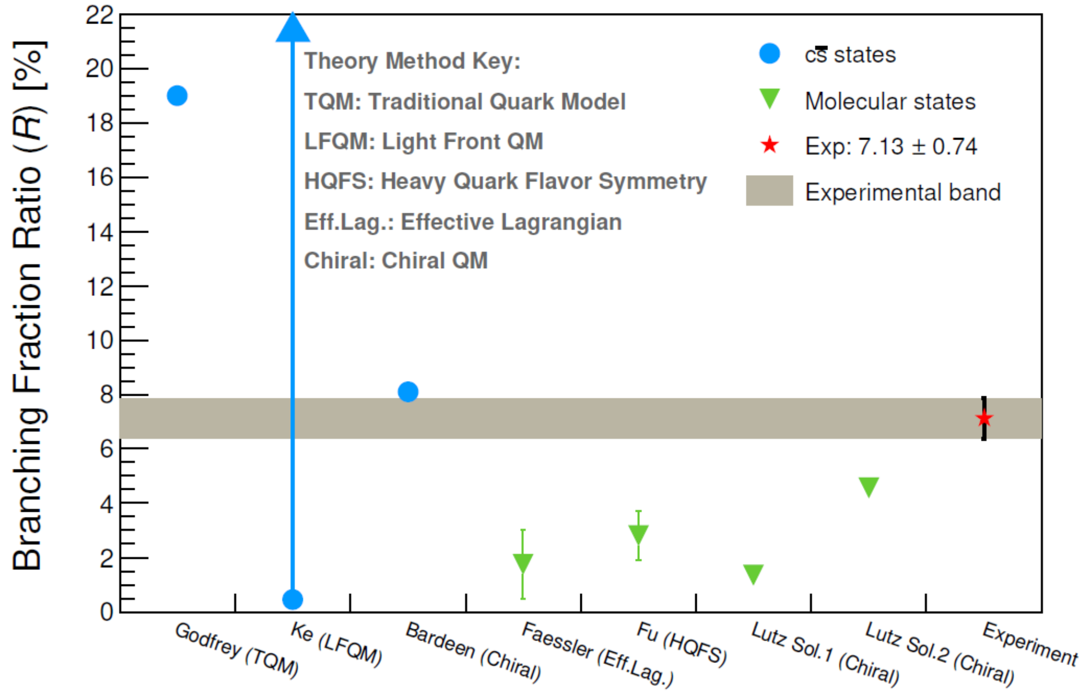
$D_{s0}(2317)^+ \to D_s^{*+}\gamma / D_s^+\pi^0$

PRL 136, 241901 (2026)

- Precise nature of $D_{s0}^*(2317)^+$ remains unresolved, underscoring the need for new and improved data.
- The width of $D_s(2317)^+$ is unknown: $\Gamma(D_s(2317)^+) < 3.8$ MeV @95% CL.



$$R = \frac{\mathcal{B}(D_s(2317)^+ \to D_s^{*+}\gamma)}{\mathcal{B}(D_s(2317)^+ \to D_s^+\pi^0)} = [7.14 \pm 0.70 \pm 0.23]\%$$



Similarly, $D_s(2460)^+ \to D_s^{*+}\gamma$ is ongoing.

More on charm radiative decays

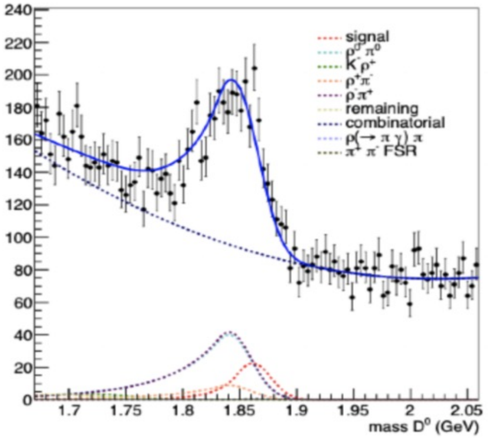
Study of $D^0 \to V\gamma$ ($V = \overline{K}^*, \phi, \rho$):

- expected improvement w.r.t Belle
- MC (428/fb) expect ~5% improvement in Acp.

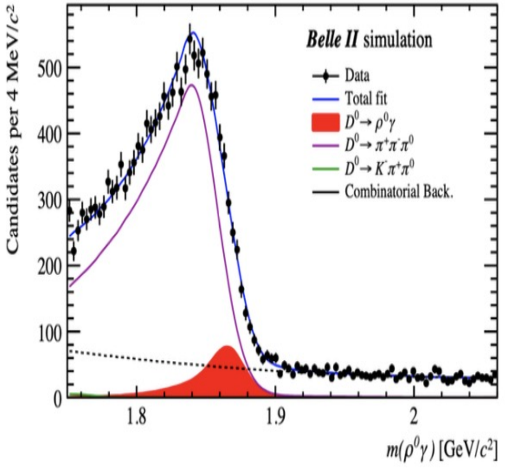
- photon polarization to test SM; study effective lifetime:

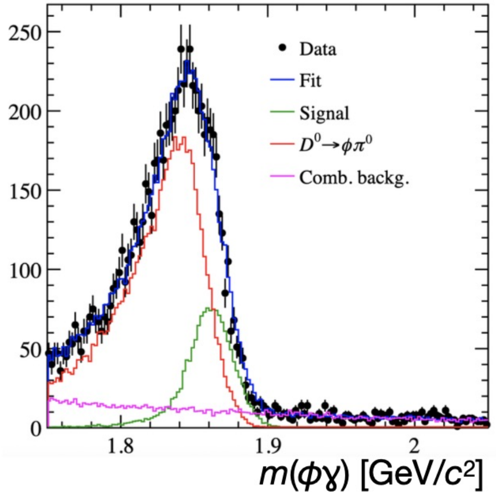
$$\Gamma(t) = \mathcal{N} e^{-\Gamma t}\left[\cosh\left(y\Gamma t\right) + A^{\Delta}\sinh\left(y\Gamma t\right)\right]$$

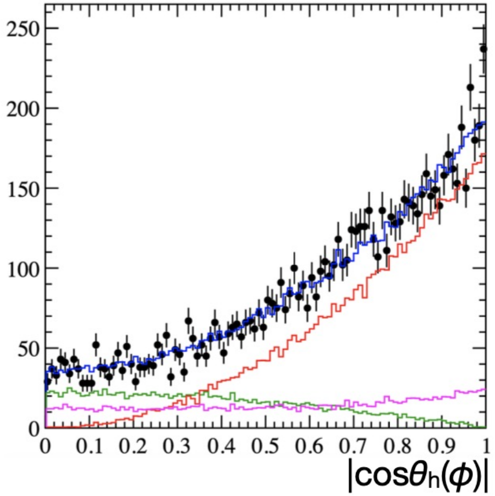
Belle data

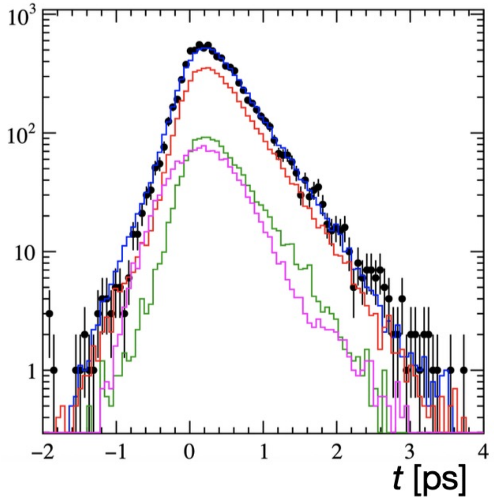


Belle II MC









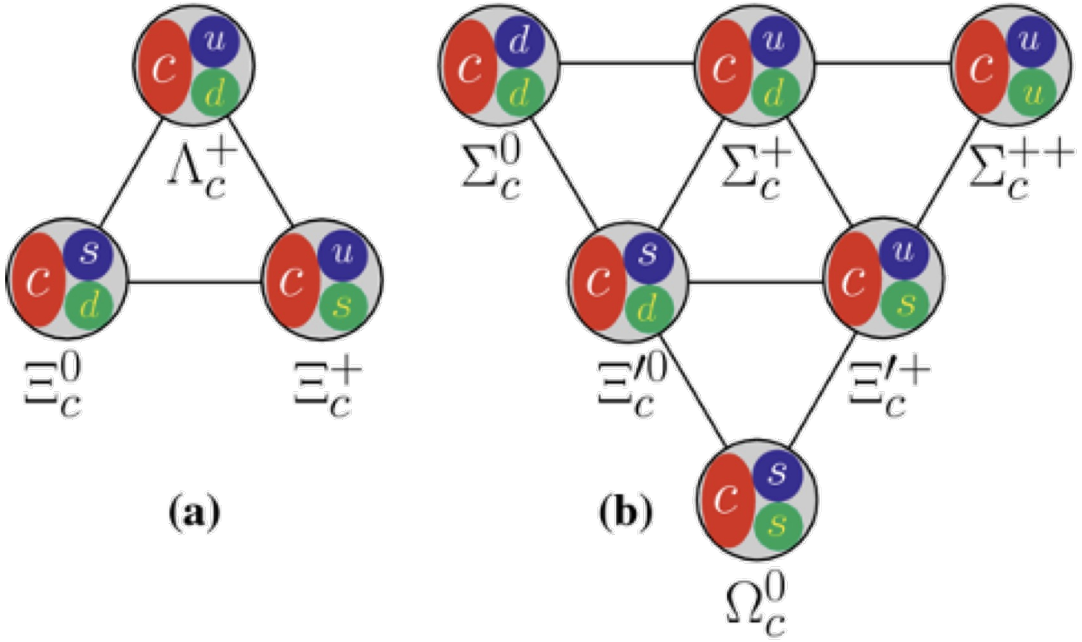
decay-time resolution limited by small ϕ opening angle.

Need more data.

近期粲物理结果介绍

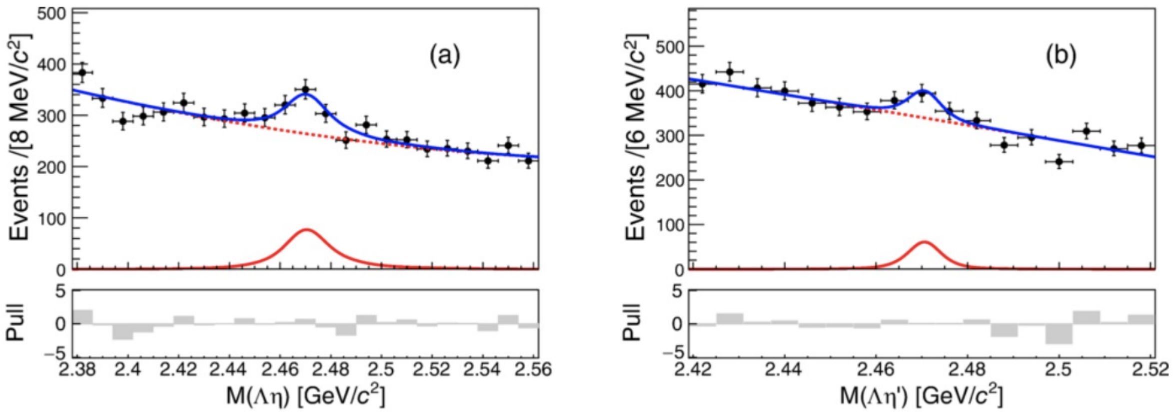
- Study of radiative decay:
  - $D_{s0}(2317)^+ \to D_s^{*+}\gamma / D_s^+\pi^0$
- Study of charmed baryon:
  - $\Xi_c^0 \to \Lambda(\pi^0, \eta, \eta')$
- Search for charm CPV:
  - $D^0 \to K_S^0 K_S^0, \pi^+\pi^-\pi^0$
  - $\Xi_c^+ \to \Sigma^+ h^+ h^-, \Lambda_c^+ \to p h^+ h^-$

[Fig. in Chin. Phys. C 50, 022002 (2026)]



粲重子$\Xi_c^{+,0}$非轻衰变的测量

- $\Xi_c^0 \to \Xi^0(\pi^0, \eta, \eta')$, JHEP 10 (2024) 045
- $\Xi_c^+ \to pK_S^0, \Lambda\pi^+, \Sigma^0\pi^+$, JHEP 03 (2025) 061
- $\Xi_c^+ \to \Sigma^+K_S^0, \Xi^0\pi^+, \Xi^0K^+$, JHEP 08 (2025) 195
- $\Xi_c^0 \to \Lambda(\pi^0, \eta, \eta')$, PRD 113, 032015 (2026)

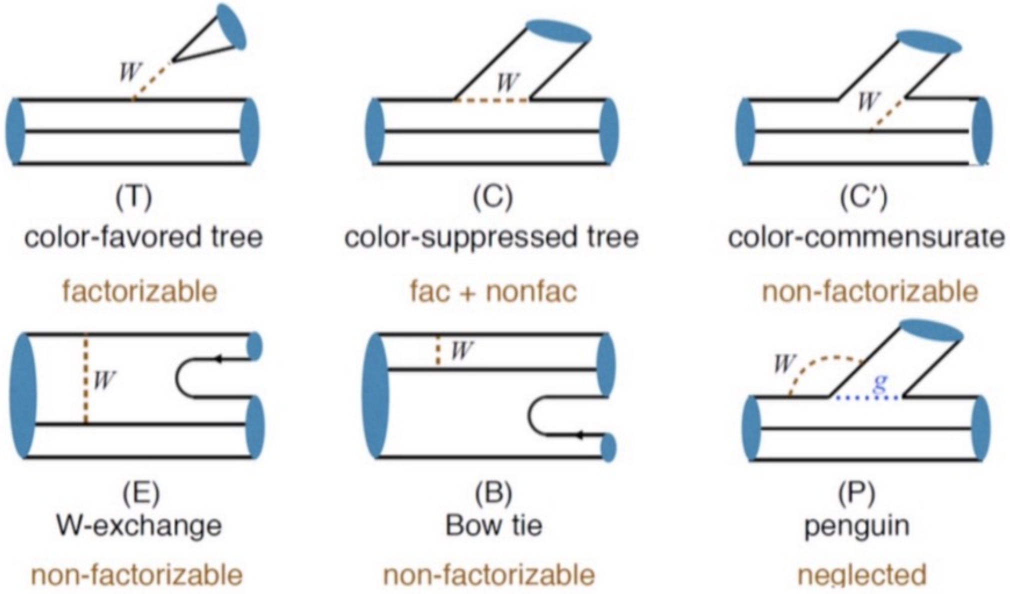


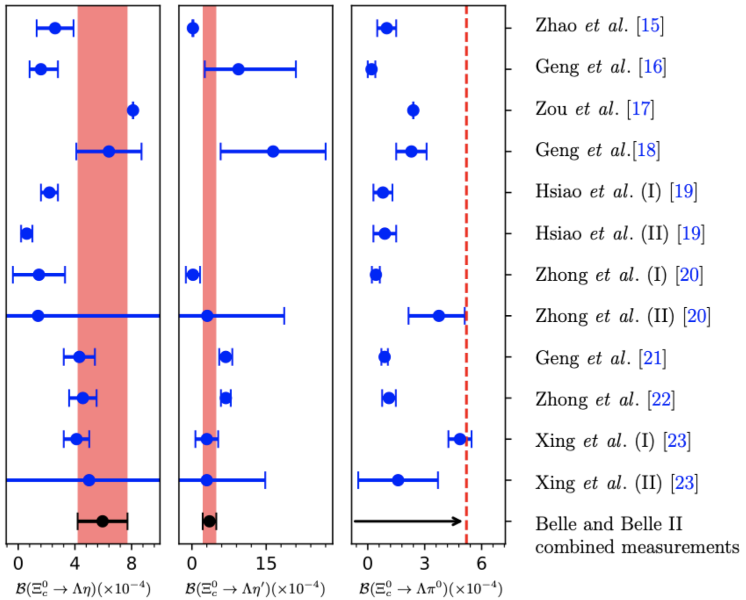
Based on B+B2 (1.4ab^{-1}) dataset:

$$\frac{B(\Xi_c^0\to\Lambda\eta)}{B(\Xi_c^0\to\Xi^-\pi^+)} = (4.16 \pm 0.91 \pm 0.23)\%$$

$$\frac{B(\Xi_c^0\to\Lambda\eta')}{B(\Xi_c^0\to\Xi^-\pi^+)} = (2.48 \pm 0.82 \pm 0.12)\%$$

$$\frac{B(\Xi_c^0\to\Lambda\pi^0)}{B(\Xi_c^0\to\Xi^-\pi^+)} < 3.5\%$$





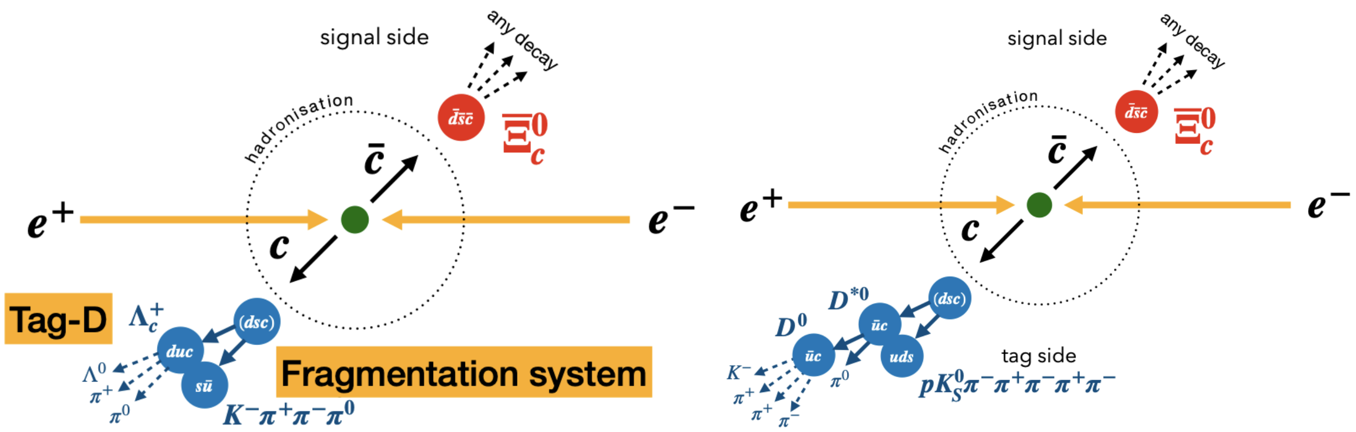
理论
+
实验

粲重子$\Xi_c^{+,0}$非轻衰变的测量

- $\Xi_c^0 \to \Xi^0(\pi^0, \eta, \eta')$, JHEP 10 (2024) 045
- $\Xi_c^+ \to pK_S^0, \Lambda\pi^+, \Sigma^0\pi^+$, JHEP 03 (2025) 061
- $\Xi_c^+ \to \Sigma^+K_S^0, \Xi^0\pi^+, \Xi^0K^+$, JHEP 08 (2025) 195
- $\Xi_c^0 \to \Lambda(\pi^0, \eta, \eta')$, PRD 113, 032015 (2026)

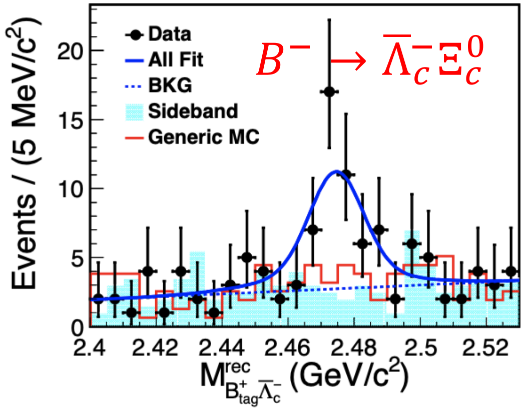
Ongoing:

- $\Xi_c^+ \to \Lambda K_S^0\pi^+, pK_S^0K_S^0$
- $\Xi_c^0 \to pK_S^0K^-, \Sigma^+K_S^0\pi^-, \Lambda K^-\pi^+$
- $\Xi_c^+ \to \Lambda K_S^0K^+, \Xi^-K^+\pi^+, \Omega^-K^+\pi^+$
- $\Xi_c^0 \to \Xi^-h^+\pi^0, \Xi^-h^+\eta$
- $\Xi_c^0 \to \Xi(1530)^{-,0}\pi^{+,0}$
- $\Xi_c^0 \to \Xi^-K^+, \Lambda K_S^0, \Sigma^+K^-$
- ……
- absolute $B(\Xi_c \to f)$



没有一个过程的截面是遥遥领先的!

PRL 122, 082001 (2019)



$N_{incl}^{B^-}(\Xi_c^0) = 45@703\text{fb}^{-1}$

based on MC study , we will obtain inclusive Ξ_c^0-signals: $N_{incl}^{c\bar{c}}(\Xi_c^0)$ ~O(10³)@428fb^{-1}.

→ Please give us more time.

近期粲物理结果介绍

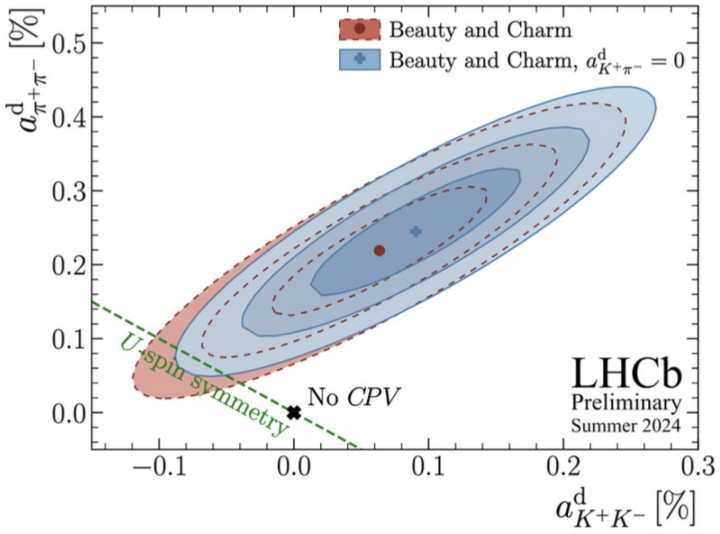
- Study of radiative decay:
  - $D_{s0}(2317)^+ \to D_s^{*+}\gamma / D_s^+\pi^0$
- Study of charmed baryon:
  - $\Xi_c^0 \to \Lambda(\pi^0, \eta, \eta')$
- Search for charm CPV:
  - $D^0 \to K_S^0 K_S^0, \pi^+\pi^-\pi^0$
  - $\Xi_c^+ \to \Sigma^+ h^+ h^-, \Lambda_c^+ \to p h^+ h^-$

粲强子CP破坏的现状

- 粲强子衰变中CP破坏效应：标准模型预期很小[1, 2]，因此是新物理的敏感探针。

- 粲介子衰变CP破坏：
  - 2019年LHCb测 $\Delta A_{CP}(D^0 \to K^+K^-, \pi^+\pi^-) = (-1.54 \pm 0.29)\times 10^{-3}$ 。首次发现粲CP破坏[3]，入选“物理十大突破”。后续研究发现其主要来自$D^0 \to \pi^+\pi^-$过程[4]。目前理论上并不能很好的解释此CP破坏的来源。因此实验需要更多“发现”和更精确测量。

LHCb-CONF-2024-004

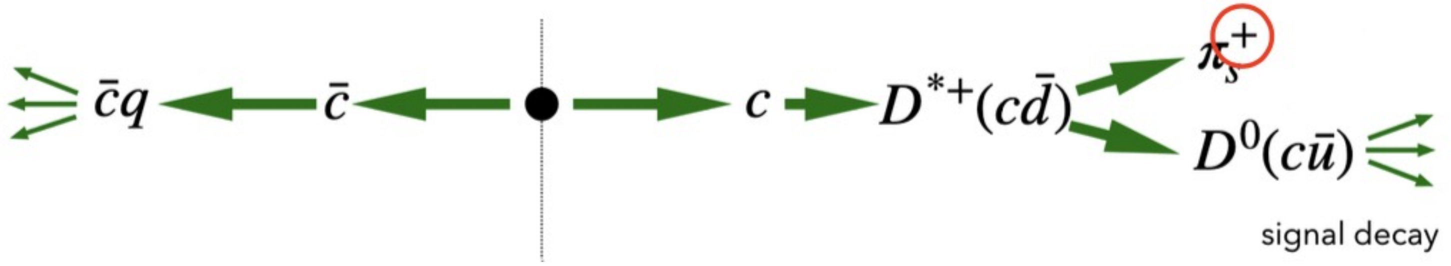


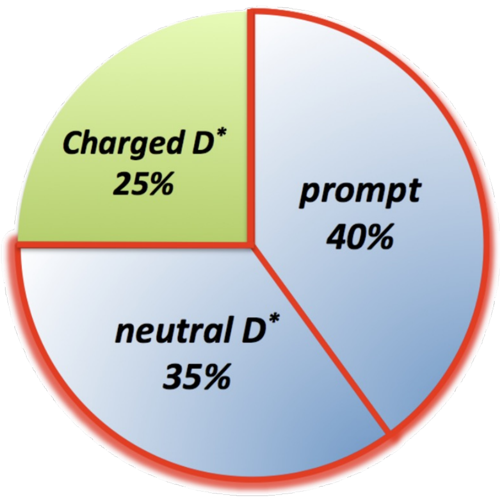
- 粲重子衰变CP破坏：
  - 2025年，LHCb在底味重子衰变中首次发现重子CP破坏[5]，入选“物理十大突破”。
  - 粲重子CP破坏：尚未发现的任何实验迹象。

[1] H.-n. Li, et al. PRD 86, 036012 (2012)
[2] H.-Y. Cheng et al. PRD 104, 073003 (2021)
[3] (LHCb) Phys. Rev. Lett. 122, 211803 (2019)
[4] (LHCb) Phys. Rev. Lett. 131, 091802 (2023)
[5] (LHCb) Nature 643 (2025) 8074

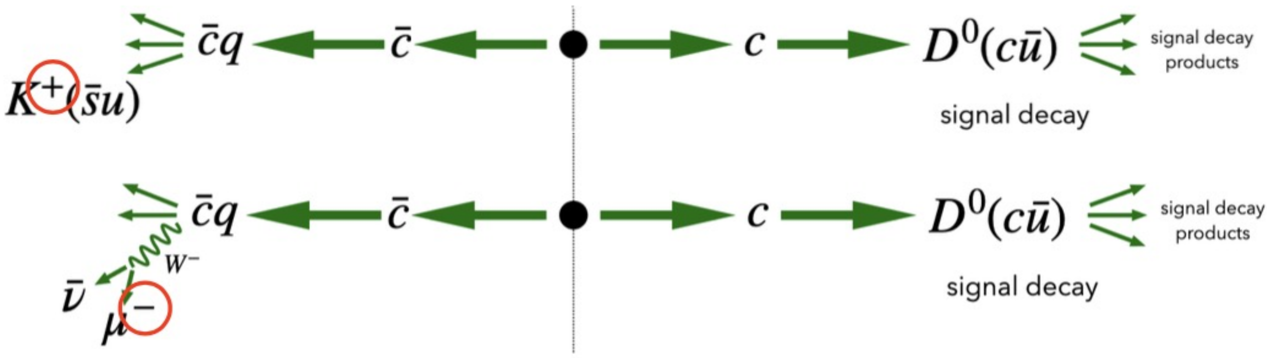
charm flavor tagging for D^0

1) using $D^{*+} \to D^0\pi^+$ to tag the D flavor:

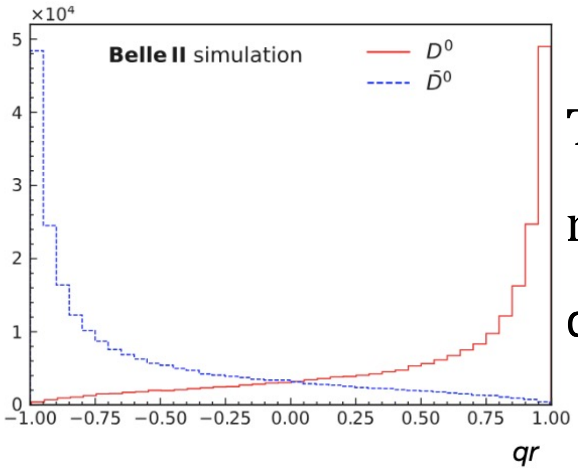




2) opposite-side flavor tagging for $e^+e^- \to c\bar{c}$:



PRD 107, 112010 (2023)



This charm flag tag (CFT) method: adding ~50% more data to D*-tag sample.

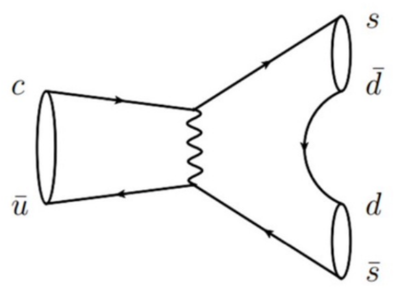
$A_{CP}(D^0 \to K_S^0 K_S^0)$

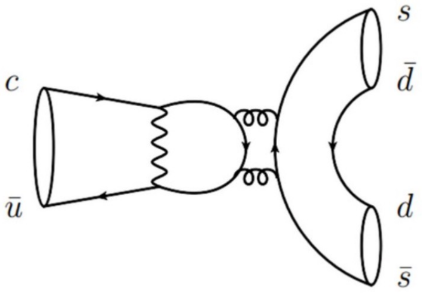
[PRD 111, 012015 (2025)](#)

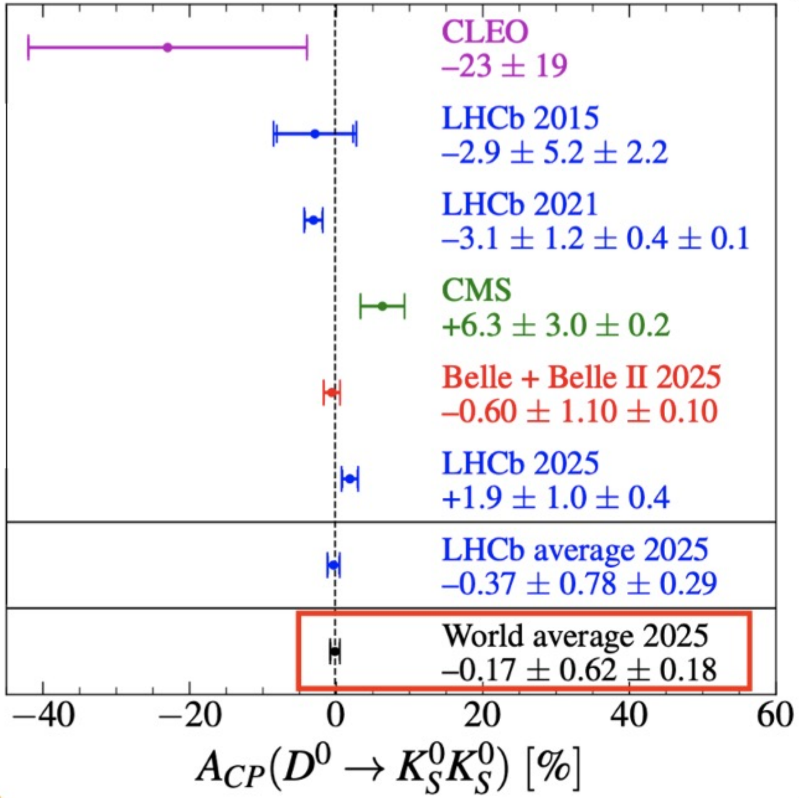
[PRD 112, 012017 (2025)](#)

$A_{CP}(D^0 \to K_S^0 K_S^0)$ may be enhanced to 1% level with the SM, by the interference of $c \to us\bar{s}$ and $c \to ds\bar{s}$ amplitudes.

[PRD 99, 113001 (2019), PRD 92, 054036 (2015)]

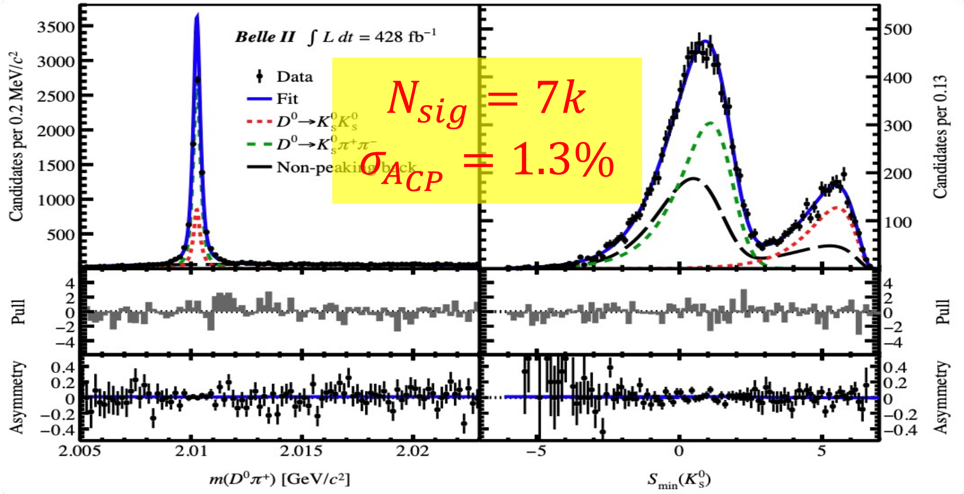






- No hints for CP violation!
- All experiments: σ_{stat} dominated

1) using $D^{*+} \to D^0\pi^+$ to tag the D flavor

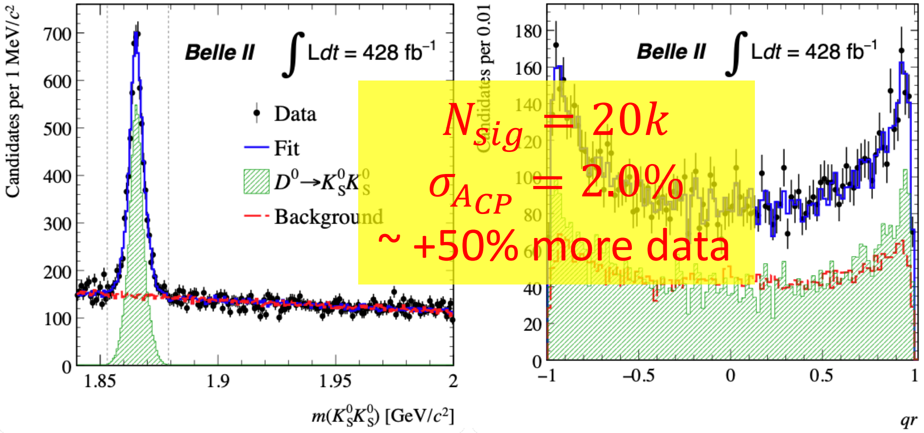


$N_{sig} = 7k$

$\sigma_{A_{CP}} = 1.3\%$

2) using opposite-side flavor tagging for $e^+e^- \to c\bar{c}$

[[PRD 107, 112010 (2023)](#)] For more details, see backup.



$N_{sig} = 20k$

$\sigma_{A_{CP}} = 2.0\%$

~ +50% more data

$A_{CP}(D_{(s)}^{+} \to f)$

- Belle II has higher efficiency on $\gamma, \pi^0/\eta$ (and long-lived particle: K_S^0 and hyperons).
- Better vertex fitter w.r.t Belle: treeFit (simultaneous fit of all vertices in a decay chain).

Belle II (428/fb , $\eta \to \gamma\gamma, \pi^+\pi^-\pi^0$)

using reference mode $D^+ \to K_S^0\pi^+$:

$A_{CP}(D^+ \to \pi^+\eta) = (xx \pm 0.5 \pm 0.2)\%$

$A_{CP}(D_s^+ \to \pi^+\eta) = (xx \pm 0.4 \pm 0.2)\%$

Vs. previous $A_{CP}(D^+ \to \pi^+\eta)$ results:

Belle (791 fb^{-1}, $\eta \to \pi^+\pi^-\pi^0$):

$\sigma = 1.1\%$ [PRL 107, 221801 (2011)]

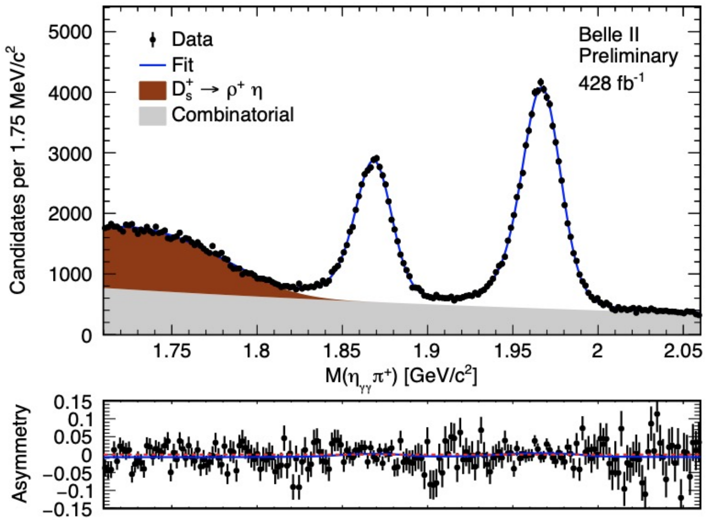
LHCb (6 fb^{-1}, $\eta \to \pi^+\pi^-\gamma$):

$\sigma = 0.7\%$ [JHEP 04 (2023) 081]

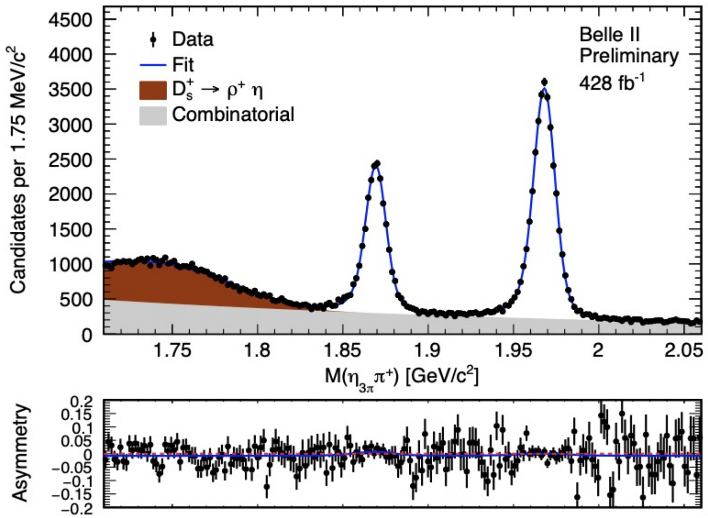
LHCb (6 fb^{-1}, $\eta \to e^+e^-\gamma$):

$\sigma = 0.8\%$ [JHEP 06 (2021) 019]

$\eta \to \gamma\gamma$



$\eta \to \pi^+\pi^-\pi^0$



The result will be released very soon. Stay tuned.

The sensitivity per luminosity is improved significantly.

$A_{CP}(\Lambda_c^+ \to p h^+ h^-, \Xi_c^+ \to \Sigma^+ h^+ h^-)$

PRD 113, 032017 (2026)

- LHCb reported [1]: $\Delta A_{CP}^{wgt} = A_{CP}(\Lambda_c^+ \to pK^+K^-) - A_{CP}^{wgt}(\Lambda_c^+ \to p\pi^+\pi^-) = (0.30 \pm 0.91 \pm 0.61)\%$
- U-spin symmetry [2,3]: $A_{CP}(\Lambda_c^+ \to pK^+K^-) + A_{CP}(\Xi_c^+ \to \Sigma^+\pi^+\pi^-) = 0$

$$A_{CP}(\Lambda_c^+ \to p\pi^+\pi^-) + A_{CP}(\Xi_c^+ \to \Sigma^+K^+K^-) = 0$$

- Using sample of $e^+e^- \to c\bar{c} \to (\Lambda_c^+ \to f) + X$ (total product yield $N_{prod}^{\Lambda_c^+}$)

raw asymmetry: $A_{raw} = \frac{N_{obs}(\Lambda_c^+ \to f) - N_{obs}(\bar{\Lambda}_c^- \to \bar{f})}{N_{obs}(\Lambda_c^+ \to f) - N_{obs}(\bar{\Lambda}_c^- \to \bar{f})} = A_{FB}^{\Lambda_c^+} + A_{CP}(\Lambda_c^+ \to f) + A_\varepsilon^f$

- **Control samples**: to remove the common A_ε^f:
  - $\Xi_c^+ \to \Sigma^+h^+h^-$: $\Lambda_c^+ \to \Sigma^+h^+h^-$
  - $\Lambda_c^+ \to ph^+h^-$: $\Lambda_c^+ \to p\pi^+K^-, D^0 \to K^-\pi^+\pi^+\pi^-$ (not $D^0 \to K^-\pi^+$ due to kinematic region)

[1] A. Raij et al. (LHCb Collaboration) JHEP 03 (2018) 182. [2] Y. Grossman and S. Schacht, PRD 99 (2019) 033005; [3] D. Wang, EPJC 79 (2019) 429.

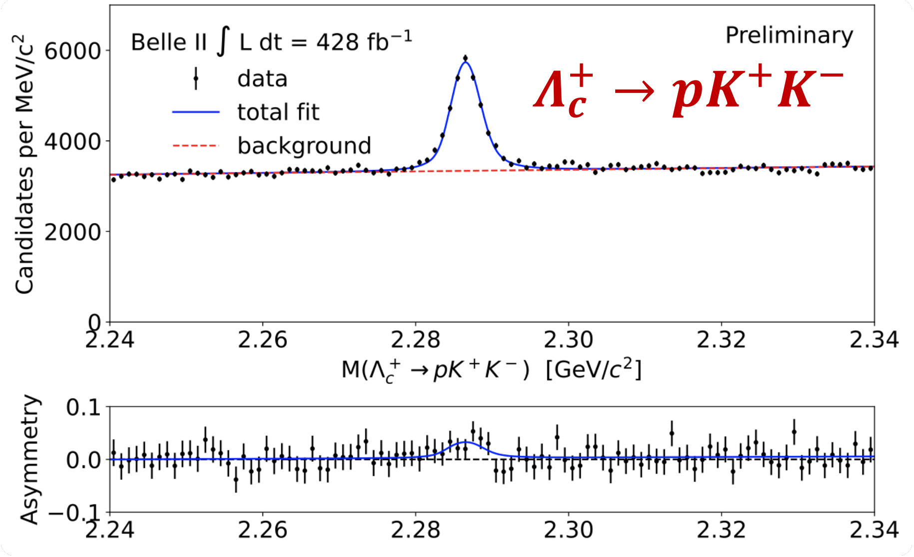
$A_{CP}(\Lambda_c^+ \to p h^+ h^-, \Xi_c^+ \to \Sigma^+ h^+ h^-)$

PRD 113, 032017 (2026)

- Belle II (428/fb) result:

$$A_{CP}(\Xi_c^+ \to \Sigma^+ K^+ K^-) = (3.7 \pm 6.6 \pm 0.6)\%,$$
$$A_{CP}(\Xi_c^+ \to \Sigma^+ \pi^+ \pi^-) = (9.5 \pm 6.8 \pm 0.5)\%,$$
$$A_{CP}(\Lambda_c^+ \to p K^+ K^-) = (3.9 \pm 1.7 \pm 0.7)\%,$$
$$A_{CP}(\Lambda_c^+ \to p \pi^+ \pi^-) = (0.3 \pm 1.0 \pm 0.2)\%,$$

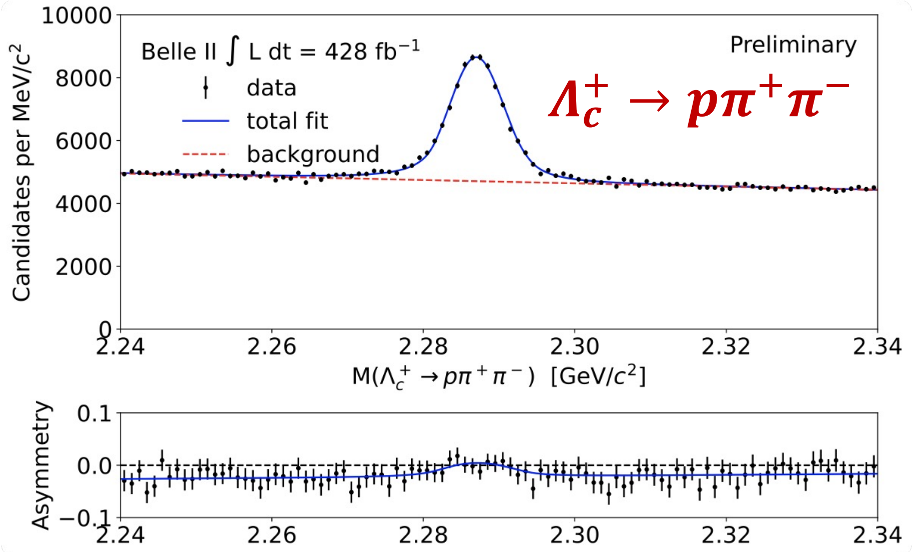
first A_{CP} for 3-body SCS decays of charmed baryons



- Testing U-spin sum rules:

$$A_{CP}(\Xi_c^+ \to \Sigma^+ \pi^+ \pi^-) + A_{CP}(\Lambda_c^+ \to p K^+ K^-)$$
$$= (13.4 \pm 7.0 \pm 0.9)\%,$$
$$A_{CP}(\Xi_c^+ \to \Sigma^+ K^+ K^-) + A_{CP}(\Lambda_c^+ \to p \pi^+ \pi^-)$$
$$= (4.0 \pm 6.6 \pm 0.7)\%,$$

σ_{stat} dominated; at few percent level;
→ more data desired.



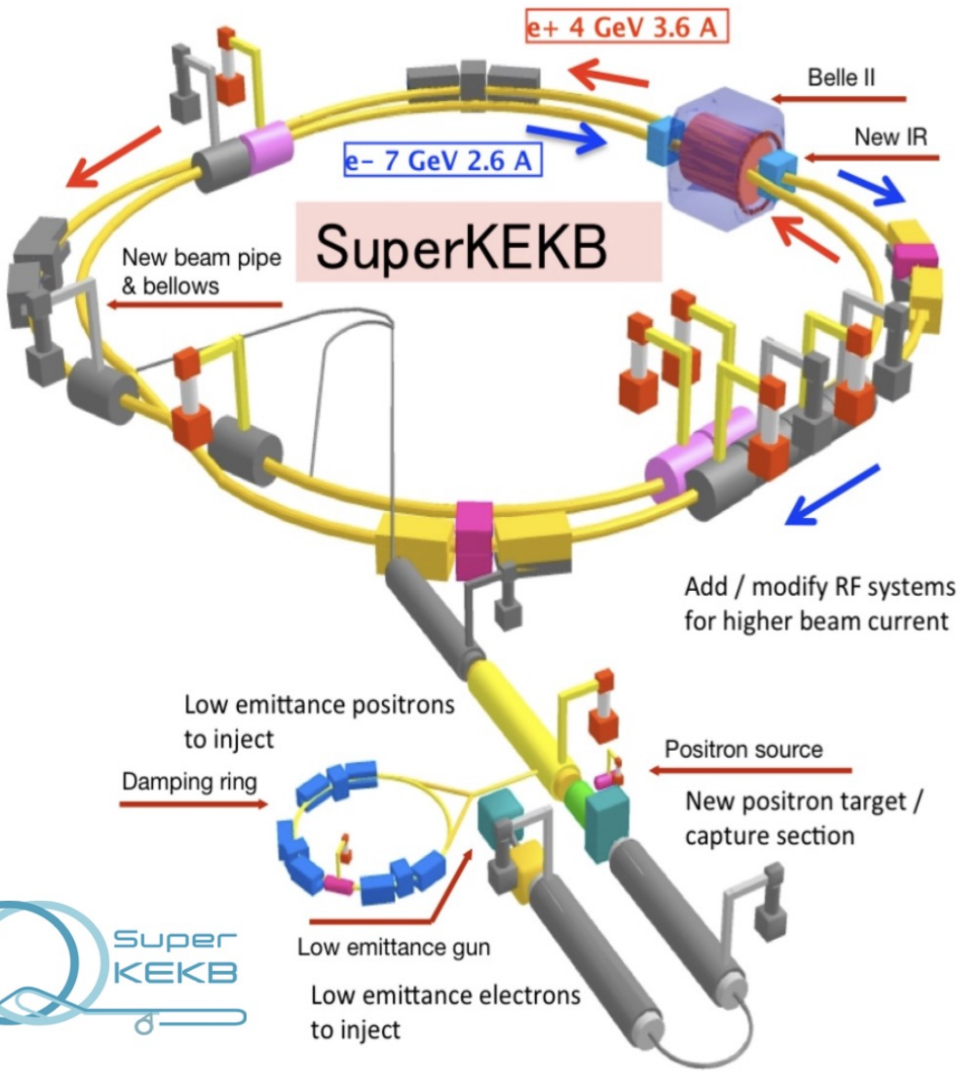
总结和展望

- Belle实验对粲物理的研究，具有巨大潜力，尤其对于末态包含中性粒子或不可见粒子的衰变过程。性能显著提升的探测器+更先进的软件/方法也提供重要保障。
- 基于428/fb数据，近期取得了最新的成果：
  - 辐射衰变： $D_{s0}(2317)^+ \to D_s^{*+}\gamma/D_s^+\pi^0$
  - 粲重子Ξ_c的系列研究： $\Xi_c^0 \to \Lambda(\pi^0, \eta, \eta')$ ……
  - 粲强子CPV的测量：$D^0 \to K_S^0 K_S^0, \pi^+\pi^-\pi^0; \Xi_c^+ \to \Sigma^+ h^+ h^-, \Lambda_c^+ \to p h^+ h^-$
- Belle II进入ab^{-1}时代。基于B+B2（2ab^{-1}）数据正开展丰富的粲物理研究工作。
  - 更多粲强子辐射衰变和非轻衰变分支比、粲CP破坏。
  - 以及 PWA $\Xi_c^+ \to \Xi^-\pi^+\pi^+, \Lambda_c^+ \to \Lambda\pi^+\pi^0, \Lambda_c^+ \to \Sigma^+\pi^+\pi^-; D \to h e^+ e^-$...
- 快马加鞭，未来可期。

Back up

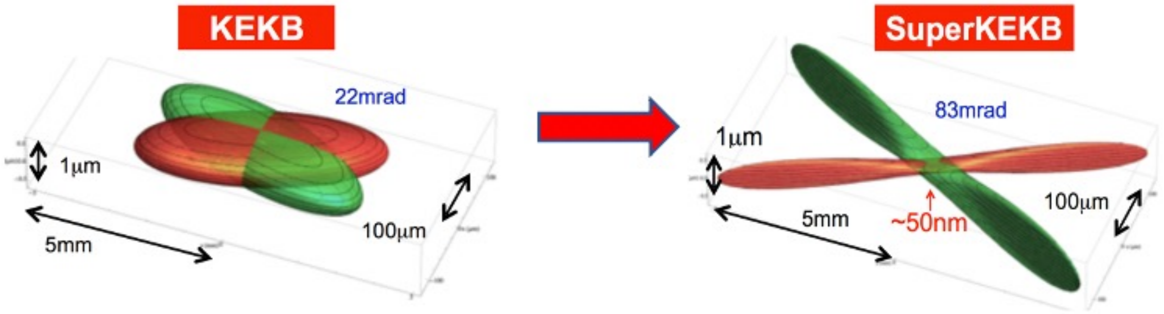

54th B2GM
2026.07.05@Vienna
The Taste of Data Taking
All the things you encounter while you take shifts!
Opening 54th B2GM
Vienna, July 2026
Florian Bernlochner
BELLE II
Amazing Design by Veronika Kratzer!

超级B介子工厂：SuperKEKB



加速器两关键参数： KEKB → SuperKEKB

- 能量（物理尺度） 10.58 GeV
- 亮度（测量精度） 1 ab^{-1} → 50 ab^{-1}



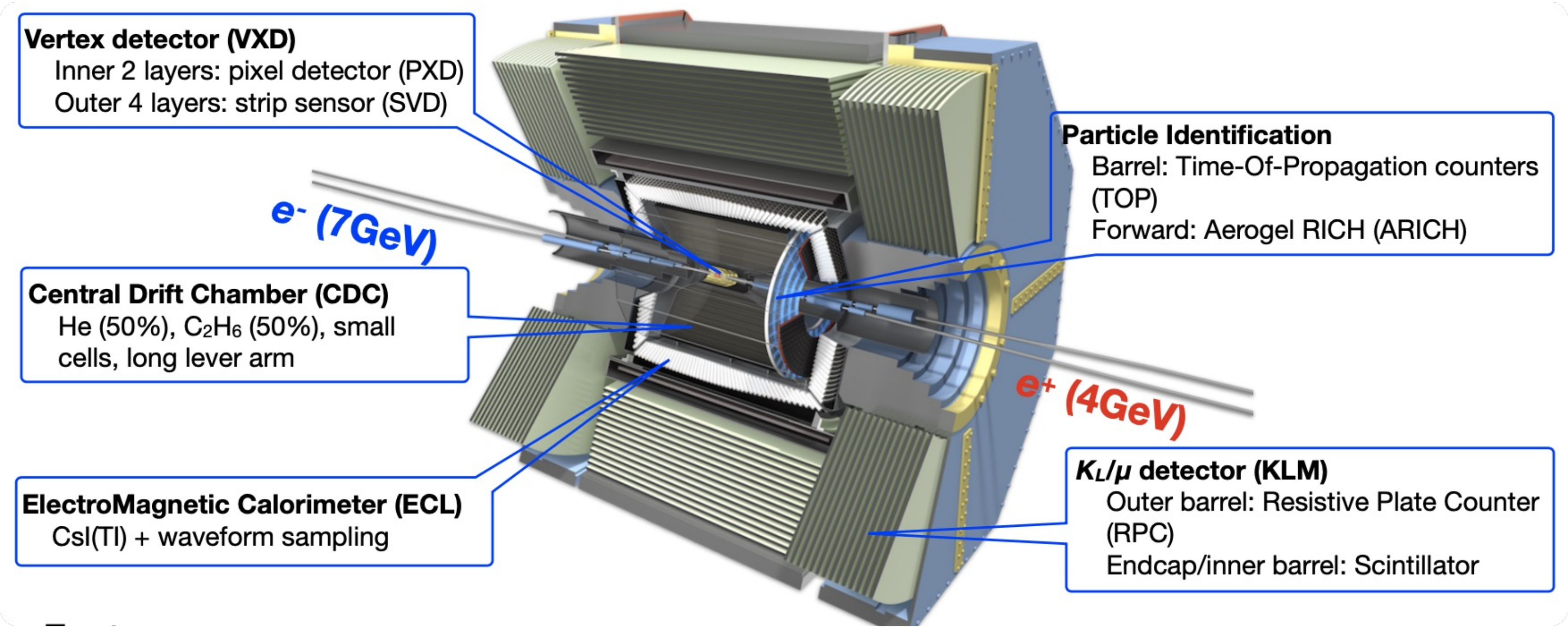
Beam current: KEKB x ~1.5

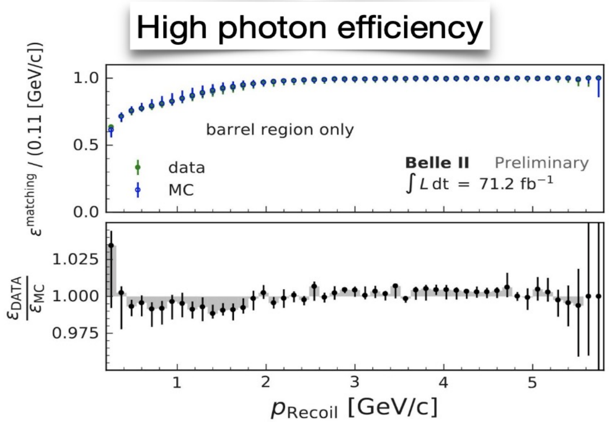
$$L = \frac{\gamma_{\pm}}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\frac{I_{\pm}\xi_{\pm y}}{\beta_y^*}\left(\frac{R_L}{R_y}\right)$$

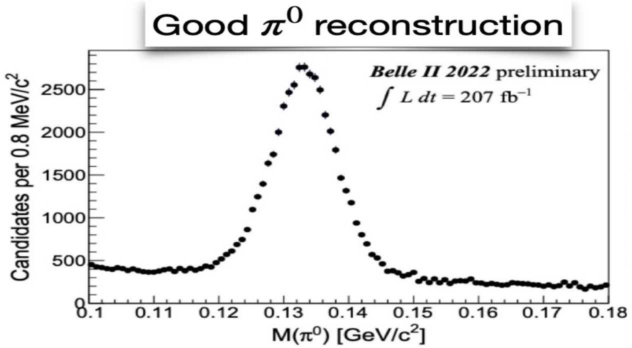
Beam squeeze: KEKB / ~20

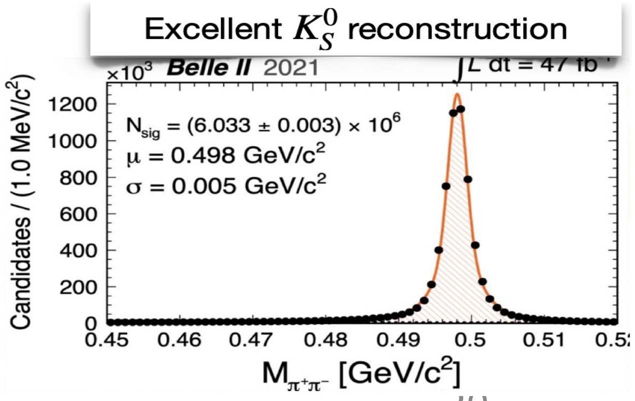
实现高亮度的实验数据！

Belle II探测器和其性能









Belle II探测器的性能优势：

- 4π立体角：高接受度
- 顶点和径迹：高空间分辨率；高粒子鉴别能力
- 中性粒子和长寿命粒子：高重建效率

CP破坏的测量@Belle II

物理量

$$A_{CP}(D\to f)=\frac{\Gamma(D\to f)-\Gamma(\bar{D}\to f)}{\Gamma(D\to f)+\Gamma(\bar{D}\to f)}$$

实验观测量

$$A_{raw}(D\to f)=\frac{N_{obs}(D\to f)-N_{obs}(\bar{D}\to f)}{N_{obs}(D\to f)+N_{obs}(\bar{D}\to f)}$$

- 例如：$e^+e^-\to c\bar{c}\to D^{*+}+\text{anything}$, 此单举过程中$D^{*+}\to[D^0\to f]\pi_s^+$味标记样本。
- 实验观测到信号数: $N_{\text{obs}}(D^{*+})=N_{prod}(D^{*+})\cdot B(D^{*+}\to D^0\pi_s^+)\cdot B(D^0\to f)\cdot\varepsilon_{det}$

$$N_{\text{obs}}(D^{*-})=N_{prod}(D^{*-})\cdot B(D^{*-}\to\bar{D}^0\pi_s^-)\cdot B(\bar{D}^0\to\bar{f})\cdot\bar{\varepsilon}_{det}$$

$$A_{\text{raw}}=\frac{N_{\text{obs}}(D^{*+})-N_{\text{obs}}(D^{*-})}{N_{\text{obs}}(D^{*+})+N_{\text{obs}}(D^{*-})}\approx A_{\text{prod}}^{D^{*+}}+A_{CP}^{D^{*+}\to D^0\pi_s^+}+A_{CP}^{D^0\to f}+A_\varepsilon^{\pi_s}+A_\varepsilon^{f}$$

- $A_{\text{prod}}^{D^{*+}}$: 是$\cos\theta^*$的奇函数。$A_{CP}^{D^{*+}\to D^0\pi_s^+}=0$（强衰变）；
- $A_{CP}^{D^0\to f}$: 所关心的 $D^0\to f$ 衰变CP破坏。
- $A_\varepsilon^{\pi_s,f}$: 末态粒子的探测不对称性；其值依赖动量和极角分布。利用控制样本可获得：

$$\mathcal{A}_{\text{raw}}^{\text{tagged}}\simeq\mathcal{A}_{\text{prod}}+\mathcal{A}_\varepsilon^{K\pi}+\mathcal{A}_\varepsilon^{\pi_{\text{tag}}}$$
$$\mathcal{A}_{\text{raw}}^{\text{untagged}}\simeq\mathcal{A}_{\text{prod}}+\mathcal{A}_\varepsilon^{K\pi},$$

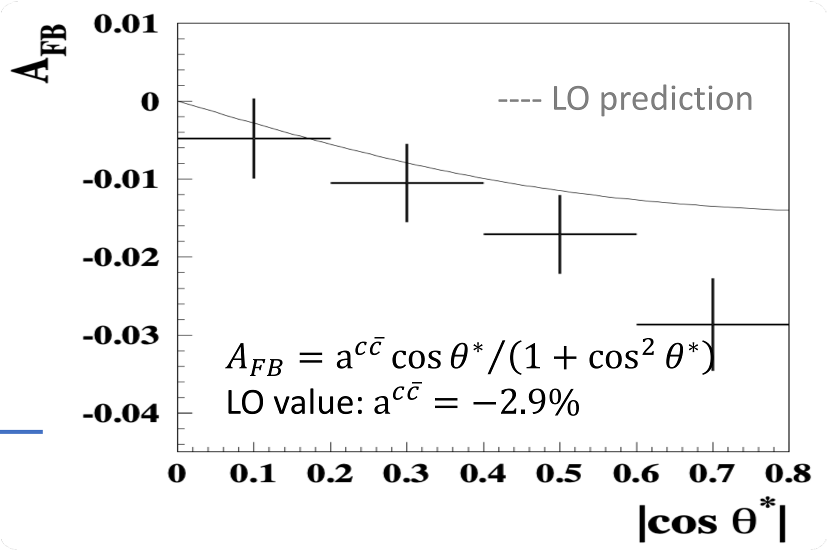
CP asymmetry using inclusive sample

- Using inclusive sample of $e^+e^- \to (\Lambda_c^+ \to f) + X$ (with total product yield $N_{\text{prod}}^{\Lambda_c^+}$), we have :
  - observed yields: $N_{obs}(\Lambda_c^+ \to f) = N_{\text{prod}}^{\Lambda_c^+} \cdot B(\Lambda_c^+ \to f) \cdot \varepsilon_{det}^{f}$

    $N_{obs}(\bar{\Lambda}_c^- \to \bar{f}) = N_{\text{prod}}^{\bar{\Lambda}_c^-} \cdot B(\bar{\Lambda}_c^- \to \bar{f}) \cdot \varepsilon_{det}^{\bar{f}}$
  - raw asymmetry: $A_{raw} = \frac{N_{obs}(\Lambda_c^+ \to f) - N_{obs}(\bar{\Lambda}_c^- \to \bar{f})}{N_{obs}(\Lambda_c^+ \to f) - N_{obs}(\bar{\Lambda}_c^- \to \bar{f})} = A_{FB}^{\Lambda_c^+} + A_{CP}(\Lambda_c^+ \to f) + A_{\varepsilon}^{p}$ (if asymmetries <<1)

- For e^+e^- collision, phase-space integrated product asymmetry $A_{FB}^{\Lambda_c^+} = 0$, but a function of $\cos\theta^*$ in e^+e^- CMS, which is induced by (1) interference by γ^* or Z^0 contributes at the percent level [4]; (2) higher-order QED effects to peak sharply in the forward and backward directions [5]. Following from CP conservation in the production, the FB asymmetry must be an anti-symmetric function of $\cos\theta^*$, i.e. $A_{FB}(\cos\theta^*) = -A_{FB}(-\cos\theta^*)$

A_{FB} in $D^0 \to K^+K^-.\pi^+\pi^+$ [6]



[1] (LHCb) JHEP 03 (2018) 182.
[2] Y. Grossman and S. Schacht, PRD 99 (2019) 033005;
[3] D. Wang, EPJC 79 (2019) 429.
[4] R.J. Cashmore et al. Z. Phys. C 30 (1986) 125.
[5] (BaBar) PRL 100, 061803 (2008)
[6] (Belle) PLB 670 (2008) 190-195.