

Analysis the decay for $\Xi_c^0 \rightarrow \Xi^- K^+$

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Outline

a brief introduction

Directory

- ✓ Motivation
- ✓ Data Set
- ✓ Example Selection
- ✓ Presentation of Relevant Distributions
- ✓ Summary

Teamwork

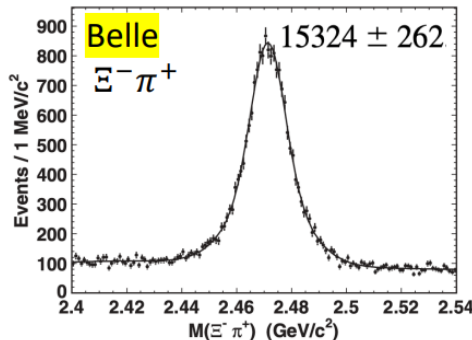
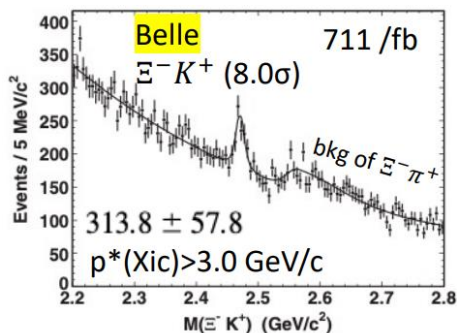
- Analyze the background of the topic and collect relevant papers. Lin Zhu
- Run the program to generate Monte Carlo (MC) simulations. Lin Zhu ;Xinyue Zhao
- Plot the invariant mass spectrum. YueWen Zhong ;Haoyu Yan;
- Analyze the signal from the Monte Carlo (MC) simulations.
- Create a PowerPoint presentation for reporting and sharing



Motivation

updated measurement of $\text{Br}(\Xi_c^0 \rightarrow \Xi^- k^+)$

- Weak decays of charmed baryons provide a useful test of many theoretical models and approaches, which include external/internal W-emission and W-exchange processes. e.g. $\Xi_c^0 \rightarrow \Xi^- k^+$ has W-exchange and external W-emission contributions.
- Belle observed (SCS) $\Xi_c^0 \rightarrow \Xi^- k^+$ based on 711 /fb of data: $2.75 \pm 0.51 \pm 0.25 \% \times \text{B}(\Xi_c^0 \rightarrow \Xi^- \pi^+)$
- preciser BR result are promising at Belle with full data set (980 /fb);
- theoretical predictions [PRD 101, 014011 (2020) vs SU(3) PLB7 94, 19(2019)] : $\text{B}(\Xi_c^0 \rightarrow \Xi^- k^+) = 3.9 \times 10^{-3}$ vs $(1.28 \pm 0.06) \times 10^{-3}$ much larger than current experimental result: $\text{B}(\Xi_c^0 \rightarrow \Xi^- k^+)_{\text{PDG}} = (4.2 \pm 1.0) \times 10^{-4}$
- very recently, predicts $\text{B}(\Xi_c^0 \rightarrow \Xi^- k^+) = (4.7 \pm 0.8) \times 10^{-4}$ using SU(3) relations. This global analysis shows the deviation is reduced to within 1σ level



→ 提高测量精度

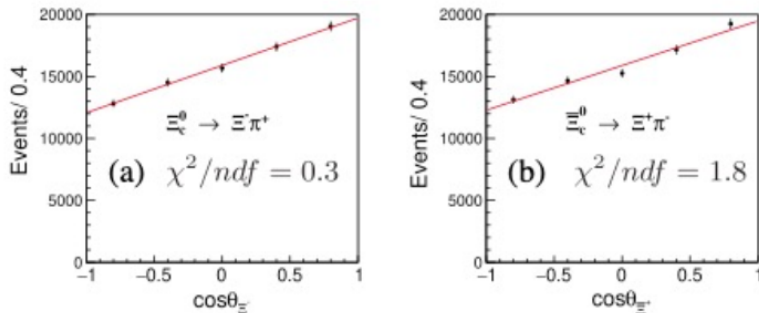
Motivation

motivation (II): Ξ_c^0 SCS decay asymmetry parameter

- using $\alpha_{\Xi^-} = -0.376 \pm 0.008$ and $\alpha_{\Xi^+} = 0.371 \pm 0.007$ from BESIII [arXiv:2105.11155] as input;
- Theoretical predictions, taking SU(3)_F approach for example,
 - SU(3)_F: $\alpha(\Xi_c^0 \rightarrow \Xi^- \pi^+) = -0.95$ vs. $\alpha(\Xi_c^0 \rightarrow \Xi^- K^+) = -0.97$ [PRD 101, 014011 (2020)]
 - $\alpha(\Xi_c^0 \rightarrow \Xi^- K^+) = -1.00_{-0.00}^{+0.01}$ [PLB7 94, 19(2019)]
 - $\alpha(\Xi_c^0 \rightarrow \Xi^- K^+) = -0.60 \pm 0.33$ [arXiv:2112.10556]
 - SU(3)_F symmetry, $\alpha(\Xi_c^0 \rightarrow \Xi^- K^+) = \alpha(\Xi_c^0 \rightarrow \Xi^- \pi^+)$. Significant bias indicate SU(3)_F symmetry violation.
- re-measurement of $\alpha(\Xi_c^0 \rightarrow \Xi^- \pi^+)$, already reported at Belle in 2021.
 - ➔ directly open box to validate our analysis/fitting codes.
 - (Lin ZHU has done this check, we can give double check.)

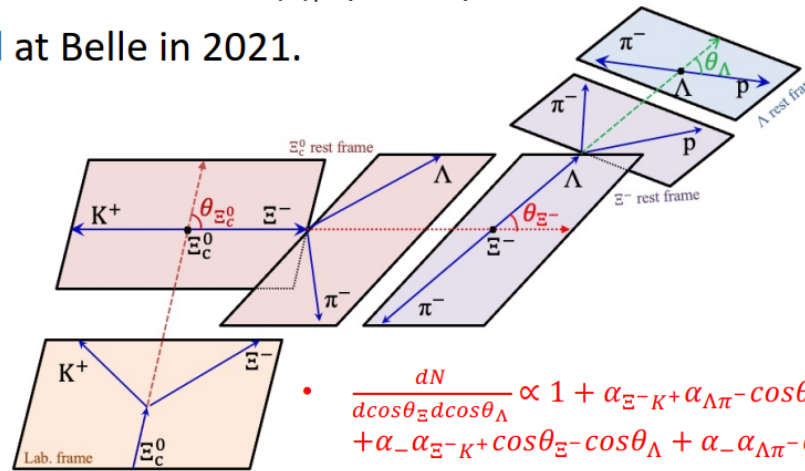
$$A_{CP} = (\alpha^+ + \alpha^-) / (\alpha^+ - \alpha^-)$$

Belle, PRL 127, 121803 (2021)



$$\alpha_{avg}(\Xi_c^0 \rightarrow \Xi^- \pi^+) = -0.63 \pm 0.03 \pm 0.01$$

$$\Rightarrow \sigma(A_{CP}^\alpha(\Xi^- \rightarrow \Lambda \pi^-)) = 0.013$$



$$\frac{dN}{d\cos\theta_{\Xi} d\cos\theta_{\Lambda}} \propto 1 + \alpha_{\Xi^- K^+} \alpha_{\Lambda \pi^-} \cos\theta_{\Xi^-} + \alpha_{\Xi^- K^+} \cos\theta_{\Xi^-} \cos\theta_{\Lambda} + \alpha_{\Lambda \pi^-} \cos\theta_{\Lambda}$$

If the angle θ_{Λ} is integrated out, one has

$$\frac{dN}{d\cos\theta_{\Xi}} \propto 1 + \alpha_{\Xi^- K^+} \alpha_{\Xi^-} \cos\theta_{\Xi^-}$$

first α -result for Ξ_c^0 SCS decays

Data and MC Samples

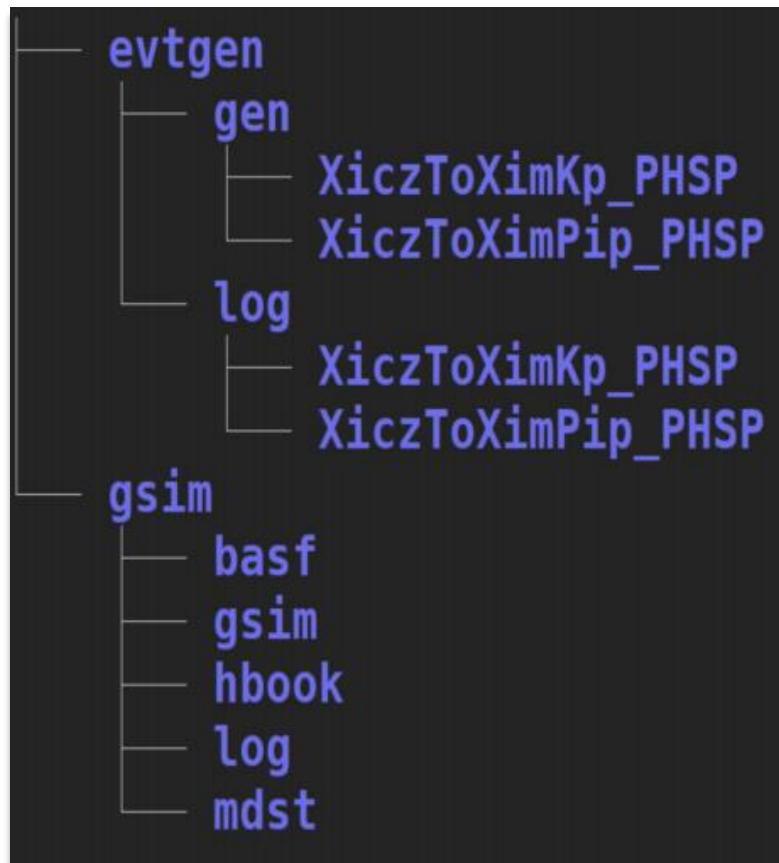
Signal MC:

- Belle: Generated 1M events for each decay mode using EvtGen generators under basf software framework.

Inclusive MC:

- Belle: Official charged, mixed, charm, anduds samples. (Υ 4S) Their luminosities are 4 times to the data samples.

蒙卡模拟 (I)



- 限于时间
- 之前分析里面采用的**Belle**上数据
 - ➔ 在**basf2**上对**belle**的信号MC进行模拟
 - ➔ 相关文件如图左所示
 - ➔ 2 M的MC样本

MC simulation

```
Alias myanti-Lambda0 anti-Lambda0
Alias myXi- Xi-
Alias myanti-Xi+ anti-Xi+
ChargeConj myLambda0 myanti-Lambda0
ChargeConj myXi- myanti-Xi+

Decay vpho
#
1.000 PYCONT d u s c b t e mu tau
0 0 0 1 0 0 0 0 0 0 0 0;
Enddecay

Decay Xi_c0
1.0 myXi- K+ PHOTOS PHSP;
Enddecay

Decay anti-Xi_c0
1.0 myanti-Xi+ K- PHOTOS PHSP;
Enddecay

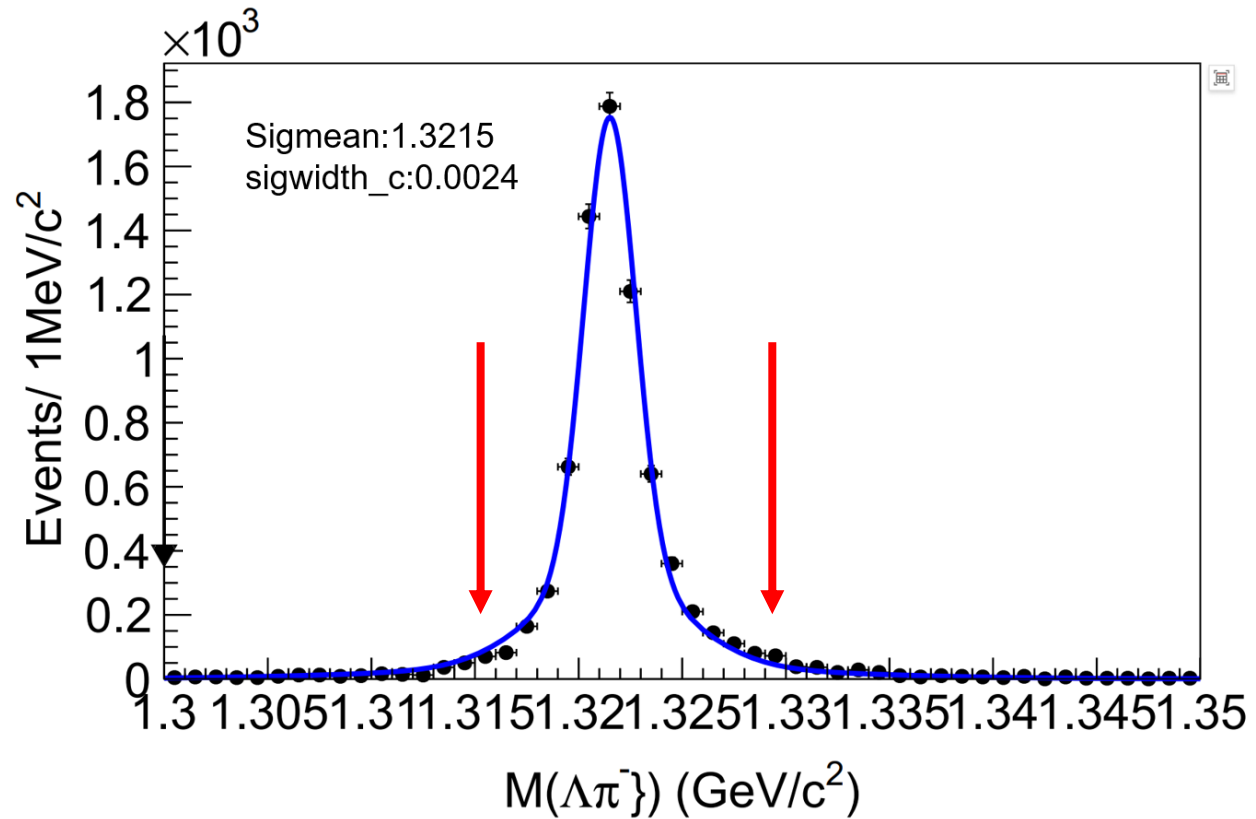
Decay myXi-
1.0 myLambda0 pi- PHOTOS PHSP;
Enddecay
CDecay myanti-Xi+

Decay myLambda0
1.00 p+ pi- PHOTOS PHSP;
Enddecay
CDecay myanti-Lambda0
```

Event Selection Criteria

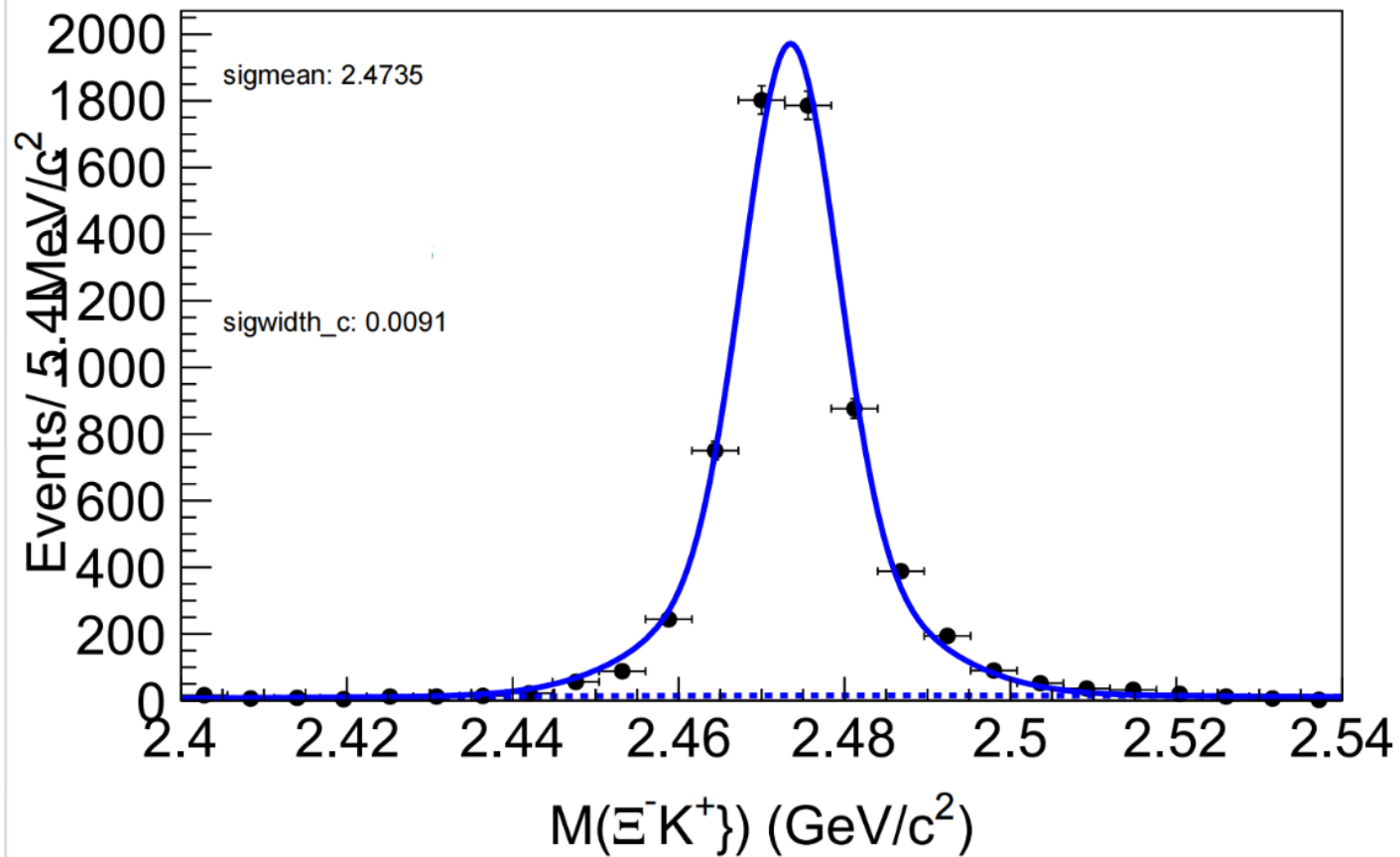
Λ candidates	$\text{goodBelleLambda} > 0$ stdLambdas and $L_{dec}/L_{\sigma}(\Lambda) > 10$ $R(p \pi) > 0.6, R(p K) > 0.6$ for proton, $ M_{p\pi} - m_{\Lambda} < 3 \text{ MeV}/c^2$
Ξ^- candidates	stdXi- requires $R(p \pi) > 0.2$ and $R(p K) > 0.2$ for proton; $ dM_{\Lambda} < 3.5 \text{ MeV}/c^2$, $\cos \theta_{\langle \vec{p}, \vec{r}_{\text{vtx}} \rangle}(\Lambda) > 0, dr^2 + dz^2 (\Lambda) > 0.35 \text{ cm}; 1.295 < M < 1.35 \text{ MeV}/c^2$ goodXi- requires treeFit with Λ mass constraint, $\cos \theta_{\langle \vec{p}, \vec{r}_{\text{vtx}} \rangle}(\Xi) > 0, 0 < dr^2 + dz^2 (\Xi) < dr^2 + dz^2 (\Lambda)$ $L_{dec}/L_{\sigma}(\Xi^-) > 5$, and $ M_{\Lambda\pi^-} - m_{\Xi^-} < 6.5 \text{ MeV}/c^2$
Prompt charged tracks	$dr < 0.5 \text{ cm}, dz < 2 \text{ cm}; R(\pi K) > 0.6$ for π ; $R(K \pi) > 0.6$ for K
Ξ_c^0 candidates	treeFit with IP constraint and hyperon (K_S^0, π^0) mass constraint ($\text{chiProb} > 0.001$) $\chi^2 < 40$

Distribution of $M(\Lambda\pi^-)$



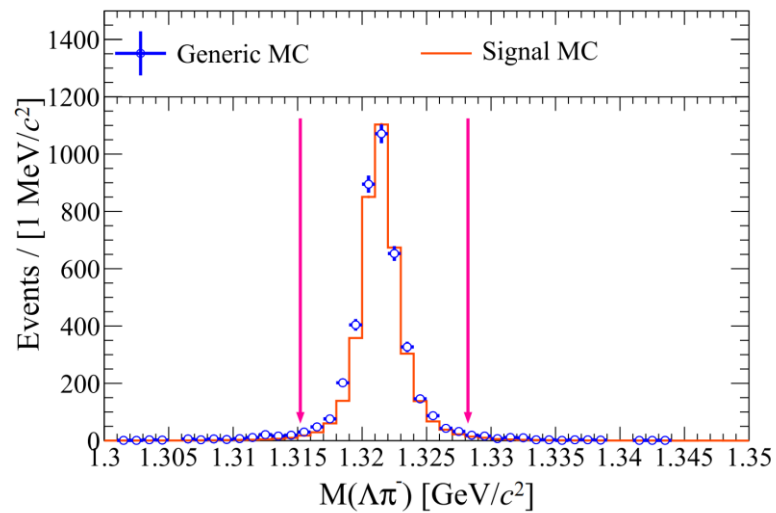
$$|M_{\Lambda\pi^-} - m_{\Xi^-}| < 6.5 \text{ MeV}/c^2$$

Distribution of $M(\Xi^- K^+)$

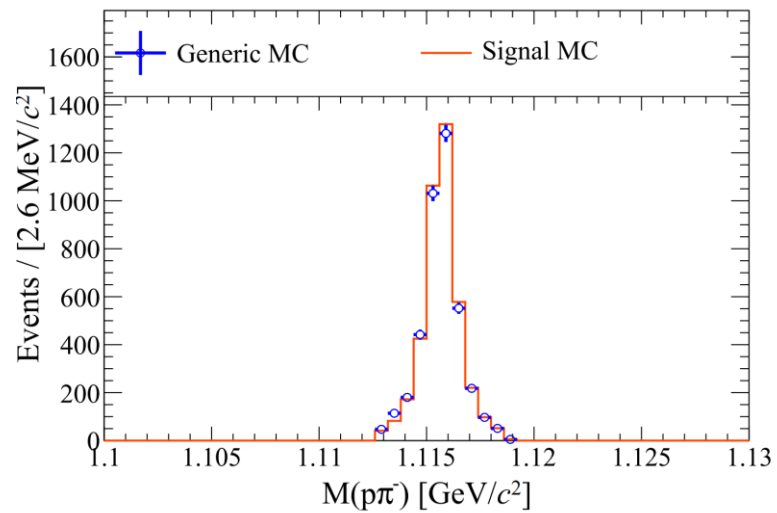


$$\Xi_c^0 \in (2.35, 2.60) \text{ GeV}/c^2$$

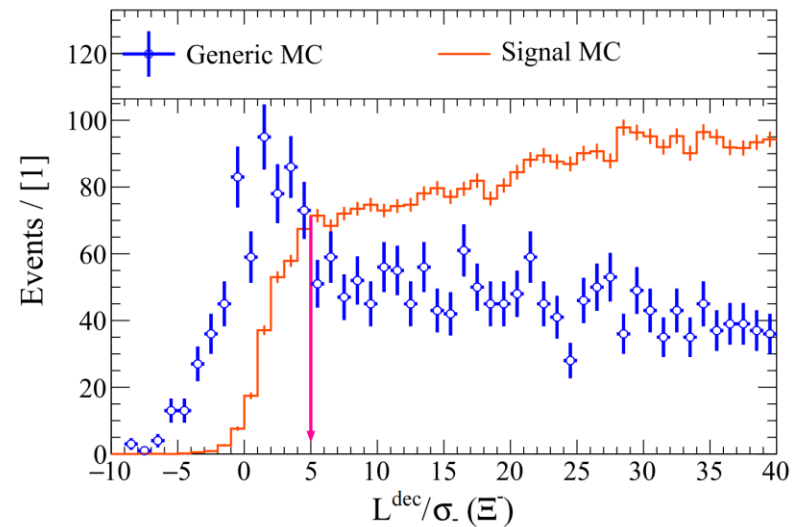
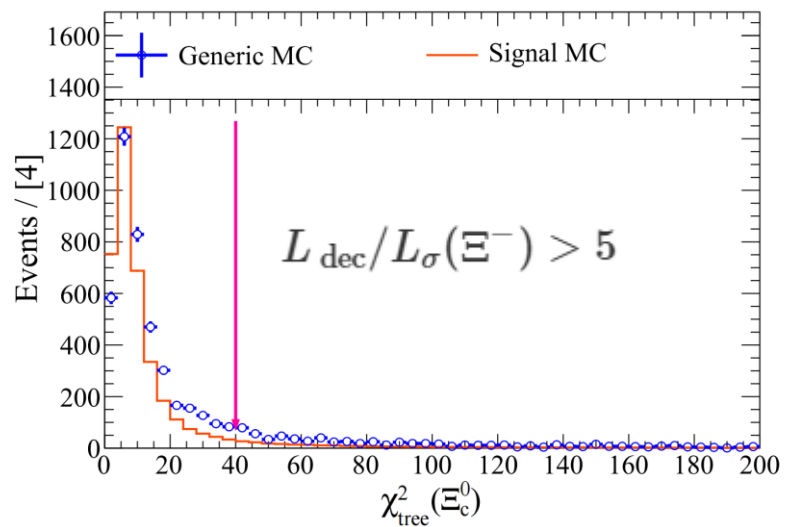
分布比较



$$|M_{\Lambda\pi^-} - m_{\Xi^-}| < 6.5 \text{ MeV}/c^2$$

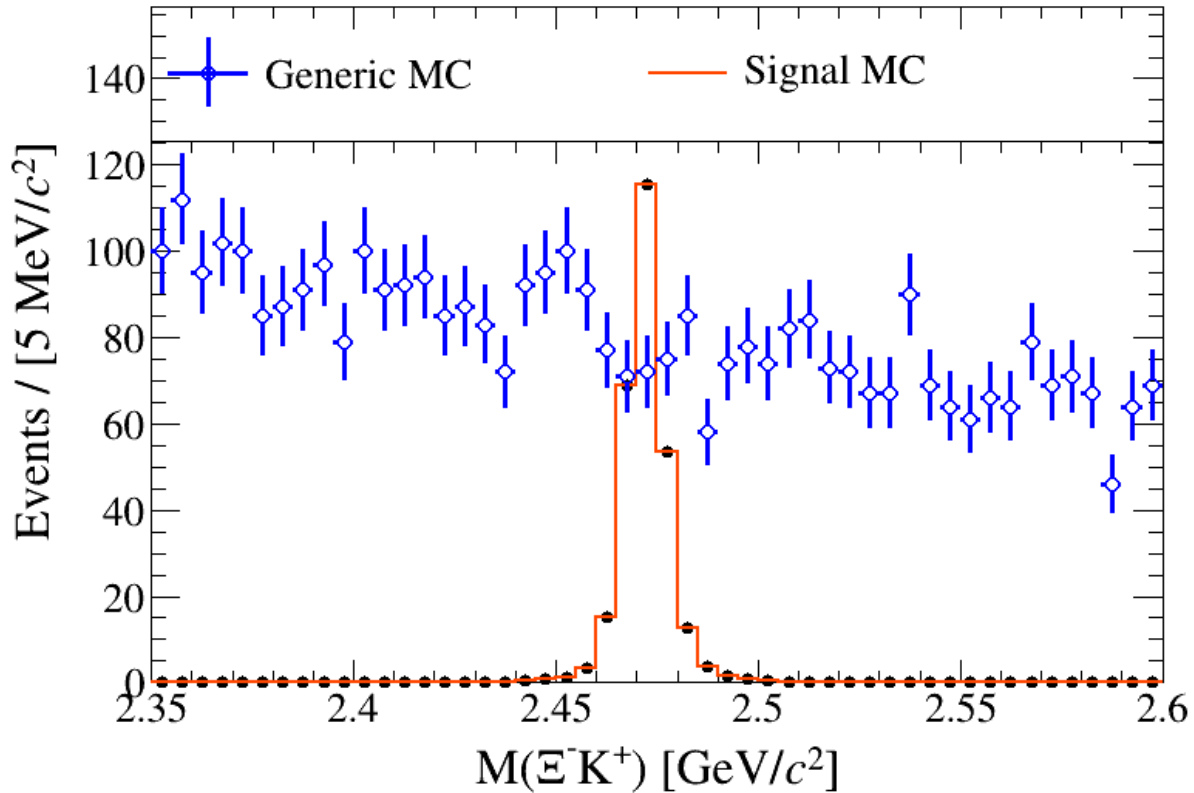


$$|M_{p\pi^-} - m_{\Lambda}| < 3 \text{ MeV}/c^2$$



$$\chi^2 < 40$$

Data and MC Samples



没有看到显著的含 Ξ_{cc}^0 贡献的本底过程!

→ 后续会进一步确认

Summary and Outlook

Summary

- ✓ A study on the event selection criteria for the process $\Xi_c^0 \rightarrow \Xi^- K^+$.
- ✓ Drawing from related analyses, we have preliminarily established the conditions to reduce the background noise.
- ✓ After the final selection criteria, the distribution in the generic MC is essentially smooth, with no significant background processes containing contributions from Ξ_c^0 being observed.

Outlook

Learning tools such as ROOT, LaTeX, and Python to carry out tasks like plotting graphs and writing experimental memos.

- **Studying to optimize event selection criteria.**
- **Learning to estimate systematic errors.**
- **Selecting the process $\Xi_c^0 \rightarrow \Xi^- \pi^+$ as a control sample to validate the research strategy.**

Thanks!

