Preliminary study of the $B^0 \to K_S^0 \psi(2S)$ at Belle II

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@ B2 winter school

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Contributions of each group member

- Jiaxin Pi: Give the report, learn basic skills
- Jing Yuan: Draw plots & Fit, teach skills
- Xiang Zhao: Determine preliminary selection criteria
- Shiming Zou: Draw plots & Fit results
- Shiqing Xie: Choose the topic, search for reference

Motivation

- Previous measurements of CP asymmetries in b → ccs transitions have been reported by Belle [1, 2] and BaBar [3].
- Results from Belle (Based on 657×10^6 $B\bar{B}$ pairs collected at the $\Upsilon(4S)$ resonance) [4]:

$$\mathcal{S}_{\psi(2S)K^0_S} = +0.72 \pm 0.09(\text{stat}) \pm 0.03(\text{syst})$$

$$\mathcal{A}_{\psi(2S)K^0_S} = +0.04 \pm 0.07(\text{stat}) \pm 0.05(\text{syst})$$

- With new collected data sample @Belle II, we can update the results of branching fraction of $B^0 \to K^0_S\psi(2S)$.

[1] K. Abe et al. (Belle Collaboration), Phys. Rev. D 71, 072003 (2005).
[2] K-F. Chen et al. (Belle Collaboration), Phys. Rev. Lett. 98, 031802 (2007).
[3] B. Aubert et al. (BaBar Collaboration), hep-ex/0703021 (submitted to Phys. Rev. Lett.).
[4] BELLE-CONF-0770

Datasets and Analysis Strategy

Run-independent signal MC:

- 1 M signal MC samples are generated using EvtGen.
- The $B^0 \to K_S^0\psi(2S)$ is generated with SSD_CP model, $\psi(2S) \to \pi^-\pi^+J/\psi$ is generated with VVPIPI model, $J/\psi \to \ell^+\ell^-(\ell = e, \mu)$ is generated with VLL model, and $K_S^0 \to \pi^+\pi^-$ decays are generated with PHSP model.

Charged-conjugate modes are implicitly assumed.

Inclusive MC:

- Belle II: MC15_ri inclusive samples, ~40 fb^{-1}.

- We reconstruct the decay modes $B^0 \to K_S^0\psi(2S)$, followed by the decays, $\psi(2S) \to \pi^-\pi^+J/\psi, J/\psi \to \ell^-\ell^+(\ell = e, \mu), K_S^0 \to \pi^+\pi^-$.
- We use the Belle II analysis software framework (BASF2) to reconstruct the events.

Event Selection Criteria

Charged track

- dr<0.5cm and |dz|<3cm
- theta in CDC acceptance
- chiProb>0
- nCDCHits>0
- pt>0.1 GeV/c
- pionIDNN>0.1

Photon

- |clusterTiming| < 200 ns
- clusterNHits > 1.5
- 0.2967<clusterTheta<2.618
- barrel: clusterE > 50 MeV
- forward endcap: clusterE > 75 MeV
- backward endcap: clusterE > 100 MeV

Electron

- stdE("FixedThresh09", "bdt", "global”
- electronID_noSVD>0.9
- 0.8<E/p<1.2

Muon

- stdMu:“FixedThresh09”, “likelihood”, “global”
- muonID_noSVD>0.9
- E/p<0.6

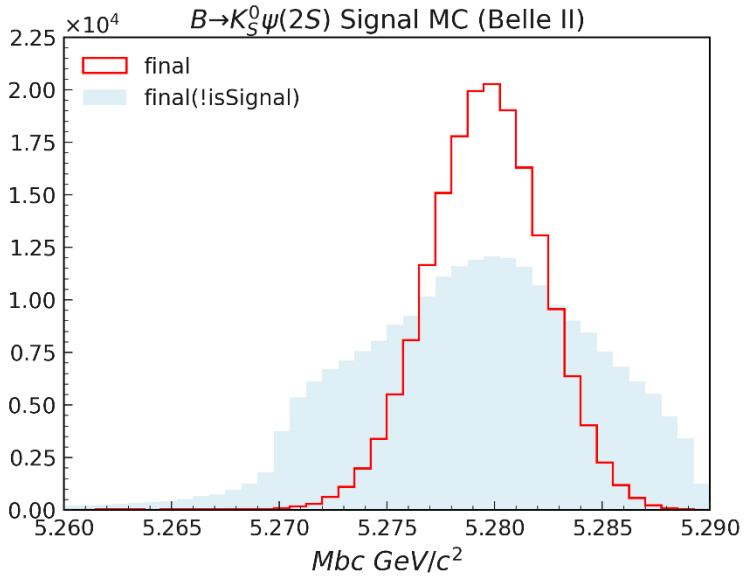
Charged lepton

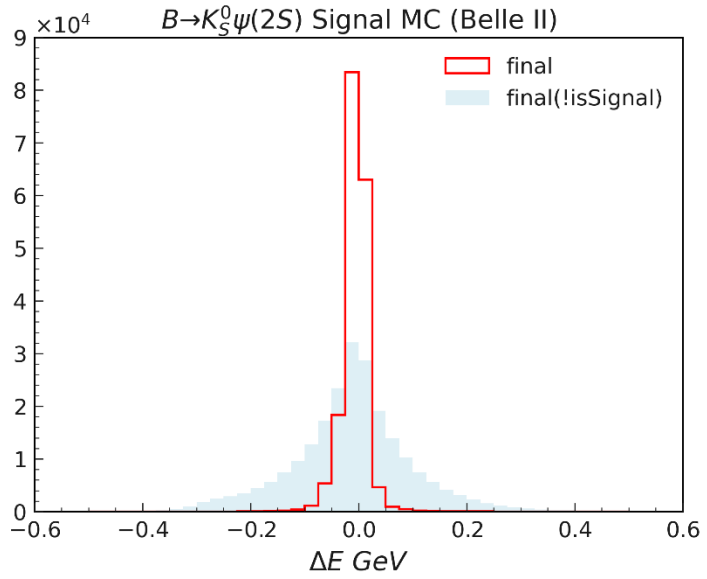
- dr<1cm and |dz|<3cm
- pt>0.1GeV
- correctBremsBelle

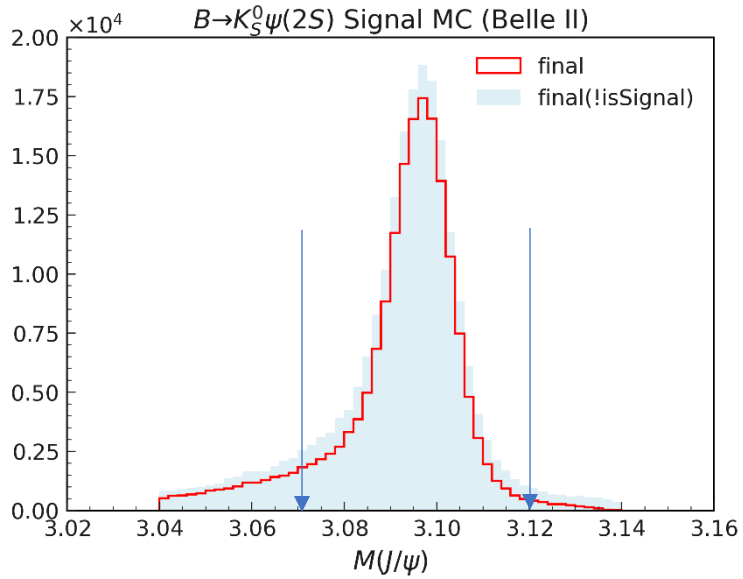
Fit

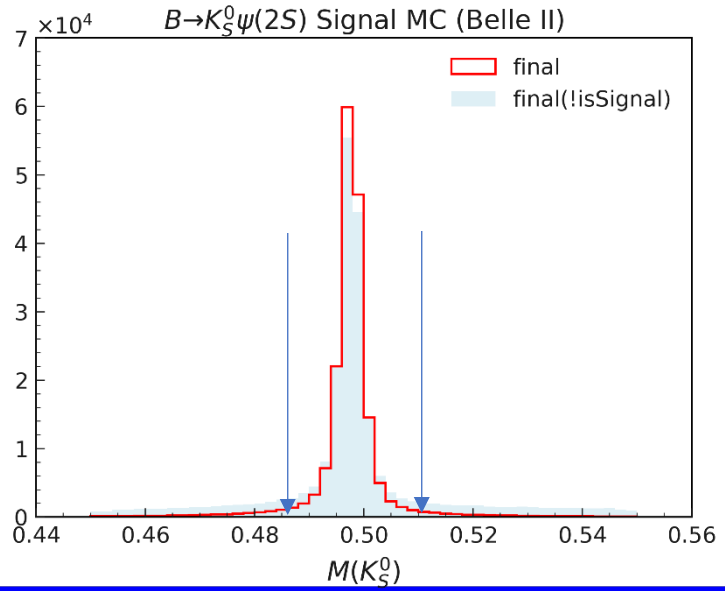
- Mass constrained vertex fit for J/ψ. TreeFit for B^0.

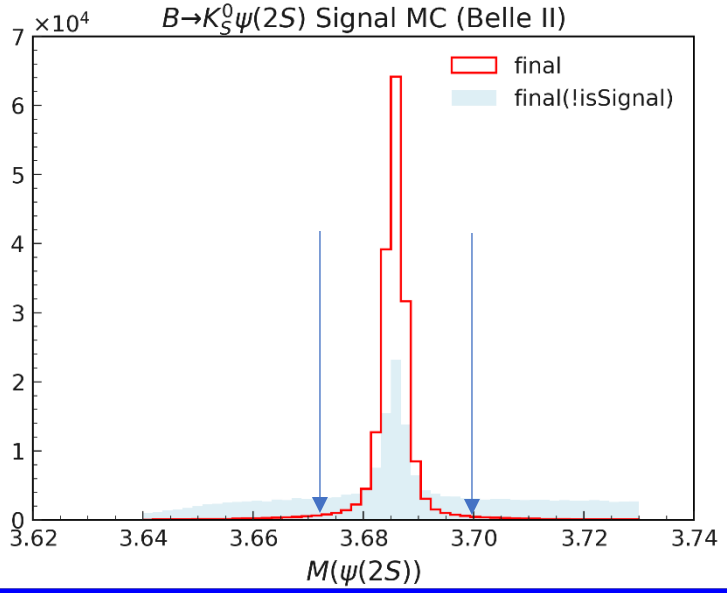
Study of the Signal MC



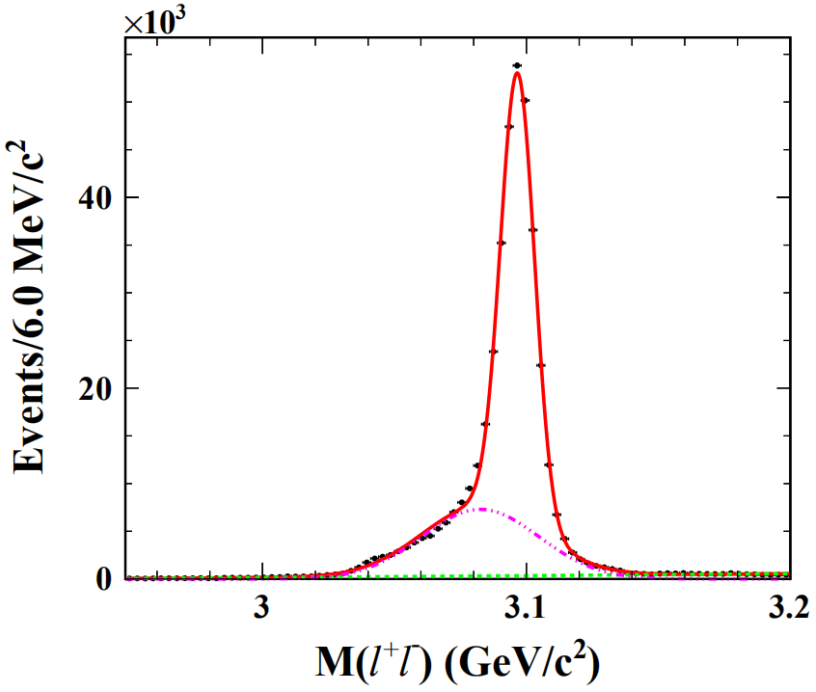




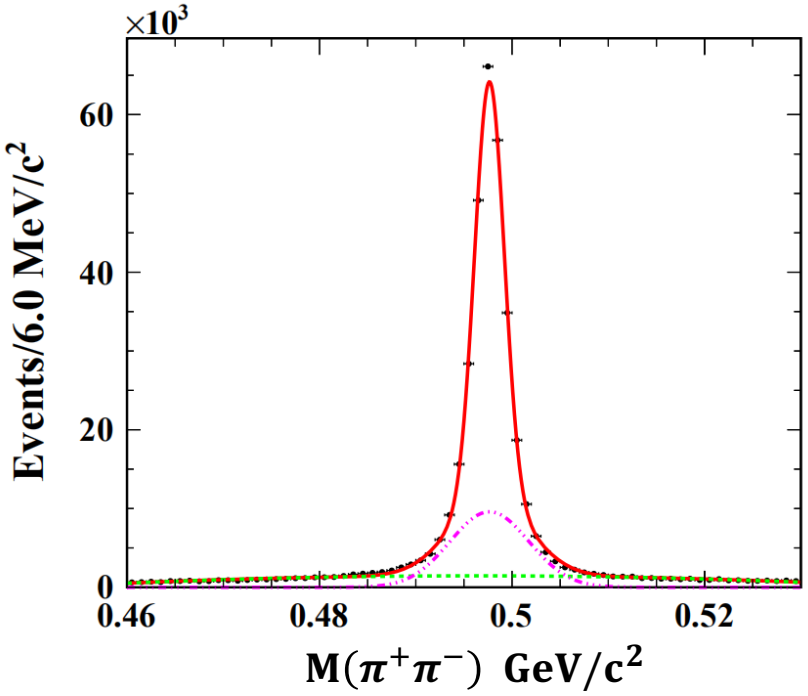




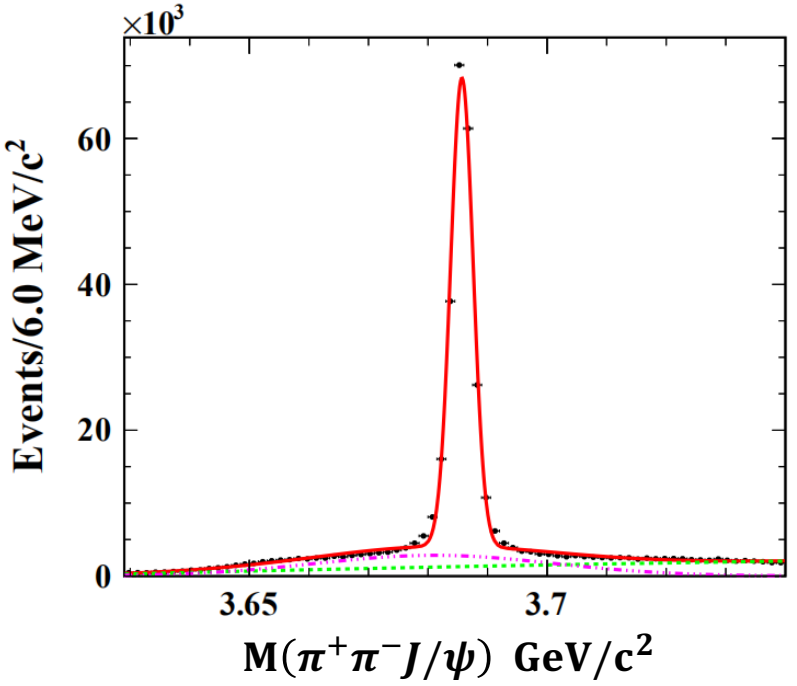
Study of the Signal MC



$M = 497.7\ \mathrm{MeV/c^2}$
$\sigma = 2.7\ \mathrm{MeV/c^2}$



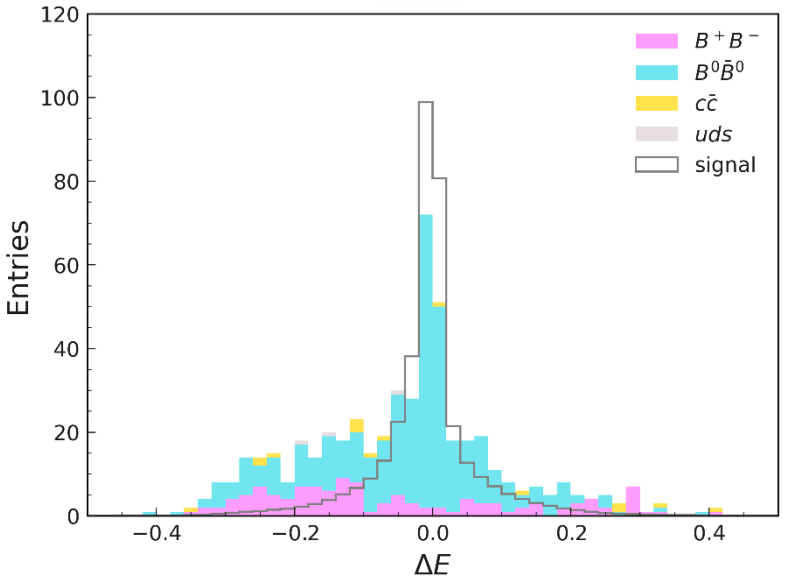
$M = 3096.7\mathrm{MeV/c^2}$
$\sigma = 6.5\ \mathrm{MeV/c^2}$

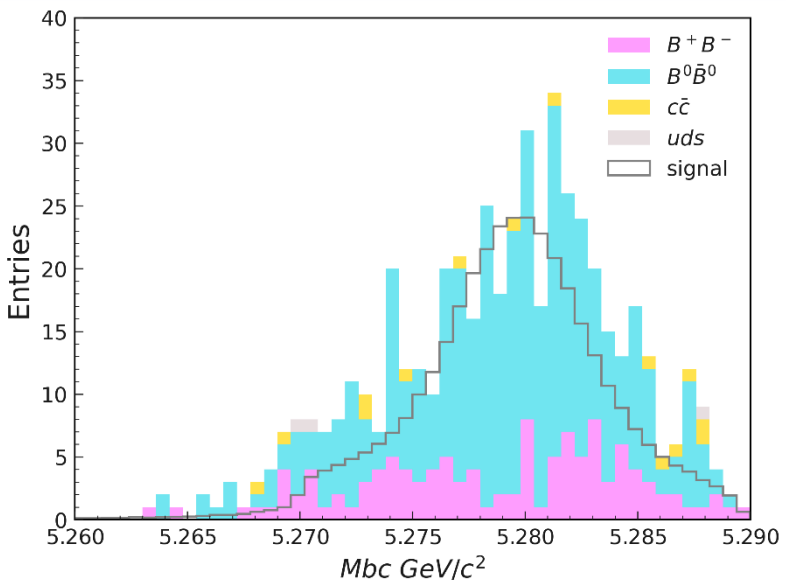


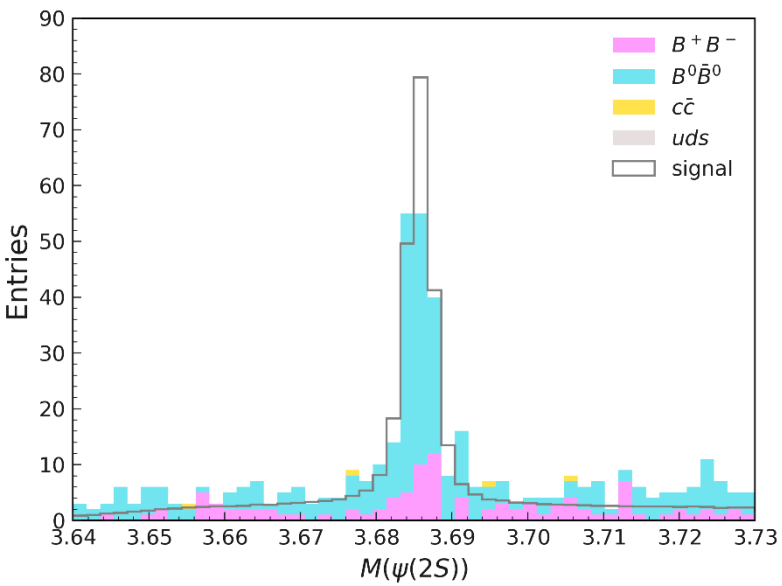
$M = 3685.7\mathrm{MeV/c^2}$
$\sigma = 1.8\ \mathrm{MeV/c^2}$

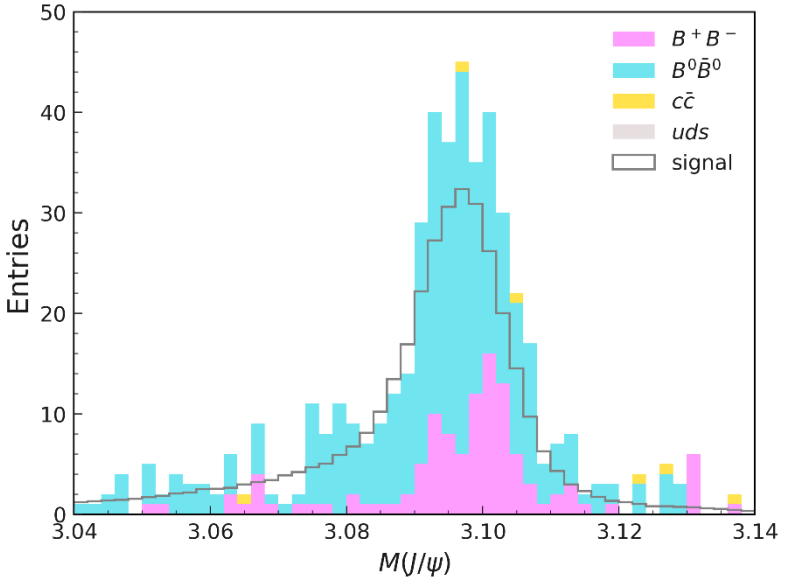
Signal: double-Gaussian
Bkg:1st –order Cheybshev

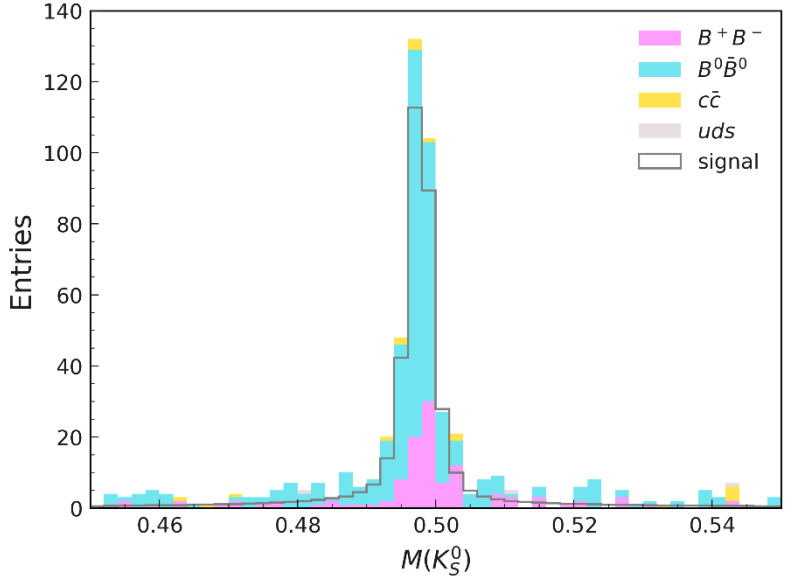
Study of the Generic MC



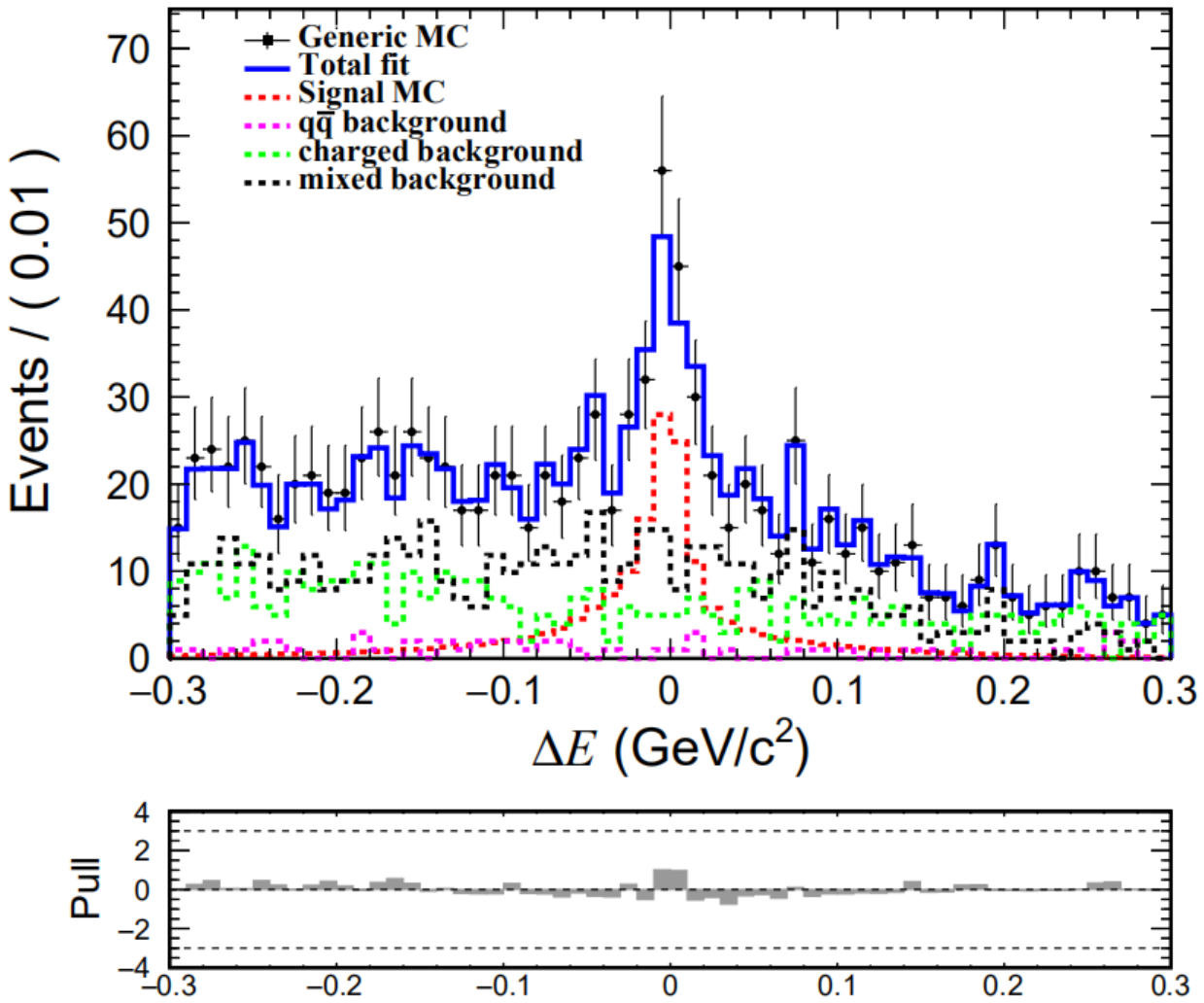


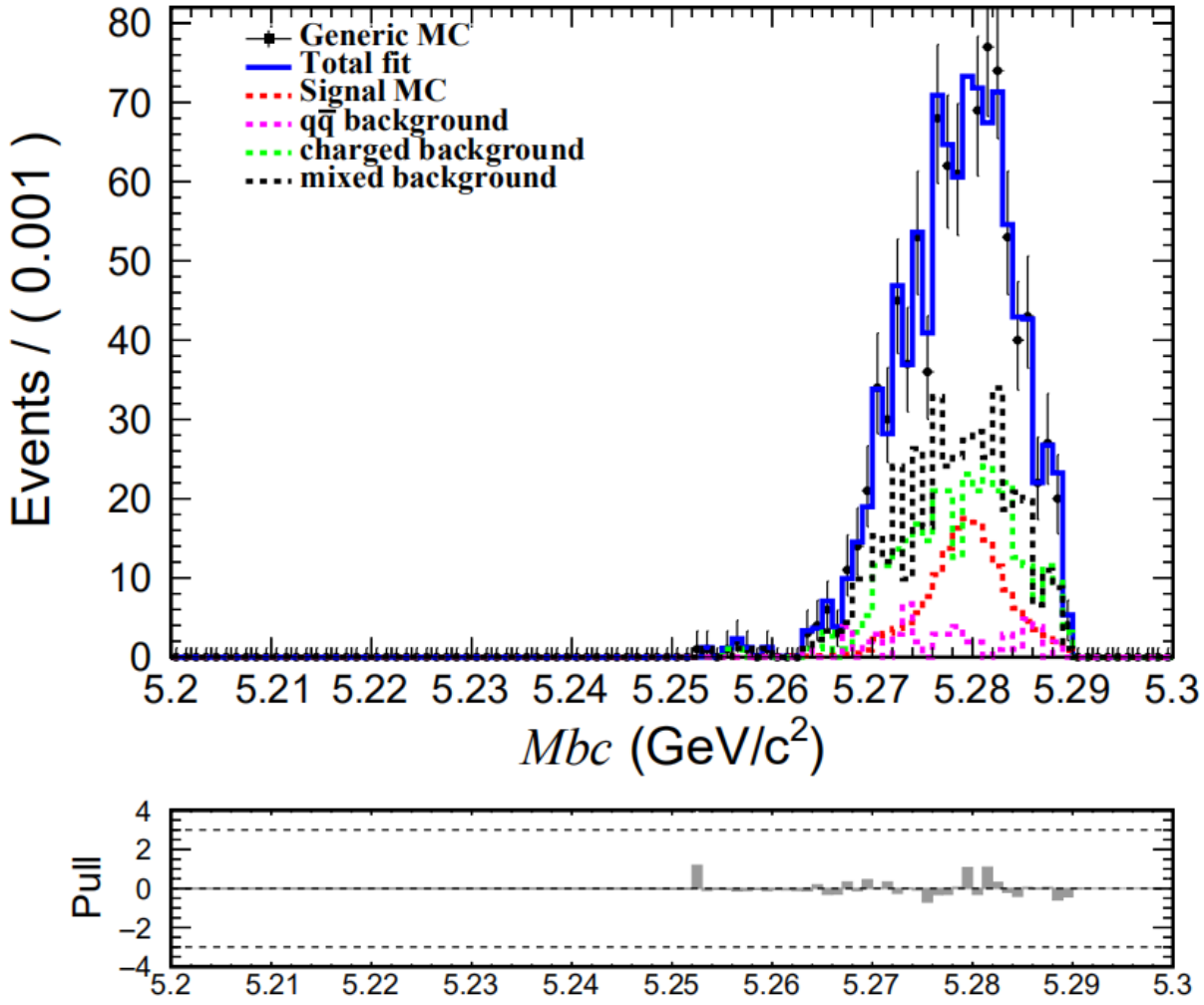






Fit of the Generic MC





$$N_{sig} = 170 \pm 23$$

Branching fraction calculation & Summary

$$\mathrm{Br} = \frac{N_{sig}}{N_{B^0} \times \Pi Br \times \epsilon}$$

$$N_{B^0} = 2 \times \sigma \times L$$

$$\epsilon = 23.0\%$$

$$\boldsymbol{Br = (6.0 \pm 0.8) \times 10^{-4}}$$

- Has the same order of magnitude with PDG value.
- We will improve the selection criteria and fit procedure in the future.

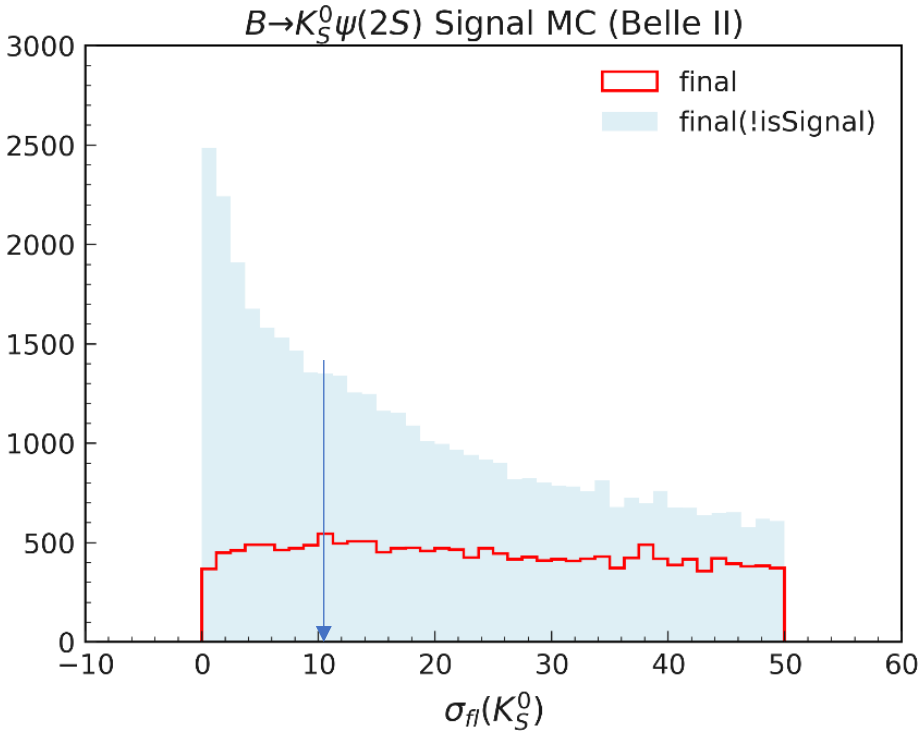
✓We determine the event selection criteria for $B^0 \to K_S^0 \psi(2S)$.

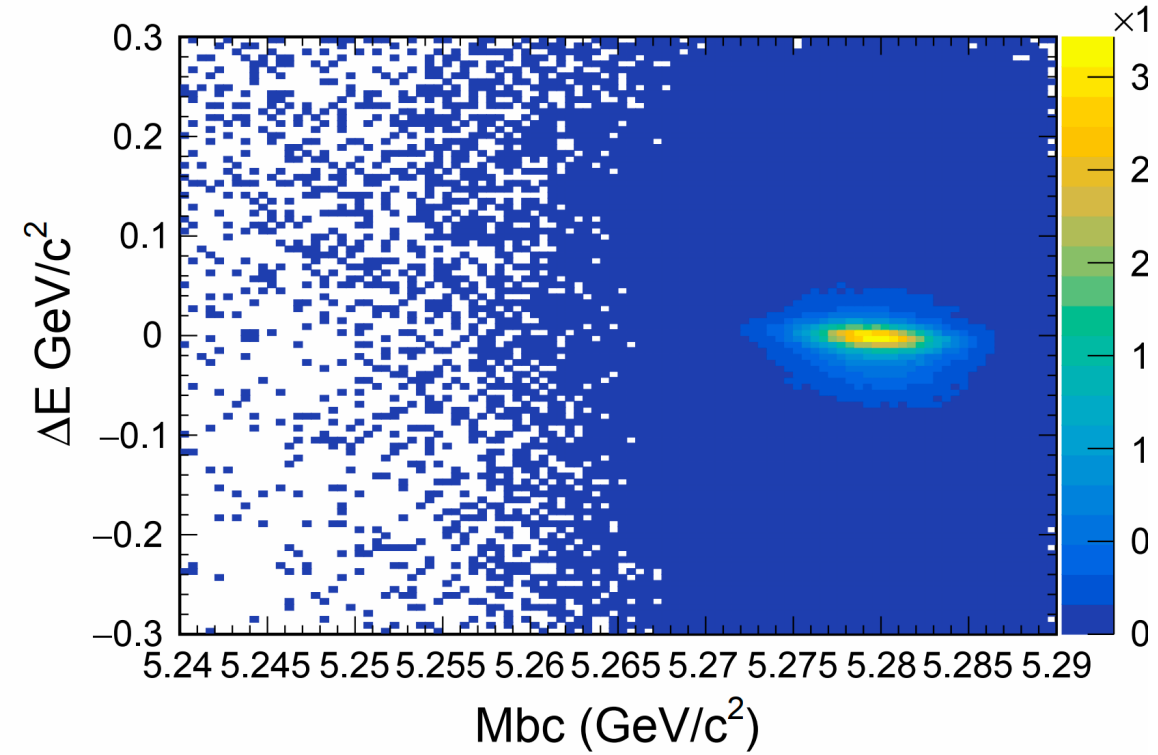
✓Distributions of signal MC and generic MC are investigated.

✓Using ~40 fb^{-1} generic MC, we perform a primary fit, and the branching fraction is calculated.

Thank you ☺

Back up


$B \to K^0_S \psi(2S)$ Signal MC (Belle II)
final
final(!isSignal)
3000
2500
2000
1500
1000
500
0
−10
0
10
20
30
40
50
60
$\sigma_{fl}(K^0_S)$


ΔE GeV/c^2
0.3
0.2
0.1
0
−0.1
−0.2
−0.3
5.24 5.245 5.25 5.255 5.26 5.265 5.27 5.275 5.28 5.285 5.29
Mbc (GeV/c^2)
×1
3
2
2
1
1
0
0