Study of $B^+ \to \chi_{c1} K^+ \pi^0$

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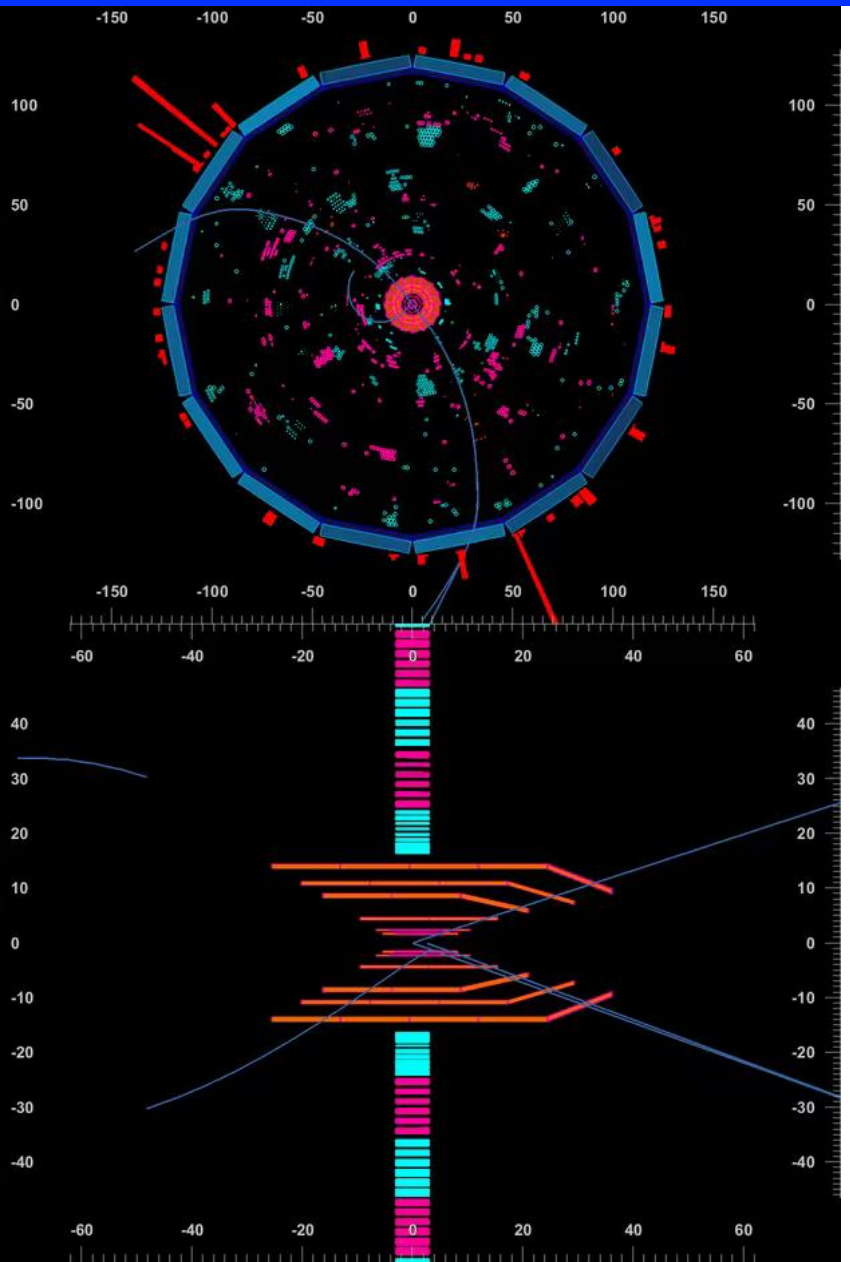
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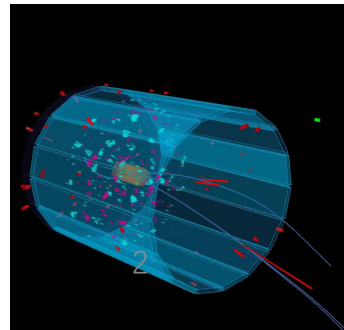
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Outline



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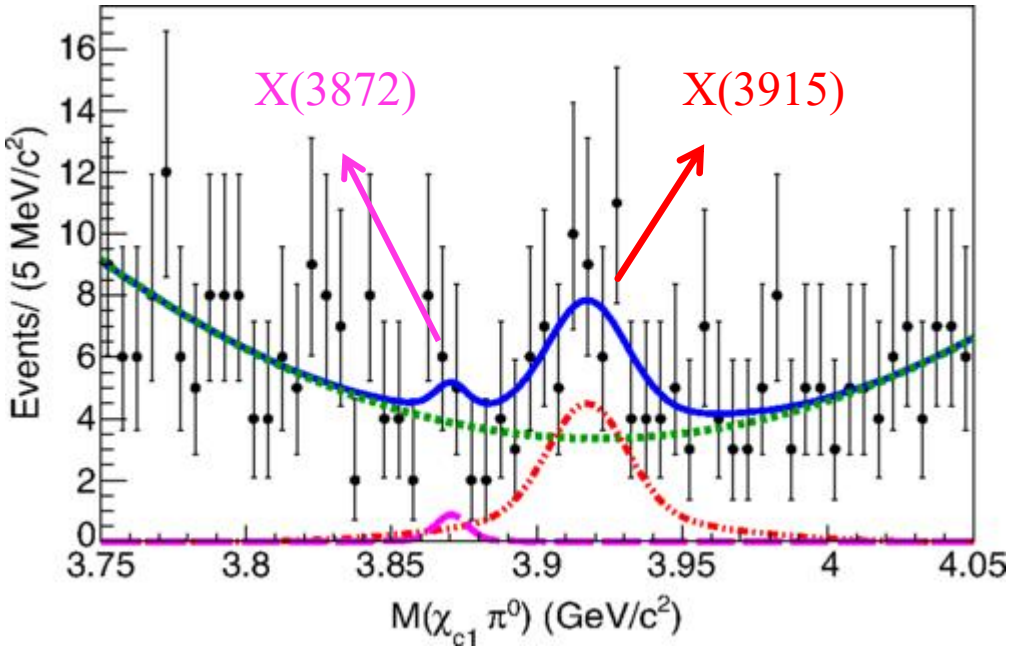
Motivation

Belle branching-fraction measurement

$\mathcal{B}(B^+ \to \chi_{c1} K^+ \pi^0) = (3.29 \pm 0.29_{\text{stat.}} \pm 0.19_{\text{syst.}}) \times 10^{-4}$

Measured with 711 fb^{-1} at $\Upsilon(4S)$.

Data sets	Luminosity($\mathcal{L}$) / fb^{-1}
Belle at $\Upsilon(4S)$	711
Belle II recorded at $\Upsilon(4S)$	808
Belle + Belle II recorded	1519



Belle Phys. Rev. D 99, 111101(R)

2.14× the luminosity of the 2016 Belle measurement

- **Improve precision of the branching fraction.**
- **Search for additional resonances.**

Belle, Phys. Rev. D 93, 052016 (2016) · Belle, Phys. Rev. D 99, 111101 (2019) · Belle II recorded luminosity through the 2026 run

Datasets

■ Signal MC

Decay	Generator model
$\Upsilon(4S) \to B^+B^-$	VSS
$\boldsymbol{B^+ \to \chi_{c1} K^+ \pi^0}$	PHSP
$\boldsymbol{\chi_{c1}} \to J/\psi\,\gamma$	VVP
$J/\psi \to l^+l^-$	PHOTOS VLL
$\pi^0 \to \gamma\gamma$	PHSP

■ Generic MC

- Belle II $\Upsilon(4S)$ generic MC (run1+run2)

■ Data

- Belle II $\Upsilon(4S)$ data $(520 \times 10^6\ B\overline{B}, 488\ fb^{-1})$

■ Analysis release

- light-2609-luna

Event selection

■ Event and track selection

- Event level: $N_{tracks} \geq 3$
- $d_r < 2$ cm, $|d_z| < 4$ cm
- thetaInCDCAcceptance
- $p_T > 0.1$GeV/c

■ Particle identification(PID)

- $K^{\pm}$: $\mathscr{L}(K/\pi) > 0.6$
- $e^{\pm}$: electron IDNN >0.1, with bremsstrahlung correction
- $\mu^{\pm}$: muon IDNN>0.1

■ Photon selection

- $E_\gamma > 70$MeV
- $\gamma_{bkg} > 0.1$, $\gamma_{fake} > 0.1$

■ π^0 reconstruction

- $\pi^0 \rightarrow \gamma\gamma$, loose mass window: $M_{\gamma\gamma} \in [0.08, 0.18]$GeV/$c^2$

■ J/ψ reconstruction

- $M_{e^+e^-} \in [2.9, 3.2]$ GeV/c^2
- $M_{\mu^+\mu^-} \in [2.9, 3.2]$ GeV/c^2

■ χ_{c1} reconstruction

- $M_{\gamma\ J/\psi} \in [3.2, 3.7]$GeV/$c^2$

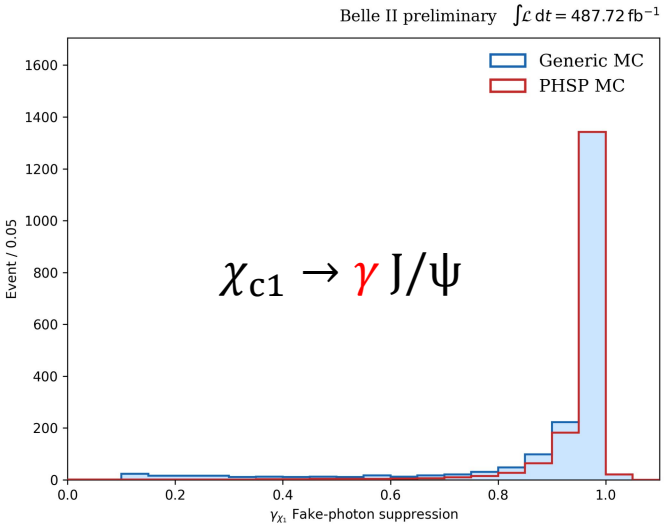
■ B candidate reconstruction

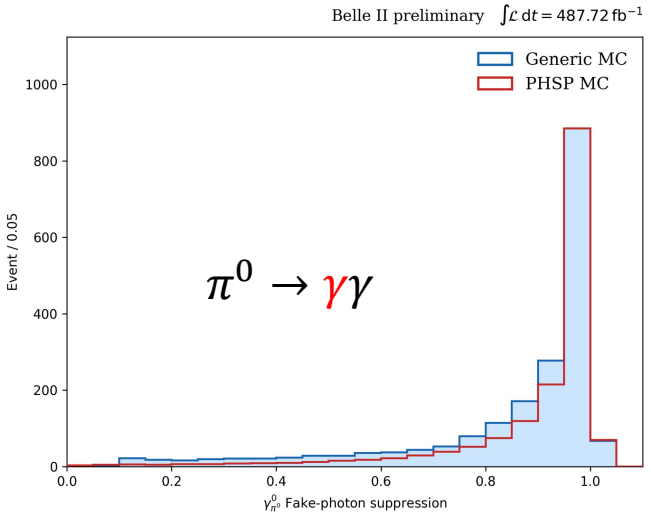
- $M_{bc} > 5.25$ GeV/c^2, $|\Delta E| < 100$MeV

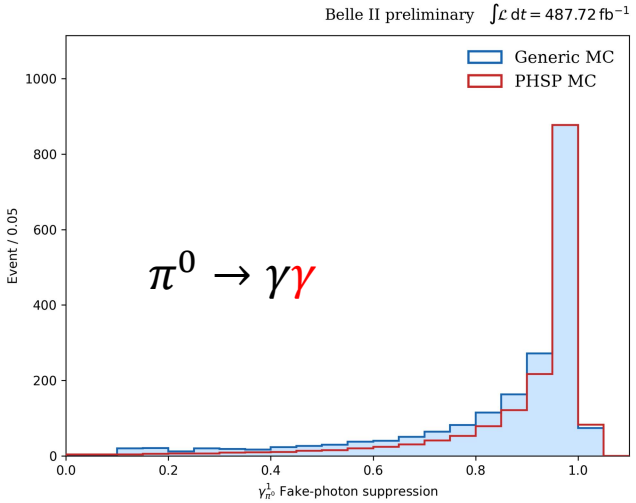
■ Optimization

- Maximize the Punzi figure-of-merit(FOM) $\frac{\varepsilon}{\frac{3}{2}+\sqrt{N_b}}$
- ε : combined signal recon. efficiency weighted by BR.
- N_b: number of background in the generic MC samples

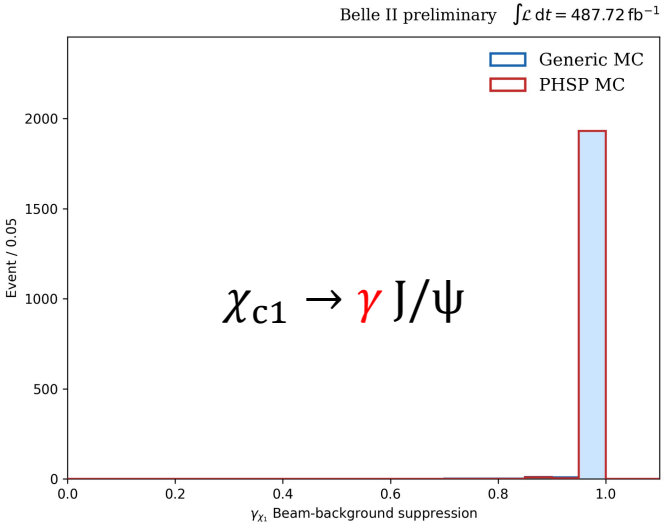
Photon background subtraction

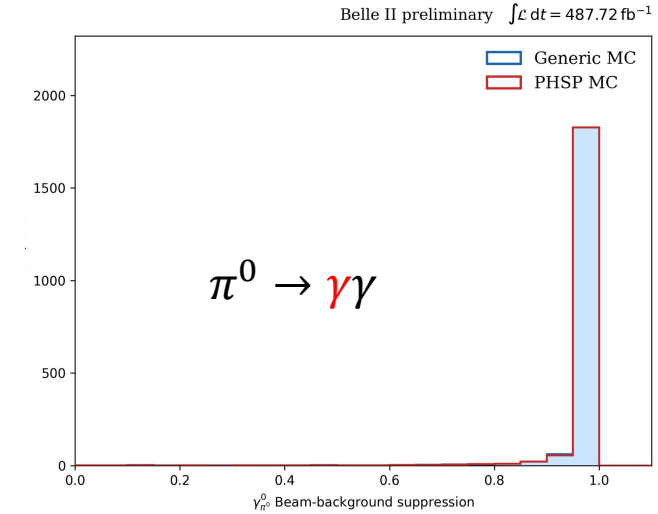


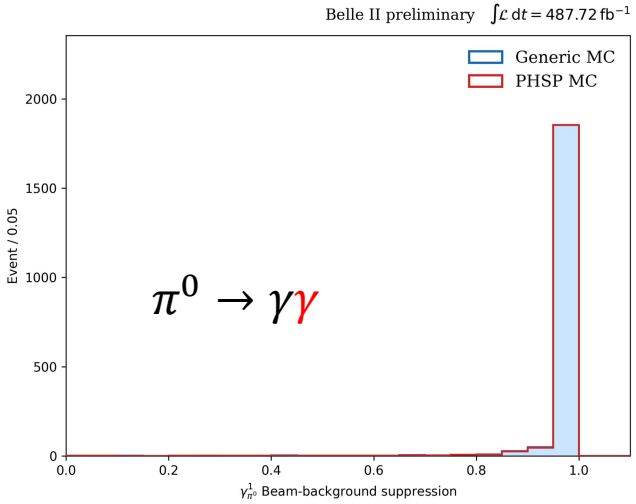




$$\gamma_{\text{sup}}^{\text{fake}} > 0.1$$

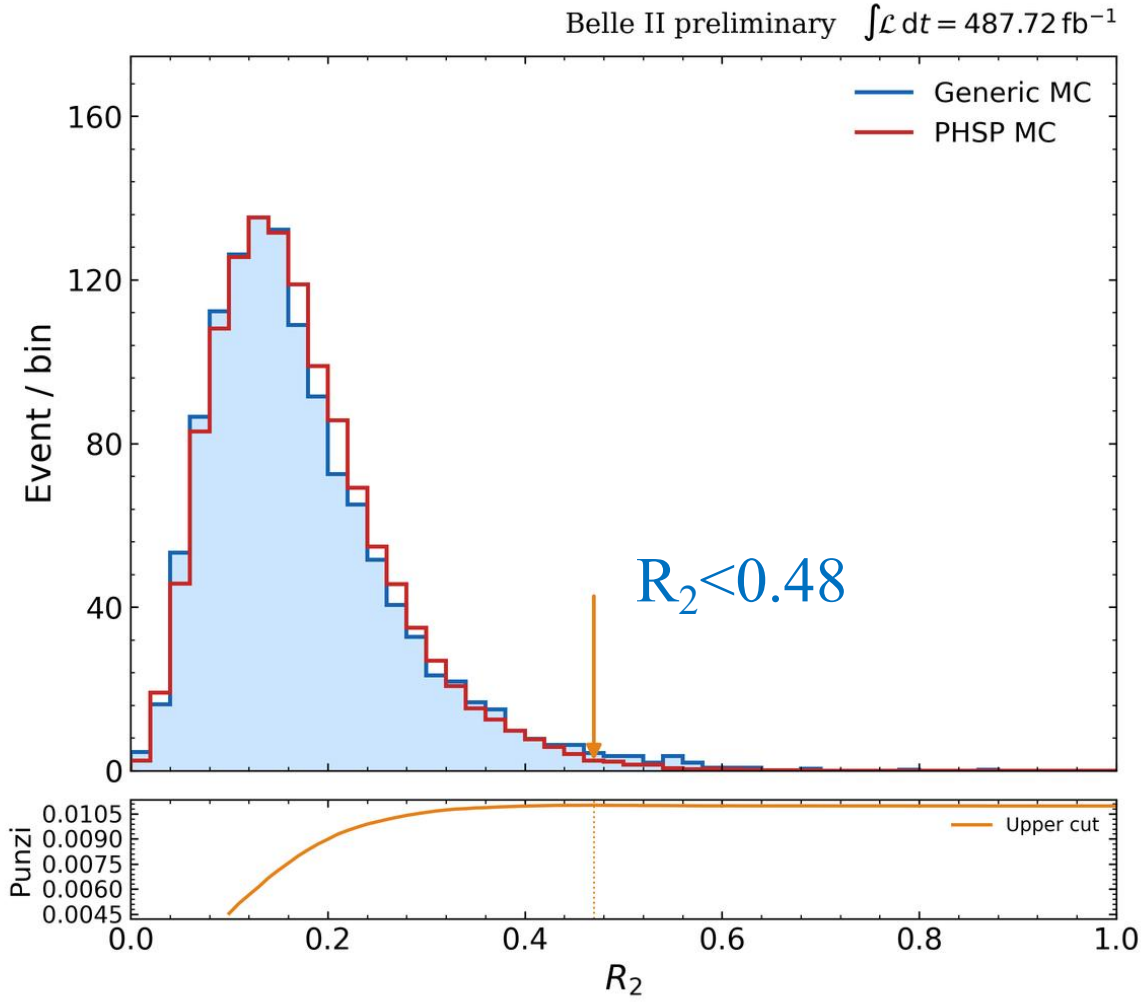






$$\gamma_{\text{sup}}^{\text{beam}} > 0.1$$

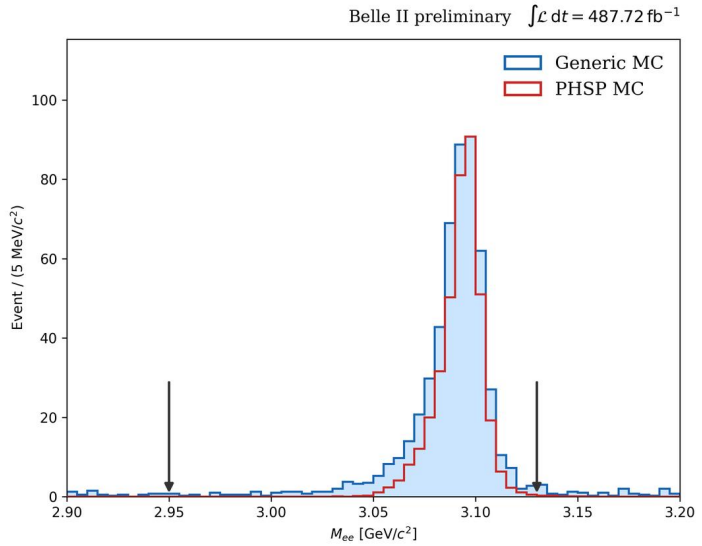
Event shape selection

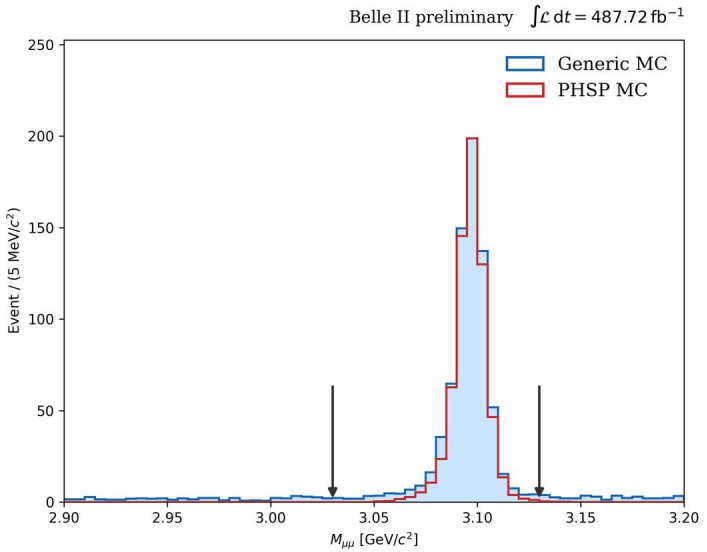


R_2

- Ratio of the second- to the zeroth-order Fox–Wolfram moment
- R_2 lies in the range [0, 1]; its value directly reflects the "shape" of an event:
  - $R_2 \rightarrow 1$: jet-like events — the typical signature of continuum background ($e^+e^- \rightarrow q\bar{q}$).
  - $R_2 \rightarrow 0$: spherical events, i.e. a more isotropic spatial distribution of the particles — the typical signature of $B\bar{B}$ signal events (e.g. $\Upsilon(4S)$ decays).

J/ψ reconstruction



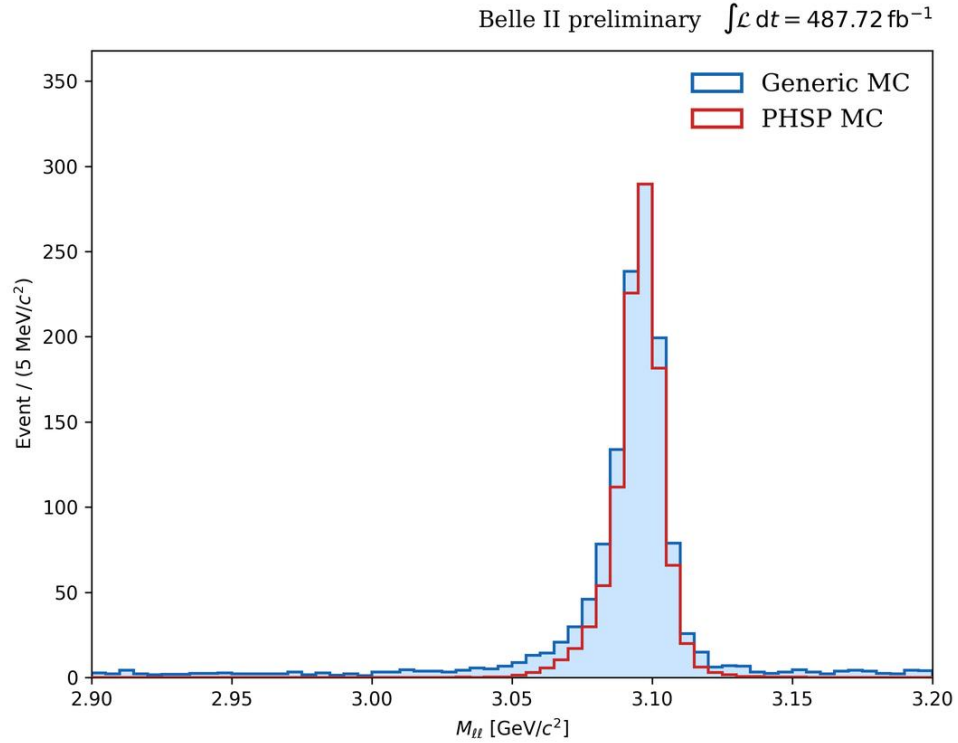


$M_{e^+e^-} \in [2.95,\ 3.13]\ \mathrm{GeV}/c^2$

Combine channels

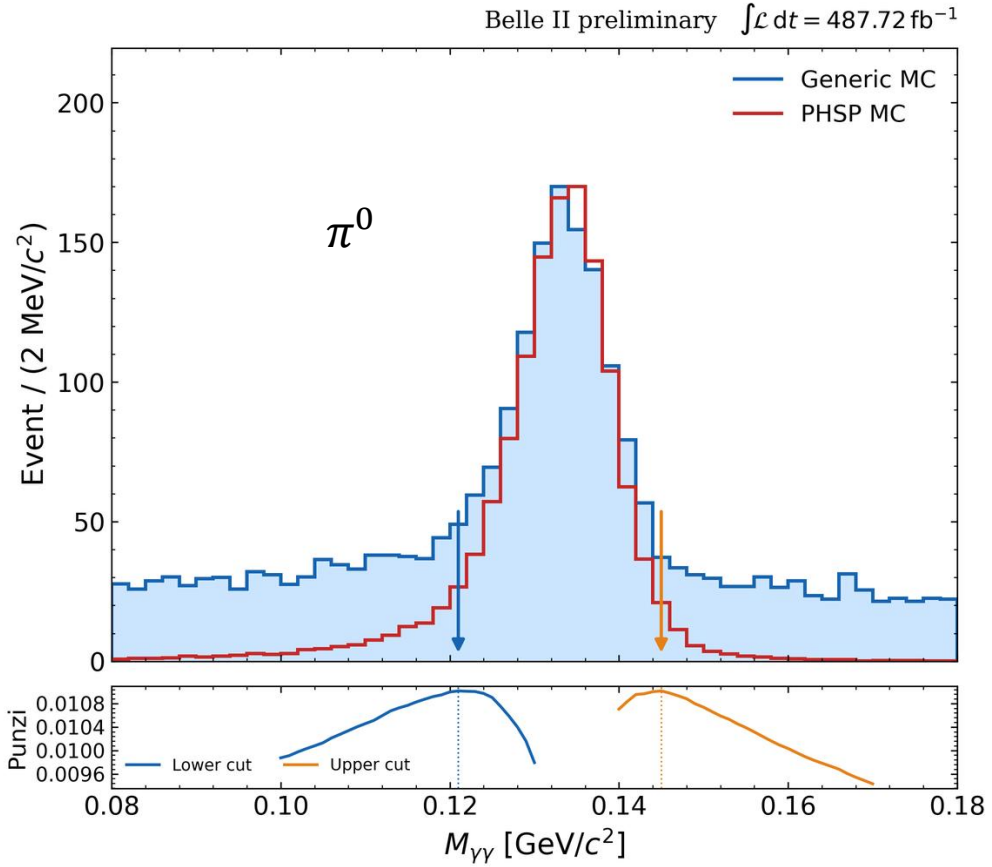
$M_{\mu^+\mu^-} \in [3.04,\ 3.13]\ \mathrm{GeV}/c^2$

Combined e^+e^- and $\mu^+\mu^-$

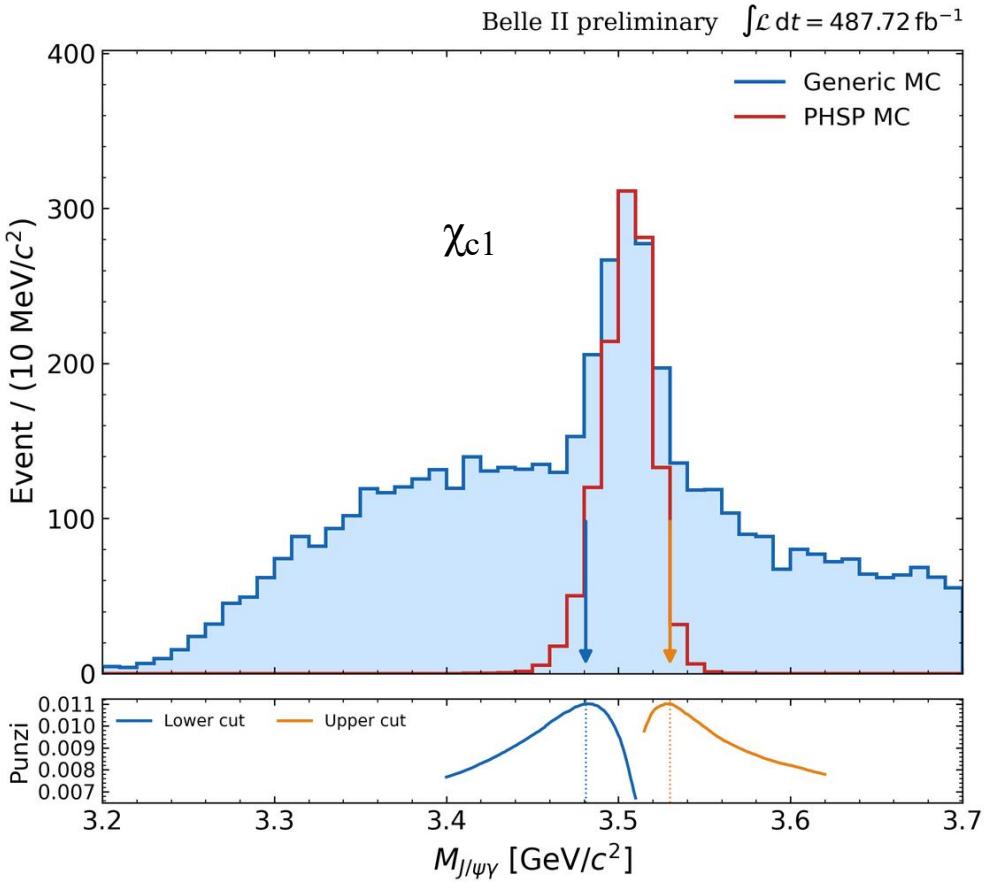


A clear J/ψ peak is observed in MC

M(γγ) and M(γJ/ψ) distributions



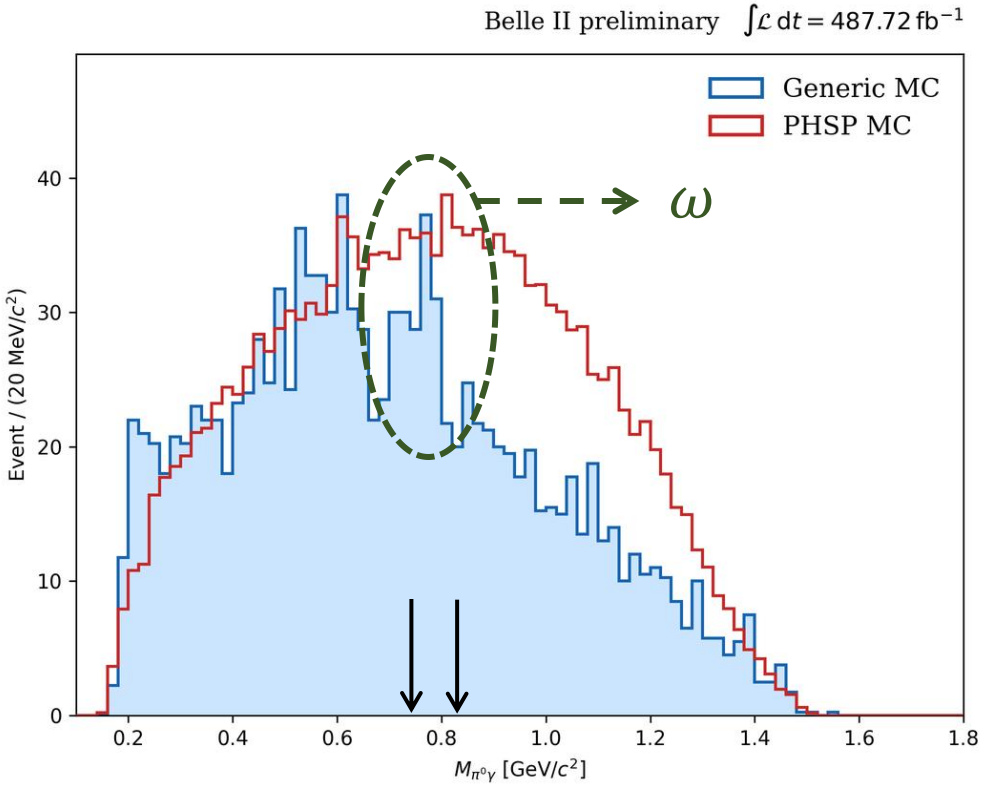
$\mathrm{M}(\gamma\gamma) \in [0.123, 0.145]\ \mathrm{GeV}/c^2$

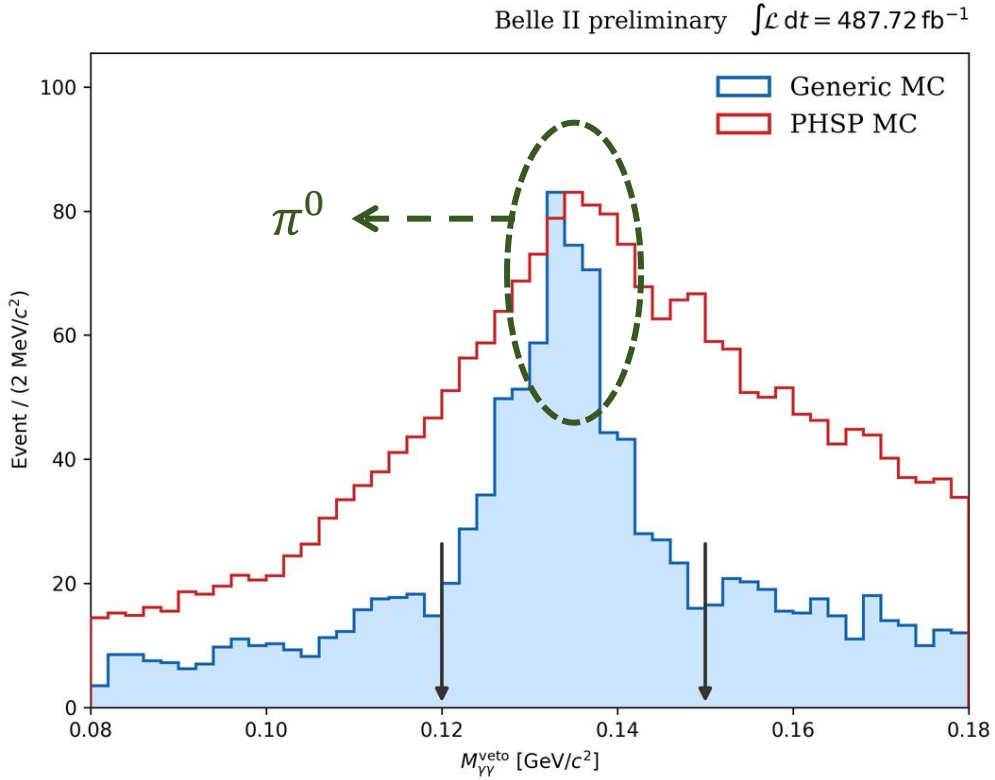


$M(\gamma J/\psi) \in [3.480, 3.530]\ \mathrm{GeV}/c^2$

Clear π^0 and χ_{c1} signals were observed.

ω and π^0 background vetoes



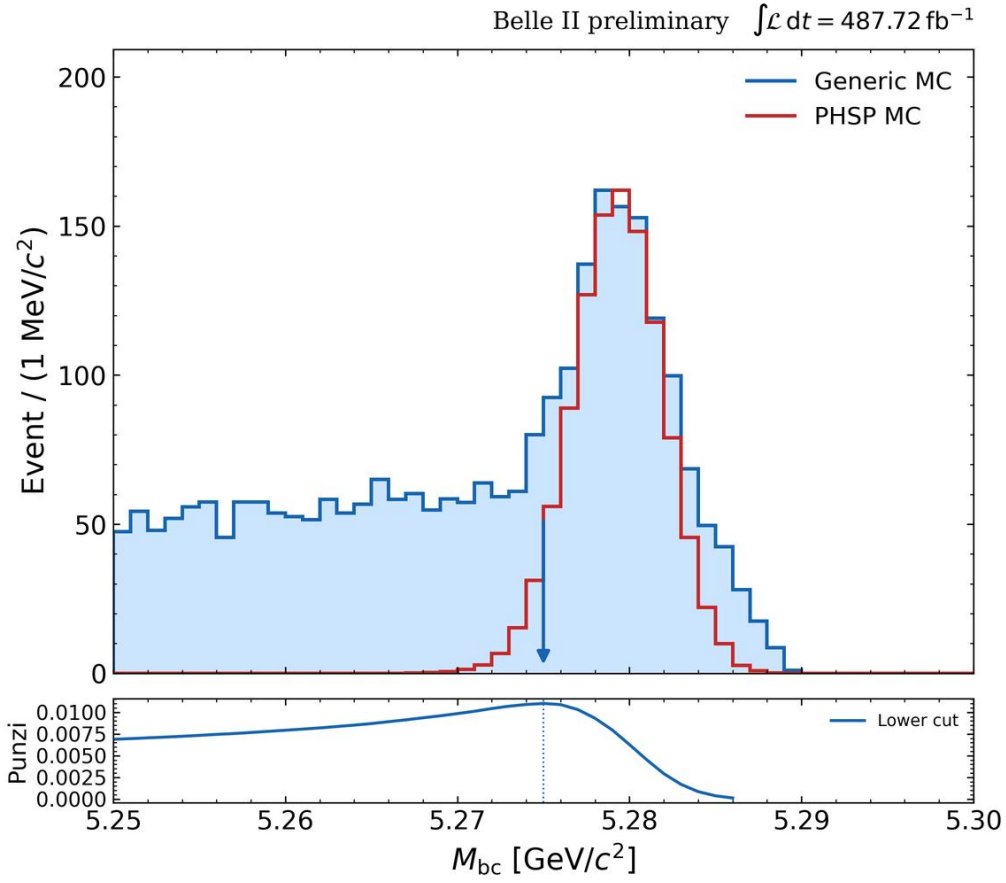


$M(\gamma\pi^0) \notin [0.760, 0.804]\ \text{GeV}/c^2$

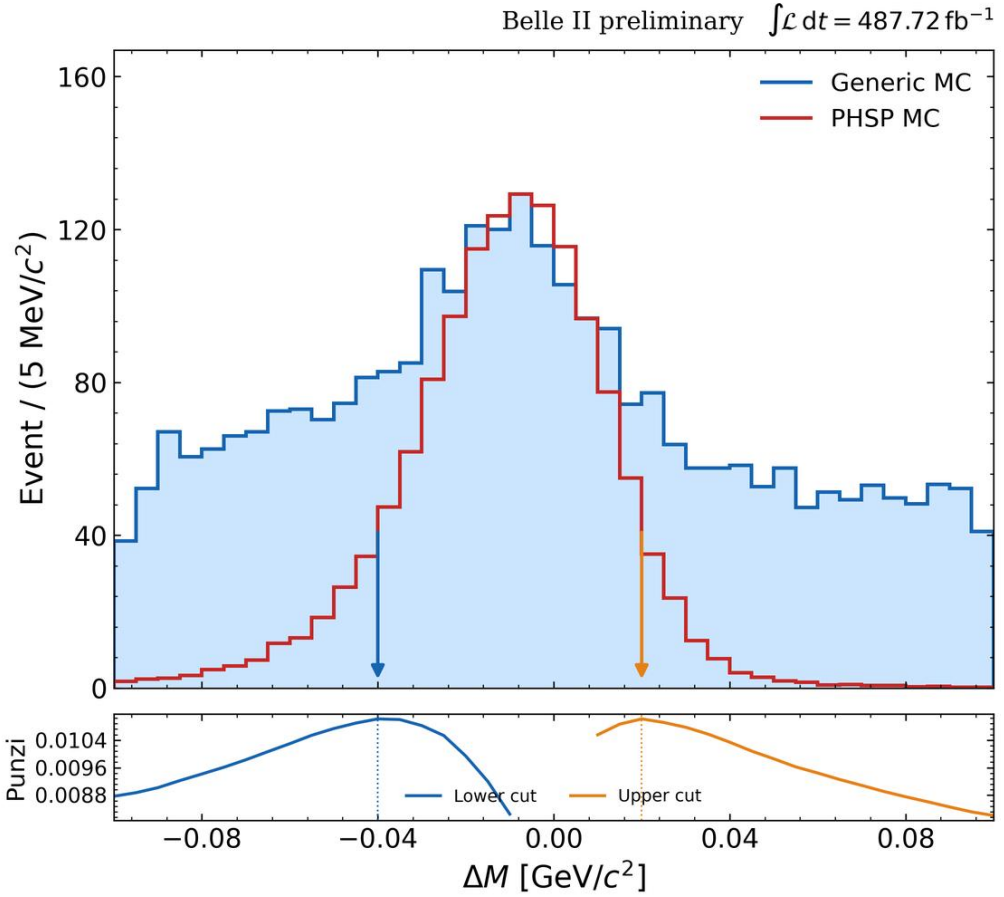
$\text{M}(\gamma_{\chi_{c1}}\gamma_{roe}) \notin [0.12, 0.15]\text{GeV}/c^2$

The ω and π^0 mass regions are vetoed to suppress peaking backgrounds.

B^+ candidate selection



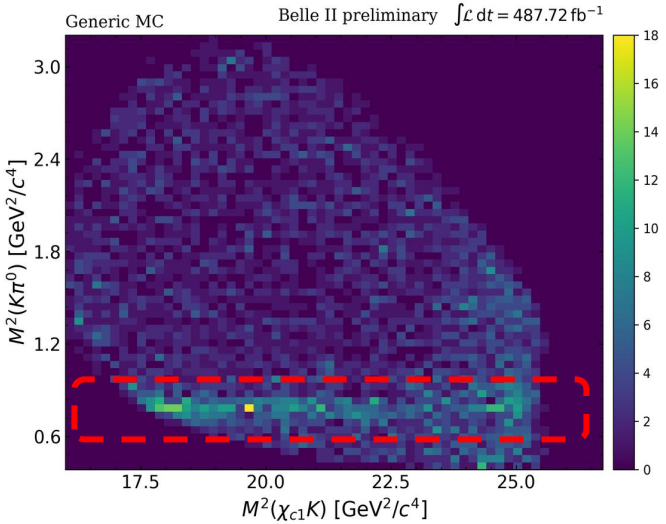
$\mathrm{M}_{bc} > 5.274\ \mathrm{GeV}/c^2$

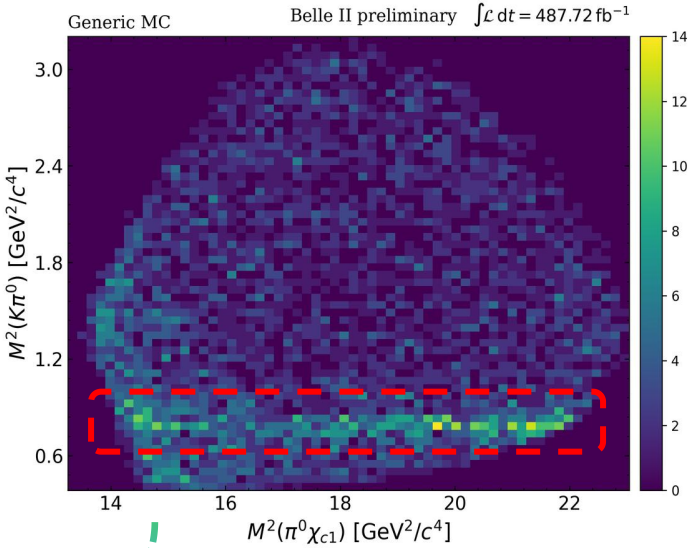


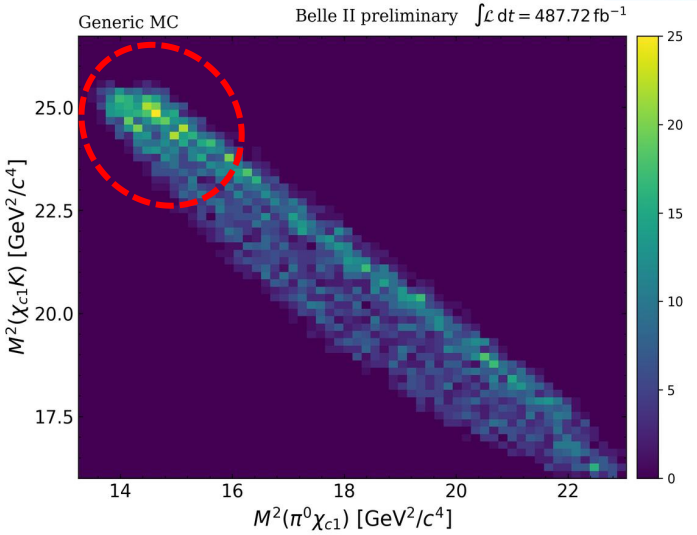
$-40\mathrm{MeV} < \Delta\mathrm{M} < 20\mathrm{MeV}$

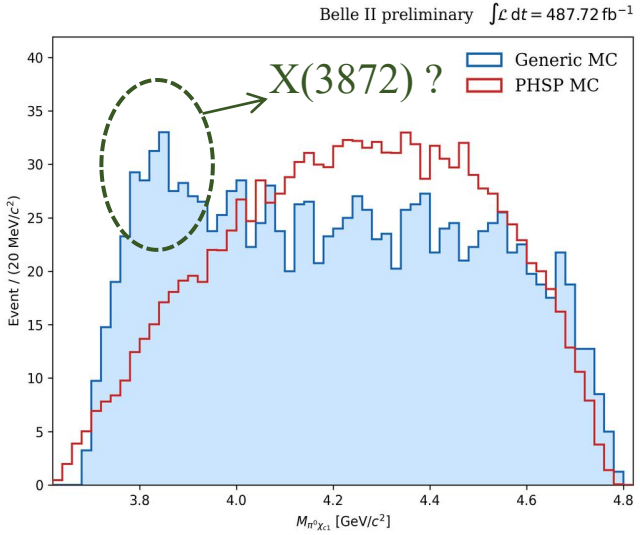
Clear B^+ signal was observed.

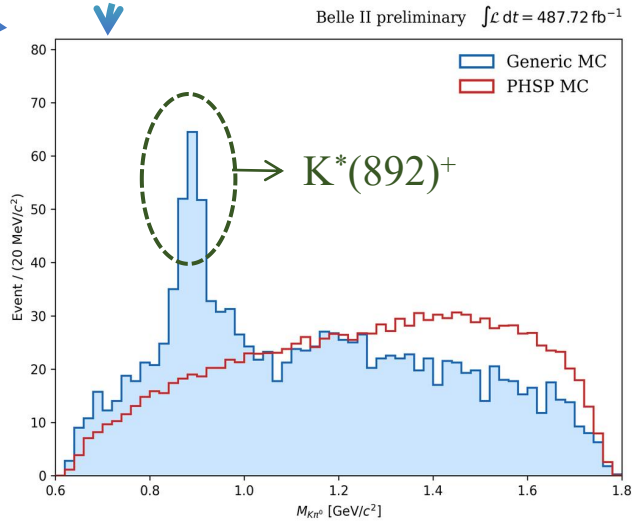
Intermediate state

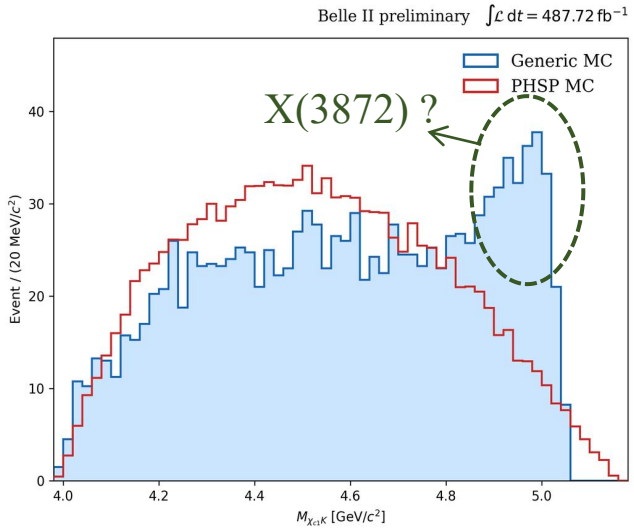












Clear K* signal was observed.

Summary and discussion

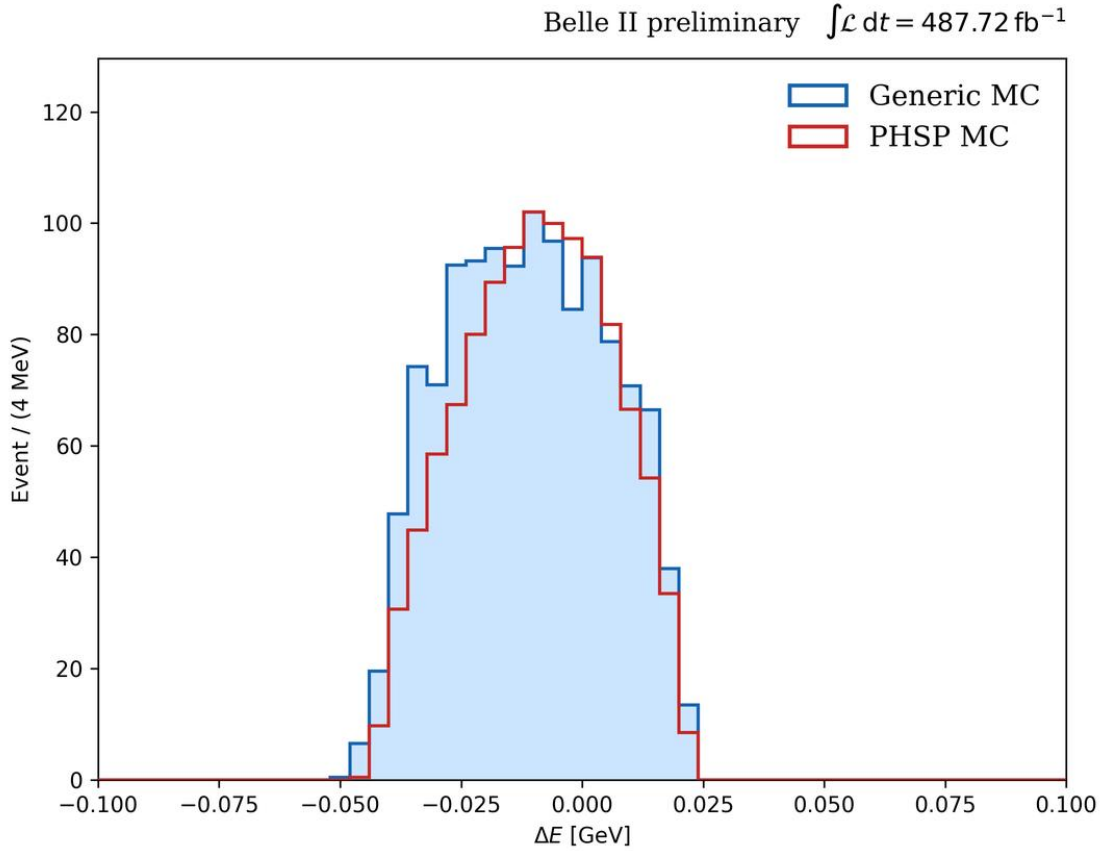
- A preliminary study of $B^+ \to \chi_{c1} K^+ \pi^0$ has been performed using Belle II MC.
- Clear $K^* \to K^+ \pi^0$ has been found.

Next to do

- Perform Treefit to improve resolution.
- Further optimize selection criteria.
- Extract the signal yield from a fit.
- Study the systematic uncertainties.

Thanks for your attention!

Back up


Belle II preliminary $\int \mathcal{L}\, dt = 487.72\,\text{fb}^{-1}$
Generic MC
PHSP MC
Event / (4 MeV)
0
20
40
60
80
100
120
−0.100
−0.075
−0.050
−0.025
0.000
0.025
0.050
0.075
0.100
ΔE [GeV]