Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

Coherent $J/\psi \to l^+ l^-$ Diffractive Pattern Simulations with the Muon ID Smearing

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Golden Channel

- Coherent $J/\psi \rightarrow l^+l^-$ diffractive pattern

- Exclusive measurements that involve the central, far backward and far forward detector
  - Muon ID
  - Tracking detector → Scattered electron and J/ψ reconstructions
  - backward Ecal → Scattered electron
  - Far forward detector → incoherent event vetoing
  - Far backward detector → low Q^2 measurements

Simulation Setup

Sartre

- eAu at 18x110 GeV
- $1 \leq Q^2 \leq 1000$ GeV^2
- Coherent events only
- Forced $J/\psi \rightarrow l^+ l^-$
- No background

Detector

- ePIC-2023.10.0
- epic_craterlake_18x110_Au.xml
- B=1.7 T

Coherent $J/\psi \rightarrow l^+l^-$ Diffractive Pattern Simulations with the ePIC Detector Setup

Track Selections and Reconstruction

Single lepton selection

- True PID
- If the electron $\eta < -1.5$, use Ecal energy instead of momentum from tracking

$\boldsymbol{J/\psi}$ reconstruction

- |pid| = 11 or 13
- Opposite charges cut on dilepton pair
- If the invariant mass is within 2 standard deviations, the dileptons are labeled as "$\boldsymbol{J/\psi}$ decayed" dileptons

Q^2

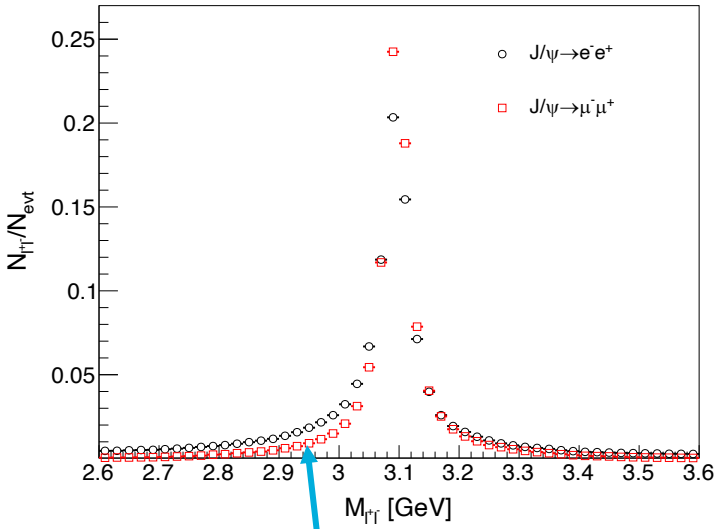
- Scattered electrons must be negatively charged
- "$\boldsymbol{J/\psi}$ decayed" electrons are excluded
- $Q^2 = -(e_{beam} - e_{scattered}).M2()$

t from method L

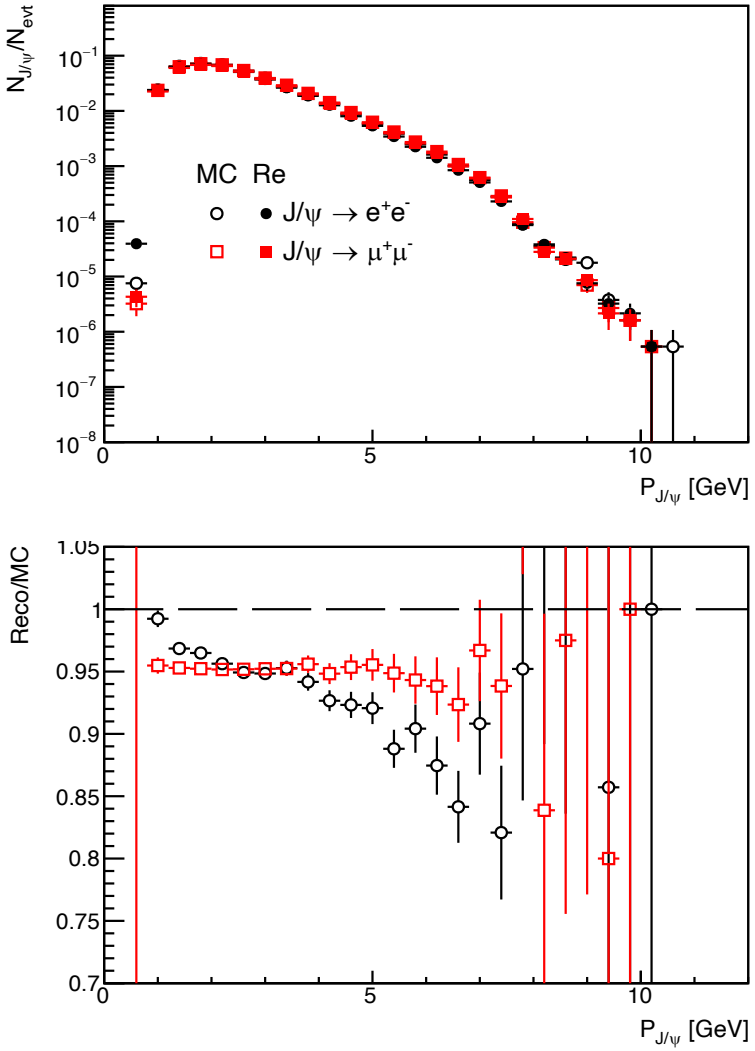
- Removed events with a mis-reconstructed $Q^2 < 1$ GeV^2
- Reconstructed $\boldsymbol{J/\psi}$ $|\eta| < 1.5$ → avoid ambiguity between scattered and decayed electrons, and avoid poor tracking region
- Require information of the proton/ion beam
- Better t resolutions

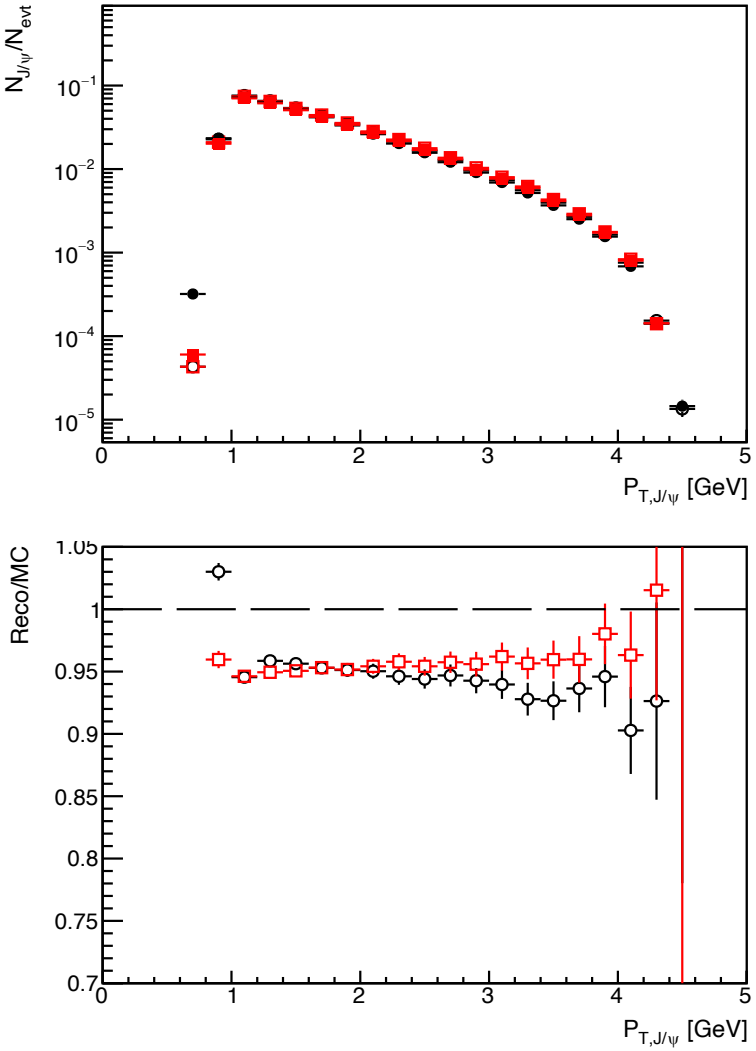
Reconstructed J/ψ

J/ψ mass window mean $\pm$ 2 std dev

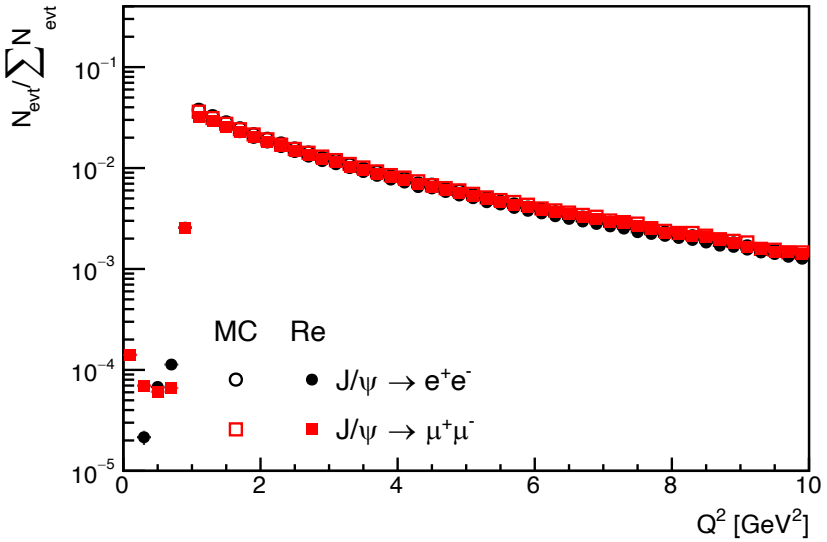


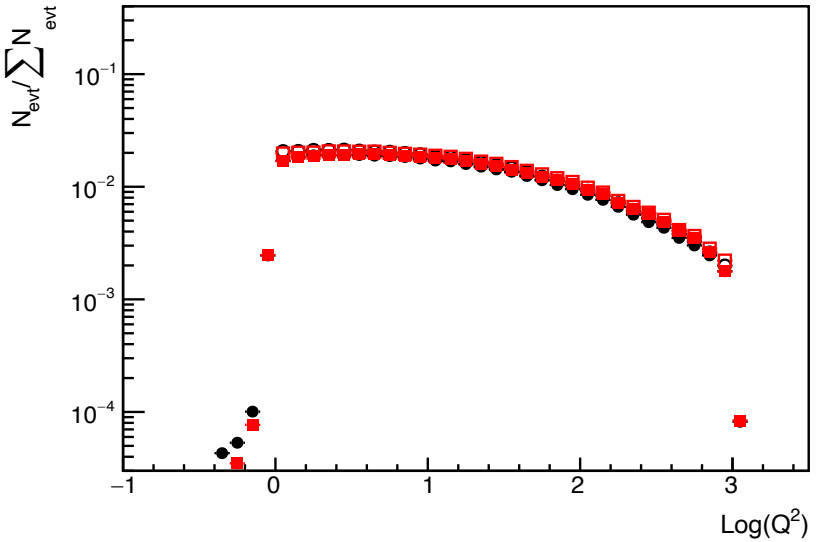
- Larger combinatorial background at lower spectrum due to bremsstrahlung radiation when using dielectron channel
- Better J/ψ efficiency at high p/p_T using dimuon channel

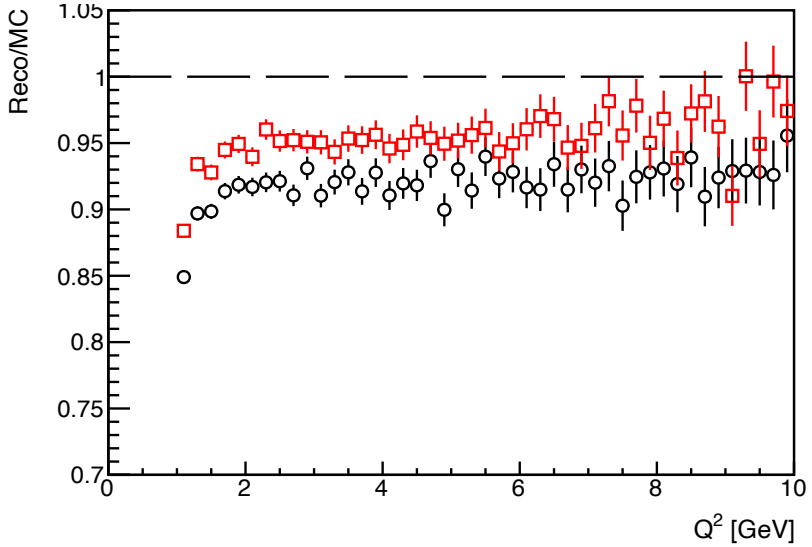


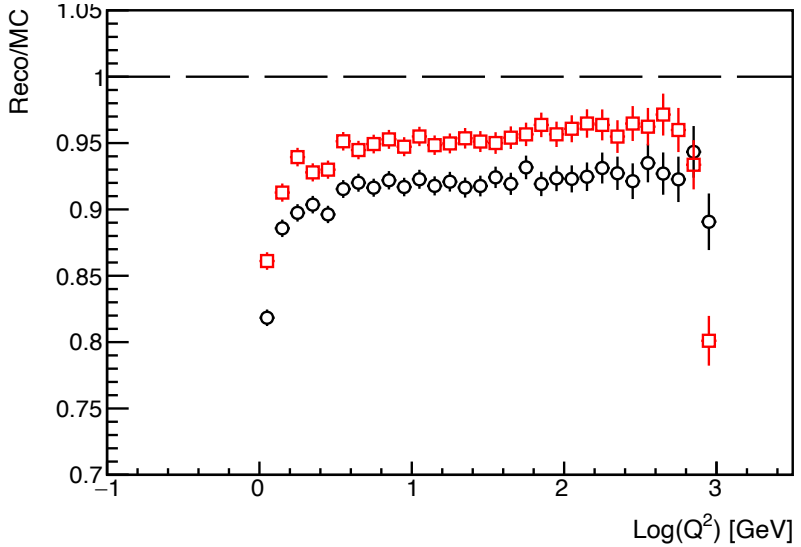


Reconstructed Q^2



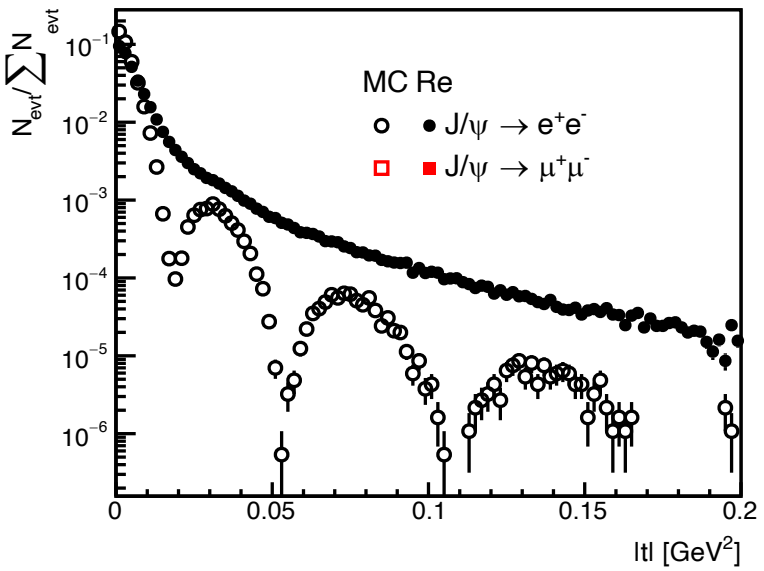


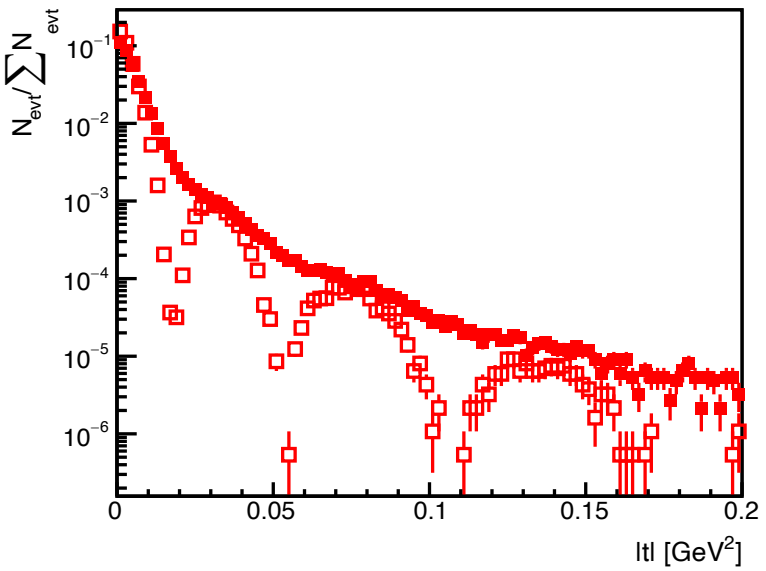


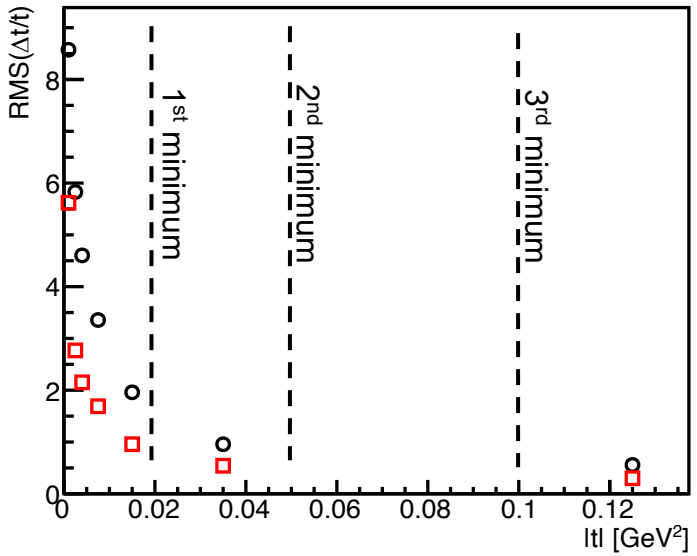


- Using dielectron channel may reduce Q^2 efficiency since scattered electron could be mixed up as "J/ψ decayed electron"
- Events with a reconstructed $Q^2 \leq 1$ GeV^2 are excluded when calculating t

Reconstructed t







- Using dimuon channel improves the coherent J/ψ diffractive measurement compared to delectron channel
  - Caveat: still using true PID in the above figures

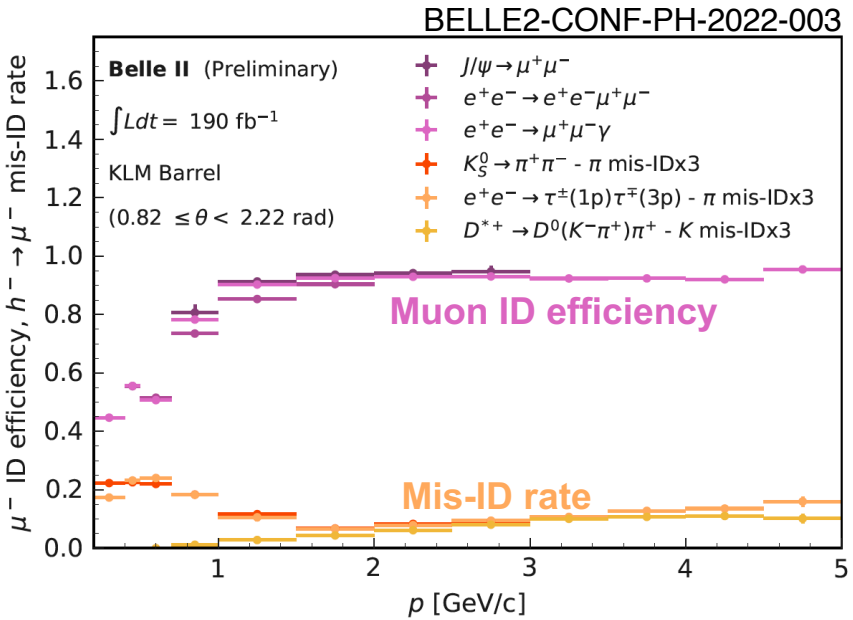
- But improvement from using dimuon is not enough
  → Require significant improvement in scattered electron measurements
  → Beyond excellent backward tracking/Ecal with a momentum/energy resolution smaller than 1%

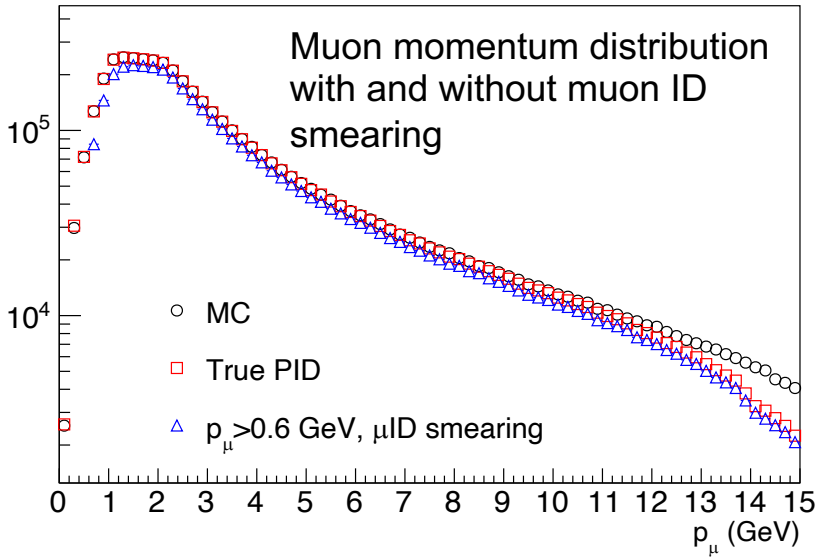
Muon ID Smearing

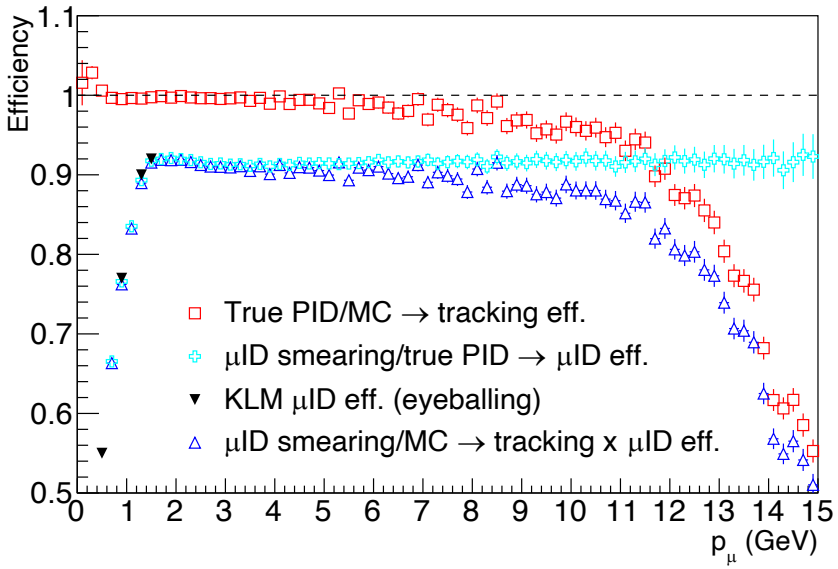
Muon Identification Smearing

Initial implementation using BELLE II KLM performance

- Threshold momentum = 0.6 GeV
- Eyeballing muon ID efficiency at p < 1.5 GeV
- Constant muon ID efficiency at p > 1.5 GeV
- No mis-ID rate applied

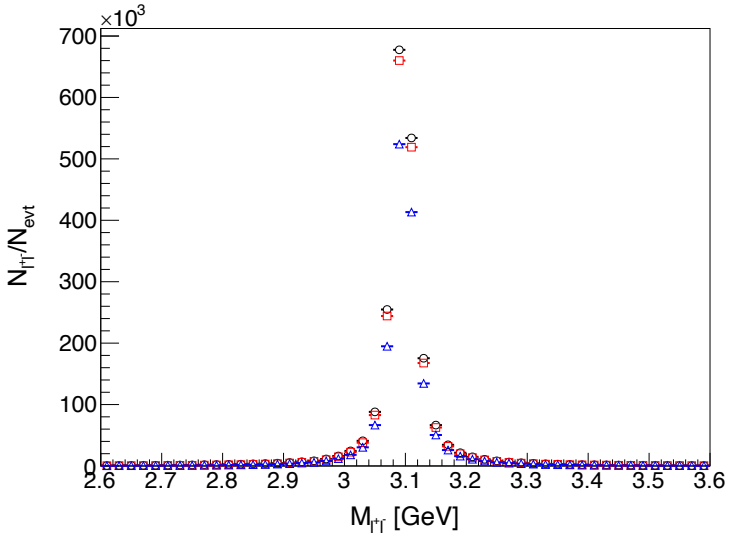


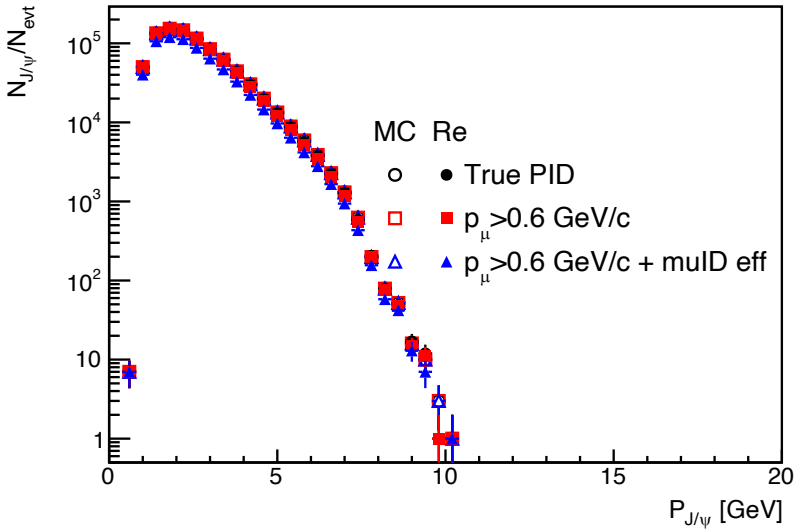


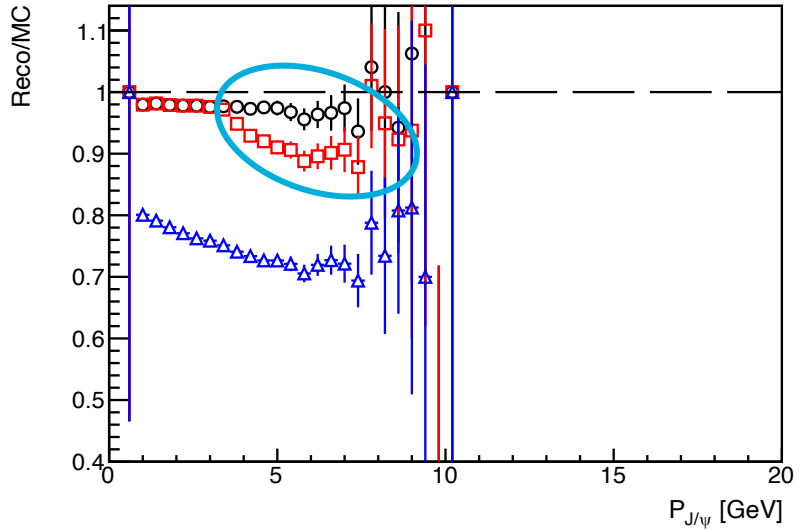


- https://docs.belle2.org/record/2895/files/Lepton_identification_Moriond_2022__v2.pdf
- https://arxiv.org/pdf/1011.0352.pdf

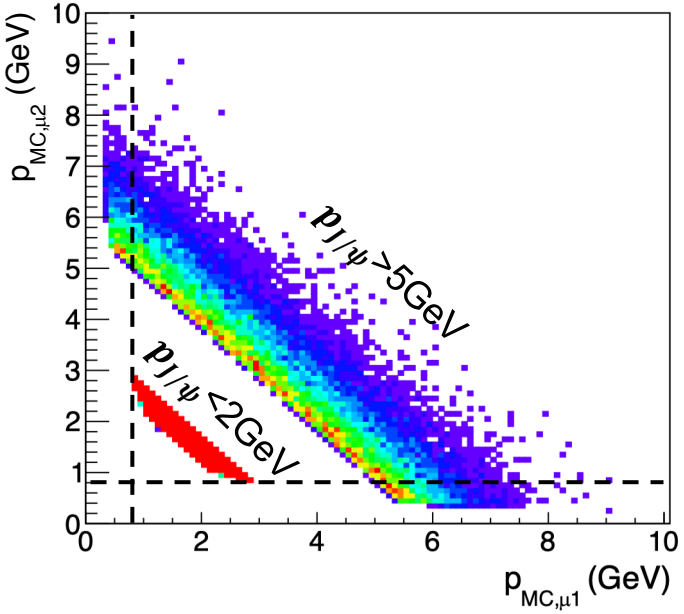
Reconstructed J/ψ





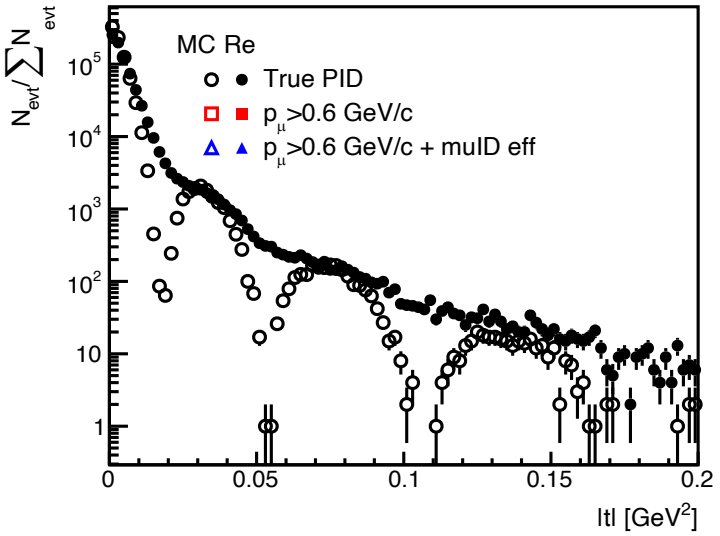


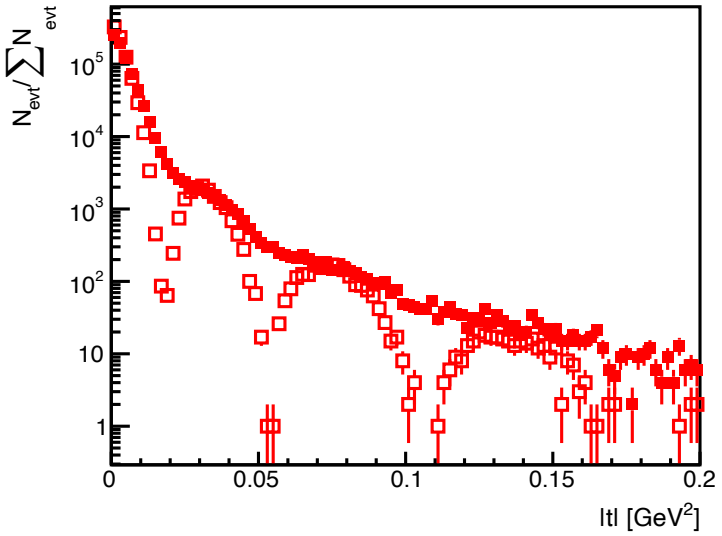
- Threshold muon momentum cut reduces reconstructed J/ψ at p > 4 GeV
- Statistics are reduced by 15-20% after μID efficiency implementation

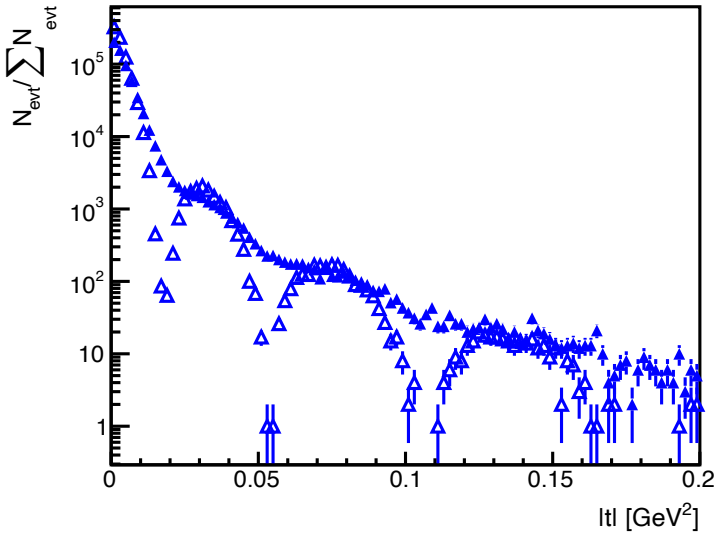


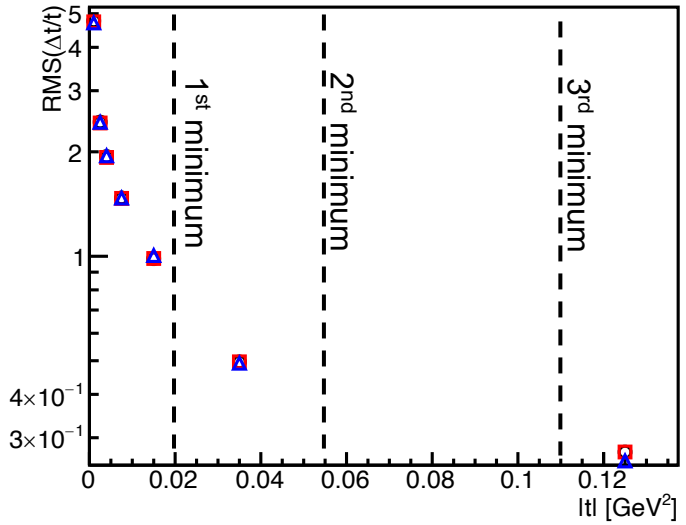
Soft muon is important to high momentum J/ψ reconstruction

Reconstructed t ($1 \leq Q^2 \leq 10$ GeV^2)









No significant changes in t resolutions from muon ID smearing

Summary

- J/ψ Diffractive Pattern using dielectron and dimuon channels with true PID
  - The dimuon channel gives better t resolution compared to dielectron channel

- Initial implementation of muon ID smearing using muon ID performance of BELLE II KLM
  - t resolution remains the same
  - No miss ID applied