

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

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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  $\rightarrow J/\psi$  reconstruction
    - backward Ecal  $\rightarrow$  Scattered electron
    - Far forward detector  $\rightarrow$  incoherent event vetoing  $\rightarrow$  Jihee – incoherent event simulations
      - Implement the second focus detector
      - Study incoherent event vetoing efficiency
    - Far backward detector  $\rightarrow$  low  $Q^2$  measurements
- } Ping – coherent event simulations
- Improve t resolution
  - Implement muon ID smearing

# Simulation Setup

## Sartre

- eAu at 18x110 GeV
- $1 \leq Q^2 \leq 1000 \text{ GeV}^2$
- 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

## $J/\psi$ reconstruction

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

## $Q^2$

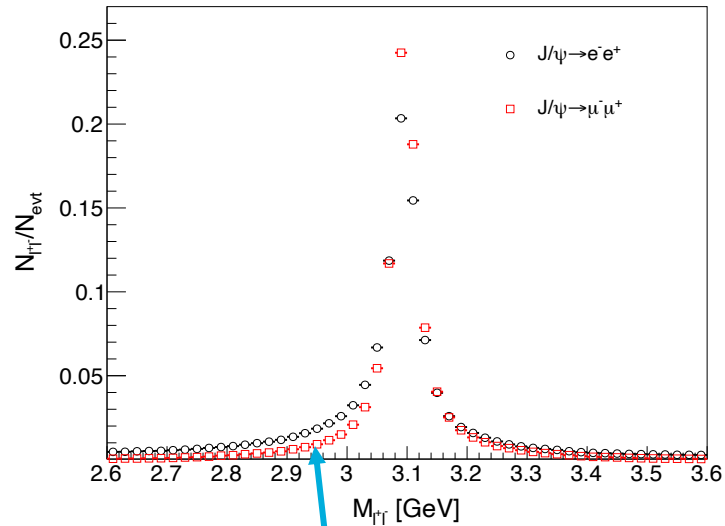
- Scattered electrons must be negatively charged
- “ $J/\psi$  decayed” electrons are excluded
- $Q^2 = -(e_{beam} - e_{scattered}) \cdot M2()$

## t from method L

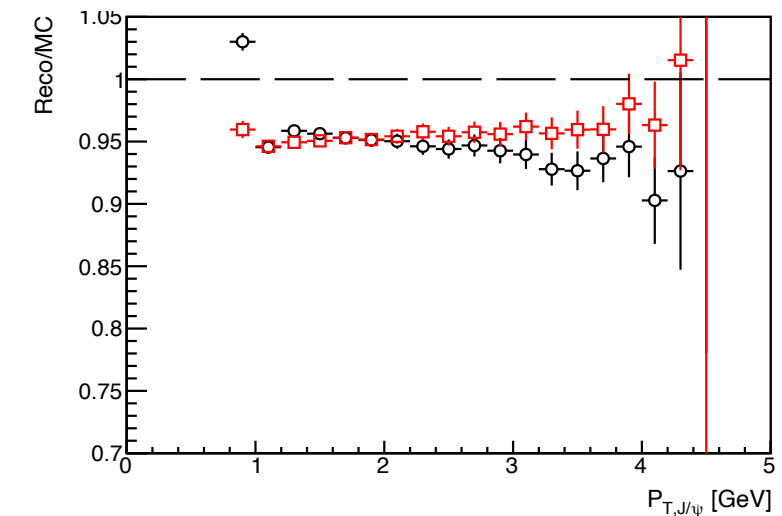
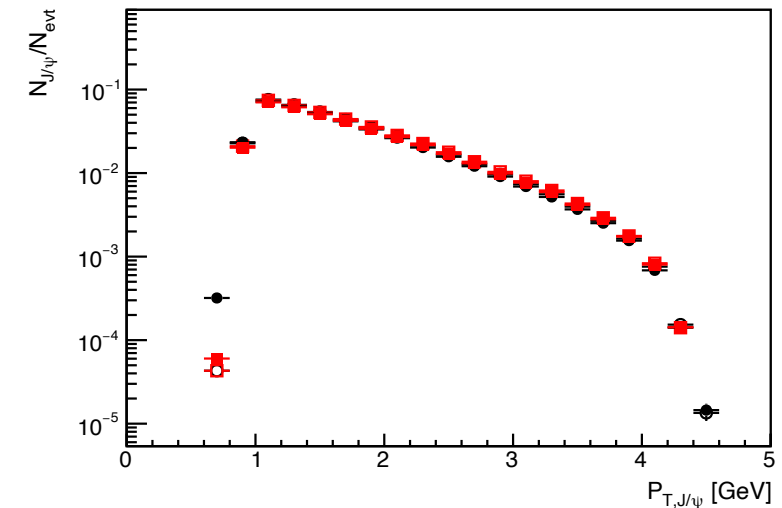
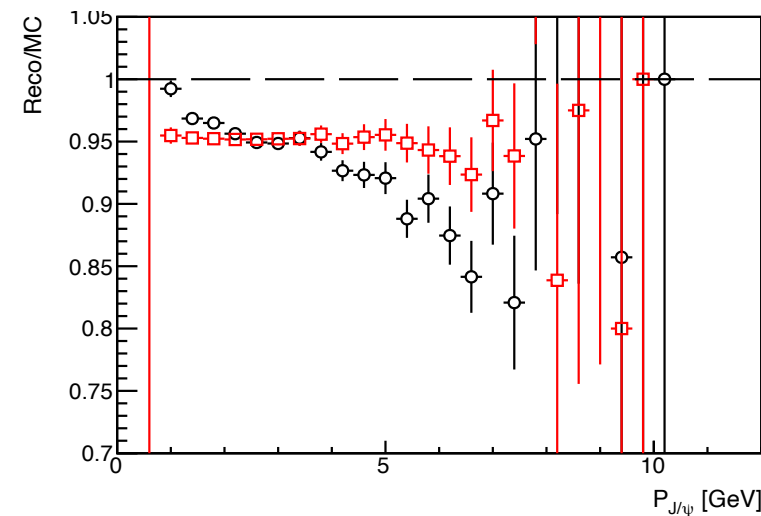
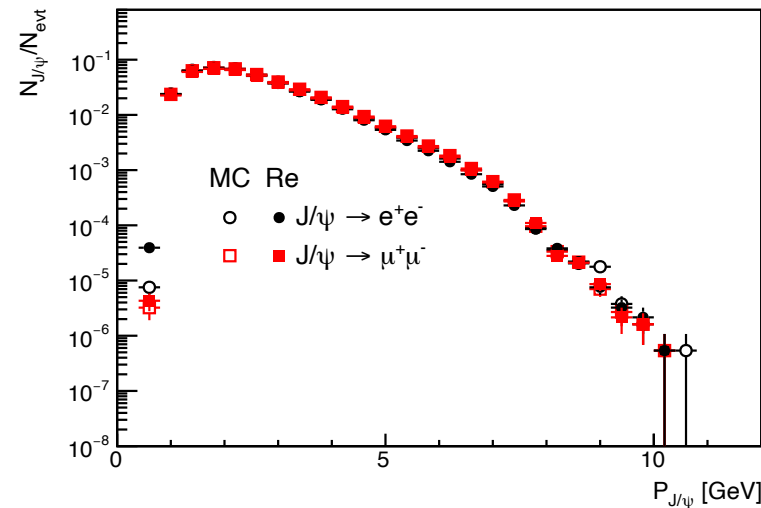
- Removed events with a mis-reconstructed  $Q^2 < 1 \text{ GeV}^2$
- Reconstructed  $J/\psi$   $|\eta| < 1.5 \rightarrow$  avoid ambiguity between scattered and decayed electrons, and avoid poor tracking region
- Require information of the proton/ion beam
- Better t resolutions

# Reconstructed $J/\psi$

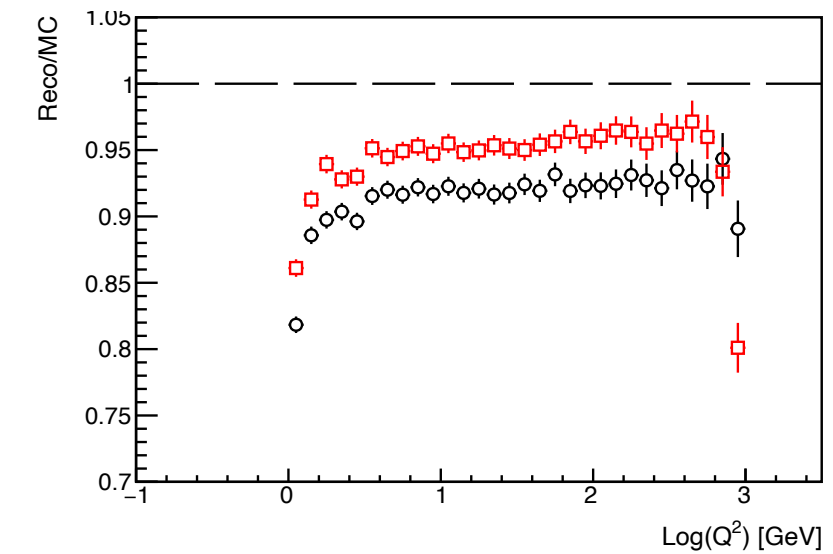
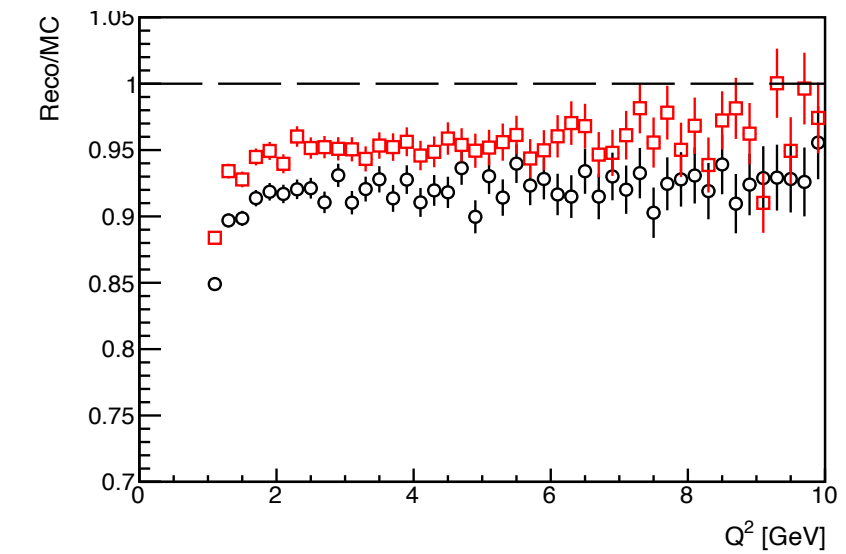
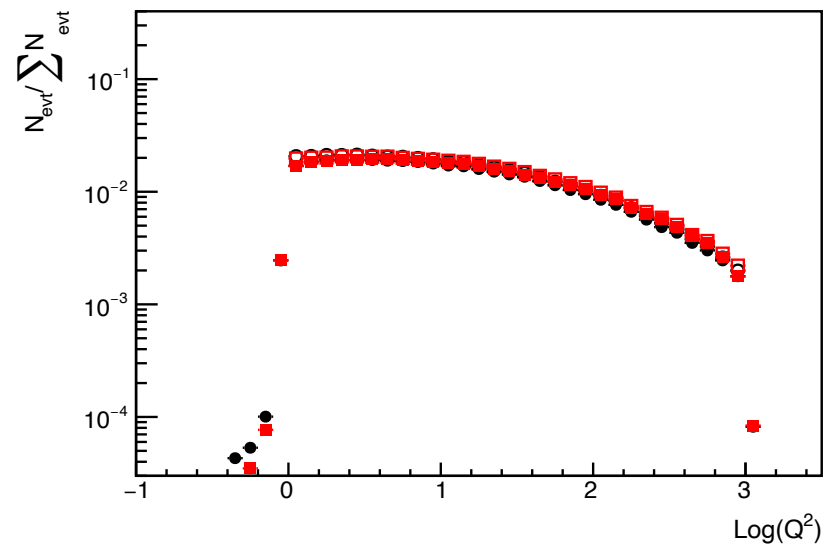
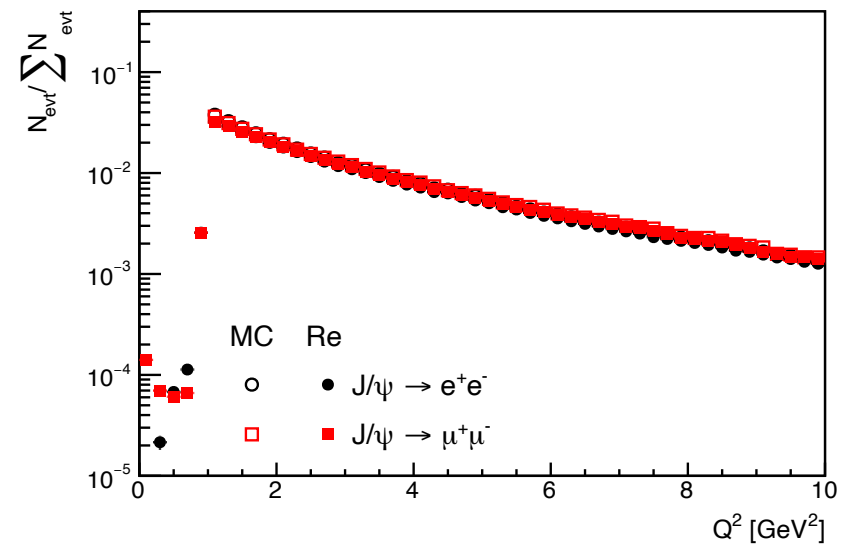
$J/\psi$  mass window mean  $\pm 2$  std dev



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

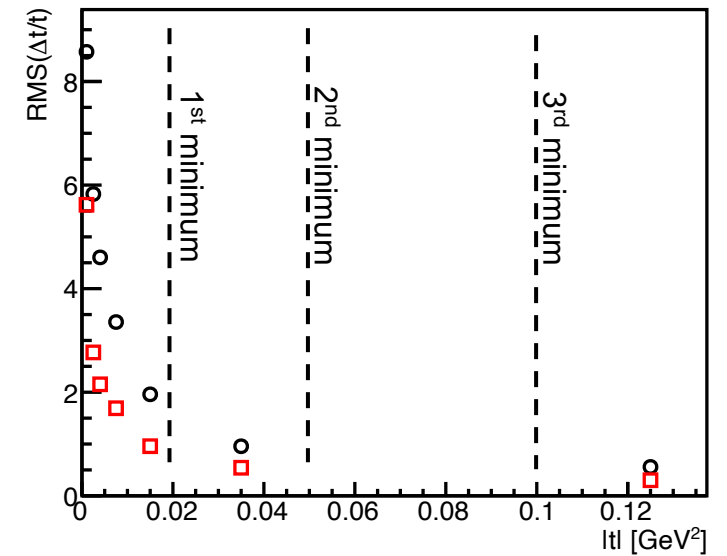
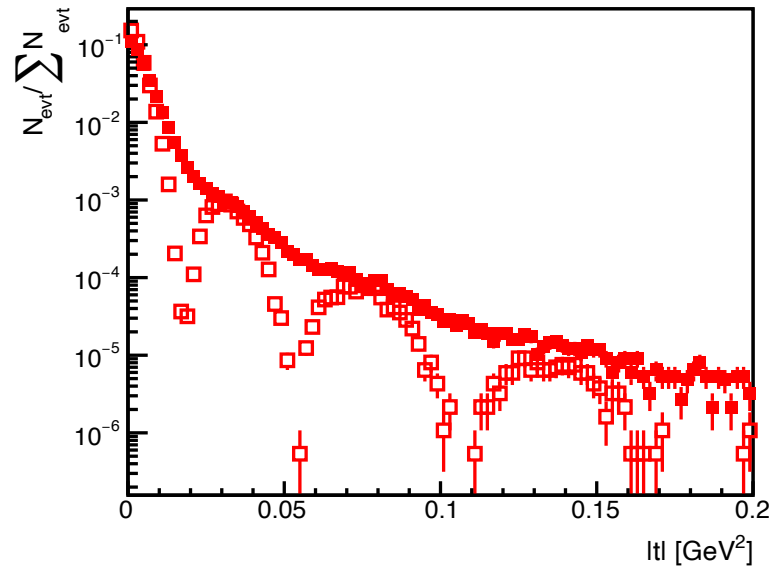
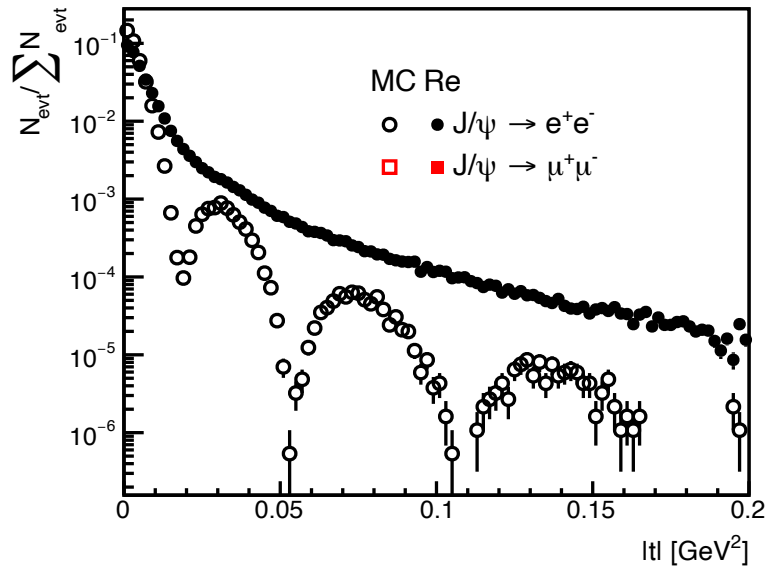


# Reconstructed $Q^2$



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

# Reconstructed $t$



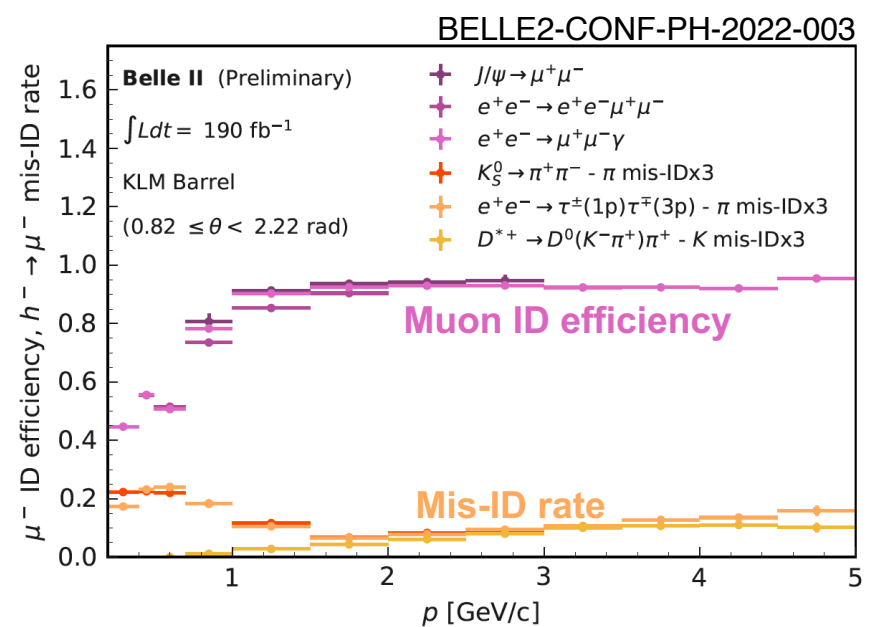
- Using dimuon channel improves the coherent  $J/\psi$  diffractive measurement compared to delectron channel
  - Caveat: still using true PID in the above figures
- But improvement from using dimuon is not enough
  - Require significant improvement in scattered electron measurements
  - Beyond excellent backward tracking/Ecal with a momentum/energy resolution smaller than 1%

# Muon ID Smearing

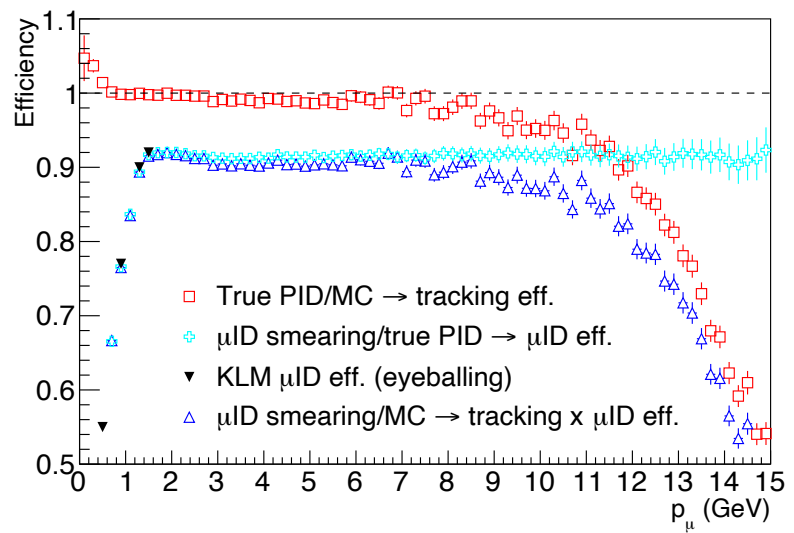
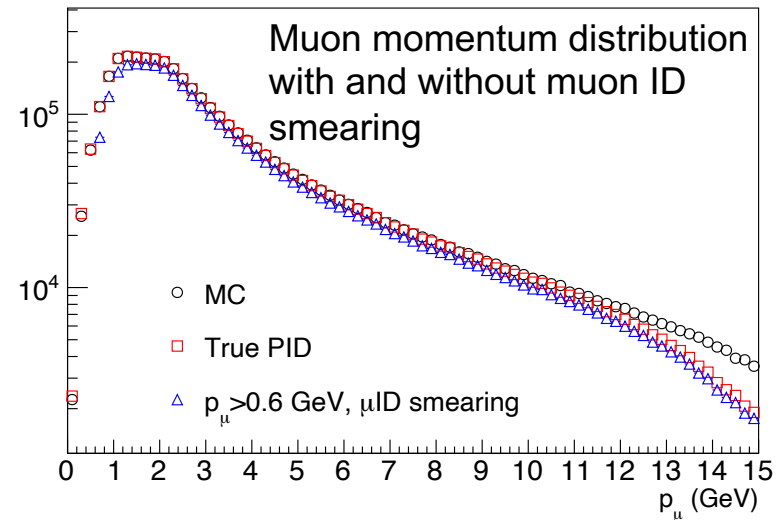
# Muon Identification Smearing

Initial implementation using BELLE II KLM performance

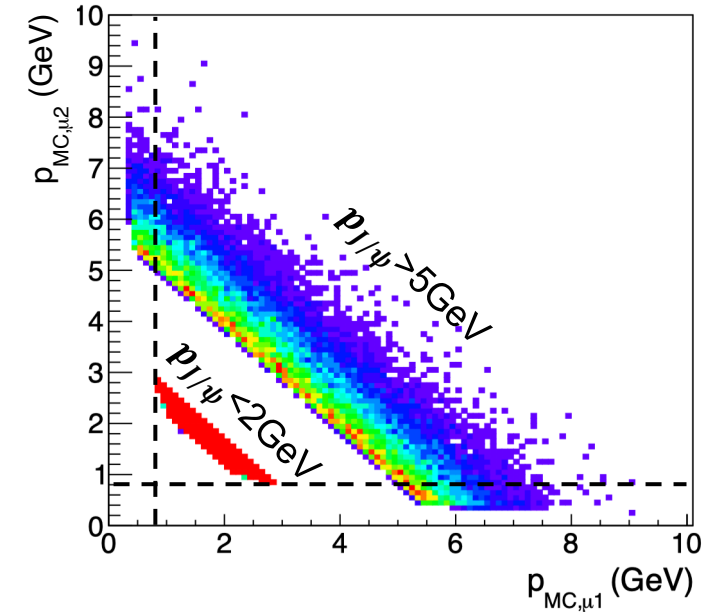
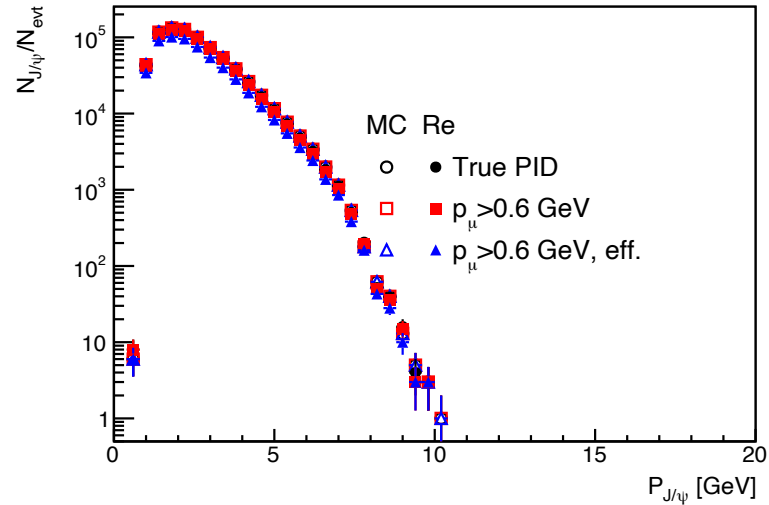
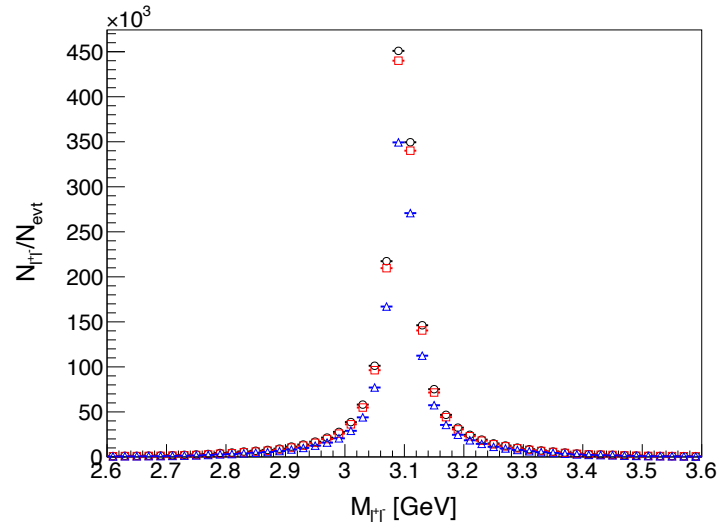
- Threshold momentum = 0.6 GeV
- Eyeballing muon ID efficiency at  $p < 1.5$  GeV
- Constant muon ID efficiency at  $p > 1.5$  GeV
- No mis-ID rate applied



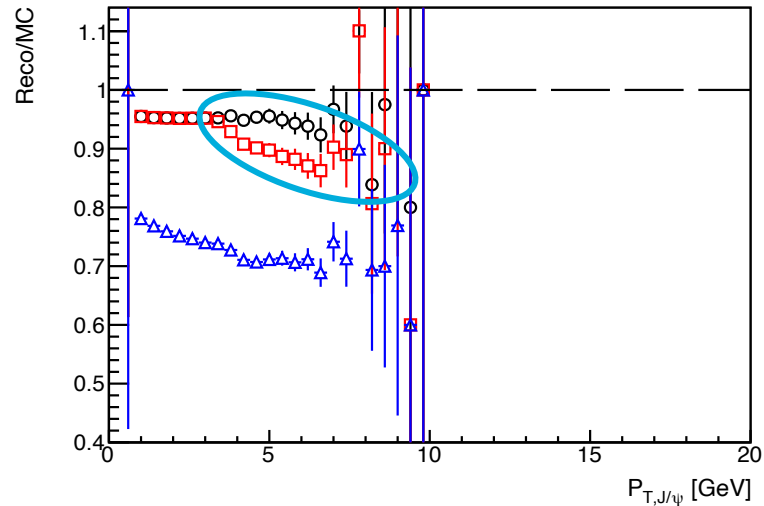
- [https://docs.belle2.org/record/2895/files/Lepton\\_identification\\_Moriond\\_2022\\_v2.pdf](https://docs.belle2.org/record/2895/files/Lepton_identification_Moriond_2022_v2.pdf)
- <https://arxiv.org/pdf/1011.0352.pdf>



# Reconstructed $J/\psi$

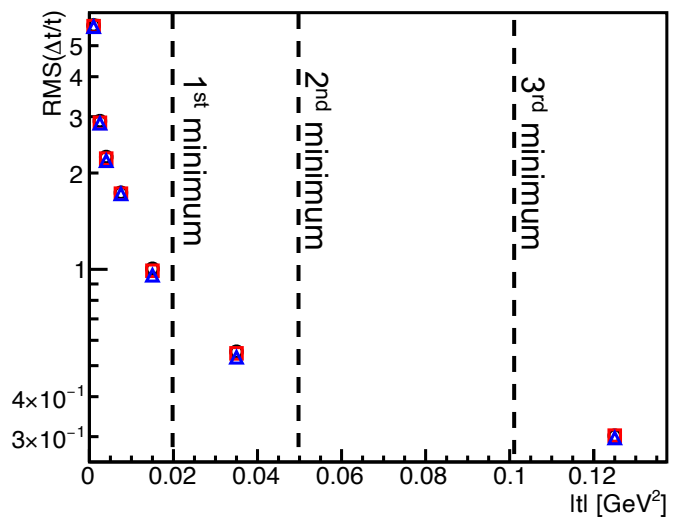
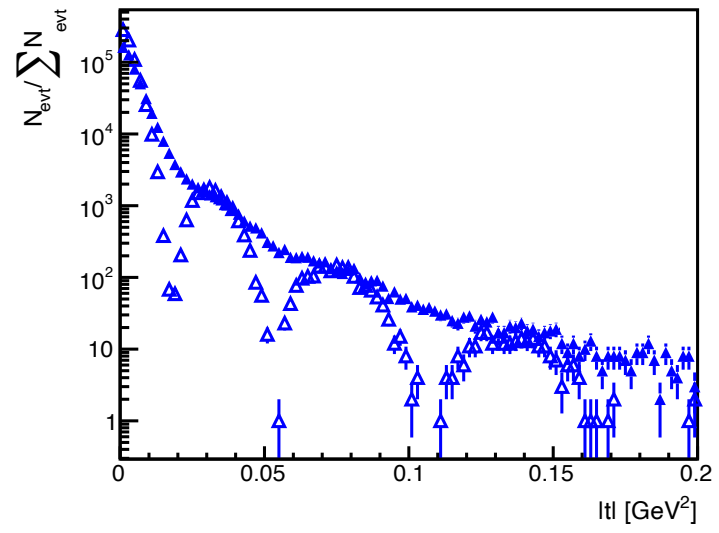
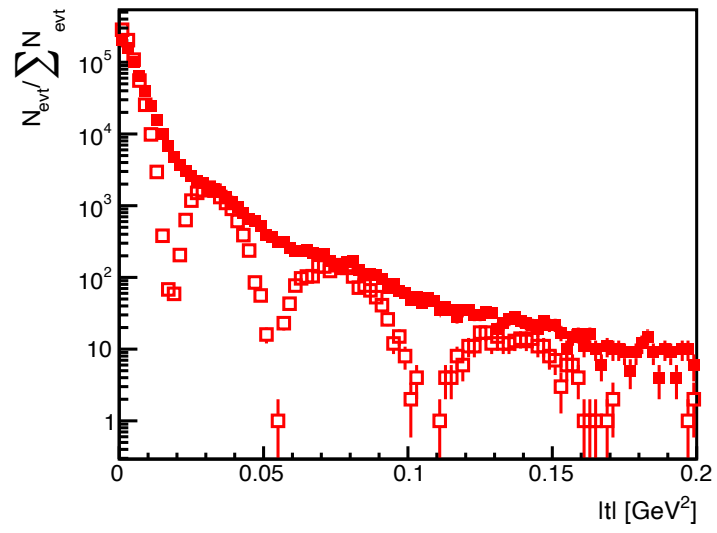
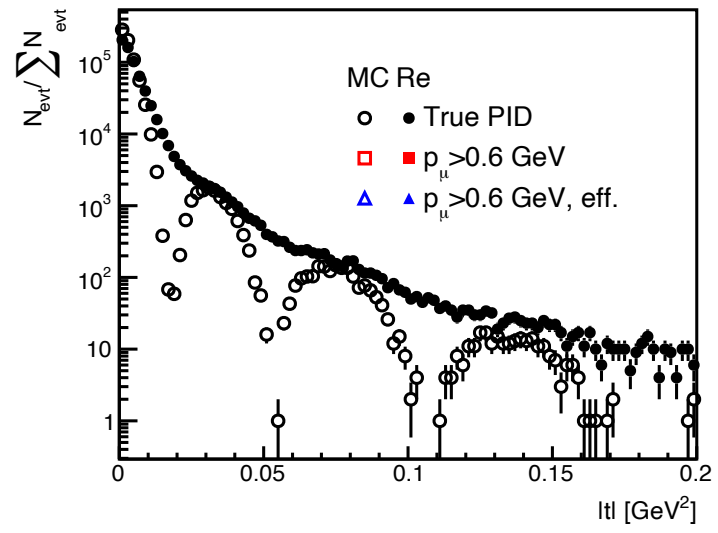


- Threshold muon momentum cut reduces reconstructed  $J/\psi$  at  $p > 4$  GeV
- Statistics are reduced by 15-20% after  $\mu$ ID efficiency implementation



Soft muon is important to high momentum  $J/\psi$  reconstruction

# Reconstructed $t$ ( $1 \leq Q^2 \leq 10 \text{ GeV}^2$ )



No significant changes in  $t$  resolutions from muon ID smearing

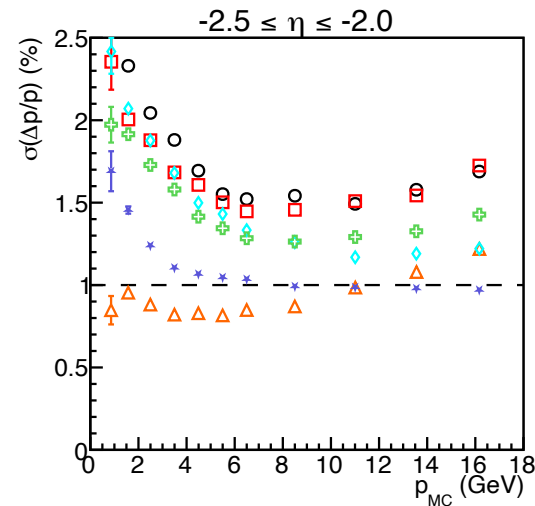
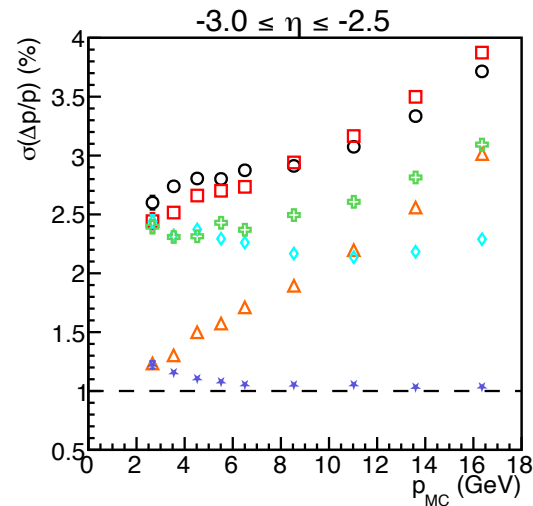
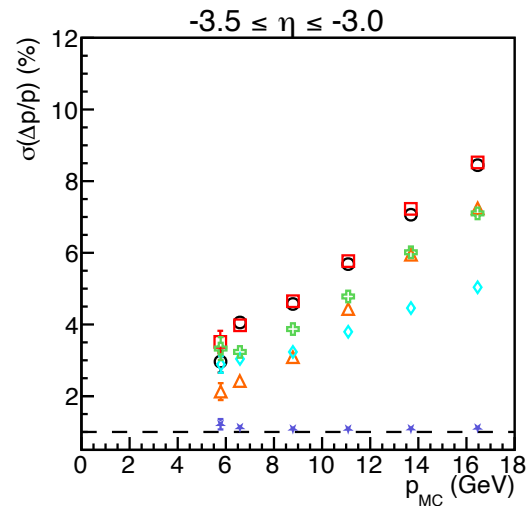
# Backward Tracking

# Ways to Improve Momentum Resolution

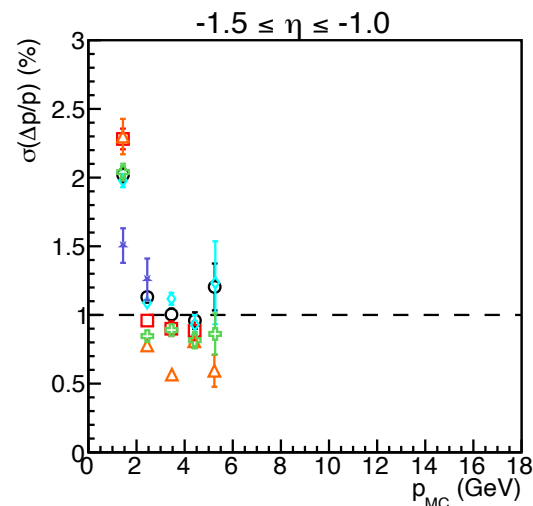
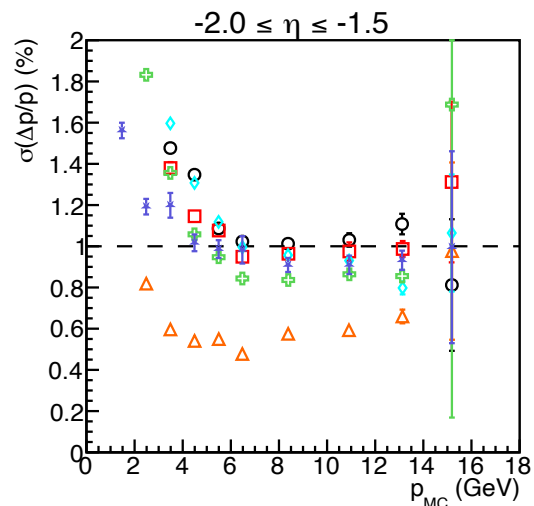
- **Material budgets**
  - Reduce error due to multiple scattering
    - Supporting/service material is the dominant factor
    - Air also plays a role
- **Length of the tracking detector**
  - Reduce momentum resolution at high momentum
- **Magnetic field (Max at 2T)**
- **Pixel pitch/size**
  - The default grid size is 20x20  $\mu\text{m}^2$
- **More disks**

See following slides

# Momentum Resolution of the Backward Tracker



- True PID



○ ePIC

□  $t_{\text{backward silicon}} = 5\mu\text{m}$  ( Thickness of the silicon wafers )

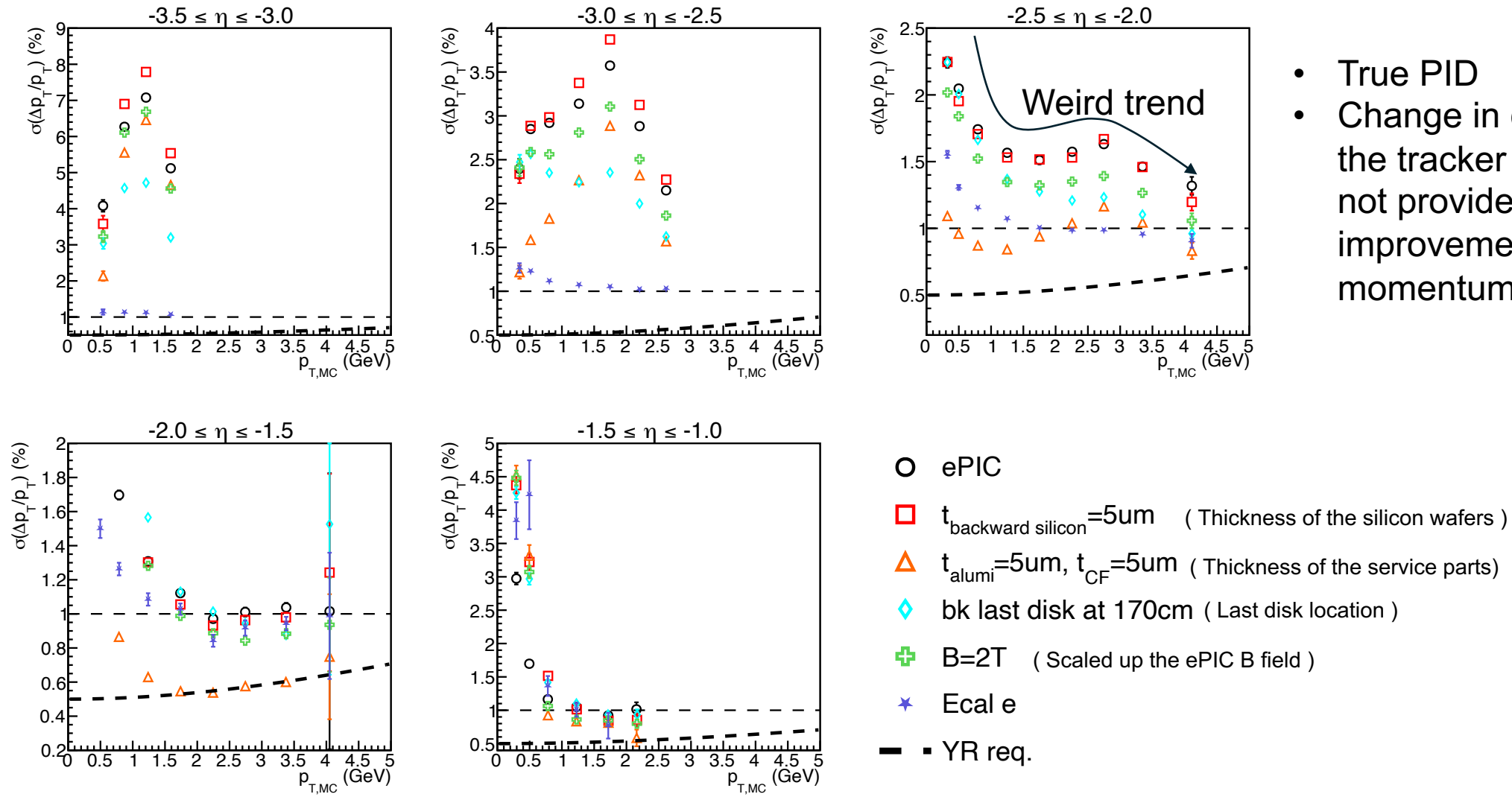
△  $t_{\text{alumi}} = 5\mu\text{m}, t_{\text{CF}} = 5\mu\text{m}$  ( Thickness of the service parts )

◇ bk disk max loc. 170cm ( Last disk location )

⊕ B=2T ( scaled up the ePIC B field )

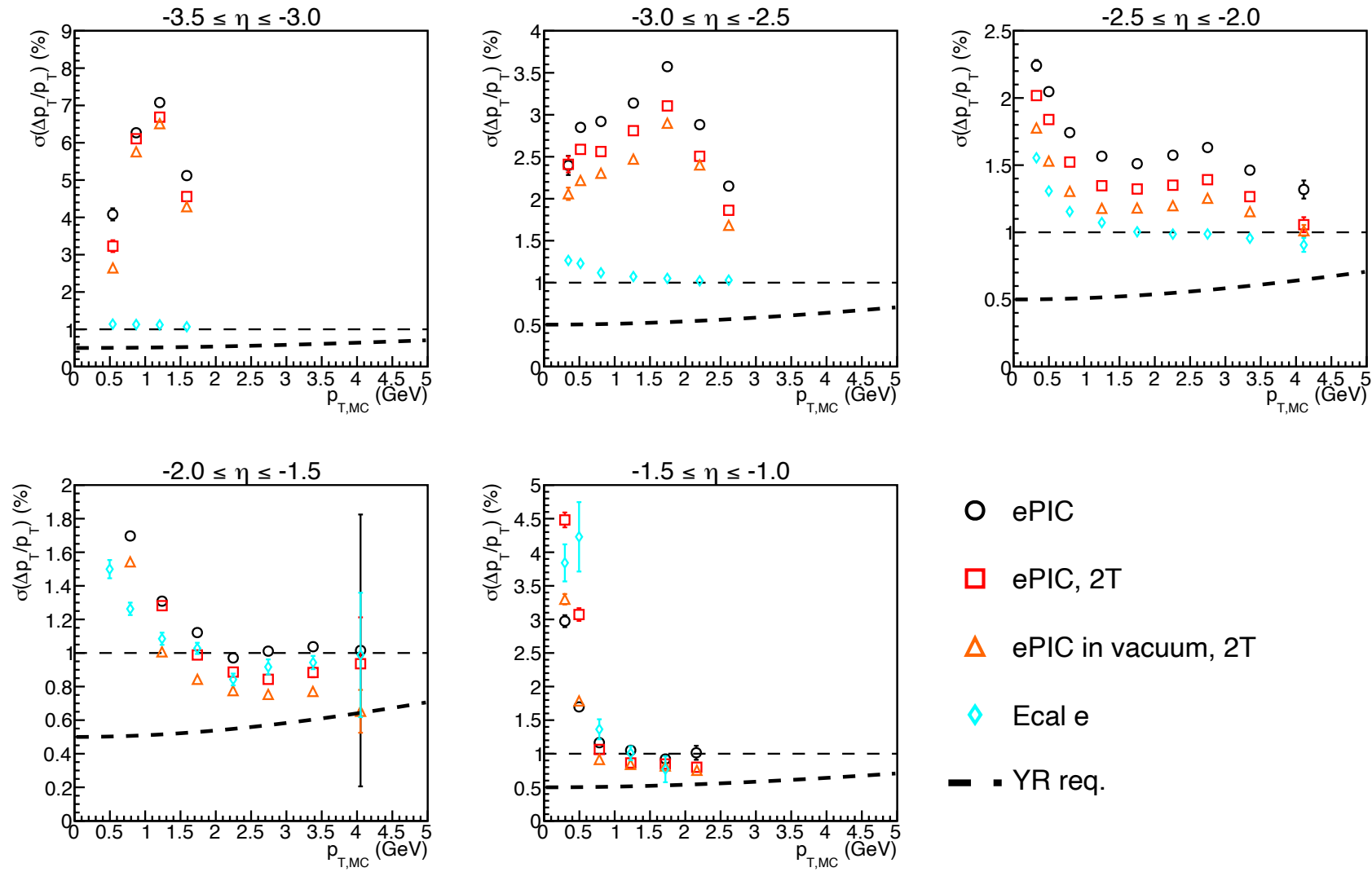
☆ Ecal e

# Transverse Momentum Resolution of the Backward Tracker



- True PID
- Change in one aspect of the tracker design does not provide sufficient improvement in momentum resolution

# Transverse Momentum Resolution of the Backward Tracker in Vacuum



# Summary

- $J/\psi$  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
- Working on different tracker designs to improve the backward tracking performance