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 → J/ψ reconstruction
    - backward Ecal → Scattered electron
    - Far forward detector → incoherent event vetoing
    - Far backward detector → low Q^2 measurements

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Ping – coherent event simulations (Muon ID, Tracking detector, backward Ecal)
- Improve t resolution
- Implement muon ID smearing

Jihee – incoherent event simulations (Far forward detector)
- Implement the second focus detector
- Study incoherent event vetoing efficiency

Simulation Setup

Sartre

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

Brookhaven National Laboratory

Detector Setup

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

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

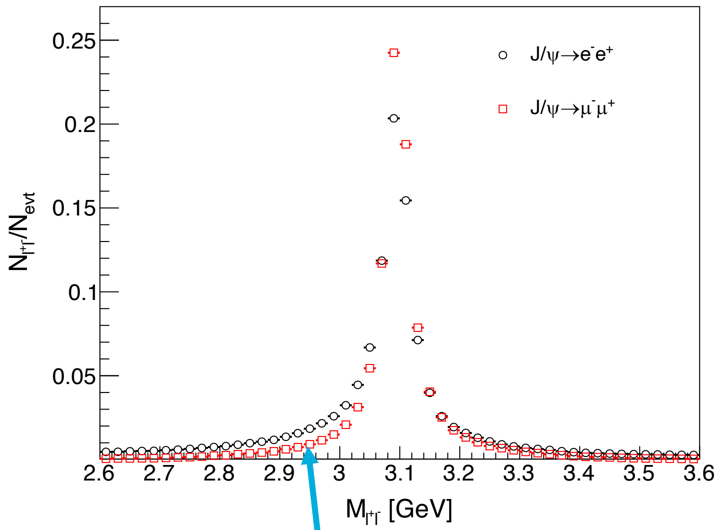
- Scattered electrons must be negatively charged
- "$\boldsymbol{J/\psi}$ decayed" electrons are excluded
- $Q^2 = -(e_{beam} - e_{scattered}).M2()$

t from method L

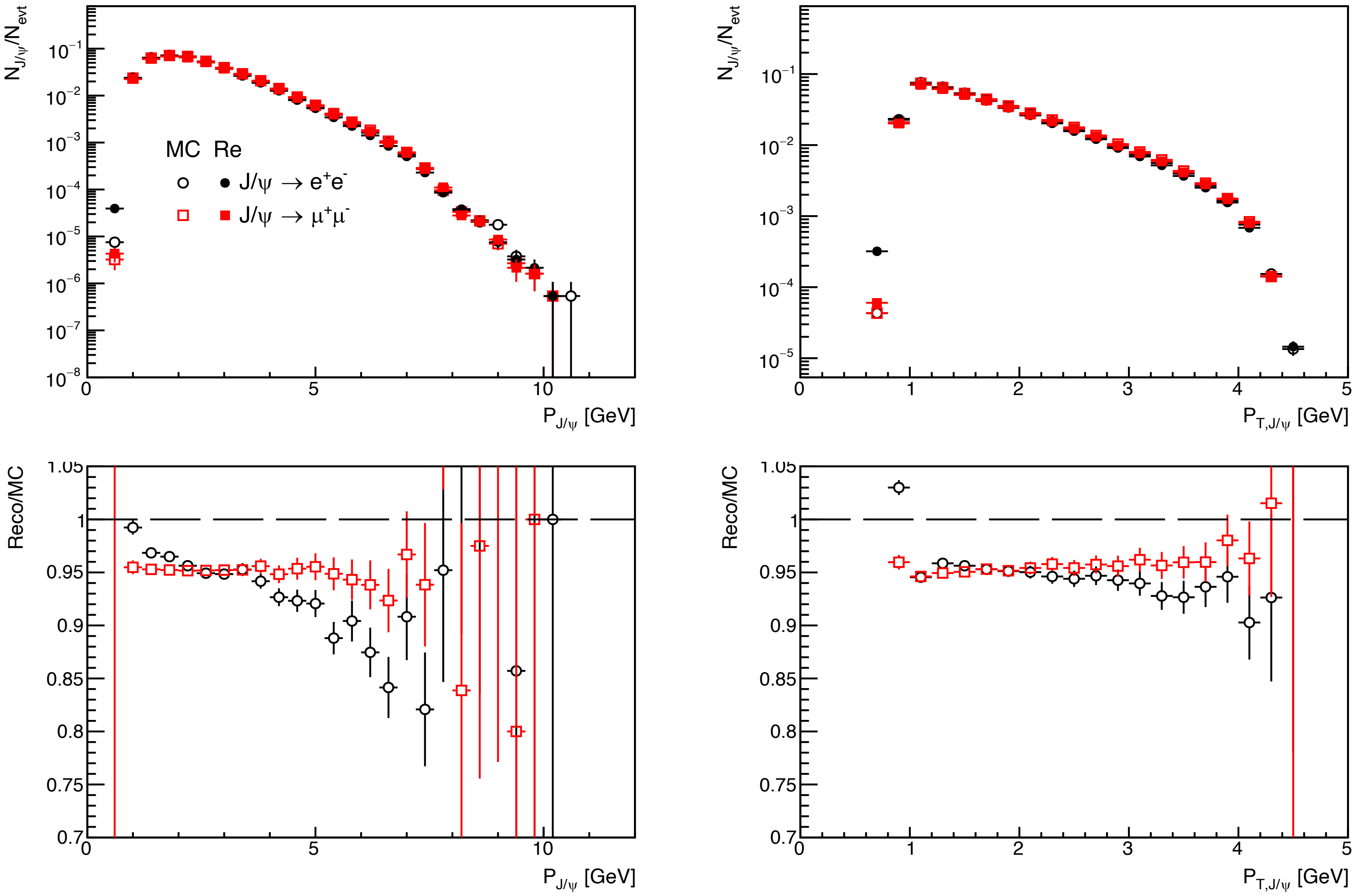
- Removed events with a mis-reconstructed $Q^2 < 1$ GeV^2
- Reconstructed $\boldsymbol{J/\psi}$ $|\eta| < 1.5$ -> avoid ambiguity between scattered and decayed electrons, and avoid poor tracking region
- Require information of the proton/ion beam
- Better t resolutions

Reconstructed J/ψ

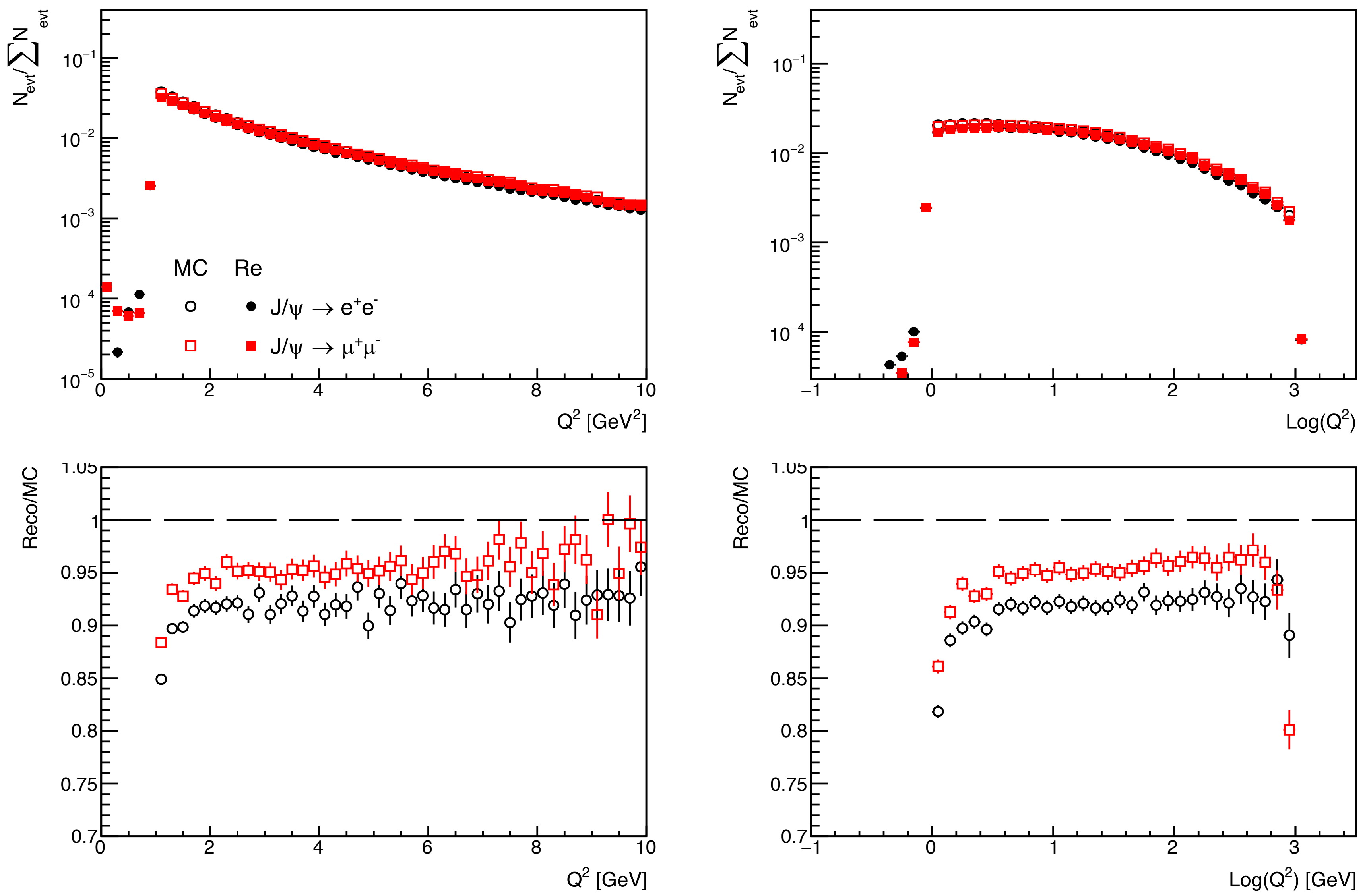
J/ψ mass window mean $\pm$ 2 std dev



- 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

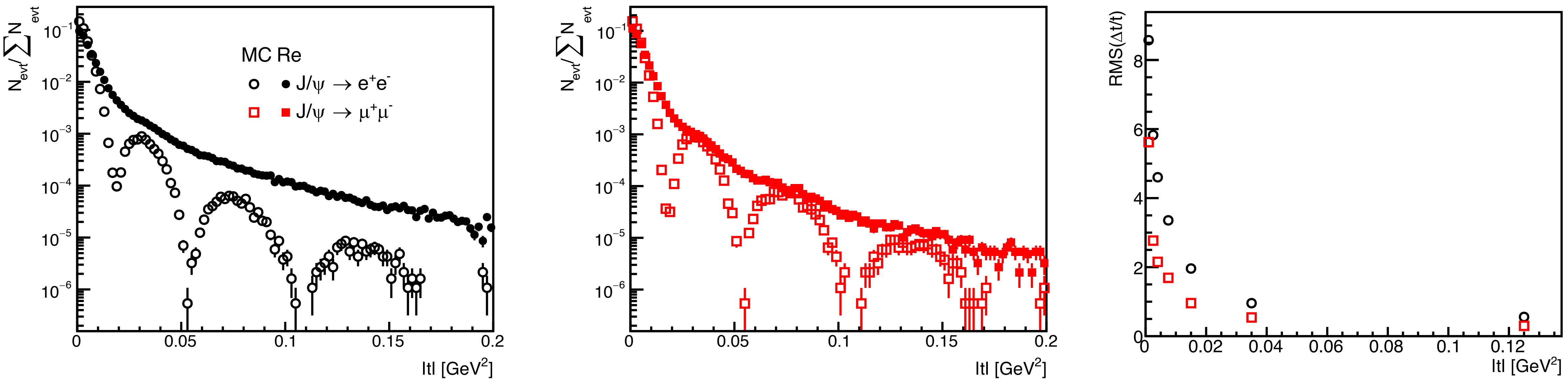


Reconstructed Q^2



- Using dielectron channel may reduce Q2 efficiency since scattered electron is defined as "not 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

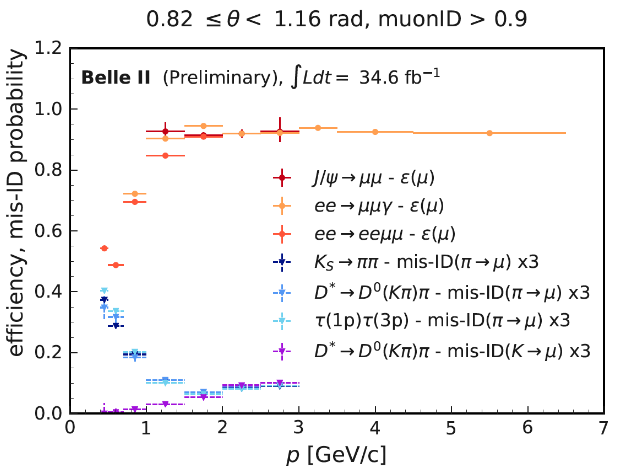
- But improvement from using dimuon is not enough
  → Require significant improvement in scattered electron measurements
  → Beyond excellent backward tracking/Ecal with a momentum/energy resolution smaller than 1%

Summary

- First look at the ePIC (craterlake) performance on coherent J/ψ diffractive pattern measurements

- Compared dielectron and dimuon channels
  - Dimuon channel gives better t resolution
  - Caveat: using true PID
  - Still need significant improvement on scattered electron measurements

- To-do list
  - Implement muon ID smear
    Start with BELLE II KLM performance
  - Improve backward tracking resolution



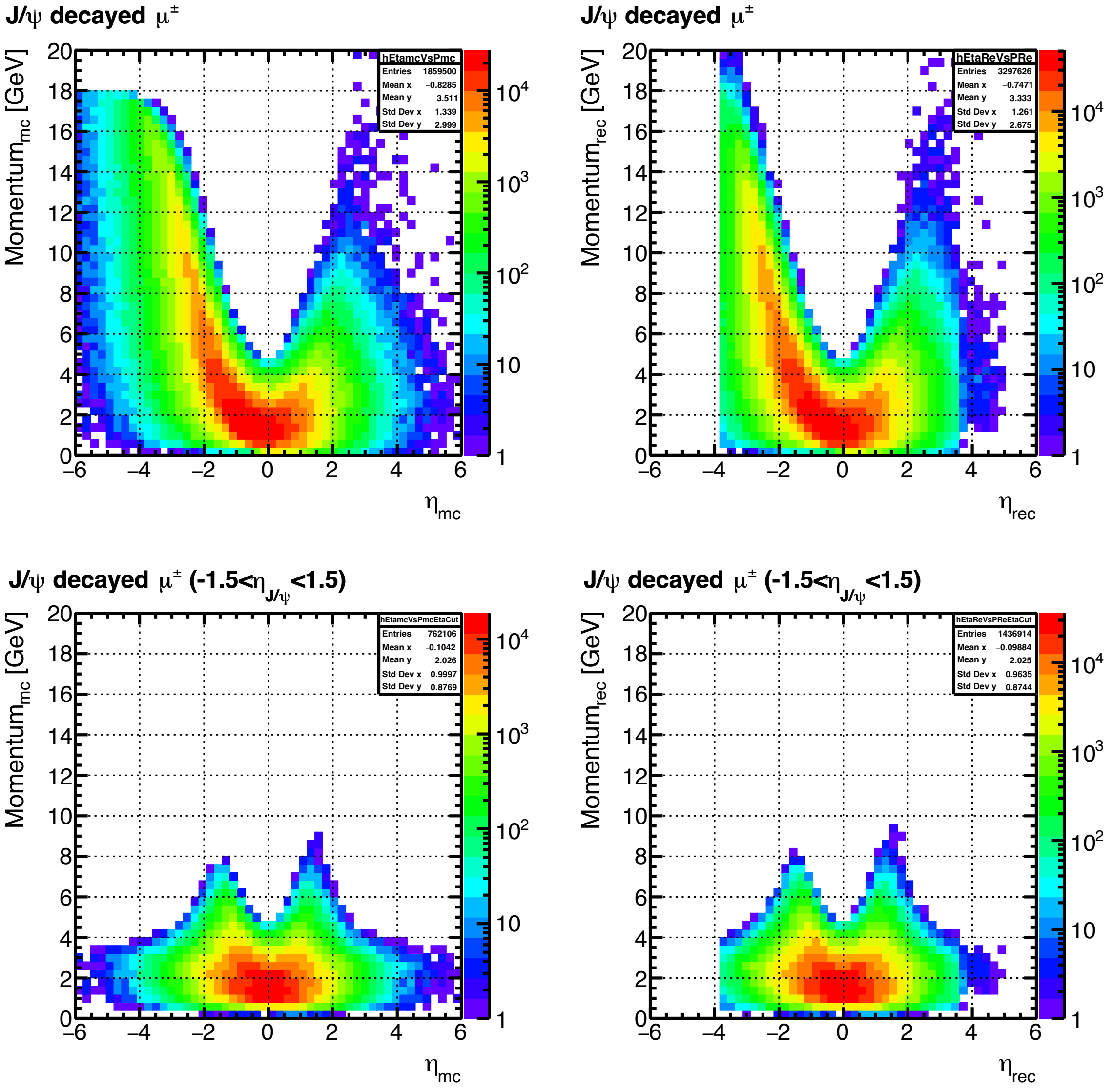
Backup

Simulation Setup

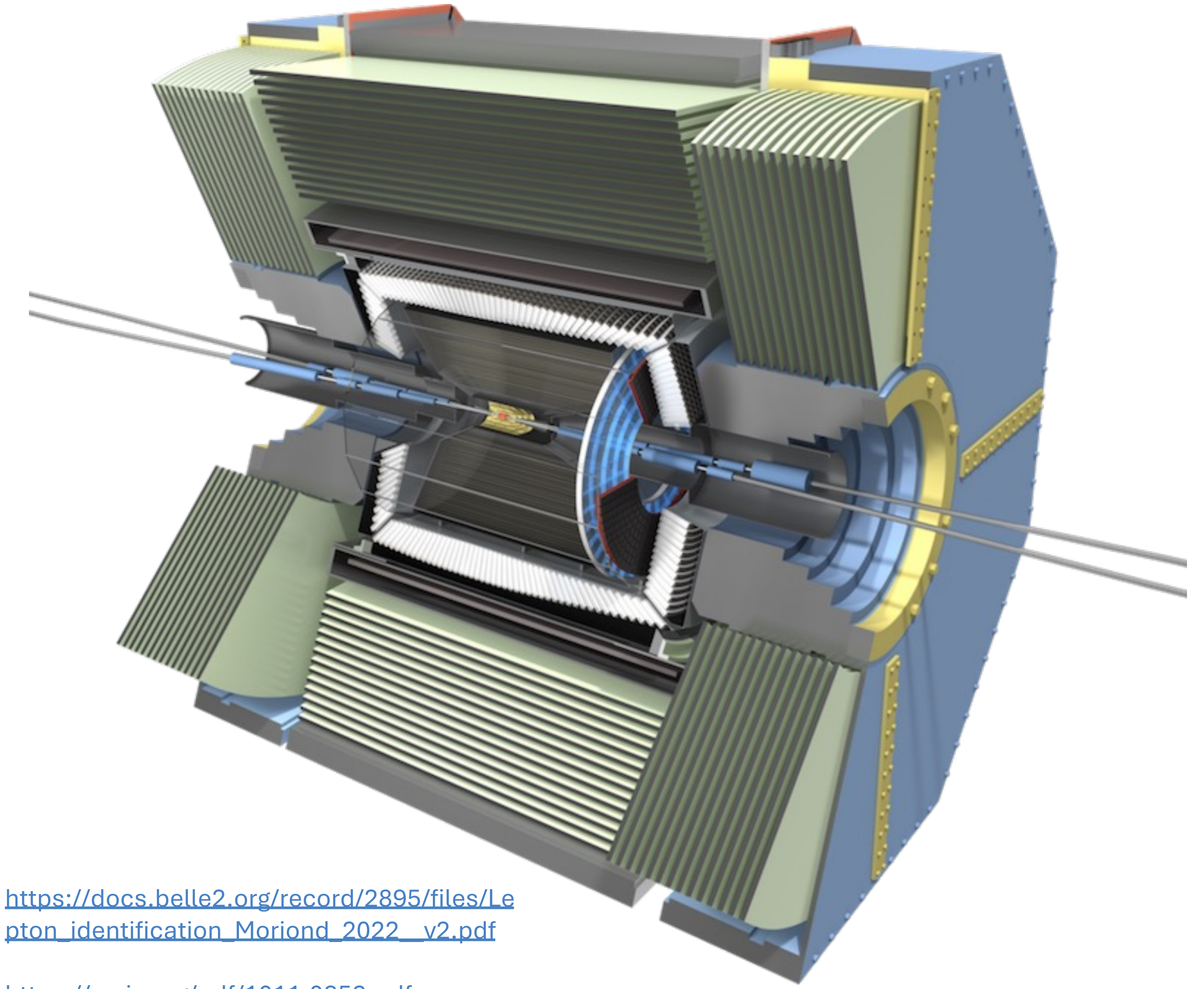
	Coherent Events	Incoherent Events
Event Generator	Sartre	Beagle (contains fragments of the ion beam)
Collisions	e+Au	e+Pb
Energy	18x100 GeV	18x108 GeV
Forced J/ψ decay	$J/\psi \rightarrow e^{+}e^{-}$ $J/\psi \rightarrow \mu^{+}\mu^{-}$	$J/\psi \rightarrow \mu^{+}\mu^{-}$ (Not reconstructed)
Q^2	$1 - 1000$ GeV^2 (Showing results in $1 \leq Q^2 \leq 10$ GeV^2)	≥ 1 GeV^2
Number of events	1.5-2M events	

No background or noise in simulated events

J/ψ Decayed Dimuon Kinematics



BELLE II KLM Performance



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

https://arxiv.org/pdf/1011.0352.pdf

Implement muon ID smearing
Starting with BELLE II KLM performance

- min μ p=0.6 GeV
- Efficiency = 89% for p≥1GeV
- Fake rate 1.3% for p≥ 0.7GeV
- Fake rate ≤3.8% for p≤ 0.7GeV