Muon Kinematics Check for Muon Detector

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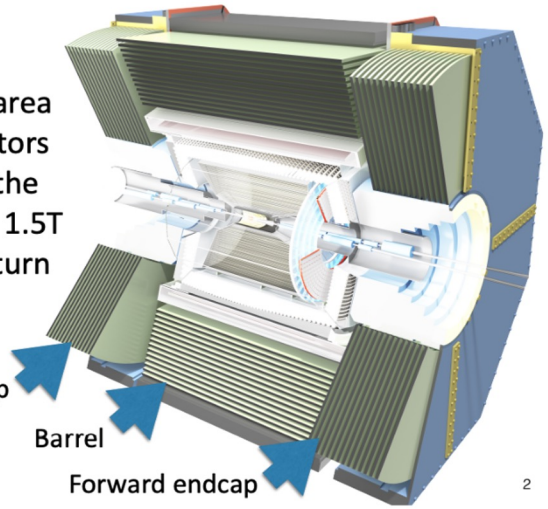
Dedicated muon ID detector

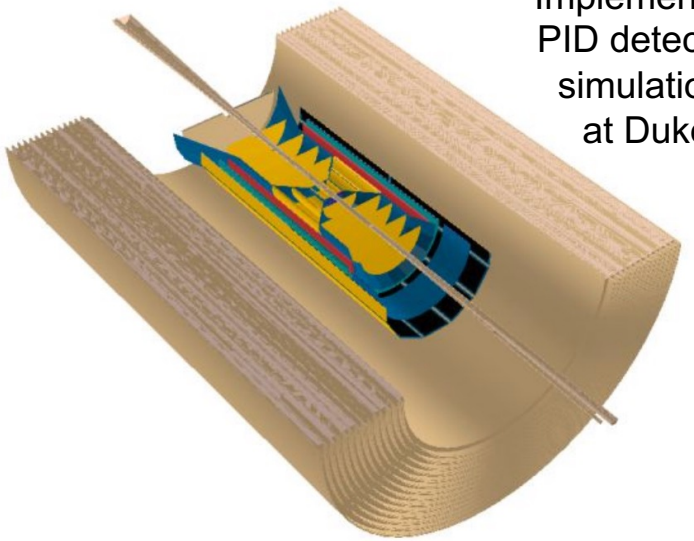
Muon Detector Idea for EIC 2nd Detector

The KLM ("K_L–Muon detector")

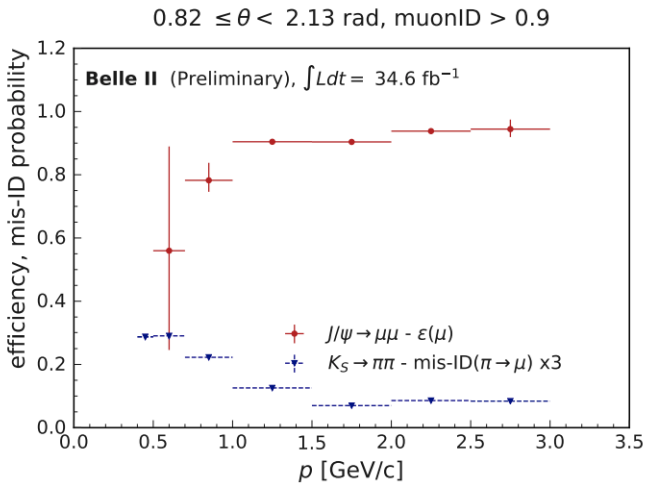
consists of large-area thin planar detectors interleaved with the iron plates of the 1.5T solenoid's flux return yoke.



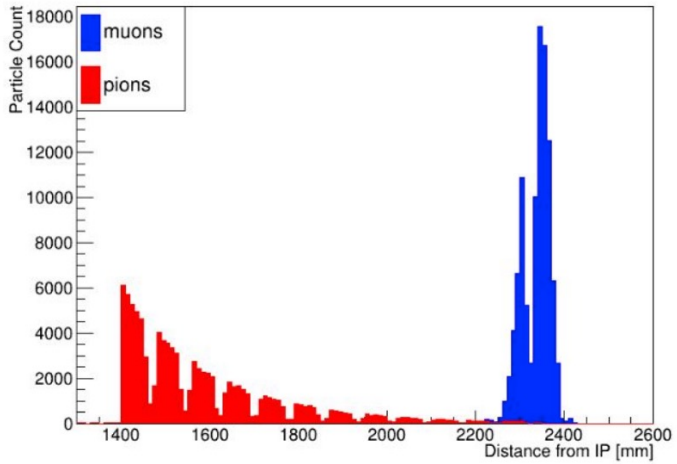
EIC Generic R&D programs:
#18 KLM-type detector



Implementation of muon PID detector in DD4hep simulation framework at Duke University



For muons
p > 0.6 GeV
1.5 T solenoid



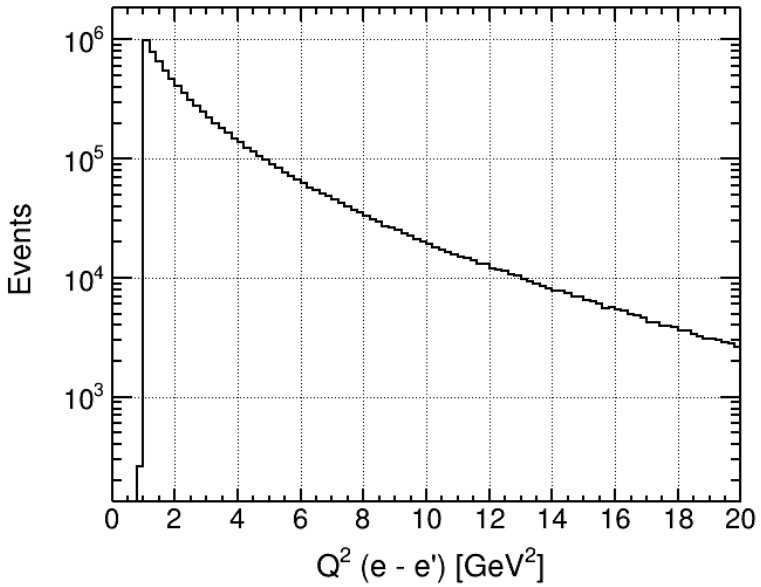
ePIC can do muon ID
Using ECAL and HCAL (mip-like events)

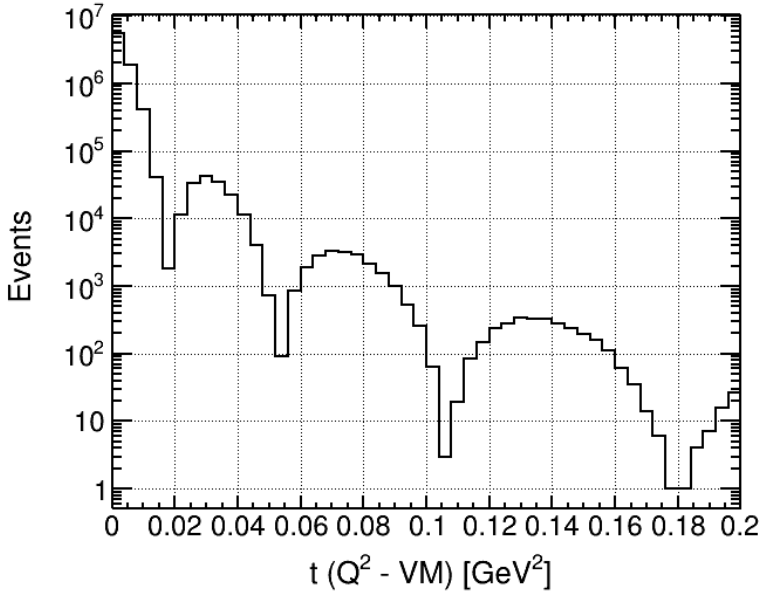
We know low energy muons curl inside the barrel EM calorimeter (do not reach HCAL) < ~ 0.9 (1.5) GeV/c for 1.7 (3)T at eta = 0 field for ePIC geometry

1.7 T solenoid
Penetration depths of pions and muons at 1 GeV

First Sample

- Sartre **eAu coherent 18×110 GeV diffractive J/ψ production**
  - Generated by Thomas with saturation effects ON – 8M events
  - Only **J/$\psi \rightarrow \mu^+\mu^-$** channel
  - **$1 < Q^2 < 20$ GeV^2**

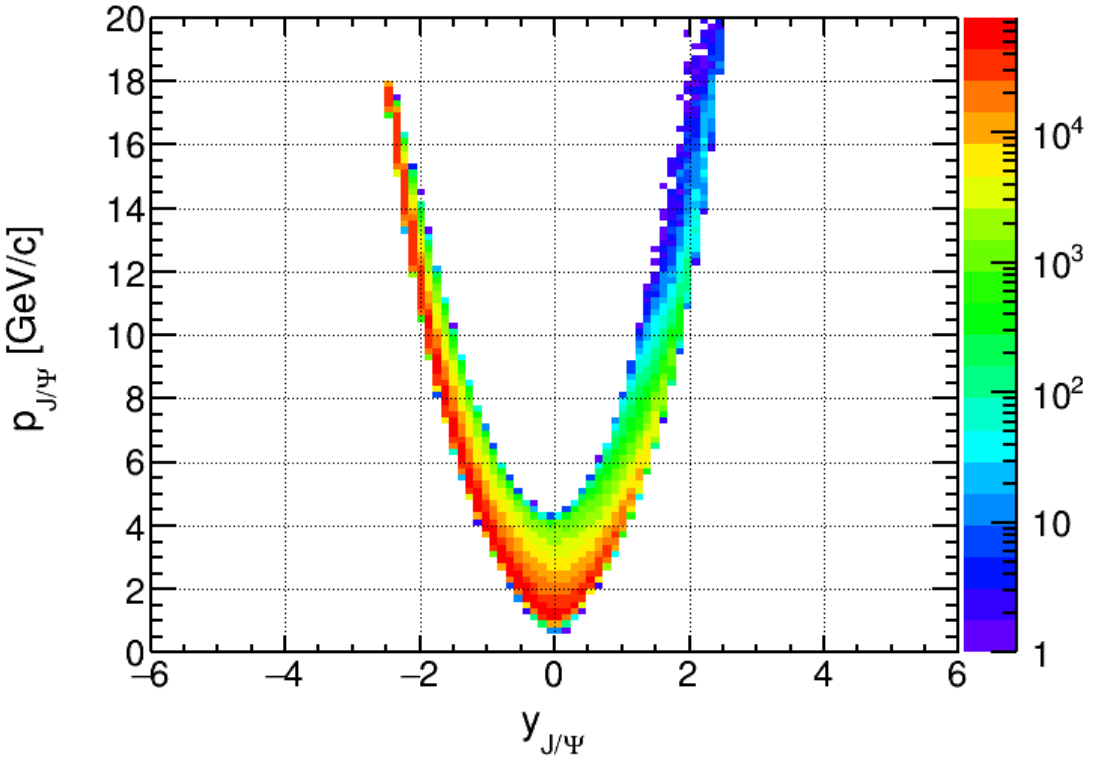




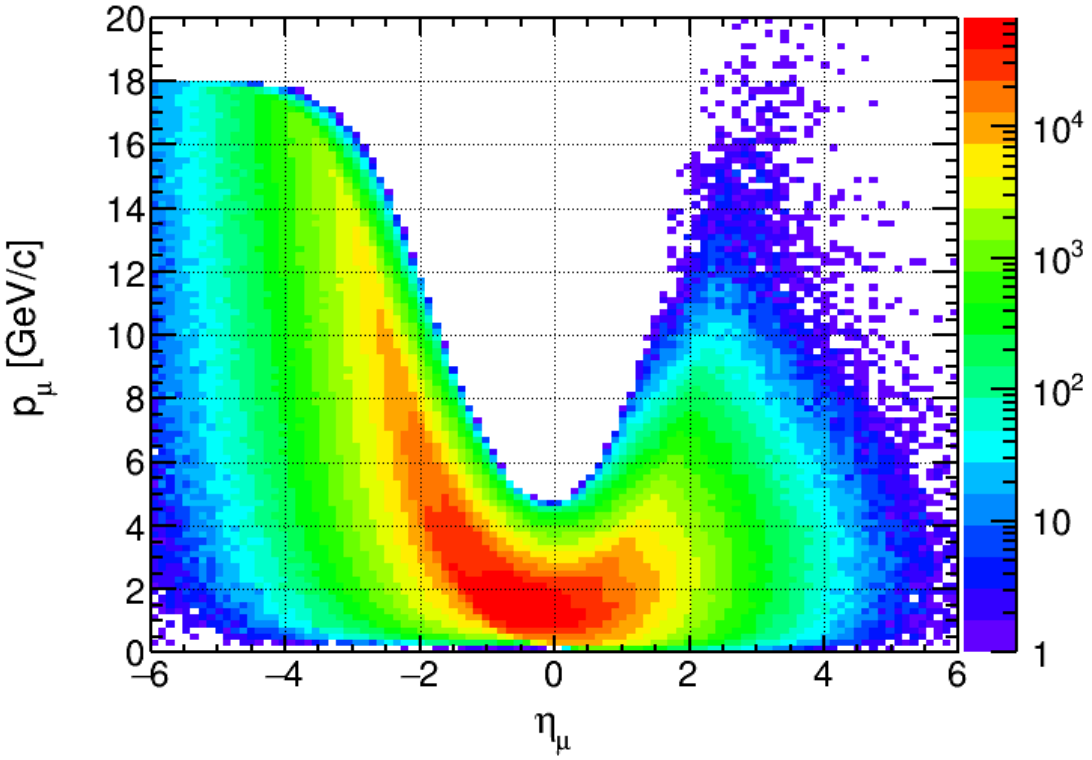
Kinematics – p for J/ψ and decay $\mu^+\mu^-$

$1 < Q^2 < 20\ GeV^2$

J/ψ



J/$\psi \rightarrow \mu^+\mu^-$



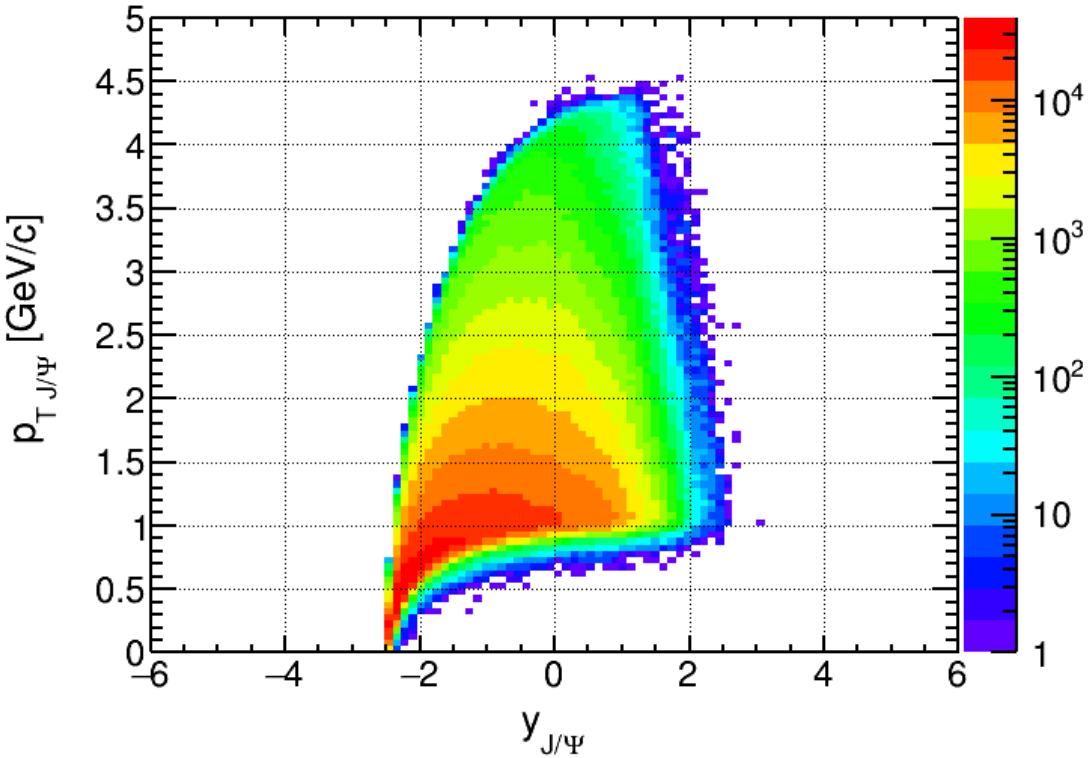
J/ψ decay muons kinematics are within $|\eta| < 2$ (hotspot) and p_μ ~ 1.5 GeV at peak, but still, plenty of muons are going outside mid-rapidity

Muon PID might be important in the forward/backward region

Kinematics – p_T for J/ψ and decay $\mu^+\mu^-$

$1 < Q^2 < 20\ GeV^2$

J/ψ



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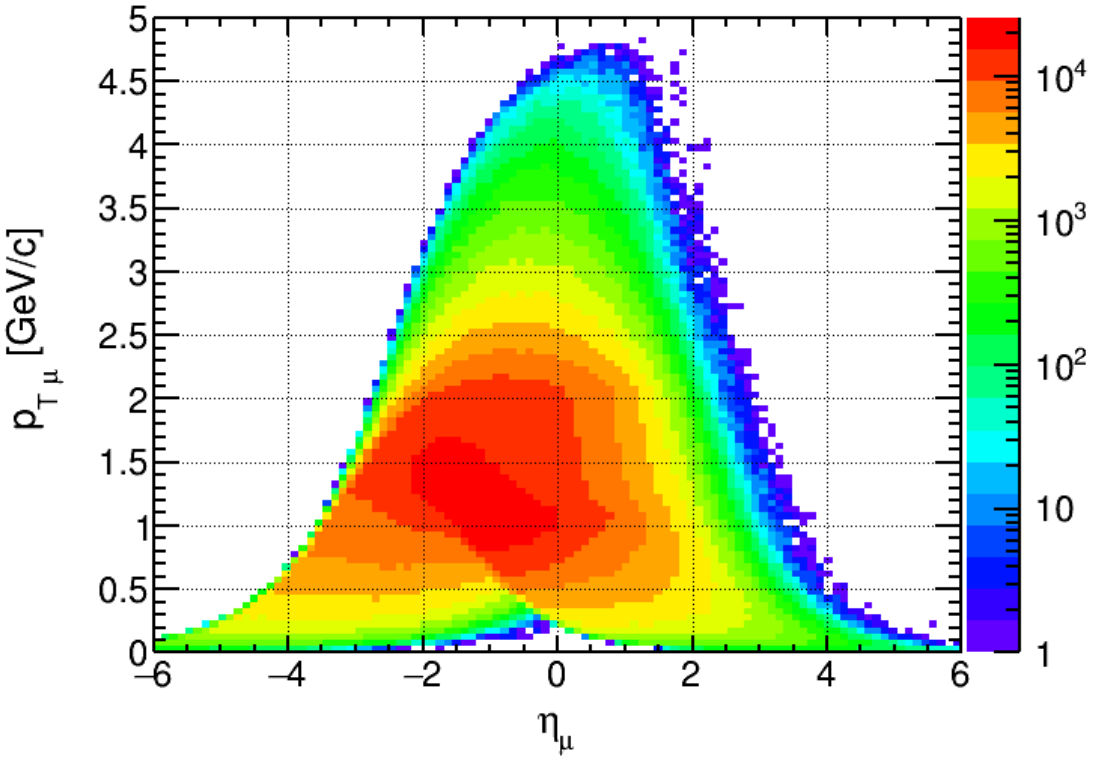
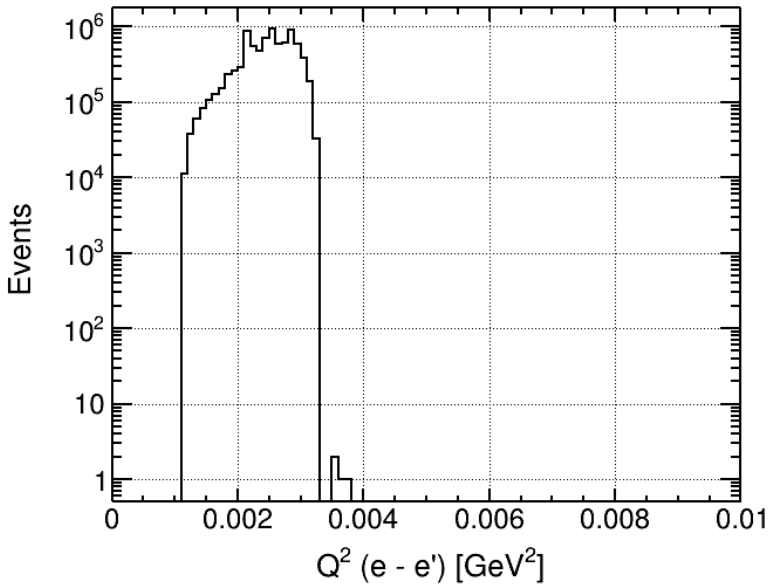


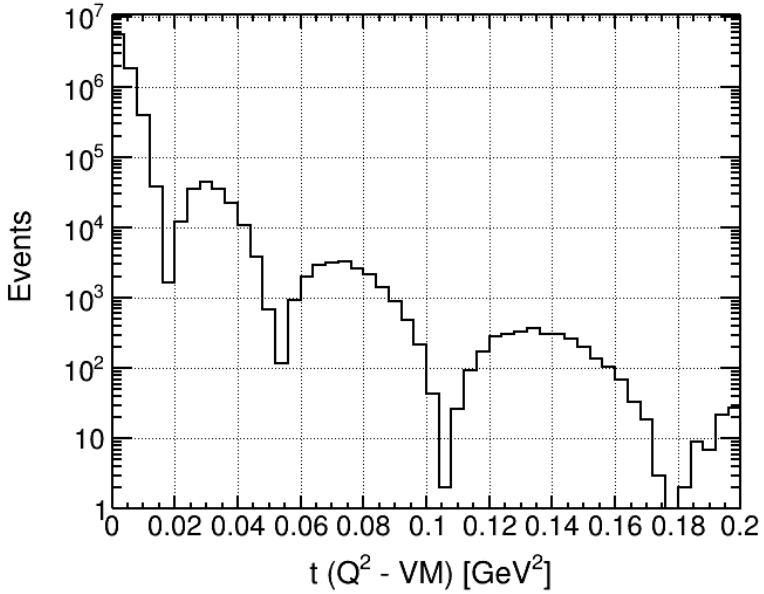
J/ψ decay muons kinematics are within $|\eta| < 2$ (hotspot) and $p_{T\ \mu} \sim 1.1$ GeV at peak, but still, plenty of muons are going outside mid-rapidity

Muon PID might be important in the forward/backward region

Second Sample

- Sartre **eAu coherent 18×110 GeV diffractive J/ψ production**
  - Generated by Thomas with saturation effects ON – 8M events
  - Only **J/ψ** $\rightarrow$ $\mu^+\mu^-$ channel
  - **Q^2 < 1 GeV^2 (photoproduction)**

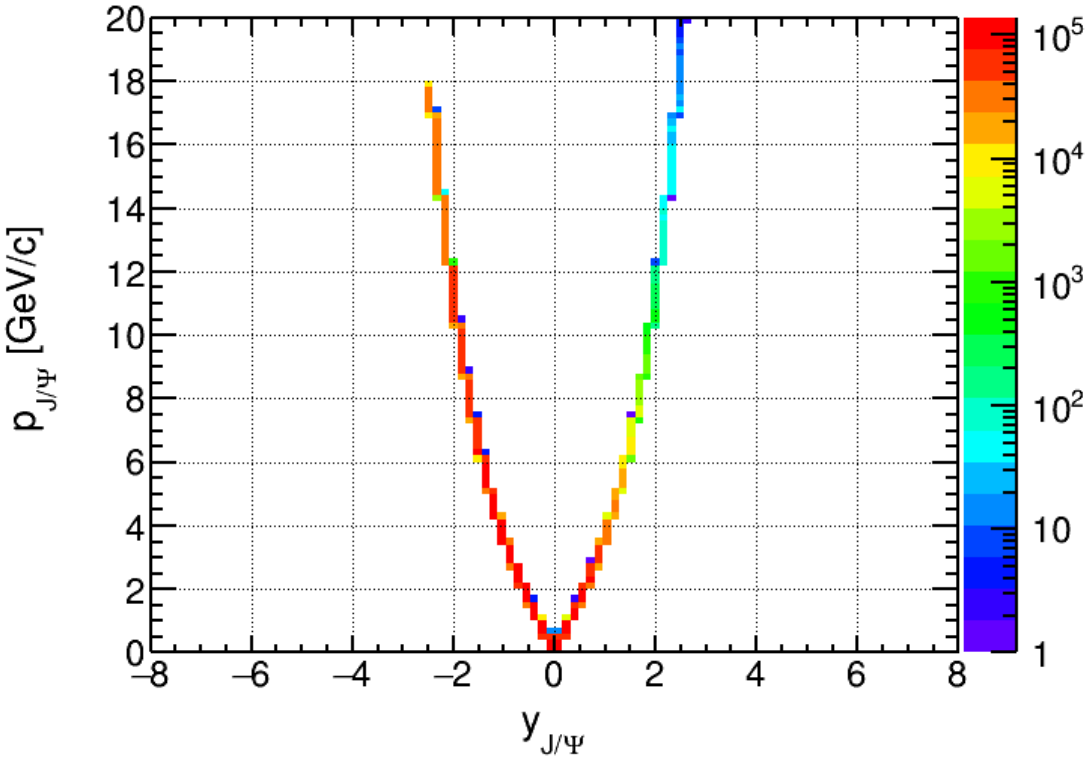




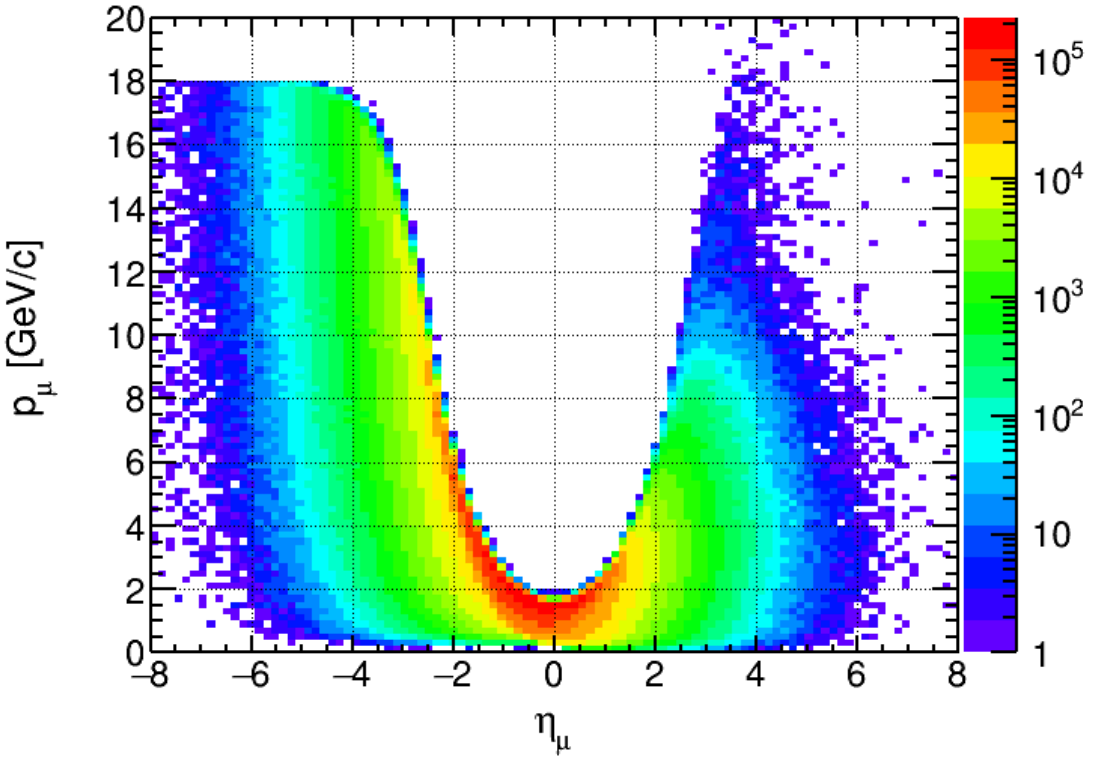
Kinematics – p for J/ψ and decay $\mu^+\mu^-$

$Q^2 < 1\ GeV^2$ (photoproduction)

J/ψ



J/$\psi \rightarrow \mu^+\mu^-$



J/ψ decay muons kinematics are within $|\eta| < 2$ (hotspot) and p_μ ~ 1.5 GeV at peak, but still, plenty of muons are going outside mid-rapidity

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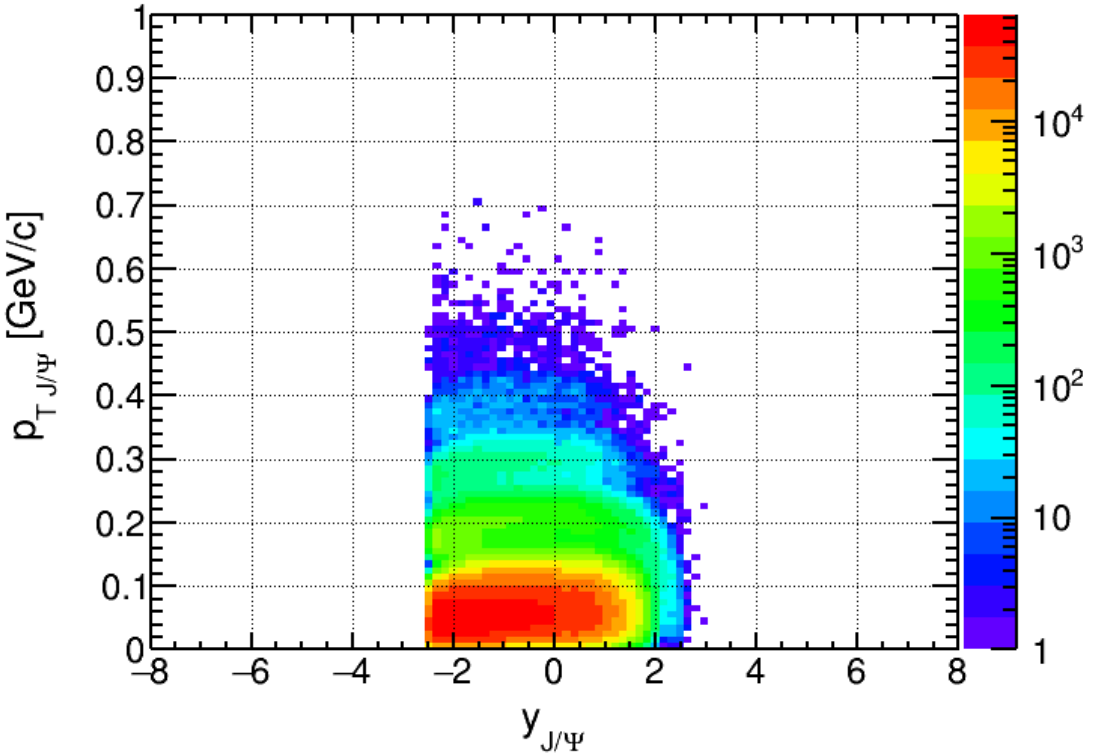

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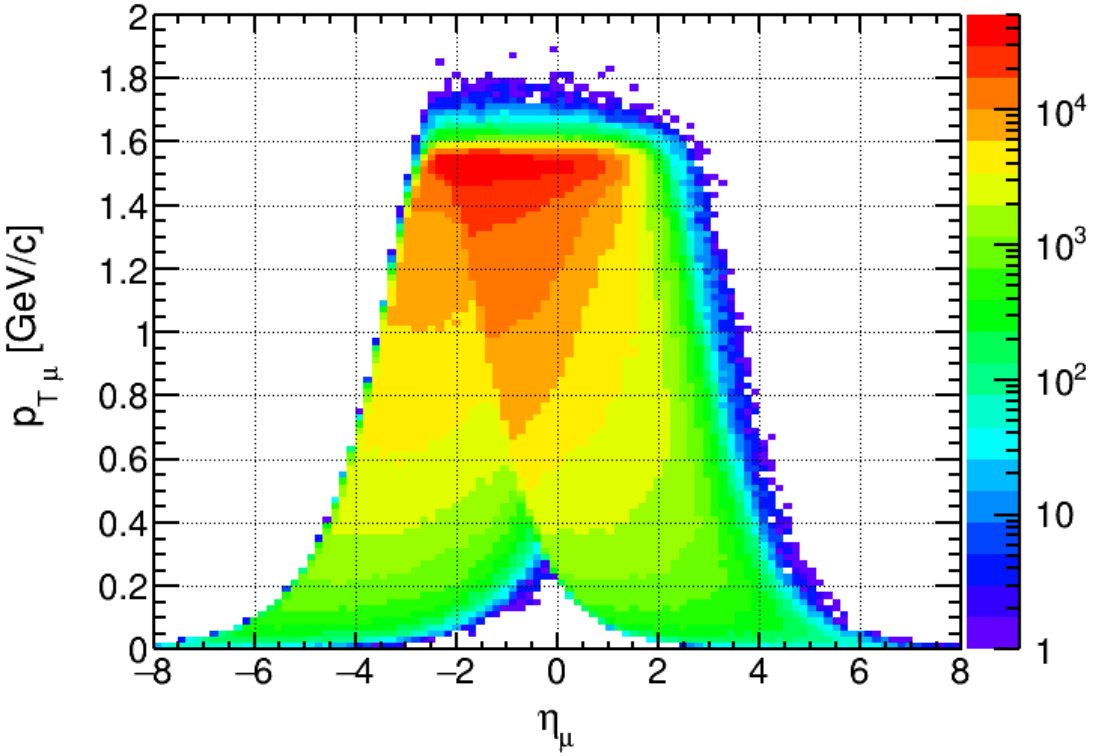


J/ψ decay muons kinematics are within $|\eta| < 2$ (hotspot) and $p_{T\,\mu} \sim 1.5$ GeV at peak, but still, plenty of muons are going outside mid-rapidity

Muon PID might be useful in the forward/backward region

Summary

- Looked at eAu coherent J/ψ sample to check muon kinematics
  - Two samples for $1 < Q^2 < 20$ GeV^2 and $Q^2 < 1$ GeV^2
  - J/ψ decay muons kinematics are mostly within mid-rapidity, but plenty of muons are going forward and backward regions.
  - Muon ID detector might be useful in the forward/backward region

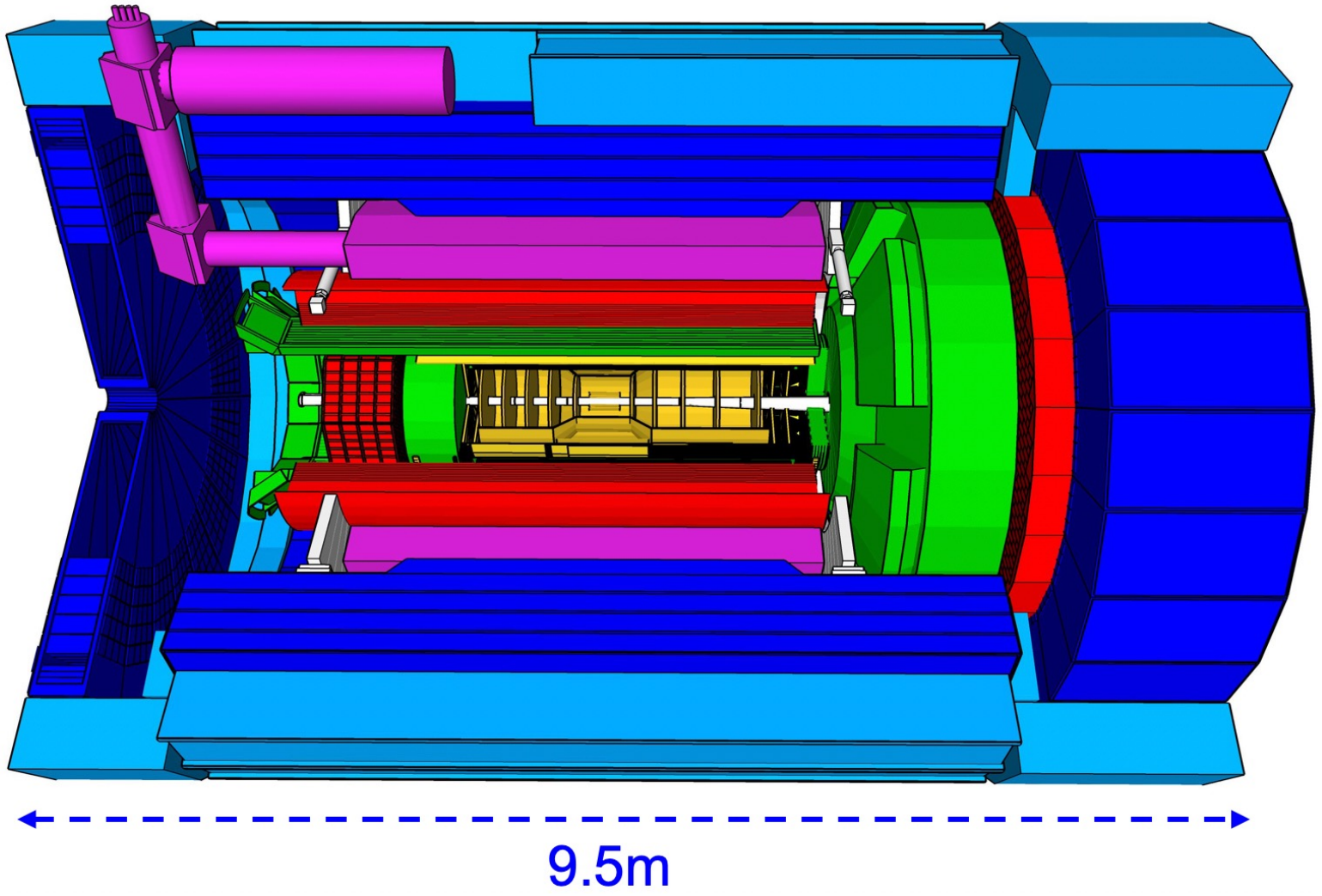
However,

- ❑ Depends on magnetic field strength and radius of solenoid
- ❑ See beam effects (afterburner), which angular divergence and momentum spread
- ❑ Run Pythia8 ep generator to check
- ❑ In forward region, PID + EMCAL + HCAL + muon ID? Enough space?

Backup Slides

Take a look at ePIC Detector

- hadronic calorimeters
- Solenoidal Magnet
- e/m calorimeters (ECal)
- Time.of.Flight, DIRC, RICH detectors
- MPGD trackers
- MAPS tracker



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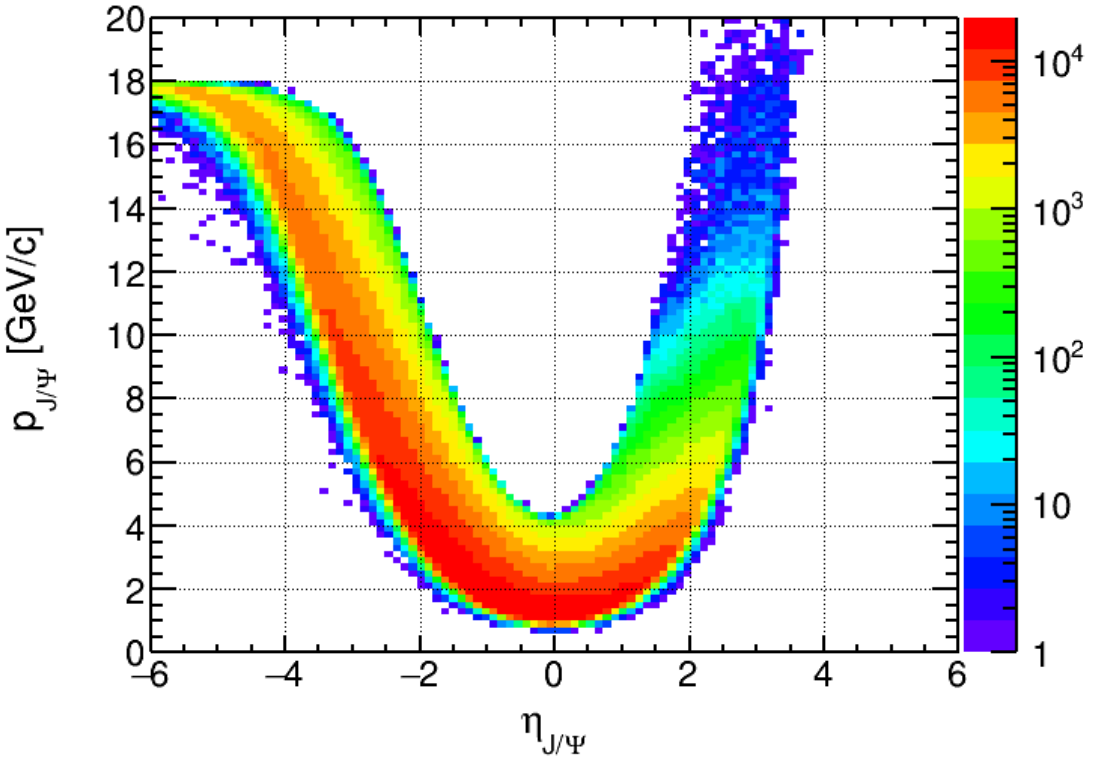

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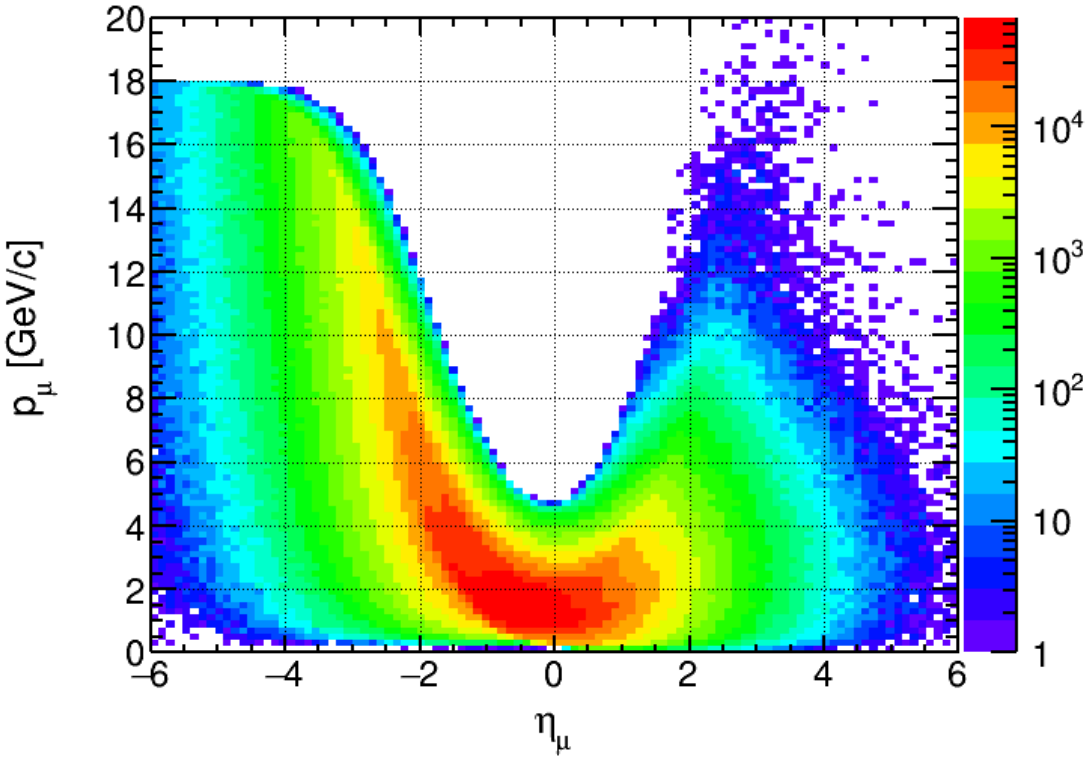

J/ψ decay muons kinematics are within $|\eta| < 2$ (hotspot) and p_μ ~ 1.5 GeV at peak, but still, plenty of muons are going outside barrel region

Muon PID might be important in the forward/backward region

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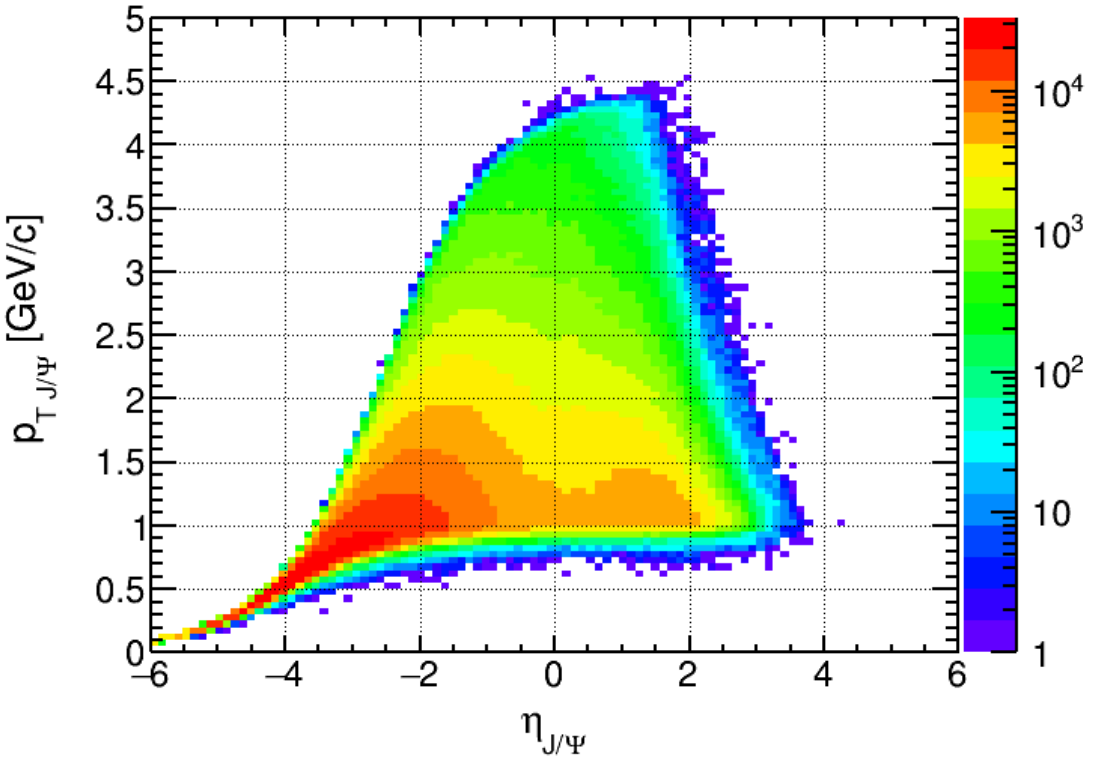
J/ψ



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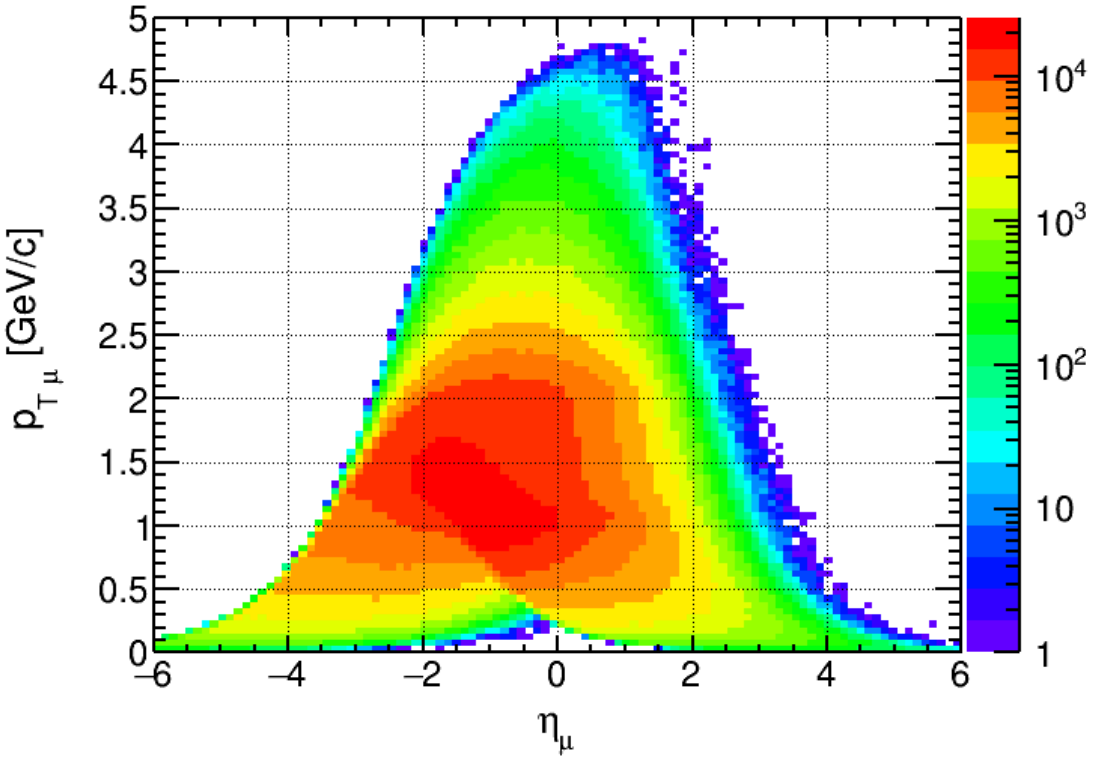

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Kinematics – p_T and p for e’

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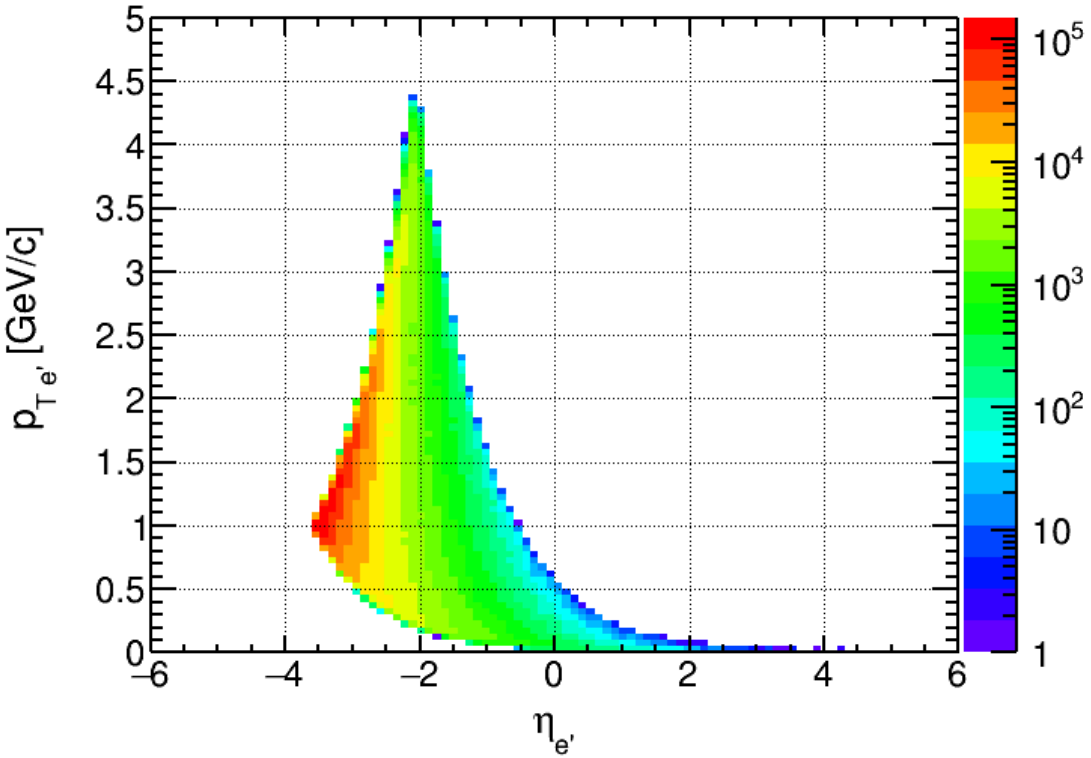

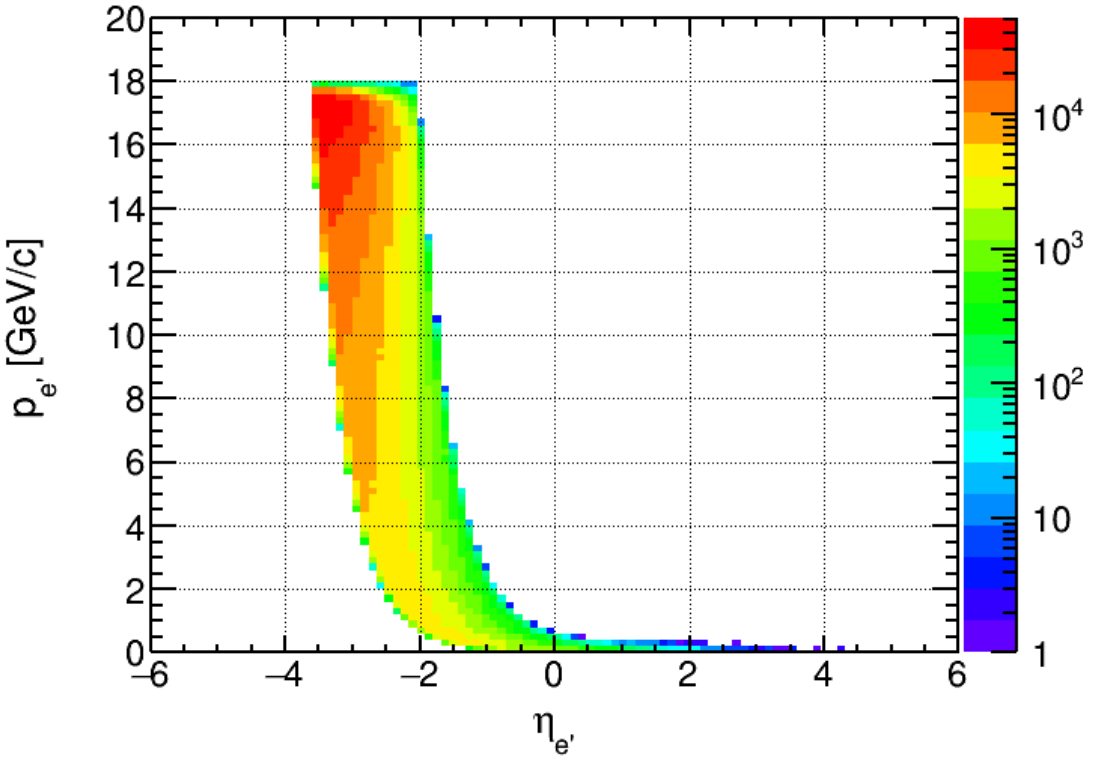

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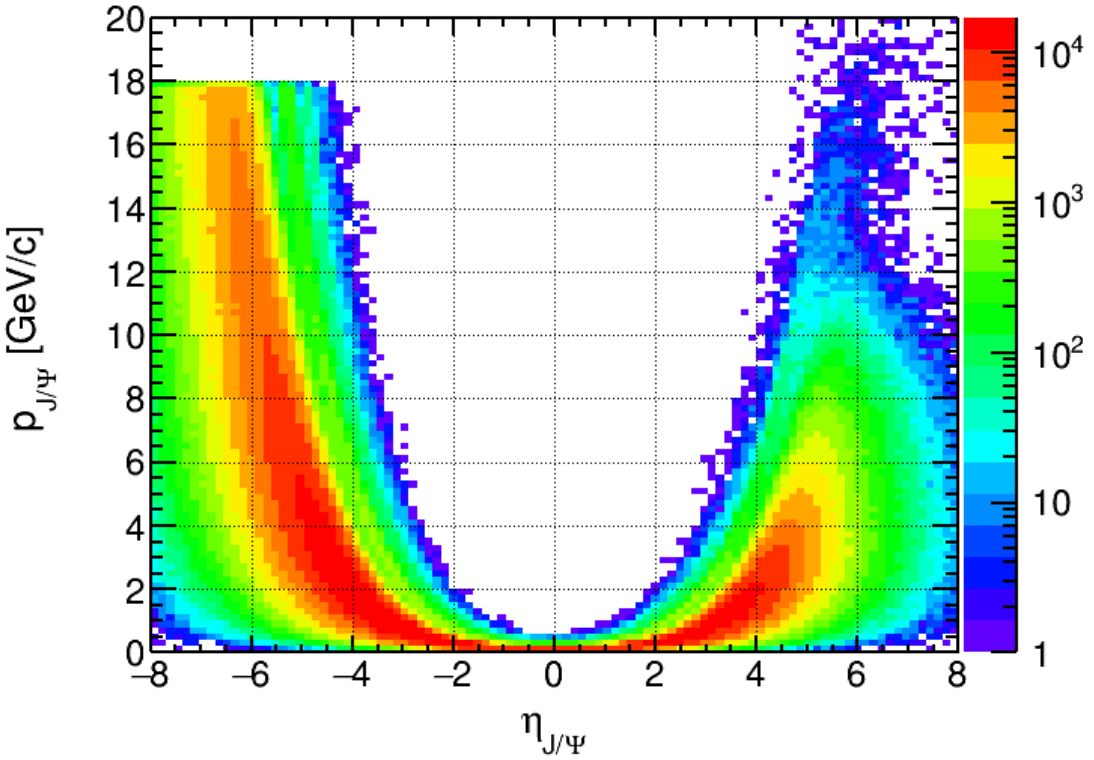
$Q^2 < 1\ GeV^2$ (photoproduction)

J/ψ



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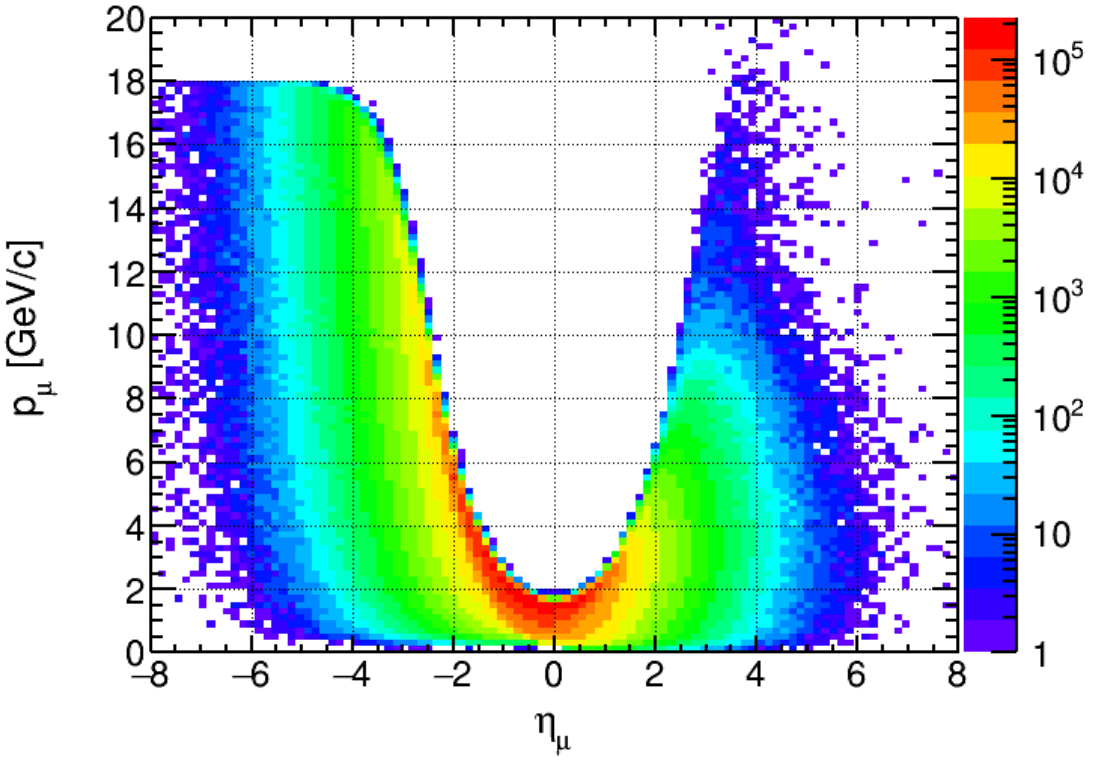

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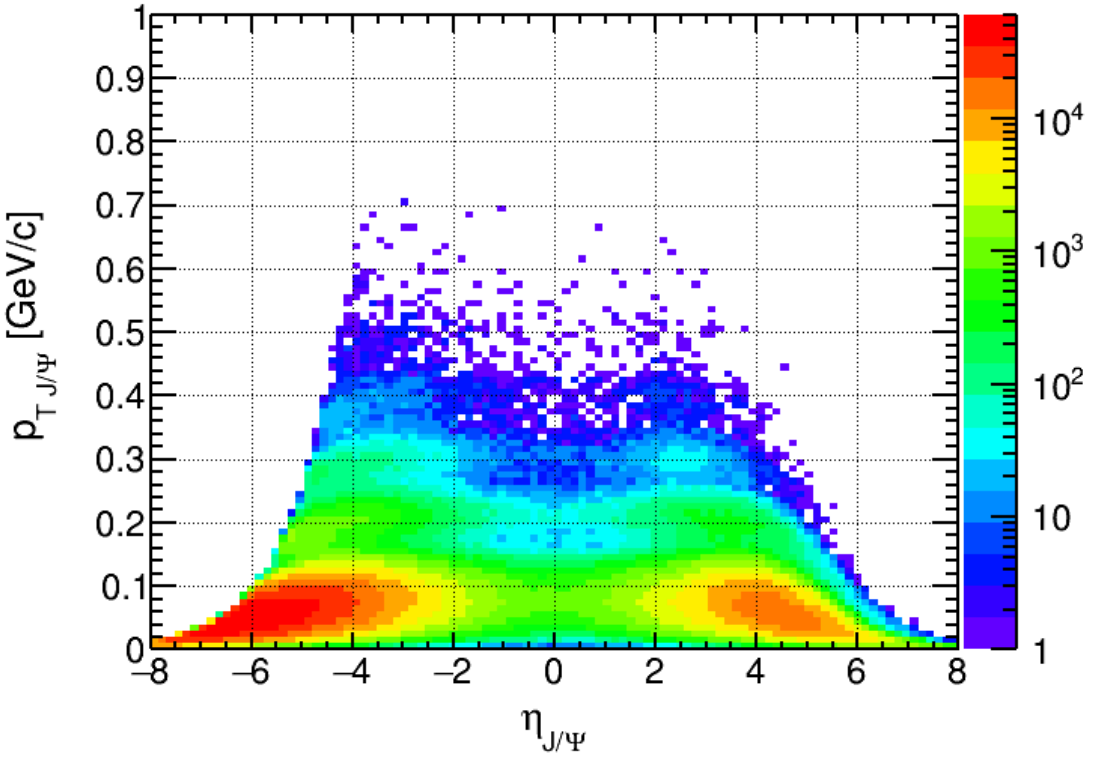

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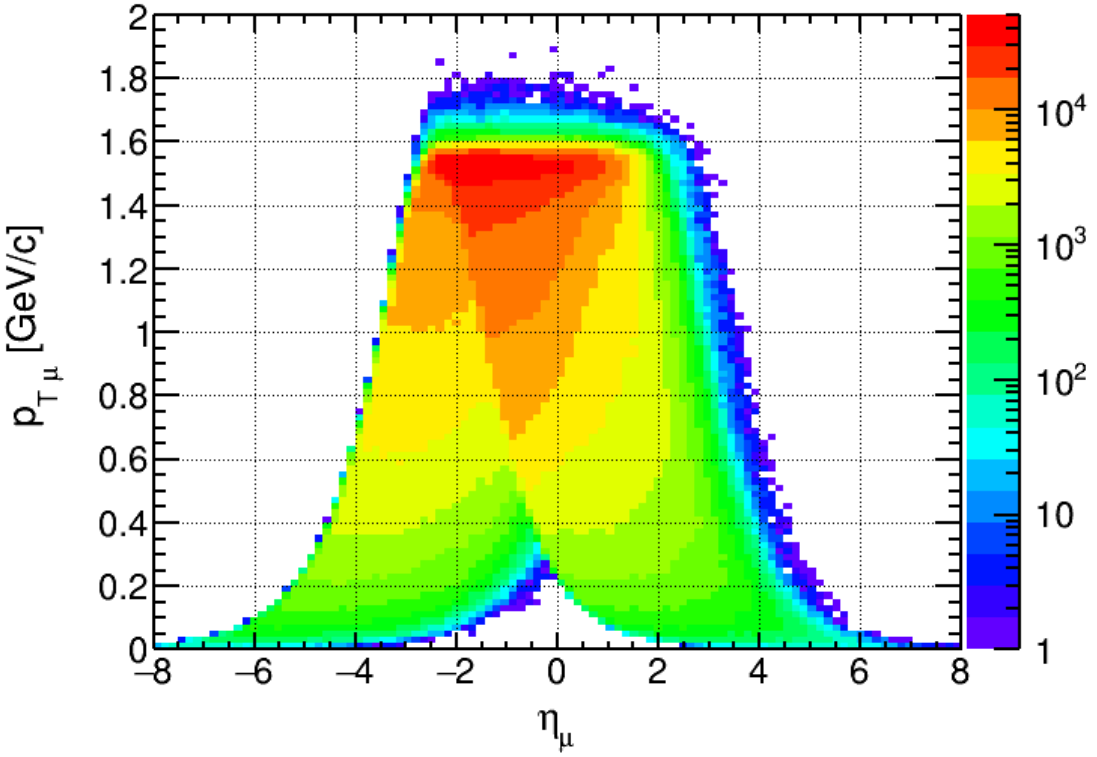

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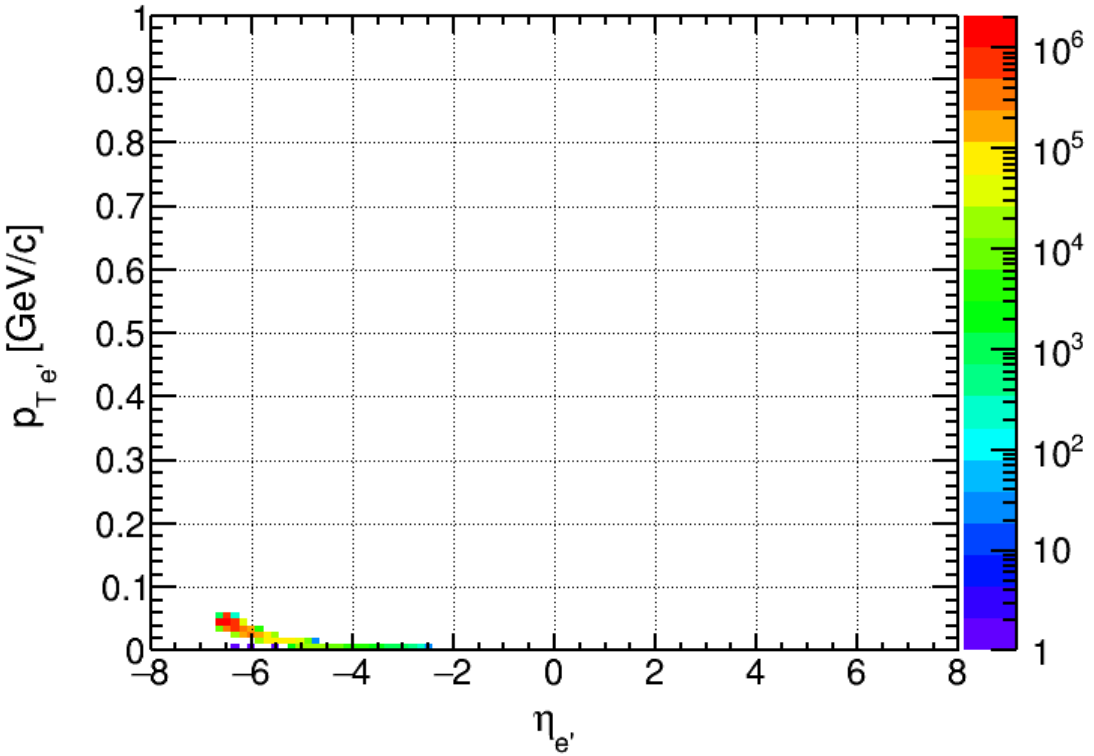
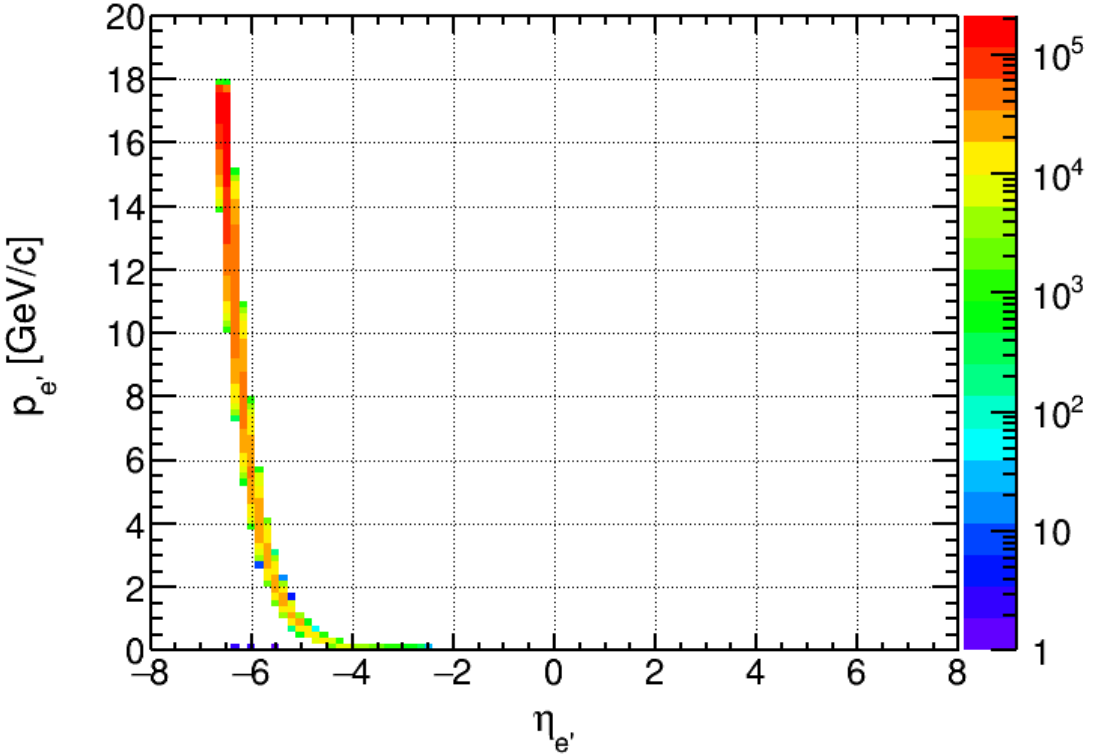
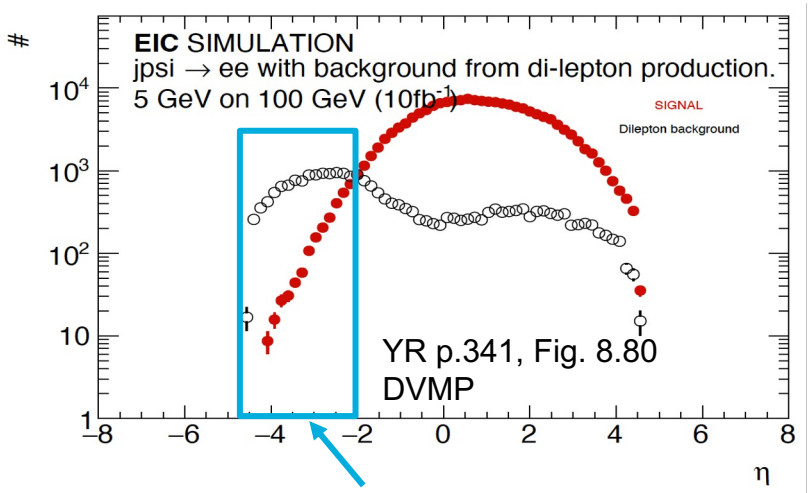




Focus Concept 1 – Muon ID

- In Detector 1 design
  - No dedicated muon ID detector
  - However, identify muon using ECAL and HCAL
- Detection of $\mu^{\pm}$ in exclusive measurements
  - **Cleaner signal** in quarkonium reconstruction compared to $e^{\pm}$
  - **Reduce ambiguity to the scattered electrons**
- **Complementary to ePIC: quarkonium reconstruction with different decay channels**
- Example muon ID technology: KLM at the B factory in KEK
  - **EIC Generic R&D programs**: #18 **KLM-type detector**



Large background at backward region when use di-electron channel

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