# Deeply Virtual J/ψ Production at ePIC

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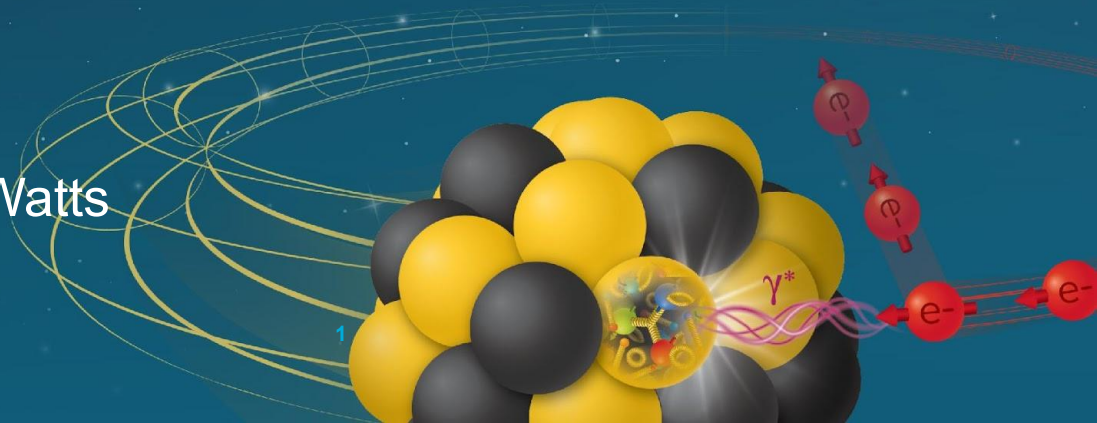
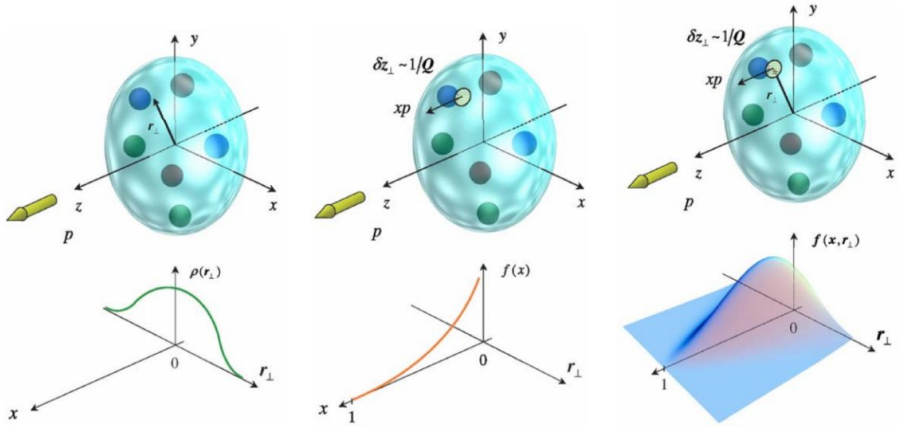
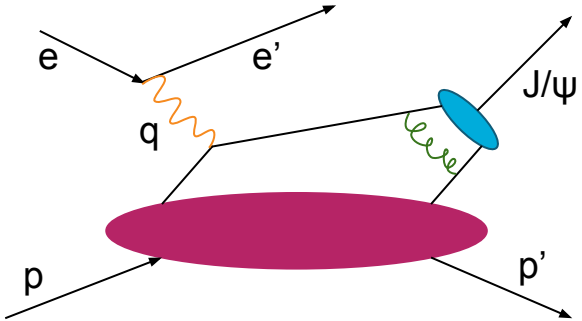
Electron-Ion Collider



# Why study DV J/ψ →μμ



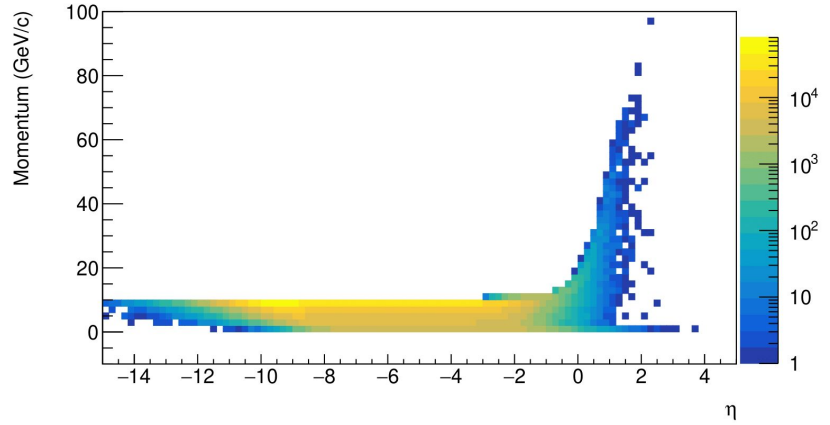

Uncovering Hadron Structure With Generalised Parton Distributions, A.V. Belitsky and A.V. Radyushkin

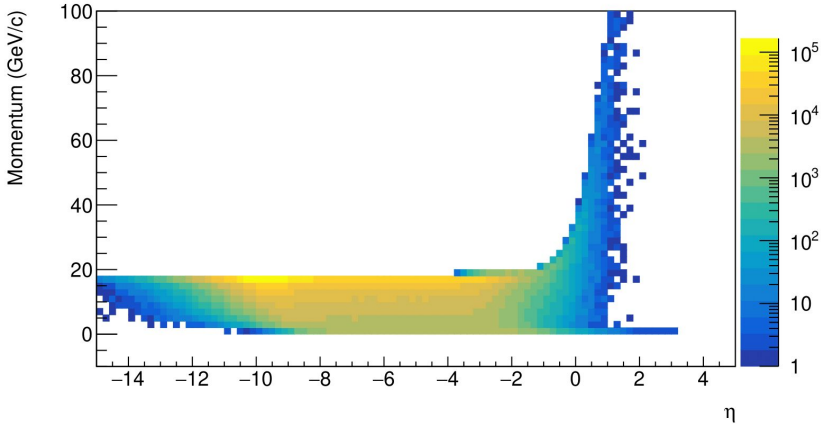



- DVMP is a complementary process to DVCS - both allow access to generalised parton distributions.
- DVMP with heavy vector mesons (such as J/ψ or Υ) can probe gluon GPDS.
- Gives an insight into gluon contribution to nucleon mass and spin as well as saturation.
- Muonic decay channel has a branching ratio of 6%.

Deeply Virtual Meson Production on the nucleon - L. Favart *et al*; 2016.
Unraveling hadron structure with generalized parton distributions - A.V. Belitsky and A.V. Radyushkin; 2005.

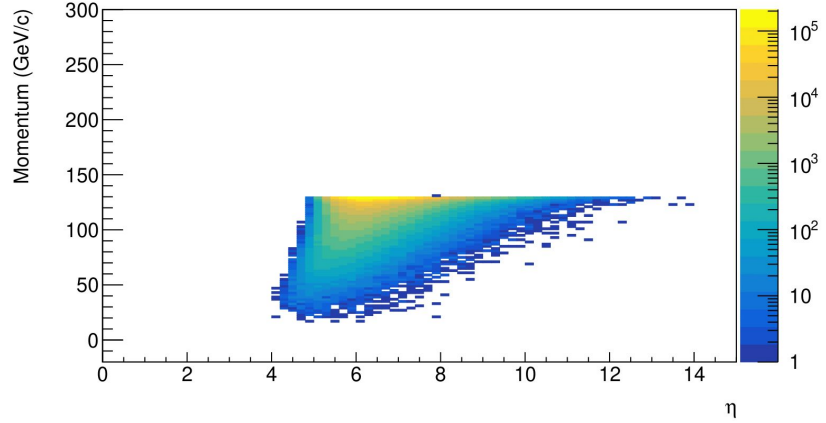
# Event sample - electrons

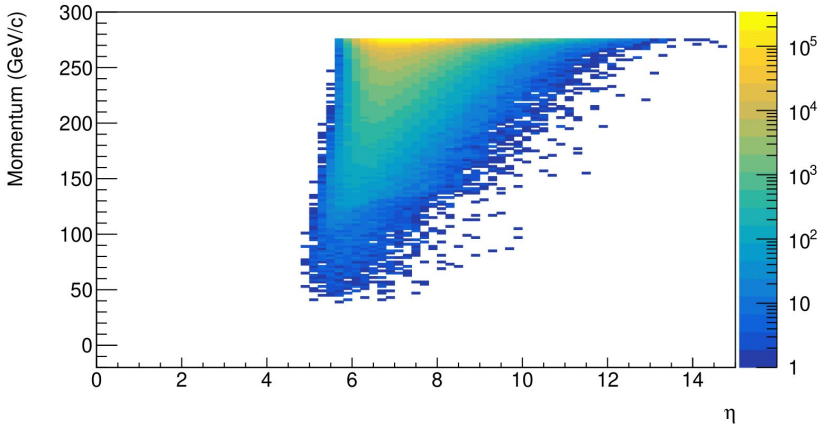



- Samples generated using lAger - Argonne generic l/A-event generator.
- 10 $fb^{-1}$ generated at 10x130 and 18x275 electron-proton beam configurations.
- Electrons generally go backwards, with most ending up in the negative endcap or low $Q^2$ taggers.

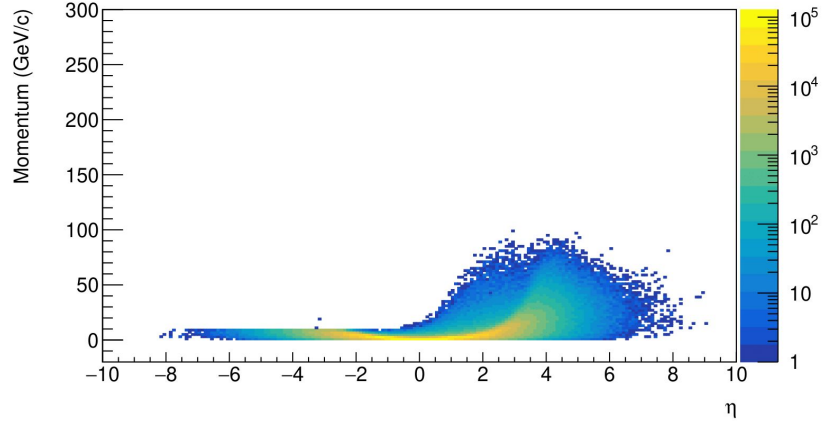
# Event sample - protons

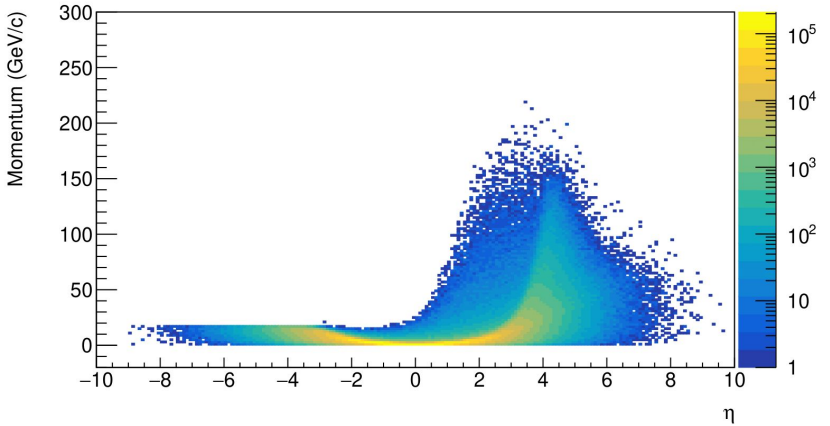



- Samples generated using lAger - Argonne generic l/A-event generator.
- 10 $fb^{-1}$ generated at 10x130 and 18x275 electron-proton beam configurations.
- Protons end up in the far-forward detectors, particularly the B0 and roman pots detectors.

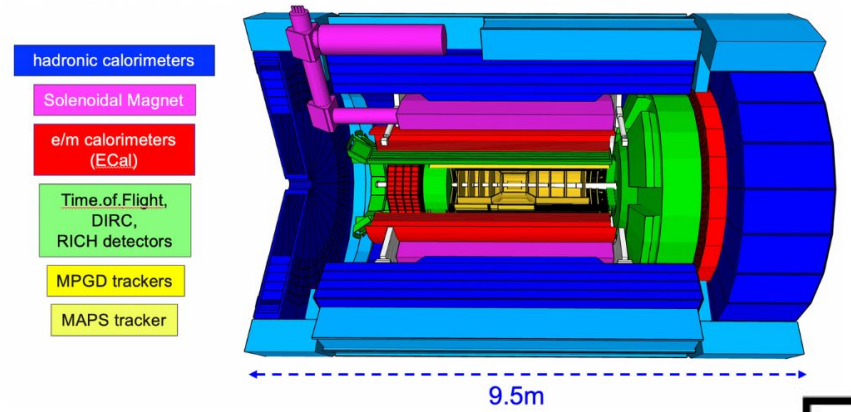
# Event sample - muons

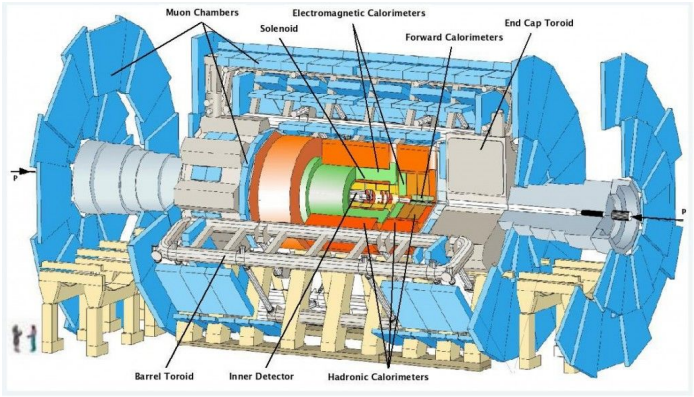



- Samples generated using lAger - Argonne generic l/A-event generator.
- 10 $fb^{-1}$ generated at 10x130 and 18x275 electron-proton beam configurations.
- Only the central detector will have capabilities to detector muons, and the majority of the muons pass through it.

# Challenges




$\mu$

$\pi^{\pm}$

- ePIC has no dedicated muon detectors.
- Main source of contamination comes from pions due to similar mass.

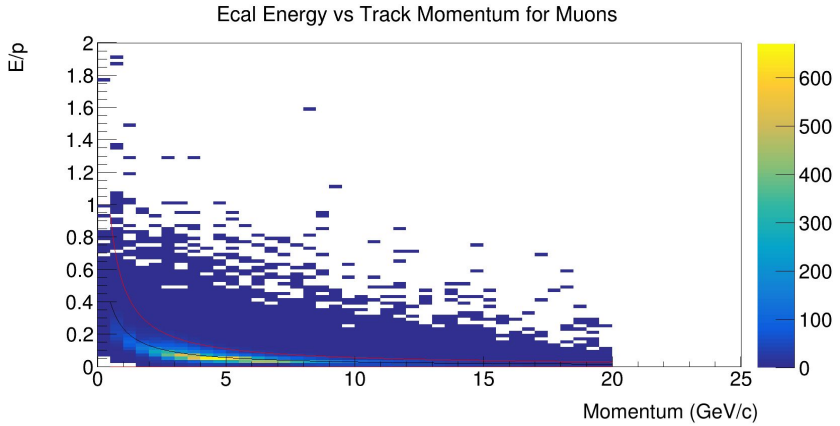
$$J = \frac{1}{2}$$

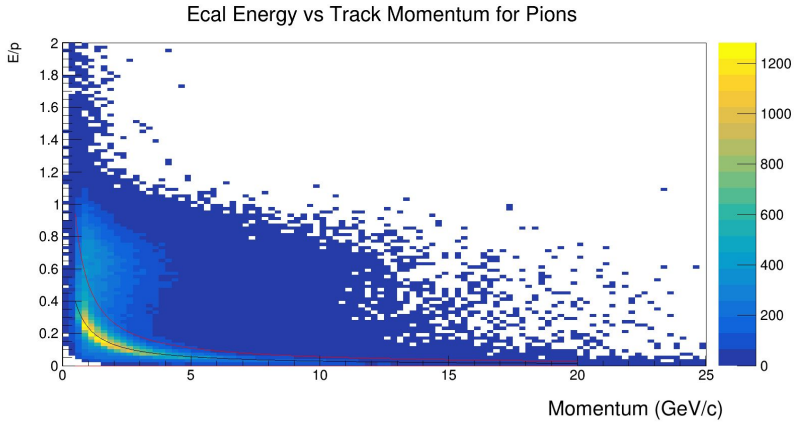
Mass $m = 0.1134289259 \pm 0.0000000025$ u
Mass $m = 105.6583755 \pm 0.0000023$ MeV
Mean life $\tau = (2.1969811 \pm 0.0000022) \times 10^{-6}$ s

$$I^G(J^P) = 1^-(0^-)$$

Mass $m = 139.57039 \pm 0.00018$ MeV $\quad (S = 1.8)$
Mean life $\tau = (2.6033 \pm 0.0005) \times 10^{-8}$ s $\quad (S = 1.2)$

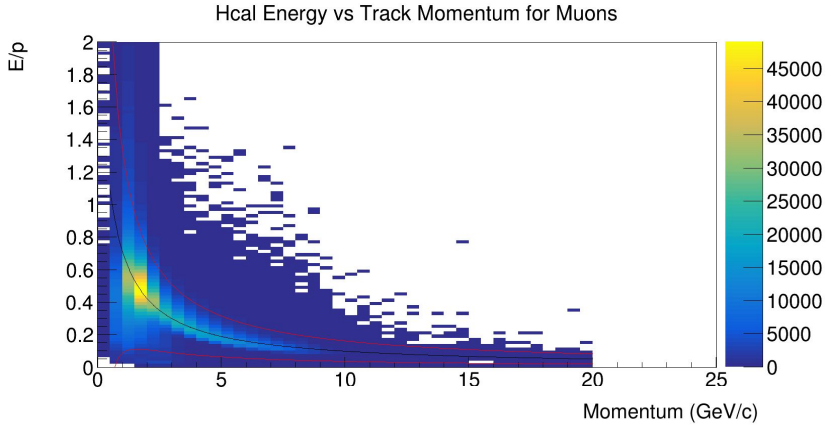
# E/p EM Calorimeter cuts (10x130ep)

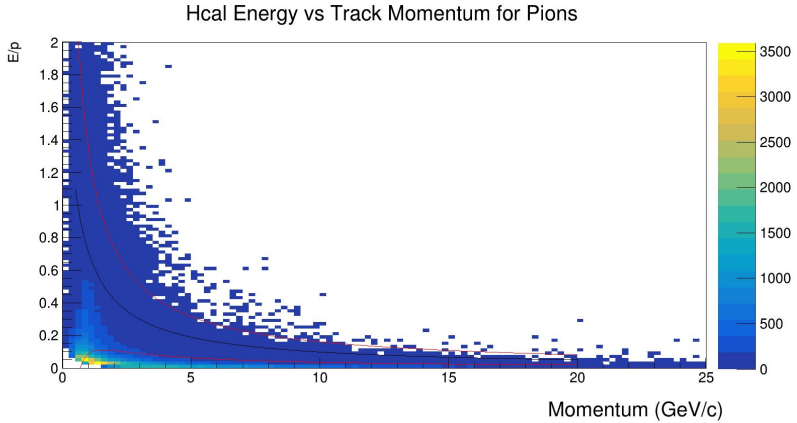



- Key to discriminating muons from pions is their energy deposition in the calorimeters.
- In the EM calorimeters, the difference will be negligible.
- Some pions are cut, particularly at lower momentum.

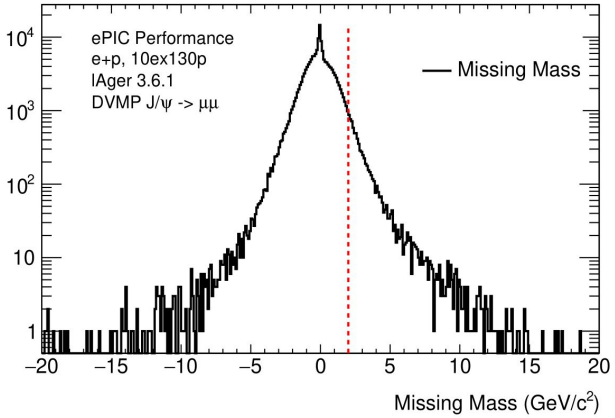
# E/p Hadron Calorimeter cuts (10x130ep)

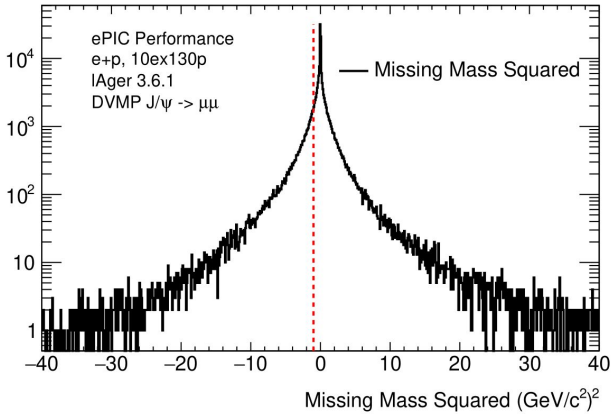



- Key to discriminating muons from pions is their energy deposition in the calorimeters.
- The central hadron calorimeters see considerably different rates of energy deposition.
- Again the best region for discrimination is at low momentum.

# Looking for the J/ψ (10x130ep)

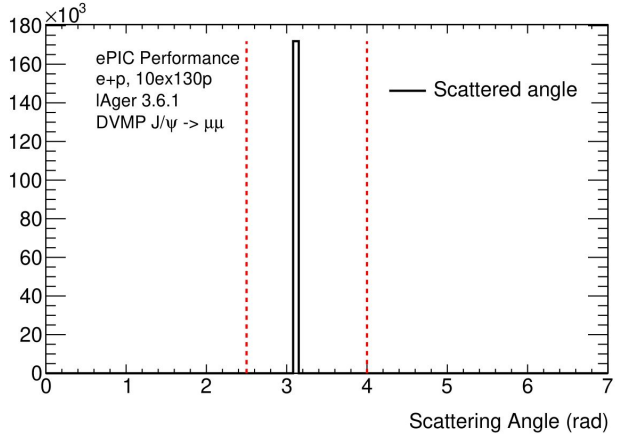


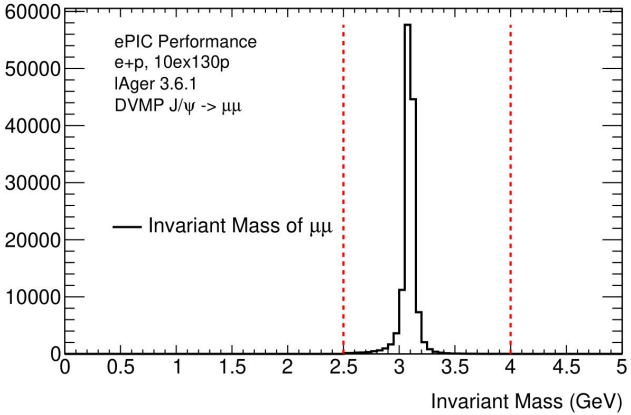




- The muons of interest come from the decay of the J/ψ.
  - There should be no mass missing, i.e. undetected particles.
  - These are produced back to back.
  - The invariant mass of the pair should equal the J/ψ mass.

- Cuts are made on missing mass and missing mass squared to ensure exclusivity.

# Looking for the J/ψ (10x130ep)

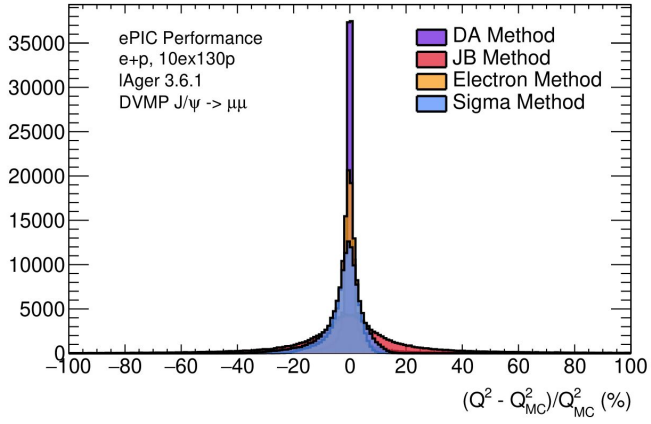


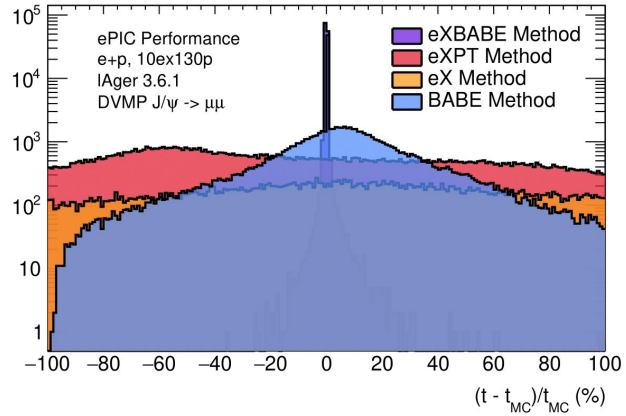




- The muons of interest come from the decay of the J/ψ.
  - There should be no mass missing, i.e. undetected particles.
  - These are produced back to back.
  - The invariant mass of the pair should equal the J/ψ mass.

- Cuts are made on the angle between the two muon tracks as well as the invariant mass of the muon pair.

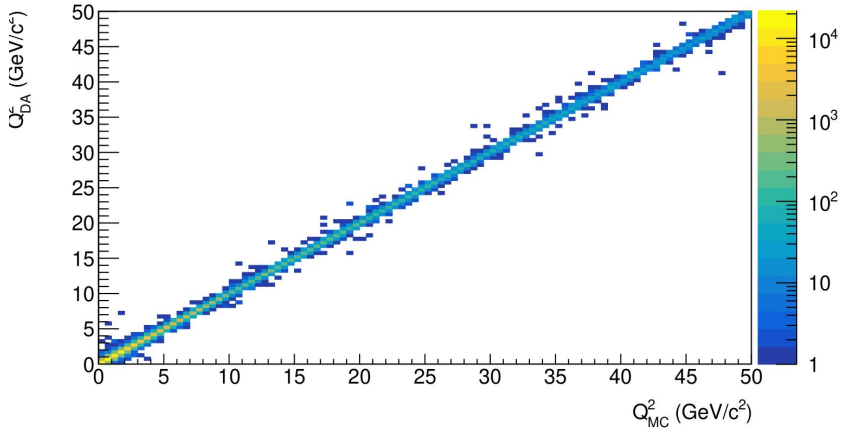
# Methods for calculating kinematics (10x130ep)

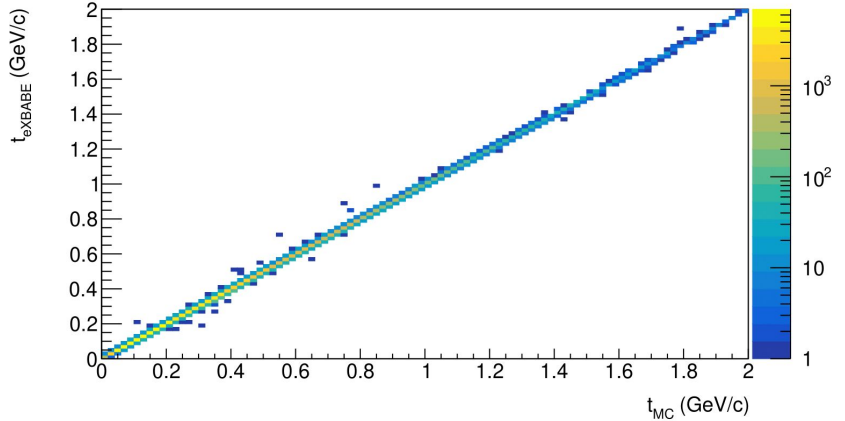



- Evaluation of methods for calculating $Q^2$ showed that the double angle method was most accurate.
- For calculating |t|, eXBABE was the only method that produced reasonable results.

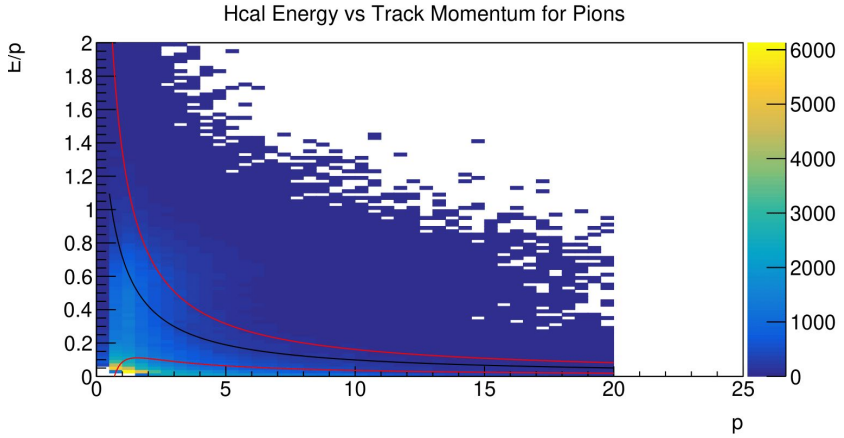
# Kinematics (10x130ep)




- Evaluation of methods for calculating $Q^2$ showed that the double angle method was most accurate.
- For calculating |t|, eXBABE was the only method that produced reasonable results.
- Both methods are accurate across the range of values in the event sample.

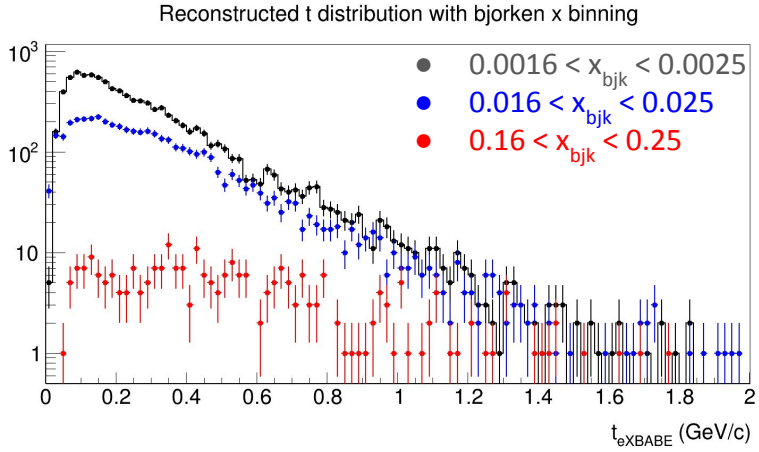
# DIS background (10x130ep)




```
Total Events Processed: 500000
Cut Flow:
  - Events with 3 tracks and sum charge of -1: 90600
  - Events with identified proton: 36603
  - Events with correct parents: 34177
  - Events with identified electron: 29053
  - Events with identified muon pair: 25571
  - Events with J/Psi candidate from muon pair: 10
  - Total Events Passing All Cuts: 10
```

- A significant number of pions can be cut using detector response (see talk by Stuart Fegan yesterday)
- The remaining cuts related to the decay of the J/Psi remove remaining events from DIS background.
- Impact of other backgrounds (beam gas etc.).

# Conclusions




- J/ψ →μμ studies are ongoing, with a strong case for the feasibility of observing this at ePIC.
- Improvements are being made in separating muons for pion contamination.
- Opportunities for new collaborators to study other vector meson decays (e.g. Υ).
- This work is part of the Exclusive, Diffractive and Tagging working group, one of many physics working groups in the ePIC collaboration.