Analysis Coordinators' Report

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Istituto Nazionale di Fisica Nucleare

ePIC Collaboration Meeting

Lehigh University

July 27, 2024

ePIC: a Collaboration driven by science!

Origin of hadron mass

Origin of proton spin

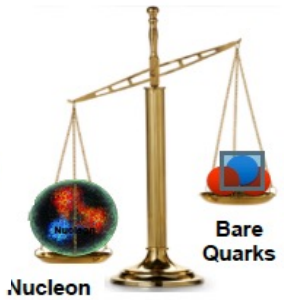
3D structure of hadrons (tomography)

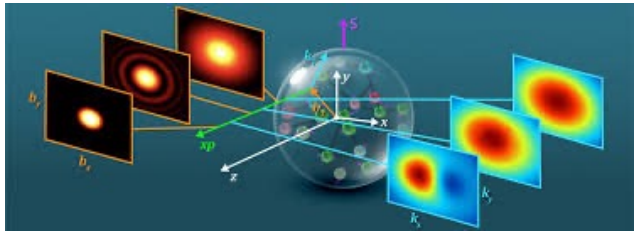
Gluon saturation

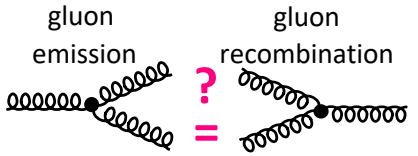
Nuclear effects

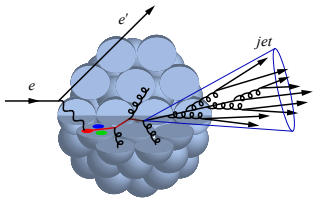
"An electron–ion collider allows us to probe of the substructure of protons and neutrons via a high energy electron"… "Some of the remaining mysteries associated with atomic nuclei include how nuclear properties such as spin and mass emerge from the lower-level constituent dynamics of quarks and gluons. Formulations of these mysteries, encompassing research projects, include the proton spin crisis and the proton radius puzzle"

Wikipedia









Structure of Physics Working Groups

ANALYSIS COORDINATORS
Salvatore Fazio (Cosenza)
Rosi Reed (Lehigh)

- **Each PWG convener is for a two-years term**
  - Rotations in each PWG are staggered every year
- **Conveners in blue** are ending their term after **1 year**

INCLUSIVE PHYSICS
Tyler Kutz (MIT)
Claire Gwenlan (Oxford)

Meeting time: Mondays (biweekly) at 12pm ET
Mailing list: eic-projdet-Inclusive-l@lists.bnl.gov
Indico: https://indico.bnl.gov/category/417/

SEMI-INCLUSIVE PHYSICS
Charlotte Van Hulse (Alcala)
Stefan Diehl (UConn)

Meeting time: Tuesdays (biweekly) at 8:30am ET
Mailing list: eic-projdet-semiincl-l@lists.bnl.gov
Indico: https://indico.bnl.gov/category/418/

JETS AND HEAVY FLAVOR
Brian Page (BNL)
Olga Evdokimov (UIC)

Meeting time: Wednesdays (biweekly) at 12:00pm ET
Mailing list: eic-projdet-jethf-l@lists.bnl.gov
Indico: https://indico.bnl.gov/category/420/

EXCLUSIVE, DIFFRACTION AND TAGGING
Raphael Dupre (Orsay)
Rachel Montgomery (Glasgow)

Meeting time: Mondays (biweekly) at 12pm ET
Mailing list: eic-projdet-excldiff-l@lists.bnl.gov
Indico: https://indico.bnl.gov/category/419/

BSM AND PRECISION EW
Ciprian Gal (JLab)
Michael Nycz (Virginia)

Meeting time: Mondays (biweekly) at 12pm ET (together with Inclusive PWG)
Mailing list: eic-projdet-semiincl-l@lists.bnl.gov
Indico: https://indico.bnl.gov/category/421/

Conveners who completed their term

❖ This is our first conveners' turnaround!

We would like to express our deepest gratitude to:

Claire, Charlotte, Brian, Rachel and Mike

for having served as conveners for the first (critical!) year of the ePIC Collaboration

New proposed PWG Conveners

Ralf Seidl [RIKEN]
SIDIS

Rongrong Ma [BNL]
JETS+HF

Zhoudunming Tu [BNL]
EXCL+DIFF+TAG

Juliette Mammei [Manitoba]
BSM + Precision EW

Presentation at C.C.

To be appointed - INCLUSIVE DIS

We are currently negotiating with an outstanding candidate while being ready with good backup options

We hope to announce a decision in next month

Other relevant meetings

❑ Regular Analysis Coordination meeting

- Every other Friday at 11:00am
  - Indico page: https://indico.bnl.gov/category/475/
- **Meetings are open to everyone – we hope to see many of the new analyzers from the collaboration meeting at our next meetings!**

❑ Joint S&C and Physics meeting

- Typically, once a month!
  - Last meeting on June 26: https://indico.bnl.gov/event/23598/
- An opportunity to coordinate efforts between the two endeavors
  - Generators, simulation campaigns, status of reconstruction, specific TDR needs and mutual feedback
- Incredibly important for a successful TDR!

❑ Joint meeting of the SCC and AC Coordinators : every Thursday at 9:00am

TDR structuring

pre–TDR (60% design completion) ⟹ early 2025

TDR (90% design completion) ⟹ ~ early 2026

- (pre)TDR are a deliverable of the EIC Project (project manager acts as editor)
  - describe the accelerator + ePIC experiment
  - Chapter 8: (hundreds pages) focus on the ePIC Detector Description, basic performance, Software, and data preservation
  - Chapter 2: (~60 pager) focus on holistic detector performance, physics performance and science reach
    - Holistic detector performance → Technical Coordinator office acts as editor
    - Physics and science reach → Analysis Coordinators act as editors
    - We envision a **couple of performance plots per PWG**

Extended physics paper

Delivered by ~ (early?) 2026 aligned with the final TDR

- The Physics WP is a deliverable of the ePIC Collaboration
- To be published on a scientific peer-reviewed journal (such as PRC or similar)
  - **Extended description** of the physics performance and science reach at ePIC
    - Holistic detector performance → Technical Coordinator office acts as editor
    - Physics and science reach → Analysis Coordinators act as editors
  - Gives full details on physics studies and performance plots
  - Includes physics impact studies (extraction of physics, e.g. PDFs, GPDs, TMDs)
- Authorship regulated by ePIC membership and publication policies

❖ Up for discussion: Spin-off papers can also be published by individual study groups **(theorists included)**

REPORT on the PWG activity

Inclusive PWG: electron ID performance

- Currently implemented algorithm:
  - Require **negative particles** with **0.9 < E/p < 1.2**, take particle with **largest** $E - p_z$
  - Using reconstructed energy and momentum, but **truth track-cluster matching**

- **Success/failure rates** from simulation (Pythia8 NC DIS, tag 24.06.0)
  (note all events have $Q^2 > 1$ GeV^2)

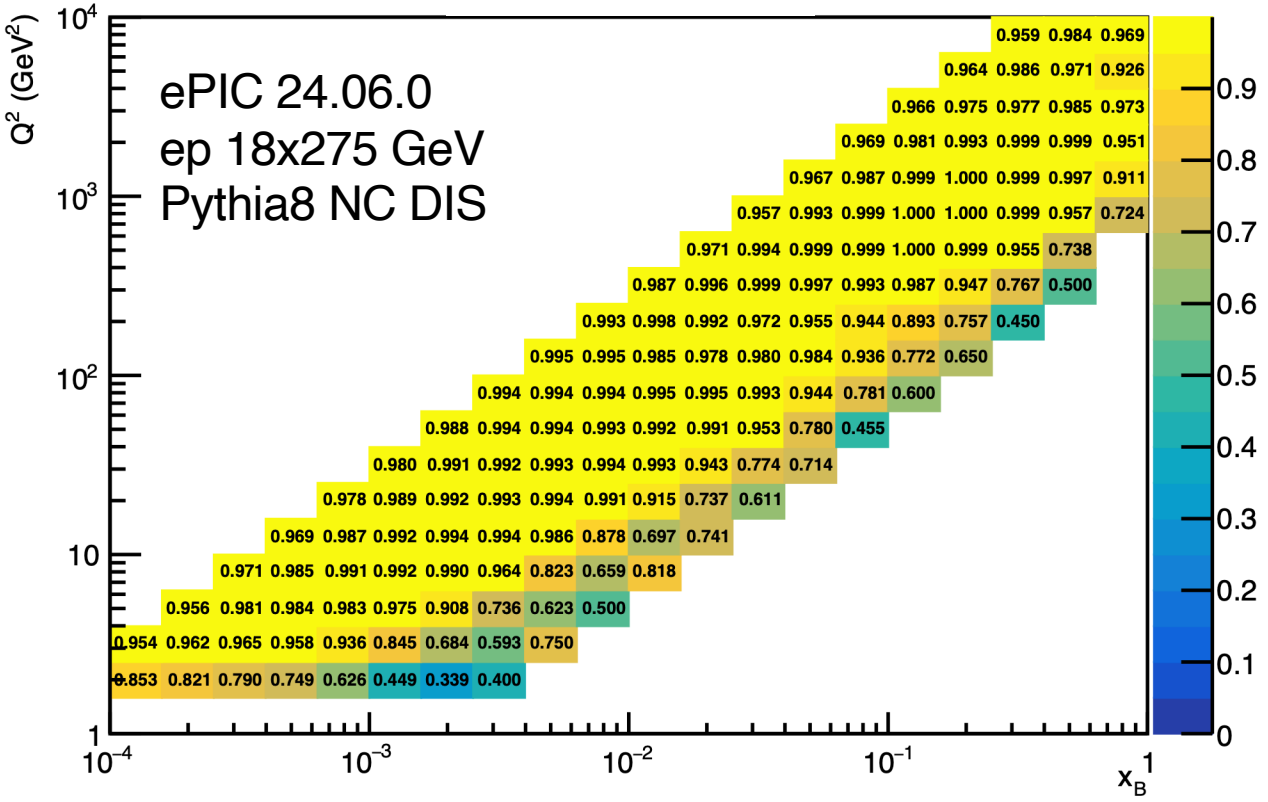
	Success	**Fail, no ID(reduced acceptance)**	**Fail, wrong ID(contamination)**
5x41 GeV	87,3%	9,9%	2,8%
10x100 GeV	91,5%	6,5%	2,0%
18x275 GeV	80,7%	16,0%	3,3%

Subject to increase with inclusion of photoproduction, min-bias events

Inclusive PWG: Impact of el. ID algo. on acceptance

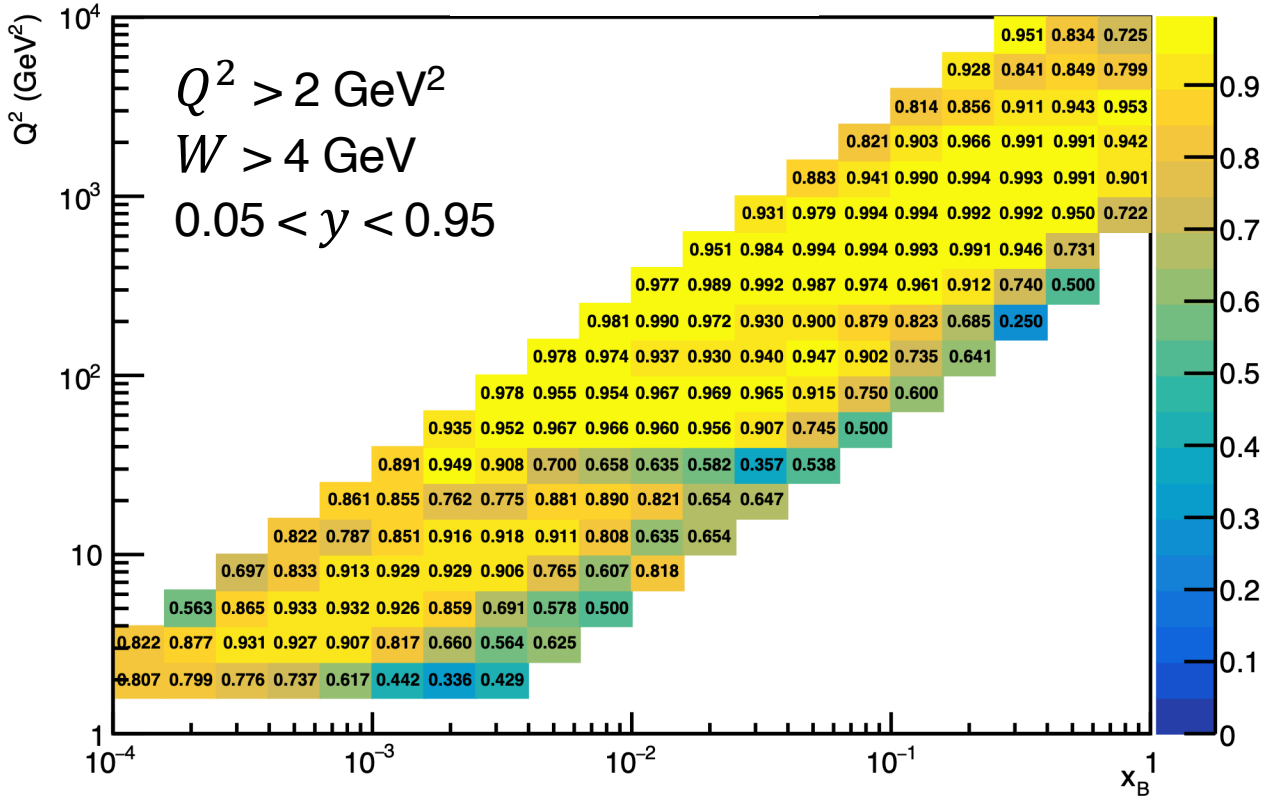
$$C_{acc} = \frac{N_{rec}(x_{gen}, Q^2_{gen})}{N_{gen}(x_{gen}, Q^2_{gen})}$$

True ID



≥ 99% acceptance nearly across the board, excepting edges of acceptance

eID



Reduced acceptance everywhere, some regions down from 99% to 70%

Inclusive observables:
NC reduced cross section

$$\frac{d\sigma}{dx_B dQ^2} = \frac{N}{C_{acc} \cdot C_{bin} \cdot L \cdot \Delta x_B \Delta Q^2}$$

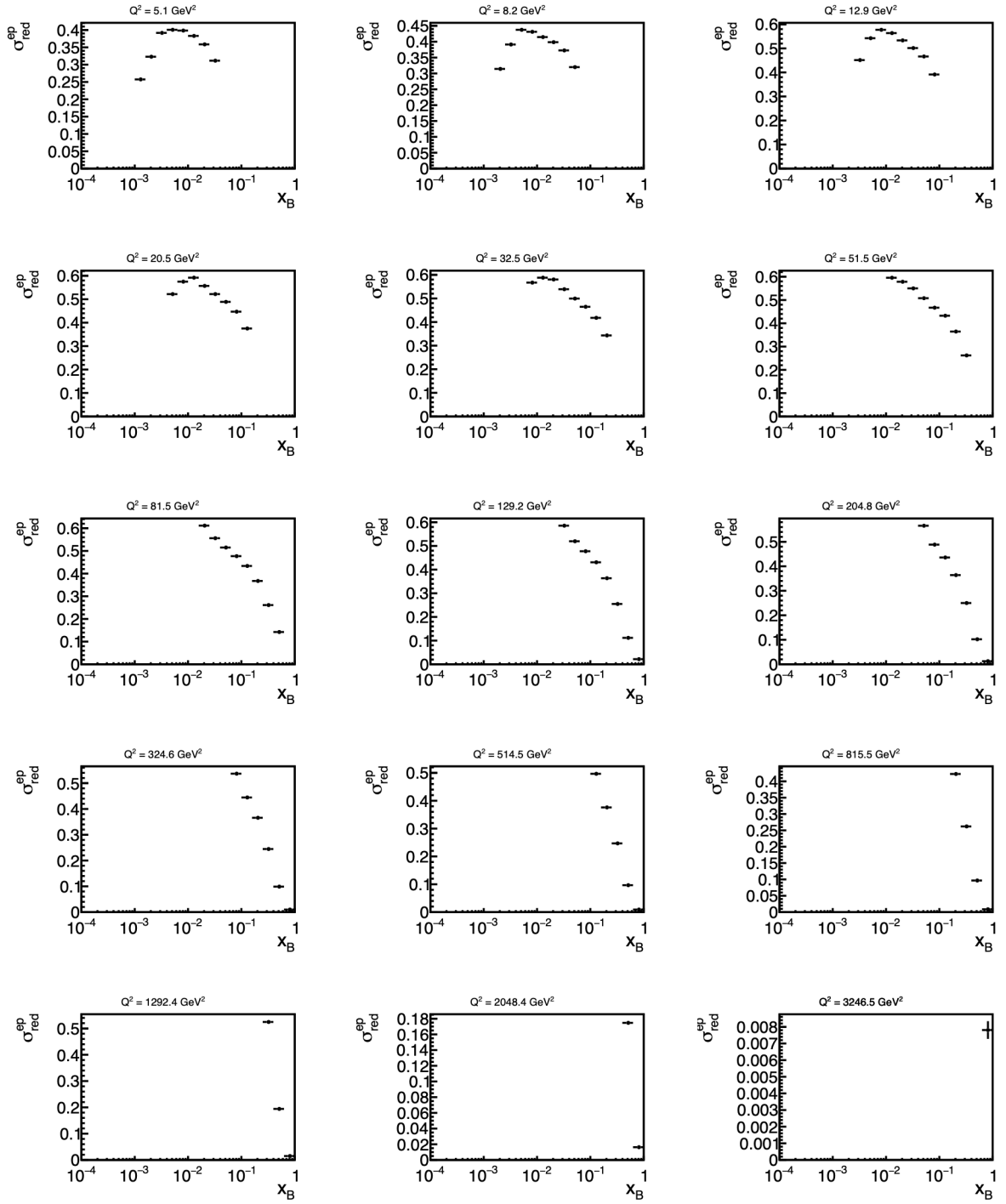
- Acceptance, bin migration corrections obtained from simulation
- Scaled to integrated luminosity L = 10 fb^{-1}

$$\sigma_{red} = \left(\frac{d\sigma}{dx_B dQ^2}\right) \cdot \frac{Q^4 x_B}{2\pi\alpha^2 Y_+ \hbar^2 c^2}$$

$$Y_+ = 1 + (1-y)^2$$

ePIC 24.06.0
10x100 GeV

$Q^2 > 2$ GeV^2
$W > 4$ GeV
$0.05 < y < 0.95$

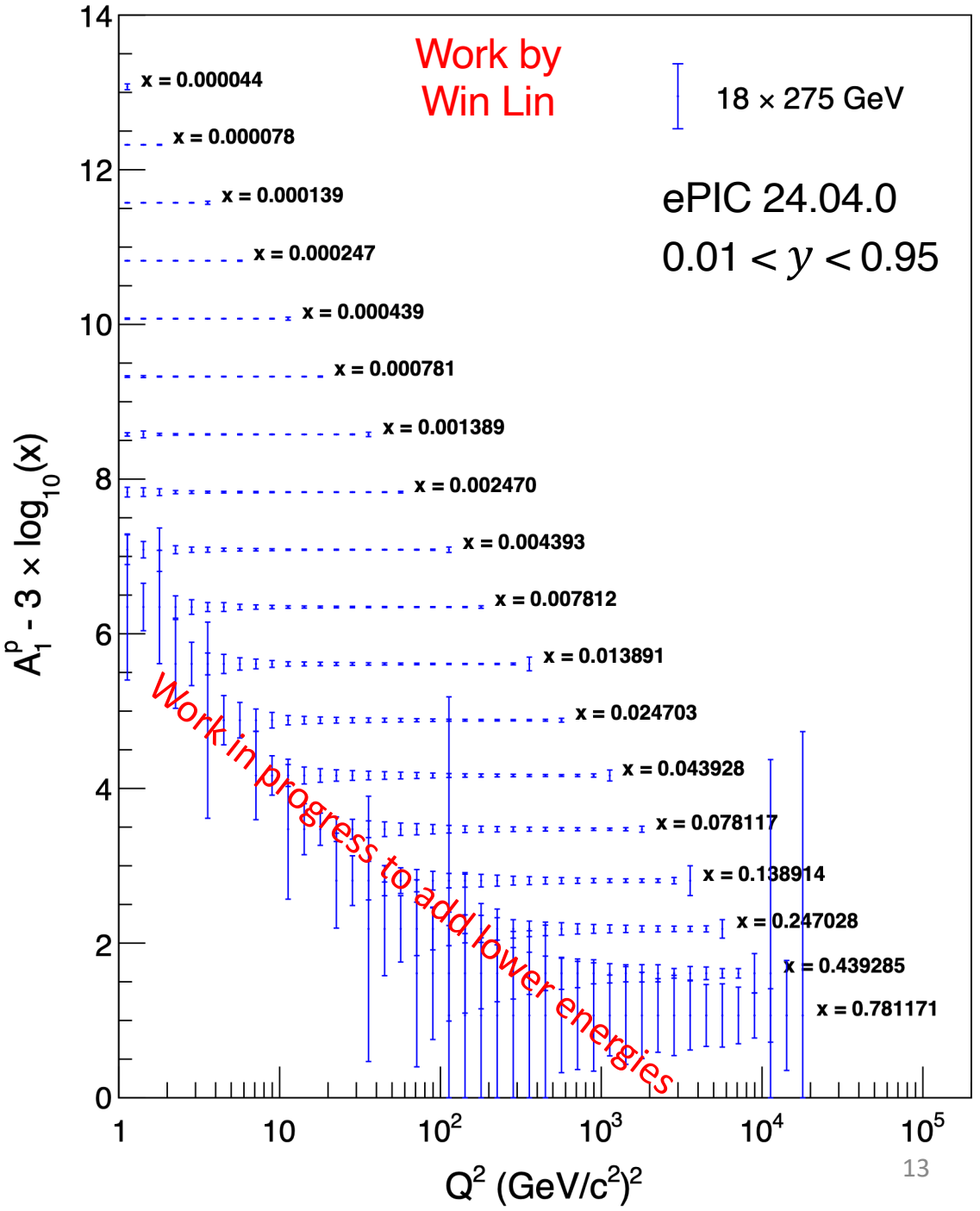


Inclusive observables: double-spin asymmetry

$$A_{||} = \frac{\sigma_{\downarrow\Uparrow} - \sigma_{\uparrow\Uparrow}}{\sigma_{\downarrow\Uparrow} + \sigma_{\uparrow\Uparrow}}, \quad A_{\perp} = \frac{\sigma_{\downarrow\Rightarrow} - \sigma_{\uparrow\Rightarrow}}{\sigma_{\downarrow\Rightarrow} + \sigma_{\uparrow\Rightarrow}}$$

$$\rightarrow A_1 \approx g_1/F_1$$

- Use model to calculate A_1 for each bin (bin center)
- $\delta A_{||,\perp} = \frac{1}{\sqrt{N} P_e P_p}$, propagated to δA_1
- Scaled to total luminosity L = 10 fb^{-1} (2.5 fb^{-1} per spin configuration)



Inclusive PWG: work in progress

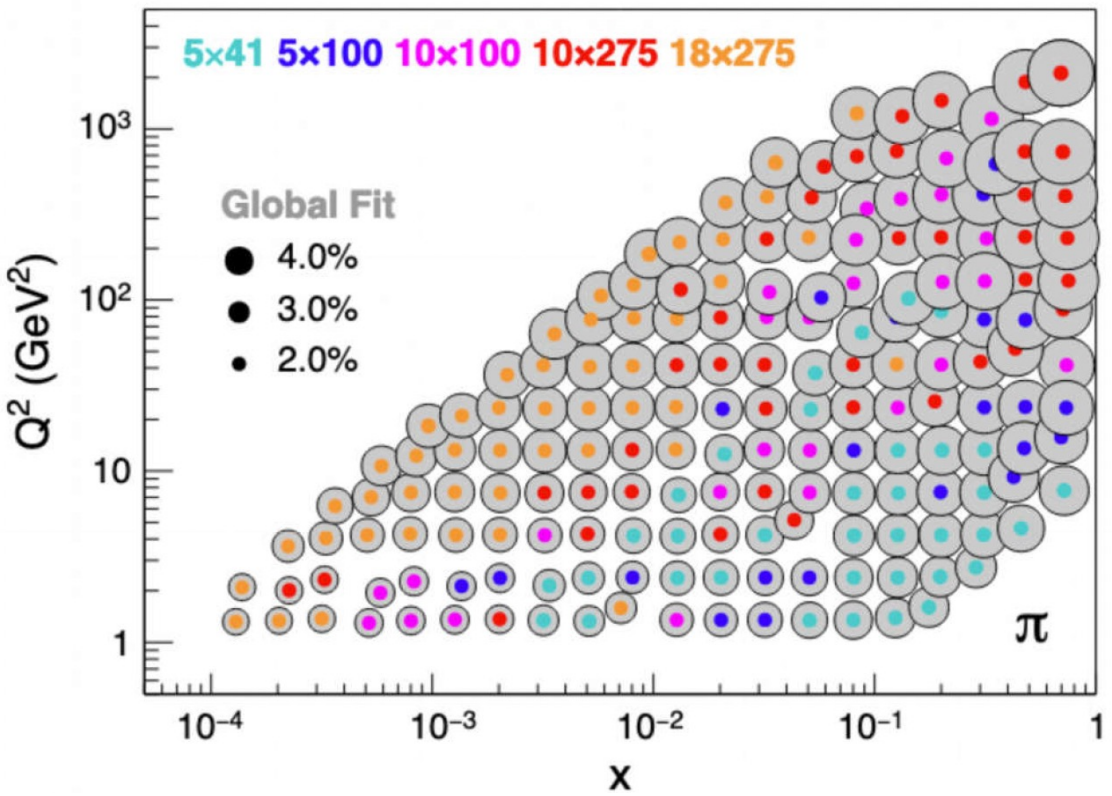
- **Electron ID/reconstruction:** ⟹(see Electron ID & Holistic Reconstruction workfest!)
  - Track-cluster matching
  - Calorimeter shower shape cuts
  - Resolution-weighted electron energy (tracking *and* calorimeter)
- **Quantifying systematics:**
  - Acceptance/resolutions
  - Energy calibration
  - Pion contamination

SIDIS PWG: Unpolarized TMDs

TDR plot 1:

plot by Gregory Matousek

Update with newest simulation version ongoing…

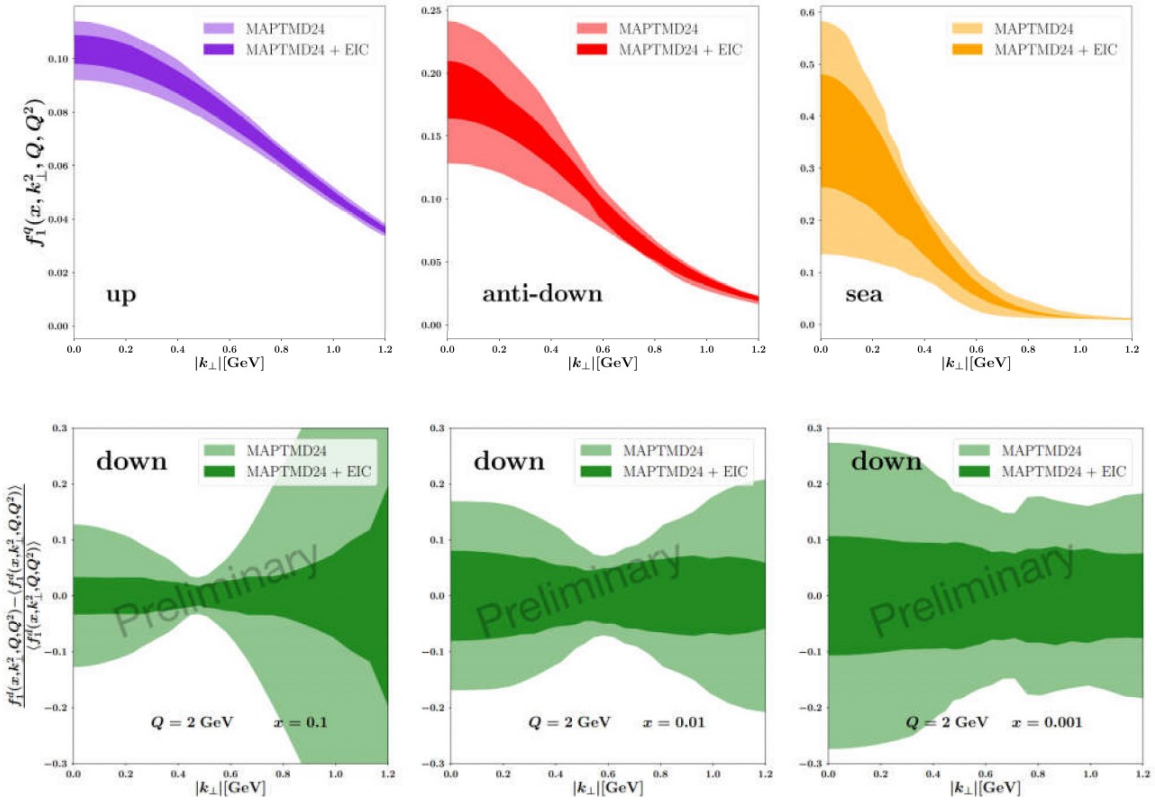


- Expected statistical uncertainties for the extraction of unpolarized TMDs
- Highlights coverage by different beam energies

First impact studies on flavor dependent extraction of unpolarized TMDs are available

Lorenzo Rossi, M. Radici, A Bacchetta

- Based on EIC pseudo data by G. Matousek

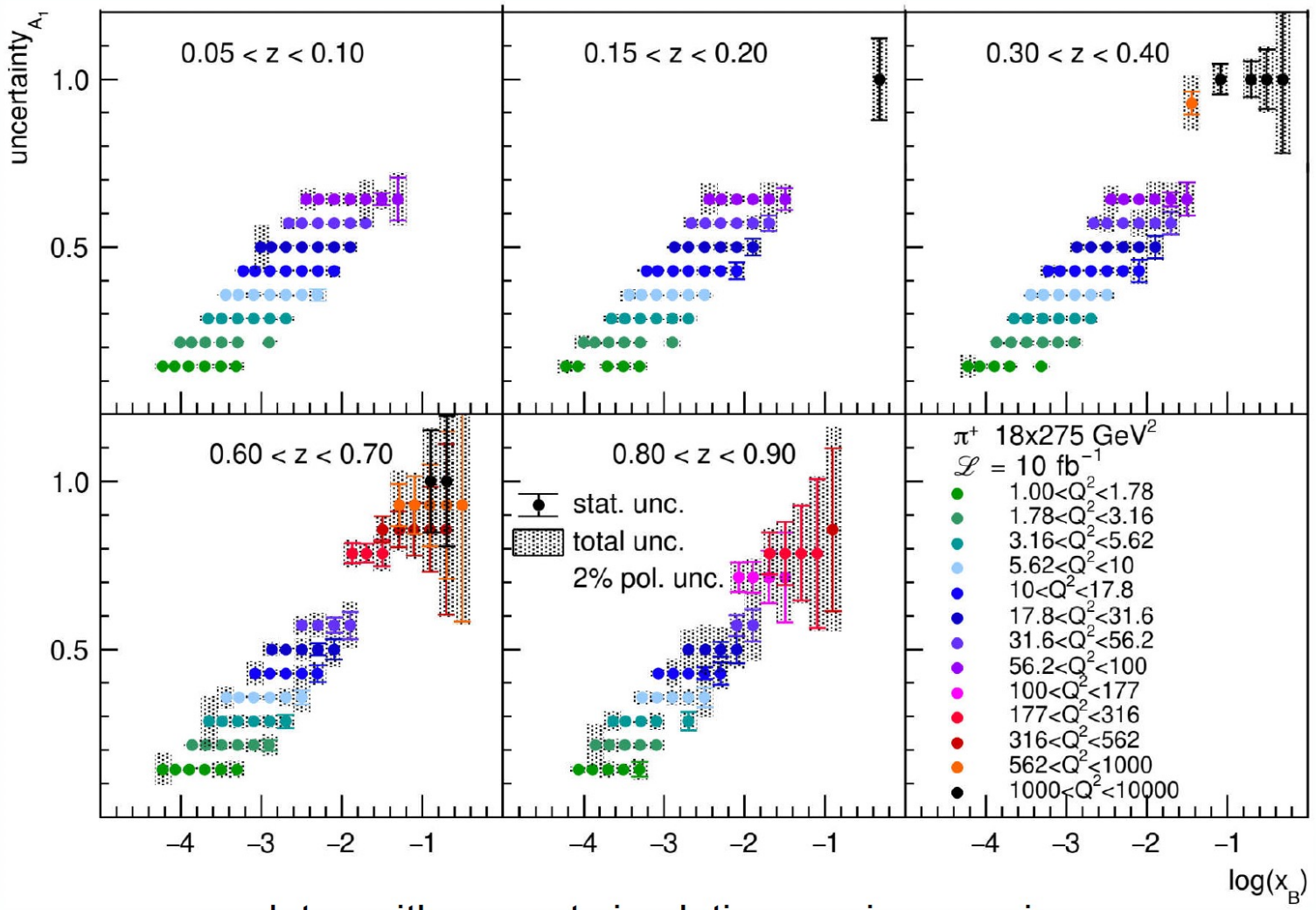


EIC data significantly reduce the uncertainties

SIDIS PWG: Helicity PDFs

TDR plot 2: Statistical and total uncertainty of A_{LL} of π^+ for helicity PDFs

plot by: Charlotte van Hulse



updates with newest simulation version ongoing …

SIDIS PWG: work in progress

Additional ongoing studies by the SIDIS group:

- PID studies as a function of the different SIDIS variables to study the newly implemented PID (**L. Polizzi**)

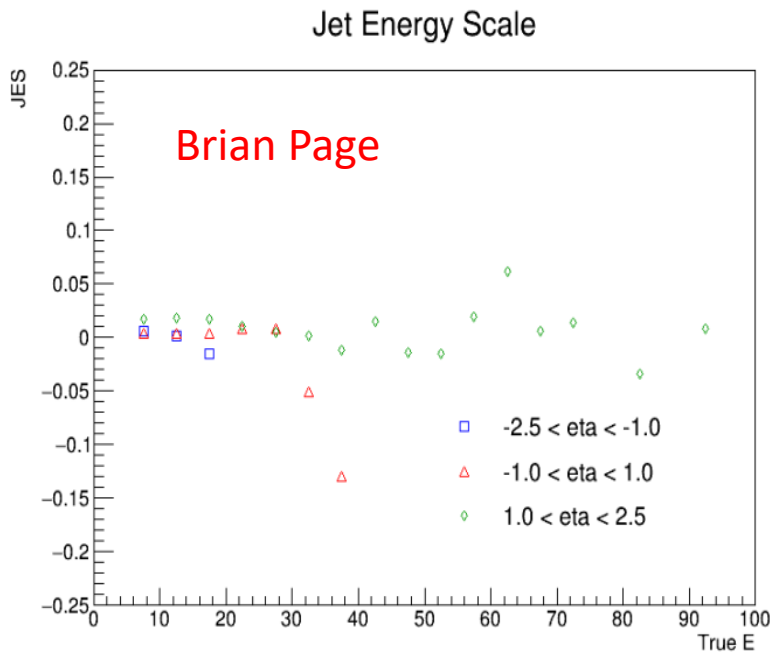
→ **New Collaborators are welcome to join the working group**

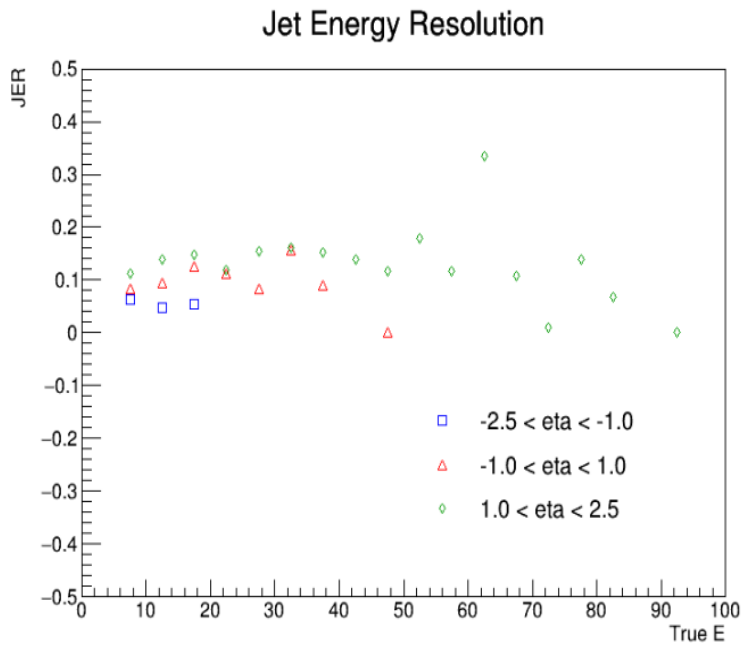
→ **Topics for analyses and possible contributions can be found on the wiki page**

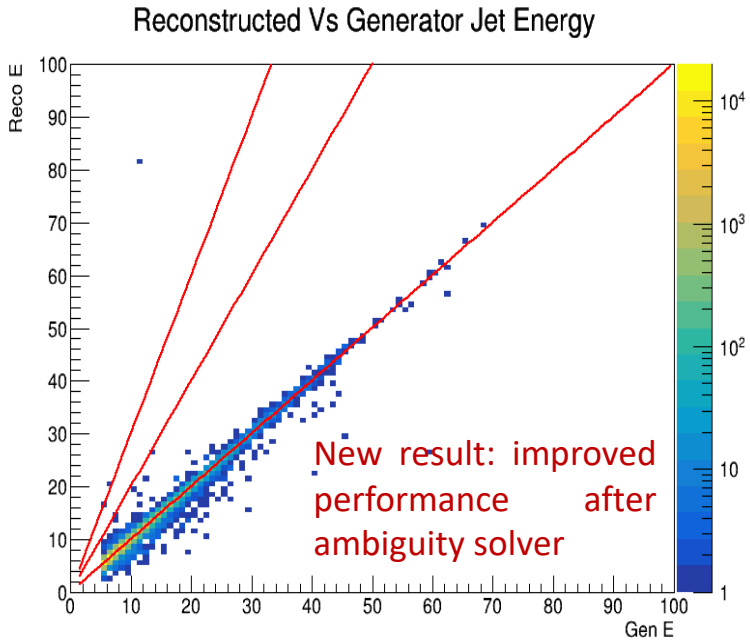
Jets + HF: proposed TDR plots

❑ Jet reconstruction performance:

- Jet energy scale and resolution; jet energy reco vs. gen
- Full simulation; jets are clustered from the Reconstructed Charged Particles (truth seeded tracks) and Generated Charged particles







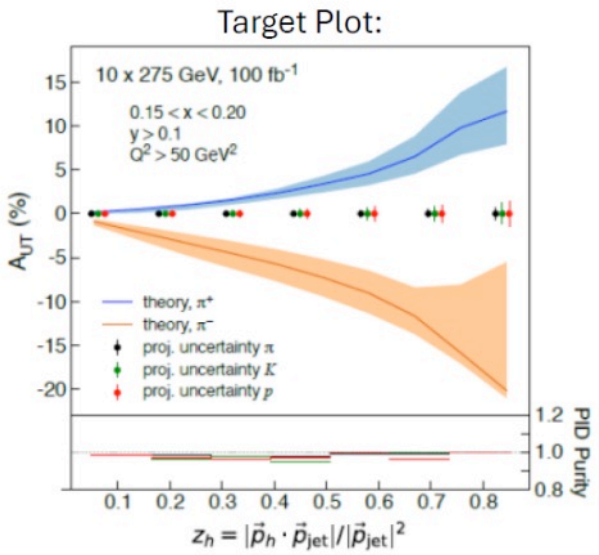
❑ A set of **jet benchmark plots** is now being generated with each monthly production and can be accessed via a web interface: https://eic.jlab.org/epic/image_browser.html# (navigate to Physics -> Jets and Heavy Flavor)

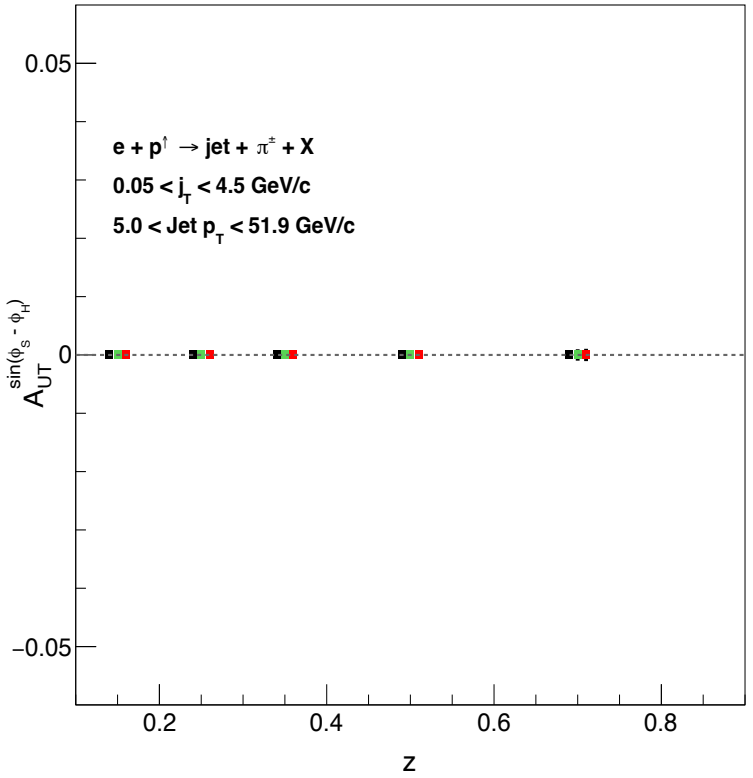
Jets + HF: proposed TDR plots

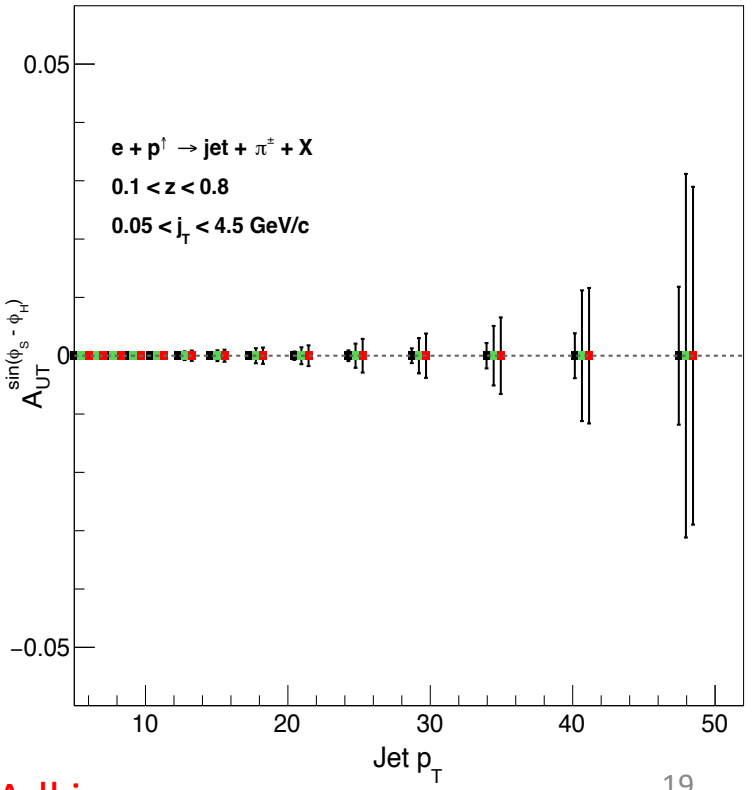
❑ Hadron-in-Jet Collins Analysis:

- Collins effect connects initial proton spin to final state azimuthal distribution of hadrons in a jet (pions, kaons, protons)
- Full simulation; same selection criteria as in the original YR plot
- **Todo:** Update electron finding method to ensure proper q_T imbalance cut; add theory curves

Target Plot:





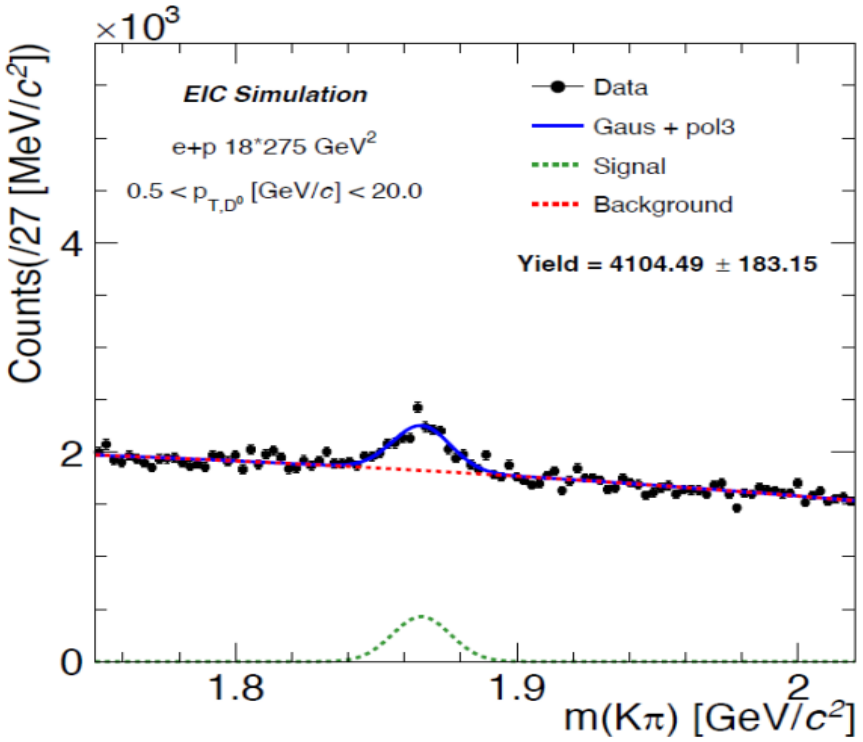


plots: Kevin Adkins

Jets + HF: other work toward TDR

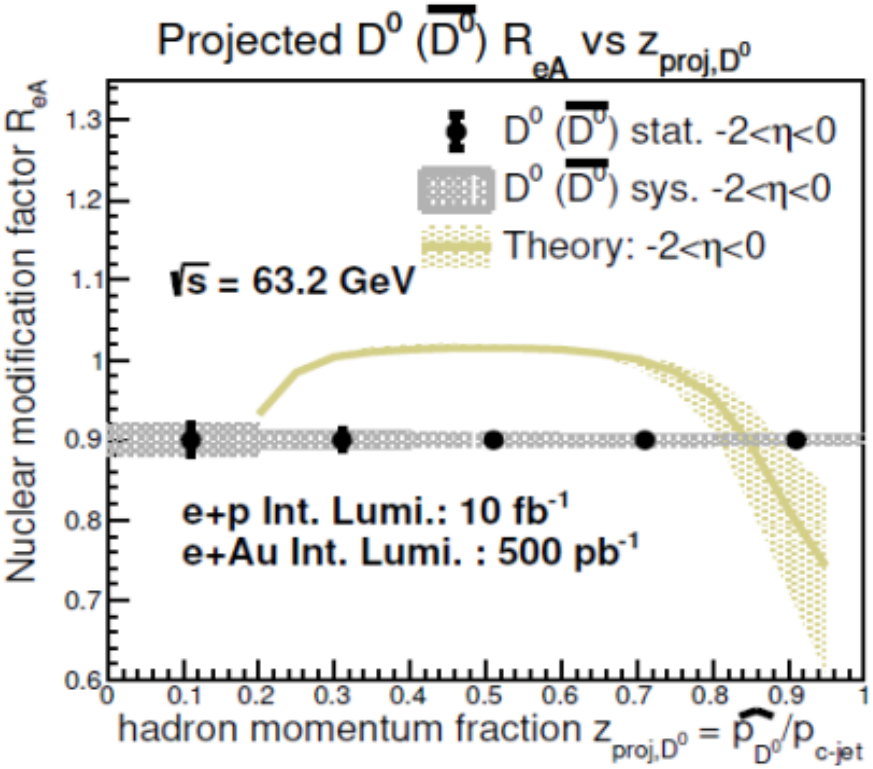
❑ Heavy Flavor Hadron reconstruction:

- **Left:** Invariant mass peak for D0 in full simu, kinematic and PID selections only, no secondary vertexing, using sPlot package in RooStats, (enhanced sample, higher signal/background levels)
- **Right:** Hadron-in-Jet nuclear R_eAu projections (standalone simulation with performance projections)
  - Ongoing work on D0-in-jet in full simu (Diptanil)



Plots:
Diptanil Roy
Enea Prifti

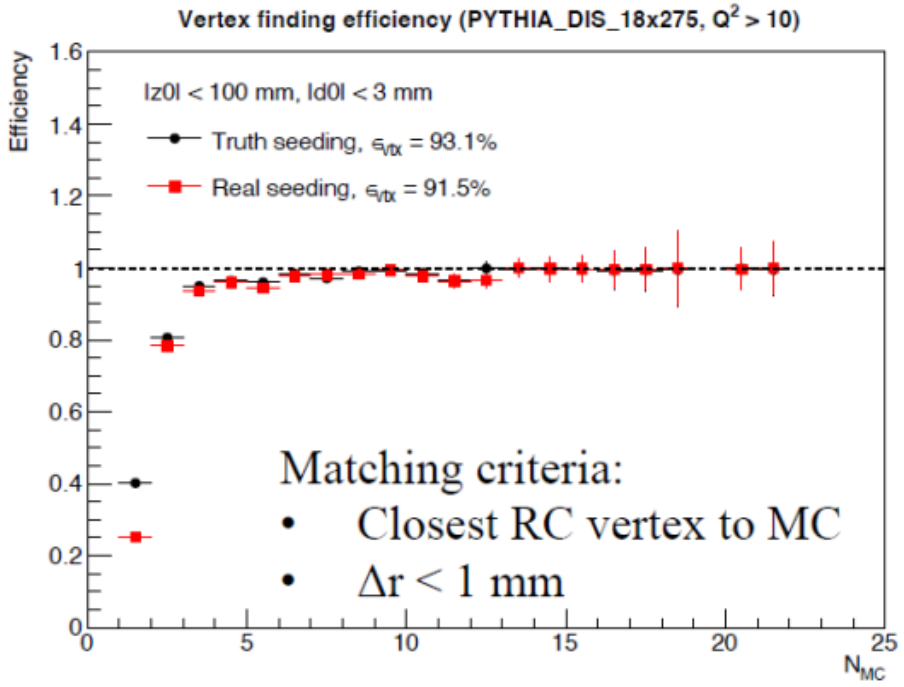
Xuan Li

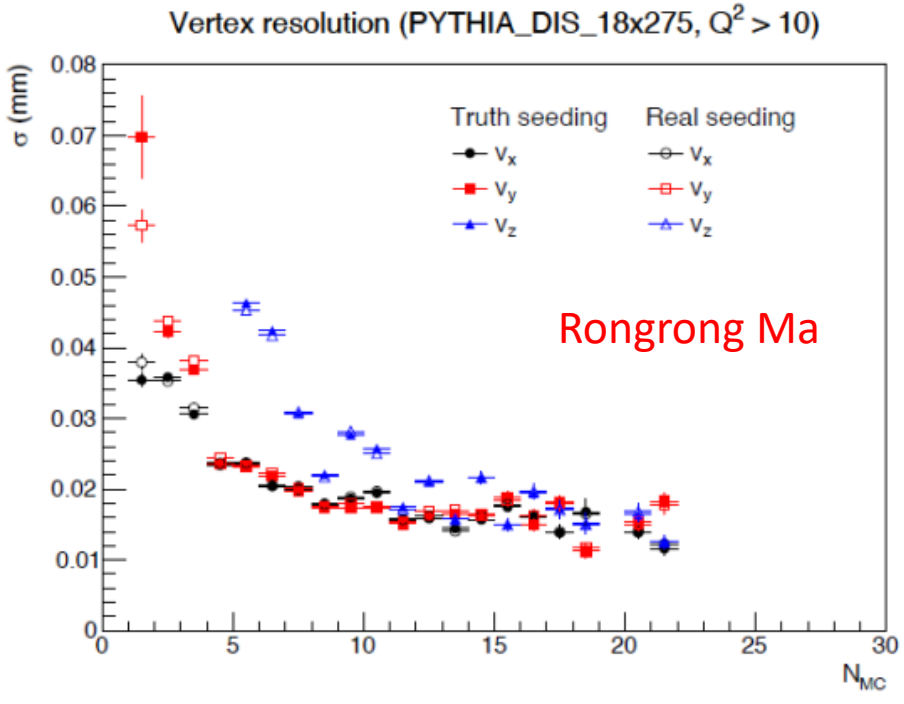


Jets + HF: other work toward TDR

❑ Vertex reconstruction performance studies

- Primary vertex reconstruction efficiency and resolution for tracking with truth and **real seeding**
- PYTHIA DIS ep 18x275 (EIC geometry: epic-24.06.0; EICrecon: 07/20/24); Vertex position: afterburner to apply beam effects
- Workfest this meeting to advance **secondary vertex** reconstructions



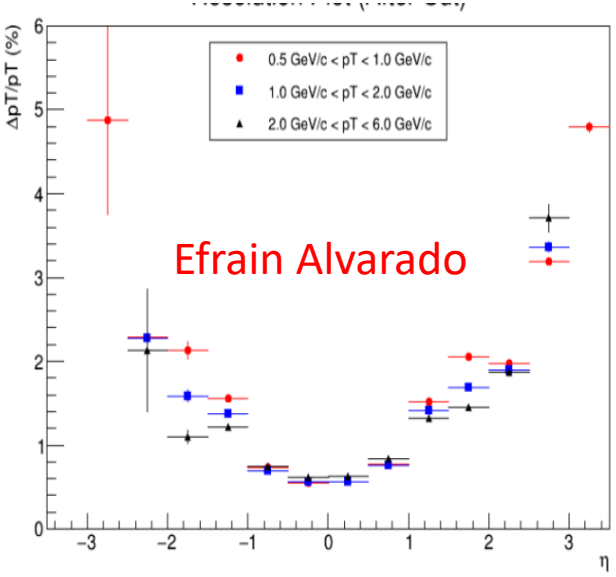


Jets + HF: work in progress

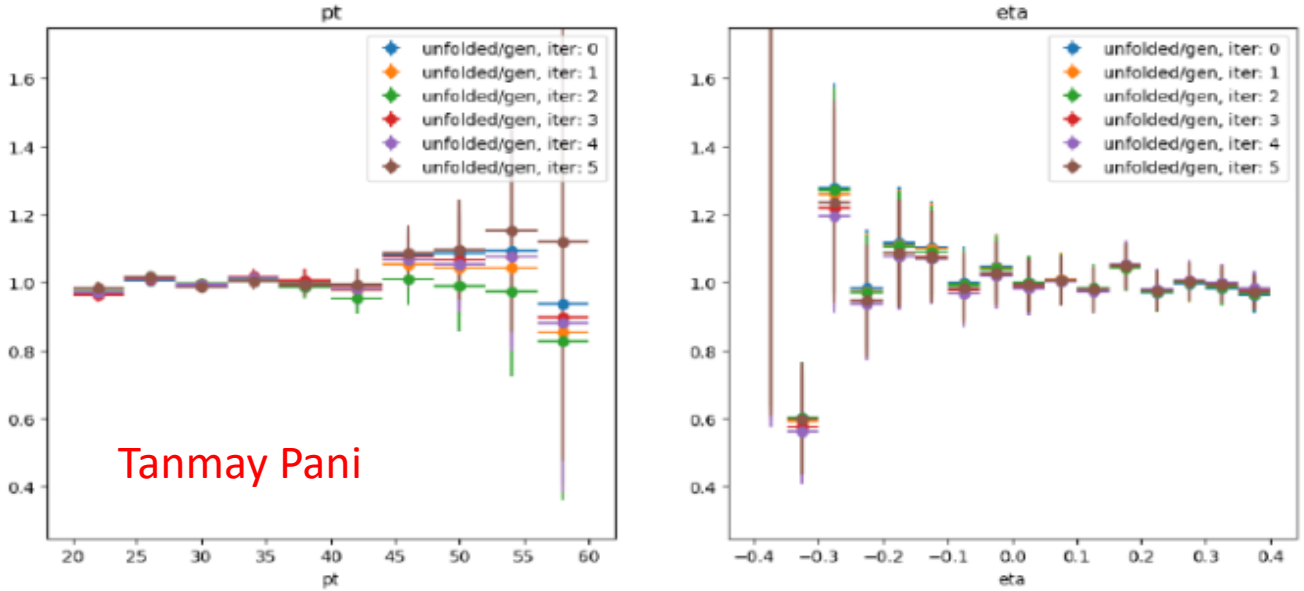
❑ Additional contributions:

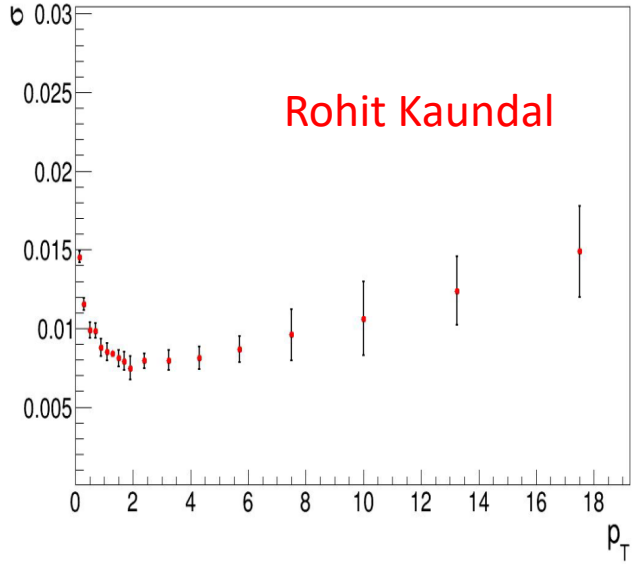
- **Onboarding new people:** more people are getting familiar with the ePIC software/data formats
- Variety of tracking resolution studies preformed /plots in hand
- Preliminary PID capability/performance studies
- Jet unfolding developments

Track momentum resolution for different kinematic regions
Full simu; truth seeding



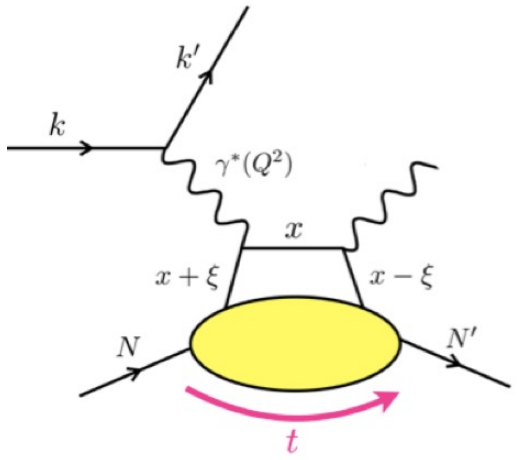
Unfolding stability check for jet kinematics. Multifolding with Dense Neural Networks (DNNs) is trained on full simu sample

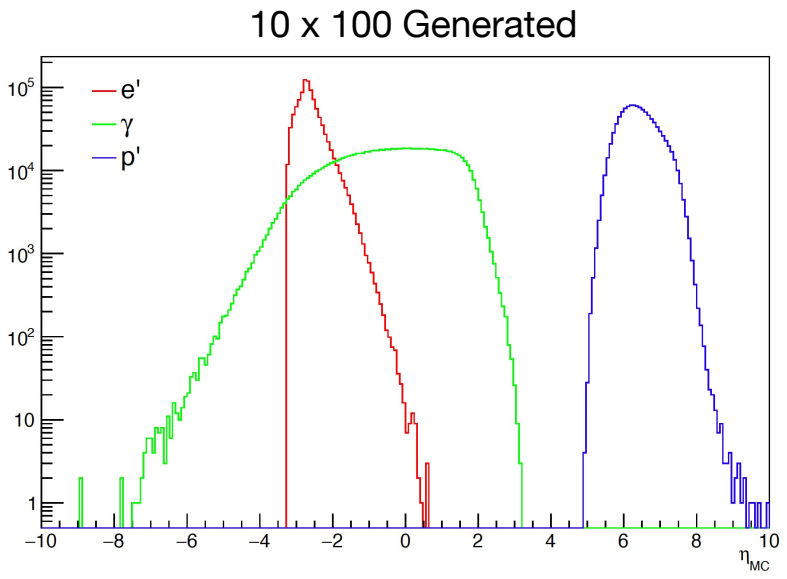


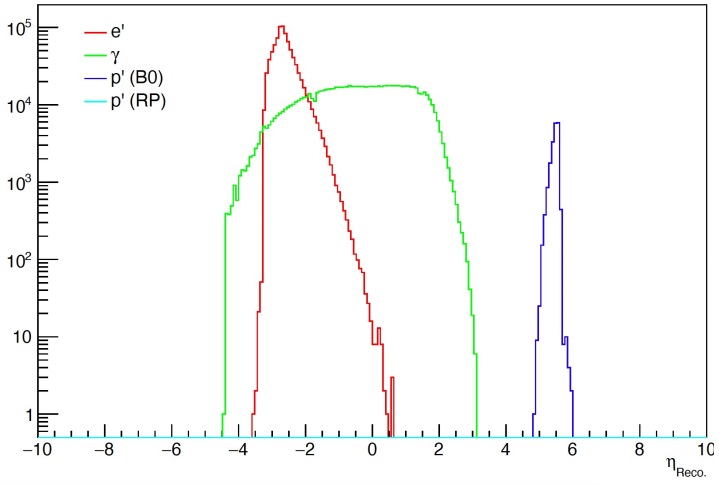


Excl+Diff+Tag PWG: DVCS in ep

Plots: O. Jevons (Glasgow)

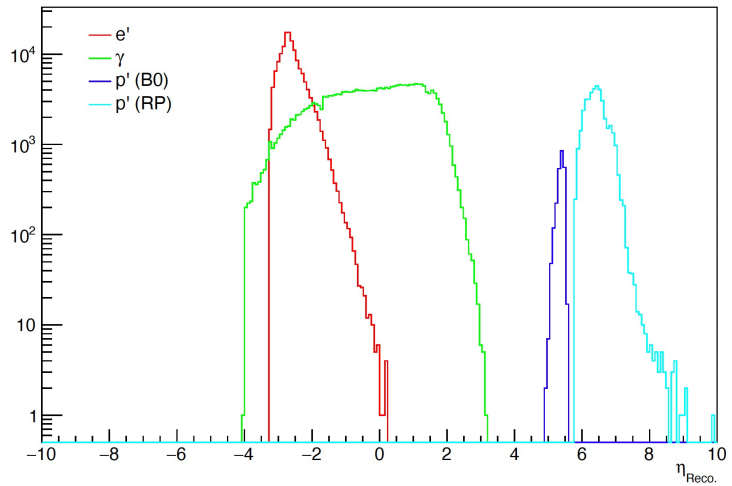






10 x 100, monthly production 24.04.0

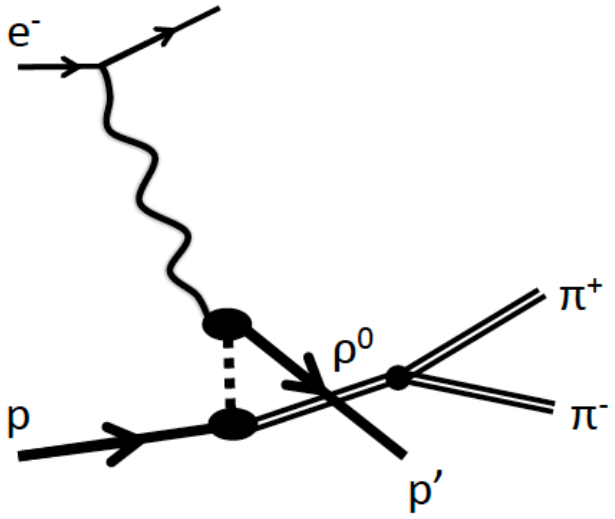
(Truth PID)



10 x 100, monthly production 24.06.0

- Nucleon tomography, origin of mass and spin
- Electron PID crucial and FF region critical for p'
- High acceptance and 10x100 ep setting shown from **24.06.0**
- Nb 24.04.0 was missing RP (restored in 24.05.0)
- 24.05.0 and 24.06.0 analysis originally missing p' in B0 due to new PID implementation
  - No particles with PDG 2212 in B0 due to lack of PID system
  - RP still uses truth PID
- Initial look at lower stats sample from **24.06.0 shown**
  - Reconstructed p' in B0 identified by recorded mass and charge of track
  - Electrons/photons use identified PID value
- Development of analysis underway

Excl+Diff+Tag PWG: u-Channel ρ^0 benchmark for B0

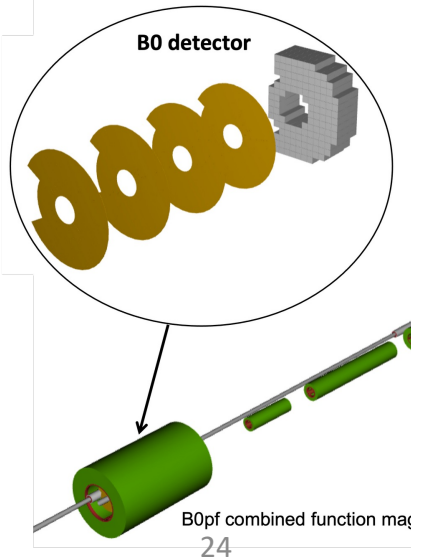


u-channel $\rho^0 \rightarrow \pi^+\pi^-$

- Low Mandelstam u, high t
- Backwards (u-channel) physics → nucleon/nuclear tomography
- Forward (t-channel) cross-sections → parton tomography via GPDs
- Backwards cross-sections → quark clusters and baryon number distributions in transverse plane via Transition Distribution Amplitudes (TDAs)
- See published paper: https://journals.aps.org/prc/abstract/10.1103/PhysRevC.106.015204

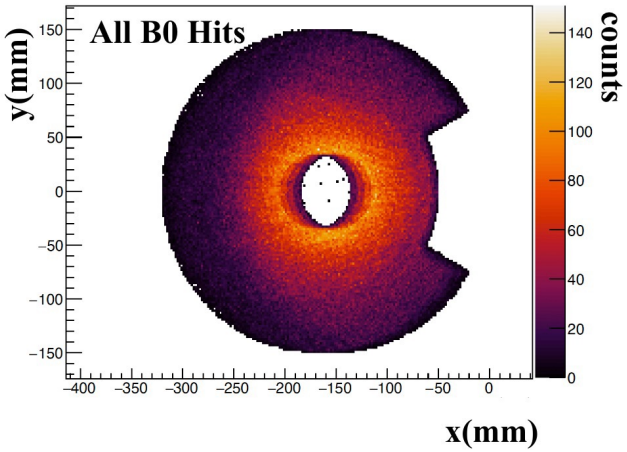
In ePIC:

- Produced VM takes most of momentum of struck nucleon → goes to the far-forward region
  - B0 spectrometer critical for measuring $\rho^0 \rightarrow \pi^+\pi^-$
- Struck nucleon shifts of several units in rapidity → ends up in mid-rapidity
- Simulation studies based on an edited version of the eSTARlight generator

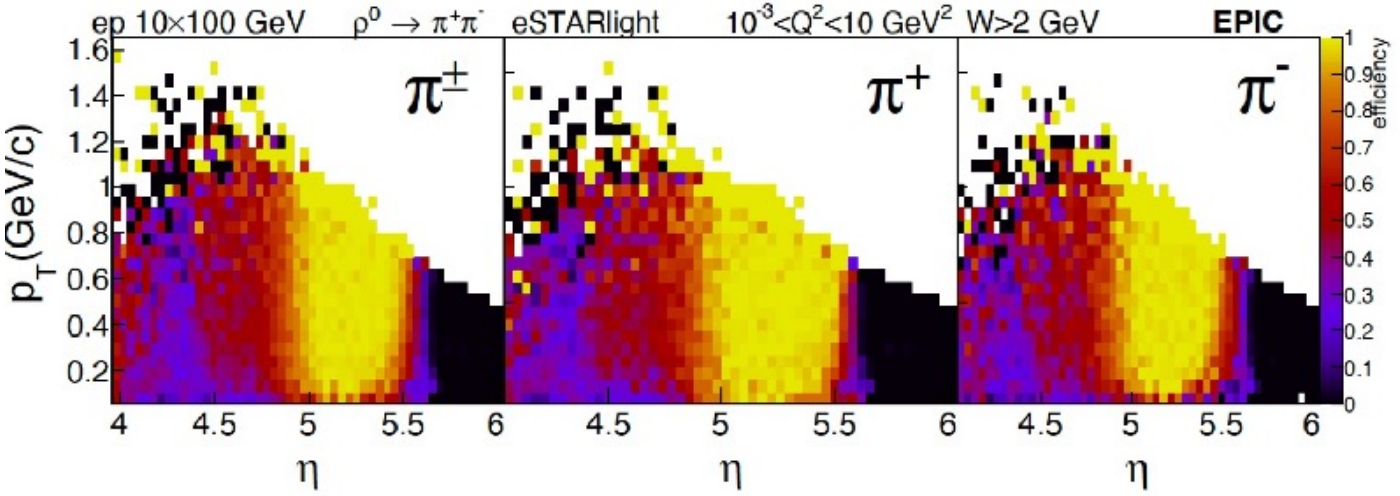


Excl+Diff+Tag PWG: u-Channel ρ^0 benchmark for B0

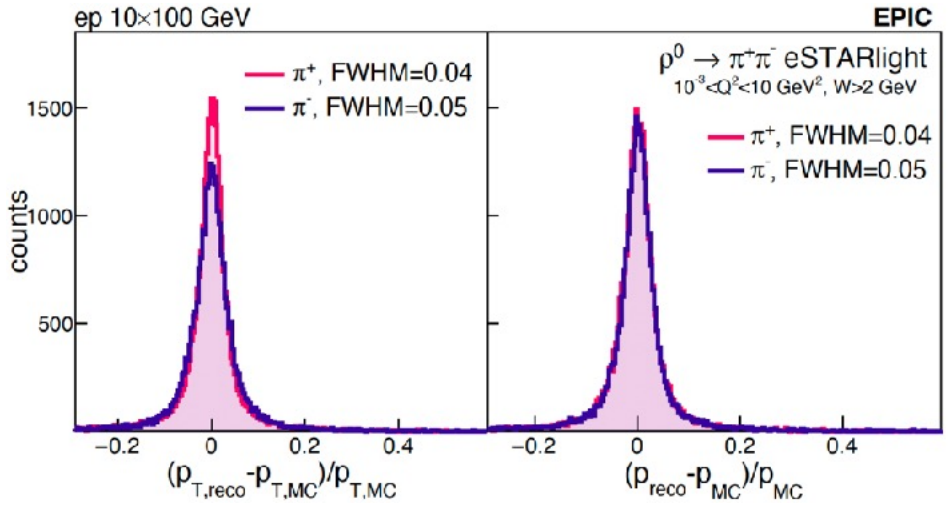
$\rho^0 \to \pi^+\pi^-$ in the B0

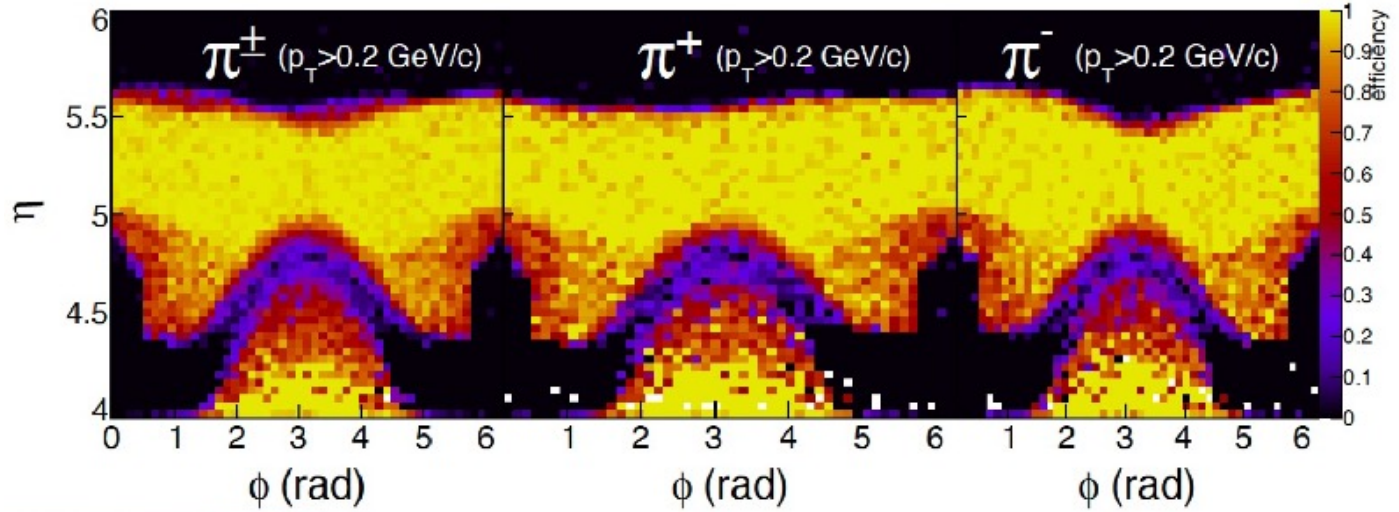


$\pi^+\pi^-$ reconstruction efficiency



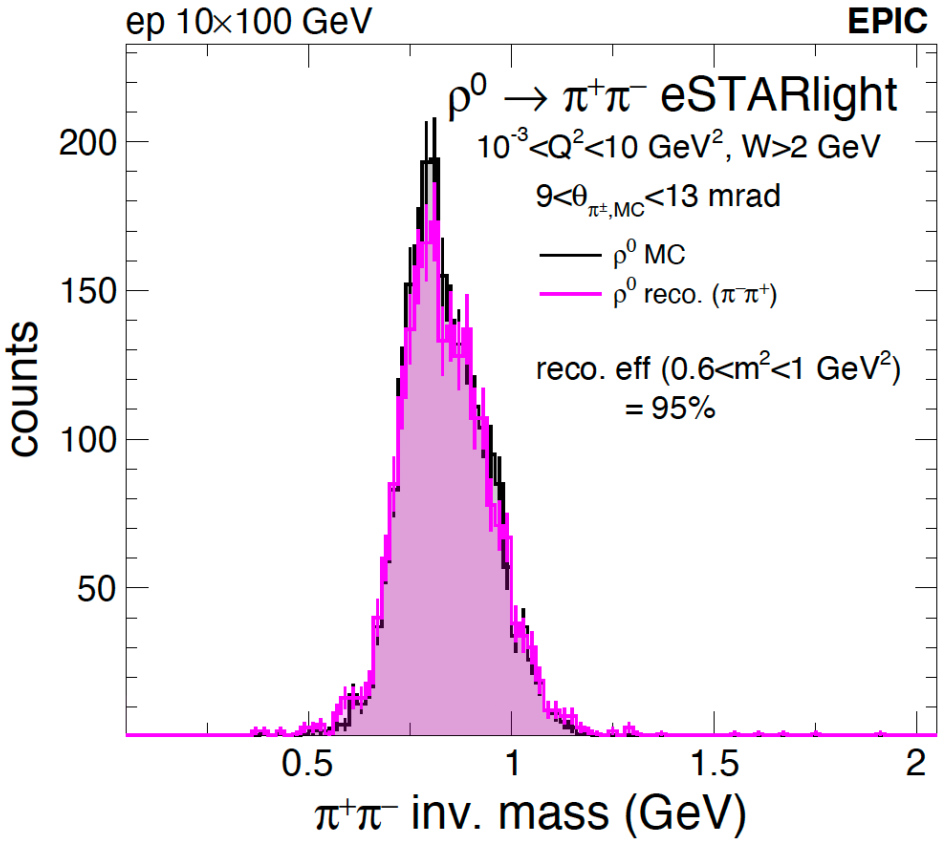
$\pi^+\pi^-$ reconstruction resolution (%)

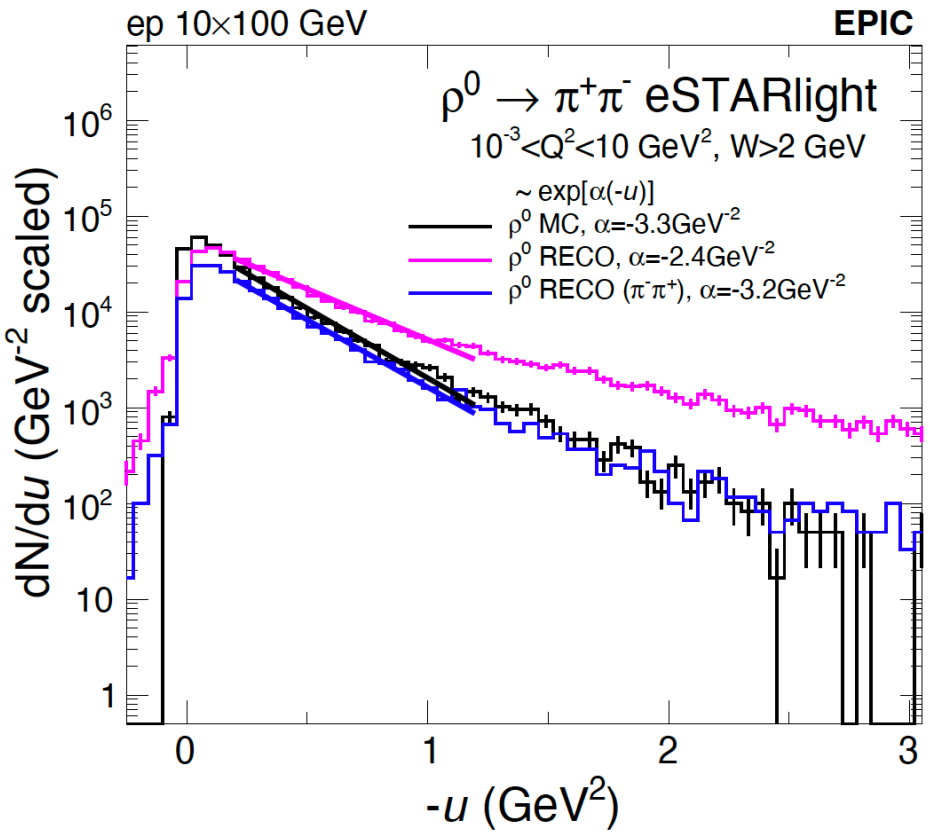




Plots: Z. Sweger (UCDavis)

Excl+Diff+Tag PWG: u-Channel ρ^0 benchmark for B0





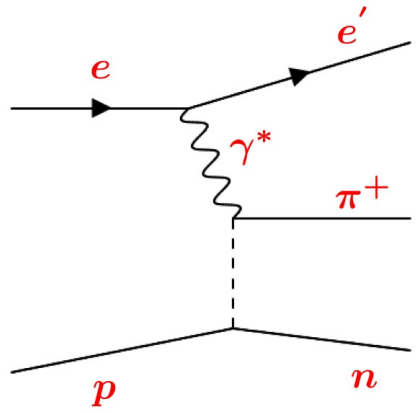
Invariant mass reconstruction

- Reco. efficiency = 95%
  - flagged bad if <90%

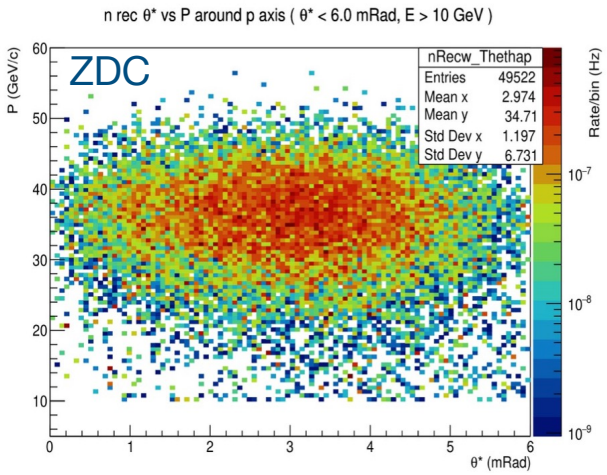
u-channel ρ^0 cross section slope reconstruction

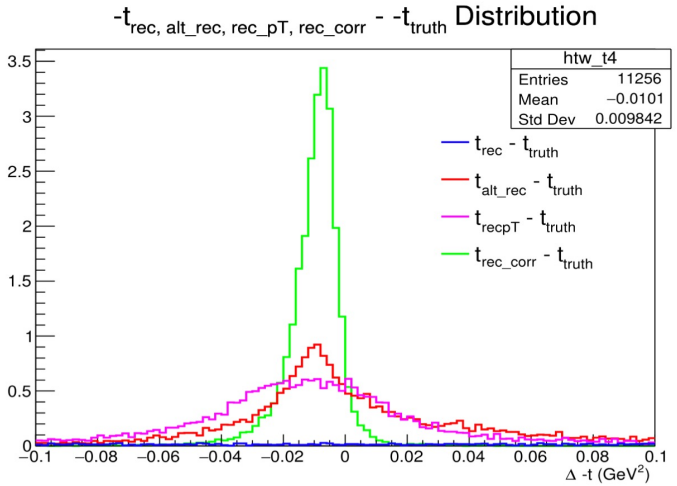
Plots: Z. Sweger (UCDavis)

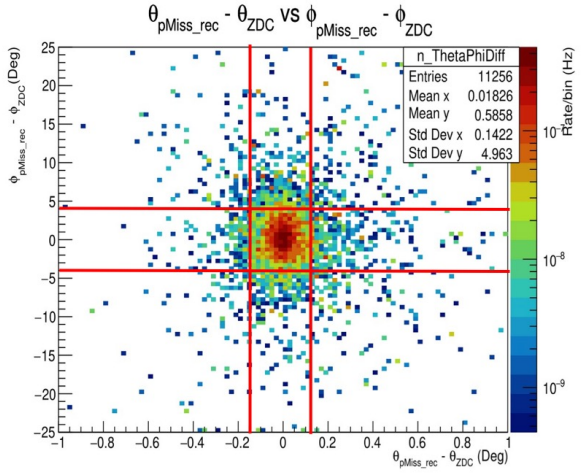
Excl+Diff+Tag PWG: meson form factors

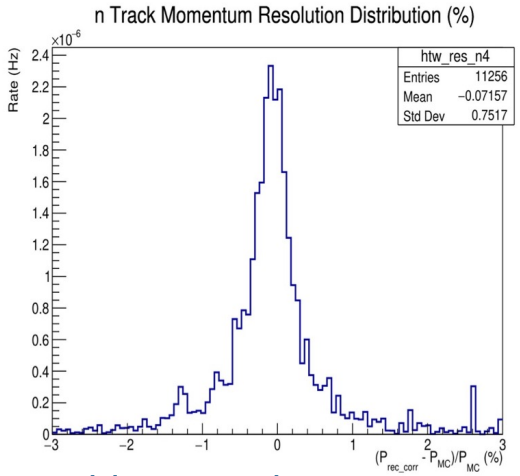


- Emergent hadronic mass enigma
- Pion form factor under study
- More info: https://indico.bnl.gov/event/23814/contributions/92533/attachments/55095/94308/Love_slides.pdf





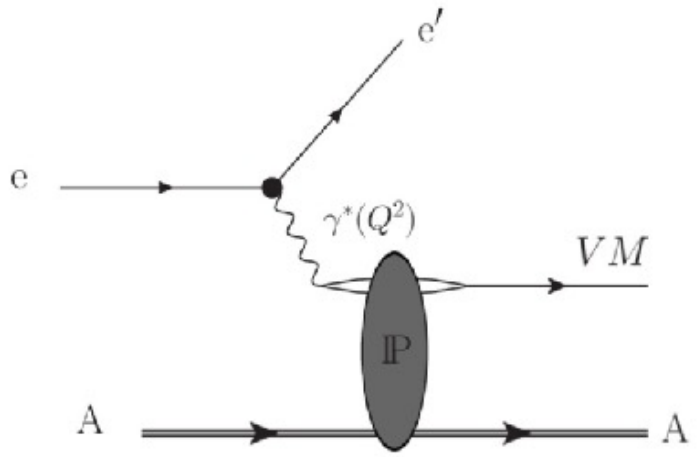




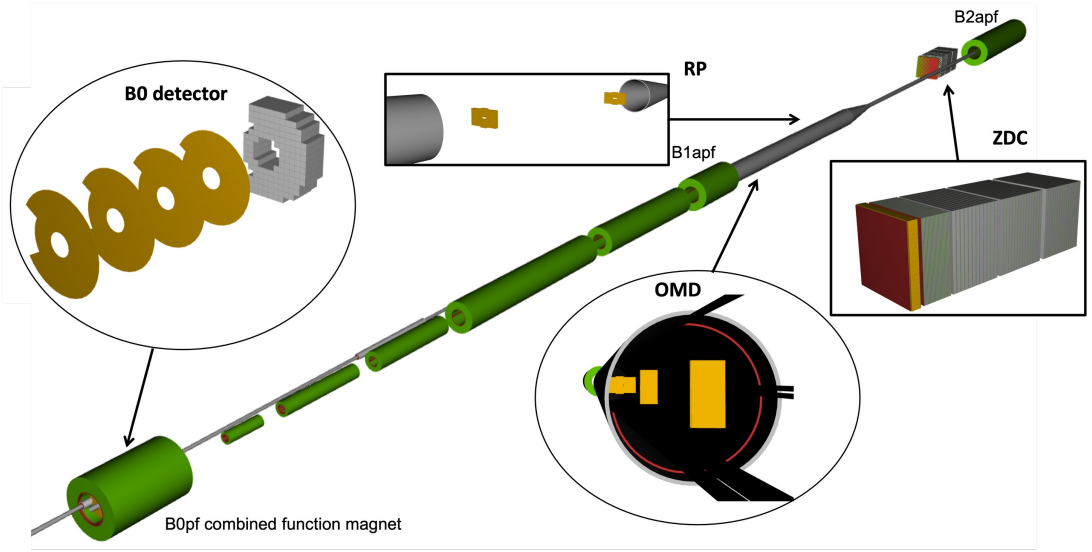
Plots: Love Preet (Regina) 5x41 24.05.0 monthly campaign

- **All final state particles reconstructed:** e’ and π^+ central detector, n FF region (mainly ZDC)
- Analysis in recent campaigns also likely affected by new PID implementation in 24.05.0
- Results promising and comparable to previous resolutions (eg neutron track angle and momentum resolutions)
- t-reconstruction method (see backup) working well
  - Post-burner next month will check offset
- Request a 5x100 campaign from simulation team for important direct comparison with previous YR results
- $F_\pi(Q^2)$ projections for TDR expected imminently
- Further plans to extend to kaons (more challenging)

Excl+Diff+Tag PWG: diffractive VM production in eA



- Probe low-*x* structure
- Sensitivity to gluon distributions in nucleon/nuclei
- Probe spatial parton structure of nuclei
- Challenges: veto incoherent background, *t*-reconstruction

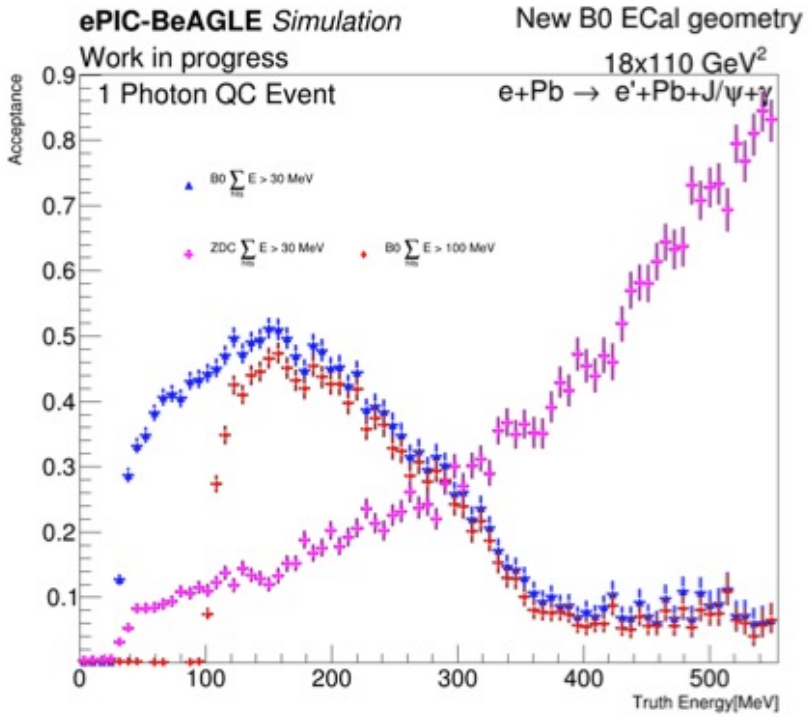


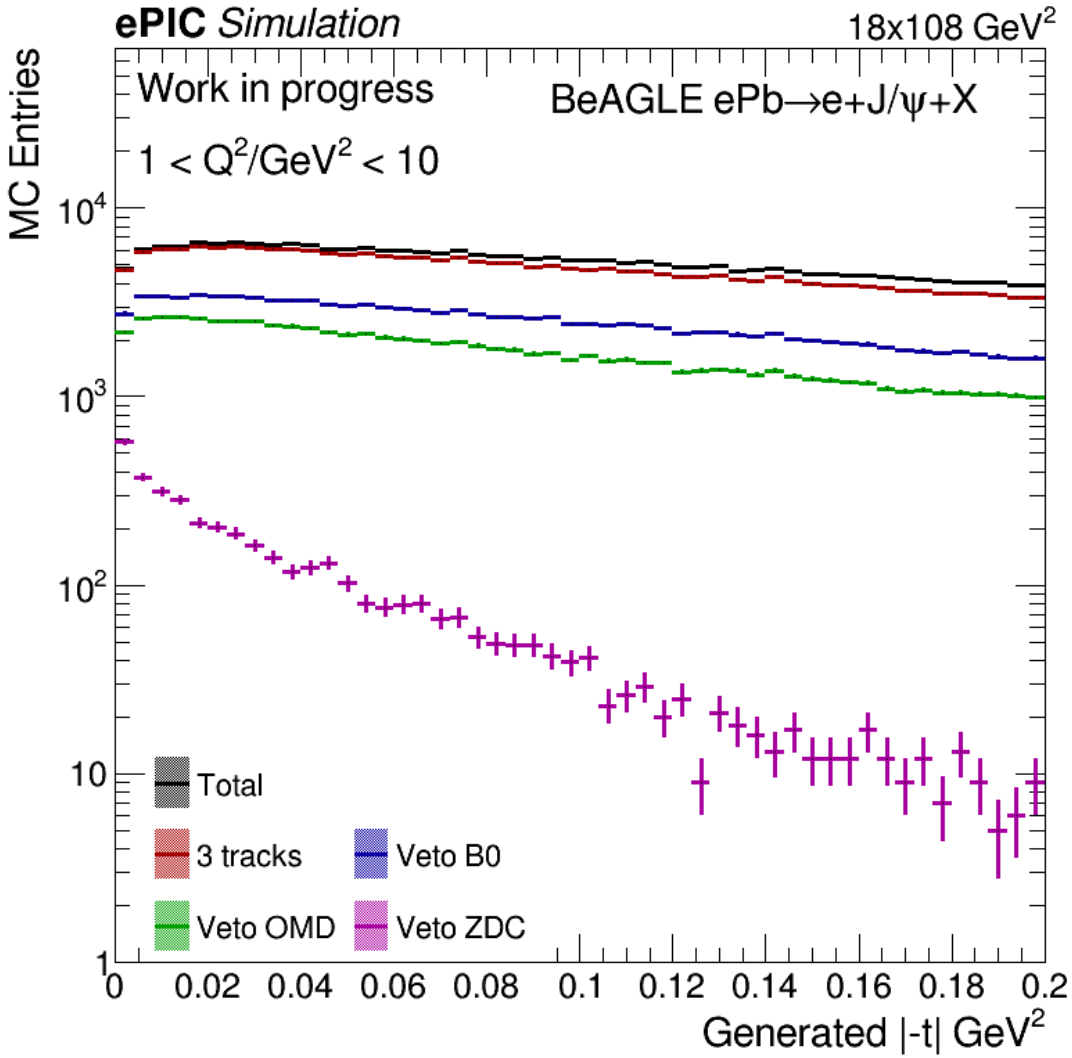
Coherent event Selection (J/ψ)

- 3 track events (at least two tracks in main detector)
- J/psi mass window of 0.4 GeV (no PID)
- Veto activity in forward region (reco/hits):
  - B0 tracks, B0 clusters, Hits in OMD/RPs, Ecal and Hcal ZDC Clusters

Excl+Diff+Tag PWG: diffractive VM production in eA

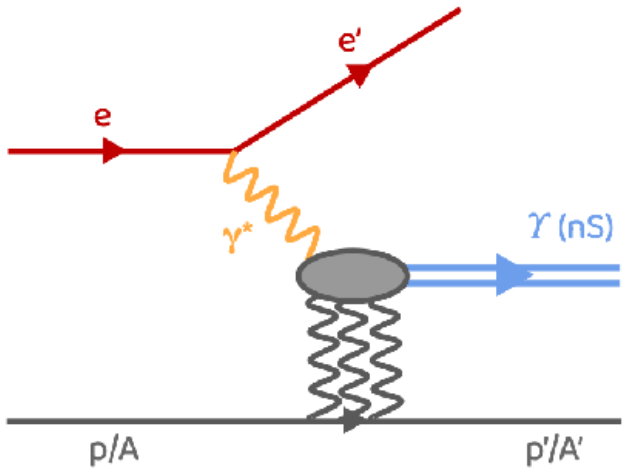
- Veto of incoherent events: promising veto performance
  - Majority of remaining background is photons from quasi-coherent events (J/Psi+Pb+photon)
    - Good sensitivity to those events in B0/ZDC
    - Some work still needed on clustering for photons in B0/ZDC to allow check of energy resolution





Plots: Michael Pitt (Ben Gurion)

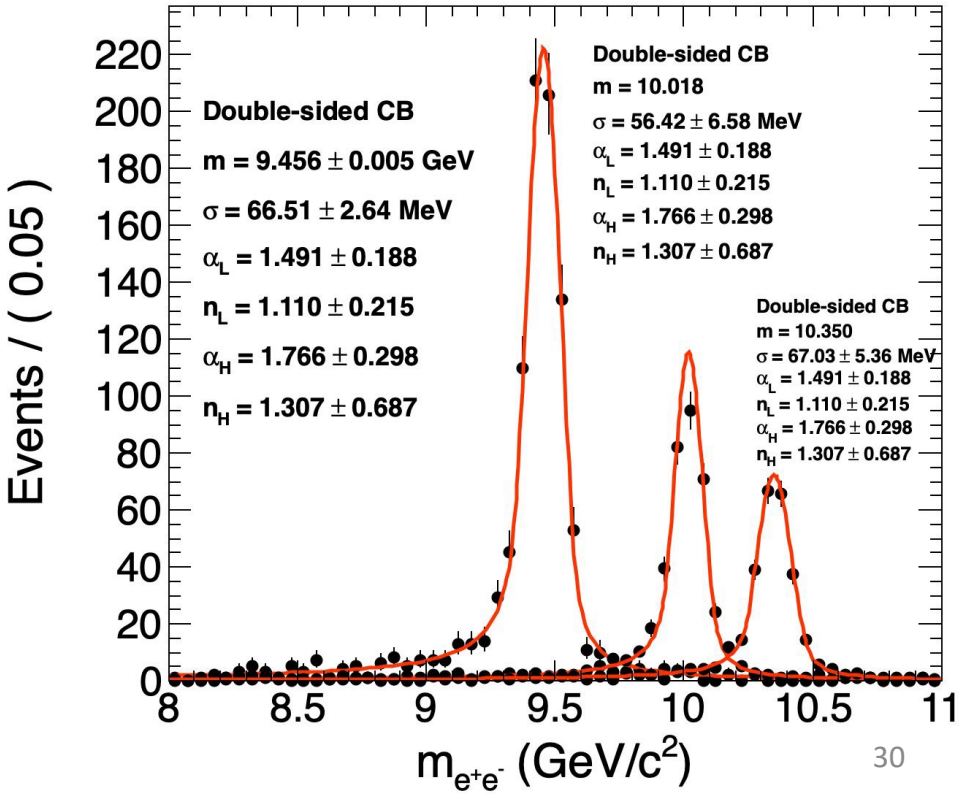
Excl+Diff+Tag PWG: Υ production



$$\Upsilon(1S), \Upsilon(2S), \Upsilon(3S) \rightarrow e^+e^-$$

- Sensitivity to gluon distributions
- Near threshold production → origin of mass
- Challenges: tracking resolution is crucial
- First studies at low Q^2

- Used Ratio yields 1 : 0.45 : 0.33 from STARlight paper
- Fitted with the **Double-Sided Crystal Ball function**
- $m_{\Upsilon nS} = m_{\Upsilon 1S} \frac{\mathrm{PDGmass}_{nS}}{\mathrm{PDGmass}_{1S}}$
- Resolution of each peak:
  - $\sigma_{1S} = 66.5 \pm 2.6$ MeV
  - $\sigma_{2S} = 56.4 \pm 6.6$ MeV
  - $\sigma_{3S} = 67.5 \pm 2.6$ MeV
- Need to reobtain values using a larger sample size

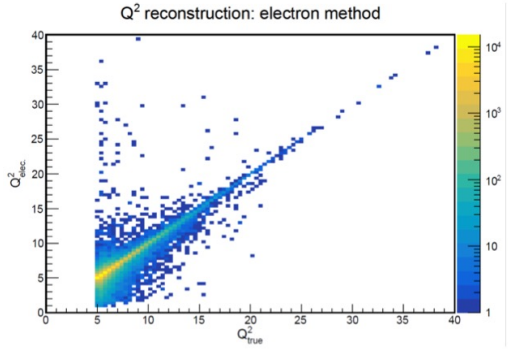


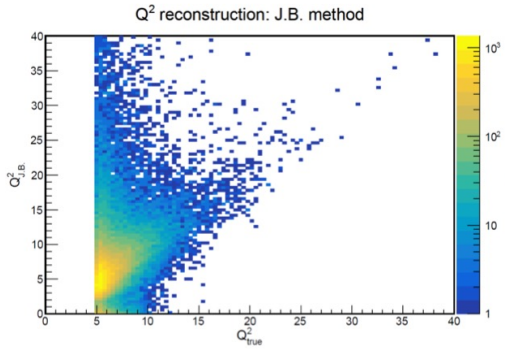
Plots: Saeahram Yoo (Berkeley)

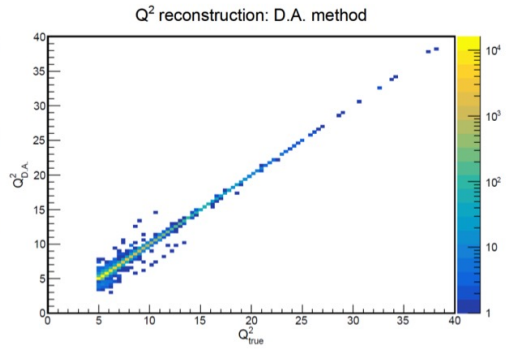
Excl+Diff+Tag PWG: Elastic e-p

- **Nucleon structure**, input for multi-dimensional imaging; over-constrained kinematics would make it **useful for detector calibrations**
- Reconstruction of elastic e-p for high Q^2 events 5 x 41, self run simulation with April version of ePIC/EICRecon (ie truth PID)
- **At 5x41 e' and p are in central detector**
- More details: https://indico.bnl.gov/event/23163/contributions/90802/attachments/54165/92670/epic_elastic_042924.pdf

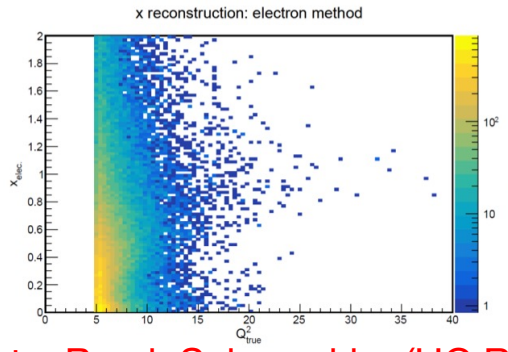
Scattered electron method | Jacquet-Blondel method | Double-Angle method

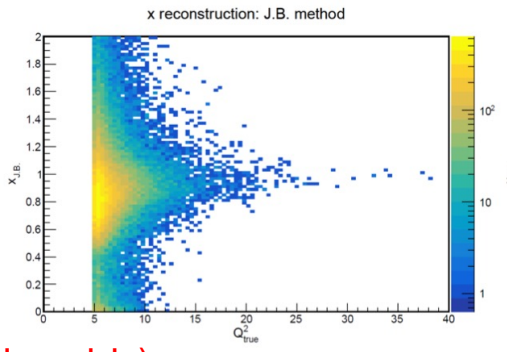


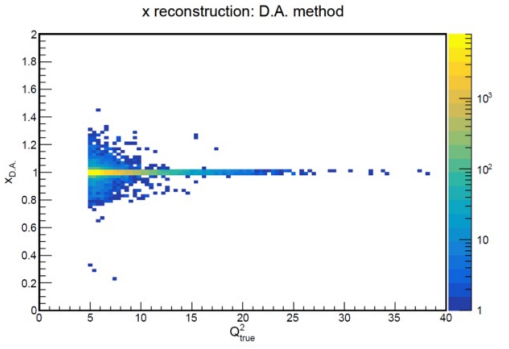




Scattered electron method | Jacquet-Blondel method | Double-Angle method







Plots: Barak Schmookler (UC Riverside)

- Good reconstruction of x and Q^2 possible if detect *both* e' and p'
- Next steps
  - Check PID/electron finder effects on analysis
  - Check higher energy configuration where p' is in FF
  - Look at low Q^2 events and QED effects
  - Develop a benchmark
- We will likely request monthly productions in future

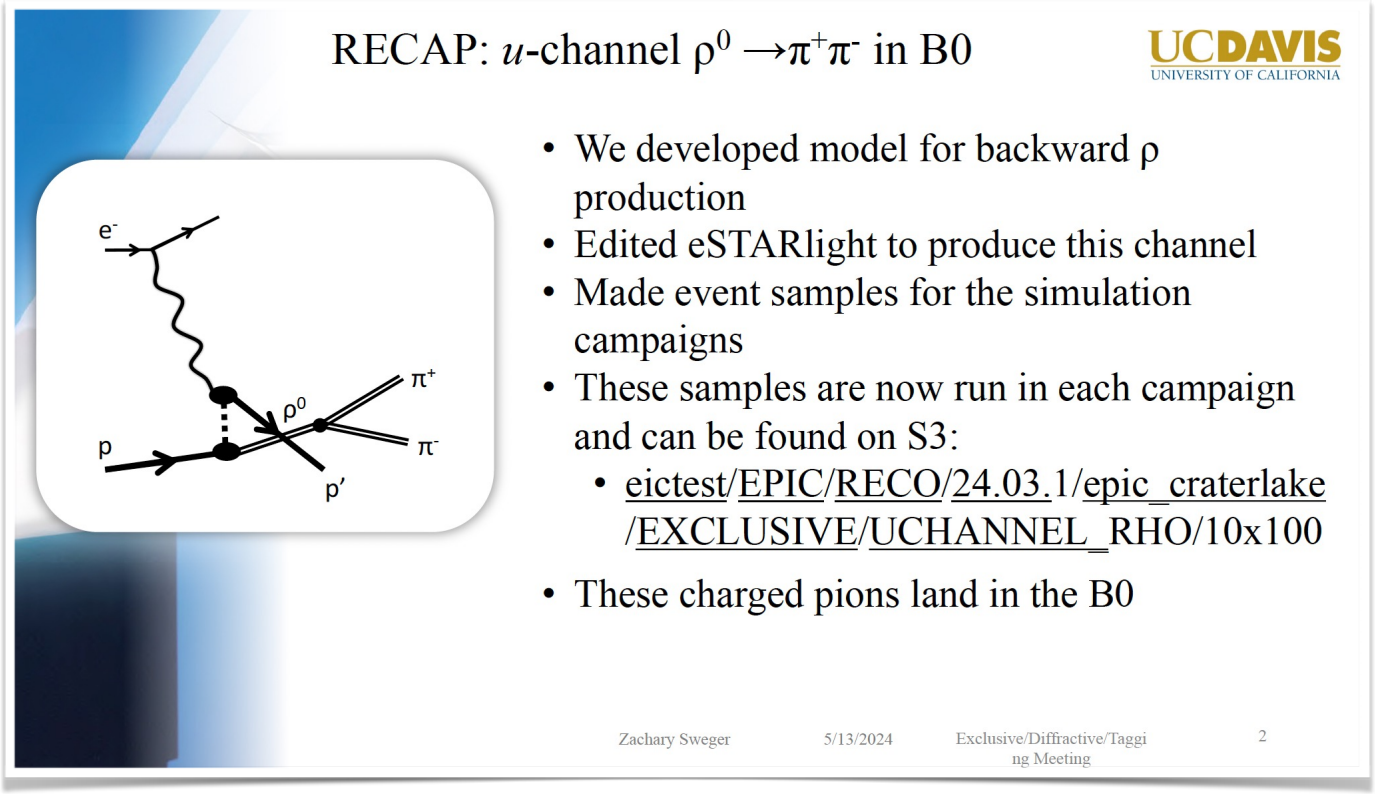
Wrapping up…

- 4 new PWG conveners identified and proposed to the C.C.
  - Inclusive PWG convener still under negotiations
- Much activity towards TDR and the ePIC physics paper
  - New physics benchmarks
  - Testing with different simulation campaigns
  - First impact studies based on ePIC simulation
  - Synergic activity on tools and reconstruction
- HOW do I join a PWG?
  - step 1: email the conveners of your favorite PWG and subscribe the mailing list!
  - step 2: join the biweekly meetings
  - step 3: actively engage in studies and efforts – **make an impact!**


BACKUP

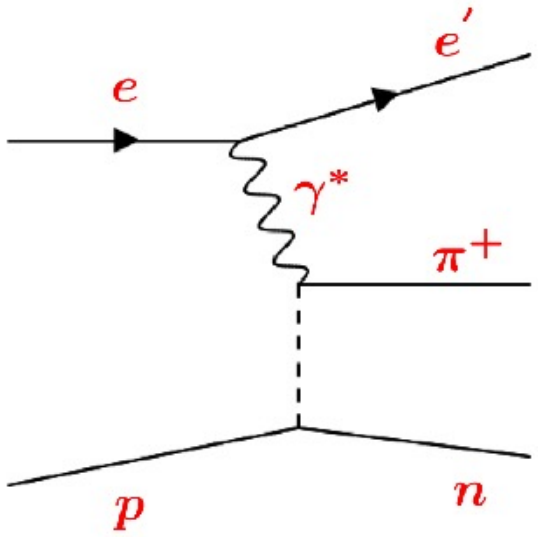
Excl+Diff+Tag PWG: u-Channel ρ^0 benchmark for B0

- Backwards (u-channel) physics → nucleon/nuclear tomography
- Forward (t-channel) cross-sections → parton distributions in transverse plane via GPDs
- Backwards cross-sections → quark clusters and baryon number distributions in transverse plane via TDAs
- Connections with baryon stopping
- See paper: https://journals.aps.org/prc/abstract/10.1103/PhysRevC.106.015204



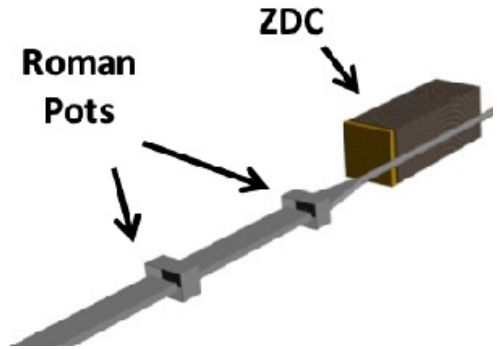
- In ePIC:
  - Produced vector meson takes most of momentum of struck nucleon → ends up in FF region
  - Nucleon shifts by several units in rapidity to mid-rapidity
- **Zachary Sweger (UCDavis) et al.**
- Backwards ρ^0 meson production
  - Low Mandelstam u, high t
- Benchmark for B0 developed
  - B0 is critical for pions in $\rho^0 \rightarrow \pi^+ \pi^-$

Excl+Diff+Tag PWG: meson form factors



$$ep \rightarrow e'\pi^+ n$$

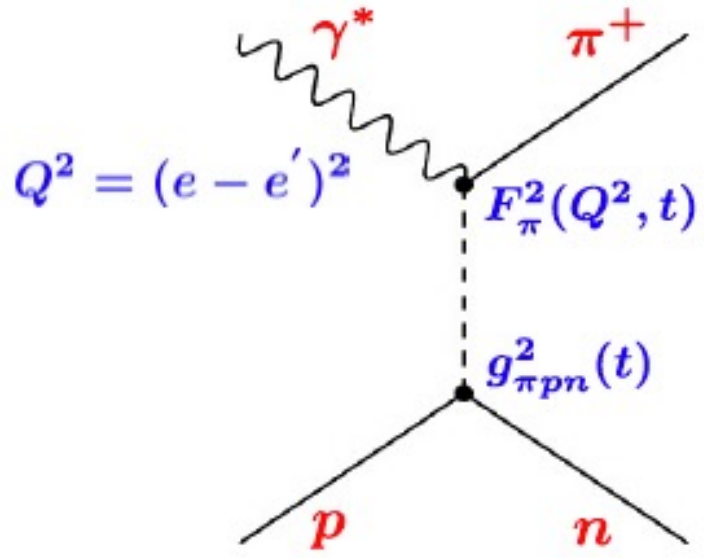
- Enigma of emergent hadronic mass
- Pion form factor under study, all final state particles reconstructed
  - e' and π^+ in central detector
  - n in FF region (mainly ZDC)
- At small $-t$, the pion pole process dominates σ_L



- In the Born model [In practice one uses a more sophisticated model], F_π^2 appears as

$$\frac{d\sigma_L}{dt} \propto \frac{-tQ^2}{(t-m_\pi^2)^2} g^2_{\pi pn}(t) F_\pi^2(Q^2,t)$$

- Q^2 and $-t$ reconstruction resolution is crucial for extracting F_π^2 from the measured cross section



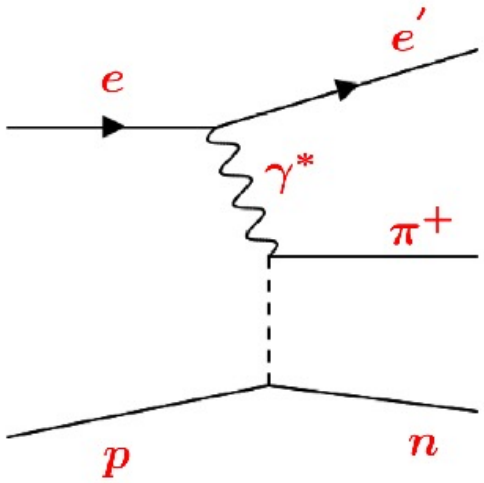
Plots: L. Preet (Regina)

Excl+Diff+Tag PWG: meson form factors

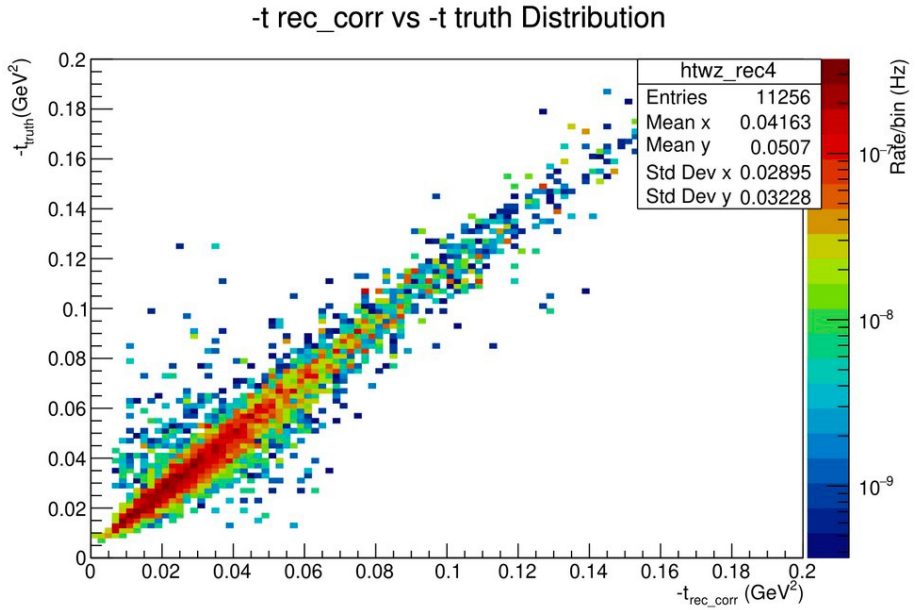
- Best method: $-t$ reconstruction using corrected *n* track
  - See paper: https://www.sciencedirect.com/science/article/abs/pii/S0168900223002280
  - n_{corr} is constructed using missing momentum information:

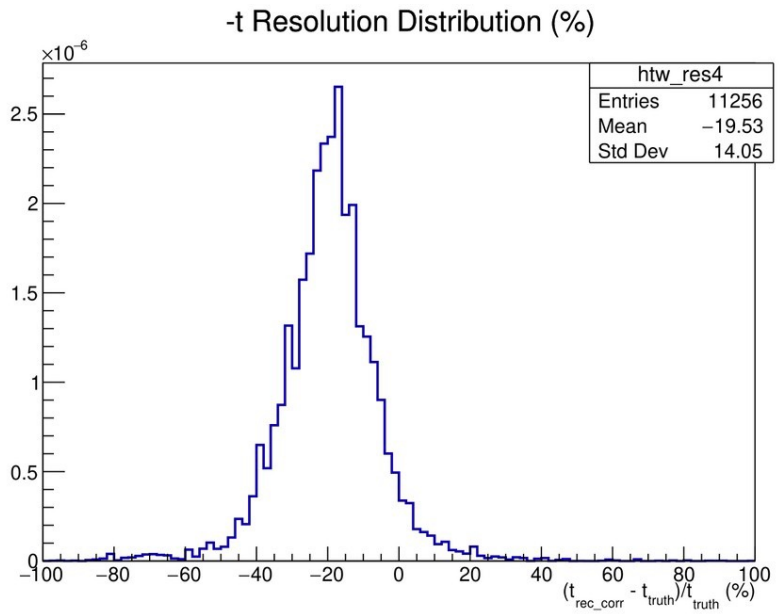
$$p_{miss} = \left|\vec{p}_e + \vec{p}_p - \vec{p}_{e'} - \vec{p}_{\pi^+}\right|$$

  - And replacing θ_{Miss}, ϕ_{Miss} with θ_{ZDC}, ϕ_{ZDC}, and fixing the neutron mass



$$-t_{truth} = -(\gamma^* - \pi^+)^2 \qquad -t_{rec\_corr} = -(p - n_{corr})^2$$

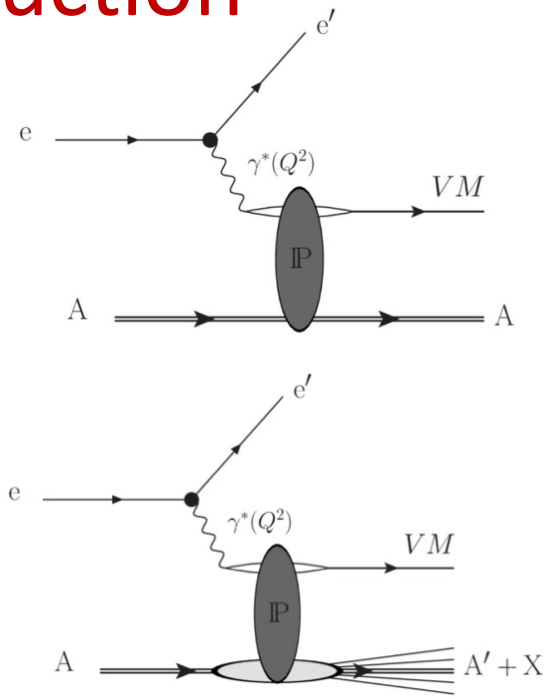


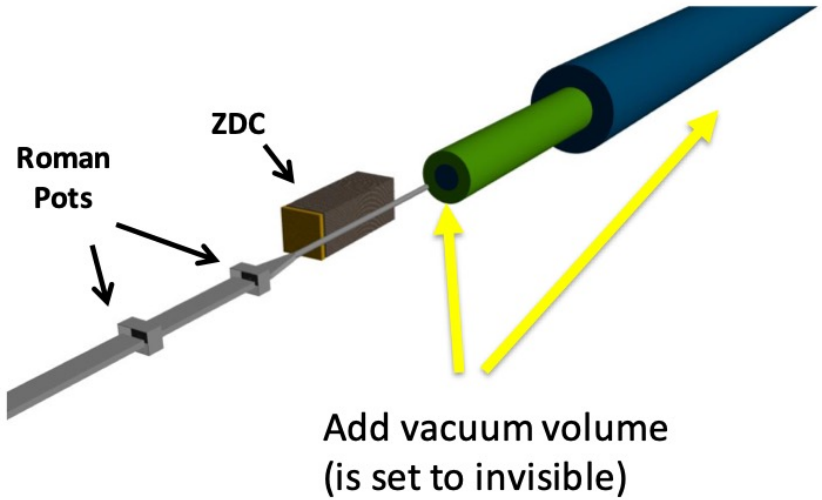


Plots: L. Preet (Regina)

Excl+Diff+Tag PWG: diffractive VM production

- Probe low-x structure, sensitivity to gluon distributions in nucleon/nuclei, probe spatial parton structure of nuclei
- Challenges: incoherent background, t-reconstruction
- More info: https://indico.bnl.gov/event/23345/contributions/91508/attachments/54637/93485/Jpsi_in_eA.pdf
- Self-run simulation
- On-going study of coherent VM production (J/Psi in ePb) and background veto for TDR
- Planning to make incoherent veto benchmark for FF region
- Coherent events eStarlight, incoherent events BeAGLE



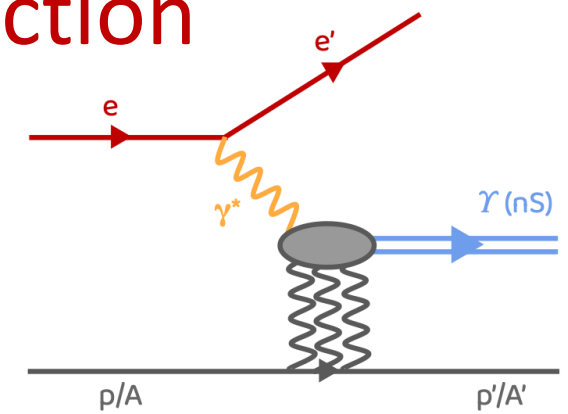


Credit: Michael Pitt (Ben Gurion)

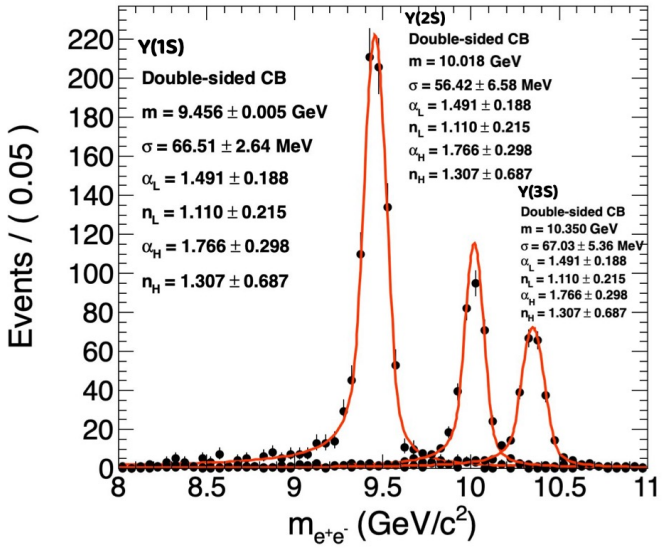
- Using latest merged FF design (PR-665) from April and April detector geometry
- To speed up reconstruction in FF, vacuum added inside hadron beam pipe (vacuum extended for Z>40)
  - Eg coherent 183.2s/ev → 16.23 s/ev
  - Incoherent 320s/ev → 35s/ev
- This is PR720 → now merged to master branch DD4HEP
- Necessary for incoherent study

Excl+Diff+Tag PWG: ϒ production

- Sensitivity to gluon distributions; near threshold production - mass enigma
- Resolution study for ϒ(1S), ϒ(2S), ϒ(3S) → e^+e^-
- Tracking crucial
- More details: https://indico.bnl.gov/event/23163/contributions/90798/attachments/54163/9



Invariant Mass Fit of Reconstructed ϒ(1S), ϒ(2S), ϒ(3S)



- Used the ratio for the yields
  1 : 0.45 : 0.33
  from the STARlight paper
- Fitted with the DSCB(Double-Sided Crystal Ball) function with the constraints on the mean and tail parameter values of ϒ(2S) and ϒ(3S).
- $m_{YnS} = m_{Y1S} * \frac{PDGmass_{nS}}{PDGmass_{1S}}$
- Resolution of each peak:
  σ_{1S} = 66.52 ± 2.64 MeV
  σ_{2S} = 56.42 ± 6.58 MeV → need to obtain values using a larger sample size
  σ_{3S} = 67.03 ± 5.36 MeV

- April 2024, self-run, eAu, 10x100
- ϒ(1S), ϒ(2S), ϒ(3S) generated for $0<Q^2<0.01 GeV^2$ (truth seeding)
- eSTARlight (generate seeds) → ~~afterburner~~ (nb afterburner *not* used here, due to a bug but will be used in future plots) → npsim → EICrecon
- Next:
  - Add afterburner; larger samples
  - realistic seeding and study different regions of detector (barrel vs endcap)
- Want to develop this into a tracking benchmark
- Have requested this to be included in monthly campaigns

Plots: Saeahram Yoo (Berkeley)