LANL EIC Study Status and Plan

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UC EIC consortium meeting at UCLA

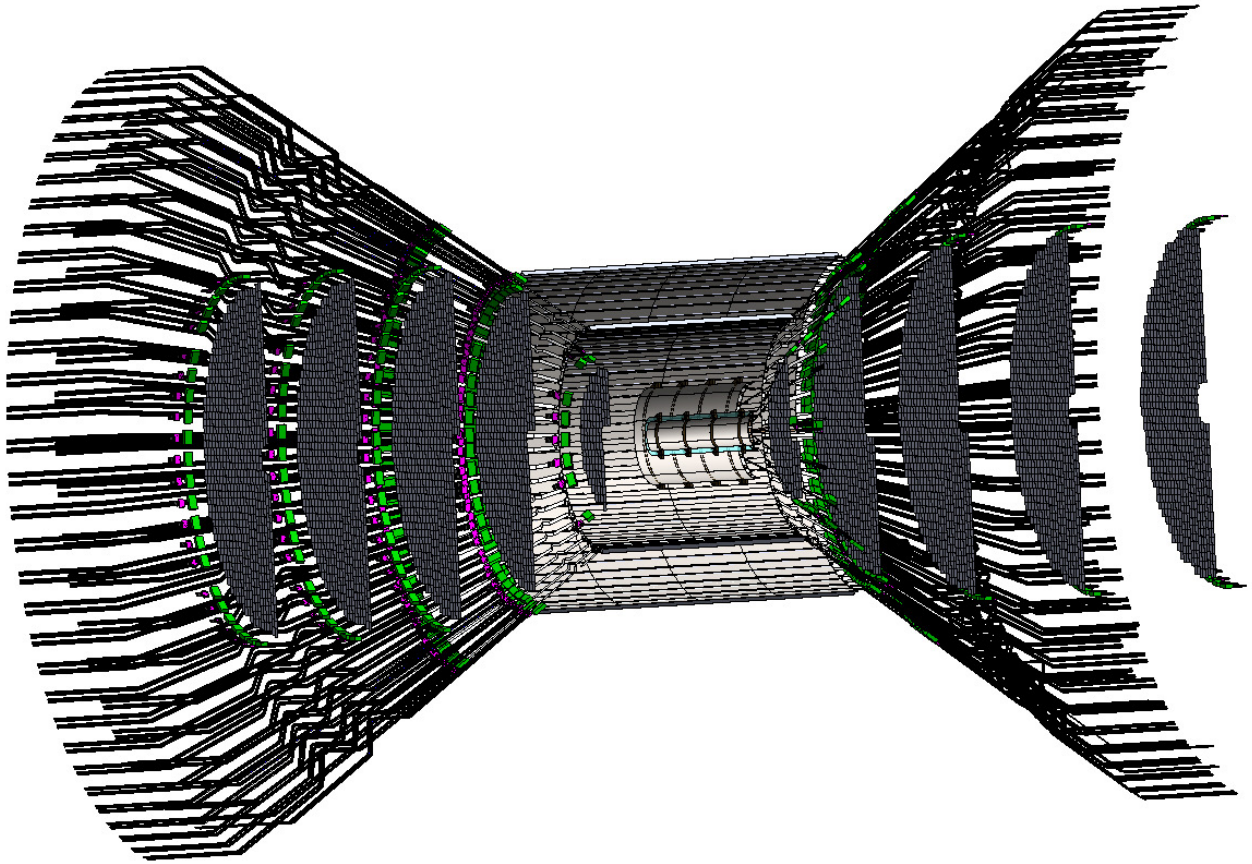
Aug. 21-22, 2023

Outline

- ePIC SVT mechanical design updates.
- EIC physics study ideas and progress.
- Plan.

ePIC MAPS detector mechanical design updates (I)

- The ePIC MAPS detector mechanical design led by Walter Sondheim at LANL, is in the process of being updated to correspond to the geometry developed at BNL, which is currently the new baseline.



Service cables from the 3 MAPS vertex layers.
No service cables from the endcap disks

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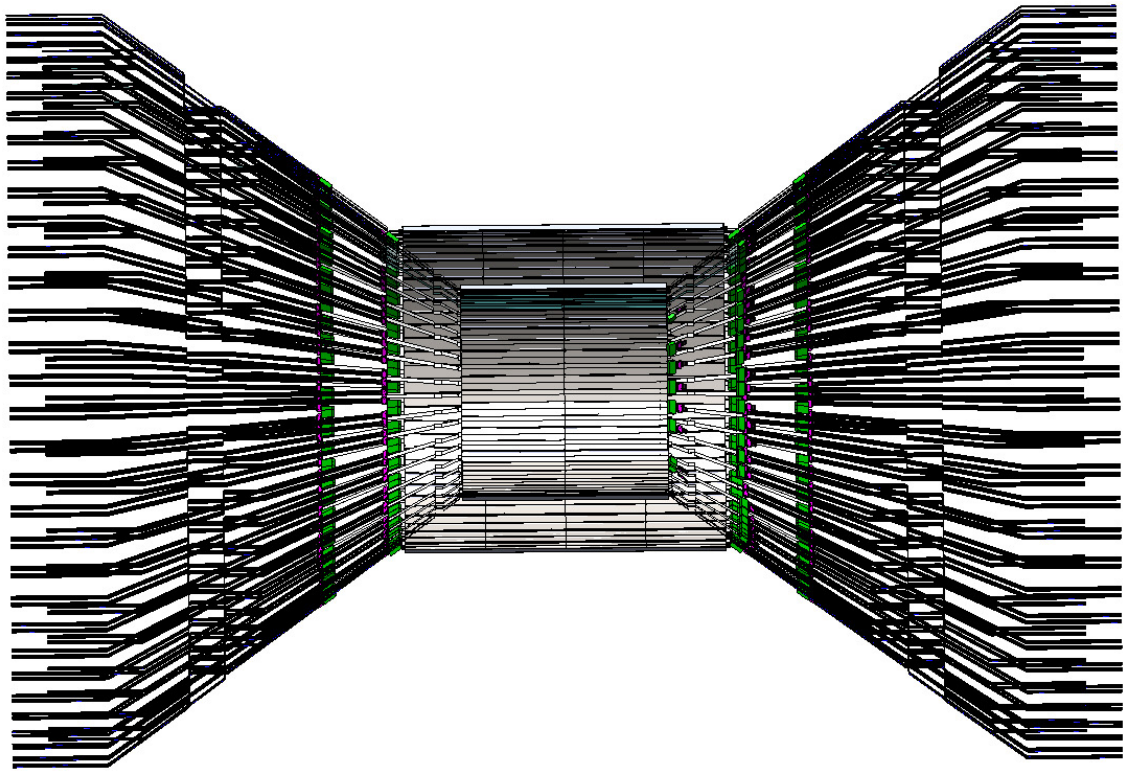
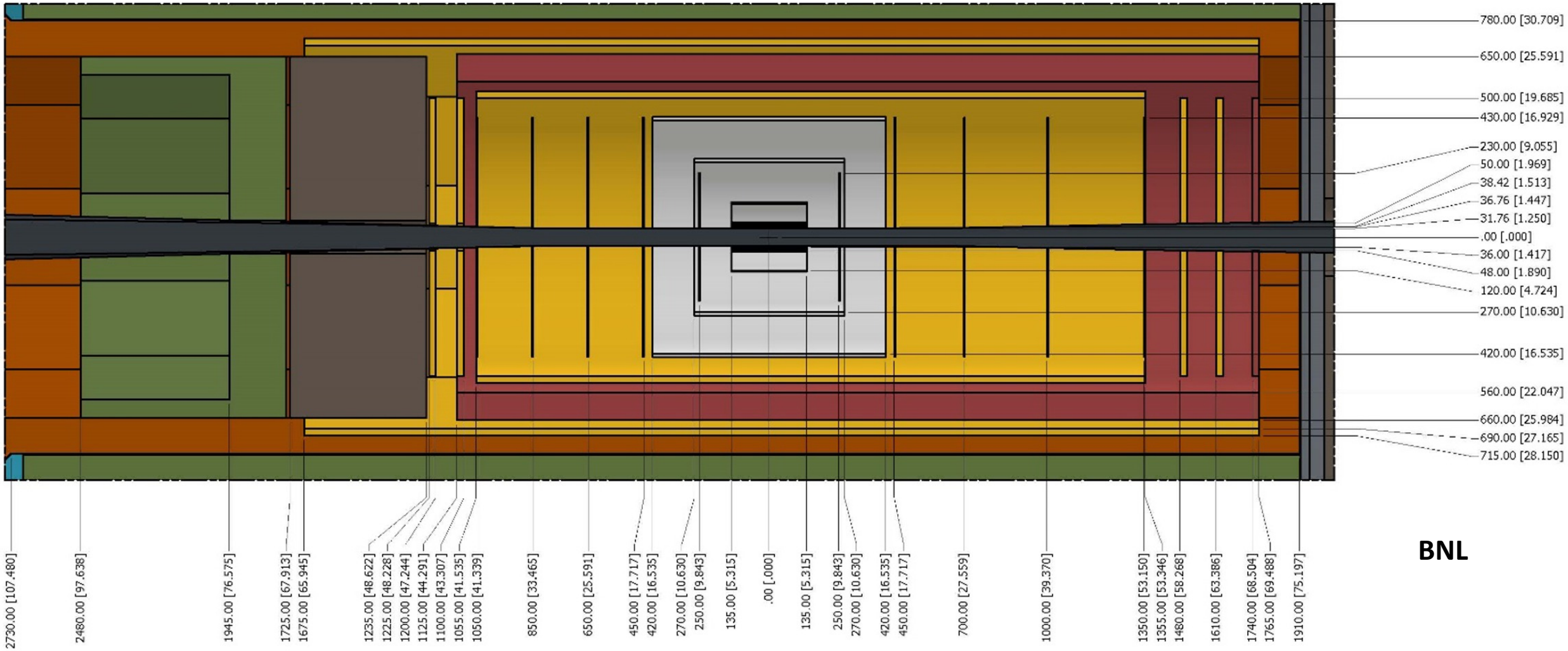


- **Service cables from the 3 MAPS vertex layers and 2 MAPS sagitta layers.**
- **No service cables from the endcap disks**
- **Will work on the endcap disk services as well.**

ePIC MAPS detector mechanical design updates (III)

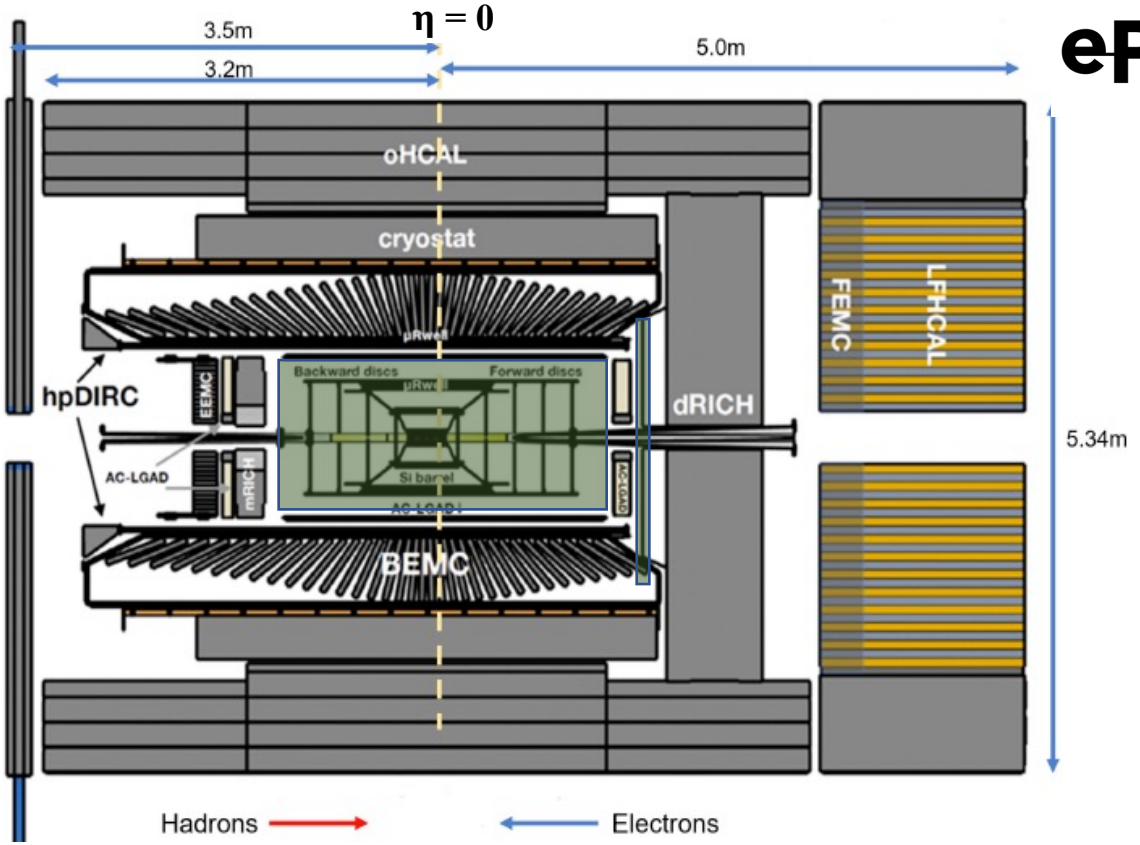
- **Need inputs about the integration with the updated MPGD layers/disks.**



BNL

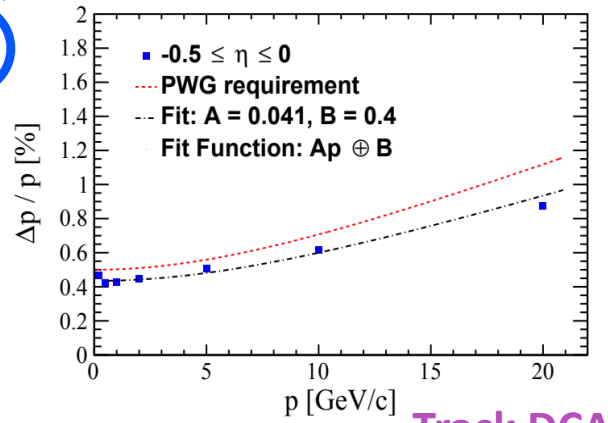
ePIC detector design and key performance for HF reconstruction

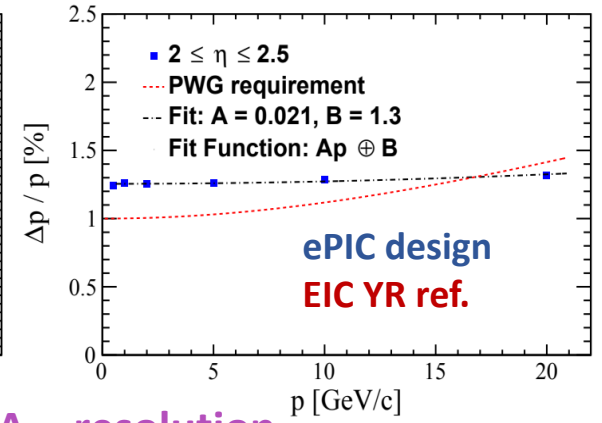
- The current EIC project detector design (ePIC), which consists of MAPS, MPGD and AC-LGAD tracking detectors, can achieve good momentum and transverse DCA (DCA_{2D}) resolutions. The ePIC detector can also provide precise particle identification and energy determination for heavy flavor reconstruction at the EIC.



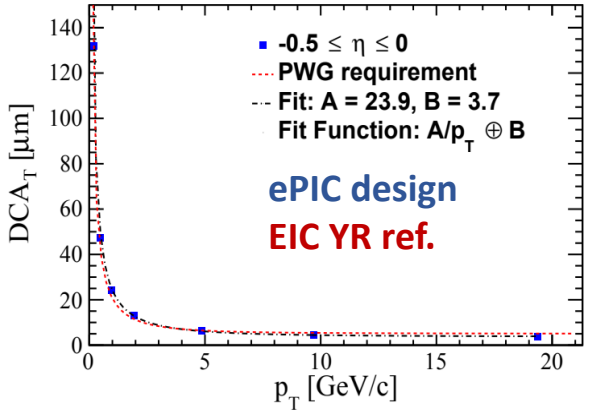
ePIC

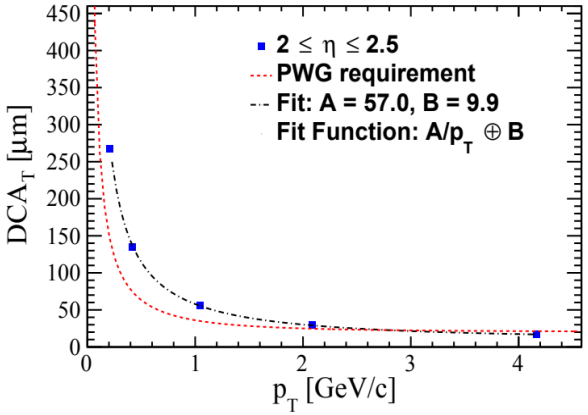
Track momentum resolution





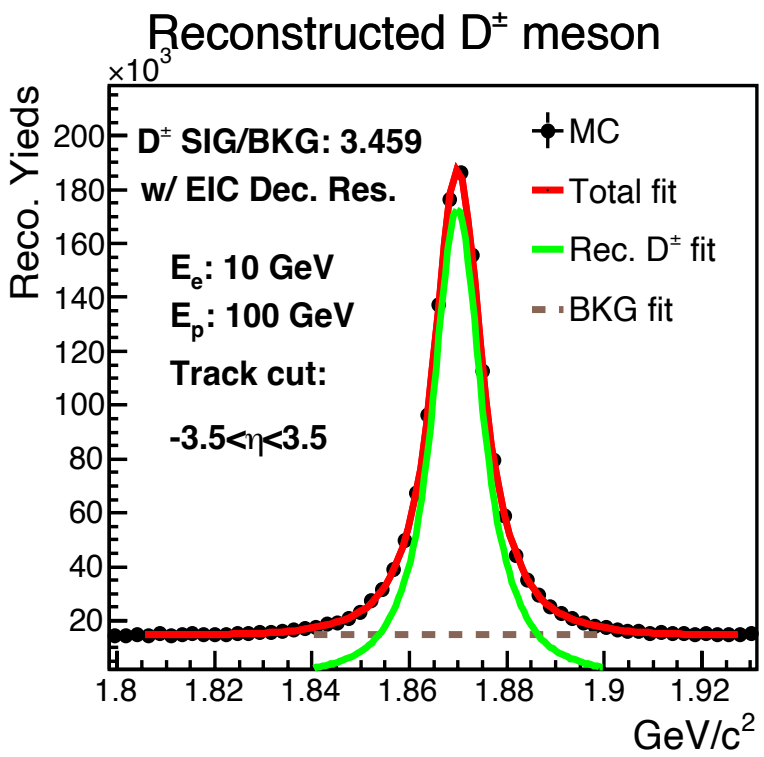
Track DCA_{2D} resolution

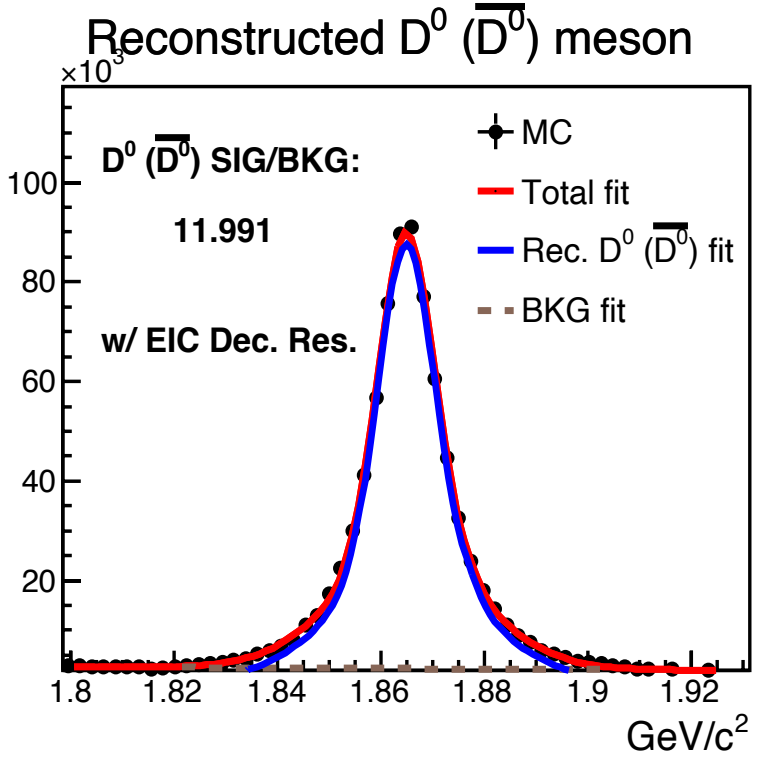


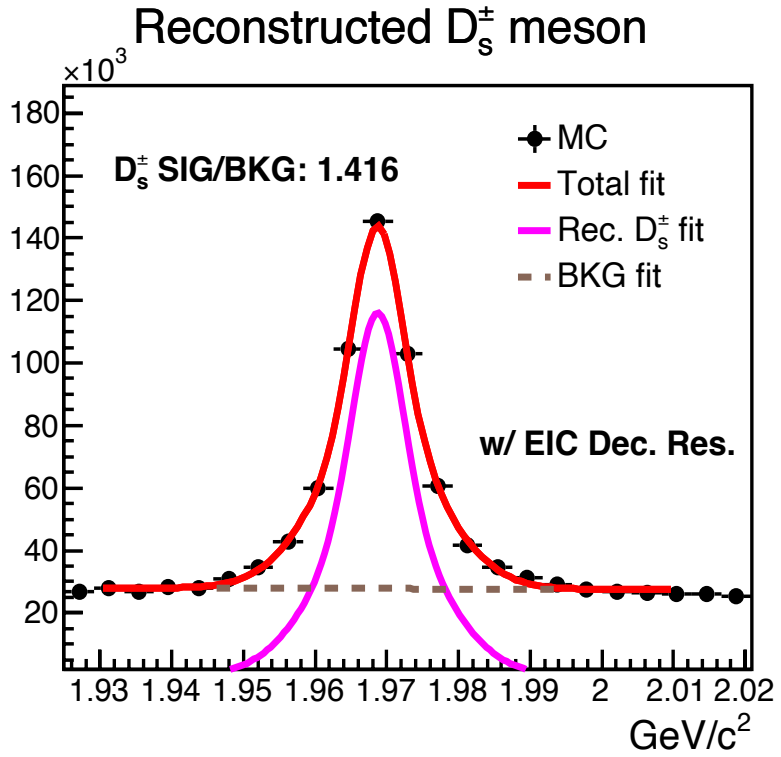


Reconstruction of open heavy flavor hadron in e+p simulation (I)

- A variety of heavy flavor hadrons have been successfully reconstructed in simulation, which includes the event generation (PYTHIA), ePIC detector performance evaluated in GEANT4 simulation, beam remnant & QCD background, and developed heavy flavor reconstruction algorithm.





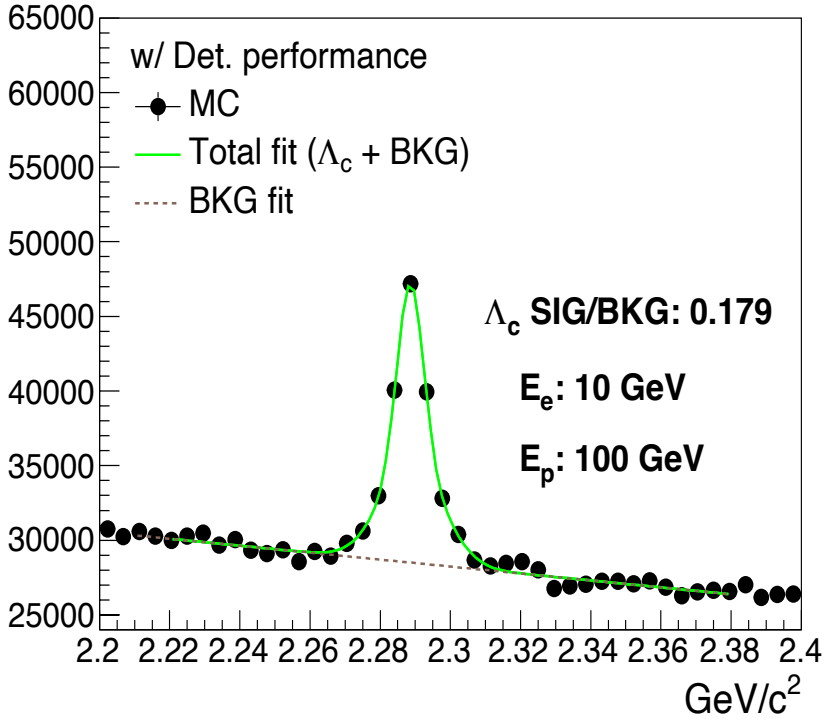


Will update these figures w/ updated ePIC tracking performance.

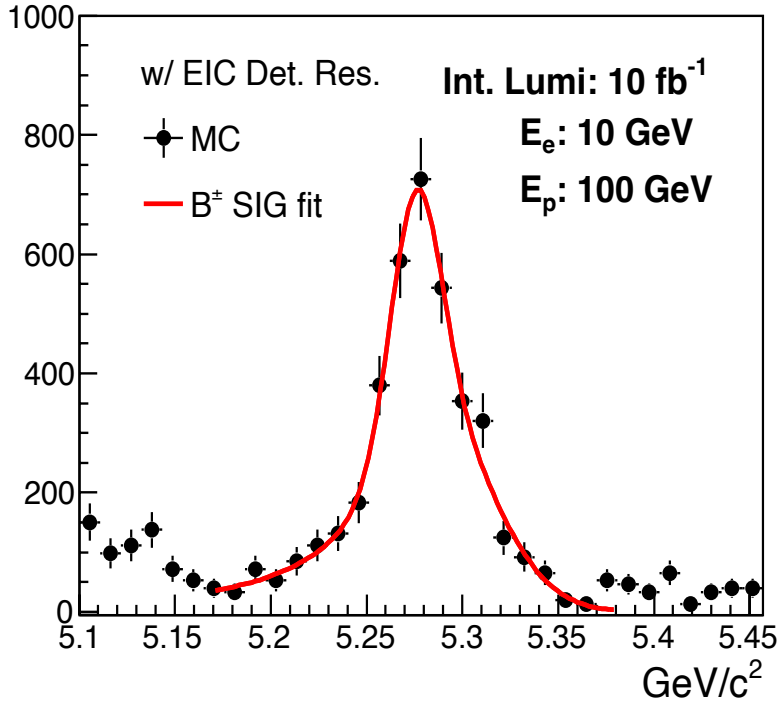
Reconstruction of open heavy flavor hadron in e+p simulation (II)

- A variety of heavy flavor hadrons have been successfully reconstructed in simulation, which includes the event generation (PYTHIA), ePIC detector performance evaluated in GEANT4 simulation, beam remnant & QCD background, and developed heavy flavor reconstruction algorithm.

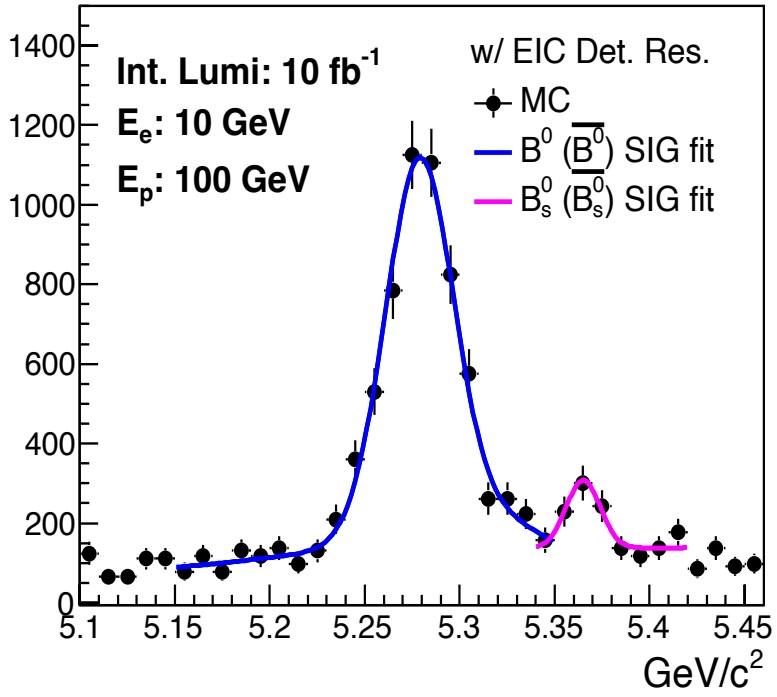
Cluster mass of $\pi^{\pm}+K^{\mp}+p$ ($\bar{p}$)



Reconstructed $B^{\pm}$ meson

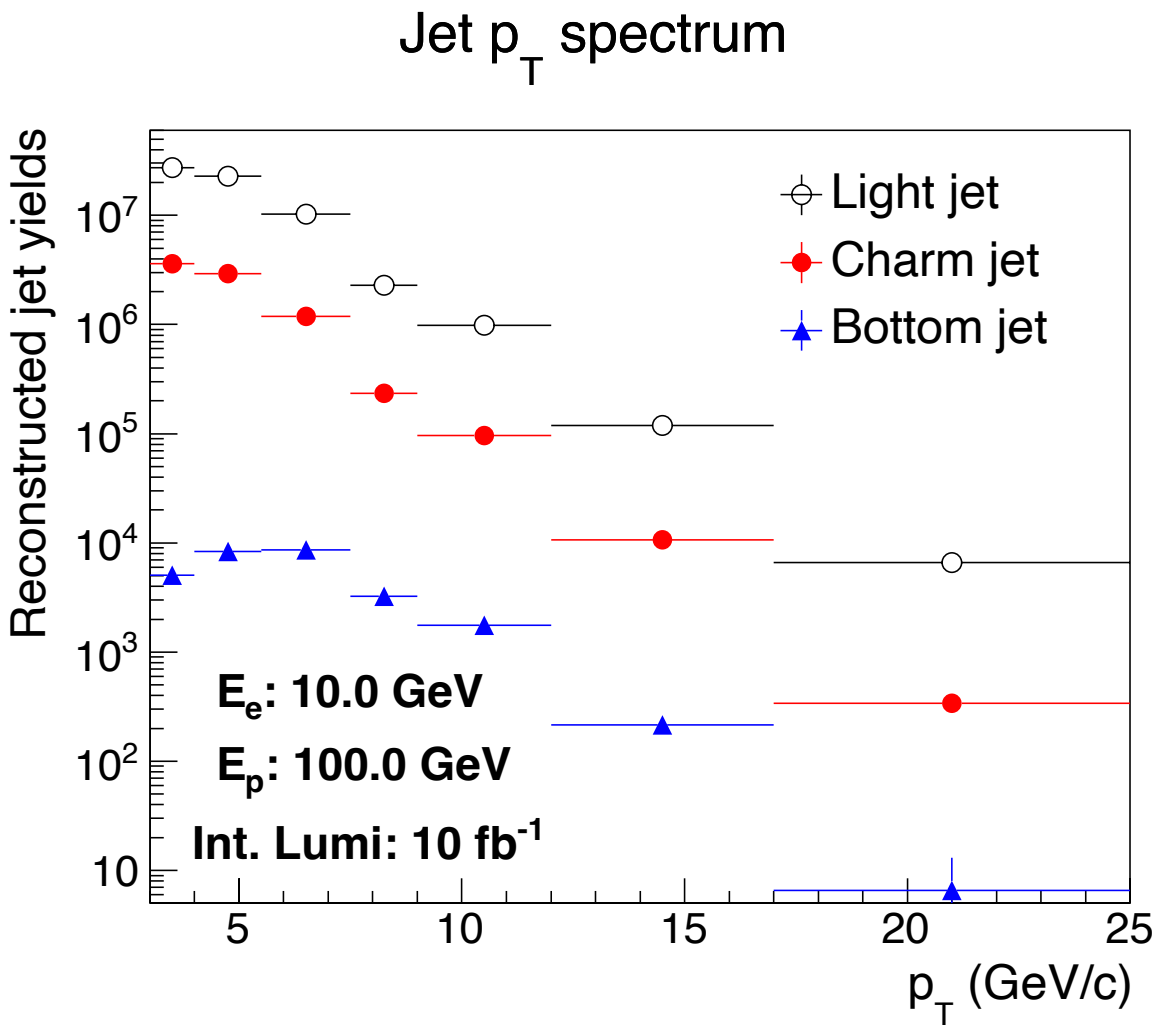


Reconstructed B^0 (B_s^0) meson



Reconstructed heavy flavor jets in e+p simulation

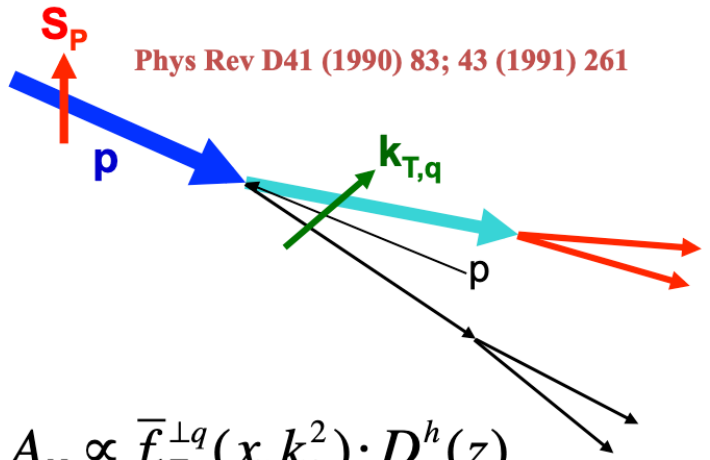
- Heavy flavor jets can be treated as the surrogate of the produced heavy quarks.
- P_T spectrum of reconstructed jets with different flavors in simulation using the ePIC detector performance in 10 GeV electron and 100 GeV proton collisions with 10 fb^{-1} integrated luminosity.
- Jets are reconstructed with the anti-k_T algorithm and cone radius R is 1.0.
- Charm-jets (bottom-jets) are tagged with the associated displaced vertex.
- Reconstructed jet yields are not corrected with the corresponding efficiency and purity yet.



Most jets with p_T < 15 GeV/c

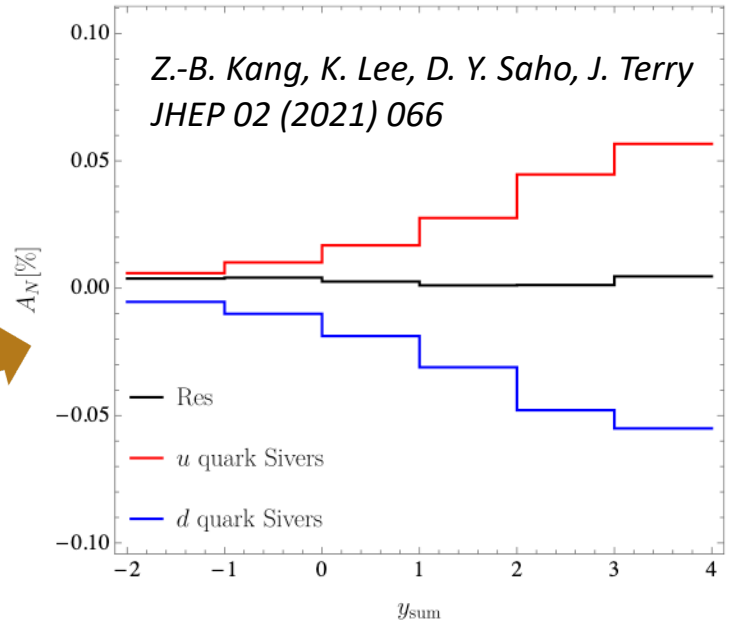
Access the gluon Sivers effect via HF A_N measurements

- Will study the transverse spin asymmetry (A_N) of charm hadrons and heavy flavor jets to extract the gluon Sivers effects. This is one of the key measurements to explore the nucleon 3D structure at the EIC.
- Interested observables: D-meson A_N, HF-jet A_N and HF di-jet A_N in SIDIS process at the EIC to test the universality of QCD description of the Transverse Single Spin Asymmetry (TSSA).



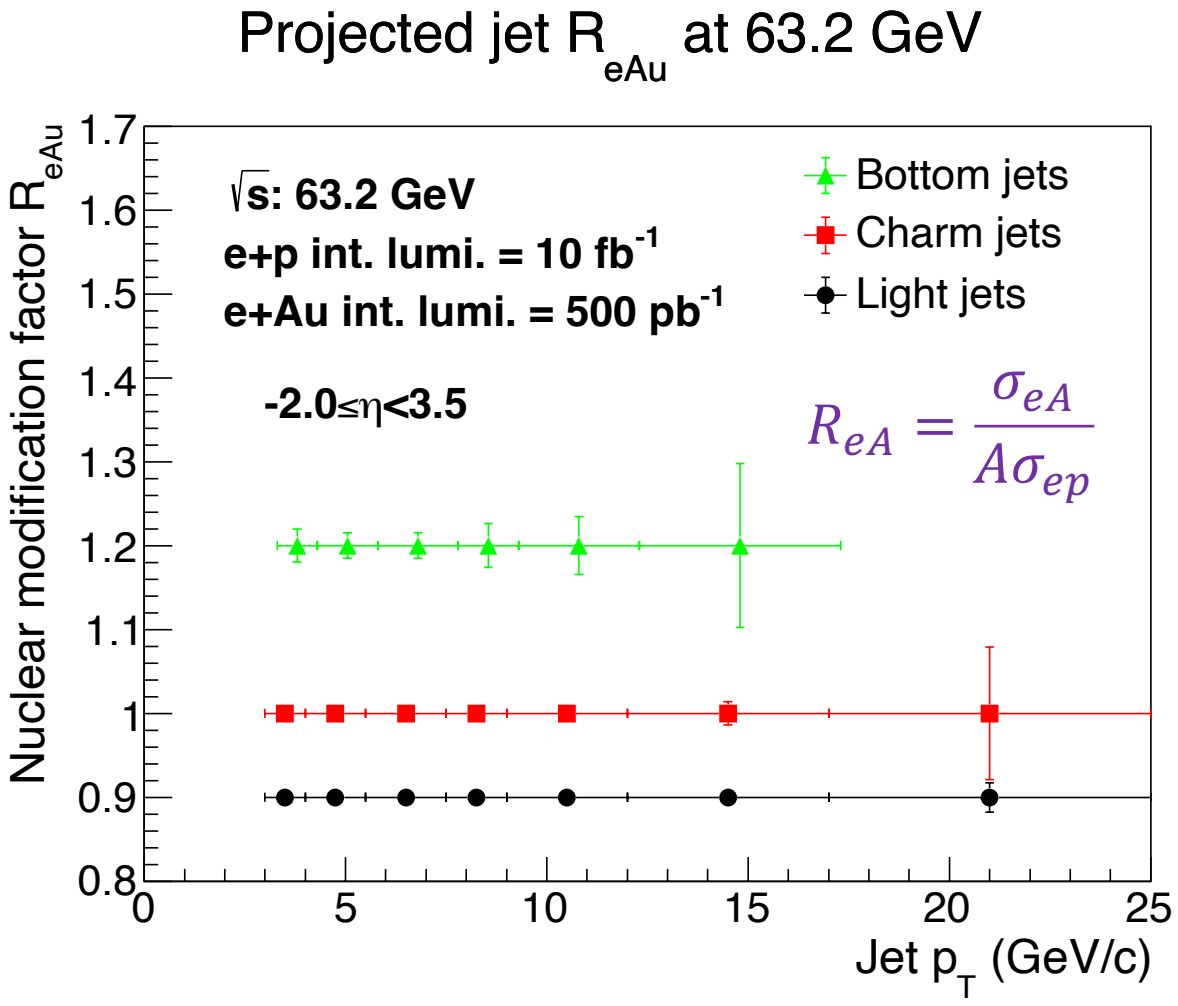
$$A_N \propto \bar{f}_{1T}^{\perp q}(x,k_\perp^2)\cdot D_q^h(z)$$

How about the HF di-jet A_N?
May need new theoretical calculations.



Constrain the parton E_{loss} with jet nuclear modification factor R_{eAu}

- Projected statistical uncertainties of R_{eAu} of light flavor jets (black), charm jets (red) and bottom jets (green) in 10 GeV electron and 100 GeV gold collisions.

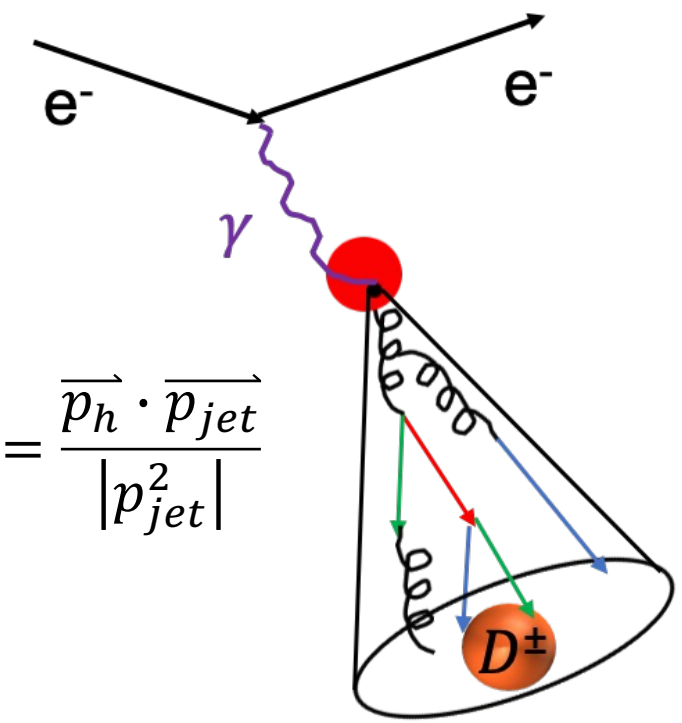


- EIC will provide unique opportunities to probe low p_T (p_T < 15 GeV/c) heavy flavor jets in cold nuclear medium with good precision to study the flavor dependent parton energy loss mechanism.
- Comparison between the EIC measurements and results achieved in heavy ion collisions (e.g. sPHENIX) can help extracting the parton transport coefficient in different nuclear media.

Hadron inside jet production to explore the hadronization process

- Hadron inside jet studies at the EIC can provide good sensitivity to directly extract the flavor dependent fragmentation functions.

$$e^- + \mathrm{p} \rightarrow e^- + jet(D^{\pm}) + X$$

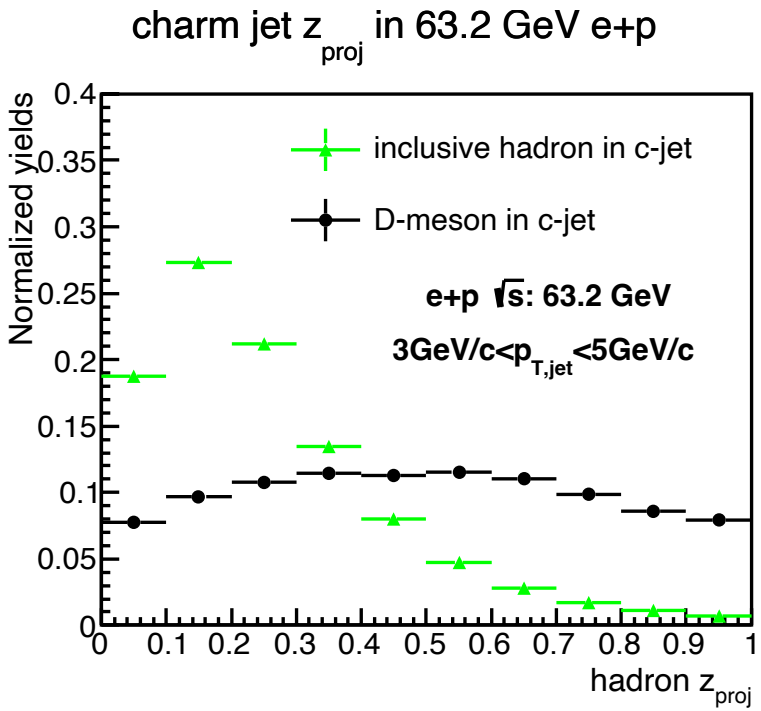


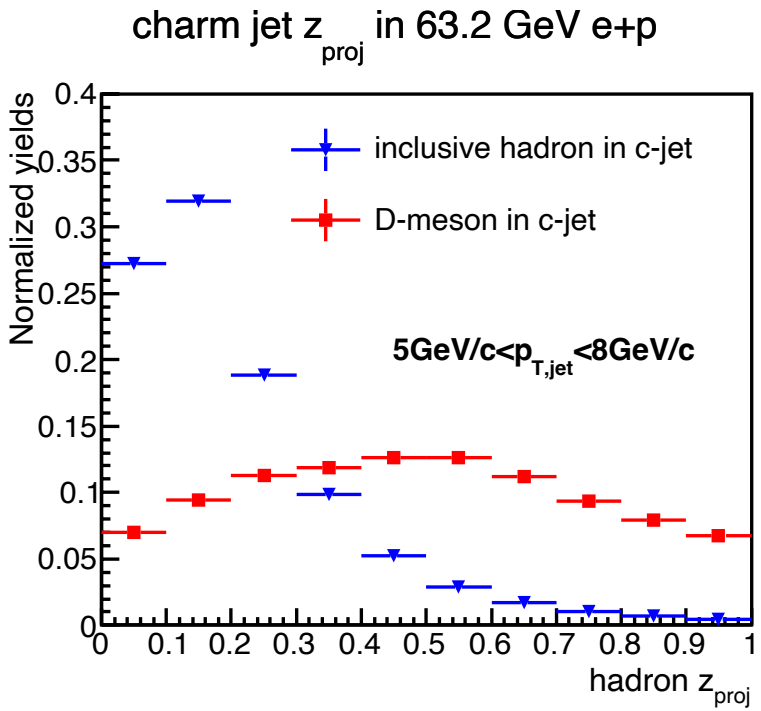
$$z_{proj} = \frac{\overrightarrow{p_h} \cdot \overrightarrow{p_{jet}}}{|p_{jet}^2|}$$

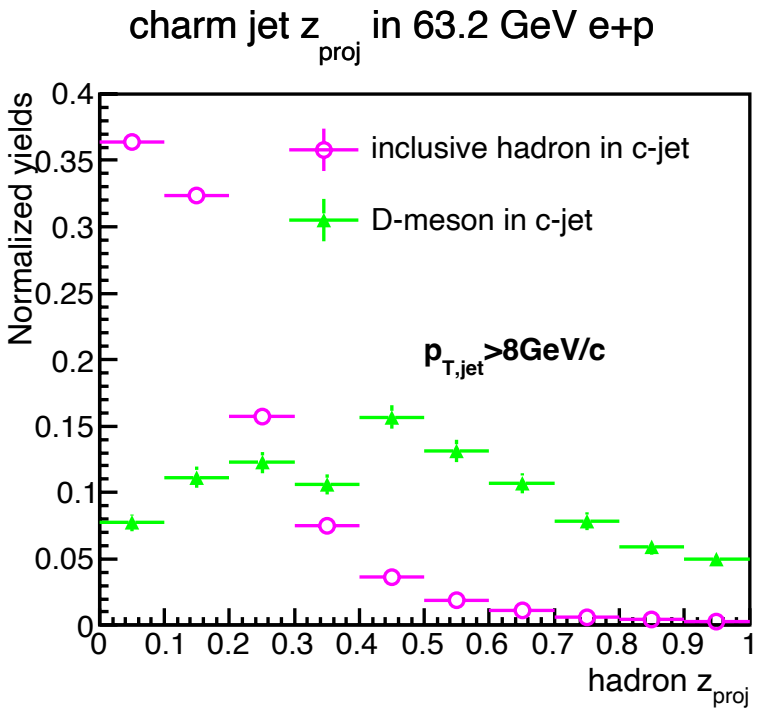
- Jet substructure observables can help extracting the jet kinematic properties and shed light on the interference between the quarks/gluons and the surrounding nuclear medium.
- We are leading the ongoing studies at the sPHENIX experiment.
- Will discuss the studies of hadron momentum fraction, z_{proj} for hadrons inside heavy flavor jets in e+p collisions and its nuclear modification factor projection in e+A collisions.

Kinematic dependent charm jet substructure in e+p collisions

- Hadron inside charm jet z_{proj} distributions with jet p_T in 3-5 GeV/c (left), 5-8 GeV/c (middle), > 8 GeV/c (right) in 10+100 GeV e+p simulation.



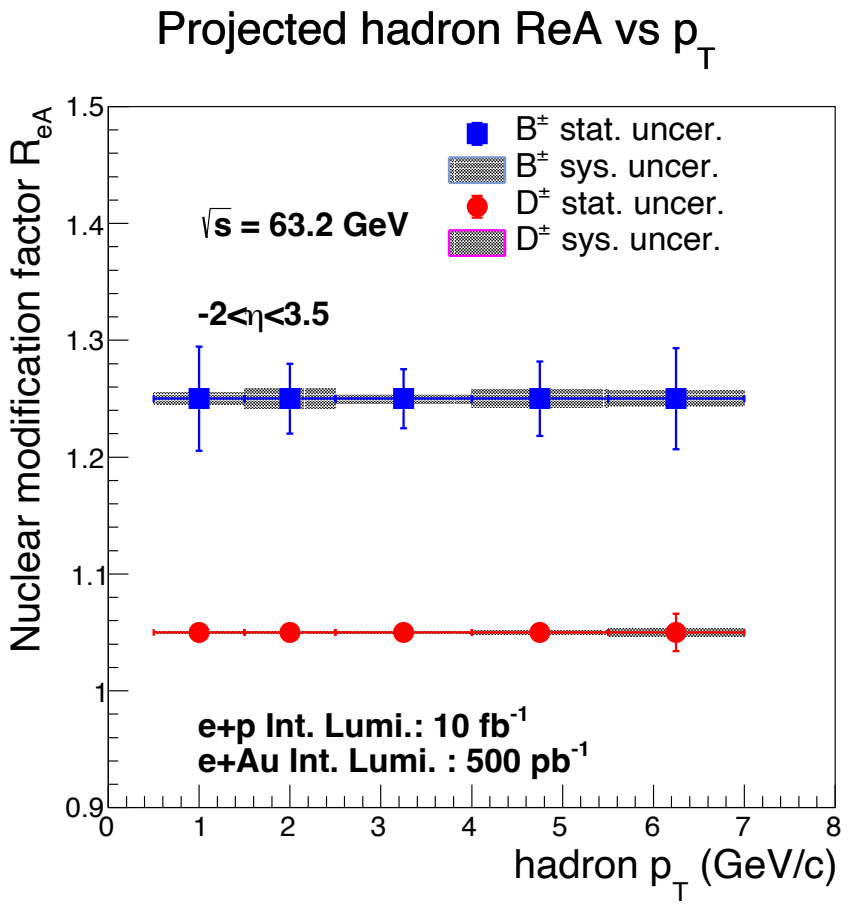


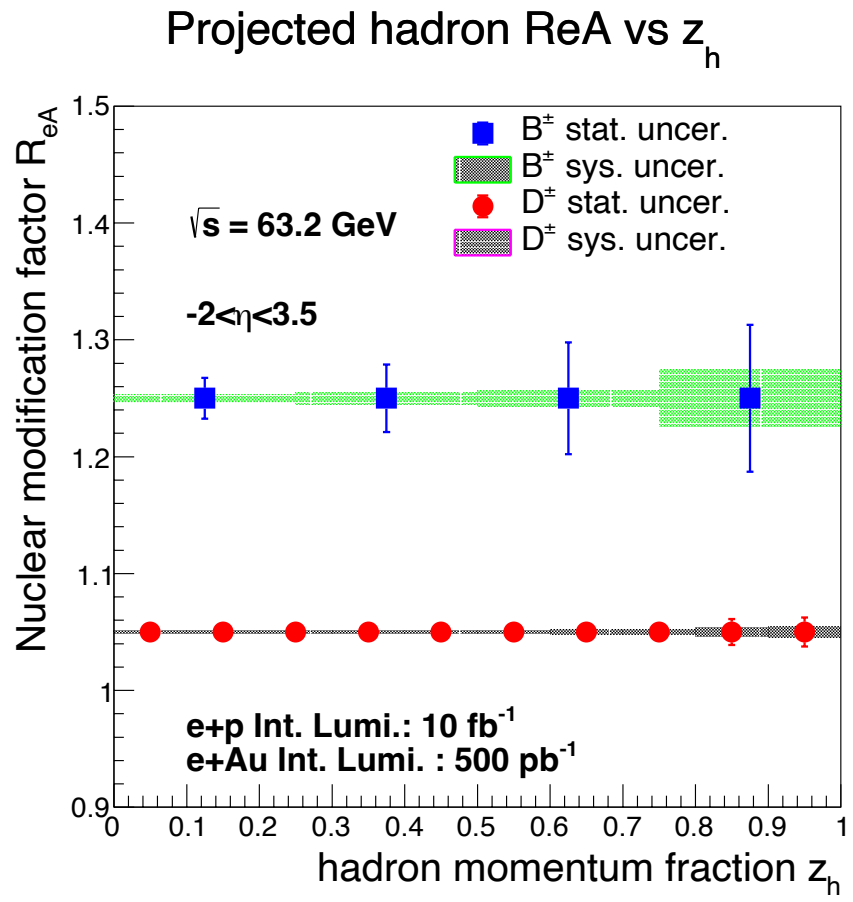


- The hadron inside charm jet z_{proj} distributions depend on the hadron flavor and jet p_T. Further studies in different e+A collisions will help exploring the flavor dependent hadronization process under different medium conditions.

Heavy flavor hadron nuclear modification factor R_{eAu} projection

- Projected R_{eAu} statistical (systematical) uncertainties of inclusive heavy flavor hadrons (left) and heavy flavor hadron inside jets (right) in 10 GeV electron and 100 GeV gold collisions.





Great precision in constraining the heavy quark hadronization process will be provided by the EIC even with one-year operation!

Plan

- We wish to get some supports through the eRD111 and eRD113 projects to continue the work on the ePIC SVT mechanical design with the EIC silicon consortium and related eRDs.
- We are also interested in the following detector subsystems for the ePIC upgrade and/or detector II:
  - Fast MAPS event activity monitoring detector.
  - Possible forward muon detectors for exclusive HF production.
- We will update the heavy flavor hadron and jet physics studies with the latest ePIC detector design and interested physics topics include:
  - Heavy flavor jet and heavy flavor hadron inside jet measurements in e+p/A collisions to explore the final-state hadronization process.
  - Constraining the gluon TMD with open charm and heavy flavor jet production.
  - HF exclusive process to study gluon GPD with high luminosity e+p/A collisions.
- We welcome UC students to visit us for EIC detector R&D and physics related work.