Heavy flavor jet energy-energy correlator feasibility studies in e+p simulation

Xuan Li (xuanli@lanl.gov)

Los Alamos National Laboratory

ePIC Collaboration meeting

Brookhaven National Laboratory, Upton, NY

January 20 – 23, 2026

Outline

- Motivation of jet energy-energy correlator studies at the EIC.
- Heavy flavor jet two-point Energy-Energy Correlator (EEC) studies in e+p simulation.
- Heavy flavor jet three-point EEC (E3C) studies in e+p simulation.
- Summary and Outlook.

Motivation to study jet substructure at the EIC (I)

- Jet substructure observables (e.g., the jet energy-energy correlator) are ideal probes to access the parton to hadron evolution in the perturbative (e.g., parton showering) and non-perturbative kinematic region (e.g., hadronization).

Schematics of jet EEC observable

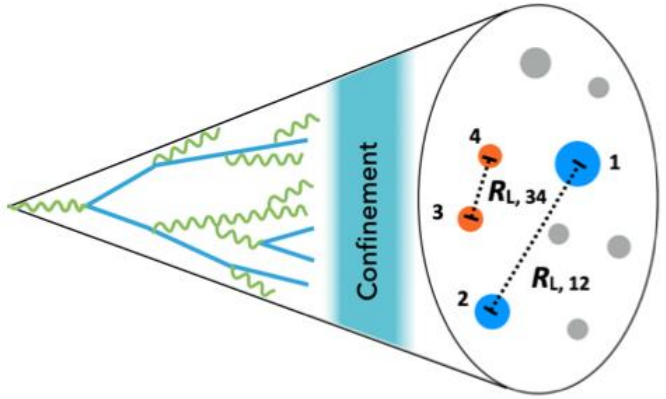


Figure from arXiv: 2409.12687

Motivation to study jet substructure at the EIC (II)

- Jet substructure observables (e.g., the jet energy-energy correlator) are ideal probes to access the parton to hadron evolution.

Schematics of jet EEC observable

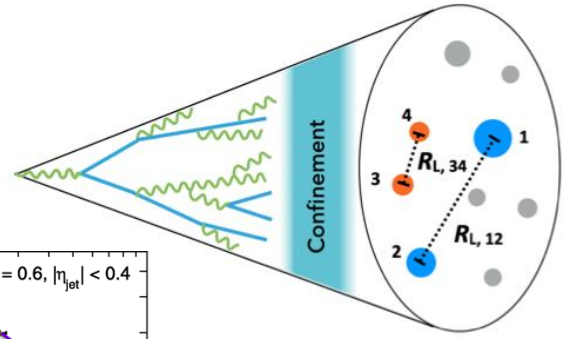
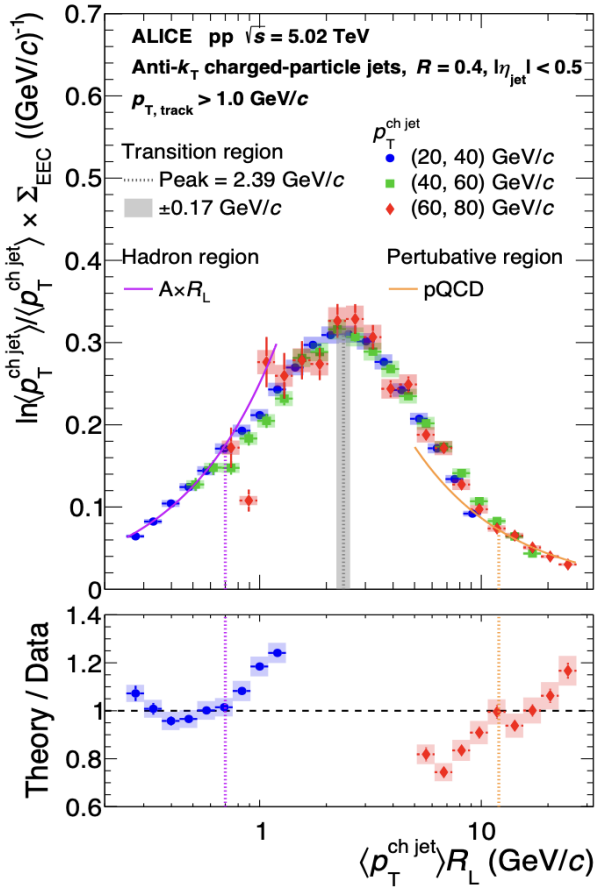
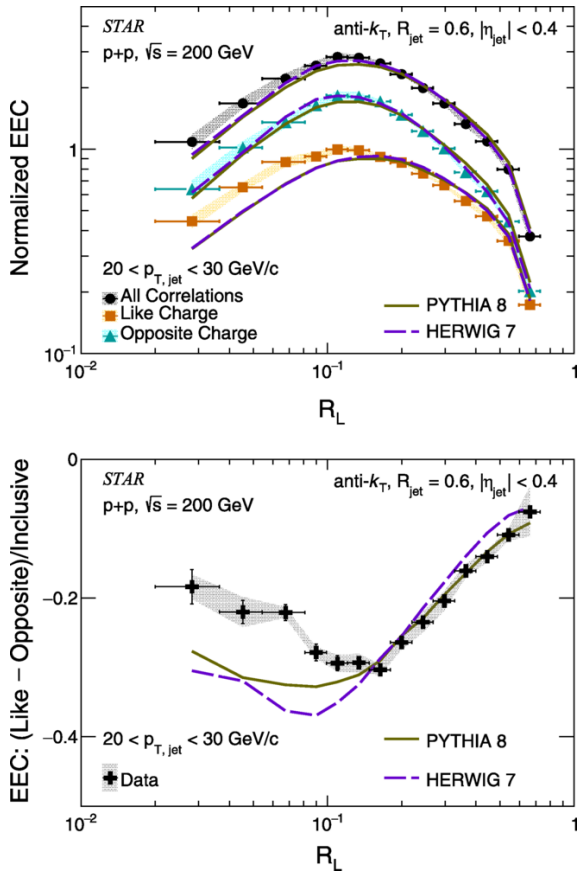


Figure from arXiv: 2409.12687

Common energy scale observed in the hadronization region by charged particle jet EEC measurements in 5.02 TeV p+p collisions by ALICE (arXiv: 2409.12687).





Deviation between jet EEC measurements in 200 GeV p+p collisions by STAR and MC models in the small R_L region indicates some of hadronization information is not included in current models (Phys. Rev. Lett. 135 (2025) 11, 111901).

Motivation to study jet substructure at the EIC (II)

- Jet substructure observables (e.g., the jet energy-energy correlator) are ideal probes to access the parton to hadron evolution.

Schematics of jet EEC observable

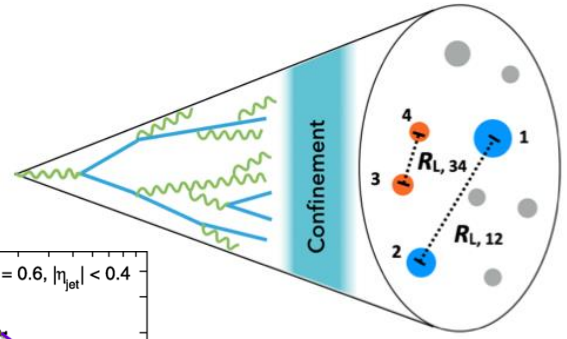
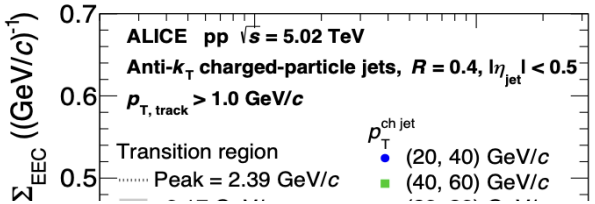
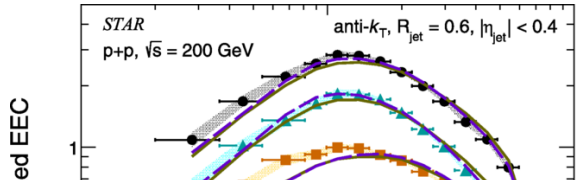


Figure from arXiv: 2409.12687

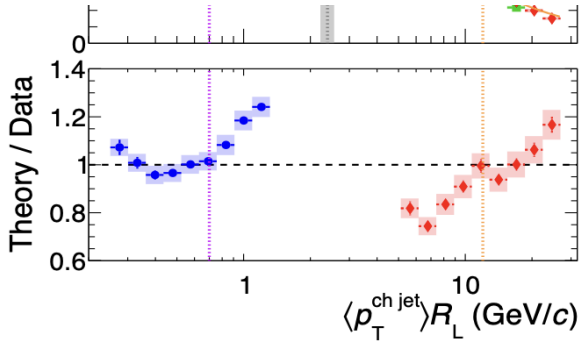


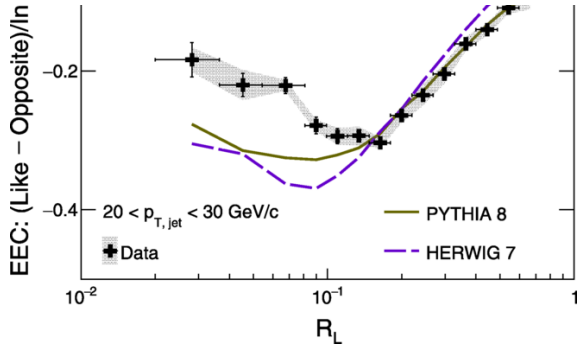


Common energy scale observed hadroniz charged measure TeV p+p ALICE (arXiv: 2409.12687).

- ***Worthwhile to check the jet EEC feasibility at the EIC, which can access initial- and final-state parton kinematics with great precision.***
- ***Heavy flavor jet is of particular interests, because the hadronization scale, and parton energy loss effects are different from light quarks.***

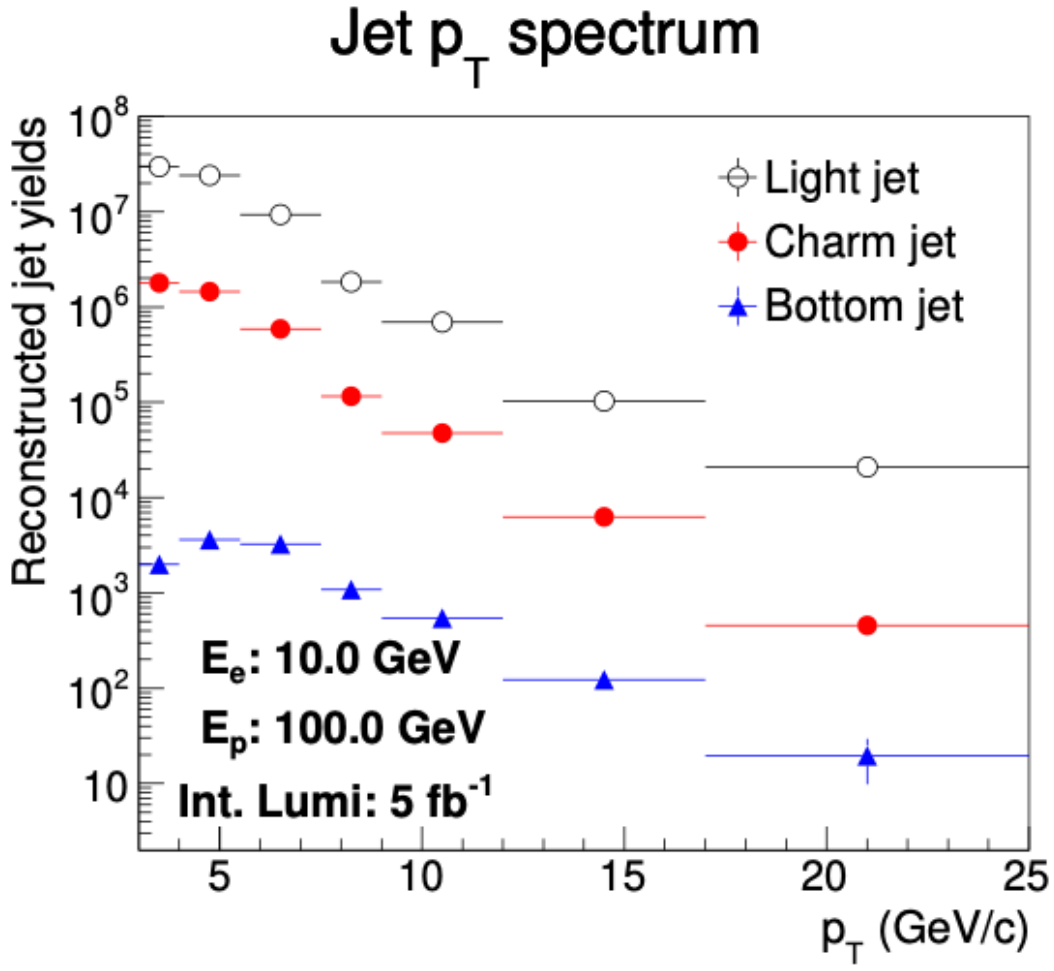
en jet EEC
n 200 GeV
STAR and
e small R_L
some of
formation
is not included in current models (Phys. Rev. Lett. 135 (2025) 11, 111901).





Reconstructed jet spectrum in e+p standalone simulation

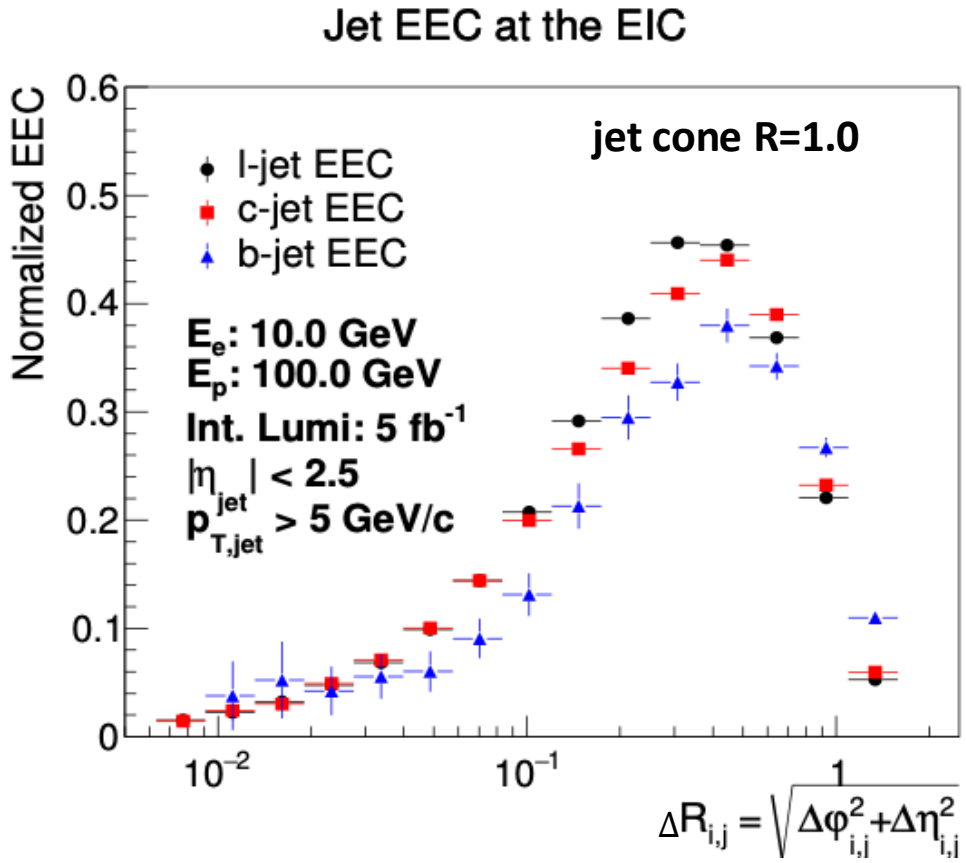
- The standalone simulation is based on event generation in PYTHIA8, and the reconstruction uses true PID information, smeared vertex, tracking and energy information following the ePIC detector parameterized response in early 2025.
- Jets are reconstructed with the anti-k_T algorithm, and jet cone radius is R=1.0. Both charged and neutral particles are used for the jet reconstruction. The jet flavor is tagged according to the displaced vertex found inside the jet.
- Start with the 10 GeV and 100 GeV e+p simulation to setup the benchmark.



- Track $p_T > 0.2$ GeV/c, Track $|\eta| < 3.5$
- No. of constituents inside jet > 3
- Jet $p_T > 3$ GeV/c

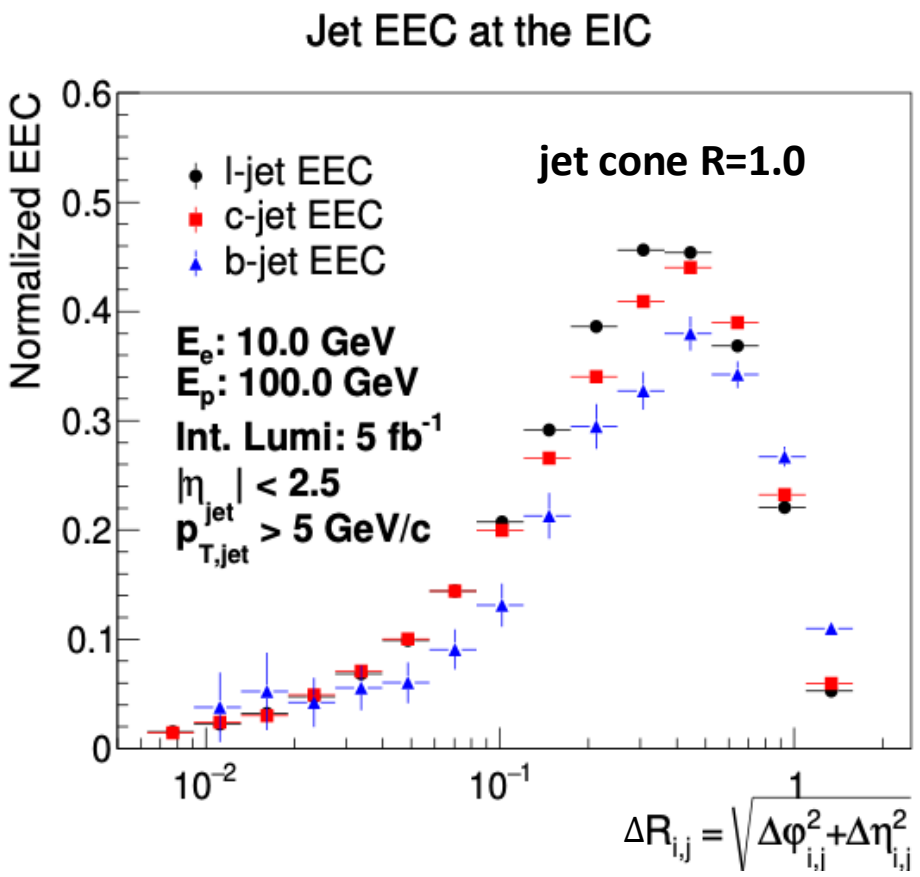
Jet Energy-Energy Correlator studies at the EIC (I)

- Jet two-point energy-energy correlator (EEC) studies at the EIC :
  - In 63.2 GeV e+p simulation, the normalized jet energy-energy correlator $(\frac{1}{N_{jet}}\frac{dEEC_{ij}}{\sum EEC_{ij}dR_{ij}})$ of charged particles inside jets versus the ΔR_{ij}, where $EEC_{ij} = \frac{p_{T,i}p_{T,j}}{(p_{T,jet})^2}$.

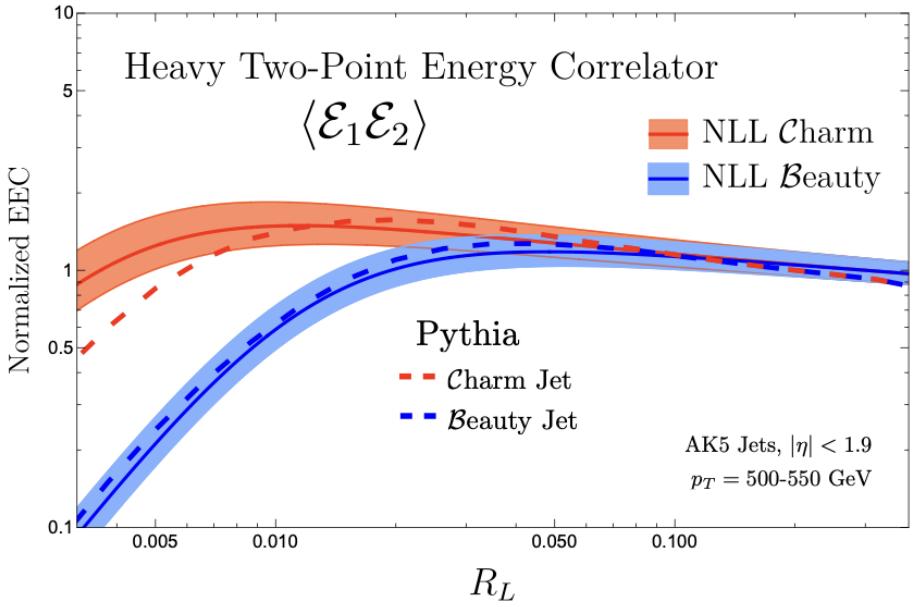


- The peak position of the normalized two-point EEC distributions moves towards a large average $\Delta R_{i,j}$ as the jet flavor changes from light flavor to heavy flavor (charm and bottom).

Jet Energy-Energy Correlator studies at the EIC (I)



arXiv: 2210.09311
High p_T jet samples (p_T > 500 GeV/c)
in p+p collisions

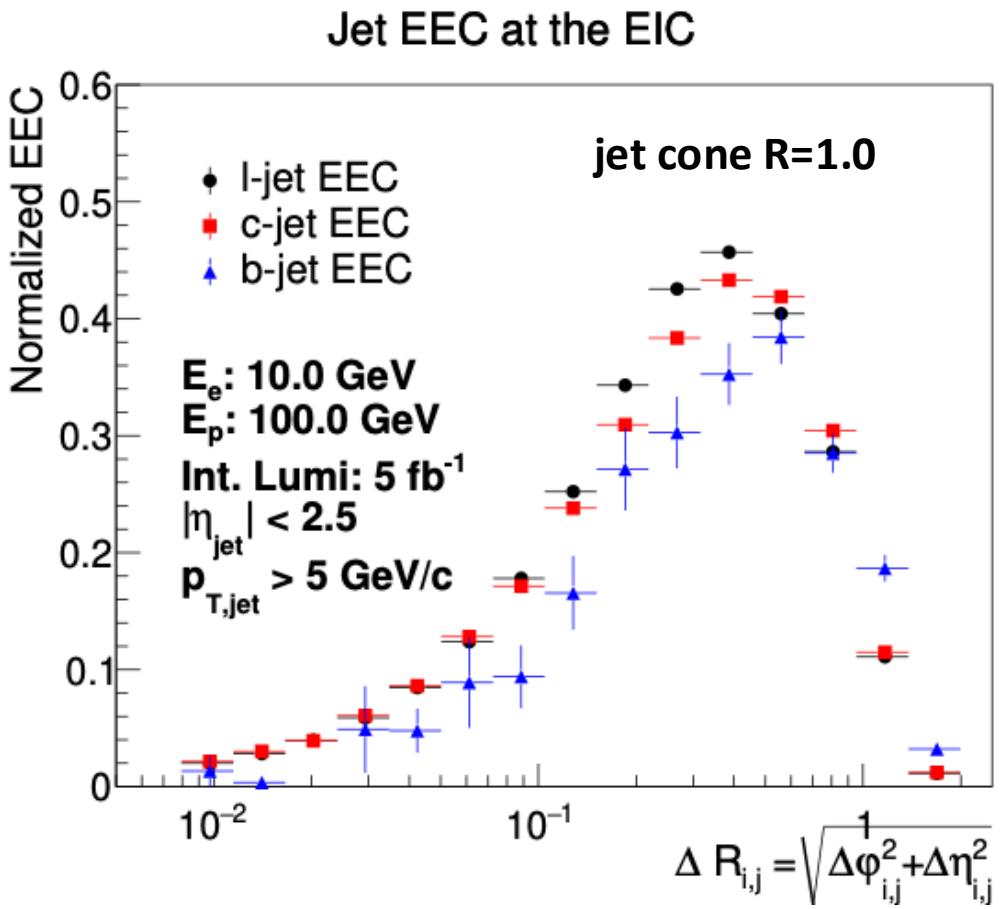


- Similar flavor dependence has been predicted by theorists for high p_T jet EEC measurements in p+p collisions.

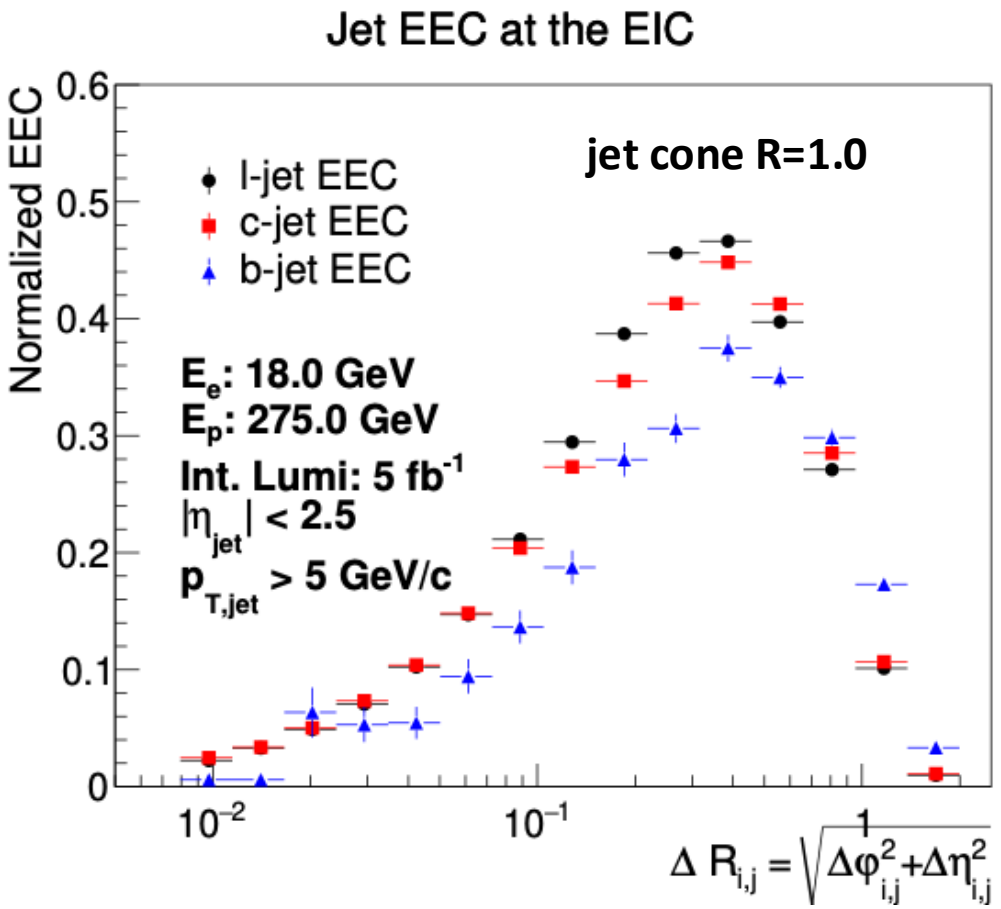
Jet two point Energy-Energy Correlator studies at different $\sqrt{s}$

- No significant collision energy dependence ($\sqrt{s} = 63.2\ GeV \rightarrow 141\ GeV$) has been observed.

63.2 GeV e+p simulation



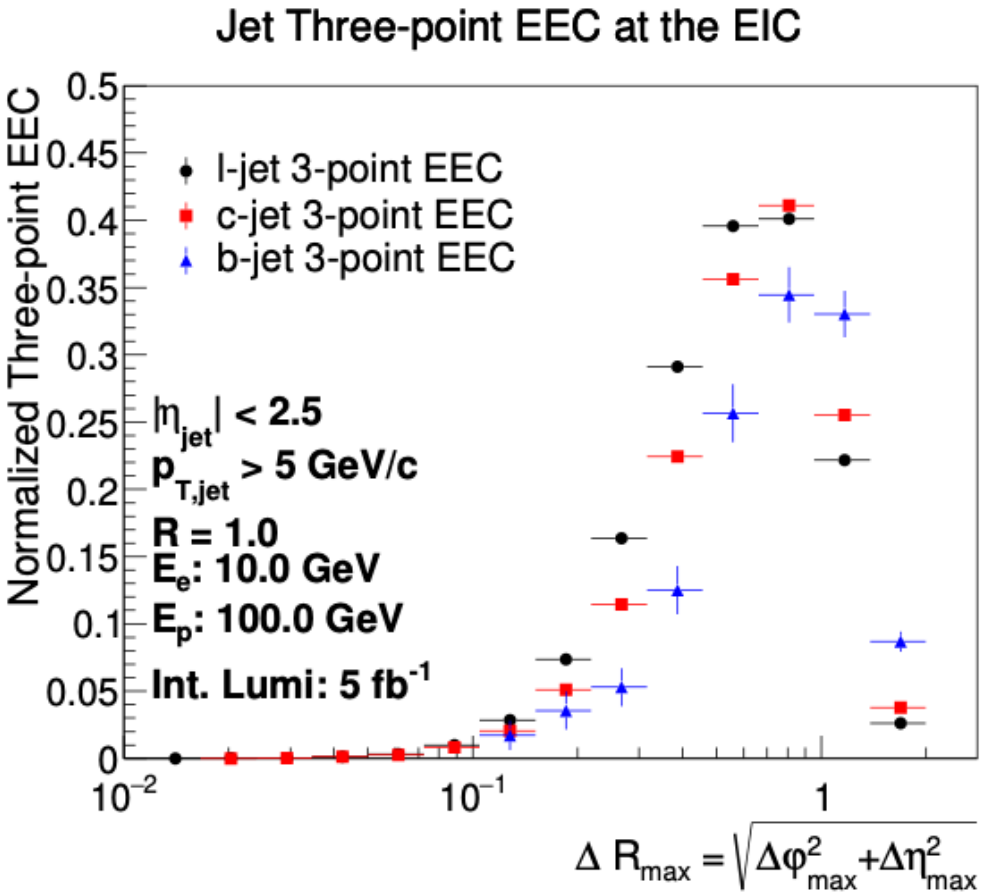
141 GeV e+p simulation



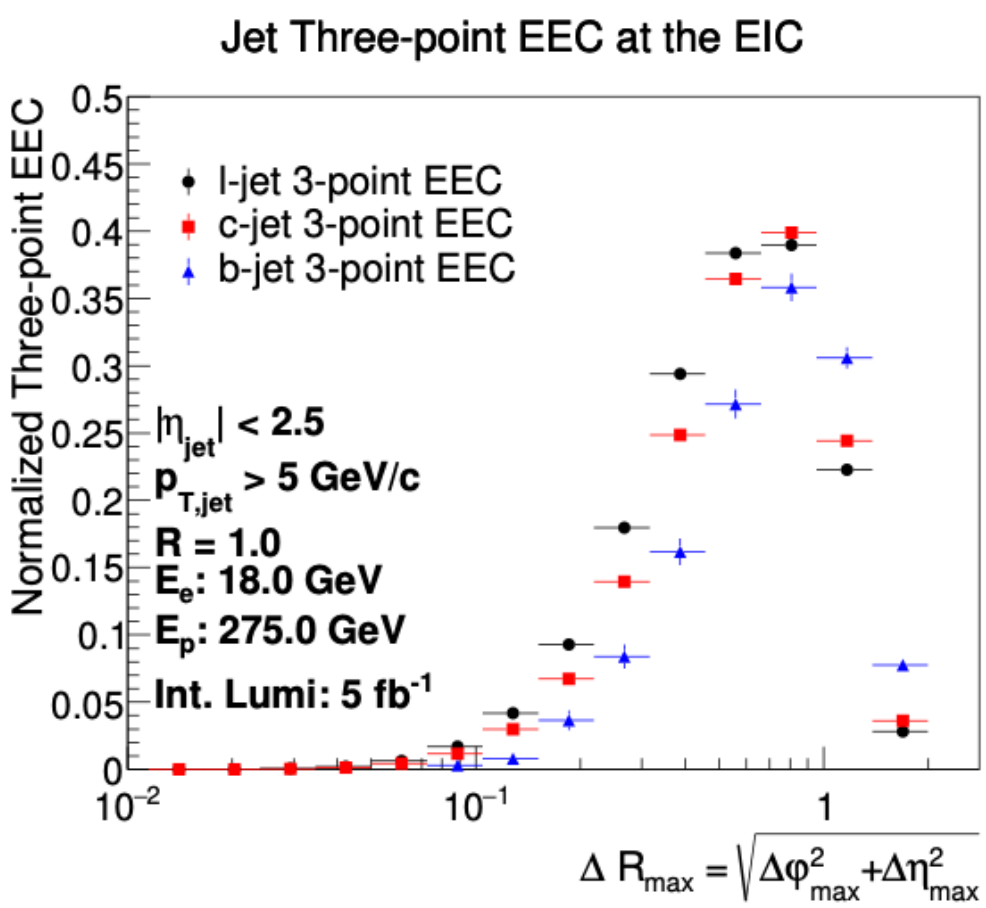
Jet three-point Energy-Energy Correlator studies at different $\sqrt{s}$

- No significant collision energy dependence ($\sqrt{s} = 63.2\ GeV \rightarrow 141\ GeV$) has been observed.

63.2 GeV e+p simulation



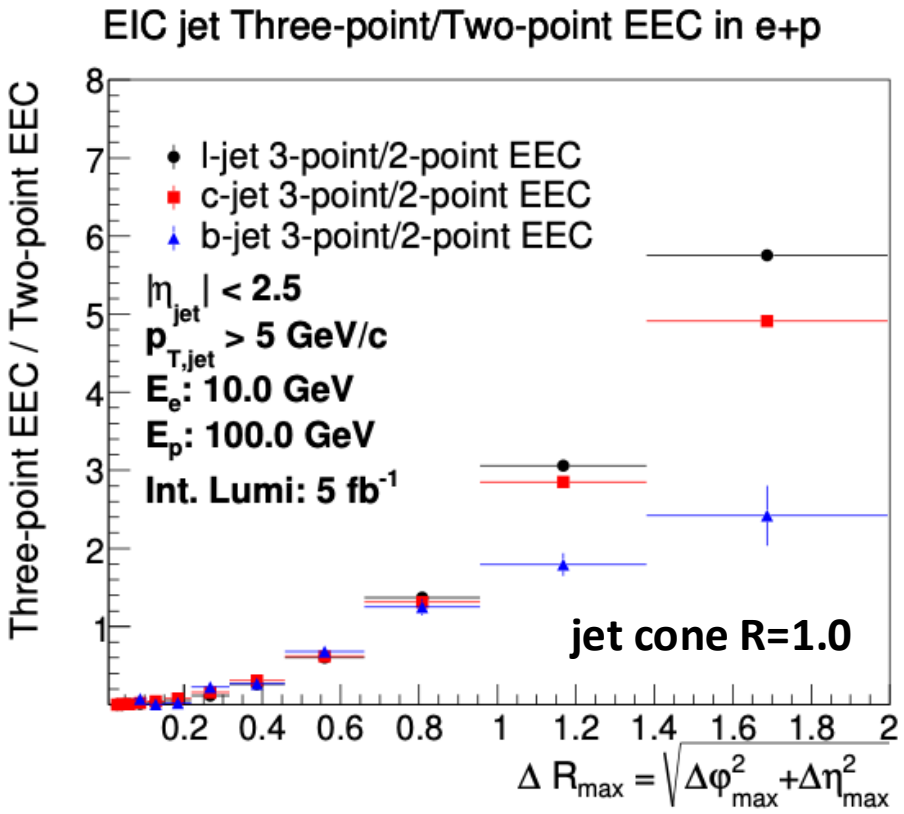
141 GeV e+p simulation



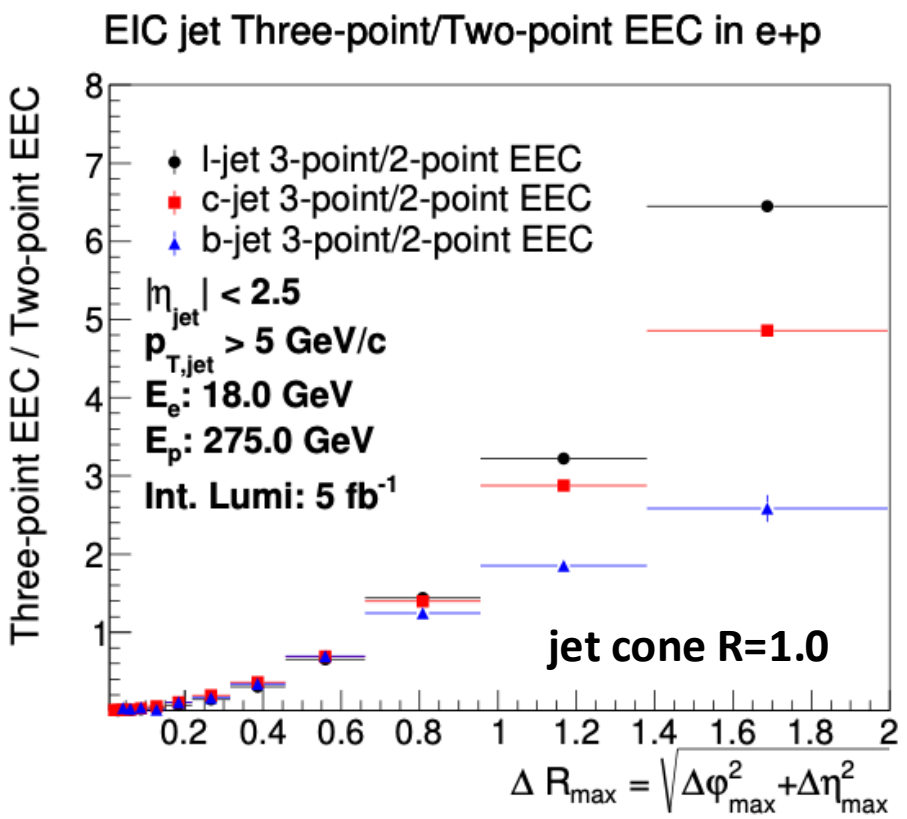
Jet Energy-Energy Correlator studies at the EIC (III)

- Ratios of three-point jet EEC over two-point jet EEC in both 63.2 GeV and 141 GeV e+p collisions are consistent with the flavor dependent energy loss mechanism.
- Slightly larger separation between different jet flavors at higher collision energy.

63.2 GeV e+p simulation



141 GeV e+p simulation



Summary and Outlook

- Initial studies of the heavy flavor jet two-point and three-point EEC in standalone simulation sample look promising. The jet E3C/EEC ratio in e+p simulation is consistent with the flavor dependent partion energy loss.
- Will check the jet p_T dependence of the jet EEC and E3C studies and plan to extend from inclusive charged particle observables to like-sign and unlike-sign pairs.
- Interested to evaluate the feasibility in e+A simulation as well.
- Require jet constituent kinematic variables and secondary vertex (or reconstructed HF hadron and jet association) kinematic variables in ePIC simulation samples for these studies. Open to inputs and suggestions about further developments.