Hadronization at the Electron Ion Collider

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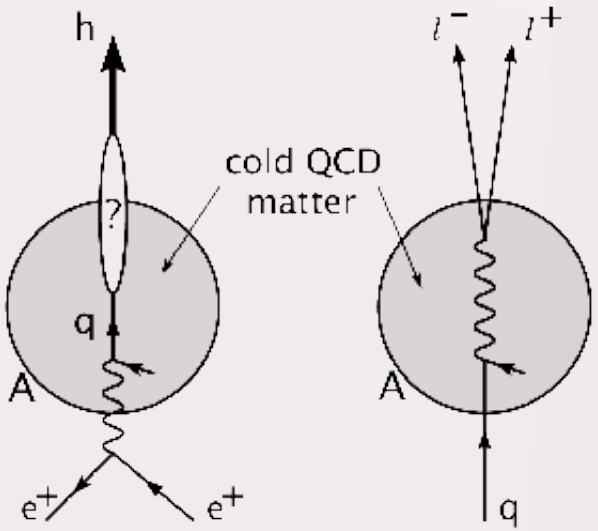
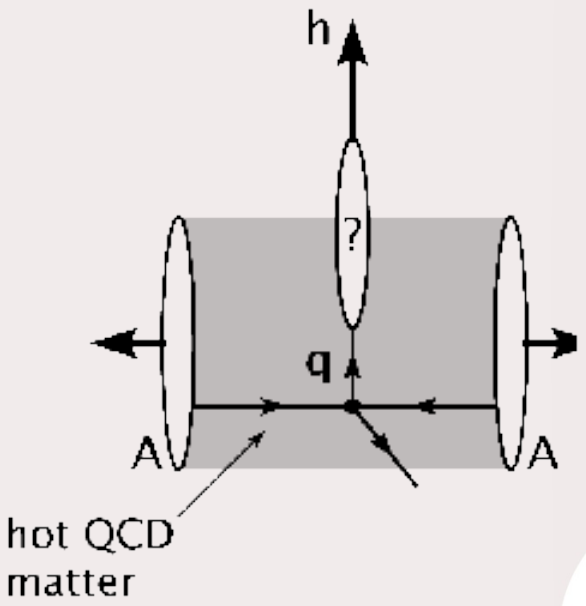
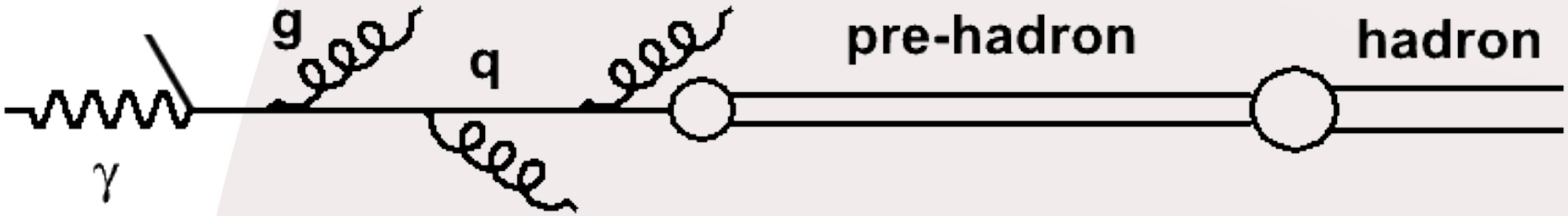
Motivations

- **Understand the hadronization process**
  - Measuring the characteristic times
  - Measuring parton energy loss in QCD medium
  - Understanding the pre-hadron structure
- **Characterization of the QCD medium**
  - Using parton energy loss (q hat)
    - BDMPS & Kopeliovich et al.
  - Characterize both cold and hot nuclear matter
  - Understand QCD evolution in medium
- **Reduce systematic effects on measurements where attenuation needs to be corrected**
  - Lepton scattering is a unique process for its control over the initial state
  - Neutrino experiments
  - Nucleon structure in nuclei





Theoretical Models

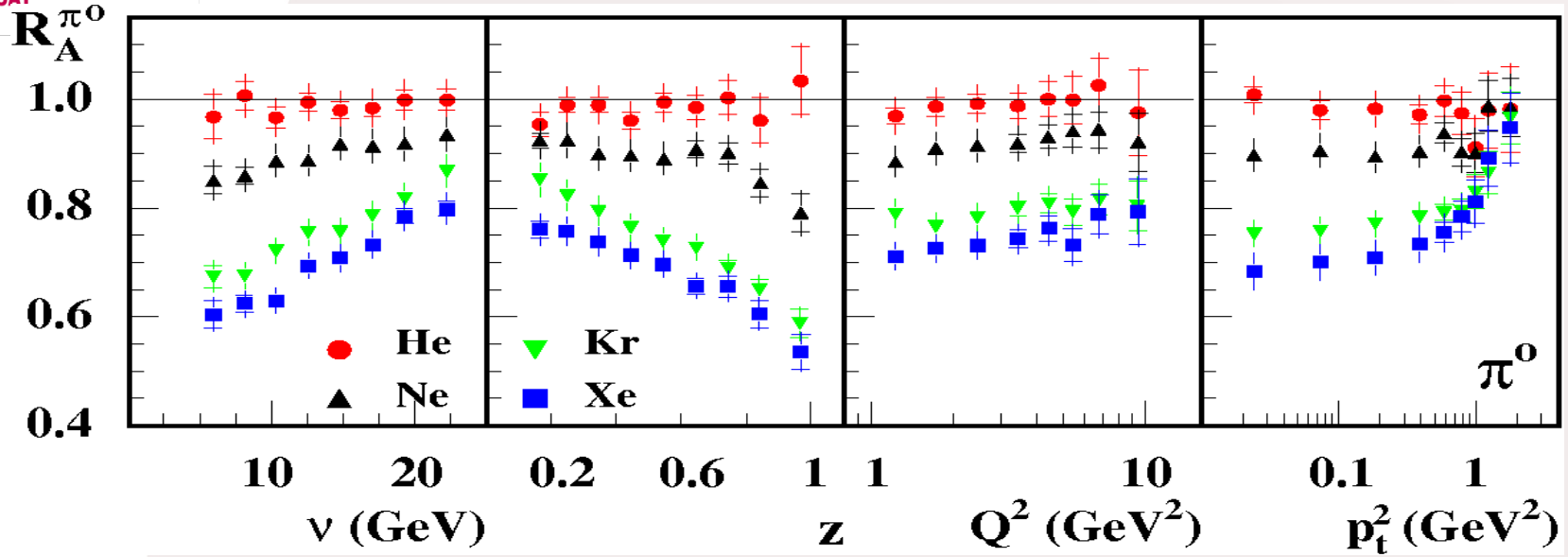


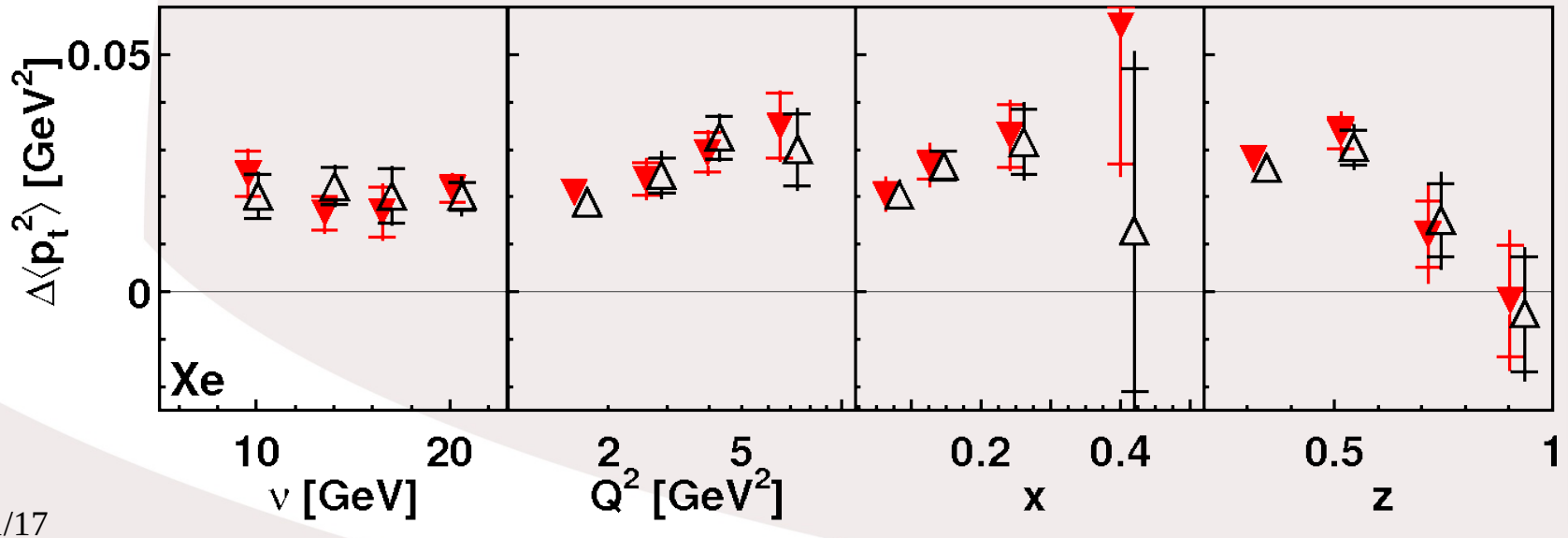
- **Important modeling questions are**
  - Absorption mainly due to parton energy loss or hadron absorption?
  - Is there a modification of the evolution in medium?
  - If yes, is it sizable in cold nuclear matter or only seen in hot nuclear matter?

- **Many models exist with different hypothesis**
  - Some pure models (either parton energy loss or hadron absorption)
  - Mixed models (with all possible combinations represented in the literature)

- **At EIC only parton energy loss will be relevant**

The HERMES data



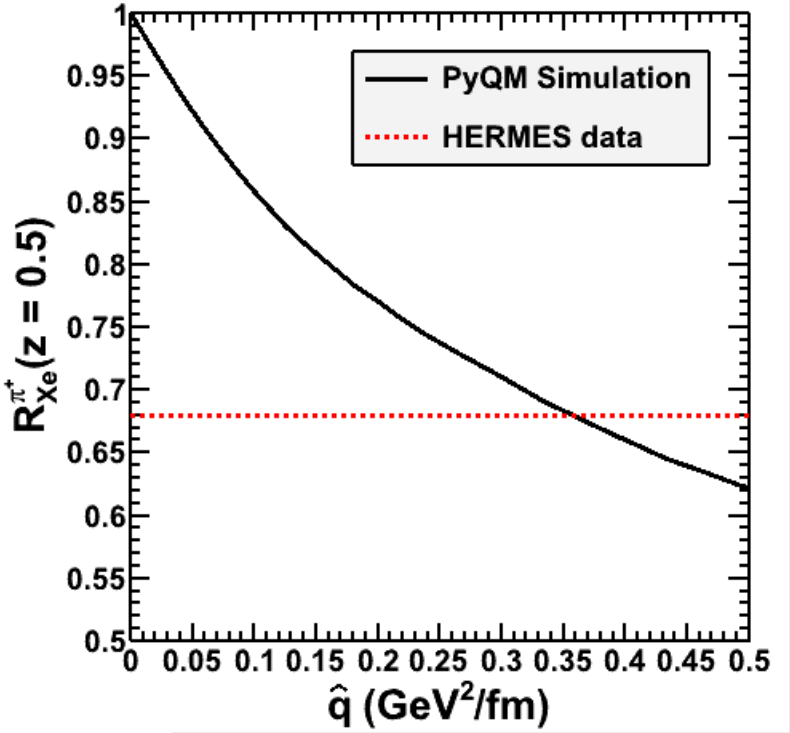


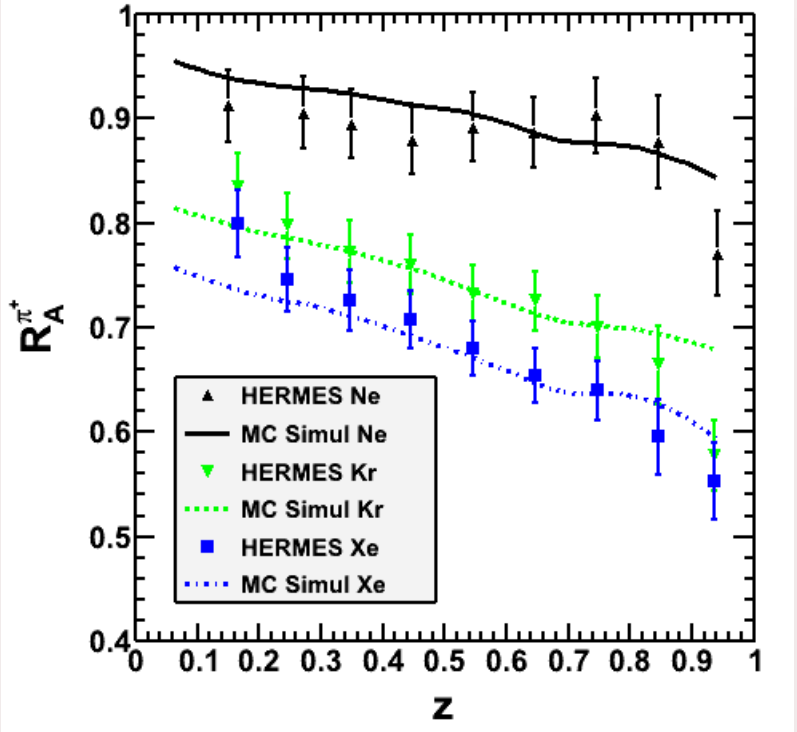
Energy Loss MC Simulation

- **Nuclear Fermi-motion of the nucleons**
- **PYTHIA Monte-Carlo**
  - Simulation of the electron-nucleon scattering
- **Parton Energy Loss**
  - Based on Salgado&Wiedmann calculation
  - Simulating nuclear material using realistic density profile
  - Assuming fragmentation will occur outside the nuclei
- **Back to PYTHIA**
  - Fragmentation of the partons
- **Basic acceptance cuts**
  - Allows more precise comparison with data

Work done with Alberto Accardi

Attenuation for HERMES

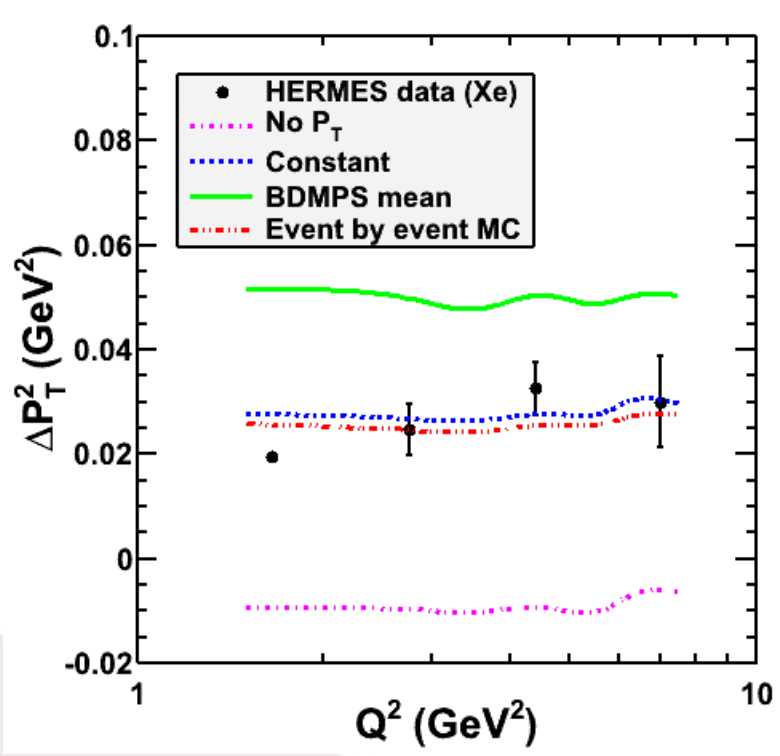


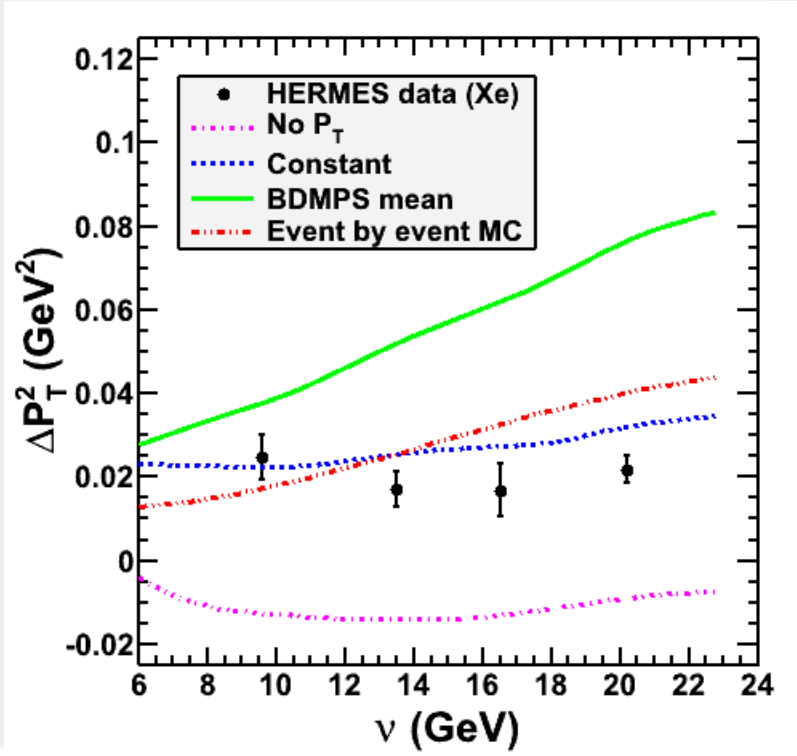


- **Good description with qhat = 0.36 GeV²/fm**
  - Single parameter model
  - Directly comparable to heavy ion collisions
- **Not consistent with observed transverse momentum?**
  - Of the order of 0.03 GeV²

Transverse Momentum

- **How do we got from Lx0.36 to a transverse momentum of ~0.03 ?**
  - Reduction by z square (~0.1)
  - Reduction due to lower parton energy
  - Reduction due to absorption
- **It matches data for all kinetic variables**





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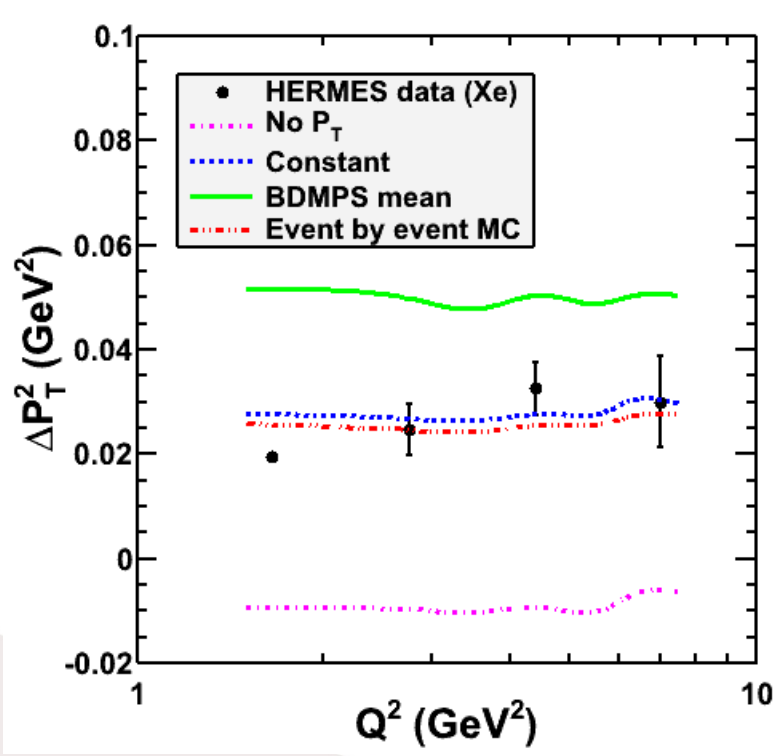
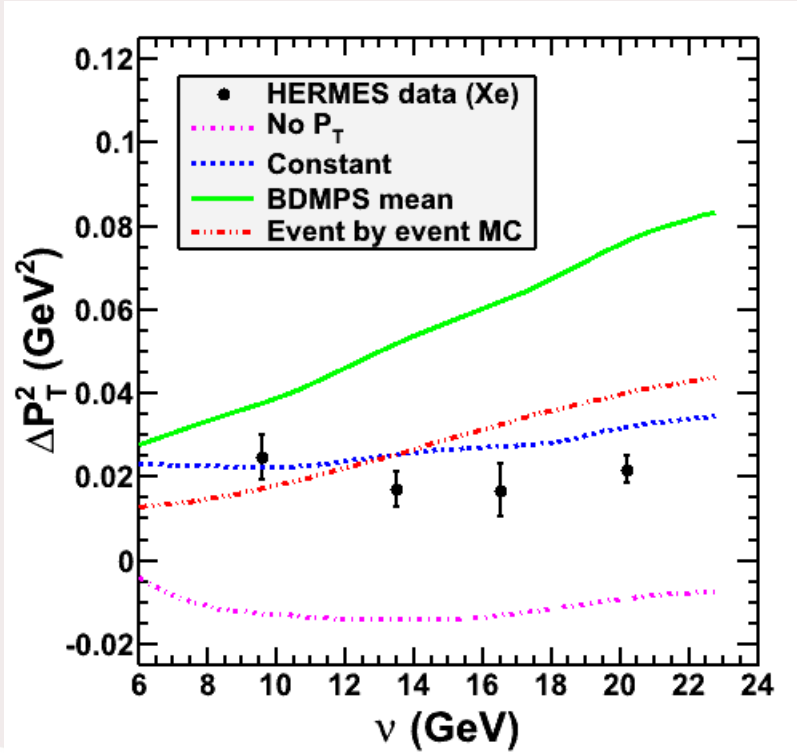
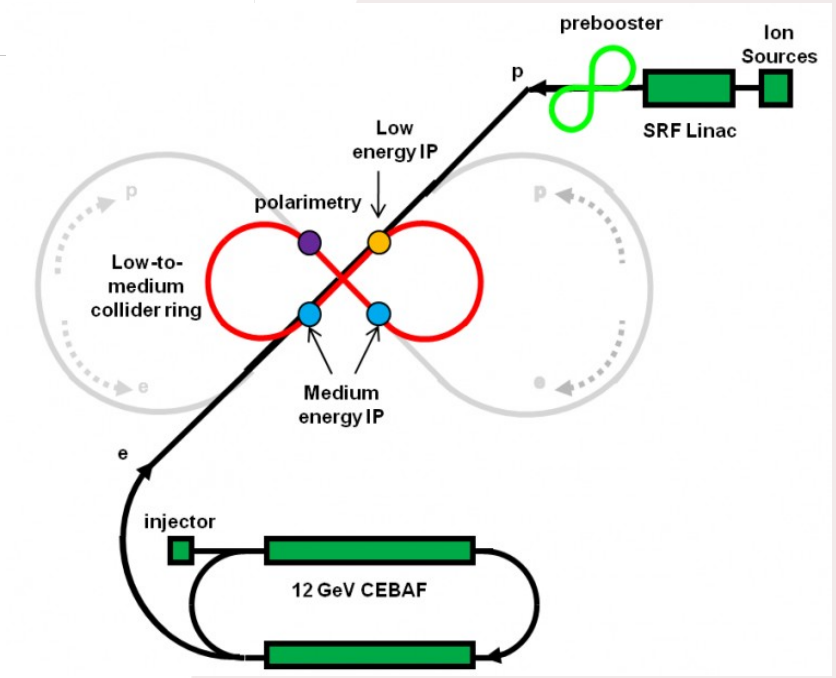
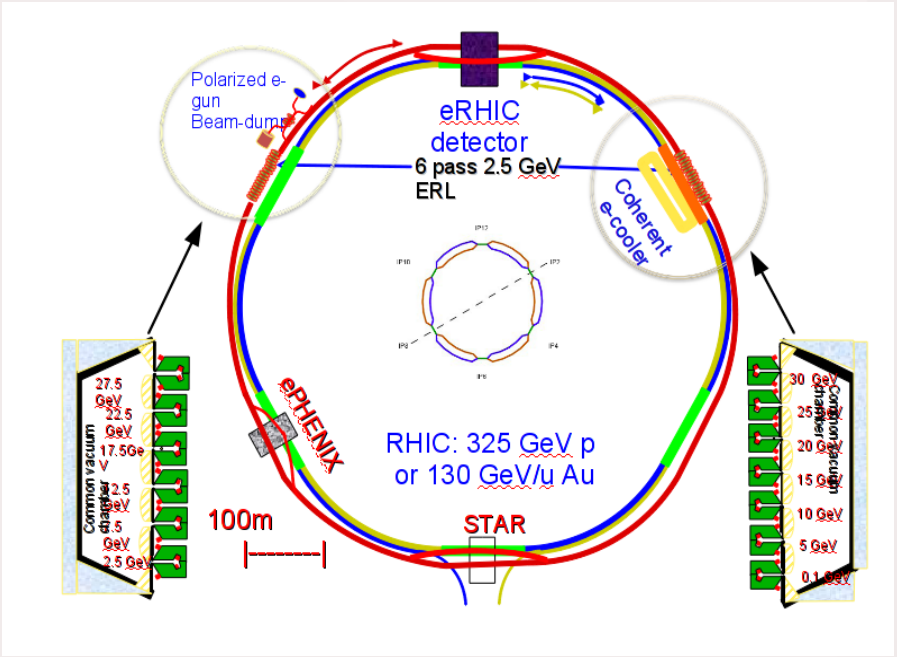




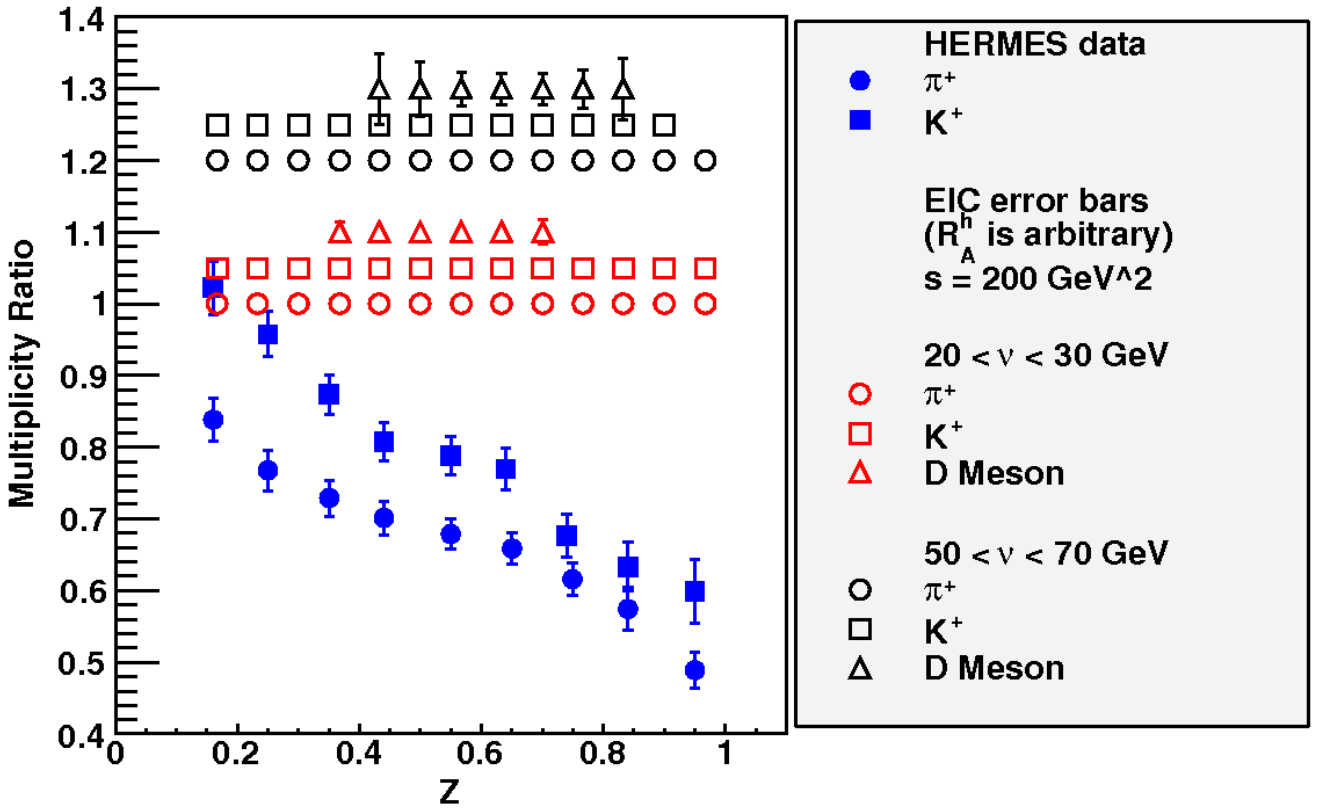
The Electron Ion Collider





- **Project of electron ion collider (EIC)**
  - **JLab and RHIC projects s~1000GeV^2 and more**
  - **Low to no attenuation region → centered on ΔP_T^2 measurement**
  - **Isolate energy loss effects and eventually modification of FF**
  - **Access to heavy flavor comparable to Heavy Ion Collisions**

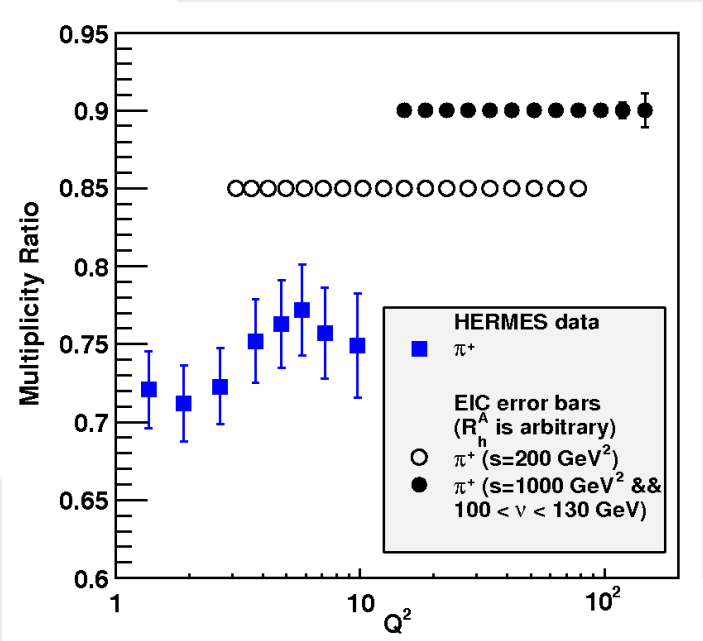
Heavy Flavors

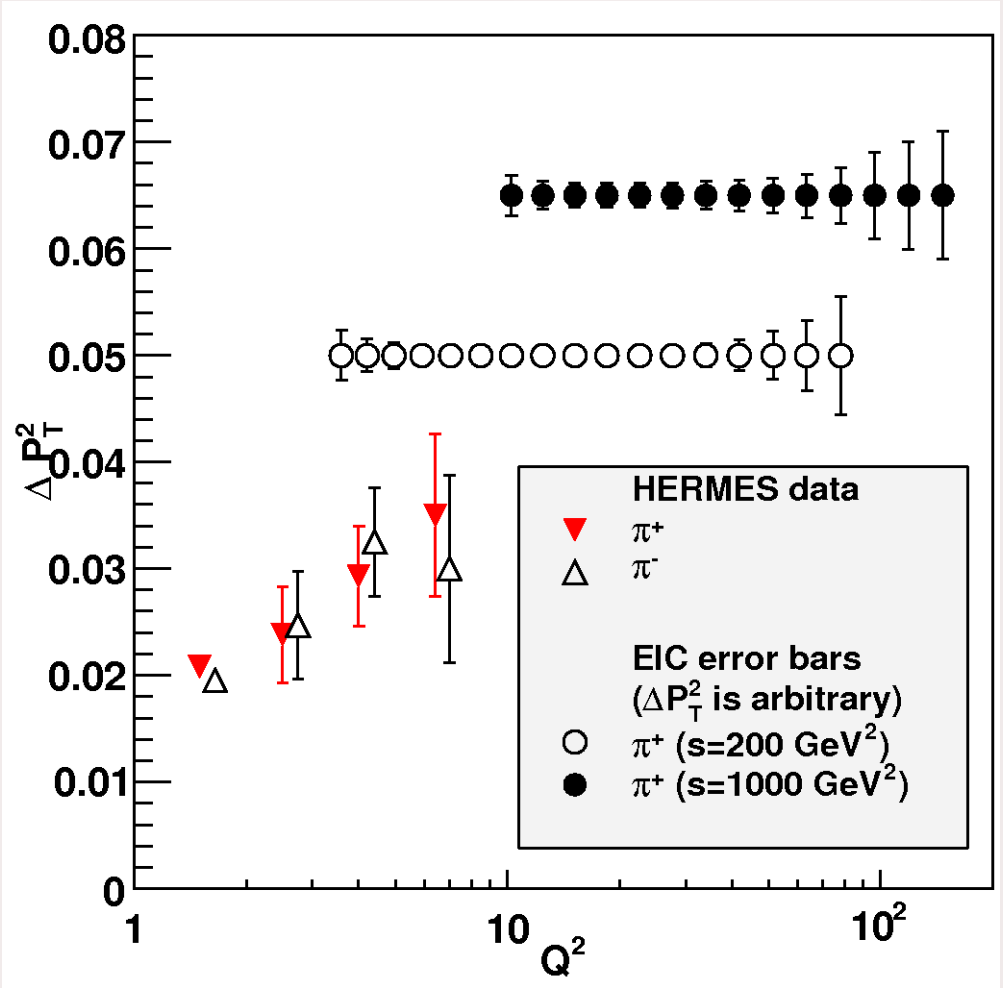


- **Will give a new insight into the measurements of RHIC and LHC**
  - Results of both pA and AA and their interpretation
- **The lepton scattering offers much stronger constraints**
  - On production mechanism and the initial kinematic of the heavy quark

Q^2 evolution

- The Q^2 dependence permit to measure any modification of the DGLAP evolution in medium
- The Q^2 variation is a very important tool to constrain energy loss calculations.





Flavor scaling of ΔP_T^2

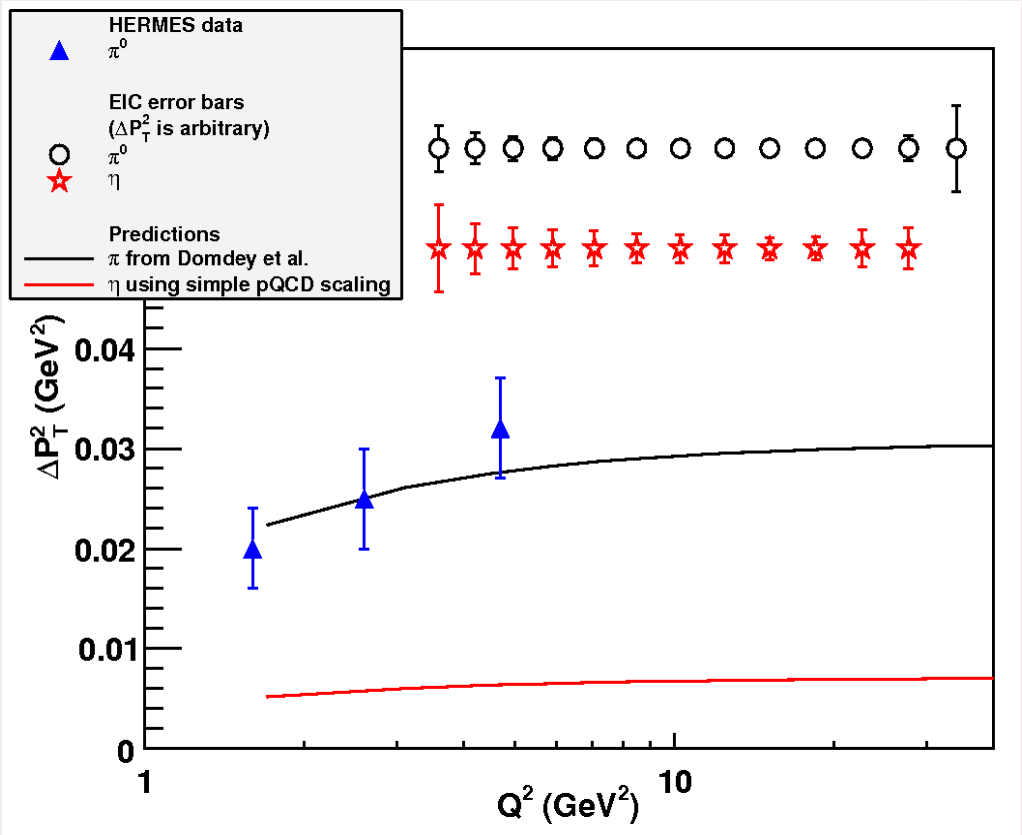
- **Simple scaling of pQCD in-medium energy loss between quark flavors**
  - Can test pQCD prediction

    S. Domdey et al. Nucl.Phys. A825 (2009) 200-211
  - Independent measurement of the saturation scale

    BDMPS, Nucl.Phys. B484 (1997) 265-282

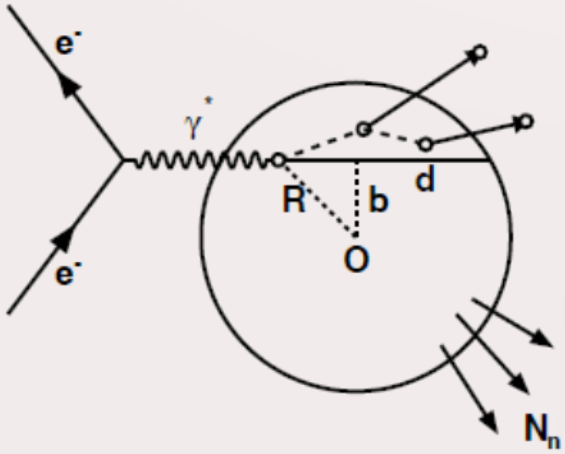
    B. Kopeliovich et al. Phys.Rev. C81 (2010) 035204

- **Can be easily measured at any EIC energy**
  - Absorption and energy loss have negligible effects



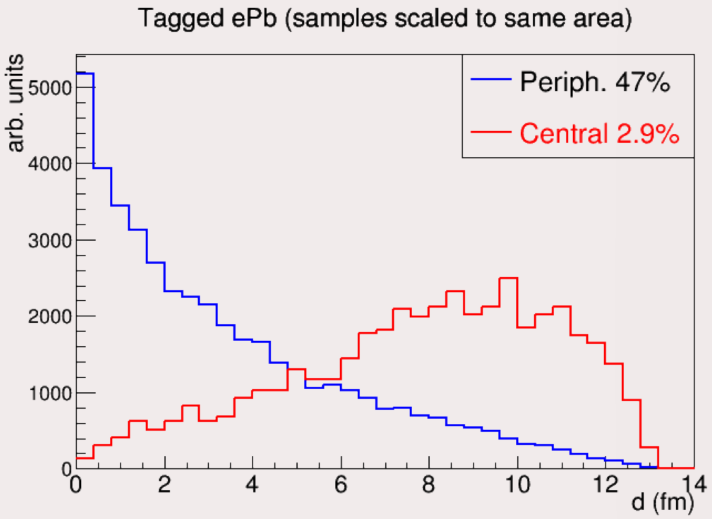
Geometrical Tagging

- **Measure the impact parameter**
  - To concentrate the nuclear effects
  - Heavy Ion Collision classic tool known to be problematic for pA
  - Is it possible using zero degree detection ?



- **LDRD project in JLab explores the question**

  Geometry tagging for heavy ions at JLEIC, V. Morozov et al.
  - Improving event generators (Beagle/SARTRE) with appropriate physics
    - In particular implementing the target fragmentation part of the previously presented model
  - Accelerator/detector studies for detection



- **Many motivations of this work are beyond hadronization**
  - Can study any nuclear effect with impact parameter
  - Can be used to isolate coherent effects

Summary

- **Hadronization in cold nuclear matter can be studied at all energies**
  - Our energy loss model can describe the attenuation with qhat~0.36 GeV2/fm
  - Transverse momentum naturally goes down to reasonable value when taking attenuation and e-loss effects into account

- **The EIC offers an ideal phase space for such studies**
  - It will isolate energy loss very well

- **Opens possibilities with heavy quarks and larger Q^2 to test pQCD applicability**
  - Compare heavy flavor behavior with pA and AA
  - Check when pQCD starts to be fully applicable

- **Offers an independent measurement of the saturation scale**