Hadronization in the Pure Energy Loss Framework

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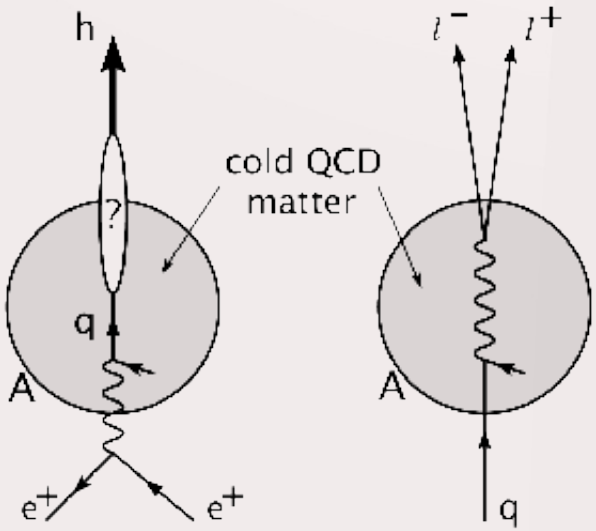
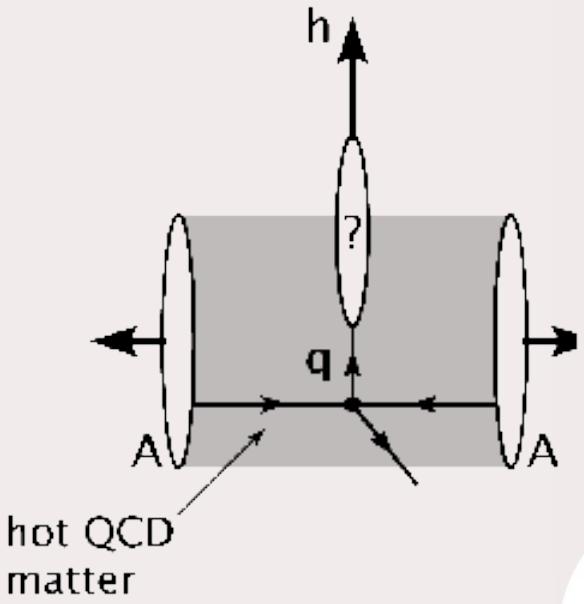
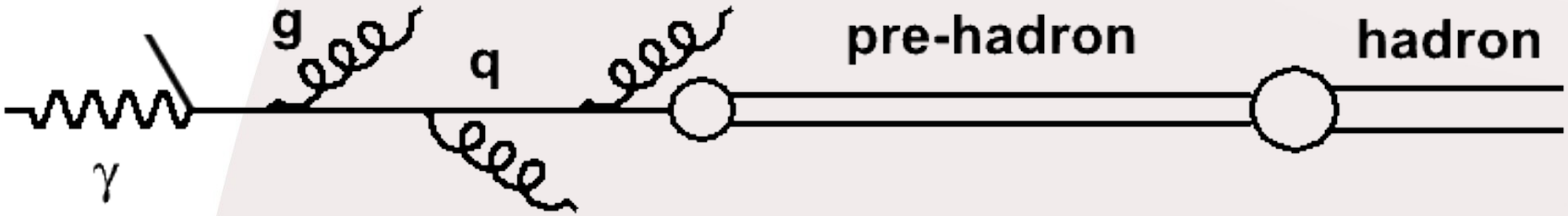
Motivations

- **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





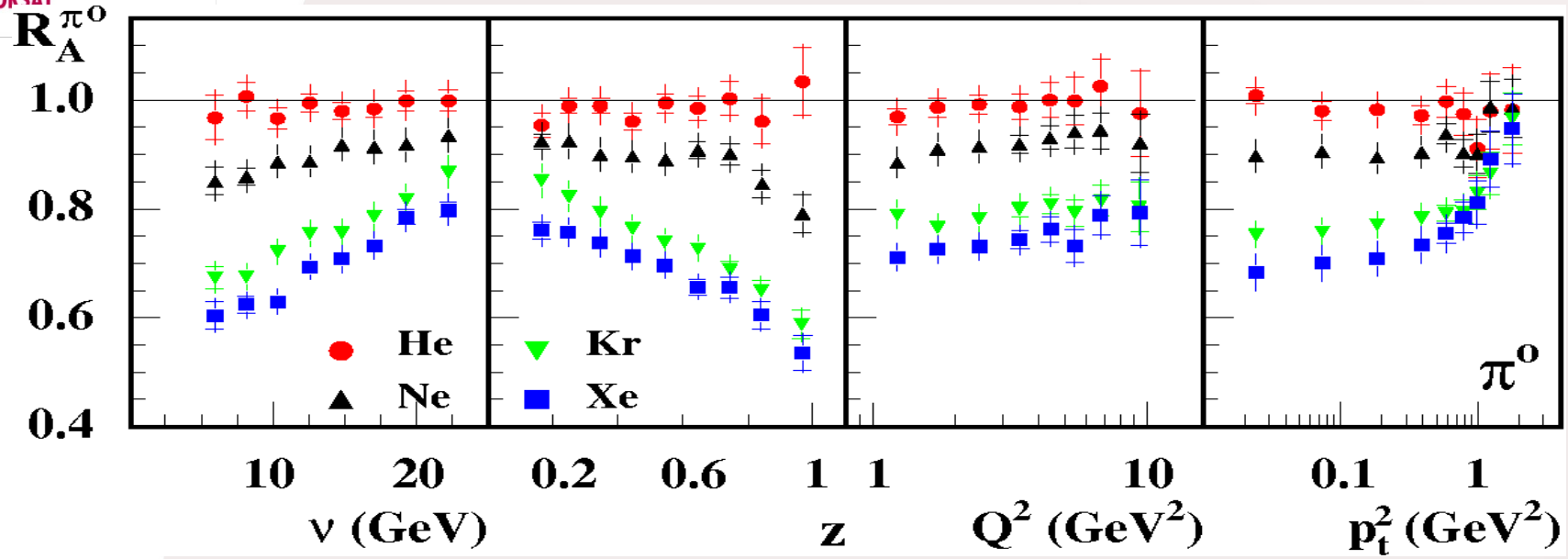
Theoretical Models

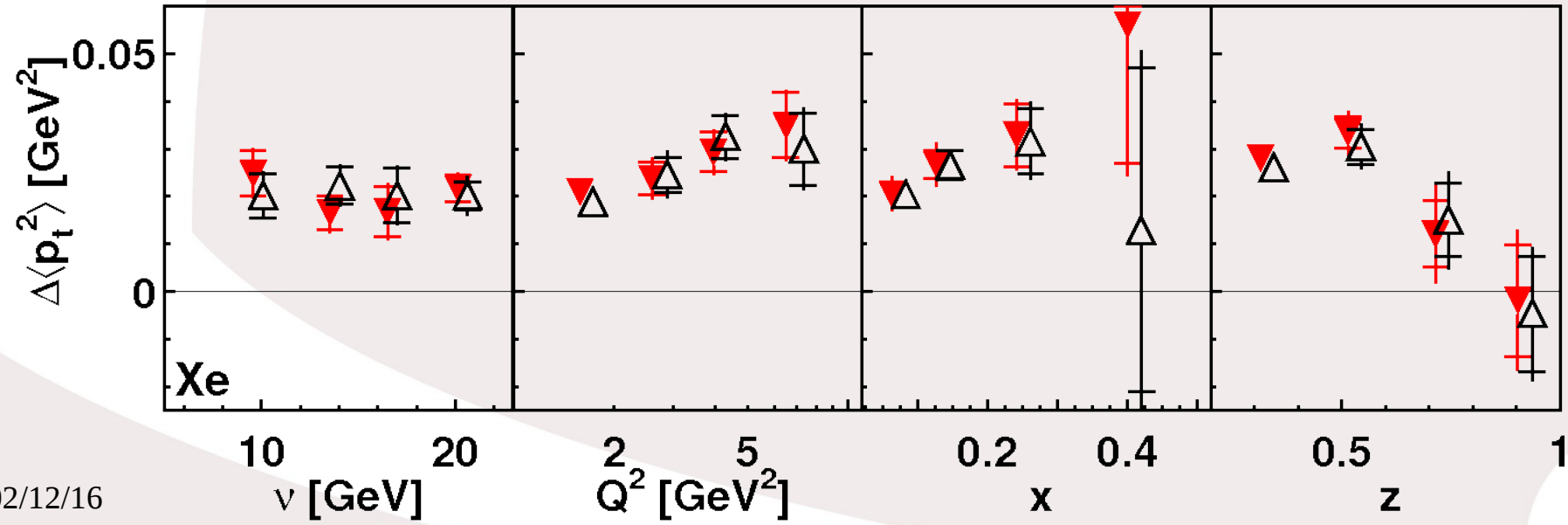


- **Important modeling questions are**
  - Absorption mainly due to parton energy loss or hadron absorption?
  - Is there a modification of the evolution in medium?
  - If yes, is it sizable in cold nuclear matter or only seen in hot nuclear matter?

- **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)

The General Picture

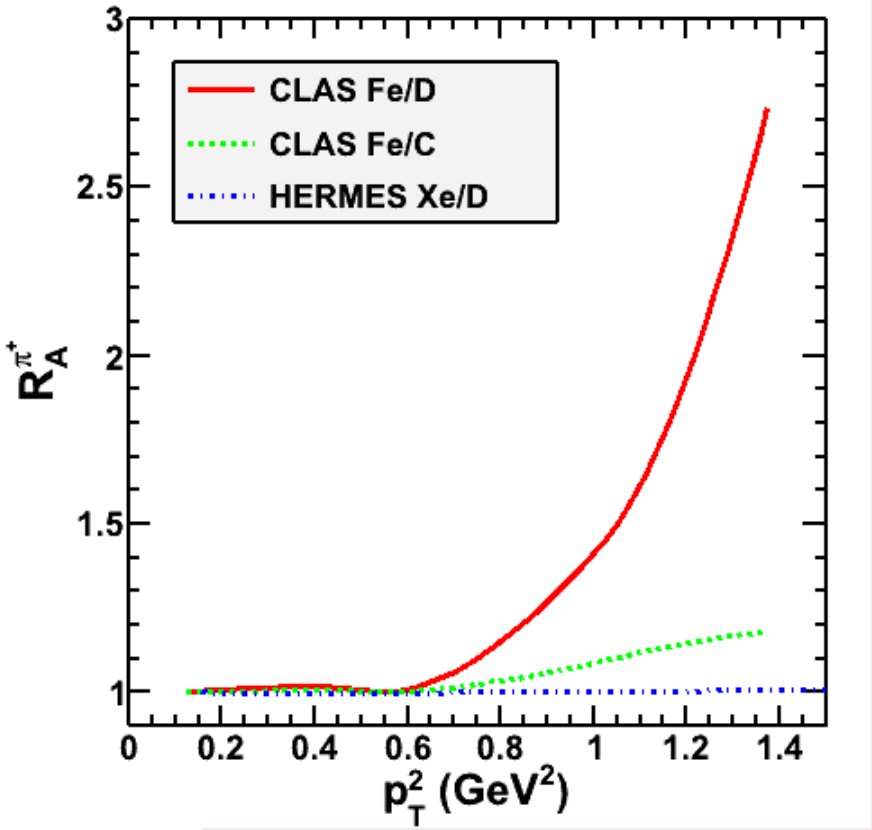


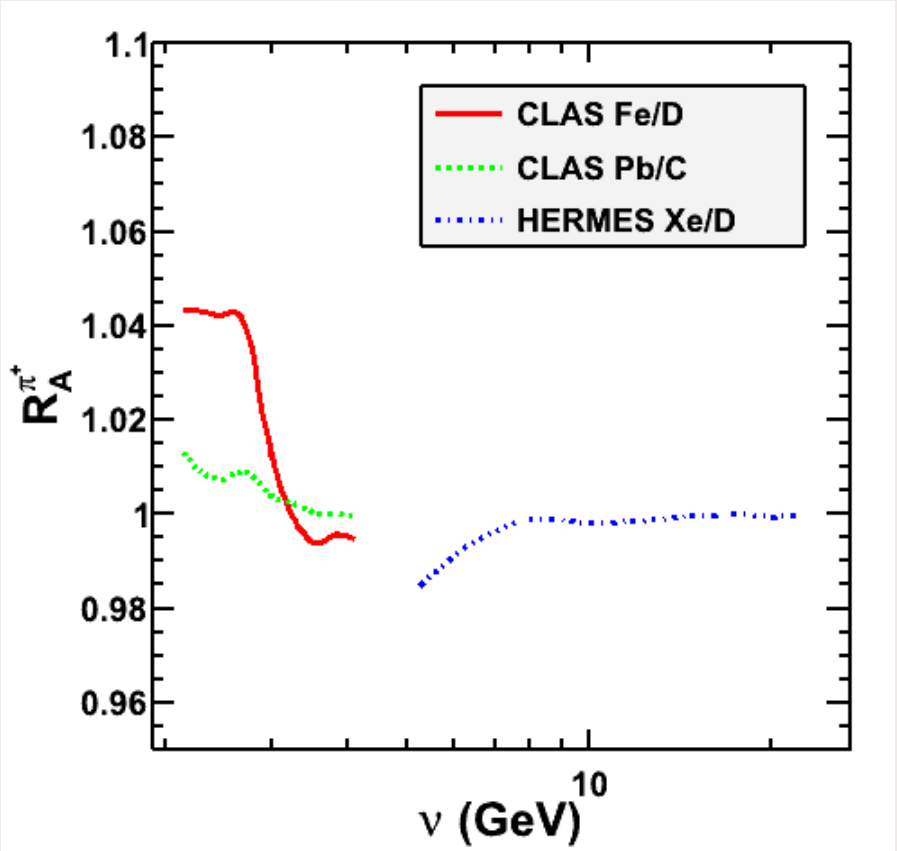


Energy Loss MC Simulation

- **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

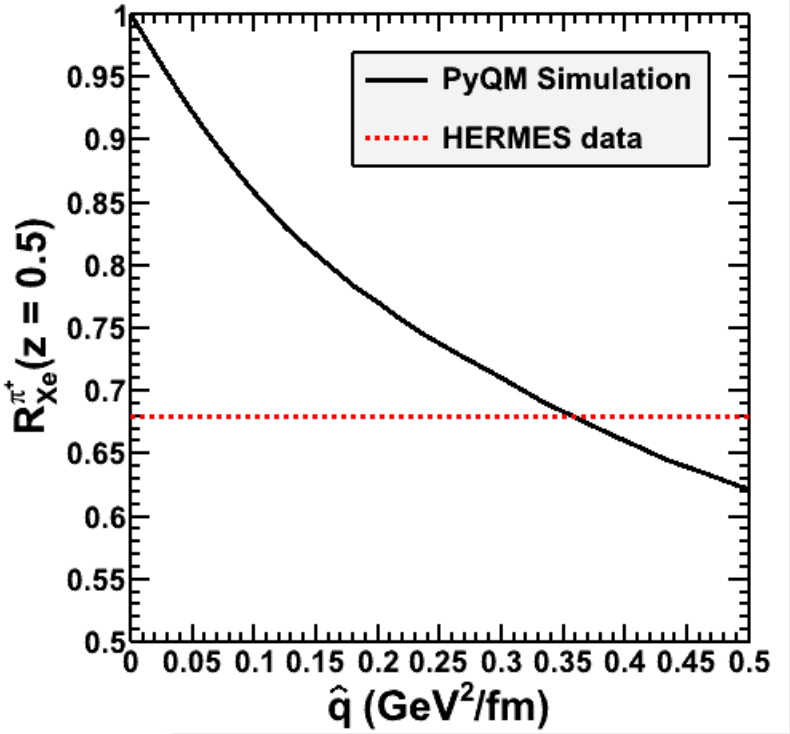
Fermi-motion

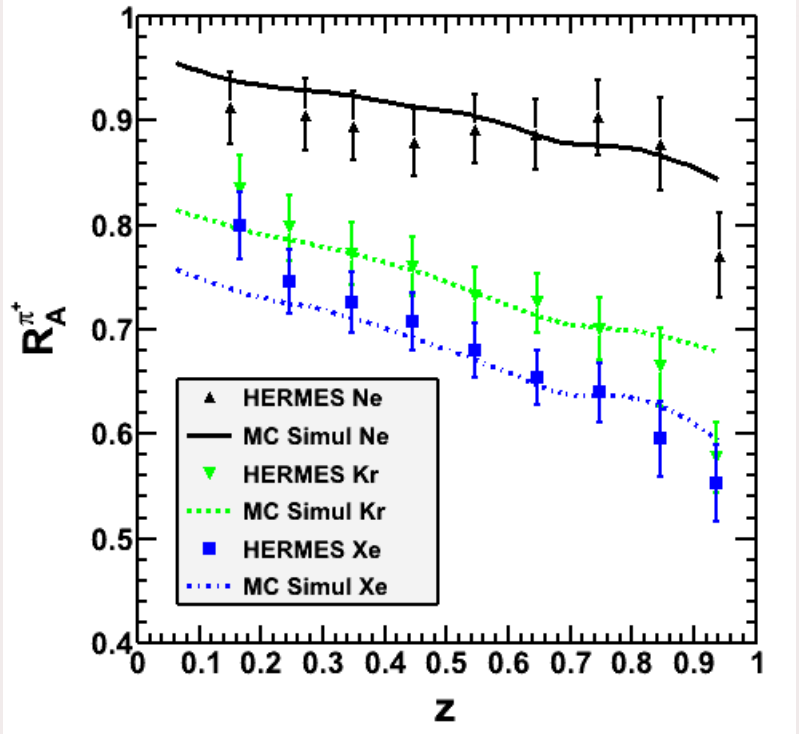




- **Fermi-motion can mimic the expected effects again!**
- **But not at HERMES energy!**

Attenuation for HERMES

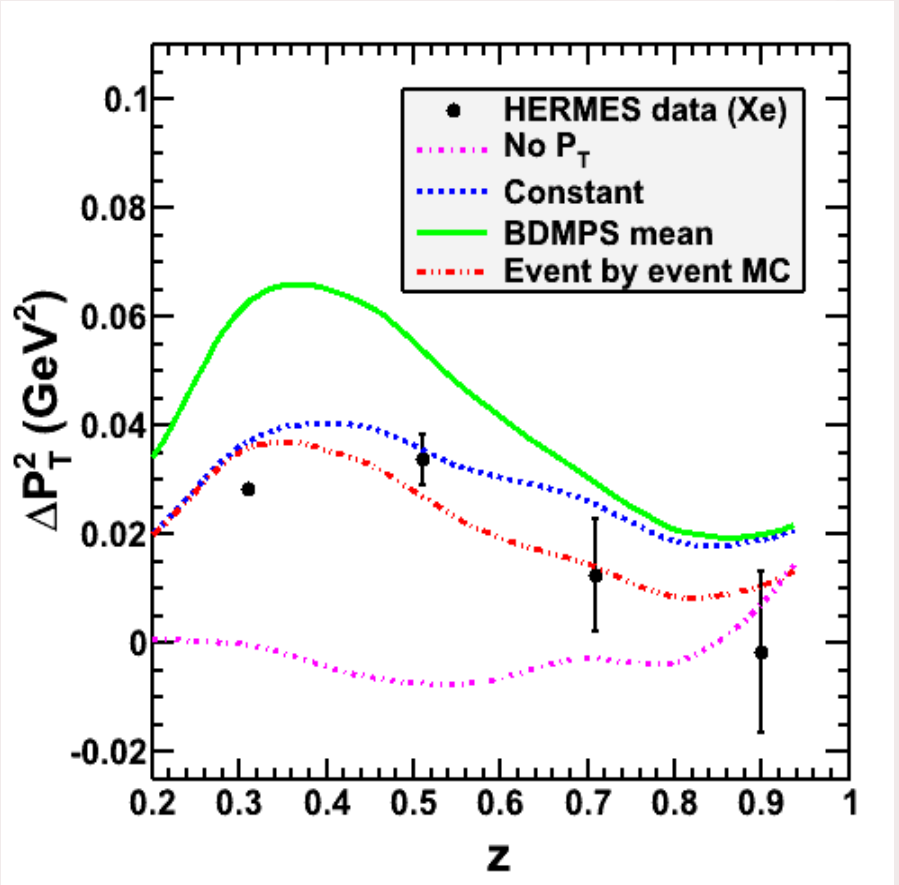




- **Good description with qhat = 0.36 GeV²/fm**
  - Single parameter model
- **Not consistent with observed transverse momentum?**
  - Of the order of 0.03 GeV²

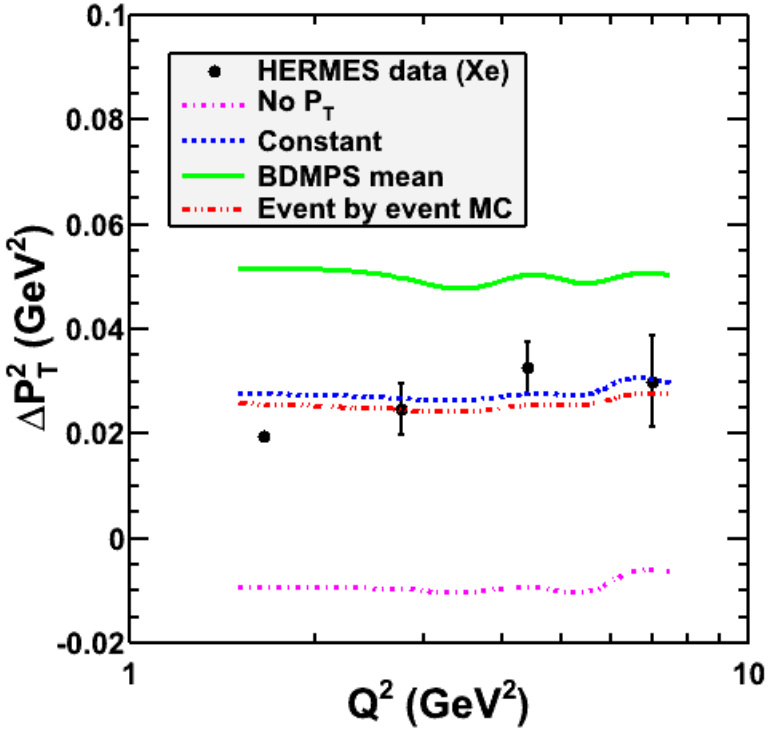
Transverse Momentum

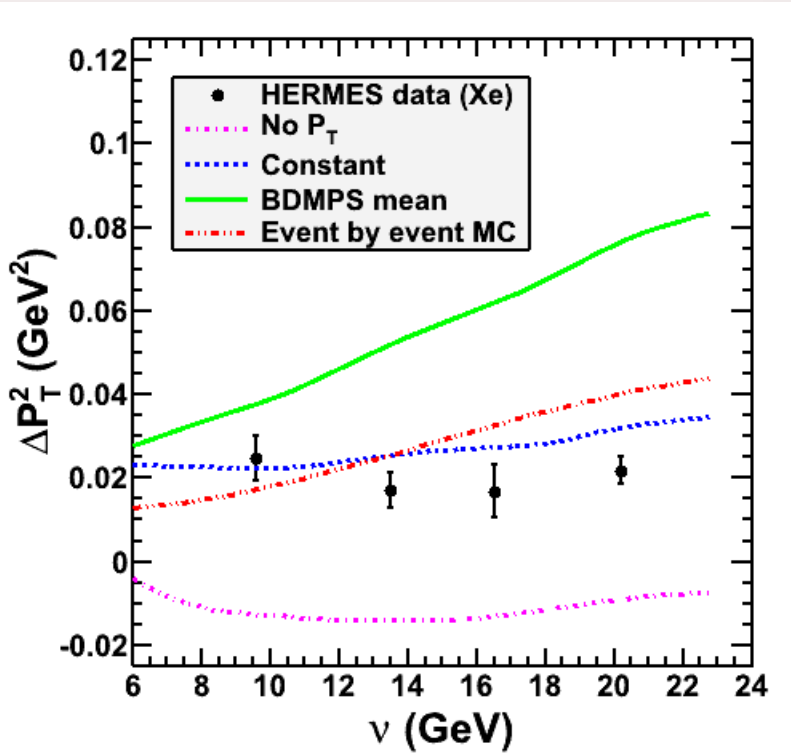
- **Can be implemented in many ways**
  - No transverse momentum added
  - Constant addition based on q hat
  - BDMPS formula
  - Event by event adapted from SW



Transverse Momentum

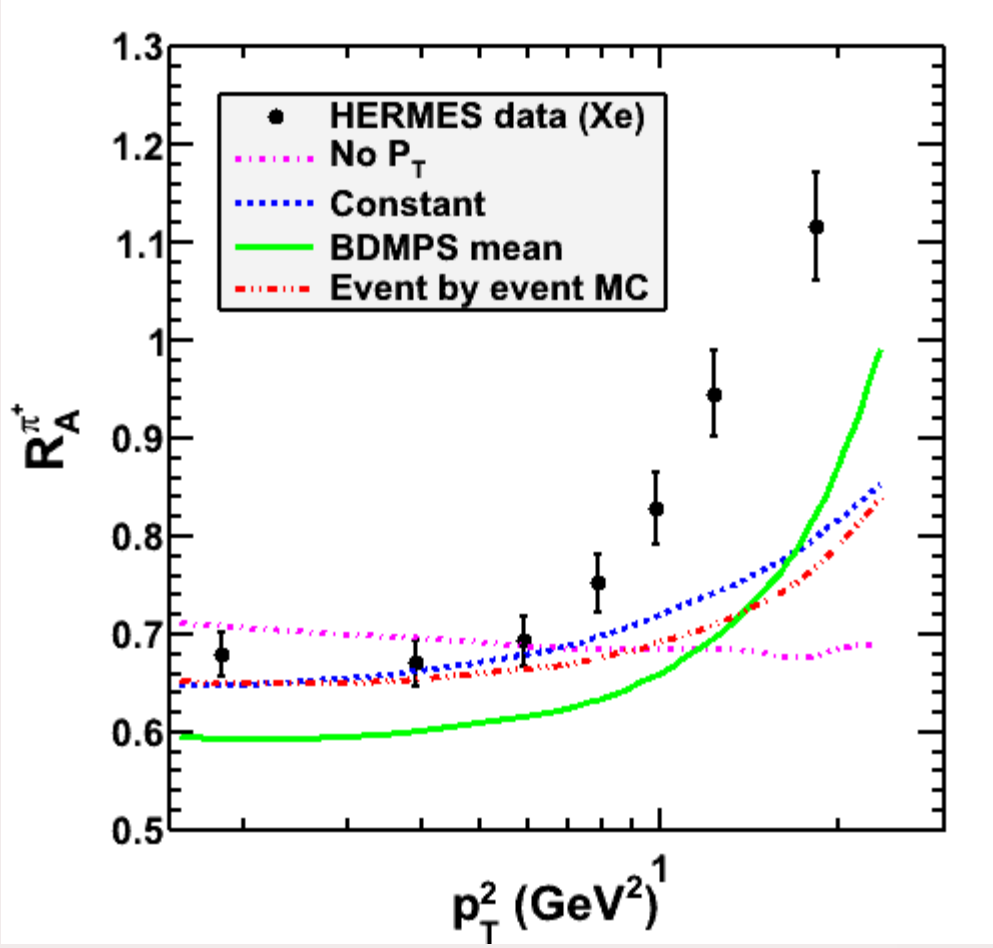
- **How do we got from Lx0.36 to ~0.03 ?**
  - Reduction by z square (~0.1)
  - Reduction due to lower parton energy
  - Reduction due to absorption
- **It matches data for all kinetic variables**



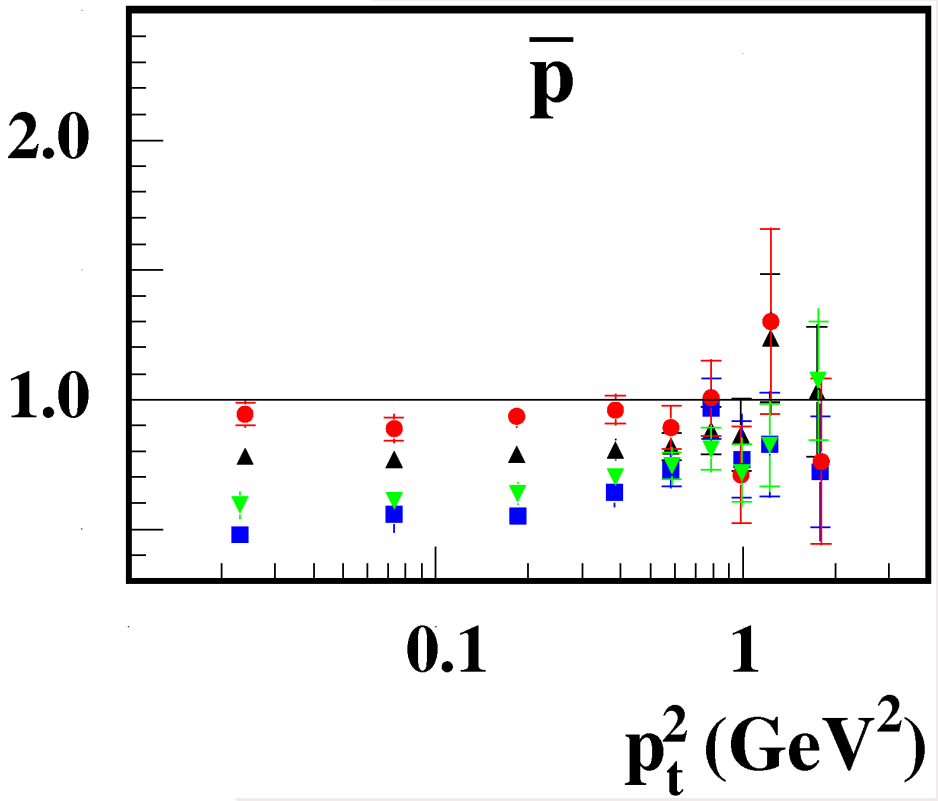


Cronin Effect

- **Effect too small in simulation**
  - Problem with simulation?
    - But ΔP_T is correct
  - Issue with FF in PYTHIA?
  - Some contamination from target fragmentation?

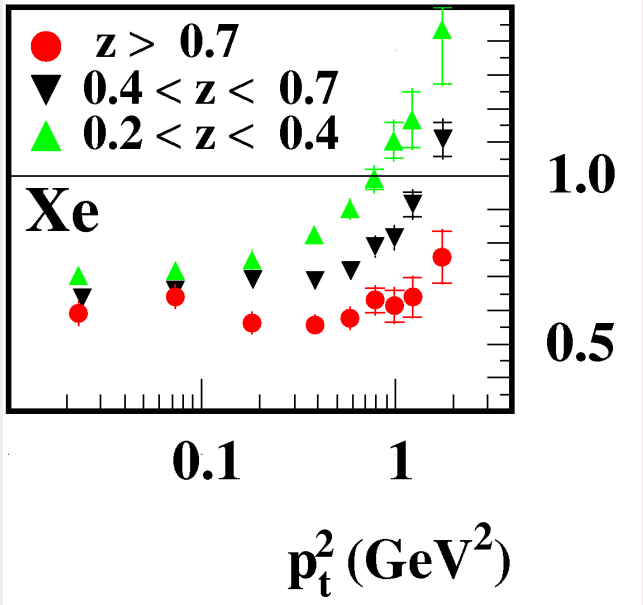


Cronin Effect



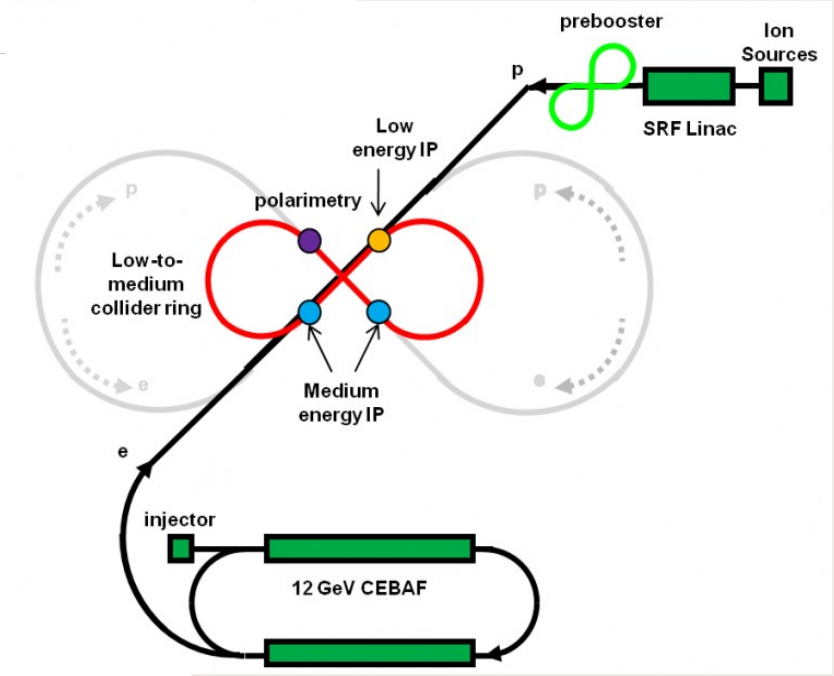
Cronin effect or target fragmentation?

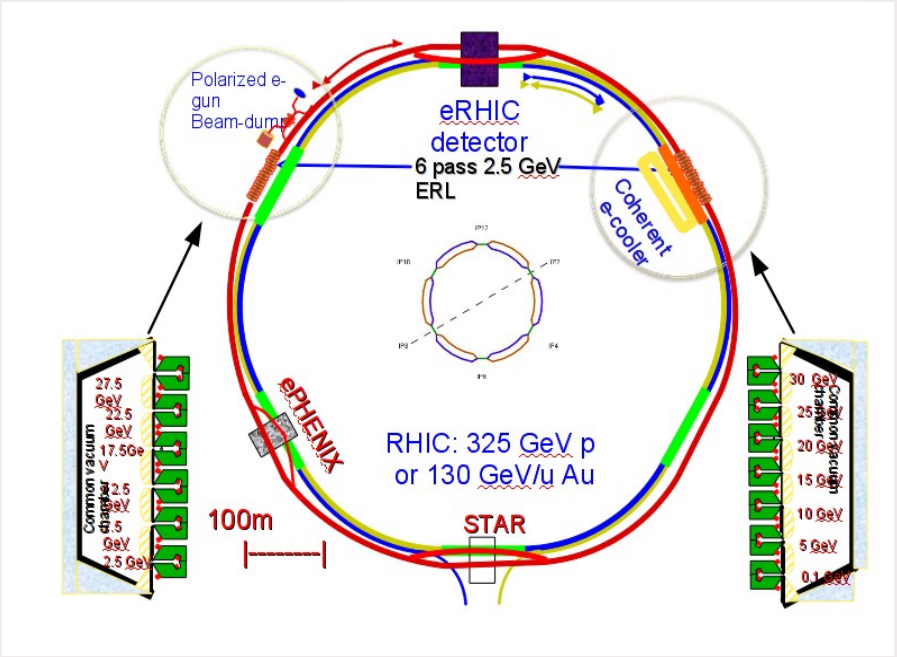
- Effect is smaller at higher z
- Small effect for anti-p



A. Airapetian *et al.*
Nucl.Phys., B780 (2007) 1.

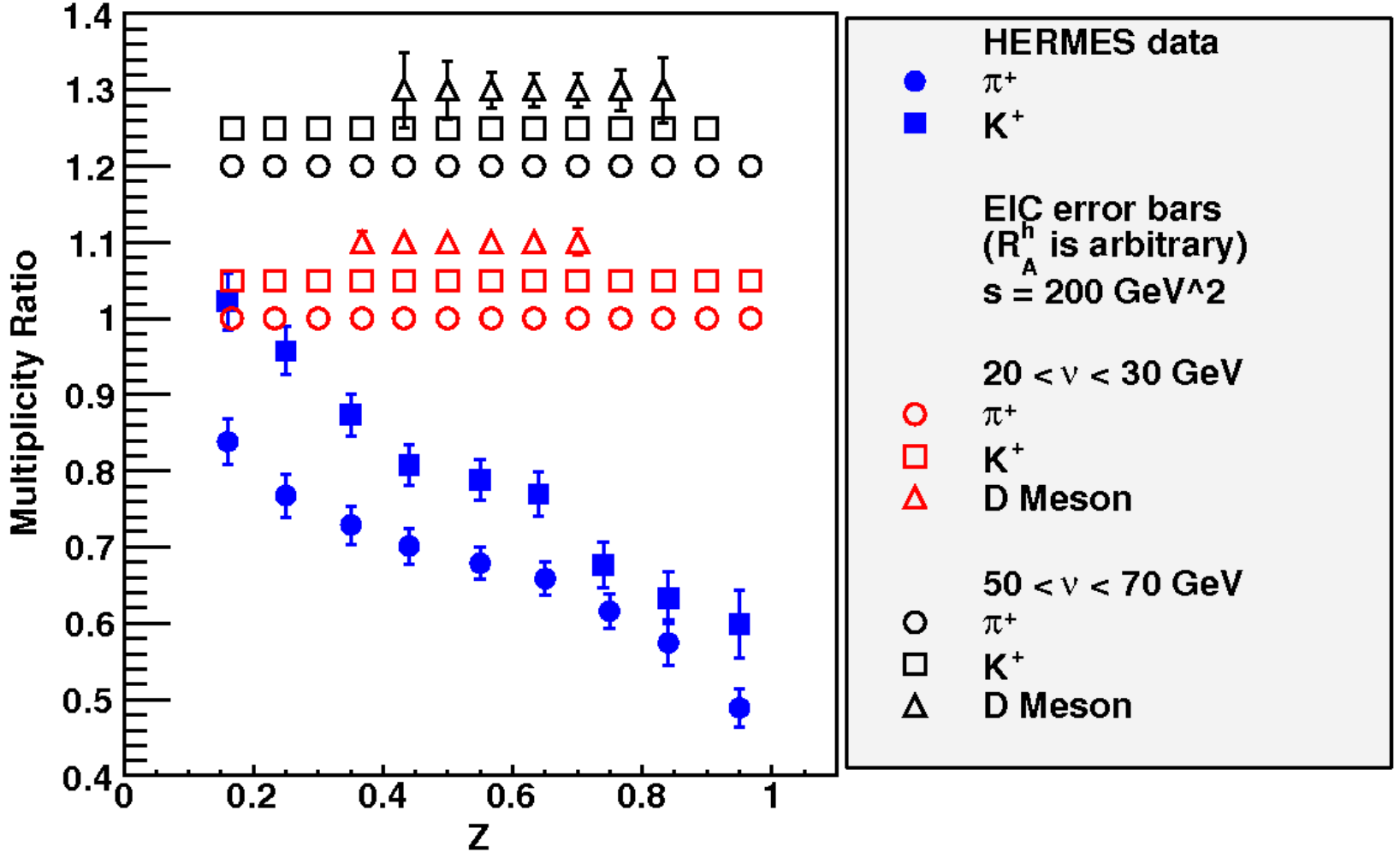
The Electron Ion Collider





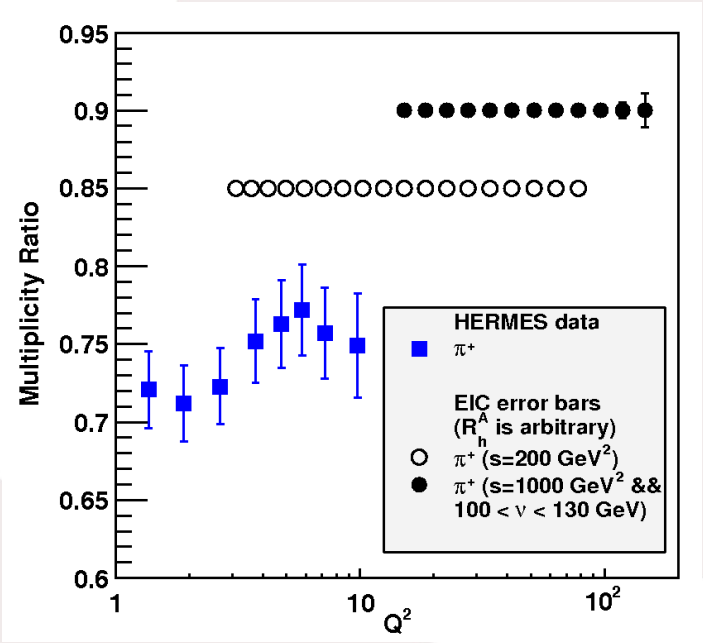
- **Project of electron ion collider (EIC)**
  - **JLab and RHIC projects s~1000GeV^2 and more**
  - **Low to no attenuation region → centered on ΔP_T^2 measurement**
  - **Isolate energy loss effects and eventually modification of FF**
  - **Access to heavy flavor for comparison with Heavy Ion Collisions**

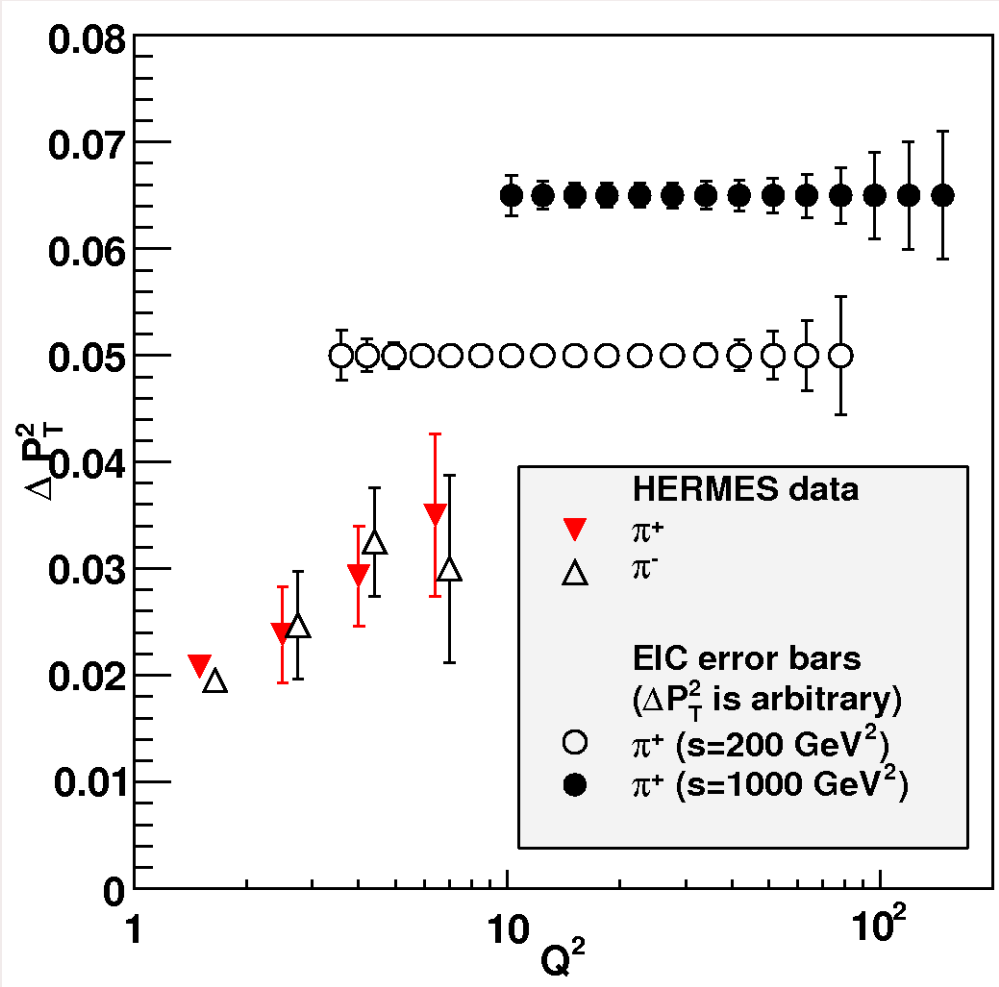
Heavy Flavors



Q2 evolution

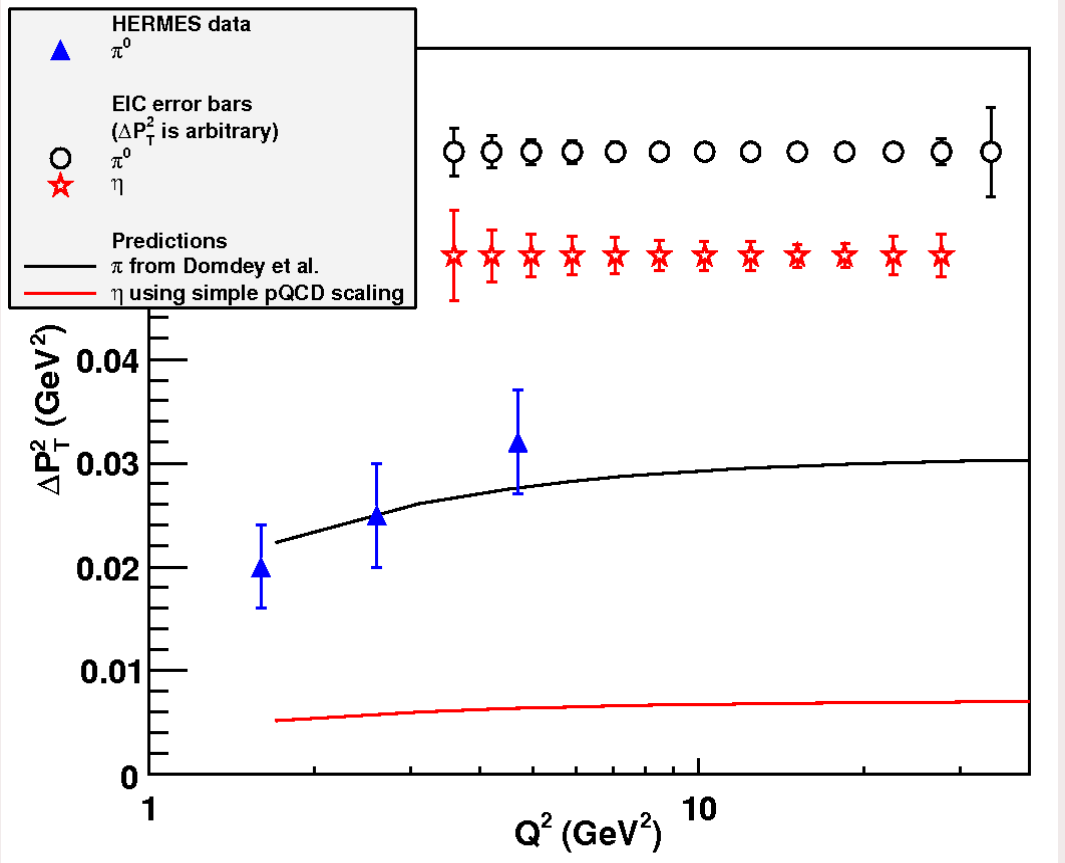
- **The Q2 dependence permit to measure any modification of the DGLAP evolution in medium**
- **The Q2 variation is a very important tool to constrain energy loss calculations.**





Flavor scaling of ΔPT2

- **Work from Domdey et al. leads to a simple scaling of pQCD in-medium energy loss between quark flavors**
- **Can be easily measured at any EIC energy**



Summary

- **Hadronization in CNM at high energy is a way to access nuclear gluons**
- **The MC simulation helps disentangle effects**
- **Energy loss models 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**
- **EIC will be able to isolate energy loss very well**
  - Extend to heavier hadrons and larger Q^2 to test pQCD applicability
  - Of particular interest since surprising heavy flavor behavior in AA