Hadronization studies at an EIC

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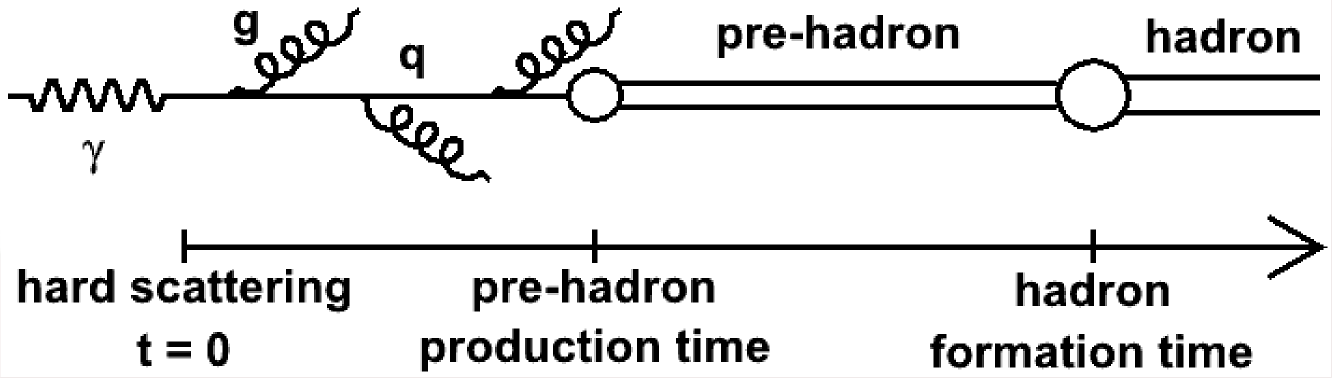
The Hadronization Process

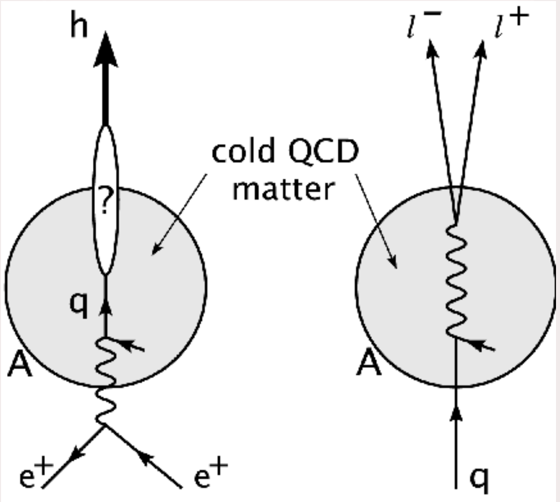


- Non perturbative QCD process
  - Need Models
- Production time → propagation of the colored quark
- Formation time → propagation of the color neutral prehadron
- No experimental knowledge of these times !
  - Models indicate few fm level
- Nuclear targets of different size can help to measure them
  - Leads to more complicated models

Motivations

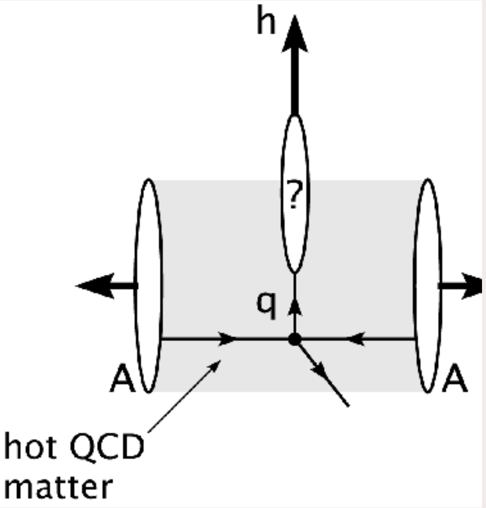
→**Understand the hadronization process by**

- → Measuring the characteristic times
- → Calculating parton energy loss in QCD medium
- → Understanding the pre-hadron structure



→**Characterization of the QCD medium**

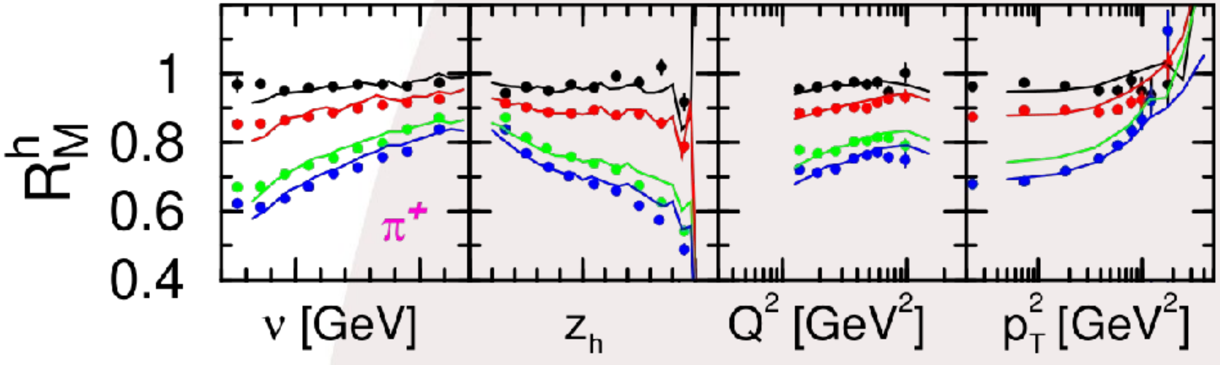
- → Using parton energy loss
- → Comparing cold and hot nuclear matter
- → QCD evolution in medium

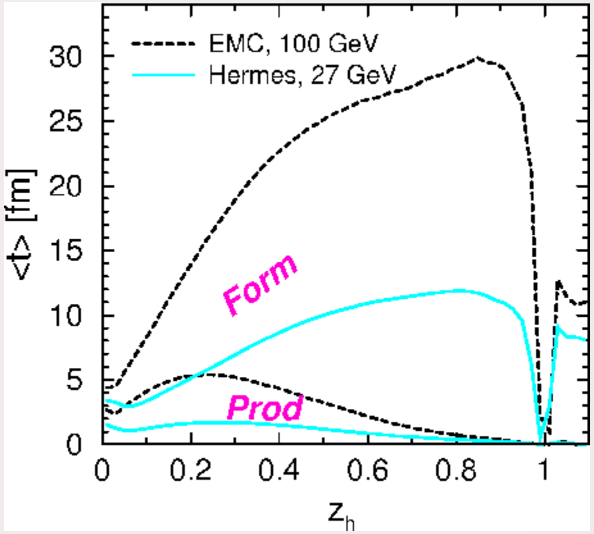


→**Reduce systematic effects when attenuation needs to be corrected**

- → Neutrino experiments especially

HERMES Results : The Pion Ratios



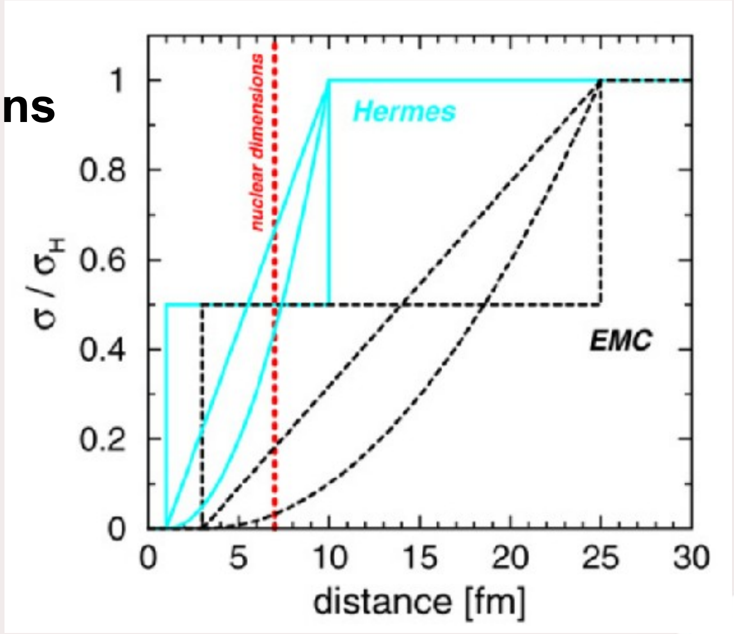


➔Pion behavior coherent with all previous results for hadrons

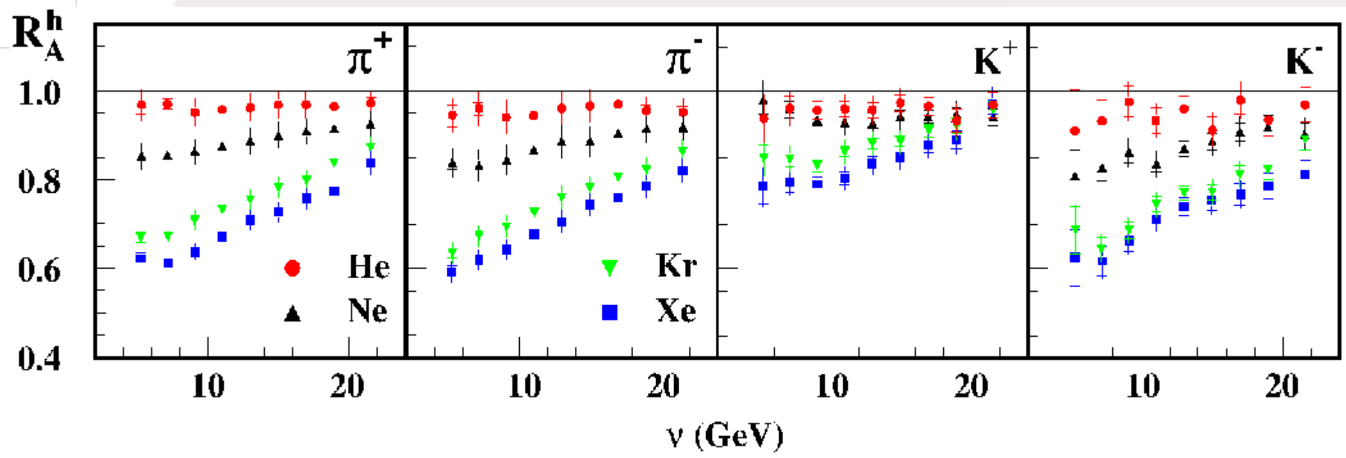
- ➔ no differences are observed with the 3 pions

➔GiBUU model based on prehadron absorption can describe these data

- ➔ no quark energy loss
- ➔ production and formation times extracted from PYTHIA
- ➔ Prehadron cross section growing linearly with time



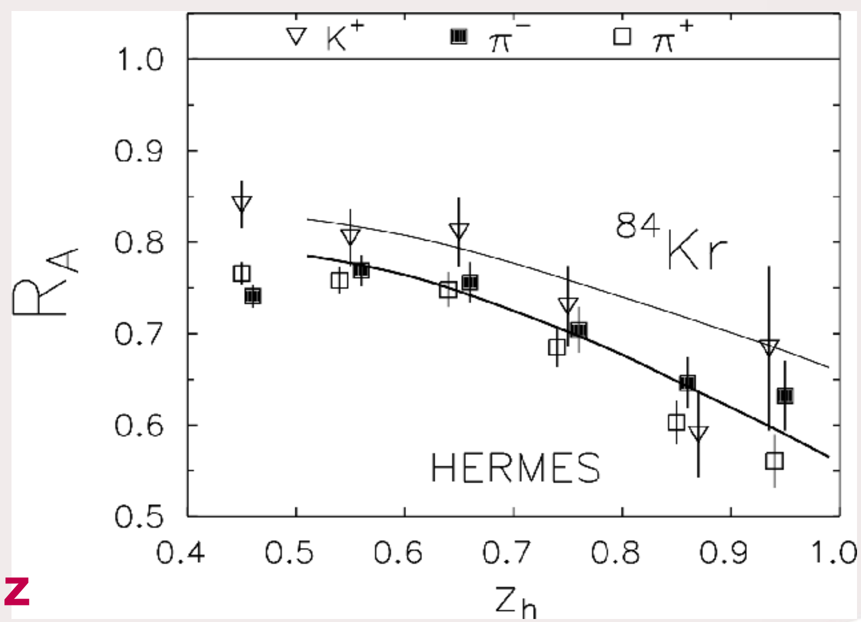
HERMES Results : The Pion-Kaon Discrepancy



➔Can be explained by

- ➔ the smaller cross section of K+
  - ➔ Success in GiBUU but miss K-
- ➔ the different behavior of the FF
  - ➔ Not enough as seen in Monte-Carlo simulation (Accardi & RD)
- ➔ contamination from π + p → Λ + K

  (Kopeliovich et al.)



➔Can be resolved by selecting higher z

- ➔ Less target fragmentation

HERMES Results : Two Pions Ratio

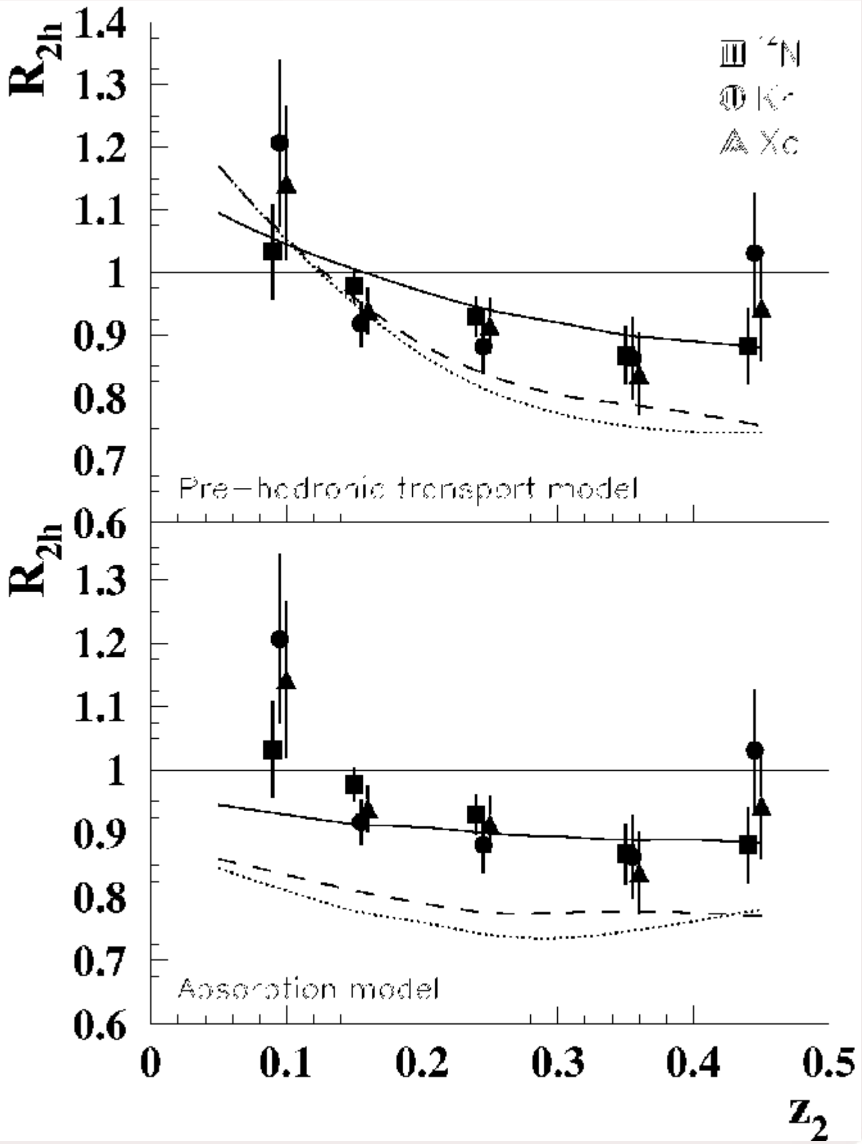
➔Multiplicity ratio of two hadrons production

➔The A scaling disappears

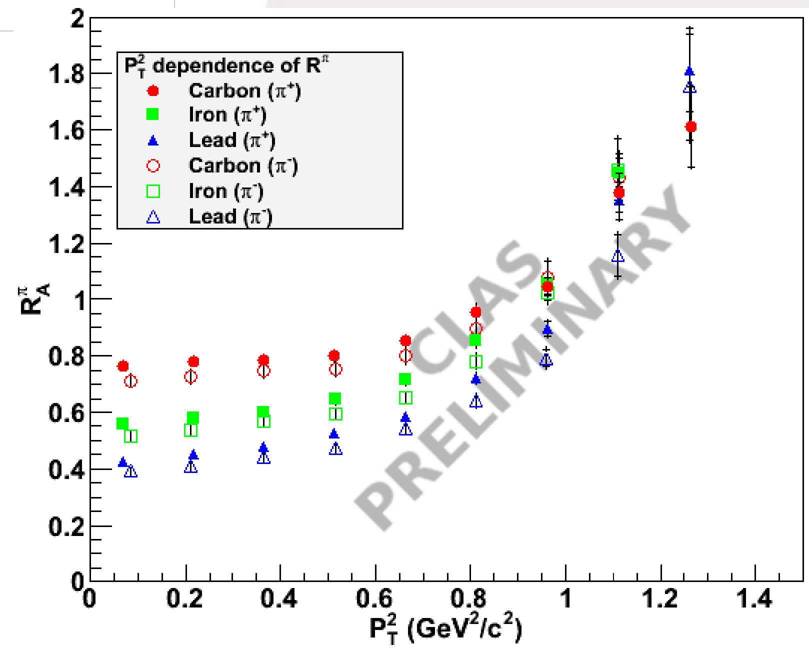
- ➔ in contradiction with all models
- ➔ most model ignore these data

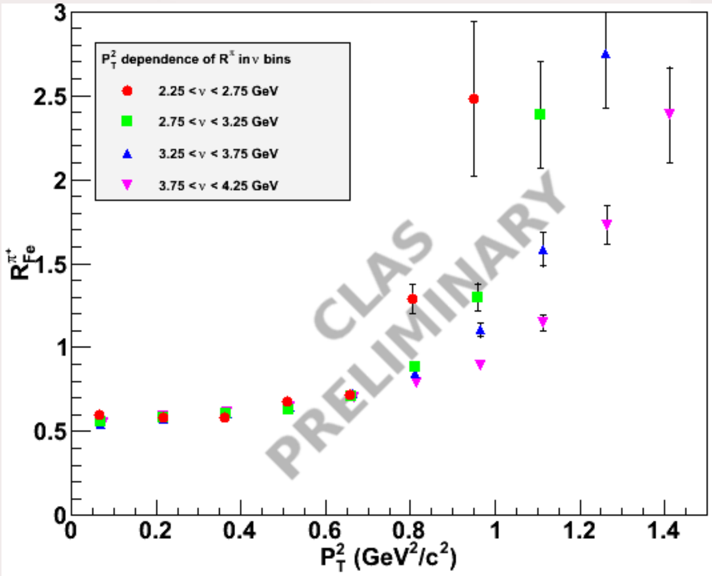
➔Explanation based on a modification of the FF ?

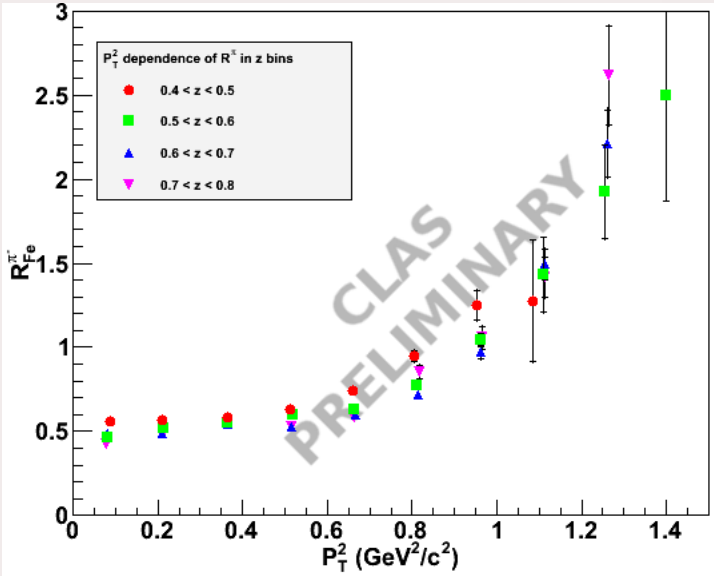
- ➔ Part of the energy lost by the leading hadron goes to the sub-leading hadrons ?



CLAS Preliminary Results: Pt broadening







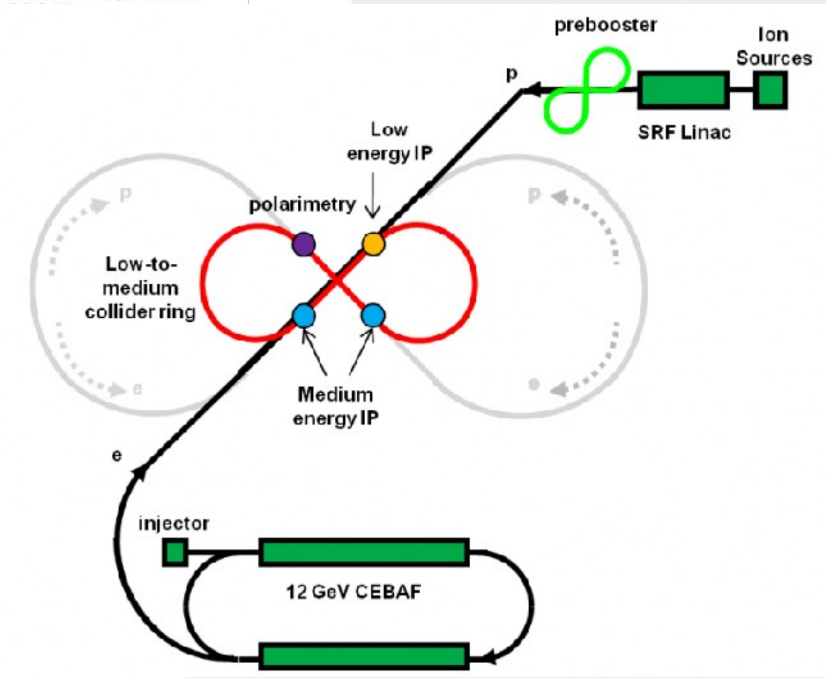
➔Cronin effect

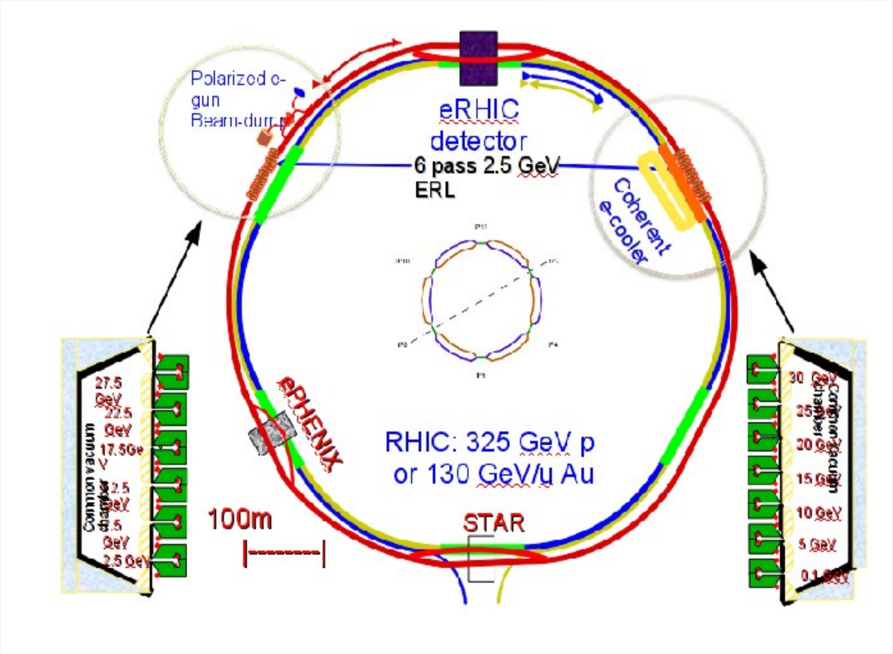
- ➔ stronger than for HERMES
- ➔ vary with nu not z unlike HERMES

➔Our higher z cut reduce the effect from target fragmentation?

➔Replaced by a Fermi motion effect?

The Electron Ion Collider (EIC)



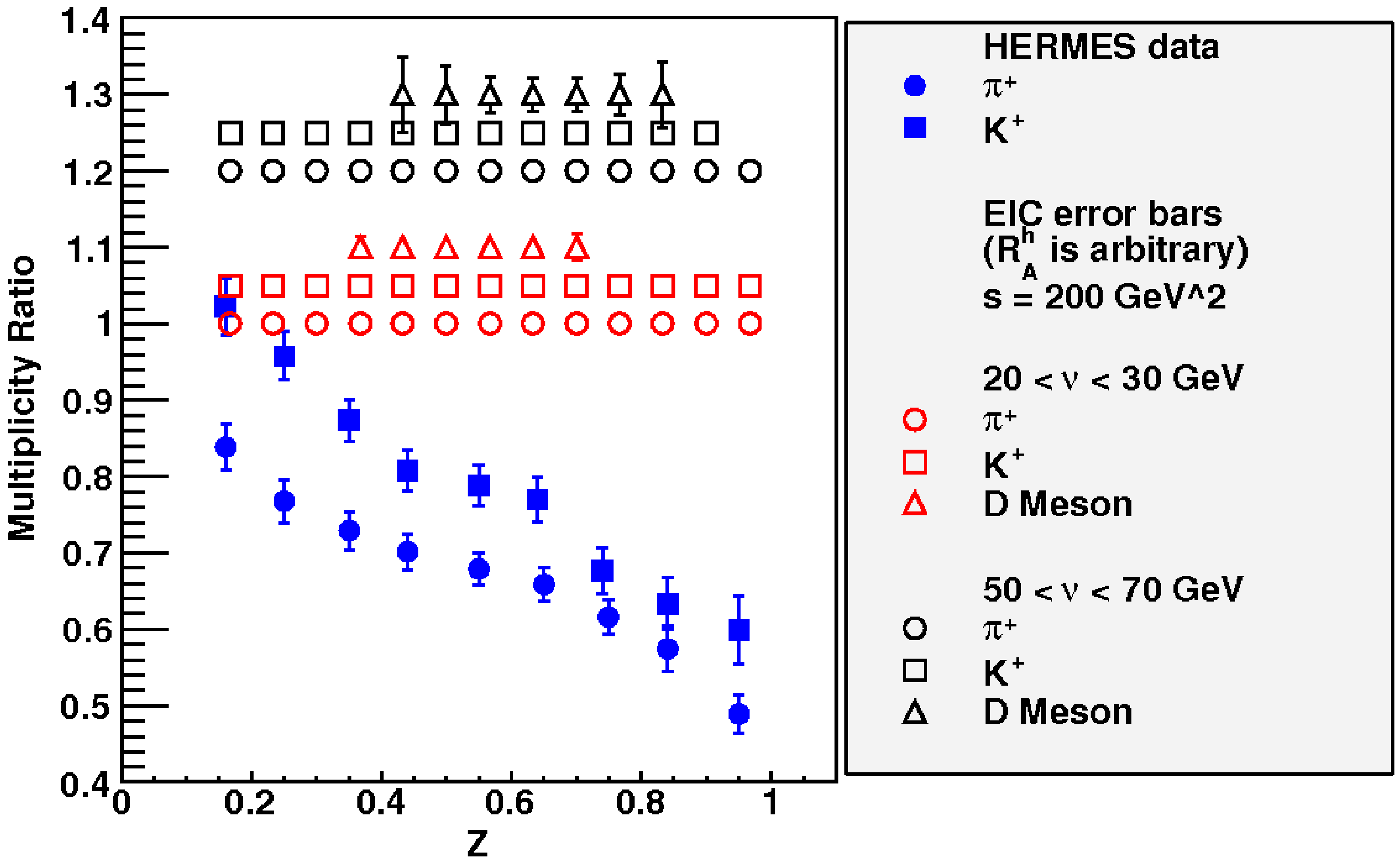


- **Project of electron ion collider (EIC)**
  - **JLab and RHIC projects s~1000GeV^2 and more**
  - **Low to no attenuation region → centered on ΔP_T^2 measurement**
  - **Isolate energy loss effects and eventually modification of FF**
  - **Access to heavy flavor for comparison with Heavy Ion Collisions**

Simulation Parameters

- Luminosity: 200 fb-1
  - or 115 days at 2.10^34 cm-2s-1 per target
- Use two energies
  - s = 200 GeV2
  - s = 1000 GeV2
- Cuts to select DIS on a single quark
  - Q2 > 1 GeV2 & W > 4 GeV
  - XBj > 0.1 (permit to suppress di-quark production)
- Cut to select leading hadrons
  - z > 0.4
- Experimental limits
  - 0.1 < y < 0.85
- Acceptance assumed
  - π, K and η A = 50%
  - D and B A = 2%

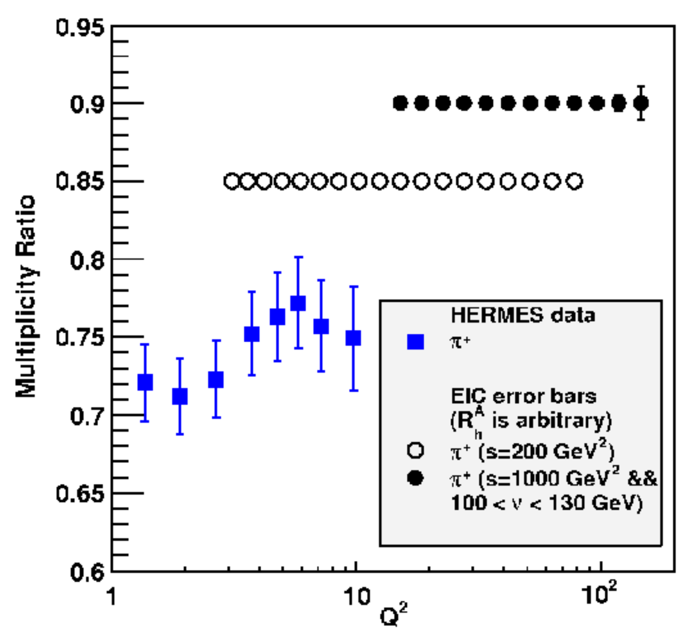
Ratio at s = 200 GeV2

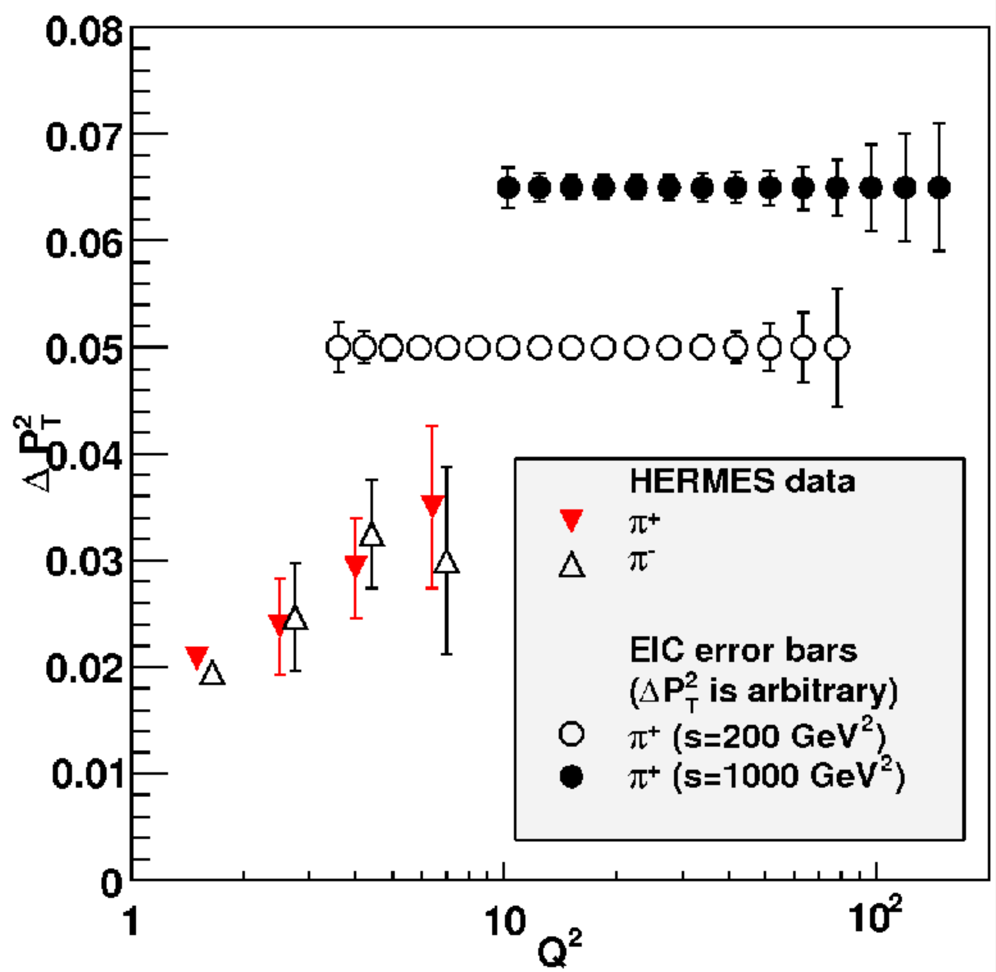


Q2 evolution

→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.

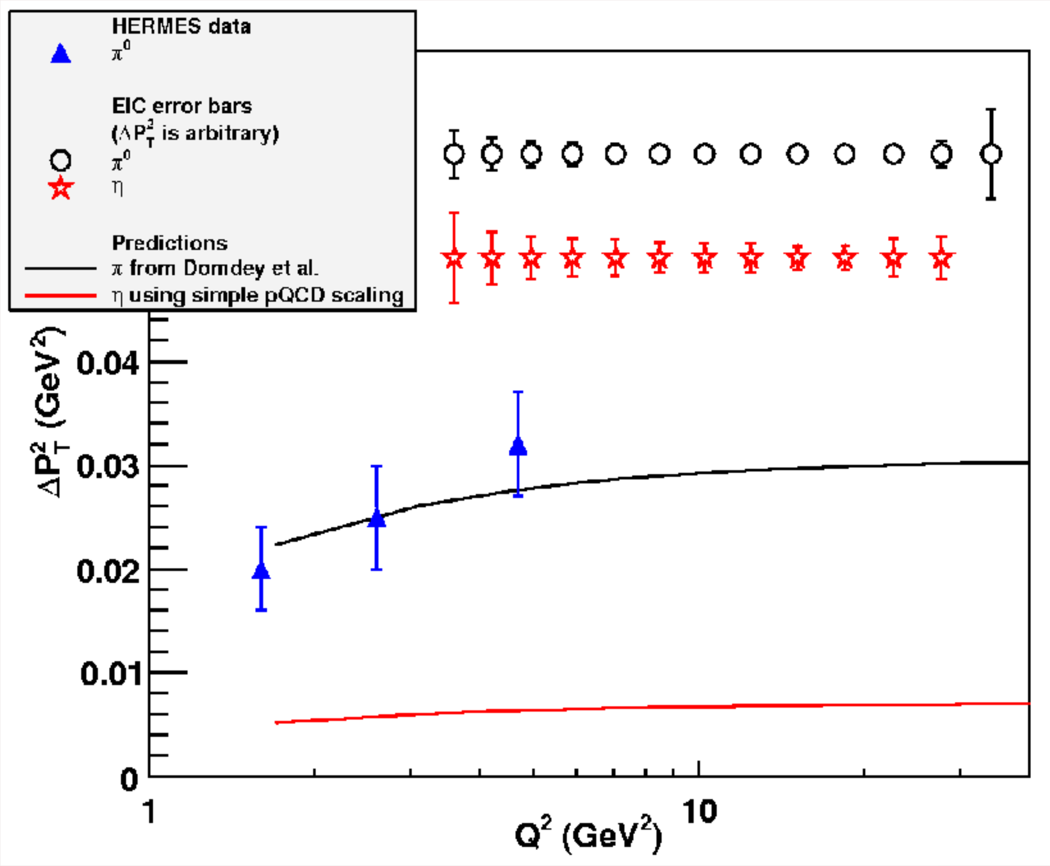




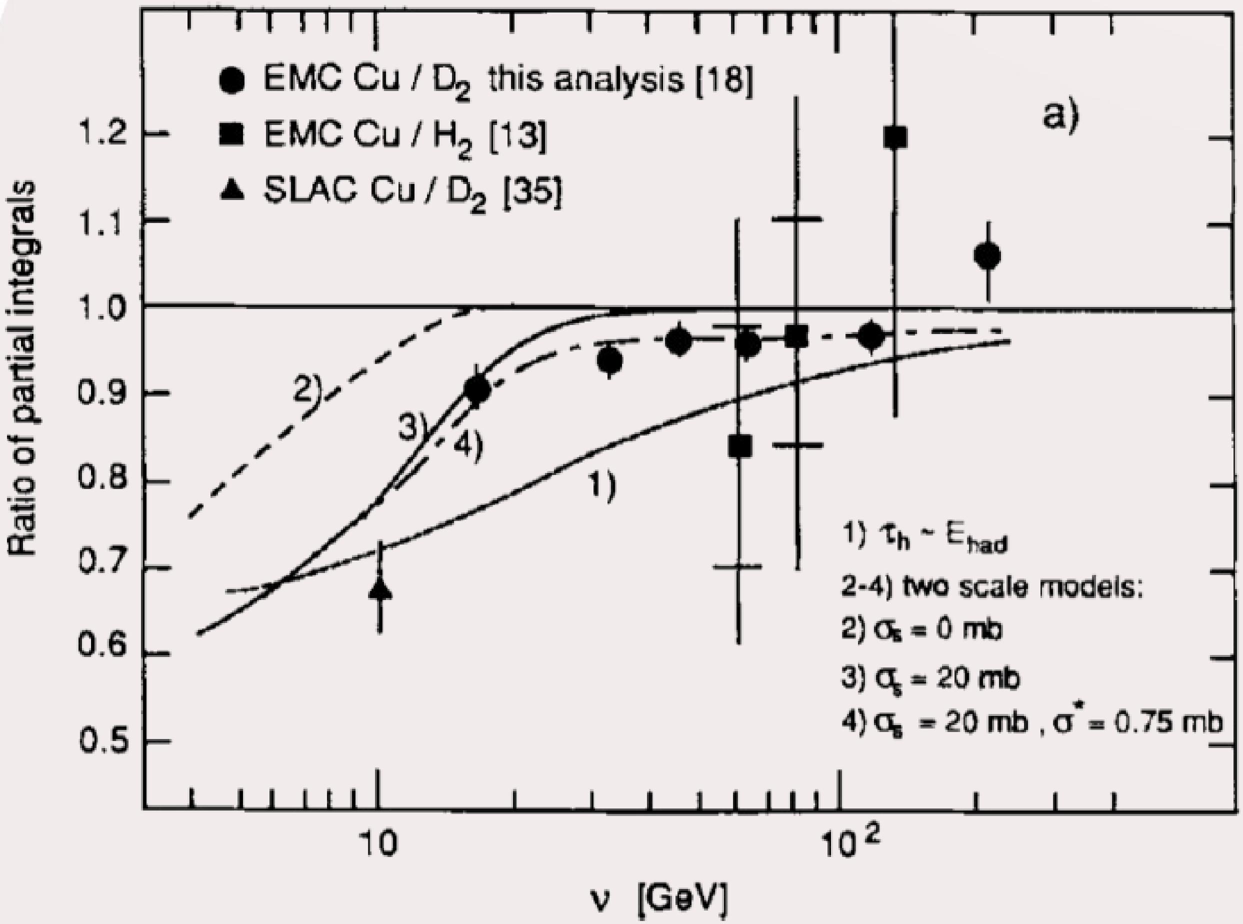
Flavor scaling of ΔPT2 (s=200 GeV2)

➔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
(here 20 < ν < 30 GeV)



What happens at high energy ?



Hadronization effect gets smaller at higher energy. How to deal with that ?

Enhancement of Nuclear Effects

➔ **Requesting Grey tracks enhance the nuclear effects !**

- ➔ **Example for hadronization studies:**

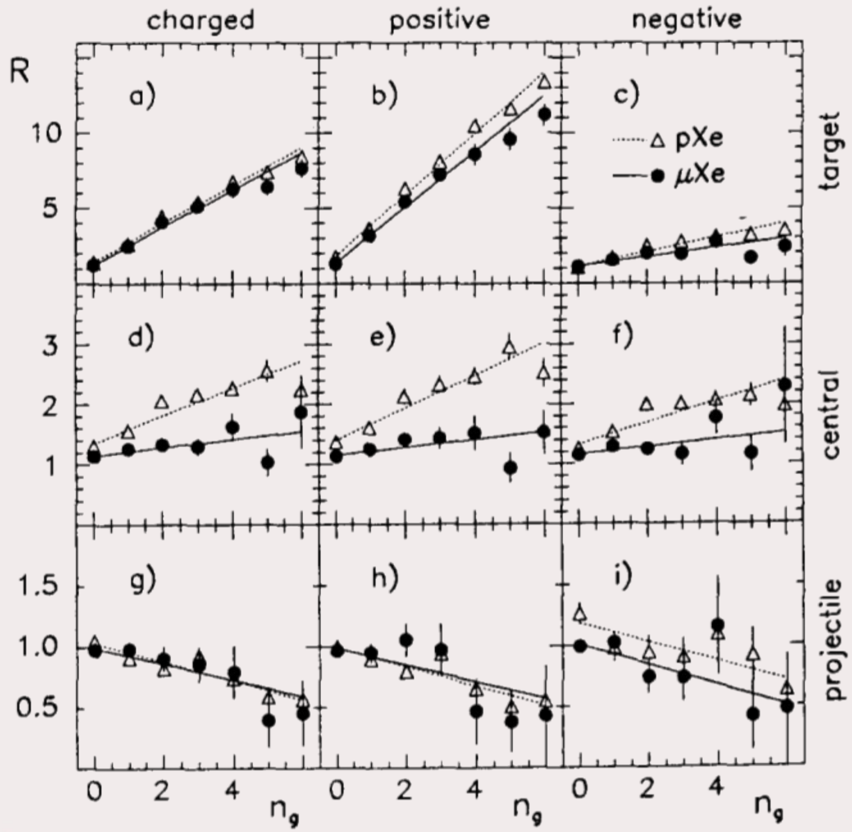


Fig. 10. Multiplicity ratio $R(n_g)_{\mu Xe}$ (full circles) and $R(n_g)_{pXe}$ (open triangles) as a function of the number n_g of grey tracks. The plots are for all charged, for positive and negative hadrons, and for three rapidity intervals (target, central, projectile). The lines are the results of straight-line fits to the data points

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Physics Outlook

➔Hadronization studies

- ➔ Measurement on lepton scattering on cold nuclear matter give great constrain on parton kinematic and medium characteristics
- ➔ Important tool to test models used in HIC

➔Hadronization at EIC

- ➔ Large kinematic coverage
- ➔ Clean access to parton energy loss
- ➔ Observation of heavy quarks in CNM

➔ Grey tracks, a tool to enhance nuclear effects