Quark Fragmentation and Hadron Formation in Nuclear Matter

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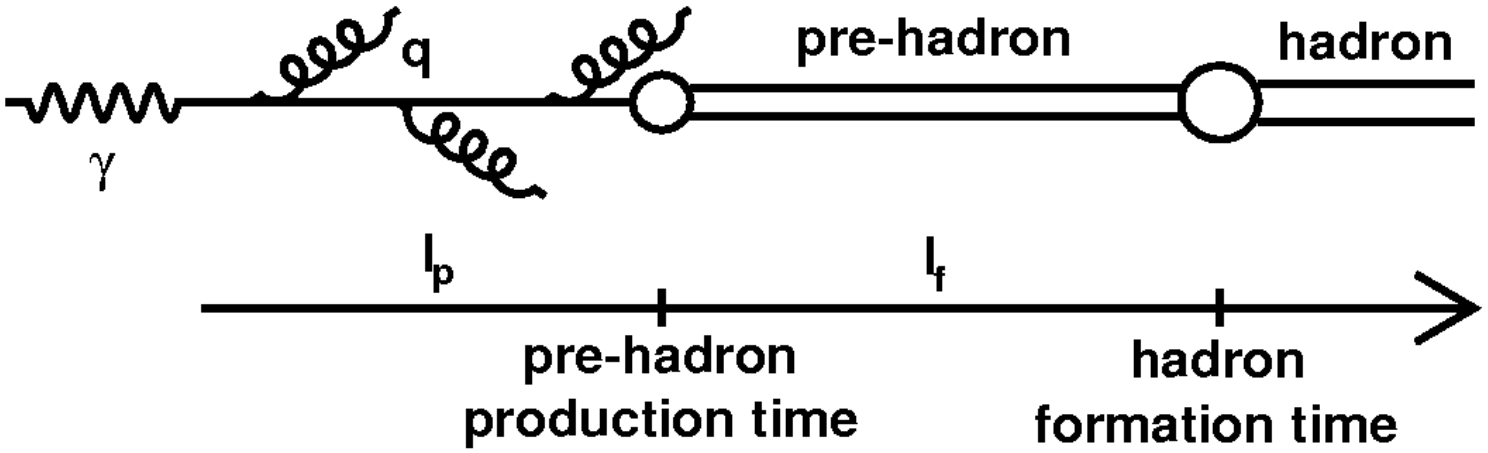
Hadronization

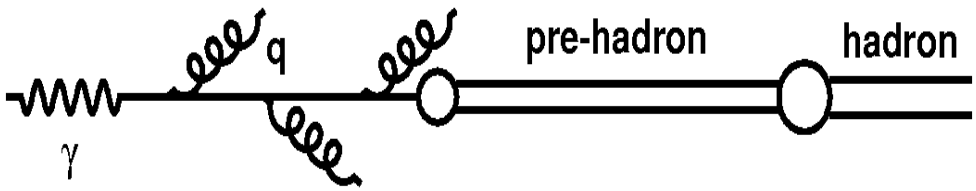


- Non perturbative process

  → cannot be exactly calculated

- Can be characterized by two times
  - Color neutralization at **production time**
  - At **formation time** hadronic properties are definitive

Motivations



- Understanding Hadronization Process
  - Measuring characteristic times
  - Being able to calculate parton energy loss
  - Understand the pre-hadron and the color transparency effects
- Characterization of cold nuclear matter
- Characterization of hot nuclear matter
- Reduce systematic effects in various experiments (such as νA and eA)

Deep Inelastic Scattering

- Momentum transfer

$$Q^2 = -q^2$$

- Photon energy

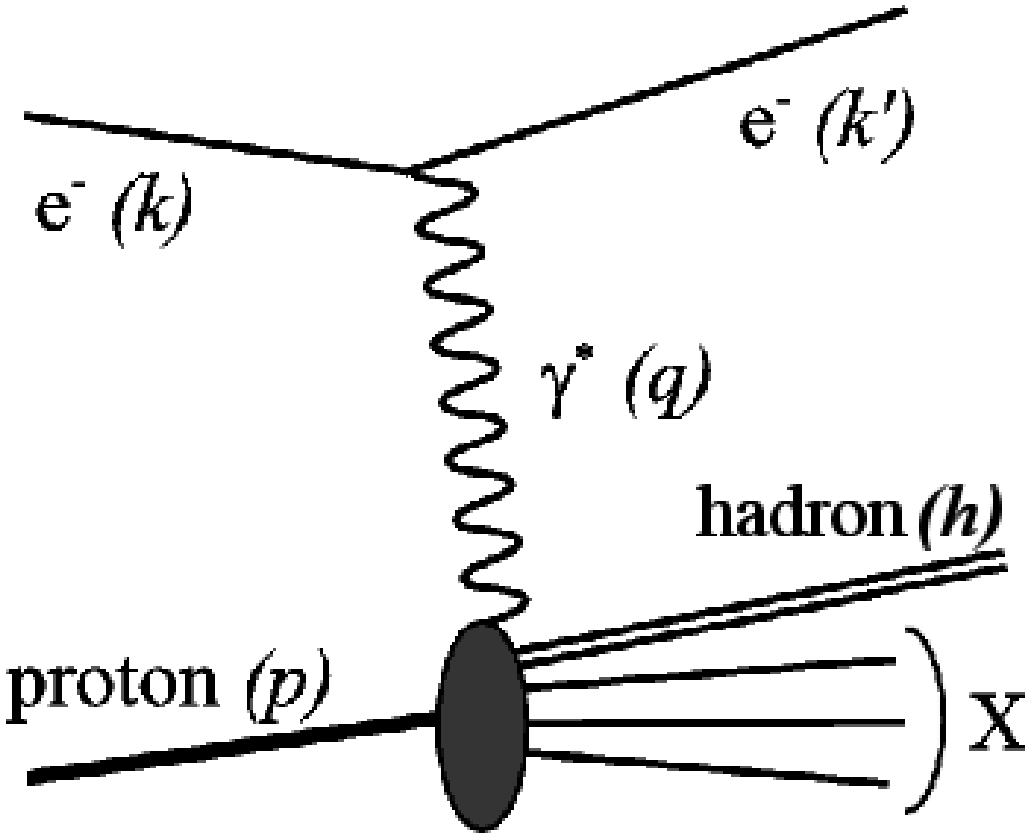
$$\nu = E_\gamma$$

- Fraction of the energy carried by the hadron

$$z = \frac{k.p}{q.p} = E_h / \nu$$

- Transverse momentum

$$\vec{P}_t = \vec{P}_h - \frac{\vec{P}_h . \vec{q}}{\|\vec{q}\|} \vec{q}$$



Observables in Nuclear DIS

- Transverse momentum broadening

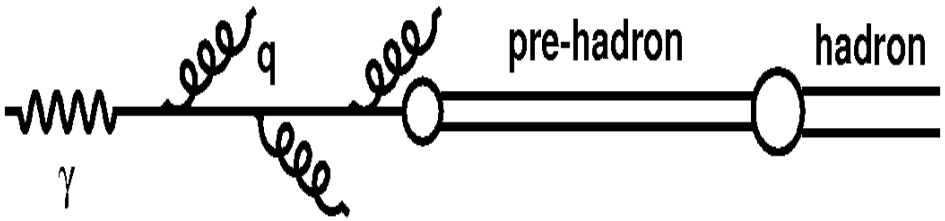
$$\Delta P_T^2 = \langle P_T^2 \rangle_A - \langle P_T^2 \rangle_D$$

- Multiplicity ratio

$$R_A^h(Q^2, x_{Bj}, z, P_T) = \frac{N_A^h(Q^2, x_{Bj}, z, P_T)/N_A^e(Q^2, x_{Bj})}{N_D^h(Q^2, x_{Bj}, z, P_T)/N_D^e(Q^2, x_{Bj})}$$

The attenuation is 1-R

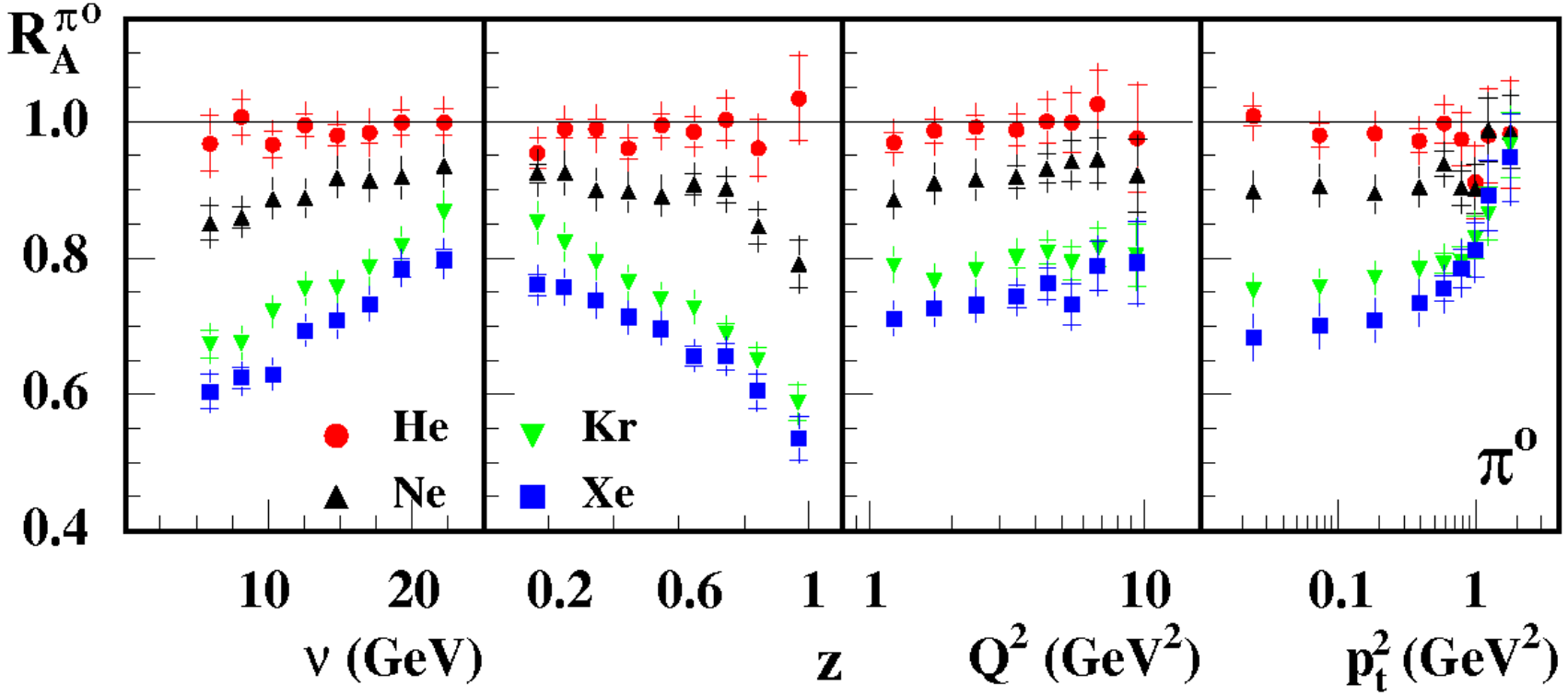
Theoretical Tools



- Parton energy loss
- (Pre-)Hadron absorption
- Medium modified fragmentation functions

→ Theoretical models are based on one or two of these ingredients

The General Picture



- Increase with ν
- Decrease with z
- Slight increase with Q^2
- Strong increase with P_T

Conclusions From HERMES

- Pions have similar behavior
- Demonstrated the raise with ν
- Provides interesting baryon measurement

However

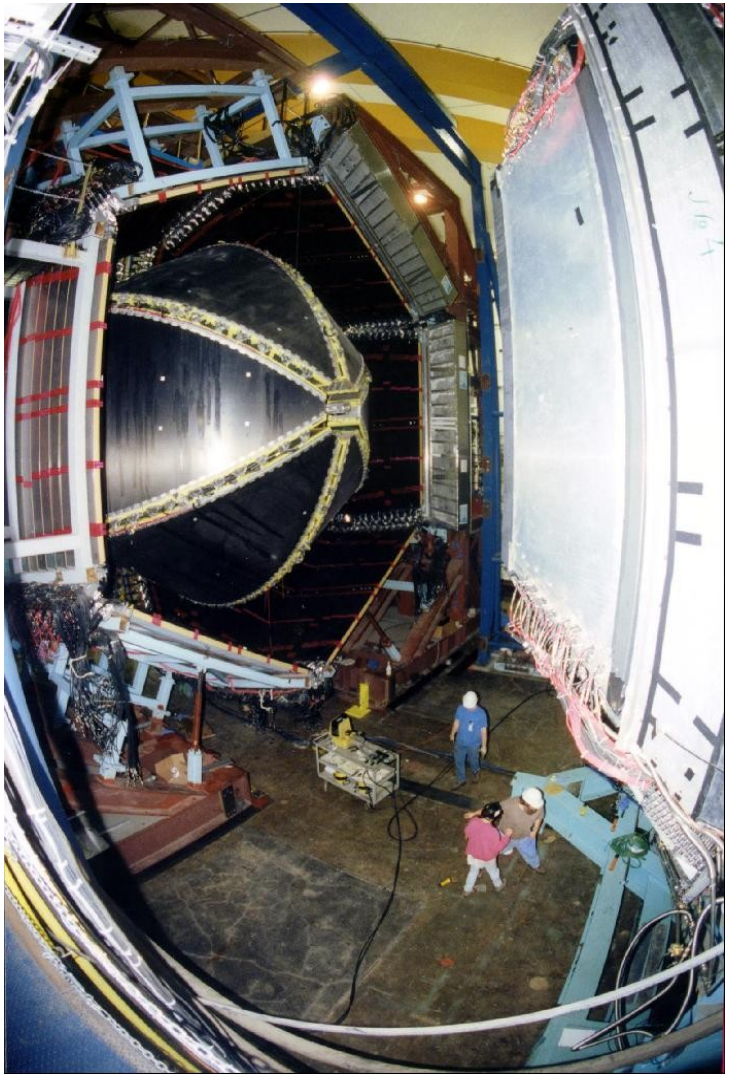
- Target fragmentation might be an issue
- All model types remain

Still to be done

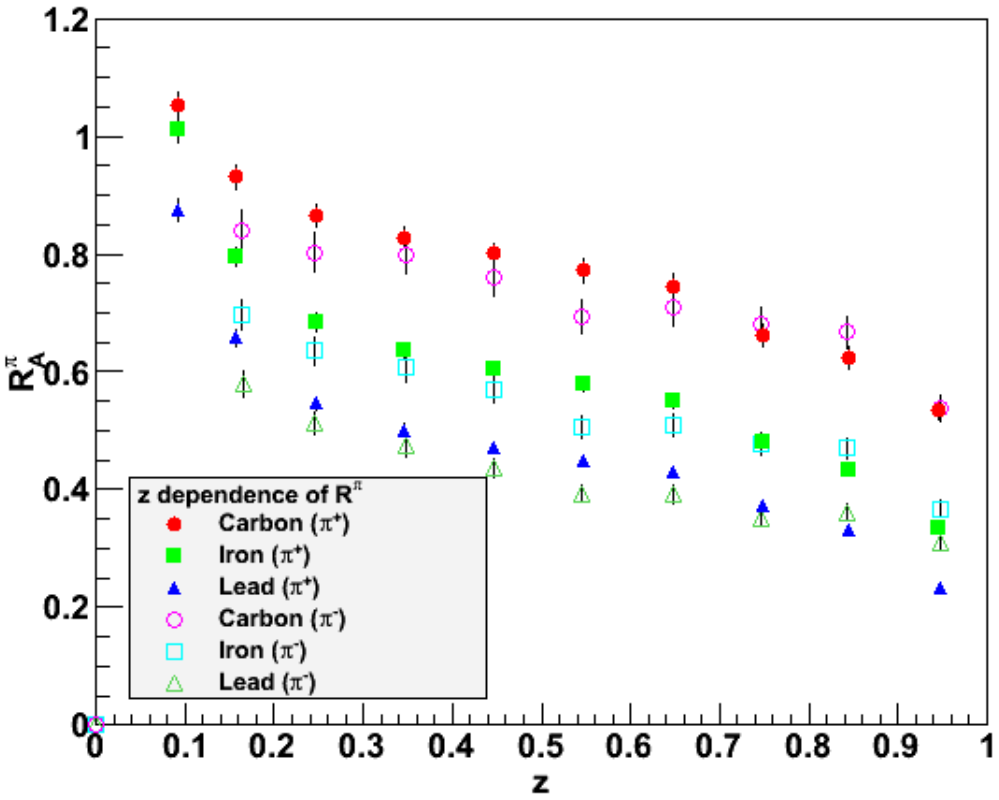
- Some multidimensional results are not confronted to models yet
- Interesting hints for a Q^2 and flavor effects need to be confirmed

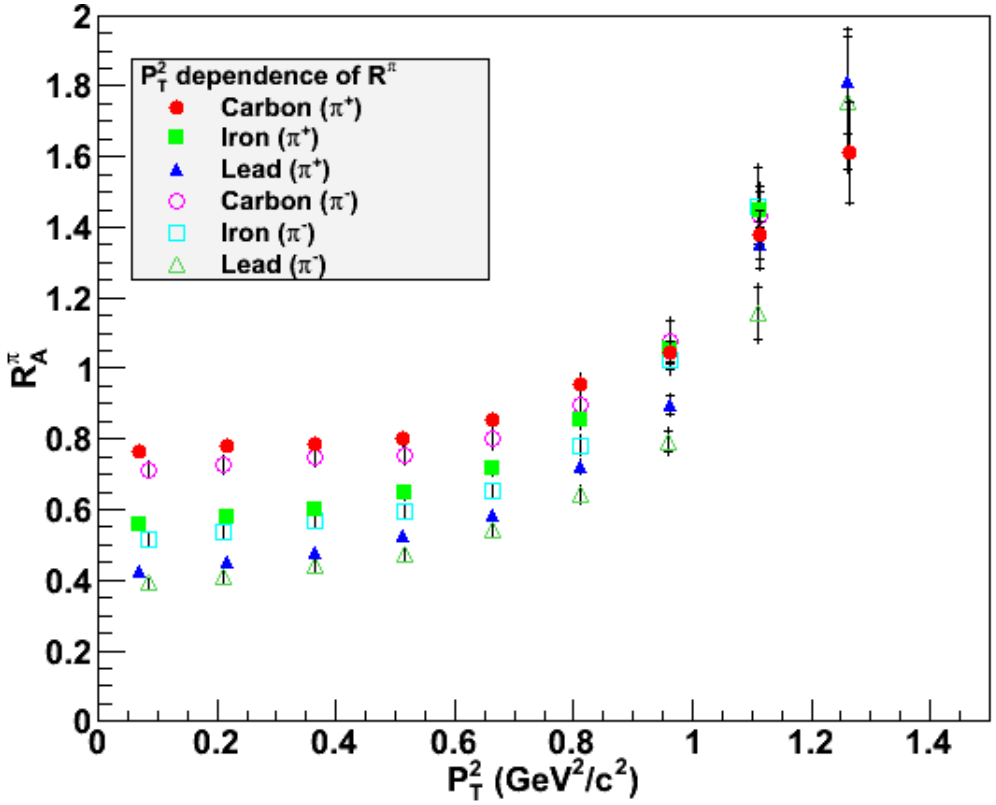
CLAS

- CEBAF Large Acceptance Spectrometer is composed of:
  - Torus magnet bending particle trajectories
  - Drift Chambers for momentum determination
  - Scintillators for time of flight measurement
    - Identification of pions and heavier particles
  - Cerenkov counters
    - Identification of electrons up to 2.5 GeV
  - Electromagnetic calorimeter
    - Identification of electrons



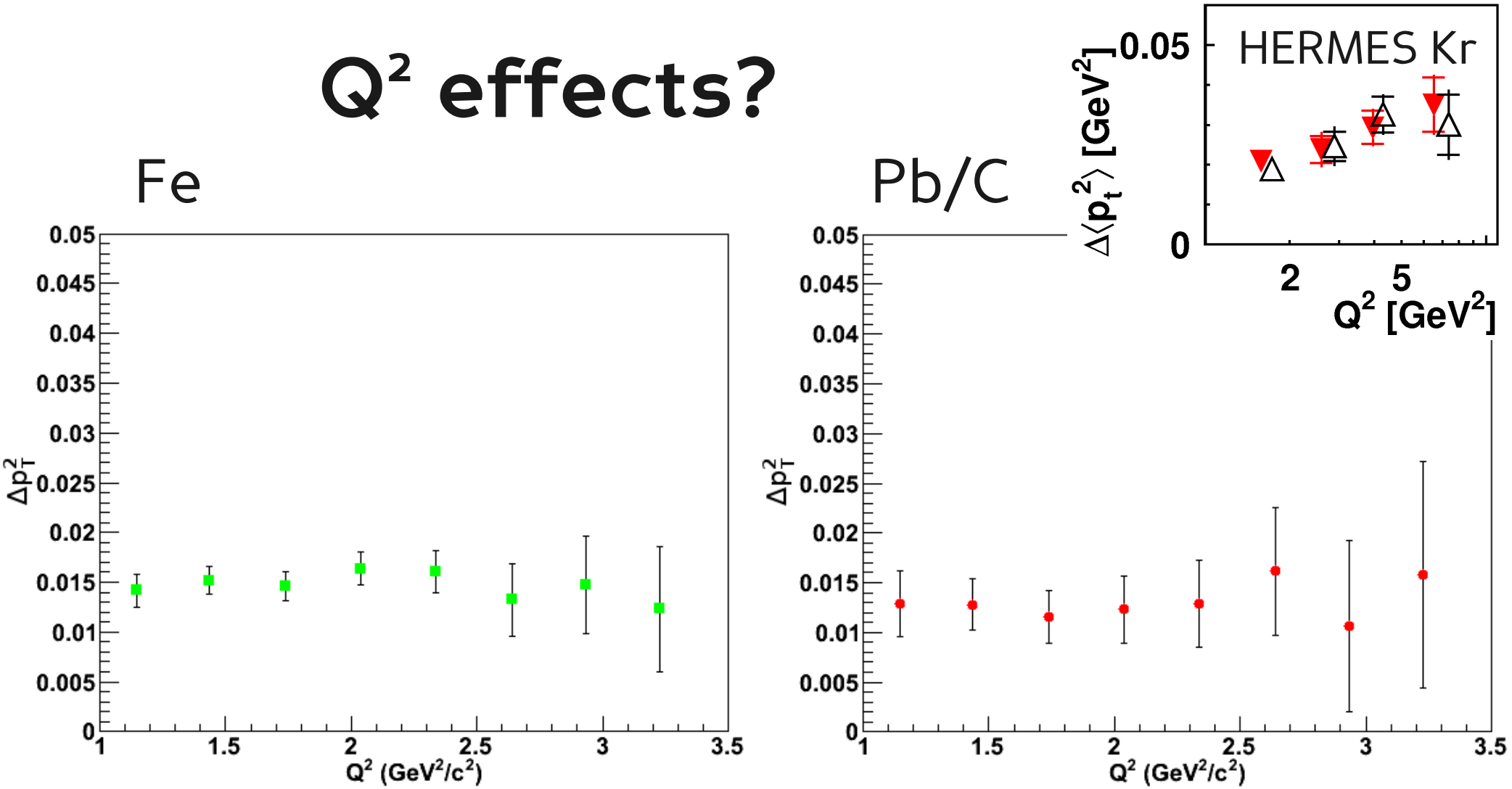
General Picture





- Similar to HERMES in z and P_T

Q^2 effects?



No modification of the transverse momentum broadening observed with Q^2

Summary

- Great progress achieved by HERMES
  - But issues with target fragmentation
  - They also raised new questions
- CLAS helps clarify some of these questions
  - No Q^2 evolution observed
- CLAS provides many new results to test models
  - Saturation of the nuclear effects at high A
  - Clean measurement of ν, Q^2, z and P_T
- The Future
  - More results can be extracted from CLAS data
  - CLAS12 to improve the observations of HERMES and CLAS
  - EIC to explore parton energy loss and medium FF