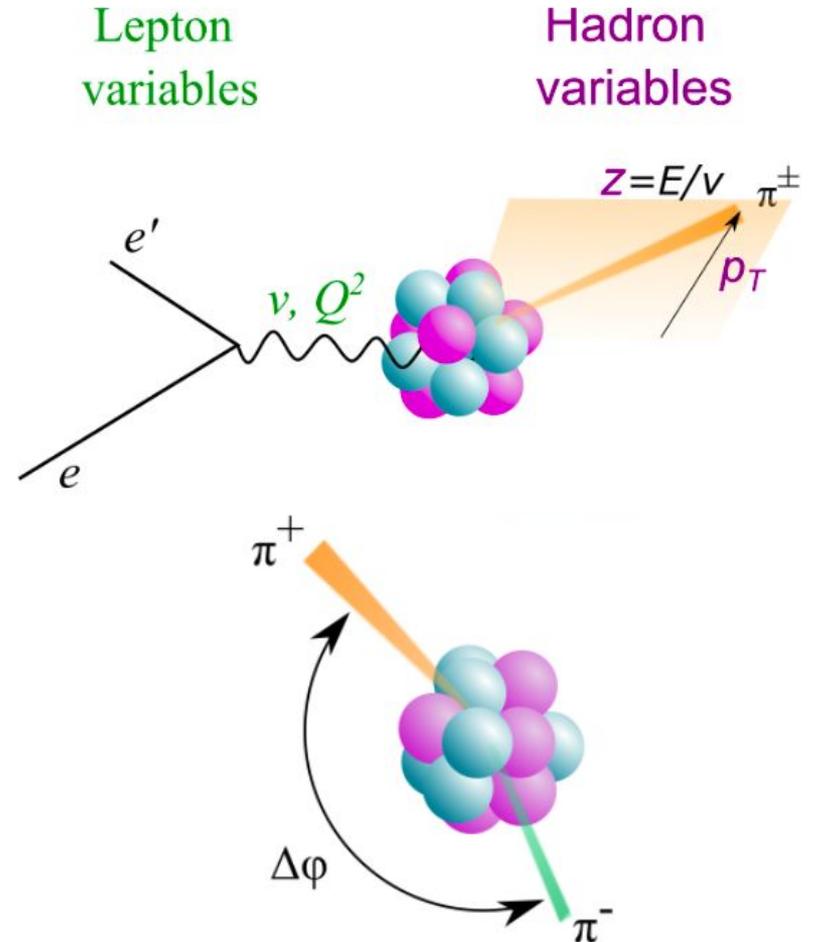


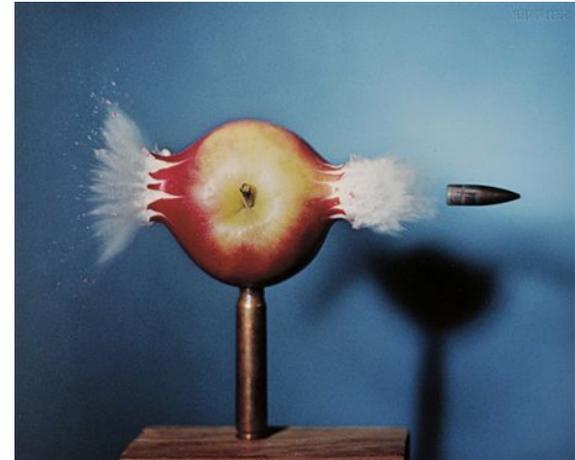
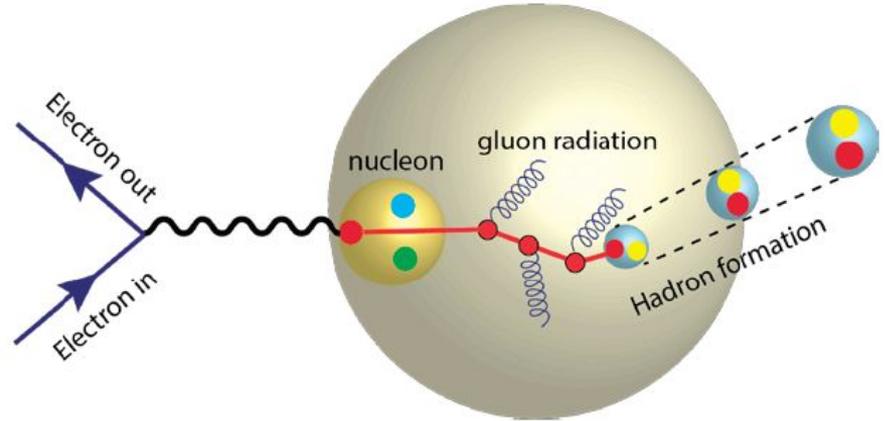
Recent Nuclear SIDIS results from Hall-B

Dr. Sebouh J. Paul
6/27/2023



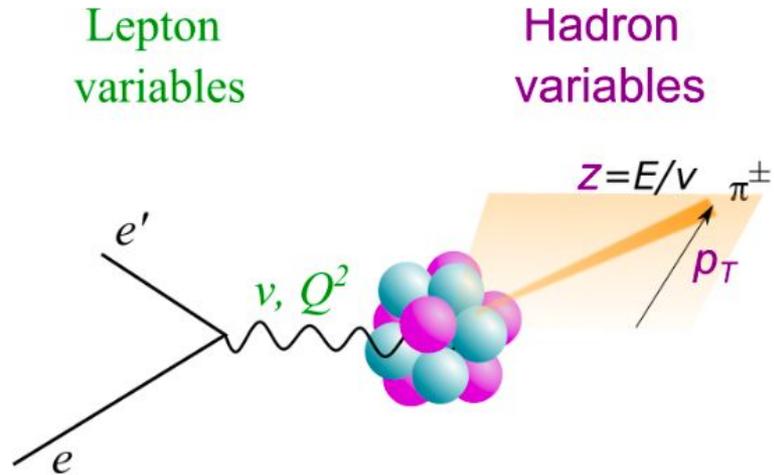
Motivation of Nuclear SIDIS program

- Striking a quark with an electron can dislodge it
- Measuring outgoing hadrons can reveal information about the interaction between quarks and the nucleus and also about the nuclear structure (i.e. nuclear TMDs)



π^\pm results

5 GeV data



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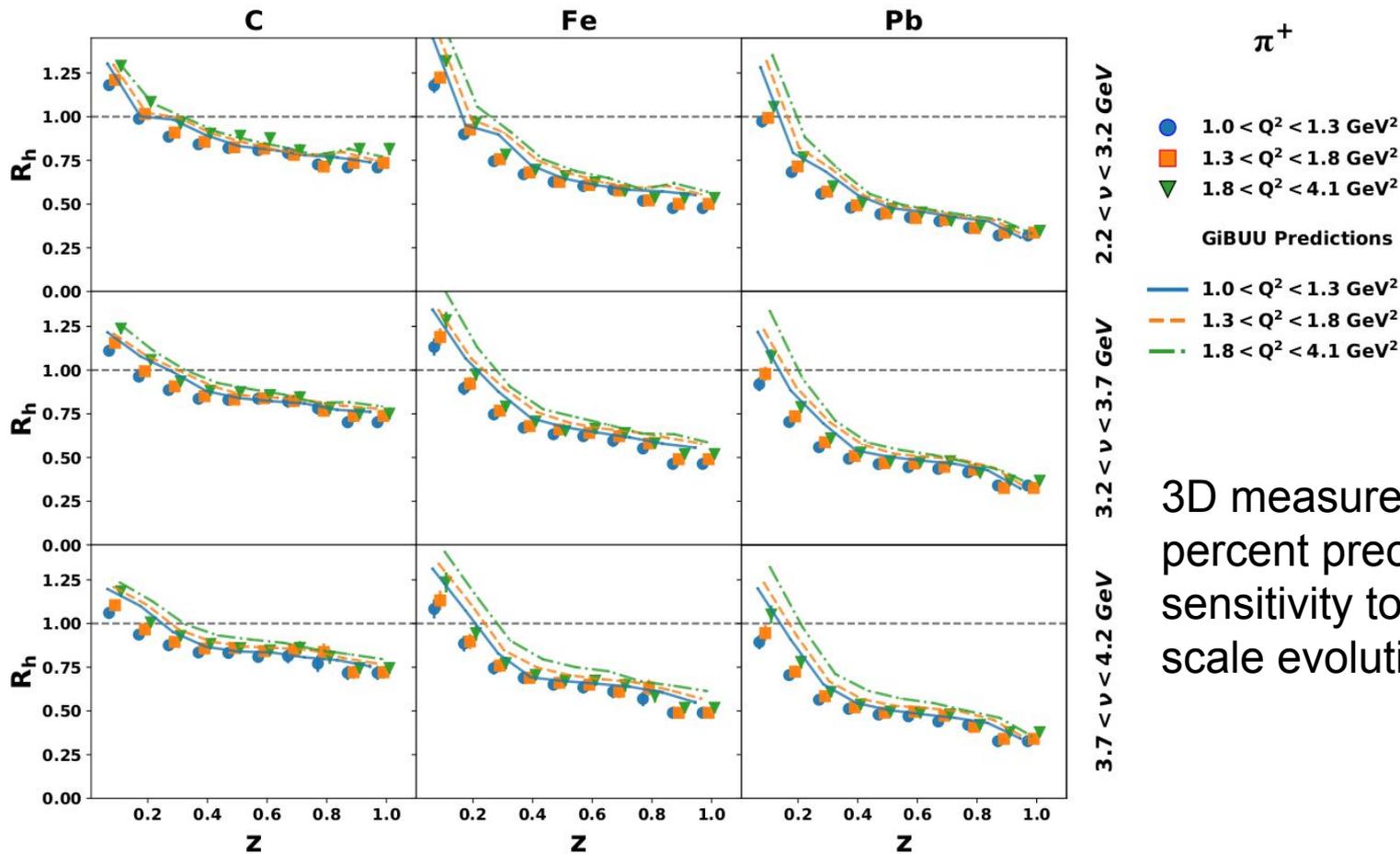
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Measurement of charged-pion production in deep-inelastic scattering off nuclei with the CLAS detector

S. Morán *et al.* (CLAS Collaboration)

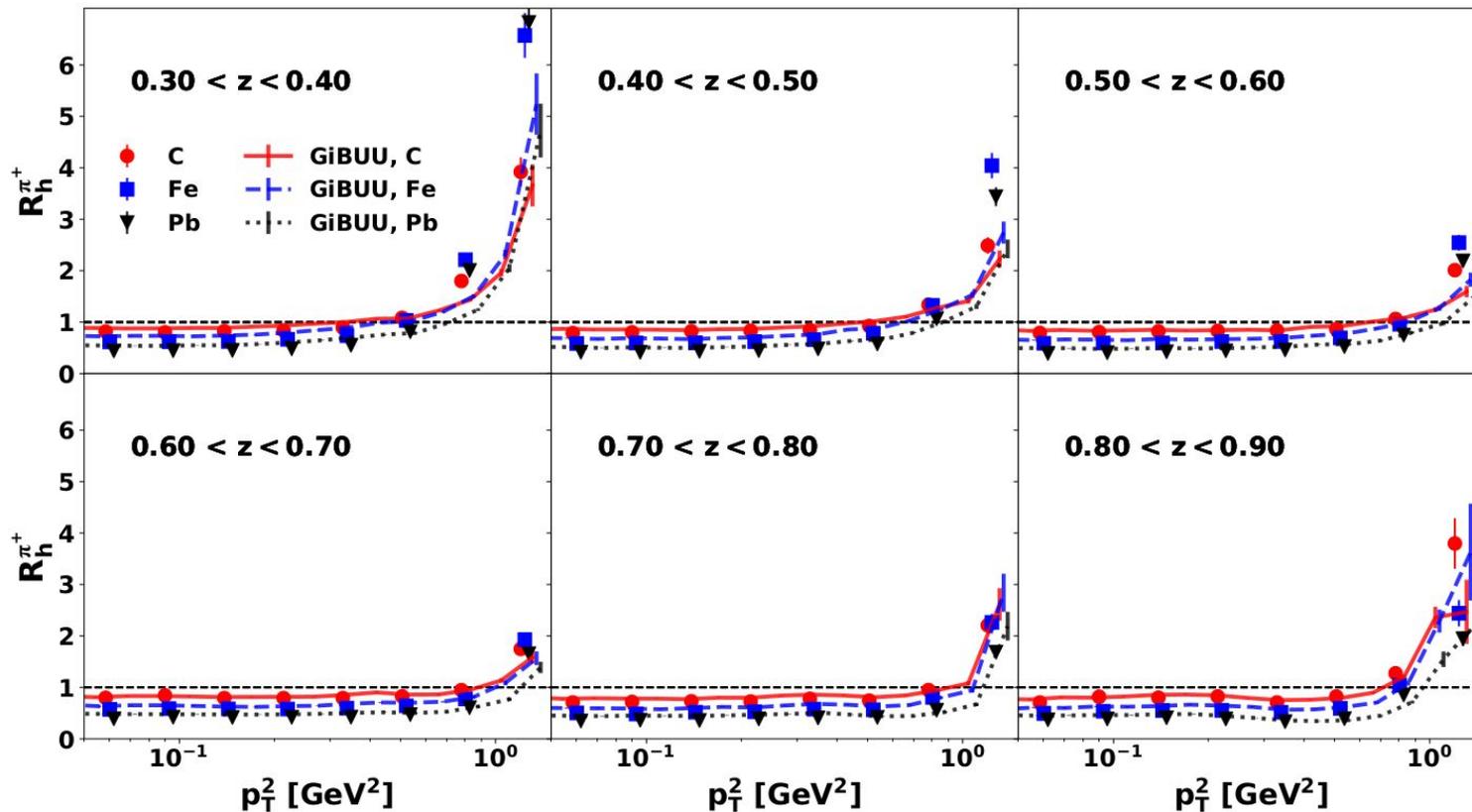
Phys. Rev. C **105**, 015201 – Published 12 January 2022

Multi-differential measurement of charged-pions



3D measurements with few percent precision, yielding sensitivity to flavour and scale evolution

Transverse-momentum dependent results

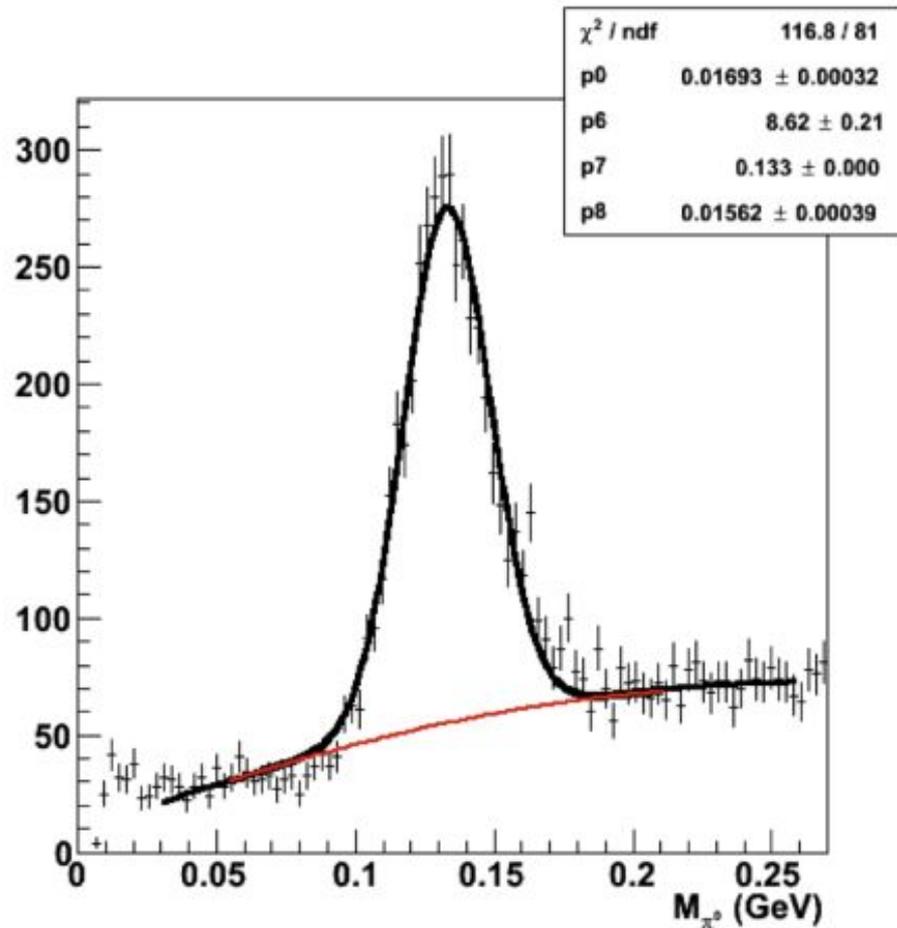


Non-monotonic dependence on z , indications of “remnant” behaviour at low z

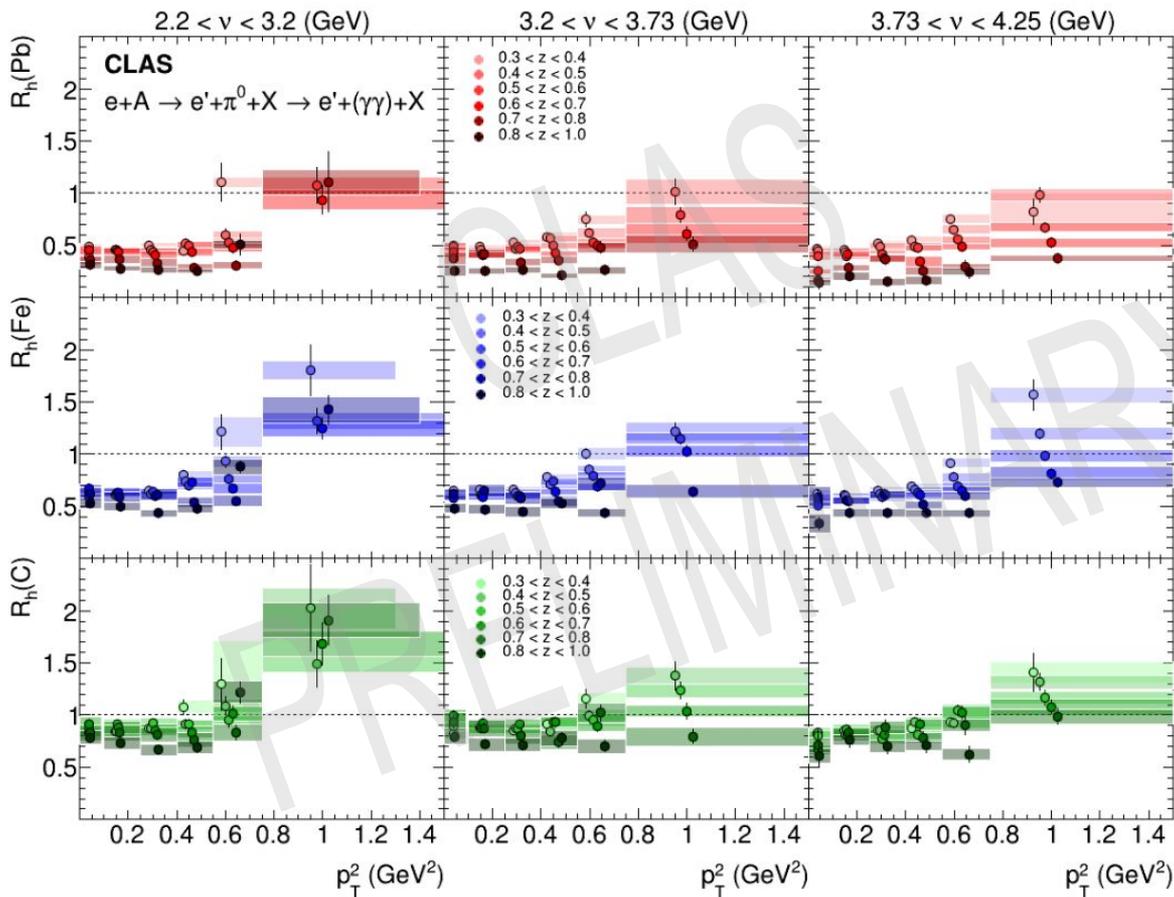
π^0 results

(preliminary, expect paper out imminently)

5 GeV data

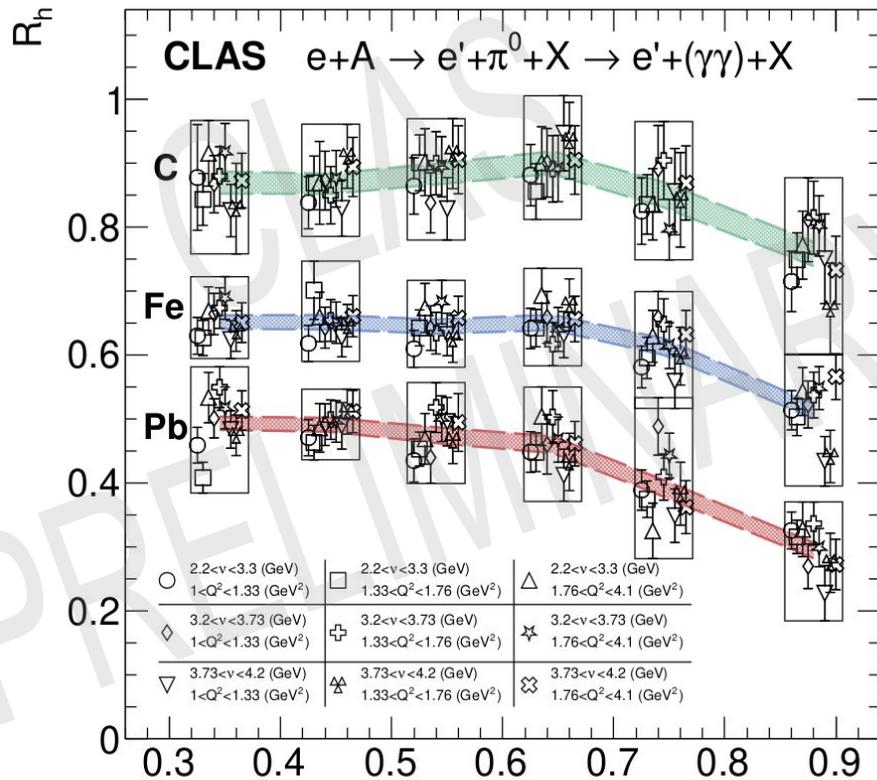


Multi-differential measurement of neutral pions



3D measurements,
complementing charged pion
results and yielding flavour
sensitivity

Summary plot for neutral pions

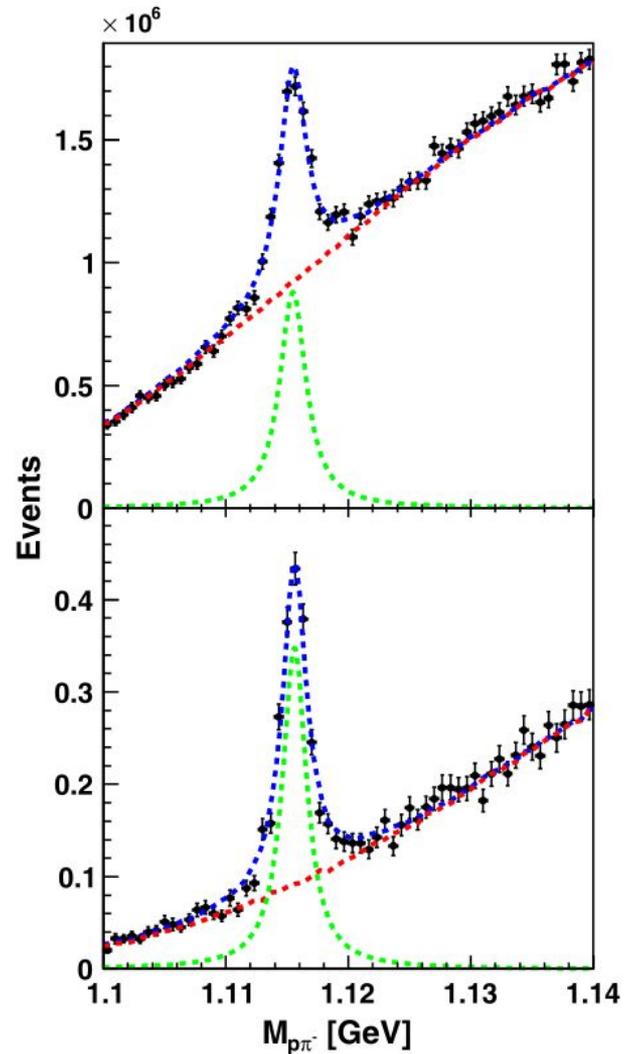


Small or no dependence on photon energy and virtuality observed.

Qualitatively different from HERMES, which motivates further studies with 11 GeV data

Λ results

5 GeV data



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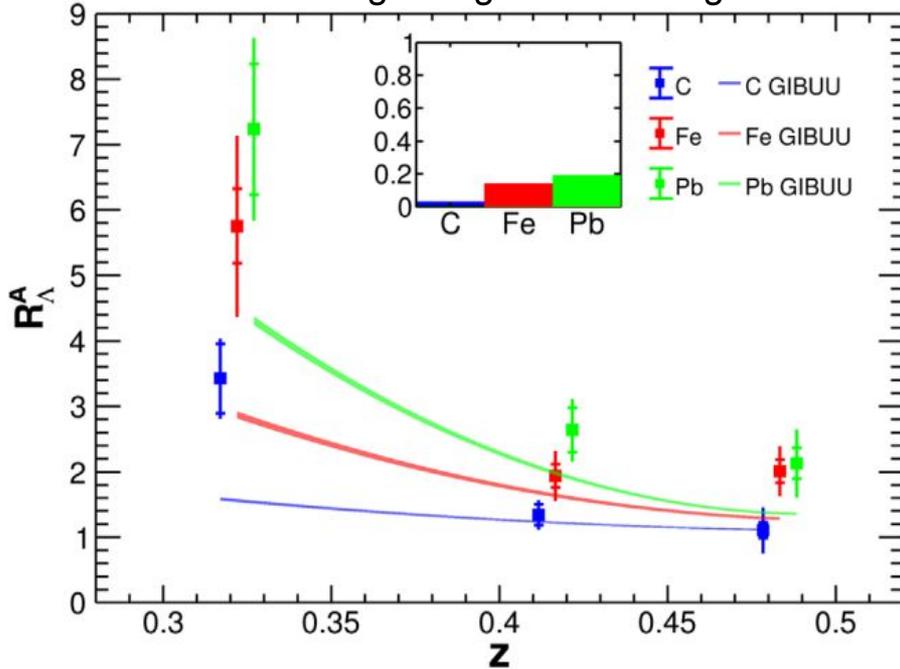
First Measurement of Λ Electroproduction off Nuclei in the Current and Target Fragmentation Regions

T. Chetry *et al.* (CLAS Collaboration)

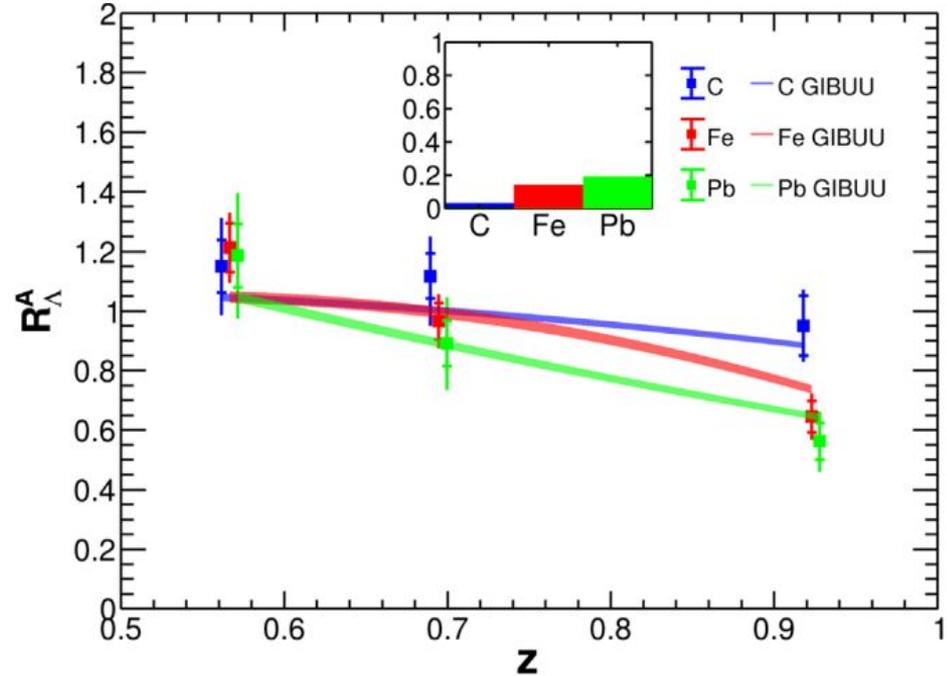
Phys. Rev. Lett. **130**, 142301 – Published 4 April 2023

Multiplicity ratio vs lambda energy

“Target fragmentation region”

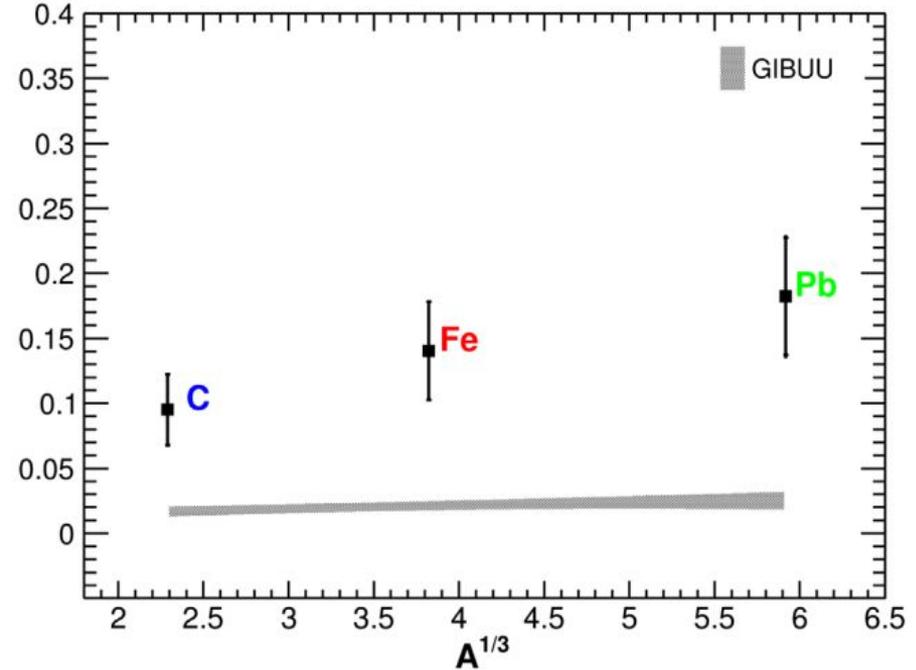
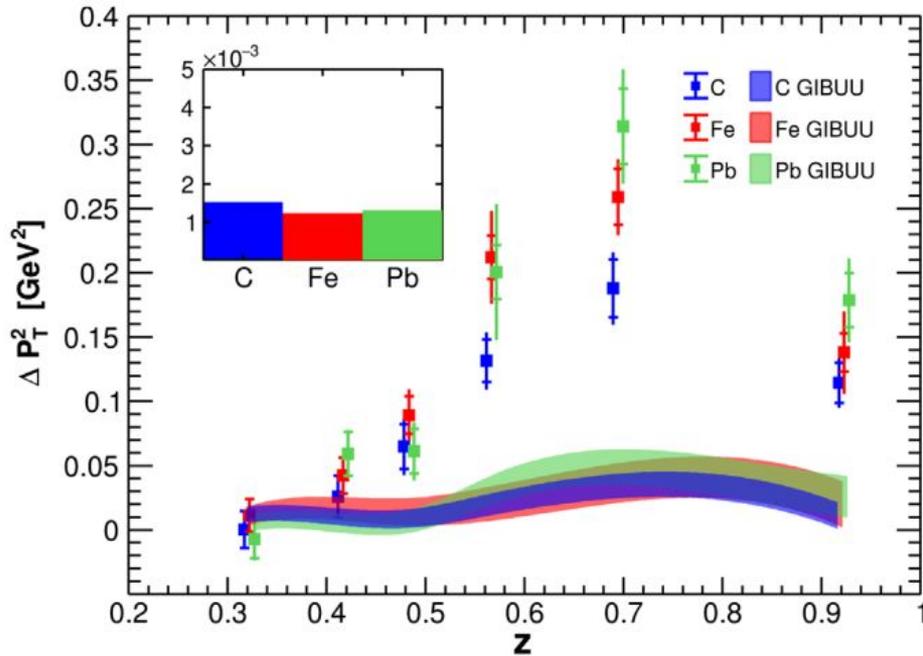


“Current fragmentation region”



- Stark contrast between target and current fragmentation region, with huge enhancements in the target region.
- Large z dependence, qualitatively described by GiBUU model

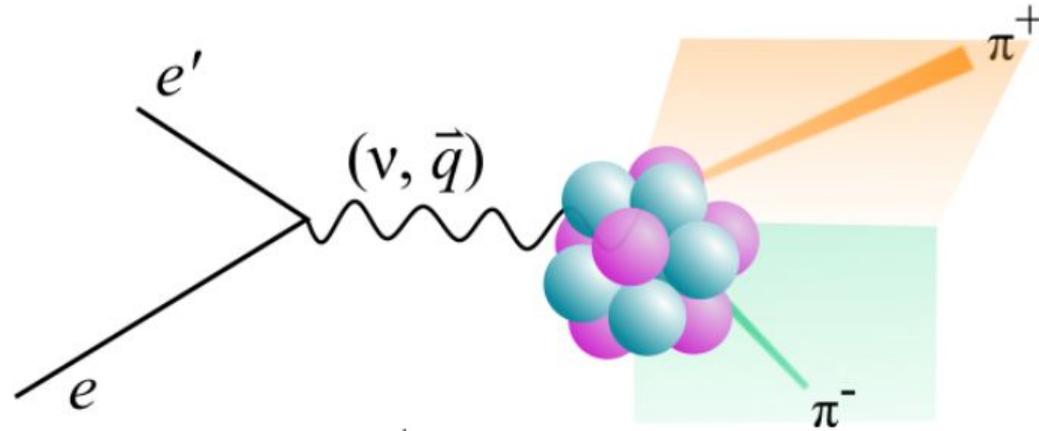
Transverse-momentum broadening



- Broadening much larger than model, and an order of magnitude larger than HERMES meson results.
- Indication of quark-diquark nucleon structure?

$\pi\pi$ results

5 GeV data



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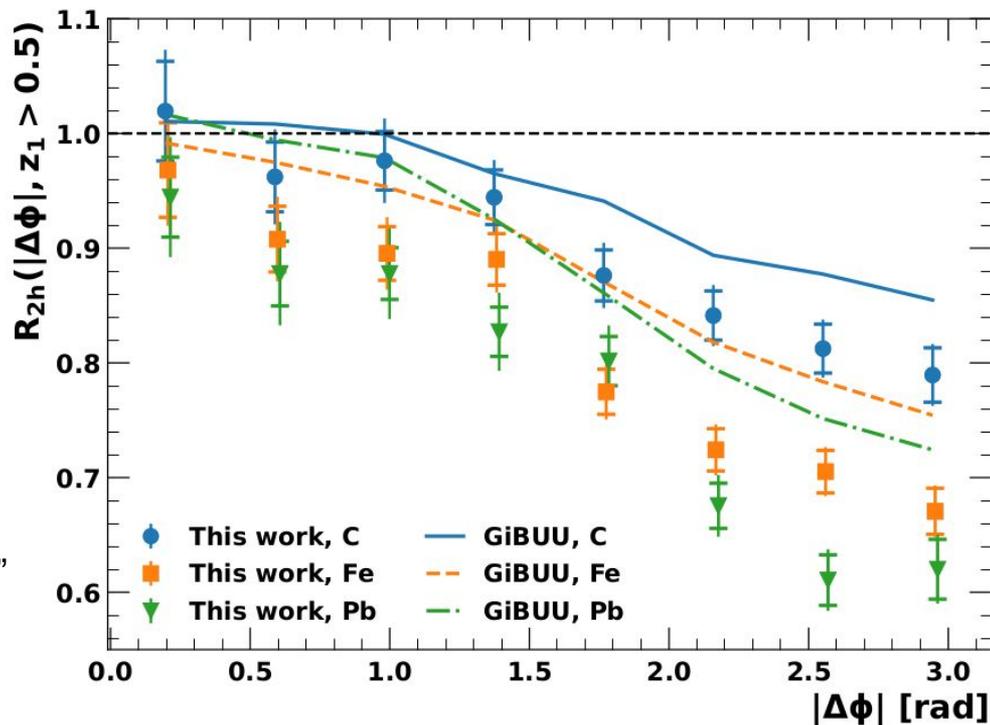
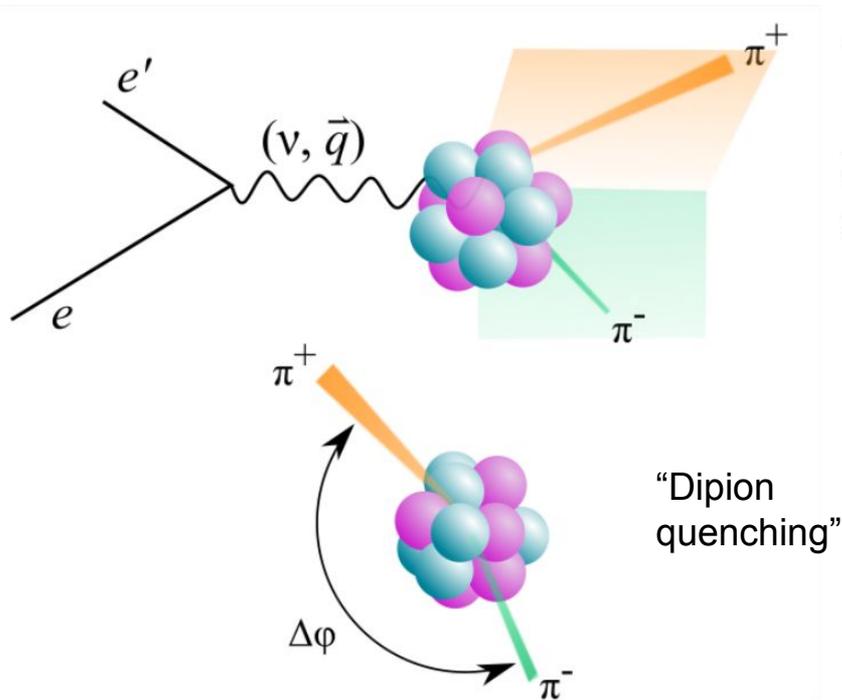
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Observation of Azimuth-Dependent Suppression of Hadron Pairs in Electron Scattering off Nuclei

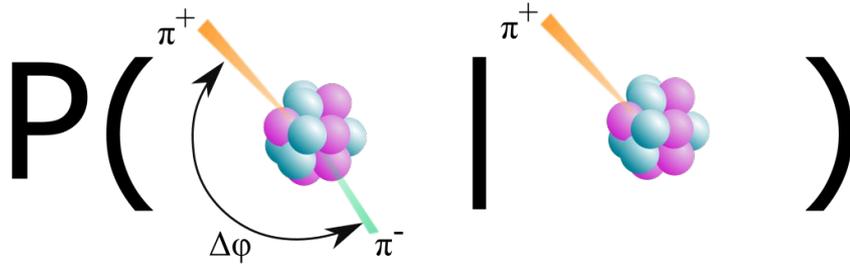
S. J. Paul *et al.* (CLAS Collaboration)

Phys. Rev. Lett. **129**, 182501 – Published 25 October 2022

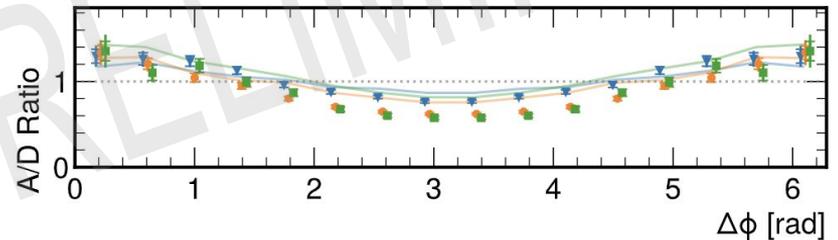
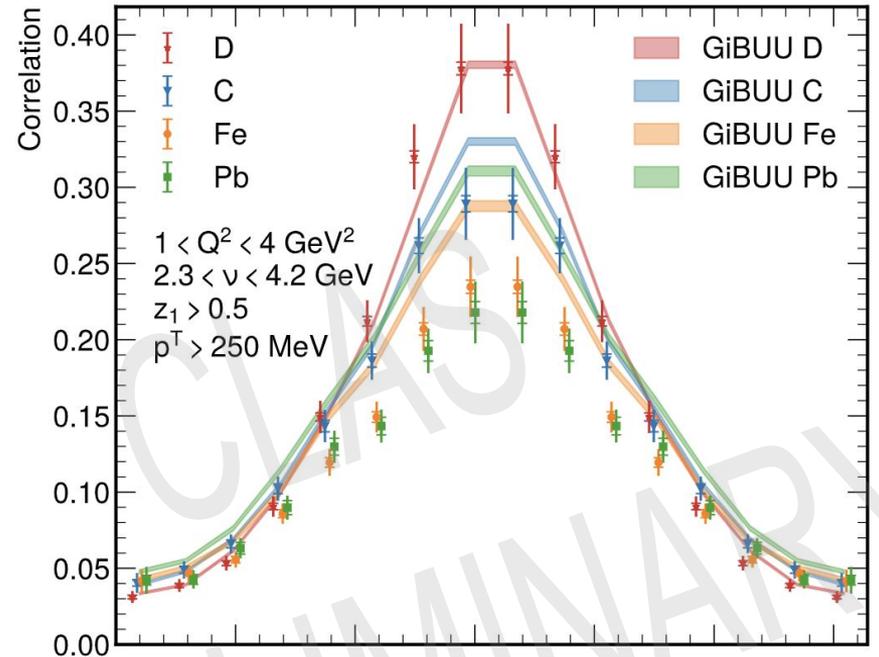
Discovery of back-to-back pion suppression in eA scattering



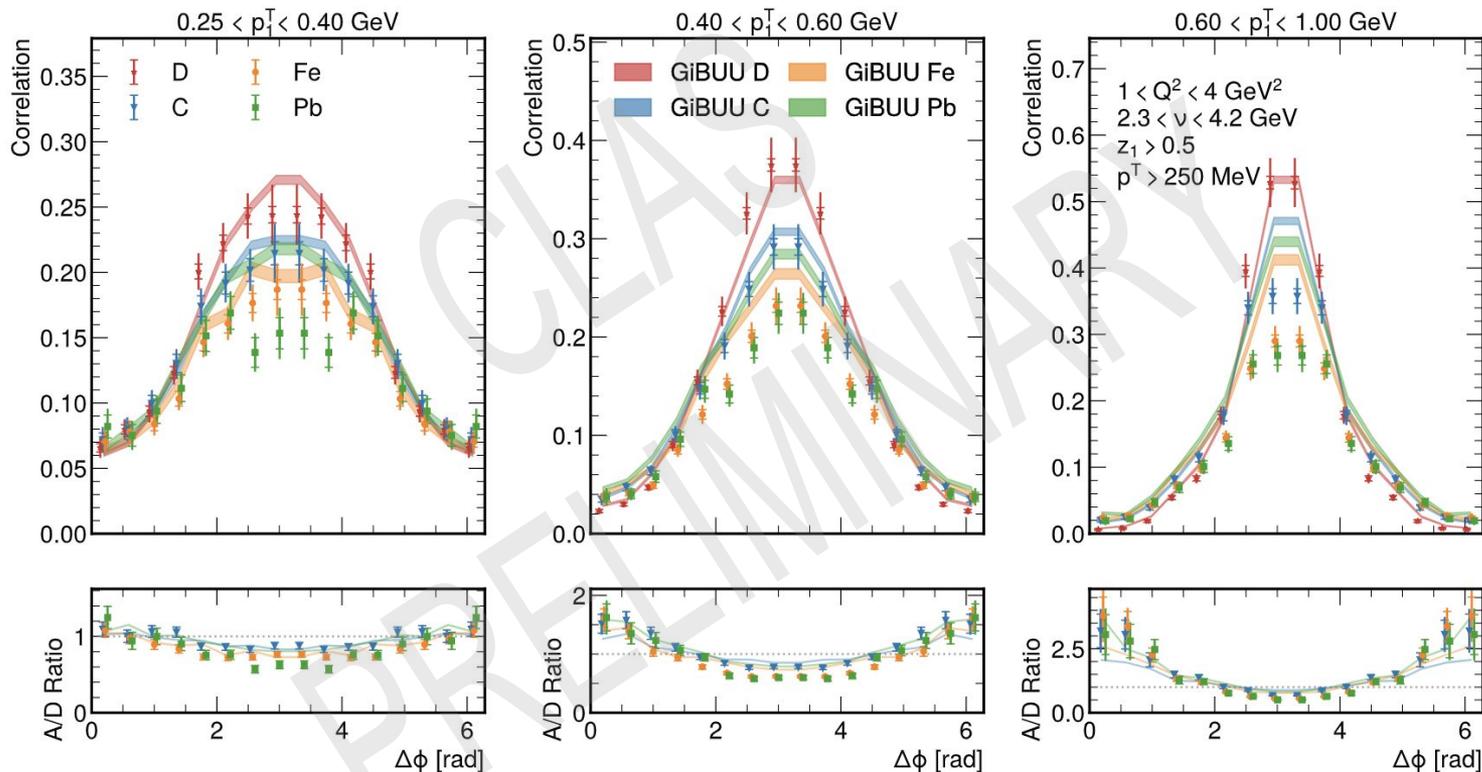
First measurement of dipion correlation function in eA



- Peak at $\Delta\phi = \pi$ (azimuthally back-to-back)
- Shorter and wider peak for nuclear, with larger values in tail compared to deuterium



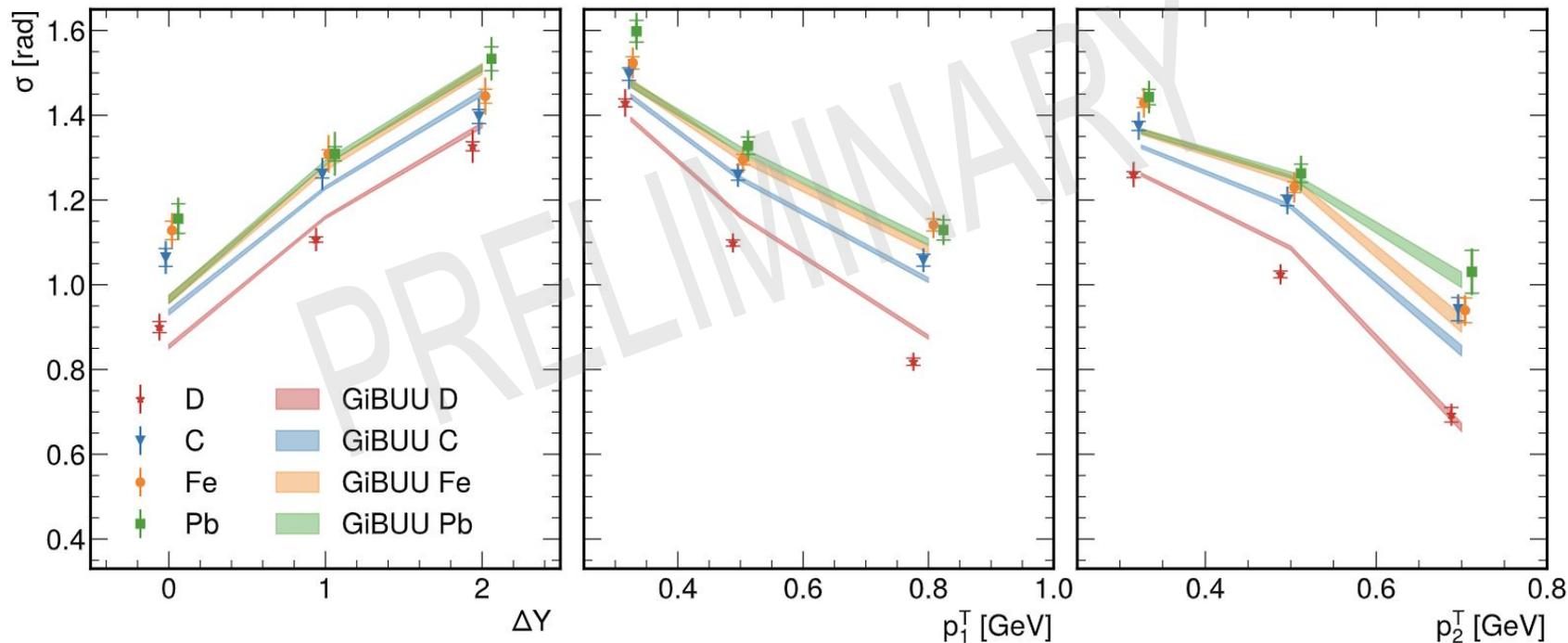
Dependence on transverse momentum of leading pion



- Strong kinematic dependence for correlations and nuclear effects

Widths of correlation functions (RMS)

$$\sigma = \sqrt{\frac{\int_0^{2\pi} d\Delta\phi C(\Delta\phi)(\Delta\phi - \pi)^2}{\int_0^{2\pi} d\Delta\phi C(\Delta\phi)}}$$



Perspective: some exciting new theory developments

“First eA MC generator” “Nuclear gluon TMDs”

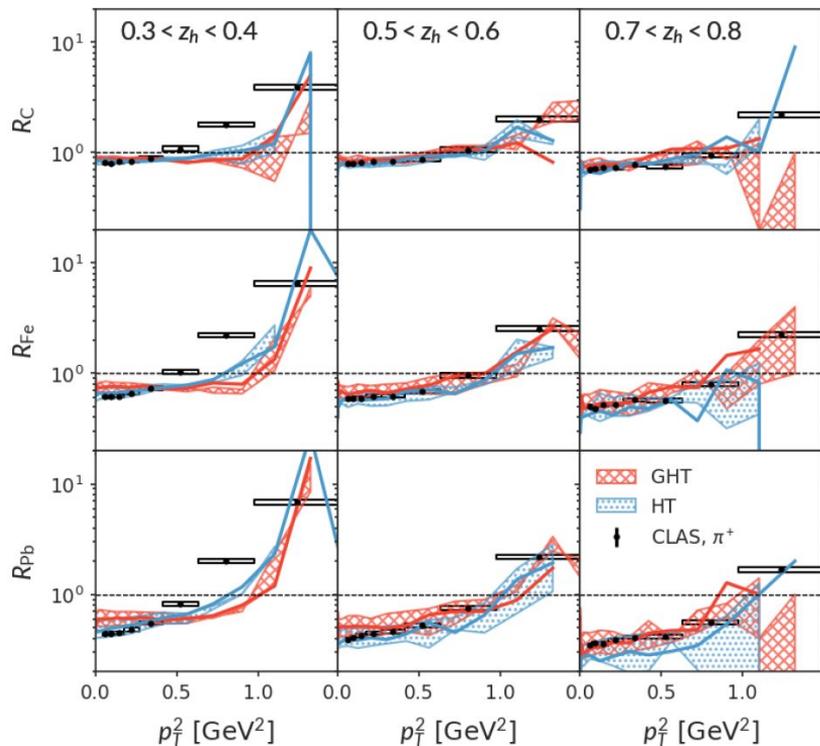
eHIJING: an Event Generator for Jet Tomography in Electron-Ion Collisions

Weiyao Ke, Yuan-Yuan Zhang, Hongxi Xing, Xin-Nian Wang

We develop the first event generator, the electron-Heavy-Ion-Jet-Interaction-Generator (eHIJING), for the jet tomography study of electron-ion collisions. In this generator, energetic jet partons produced from the initial hard scattering undergo multiple collisions with the nuclear remnants with a collision rate that is proportional to the transverse-momentum-dependent (TMD) gluon densities in the nucleus. Medium-modified QCD parton splittings within the higher-twist and generalized higher-twist framework are utilized to simulate parton showering in the nuclear medium that takes into account the non-Abelian Landau-Pomeranchuk-Midgal interference in gluon radiation induced by multiple scatterings. The TMD gluon distribution inside the nucleus is given by a simple model inspired by the physics of gluon saturation. Employing eHIJING, we revisit hadron production in semi-inclusive deep inelastic scattering (SIDIS) as measured by EMC, HERMES as well as recent CLAS experiments. eHIJING with both the higher-twist and generalized higher-twist framework gives reasonably good descriptions of these experimental data. Predictions for experiments at the future electron-ion colliders are also provided. It is demonstrated that future measurements of the transverse momentum broadening of single hadron spectra can be used to map out the two dimensional kinematic (Q^2, x_B) dependence the jet transport parameter \hat{q} in cold nuclear matter.

Tested with “recent CLAS experiments”

Example of impact of CLAS data: nuclear TMD studies with eA generator eHIJING <https://arxiv.org/abs/2304.10779>



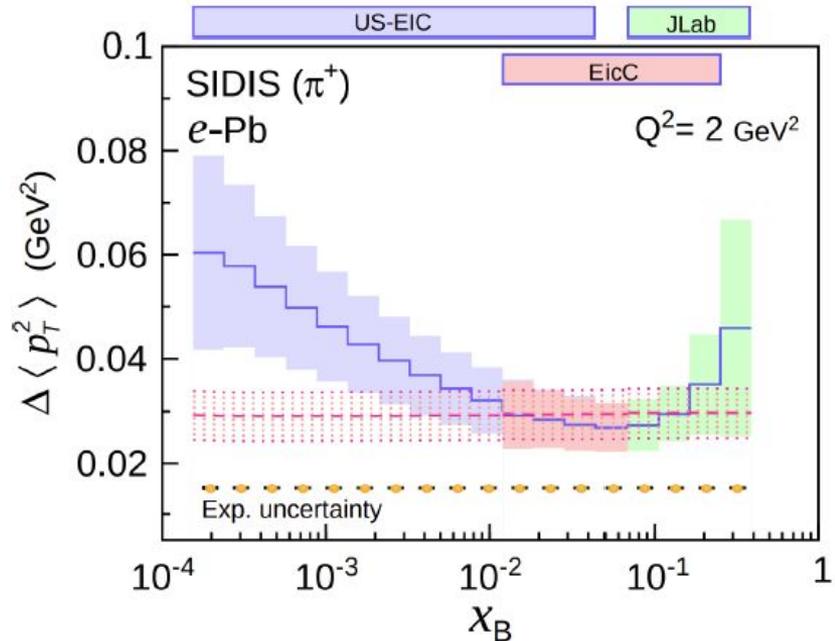
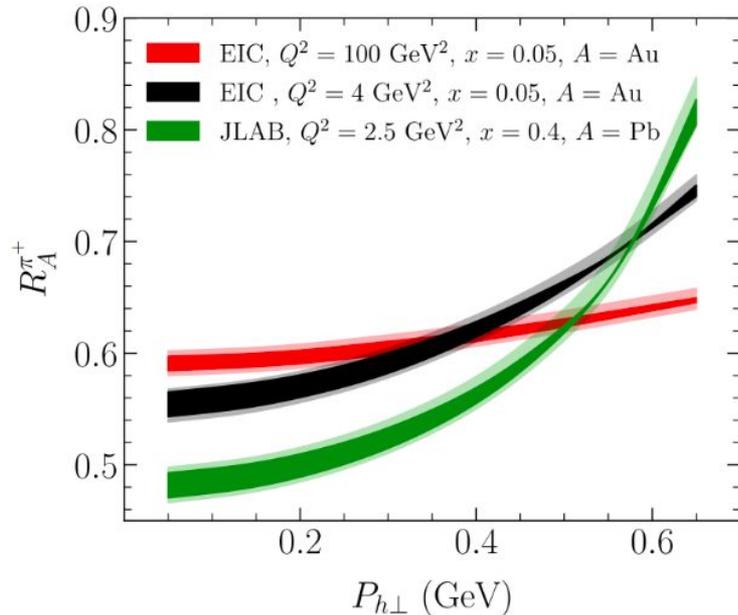
Still early days for eA TMD and MC developments.

CLAS12 data essential

Groundbreaking new theory developments, all of which make predictions for CLAS12.

“First nuclear TMD fit” [Phys. Rev. Lett. 129, 242001](#)

“First extraction of transport parameter of nuclei” [Phys. Rev. D 103, L031901](#)



Summary

- New results on charged pion, Neutral pion, dipion, and Lambda production with 5 GeV data (legacy papers)
- Complementary channels, yielding quark flavour sensitivity and stress test theory.
- Exciting new theory pertinent to these kinds of studies, with theory predictions for JLab 11 GeV coming up
- Exciting times ahead with 11 GeV and planned experiments RG-D and RG-E this and next year

