Charged Single- and Di-pion production in eA scattering with CLAS

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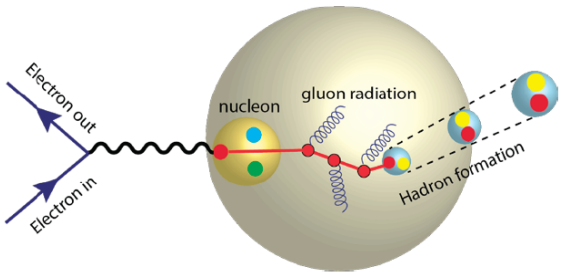
Outline

- Introduction
- Single-pion results/discussion
- Motivation for di-pion measurements
- Di-pion results
- Conclusions

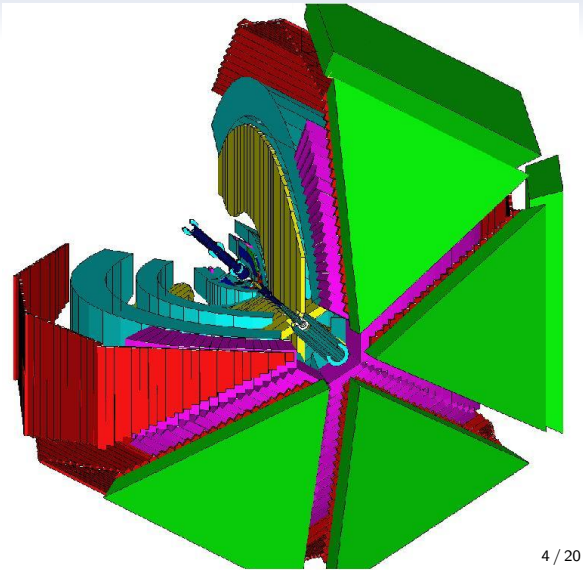
Introduction

- What happens when a fast moving quark moves through a nucleus?
- Struck quark $\rightarrow$ primary hadron
- Final-state interactions $\rightarrow$ secondary-hadron cascade
- Probability of hadron absorption may depend on momentum, production position, and type



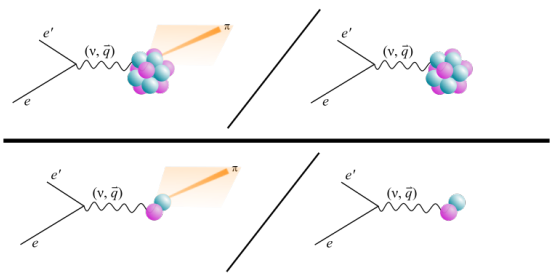
Dataset/Experimental Setup

- EG2 data from CLAS6
- $E_{beam} = 5.014$ GeV
- deuterium target in tandem with nuclear targets: C, Fe and Pb
- Setup minimizes systematic uncertainties for nuclear-to-deuterium ratios

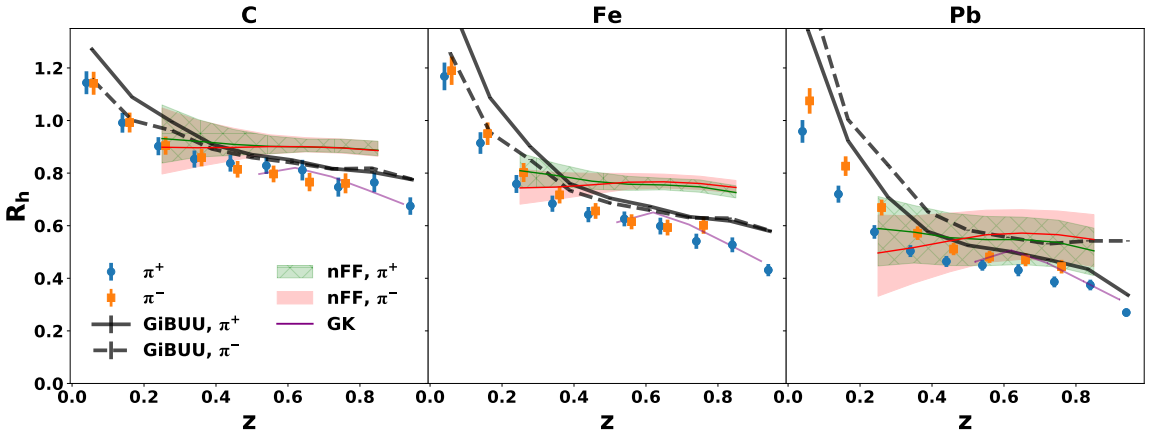


Single-pion observable: multiplicity ratio R_h

- $R_h(z) = \frac{(dN^A_{e\pi}/dz)/N^A_e}{(dN^D_{e\pi}/dz)/dN^D_e}$
- Some of the systematics cancel out in the double ratio
- results recently published: S. Moran et al, Phys. Rev. C 105 (2022), 015201



Results: Single pion



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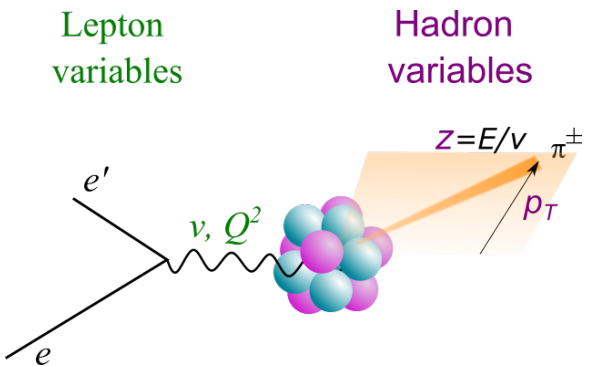
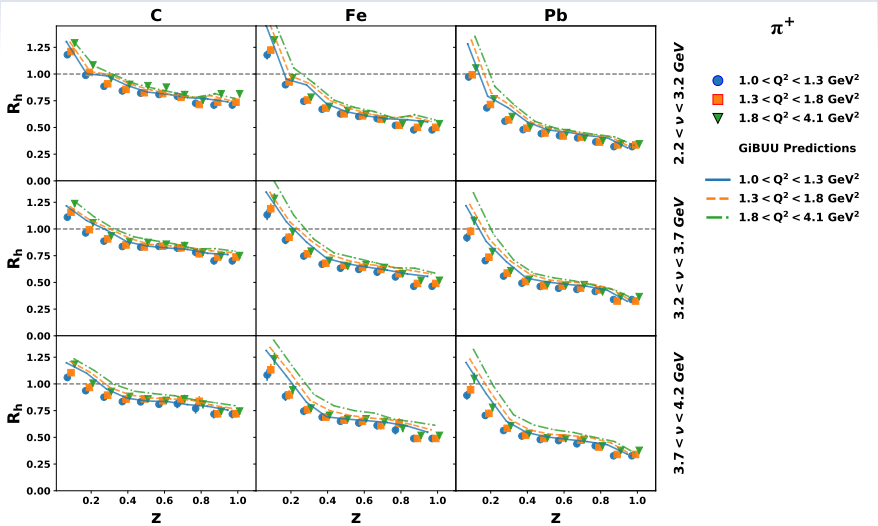
Multi-dimensional measurements

- Can the results in the previous slide be attributed to correlations between kinematic variables?
- Which kinematic variables strongly affect R_h?



Multidimensional Results: π^+



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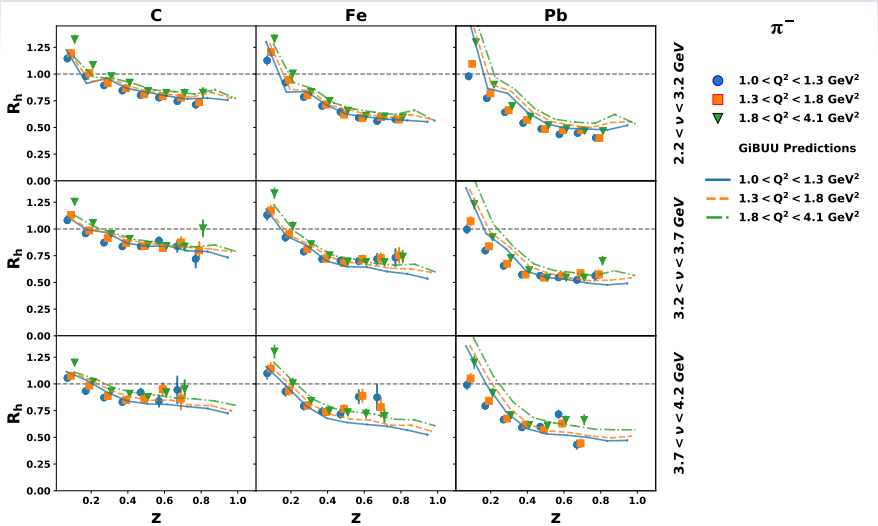
Multi-dimensional results π^-



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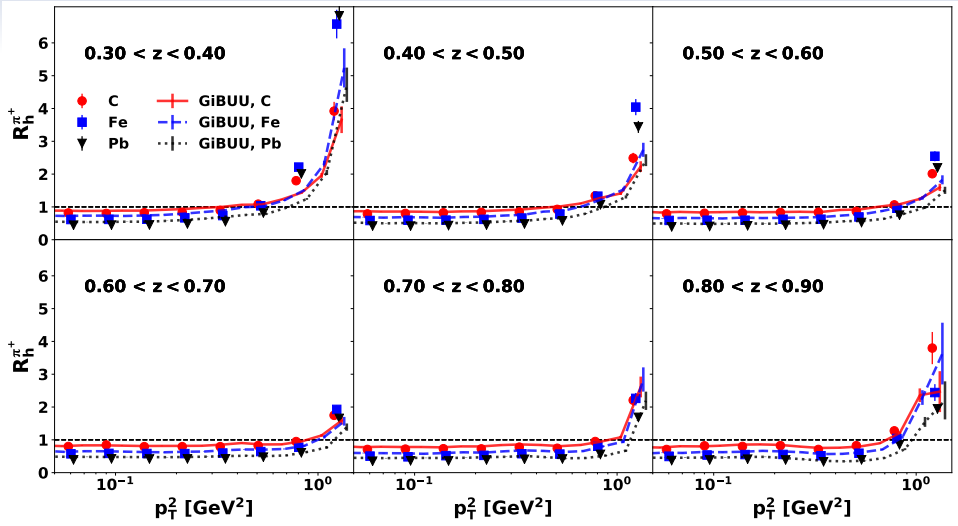
p_T dependence π^+



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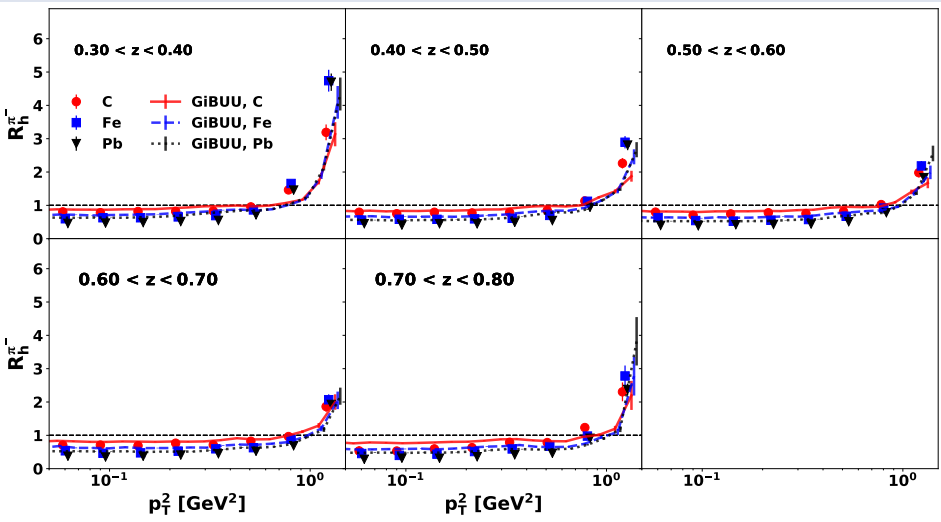
p_T dependence π^-



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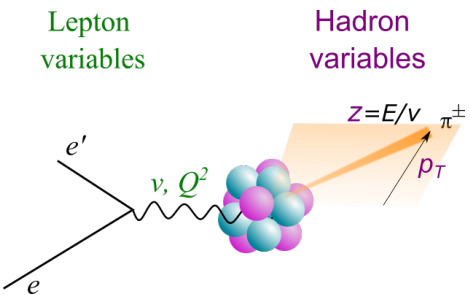
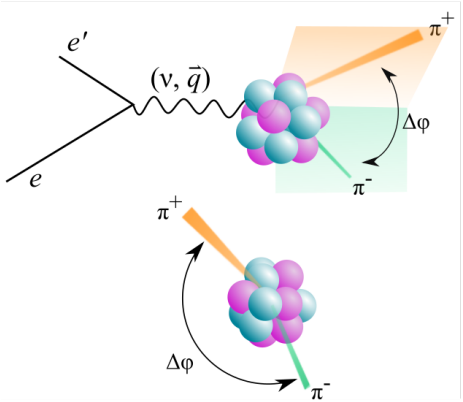
Summary of single-pion results

- Results highly sensitive to hadron variables and A, not so much to lepton variables.
- Enhancement at low z, suppression elsewhere.
- Uptick at high p_T.
- Qualitatively well-described by GiBUU model.
  - enhancement at low z due to secondary hadron creation in FSI.
  - suppression elsewhere due to absorption
  - high-p_T uptick caused by FSI modifying initially low-p_T hadrons



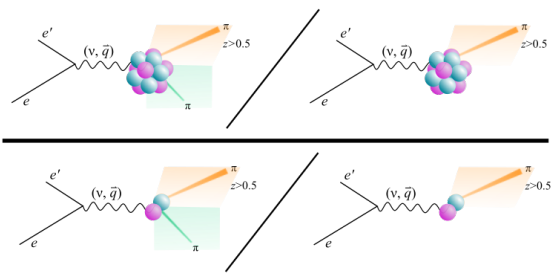
Why measure di-pion events?

- More sensitivity to nuclear effects,
- More kinematic variables
- Correlation effects not visible in single-pion measurements



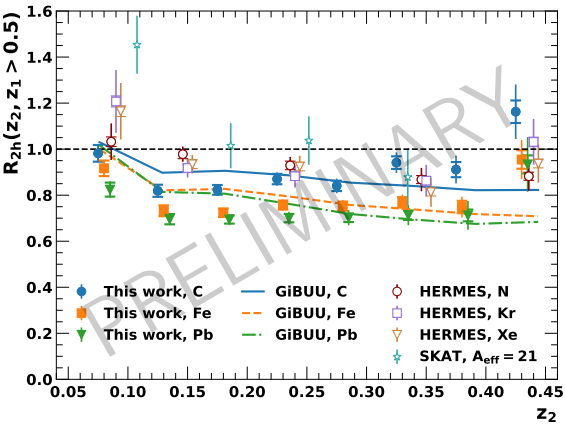
Di-pion observable: Conditional modification factor R_{2h}

- $R_{2h}(z_2) = \frac{(dN^A_{e\pi\pi}/dz_2)/N^A_{e\pi}}{(dN^D_{e\pi\pi}/dz_2)/dN^D_{e\pi}} | z_1 > 0.5$
- Even more cancellation of double-ratios in this double ratio than in R_h.
- Results are still preliminary.



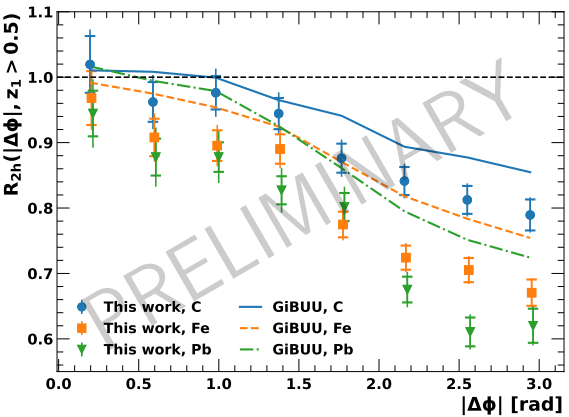
Di-pion results: z_2 dependence

- Clear nuclear dependence of R_{2h}
- Qualitatively described by the GiBUU model



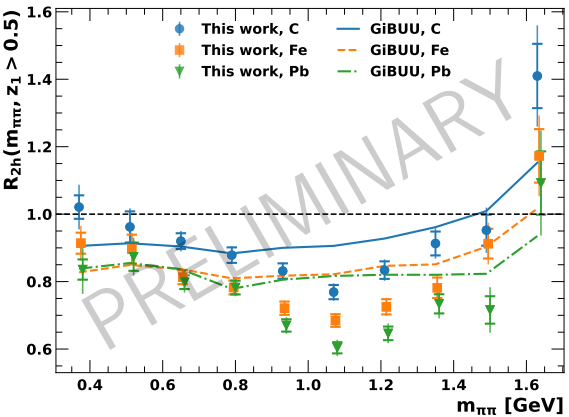
Di-pion results: $|\Delta\phi|$ dependence

- More suppression at high $|\Delta\phi|$.
- Can be interpreted as more absorption due to longer path length exiting nucleus



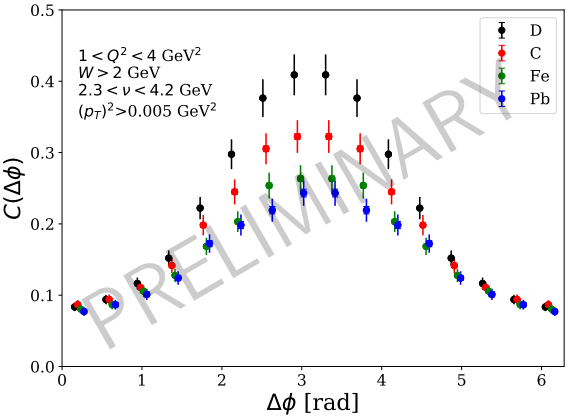
Di-pion results: $m_{\pi\pi}$ dependence

- No abrupt behavior at $\rho(770)$ mass
- Suggests that R_{2h} more closely related to the interactions between hadron and nucleus than to initial hadron-production means

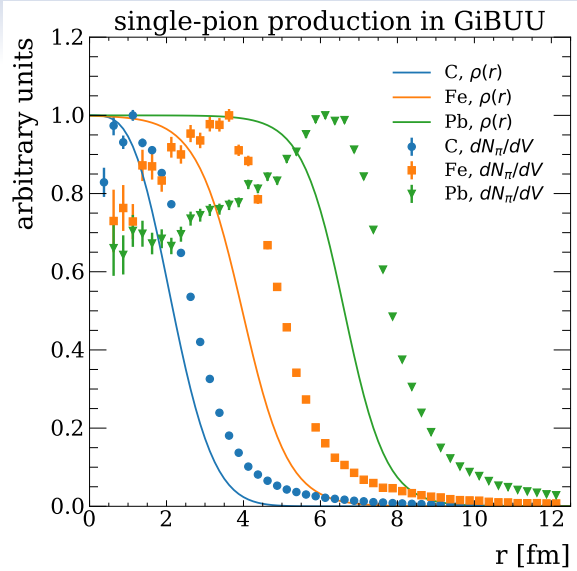


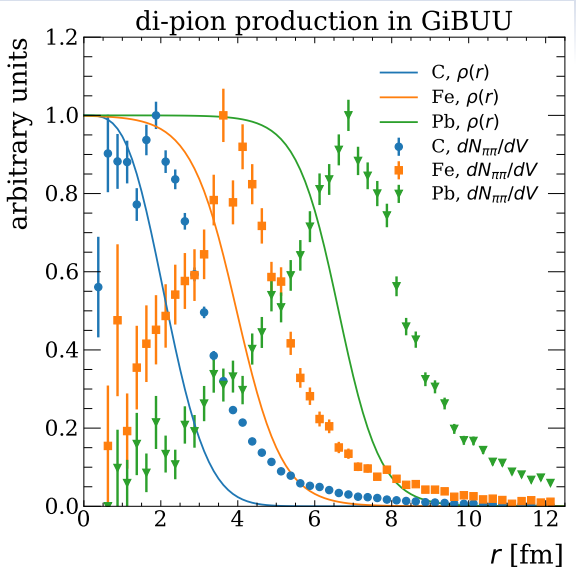
Azimuthal correlations

- Besides R_{2h}, another observable is the correlation function
- Probability of observing one hadron given the observation of another that is $|\Delta\phi|$ away.
- Larger statistical uncertainties than R_{2h}



Surface bias (GiBUU model)





Conclusions

- Charged single- and di-pion measurements were performed at CLAS with a clear nuclear dependence
- The GiBUU model qualitatively describes both datasets well.
- Nuclear modifications to both single- and di-pion yields can be explained by absorption and secondary-production effects.
- Di-hadron measurements compliment the single-hadron measurements by providing a geometric handle on the production position.
- Both our single- and di-pion results may be used in future fits to extract transport parameters needed to fine-tune models of interactions between hadrons and nuclei