Updates in di-hadron electroproduction off nuclei with EG2 data

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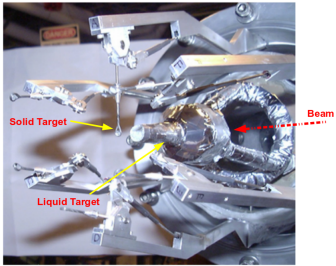
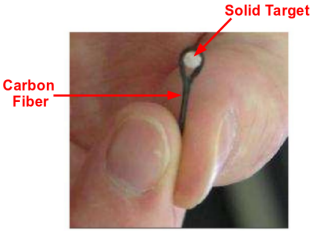
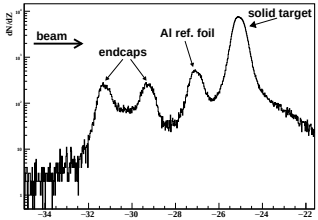
Introduction

EG2 CLAS Experiment



Two targets exposed to a 5,014 GeV electron beam simultaneously





center of CLAS at $z = 0$ [cm]

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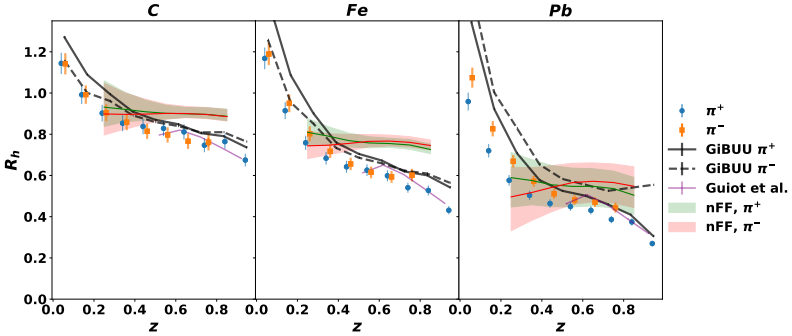
Previous Study: Single Hadron Ratio (R_h)

Main Results: $R_h = (N_h/N_e)|_A/(N_h/N_e)|_D$



- **Suppression increases with A**
- **Enhancement at low z**
- **Data qualitatively described by GiBUU model.**

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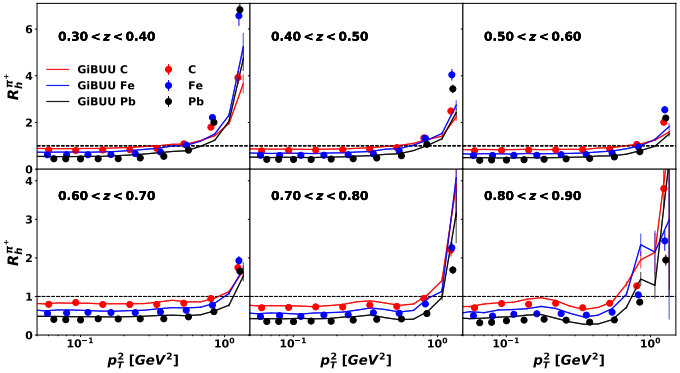
Previous Study: Single Hadron Ratio (R_h)

Main Results:



Weak P_T^2 dependence up to high values, where a strong rise is observed $\longrightarrow$ Cronin Effect

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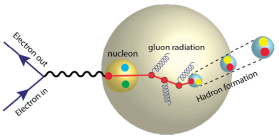
Current Study: Double Hadron Ratio (R_{2h})

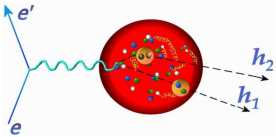
For double-hadron we select events with at least two charged pions.
One of the pions must have $z > 0.5$ (h_1 or "leading").
The sub-leading hadron is called h_2.

The conditional modification factor, R_{2h}, as a function of z_2, is defined as:

$$R_{2h}(z_2) = \frac{N_h^A(z_2, z_1 > 0.5)/N_h^A(z_1 > 0.5)}{N_h^D(z_2, z_1 > 0.5)/N_h^D(z_1 > 0.5)} \quad (1)$$



Double-hadron leptoproduction offers an additional way to study hadronization.



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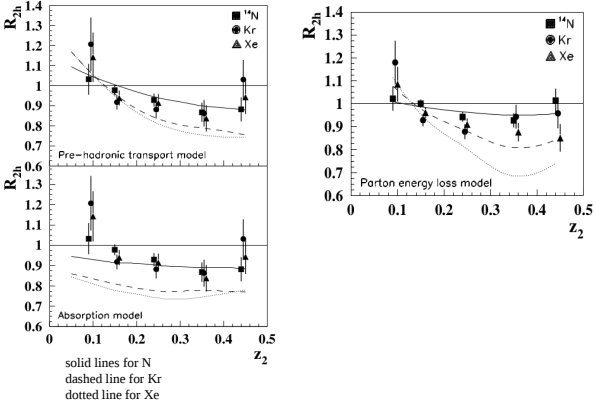
Previous Results on R_{2h}: HERMES (27.6 GeV positron beam) [1]



Main Conclusions:

- **Nuclear effects on the additional hadron are clearly observed (smaller than single-hadron).**
- **Small A dependence.**
- **Small effect from exclusive ρ^0 production.**
- **Data in conflict with models.**

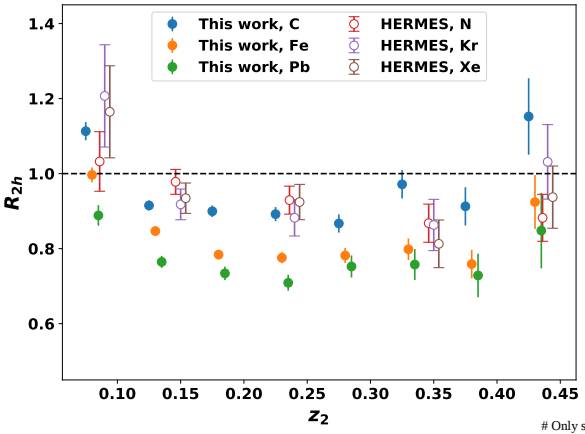
[1] Taken from A. Airapetian et al. *Double hadron leptoproduction in the nuclear medium, Phys. Rev. Lett. 96, 162301.* arxiv-link

Some Preliminary Results

R_{2h}: Fractional energy of sub-leading hadron (z_2) dependence. HERMES Comparison

Table 1: Mass numbers

Targ	A
C	12
N	14
Fe	56
Kr	84
Xe	131
Pb	208



- **Evidence for A-dependence (unlike HERMES)**

Table 2: Experiments coverage

	HERMES (e-A)	CLAS 6
Event Selection	$Q^2 > 1$ GeV2, $W > 2$ GeV, $y < 0.85$, $\nu > 7$ GeV	$Q^2 > 1$ GeV2, $W > 2$ GeV, $y < 0.85$
Average Kinematics	$\langle Q^2 \rangle = 2.4$ GeV2 $\langle \nu \rangle = 17.7$ GeV	$\langle Q^2 \rangle = 1.6$ GeV2 $\langle \nu \rangle = 3.4$ GeV
Targets	Ne, Kr, Xe Statistic limited No PID	C, Fe, Pb Large statistic PID

- **Our results are more precise than HERMES**

Only statistical errors are shown

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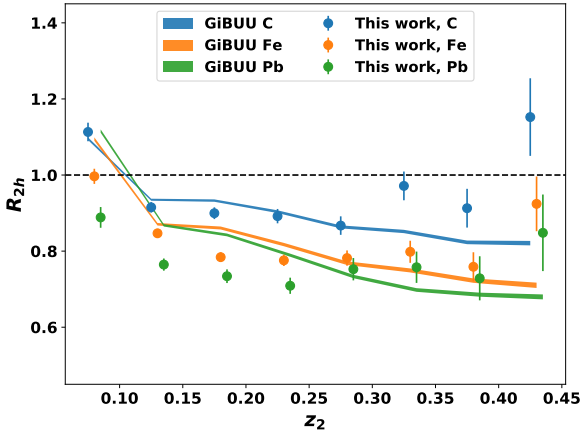
R_{2h}: Fractional energy of sub-leading hadron (z_2) dependence. Comparison with GiBUU



- **Qualitatively described by GiBUU**

Only statistical errors are shown

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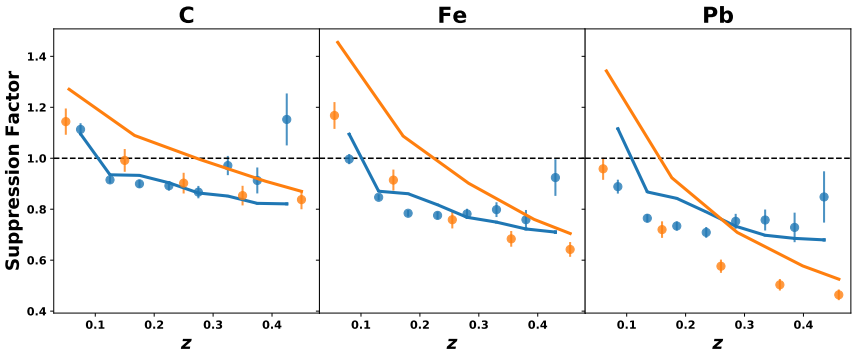
Single v/s Double Suppression Factor



In absence of correlations induced by nuclear effects, it should holds that

$$R_{2h} = R_h$$

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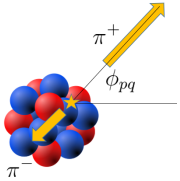
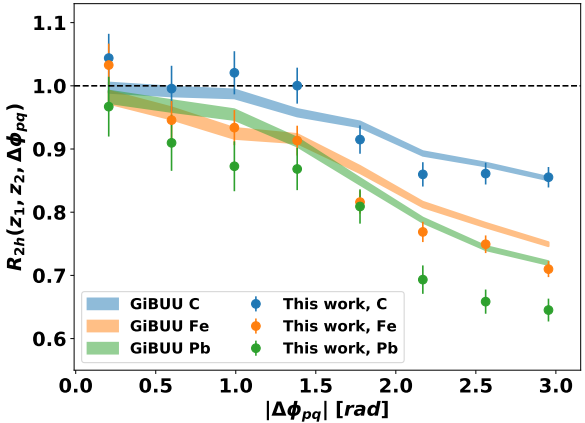
R_{2h}: Azimuthal difference of pion pair dependence





- **Strong dependence on $\Delta\phi$ for all targets**
- **Qualitatively described by GiBUU**
- **Back-to-back pairs present the strongest suppression**

Only statistical errors are shown

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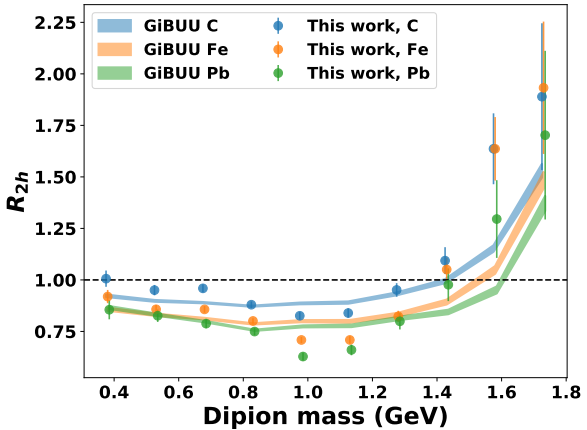
R_{2h}: Pion-pair invariant mass dependence



- **Small dependence until large values (“Cronin-like” effect)**
- **Qualitatively described by GiBUU**
- **No observable effect at ρ^0 mass**

Only statistical errors are shown

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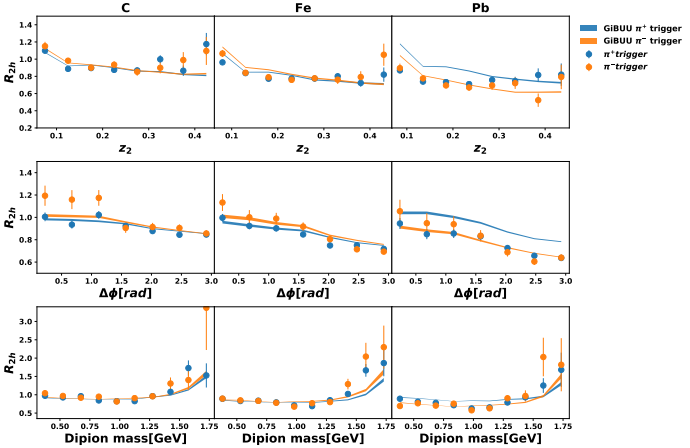
π^+/π^- Trigger Results



- **Breaking the R_{2h} into two categories: π^+ trigger only and π^- trigger only.**
- **Compatibility for most ranges.**
- **GiBUU predicts a difference for Pb that is not supported by the data.**

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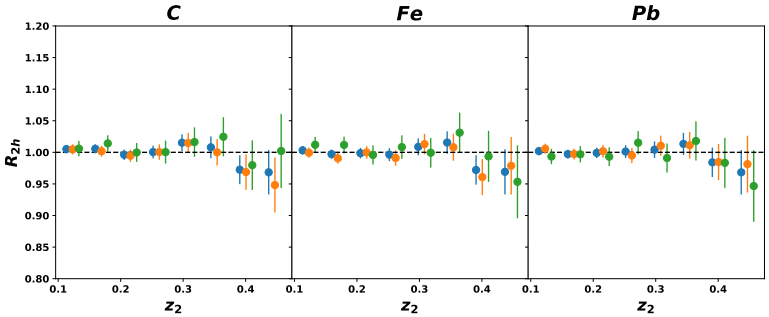
R_{2h}: MC study: acceptance correction cancellation



- Ratio consistent with unity within uncertainties.
- Same behavior for R_{2h} as a function of $\Delta\phi$ and inv mass of the pair.

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Conclusions

Conclusions

1. **Reported results on R_{2h} as a function of z_2 shows discrepancies with HERMES.**
2. **Reported results on R_{2h} as a function of dipion invariant mass shows Cronin-like effects.**
3. **We have reported the first measurement of azimuthal correlations in di-hadron production in DIS.**
4. **GiBUU model qualitatively described the data.**
5. **These measurements present a significant extension over HERMES's results.**

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Next Steps

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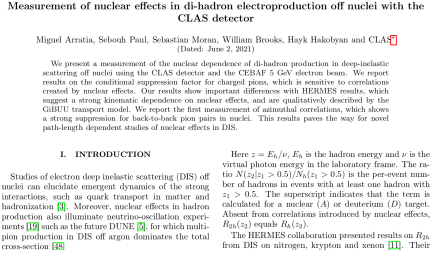
Next Steps

1. **Finish systematic studies**
2. **Continue the writing process of the Analysis Note. Taking shape fast!, heavily based on previous and recently approved single hadron Analysis Note.**
3. **Continue to work on paper draft for this analysis. The paper will have 3 plots: $R_{2h}(z_2)$, $R_{2h}(\Delta\phi)$, and R_{2h}(dipion inv. mass).**



Measurement of nuclear effects in di-hadron electroproduction off nuclei with the CLAS detector

Miguel Arratia, Sebouh Paul, Sebastian Moran, William Brooks, Hayk Hakobyan and CLAS*

(Dated: June 2, 2021)

We present a measurement of the nuclear dependence of di-hadron production in deep-inelastic scattering off nuclei using the CLAS detector and the CEBAF 5 GeV electron beam. We report results on the conditional suppression factor for charged pions, which is sensitive to correlations created by nuclear effects. Our results show important differences with HERMES results, which suggest a strong kinematic dependence on nuclear effects, and are qualitatively described by the GiBUU transport model. We report the first measurement of azimuthal correlations, which shows a strong suppression for back-to-back pion pairs in nuclei. This results paves the way for novel path-length dependent studies of nuclear effects in DIS.

I. INTRODUCTION

Studies of electron deep inelastic scattering (DIS) off nuclei can elucidate emergent dynamics of the strong interactions, such as quark transport in matter and hadronization [3]. Moreover, nuclear effects in hadron production also illuminate neutrino-oscillation experiments [19] such as the future DUNE [5], for which multi-pion production in DIS off argon dominates the total cross-section [18].

Here $z = E_h/\nu$, E_h is the hadron energy and ν is the virtual photon energy in the laboratory frame. The ratio $N(z_2|z_1 > 0.5)/N_h(z_1 > 0.5)$ is the per-event number of hadrons in events with at least one hadron with $z_1 > 0.5$. The superscript indicates that the term is calculated for a nuclear (A) or deuterium (D) target. Absent from correlations introduced by nuclear effects, $R_{2h}(z_2)$ equals $R_h(z_2)$.

The HERMES collaboration presented results on R_{2h} from DIS on nitrogen, krypton and xenon [11]. Their

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Thanks!

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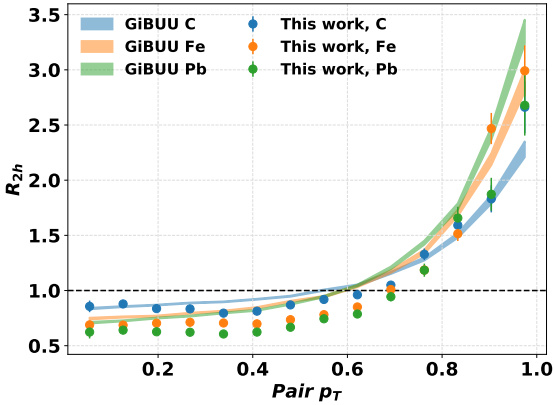
R_{2h}: Transverse momentum of the dipion dependence



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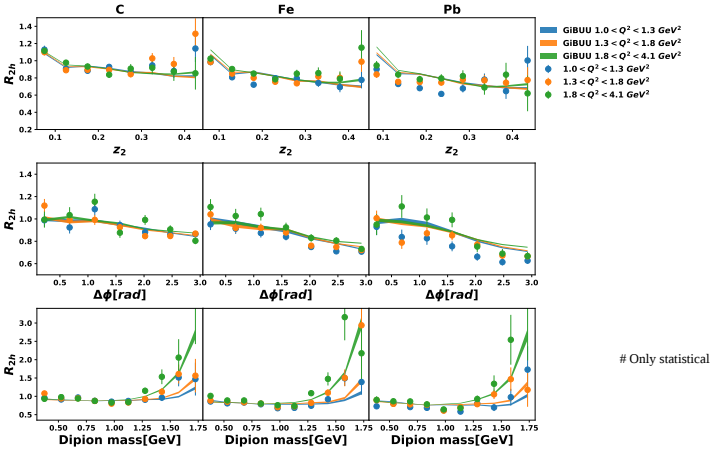
R_{2h}: Dependence on leptonic variables (Q^2 [GeV^2])



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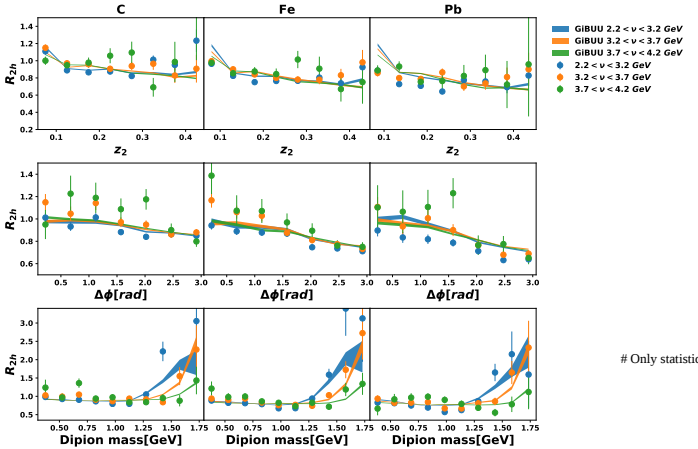
R_{2h}: Dependence on leptonic variables (ν [GeV])



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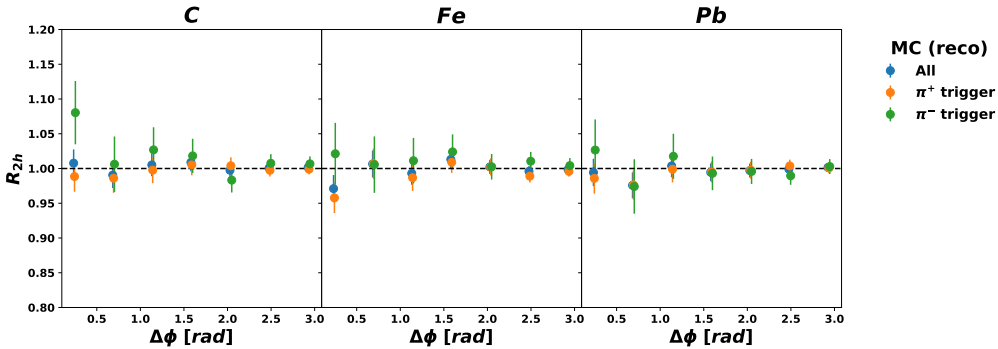
R_{2h}: MC study: acceptance correction cancellation



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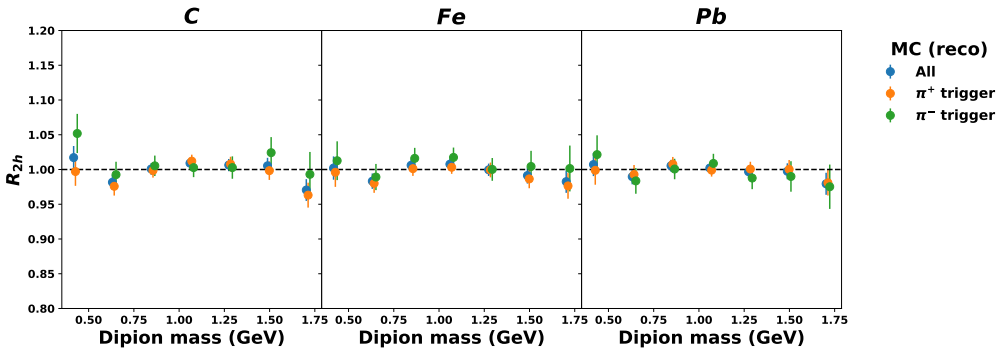

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