First Look at Charged Pions SIDIS Kinematics on RG-D Data

CLAS Collaboration Meeting

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Outlines

Semi-inclusive Deep Inelastic Scattering

- ✓ SIDIS process is considered as;

$$\boldsymbol{e}\ (\boldsymbol{l}) + \boldsymbol{p}\ (\boldsymbol{P}) \rightarrow \boldsymbol{e}'\ (\boldsymbol{l}') + \boldsymbol{h}\ (\boldsymbol{P_h}) + X$$

- ✓ Kinematical variables

$l = (E, \vec{l})$, $l' = (E', \vec{l}')$, $\boldsymbol{P} = (M, \vec{0})$; where M is Mass of a proton, and $q = l - l'$,

$$\nu = E - E'$$

$$Q^2 = -q^2 = 4EE' \sin^2\left(\frac{\theta_e}{2}\right),$$

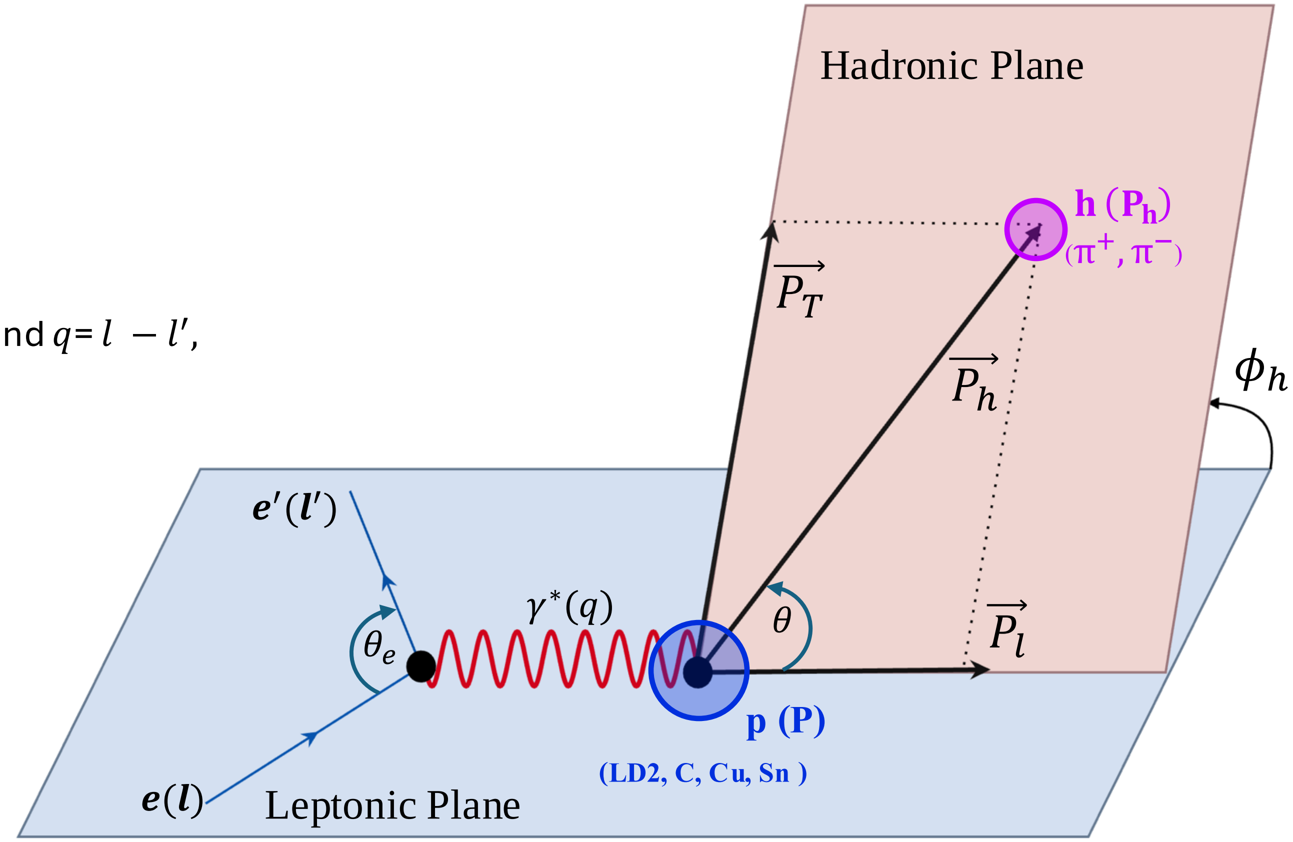
$$x_{Bj} = \frac{Q^2}{2\,\boldsymbol{P}.q} = \frac{Q^2}{2M\nu},$$

$$y = \frac{\boldsymbol{P}.q}{\boldsymbol{P}.l} = \frac{\nu}{E},$$

$$z_h = \frac{\boldsymbol{P}.\boldsymbol{P_h}}{\boldsymbol{P}.q} = \frac{E_h}{\nu},$$

$$W^2 = M^2 - Q^2 + 2M\nu,$$

$$P_T^2 = \left(\frac{|\vec{q}\times\vec{\boldsymbol{P_h}}|}{|\vec{q}|}\right)^2 = \left|\vec{\boldsymbol{P_h}}\right|^2 \sin^2\theta; \text{ where } \sin\theta = \frac{|\vec{q}\times\vec{\boldsymbol{P_h}}|}{|\vec{q}||\vec{\boldsymbol{P_h}}|}$$



Experimental Observables

Hadron Multiplicity Ratio

$$R_M^h(z,\nu,Q^2,P_T^2) = \frac{\dfrac{N_A^h(z,\nu,Q^2,P_T^2)}{N_A^e(\nu,Q^2)}}{\dfrac{N_D^h(z,\nu,Q^2,P_T^2)}{N_D^e(\nu,Q^2)}}$$

where,

N_A^h & N_A^e = Number of SIDIS hadron h and DIS electrons on a target A
N_D^h & N_D^e = Number of SIDIS hadron h and DIS electrons on LD2 target

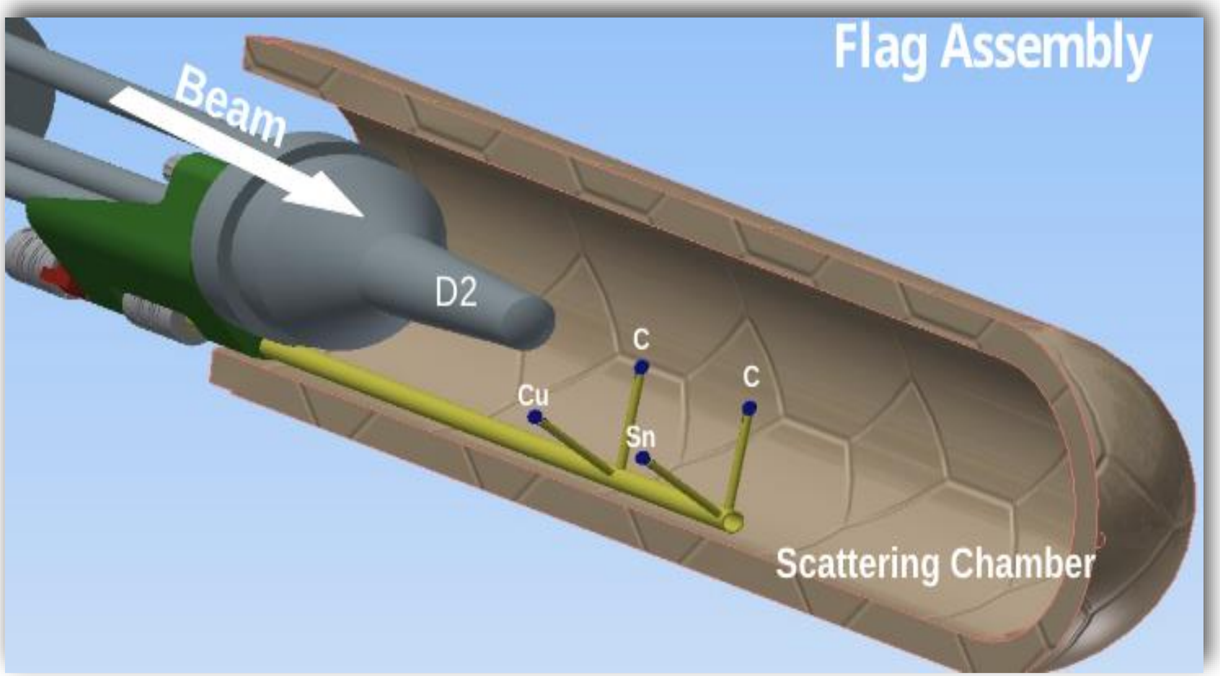
Azimuthal Asymmetry

$\langle \cos \phi_h \rangle$, $\langle \sin \phi_h \rangle$, and $\langle \cos 2\phi_h \rangle$

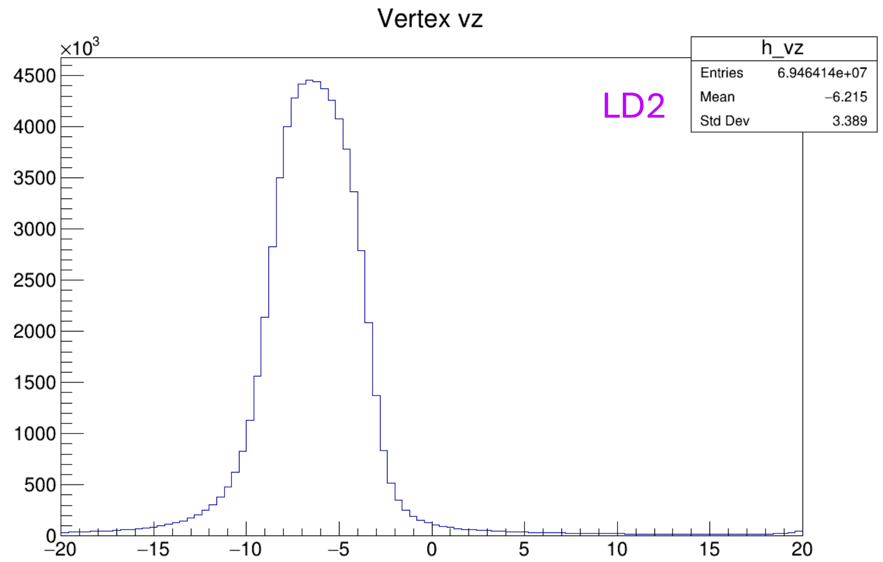
- Explore the nuclear transverse momentum distributions (nTMDs) for charged pions

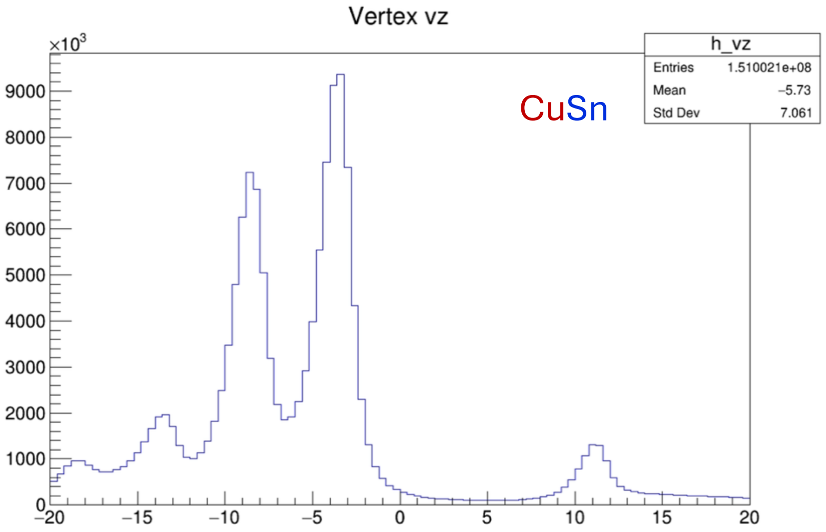
RG-D Target Configuration

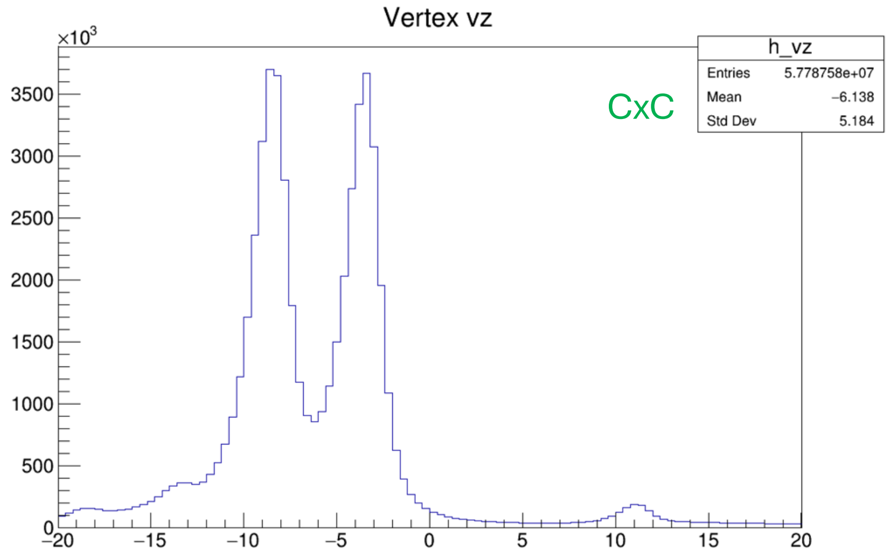
- ✓ Nuclear targets : LD2, Carbon (C), Copper (Cu), and Tin (Sn)
- ✓ Used a polarized electron beam with an energy of 10.5 GeV
- ✓ 5-cm-long LD2 cell positioned at -5 cm relative to the CLAS12 center within the newly constructed cryogenic system
- ✓ 5-cm-apart solid foils centered at -5 cm



RG-D Target Configuration Contd.







Target	**Z-Vertex (cm)**
Liquid Deuterium (LD2)	(-15.000,5.000)
Carbon (CxC)	(-10.784, 5.000)
Copper (Cu)	(-11.463, -6.576)
Tin (Sn)	(-6.137, 5.000)

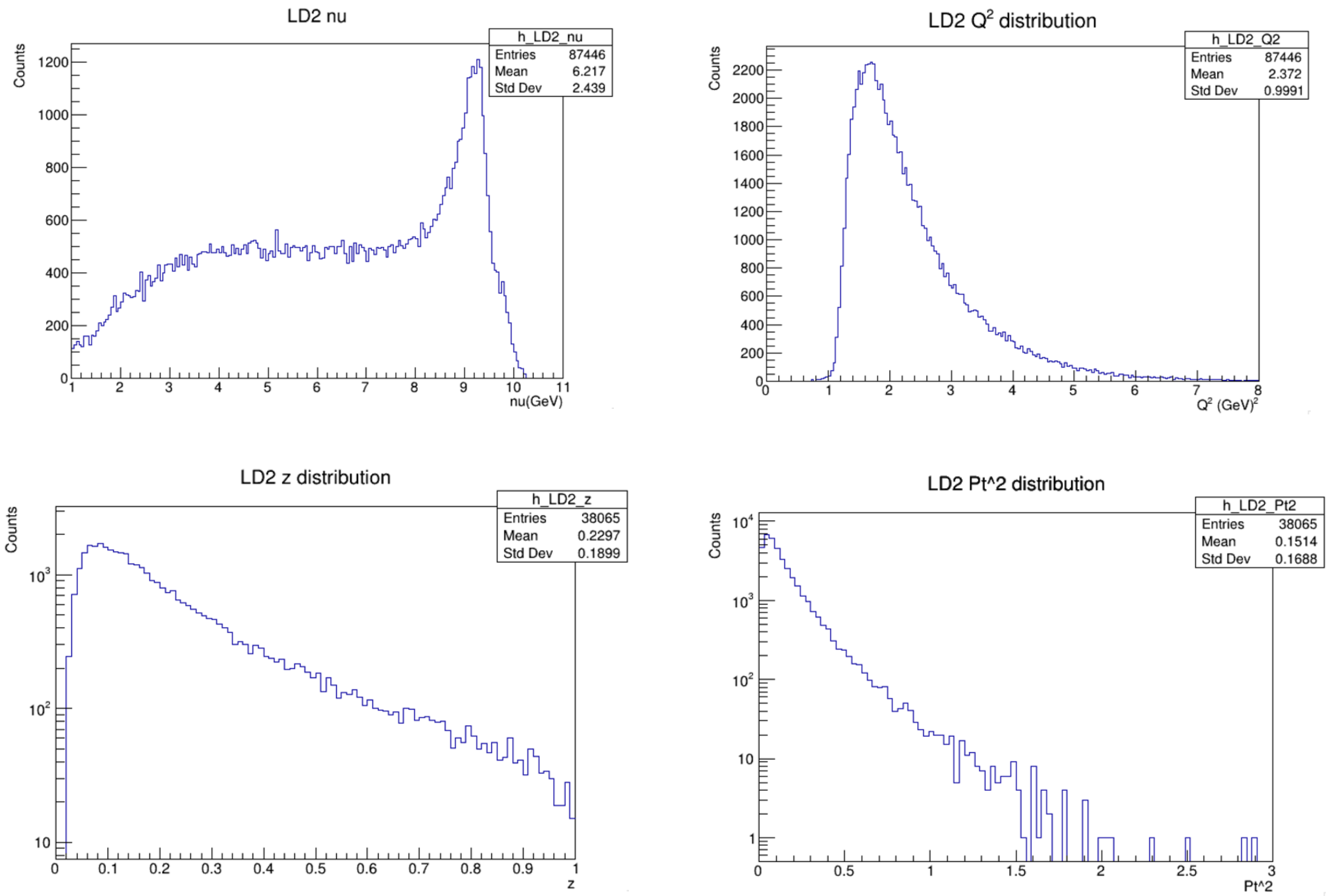
Credit of Mathieu Ouillon

Preliminary Analysis Results

- ✓ Using the reconstructed particle bank for the particle identification (PID)
- ✓ Fiducial cuts are still under study and are not implemented yet,

1. For electron selection
   - I. PID= 11
   - II. Status < 0
   - III. -5 <chi2Pid < 5
2. For +ve pion selection
   - I. PID= 211
   - II. -10 < chi2Pid < 10
3. For –ve pion selection
   - I. PID= -211
   - II. -10 < chi2Pid < 10

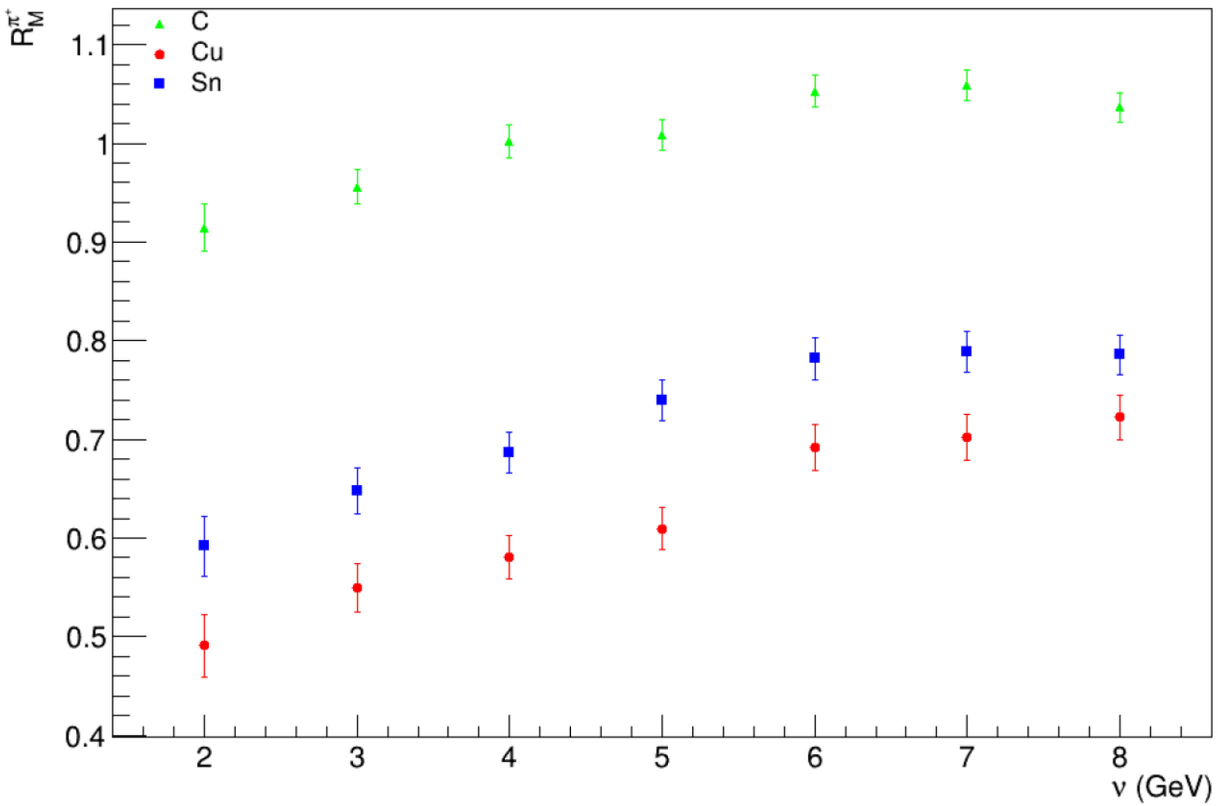
Kinematical variables for LD2 target



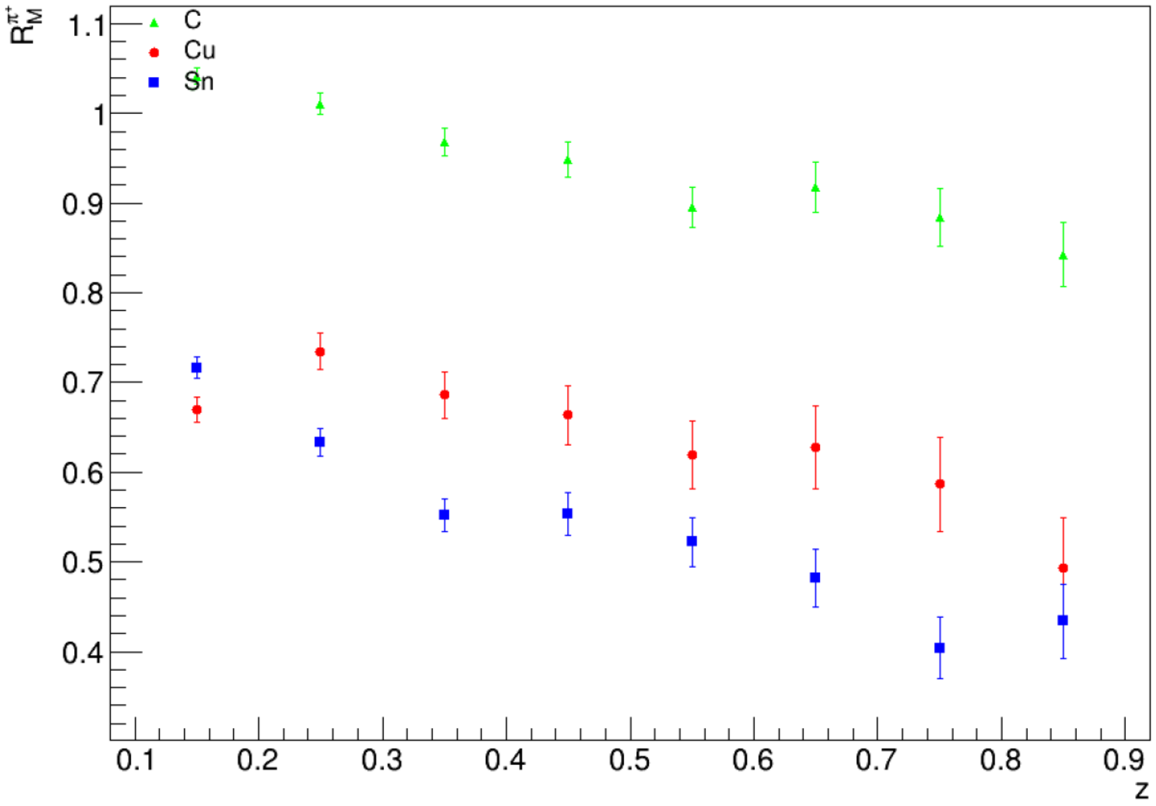
Preliminary Multiplicity Ratio Analysis

$R_M^{\pi^+}(\nu) = \frac{N_A^{\pi^+}(\nu)/N_A^e(\nu)}{N_D^{\pi^+}(\nu)/N_D^e(\nu)}$ $R_M^{\pi^+}(z_h) = \frac{N_A^{\pi^+}(z_{\pi^+})/N_A^e}{N_D^{\pi^+}(z_{\pi^+})/N_D^e}$ $z_{\pi^+} = \frac{E_{\pi^+}}{\nu}$ $A \rightarrow C, Cu, Sn$ $D \rightarrow LD2$

Multiplicity Ratio vs. ν for Carbon, Copper, and Tin

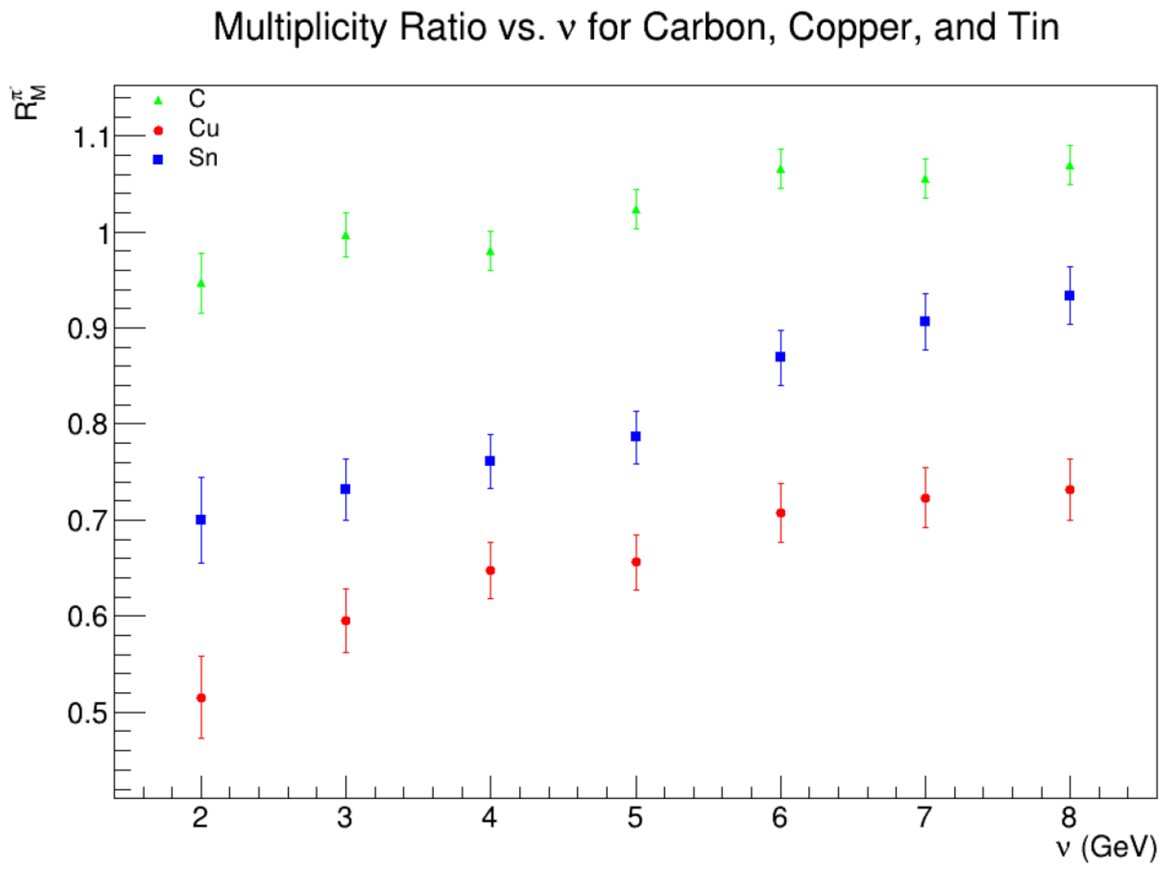


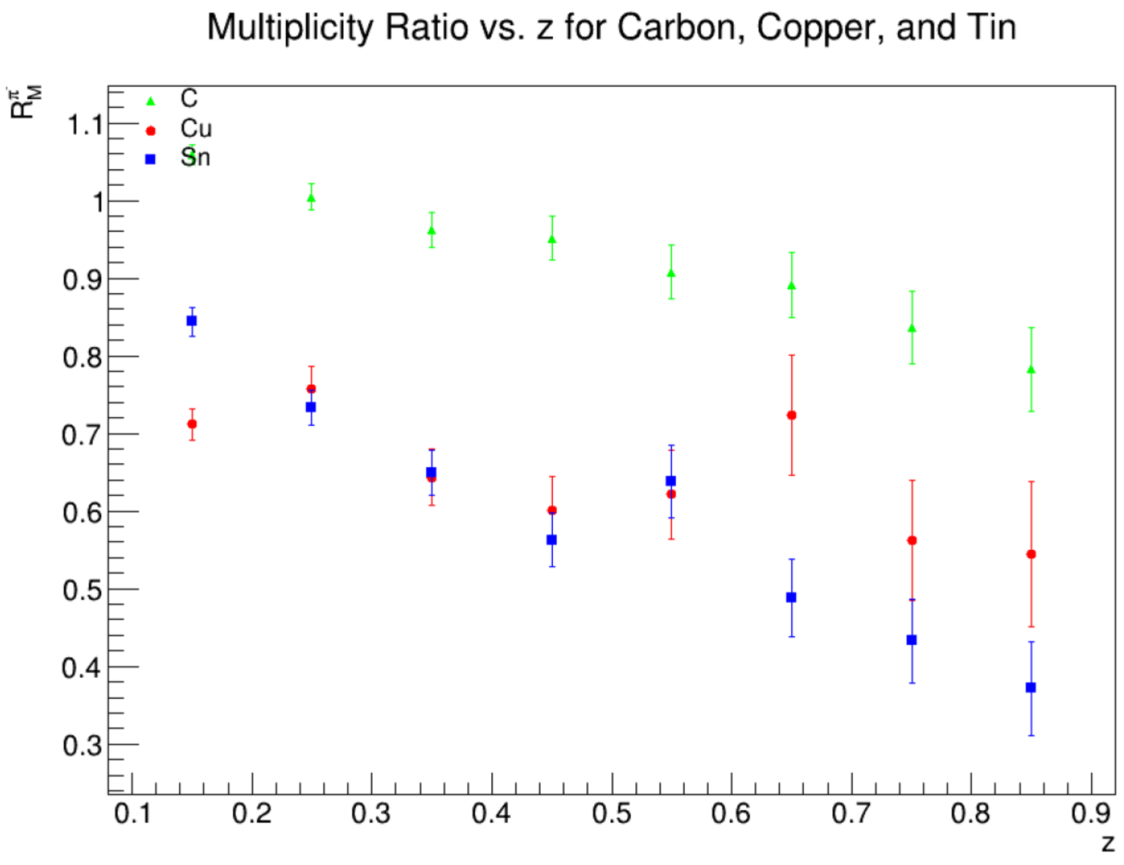
Multiplicity Ratio vs. z for Carbon, Copper, and Tin



Preliminary Multiplicity Ratio Analysis Contd.

$R_M^{\pi^-}(\nu) = \frac{N_A^{\pi^-}(\nu)/N_A^e(\nu)}{N_D^{\pi^-}(\nu)/N_D^e(\nu)}$ $R_M^{\pi^-}(z_h) = \frac{N_A^{\pi^-}(z_{\pi^-})/N_A^e}{N_D^{\pi^-}(z_{\pi^-})/N_D^e}$ $z_{\pi^-} = \frac{E_{\pi^-}}{\nu}$ $A \to C, Cu, Sn$ $D \to LD2$





Summary and Outlook

- ✓ As debugging of analysis codes and methods, multiplicity ratios for charged pions and various nuclear targets have been extracted before fiducial cuts and corrections
- ✓ Next, azimuthal asymmetries will be studied
- ✓ Then, charged pions nTMDs will be explored via the extracted azimuthal asymmetries

Acknowledgement

Jefferson Lab

clas

Hall B

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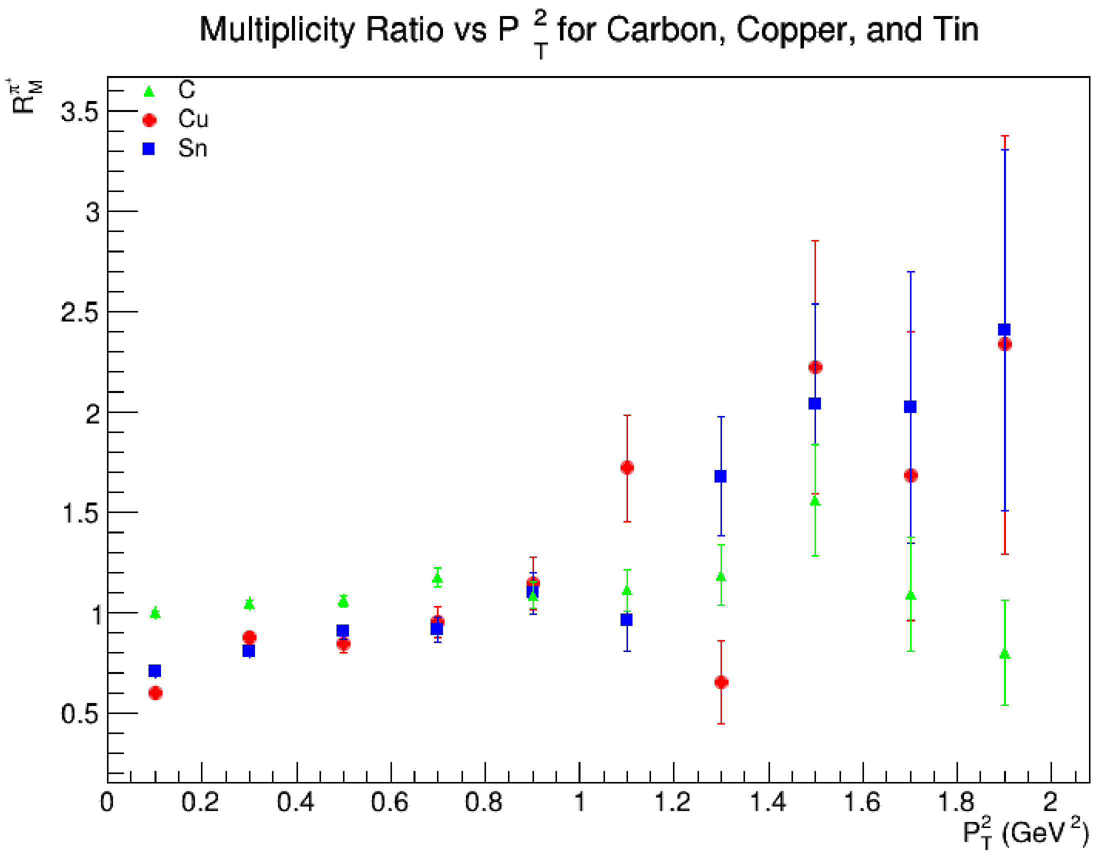
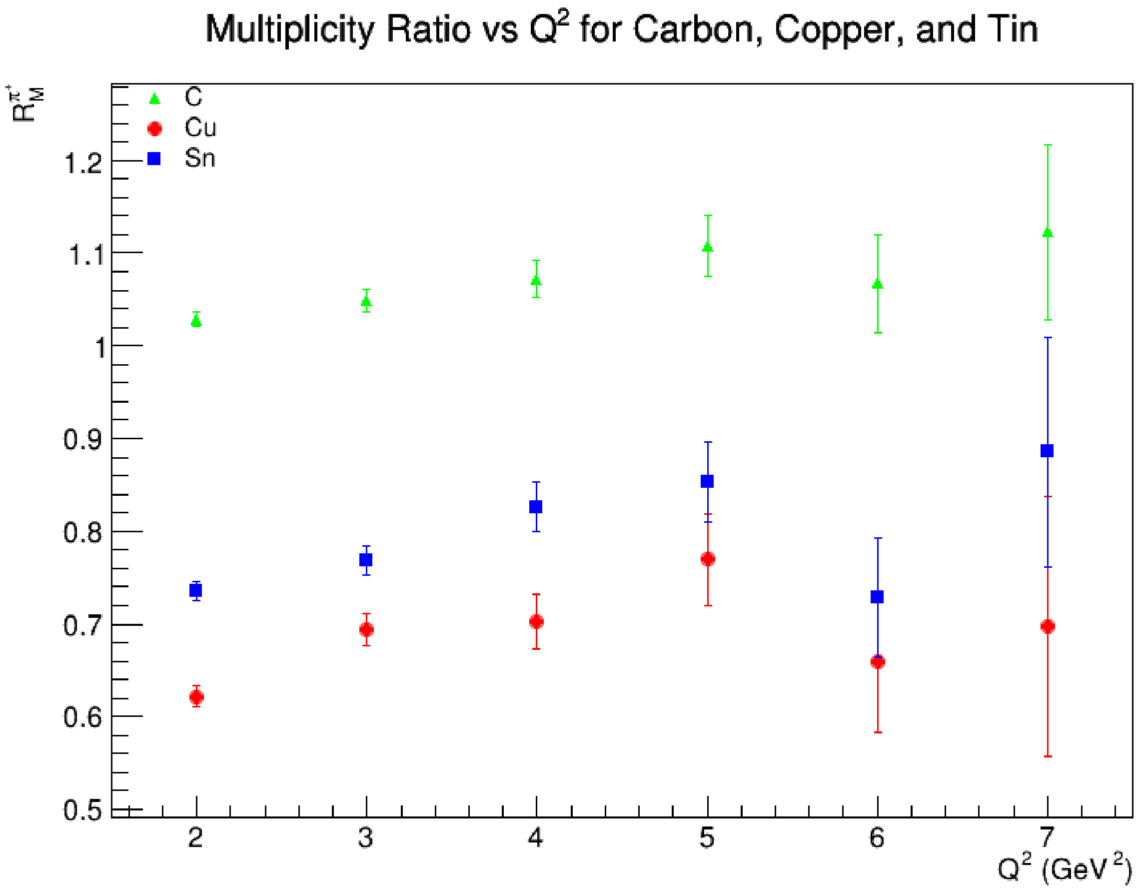
Thank You

Backup Slides


Multiplicity Ratio vs P_T^2 for Carbon, Copper, and Tin
$R_M^{\pi^+}$
C
Cu
Sn
3.5
3
2.5
2
1.5
1
0.5
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
P_T^2 (GeV^2)


Multiplicity Ratio vs Q^2 for Carbon, Copper, and Tin
$R_M^{\pi^+}$
C
Cu
Sn
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
2
3
4
5
6
7
Q^2 (GeV^2)