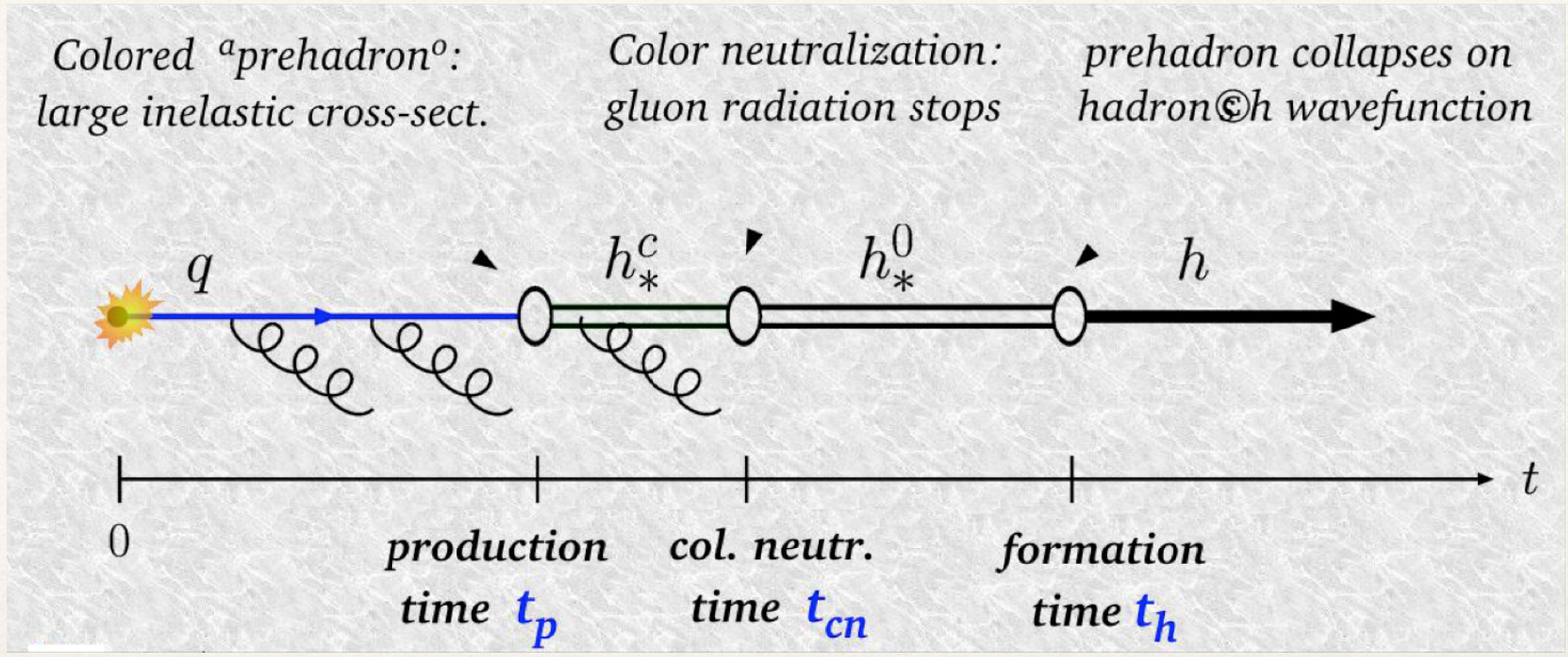


Update of the Hadronization Analysis of Protons with eg2 Data

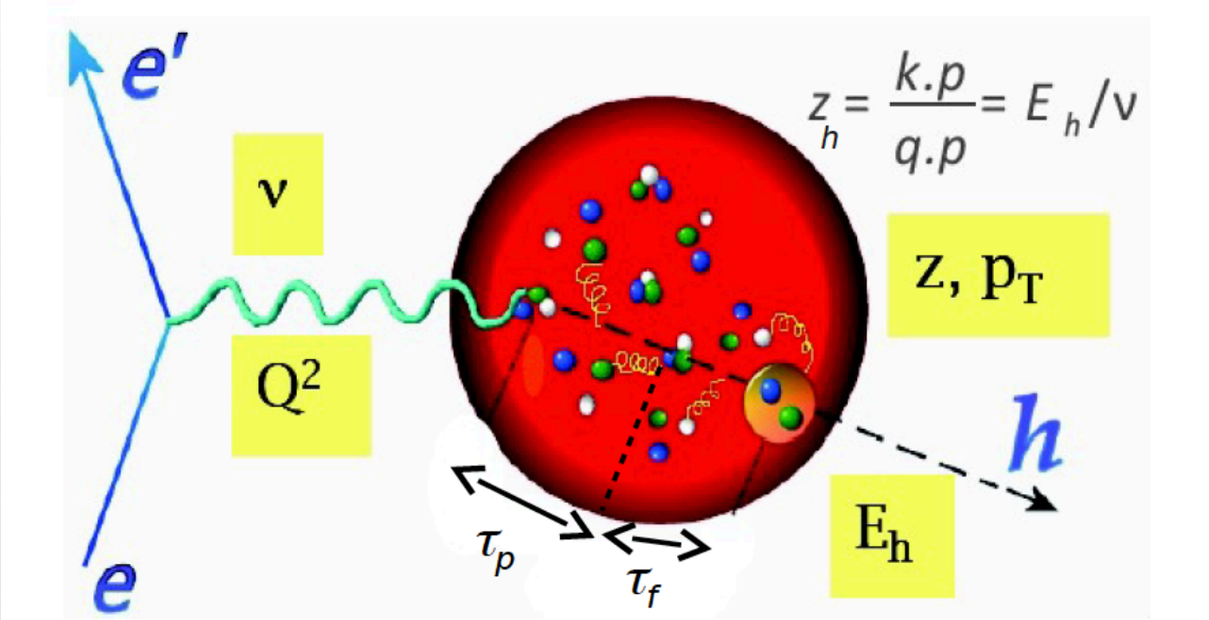
Michael H. Wood
Canisius College, Buffalo, NY, USA

Jefferson Lab
Thomas Jefferson National Accelerator Facility

CEBAF Large Acceptance Spectrometer

Hadronization

Study hard processes in nuclei to probe the QCD confinement dynamics: Color propagation (CP) and fragmentation - **Hadronization process**



Motivation - E_{e+}=27 GeV studies by Hermes

Production time τ_p: Time spent by a deconfined quark to neutralize its color charge. Stimulated by energy loss to the medium by gluon exchange.

Observable: transverse momentum broadening.

$$\Delta p_T^2 = < p_A^2 > - < p_D^2 >$$

Formation time τ_f: Time required to form a regular hadron. Interactions with hadron cross sections.

Observable: multiplicity ratios

$$R_M^h = \frac{\left[\frac{N_h^{DIS}}{N_e^{DIS}}\right]_A}{\left[\frac{N_h^{DIS}}{N_e^{DIS}}\right]_D}$$

The eg2 Hadronization Program

Mesons

π^+, π^- - S. Moran, R. Dupre, H. Hakobyan (under review)

π^0 - T. Mineeva (under review)

K^0 - A. Daniels *et al.*, Phys. Lett. B 706, 26 (2011)

η - O. Soto (thesis)

ω - A. Borquez (Master's thesis)

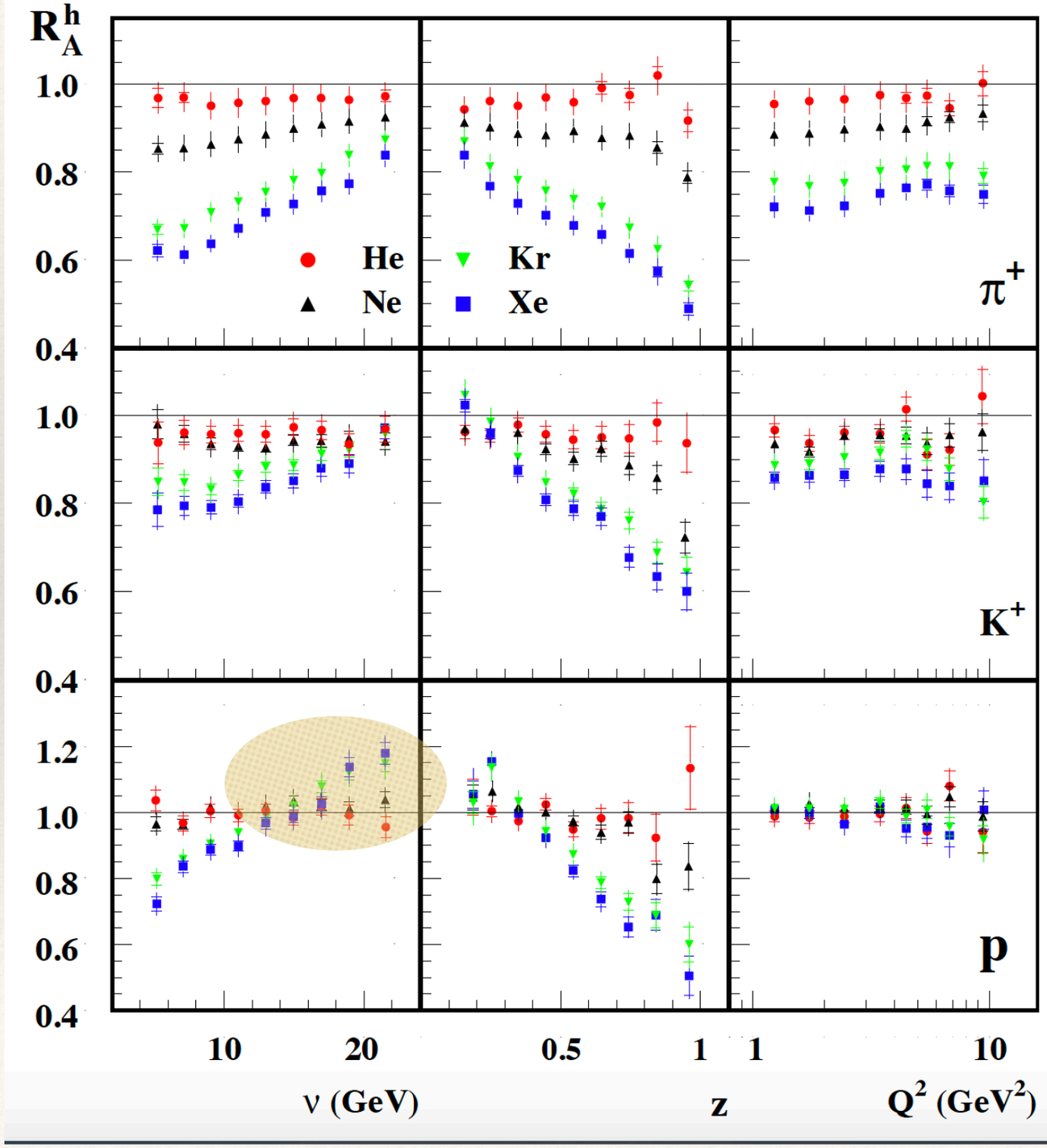
Di-pions - A. Radic, M. Arratia

Baryons

$\Lambda(1520)$ - T. Chetry, L. El Fassi (under review)

Proton - M. Wood

Results from Hermes



Hermes results

A. Airapetian, *et al.*, Nucl. Phys. B 780 (2007) 1.

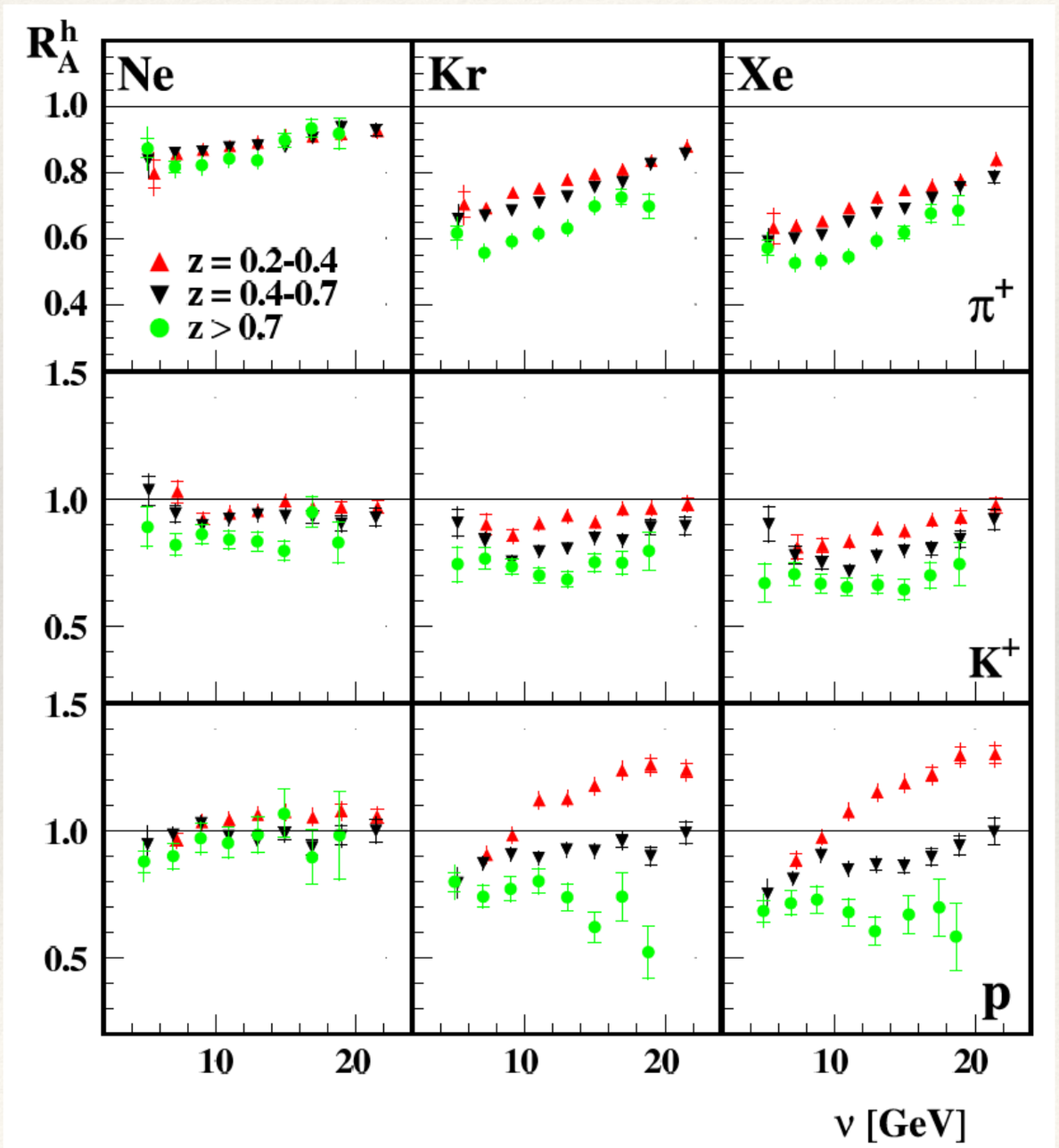
E= 27 GeV; Positron beam

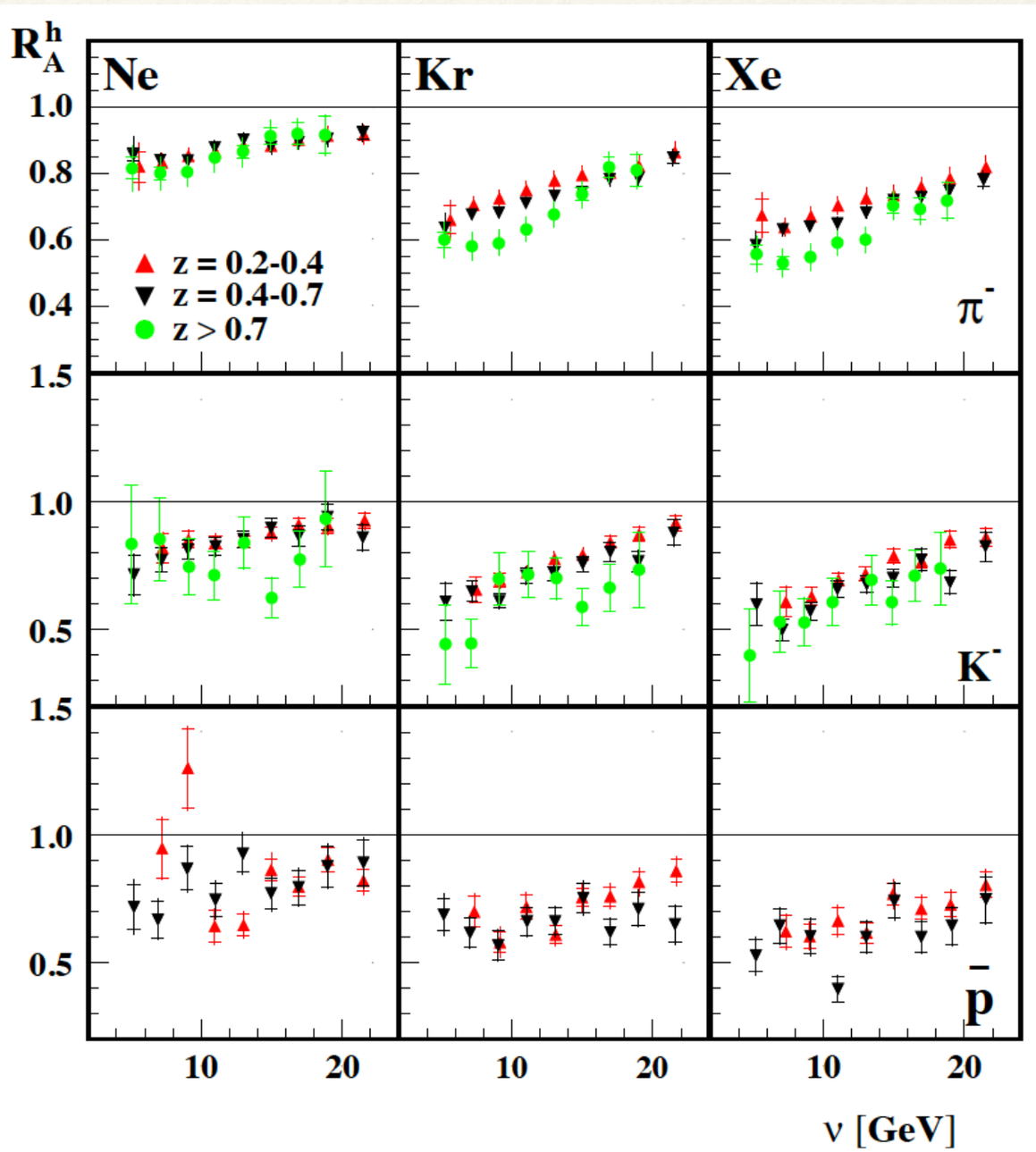
Pions and kaons give similar attenuation

The results for protons cannot really be related to those for any of the other particles. Because protons are already present in a nucleus, an appreciable fraction of them may not come from hadronization.

Multidimensional Analysis by HERMES

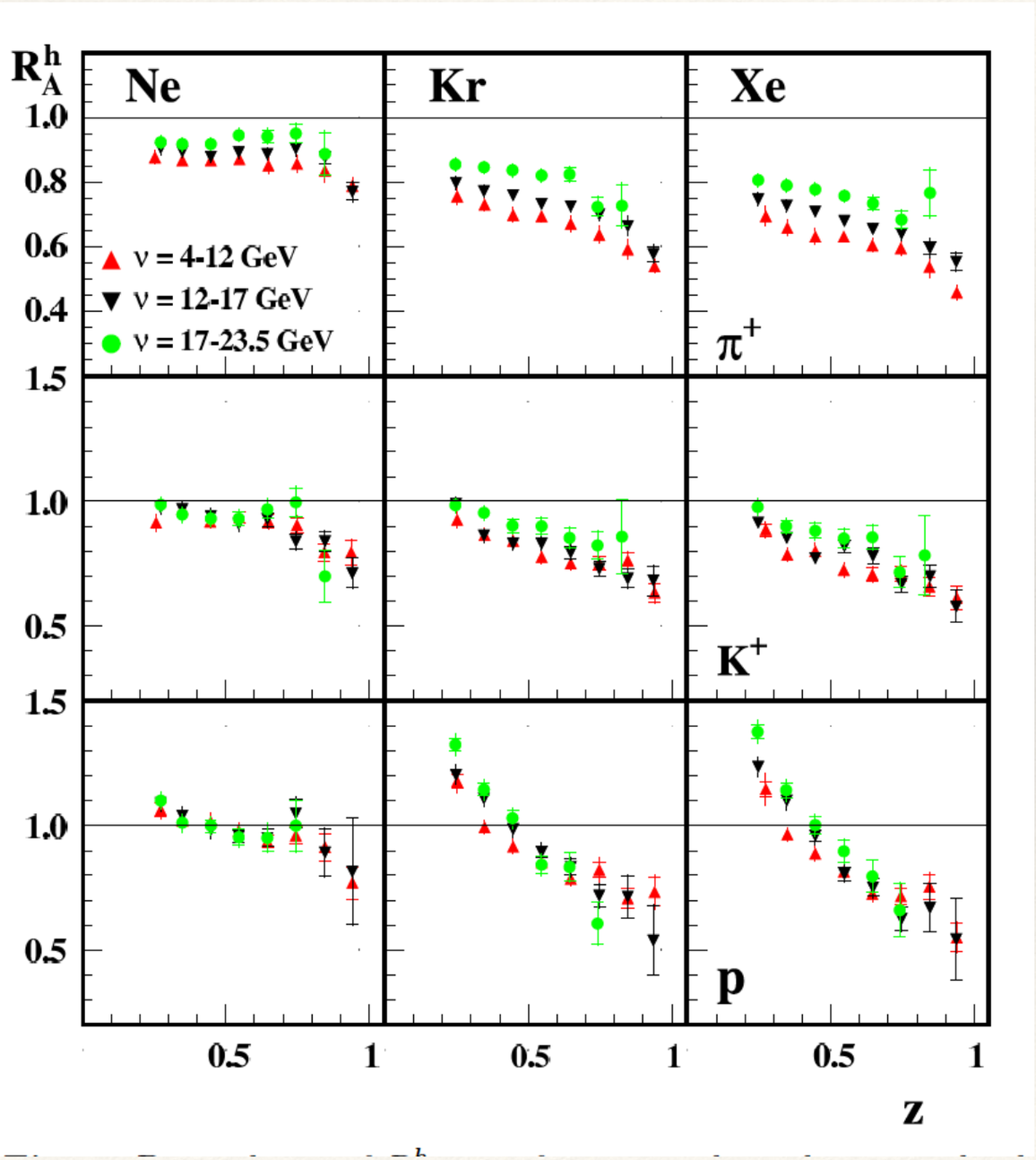
A. Airapetian, *et al.*, Eur. Phys. J. A (2011) 47: 113

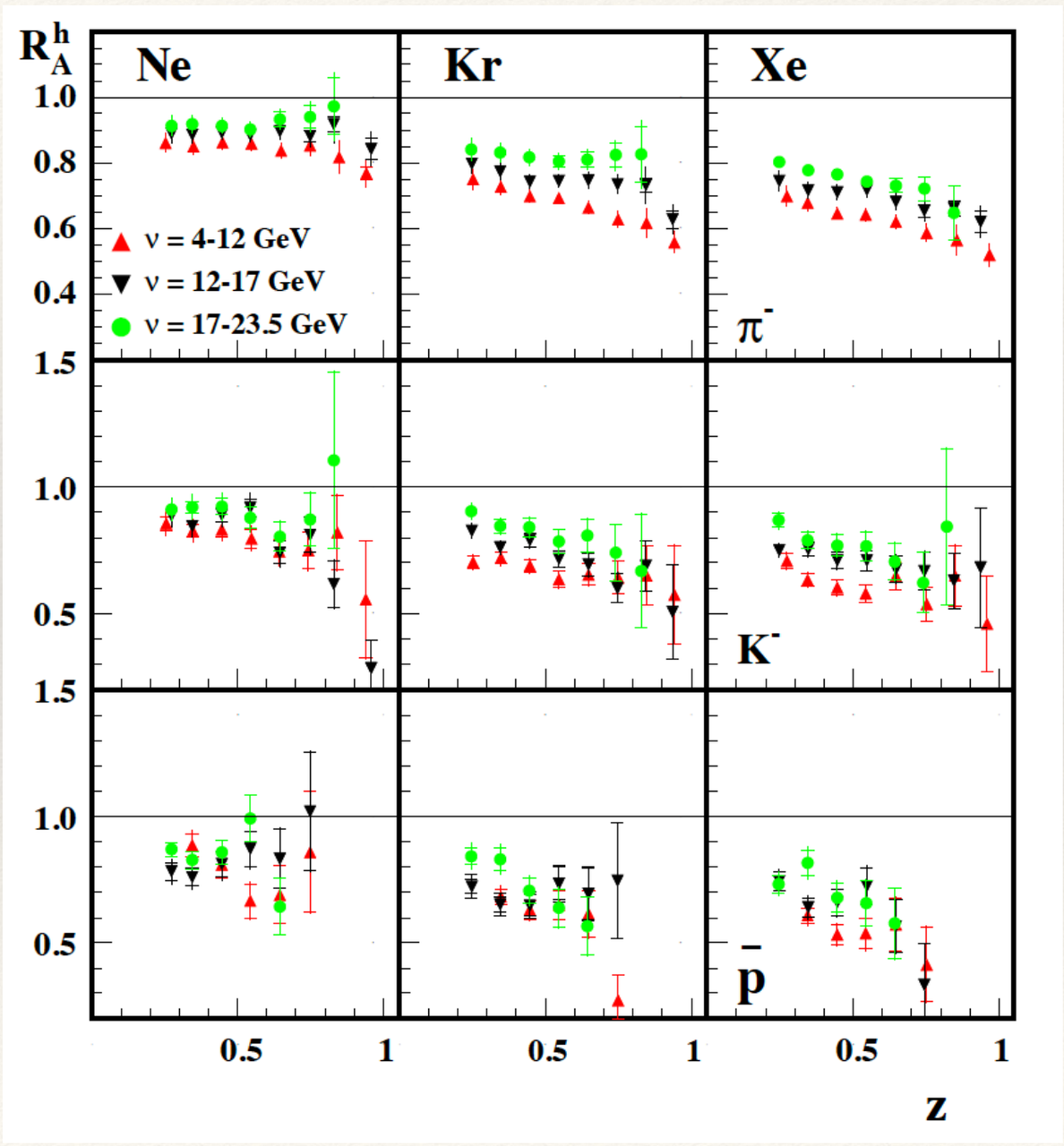




Multidimensional Analysis by HERMES

A. Airapetian, *et al.*, Eur. Phys. J. A (2011) 47: 113

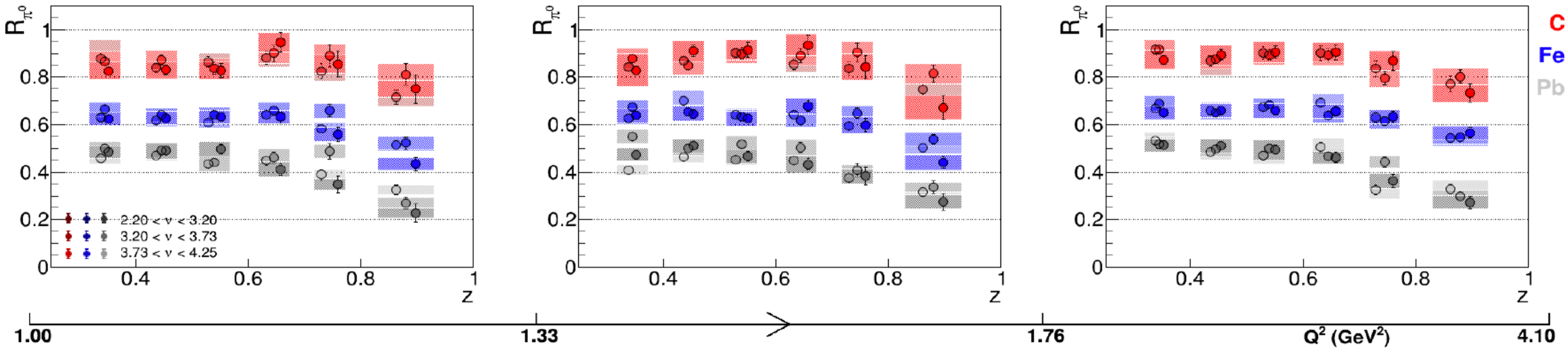




Multiplicity Ratios - 3D

Neutral pions - results by T. Mineeva

3D binning - Q2, ν, z_h



Currently under review.

Event Selection

Kinematical cuts

$Q^2 \geq 1\ \mathrm{GeV}^2$

$W \geq 2\ \mathrm{GeV}$

$$y = \frac{\nu}{E_e} \leq 0.85$$

Applied electron ID cuts

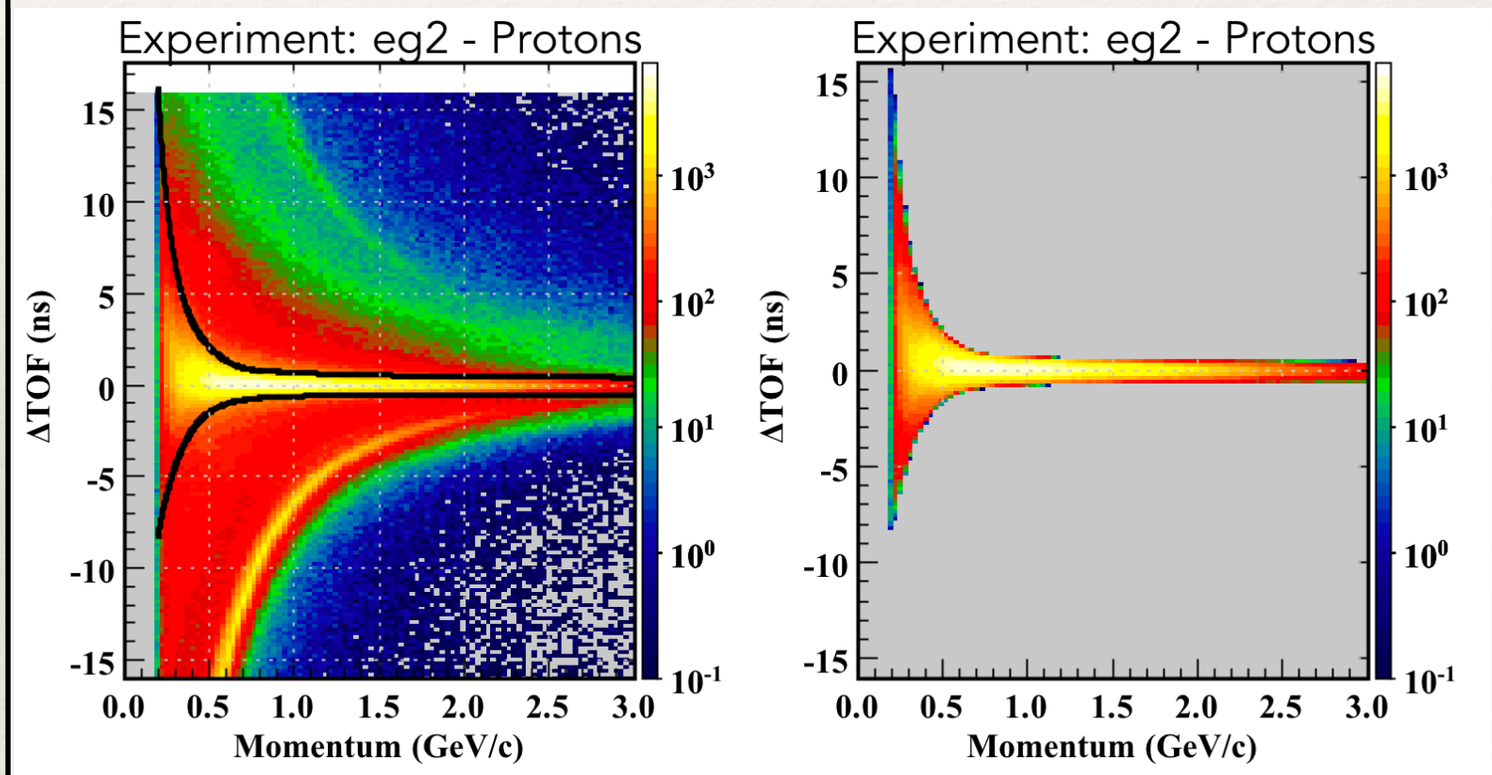
EC E_{tot}/P sampling fraction

CC # photo-electrons > 28

EC E_{IN} > 60 MeV

Momentum > 650 MeV

Select positively charged particles and make a cut on the TOF based on the proton mass.

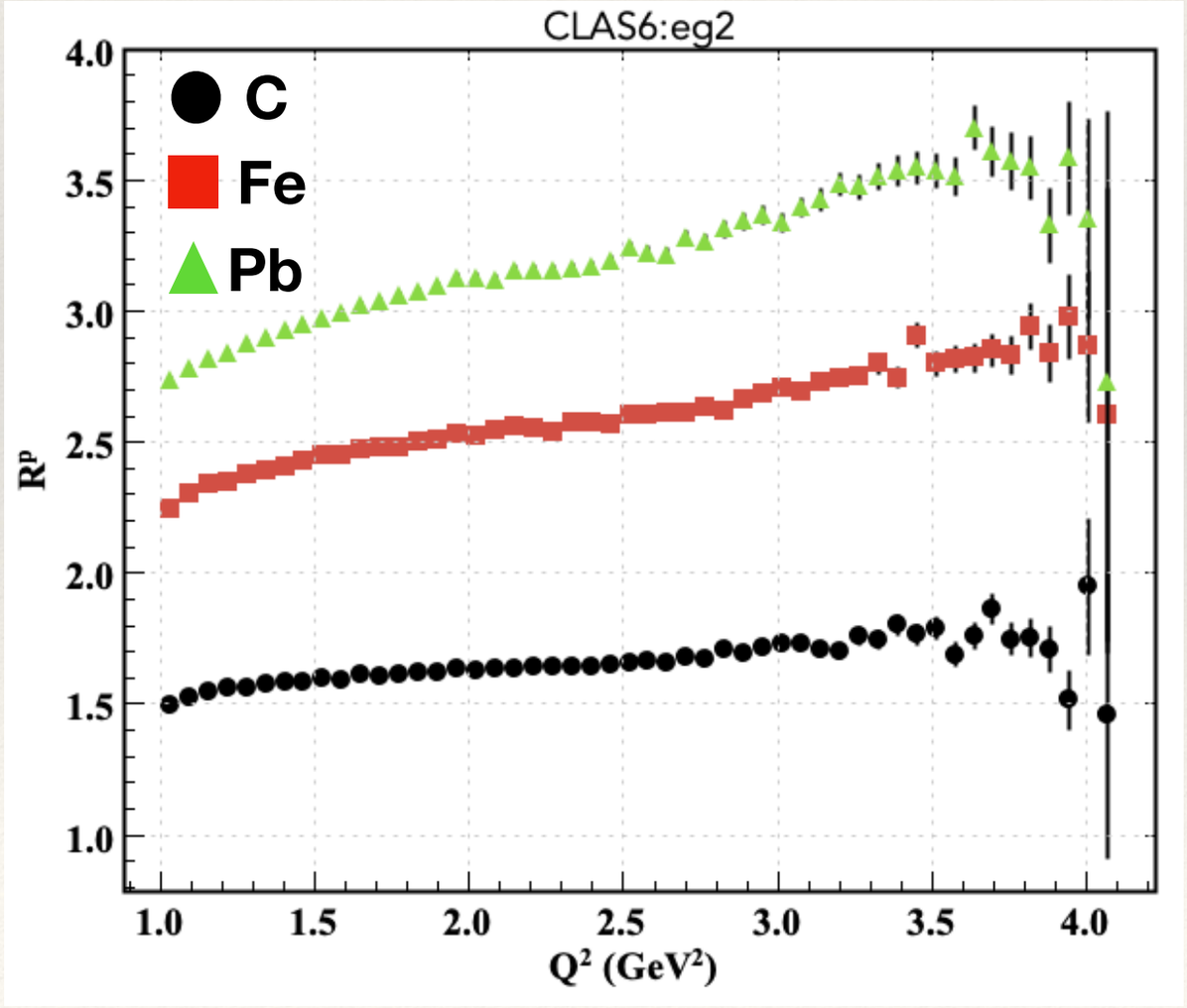


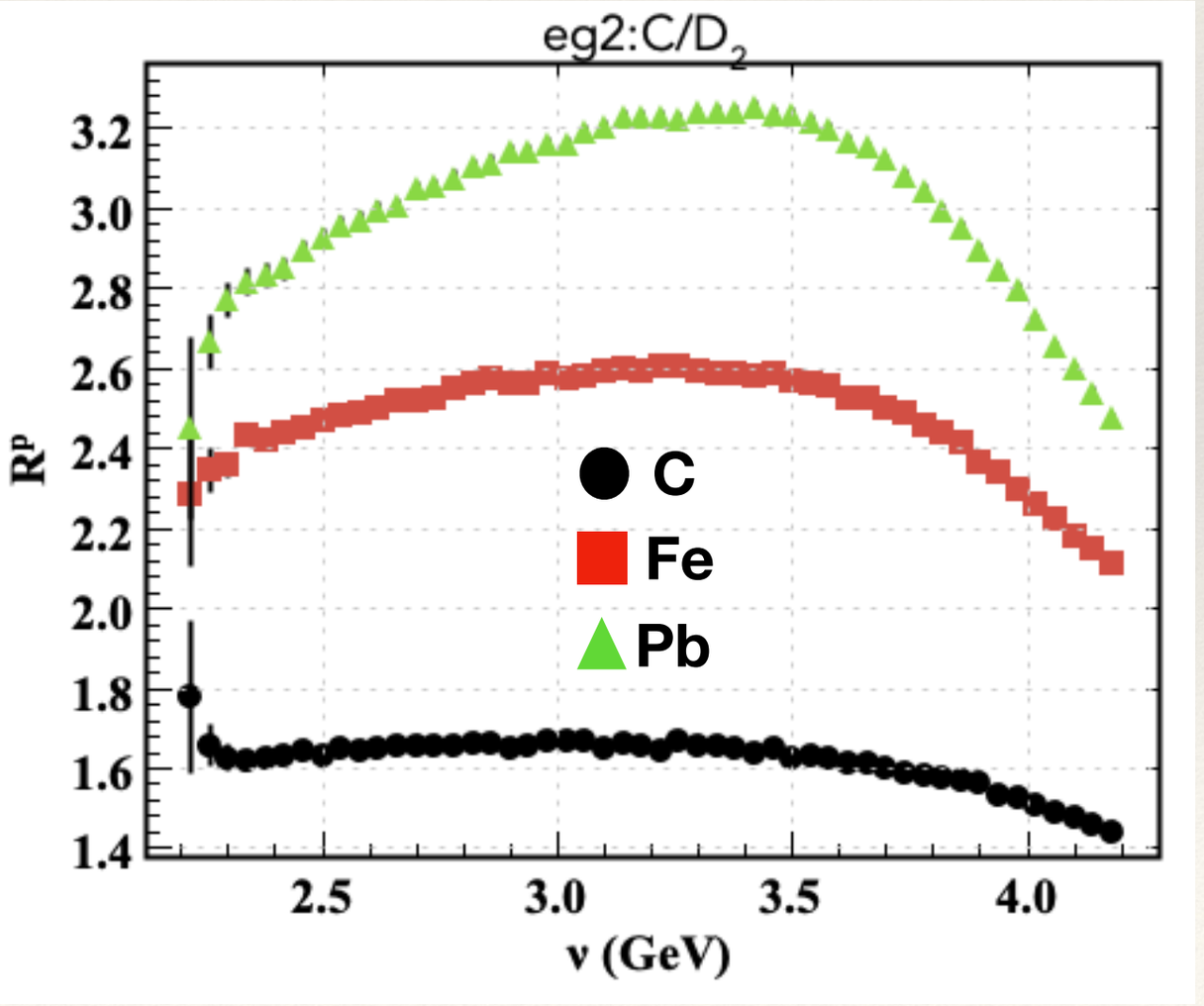
Fiducial cuts applied

eg2 Proton MR - 1D

Applied the normalization for the number of DIS electrons per target, radiative correction, and Coulomb correction from charged pion analysis (Sebastian Moran).

Statistical errors.



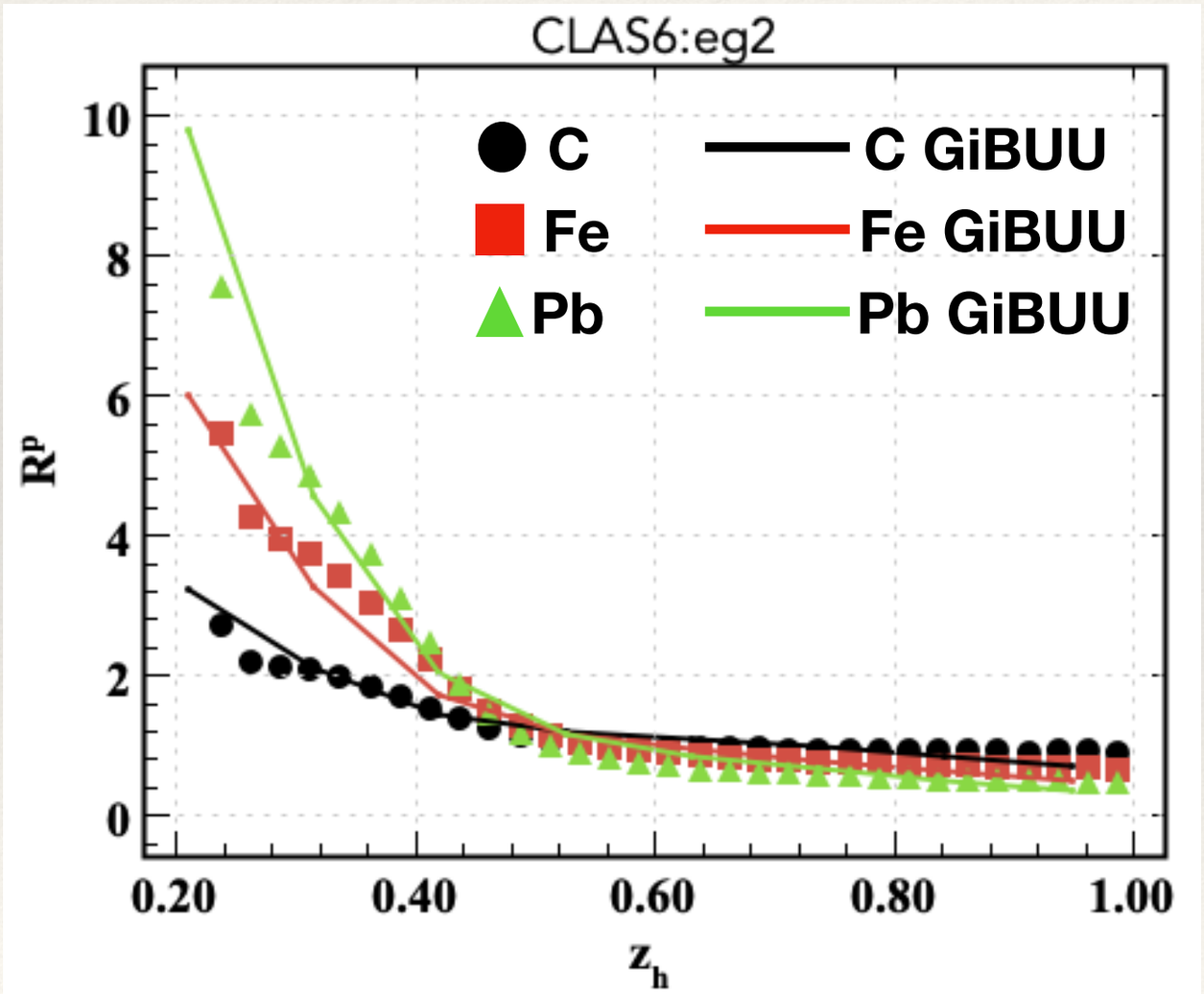


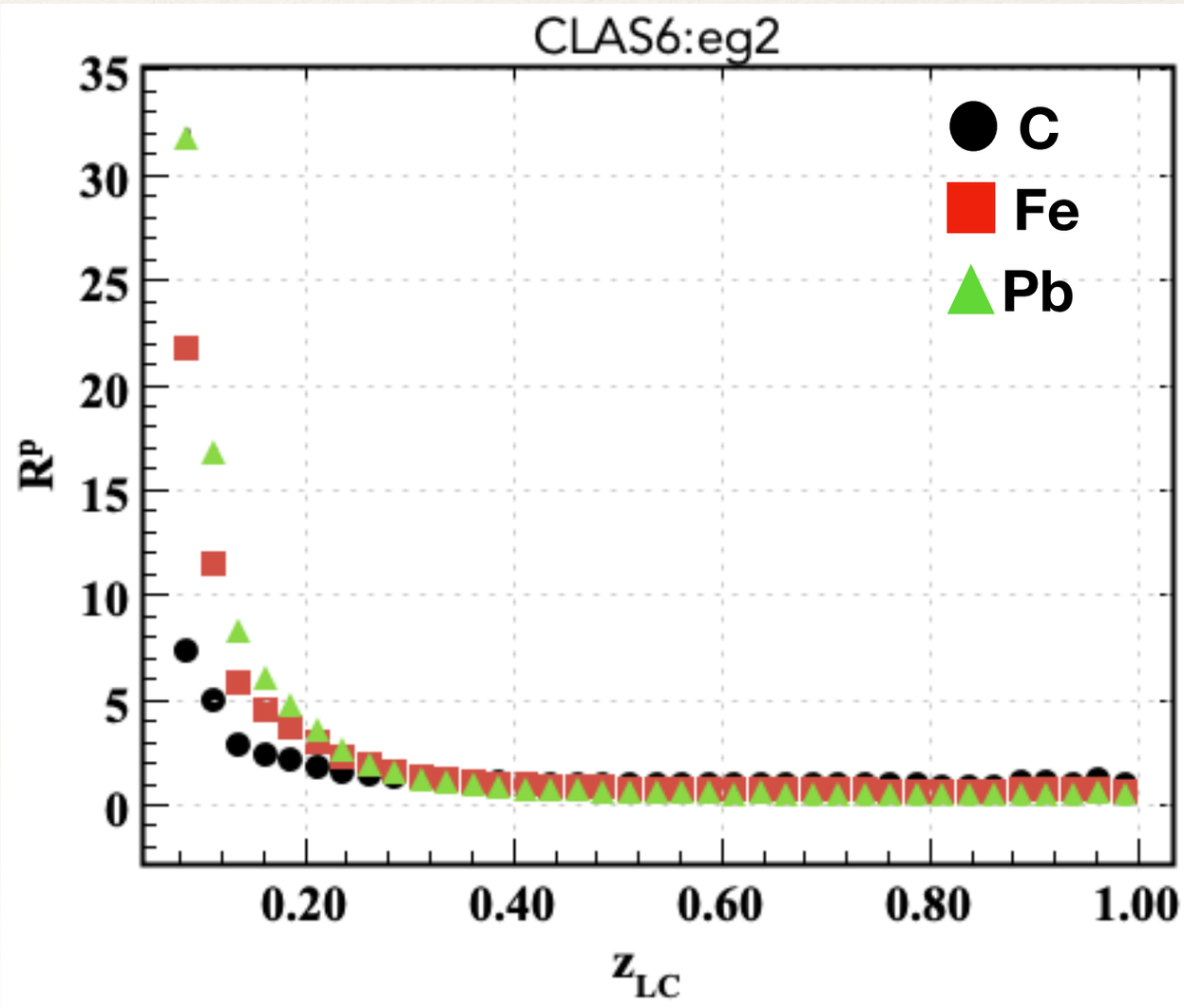
eg2 Proton MR - 1D

$$z_h = \frac{E_h}{\nu}$$

$$z_{LC} = \frac{p_h^+}{P+}$$

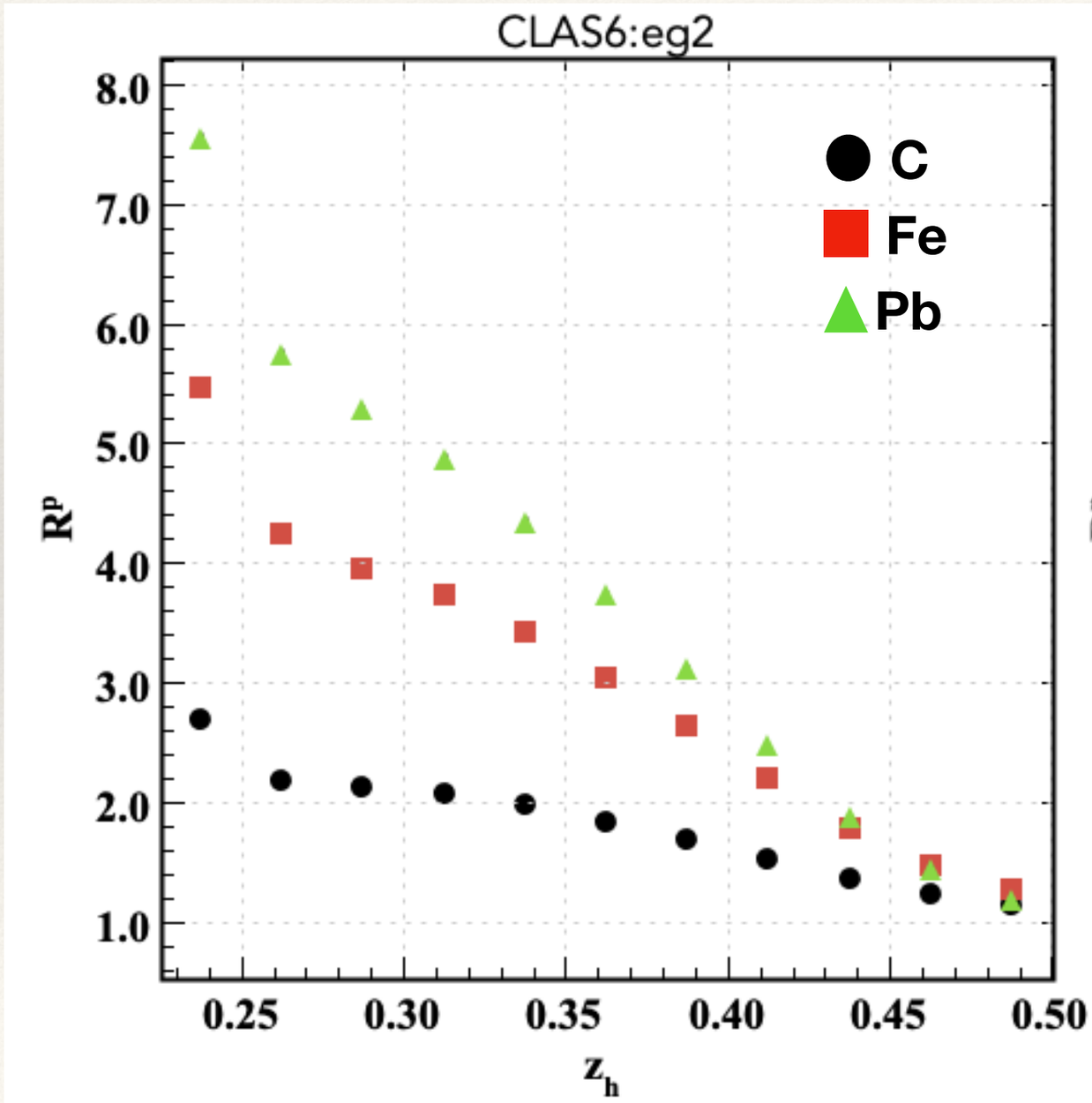
Statistical errors.

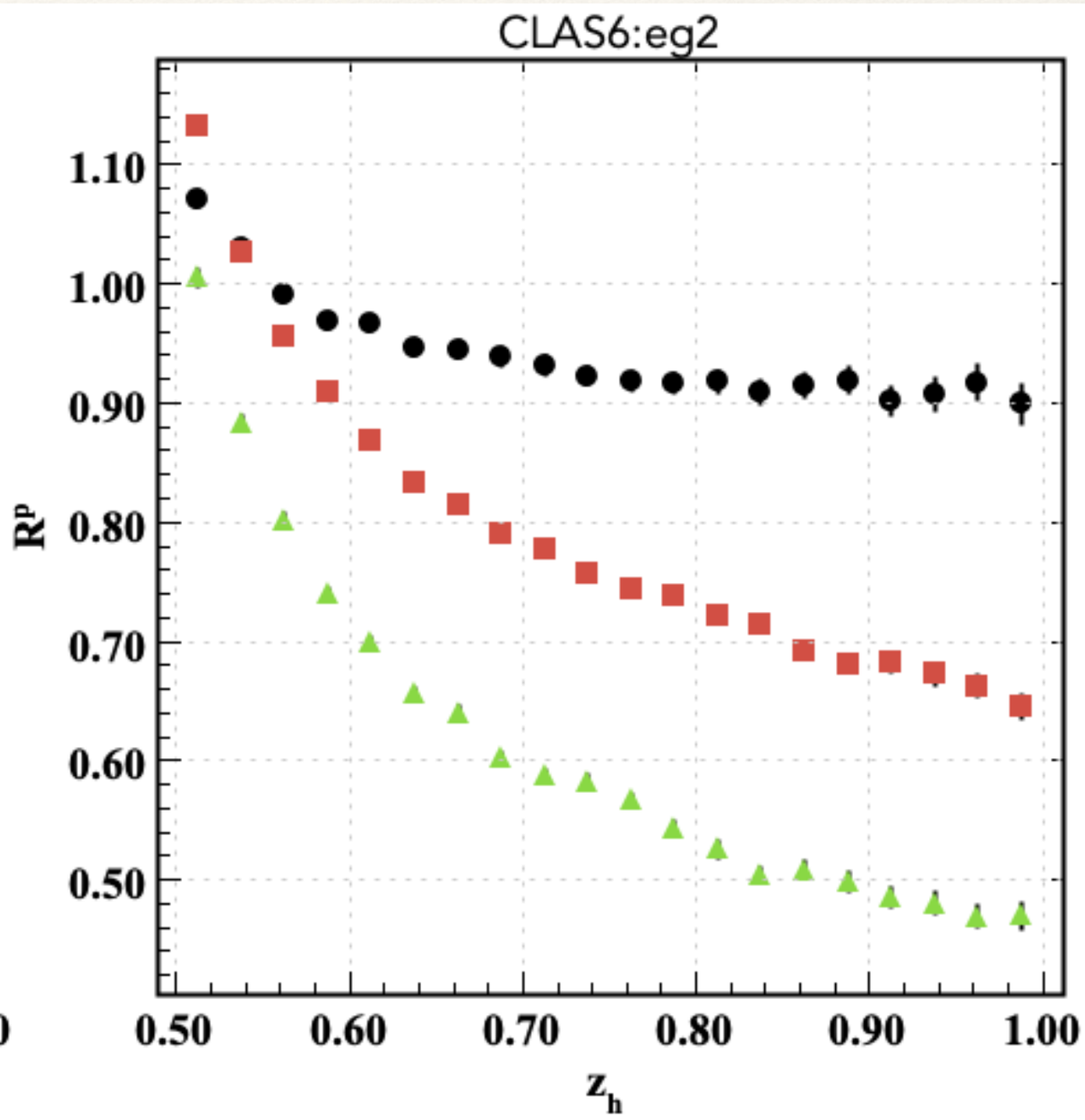




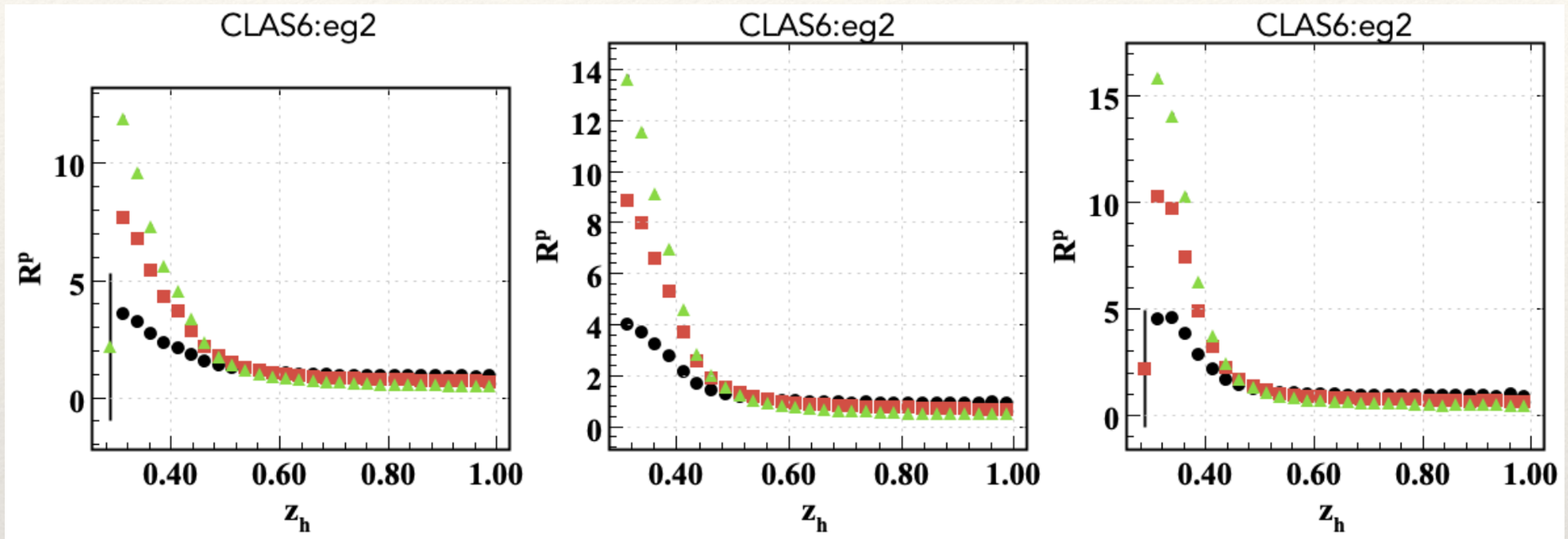
eg2 Proton MR - 1D

Statistical errors.

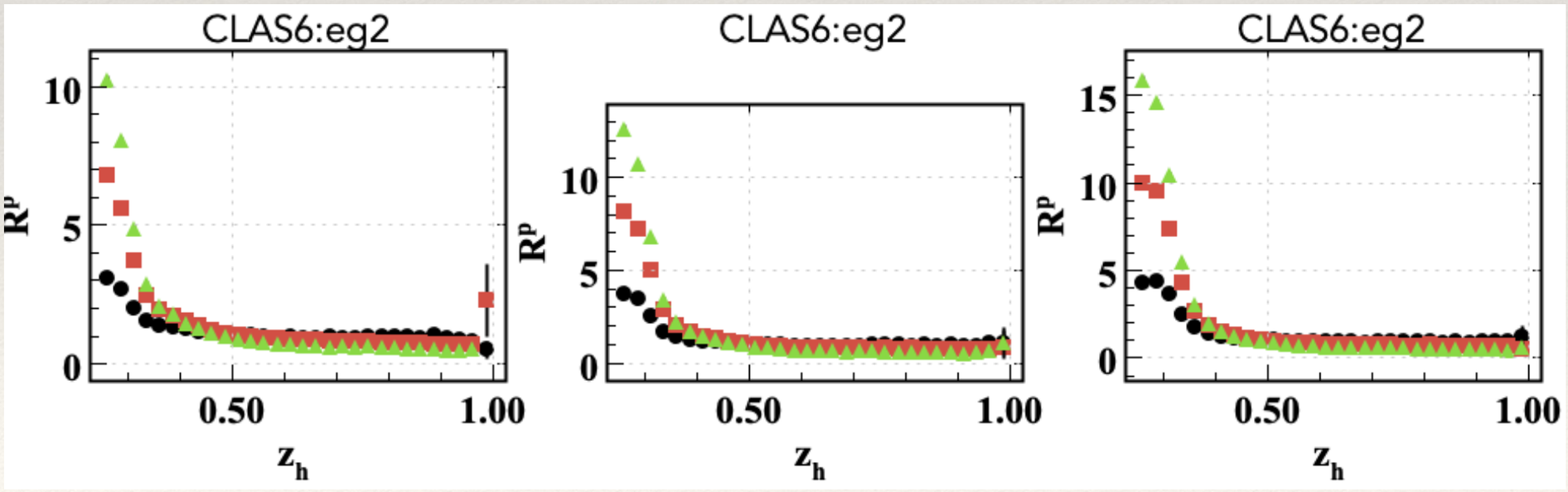




eg2 Proton MR - 3D



$2.20 < \nu < 3.20$ GeV



$3.30 < \nu < 3.73$ GeV

1.00 1.33 1.76 4.10 Q^2 (GeV^2)

Acceptance

$$R_M^h = \frac{\left[\frac{N_h^{DIS}}{N_e^{DIS}}\right]_A}{\left[\frac{N_h^{DIS}}{N_e^{DIS}}\right]_D} = \left[\frac{N_A^{DIS}}{N_D^{DIS}}\right]_h \left[\frac{N_D^{DIS}}{N_A^{DIS}}\right]_e$$

$Y =$ Yields

$\epsilon = \frac{rec}{gen} =$ acceptance

$N =$ acceptance correctved yield

$$R_M^h = \left[\frac{\frac{Y_A^{DIS}}{\epsilon_A}}{\frac{Y_D^{DIS}}{\epsilon_D}}\right]_h \left[\frac{N_D^{DIS}}{N_A^{DIS}}\right]_e = \left[\frac{Y_A^{DIS}}{Y_D^{DIS}}\right]_h \left[\frac{N_D^{DIS}}{N_A^{DIS}}\right]_e \left[\frac{\epsilon_D}{\epsilon_A}\right]$$

Acceptance

$$R_M^h = \frac{\left[\frac{N_h^{DIS}}{N_e^{DIS}}\right]_A}{\left[\frac{N_h^{DIS}}{N_e^{DIS}}\right]_D} = \left[\frac{N_A^{DIS}}{N_D^{DIS}}\right]_h \left[\frac{N_D^{DIS}}{N_A^{DIS}}\right]_e$$

$Y =$ Yields

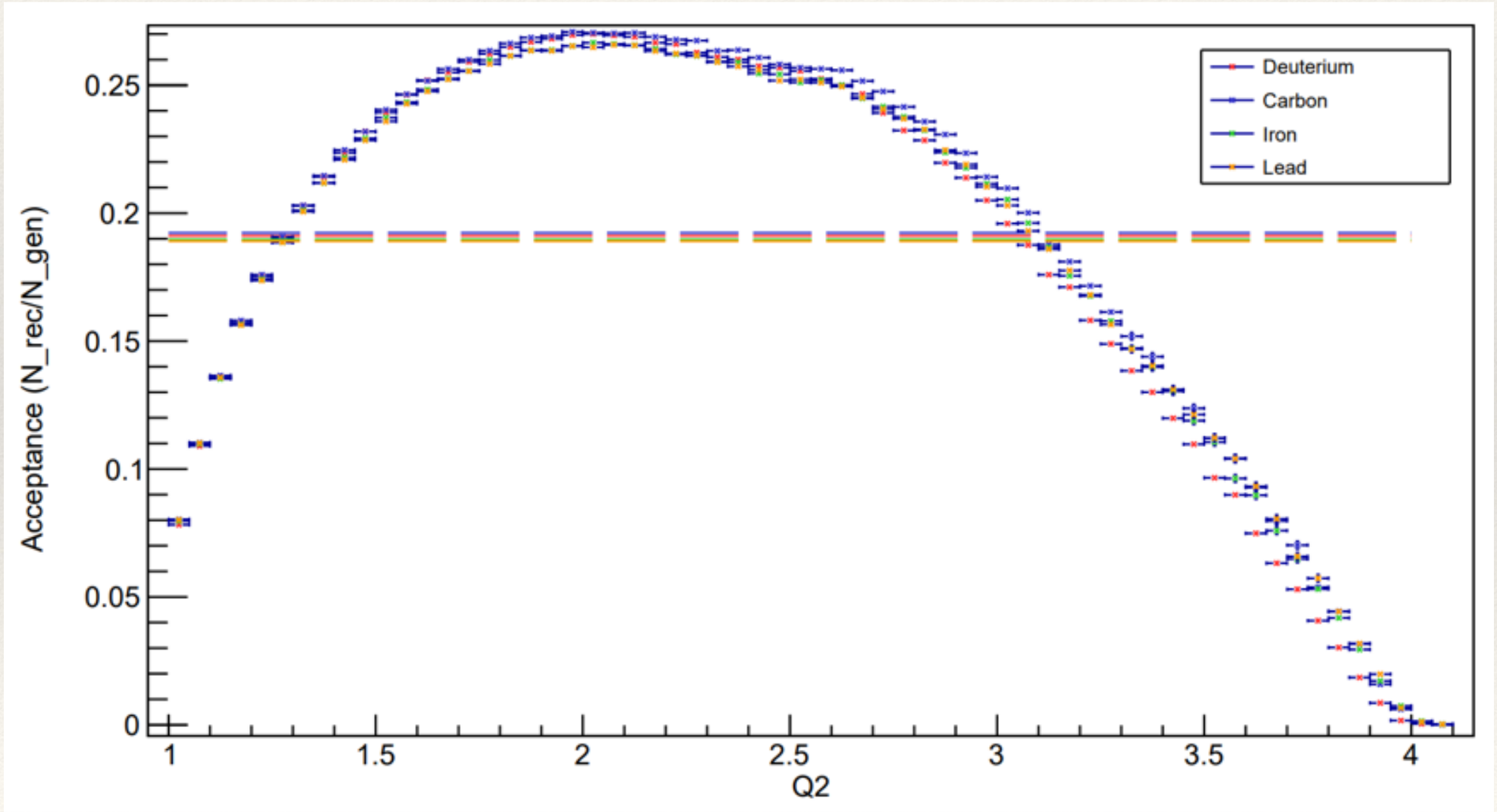
$\epsilon = \frac{rec}{gen} =$ acceptance

$N =$ acceptance correctved yield

$$R_M^h = \left[\frac{\frac{Y_A^{DIS}}{\epsilon_A}}{\frac{Y_D^{DIS}}{\epsilon_D}}\right]_h \left[\frac{N_D^{DIS}}{N_A^{DIS}}\right]_e = \left[\frac{Y_A^{DIS}}{Y_D^{DIS}}\right]_h \left[\frac{N_D^{DIS}}{N_A^{DIS}}\right]_e \left[\frac{\epsilon_D}{\epsilon_A}\right]$$

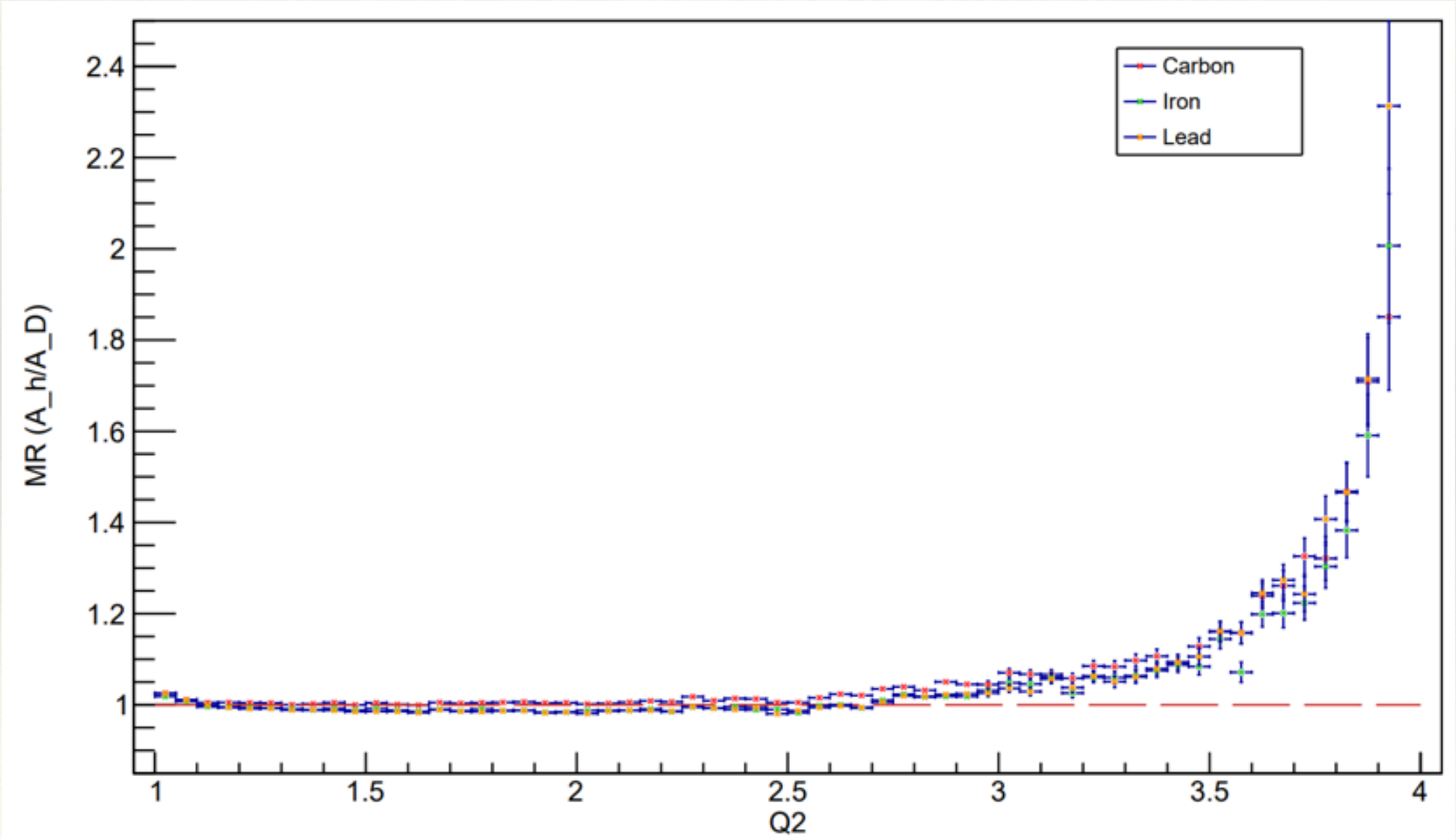
Acceptance

Juan Pablo Garces, UTFSM undergraduate

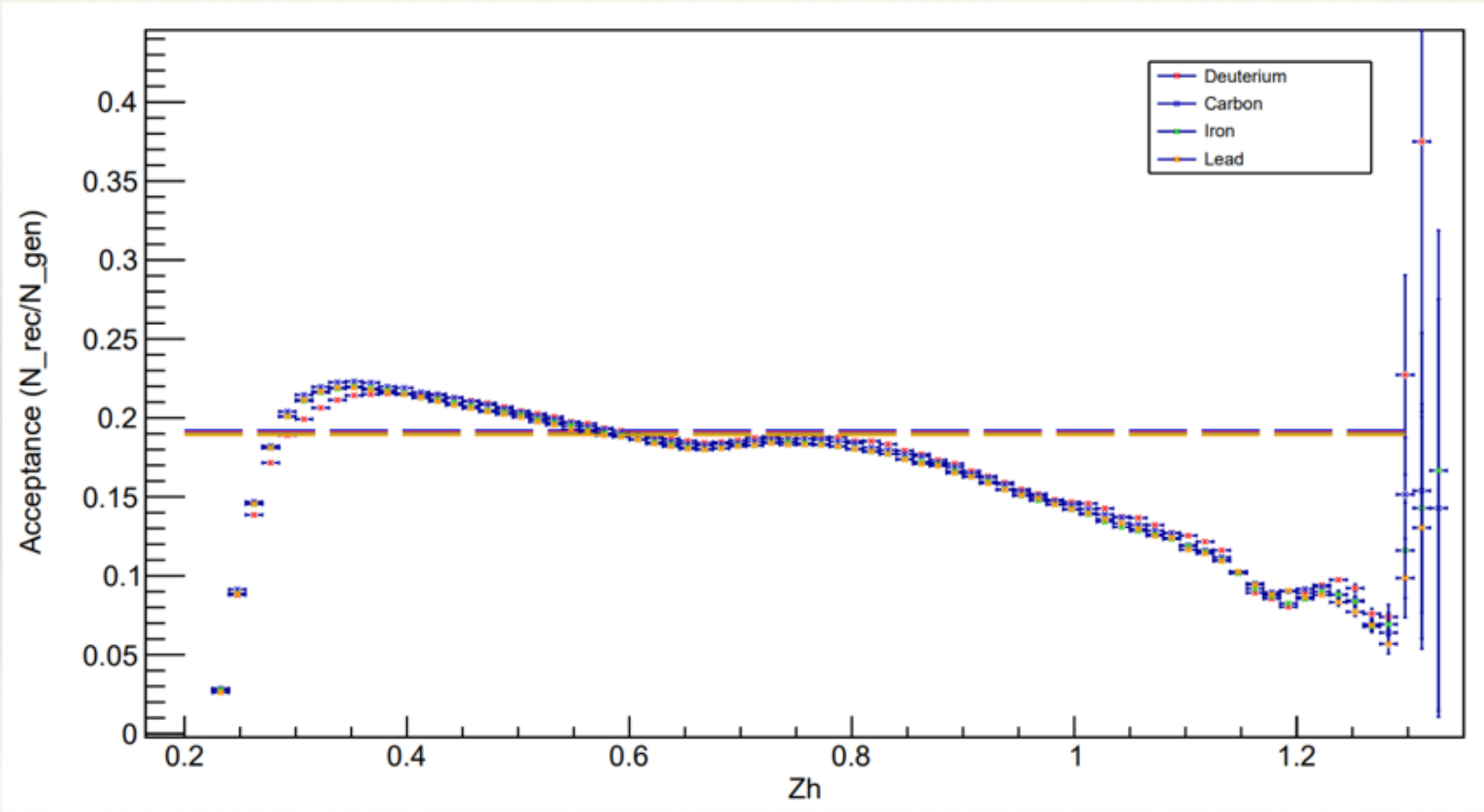


Acceptance

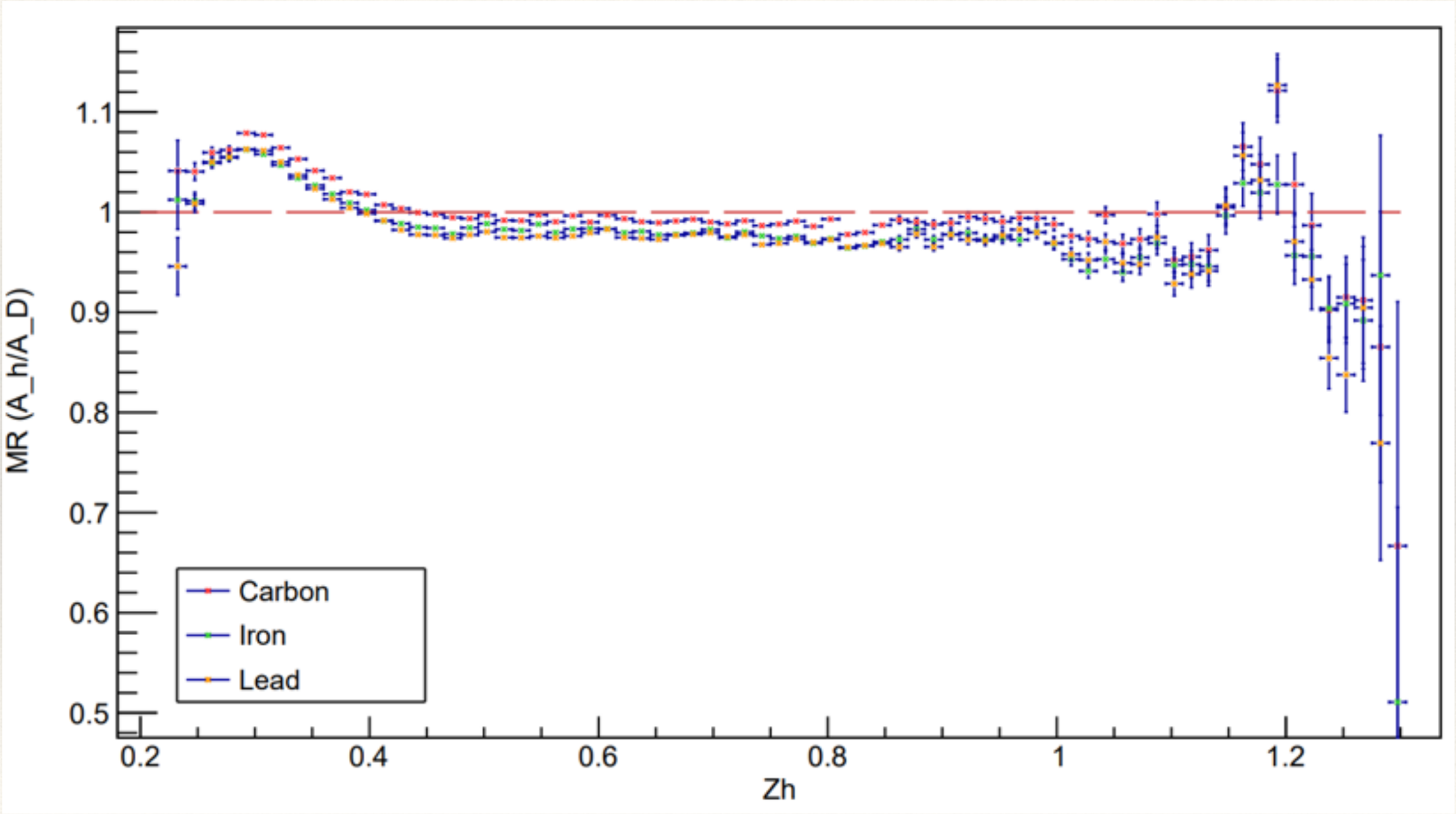
Juan Pablo Garces, UTFSM undergraduate



Acceptance


Deuterium
Carbon
Iron
Lead
Acceptance (N_rec/N_gen)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.2
0.4
0.6
0.8
1
1.2
Zh

Acceptance



Summary

The analysis is proceeding

- Analysis of eg2 data (M. H. Wood)
- Need to apply the acceptance correction
- Try different combination for multi-dimension analysis
- Start systematic error analysis
- Analyze p_T^2 and $< \Delta p_T^2 >$

Interesting trends

- Large R^p at low z_h
- Nuclear dependence in low vs high z_h
- Good agreement with GiBUU

Backup slides

The Program

DIS channels: *stable* hadrons, accessible with 11 GeV
JLab experiment PR12-06-117

Actively underway with existing 5 GeV data

meson	cτ	mass	flavor content
π^0	25 nm	0.13	$u\bar{u}d\bar{d}$
π^+, π^-	7.8 m	0.14	$u\bar{d}$, $d\bar{u}$
η	170 pm	0.55	$u\bar{u}d\bar{d}s\bar{s}$
ω	23 fm	0.78	$u\bar{u}d\bar{d}s\bar{s}$
η'	0.98 pm	0.96	$u\bar{u}d\bar{d}s\bar{s}$
ϕ	44 fm	1.0	$u\bar{u}d\bar{d}s\bar{s}$
f1	8 fm	1.3	$u\bar{u}d\bar{d}s\bar{s}$
K^0	27 mm	0.50	$d\bar{s}$
K^+, K^-	3.7 m	0.49	$u\bar{s}$, $\bar{u}s$

baryon	cτ	mass	flavor content
p	stable	0.94	ud
$\bar{p}$	stable	0.94	$\bar{u}\bar{d}$
Λ	79 mm	1.1	uds
$\Lambda(1520)$	13 fm	1.5	uds
Σ^+	24 mm	1.2	us
Σ^-	44 mm	1.2	ds
Σ^0	22 pm	1.2	uds
Ξ^0	87 mm	1.3	us
Ξ^-	49 mm	1.3	ds