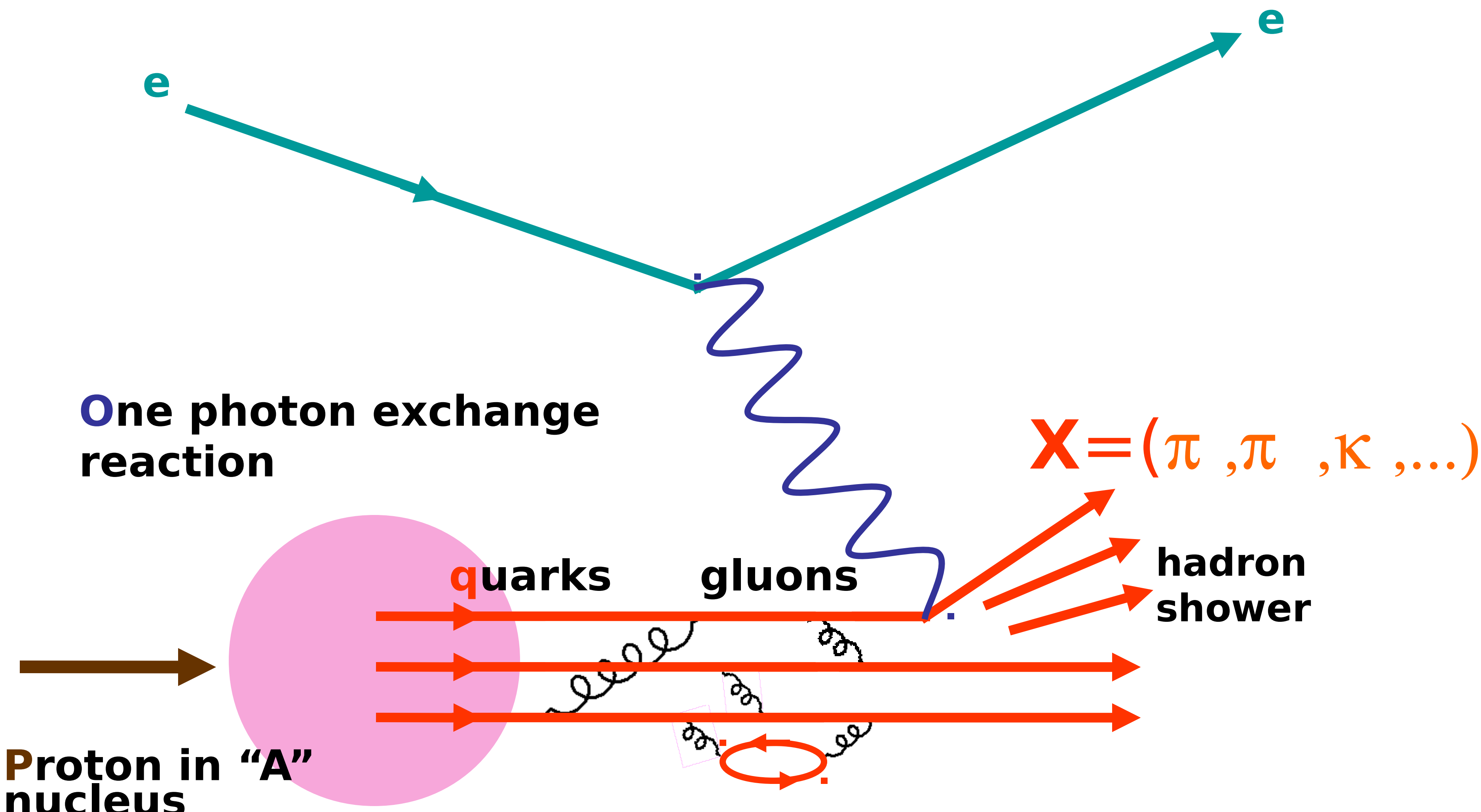
Quark propagation and hadron formation in the nucleus

(results of CLAS EG2 experiment)

Hayk Hakobyan for UTFSM group

CLAS collaboration meeting
March, 2017

Schematic diagram describing semi-inclusive Deep Inelastic Scattering of a lepton off a nucleon



Experimental Variables

ν – energy transferred by the electron, = initial energy of struck quark, (2 ~ 4.5) GeV here

Q – probe, (1 ~ 4) GeV^2 here

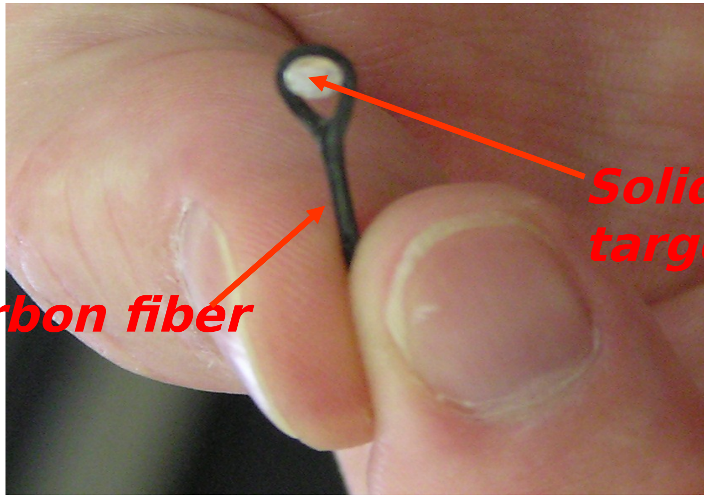
z_h – energy fraction carried by hadron; $0<z_h<1$

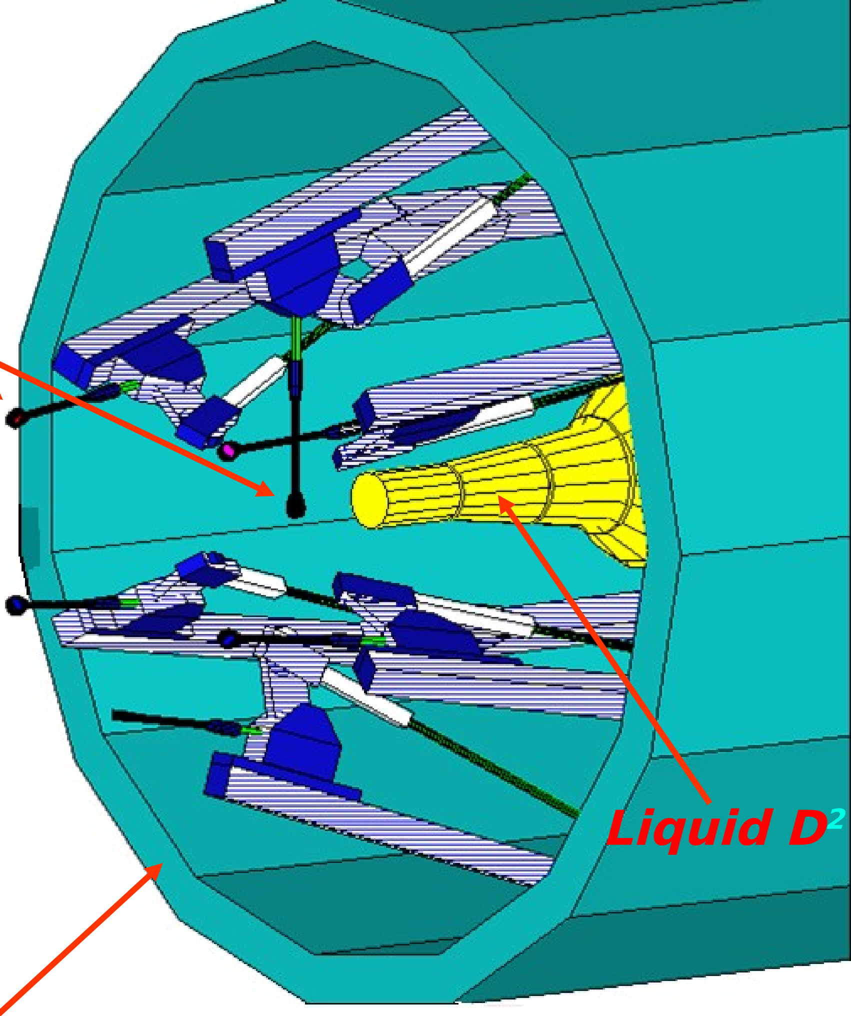
p_T – hadron momentum transverse to virtual photon direction

Φ – hadron azimuthal angle to virtual photon direction

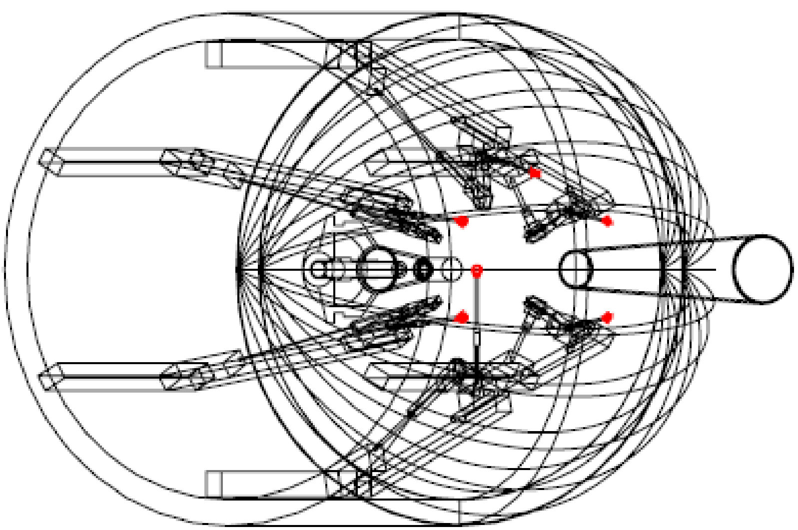
E_{BEAM}=5 GeV (CLAS)

Experimental details





Rohacell foam scattering chamber

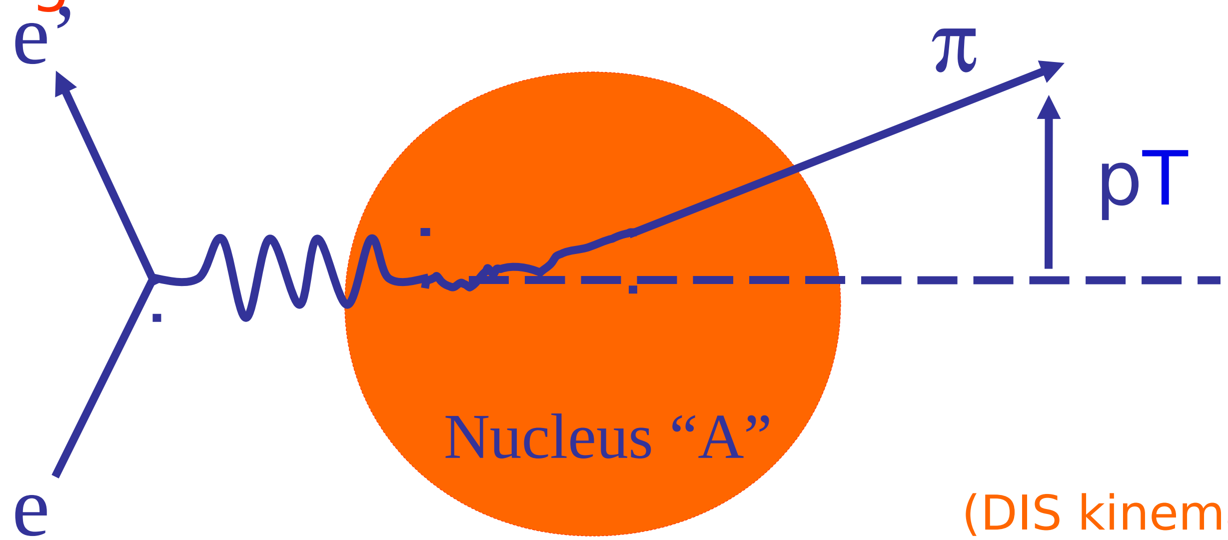


EG2 Experiment target in GEANT3
Solid (C, Al, Fe, Sn, Pb) target
simultaneously with deuterium target

Experimental Observables

Transverse momentum broadening

$$\Delta p_T^2 = p_T^2(A) - p_T^2(^2H)$$



(DIS kinematics)

Hadronic multiplicity ratio

$$R_M^h(z,\nu,p_T^2,Q^2,\phi) = \frac{\left\{ \dfrac{N_h^{DIS}(z,\nu,p_T^2,Q^2,\phi)}{N_e^{DIS}(\nu,Q^2)} \right\}_A}{\left\{ \dfrac{N_h^{DIS}(z,\nu,p_T^2,Q^2,\phi)}{N_e^{DIS}(\nu,Q^2)} \right\}_D}$$

Data analysis procedure

- Particle Identification Scheme for electrons and pions. Fiducial Cuts.
- PYTHIA 6.319 Adaptation to the EG2 Experiment phase-space.
- EG2 Target implementation in the GSIM.
- Acceptance Correction in 5 dimensional binning

(up to 3% correction on Multiplicity Ratio).

- Radiative corrections using HAPRAD2

  (up to 3% correction on Multiplicity Ratio)..

- Momentum correction.

3 pions 1 dimensional Multiplicity Ratios distributions paper

Coordination – William Brooks

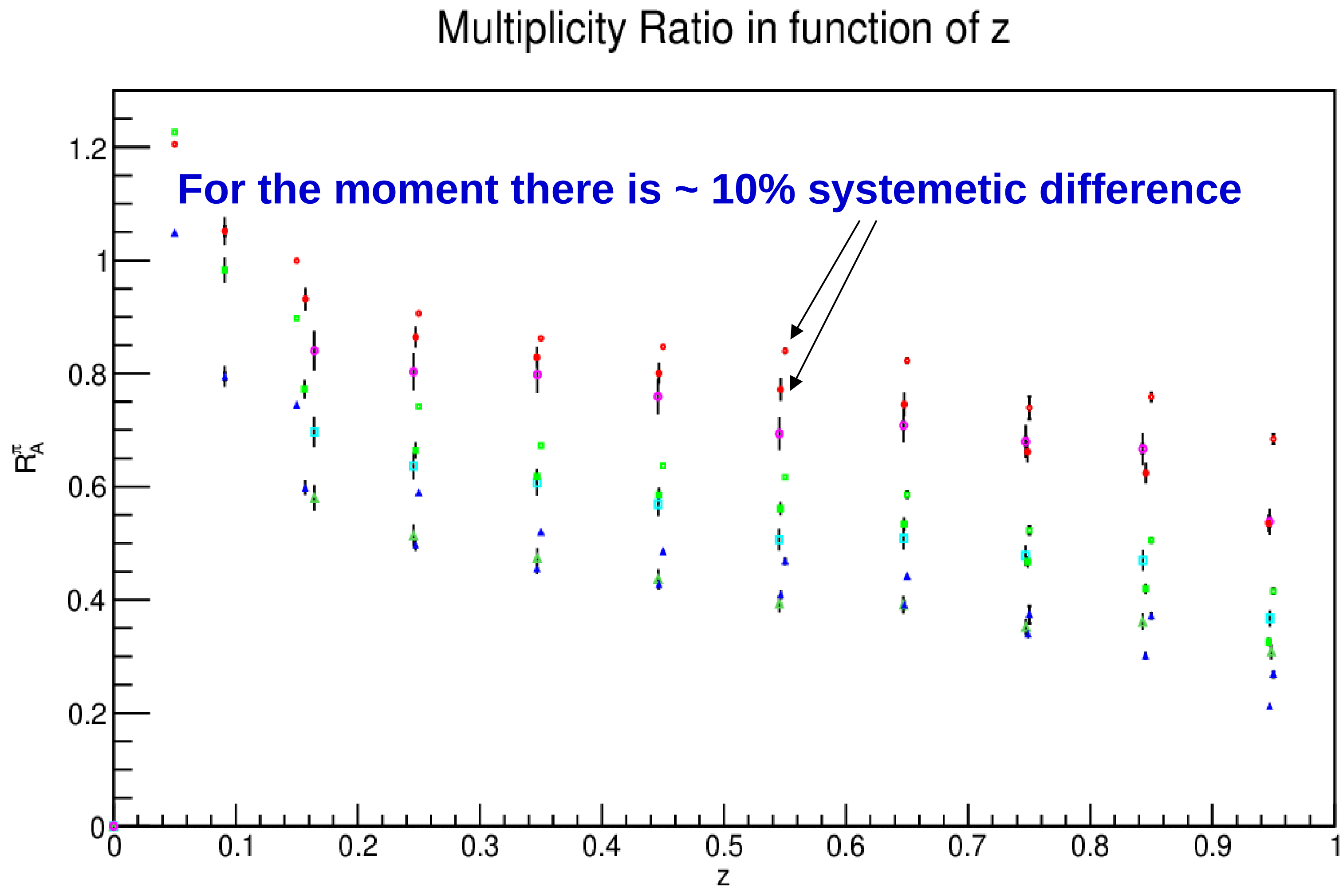
Positive Pions – Raphael Dupre, Hayk Hakobyan, Rodrigo Mendez

Negative Pions – Raphael Dupre, Ahmed El Alaoui

Neutral Pions – Taiysia Mineeva, Orlando Soto

Two analysis notes are under review

Integrated distribution comparison between Raphael and Hayk analysis



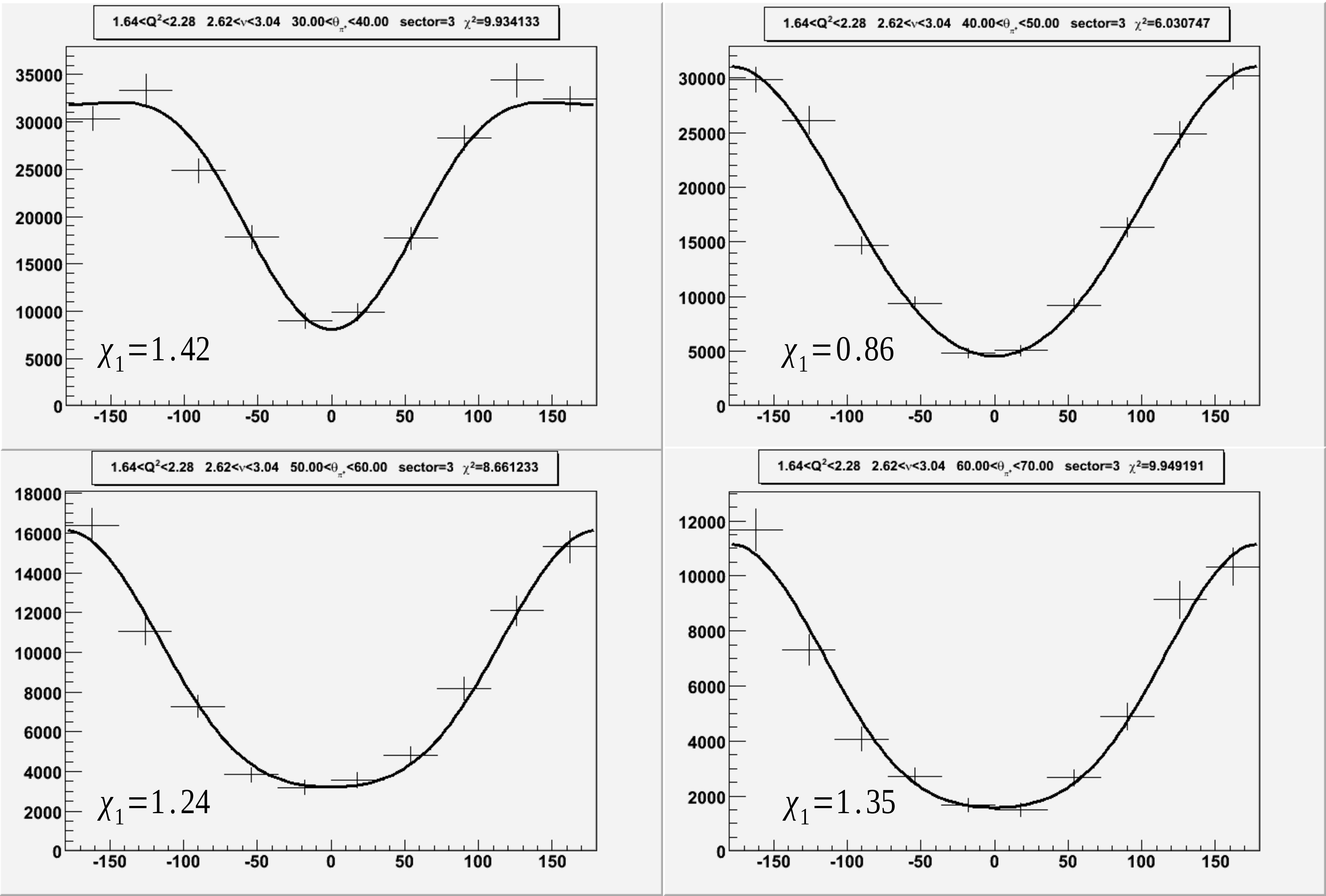
Possible sources for discrepancies

- Different dimensional binning in acceptance correction procedure (5 dim. - Hayk (up to 3% correction) & 4 dim. Raphael (10% correction))
- Tighter particle ID cuts in the case of Raphael's analysis for electrons and for pions.
- Different approaches in pion identification:

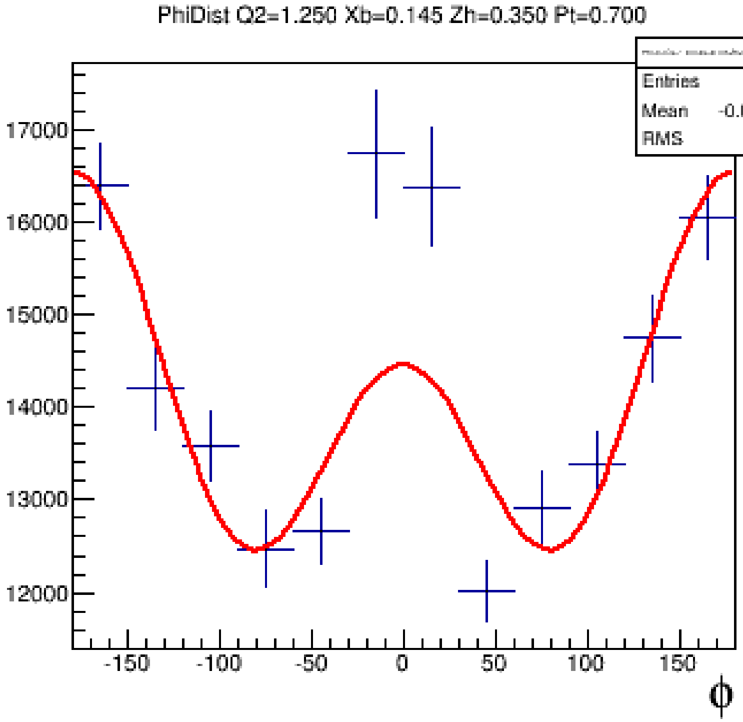
Δt – Hayk & $\Delta\beta$ – Raphael

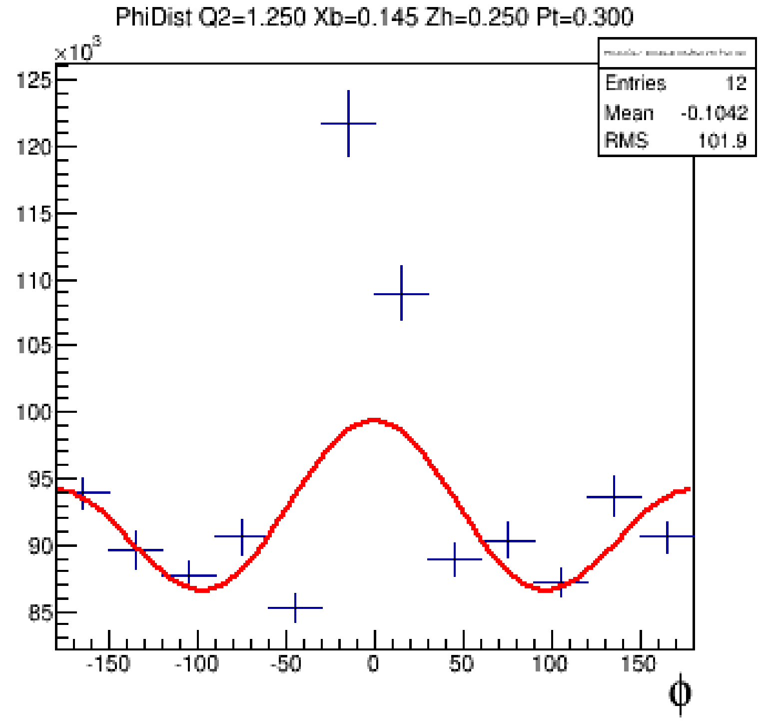
- Raphael doesn't have the Radiative Corrections implemented yet.
- Hayk doesn't have Isospin correction implemented

Fitting function: $f\left(\varphi_{q\pi^+}\right)=A+B\cos\left(\varphi_{q\pi^+}\right)+C\cos\left(2\cdot\varphi_{q\pi^+}\right)$ **GOOD**

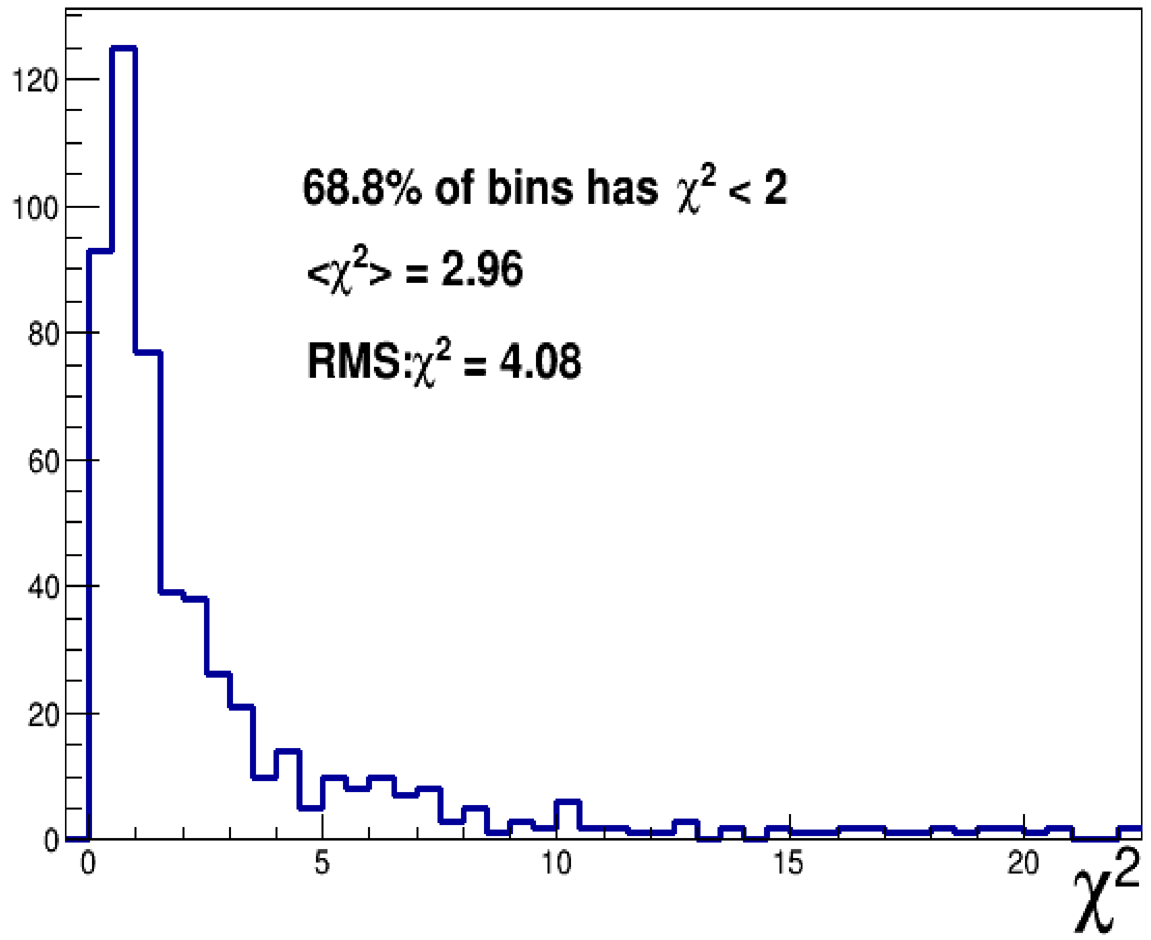


Fitting function: $f\left(\varphi_{q\pi^+}\right)=A+B\cos\left(\varphi_{q\pi^+}\right)+C\cos\left(2\cdot\varphi_{q\pi^+}\right)$ **BAD**

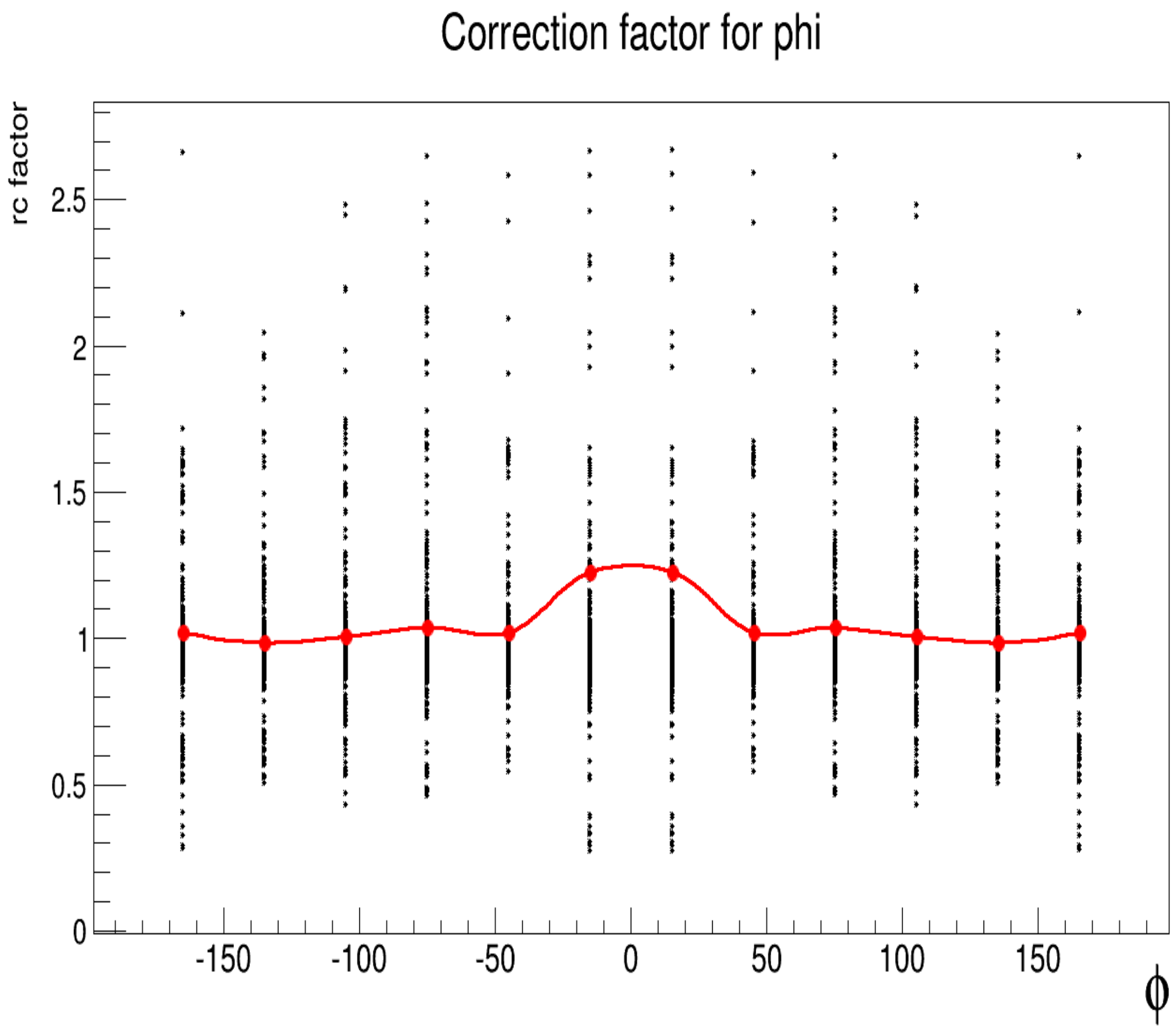




Radiative corrections with HAPRAD2

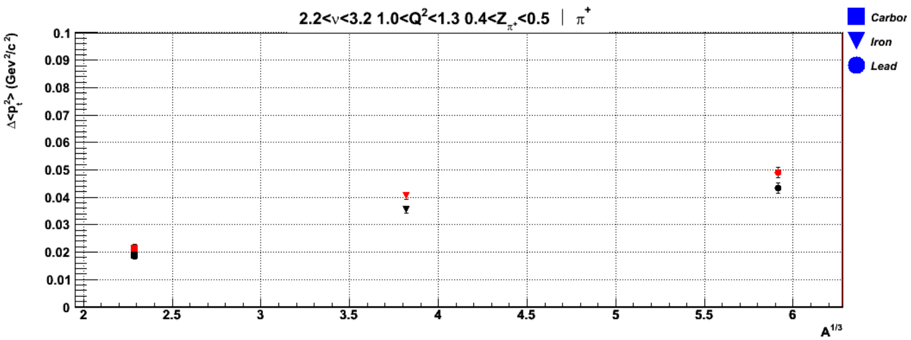


Radiative corrections with HAPRAD2



Further pi+ multi-bin publications

Transverse momentum dependence on 1/3 of nuclear mass number (all together in 24 kinematical region)

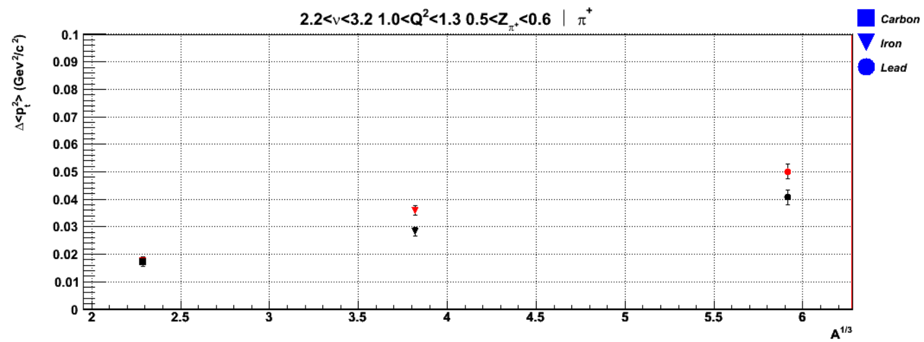


C_{mean}=0.0214 Fe_{mean}=0.0404 Pb_{mean}=0.0490

C_{err}=0.0013 Fe_{err}=0.0012 Pb_{err}=0.0019

Corrected data

C_{mean}=0.0189 Fe_{mean}=0.0355 Pb_{mean}=0.0434

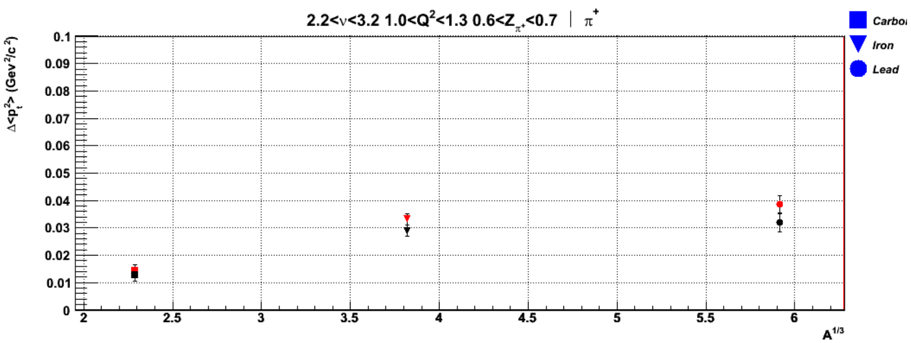


C_{mean}=0.0174 Fe_{mean}=0.0359 Pb_{mean}=0.0501

C_{err}=0.0018 Fe_{err}=0.0017 Pb_{err}=0.0027

Corrected data

C_{mean}=0.0173 Fe_{mean}=0.0282 Pb_{mean}=0.0407

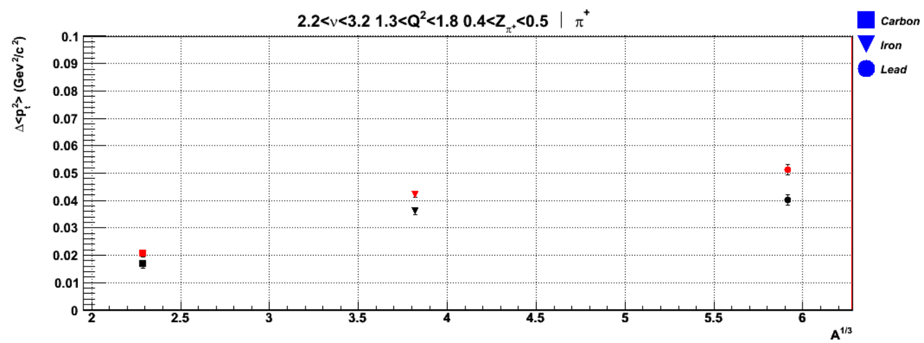


C_{mean}=0.0144 Fe_{mean}=0.0333 Pb_{mean}=0.0385

C_{err}=0.0023 Fe_{err}=0.0021 Pb_{err}=0.0034

Corrected data

C_{mean}=0.0129 Fe_{mean}=0.0290 Pb_{mean}=0.0320



C_{mean}=0.0206 Fe_{mean}=0.0422 Pb_{mean}=0.0512

C_{err}=0.0013 Fe_{err}=0.0012 Pb_{err}=0.0019

Corrected data

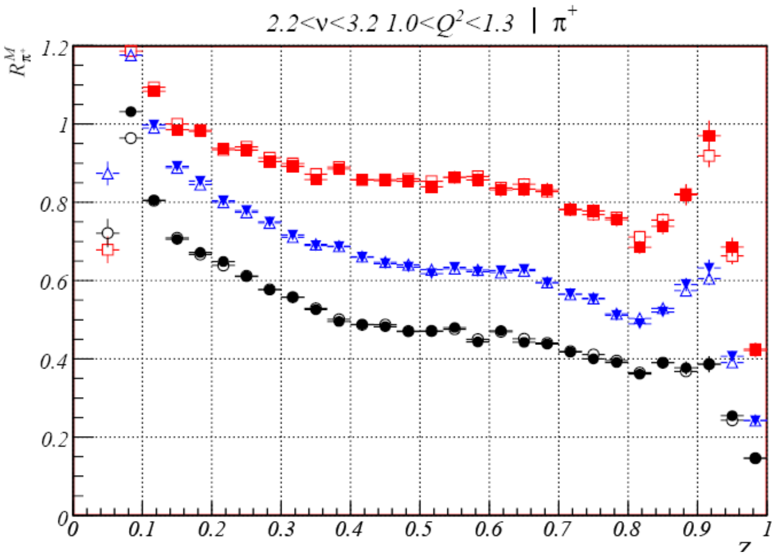
C_{mean}=0.0167 Fe_{mean}=0.0360 Pb_{mean}=0.0403

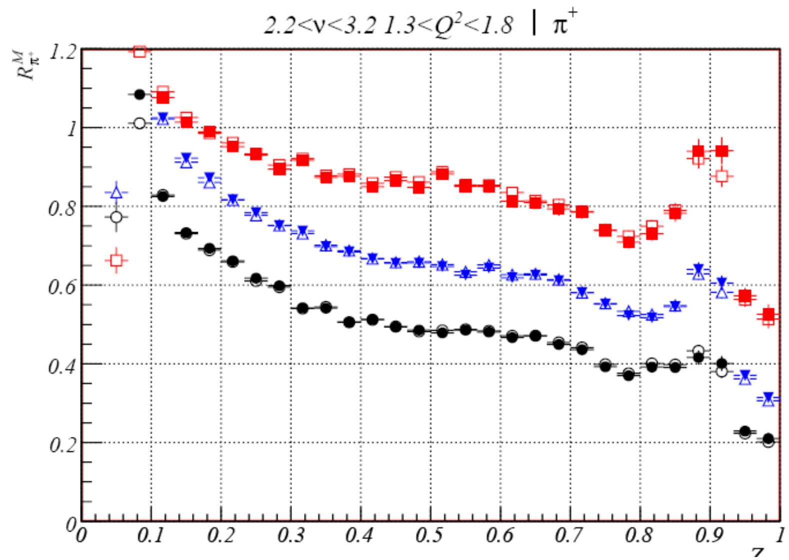
Acceptance correcion less than 14 %

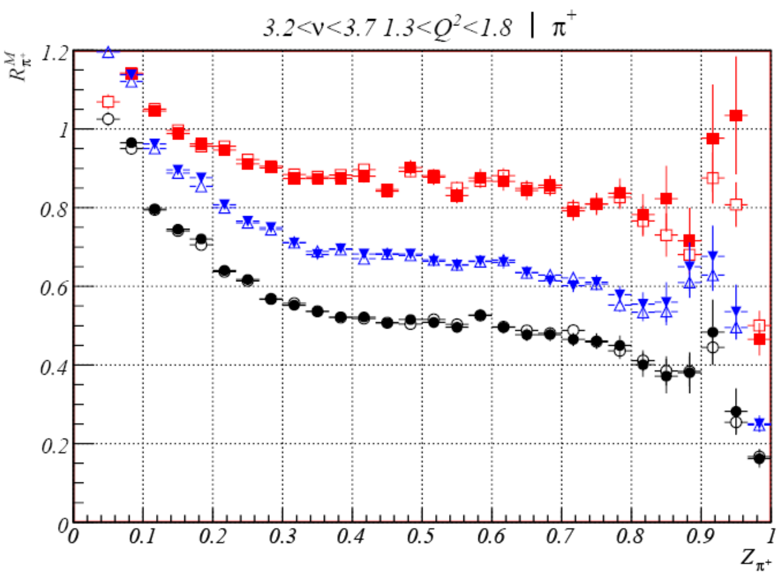
CLAS Data: binning

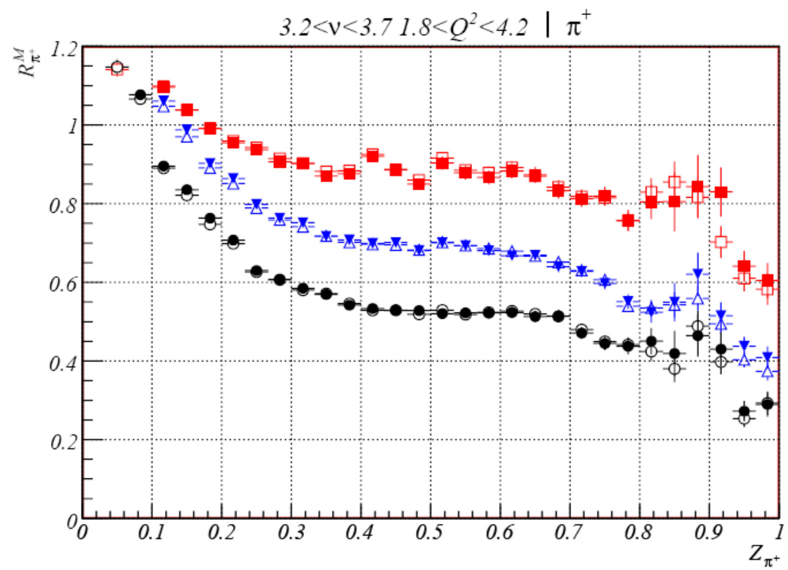
Only a fraction of the many bins of CLAS Data

Multiplicity Ratio Dependence on Z_h in different Q^2 and ν bins

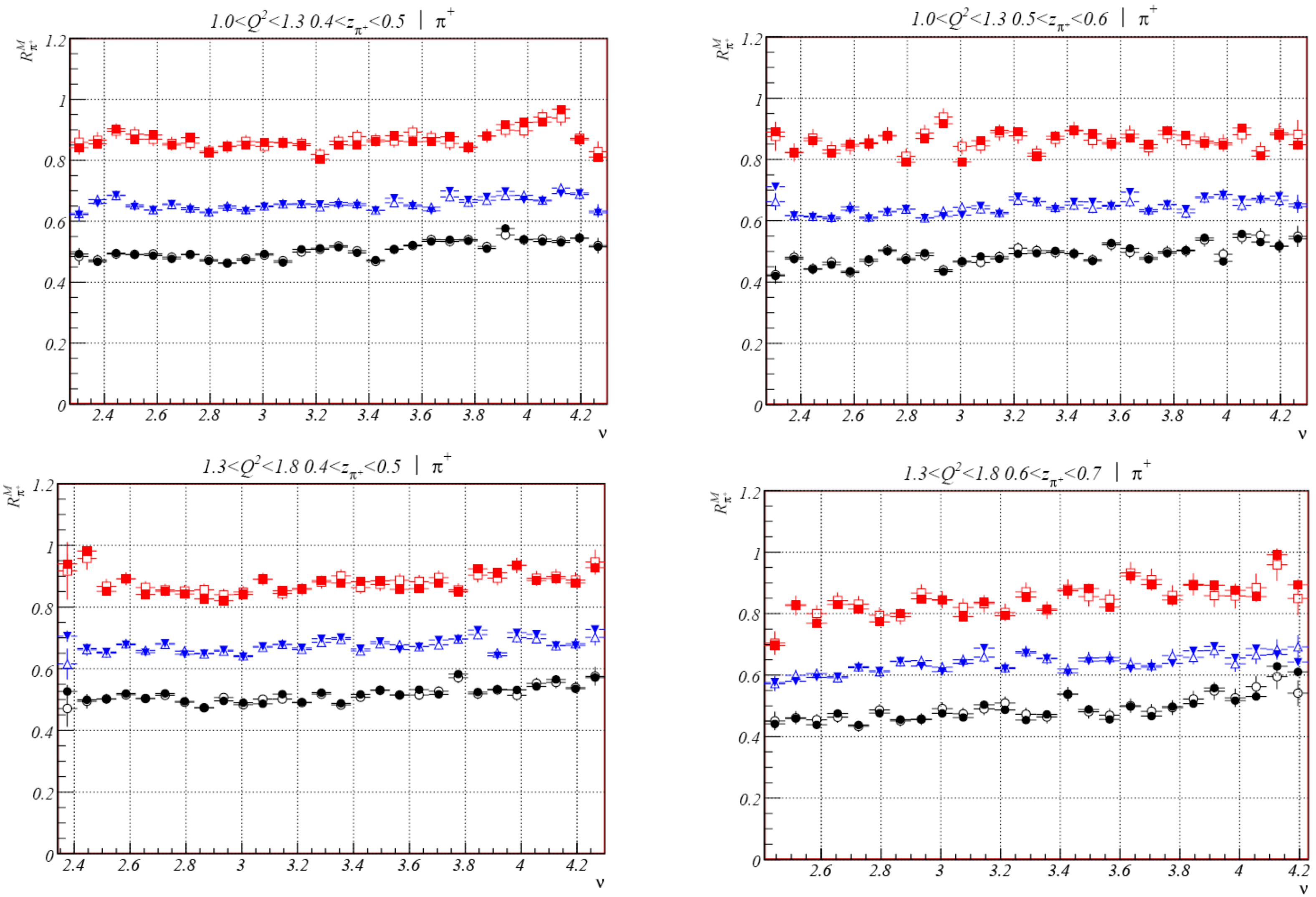




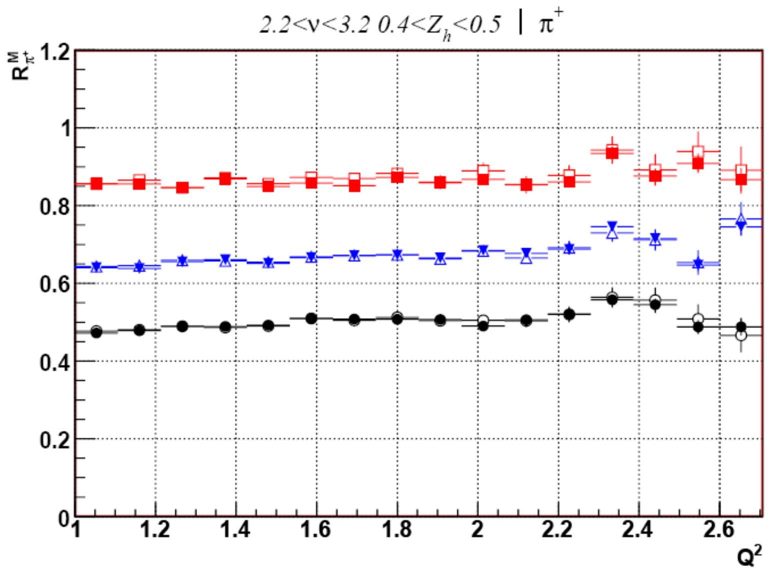


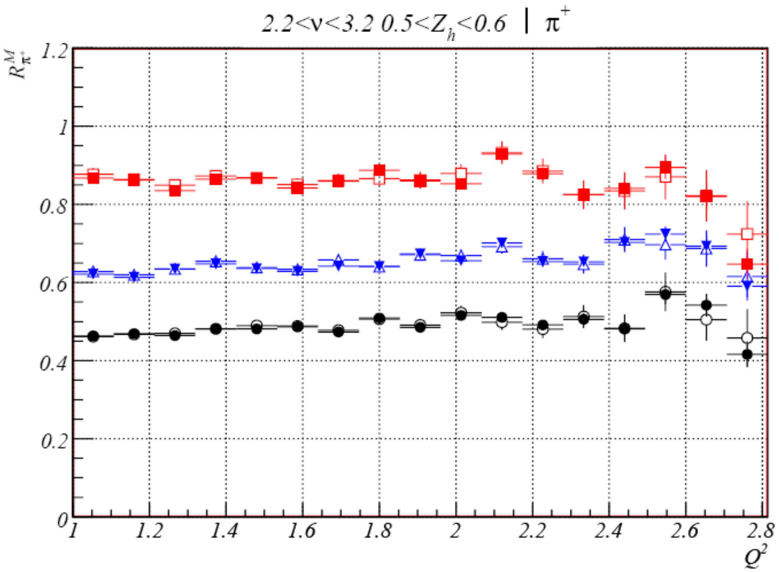


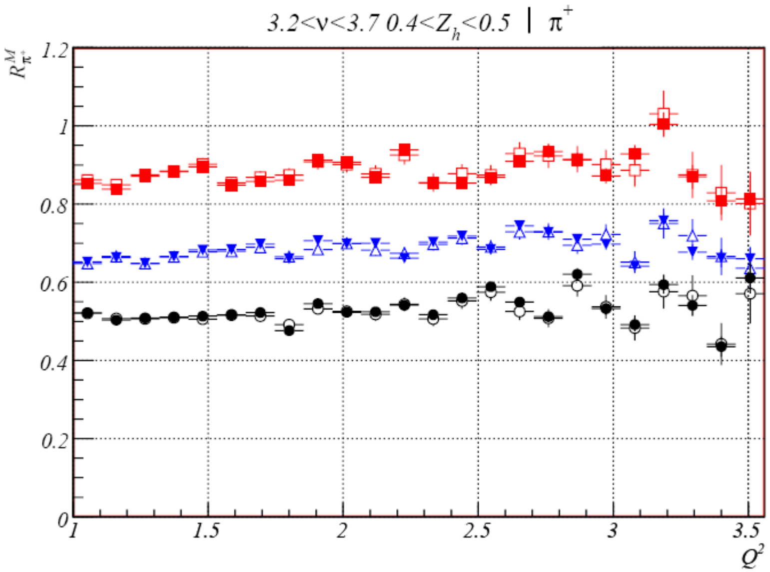
Multiplicity Ratio Dependence on ν in different Q^2 and Z_h bins

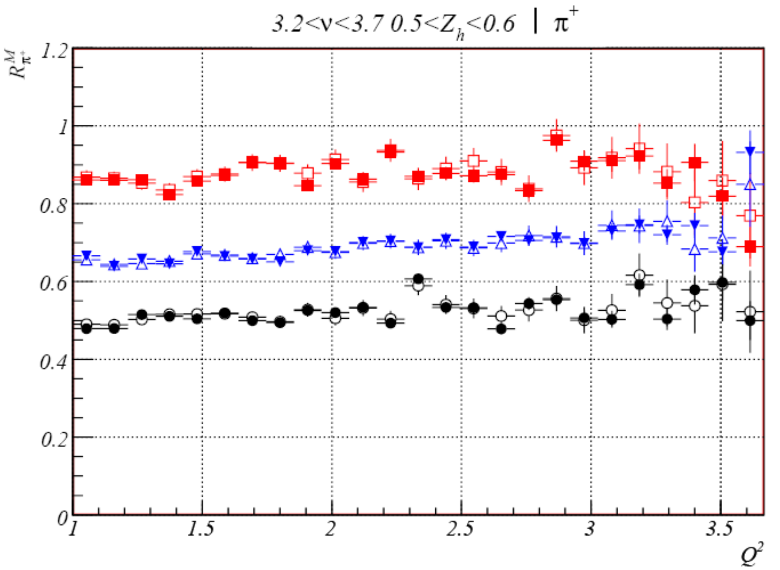


Multiplicity Ratio Dependence on Q^2 in different Z_h and ν bins

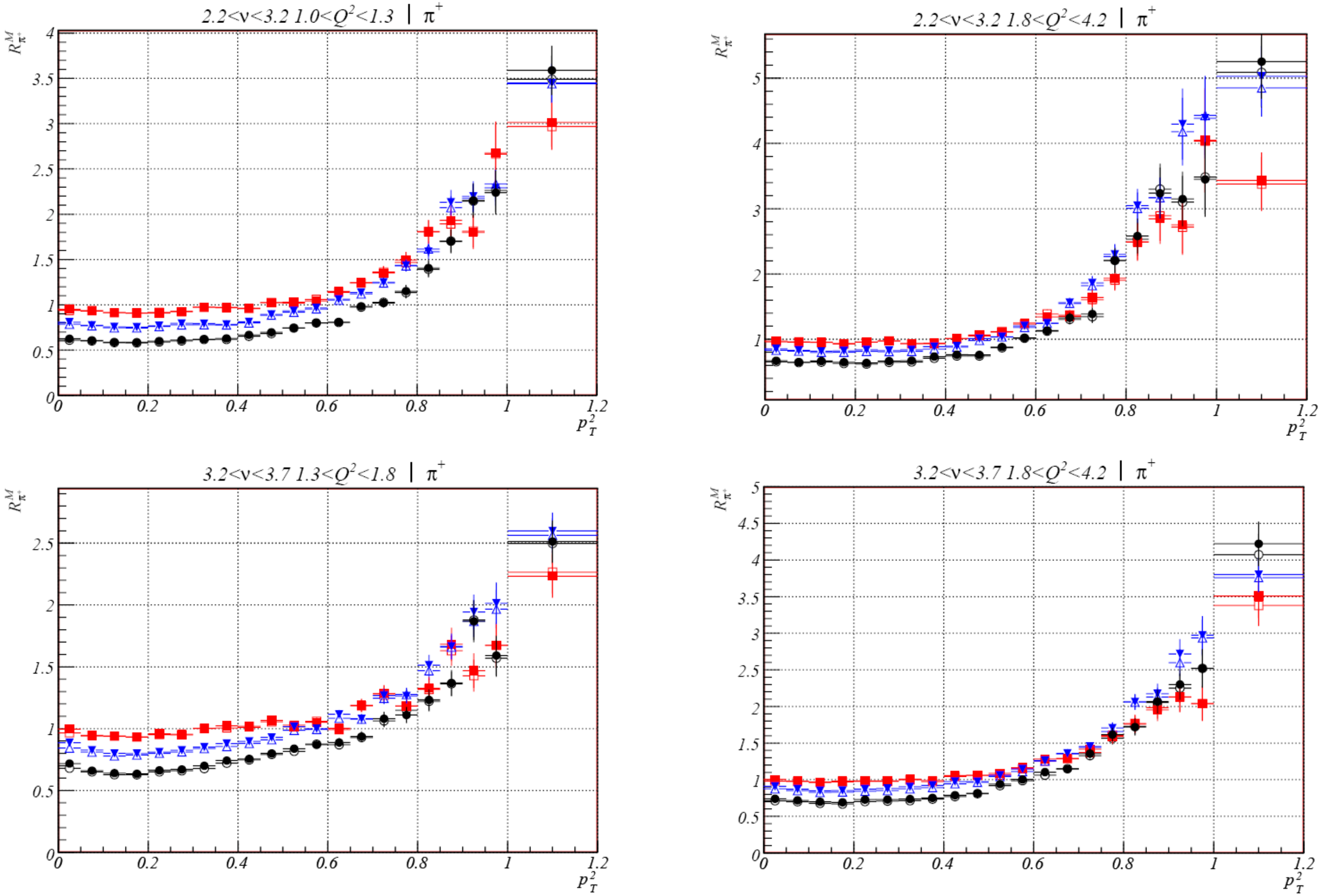








Cronin effect in different ν և Q (0.4< Z^h<0.7) kinematical regions



J.W. Cronin et al, Production of hadrons with large transverse momentum at 200 GeV, 300 GeV, and 400 GeV. Phys. Rev., D11:3105, 1975.

Cronin Effect – Dependence on $A^{1/3}$, x_B, and Q^2