Nuclear Physics Working Group Meeting
November 20, 2009 A110

Agenda

13:30-13:40 'Update on reviews', Jerry Gilfoyle,
13:40-14:05 'Update on K0 hadronization analysis' - Aji Daniel
14:05-14:30 'Update on the Data Mining Initiative' - Sebastian Kuhn or
Larry Weinstein
14:30-14:55 'Preliminary Cross sections for gamma+D->pi- p p' -
Jerry Gilfoyle for Nikolai Pivnyuk
14:55-15:15 Break
15:15-15:40 'Update on pi minus analysis in eg2' - Raphael Dupre
15:40-16:05 'Polarized EMC effect' - Will Brooks
16:05-16:30 'Update on the neutrino project' - Steve Manly
16:30-16:55 'Status Report on K+ Lambda Hadronization' - Lamiaa El Fassi
16:55-17:20 'Photon energy Correction' - Taya Mineeva
17:20-17:30 'Additions to the Project List' - All

Current and Recent Reviews*

M.Wood, R. Nasseripour, D.Weygand, C.Djalali - CAN: Absorption of the Omega and Phi Mesons from the g7a data set.
Committee: Maurik Holtrop (chair), Pawel Nadel-Turonski, Igor Strakovsky.
Approved.

Hovhannes Baghdasaryan - 3He(e,e'pp)n Analysis
Committee:Mike Vineyard (Chair), Dan Protopopescu, Steffen Strauch
Approved.

Dan Protopopescu - Multipole Analysis of the Delta0(1232) in 3He
Committee:Kyungseon Joo (Chair), Mike Vineyard, ;Mike Wood
Ongoing – DP will complete data analysis; no recent changes.

Alex Vlasov – CAN: Source size measurements in the eHe -> e'pΛ X reaction.
Committee: Larry Weinstein (chair), Pavel Degtyarenko, Yordanka Ilieva
Ongoing – Committee responded to revised Note last summer.

K. Hafidi et al. - CAN:Color Transparency in eg2
Committee: Hovanes Egiyan (chair), Mike Wood, Stepan Stepanyan
Ongoing – 'mostly converged'; authors have some final comments to address.

Aji Daniel and Ken Hicks – CAN: A measurement of the nuclear dependence of hadronization of neutral kaons (using EG2 data set)
Commitee: Reinhard Schumacher (chair), Steve Manly, Lamiaa Elfassi
Ongoing – Several exchanges between authors and committee. Meeting on Nov 20.

R. Nasseripour and Barry Berman - CAN - pi+ Photoproduction on 3He
Committee: Ken Hicks (chair), Raffaella Devita, Carlos Salgado.
Ongoing – Committee responded to first draft in August.

* If you want to modify this list send email to gilfoyle@jlab.org

SHORT DISTANCE STRUCTURE OF NUCLEI
MINING THE WEALTH OF EXISTING JEFFERSON LAB DATA

Larry Weinstein

1. Large effort: 19 co-authors.
2. Examine existing data from ten run periods.
3. Targets: ^{1}H, ^{3}He, ^{4}He, ^{12}C, Al, Ni, ^{208}Pb.
4. Build on existing expertise in run groups.

Great physics still to do:

SRC studies:

- *A* dependence
- Q^2 dependence
- Isospin dependence
- Non-nucleonic decays of SRC: backward Δ and forward Δ^{++}
- 3N SRC

The deuteron:

- Increase the kinematic range in D(e,e'p)X: spectator detection and Q^2
- R_{LT}' (fifth response fn)
- $\Delta\,\Delta$ components
- Spin structure of SRC (with polarized deuterium)

Color transparency:

- deuteron in transverse kinematics: suppression of transverse Δ production with Q^2
- Resonance vs. non-resonance production: compare ρ vs $\pi\pi$ emission
- S_{11} production

Timeline

1. Explore existing data set to identify promising channels (6-12 months).
2. Recook selected data (data mining postdoc) and theory postdoc.
3. Physics analysis (all).

Resources

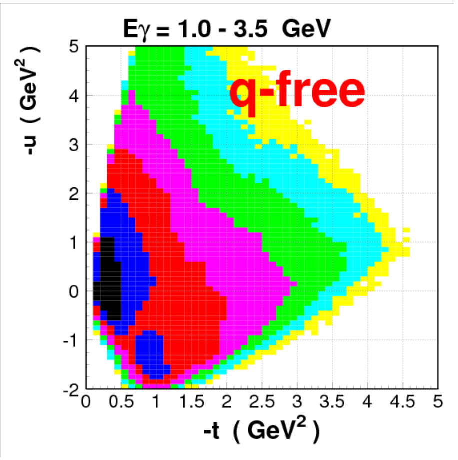
1. Experimental postdoc at JLab
2. Theory postdoc starting in the 2nd year
3. Grad student
4. Yearly summer workshops

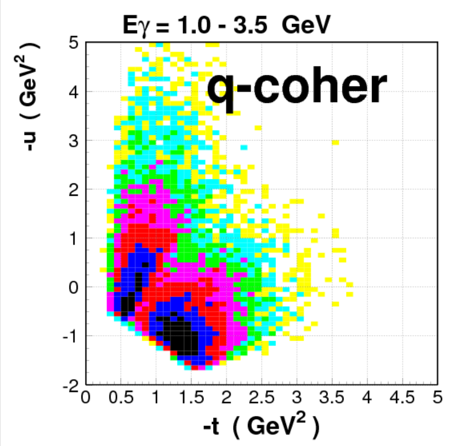
Mechanism of Quasi-Coherent π^- - photoproduction off Deuterium in $\gamma\ D \rightarrow \pi^-\ p\ p$ reaction

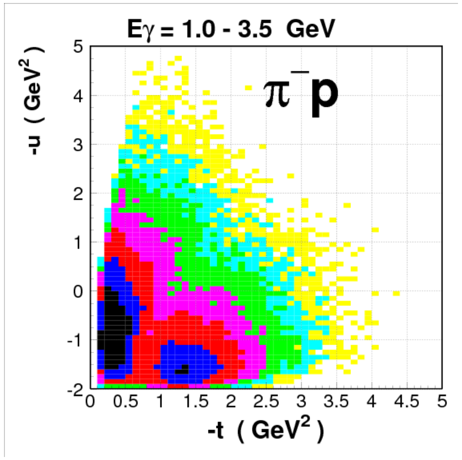
CLAS Experiment g10
JLab

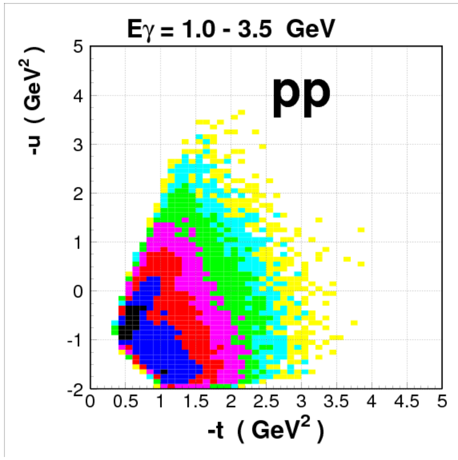
N.Pivnyuk, J.-M. Laget, E.Pasyuk, T.Mibe

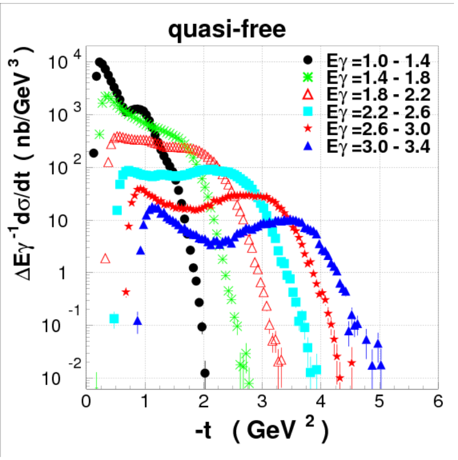
-t distributions

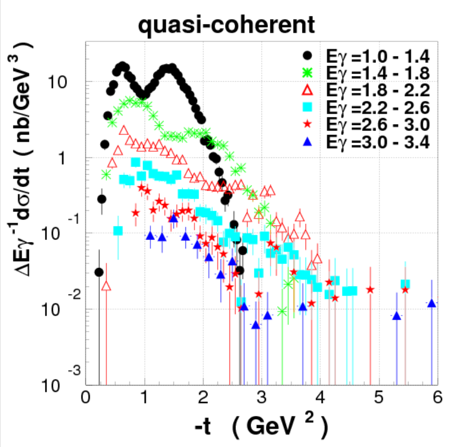


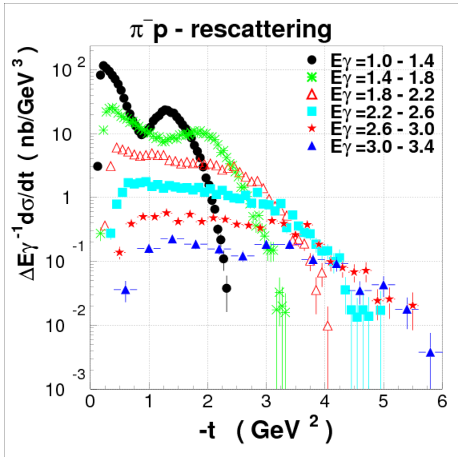


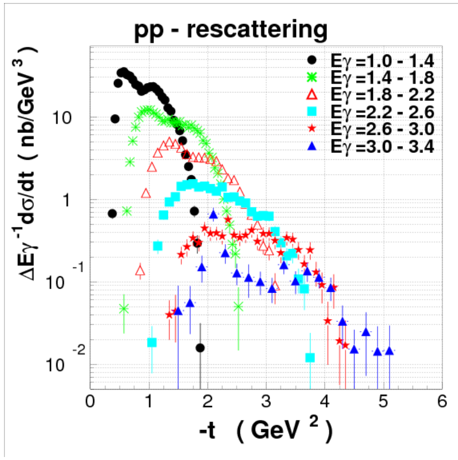




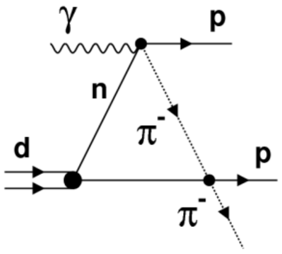






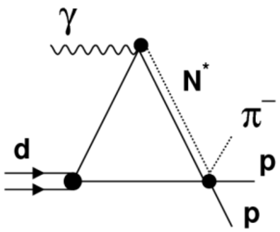


simulation



"t channel "

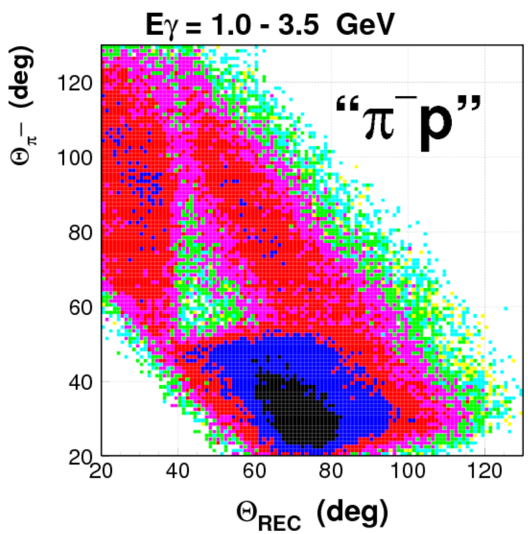
1. d → np : Bonn deuteron wave function.
2. γn → π⁻p : g10 quasi-free sector . Cut on missing momentum 50 MeV/c.
3. π⁻p → π⁻p : Saclay data . SAID data base. Tkin ≈ 700 MeV.

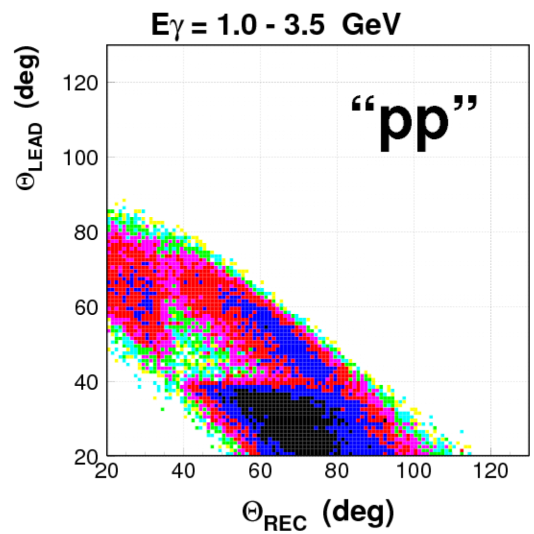


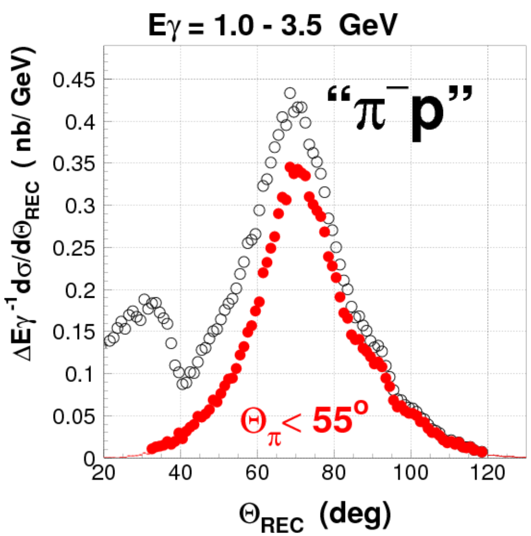
" s channel "

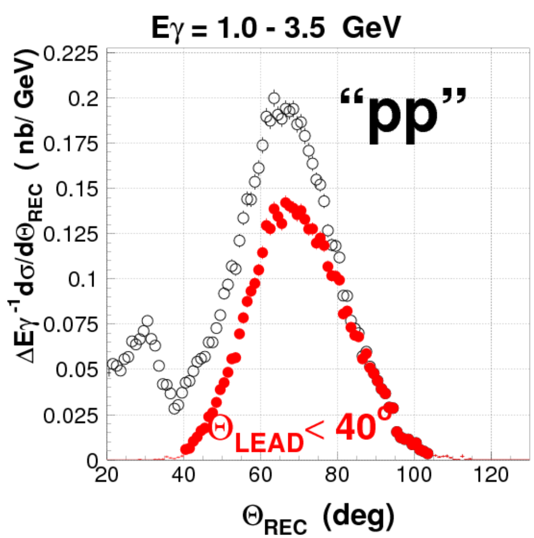
1. γd → π⁻**(pp)** : quasi-two-body reaction . Uniform in CM .
2. **(pp)** → pp : Uniform in CM .

Rescattering sector





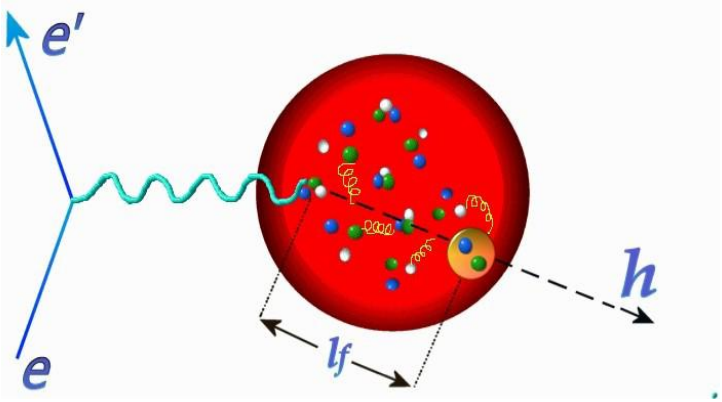




Emission angles of recoiling Proton

Update on K0 hadronization studies
(preliminary results from CLAS EG2)

Aji Daniel and Ken Hicks



$z=E_{hadron}/\nu$ is the fraction of the struck quark's initial energy carried by the hadron.

Quark propagation and hadron formation

Deep Inelastic Scattering on Nuclei

•Quark is struck by virtual photon

Initial state characterized by

Energetic interactions, compared to the proton mass (W>2 GeV)

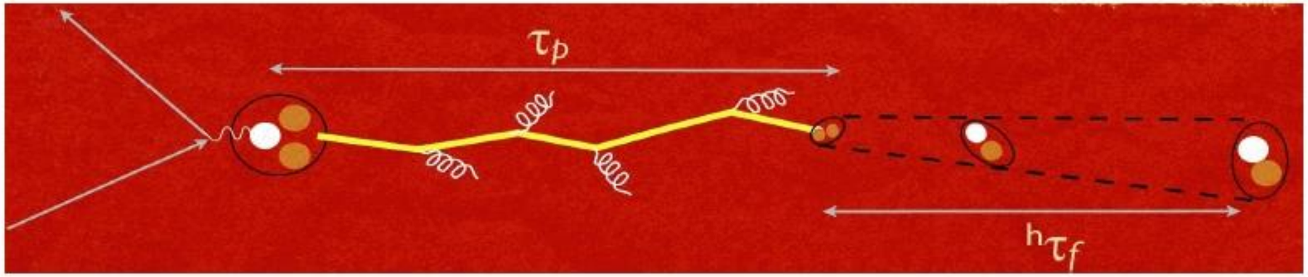
Short-range interaction, compared to the proton size (Q2>1 GeV2)

Energy is transferred to a single valence quark (x>0.1)

Afterwards, the struck quark propagates through nuclear medium

Measure K^0 channel via the $\pi^+\pi^-$ decay.

Quark propagation and hadron formation



Production time (t_p) :

How long does a light quark remain deconfined?

Measurement of P_T^2 broadening (directly proportional to quarks in medium path) gives information about this. Once pre-hadron is formed, no further broadening occurs.

$$\Delta P_T^2 = \langle P_T^2 \rangle_A^{DIS} - \langle P_T^2 \rangle_D^{DIS}$$

Formation time(t^h_f) :

How long does it take to form a fully dressed hadron?.

Measurement of hadron attenuation (**R**) gives information about this.

$$R_M^h(z,\nu,P_T^2,Q^2) = \frac{\left[\frac{N_h^{DIS}(z,\nu,P_T^2,Q^2)}{N_e^{DIS}(\nu,Q^2)}\right]_A}{\left[\frac{N_h^{DIS}(z,\nu,P_T^2,Q^2)}{N_e^{DIS}(\nu,Q^2)}\right]_D}$$

Analysis Details

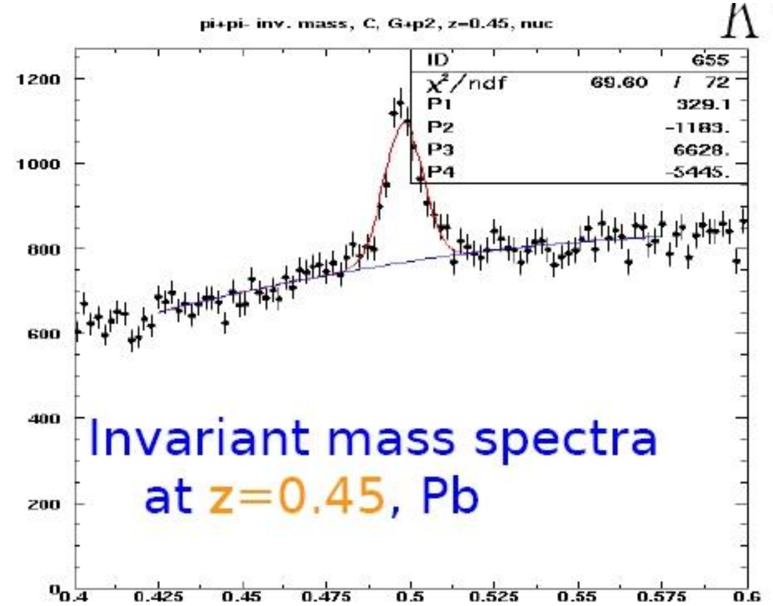
Standard e- selection

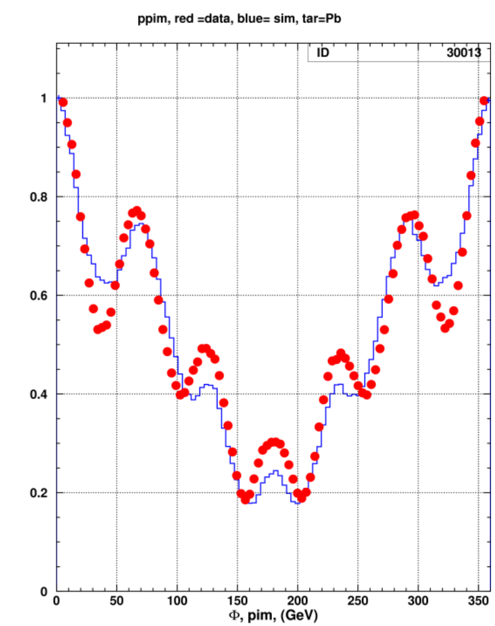
Kinematic cuts for DIS

- W> 2GeV
- Q2>1 GeV2
- Y(=) <0.85

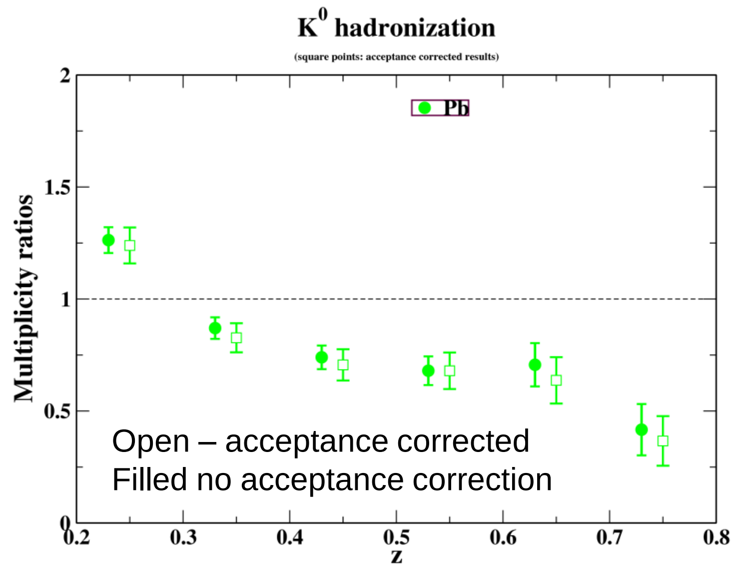
Timing cut: Electron and at least one $\pi^+\pi^-$ pair within 1.0 ns.

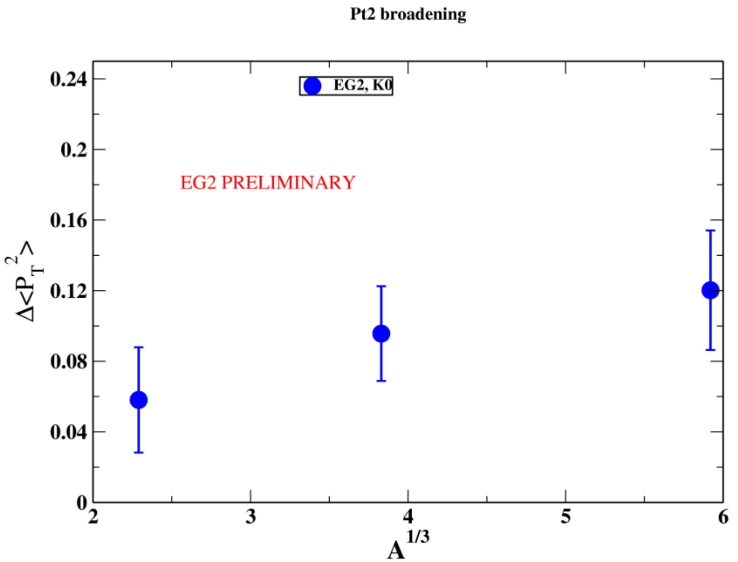
Acceptance corrections: PYTHIA event generator





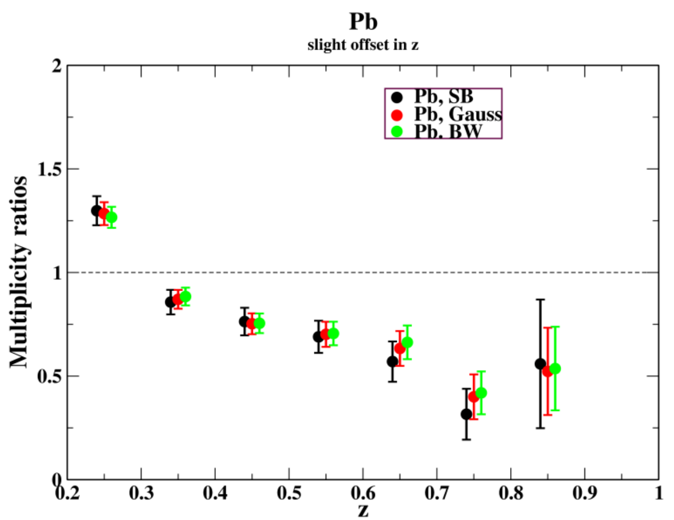
Results

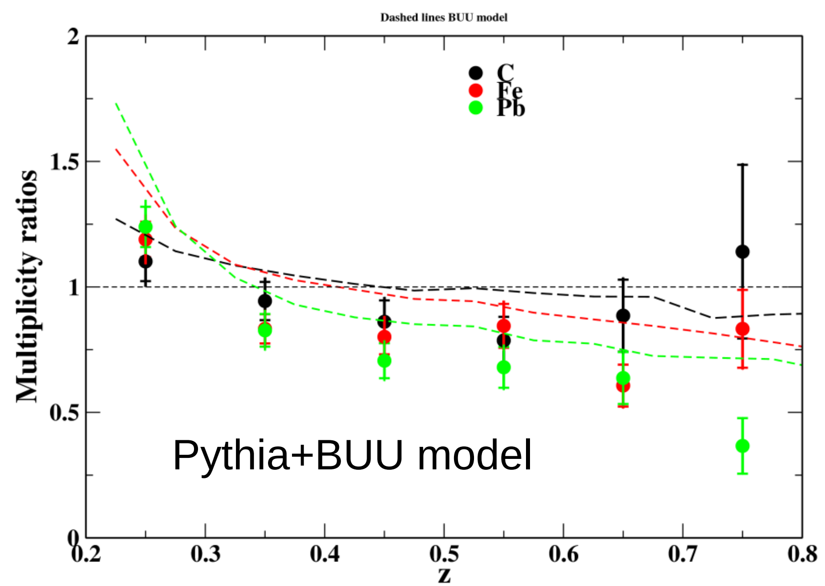




Background Subtraction:

- Sideband subtraction
- Briet Wigner +2nd order polynomial
- Gaussian + 2nd order poly





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Update on Hadronization Analysis with eg2 Data

Study quark propagation and hadronization in nuclear matter.

Raphaël Dupré

Argonne National Laboratory
Université Claude Bernard Lyon 1

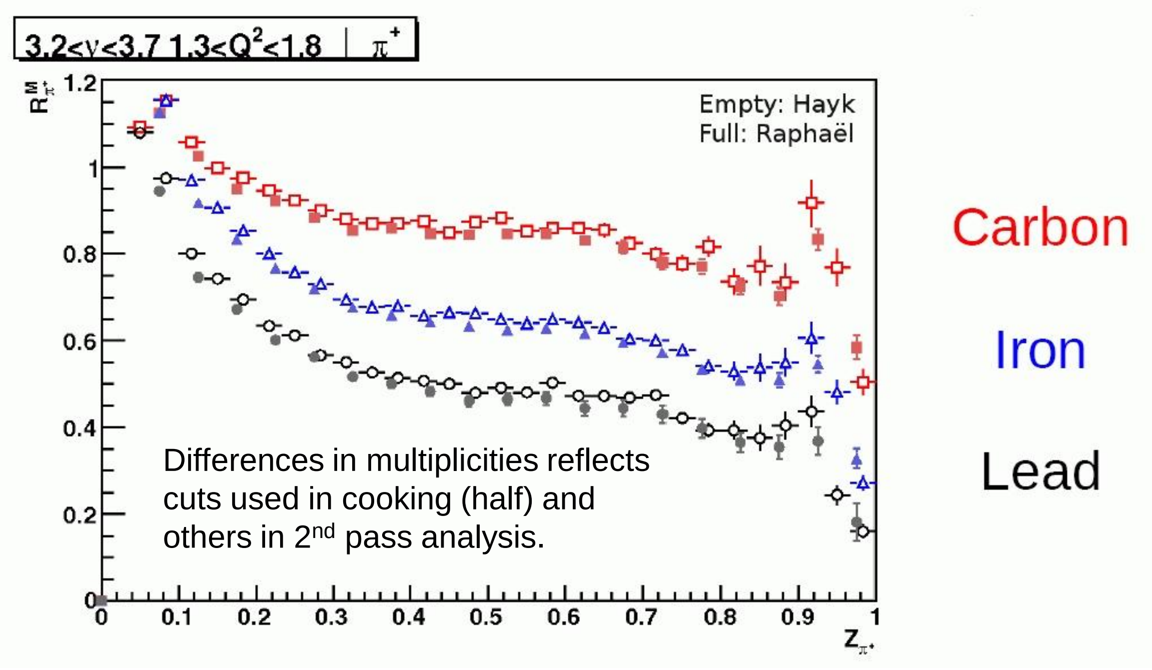
Analysis Plan

Lamiaa and I plan to extract in parallel

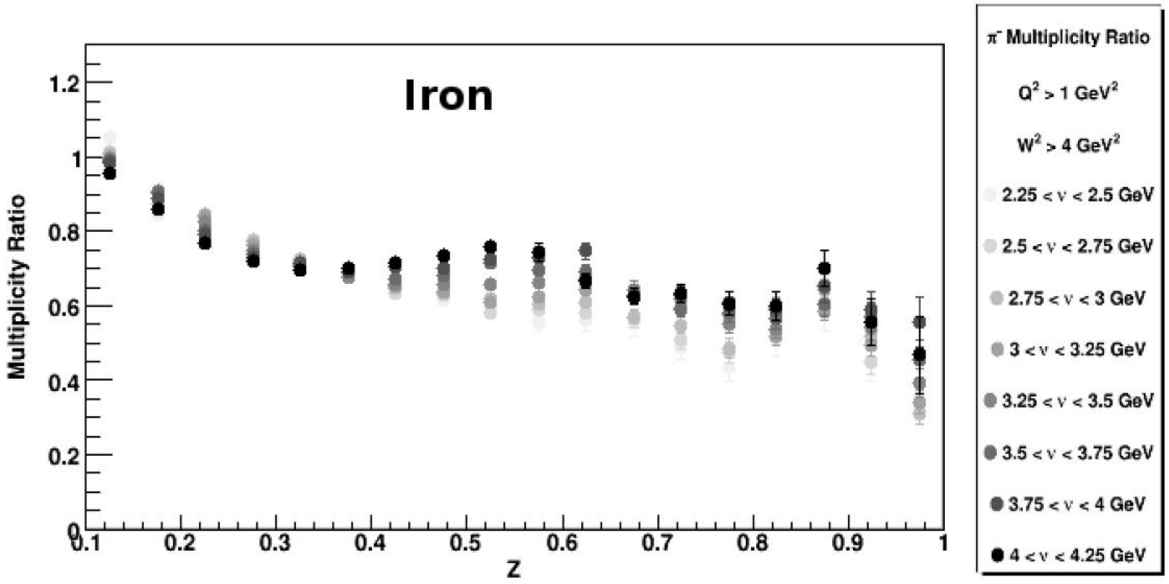
- π+ to compare with Hayk's (without corrections)
- π- should be similar to π+ (**Main focus now**)
- K+ for process's flavor dependence
- Proton and Lambda for Baryon hadronization
- Low energy protons maybe also be interesting to study target fragmentation

Electron cuts are similar to Lamiaa's ρ^0 analysis

- Cut on EC / CC / DC status
- Pions
- Time of flight cut
- Veto cut with CC for low energies to clean up electro (applied to both pions for consistency)



Results

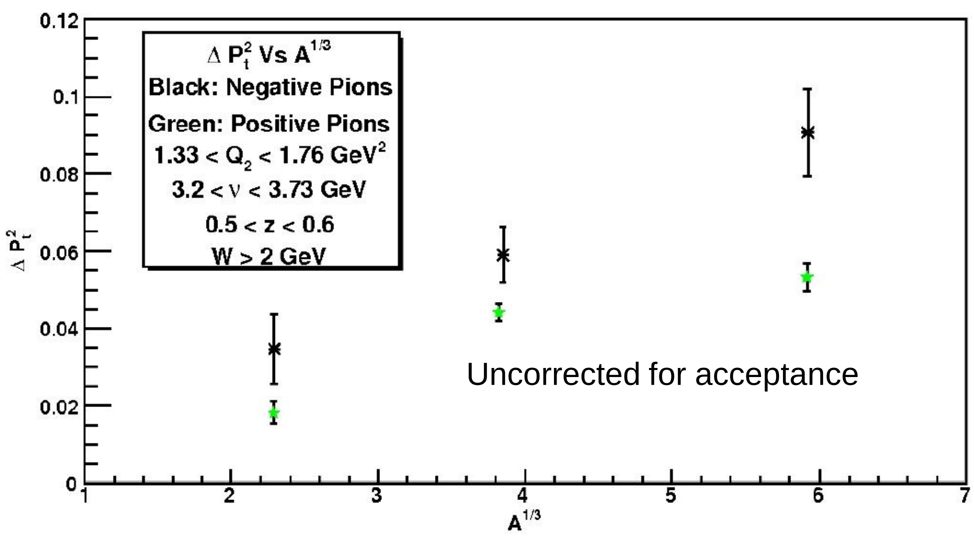


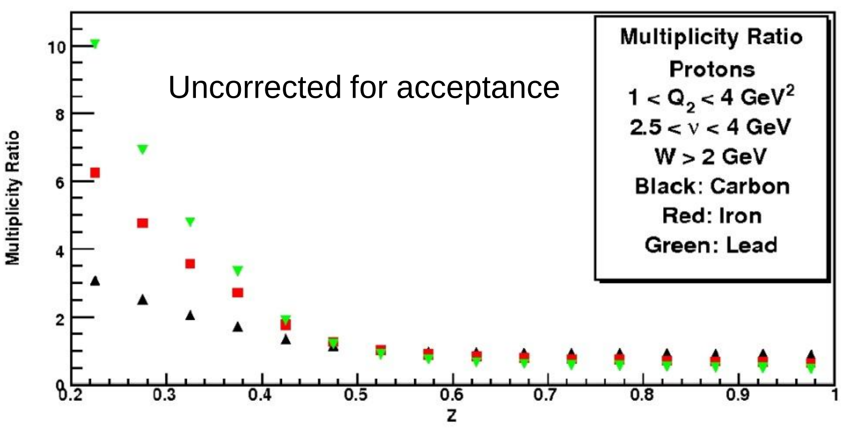
Preliminary proton results

Motivation:

HERMES data show a huge difference between protons and anti-protons that is unexplained.

Low-energy protons permit studies of the target fragmentation.





Status Report on Kplus & Lambda Hadronization

Study quark propagation and hadronization in nuclear matter.

CLAS Collaboration Meeting

November 20th, 2009

Lamiaa El Fassi

Rutgers University

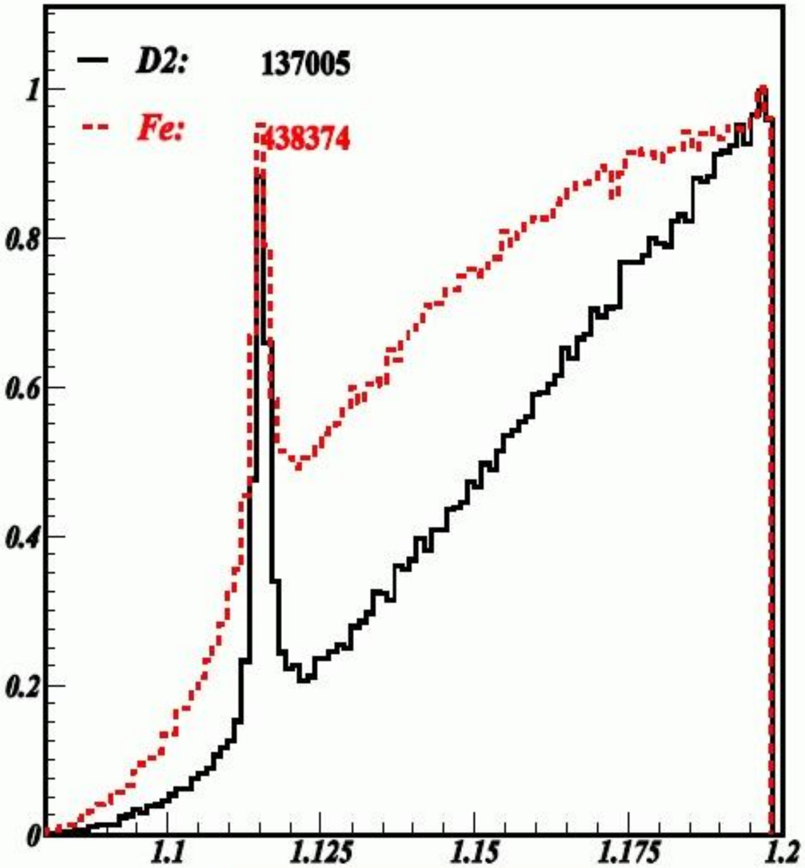
Analysis Details:

•Select K^+ events using cuts on $\Delta\beta = \beta_{meas} - \beta_{calc}$ and momentum.

• Select Λ using $\Delta\beta = \beta_{meas} - \beta_{calc}$ cut for protons.

Λ^0 & K^+ Hadronization Status

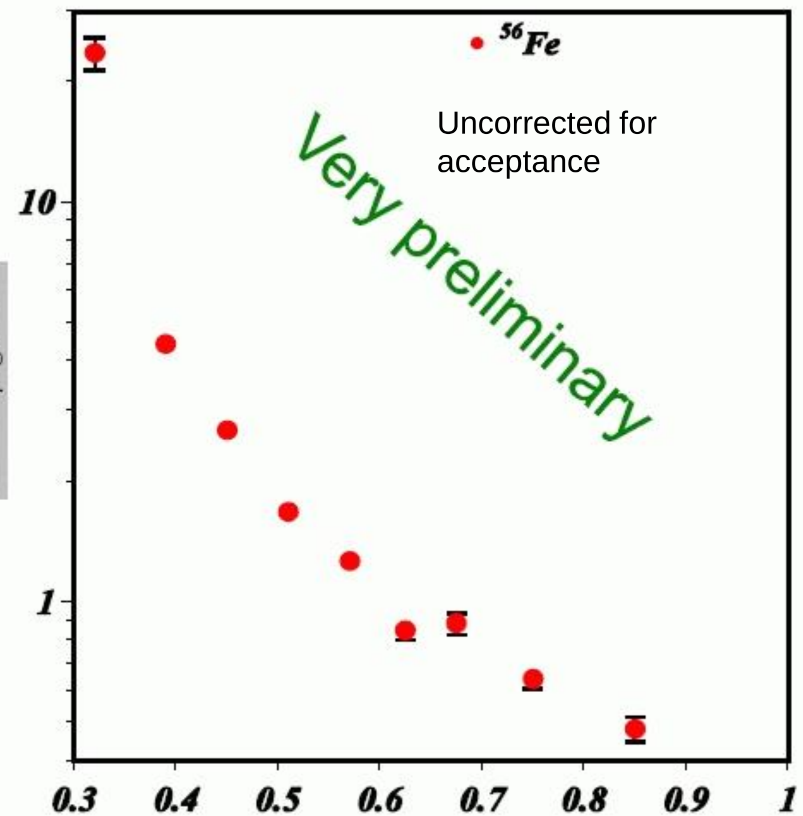
DIS Events: $Q^2 > 1$ GeV^2, $W > 2$ GeV & $y = \nu/E < 0.85$



M_Λ (GeV/c)

Hadronic multiplicity ratio

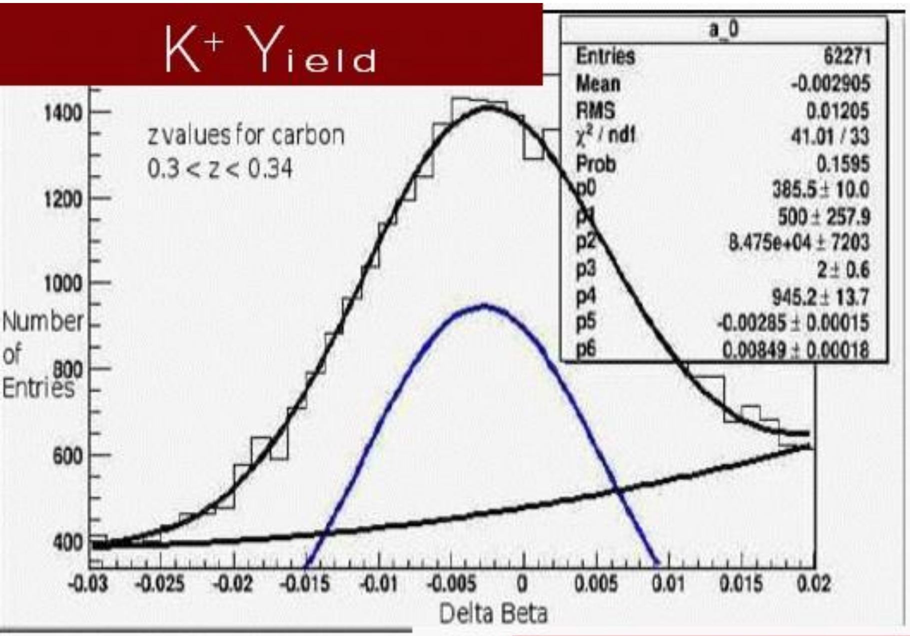
$$R_M^h(z,\nu,p_T^2,Q^2,\phi) = \frac{\left\{\frac{N_h^{DIS}(z,\nu,p_T^2,Q^2,\phi)}{N_e^{DIS}(\nu,Q^2)}\right\}_A}{\left\{\frac{N_h^{DIS}(z,\nu,p_T^2,Q^2,\phi)}{N_e^{DIS}(\nu,Q^2)}\right\}_D}$$



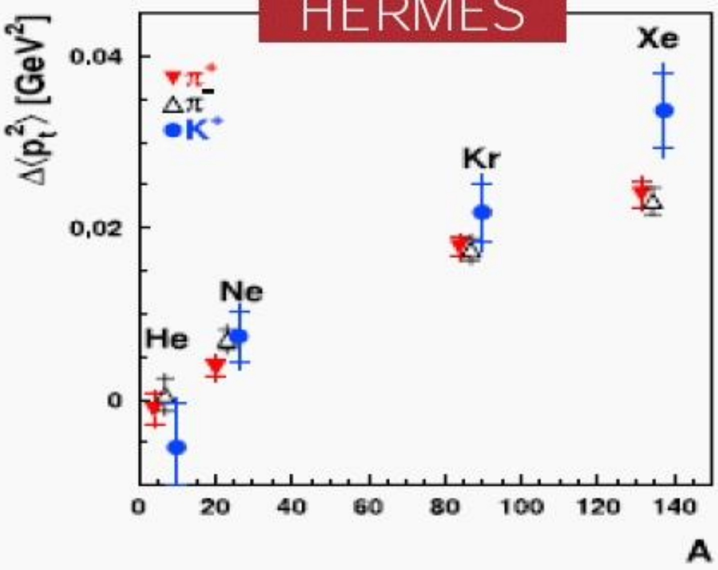
R_{Fe}^{Λ}

$z = E_\Lambda/\nu$

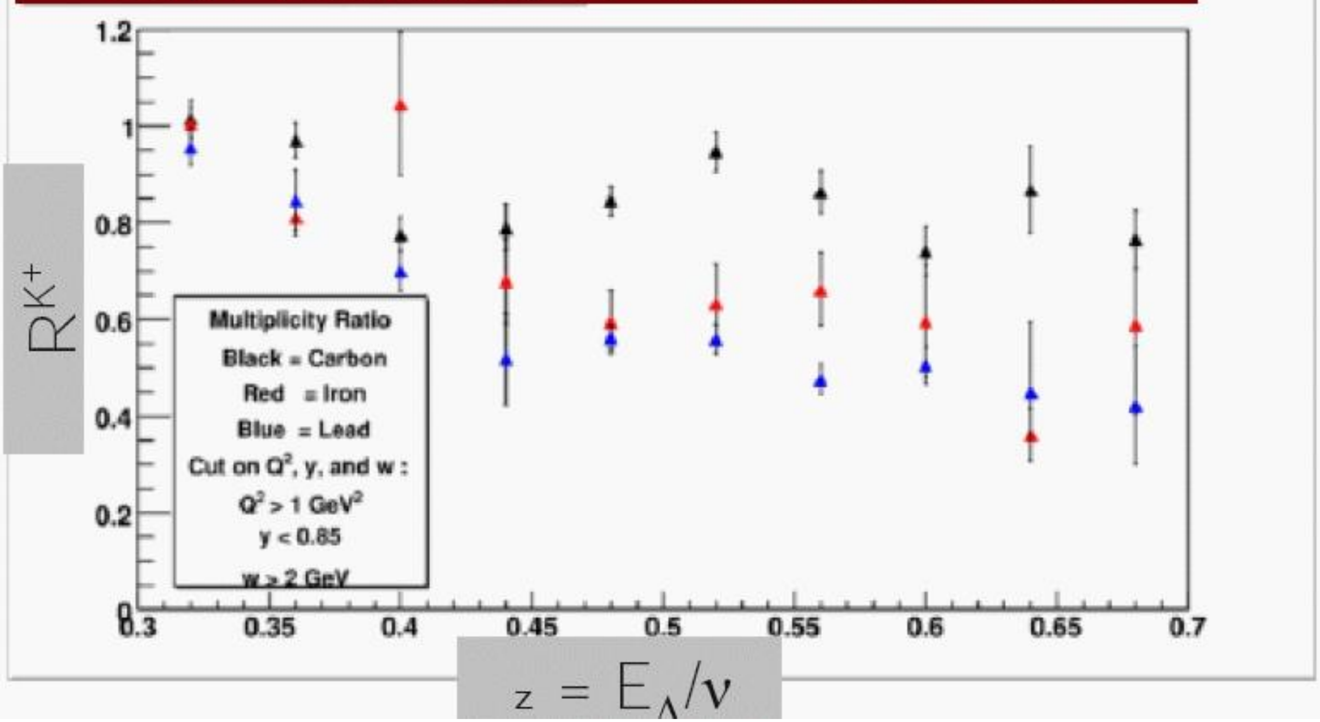
K^+ Yield



HERMES



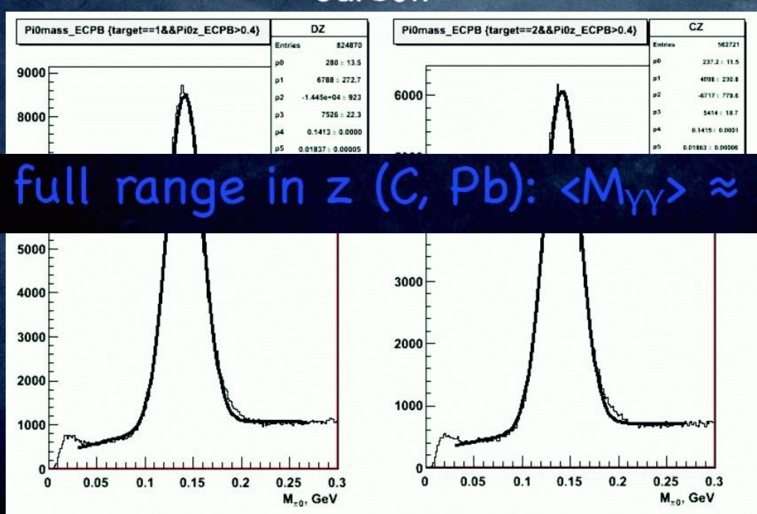
Very Preliminary K^+ Multiplicity Ratio



Photon energy correction for C, Fe, Pb.

Taisiya Mineeva

Carbon



For full range in z (C, Pb): $\langle M_{\gamma\gamma} \rangle \approx M_{\pi 0}$

For z>0.4 (C, Pb): $\langle M_{\gamma\gamma} \rangle$ is ~5% above $M_{\pi 0}$

For full z (Fe): $\langle M_{\gamma\gamma} \rangle$ is ~4% below $M_{\pi 0}$

For z>0.4 (Fe): $\langle M_{\gamma\gamma} \rangle \approx M_{\pi 0}$

Correction Method

See CLAS Note 2006-015

1. Use the invariant mass assuming the form of the correction

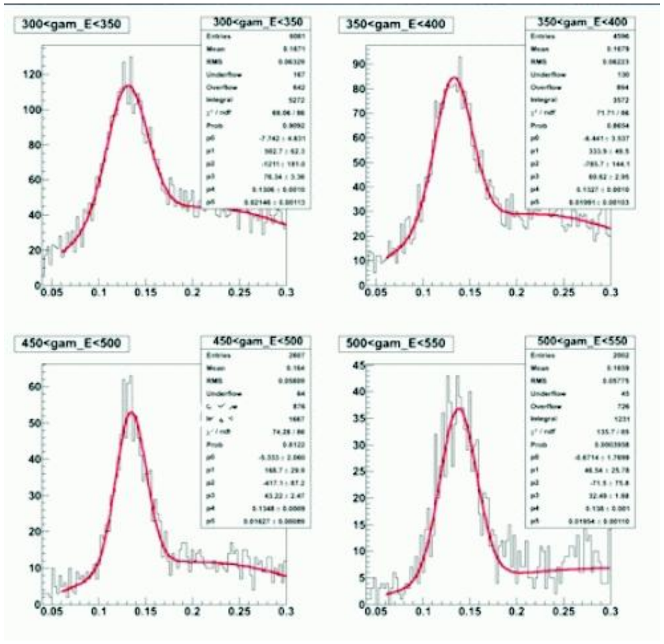
$$M^{corr}_{\gamma_1\gamma_2} = \sqrt{\frac{E_{\gamma_1}}{corr(E_{\gamma_1})}} \cdot \sqrt{\frac{E_{\gamma_2}}{corr(E_{\gamma_2})}} \cdot \sin\left(\frac{\theta_{\gamma_1\gamma_2}}{2}\right)$$

and start with $E_{\gamma 1}=E_{\gamma 2}$ so $\frac{m_{\pi^0}}{0.135} = corr(E_{\gamma_1})$. Plot $M_{\gamma\gamma}$ versus E_γ and

fit with $a + \frac{b}{E_\gamma} + \frac{c}{E_\gamma^2}$.

Get ⟶

for carbon data.

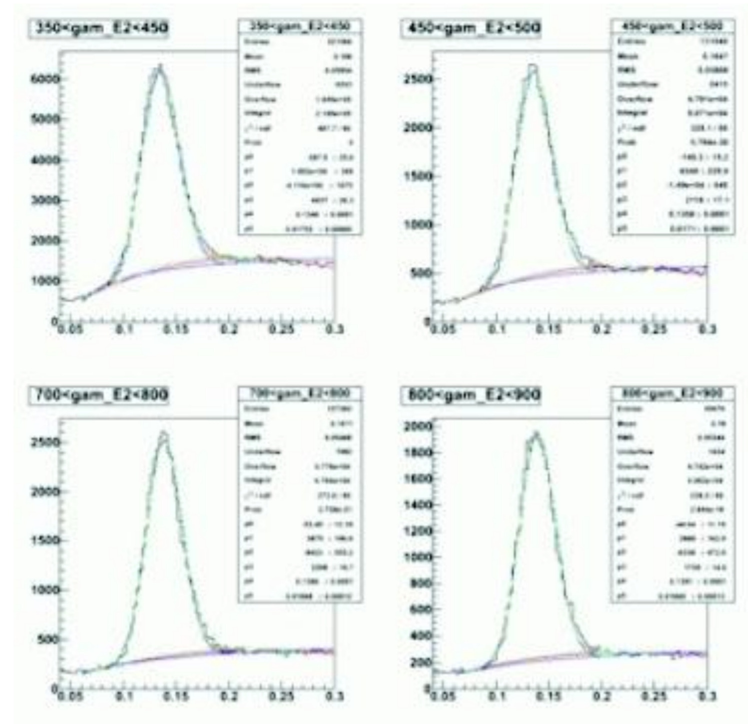


Correction Method

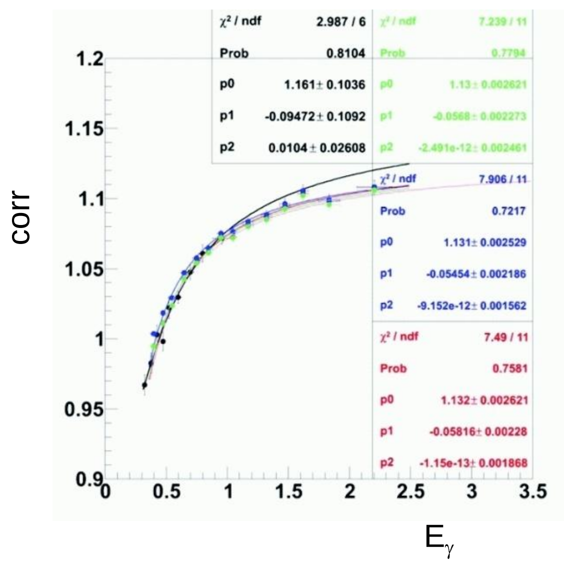
2. Repeat for all E_γ, but now if $E_{\gamma 1}$ or $E_{\gamma 2}$ lies in the energy range of step 1 correct the other photon using

$$\frac{m_{\pi^0}}{0.135} = \sqrt{corr(E_\gamma)}.$$

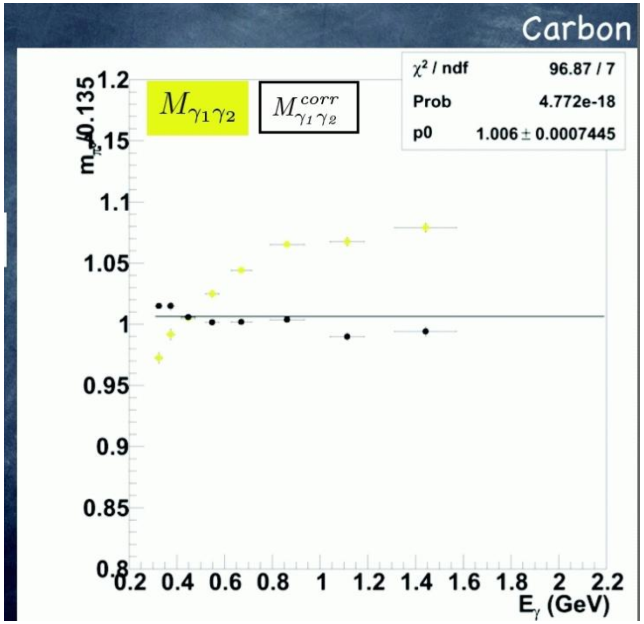
and get the following for carbon. →



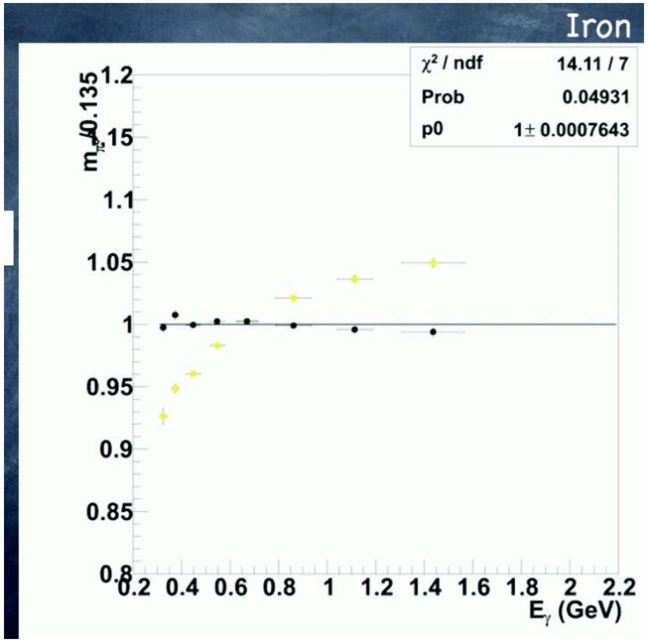
3. Repeat!

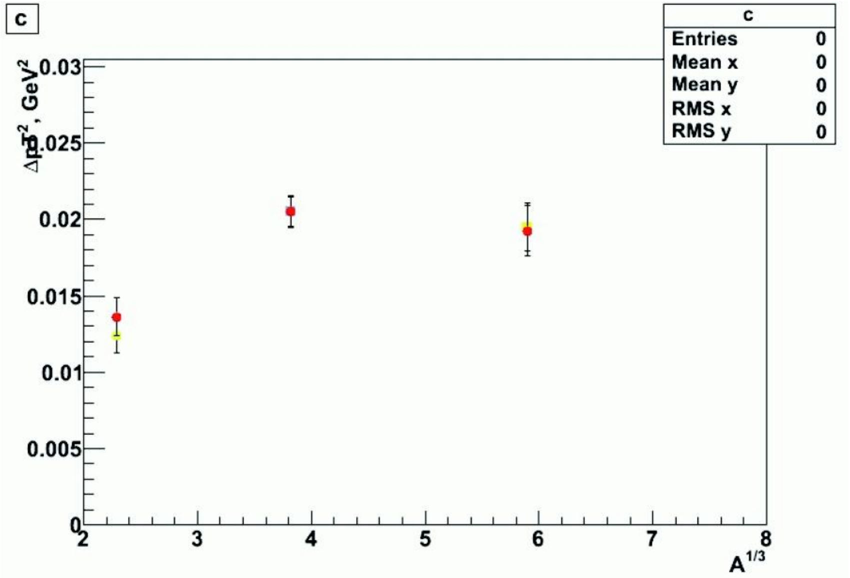


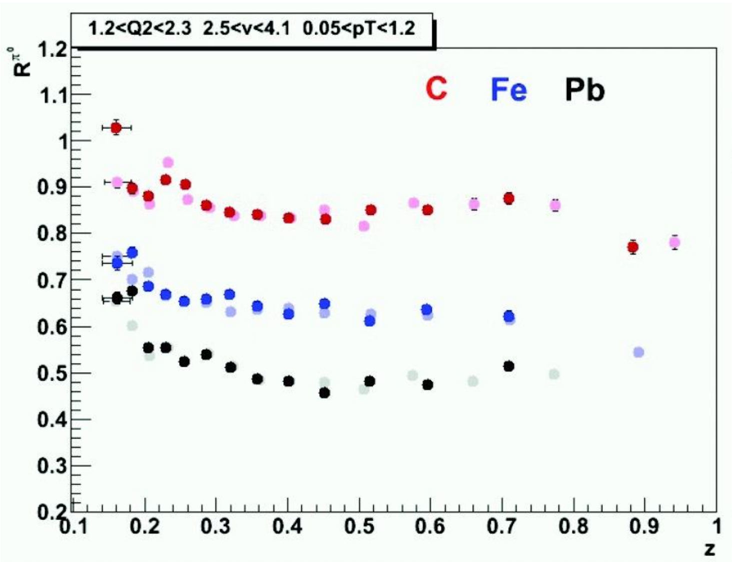
Results



Now good agreement with expected π^0 mass (and η mass).







The “Polarized EMC Effect” in ^{7}Li-

a 12 GeV LOI

Wolfgang Bentz*, Peter Bosted, Will Brooks, Ian Cloet*, Don Crabb, Alexandre Deur, Vipuli Dharmawardane, Sebastian Kuhn, Tony Thomas*, Larry Weinstein, Xiaochao Zheng; open for collaboration

*theory support

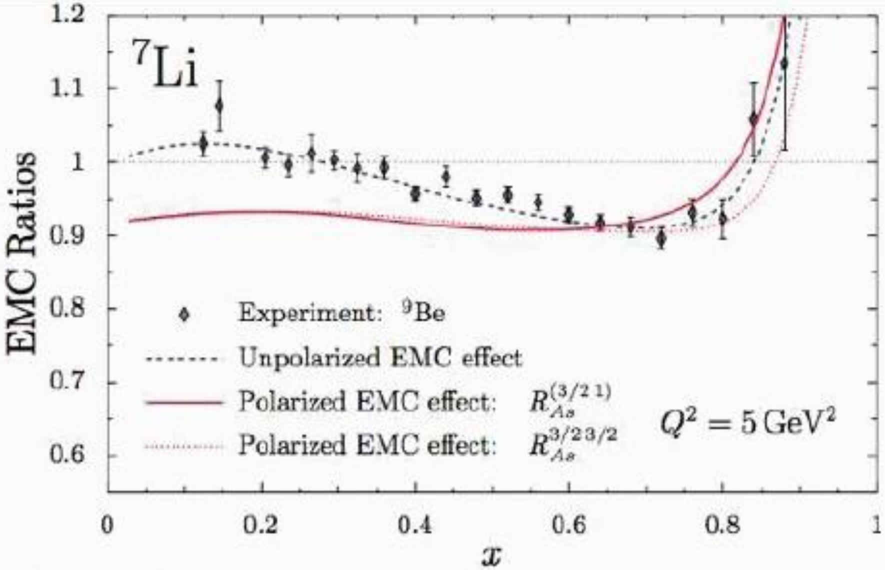


FIG. 6: The EMC and polarized EMC effect in ^{7}Li. The empirical data is from Ref. [31].

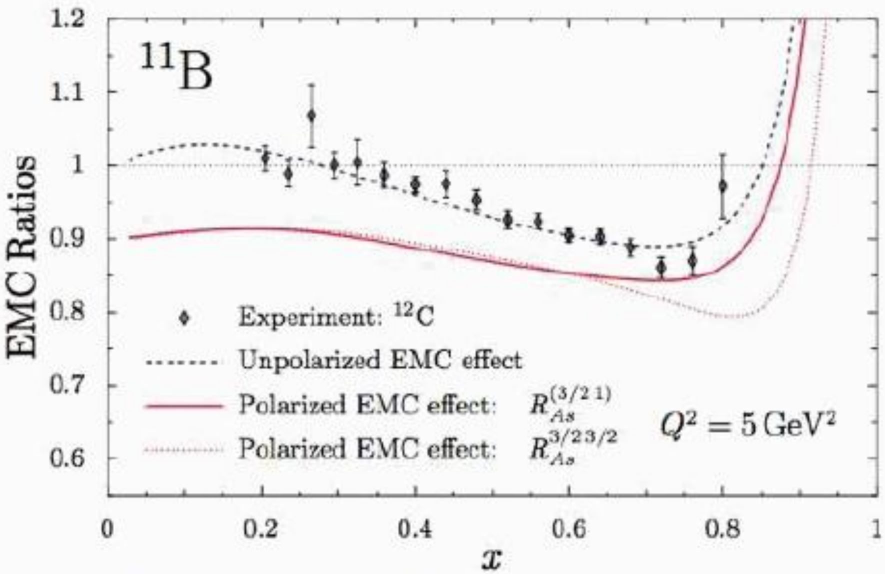


FIG. 7: The EMC and polarized EMC effect in ^{11}B. The empirical data is from Ref. [31].

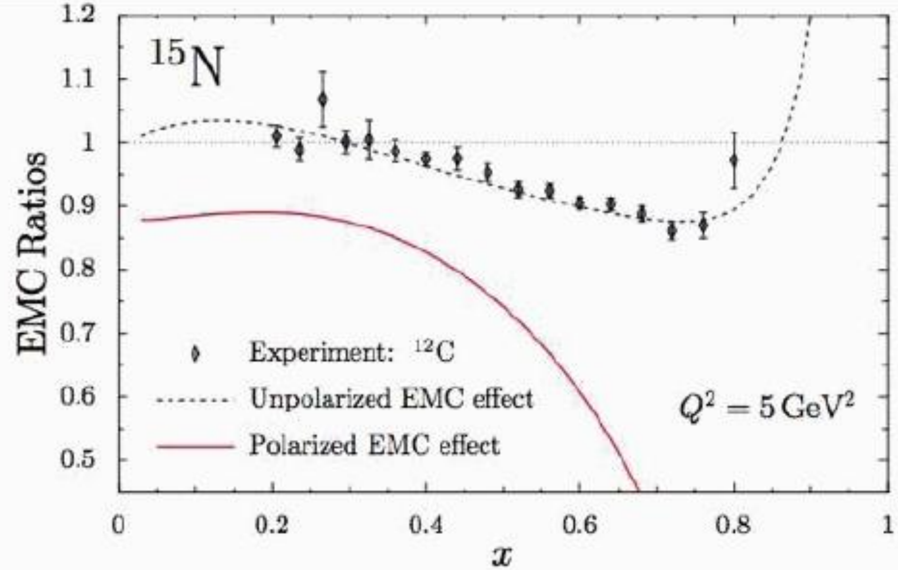


FIG. 8: The EMC and polarized EMC effect in ^{15}N. The empirical data is from Ref. [31].

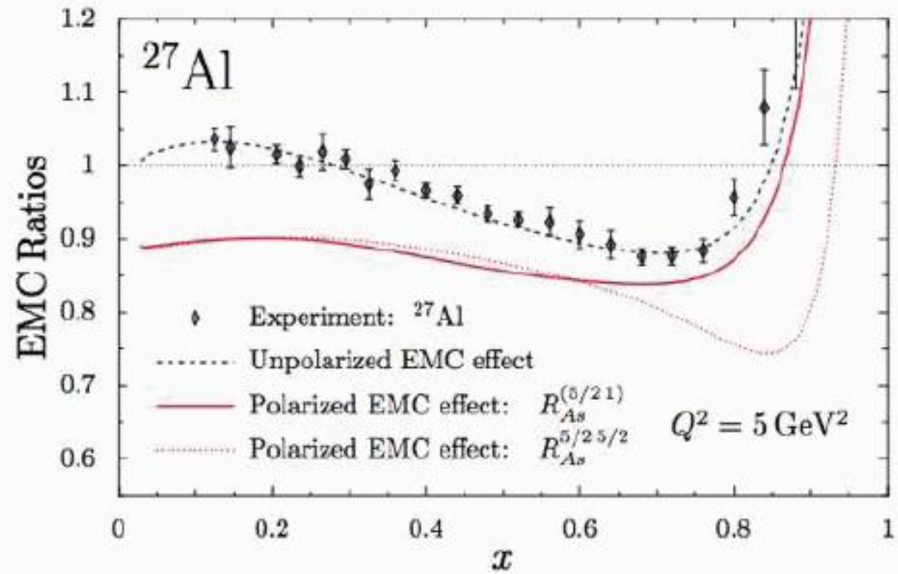


FIG. 9: The EMC and polarized EMC effect in ^{27}Al. The empirical data is from Ref. [31].

I. C. Cloet, W. Bentz, A. W. Thomas, Phys. Lett. B642 (2006) 210-217

Experimental Possibilities

- Choice of polarized target material is constrained:
  - Need high-accuracy (few %) nuclear physics calculations for polarization properties in-medium ➡ $A \leq 13$
  - Need nuclear target which can maintain high polarization with an incident electron beam
  - Minimize dilution factor and the effects of other materials in the target
- Here, discuss ^{7}LiH

Theoretical Descriptions

- Constraints from Bjorken Sum rule in an extension of Gribov theory were used to describe $0.03<x<0.2$, Vadim Guzey and Mark Strikman
- Quark-Meson Coupling Model (QMC), Ian Cloet, Wolfgang Bentz, Tony Thomas
  - quarks inside nucleons in nucleus interact through exchange of mesons (MIT bag, NJL)
  - related to earlier work by Tsushima, Saito, Ueda, Thomas (2002) on Li nuclides
- Chiral Quark Soliton Model, Jason Smith, Jerry Miller
  - quarks in nucleons (soliton) exchange pairs of pions, vector mesons with nuclear medium

How does it work?

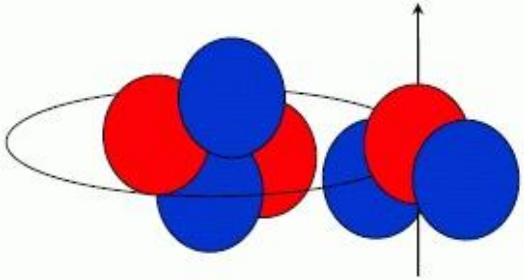
- In a polarized target, the nucleus is polarized overall

- Within the nucleus, the spins of specific nucleon states are aligned to varying degrees with the spin of the overall nucleus

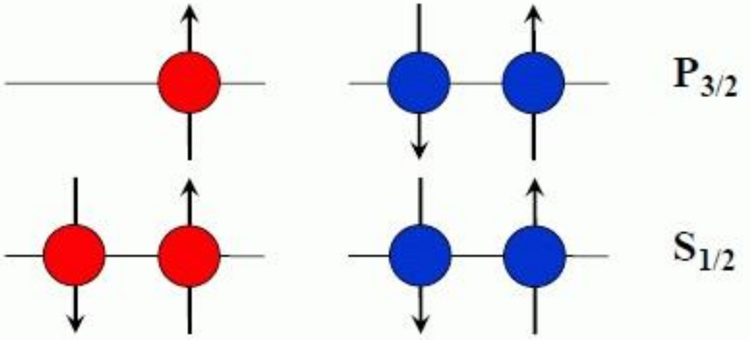
    - thus, have polarized nucleons within the medium

$g_1(A)$ – "Polarized EMC Effect" – ^{7}Li as Target

- Shell model: 1 unpaired proton, 2 paired neutrons in $P_{3/2}$, closed $S_{1/2}$ shell.
- Cluster model: triton + alpha



- ^{7}Li polarization: 94%
- Nucleon polarization calculations:
  - Cluster model: 86%
  - GFMC: 89%
  - 89% x 94% = 84%



→ ***Proton embedded in ^{7}Li with over 80% polarization!***

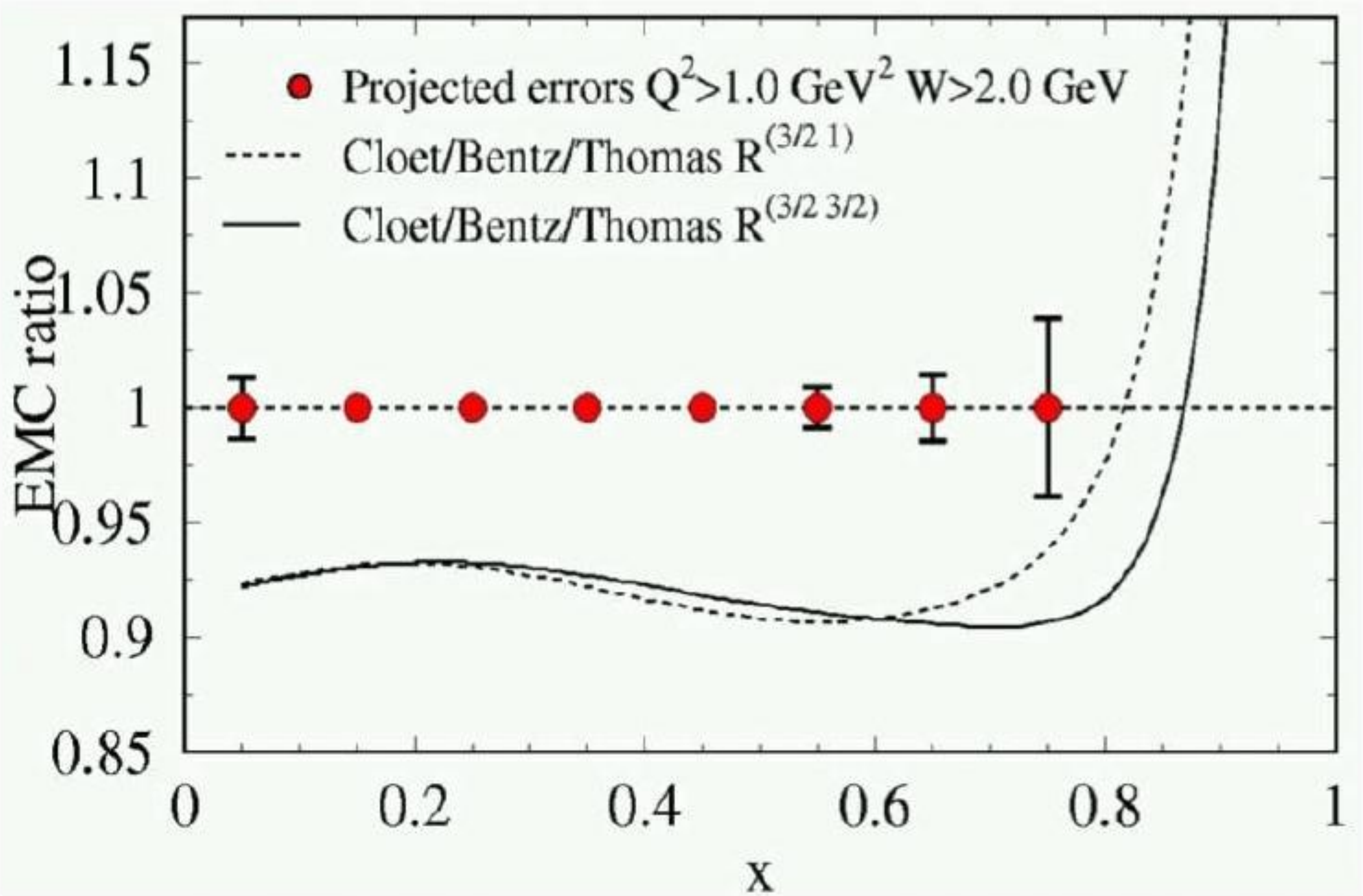


Figure 4: A plot of the polarized EMC effect for an 11 GeV beam, 40% target polarization, 80% beam polarization, and 70 PAC days measured in `CLAS12`. The two curves are for the two dominant structure function multipoles for this ($J^{\pi} = 3/2^{-}$) nucleus; the dashed line is for $K = 1$ and the solid line is the $M = J$ case.

eA for neutrinos project update

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University of Rochester
CLAS nuclear physics working group meeting
Nov, 20, 2009

Project Description

1. High precision accelerator neutrino experiments taking place in 0.5-2 GeV region on nuclei.
2. No longer statistics limited (hopefully).
3. Experiments on nuclei (O, C, Fe mostly).
4. Need to have decent model of nuclear effects.
5. Need to understand neutrino x-sections better.
6. Project is to measure pion production in eA on different nuclei and use data to tune parts of the neutrino MC.

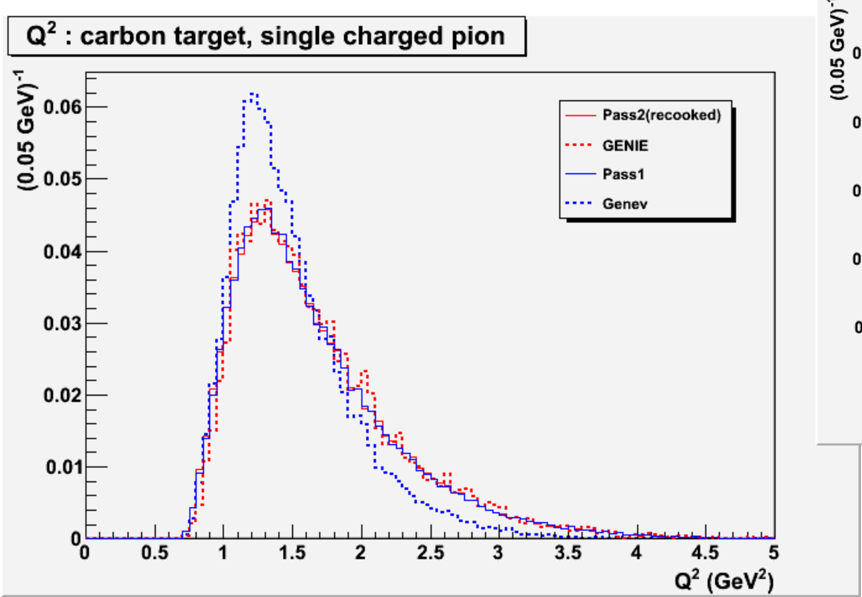
Need for an eA Monte Carlo

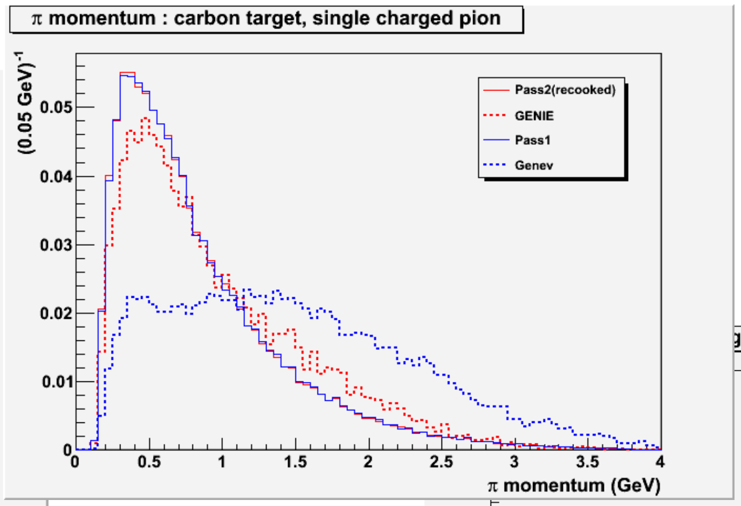
1. Plan to use eg2 data and study pion production on different nuclei.
2. Starting place: Determine differential x-sections for single charged pion production … super high precision not necessary.
3. Need MC for acceptance and radiativecorrections.

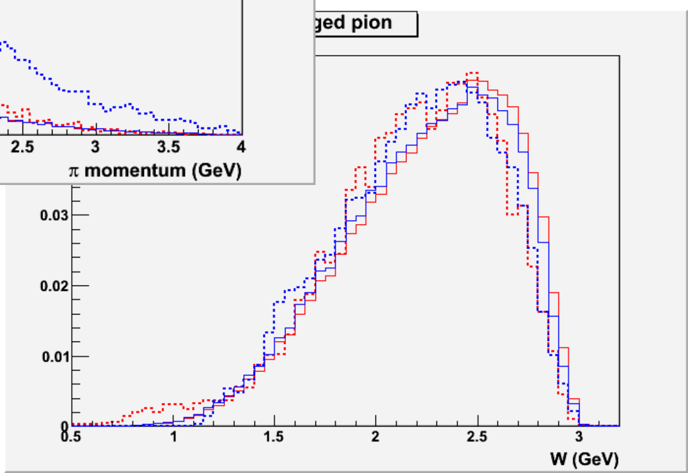
Compare MCs with eg2 Data

Data from run 42011(C+D2) : 10,182,882 events (two ways)

- MC from genev& GENIE (is to be the canonical neutrino event generator).
- Genev: 1M events generated. Genev was the best generator before trying GENIE for my study.
- GENIE : 1M events generated. Including “Quasi-elastic”, Baryon Resonances, and DIS processes







GENIE does better, but still in `bootleg’ version.