Nuclear Physics Working Group

CLAS Collaboration Fall Meeting

Nov. 4th, 2016

Lamiaa El Fassi

MISSISSIPPI STATE UNIVERSITY™

Nuclear Physics Working Group

CLAS Collaboration Fall Meeting

Nov. 4th, 2016

Lamiaa El Fassi
(on behalf of Michael Wood)

Past NPWG Chair
Kawtar Hafidi

Summer Election Results

New NPWG Chair
Michael Wood

Nuclear Physics Working Group Business

M. H. Wood, Canisius College

November 3, 2016

Current Analysis Reviews

Analysis Note	Author	Committee	Status
Study of the hadronization of charged pions	R. Dupre et al.	M. Wood (chair), S. Manly, A. Kim	1st round ends Nov. 30, 2016
PROBING 2N-SRC in 12C, 27Al, 56Fe, and 208Pb using the A(e,e′n) and A(e,e′p) reactions	M. Deur et al.	S. Stepanyan (chair), L. El Fassi, D. Watts	1st round ended Sep. 5, 2016
DVCS off of He-4	M. Hattawy et al.	M. Garcon (chair), S. Kuhn, Z. Meziani	Last version on Sep. 27, 2016
Neutral pion electroproduction ratios off C, Fe, and Pb to D	T. Mineeva et al.	L. Weinstein (chair), M. Wood, Y. Ilieva	1st round ended on June 2, 2014
gd->pi p p_SPEC (Eg=1.0-1.6 GeV) in Quasi-free Region	N. Pivnyuk et al.	S. Strauch (chair), B. McKinnon, M. Mirazita	Disbanded Nov. 1, 2016. Forming a new committee.
Measurement of the Fifth Structure Function of the Deuteron	G. Gilfoyle et al.	S. Kuhn (chair), A. El Alaoui, K. Hafidi	1st round ended Jan. 7, 2013

PAC44 Proposals

Proposal	Title	Contact Person
PR12-16-011	Tagged EMC Measurements on Light Nuclei	Raphael Dupre
PR12-16-011A	Partonic Structure of Light Nuclei	Zein-Eddine Meziani
PR12-16-011B	Tagged Deeply Virtual Compton Scattering Off Light Nuclei	Whitney Armstrong

PAC decision: Deferred

NPWG Webpage

The NPWG secure webpage is https://www.jlab.org/Hall-B/secure/nuclear/

It is linked in a few places on the Hall B webpages:
CLAS wiki: https://clasweb.jlab.org/wiki/index.php/CLAS_Wiki
CLAS12 wiki: https://clasweb.jlab.org/wiki/index.php/CLAS12_Wiki

What would the group like to see on the page?

Talks

preceded by a brief discussion about Common Tools Committee Report

14:00 - 18:00 Nuclear Physics Working Group

Convener: Lamiaa El Fassi (MSU)

Location: CEBAF CEnter (A110)

14:00	**Nuclear Physics Working Group business** *15'*
14:15	**Probing 2N-SRC with the A(e,e'n) and A(e,e'p) reactions.** *35'* Speaker: Meytal Deur (Tel Aviv University)
14:50	**Study of SRC with the A(e,e'pn) reaction.** *35'* Speaker: Igor Korover (Tel Aviv University)
15:25	**Coherent Electro-production of the Neutral Pion off He-4** *35'* Speaker: Bayram Torayev (Old Dominion University)
16:00	**Coffee Break** *30'*
16:30	**EC Calibration for Improved eta and pi0 Reconstruction** *35'* Speaker: Frank Cao (University of Connecticut)
17:05	**BoNuS12 Tracking Update** *35'* Speaker: Krishna Adhikari (Mississippi State University)

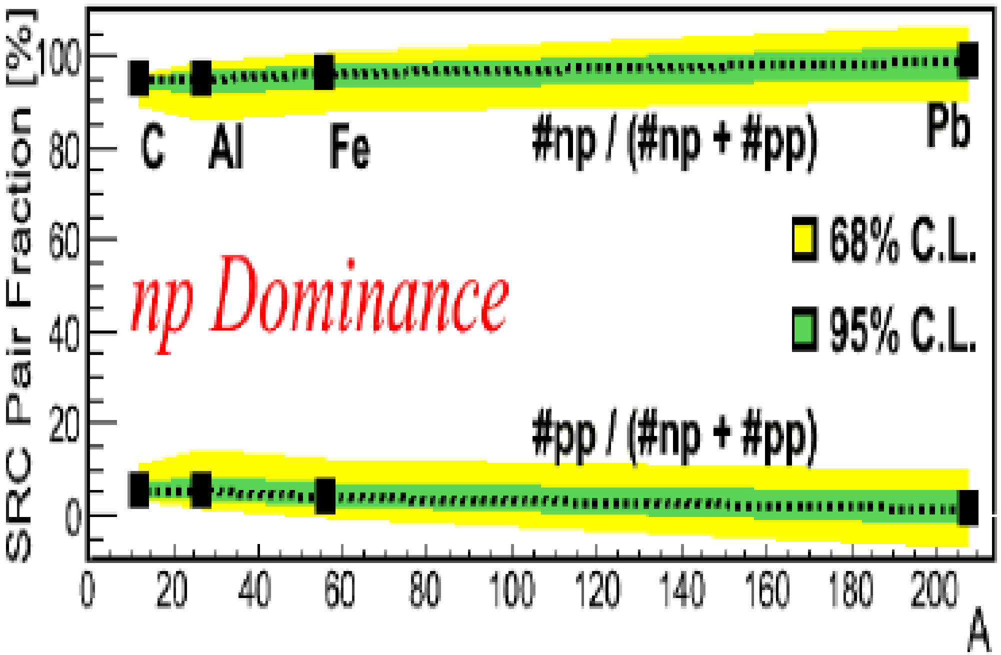
Probing 2N-SRC with the A(e,e'n) and A(e,e'p) reactions

A data-mining project using CLAS EG2 data

Meytal Duer (TAU)

Motivation

np-dominance in asymmetric neutron rich nuclei



O. Hen et al., Science 346, 614 (2014)

Probing 2N-SRC with the A(e,e'n) and A(e,e'p) reactions

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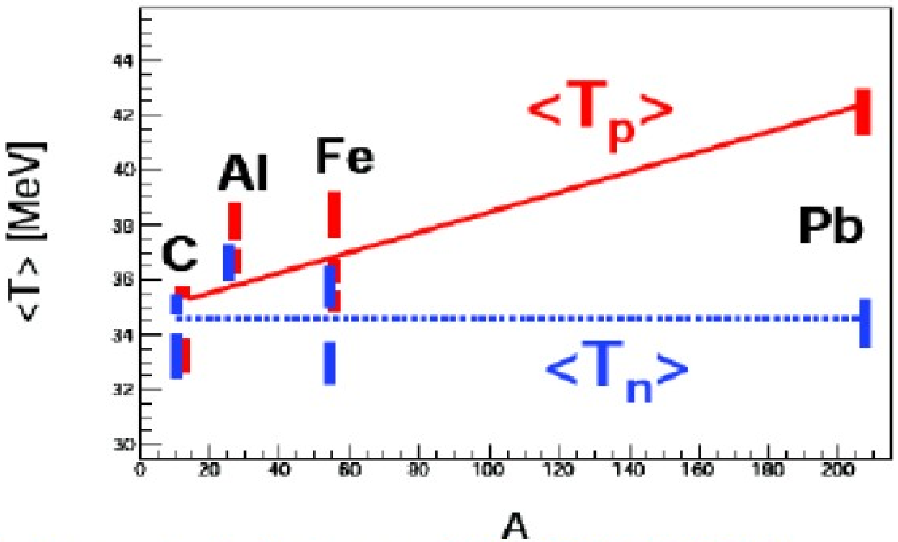
Prediction:



O. Hen et al., Science 346, 614 (2014)

$$n_p(k) = \begin{cases} \eta \cdot n_p^{M.F.}(k) & k < k_0 \\ \frac{A}{2Z} \cdot a_2(A/d) \cdot n_d(k) & k > k_0 \end{cases}$$

(And similar for neutrons)

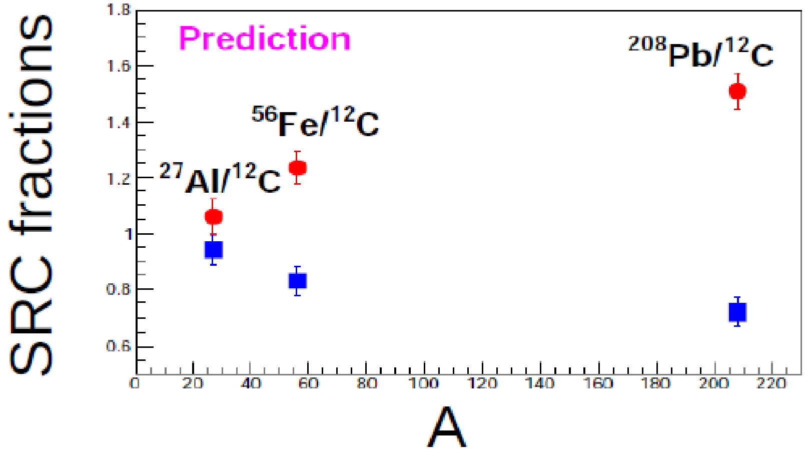
Inversion of the momentum sharing?

How to check that experimentally?

Extracting $\dfrac{A(e,e'n)_{high}/A(e,e'n)_{low}}{{}^{12}C(e,e'n)_{high}/{}^{12}C(e,e'n)_{low}}$ ratios

(and same for protons)

Based on the np-dominance model:



protons

neutrons

To do so:

* Identify (e,e'n) mean-field events
* Identify (e,e'n) 2N-SRC events
* Extract ratios and their uncertainties

Electrons (Approved CLAS analysis note, L. El Fassi, 2011)

Protons (Approved CLAS analysis note, O. Hen, 2012)

Neutrons - detecting neutrons in CLAS EC.

Analysis of QE events:

- [x] I. A(e,e'p)/A(e,e'n) mean-field. ratios
- [x] II. A(e,e'p)/C(e,e'p) high momentum ratios
- [ ] III. A(e,e'n)/C(e,e'n) high momentum ratios

Future Plans

Detecting neutrons in CLAS LAC

np- dominance

$$\frac{A(e,e'n)/^{12}C(e,e'n)|high}{A(e,e'n)/^{12}C(e,e'n)|low}$$

3N- SRC
(e,e'npp)

$2N-SRC$

$(e,e'np_{back})$

CLAS6 (eg2): Study of SRC with the A(e,e'pn) reaction

Data Mining Project

Igor Korover

Tel Aviv University / NRCN

CLAS Collaboration meeting

November 3, 2016

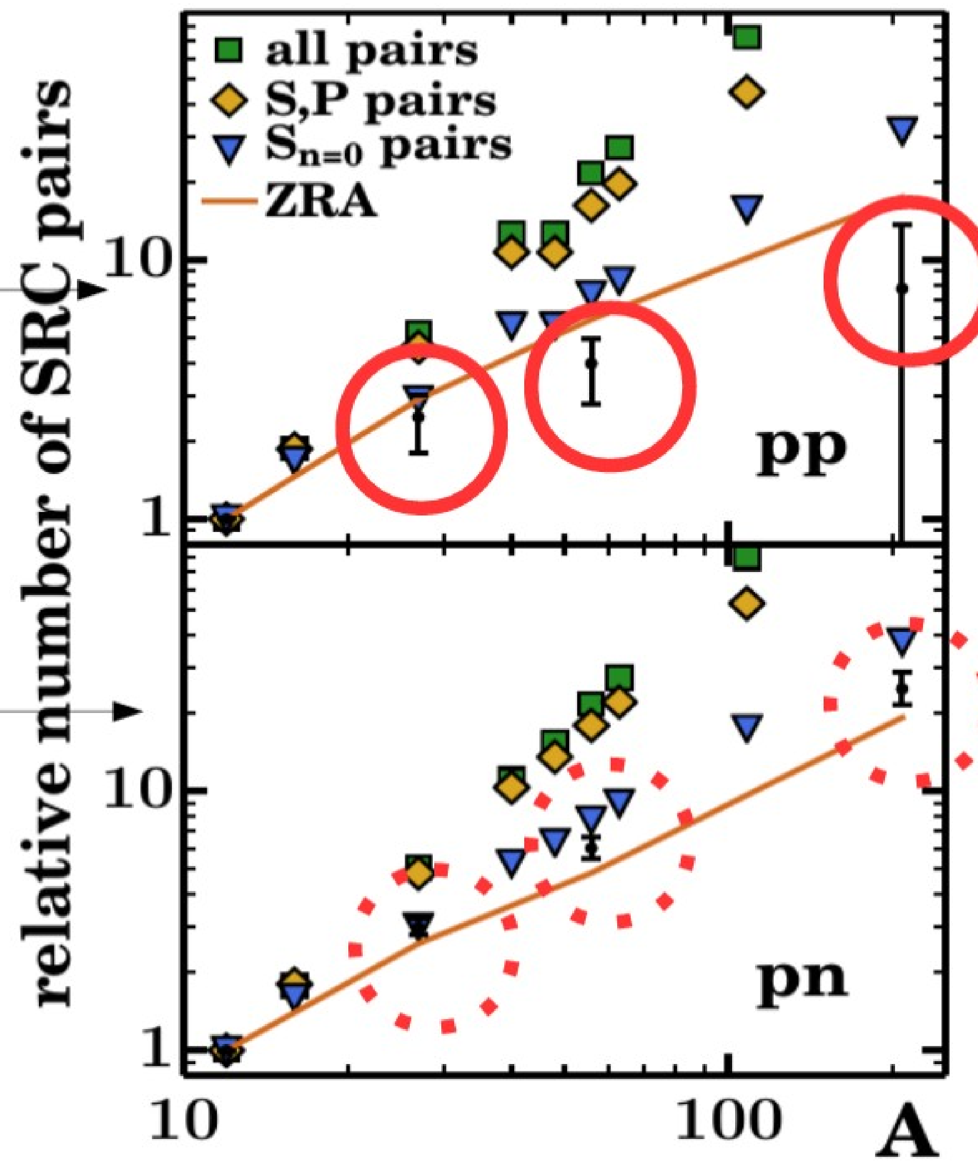
A(e,e'pN) analysis done on eg2a run period

Measured

Predicted

C. Colle *et al.*
Phys. Rev. C **92**, 024604 (2015)

np data obtained from
(e,e'p) – (e,e'pp)



Motivation for the current analysis

Extend A(e,e'pn) measurements to heavier nuclei (Fe, Pb).

(Done on He and Carbon only)

Measure the fraction of np – SRC as function of A

↓

Combine with pp-SRC estimate the total amount of 2N-SRC in the nuclei (C, Al, Fe, Pb)

Data Analysis   Extraction of neutron from eg2a data

Neutron hits in the TOF counters can be extracted from tracking plus SCRC bank data.

Technical issue: Current ClasTool does not read SCRC BOS bank.

Solution: (1) Implement SCRC in ClasTool, Gagik help.

(2) At this point, we access the bank directly (without ClasTool) to develop analysis methodology until step (1) is done.

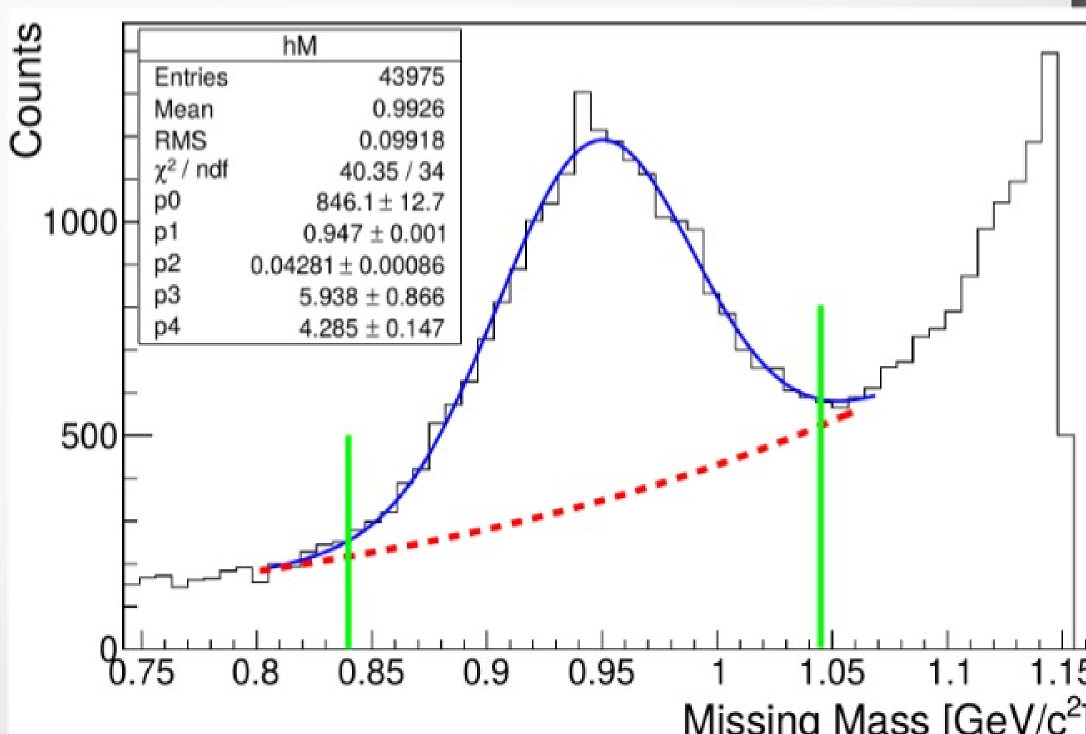
The following results are therefore very preliminary.

Neutron detection efficiency.

Efficiency determined by ratio $\frac{\#\ d(e,e'pn)}{\#\ d(e,e'p)}$

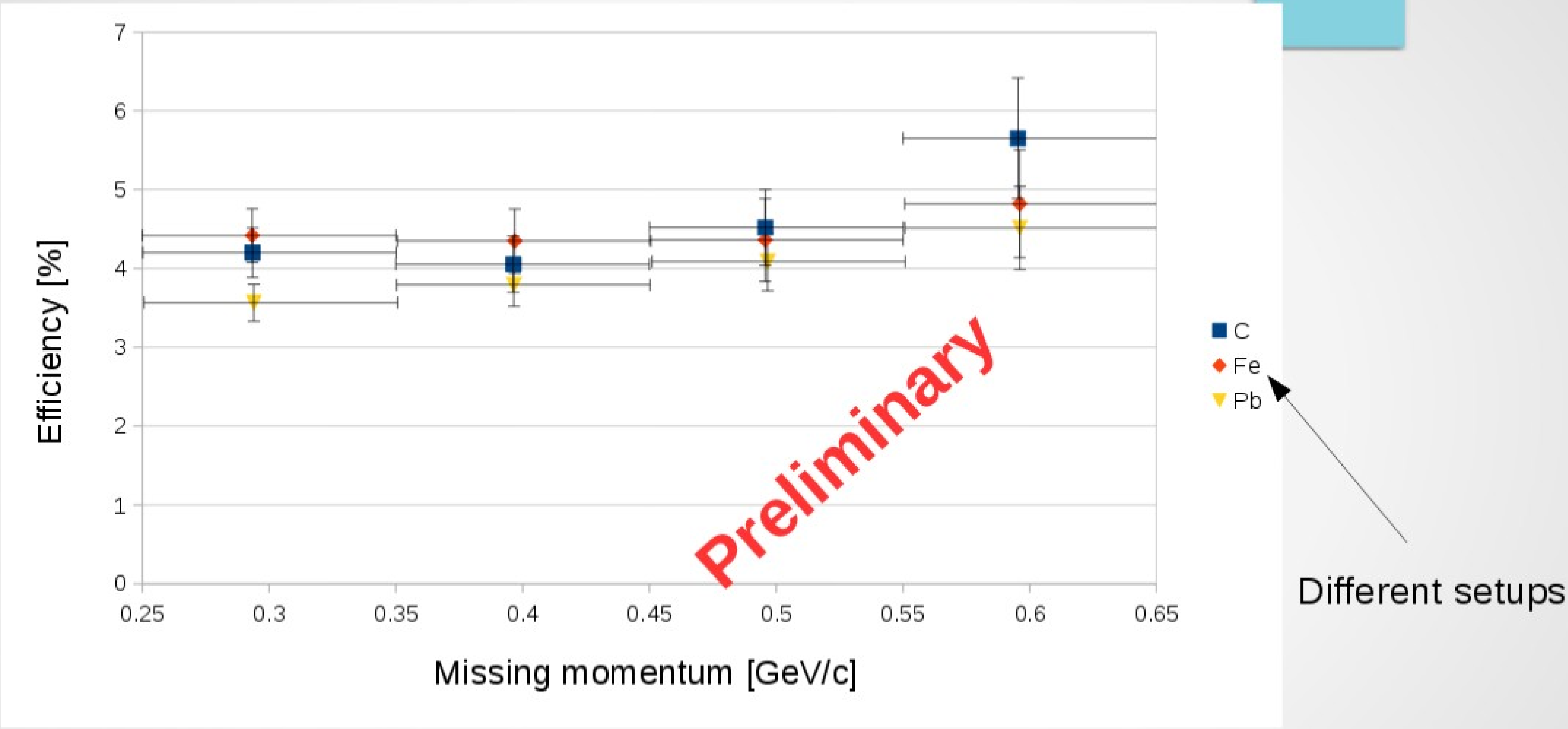
Count of #d(e,e'pn) reaction is straight forward

In #d(e,e'p) events there is large background



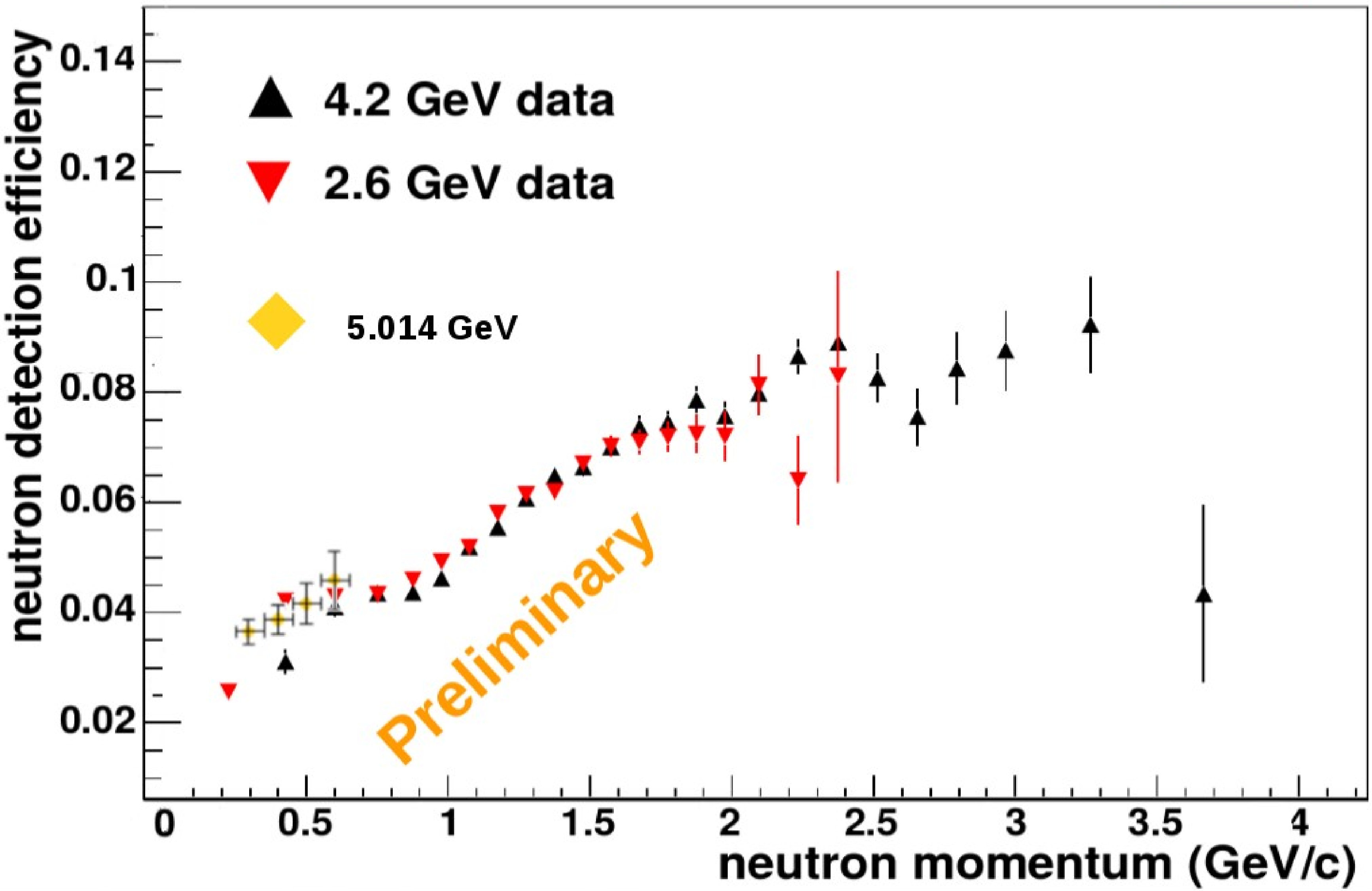
#d(e,e'p) events above red dash line

Efficiency Results:



Although we did not removed the unreconstructed tracks that mimic neutral hits in the efficiency result is consistent with Gn analysis

Neutron efficiency: Gn analysis



Future plans:

1) Modify ClasTool to extract the TOF counters hits

2) Extract the wires hit data from dc0 BOS bank – improve Veto algorithm

3) Redo deuteron calibration

4) Extract the number of A(e,e'pn) events from the solid targets

5) Extract the ratio A(e,e'pn)/C(e,e'pn) (**no** absolute neutron detection efficiency needed)

6) Measure A(e,e'pn)/A(e,e'p) (neutron detection efficiency needed)

7) Measure the CM momentum of the 2N- SRC

8) More physics … :)

Coherent elecroproduction of neutral pion off a helium-4

Bayram Torayev, ODU

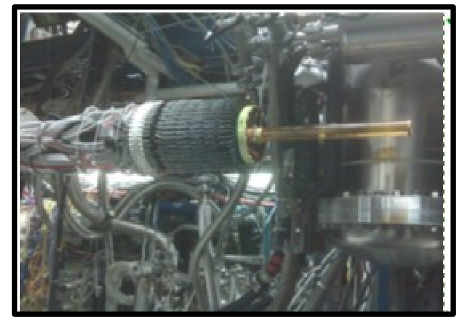
$$e + {}^4He \rightarrow e' + {}^4He' + \pi^0$$

- The data was collected in 2009 with 6 GeV longitudinally polarized electron beam
- The avarage polarization was: 83.67%
- 23 cm long helium-4 gaseous target at 6 atm was used
- The Beam Spin Asymmetry was measured for the first time at deep exclusive regime:

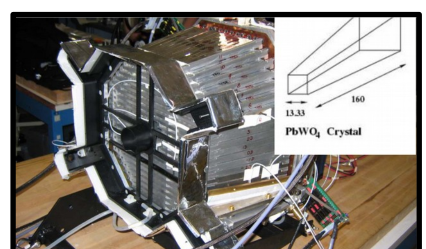
$$<Q^2> = 1.5 GeV^2$$

$$<t> = 0.14 GeV^2 \quad <x_B> = 0.18$$

CLAS



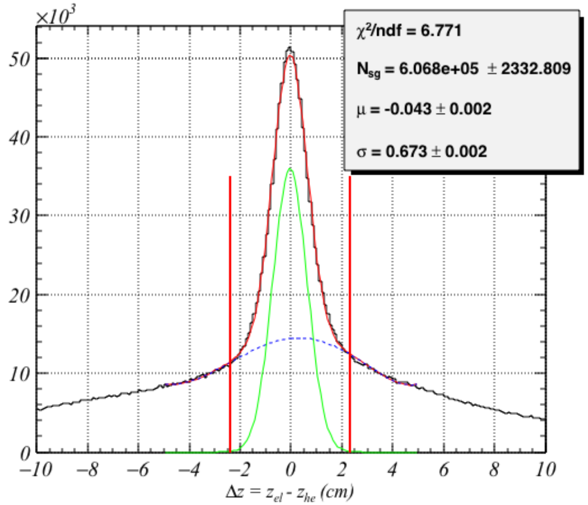
RTPC is used for detection and identification of low momentum recoil helium-4.

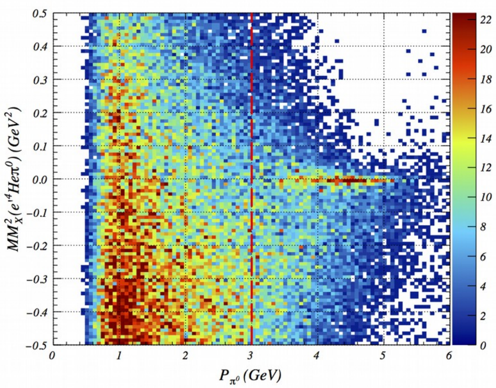


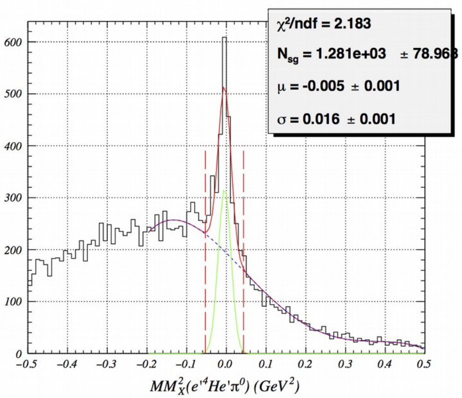
Inner Calorimeter is used to detect forward going photons **[4^0, 14^0]** and reconstruct pion.

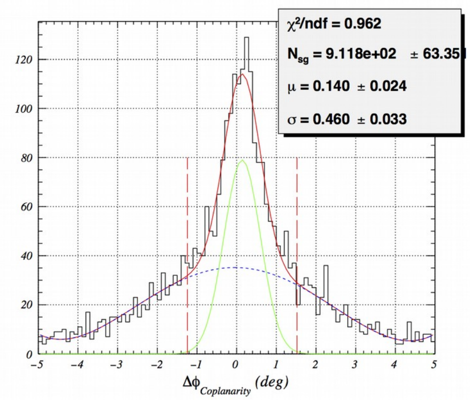
Exclusive Cuts

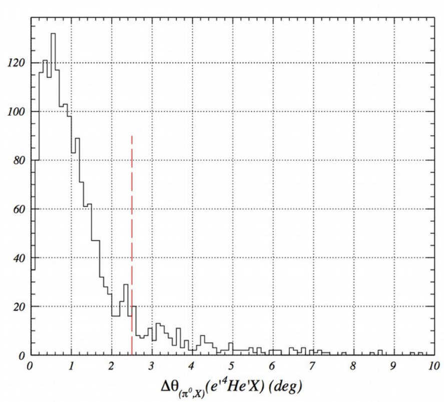
- Vertex of electron and vertex of RTPC track needs to match
- Pion Momentum cut *(P>3.0 GeV)*
- Squared Missing Mass Cut *(e+^{4}He+π^0)*
- Virtual photon, ^{4}*He* and π^0 are coplanar.
- Cone angle between missing π^0 and detected one *(2.5^0)*.
- Squared Missing Mass Cut *(e+π^0)*
- Estimated background relative to signal after all exclusivity cuts is about 7%

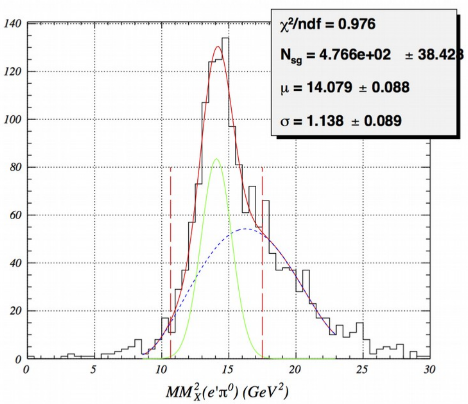


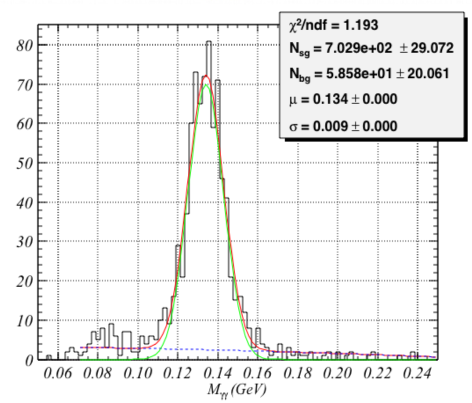












Results

- The beam spin asymmetry has same sign in both coherent and incoherent DVCS process on a helium-4 target.

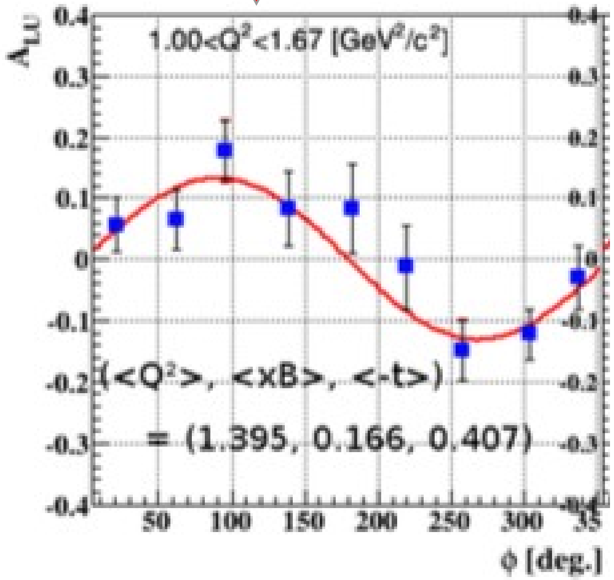
- The beam spin asymmetry of coherent pion electroproduction on helim-4 has opposite sign than the asymmetry measured for pion production on the proton

$$A_{LU} = -0.089 \pm 0.053$$

$$\Delta A_{LU}^{Syst} = 26.3\%$$

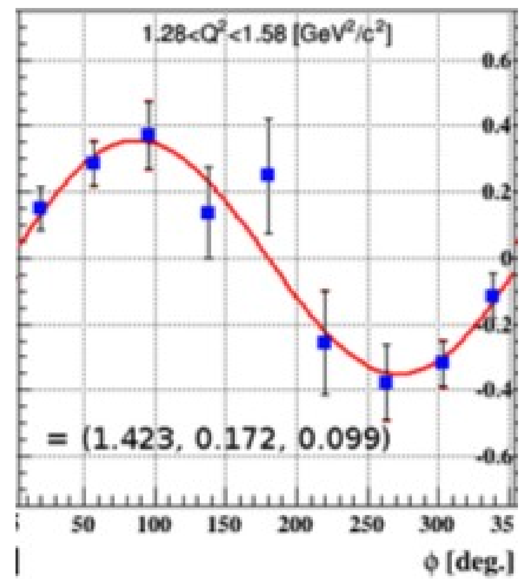
Proton

M. Hattawy

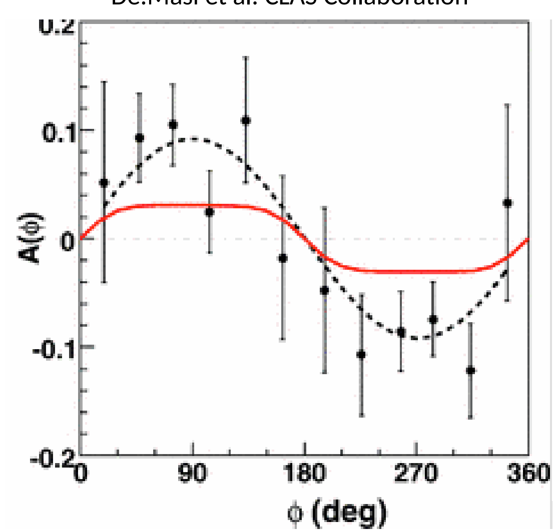


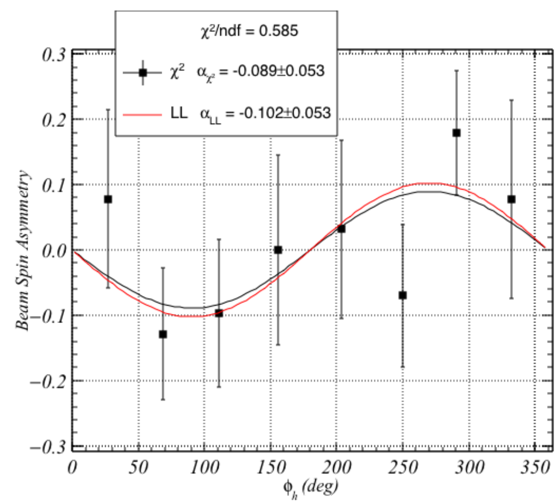
Helium-4

M. Hattawy

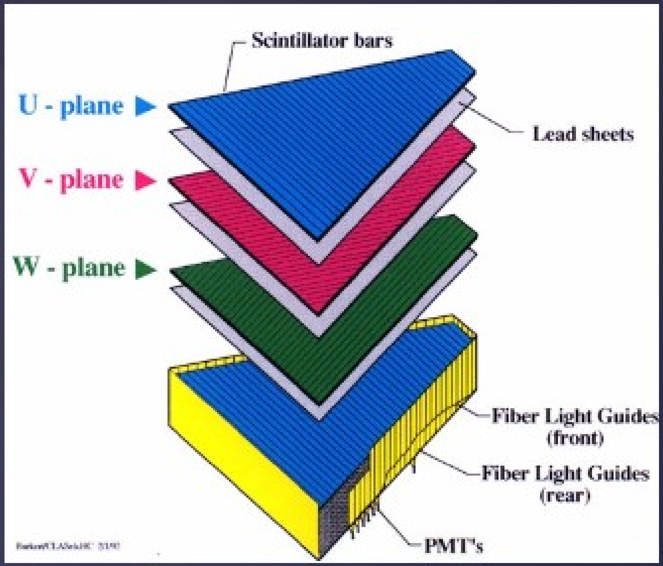


De.Masi et al. CLAS Collaboration





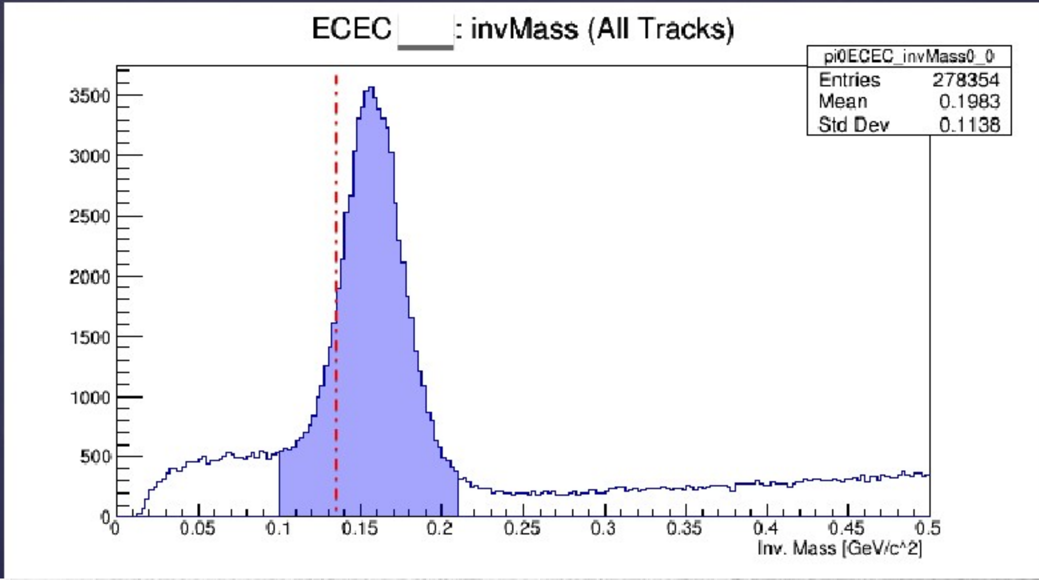
EG6: EC Calibration

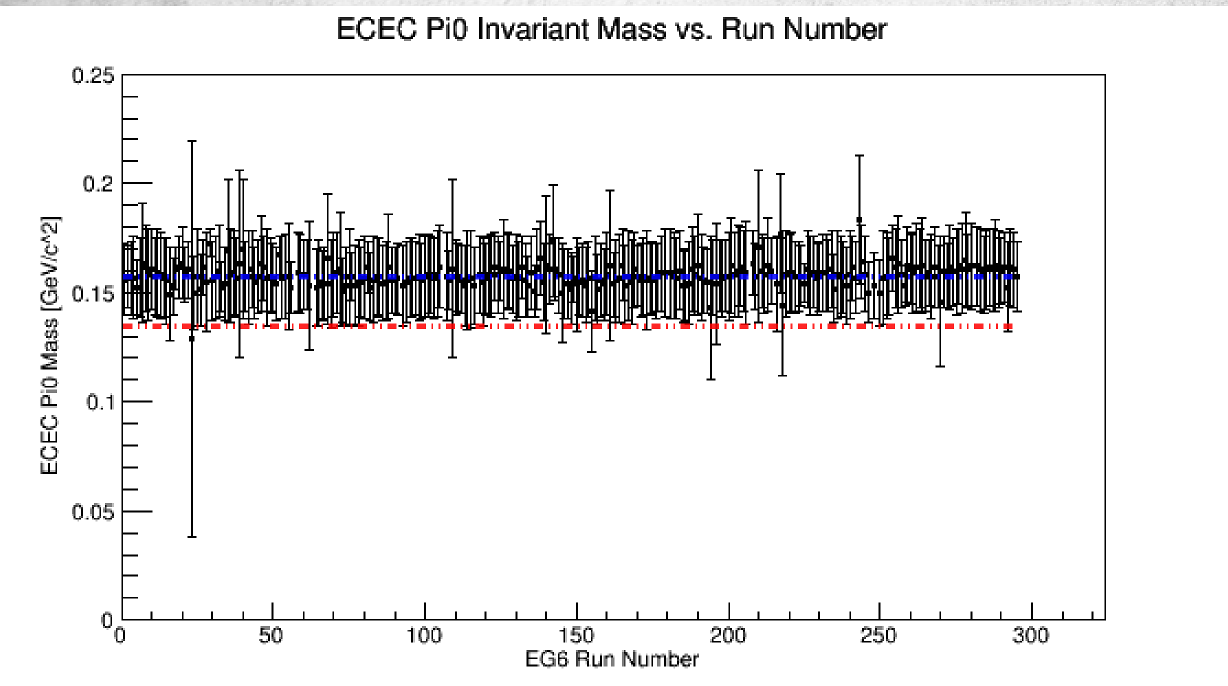


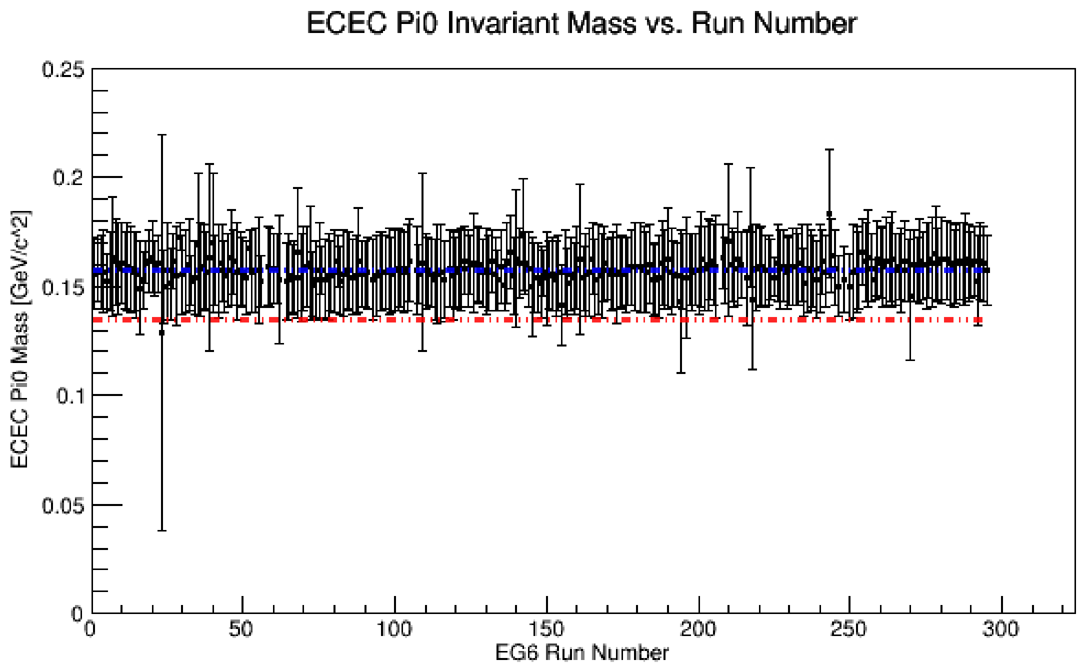
Using reconstructed π^0 and η to calibrate for energy and position of individual photons

Frank Thanh Cao
UConn

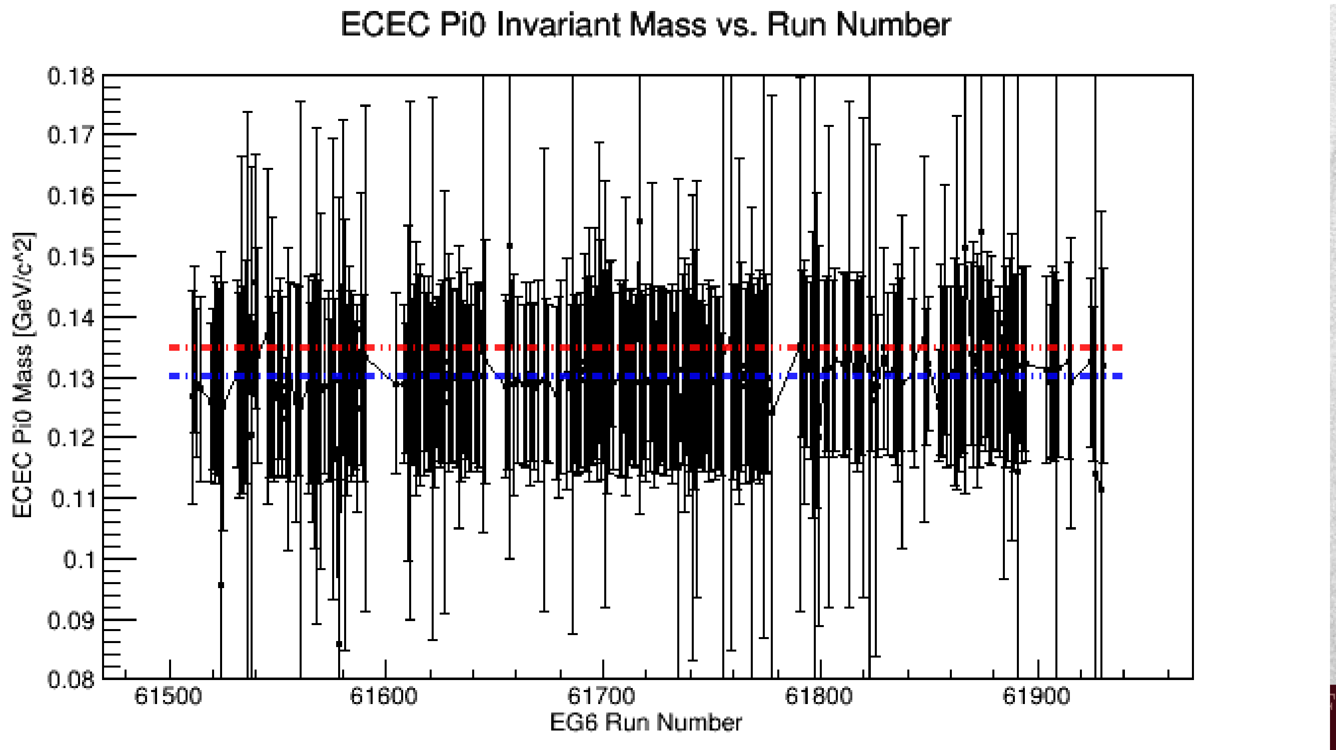
Shifted π^0_{ECEC} Invariant Mass



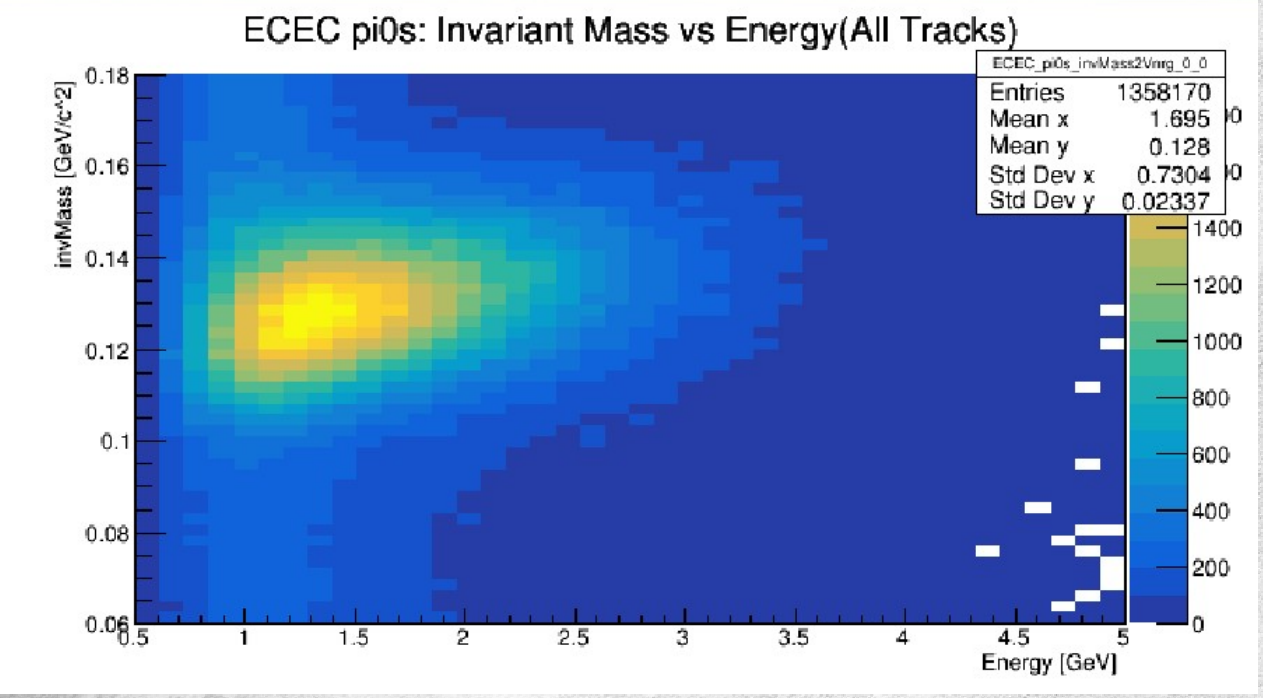




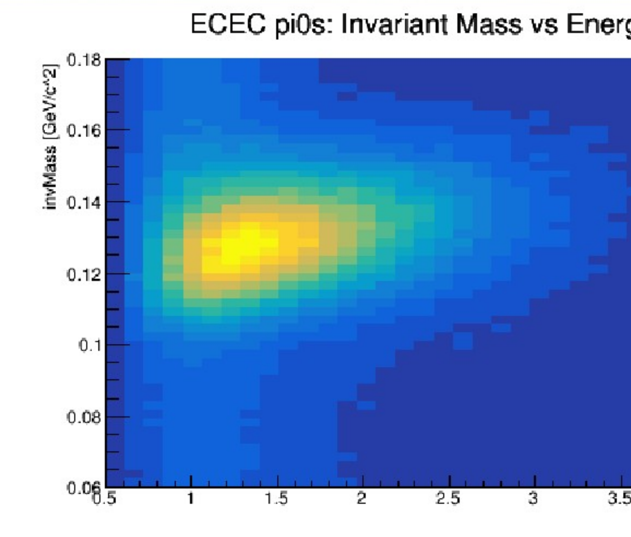
After EG6 Sampling fraction correction developed by N. Baltzell



π^0_{ECEC} Mass Changes with Energy



π^0_{ECEC} Mass Changes with Energy



Scaling Factor

The correction to the photon energy is

$$E_\gamma \quad \rightarrow \quad E'_\gamma = c_{\text{SF}} E_\gamma$$

If we take the symmetric case, where $E_1 \sim= E_2 =: E$, and solve for c_{SF}, in terms of the energy of the reconstructed π^0, we have

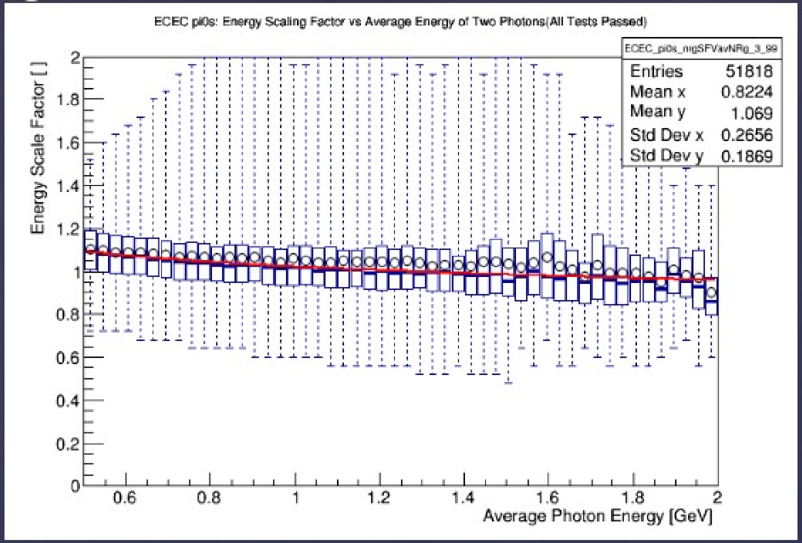
$$M^2 = (c_{SF}^2)(2E^2(1 - \cos\theta))$$

$$\Rightarrow c_{SF} = \frac{M}{E}\sqrt{2(1 - \cos\theta)}$$

With

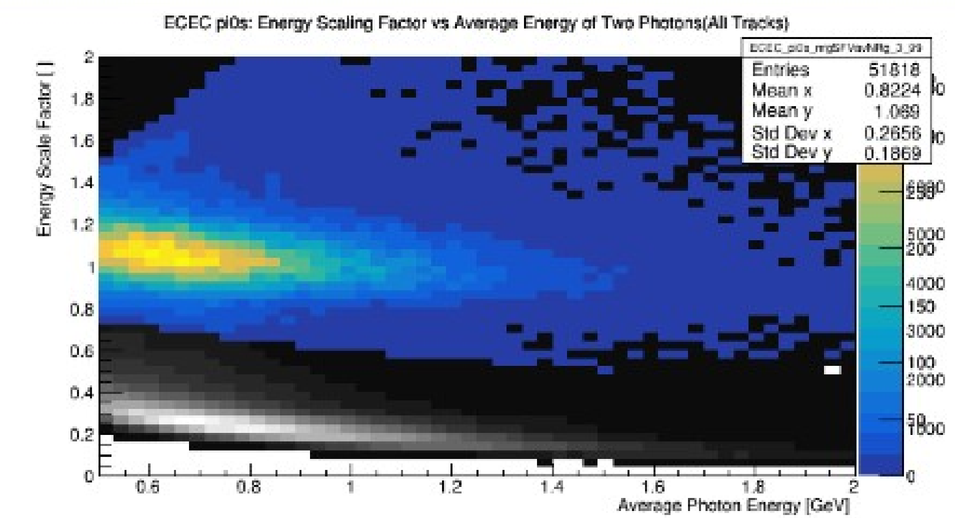
$$\delta E := |E_1 - E_2| \leq 100 \text{ MeV}$$

Scaling Factor Correction

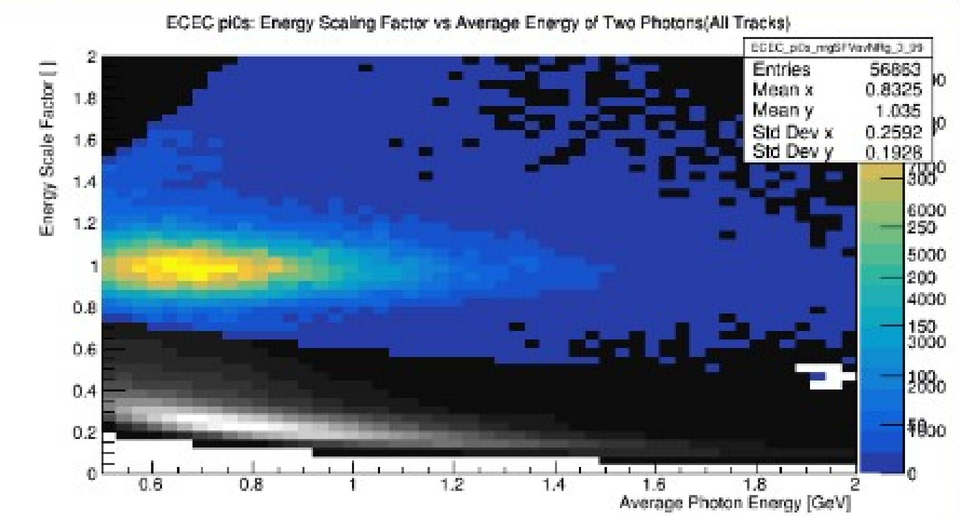


$$c_{SF} = 1 + (-0.0354677)E + \frac{0.0563963}{E}$$

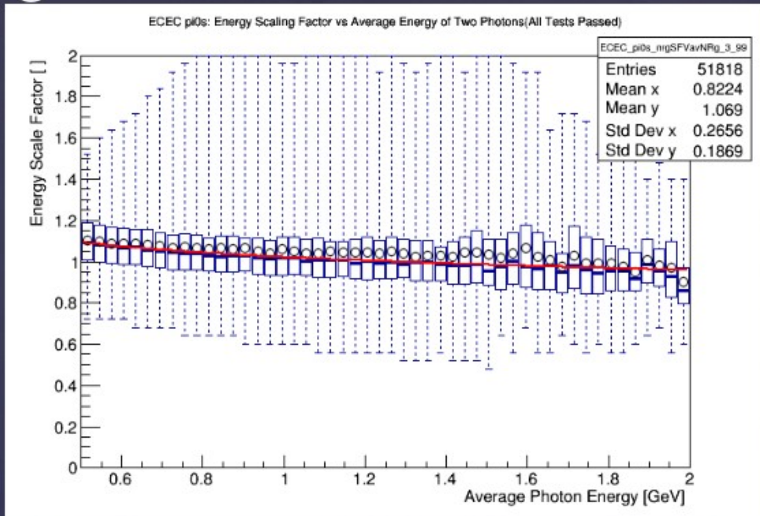
Before



After



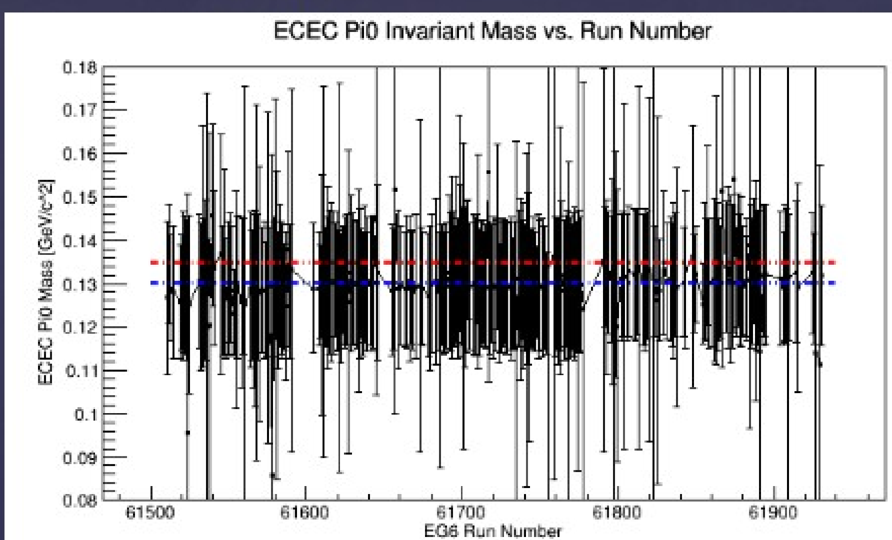
Scaling Factor Correction



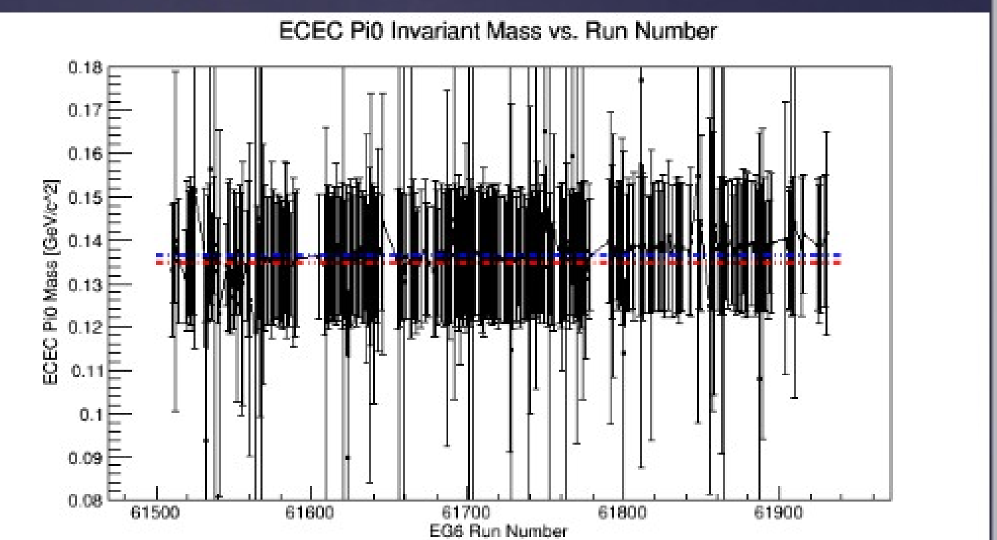
$$c_{SF} = 1 + (-0.0354677)E + \frac{0.0563963}{E}$$

π^0_{ECEC} Results

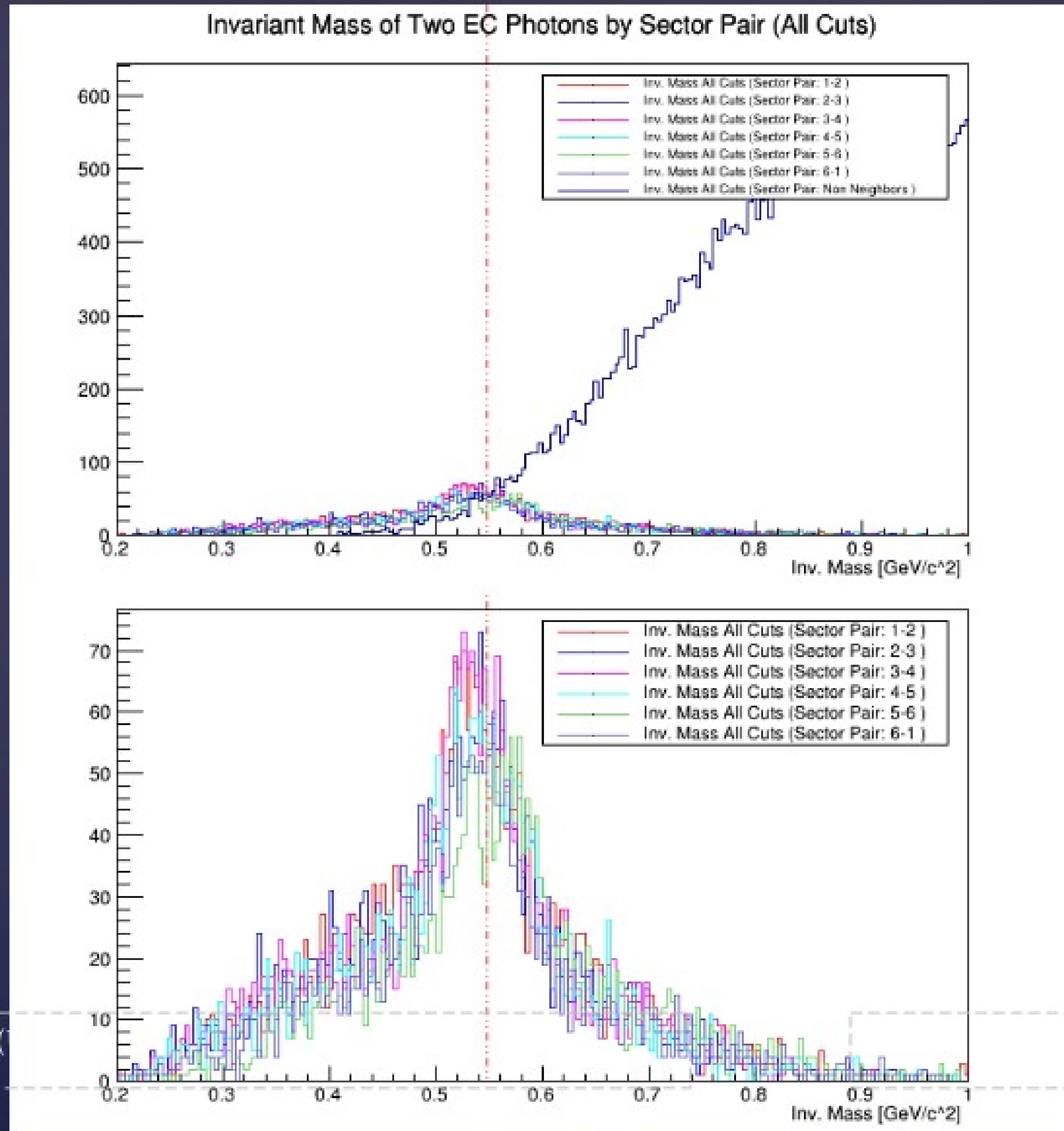
Before



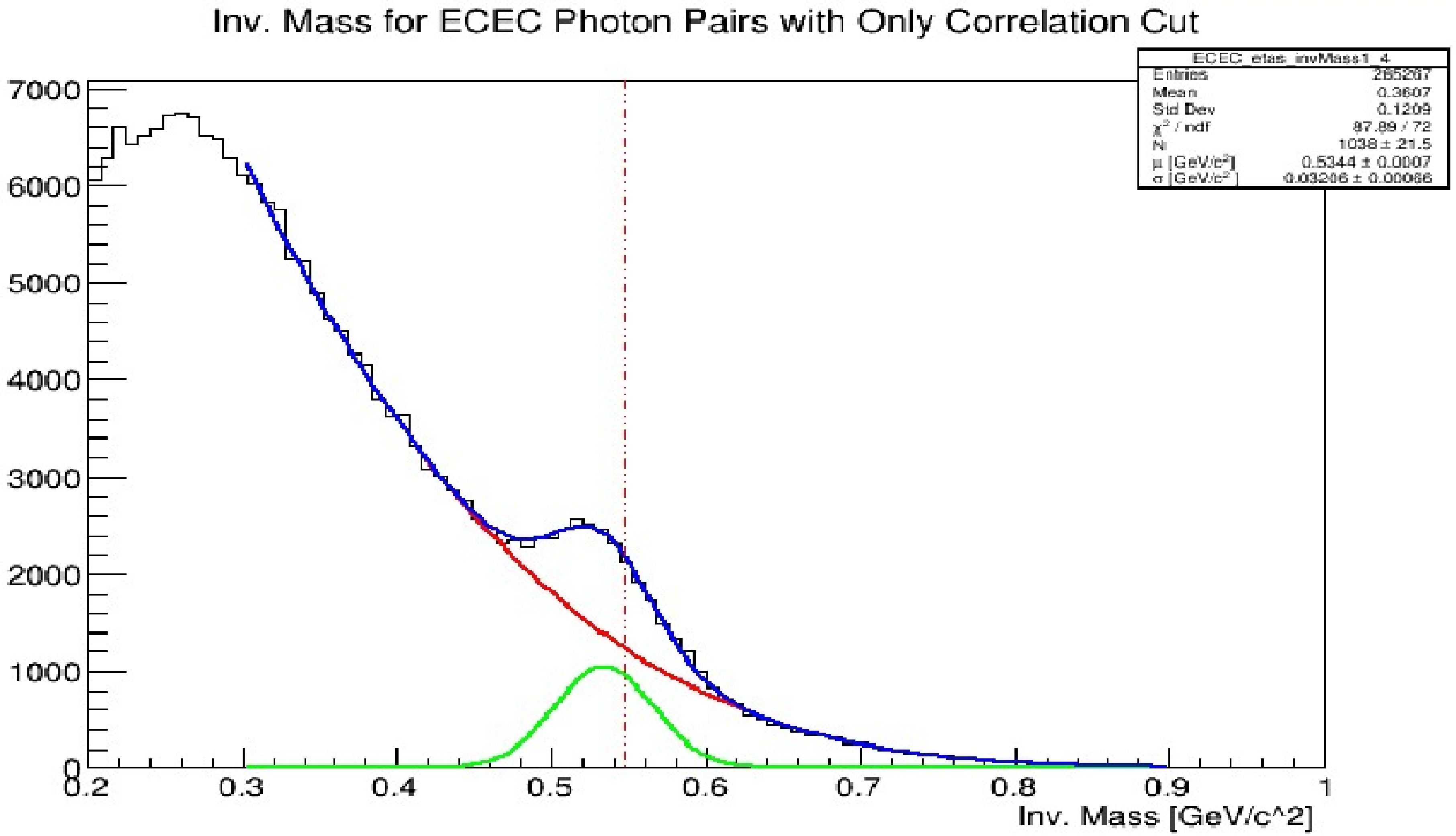
After



η_{ECEC} Breakdown



Without Energy Cut, With Correlation Cut



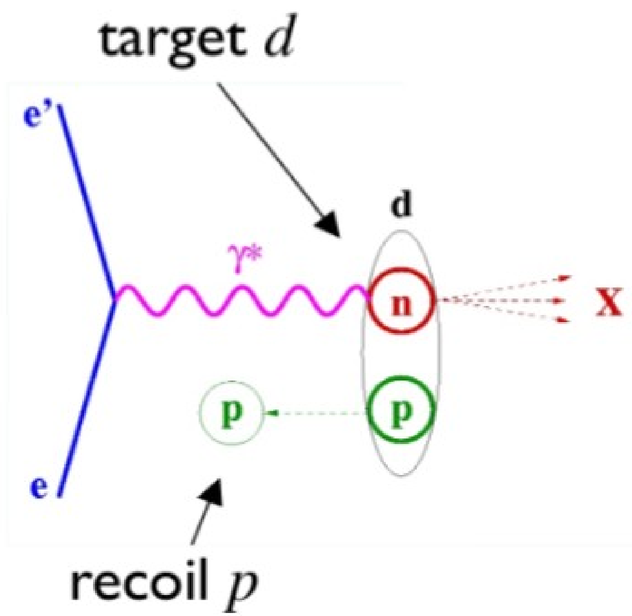
Tracking in BONuS12

Krishna Adhikari (M. S. U.)

Jixie Zhang (U.VA.)

Carlos Ayerbe (W & M)

Use the Spectator tagging technique to study neutron structure function at high Bjorken x



RTPC12 Design

Target: D2 gas, 293k, 7.0 ATM, 40 cm long

Target Wall: **28 um** kapton, 3 mm radius

Drift Region: 3<R<7 cm

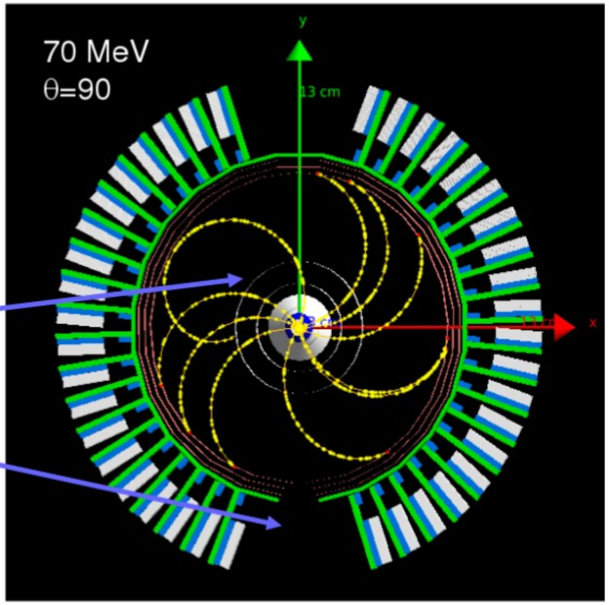
Drift Gas: 293k, 1 ATM, He/DME (90/10)

Sensor Wires are removed!
No wires here

φ coverage = 360 degrees,
NO φ acceptance loss here

Readout pad at R=8 cm
Pad size 2.79 (tran.) x 4 mm (z),
18000 pads in total

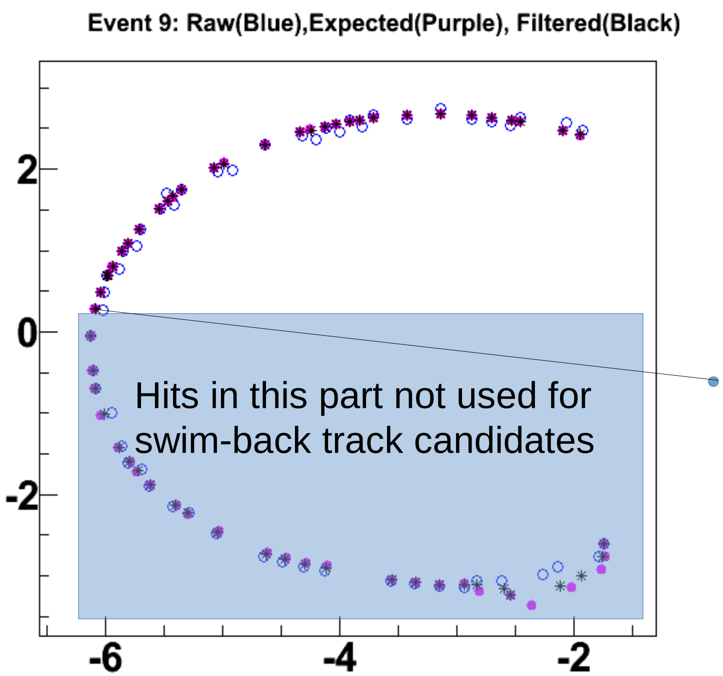
TIC window = 200ns



Use CLAS12 Solenoid with -5T field (pointing upstream)

BONuS12 Tracking Update

❖Tracking program based on Global-Helix-Fitter (GHF) and Kalman Filter (KF) has been developed.



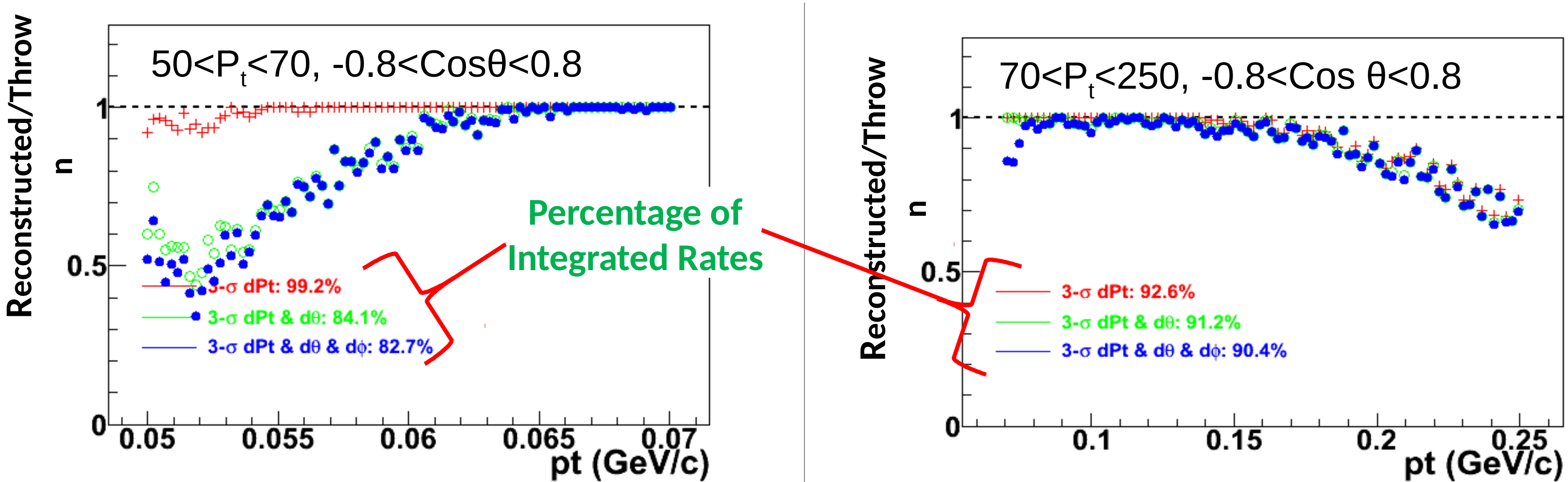
❖If a track swims back Fitting whole track doesn't work as well as for forward going tracks. Fitting only forward part of the track works!

❖KF is sensitive to initial values. To first order, reconstructed P_t and ϕ are sensitive to initial R and ϕ, while reconstructed θ is sensitive to initial θ. If there are offsets in these initial values, these offsets are still seen in the final results.

❖ For curve-back tracks, Iter1-KF does not reconstruct ϕ well. Only Iter2-KF gives a better ϕ fit.

❖ For non-curve-back tracks, both global helix fitter and Iter1-KF give roughly similar results but Iter1-KF is slightly better!

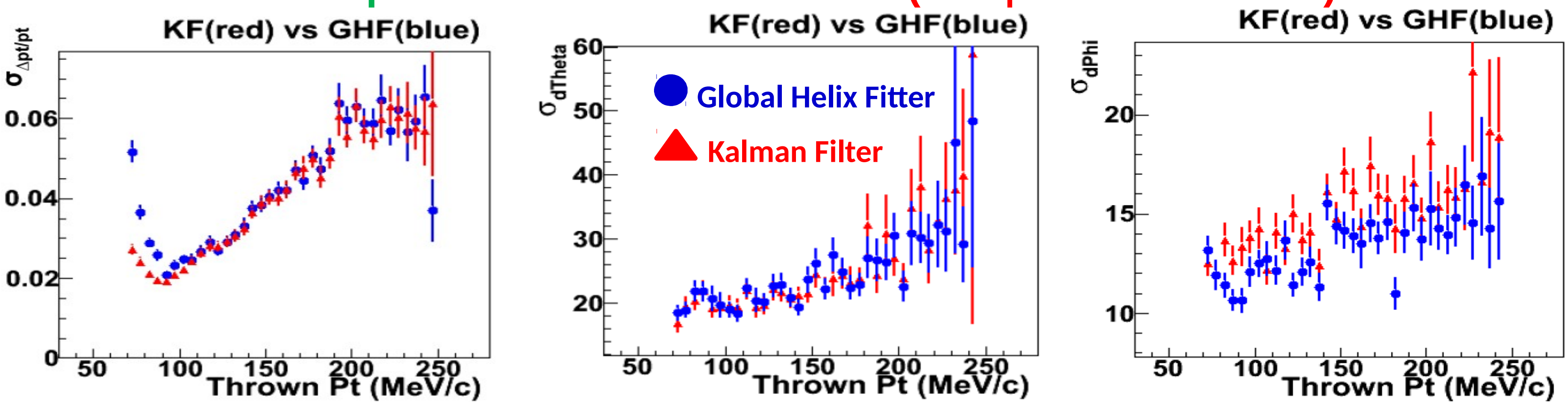
Kalman Filter Performance



50<Pt<70: 82.7% valid reconstruction, 15% lost due to θ reconstruction at small Pt region (Pt<0.063)

70<Pt<250: 90.4% valid reconstruction, 7.4% lost due to Pt reconstruction in large Pt region (Pt>0.17)

Resolution comparison between KF & GHF (θ & φ in milli radians)



60<P<300, -0.8<cosθ<0.8, Use fitted parameters at last site from helix fitter as input