By: Igor Korover

Tel Aviv University and NRCN

July 12, 2018

Study of SRC with recoil neutron detection in CLAS6

On going Data Mining analysis

Hall B, NPWG – Jefferson Lab, Newport News

Short Range Correlation

High energetic projectiles and large momentum transfer reactions probe small distances and disintegrate the SRC pair

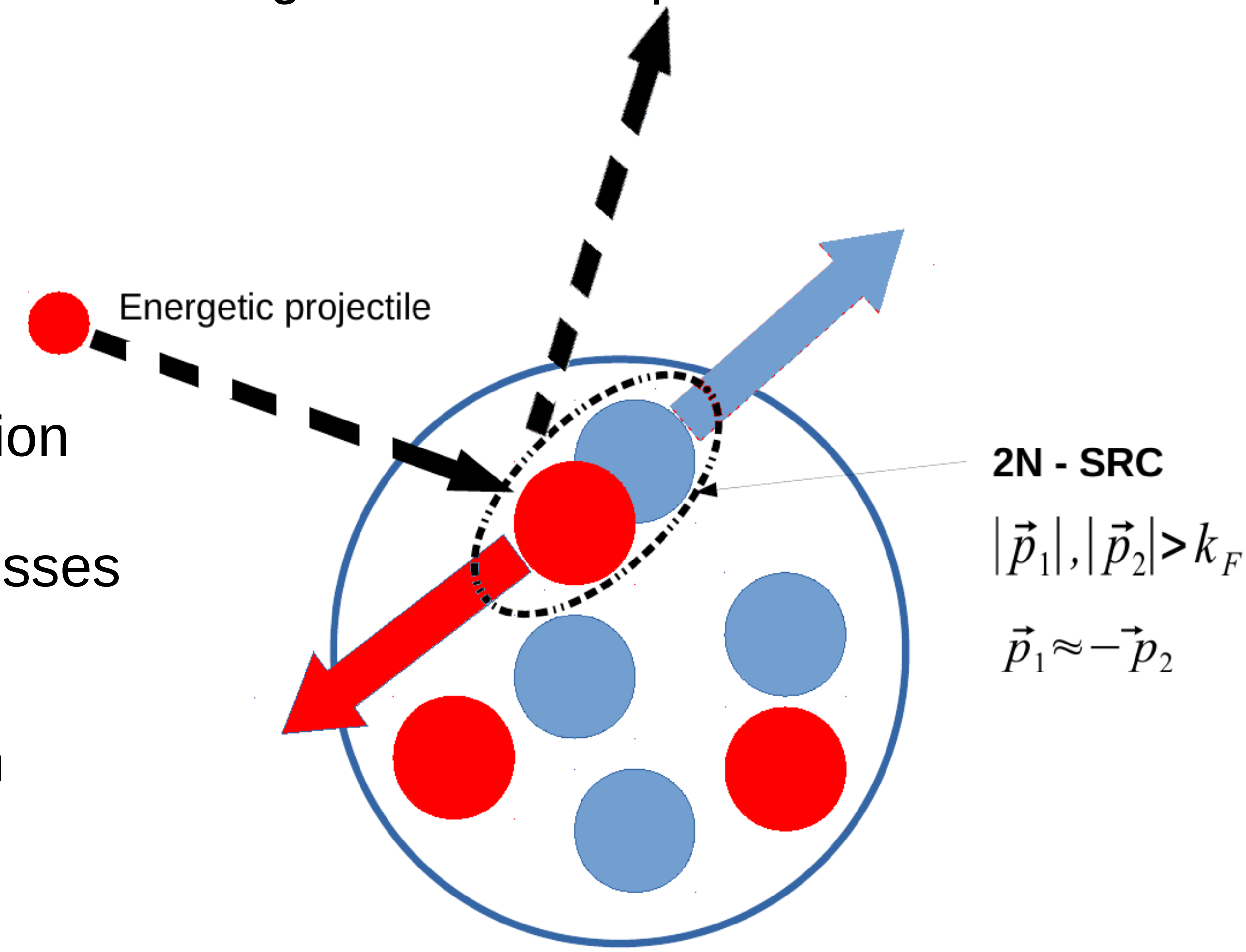
Why going to high missing momentum?

$$p_{miss} = p_f - q$$

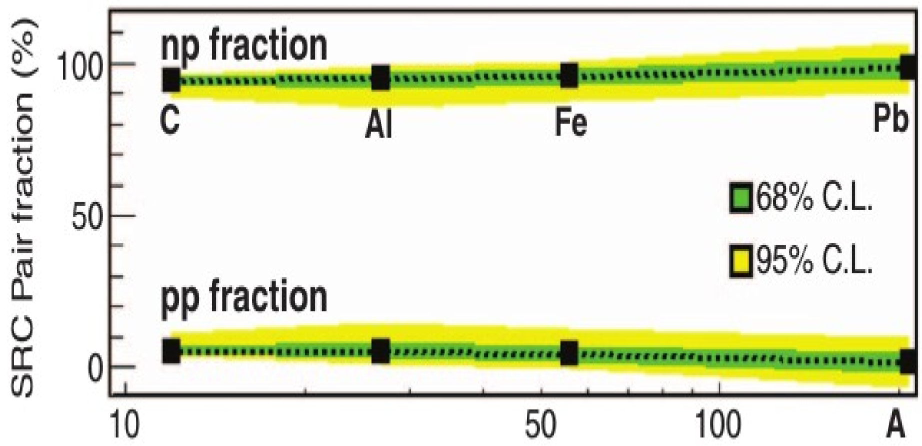
* Go above mean field region

* Reduce competing processes

* FSI is described well by a Glauber Approximation



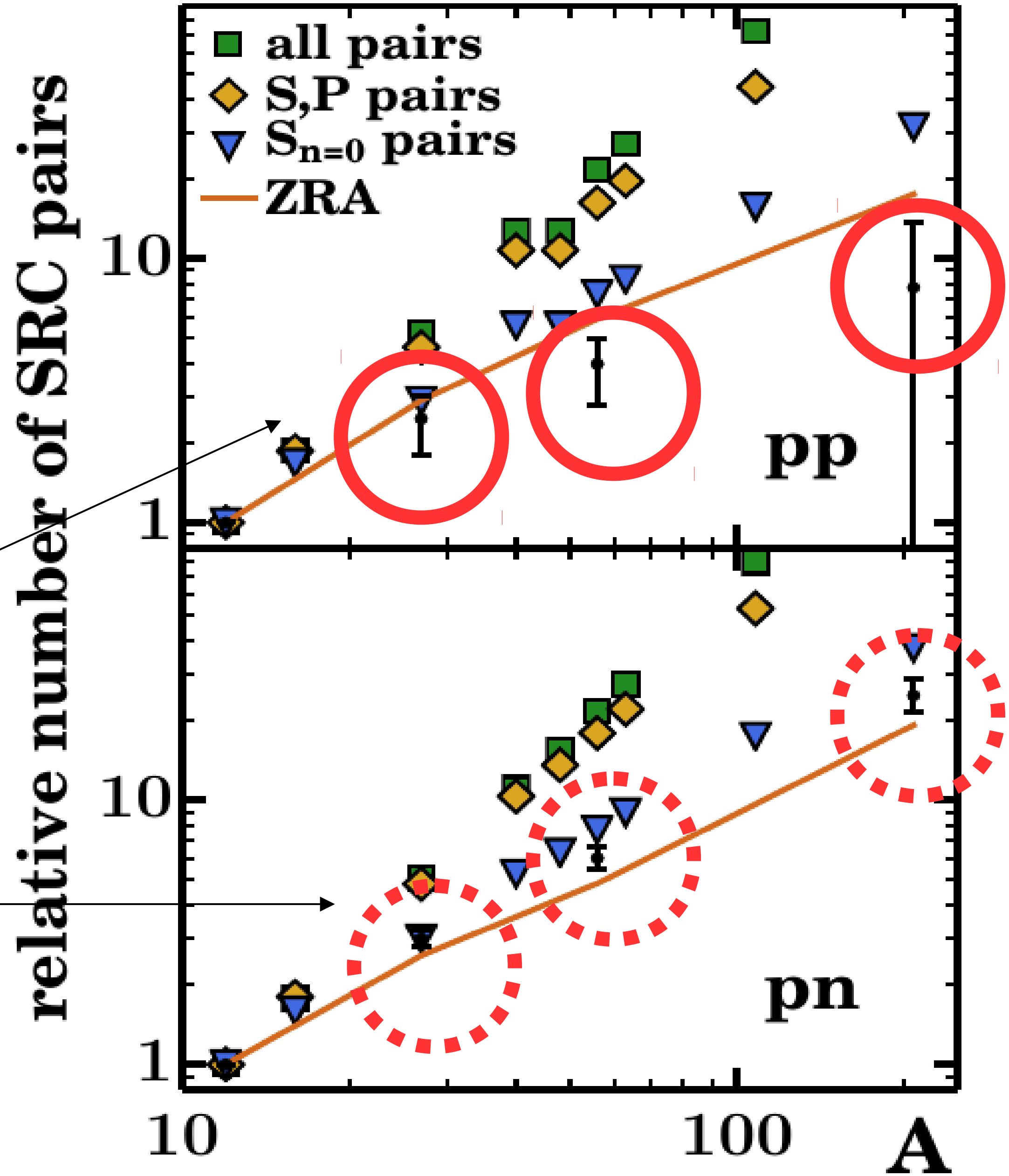
A(e,e'pp) analysis done on eg2a run period



O. Hen, *et el.*,
Science 346, 614 (2014)

Measured

Deduced



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

Detection of neutron from CLAS detector

Electromagnetic Calorimeter (EC): see Meytal Duer talk.
(leading neutron detection)

Versus

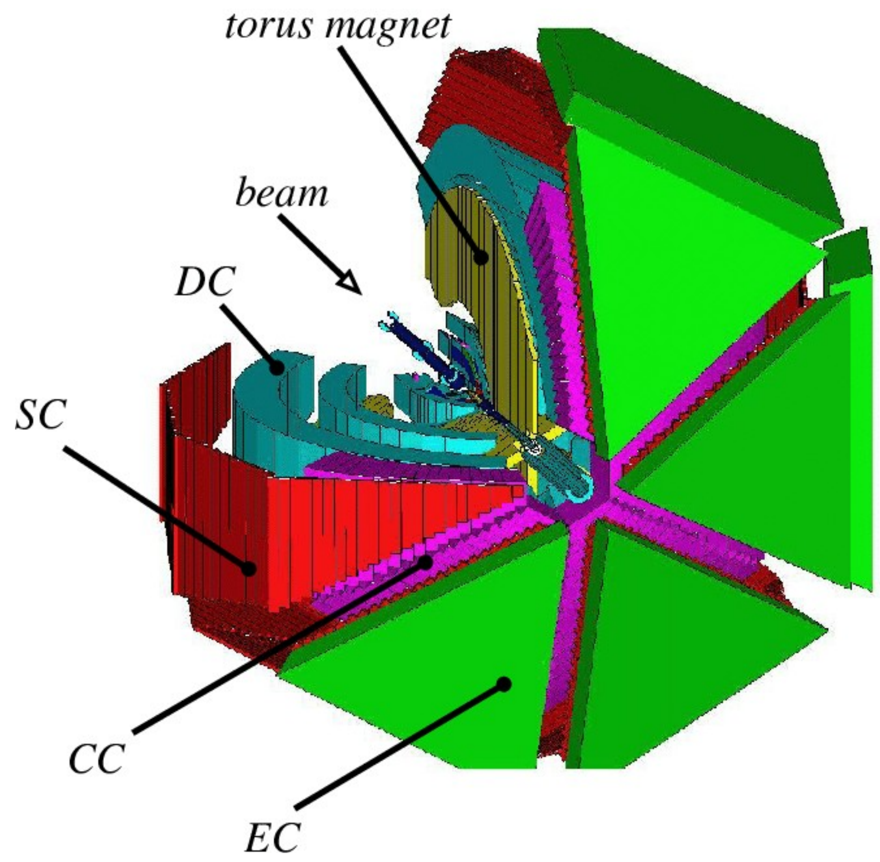
Neutrons detected from TOF counters (SC)
(recoil neutron detection)

Advantage: Large acceptance
Better Momentum Resolution

Disadvantage: Low detection efficiency

Previous analysis with neutrons
in TOF scintillators:

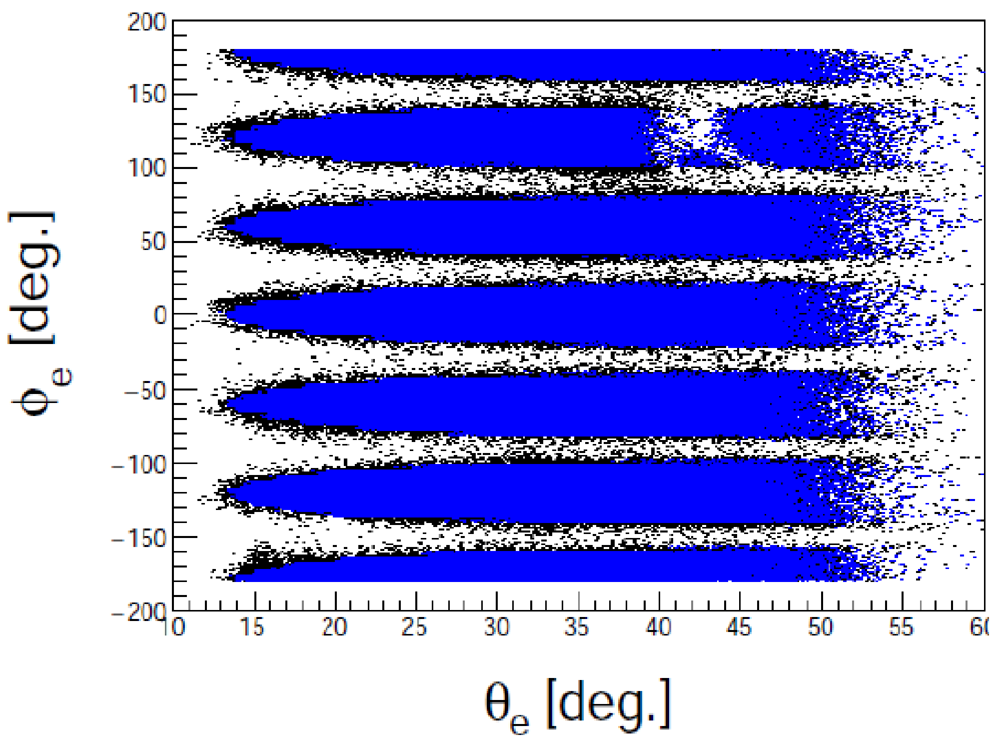
A high precision measurement of the neutron magnetic form factor using the CLAS detector

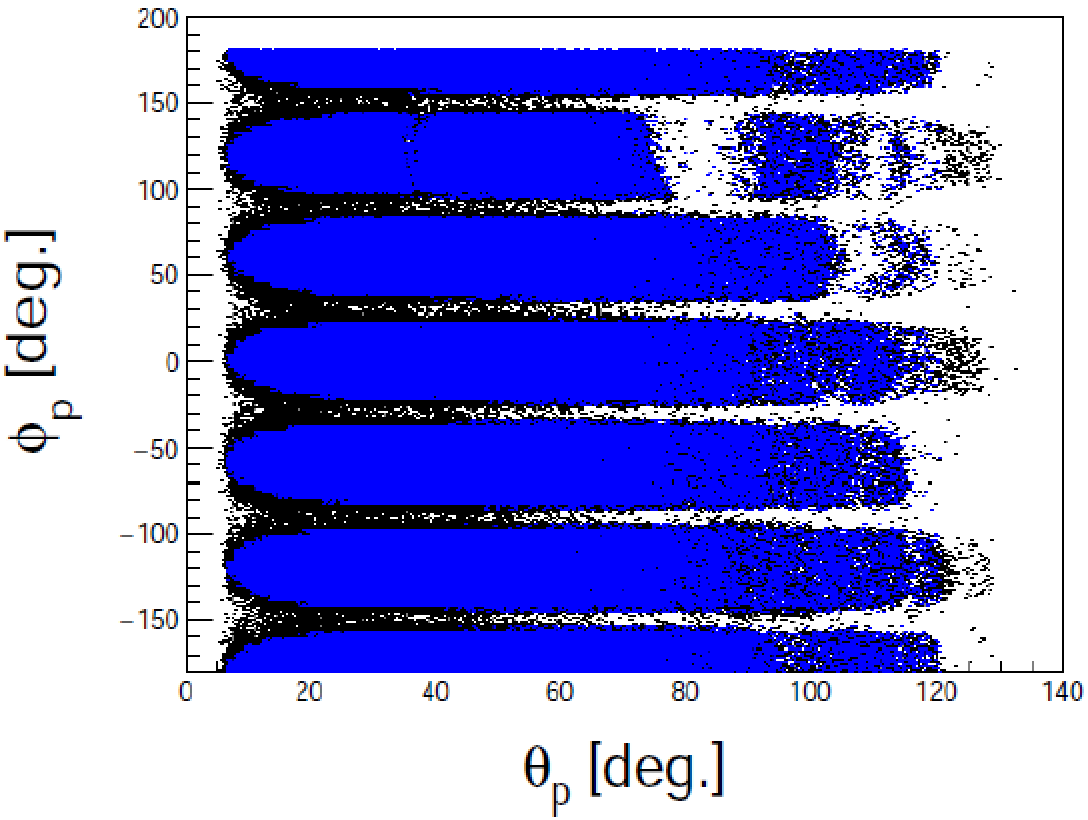


Selection of protons and electrons

<u>Selection of electrons and protons with standard ClasTool.</u>

Fiducial cuts identical to previous approved analyses.

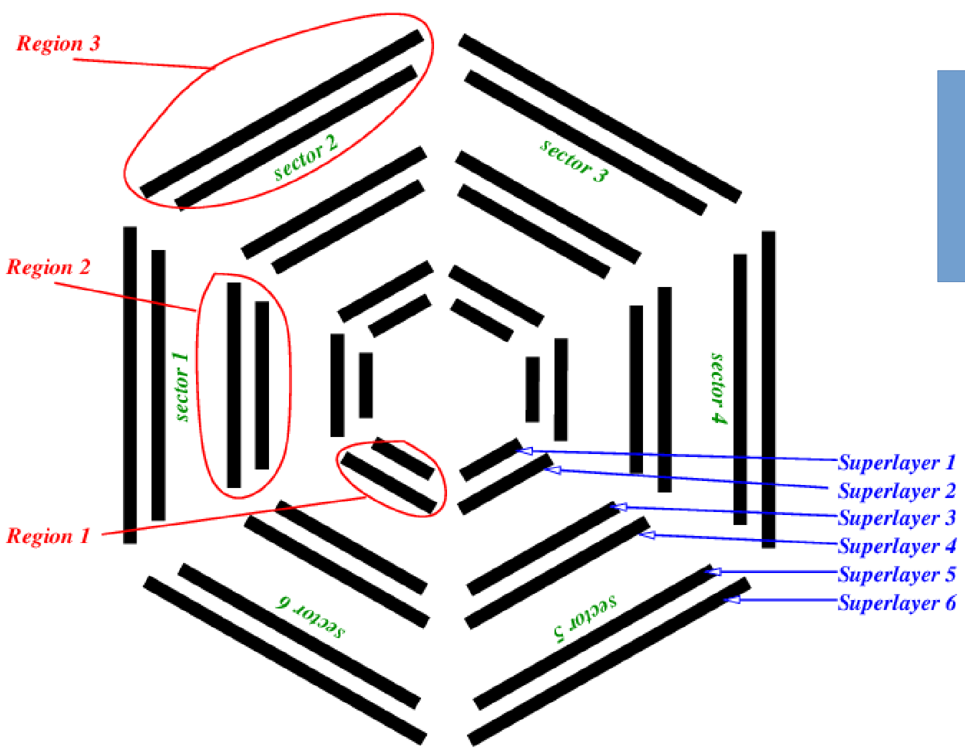




Neutral Particle Identification: Veto Algorithm

Main Goal: Separate neutral from charged particles hits in the scintillators

Drift chambers layout of CLAS



Charge particles leave tracks in drift chambers

Neutral hit do not have correlated track in the chambers

Technical details

Gn analysis: Use of dc1 bos bank to project hits in scintillators

This analysis: dc1 bank is not available

Use tracks from DCPB and HBLA bos banks

DCPB – standard track bank
HBLA – intermediate bank that store hits in each layer

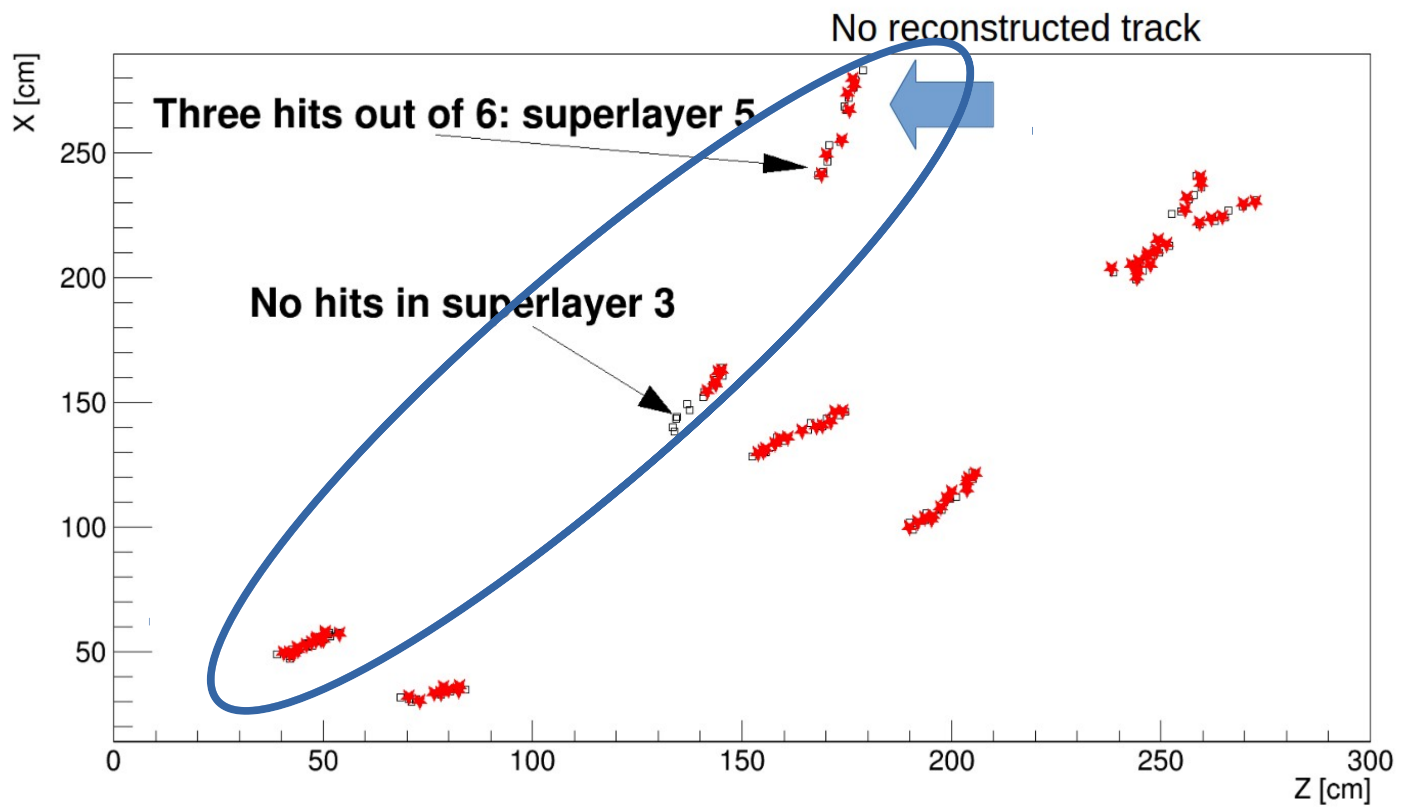
Step 1:

Remove all hits from SCRC bos bank that correlate to tracks (DCPB bank)

Example of track that are not included in DCPB

Step 2:

Use of HBLA bos bank
to reconstruct tracks
from hits in drift chamber

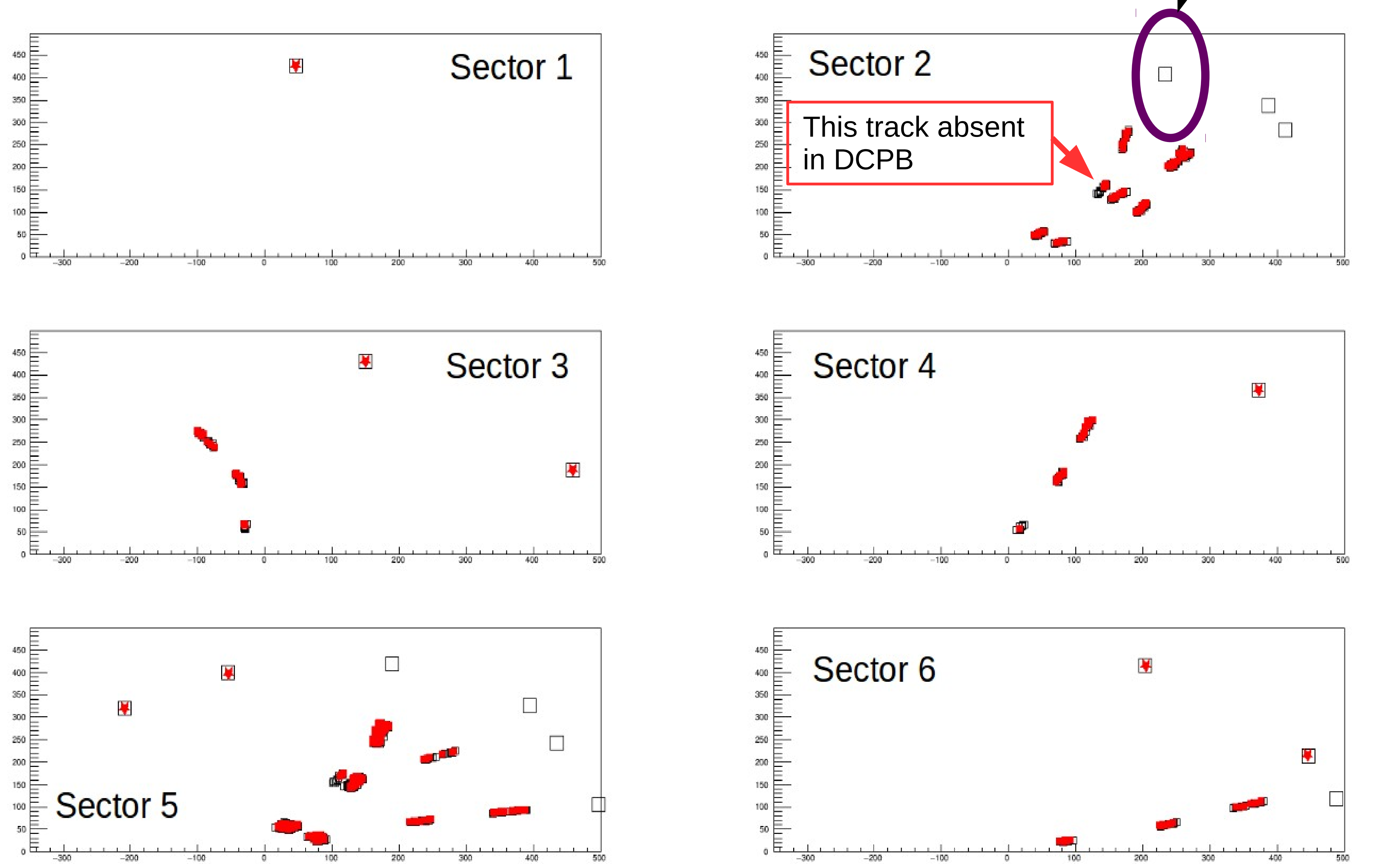


HBLA bos bank – store hit information in each layer. If there is no hit, reconstruction code fill this gap based on adjacent hits.

Empty squares – expected hit position in each layer.
Red stars – actual hits in each layer.

Example for neutral candidates an arbitrary event

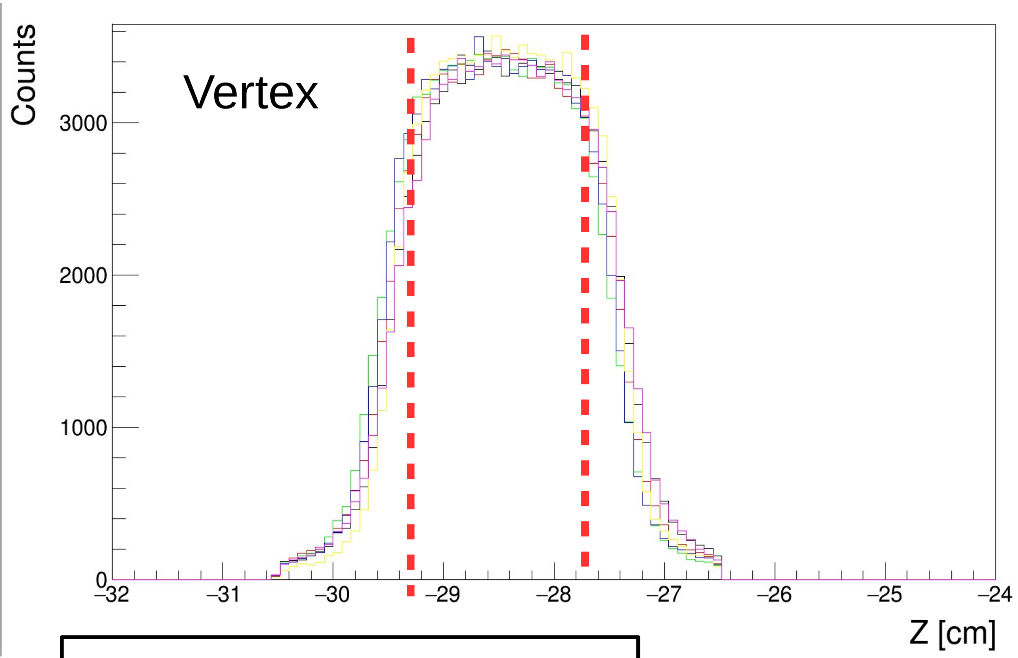
Only DCPB will identify this hit as neutral

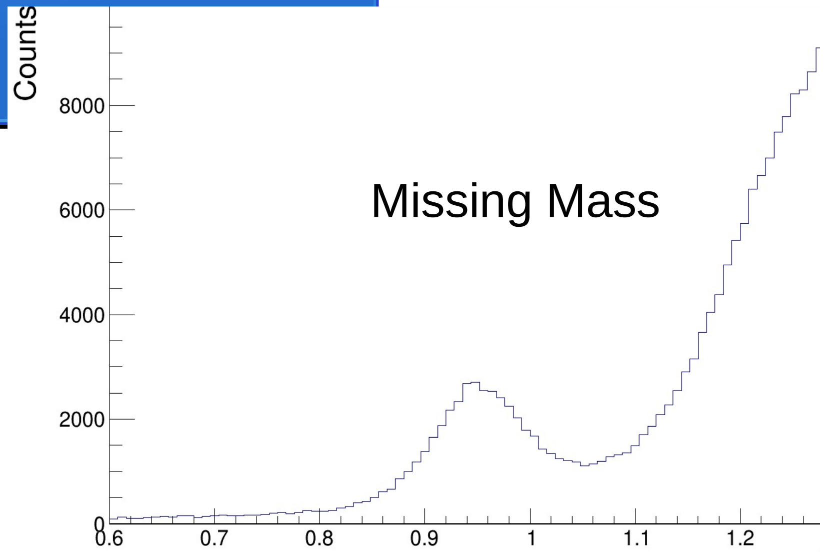


From neutral hits to neutrons

We use exclusive d(e,e'pn) reaction

Select Deuteron target

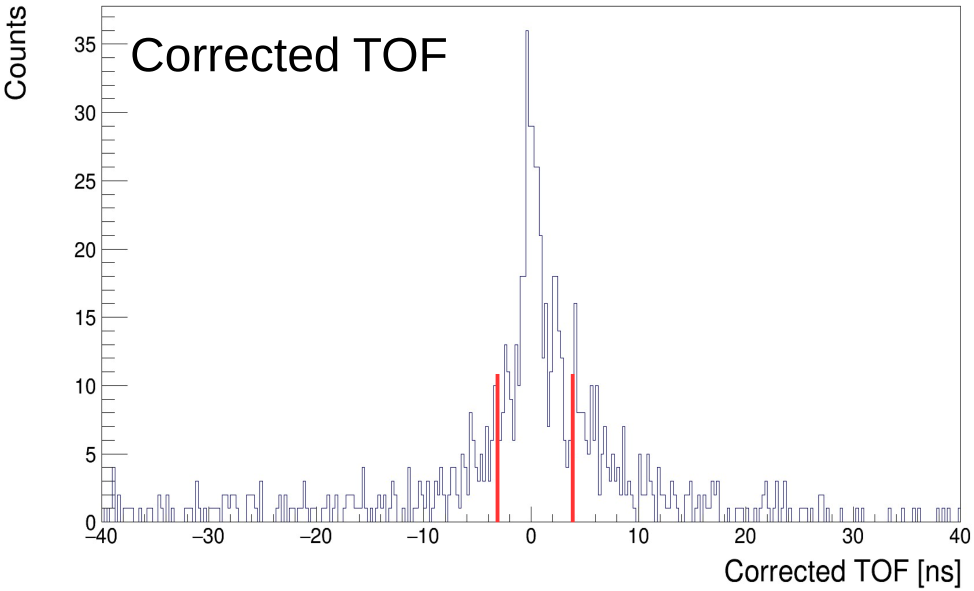




Leading proton d(e,e'p):

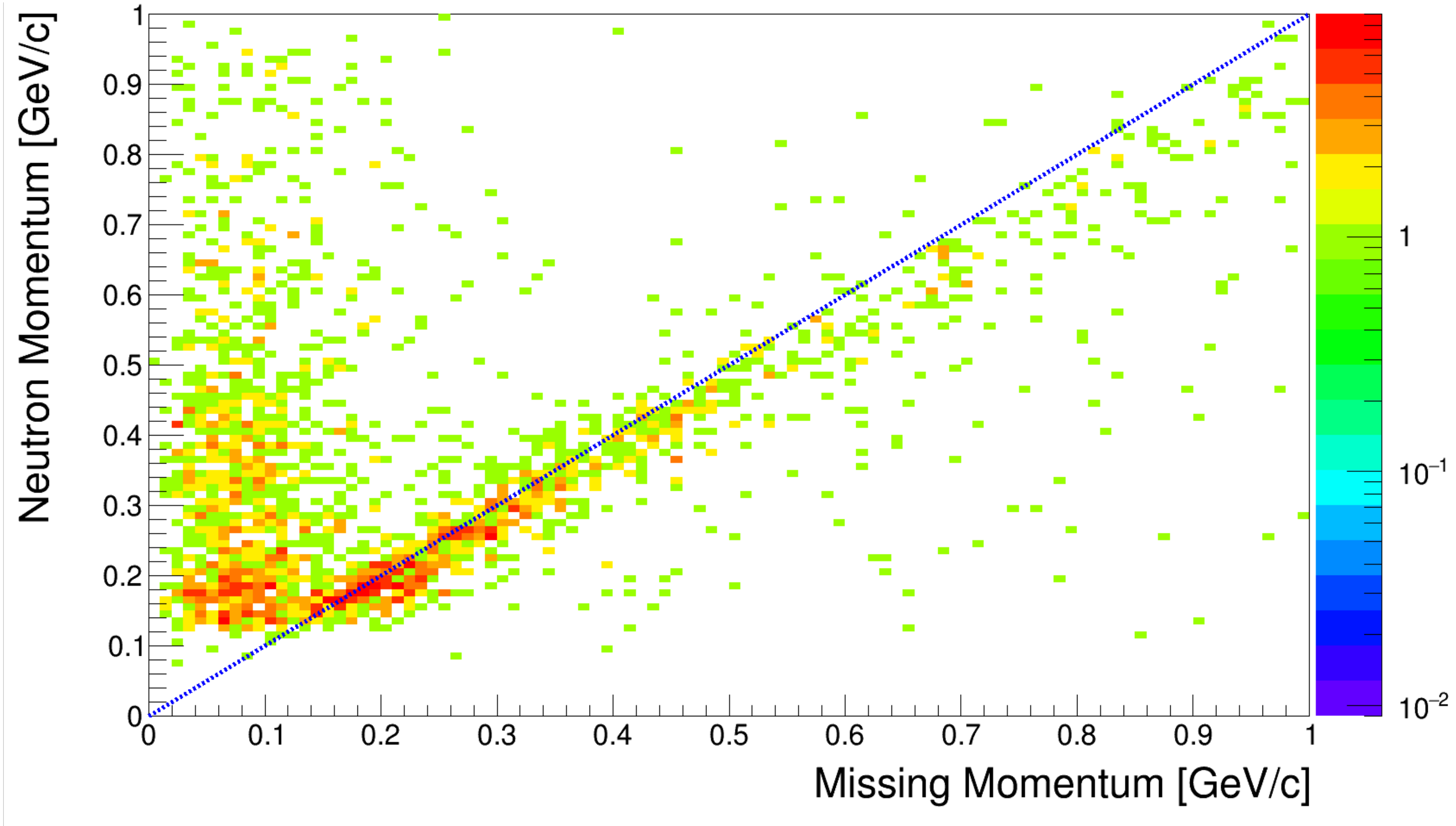
$$\frac{|\vec{p}|}{|\vec{q}|} > 0.65$$

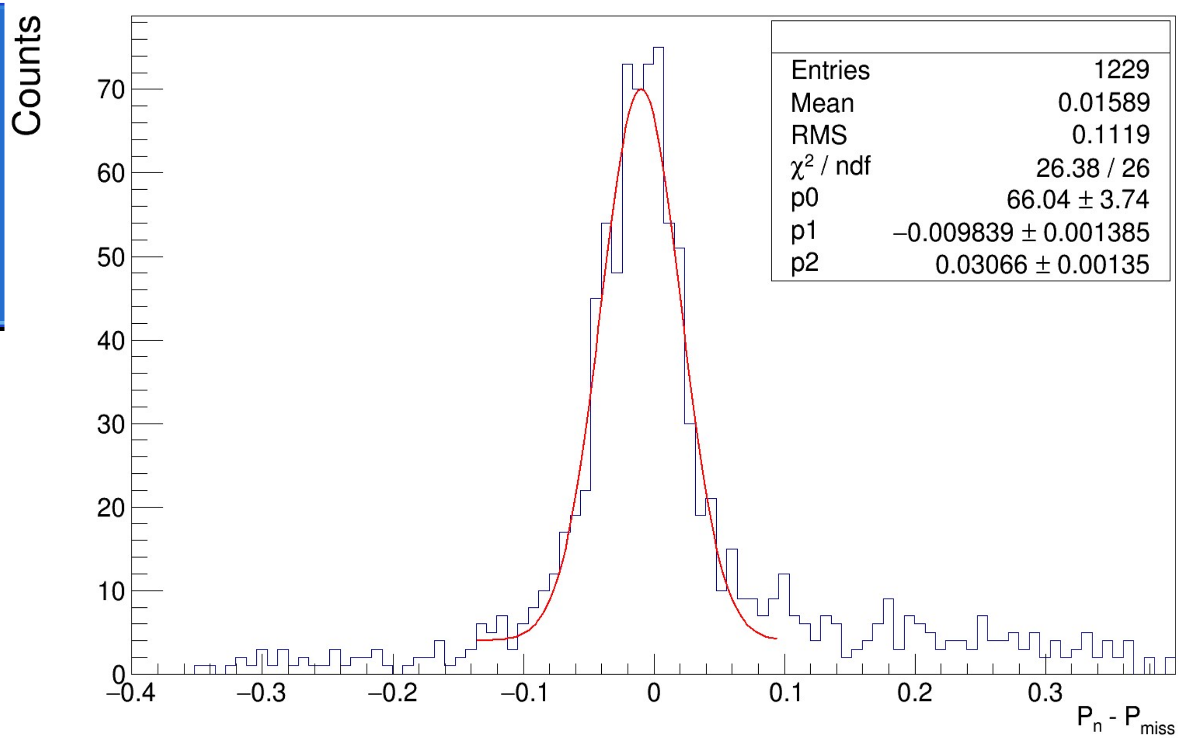
$$\cos\left(\vec{p}\cdot\vec{q}\right) < 25^{0}$$



$$\text{Corrected TOF} = \text{Measured} - \text{Expected} = \text{Measured} - \frac{\text{distance}}{0.3\cdot\beta}$$

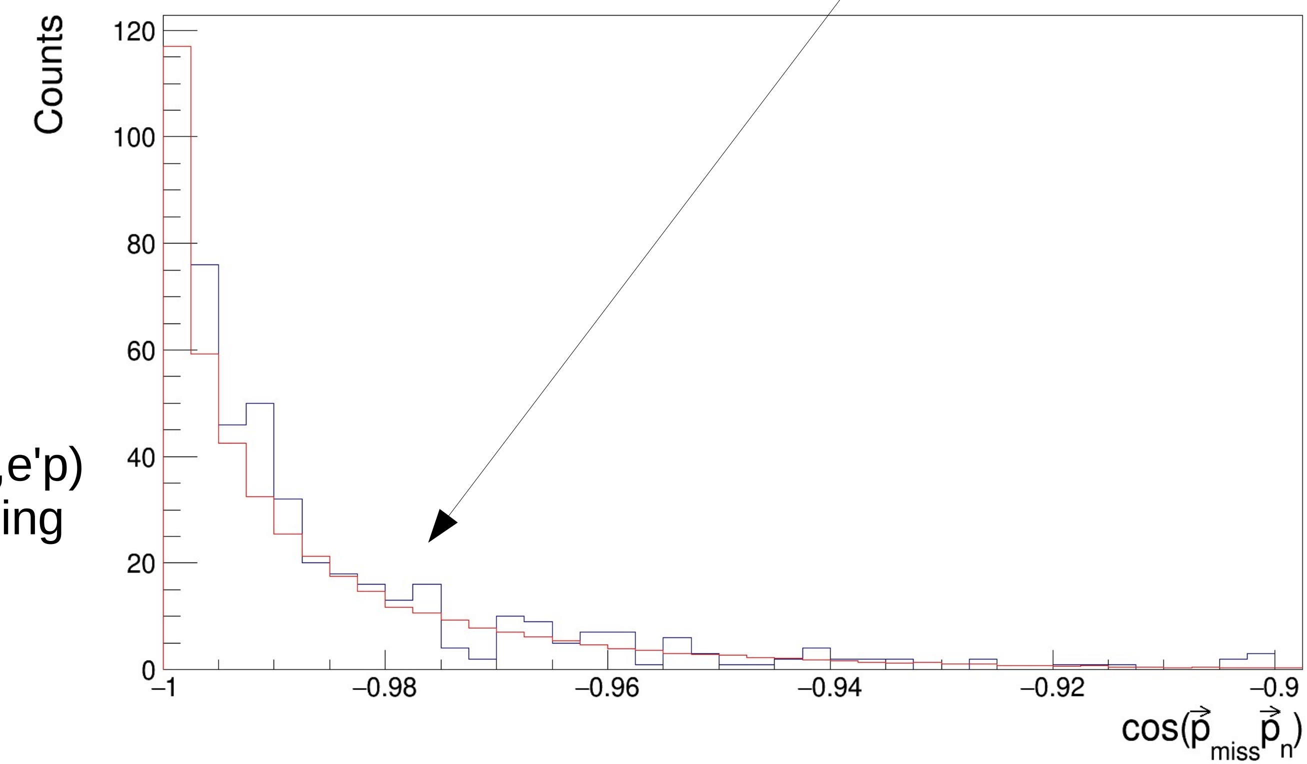
Missing Momentum and Neutron Momentum





Blue – data
Red – simulation

$$\frac{\Delta p}{p} \approx \frac{30.7}{433} \approx 7\,\%$$



<u>Simulation:</u>

Simulate neutrons based on d(e,e'p) reaction and smearing the outgoing neutron with the resolution

Neutron detection efficiency

$$\eta \equiv \frac{\#d(e,e'pn)}{\#d(e,e'p)}$$

Event Selection:

d(e,e'p)

1) Deuteron Vertex.
2) Vertex difference.
3) Defining the proton as the knocked-out particle.
4) Restriction of missing momentum to point between 10 and 140 degrees.

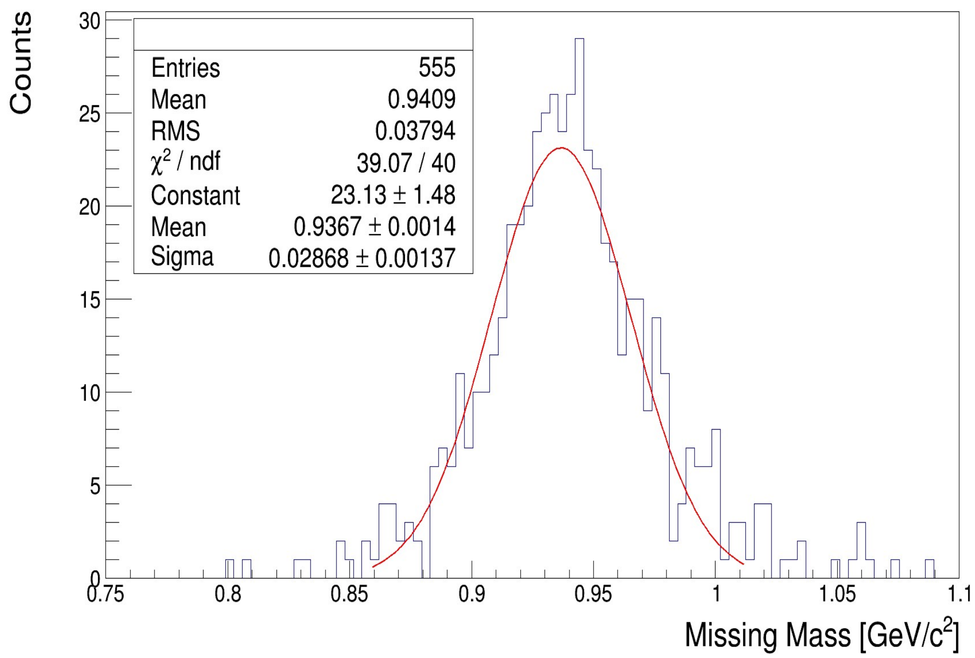
d(e,e'pn)

5) Energy deposition cut.
6) Corrected TOF with neutron mass.
7) Cutting out 5 cm from each edge of the scintillators
8) Back to back correlation between missing and neutron momentum.

Background
Counting of d(e,e'p) and d(e,e'pn) events

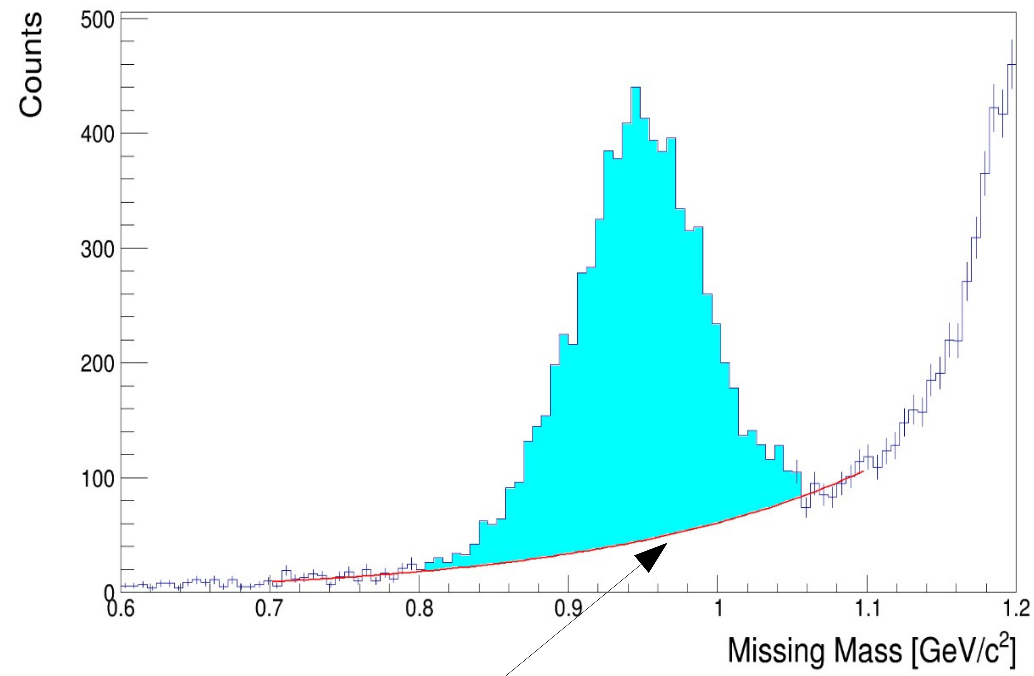
Very low background level

d(e,e'pn)



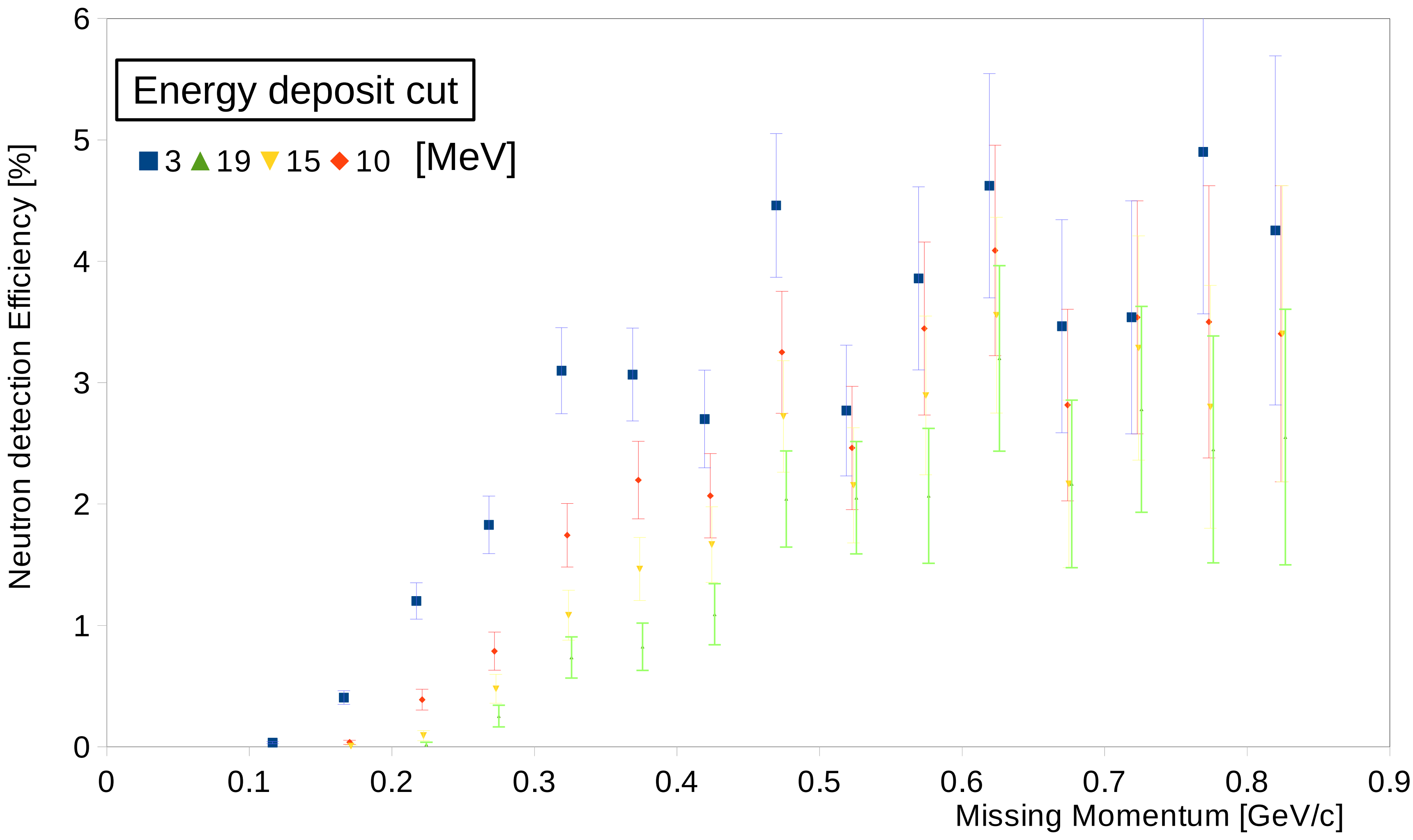
Relatively large background

d(e,e'p)

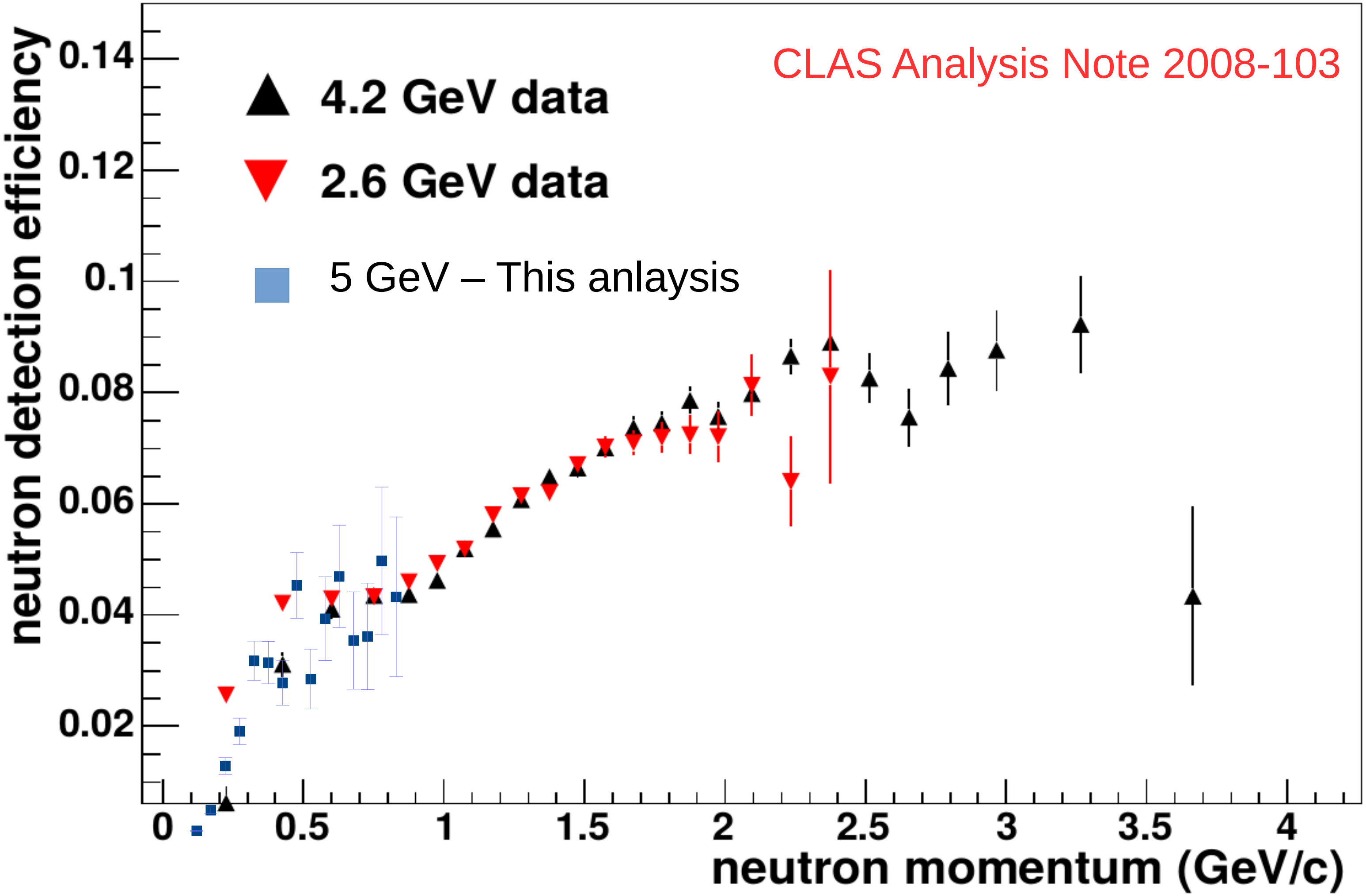


Background estimation

Efficiency is sensitive to the energy deposit cut:



Efficiency comparison



Gn Analysis

$$ep \rightarrow e\,\pi^{+}(n)$$

First Physical Results

Search of np-SRC from solid targets: 12C, 27Al, 56Fe, 208Pb

Step 1: Select A(e,e'p) events

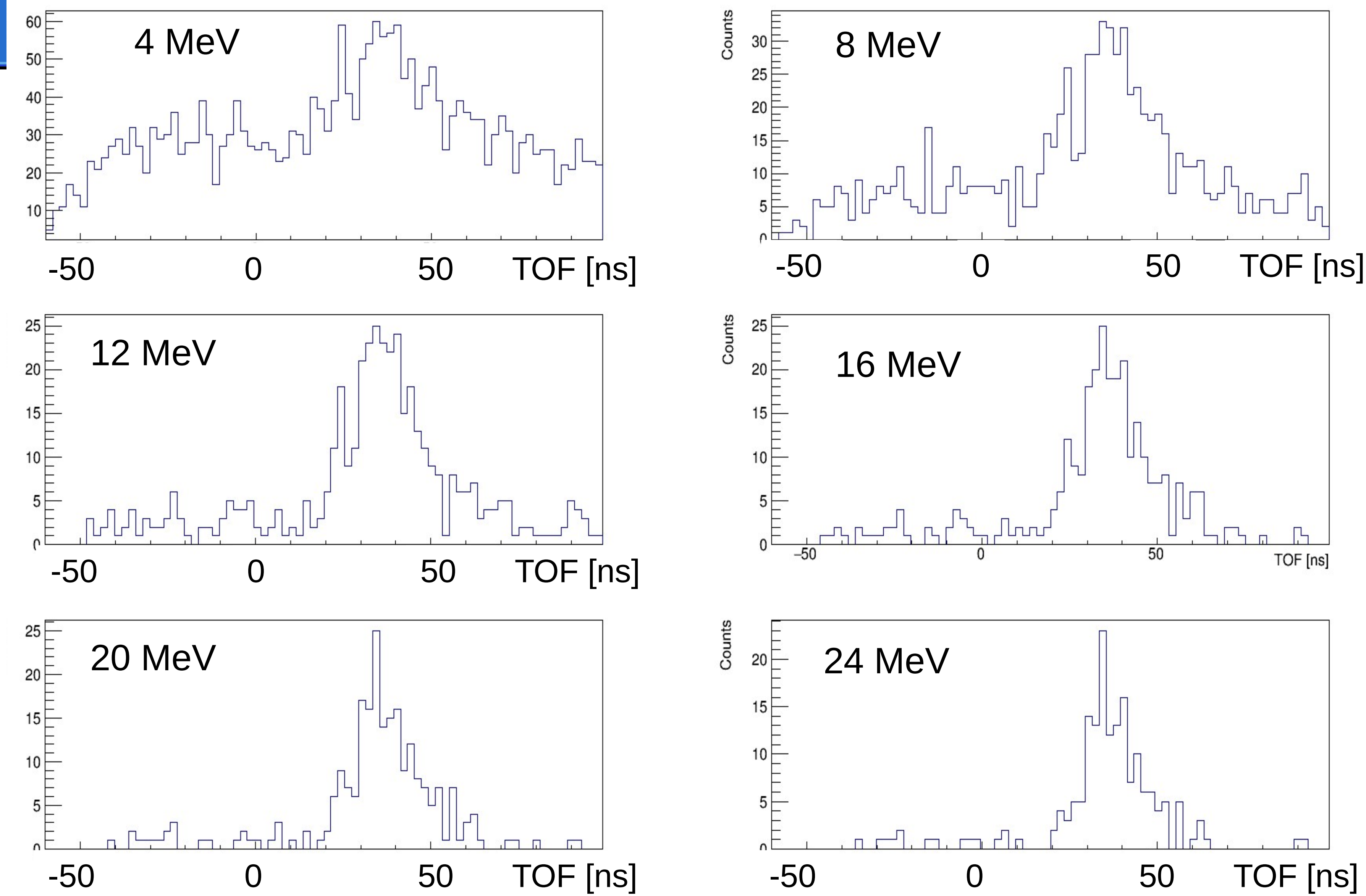
- Vertex
- Missing Momentum $300\,\text{MeV/c} < P_{miss} < 1\ \text{GeV/c}$
- X Bjorken $x_B > 1.1$
- Leading proton cut $\frac{|p|}{|q|} > 0.65 \ \text{and}\ \cos(pq) < 25^o$
- Missing Mass $Miss_{mass} < M_{nucl} + \pi_m < 1.1$

Step 2: A(e,e'pn) Cuts

All (e,e'p) cuts and:

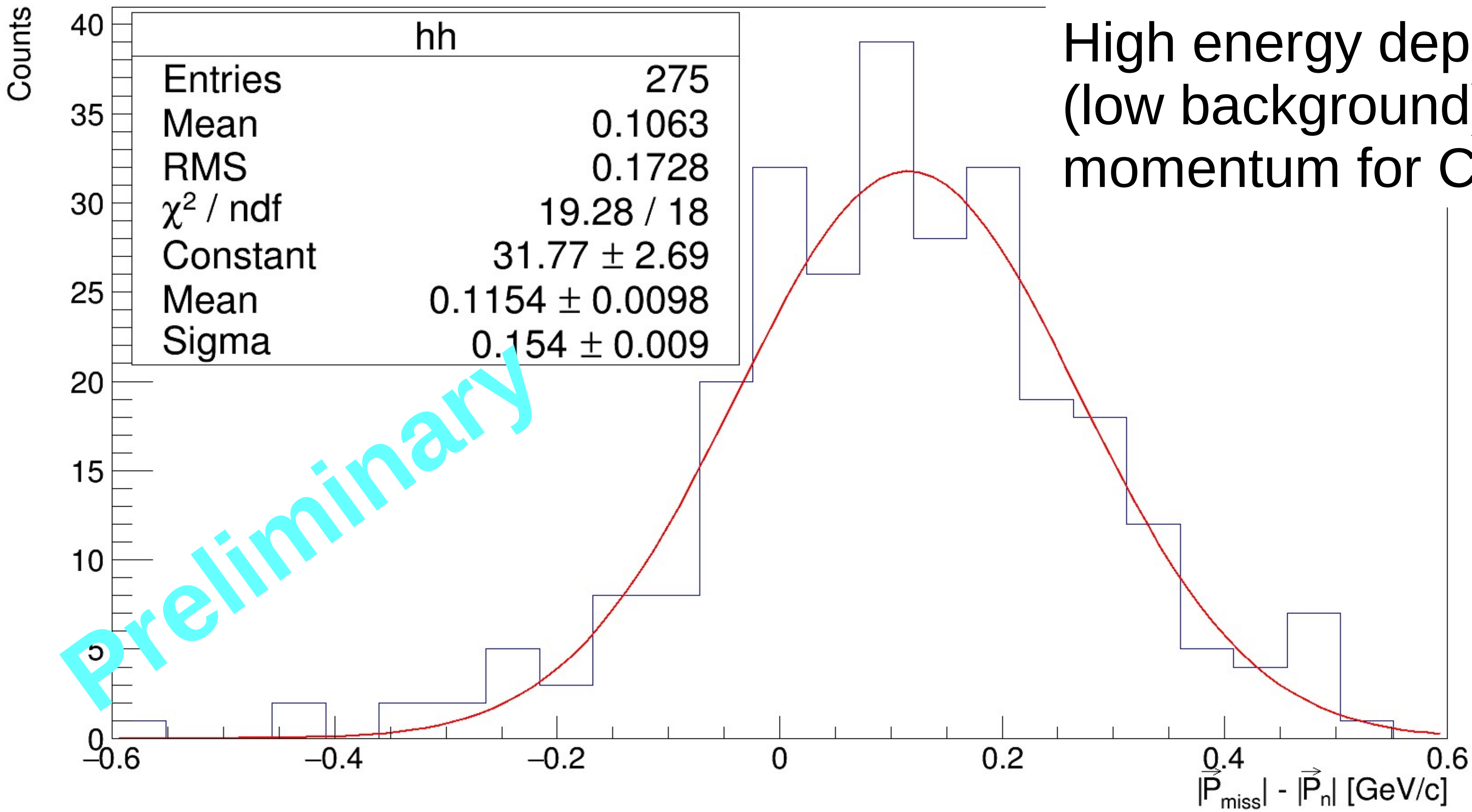
- Scintillator geometry: remove 5 cm from each side
- Time window: between 25 and 60 ns from reaction time.
- Energy deposition cut > 5 MeV

Energy deposition cut sensitivity



<u>Large energy deposit cut reduce BG and enable event by event analysis</u>

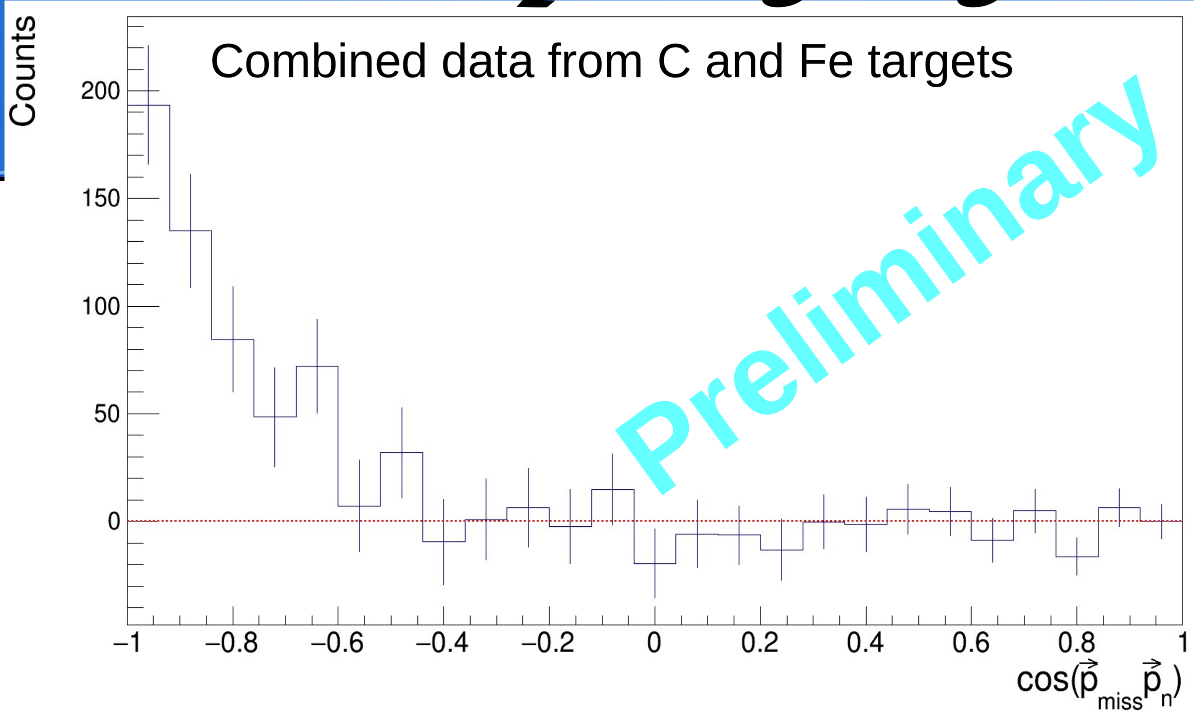
CM momentum example



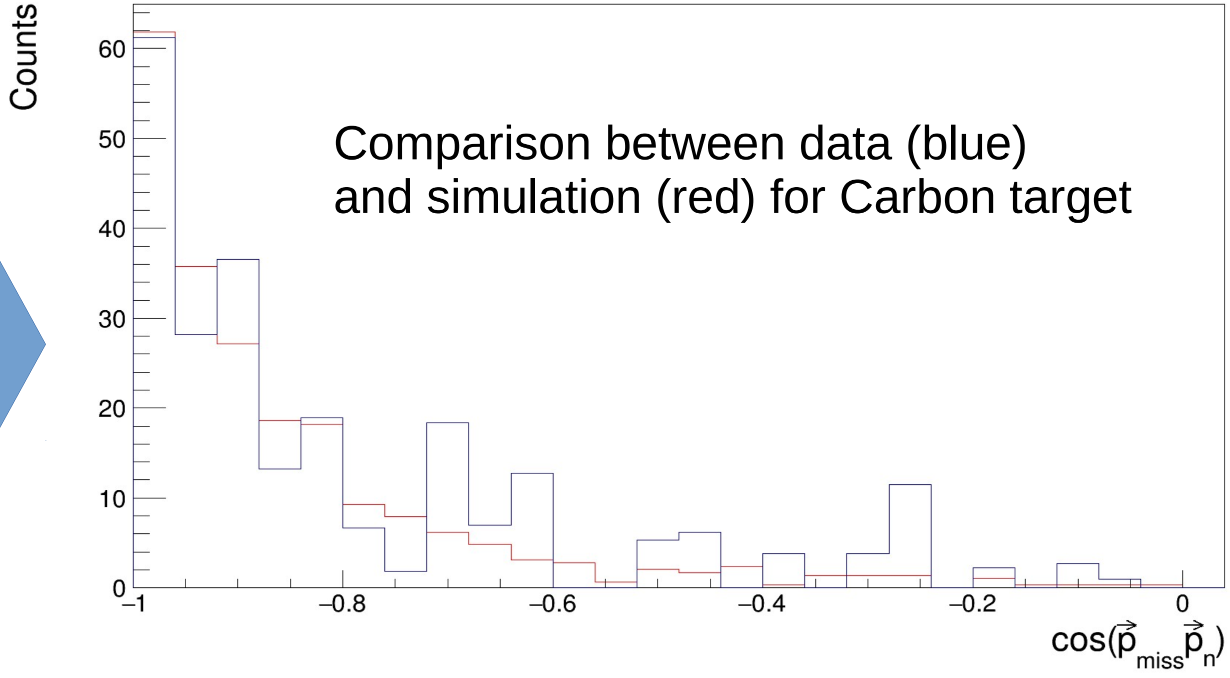
High energy deposition (low background) CM momentum for Carbon target

After sensitivity tests the CM momentum as a function of missing momentum will be analyzed

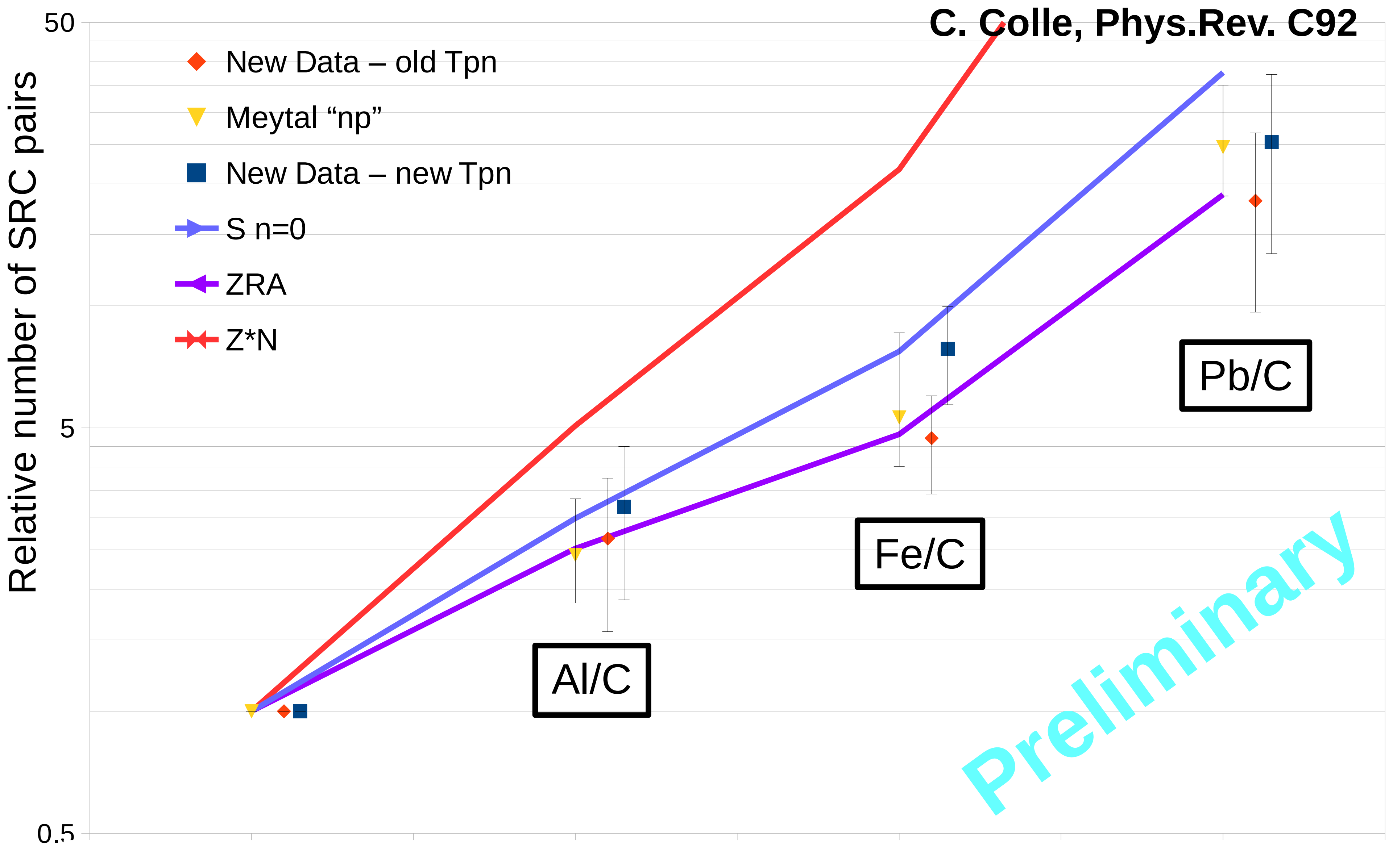
Opening angle example



Simulation is done by smearing (e,e'p) events with the known CM motion



A(e,e'pn) / C(e,e'pn)



C. Colle, Phys.Rev. C92
50
5
0.5
Relative number of SRC pairs
New Data – old Tpn
Meytal “np”
New Data – new Tpn
S n=0
ZRA
Z*N
Al/C
Fe/C
Pb/C
Preliminary

Outlook

1) Write a detailed analysis report to be reviewed
2) Finalize sensitivity and Fiducial cuts
3) Correct extracted A(e,e'pn)/C(e,e'pn) to
   single charge exchange (SCX).
4) Extract ratios as function of missing momentum.
5) Extract triple to double, (e,e'pn)/(e,e'p) ratios as function
   of missing momentum.
6) Extract CM momentum for different nuclei
   (high energy deposit cut).
7) Perform acceptance corrections for recoil neutron.