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

Data Mining Project

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CLAS Collaboration meeting

November 3, 2016

Outline

1) Motivation

2) Method of identifying neutrons (TOF counters)

3) Calibration with Deuteron

4) Next Steps

Short Range correlation

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

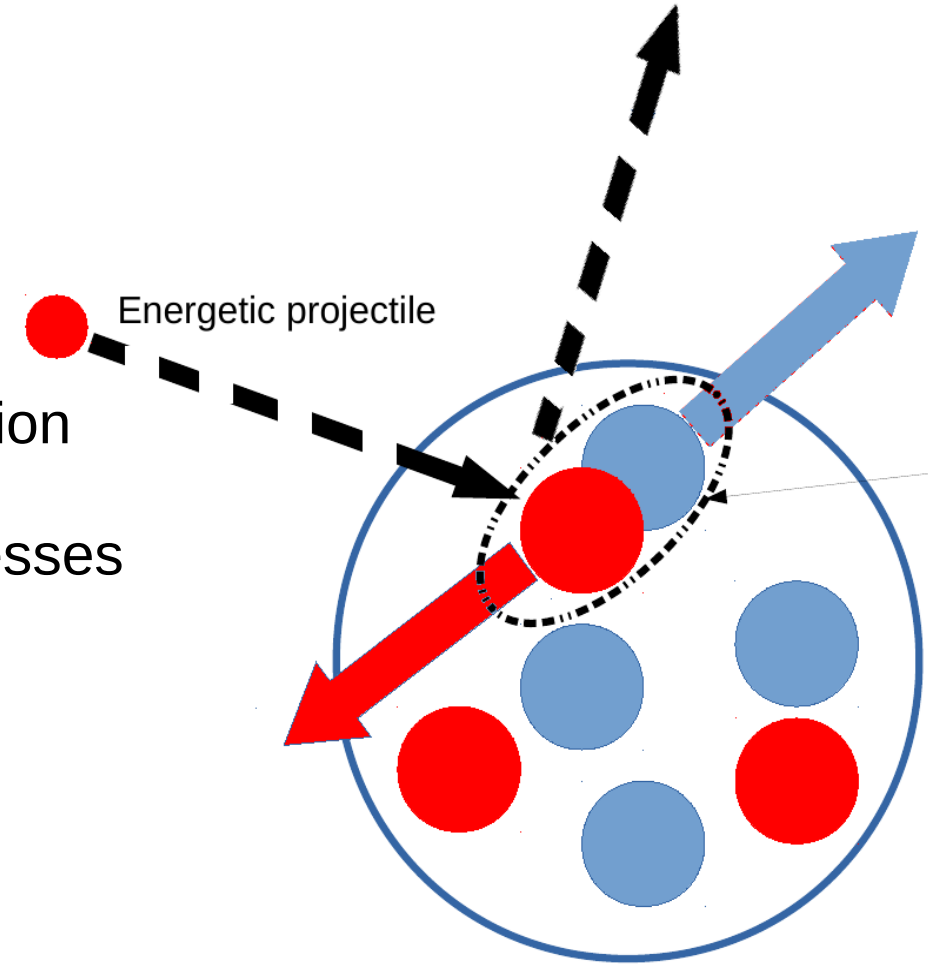
Why going to high missing momentum?

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

* Go above mean field region

* Reduce competing processes

* confine FSI between the SRC pairs



2N-SRC

$|\vec{p}_1|, |\vec{p}_2| > k_F$

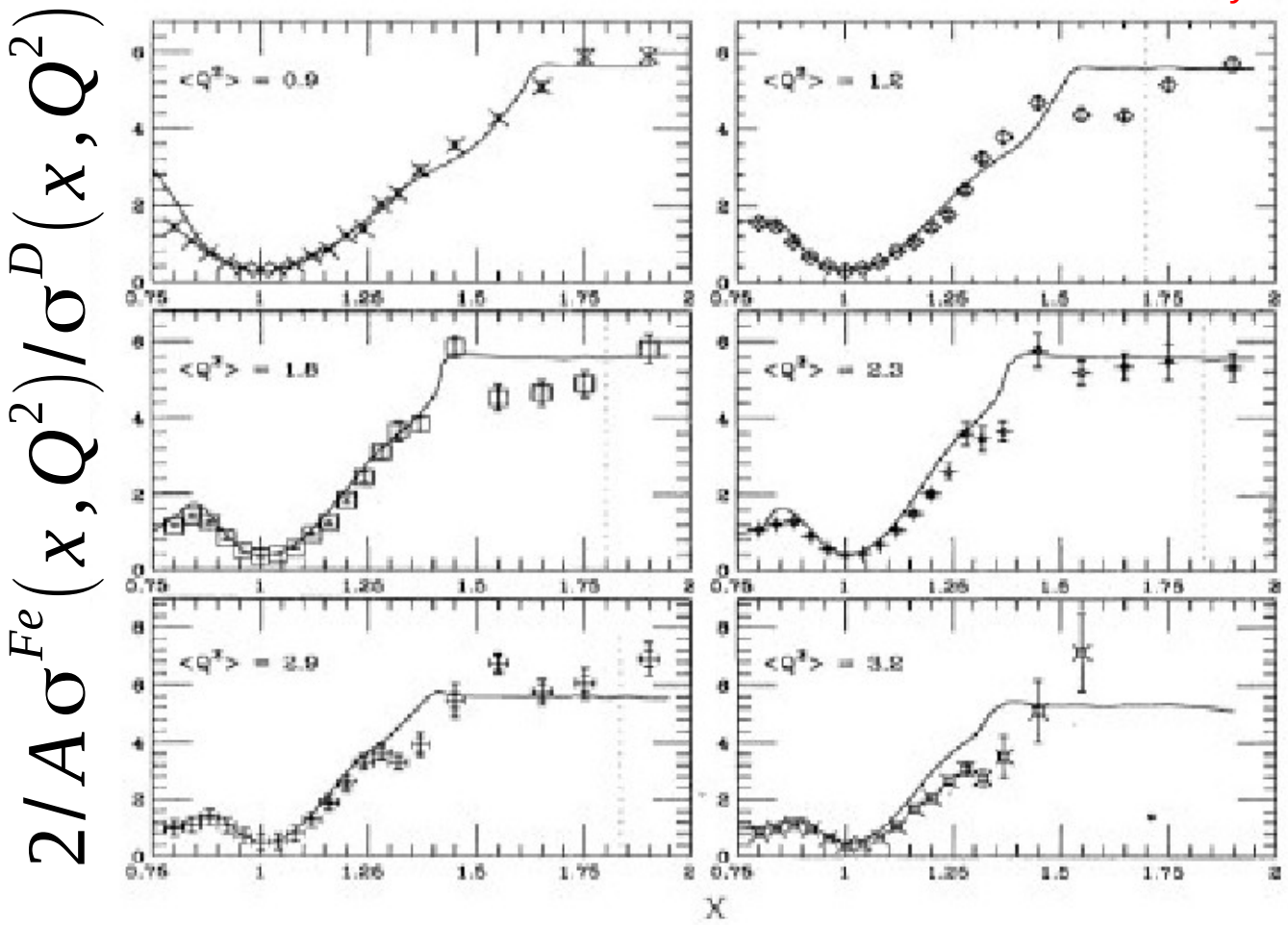
$|\vec{p}_1| \approx -|\vec{p}_2|$

Indication for SRC

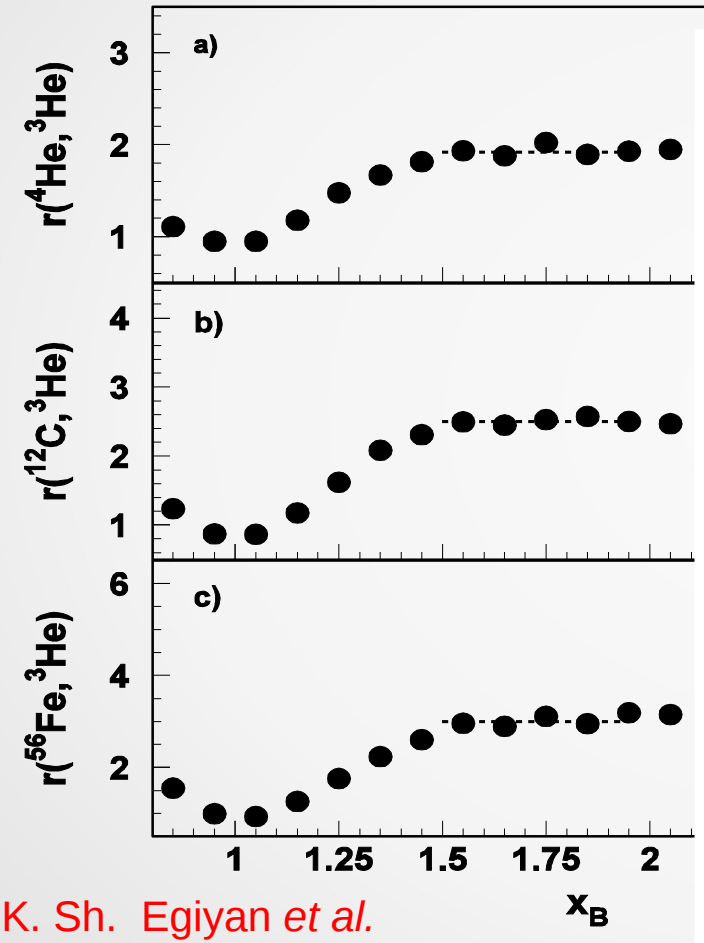
* Inclusive scattering at SLAC and
at JLAB, measured scaling effect at Bjorken X

Phys. Rev. Lett **59**,427(1987)

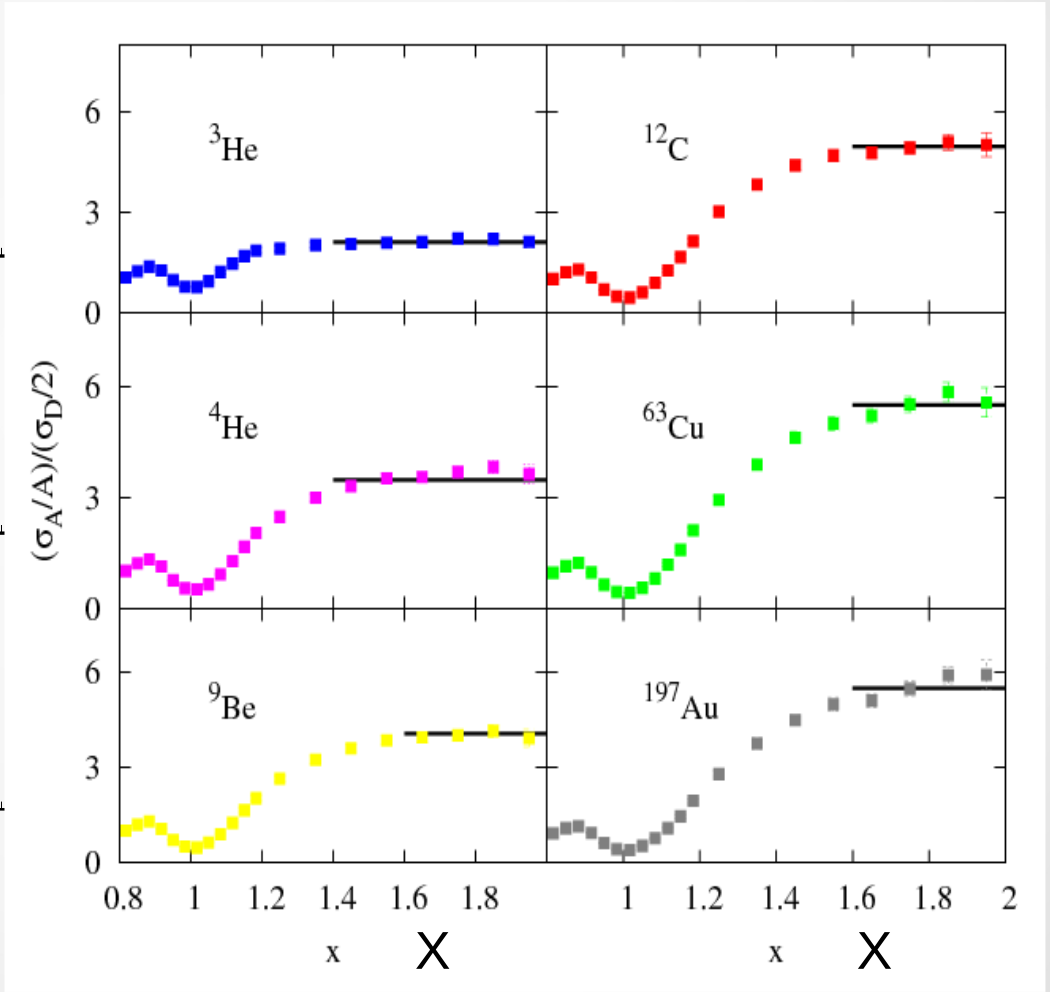
Phys. Rev. C48, 2451(1993)



Inclusive Scattering



K. Sh. Egiyan *et al.*
Phys. Rev. C **68**, 014313 (2003)



N. Fomin *et al.*,
Phys. Rev. Lett. **108**, 092502 (2012)

K. Sh. Egiyan *et al.*
Phys. Rev. Lett. **96**, 082501 (2006)

Exclusive measurements

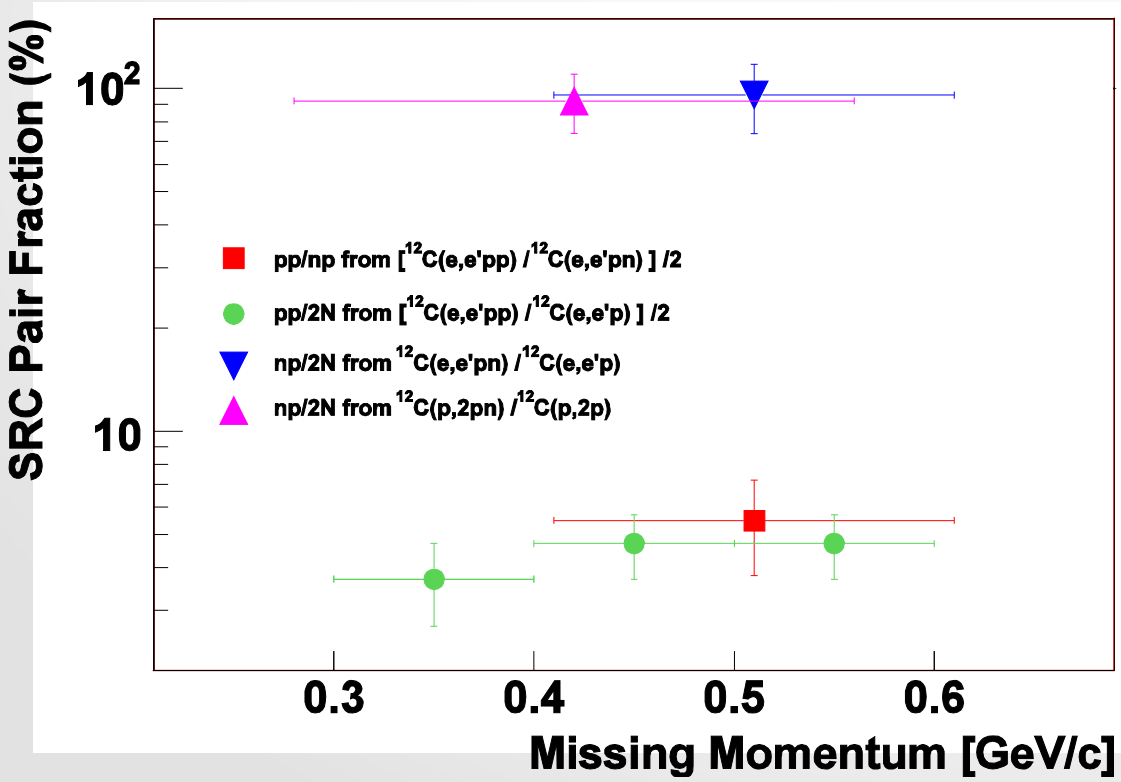
Direct measurement of 2N-SRC done using

BNL: ^{12}C(p,2pn)

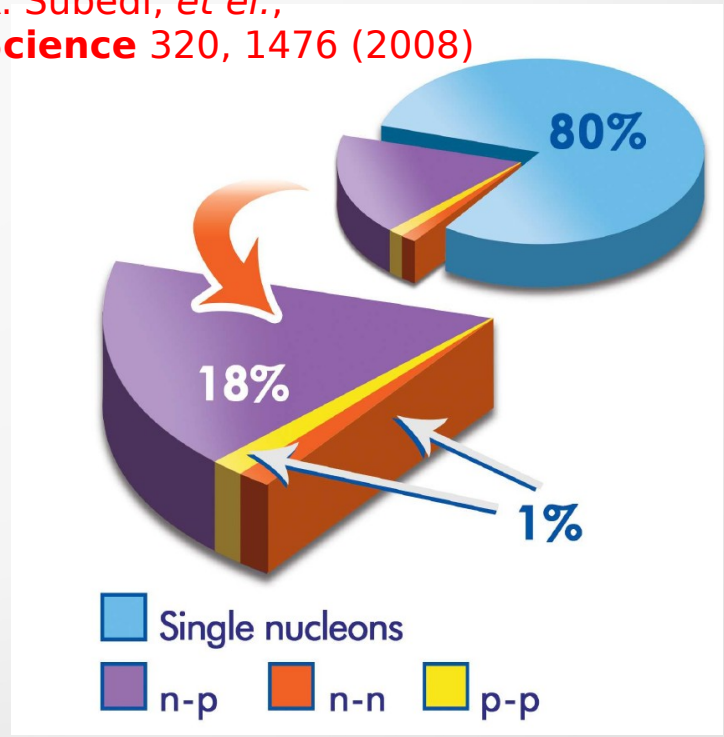
Jlab (Hall A): C(e,e'pN)

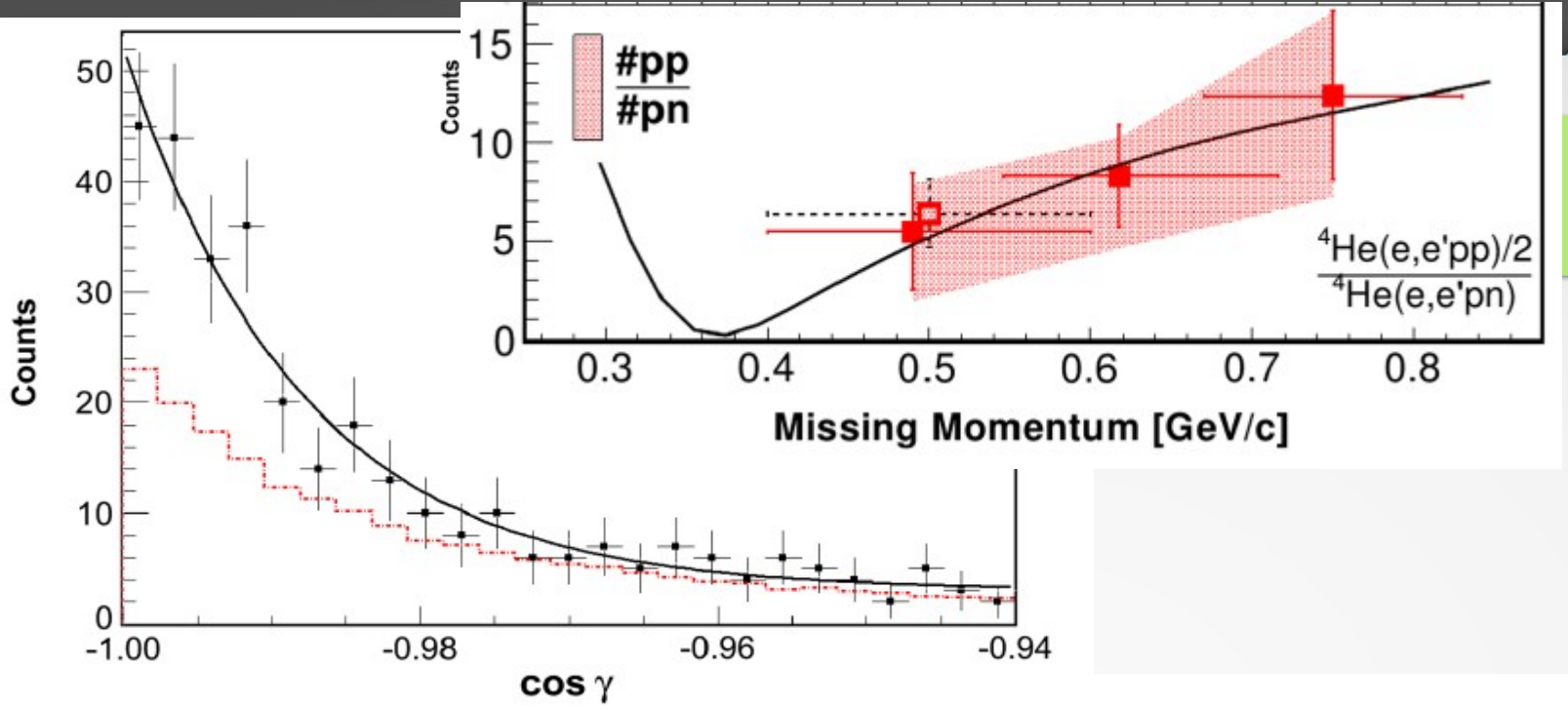
Jlab (Hall A): He(e,e'pN)

Jlab (CLAS): A(e,e'pp) (C, Al, Fe, Pb)

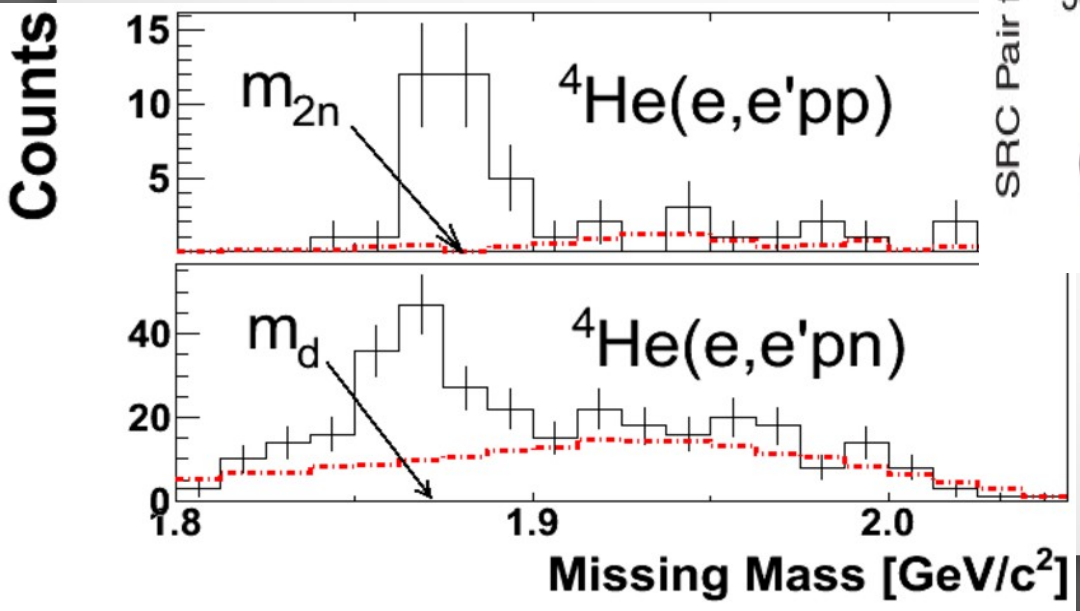


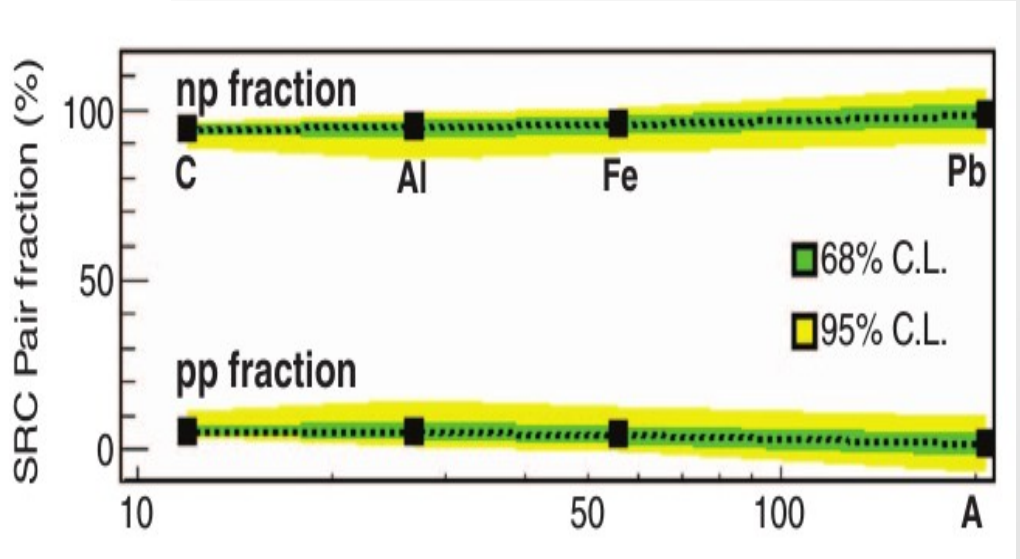
R. Subedi, *et el.*,
Science 320, 1476 (2008)





I. Korover
PhysRevLett.**113**, 022501 (2014)





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

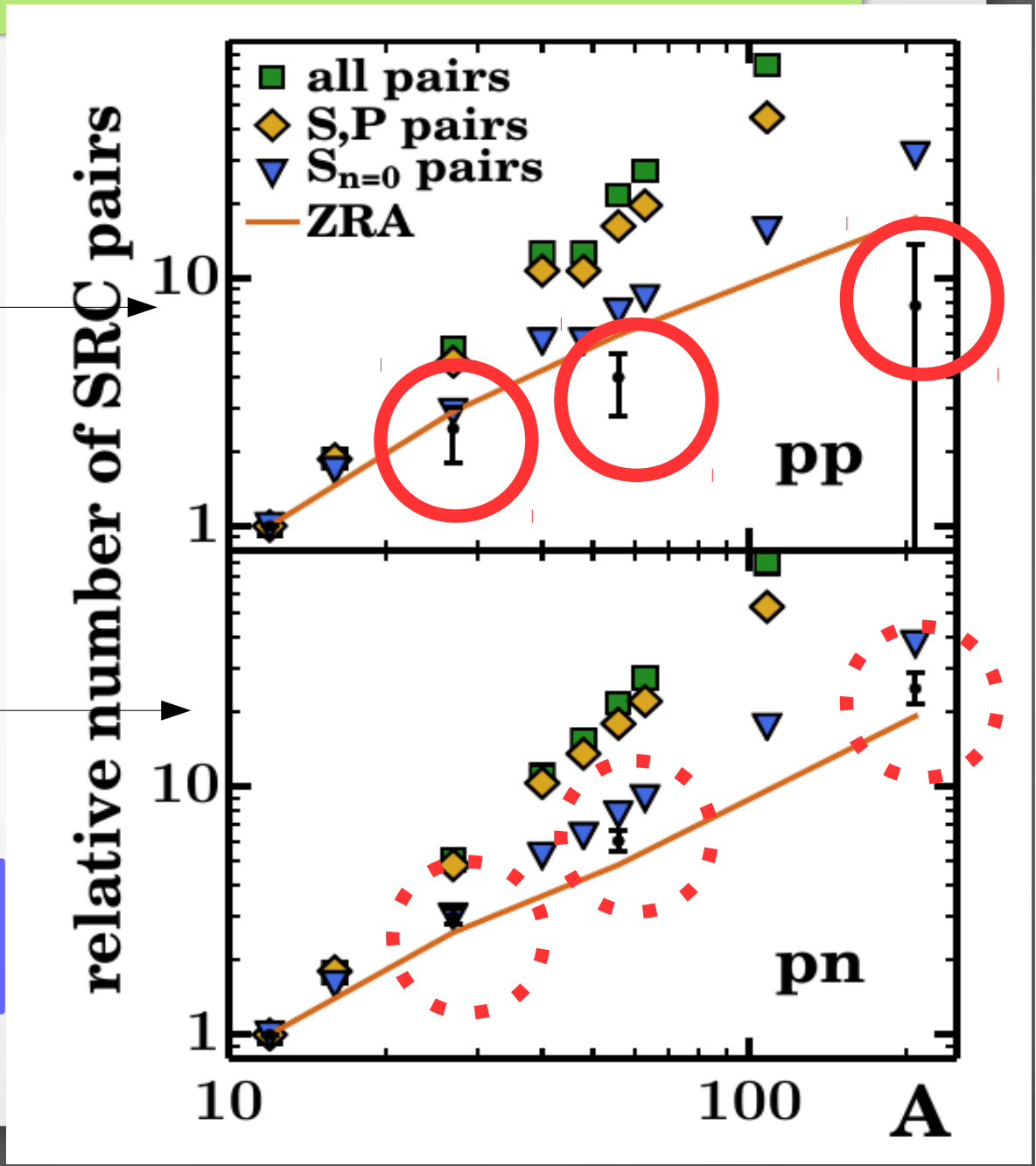
A(e,e'pN) analysis done on eg2a run period

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)

Use of eg2a run period to measure A(e,e'pn).

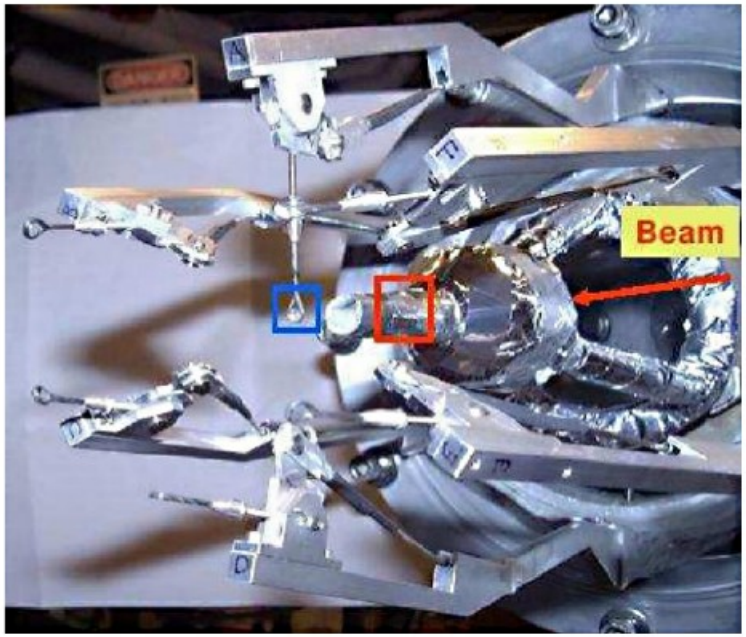
Advantages:

CLAS: open trigger

Nuclei, from light 12C up to 208Pb
Allow to study the np fraction as function of A

Existence of liquid deuterium target
Measurement of neutron detection efficiency.

Large angular coverage
(Compared to previous experiments)



Challenges:

Low neutron detection efficiency of TOF counters

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.

Information on hits in TOF counters:

Sector: Number of the sector of interest (from 1 to 6)

Id: Paddle number in the sector (from 1 up to 48)

Energy: Energy deposit in MeVee

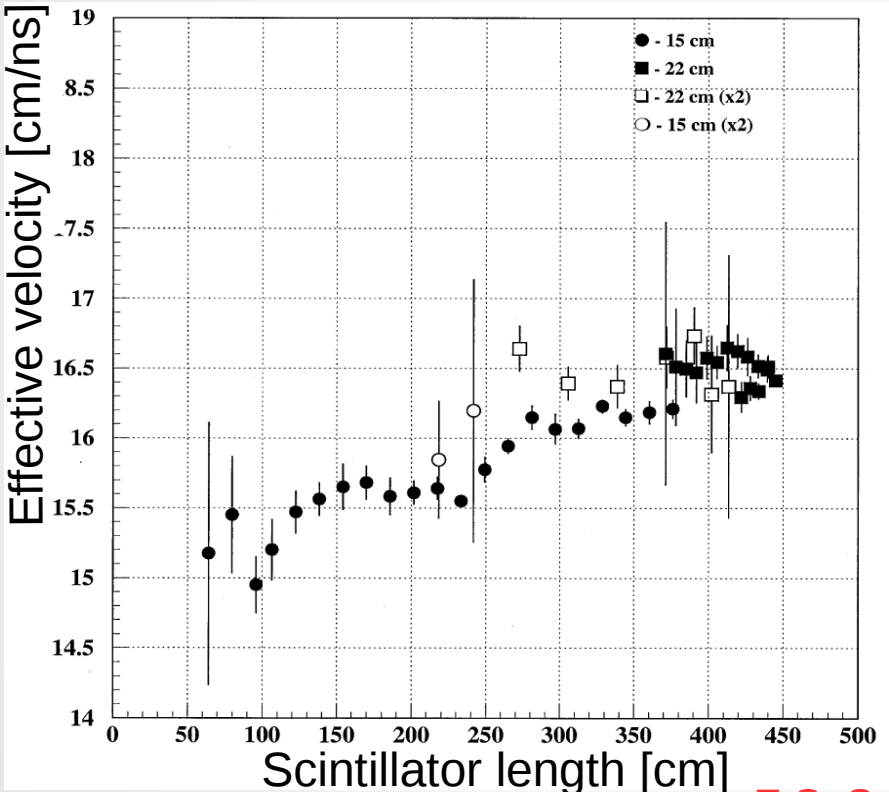
Position: Hit position in the sector coordinate system.

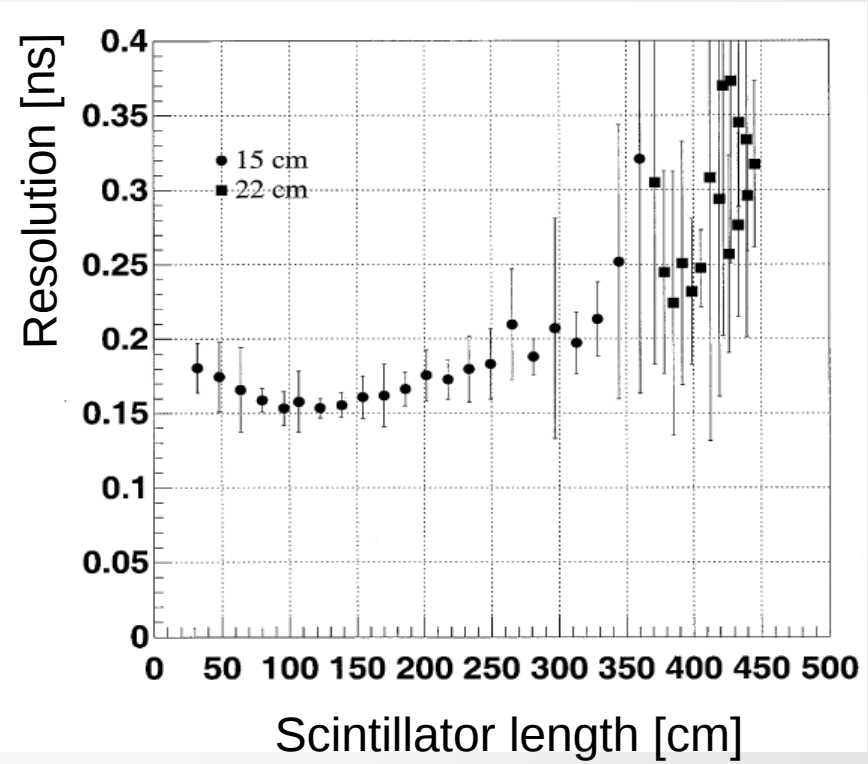
Time: Timing information

(For absolute time the start time is subtracted)

Cuts for Veto:

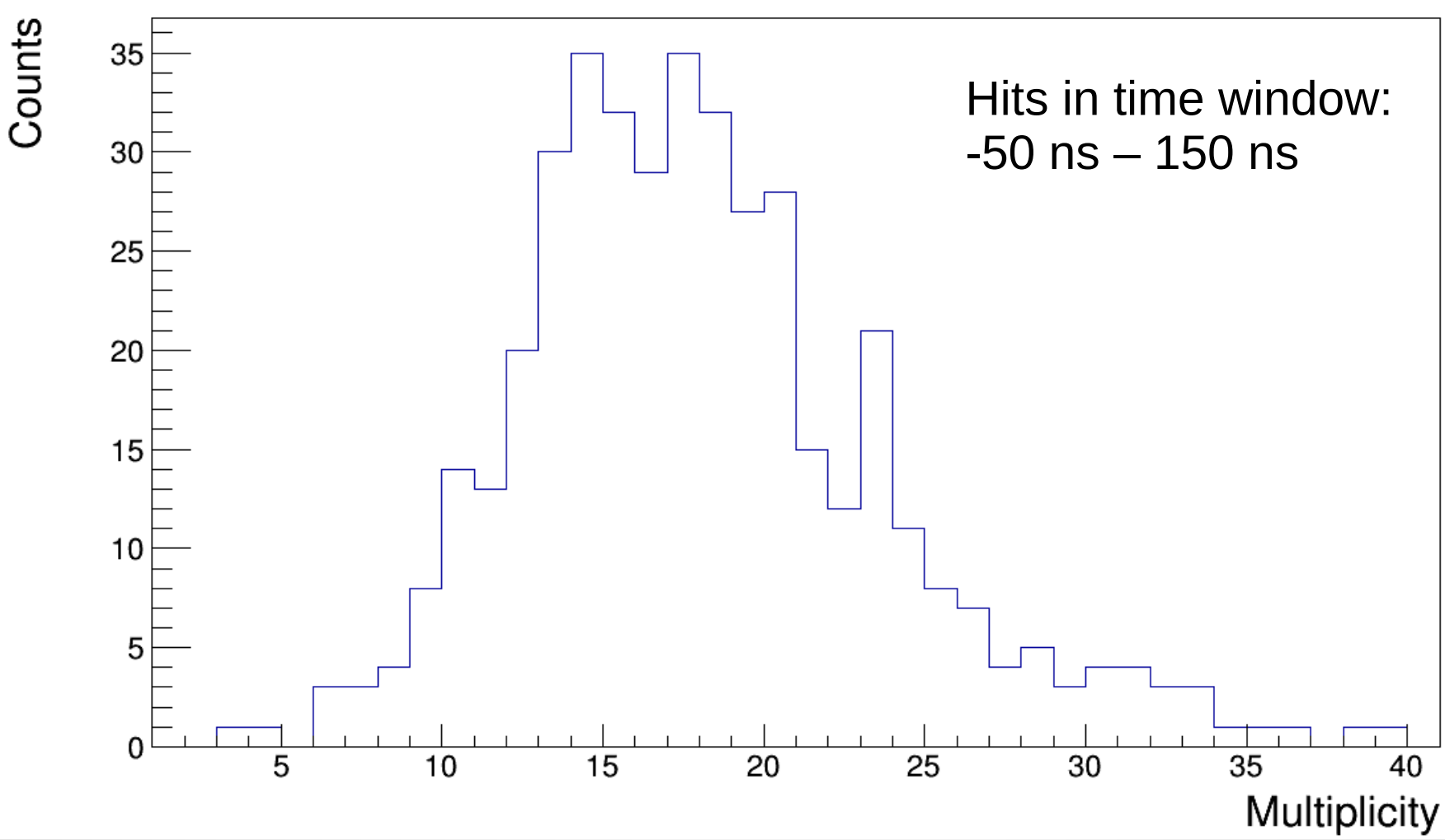
1) Neutral hits are defined by requiring no tracks within ±10 cm.





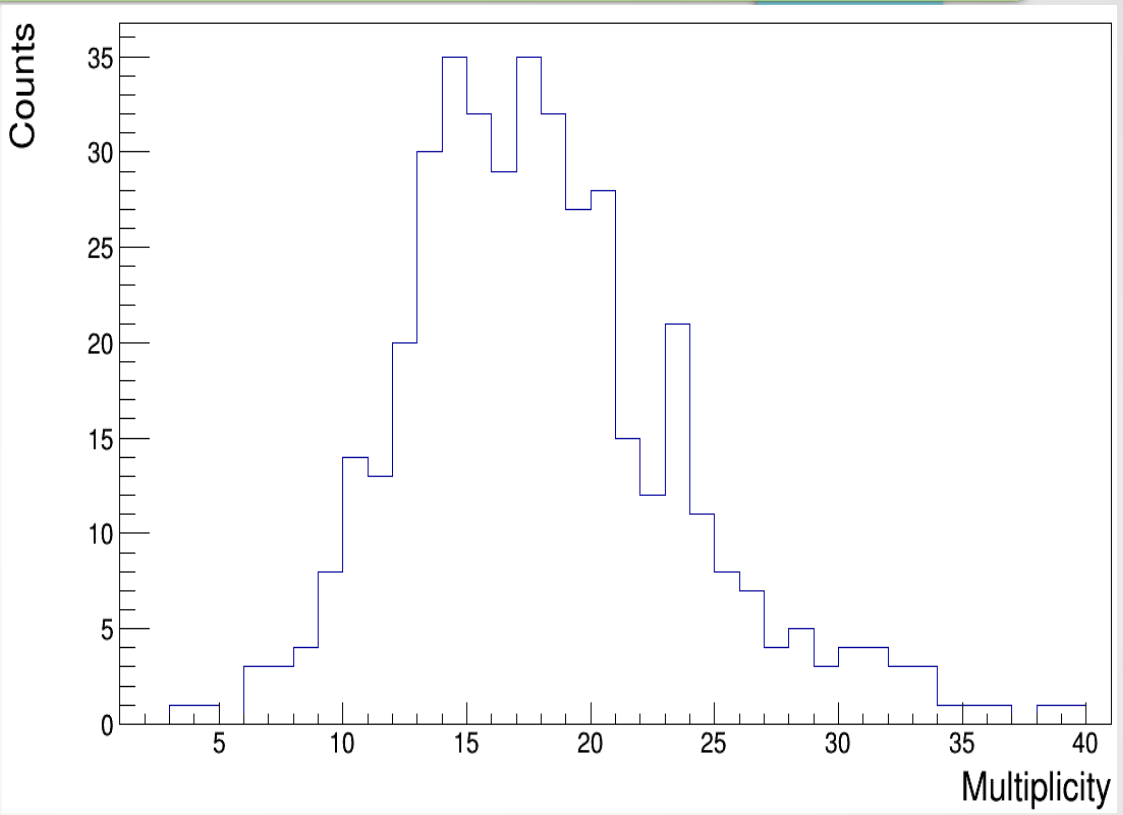
E.S. Smith et al.
Nucl. Instr. Methd. In Phys. Research A **432**, 265 (1999)

“Neutral” hits multiplicity:



Most “neutral” hits are gamma and unreconstructed charged particles.

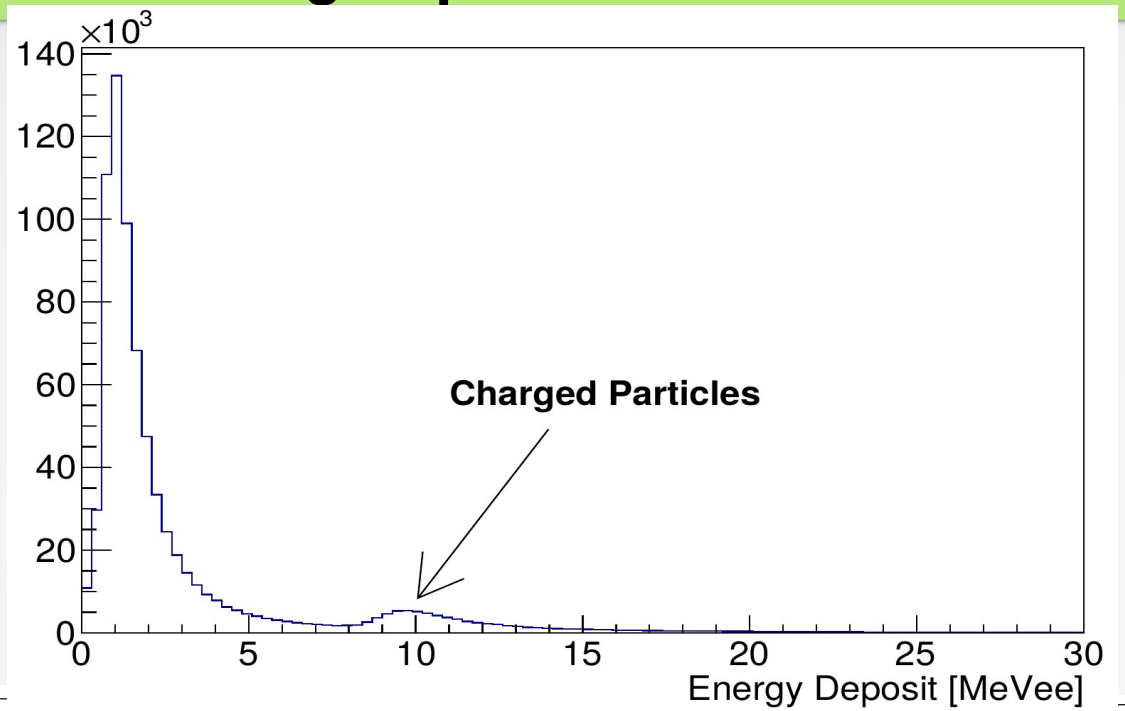
We aim to study neutrons
in momentum range:
300 – 700 MeV/c

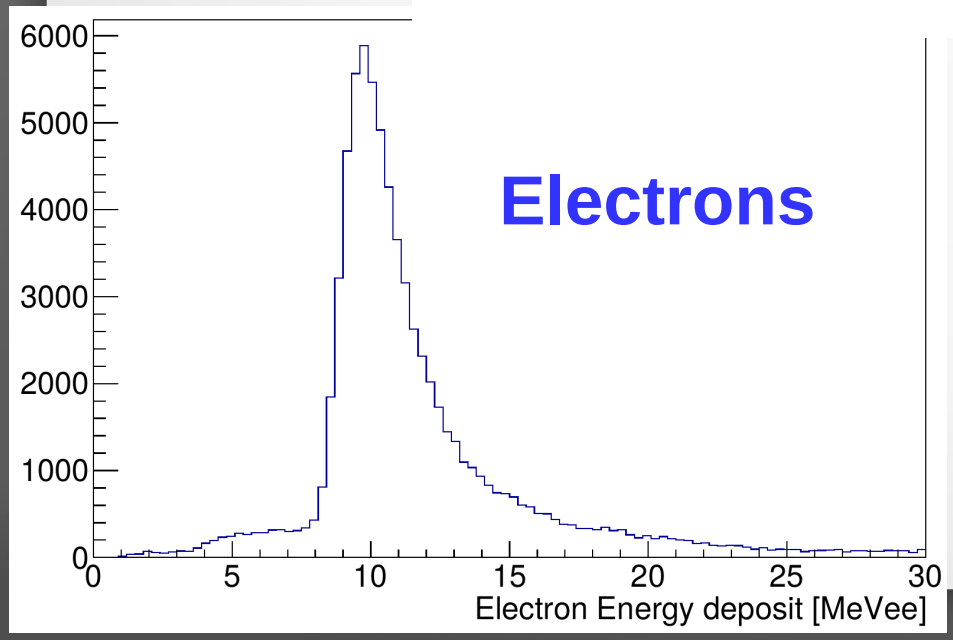


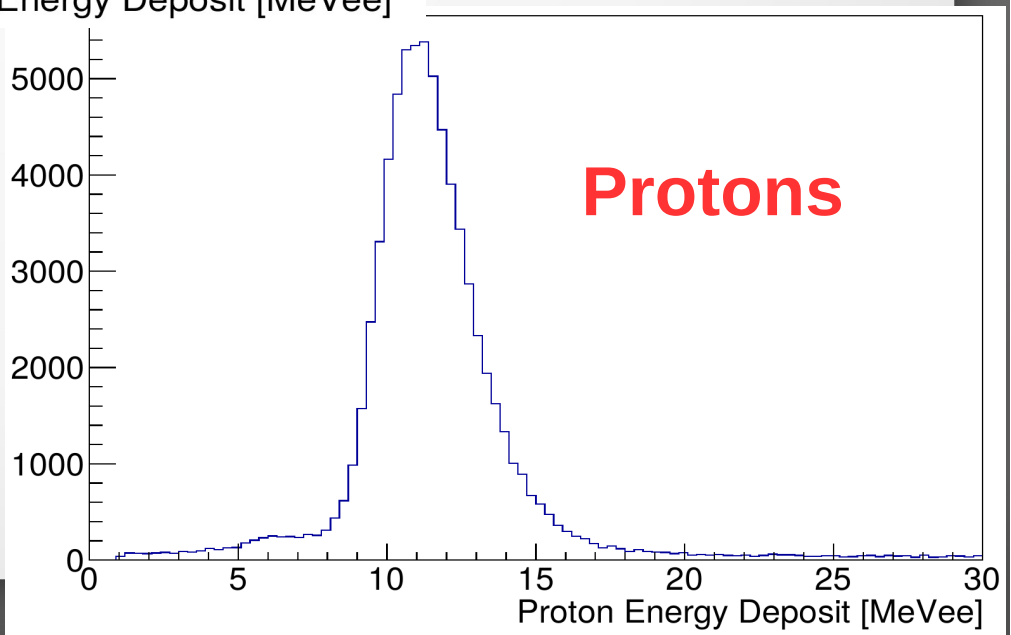
Relevant time window 30 – 70 ns

~1.05 hits per event in this time window

Contamination of "neutrals" with unreconstructed charged particles





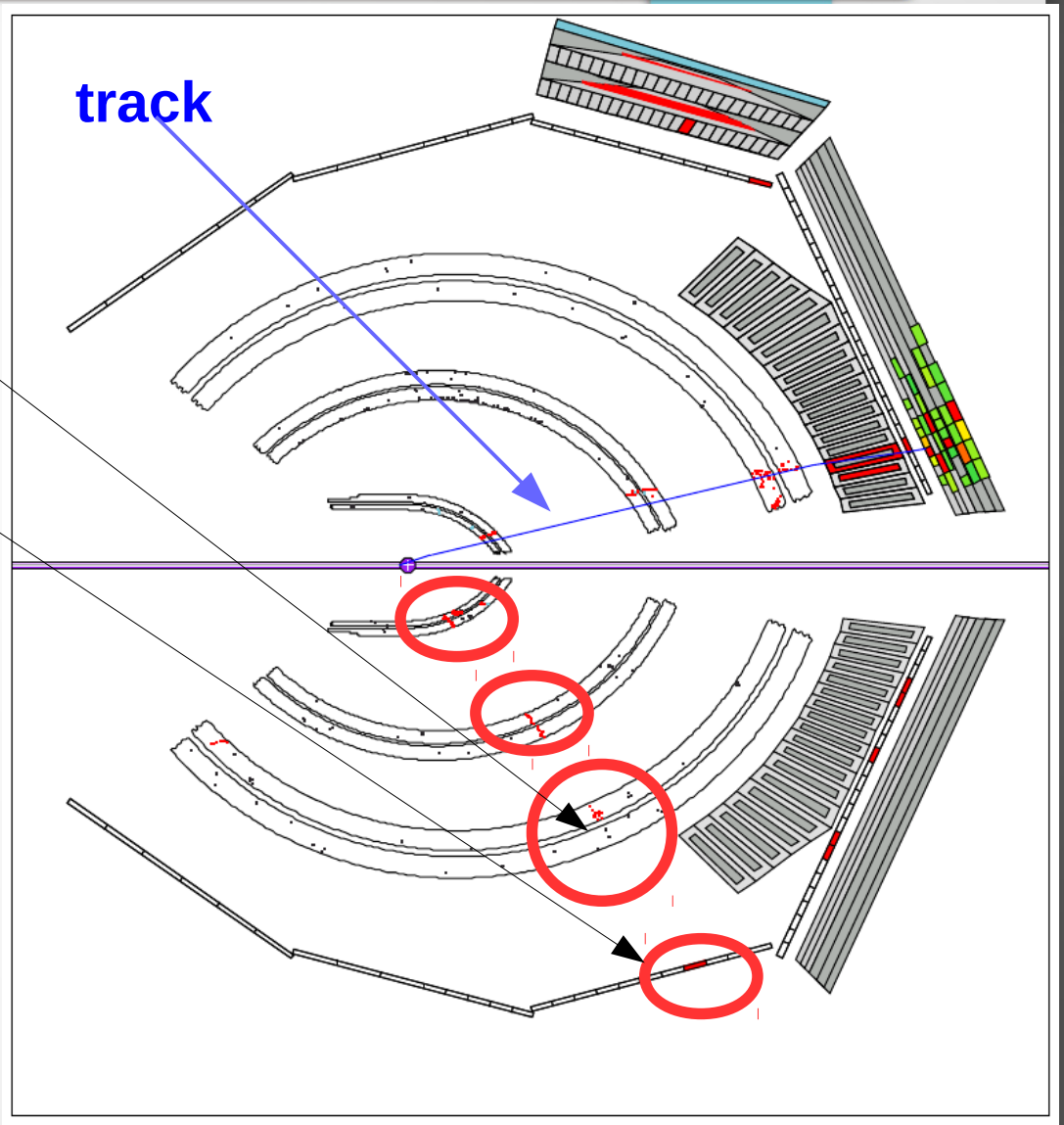


Event display Program – CED

From Gn analysis
CLAS analysis Note 2008-103

No hit in the chamber

Candidate for “neutron”

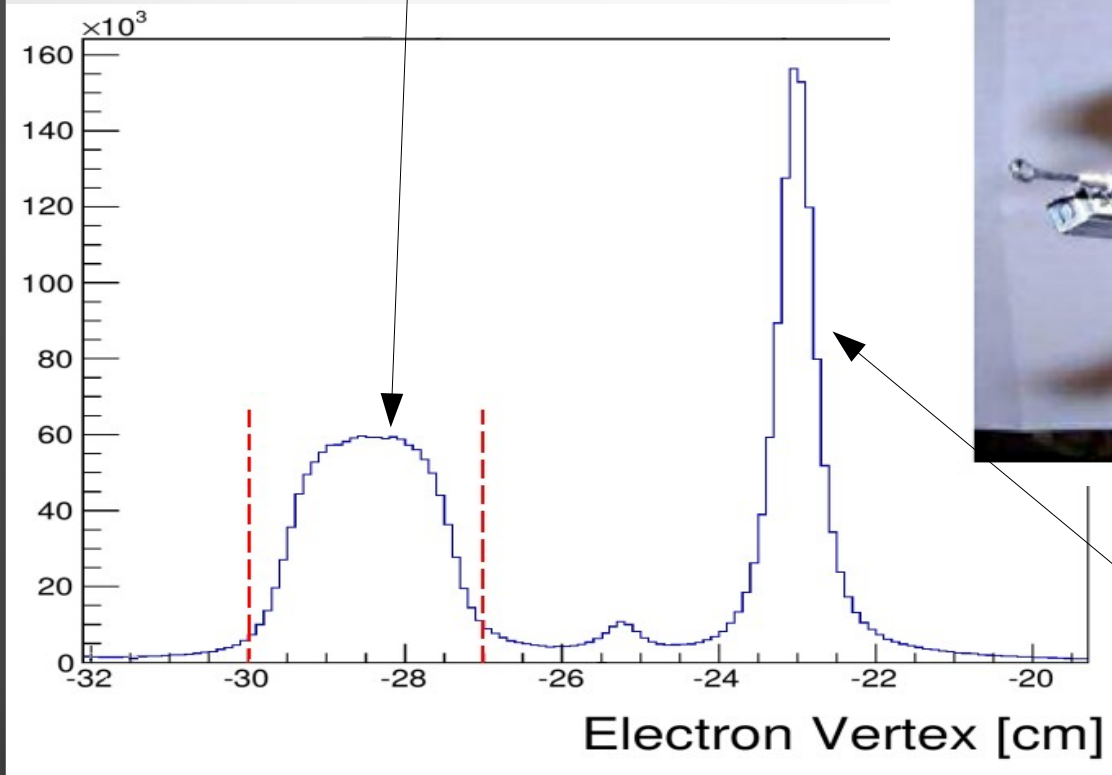


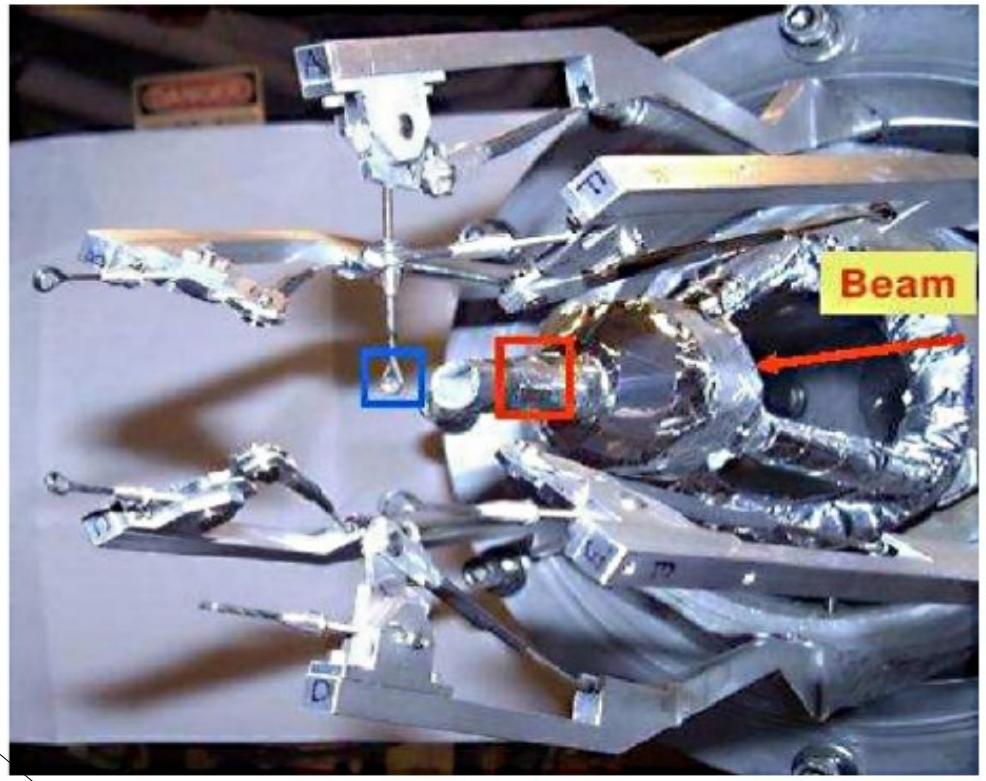
Clearly track due to charged particles.

However, before we include wire data for Veto algorithm improvement, we continue to see how far we can get

Neutron Calibration with deuteron

Liquid deuterium

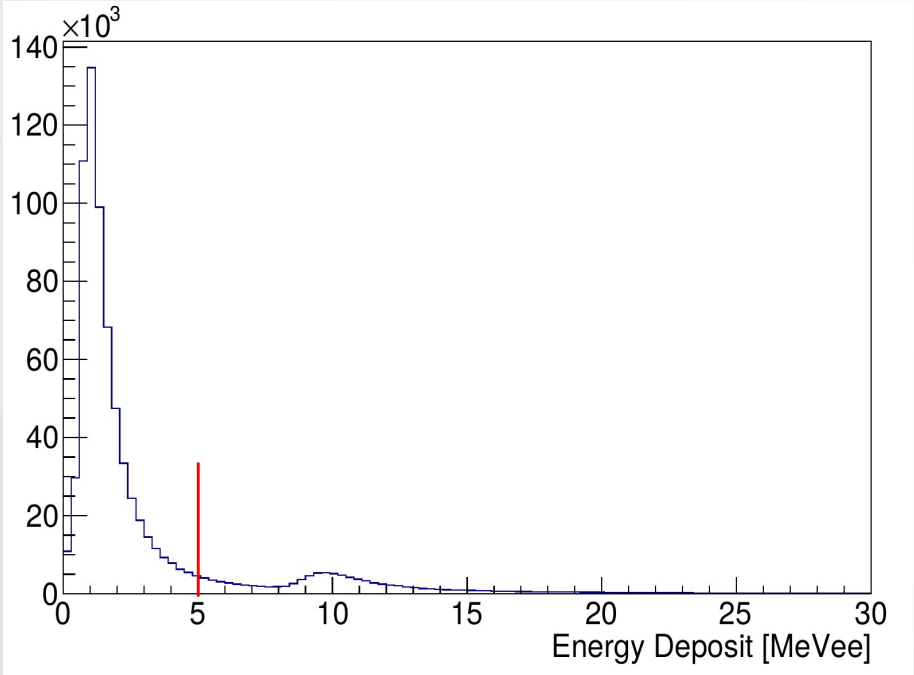




Solid Target

Deuteron Analysis

Energy deposit > 5 MeVee



Eliminate contribution from
low energy events
(low energy photon background)

Compare to the previous analysis
done in CLAS

Absolute Time – Neutron Momentum

The energy of the neutrons can be determined by the Time-of-flight measurement.

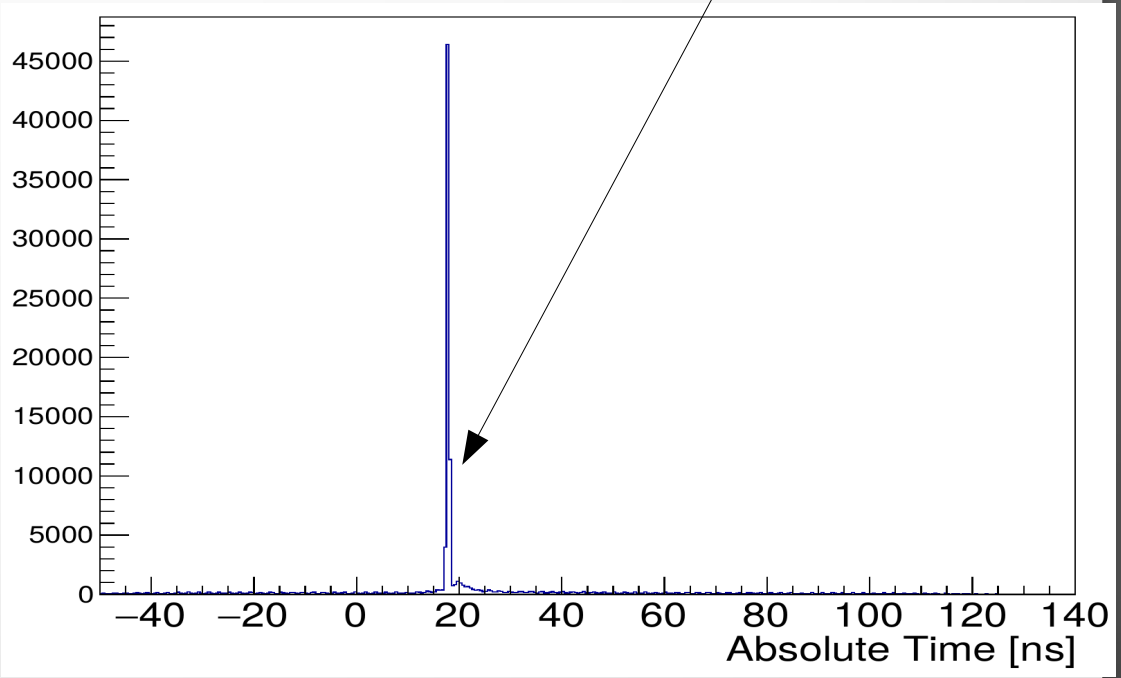
Translation from TOF to momentum

$$p_n = \frac{m}{\sqrt{\left(\frac{0.3 \cdot t}{d}\right)^2 - 1}}$$

Distance from Vertex

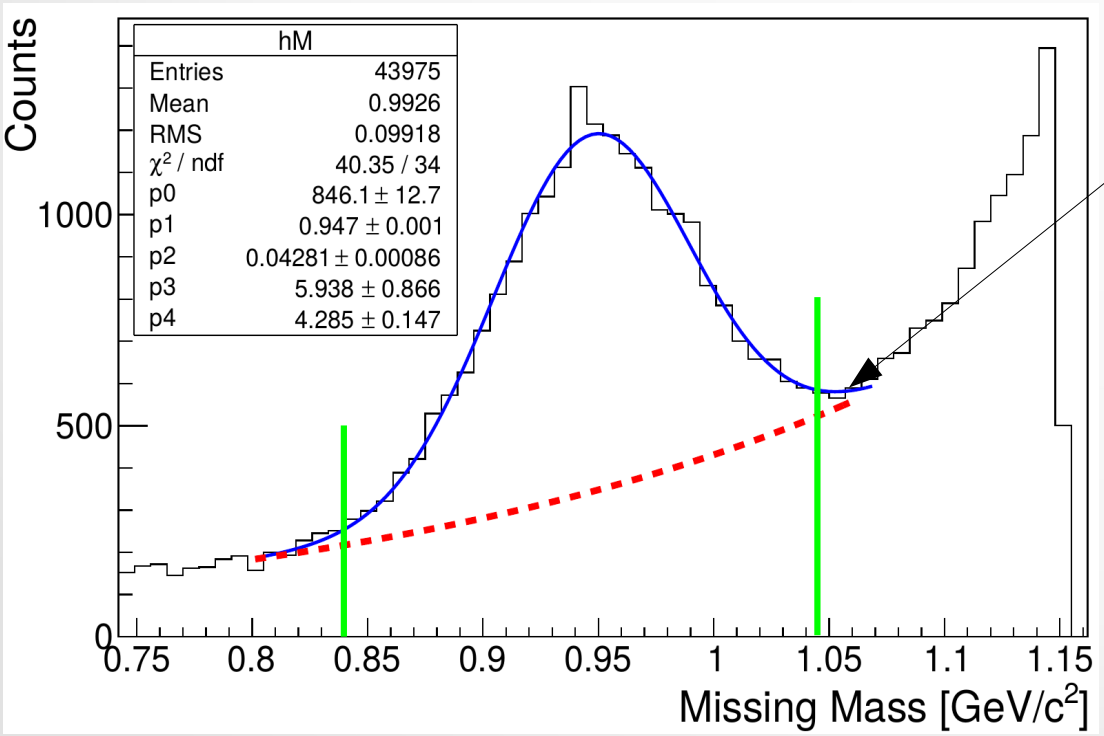
Time from reaction

Expected arrival time for Photons



Missing Mass of d(e,e'p)

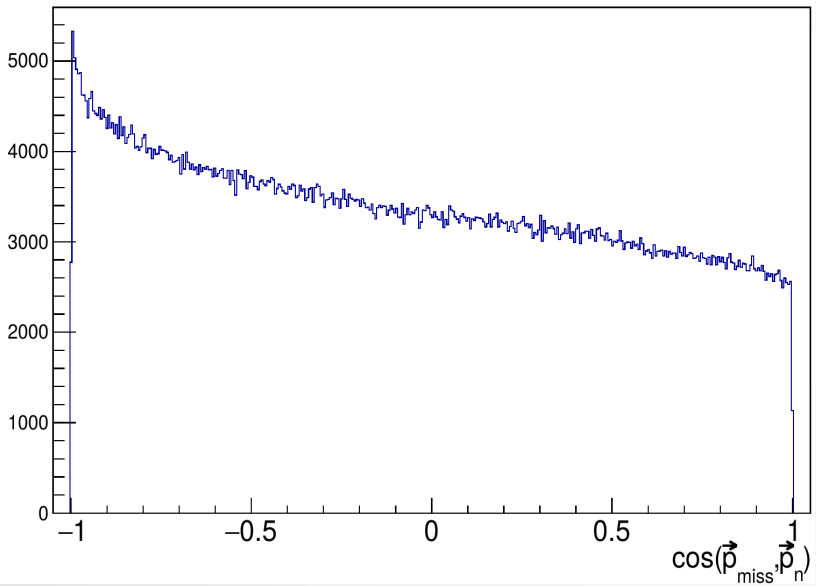
Missing Mass for d(e,e'p)
(Double coincidence events)



Large background

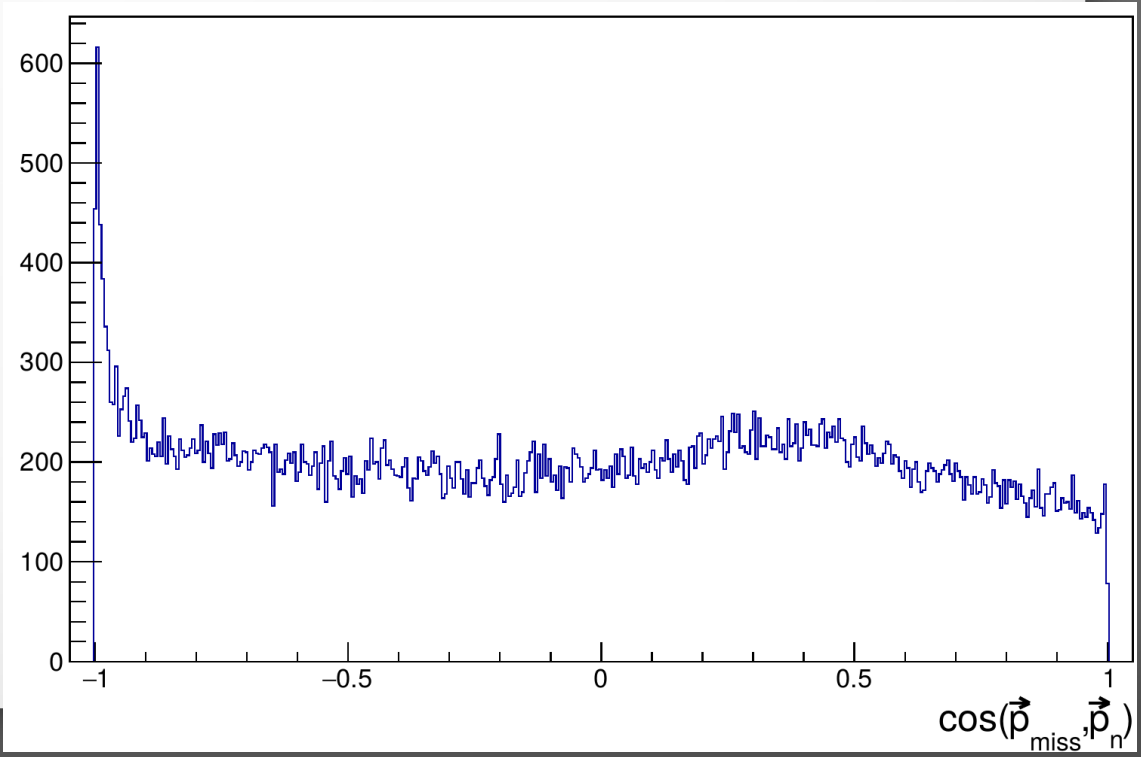
Opening Angle

Opening angle between measured neutral hit and expected neutron
From d(e,e'pn) reaction.

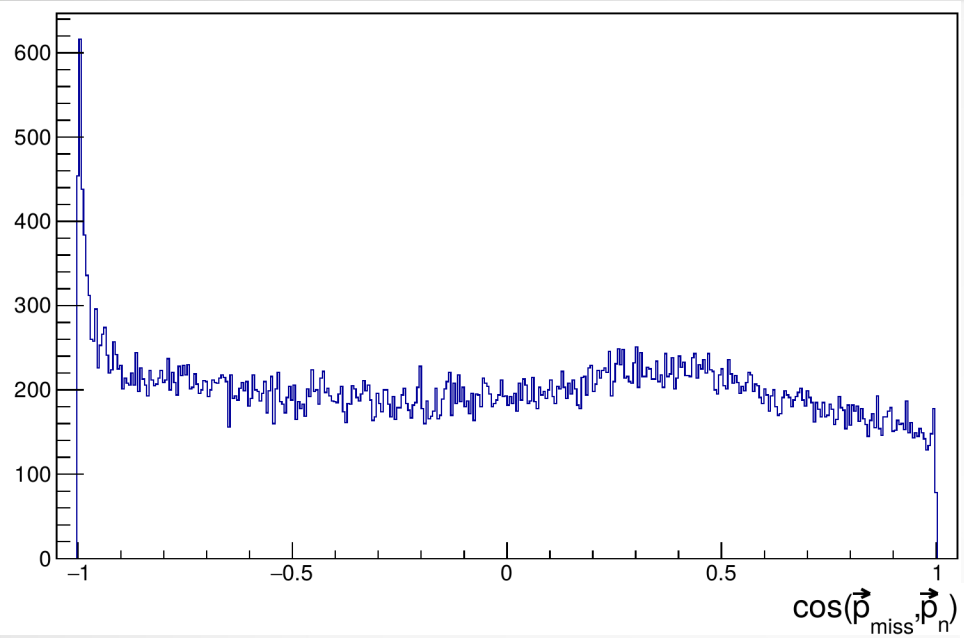


Energy deposit > 5 MeVee

Missing mass

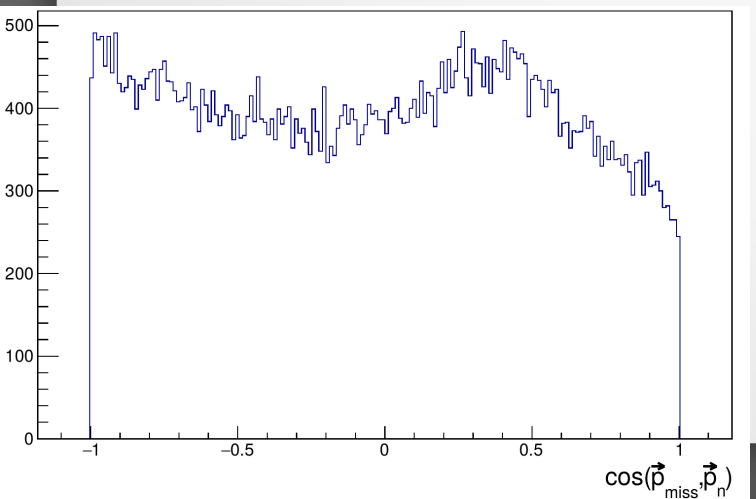


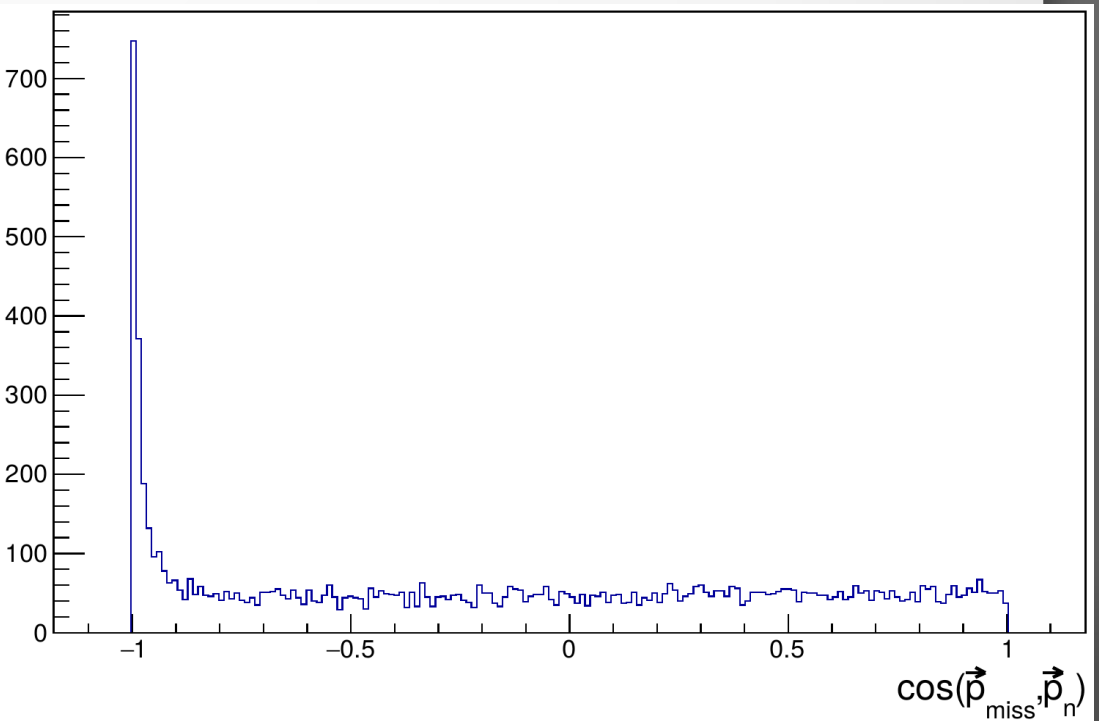
Opening angle



Energy deposit
Missing Mass
Time Window
30 – 65 ns

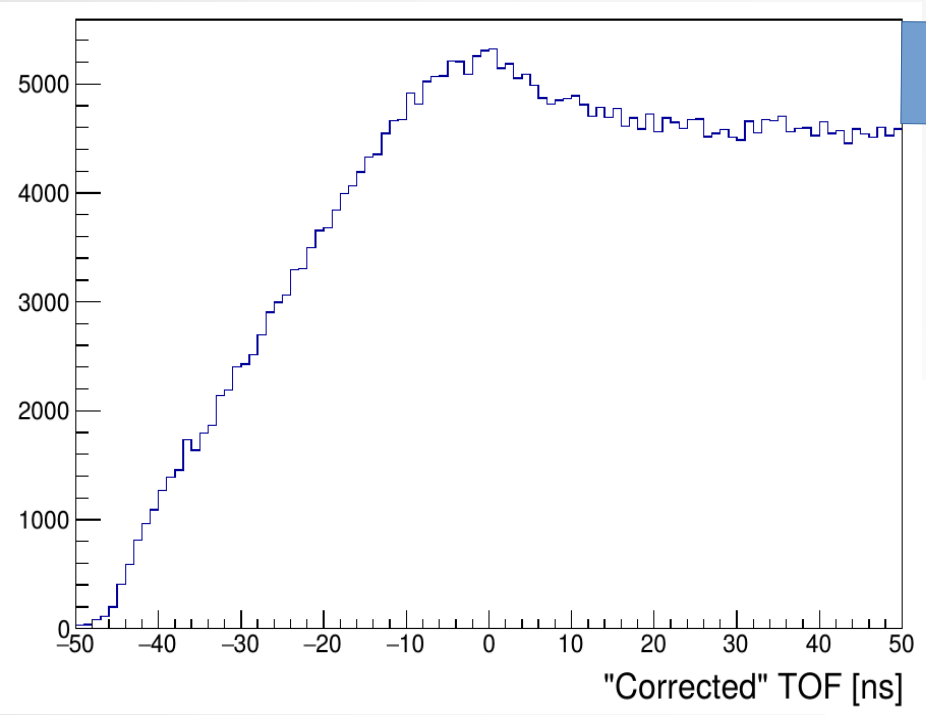
Out of time





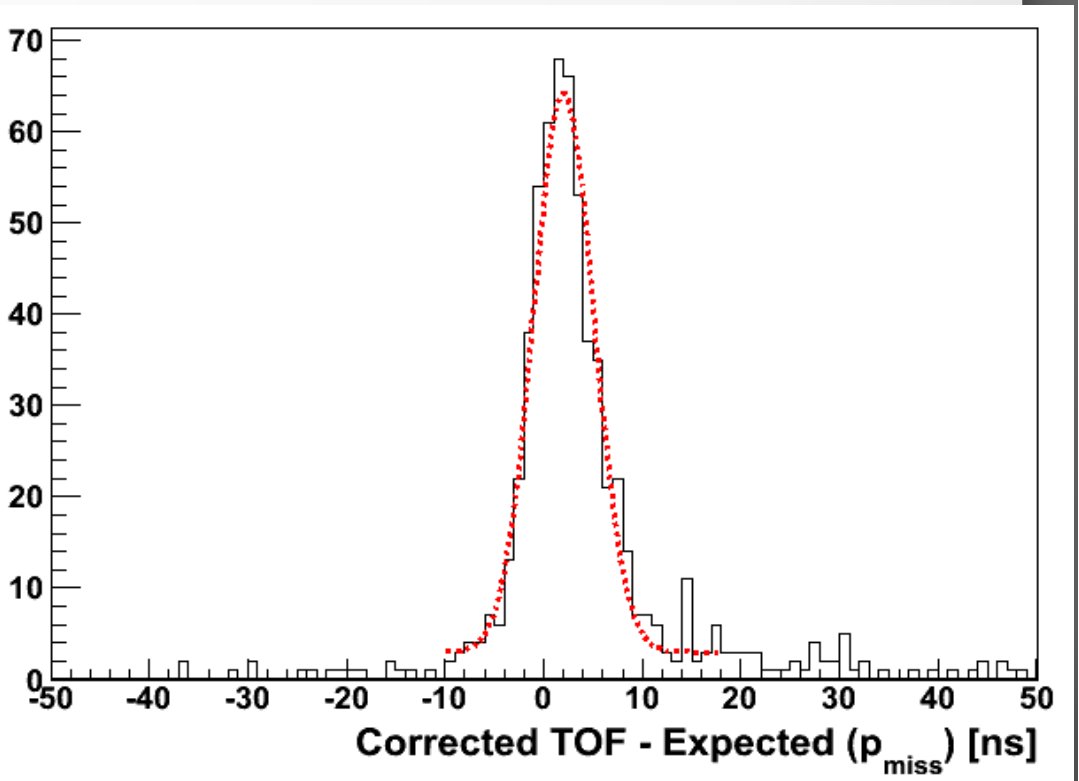
Corrected TOF

"Corrected" TOF



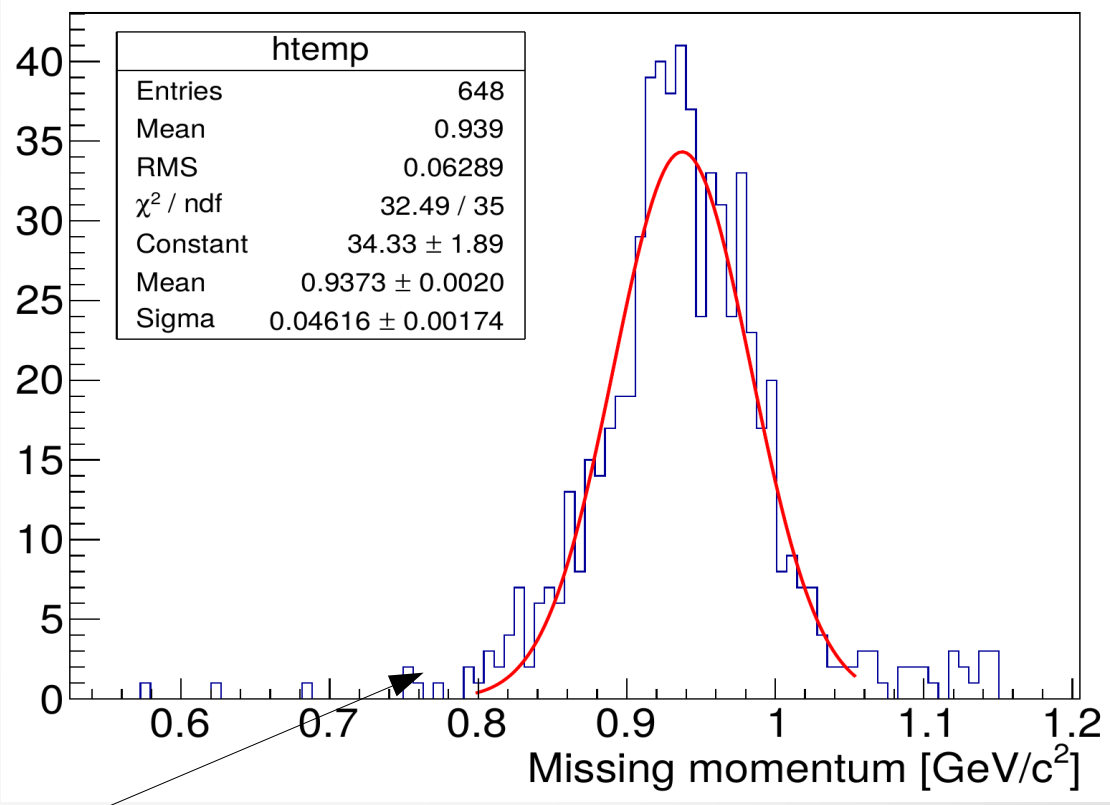
With Cuts:

Energy deposit
Missing mass
Time Window
Opening angle



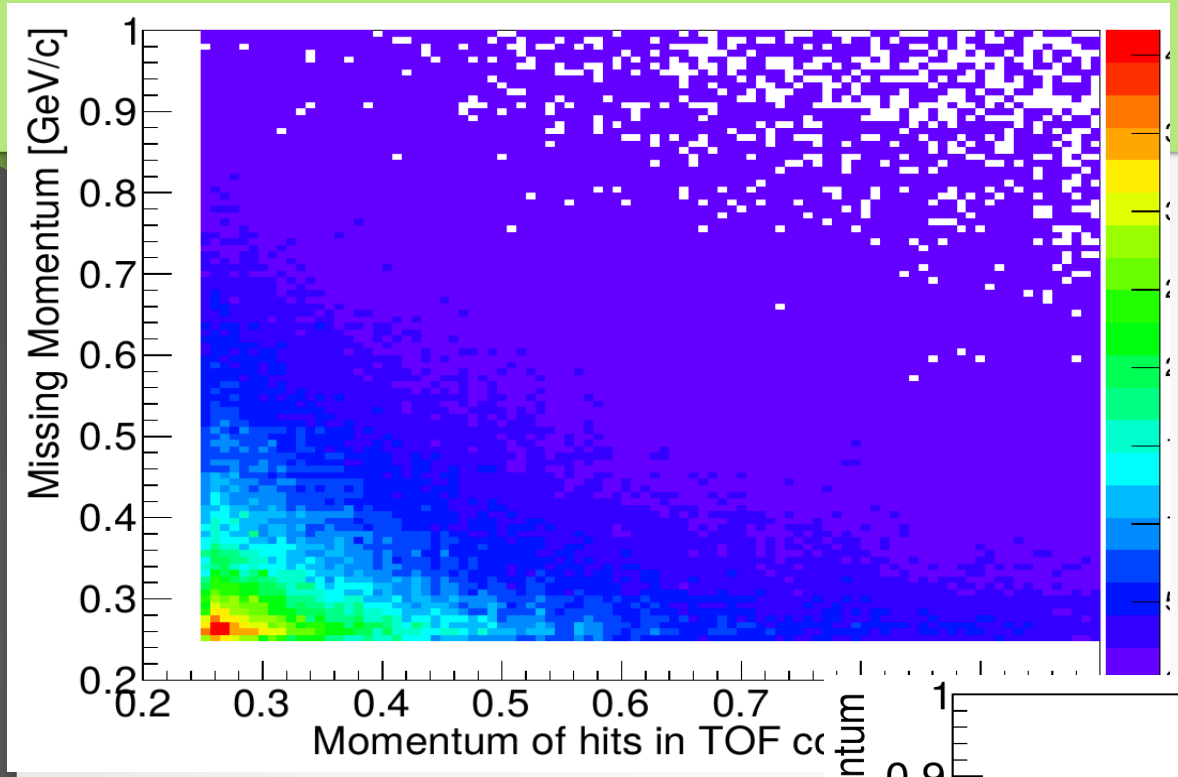
Missing Mass for d(e,e'p) + neutral hit

Missing Mass for d(e,e'p) + neutron hit

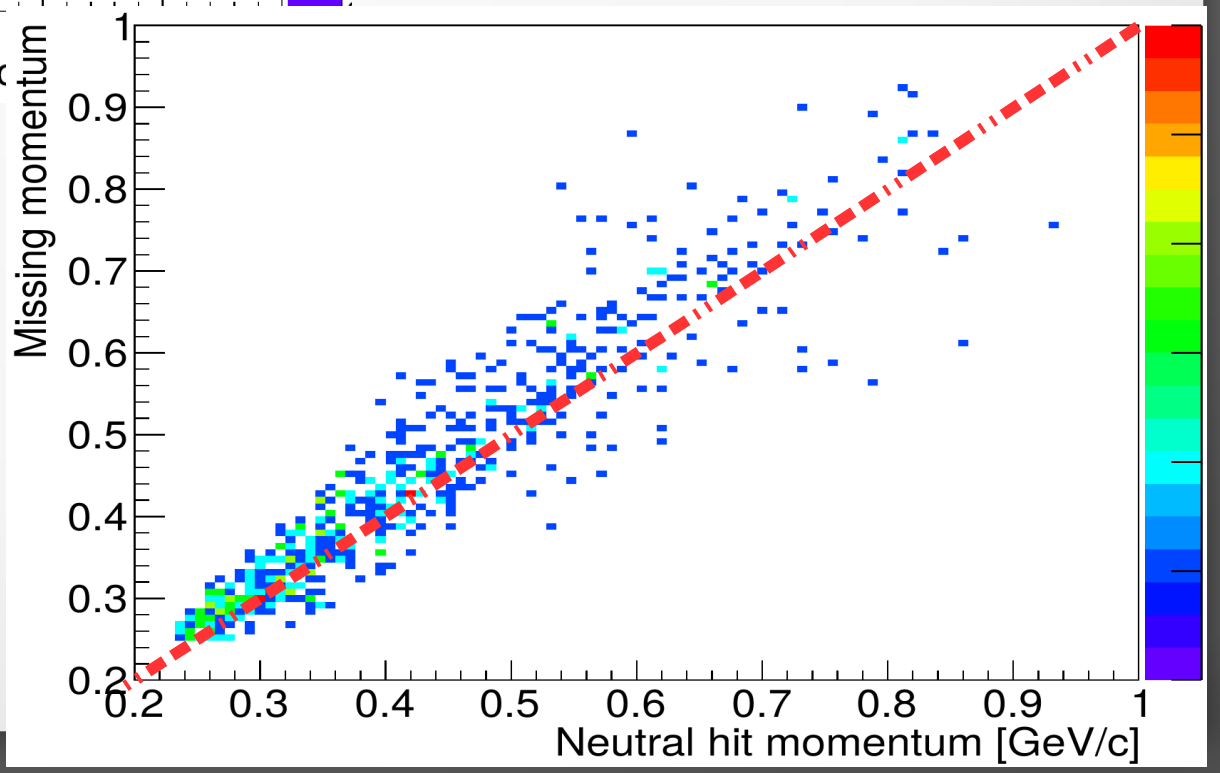


Cuts:
Energy deposit
Missing Mass
Time Window
Opening angle

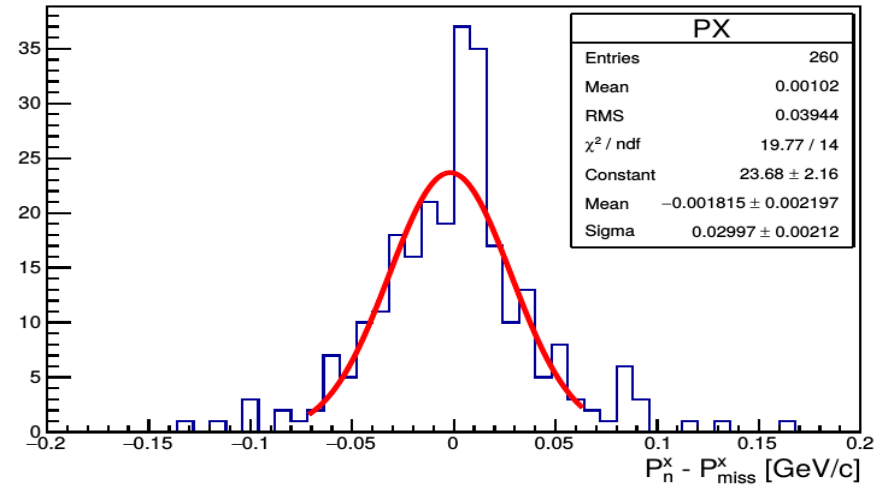
Low Background

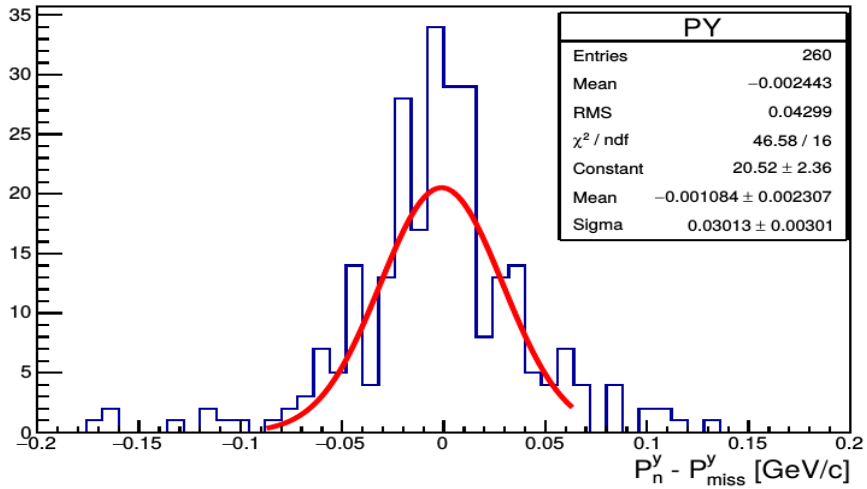


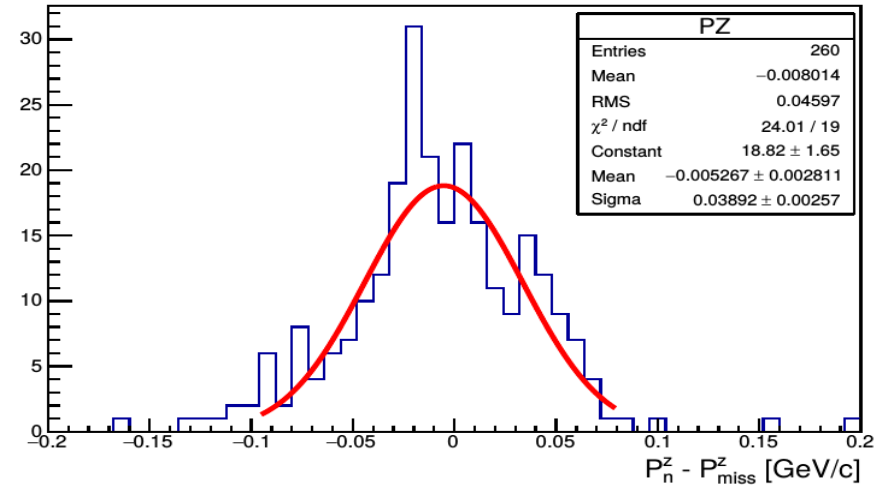
Energy Deposit
Missing Mass
Corrected TOF
Angles differences

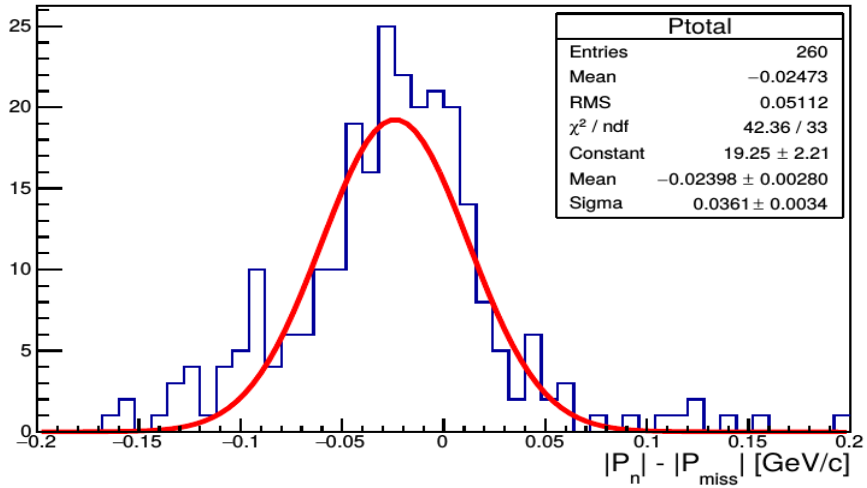


Reconstructed momentum resolution:









$$\frac{\Delta p}{p} \approx 10\,\%$$

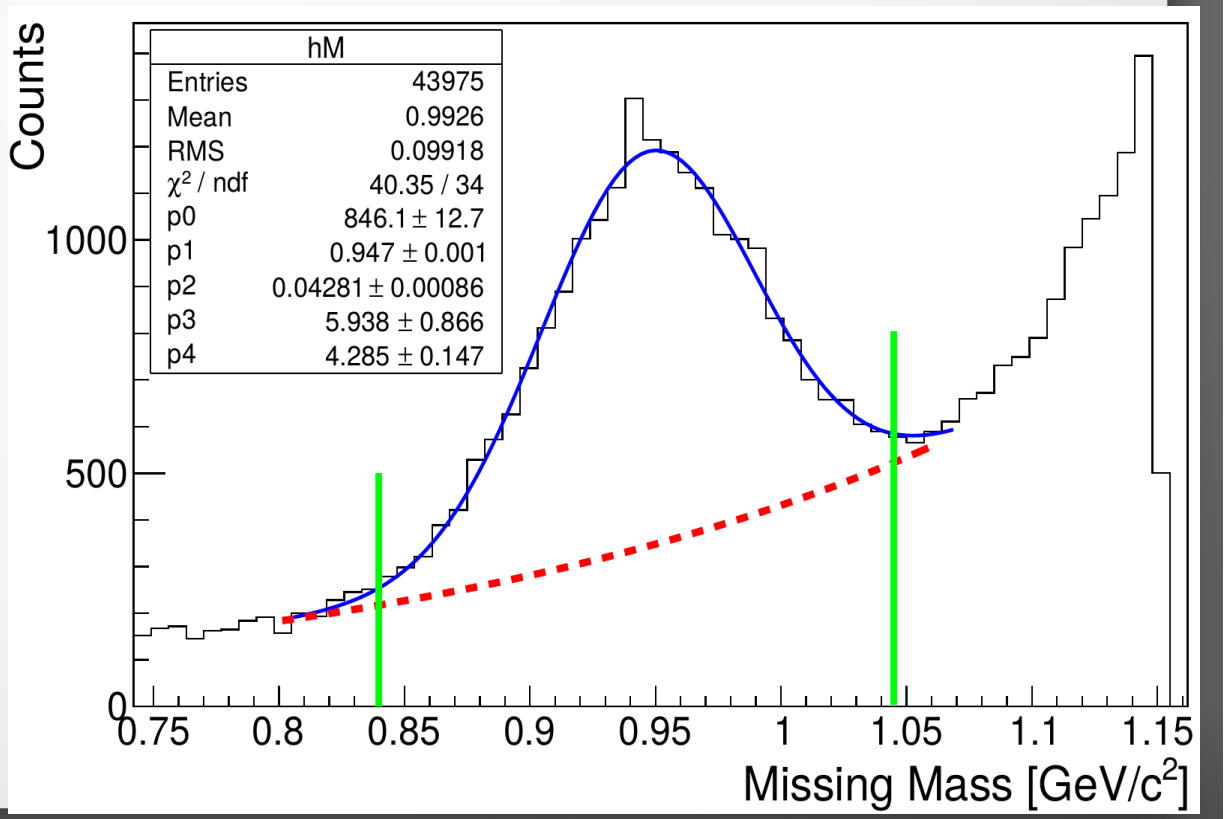
Neutron detection efficiency.

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

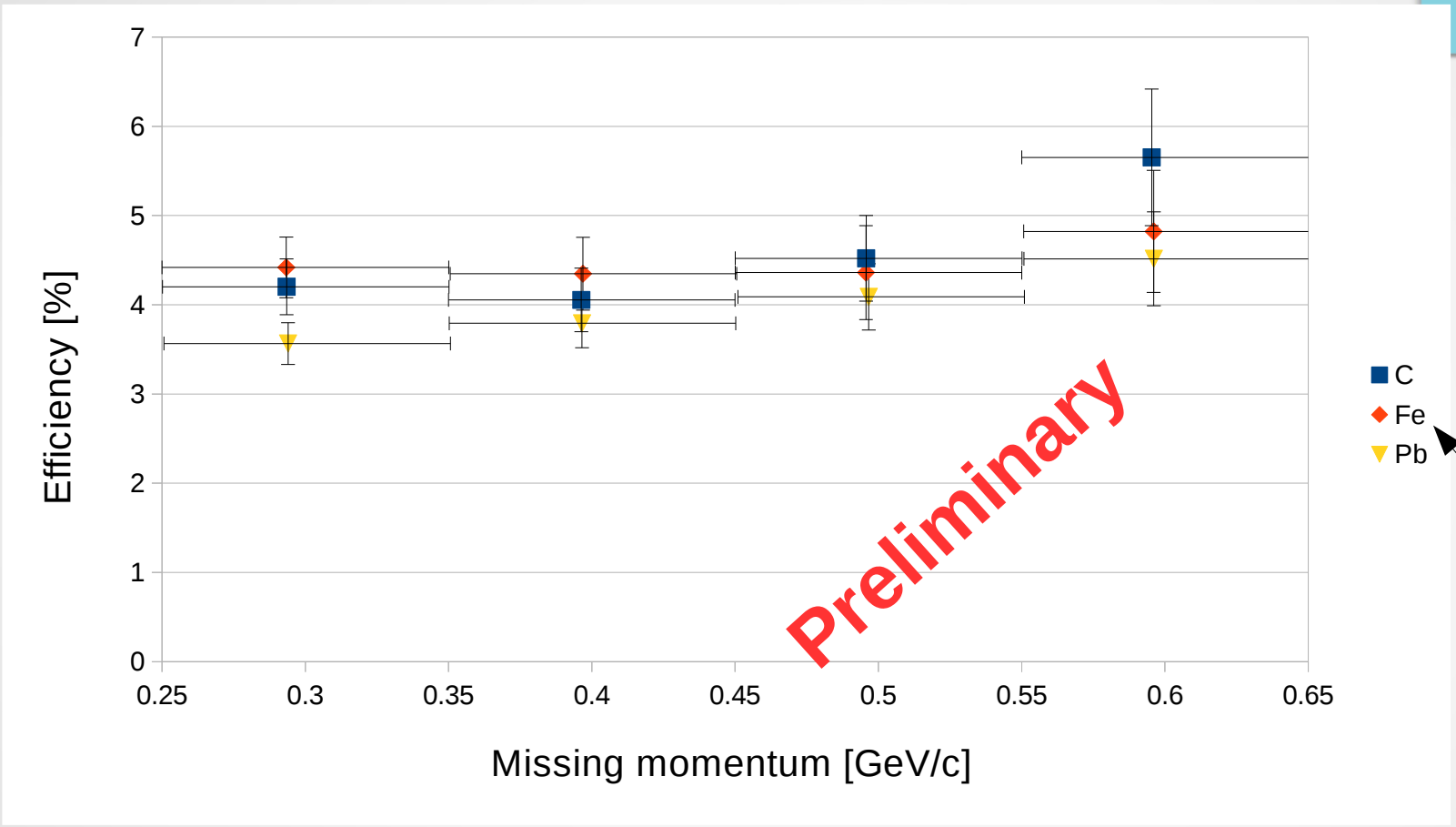
Count of #d(e,e'pn) reaction is straight forward

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

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



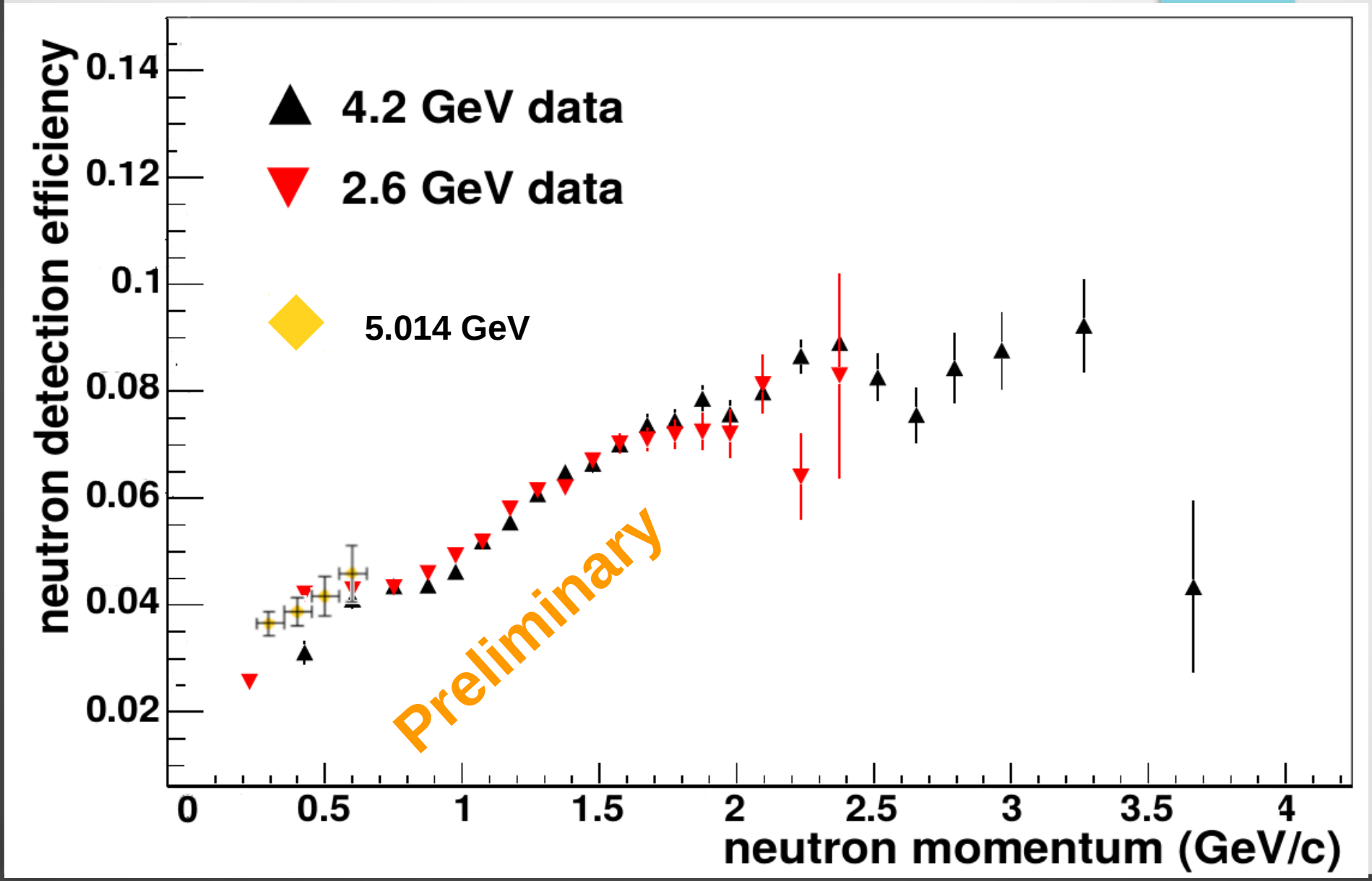
Efficiency Results:



Different setups

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 … :)

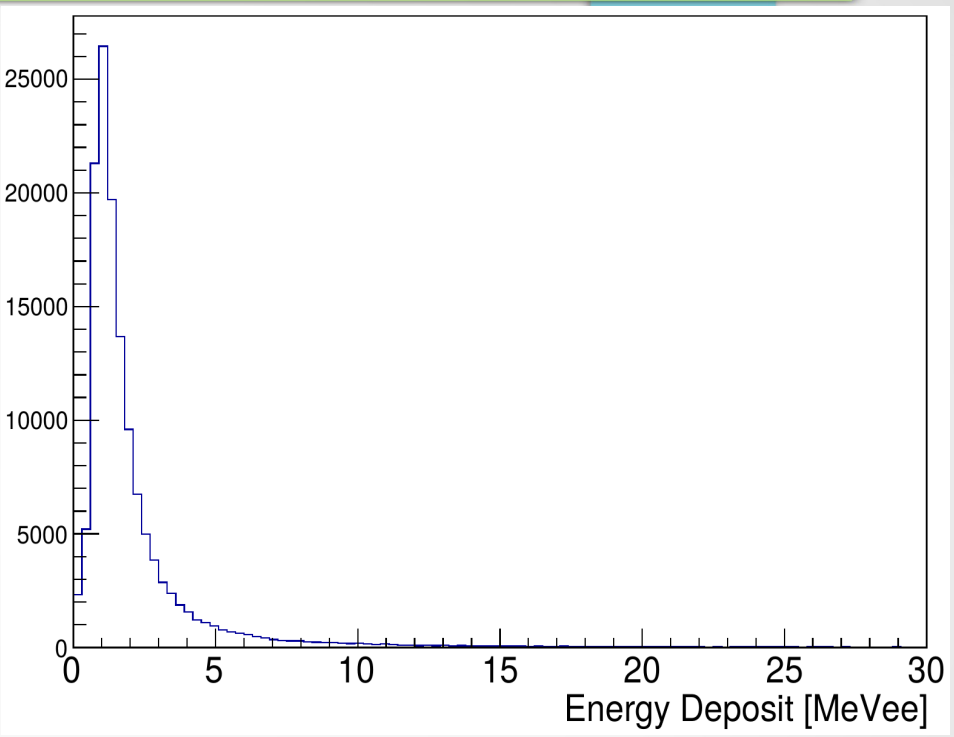
Collaborators

Tel Aviv University	***MIT***	***ODU***
Meytal Duer	Or Hen	Larry Weinstein
Erez Cohen	Shalev Gilad	
Adi Ashkenazi		
Eli Piasetzky		

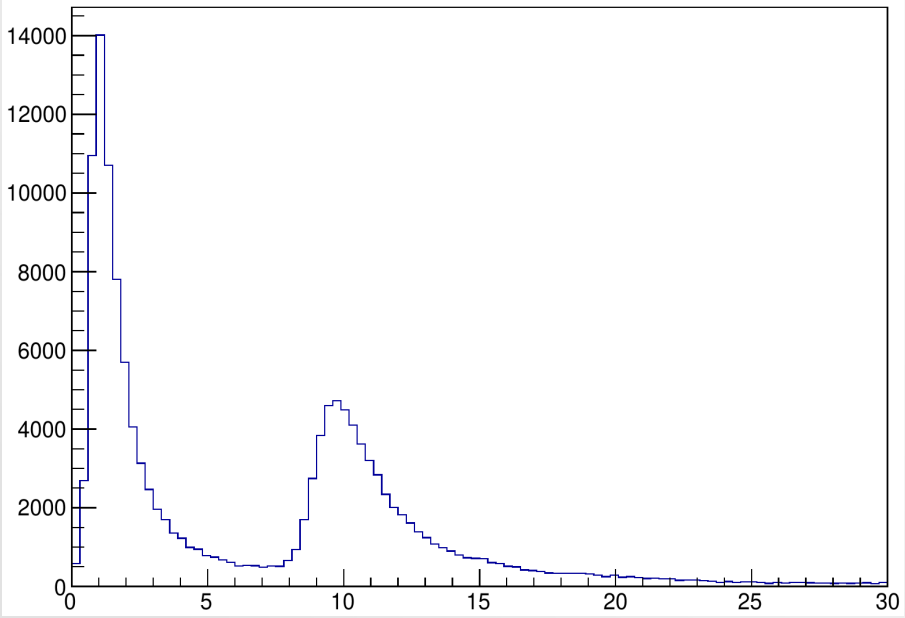
Thank you

Energy deposit

Time window: 30 – 70 ns



Time Window for gamma:



Neutron calibration

1) Develop method for neutron extraction

2) Identify neutrons from d(e,e'pn) reaction in the TOF counters

3) Measure absolute neutron detection efficiency

Data Analysis — Extraction of neutron from eg2a data

Cooked data does not include neutron hits in the

SCPB BOS bank, however raw hits data is stored in SCRC BOS bank.

Group: **SCRC** Sector: **1** Nhits: 3 Next ind: 1838

id: 22 energy: 1.448 time: 55.544 pos >x: 366.114655, y:-2.500206, z:376.719238

err > x: 0.000000, y:103.992226, z:0.000000

status: 3 denergy: 0.000 dtime: 6.454

id: 30 energy: 1.561 time: 100.272 pos >**x: 412.525085, y:184.872711, z:217.826065**

err > x: 0.000000, y:23.329113, z:0.000000

status: 11 denergy: 0.241 dtime: 1.408

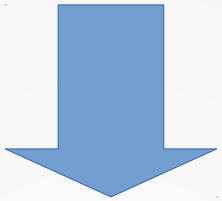
id: 40 energy: 1.399 time: 1.358 pos >**x: 411.805756, y:6.217634, z:-6.877030**

err > x: 0.000000, y:50.179745, z:0.000000

status: 11 denergy: 0.185 dtime: 3.034

Synchronizing tracking data with the SCRC bank

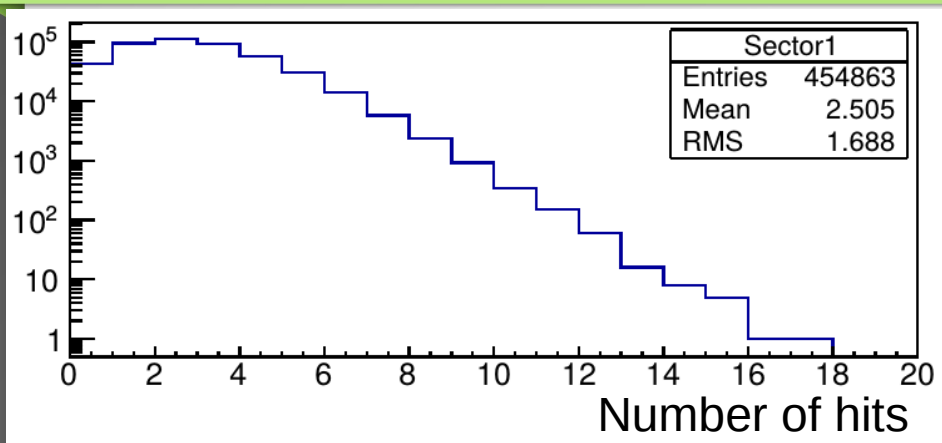
In order to synchronize the TOF hits with the EVNT bank information

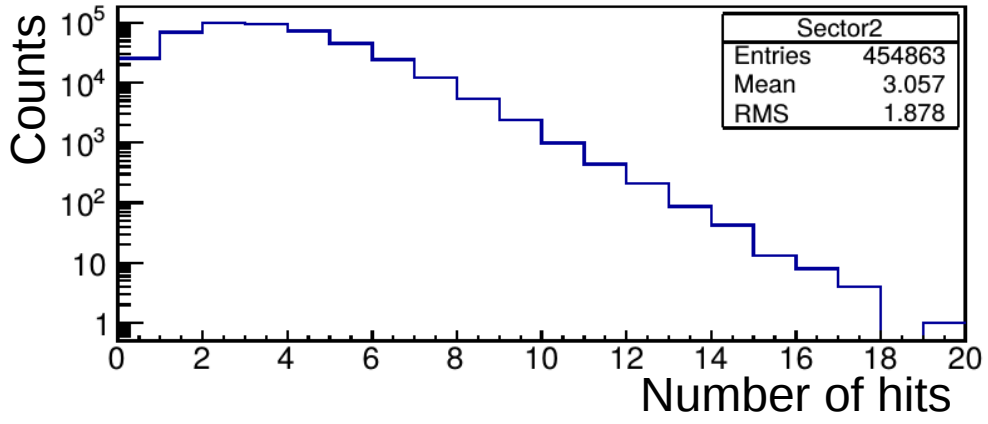


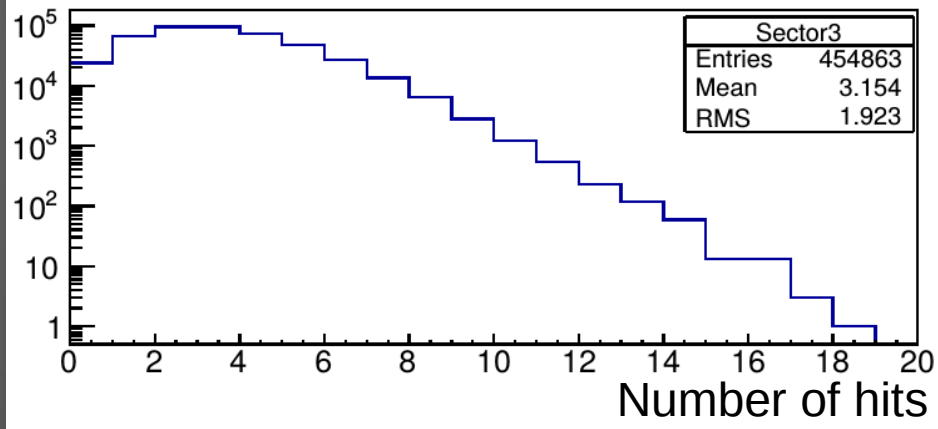
HEAD BOS bank

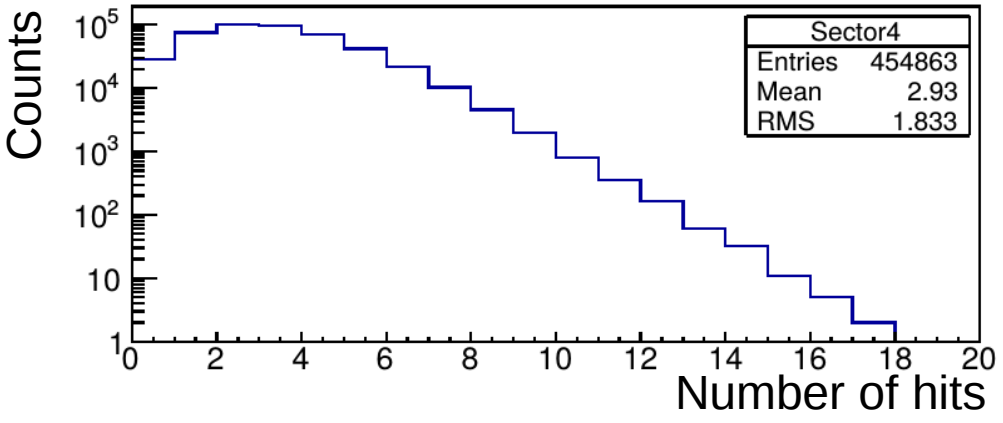
Group: **HEAD** Sector: 0 Nhits: 1 Next ind: 0
Version: 0
Run: 42011
Event: 58
Type: 1 (physics data)
ROC: 0
CLASS: 3
Trgbit: 0xc004
TIME: Thu Feb 26 22:18:08 2004

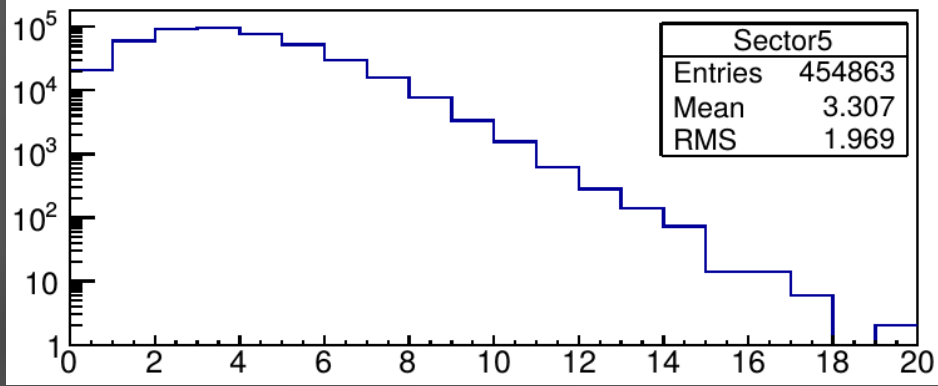
For each event we have multiple hits in each sector

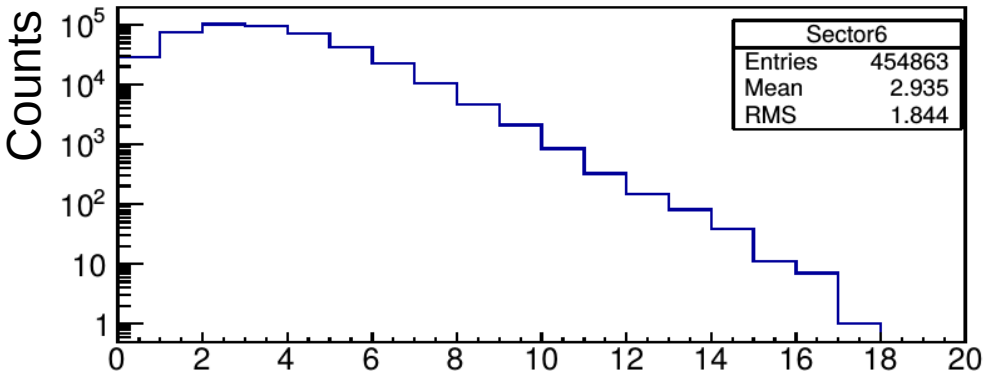












Definition of neutral hits in TOF counters

We define hit in TOF counter to be a neutral hit if there is **no track** in the drift chambers

Each track is stored in the DCPB BOS bank and have hit position in TOF counter

Group: DCPB Sector: 0 Nhits: 3 Next ind: 0

ScTr: 201 x_SC: 426.566 y_SC: -165.796 z_SC: 168.012 CX_SC: 0.883 CY_SC: -0.355

CZ_SC: 0.306 X_EC: -1.306 Y_EC: 1.684 Z_EC: -23.579 Th_CC: 4.261 Chi2: 3.814 Status: 1

ScTr: 202 x_SC: 326.264 y_SC: 107.564 z_SC: -196.830 CX_SC: 0.792 CY_SC: 0.276

CZ_SC: -0.544 X_EC: -0.662 Y_EC: 0.149 Z_EC: -33.423 Th_CC: 1.358 Chi2: 2.723 Status: 2

ScTr: 203 x_SC: 130.349 y_SC: -30.233 z_SC: 484.604 CX_SC: 0.028 CY_SC: 0.062

CZ_SC: 0.998 X_EC: 130.845 Y_EC: -29.133 Z_EC: 502.305 Th_CC: 0.417 Chi2: 1.618 Status: -1

ScTr : 100*sector+track_ID in *BTR

Position: x_SC, y_SC, z_SC (given in sector coordinate system)