March 8, 2018

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**Tel Aviv University**

# Study of SRC with recoil neutron detection in CLAS6 – Data Mining

On going 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

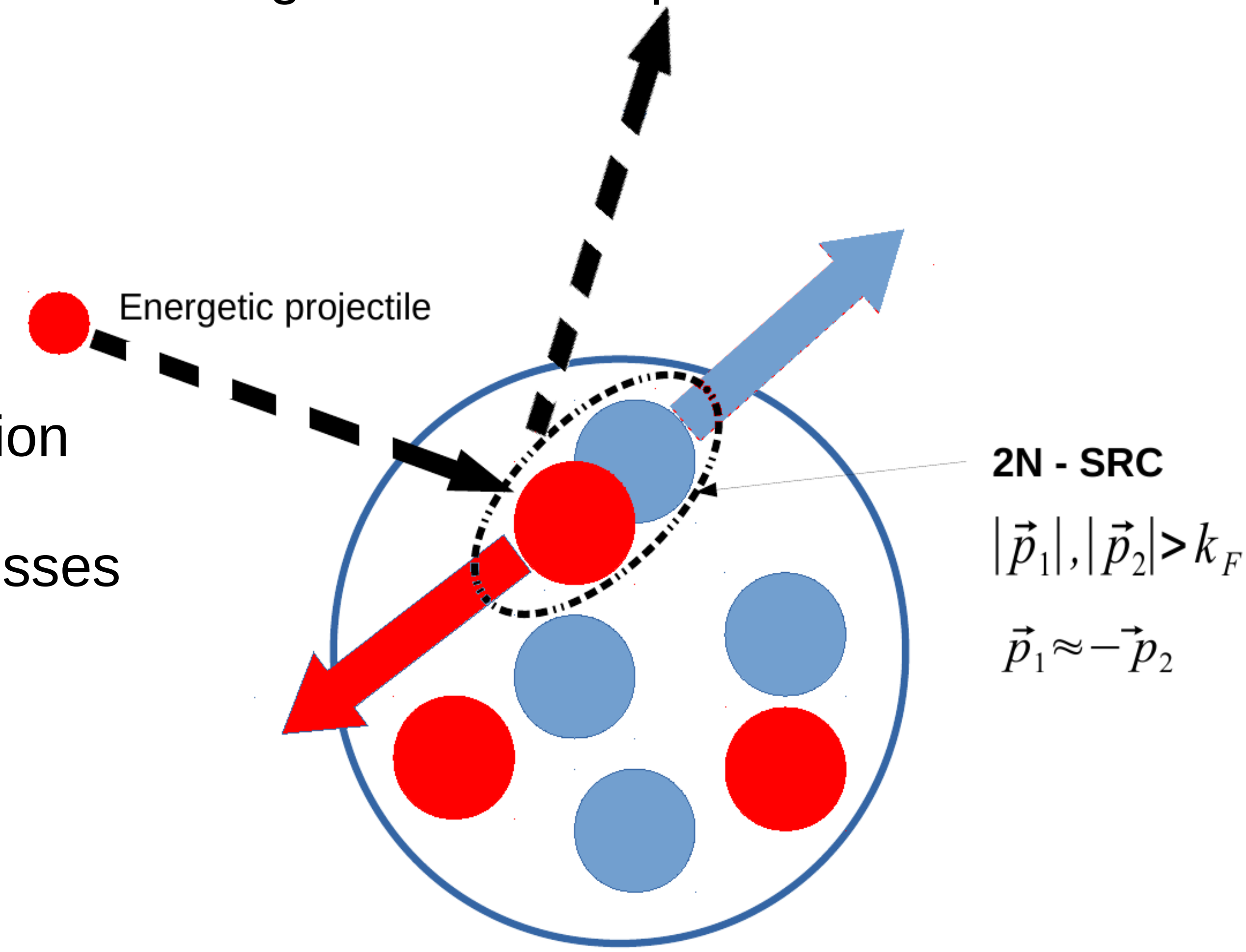
Why going to high missing momentum?

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

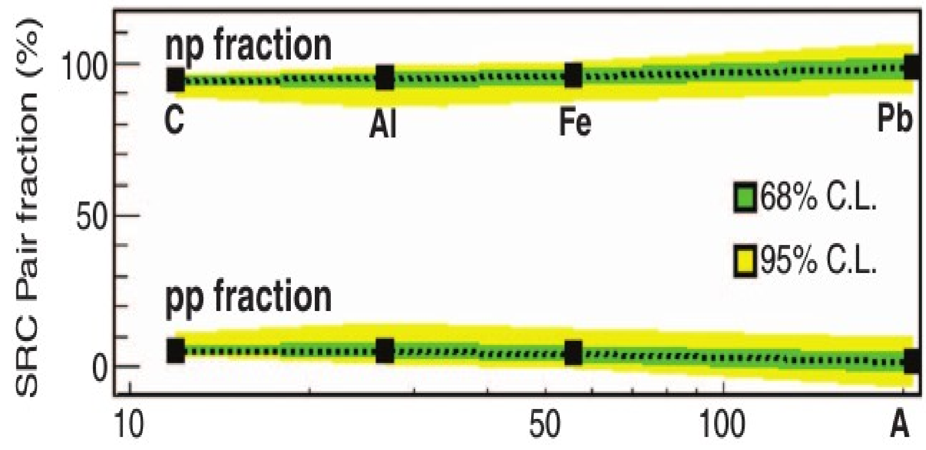
* Go above mean field region

* Reduce competing processes

* confine FSI between the SRC pairs



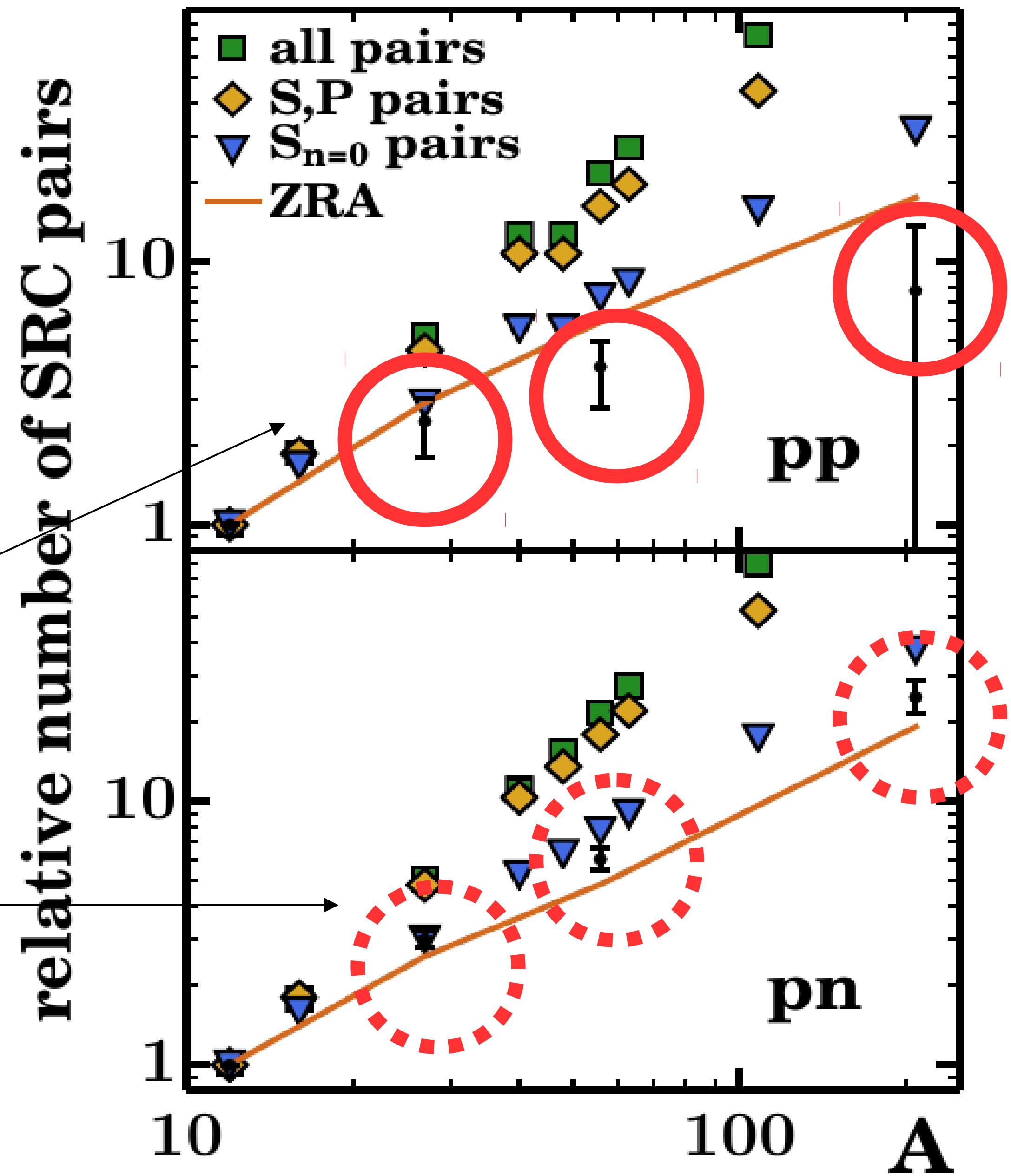
# A(e,e'pp) analysis done on eg2a run period




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

**Measured**

**Predicted**




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

# A(e,e'pn) analysis on eg2a - Motivation

Complete the A(e,e'pp) analysis

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

Compare to Meytal Duer analysis in case of **A(e,e'np)** reaction

| | Or | Meytal | Current | Hall A |
|---|---|---|---|---|
| $^{4}$He | - | - | - | (e,e'pN) |
| $^{12}$C | (e,e'pp) | (e,e'**n**p) | (e,e'p**n**) | (e,e'pN) |
| $^{27}$Al | (e,e'pp) | (e,e'**n**p) | (e,e'p**n**) | - |
| $^{56}$Fe | (e,e'pp) | (e,e'**n**p) | (e,e'p**n**) | - |
| $^{208}$Pb | (e,e'pp) | (e,e'**n**p) | (e,e'p**n**) | - |

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 $^{12}C$ up to $^{208}Pb$

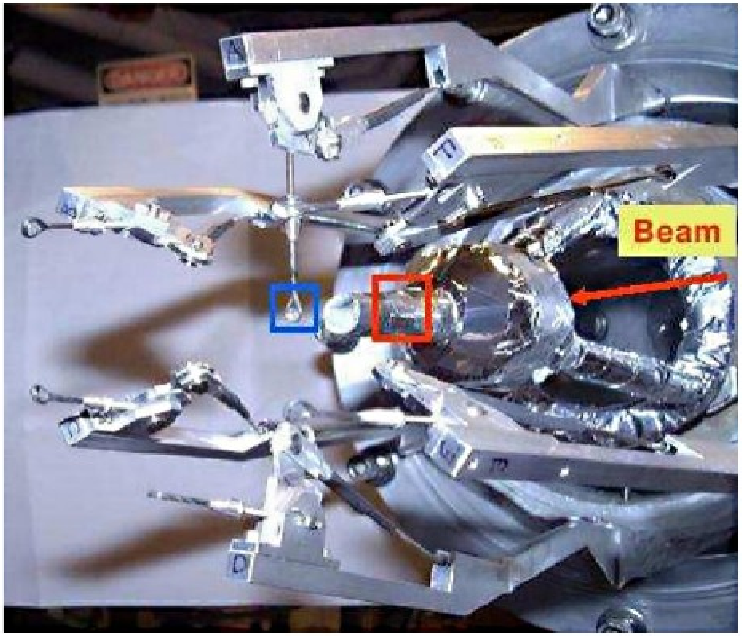
Allow to study the np fraction as function of A

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

# Hit in TOF scintillators

Cooked eg2a data contain intermediate BOS bank: SCRC

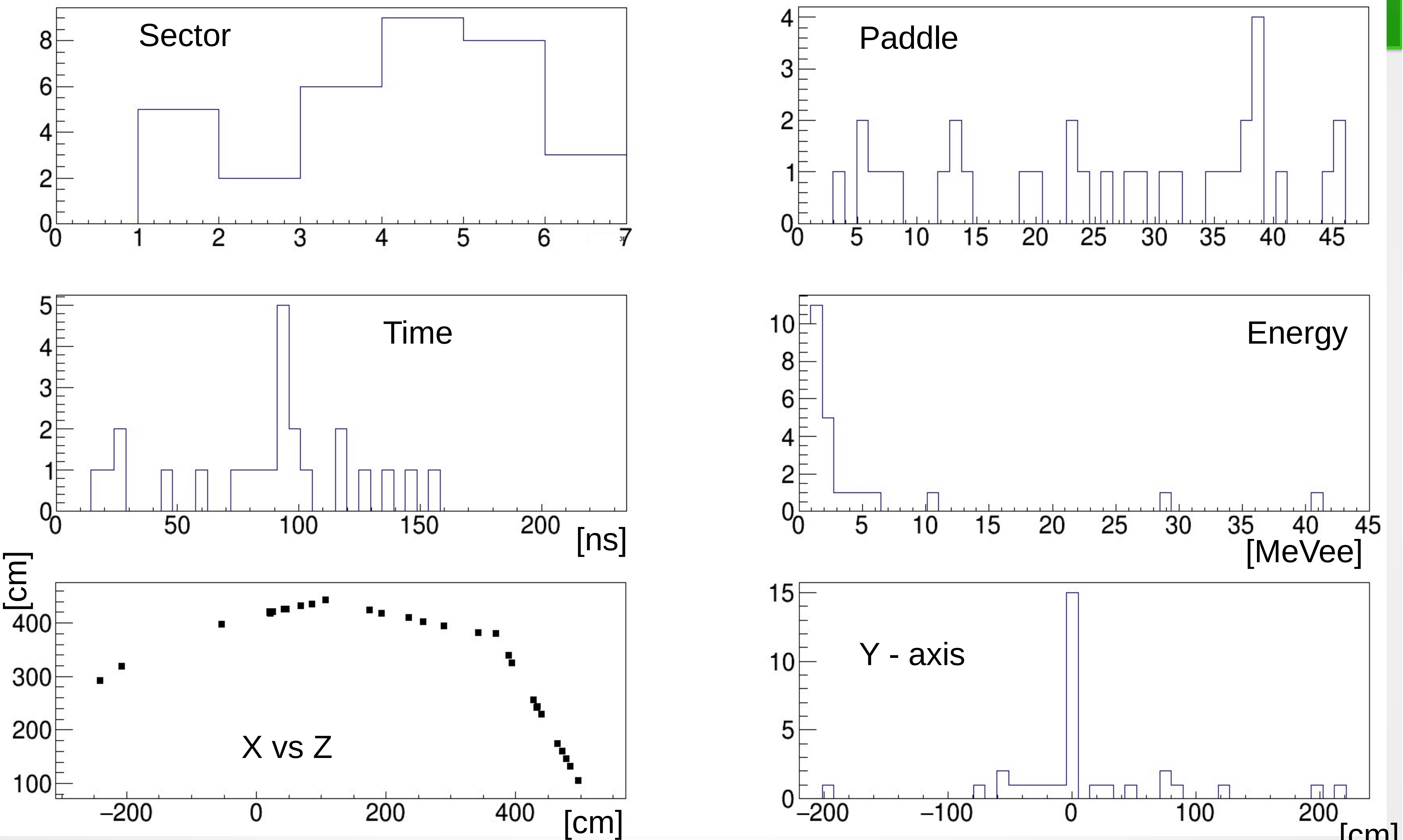
Accessible information:
- Sector
- Paddle
- Time
- Energy
- Position

This bank can't be read by standard Clas Tool

Modification to CLAS TOOL done with the help of Gagik Gavalian

**Consistency check:**
Hits in SCPB bank (hits in TOF that correlate to actual event bank) must be in the SCRC with identical physical information (sector, id, position etc.)

# Event Example From SCRC bank



# Neutron ID problem

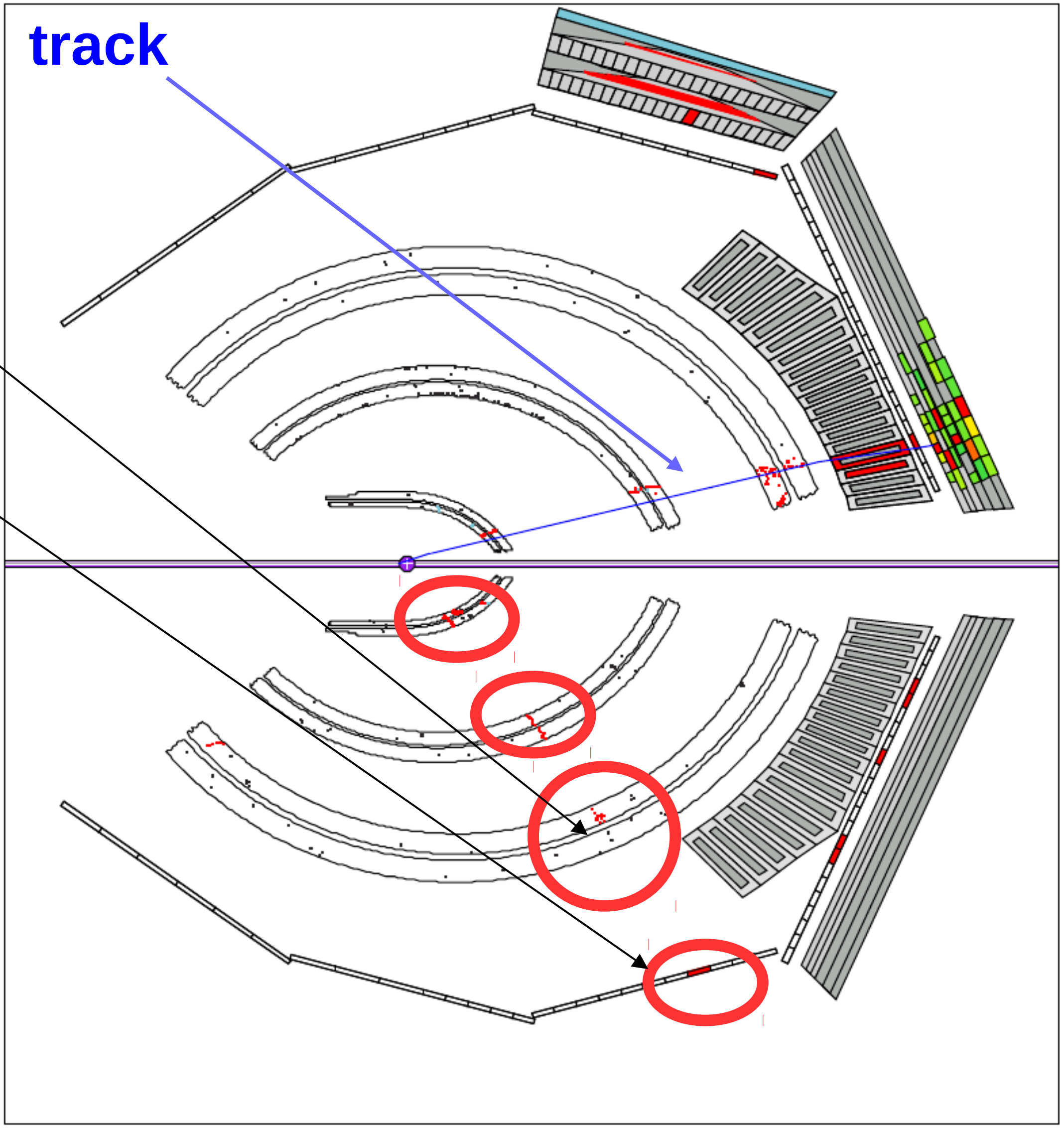
Removal of charged track using the DCPB (standard track bank) is not enough

In order to distinguish between charged hit in scintillators to neutral hit, veto algorithm required

No hit in the chamber

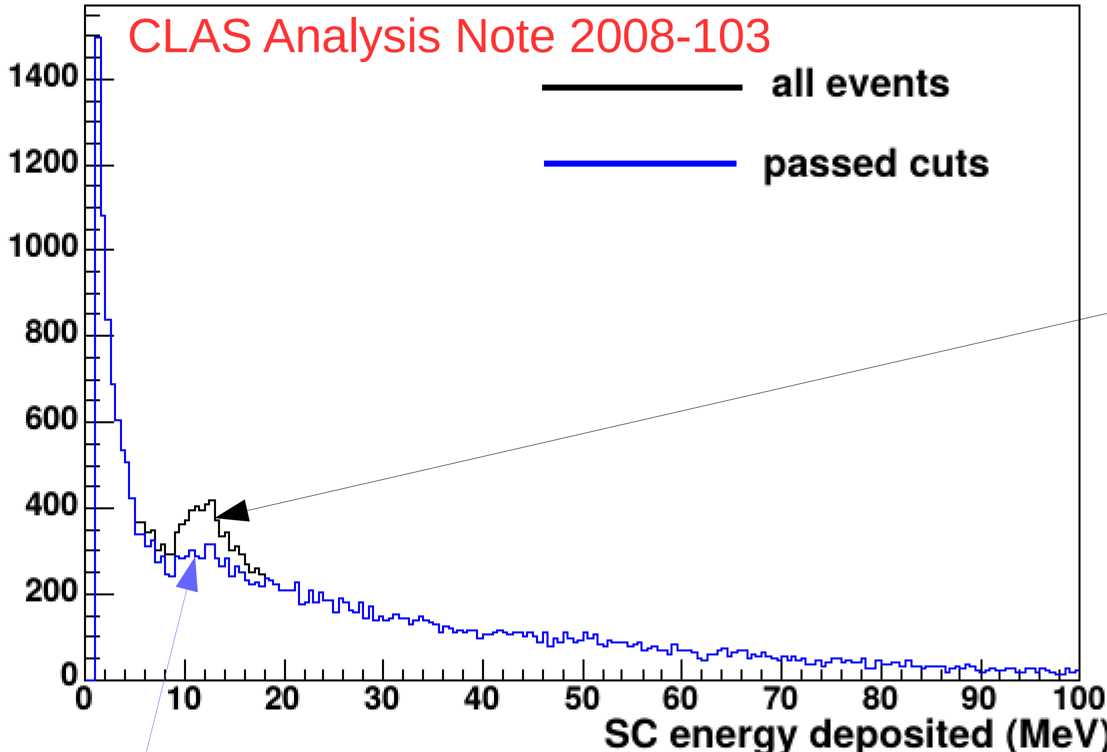
Candidate for “neutron”

Clearly track due to charged particles.




From Gn analysis
CLAS analysis Note 2008-103

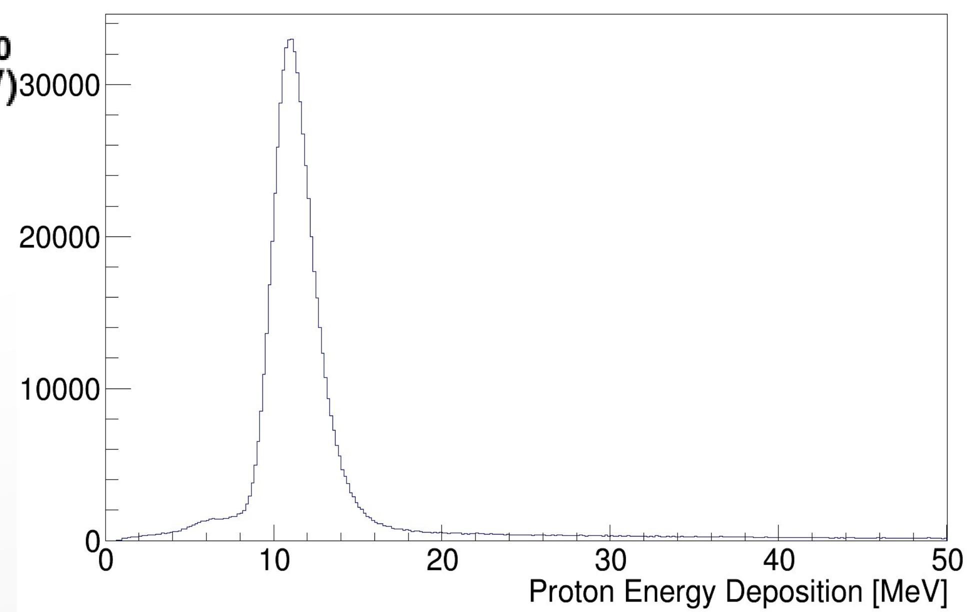
# Neutral particle misidentification




Charged particles identified as neutrals

Energy deposition of charged particles

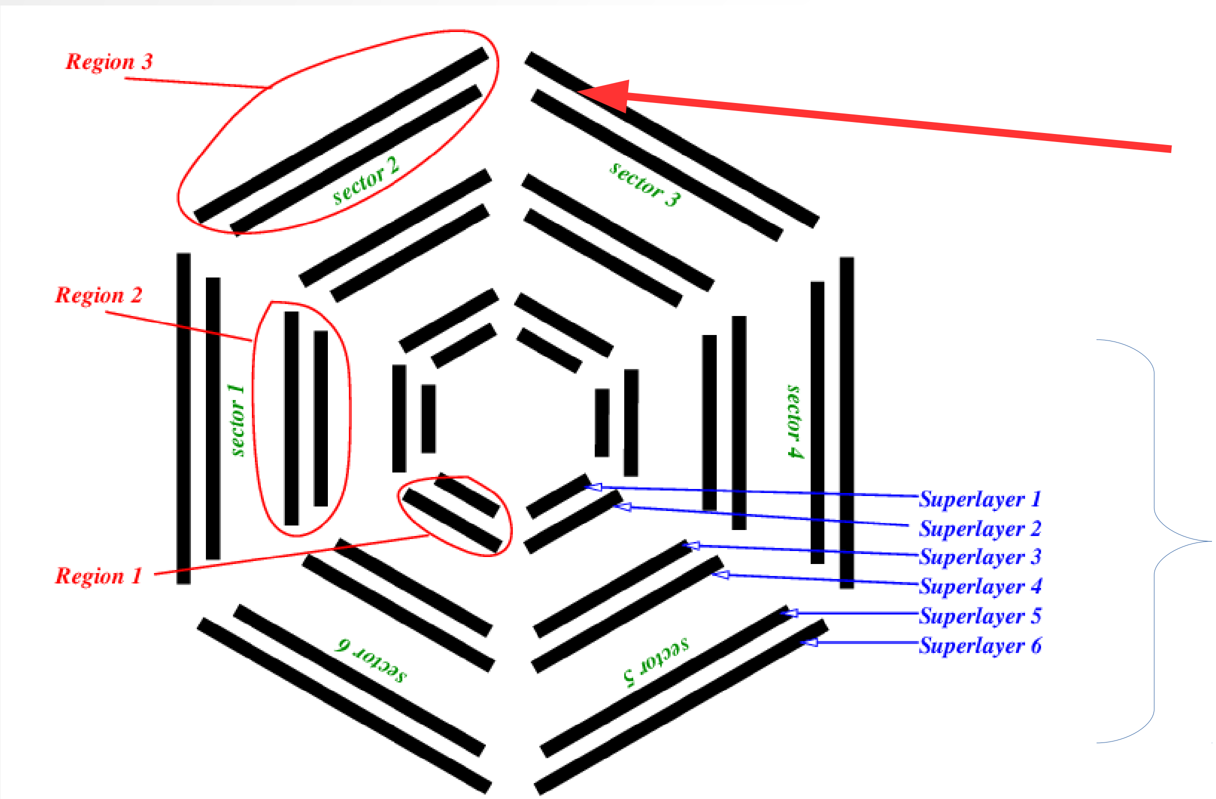
Veto algorithm based on dc1 BOS bank



# Extraction of tracks

We use HBLA BOS bank (not present in the cooked data)

This bank include tracks positions in each layer of the drift chambers



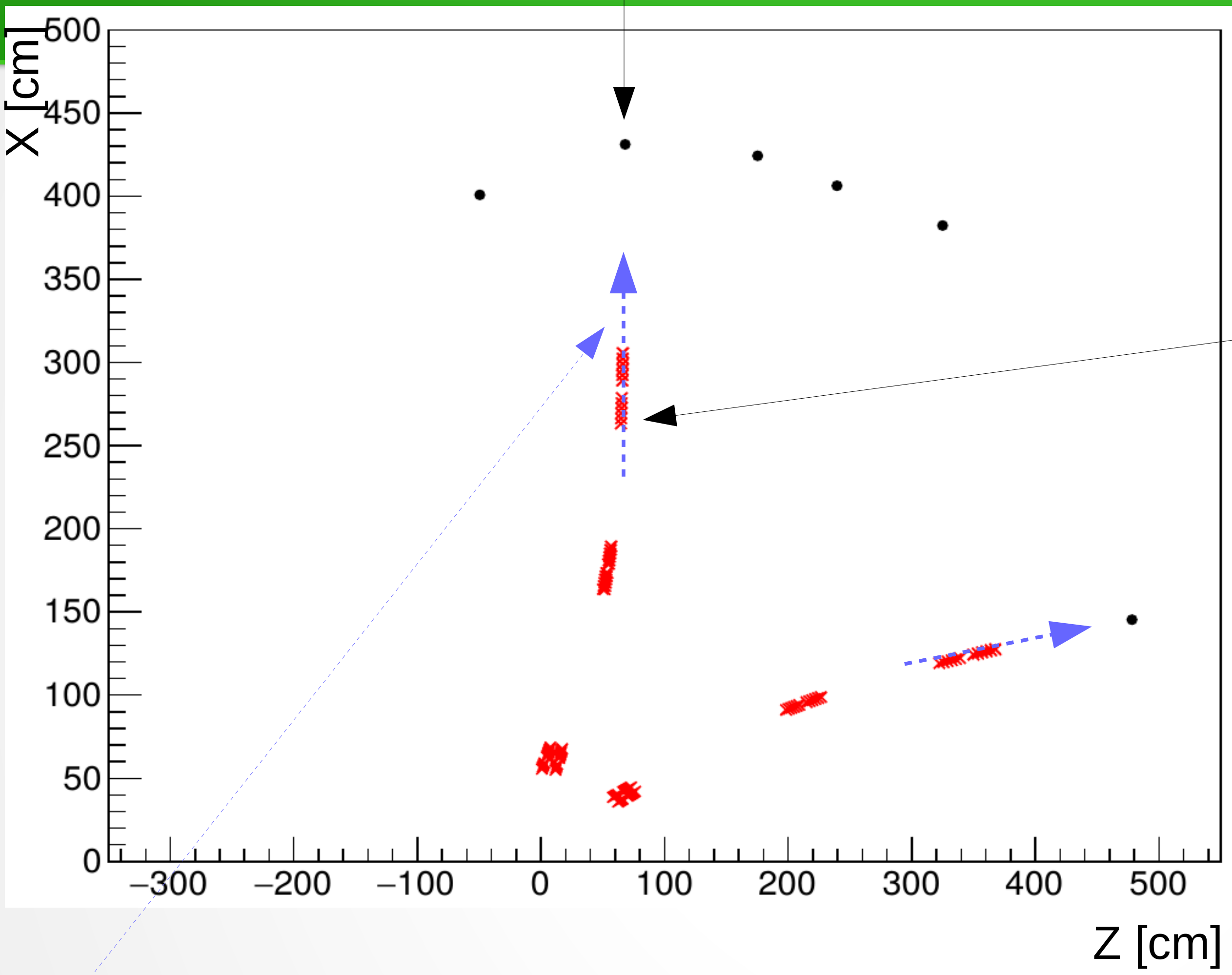

Between Region 3 and TOF counters there is no magnetic field

34 layers

Cooking the data with only two banks: HEAD and HBLA

Needed to correlate events from new cooked data to existing

# Hits in TOF paddles and Drift Chambers

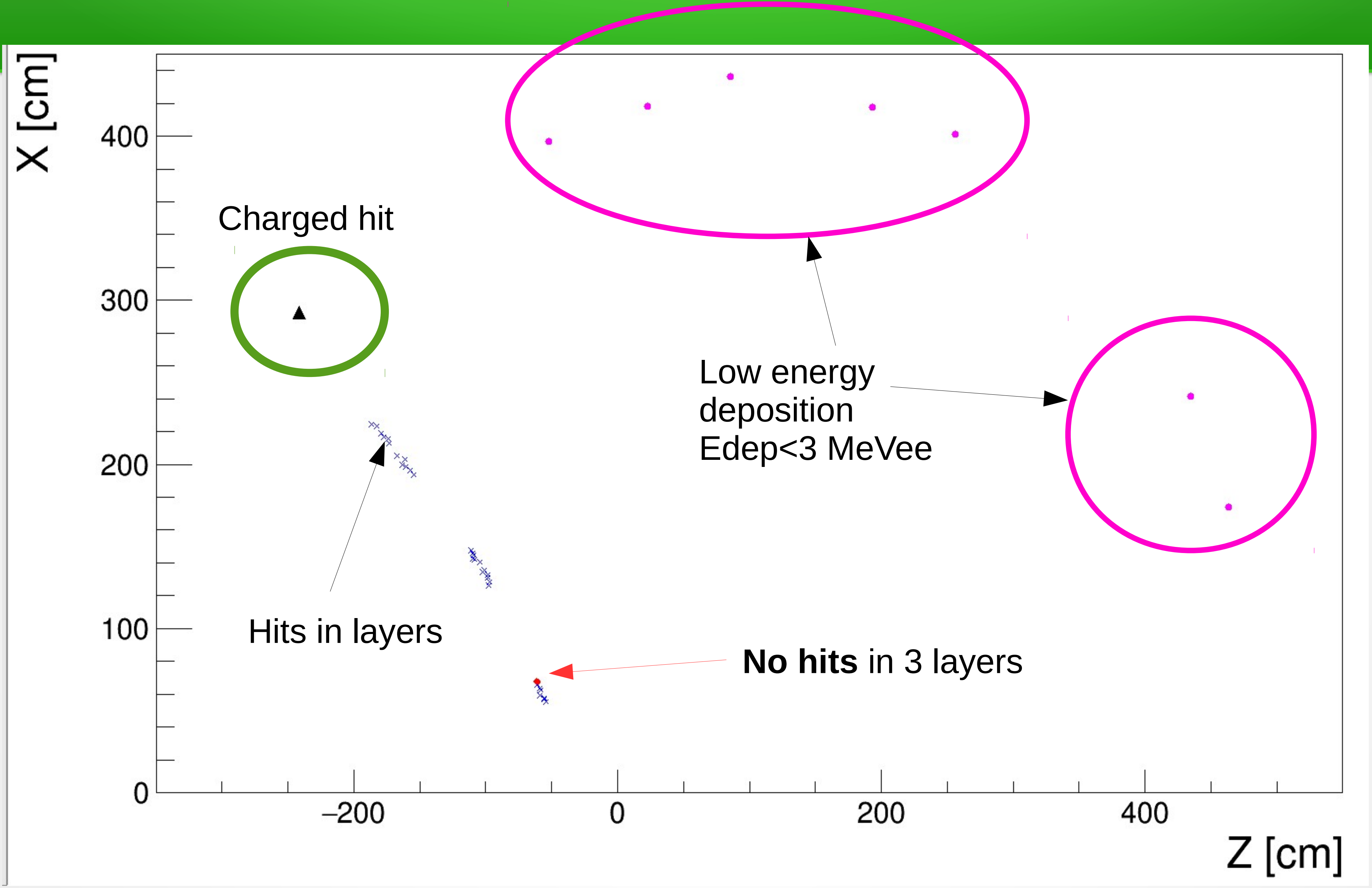



Hits in drift chambers from HBLA Bank

Fit the track direction based on the hits in super layer (34 layers)

Projection to TOF paddles using hits in Region 3 – no magnetic field.

# Additional Example



# Veto Algorithm

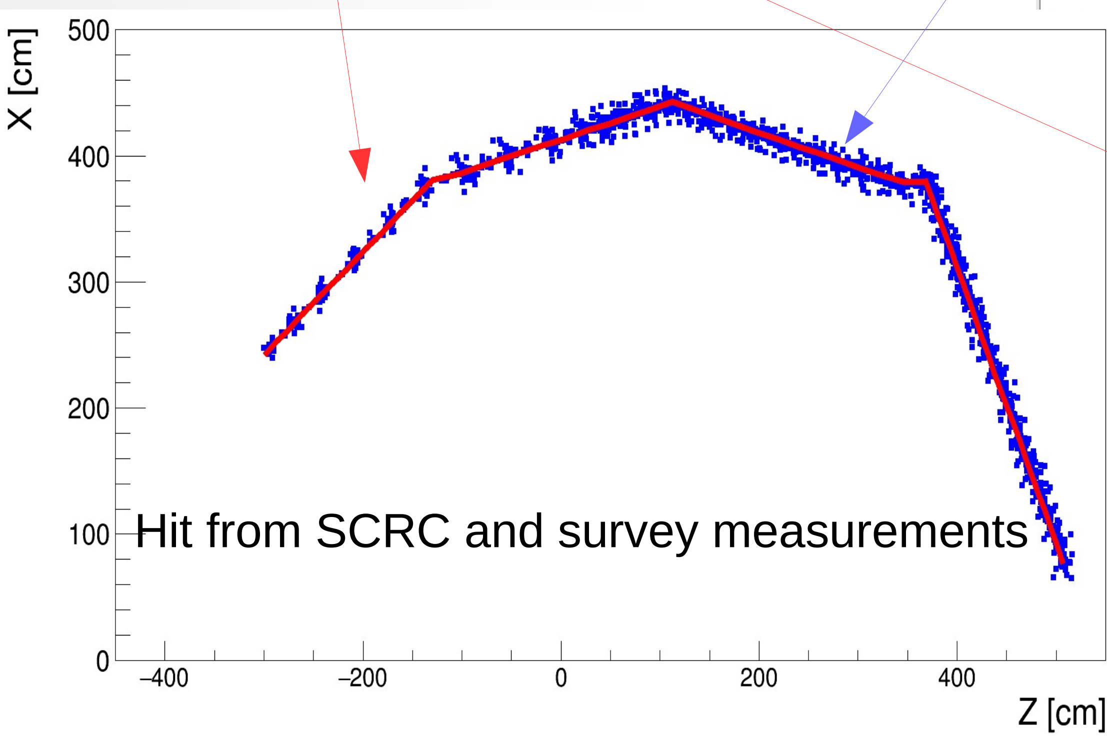
I. Create expected hit position on TOF paddle based on track (from HBLA)

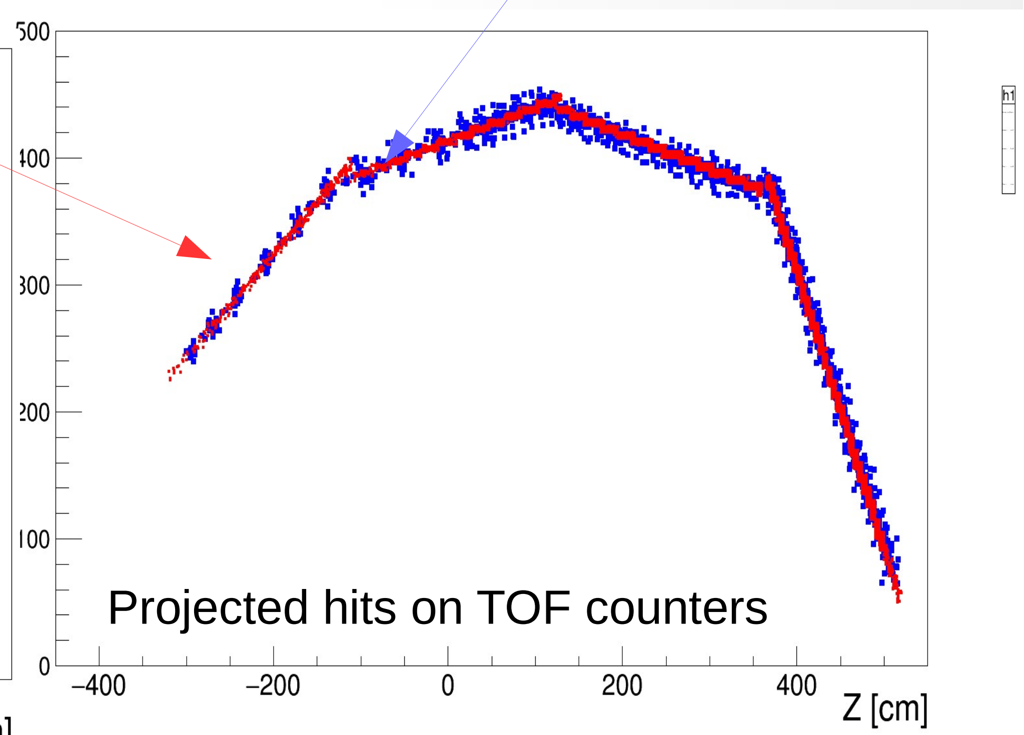
E.S. Smith *et al.*,
Nucl. Inst. Meth. In Phys. Res. A432,265 (1999)

Red: Paddle position based on survey measurements

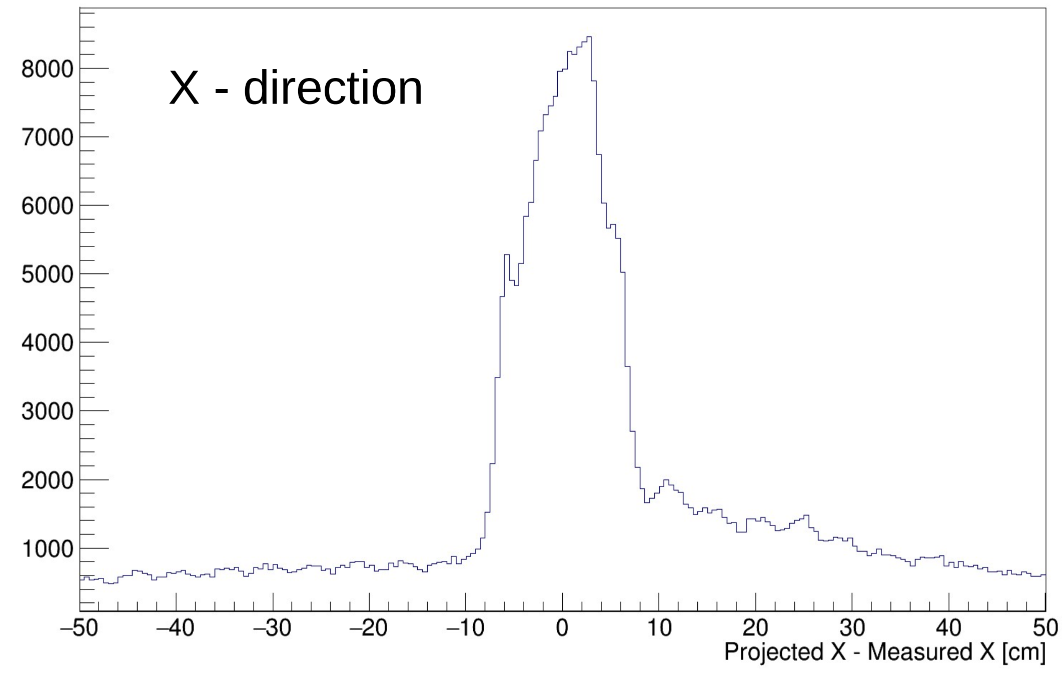
Blue squares: Hits from SCRC

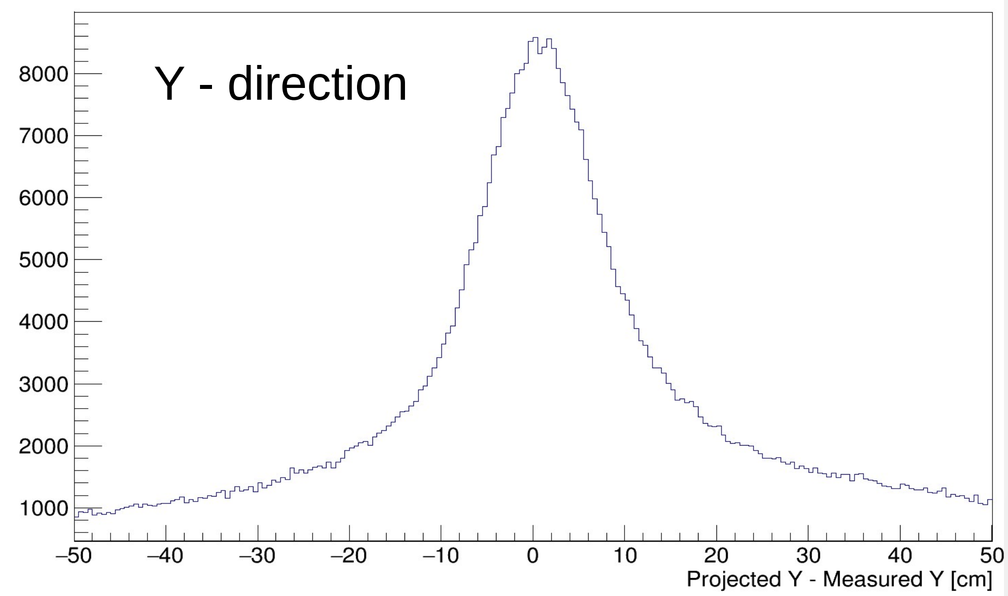
Blue squares: Projection from tracking algorithm

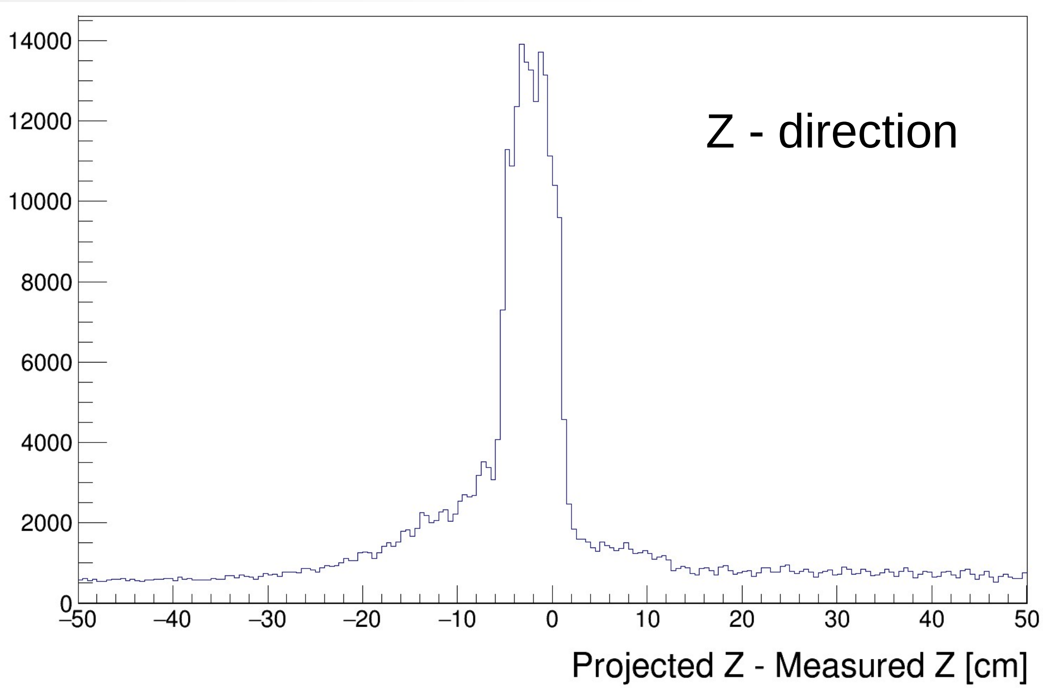


# Projected hits vs Measured Hits

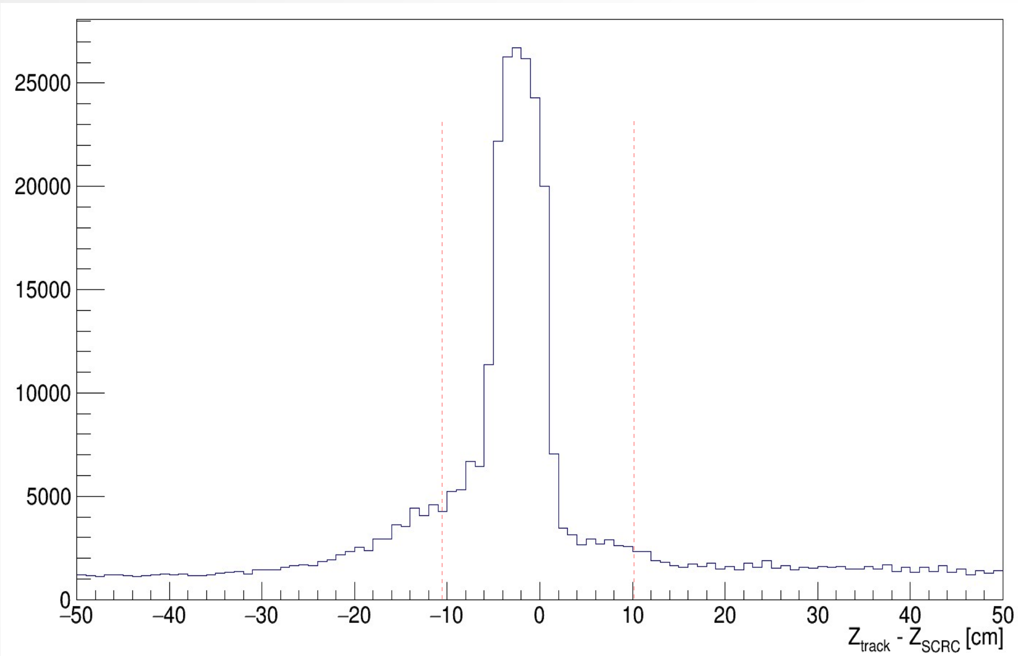


# Veto Algorithm

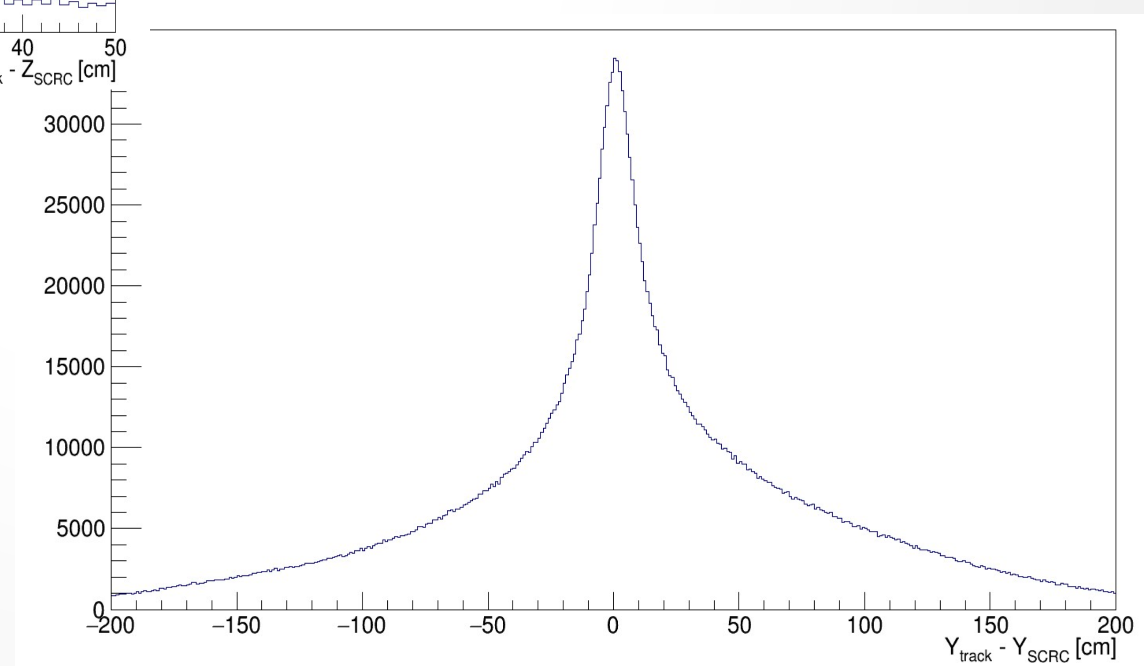
II. Remove hits from SCRC bank that correspond to expected charged hits based on HBLA tracking



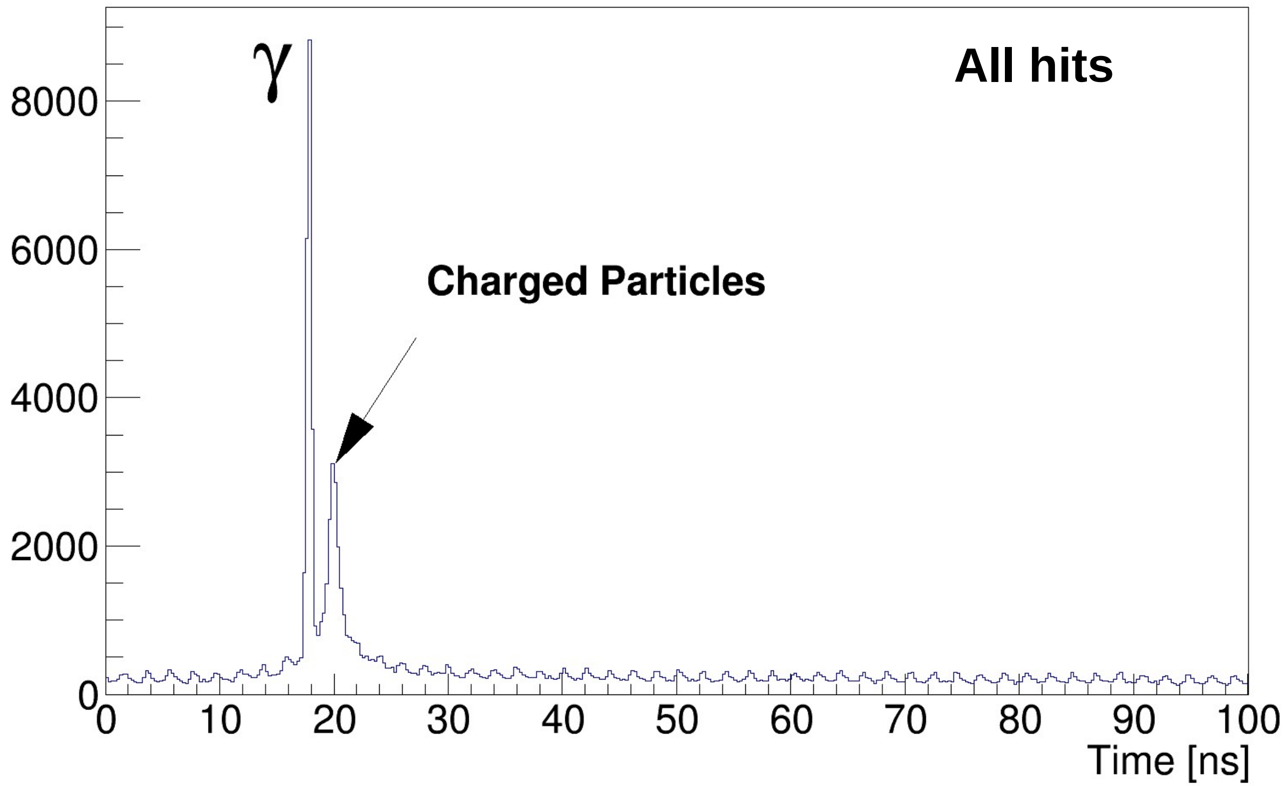

Coordinate system defined as a lab coordinate system, where Z axis is along the beam

We decided to **remove whole bar** (sensitivity should be tested)

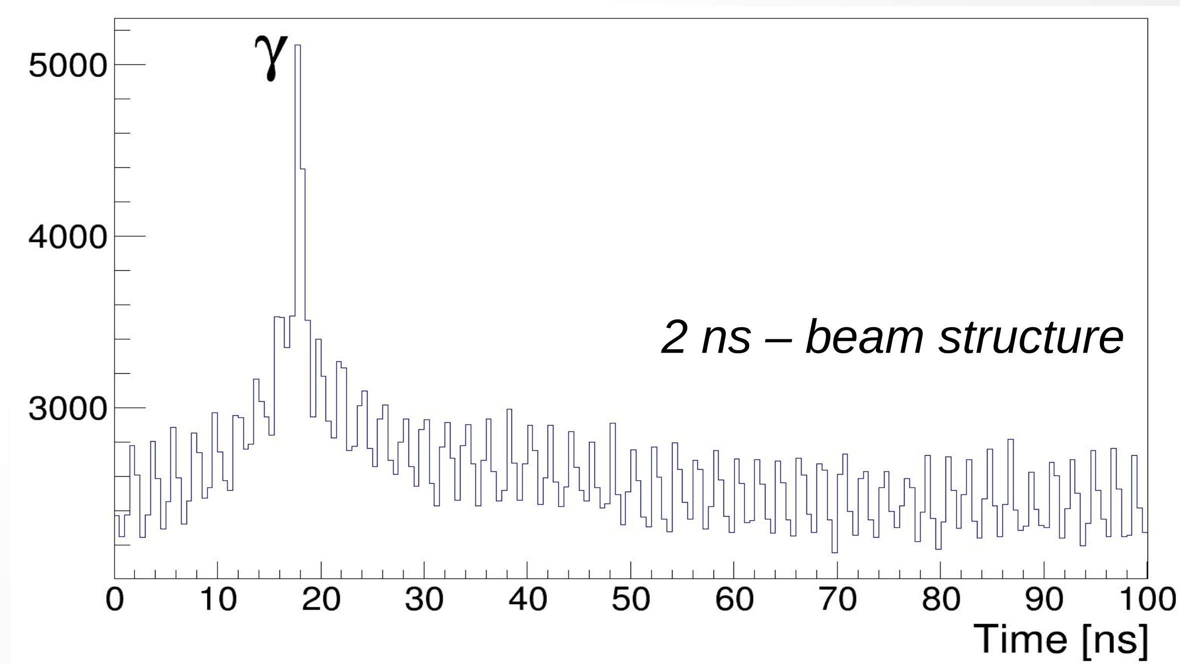
Sensitivity should be tested

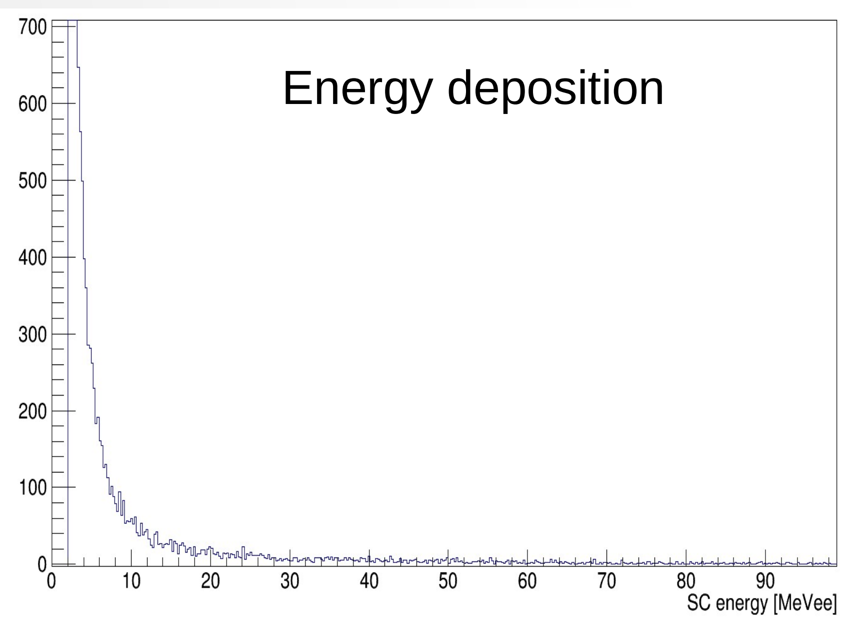


# Neutral algorithm



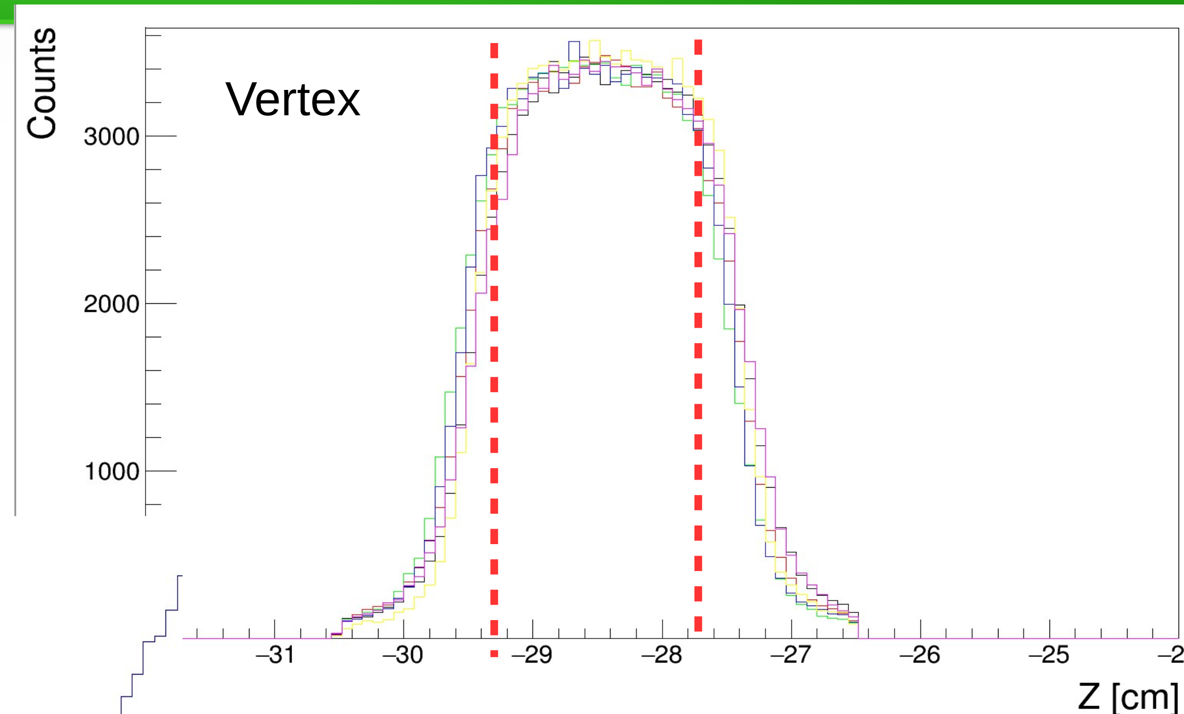

**Neutral hits**

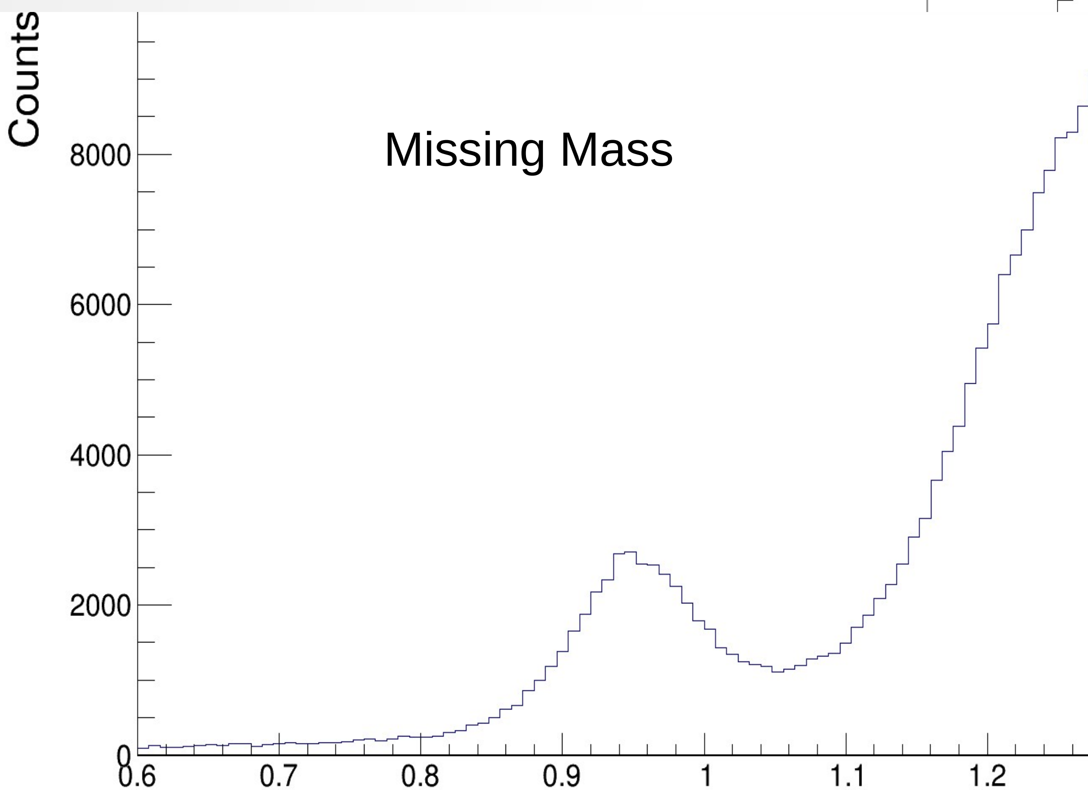


# **Exclusive LD2 reaction** – Goal find neutron detection efficiency

## Selection of d(e,e'p)

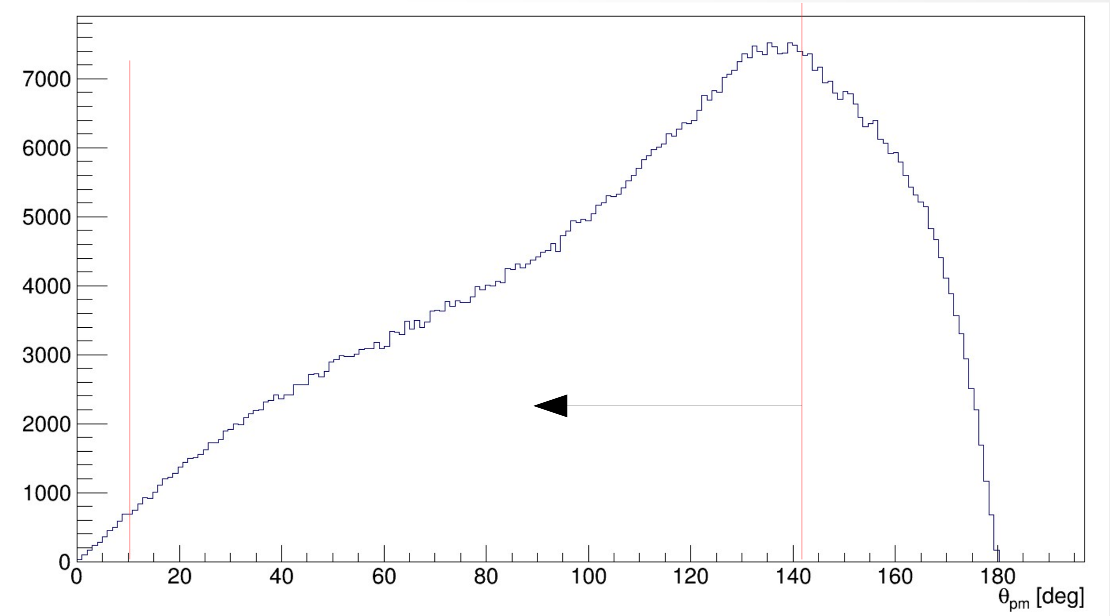


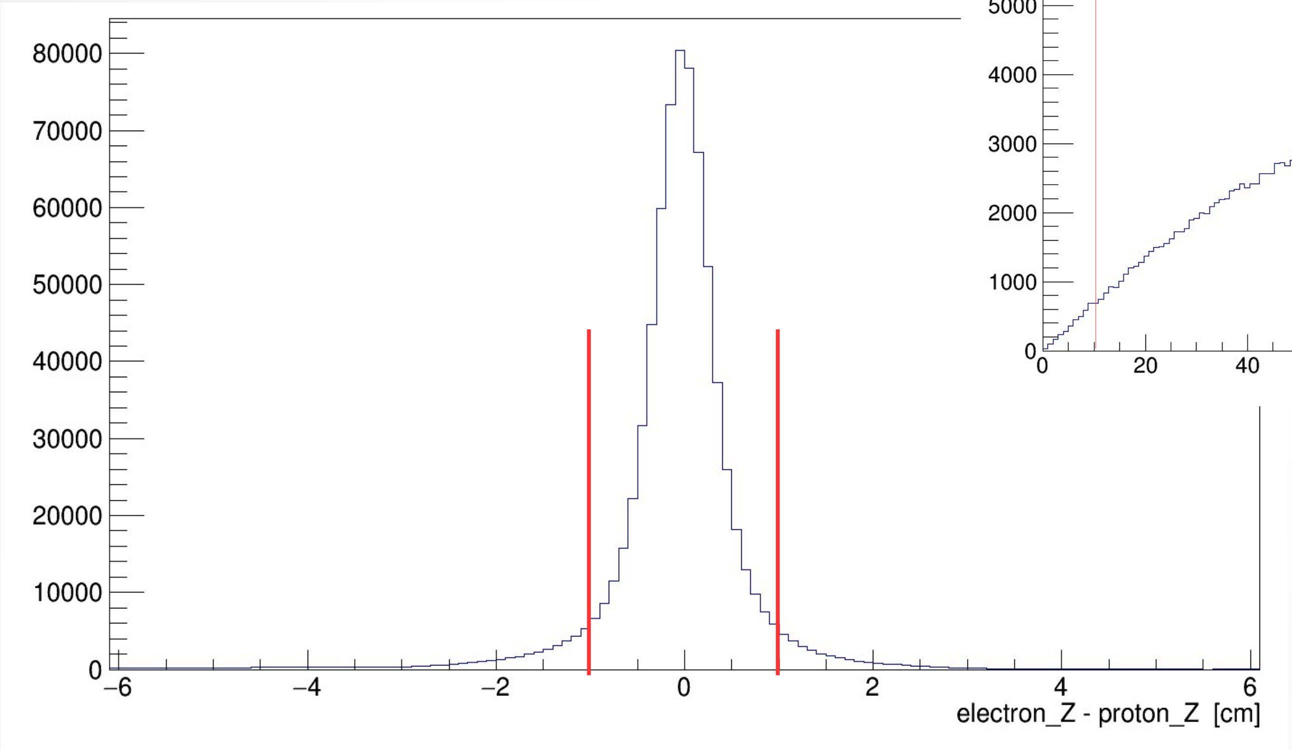



# Selection of D(e,e'p) Events

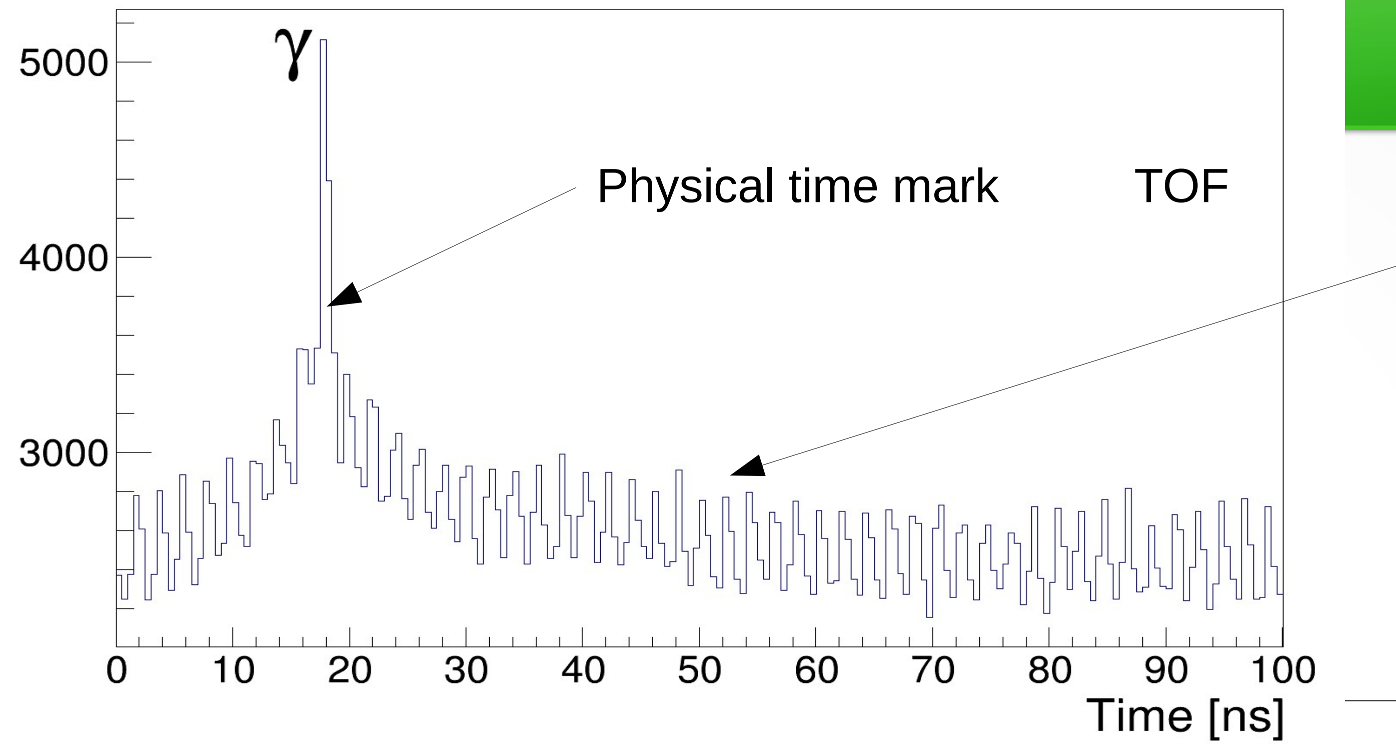
## Cuts for (e,e'p) events

- Vertex (Deuterium target)
- Vertex difference (between electron and proton vertex reconstruction).
- Missing momentum smaller than 1 GeV/c and greater 0.25 GeV/c.
- Missing momentum angle (Theta) smaller than 145 deg and greater than 10 deg (no scintillators at these angles).
- Missing mass cut (<1.05 GeV/c^2).



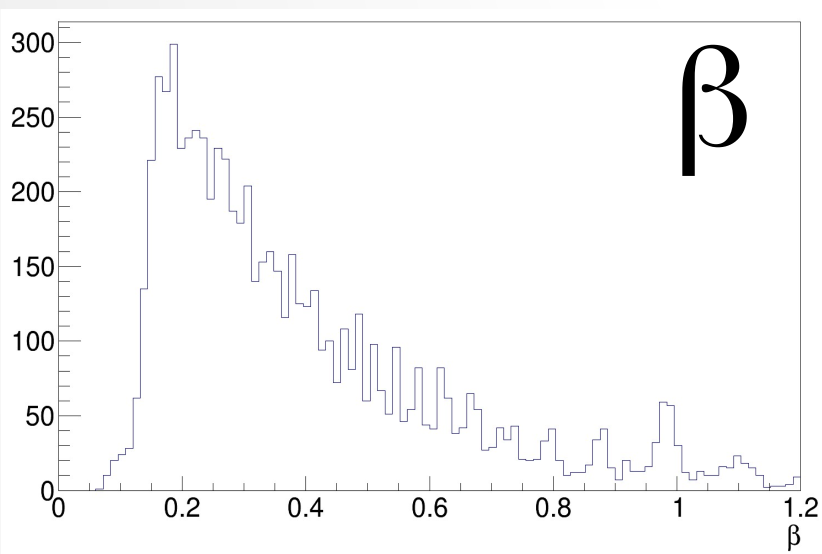



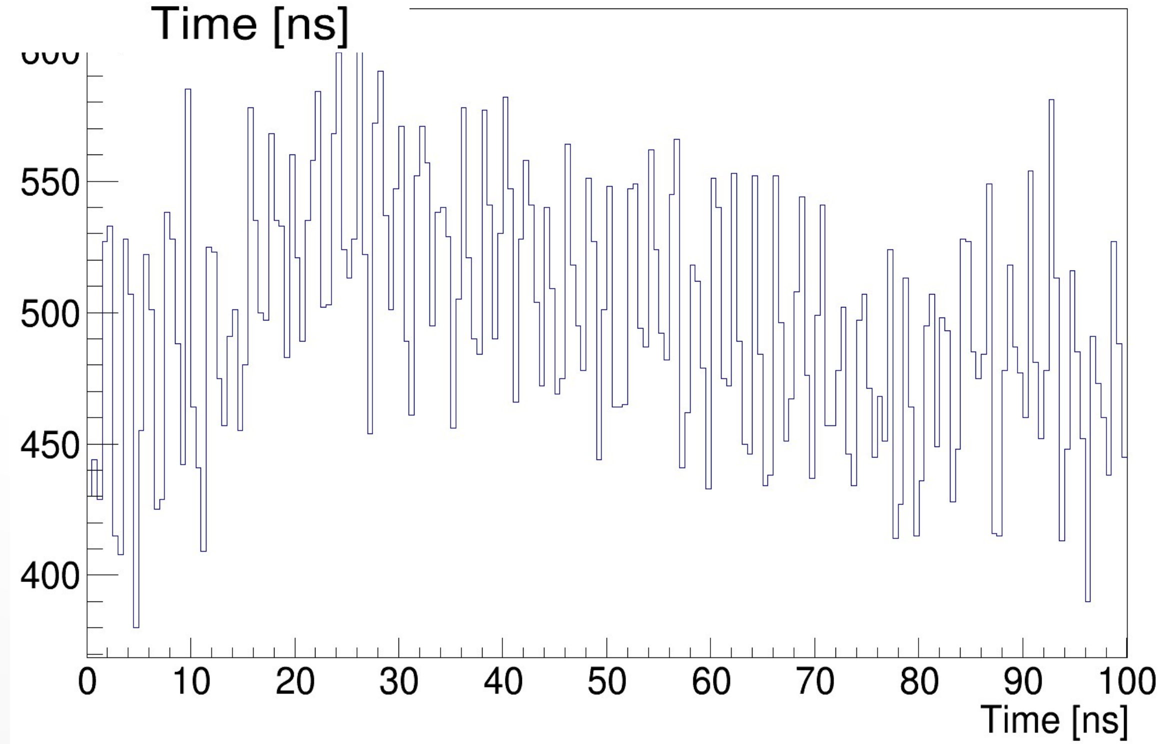
# Exclusive Triple Coincidence D(e,e'pn) Events



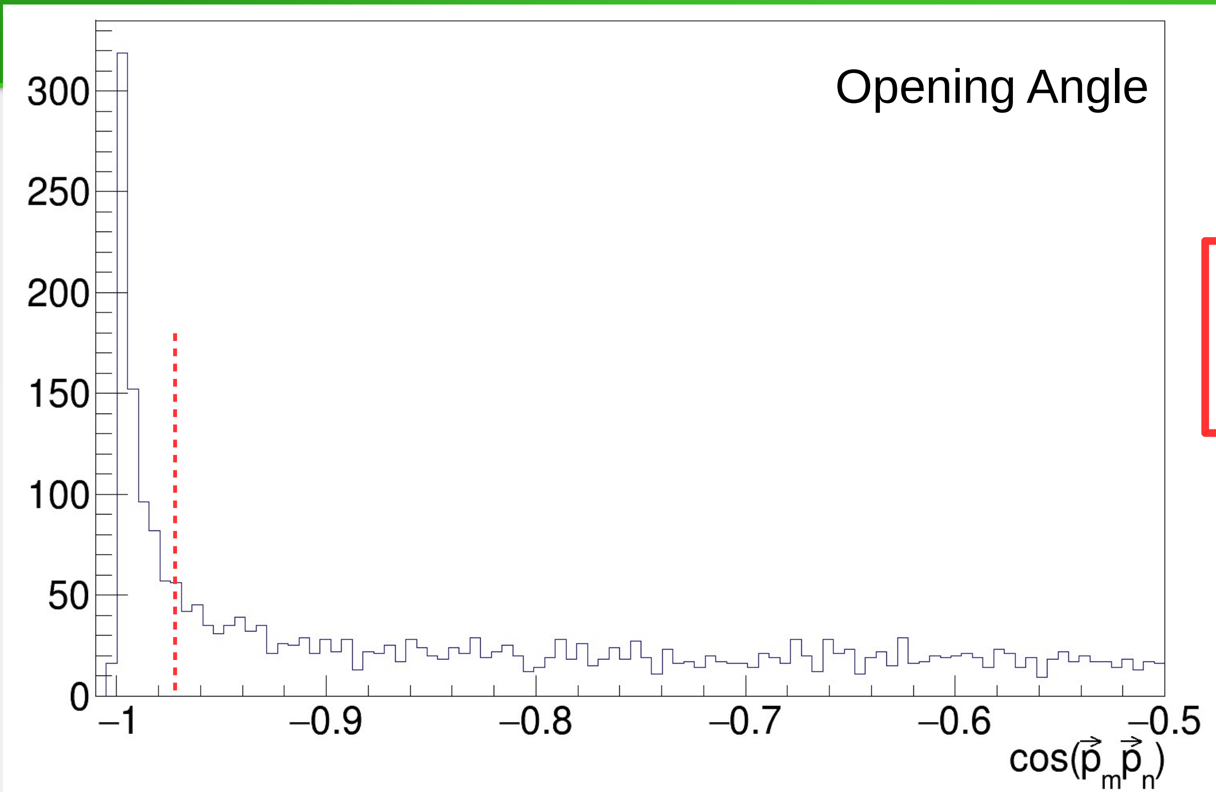

2 ns – beam structure

Adding Missing Mass cut



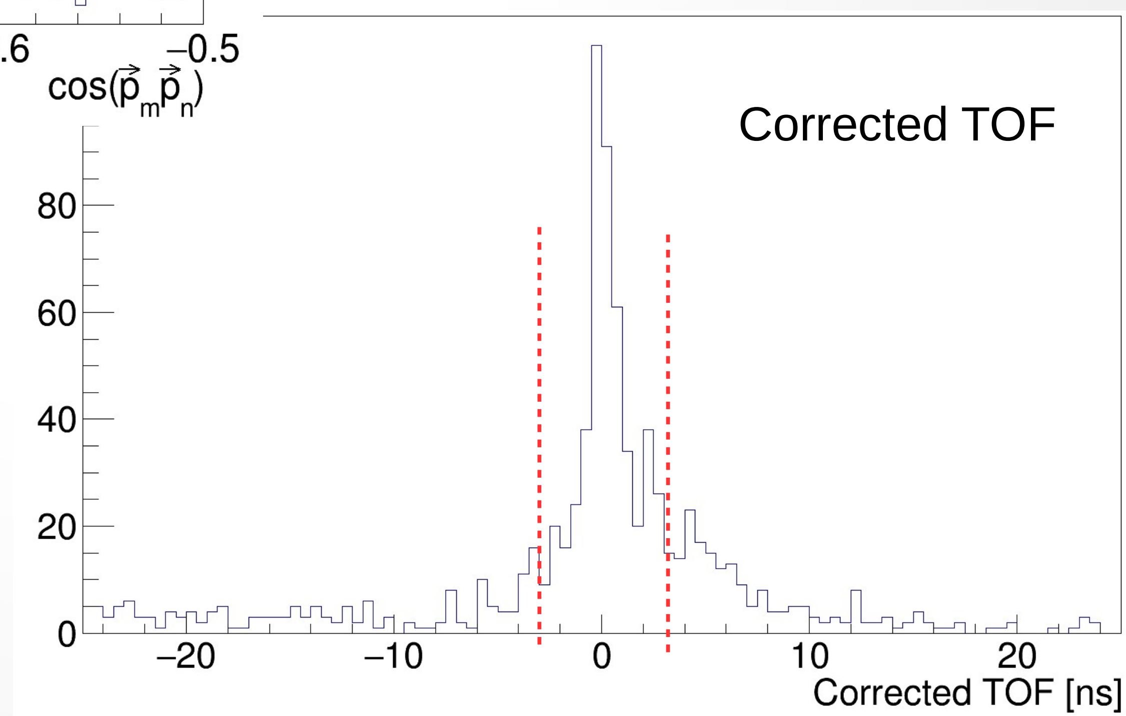
# Characterization of D(e,e'pn) Events



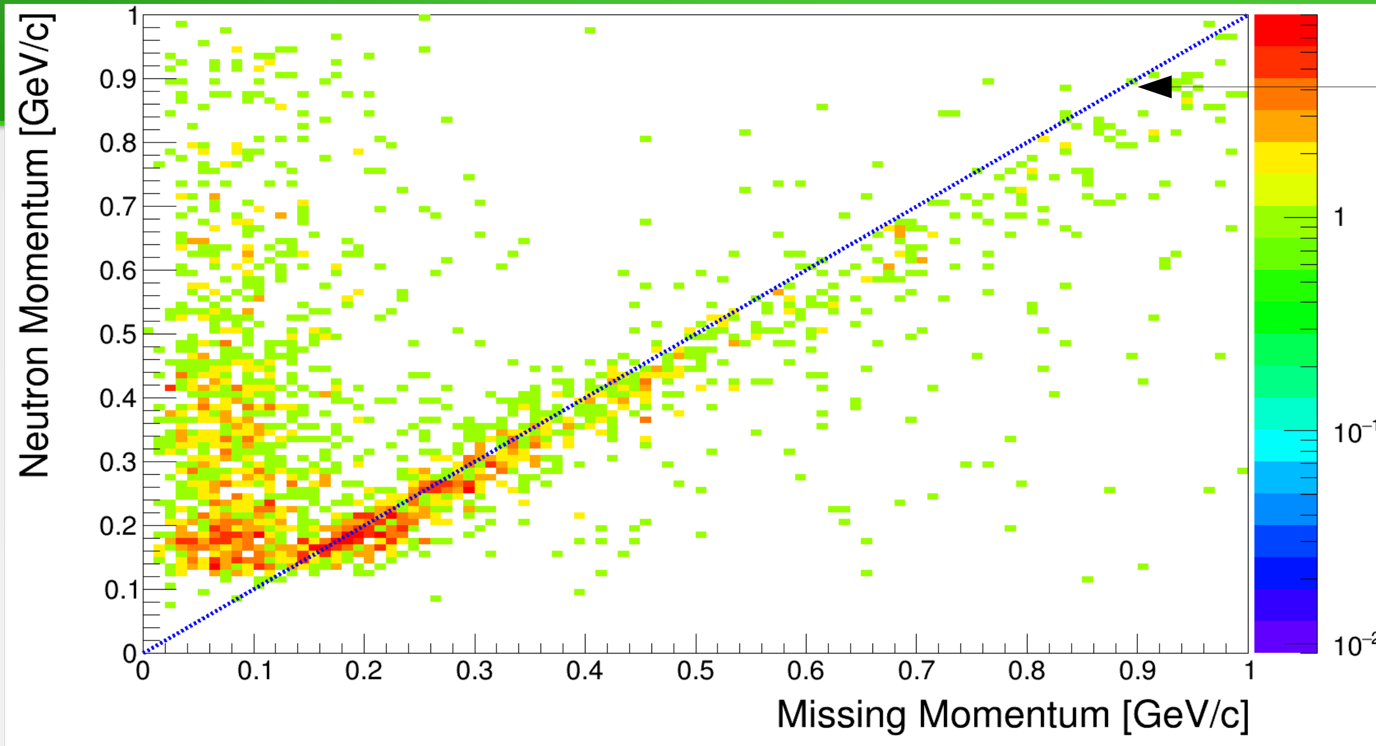

*Measured*

$$Corrected\,TOF = T_{neutral} - \frac{Distance}{c \cdot \beta}$$

Expected, based on Missing Momentum

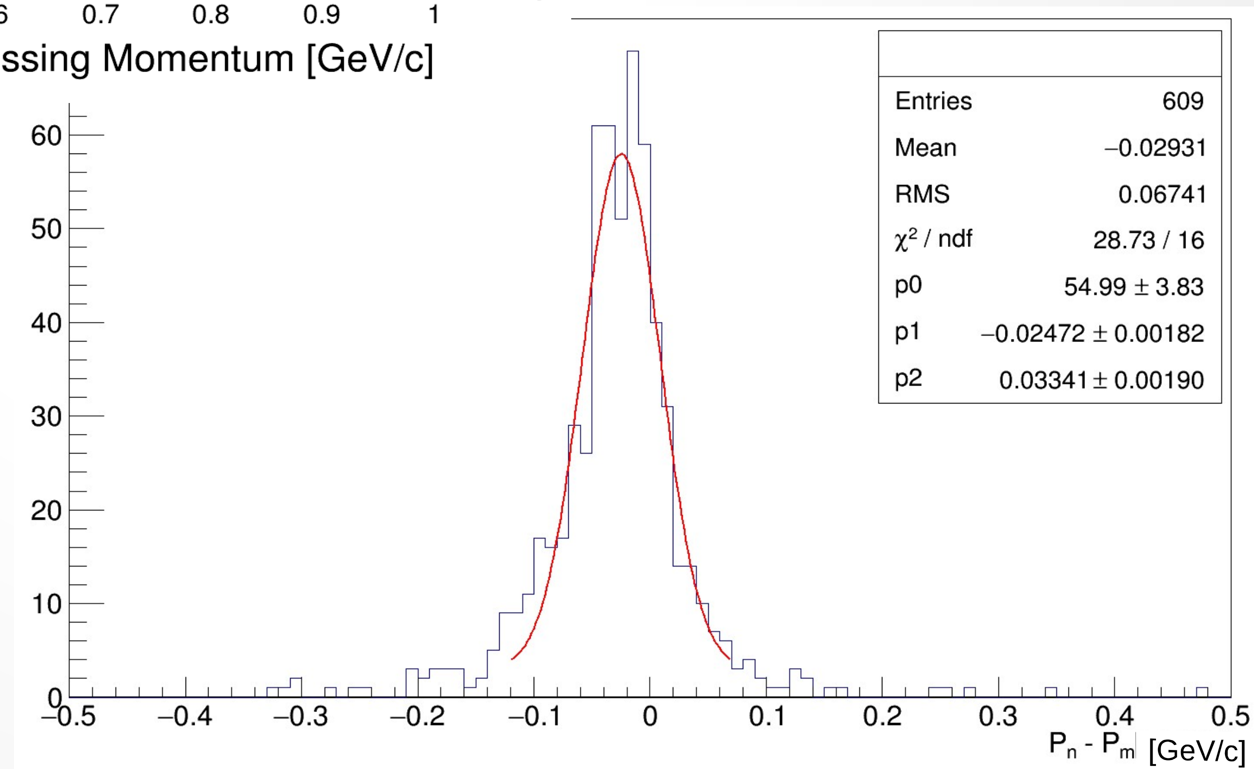


# Identification of neutrons from D(e,e'pn) Events




Dashed line only for guidance

Corrected TOF is not included

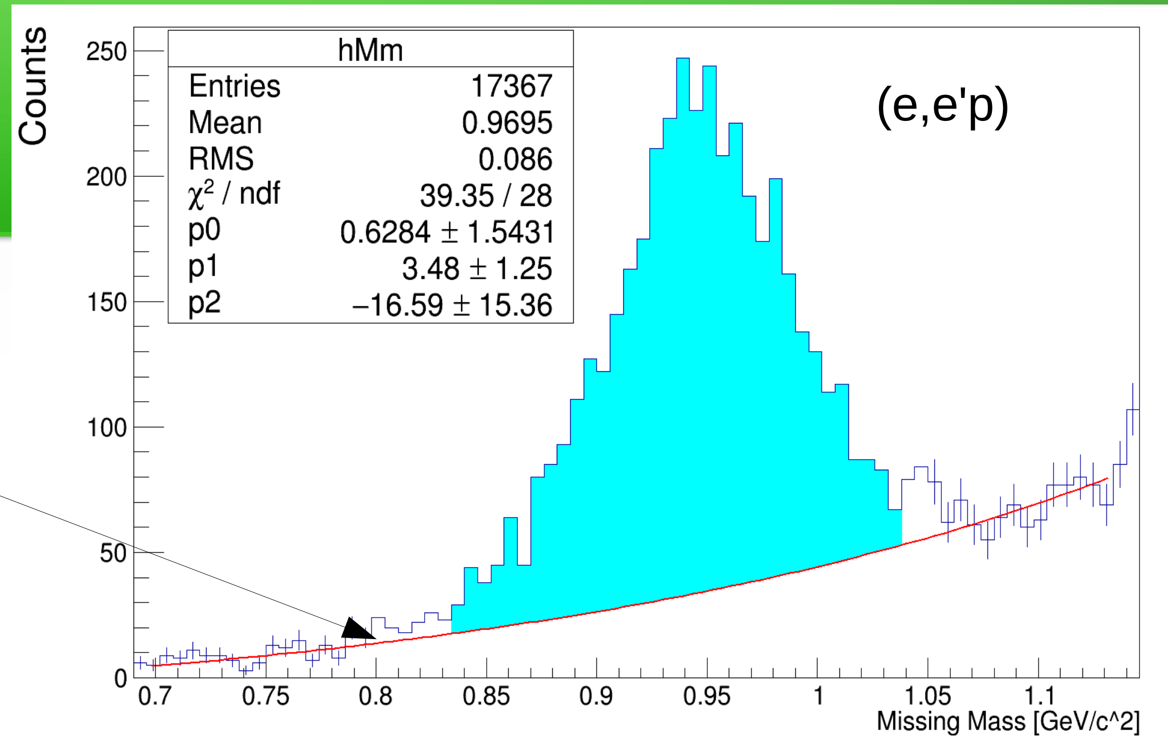


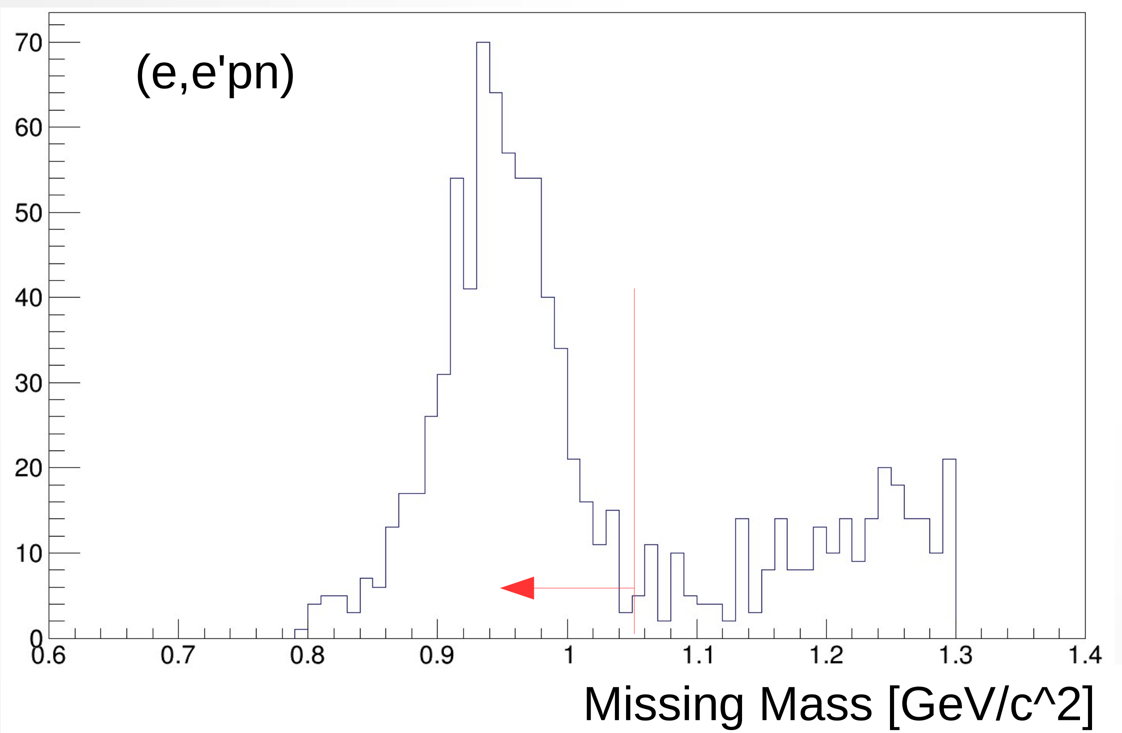

Momentum Resolution

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

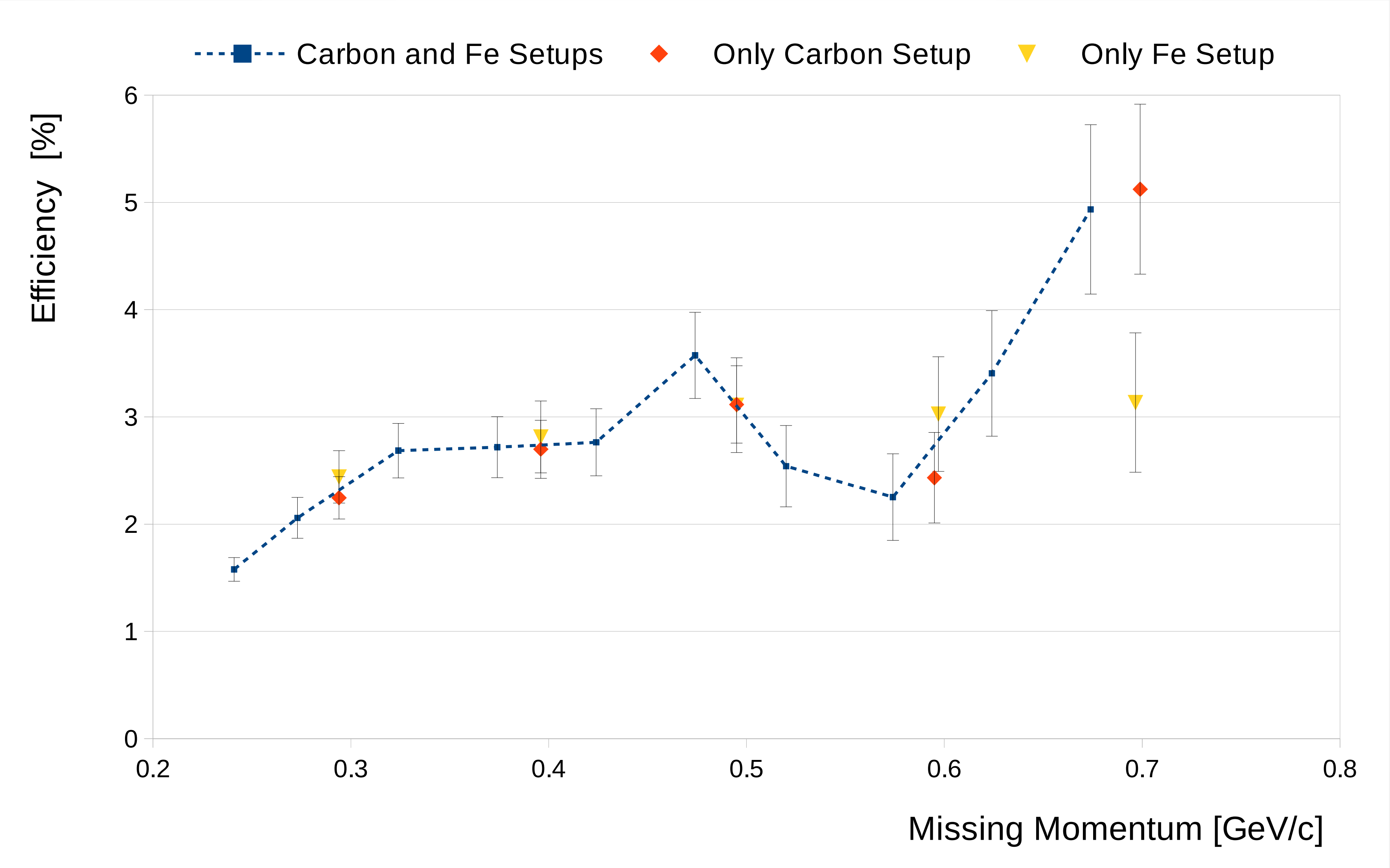
# Backgrounds From Subtraction

Red Line: Empirical fit to the data



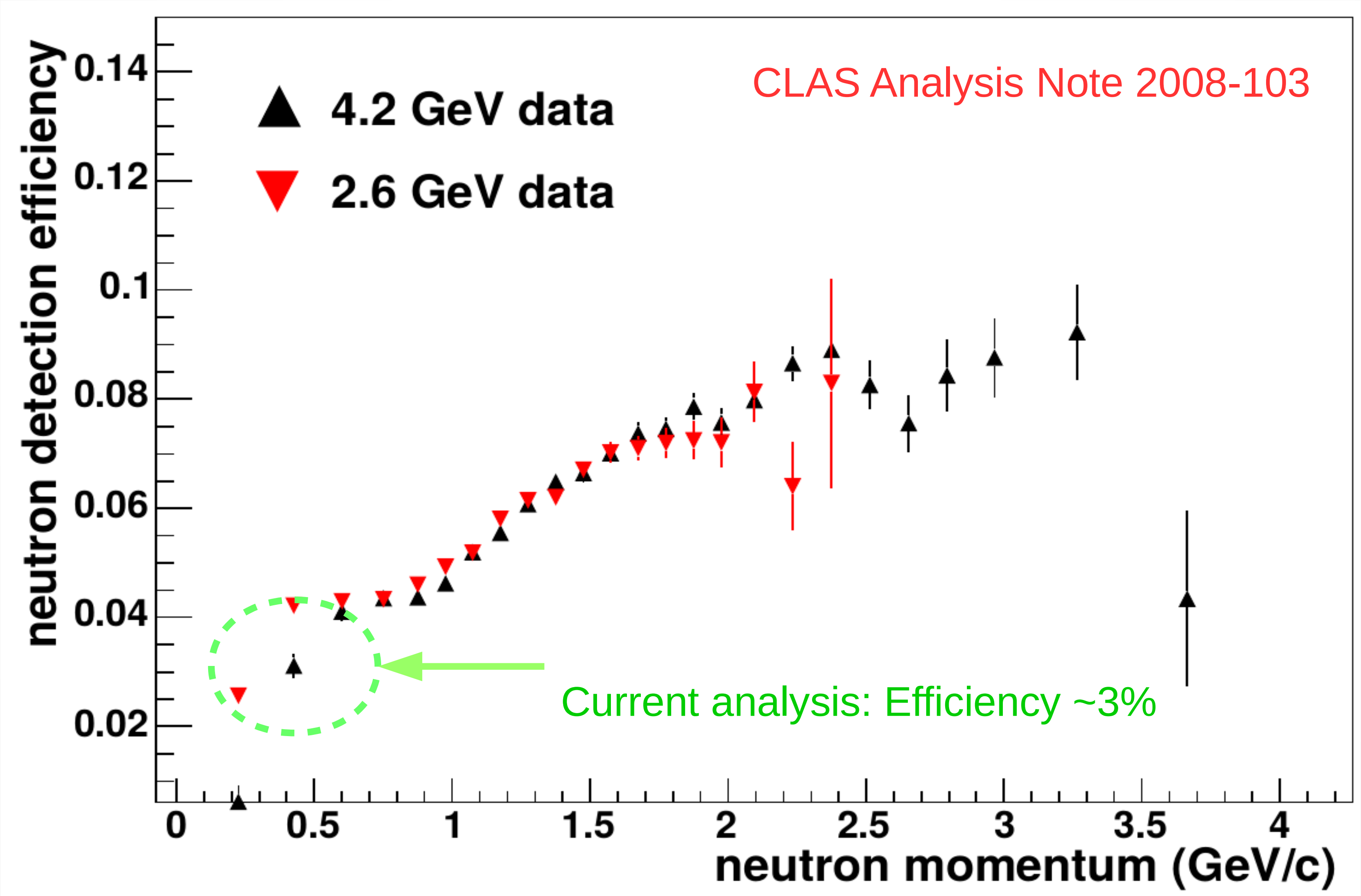



# Neutron detection efficiency



# Neutron Detection Efficiency (Gn analysis)

Efficiency determined using: $ep \rightarrow e\pi^+(n)$



# Summary:

1) Good identification of neutrons

2) No contamination of charged particles in the data – Veto algorithm

3) Consistent efficiency with previous analysis

**Future plans:**

1) Fiducial cuts

2) Sensitivity tests

3) Extract SRC ratios for different nuclei