CLAS Collaboration Meeting
July 22, 2020

Neutron Detection Efficiency in the Forward Calorimeter

$$e\,p \longrightarrow e'\pi^{+}(n)$$

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Outline and Physics Motivation

Motivation :

Necessary for G_M^n measurements in Run Group B and to other analyses/run groups.

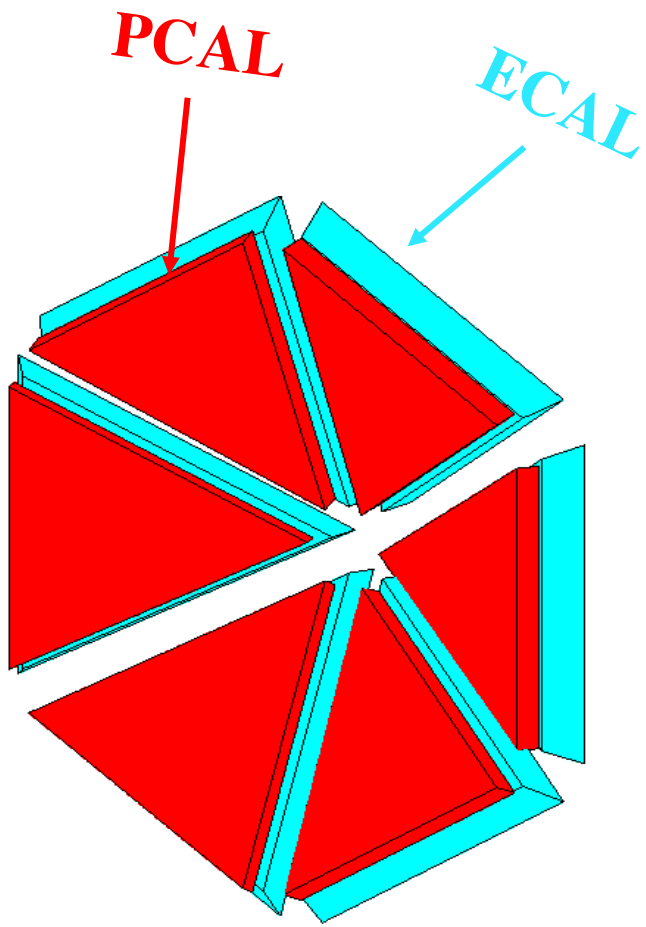
These studies are important in refining neutral particle identification.

Outline :

Method to extract neutron detection efficiency (NDE).

Calculate neutron efficiency for both PCAL and ECAL combined.

Calculate neutron efficiency separately and for each sector.

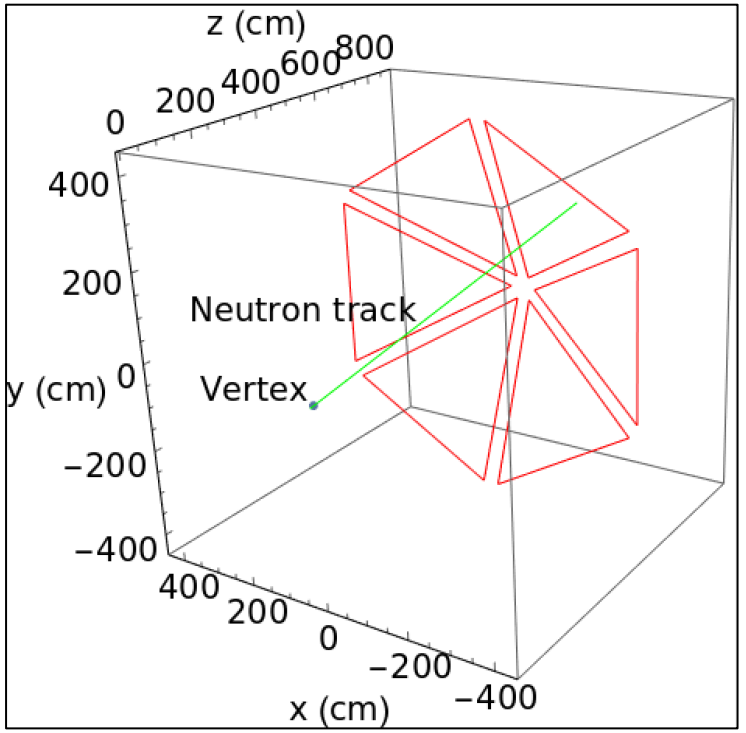


Extracting Neutron Detection Efficiency

Determine the neutron detection efficiency (NDE) by using:

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

- Select $e'\,\pi^{+}$ final state with no other charged particles $p(e, e'\,\pi^{+})X_n$.
- Assume the missing particle is a neutron, calculate the missing momentum of the neutron and it's trajectory through CLAS12 from the $e'\ \pi^{+}$ vertex.
- Check if the neutron's path intersects with the front face of PCAL/ECAL



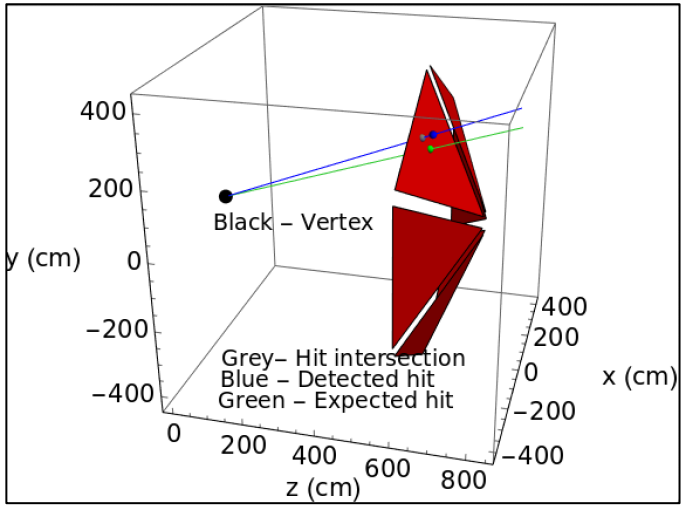
Yes → counted as expected

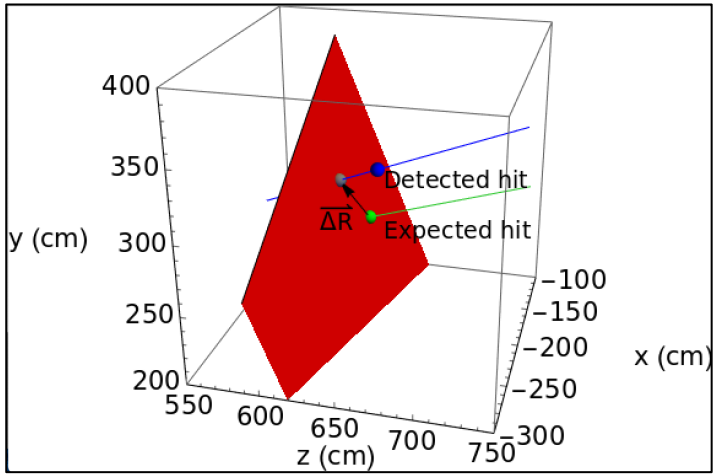
NO → skipped the event

Extracting Neutron Detection Efficiency

- Loop over neutral PCAL/ECAL hits:
  - ✓ Get intersection of ray with the PCAL/ECAL face by drawing a line from the e′ π^+ vertex to the actual neutral PCAL/ECAL hit.
  - ✓ Calculate ΔR for each actual neutral PCAL/ECAL hits, which is the distance between the intersection of the PCAL/ECAL hit and the intersection of the expected neutron trajectory.
  - ✓ Select hit with the smallest ΔR.
  - ✓ To identify neutrons we applied cut on:
    - ✓ Direction cosine of the expected neutron intersection to coincide with the direction of the detected neutral intersection.
    - ✓ Mass squared calculated from the measured $\beta_{neutral}$ in PCAL/ECAL and missing momentum.

$$\mathrm{NDE} = \frac{N_{detected\,(n)}}{N_{expected\,(n)}}$$





Particle Identification

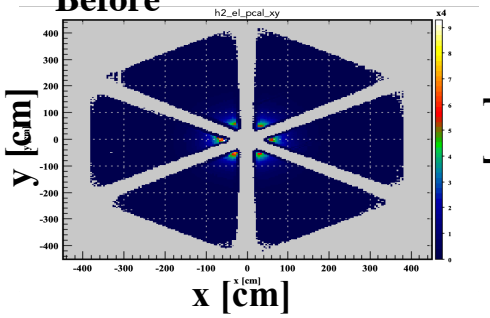
Using RG-A data from fall 2018 (pass 1 cooking)

Cuts are applied to clean up the electron and π^+ sample:

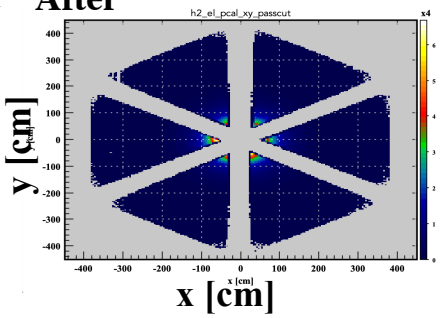
- **Electromagnetic Calorimeter fiducial cut**

Medium cuts based on Stefan's DPWG presentation on Sep 12th.

Before



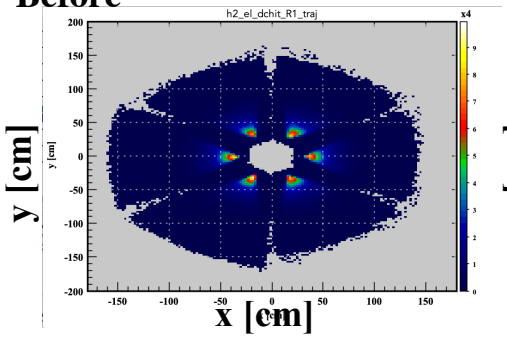
After



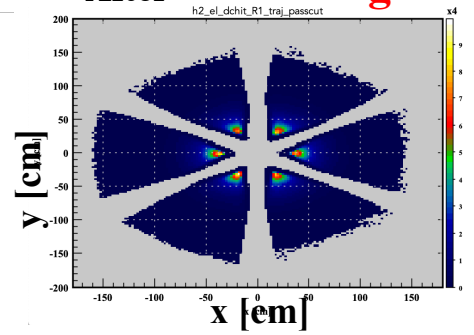
- **Drift chamber region 1,2,3 fiducial cut**

DC region 1

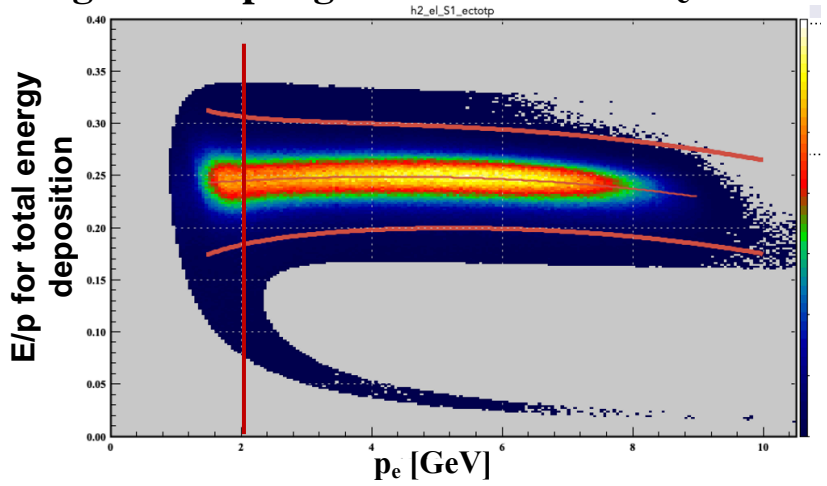
Before



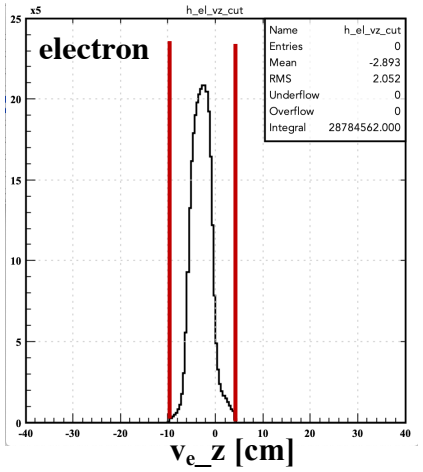
After



- **3 Sigma Sampling fraction cut && $P_e > 2.1$ GeV**

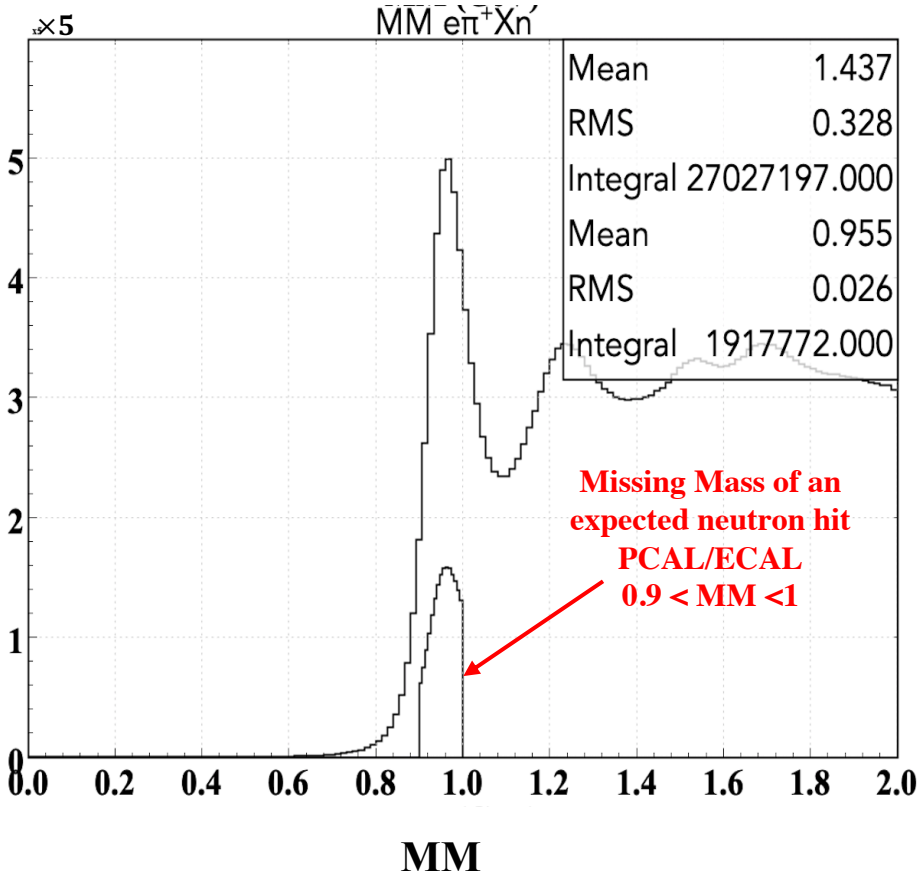


- **3 sigma z-vertex position cut for both electron and π^+**

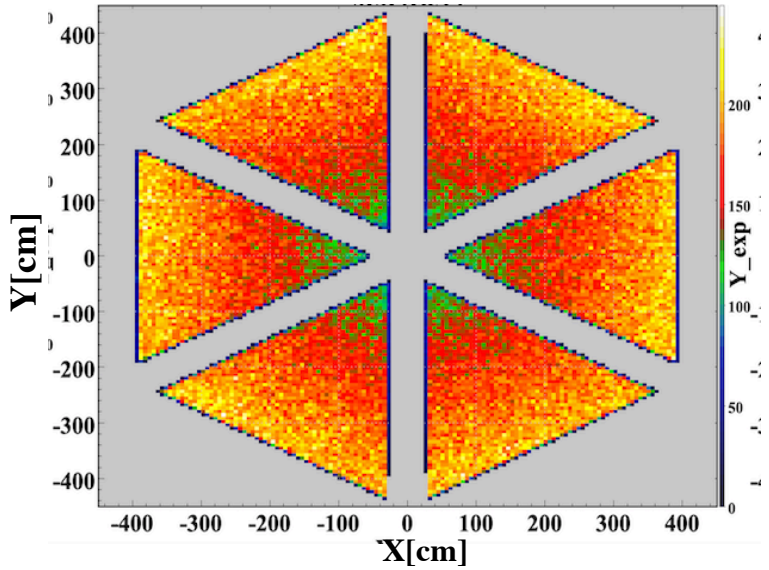


- **$-2 < Chi2\_pip < 2$**

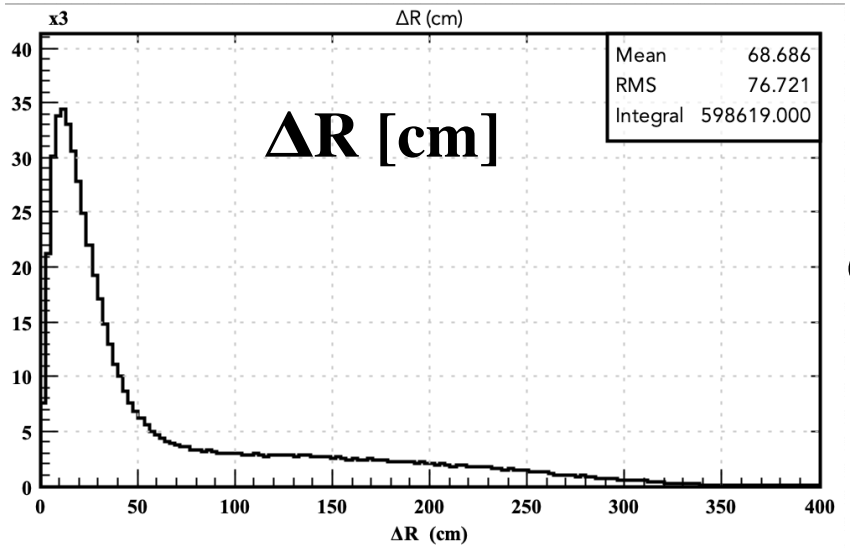
Missing Mass of Expected Neutron PCAL/ECAL



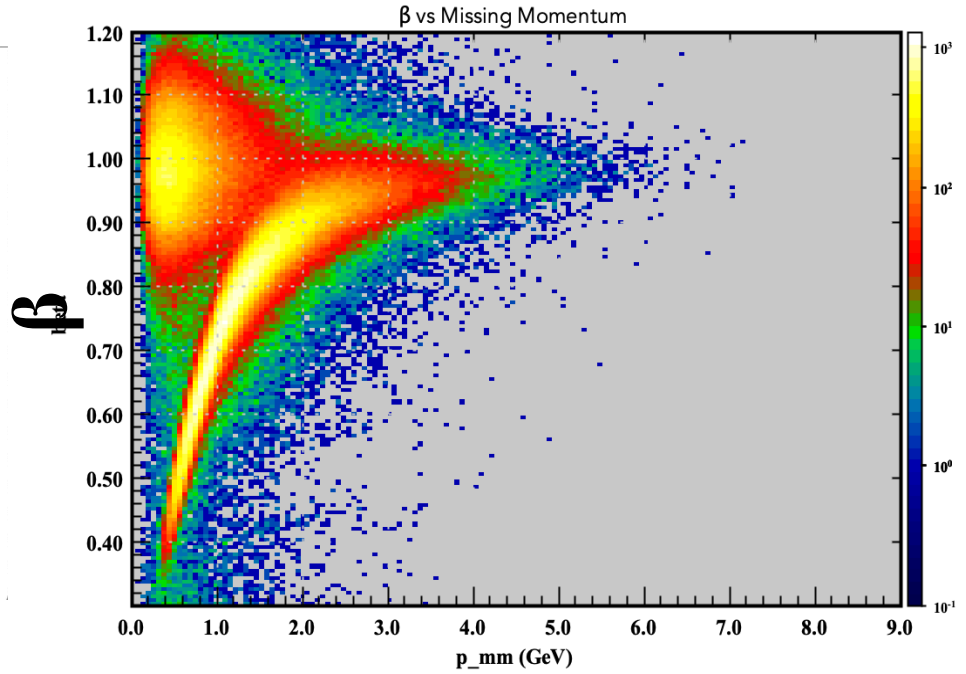
Intersection point of expected neutron with front face of PCAL/ECAL



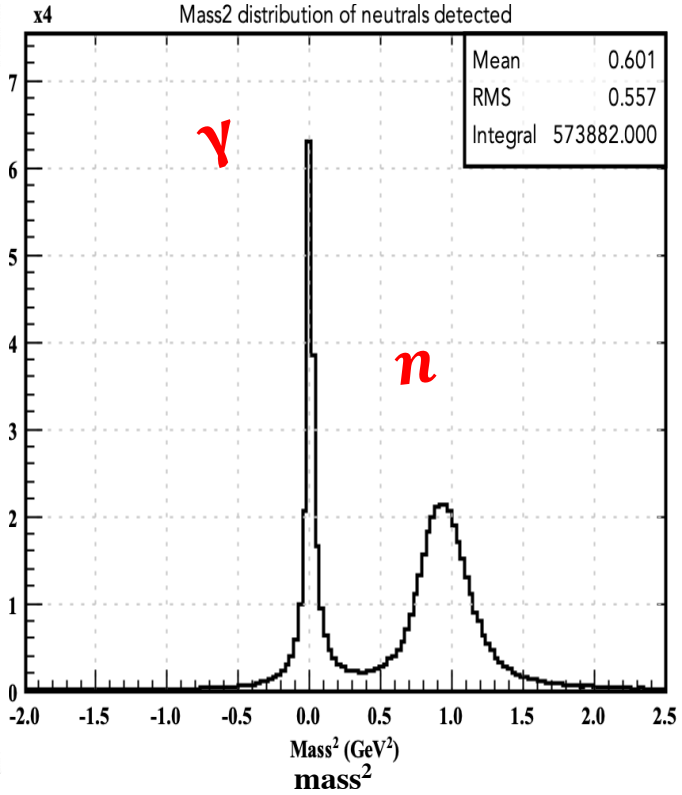
Neutral Particles Measured in PCAL/ECAL



ΔR is the distance between the Intersection point of expected neutron and the intersection of detected neutral particles with the front face of PCAL/ ECAL



$\beta_{neutral}$ calculated from the path/time in PCAL/ECAL vs p_mm



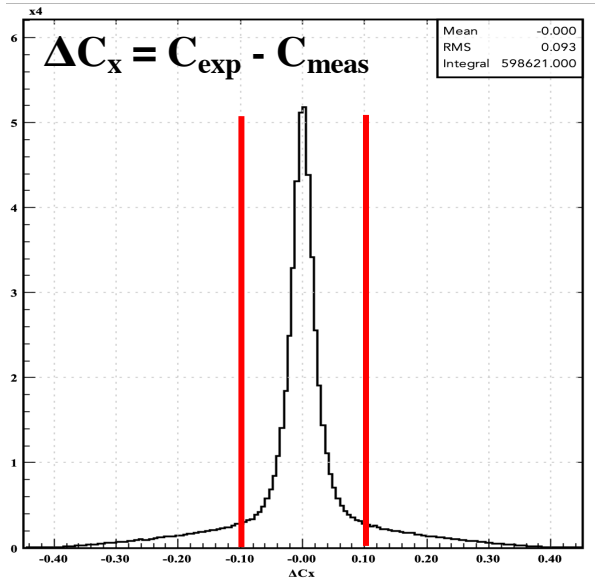
mass^2

mass^2 distribution of the neutral particles calculated from the measured β *neutral* and missing momentum

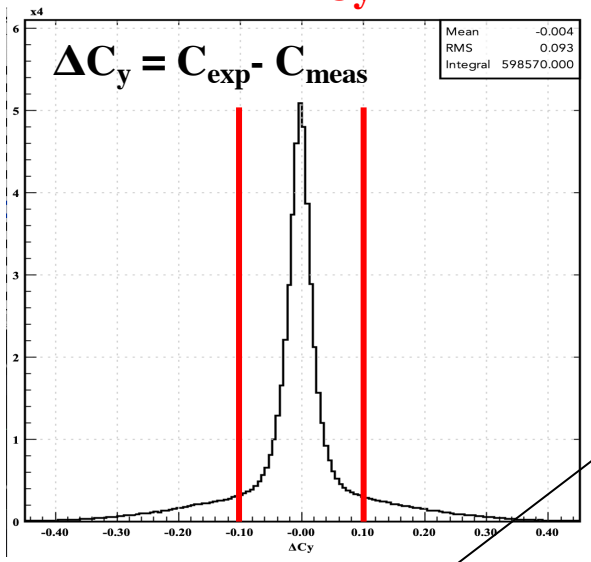
Identifying Neutron in PCAL/ECAL

Here Using Cole Smith Cuts

-0.1 < ΔCx < 0.1



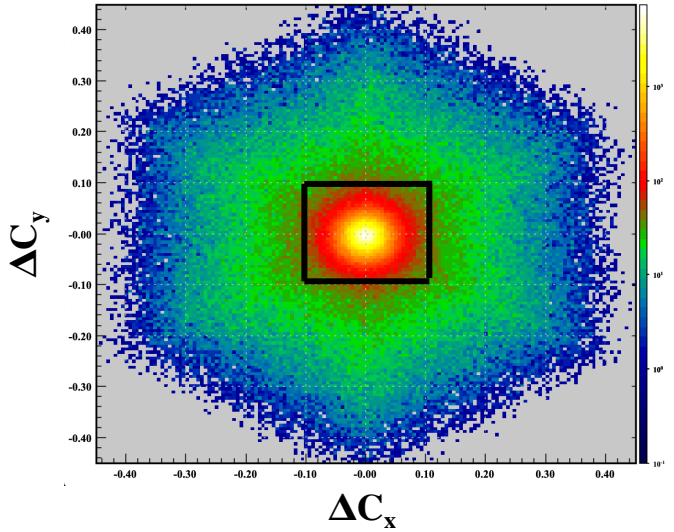
-0.1 < ΔCy <0.1



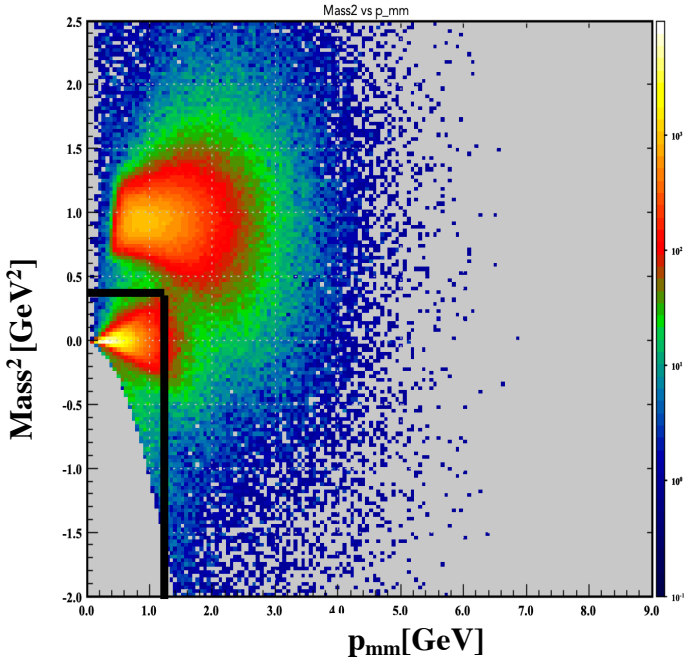
To identify neutron hits:

Required the direction cosine of the expected neutron C_{exp} to coincide with the direction of the measured neutral particles C_{meas}

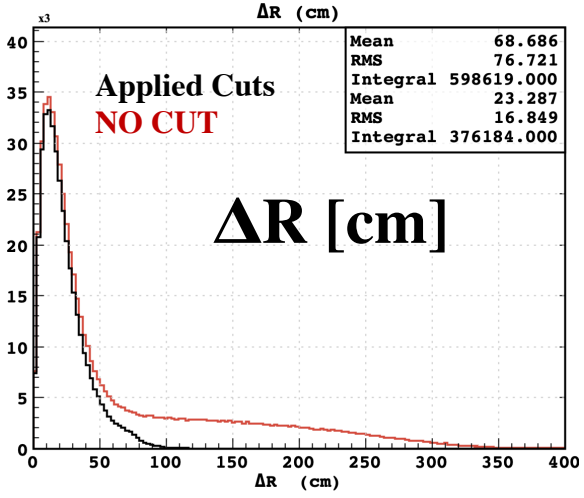
$\Delta C = C_{exp} - C_{meas}$

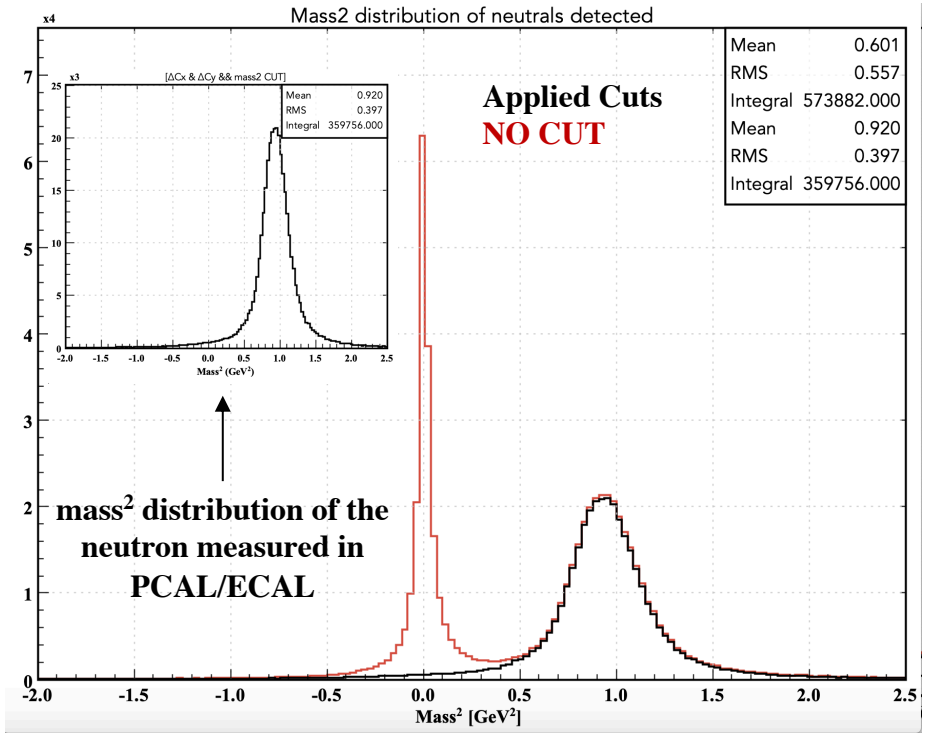


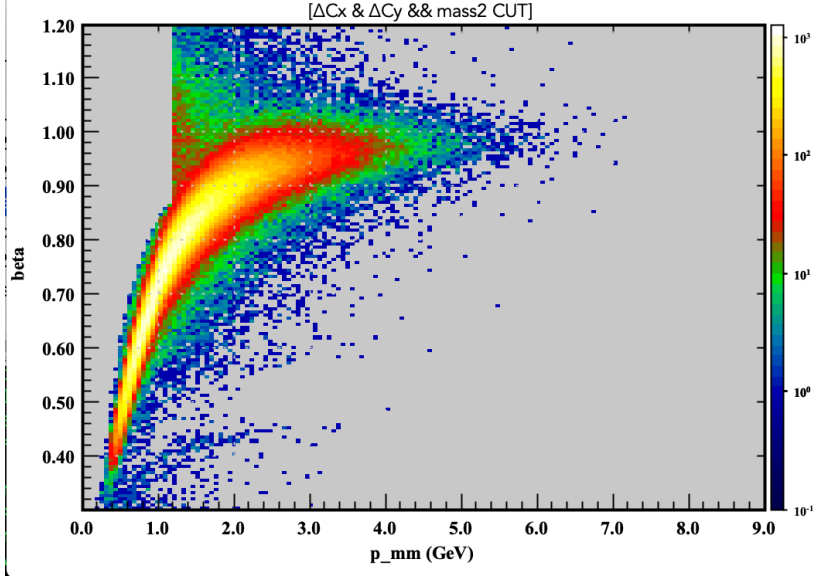
$mass^2 > 0.45$ If p_mm <1.2



Neutron Particles Measured in PCAL/ECAL







Cuts Applied:

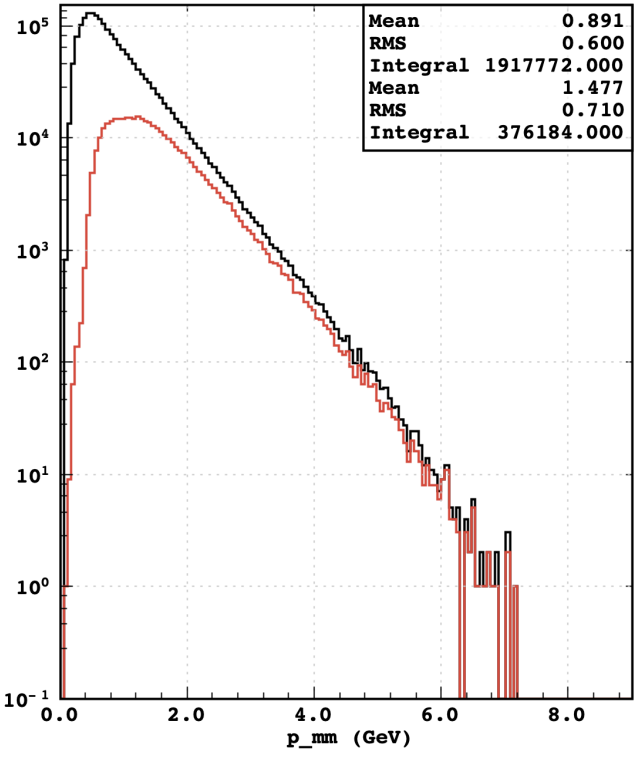
$-0.1 < \Delta Cx < 0.1$

$-0.1 < \Delta Cy < 0.1$

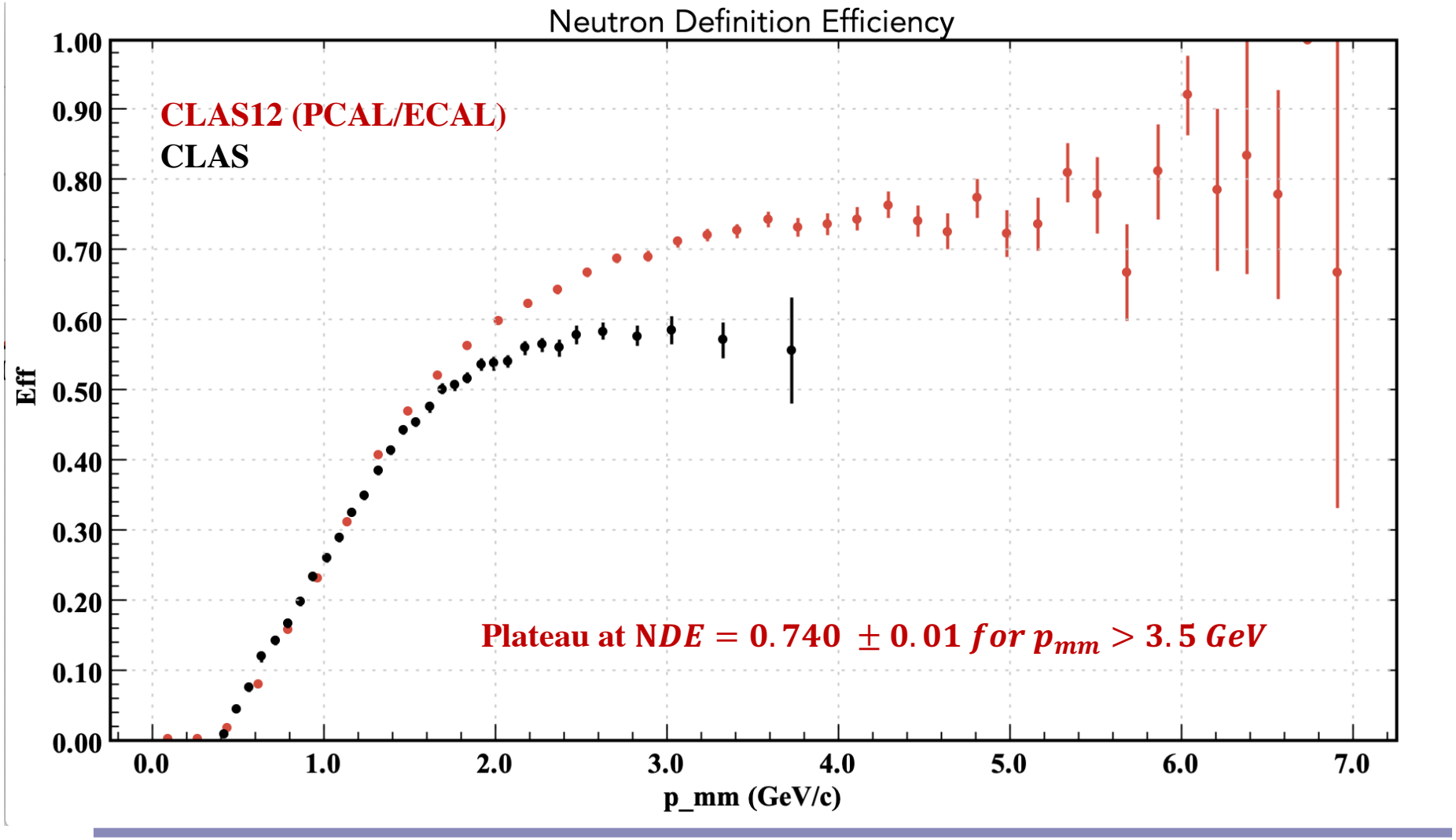
$mass^2 > 0.45$ If p_mm <1.2

Missing Momentum of Expected neutron

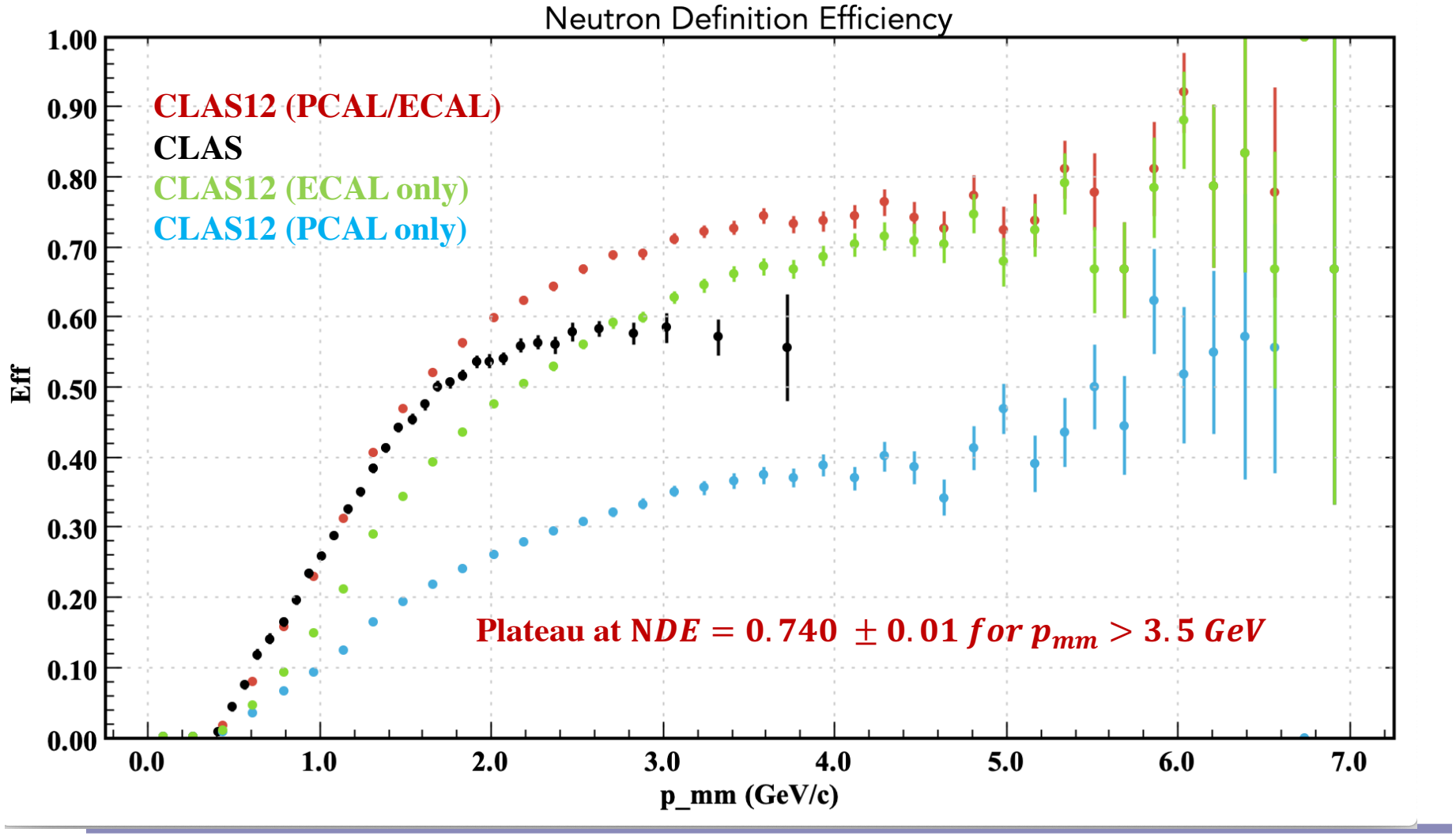
Missing Momentum of Detected neutron

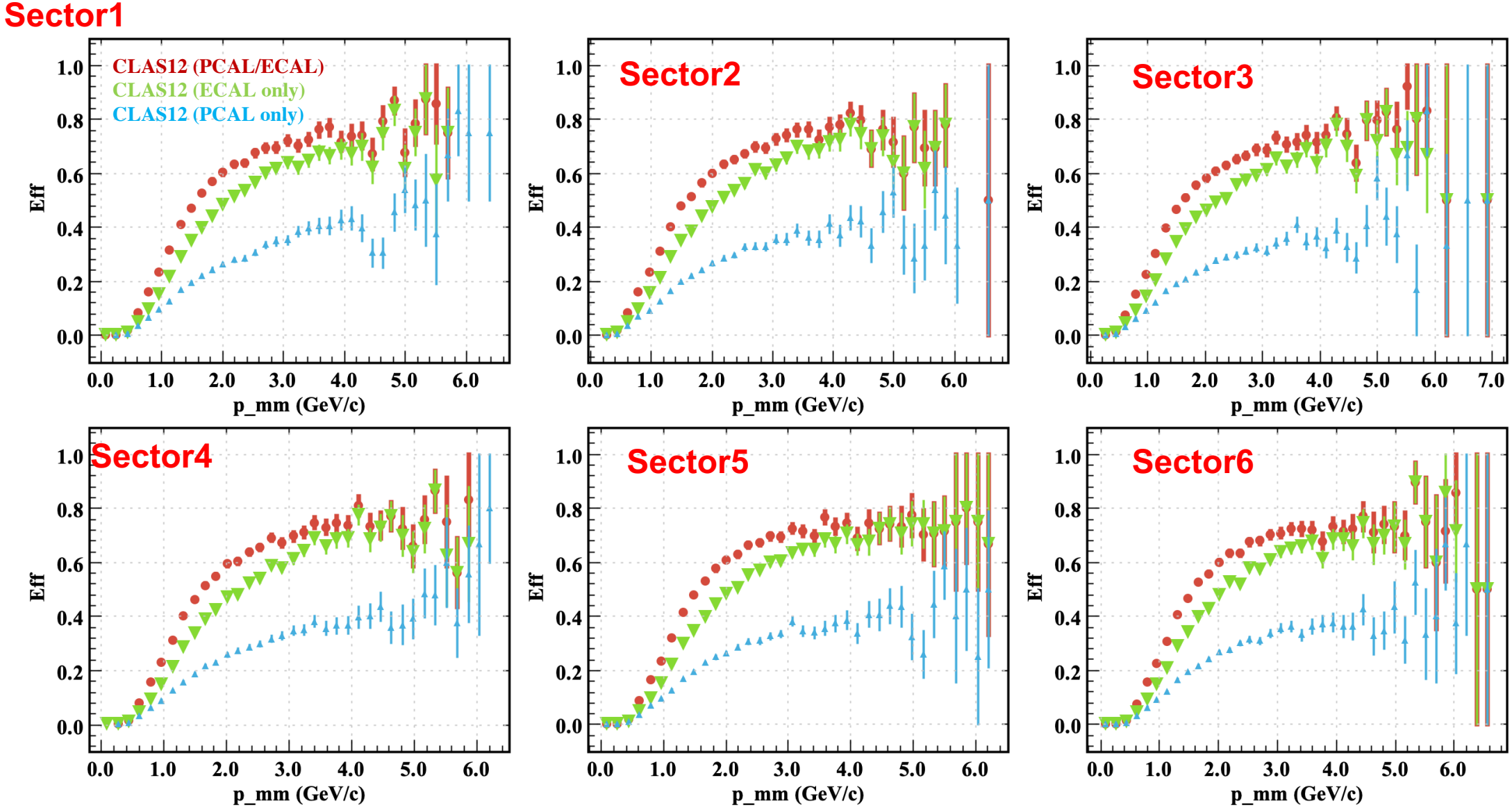


Results of NDE



Results of NDE

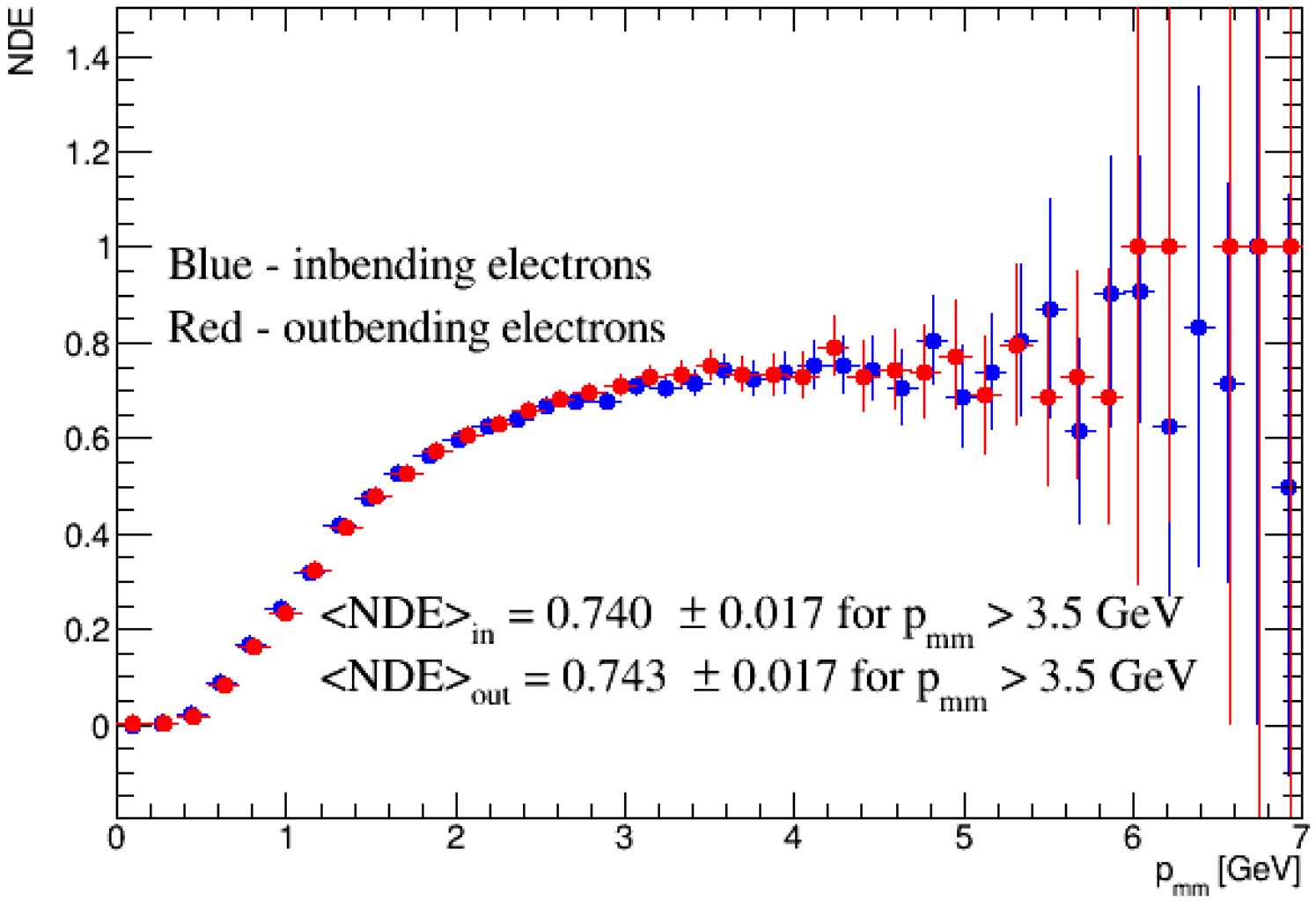




NDE similar in each sector

Need to make quantitative comparison

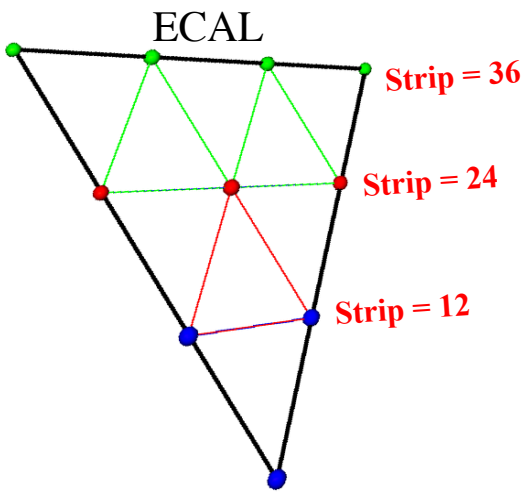
Results of NDE of inbending and outbending data

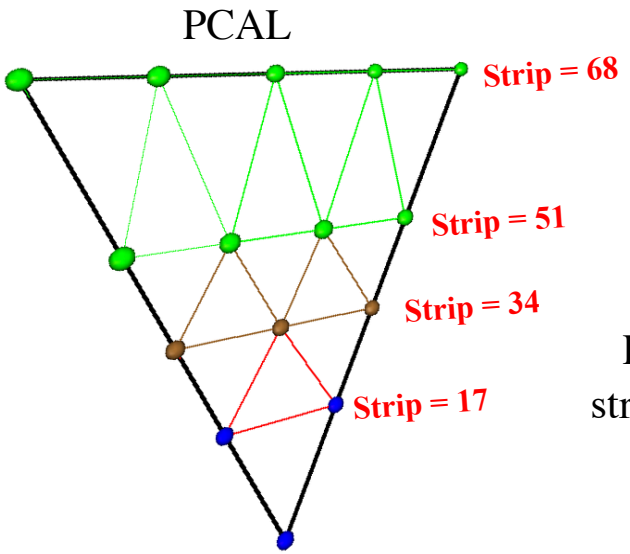


What is Next ….

- Improve the accuracy of both the numerator and denominator of the efficiency ratio by determine the right shape background.

- Subdivide the Calorimeter into smaller units (based on a readout) and calculate NDE for each unit



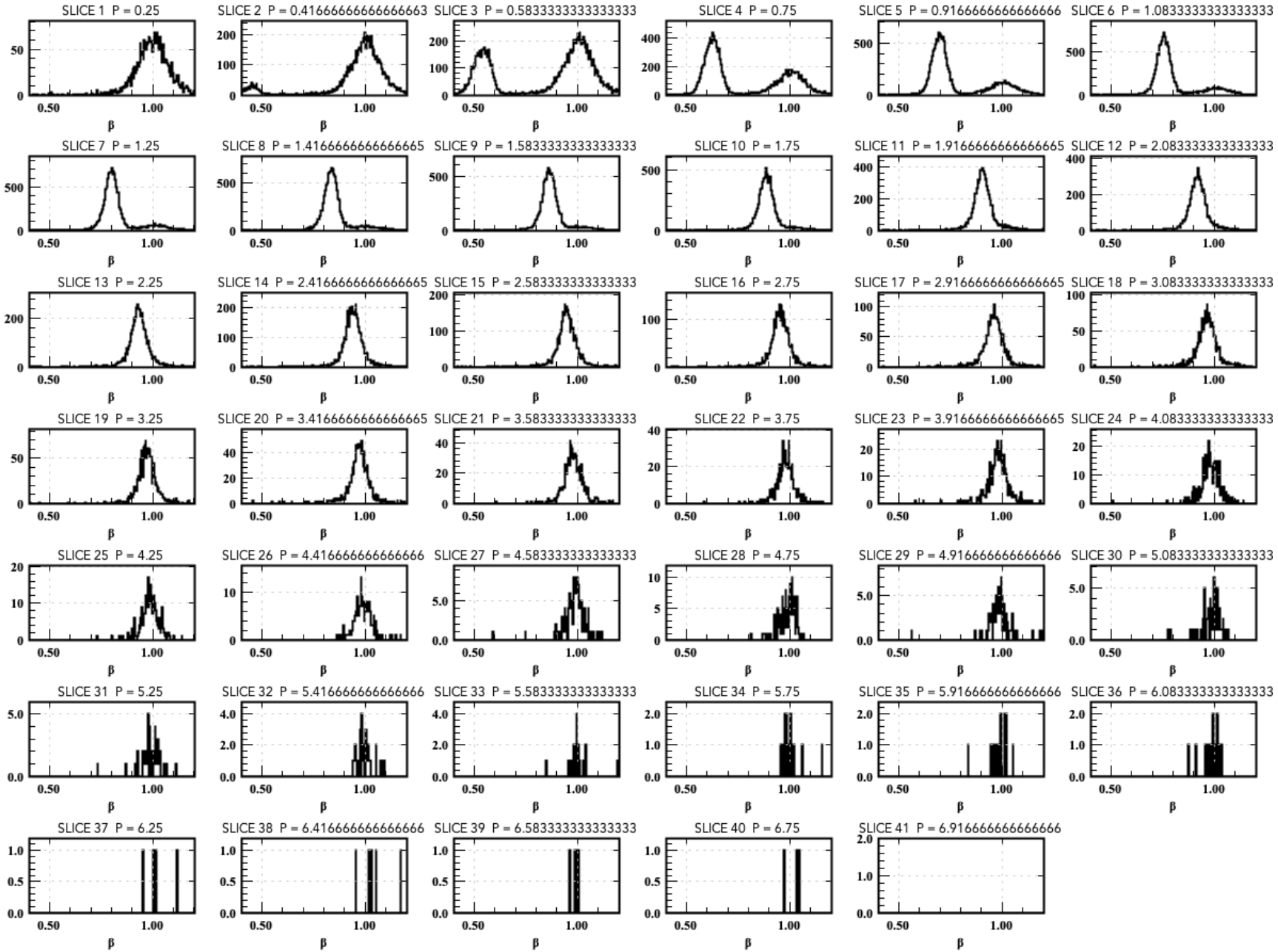


PCAL has 84 strips: the shortest 52 strips are read out individual and 32 are paired into 16 readout
Total readout =68

Thank you ..

Backup Slides

Beta of neutral particles in each missing momentum bin



Beta of neutral particles in each missing momentum bin

Cuts Applied:

$-0.1 < \Delta Cx < 0.1$

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$mass^2 > 0.45$ If p_mm <1.2