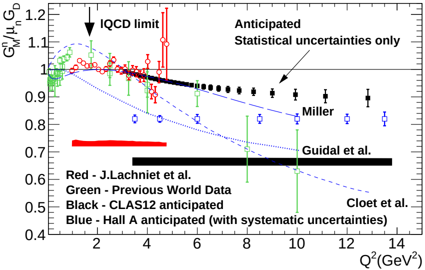
Update on Neutron Detection Efficiency for G_M^n

1. Lamya Baashen, B.Raue, J.Gilfoyle, C.Smith.
2. Ratio Method on Deuterium:

$$R = \frac{\frac{d\sigma}{d\Omega}[^2\mathrm{H}(e,e'n)_{QE}]}{\frac{d\sigma}{d\Omega}[^2\mathrm{H}(e,e'p)_{QE}]}$$

$$= a \times \frac{\sigma_{Mott}\left(\frac{(G_E^n)^2+\tau(G_M^n)^2}{1+\tau}+2\tau\tan^2\frac{\theta_e}{2}(G_M^n)^2\right)}{\frac{d\sigma}{d\Omega}[^1\mathrm{H}(e,e')p]}$$

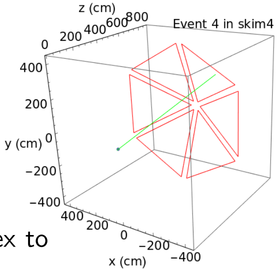
where a is nuclear correction.



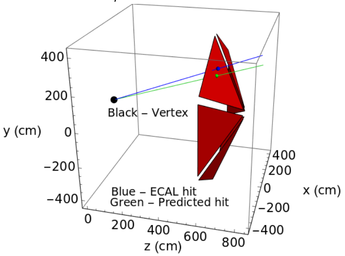
3. Precise neutron detection efficiency needed to keep systematics low.
   - tagged neutrons from $^1\mathrm{H}(\mathrm{e},\mathrm{e}'\pi^+(\mathrm{n}))$.
   - LH_2 target (RGA).
   - Select $e'\pi^+$ final state with no other charged particles.
   - Use missing mass to separate out neutrons.
   - Assume the missing particle is a single neutron and calculate it's 3-momentum and it's trajectory through CLAS12 from the $e'\pi^+$ vertex.

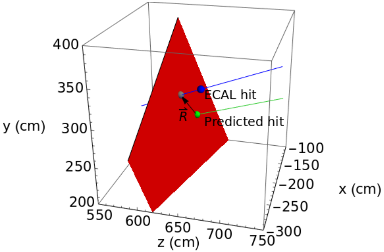
Extracting the Neutron Detection Efficiency

4. Do we expect the neutron to hit the PCAL/EC?
   - Yes $\longrightarrow$ Keep expected neutron.
   - No $\longrightarrow$ Skip event.



5. Get intersection of expected/predicted neutron trajectory and PCAL/EC face.
6. Loop over neutral PCAL/EC hits.
   - Get intersection of ray from the $e'\pi^+$ vertex to the PCAL/EC hit with the PCAL/EC face.

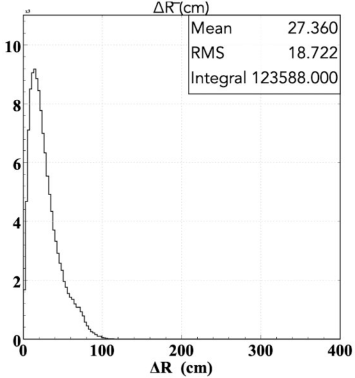




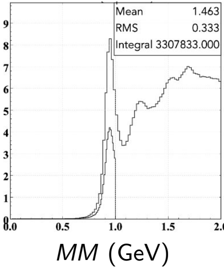
Extracting the Neutron Detection Efficiency

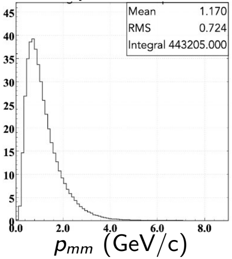
7. Continuing loop over neutral ECAL hits.
   - Calculate ΔR, the distance between the reconstructed neutron intersection and the ECAL hit intersection.
   - ΔR small $\rightarrow$ measured neutron.
   - ΔR large $\rightarrow$ skip.

8. $$NDE = \frac{measured\ \ neutrons}{expected\ \ neutrons}$$

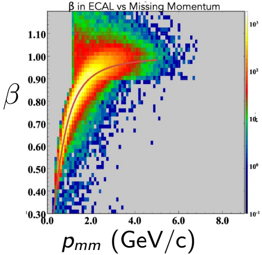


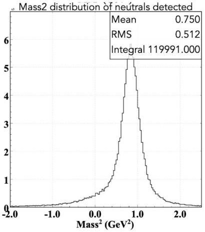
9. Missing mass cut momentum of expected neutron.



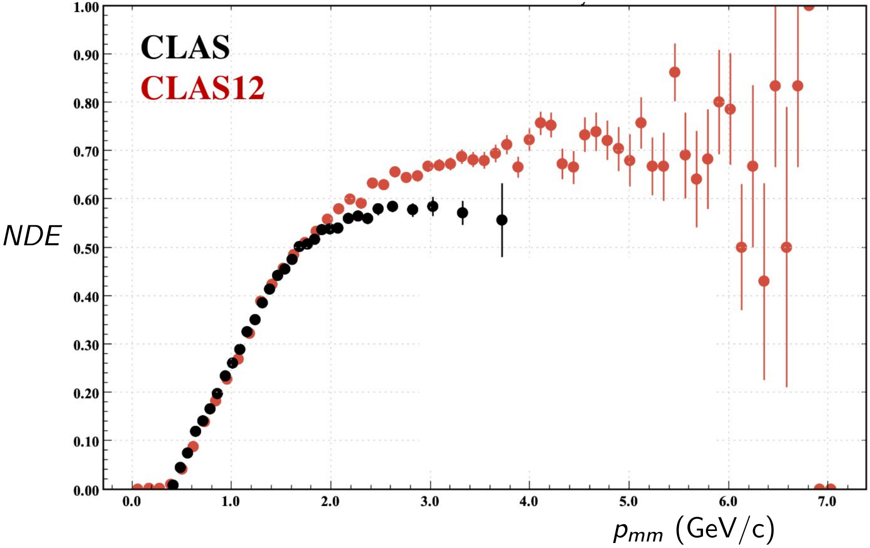


10. Neutral particles measured in PCAL/EC

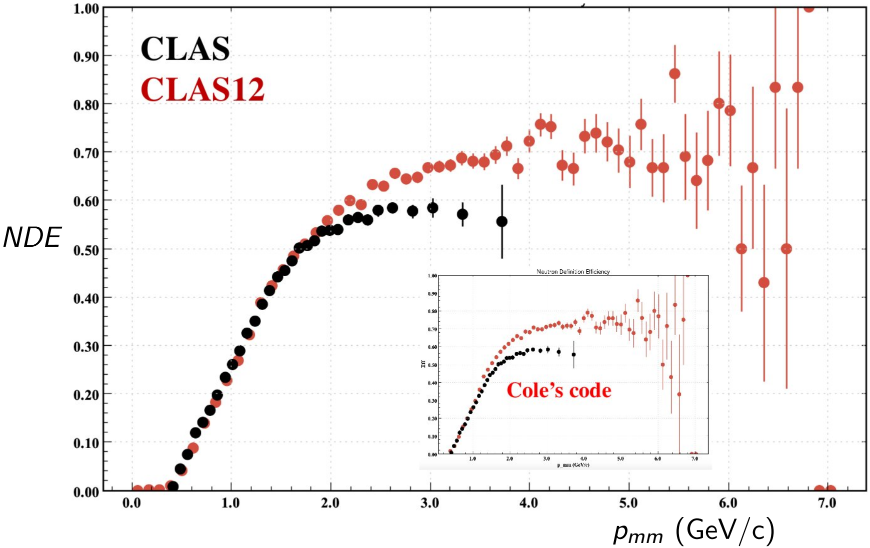




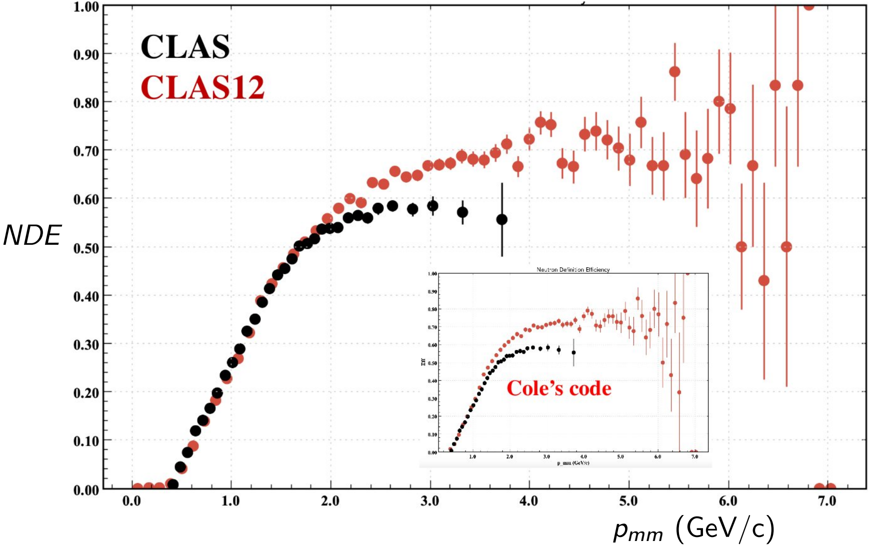
Extracting the Neutron Detection Efficiency

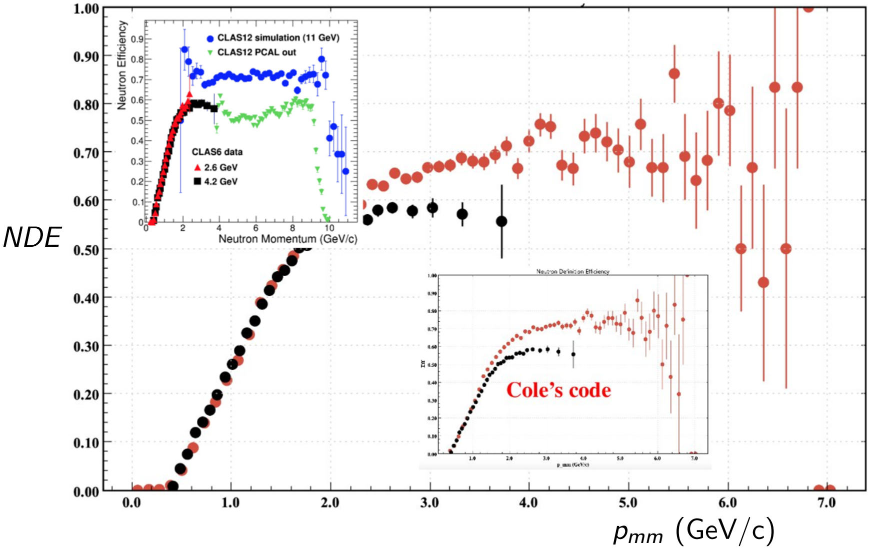


Extracting the Neutron Detection Efficiency



Extracting the Neutron Detection Efficiency




NDE
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
p_{mm} (GeV/c)
Neutron Efficiency
CLAS12 simulation (11 GeV)
CLAS12 PCAL out
CLAS6 data
2.6 GeV
4.2 GeV
Neutron Momentum (GeV/c)
Cole's code

Summary and Plans

- Preliminary results for extracting neutron detection efficiency (NDE) in the CLAS12 Forward Detector.
- Compared two codes for extracting NDE (Lamya Baashen (LB) and Cole Smith (CS)).
- Both results overlap with the CLAS6 measurement for $p_{mm} < 1.2\ \mathrm{GeV/c}$
- Results for average NDE at large p_{mm} are similar: $NDE \approx 0.7$ (LB code) and $NDE \approx 0.75$ (CS code).
- Making step-by-step comparison to study differences between the two results.
- Submit abstract to fall DNP meeting.

Two Ways To Calculate NDE

Our Method

Expected Neutron:

neutron's path intersects with the front face of ECAL

Detected Neutron:

loop over Calorimeter Bank
Select the smallest ΔR
Then Apply Cut on:
1 - Direction cosine
2- Mass squared: calculated from the measured $\beta_{neutral}$ in ECAL and missing momentum

Cole's Method

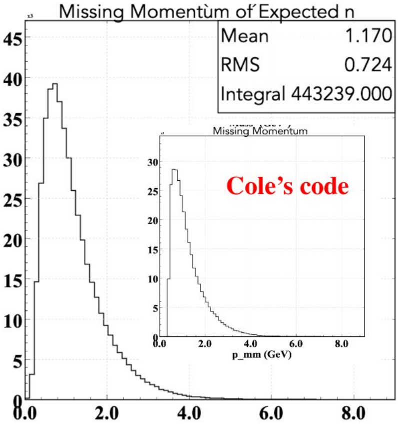
Expected Neutron:

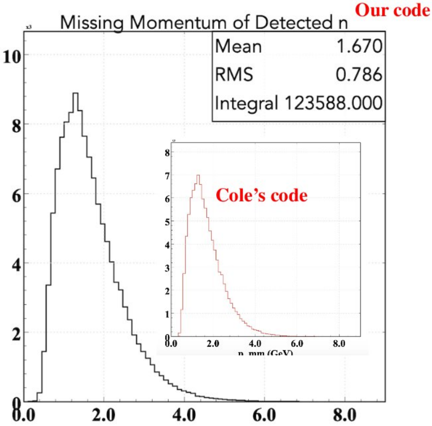
neutFiduc = $cx > 0.07$ &&
$\sqrt{(cx+0ff)^2+cy^2} < (0.52+off)$ &&
$|cy| < 0.57 * (cx - 0.07)$

Detected Neutron:

loop over all neutral particles and select one that pass both Direction cosine && Mass squared cuts

Compare Codes

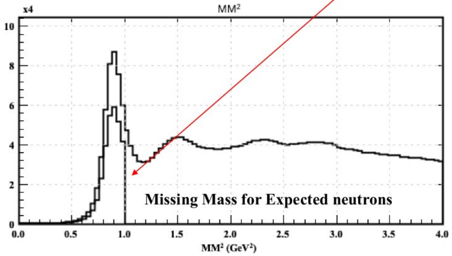


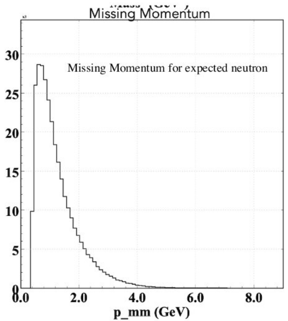


Missing Mass and Missing Momentum for Neutron

Cole's code

neutFiduc = $cx > 0.07$ &&
$\sqrt{(cx+0ff)^2+cy^2} < (0.52+off)$ &&
$|cy| < 0.57*(cx-0.07)$

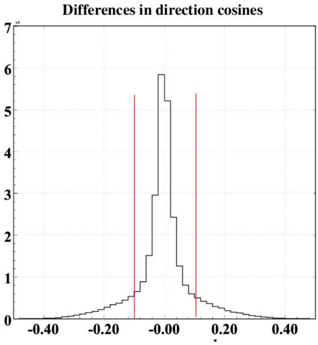


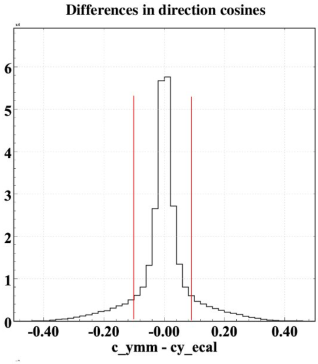


Neutral particles measured in EC

Applied cut: -0.1 < ΔCx < 0.1 && -0.1 < ΔCy <0.1

C





CS Code

Neutral particles measured in EC

If p_mm <1.2 cut mass^2 > 0.45

Cole's code