Short-Range Correlations Experiment

(E01-015)

Status Report

Ramesh Raj Subedi

(For E01-015 Collaboration)

Kent State University, Kent, OH 44242

Hall A Collaboration Meeting

12 / 06 / 2005

- Spokespersons:
  - Bill Bertozzi, Eli Piasetsky, John Watson, Steve Wood
- Physics liaison: Doug Higinbotham
- Graduate students and their research topics:
  - Peter Monaghan (MIT): ^{12}C(e,e′p) at $x_B > 1$.
  - Ran Shneor (Tel Aviv University, Israel): ^{12}C(e,e′pp).
  - Ramesh Raj Subedi (Kent State University): ^{12}C(e,e′pn).
  - Neil Thomson (University of Glasgow, Scotland, UK): ^{12}C(e,e′X), X is other than p.

Collaboration List

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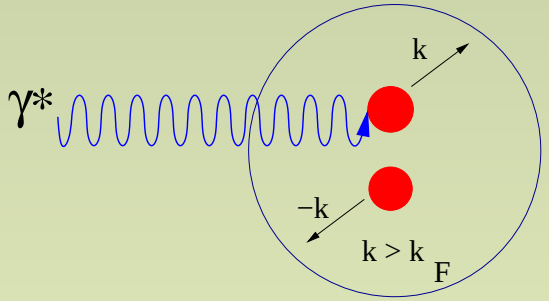
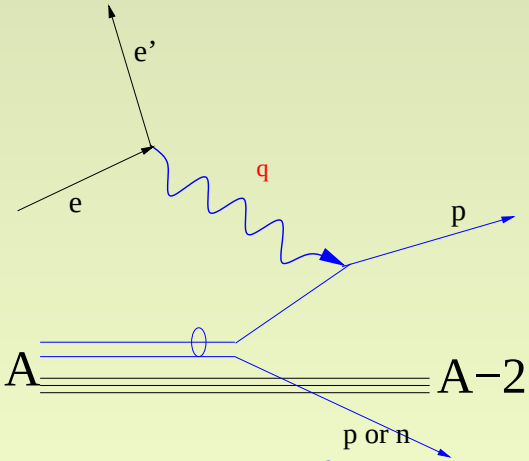
Outline

- Goal of Experiment
- Data Taking
- HRS Calibration
- BigBite Calibration
- Neutron Detector Calibration
- Conclusions

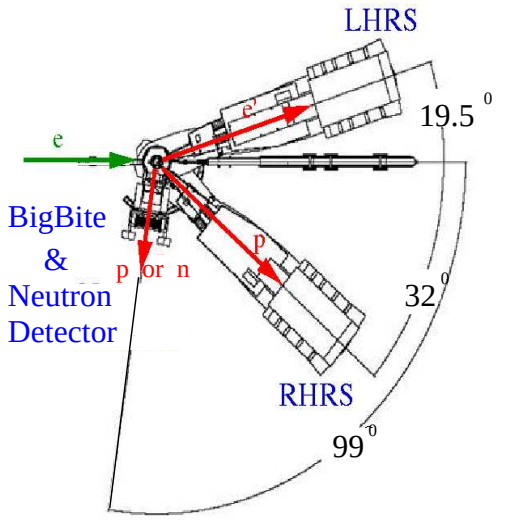
Goal of Experiment



Correlated pair of nucleons



Reaction diagram for nucleons knockout



Typical Kinematics

Goal of Experiment

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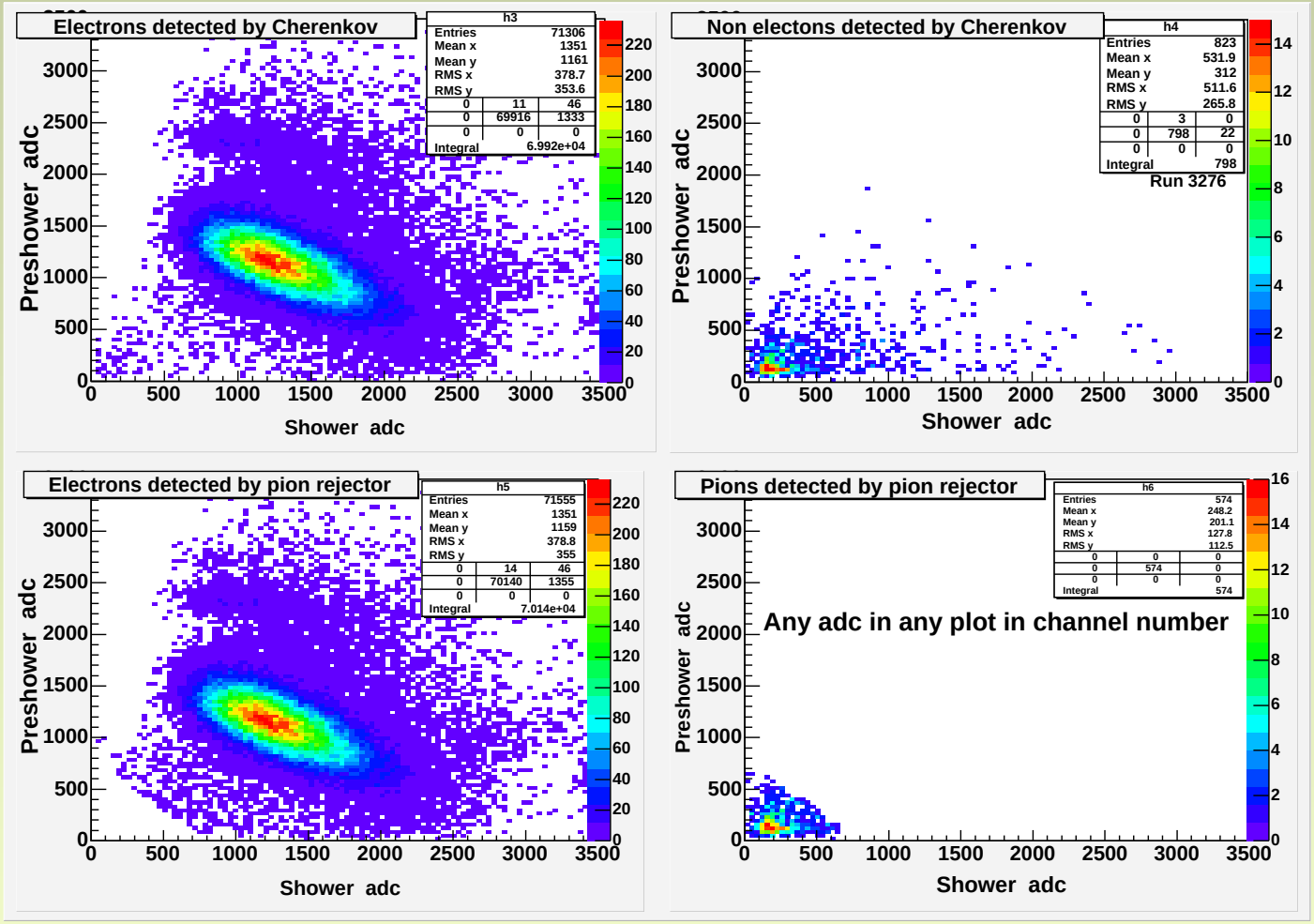
- Minimize IC, FSI and MEC by taking data at $Q^2 = 2$ GeV^2/c^2 and x$_B$ =1.2.
- Measure cross section ratios for the reactions $^{12}C(e,e'pp)$ to $^{12}C(e,e'p)$ and $^{12}C(e,e'pn)$ to $^{12}C(e,e'p)$.

Data Taking

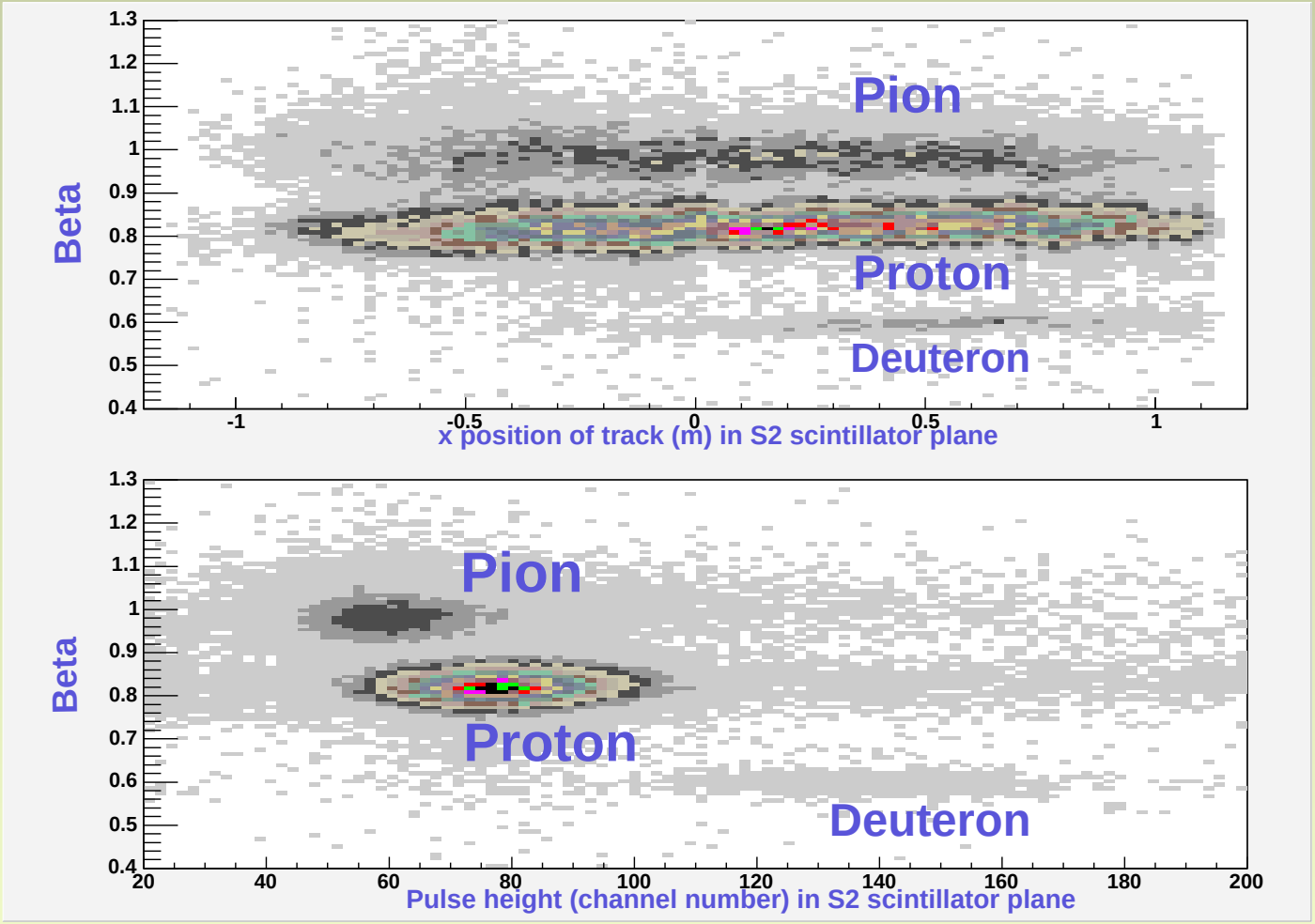
- Experiment run periods:
  - First run period $\rightarrow$ Jan 8 - Feb 1, 2005.
  - Second run period $\rightarrow$ March 8 - April 13, 2005.
  - Total number of beam days = 63.
- E = 4.62 GeV, E' = 3.72 GeV and p_p = 1.36 to 1.45 GeV/c.
- Main triggers collected only in ^{12}C production runs :
  - right HRS main (T1) = 51 M (34%), M for million.
  - left HRS main (T3) = 68 M (45%).
  - coincidence (T5) = 0.4 M (0.26%).
  - total of all types (T1 to T8) of triggers =152 M(100%).
- Analysis is ongoing, still in the calibration phase.

HRS Calibration

- The left HRS provides a time reference for both BigBite and the Neutron Detector.
- For HRS PID, the left HRS has been calibrated for electron detection while the right HRS for proton detection.
- Better PID and timing calibrations of both HRSs are important to get high quality result from both the BigBite and the Neutron Detector.

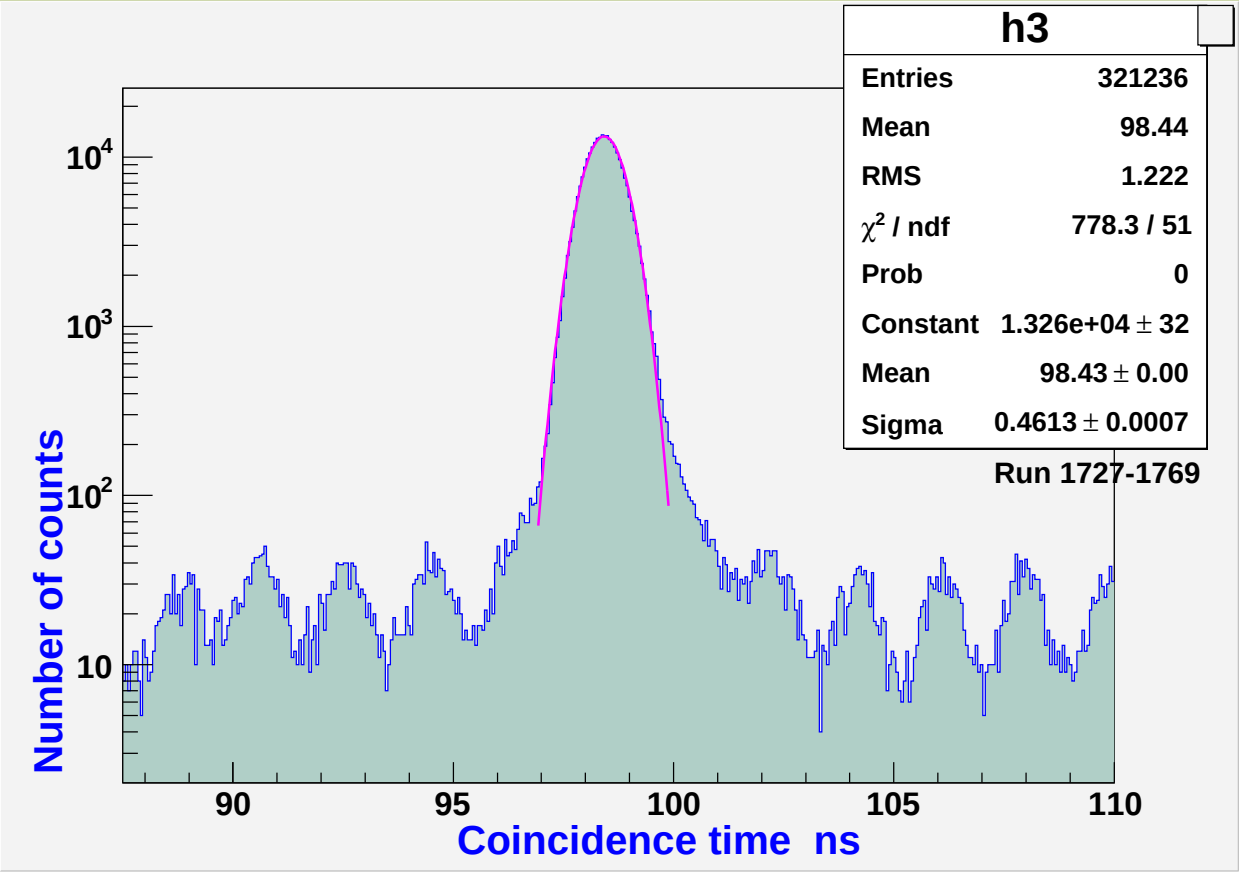


- Left HRS calibrated for electron detection and for pion rejection.



- Right HRS calibrated for proton (of momentum = 1.36 GeV/c, in this plot) detection.

- Below is a plot for the coincidence time from 2.345 GeV deuterium target data after the HRS calibrations; 2 ns beam structure is also visible in the background. Note the log scale in the vertical direction.

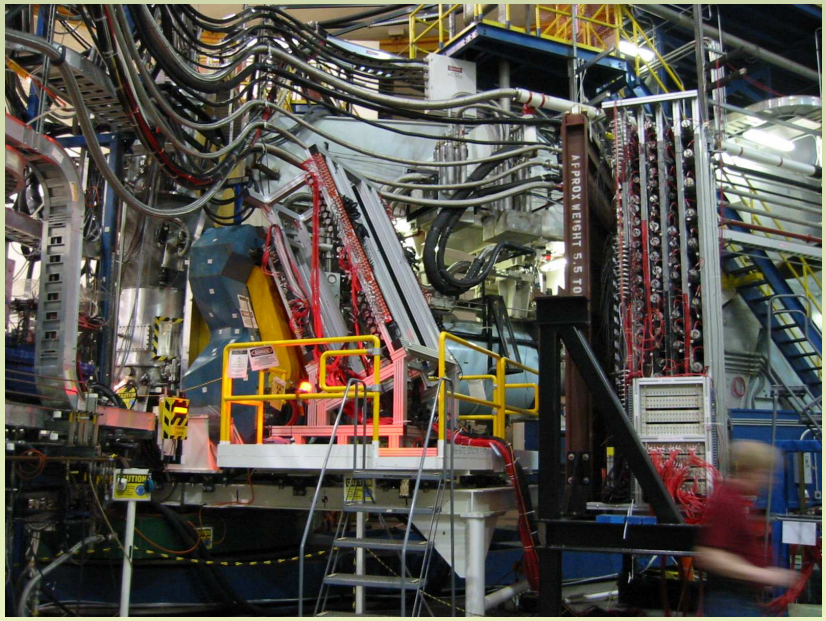


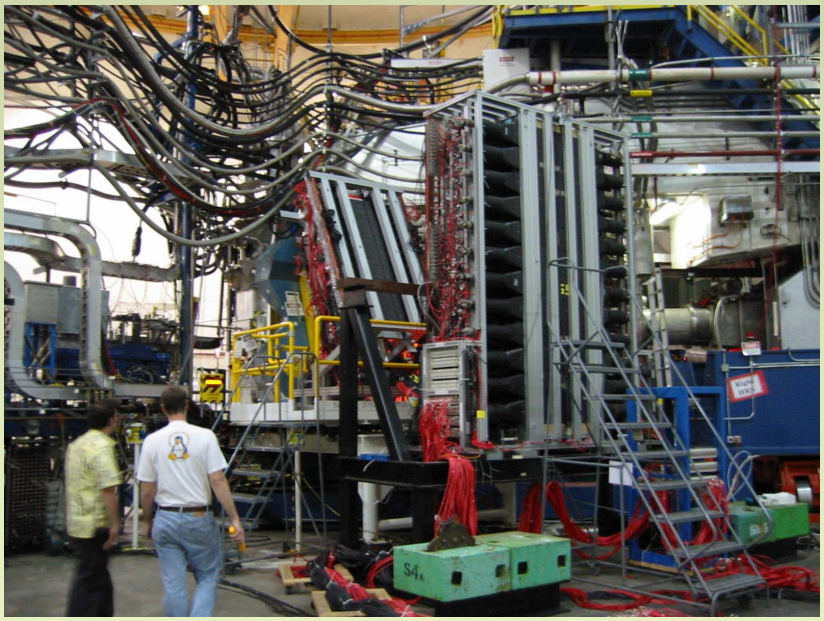
- The measured coincidence time resolution is less than 0.5 ns.

BigBite Calibration

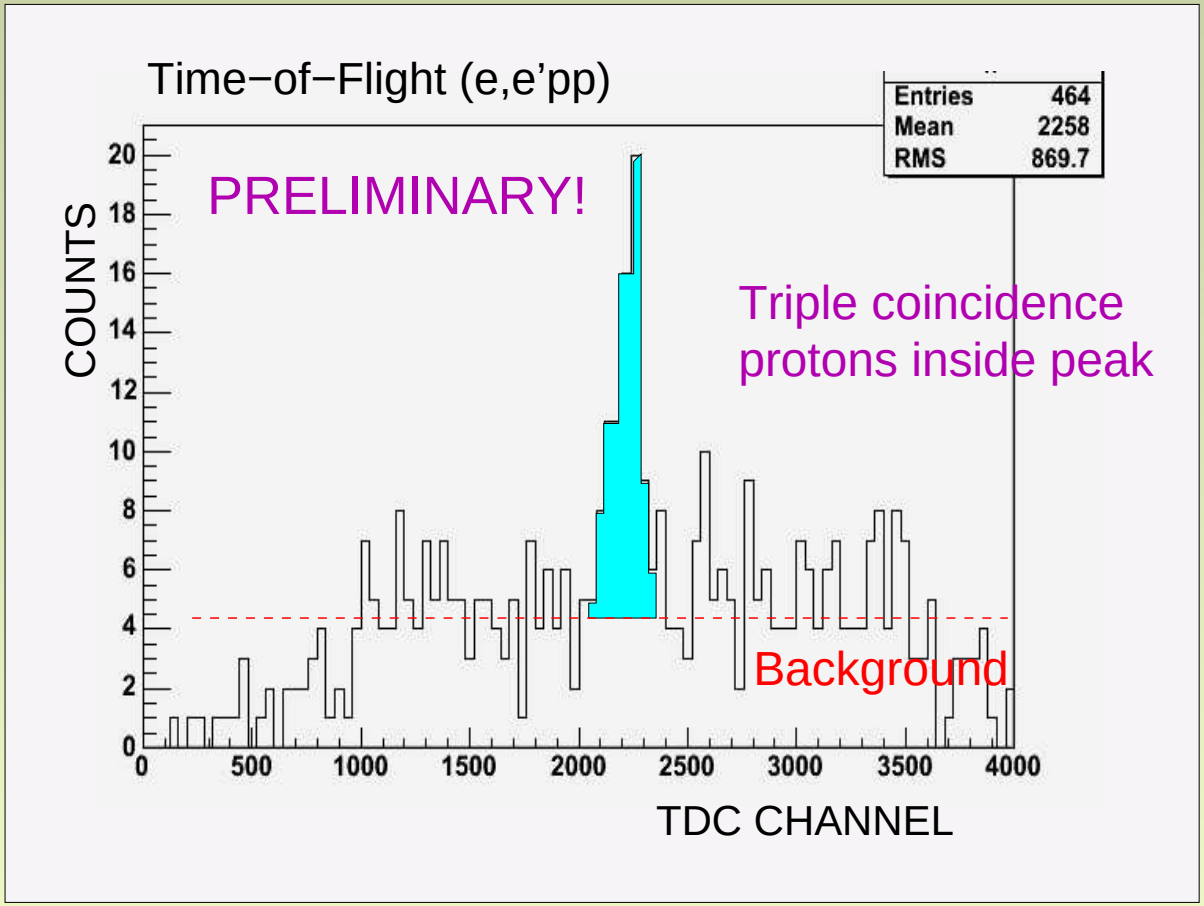
Detector Make-up:

- BigBite detects the recoiling protons.
- This detector has three planes of thin segmented plastic scitillators.
- First plane: 0.25 cm thick auxiliary plane of 56 bars of dimensions 35x2.5x0.25 cm^3.
- Second plane: 0.3 cm thick delta-E plane of 24 bars of dimensions 50x8.6x0.3 cm^3 at about a meter away from the auxiliary plane.
- Third plane: 3 cm thick E plane of 24 bars of dimensions 50x8.6x3 cm^3 located just behind the delta-E plane.

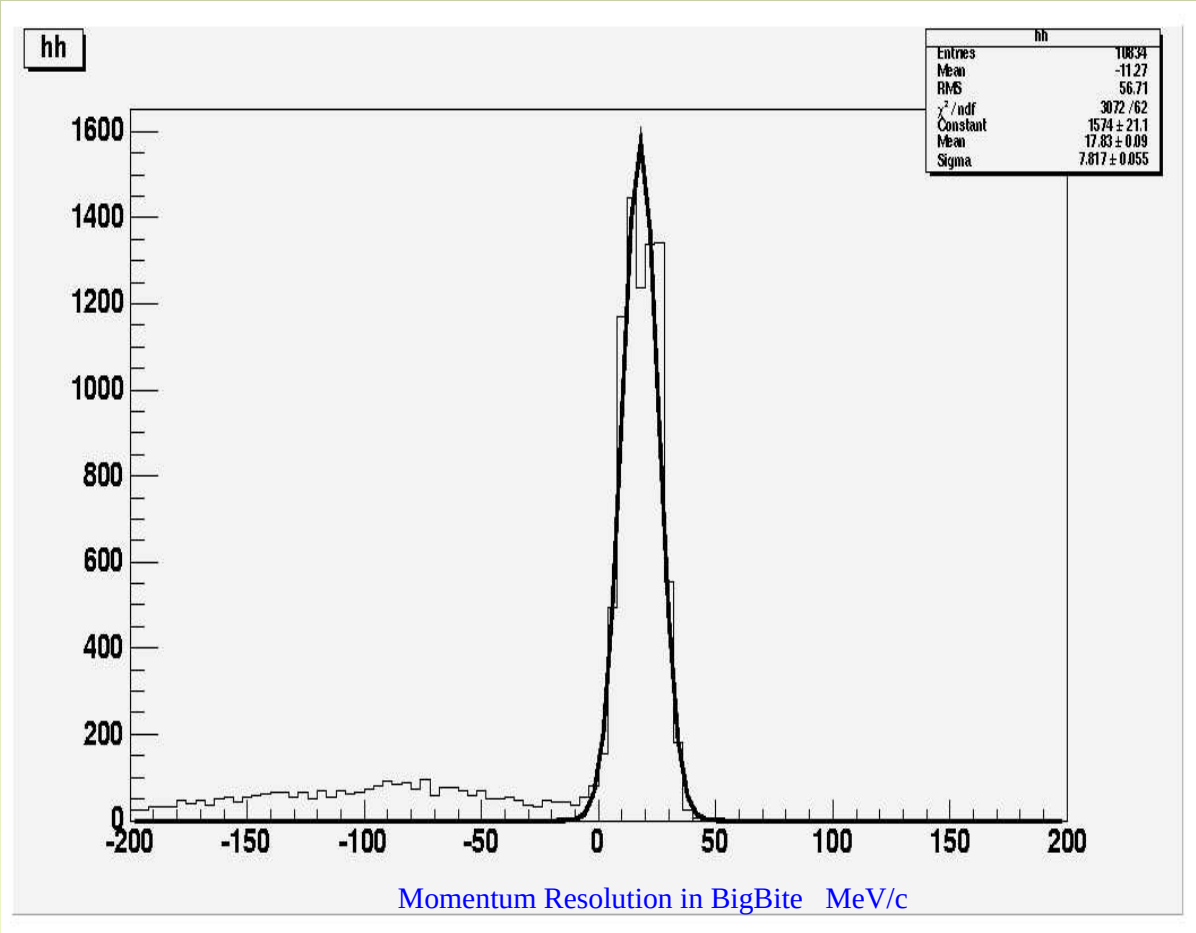




- Detector arrangement in the hall.



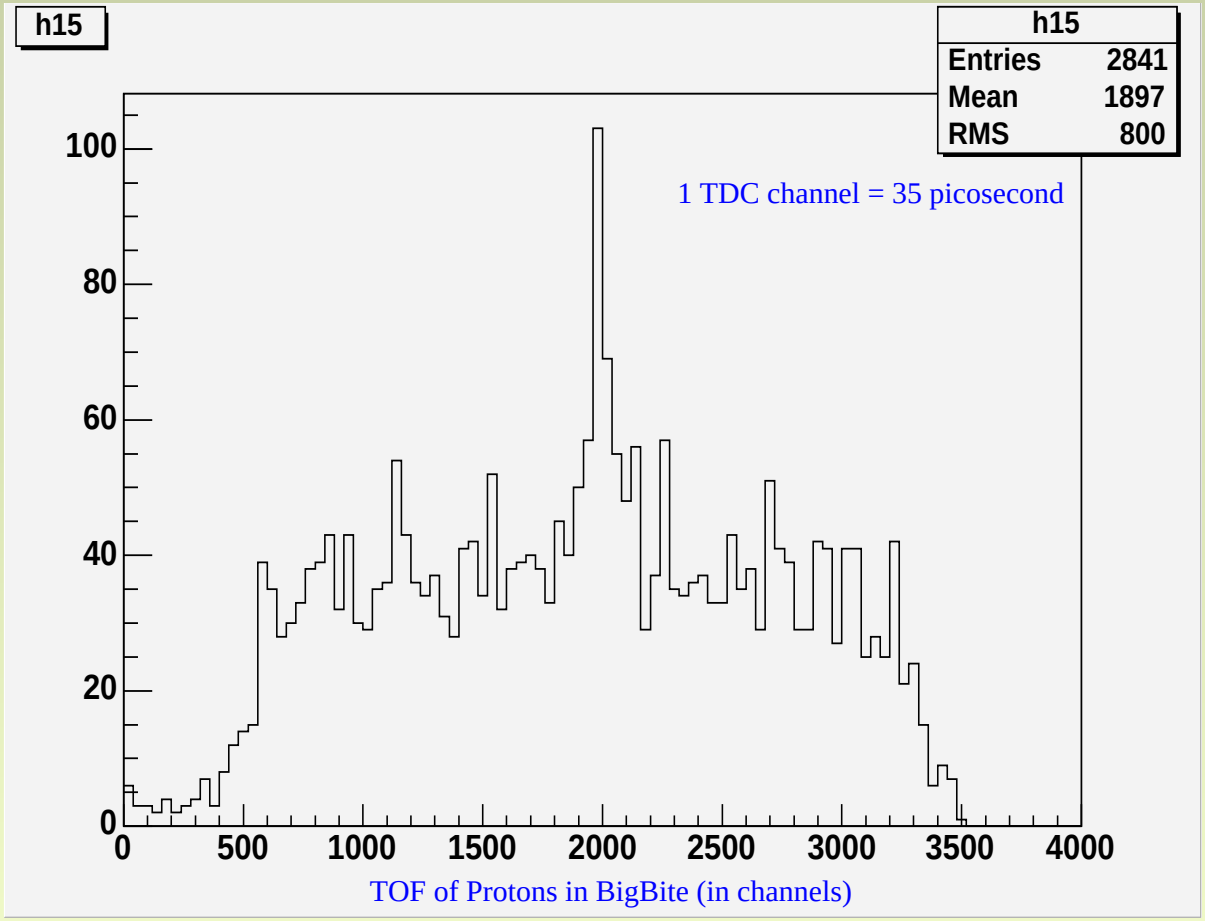
- Typical plot showing the triple coincident protons in BigBite before the calibration started.



Momentum Resolution in BigBite MeV/c

- Typical plot of momentum resolution of protons in BigBite; the resolution is about 10 MeV/c for protons of momenta 250 - 400 MeV/c.

- The left HRS main trigger provided a COMMON START for BigBite TDCs.



- This plot shows the triple coincident protons in BigBite in the 500 MeV/c P_{miss} kinematics.

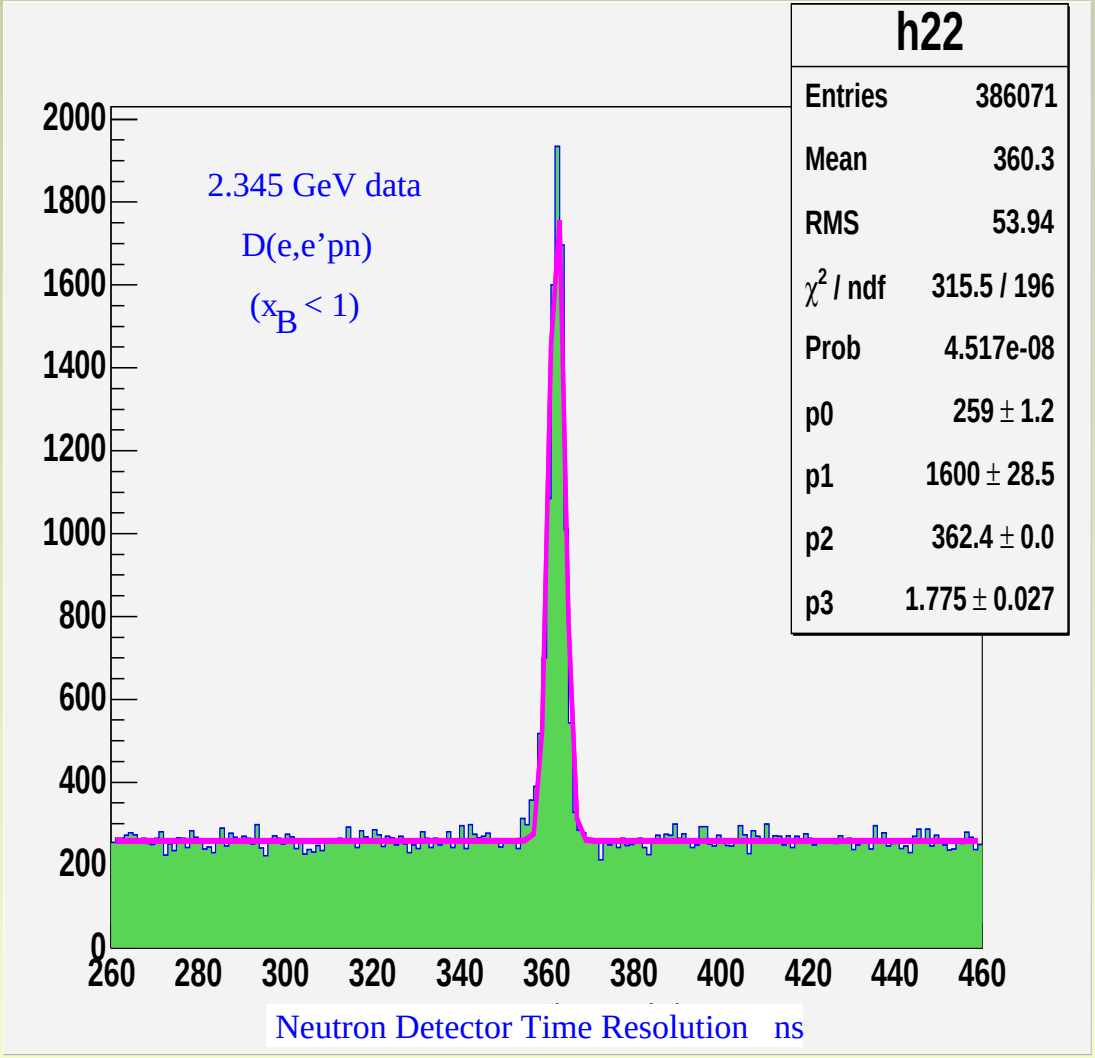
Neutron Detector Calibration

Detector Make-up:

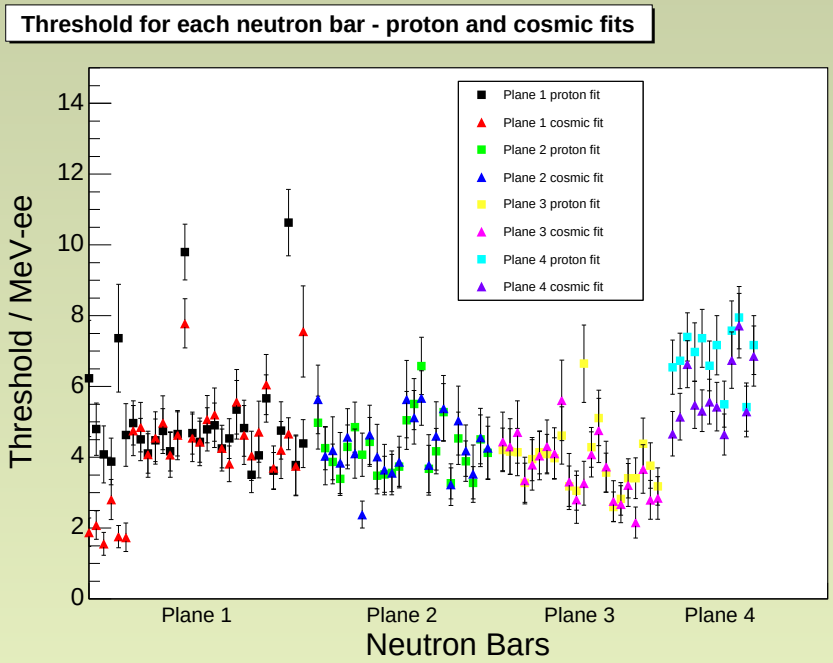
- The Neutron Detector detects recoiling neutrons.
- This Detector has 4 segmented 10 cm thick plastic scintillator planes of 1 m width and 3 m height along with a 2 cm thick veto layer in front of it.
- Veto plane: 64 bars of 11 cm height placed in 32 rows.
- First plane: 30 bars of 10 cm height.
- Second plane: 24 bars of 12.5 cm height.
- Third plane: 22 bars of mixed heights (2 bars of 10 cm, 8 bars of 12.5 cm and 12 bars of 15 cm).
- Fourth plane: 12 bars of 25 cm height.

Neutron Detector Time Resolution

- Left HRS main trigger provides COMMON STOP for Neutron Detector TDCs.
- Time resolution:
  - Predicted TOF - Observed time from deuterium target.
  - Measured $\rightarrow$ 1.775 ns, from the triple coincident events.
  - Expected $\rightarrow$ 1.74 ns.

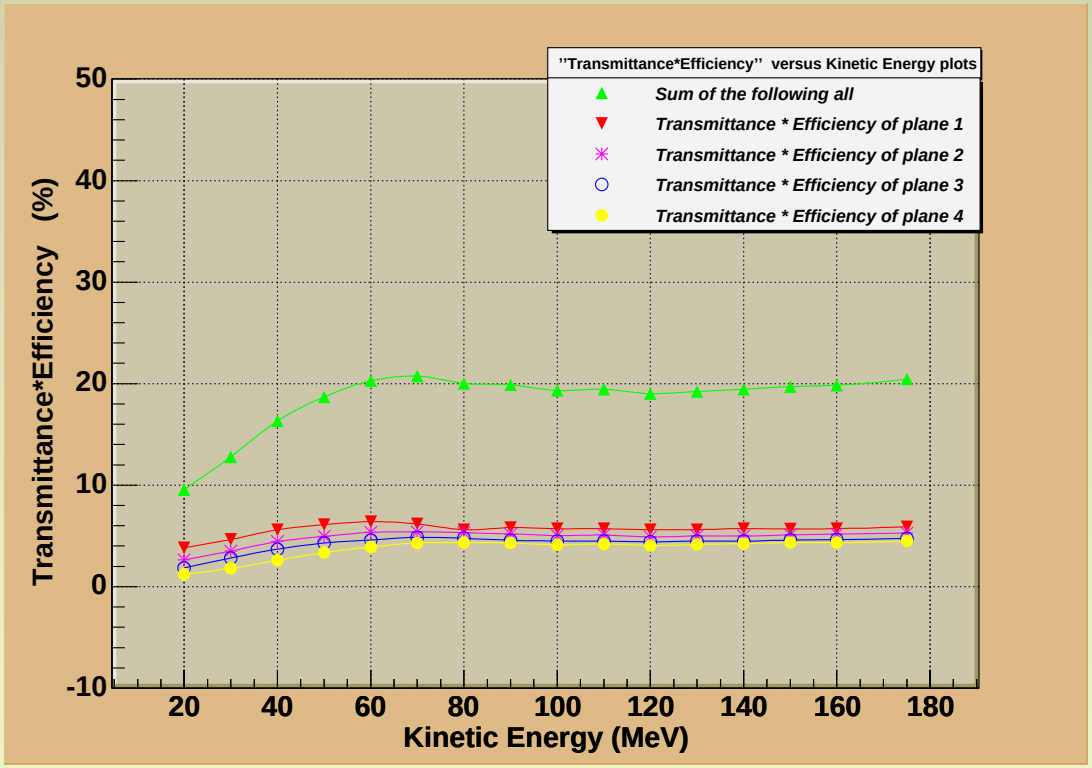

h22
Entries 386071
Mean 360.3
RMS 53.94
χ² / ndf 315.5 / 196
Prob 4.517e-08
p0 259 ± 1.2
p1 1600 ± 28.5
p2 362.4 ± 0.0
p3 1.775 ± 0.027
2.345 GeV data
D(e,e'pn)
(x_B < 1)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
260 280 300 320 340 360 380 400 420 440 460
Neutron Detector Time Resolution ns

- Threshold determination of a neutron bar is essential to calculate its efficiency.

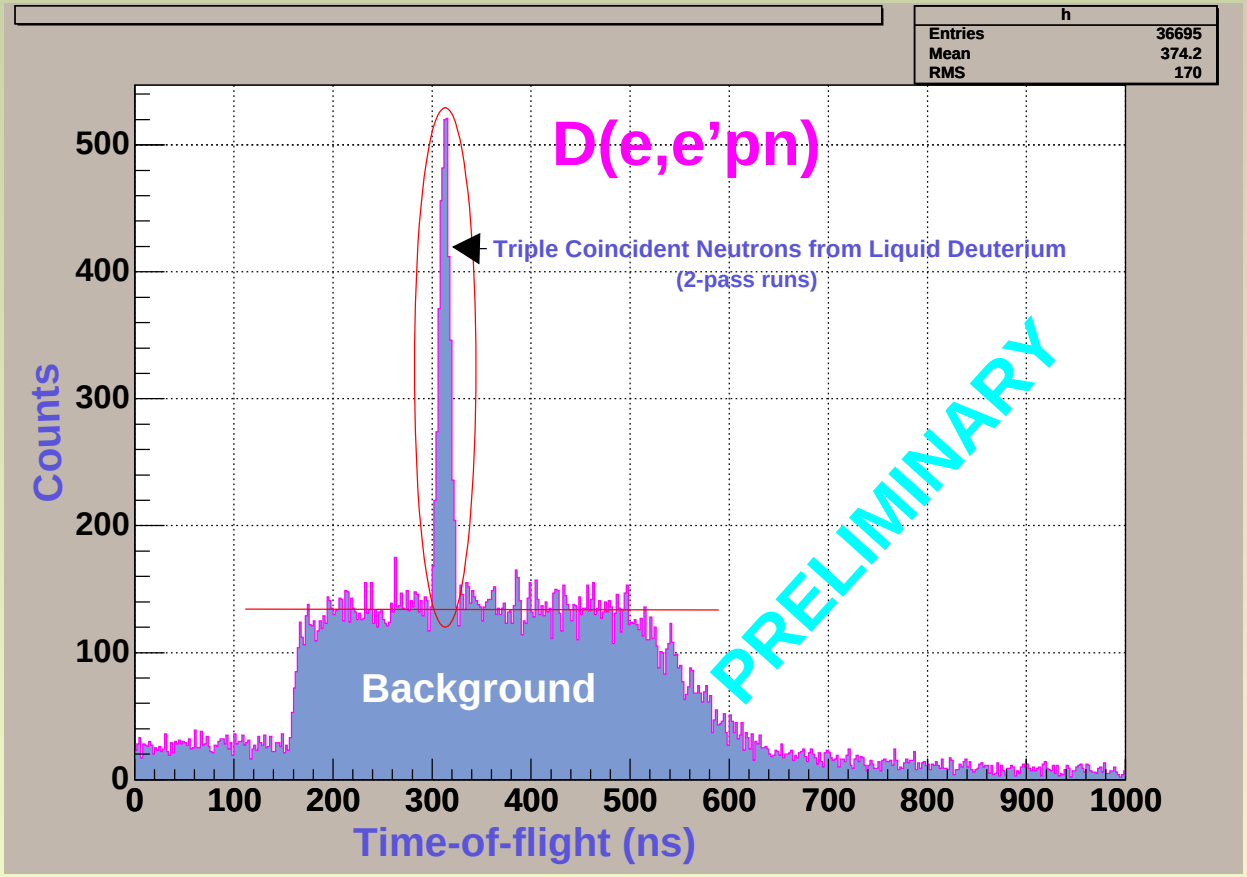


- Threshold for first and second planes = 4.5 MeVee.
- Threshold for third plane = 4.0 MeVee.
- Threshold for fourth plane = 7.0 MeVee.
- MeVee Definition: ”MeV-electron-equivalent” or MeVee is a unit for light production in a scintillation counter based on what electrons produce, i.e. 4 MeV electrons produce 4 MeVee of light, etc.

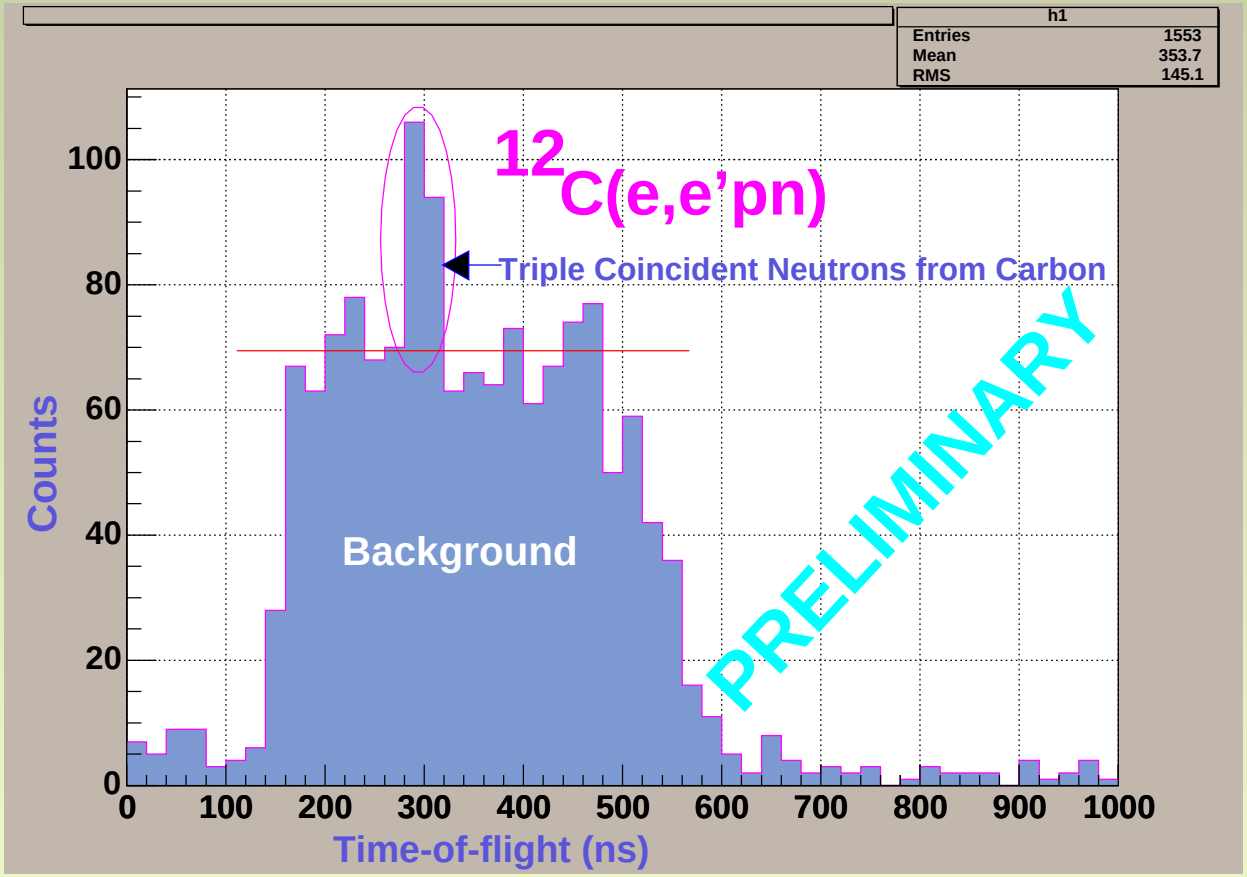
- “Kent State” computer simulation code by R.Cecil at.al. used to calculate efficiency of a neutron bar.



- Neutron Detector “Transmittance∗Efficiency” found to be about 20 %.



- Typical plot showing the triple coincident neutrons in neutron detector from Deuterium target runs.



- Typical plot showing the triple coincident neutrons in neutron detector from Carbon runs.

Conclusion

- The BigBite detector and Neutron detector have shown excellent performance.
- Data analysis is almost at the end of calibration phase.
- Jobs completed:
  - HRSs PID and coincidence time calibration.
  - Various techniques of proton momentum calculation in BigBite.
  - TOF determination of protons in BigBite.
  - Effi ciency and time resolution calculation of Neutron Detector.
- There is a lot to do in the analysis.

Thank You.

Back to back momentum of pair

Since the recoiling particle (either n or p) is a spectator, its initial- and final-state momenta are equal, and thus each is equal to missing momentum (p_m). The initial-state of pair (np or pp) is at rest in the lab frame (which means that wherever the pair is located initially, call it as the lab frame. Note that in CM frame, both the initial- and final-states are always at rest). Thus the constituents of the pair in the initial-state will have equal and opposite momenta and hence initial-state proton will have momentum p_p^i = - p_m.

Expected TOF Resolution

- Calculation of Expected 1.74 ns time resolution of Neutron Detector:
  Assuming:
  - 240 MeV/c neutrons
  - Flight path = 6.04 m

  Then:
  - K.E. = 30 MeV
  - $\beta = 0.25$
  - speed (v) = β*c = 0.25 $*$ 0.3 since c = 0.3 m/ns
  - tof = 6.04 / (0.25 $*$ 0.3) = 80.533 ns
- Due to intrinsic TDC time resolution:
  $\sigma_i^2 = 0.5^2$
- Due to 10cm bar thickness, flight path uncertainty correction:
  $\sigma_{th}^2 = ((0.1/6.04) * 80.533)^2 = 1.33^2$.
- Due to 3 MeV/c missing momentum resolution:

$$\sigma_p^2 = ((3/240) * 80.533)^2 = 1.01^2$$

- Hence $\sigma_{total} = (0.5^2 + 1.01^2 + 1.33^2)^{1/2} = 1.74\, ns$

IC, FSI and MEC suppression

- IC $\sim 1/Q^2$. Higher Q^2 minimizes IC.
- FSI and MEC are minimized at $x_B > 1$