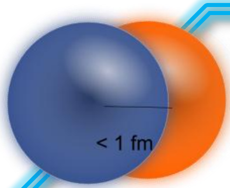
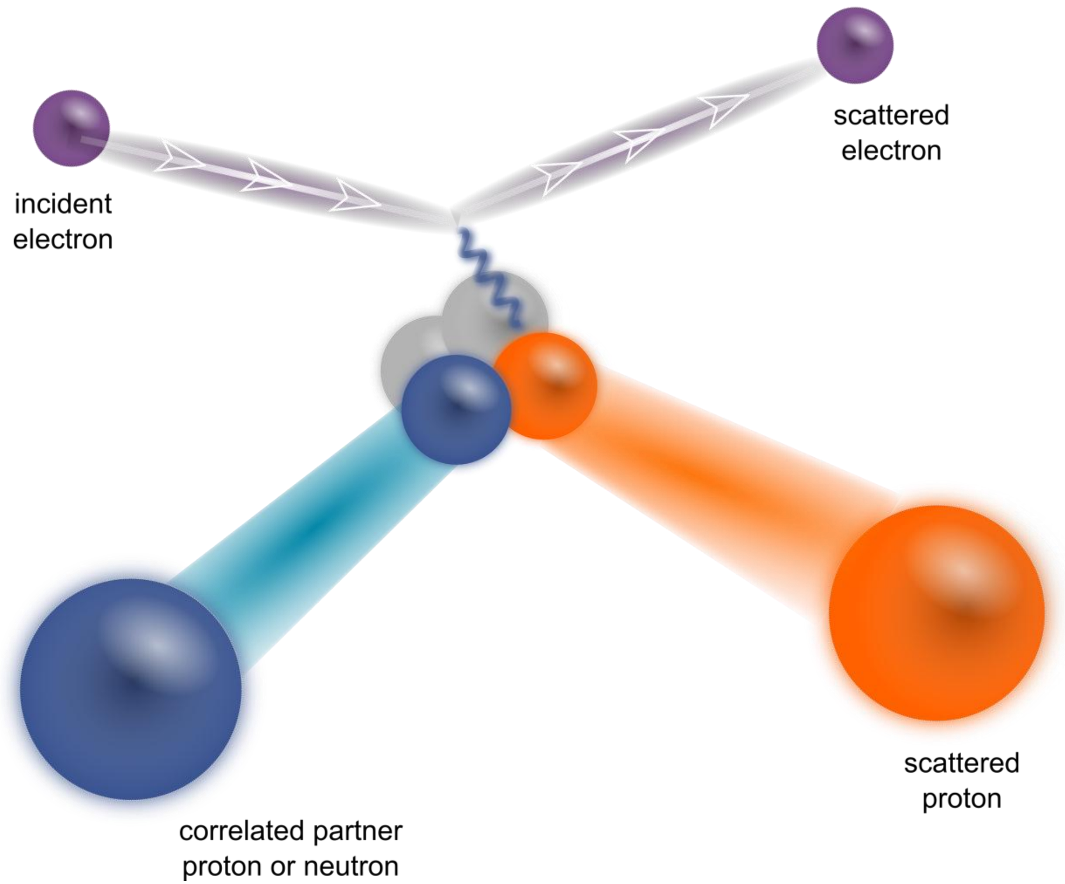
E07-006 :Status Report
Nucleon-Nucleon Short-Range Correlation (NN SRC) on He^4 target





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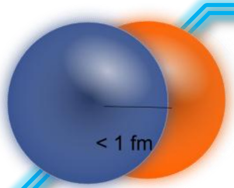
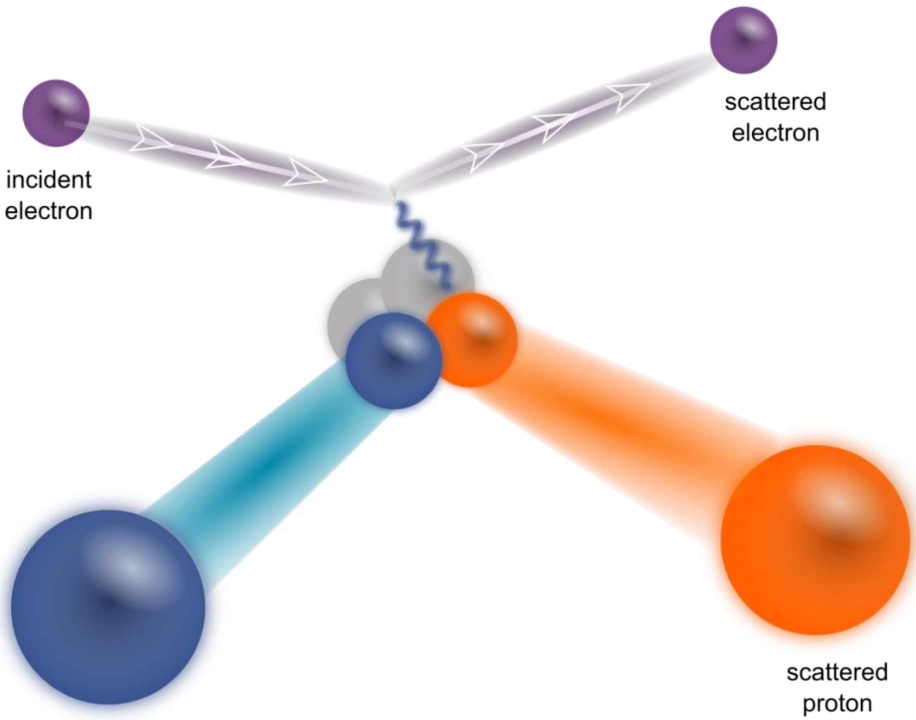
Outline [General SRC]

- What is Nucleon-Nucleon Short Range Correlation(NN-SRC)?
- Why is NN-SRC interesting?
- What has been done?
- Our Unique Experiment Setting.
- What we have from Spring 2011 running period?
- Analysis Progress

- Experiment/Analysis Approaches
  - Inclusive X(e,e')
  - Double coincident X(e,e'p)
  - Triple coincident X(e,e'pN)
  - (new approach) Double coincident on the recoil partner X(e,e'N_recoil) (backward nucleon)





WHAT IS NUCLEON-NUCLEON SHORT RANGE CORRELATION(NN-SRC)?

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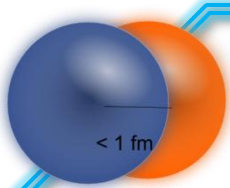
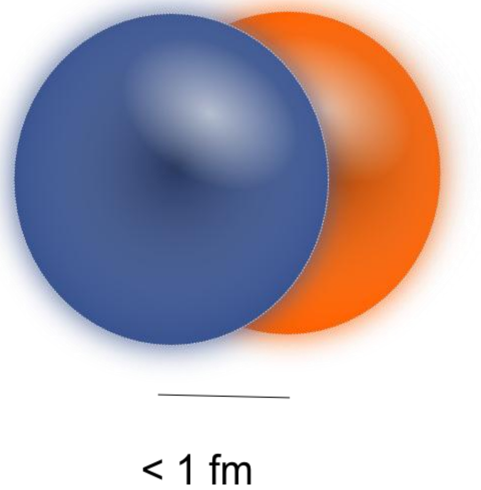
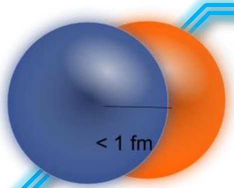
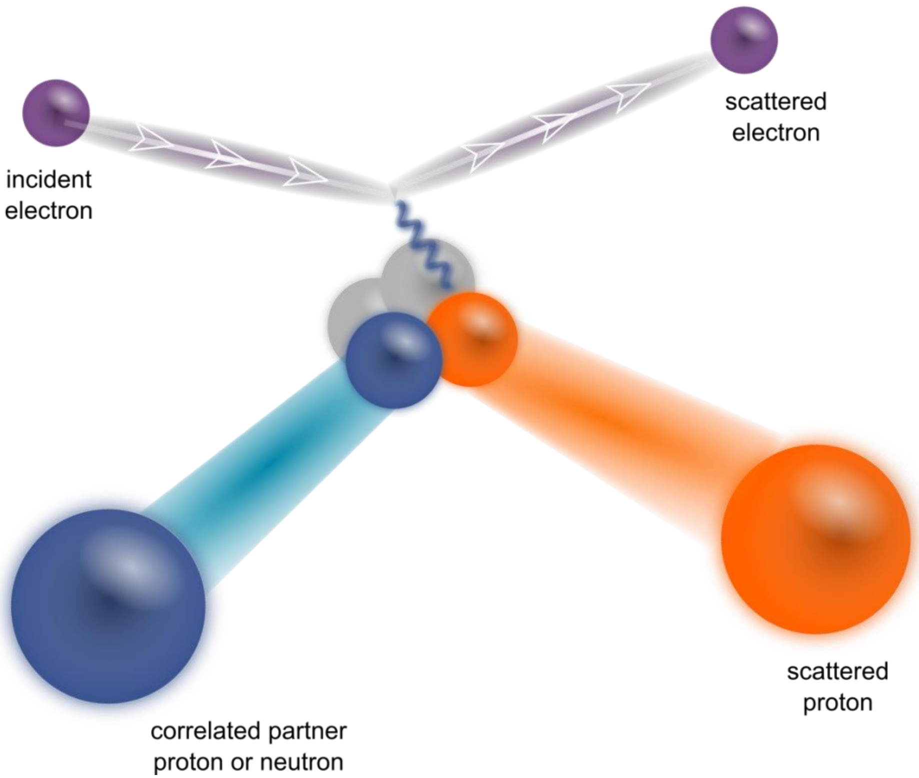


What is Nucleon-Nucleon Short Range Correlation (NN-SRC)?

- the phenomena are when the wave functions of the two nucleons are strongly overlapping





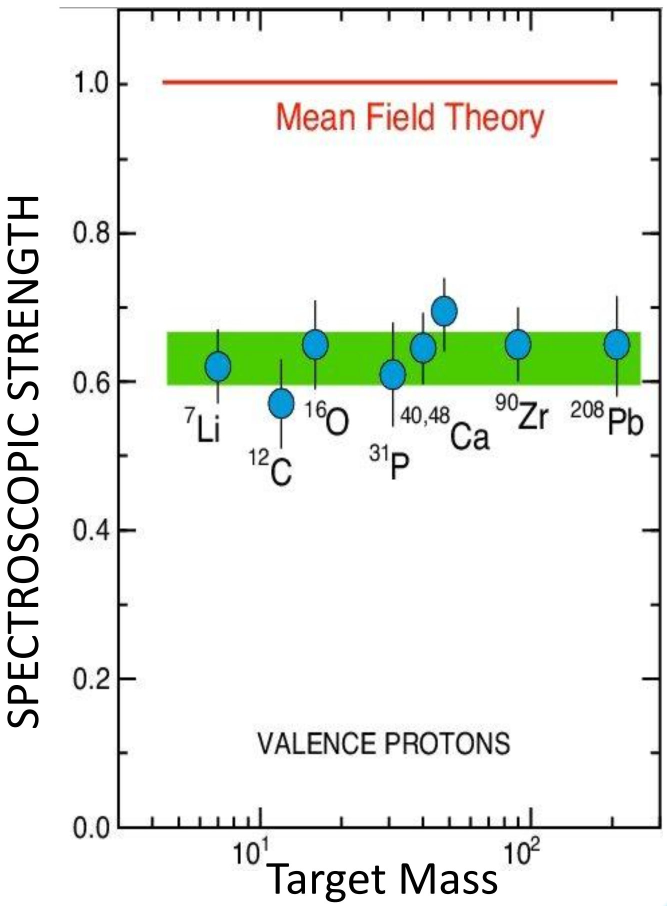


WHY IS NN-SRC INTERESTING?

NN-SRC is interesting because

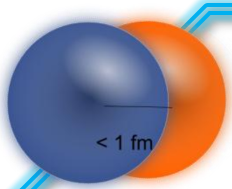
…

- The nuclear shell model can only predict 60% of the spectral function. Long range correlation can only provide a 20% contribution. The short range correlation is believed to contribute the remaining 20%.



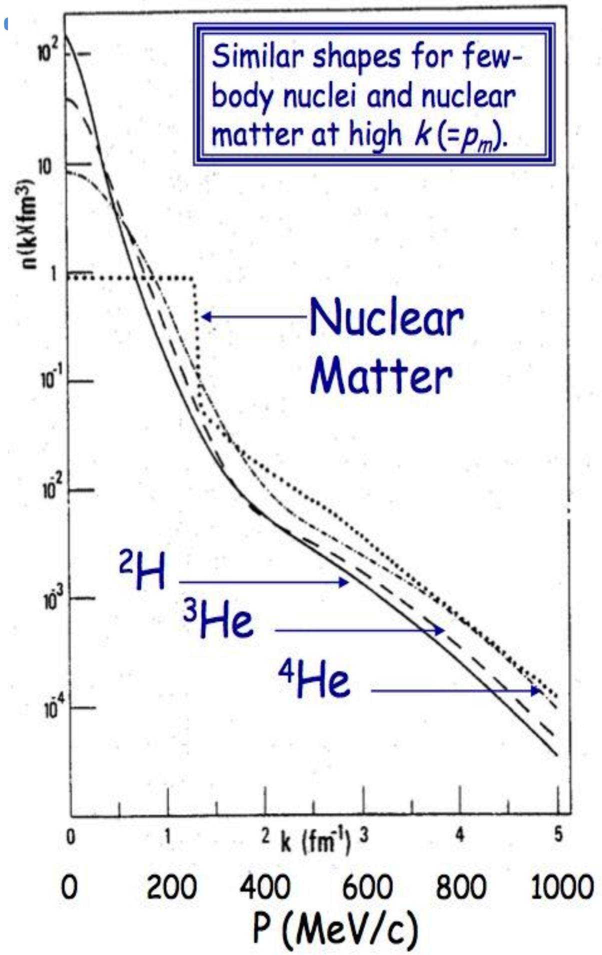
L. Lapikas, Nucl. Phys. A553 (1993) 297.

NN-SRC is interesting because



…

- The measurement of nucleon momentum distributions for various nuclei yields a similar ***high momentum tail***. Along with the shell model, the existence of NN-SRC pairs within the nuclei is believed to explain this phenomenon.



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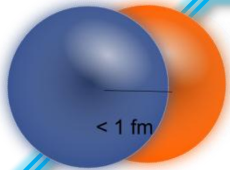
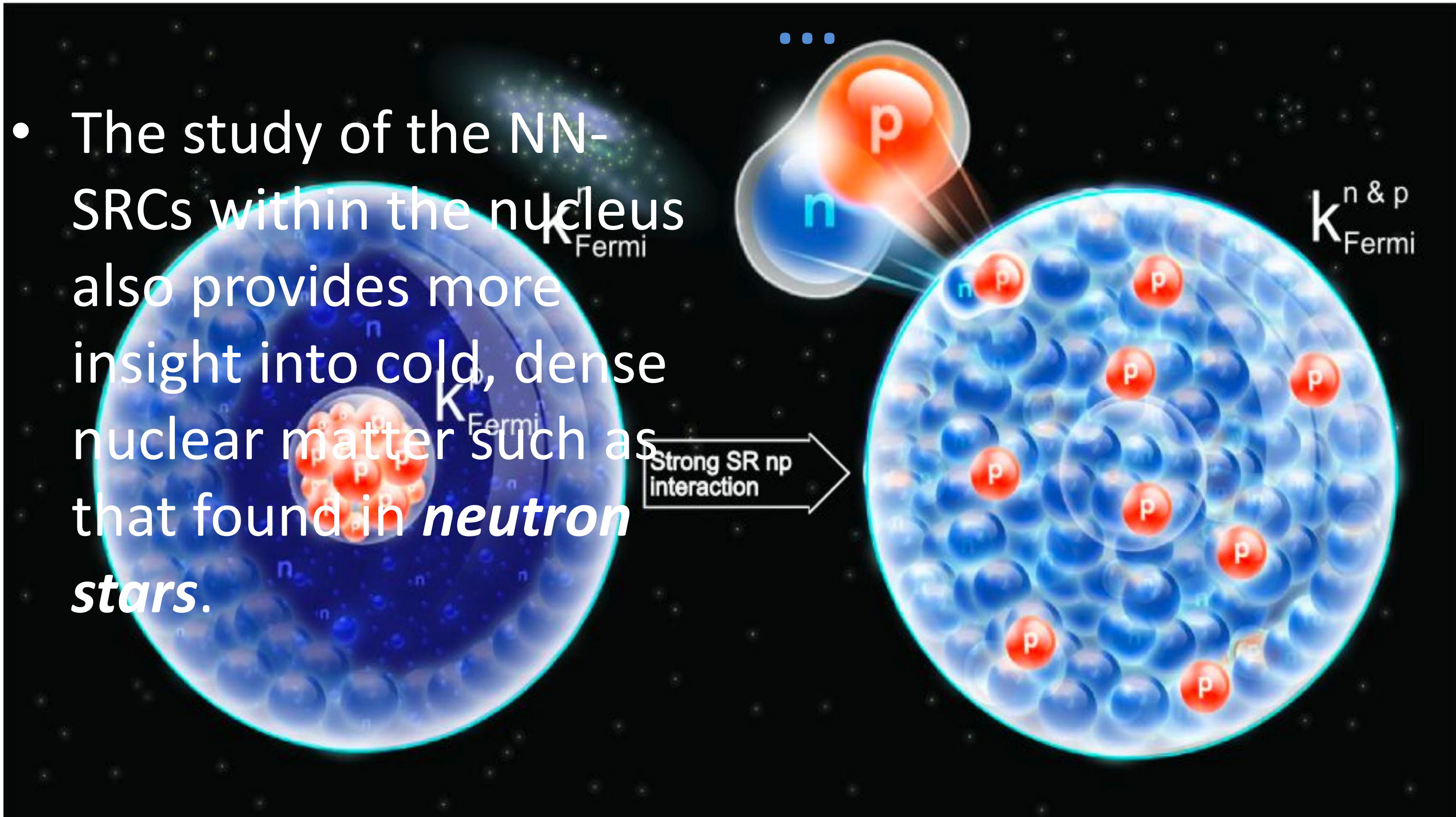


NN-SRC is interesting because

…

- The study of the NN-SRCs within the nucleus also provides more insight into cold, dense nuclear matter such as that found in ***neutron stars***.



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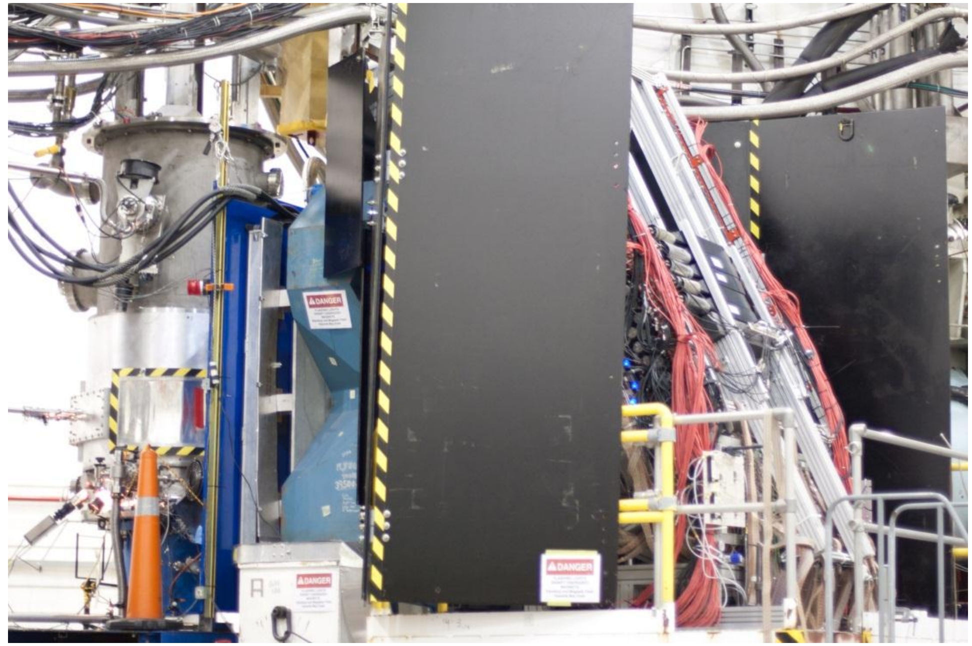
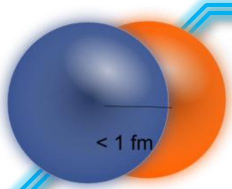


WHAT HAS BEEN DONE?

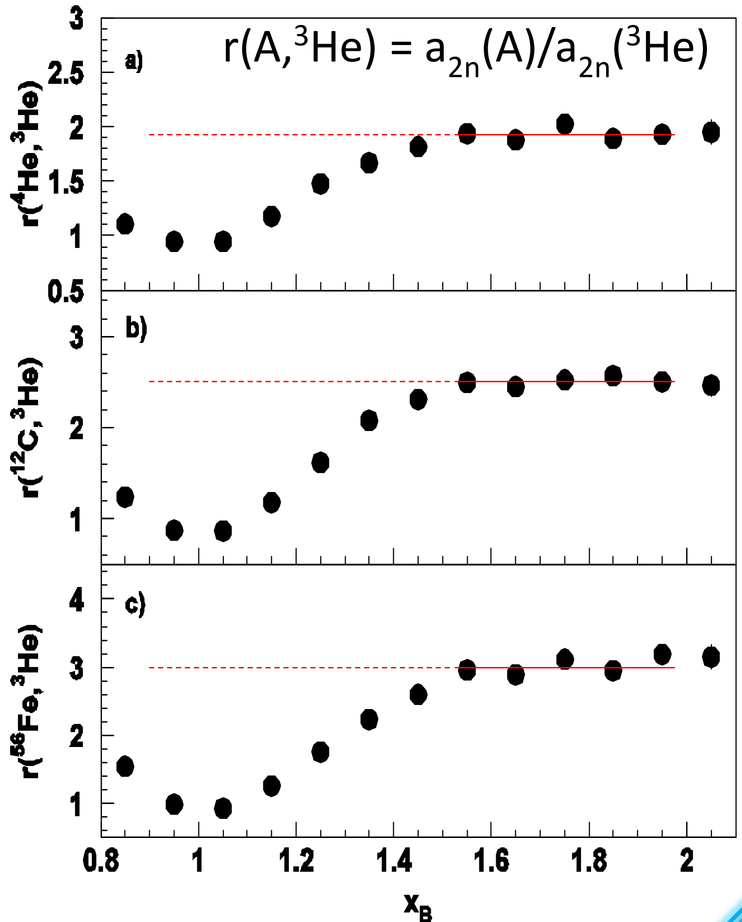


Inclusive Measurement

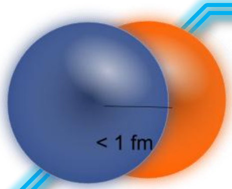
CLAS A(e,e') data

$$x = \frac{Q^2}{2M\omega} > 1.5 \qquad Q^2 > 1.4\ [\mathrm{GeV/c}]^2$$

- The observed *scaling* means that the electrons probe the high-momentum nucleons in the 2N-SRC phase, and the scaling factors determine the per-nucleon probability of the 2N-SRC phase in nuclei with A>3 relative to ^{3}He

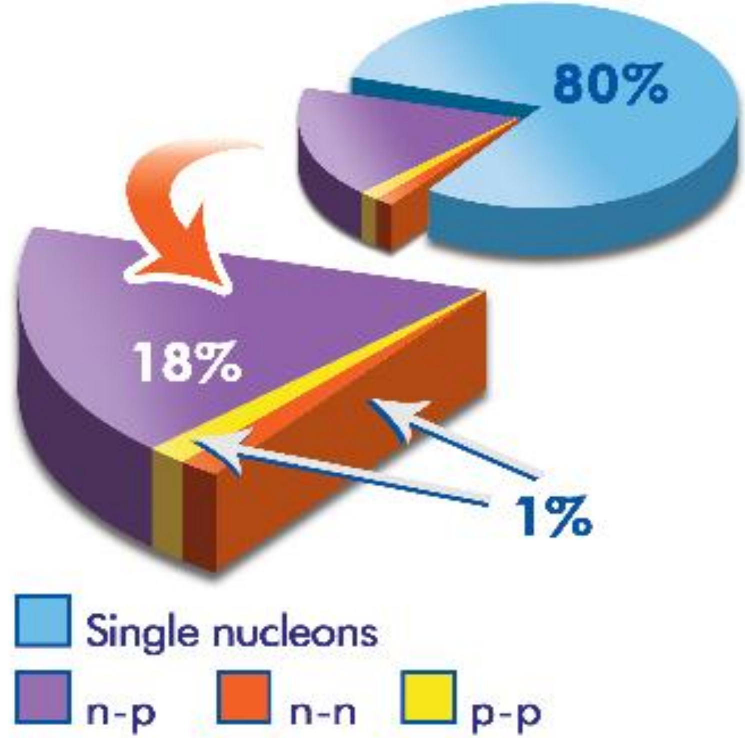


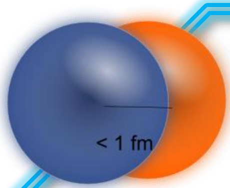
K. Sh. Egiyan *et al.*, Phys. Rev. C **68** (2003) 014313.



Result (e,e') and (e,e'p) and (e,e'pN) from E01-015

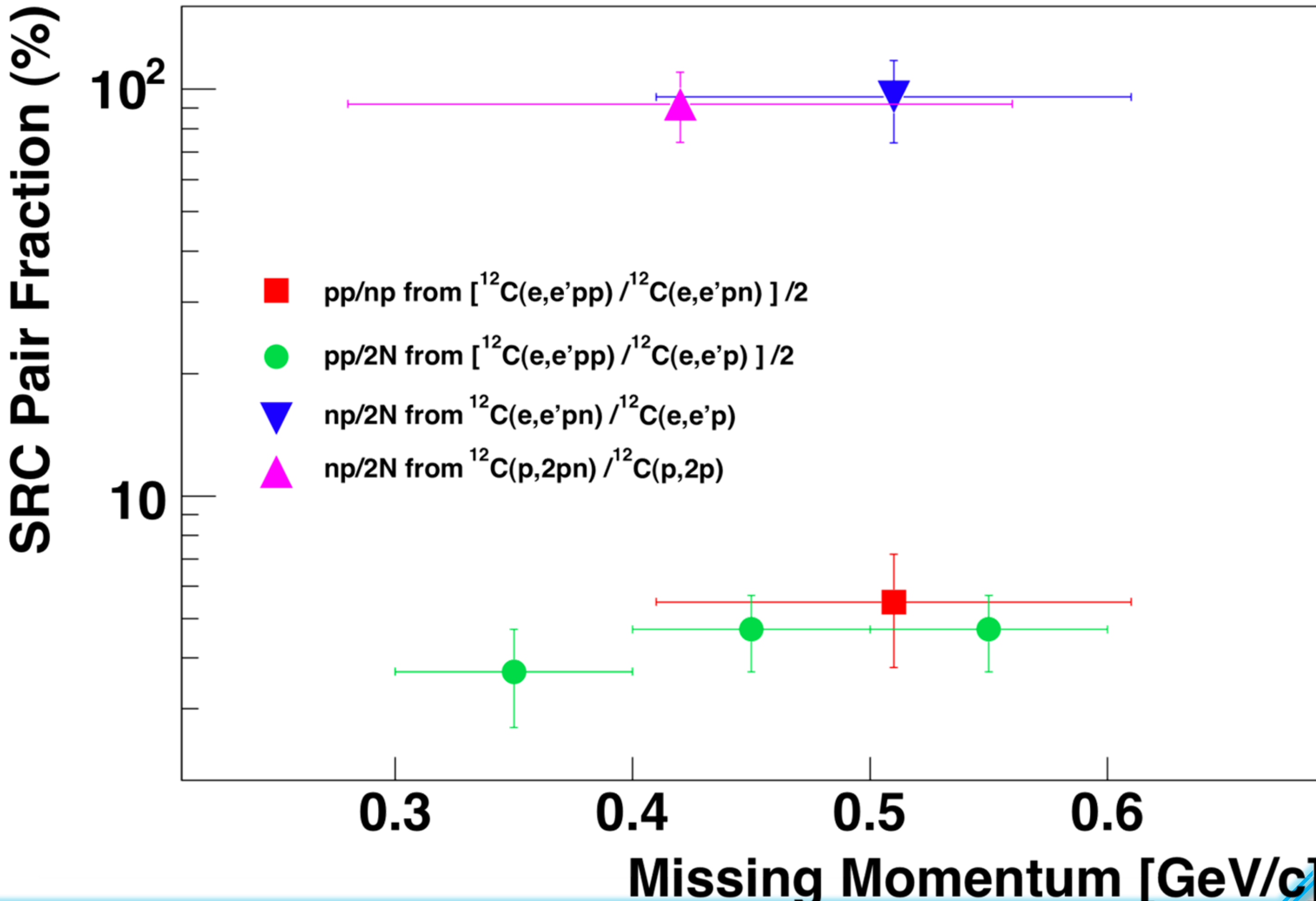
- 80 +/- 5% single particles moving in an average potential
  - 60 – 70% independent single particle in a shell model potential
  - 10 – 20% shell model long range correlations
- 20 +/- 5% two-nucleon short-range correlations
  - 18% np pairs
  - 1% pp pairs
  - 1% nn pairs (from isospin symmetry)
- Less than 1% multi-nucleon correlations

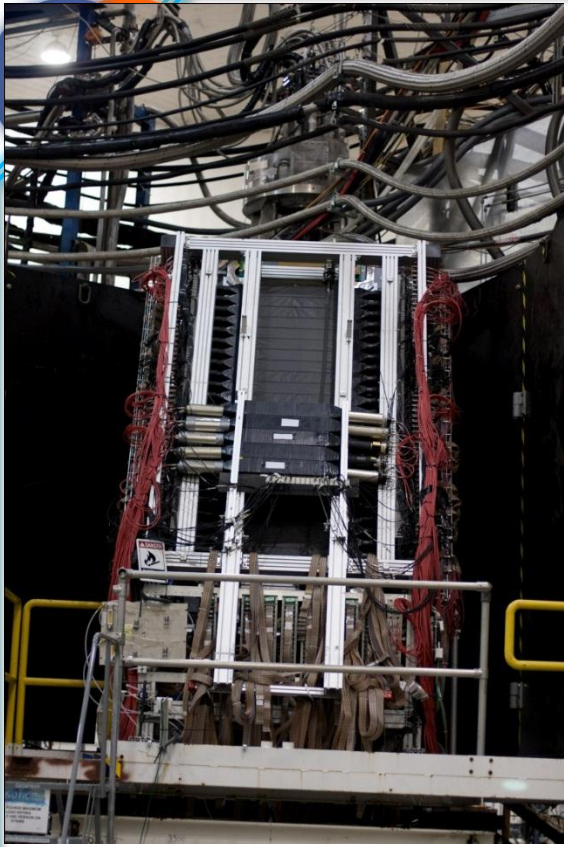


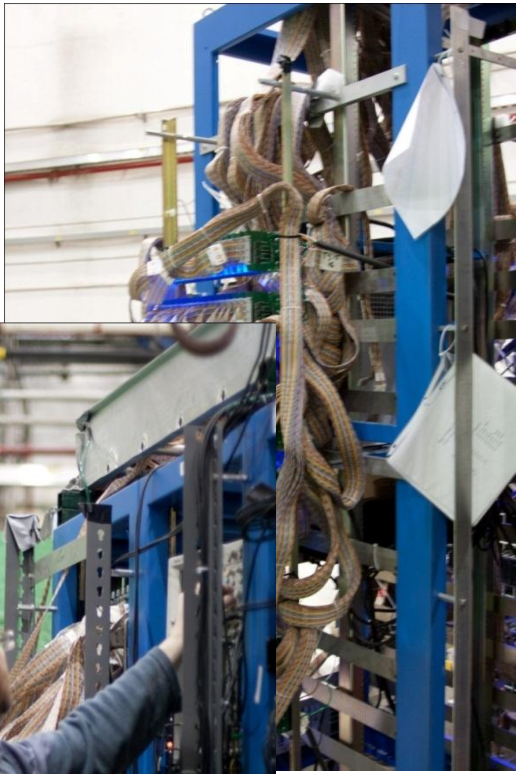


Correlated Pair Fractions from ^{12}C

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







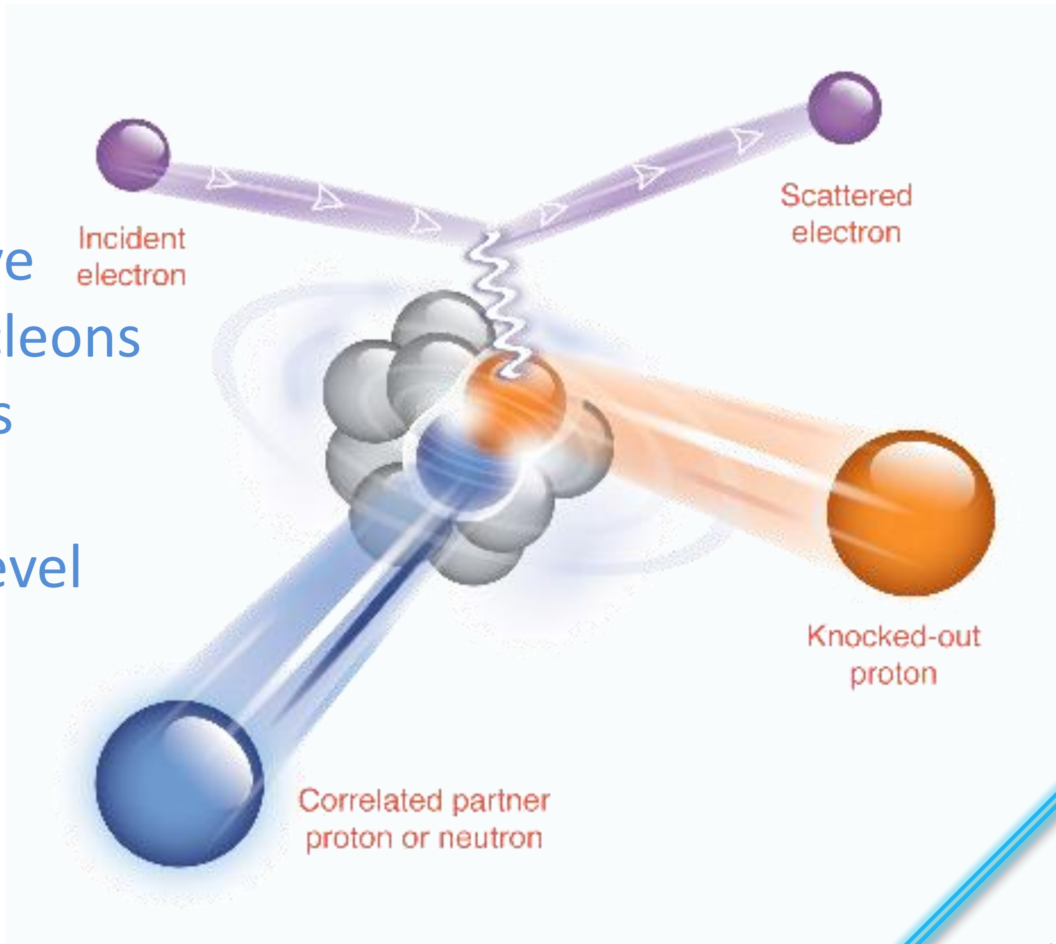
OUR UNIQUE EXPERIMENT

Customized (e,e'pN) Measurement

A pair with "large" relative momentum between the nucleons and small center of mass momentum

Relative to the Fermi-sea level

~ 250 MeV/c

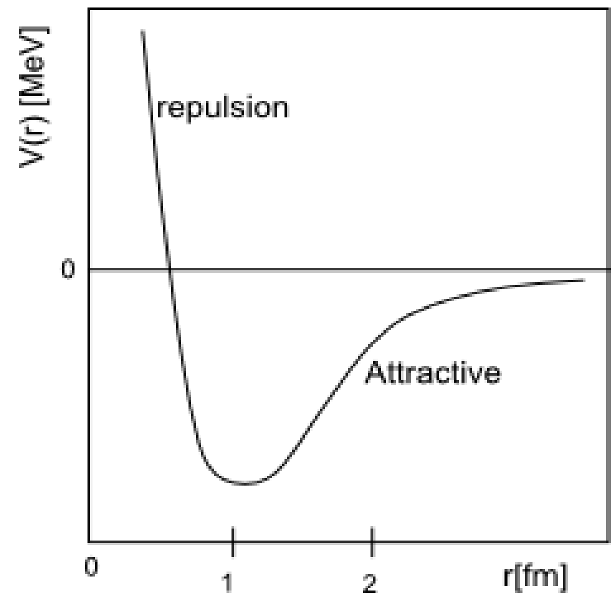


- High Q^2 to minimize MEC ($1/Q^2$) and FSI
- x>1 to suppress isobar contributions

Experiment E07-006 vs E01-015

Missing momentum 400 – 800 MeV/c → Tensor to Repulsive Core

E01-015	E07-006
$X_B > 1$, $Q^2 = 2\ [\mathrm{Gev/c}]^2$	$X_B > 1$, $Q^2 = 2\ [\mathrm{Gev/c}]^2$
300 – 600 MeV/c	400 – 800 MeV/c
Tensor Force	Tensor to Repulsive core
Target – ^{12}C	Target – ^{4}He (Less FSI)
BigBite and HAND	BigBite with MWDCs Upgraded HAND (new lead wall)



Pushing Limits of NN Potential

- Long range attraction
- Short range repulsion

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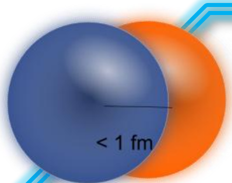


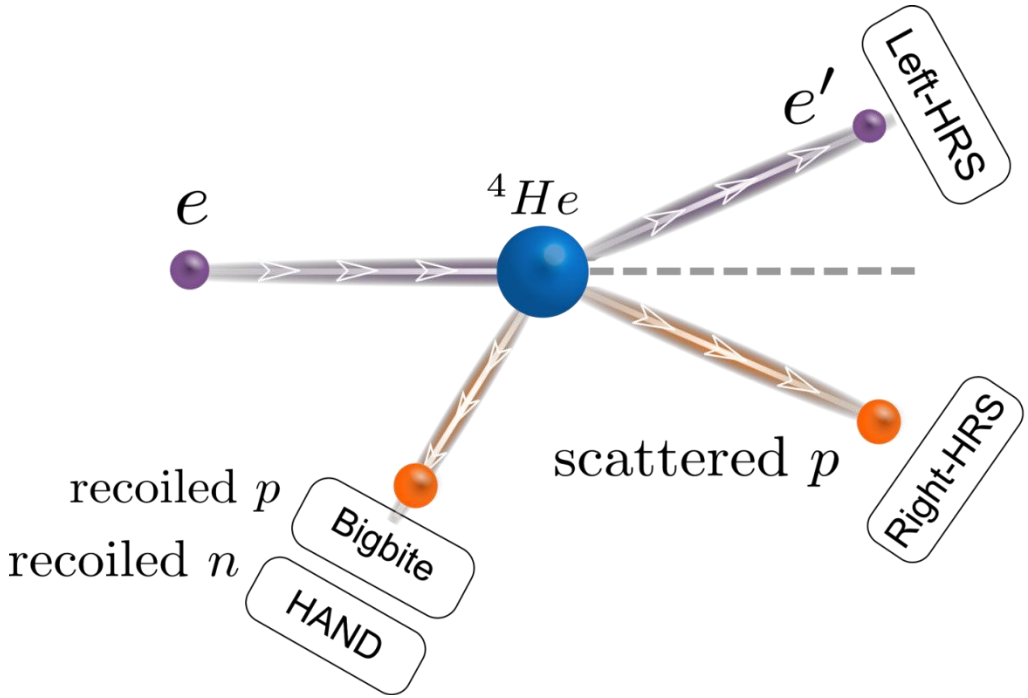
E07-006: ^{4}He(e,e'pN)pn SRC

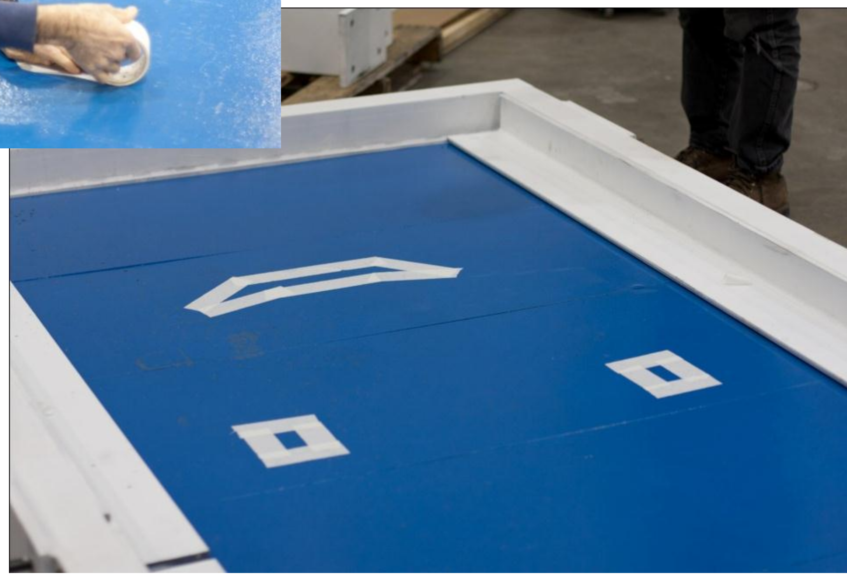
- ^{4}He Target
  - Dense Nuclear Matter
  - *Mean Feild & Exact* Calculations
- P_m from 400 – 800 MeV

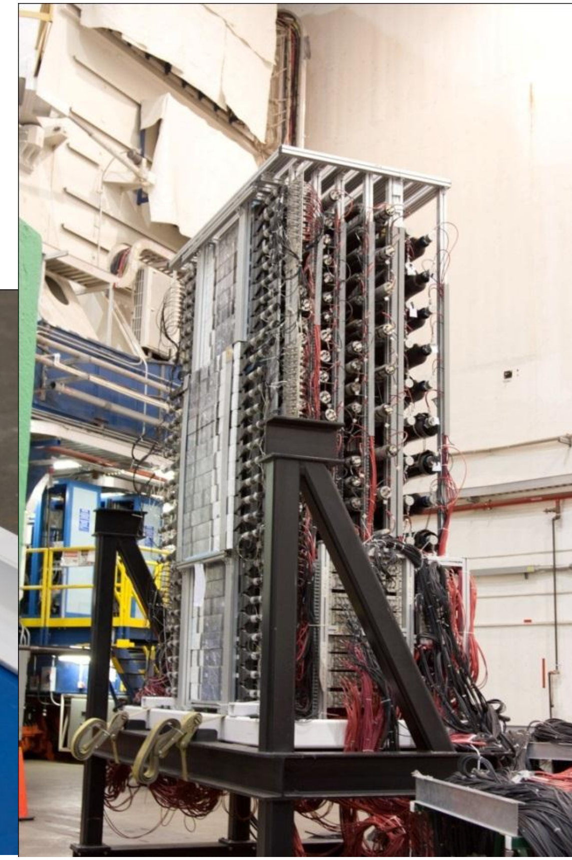
3 Kinematic setting:

500,650 & 750 MeV/c

This reduce to two kinematic for (e,e'N_recoil) , BigBite is at 97 degree and 92 degree.







WHAT WE HAVE FROM OUR EXPERIMENT RUN-PERIOD?

Production data

Production period	March 15 - April 13, 2011 May 11-12, 2011
Beam	4.46 GeV
Current	4 uA
Target	He4 20 cm loop
HRS, Left Arm (fixed):	20.3 deg, 3.6 GeV/c

Production data

Kinematic Setting	Right HRS	BigBite	Cumulative Charge
Kin 1 : (p_miss = 500 MeV/c)	33.5 deg, 1.38 GeV/c	Angle: 97 deg Current: 518 A	1.6 C With 0.7 C has no major problems
Kin 2 : (p_miss = 650 MeV/c)	29.0 deg, 1.31 GeV/c	Angle: 97 deg Current: 518 A	1.67 C
Kin 3: (p_miss = 750 MeV/c	24.5 deg, 1.196 GeV/c	Angle: 92 deg Current: 518 A	2.98 C

ANALYSIS PROGRESS…

Calibration Phase

Detector	What has been done?	Ongoing	What Not?	Problems/Concerns
Beam Line	- BPM - BCM			

Calibration Phase

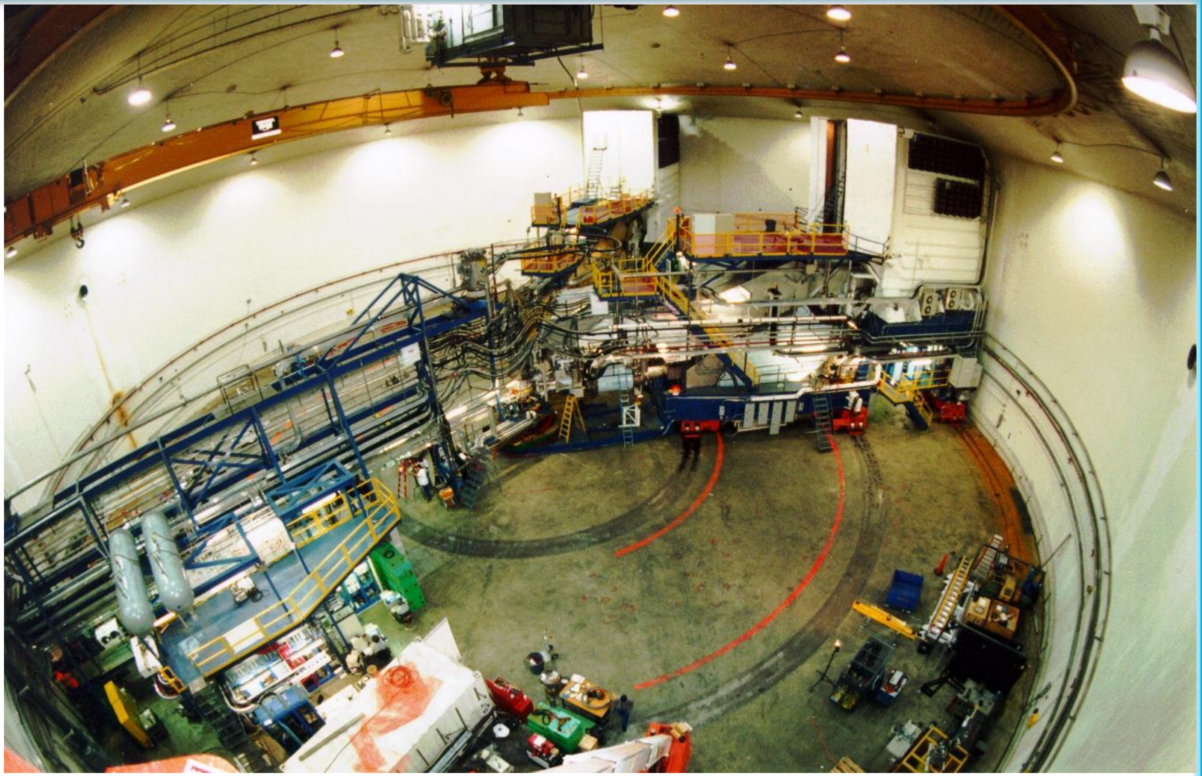
Detector	What has been done?	Ongoing	What Not?	Problems/Concerns
Left HRS : as electron spectrometer	- Vetex, theta,phi optics matrix - Vdc t0 - S2 scintilator Time - Cherenkov - Lead Glass	- Momentum optics matrix	-	½ of Kinematics 1 has overflow of the Cerenkov., .. Only use the Lead Glass detector as Particle Identification (PID)

Calibration Phase

Detector	What has been done?	Ongoing	What Not?	Problems/Concerns
Right HRS : as proton spectrometer	- Vdc t0 - S2 & S1 scintillators relative time	- optics matrix - S2 time by itself	other detectors that not applicable for proton PID are not calibrated	

Calibration Phase

Detector	What has been done?	Ongoing	What Not?	Problems/Concerns
BigBite	- MWDC t0 calibration - E & dE TDC & ADC calibration	Optics	N/A	
Neutron	Extraction Code aiming for the maximum identify neutron			



LEFT HRS OPTIC CALIBRATION

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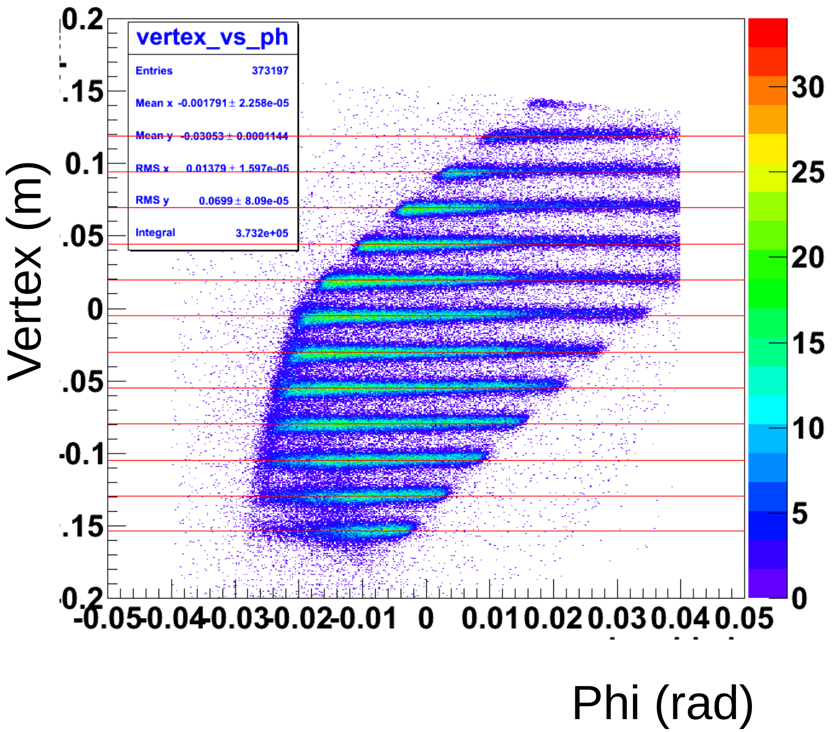
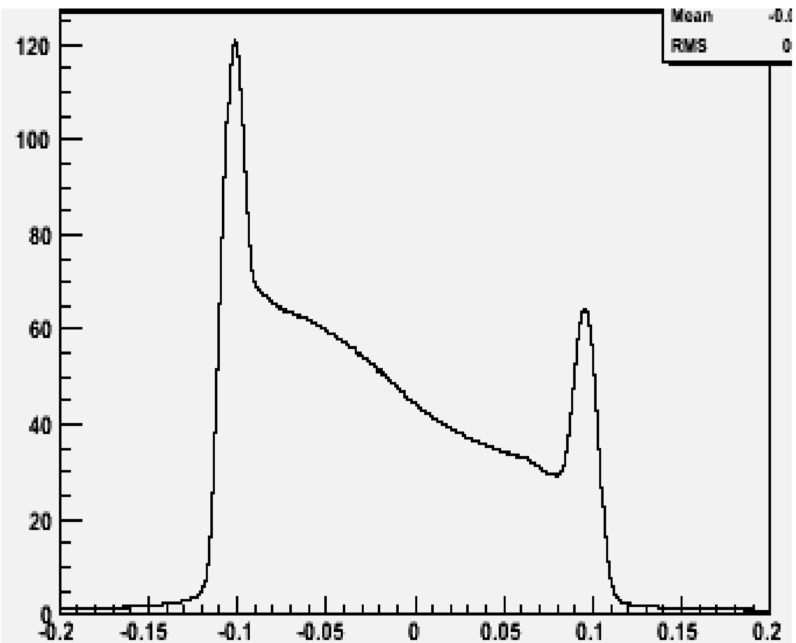
Vertex Calibration



- Vertex calibration with 13 carbon foils with 25 mm separation (300 mm total length)
- Achieve the resolution of 2.5 to 3.9 mm
- Show the possibility of using high density optic foils.

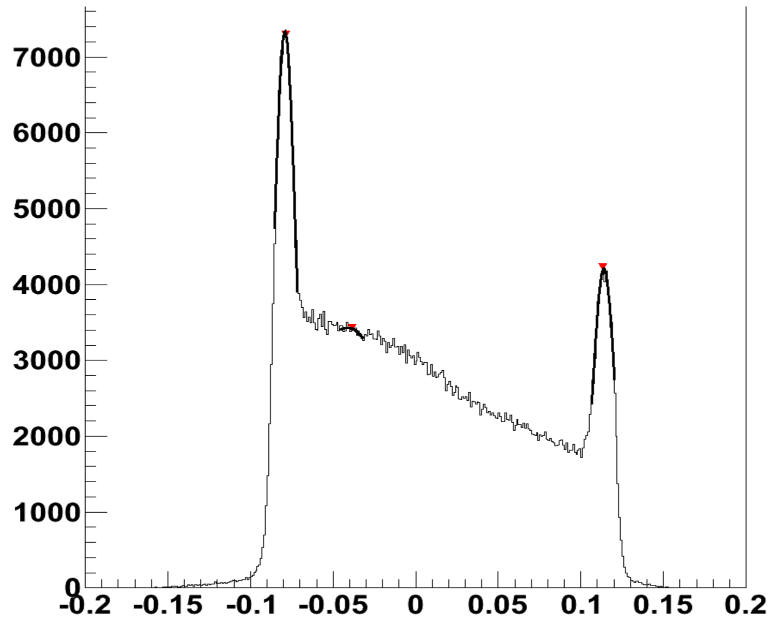
Vertex Reconstruction for 20 cm He4 target

Before Calibration



Vertex z (m)

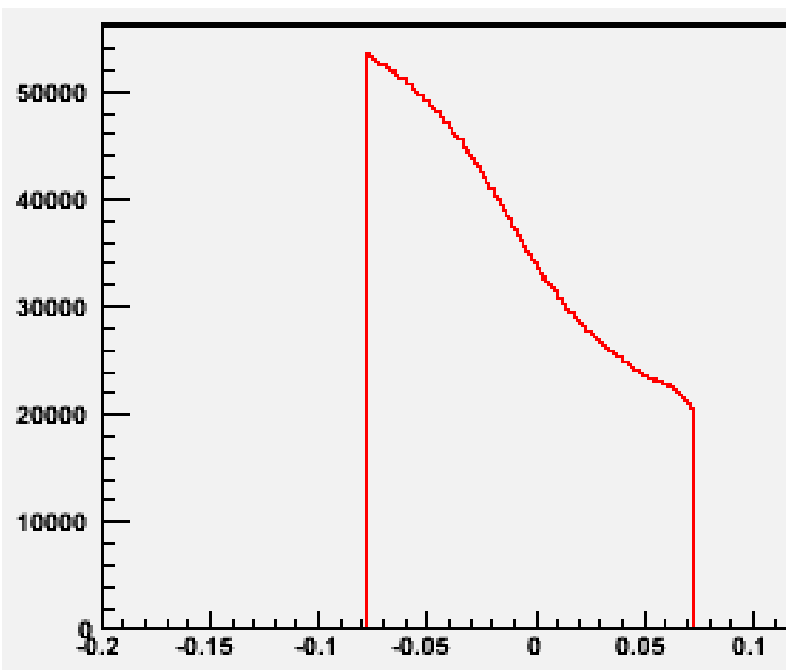
New Calibration



Vertex z (m)

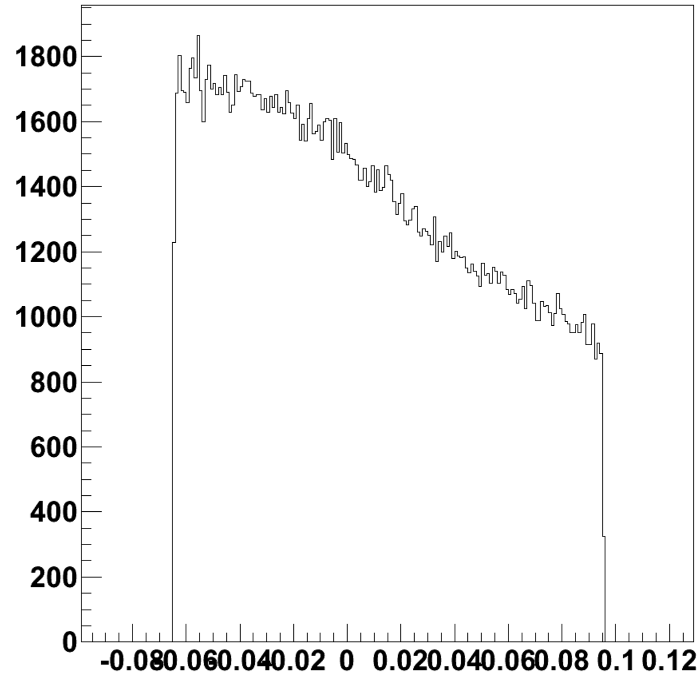
Vertex Reconstruction for 20 cm He4 target

Before Calibration (cut window)



Vertex z (m)

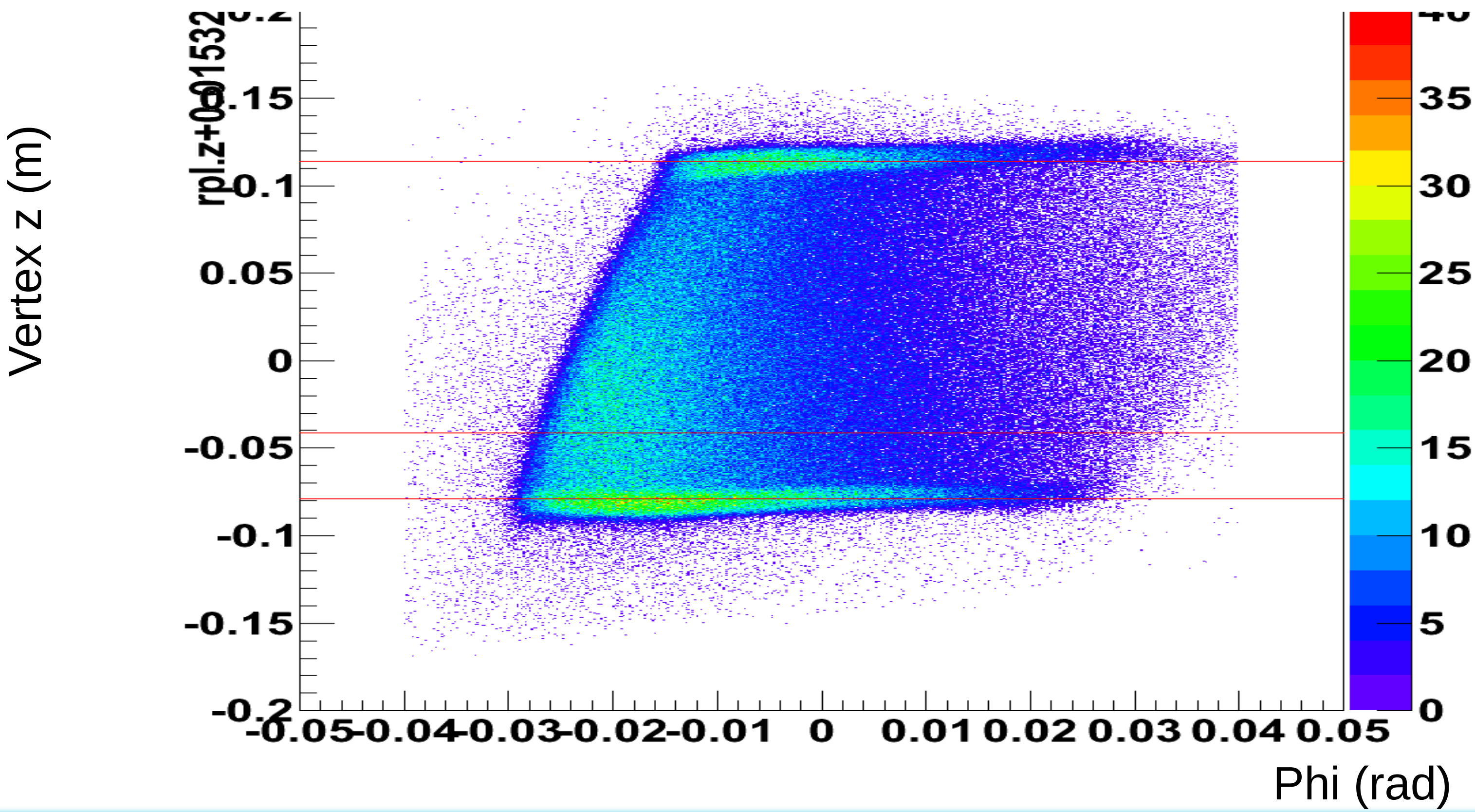
New Calibration (cut window)



Vertex z (m)

Vertex Reconstruction for 20 cm He4 target

New Calibration (cut window)



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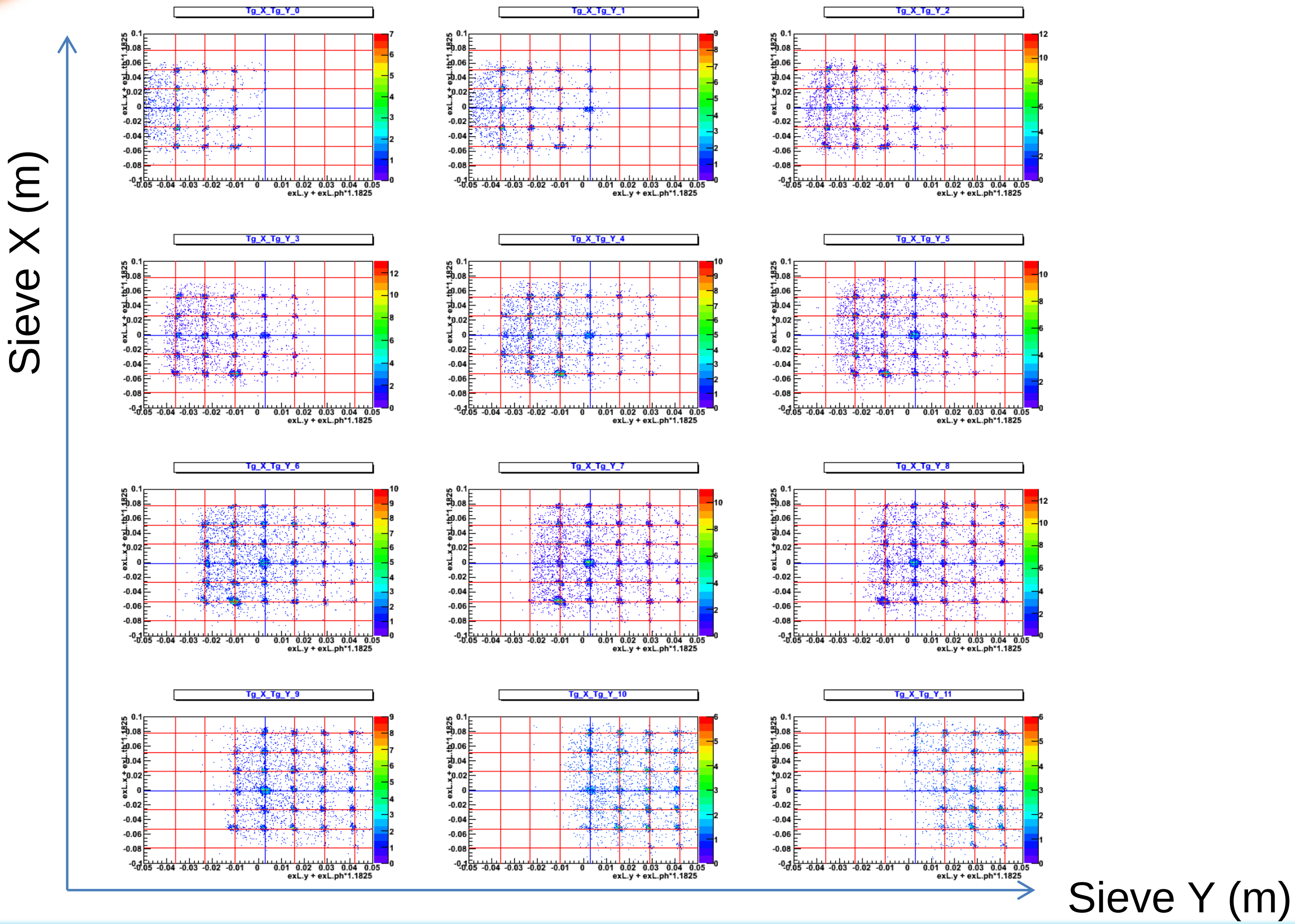
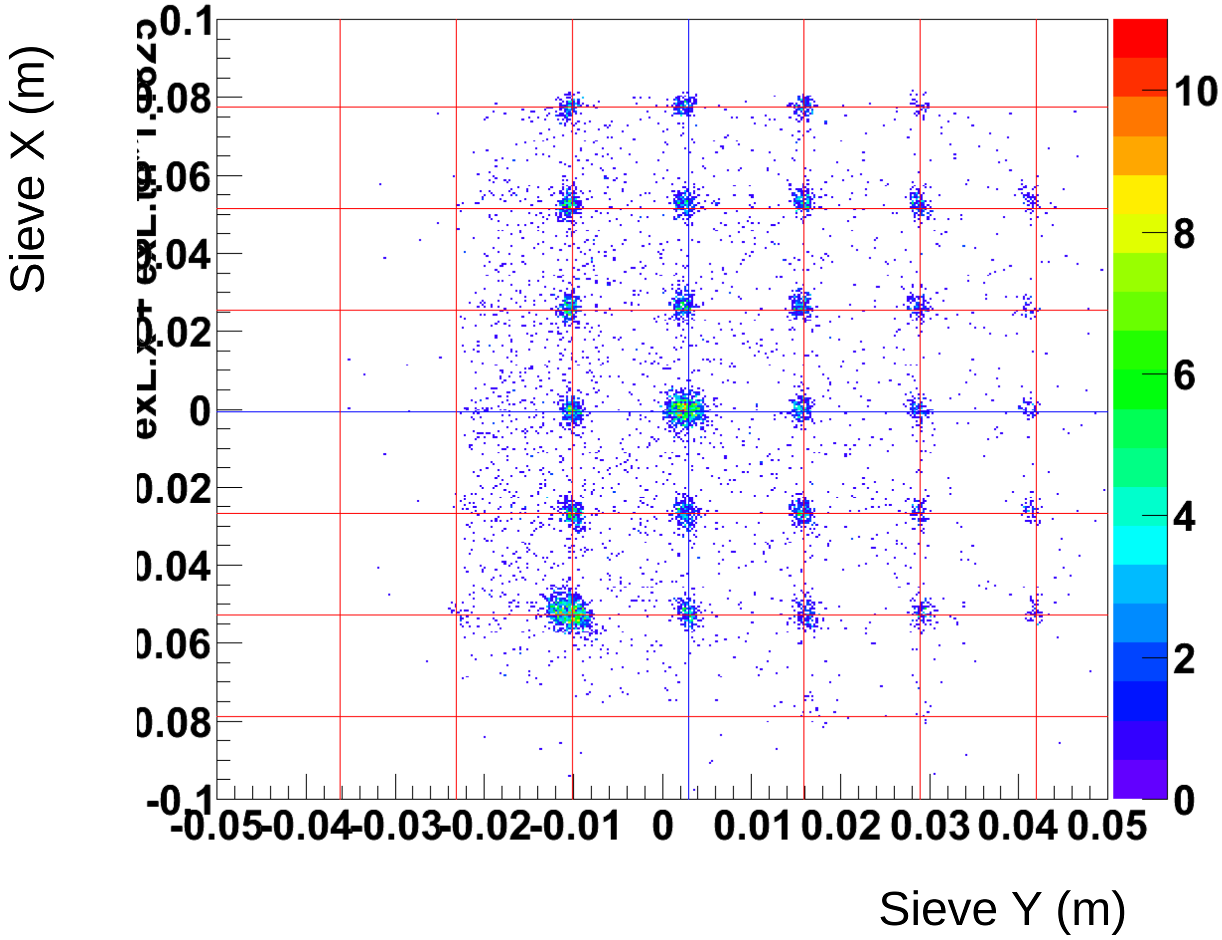
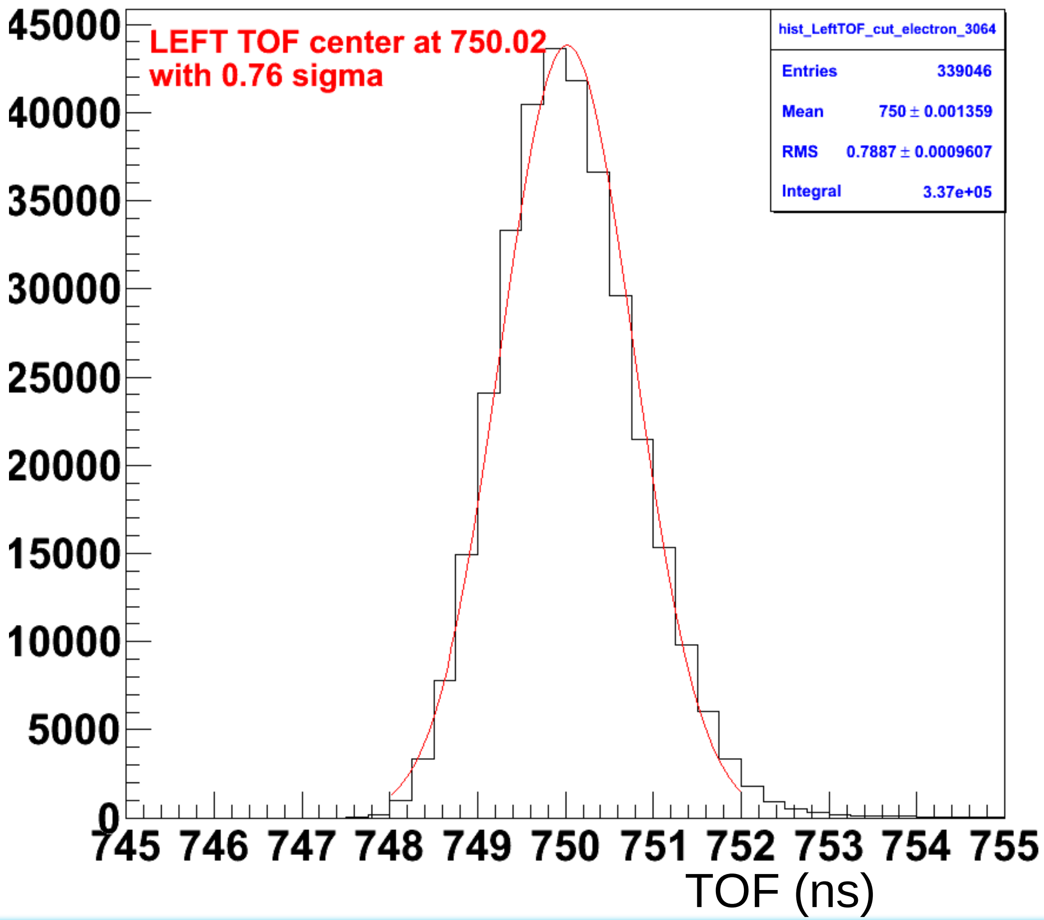
In-plane & out-of-plane angles Calibration



In-plane & out-of-plane angles Calibration



S2 Timing Calibration

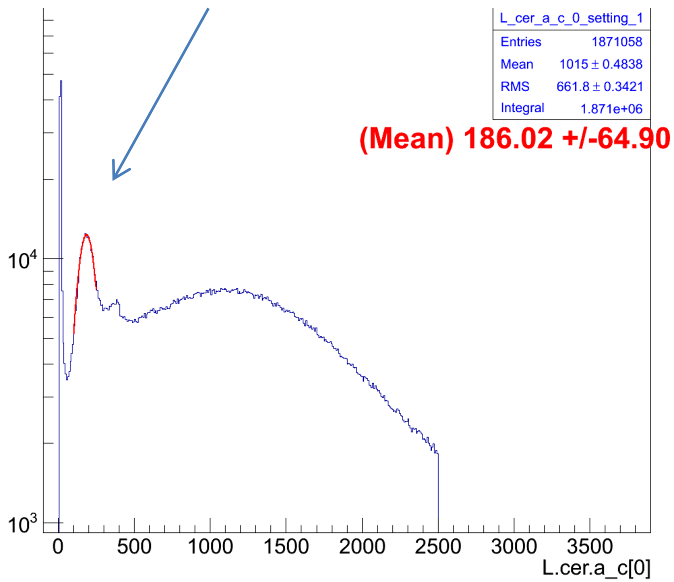


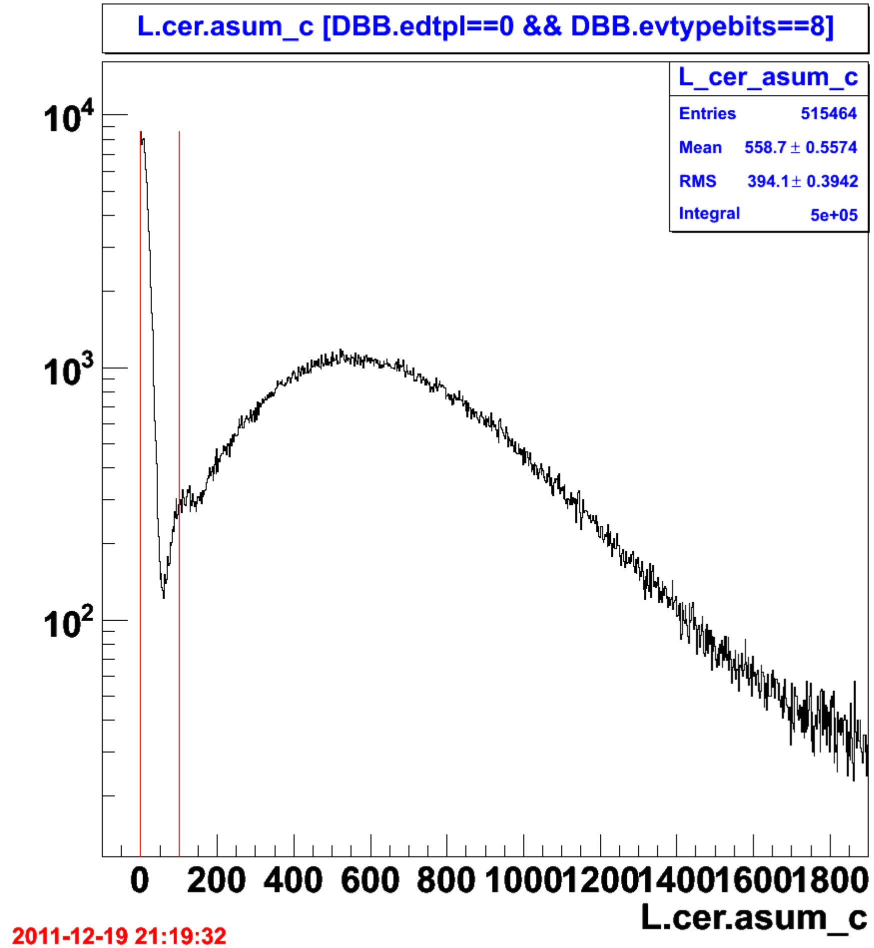
[Define]
TOF
 =
S2Time –
pathlength/(beta*c)

Cherenkov Calibration

After calibration

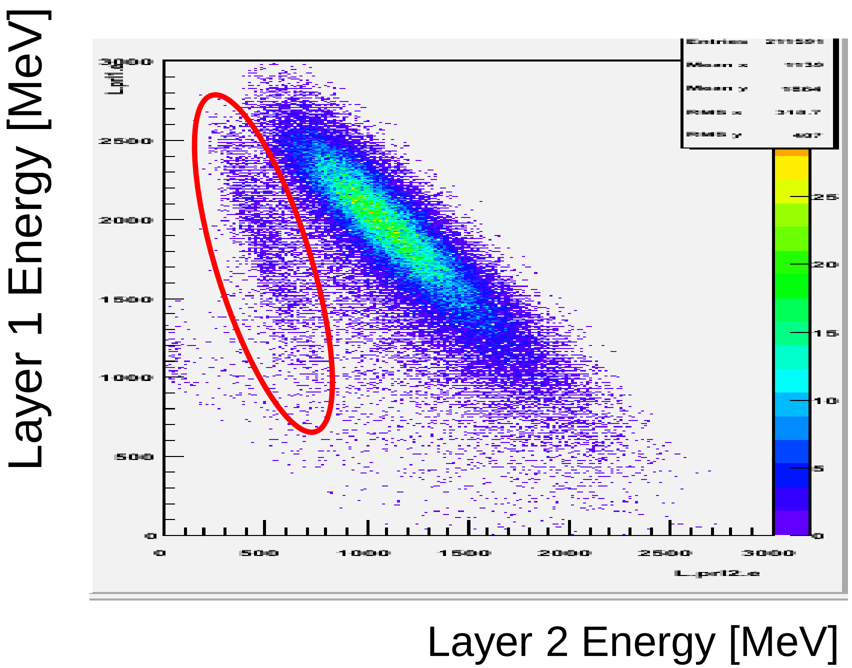
Before calibration



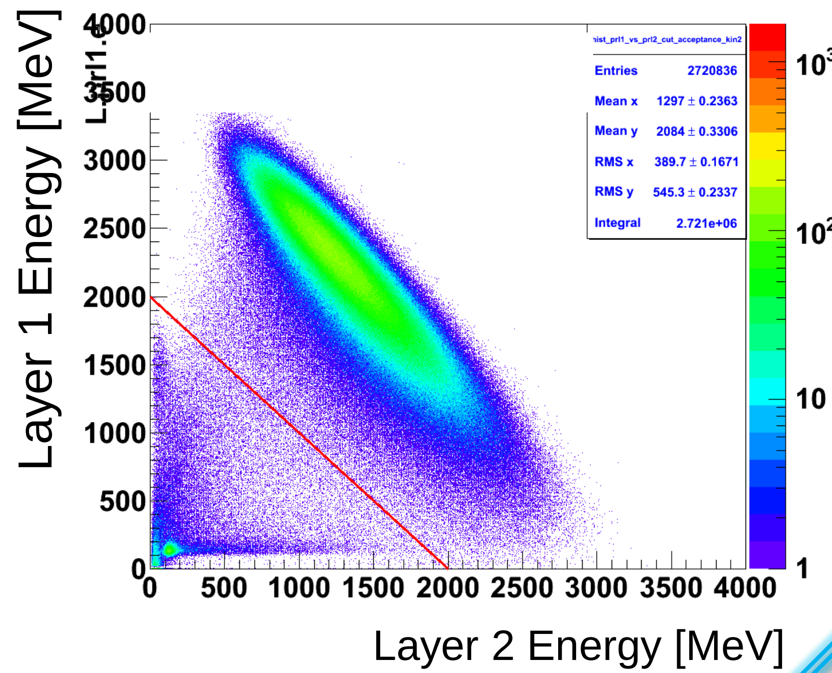


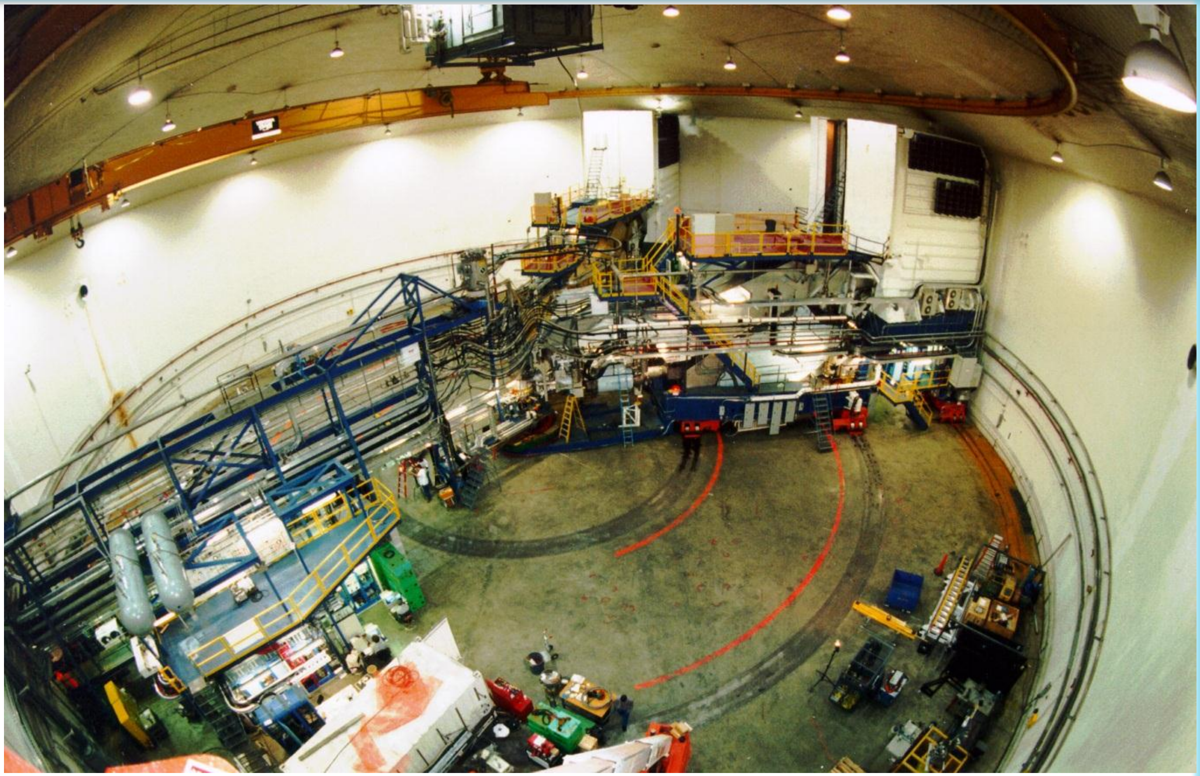
Pion Rejecter Calibration

Before Calibration



Energy Deposit in Pb Glass Detector





RIGH HRS OPTIC CALIBRATION

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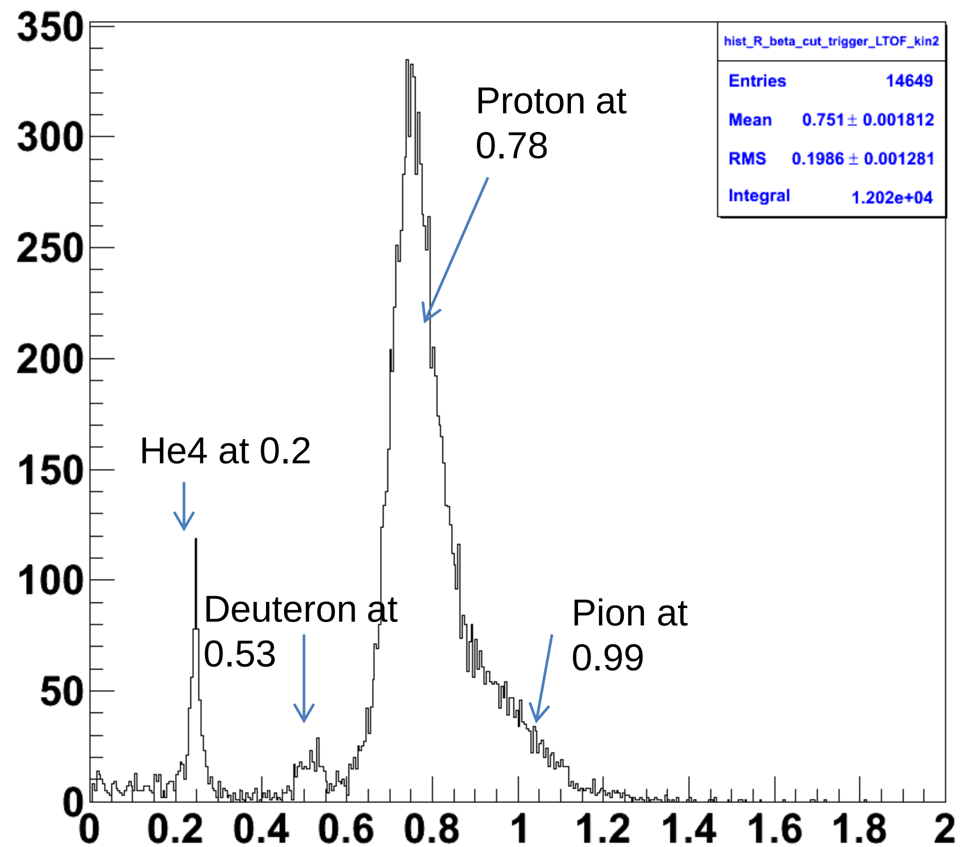
Right Beta distribution

Beta calculation from beta = (pathlength)/(time*c)

between S1 and S2 Scintilators



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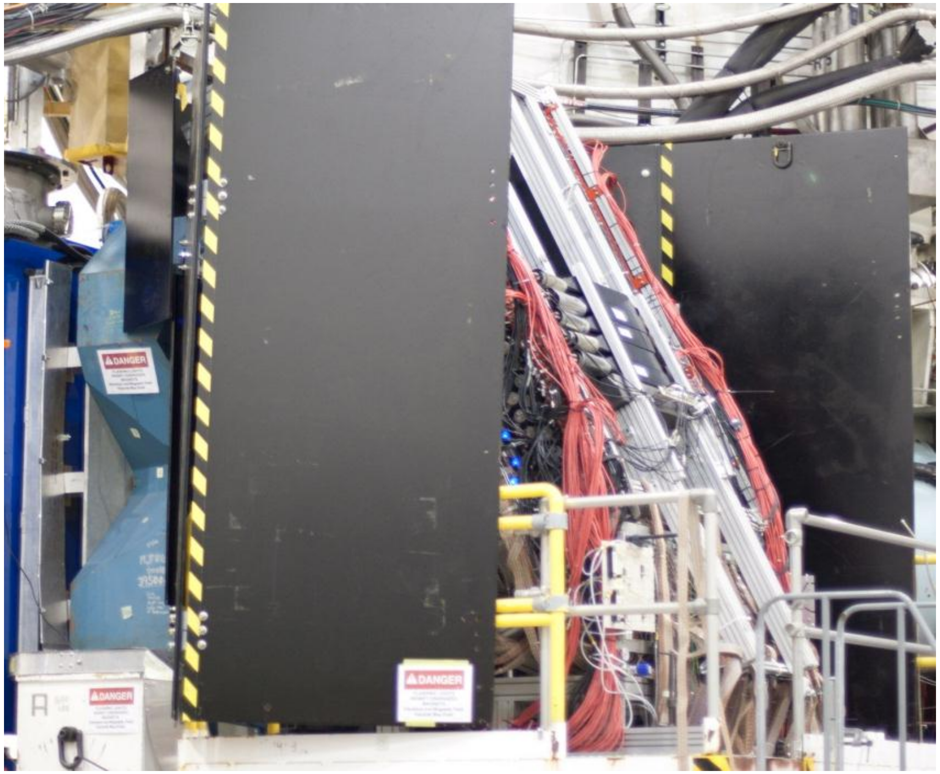
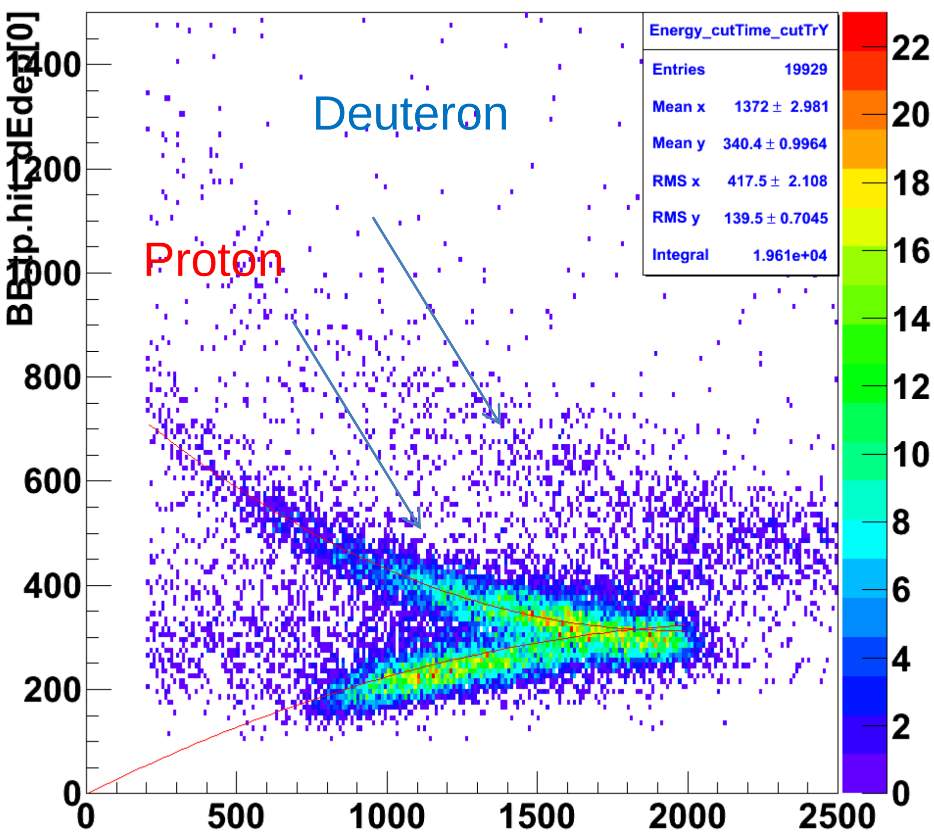


BIGBITE CALIBRATION

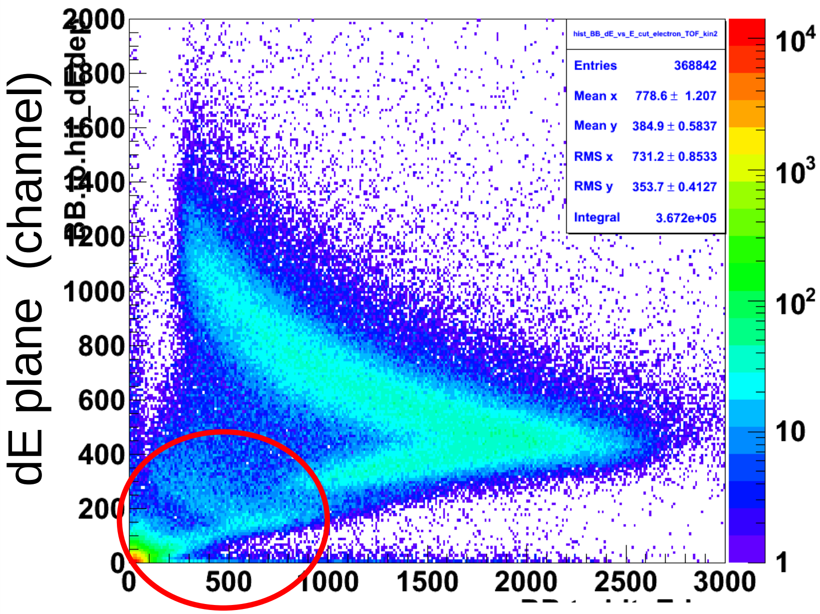
BigBite Calibration



- Calibration of the dE vs E energy deposit

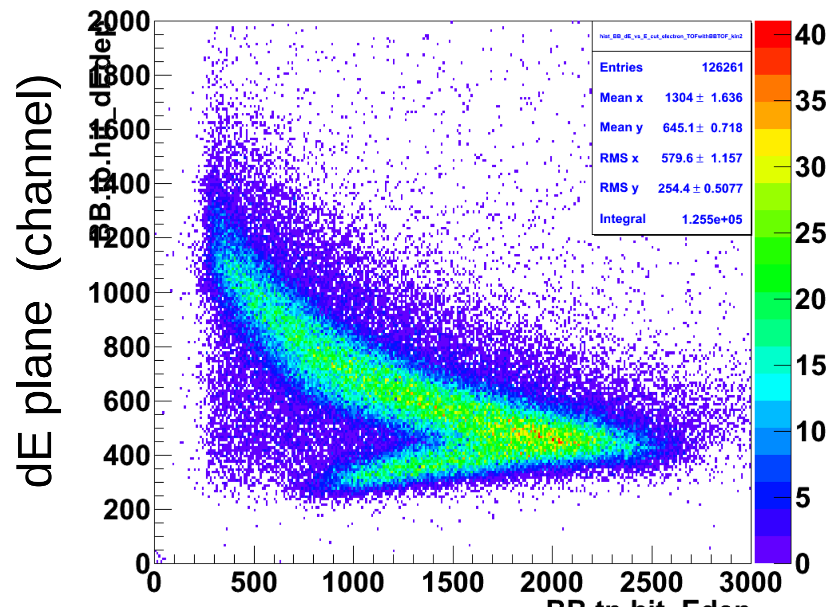
Trigger planes

Energy deposit with taging electron



E plane (channel)

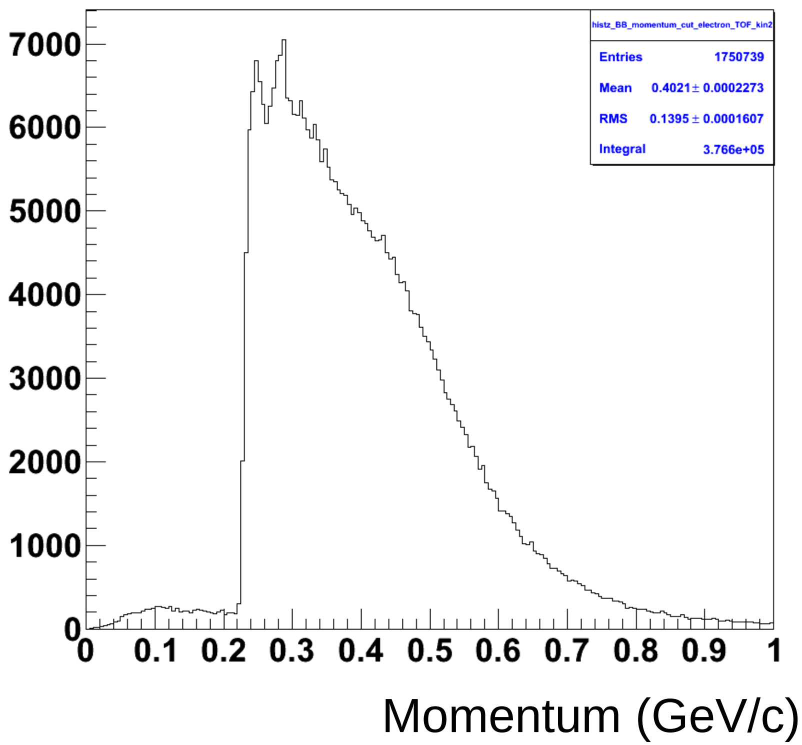
Energy deposit with coincidence timing with electron



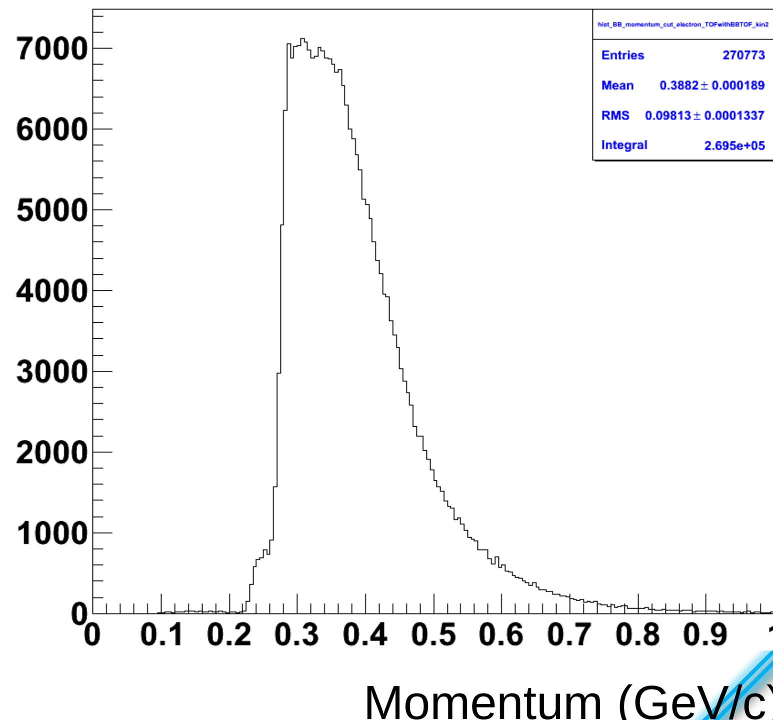
E plane (channel)

BigBite Momentum from Analytical Model

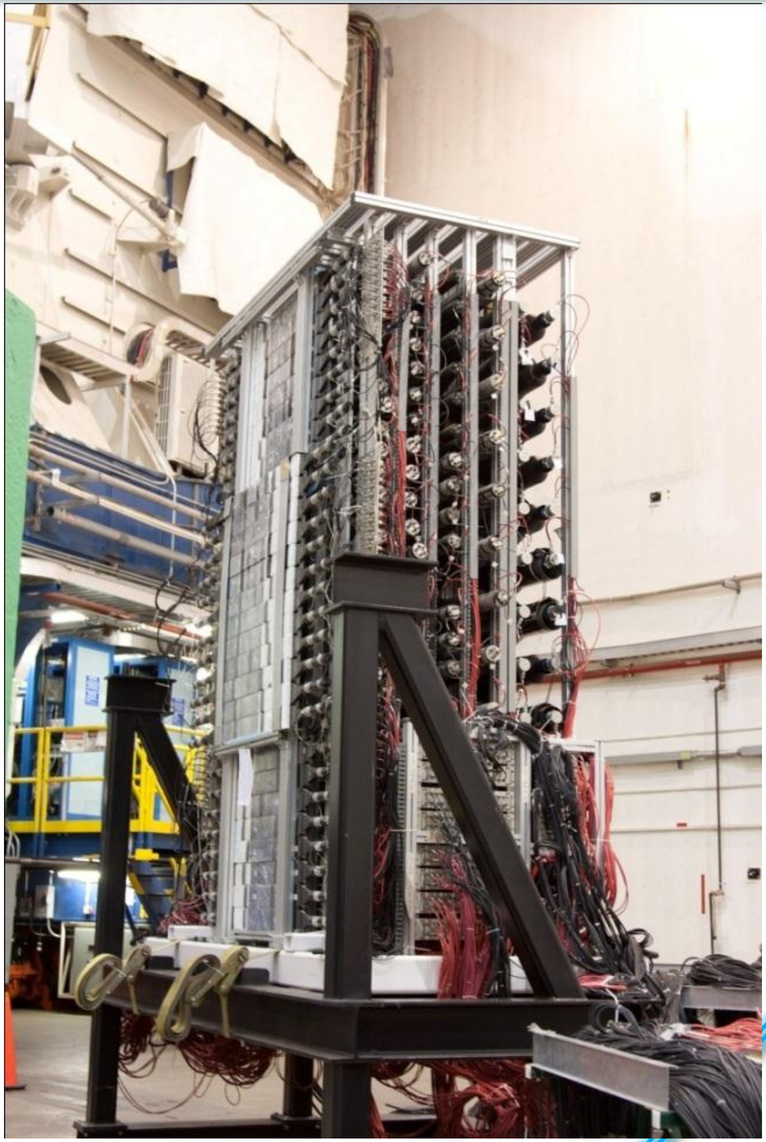
With tagging electron



With coincidence timing with electron



NEUTRON CALIBRATION



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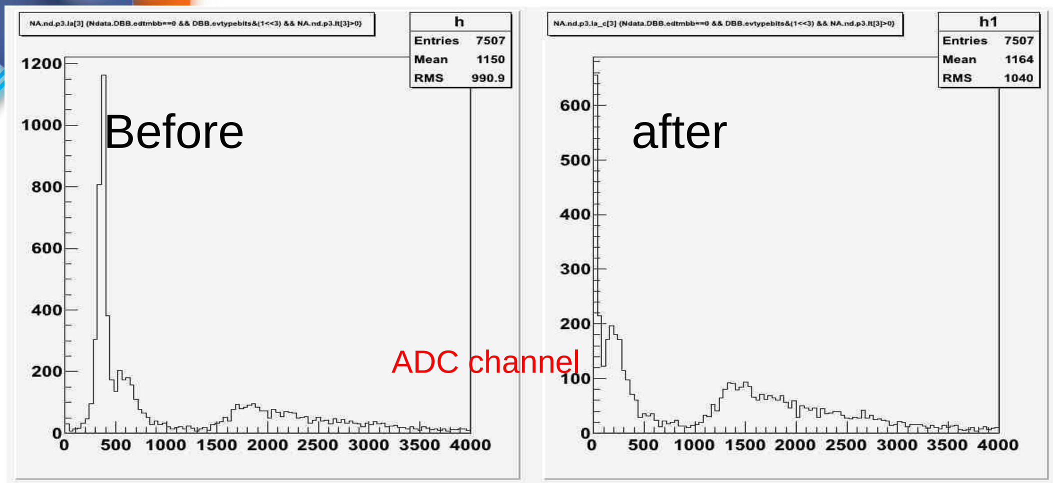
Pedestals Alignment

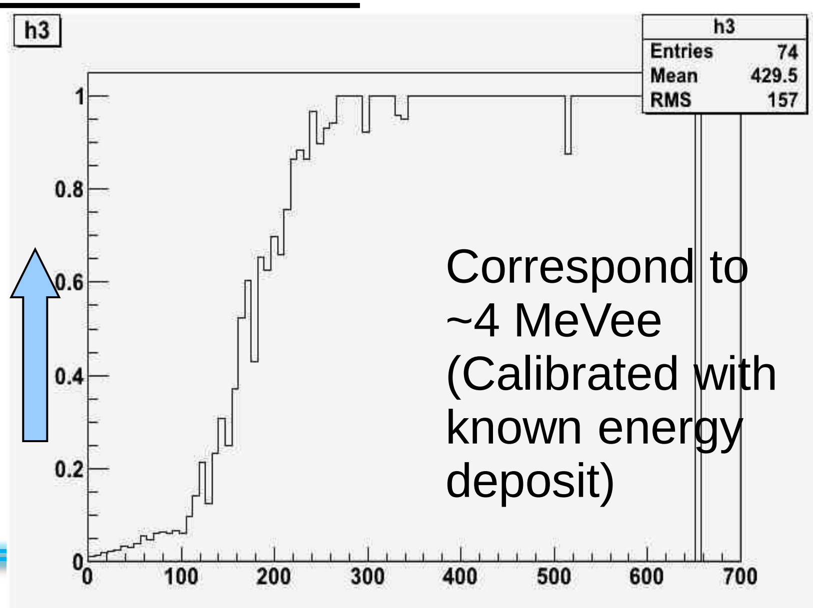


HAND calibration

* Pedestals alignment
* Threshold determination
* TDC alignment
* Time walk correction
* Position calibration
* TOF calibration for elastic scattering
* Neutron detection efficiency

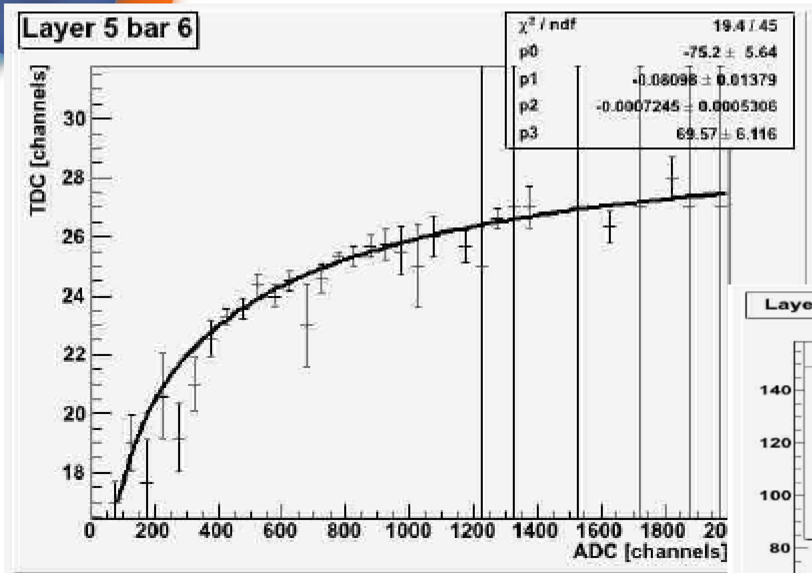
Threshold determination

ADC Histogram (with TDC>0) divided by ADC Histogram with no TDC cut



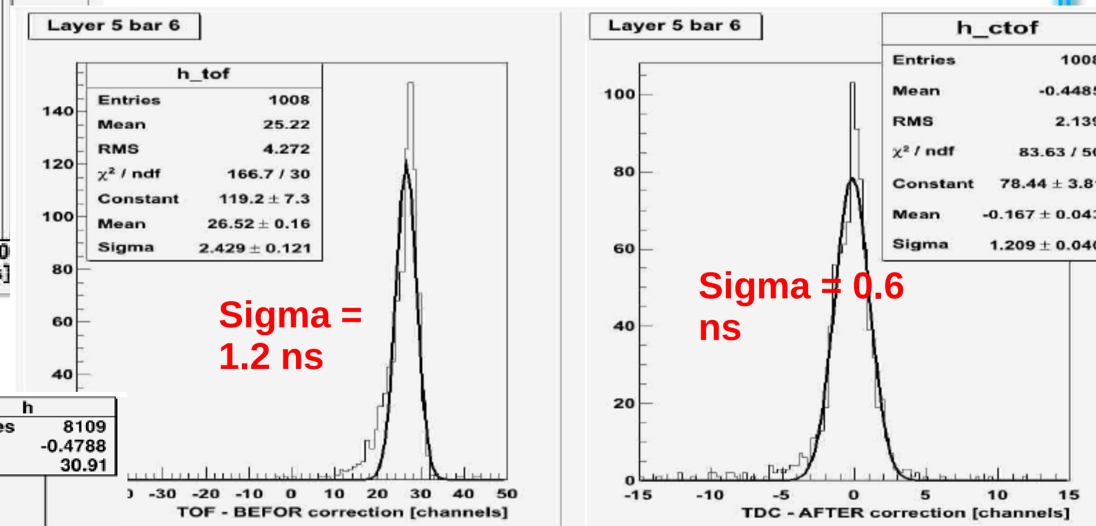
ADC Channel

Time walk correction

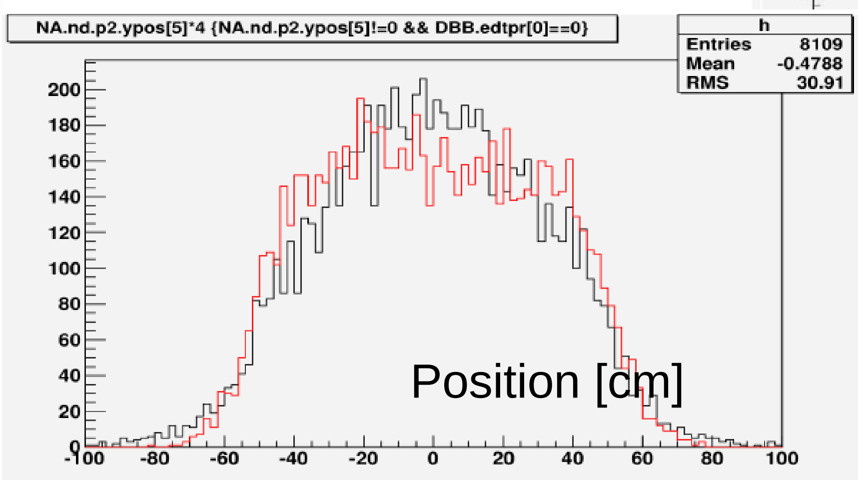


Data is fitted to:

$$TDC = a * X^{b} + c * X + d$$



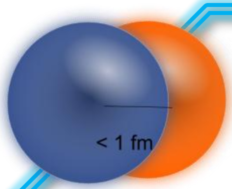
Position Calibration



Position:

* Black – data after calibration.

* Red – uniform distribution from -50 to 50 (c... with Gaussian resolution of 10 cm.

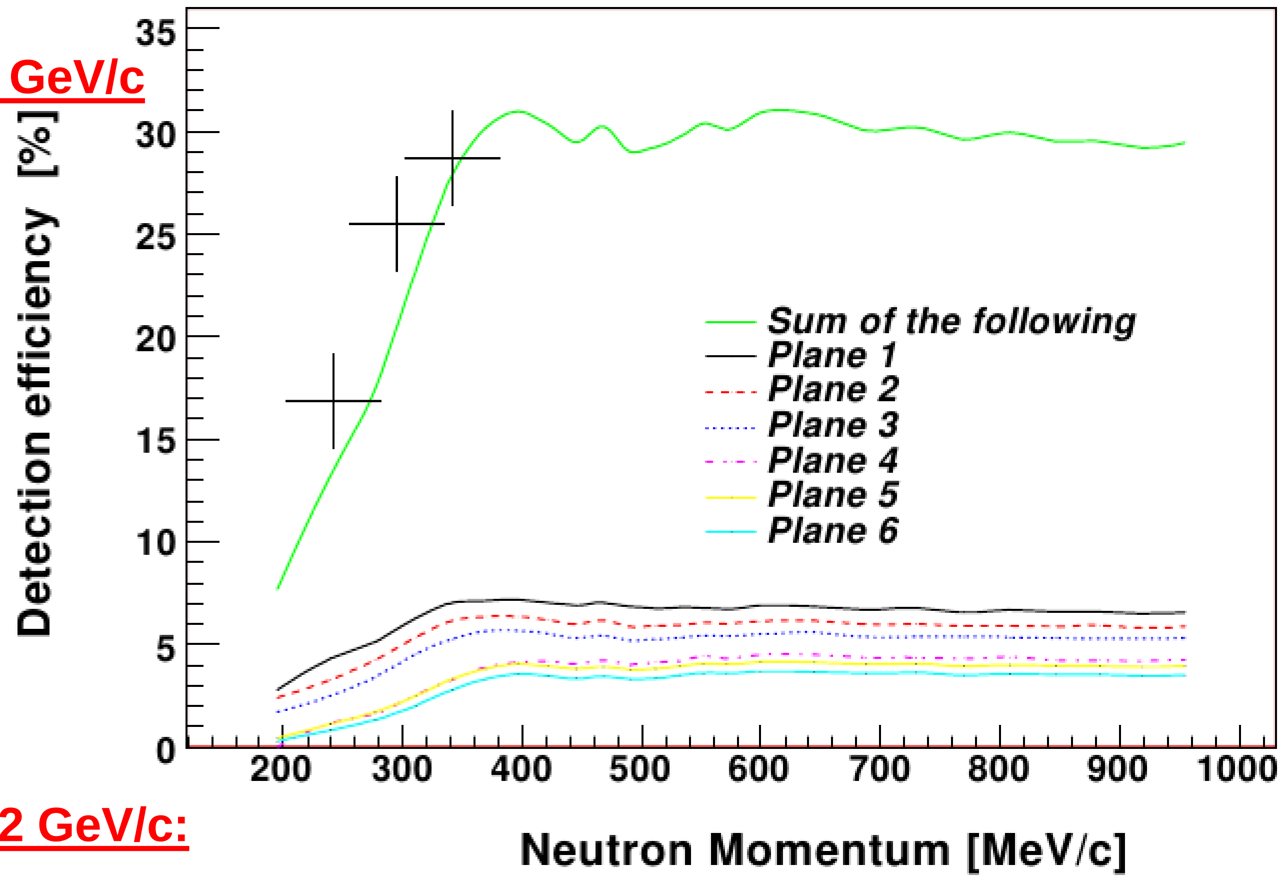


Neutron detection efficiency

We have d(e,e'pn) coincidence data at two kinematic settings :

* Pmiss between 0.22 – 0.38 GeV/c
* Pmiss between 0.38 – 0.52 GeV/c

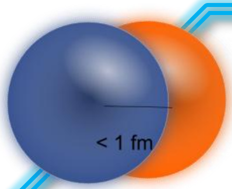
Pmiss: 0.22 – 0.38 GeV/c



Pmiss 0.38 – 0.52 GeV/c:

In progress

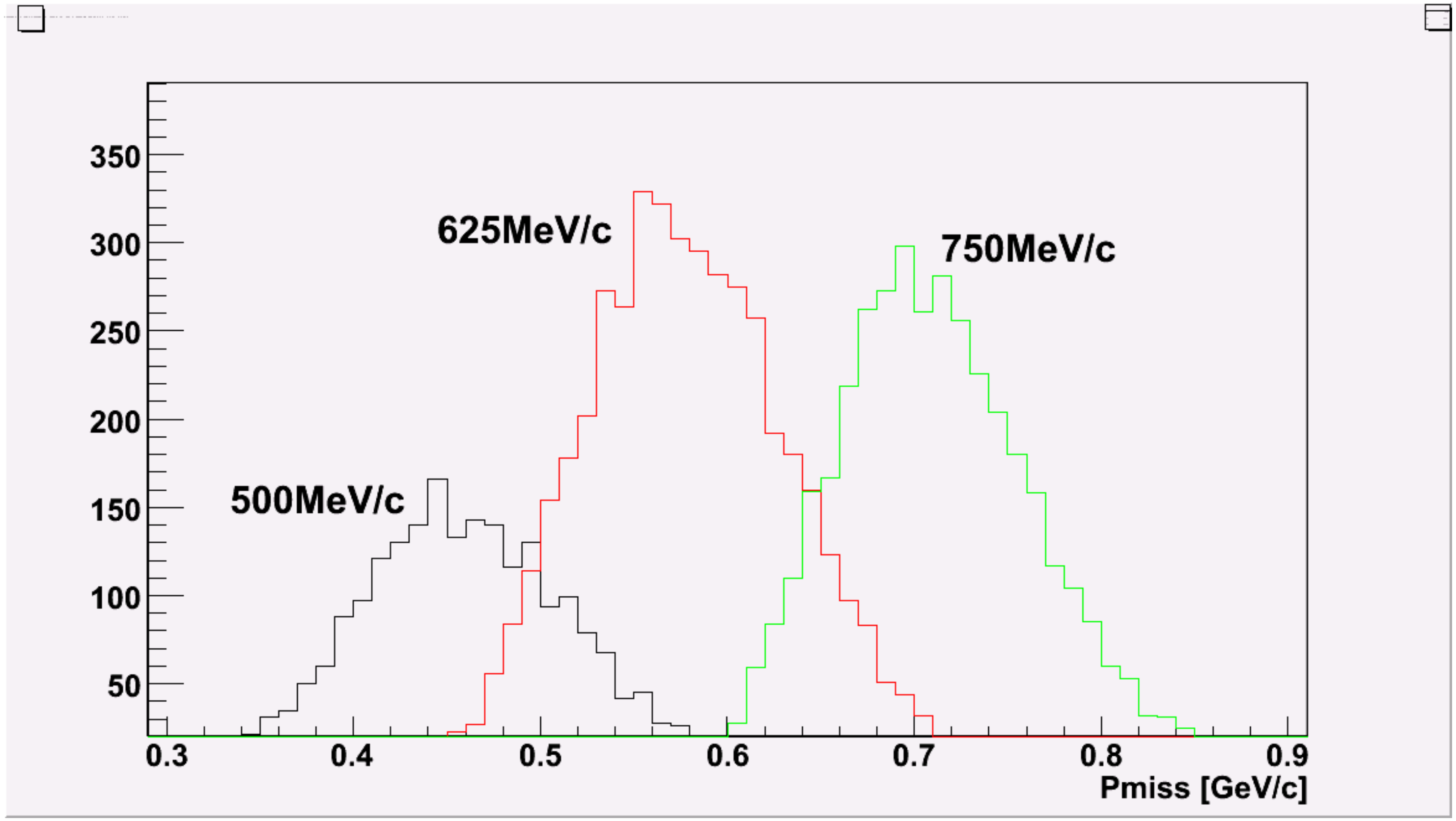
PRELIMINARY RESULTS



Two Aimed Results

- 1. The triple coincident result:
  - Ratio (e,e’pp)/(e,e’p)
  - Ratio (e,e’pn)/(e,e’p)
  - Ratio (e,e’pp)/(e,e’pn)
- 2. the double coincident with backward (recoiled) nucleon.
  - Absolute cross-section (e,e’N_recoiled)
  - Ratio (e,e’p_recoiled)/(e,e’n_recoiled)

Preliminary Triple Coincident



- The P_miss distribution of each kinematic.

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    - Zhihong Ye (Uva)

Navaphon Muangma (Tai)
"Hall A Meeting" June 2012

Jefferson Lab
Thomas Jefferson National Accelerator Facility

The END

Follow our analysis at

http://hallaweb.jlab.org/experiment/E07-006/analysis_page.html

Electron PID using Lead Glass Detector

After calibration we have the clear separation of the electron from pion. At our kinematic setting for the Left HRS, we rarely have the contamination from the pion, i.e., 97% electron production rate.

Current Status

- Electron PID
  - Separating electron from pion

- Two possible requirements for Election PID:
  - Create Signal above background in Cherenkov detector (NOT USE)
  - Deposit large amount of energy in (two-layer) lead glass where (Aprox.) E/p = 1.