OLD DOMINION UNIVERSITY
IDEA FUSION

Old Dominion University 2015

Comparing proton and neutron momentum distributions in ^{3}He

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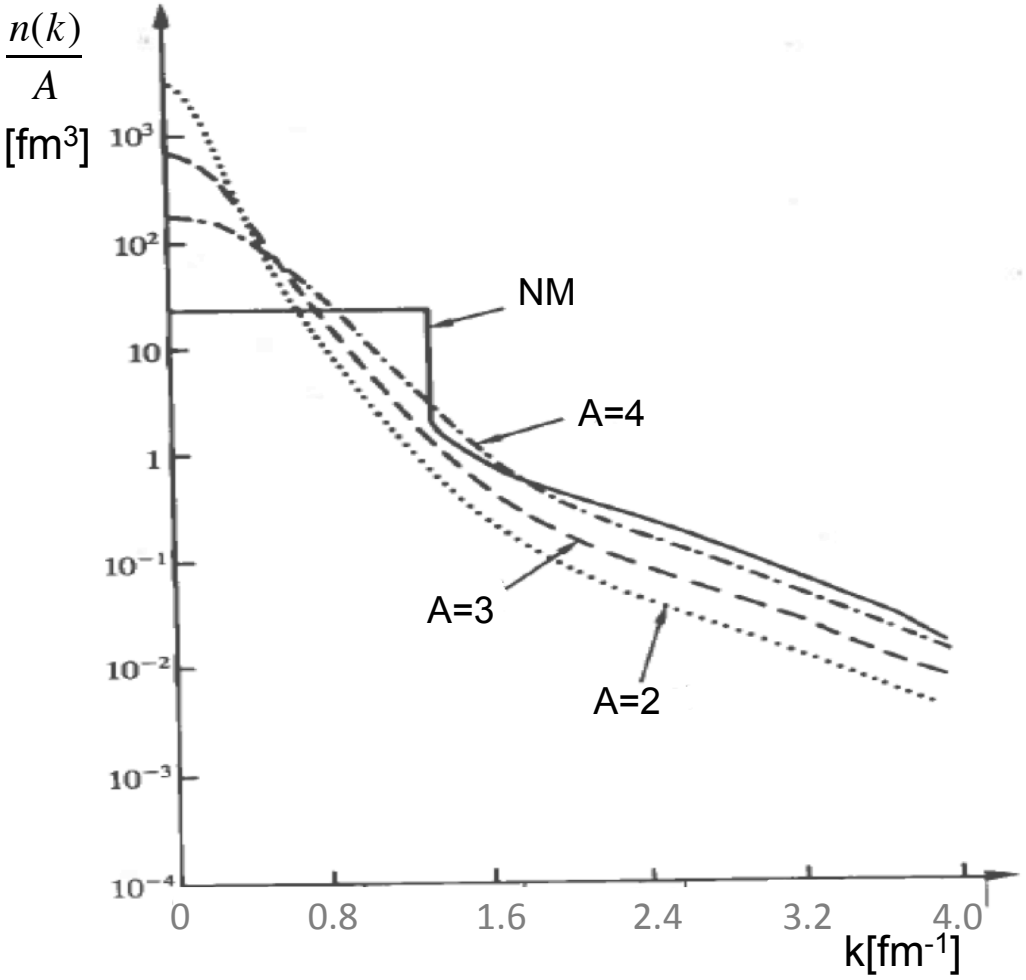
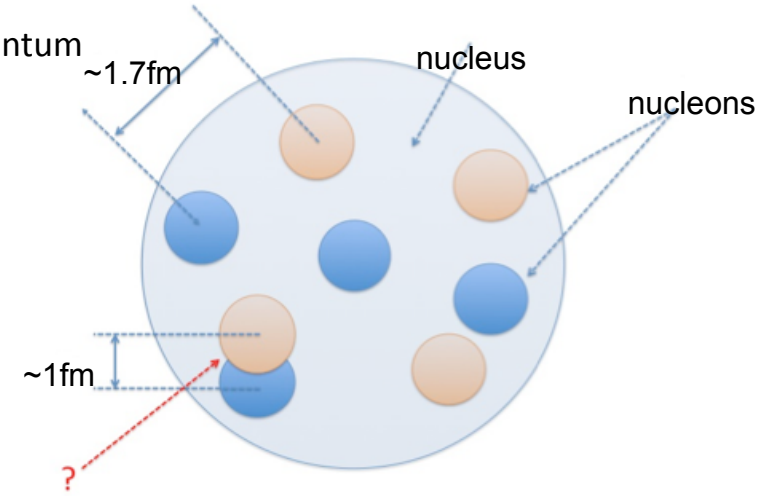
What are SRC?

2N-SRC are pairs of nucleons with;

- with small distance between each other(~10^{-15}m)
- High relative momentum and small center of mass momentum with respect to Fermi momentum(250-270 MeV/c)



N(k)/A calculated by Schiavilla et al.(1986) in A=2,3 and 4 nuclei and nuclear matter (NM).



n-p pairs dominate over p-p,n-n pairs.

- n-p(90%)
- p-p(5%)
- n-n(5%)

- Almost all high momentum nucleons belong to SRC pairs
- Not described by I.P.M. (the motion of the nucleon is not affected by the other individual nucleons)

Measure momentum distribution in A=3 (e,e'N)

Scatter electrons from 3He and detect knocked out n or p

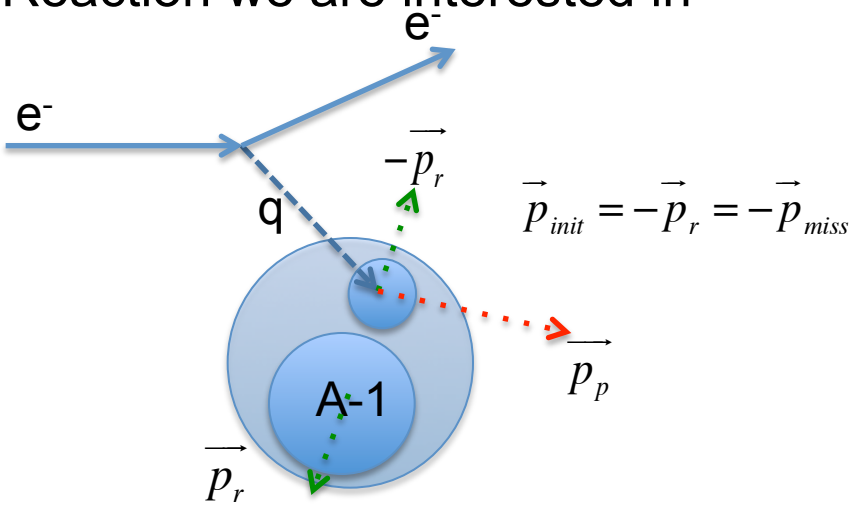
$$\frac{d\sigma}{dE_{e'}d\Omega_e dE_N d\Omega_N} = K\sigma_{eN}S(E_m, p_m)$$

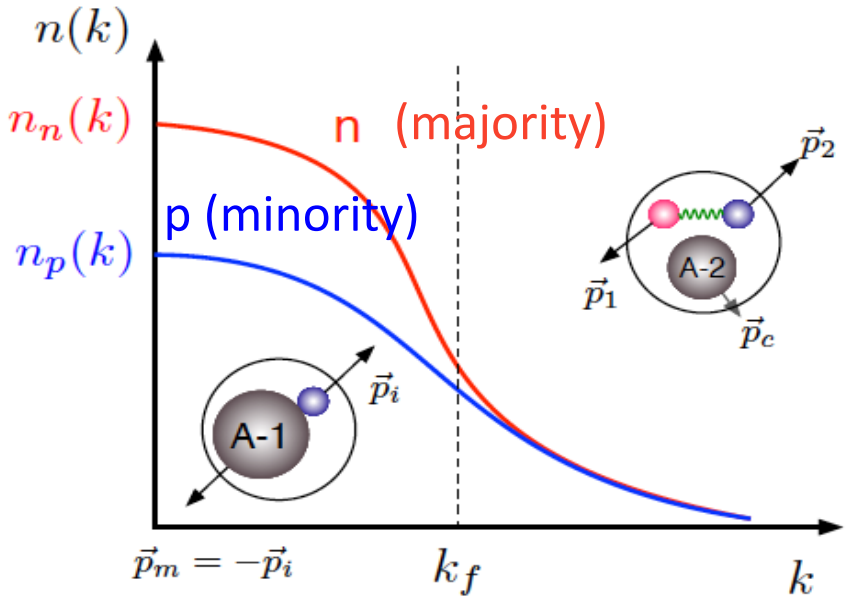
$$K = \frac{E_N p_N}{(2\pi)^3}$$

$$E_{miss} = \omega - T_N - T_{A-1}$$

$$\vec{p}_{miss} = \vec{q} - \vec{p}_N$$

Reaction we are interested in





The momentum distribution of protons and neutrons in ^{3}H.

From isospin symmetry the momentum distribution of p in ^{3}H should be equal to that of n in ^{3}He.

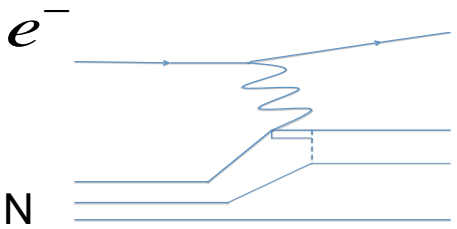
Majority	Minority
p in ^{3}He	n in ^{3}He
N in ^{3}H	p in ^{3}H

Hall A experiment

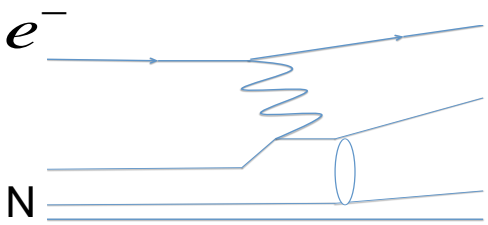
Will study majority and minority nucleon (p in ^{3}He and p in ^{3}H) momentum distributions in A=3 asymmetric nuclei.

$p_{miss}=p_{initial,}$ only if there are no final state interactions or other interactions.

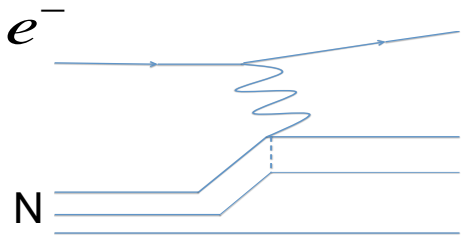
Processes we want to avoid



Excitation of the nucleon into intermediate Delta.



Final State Interactions



MEC(Meson exchange currents)

Kinematics:

- $x = \frac{Q^2}{2m\omega} > 1$ to suppress Delta production.
- High Q^2 (Q^2~2$(GeV/c)^2$) to minimize meson exchange currents (MEC)
- Small $\theta_{rq} < 40^o$ (angle between recoil momentum and momentum transfer) to suppress Final State Interactions

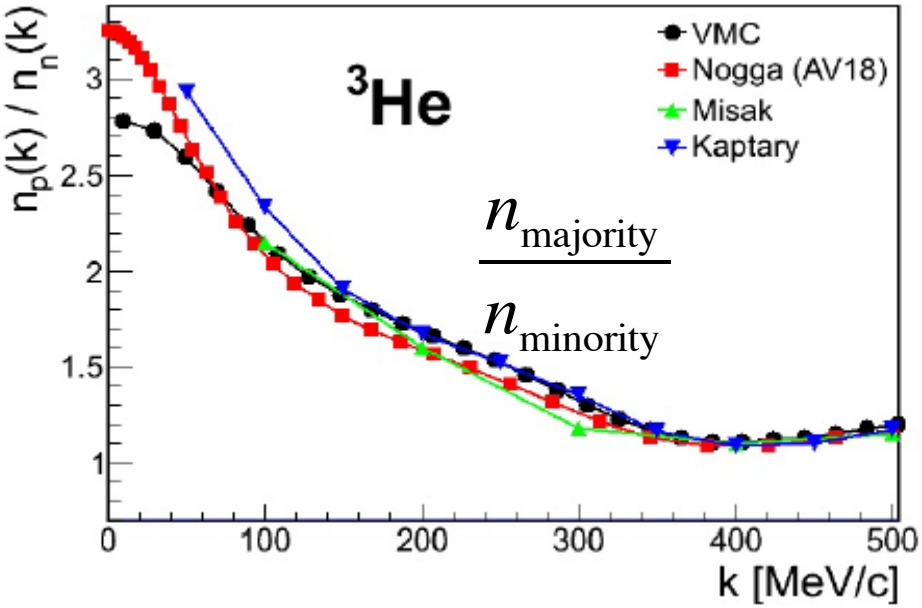
The power of ratios

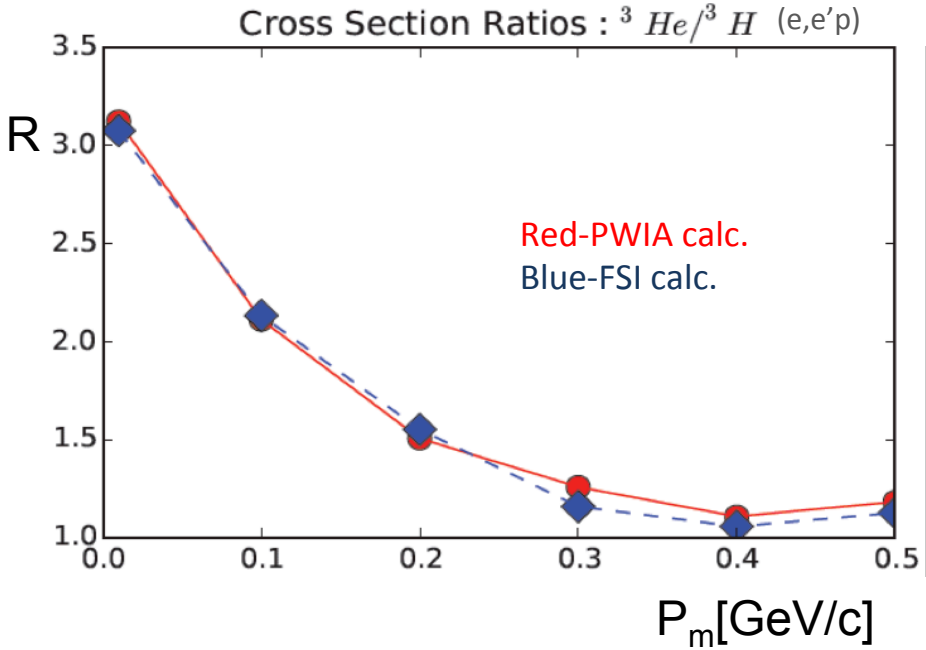
^{3}He(e,e'p)/^{3}He(e,e'n) cross section ratios and $n_p(k)/n_n(k)$ provide:

- Information about majority and minority momentum distributions

$$\frac{n_{maj}(k)}{n_{\min}(k)} \approx \frac{\sigma[^3\mathrm{He}(e,e'p)]}{\sigma[^3\mathrm{He}(e,e'n)]}$$

- Transition to SRC dominance



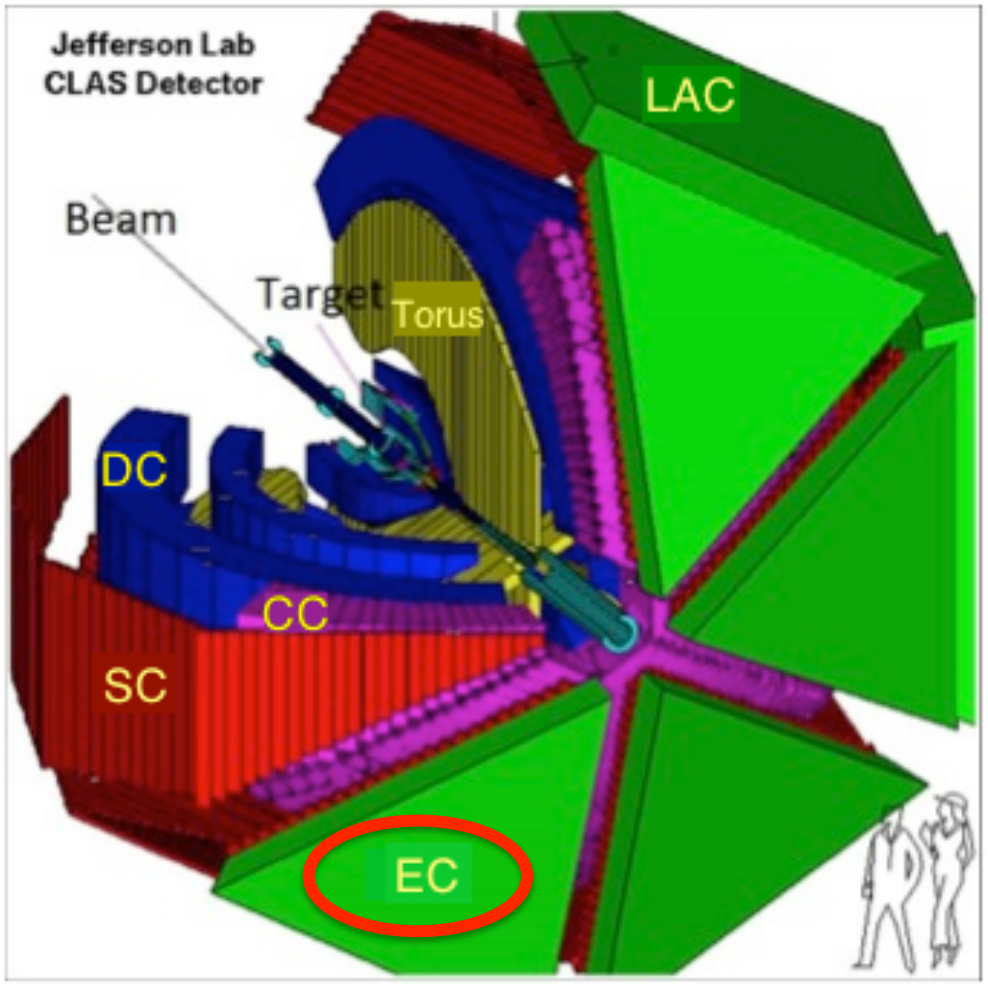


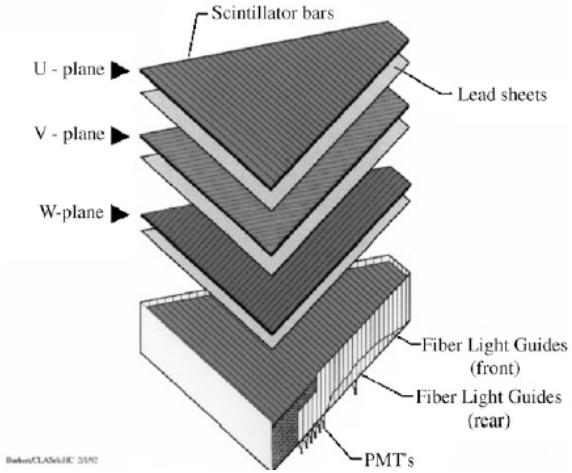
Hall A: $^3\mathrm{He}(e,e'p) / {}^3\mathrm{H}(e,e'p)$

CLAS : $\dfrac{^3\mathrm{He}(e,e'p) / {}^3\mathrm{He}(e,e'n)}{^4\mathrm{He}(e,e'p) / {}^4\mathrm{He}(e,e'n)}$

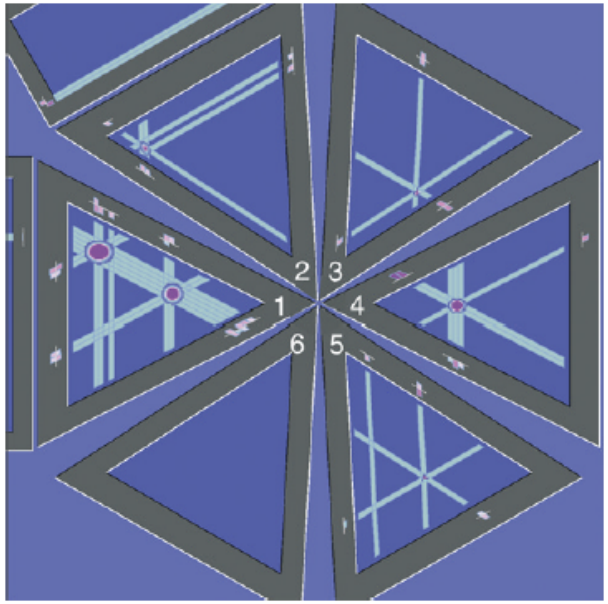
Expect ^{4}He(e,e'n)/(e,e'p)=1.
Difference from 1 show detector effects.
Use to correct for this effects

Hall B neutron detection with EC





The detailed view of one the EC modules.



Event reconstruction in EC

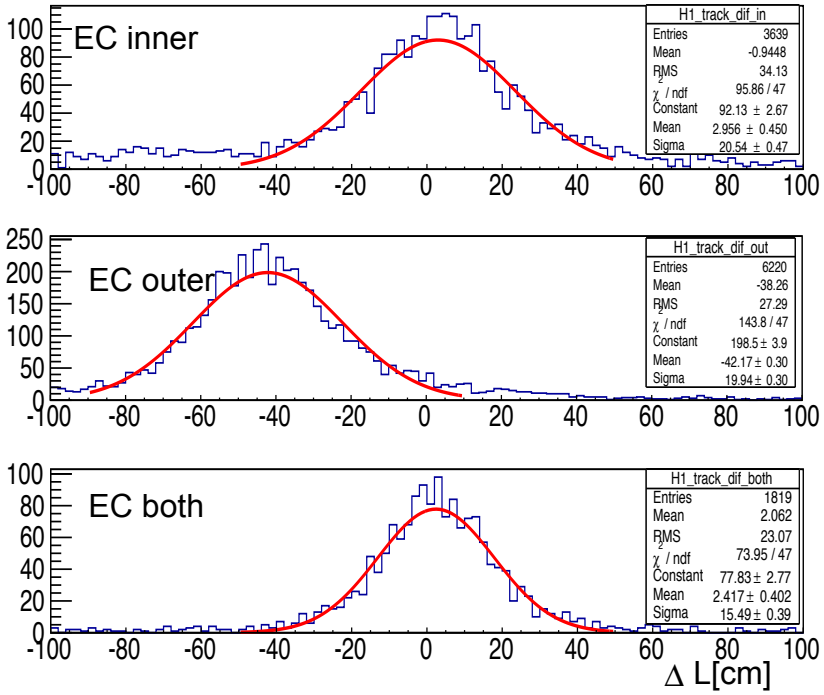
Forward electromagnetic calorimeter(EC) covers $\theta < 45^{o}$

2.EC neutron path length corrections.

E2b 4.7Gev H(e,e'π^+)n

Before corrections

R_n_calc-R_n_reconst

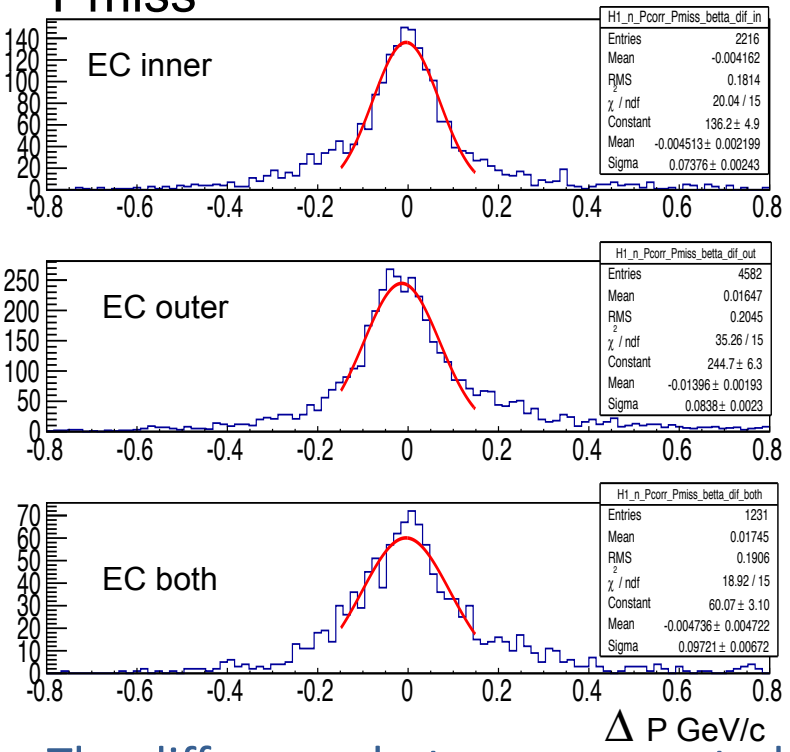


Neutron path length :measured minus calculated

Had to correct the n momentum because of the bug in RECSIS for e2

After corrections

Difference between Pcorr and Pmiss

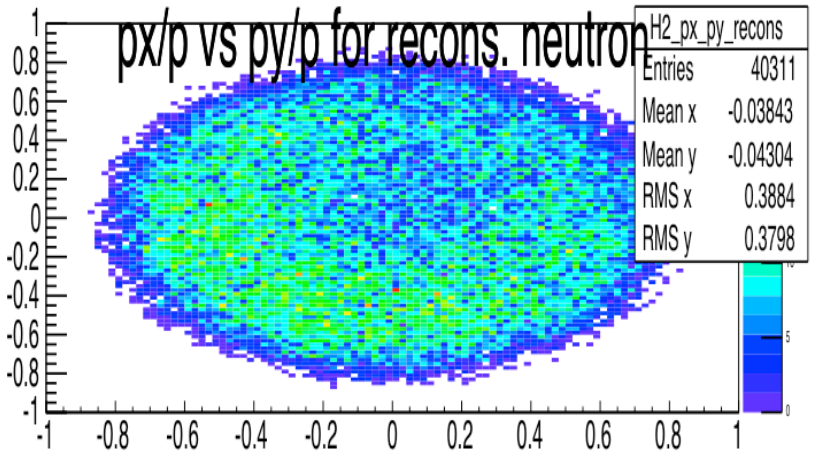


The difference between corrected measured n momentum and missing momentum.

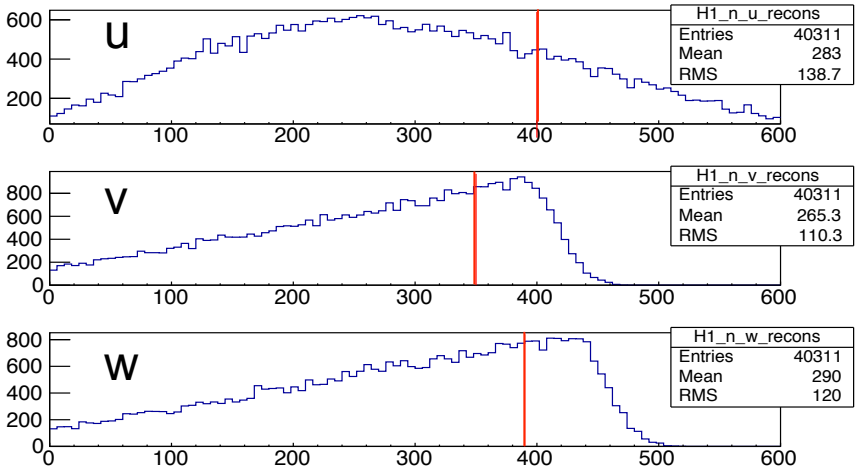
EC local coordinates of neutron

E2b 4.7Gev H(e,e'π^+)n

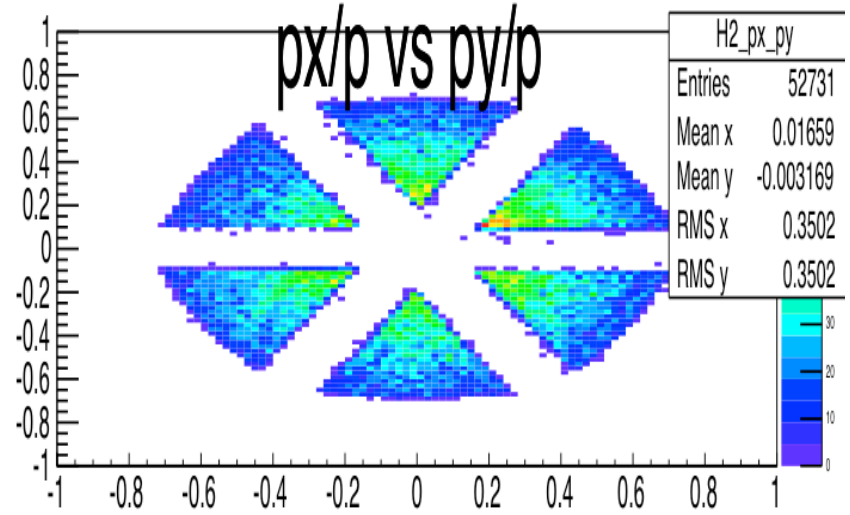
Reconstructed n

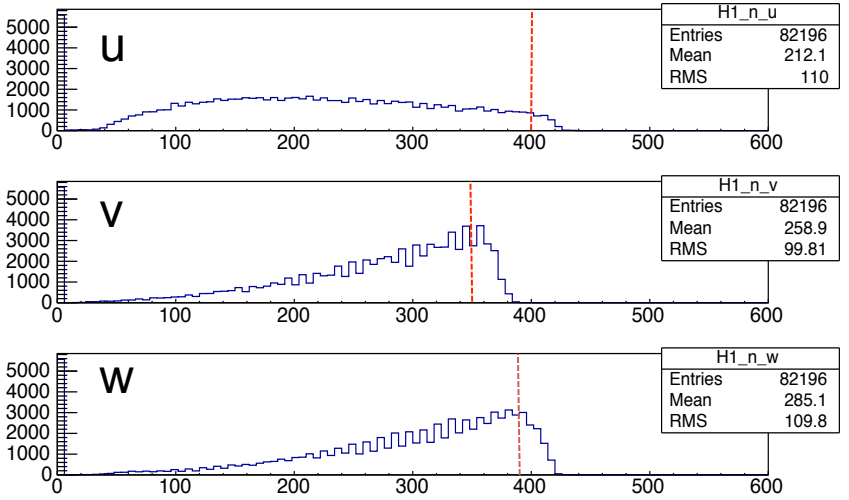


cuts

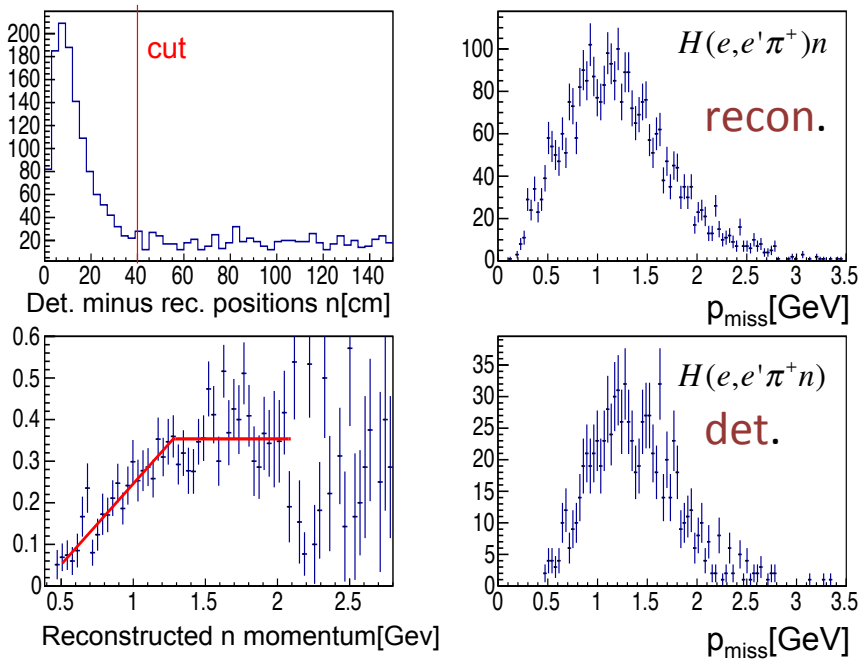


Detected n





e2b $H(e,e'\pi^+n)/H(e,e'\pi^+)n$



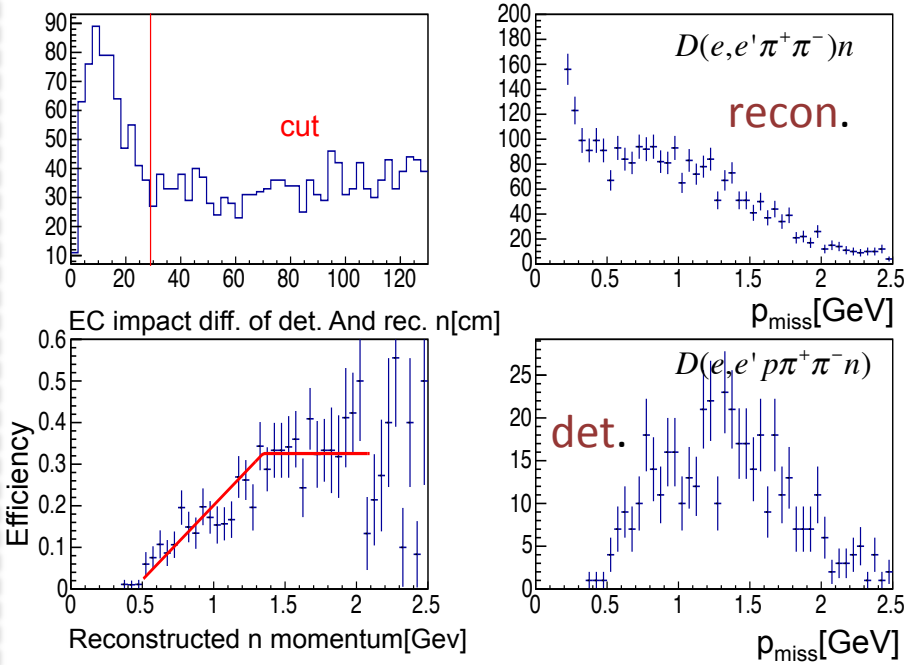
Cuts on reconstructed neutron

1. 0.9 < Missing Mass < 1
2. u_recons<400 ,v_recons<350,w_recons<390
3. Vertex cuts

Cuts on detected neutron are

1. Total energy deposited in EC>0
2. The time detected by EC>0
3. -0.5 < p-pmiss < 0.5
4. Distance between det. and rec. n<40cm

e6 $D(e,e'p\pi^+\pi^-n)/D(e,e'\pi^+\pi^-)n$



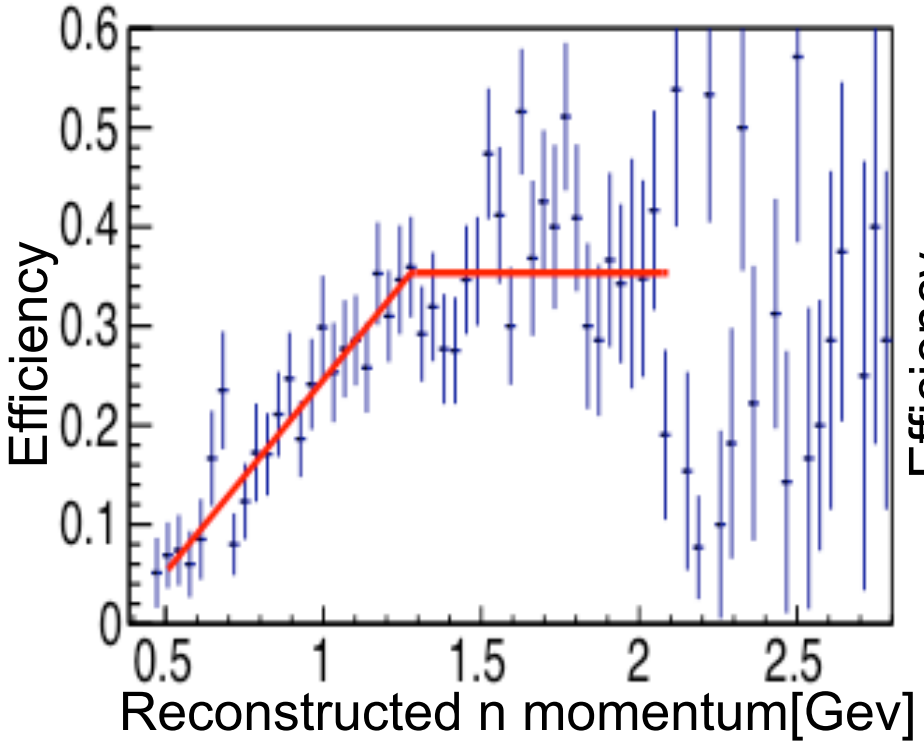
Cuts on reconstructed neutron

1. 0.85 < Missing Mass < 1
2. u_recons<400 ,v_recons<370,w_recons<390
3. Vertex cuts

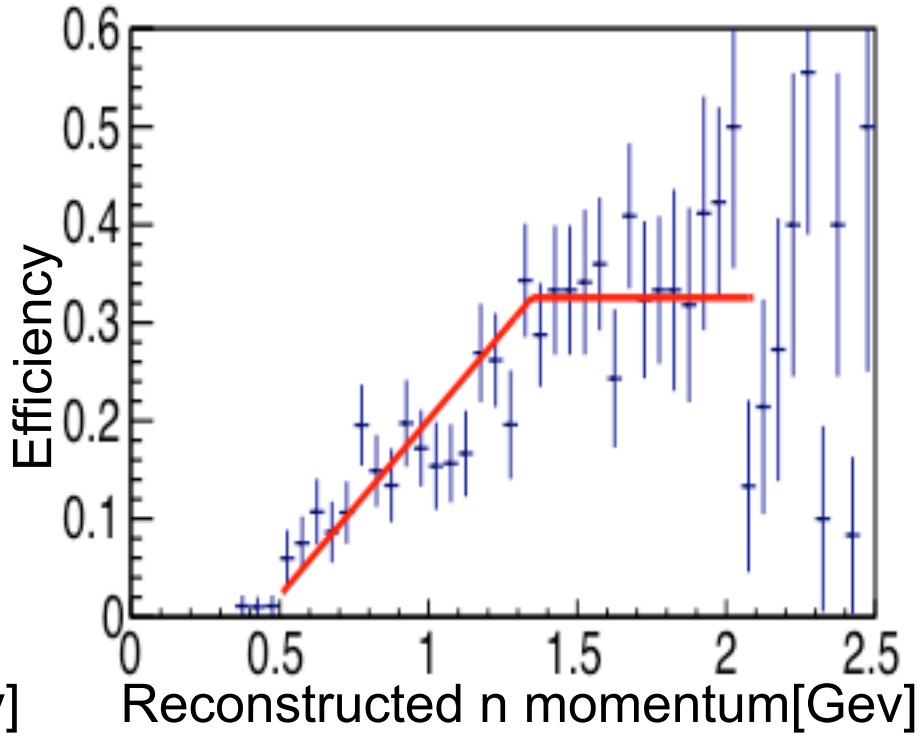
Cuts on detected neutron

1. Total energy deposited in EC>0
2. The time detected by EC>0
3. -0.5 < p-pmiss < 0.5
4. Distance between det. and rec. n<30cm

e2b $H(e,e'\pi^+n)/H(e,e'\pi^+)n$

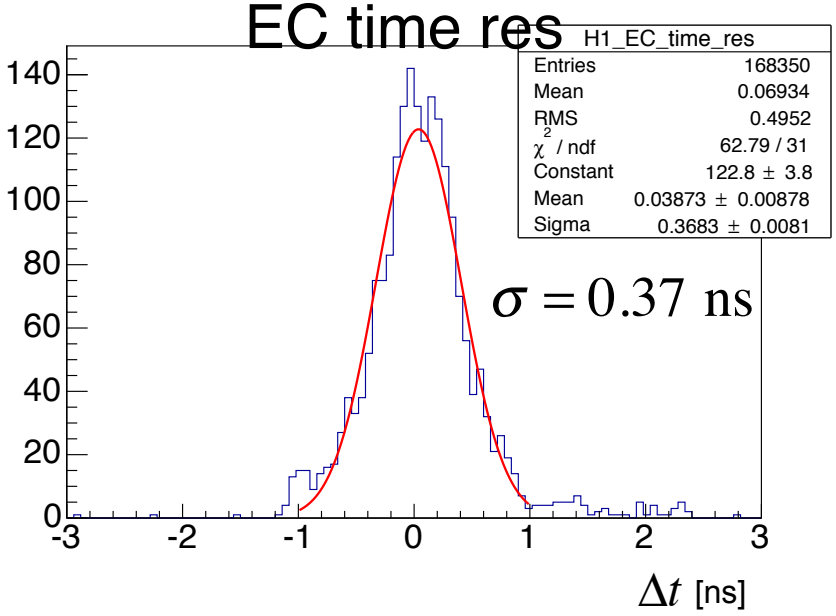


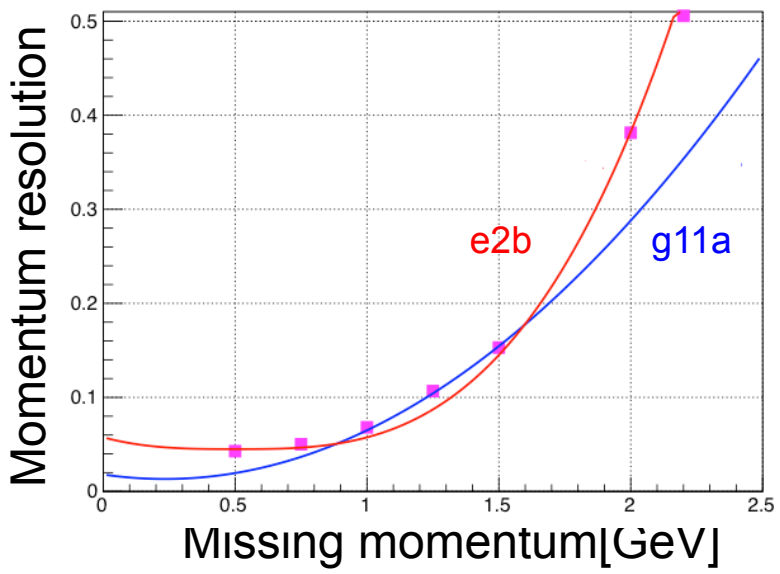
e6 $D(e,e'p\pi^+\pi^-n)/D(e,e'\pi^+\pi^-)n$

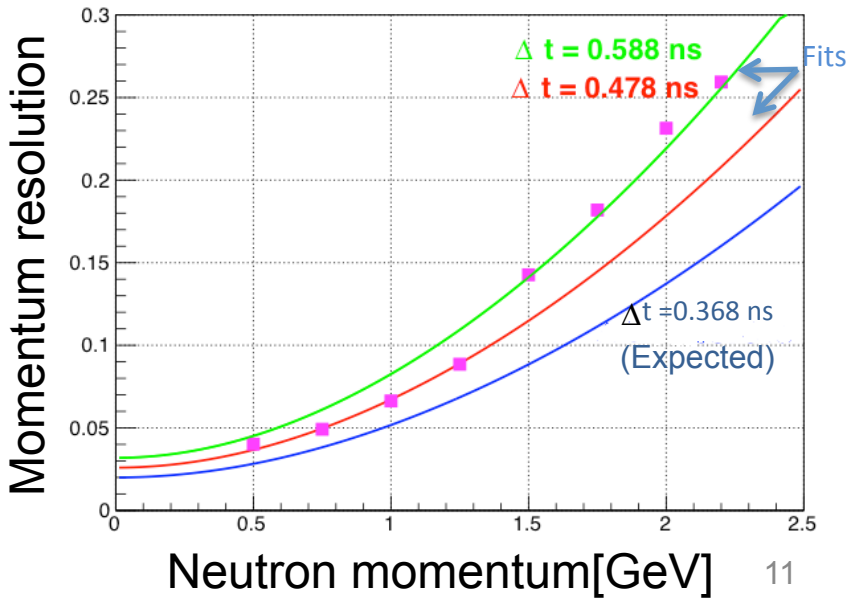


EC time resolution and momentum resolution

$$\Delta t = t_{EC} - \frac{d_{EC} - d_{TOF}}{c} - t_{TOF}$$





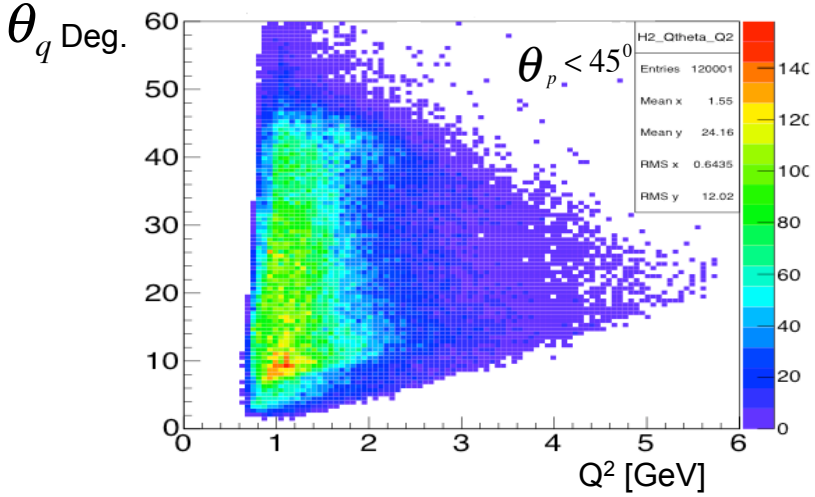


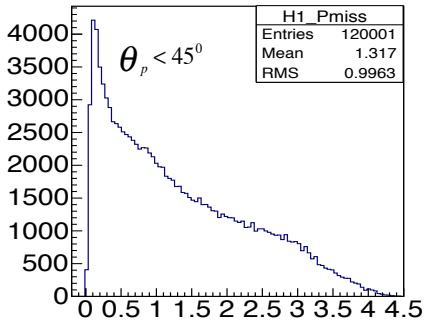
Use e2b ^{3}He(e,e'p) and ^{3}He(e,e'n) to compare n(p_n) and n(p_p)

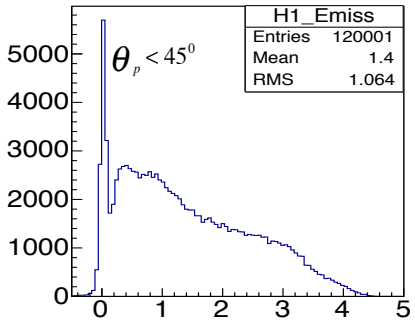
To compare these:

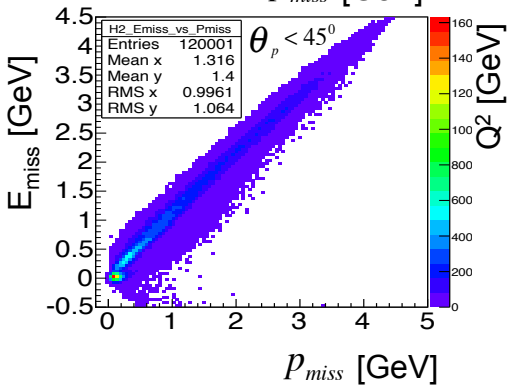
- Correct (e,e'n) for detection efficiency
- Smear (e,e'p) with n resolution
- Require $\theta_p < 45^0$

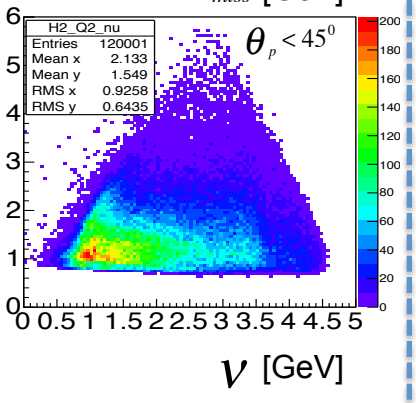
$^3He(e,e'p)$



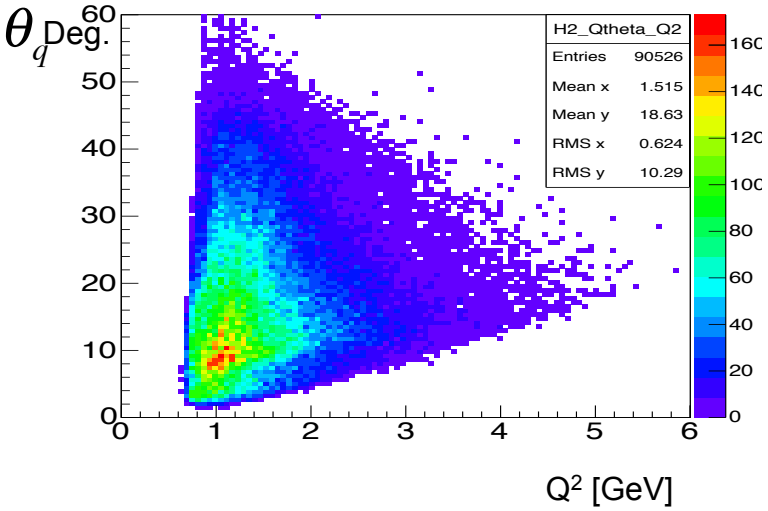


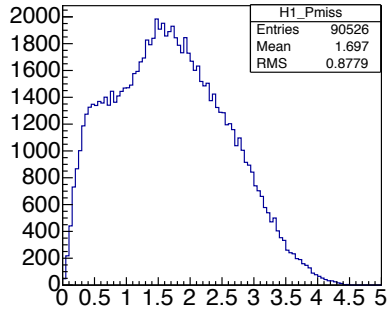


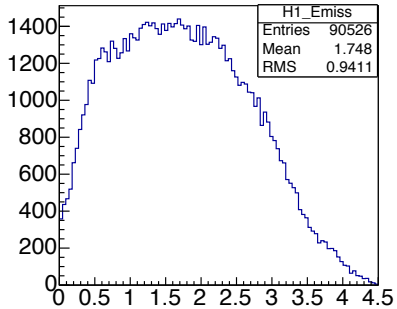


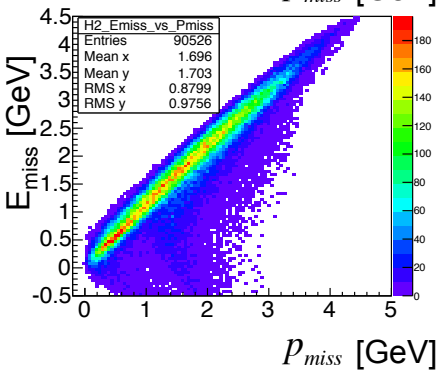


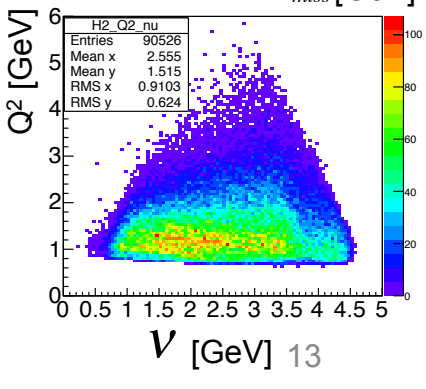
$^3He(e,e'n)$









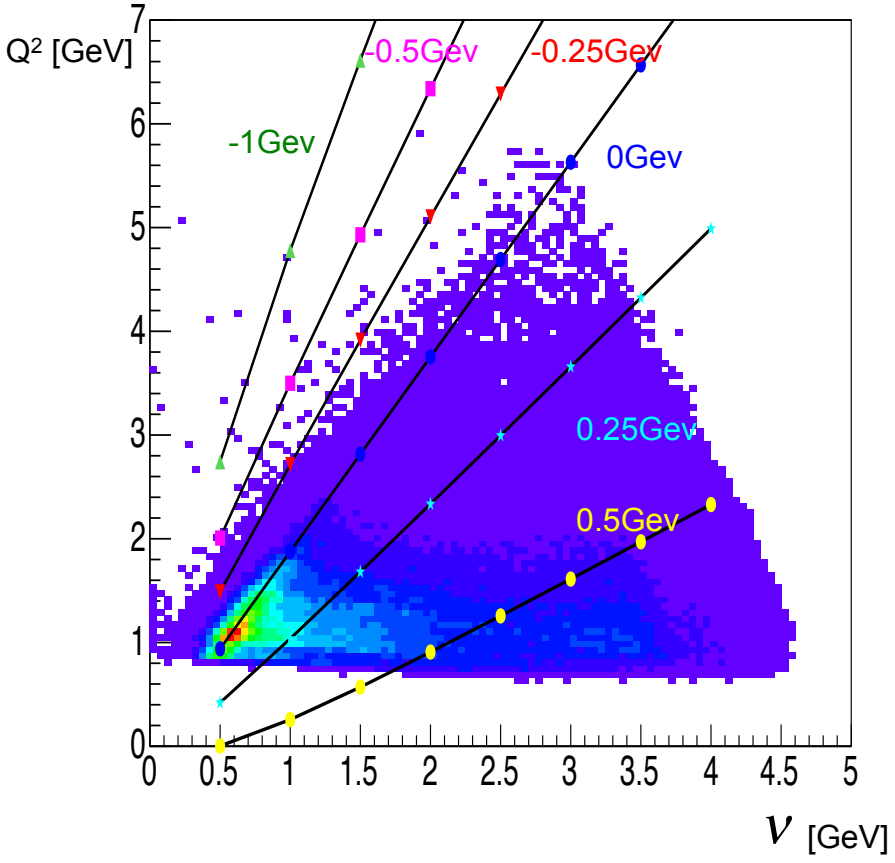


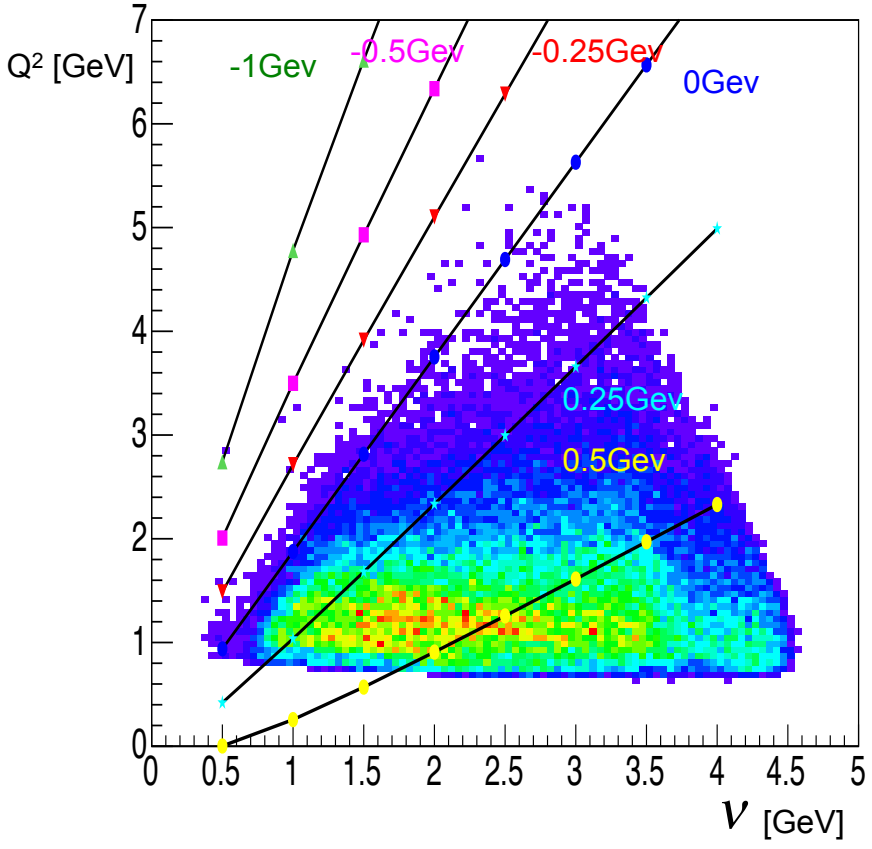
$^3He(e,e'p)$

$^3He(e,e'n)$

$$\nu + M_A = \left(M^2 + q^2 + y^2 + 2yq\right)^{1/2} + \left(M_{A-1}^2 + y^2\right)^{1/2}$$

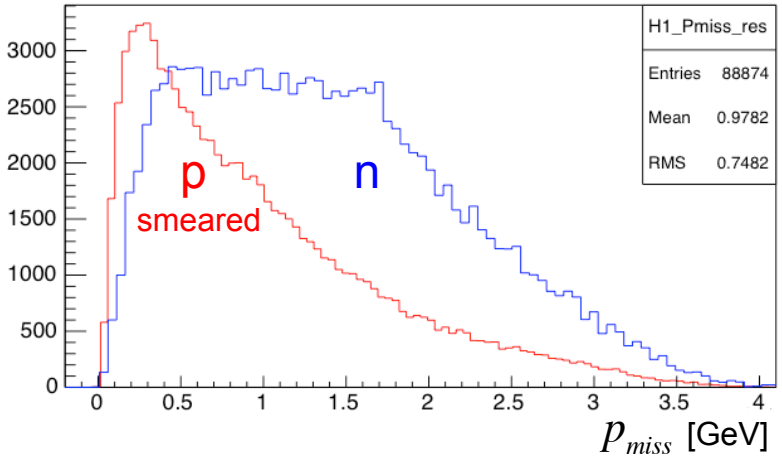
$$\nu = E - E'$$

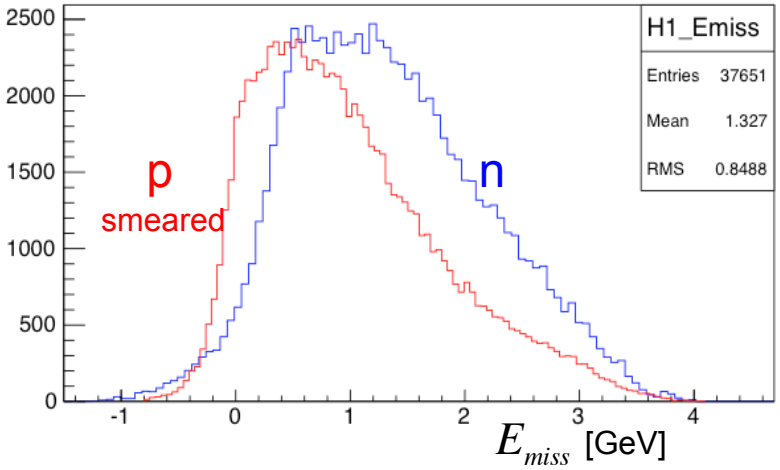




Cut on y<0.5GeV/c

Cut on y<0.5GeV/c

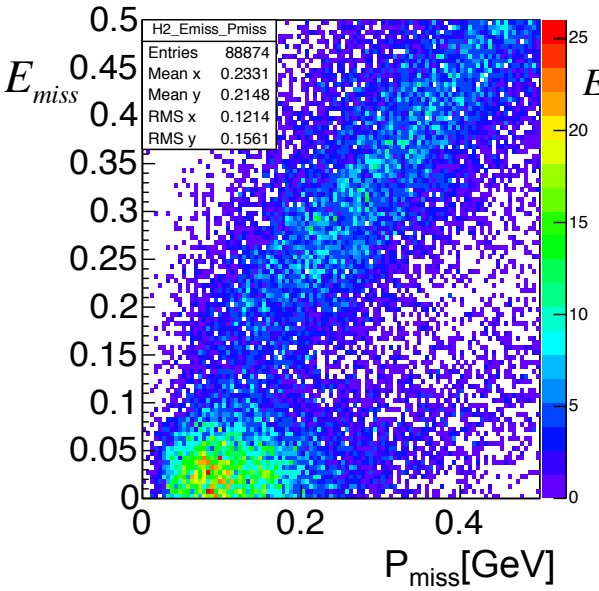




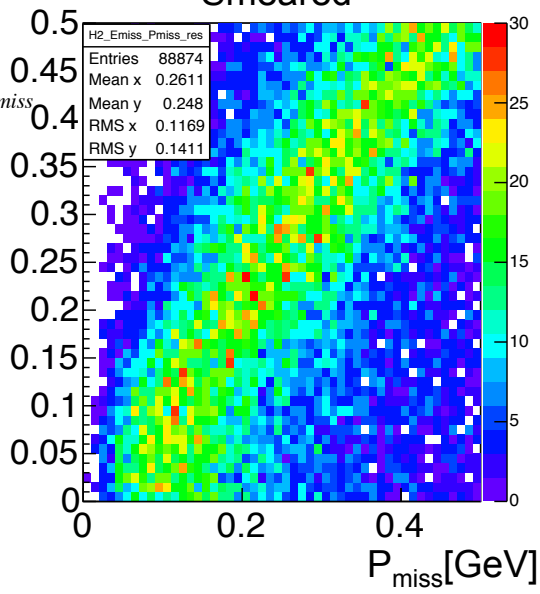
Proton

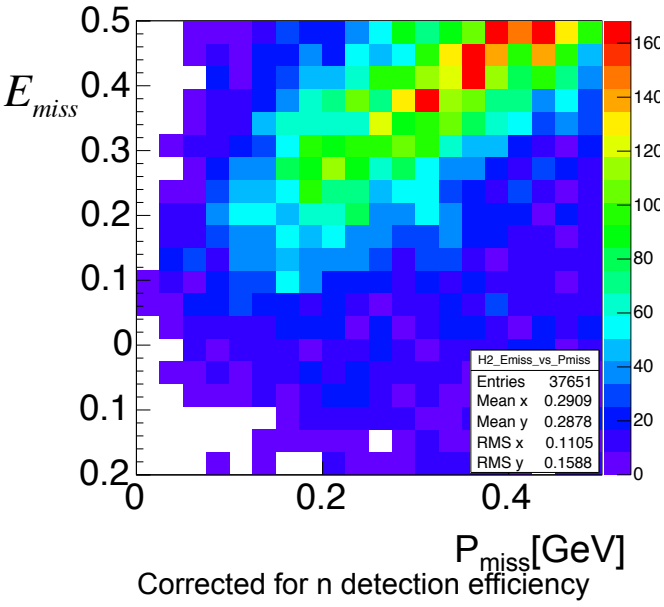
Neutron

Unsmeared



Smeared





Corrected for n detection efficiency

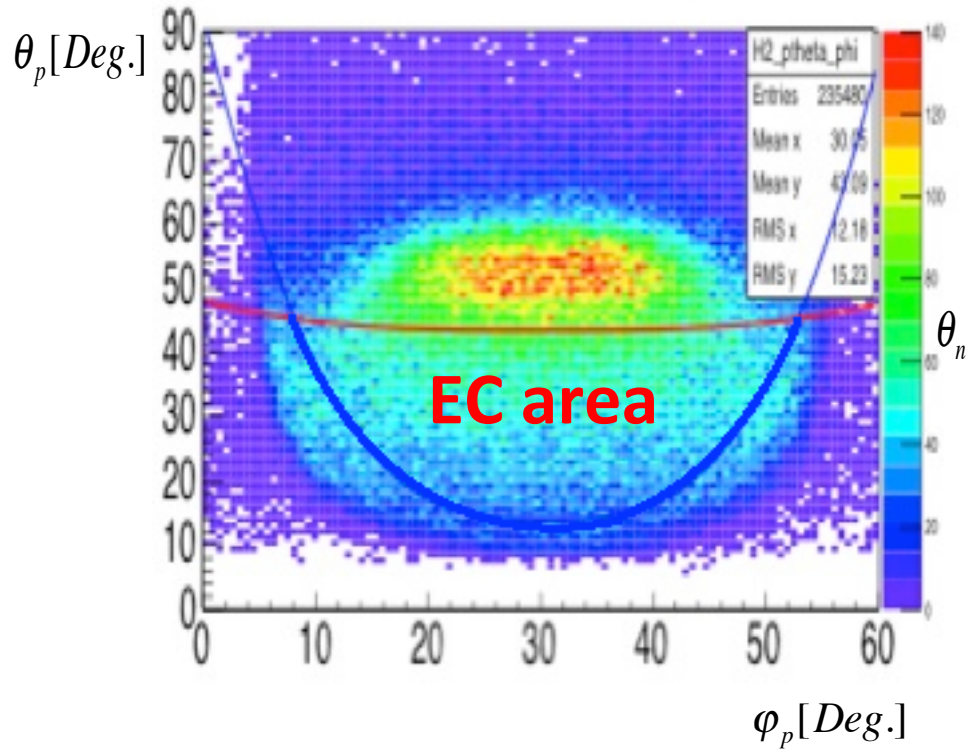
Where are the QE (e,e'n) events?

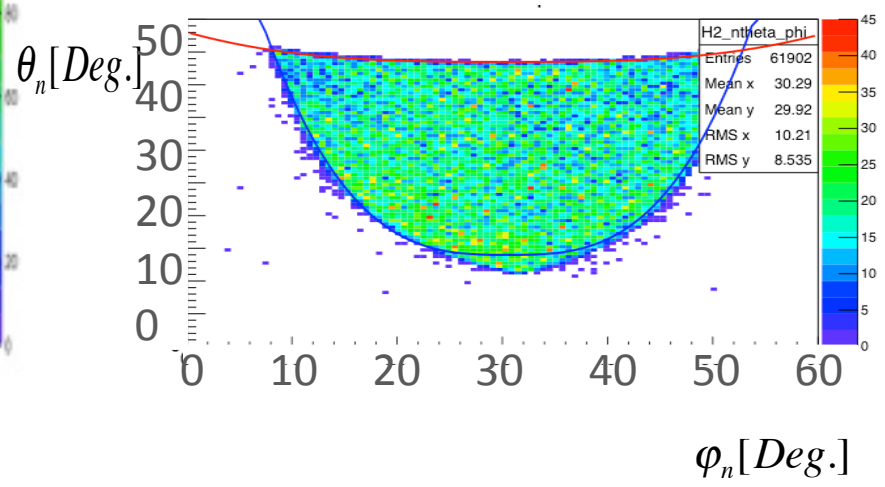
$^3He(e,e'p)$

$^3He(e,e'n)$

protons

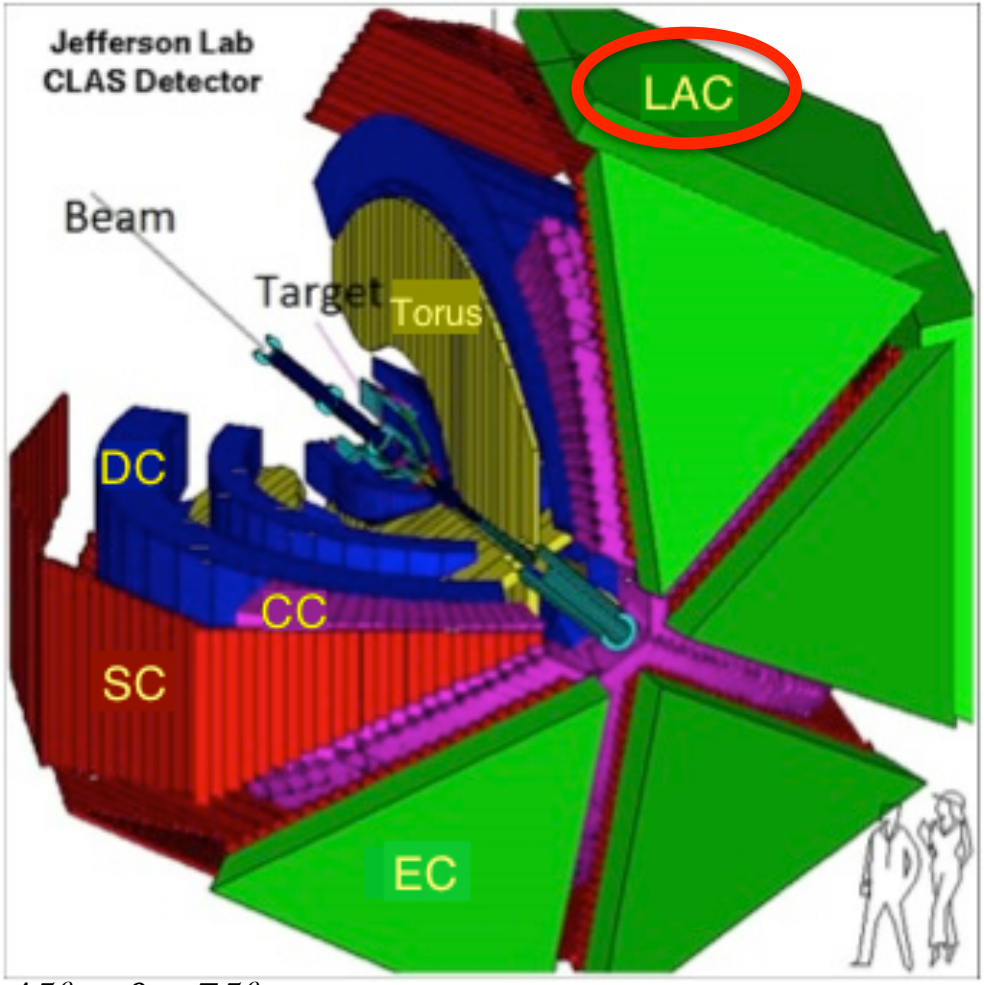
neutrons





Quasielastic events are at $\theta_p > 45^0$ ➡ Need LAC!

HALL B neutron detection with LAC

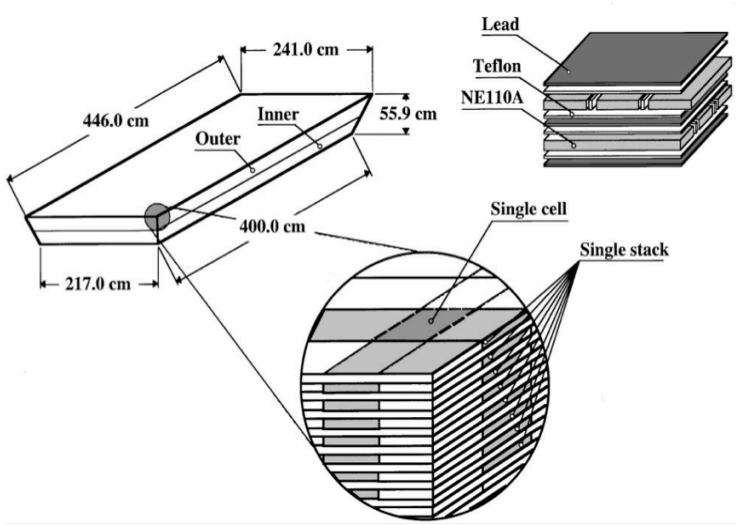


$45^o < \theta < 75^o$

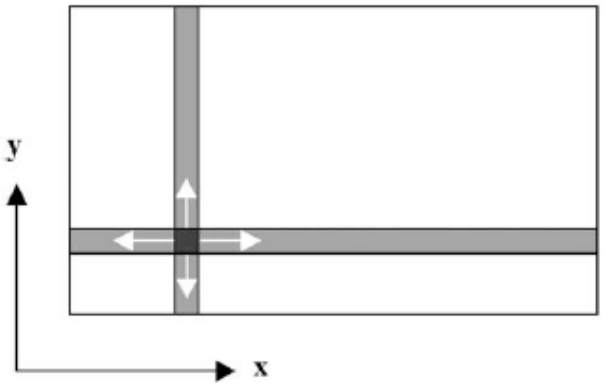
$-30^o < \varphi < 90^o$

Sectors 1,2

Rarely used



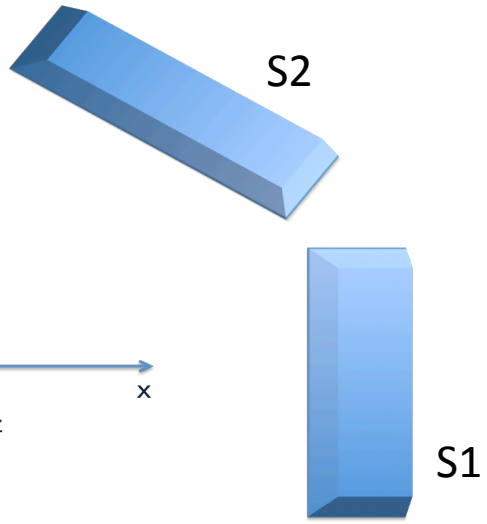
The detailed view of one of the LAC modules.

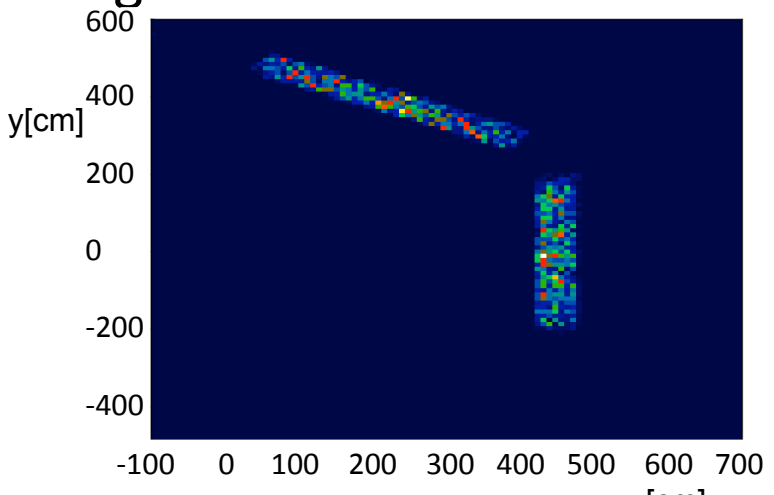


LAC local x and y views

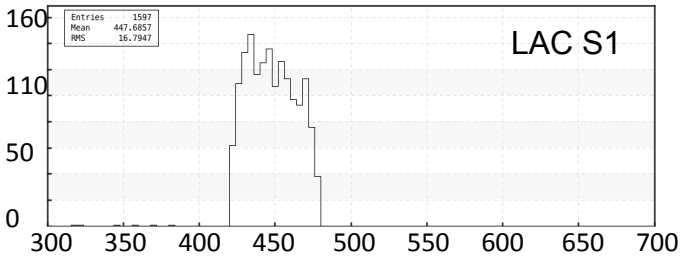
LAC timing

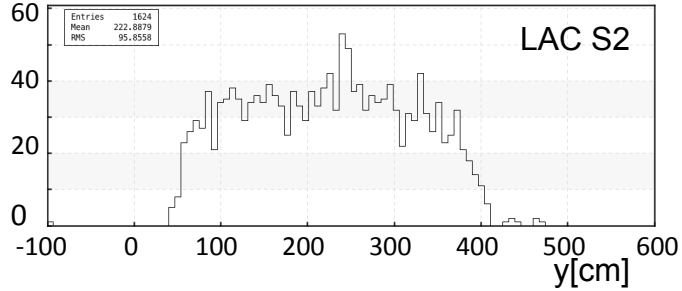
E2a 2.26Gev He4



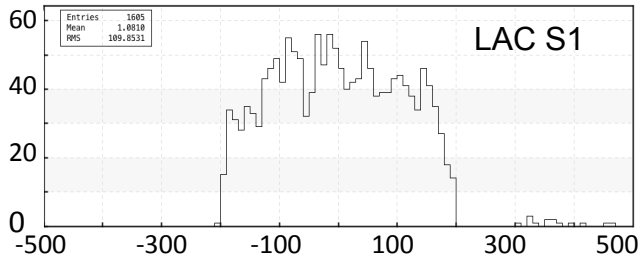


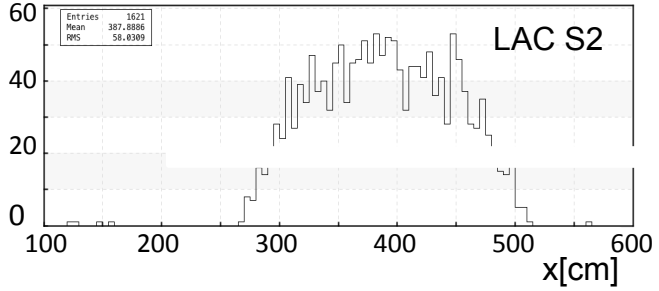
The y vs x global coordinate of π^+ in LAC





y global coordinate of π^+





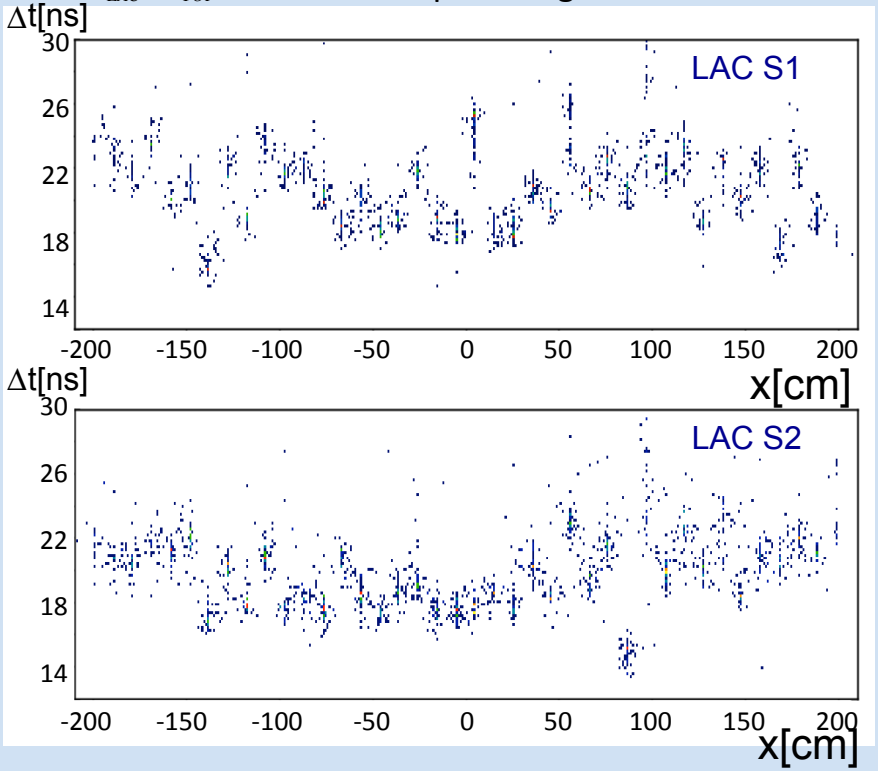
x global coordinate of π^+

Rotate x,y coordinates to local coordinates

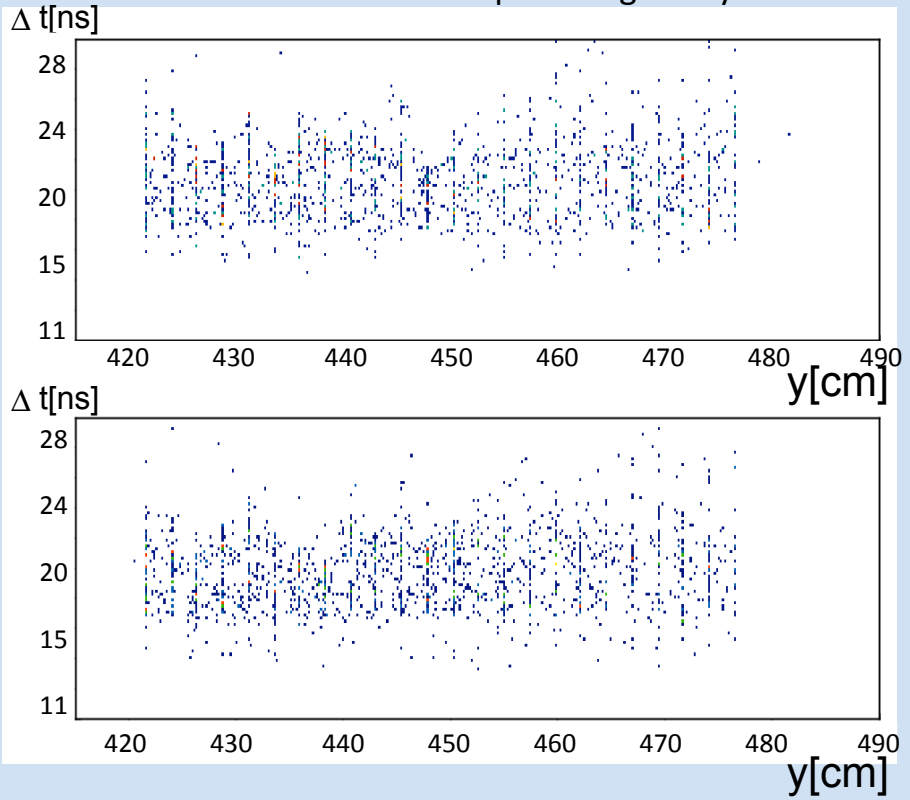
LAC timing

E2a 2.26Gev He4

$t_{LAC} - t_{TOF}$ corrected for path length vs x of π^+



$t_{LAC} - t_{TOF}$ corrected for path length vs y of π^+

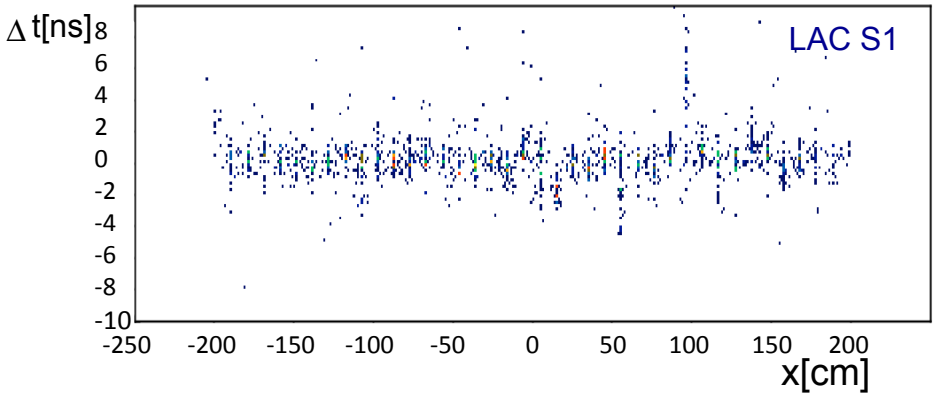


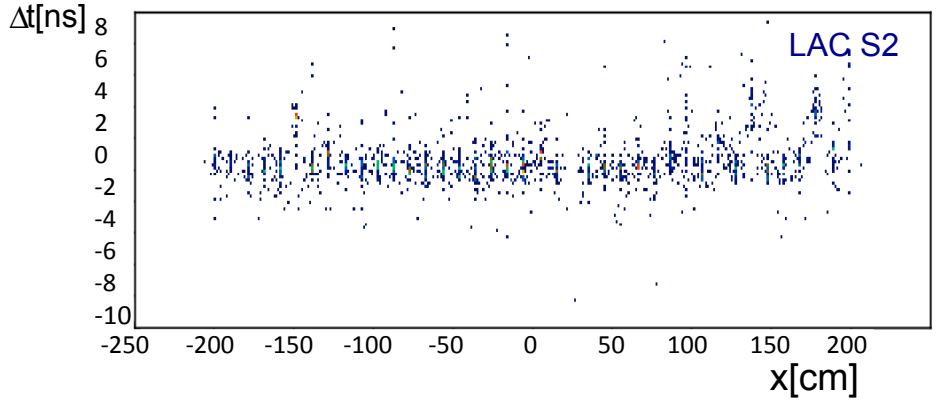
Timing depends on x not y

LAC timing after offset correction

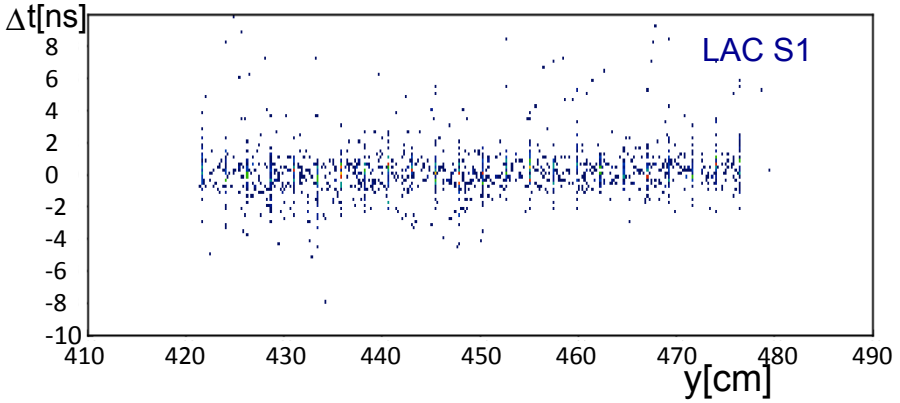
E2a 2.26Gev He4

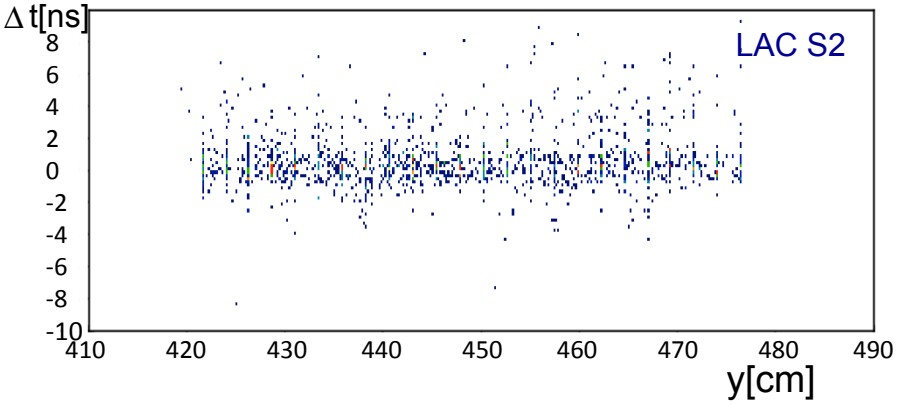
$t_{LAC} - t_{TOF}$ after correction vs x



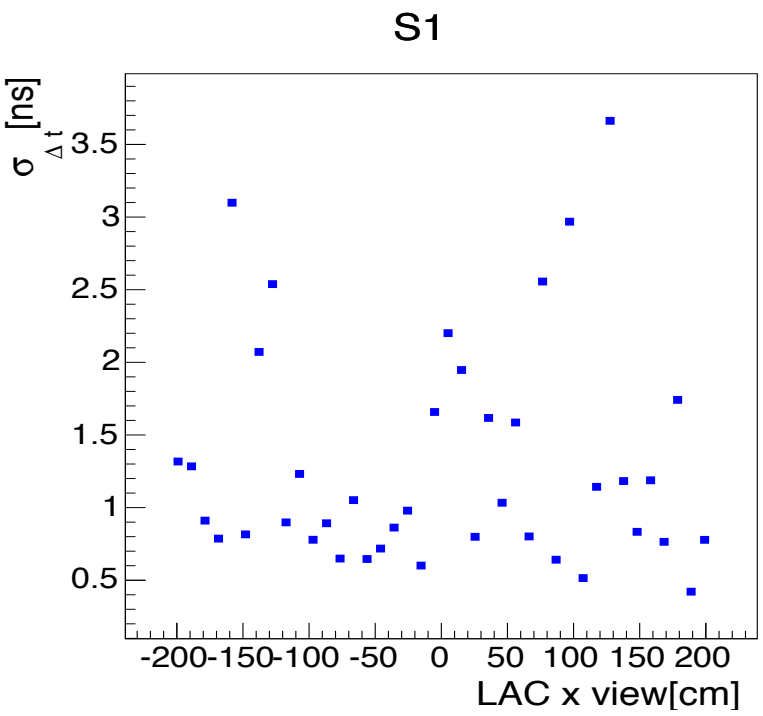


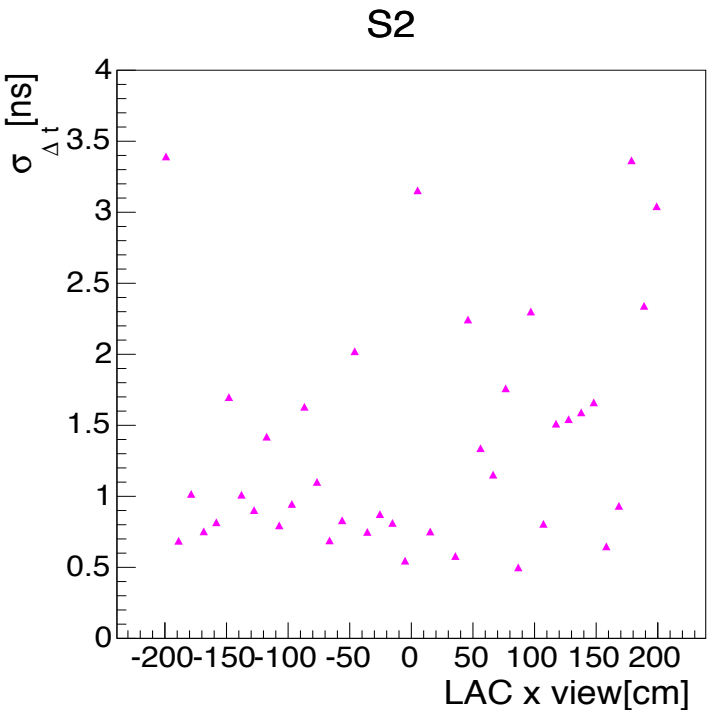
$t_{LAC} - t_{TOF}$ after correction vs y





LAC timing resolution



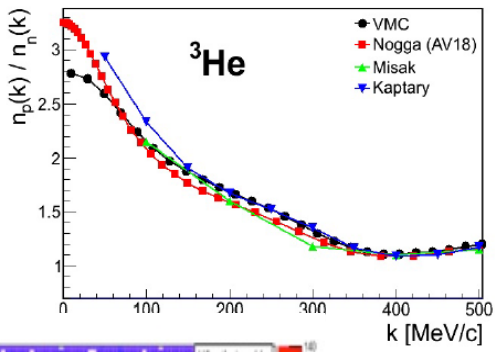


Need more precise time calibration of LAC!

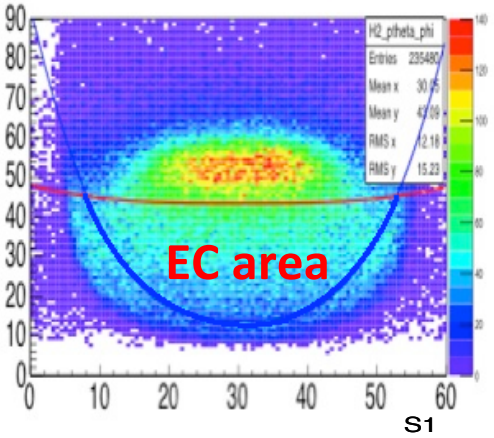
Need to recook the data to include individual TDC information for all PMTs

Conclusions

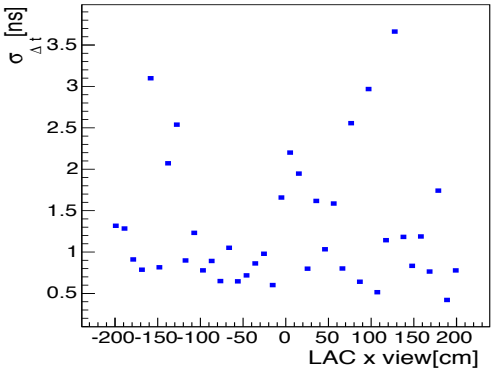
- Want to measure $\frac{^3He(e,e'n)/^3He(e,e'p)}{^4He(e,e'n)/^4He(e,e'p)}$ using e2a and e2b



- Calibrated EC for e2b
  - ε ~ 0.35
  - σ_p consistent with g11a
  - Quasielastic neutrons at 2.2 and 4.7 Gev miss the EC



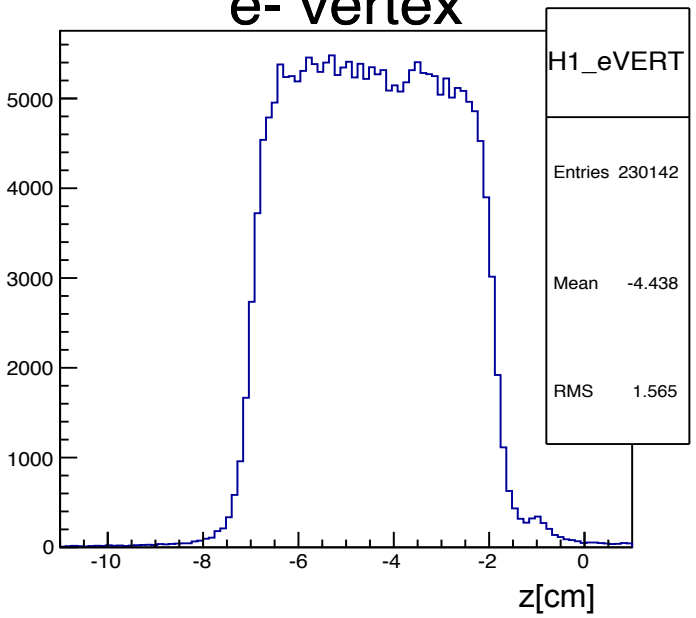
- Calibrating LAC
  - LAC timing offsets vs x-strip determined
  - LAC timing resolution is horrible



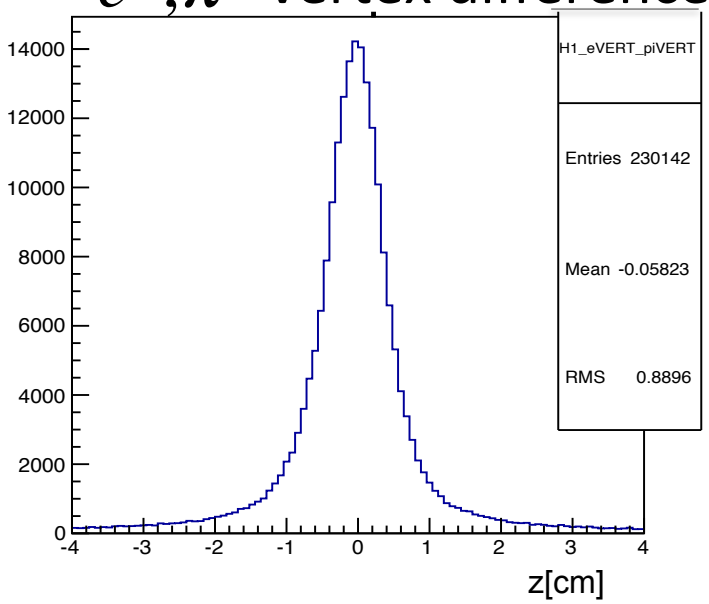
- recooking and calibrating LAC

p(e,e'π^+)X

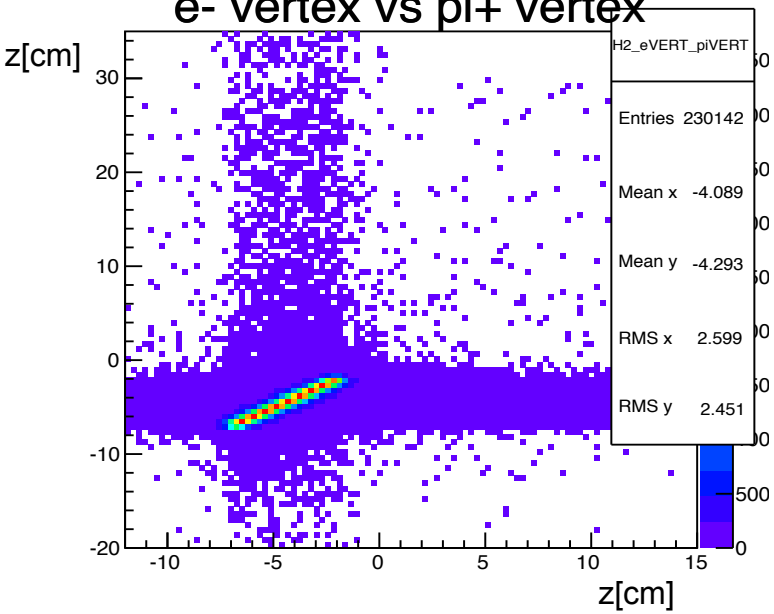
e- vertex



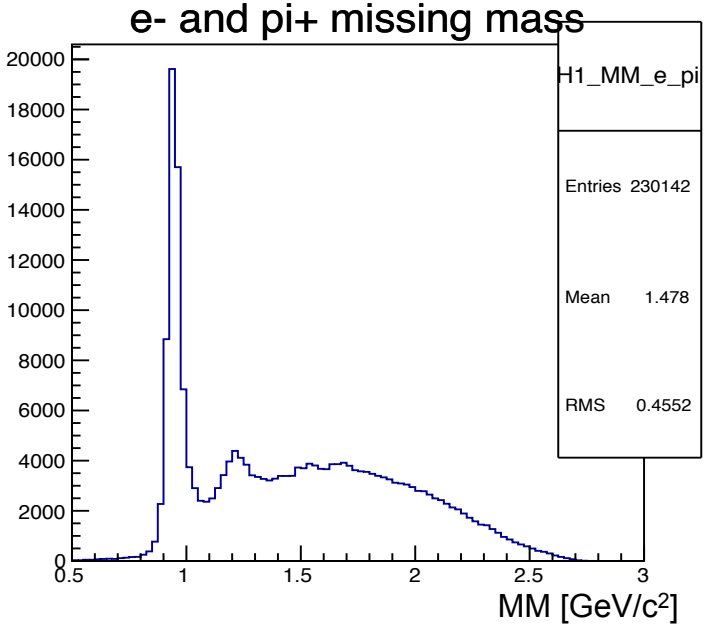
e^-, π^+ vertex difference



e- vertex vs pi+ vertex



e- and pi+ missing mass

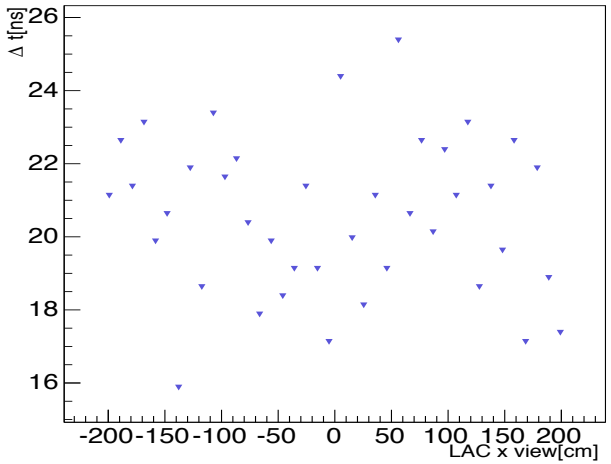


LAC time calibration attempt

E2a 2.26Gev He4

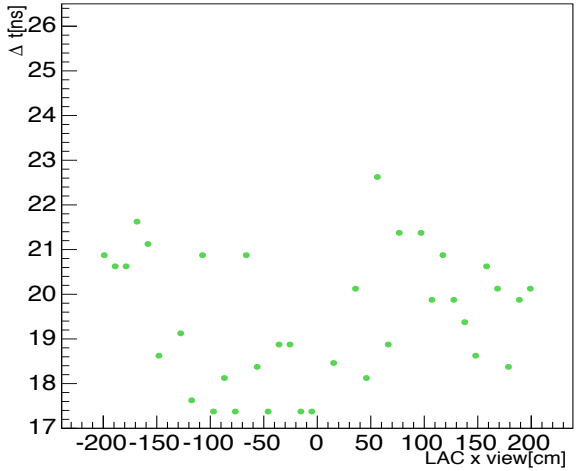
The mean of $t_{LAC} - t_{TOF}$ distribution corrected for path length vs x

S1



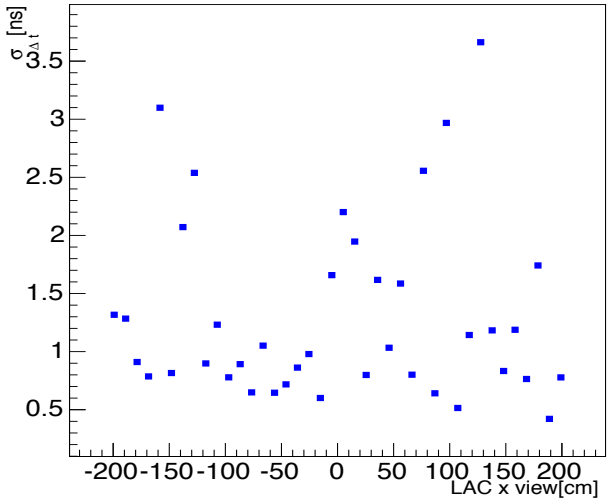
The mean of $t_{LAC} - t_{TOF}$ distribution corrected for path length vs x

S2



The sigma of $t_{LAC} - t_{TOF}$ distribution corrected for path length as a function of x

S1



The sigma of $t_{LAC} - t_{TOF}$ distribution corrected for path length as a function of x

S2