LHRS Analysis for d_2^n

Beam Trip Studies, Scintillators, SAMC, and A_1^n Statistical Error

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Outline

Beam Trip Study (1)

BeamTrip Class

- I have written a class `BeamTrip`
  - Combines the three scripts '`FindBeamTrips.C`','`ProcessCuts.C`', and '`CheckBeamTrips.C`' so that we can do the beam trip analysis all at once
  - There is a README and a CHANGELOG available to see how the code works and all the changes I've been making
  - You can find my code here

Beam Trip Study (2)

Completed Kinematics

Completed Kinematics: Negative Polarity				
E (GeV)	p (GeV)	# of Runs	$I_{\text{avg.}}$ (μA)	$Q_{\text{tot.}}$ (C)
4.73	0.60	11	15.15	0.4365
5.89	0.60	21	14.85	0.9850
4.73	0.80	13	15.16	0.3947
5.89	0.90	19	15.10	0.6906
5.89	1.13	20	15.13	0.9142
5.89	1.20	19	14.81	0.6274
5.89	1.27	20	15.07	1.0346
4.73	1.42	11	14.89	0.8186
5.89	1.42	14	15.04	0.9471
4.73	1.51	18	15.14	1.1425
5.89	1.51	19	15.02	1.2765
4.73	1.60	18	15.13	1.1589
5.89	1.60	21	14.95	1.5287
5.89	1.70	10	15.06	1.2977

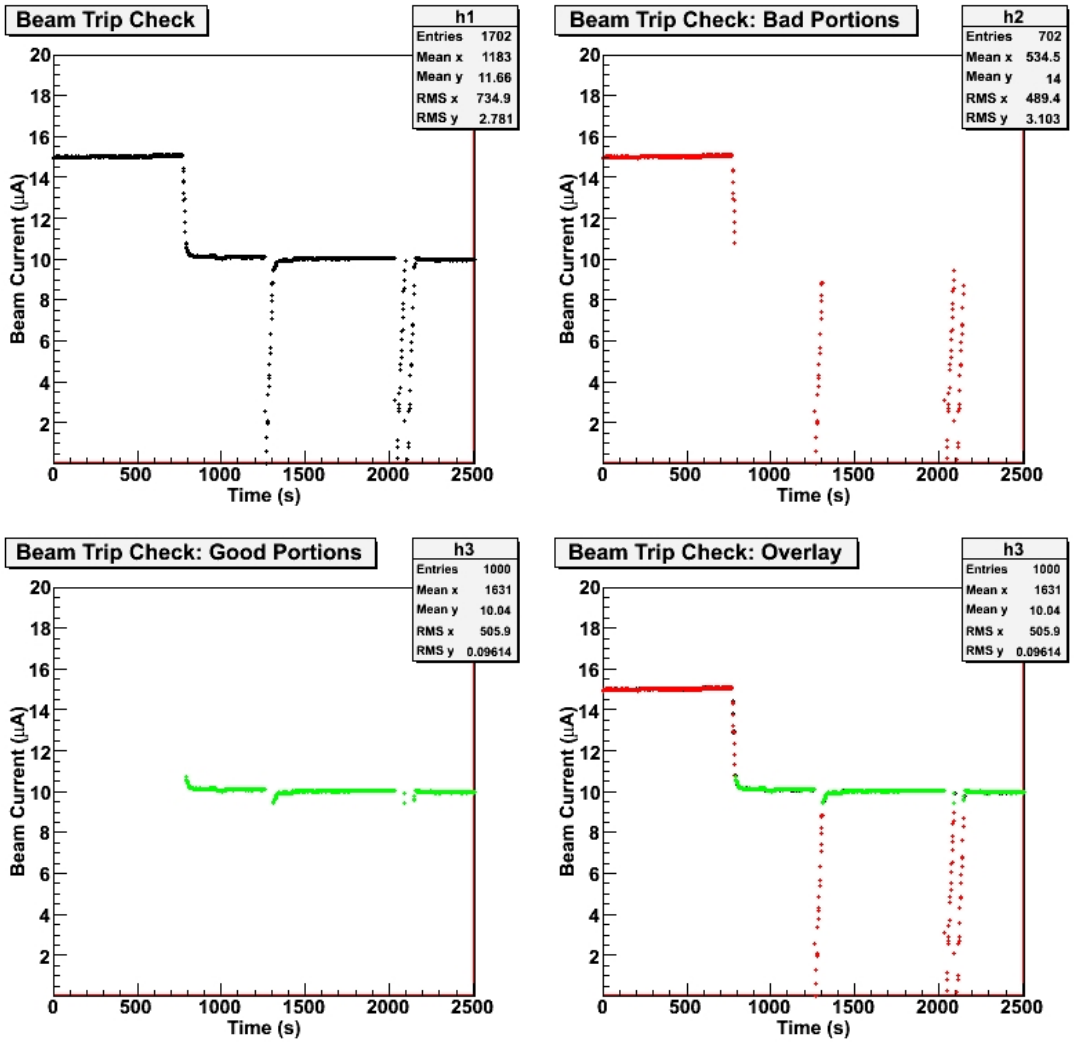
Beam Trip Study (3)
Questionable Runs

Questionable Runs: Negative Polarity		
E (GeV)	p (GeV)	Questionable Runs
4.73	0.60	–
5.89	0.60	20157,20158
4.73	0.80	–
5.89	0.90	–
5.89	1.13	–
5.89	1.20	20477†, 20480†, 20551–20553†, 20565†
5.89	1.27	20287–20289, 20290†,20304
4.73	1.42	20556†, 20558†, 20569, 20571–20572†, 20580†,20583†, 20585
5.89	1.42	20279†,20280†, 20281†, 20282–20285
4.73	1.51	20390†, 20391
5.89	1.51	20431
4.73	1.60	–
5.89	1.60	20220, 20241†
5.89	1.70	–

- color code:
  $I \sim 1\ \mu$A
  $I \sim 2\ \mu$A
  $I \sim 5\ \mu$A
  $I \sim 10\ \mu$A
  $I \sim 12\ \mu$A
  $I \sim 13\ \mu$A
  $I \sim 14$–$15\ \mu$A
- † = Junk run (short run time, no events, etc.)

Beam Trip Study (4)

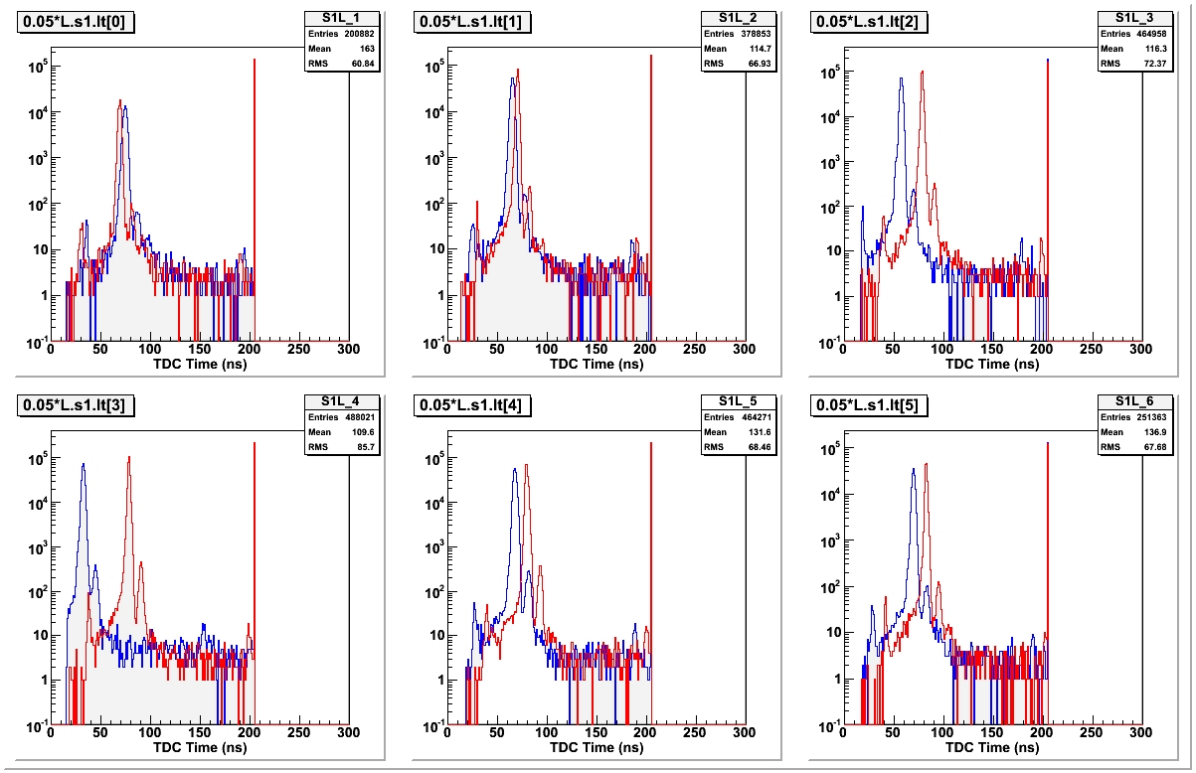
Questionable Run: 20281 ($p = 1.42$ GeV, 5-pass)



Scintillator Study (1)

S1 Raw Times

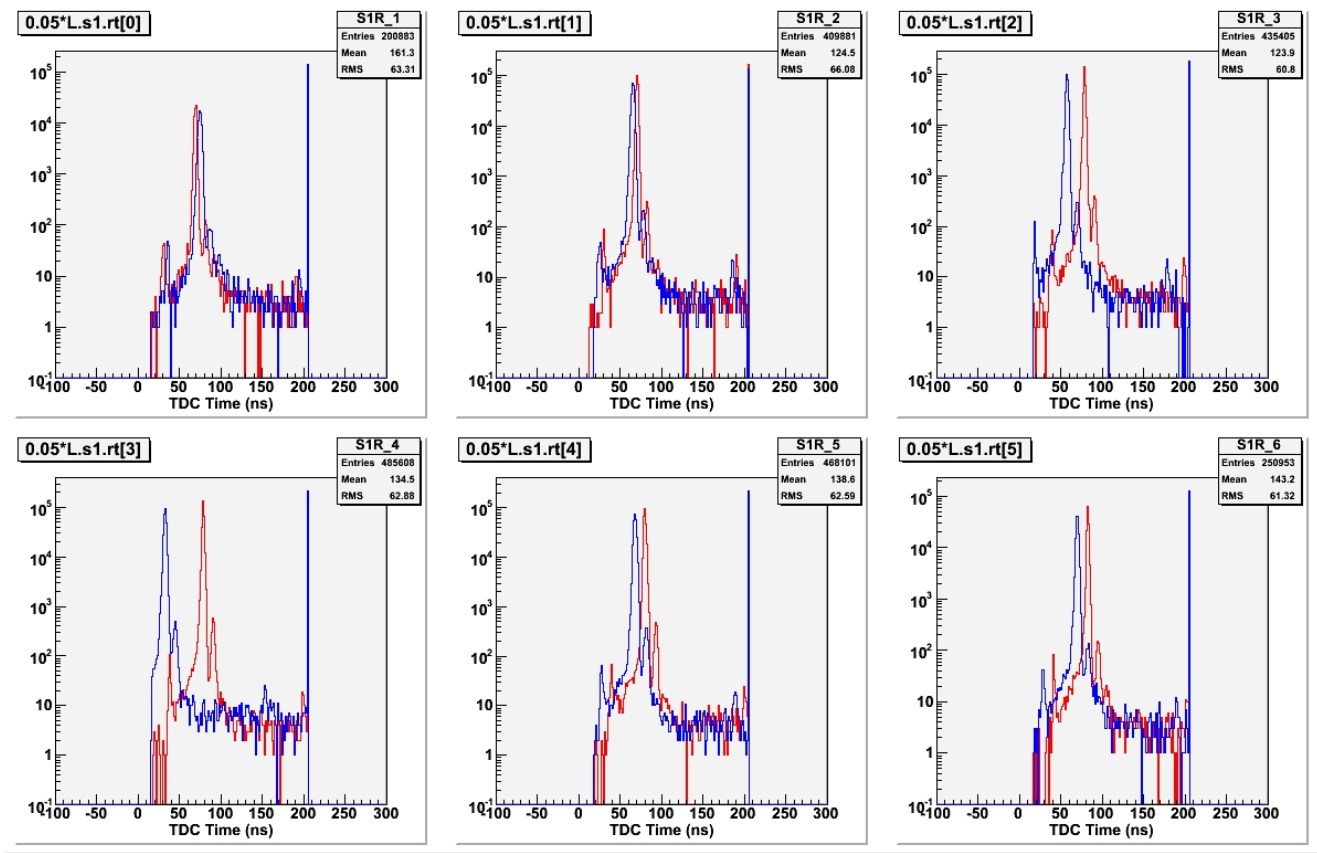
- We try to see how the S1 raw times look for each paddle (color code: left, right)
- As they are – no cuts (for run 20676)



Scintillator Study (2)

S1 Raw Times

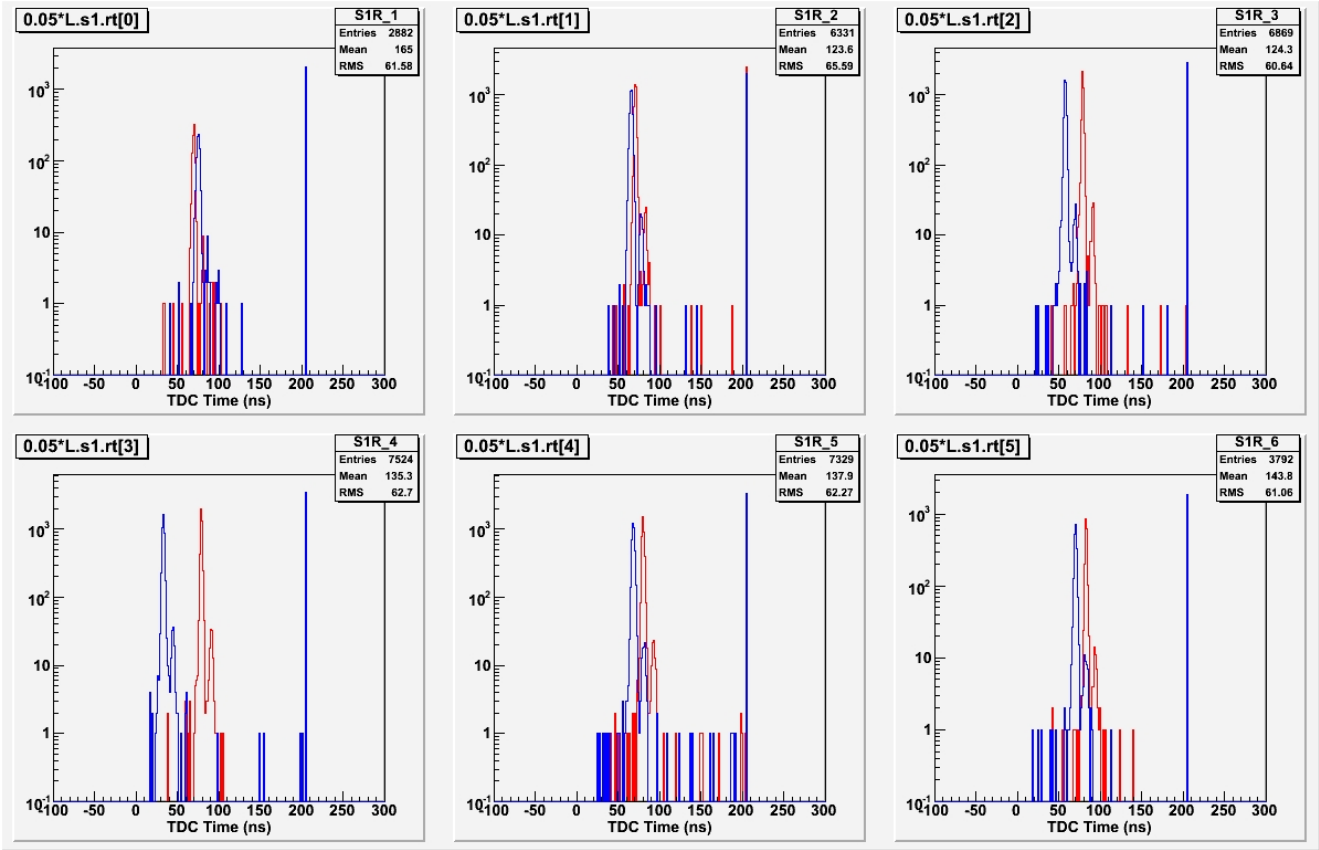
- Trigger cuts



Scintillator Study (3)

S1 Raw Times

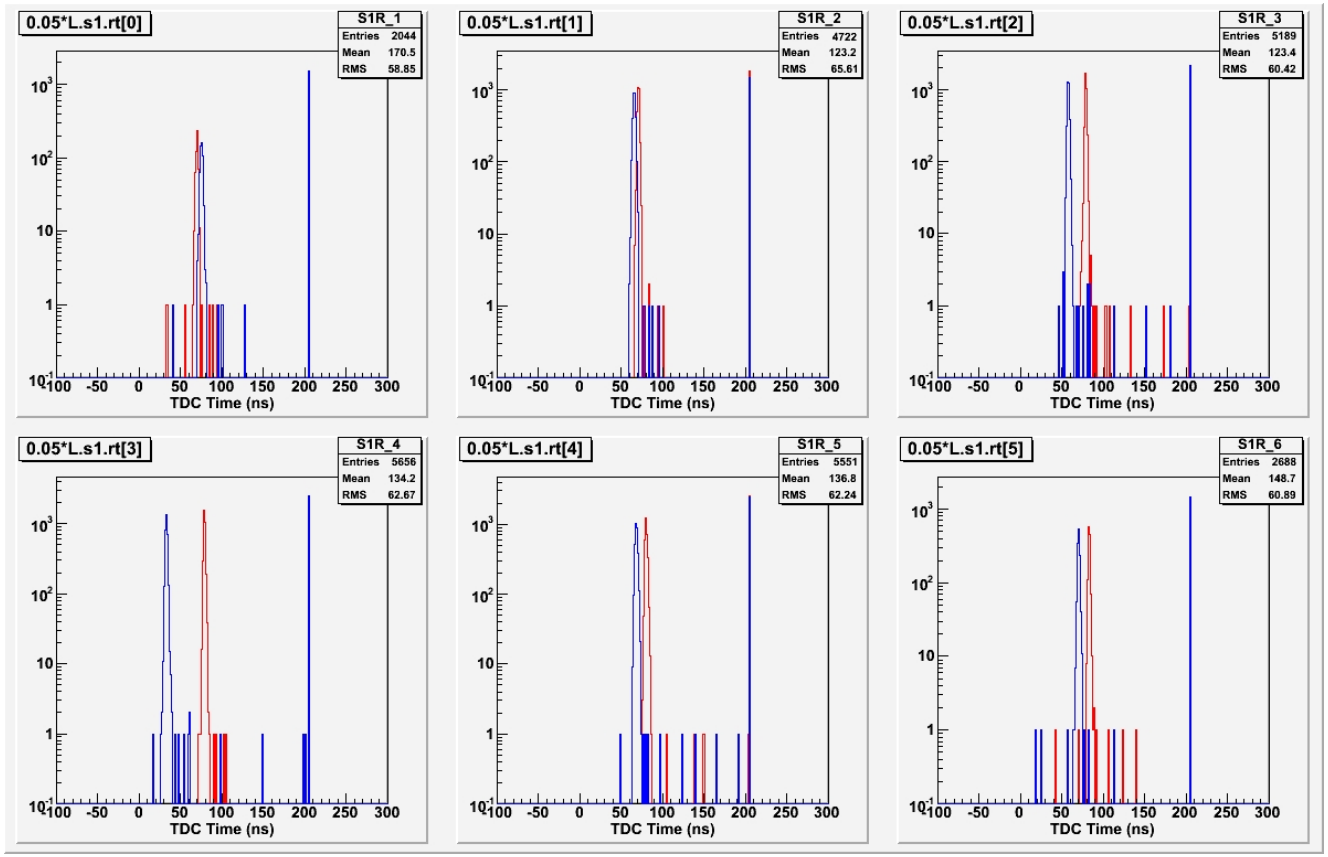
- Trigger cuts and electron cuts (GC $>$ 300)



Scintillator Study (4)

S1 Raw Times

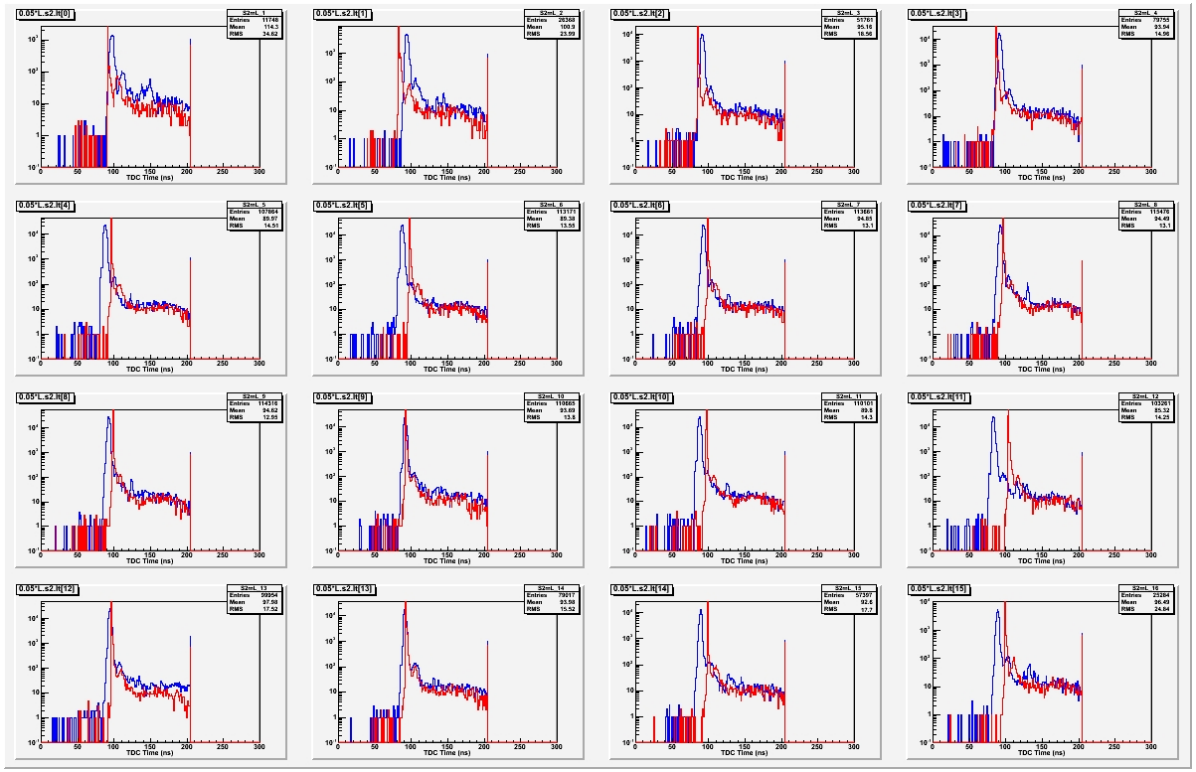
- Trigger cuts and electron cuts
  (GC > 300, $E/p > 0.54$, L.prl1.e > 200)



Scintillator Study (5)

S2m Raw Times

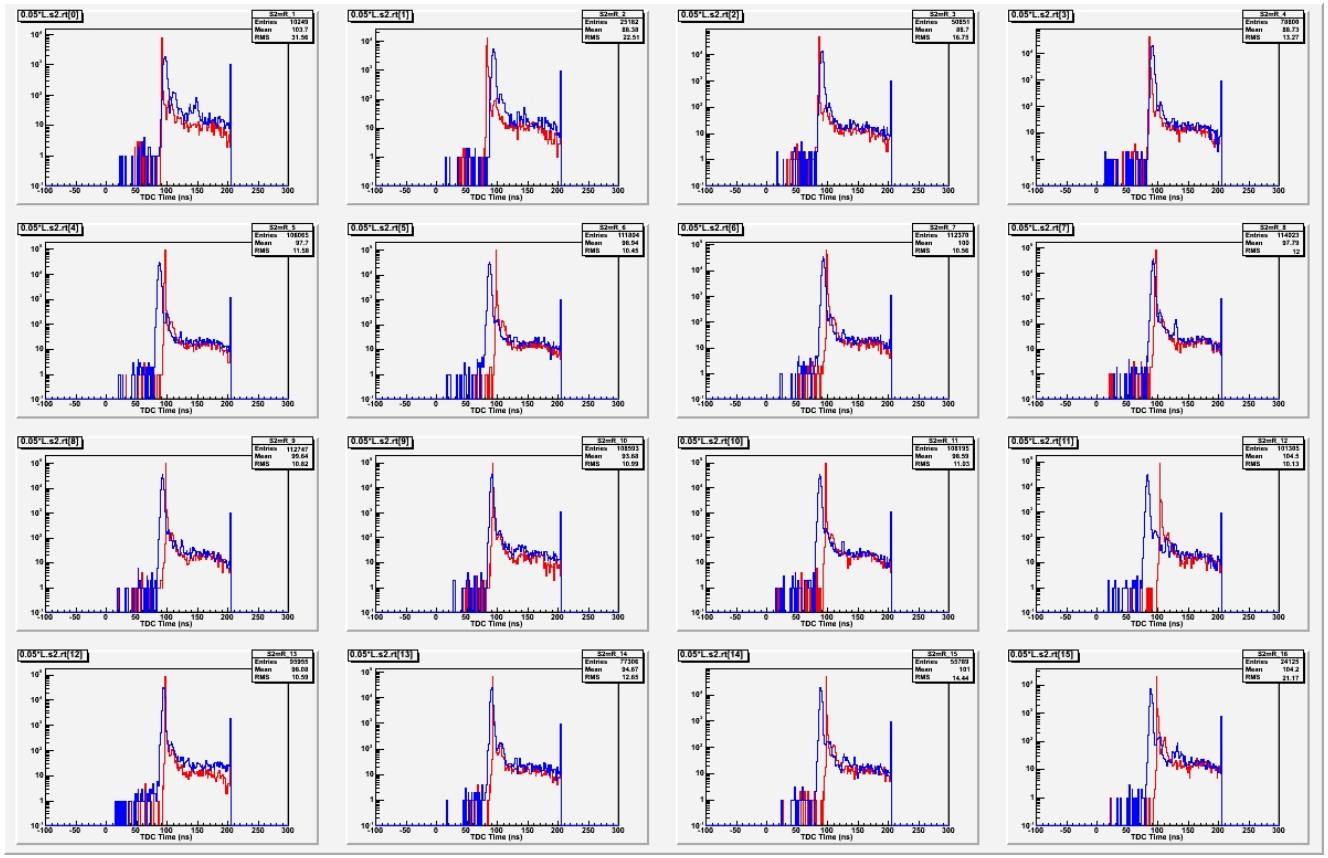
- We try to see how the S1 raw times look for each paddle (color code: left, right)
- As they are – no cuts (for run 20676)



Scintillator Study (6)

S2m Raw Times

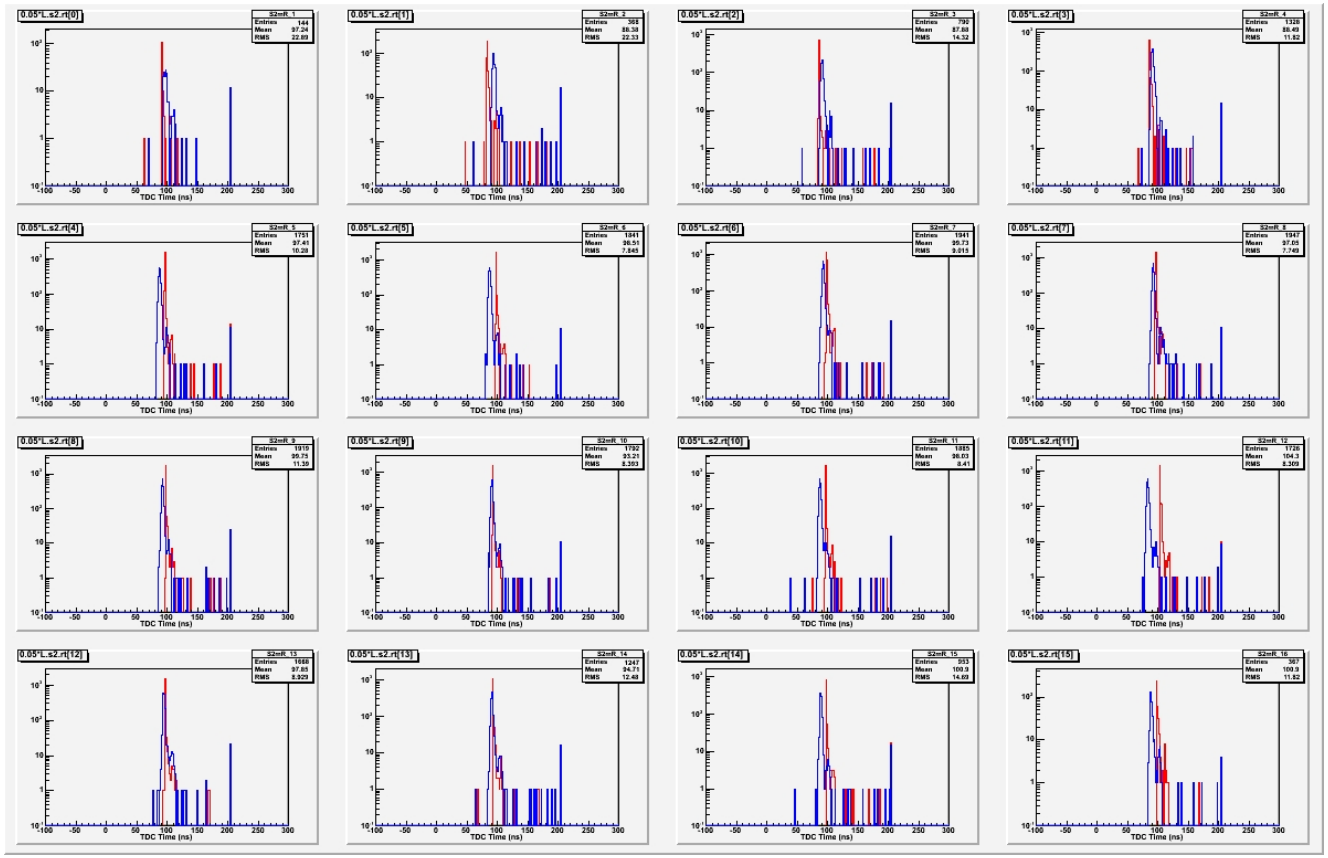
- Trigger cuts



Scintillator Study (7)

S2m Raw Times

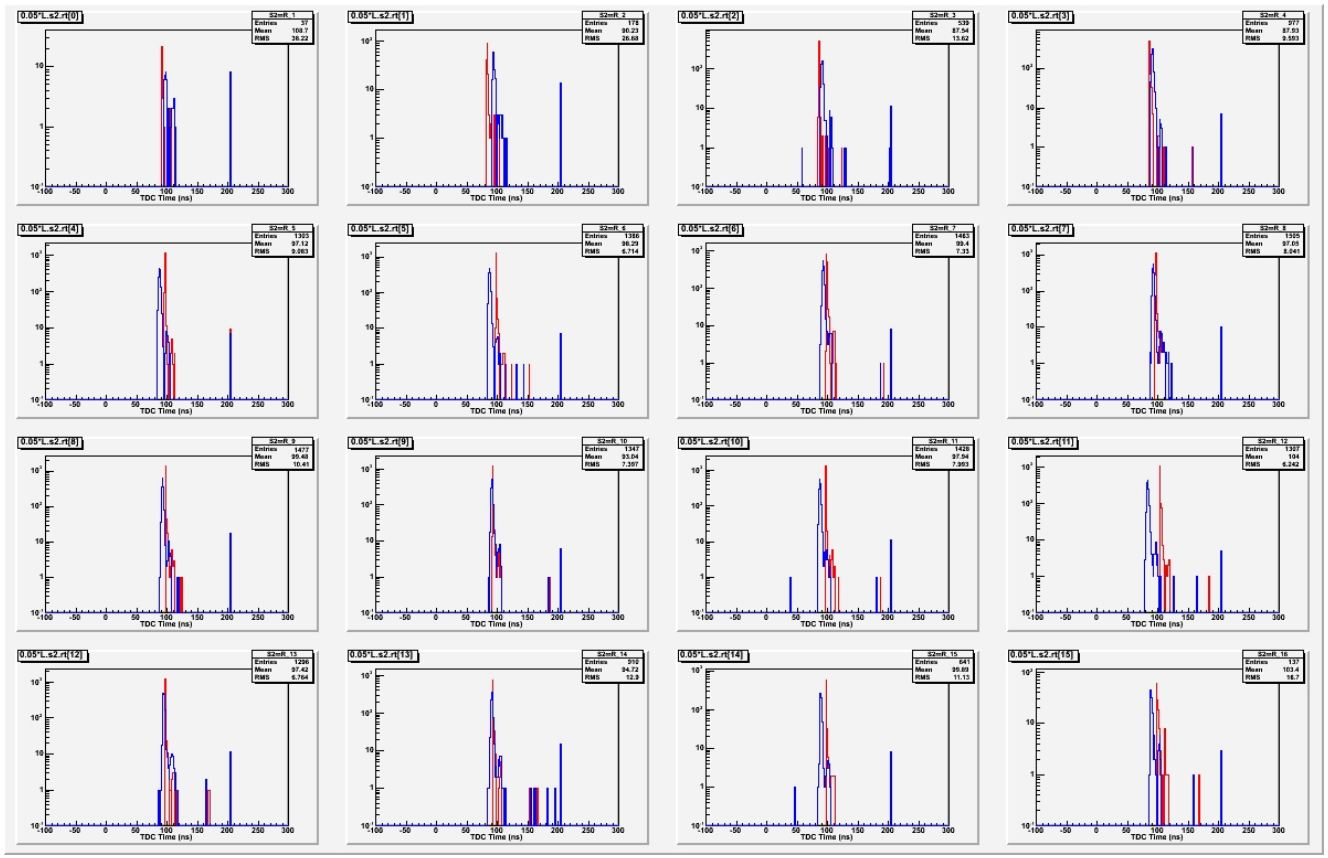
- Trigger cuts and electron cuts (GC $>$ 300)



Scintillator Study (8)

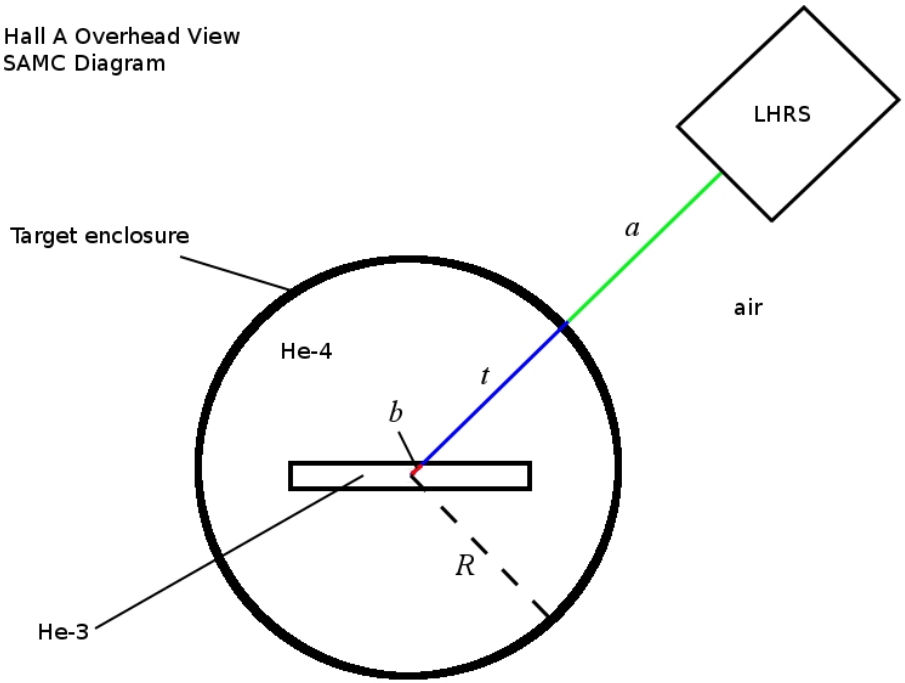
S2m Raw Times

- Trigger cuts and electron cuts
  (GC > 300, $E/p > 0.54$, L.prl1.e > 200)



SAMC (1)

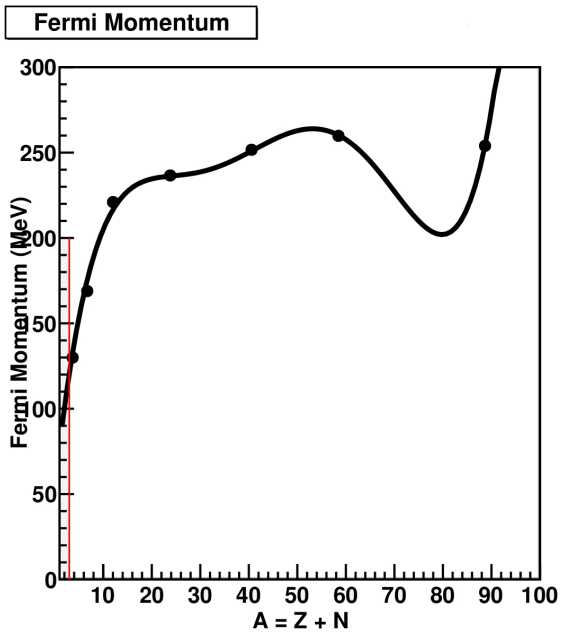
Total Length From LHRS Front to Target

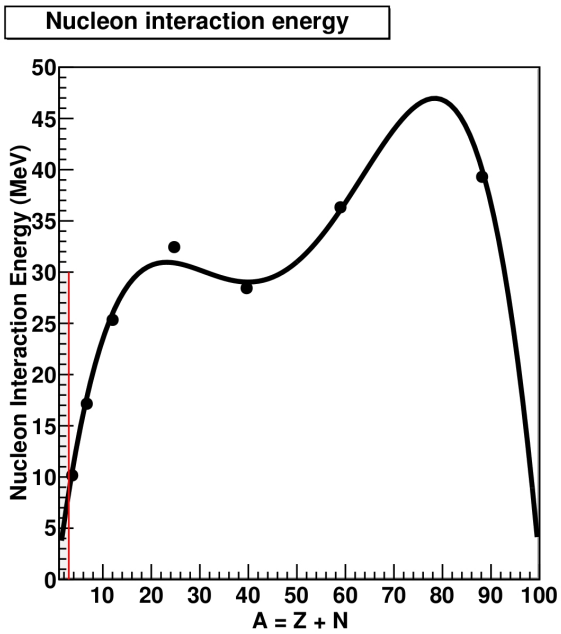


- $a = 51.23$ cm
- $b = r/\sin\theta = 0.67$ cm
  - $\theta = \pi/4$
  - $r = 0.474$ cm (radius of target cell)
- $t = 79$ cm
- $L = a + b + t = 130.90$ cm
- SAMC: $L = 116$ cm (!)
  - Survey 1239 says $L = 118.25$ cm
- a and t are from Chiranjib

SAMC (2)

Fermi Momentum and Interaction Energy per Nucleon





- Used Huan's code to get the fits
- $E_F \approx 120.79\ \mathrm{MeV}$ (5^{th} order polynomial fit)
- $\bar{\epsilon} \approx 8.59\ \mathrm{MeV}$ (4^{th} order polynomial fit)
- Data from *Phys. Rev. Lett.* **26**, *445 (1971)*

A_1^n Error Estimation (1)

R: Ratio of Unpolarized Structure Functions

- The estimation of the error on A_1^n is:

$$\Delta A_1^n = \frac{1}{P_b P_t R D \sqrt{N_{\text{eff}}}}$$

- A few assumptions go into determining R:

$$\mathcal{R}^{^3\text{He}} = \frac{F_2^{^3\text{He}}}{F_2^n + 2F_2^p} \approx 1 \quad \text{The EMC ratio}$$

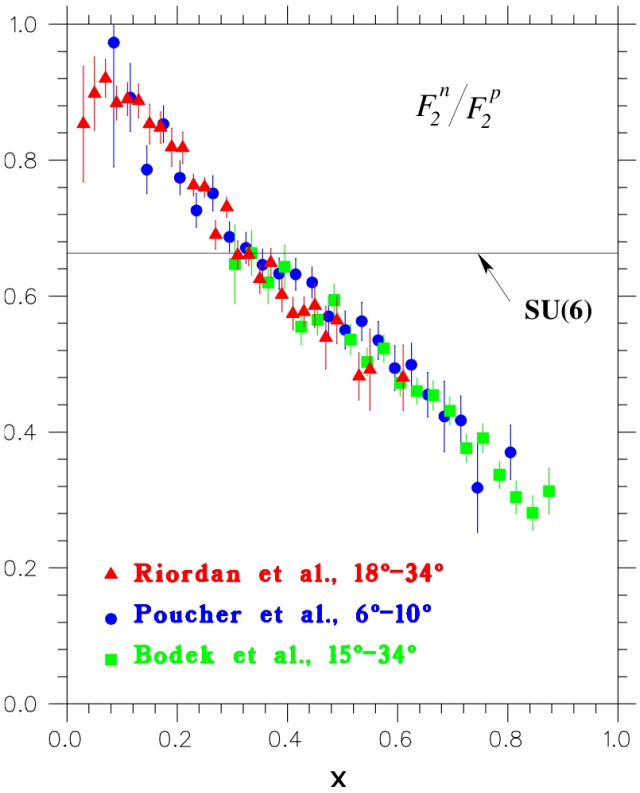
$$R^{np} = \frac{F_2^n}{F_2^p} \approx 1$$

$$\Rightarrow R = \frac{F_2^n}{F_2^{^3\text{He}}} = \frac{F_2^n}{F_2^n + 2F_2^p} \approx \frac{1}{3}$$

A_1^n Error Estimation (2)

R: Ratio of Unpolarized Structure Functions

- However, SU(6) symmetry predicts $R^{np} = 2/3$
- SU(6) is broken, of course (plot from Xiaochao's thesis):



- $R^{np} \approx 1 \Rightarrow$ low x, large amount of sea quarks (our experiment covers $0.2 \leq x \leq 0.8$)
- Maybe it is more accurate to approxmate R^{np} at each x bin?

A_1^n Error Estimation (3)

R: Ratio of Unpolarized Structure Functions

- In which case, if we consider $R^{np} \approx 0.4$ ($x \sim 0.6$),

$$\begin{aligned} F_2^n &= 0.4 F_2^p \\ R &= \frac{F_2^n}{F_2^{^3\mathrm{He}}} = \frac{F_2^n}{F_2^n \left(1 + 2 \times 0.4\right)} = 0.56 \end{aligned}$$

Summary

- Beam studies:
  - `BeamTrip` class: easier to manage large-scale jobs
  - Overall, things look good for negative polarity data
    - A few runs for which $I \neq 15\ \mu\text{A}$, but can keep them
    - Some junk runs that we can get rid of (no events, erratic beam quality, etc.)
- Scintillator study:
  - Even with strict e^- cuts, still cannot remove the large peak at $\sim 200\ \text{ns}$ in the S1 time average
- SAMC:
  - We have gathered all input values, including E_F and $\bar{\epsilon}$
  - Still having issues with the true distance between the target and the front of the LHRS
- A_1^n Statistical Error:
  - $R = F_2^n / F_2^{^3\text{He}}$ can be improved using a better est. of R^{np}

What's Next?

- Beam studies:
  - Double check negative polarity results
  - Extend to positive polarity
- Scintillator study:
  - Maybe cut out the peak at $\sim 200\text{ns}$?
- SAMC:
  - Get this input parameter L figured out
- A_1^n Statistical Error:
  - Recalculate A_1^n with better estimations of R