LHRS Analysis for d_2^n

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

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10/21/10

Outline

1. Data Analysis
   - Beam Studies
   - Scintillator Study
   - Positive Polarity Data
2. Simulations and Calculations
   - SAMC Input Parameters
   - A_1^n Error Estimation
3. Summary

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: Negative Polarity

Completed Kinematics: Negative Polarity				
E (GeV)	p (GeV)	# of Runs	$I_{\text{avg.}}$ (μA)	$Q_{\text{tot.}}$ (C)
4.73	0.60	10	15.15	0.4224
5.89	0.60	20	14.85	0.9702
4.73	0.80	12	15.16	0.3496
5.89	0.90	18	15.09	0.6507
5.89	1.13	20	15.13	0.9142
5.89	1.20	17	14.78	0.6266
5.89	1.27	19	15.08	1.0208
4.73	1.42	11	14.89	0.8186
5.89	1.42	14	15.04	0.9471
4.73	1.51	16	15.14	1.1182
5.89	1.51	18	15.02	1.2702
4.73	1.60	17	15.13	1.1508
5.89	1.60	20	14.94	1.4993
5.89	1.70	9	15.06	1.1955

Beam Trip Study (3)

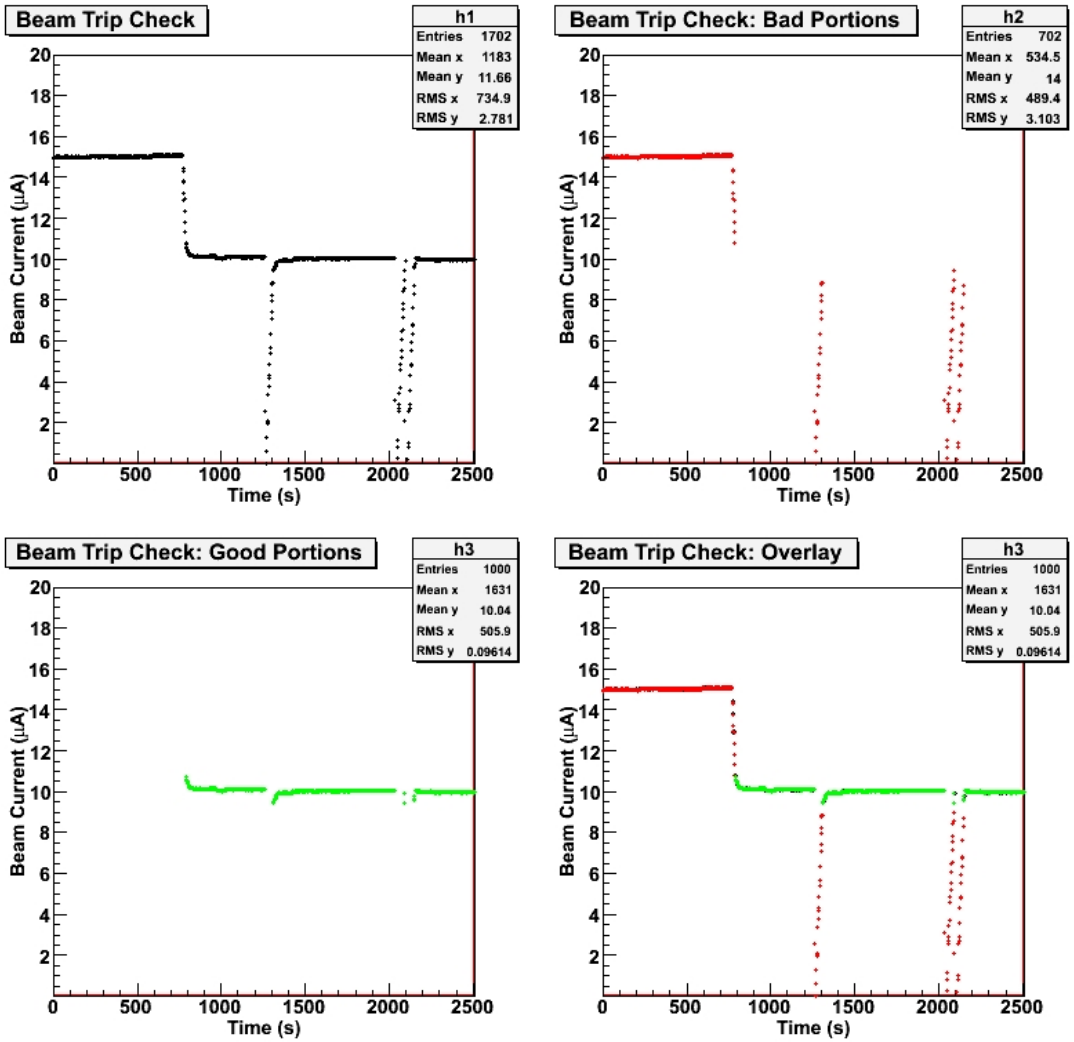
Questionable Runs: Negative Polarity

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, Negative Polarity)



Beam Trip Study (5)

Completed Kinematics: Positive Polarity

Completed Kinematics: Positive Polarity				
E (GeV)	p (GeV)	# of Runs	$I_{\text{avg.}}$ (μA)	$Q_{\text{tot.}}$ (C)
4.73	0.60	6	15.03	0.0485
5.89	0.60	5	14.15	0.0714
5.89	0.80	5	14.13	0.0860
4.73	0.90	6	15.01	0.0853
5.89	1.12	4	14.14	0.0842
4.73	1.13	7	14.99	0.1455
4.73	1.27	4	15.00	0.1512
5.89	1.34	1	14.14	0.0505

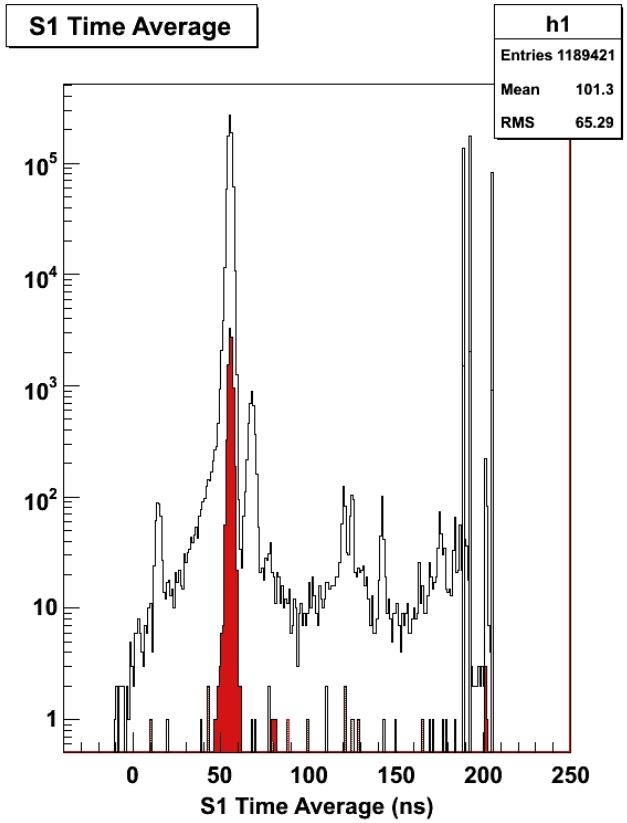
Beam Trip Study (6)
Questionable Runs: Positive Polarity

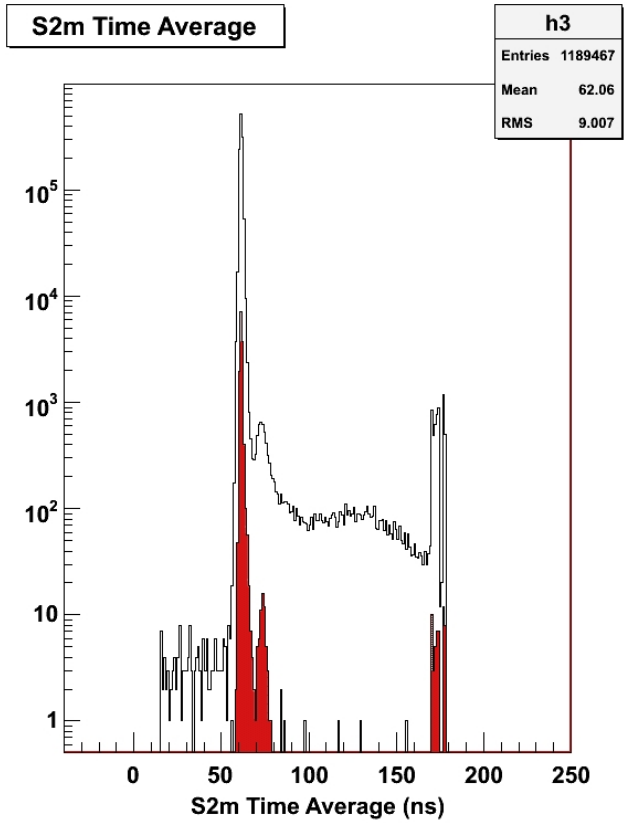
Questionable Runs: Positive Polarity		
E (GeV)	p (GeV)	Questionable Runs
4.73	0.60	20512–20514†,20515†, 20516–20522†
5.89	0.60	20634†, 20635†
5.89	0.80	20624–20627†, 20646†,20648†
4.73	0.90	20510†, 20511
5.89	1.12	20623, 20644†, 20645
4.73	1.13	20500, 20503, 20504†, 20505
4.73	1.27	20493†, 20494, 20495
5.89	1.34	20637†, 20638, 20639†, 20640†, 20641

- 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.)

Scintillator Study
S1 and S2m Time Averages

- Run 20676
- red indicates e^- cuts in the GC and PR

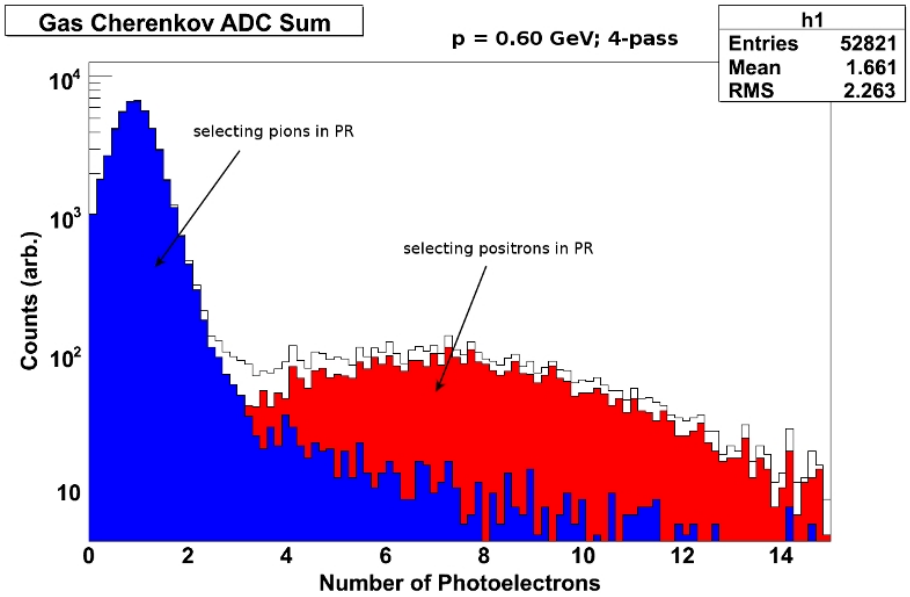


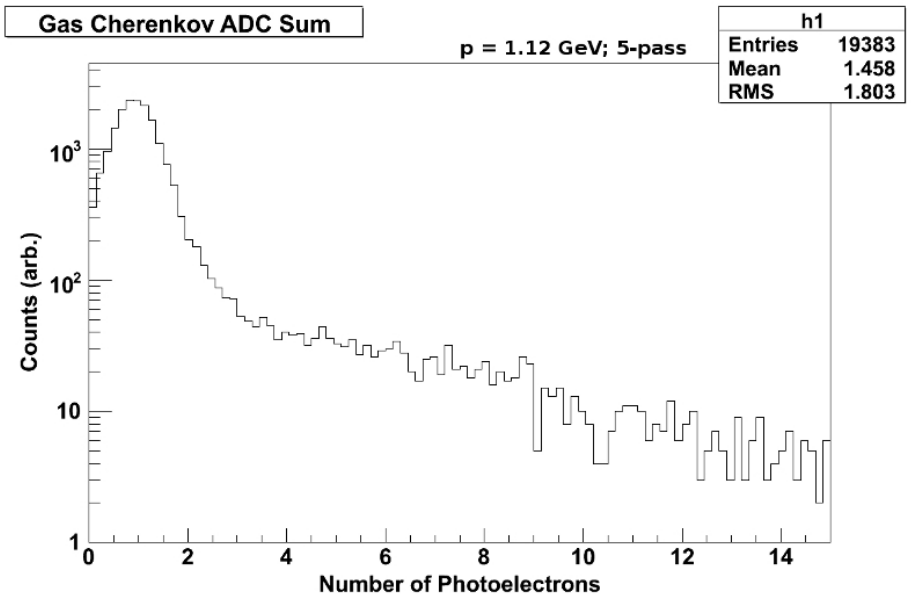


Positive Polarity Data (1)

Gas Čerenkov: $p = 0.60$ GeV, $p = 1.12$ GeV

- A lot of background (π^+)
  - Some from e^+ ($\pi^0 \rightarrow e^+e^-$)

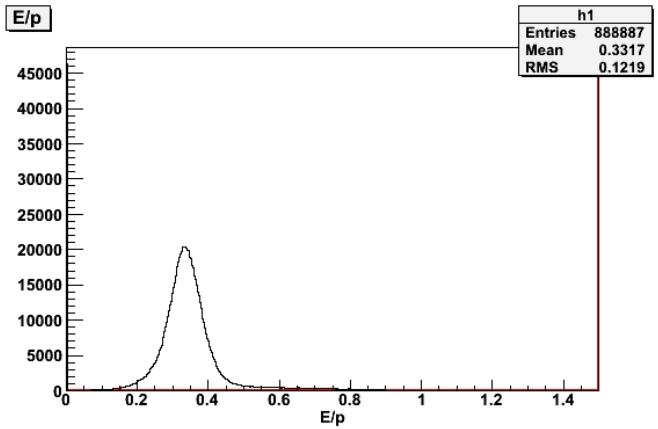


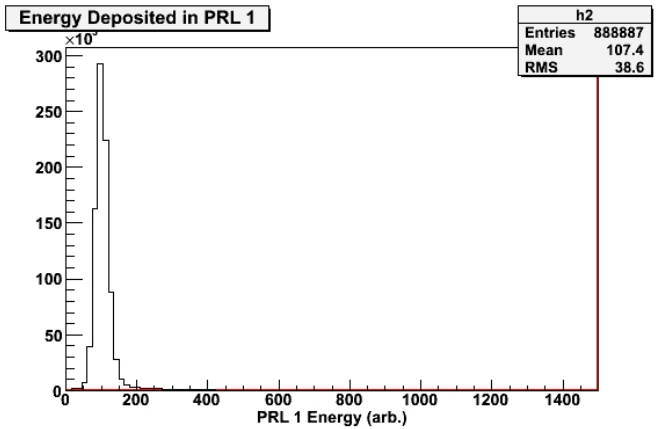


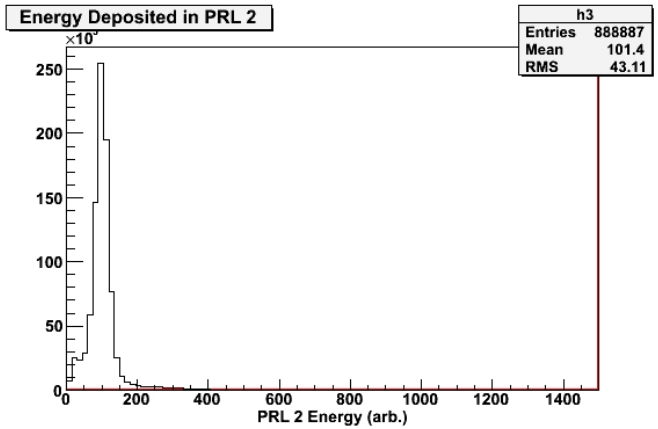
Positive Polarity Data (2)

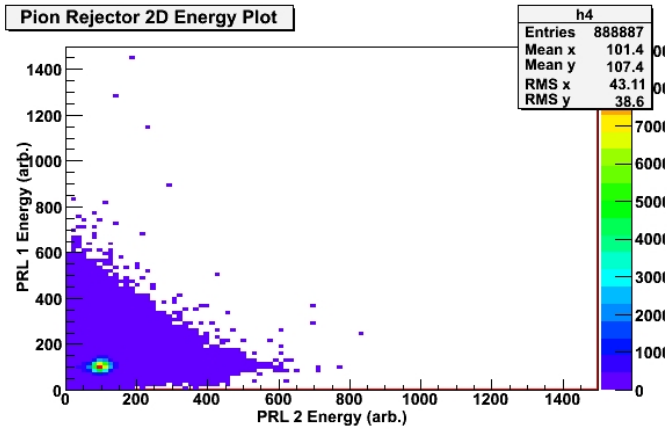
Pion Rejector: $p = 0.60$ GeV, 4-pass

- Anti-Čerenkov cut





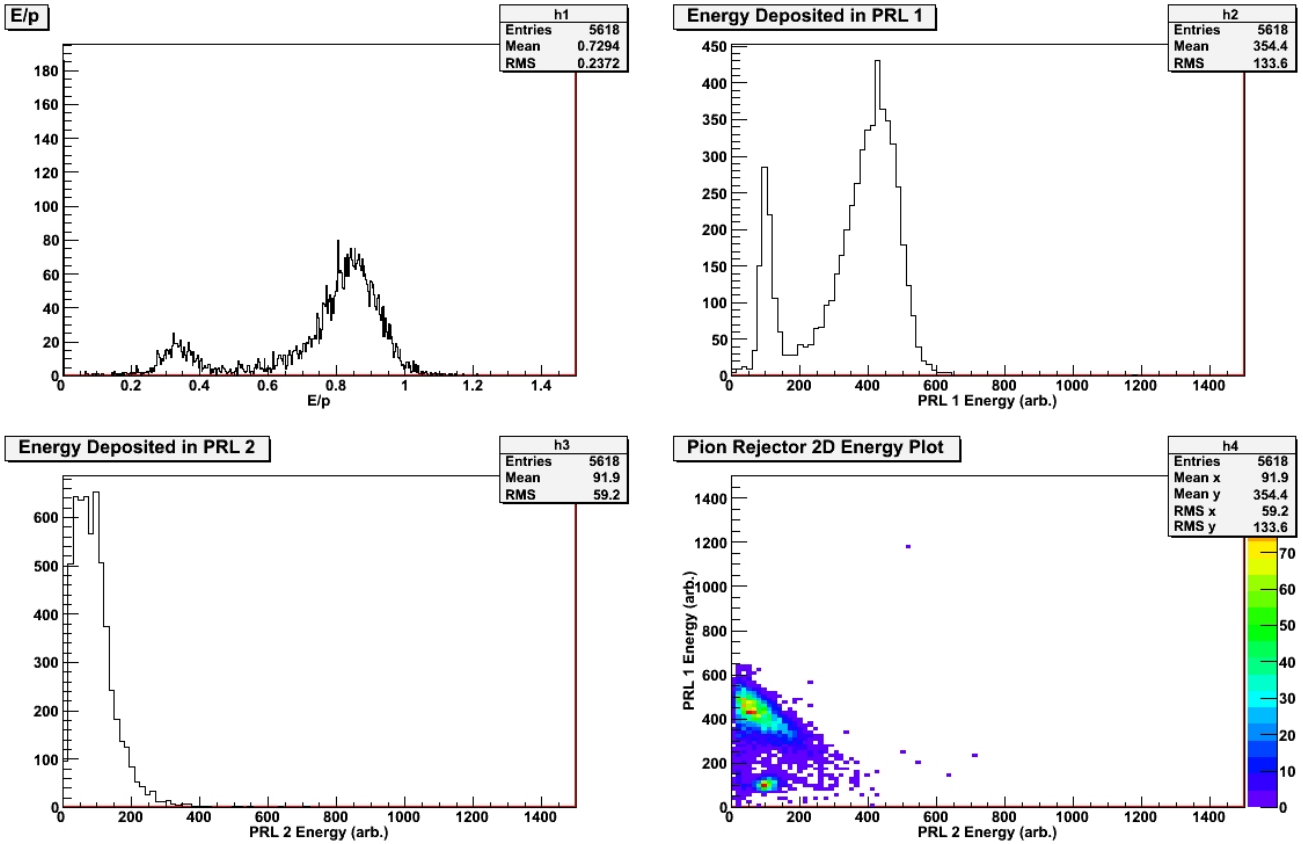




Positive Polarity Data (3)

Pion Rejector: $p = 0.60$ GeV, 4-pass

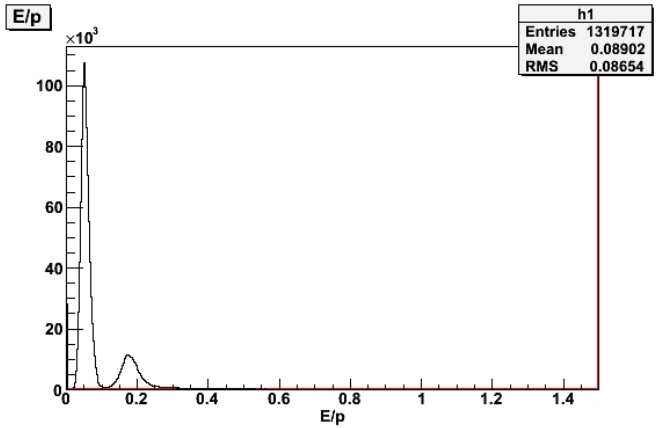
- e^+ cuts (GC > 300)

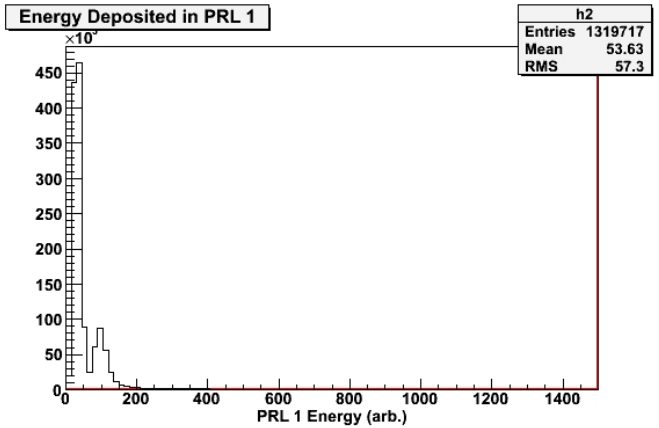


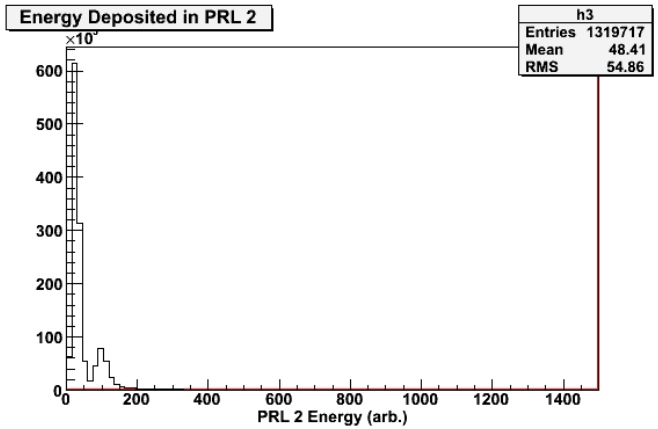
Positive Polarity Data (4)

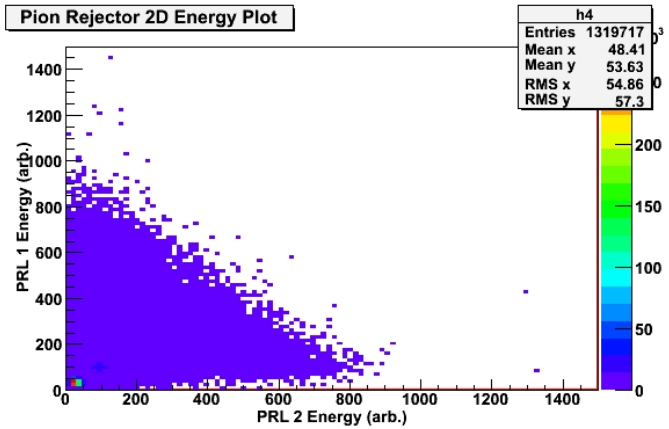
Pion Rejector: $p = 1.12$ GeV, 4-pass

- Anti-Čerenkov cut
  - Double-peak structure causes problems for calibration



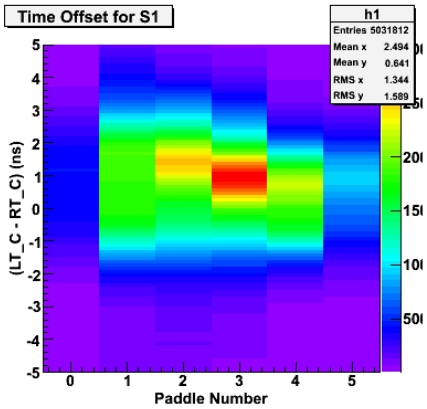


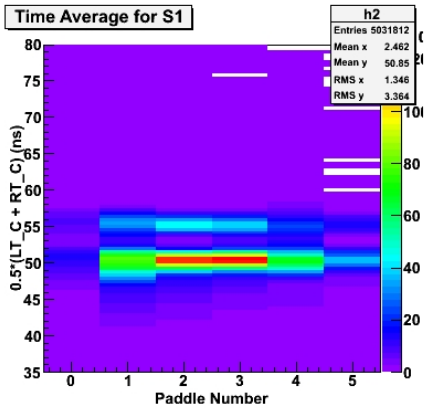


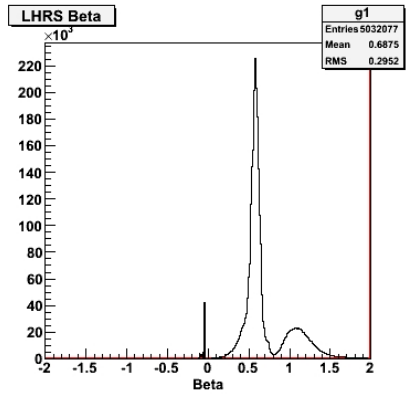


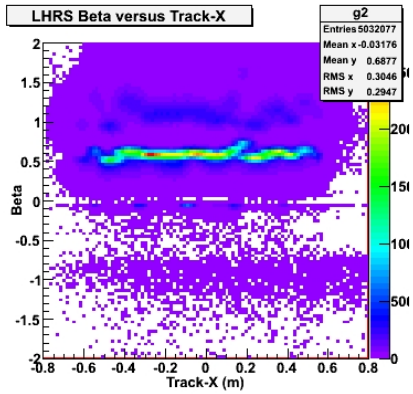
Positive Polarity Data (5)

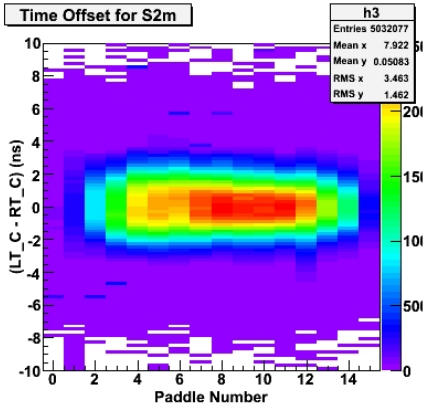
β: $p = 0.60$ GeV, 4-pass

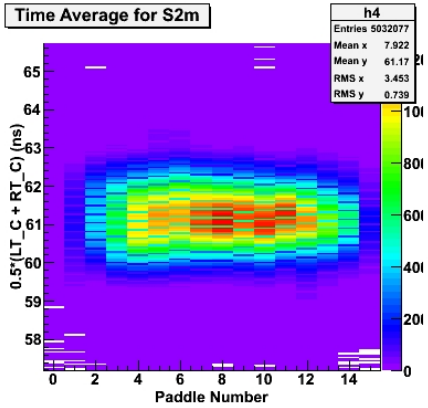


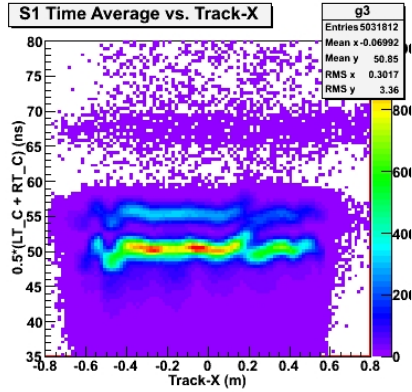


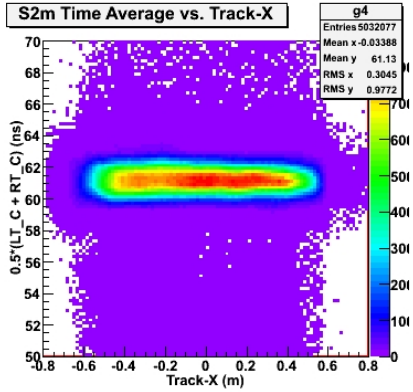






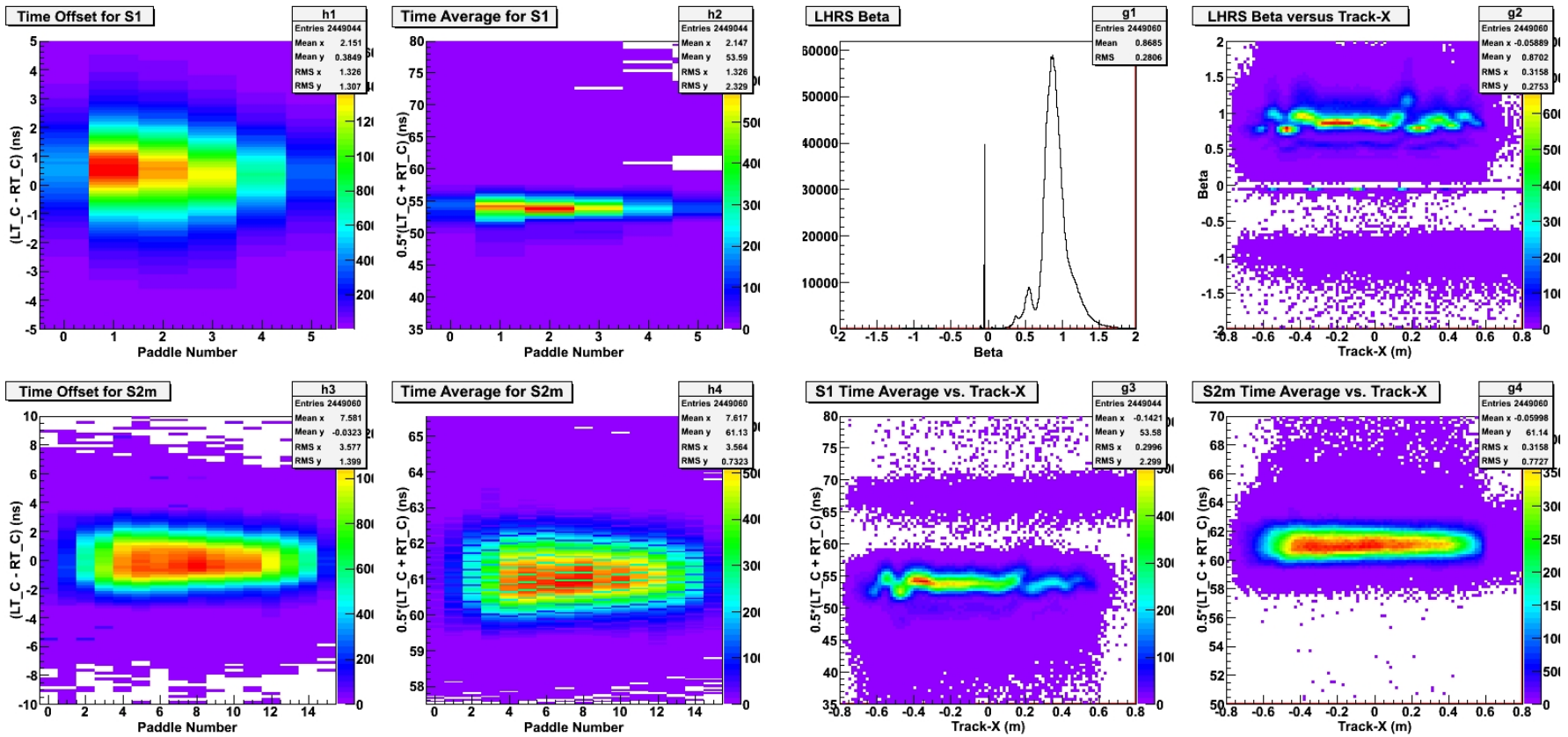




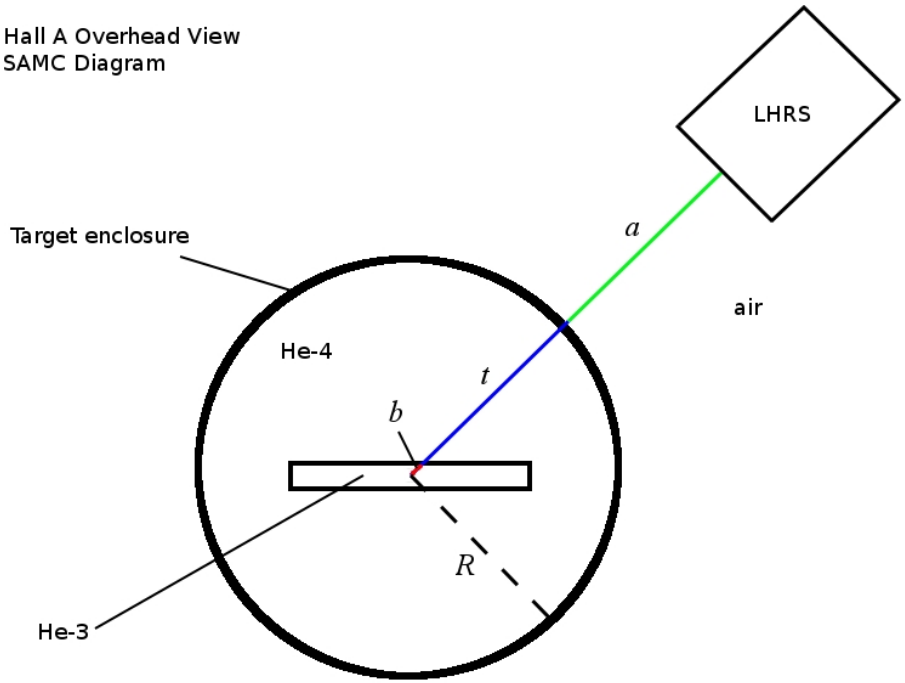


Positive Polarity Data (6)

β: $p = 1.12$ GeV, 4-pass



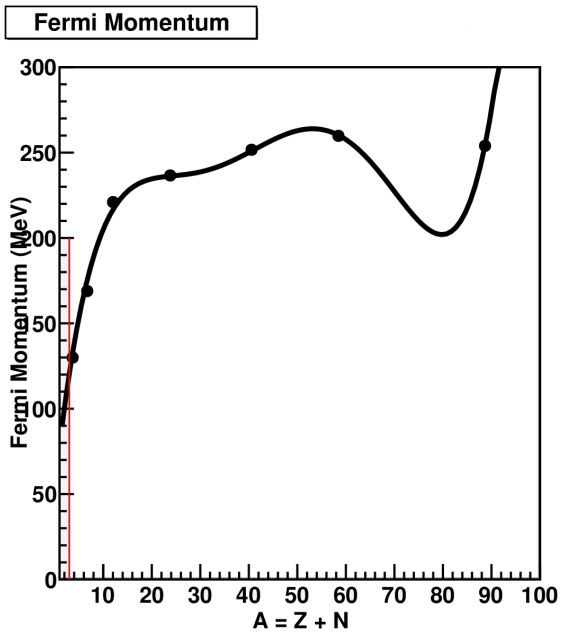
SAMC (1)
Total Length From LHRS Front to Target

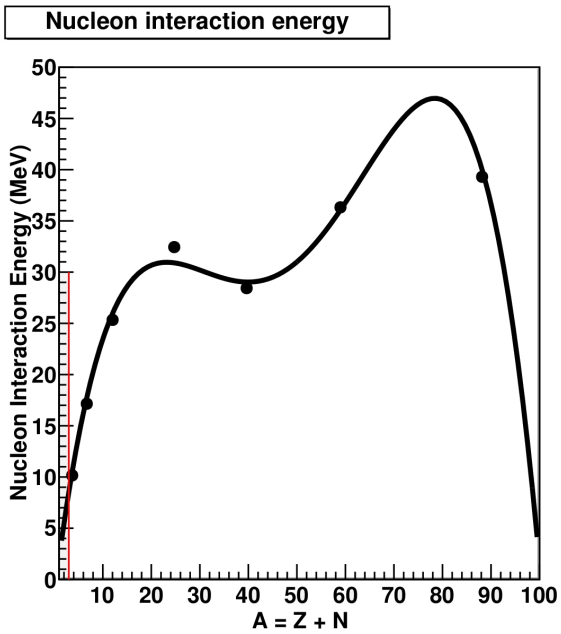


- $a = 51.23$ cm
- $b = r/\sin\theta = 0.67$ cm
  - $\theta = \pi/4$
  - $r = 0.474$ cm (radius of target cell)
- $t = 79$ cm
- $L = a + b + t = 130.90$ cm
- SAMC: $L = 116$ cm (!)
  - Survey 1239 says $L = 118.25$ cm
- a and t are from Chiranjib

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:

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

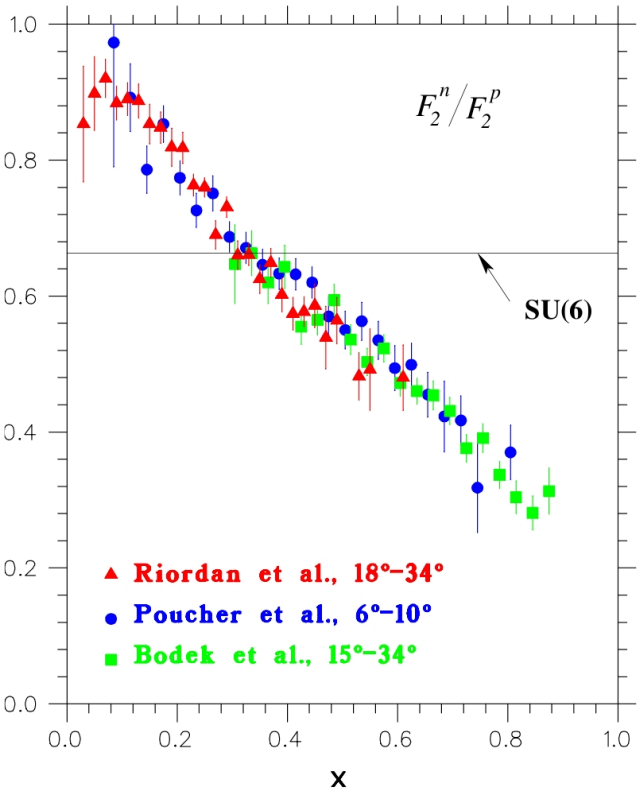
$$R^{np} = \frac{F_2^n}{F_2^p} \approx 1$$

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

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 (1)

- Beam studies:
  - `BeamTrip` class: easier to manage large-scale jobs
  - Overall, things look good for both negative and positive 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 doesn't necessarily clean things up...
- Positive Polarity Data:
  - GC calibration looks good (using work from negative polarity data)
  - PR has some odd structure to it – is it due to the π^+ background?
  - Double-peak structure in β as well

Summary (2)

- 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:
  - $R = F_2^n / F_2^{^3\mathrm{He}}$ can be improved using a better approximation of R^{np}

What's Next?

- Data Quality:
  - Skim ROOTfiles: Stage 1
    - Produce ROOTfiles with no beam trips
  - Start looking at Skim ROOTfiles: Stage 2
    - Detector trips
- Scintillator study:
  - Not quite sure...
- Positive Polarity Data:
  - Figure out double-peak structure in PR, β
  - Finish off GC and PR calibrations for $p = 1.12\,\mathrm{GeV}$ and $p = 1.34\,\mathrm{GeV}$
- SAMC:
  - Get this input parameter L figured out
- A_1^n Statistical Error:
  - Recalculate A_1^n with better approximations of R (maybe $R \to R\,(x)$?)