LHRS Analysis for d_2^n

Data Quality, Trigger Variable, & Scintillator Studies

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Outline

A_1^n Statistical Error Projection (1)

Sample Calculation

- From the note, we have various quantities:
    - N_p = Number of events that remain after a momentum cut only
    - N_{cut} = Number of events that remain after all cuts
    - N_{raw} = Number of events recorded for the sample run 2060
    - N_T = Number of events recorded in parallel running over the run ranges 1530–1553 and 1702–1719
    - $N_{\text{eff}} = (N_{\text{cut}}/N_{\text{raw}}) N_T$ = Effective number of events that would remain after all cuts are applied to all parallel data

- The momentum cut:
    - $\delta p_{i,i-1}/2 < p_i < \delta p_{i,i+1}/2$
      $\delta p_{i,j} = |p_i - p_j|, \, j = i - 1, i + 1$
    - For instance, if $p_i = 1.20, p_{i-1} = 1.13, p_{i+1} = 1.27$
      (5-pass LHRS p settings)
      $\Rightarrow$ cut $= 1.165 <$ `BB.tr.p[0]` < 1.235

A_1^n Statistical Error Projection (2)

Sample Calculation

- Utilizing all the good electron cuts (see the note), we obtain:
  - $N_p = 30386$
  - $N_{\text{cut}} = 4372$
  - $N_{\text{raw}} = 4681052$
  - $N_T = 214350416$
  - $\Rightarrow N_{\text{eff}} = 200199$

- The errors on the parallel asymmetry and A_1^n:

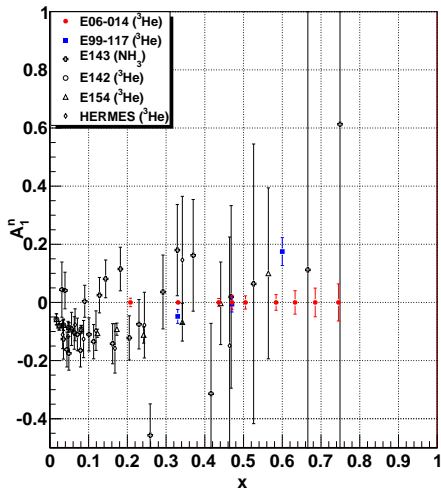$$\Delta A_\parallel^{raw} = \frac{1}{\sqrt{N_{\text{eff}}}} = 0.223\%$$

$$\Delta A_1^n \approx \Delta A_\parallel^{phys} = \frac{1}{P_b P_t R D \sqrt{N_{\text{eff}}}} = 2.388\%$$

- Physics quantities:
  - $P_b \approx 0.65$ is the beam polarization
  - $P_t \approx 0.60$ is the target polarization
  - $R \approx 0.30$ is the ratio of ^{3}He to neutron structure functions
  - $D \approx 0.80$ is the dilution factor

A_1^n Statistical Error Projection (3)

E06-014 (5-pass Data) Compared to World Data

Scintillator Calibration (1)
Corrected S2m time − S1 raw time: Method

- With the S2m paddles calibrated, we now look to the S1 paddles
  - Look at the time difference between the two planes to see how to manipulate the time offsets for S1
  - The left-right (L-R) time offset for each paddle in S1 has already been done (and implemented in the DB)

- We consider the time difference between S2m (corrected) and S1 (raw) paddles :

$$\Delta t_{jk} = t_{\text{S2m}_j} - t_{\text{S1}_k}$$

  - From this, we determine what offset needs to be applied to both the L and R PMTs
  - We keep in mind the fact that the S2m paddles have each been calibrated to 61.15 ns
  - Choose $\Delta t_{jk} = 6$ ns

Scintillator Calibration (2)

Corrected S2m time — S1 raw time: Method

- There are only six time offsets to work with in the DB for the L and R PMTs
  - Utilize the average time difference for each paddle (in S1) in the quantity $\Delta t_{jk} \Rightarrow \Delta t_{jk,\mathrm{avg}}$
  - This should be fine as long as the Δt_{jk}'s are consistent with one another for a given S1 paddle
- Each (L and R) S1 PMT acquires the offset (in the DB):

$$
\begin{aligned}
t_{\mathrm{off},L}^k &= \delta t_L^k + f \delta t^k \\
t_{\mathrm{off},R}^k &= \delta t_R^k + f \delta t^k \\
\delta t^k &= 6.00 - \Delta t_{jk,\mathrm{avg}} \\
f &= 20 \text{ ch./ns}
\end{aligned}
$$

Scintillator Calibration (3)

Corrected S2m time — S1 raw time: Before

Scintillator Calibration			
S1 Paddle	S2m Paddle	Δt_{jk} (ns)	$\Delta t_{jk,avg}$ (ns)
0	0	17.21	
	1	17.36	17.27
	2	17.25	
1	3	15.59	
	4	15.55	15.56
	5	15.55	
2	5	7.93	
	6	7.92	7.93
	7	7.91	
3	8	8.05	
	9	8.07	8.05
	10	8.04	
4	10	6.92	
	11	6.92	6.92
	12	6.91	
5	13	4.23	
	14	4.18	4.21
	15	4.23	

Scintillator Calibration (4)

Corrected S2m time — Corrected S1 time: After

- Most Δt_{jk} are consistent

- Is it S1 or S2m yielding the discrepancy?

- Is the discrepancy too small to fix?

Scintillator Calibration			
S1 Paddle	S2m Paddle	Δt_{jk} (ns)	$\Delta t_{jk,avg}$ (ns)
0	0	5.99	5.99
	1	5.98	
	2	6.02	
1	3	5.95	5.96
	4	5.96	
	5	5.96	
2	5	5.98	5.99
	6	6.01	
	7	6.00	
3	8	6.02	6.02
	9	6.04	
	10	6.01	
4	10	5.99	5.99
	11	5.99	
	12	5.98	
5	13	5.99	5.99
	14	6.01	
	15	5.99	

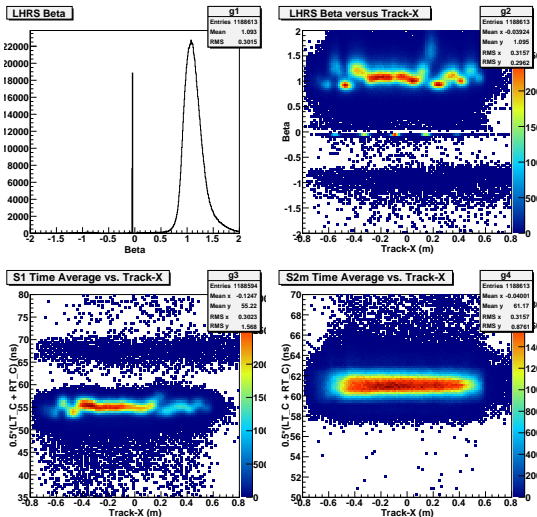# Scintillator Calibration (5)
Corrected Time Averages

S2m Time Averages	
Paddle	t_{avg} (ns)
0	61.17
1	61.15
2	61.19
3	61.15
4	61.15
5	61.15
6	61.19
7	61.19
8	61.17
9	61.19
10	61.16
11	61.17
12	61.15
13	61.15
14	61.16
15	61.14

S1 Time Averages	
Paddle	t_{avg} (ns)
0	55.17
1	55.19
2	55.18
3	55.15
4	55.18
5	55.15

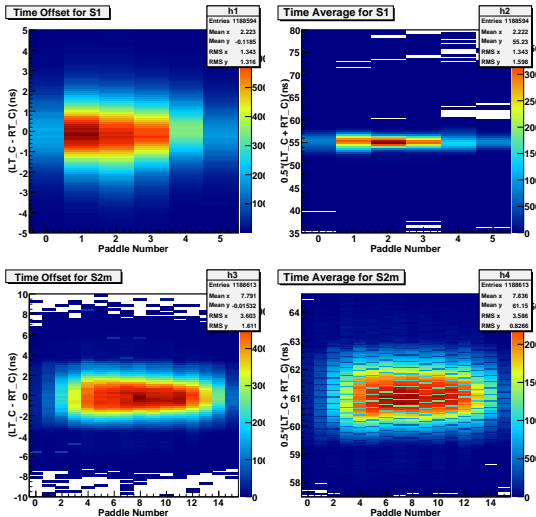- Fairly good agreement

- TDC resolution is 0.05 ns/ch.

Scintillator Calibration (6)

β Distribution

Scintillator Calibration (7)

S1, S2m Distributions

Summary

- The projected statistical error on A_1^n is promising
  - Will provide a direct test on the JLab E99-117 result
  - Extend the precision data coverage to large-x
- Δt_{jk} adjusted to 6 ns for appropriate S2m, S1 paddle combinations
  - β still displays significant jitter — is it due to the ~ 0.01–0.04 ns differences in S2m, S1 paddle times — or is this time difference too small to fix?
  - Didn't get a chance to fine tune these numbers yet. . .

What's Next?