

Beam Off Asymmetry Analysis - Run Checking 2

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Rev. 1: updated Slides 8 and 20

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Methods

Summer Running

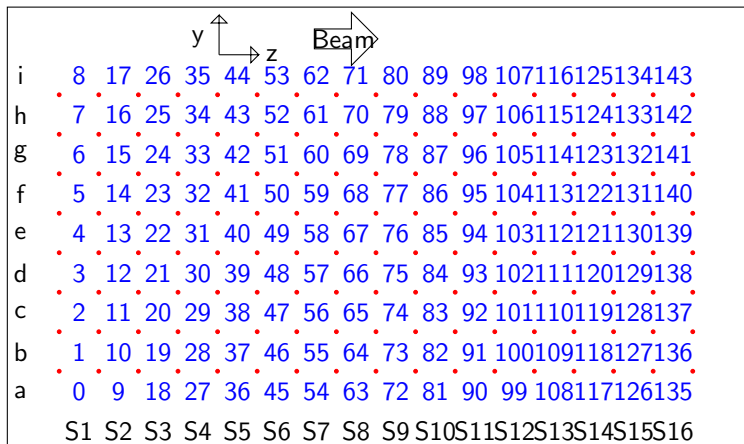
Tuesday Running

All Runs

Error Weighted Averaging

Conclusion

Wire Numbering



- **HV** 17 HV Frames with 8 wires each
- **Signal** 16 signal Frames with 9 wires each

Beam Off Asymmetry Calculation

The single wire instrumental asymmetries were calculated using a simple difference formula normalized by one volt to render it unitless.

$$A_{j,q,t} = \frac{w_{j,t,i=\text{even}} - w_{j,t,i=\text{odd}}}{1V} \quad (1)$$

where j is the run number, t time is the time bin number, i is the pulse type, and q is the asymmetry number. Pulse and asymmetry numbers are indexed starting at zero.

Note: Beam on physics asymmetries were calculated over time bins 5 – 44, and that same time bin range was used for all parts of the following analysis.

Run Analysis

- ▶ Seven values of interest were calculated for each run:
 - ▶ Wire Yield Mean
 - ▶ Wire Yield Standard Error of the Mean
 - ▶ Beam Off Instrumental Asymmetry Mean
 - ▶ Wire Yield Standard Error of the Mean
 - ▶ Sum of Square of Wire Yields
 - ▶ Sum of Square of Instrumental Asymmetries
 - ▶ Phase Difference between the runs

List of Runs

A list of good beam off runs has been provided by Kabir, and are now on the n3He wiki Instrumental Asym. webpage for reference by the group.

Summer Run List

Date Range	Initial Run	Final Run
2015-06-25	38081	38124
2015-06-26	38125	38215
2015-08-03	38216	38301
2015-08-04	38302	38416
2015-08-10	38417	38493
2015-08-11	38494	38657
2015-08-12	38658	38769

Tuesday Run List

Tuesday Run List					
Date Range	Initial Run	Final Run			
T1	17784	17834	T9	32503	32535
T2	19114	19158	T10	45032	45054
T3	20444	20493	T11	46416	46466
T4	21869	21919	T12	49663	49697
T5	24011	24061	T13	51076	51127
T6	26461	26503	T14	52467	52517
T7	27729	27755	T15	56073	56076
T8	30058	30074			

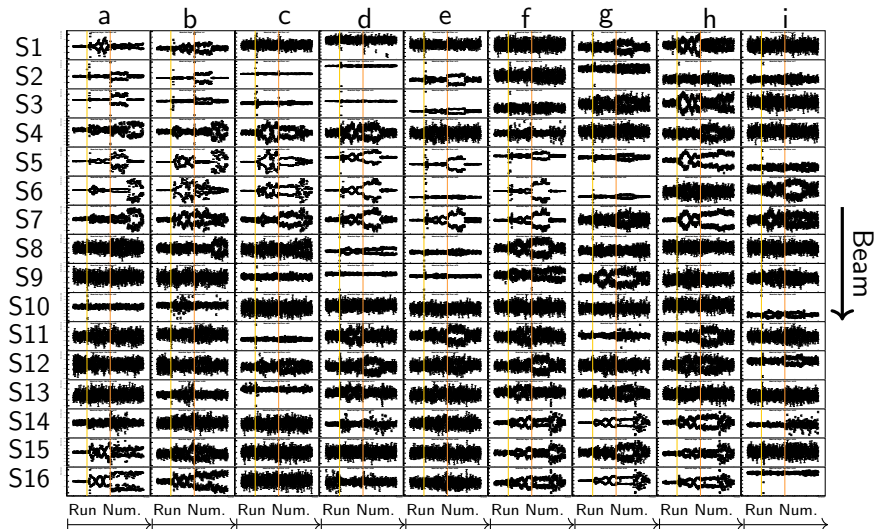
Runs were taken between 9:00am and 4:00pm while beam was off for maintenance

Run Statistics

- ▶ Run Durations:
 - ▶ Standard run length is 24996 pulses long
 - ▶ 6.94 minutes per run (8.6 runs per hour)
 - ▶ 4.8 days per 1000 runs
- ▶ Number of Runs:
 - ▶ Total Beam Off Runs: 4035
 - ▶ Summer Runs All: 676
 - ▶ Summer Runs Period 1: 128
 - ▶ Summer Runs Period 2: 198
 - ▶ Summer Runs Period 3: 350
 - ▶ Tuesday Runs: 565
 - ▶ Other Beam Off Runs: 2794

Summer run counting was corrected as part of rev. 1.

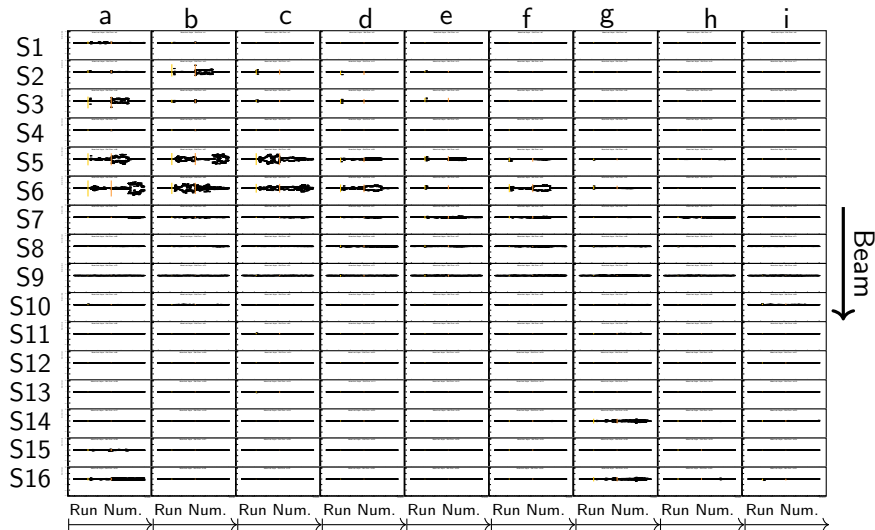
Summer Instrumental Asymmetry



X-axes are all the same.

Y-axes are all **different**

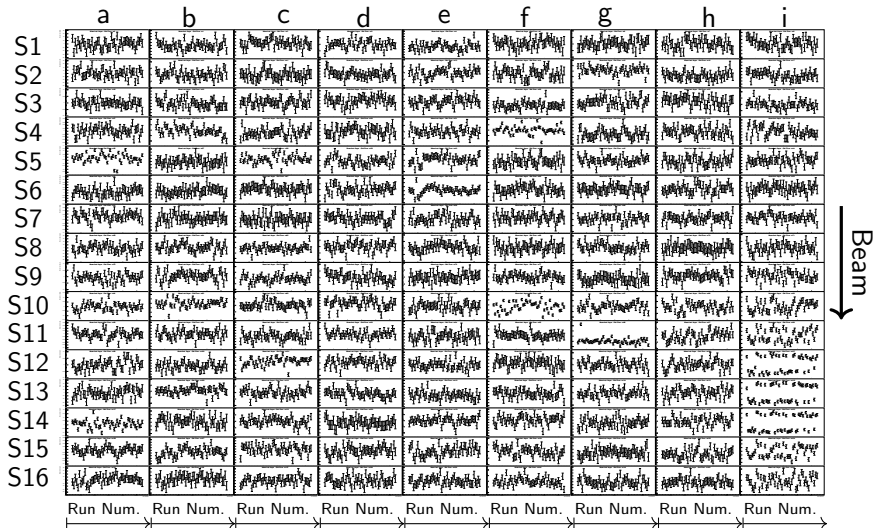
Summer Instrumental Asymmetry



X-axes are all the same.

Y-axes are all the same

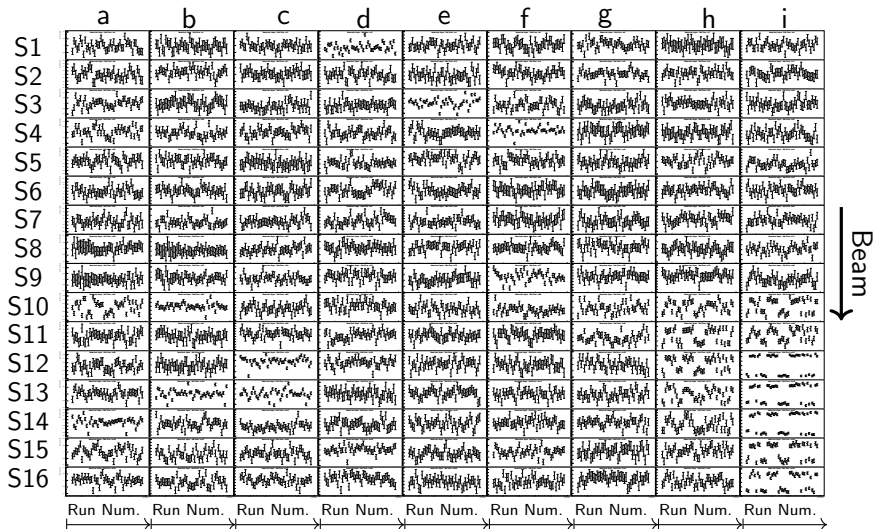
Tuesday 1 Instrumental Asymmetry



X-axes are all the same.

Y-axes are all **different**

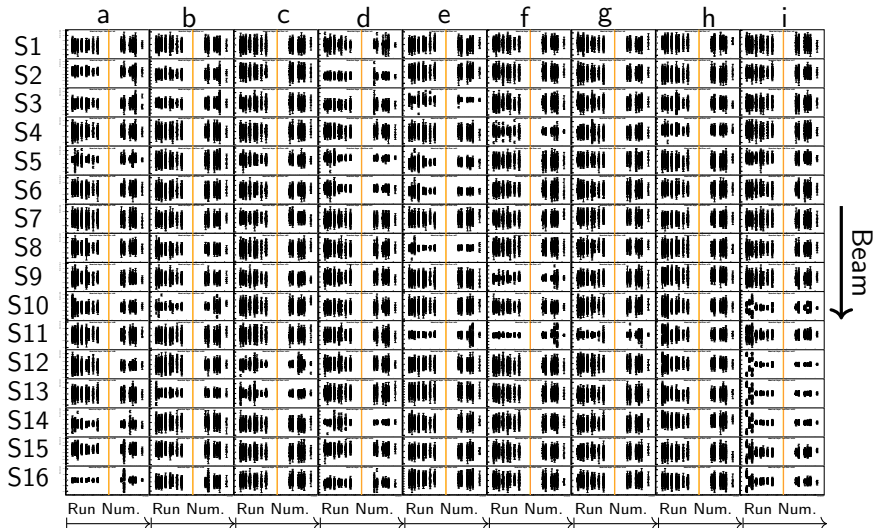
Tuesday 2 Instrumental Asymmetry



X-axes are all the same.

Y-axes are all the **different**

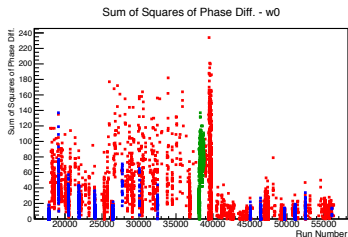
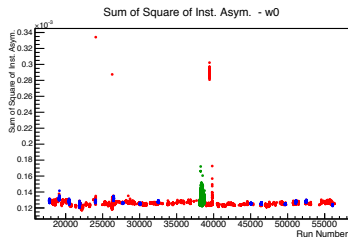
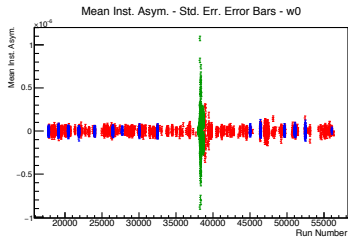
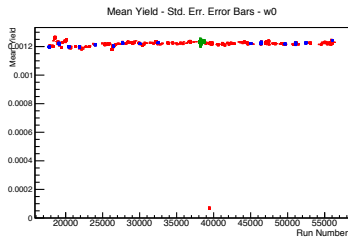
Tuesday All Instrumental Asymmetry



X-axes are all the same.

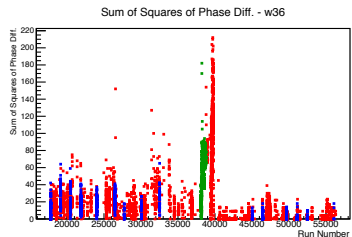
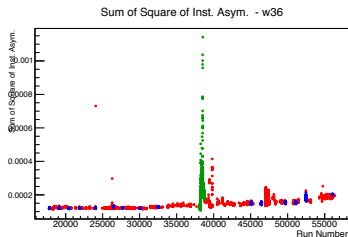
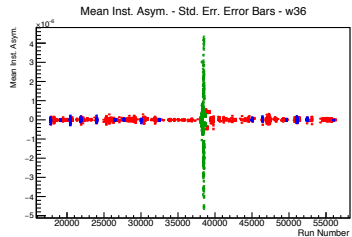
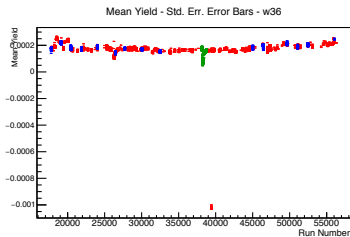
Y-axes are all the **different**

All Beam Off Runs - Wire 0 Select Plots



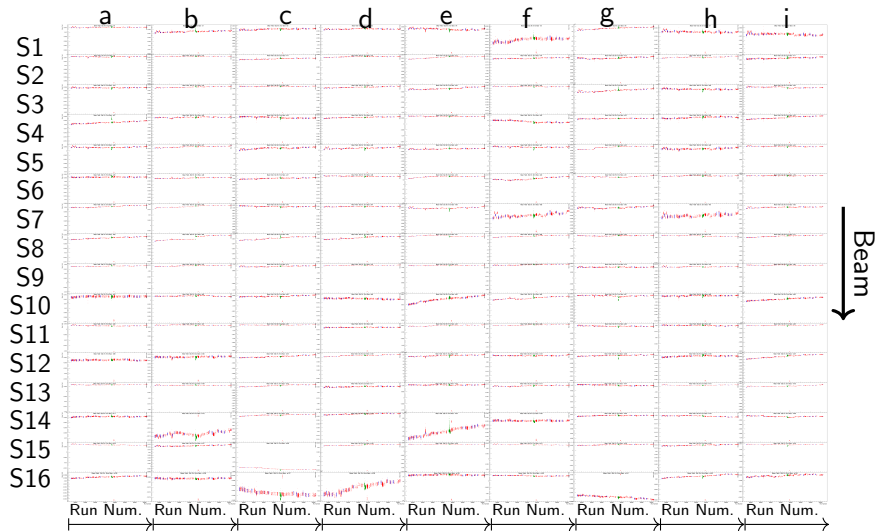
Blue is Tuesdays, Green is summer, Red is all other beam off runs.

All Beam Off Runs - Wire 36 Select Plots



Blue is Tuesdays, Green is summer, Red is all other beam off runs.

All Beam Off Runs - Mean Wire Yield

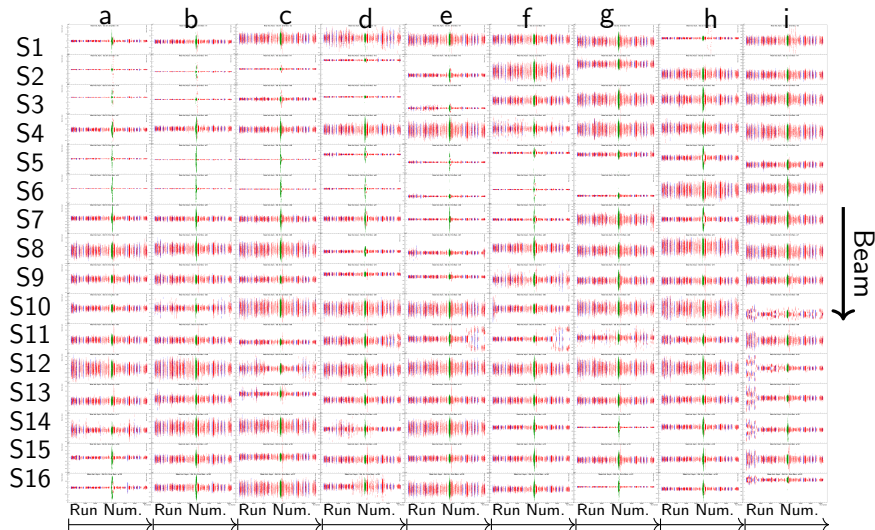


X-axes are all the same.

Y-axes are all **different**

Blue is Tuesdays, Green is summer, Red is all other beam off runs.

All Beam Off Runs - Mean Instrumental Asymmetry



X-axes are all the same.

Y-axes are all **different**

Averaging Method

$$\bar{x} = \frac{\sum_i x_i / \sigma_i^2}{\sum_i \frac{1}{\sigma_i^2}} \quad (2)$$

$$\sigma_{\bar{x}} = \sqrt{\frac{1}{\sum_i \frac{1}{\sigma_i^2}}} \quad (3)$$

where $\bar{x}$ is the average of x , and σ the uncertainty in x . The standard error was used as the uncertainty for all values presented here.

For each run the average instrumental asymmetry was calculated per wire with a standard error that will be used as the uncertainty σ in the error weighted average.

Instrumental Asymmetry Error Weighted Average

Runs	Error Weighted Avg. Wire Yield
All Beam Off	$0.0002230 \pm 2 \times 10^{-11}$
Summer All	$0.0002032 \pm 5 \times 10^{-11}$
Summer Day1	$0.0002312 \pm 2 \times 10^{-10}$
Summer Day2	$0.0002123 \pm 9 \times 10^{-11}$
Tuesdays	$0.0002292 \pm 5 \times 10^{-11}$
Other	$0.0002268 \pm 2 \times 10^{-11}$

Runs	Error Weighted Avg. Inst. Asym.
All Beam Off	$-7.07 \times 10^{-11} \pm 3 \times 10^{-11}$
Summer All	$8.39 \times 10^{-11} \pm 8 \times 10^{-11}$
Summer Day1	$-8.28 \times 10^{-11} \pm 3 \times 10^{-10}$
Summer Day2	$2.79 \times 10^{-10} \pm 1.6 \times 10^{-10}$
Tuesdays	$-1.34 \times 10^{-10} \pm 9 \times 10^{-11}$
Other	$-9.40 \times 10^{-11} \pm 4 \times 10^{-11}$

NOTE: There seems to be some error in the relative sizes of these with the Tuesday runs having too large of an asymmetry size, this is currently being investigated.

Kabir's Instrumental Asymmetry Method

Instrumental Asymmetry

$$A_i = \frac{Y_i^\uparrow - Y_i^\downarrow}{Y_i^\uparrow + Y_i^\downarrow} = \frac{(S_i^\uparrow + b_i^\uparrow) - (S_i^\downarrow + b_i^\downarrow)}{(S_i^\uparrow + b_i^\uparrow) + (S_i^\downarrow + b_i^\downarrow)} \approx \frac{S_i^\uparrow - S_i^\downarrow}{S_i^\uparrow + S_i^\downarrow} + \frac{b_i^\uparrow - b_i^\downarrow}{S_i^\uparrow + S_i^\downarrow} \quad (5)$$

where $b_i^{\uparrow\downarrow}$ is the contribution from pedestal.

$$A_{inst}^i = \frac{1}{G_i} \frac{b_i^\uparrow - b_i^\downarrow}{2S_i} \quad (6)$$

$$A_{inst} = \frac{\sum_i w_i A_{inst}^i}{\sum_i w_i} \quad (7)$$

$$(\delta A_{inst})^2 = \frac{\sum_i w_i^2 (\delta A_{inst}^i)^2}{(\sum_i w_i)^2} \quad (8)$$

where,

$$w_i = \delta^{-2} A_{phy}^i \quad (9)$$

From meeting on 2017/04/28, Systematics 7, by Kabir.

Note: Geometry factors and averages signals are used for Kabir's asymmetries, and most of those values are less than 1.

Instrumental Asymmetry: Tuesday runs vs Summer runs vs all runs

Summer runs (Total 677 runs):

$$A_{inst} = (13.12 \pm 1.14) \times 10^{-9}. \quad (11)$$

Tuesday runs (Total 620 runs):

$$A_{inst} = (6.918 \pm 1.15) \times 10^{-9}. \quad (12)$$

All runs (Total 4383 runs):

$$A_{inst} = (3.14 \pm 0.60) \times 10^{-9}. \quad (13)$$

From meeting on 2017/05/12, Systematics 9, by Kabir.

Prior version of the presentation had incorrect run counts from old version of the presentation.

Kabir also restricted most of his analysis to the first 126 chamber wires.

Analysis Results

- ▶ I need to incorporate the average wire signal and geometry factors into my analysis.
 - ▶ Those values were found between yesterday and this morning are ready to be incorporated in the the averages.
- ▶ The summer runs, and some additional runs in the next few days have large asymmetries.
 - ▶ It may be feasible just to cut this range from the instrumental and physics asymmetry calculations
- ▶ The bad run averaging will be checked against histograms of the data to try to find where the error is coming in.