Beam On Physics Asymmetry

What was done:

- **Up-Down physics asymmetry analysis for four different ways to form the asymmetry**

  From Kabir's thesis:

  - **Single wire asymmetry (normalized by chamber integral yield):**

$$A_k^n = \frac{\mathcal{Y}_k^{\uparrow} - \mathcal{Y}_k^{\downarrow}}{\mathcal{Y}_k^{\uparrow} + \mathcal{Y}_k^{\downarrow}},$$

$$= PG_k A_p$$

$$\mathcal{Y}_k^{\uparrow} = \frac{Y_k^{\uparrow} - b_k}{I^{\uparrow}}, \qquad I^{\uparrow} = \sum_k (Y_k^{\uparrow} - b_k),$$

$$\mathcal{Y}_k^{\downarrow} = \frac{Y_k^{\downarrow} - b_k}{I^{\downarrow}}, \qquad I^{\downarrow} = \sum_k (Y_k^{\downarrow} - b_k).$$

  - **Wire pair asymmetry (1)**

$$A_{kk^*}^r = \frac{R_{kk^*}^{\uparrow} - R_{kk^*}^{\downarrow}}{R_{kk^*}^{\uparrow} + R_{kk^*}^{\downarrow}}$$

$$= \frac{4PG_k A_p}{2 + 2(PG_k A_p)^2}$$

$$R_{kk^*}^{\uparrow} = \frac{y_k^{\uparrow}}{y_{k^*}^{\uparrow}} \text{ and } R_{kk^*}^{\downarrow} = \frac{y_k^{\downarrow}}{y_{k^*}^{\downarrow}},$$

$$y_k^{\uparrow} = Y_k^{\uparrow} - b_k \qquad y_k^{\downarrow} = Y_k^{\downarrow} - b_k$$

Beam On Physics Asymmetry

What was done:

- **Up-Down physics asymmetry analysis for four different ways to form the asymmetry**

  From Kabir's thesis:

  - **Wire pair asymmetry (2)**

$$A_k - A_{k^*} = \frac{y_k^{\uparrow} - y_k^{\downarrow}}{y_k^{\uparrow} + y_k^{\downarrow}} - \frac{y_{k^*}^{\uparrow} - y_{k^*}^{\downarrow}}{y_{k^*}^{\uparrow} + y_{k^*}^{\downarrow}} \qquad y_k^{\uparrow} = Y_k^{\uparrow} - b_k \qquad y_k^{\downarrow} = Y_k^{\downarrow} - b_k$$

$$\approx PG_k A_p + \frac{I_0^{\uparrow} - I_0^{\downarrow}}{I_0^{\uparrow} + I_0^{\downarrow}} - \frac{I_0^{\uparrow} - I_0^{\downarrow}}{I_0^{\uparrow} + I_0^{\downarrow}} + PG_k A_p \quad \approx 2PG_k A_p.$$

  - **Wire pair / beam asymmetry (3)**

$$A_k + A_{k^*} \approx 2\frac{I_0^{\uparrow} - I_0^{\downarrow}}{I_0^{\uparrow} - I_0^{\downarrow}}$$

Beam On Physics Asymmetry

What was done:

- Single asymmetries were calculated from pulse pairs (quartet and null to follow later)
- Asymmetries were grouped by batches (same as in Kabir's thesis) and calculated from error weighted averages / separated into complete 600 pulse sequences with spin up or down as starting pulse.
- Same cuts as implemented by Kabir were used (1 before and 19 after a dropped pulse)
- Beam fluctuation cut was implemented based on monitor data (> +- 1% variation between pulses in a pair)
- Wire/pair asymmetries were combined with error weighted averages, taking correlations into account.
- Separate asymmetries were obtained for 600 pulse sequence starting spin up and down, as well as the combined asymmetry.

Beam On Physics Asymmetry

$$A_{UD}^{SW} = 10 \pm 8 \text{ ppb}$$

$$A_{UD}^{WP,1} = 11 \pm 9 \text{ ppb}$$

$$A_{UD}^{WP,2} = 11 \pm 9 \text{ ppb}$$

$$A_{Beam}^{WP,2} = -101 \pm 20 \text{ ppb}$$

Kabir's Result:

$$A_{\mathrm{UD}} = (0.9528 \pm 0.9527) \times 10^{-8}$$

Program output:

Final Single Wire Asymmetry = 0.0989248 +- 0.0768935
swght = 125.353
Final Wire Pair Asymmetry = 0.111824 +- 0.0910967
swght = 125.353
Final Wire Pair Asymmetry 2 = 0.111824 +- 0.0910967
swght = 77.334
Final Wire Beam Asymmetry = -1.0105 +- 0.197509
Final Single Wire Asymmetry (pseq. spin -1) = 0.117238 +- 0.108775
Final Single Wire Asymmetry (pseq. spin 1) = 0.0806264 +- 0.108712
Final Wire Pair Asymmetry (pseq. spin -1) = 0.154746 +- 0.123973
Final Wire Pair Asymmetry (pseq. spin 1) = 0.0524535 +- 0.1239
Final Wire Pair Asymmetry 2 (pseq. spin -1) = 0.154745 +- 0.123973
Final Wire Pair Asymmetry 2 (pseq. spin 1) = 0.0524552 +- 0.1239
Final Wire Beam Asymmetry (pseq. spin -1) = -0.421591 +- 0.187672
Final Wire Beam Asymmetry (pseq. spin 1) = -1.42804 +- 0.187362

Beam On Physics Asymmetry

$$A_{LR}^{SW} = -363 \pm 40 \text{ ppb}$$

$$A_{UD}^{WP,1} = -393 \pm 50 \text{ ppb}$$

$$A_{UD}^{WP,2} = -393 \pm 50 \text{ ppb}$$

$$A_{Beam}^{WP,2} = -158 \pm 103 \text{ ppb}$$

Kabir's Result:

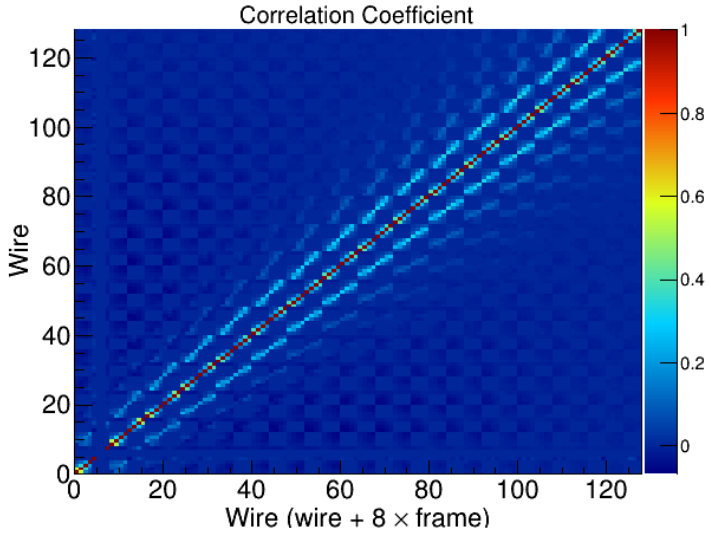
$$A_{\mathrm{LR}} = (-4.12 \pm 0.52) \times 10^{-7}.$$

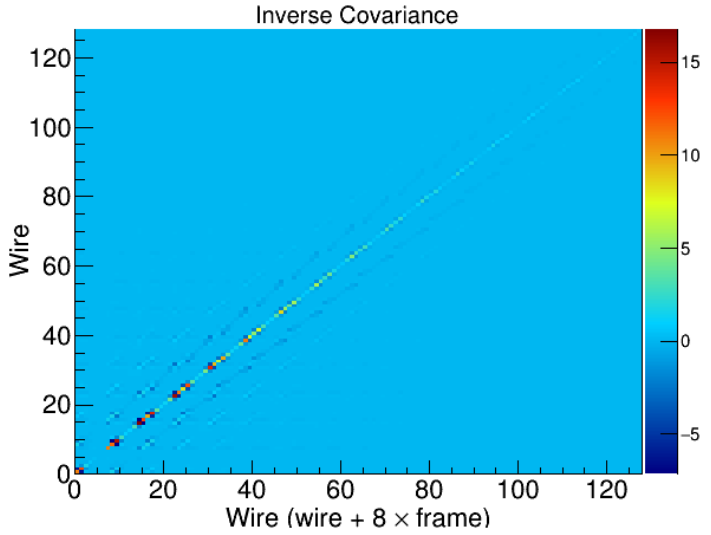
Program Output:

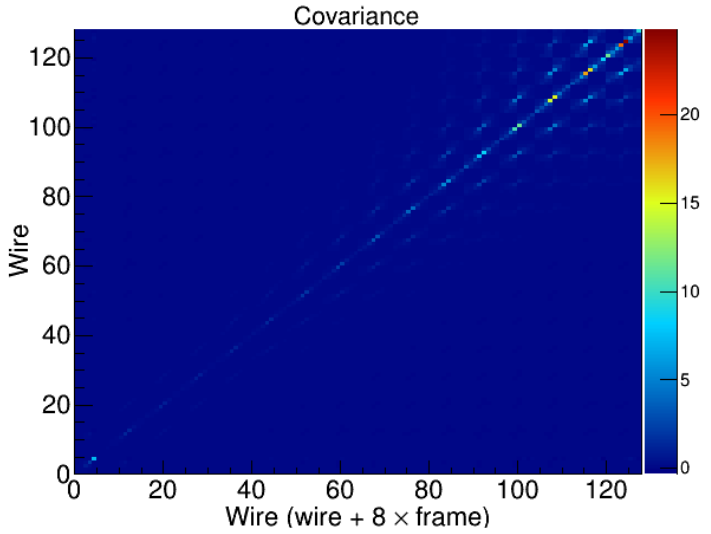
Final Single Wire Asymmetry = -3.63355 +- 0.421451
swght = 4.0399
Final Wire Pair Asymmetry = -3.93433 +- 0.507592
swght = 4.0399
Final Wire Pair Asymmetry 2 = -3.93433 +- 0.507593
swght = 2.84096
Final Wire Beam Asymmetry = 1.58046 +- 1.03768
Final Single Wire Asymmetry (pseq. spin -1) = -4.9835 +- 0.593782
Final Single Wire Asymmetry (pseq. spin 1) = -2.26422 +- 0.598288
Final Wire Pair Asymmetry (pseq. spin -1) = -4.56257 +- 0.686844
Final Wire Pair Asymmetry (pseq. spin 1) = -2.89759 +- 0.692067
Final Wire Pair Asymmetry 2 (pseq. spin -1) = -4.56258 +- 0.686844
Final Wire Pair Asymmetry 2 (pseq. spin 1) = -2.89758 +- 0.692068
Final Wire Beam Asymmetry (pseq. spin -1) = 8.81618 +- 0.979183
Final Wire Beam Asymmetry (pseq. spin 1) = -6.86157 +- 0.981181

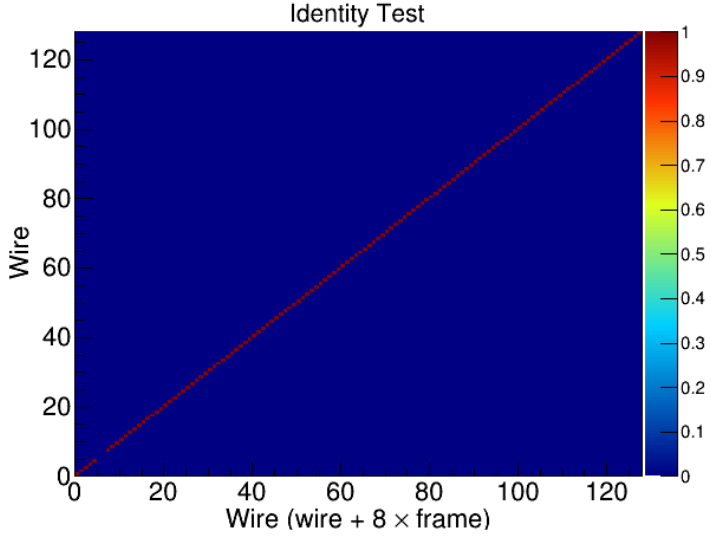
Beam On Physics Asymmetry

Single wire correlation coefficients, covariance and inverse covariance:



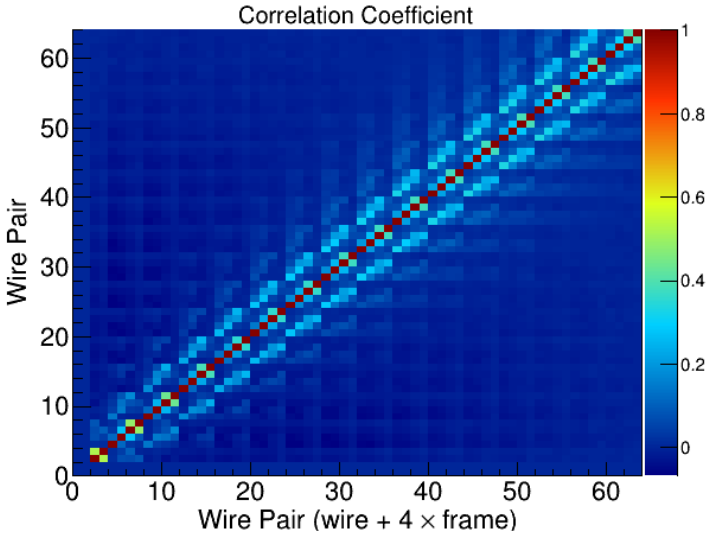


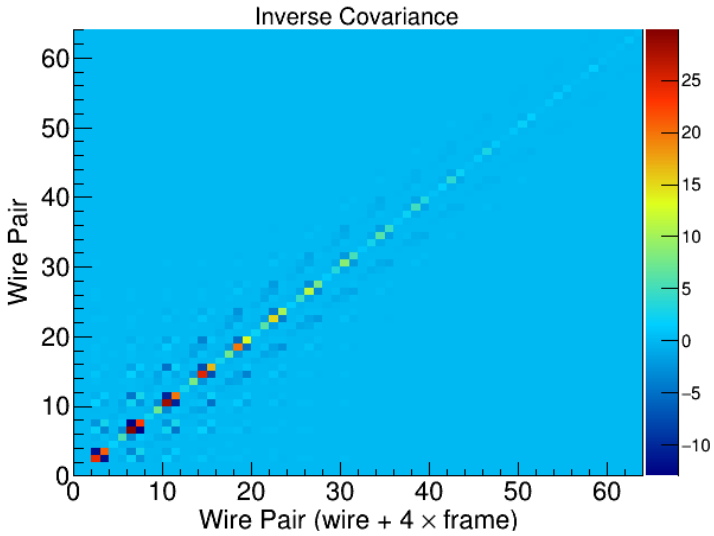


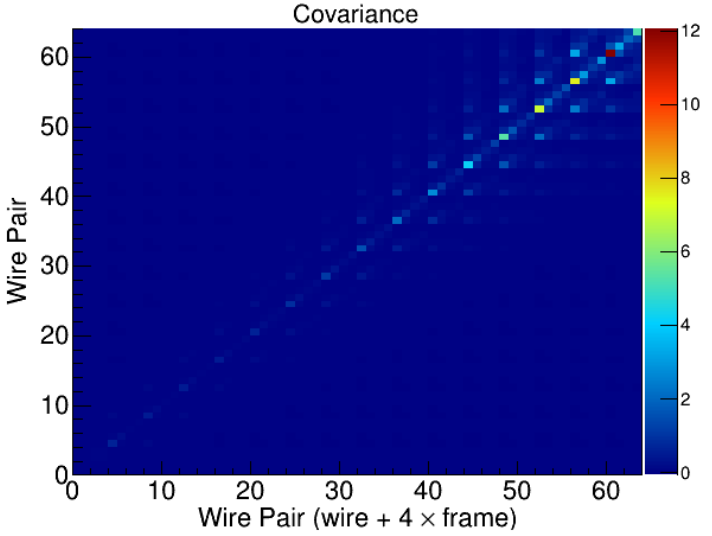


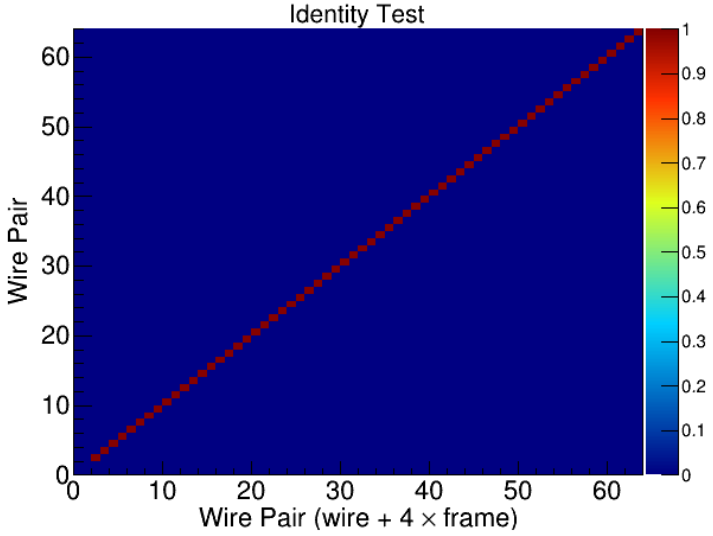
Beam On Physics Asymmetry

Wire pair correlation coefficients, covariance and inverse covariance:



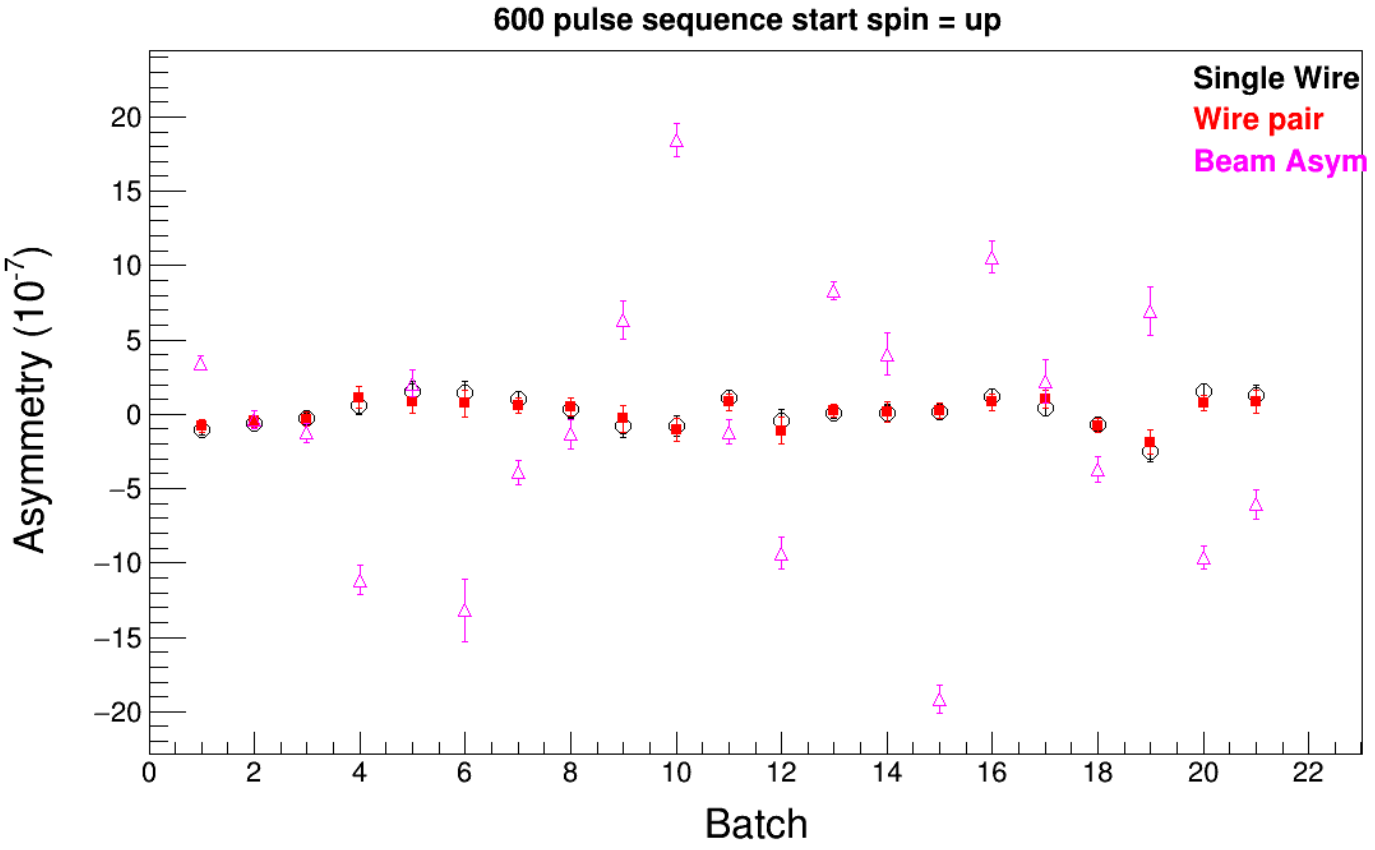






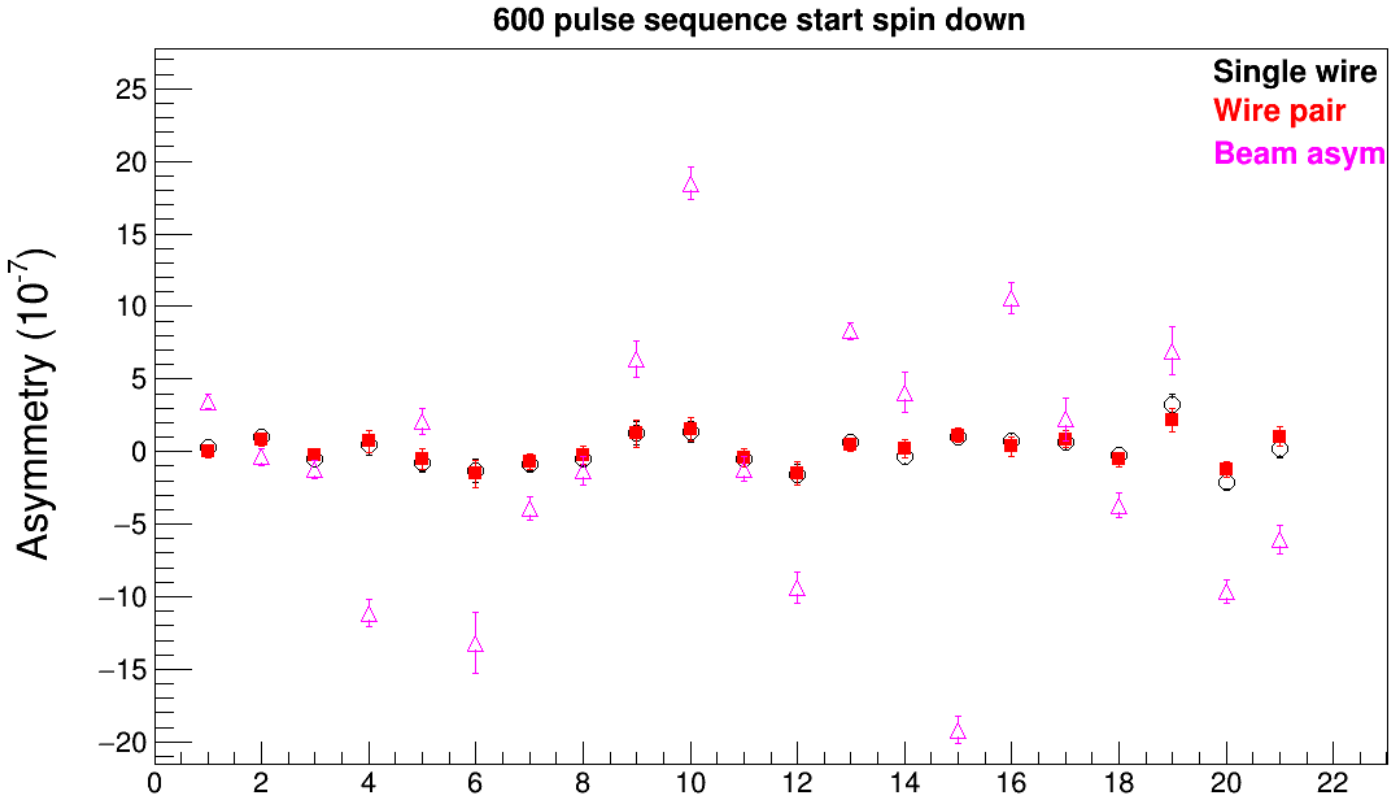
Beam On Physics Asymmetry

UD Asymmetry by batch for starting pulse spin up (zoomed on the UD asymmetrys):



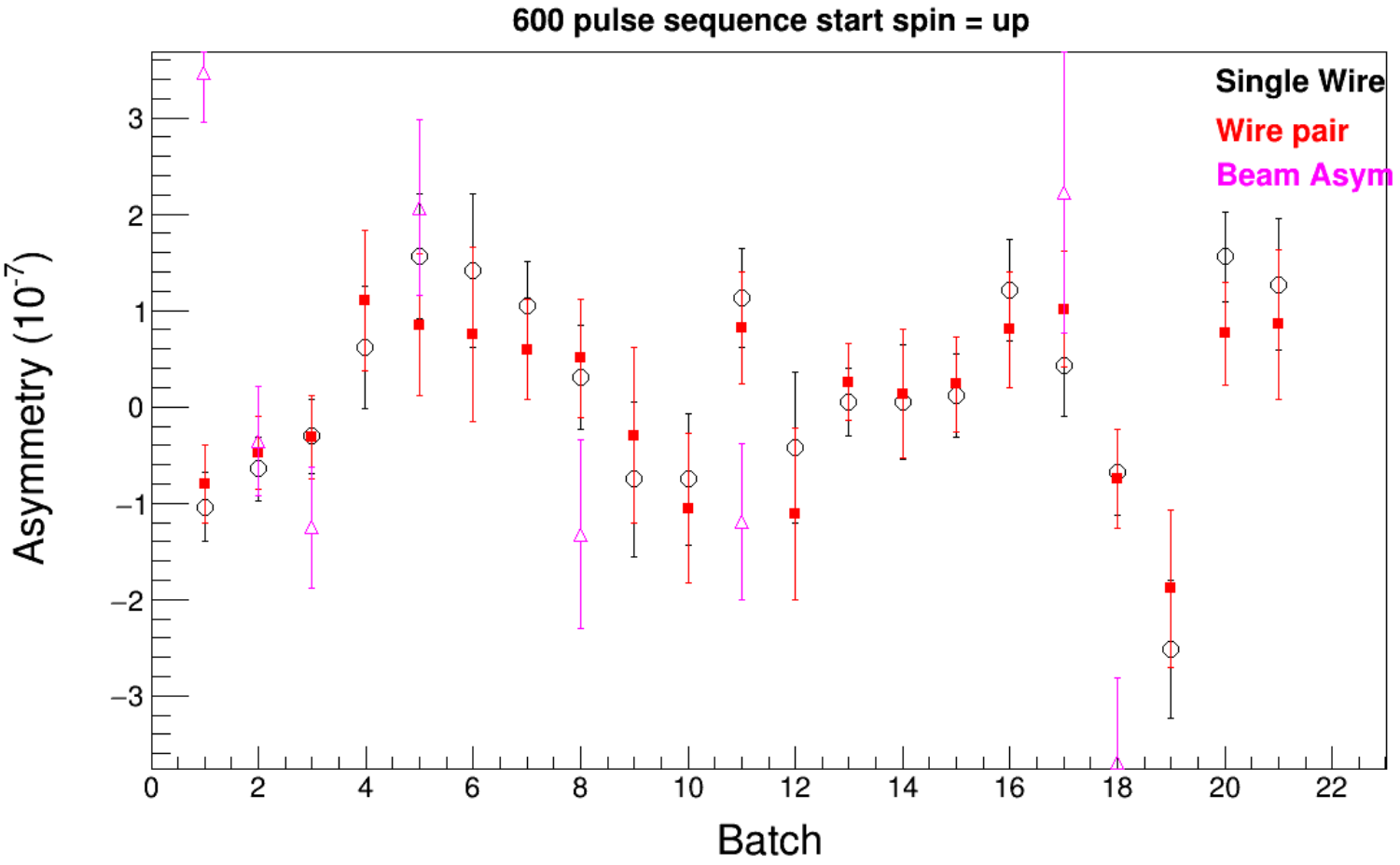
Beam On Physics Asymmetry

UD Asymmetry by batch for starting pulse spin down:



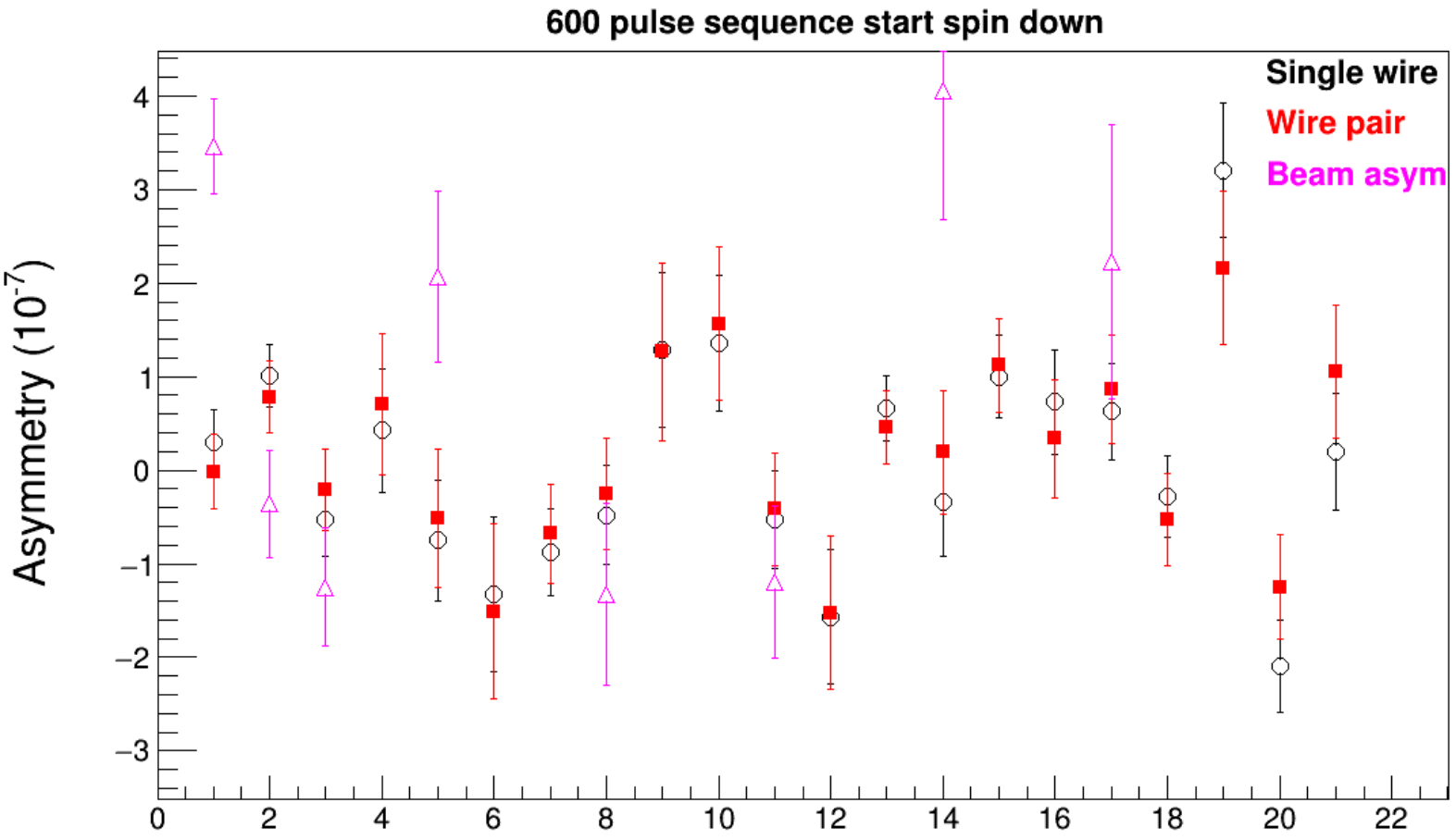
Beam On Physics Asymmetry

UD Asymmetry by batch for starting pulse spin up (zoomed on the UD asymmetrys):



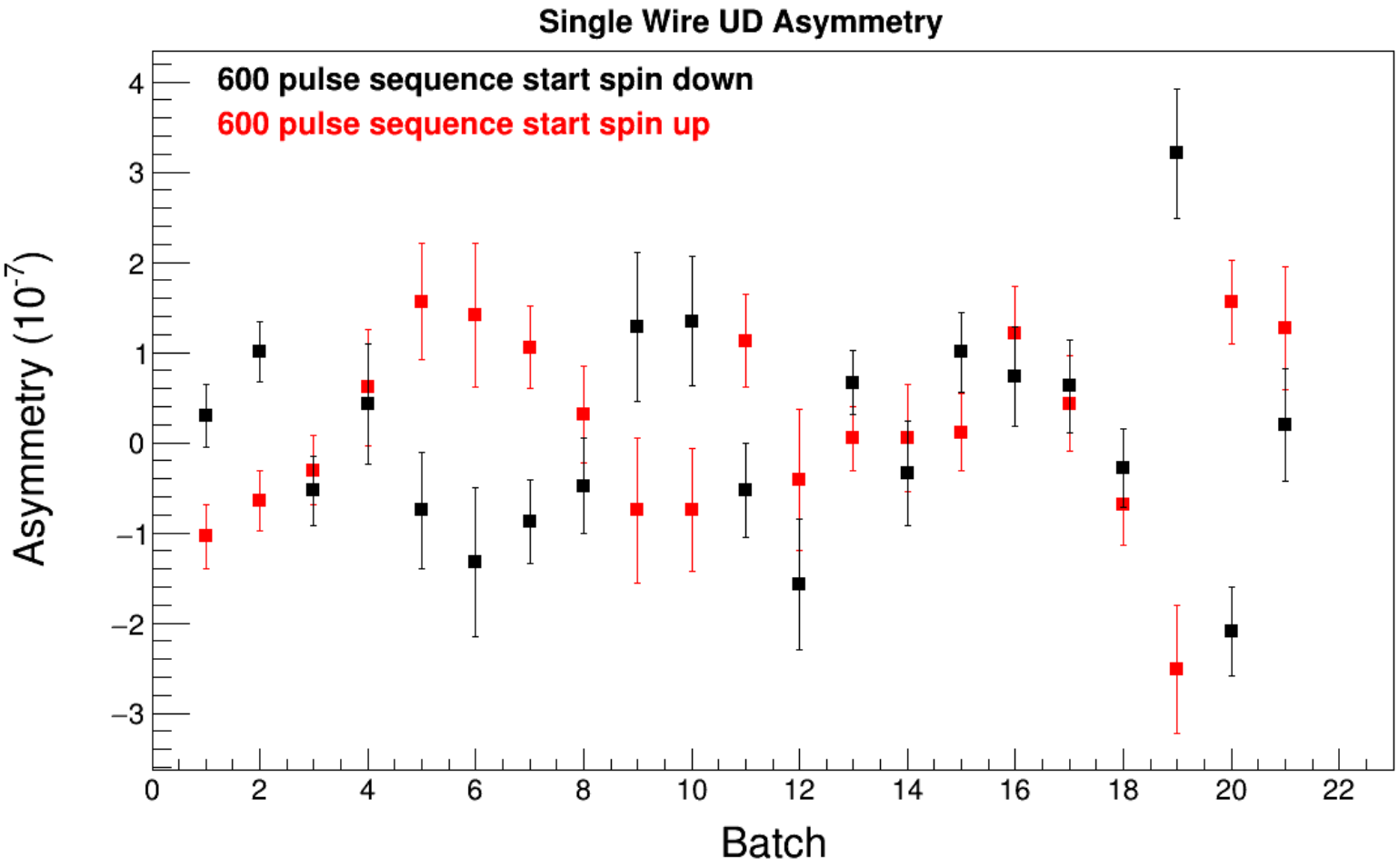
Beam On Physics Asymmetry

UD Asymmetry by batch for starting pulse spin down (zoomed on the UD asymmetrys):



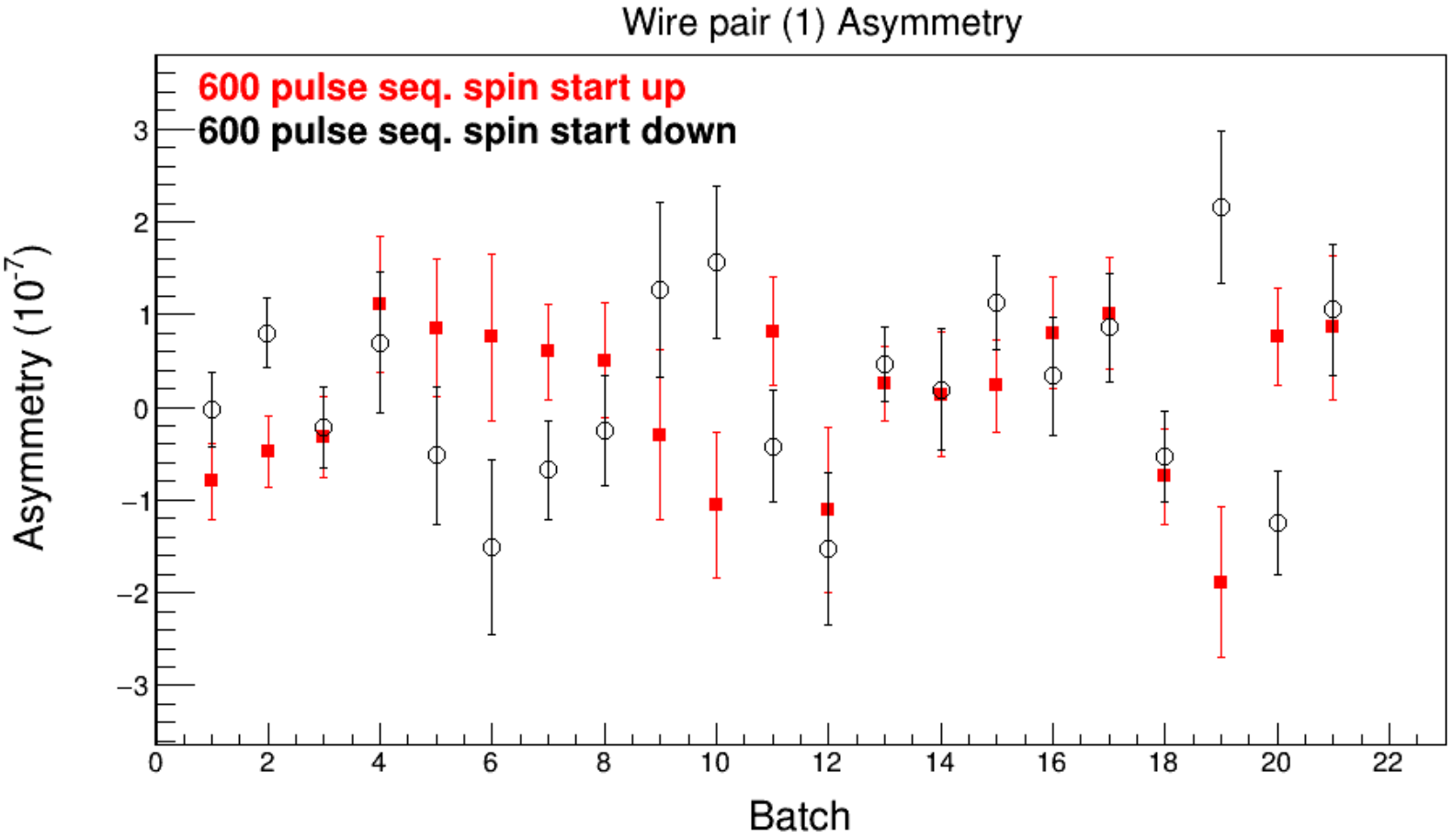
Beam On Physics Asymmetry

UD Asymmetry by batch for both starting spins:



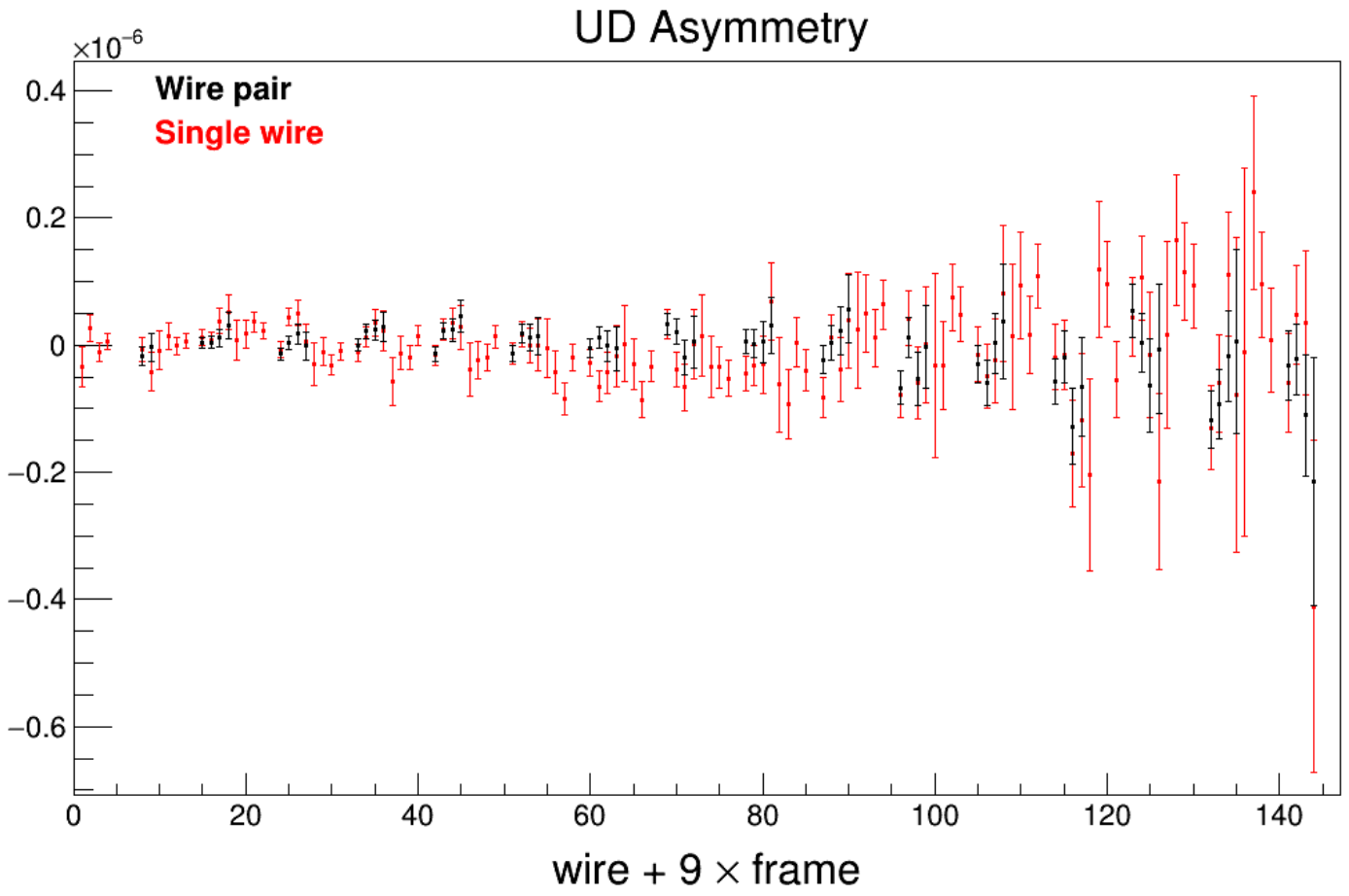
Beam On Physics Asymmetry

UD Asymmetry by batch for both starting spins:



Beam On Physics Asymmetry

UD Asymmetry vs wire for both starting spins:



Beam On Physics Asymmetry

Beam asymmetry vs wire for both starting spins (from wire pair analysis):