Preliminary asymmetry analysis (now with asymmetries!)

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Outline

Continuing from last week (2015-11-23 presentation)

Method, summarized

- From raw data:
  - Compute summaries: mean signal per pulse for all channels
  - Summary size: 19 MB/run
- From summaries:
  - Identify "good" sequences
  - Compute wire differences, sums, asymmetries
  - Combine wire asymmetries by conjugate pairs
  - Compute ratios of signals in conjugate pairs
  - Compute asymmetries of ratios
  - Store mean $\pm$ s.e.m. of each asymmetry
  - Asymmetry size: 40 MB/900 runs
- From run-level asymmetries:
  - Compute error-weighted means of each asymmetry
  - Compute χ^2 for each asymmetry
  - Combine wire/pair asymmetries using geometry factors

New this presentation

- Kabir's parity-conserving runlist
- Asymmetry and χ^2 plots
- Comparisons: physics asymmetry from signal ratios vs. wire differences
- Geometry factors
- Asymmetry over dataset

Ongoing / future

- Wire asymmetries: sensitive to relative phase of spin flipper and accelerator clock?
- Comparisons: beam asymmetry from monitor, center wire, sums of conjugate wires
- Time variation of asymmetry width
- Parity-violating asymmetries

Asymmetry computation: formalism

Definitions and assumptions

Beam current	$I^{\pm}$
Beam polarization	$P^{\pm}$
i-th detector "efficiency"	e_i
Geometric sensitivity	g_i
Physics asymmetry	A

Yield from i-th detector:

$$Y_i^{\pm} = e_i I^{\pm} \left(1 + g_i P^{\pm} A\right)$$

Spin flipper efficiency, detector symmetry are good:

$$P^+ \approx -P^-$$

$$g_i \approx -g_j$$

Possible asymmetries

$$A_{\text{beam}} = \frac{I^+ - I^-}{I^+ + I^-}$$

Wire asymmetry:

$$A_i = \frac{Y_i^+ - Y_i^-}{Y_i^+ + Y_i^-} = \frac{A_{\text{beam}} + g_i PA}{1 + A_{\text{beam}} g_i PA}$$

$$A_i + A_j \approx 2A_{\text{beam}} + (g_i + g_j)PA$$

$$A_i - A_j \approx 2g_i PA(1 - A_{\text{beam}}^2)$$

Ratio of pairs:

$$R_{ij}^+ = Y_i^+ / Y_j^+$$

$$A_{R_{ij}} = \frac{R_{ij}^+ - R_{ij}^-}{R_{ij}^+ + R_{ij}^-} \approx \frac{2g_i PA}{1 + (g_i PA)^2}$$

Non-leading terms are a little iffy.

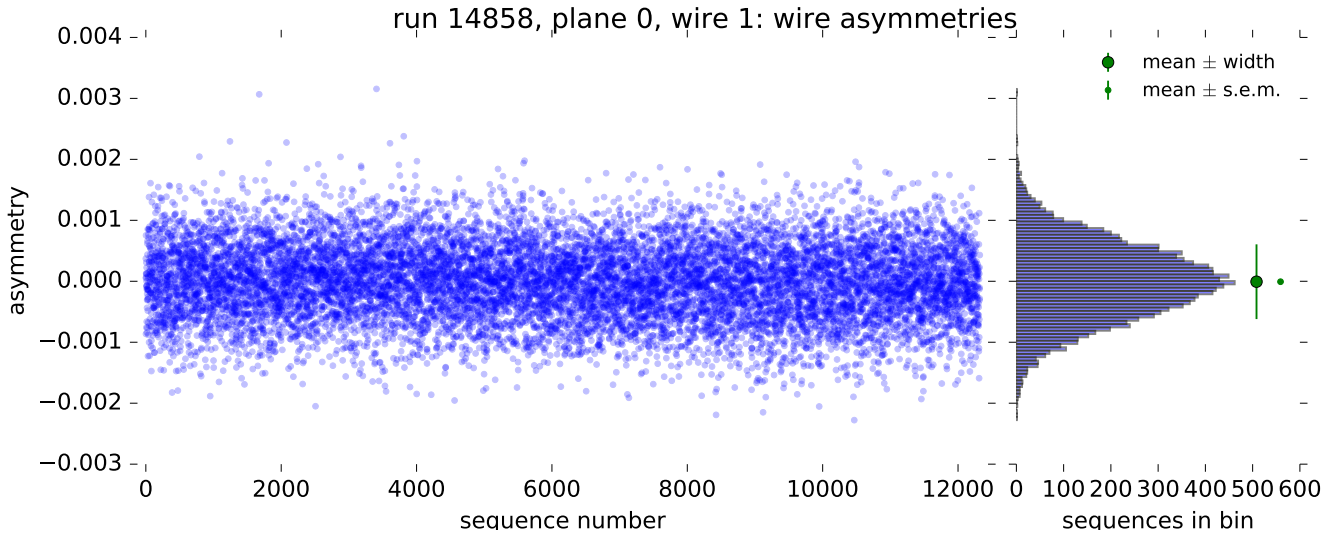
Kabir's list of parity-conserving runs

last updated 2015-11-02: `basestar:/mnt/idata05/summary/runListLR.txt`

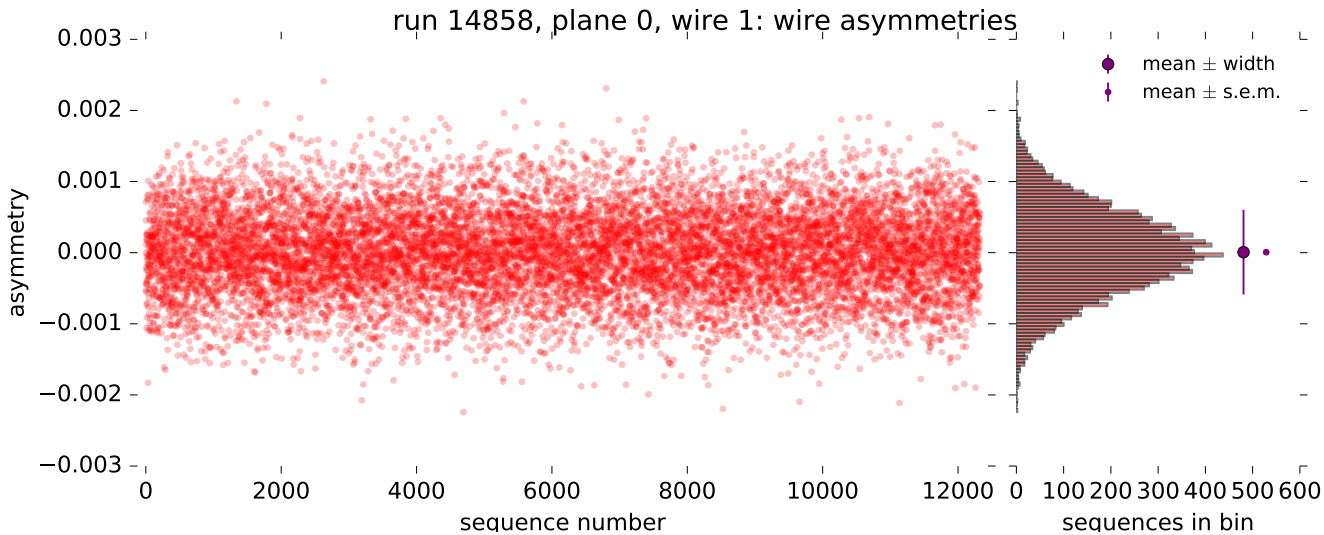
```
How many   Run status
       1   DIFFERENT_NUMBER_OF_ENTRIES
     684   GOOD
     244   HEADER_ISSUE
       1   HI_VOLTAGE_DROPPED
      53   NO_DATA_FILE
      16   PARTIAL_OR_NO_BEAM
       2   SYNC_ISSUE

896 runs from 'datasummary/asym.14785-15784.pkl'
Present in Kabir's list, absent in mine
[14800, 15210, 15273, 15299, 15336, 15420, 15466, 15622, 15785]

This analysis: 675 runs
```

Recall: asymmetries for a single channel

A single-wire asymmetry. $\langle A_{01} \rangle_{14858} = (-7.2 \pm 5.5) \times 10^{-6}$

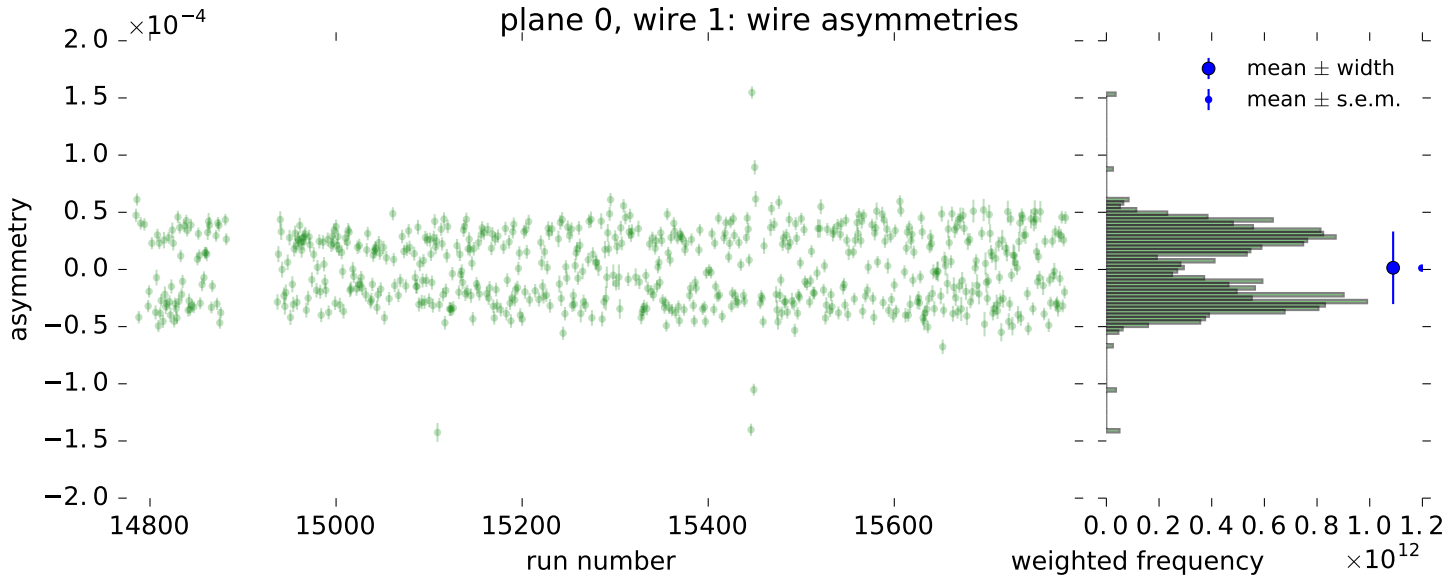


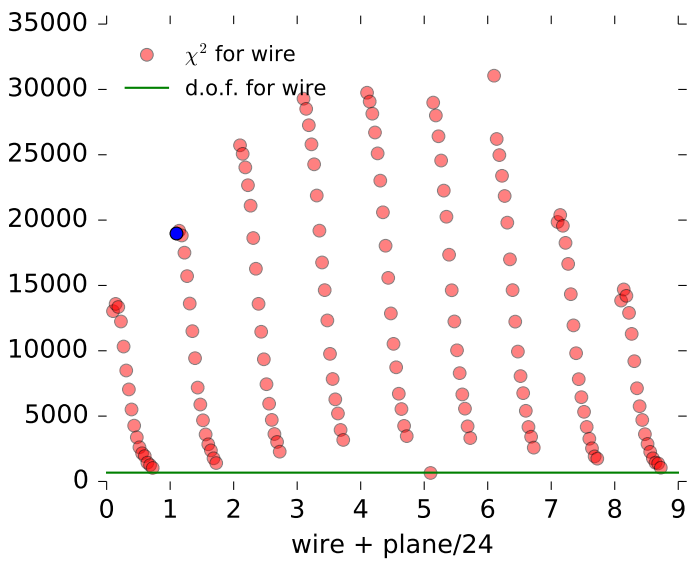
Differences of asymmetries. $\langle A_{01} - A_{07} \rangle_{14858} = (+7.0 \pm 5.4) \times 10^{-6}$

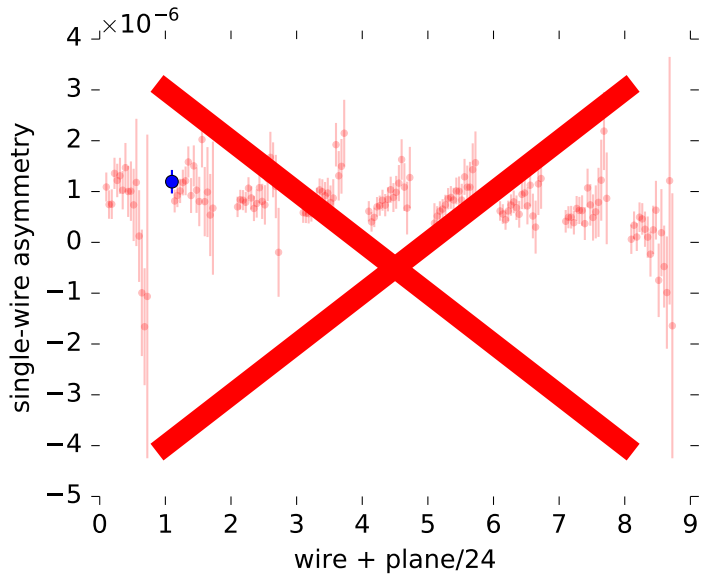


Combined run-level asymmetries: single wire

Single-wire asymmetry looks terrible: $\chi^2/\text{d.o.f.} = 19000/674$

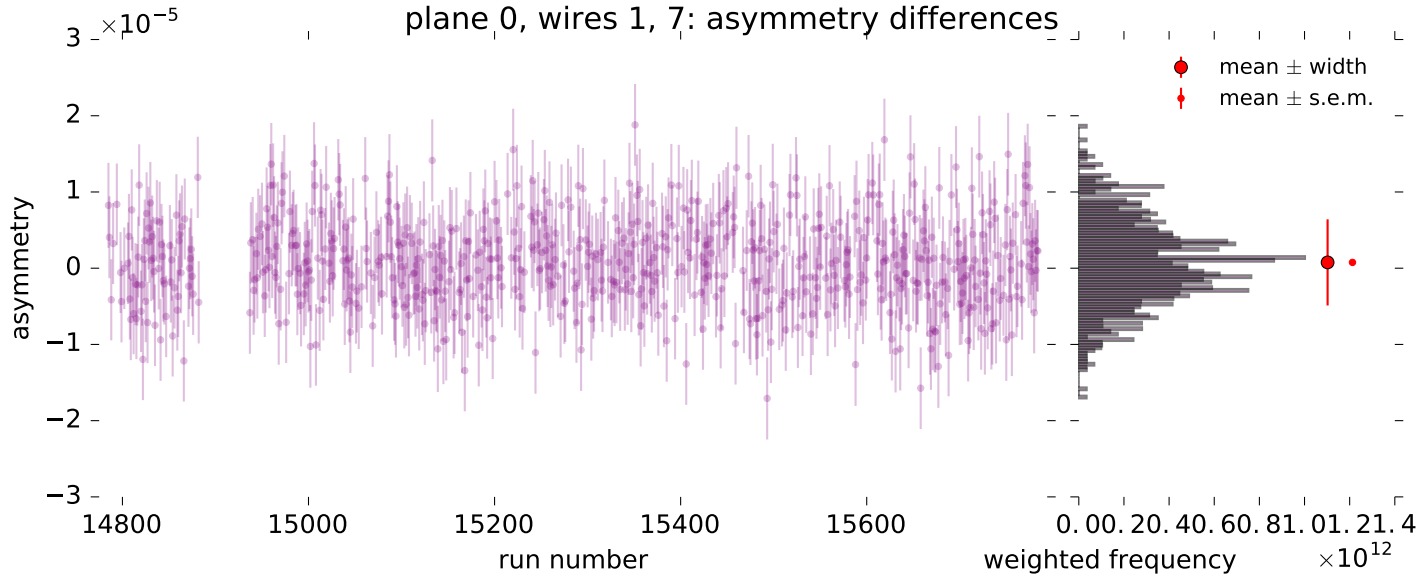






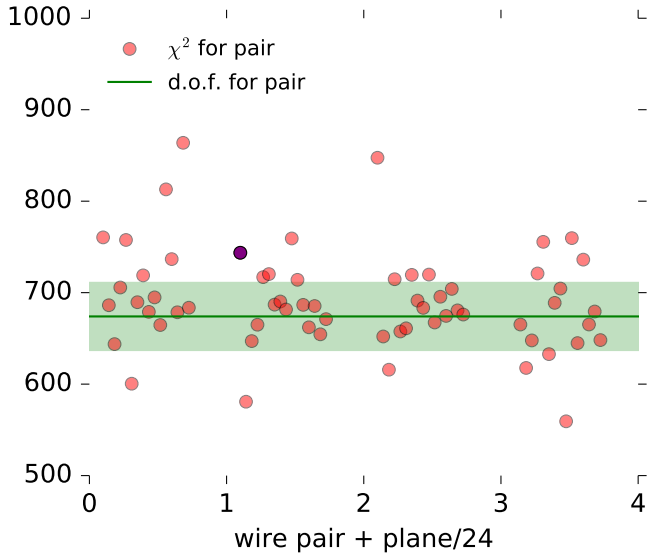
Combined run-level difference and ratio asymmetries look a lot prettier

$$\langle A_{01} - A_{07} \rangle_{\textbf{675 runs}} = (+7.6 \pm 2.1) \times 10^{-7} \qquad \chi^2/\text{d.o.f.} = 745/674$$



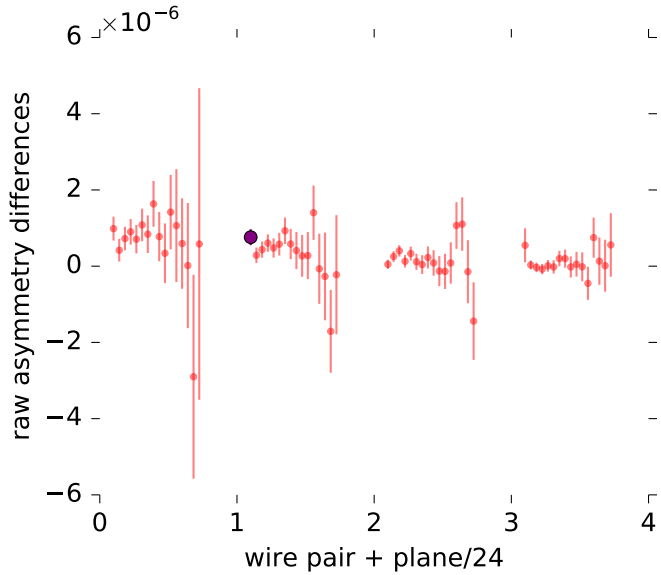
Difference asymmetries

χ^2 distribution looks lovely



- Reminder: χ^2 distribution with ν degrees of freedom has mean value ν, width $\sqrt{2\nu}$.
- Here $\nu = 674$, $\sqrt{2\nu} = 37$.
- Off-scale: plane 0, pair 3 with $\chi^2 = 6400$. Recall wire (0,5) is disconnected.

Asymmetry distribution looks sensible



Note: grouped by wire rather than by plane

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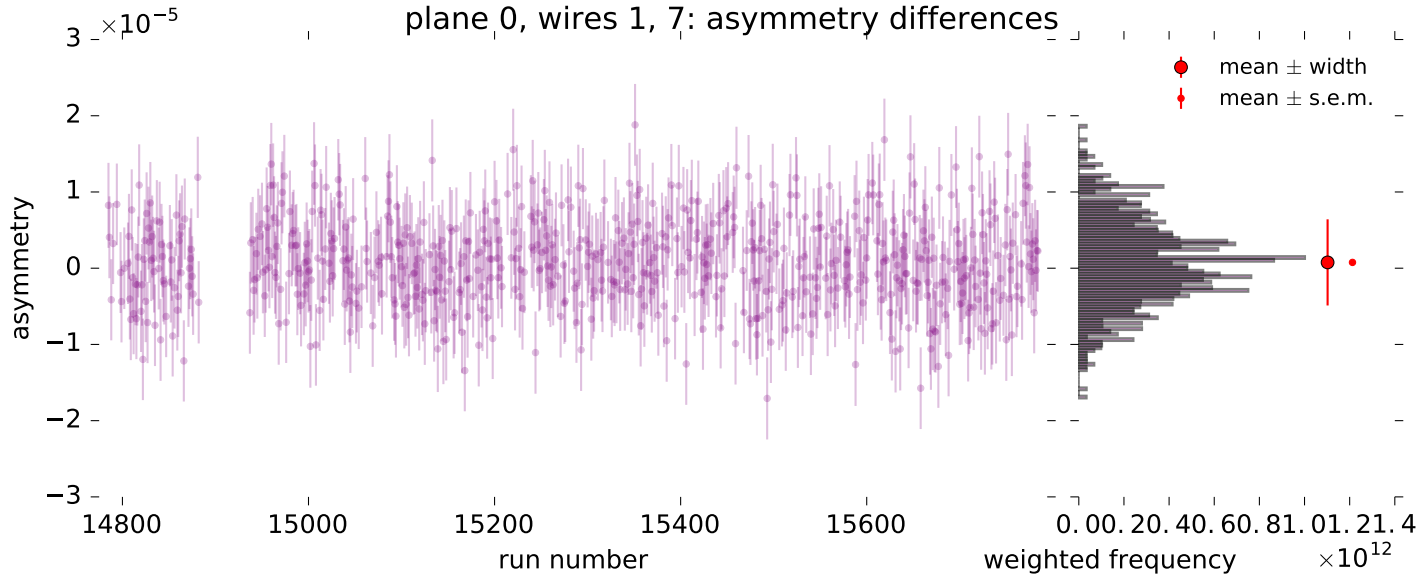
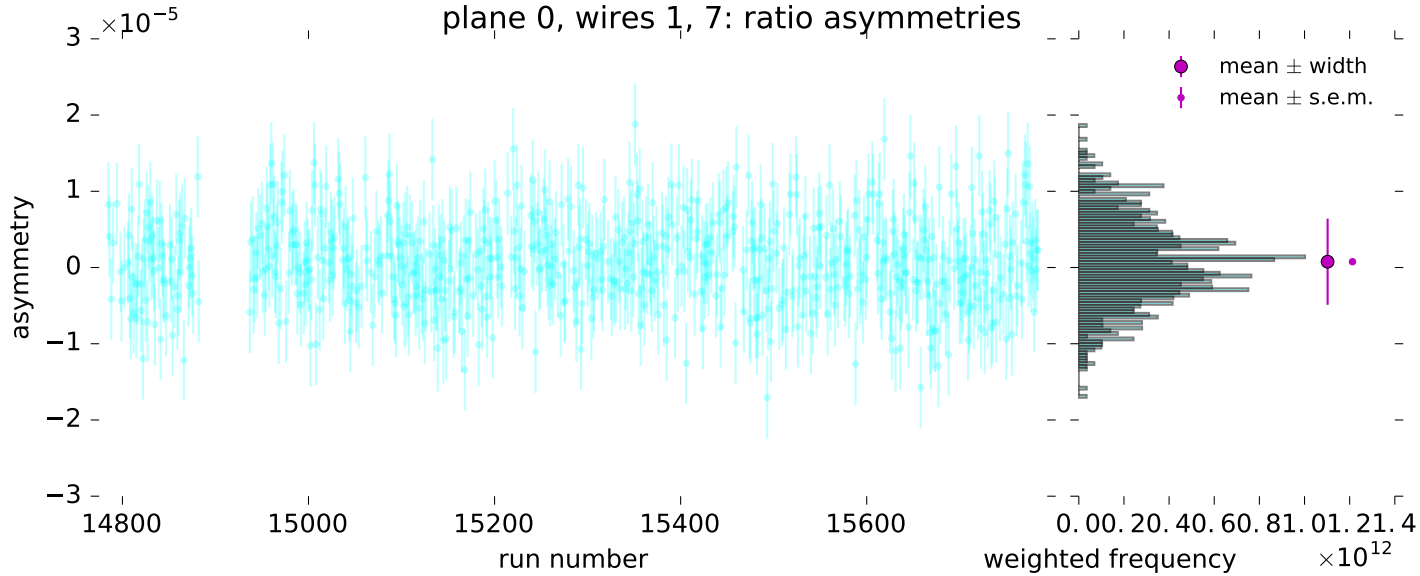
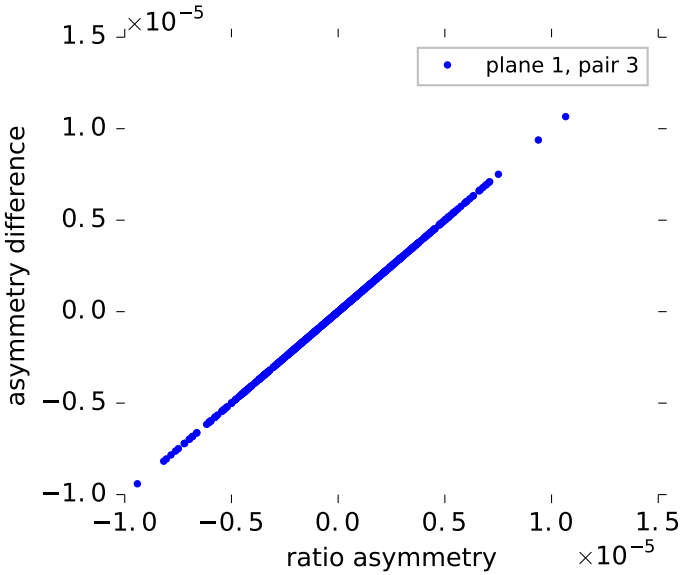
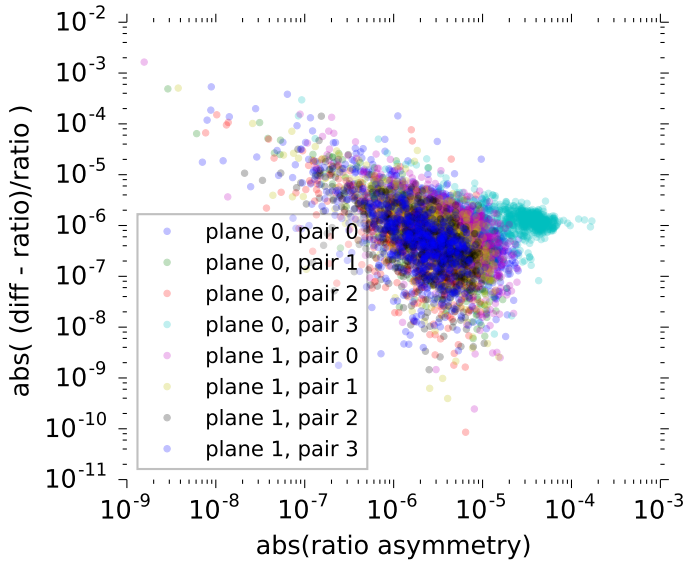




Actually, the asymmetry differences look suspiciously close to the ratio asymmetries . . .

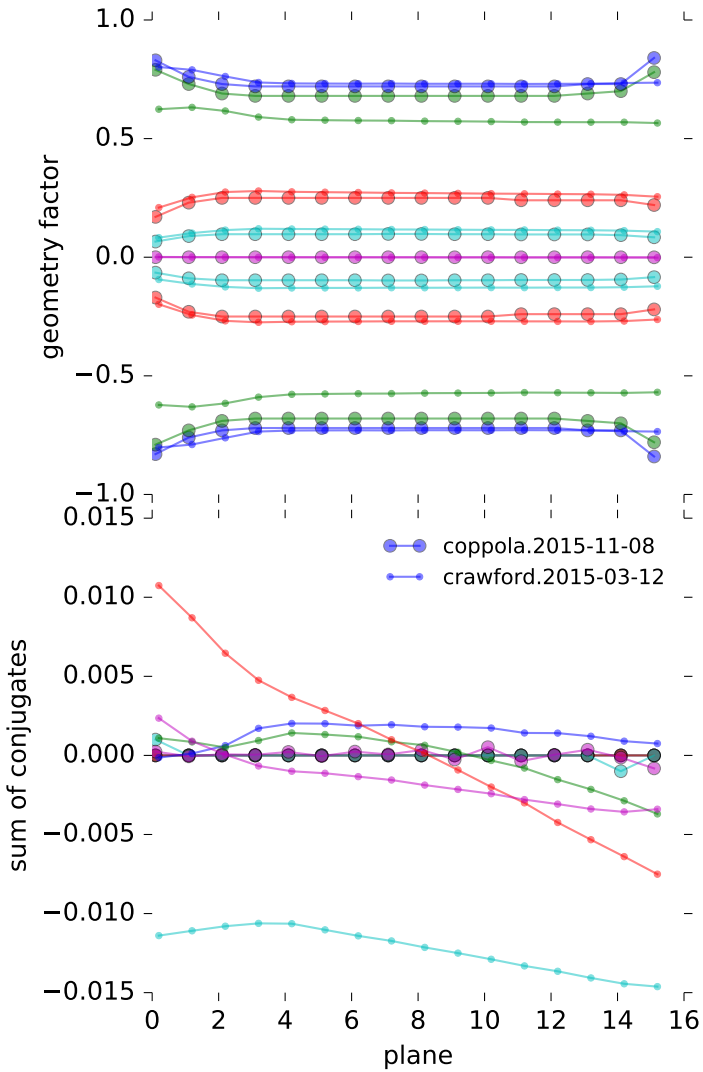
Ratio asymmetries





At run level, difference asymmetries and ratio asymmetries agree to five or more significant figures. So don't separately analyze ratio asymmetries.

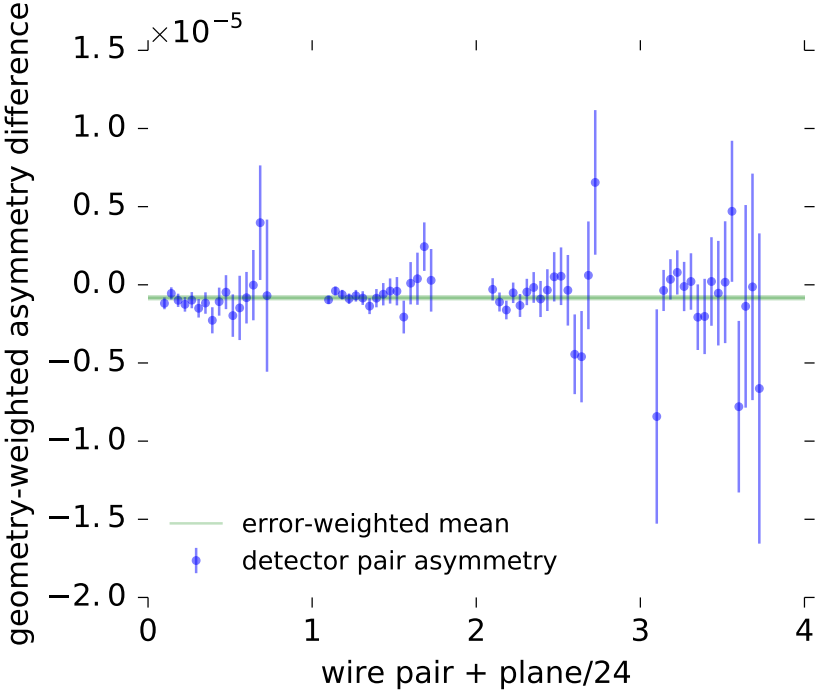
Two sets of geometry factors available



- Crawford 2015-03-12, Coppola 2015-11-08
- Crawford (plausibly) shows differences between geometry factors on conjugate wires
- Coppola shows more symmetry between conjugate wires, but results are presented rounded to nearest 0.001
- Different geometry factors for left-right vs. up-down?
- Choose Coppola while wondering about zero subtraction, alignment of time bins, etc.

Geometry-weighted asymmetry differences

Divide difference asymmetries by Coppola 2015-11-08 geometry factors for wires 0–3.



Geometry-weighed, parity-conserving asymmetry

$$2PA = (-8.3 \pm 0.9) \times 10^{-7}$$

Goodness of fit

$$\chi^2/\text{d.o.f} = 42/63$$

A little *too* good . . . perhaps because wire asymmetries are correlated?

Still not included

- Correction for finite polarization
- Correction for correlations
- ???