Simultaneous Weak Events

a new temporal analysis project

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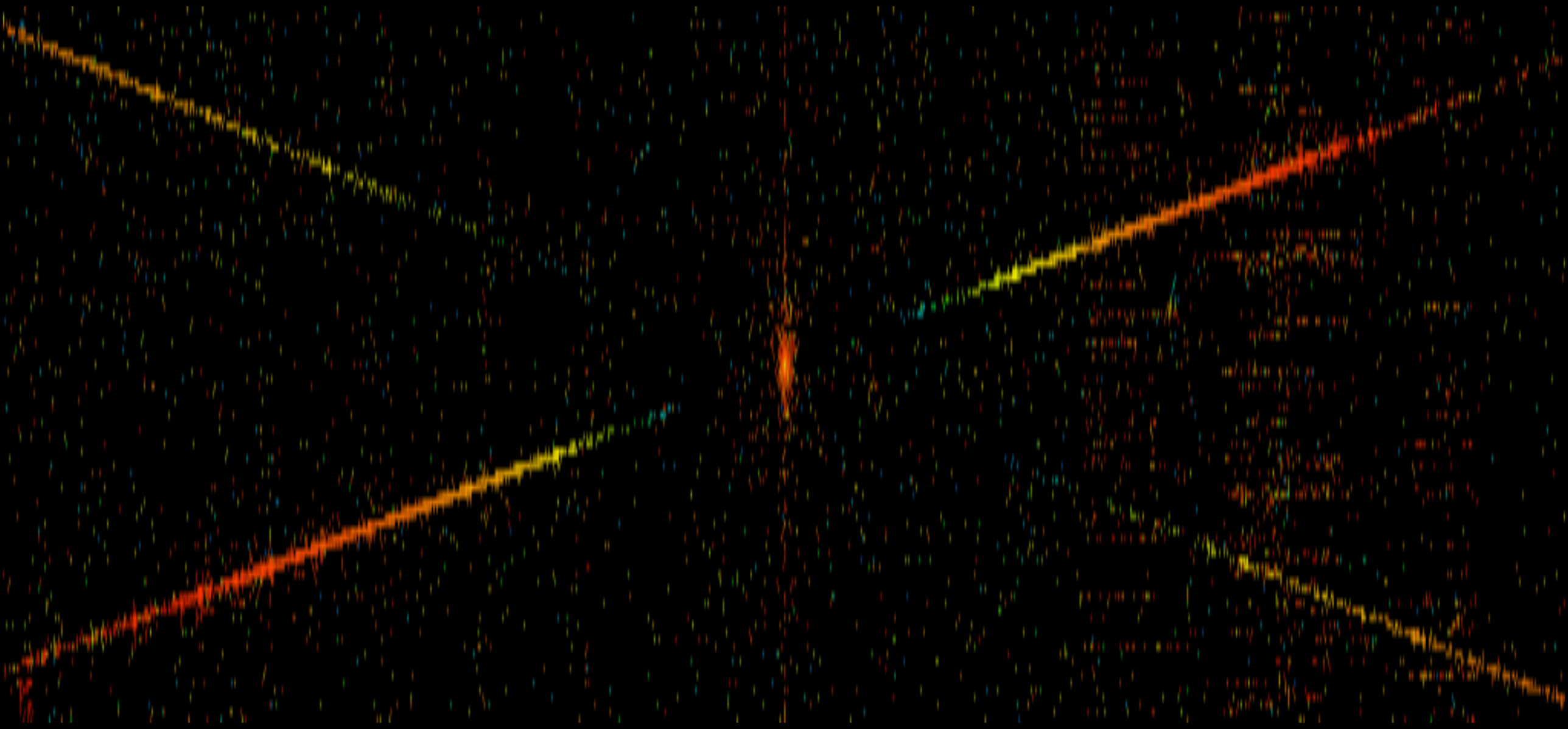
Chandra HETGS+ACIS-S grating dispersed events



AU Mic : ObsID 17 ; HETGS+ACIS-S

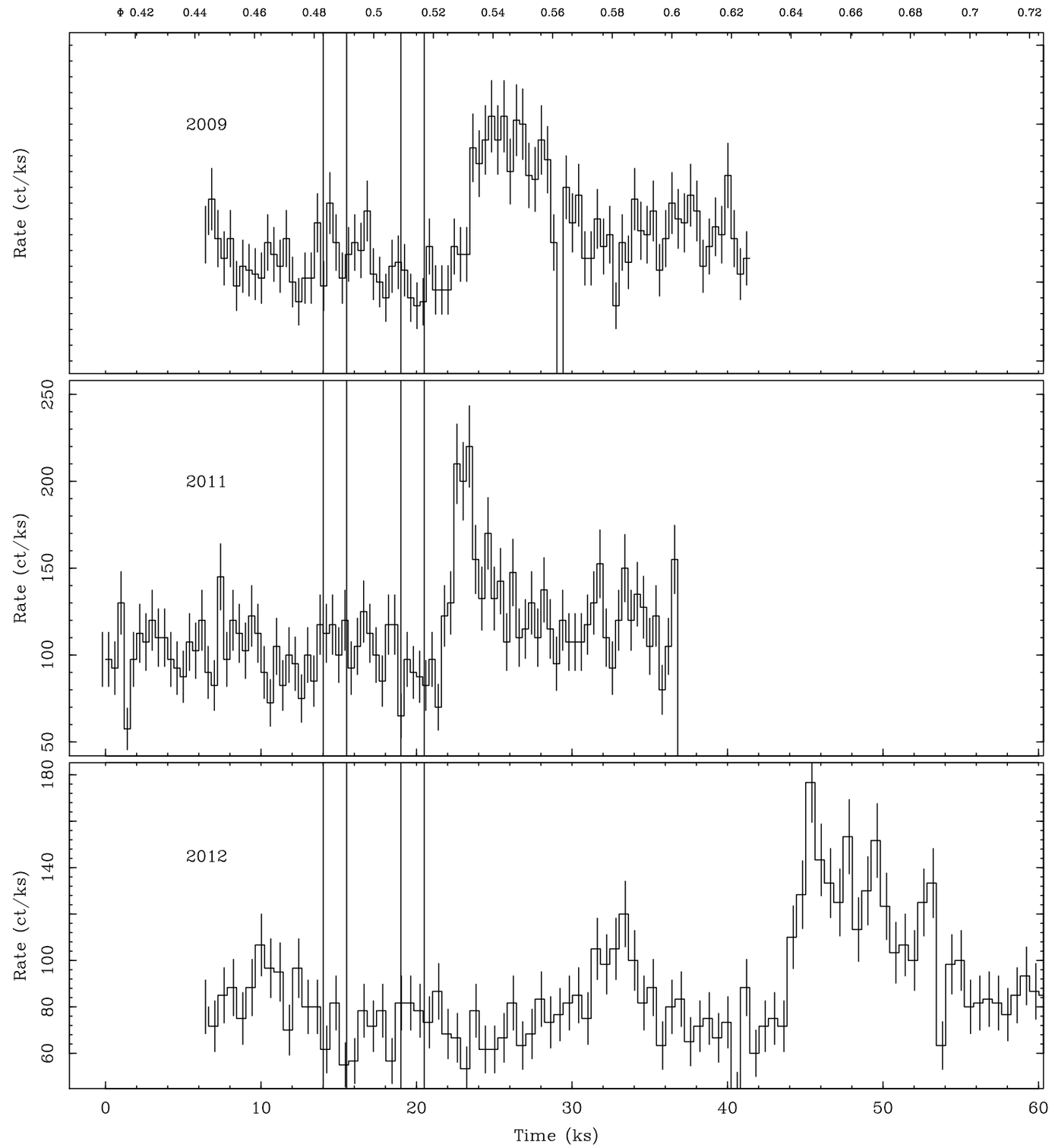
count rate

5
4
3
2
1

10
20
30
40
50
60

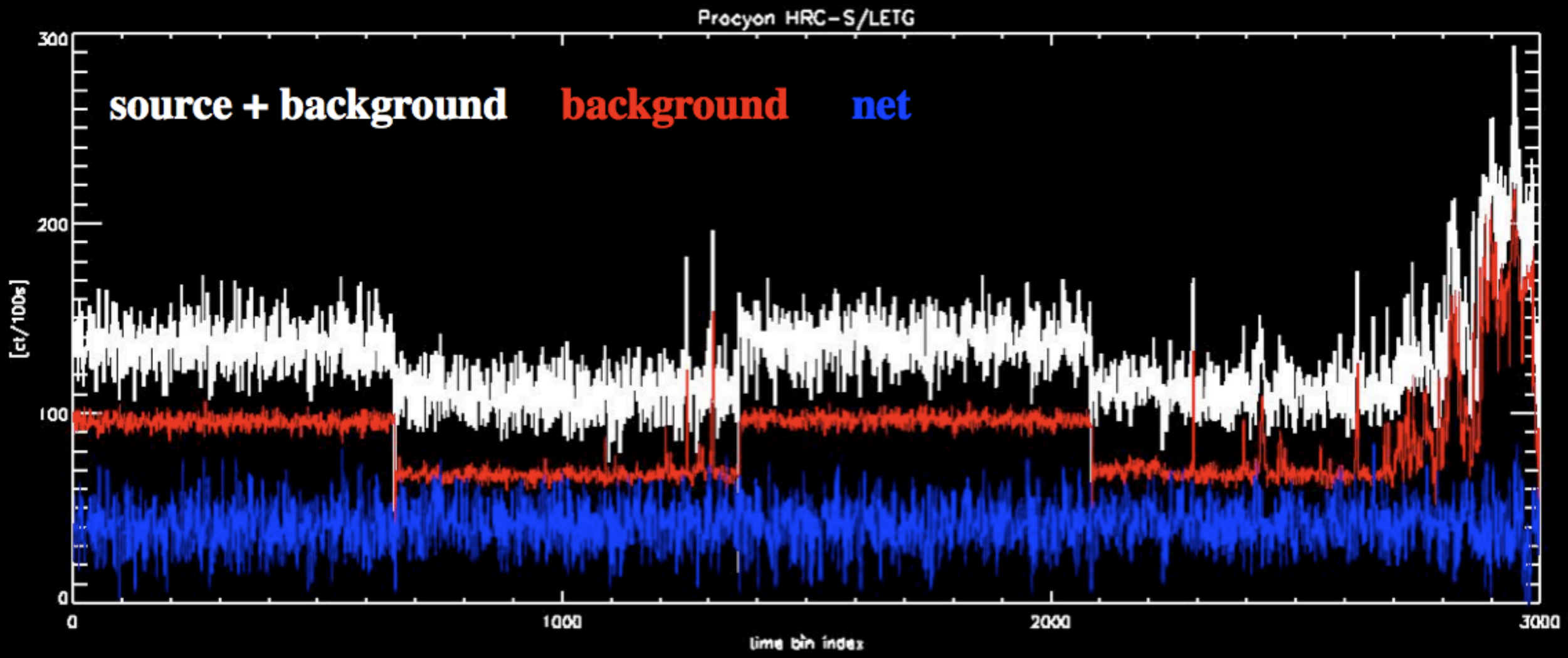
Time +90397.273 [ks]

Flares on HD 189733 that seem to be tied to planetary phase



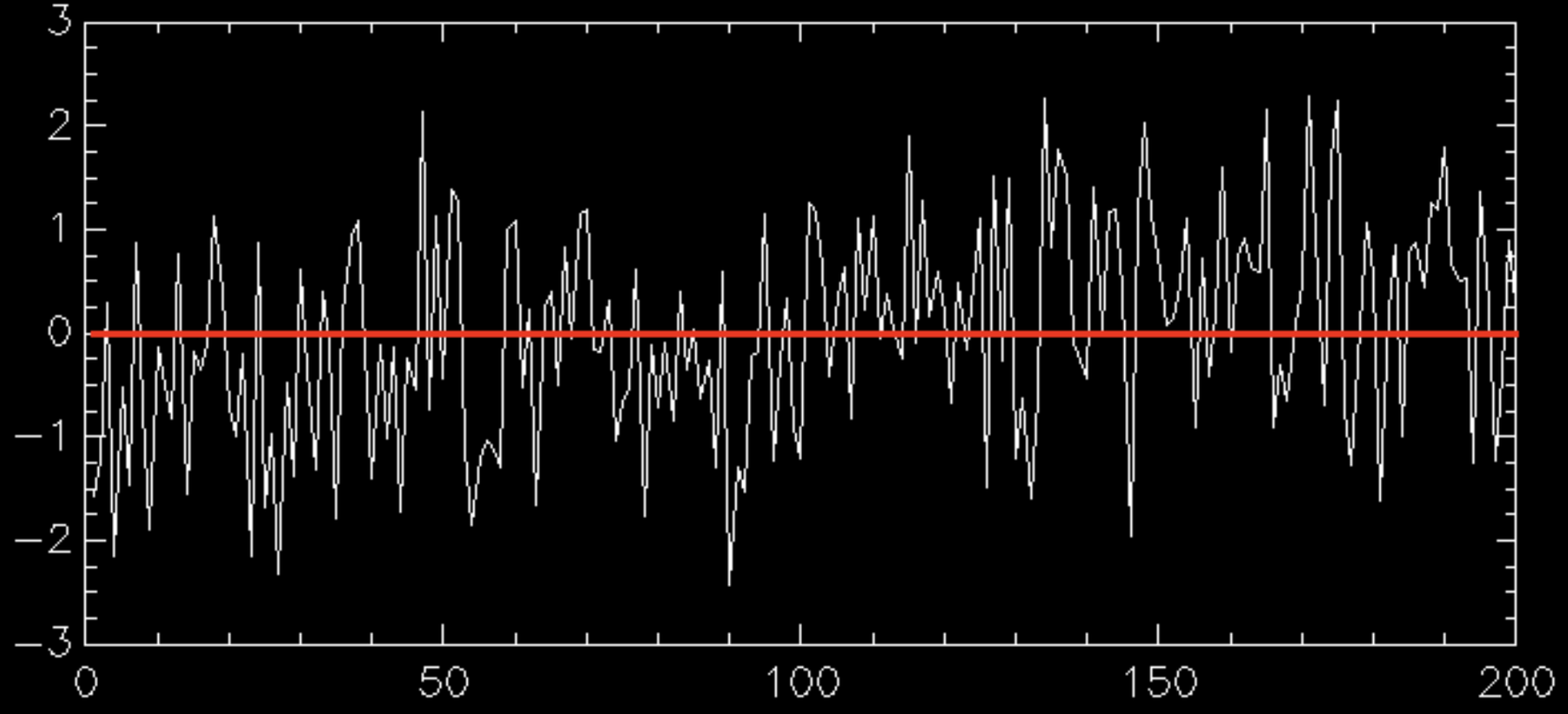
Pillitteri et al. 2012, Cool Stars 17

Procyon : is there any variability?

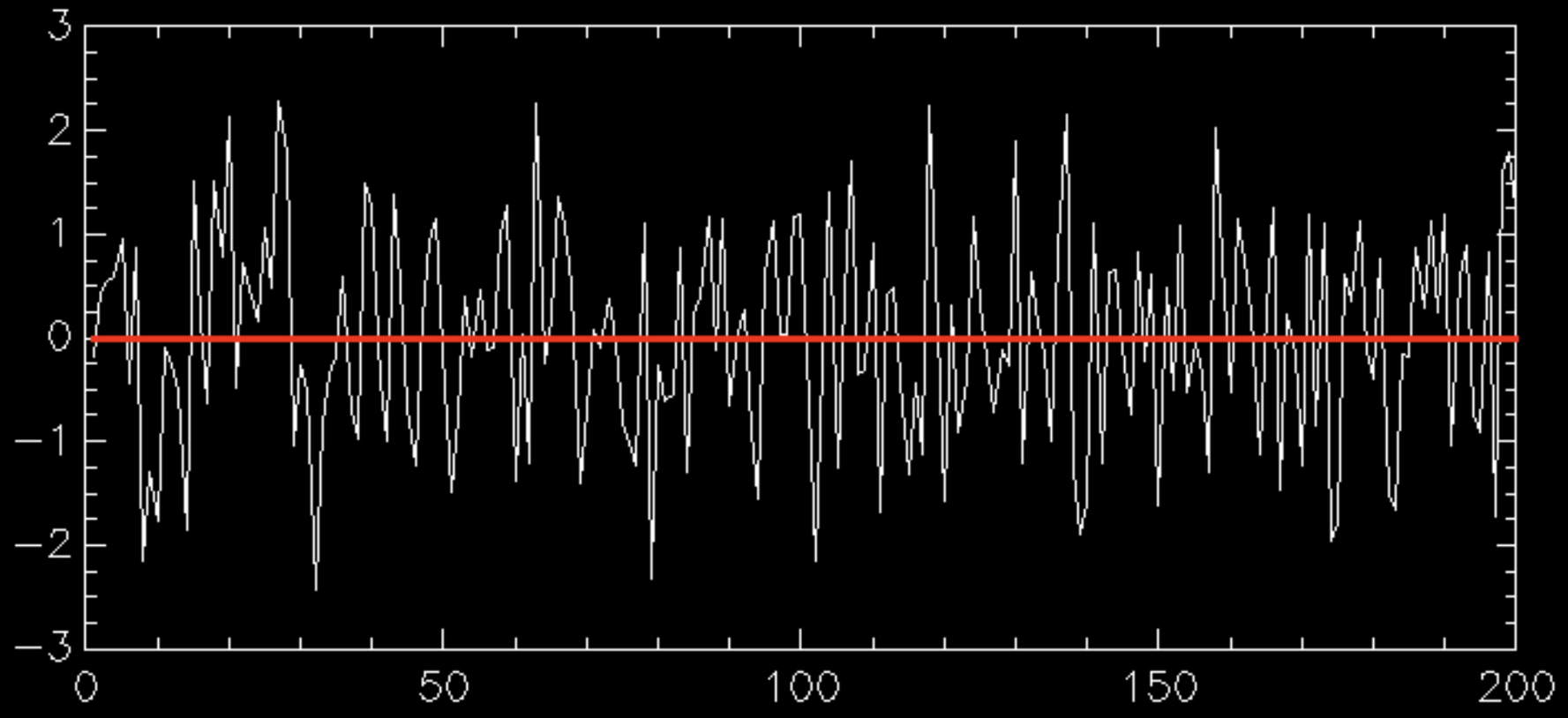


Limitations in current analyses

- Likelihoods are constructed with no regard to data order
  - ignoring auto-regression and ICA/SCA
  - fluctuations in consecutive bins, or groups of like fluctuations require human intervention via residual analysis



χ^2=214.0



Limitations in current analyses

- Likelihoods are constructed with no regard to data order
  - ignoring auto-regression and ICA/SCA
  - fluctuations in consecutive bins, or groups of like fluctuations require human intervention via residual analysis
- Coincidences cannot be evaluated non-parametrically in multiple data streams
  - we are more likely to believe that something is real if a signal is seen simultaneously in independent data streams

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Simulation

- Generate 500 draws from $\mathcal{N}(0,1)$
    - Find all fluctuations at >1,1.5,2,2.5,3 sigma
- Repeat 100 times
    - During each repetition, check how often a similar fluctuation is coincident with original fluctuation
    - Compute average frequency of coincidence
- Repeat 100 times
- Compare coincidence frequency with nominal probability of seeing coadded fluctuations of same sizes

Type I Error:
Fraction of fluctuations that exceed $k\,\sigma$

k	1	1.5	2	2.5	3
$\mathcal{N}(\cdot)$	0.16	0.067	0.022	0.006	0.0013
$< \mathcal{N}(\cdot)\| \mathcal{N}(\cdot)>$	0.025	0.0045	0.0005	0.0004	$8\ 10^{-7}$
$\mathcal{N}(\cdot)+ \mathcal{N}(\cdot)$	0.078	0.017	0.002	0.00015	10^{-5}
$\mathcal{N}(\cdot)$^2	0.025	0.0045	0.0005	0.0005	$4\ 10^{-6}$

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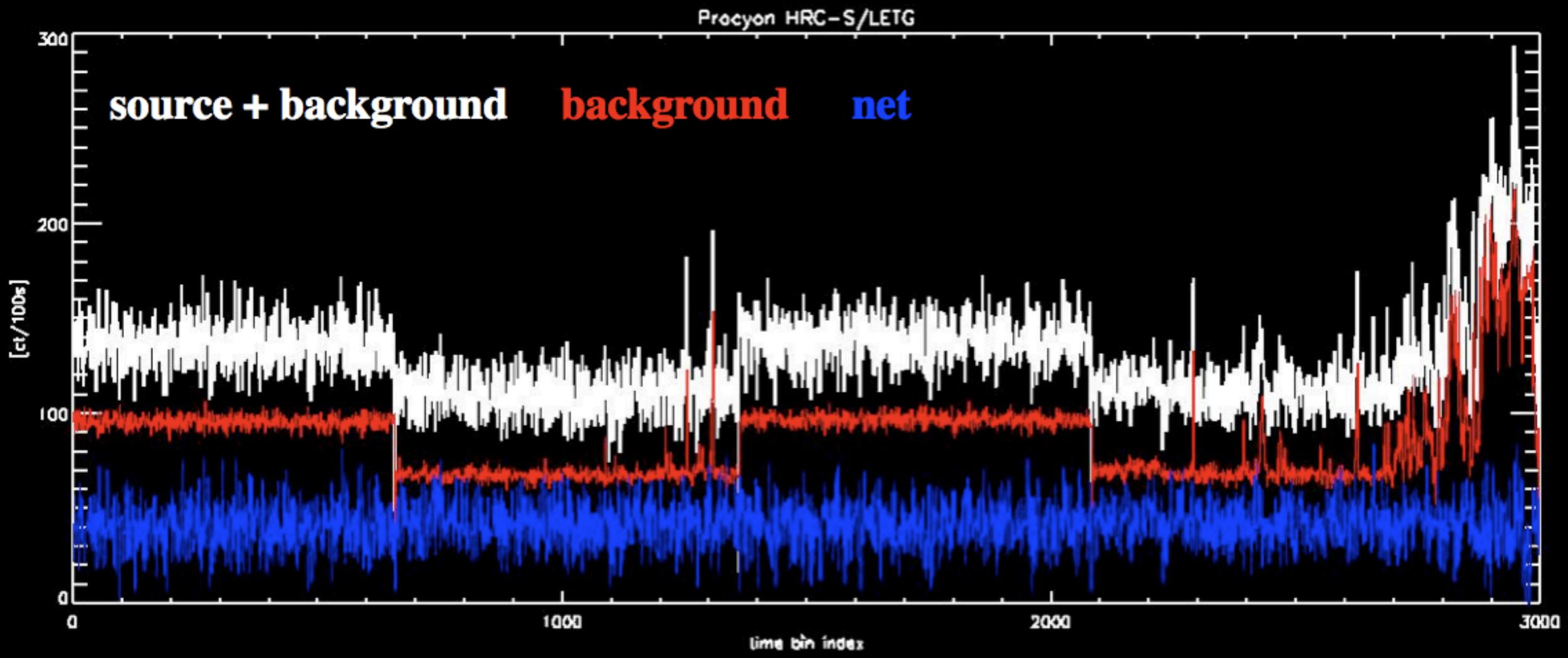

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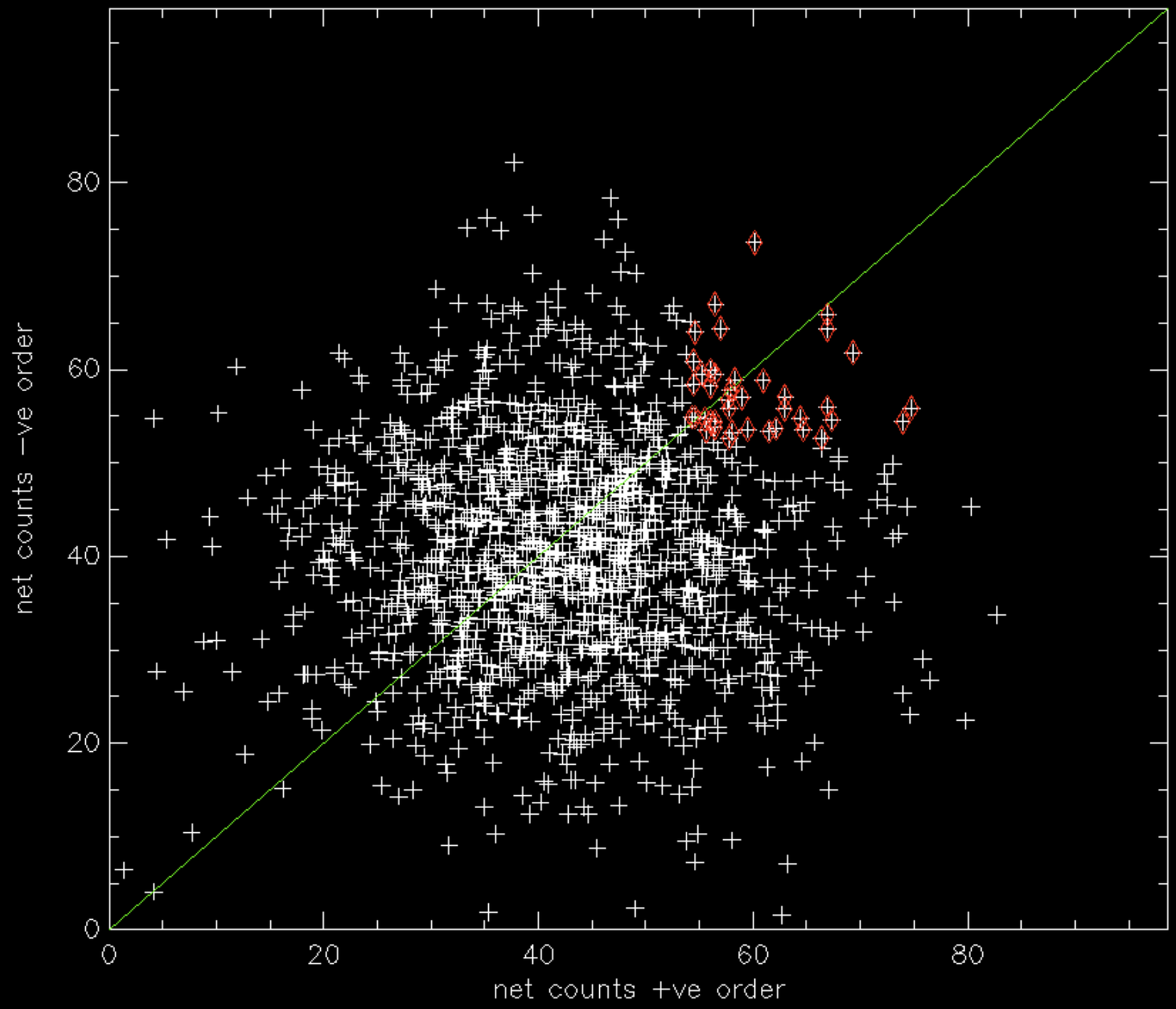

Not the first time someone has tried to figure this out.

Stetson & Welch 1993

Lehner et al. 2010

Stetson & Welch 1993, AJ 105, 1813

- variability index for two simultaneous streams
- first compute variance-weighted means
- then compute $\delta\chi$ for each stream
- compute variability index as sum of $\delta\chi^{(1)}* \delta\chi^{(2)}$

Lehner et al. 2010, PASP 122, 959

- Not the first time someone has tried to figure this out.
- Lehner et al. constructed a rank-ordered p-value statistic to find occultation events.
- p-value defined as $p(Z > z_j = -\ln((\prod_{i=1}^{T} r_{ij}) / N_p^T))$
- Optimized for occultation events with no large time-scale trends in the intensities
- Requires that statistical noise is not large

Type I is (relatively) easy; Type II is not.

Still can't deal with grouped fluctuations.

Want to detect weak events in streams dominated by background and statistical noise.