A Waveform Consistency Test for Binary Inspirals using LIGO data

Andres C. Rodriguez
Gabriela González
(Louisiana State University)

Peter Shawhan
(LIGO | Caltech)

Evan Oshsner
(University of Maryland)

LSC Inspiral Analysis Working Group

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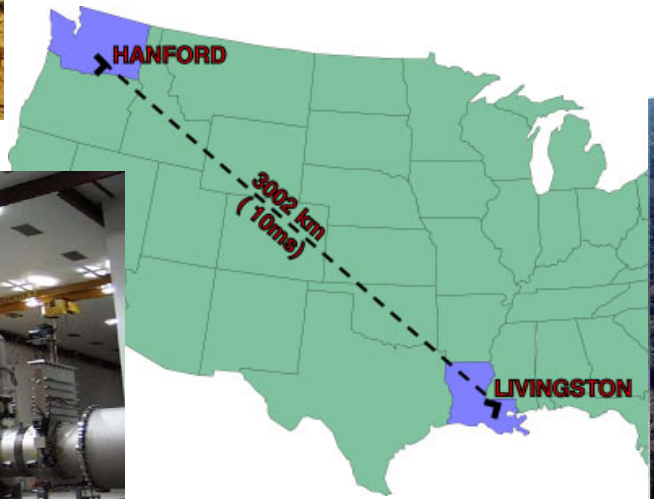
LIGO Observatories

Hanford: two interferometers in same vacuum envelope (4km(H1), 2km(H2))



Livingston: one interferometer (4km(L1))

Template based Matched Filtering

- Data stream searched using matched filtering between data & template waveform.

$$s(t) = n(t) + h(t)$$

- Transform data to frequency domain : $\tilde{s}(f)$
- Calculate template in frequency domain: $\tilde{h}(f)$

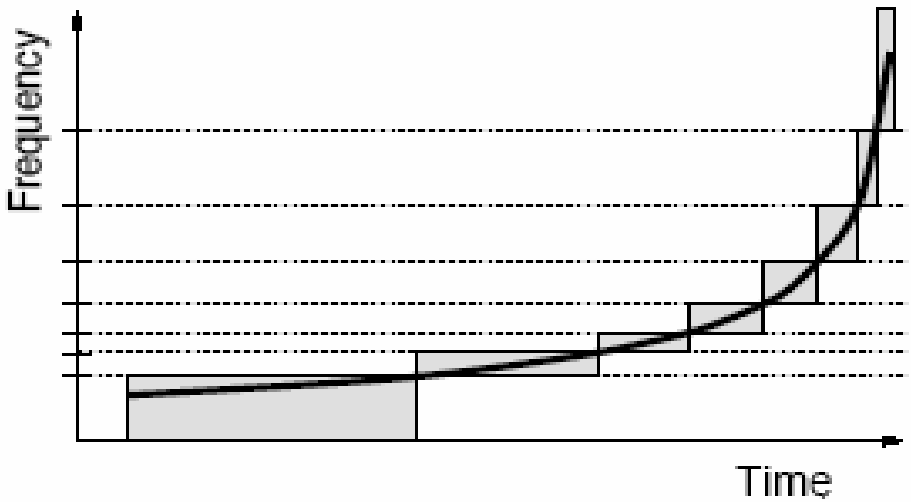
$$z(t) = 4 \int_0^\infty \frac{\tilde{s}(f)\ \tilde{h}^*(f)}{S_h(|f|)}\ e^{2\pi i f t}\ df$$

Template based Matched Filtering

- Signal to Noise (ρ): $\rho = |z|/\sigma$

- χ^2:

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.



Template based Matched Filtering - Thresholds

- Signal to Noise (ρ): ρ > threshold (ρ^*)

- χ^2 :

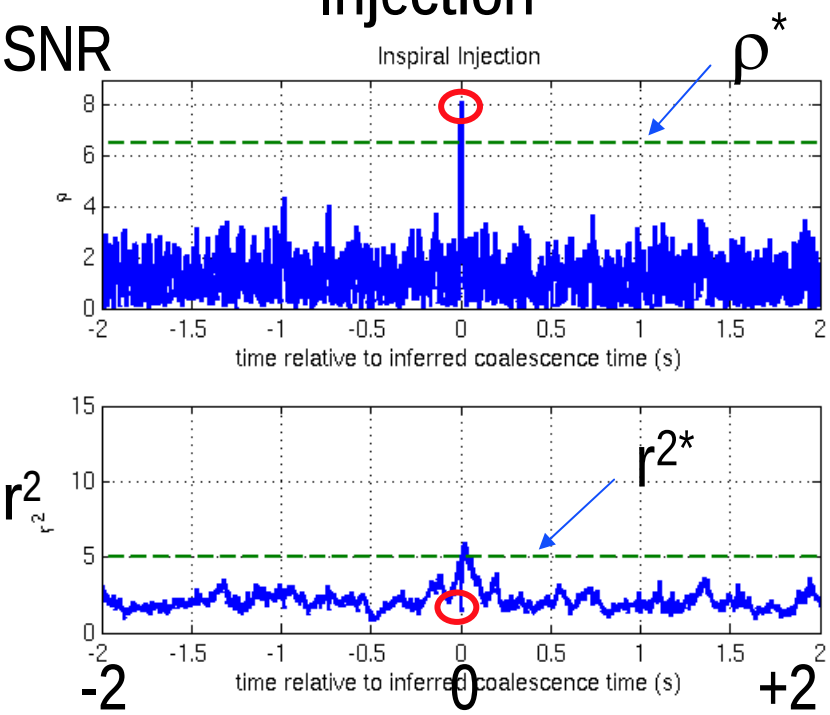
  » really: $r^2 = \dfrac{\chi^2}{(p + \delta^2 \rho^2)}$ < threshold (r^{2*})

- So if $\rho > \rho^*$ and $r^2 < r^{2*}$ --> inspiral “trigger”

Simulated Inspiral (Injection)

Injection

SNR



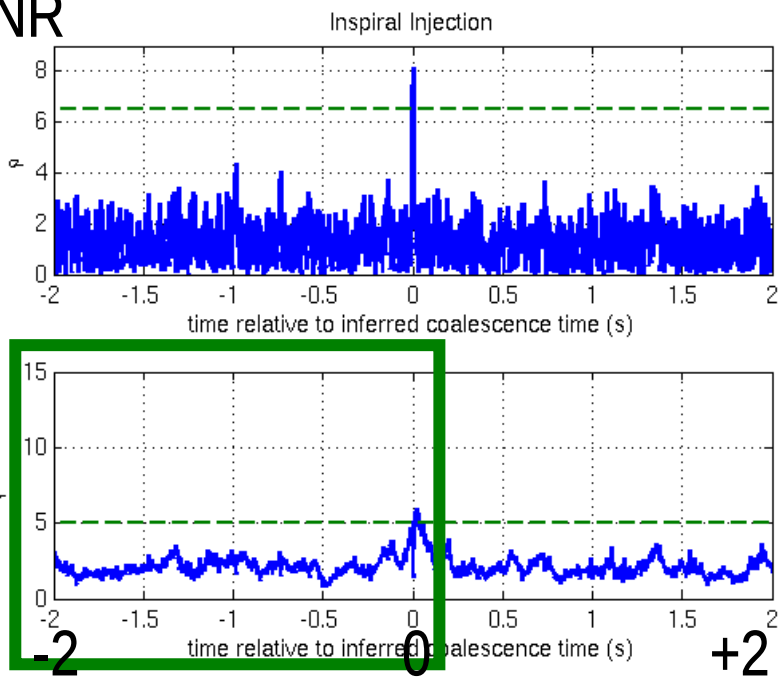
-2 0 +2

time (s) to inferred coalescence

Injection vs. Trigger

Injection

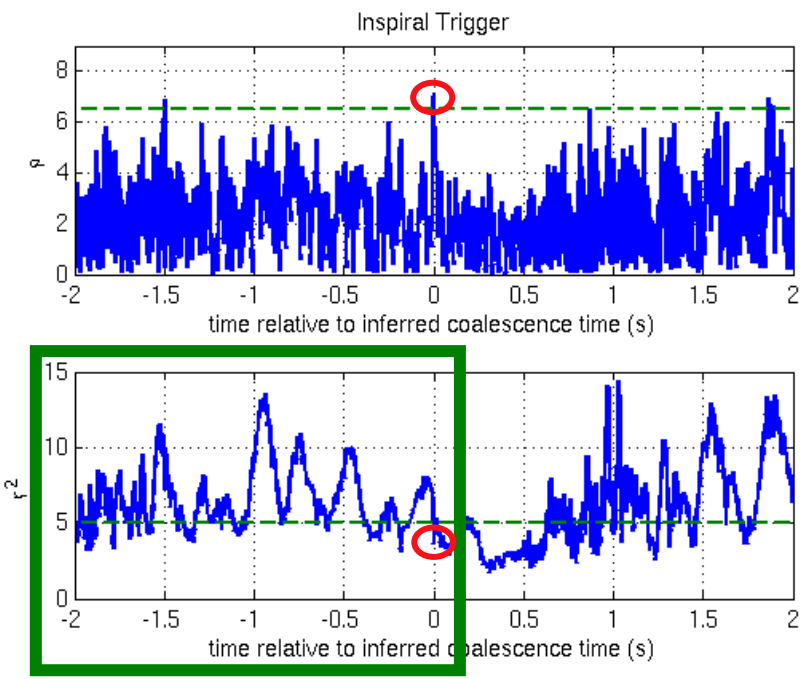
SNR



-2 0 +2

time (s) to inferred coalescence

Trigger

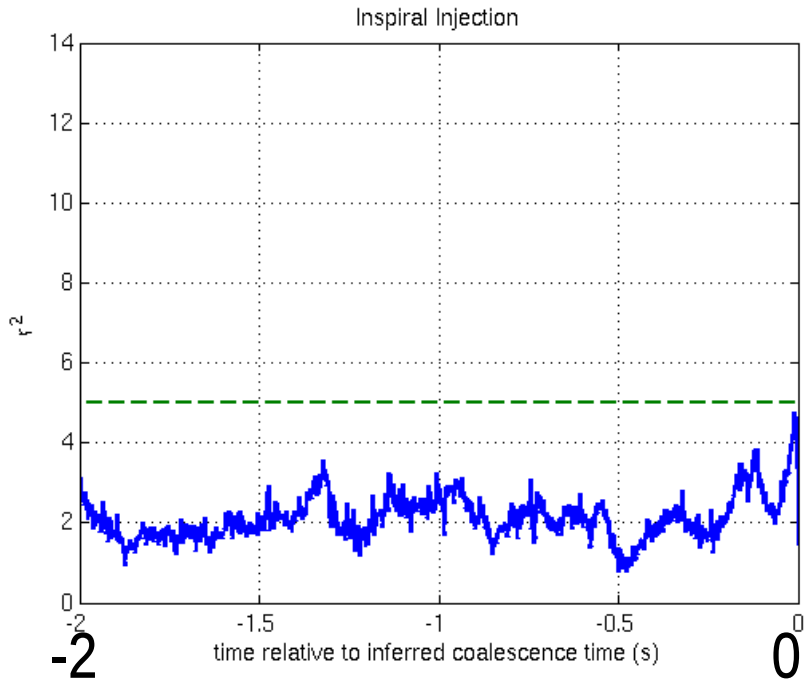


Injection vs. Trigger

Injection

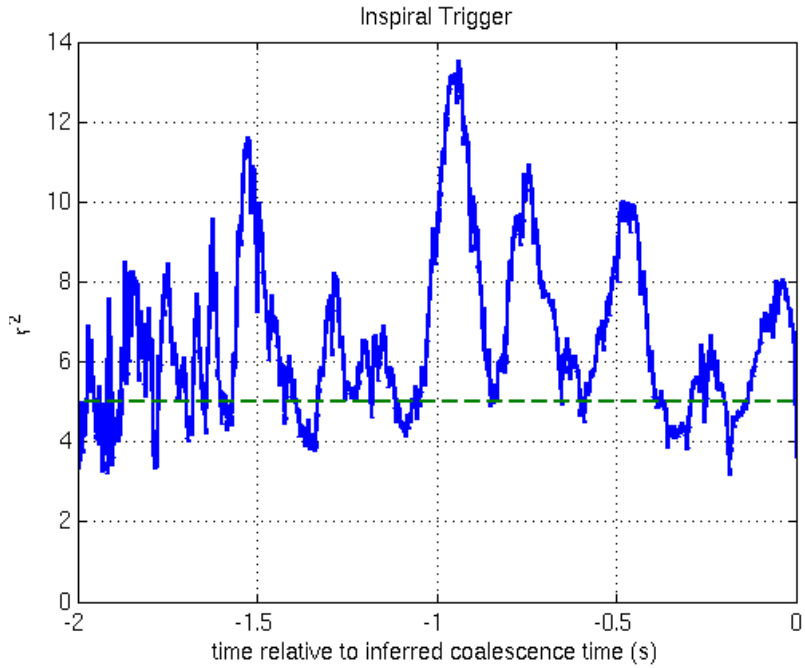
Trigger

r^2



-2 0

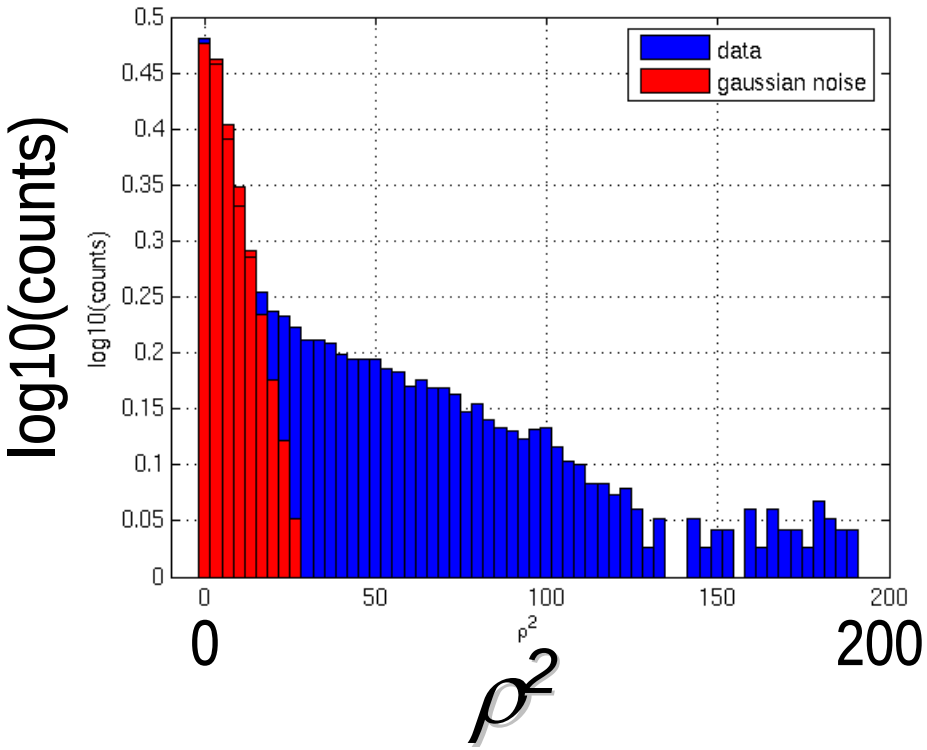
time (s) to inferred coalescence

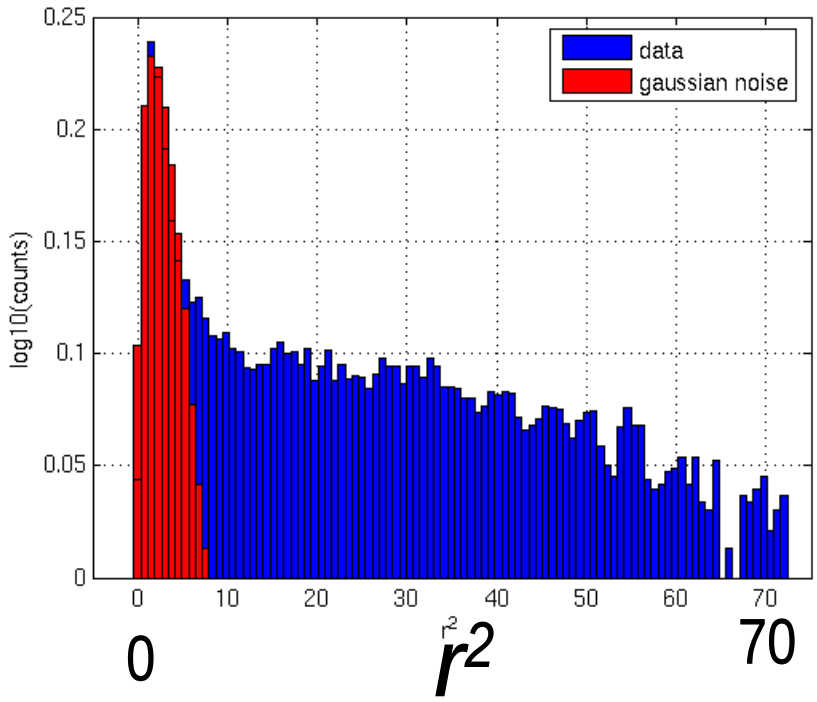


The Test

- Use the r^2 time series as a method to search for excess noise
- Impose a “looser” r^2 threshold than the search employs
  - » Count the number of time samples above a given threshold in a time interval *before* inferred coalescence
  - » Count the number of threshold crossings
- Time interval “window” chosen to be 2 seconds
- Do my triggers behave like software, hardware injections?
  - » yes ->> keep
  - » no ->> veto

ρ^2 , r^2 distribution





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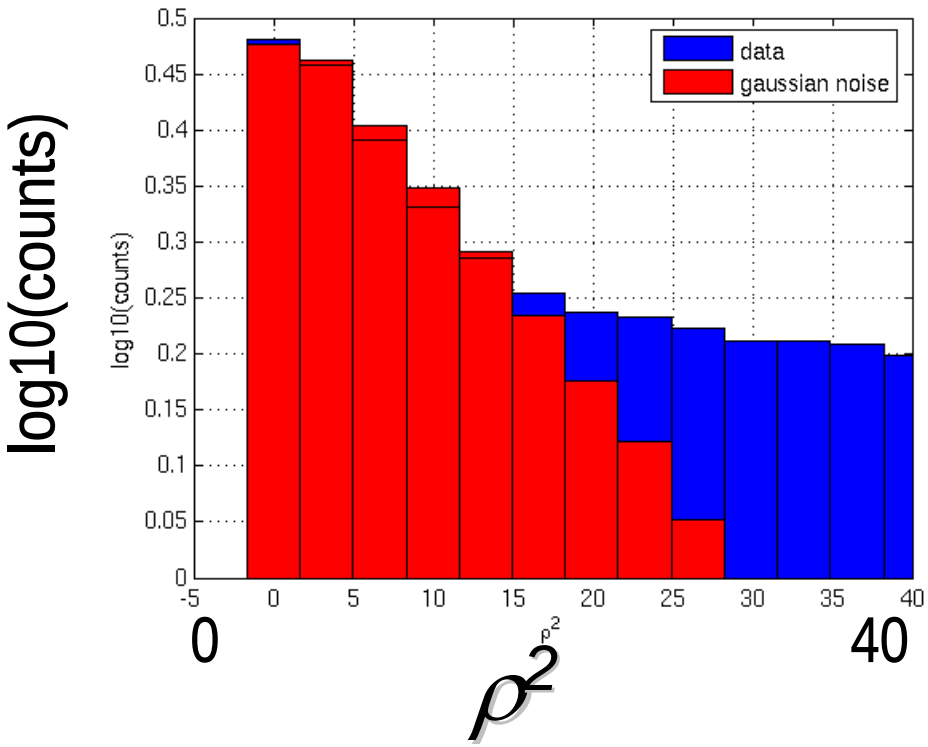
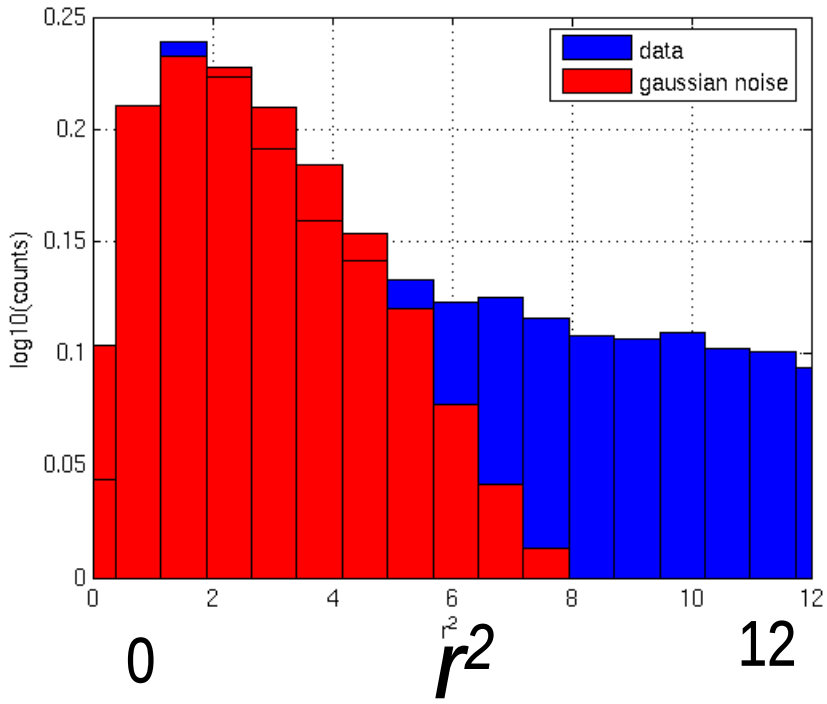


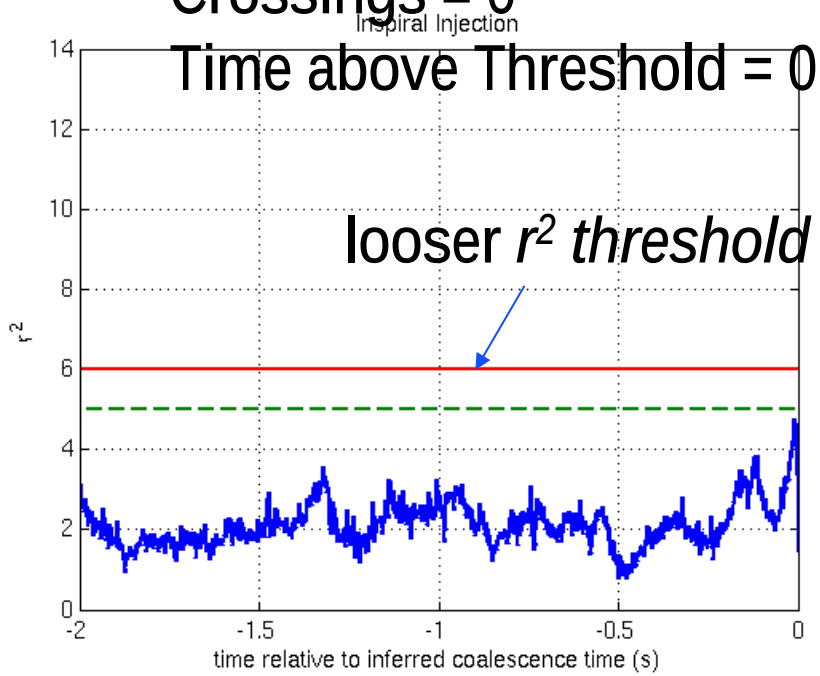


Injection vs. Trigger

Crossings = 0

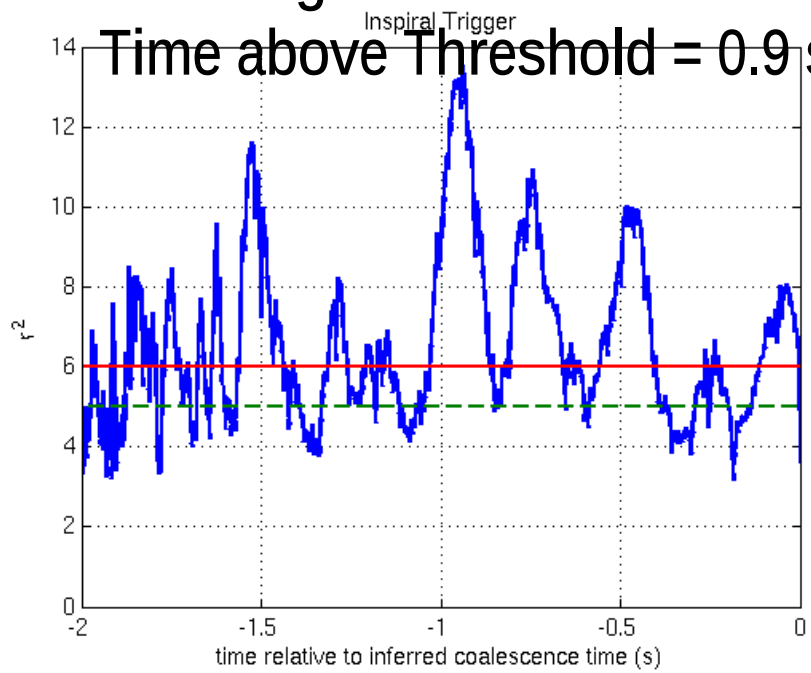
Time above Threshold = 0 sec

looser r^2 *threshold*

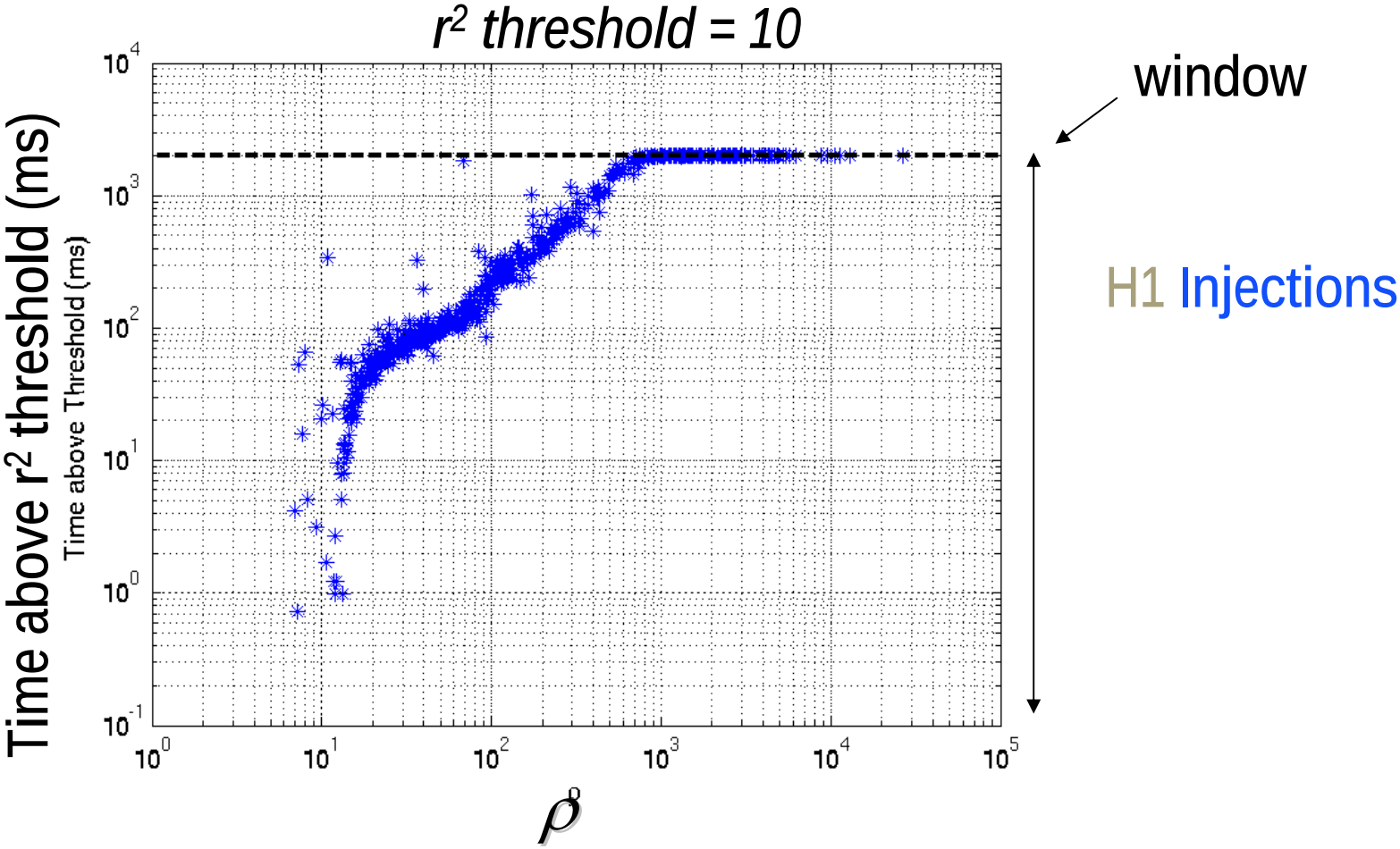


Crossings = 52

Time above Threshold = 0.9 sec



Preliminary Results for H1 Injections + Playground Data



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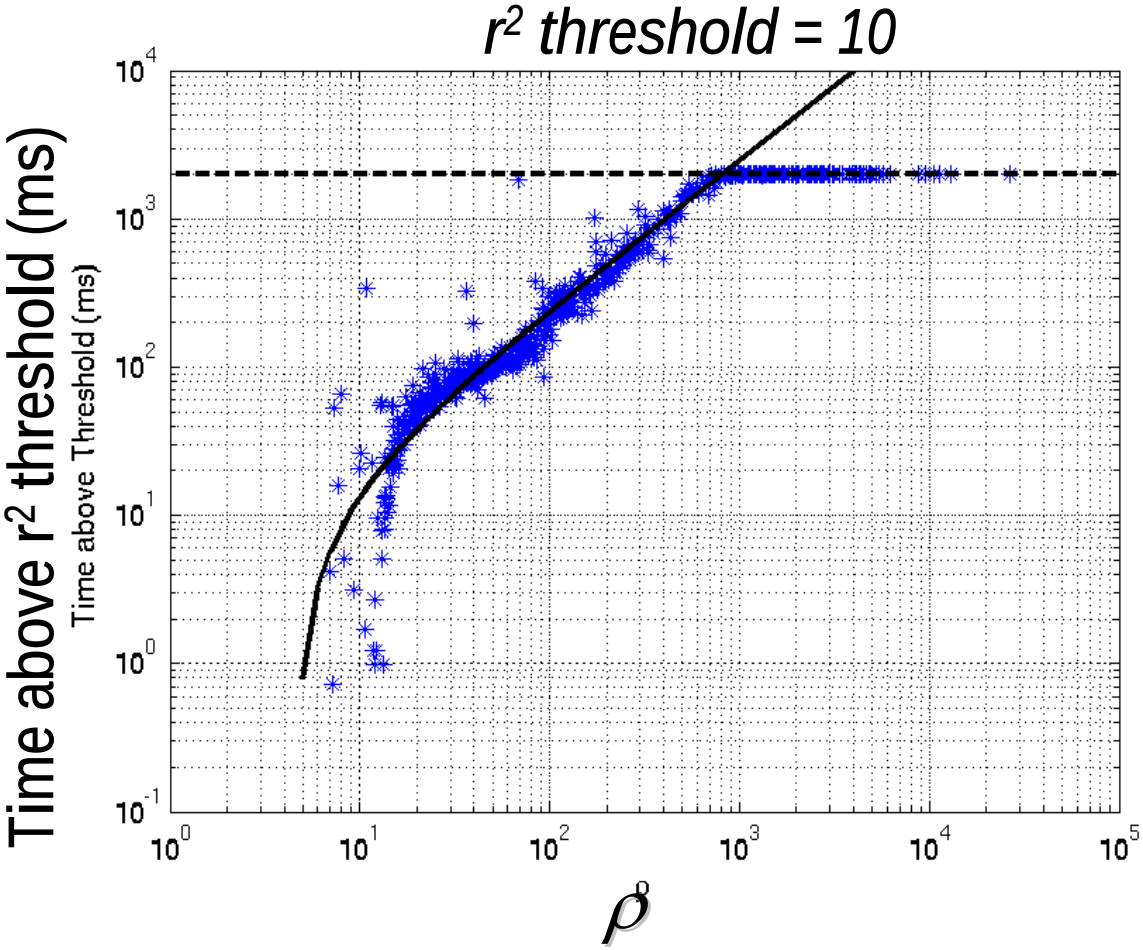
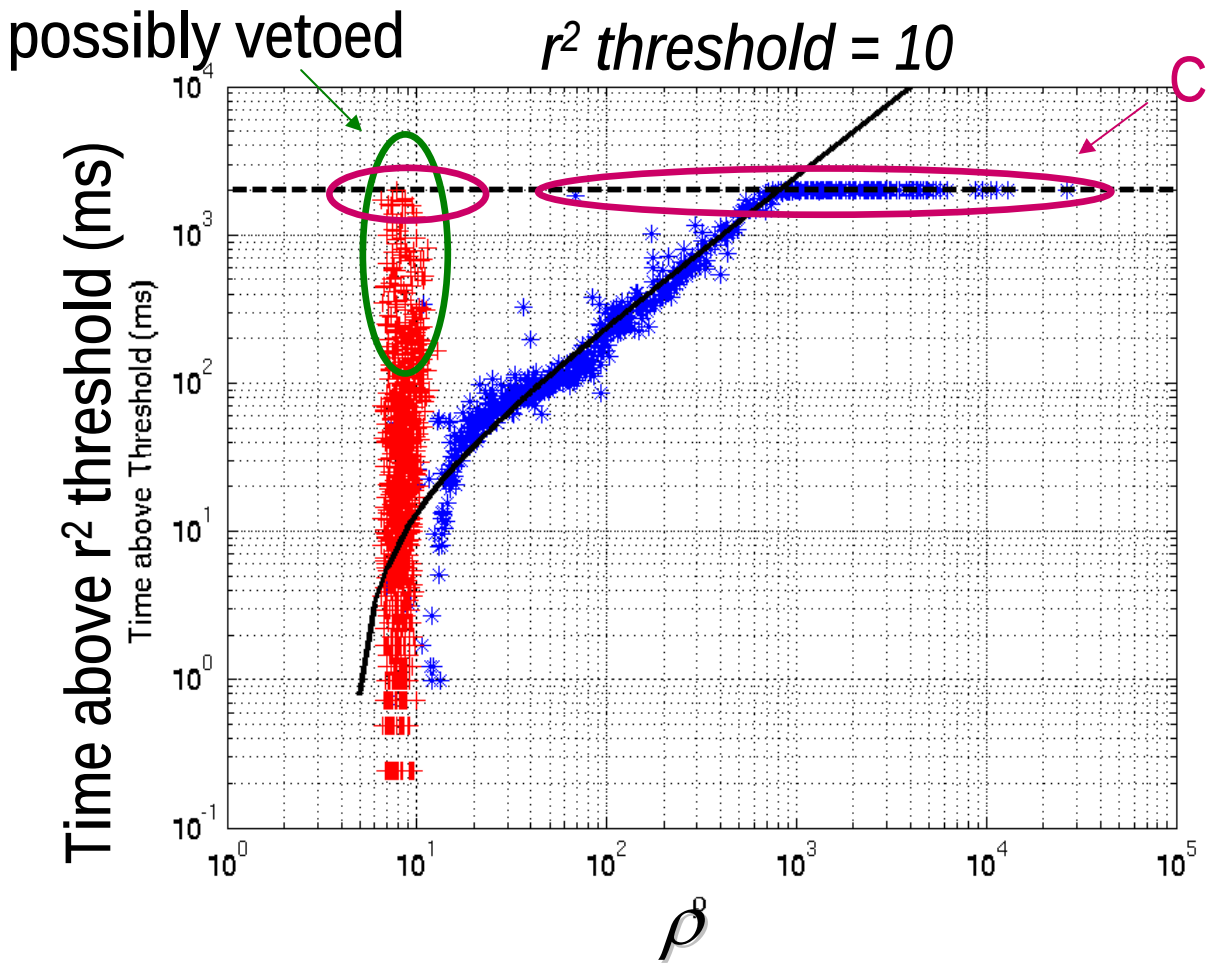


H1 Injections

Preliminary Results: H1 Injections + Playground Data



Summary and Plans

- Preliminary testing r^2 thresholds set to 6, 8, & 10.
- The test would be able to eliminate many of our loudest false triggers --> reduces false alarm rate.
- Additional tuning using S3 Hardware Injections and testing on S3 playground data from L1,H2.
- Will be incorporated into S3, S4 BNS search, and future online analysis.