



A Waveform Consistency Test for Binary Inspirals using LIGO data

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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 the the output of optimal filter in frequency domain: $\tilde{h}(f)$

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

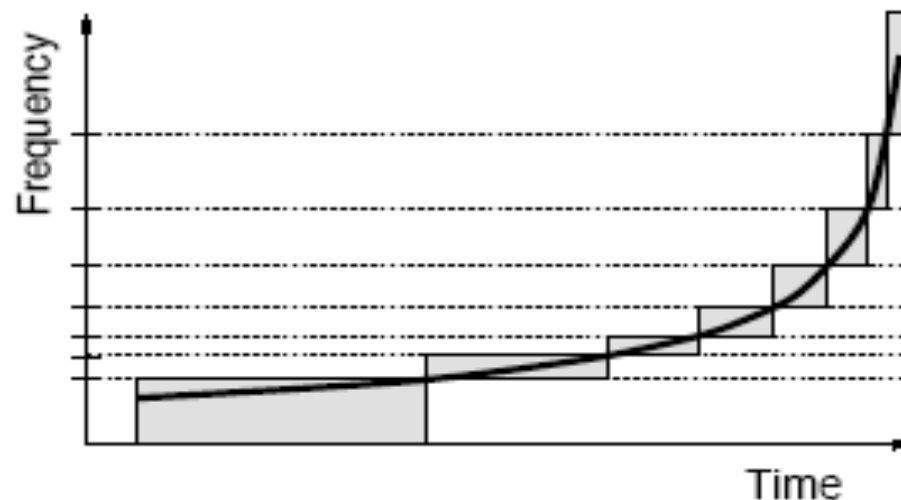
Template based Matched Filtering

- Signal to Noise:

$$\rho = |z|/\sigma$$

- χ^2 :

$$\chi^2(t) = \frac{p}{\sigma^2} \sum_{l=1}^p |z_l(t) - z(t)/p|^2$$



Template based Matched Filtering - Thresholds

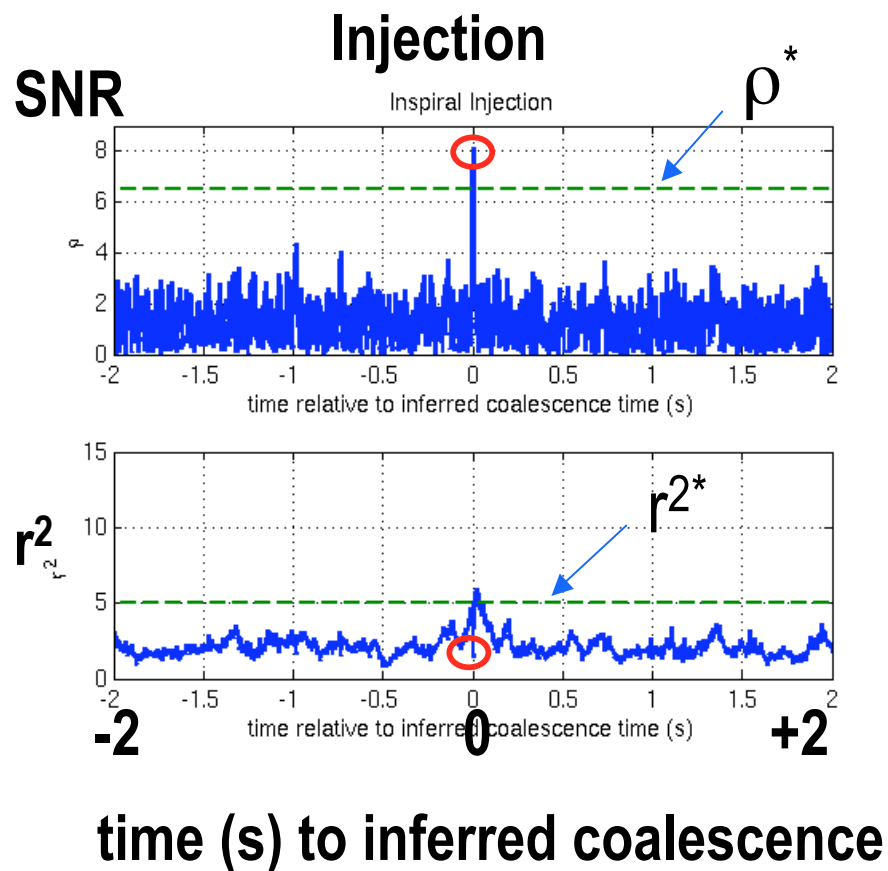
- Signal to Noise: Require $\rho > \rho^*$
- χ^2 : Use ρ -dependent threshold to account for template mismatch

» Consider:
$$r^2 = \frac{\chi^2}{(p + \delta^2 \rho^2)}$$

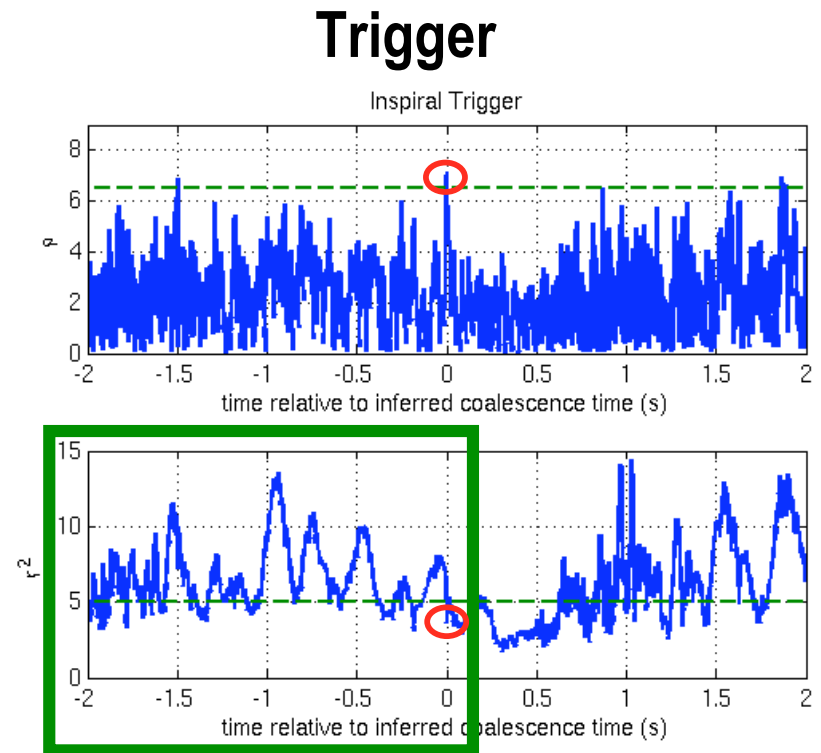
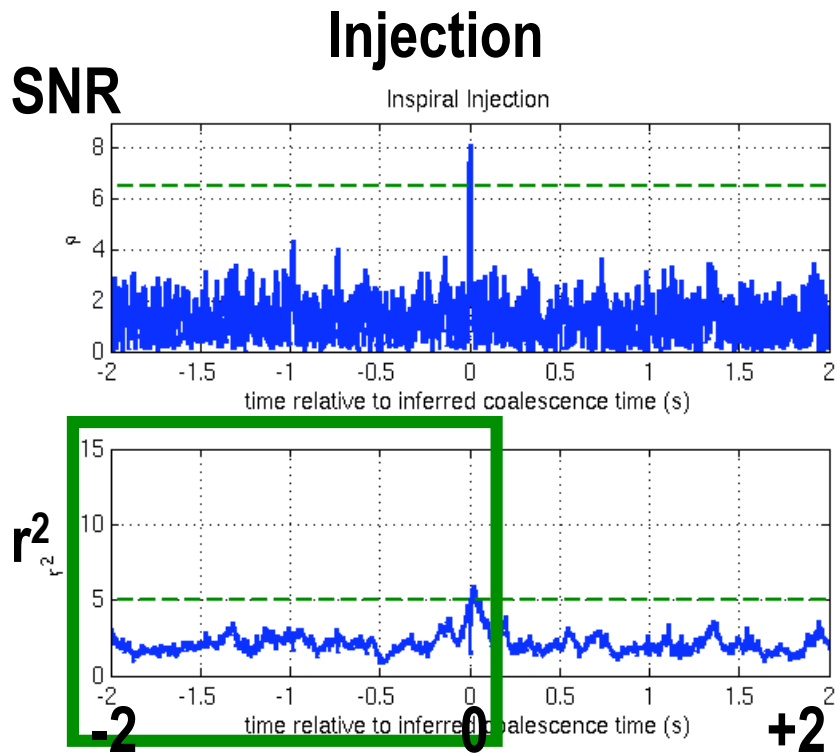
» Require $r^2 < r^{2*}$

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

Simulated Inspiral (Injection)



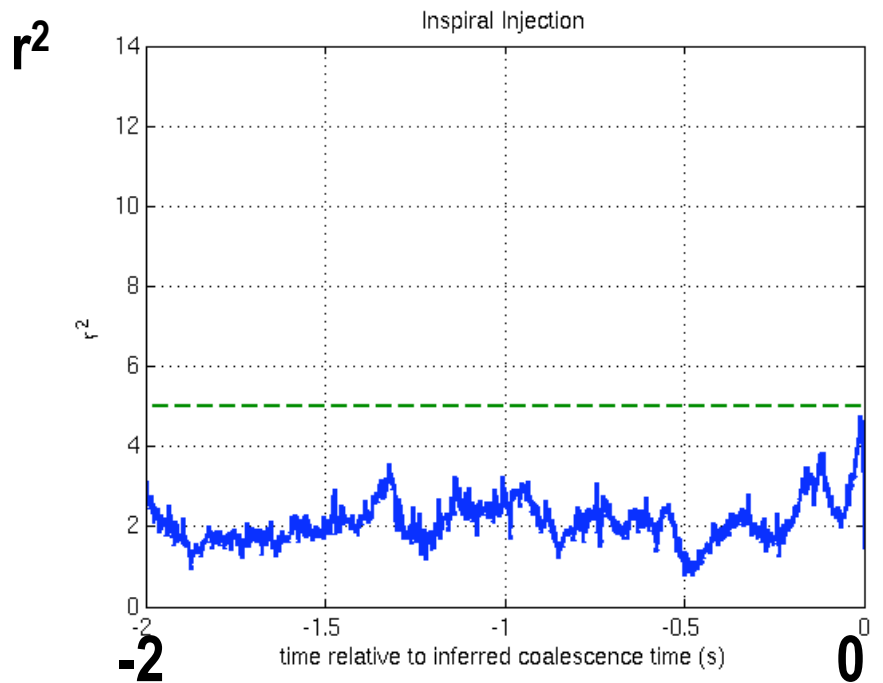
Injection vs. Trigger



time (s) to inferred coalescence

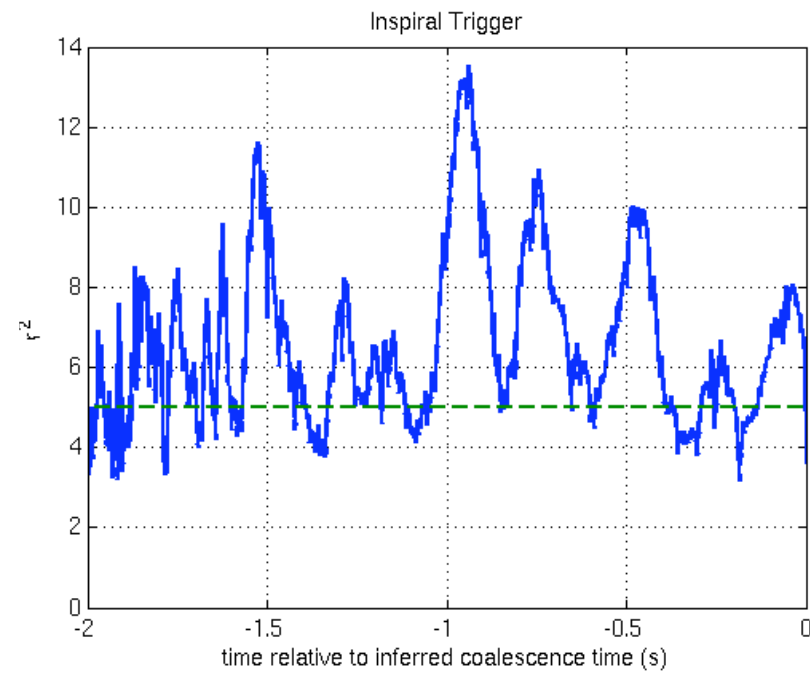
Injection vs. Trigger

Injection



time (s) to inferred coalescence

Trigger

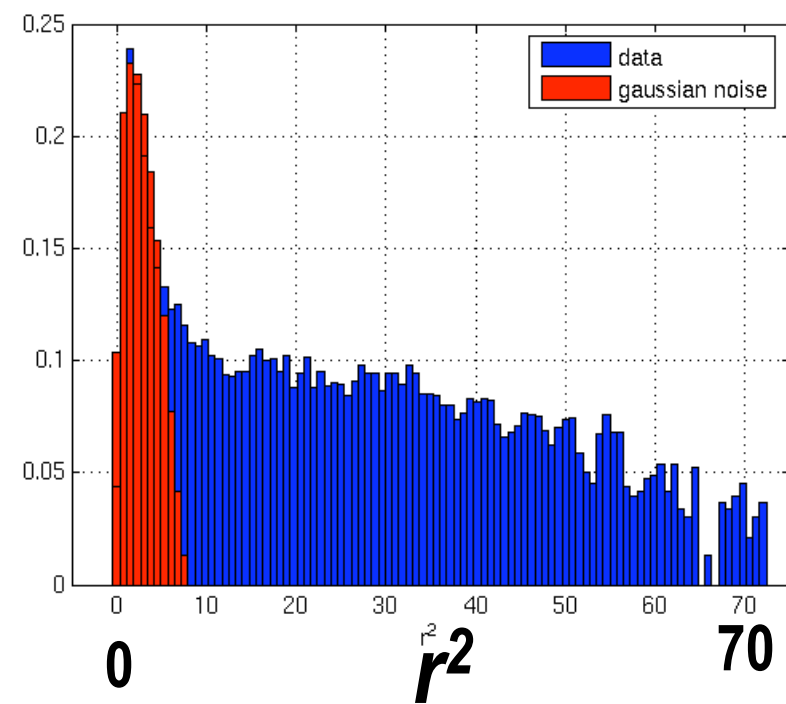
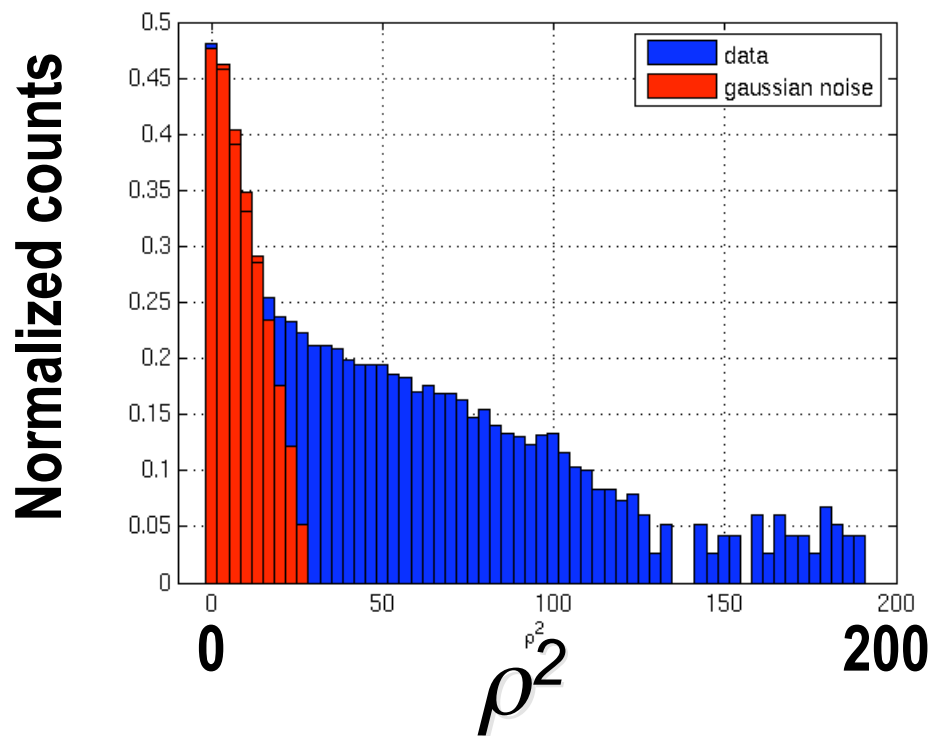




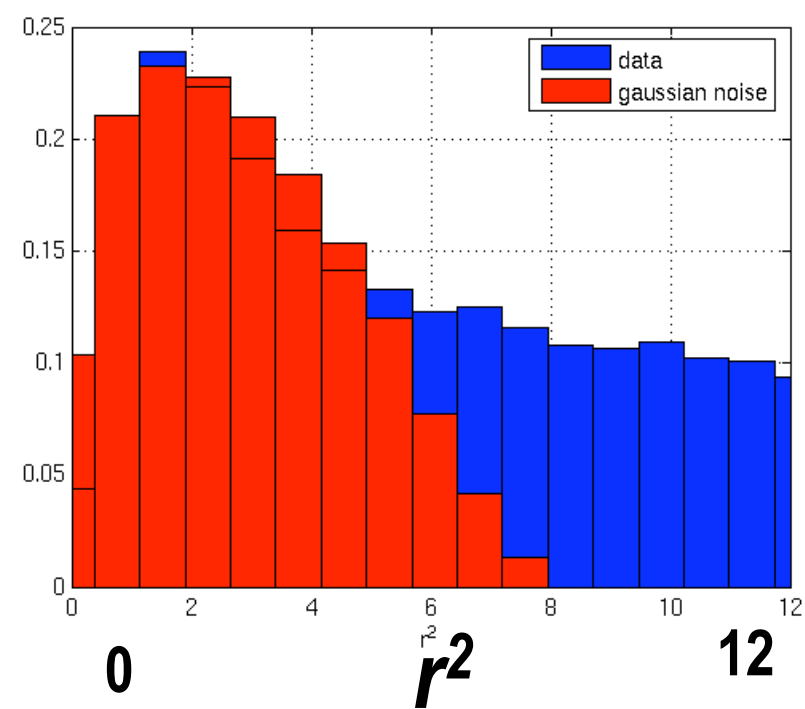
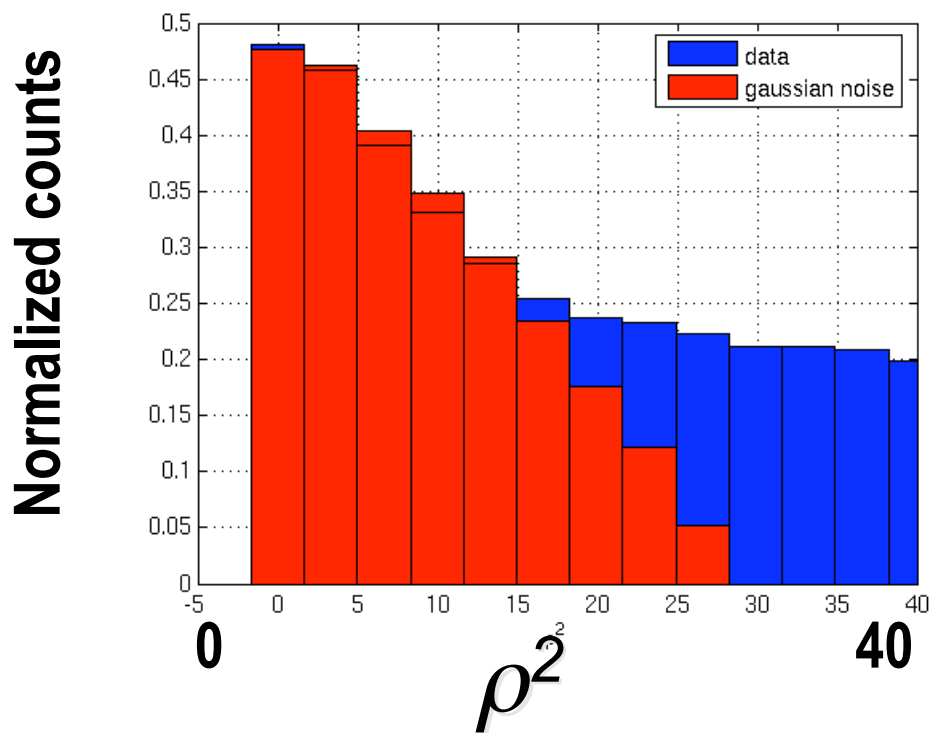
The Test

- Use the r^2 time series as a method to search for excess noise
- Choose a test threshold “looser” than the r^2 threshold the search employs
 - » Count the number of time samples above a given threshold in a time interval *before* inferred coalescence
- 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

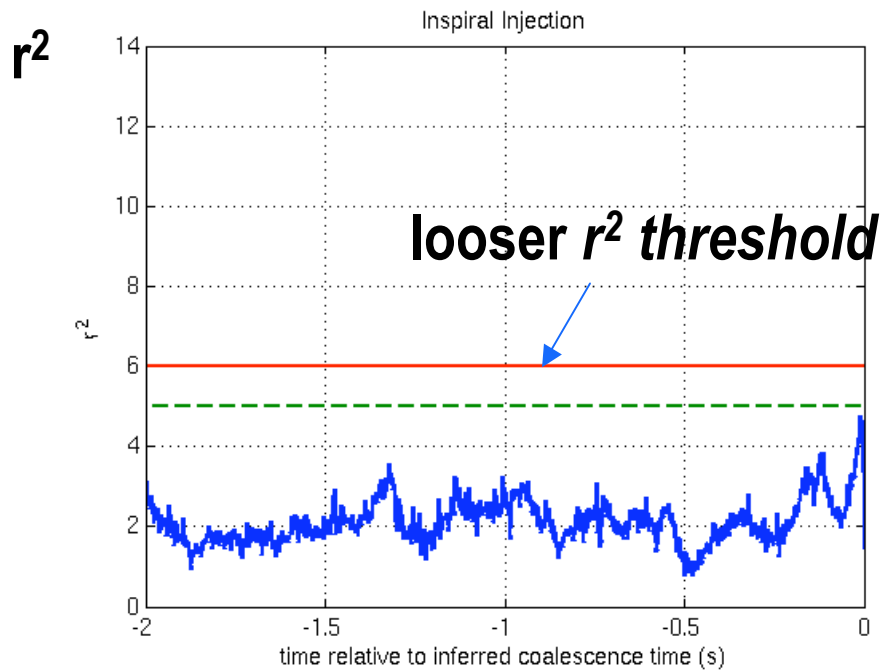


ρ^2 , r^2 distribution

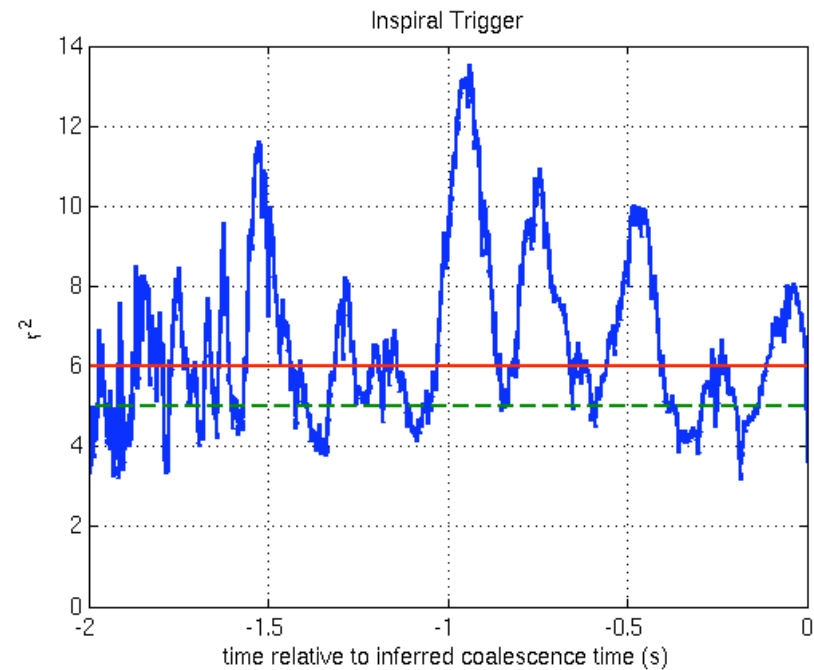


Injection vs. Trigger

Time above Threshold = 0 sec

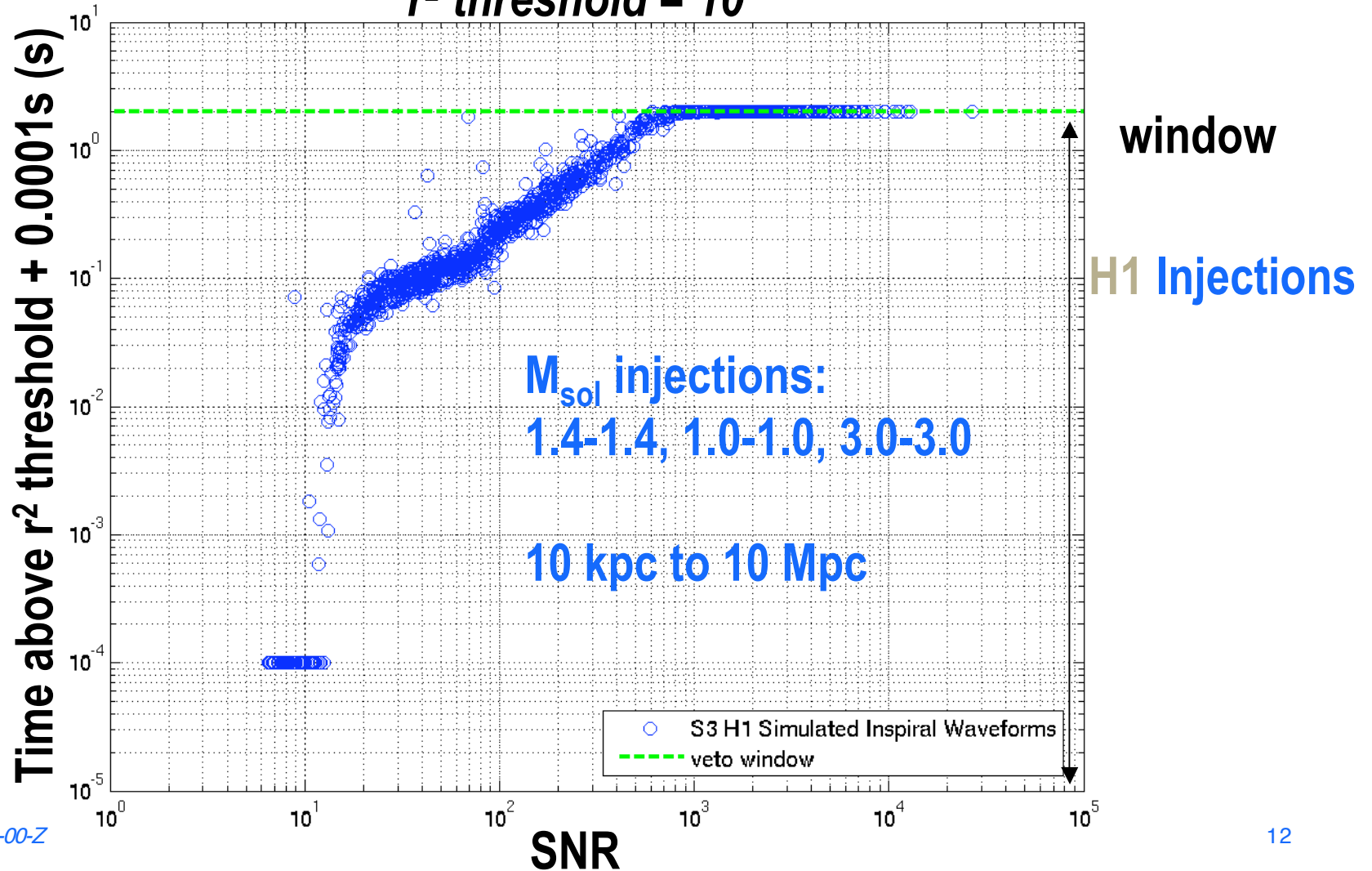


Time above Threshold = 0.9 sec

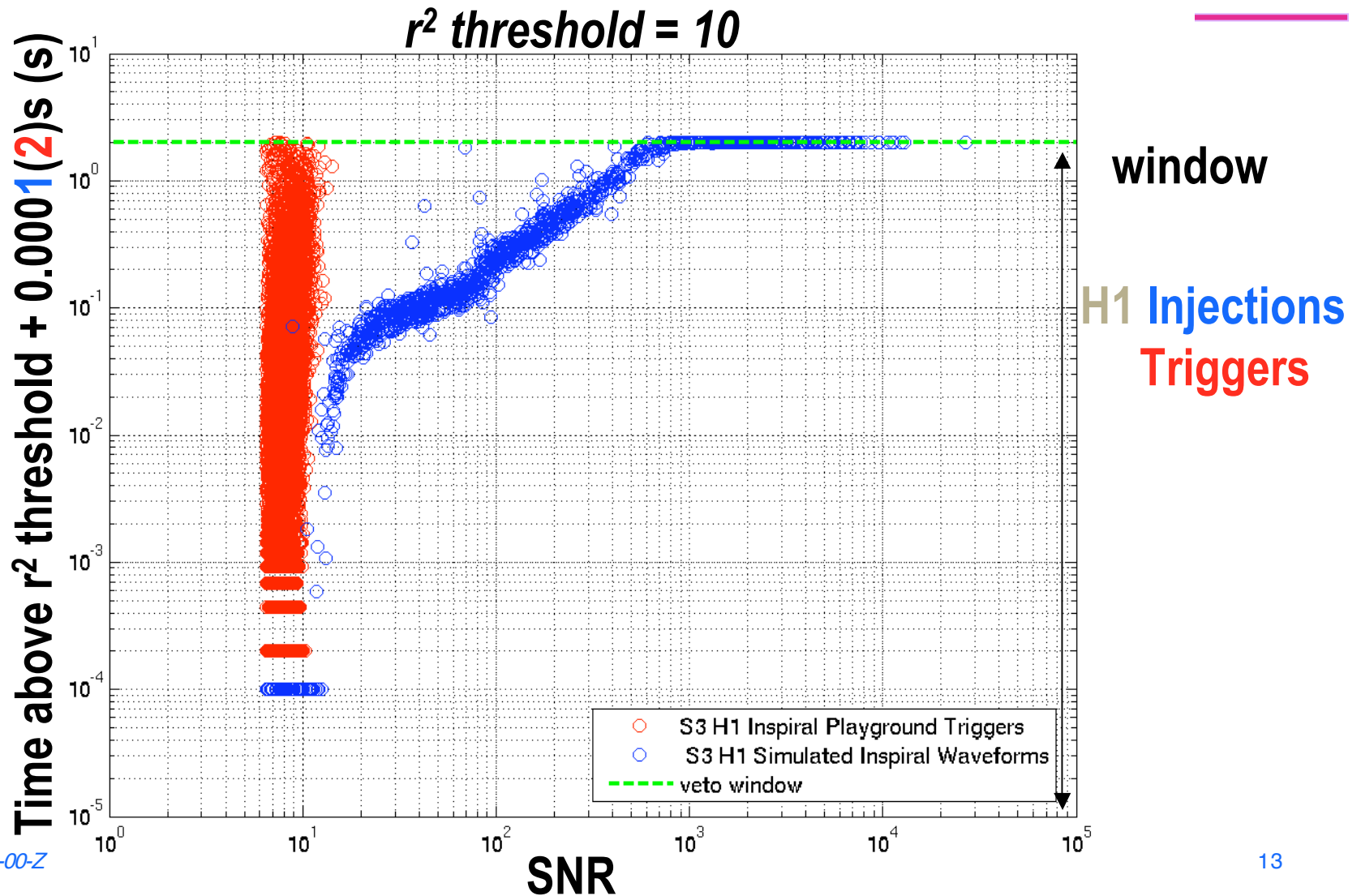


Preliminary Results for S3 H1 Injections + S3 Playground

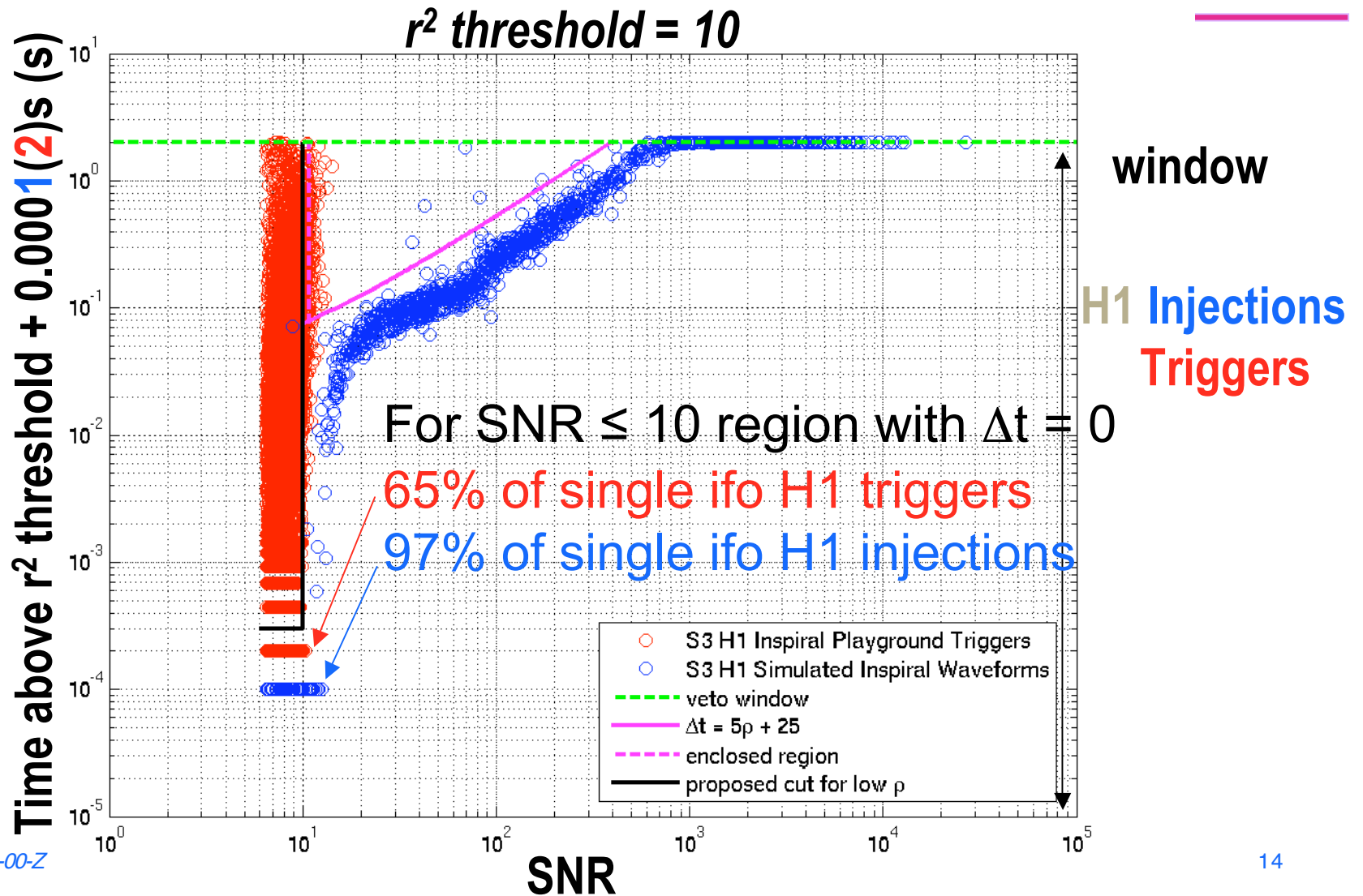
r^2 threshold = 10



Preliminary Results for S3 H1 Injections + S3 Playground



Preliminary Results for S3 H1 Injections + S3 Playground





Summary and Plans

- Preliminary testing r^2 thresholds set to 10, with similar behavior for all three ifo's.
- The test would be able to eliminate many of our loudest false triggers.
- Low SNR region is currently being investigated.
- Additional tuning using S3 Hardware Injections and injections into no noise.
- Will be incorporated into S3, S4 BNS search, and future online analysis.