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Inspiral Waveform Consistency Tests

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The Standard χ^2 Test

Divide template into p parts, each expected (on average) to contribute equally to the total SNR, and calculate a χ^2 :

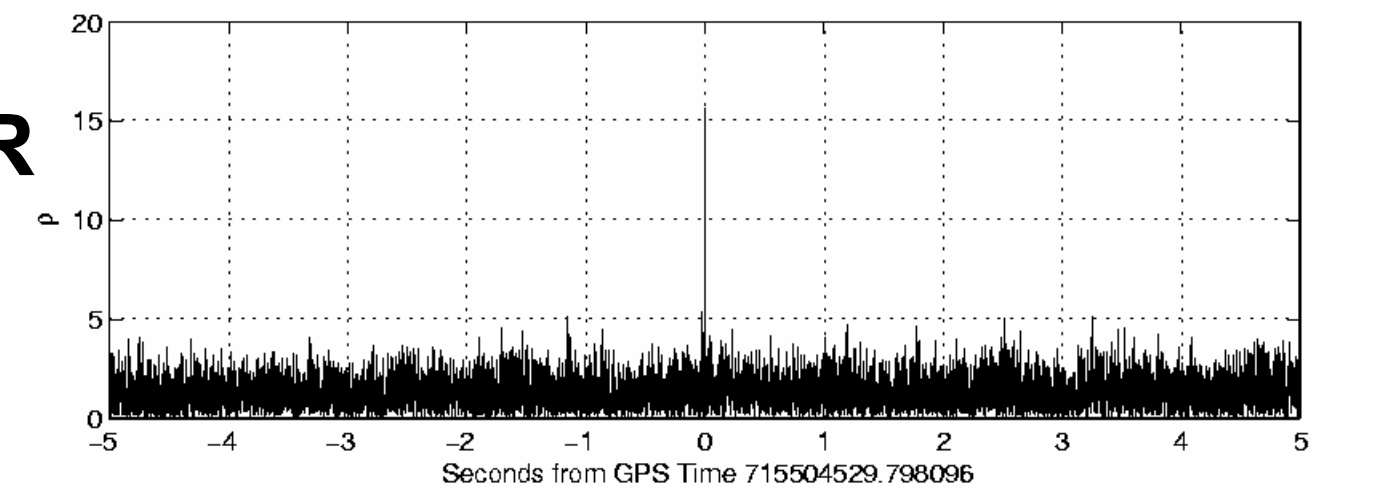
$$\chi^2(t) = p\sum_{l=1}^{p} \left| z_l(t) - z(t)/p \right|^2$$

z and z_l are complex numbers

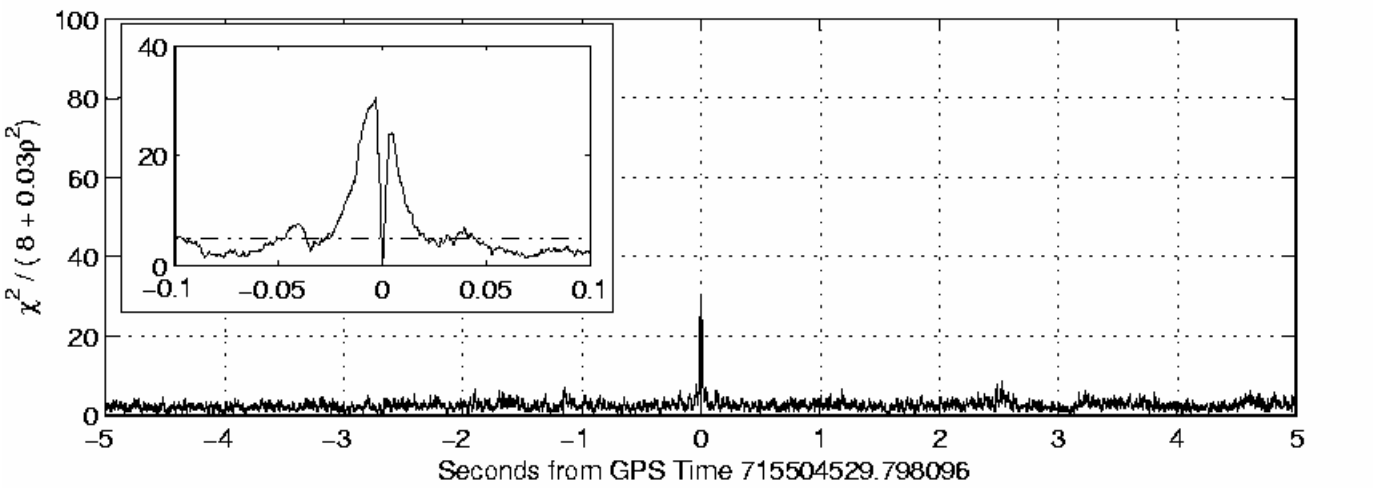
LSC inspiral analysis group has used p=8 in the past, currently is using p=14

A Simulated Inspiral

SNR

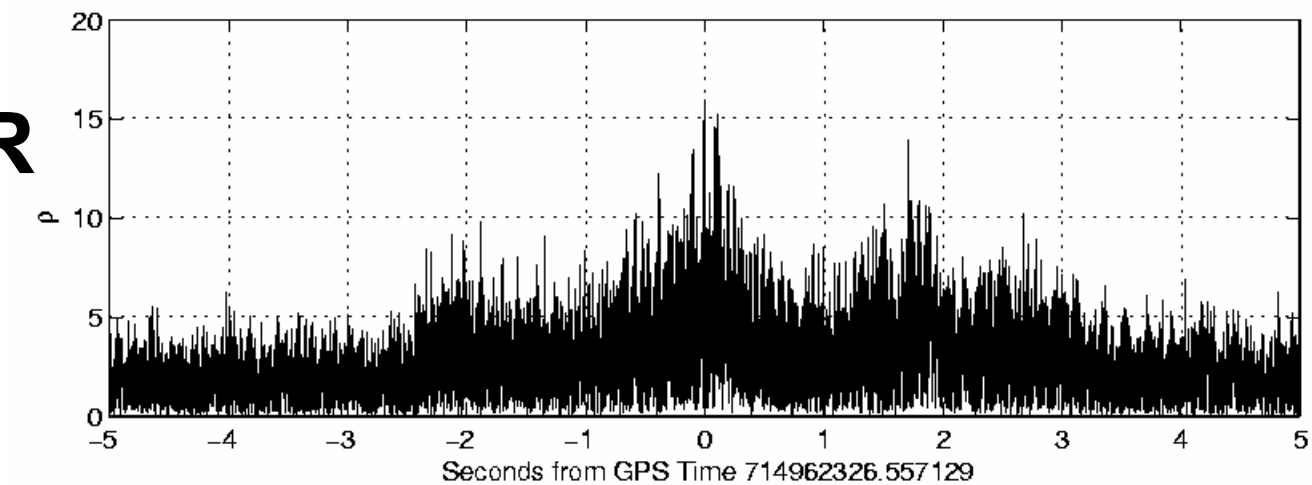


χ^2

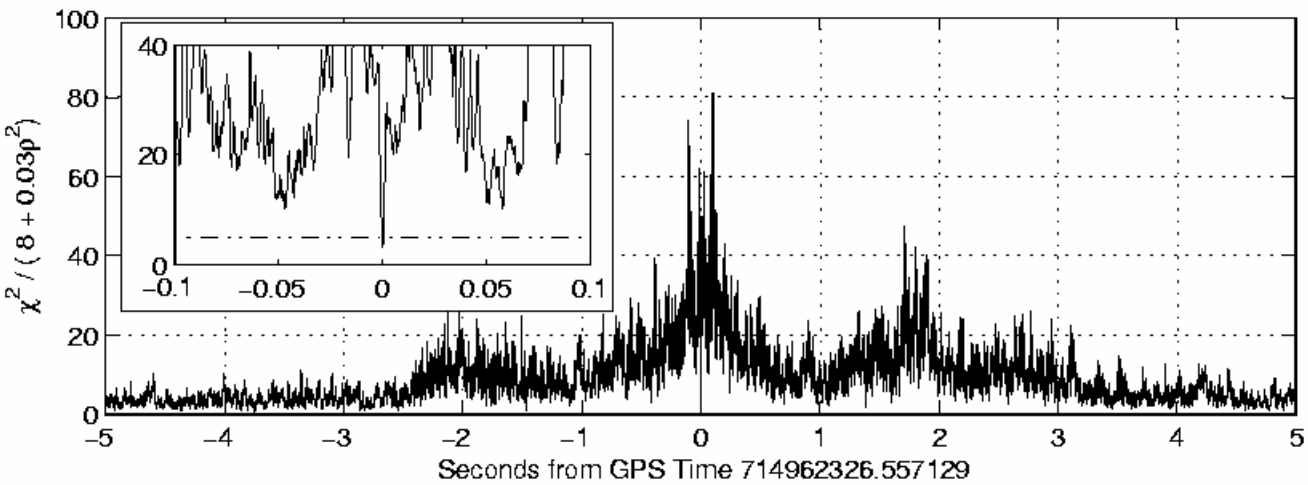


The Loudest L1 Event in the S1 Analysis

SNR

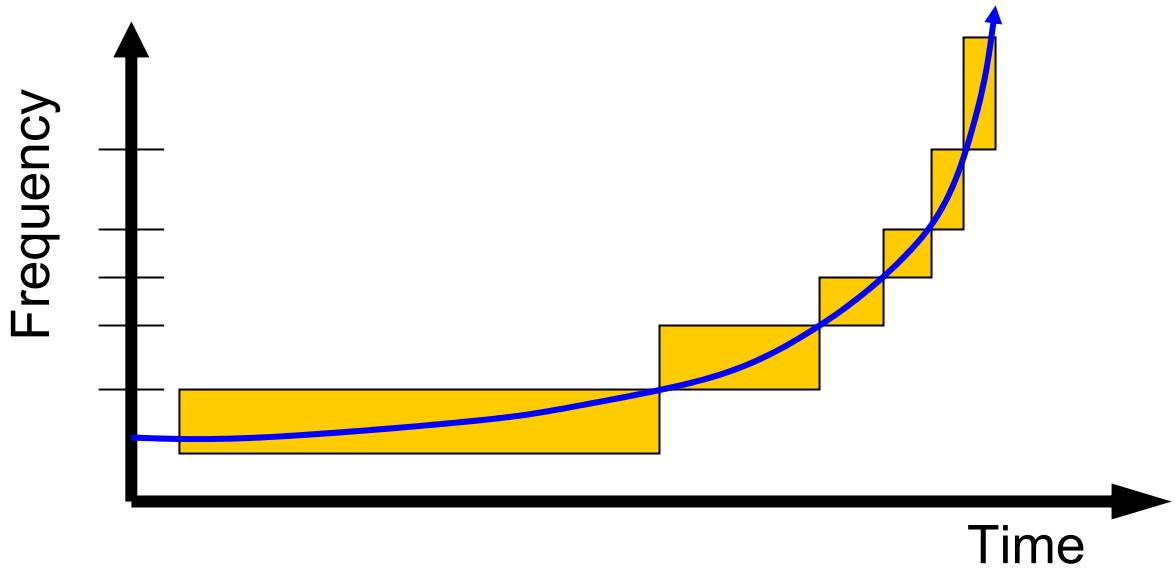


χ^2



Why Do Garbage Events Survive the χ^2 Test ?

The χ^2 test only uses a "slice" out of the time-freq plane

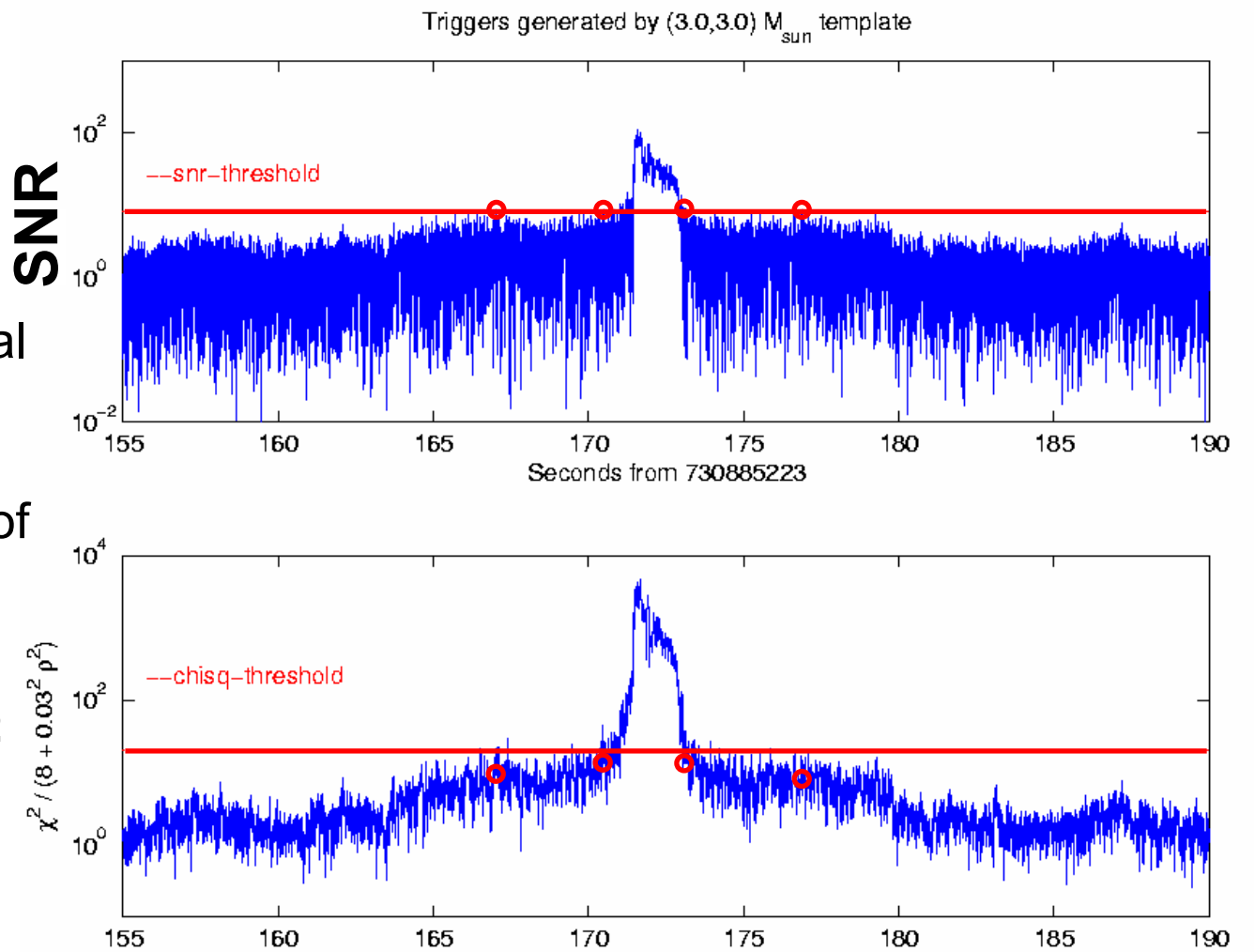


SNR threshold is determined by noise averaged over job

During a time interval with excess noise, the matched filter is likely to find *some* point in time with acceptable SNR & χ^2

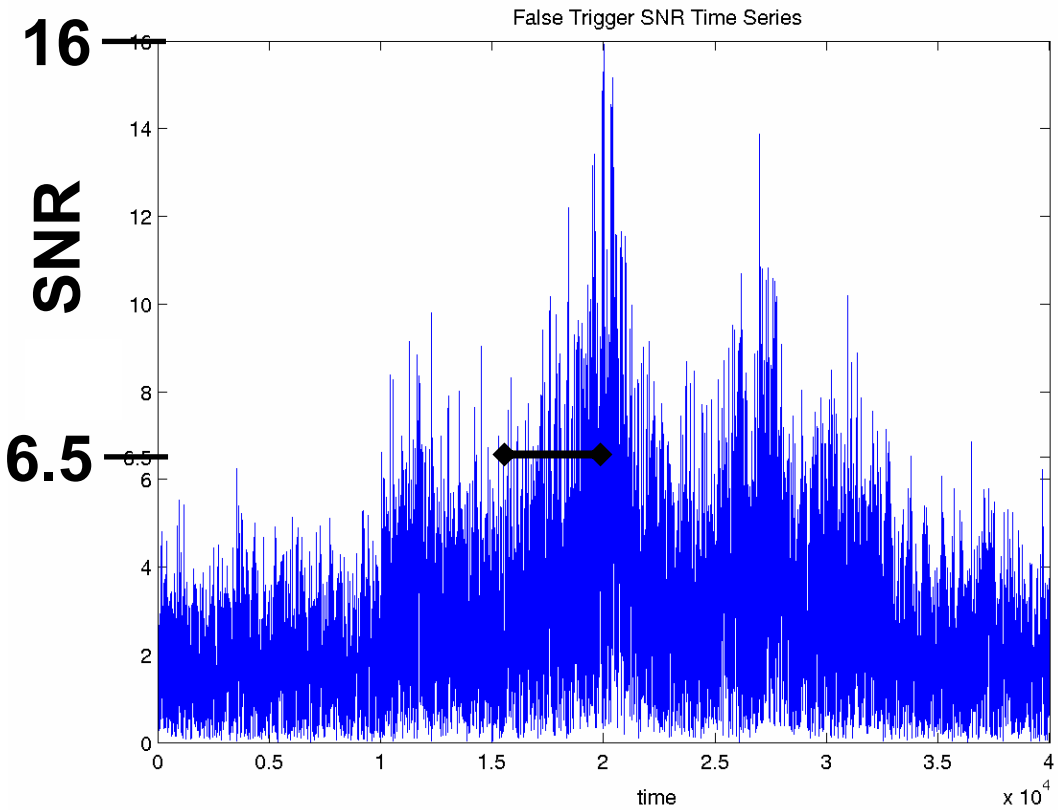
Garbage Events Near a Big Glitch

"Inaccurate" inspiral coalescence times are understood to arise from ringing of the template filter



Additional Waveform Consistency Tests

Look for excess noise just before the event time, using the matched filter output as a measure of noise in some way



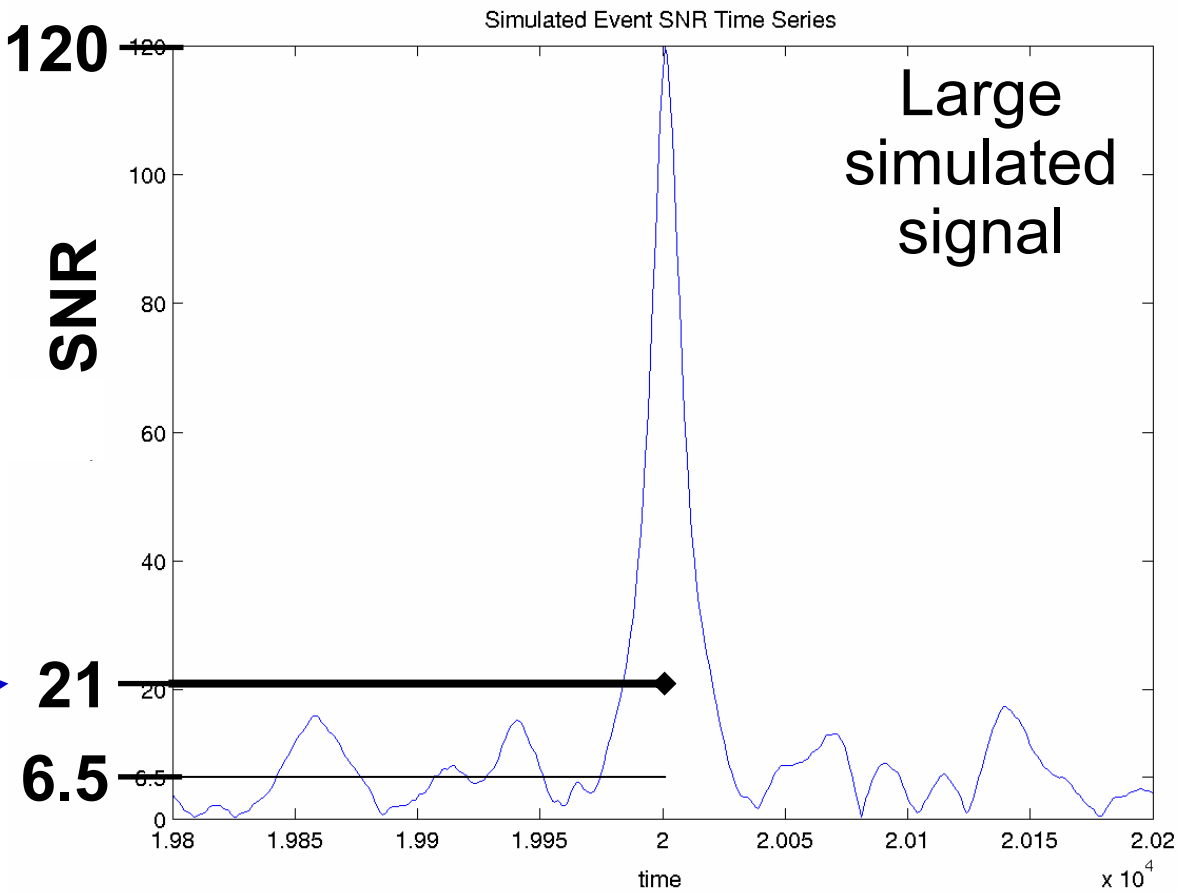
Count number of time samples above a threshold, or number of threshold crossings, over some time interval

Threshold=6.5 seems good for weak events

Allow for Large Signals

Use a threshold which depends on the peak SNR (ρ)

$$threshold = \sqrt{6.5^2 + (\rho/6)^2}$$



Evaluate Tests Using S1 Data

Modified filtering function in LAL to implement a few variations on these tests

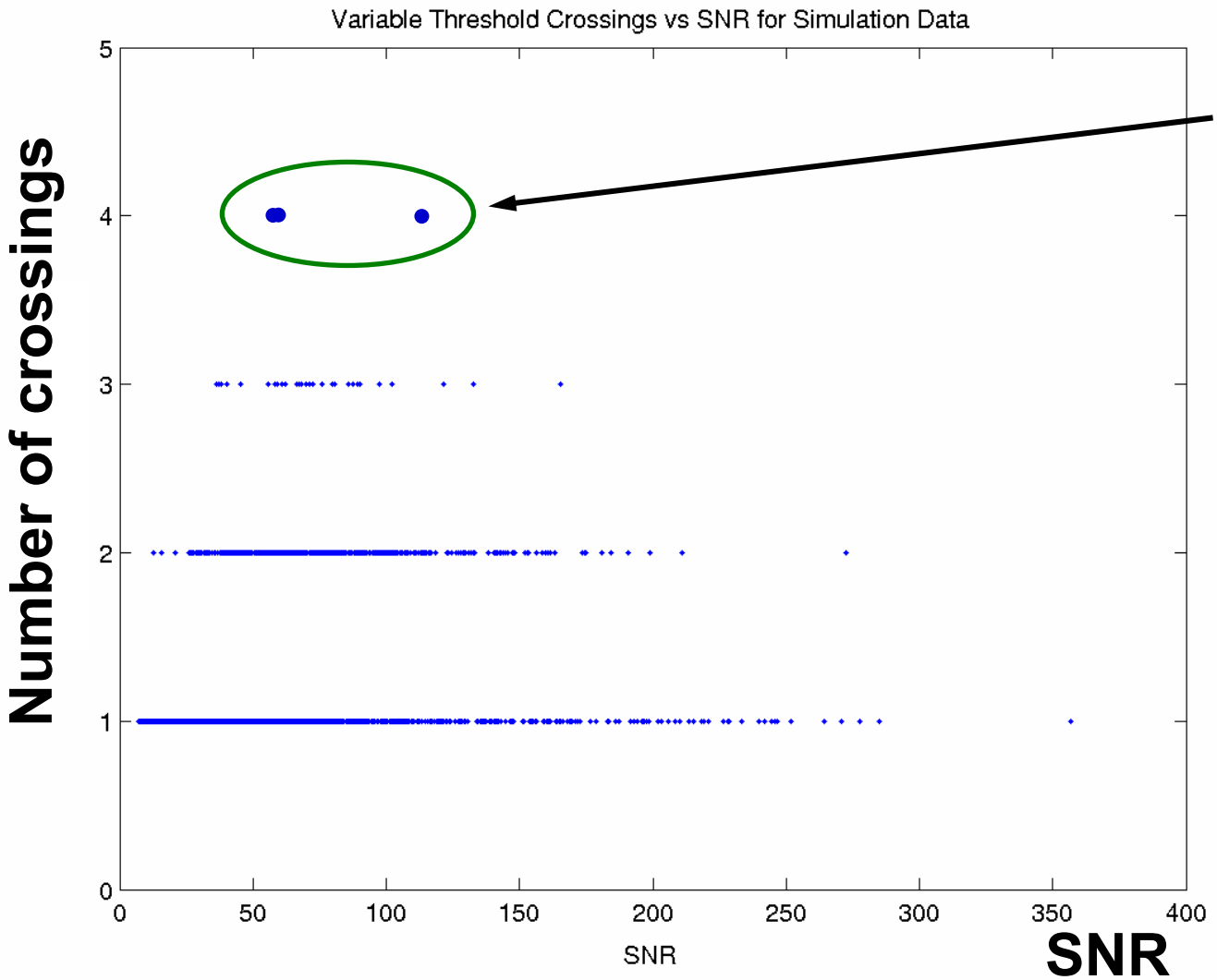
- (Chosen based on examining several of the loudest events)
- Fixed vs. adjusted SNR threshold
- A few different time windows

Re-ran the entire S1 inspiral analysis

- Analyzed full data set with Caltech LDAS
- Separate set of jobs with (software) injections, to calculate efficiency
- Stored triggers, with extra information, in database
- Studied effectiveness of the different test variations

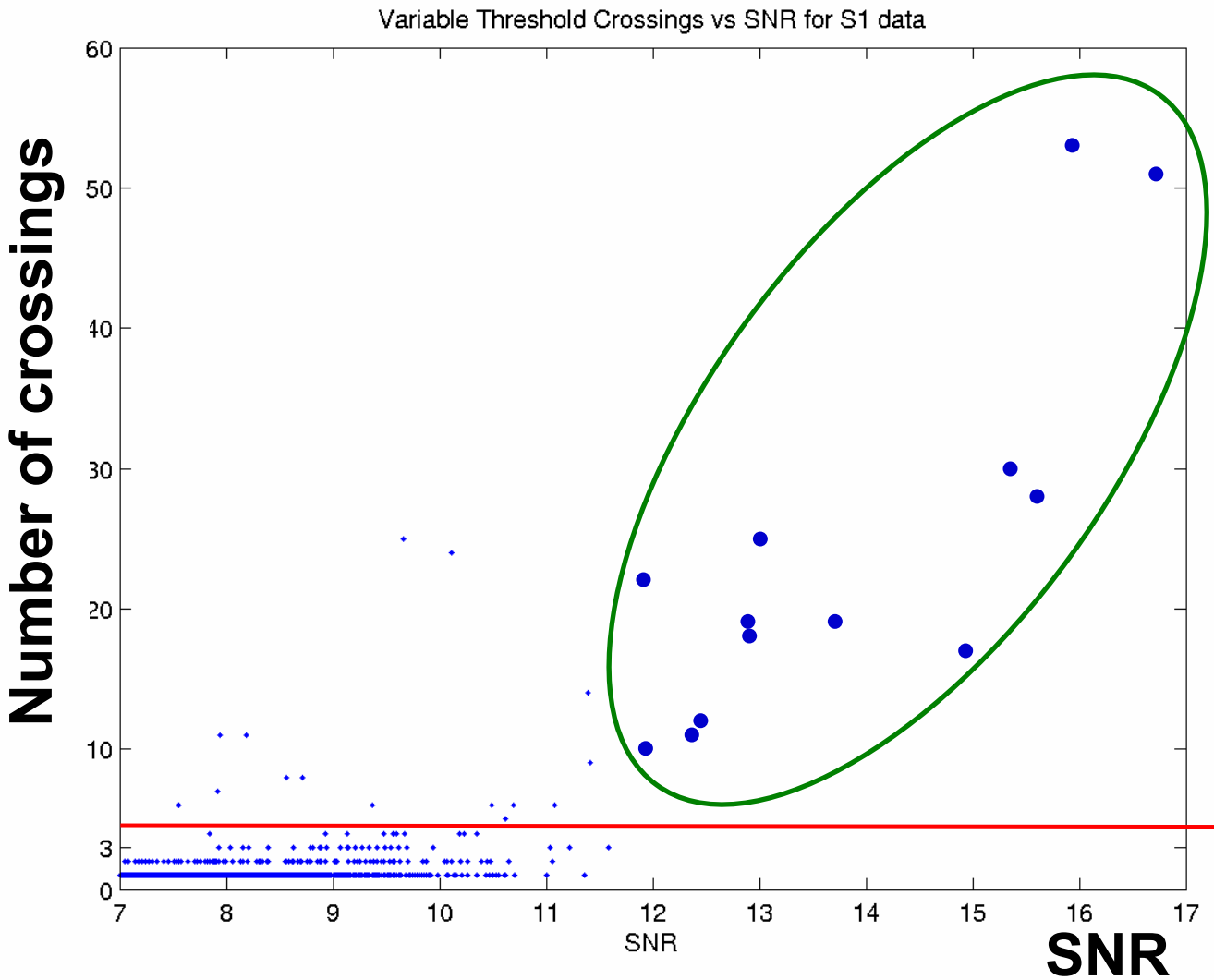
Test which seemed to provide best discrimination: number of crossings over adjusted SNR threshold

Results for Simulated Signals



3 simulated events out of 2905 have 4 crossings

Results for Data



Cutting events with more than 4 crossings eliminates the loudest 13 events !

Summary and Plans

A test of this sort would have cleaned up the S1 data

- Very clean – no inefficiency for signal ! (*** But tuned on these events)
- Reduced maximum SNR from 15.9 to 11.6
- Rate limit would have improved from 170 to 140 per year per MWEG

Needs to be properly incorporated into LAL

Should probably develop a more robust way to deal with large signals

Needs to be re-tuned using S2 playground data

Hopefully, this will help the S2 analysis significantly

- Especially since we've had limited luck with auxiliary-channel vetoes