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Data Quality and Vetoes in Searches for Compact Binary Coalescences and Gravitation Wave Bursts in LIGO's Fifth Science Run

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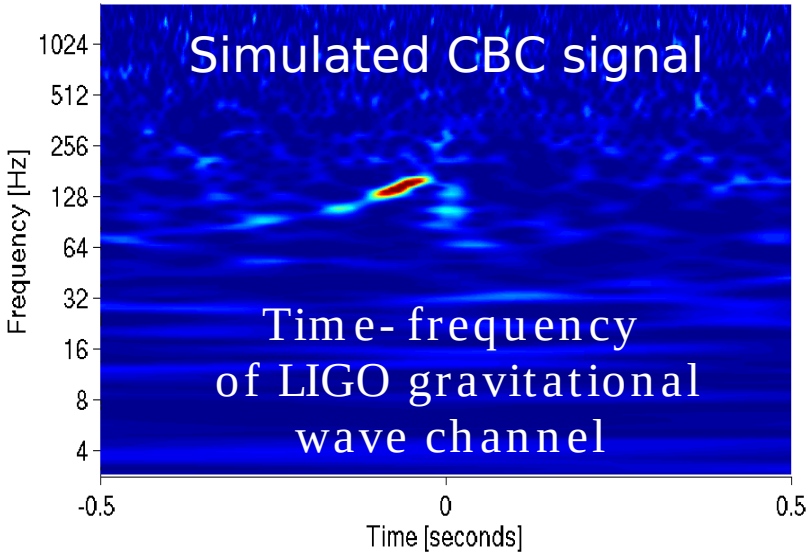
Motivation

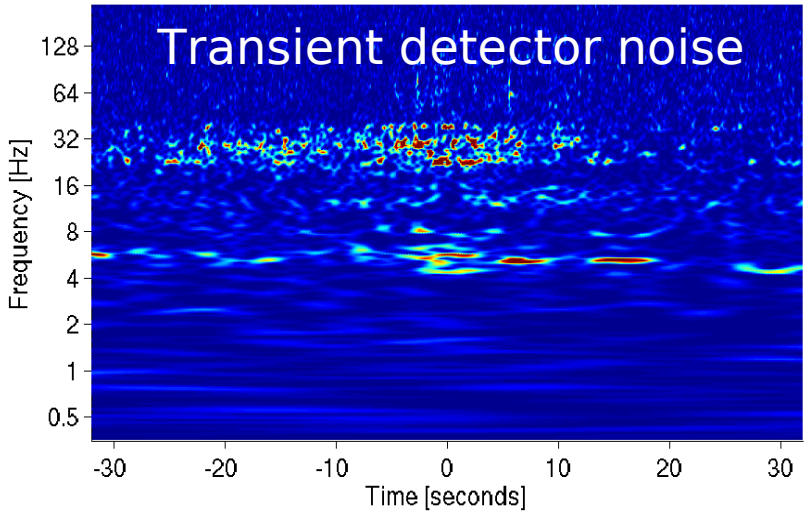
Gravitational wave searches for compact binary coalescences (CBCs) and un-modeled sources (Bursts), are hindered by the presence of transient, non-Gaussian detector noise, which can produce false signals.

Cannot rely on coincidence to get rid of all the transient noise

Use auxiliary channels to identify instrumental and environmental artifacts

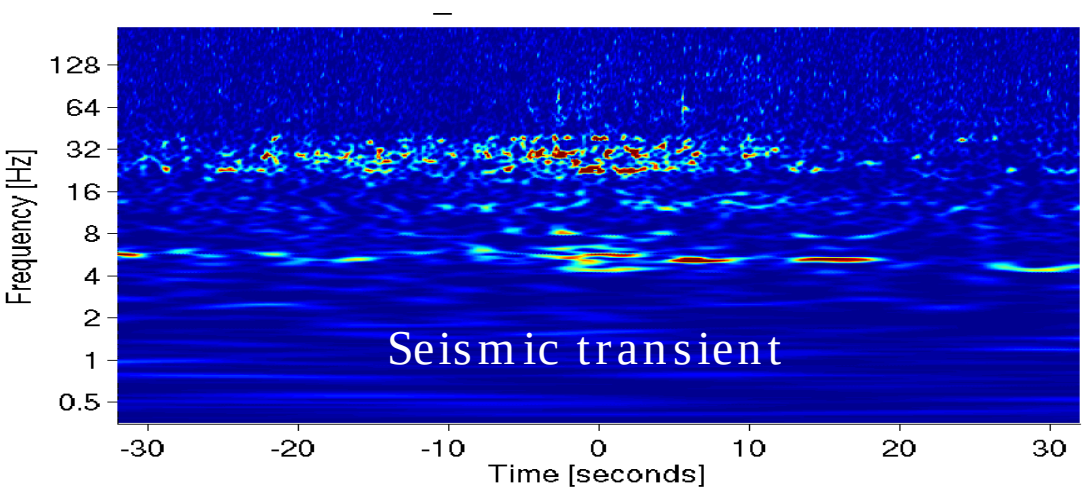
We find time intervals effected by these artifacts, and use them as vetoes in our searches.



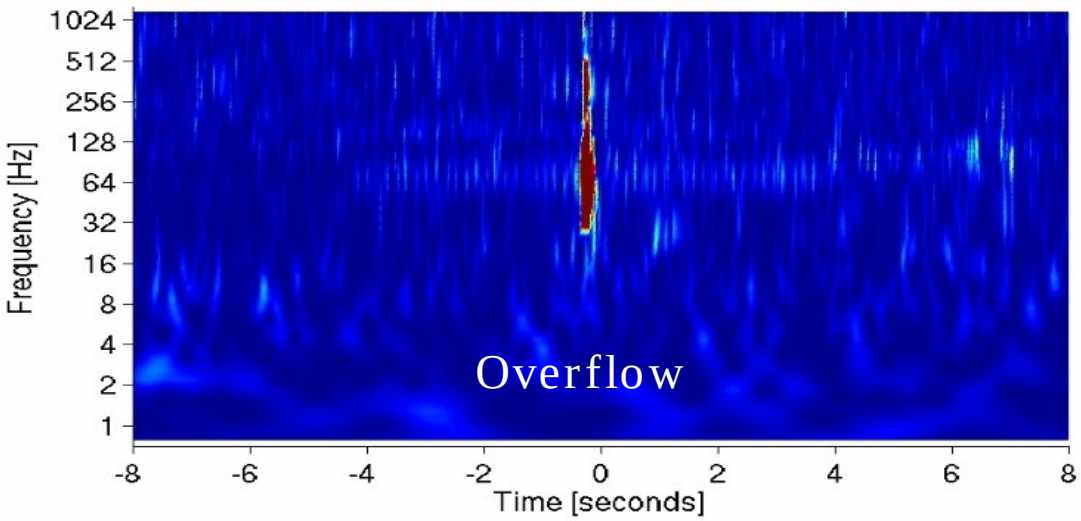


Transient noise sources

Transients of environmental origin:
- Seismic motion
- Acoustic motion
- Electromagnetic noise
- ...



Transient noise originating in the interferometers:
- Photodiode saturations
- Overflows in the digital control channels
- ...

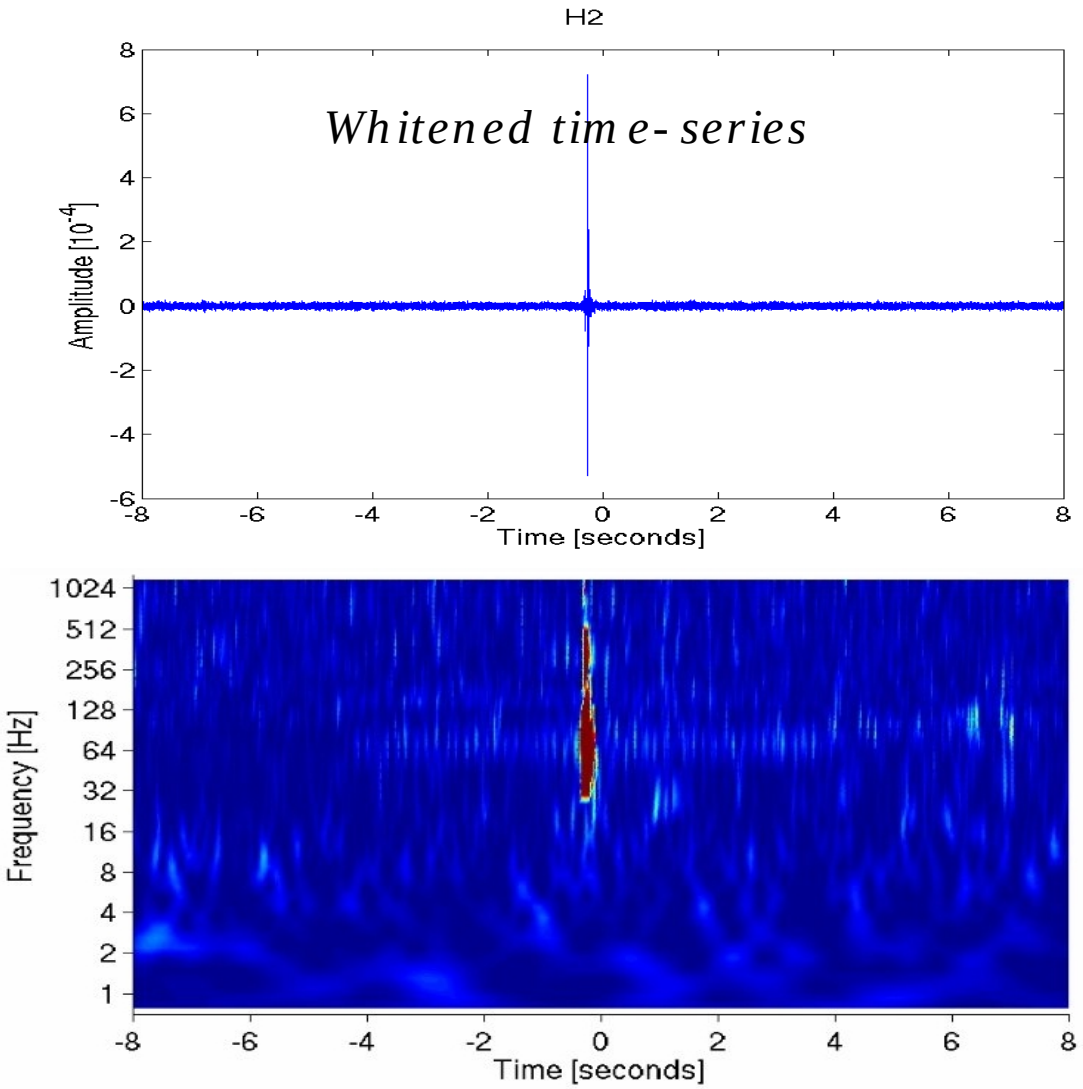


Example: Overflow in the feedback control loop signals

Overflows create glitches short in duration, broad in frequency.

They also create some of the loudest single-interferometer triggers for the CBC and GW burst searches.

We cannot rely on coincidence alone to assure they do not contaminate results.

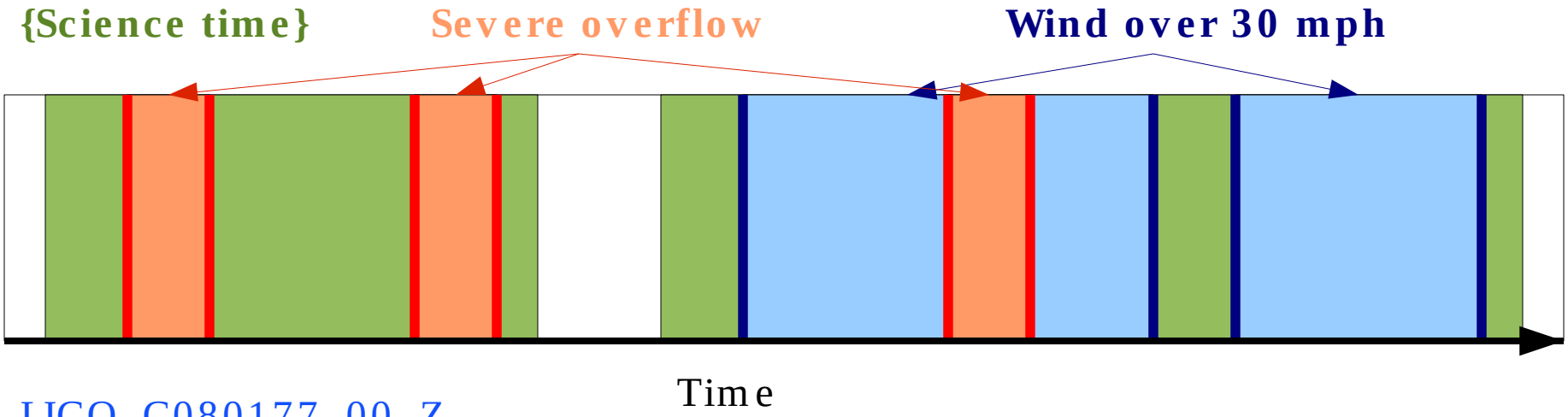


Data quality

Members of the LSC Detector Characterization Group investigate these transient noises.

Time intervals (segments) containing suspected artifacts are “flagged.” These flags are documented and published to the collaboration as a whole in a database.

The data analysis groups evaluate the usefulness and safety of each set of flags.



Veto evaluation

We evaluate DQ flags as vetoes using several metrics:

-Efficiency: percentage of triggers vetoed by DQ flag above a given threshold.

-Used fraction: percentage of the veto windows containing at least one trigger.

-Dead-time: percentage of the time analyzed that is removed by this veto.

-Safety: cannot use auxiliary channel that is sensitive to gravitational wave signals.

Veto evaluation

Example: overflow in feedback control loop signal

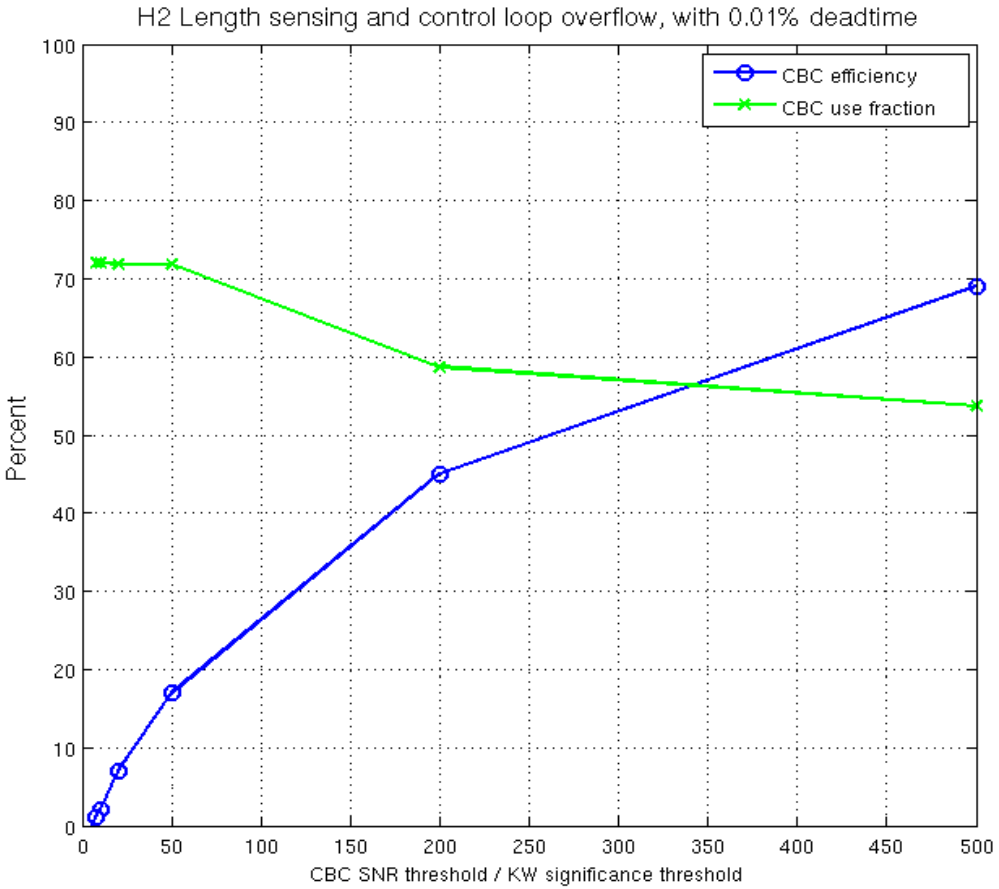
CBC:

Efficiency (SNR >8): 1%

Efficiency (SNR >50): 17%

Used Fraction(SNR >8): 72%

Dead time: 0.014%



SNR threshold

Veto categorization

We develop effective and safe vetoes of several categories:

Cat 1: Segments not to be analyzed by the search pipelines (*calibration problems, improper detector configuration...*)

Cat 2: Segments containing well understood problems (*overflows in control channels, glitches in the power lines...*)

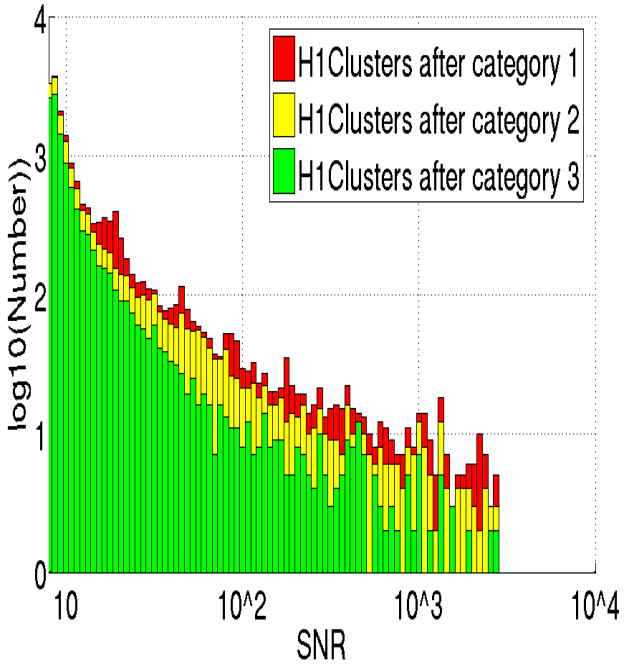
Cat 3: Segments containing incompletely understood problems, with positive correlation to loud triggers (*seismic noise, high winds, dips in power in the arms...*)

Cat 4: Segments not automatically used as vetoes, but to be considered when following up candidate events.

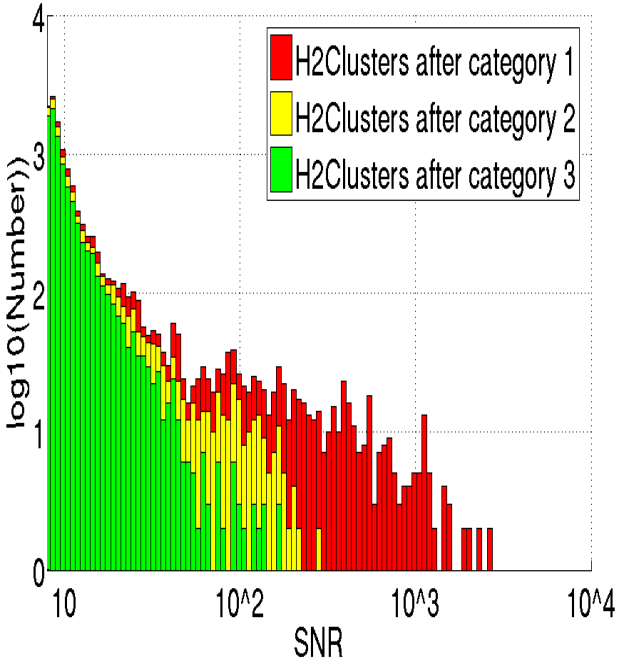
Effect of DQ vetoes on the CBC search

The effect of vetoes is different for each interferometer.

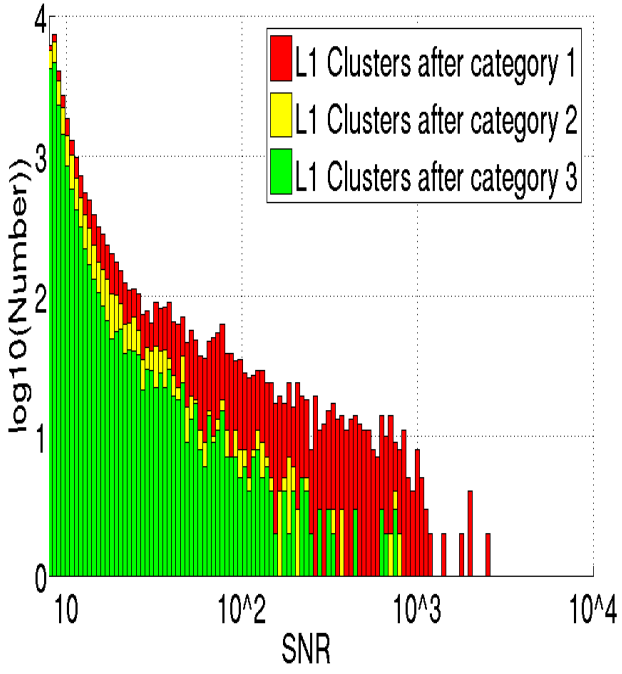
H1



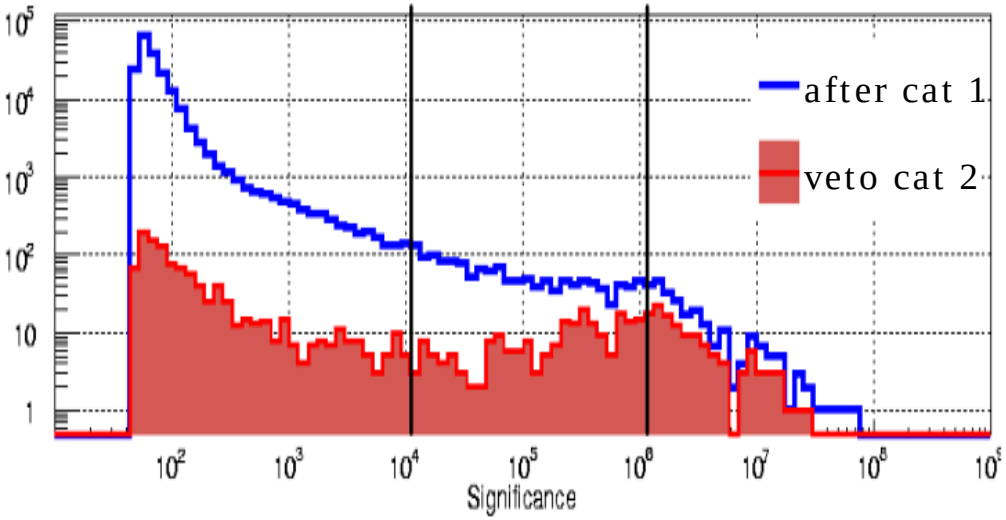
H2



L1



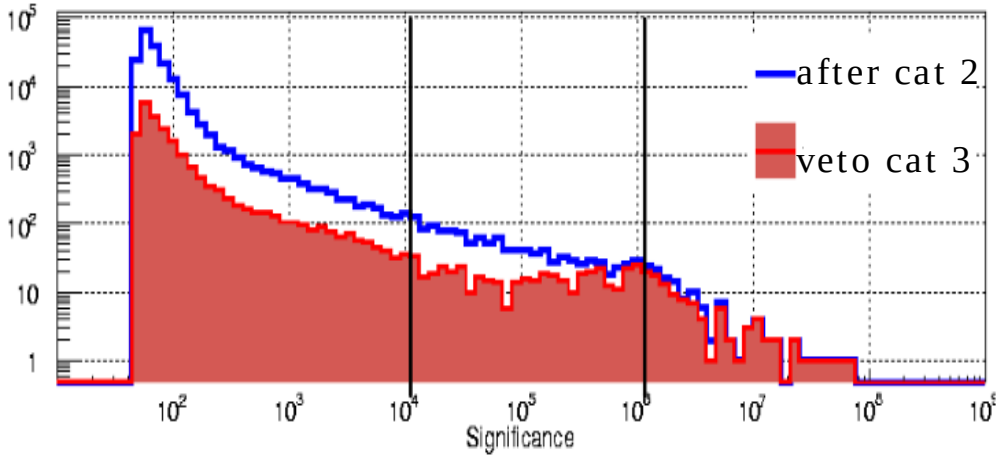
LIGO Effect of DQ vetoes on the Q-pipeline (burst) search

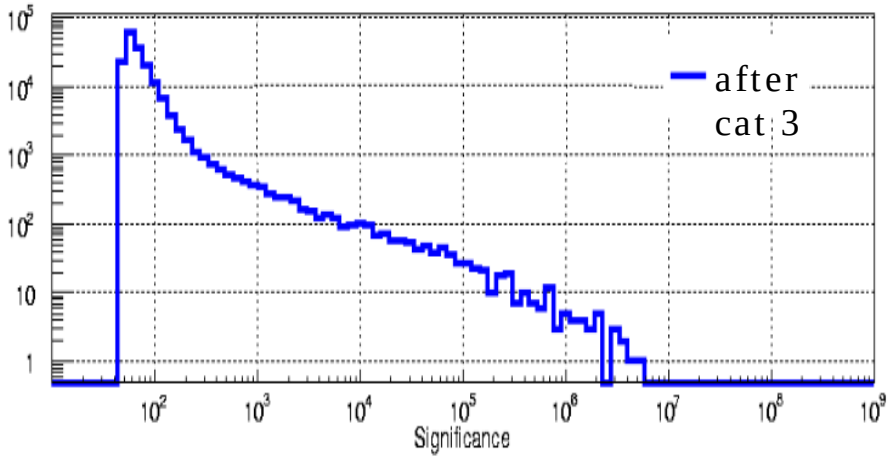


Trigger histograms from search of H1 data

Significance: Z = (SNR^2)/2

Dead time of cat2: 0.096%
Dead time of cat3: 5.889%





Summary

Searches for gravitational waves are impeded by false signals generated by transient detector noise.

We have defined time intervals effected by these artifacts, evaluated them for efficiency and safety, and categorized them to be used as vetoes.

These efforts reduced the amplitude and number of the loudest triggers from each search pipeline.