Search for Gravitational Wave Bursts in LIGO's S5 run

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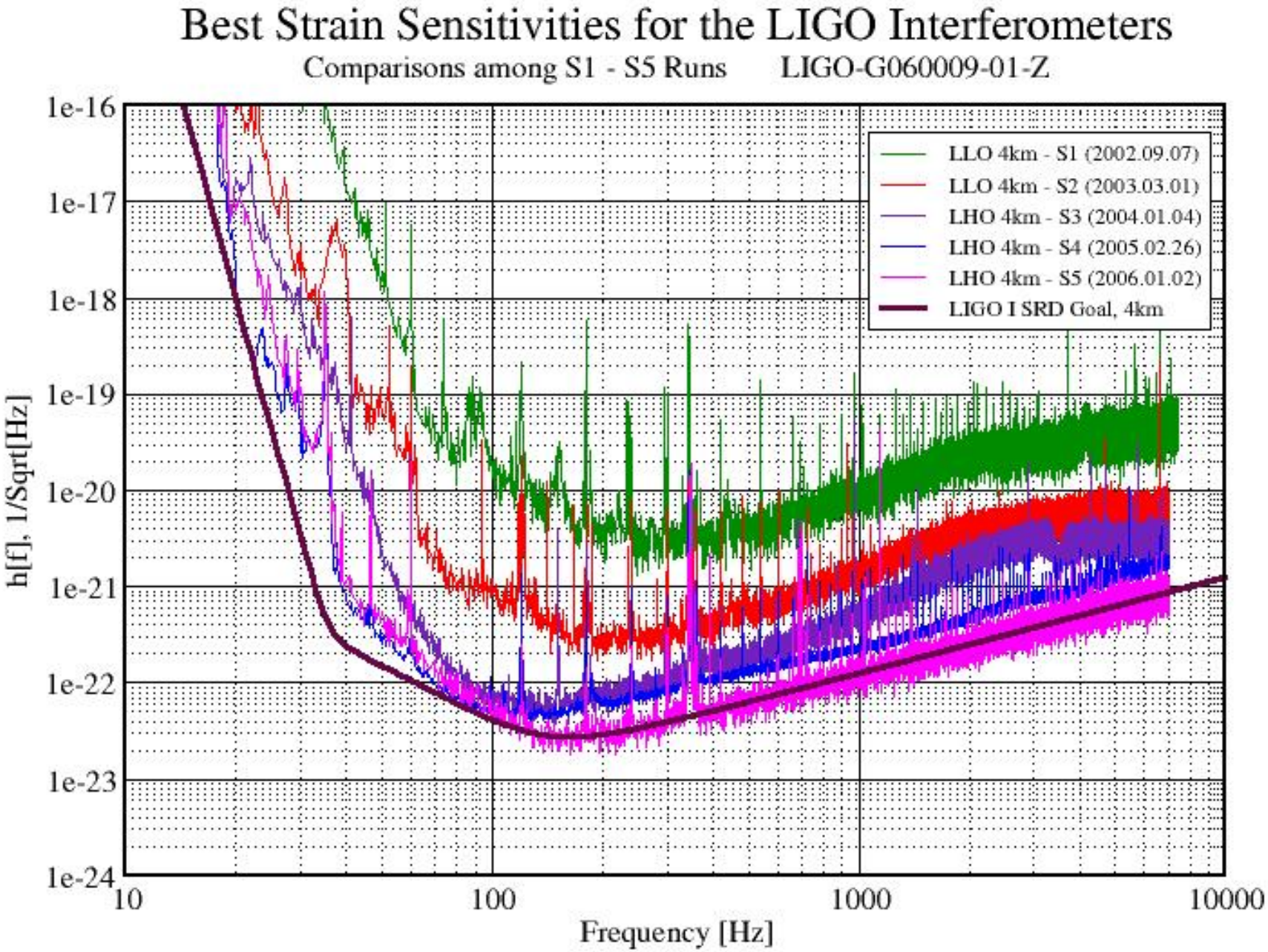
S5 run

- By the end of 2005, the LIGO detectors reached their design sensitivity. The S5 run started in November 2005, and is expected to collect a year's worth of coincident data. We present the status of the search for unmodeled short-duration bursts during the first few months of the S5 run: between Nov 14 2005 and Feb 1 2006.
- The typical binary inspiral range for 1.4/1.4 Msun:
  - H1: 12 Mpc;
  - H2: 5.2 Mpc;
  - L1: 10.4 Mpc.
- However, the interferometer sensitivity continues to improve during the run and is better now than at the beginning of S5.


Best Strain Sensitivities for the LIGO Interferometers
Comparisons among S1 - S5 Runs
LIGO-G060009-01-Z
LLO 4km - S1 (2002.09.07)
LLO 4km - S2 (2003.03.01)
LHO 4km - S3 (2004.01.04)
LHO 4km - S4 (2005.02.26)
LHO 4km - S5 (2006.01.02)
LIGO I SRD Goal, 4km
h[f], 1/Sqrt[Hz]
1e-16
1e-17
1e-18
1e-19
1e-20
1e-21
1e-22
1e-23
1e-24
10
100
1000
10000
Frequency [Hz]

Data analysis pipeline

- In S5 we use the same burst search pipeline as was applied to S2, S3 and S4.
- We distinguish between an online high threshold analysis (HTA) and offline final low threshold analysis (LTA):
  - HTA:
    - Quickly learn about obvious loud events;
    - Detector characterization.
  - LTA:
    - Once all the data quality (DQ) cuts and vetoes are defined (months after data is collected), we do the final LTA.
- This talk presents the results of high threshold online analysis on data from the beginning of S5.

Data analysis pipeline

- Data Selection
- WaveBurst is a time-frequency wavelet-based method for searching for short duration bursts; it is used for the initial generation of triple coincidence candidate triggers and determining their properties (time, duration, frequency, bandwidth, SNR, strength, etc); 100+1 time shifts for background estimation; 64-2048Hz
  - significance cut;
  - H1/H2 amplitude cut; $1/2 < \frac{hrss_{H_1}}{hrss_{H_2}} < 2$

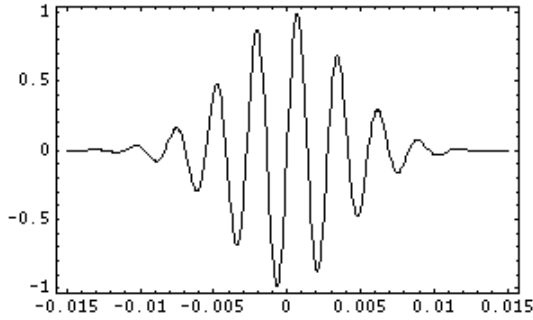
$$hrss = \sqrt{\int |h(t)|^2 dt}$$

- CorrPower computes correlation of time series for all pairs of detectors around triggers, found by WaveBurst, and estimates the similarity of the waveforms in different detectors;
  - H1/H2 correlation sign cut;
  - significance cut.
- Final data quality and veto cuts
- Output: N +M triggers
  - N background triggers in 100 non-zero time lags;
  - M foreground triggers.
- High vs low threshold analysis:
  - Preliminary calibration;
  - Online preliminary data selection;
  - High WaveBurst significance threshold;
  - Preliminary minimal choice of CorrPower significance cut;
  - No data quality or veto cuts.

Sensitivity

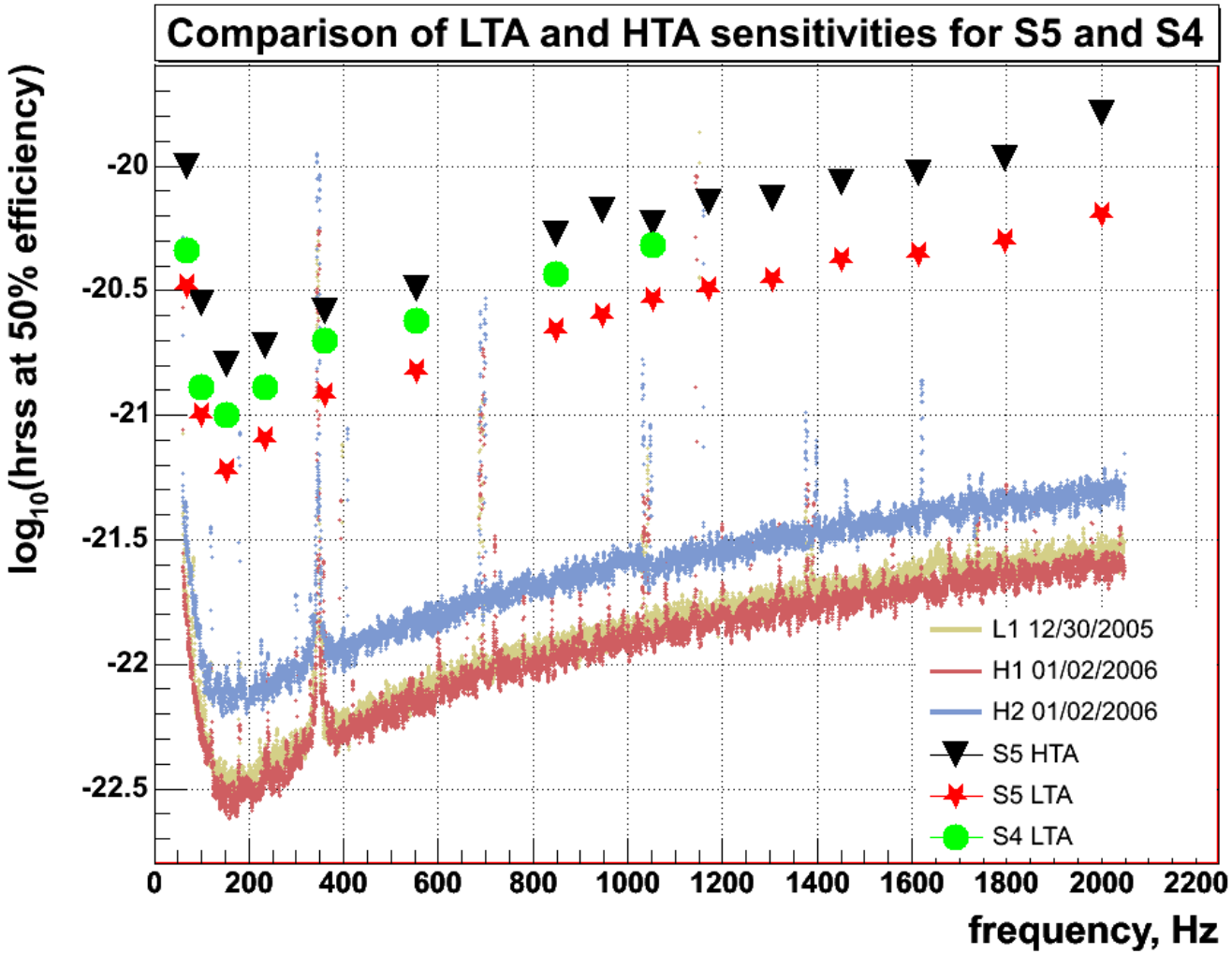
$$h(t) = h_0 \sin(2\pi f t) \exp\left(-2\left(\frac{\pi f t}{Q}\right)^2\right)$$

$$Q = 9$$

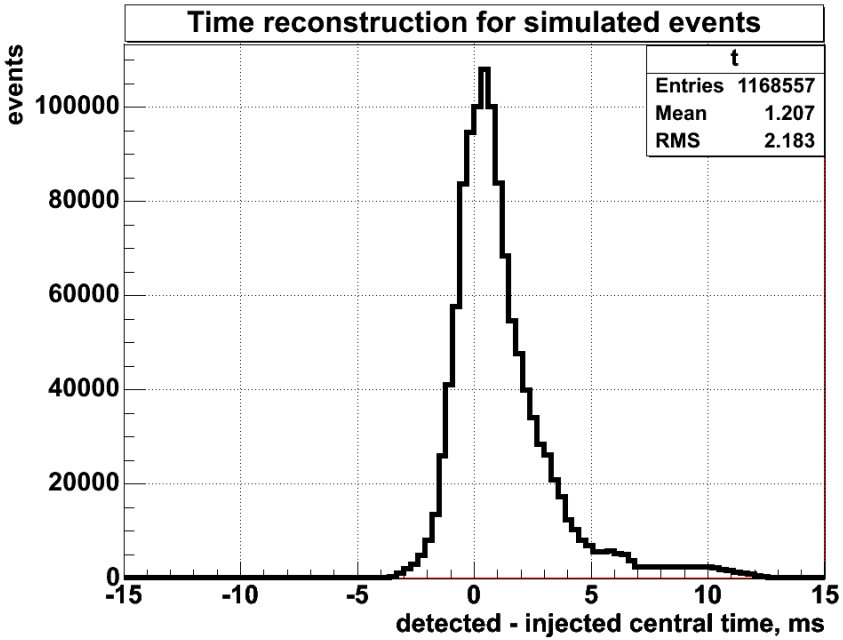


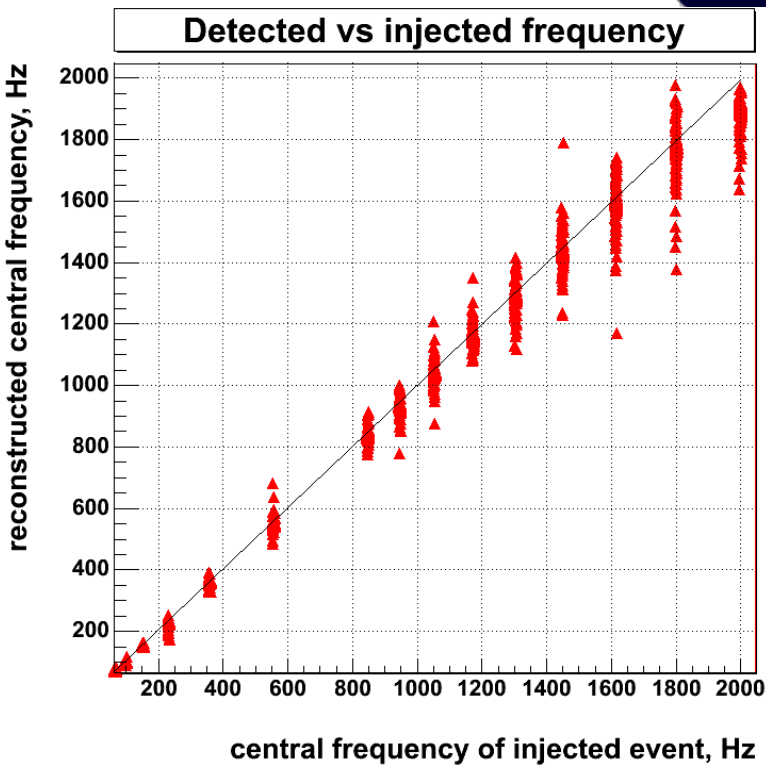
- The sensitivities are estimated by adding sine-gaussian signals to raw data:

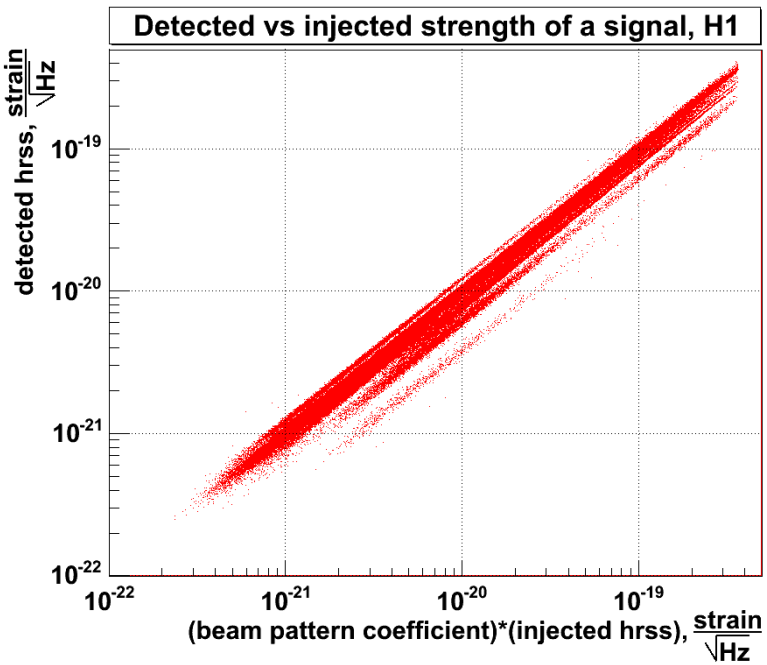
- The sensitivities are measured in terms of hrss at which 50% of injected signals are detected.
- All sky search: the source sky location and polarization are chosen randomly for each simulated signal.
- Linear polarization.
- S5 HTA is about 2.5 times less sensitive than what we expect from the final S5 LTA.
- The expected sensitivity of S5 LTA is about 1.5 times better than for S4 LTA.



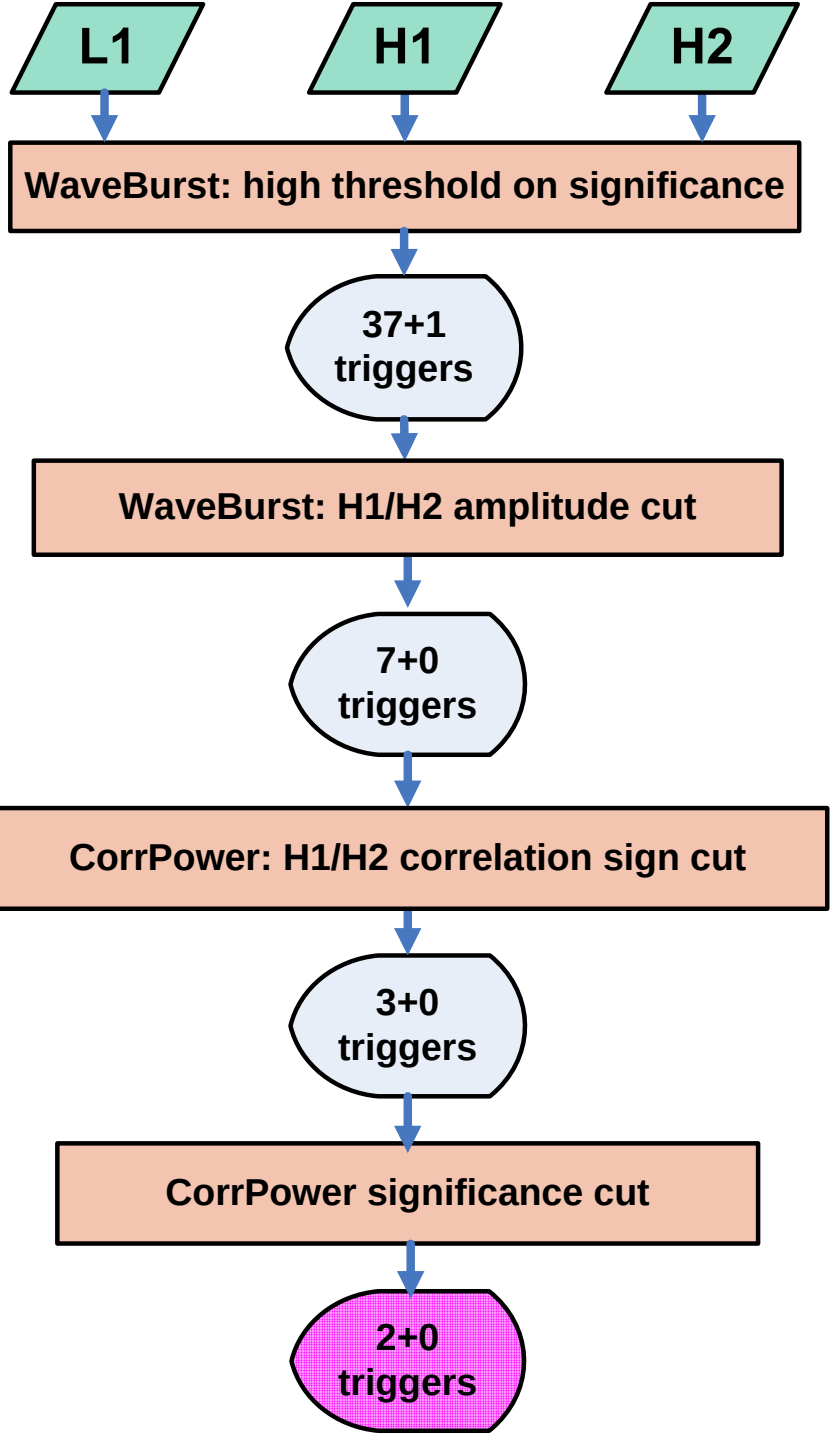
Event property reconstruction







- The time of an event can be reconstructed with a precision of a few milliseconds;
- Very good frequency reconstruction;
- hrss is reconstructed well for most of the frequencies, except for those that are too close to 64 or 2048 Hz frequency boundaries of the search; for such events part of an energy is outside of the bandwidth of the search and is lost.



Loud triggers study

- The remaining two background triggers at non-zero time lags:
  - have central frequency around 80-90Hz;
  - are due to strong glitches in H1 and H2 coinciding with some noise in L1;
- No gravitational waves identified so far.

Conclusion

- The high threshold analysis of the first few months of S5 found no credible gravitational wave events.
- After all data quality flags and vetoes are defined, we shall reanalyze data using low threshold to obtain final results.
- We shall continue processing S5 data in this fashion: high threshold online analysis followed by the final low threshold offline analysis.
- According to the preliminary estimates, we expect to be about 50% more sensitive in S5 than in S4.
- Much longer S5 run should lead to much lower rate limit or discovery.