Status of the untriggered burst search in S3 LIGO data

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LIGO-G040530-00-Z

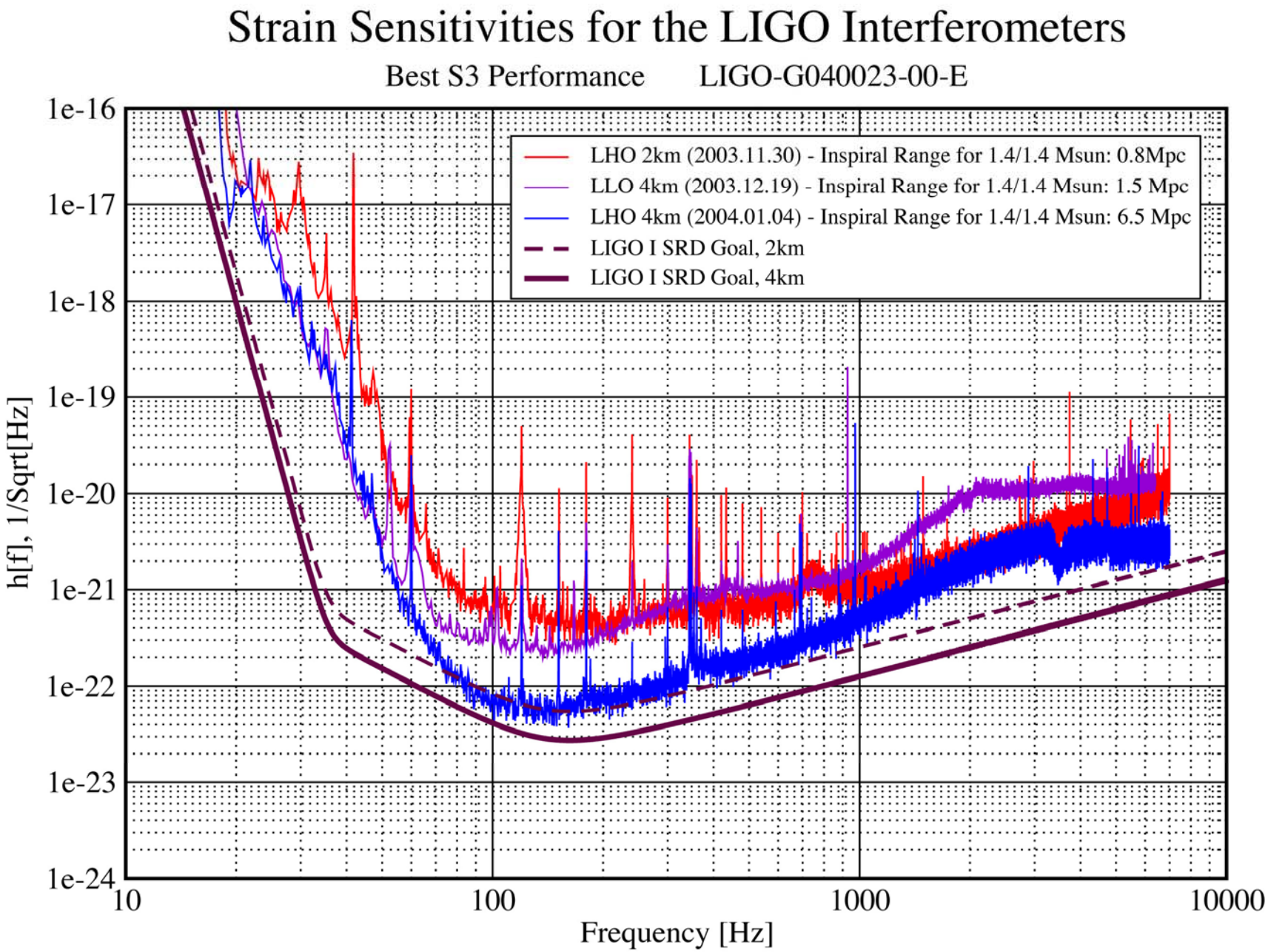
Overview

- **Differences in comparison with S2 run**
  - **Data quality**
  - **Analysis pipeline: same as in S2 with a few improvements:**
    - **Multiple time-frequency resolution in waveburst**
    - **r-statistics upgrade**
    - **Amplitude cut**
- **Results on S3 playground**
  - **Background rate**
  - **Detection efficiency**
  - **Event property reconstruction**
- **Summary & Plans**

S3

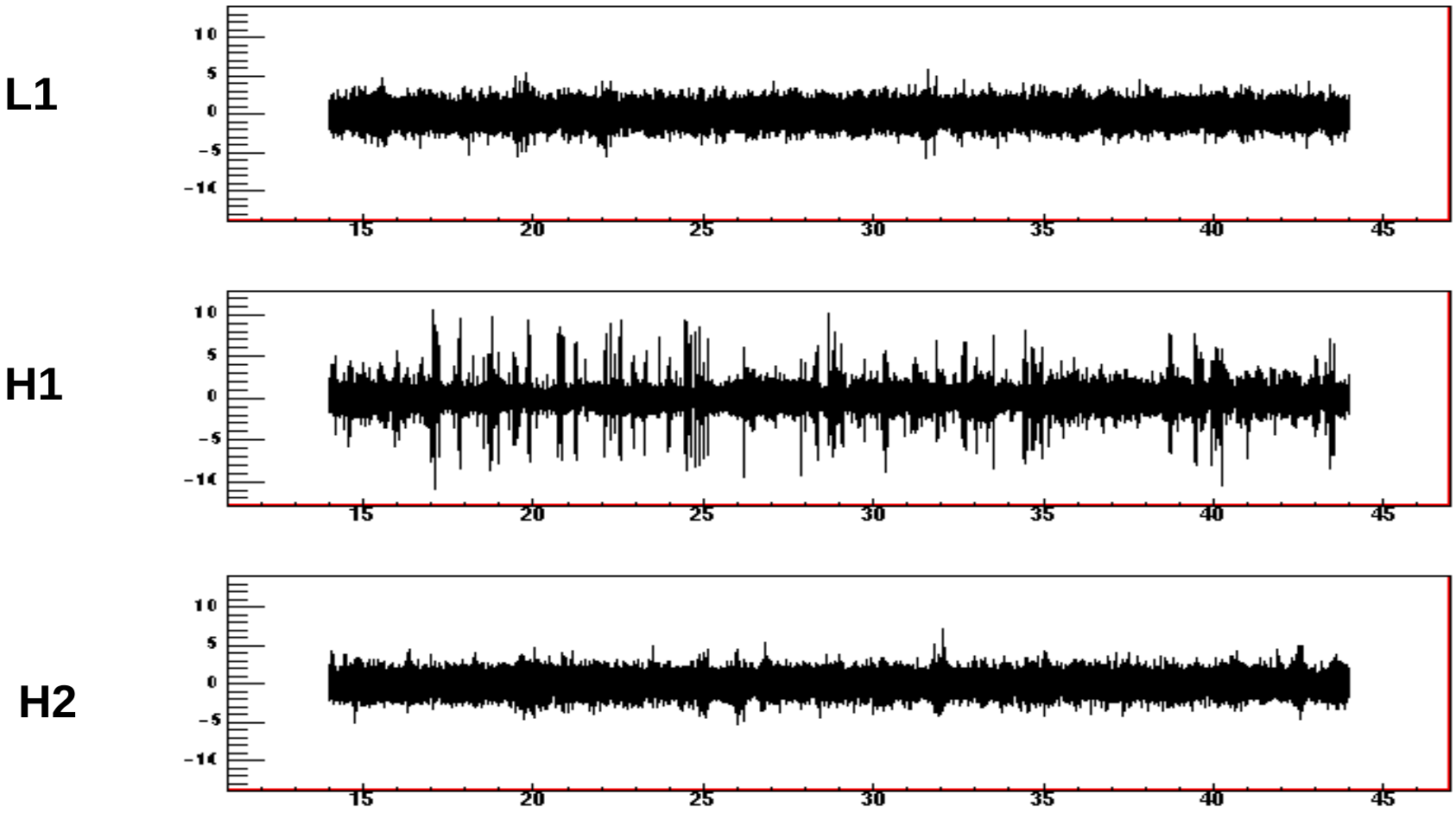
- Dates: 10/31/2003 - 01/09/2004
- Triple coincidence playground lock segments: 73600 seconds (~10% of the total S3 data)
- H1 – the most sensitive but also the most glitchy detector

S3 data


Strain Sensitivities for the LIGO Interferometers
Best S3 Performance
LIGO-G040023-00-E
LHO 2km (2003.11.30) - Inspiral Range for 1.4/1.4 Msun: 0.8Mpc
LLO 4km (2003.12.19) - Inspiral Range for 1.4/1.4 Msun: 1.5 Mpc
LHO 4km (2004.01.04) - Inspiral Range for 1.4/1.4 Msun: 6.5 Mpc
LIGO I SRD Goal, 2km
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]

S3 data glitches

- More glitches (H1xH2xL1 rates 20 times higher then for S2)



WaveBurst upgrade since S2

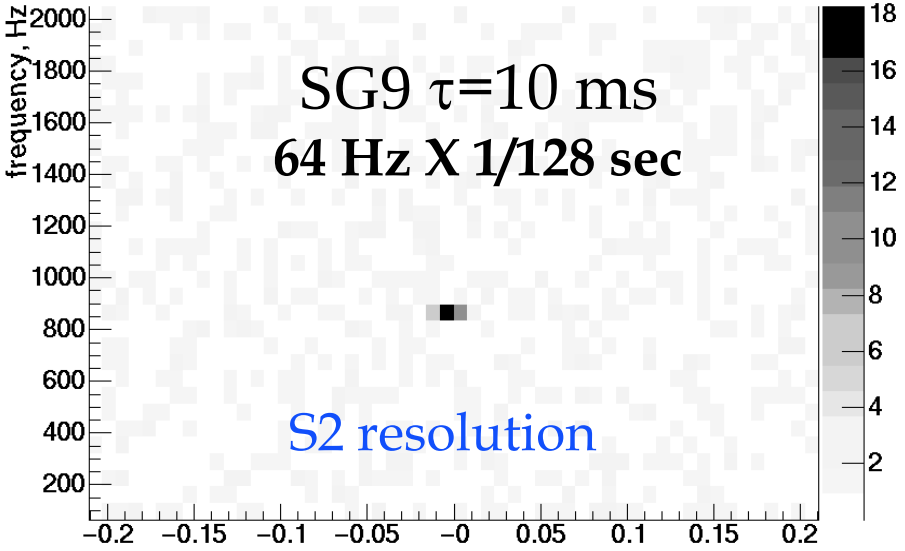
- The search band 64-1100 Hz
- Multiple TF resolution
  - Better sensitivity, especially at low frequencies
  - Allowed to detect longer duration signals
  - Detection is less dependent on the waveform morphology
- Data conditioning: better handling of non-stationarity
- Single and coincident detector options
  - Run triple H1xH2xL1 configuration for this study
  - Can run on any combination of ifos or on a single detector
- Different analysis environment: DMT+Condor
  - Shorter development cycle
  - Much faster
  - Simplify debugging, validation and testing

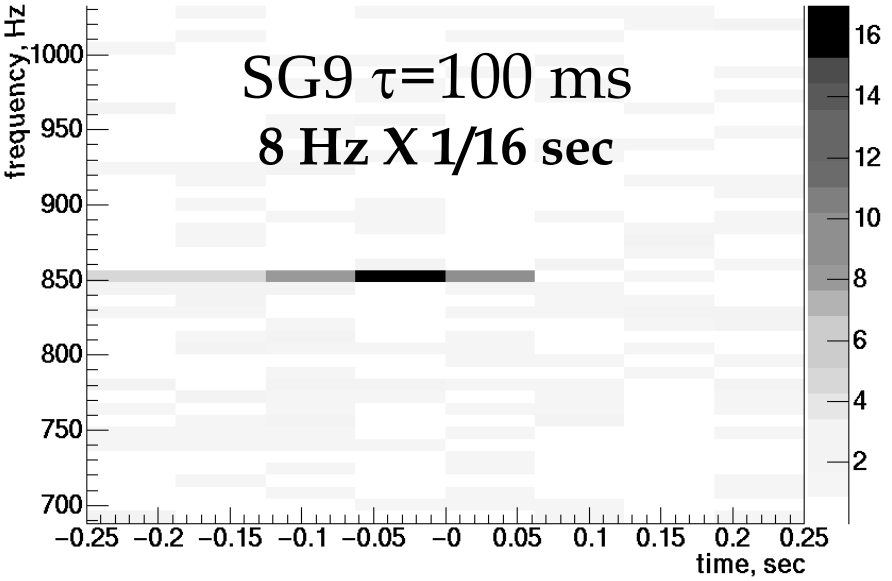
Multiple TF resolution

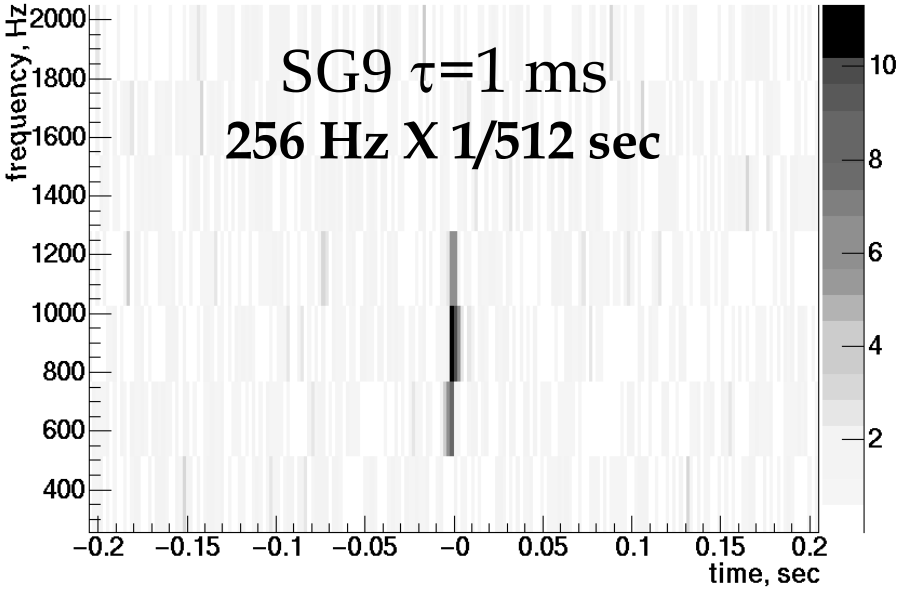
- Run S3 analysis at 6 different TF resolutions:

8-16-32-64-128-256 Hz

$\Delta T \sim 0.002 - 0.1$ sec







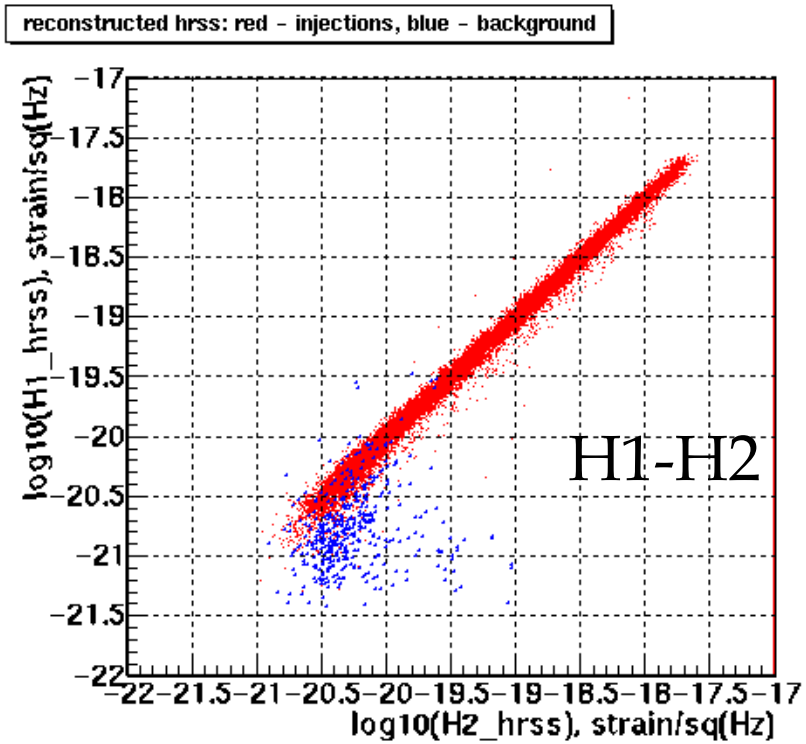
R-statistics upgrade

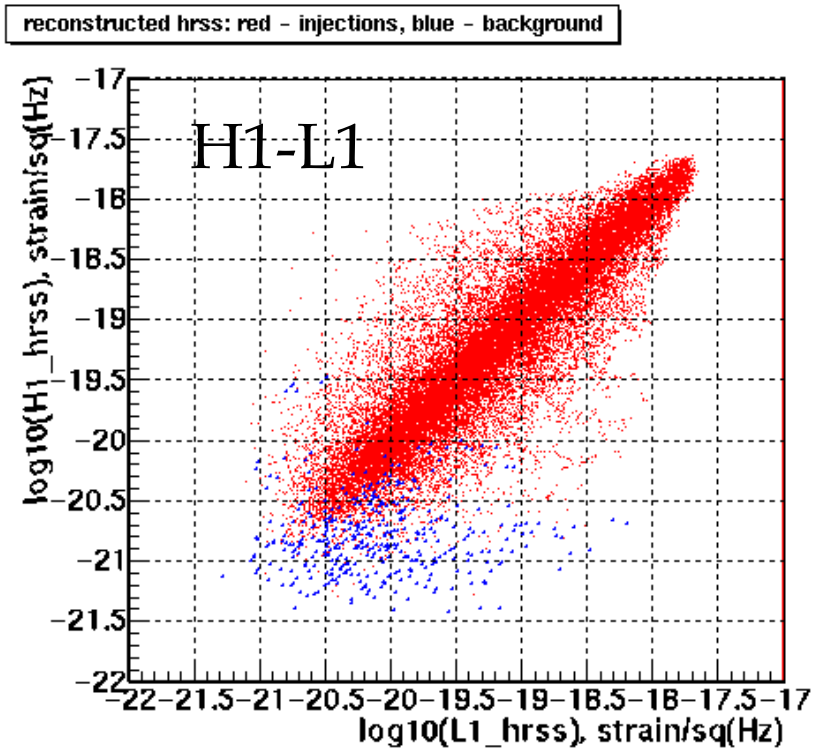
L. Cadonati

- improved data conditioning (better band-pass, higher resolution in linear predictor filter)
- use frequency-domain calibration (in S2 uncalibrated data was used)
- allow for 1 ms between H1-H2 and 11 ms between LLO-LHO (in S2 10ms was used for all pairs)
- tunable overlap between consecutive windows (50% in S2, 99% in S3).

Amplitude cut

- In comparison with S2 analysis, a new selection cut was added - H1/H2 amplitude consistency check. Because of the same beam pattern functions the H1 and H2 interferometers are detecting the same GW waveforms. Therefore the measured hrss should be consistent within the amplitude resolution of the WB method and the calibration errors.





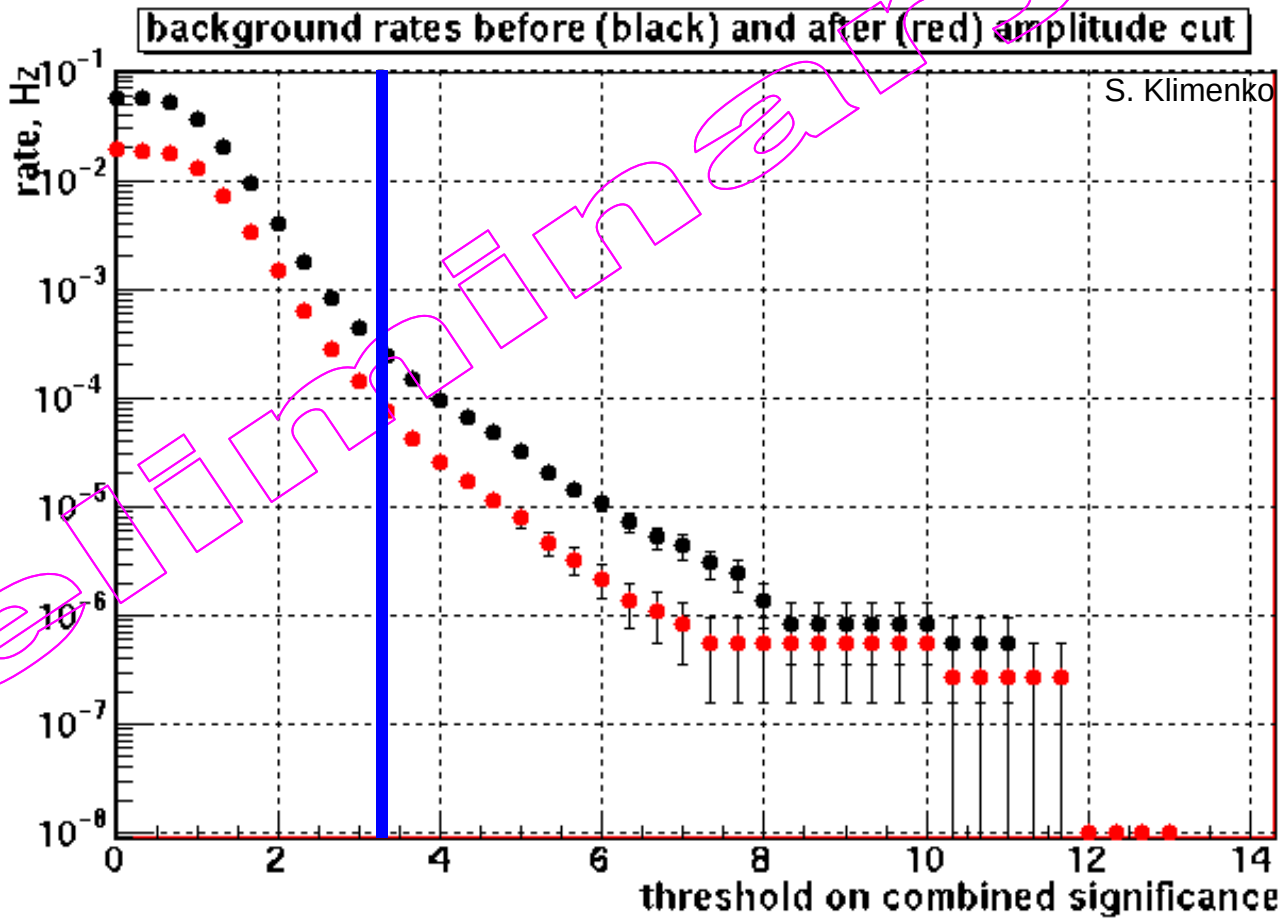
Amplitude cut

$$\left|\log_{10}\left(\frac{hrss(H1)}{hrss(H2)}\right)\right| < 0.3$$

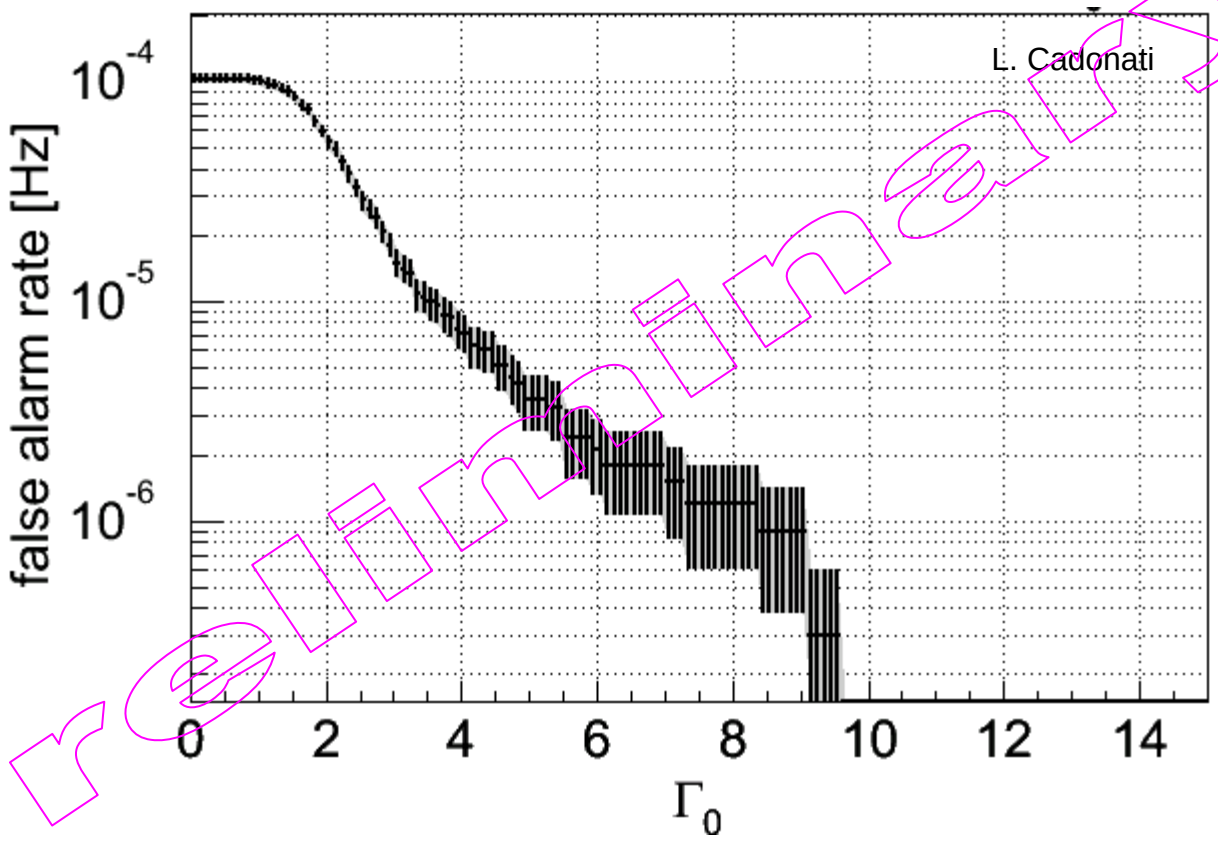
- Rejection fraction for software injections: 0.4%
  - All injection waveforms are cut about equally
- Rejection fraction for background events: 76%
  - Mostly low frequency noise events in the band 64-300 Hz are removed

Background rate after waveburst

- Background rate is computed using 50 time lags



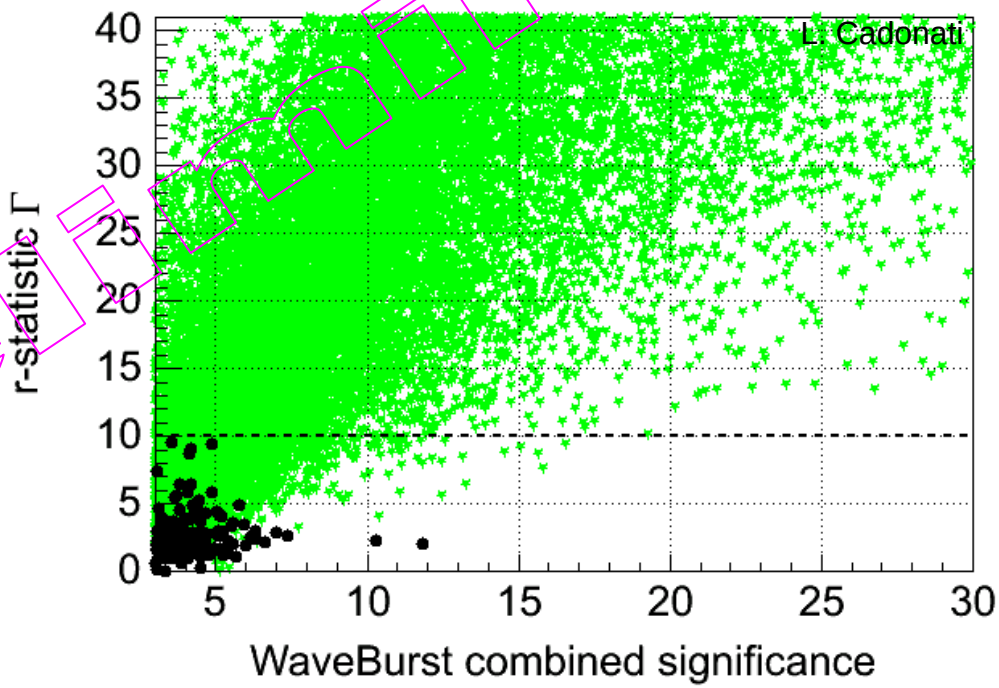
R-statistics test



Threshold selection

- Suggested thresholds
  - WaveBurst: 3.2
  - R-statistics: 10
- Resulting background rate is < 0.2 μHz

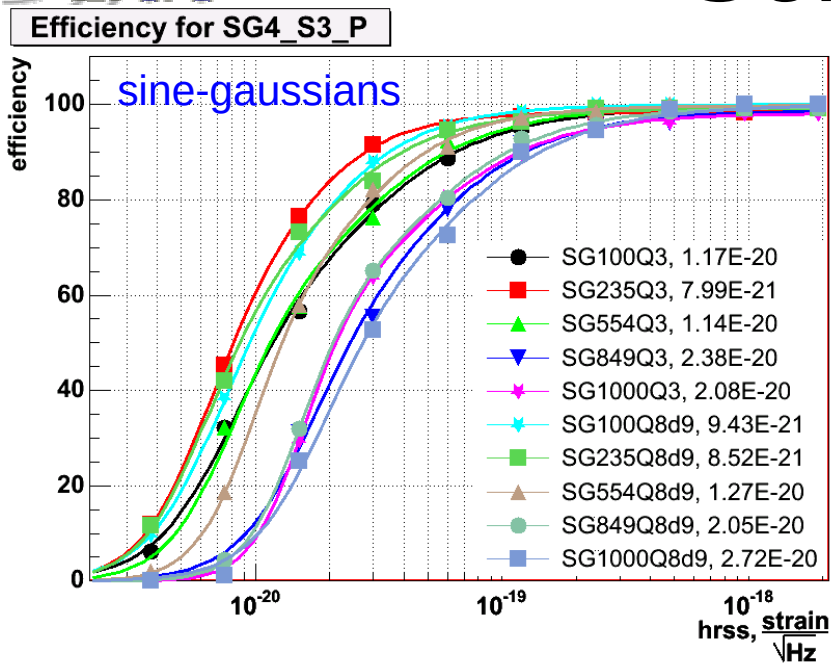
Background - black
Injections - green

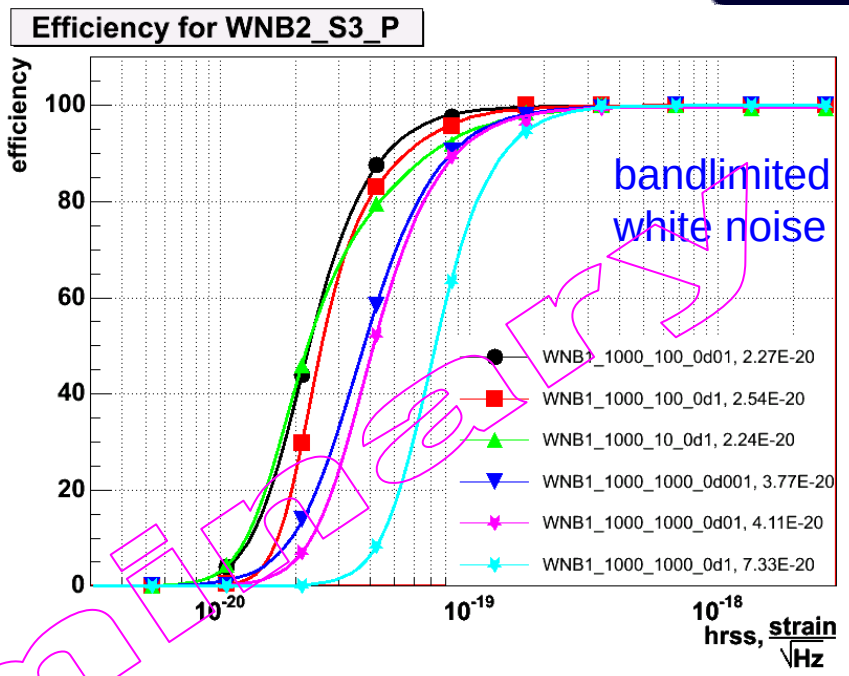


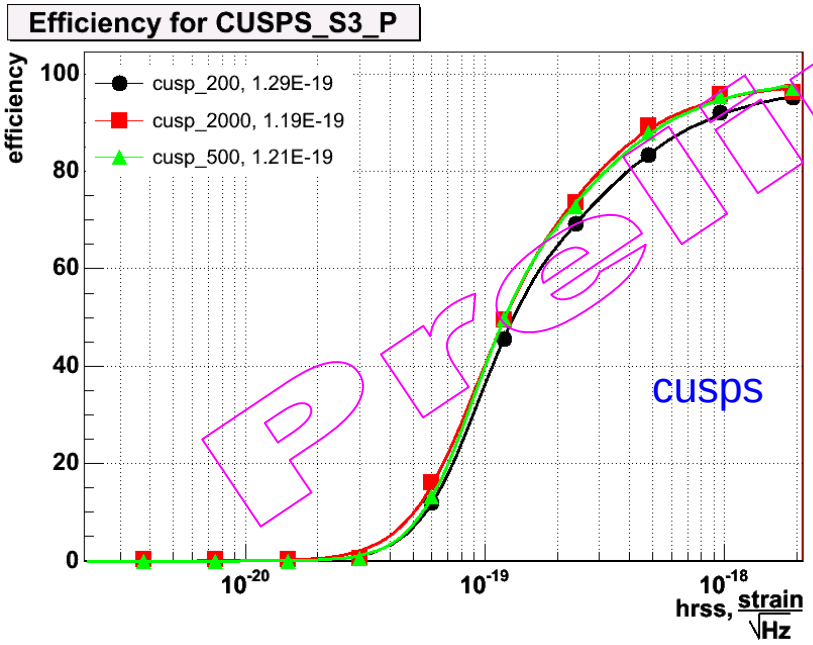
Sensitivity study

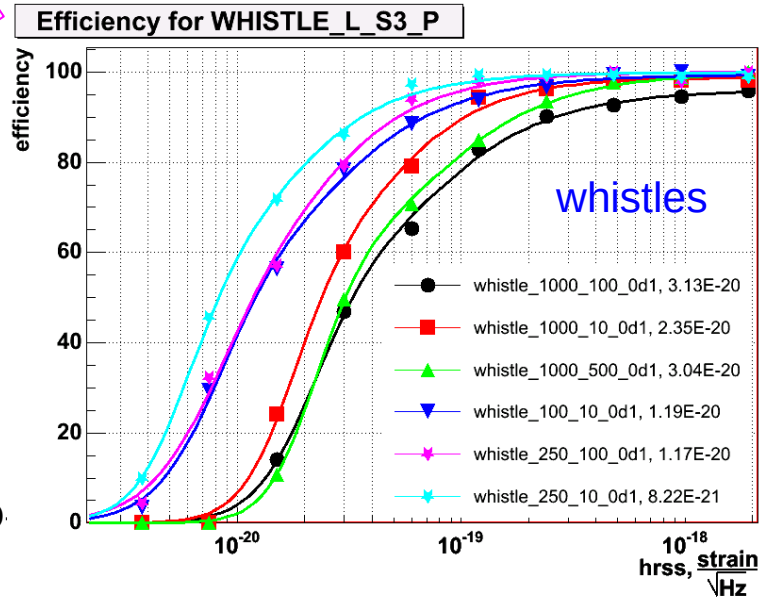
- In S3 we use much bigger variety of waveform morphologies (58 waveforms) than in S2:
  - Short and long duration sine-gaussians
  - Gaussians
  - Cusps
  - White band-limited noise with large TF volume
  - Whistles
  - BH10-BH10 inspiral
  - Some supernova collapse waveforms.
- Duration from 0.1 to 100 milliseconds
- TF volume 1-100
- Total number of injections ~100,000

Sensitivity study









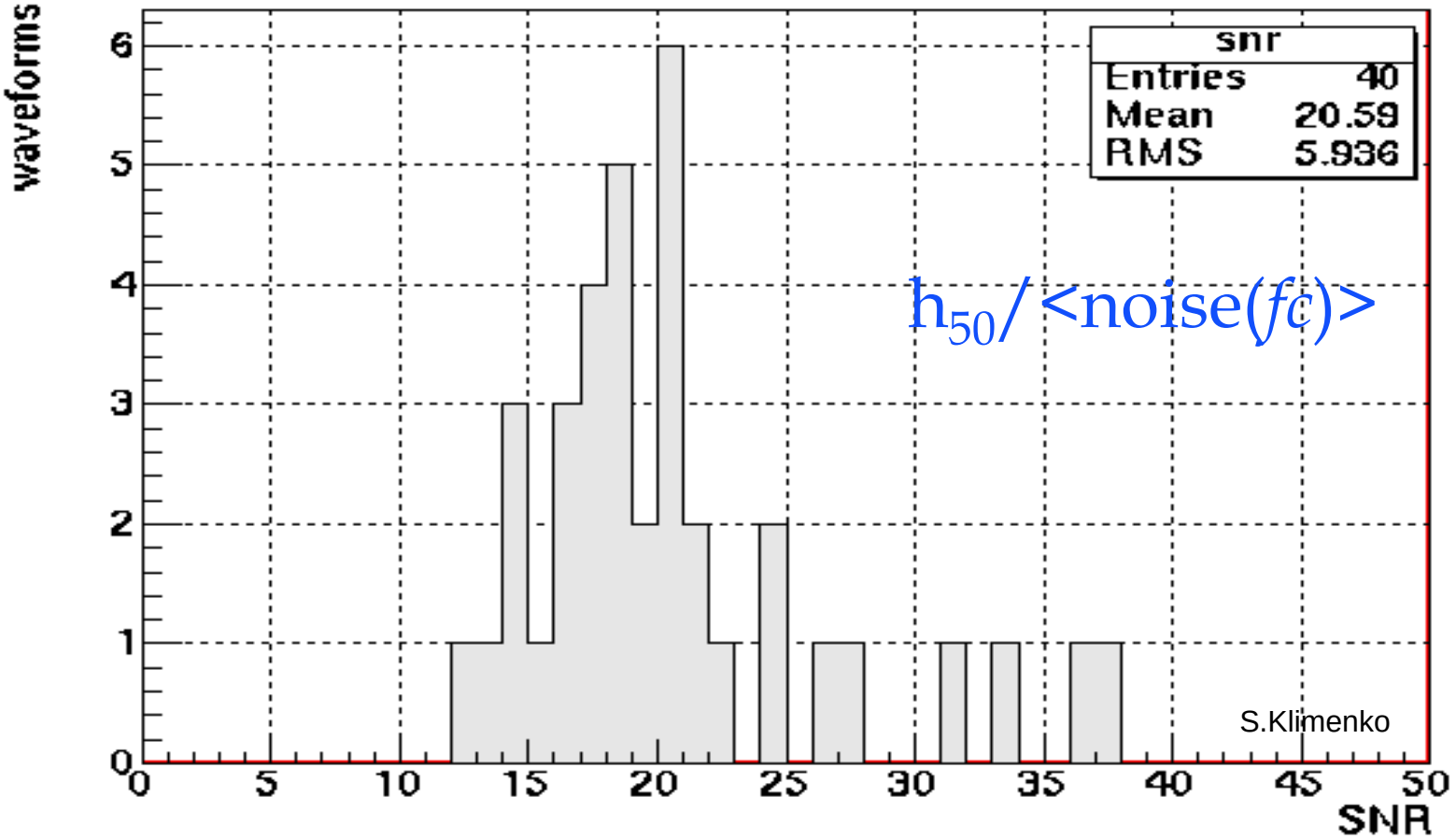
Sensitivity study: comparison with S2 for sine-gaussian injections

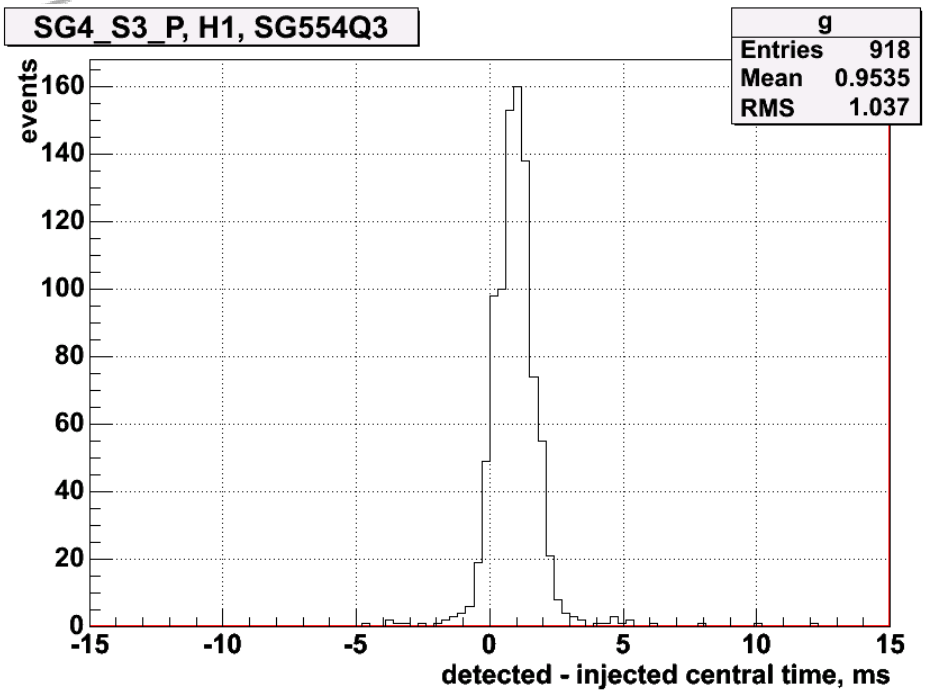
The table compares hrss at 50% efficiency measured in units of $10^{-20}\ \frac{strain}{\sqrt{Hz}}$

Freq, Hz	100	235	554	849
S2	7.96	1.33	2.17	3.64
S3	0.94	0.85	1.27	2.05

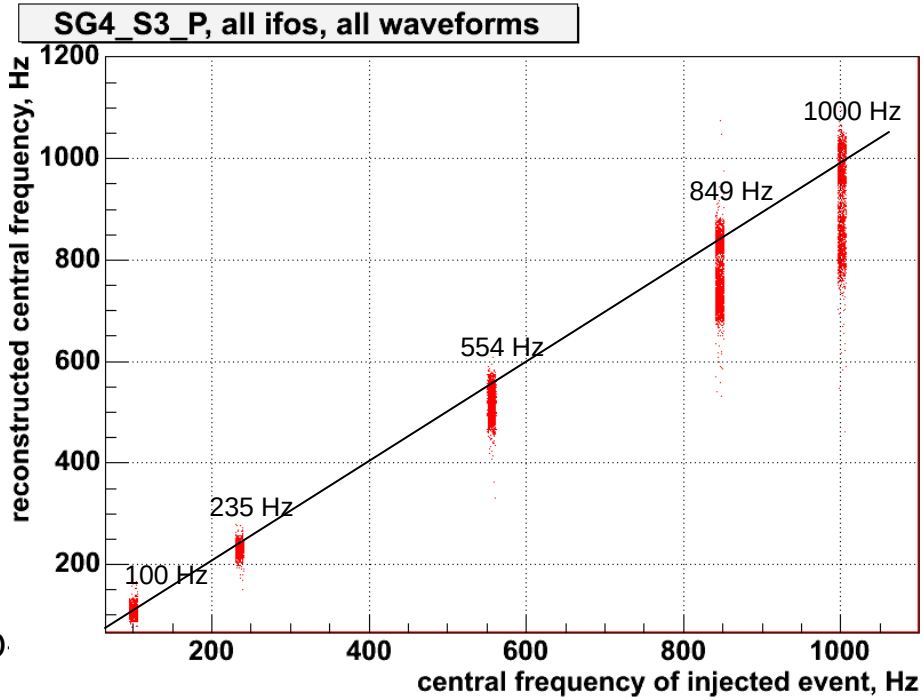
Independence on waveform morphology

Detection SNR is quite independent on the waveform morphology



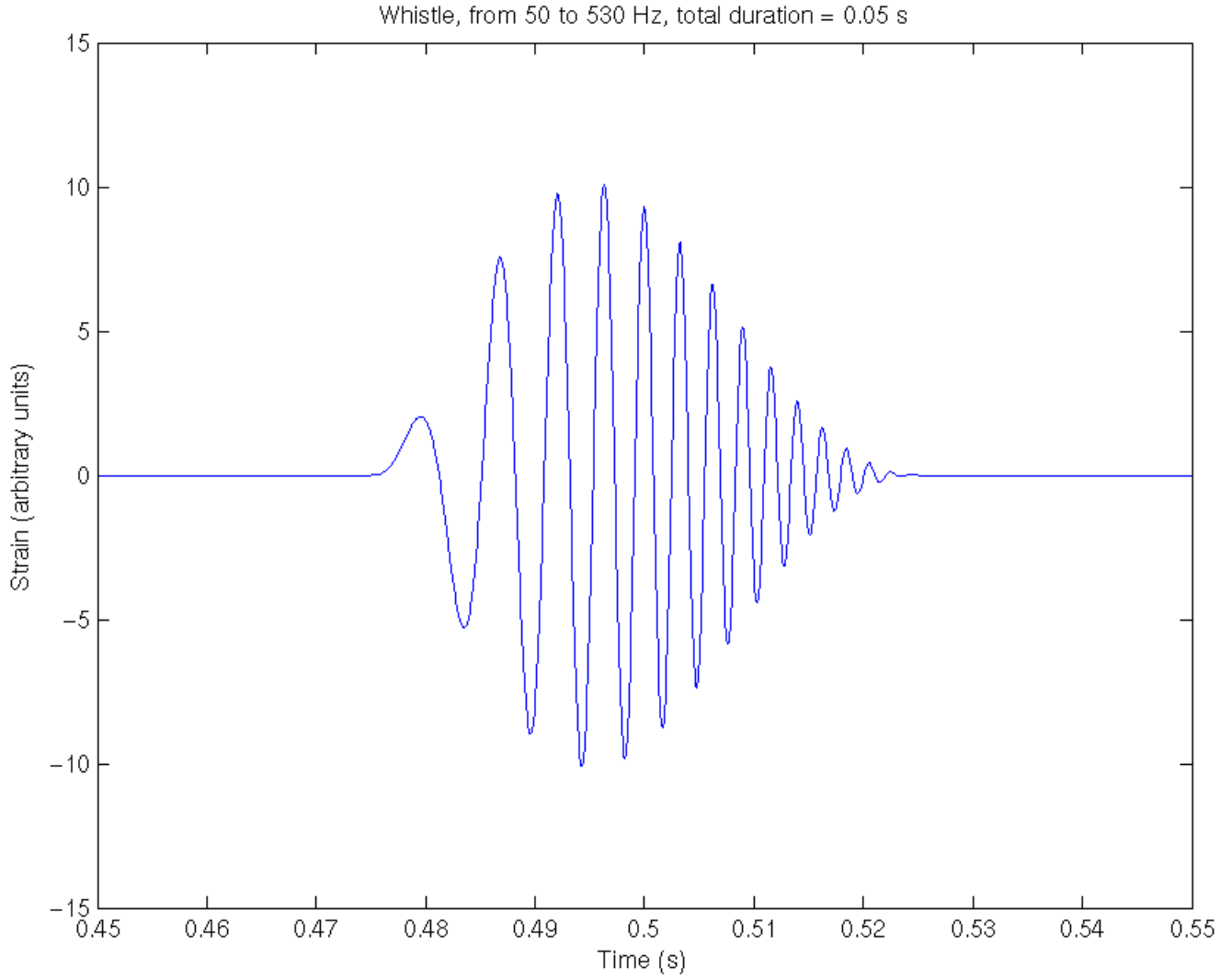


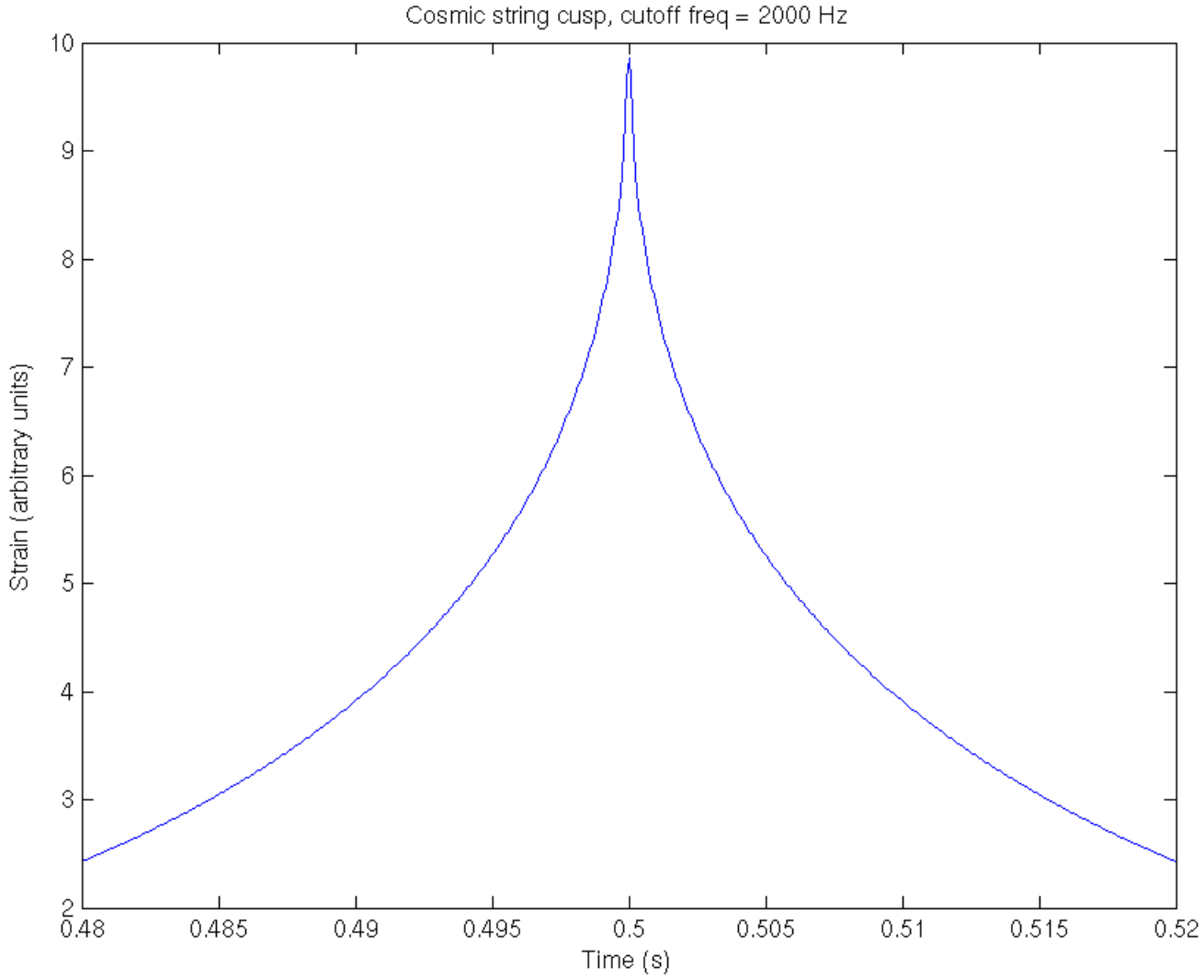
Time and frequency reconstruction



Summary & Plans

- S3 playground study is almost complete
  - False alarm rate (64-1100 Hz band): < $0.2\,\mu Hz$
  - New selection cut used (amplitude consistency check)
  - Much more elaborate study of the detection efficiency: pipeline sensitivity is quite independent on waveform morphology
  - Detection sensitivity 6.e-21 – 4.e-20 strain/sqrt(Hz)
- What remains to be done:
  - Still debating whether to use vetoes (talk by A. Di Credico)
  - Have not finalized the choice of waveburst and r-statistics thresholds
  - Waiting for the final version of calibration coefficients and science segments
- Expect to be ready to process full S3 in January


Whistle, from 50 to 530 Hz, total duration = 0.05 s
Strain (arbitrary units)
Time (s)
15
10
5
0
−5
−10
−15
0.45
0.46
0.47
0.48
0.49
0.5
0.51
0.52
0.53
0.54
0.55


Cosmic string cusp, cutoff freq = 2000 Hz
Strain (arbitrary units)
Time (s)
10
9
8
7
6
5
4
3
2
0.48
0.485
0.49
0.495
0.5
0.505
0.51
0.515
0.52