Status of the burst search with LIGO and GEO detectors

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Outline

• Introduction
  ➢ overview of detectors, pipeline
  ➢ playground analysis

• Results
  ➢ background rates
  ➢ pipeline efficiency

• Summary
Overview

• S3 run
  - GEO S3a: November 5, 2003 – November 12, 2003
  - GEO S3b: December 30, 2003 – January 13, 2004

• Un-triggered burst search
  - using coincidence of LIGO and GEO detectors
  - in the frequency band 768 – 2048 Hz
  - with the WaveBurst algorithm

*Class. Quantum Grav.* 21 (2004) S1819-S1830 and S1685-S1694
**Data**

- **Quadruple coincidence**
  - L1+H1+H2+G1(II) 59.3 hours
  - L1+H1+H2+G1(I) 18.9 hours

- **Triple coincidence**
  - L1+H1+G1(II) 7.8 hours
  - L1+H1+G1(I) 6.0 hours
  - L1+H2+G1(II) 3.6 hours
  - L1+H2+G1(I) 3.4 hours
  - H1+H2+G1(II) 105.6 hours
  - H1+H2+G1(I) 46.3 hours

- **Detectors**
  - Livingston 4k (L1)
  - Hanford 4k (H1)
  - Hanford 2k (H2)
  - GEO (G1)

- **Analysis plans:**
  - H1 x H2 x G1(II)
  - H1 x H2 x L1 x G1(II) samples (164.6 hours)

- **Current playground studies:**
  - full PG set (15h), but 3 IFO combination only (H1 x H2 x G1(II))
LIGO Sensitivity

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

1-10 x 10^{-21}

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Typical GEO600 S3II sensitivity

Typical S3 II Sensitivity

- Duty cycle ~ 99%
- 5-20 x 10^{-21}

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Analysis pipeline

The same as for S3 LIGO low frequency search except that the r-statistics is applied to H1-H2 only.
Background rates

Output of WaveBurst pipeline

~53326 seconds analysed
50 time lags between ±106 sec

background rate ~10 µHz
for \(-\log_{10}(\text{significance}) > 3.2\)

\[
\log_{10}(S_{tot}) = \sqrt[3]{\log_{10}(S_{H1}) \times \log_{10}(S_{H2}) \times \log_{10}(S_{GEO})}
\]

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Simulation

- **Software injection of sine-gaussian signals** are performed to estimate the **detection efficiency** of the pipeline.

- Signals are uniformly distributed over the sky locations.

\[ Q = f_0 \sqrt{2\pi \tau} \]

\( \tau \) - duration

\( f_0 \) - central frequency

\[ \int |h(t)|^2 \, dt = 10^{-22} \]

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Detection efficiency

Efficiency for SG signals for WB threshold $-\log_{10}(\text{significance}) > 3.2$

At 1053 Hz, hrss at 50% efficiency point = $3.5 \times 10^{-20}$ Hz$^{-1/2}$
Average detector noise

The graph shows the average S3 pg noise as measured by WaveBurst. The noise is plotted against frequency in Hz. The graph includes data points for GEO, H2, and H1 detectors. The injected hrss @50% efficiency is noted in the graph.

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R-statistic test

Detection with H1-H2 only
H1-H2 waveform consistency

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expect background reduction after r-statistics test down to <0.2 Hz

excess power in H1,H2,GEO
Affected by difference in Hanford and GEO antenna patterns
Summary

• analysed **53326 seconds of playground data** from GEO600, Hanford 2km and 4km detectors

• Preliminary results
  - Expected background rate is \(<20 \mu Hz\) for WB significance>3
  - Expected sensitivity \(3.5-7.0 \times 10^{-20} \text{ Hz}^{-1/2}\) at 50% detection efficiency and frequency band 768–2048 Hz.

• R-statistic test on H1-H2 pair will further reduce background with minimal reduction in detection efficiency

• Expected false alarm rate after all cuts \(<0.2 \mu Hz\)

• Plan more detailed simulation studies with different waveform morphologies and analysis of the quadruple H1xH2xL1xGEO data.