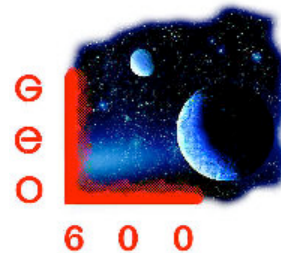


Search for burst gravitational waves in LIGO-GEO S4 data



Ik Siong Heng
for
The LIGO Scientific Collaboration



Overview



- Overview of S4 and the LSC detectors
- Analysis pipelines
- Waveburst-CorrPower analysis overview
- coherent Waveburst analysis overview
- comparison of efficiency
- summary



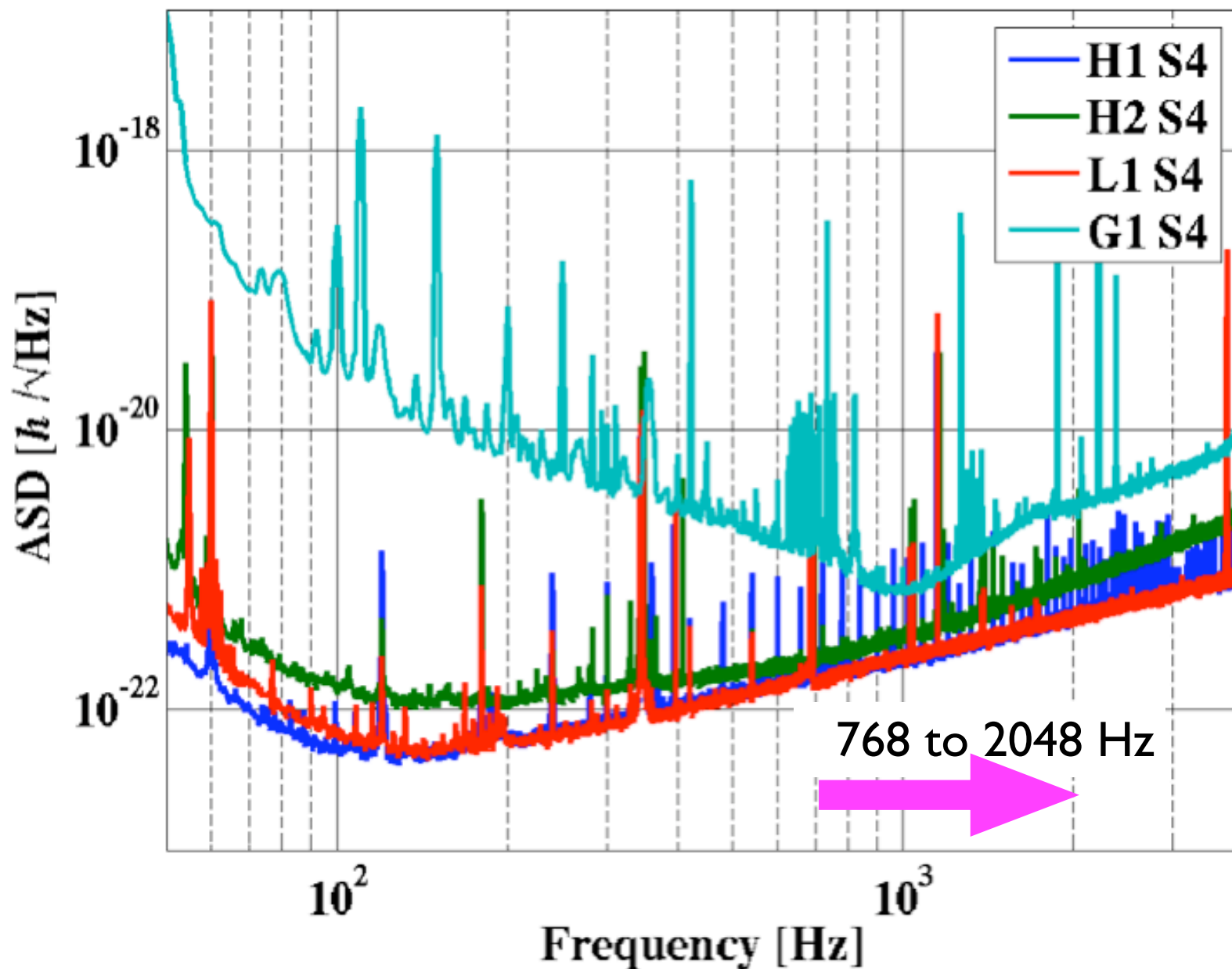
S4 run and detectors



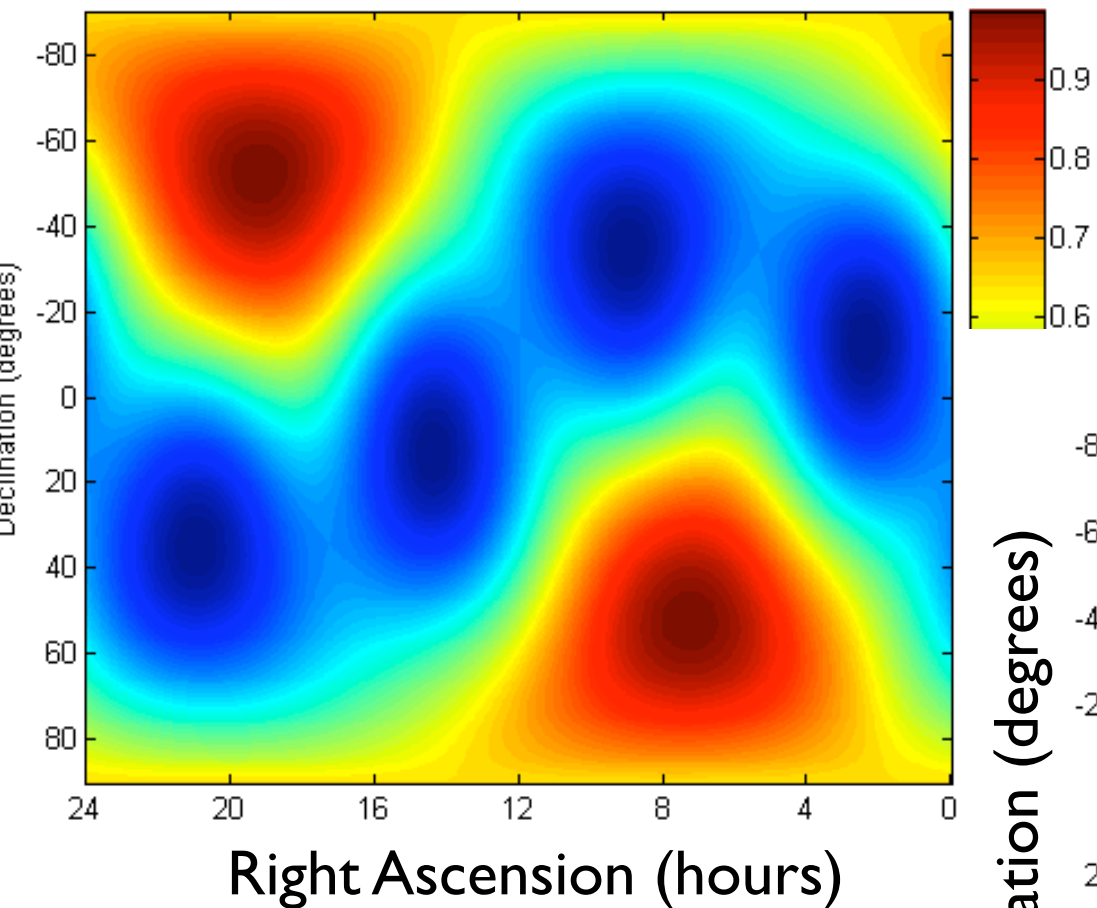
- S4 run: 22nd of February to 23rd of March, 2005
- four LSC detectors in joint operation
 - H1, H2: Hanford 4 km and 2 km respectively
 - L1: Livingston 4 km
 - G1: GEO 600
- total of 1202645.0 seconds of quadruple coincidence livetime
- detectors at Hanford and Livingston are almost aligned, GEO 600 is not aligned to other detectors
- use both Waveburst-CorrPower and coherent Waveburst pipelines
- **compare efficiencies** for the same accidental coincidence (background) rate observed for each pipeline
- also compare with LIGO-only network

S4 sensitivities

LIGO/GEO600 S4 Strain Sensivities



GEO

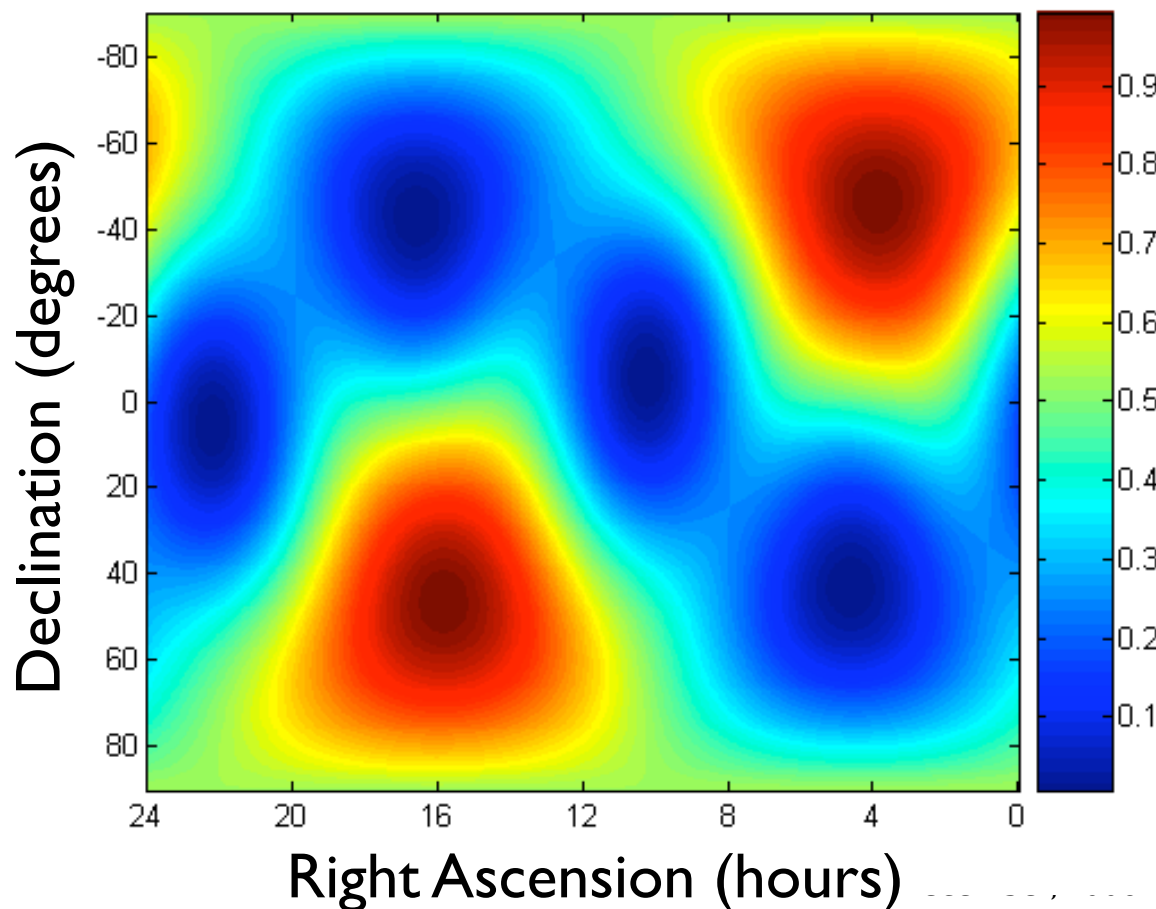


Test bed for
coherent analysis
on real data

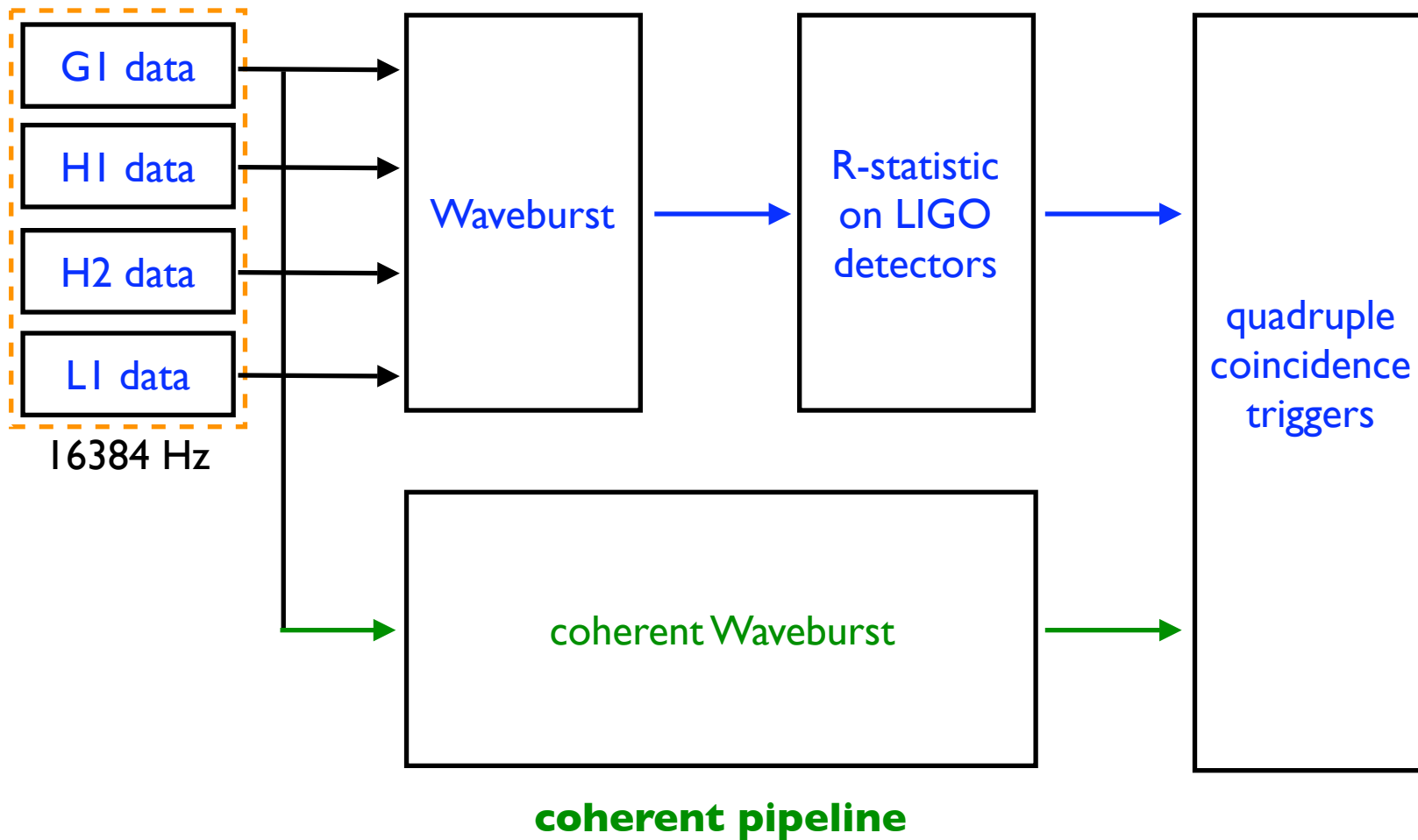
G06XXXX-XX-Z

$$F_+^2 + F_x^2$$

Hanford



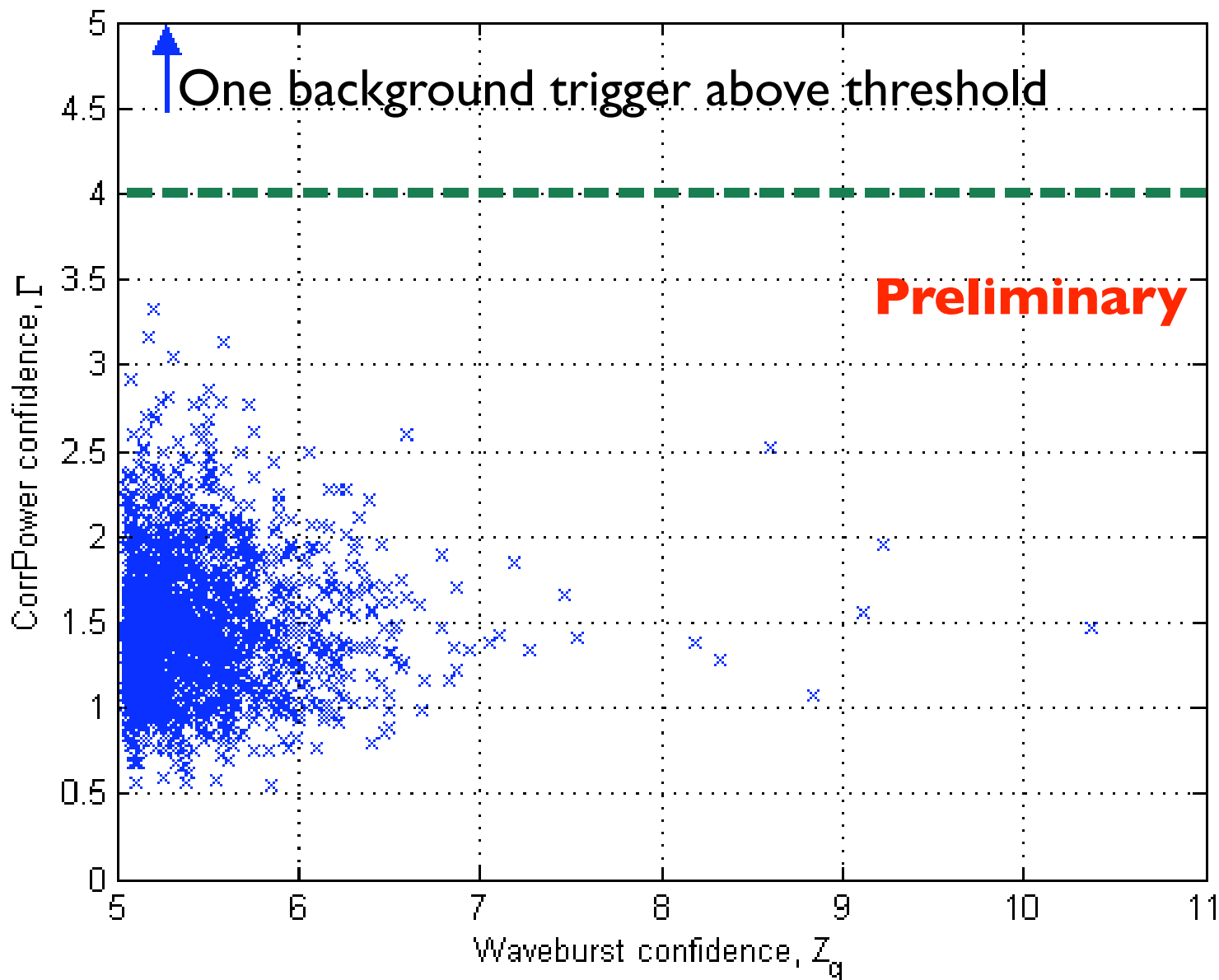
blue - Waveburst-CorrPower pipeline



- process LIGO and GEO data with Waveburst between 768 to 2048 Hz
- Tune thresholds on time shifted data
- 100 time shifts from -156.25 to 156.25 seconds in steps of 3.125 seconds (zero-lag not included)
- use CorrPower to calculate R-statistic of data from LIGO detectors at coincident trigger times
- impose H1-H2 consistency cuts: measured amplitude within a factor of 2 and positive correlation of calibrated signals
- measure efficiency by injecting sine gaussians
- tuning two thresholds:
- Waveburst confidence, Z_g : significance of coincidence excess power
- CorrPower confidence, Γ : significance of R-statistic value compared to that expected for noise

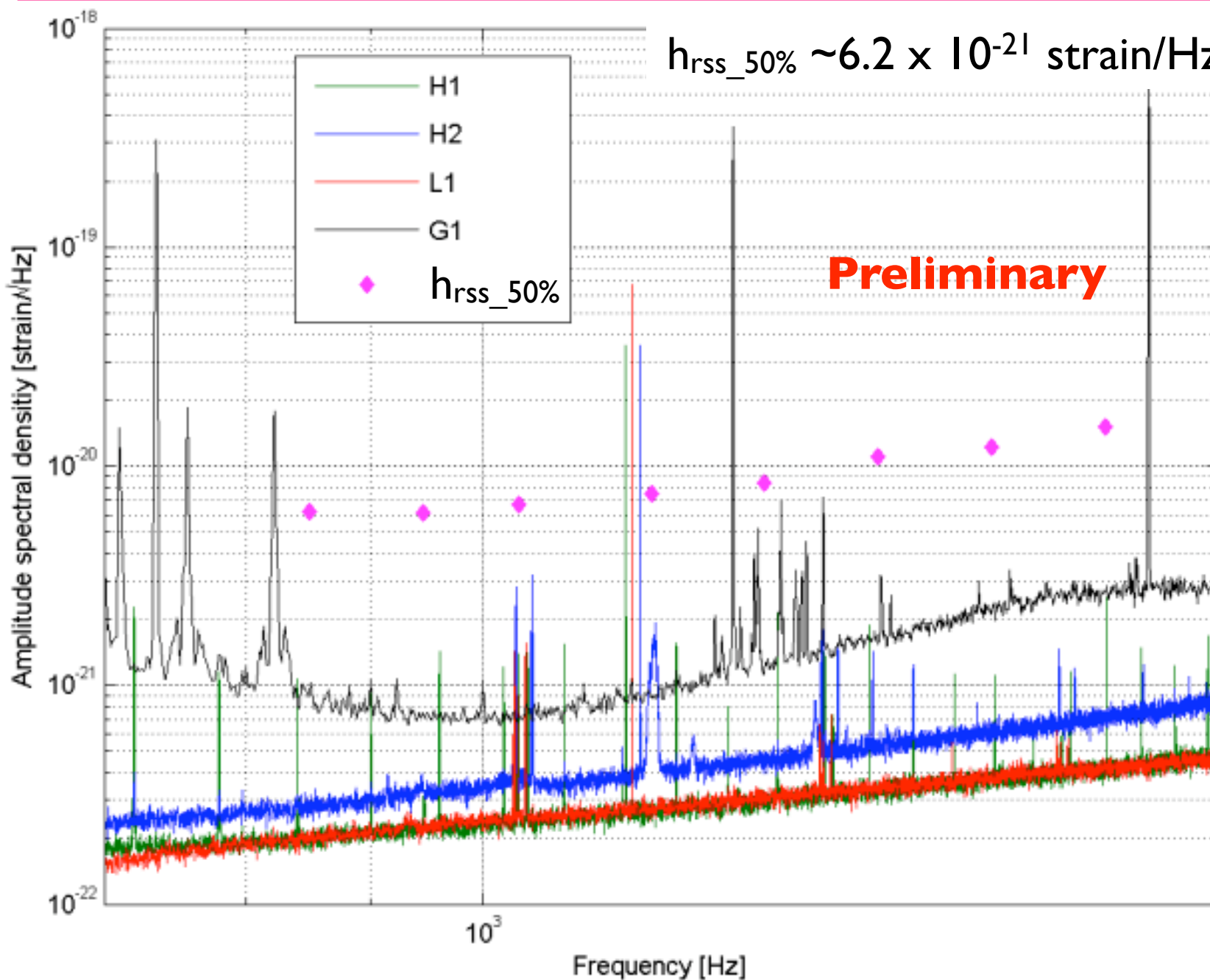
Z_g v Γ background

Waveburst confidence, Z_g , against CorrPower confidence, Γ





Waveburst-CorrPower sensitivity



$h_{\text{rss_50\%}} \sim 6.2 \times 10^{-21}$ strain/Hz^{-1/2} @ 849 Hz

Preliminary



Coherent Waveburst



- coherent Waveburst run from 768 to 2048 Hz
- also tune thresholds on time shifted data set
- 100 time shifts from -156.25 to 156.25 seconds in steps of 3.125 seconds
- apply 3-detector likelihood and networks cuts
- also measure efficiency using sine-gaussian injections

$$L = \sum_i \sum_k \frac{1}{2\sigma_k^2} \left[\frac{x_k^2[i]}{\sigma_k^2} - (x_k[i] - \xi_k[i])^2 \right]$$

from talk by
S. Klimenko

Energy normalised by detector noise (SNR)

- threshold on reconstructed energy
- $L_{012} > 50 \ \&\& \ L_{013} > 50 \ \&\& \ L_{023} > 50 \ \&\& \ L_{123} > 50$
- where $L_{ijk} = \text{snr}[i] - \text{null}[i] + \text{snr}[j] - \text{null}[j] + \text{snr}[k] - \text{null}[k]$
- $\text{snr}[i]$ - data stream energy for i-th detector normalized by the noise variance,
- $\text{null}[i]$ - reconstructed noise energy normalized by the noise variance (null stream)
- 0 - L1, 1 - H1, 2 - H2, 3 - G1

$$L = \sum_i \sum_k \frac{1}{2\sigma_k^2} \left[x_k^2[i] - \underbrace{(x_k[i] - \xi_k[i])^2}_{\substack{\uparrow \\ \text{Null energy normalised by detector noise}}} \right]$$

from talk by
S. Klimenko

Null energy normalised by detector noise

- threshold on reconstructed energy
- $L_{012} > 50 \ \&\& \ L_{013} > 50 \ \&\& \ L_{023} > 50 \ \&\& \ L_{123} > 50$
- where $L_{ijk} = \text{snr}[i] - \text{null}[i] + \text{snr}[j] - \text{null}[j] + \text{snr}[k] - \text{null}[k]$
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- also use combined network cut:

$$\sqrt{rSNR} C_{net} > T$$

- C_{net} - network cross-correlation

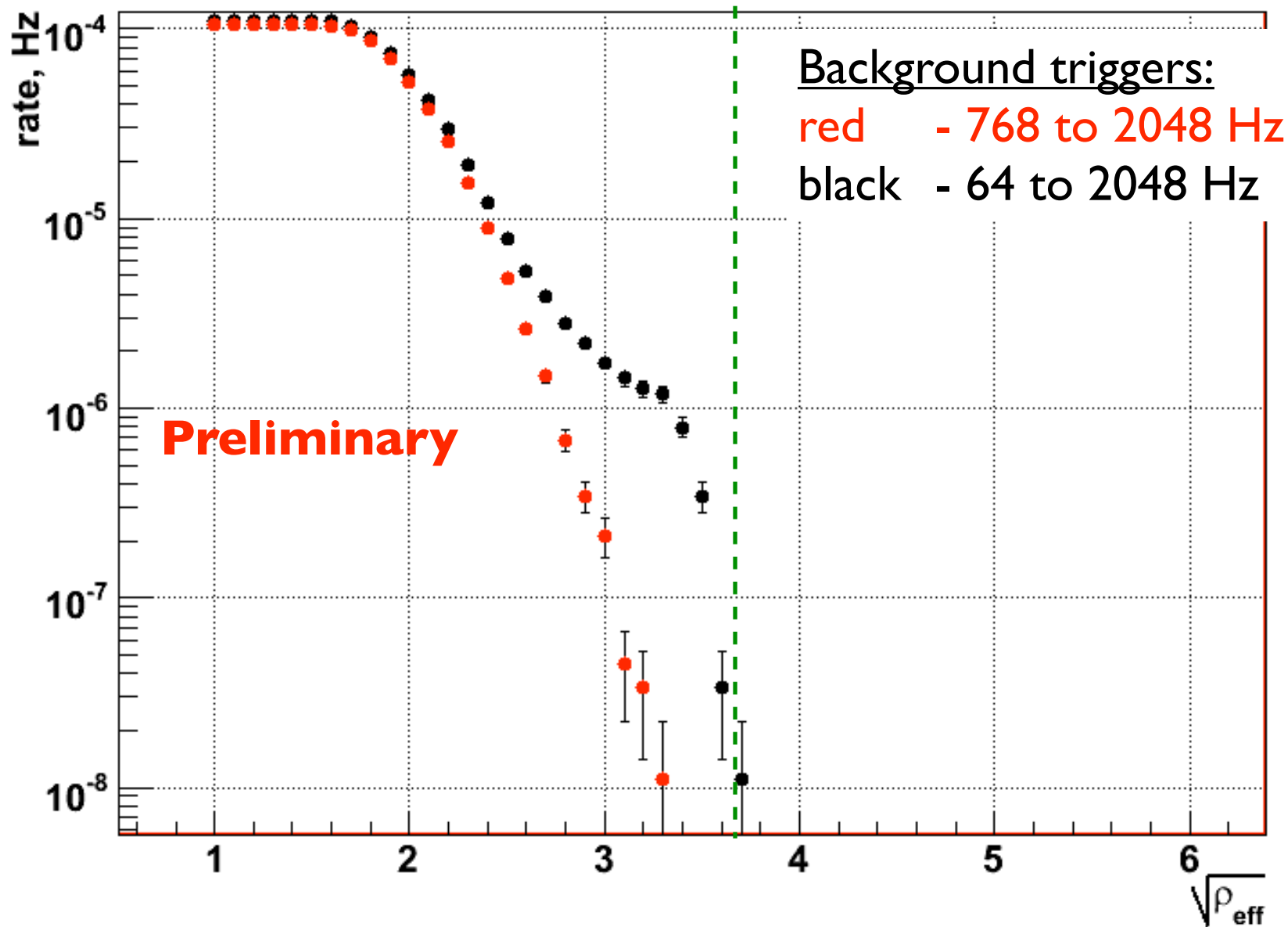
$$C_{net} = \frac{E_{coherent}}{N_{null} + E_{coherent}}$$

from talk by
S. Klimenko

- rSNR - average rank SNR
- from tuning, choose T to be 3.67, we get 0 accidental coincidences (background)

background coincidences

rate vs threshold



Preliminary

- coherent and Waveburst-CorrPower pipelines on LIGO-GEO S4 data

Pipeline	accidental coincidence rate [Hz]	$h_{\text{rss_50\%}, \text{SG @ 849 Hz}}$ [$\times 10^{-21} \text{ Hz}^{-1/2}$]	$h_{\text{rss_50\%}, \text{SG @ 1053 Hz}}$ [$\times 10^{-21} \text{ Hz}^{-1/2}$]
Waveburst-Corppower	0.01 μHz	6.2	6.7
coherent Waveburst	<0.01 μHz^*	4.0	4.9

*0 coincidences between 768 and 2048 Hz observed in 100 time shifts

- compare LIGO-GEO coherent efficiencies with LIGO-only S4

network	accidental coincidence rate [Hz]	$h_{\text{rss_50\%}, \text{SG @ 849 Hz}}$ [$\times 10^{-21} \text{ Hz}^{-1/2}$]	$h_{\text{rss_50\%}, \text{SG @ 1053 Hz}}$ [$\times 10^{-21} \text{ Hz}^{-1/2}$]
LIGO-only	0.02 μHz	4.0	5.6
LIGO-GEO	<0.01 μHz	4.0	4.9

- have tuned thresholds for Waveburst-CorrPower and coherent Waveburst pipelines
- detection efficiencies for coherent Waveburst pipeline better than Waveburst-CorrPower for LIGO-GEO S4
- detection efficiencies similar for coherent Waveburst pipeline when comparing LIGO-GEO to LIGO-only in S4

Future plan

- finalise analysis and look for zero-lag coincidences
- write paper comparing efficiencies and background of both pipelines