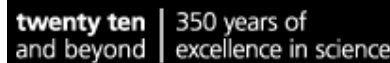




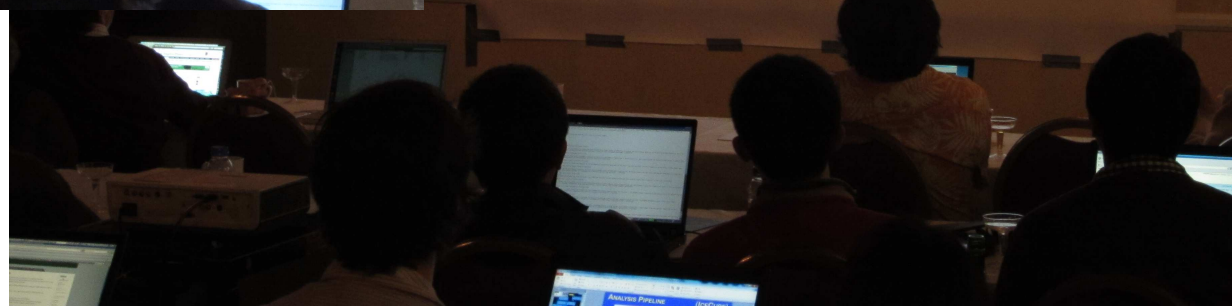
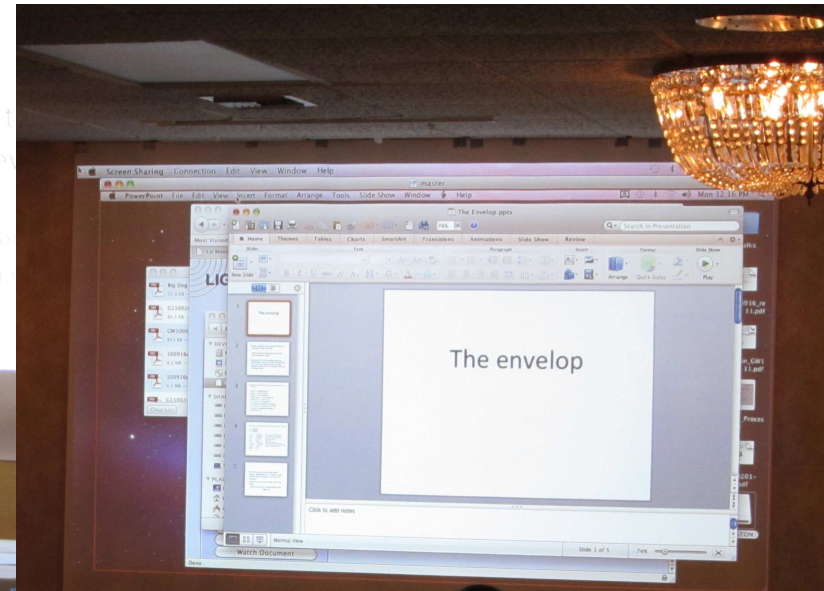
The Big Dog “GW event”

Stephen Fairhurst

on behalf of the LIGO Scientific
and Virgo Collaborations



Blind Injection Challenge



The Result

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"BLIND INJECTION" STRESS-TESTS LIGO AND VIRGO'S SEARCH FOR GRAVITATIONAL WAVES

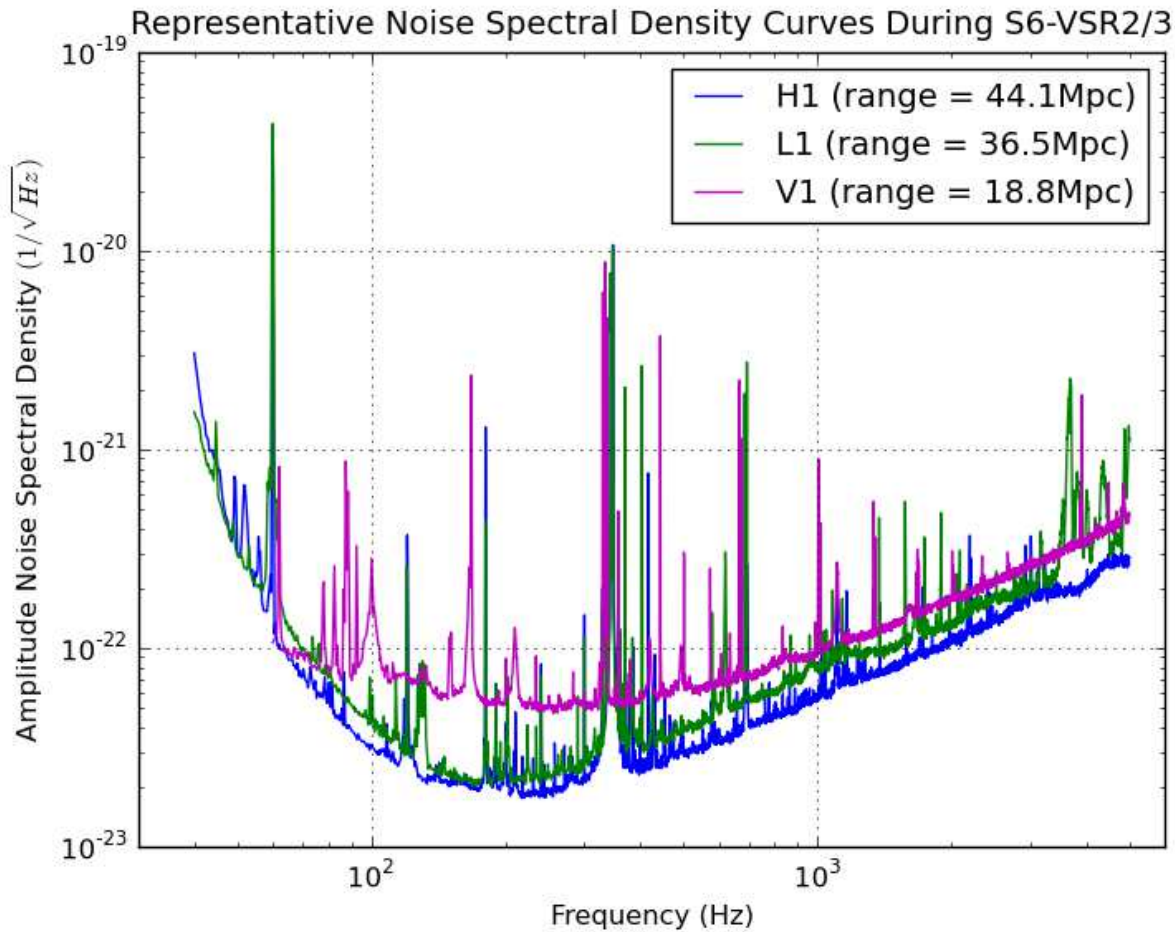
The LIGO Scientific Collaboration and the Virgo Collaboration completed an end-to-end system test of their detection capabilities at their recent joint collaboration meeting in Arcadia, CA. Analysis of data from LIGO and Virgo's most recent observation run revealed evidence of the elusive signal from a neutron star spiraling into a black hole. Shortly after the collaboration approved a scientific paper reporting the ground-breaking "discovery", LIGO and Virgo management revealed that the signal was a "blind injection" --- a fake signal secretly added to the data to test the detector and analysis.

While the scientists were disappointed that the discovery was not real (they knew that it could be a blind injection), the success of the analysis was a compelling demonstration of the collaboration's readiness to detect gravitational waves. LIGO and Virgo scientists are looking forward to observations with the advanced detectors which are expected to contain many real signals from the distant reaches of the universe.

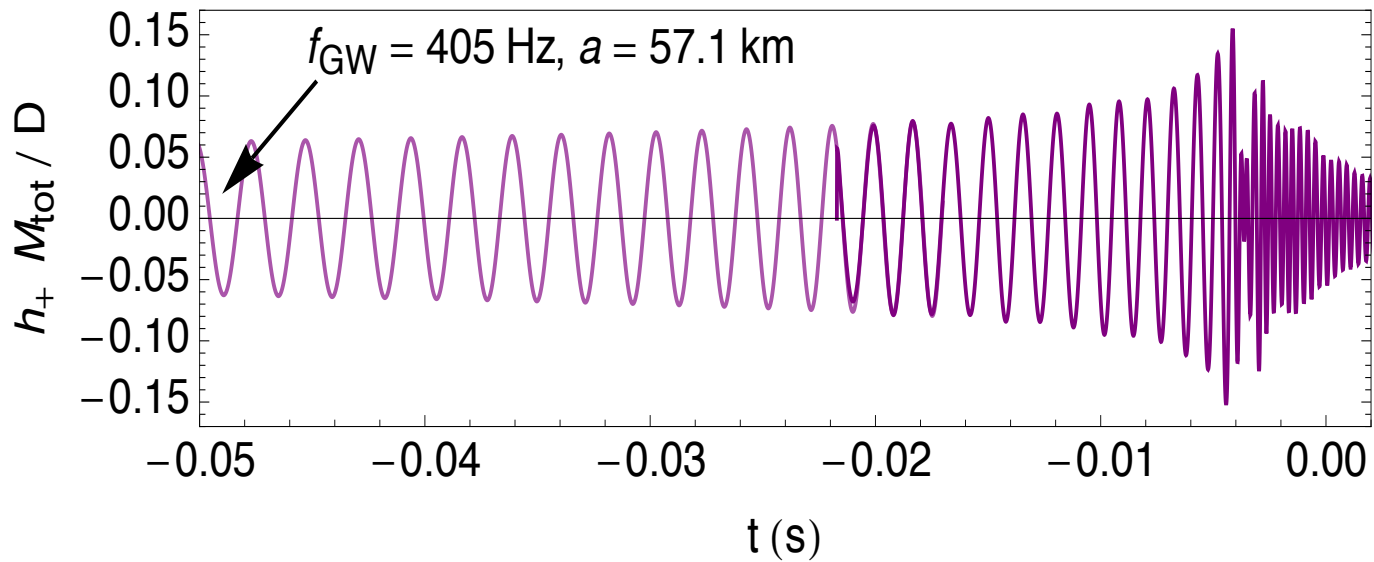


And how we got there...

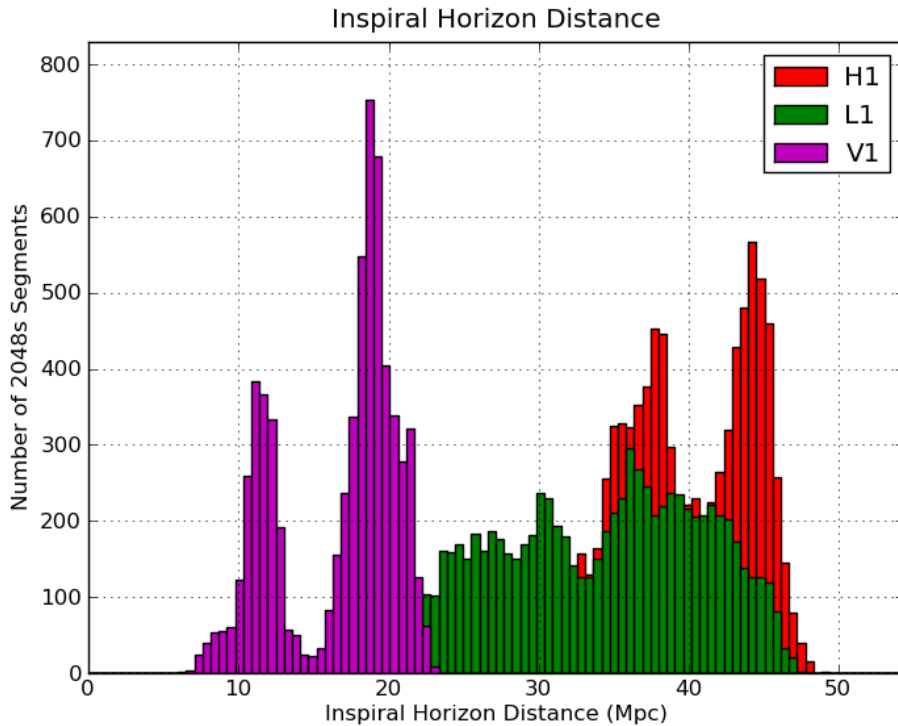
The detectors



The sources



Detector sensitivity

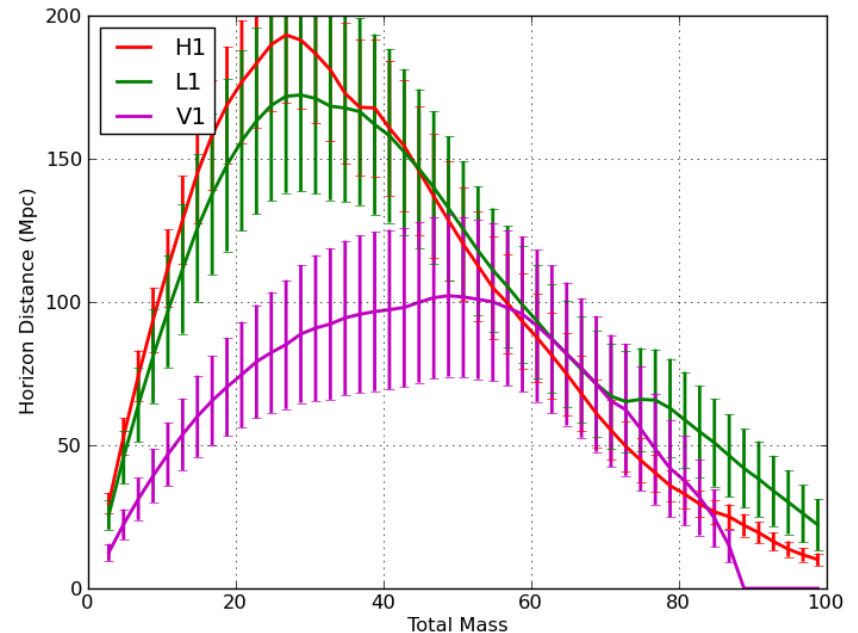


Expected Rate (per $\text{Mpc}^3 \text{ Myr}$)

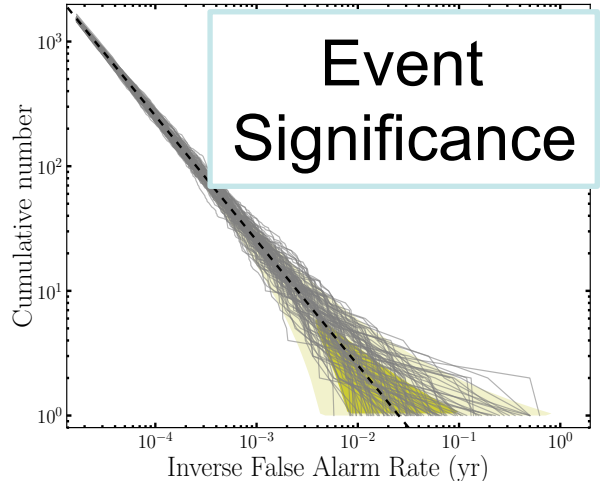
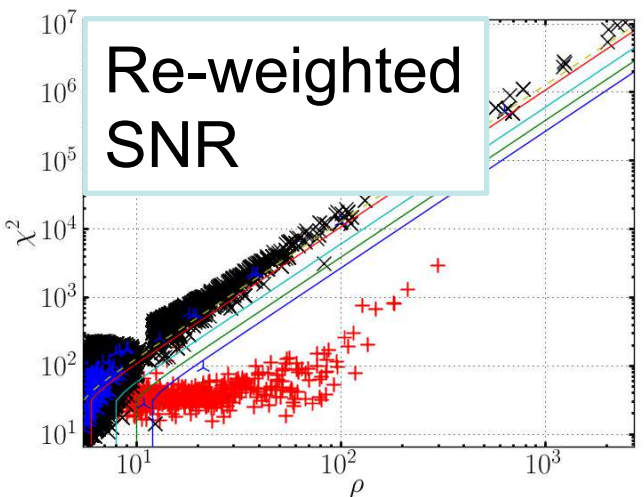
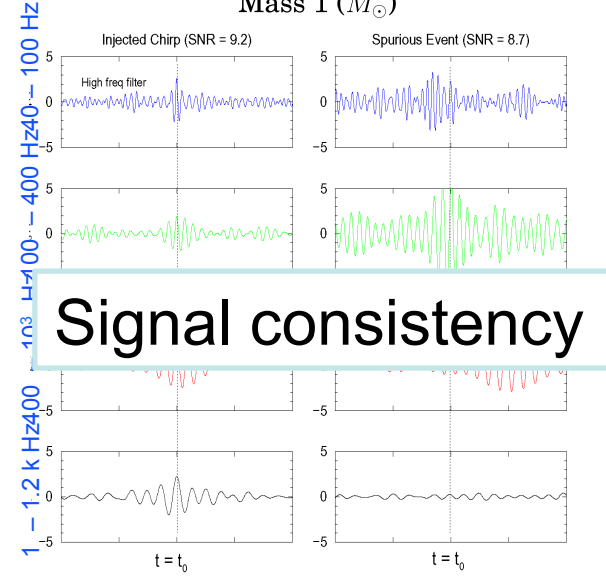
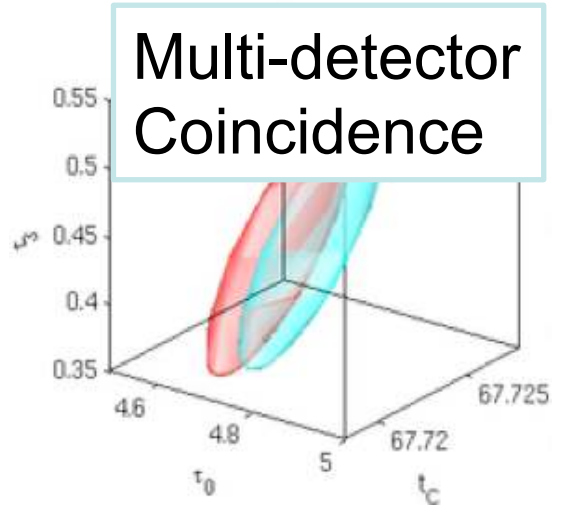
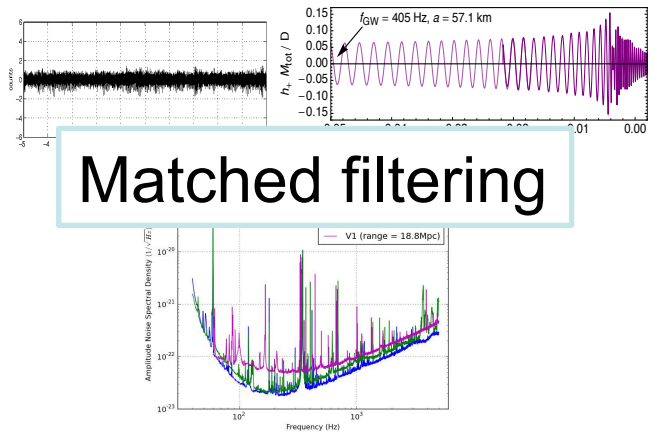
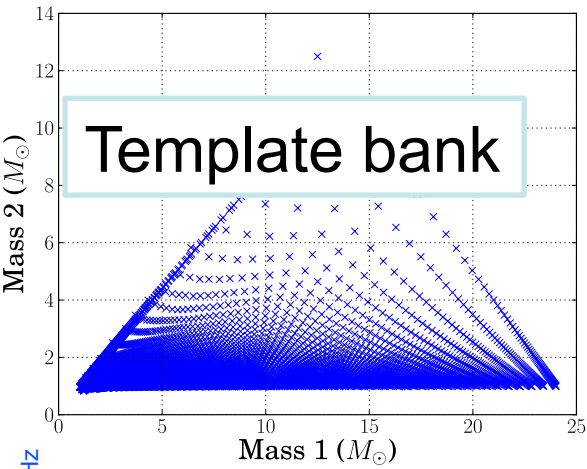
NS-NS $10^{-2} - 10$

NS-BH $6 \times 10^{-4} - 1$

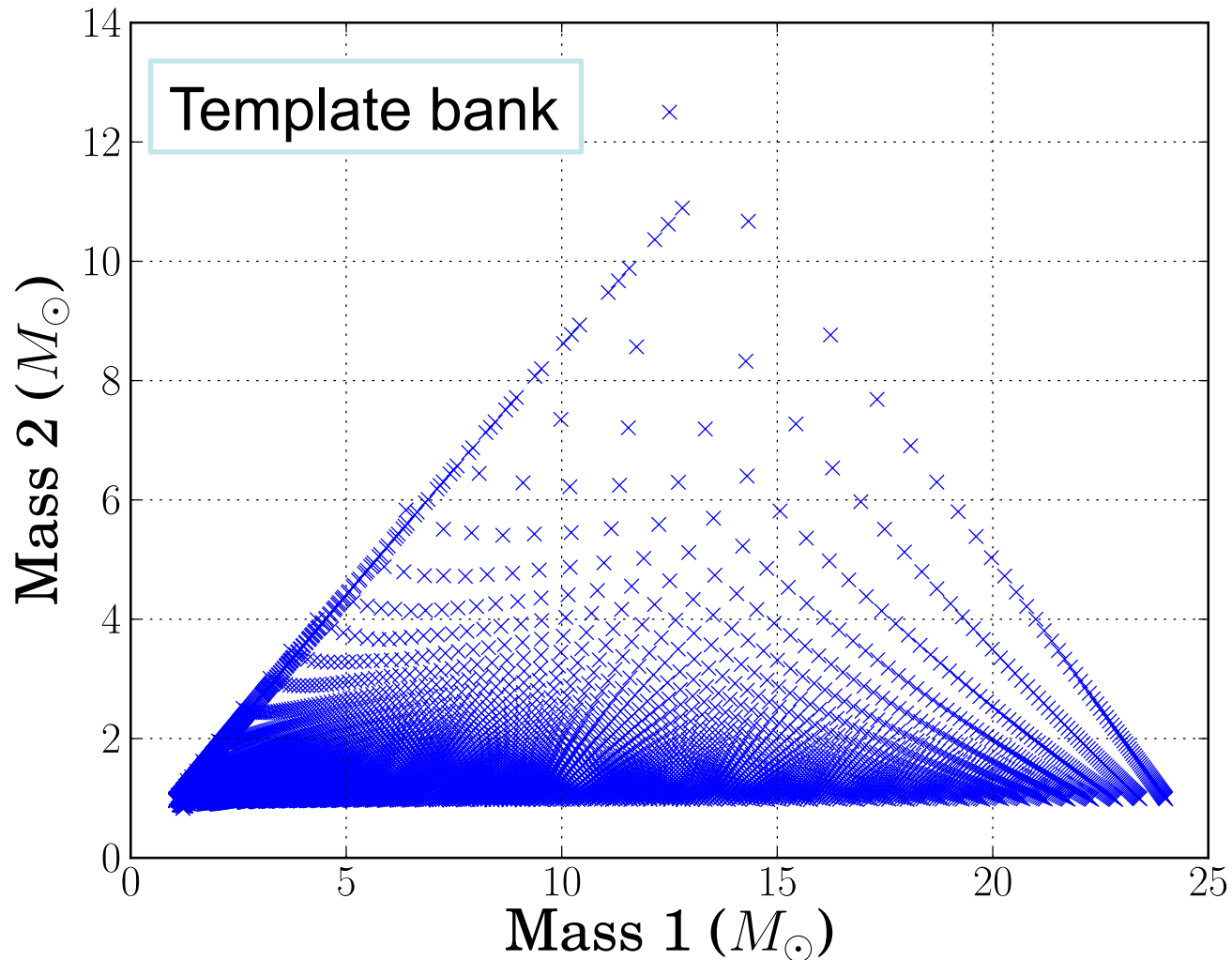
BH-BH $10^{-4} - 0.3$



The search

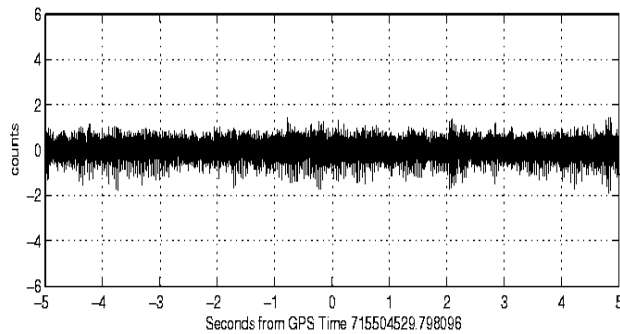


The search

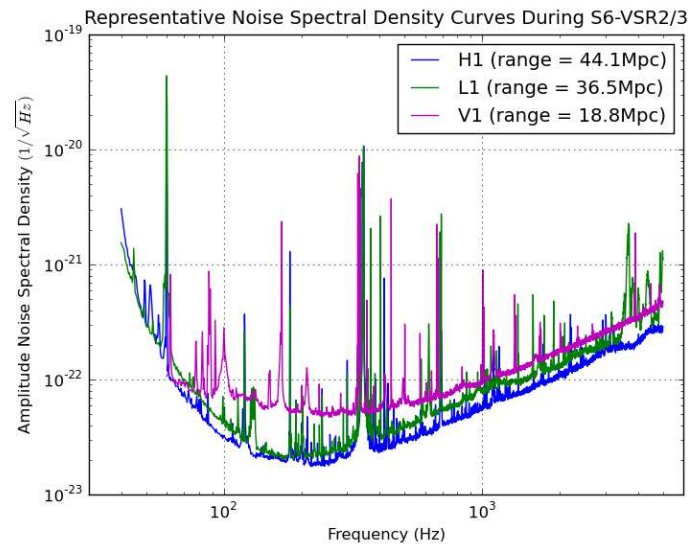
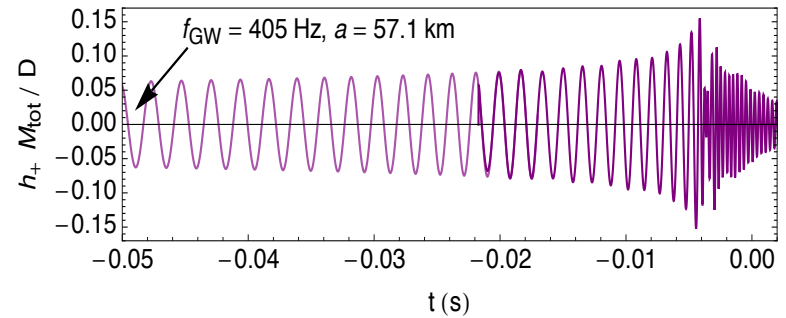


The search

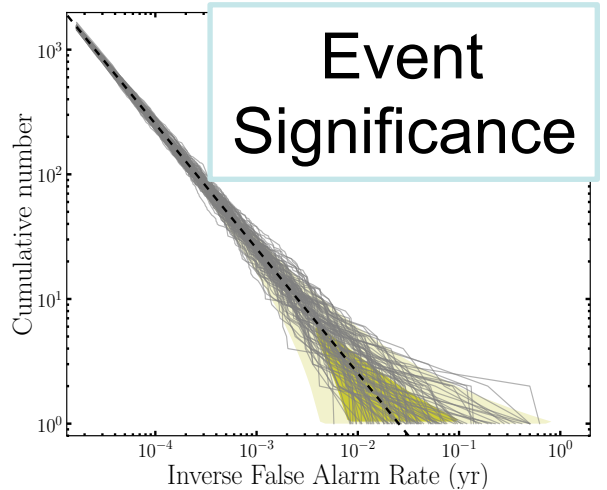
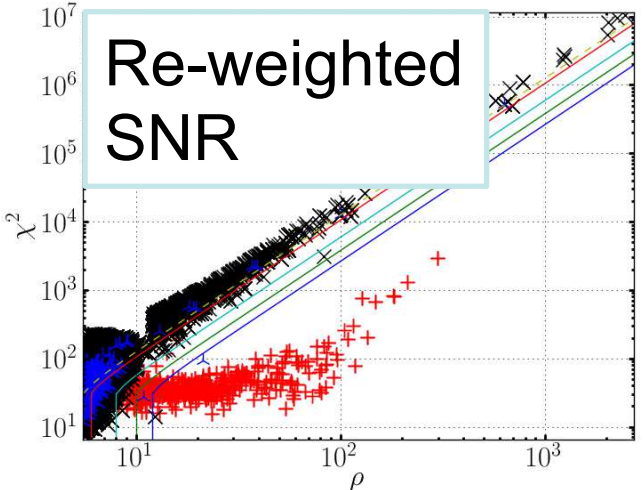
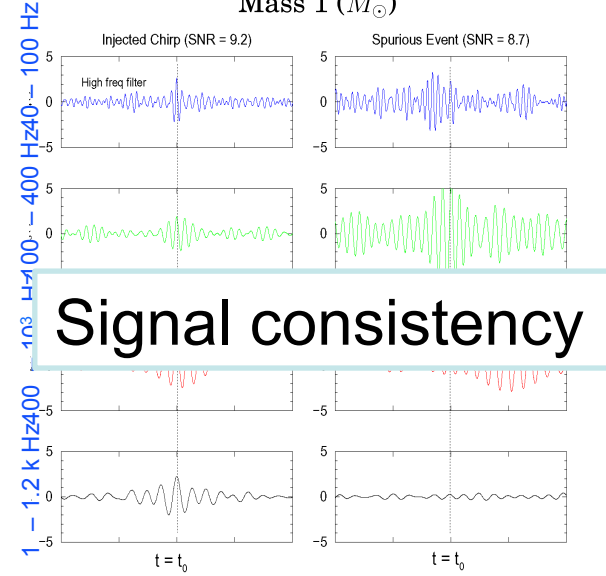
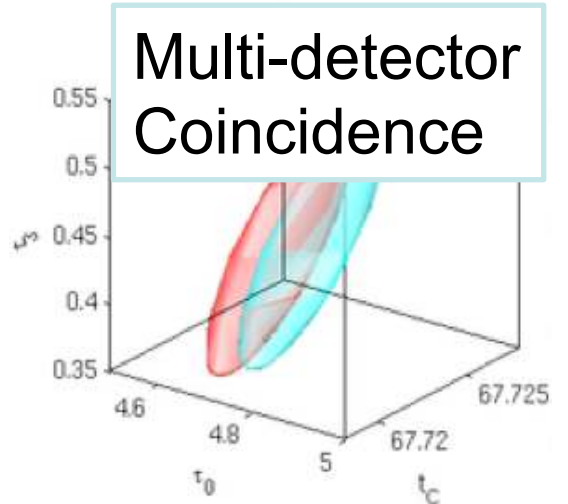
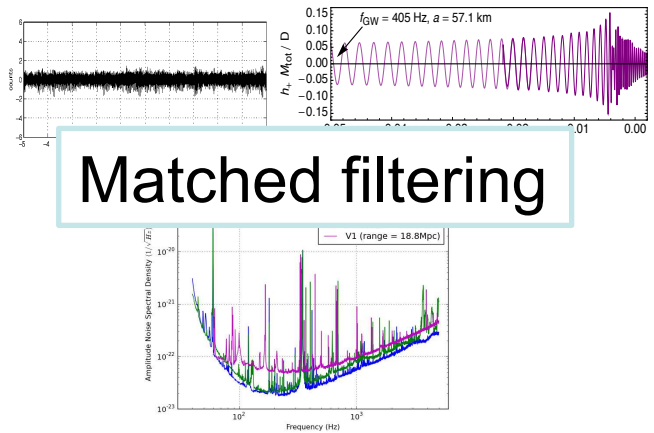
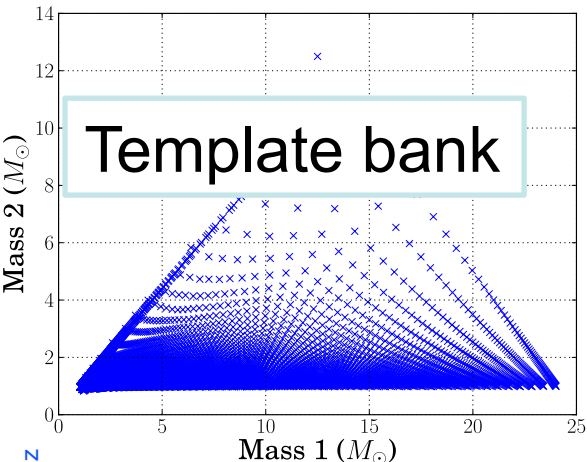
Matched filtering



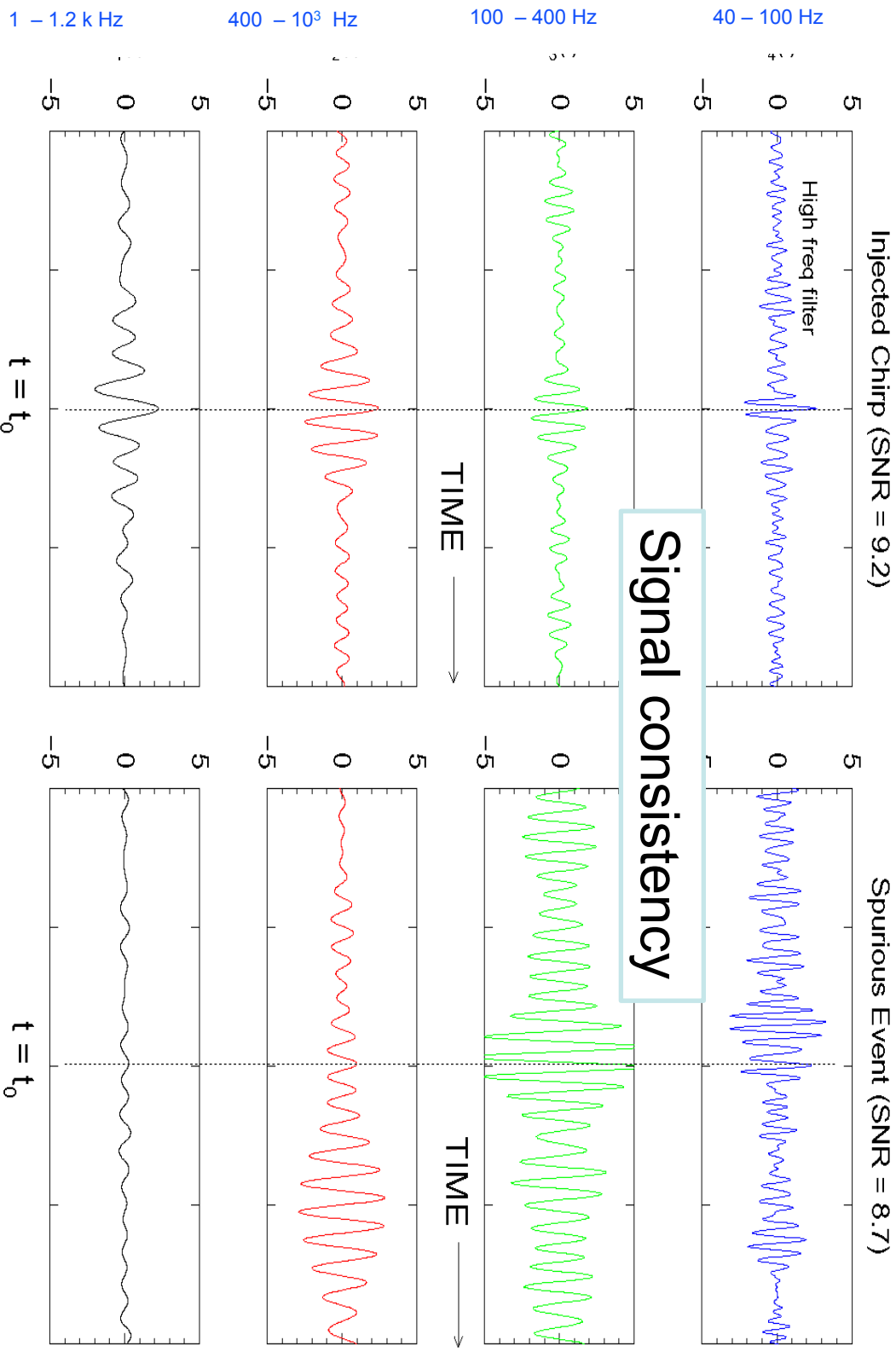
X



The search

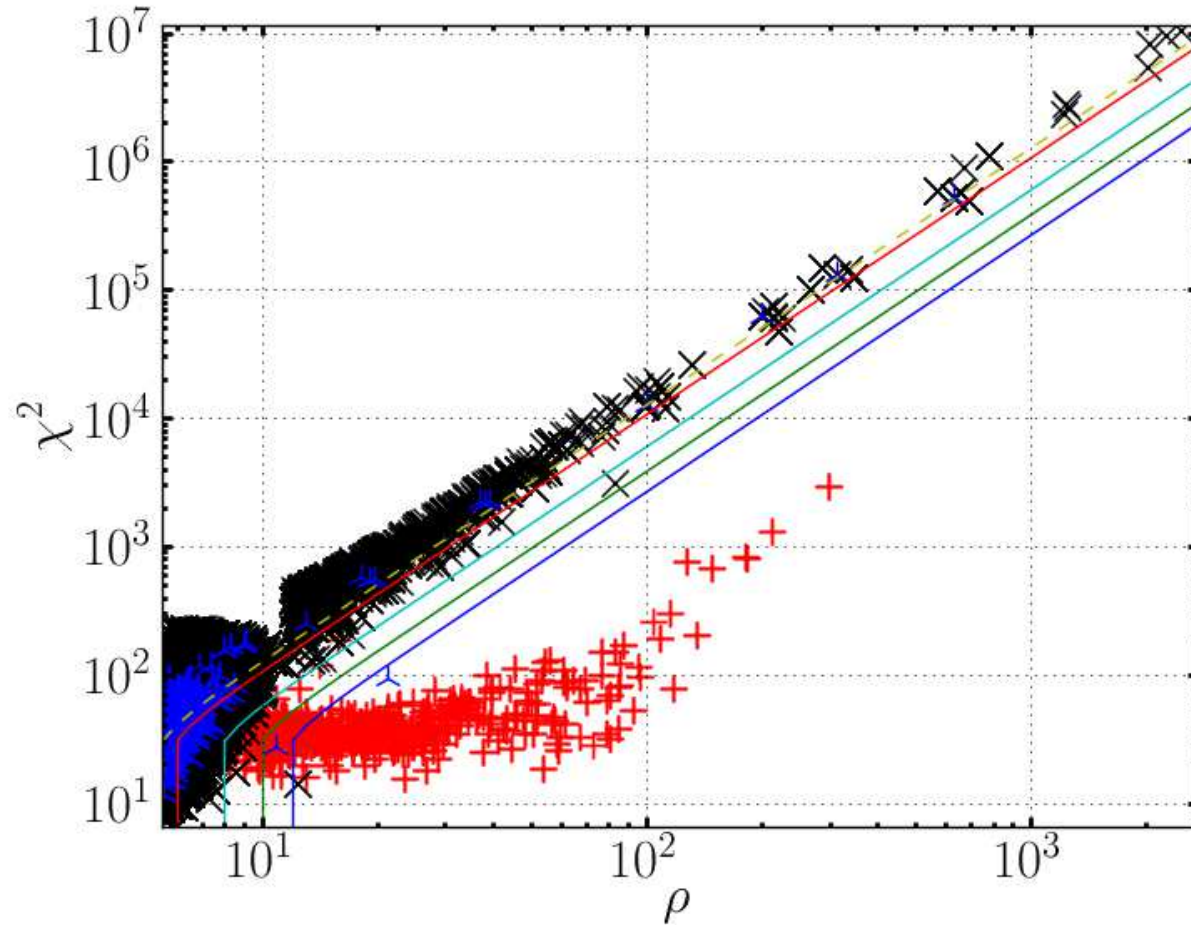


The search

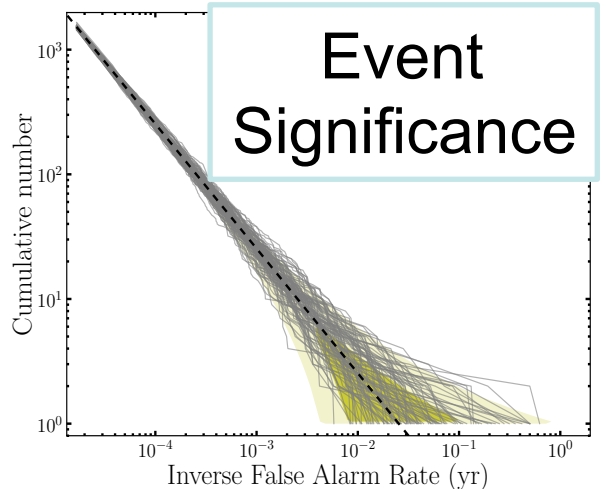
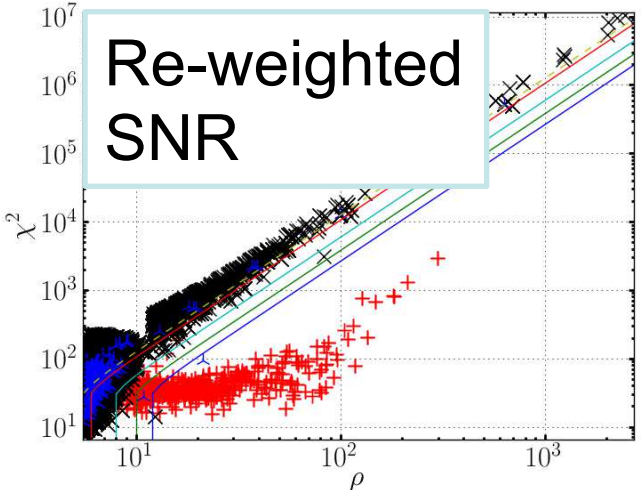
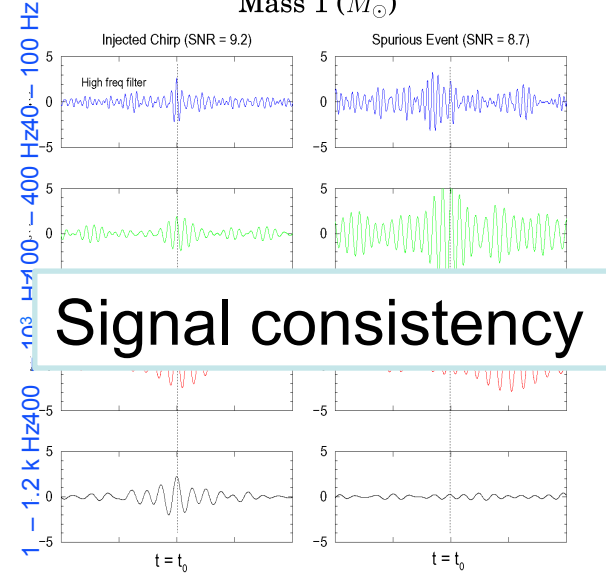
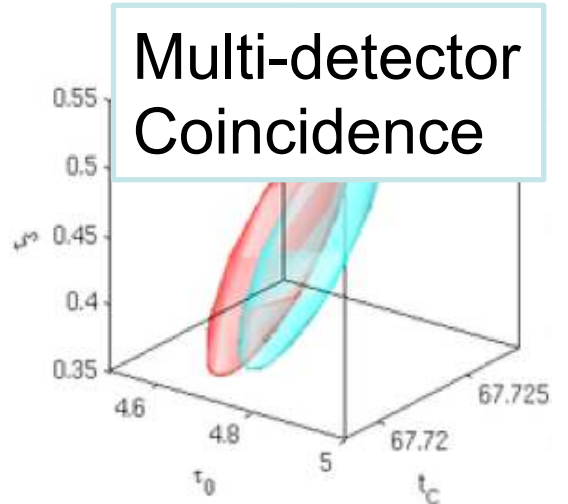
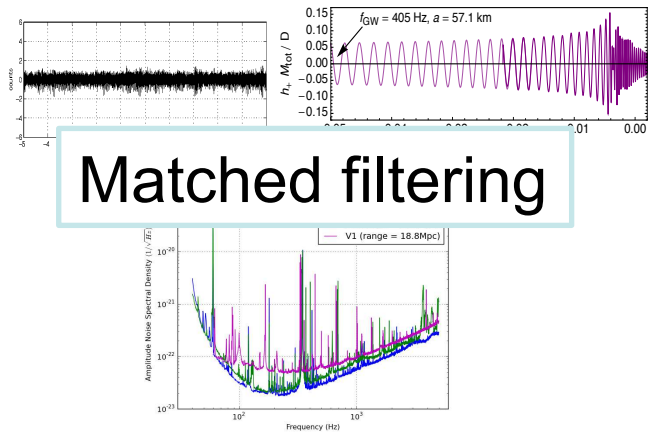
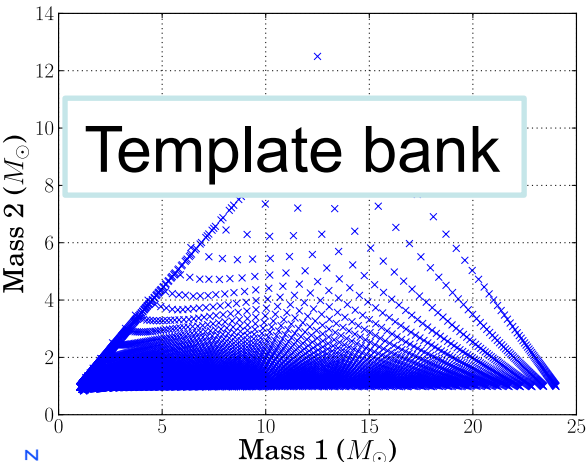


The search

Re-weighted
SNR

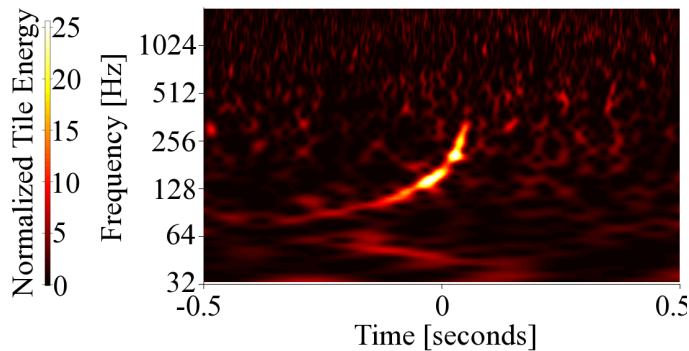


The search



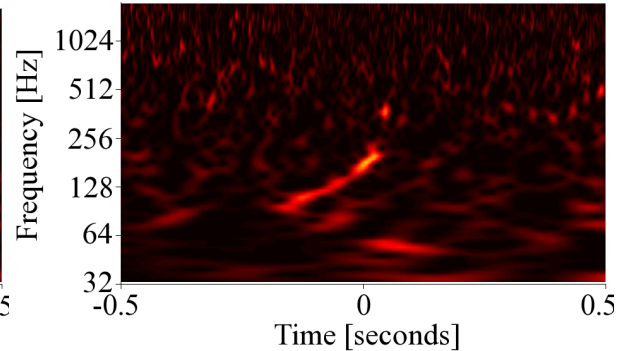
The signal

H1



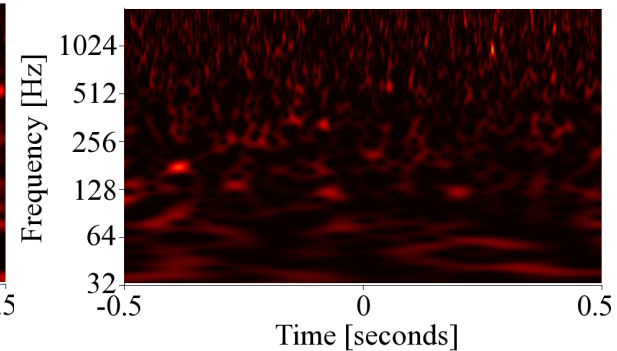
- SNR = 15
- Chirp Mass = $4.7M_{\odot}$

L1



- SNR 10
- Chirp Mass = $4.4M_{\odot}$

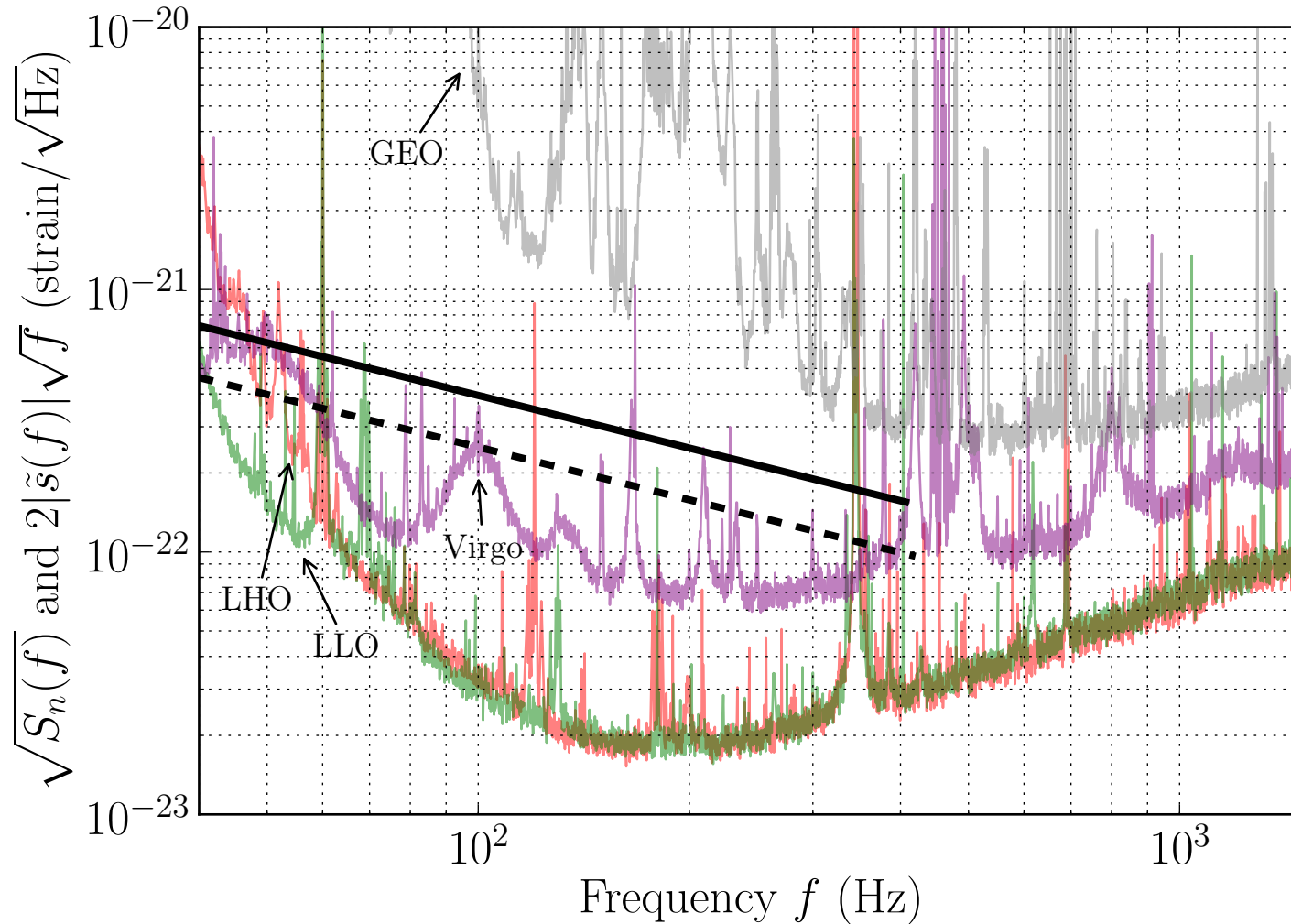
V1



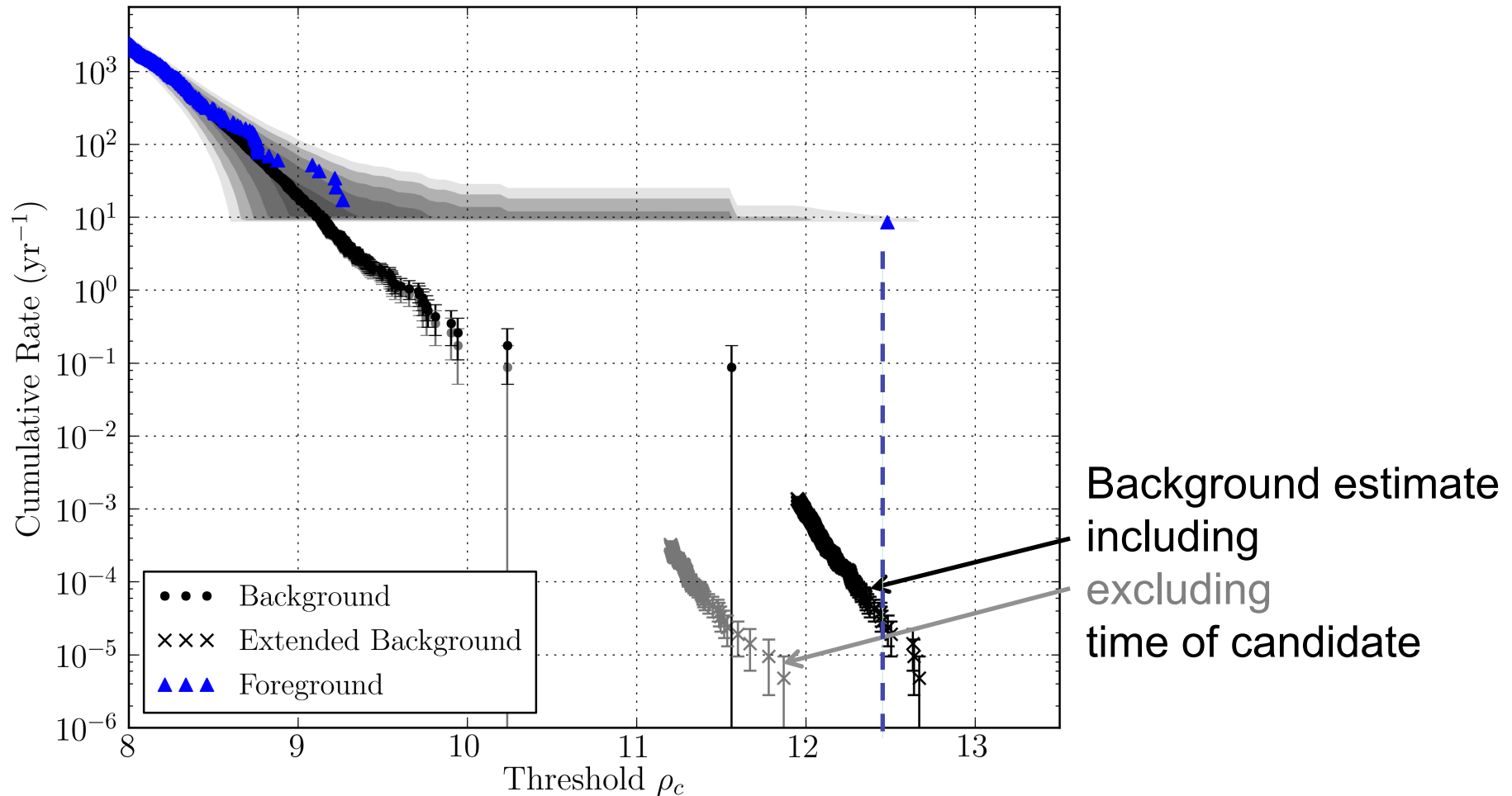
No trigger above threshold

A coincident signal was observed by the two LIGO detectors at 2010 September 16, 06:42:23 UTC, with $\rho_c = 12.5$

The signal



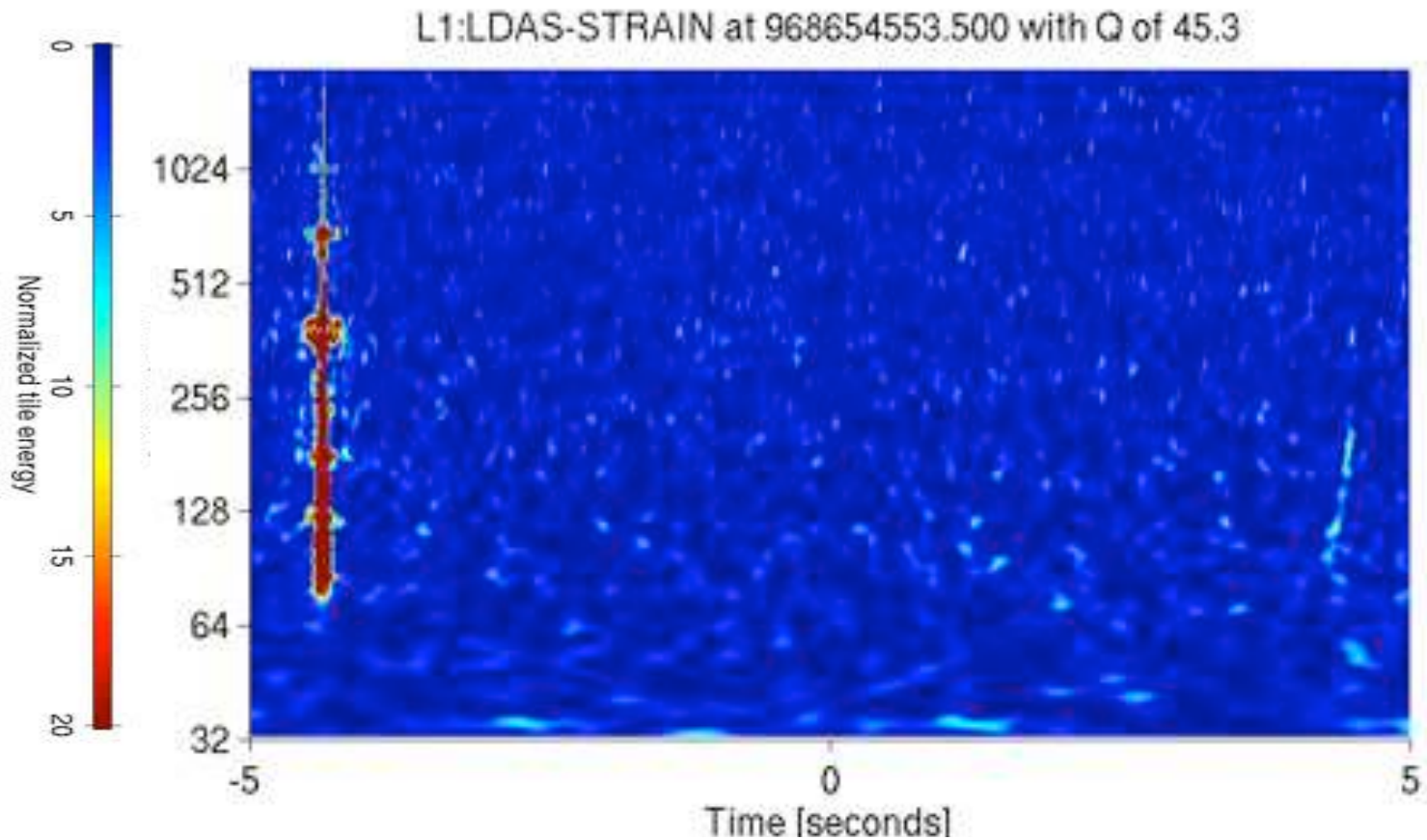
The significance



The event has a false alarm rate of less than 1 in 7000 y.

Instrumental Validation

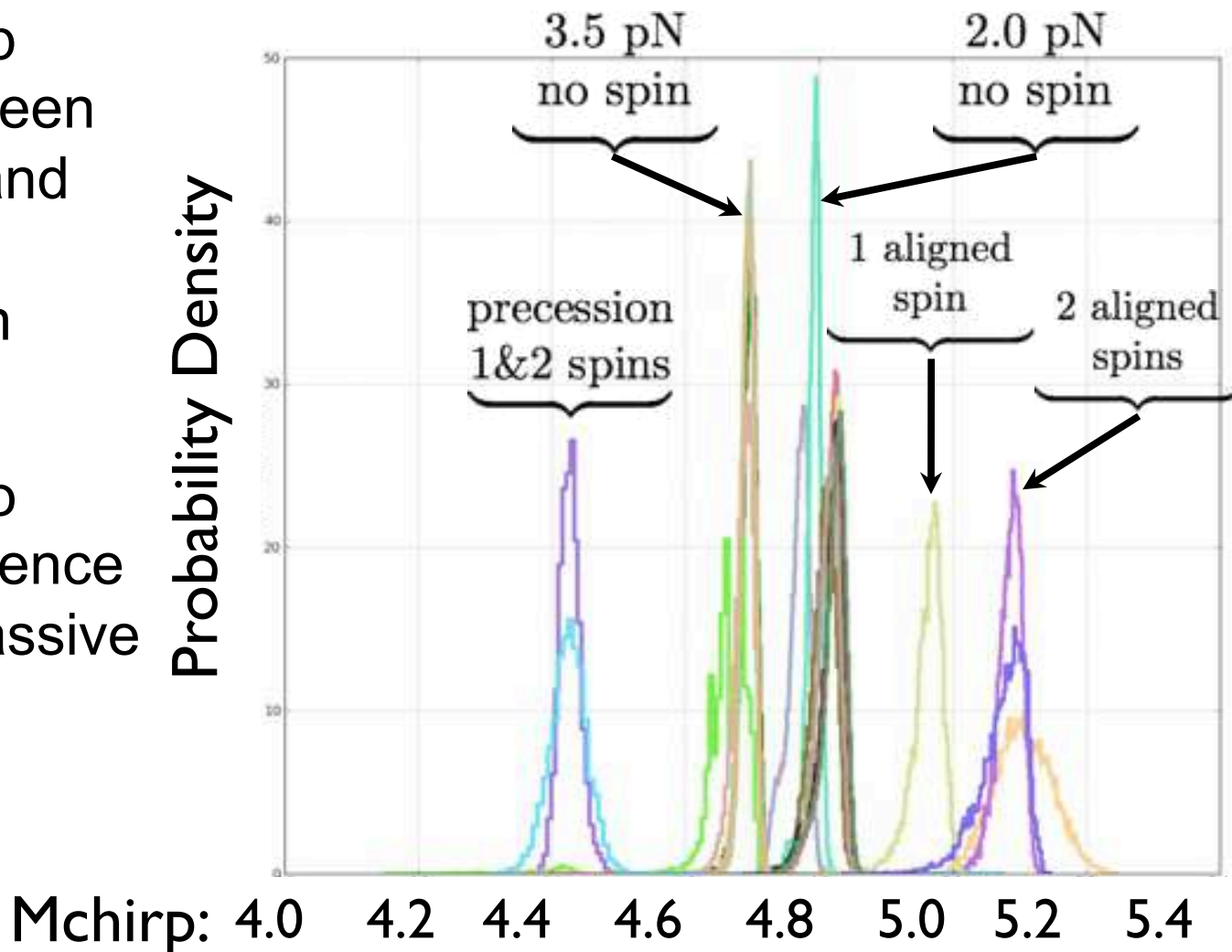
We find no evidence that the signal was of instrumental or environmental origin.



Source Parameters

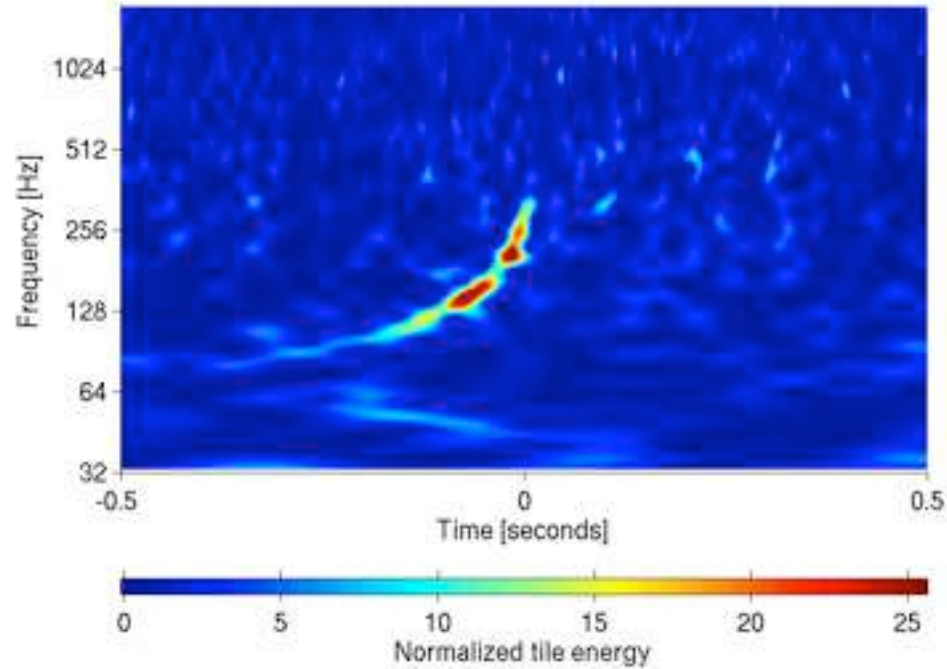
We find the chirp mass to lie between 4.4 and 5.2 M_{\odot} and the mass ratio (m_1/m_2) between 4 and 1.

The analysis also shows clear evidence that the more massive object has a spin above 0.67.

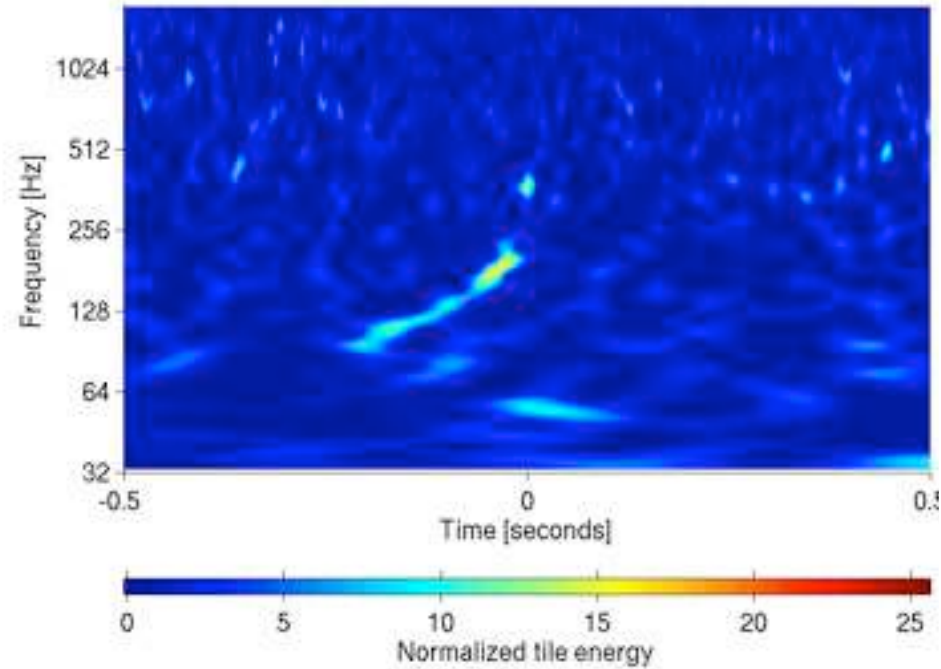


Waveform Subtraction

H1:LDAS-STRAIN at 968654558.000 with Q of 22.6

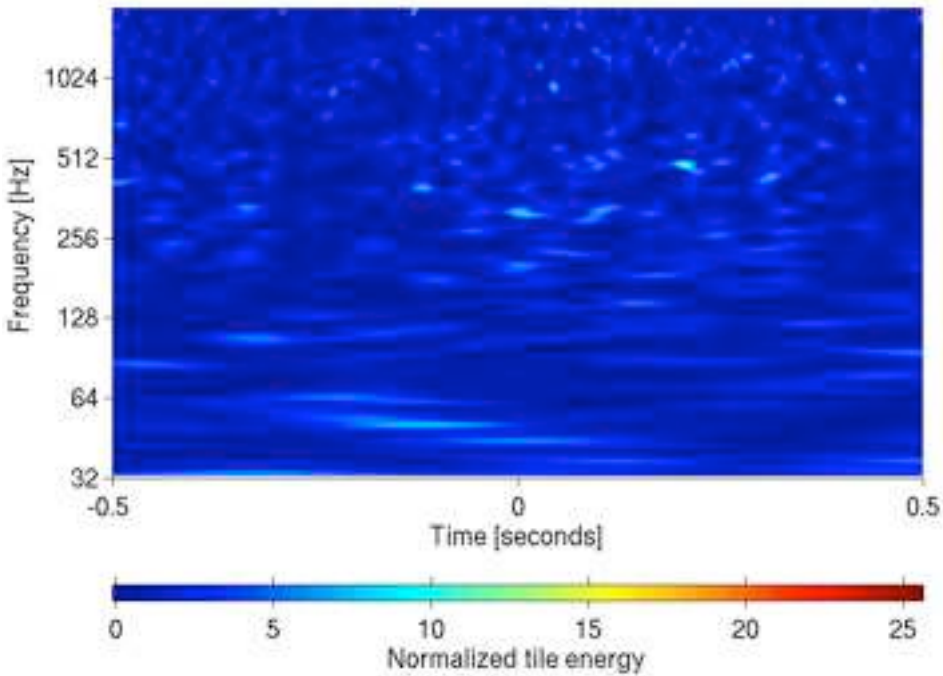


L1:LDAS-STRAIN at 968654558.000 with Q of 22.6

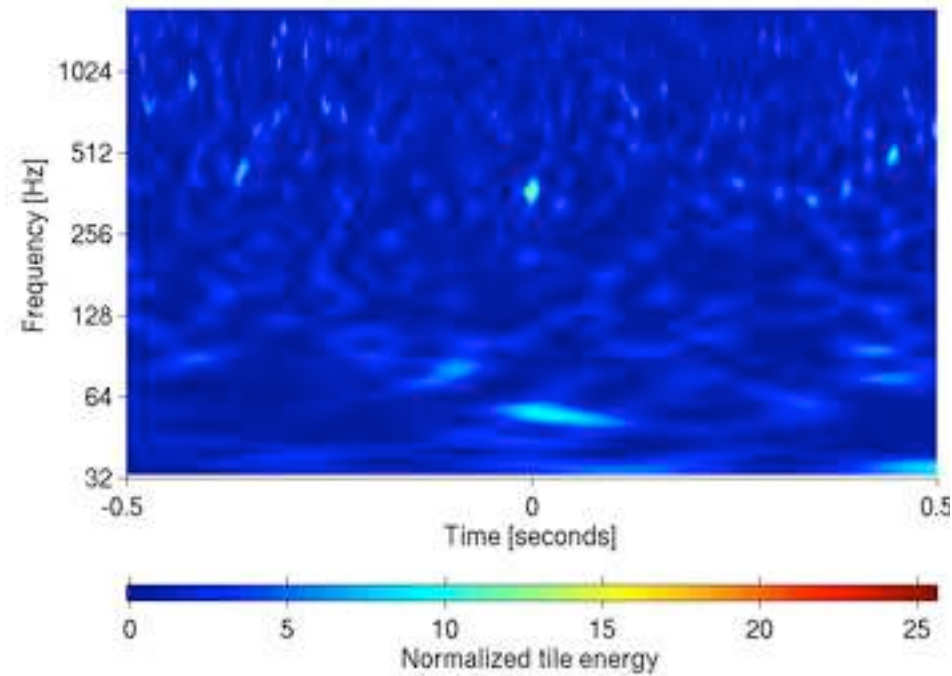


Waveform Subtraction

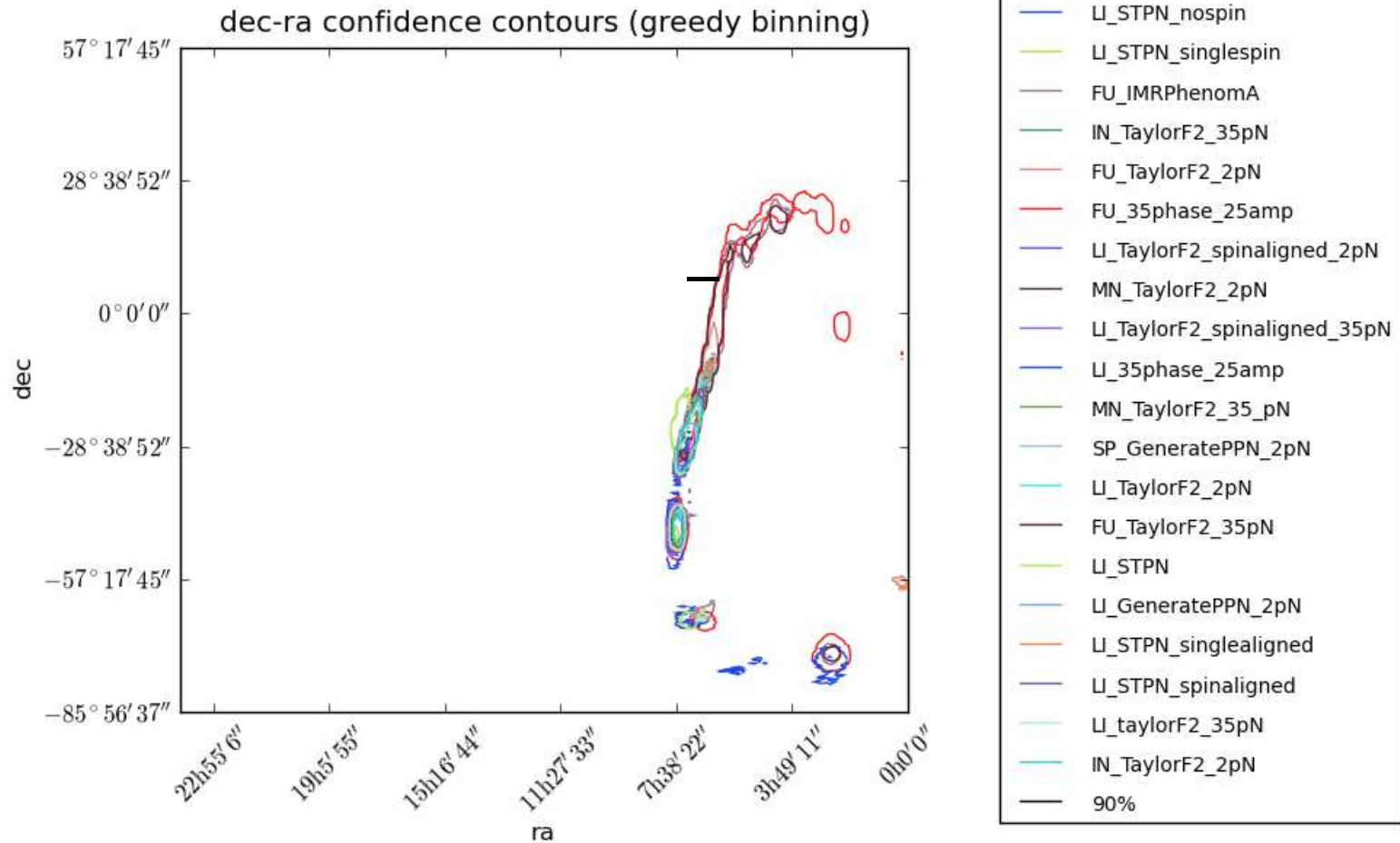
H1:LDAS-STRAIN at 968654558.000 with Q of 45.3



L1:LDAS-STRAIN at 968654558.000 with Q of 22.6

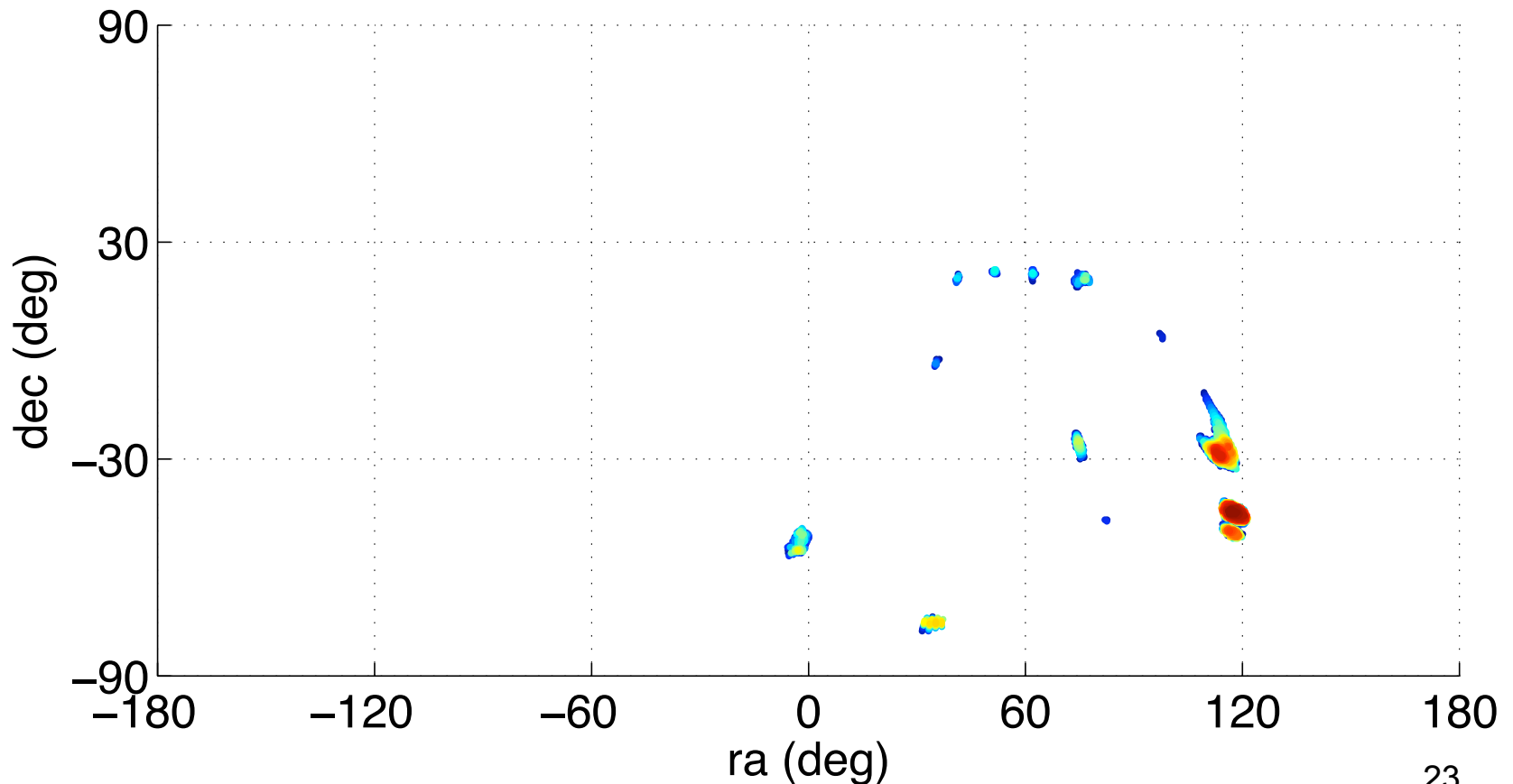


Parameters – sky location

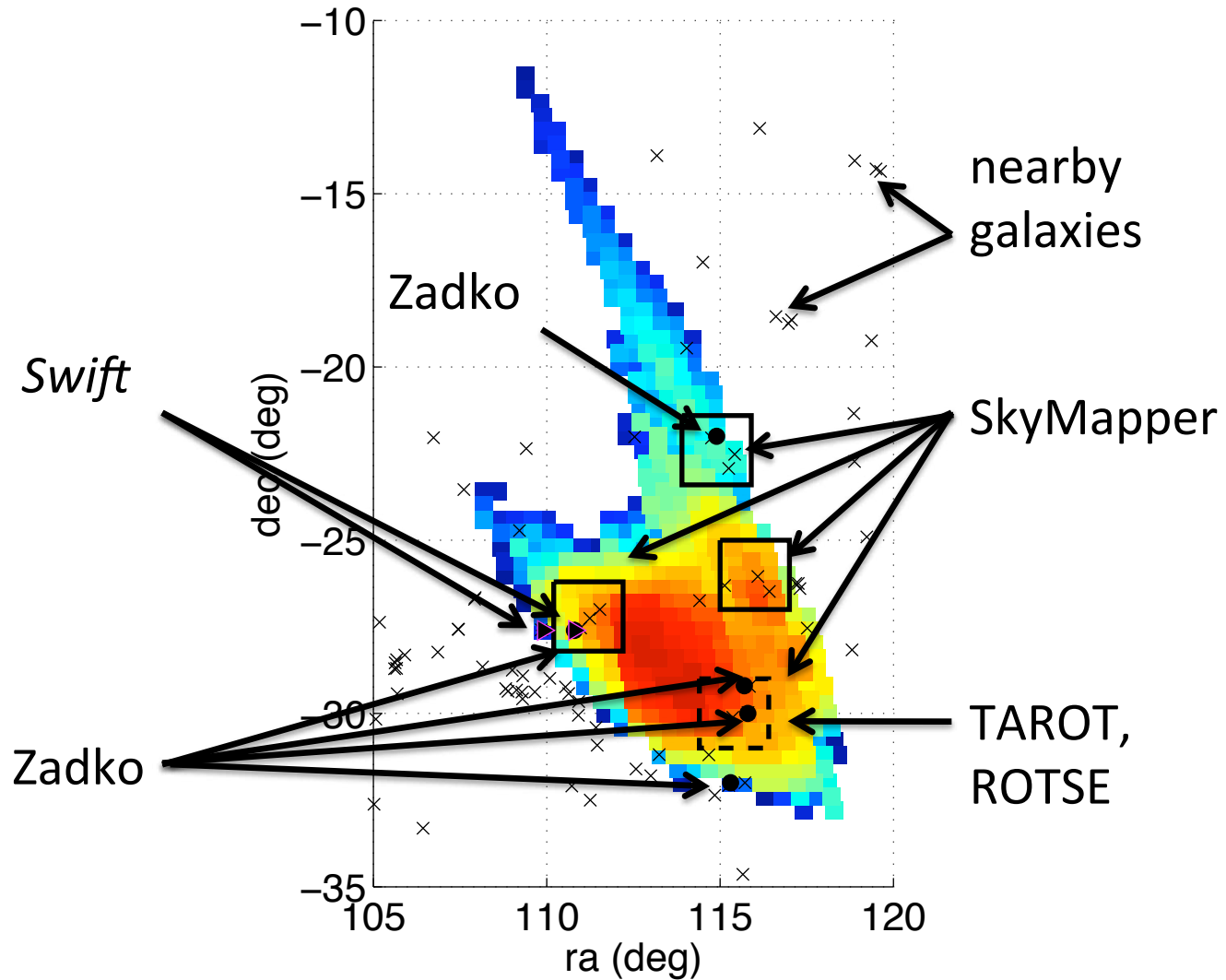


Low latency search

The sky location was estimated within an error region exceeding 160 square degrees (the maximum reported by the search).



Regions Imaged



Summary

- The “Big Dog” was a blind injection performed into the LIGO and Virgo detectors
- It was successfully recovered as a detection candidate with a false alarm rate $< 1/7000$ y.
- The process was a valuable end-to-end test of our analyses.
- Described in “Search for Gravitational Waves from Low Mass Compact Binary Coalescence in LIGO's Sixth Science Run and Virgo's Science Runs 2 and 3”, arXiv:1111.7314.
- The data around the time of the event is publically available at <http://www.ligo.org/science/GW100916/>