Veto Analysis in PyCBC

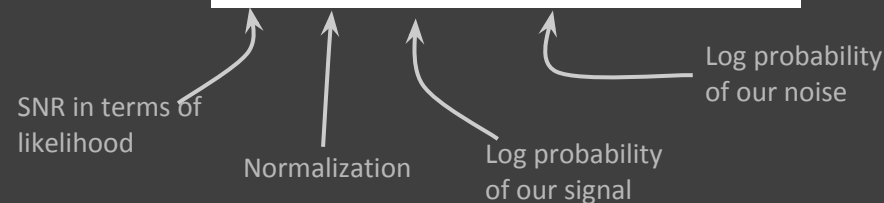Brina Martinez
LIGO SURF 2020

Topics we will cover

- What is PyCBC and Veto analysis?
- What are the motivation and goals of our project?

PyCBC Search Pipeline

- The PyCBC pipeline is used in the search for Gravitational Waves from a Compact Binary Coalescence
- PyCBC shows us the SNR and ranking statistics for our signals when correlated with expected waveforms
- PyCBC uses matched filtering to match templates and data
- PyCBC also uses a chi-squared consistency test to downrank triggers in the data and increase the significance of our signals. The SNRs of our triggers are weighted along this consistency test and outputs a new ranking statistic or re-weighted SNR

One of PyCBC's ranking equations:

$$\varrho^2 \propto 2\left[\log p^S(\vec{\theta}) - \log p^N(\vec{\theta})\right] + \text{constant.}$$

SNR in terms of likelihood

Normalization

Log probability of our signal

Log probability of our noise

Data Quality Veto Analysis

- Used to identify transient noise in data and remove segments to improve the analysis pipeline such as PyCBC
- In order for a flag to identify these transient noises they need to be correlated with some error in the detector or around it
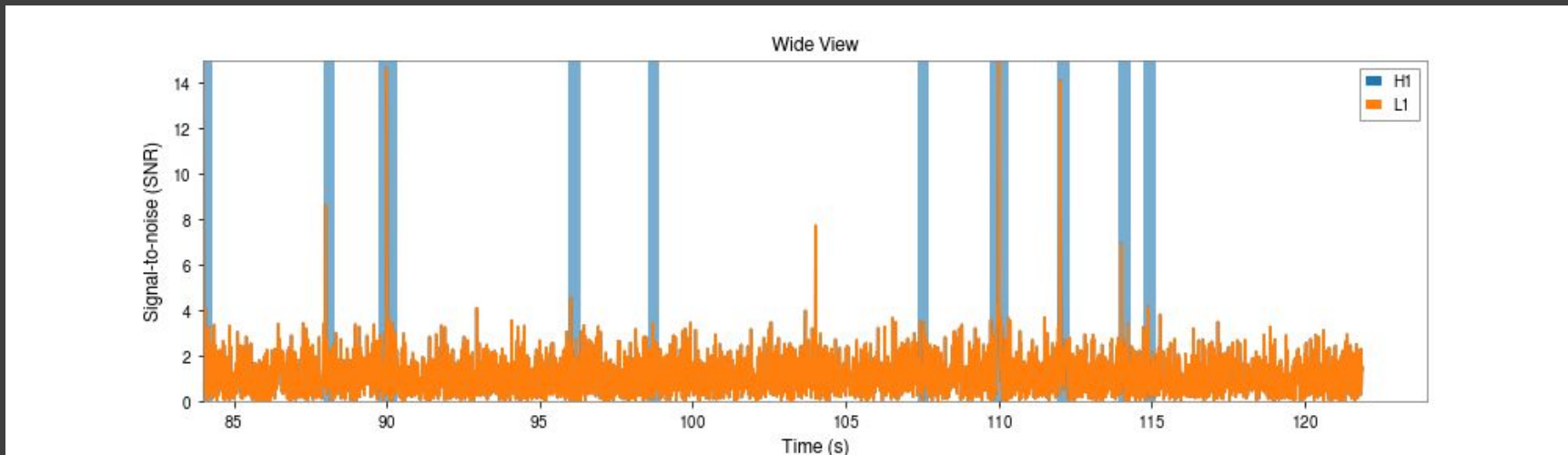
Current Status of PyCBC Veto Methods

- PyCBC has been great for extremely loud signals such as GW150914 but can be improved to detect quieter signals or signals covered by extremely loud glitches.
- A few problems we can see with current methods of veto analysis in PyCBC are:
  - Not removing enough glitches can decrease the search sensitivity
  - The possible removal of a signal if it occurs the same time as a glitch

B. P. Abbott *et al.* Phys. Rev. Lett. 119, 161101
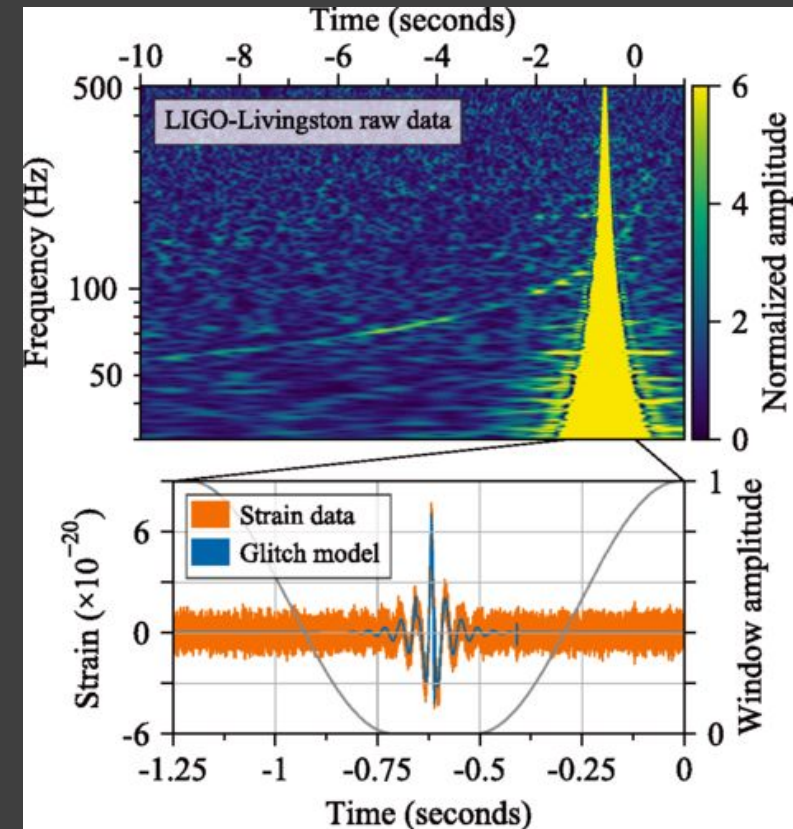
Choosing Flags

- Vetoes generate flags which identify segments in data where glitches or noise make it difficult to run analysis on signals.
- When choosing flags to correlate with glitches we want to identify flags that are useful in making our signal more significant.
- What types of flags can we use?
  - Auxiliary channels such as PEM (we do not want to use channels that mistakes injected signals or real signals as a glitch and remove them)
  - Hveto
  - Gravity Spy

B P Abbott et al. Class. Quant. Grav., 33 (2016)
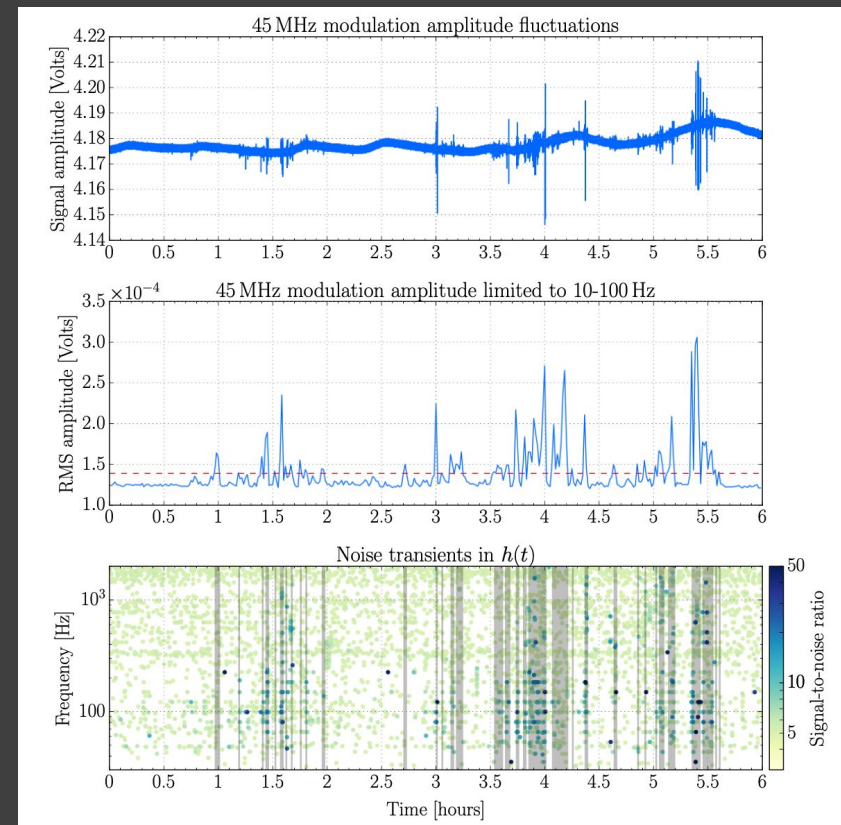
Downranking Time Around Signals

- One method of downranking triggers around signals is by using a chi-square consistency test
- In our investigation we will use the flags we choose to downrank triggers

- Since we aren't removing triggers completely, downranking the data can help us find more signals that could have a glitch near them

B.P. Abbott et al. Phys. Rev. Lett. 116 061102 (2016)
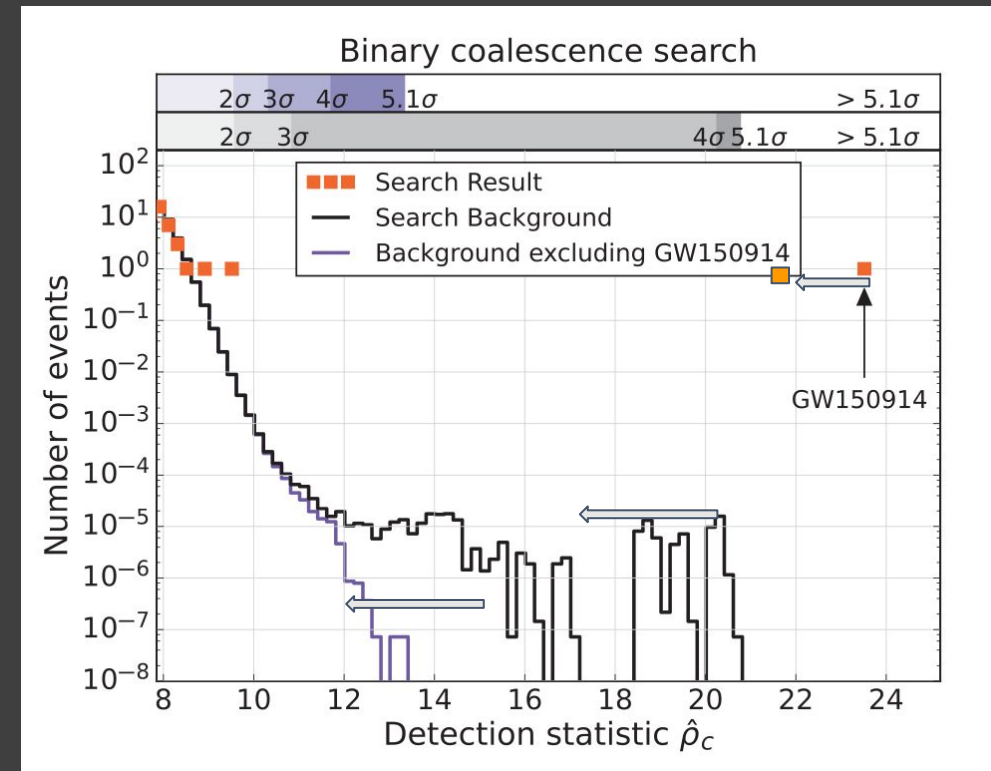
Improving Search Background

- We can compare our search with and without DQ vetoes
- Measuring search sensitivity
- Measuring the change in background

B P Abbott et al. Class. Quant. Grav., 35(6):065010, 2018.