GENERATING SIMULATED LIGO-VIRGO DATA USING GLITCH & GW MODELS

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INTRODUCTION

- We have several rapid analysis methods that help automate the process of validating gravitational-wave candidates prior to source property estimation.
- One powerful approach is **machine learning models** that look at images to identify artifacts in the data (glitches or GWs)
- Glitches are (mostly) short-duration noise artifacts that can interfere with gravitational wave detection

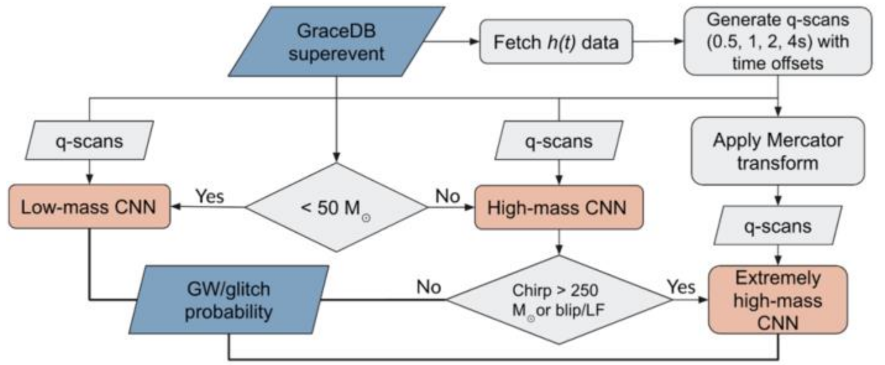
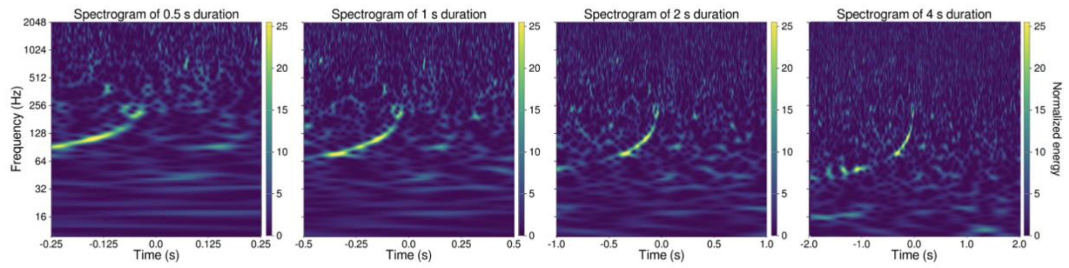


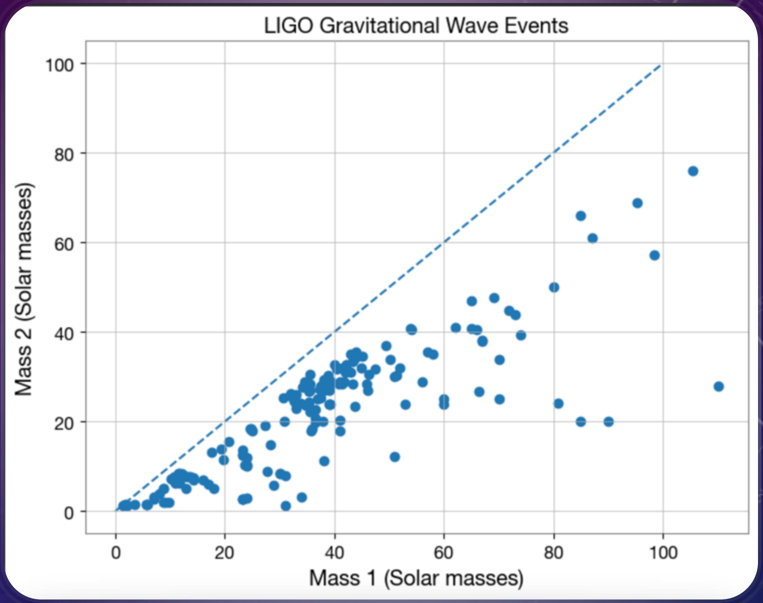
Figure 3. GSpyNetTree architecture: Triggered by a GraceDB superevent [31], time series (strain) data is fetched to generate spectrograms of 0.5, 1, 2, and 4 s durations. Time-frequency spectrogram visualizations are sent to the classifiers based on the estimated candidate merger mass, and the Mercator transform is applied to the extremely high mass GW candidate visualizations. Each CNN outputs the probability that the input visualization contains a GW, an included class of glitch, or no glitch.

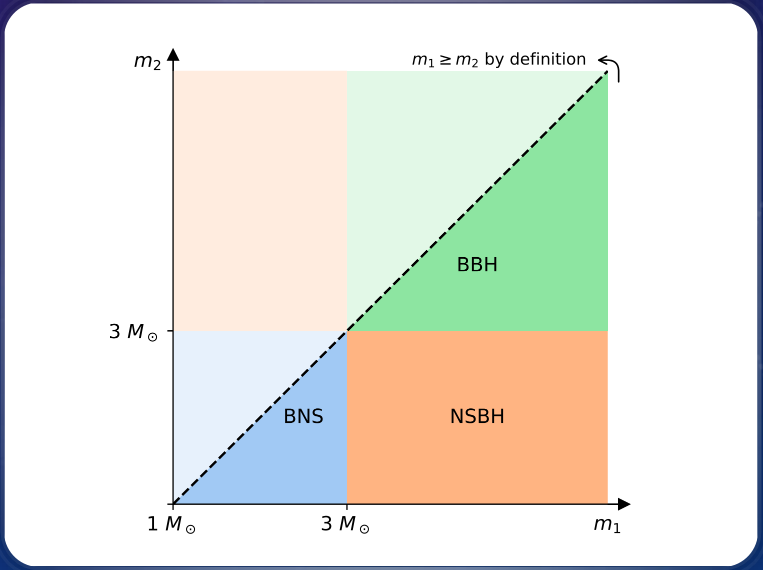


https://iopscience.iop.org/article/10.1088/1361-6382/ad2194/pdf

THE DATA PROBLEM

- To improve these models, it is very important to have data for which we already know all the information about
- The problem with using real detector data is the lack of input control.
  - We can't turn off the Universe (for GWs or glitches)
  - **There may be crucial corner cases/regions of the GW/glitch parameter space that the model handles poorly**
- We examine these less common regions using **simulated data**



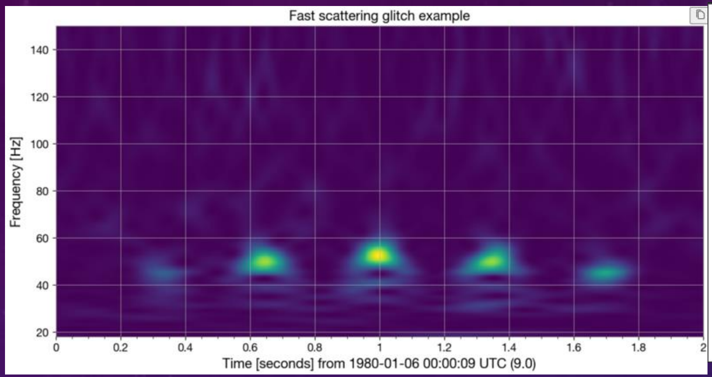


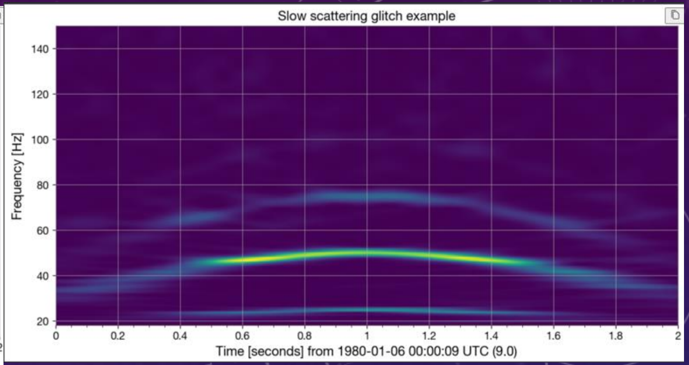
Source: https://emfollow.docs.ligo.org/userguide/content.html

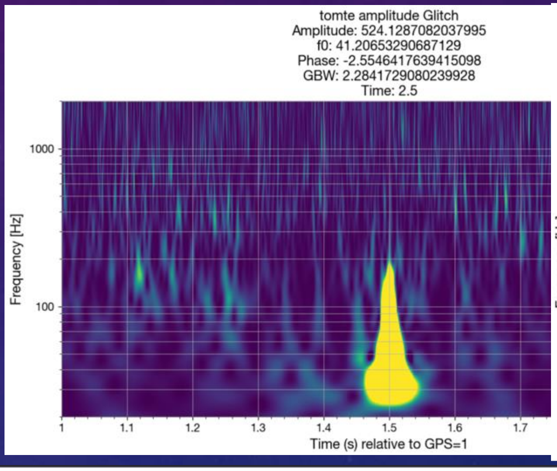
GLITCHPOP

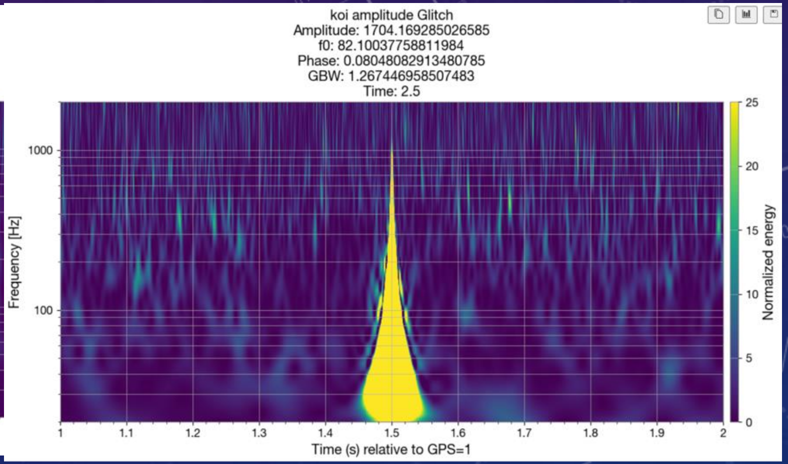
- GlitchPop is the Python package first developed by **Sean Collins** to simulate detector data using real PSDs from the previous observing runs, and injections of simulated GWs and glitches

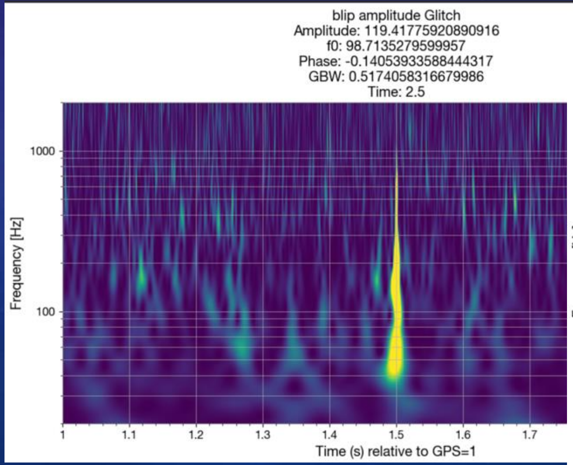
- The most advantageous part of GlitchPop is our fully analytic **glitch modelling**
  - GlitchPop includes models of scattering (Udall & Davis, 2022) and short-duration glitches (Bondarescu, Lundgren, & Macas, 2023) fully described by physical parameters.

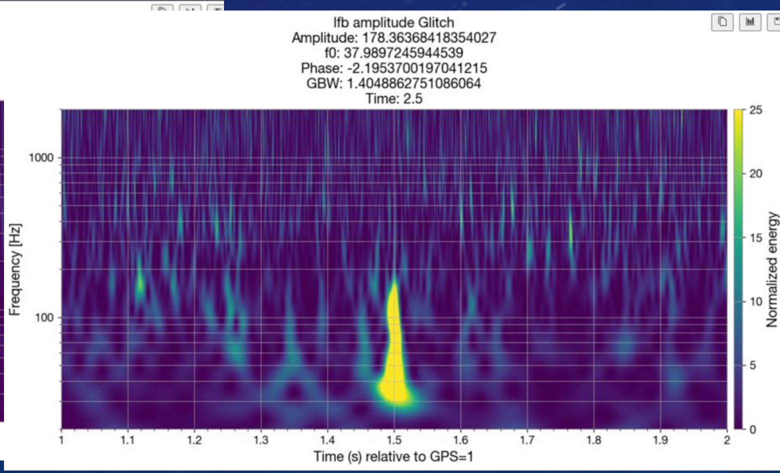








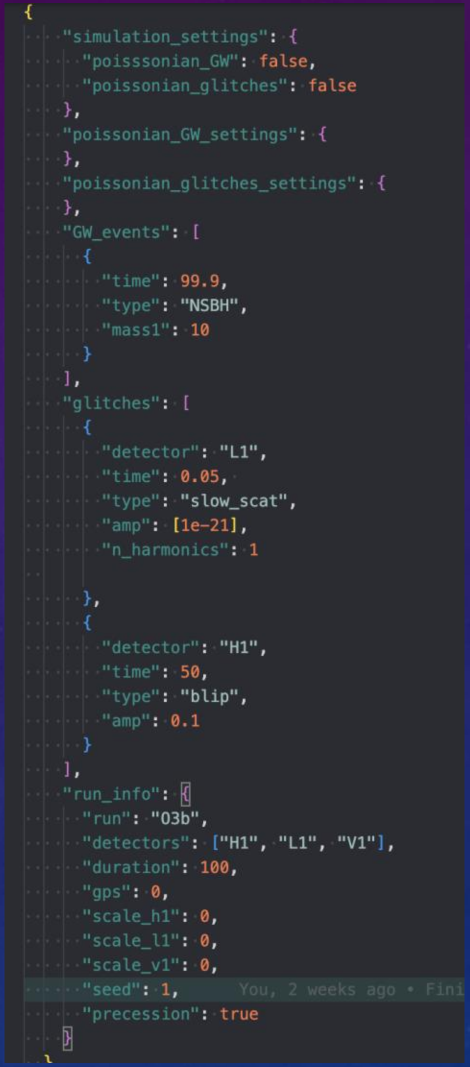




GLITCHPOP FUNCTIONALITY

- Another great part about GlitchPop is its extensive customization functionality that lets you specify as much or as little as you want about the simulated data output
- All the way from completely generated to custom glitch and GW signals in each detector
- Customization of run ->

JSON input



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        "amp": [1e-21],
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        "time": 50,
        "type": "blip",
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    ],
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      "gps": 0,
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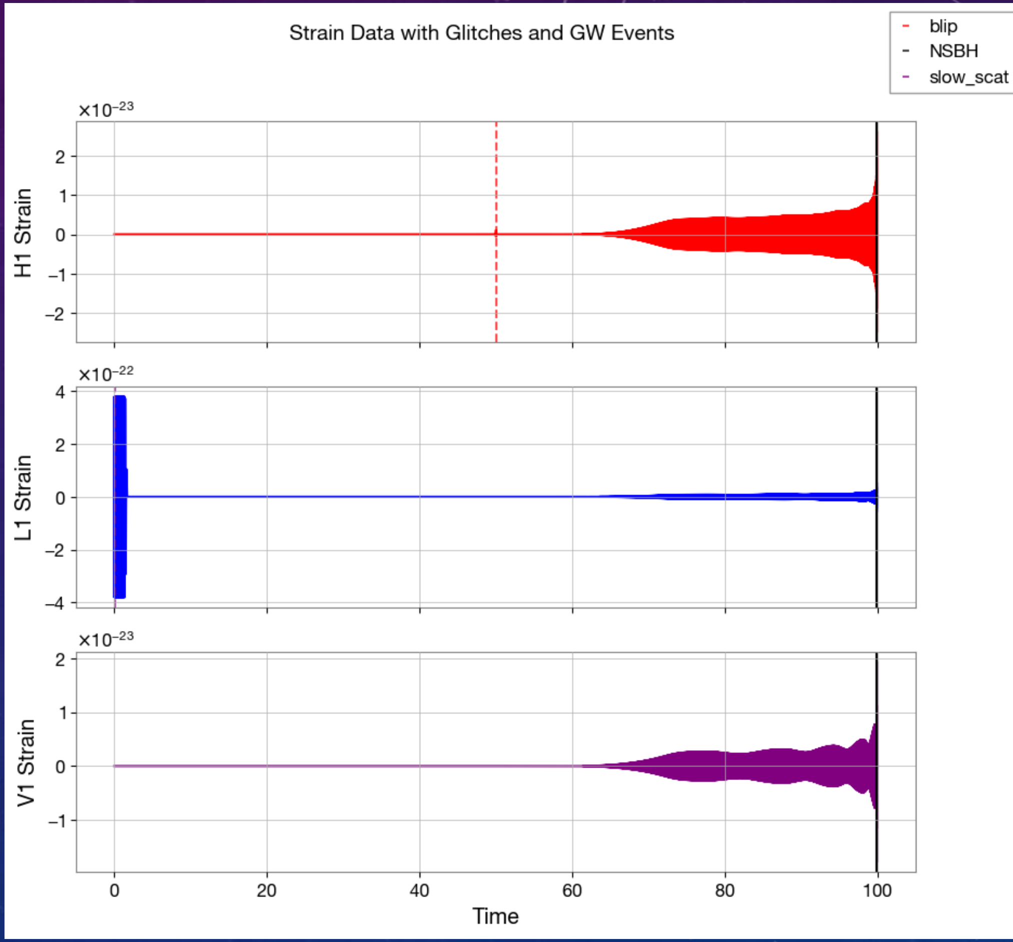
      "scale_l1": 0,
      "scale_v1": 0,
      "seed": 1,          You, 2 weeks ago • Fini
      "precession": true
    }
}
```

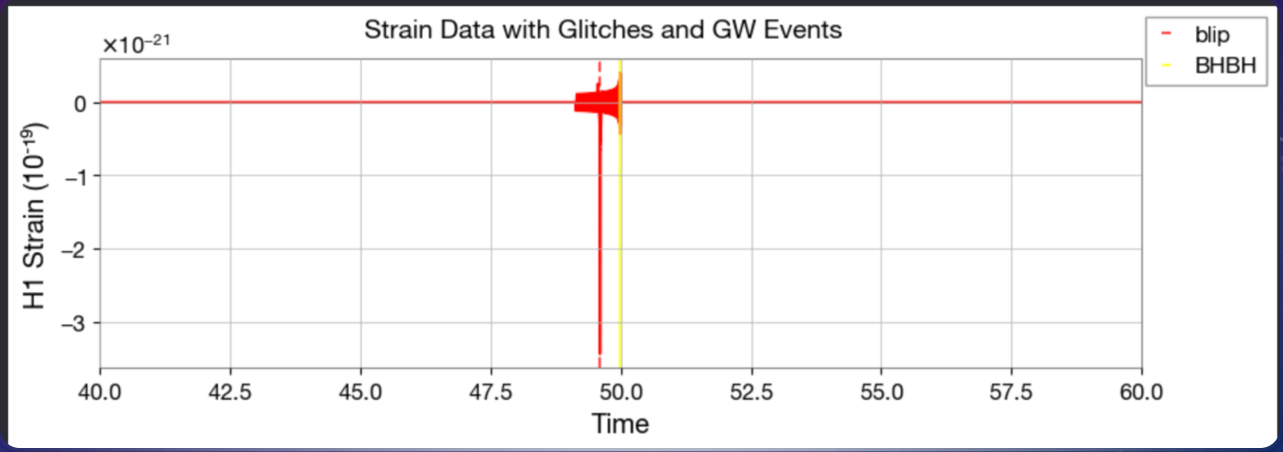
--> Output (no noise so you can see the signals)



Output is a .JSON file and .xml file with all the information about events and simulation/run settings The strains are sent to frame (.gwf) files in the same directory.

APPLICATIONS OF GLITCHPOP

- For the rest of the summer, I (and hopefully others) will be using GlitchPop to test and improve various signal recognition machine learning models, e.g. GSpyNetTree, GWSkyNet
- More specifically, some cases of interest are:
  - Sliding glitches across signals to assess where the models tend to give incorrect predictions
  - Testing how models react to different merger time spacings across different detectors, crossing into unphysical spacing predicted by GW propagation speeds



THANK YOU FOR LISTENING!

Questions/comments?