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Extending a Plotting Application and Finding Hardware Injections for the LIGO Open Science Center

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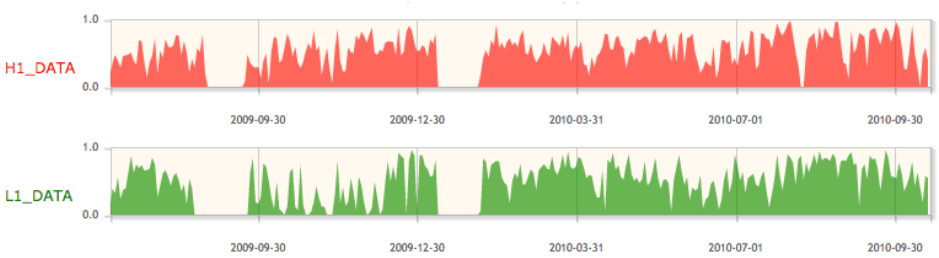
Outline: Two Projects

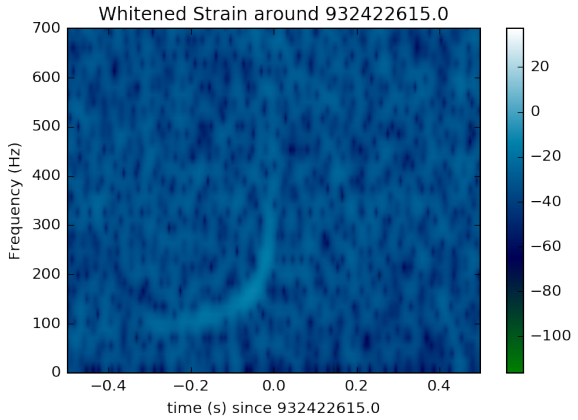
- Introduction to the LIGO Open Science Center
- Extending an online plotting application
- Searching for hardware injections in O1 data

The LIGO Open Science Center

- Publicly accessible data repository
  - » Bulk strain data and documentation
  - » S5 and S6 datasets
  - » Data around events
- Variety of analysis tools
  - » Python tutorials
  - » Timelines
  - » Quickview
- O1 dataset to be released
  - » Full documentation necessary

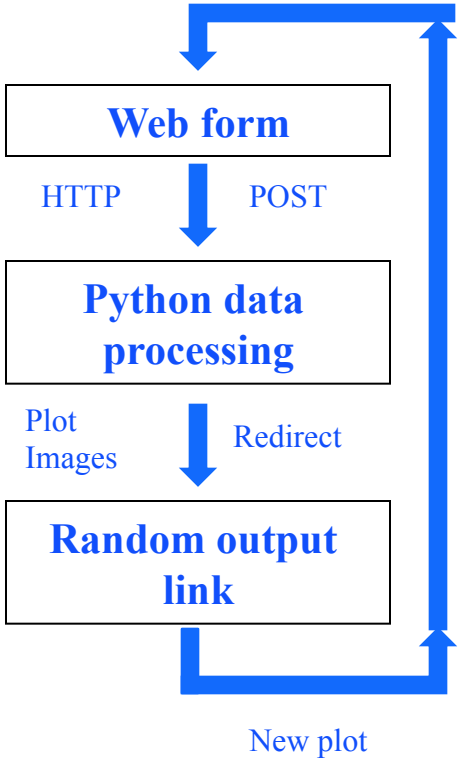
All of this at losc.ligo.org





The Online Plotting Application

- splot – instantly generates plots from web form
  - » Input
  - » Output
- Static images
  - » Cumbersome for data examination
- Stored on server statically
  - » Releasing for public problematic



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Plotly.js

- Open source JavaScript library
- Rich Interactivity
  - » Box to zoom
  - » Pan, select, hover to show data
  - » Download plots to disk as png
- Plot types needed built in
  - » Heatmap
  - » Linked scatter plot

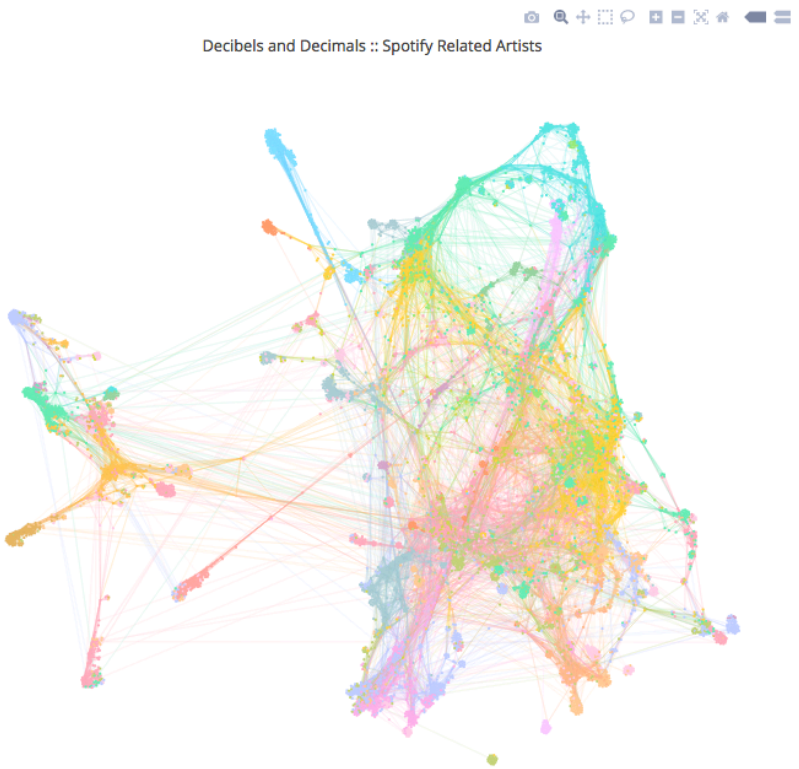

Image source: plot.ly website

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Bringing it all together

- Finished product uses one URL
  - » splot on losc-scratch
- Plotly library enables interactive use
  - » Box zoom most relevant feature
- Web framework links form to plots without disk use
- JavaScript links plots on the front end

Working version here:

https://losc-scratch.ligo.caltech.edu/splot/

Hope to release to public soon.

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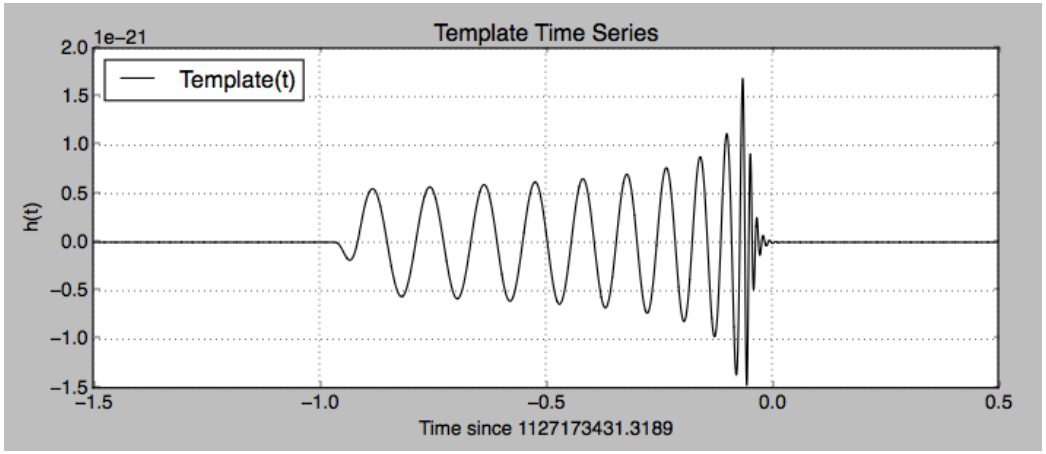
What are hardware injections?

- Simulated signals injected using control actuators
  - » Mirrors moved to same strain as real GWs
- Injections used for testing
  - » Detector characterization
  - » Search pipelines
    - – CBC
    - – Burst
    - – Stochastic
- O1 LOSC release
  - » HWI need record



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FINDCHIRP: A Matched Filter

- Searches for signal based on template
  - » Filter output is un-normalized SNR
- Applies the filter independently of time
  - » Works in the frequency domain
- Normalization factor function of template and noise

$$z(t) = 4 \int_0^\infty \frac{\tilde{s}(f)\tilde{h}^*_{template}(f)}{S_n(f)} e^{2\pi i f t} df$$

$$\rho_m(t) = \frac{|z_m(t)|}{\sigma_m}$$

Source: Allen, et. al. 2011

State of Hardware Injection Documentation

- Documentation spread over multiple sources
  - » Wiki pages
  - » aLogs
  - » Hardware injection schedules
- Documentation must be collected for public release
  - » Information on each injection necessary to avoid confusion

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Matched Filter Results

- Schedule file used for input
  - » Determined to be most complete documentation
- Burst and CBC injections scanned
  - » Detchar and stochastic injections still need recovery
- Small majority of injections failed to reach data
  - » 20% occurred with the detector not recording data
  - » 34% had less than 6 SNR recovered
- Successful injections recovered at close to 1 to 1
  - » Table created with results and injection parameters

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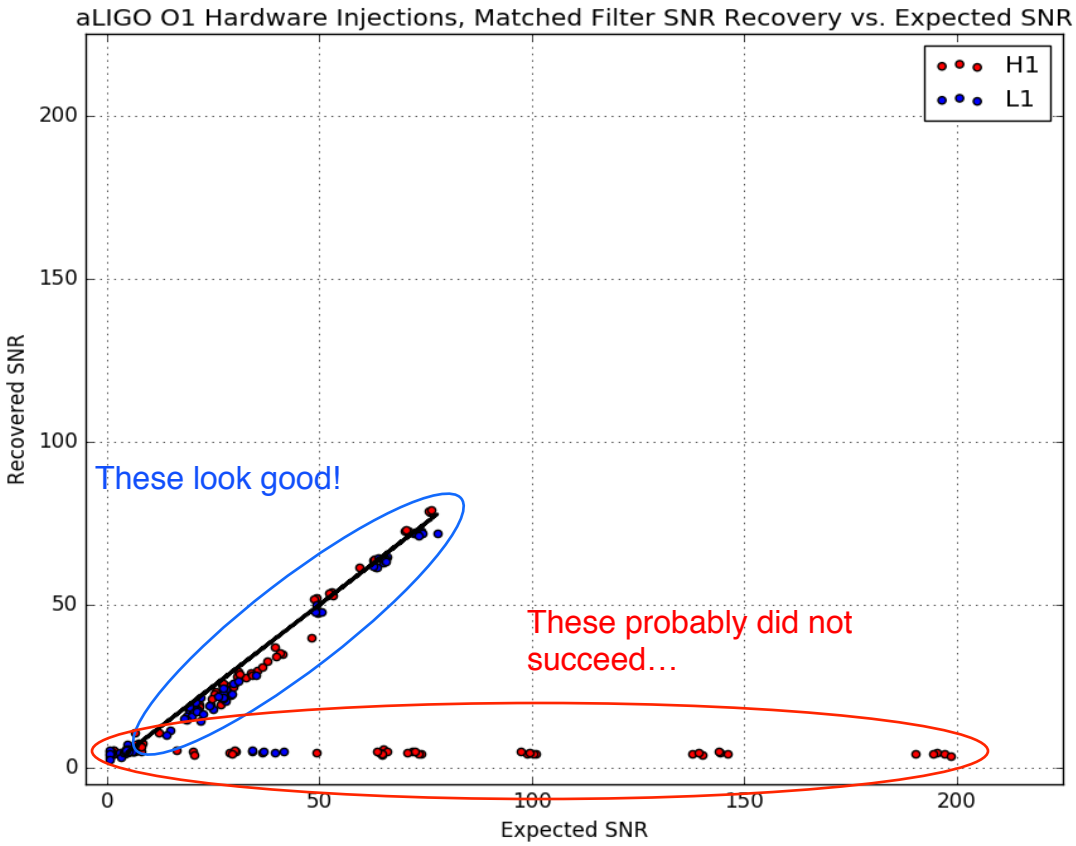
Match Filter Results



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Next steps for HW Injections

- Clean up edge cases
  - » Verify that low recovery injections failed
  - » Validate injection catalog resources
  - » Missing parameter files
- Search over injections from other groups
- Check results against injection channels
  - » Stream of data used for injections – must be complete
  - » Could contain undiscovered injections
- Generalize code for use on future science runs

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Acknowledgements

- My mentors: Eric Fries, Jonah Kanner and Alan Weinstein
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- The Hardware Injection team
- LIGO SURF Program
- LIGO Laboratory
- Caltech
- NSF

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References

https://losc.ligo.org

https://plot.ly/javascript/

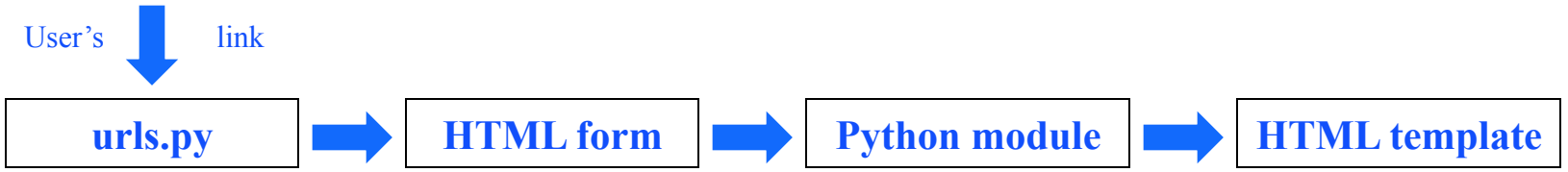
https://plot.ly/~fowler.brady/41/decibels-and-decimals-spotify-related-artists/#plot

https://docs.djangoproject.com/en/1.9/

https://arxiv.org/abs/gr-qc/0509116

The Python web framework: Django

- Full stack Python web framework
  - » Makes web programming accessible to Python coder
- Unifies Python in backend with HTML views
  - » URLs parsed to call Python methods
  - » Data passed between backend and HTML as Python objects
- splot written in Python, easily adaptable



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Future work on splot

- Expand education opportunities
  - » Further description of plots and processing
  - » Elaborate hardware injection information
- Prepare for public release
  - » Strengthen error checking
  - » Prep for O1 dataset release
- Implement other plots or more interactive resources?
  - » Active parameter changes?
  - » Real time data analysis?