



Recovering Burst Injections in LIGO S5 Data

Alex Cole

Data Analysis Meeting

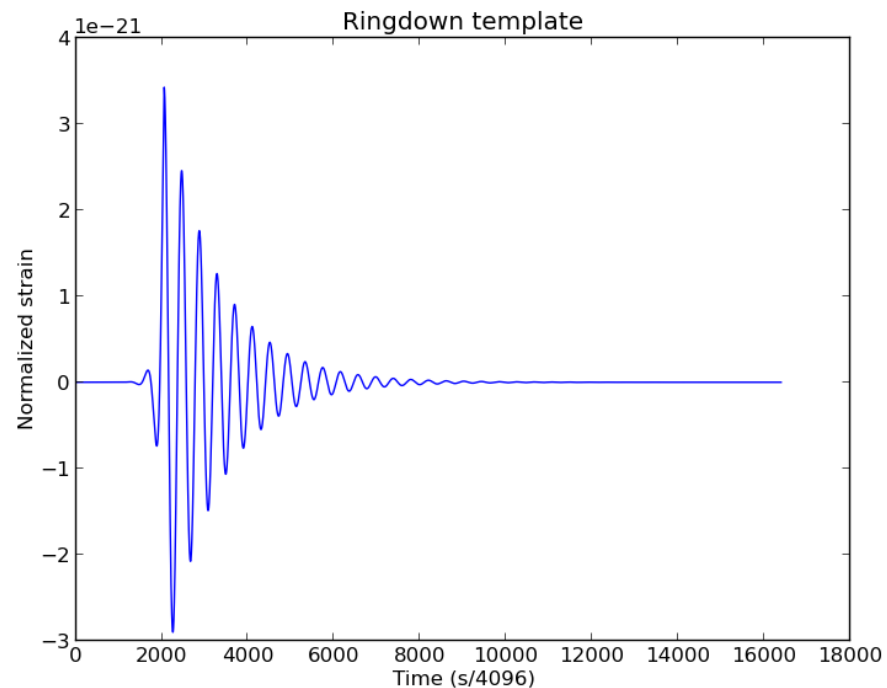
May 6, 2014

Motivation

- LOOSC – LIGO’s commitment to open science
- S5 Science Run (2005-2007)
 - » “strain” files at 4096 Hz
- Injections – test the pipeline, calibrate detectors
- Interesting computational task of finding signal in noise
- Previous work on CBC injections – Ashley Disbrow

Injections

- Types:
 - » Sine-Gaussian
 - » Gaussian
 - » Zwerger-Mueller
 - » Ringdown
 - » Cosmic string cusp
 - » White noise burst
- Parameters:
 - » GPS time, offset
 - » Scale
 - » Log message
 - Successful
 - Not in Science Mode
 - Injection Process Off
 - GRB-Alert
 - Injection Compromised



Finding a GW Signal

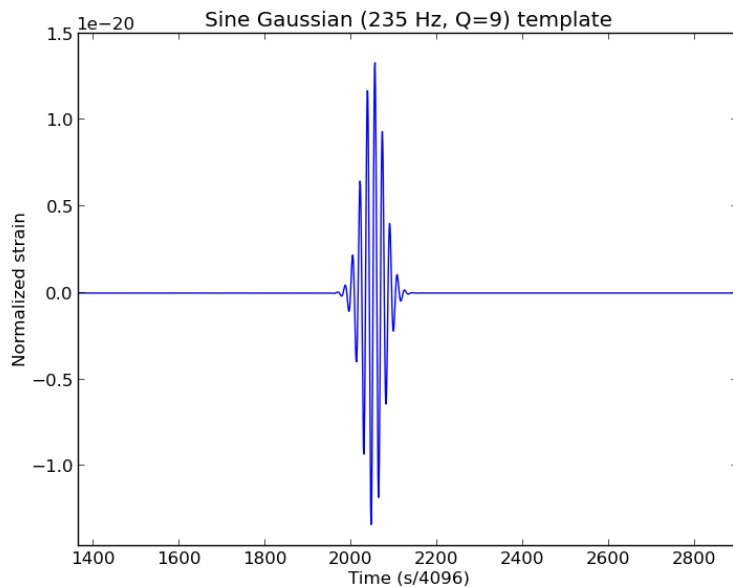
- Matched filter
 - » Perform weighted cross-correlation in frequency domain
 - » Weight by inverse of noise power

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

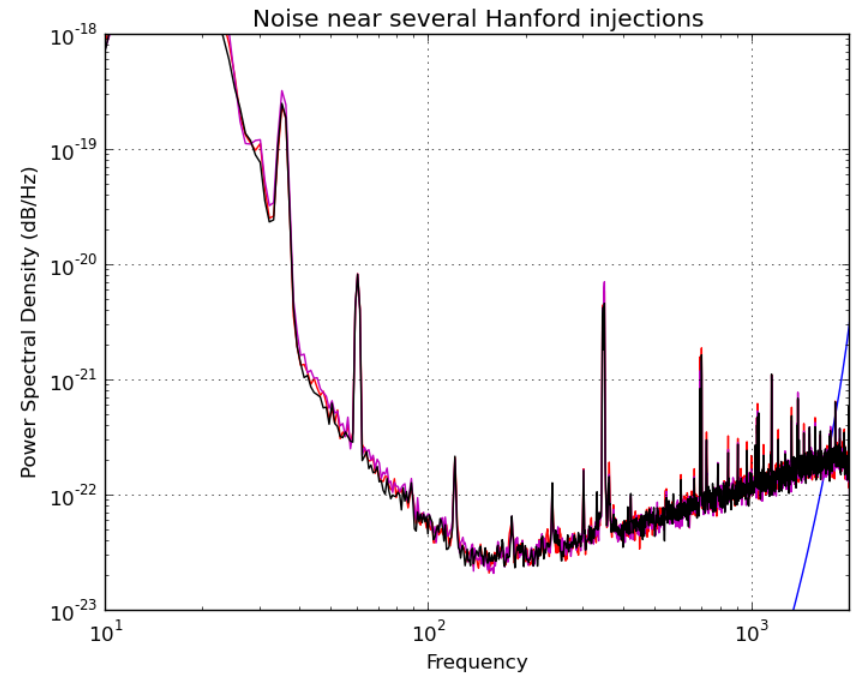
Matched Filter Search

- Generate template (and FFT)
- Grab PSD of noisy data

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



LIGO-G1400501-v2

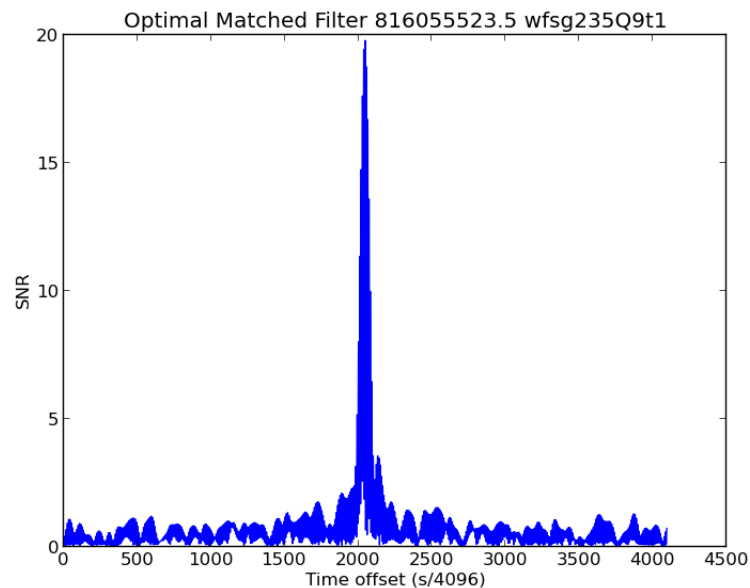
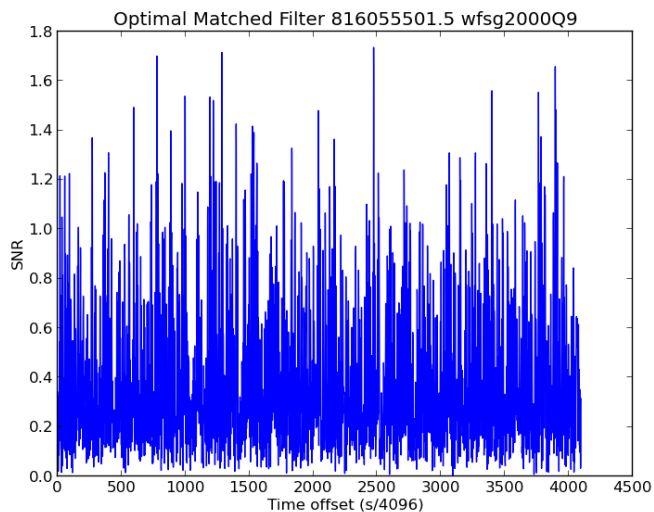


Matched Filter Search – Part 2

- Cross-correlate with noise weight
- IFFT and normalize \rightarrow SNR

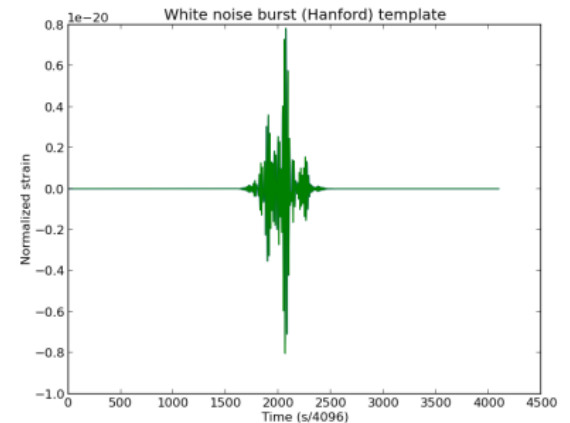
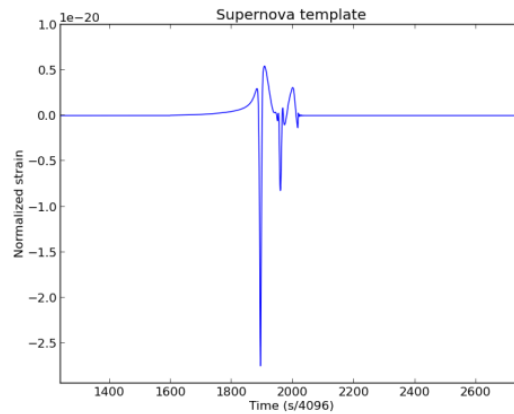
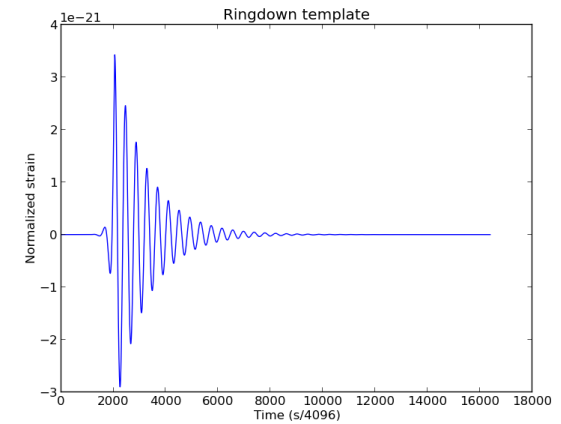
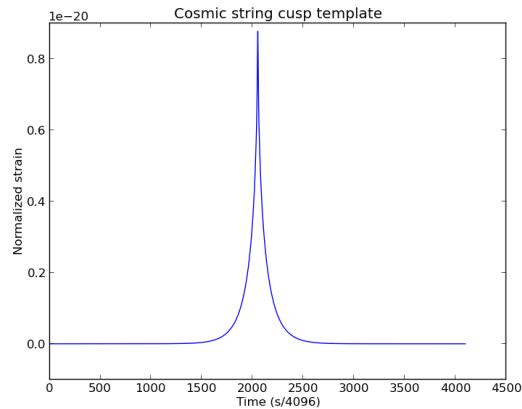
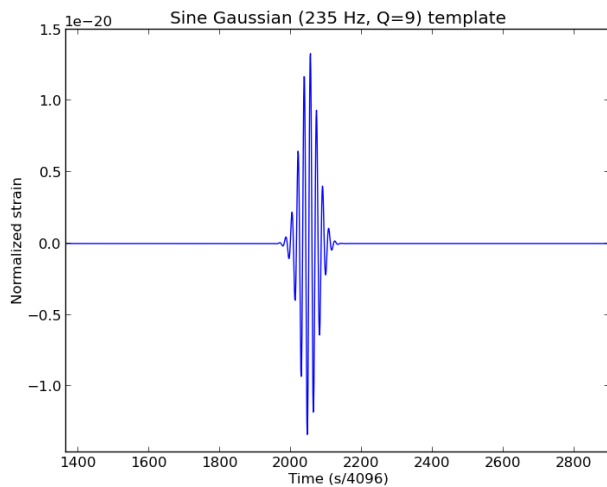
$$x(t) = 4 \operatorname{Re} \int_0^\infty \frac{\tilde{s}(f) \tilde{h}_{\text{template}}^*(f)}{S_n(f)} e^{2\pi i f t} df$$

$$\sigma_m^2 = 4 \int_0^\infty \frac{|\tilde{h}_{1\text{Mpc},m}(f)|^2}{S_n(f)} df.$$



Techniques: Templates

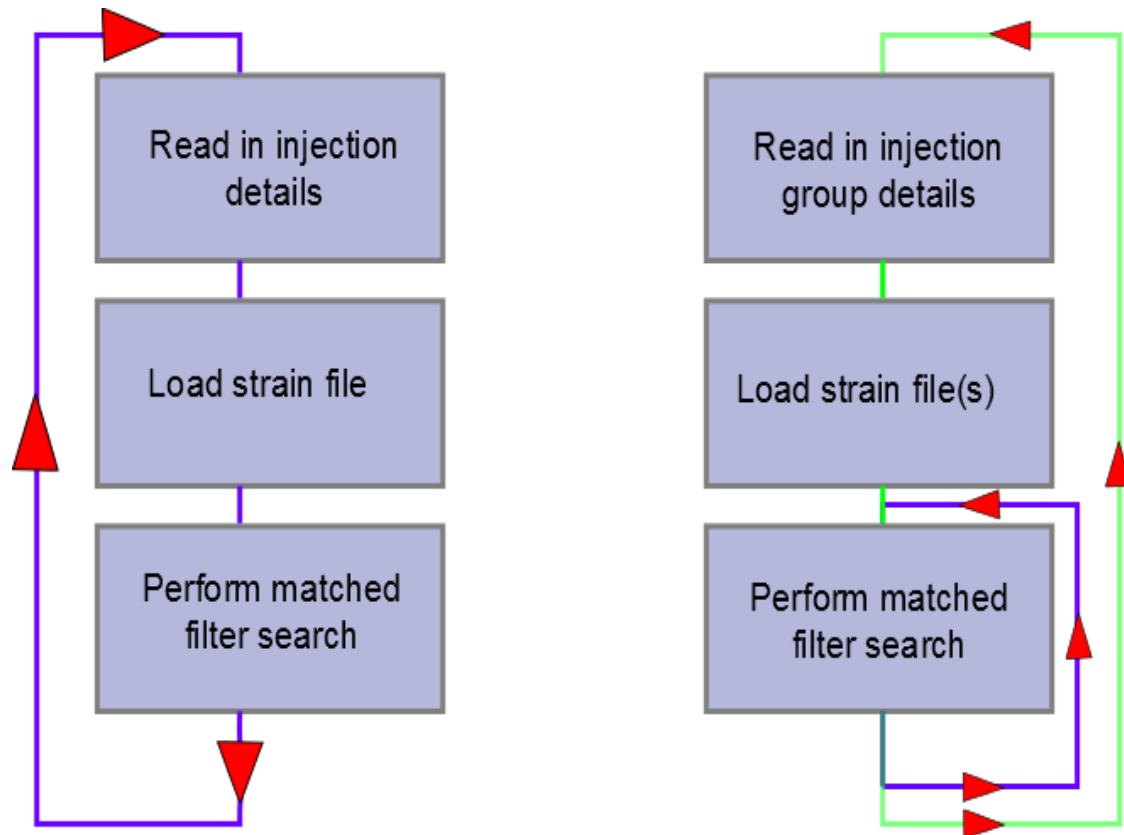
- Template generation
 - » Many types!
 - » Python, downsampling



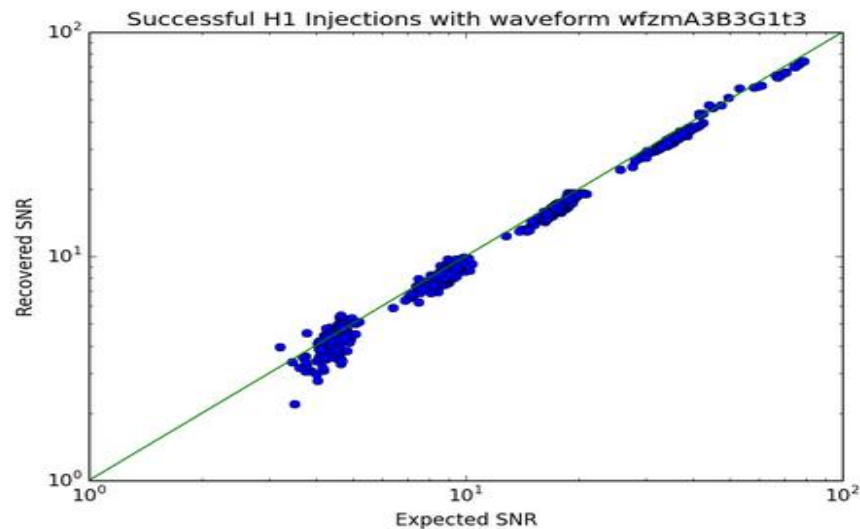
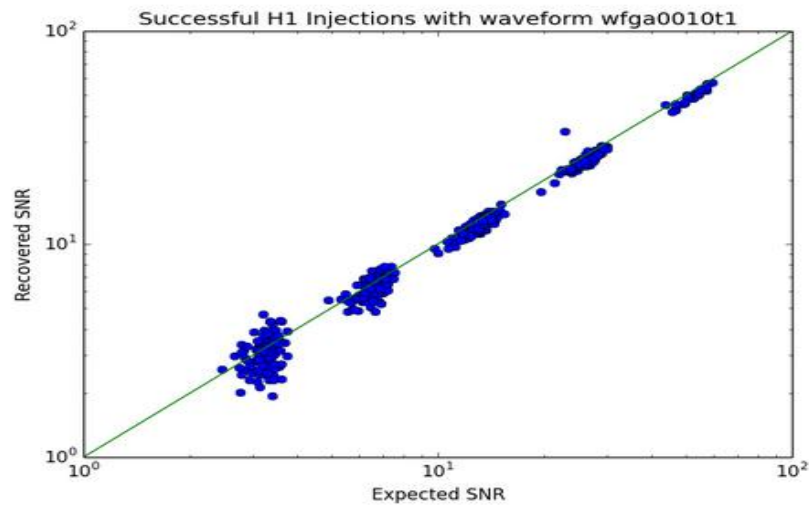
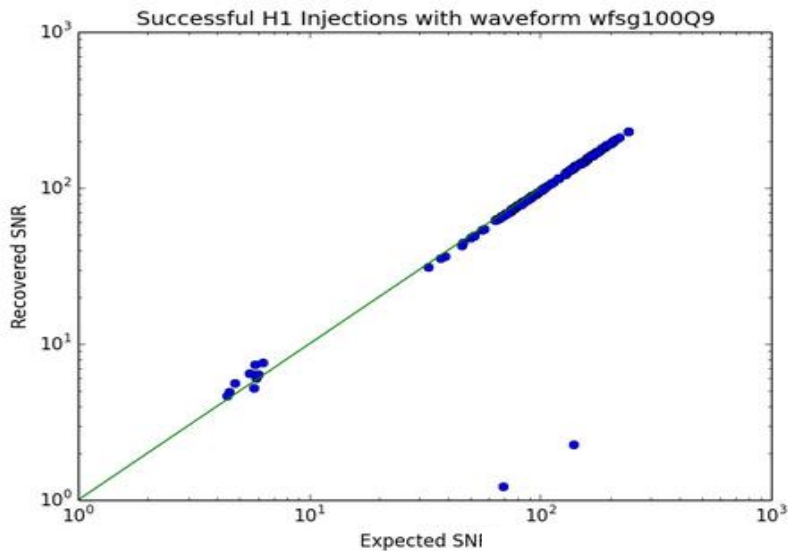
Techniques: Efficiency

- Efficiency overhaul

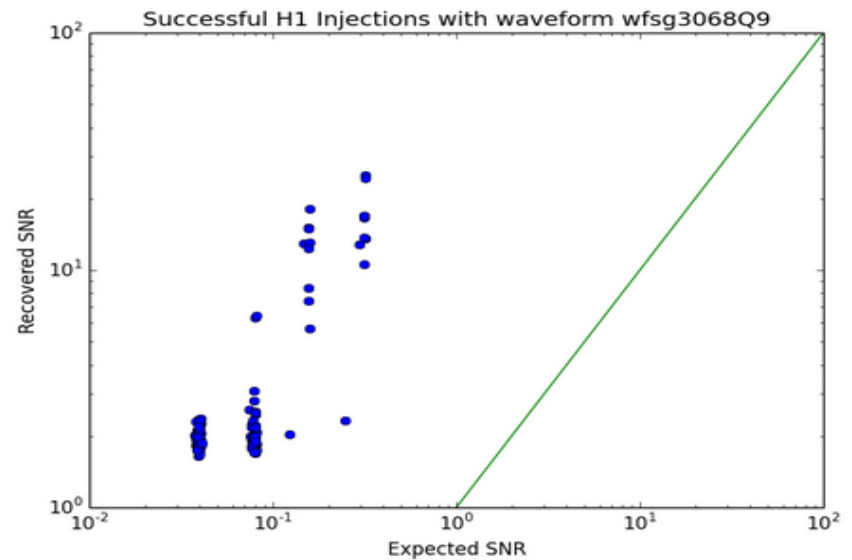
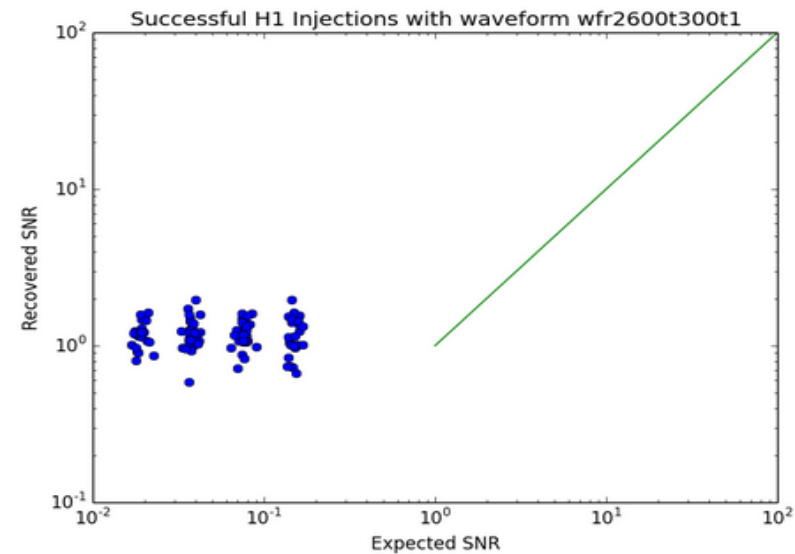
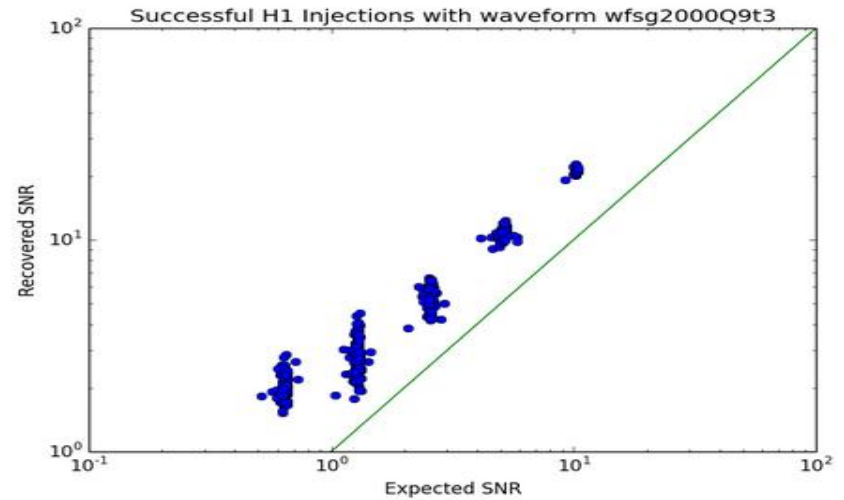
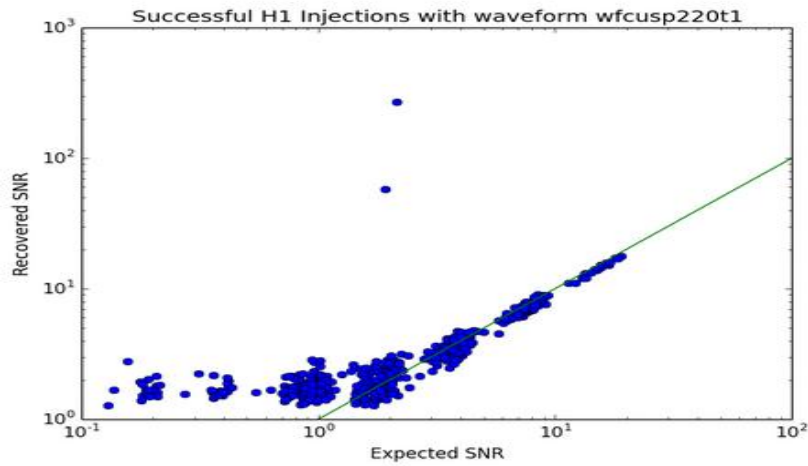
- » 60,000 burst injections! (cf. 1,492 “successful” CBC injections)
 - 4 hours vs. 1 week
- » Group injections (<200 seconds to next neighbor)
- » Groups of 3-36



Results – Successful Injections 1

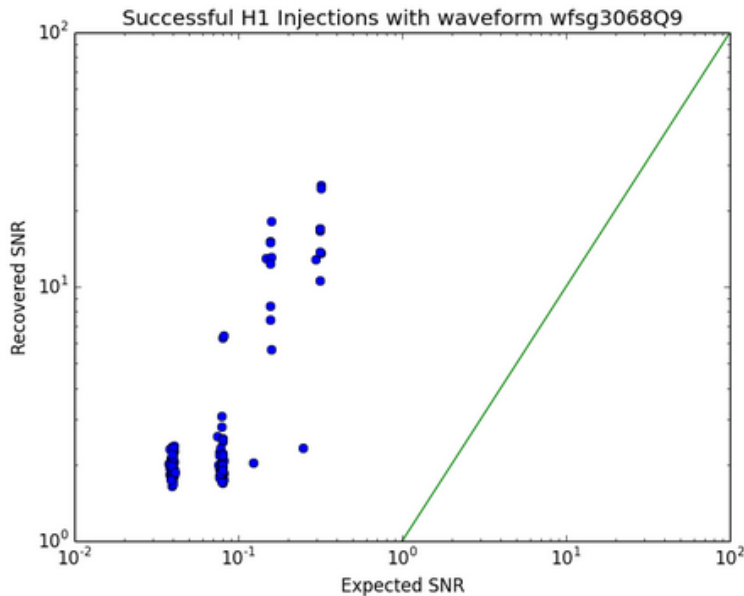


Results – Successful Injections 2

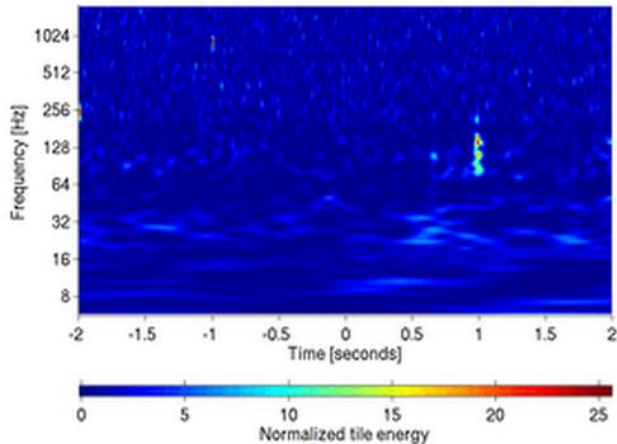


Outliers

- Omega scans
- “H1 MASTER OVERFLOW LSC 825691756 -1 825691759 +2”
- SNR ~ 5000, expSNR much smaller
- Conclusion: control system overwhelmed



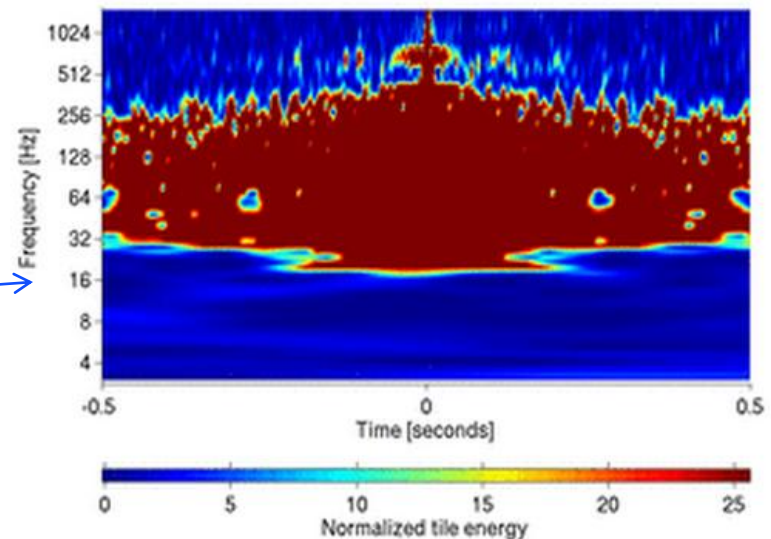
H1:LSC-STRAIN at 826280742.350 with Q of 22.6



Good

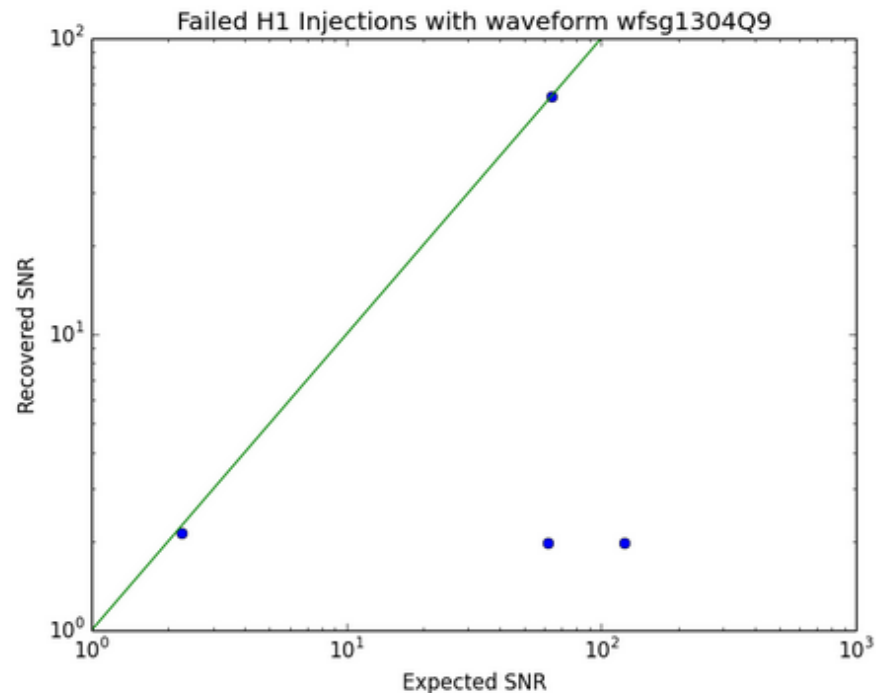
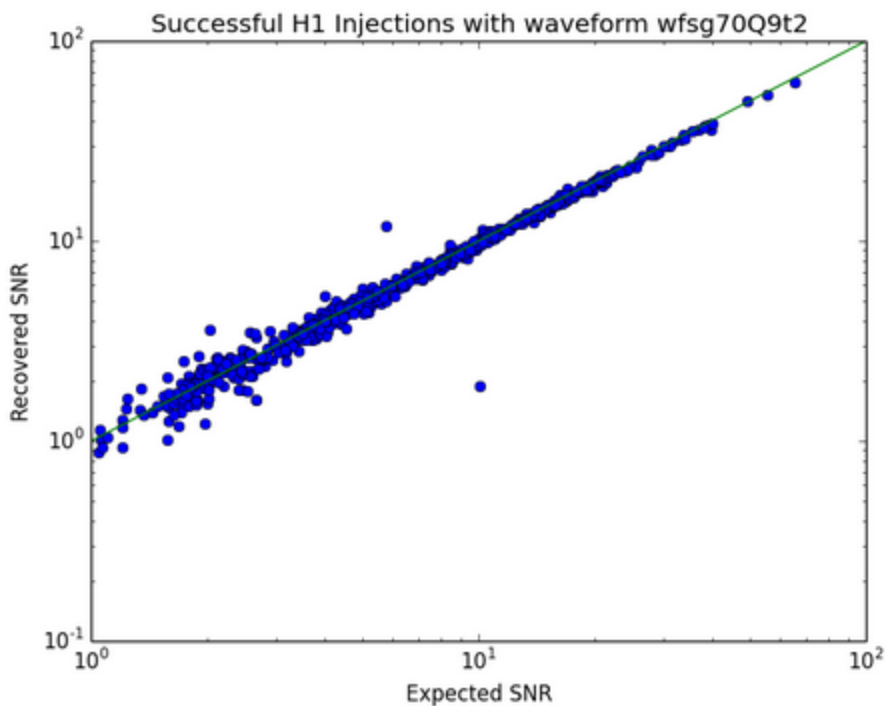
Bad

H1:LSC-STRAIN at 825691757.500 with Q of 11.3



Outliers 2

- “Injection compromised” flag
- Injection process off



Future Work

- Results: <https://losc-dev.ligo.org/s5hwburst/>
- Stochastic injections
- Efficiency (PSDs)
- Work on tutorials – LOSC
- Release S5 bulk data
- Move on to S6...

Acknowledgments

- Jonah Kanner – LIGO, Caltech
- Alan Weinstein – LIGO, Caltech
- Ashley Disbrow – Carnegie Mellon
- Peter Shawhan – LIGO, U. Maryland
- Thomas Moore – Pomona College
- Greg Ogin – Whitman College