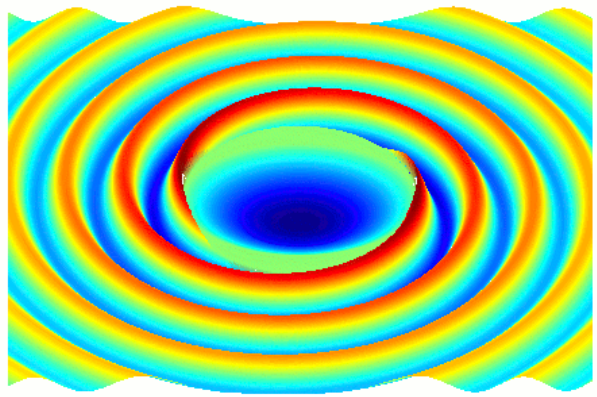
APS April 2006

Stackslide search for continuous gravitational waves using LIGO S4 data.



Supported by the National Science Foundation

http://www.ligo.caltech.edu

Gregory Mendell, LIGO Hanford Observatory
on behalf of the LIGO Scientific Collaboration

LIGO-G060177-00-W

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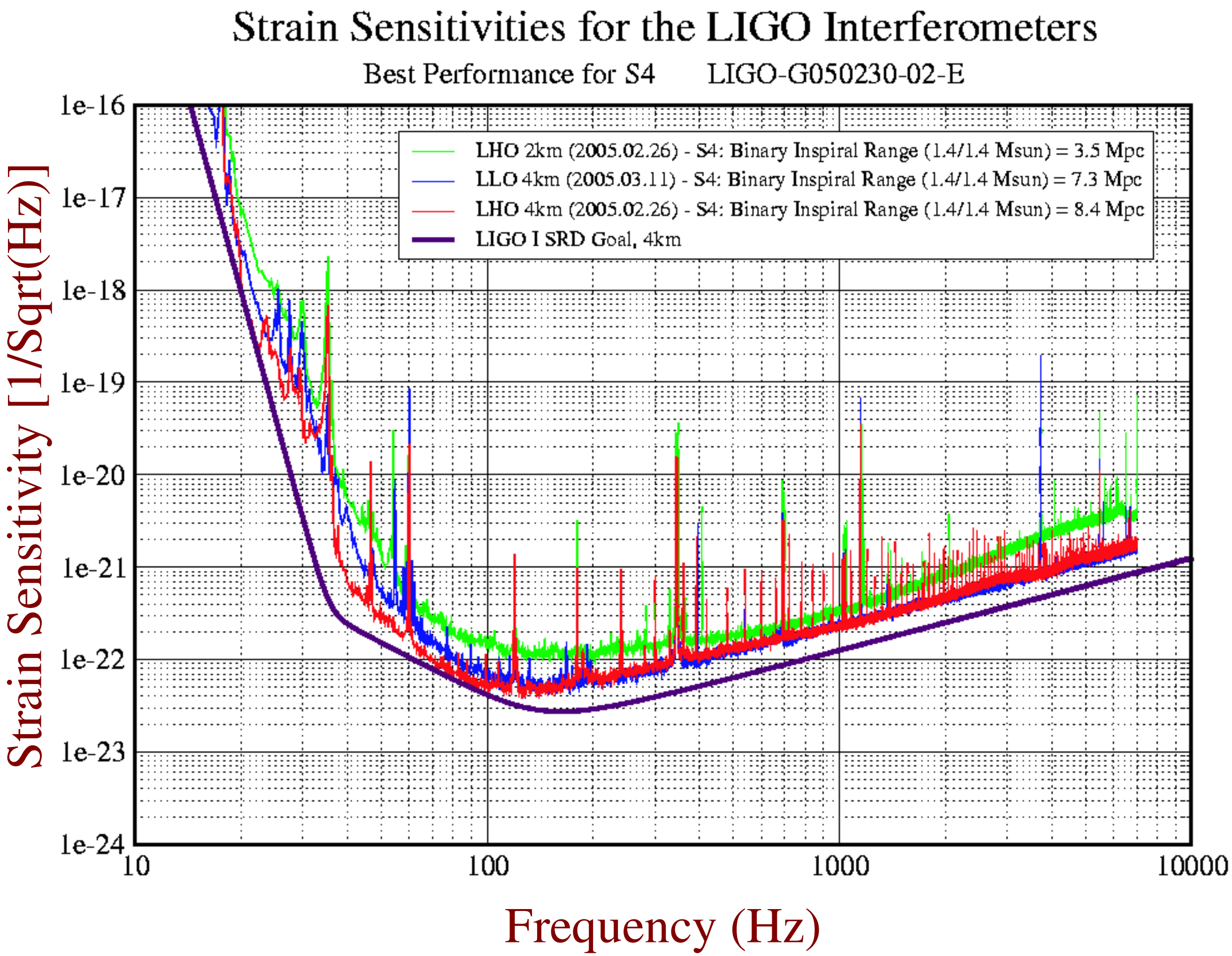
Fourth Science Run (S4) Sensitivity

(February 22, 2005 – March 23, 2005)

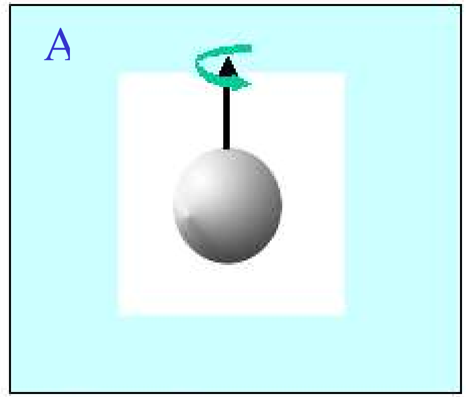


S5 is currently running at design sensitivity!

Sources of Continuous Gravitational Waves
(This talk shows results for isolated sources only.)

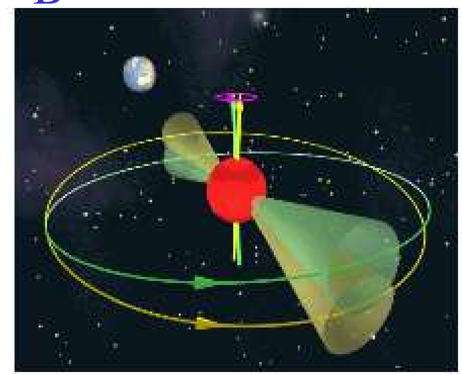
Search can detected any periodic source.

Upper limits are set on gravitational-wave amplitude, h_0, of rotating triaxial ellipsoid.

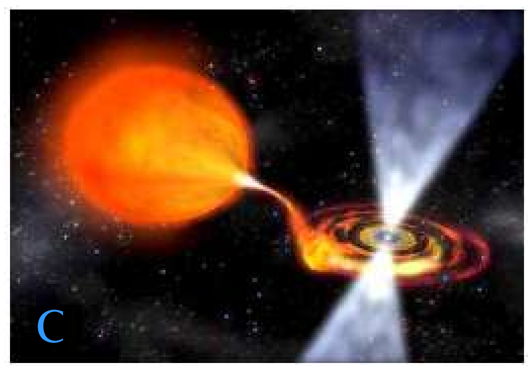


Mountain on neutron star

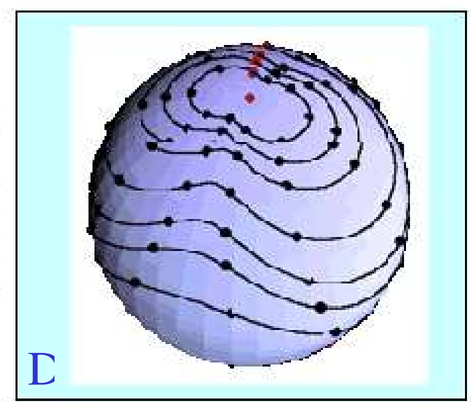
B



Precessing neutron star



Accreting neutron star



Oscillating neutron star

Credits:

A. image by Jolien Creighton; LIGO Lab Document G030163-03-Z.

B. image by M. Kramer; Press Release PR0003, University of Manchester - Jodrell Bank Observatory, 2 August 2000.

C. image by Dana Berry/NASA; NASA News Release posted July 2, 2003 on Spaceflight Now.

D. image from a simulation by Chad Hanna and Benjamin Owen; B. J. Owen's research page, Penn State University.

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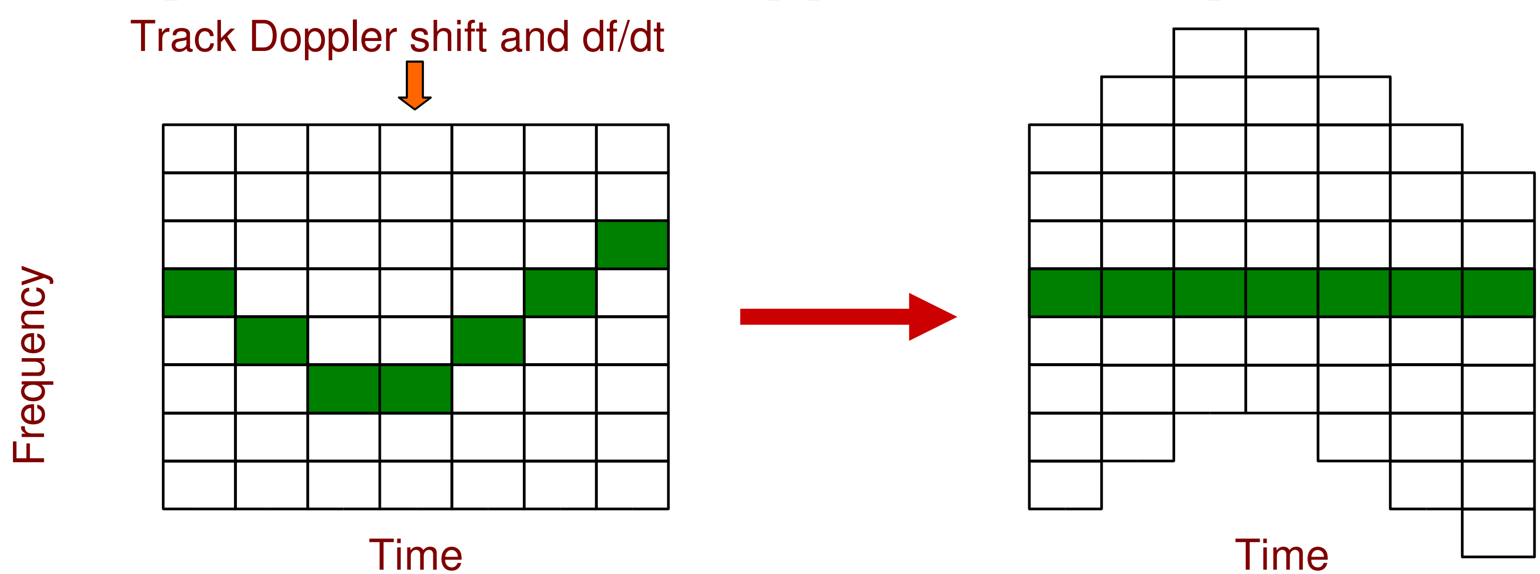
The StackSlide Method

- **Break up data into segments; FFT each, producing Short (30 min) Fourier Transforms (SFTs) = coherent step.**
- **StackSlide: stack SFTs, track frequency, slide to line up & add the power weighted by noise inverse = incoherent step.**
- Other semi-coherent methods:
  - Hough Transform: Phys. Rev. D72 (2005) 102004; gr-qc/0508065.
  - PowerFlux: see next talk, W11.00005
- Fully coherent methods:
  - Frequency domain match filtering/maximum likelihood estimation (C7.00001; W11.00006)
  - Time domain Bayesian parameter estimation (C7.00002)
- **Improvements and hierarchical pipeline under development.**



The StackSlide S4 Pipeline

Search

Read in command line argument, data, and initialize variables

Clean narrow instrument lines

For each point in the parameter space:

- Stack, slide, and sum the power
- Search for peaks above a threshold or the loudest power

Monte Carlo Simulation

Read in command line argument, data, and initialize variables

Generate fake signal and add it to the data.

Clean narrow instrument lines

For points surrounding the injection:

- Stack, slide, and sum the power
- Search for the loudest power

Done?

Yes

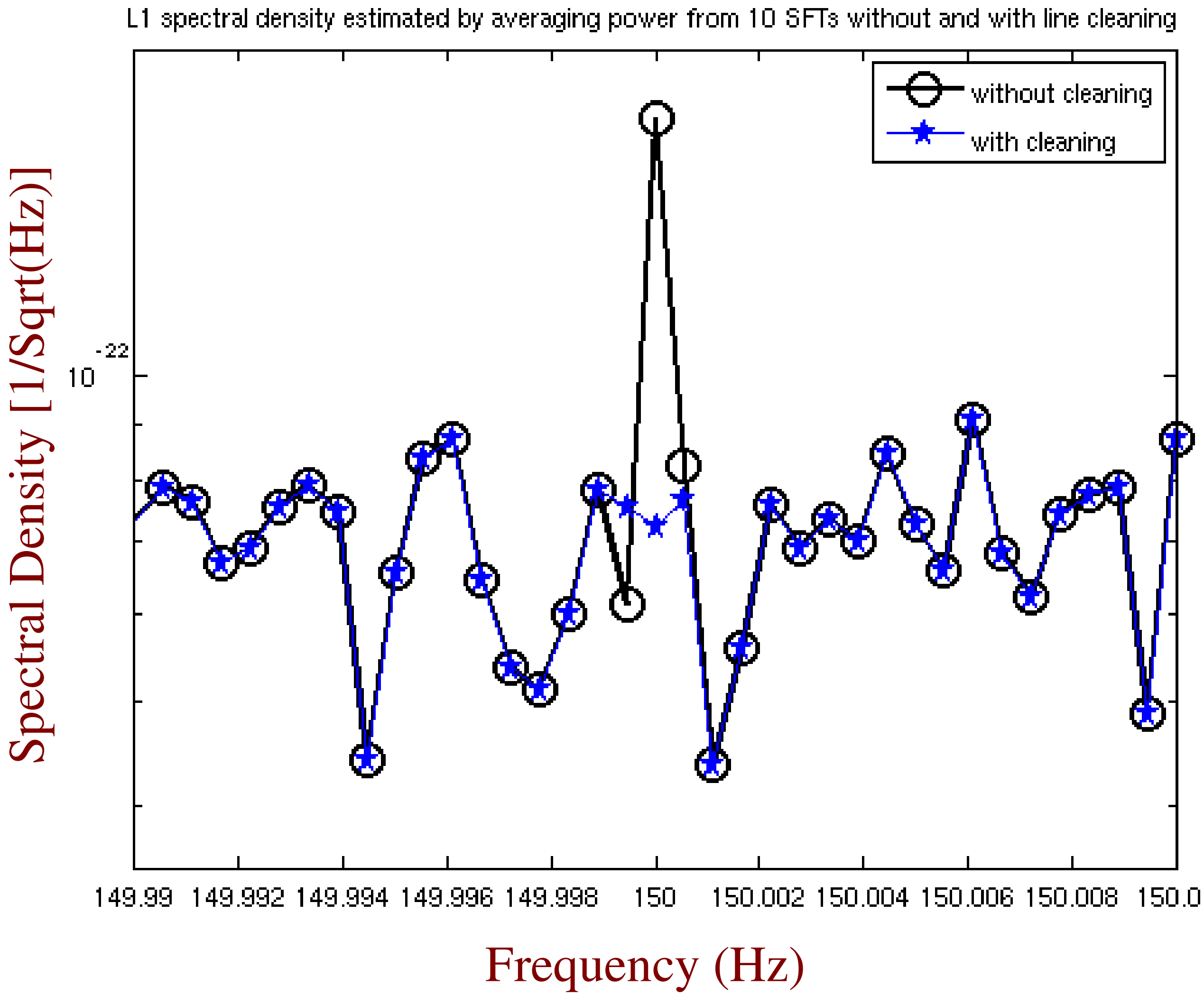
No

Matlab code:

- Finds upper limits
- Makes plots

Line Cleaning Method

(Only clean known lines; those wider than 0.021 Hz are not cleaned.)



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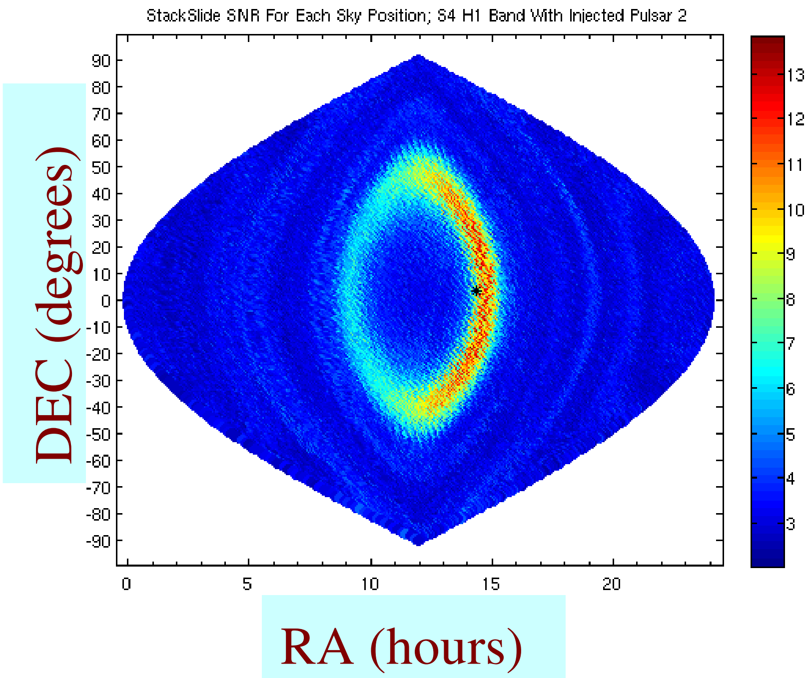
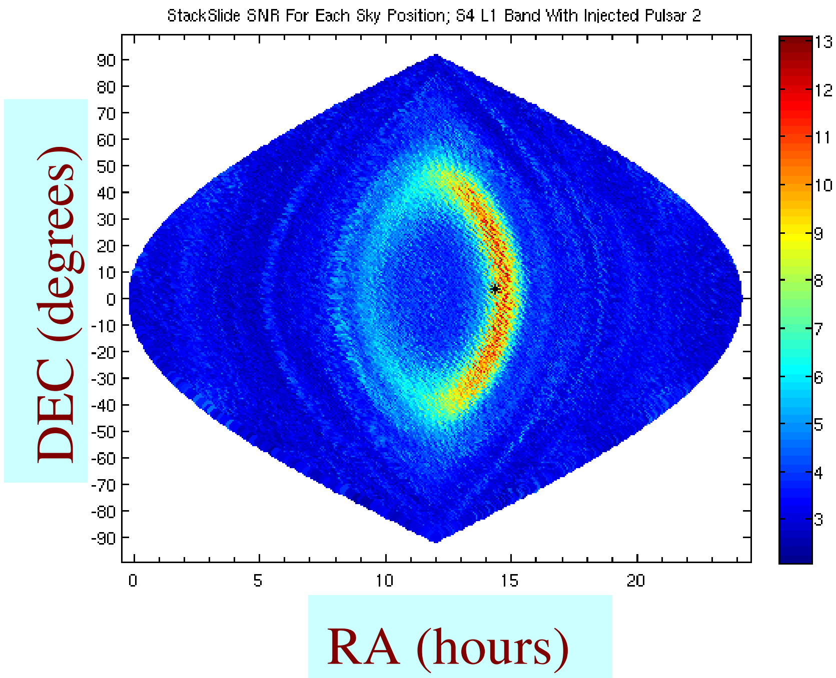
Analysis of Hardware Injections

Fake gravitational-wave signals corresponding to rotating neutron stars with varying degrees of asymmetry were injected for parts of the S4 run by actuating on one end mirror. Sky maps for the search for an injected signal with h_0 ~ 7.5e-24 are below. Black stars show the fake signal's sky position.





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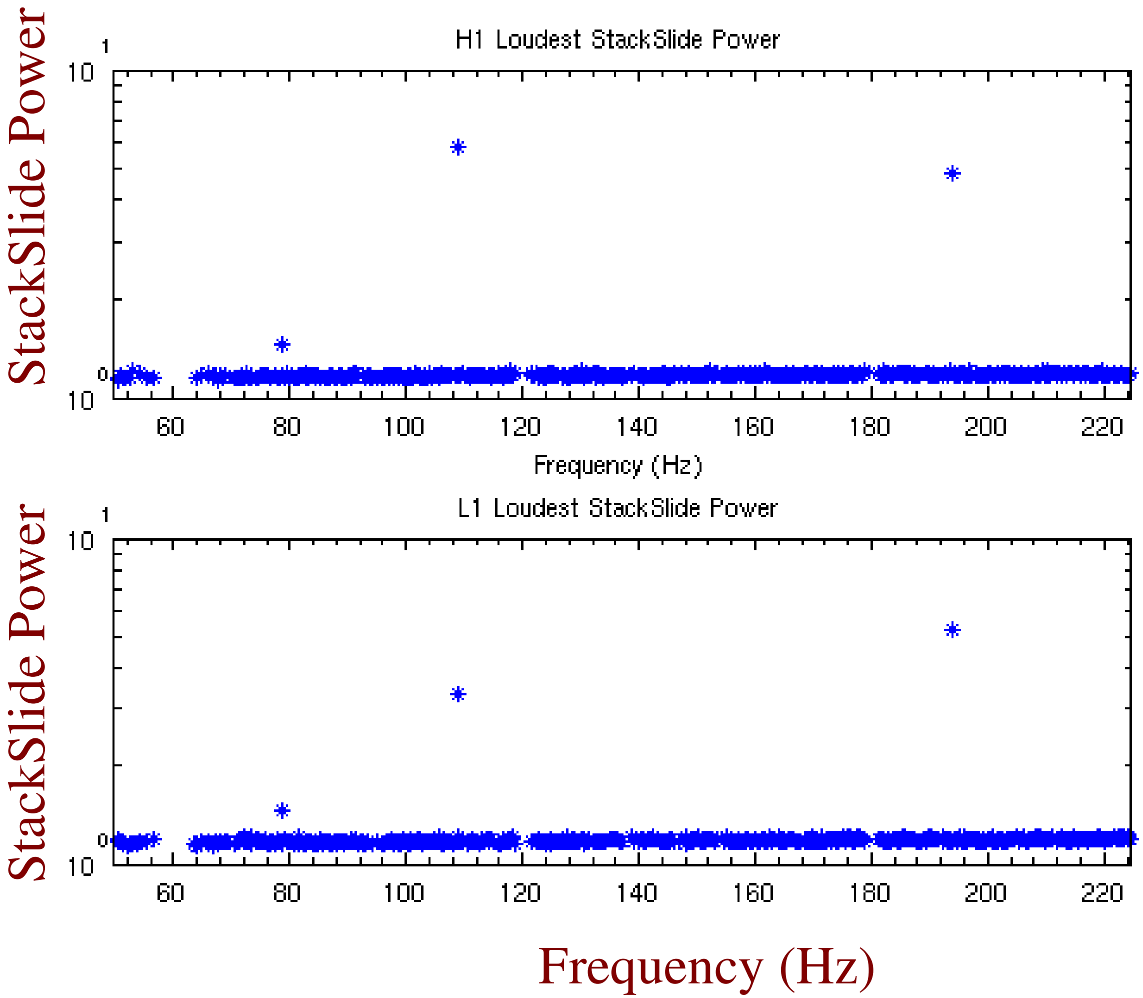
S4 StackSlide "Loudest Events" 50-225 Hz



- Searched 450 freq. per .25 Hz band, 51 values of df/dt, between 0 & -1e-8 Hz/s, up to 82,120 sky positions (up to 2e9 templates). The expected loudest StackSlide Power was ~ 1.22 (SNR ~ 7)
- Veto bands affected by harmonics of 60 Hz.
- Simple cut: if SNR > 7 in only one IFO veto; if in both IFOs, veto if abs(f_{H1}-f_{L1}) > 1.1e-4*f0

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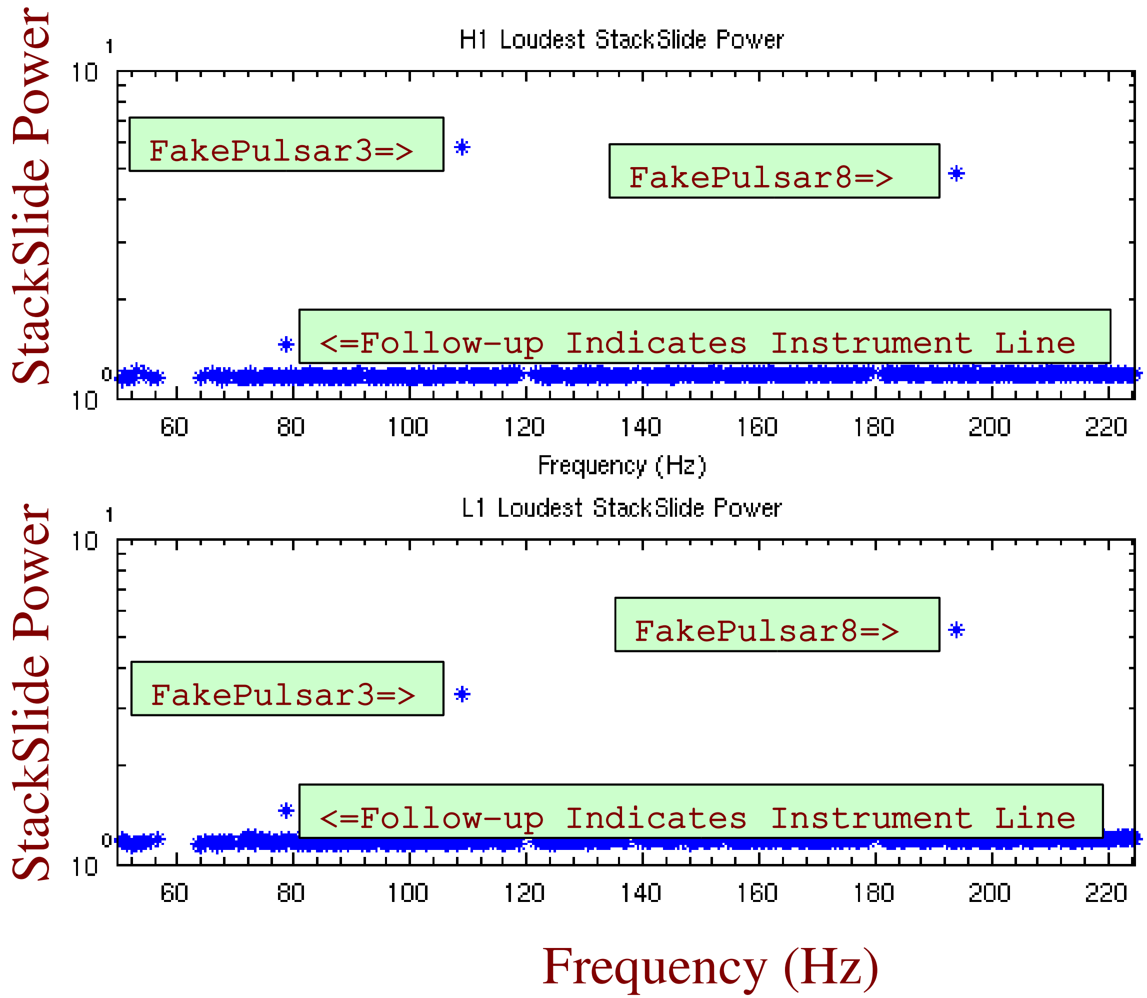
S4 StackSlide "Loudest Events" 50-225 Hz



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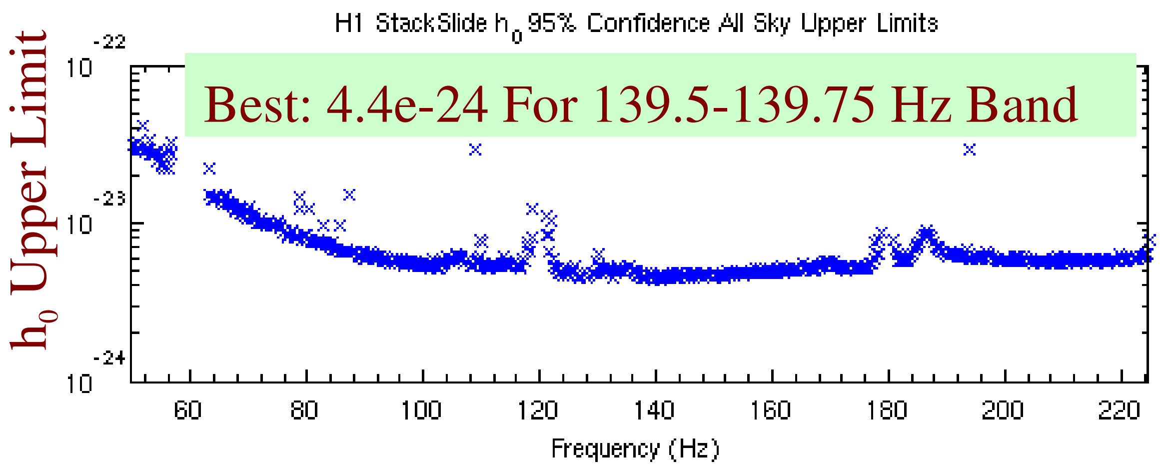
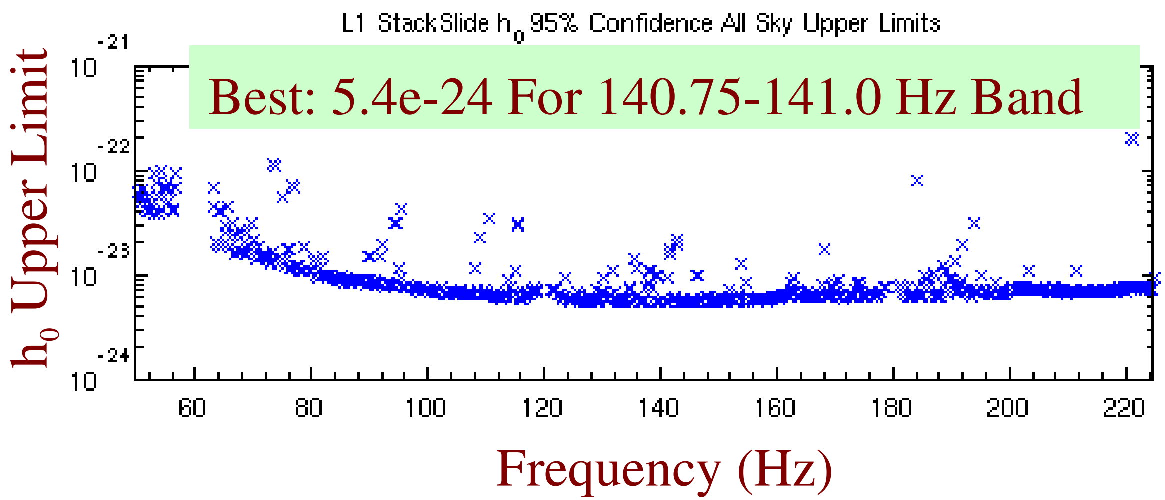
S4 StackSlide h_0 95% Confidence All Sky Upper Limits 50-225 Hz





Note that h_0 is the gravitational-wave amplitude for a rotating triaxial ellipsoid. Monte Carlo injections of triaxial sources over the search parameter space & source orientations set the ULs.

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Conclusions

- **These results are interesting, but much better results are on the way!**
- **Improvements:**
  - **S5: ~ 2x better sensitivity, 12x or more data.**
  - **Increase time baseline of coherent step**
  - **Multi-ifo code**
  - **Refined coincidence steps**
- **Hierarchical pipeline under development that combines coherent and semi-coherent searches.**

END APS SLIDES