The StackSlide Search

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Update: March 2004 LSC Meeting

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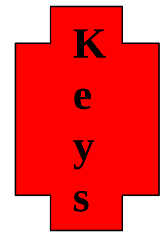
Outline

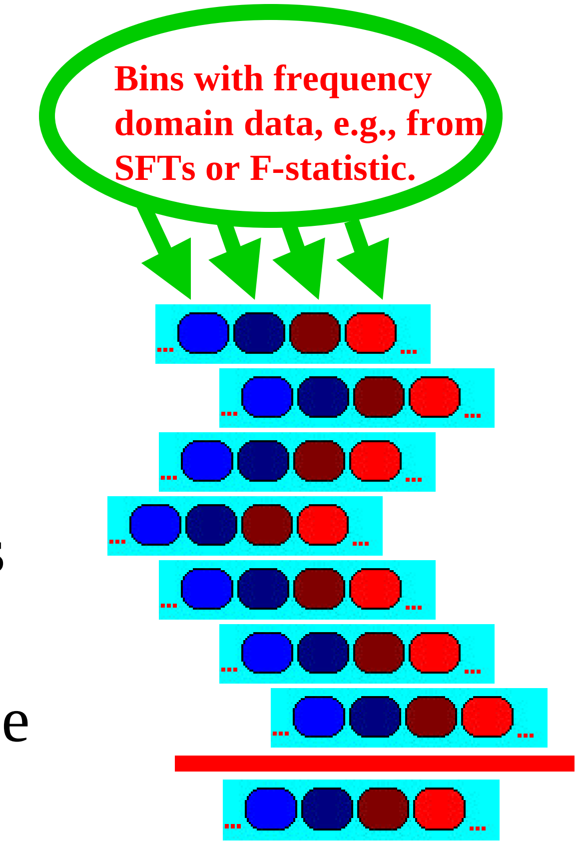
- Overview/highlights since last LSC meeting.
- The Keys To The City
  - Version Control
  - Documentation
  - Validation/Verification
- Statistics
- Preliminary S2 results

(Reproducibility)



The StackSlide Search

- An incoherent search method that stacks and slides power to search for periodic sources. *(P. Brady & T. Creighton Phys. Rev. D61 (2000) 082001; gr-qc/9812014.)*
- The periodic search is computationally bound. A hierarchical approach that combines coherent & incoherent methods is needed to optimize sensitivity.
- Sources like LXMBs with short coherence times (~ 2 weeks) require incoherent methods.
- Want to add StackSlide to the incoherent toolbag along with Hough transforms.



A. Stack the power.

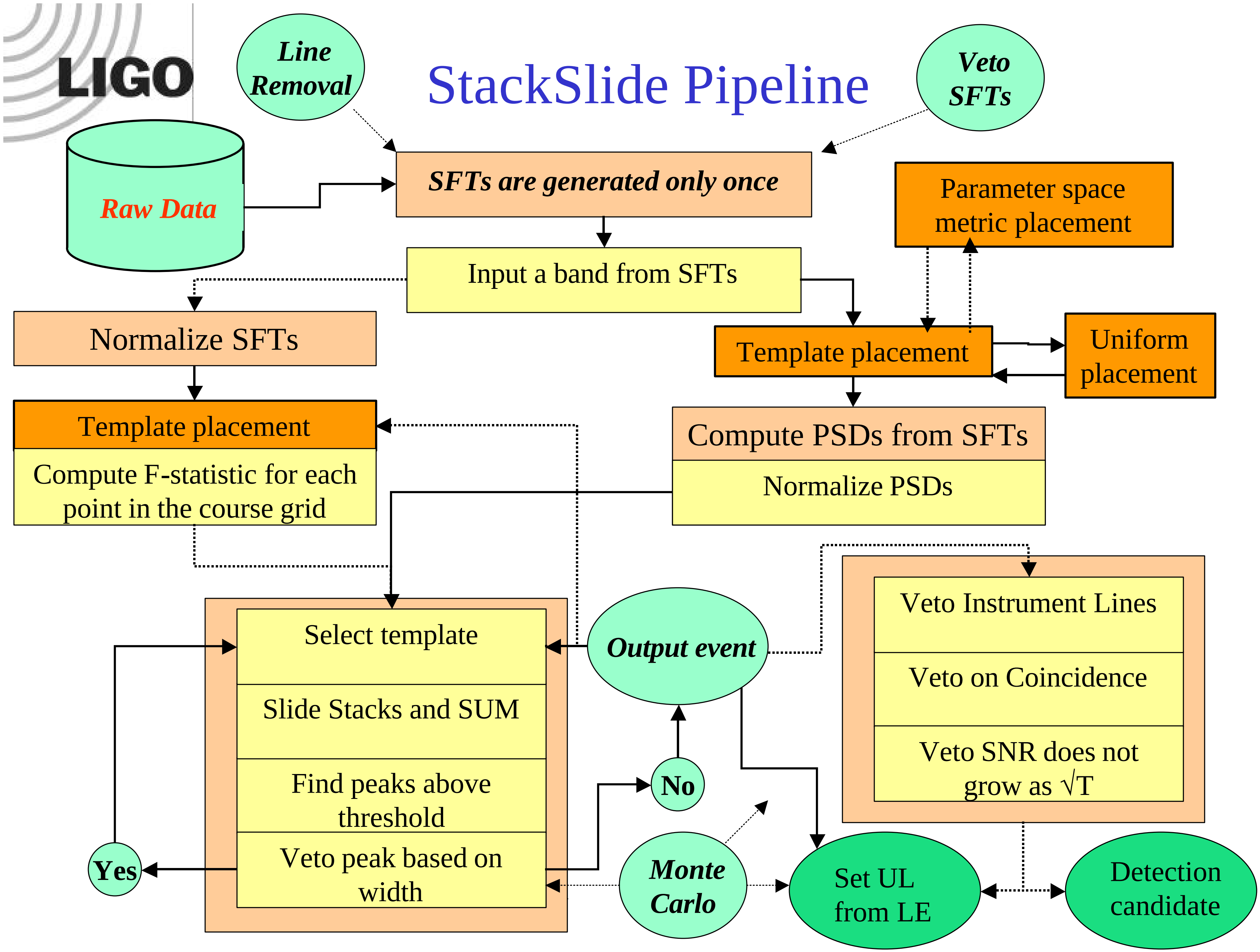
B. Slide to correct for spindown/doppler shifts.

C. Sum and search for significant peaks.

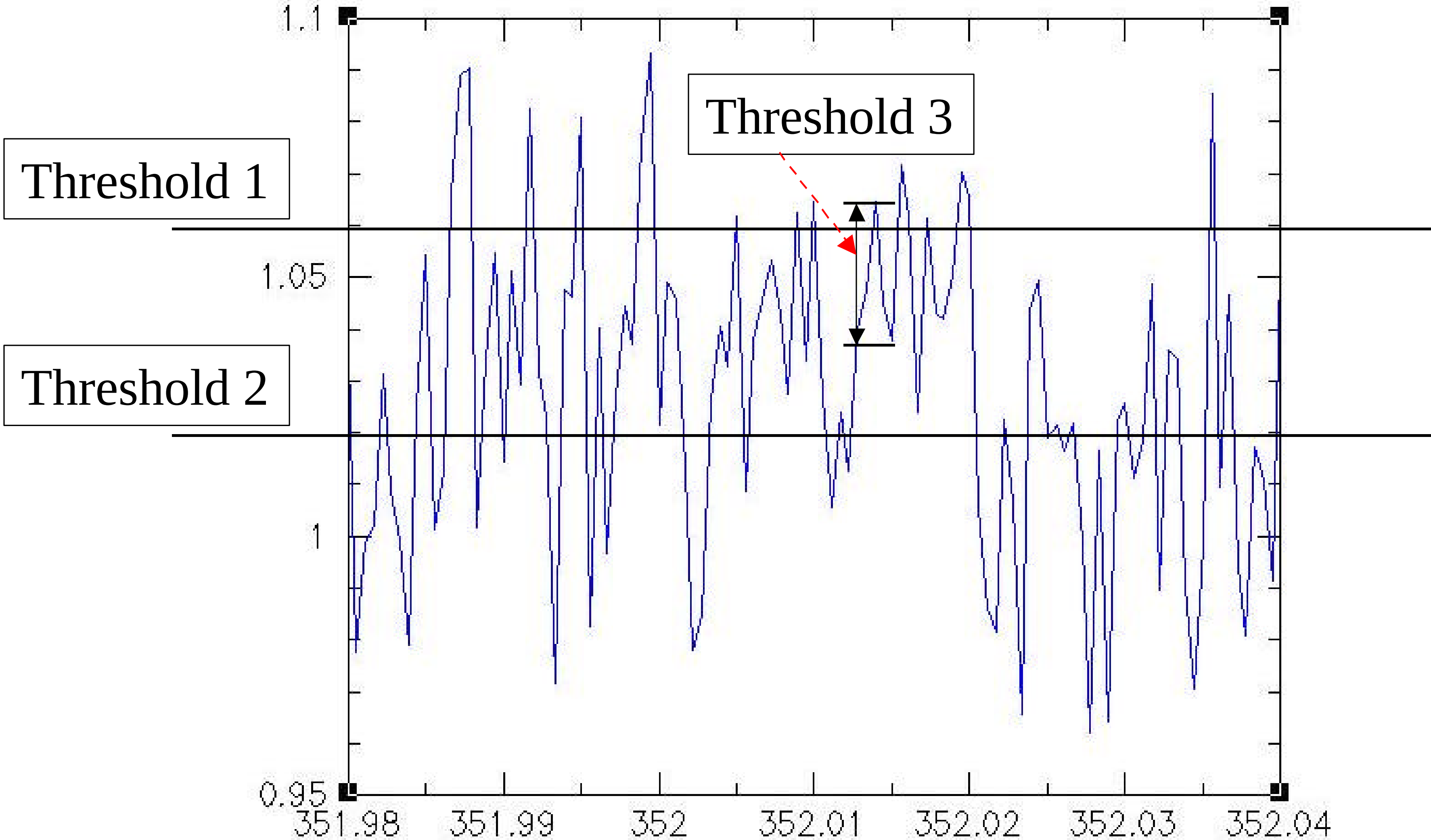
Highlights Since Last LSC

- The code now runs under Condor as an executable statically linked to LAL.
- A driver script runs the code in standalone mode or creates a condor submit file for parallel jobs.
- The first version of the sliding function is finished.
- Added a peak finding algorithm; the code can find all or loudest events above a threshold.
- The code outputs the process, process params, search summary, search summary vars, stackslide summary and stackslide event tables in xml format.
- Matlab scripts exist to find an estimated UL based on loudest event (if no detection).

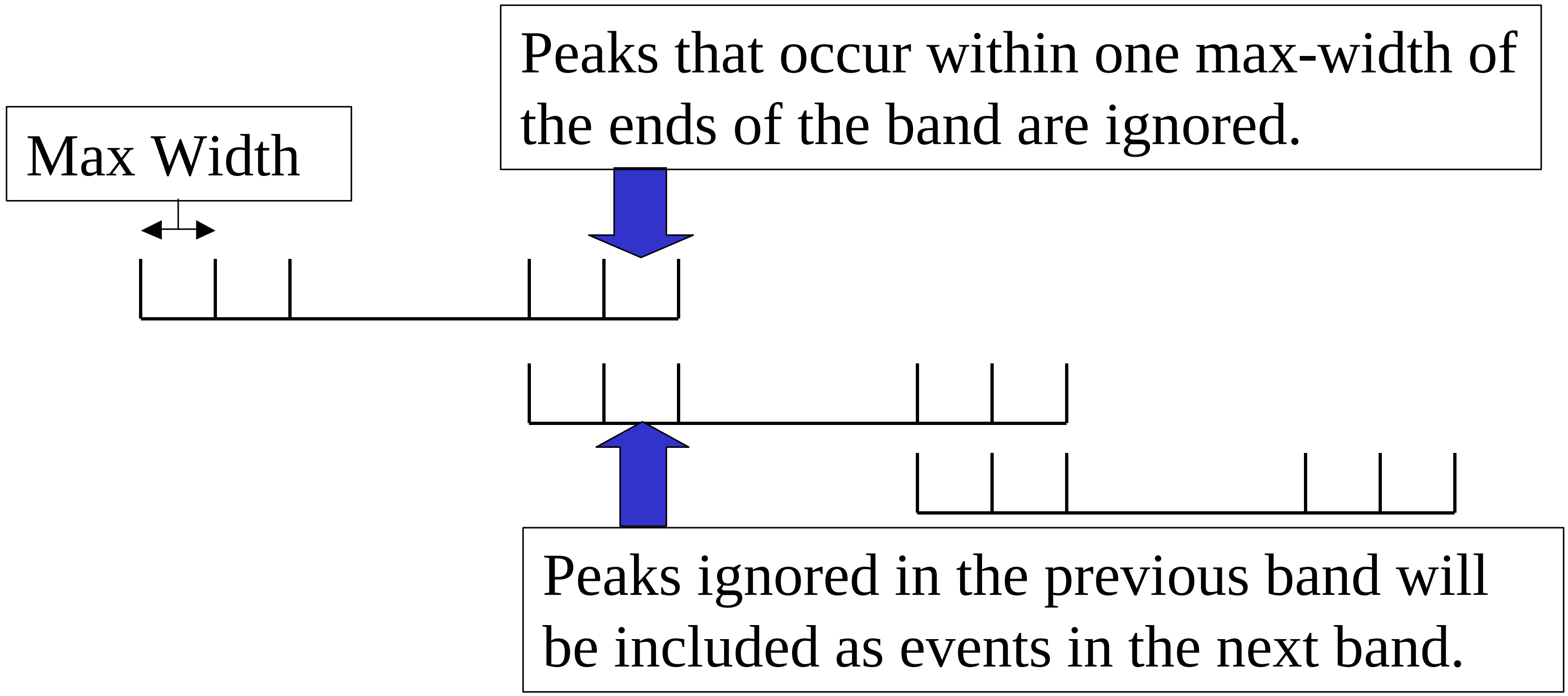
StackSlide Pipeline



Peak Finding Algorithm



Overlapping Bands

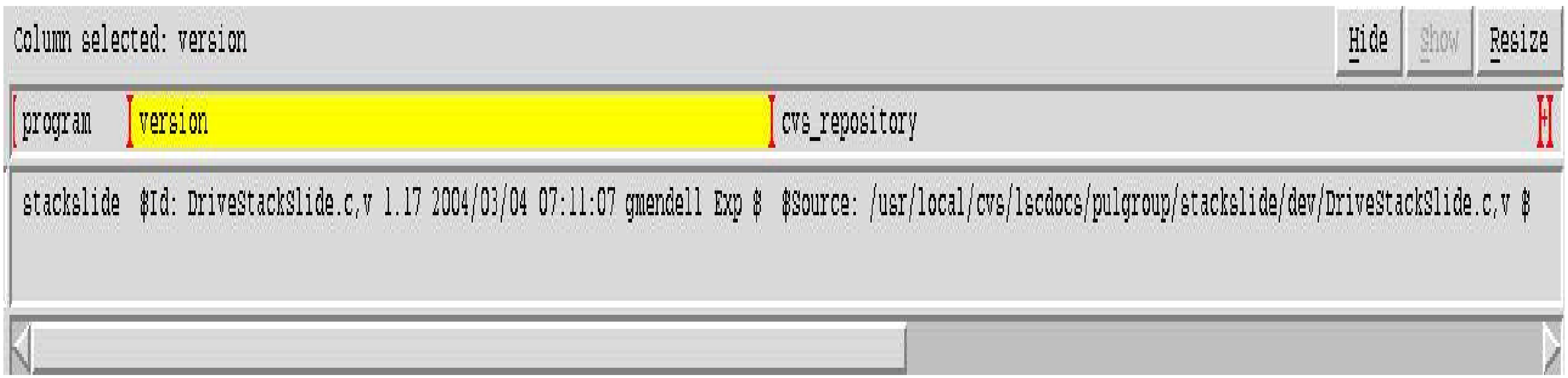


Need to overlap frequency bands by twice the maximum expected width.

Reproducibility: Version Control

- XML output contains the CVS Id of the driver code.
- Need to include CVS tags to all code and scripts.

Keys



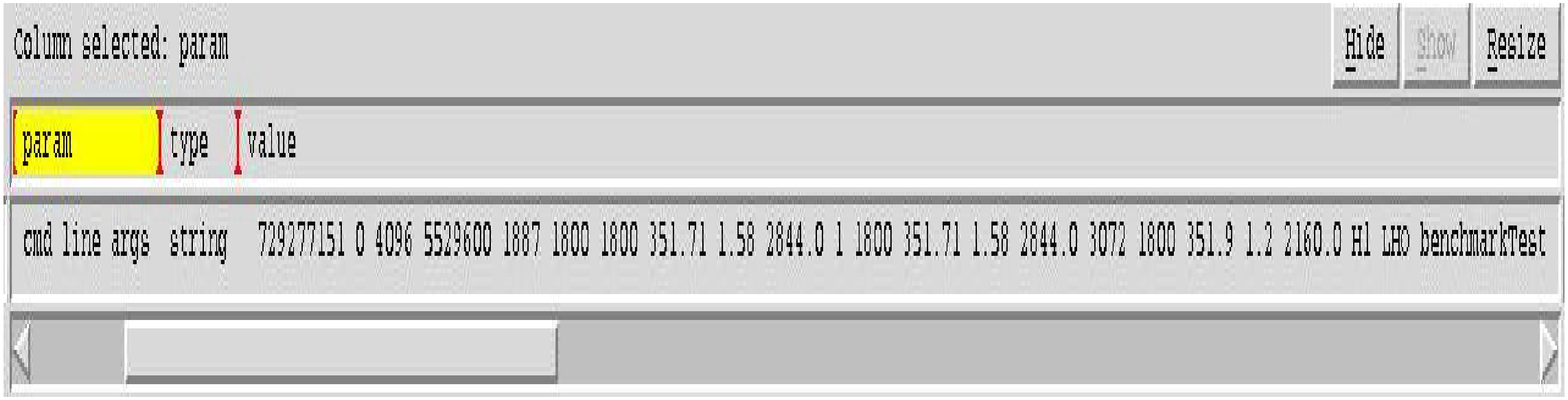
Process Table

(Note that the XML file can be viewed using guild or read into Matlab.)

Reproducibility: Documentation

- The XML output contains all the command line arguments needed to rerun the code.
- This includes the path and pattern used to find the data.

Keys



Process Params Table

Reproducibility: Documentation

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- In CVS: README_ComputeStackSlideSums and README_CommandLineArguments.
  - README_CommandLineArguments is in the form of a tcl script that sets each arguments along with comments describing each argument.
  - A preprocessor flag can be set to output the command-line-arguments documentation showing those used in an a job.
  - Only need to maintain this in one place in the code.
- Need to incorporate this into tex documentation.

Validation/Verification: SNR

Keys

The JKS optimal SNR for 1 SFT, averaged over M SFTs:

$$< d^2 >= \frac{A_+^2 T_{\mathrm{SFT}}}{S_h} < F_+^2 >_{\mathrm{obs}} + \frac{A_\times^2 T_{\mathrm{SFT}}}{S_h} < F_\times^2 >_{\mathrm{obs}}$$

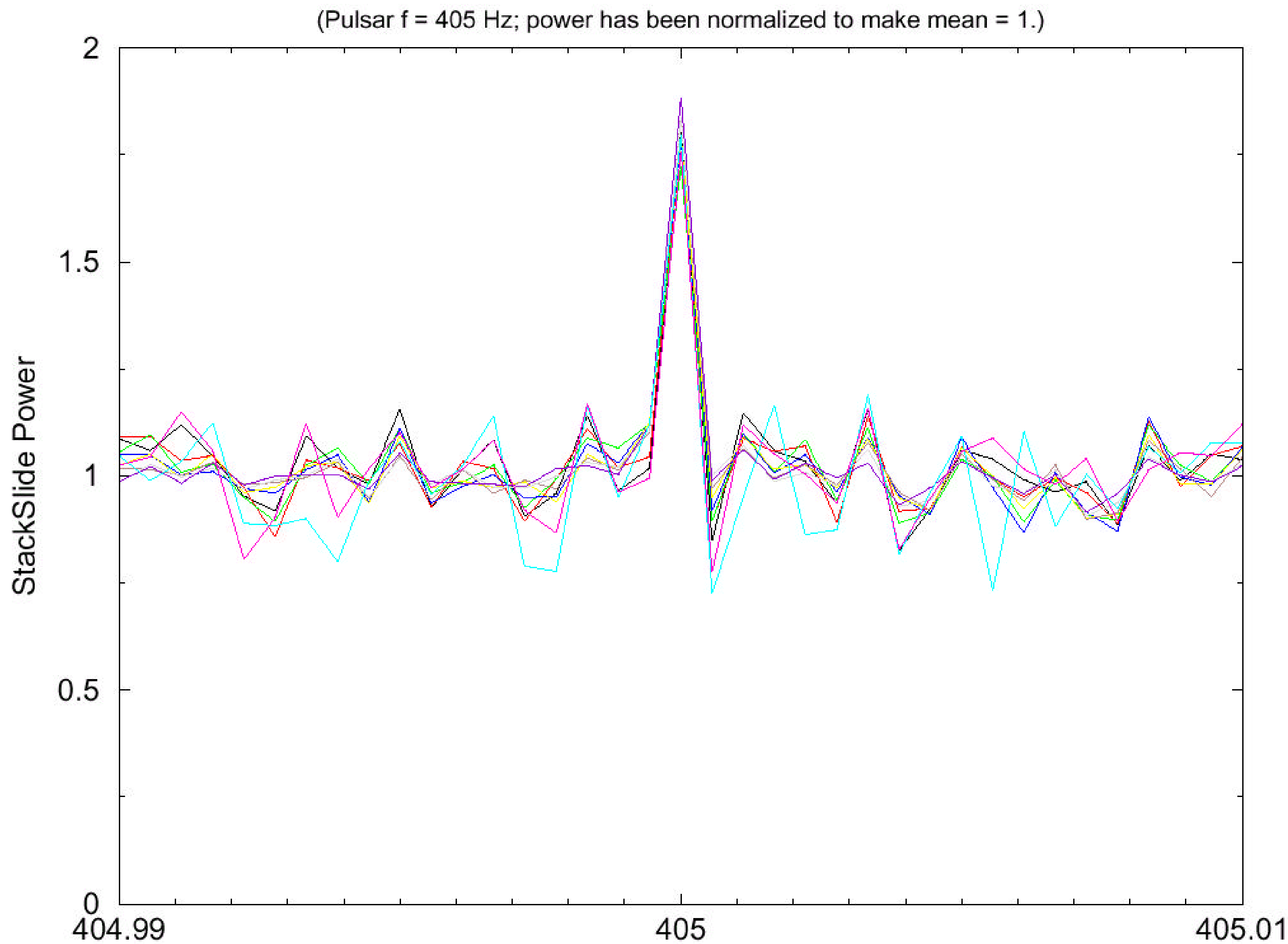
$$A_+ = \frac{1}{2} h_0 (1 + \cos\iota) \quad ; \; A_\times = h_0 \cos\iota$$

The StackSlide Power SNR for M SFTs normalized so that the mean noise power is 1:

$$\mathrm{SNR} = (1 + \frac{1}{2} < d^2 >)\sqrt{M}$$

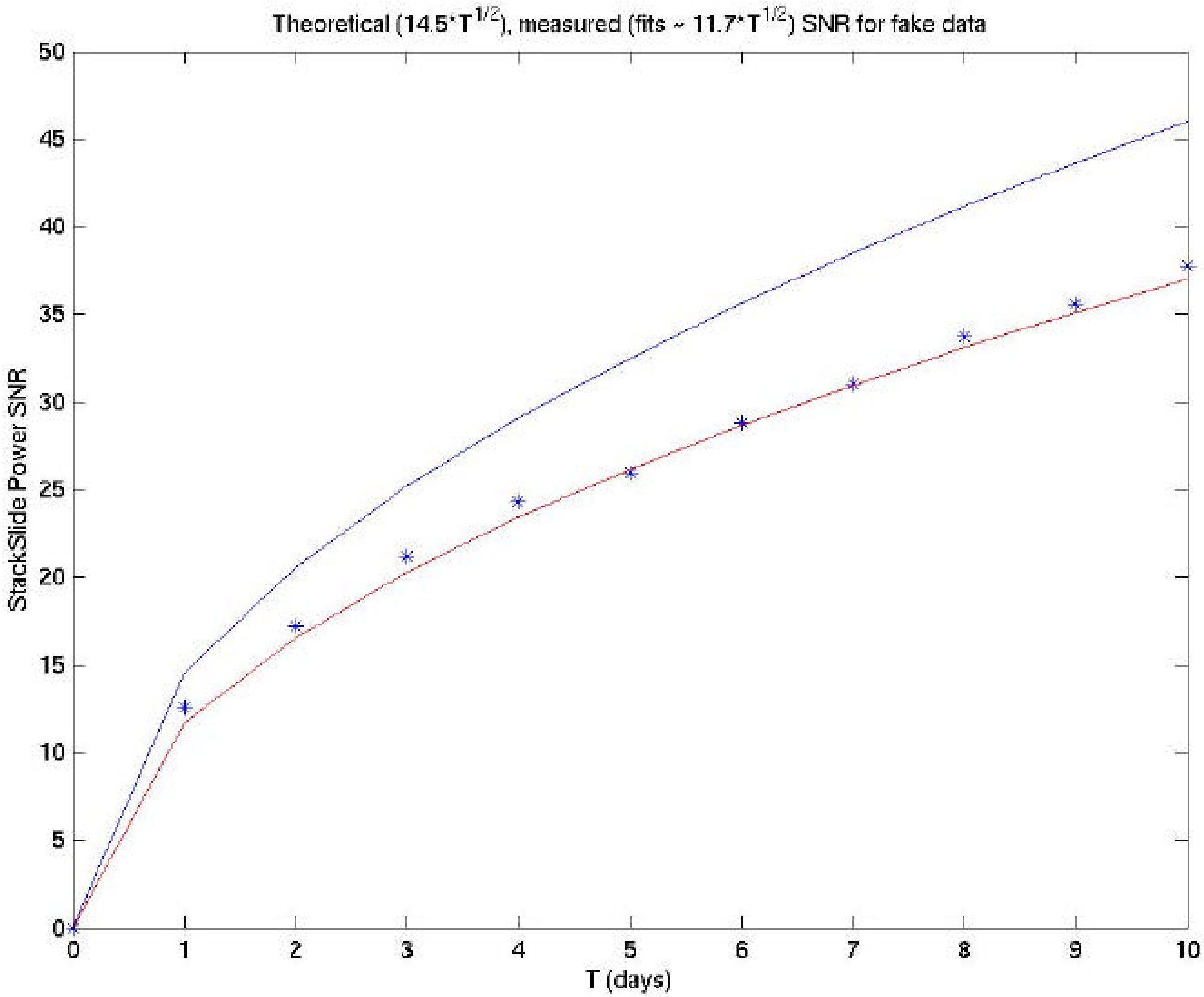
Validation: Fake Pulsar Signal

StackSlide Power vs. frequency for 1−10 days of fake data.



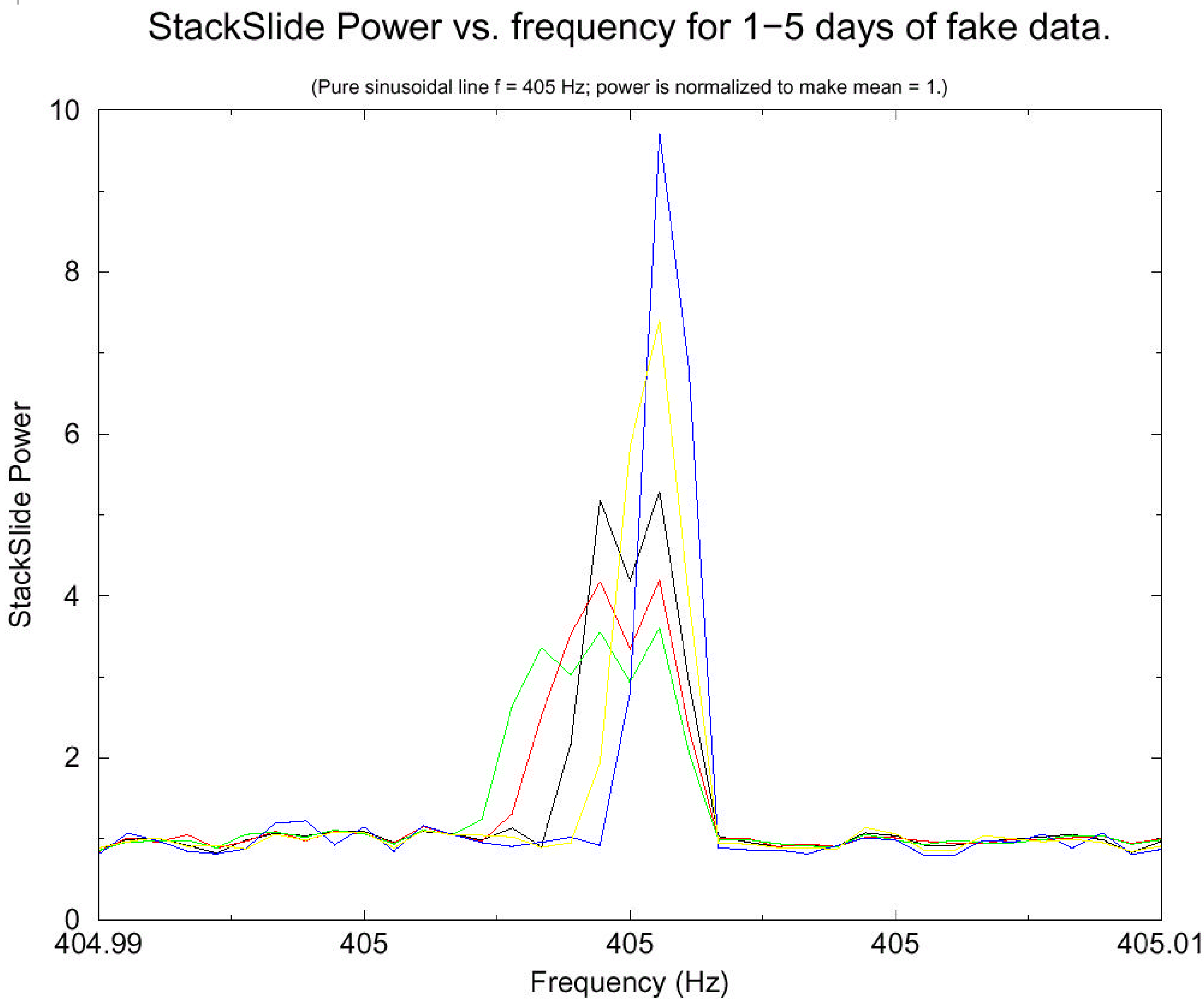
Validation: Fake Pulsar Signal

Keys



Validation: Fake Instrument Line

Keys



Validation: Fake Instrument Line

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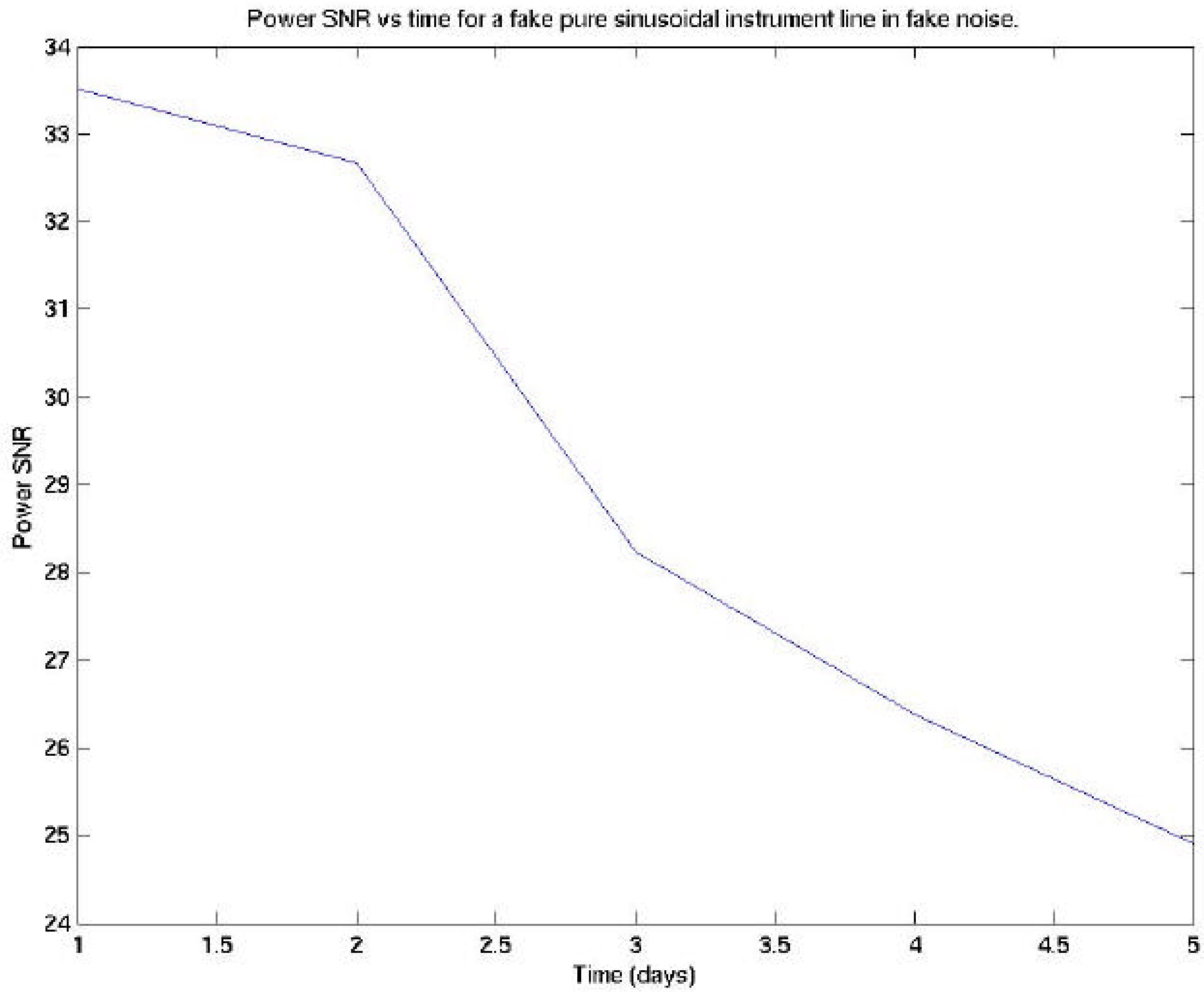

Validation: Injected S2 Pulsar 1

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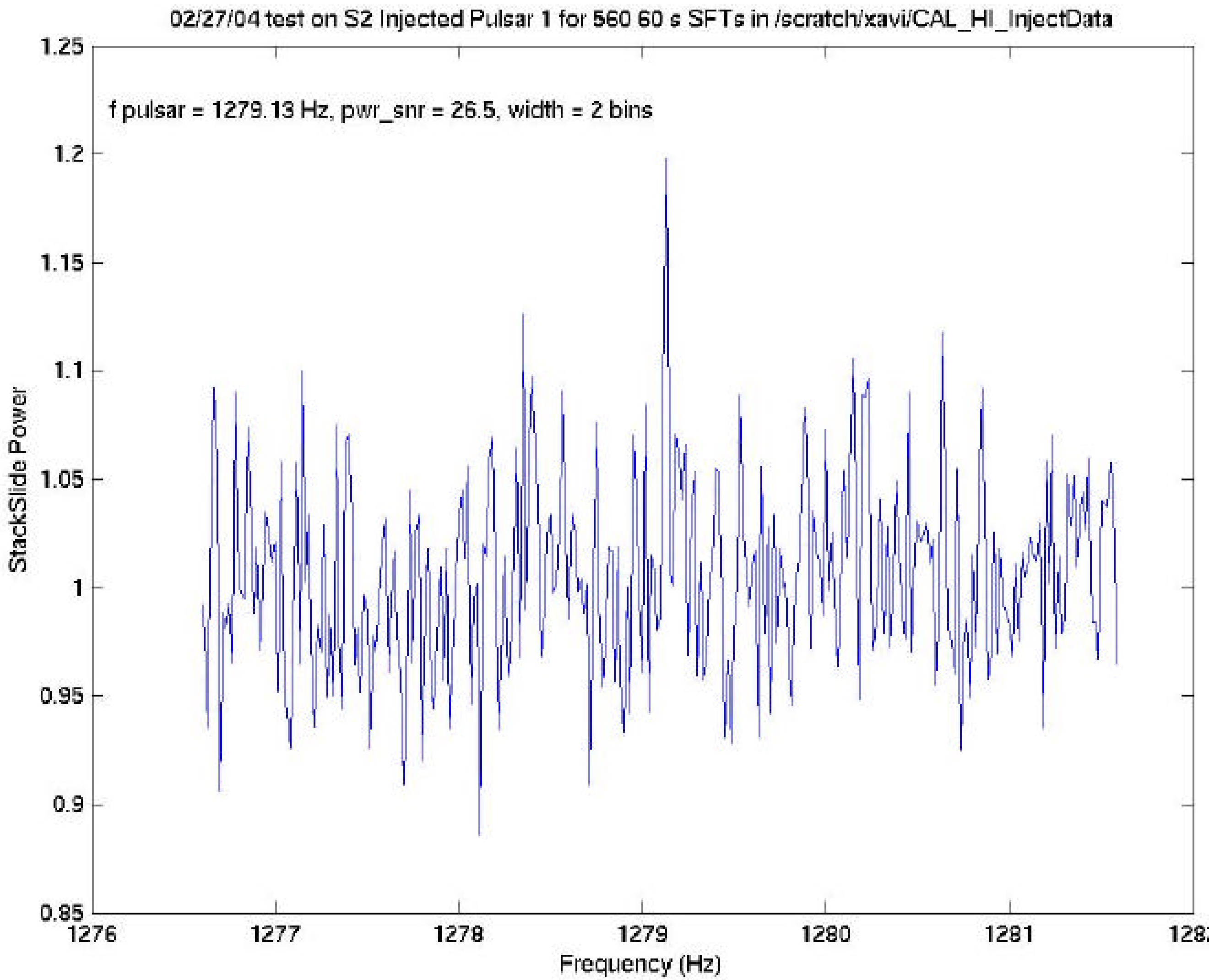
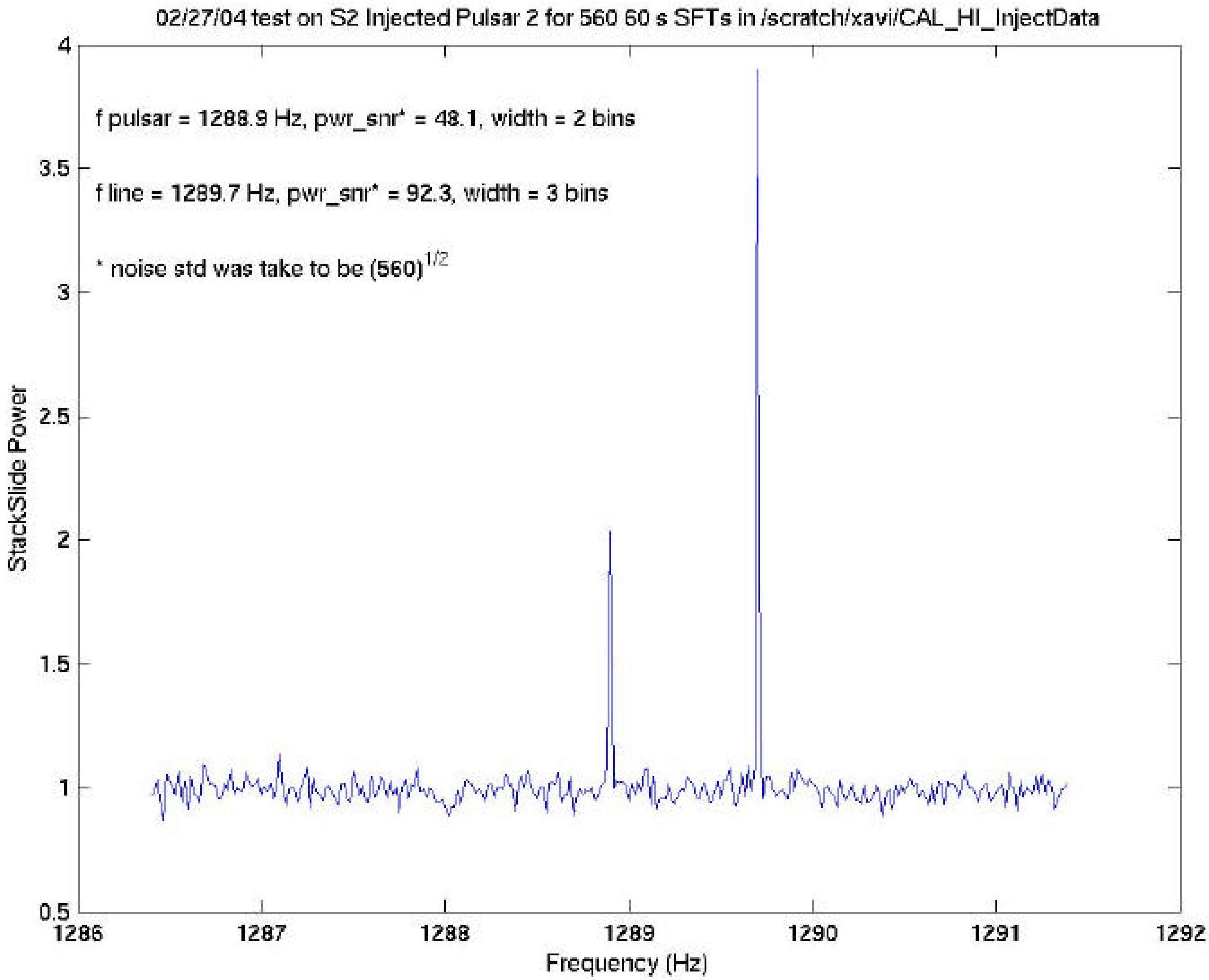


Validation: Injected S2 Pulsar 2



Statistics: PDFs

The StackSlide Power is the sum of the Power in M SFTs:

$$\rho = P_1 + P_2 + P_3 + ... + P_M,$$

where each P has been normalized to follow an exponential distribution (for gaussian white noise) $\exp(-P)$, i.e., $2P_i$ follows χ^2 distribution with 2 degrees of freedom. Thus 2ρ will follow a χ^2 distribution with $2M$ degrees of freedom.

$$\mathrm{PDF}(\rho; M)d\rho = \frac{1}{(M+1)!}\rho^{M-1}e^{-\rho}d\rho$$

If a signal is present, then the distribution for 2ρ is a χ^2 with $2M$ degrees of freedom and noncentrality parameter d^2.

$$\mathrm{NCPDF}(\rho; M, < d^2 >)d\rho =$$

$$C\left(\frac{2\rho}{Md^2}\right)^{\frac{M-1}{2}} I_{M-1}\left(\sqrt{2M\rho d^2}\right) e^{\frac{-2\rho - Md^2}{2}}d\rho$$

Statistics: CDFs

The false alarm rate, C_a, is set, and this determines the cutoff on StackSlide power ρ_c:

$$C_a = \int_{\rho_c}^{\infty} \mathrm{PDF}(\rho; M) d\rho.$$

The false dismissal rate, C_d, is set and this determines the SNR d^2:

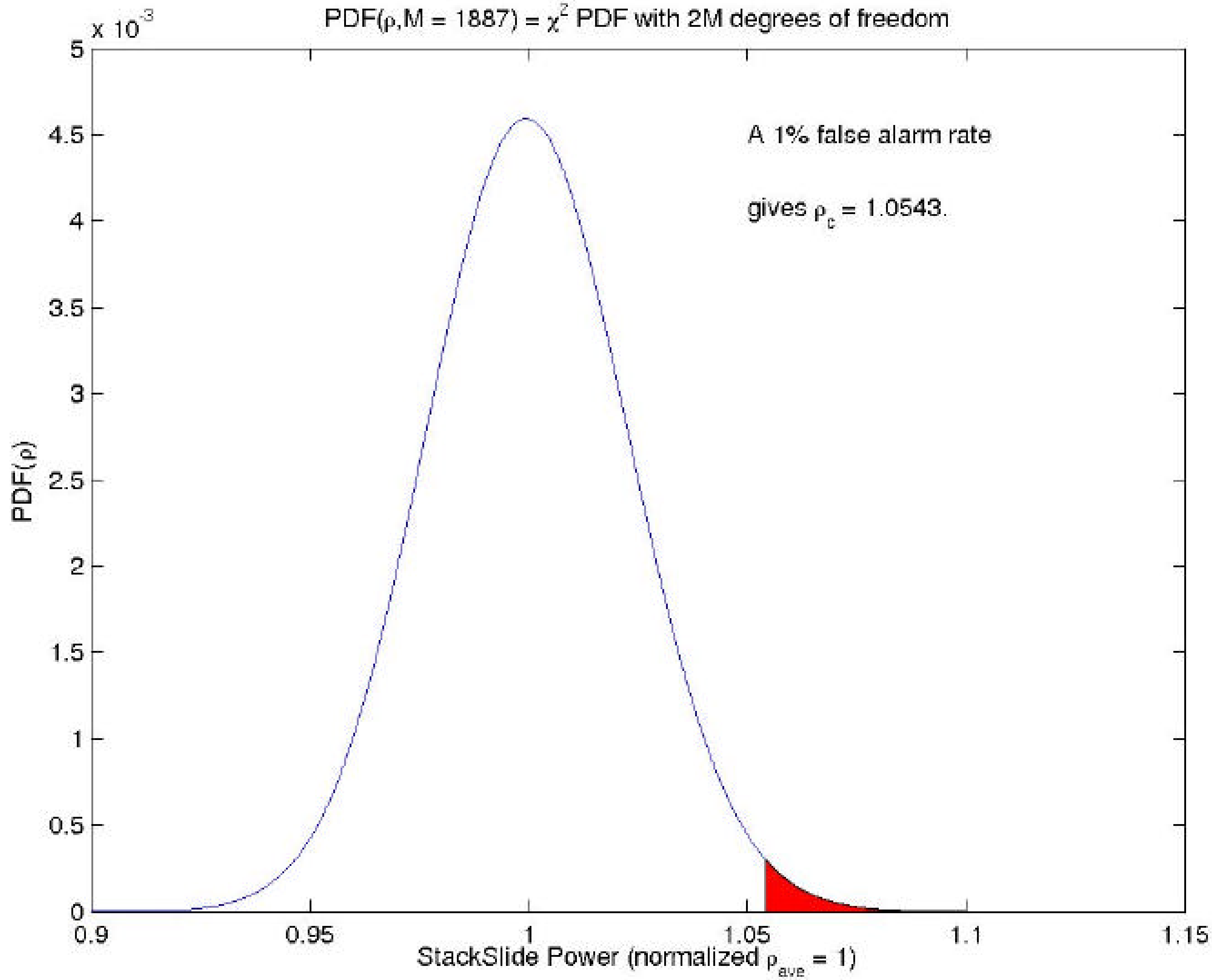
$$C_d = \int_{0}^{\rho_c} \mathrm{NCPDF}(\rho; M, d^2) d\rho.$$

The SNR can then be used to place an upper limit on the signal amplitude h_0. For a 1% false alarm rate, 5% false dismissal rate, and averaging over all sky positions, the estimated upper limit is:

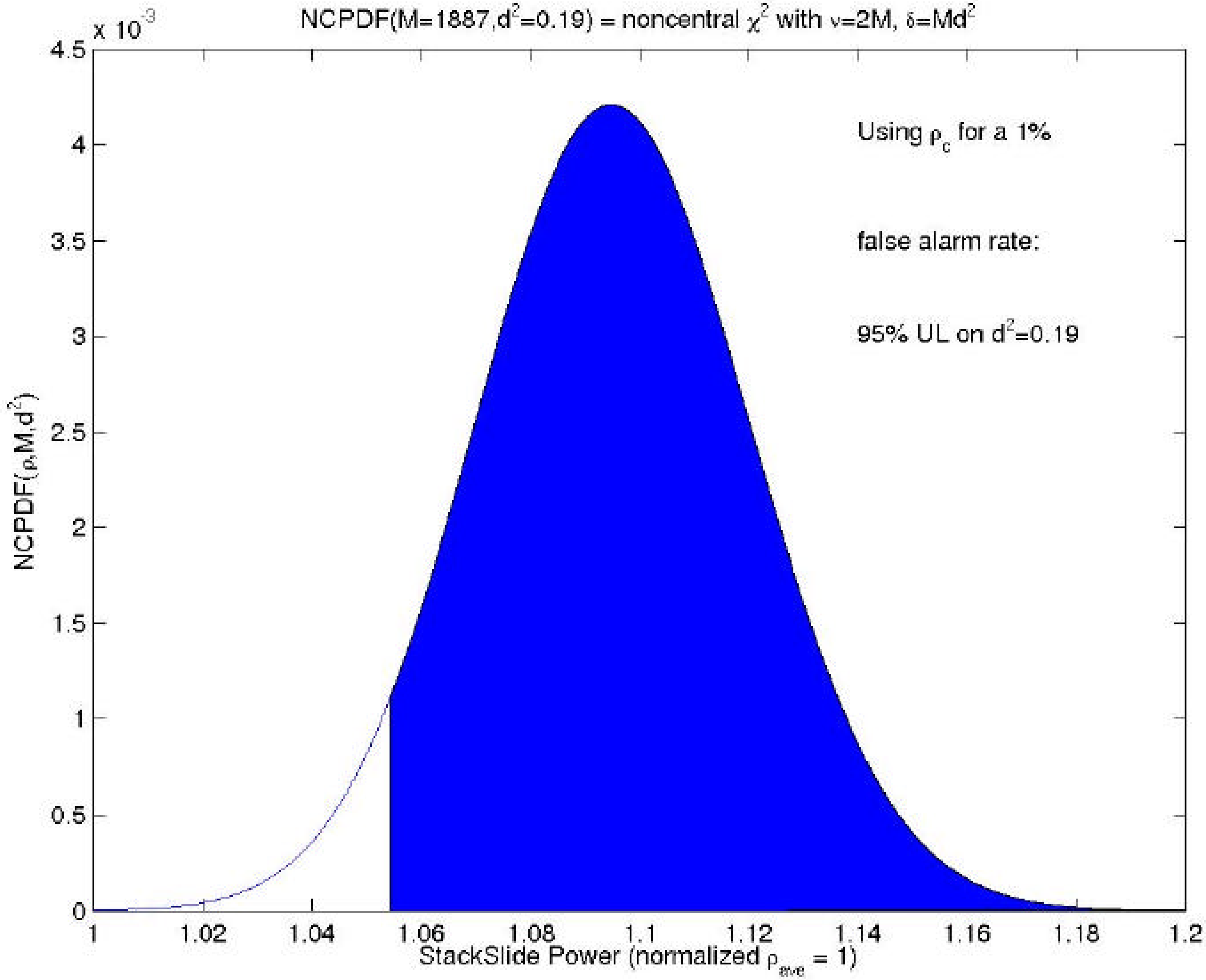
$$h_0 < 7.4 M^{1/4} \sqrt{S_h / T_{\mathrm{obs}}},$$

where the fit to $M^{1/4}$ was found for $1000 < M < 3000$ to be good to within a few percent.

Statistics: False Alarm Rate



Statistics: UL from Loudest Event



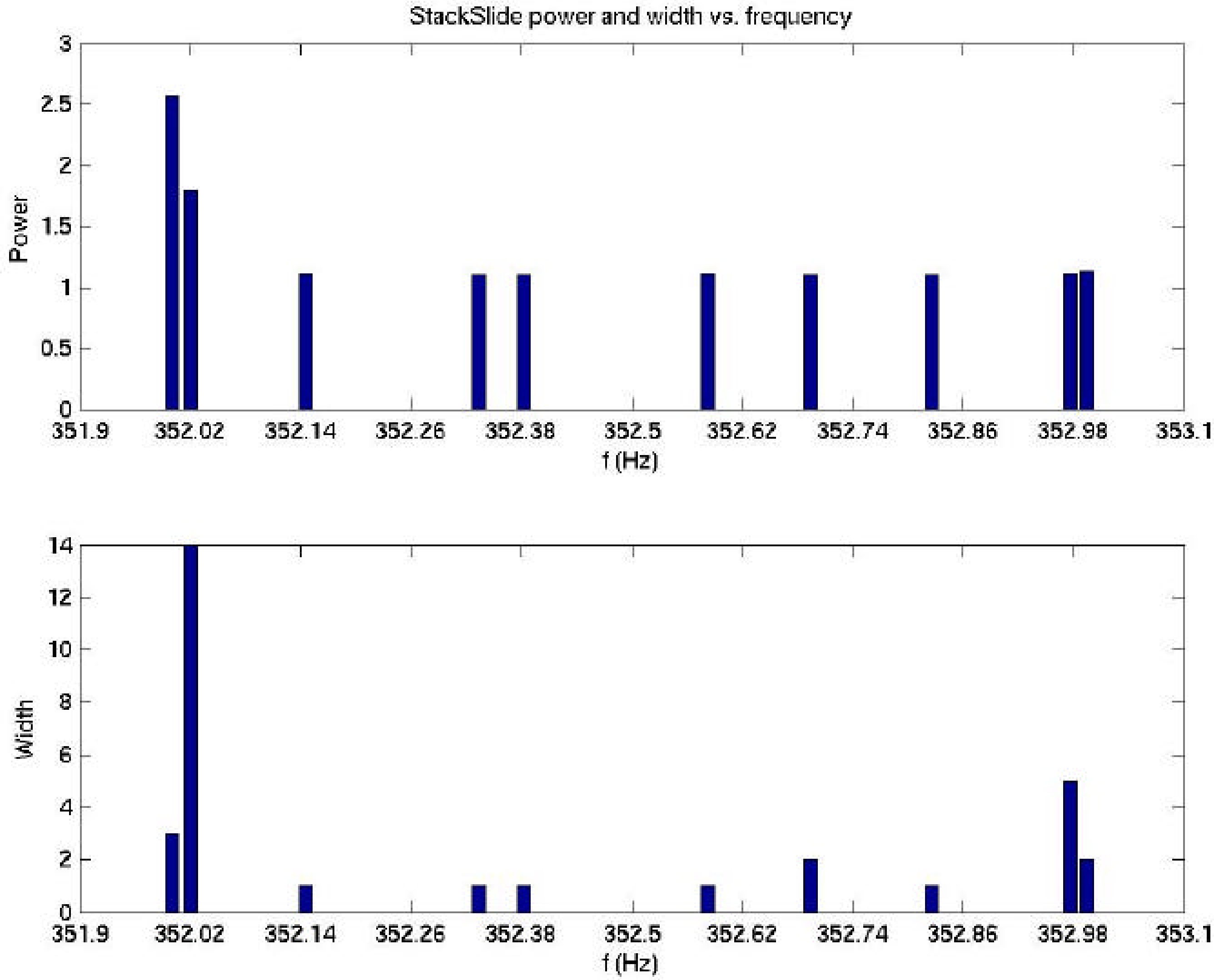
Results: S2 H1 352-353 Hz Band Loudest Event

Column selected: frequency

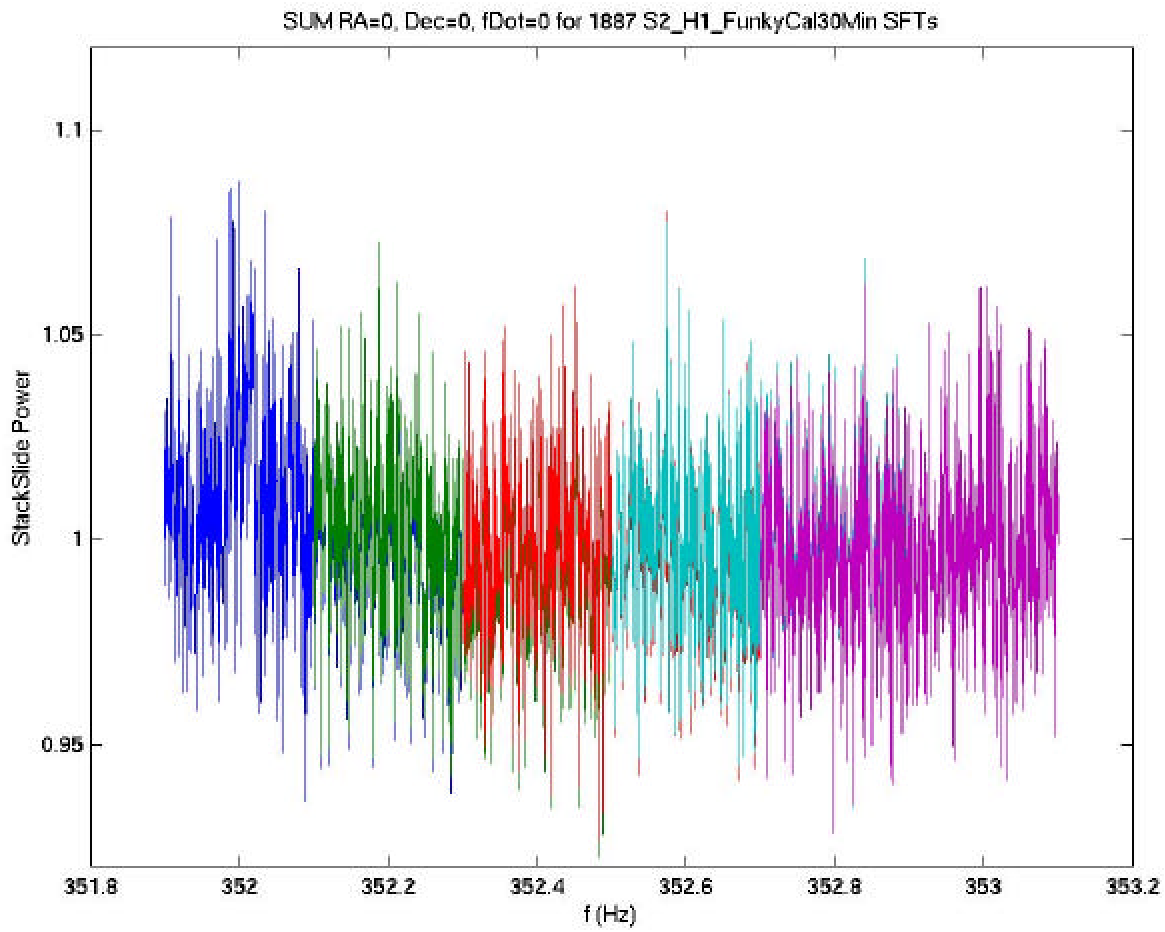
Hide Show Resize

	frequency	power	width	num_subpeaks	pwr_snr	sky_ra	sky_dec	fderiv_1
1	3.520000000000000e+02	2.567490e+00	3	0	1.209744e+02	1.379851800666203le+00	-1.200000000000000e+00	-5.000000000000003e-10
2	3.520211111111111e+02	1.795609e+00	14	3	8.469804e+01	1.765047025448204 9e+00	1.400000000000001e+00	-6.000000000000000e-10
3	3.521461111111111e+02	1.114519e+00	1	0	5.172402e+01	1.809037653120819 9e+00	-9.999999999999922e-02	-3.000000000000000e-10
4	3.523333333333331e+02	1.104465e+00	1	0	5.137996e+01	2.865985705332567 2e+00	-1.100000000000001e+00	-7.000000000000006e-10
5	3.523833333333333e+02	1.101642e+00	1	0	5.170551e+01	4.489490917741248 3e+00	2.000000000000009e-01	-1.000000000000001e-09
6	3.525827777777778e+02	1.108553e+00	1	0	5.159688e+01	2.614918519467188 7e-01	7.000000000000018e-01	-4.000000000000001e-10
7	3.526938888888886e+02	1.100468e+00	2	0	5.204408e+01	1.543223072102151 6e+00	-1.100000000000001e+00	-8.000000000000003e-10
8	3.528255555555552e+02	1.103327e+00	1	0	5.185260e+01	5.900000000000004e+00	8.326672684688674 1e-17	-1.000000000000001e-09
9	3.529766666666663e+02	1.109178e+00	5	0	5.255860e+01	4.415525762131849 8e+00	-1.200000000000000e+00	-4.000000000000001e-10
10	3.529944444444441e+02	1.127921e+00	2	0	5.302579e+01	4.627039294202315 7e+00	1.000000000000002e+00	0.000000000000000e+00

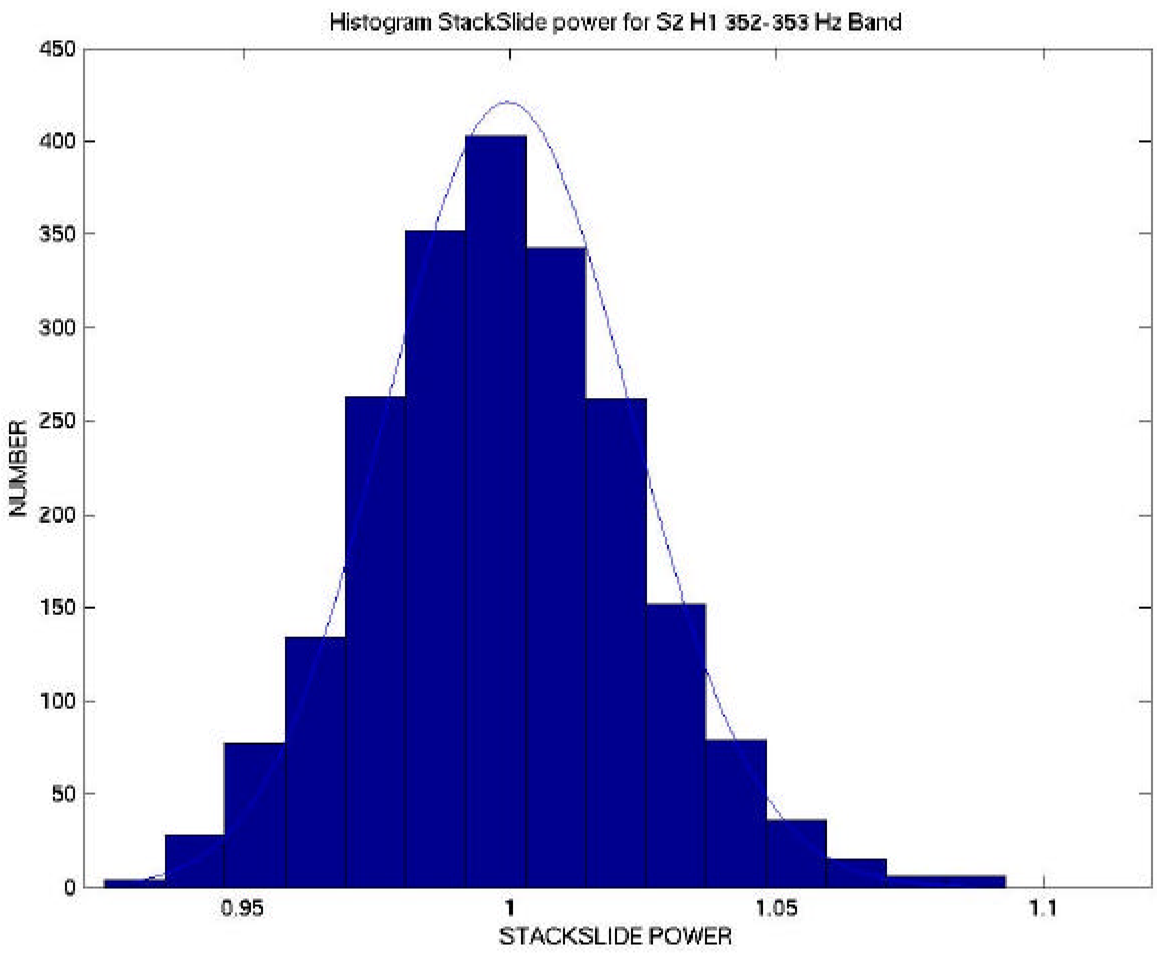
Results: S2 H1 352-353 Hz Band Loudest Event



Results: S2 H1 352-353 Hz Band Loudest Event



Results: S2 H1 352-353 Hz Band Loudest Event



Results: S2 H1 Preliminary Upper Limits for 352-353 Hz Band

(Estimated using all sky average and one value for S_h)

- back-of-envelope estimate: $h_0 < 1.4e\text{-}22$
- From loudest events:
  - $h_0 < 5.7e\text{-}22$ (if no vetos)
  - $h_0 < 4.0e\text{-}22$ (if veto 352 Hz instrument line)
  - $h_0 < 1.8e\text{-}22$ (if veto 14 bin wide event)