Data and Detector Characterisation at GEO600

Martin Hewitson for the LSC

DC work at GEO

- DC is
  - Detector characterisation
    - Detector state
    - Noise-projections
    - calibration
  - Data characterisation
    - Sensitivity
    - Glitch rates
    - Veto development

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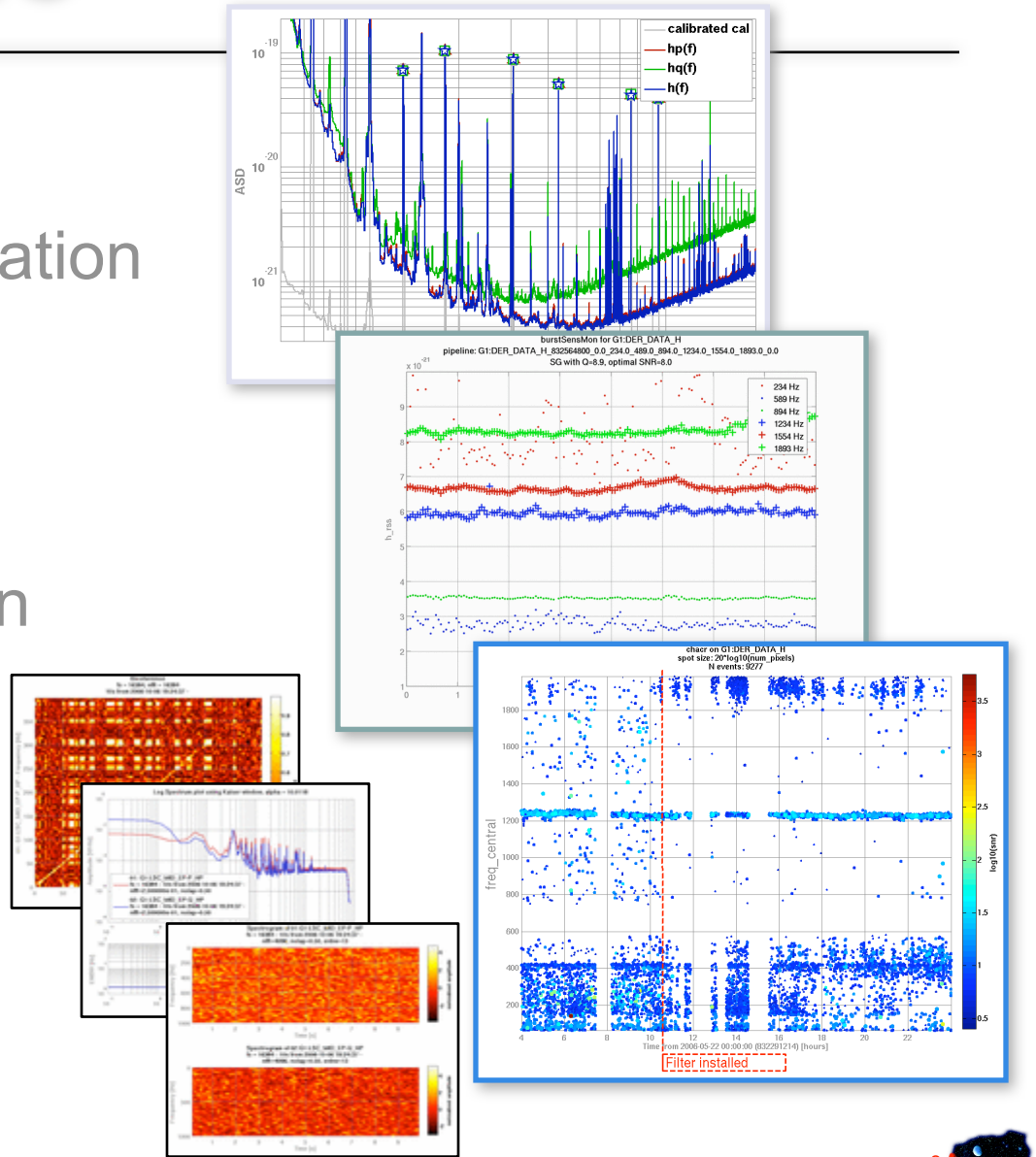

Tracking the detector state

- Fixed format reports
  - Automatically produced
  - 3 per day
  - www format

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#	Report Tag	Start Time (UTC)	Start Time (GPS)	Duration (s)	Duration (H)	Duty Cycle (%)	Link
1	Wed_1	2006-05-30 22:59:46	833065200	28800	8.00	100.00	GREP_Wed_1_20060530_225946_833065200_28800
2	Tue_3	2006-05-30 14:59:46	833036400	28800	8.00	100.00	GREP_Tue_3_20060530_145946_833036400_28800
3	Tue_2	2006-05-30 06:59:46	833007600	28800	8.00	88.78	GREP_Tue_2_20060530_065946_833007600_28800
4	Tue_1	2006-05-29 22:59:46	832978800	28800	8.00	100.00	GREP_Tue_1_20060529_225946_832978800_28800
			50000	28800	8.00	85.72	GREP_Mon_3_20060529_145946_832950000_28800
			21200	28800	8.00	93.87	GREP_Mon_2_20060529_065946_832921200_28800
			92400	28800	8.00	97.64	GREP_Mon_1_20060528_225946_832892400_28800
			63600	28800	8.00	99.20	GREP_Sun_3_20060528_145946_832863600_28800
			34800	28800	8.00	40.58	GREP_Sun_2_20060528_065946_832834800_28800
			77200	28800	8.00	0.00	GREP_Sat_3_20060527_145946_832777200_28800
			48400	28800	8.00	92.11	GREP_Sat_2_20060527_065946_832748400_28800
			19600	28800	8.00	100.00	GREP_Sat_1_20060526_225946_832719600_28800
			90800	28800	8.00	91.79	GREP_Fri_3_20060526_145946_832690800_28800
			62000	28800	8.00	100.00	GREP_Fri_2_20060526_065946_832662000_28800
			33200	28800	8.00	98.64	GREP_Fri_1_20060525_225946_832633200_28800
			04400	28800	8.00	100.00	GREP_Thur_3_20060525_145946_832604400_28800
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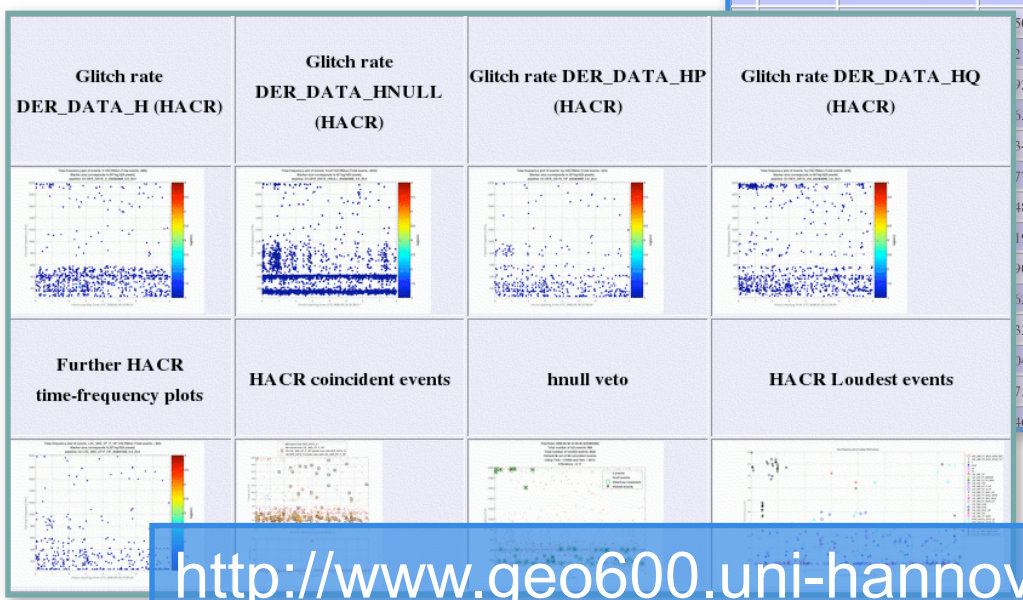
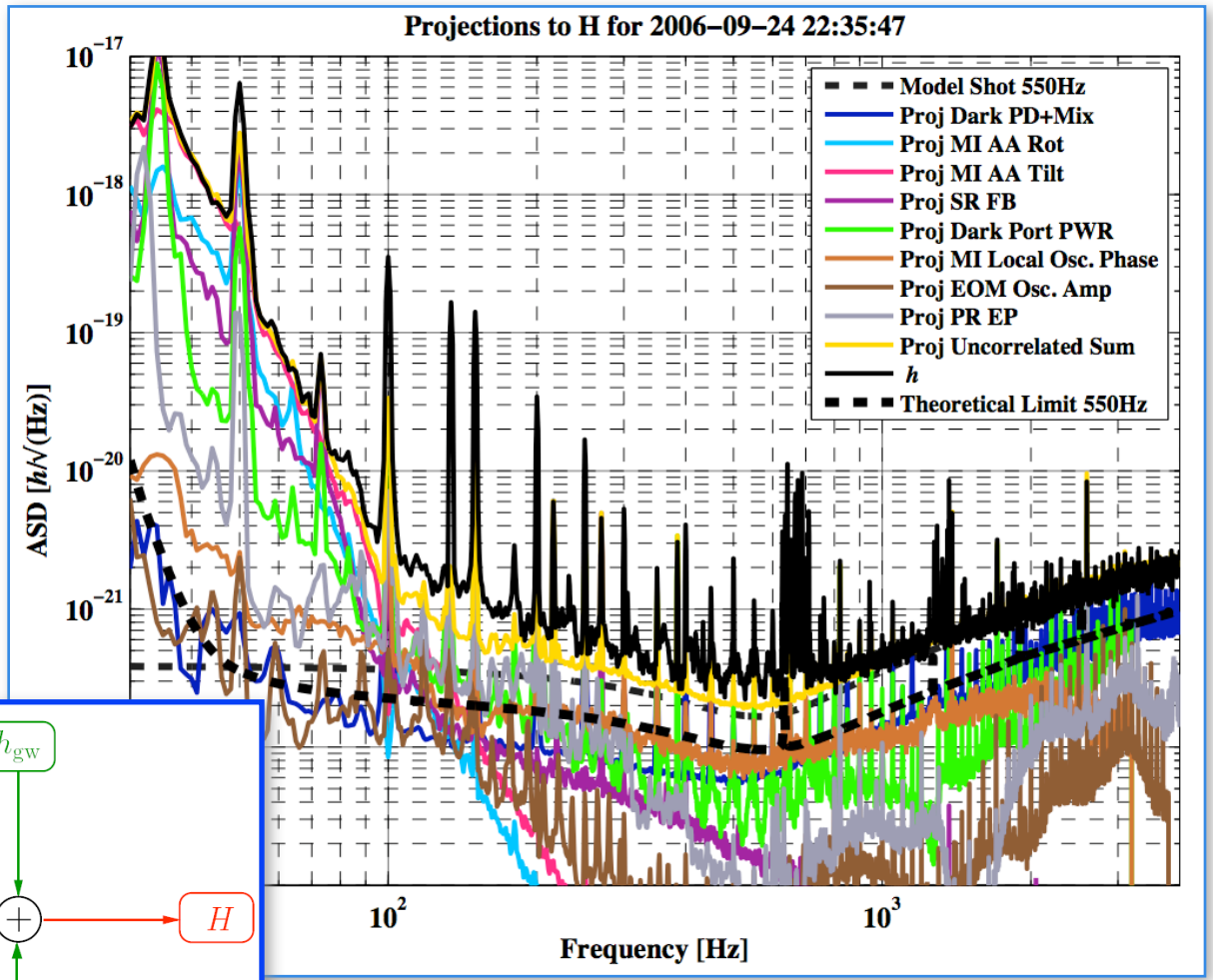
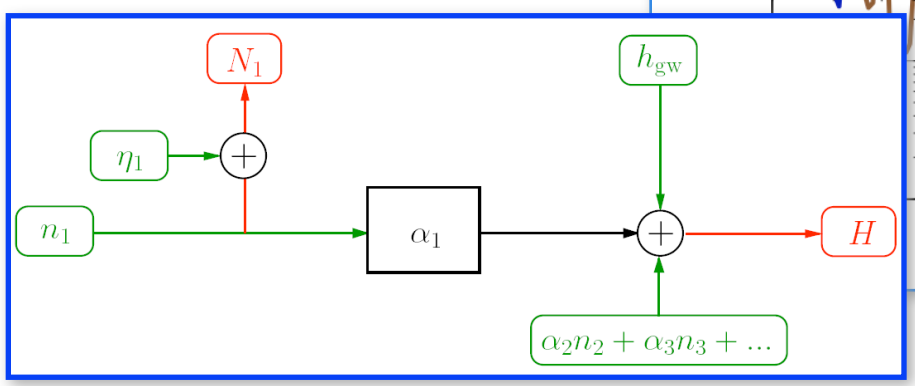


http://www.geo600.uni-hannover.de/georeports/

Noise projections

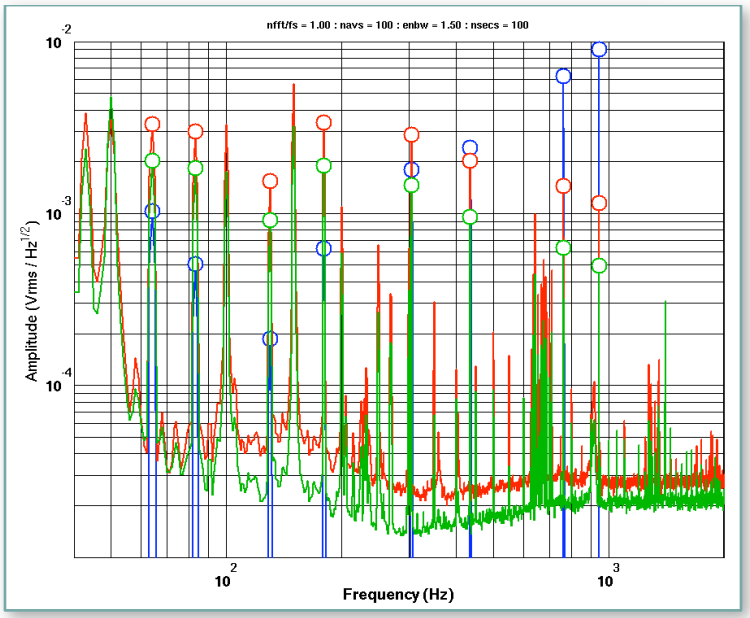
- Measure couplings of various subsystems to h(f)
- 'project' different subsystem ASDs to h(f)





h(t) calibration

- New quasi-model-less calibration routine
- Inject multiple calibration lines
  - Monitor lines at actuator feedbacks and main detector output
    - once per second
  - Fit detector model to measurements
    - Parameterised optical gains for two quadratures
  - Reconstruct two estimates of h(t) using time-domain filters based on model
    - Fixed filters for feedback actuators
  - Combine two estimates to get optimal h(t)



$$G_{\mathrm{opt_P}}(s) = G_{\mathrm{P}} \frac{(s - z_{\mathrm{P}})}{(s - p_{\mathrm{P}})(s - p_{\mathrm{P}}^*)}$$

$$G_{\mathrm{opt_Q}}(s) = G_{\mathrm{Q}} \frac{(s - z_{\mathrm{Q}})}{(s - p_{\mathrm{Q}})(s - p_{\mathrm{Q}}^*)}$$

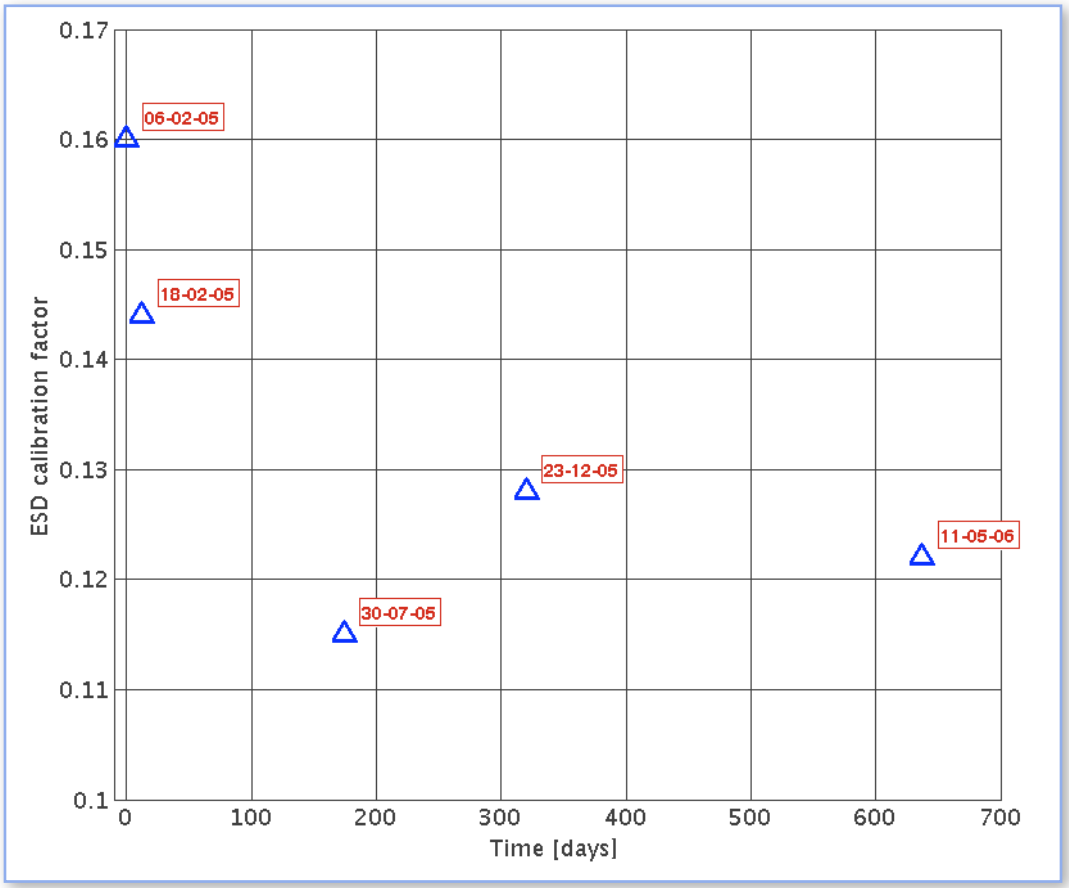
Basis for absolute calibration

Absolute ESD calibration

I. Both ESDs are balanced to give equal displacement
II. East ESD is calibrated against common-mode servo actuator [52uV/V]
III. Common-mode servo is calibrated against master laser piezo [18kHz/V]
IV. Master laser piezo is calibrated against FSR of MC1 [114MHz/V]

⇨ Known to <1%

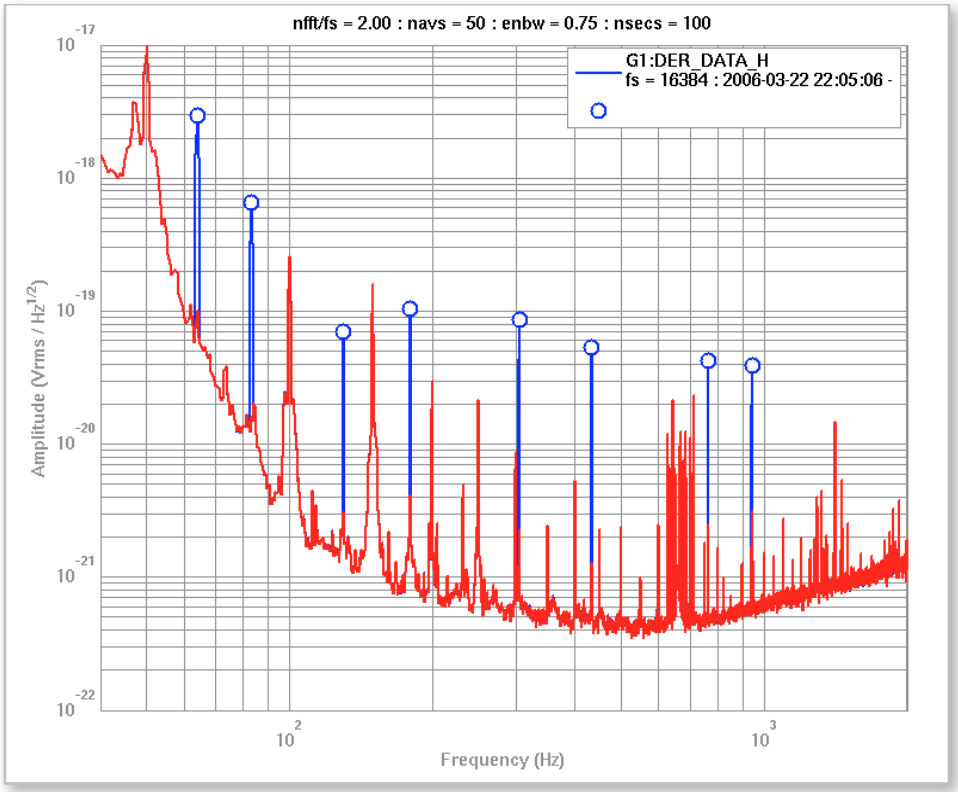
Good to ± 5%



Relative calibration accuracy

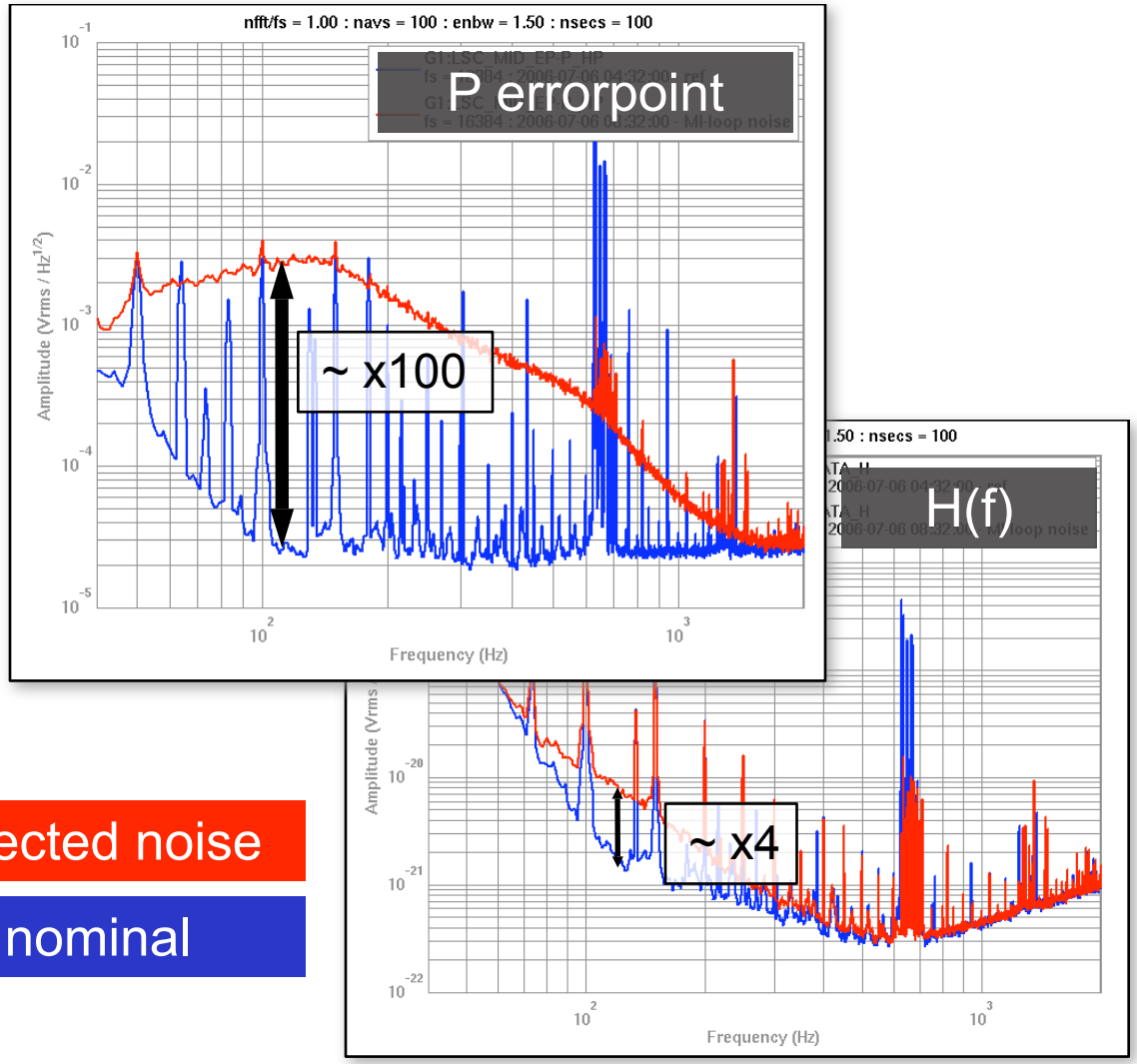
Various pieces of evidence:

1. Suppression of calibration lines in h(t)
2. Suppression of MID loop noise in h(t) [same as 1.]
3. Agreement of injected noise with pendulum model

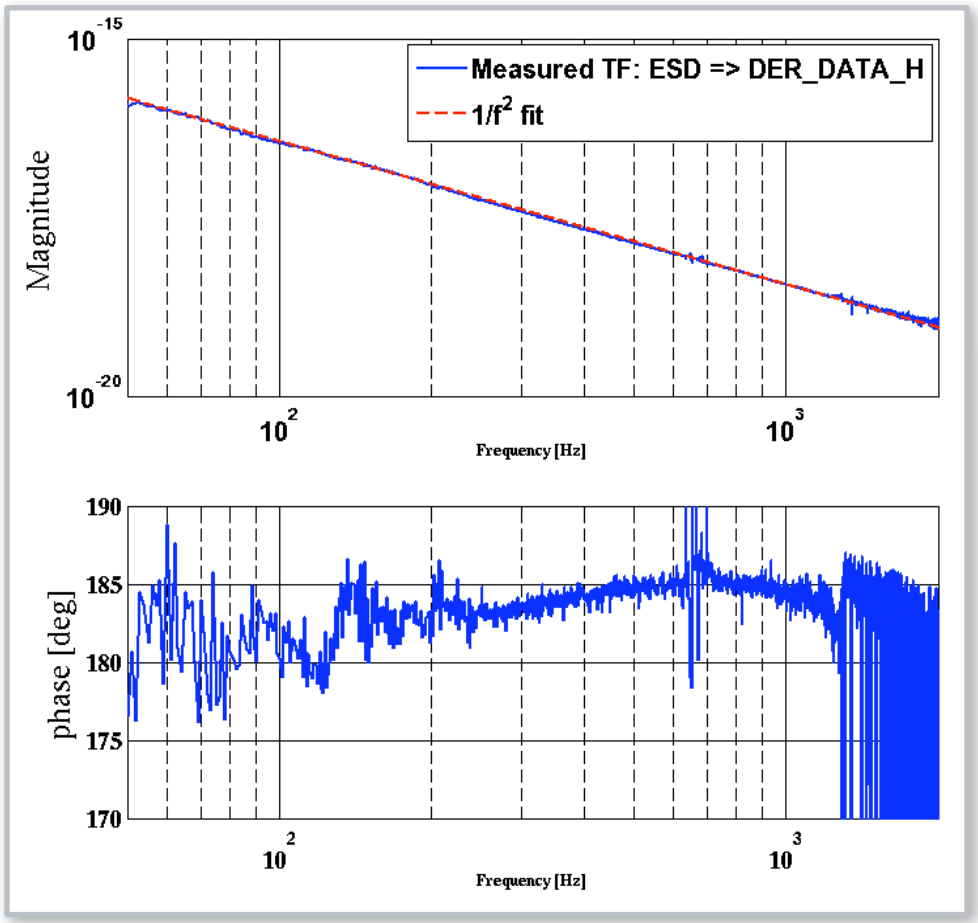


Suppressing noise in MID loop

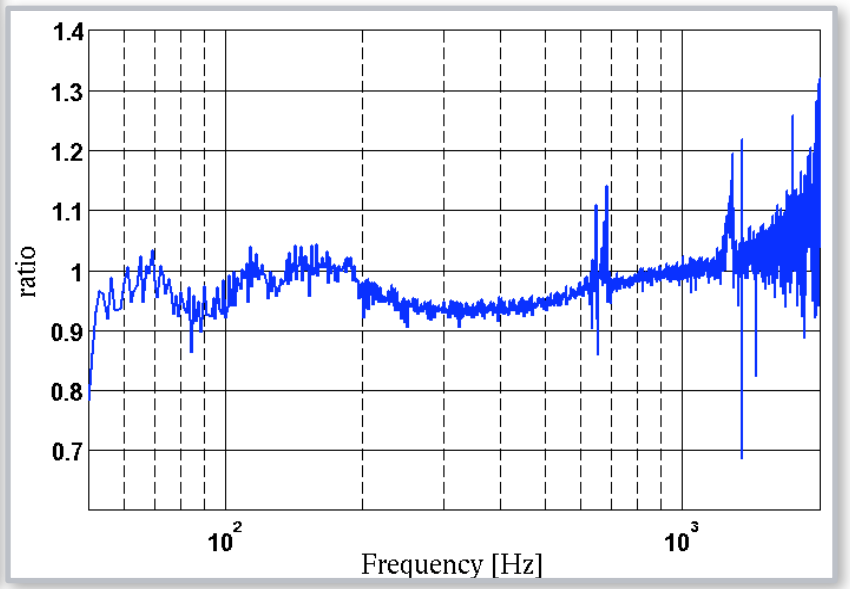
- Noise added between recording points of MI-loop error-point and feedback point is suppressed in new calibration method
  - We have more information since we can compare these two measurement points



Driving ESD with flat force



Inject white-noise into MI loop after feedback recording point



Outputs of calibration process

RDS3

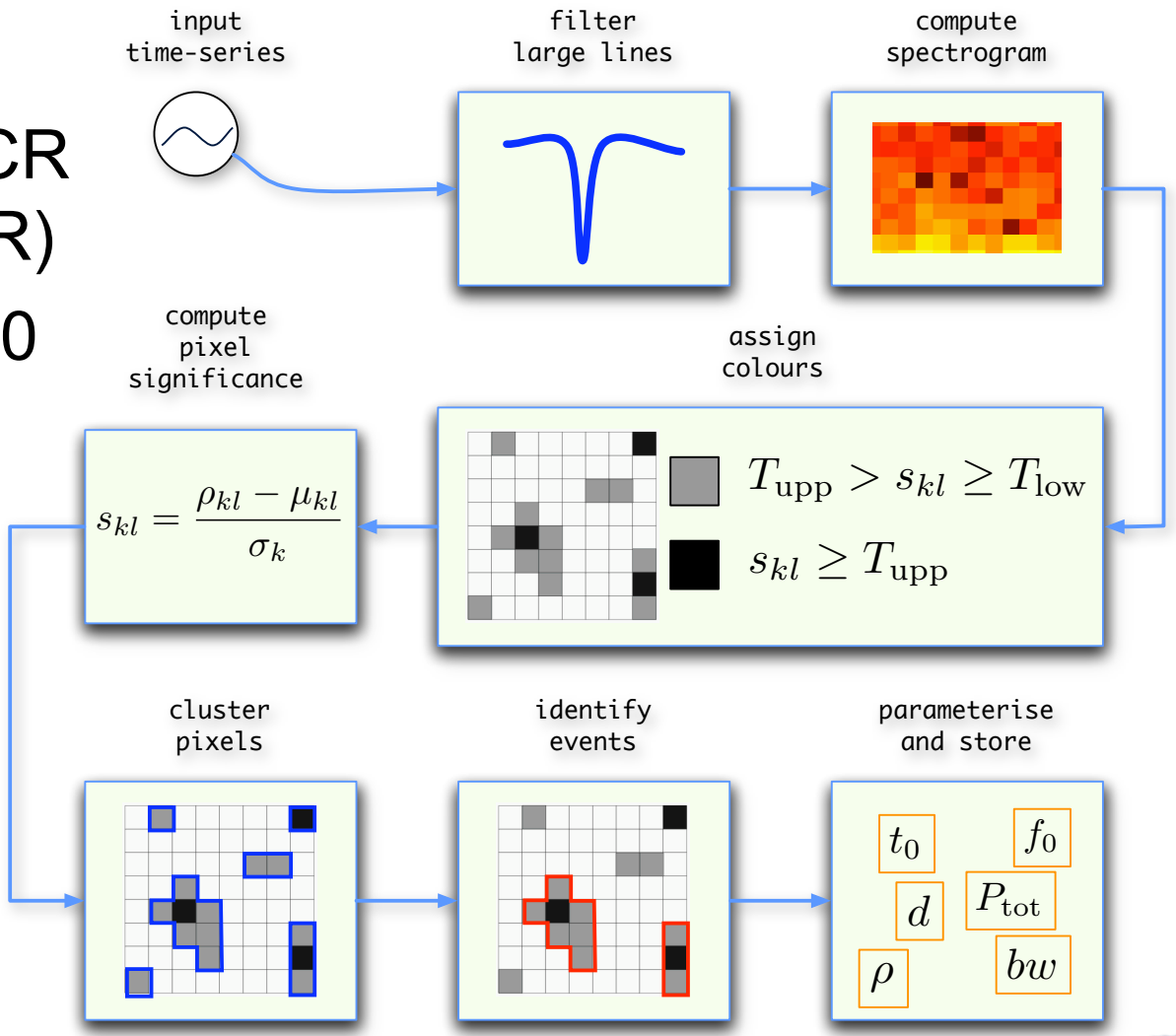
Channel	Description
G1:DER_DATA_H	Optimal h(t) signal
G1:DER_DATA_HP	Calibrated strain signal from P quadrature
G1:DER_DATA_HQ	Calibrated strain signal from Q quadrature
G1:DER_DATA_HNULL	Null-stream output of GEO600
G1_DER_DATA_CHISQ	Calibration quality measure
G1:DER_DATA_TOFF	Measured timing offset of main DCU
G1:DER_PARAM_0	Overall gain of P quadrature response
G1:DER_PARAM_1	Pole frequency of P quadrature response
G1:DER_PARAM_2	Pole Q of P quadrature response
G1:DER_PARAM_3	Zero frequency of P quadrature response
G1:DER_PARAM_4	Overall gain of Q quadrature response
G1:DER_PARAM_5	Pole frequency of Q quadrature response
G1:DER_PARAM_6	Pole Q of Q quadrature response
G1:DER_PARAM_7	Zero frequency of Q quadrature response

16384 Hz

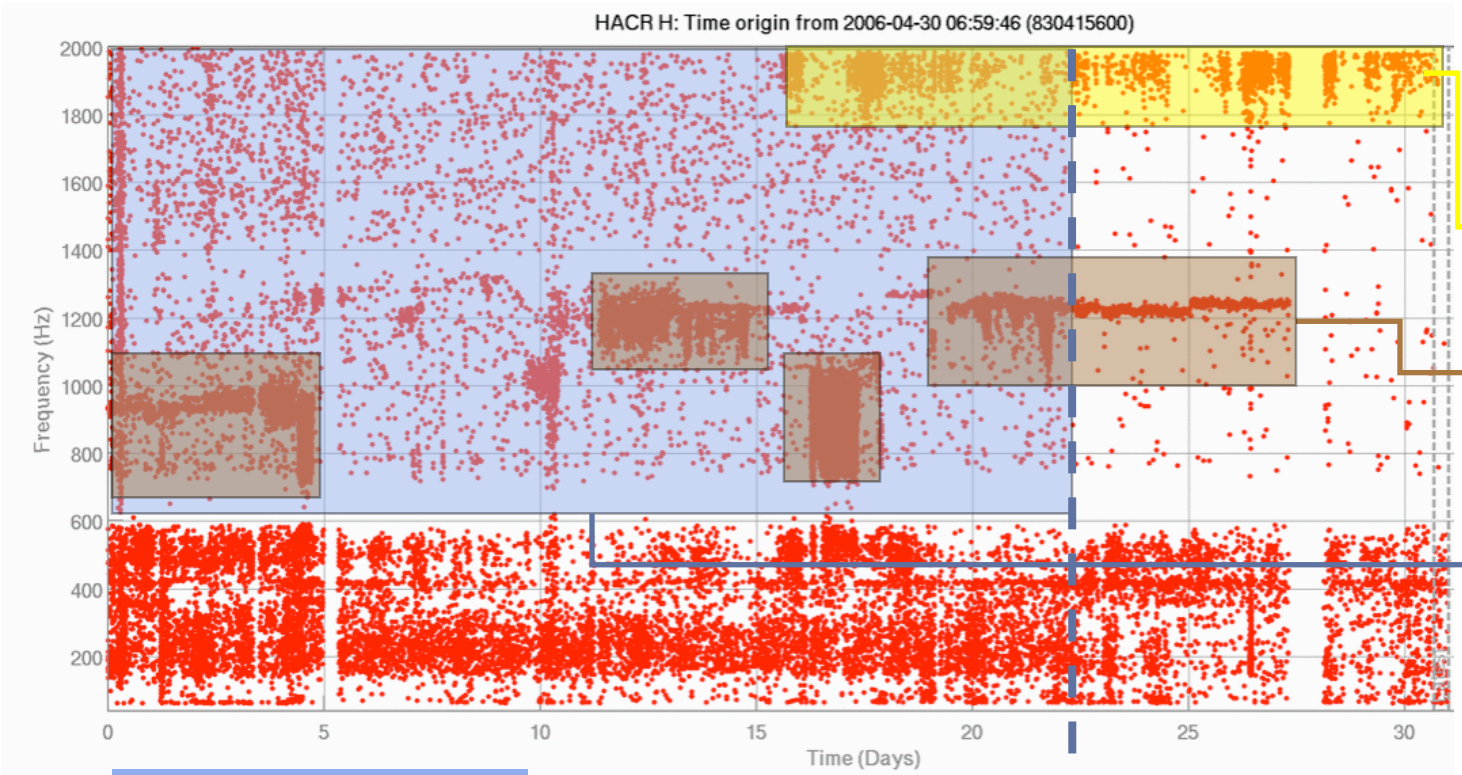
1 Hz

Measuring glitch rates

- Use modified HACR algorithm (mHACR)
- Run on-line on ~30 channels
- T-F based ETG
- Parameterised events stored in database



h(t) glitch rate - May 2006



Frequency-noise glitches

'Owl' glitches

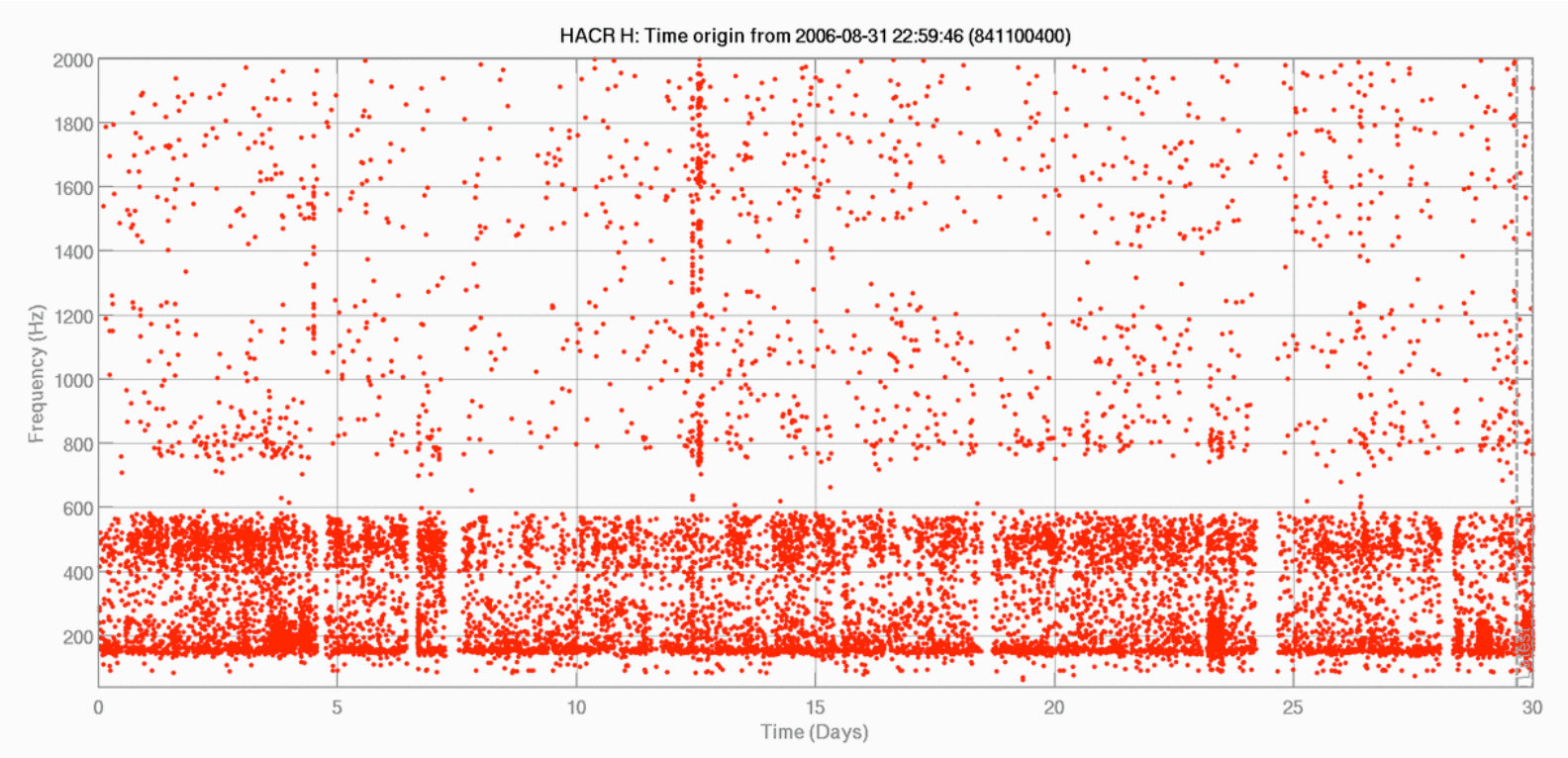
Dust glitches

324942 glitches with snr>6 and f_0>500Hz

[0.12 Hz]

AC filtering improved

h(t) glitch rate - October 2006



24402 glitches with snr>6 and f_0>500Hz

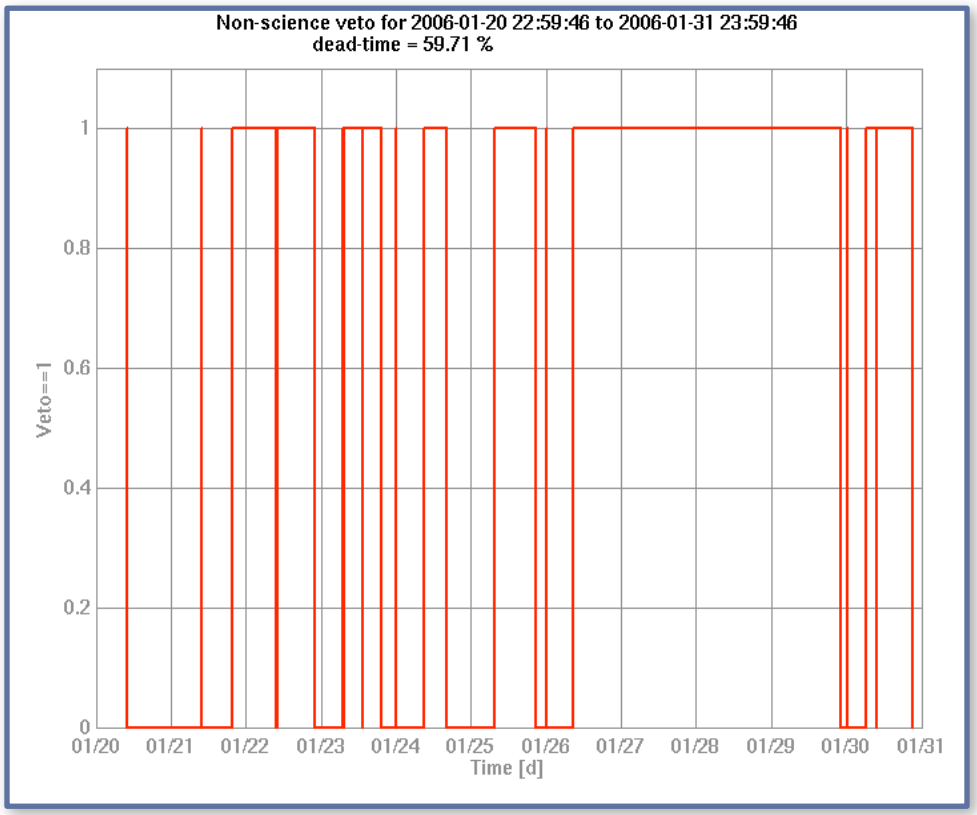
[0.01 Hz]

DQ flags and veto development

- Main focus on veto development:
  - Triggers from many channels with mHACR
  - False-alarm studies
  - Time-shift studies
  - Hardware injections

Veto Methods under development

- science segments (obviously)
- χ^2 veto
- GEO null-stream veto
- noise-projection vetoes
- statistical vetoes



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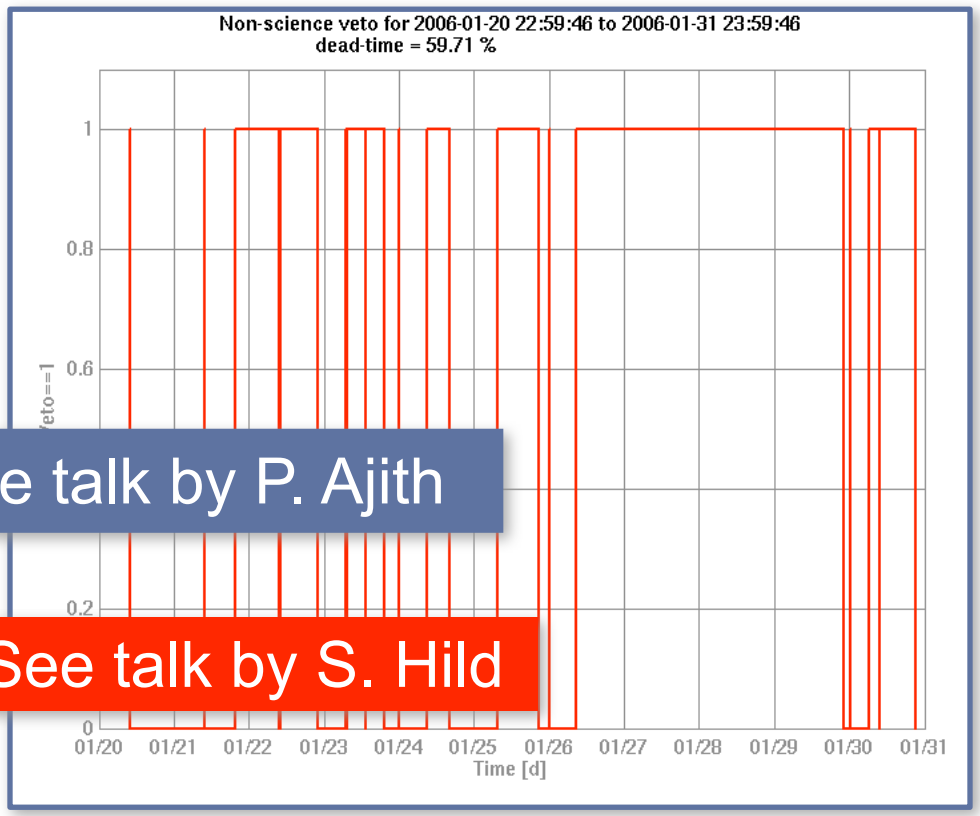
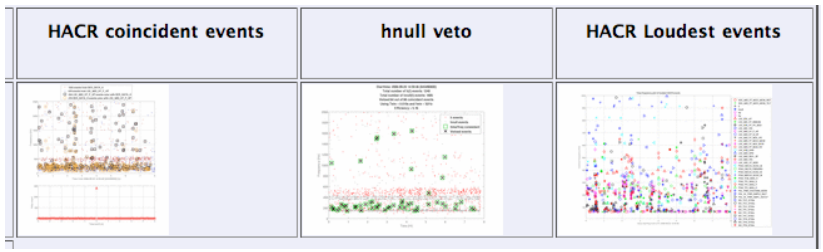
See talk by P. Ajith

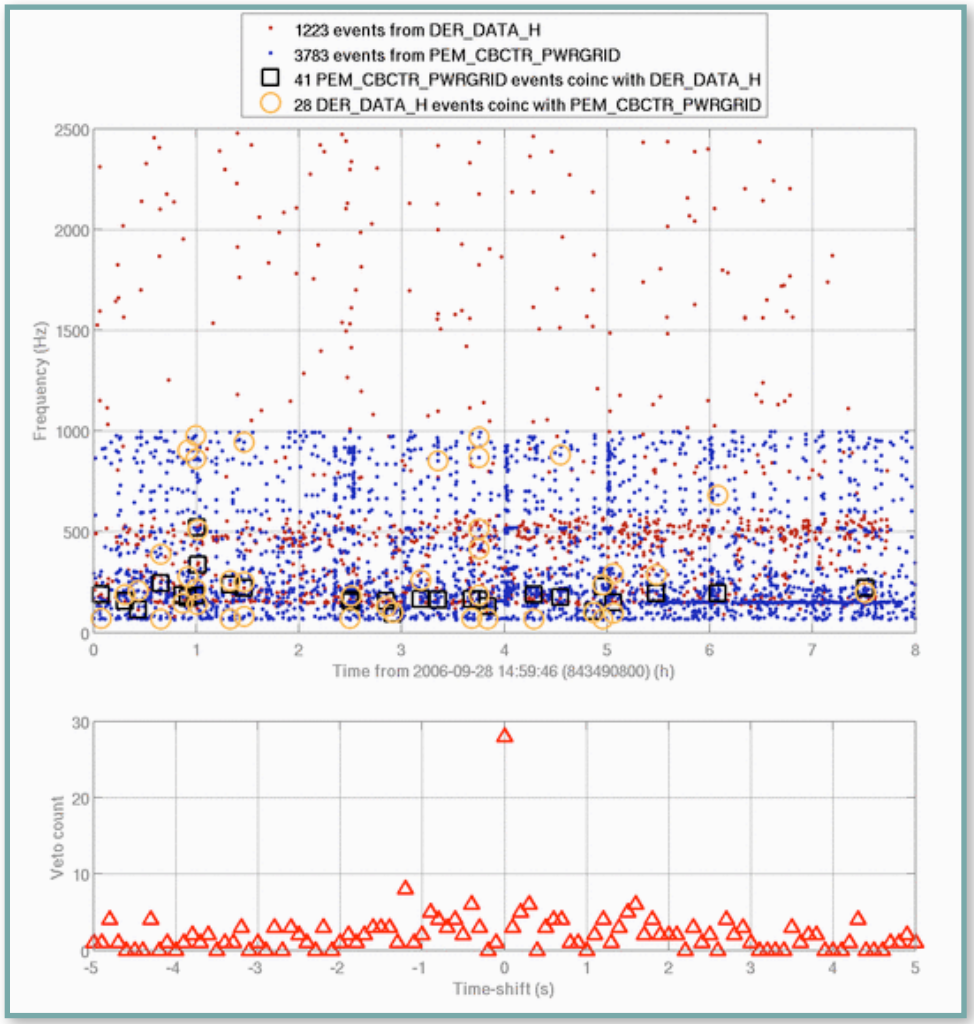
See talk by S. Hild



Veto quick-look

- Summary pages provide quick-look coincidence checks for many channels

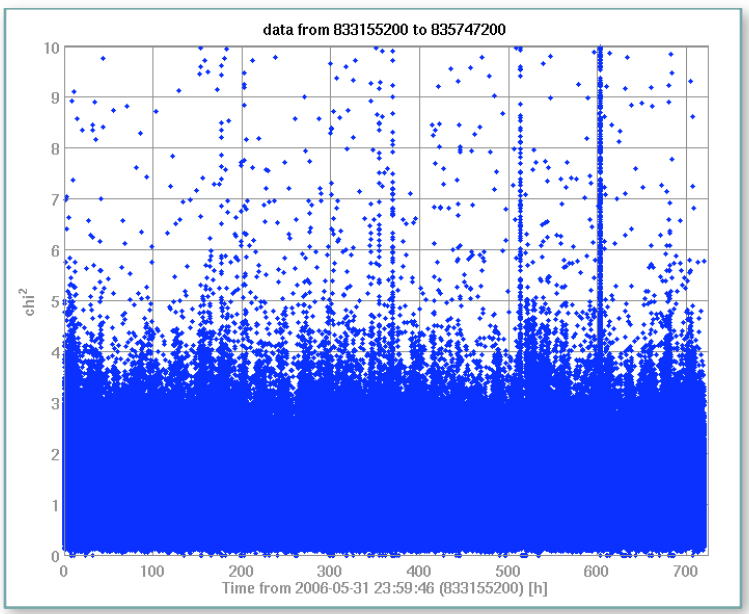


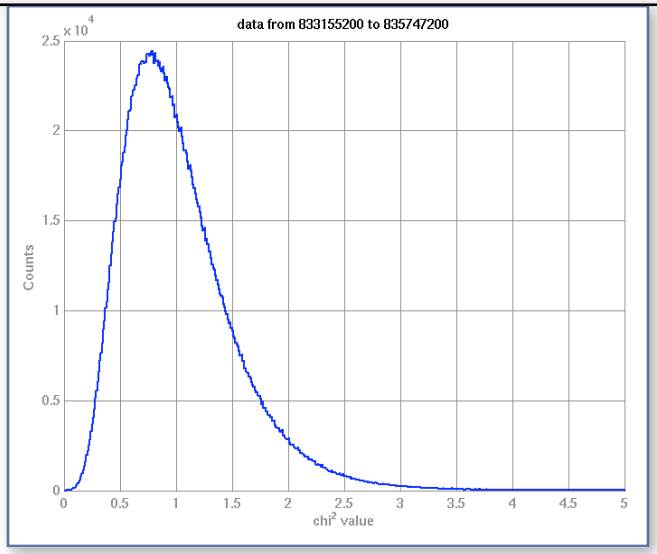


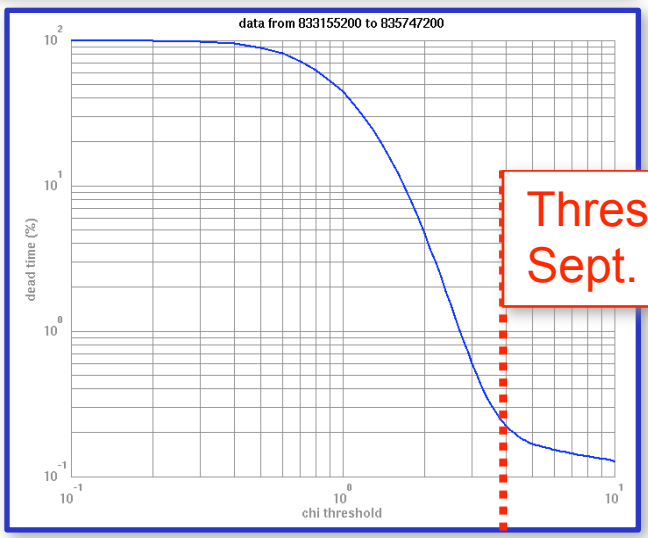
Mains Power Glitches couple to H

χ^2 data quality flag

- χ^2 is a measure of quality of calibration process [1Hz]
- Set a threshold on value
- Exclude data where threshold is exceeded for 10 consecutive seconds







Threshold=4
Sept. 2006

The null-stream veto

Start with:

$$h_{\mathrm{P}}(t) = h(t) + n_{\mathrm{P}}(t)$$

$$h_{\mathrm{Q}}(t) = h(t) + n_{\mathrm{Q}}(t)$$

$$\begin{aligned} h_{\mathrm{null}}(t) &= h_{\mathrm{P}}(t) - h_{\mathrm{Q}}(t) \\ &= n_{\mathrm{P}}(t) - n_{\mathrm{Q}}(t) \end{aligned}$$

contains no GW information

(to within relative calibration accuracy of h_P and h_Q)

The method

- Since h_{null} contains no (or significantly less) GW information that h we can make a signal veto
- We need:
  - An event in h_{null} that is consistent in time and frequency with an event in h
  - To compute the ratio of amplitudes of the two events

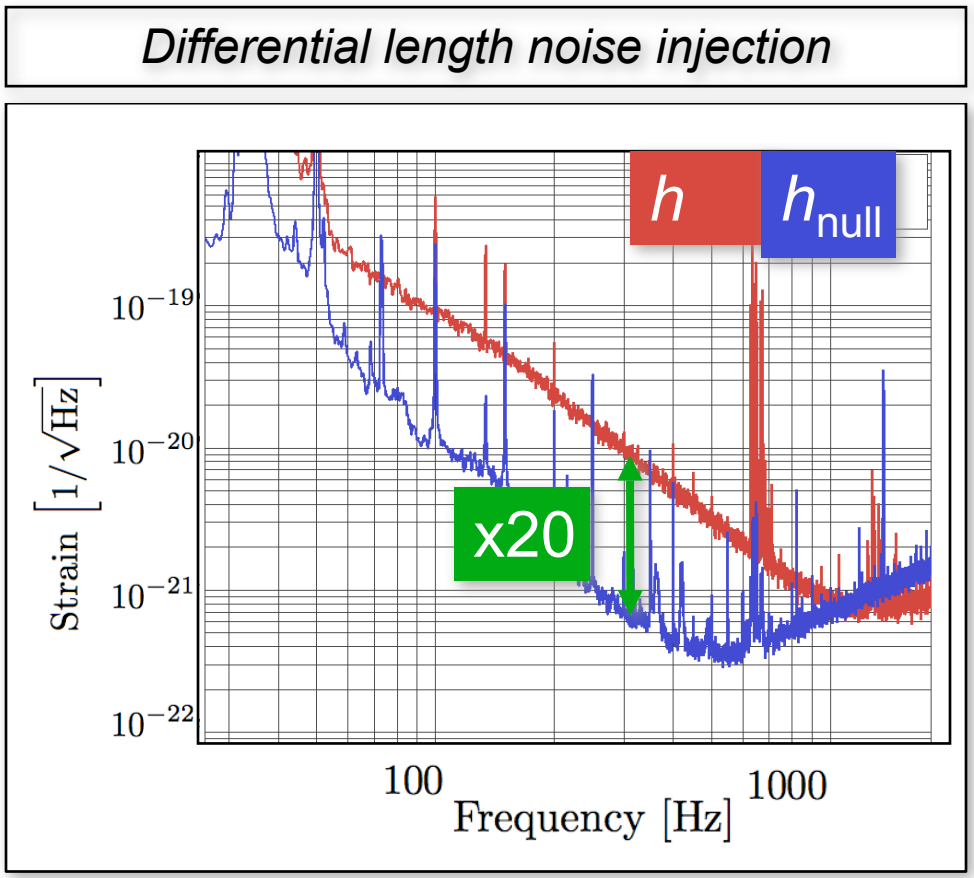
GWs appear in h_{null} with N times lower amplitude than in h; instrumental bursts need not

Amplitude consistency test

$$\frac{h_a}{h\mathrm{null}_a} < a_{\mathrm{thresh}}$$

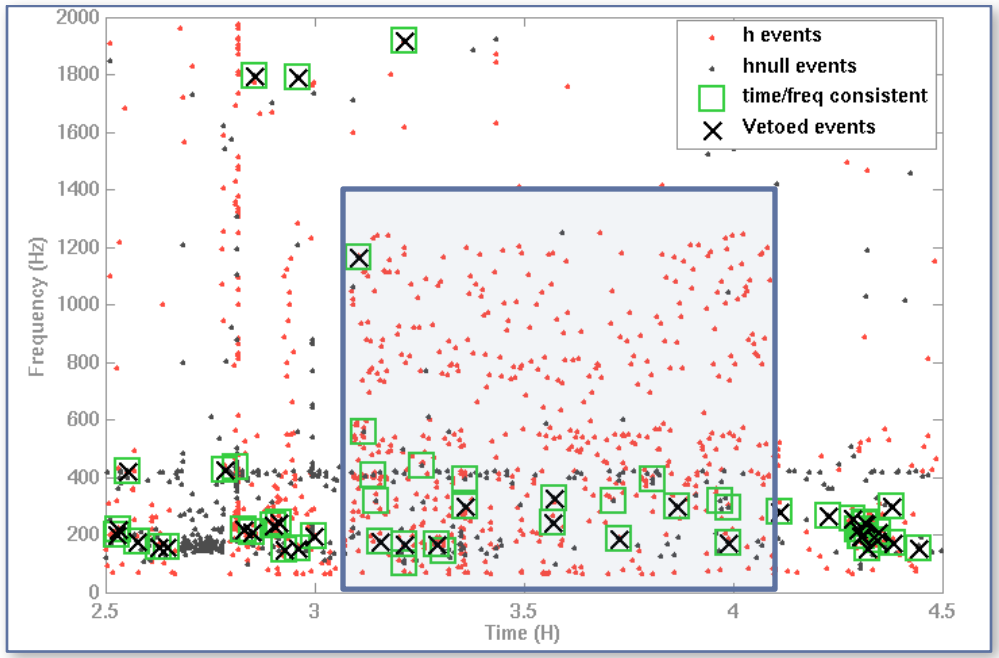
Determining the threshold

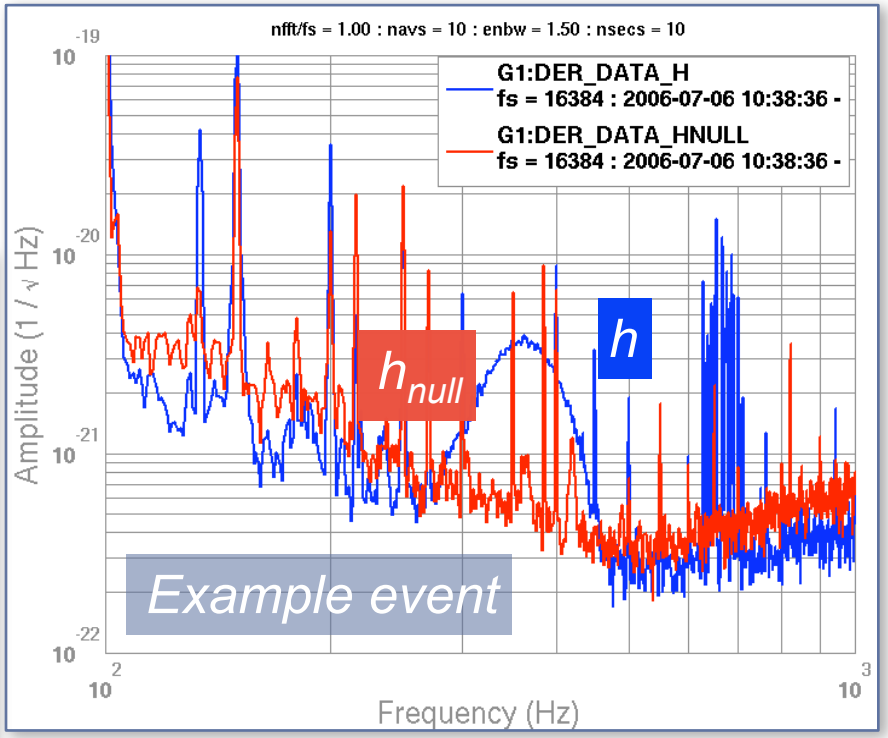
- Educated guess from calibration line heights in h and h_{null}
  - Gives a threshold of around 10
- Differential length noise injection
- More rigourous is to do hardware burst injections
  - Instrumental bursts to get efficiency
  - GW-like bursts to get false-veto rate
- Time-shift analysis is a good compromise



Burst hardware injections

Injected sine-gaussian waveforms every 12s for 1 hour with varying central frequency and amplitude



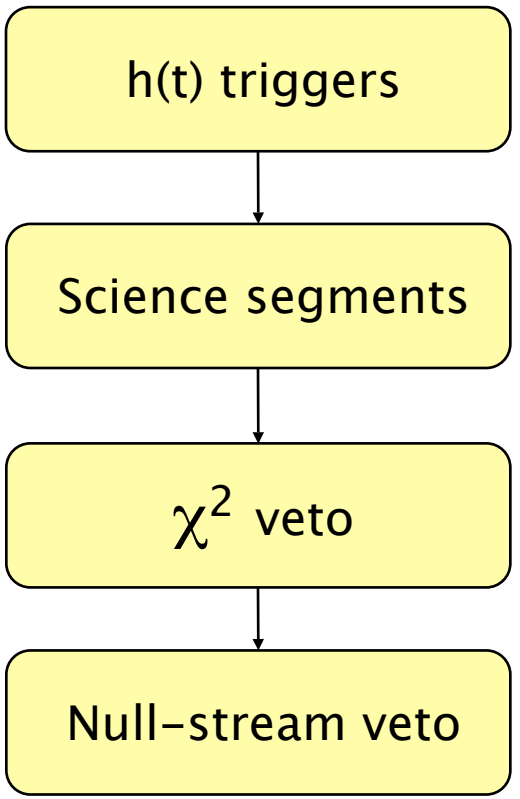


Time window: 20ms
Freq window: 32Hz
Amplitude ratio: 8

0 hardware injections vetoed

Null-stream application - September 2006

- Apply null-stream veto to one month of triggers from S5 (07-06)
- Perform time-shift analysis to estimate false veto rate



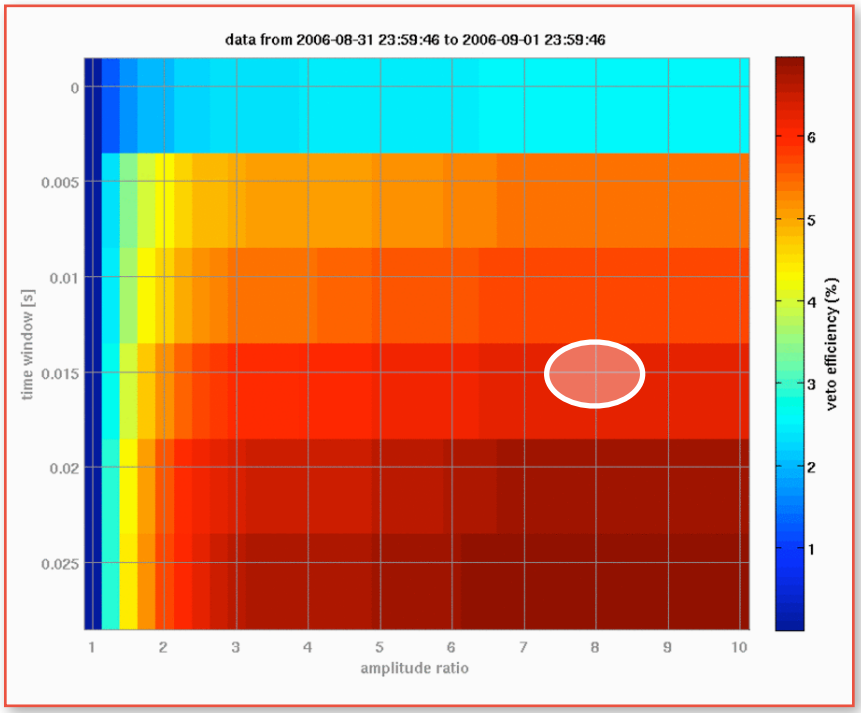
Window tuning

Using first day of September for tuning

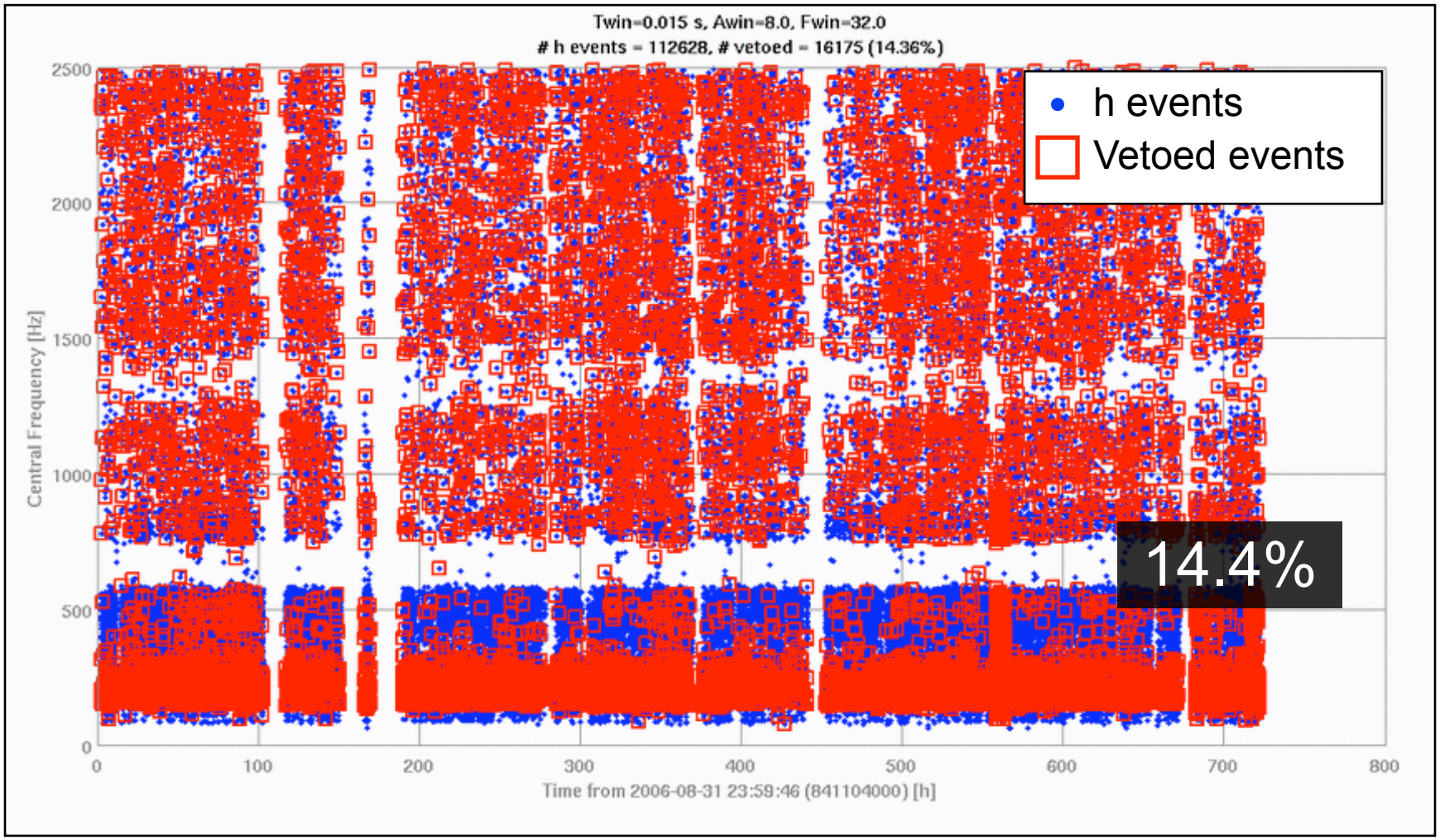
Time window: 15ms
Freq window: 32Hz
Amplitude ratio: 8

Background rate ~1 per day

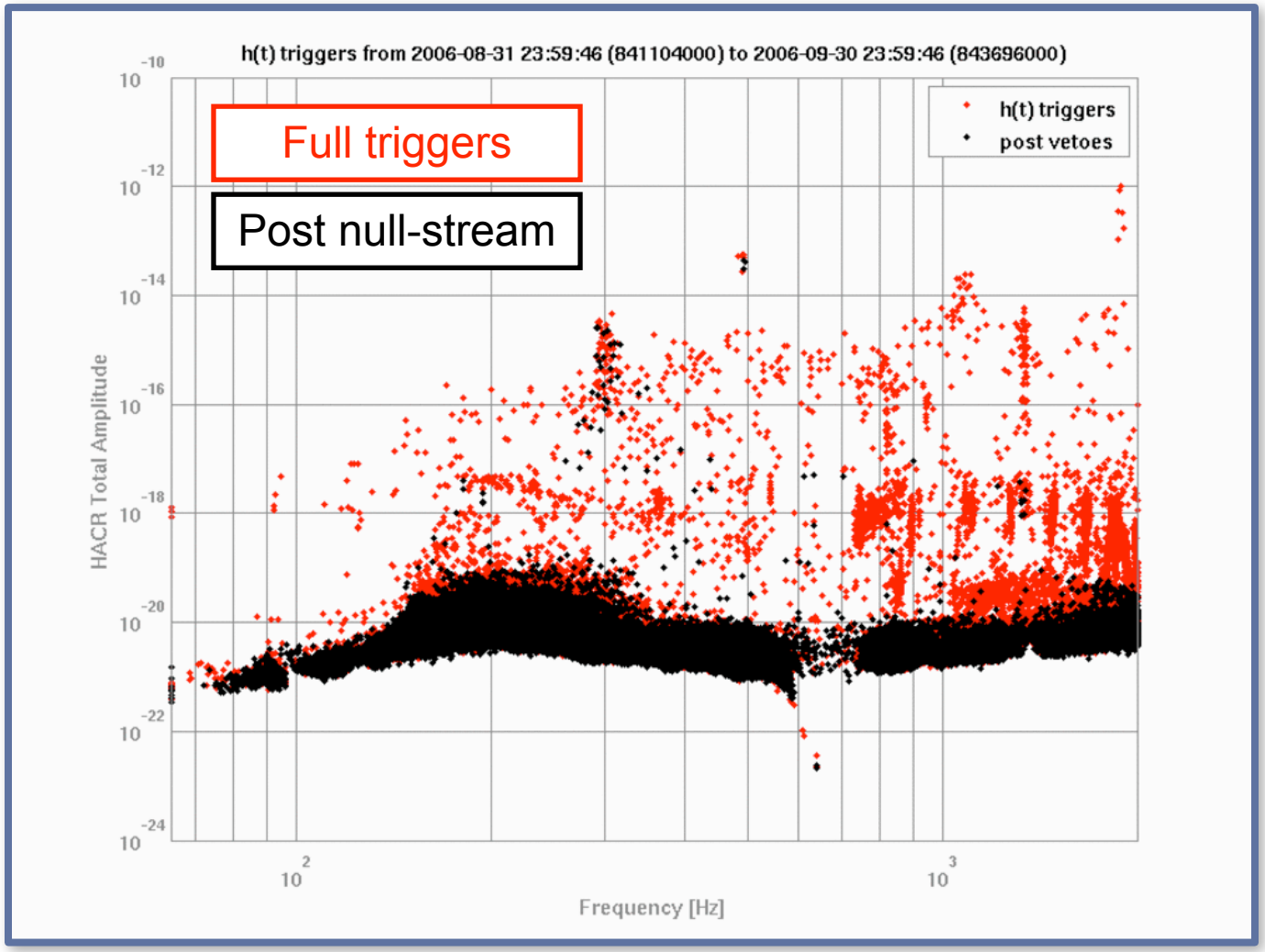
Efficiency Surface



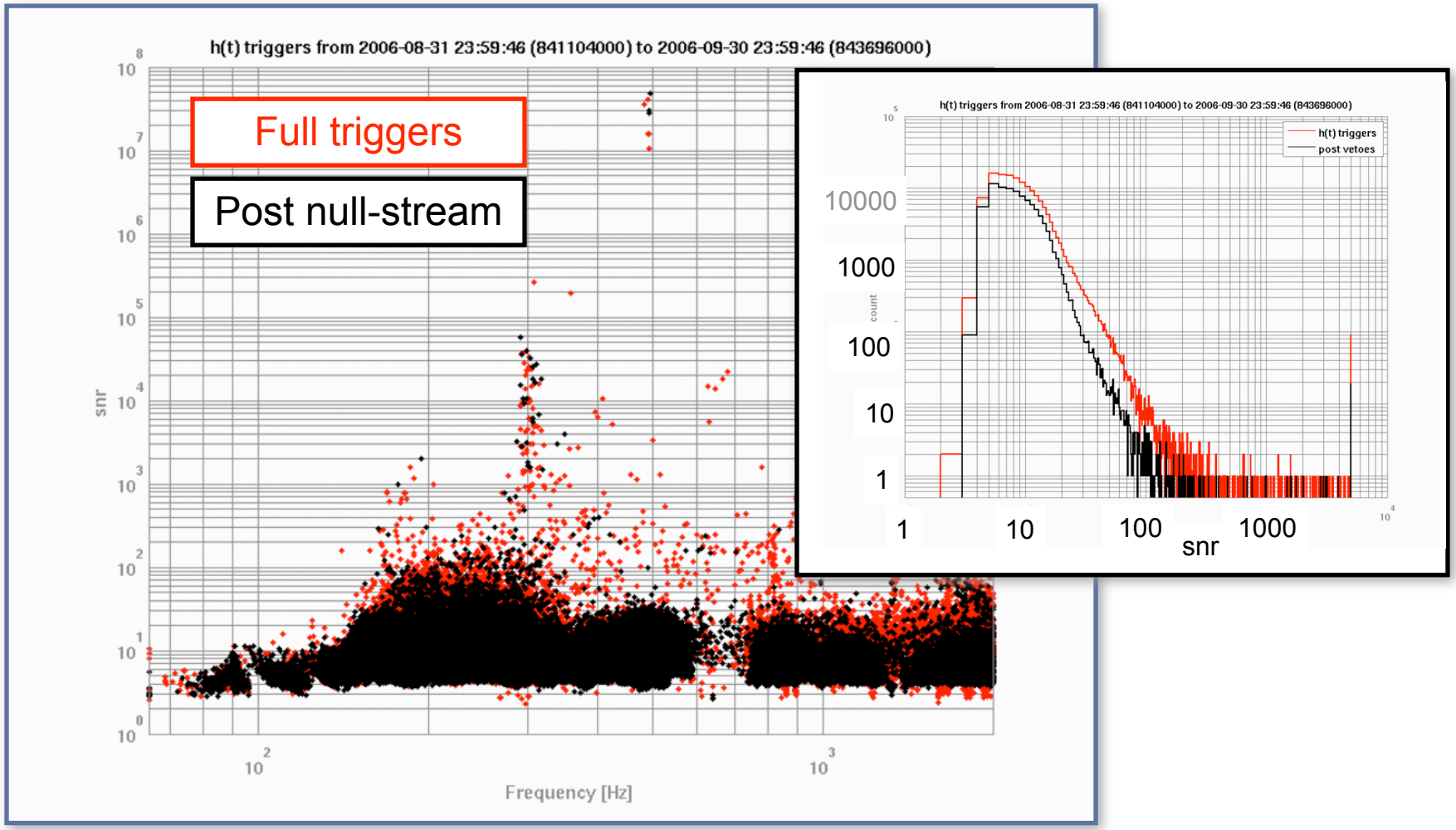
Time-frequency map - Sept 2006



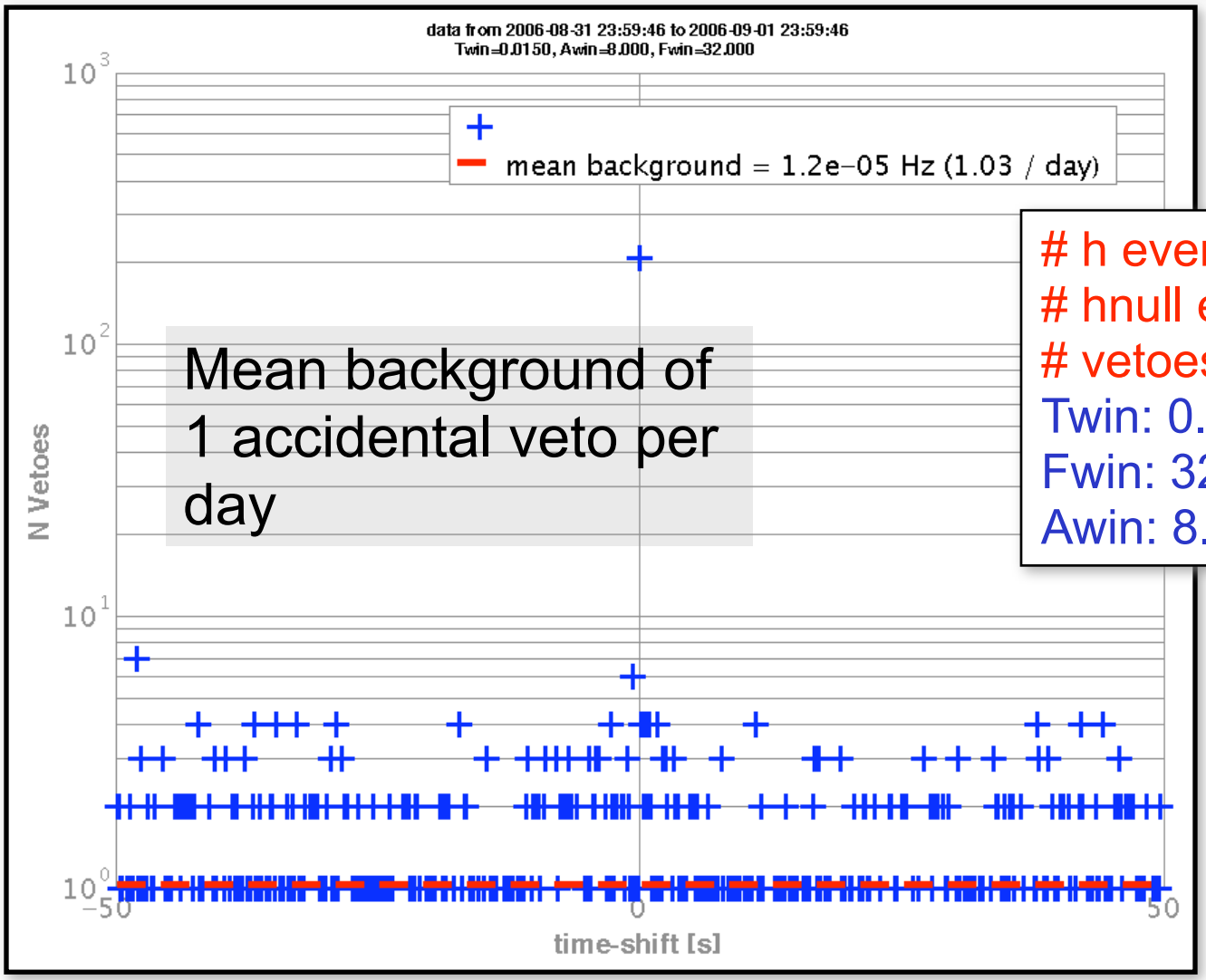
Event properties - amplitude



Event properties - snr



Time-shift of full pipeline



h events: 112628
hnull events: 196360
vetoes: 16175 [14.4%]
Twin: 0.015
Fwin: 32.000
Awin: 8.000

PEM_BIRD?

THE END