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Instrumental and environmental noise in GEO600

Joshua Smith for the GEO 600 team

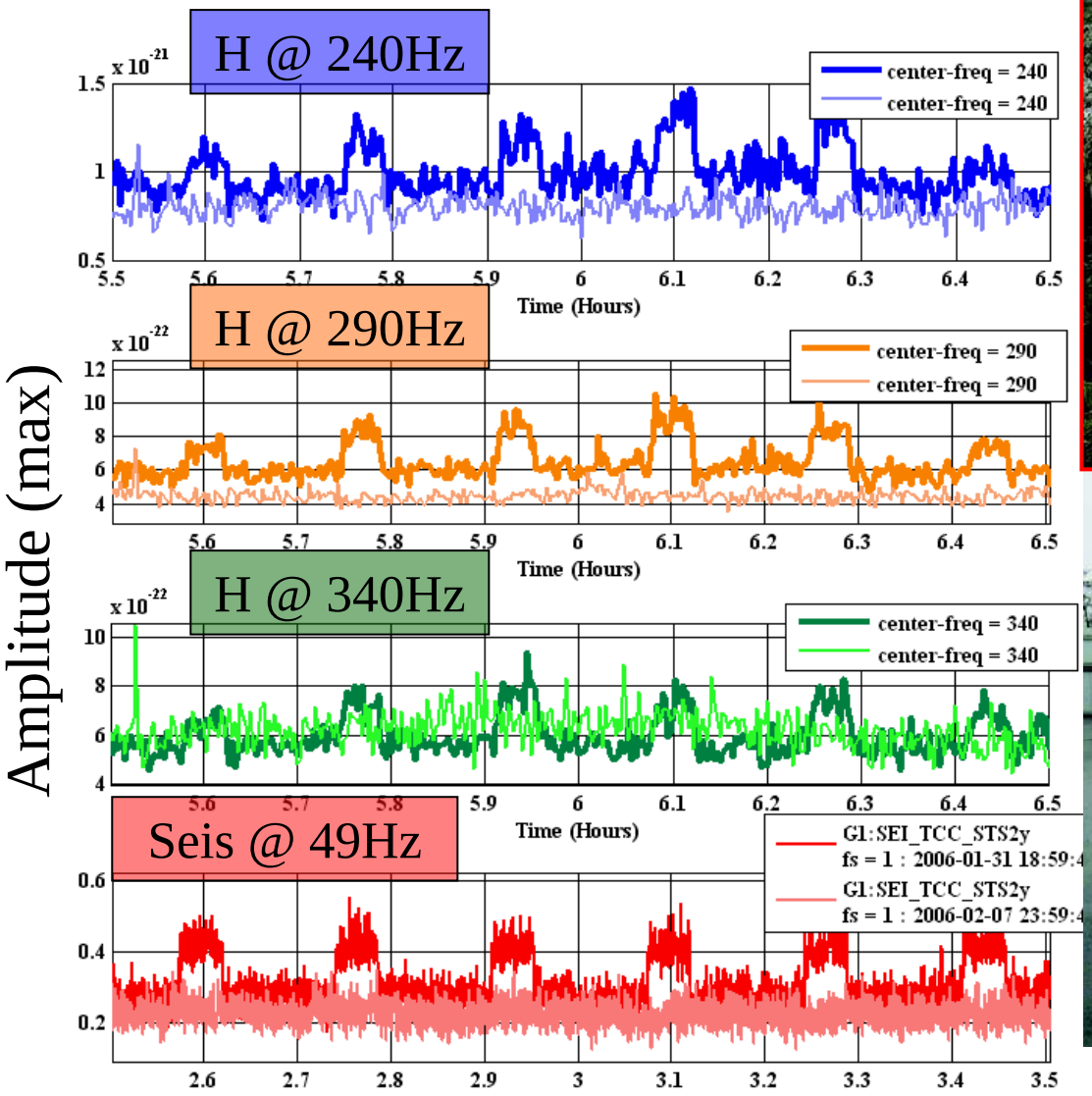
Elba, Italy 31.05.06

Overview

A selection of recent detector characterization work

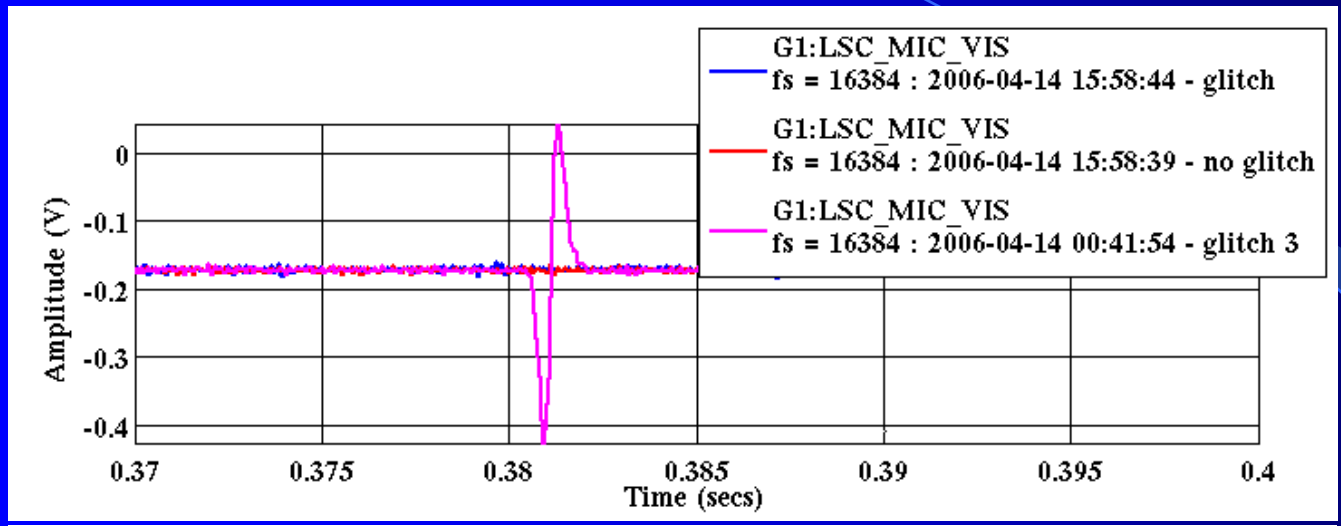
- Environmental:
  - Seismic
  - Dust
  - Magnetic fields / Mains
- Instrumental:
  - Noise Projections
  - Tracking couplings
  - Noise subtraction
  - Noise vetoes

Seismic / up-conversion

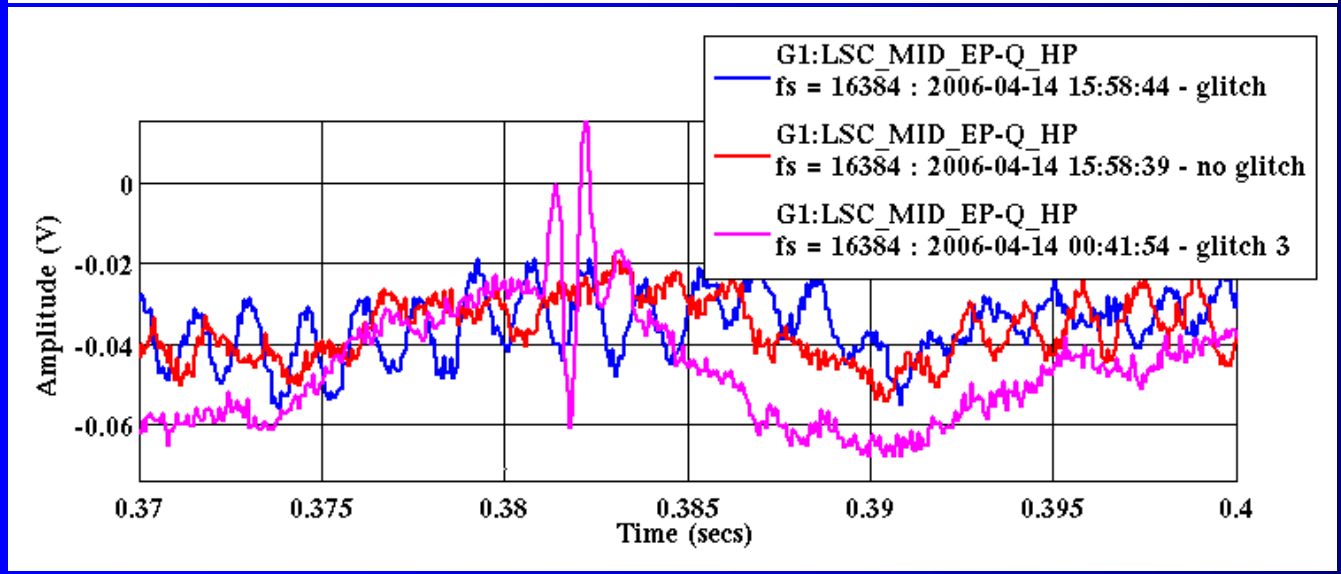


Dust

Power glitches



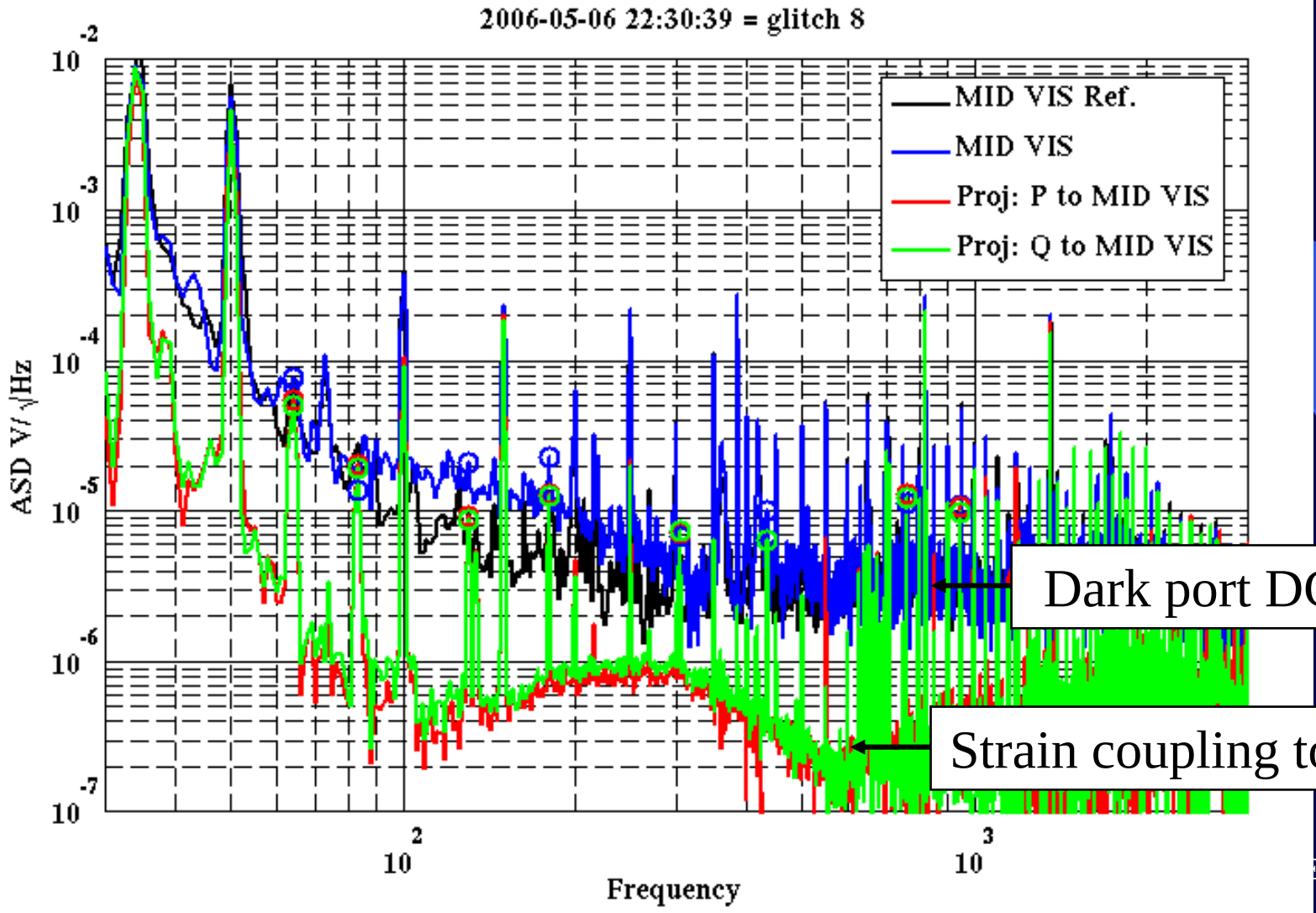
Input port power



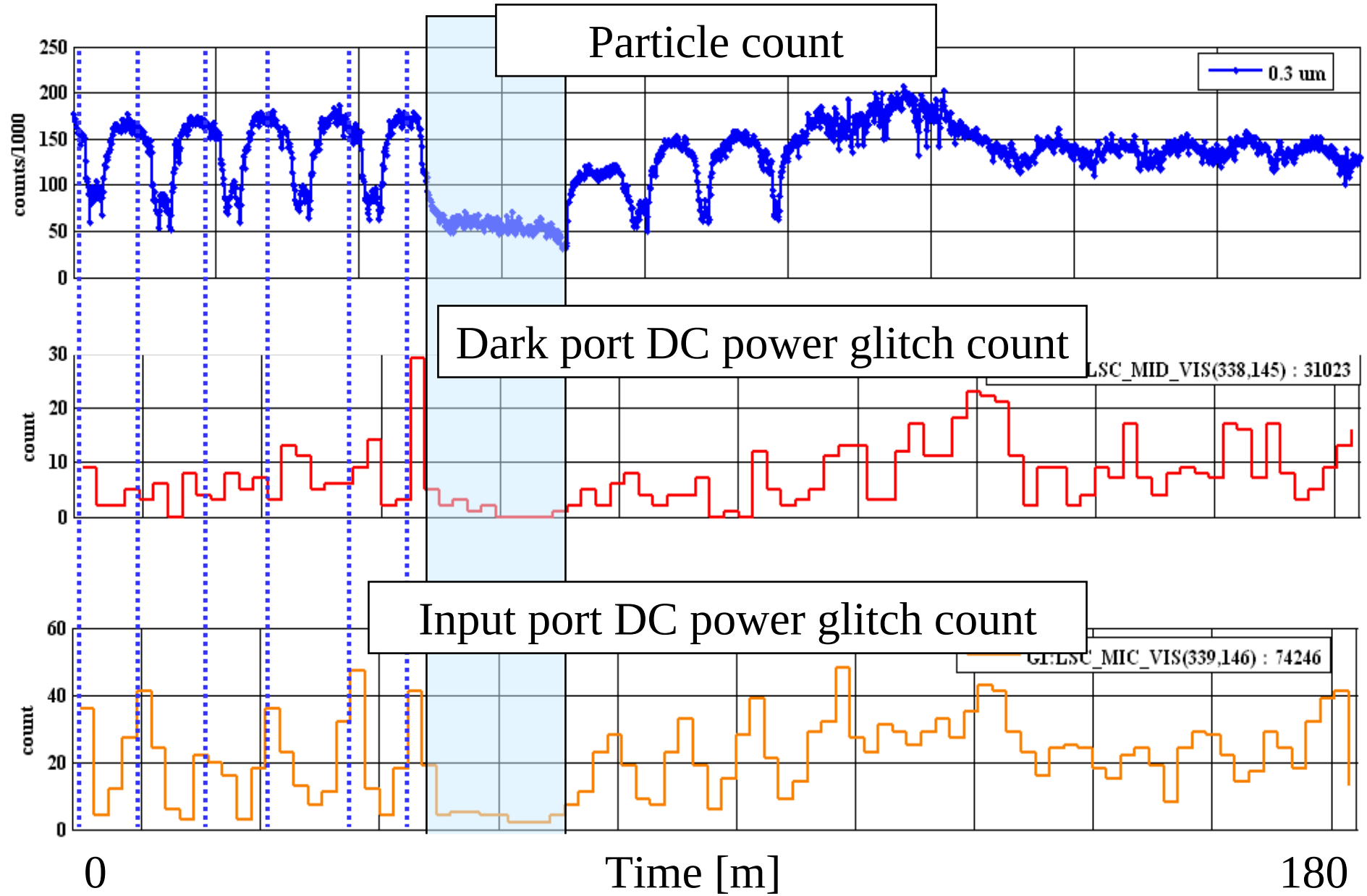
Detector output

Back-coupling?

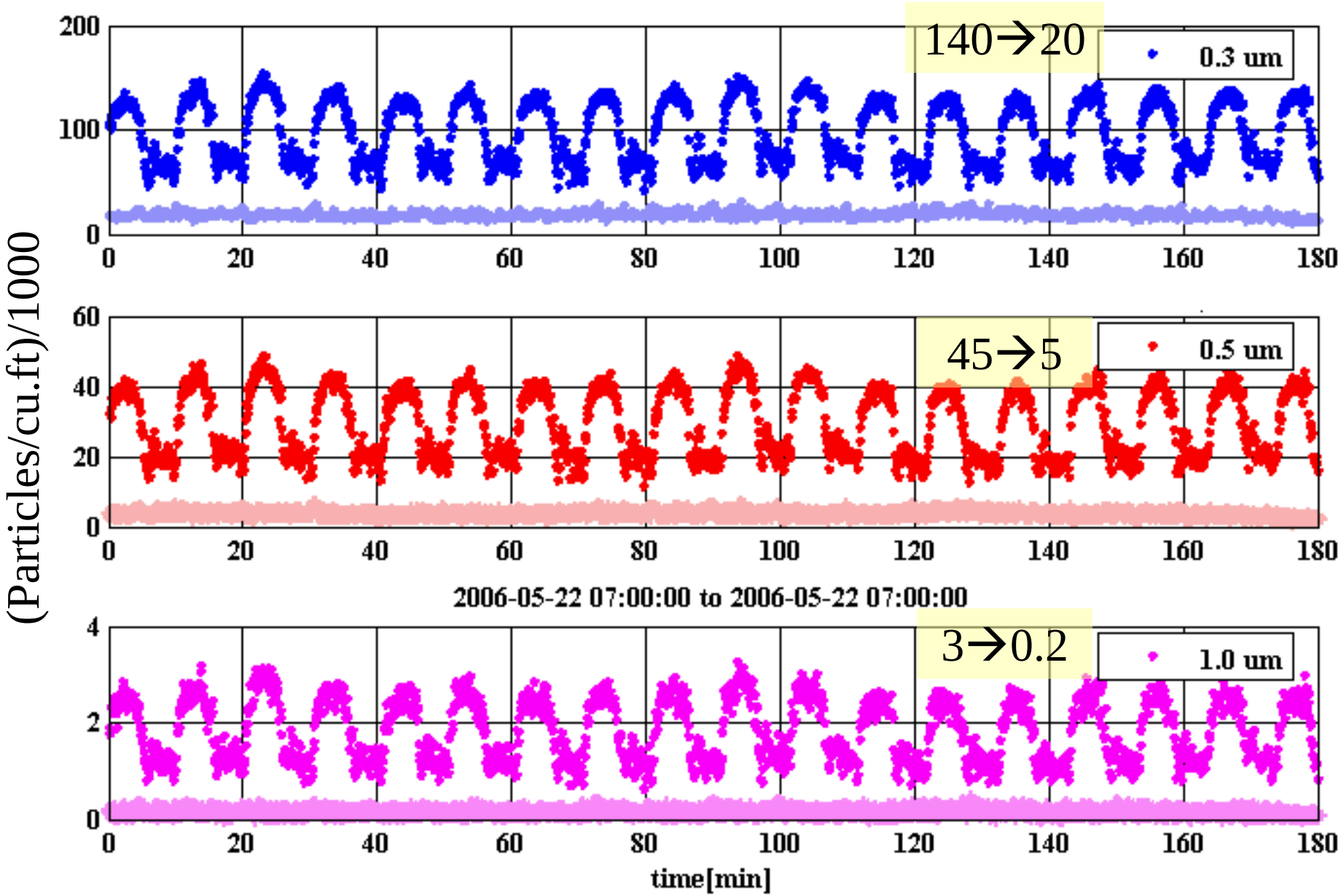
Strain back-coupling doesn't explain instrumental channel coincidence



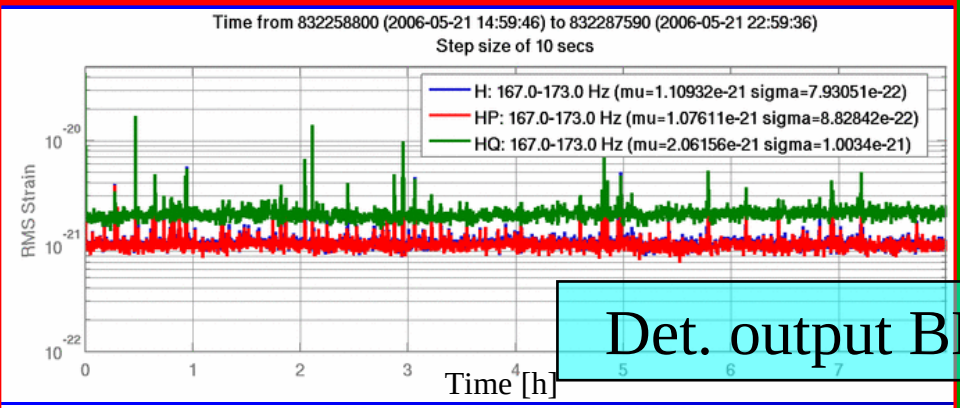
Power glitches vs. dust

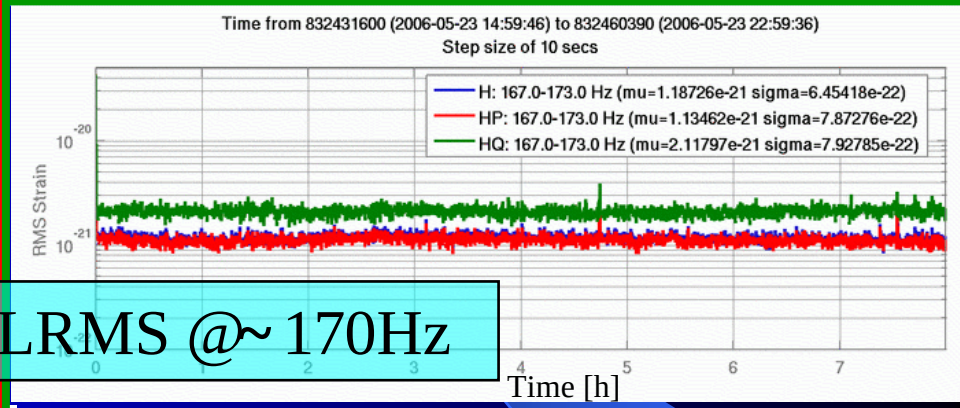


Particle waves filtered

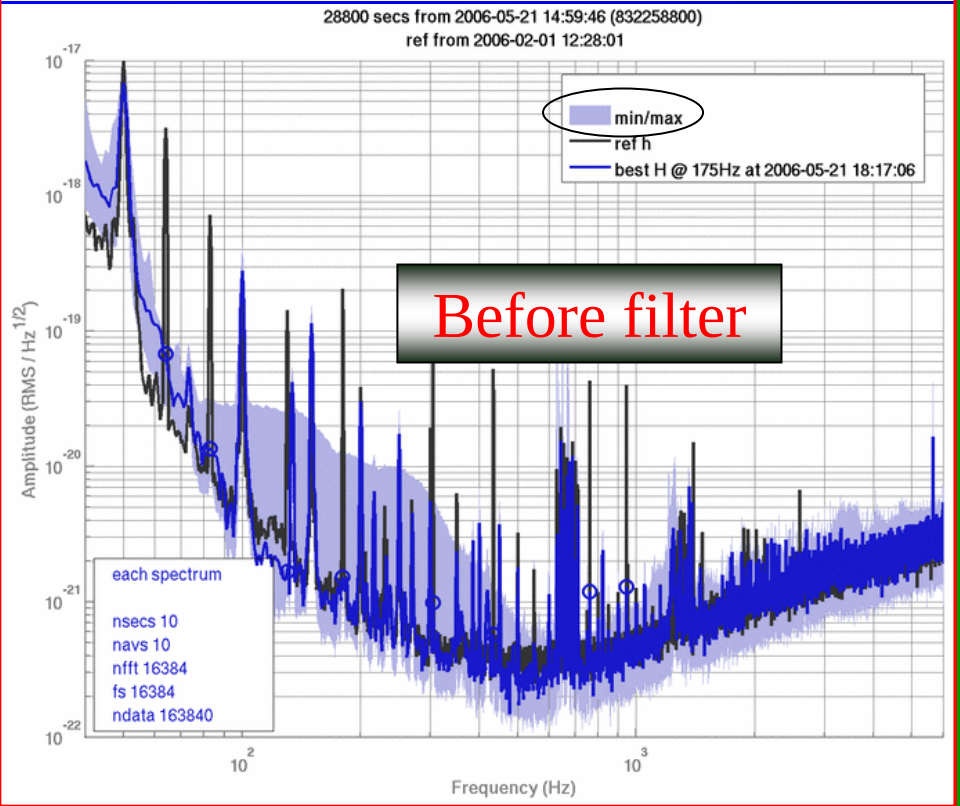


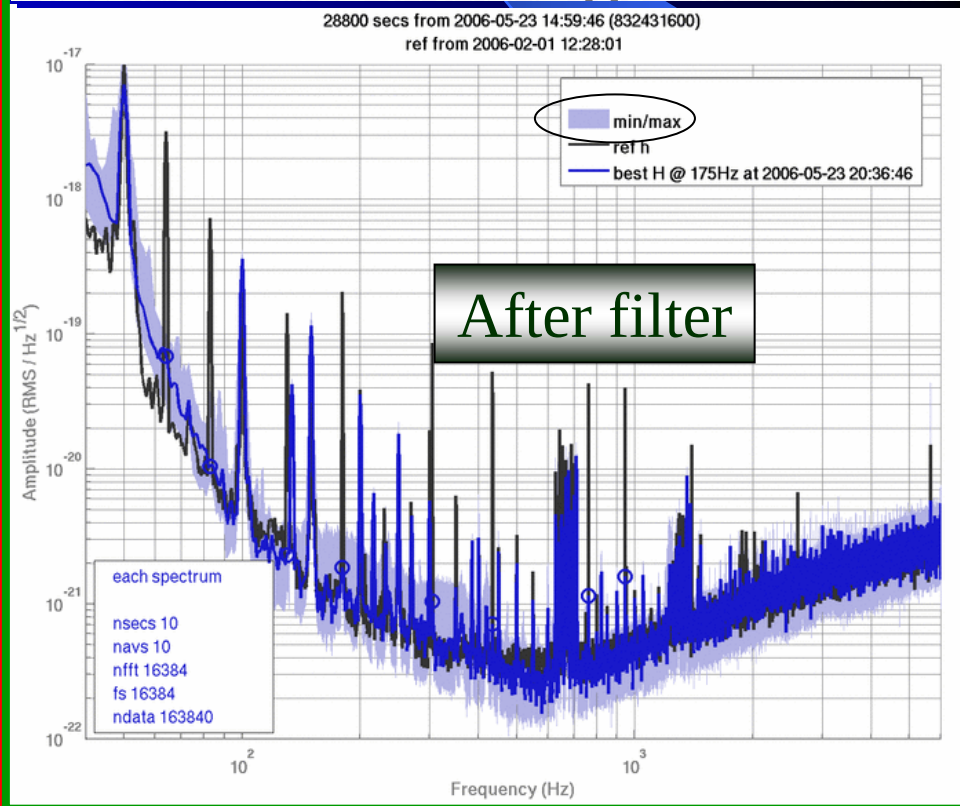
Dust made loudest glitches





Det. output BLRMS @~ 170Hz





Magnetic fields / Mains

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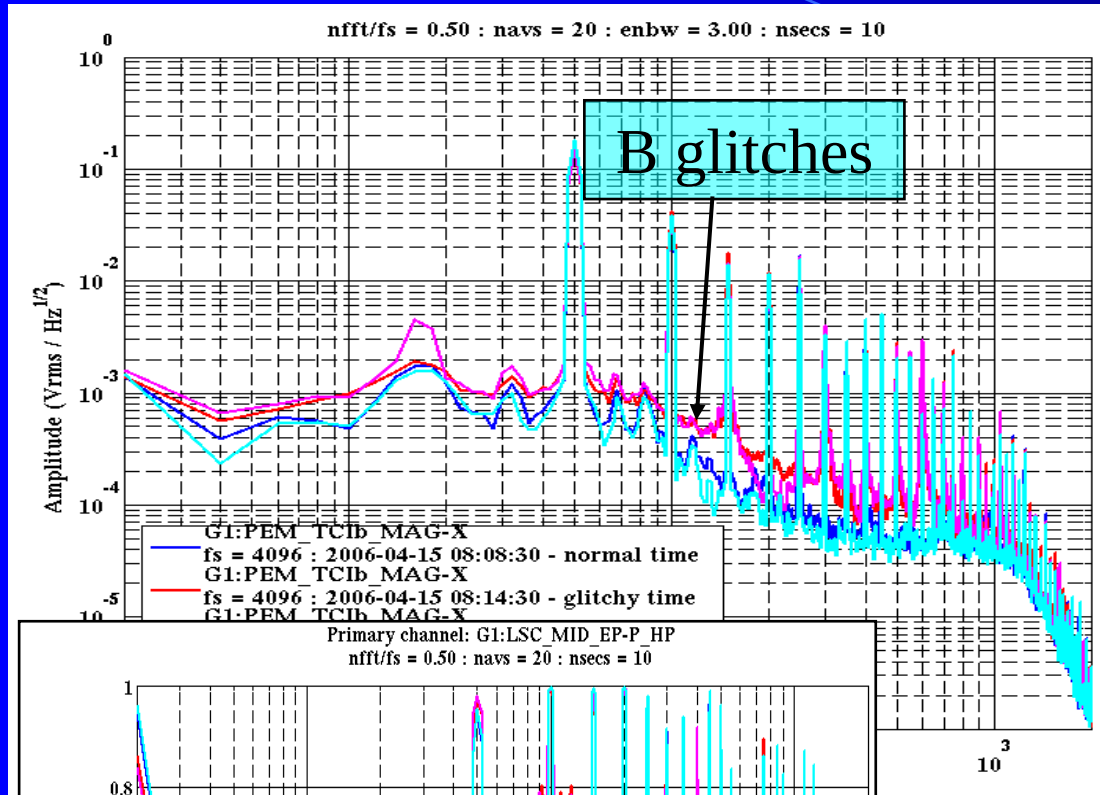
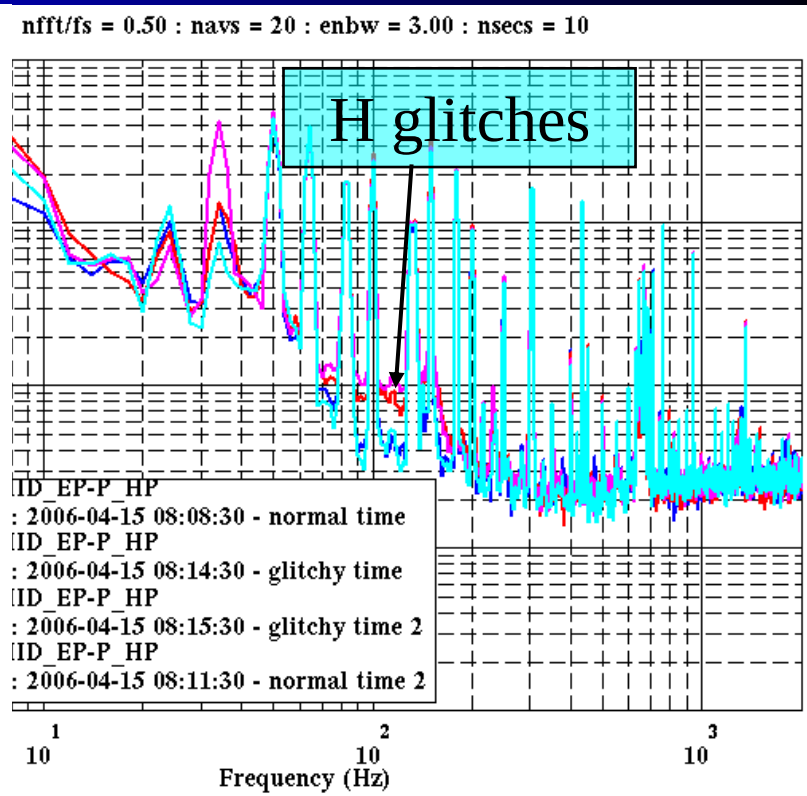
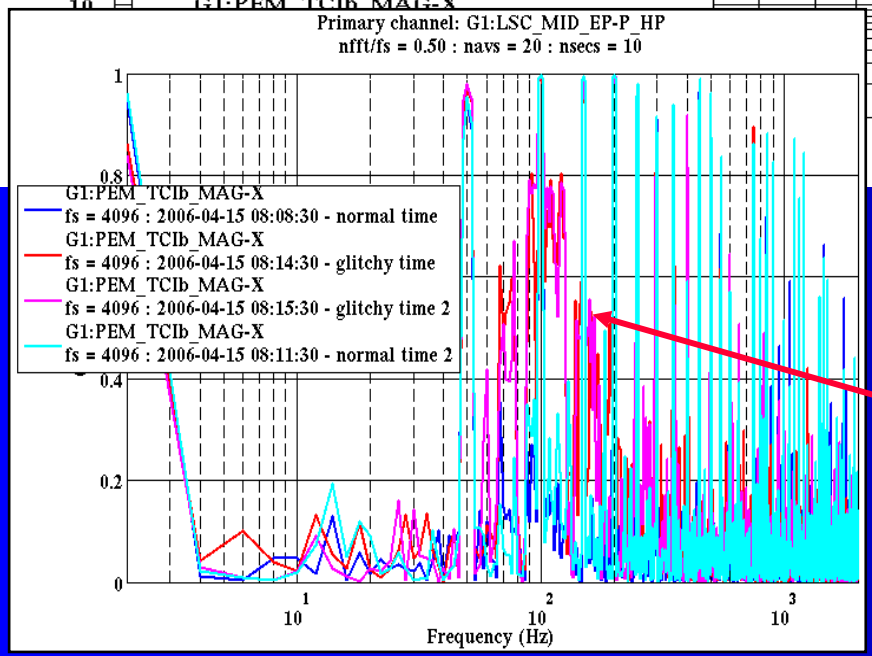
Magnetic field glitches



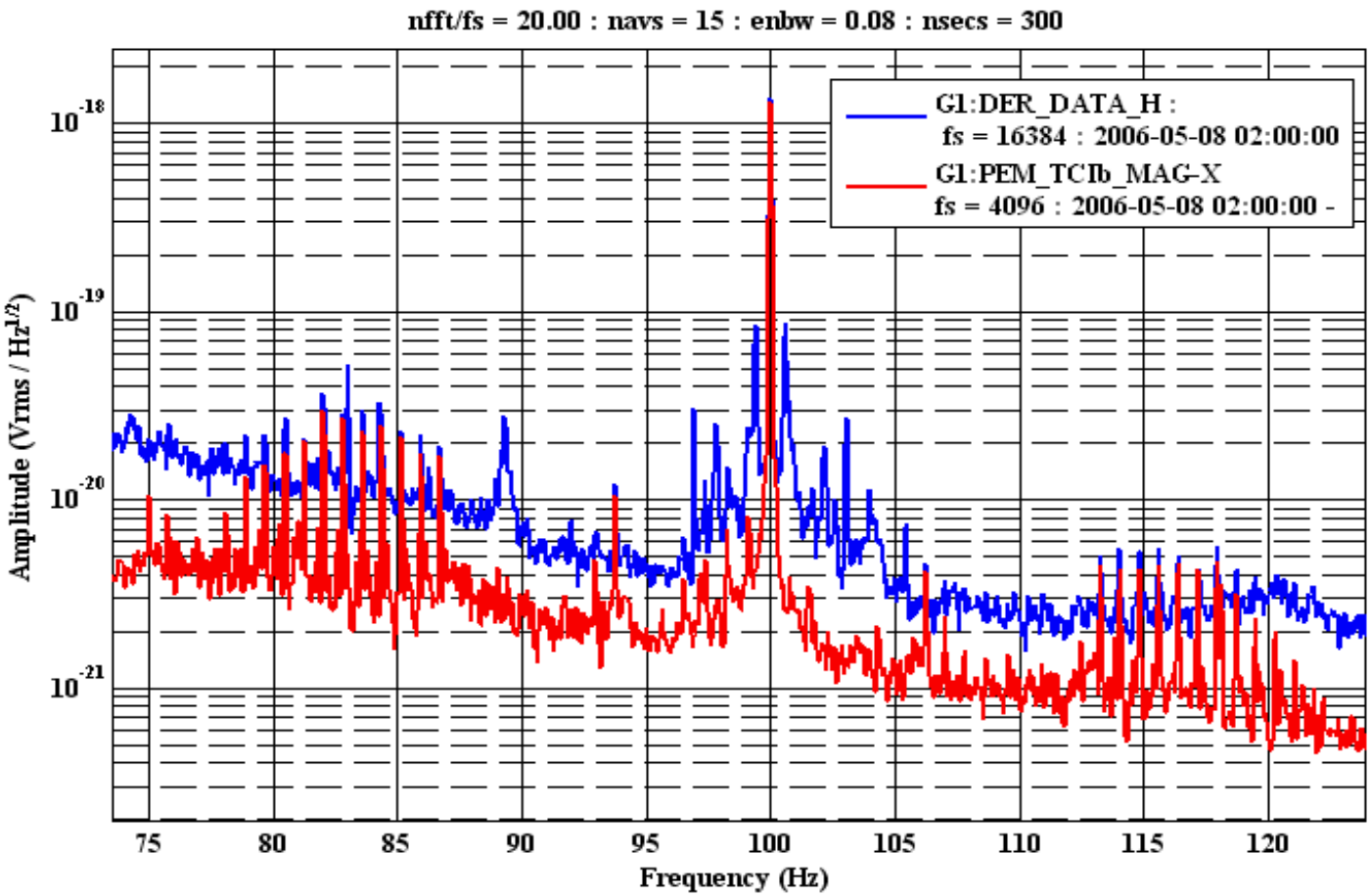




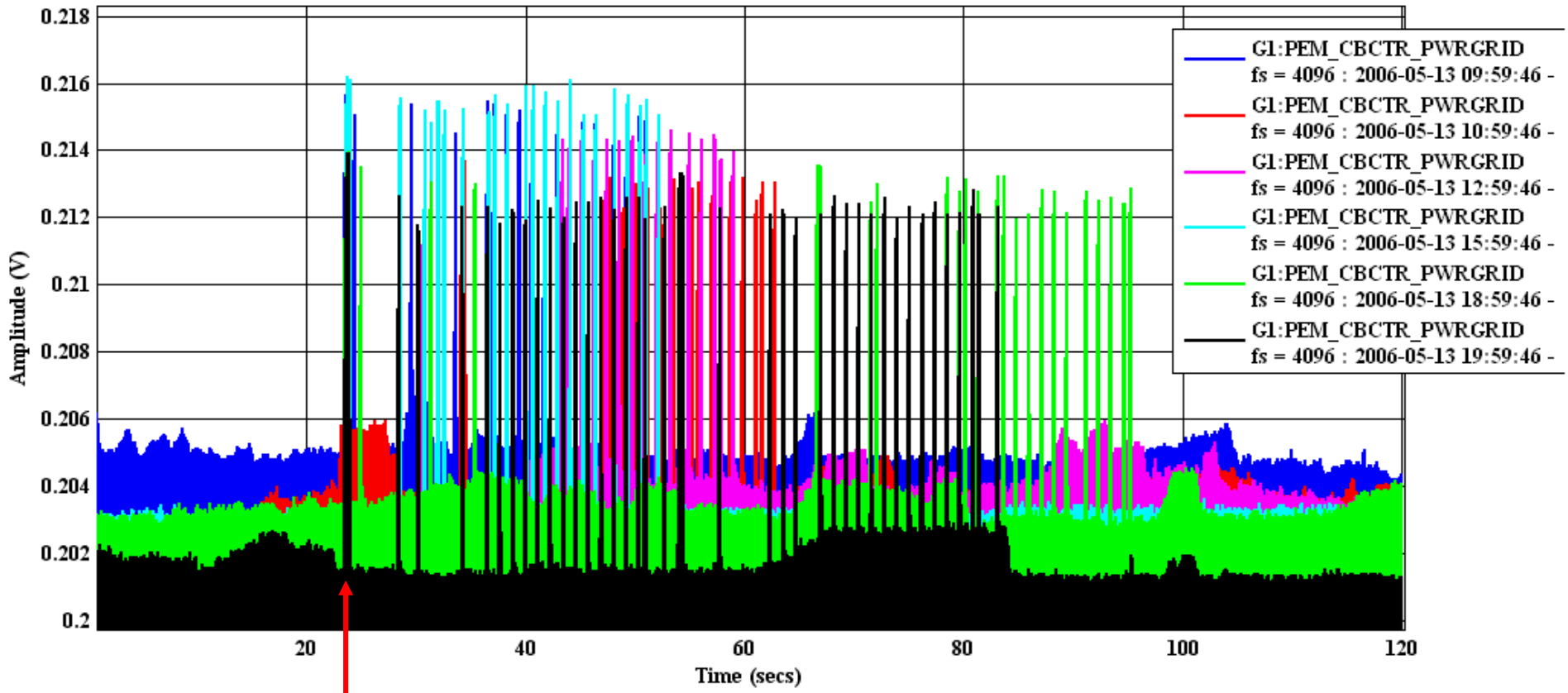
Linear coupling, coherence

Magnetic field “projection”

- B-field nearly limiting noise around 100Hz?
  - Coupling not yet understood
  - Checks: magnetometer measures B-field, IFO back-coupling ruled out



Hourly mains glitches



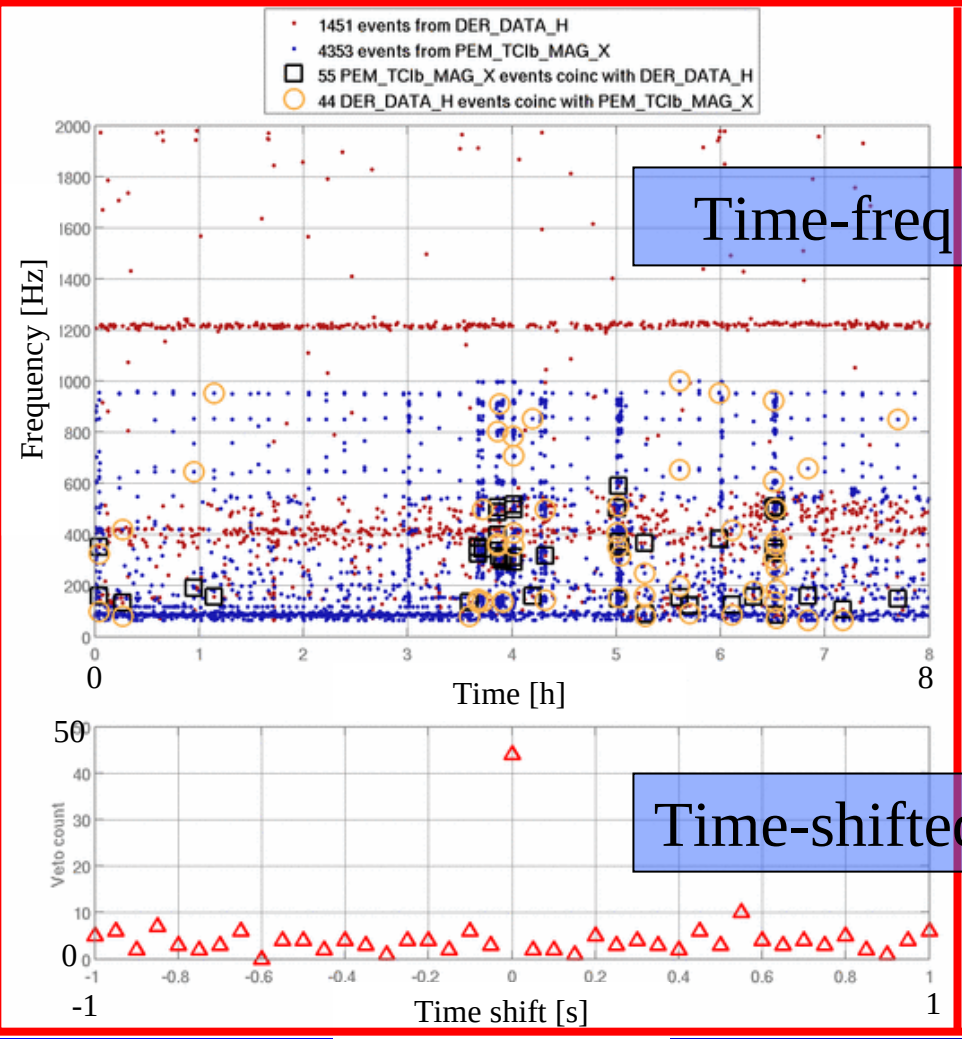
24s

- Hourly series start:
  - 24 secs after GPS hour
  - 10 secs after UTC hour

Mag./mains coinc. with H

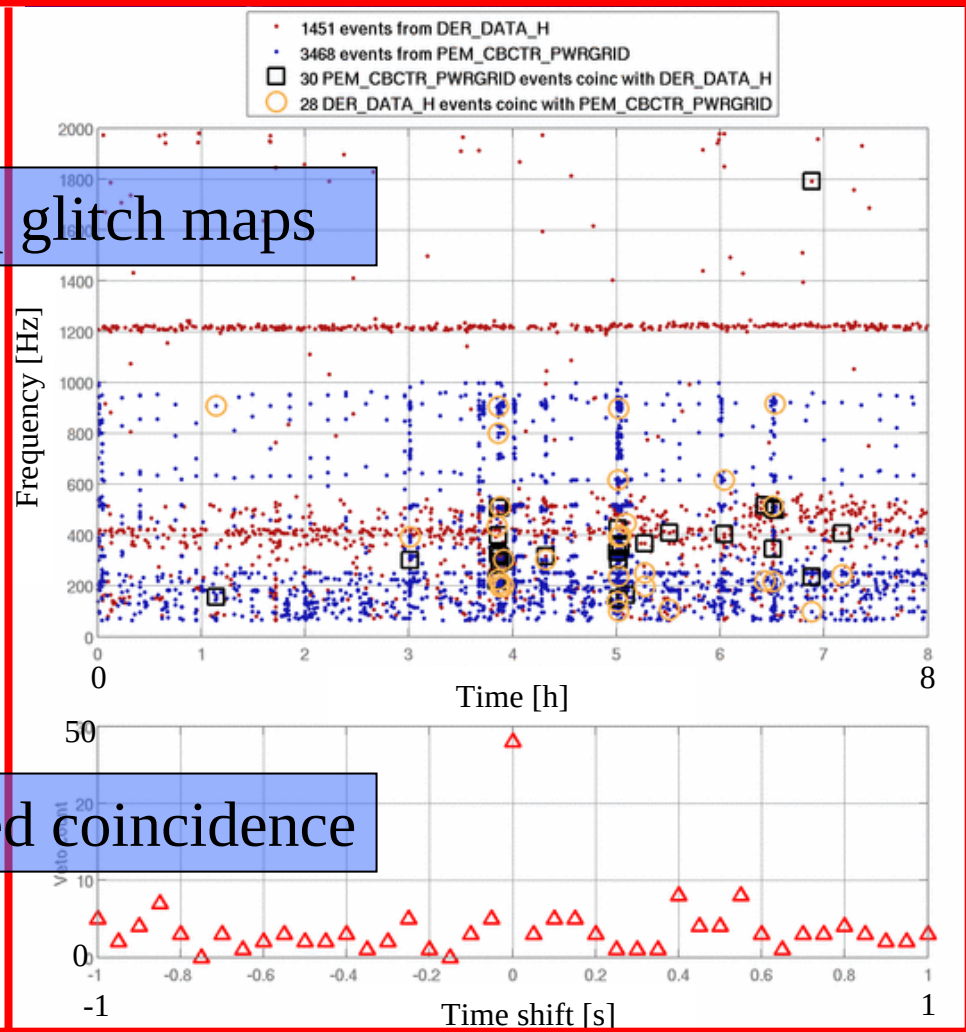
Magnetometer central building ~ 50coinc./8hrs

Mains monitor central building ~ 30coinc./8hrs



Time-freq glitch maps

Time-shifted coincidence



Noise Projections

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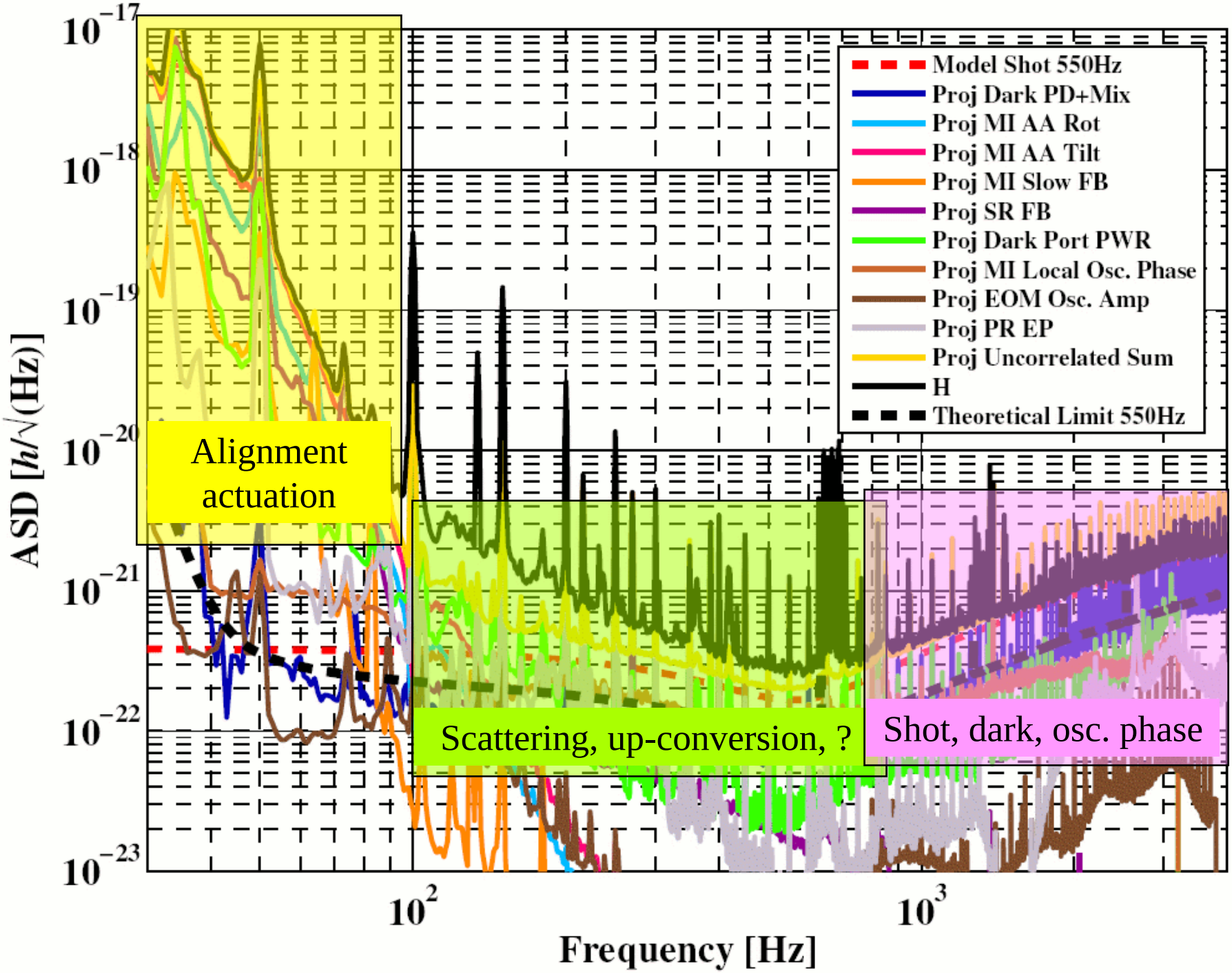
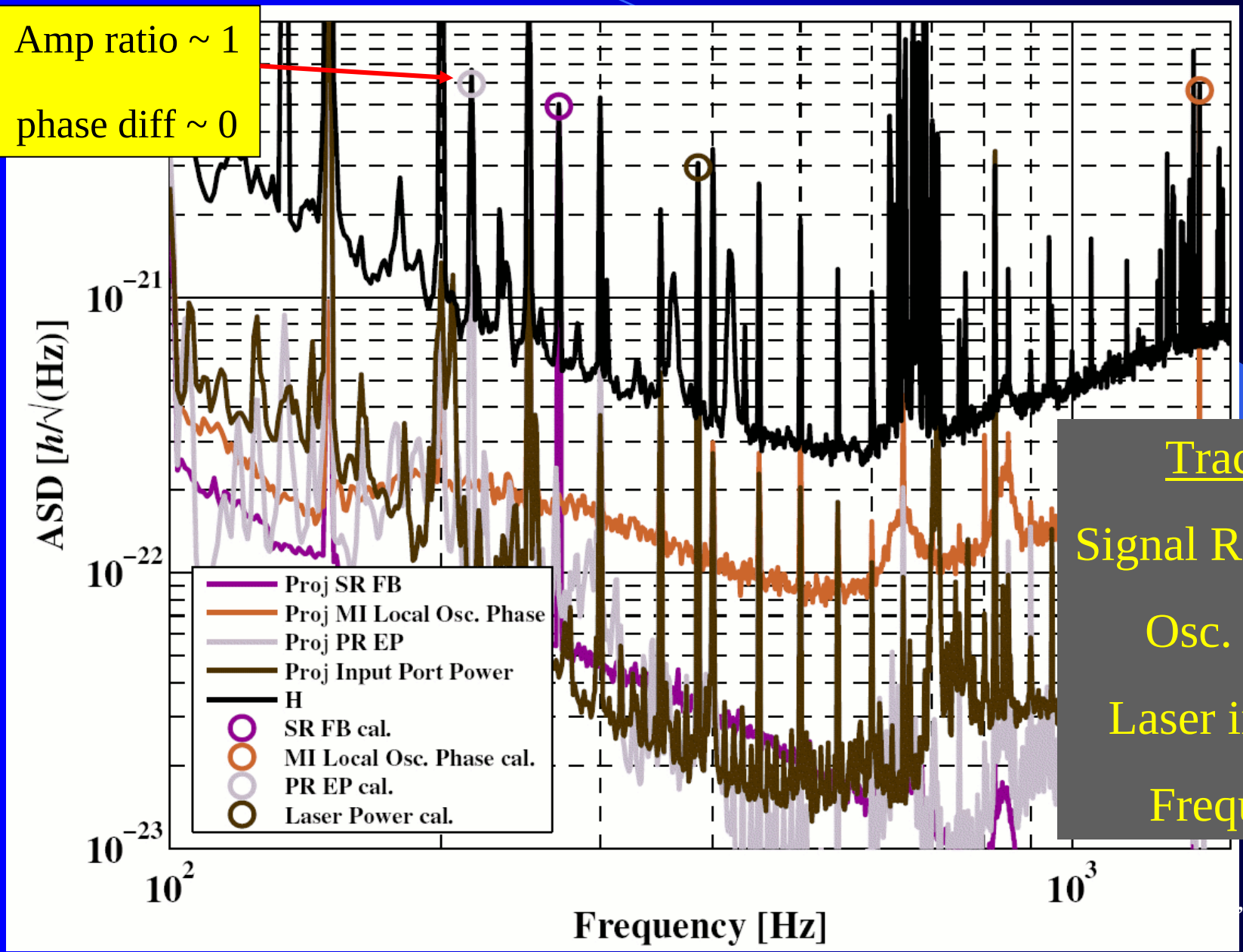

Model Shot 550Hz
Proj Dark PD+Mix
Proj MI AA Rot
Proj MI AA Tilt
Proj MI Slow FB
Proj SR FB
Proj Dark Port PWR
Proj MI Local Osc. Phase
Proj EOM Osc. Amp
Proj PR EP
Proj Uncorrelated Sum
H
Theoretical Limit 550Hz
Alignment actuation
Scattering, up-conversion, ?
Shot, dark, osc. phase
ASD [h/√(Hz)]
Frequency [Hz]
10^-17
10^-18
10^-19
10^-20
10^-21
10^-22
10^-23
10^2
10^3

Tracking noise transfer func's

Amp ratio ~ 1

phase diff ~ 0



Tracked:

Signal Recycl. FB

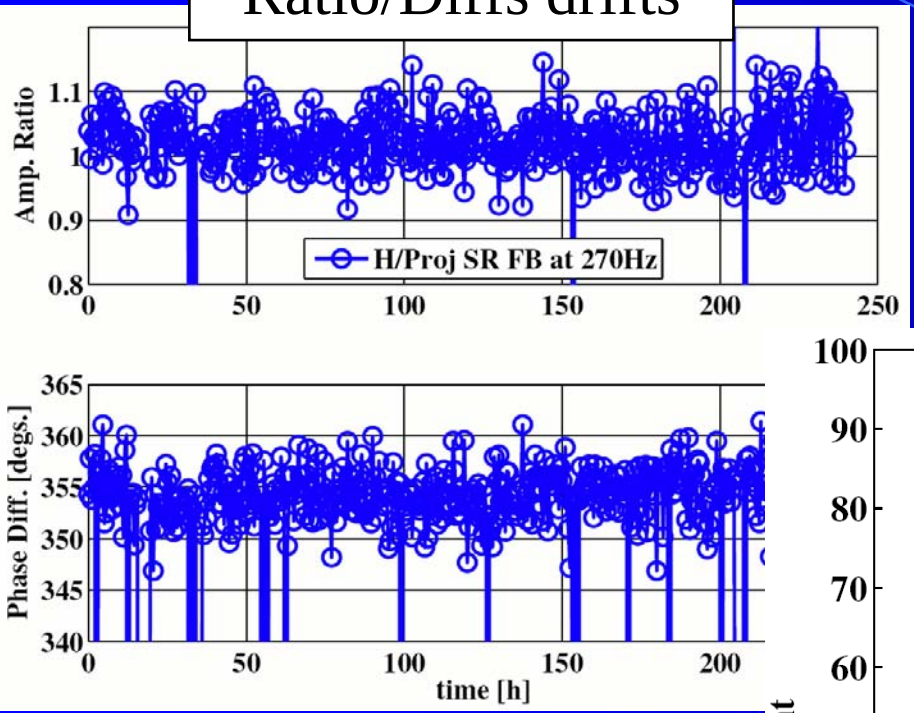
Osc. Phase

Laser intensity

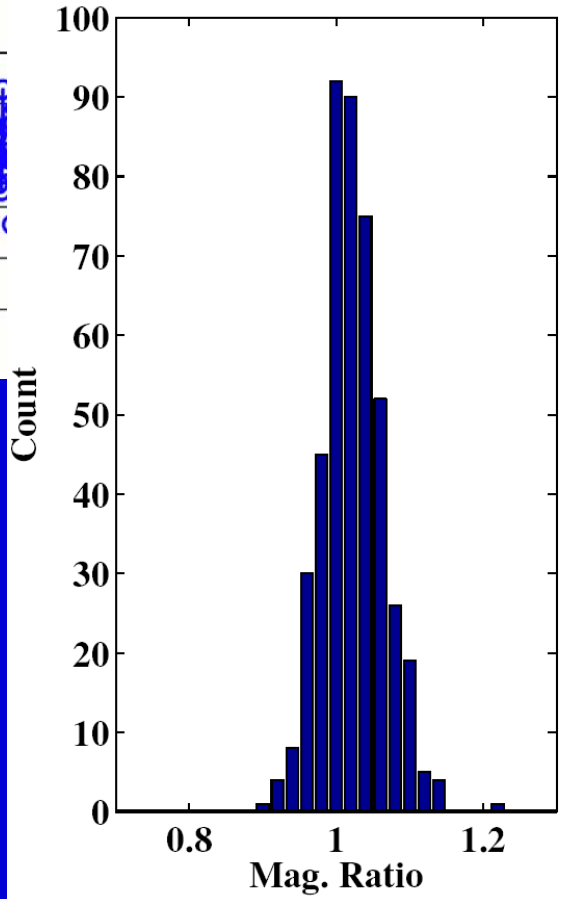
Frequency

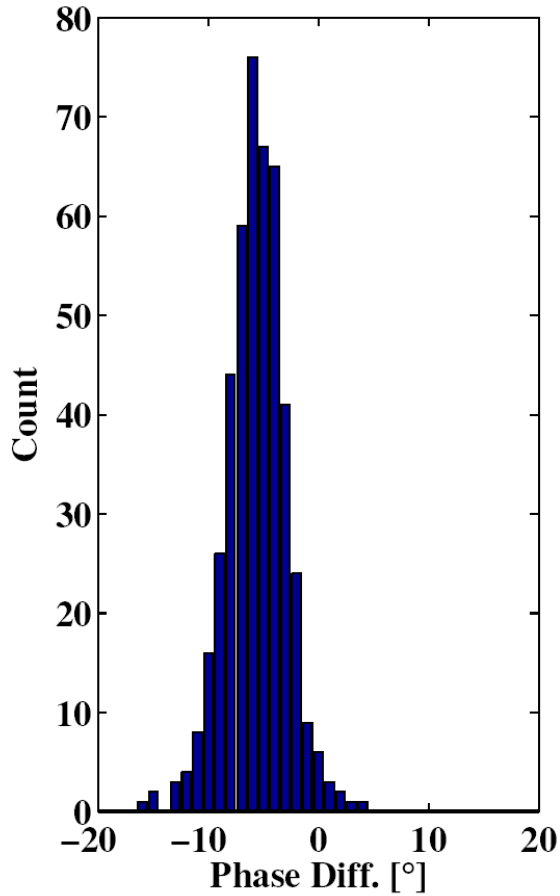
Transfer func's: long-term (10d)

Ratio/Diffs drifts



Histogram of drifts





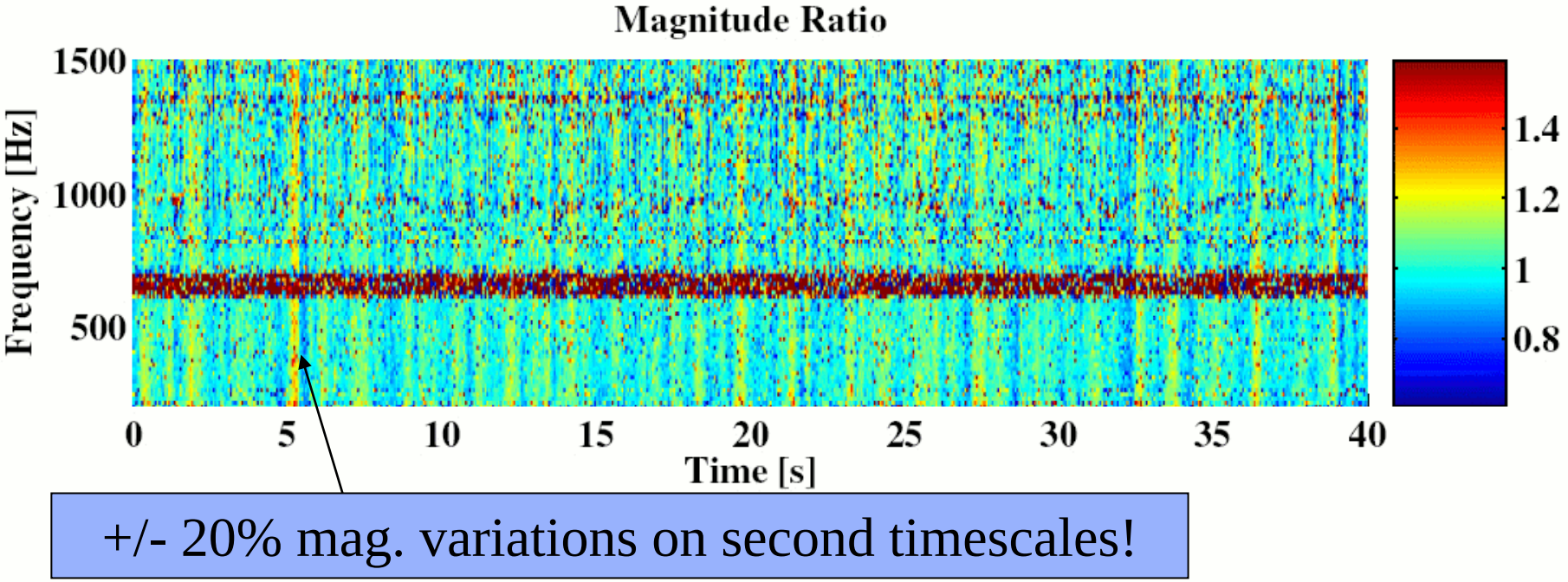
10 days, most projections:

+/- 10% mag

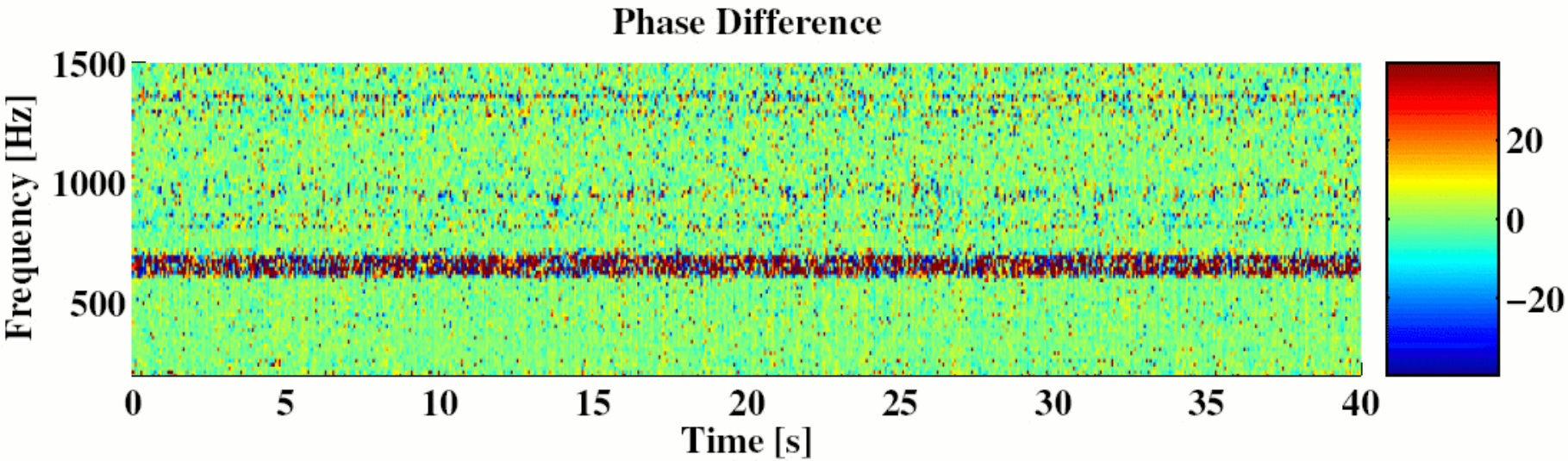
+/- 10 degs phase

So, long-term stable

Noise transfer func's: short-term

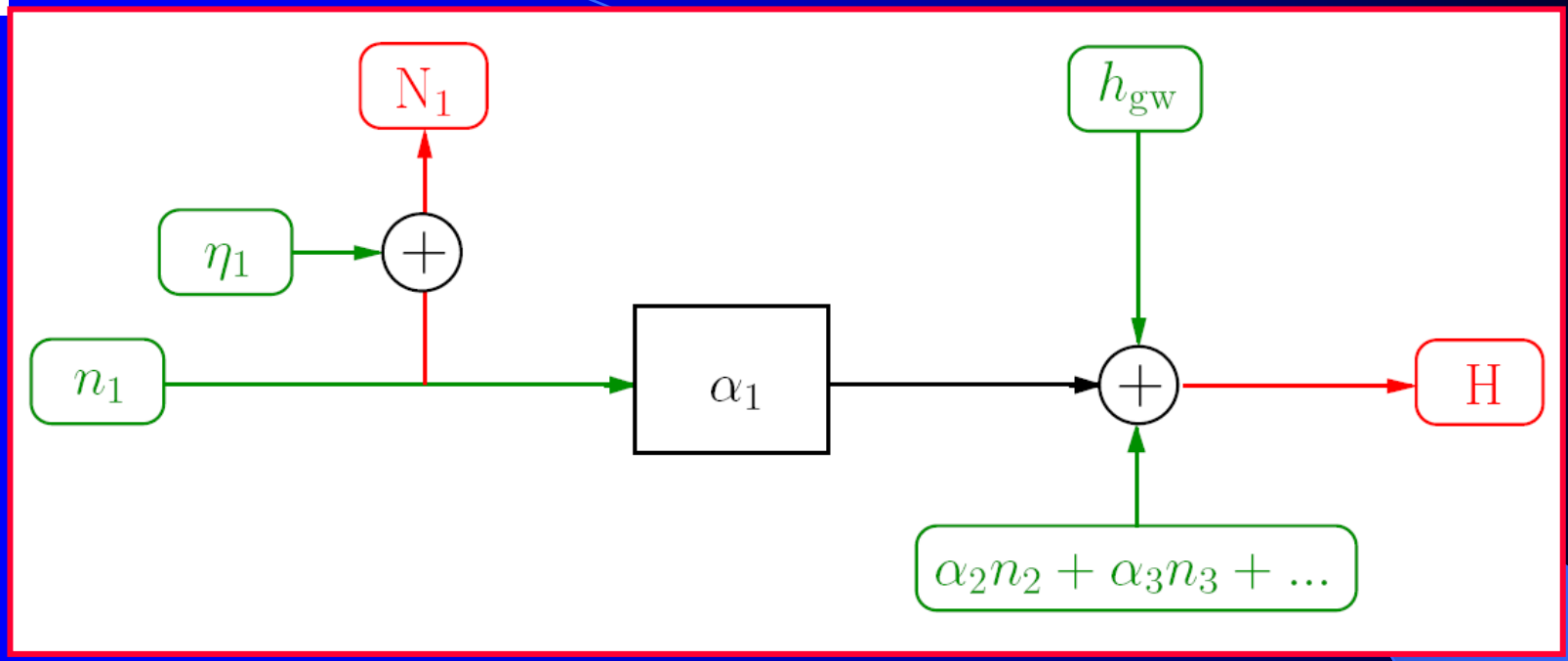


+/- 20% mag. variations on second timescales!



Noise Subtraction

Detector output and noise



Detector output

$$\tilde{\mathrm{H}} = \tilde{h}_{\mathrm{gw}} + \sum_i \alpha_i \tilde{n}_i,$$

Noise projection

$$\tilde{\mathrm{M}}_j = \alpha_j \tilde{\mathrm{N}}_j.$$

Noise chans.

$$\tilde{\mathrm{N}}_j \simeq \tilde{n}_j.$$

Noise budget

$$\tilde{\mathrm{M}} = \sum_j \alpha_j \tilde{\mathrm{N}}_j.$$

Record subset

$$n_j \subset n_i$$

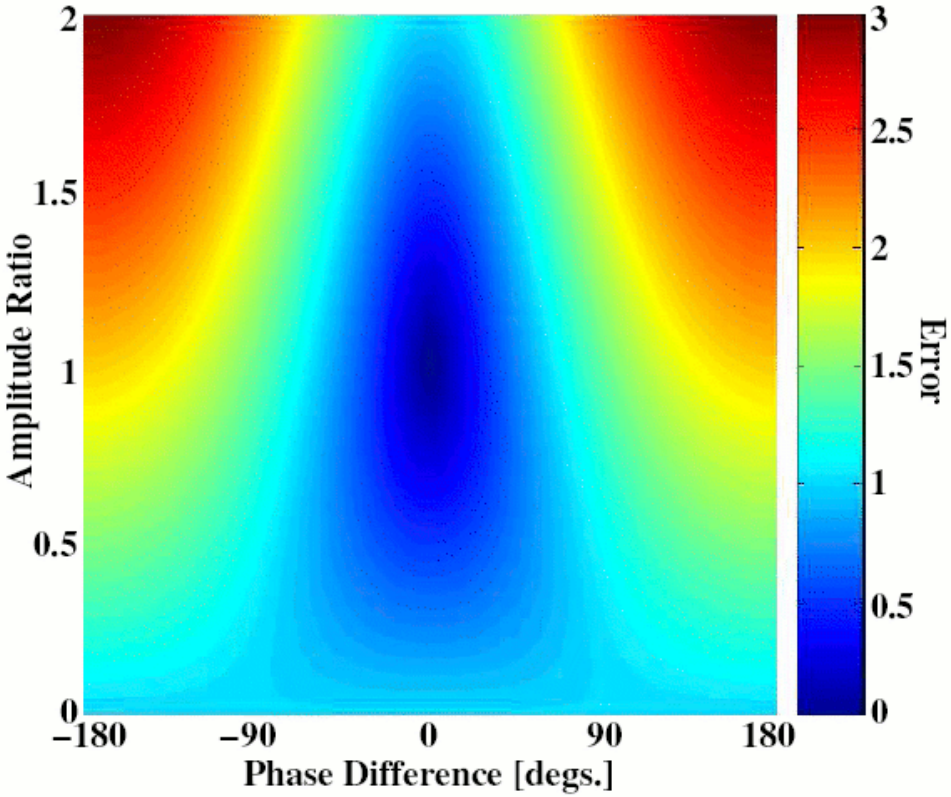
Improved H

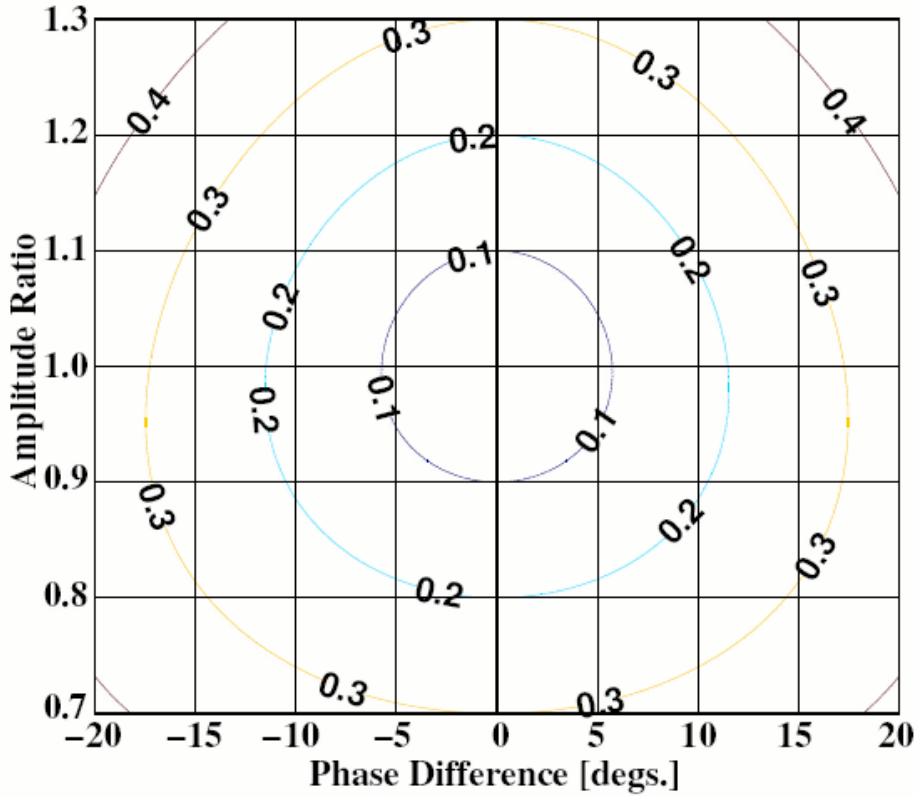
$$\tilde{\mathrm{H}}' = \tilde{h}_{\mathrm{gw}} + \sum_i \alpha_i \tilde{n}_i - \sum_j \alpha_j \tilde{\mathrm{N}}_j.$$

Noise subtraction requirements

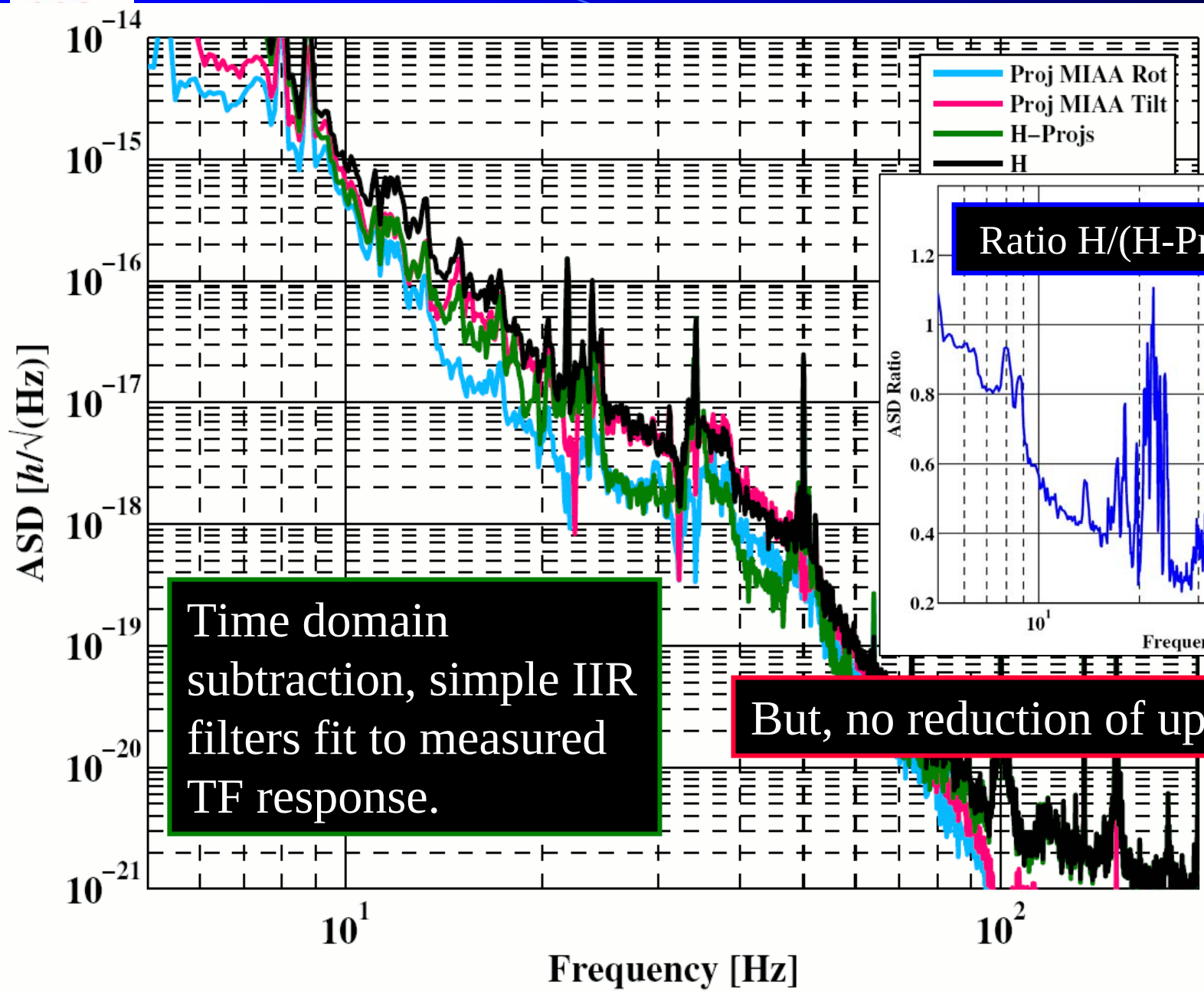
Subtraction factor depends on amplitude ratio and phase difference of filter used and real transfer function response.

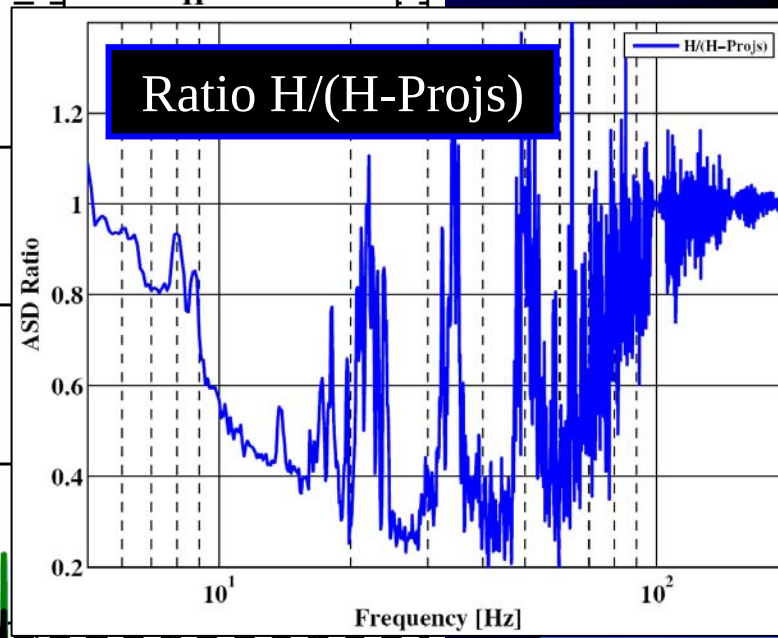
$$\bar{\delta}\left(\frac{A_o}{A_f},\phi\right) = \sqrt{\left(\frac{A_o}{A_f}\right)^2 - 2\frac{A_o}{A_f}\cos(\phi) + 1},$$





Noise subtraction results





Time domain subtraction, simple IIR filters fit to measured TF response.

But, no reduction of up-conversion

Technical noise veto

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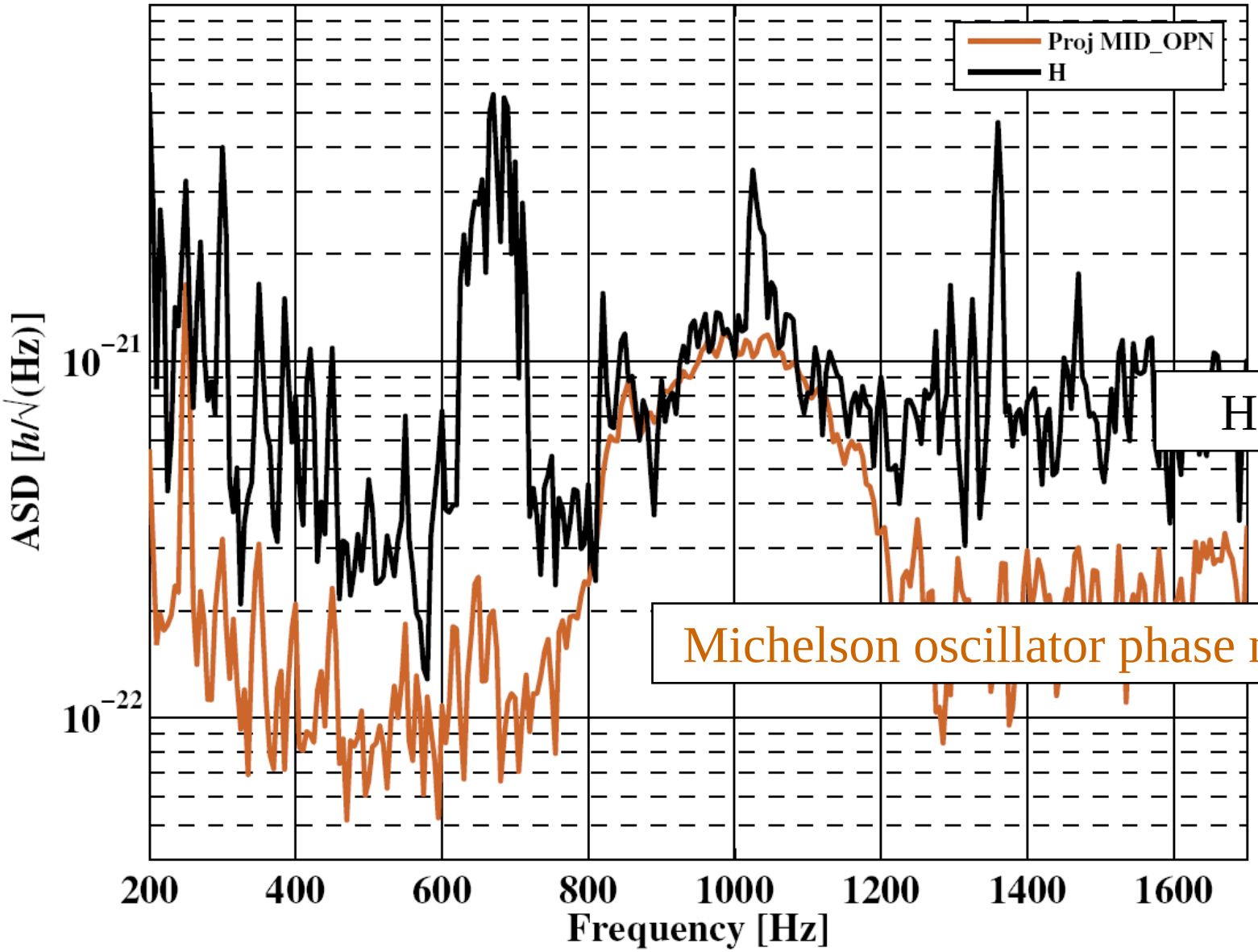
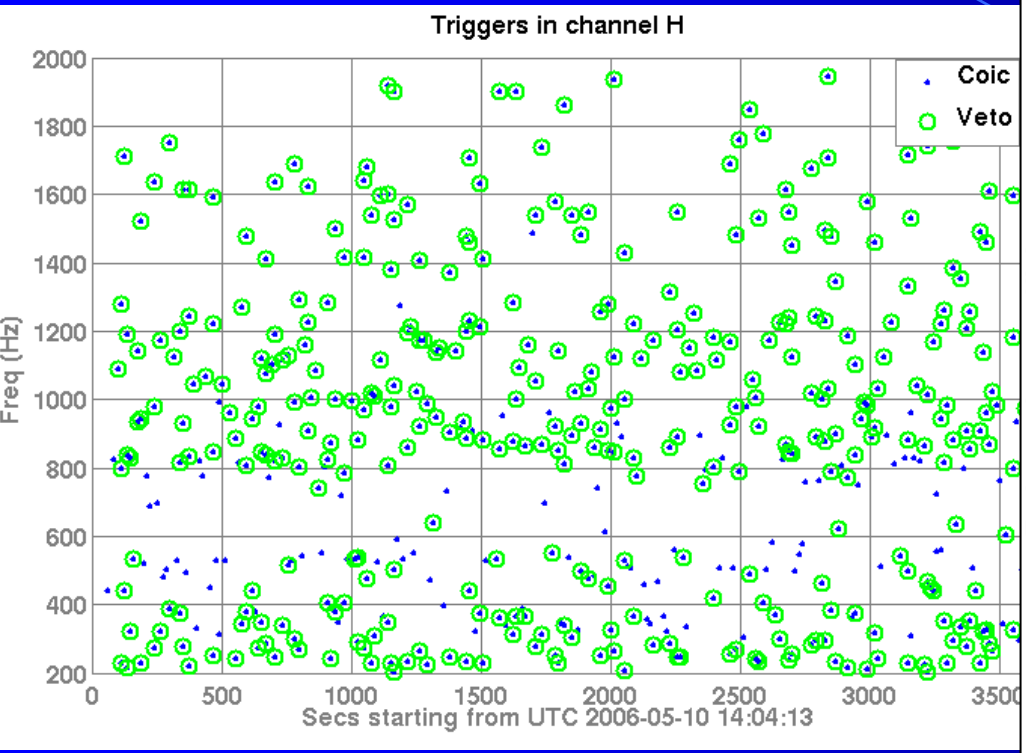
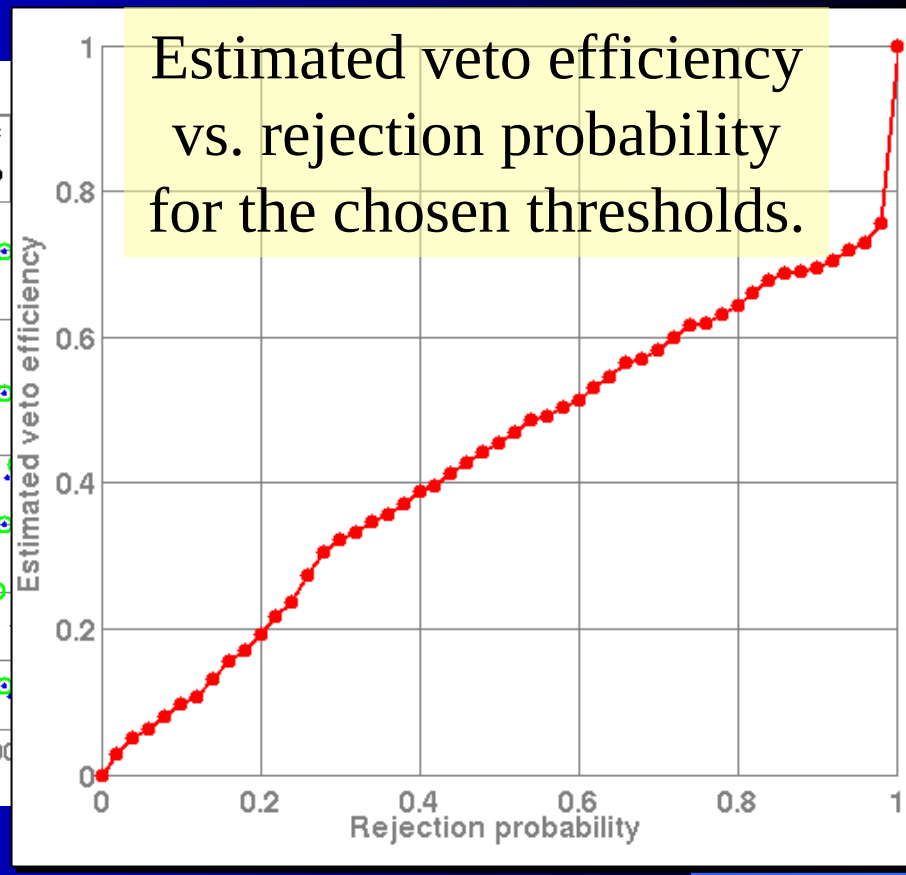
Noise veto: eg. injection



Noise veto performance





Estimated veto efficiency vs. rejection probability for the chosen thresholds.

"Robust vetoes for gravitational-wave burst triggers using known instrumental couplings"

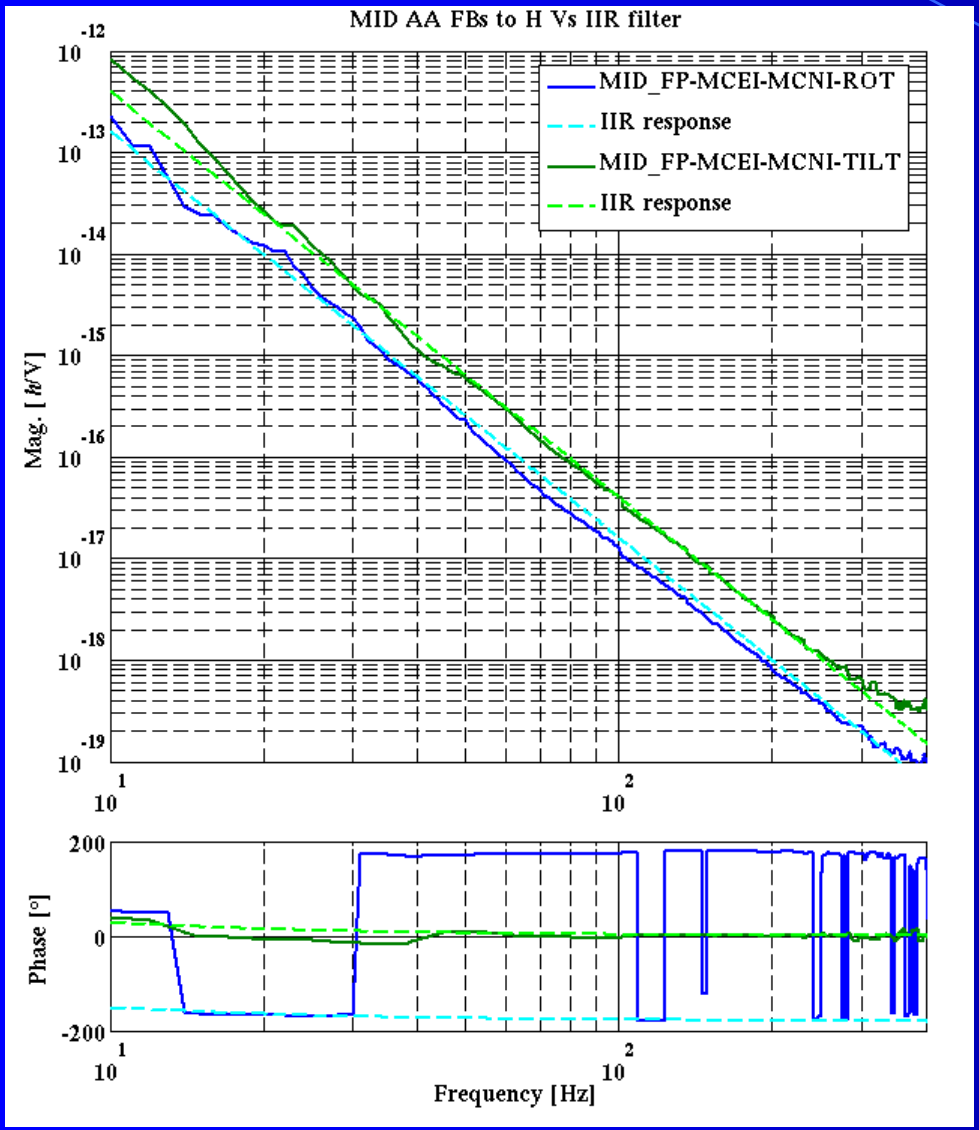
P. Ajith, M. Hewitson, J. R. Smith, K. A. Strain, submitted to CQG, http://arxiv.org/abs/gr-qc/0605079

The end

'falco tinnunculus',

better know as 'Turmfalke'

Noise subtraction II



Used simple IIR filters

- good match to simple transfer function

Statistical dust veto?