

# Environmental couplings in GEO



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# Non linear noises

At the moment GEO's sensitivity (100 –600 Hz) seems to be partly limited by :

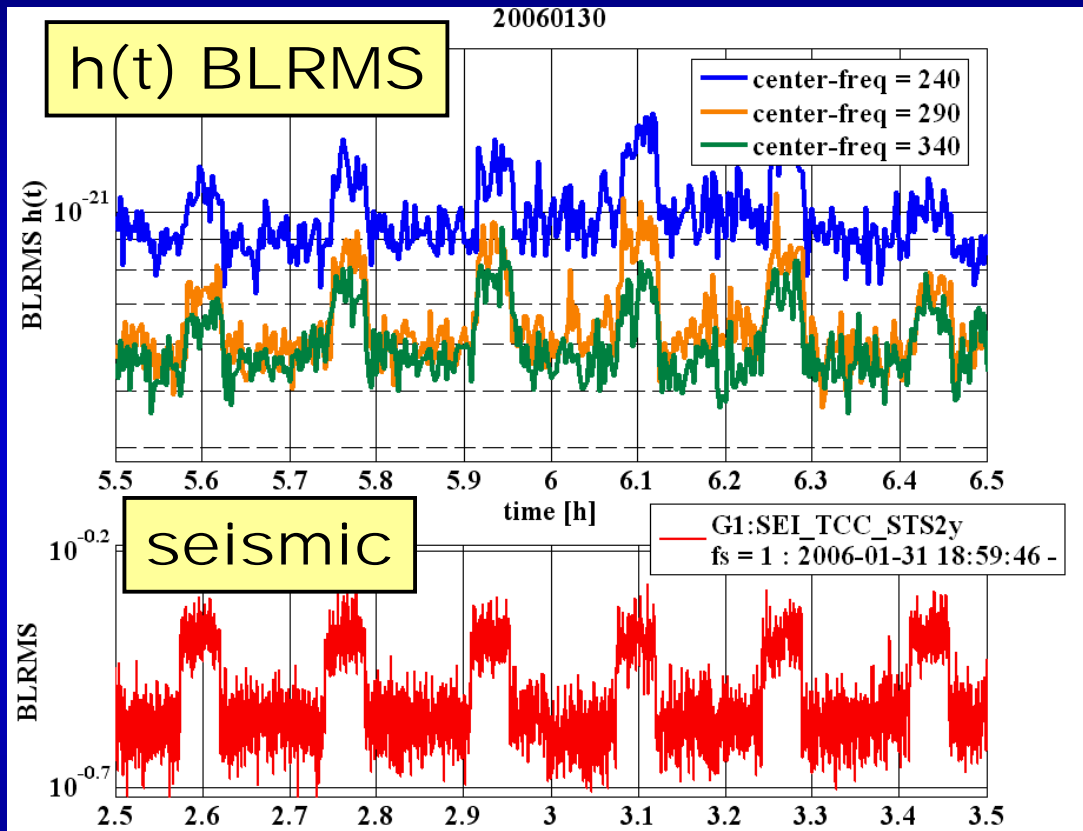
- noises that don't couple linearly
- noises that are difficult to project
- noises driven from environmental excitation

Seismic

Scattered light ????

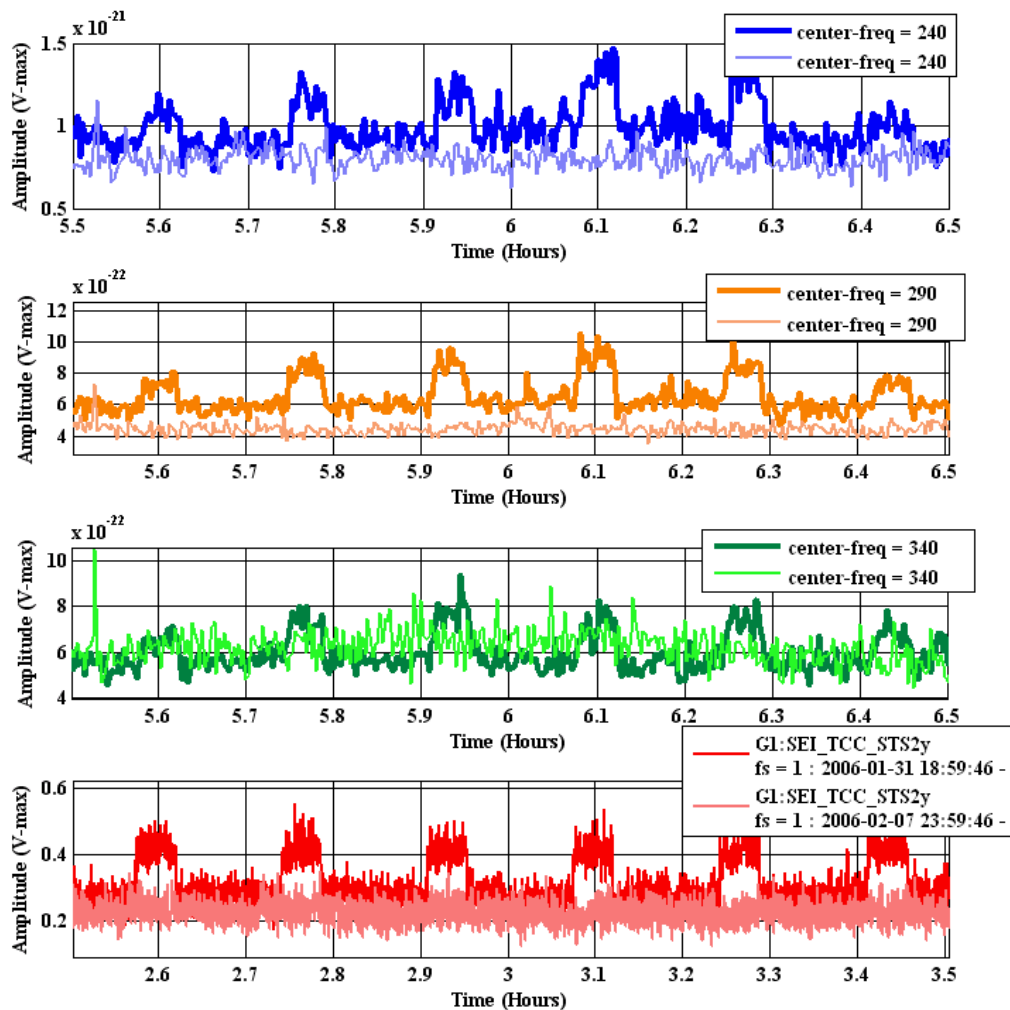
acoustic noise ????

# Correlation between $h(t)$ and seismic



In some frequency bands  $h(t)$  was limited by seismic noise from the air conditioning outdoor unit (12m distance from central building)

# Correlation between $h(t)$ and seismic



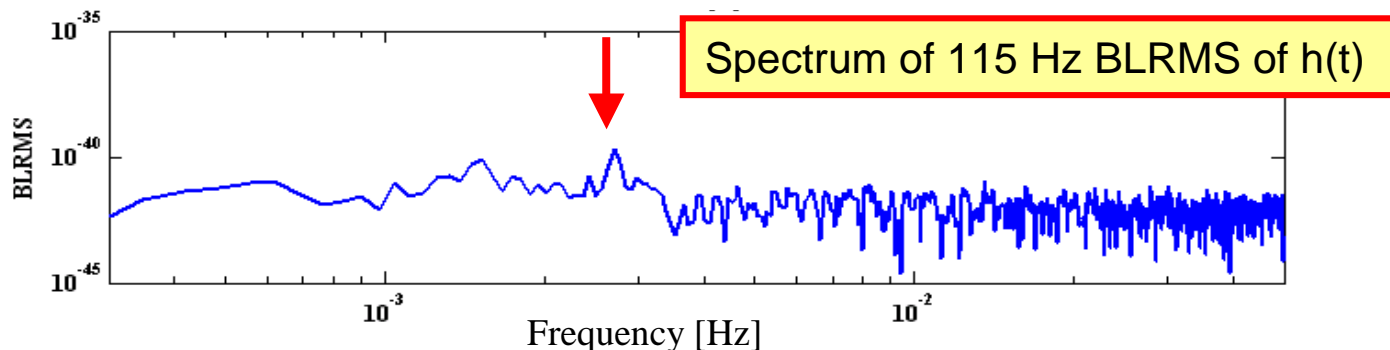
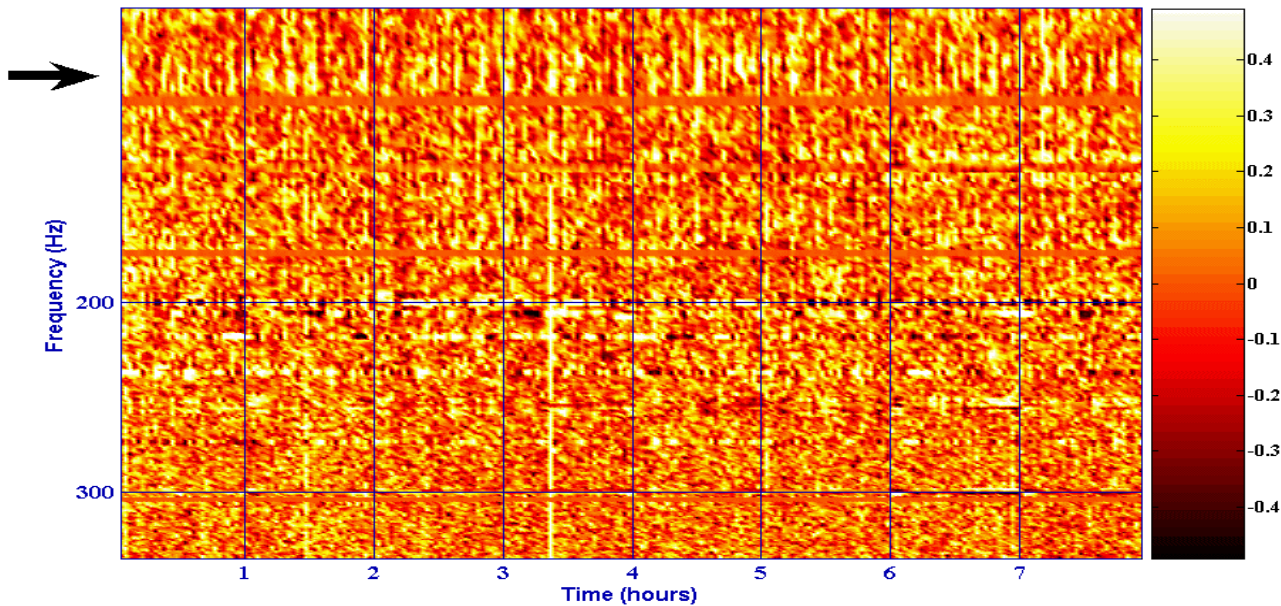
The vibrations were transmitted by rigid pipes.

Inserting some flexible tubes reduced the seismic excitation of the central building and cured sensitivity.

Afterwards no correlation between  $h(t)$  and seismic anymore.

# Seismic from endstation to $h(t)$

Normalised spectrogram of  $h(t)$  using 28800 secs from 2006-02-09 22:59:46 (823561200) with 10 secs every 120 secs

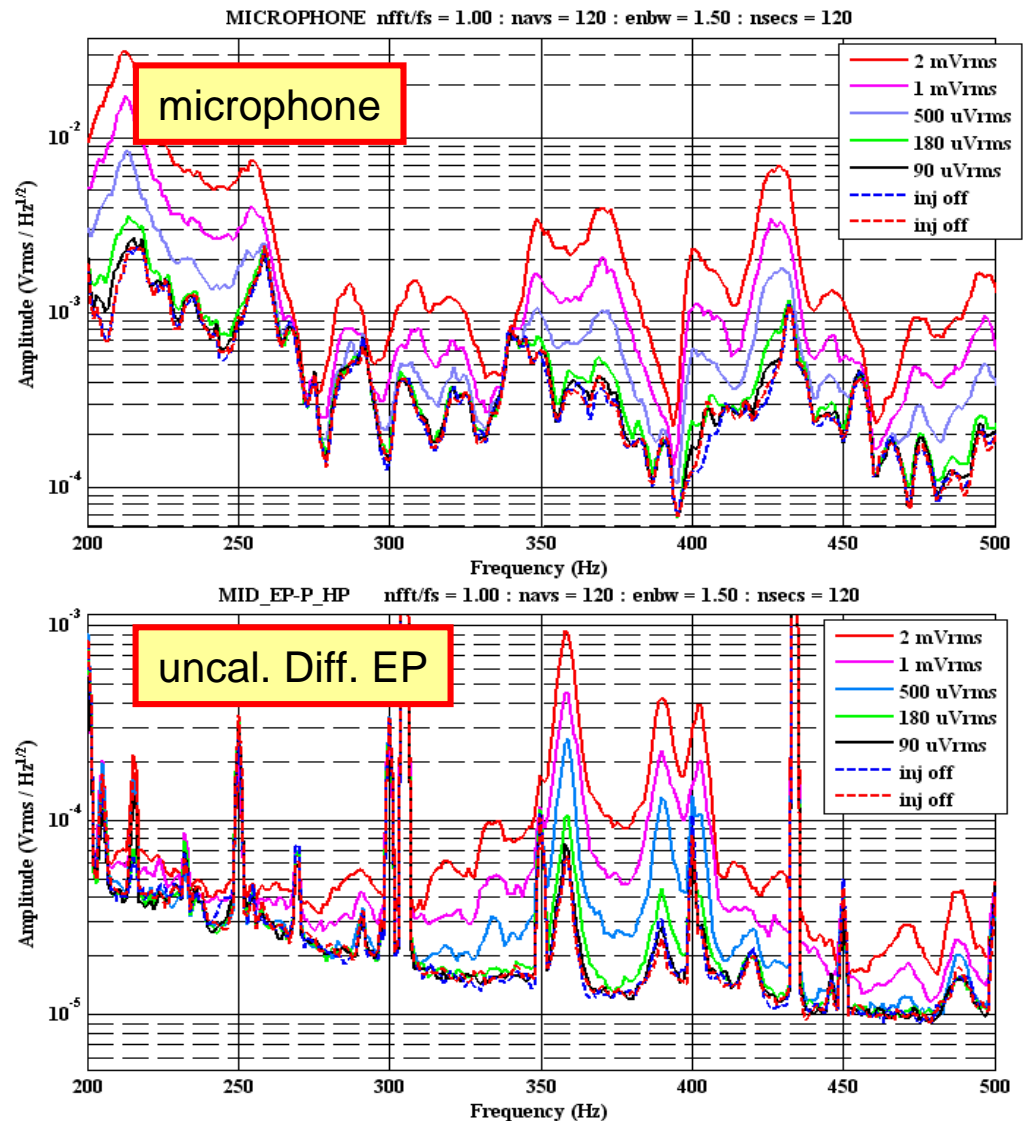


Problem was solved by stiffening of an optical table.

# Acoustic injections at the output bench

Injected white acoustic noise at the output bench.

Result:  
Some of the resonances in the sensitivity seem to be driven by ambient acoustics.





# How to deal with environmental couplings?

## Two general approaches:

- Reducing the environmental noise
- Reducing the coupling to  $h(t)$

**If neither is possible and TF of couplings don't change:**

- Monitor the environmental noise



# Reduction of environmental noises

## Acoustic:

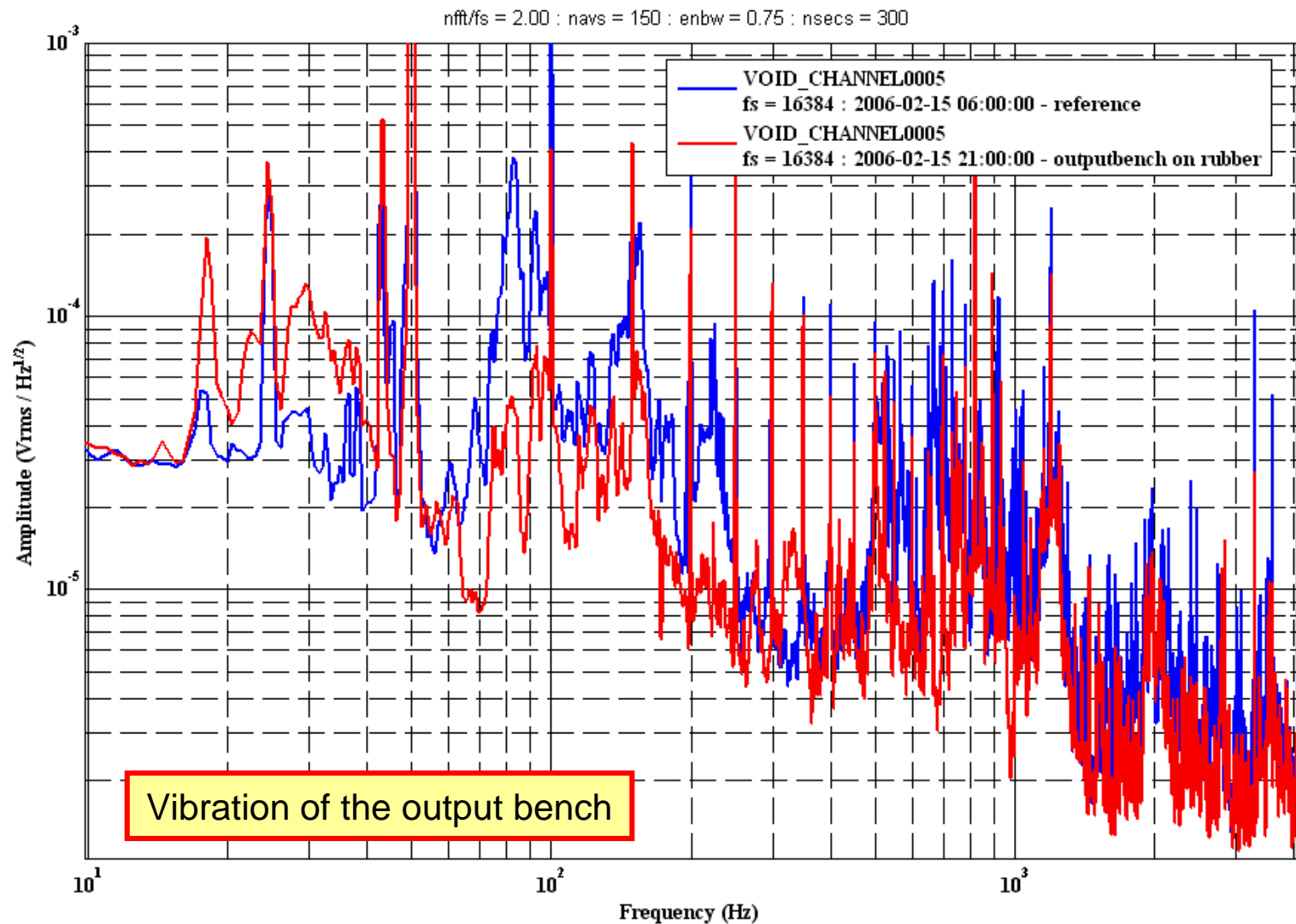
- Acoustic shielding of important components or even of whole optical tables.

## Seismic / vibrations:

- Removing unnecessary noisy components
- Better seismic isolation for vacuum pumps and air fans
- Better seismic isolation of optical tables (may increase acoustic coupling)



# Putting the output bench onto rubber feet





# Reducing the couplings

## Coupling pathes:

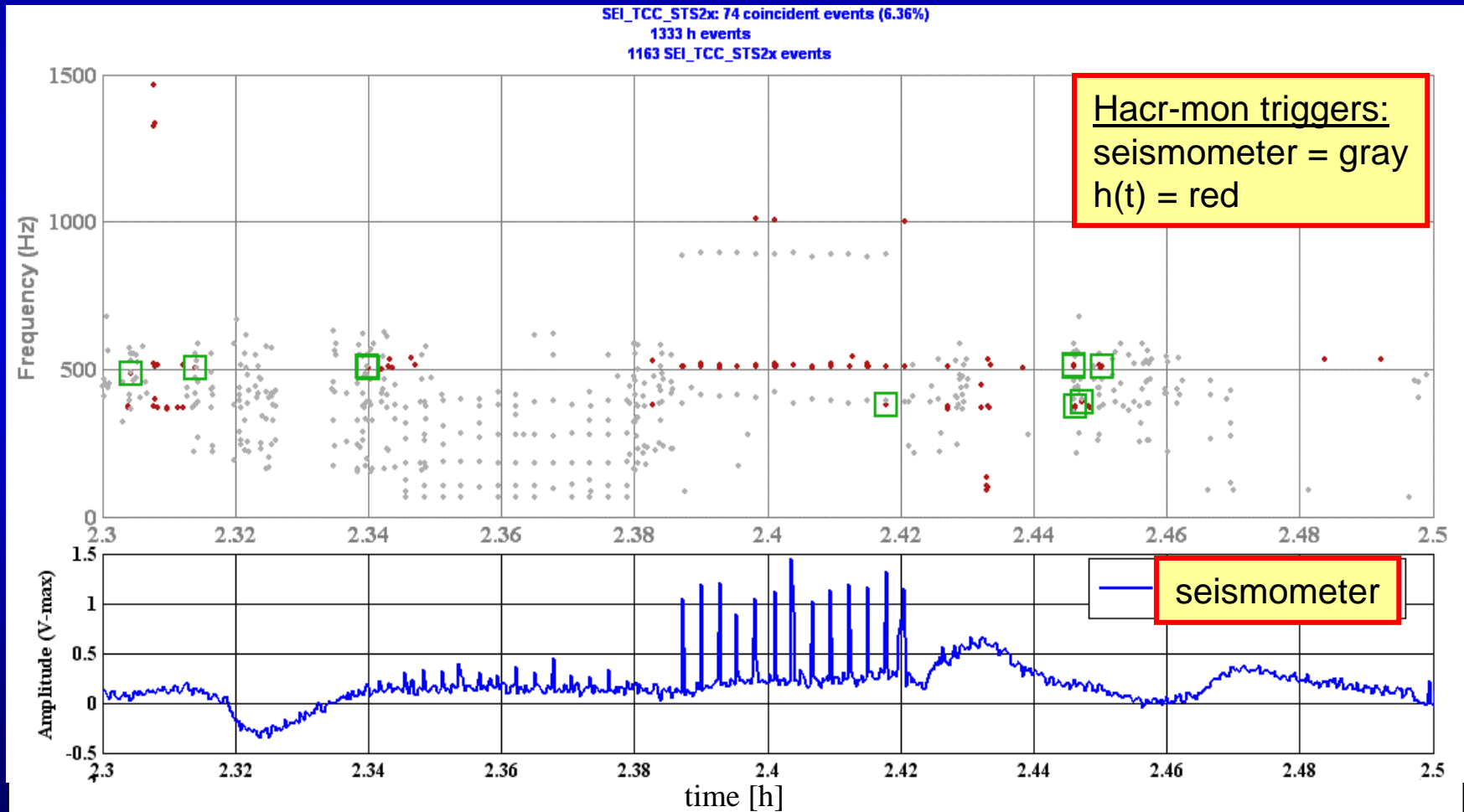
- Via suspension (?)
- Beam clipping
- Beam pointing on photodiode
- Scattered light

## Reduction of coupling:

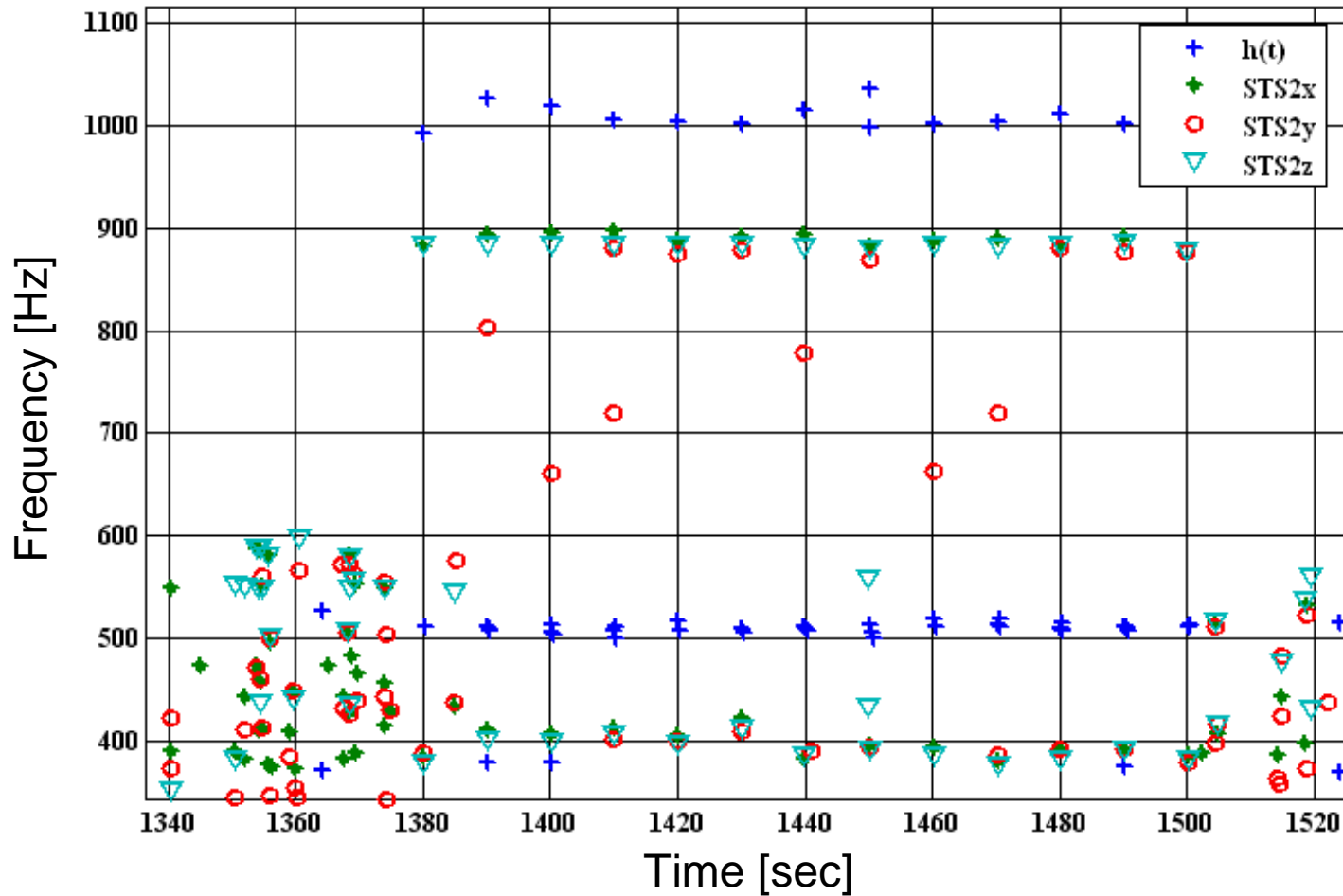
- Using better components (for instance more rigid mirror mounts)
- Using larger diodes (for example we are currently using a 3mm InGaAs at the darkport )
- Using properly coated windows for all important diodes
- Controlling all important beam paths (6 DOF of output optic)

# Seismic injections in central building

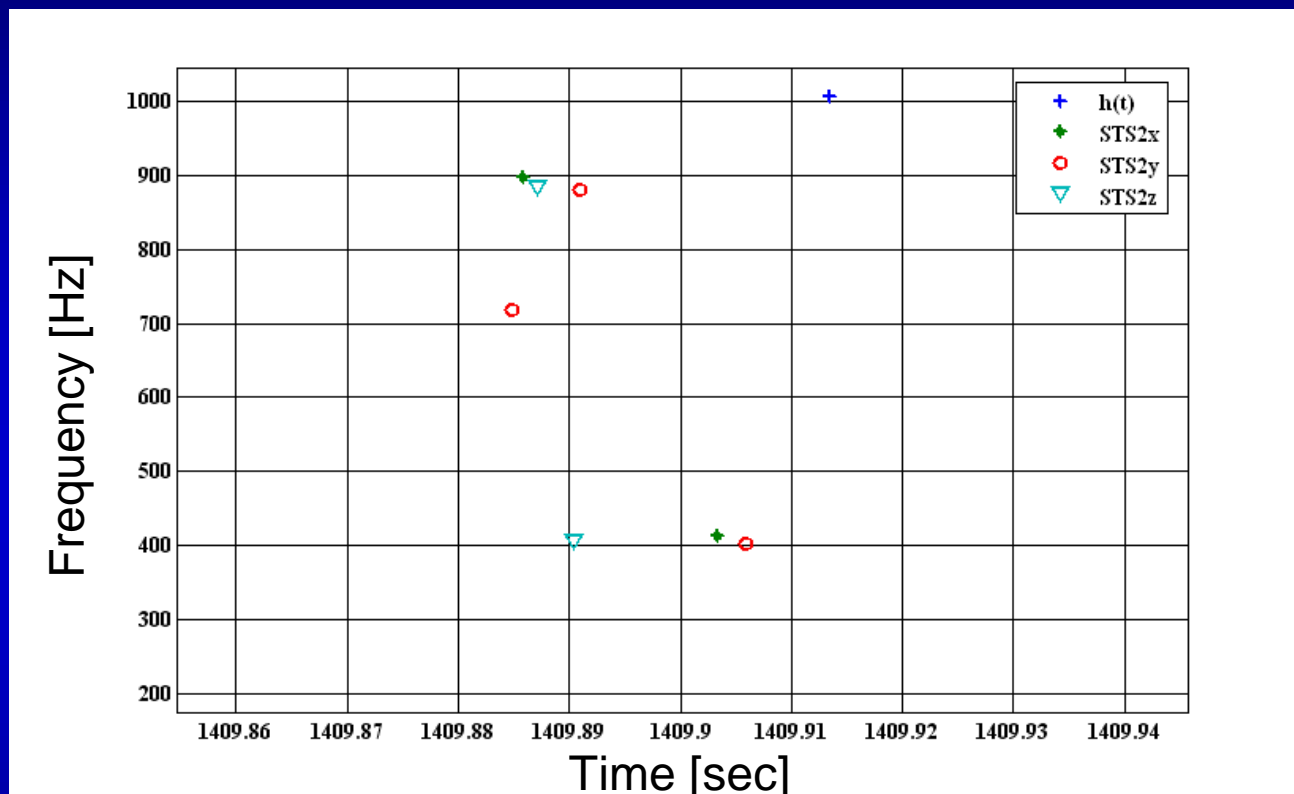
Hitting different foundations with a hammer:  
2.34 to 2.38 green foundation, 2.39 to 2.42 red foundation.



# hacrmon triggers: $h(t)$ vs seismic



# Estimating time delay



- Triggers in seismic channels are all within 20 to 30 milliseconds
- Triggers show up in  $h(t)$  with a delay of 30 to 100 milliseconds
- Frequency window has to be reasonably large

**First try of vetoing seismic events: time-window = 100 msec.**



## Summary / Outlook

- We observed several environmental noises limiting GEO's sensitivity.
- At the moment doing both: reducing the sources and reducing the couplings.
- As soon as we recognize an environmental noise coupling to  $h(t)$  we try to eliminate it. (So far has always been successful)
- Planning for a full quiet run (at the end of the week)
- As long as we improve the detector on a daily basis couplings may change, too. Thus it is hard to veto environmental noises reliably.