From *Coherence* to *Source Location*: Environmental Noise Hunting in VIRGO

Federico Paoletti – EGO and INFN Pisa
on behalf of the
VIRGO collaboration

Slow monitoring (f sample = 1Hz)

➢ temperature probes (160)

➢ humidity probes (11)

➢ pressure probes (11)

➢ weather station (1)

➢ lightning detector (1)

Fast monitoring (50Hz < f sample < 20kHz)

➢ vertical high frequency accelerometers (13)

➢ triaxial mid-low frequency accelerometers (5)

➢ triaxial low frequency velocimeter (1)

➢ horizontal very low frequency accelerometers (2)

➢ broadband magnetometers (9)

➢ broadband microphones (6)

➢ RF broadband antenna (1)

➢ Line monitoring probes (2)

Federico Paoletti
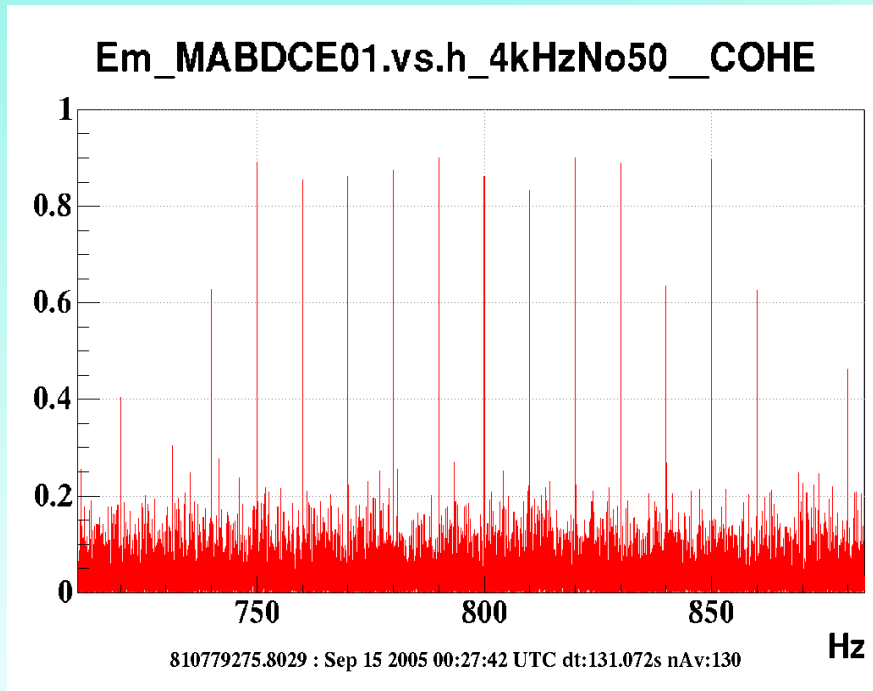Elba GWADW
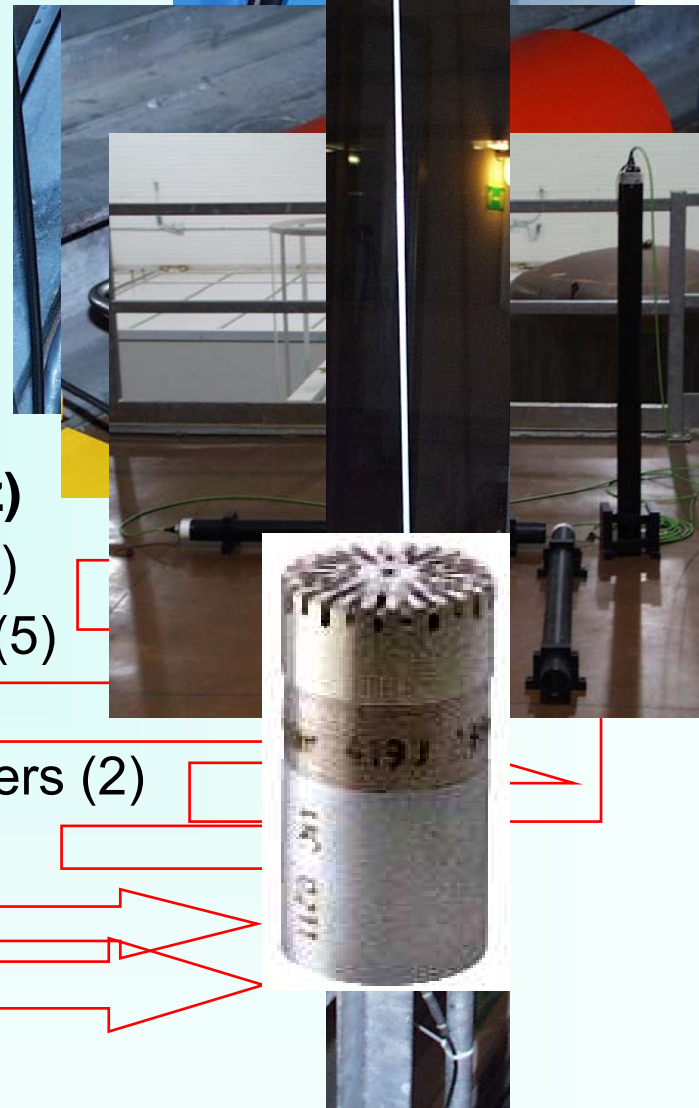
Some useful tools

Two big coils, >40kg of copper each

Two loudspeakers with integrated 200W amplifier

- Gathering information on unknown lines / noises

- Locate noise sources; if necessary, go into the lab with portable equipment

  (spectrum analyser + Hall probe, seismometer, microphone …).

- Attempting to identify the physical path used by the signal entering the interferometer

- Record and post a library of results

Example #1 (magnetic)

see Elena's talk

Lines Identification tools see 10 Hz signal in C6 and C7 data

Em_MABDCE01.vs.h_4kHzNo50__COHE

810779275.8029 : Sep 15 2005 00:27:42 UTC dt:131.072s nAv:130
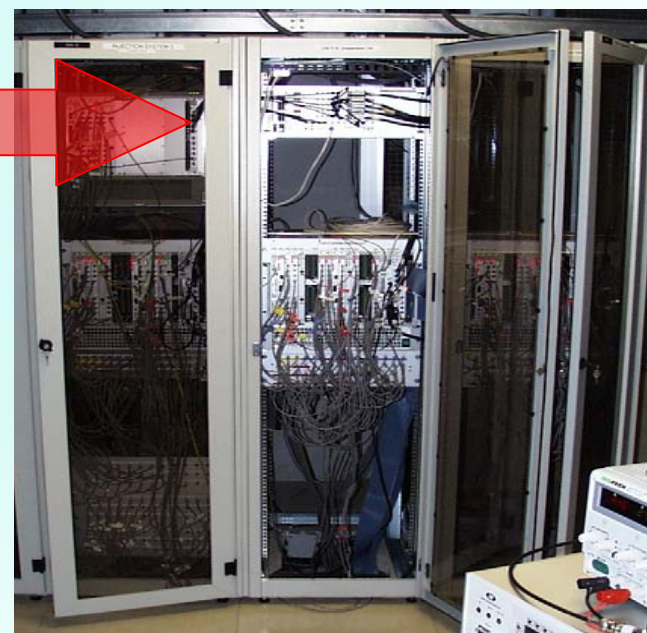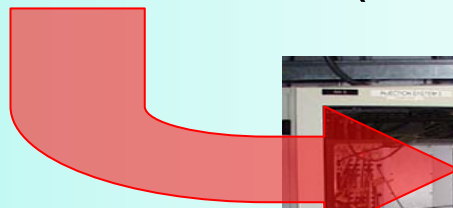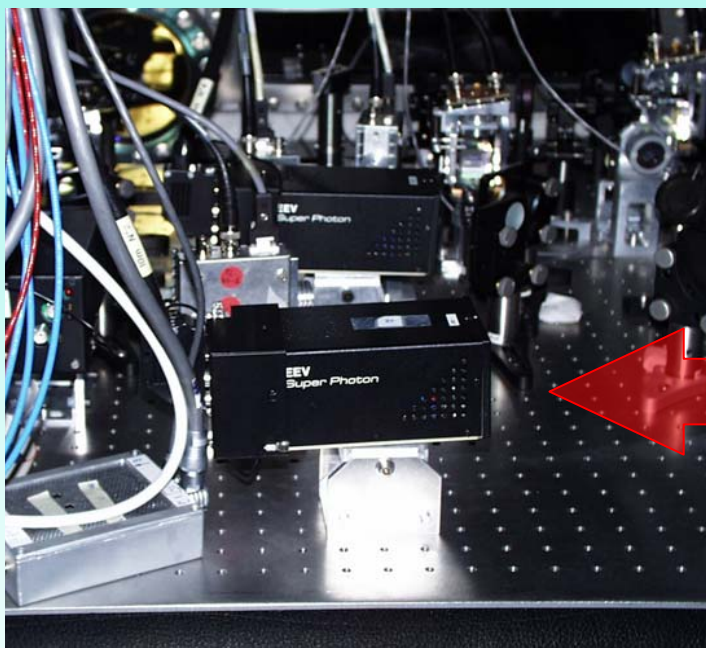
What are
these lines appearing
every 0.1s ?

Going into central building
with a Hall Probe

Very strong emission from Crate 56 in DAQ room, with connections to Laser Lab cameras (ext. injection bench)

Digital cameras looking at the beam, driven by the timing system, are located on <u>all optical benches</u>.

Large coherence at 10 Hz and harmonics between
   Dark Fringe and

- **Bs_IMC_D1T_DCHF**

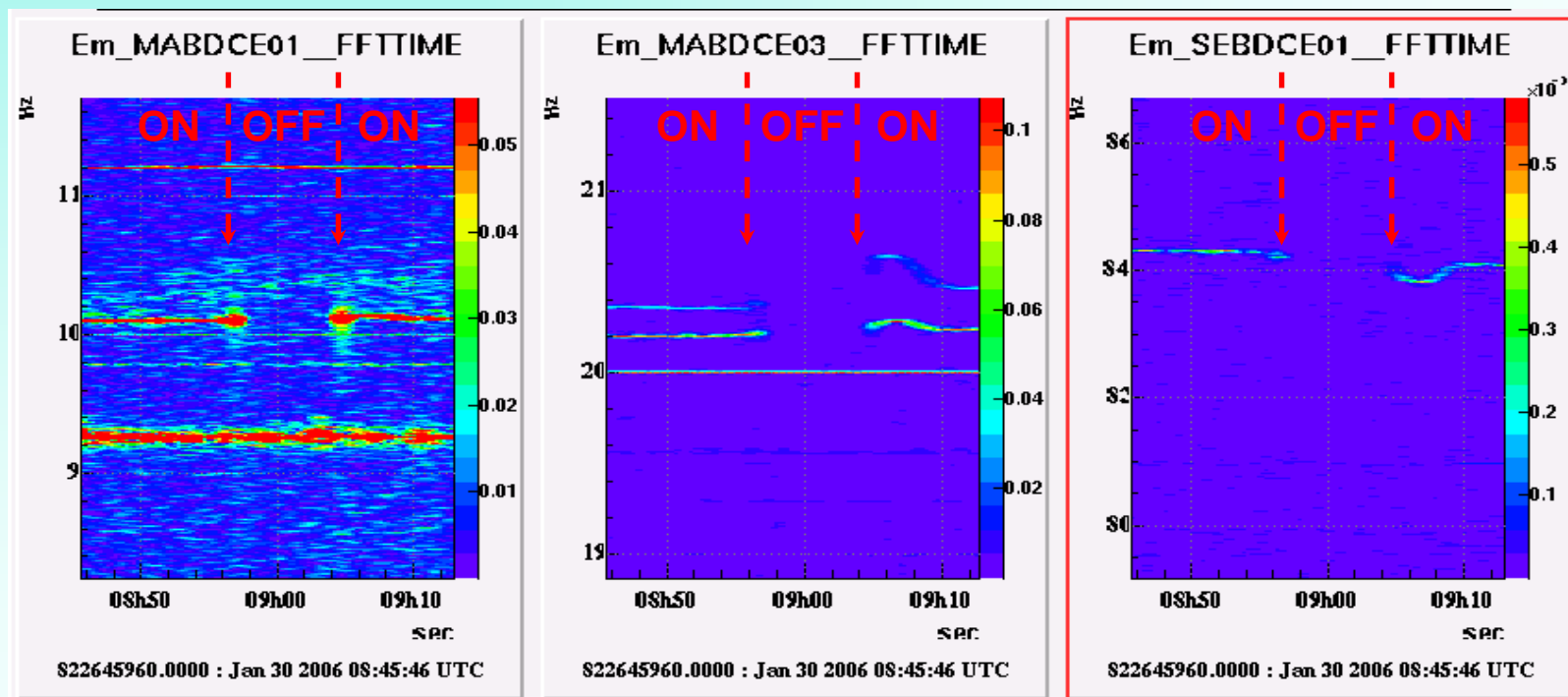   monitoring the **IMC transmission**

- **Pr_B5_DC**

   monitoring the **PR cavity power**

- **…**

   → **Laser power noise?**

   → **readout EM coupling ?**

   → **…**

Further analysis is scheduled

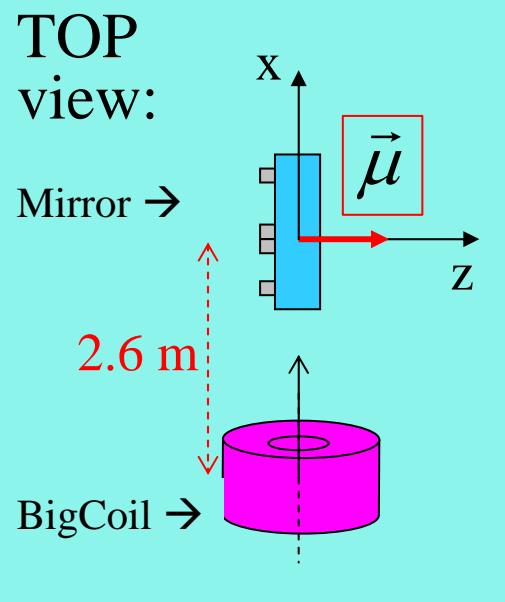While hunting the 10 Hz, also found source of strong line at 10.1 Hz: the Air Conditioning Unit in DAQ room
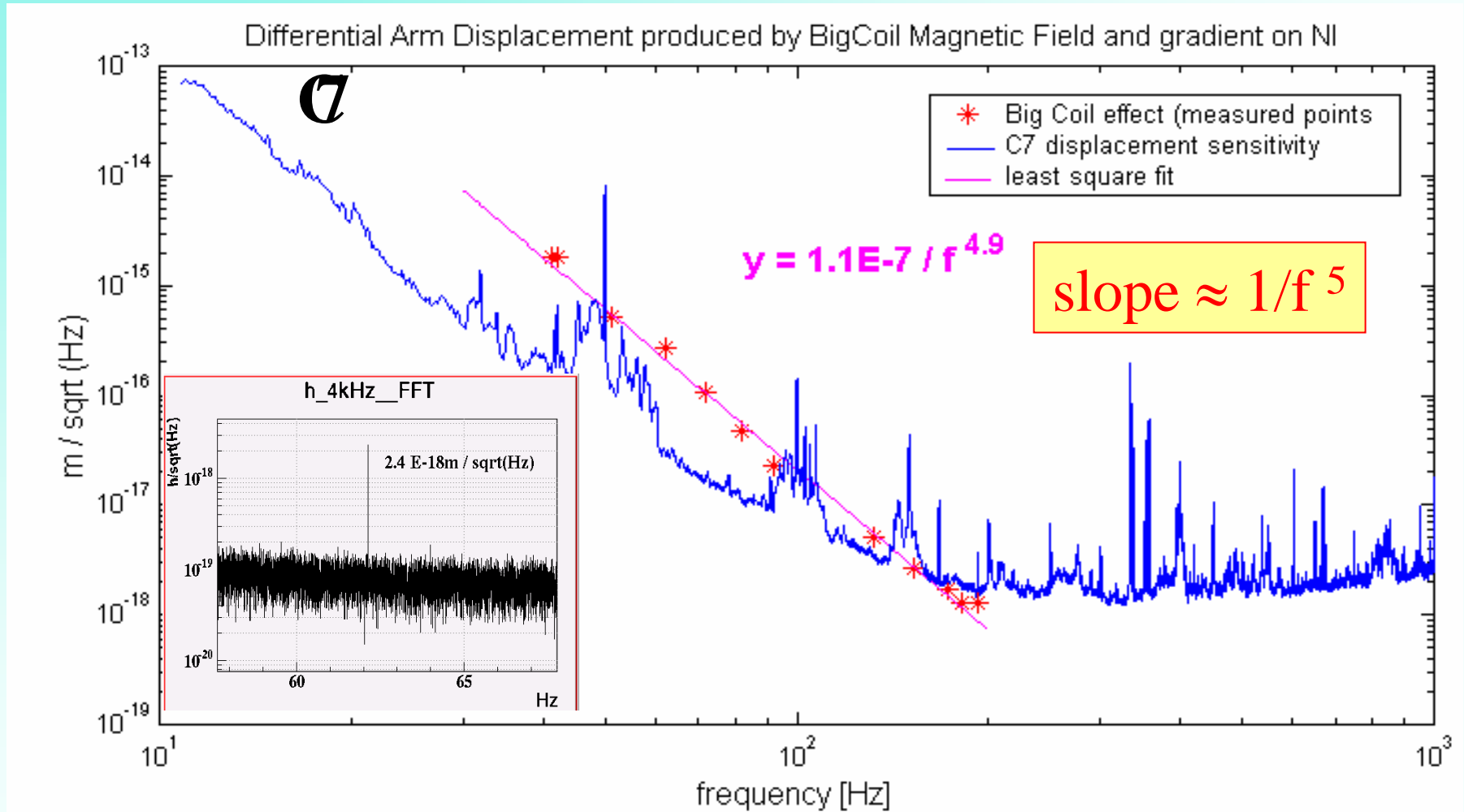

see:
http://wwwcascina.virgo.infn.it/DataAnalysis/Noise/EnvStudies/buildingCENTRAL/AirCond_DAQ/AAA_logbook_30jan06.txt
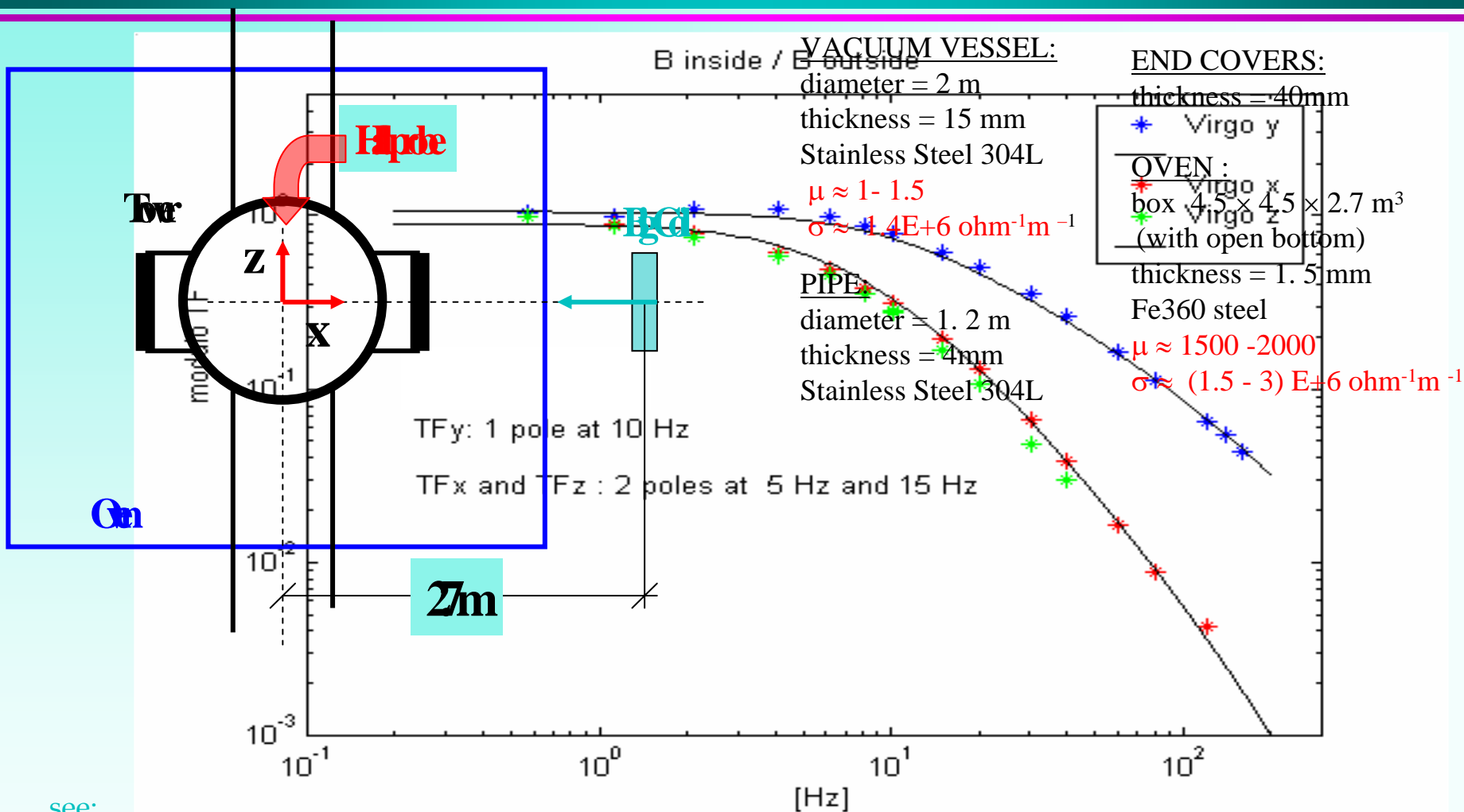
During C7 run we tried to evaluate the transfer function between an external magnetic field and mirror's magnetic actuators

sinusoidal voltage: 560 Vpp

adjustable frequency: 40 Hz to 200 Hz

generated field (gradient) 10 – 100 nT (nT/m)

TOP view:

Mirror →

$\vec{\mu}$

x

z

2.6 m

BigCoil →

Differential Arm Displacement produced by BigCoil Magnetic Field and gradient on NI

$$y = 1.1E\text{-}7 / f^{4.9}$$

slope $\approx 1/f^5$

VACUUM VESSEL:
diameter = 2 m
thickness = 15 mm
Stainless Steel 304L
$\mu \approx 1 - 1.5$
$\sigma \approx 1.4E+6$ ohm^{-1}m^{-1}

PIPE:
diameter = 1. 2 m
thickness = 4mm
Stainless Steel 304L

END COVERS:
thickness = 40mm

OVEN :
box $4.5 \times 4.5 \times 2.7$ m^3
(with open bottom)
thickness = 1. 5 mm
Fe360 steel
$\mu \approx 1500 - 2000$
$\sigma \approx (1.5 - 3) E+6$ ohm^{-1}m^{-1}

B inside / B outside

TFy: 1 pole at 10 Hz

TFx and TFz : 2 poles at 5 Hz and 15 Hz

27m

see:
http://wwwcascina.virgo.infn.it/DataAnalysis/Noise/EnvStudies/MagneticNoise/MagneticShieldPR/AAA_logbook_16nov2005.txt

Example #2 (seismic)

45 Hz "horns" appeared in the C7 dark fringe channel, then vanished when Injection Bench turbo pump (rpm=36000) was turned off

Pr_B1_ACp__FFT
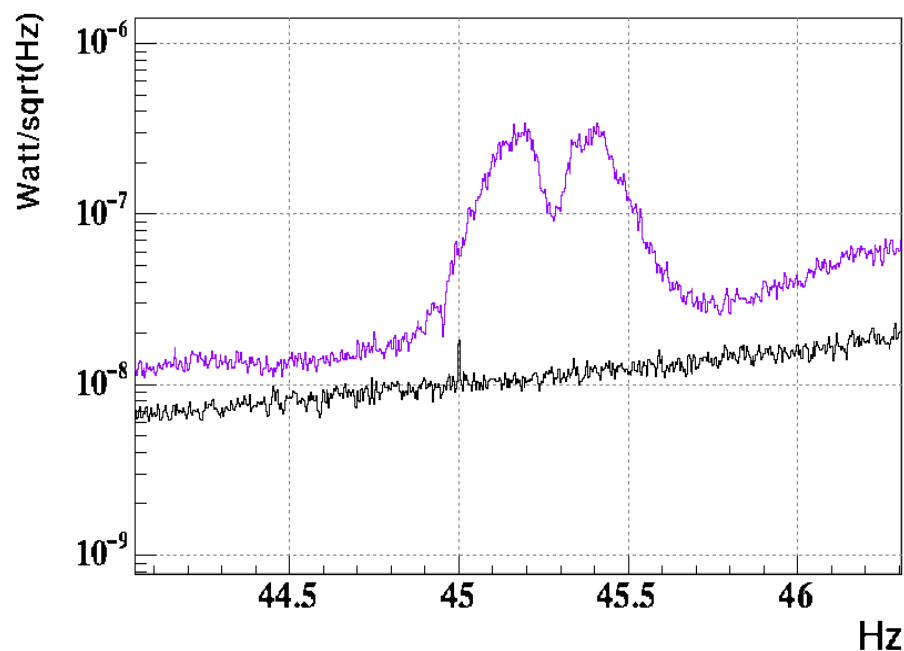
811083781.9400 : Sep 18 2005 13:02:48 UTC dt:327.68s nAv:196

Spectrogram_spectro_Pr_B1_ACp_300_100_0_100
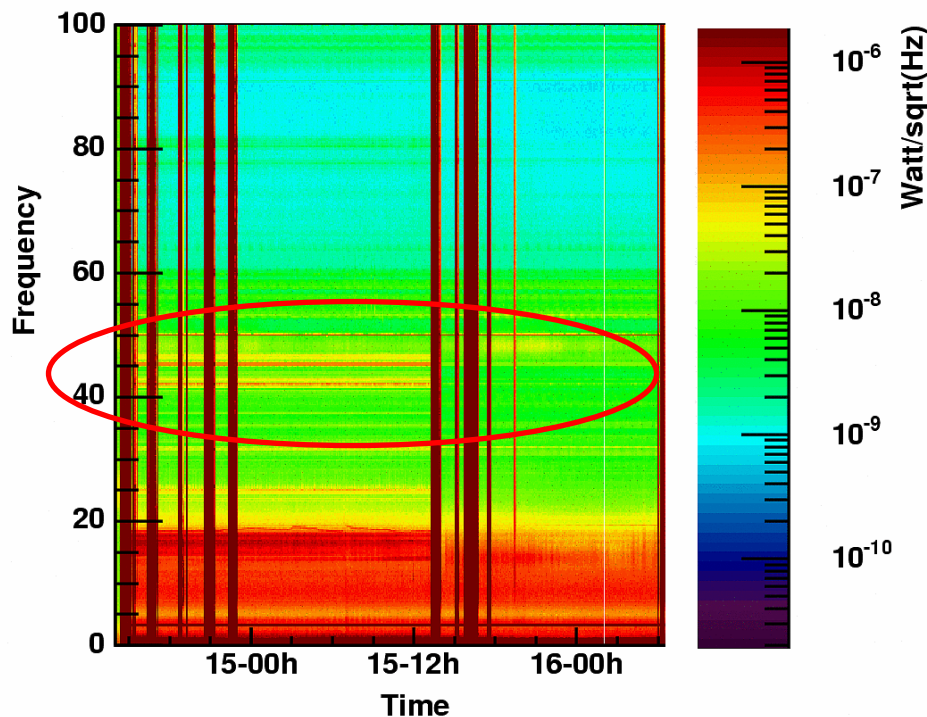
we use a portable
accelerometer
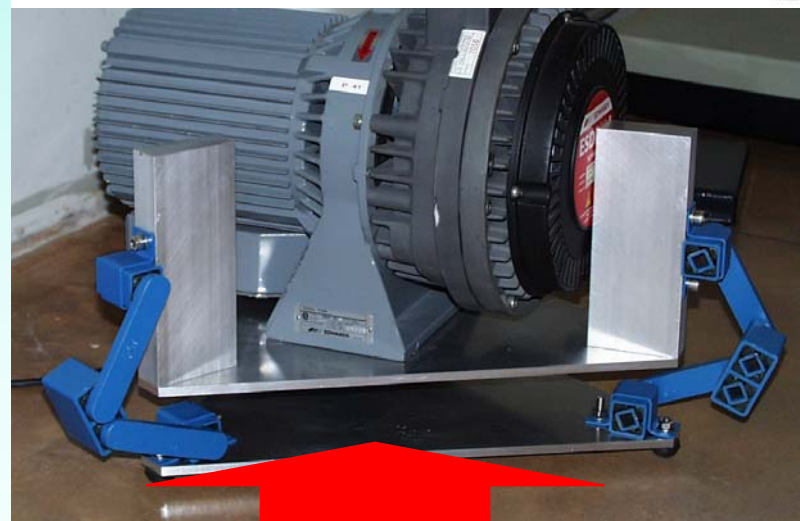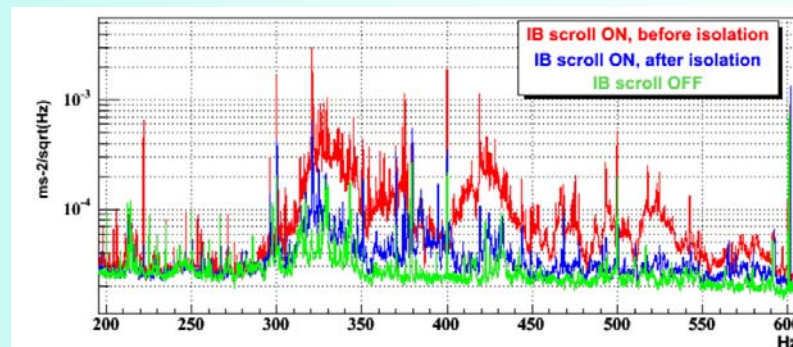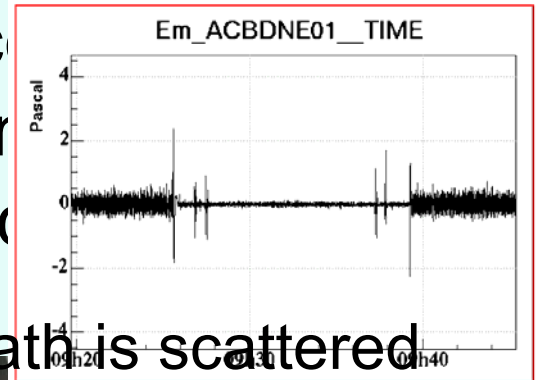
source is two small
cooling fans on vacuum
turbo pumps

see:
http://wwwcascina.virgo.infn.it/DataAnalysis/Noise/EnvStudies/TurboPumps/TurboFansLines.txt
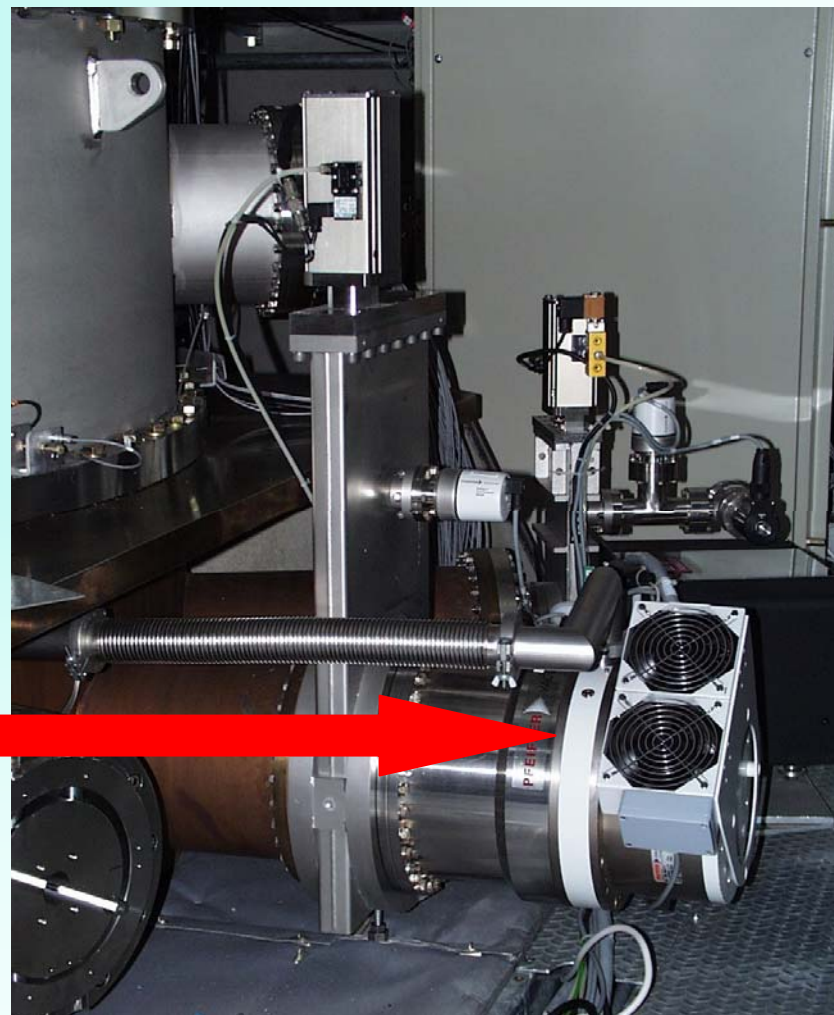
We observed similar coupling effect with scroll pumps
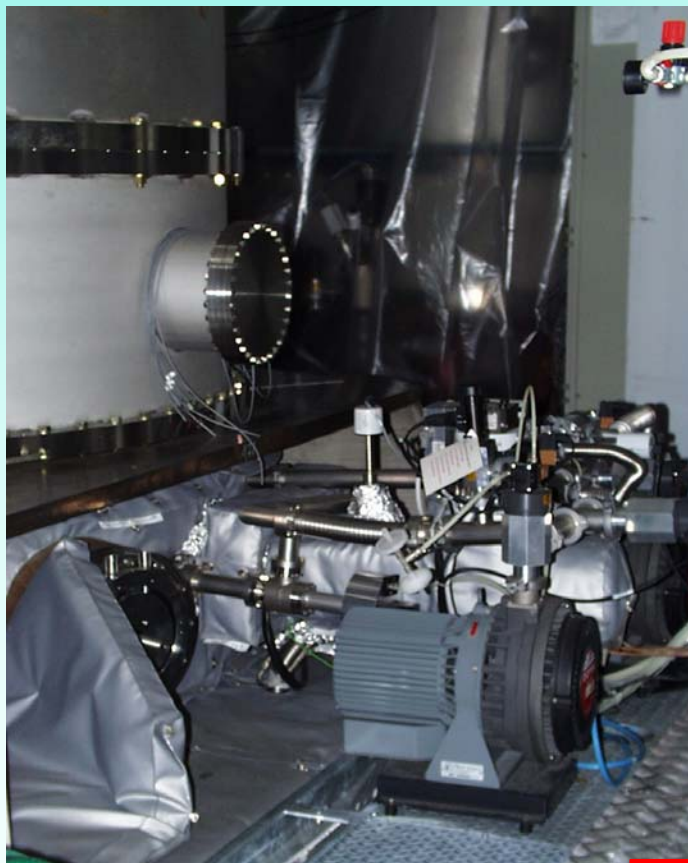
An isolating system is under evaluation

Federico Paoletti
Elba GWADW

Example #3 (acoustic/seismic)

VIRGO

C7 lines at 31.6 and 31.9 Hz seen in _coherence catalogue_

see Elena's talk

- 31.6 Hz correlation between dark fringe and
  - ◆ **north end** microphone
  - ◆ **north end** **vertical accelerometer** (ext. detection bench)

- 31.9 Hz correlation between dark fringe and
  - ◆ **west end** microphone
  - ◆ **west end** **vertical accelerometer** (ext. detection bench)

Em_SEBDNE01

see:
http://wwwcascina.virgo.infn.it/DataAnalysis/Noise/doc/C7/coherence/webpage/catalogue.html
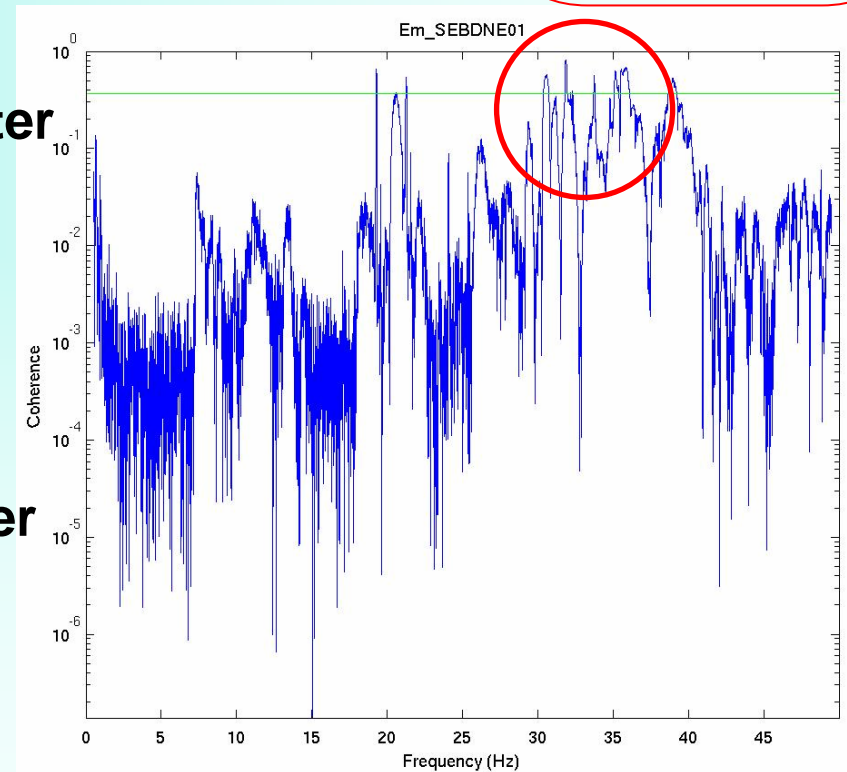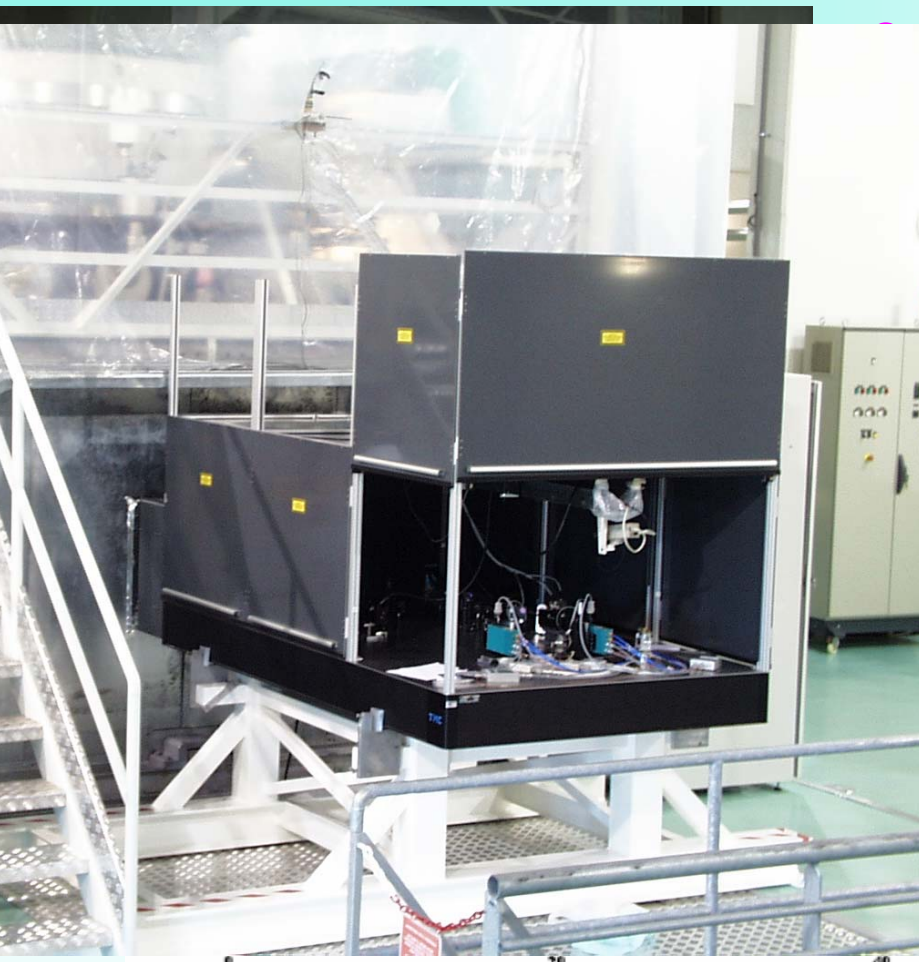
Portable acc...
confirmed this...
showed stron...
tioning system...
external optic...

Em_ACBDNE01__TIME

Possible path is scattered
light impinging on the
plastic coverage, damping
is under evaluation

47.2 Hz

49.0 Hz
(scroll x 2)

Microphone in NE hall
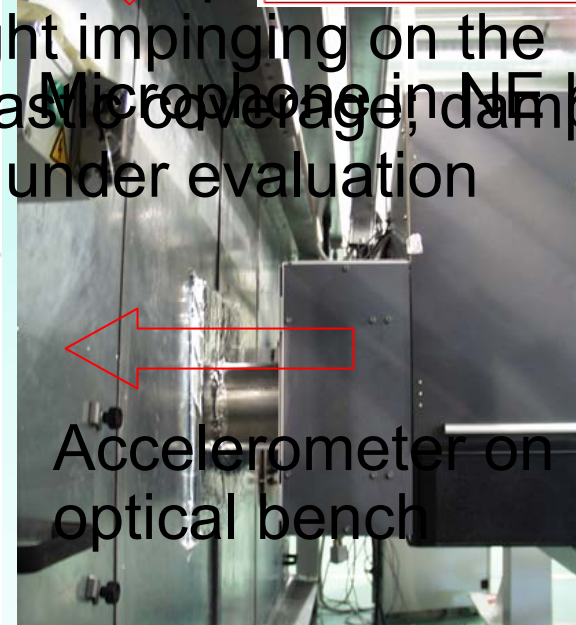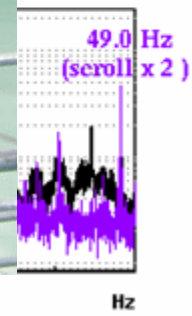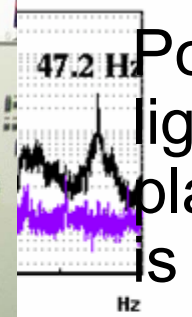
Accelerometer on NE
optical bench

see:
http://wwwcascina.virgo.infn.it/DataAnalysis/Noise/EnvStudies/buildingNE/OpticalBenchNE/AAA_logbook_14feb2006.txt

Federico Paoletti
Elba GWADW

Example #4 (acoustic tests)

Acoustic isolation of optical benches is scheduled
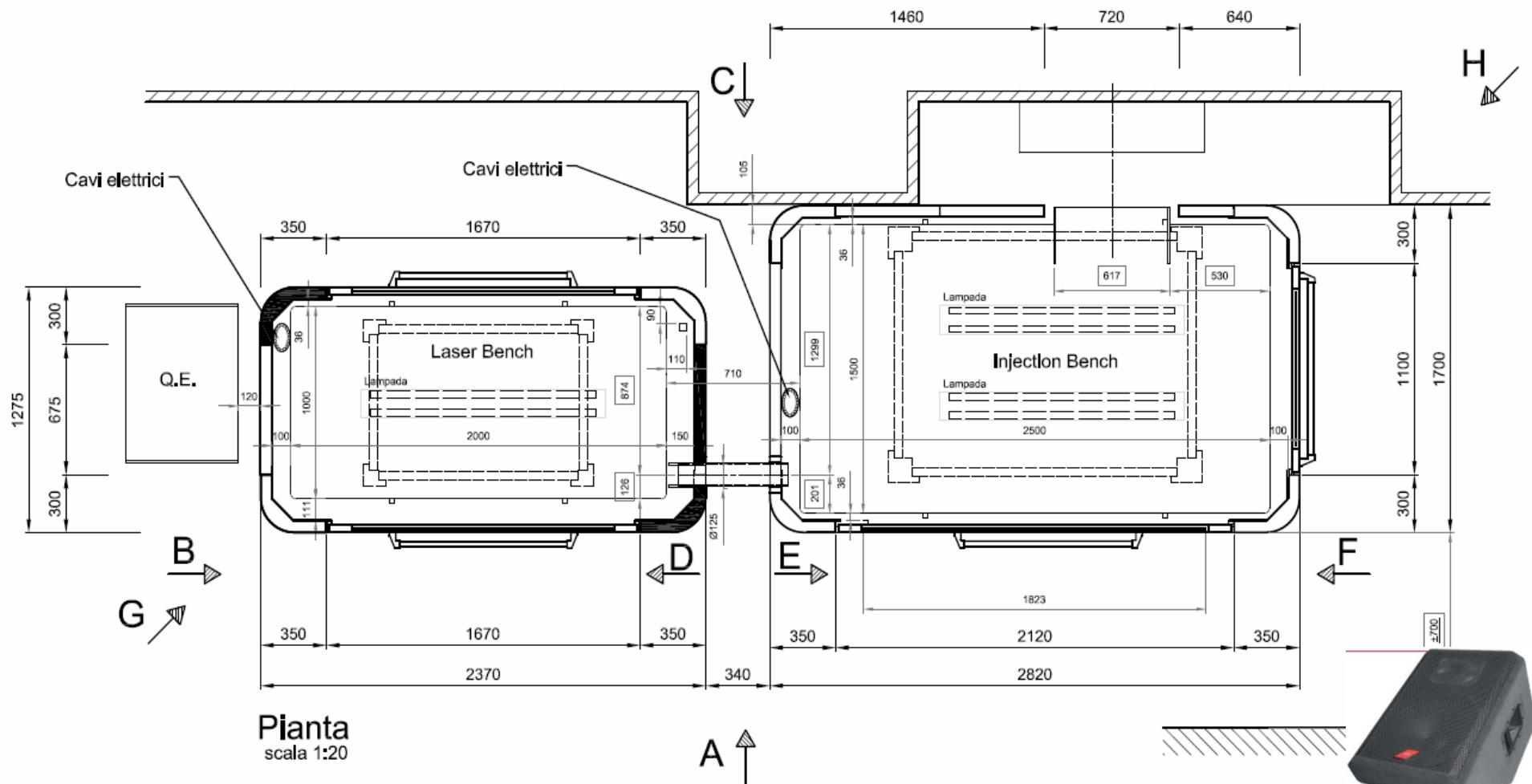
Many other examples have been studied
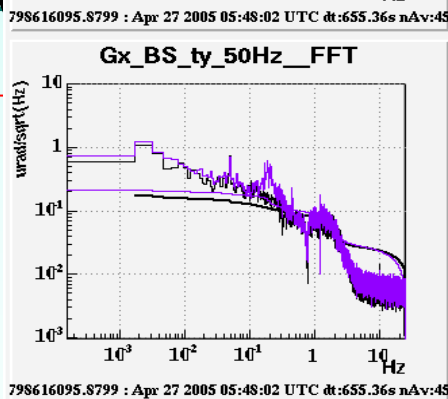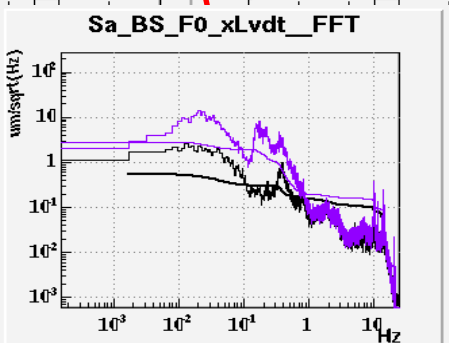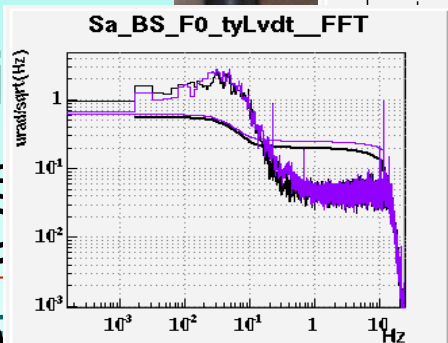
- wind effect
- mains disturbances
- ai (dete
- lig

see Giovanni's talk

see e talk
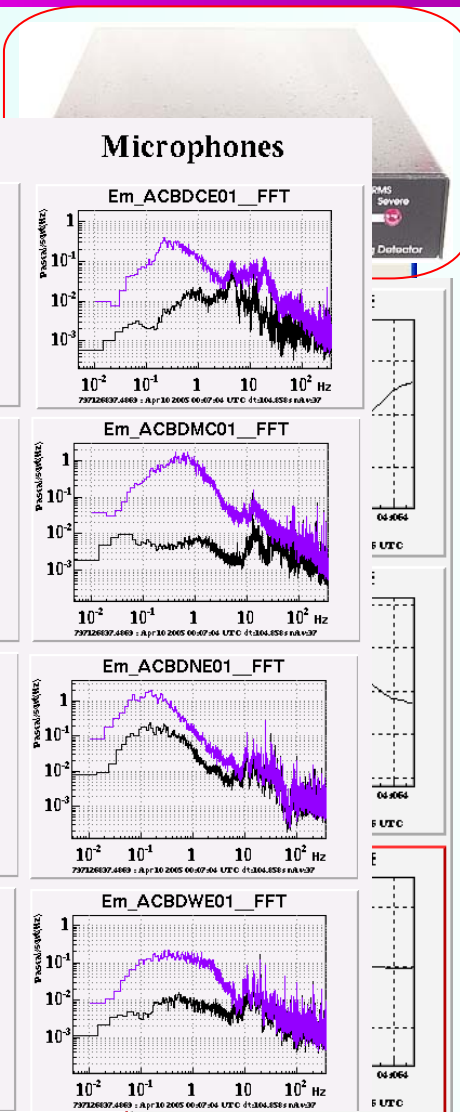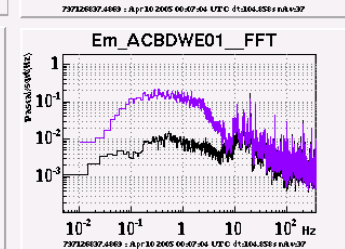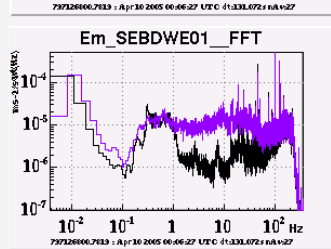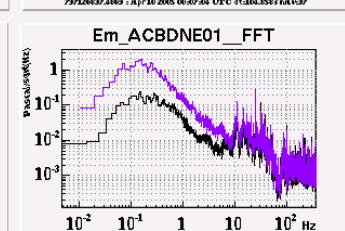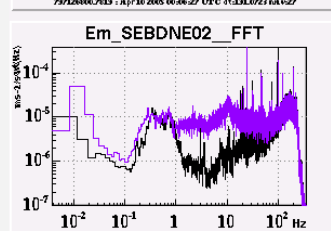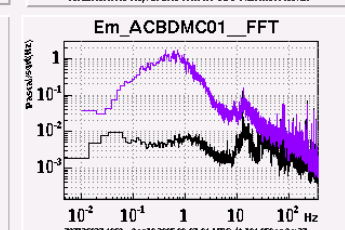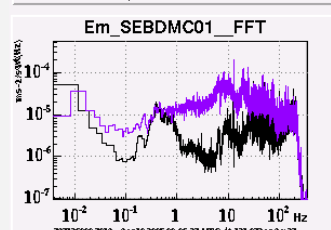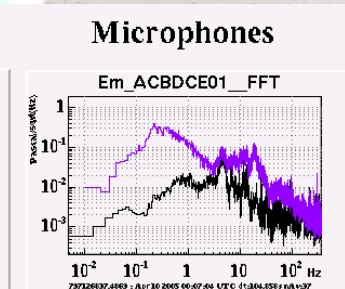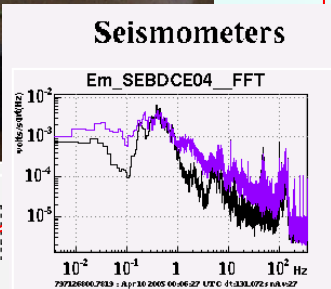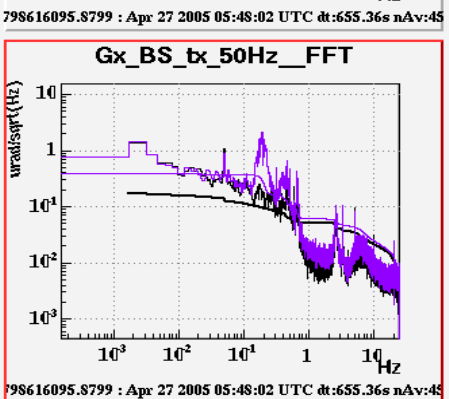
- We started understanding the most obvious environmental disturbances which can interfere in the Virgo operation

but …

- As sensitivity increase, noise investigations become more important and more difficult:

    it's a *never-ending* story

and …

- Environmental Noise Groups must be always on "red alert" condition, ready for the next problem

Thanks to the works of Nelson Christensen, Elena Cuoco, Rosario De Rosa, Isidoro Ferrante, Francesco Fidecaro, Irene Fiori and many others "noise hunters" I'm forgetting right now....