Virgo Status Report

Patrice Hello, LAL-Orsay

Orsay, June 11, 2008

LIGO-G080355-00-Z

OUTLINE

- North End Tower Incident
- Spring detector work
- Commissioning results
- Virgo+ upgrade Advanced Virgo Status
- Perspective

Incident at the Virgo NE tower

Cascina, May 9, 2008

Very nice progress were achieved with the Virgo interferometer.

Unfortunately at 11:48 UTC a view port of the North End tower broke during air evacuation.

Nobody was hurt but the payload, its mirror and other components of the tower were damaged.

The causes of the incident are being investigated.

Three weeks of tests were foreseen before the Virgo+ shutdown, which will now be anticipated to minimze the down time.

Every effort will be made not to delay the start of the Virgo+ science next year.

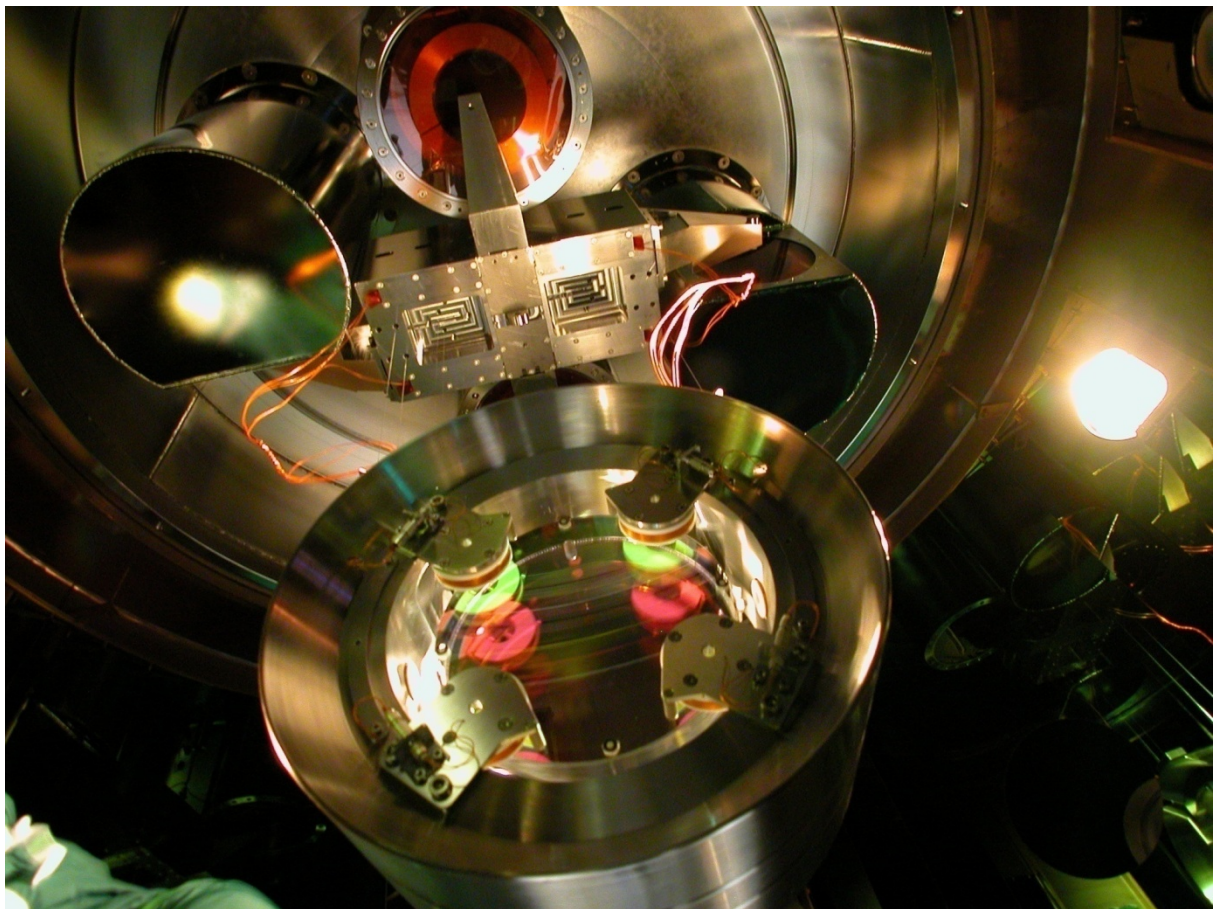
Jacques Colas
EGO Director

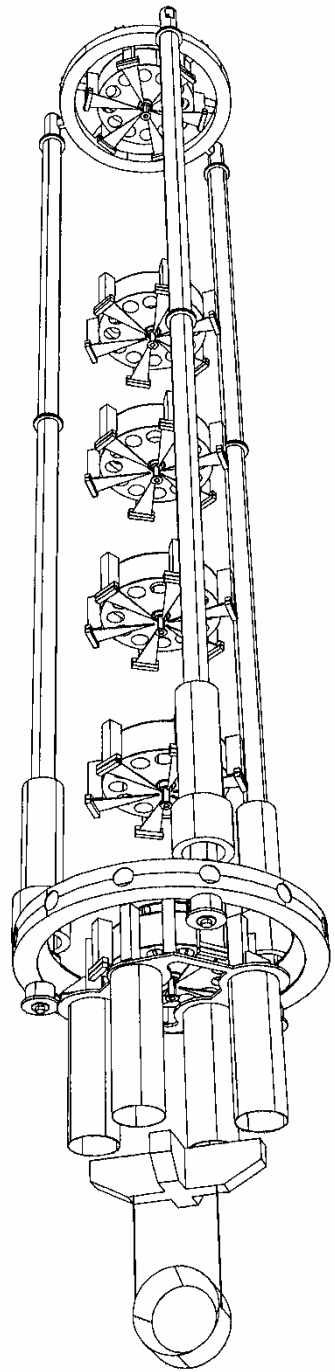
Francesco Fidecaro
Virgo Spokesperson

Incident description

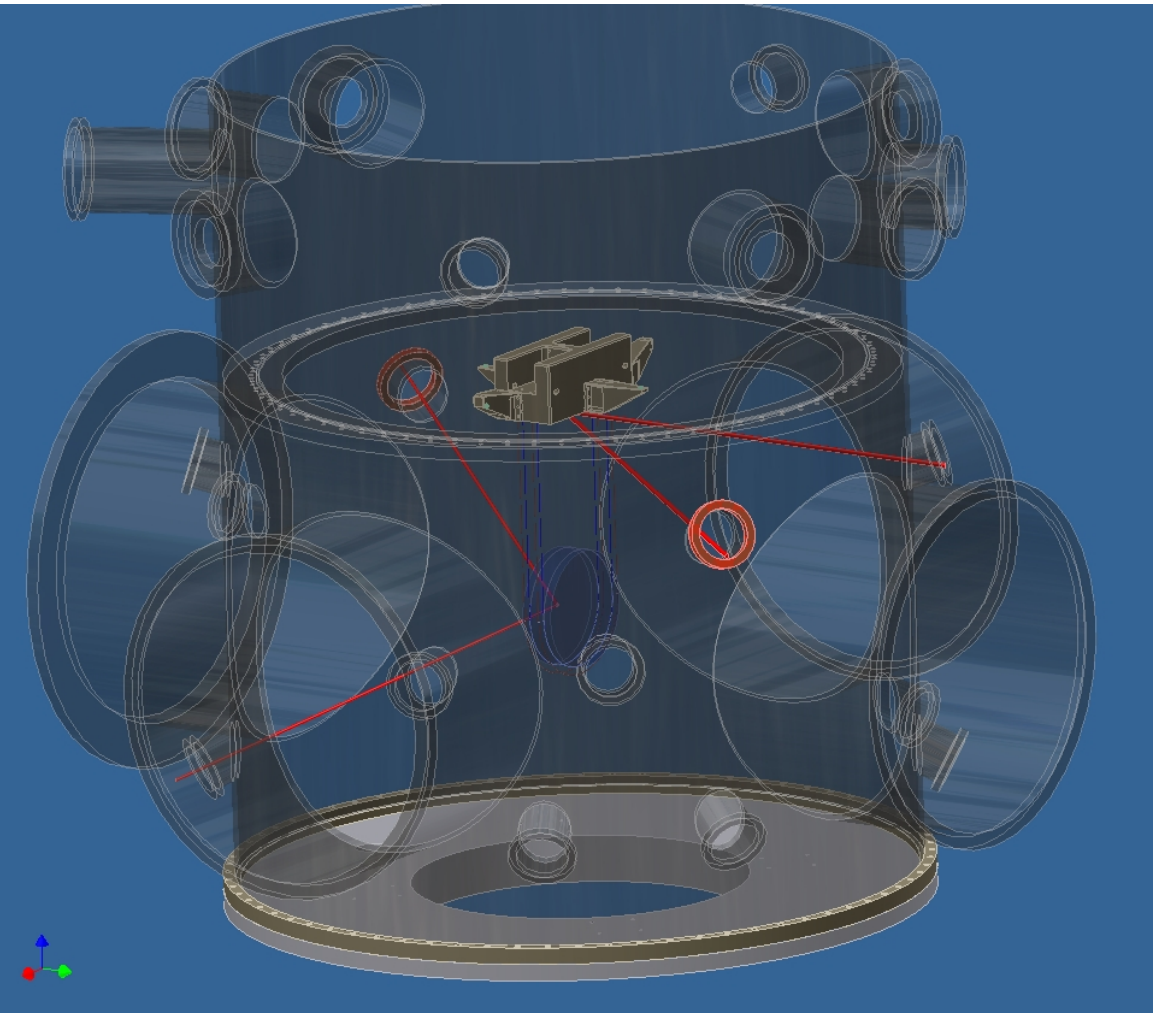
- May 9, 2008 at 13:48:16 CEST (11:48:16 UTC) a huge oscillation of the suspended payload in the NE tower has been observed in the TV screen in the control room

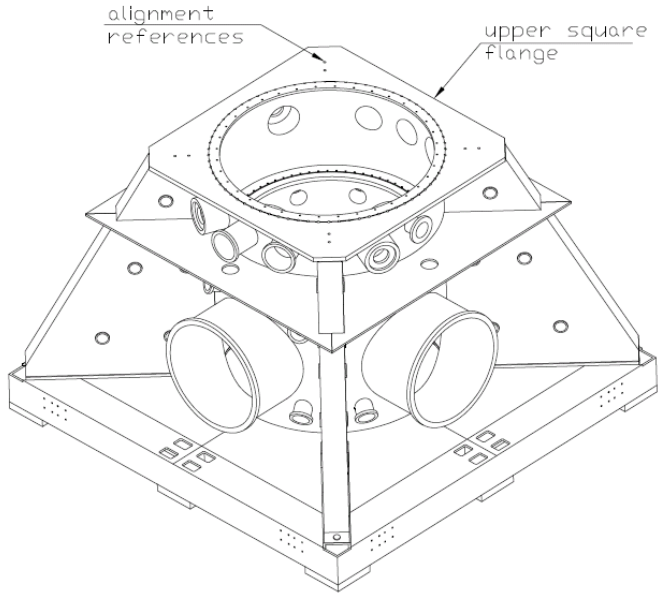
BS payload





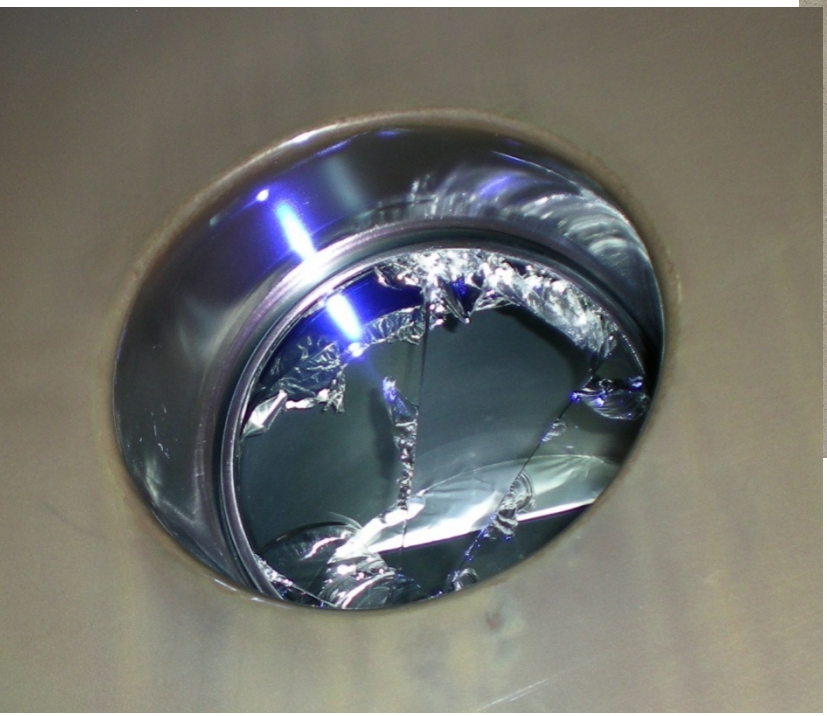
The NE tower





The broken viewport is normally traversed by 1 mW red laser light and outside a PSD sensor is located (protected by an aluminum foil box)

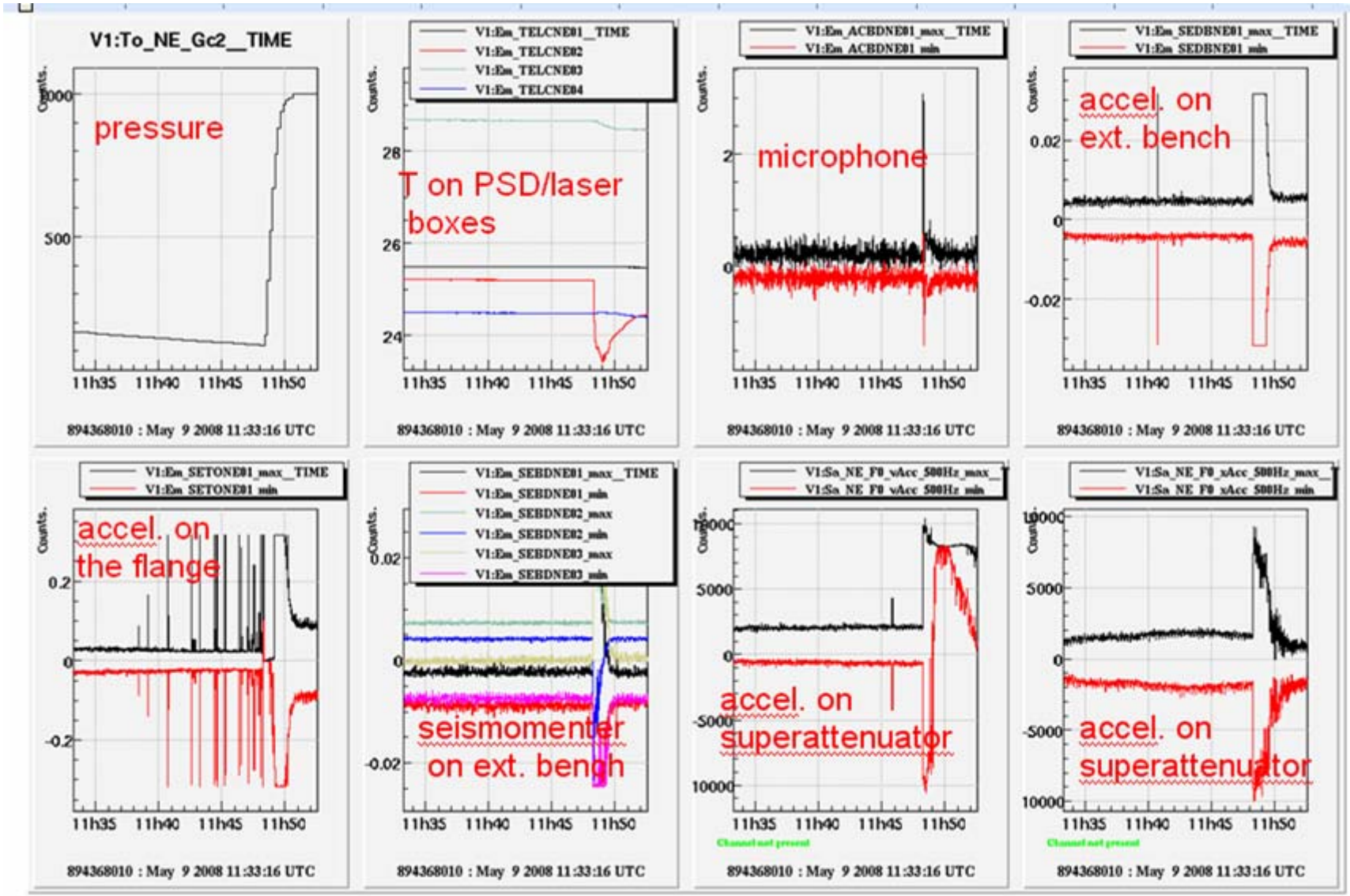
Broken Viewports



From inside

From outside

Probe signals



Results from probe signals analysis

- Incident occurred during evacuation @ 120mbar
- In 20s we were back at 500mbar and in about 1 minute at 1 atm
- Piezo-accelerometers attached to the towers revealed spikes starting from 10 minutes before the failure that we identified as precursors of the event
- The frequency content of these spikes is concentrated around 2kHz, and we are able to mimic a similar frequency content only hitting the tower on the viewport (FEM study points at confirming viewport eigenfrequencies)
- Similar glitches have been found during the last venting on the same tower, but not in other towers

Status

- Meeting with experts on June 4
  - M.Zucker (LIGO, by telecon), R.Veness (CERN), A.Franceschi (Frascati), A.d'Este (Glass experimental study station, Murano), Virgo-EGO physicists.
- General agreement: Strength of viewport depends less on thickness of glass than on care in handling (scratches,...)

Unless falsified by further examinations, tests, FEM simulations

"the failure is due to a construction problem or to an accidental damage of this particular viewport“

- More details available from people directly following the recovery
  - Carlo Bradaschia, Antonio Pasqualetti, Michele Punturo, Henrich Heitmann, Vincenzo Dattilo

Plans

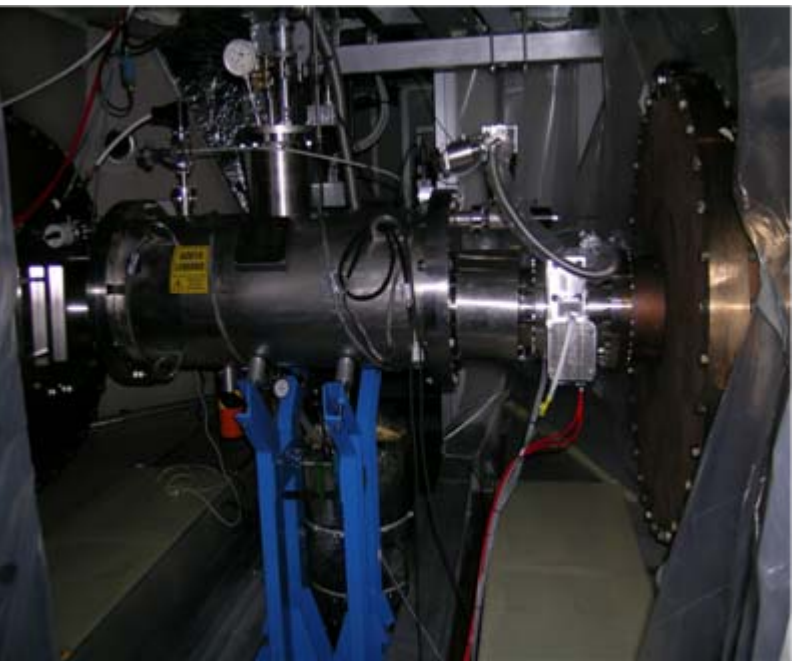
- Vacuum test, if valve tight then start evacuation of N arm by next week
- Within two weeks
  - Damage in other NE viewports?
  - Establish handling and safety procedures to work around viewports
- Within one month second vacuum test with more sensors, then vacuum chamber operative
- Within next two months
  - Buying new scratch free viewports.
  - Vacuum tests on NE tower for deformations, tightness, resonances, then evacuating N arm
  - Study deformation and possibly rupture on test setup
- All the other V+ activity will progress as planned
- With a special effort by LMA a new NE mirror will be available mid August for installation in the tower

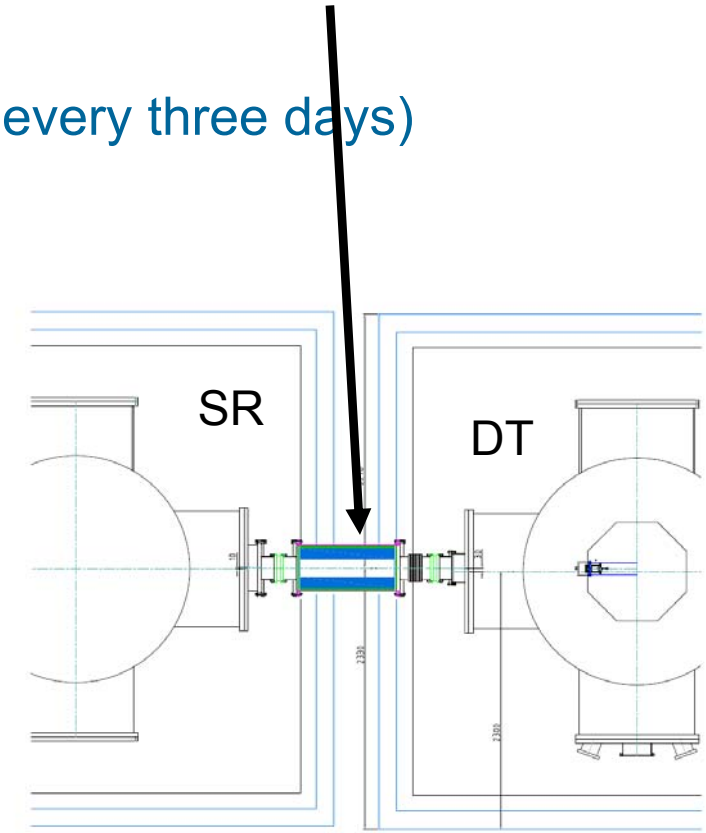
Detector pre-shutdown activities

- After the VSR1, the detector upgrade activity has been addressed to the support to the commissioning and to the preparation of the V+ shutdown
- Reduction of the environmental noise coupling
  - Cryo-trap design and installation (EGO, Pisa)
  - DAQ room acoustic and seismic noise reduction (EGO)
- Low frequency noise reduction
  - Eddy currents suppression through mirror magnets intensity reduction (Roma 1, Perugia)
  - Coil drivers testing and replacement (EGO, Pisa)
- High laser power package “preparation”
  - High power laser (Nice)
  - Thermal compensation (partial) installation (Roma 2)

Cryo-Trap

- The Brewster's window between the Signal Recycling (SR) empty tower and the Detection Tower (DT) is suspected to introduce acoustic and seismic noise in the dark fringe signal (diffused light)
- Vacuum link replaced by a liquid Nitrogen trap to prevent contamination of the Virgo large optics.
- Vacuum quality is good
- Refilling is planned to be once / week (now every three days)





Actuation noise and Coil Drivers

- Actuation noise has been one of the most discussed problem in Virgo
  - New coil drivers with multi-low noise sections introduced
- Hypothesis of an increase of thermal noise due to the eddy currents dissipation of the mirror magnets in the reference masses
  - (aluminum RM, too intense SmCb magnets)
- New solution for magnets
  - replace all the mirror magnets with 5.5 times less intense SmCb magnets
  - removing the lateral magnets
  - No problems except in the WI mirror where we had to reattach the FS support (Glitches by water glass glue?)
- No more limit expected in Virgo (+) by eddy currents in RM

- Last magnets replaced were those of the North End Mirror …

Commissioning activities

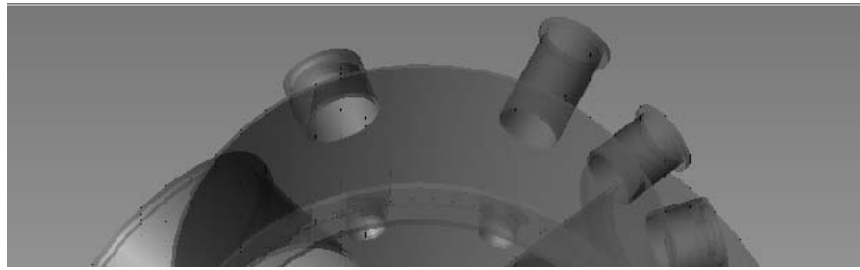
- Control noise
- Thermal compensation
- Environmental noise
- Automation

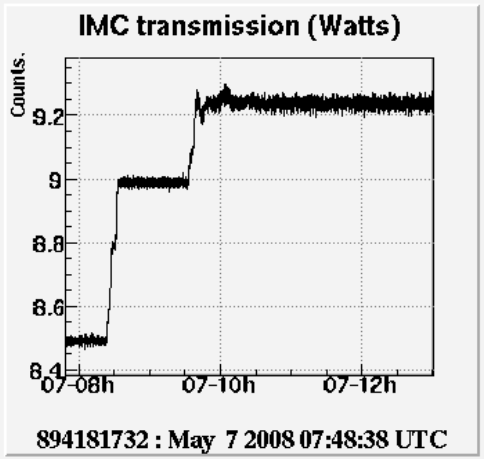
Control and environmental noises

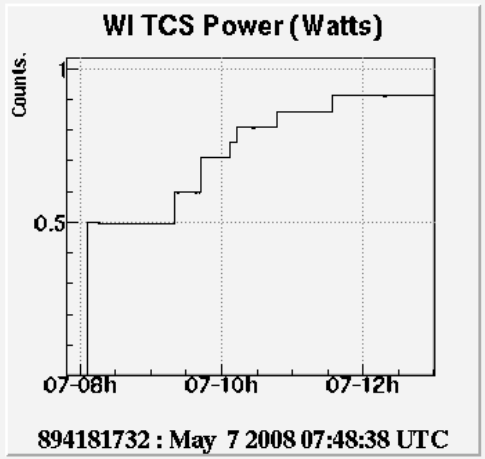
- Longitudinal control
  - 8 MHz signal
  - New sensing scheme for the central interferometer control
  - Optimization of control filters to improve low frequency accuracy and reduce high frequency noise re-introduction
  - Improvement of noise subtraction techniques.
- Angular control
  - Better beams and optics,
  - Improved control filters
  - Galvos
- Suspension control
  - Actuation noise
- Beam jitter before input mode cleaner
  - Modification of beam steering mirror supports
- Scattered light on benches
  - Modifications in layout
  - Dedicated tests with shakers, loudspeaker
- Magnetic noise
  - Dedicated tests with coils, study of field with Hall probe

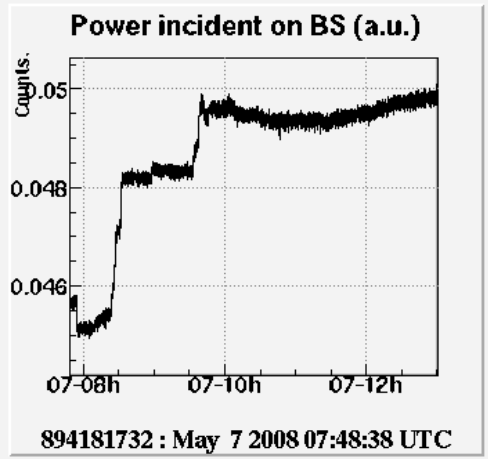
Thermal Compensation System

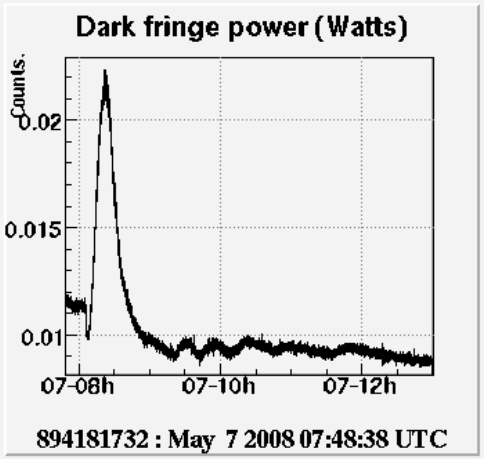
- Thermal lensing in input mirror limits laser power
- TCS system, based on a CO2 laser ring for
  - Large econ effort
  - Installation week in Ap
- One of the two from Access L
  - Sent back b order
  - WI TCS par many things
  - First encoul

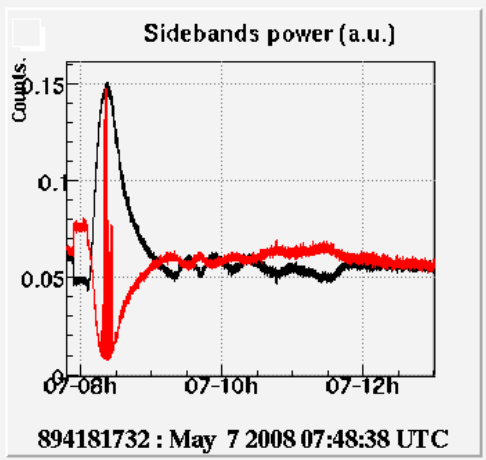






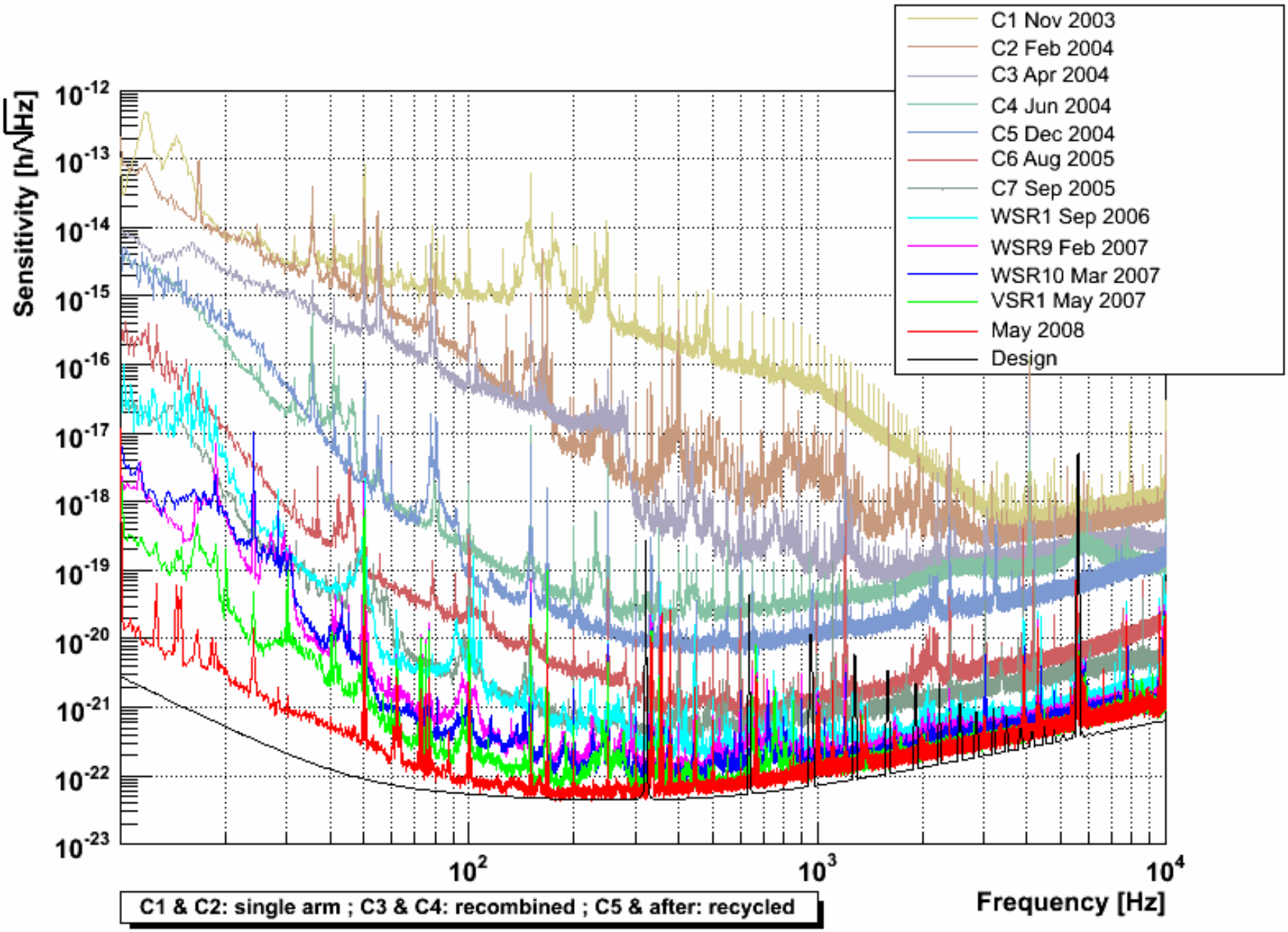




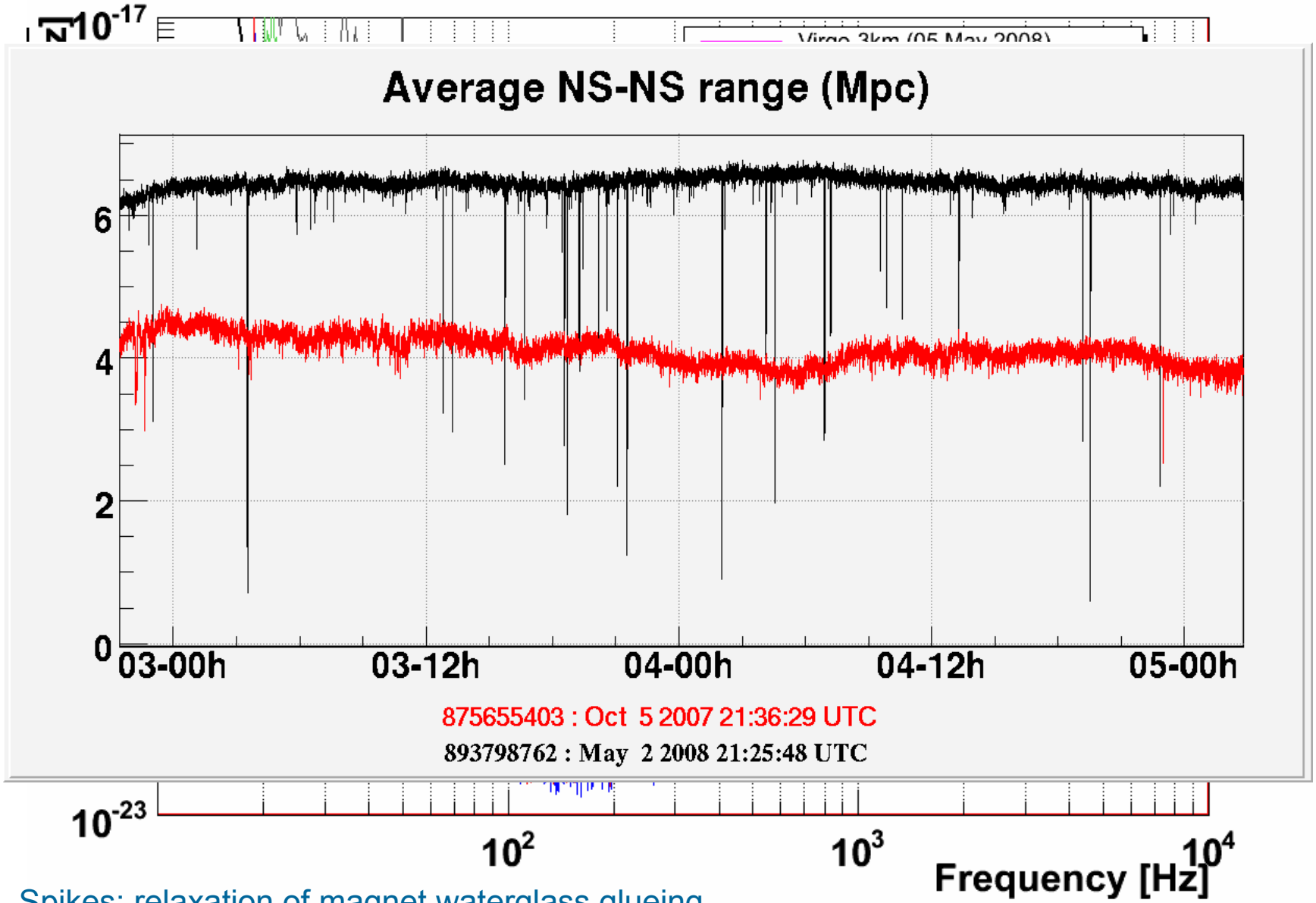


Interferometer lock at 9.2 W

Virgo Progress



Virgo sensitivity: April 2008



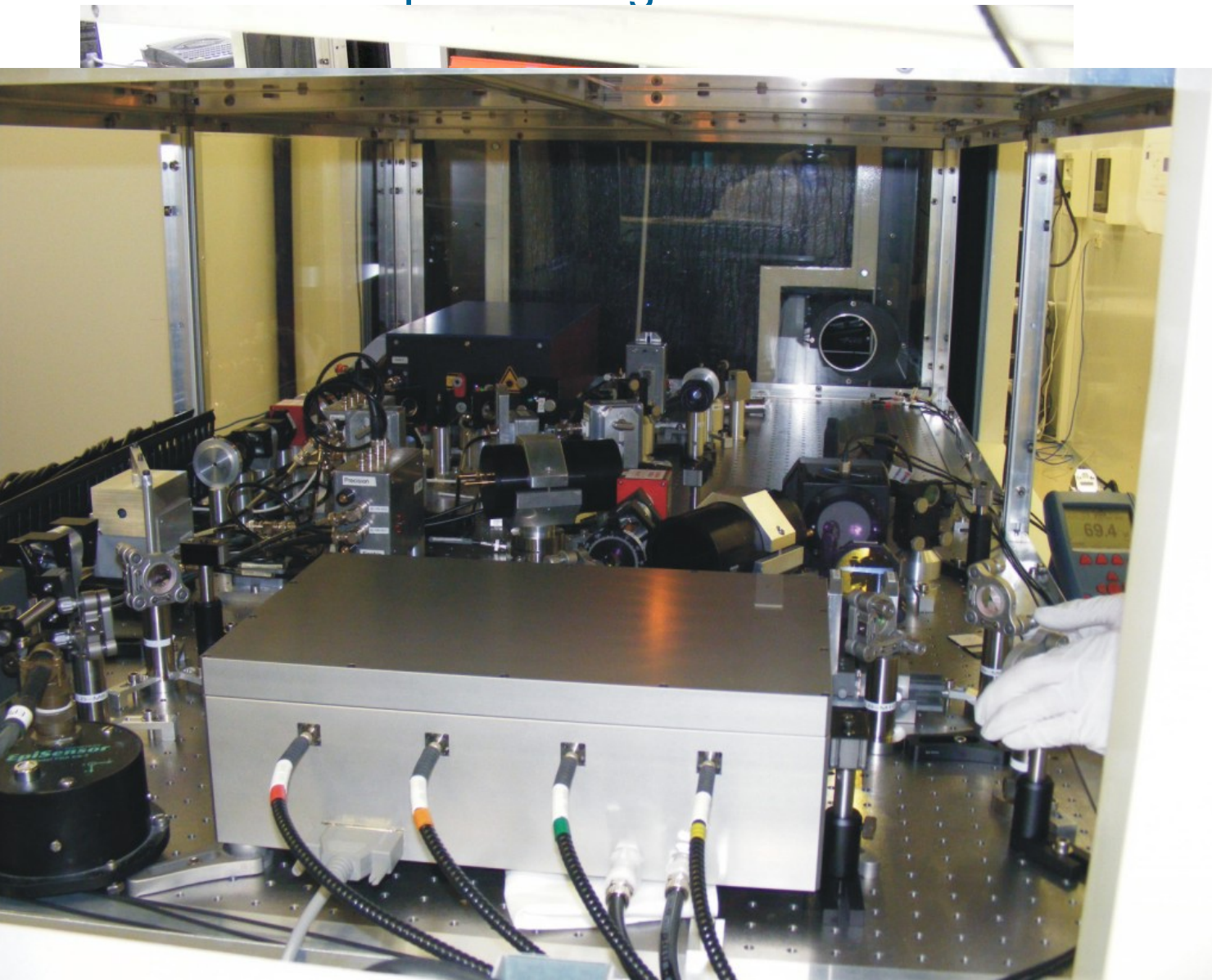
Spikes: relaxation of magnet waterglass glueing

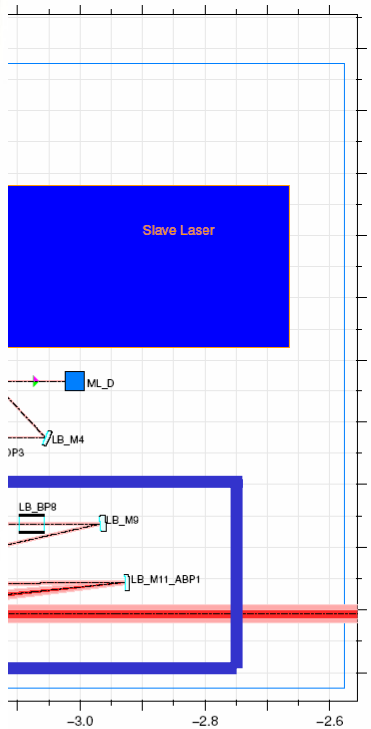
Virgo+

- High power laser and compliant optics integration
- Control and DAQ Electronics
- Environmental noise mitigation
- Control electronics
- Photodiodes under vacuum

Amplifier Integration

- The laser amplifier integration started the 22/05 (EGO, Nice)





The external injection bench

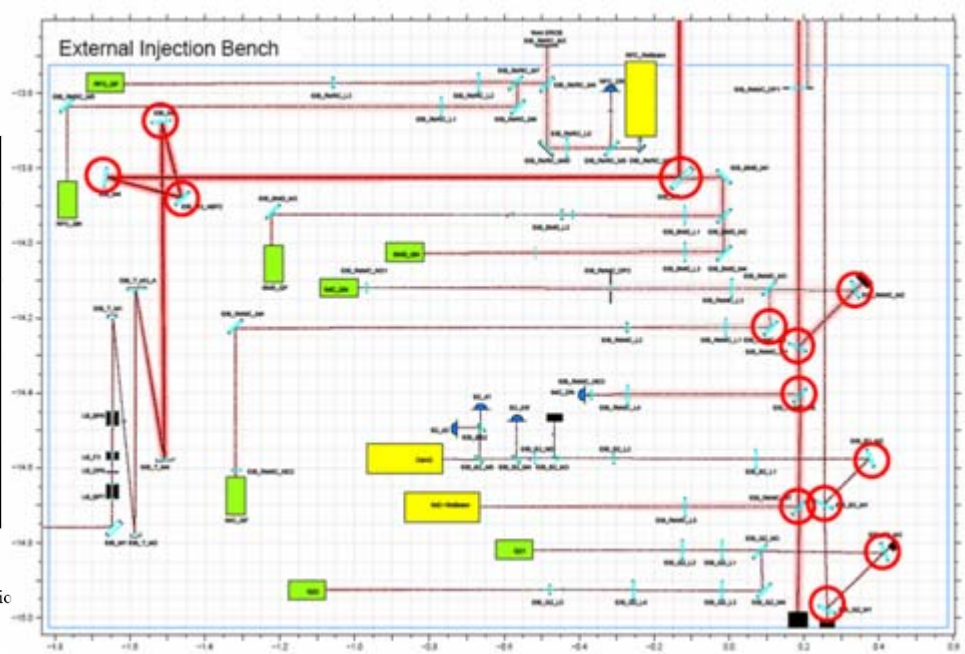
- Scattering on the injection optics is even more important with higher laser power
- A large fraction of the mirrors (13) will be replaced with mirrors superpolished by General optics and coated by LMA
- All these mirrors have been delivered to the site

LABORATOIRE MATÉRIAUX AVANCÉS

50 mm mirrors for External Input Bench (no wedge)

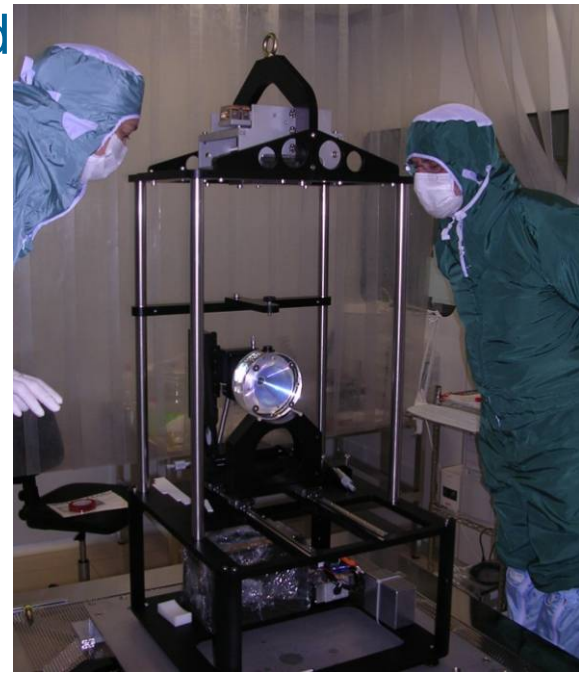
Reference	Virgo Reference	Average scattering (∅ 30 mm)	Absorption	Average Transmission (∅ 30 mm)
08019/1 T < 10 ppm S polarization, **15° inc.**	EIB_M3_ABP2	8 ppm (∅ 30 mm)	0.78 ppm	4.1 ppm
08019/2 T < 10 ppm **S polarization, 10°** inc.	EIB_M2	30 ppm (∅ 30 mm) 10 ppm (∅ 10 mm)	0.78 ppm	4.7 ppm
08018/1 T < 10 ppm S polarization, **22.5° inc.**	EIB_B2_M2	5.2 ppm (∅ 30 mm)	0.68 ppm	4.7 ppm
08018/2 T < 10 ppm S polarization, **22.5° inc.**	EIB_M4	7 ppm (∅ 30 mm)	0.64 ppm	4.2 ppm

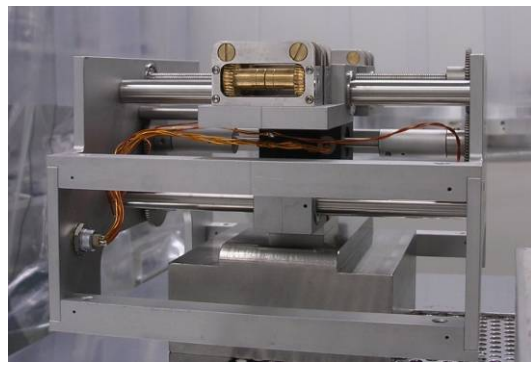
Important : the high reflectivity side is marked with an arrow on the edge of the mirror.
Nota : On the back side of these mirrors, one can see some "cracks" in silica bulk which occur during the coating depositic
Nevertheless, this problem does not affect the mirror performances.



Input Mode Cleaner

- The input mode cleaner end mirror will be replaced
  - Bad substrate quality
    - Poor coating
    - High scattering
  - Too light (360g) for the increased power
  - Payload (RM) too light
- New payload (Nikhef, Roma1, LMA)
  - Heavier (1.4kg) and better substrate
    - Better coating (protected by “first contact” film)
  - Better RM design (single piece)
  - Wider displacement range





Control and DAQ Electronics package

- A huge electronics renewal is expected during the V+ shutdown
  - Obsolescence
  - Reduction of noise
- New DAQ electronics has been developed by LAPP and the deployment of it is partially already started
- New DSP by Pisa to increase by factors real time computing power available for suspension control

Environmental noise reduction

- The reduction of the environmental noises is a “never ending story”
- During the shutdown a series of tests and actions is scheduled
- The major ones are
  - the creation of the EE room and the displacement of the laser lab electronic
  - the displacement of the detection photodiodes under vacuum

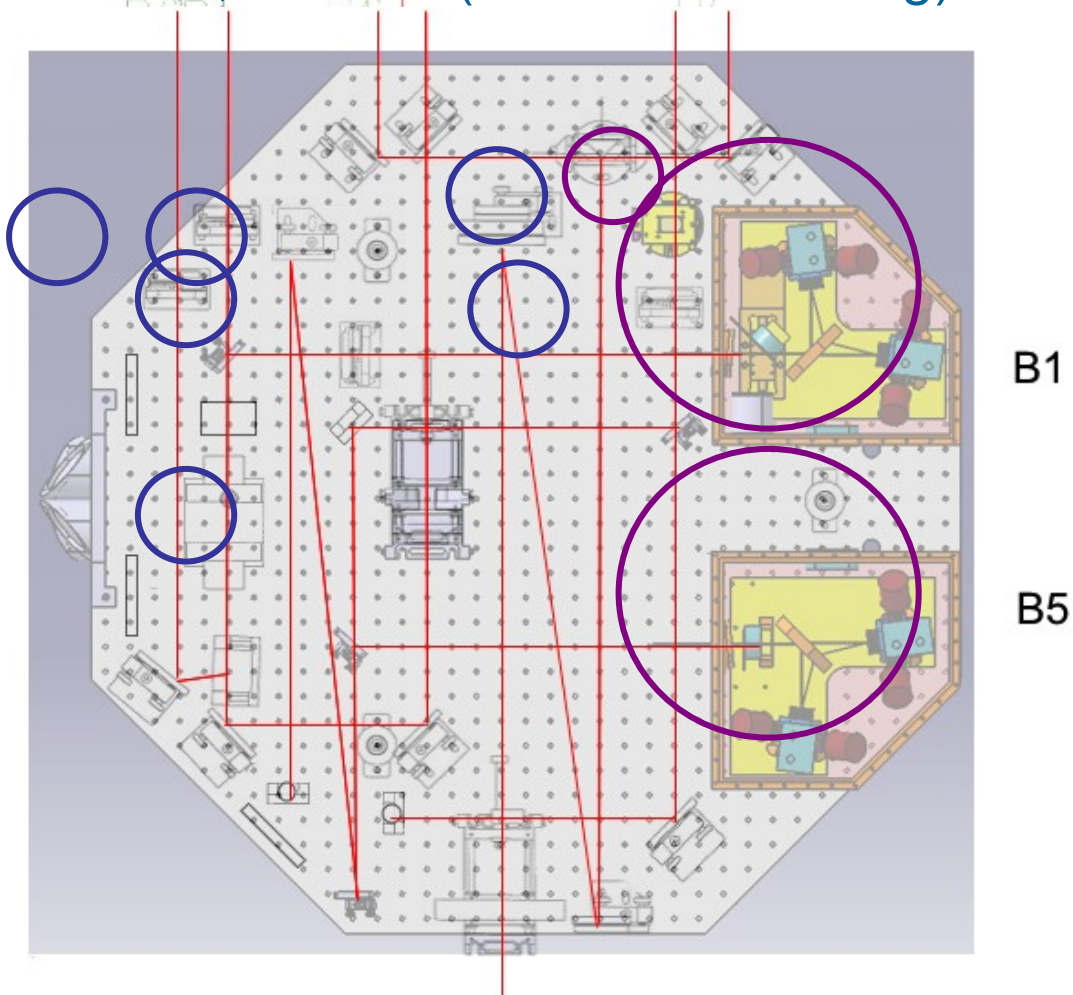
PD under vacuum

- The reduction of the environmental noise coupling will benefit of the displacement of the detection photodiodes under vacuum
- The photodiodes, the pre-amplifier, the motors and supports will go under two vacuum proof boxes, air filled (electronics cooling)

B1 is the interferometer output beam

B5 is the second Beam splitter face beam

Development by LAPP

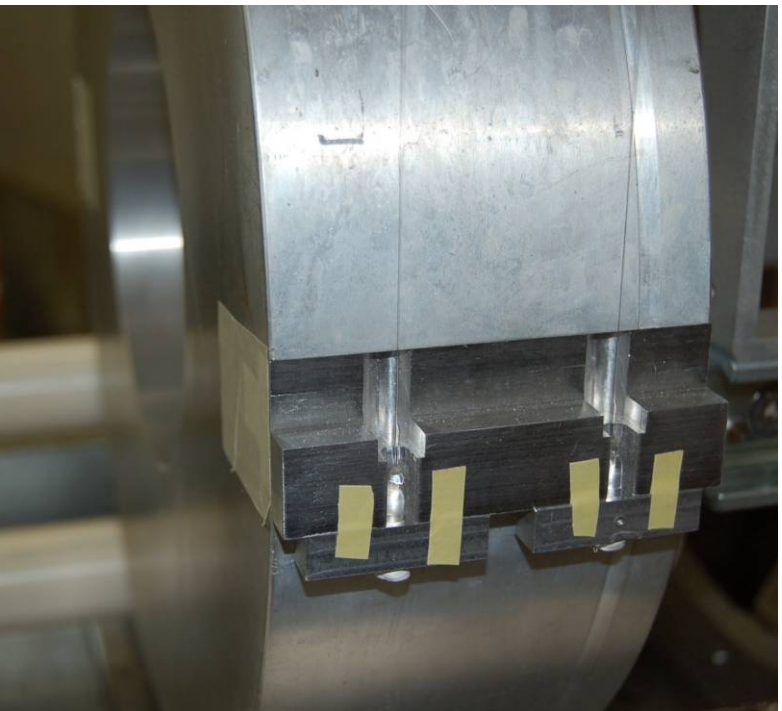


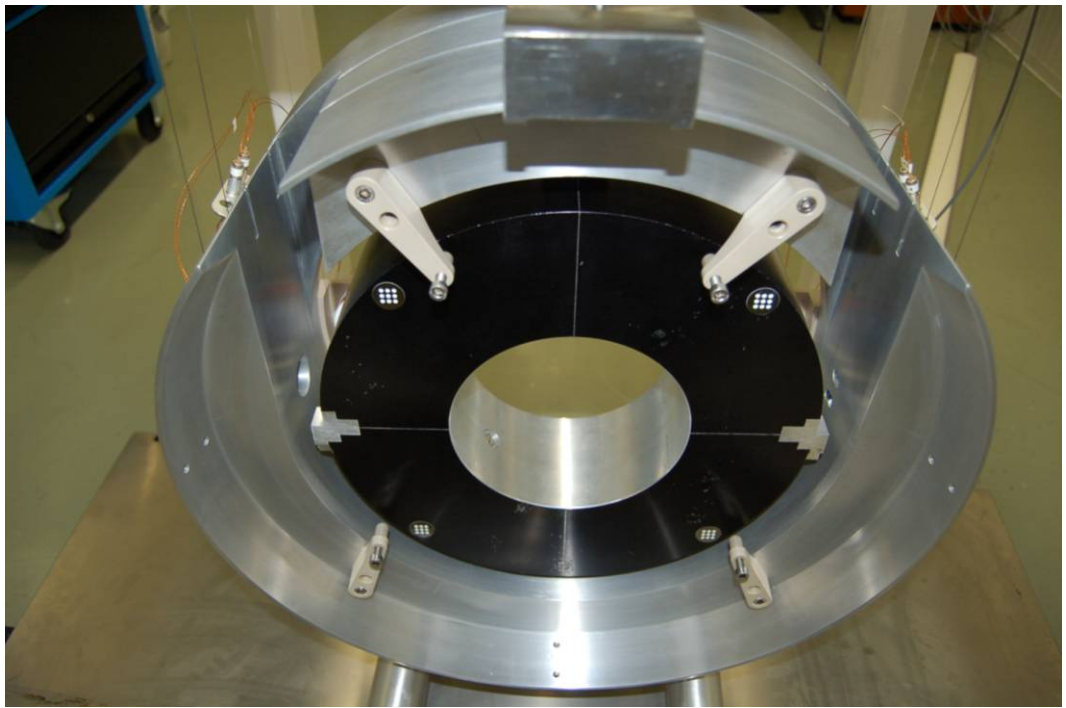
Monolithic suspension

- Monolithic suspension activity quickly progressed in the past months
  - Fiber production is well controlled by the CO2 machine (Firenze) originally realized by Glasgow
- Prototypes of the mechanical components (Marionette, RM) of the new
  en produced
  oring and control chain of the new suspension a

First (fake) prototype

- The success of the new design has been demonstrated by the first fake suspension
  - Lower clamp mimic by an aluminum ear and “matrix” (FS still to be delivered)
  - Suspension successful and repeatable
  - First control test started





THE PATH TO 2nd GENERATION

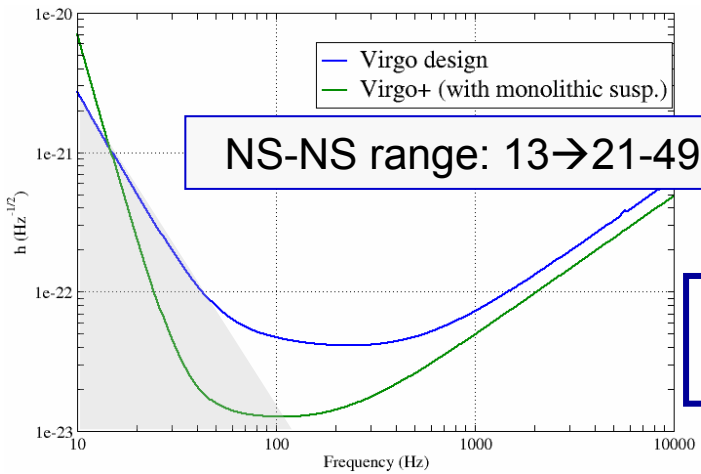
Exploit available technology to enhance the sensitivity by 2-3x.
Increase the detection probability by about one order of magnitude.
Test solutions for the 2nd generation detectors.

VIRGO+

- Increase the laser power and compensate for thermal lensing
- New electronics
- *Monolithic suspensions and new mirrors*

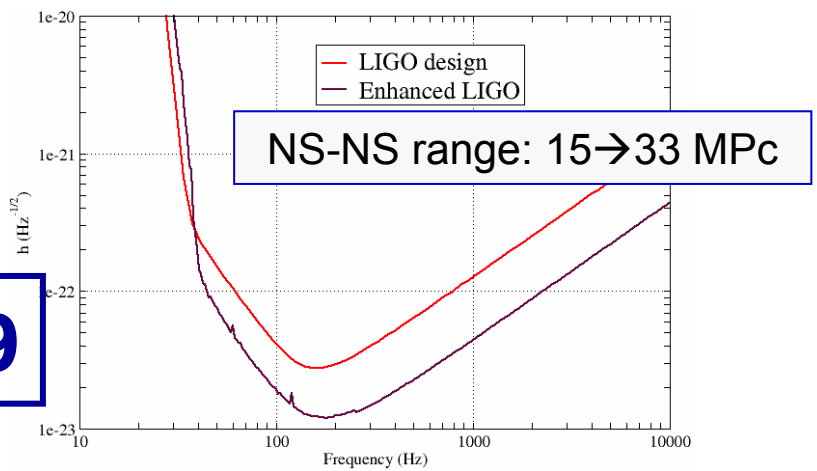
ENHANCED LIGO

- Increase the laser power
- Reduce the effect of environmental noise
- Direct (homodyne) readout of GW



NS-NS range: 13→21-49 MPc

2009

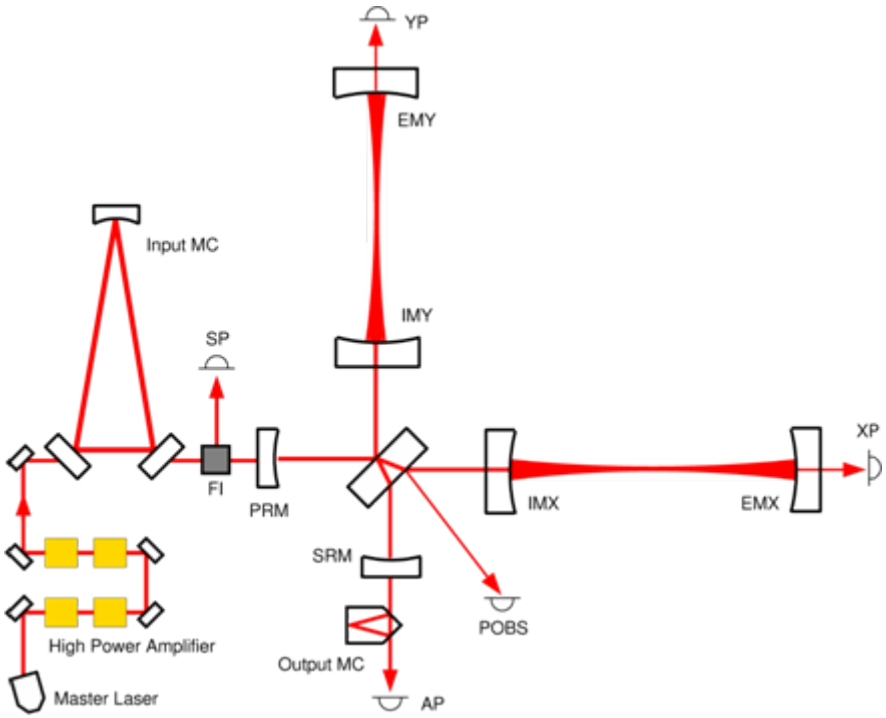


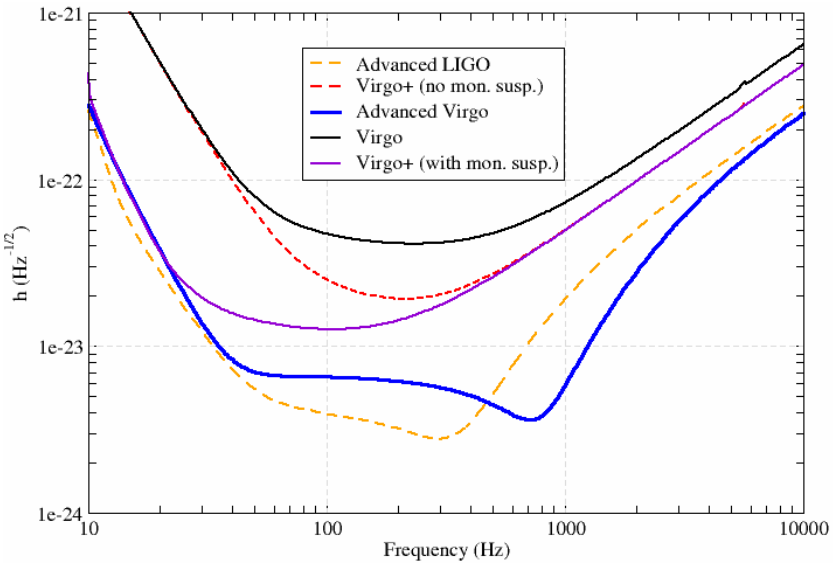
NS-NS range: 15→33 MPc

ADVANCED VIRGO (*AdV*)

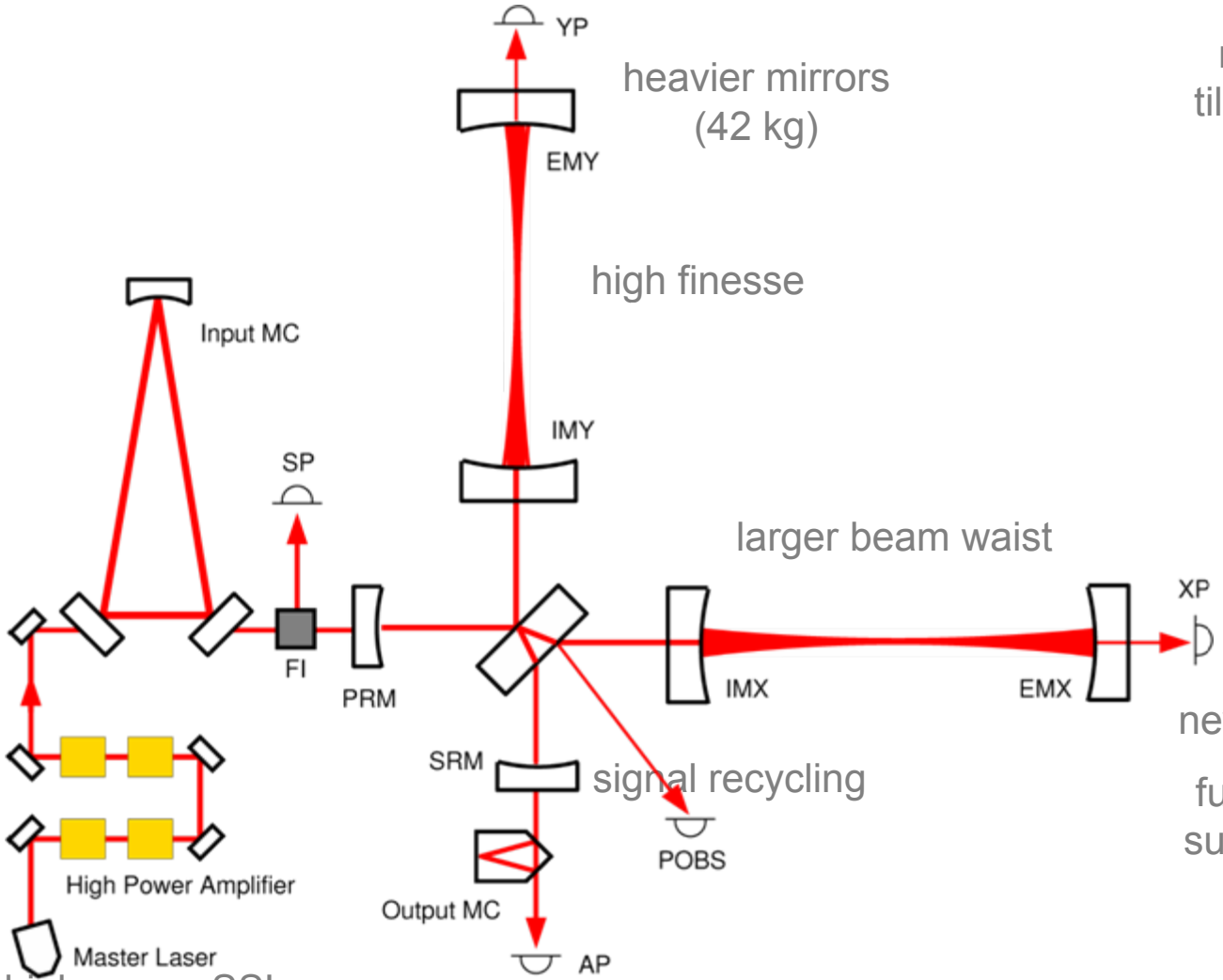
GOALS:

- Sensitivity: about 10x better than Virgo
- Timeline: be back online with Adv LIGO





AdV BASELINE - SUMMARY



heavier mirrors
(42 kg)

high finesse

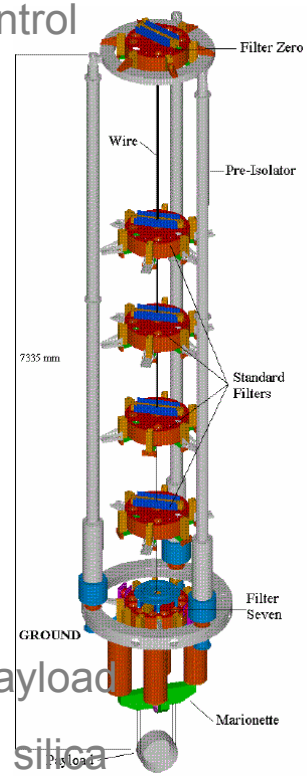
larger beam waist

signal recycling

high power SSL
(200 W)

DC detection

new IP
tilt control



new payload

fused silica
suspensions

AdV developments

Infrastructures:

- environmental noise mitigation

Optical configuration:

- DUAL RECYCLED INTERFEROMETER (RSE)
- HIGH FINESSE FP CAVITIES – F=885
- 200 W SOLID STATE LASER AMPLIFIER (LZH)
- WAIST IN THE CAVITY CENTER
- VACUUM LINKS IN CENTRAL AREA

Detection:

- PHOTODIODES IN VACUUM
- DC DETECTION

Mechanics:

- BETTER SUSPENSION POINT: IP
- NEW PAYLOAD DESIGN(MRM)
- MONOLITHIC SUSPENSIONS
- ELECTROSTATIC ACTUATORS ?

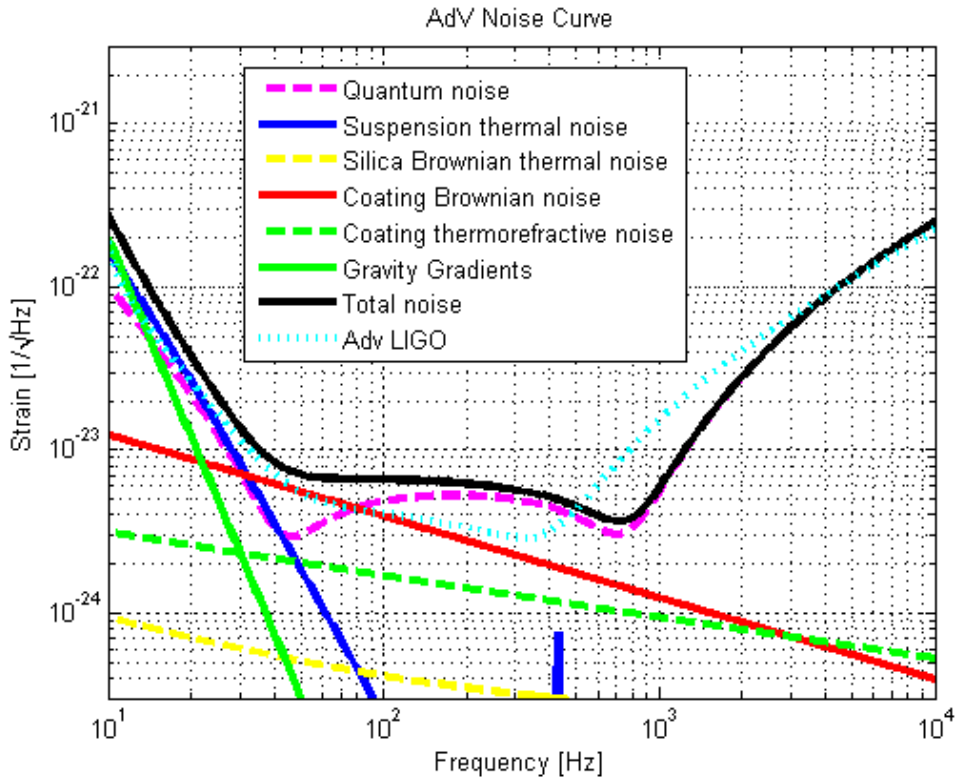
SENSITIVITY CURVE - preliminary

Reference ***AdV*** sensitivity curve. Not a frozen optical design.
Useful to start studying the impact of the various noise sources.

DESIGN PARAMETERS:

- SR mirror transmittance: 0.04
- Input mirror transm: 0.007
- Finesse: 885
- PR factor: 23.5
- Power on BS: 2.9 kW

BNS range: **121** Mpc
BBH range: **856** Mpc
1 kHz sens.: 6 $10^{-24}/\sqrt{Hz}$



Subsystem managers

- IME Infrastructure modifications A. Paoli
- VAC Vacuum A. Pasqualetti
- OSD Optical simulation and design A. Freise
- LAS Laser C.N. Man
- INJ Injection E. Genin
- DET Detection E. Tournefier
- MIR Mirrors L. Pinard
- TCS Thermal compensation V. Fafone
- ISC Sensing and control E. Calloni
- SAT Superattenuators R. Passaquieti
- PAY Payload P. Rapagnani
- DAQ Data acquisition R. De Rosa

AdV NEXT STEPS

1. *Realization of the Conceptual Design and PEP 2006-07*
2. Realization of the Technical Design 2008-2010
3. Completion of R&D and procurement 2009-11
4. Assembly and integration 2011-12

VAC	Vacuum
SAT	Superattenuators
PAY	Payload
MIR	Mirrors
TCS	Thermal compensation
LAS	Laser
INJ	Injection system
DET	Detection system
OSD	Optical simulation and design
ISC	Interferometer sensing and control
DAQ	Electronics, software and data acquis
DAM	Data management
IME	Infrastructure modifications for env. n reduction

- **Mid 2008:** subsystem breakdown and work plans
- **Fall 2008:** first ***AdV*** review
  - to review the subsystems plans and activities
  - to take a final decision on the open options with the biggest impact on the design

Collaboration News

- Next Virgo (and LV) meetings
  - June 23-24: EGO Council meeting (R&D Budget)
  - July 15-17: V Week; Cascina
  - **Sep 22-25: LV meeting Amsterdam** (With “Instrument Science” topics)
    - 20-21: f2f in Nikhef
    - Thomas Bauer (Nikhef) for organization
    - Post meeting expected?
  - November: EGO Council meeting (Advanced Virgo ?)

Perspectives

- The NE tower incident is serious but the Virgo collaboration is doing its best to start VSR2 with eLIGO
- Improvements in sensitivity at low frequency are very stimulating, no principle limitation seen
- Further improvements are on track for a performing Virgo+ interferometer
- Advanced Virgo is seen as the necessary continuation of the project, although we are in difficult times for resources

FROM THE EGO COUNCIL REPORT

- **The Council (…) recognizes the importance of the *AdV* program which will allow entering into the domain of gravitational wave astronomy.**

- The Council supports the ***AdV*** project and takes note of the proposed milestones. Adding new collaborators would certainly make the funding easier and this should be actively pursued. The Council also took note of the need to involve the funding Institutions in order that a decision on its funding be taken timely as the work plan indicates and as needed to have ***AdV*** operative at the same time as Advanced LIGO.