



# VIRGO STATUS REPORT

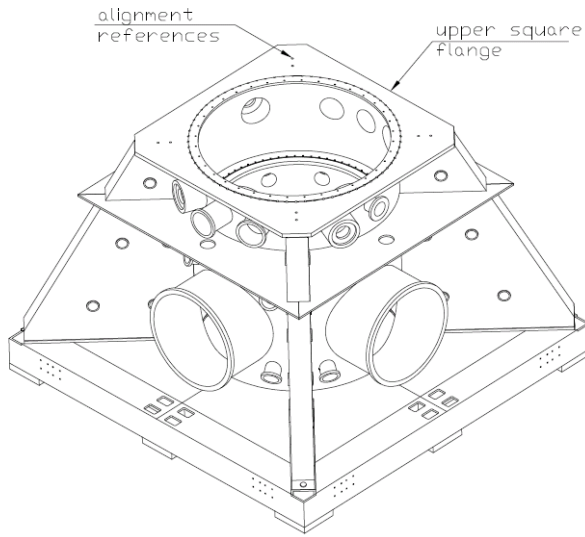
F. Fidecaro

Amsterdam, September 22, 2008



- Viewport status
- Detector and commissioning plans
- Data Analysis
- Advanced Virgo

# The North End tower accident - May 9, 2008



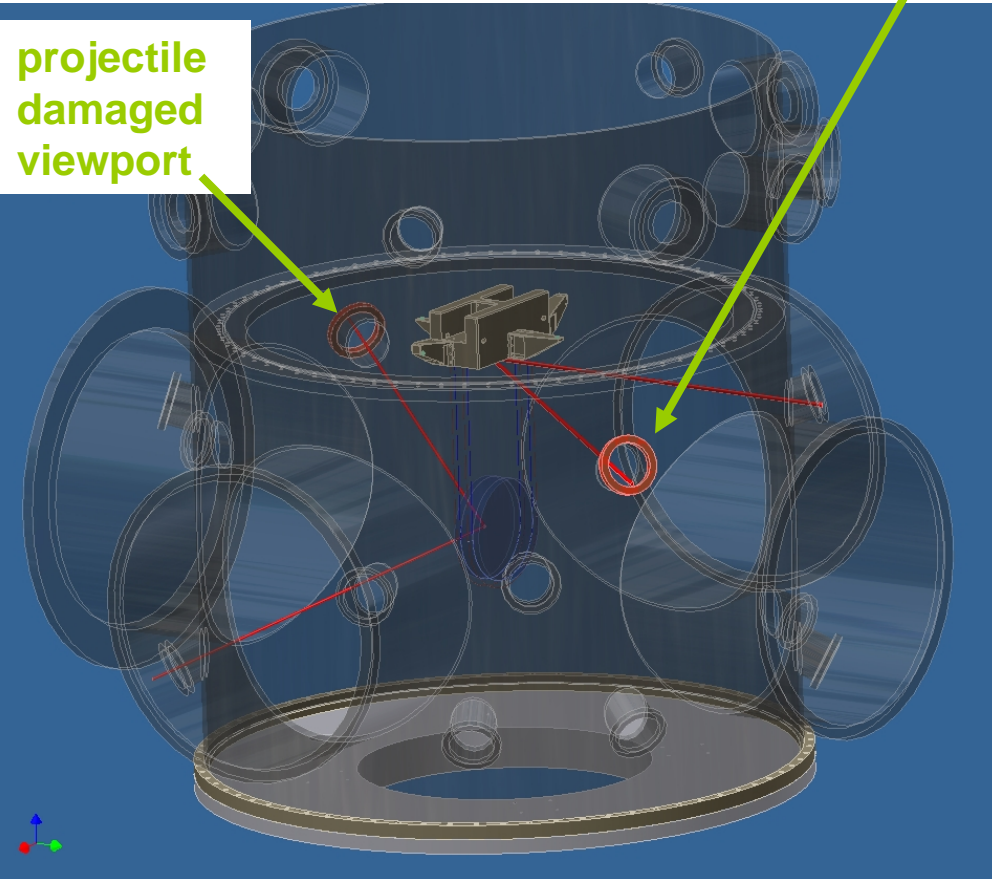
This **viewport imploded at 0.12 bar ( $\Delta P = 0.88$  bar)**, about 90' after evacuation start (the valve to the 3 km tube was closed)

- One fragment hit another (facing) viewport
- CF150 standard viewports off the catalog
- In Virgo >100 such viewports

These viewports are crossed by 1 mW red laser beams for payload position control

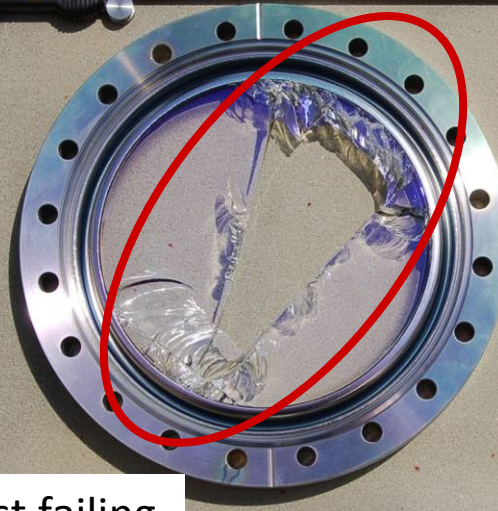
Accelerometers and microphones detected "precursor" cracks about 10' before the failure

Slow air re-enter:  
 back to 0.5 bar in 20 sec  
 back to 1.0 bar in 100 sec

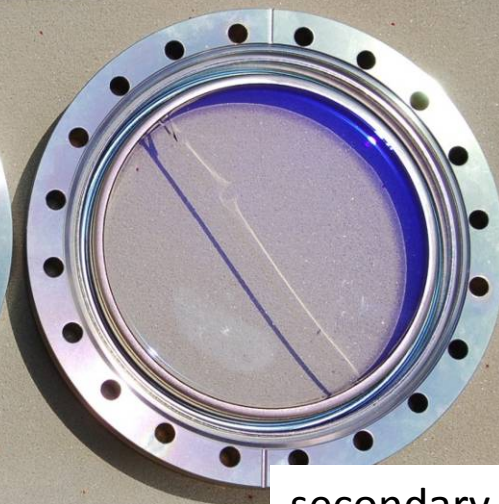




# Broken Viewports



first failing



secondary



From inside

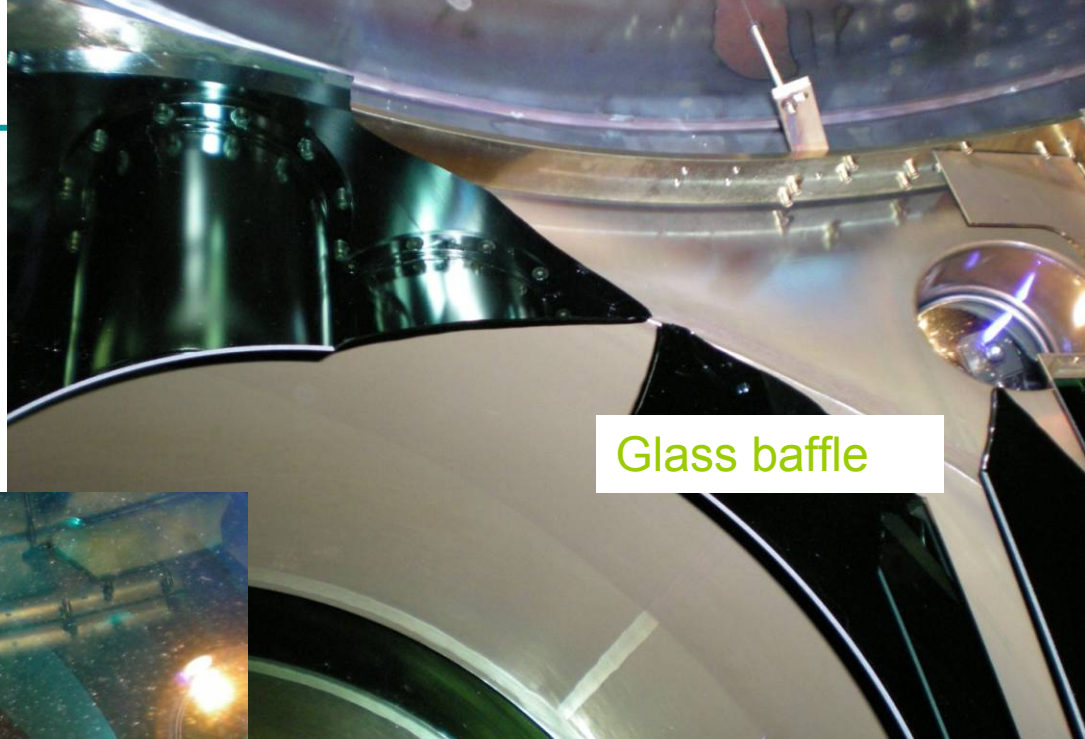


From outside





# Additional damages



Glass baffle



NE mirror



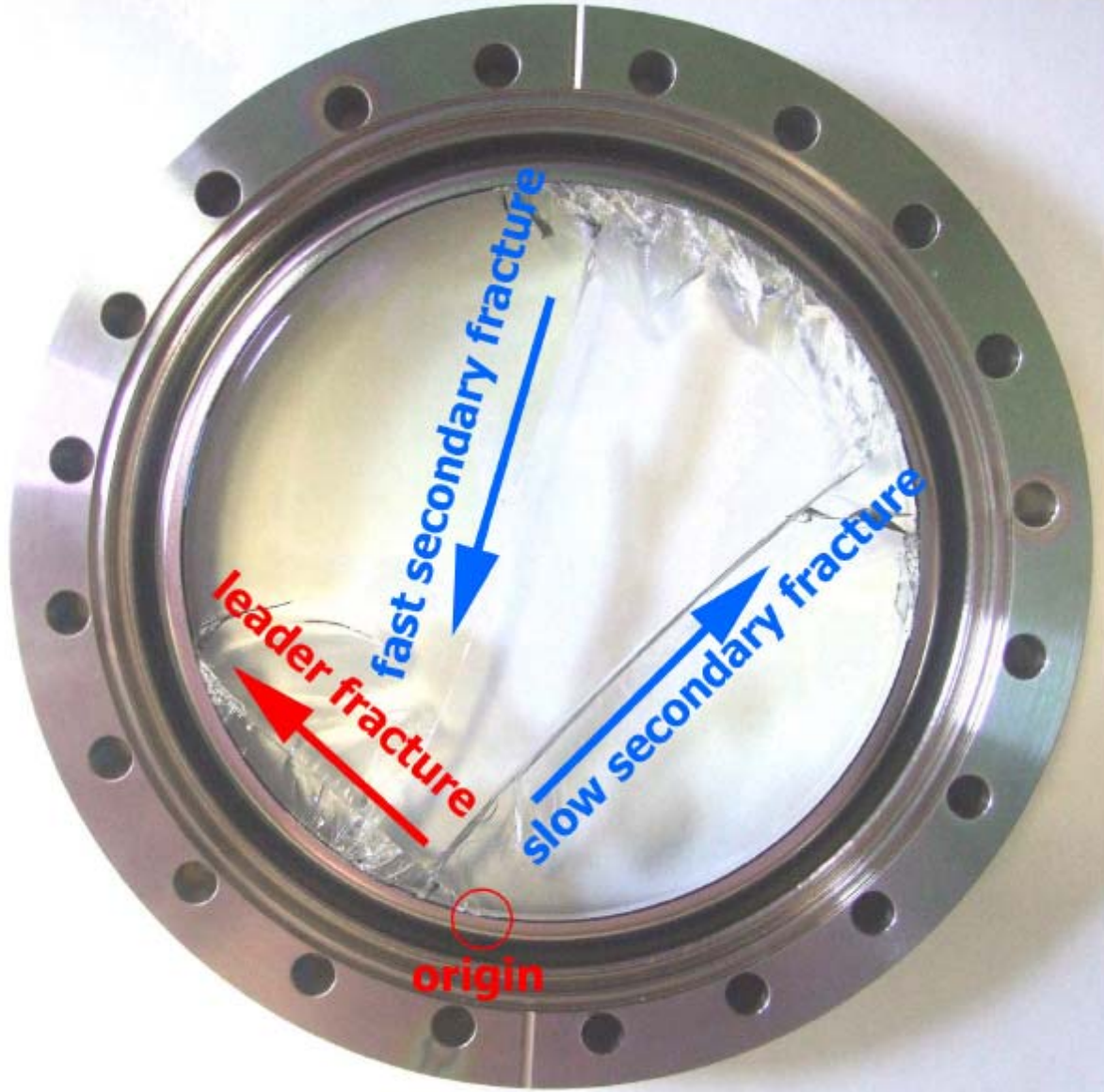
NE recoil mass



- North arm tube venting (safety)
- payload and broken glass baffles removal from NE tower
- tower and large valve: inside inspection and cleaning (glass debris everywhere)
- glass viewports replacement by blind flanges
- tower evacuation checking for tightness and anomalous deformations
- arm tube evacuation
- review of safety rules to work in proximity of viewports (never with vacuum)



- NE accident investigation group ( ~ weekly meetings)
- Signal analysis (seismometers, accelerometers, microphones, thermometers, pressure gauges, etc)
- Enquiries (manufacturers, literature, laboratories)
- Brainstorming meeting at Cascina, June 4, 2008  
(LIGO, CERN, INFN Frascati, SSV Murano, EGO, Virgo)
  - fracture analysis (no shock evidence)
  - viewport FEM (weak design)
  - hydraulic breaking tests (low safety, break down at 1.5 – 3.5 bar)
  - pre- post-installation viewport inspection methods
  - safer-design-manufacturer search (Larson, CA)
  - tower FEM (safety confirmed)
  - Virgo custom viewports FEM (safety confirmed)



**Fracture analysis by  
Stazione Sperimentale del  
Vetro**

**Murano, Venezia**

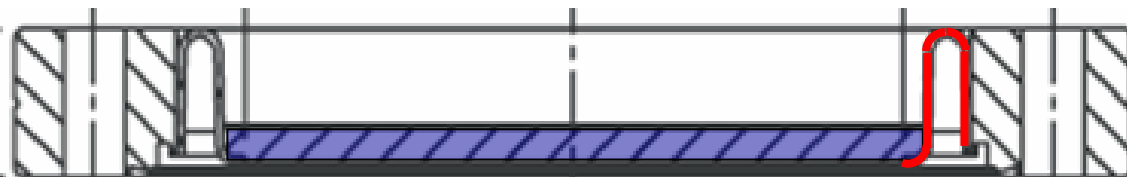
Failed viewport seen from  
vacuum side

Semicircular origin  
 $r=0.7\text{mm} \rightarrow 20\text{ MPa}$

no shock evidence

**Reason for failure**

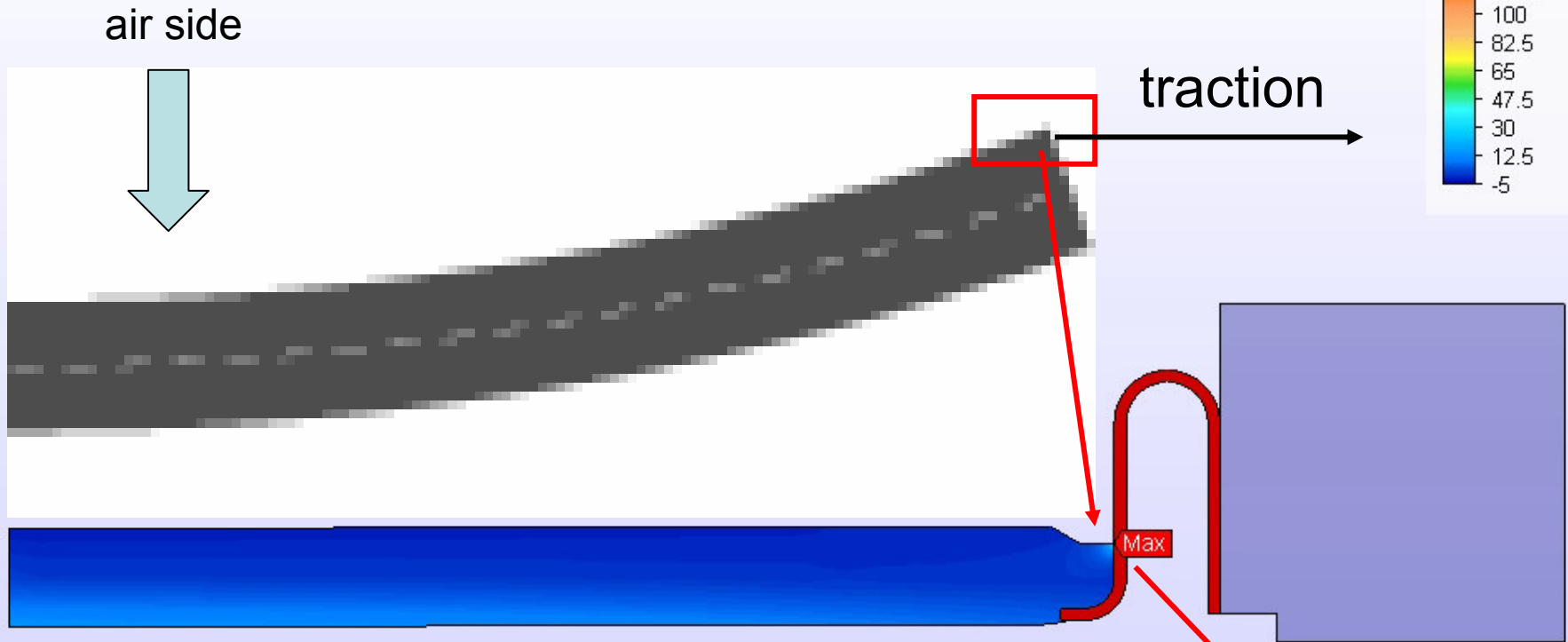
Initial defects (little bubbles)  
+ weak design







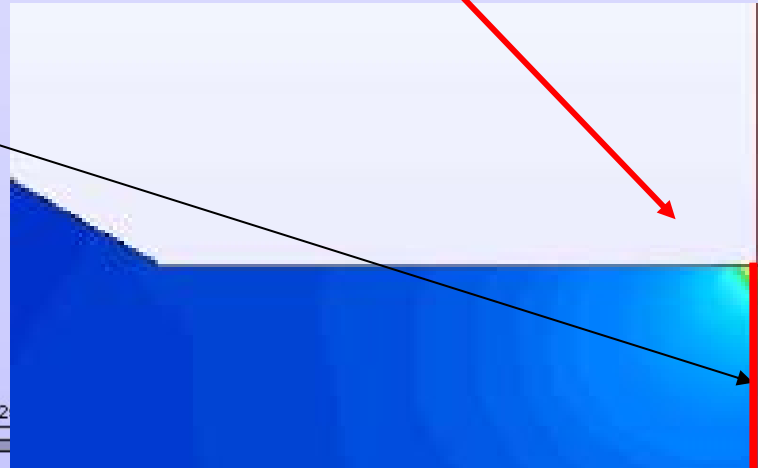
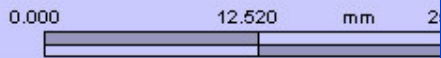
# stazione sperimentale del vetro



Under vacuum the **lateral brazing** creates excessive tensile stress

Good practice suggests to stay below 10 MPa

maximum value 135 MPa





Hydraulic tests - Viewport 72 – failed < 1.5 bar



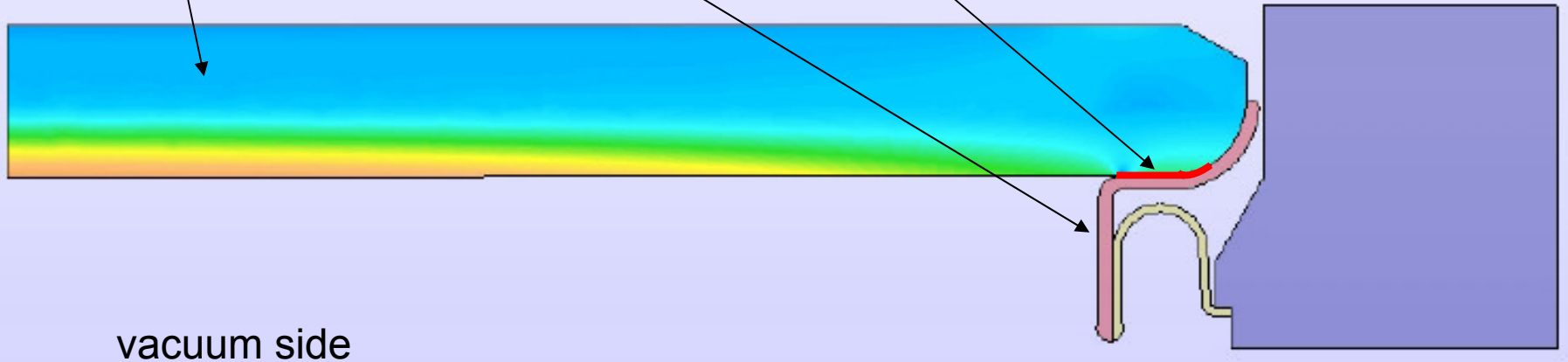
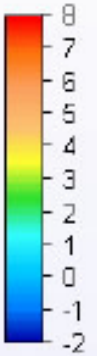


# stazione sperimentale del vetro

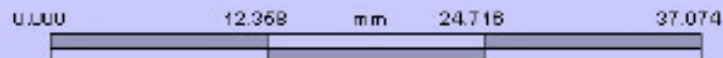
Stress  
Maximum Principal  
N/(mm<sup>2</sup>)

## Larson viewport

- Glass thickness 9.5 mm instead of 6.5 mm
- Double soft connection to the flange
- No lateral **brazing** (only front face)  
low tensile stress



maximum value 7.9 MPa





1. Original Virgo viewports are unsafe; "good" viewports have been identified.
2. All Virgo viewports have to be changed
3. Towers progressively put into a safe mode to protect the ITF:
  - no tower re-evacuated with old viewports
  - viewports replaced by blind flanges and towers re-evacuated (cleanliness)
  - while this was progressively done, commissioning activity went on
4. Safe viewports have been ordered and are being installed. **Sequence arranged to boost Virgo+ commissioning: full Virgo operative at Oct. 31\***
5. The goal remains to start VSR2 by mid 2009

\* all minimum necessary viewports already delivered





- Choice of best substrate
  - Radius of curvature similar to WE (3630 m)
  - Reasonable flatness (3 nm rms)
- Coating using Ta<sub>2</sub>O<sub>5</sub>
  - No need for Ti doped Ta<sub>2</sub>O<sub>5</sub> (mirror substrate is in Herasil)
  - HR, transmission 10-15 ppm, diameter = 330 mm
  - AR, reflection < 100 ppm, diameter = 270 mm

Laboratoire des Matériaux Avancés - Villeurbanne - France

TC00059.10R

Wavelength  
= 1.0640 μm

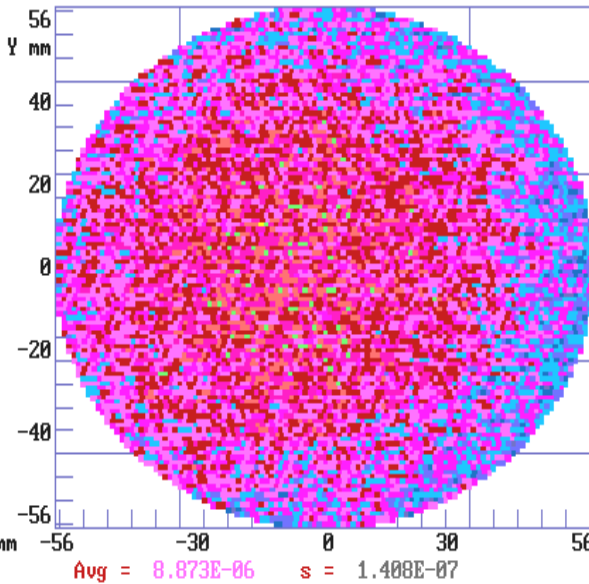
Reflectance  
R = 0.9E-05

Angles:  
θ<sub>i</sub> = 1.00°  
θ<sub>s</sub> = 1.00°  
α = 0.00°

Spot Dia., mm  
= 1.000

Step Size, mm  
= 1.000

Scan Ctr., mm  
X = 0.000  
Y = 0.000



Average transmission 9 ppm

Laboratoire des Matériaux Avancés - Villeurbanne - France

RC00059.10R

Wavelength  
= 1.0640 μm

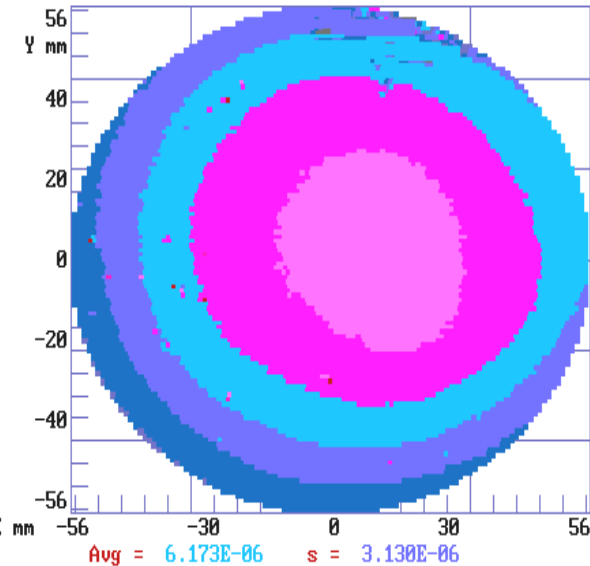
Reflectance  
R = 0.1E-04

Angles:  
θ<sub>i</sub> = 4.00°  
θ<sub>s</sub> = 4.00°  
α = 0.00°

Spot Dia., mm  
= 1.000

Step Size, mm  
= 1.000

Scan Ctr., mm  
X = 0.000  
Y = 0.000



Average reflection 6 ppm



- Mirror characterization
  - Scattering
  - Absorption

Laboratoire des Matériaux Avancés - Villeurbanne - France

C08059B.10R

Wavelength  
= 1.0640 μm

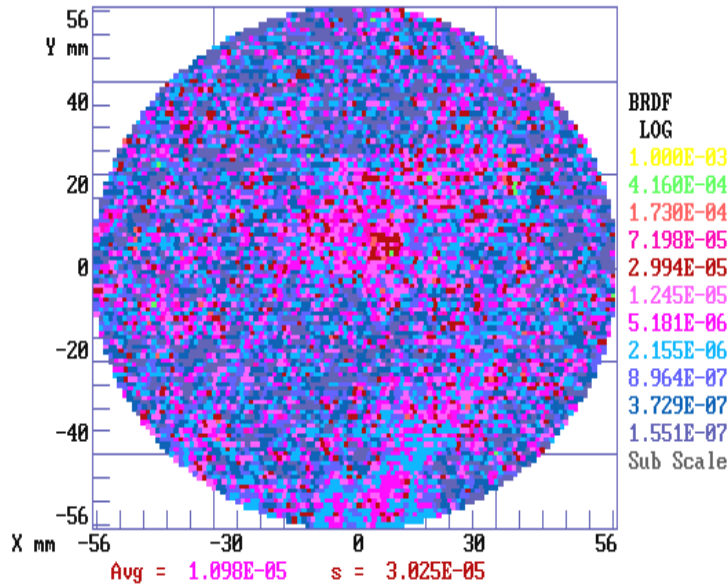
Reflectance  
R = 0.9238

Angles:  
θ<sub>i</sub> = 4.00°  
θ<sub>s</sub> = 14.00°  
α = 0.00°

Spot Dia., mm  
= 1.000

Step Size, mm  
= 1.000

Scan Ctr., mm  
X = 0.000  
Y = 0.000

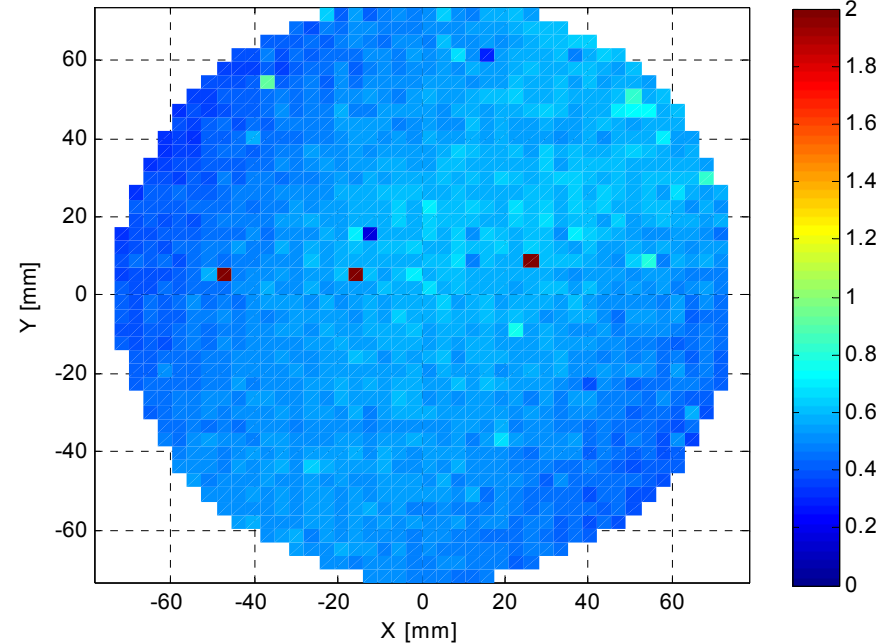


Average scattering 5.5 ppm

No points with large scattering :

No bubbles

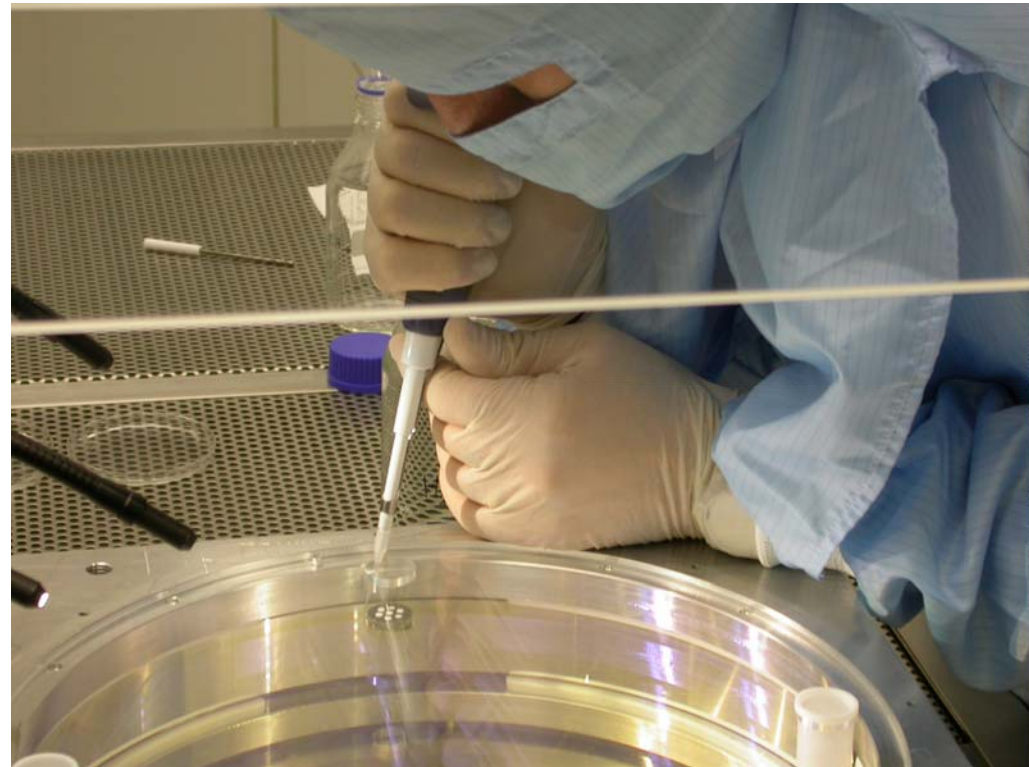
Absorption [ppm], échantillon : VEM05a01



Average absorption 0.5 ppm



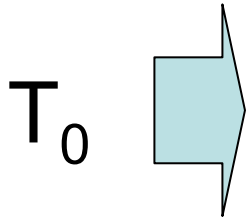
- Mirror preparation: spacers, markers, magnets glued
- Protection film added
- Marionetta cleaned, recabled and balanced
- Steel wire thermal cycling
- To be assembled in one week from now (Sep 29)
- To be suspended with small magnets the following week (Oct 6)





## Definition of $T_0$

- ISYS commissioned
- All needed viewports installed
- NE new payload installed



Expected  $T_0$  date : Oct 31



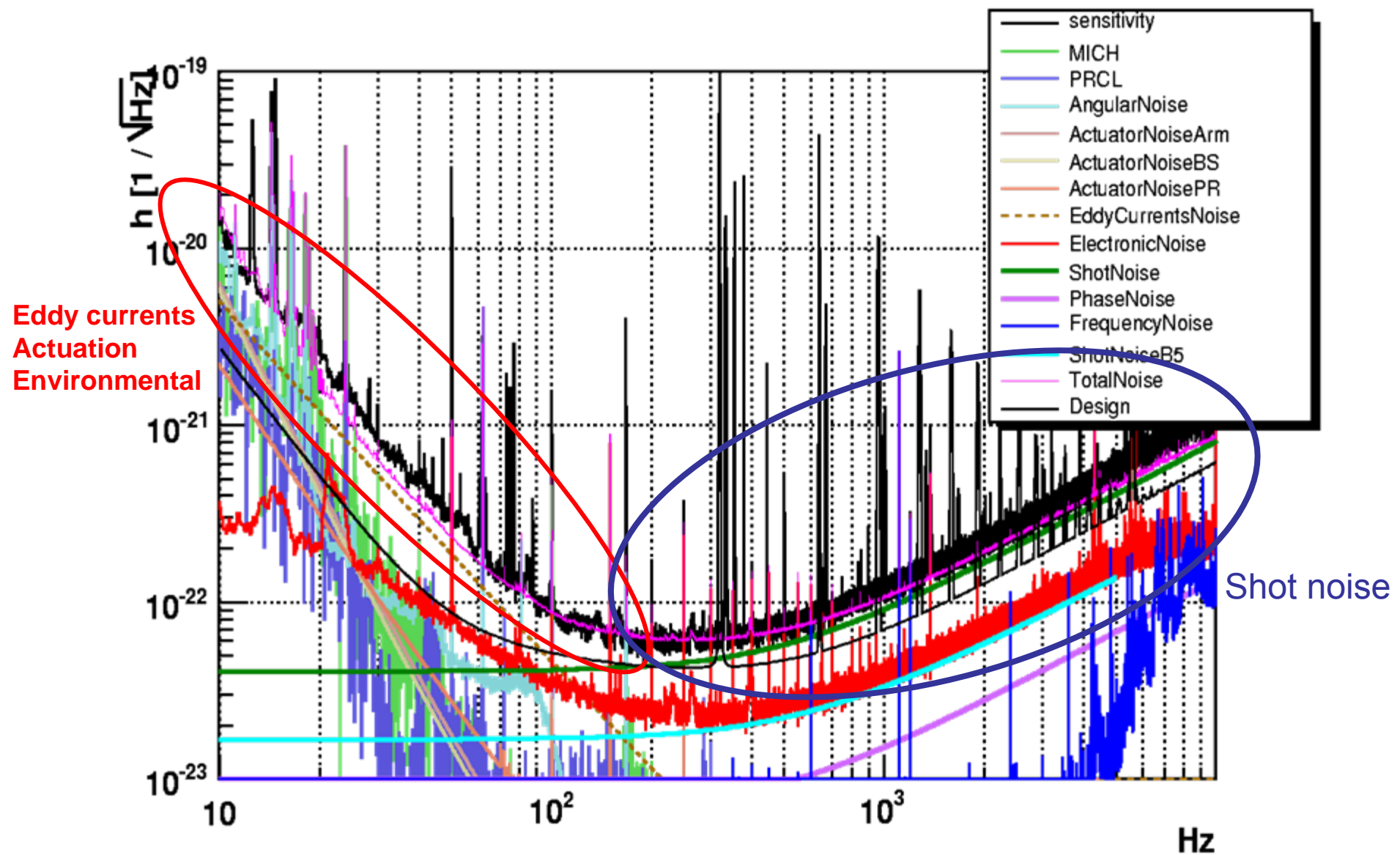


- 1) Reasonable hot ITF sensitivity (May 2008 situation)
  - Tuning of controls
  - Noise hunting
- 2) Standard configuration with TCS (“cold-8 watts”)
  - Cold 1 W interferometer
  - Increase to 8 W
- 3) Full power and high sensitivity
  - Science mode definition at low power
  - High power

Interleaved: hardware work (electronics, phase camera, HVAC?)



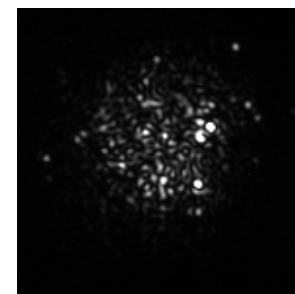
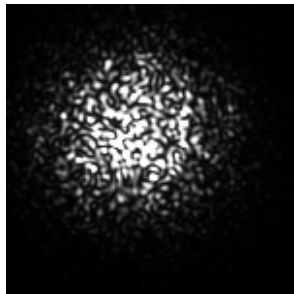
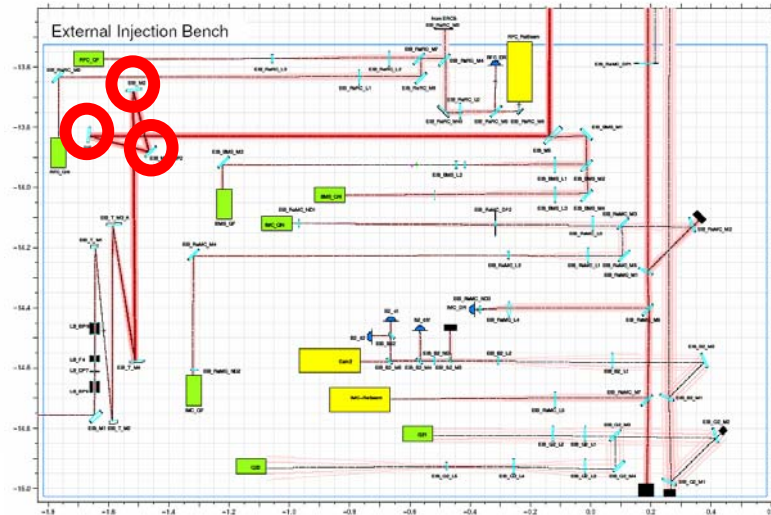
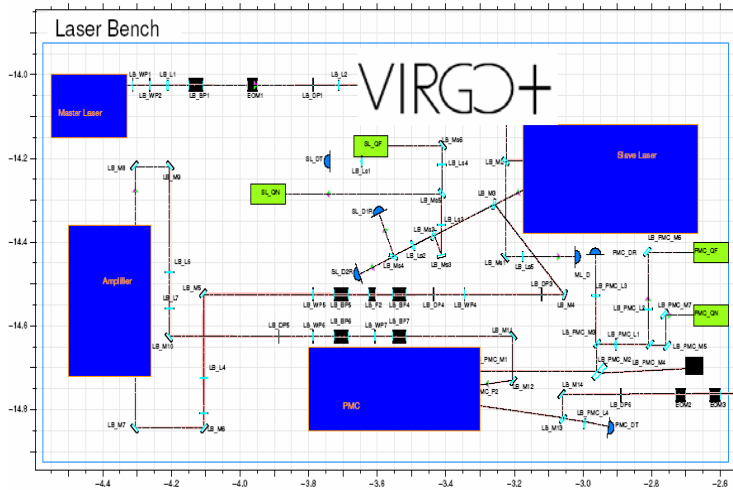
# Typical noise budget May 2008





- Laser amplifier integration (end of may)
  - Pre Mode-Cleaner cavity integration (june)
    - Seed power : 19W  $\Rightarrow$  Power on PMC = 60.3W  $\Rightarrow T_{\text{PMC}}=87.7\% \Rightarrow P_{\text{outPMC}} = 52.9 \text{ W}$ .
  - New IMC end mirror has been installed in parallel with the previous actions.
  - IMC relock (mid-july)
  - Remote control of power adjustment and loop gains
  - IMC and SIB faraday isolator thermal effects checks.
  - Laser pumping diodes displacement in External Electronics room (august)
  - SIB Faraday isolation improvement by adding an halfwave plate between the first polarizer and the Magneto-optic crystal (2 weeks are needed).
- $\Rightarrow$  ISYS commissioning should be completed by the end of october.

Unexpected work : laser chiller substitution.



Beam image on the mirror (old optics)    Beam image on the mirror (new SP mirrors)





## **CBC:**

- Joint LSC-Virgo low mass search + follow-up
- GRB: working to include Virgo data in the search
- Contributing to the computing effort to run LSC pipeline through GRID (with Lyon and Bologna CCs in mind)
  - Low latency Virgo CBC analysis for detector characterisation
  - Contributing to the low latency LSC-Virgo analysis configuration and organization for VSR2/S6

## **BURST:**

- All Sky search (EGC pipeline), 300-5000 Hz, S5/VSR1. This will be a search only for detection purpose
- All Sky High Frequency search (cWB), 1000-6000 Hz, S5/VSR1. It could be ready for the internal review.
  - Low latency Virgo Burst analysis for detector characterization
  - Contributing to the low latency LSC-Virgo analysis configuration and organization for VSR2/S6
  - Two paper accepted (GRB, Virgo bars) for publication in CQG, one in the final phase of internal review (all-sky). All on C7 analysis
- GRB070729 studied jointly (WDF and X-pipeline) to allow a detailed comparison of both pipelines. All other GRBs post 2007 May 18th : pipeline TBD.

**DQ/Vetoos:** work essentially completed for VSR1



## CW

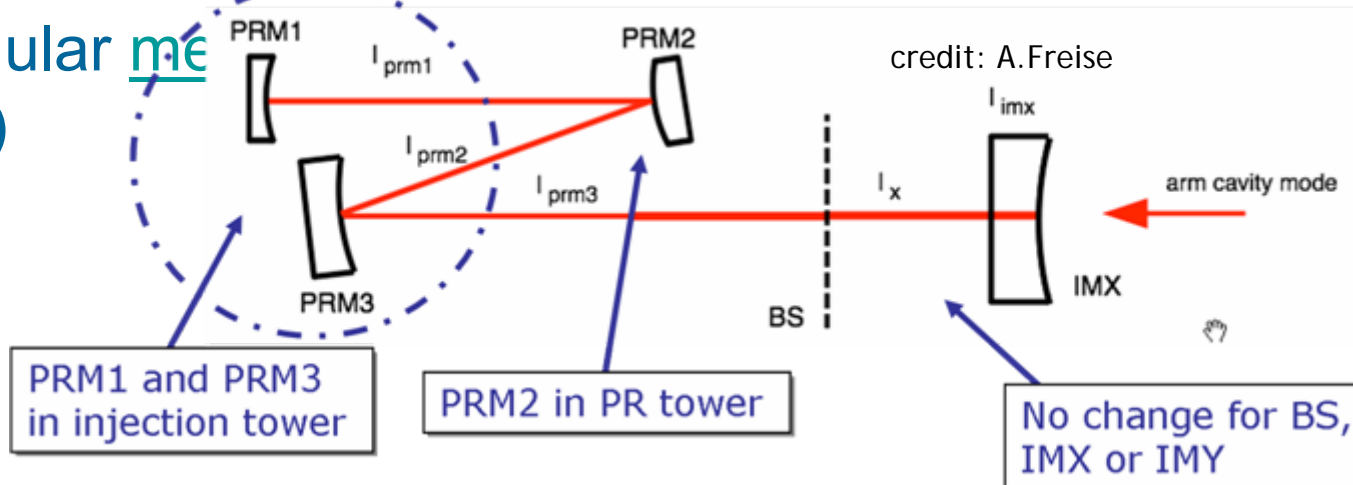
- targeted search for known isolated NS (e.g. Vela, Crab)
  - 2 methods in good state of progress. Pipelines ready by the end of the year.
- semi-targeted search for isolated NS (e.g. sources in globular clusters)
  - re-sampling code developed and tested.
- blind search for isolated unknown NS
  - hierarchical search: started analysis on VSR1-v2 data
  - optimal search on 2-days segments: started analysis on VSR1-v2 data
- blind search for unknown NS in binary systems
  - software in development; first tests done
  - LIGO/Virgo joint analysis discussed at the f2f
- development of a Doppler correction technique independent of the source frequency

## STOCHASTIC BACKGROUND

- Isotropic search: started to use the Virgo pipeline. Interrupted this week due to a data loss. Will restart after this meeting.
- Spherical harmonics decomposition: currently testing pipeline via software injections
- Non-gaussian SB: popcorn pipeline (in LALAPPS) tested on gaussian noise and currently running on the full set of project1b data
- LIGO/Virgo time-shift analysis results: adding Virgo to the network will decrease the error bar by a factor of 2
- Results in the high frequency band is expected to improve on previous results
- Hardware injection problems nearly understood: estimated delay in the VIRGO injection pipeline in agreement with findings of other groups and rough expectations

- Moving from conceptual to preliminary design
- Main open issues:
  - **non degenerate recycling cavities:** we are currently studying the impact on the facilities and the solutions to suspend the extra mirrors
  - **thermal compensation:** which scheme?
  - **cryotraps** to separate the pipes from the towers and allow the bakeout
  - **mirror mass:** 40 or 60 kg?

• Regular  $m_e$  join)



to



- AdV to face a two-step project review by an external committee.
  - 1st meeting: 3-5 Nov 08
  - 2nd meeting: Spring 09
- **Members of the External Review Committee**
  - B. Barish – Chair, former LIGO Director
  - H. Lueck – STAC chairman
  - P. Dargent – CNRS, IN2P3 Technical Director
  - C. Salomon – CNRS, member of STAC
  - G.Tino – INFN, Virgo referee for INFN
  - G.Cantatore – INFN, Virgo referee for INFN
- Issue recommendations to the EGO Council (composed by delegates of CNRS and INFN)





- Viewport story seems to come to an end
- Progress toward Virgo+ is steady, light will be circulating again soon
- Path toward VSR2 is established
- Data analysis activities are progressing, LSC-Virgo integration is in progress in all groups
- Intense effort for AdV approval