Thermal Compensation System for Virgo+

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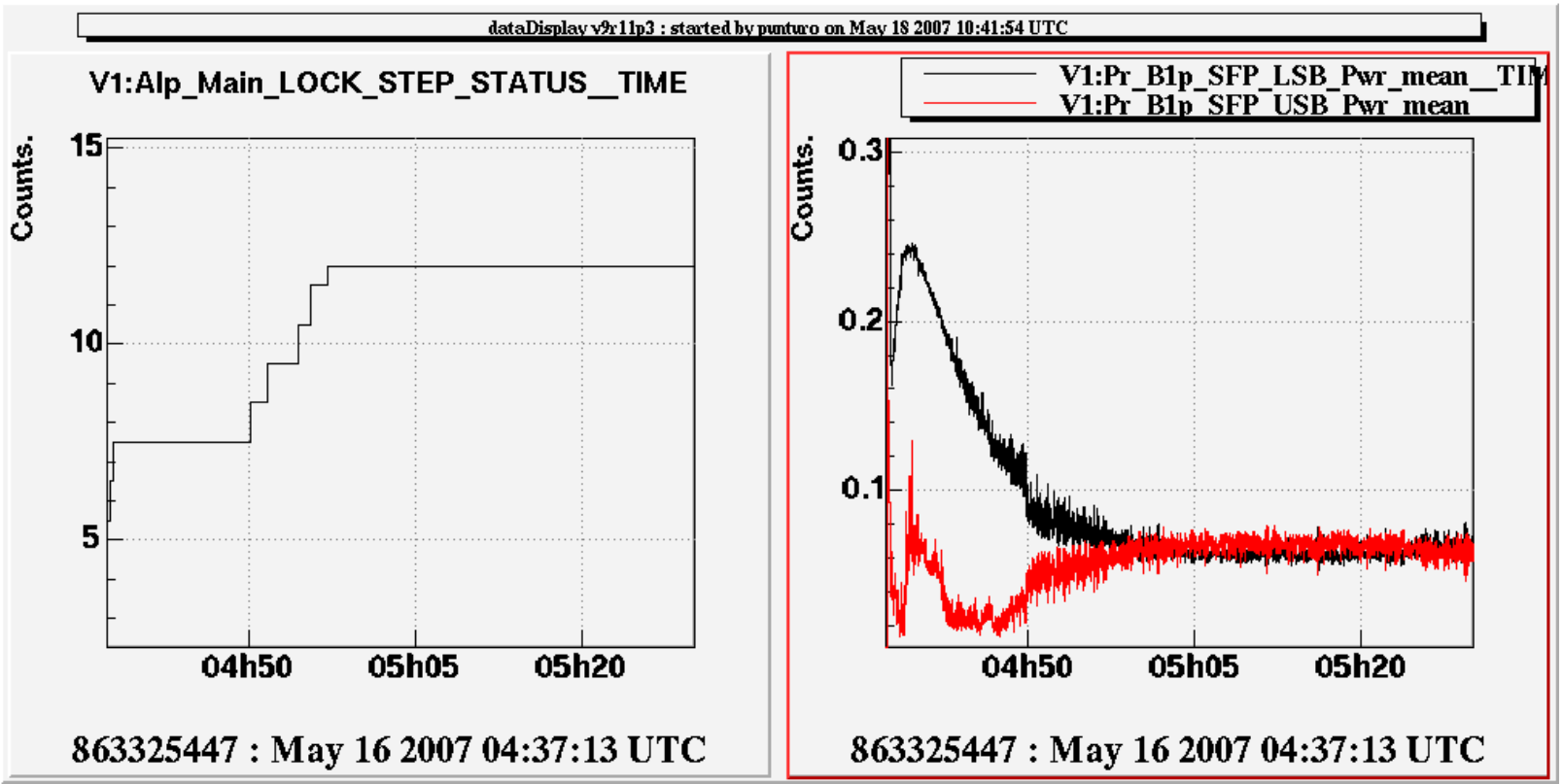
LIGO-G070734-00-Z

Thermal Lensing

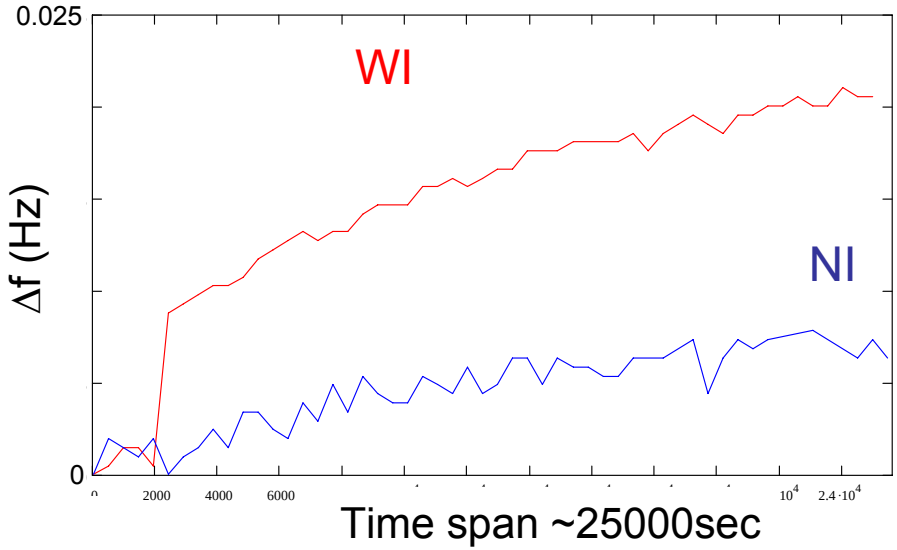
- Observed in Virgo through reduction of the sidebands gain.

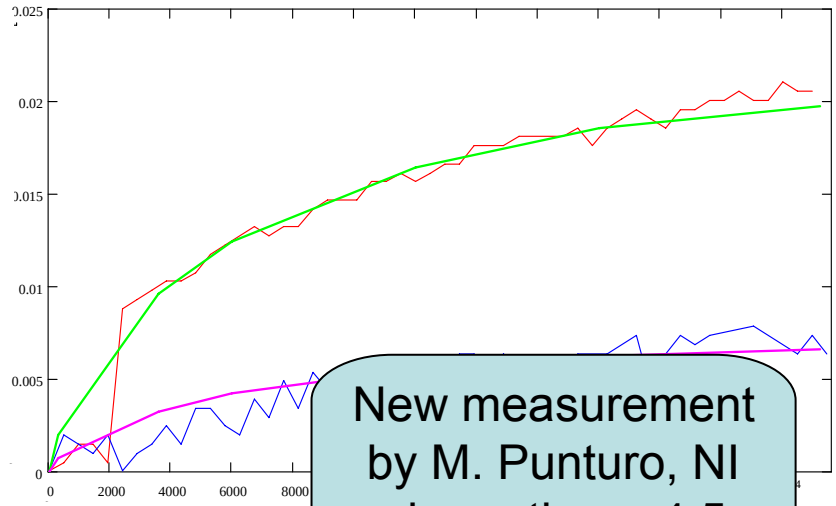


ITMs absorptions evaluated through coupled thermal-modal FEM with Ansys

Red and blue curves experimental frequency shifts

green and pink FEM results





New measurement by M. Punturo, NI absorption ~ 4.5 ppm

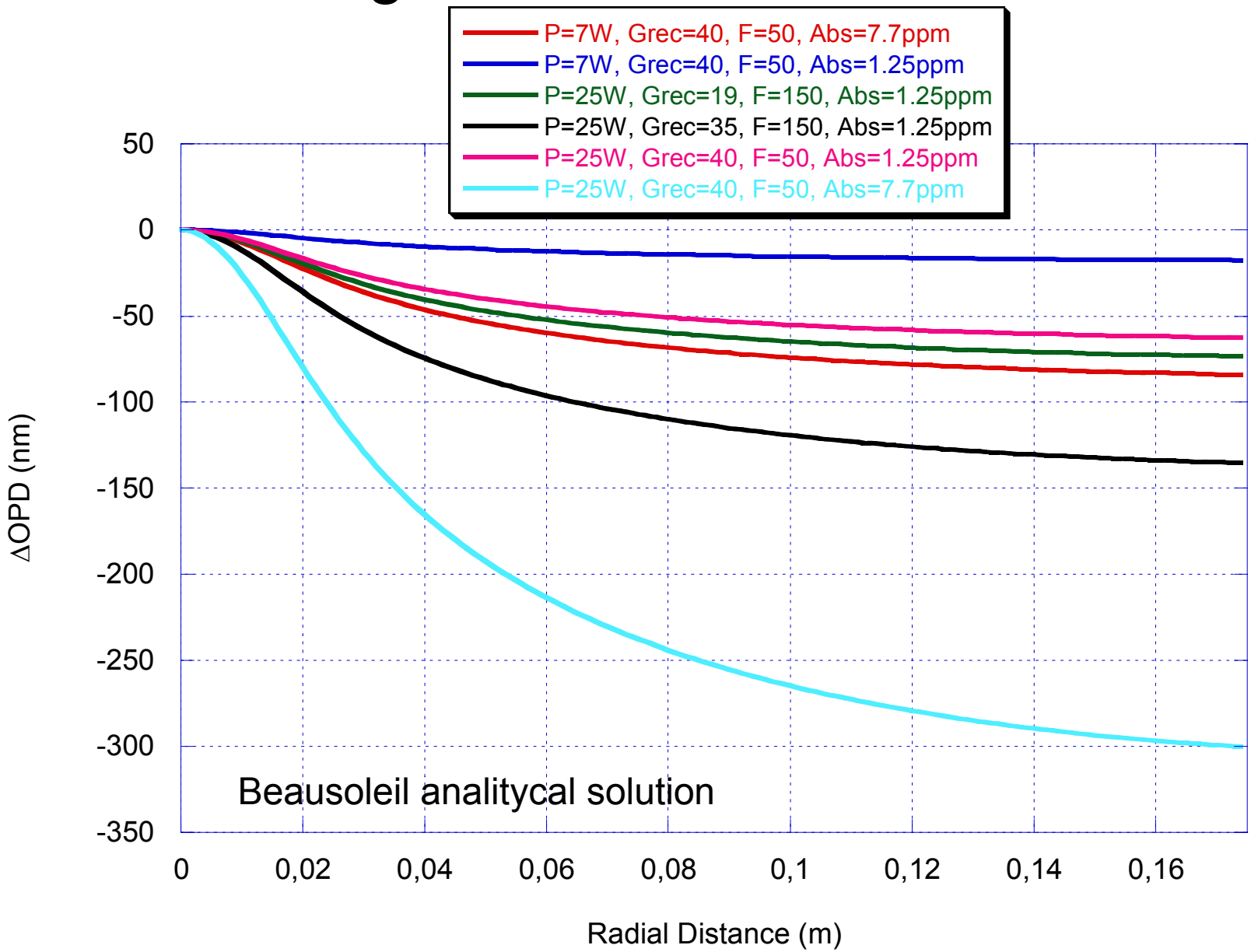
ITMs effective absorptions

WI (7.8±1.1) ppm

NI (2.3±0.3) ppm

Errors come from dependency of the model from uncertainty on elastic parameters dependency on temperature

Thermal lensing evaluation



Thermal Compensation System

- TCS for Virgo+: annular heating of ITMs with dc CO_2 laser
- "Annular" profile
  - from simulations: reasonable parameters to compensate inner radius~2.5 cm, outer radius~11÷14 cm

Desirable properties:

- It is easily adaptable as new understanding of the ITF is realized
- It does not require a significant vacuum incursion to install as this would lead to significant down time to the instrument

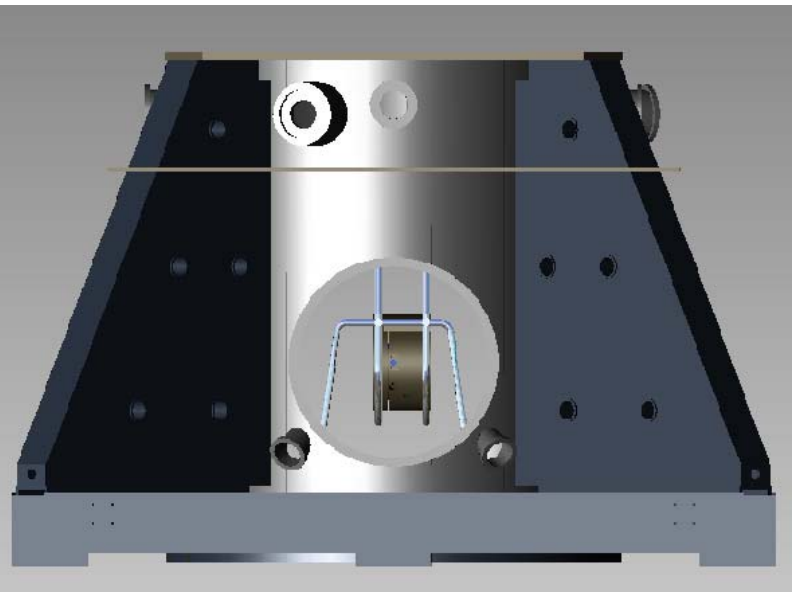
Two phases installation:

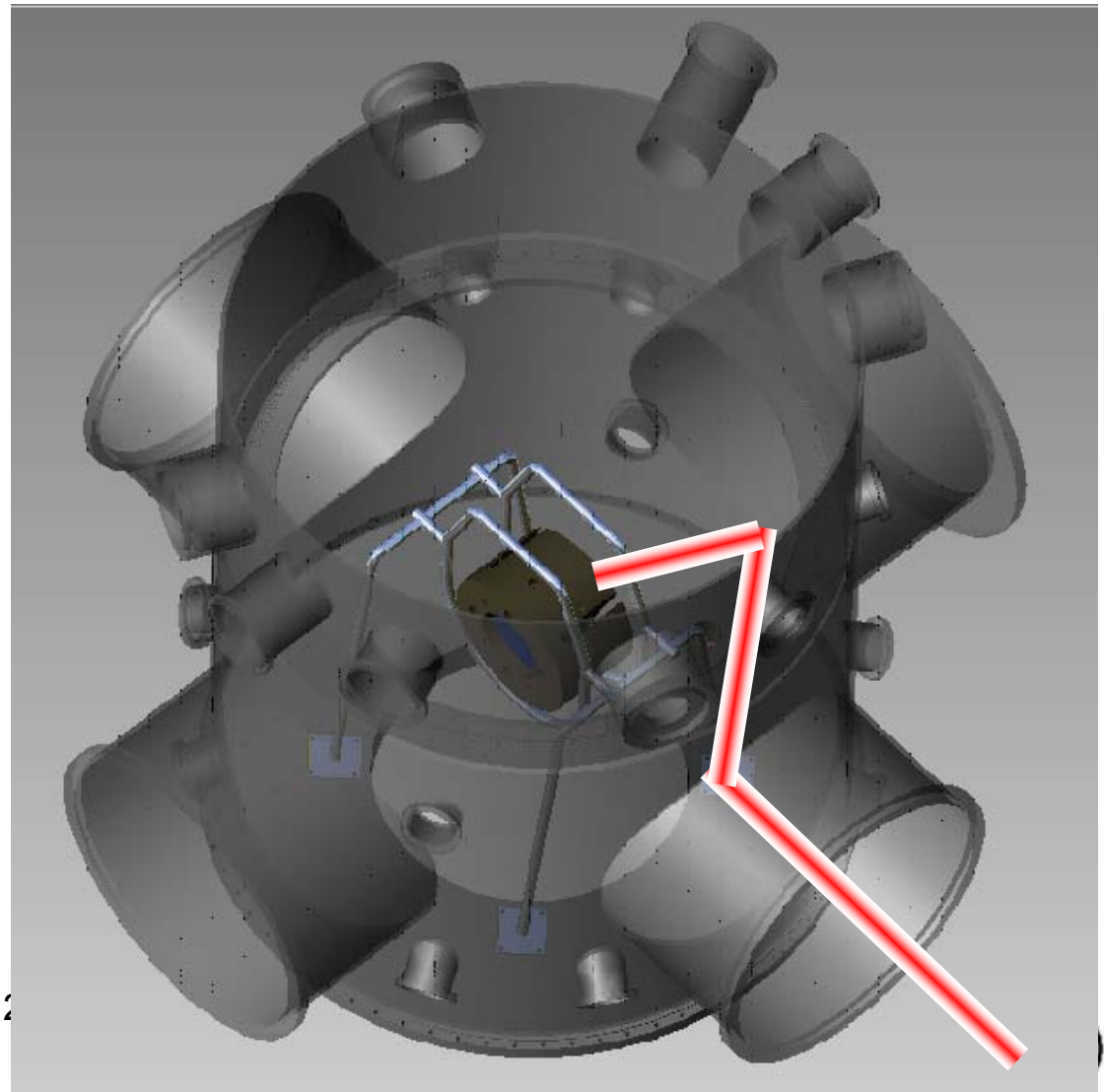
1. Feb 2008, system without power stabilization control loop
2. May-June 2008, installation of the power stabilization control loop

TCS Power requirements

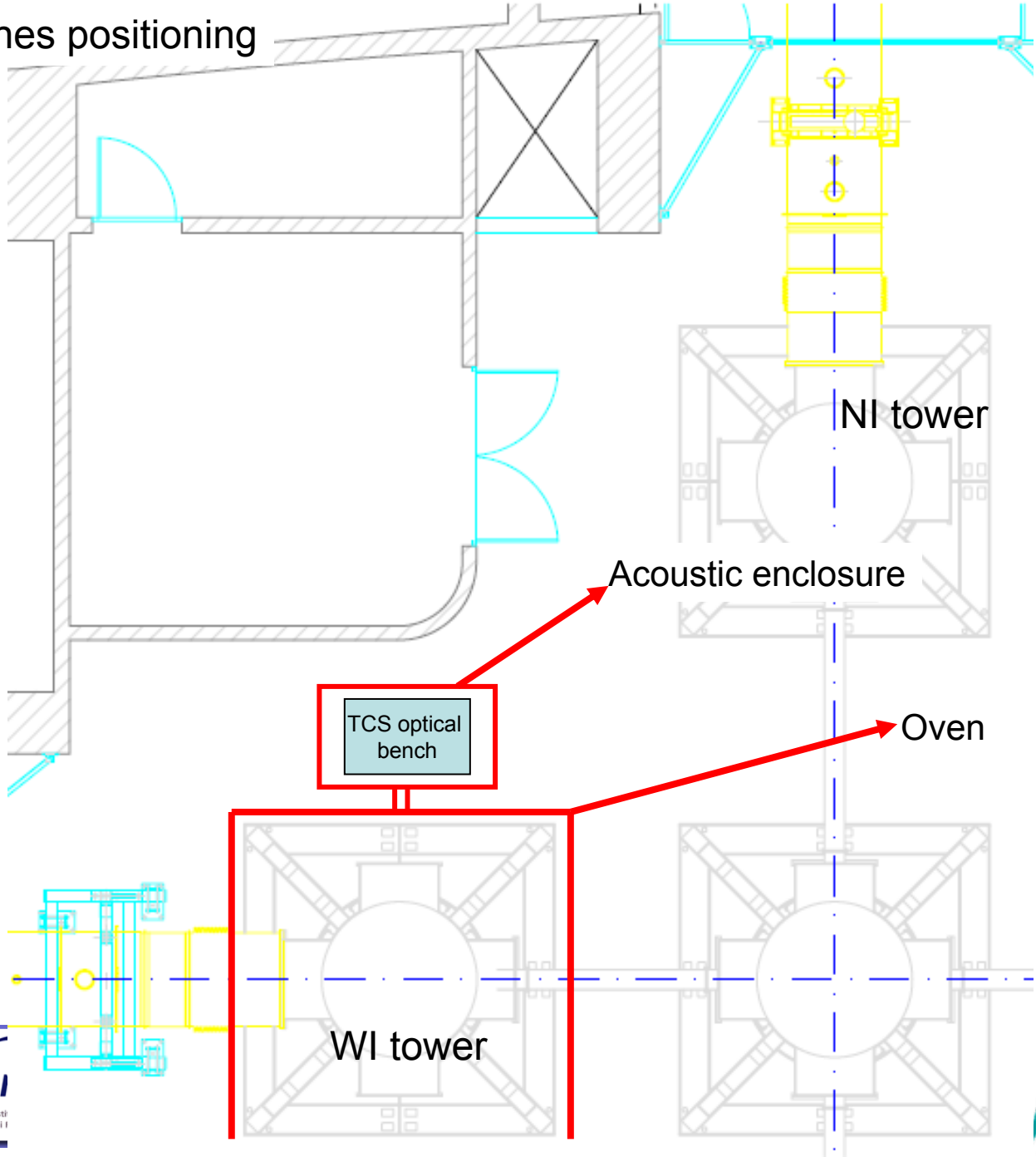
Virgo on WI mirror (absorption 7.7ppm)	~1.8 W
Virgo (nominal absorption)	~0.4 W
Virgo on WI mirror (absorption 7.7ppm, P_{las}=25W)	~6.2 W
Virgo (nominal absorption, P_{las}=25W)	~1.3 W
Virgo+, (F=150, G_{rec}=19) (nominal absorption)	~1.5 W
Virgo+ (F=150, G_{rec}=35) (nominal absorption)	~2.8 W

Optical layout

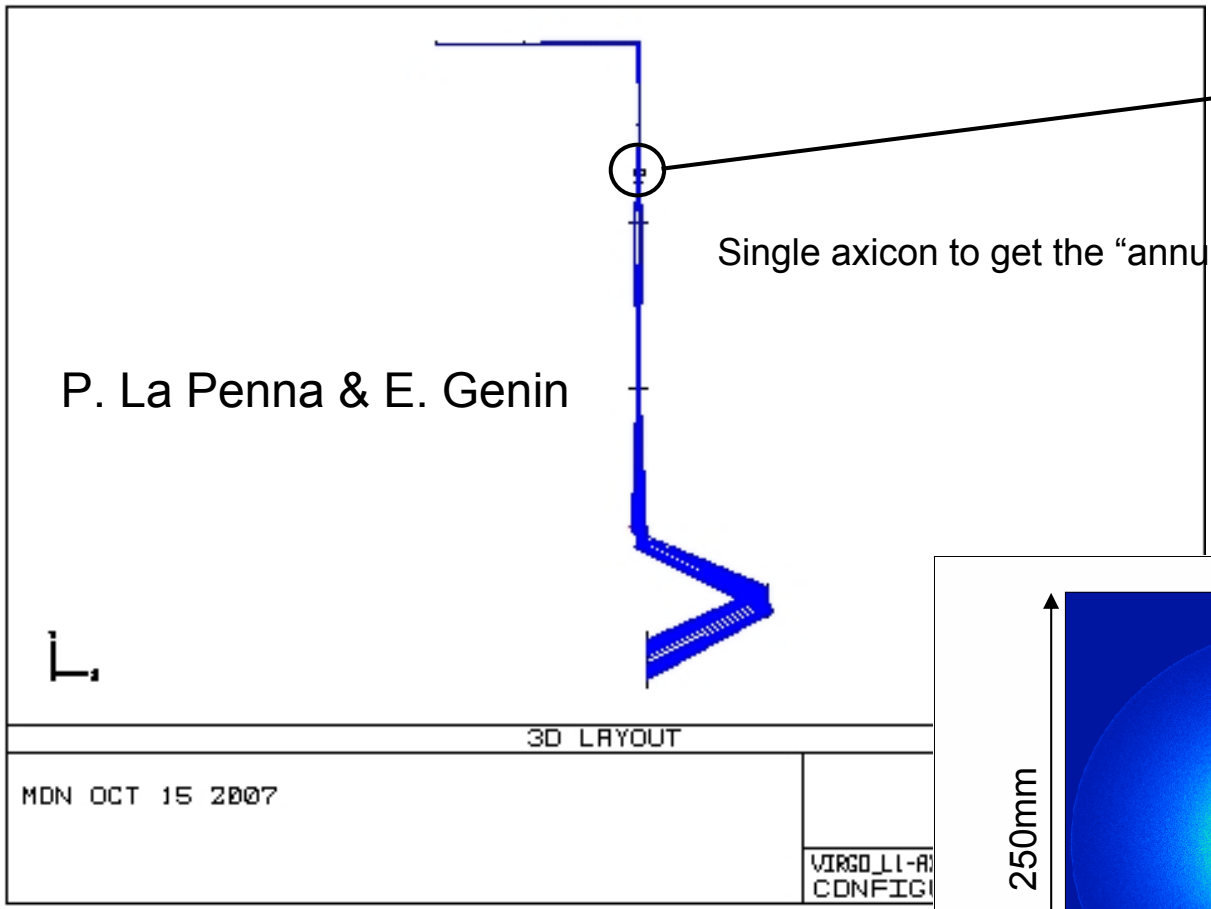


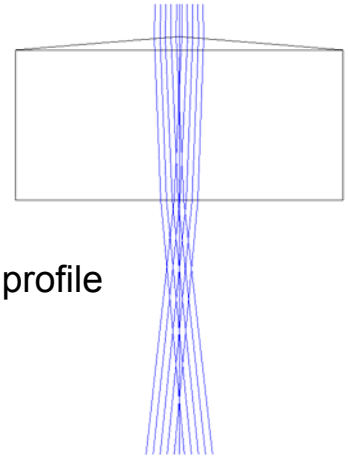


Optical benches positioning



Final design of the Optical Imaging System

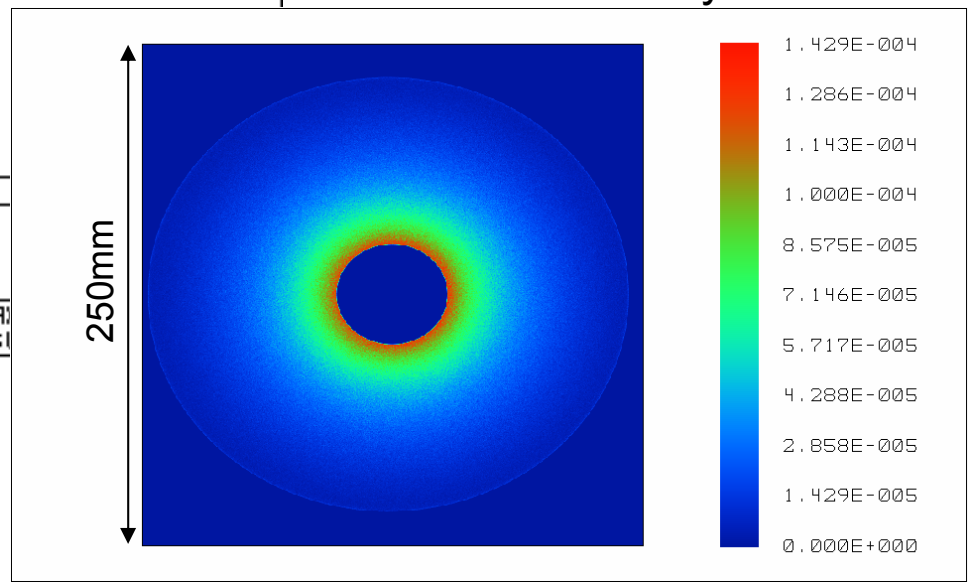


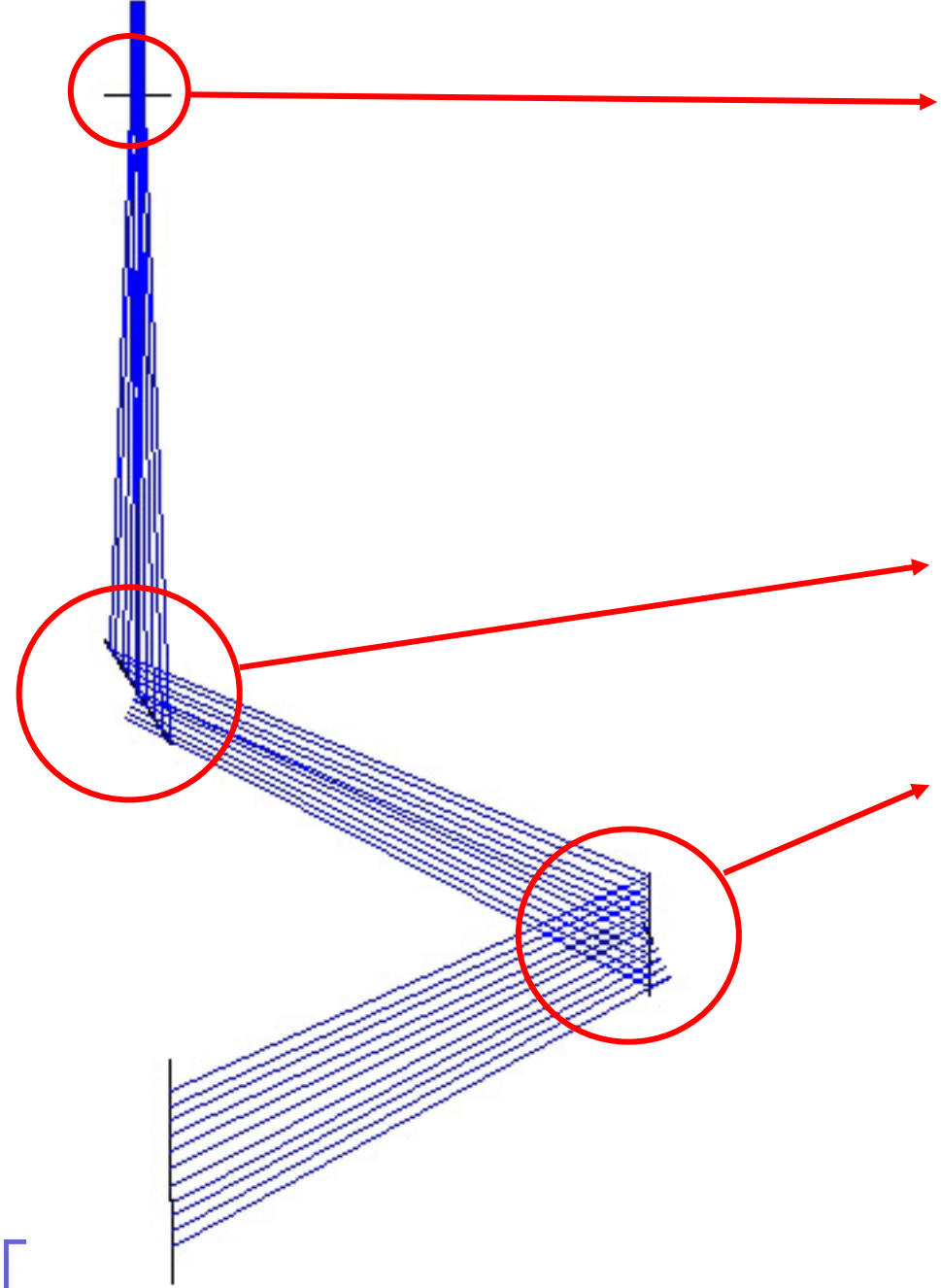


Single axicon to get the “annular” profile

P. La Penna & E. Genin

100% efficiency





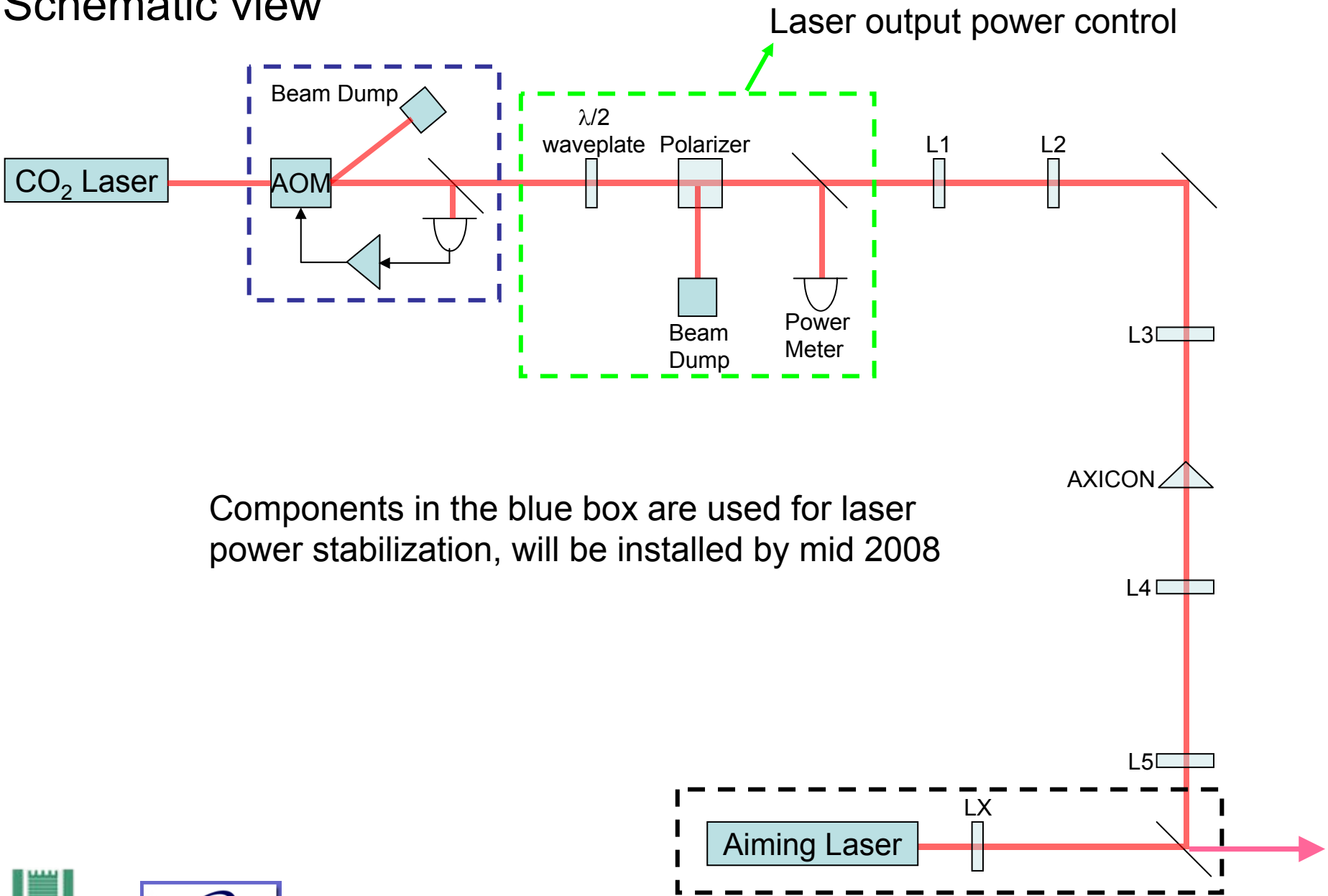
UHV ZnSe viewport
DN100CF
Clear aperture 90mm

Two large in-vacuum steering mirrors (ϕ=190mm)

Positioning controlled manually in all DOFs

Remotely controlled via stepping motors in angular DOFs and one translation

Schematic view



Components in the blue box are used for laser power stabilization, will be installed by mid 2008

Tests in Tor Vergata Labs before installation on Virgo

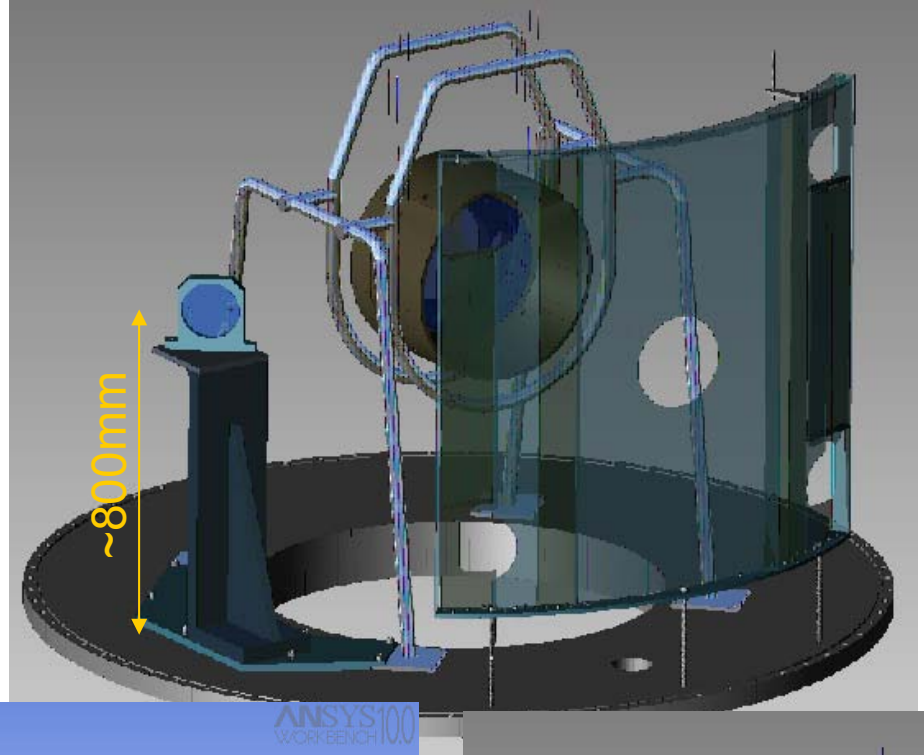
- Measure the RIN of the laser
  - So we can have an estimate of the injected noise in the first phase installation

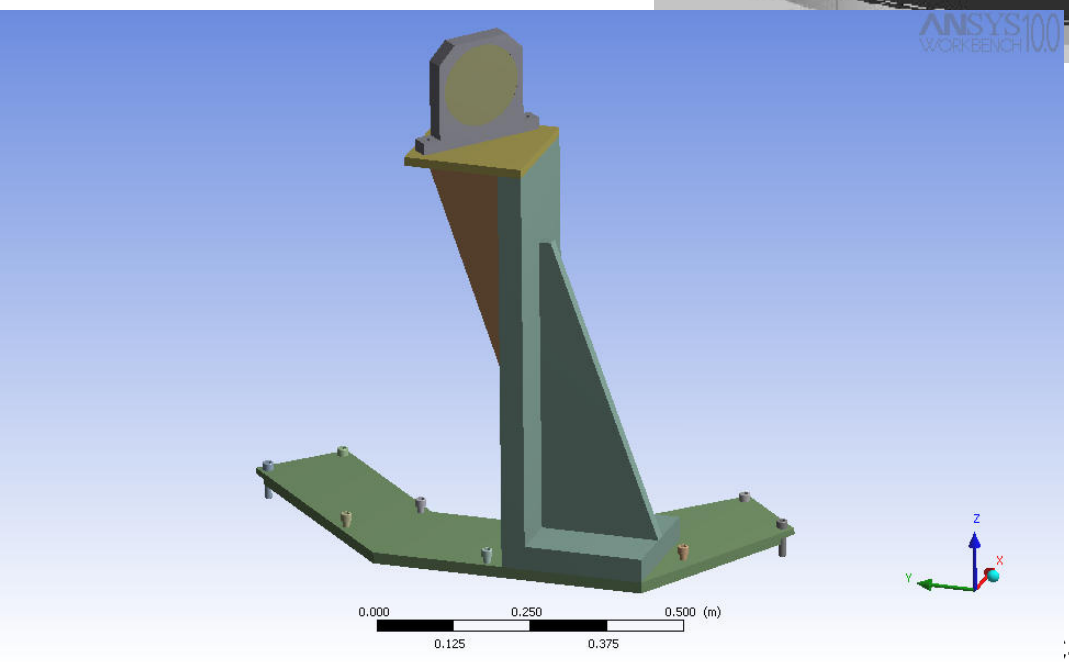
- Check the efficiency of the Optical Imaging System

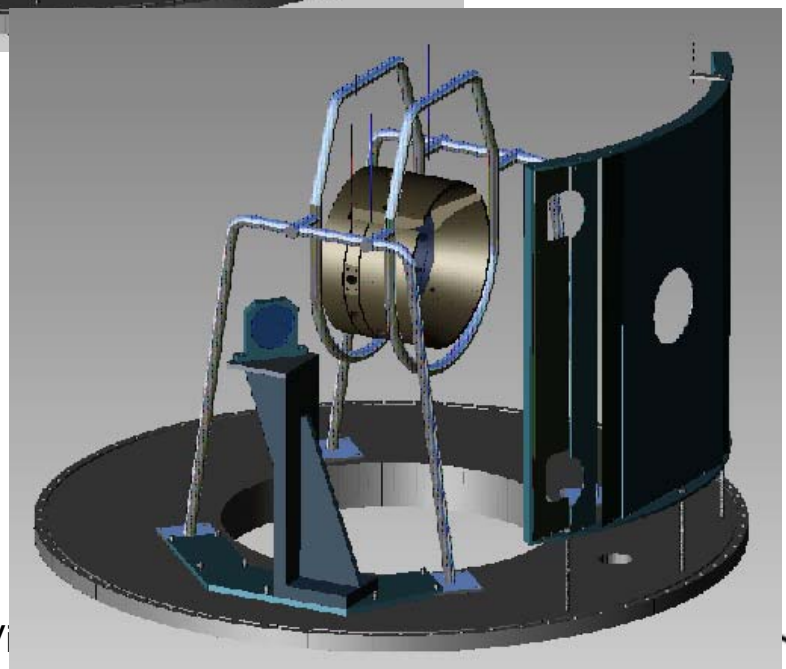
Preliminary design
of the first in-vacuum mirror

Material: Aluminum

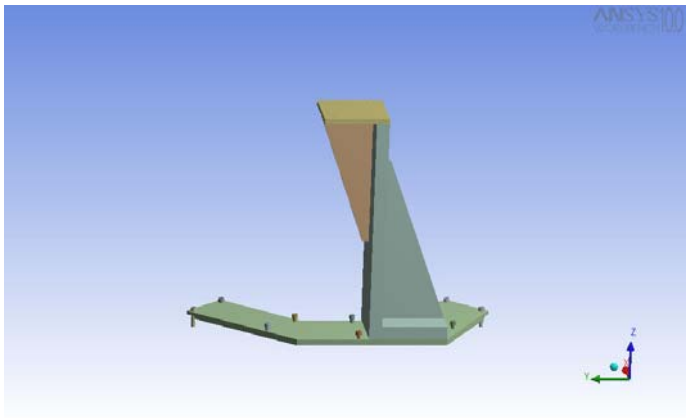
T. Zelenova

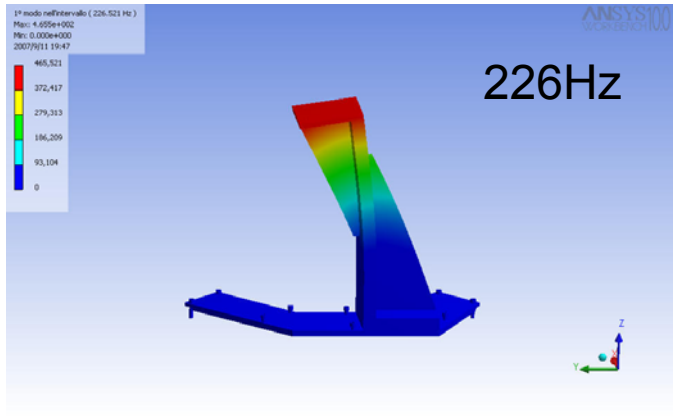


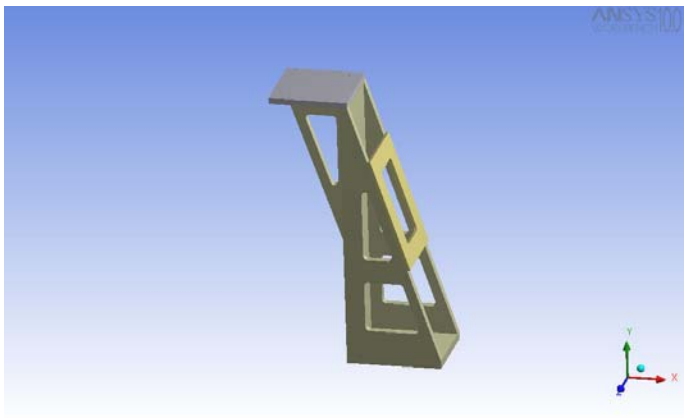


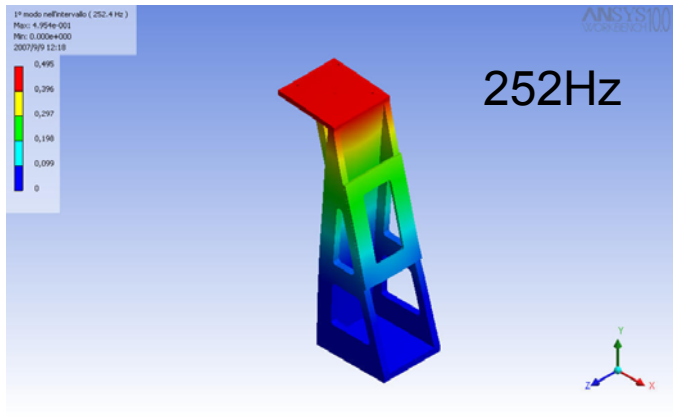


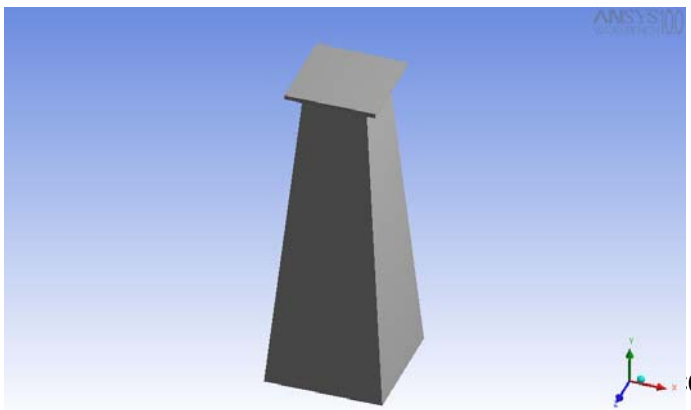
Exploring different designs for the in-vacuum optics holders, with T. Zelenova

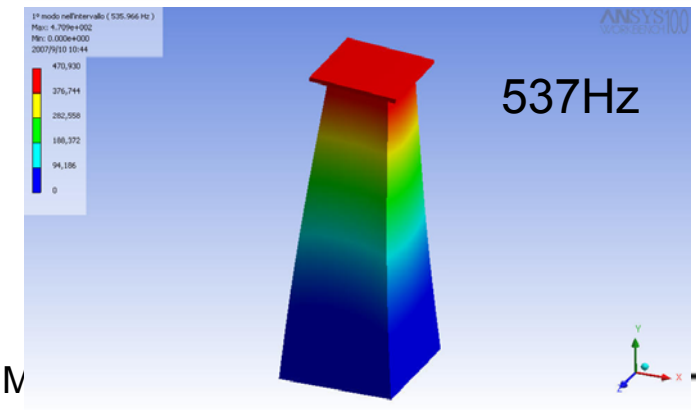




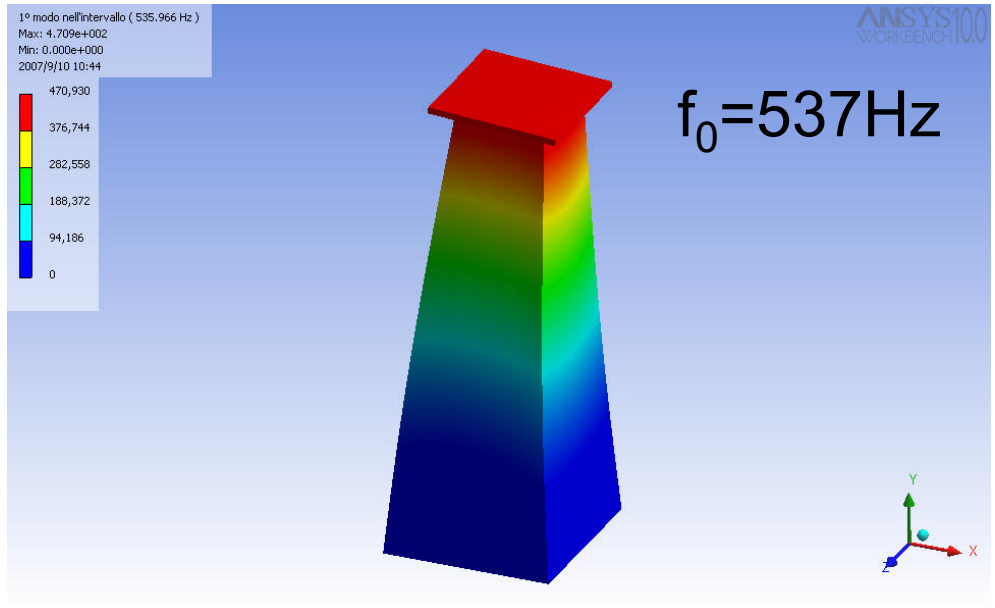


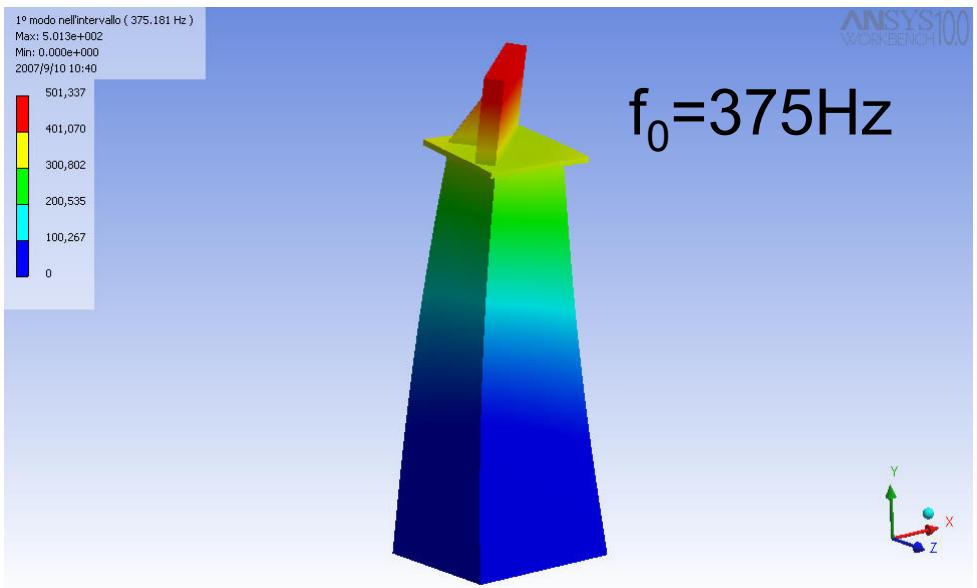






Unloaded

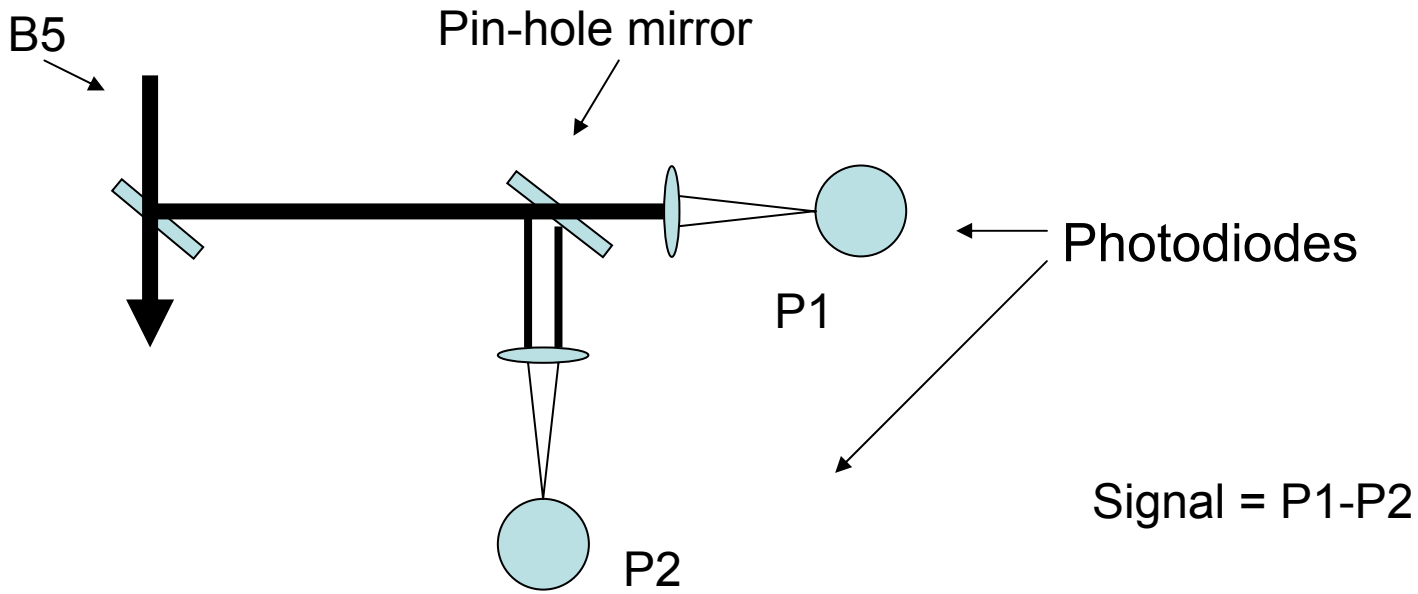




Loaded with mirror (2kg)

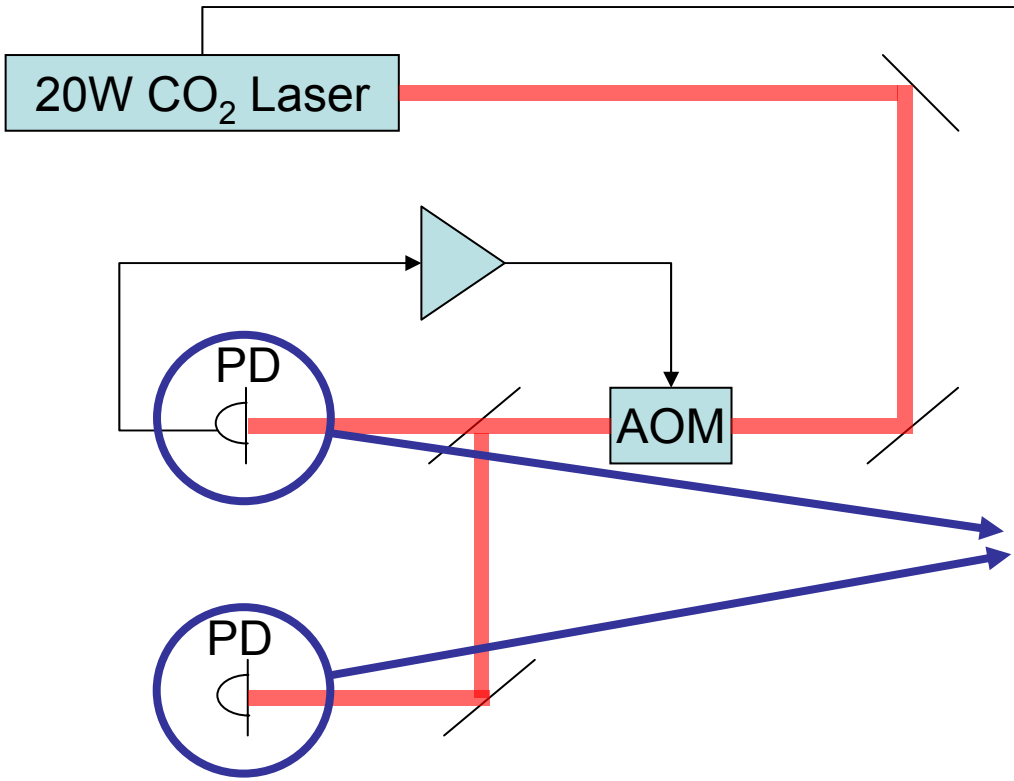
Error signal generation

- E. Calloni & M. Laval demonstrated that Phase camera 0 + DarkF → tools to "measure" TCS
- Pine-hole photodiodes → error signal generation
- Phase camera 1 → an upgraded tool to understand sidebands and TCS



This is only one error signal, but two are needed. Investigating the possibility to use the signal from B2

CO_2 laser power stabilization



New LASY-20S from Access Laser Co, pre-stabilized, temperature tuned (no line hops)

Critical components

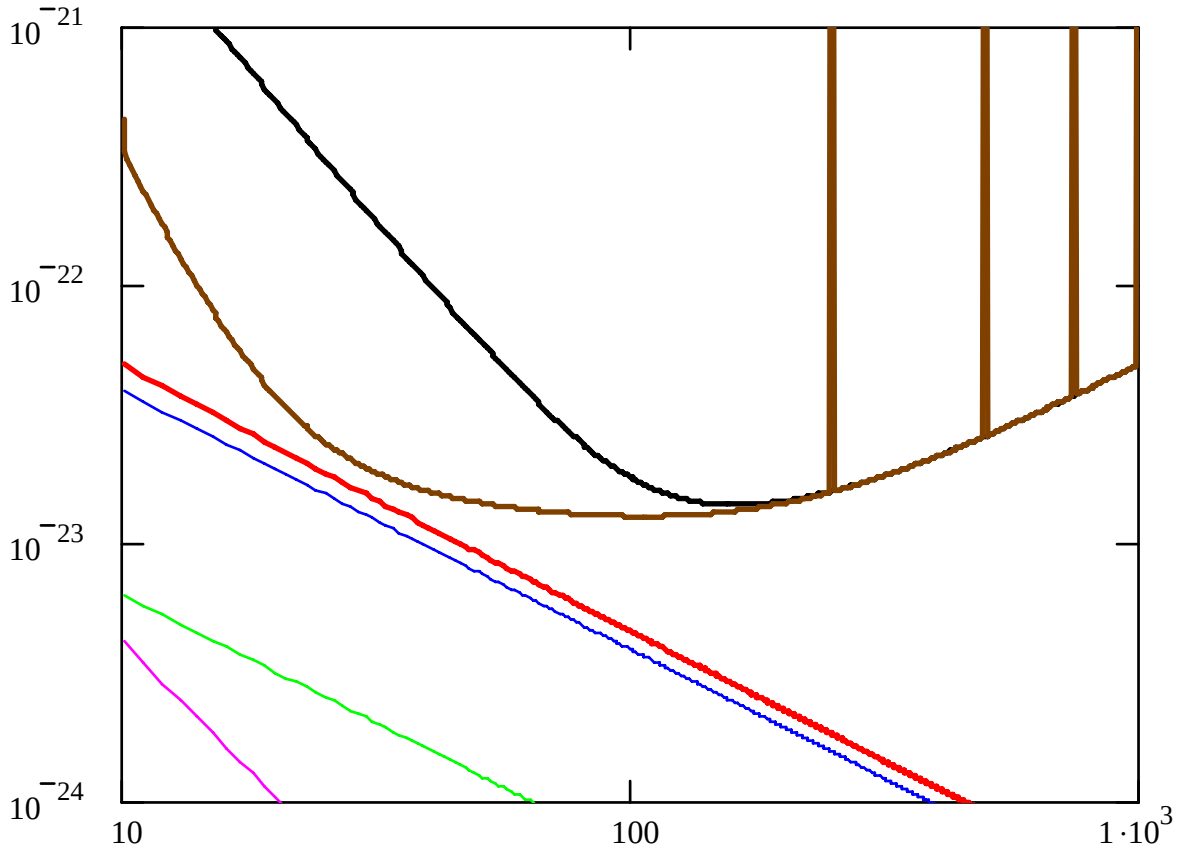
$$RIN = \frac{\sqrt{Area}}{P_{inc} \cdot D^*}$$

	Detectivity (cmHz$^{1/2}$/W)		Area	
	TE	Room Temp.	TE	Room Temp.
VIGO photodiodes	$10^8 - 10^9$	10^7 - 10^8	0.5x0.5 – 2x2 mm^2	2x2 – 4x4 mm^2
Coherent photodiodes		$2.2 \cdot 10^8$		5x5mm^2

Noise budget

Evaluation of TCS noise injected in Virgo+, if RIN is stabilized @ $3\times10^{-7}/\sqrt{Hz}$, flat over the frequency range 10 Hz to 1000 Hz, TCS power=1.5W.

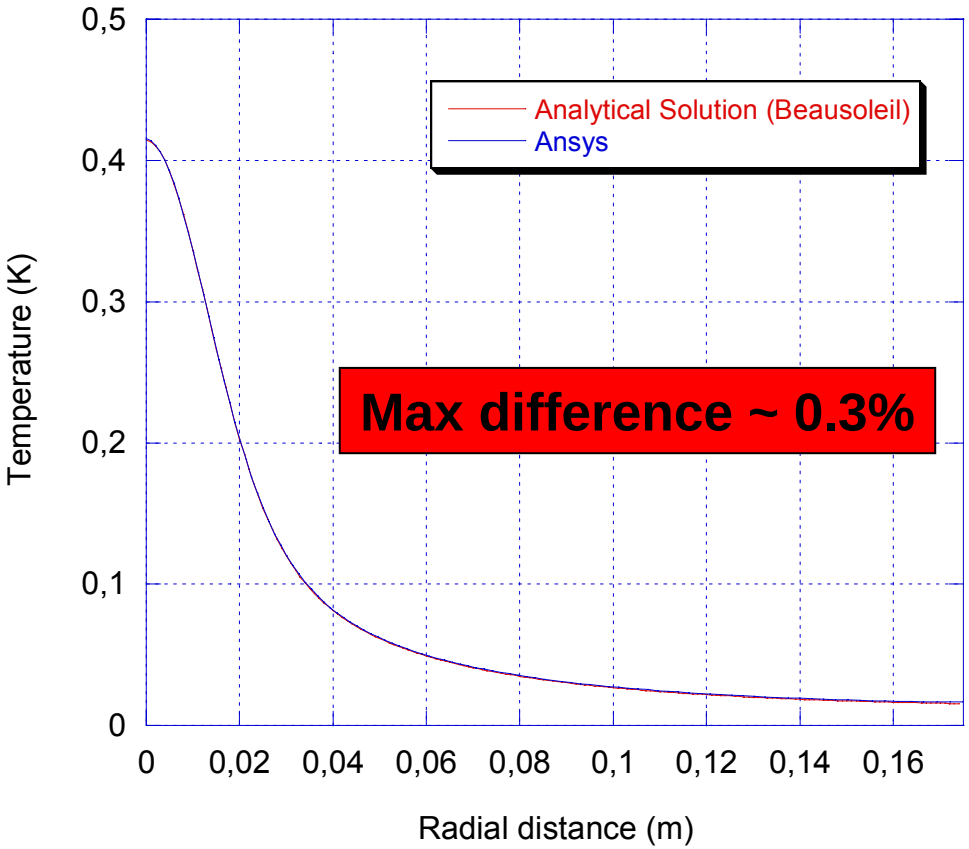
Virgo+ sensitivity
(without monolithic suspensions)
Virgo+ sensitivity
(with monolithic suspensions)
Total
Flexural
Thermoelastic+Thermorefractive
Radiation pressure

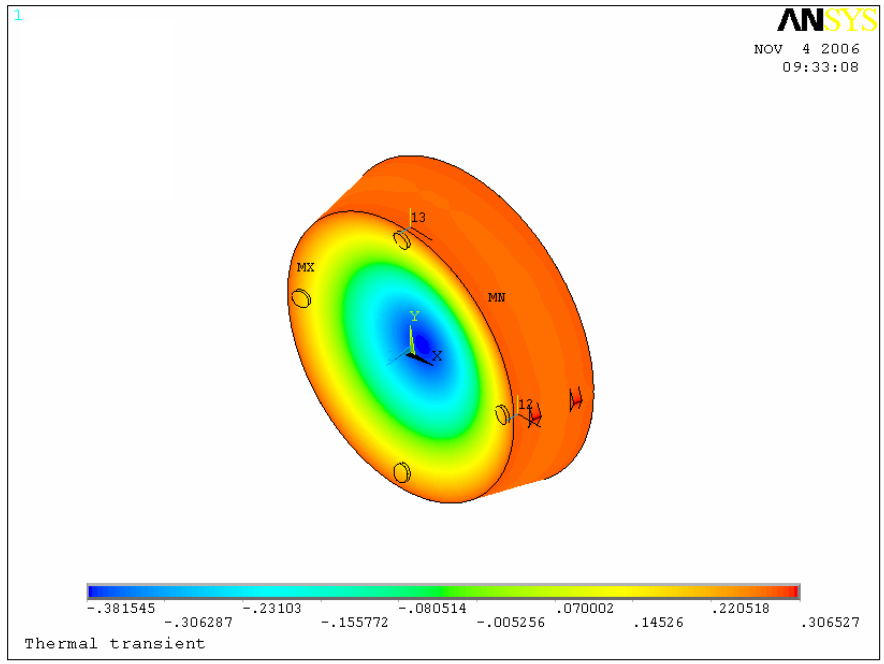


The End

Building and validating the FE model

Comparison with analytical solution Beausoleil (LIGO-P020026-00-D)





- DRUM MODE
- ANSYS FEM f= 5584.15 Hz
- Experimental value f= 5584.7 Hz

Difference is 0.55Hz less than 0.01%

Possible optical layout

AXICON