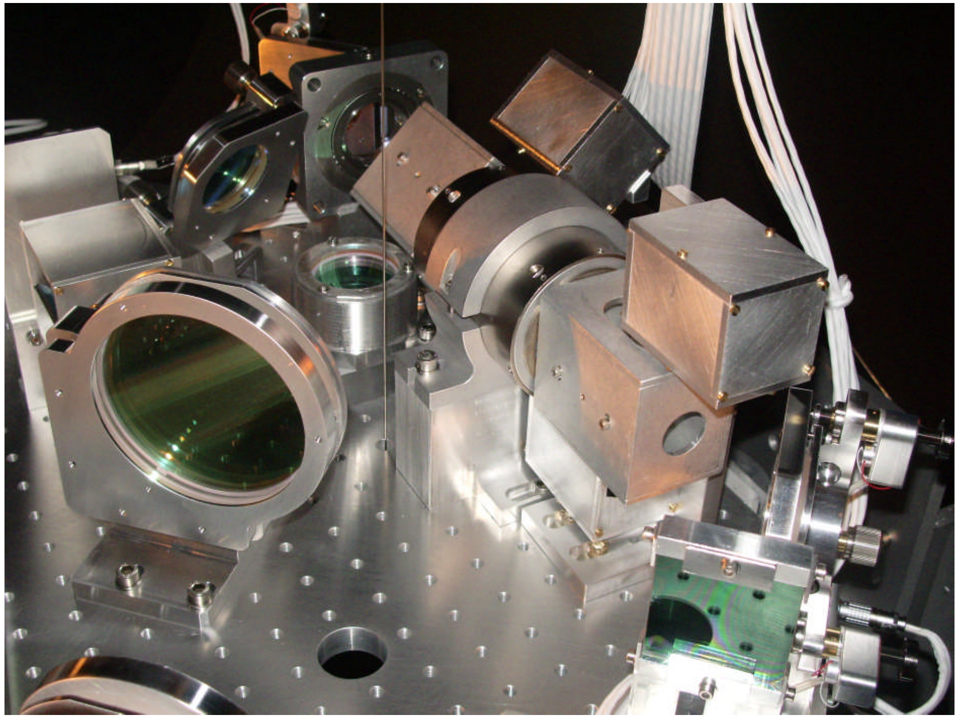
Faraday thermal lensing numerical simulations



Slim Hamdani
EGO

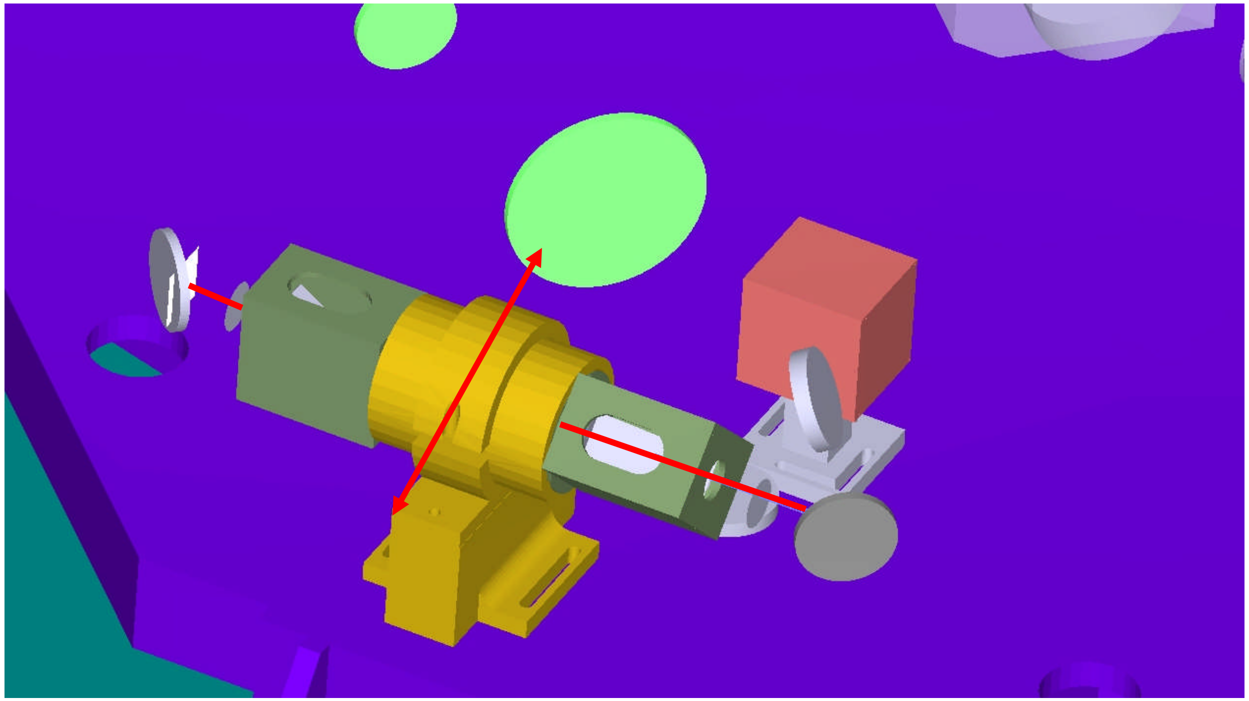
LIGO-G070358-00-Z

When heated, the Faraday isolator:

-Changes its polarization (isolation)

-Change non uniformly its refraction index (lensing)

-Change non uniformly its dimensions (lensing)



Virgo:
-10W + 3W
- mismaching:~0.5%

Virgo +:
- 40W + 10W
- mismaching:~5%

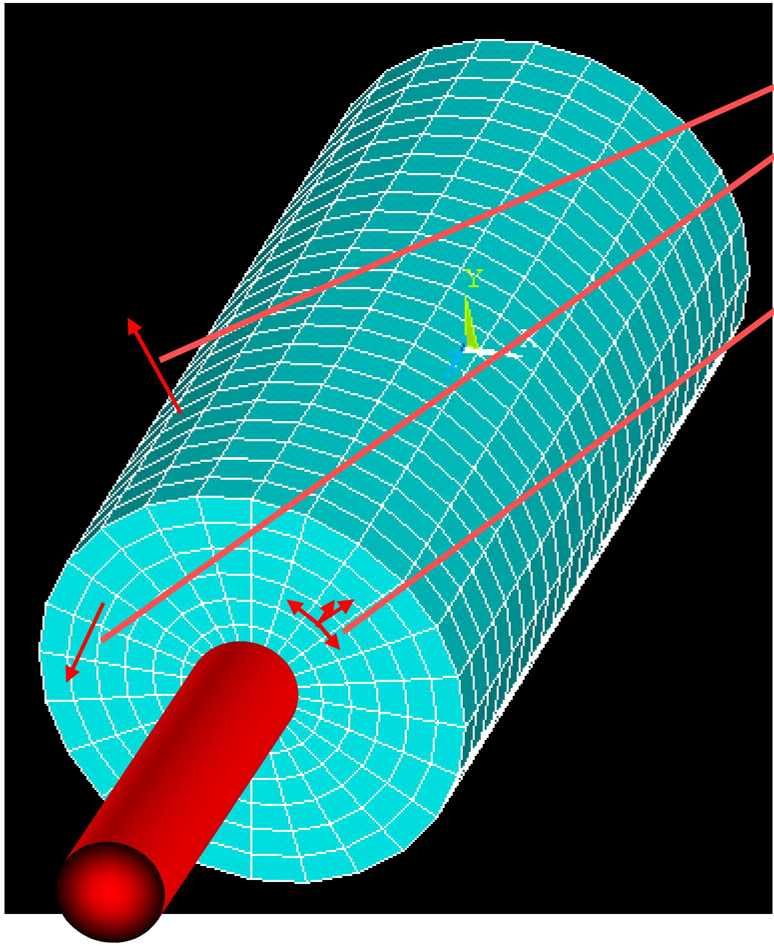
Advanced Virgo:
- 150W + 50W
- mismaching:~37%

Finite elements

M. Punturo Matlab's algorithm

radiation

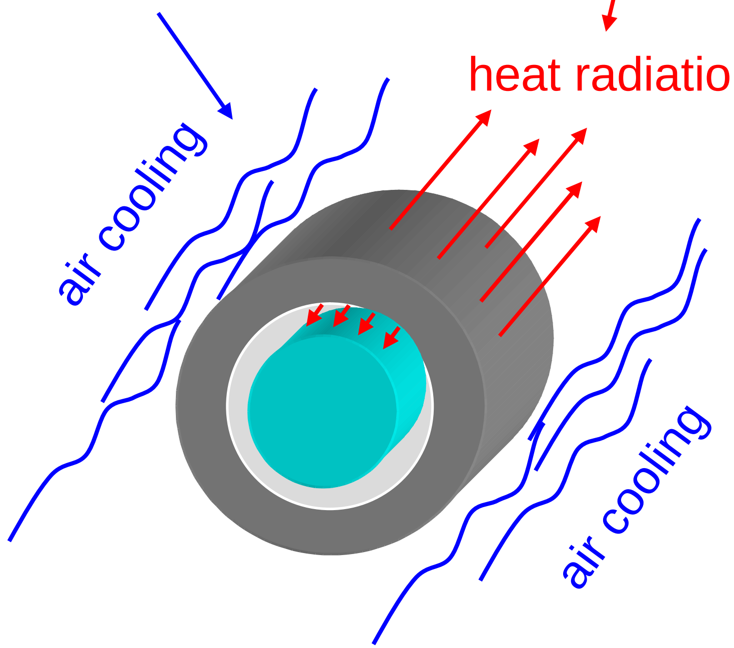
conduction



Gaussian beam

Shield or not

Vacuum or not



Heat transfer equations

conduction $\dot{Q} = \kappa A \Delta T / d$

$\dot{Q}$ [Watt/sec] rate of heat flow

κ [$Wm^{-1}K^{-1}$] thermal conductivity

A [m^2] contact area

ΔT temperature difference

d [m] distance of heat flow

radiation $\dot{Q} = A\sigma\varepsilon(T^4 - T_0^4)$

$\dot{Q}$ [Watt/sec] rate of heat flow

A [m^2] contact area

σ [$Wm^{-2}K^{-4}$] Stefan Boltzmann cst

ε emissivity

T [K] temperature

External conditions simulation

Air or vacuum

convection $\dot{Q}=\beta(T-T_{air})A$

$\dot{Q}$ [Watt/sec] rate of heat flow

β [Wm-1K-1] flux caracterization

ΔT[K] sample temperature

ΔT_{air}[K] air temperature

A [m2] contact area

β=[10:100] turbulent or laminar flux

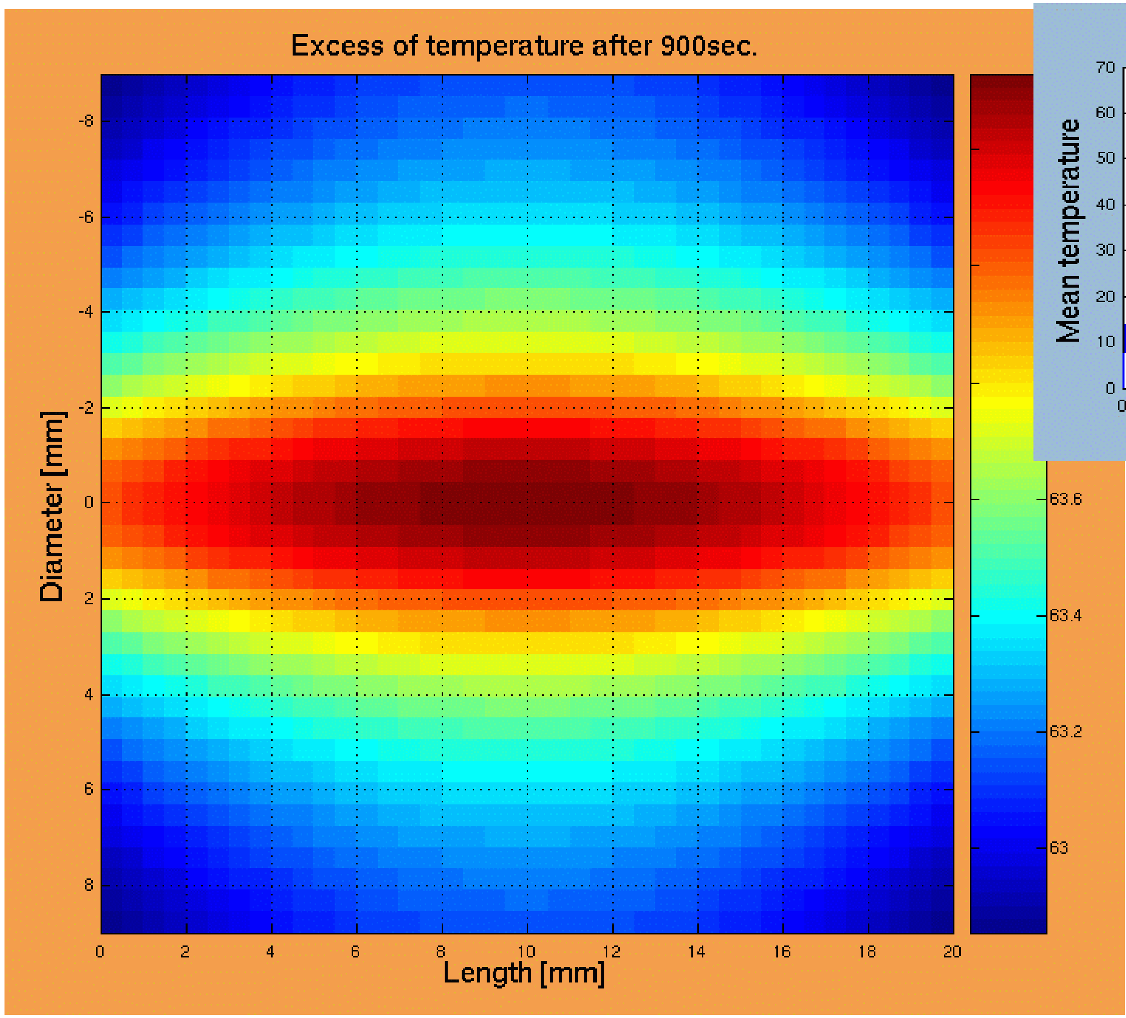
Shield or free

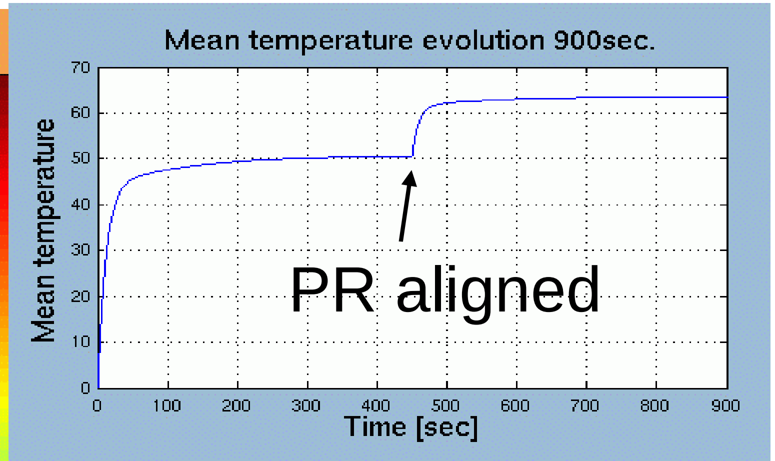
radiation $\dot{Q}=A\sigma\varepsilon(T^4-T_0^4)$

Radiation transfer

(with the shield considered always thermalized)

TGG heated by a 150 + 50 Watt Yag



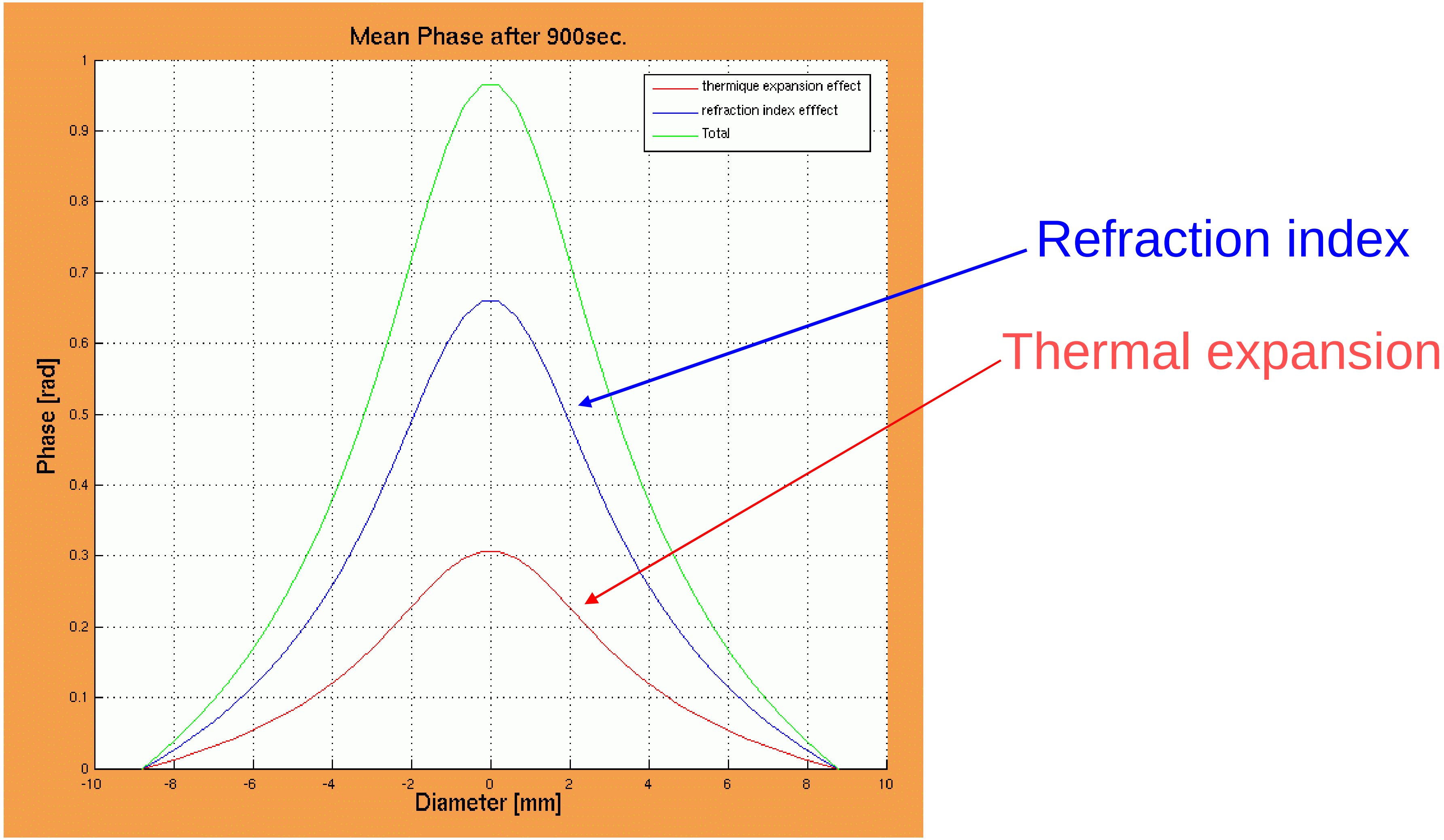


Temperature map

⇓

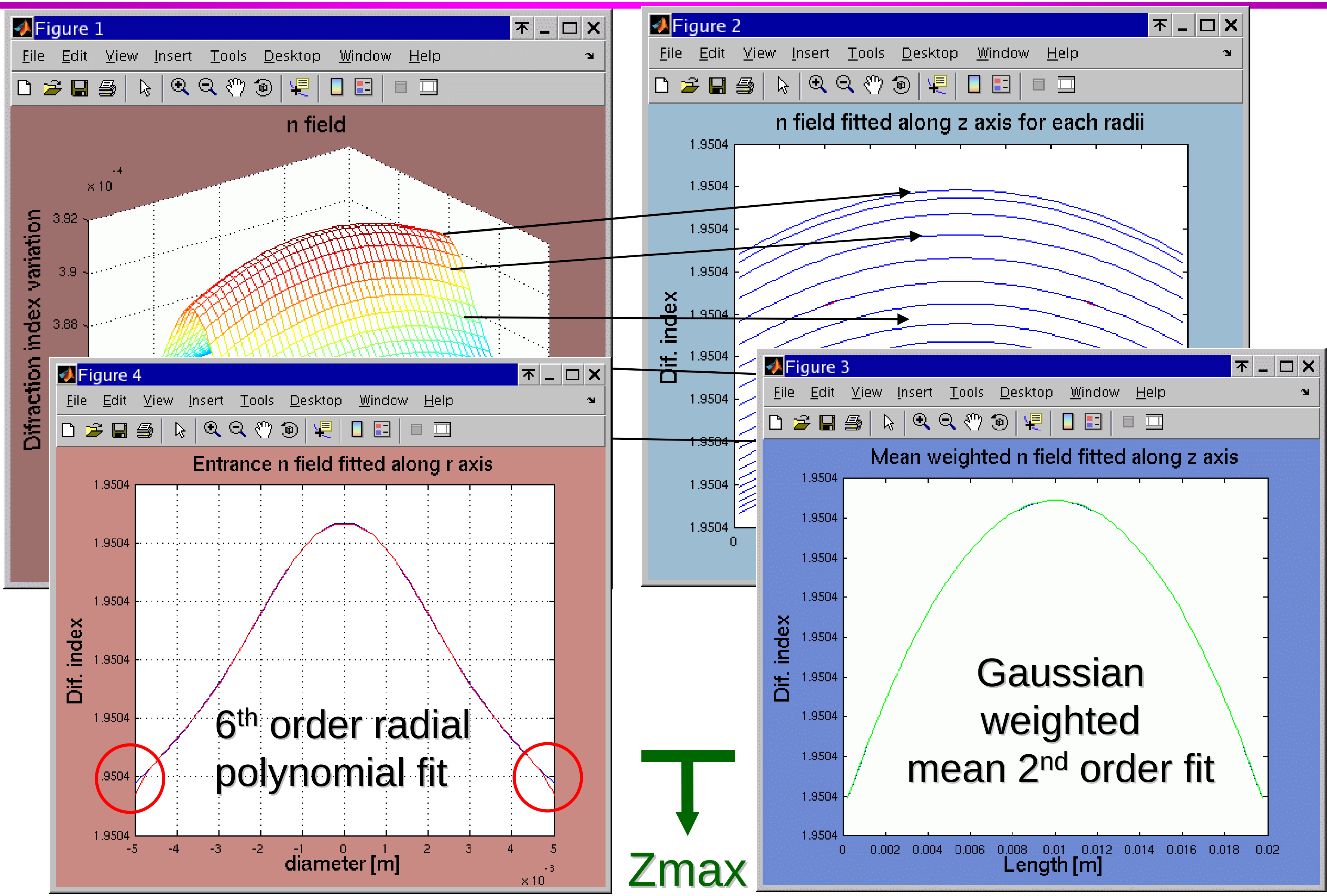
Refraction index map
&
Verdet cst map

Mean phase change

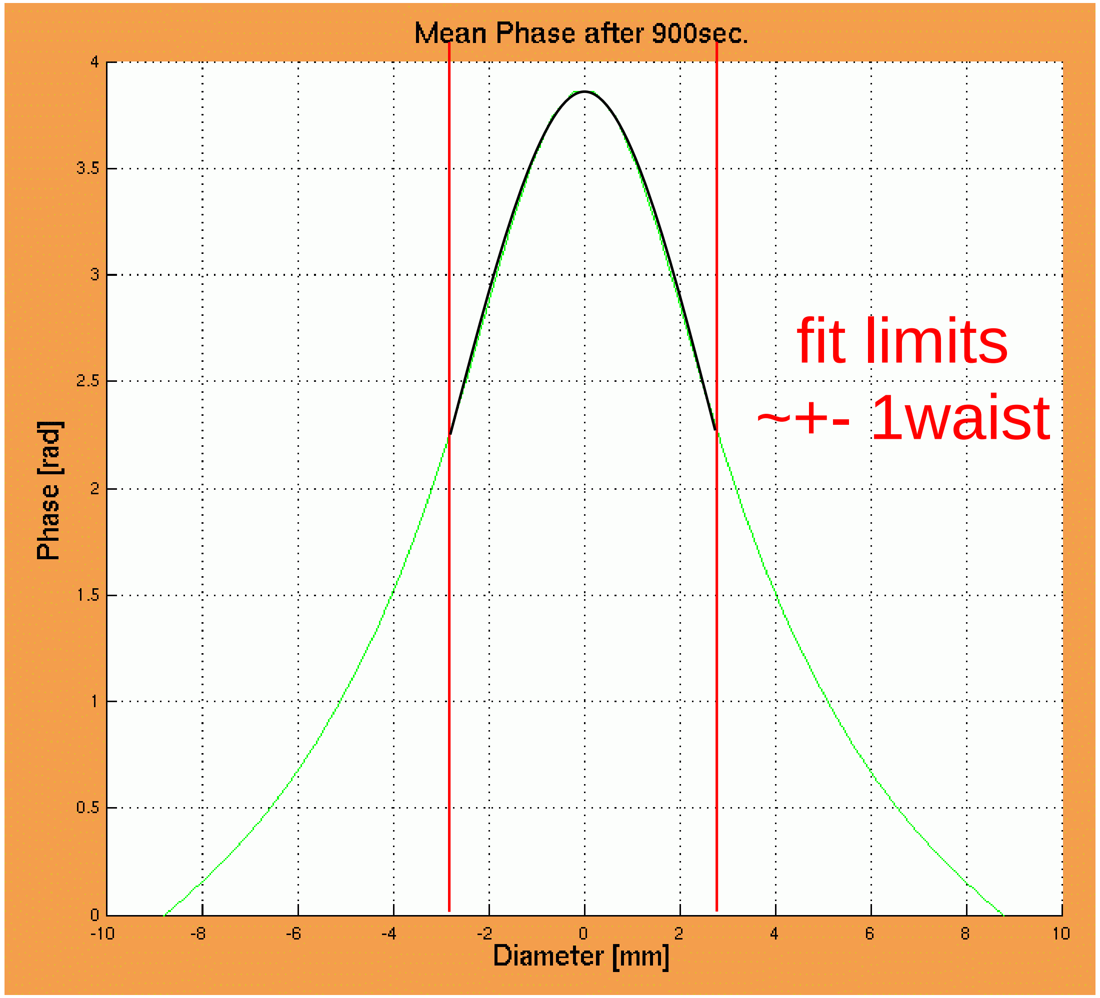


TGG heated by a 150 + 50 Watt Yag

N index fit -> Zmax



Focal approximation



Circle fit

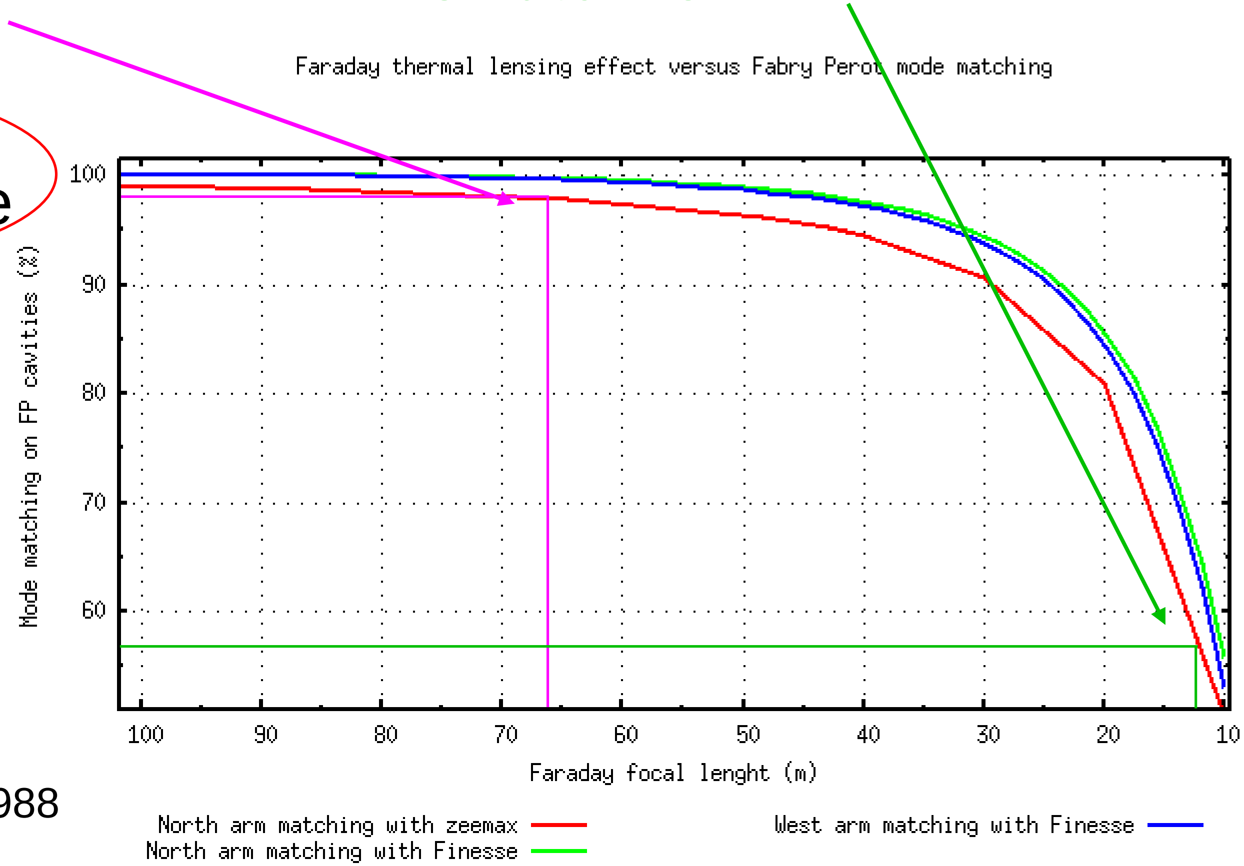
Radius of curvature

focal

VIRGO+ (50Watt)
Thermal lens: f=66m
Mismatch: 5%

Advanced VIRGO (200Watt)
Thermal lens: f=13m
Mismatch: 37%

tunable with
the input telescope



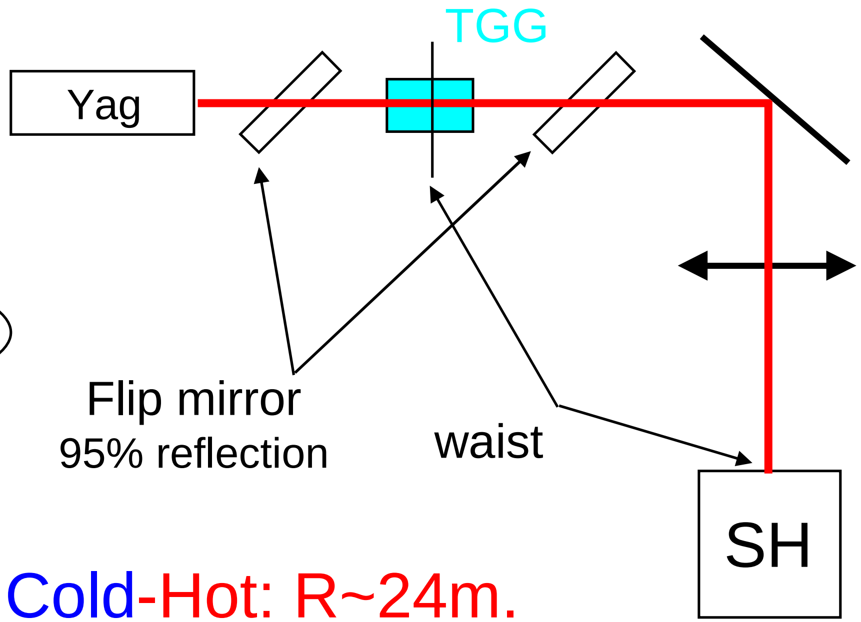
E. Genin
logbook entry 13988

TGG characterization

	TGG
emissivity	*0.89*
thermal conductivity [K W/m]	7.4
density [g/cm^3]	7.32
specific heat [J/(K kg)]	
substrate losses [1/cm]	1.65e-3 2.70e-3
thermal expansion [1/K]	9.4e-6
refraction index	1.94
dn/dT [1/K]	1.9e-5

Depending of the sample +- 4 times

Preliminary test with a 650mWatt Yag, waist: 180μm

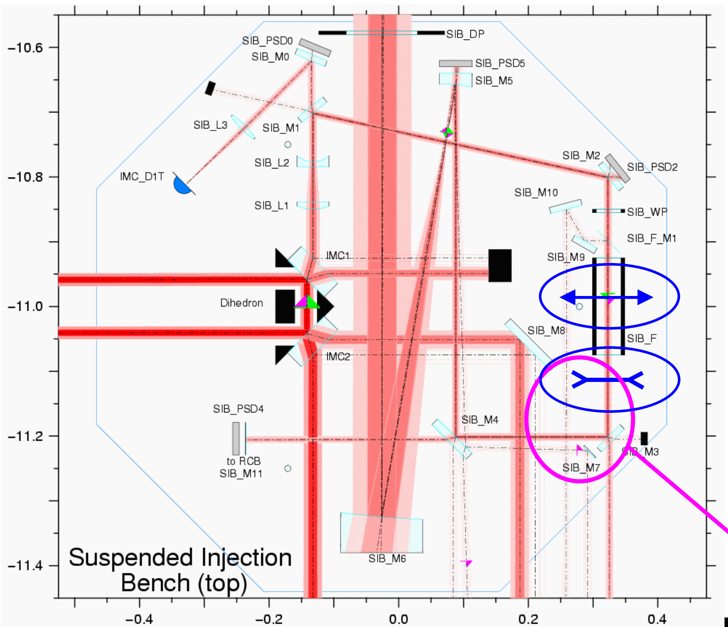


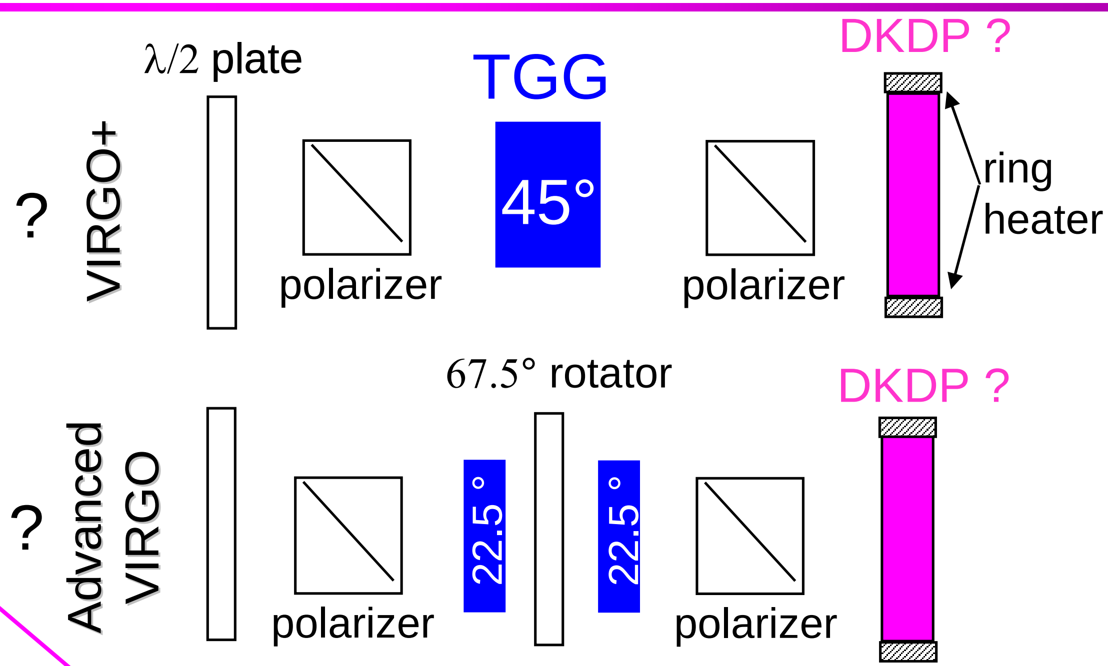
Cold-Hot: R~24m.

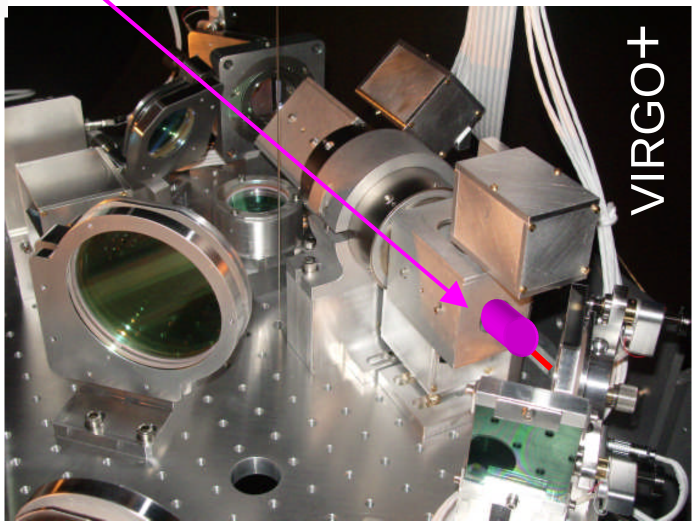
Simulation: R=24.3m.

Next test wit a 0-200 Watt Yag

Faraday compensation







Kazanov et al 2004

Thermal lensing:
- converging lens

Compensator:
- thermal diverging lens

To do

- Depolarization measurements
  @ 50W and 200W on TGG, DKDP or others

-Physical parameters characterization of TGG

-Validation of the simulation with the
  metallic shield and under vacuum

- Test final design for VIRGO+

- Studying the design for Advanced VIRGO