# Status of the ACIGA Gingin Research Facility

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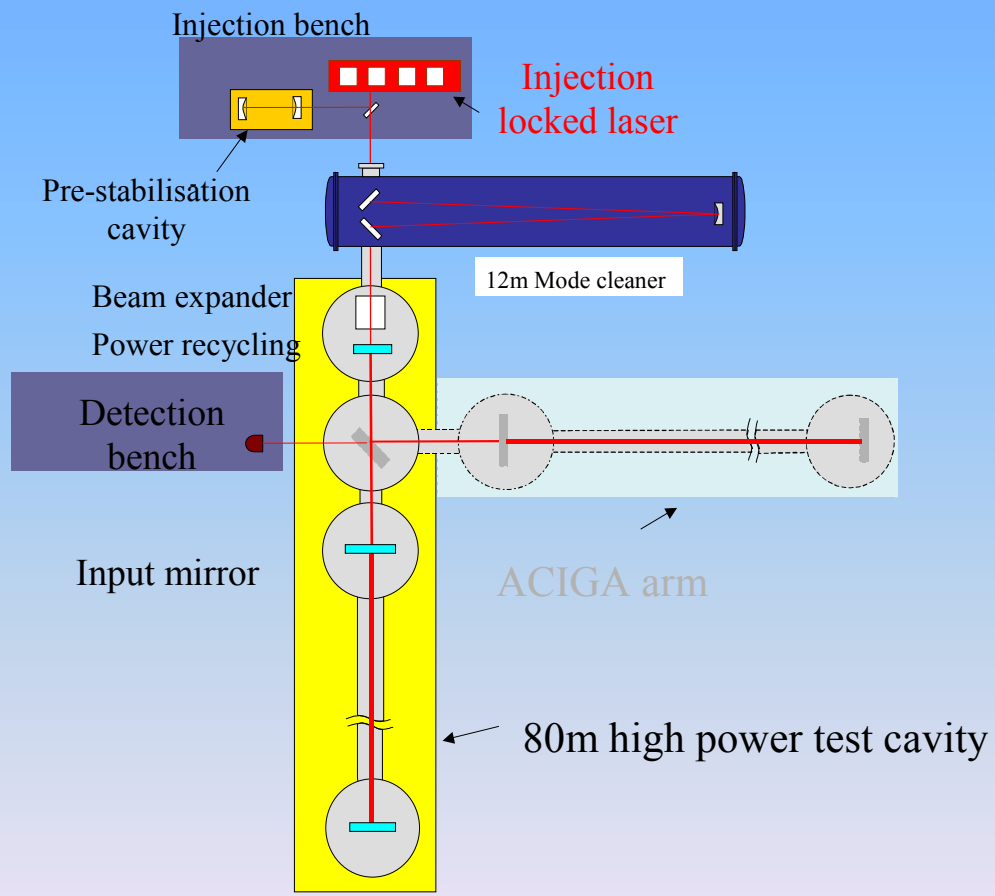
LSC meeting
Livingston, March 2003

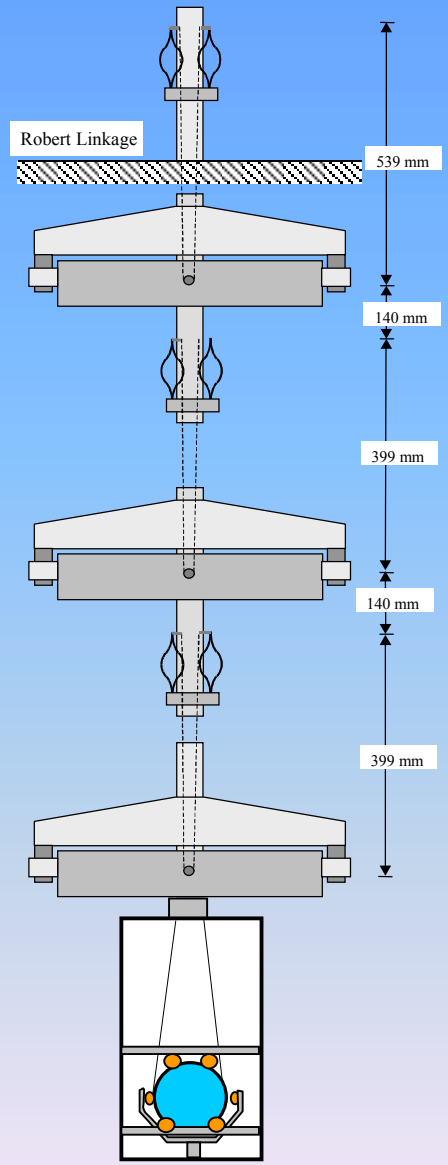
# Gingin Research Facility

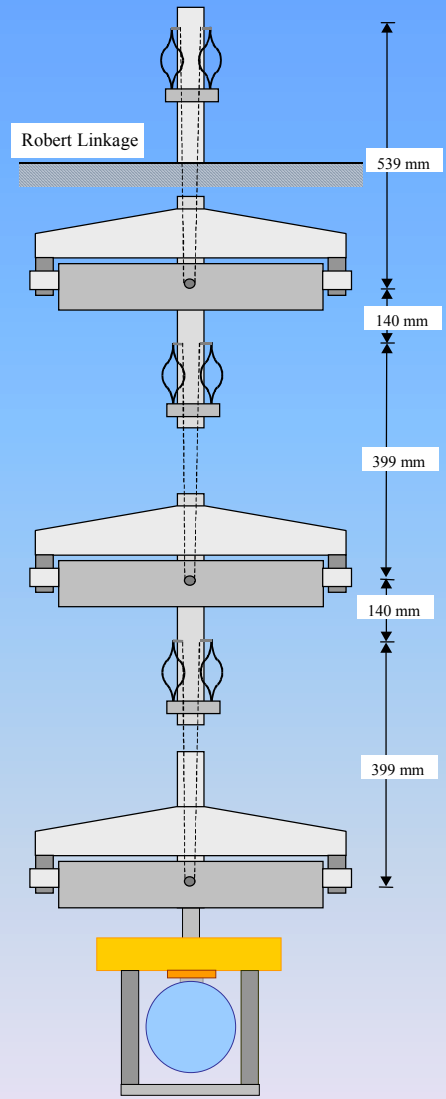
# Objective

Primarily to collaborate with LIGO to investigate phenomena due to very high optical power in a laser interferometer for gravitational wave detection.

# Facility Configuration




Robert Linkage
539 mm
140 mm
399 mm
140 mm
399 mm


Robert Linkage
539 mm
140 mm
399 mm
140 mm
399 mm

# A sequence of 3 tests

Test 1

Input power ≈ 6 W

Intra-cavity power ≈ 2.1 kW

Test 2

Input power ≈ 50W

Intra-cavity power ≈ 100 kW

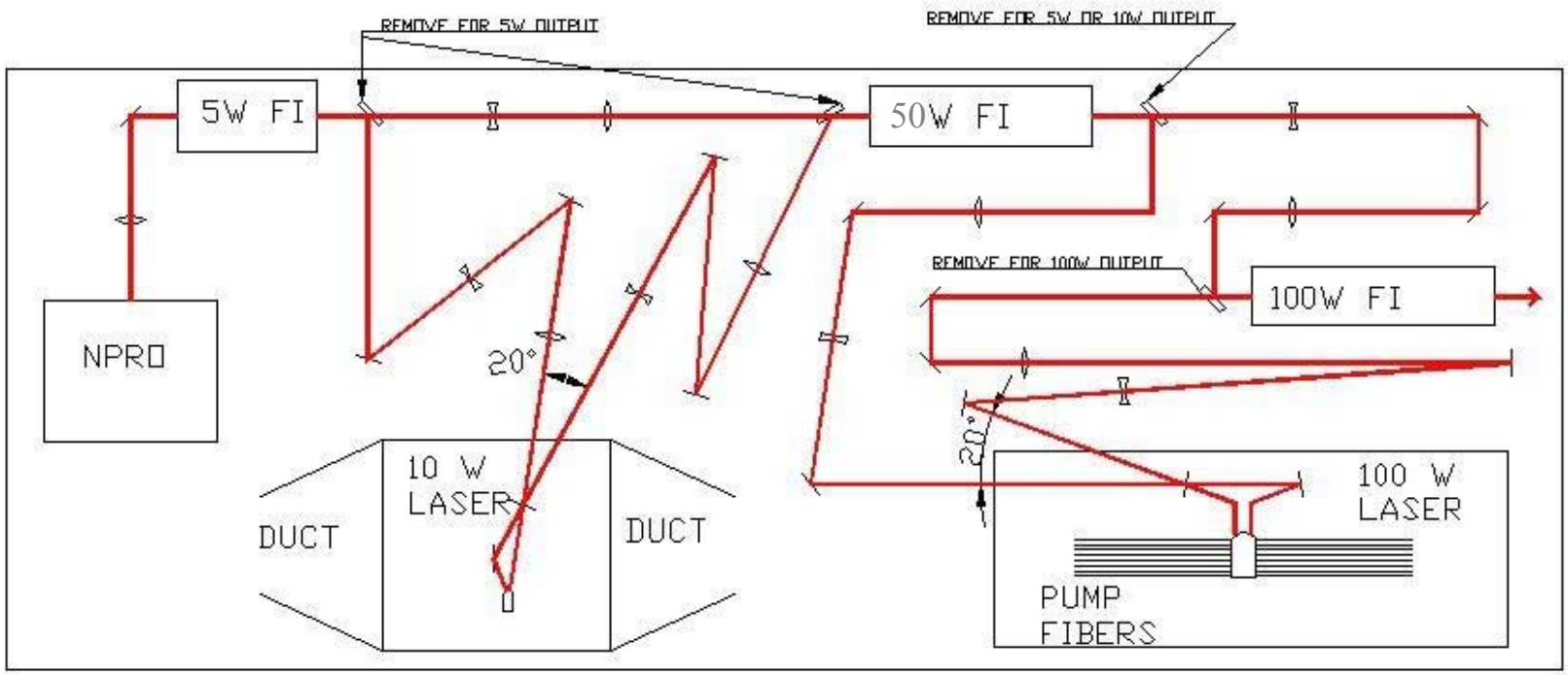
Test 3

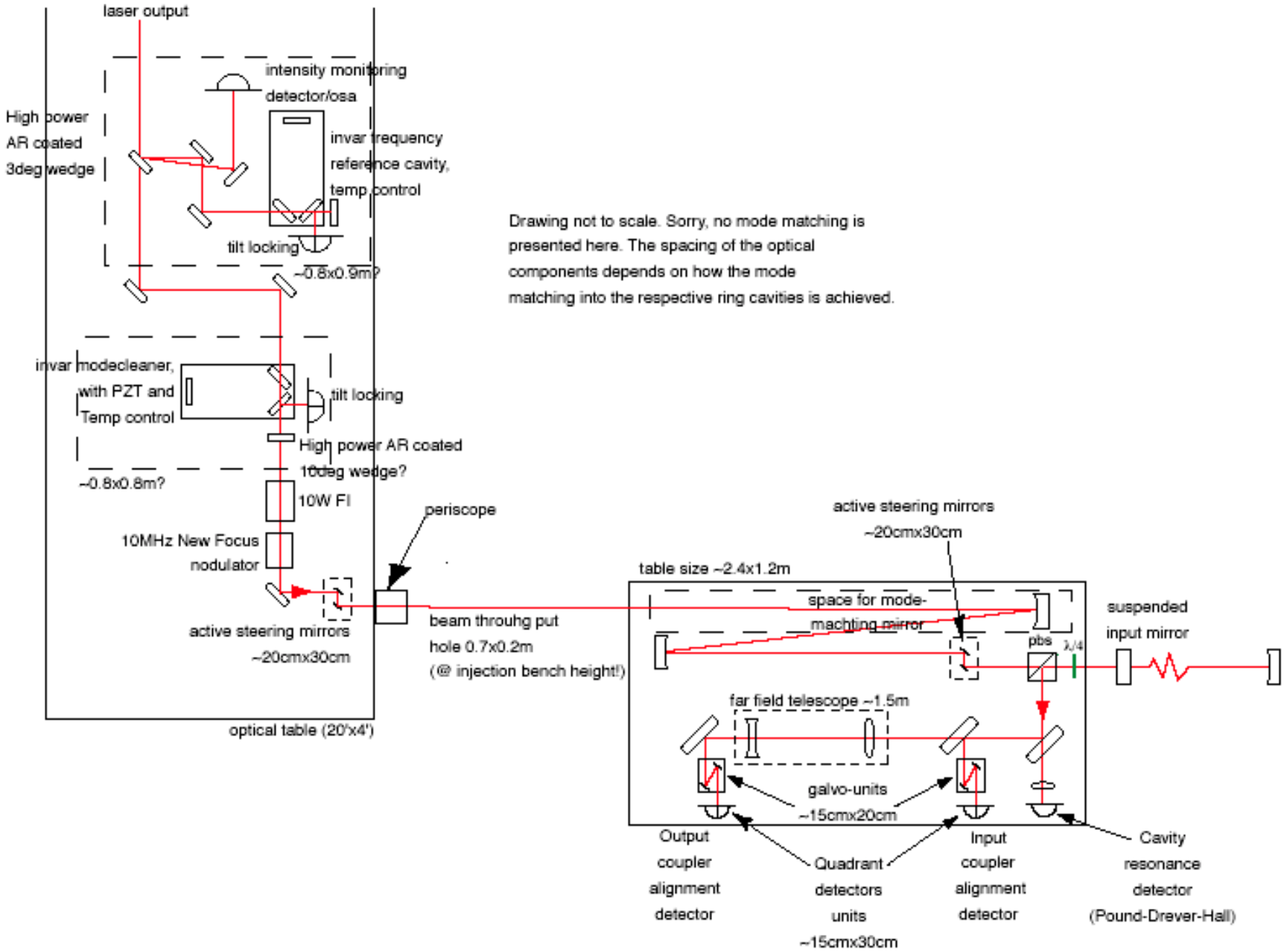
Input power ≈ 50W

Recycling cavity power ≈ 4 kW

Arm cavity power ≈ 200kW

# Laser Table Layout




laser output
intensity monitoring
detector/osa
High power
AR coated
3deg wedge
invar frequency
reference cavity,
temp control
tilt locking
~0.8x0.9m?
invar modecleaner,
with PZT and
Temp control
tilt locking
High power AR coated
10deg wedge?
~0.8x0.8m?
10W FI
10MHz New Focus
nodulator
periscope
active steering mirrors
~20cmx30cm
optical table (20'x4')
beam throuhg put
hole 0.7x0.2m
(@ injection bench height!)
Drawing not to scale. Sorry, no mode matching is
presented here. The spacing of the optical
components depends on how the mode
matching into the respective ring cavities is achieved.
active steering mirrors
~20cmx30cm
table size ~2.4x1.2m
space for mode-
machting mirror
pbs
λ/4
suspended
input mirror
far field telescope ~1.5m
galvo-units
~15cmx20cm
Output
coupler
alignment
detector
Quadrant
detectors
units
~15cmx30cm
Input
coupler
alignment
detector
Cavity
resonance
detector
(Pound-Drever-Hall)

# Project Status

- Infrastructure:
  - Facilities
  - Vacuum System
- Vibration Isolation
- Isolator Controls
- Sapphire Test Masses
  - Simulation of thermal lensing and its compensation
  - Scattering measurement


$T = \frac{c^4}{8\pi G} G$

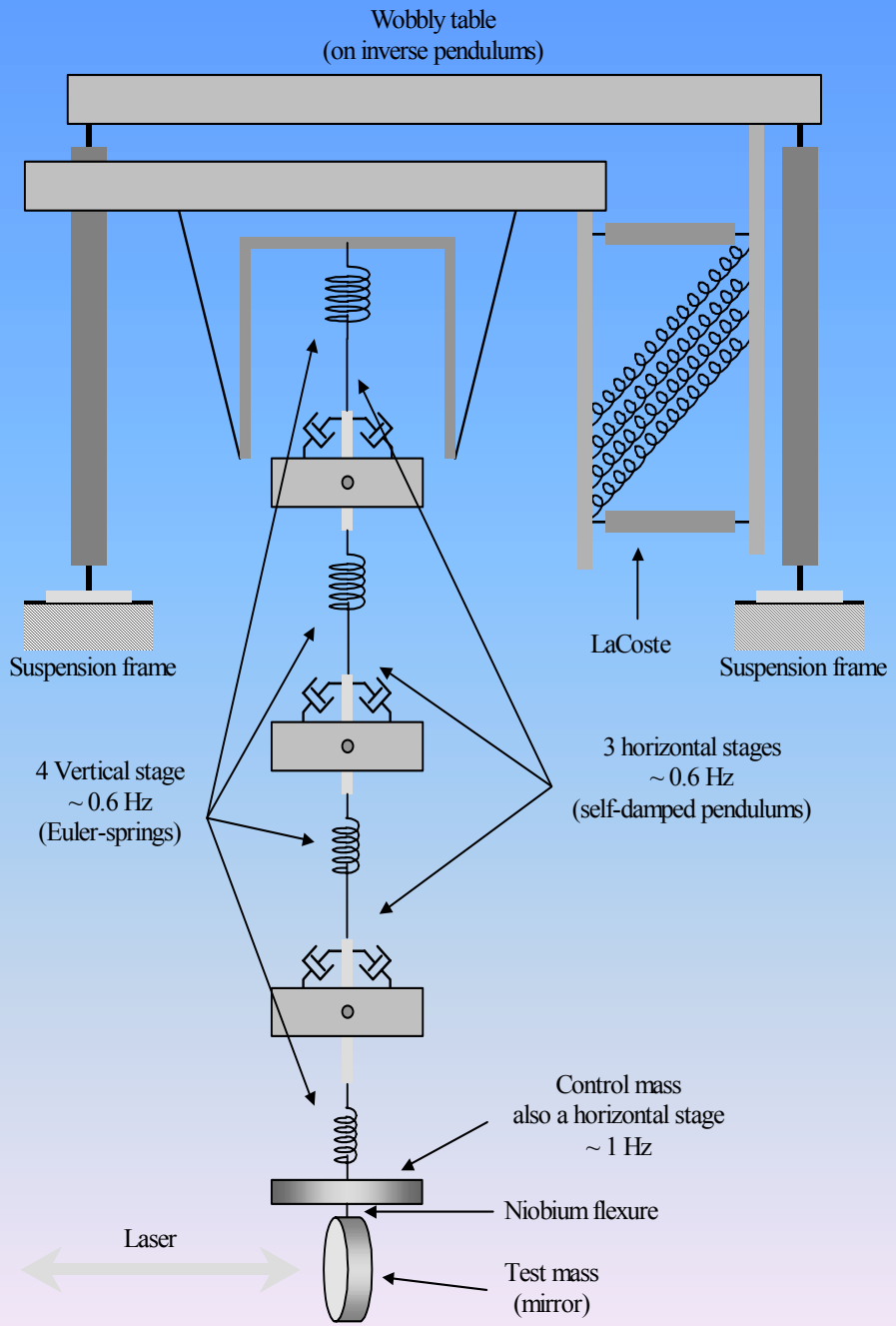
# Vacuum Systems

- The best pressure achieved so far
  - in Central Tank

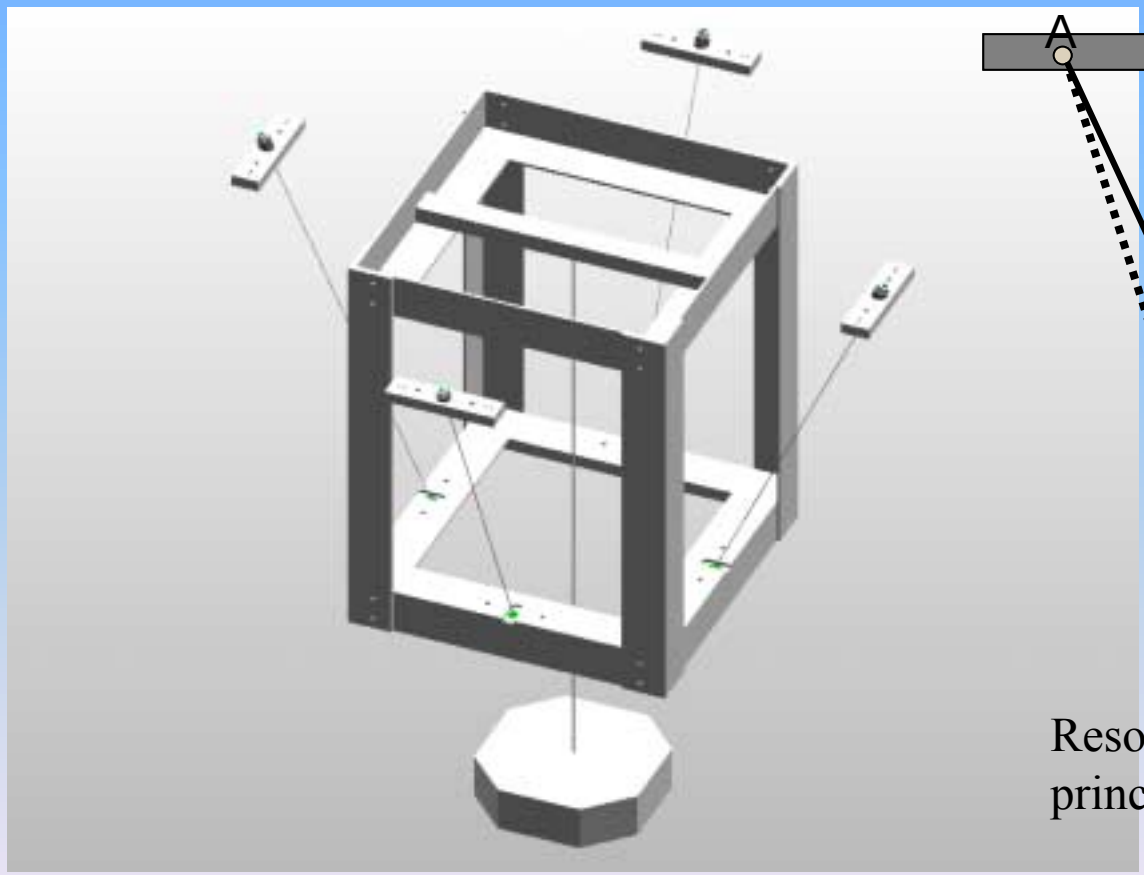
    $8.0 \times 10^{-7}$ mbar
  - in South Intermediate Tank

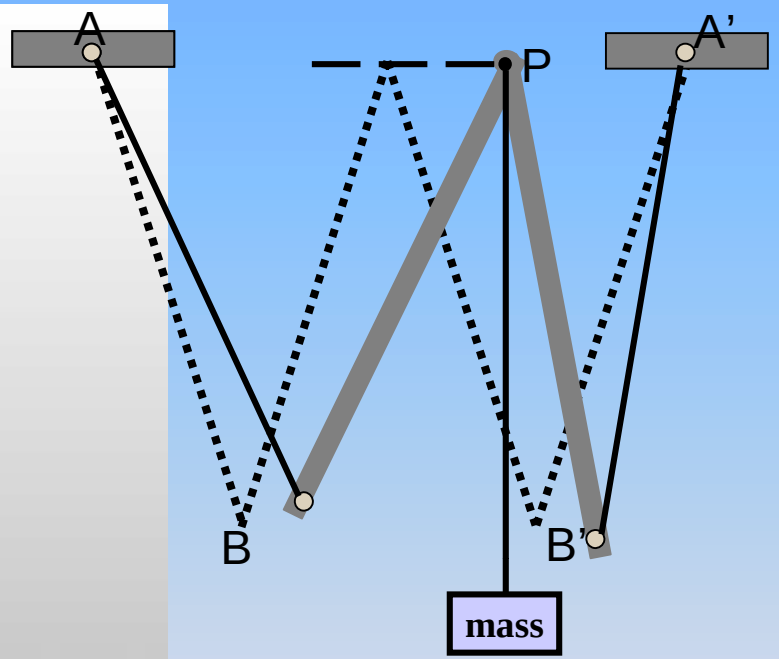
    $7.8 \times 10^{-7}$ mbar.
  - in South End Station Tank (detected some leaks)

    $8.3 \times 10^{-6}$ mbar


Wobbly table
(on inverse pendulums)
Suspension frame
LaCoste
Suspension frame
4 Vertical stage
~ 0.6 Hz
(Euler-springs)
3 horizontal stages
~ 0.6 Hz
(self-damped pendulums)
Control mass
also a horizontal stage
~ 1 Hz
Niobium flexure
Laser
Test mass
(mirror)

# The Roberts linkage



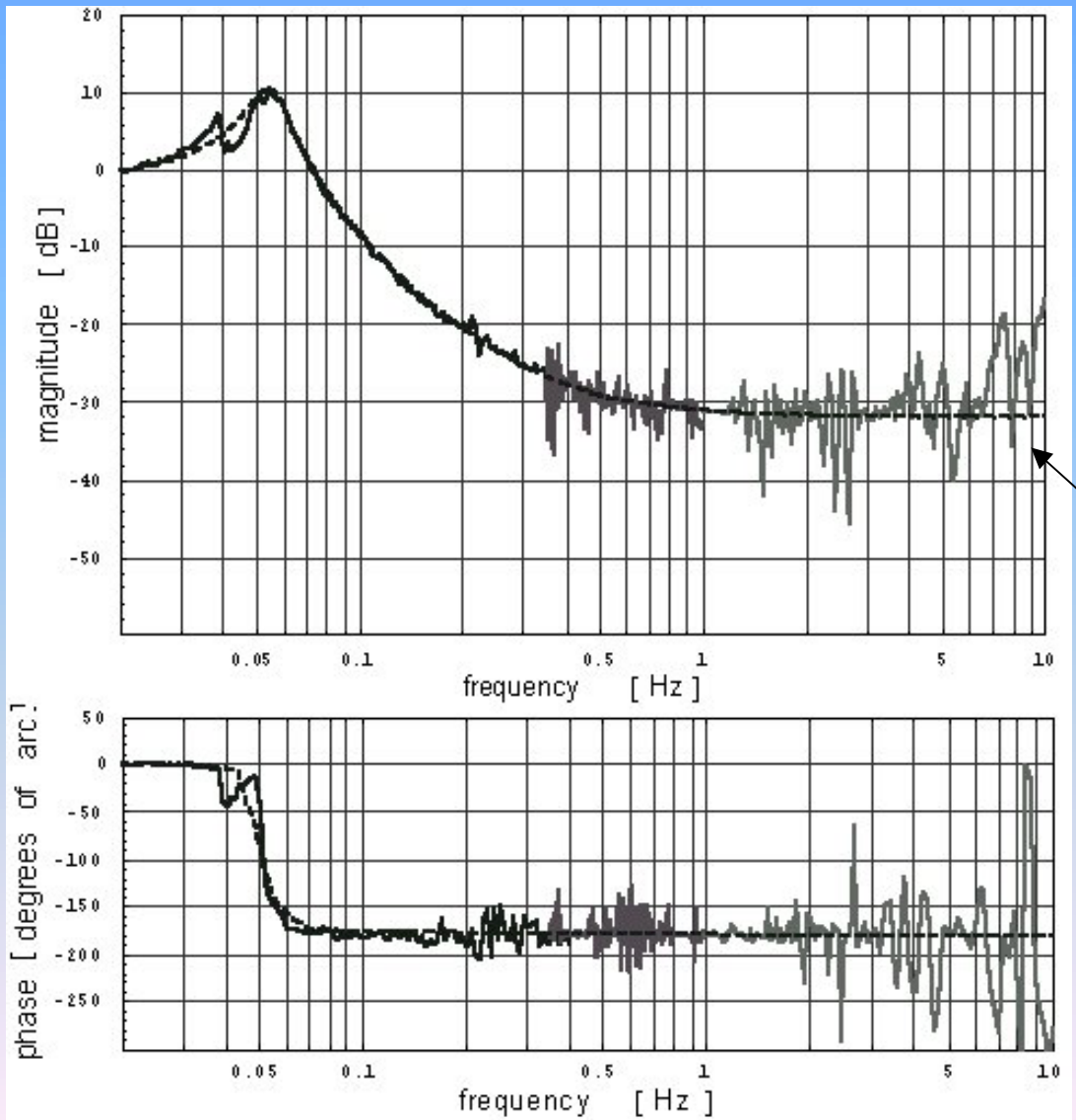



Resonant frequency (on the two principal directions of oscillation):

54mHz

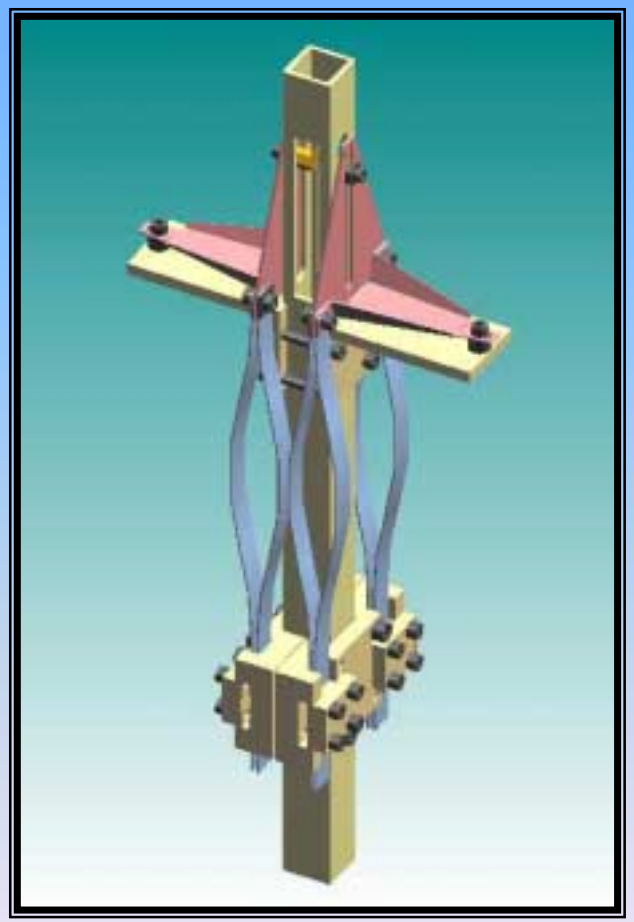
39mHz

# Roberts linkage results

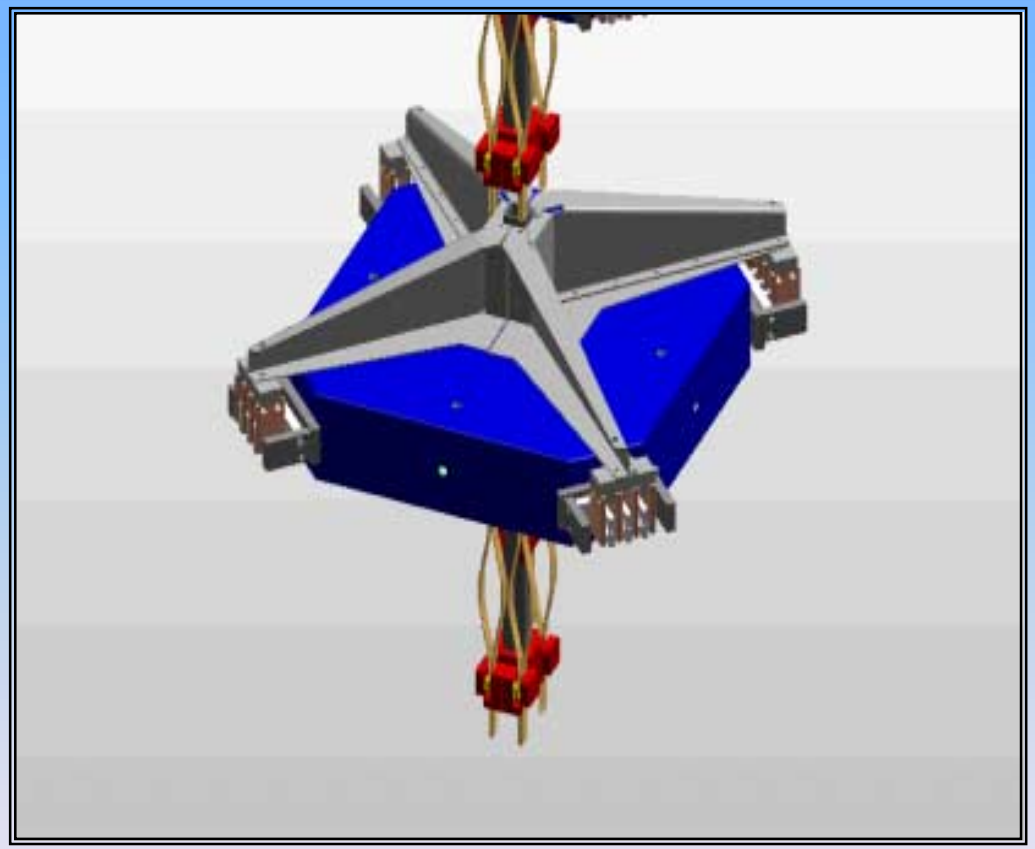



Centre of Percussion tuning limited level

# Euler Vertical Stages

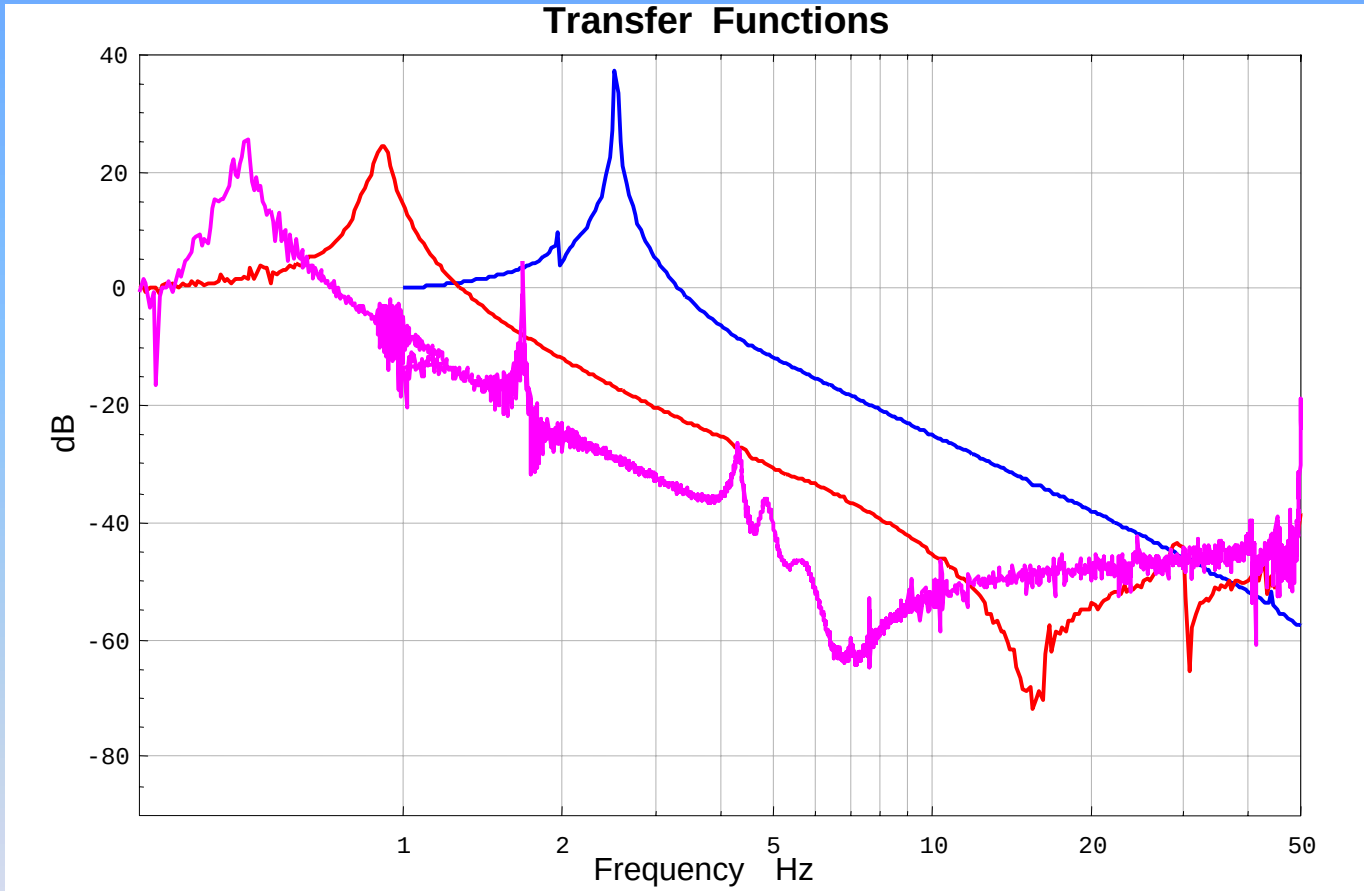


Euler springs



One isolator stage

# Results



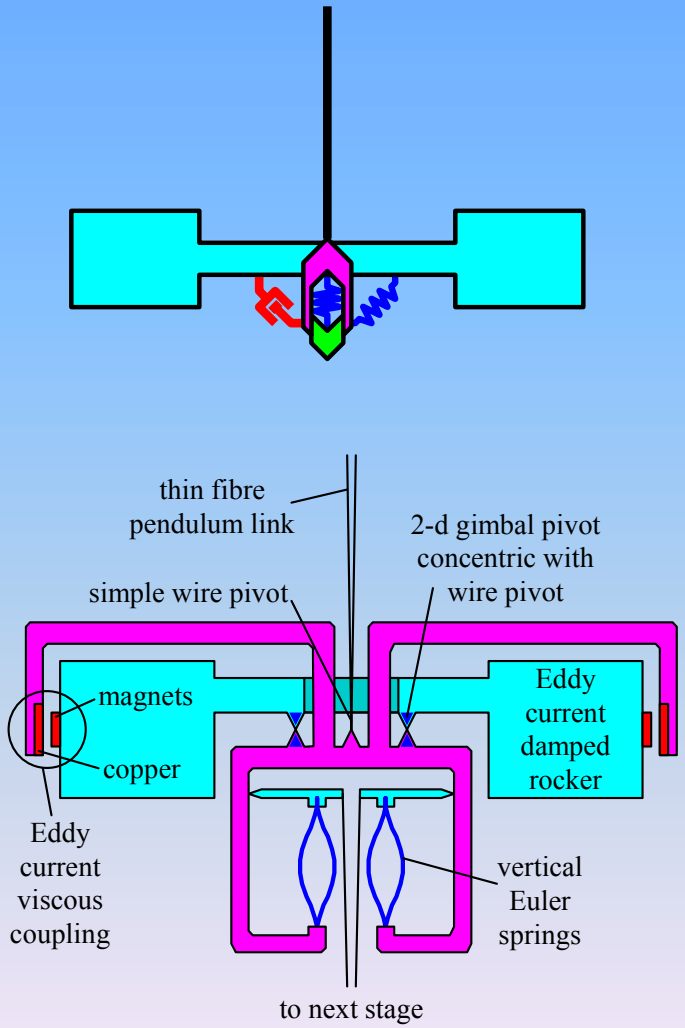

Former "wishbone" rotational arm design f = 2.4Hz.

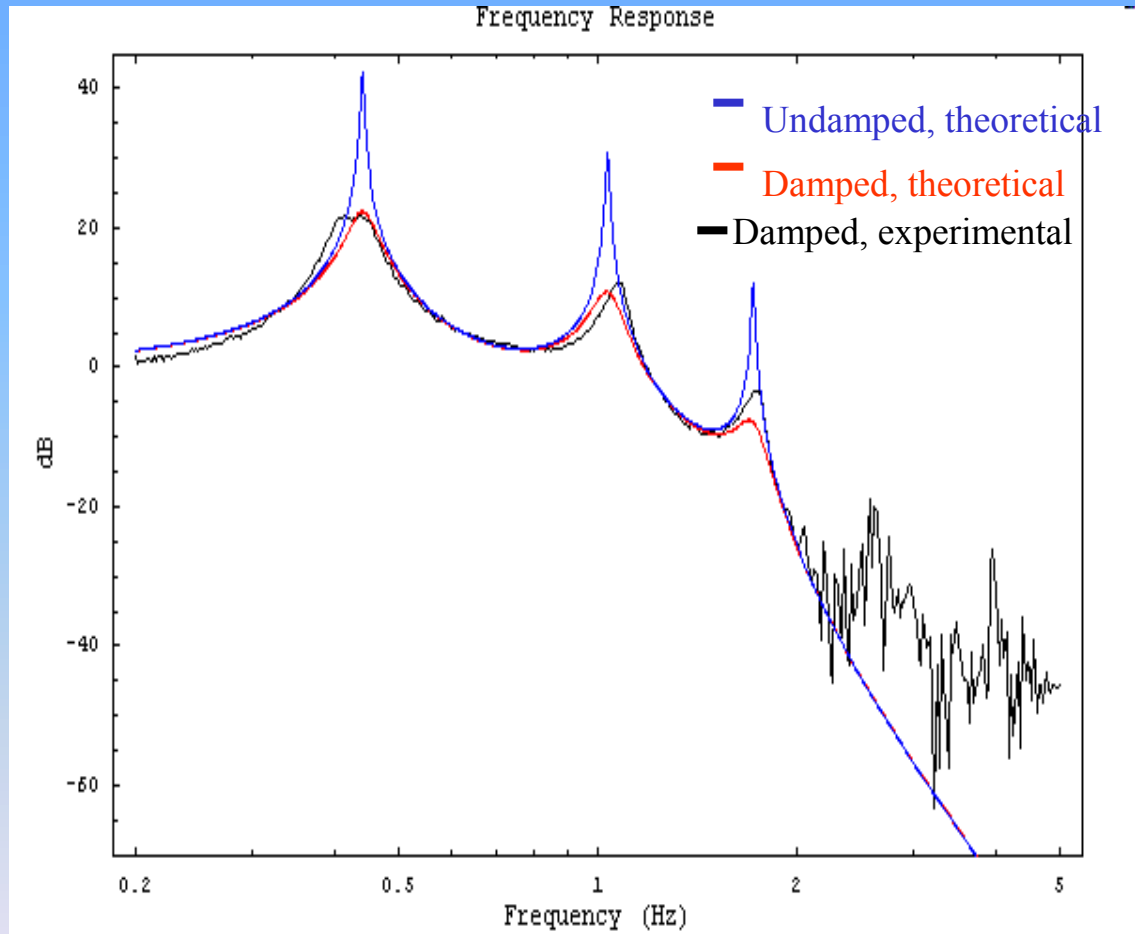
Initial design of the Euler stage f = 0.95Hz

Current design f = 0.5Hz, about 35dB improvement.

Progressive improvement of resonant frequencies in a single vertical vibration isolation stage.

# Self-damped Pendulum

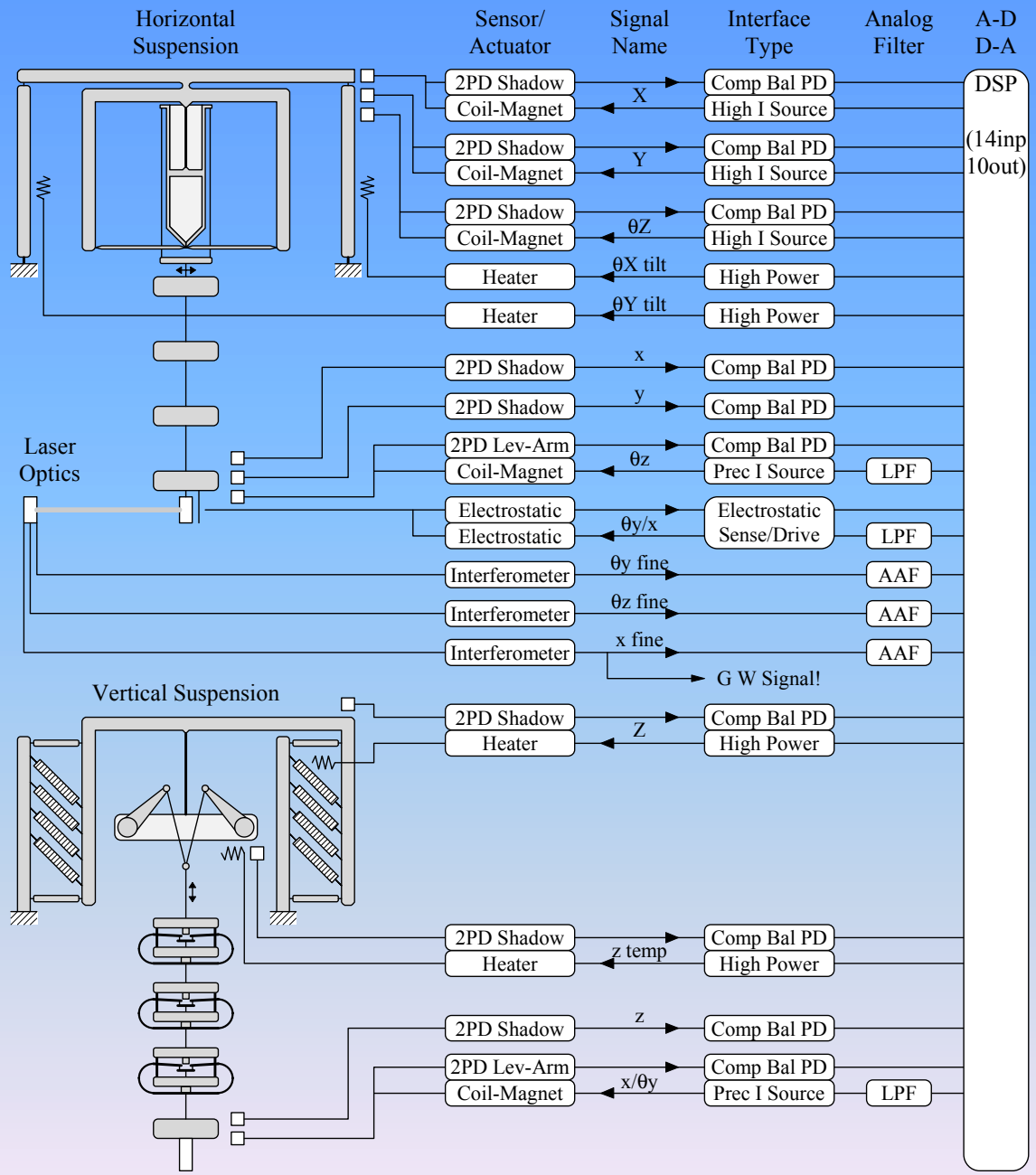


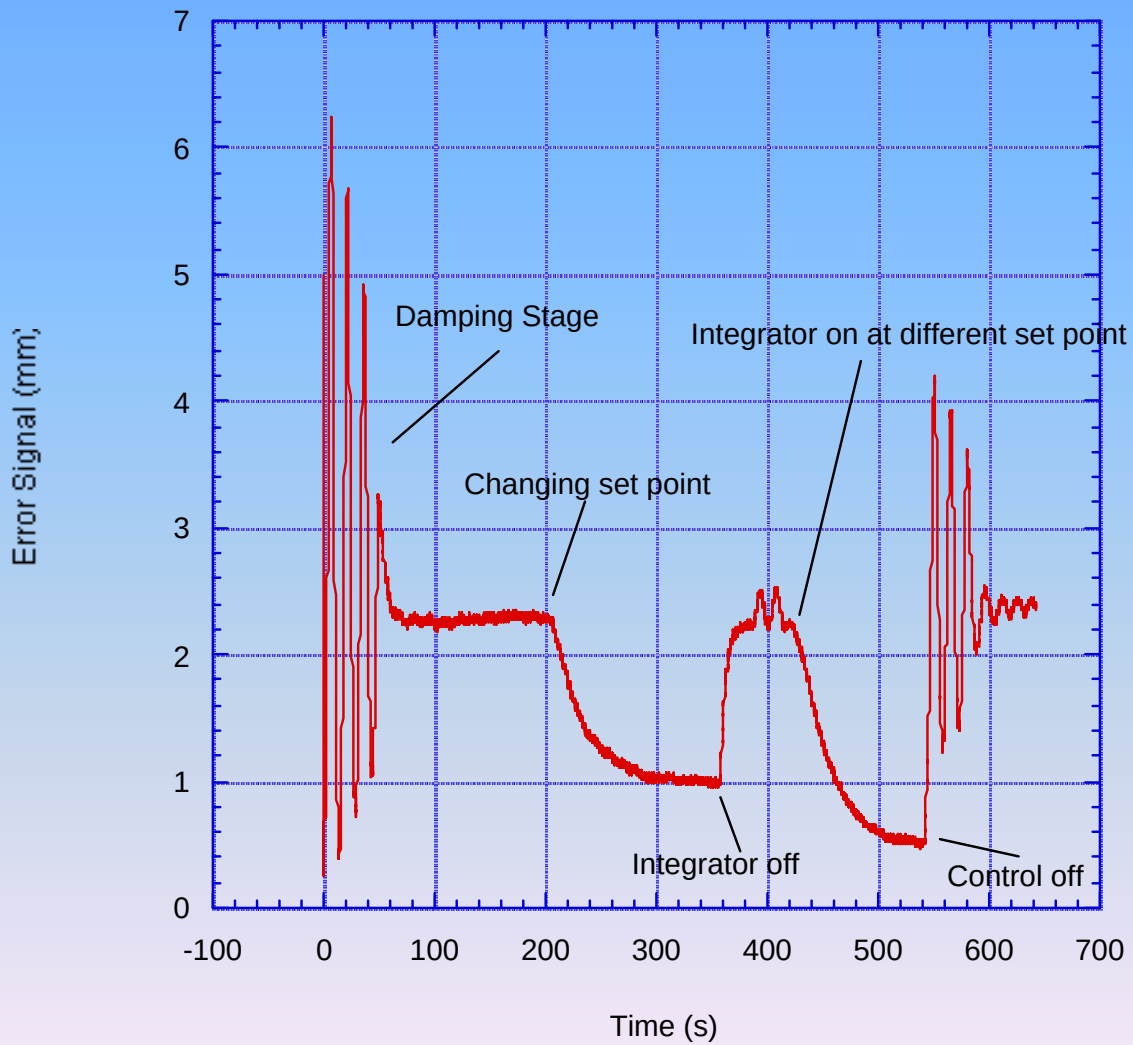
# Isolators

- Three pre-isolators have been completed
- The isolator chains are in manufacturing stage

# Control system



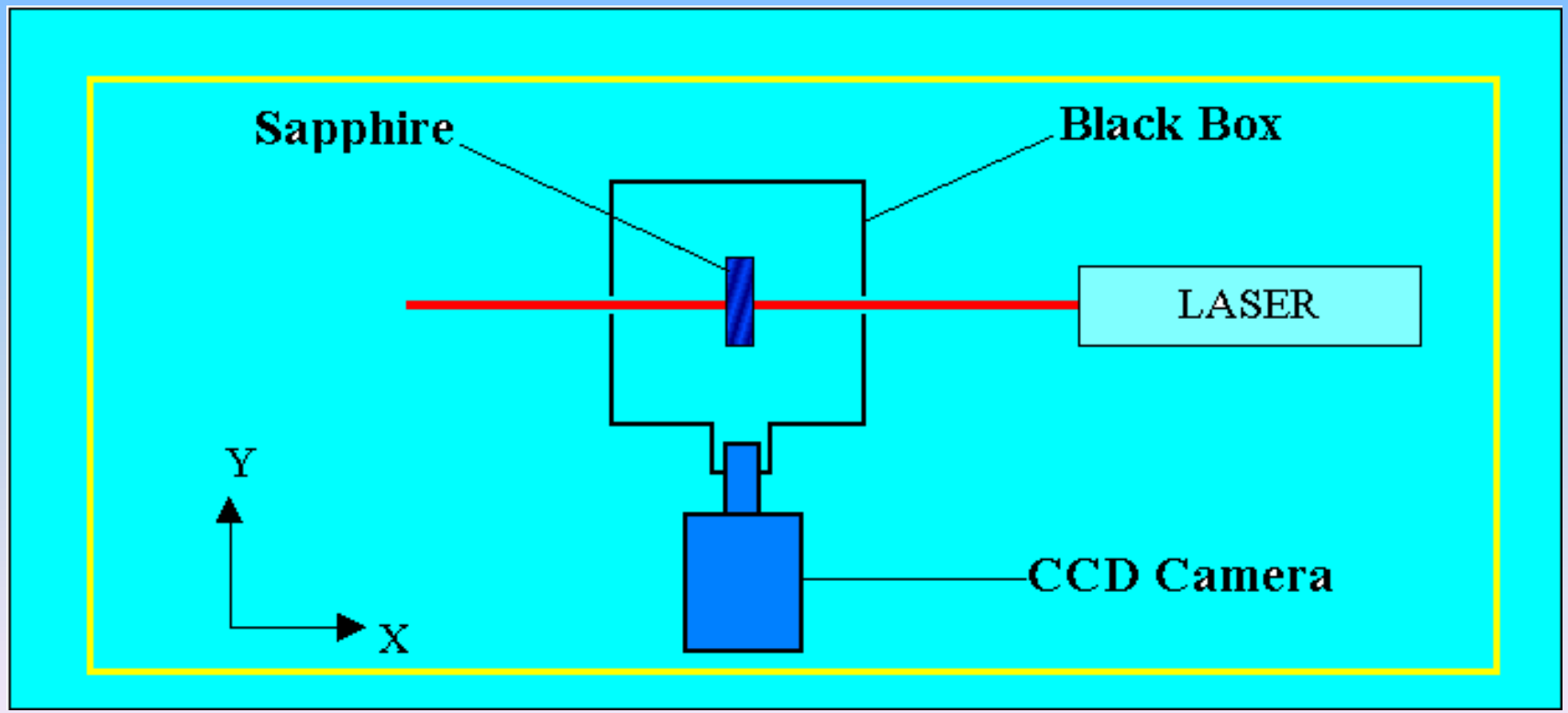
## Demonstration of the Pre-isolator Control



# Isolator Controls

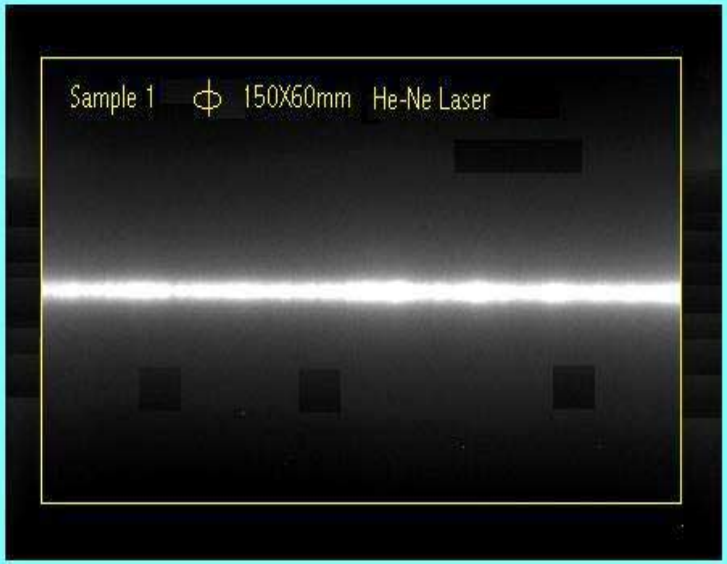
- Traditional Coil/Magnet actuators for pre-isolators and isolator chains control
- DSP based digital control system
- Experimentally demonstrated enough force to control the pre-isolator
- Successfully controlled one axis of the pre-isolator

# Rayleigh Scattering Study of Sapphire Test Masses



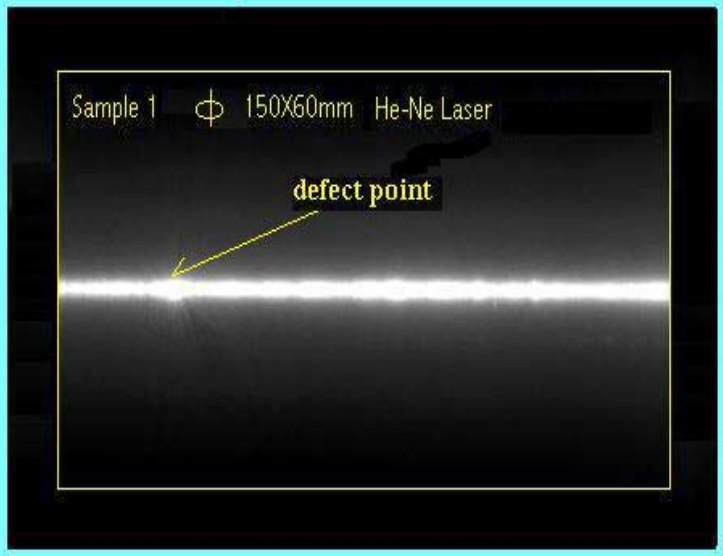
# Sample 1

Picture1 exposure time:10s




Position 1A

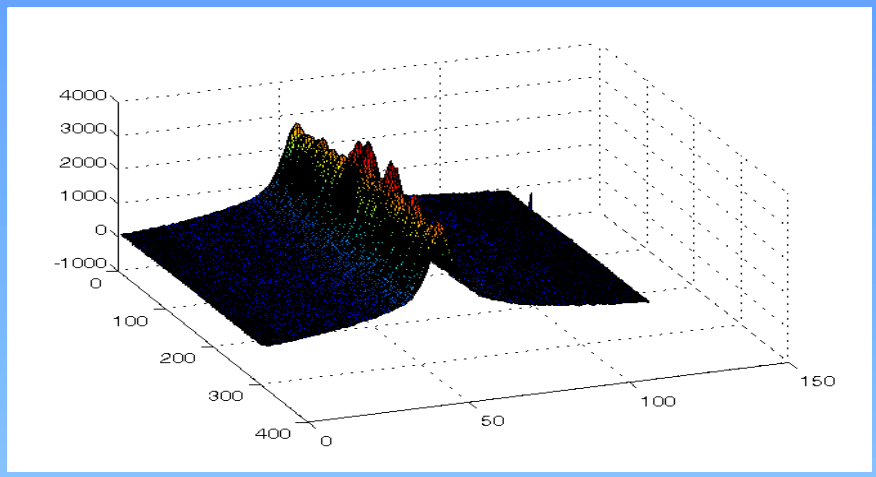
Picture2 exposure time:10s

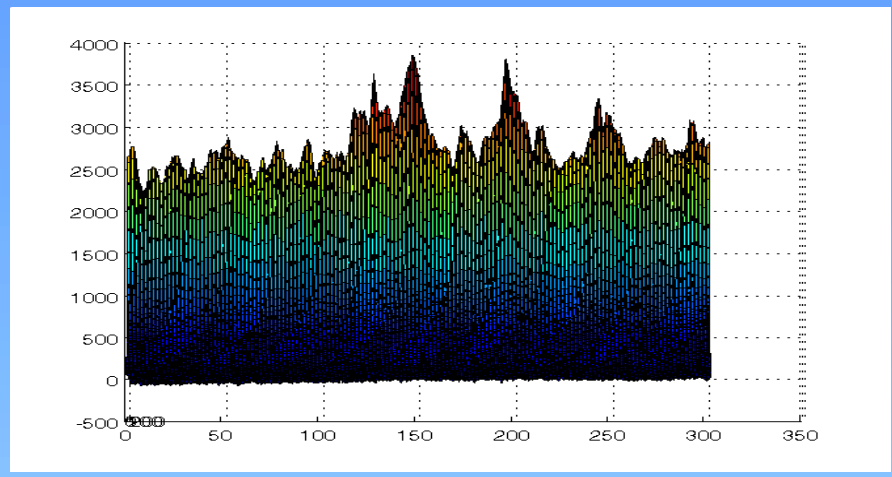



Position 1B

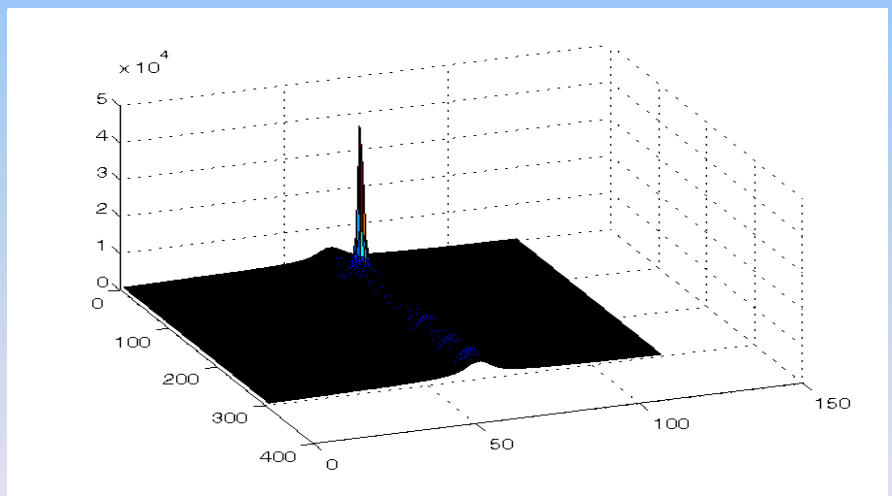
**The scattering is non-uniform along the beam. There is a big point defect in picture2 (position 1B).**

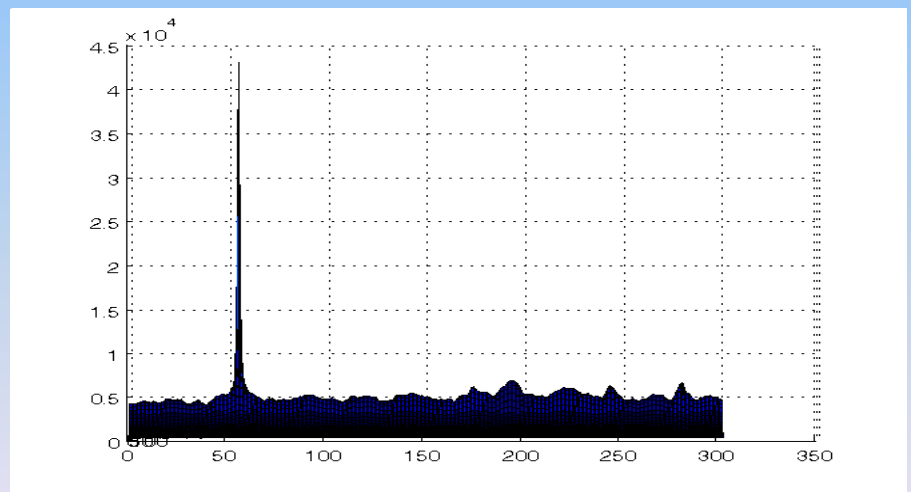
# Sample 1




**Relative intensity of scattering of position 1A. Maximum value <4000**

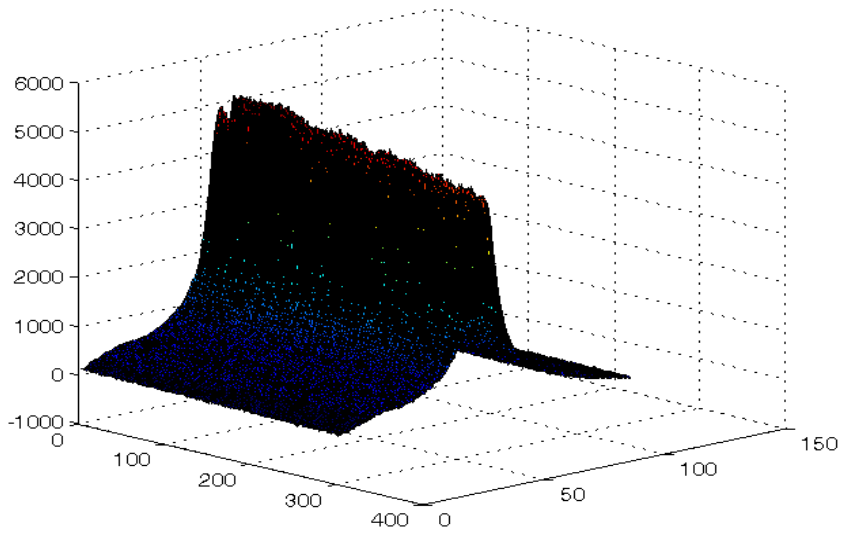


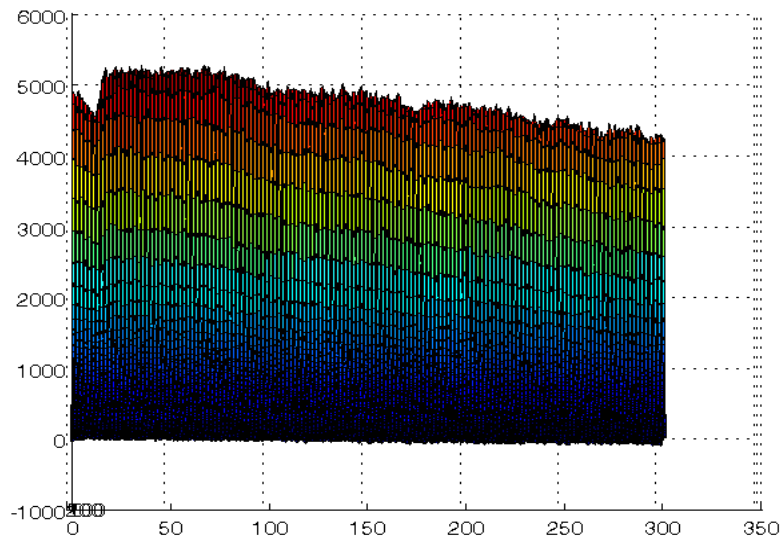




**Relative intensity of scattering of position 1B. "Ordinary" Level ~ 5000. There is a sharp peak at the point defect ~ 45000.**

# Sample 2


**Relative intensity ~4000-5000. The tendency of scattering changing along the length is all trough the sample.**



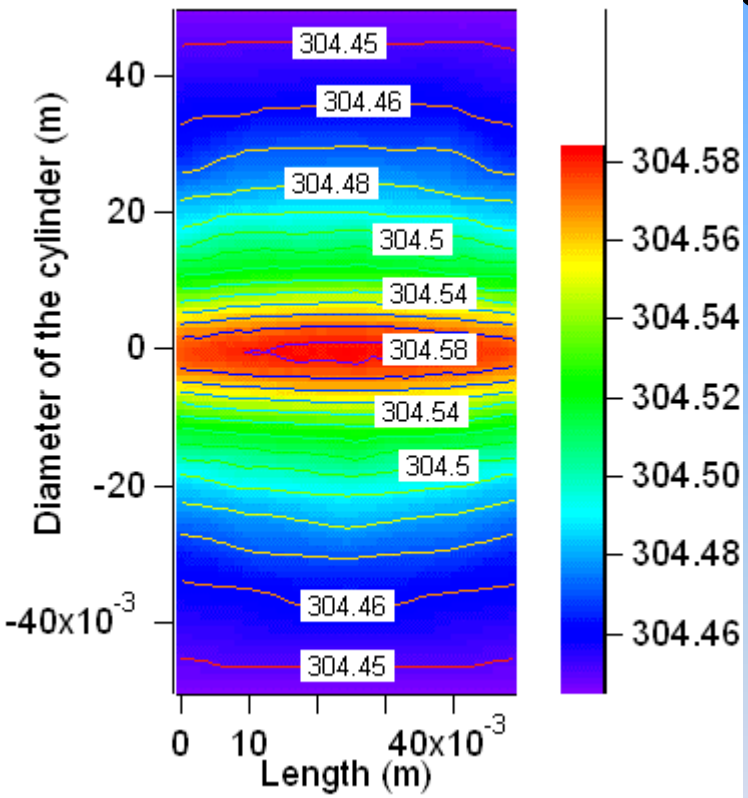



# Rayleigh Scattering Light

| Sample | Scattering light (digital unit/cm) | $R_{632.8nm}$ (ppm/cm) |
|---|---|---|
| Calibration sample* | 5500897 | 9.3 |
| 1 (without the point defect) | 1090083 | 1.8 |
| 2 | 2031482 | 3.4 |

*Previous measurements

# Thermal lensing at ACIGA




*Temperature profile of the ITM (1W absorbed)*

Sapphire test mass (abs = 50 ppm/cm)

+

High laser power (4kW)

=> Strong thermal lensing (1)

OP difference @waist ~ 30nm

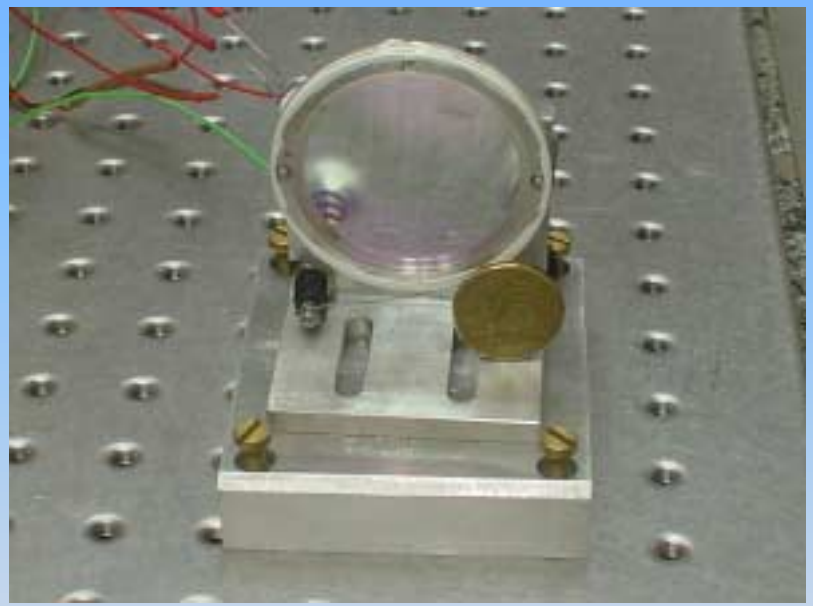
Relatively small waist (8mm)

=> High temperature gradient (2)

CL (1) + (2) : Compensation by heating ring difficult

# Compensation plate

Fused silica compensation plate wrapped around an heating wire



Advantage:

- Don’t heat the TM
- Heating by conduction

Disadvantage

- Need high AR
- Suspended ?

The power required to correct the thermal lens is only 3W

=> Solution planned for Gingin

# ACIGA Team