# Current status of the Mesa beam experiment: Tilt sensitivity

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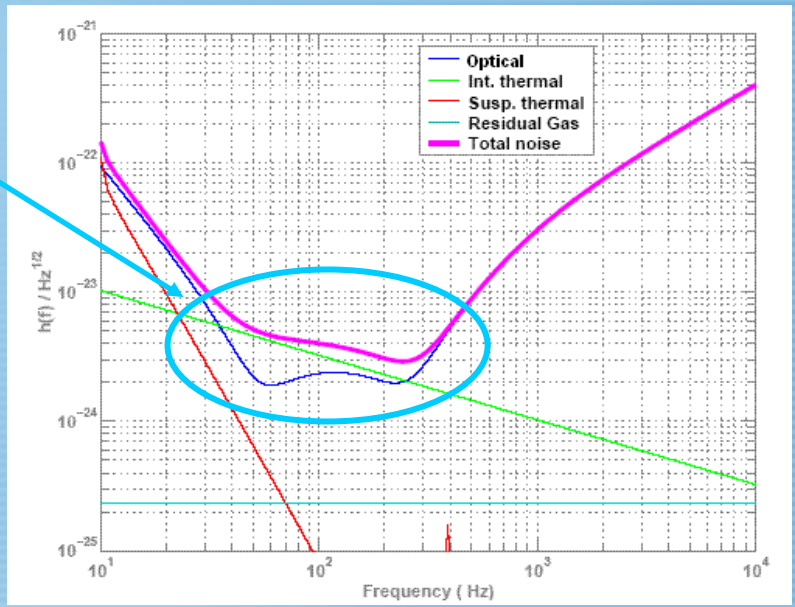
# Summary

- Introduction
- Current Status of Mesa Beam Experiment
- Tilt Sensitivity
- Results of work done
- Future work

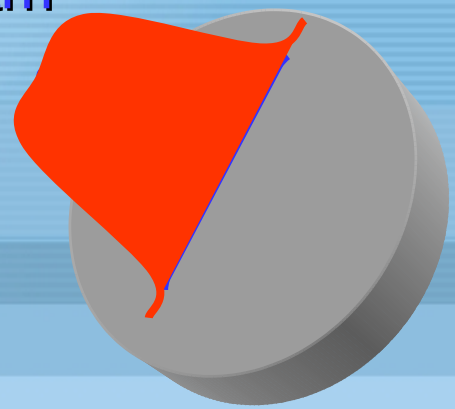
# Introduction

Thermal noise limits the sensitivity of gravitational wave interferometric detectors



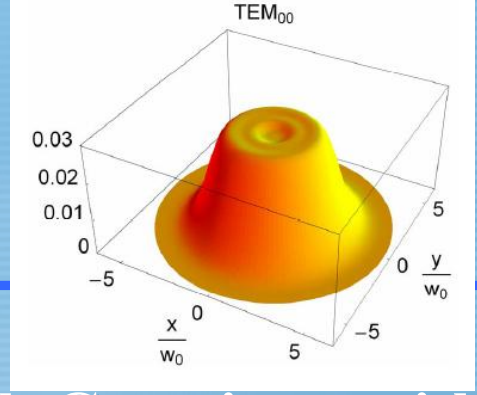

Gaussian Beam ⟶ Mesa Beam

Gaussian Beam



Mesa Beam

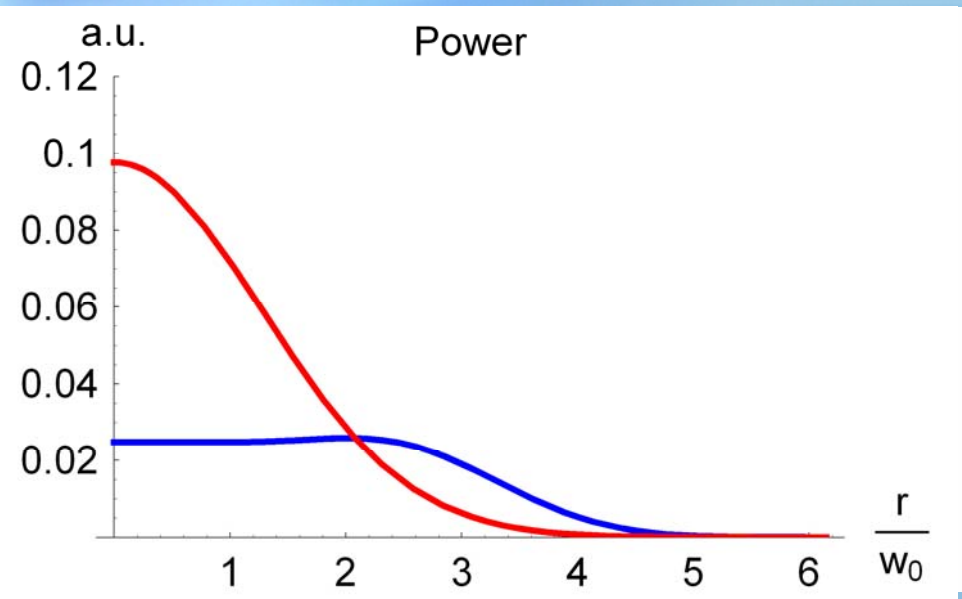
# Introduction

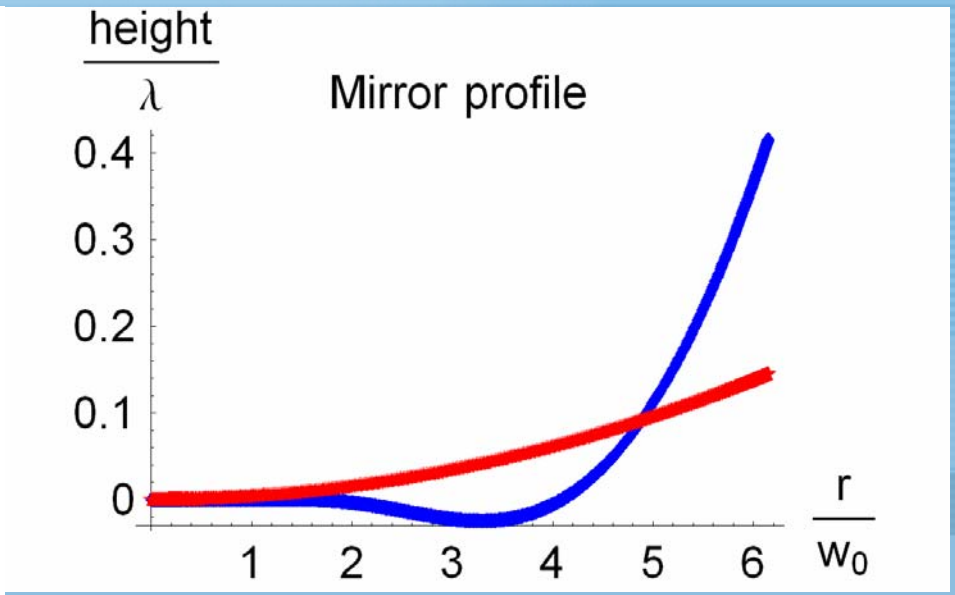



The Mesa Beam is a superposition of minimal Gaussians with $w_0=\sqrt{(L/k)}$

$$U(D,r)=\int_{C_D}\exp\left[\frac{-\left[(x-x_0)^2+(y-y_0)^2\right]\left[1+i\right]}{2w_0}\right]dx_0dy_0$$

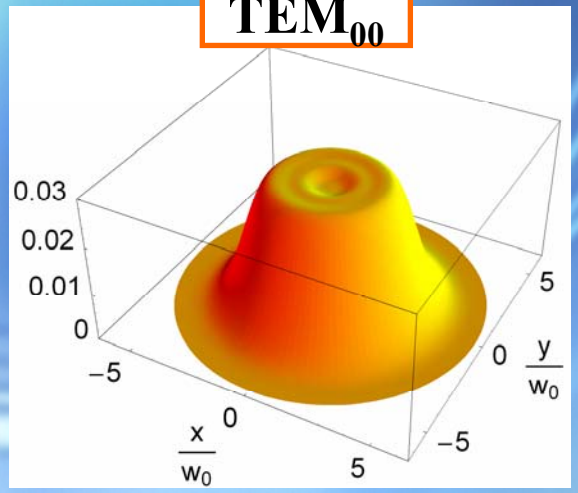
Supported by *nearly-flat* mirrors with **"Mexican-hat"** profile



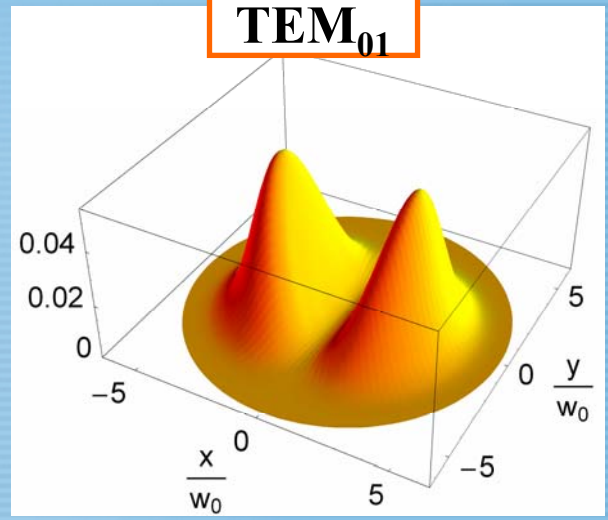



# Introduction

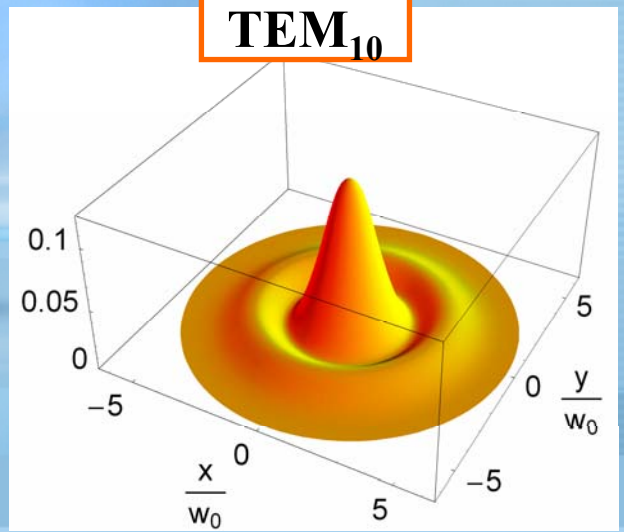
$TEM_{00}$



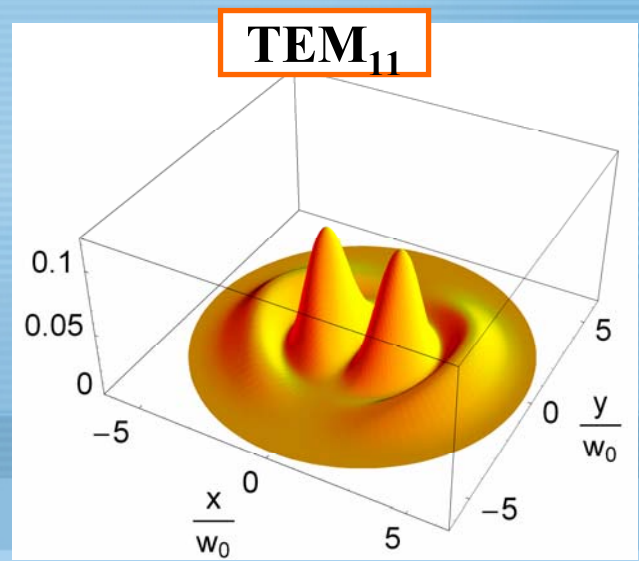

$TEM_{01}$




$TEM_{10}$

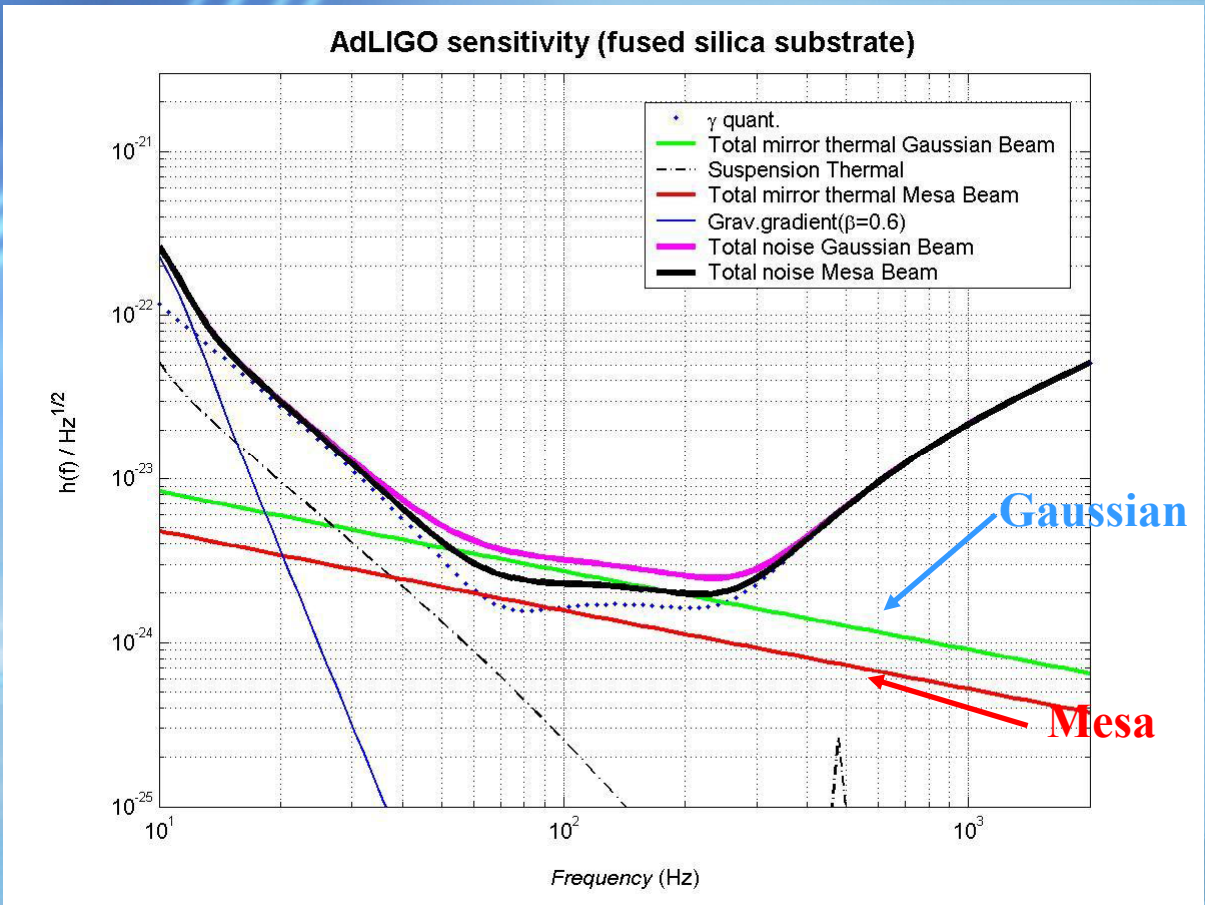



$TEM_{11}$



# Introduction

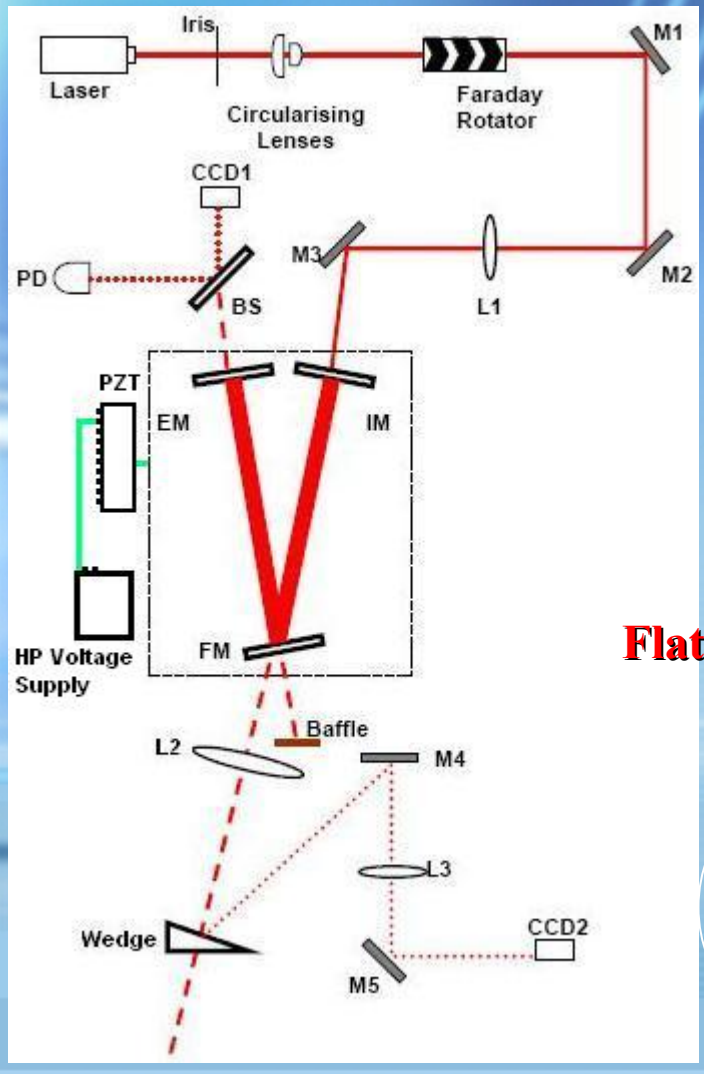
## Excepted Thermal noise reduction






Ref. Agresti LIGO-G050310-00-R

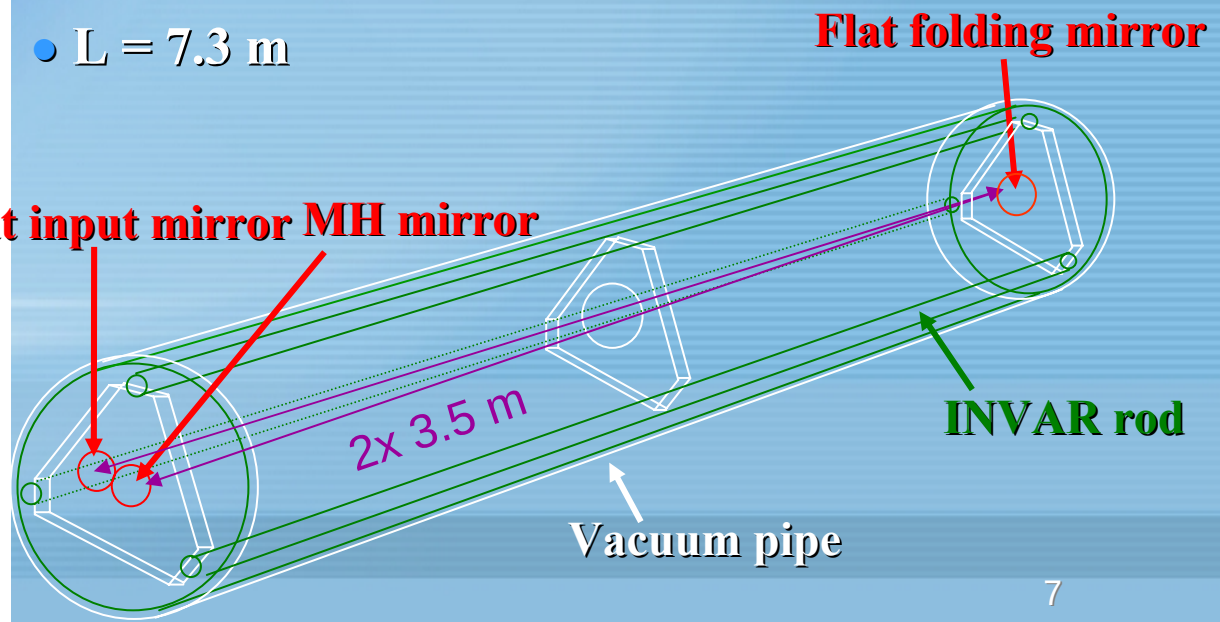
# Fabry-Perot Cavity




Reshaping the FP arm cavity mirrors it is possible to obtain a flat top beam

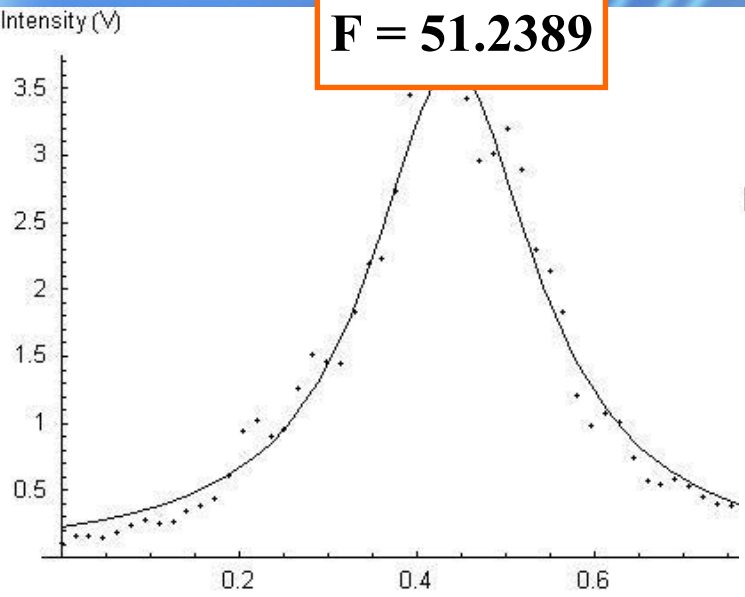
Caltech prototype

- Rigid, folded and suspended
- L = 7.3 m

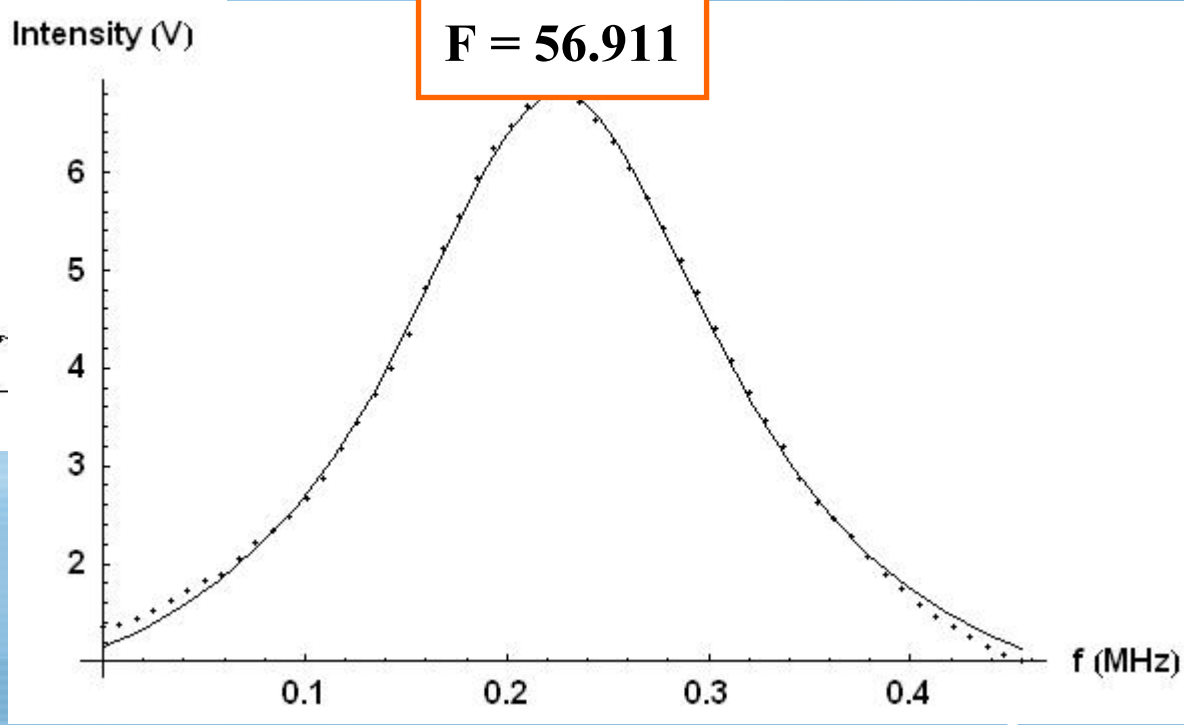


# Cavity Finesse

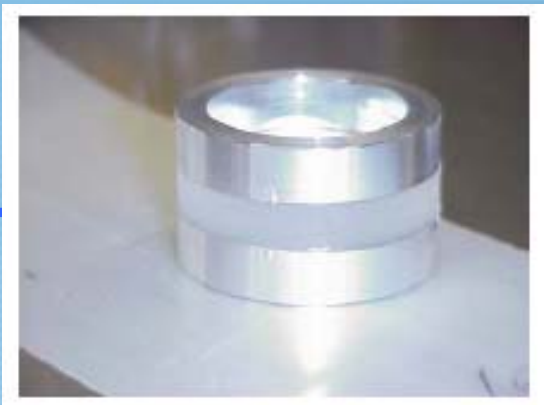
**F = 51.2389**

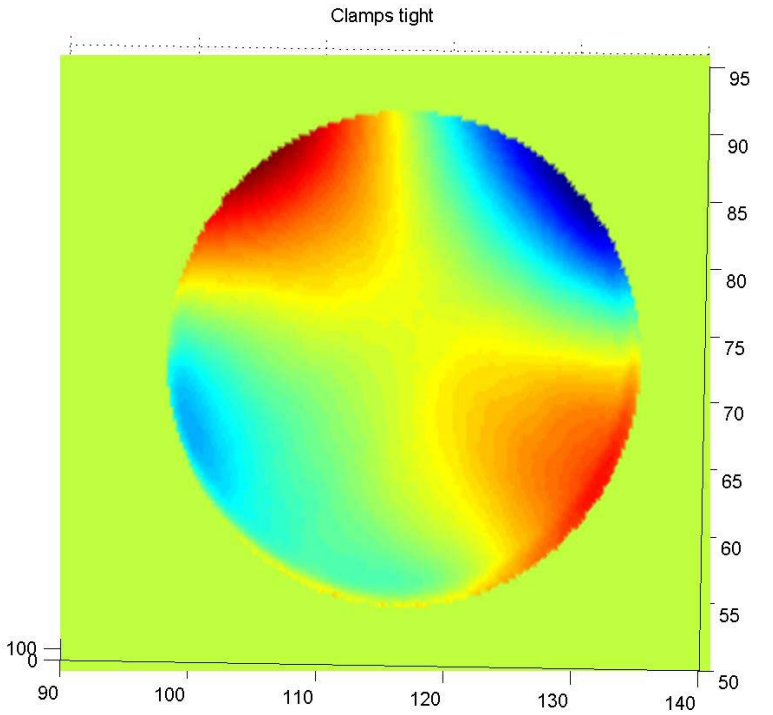


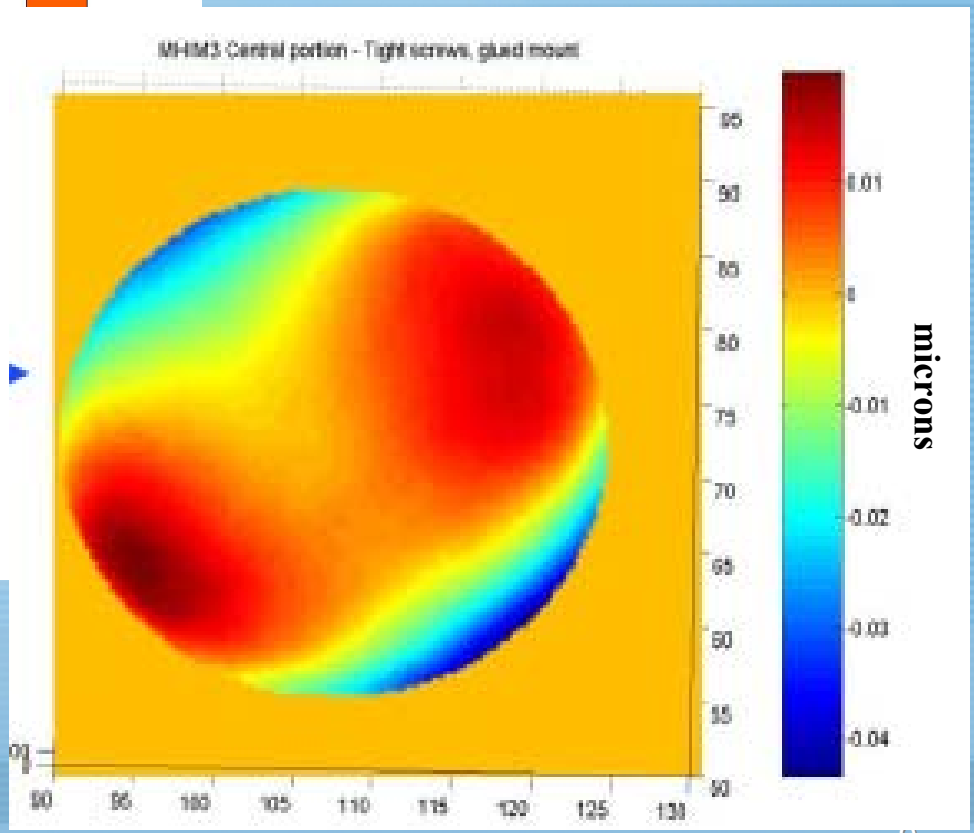

**F = 56.911**



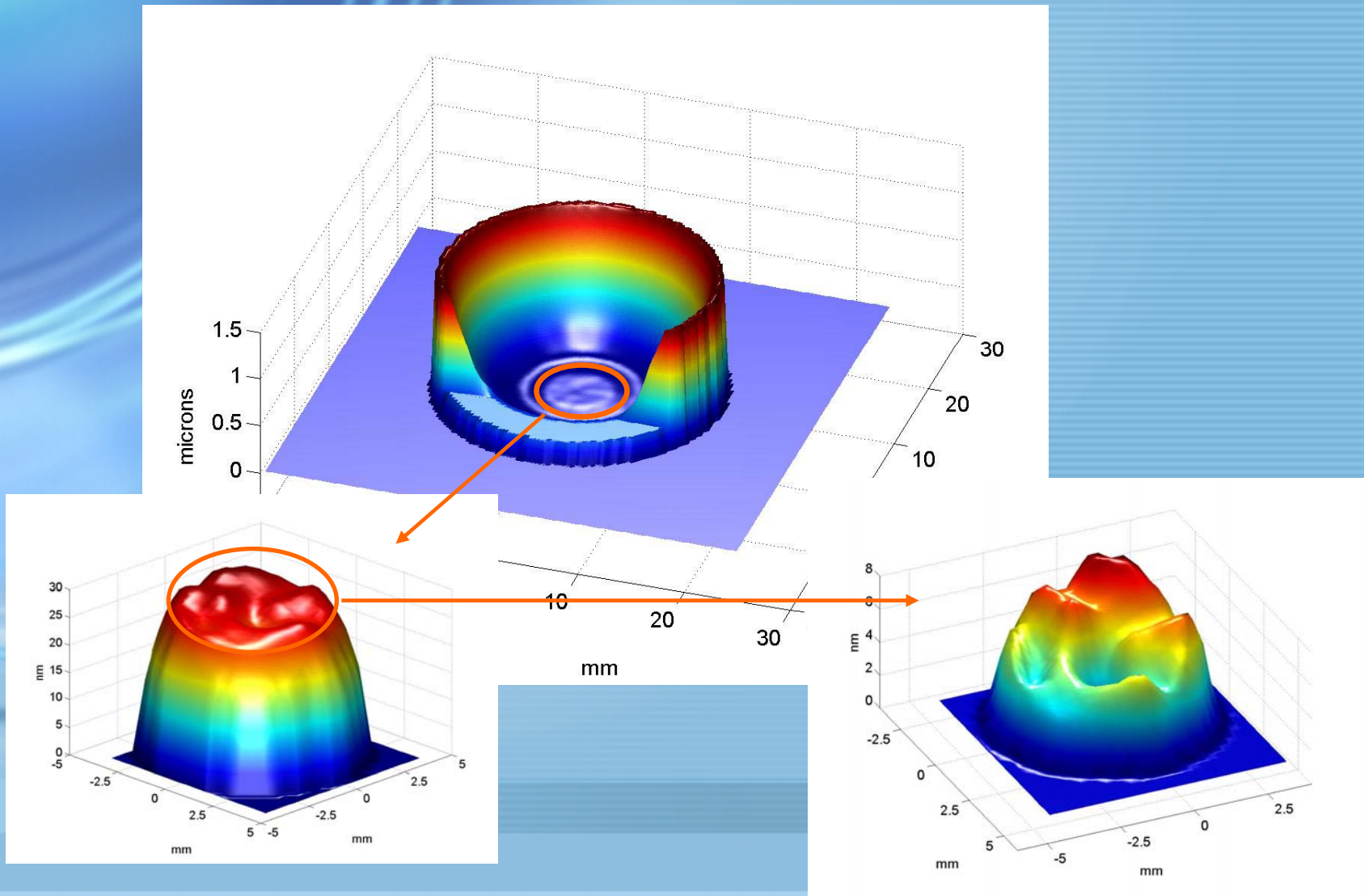
# Mirror maps




Clamps tight
0.04
95
90
85
80
75
70
65
60
55
50
100
0
90
100
110
120
130
140

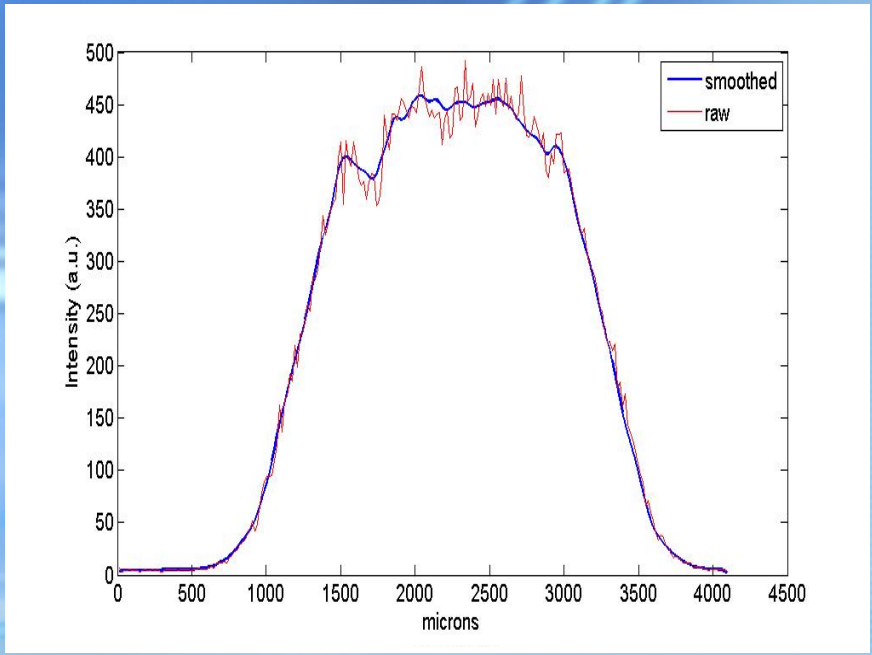

MHM3 Central portion - Tight screws, glued mount
0.01
0
-0.01
-0.02
-0.03
-0.04
microns

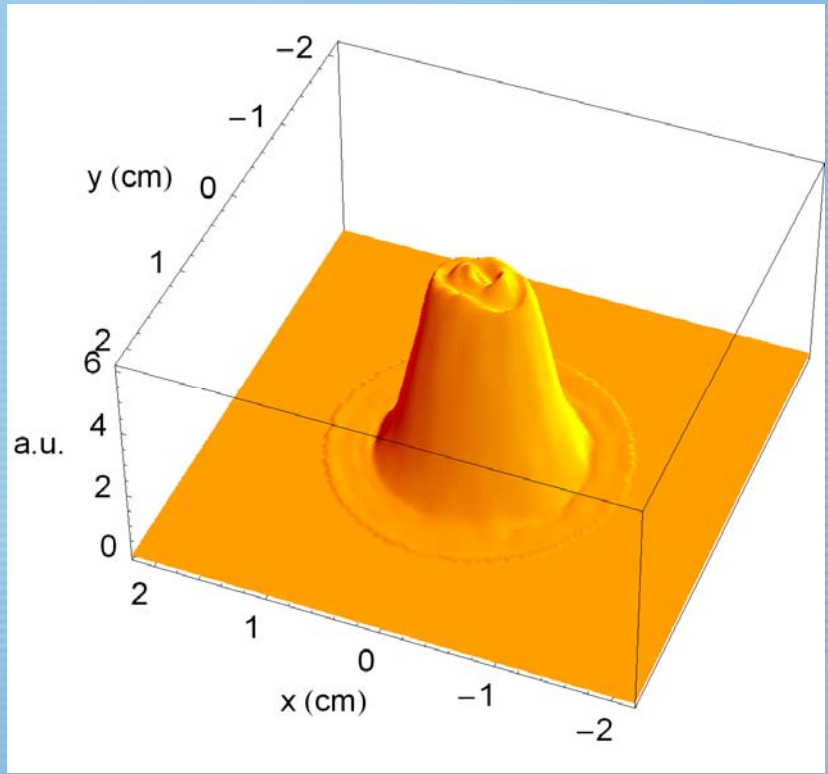
# Mirror maps



# Current status

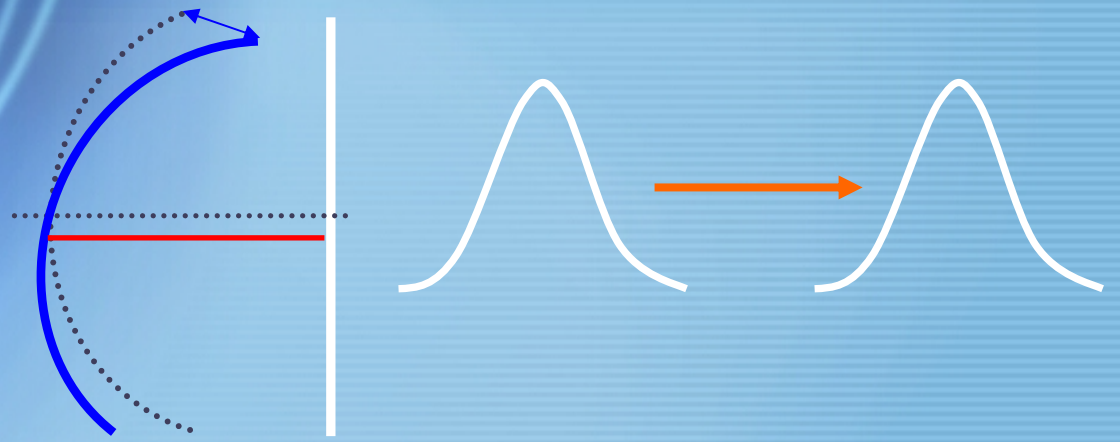
## Production of acceptable flat beam w/ imperfect optics



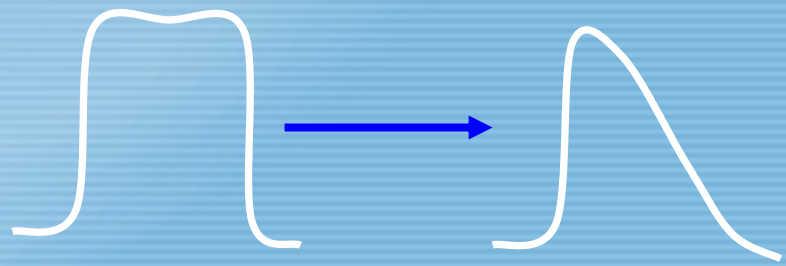
# Tilt

Tilts of spherical mirrors translate optical axis



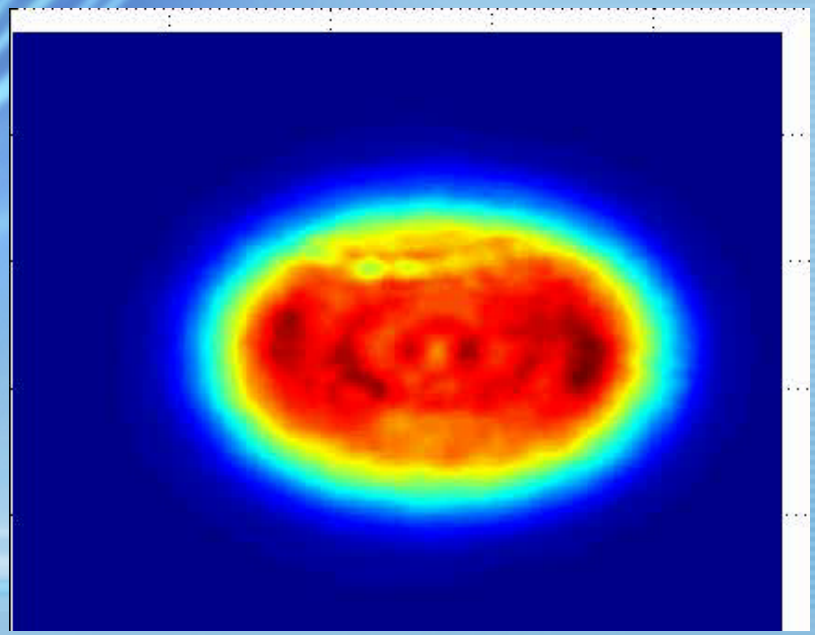
Tilts of MH mirrors:

- change in the optical axis
- resonant beam phase front change with the alignment

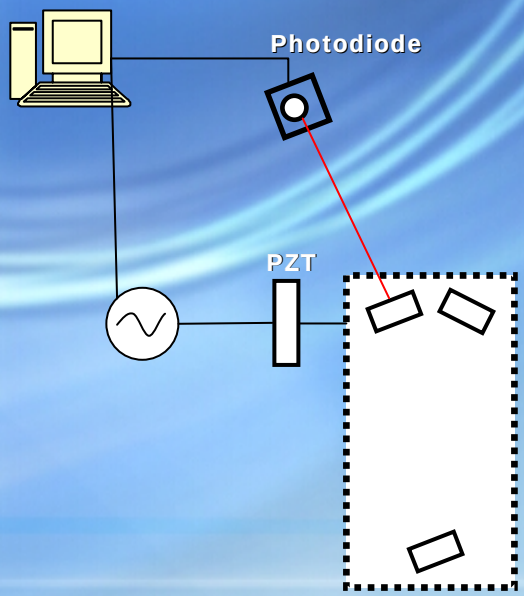


# Tilt Sensitivity

**Investigate the susceptibility of mesa field to tilts of MH mirror**

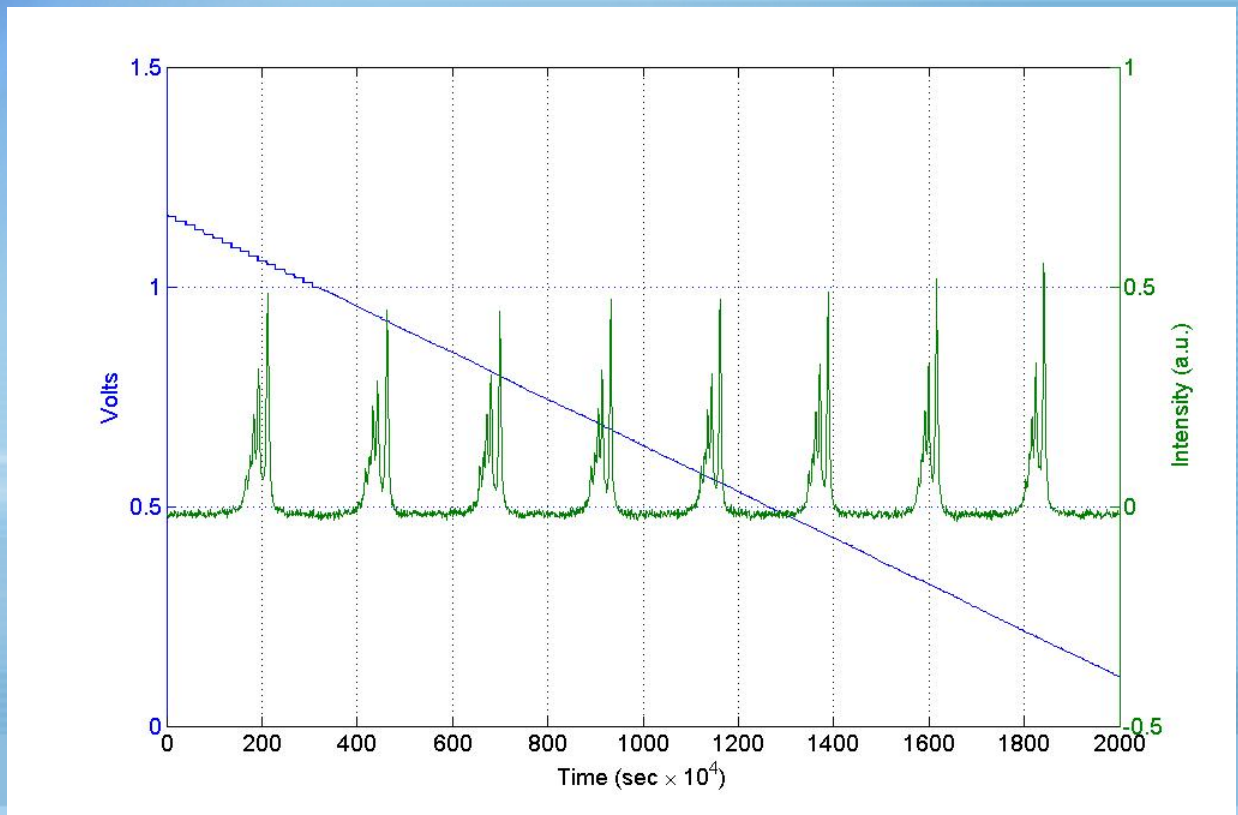


# Tilt measurement, first approach: PZT

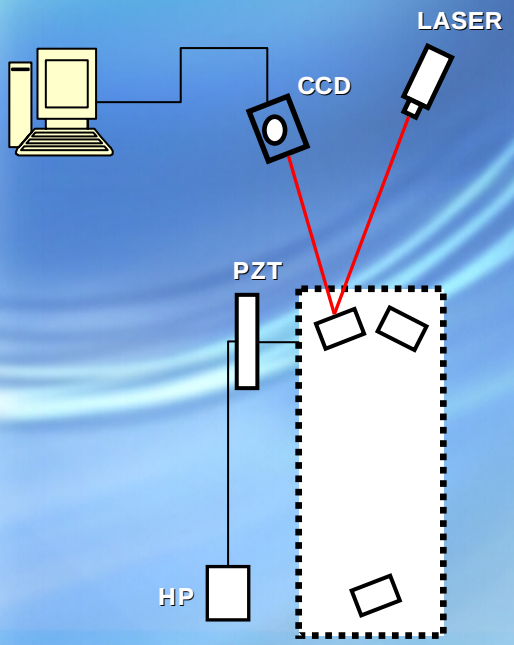


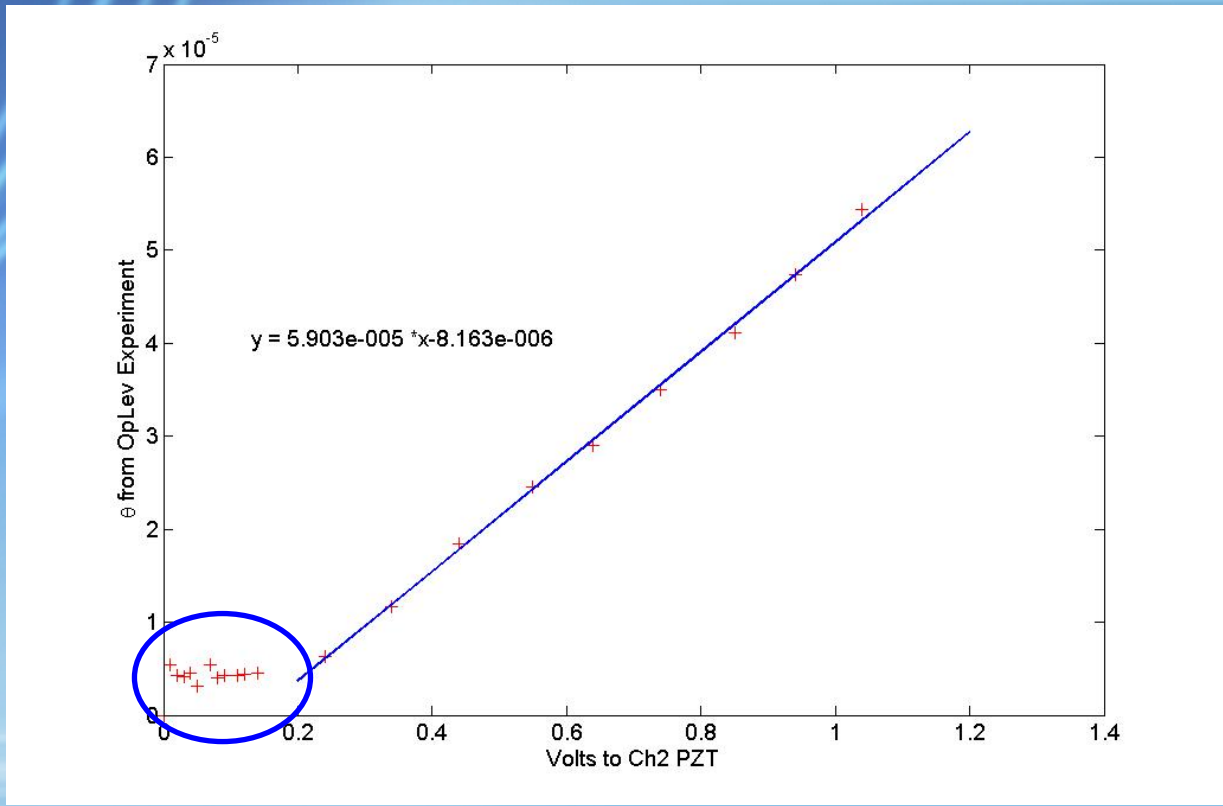

PZT procedure:

- Lock the cavity
- Sweep one mirror

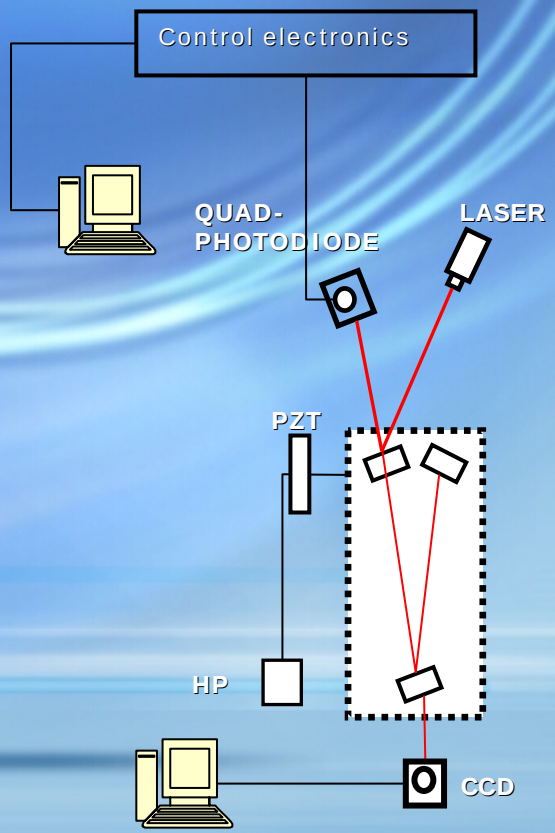


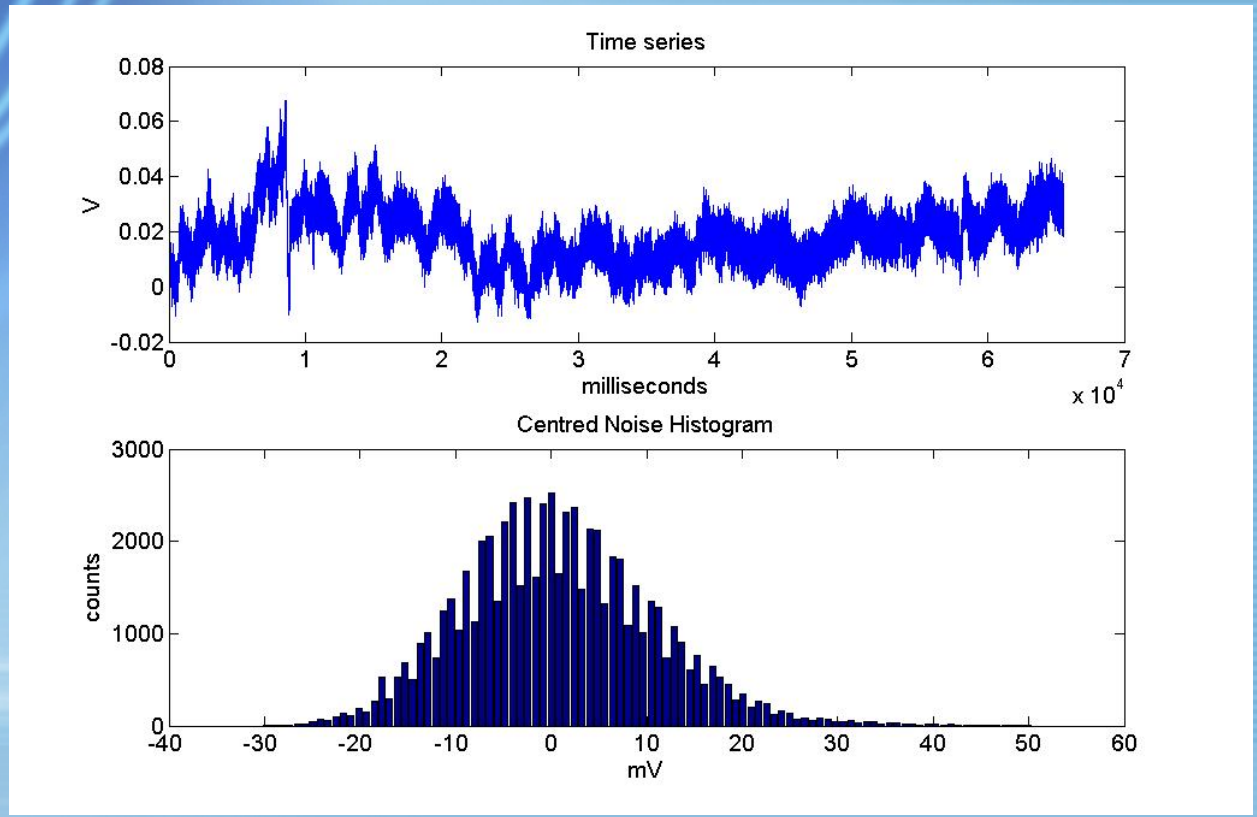
# Tilt measurement, Second Approach: Optical Lever & CCD



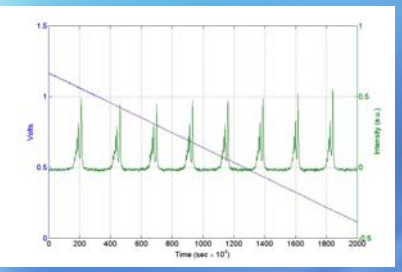
# Tilt measurement, Third Approach:
# Optical Lever & Quad-Photodiode

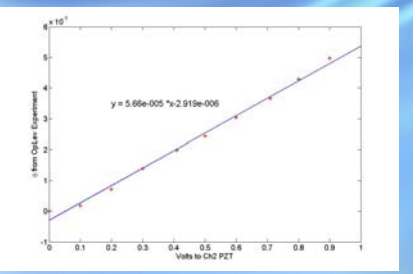


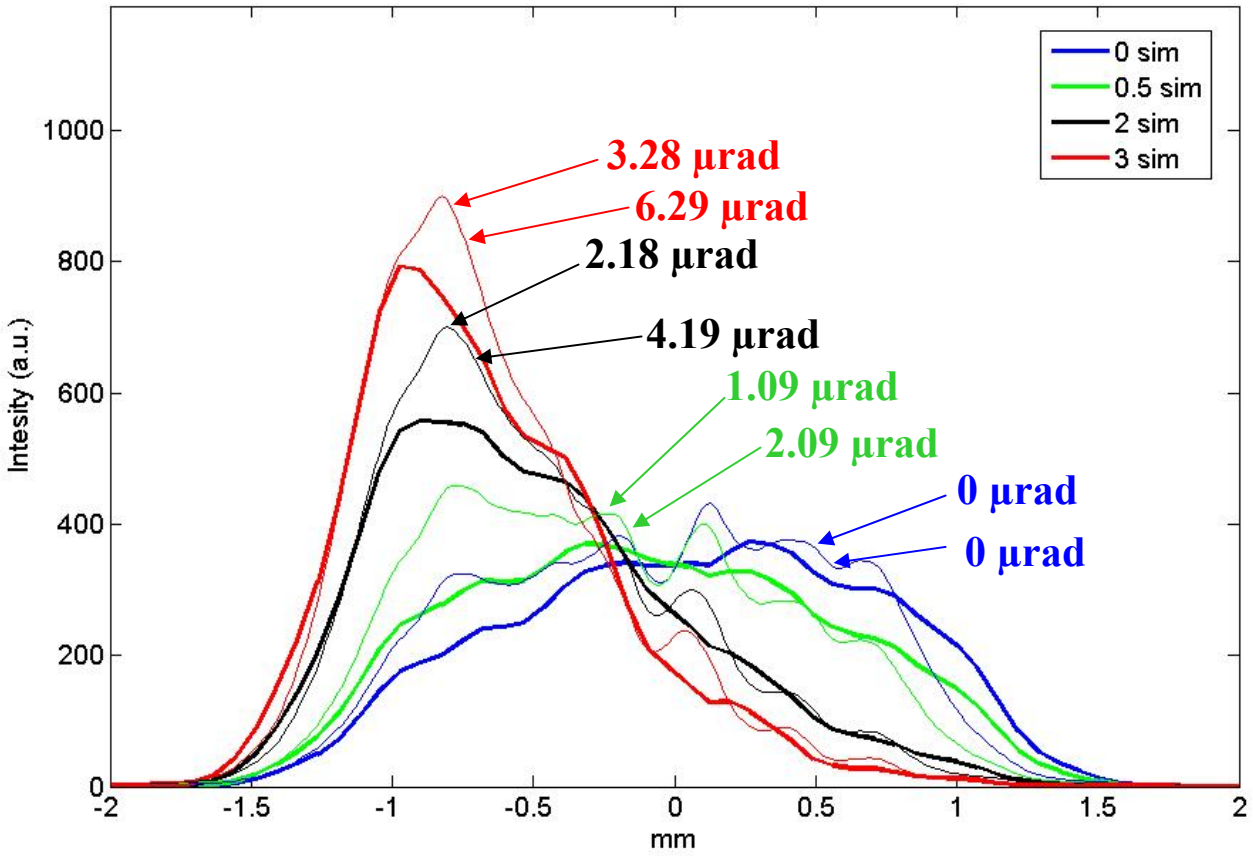

Laser off

# Results





**OPlever** **PZT**



# Future Work

**Caltech**

- Improve methods for tilt measurement
  - Subtract beam jitter away
  - Fibre-coupled laser
  - Triggered beam capture with lock-in detection
- Power Recycling
- New Flat Mirrors (LMA)

# Future Work

**Possibly Elsewhere**

- Build a nearly Concentric MH mirror cavity
- Thermal noise measurements (MH-TNI)

# Thanks...

- Riccardo De Salvo
- Innocenzo M. Pinto
- Vincenzo Galdi
- John Miller
- Monica Varvella
- Juri Agresti
- Marco Tarallo