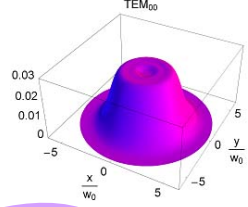

The Mesa Beam

Update

UNIVERSITY of GLASGOW

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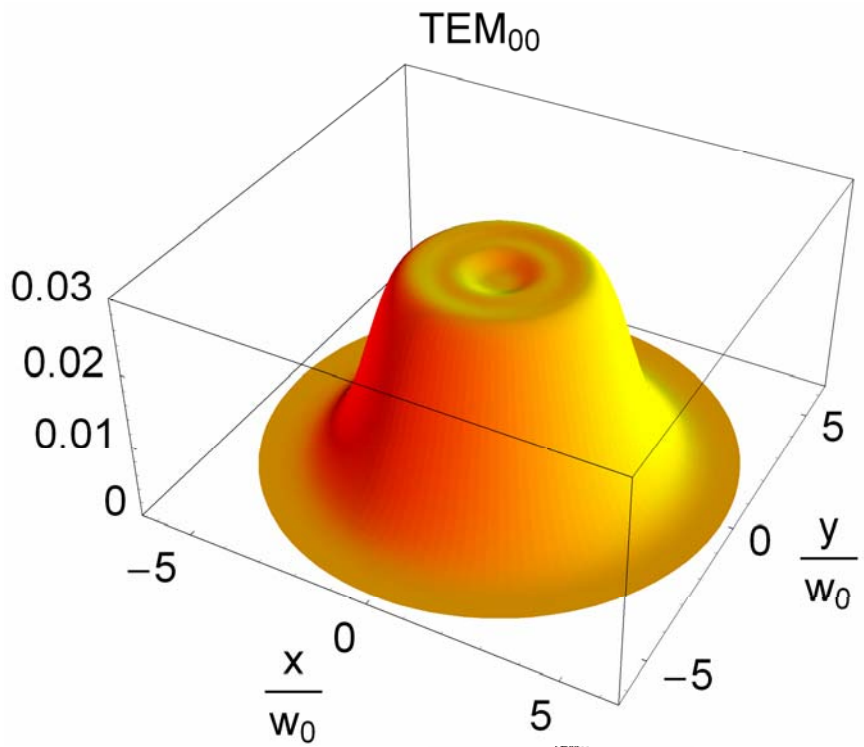
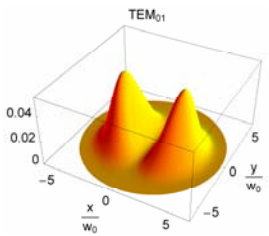
1. Caltech/ LIGO
2. LMA Lyon/ EGO
3. University of Glasgow

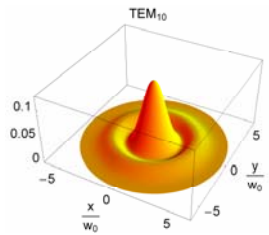
LIGO-G050481-00-R

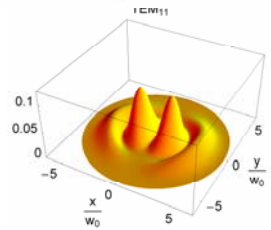
Overview

- Introduction
- Results
  - » HOM
  - » Fundamental mode
- Tilt sensitivty

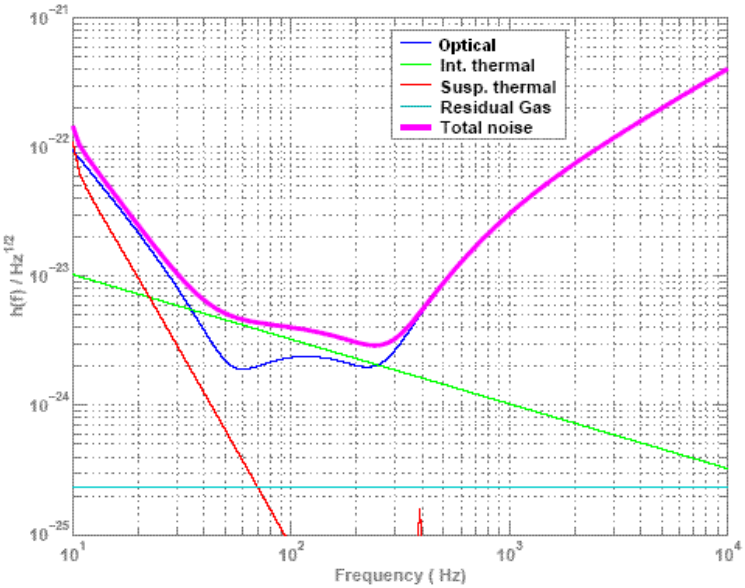








Introduction



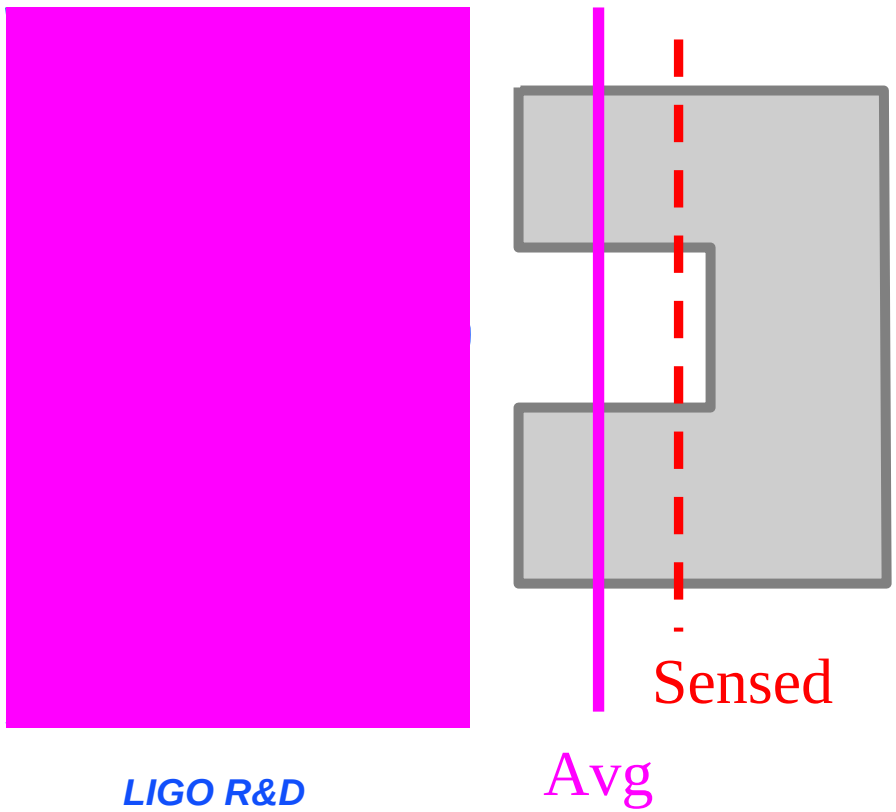
$$S_h \propto \frac{1}{w^n}$$

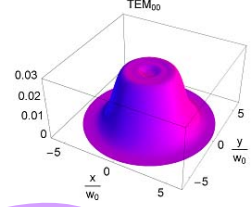
$$\ell_{clip} = \exp\left[-2\frac{m^2}{w^2}\right]$$

- Detectors limited by fundamental thermal noise
- Spectral density scales as $1/w^n$ (different n for each type of noise)
- Diffraction prevent dramatically increasing beam size

Introduction

- Gaussian beams sample a small portion of mirror's surface

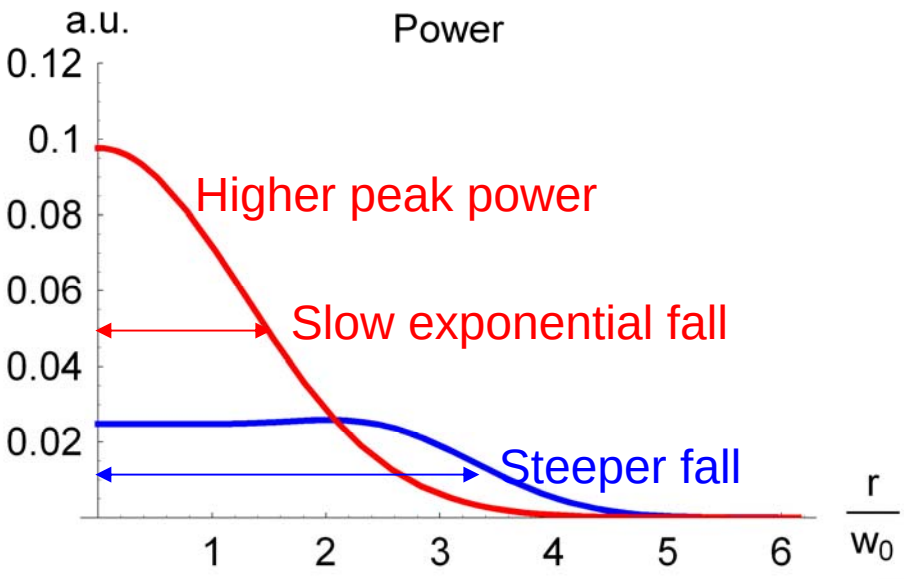


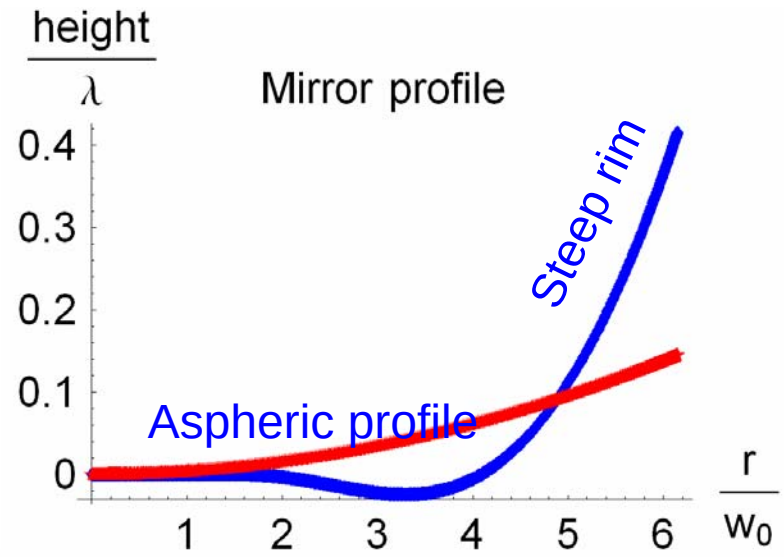


Mesa Beam

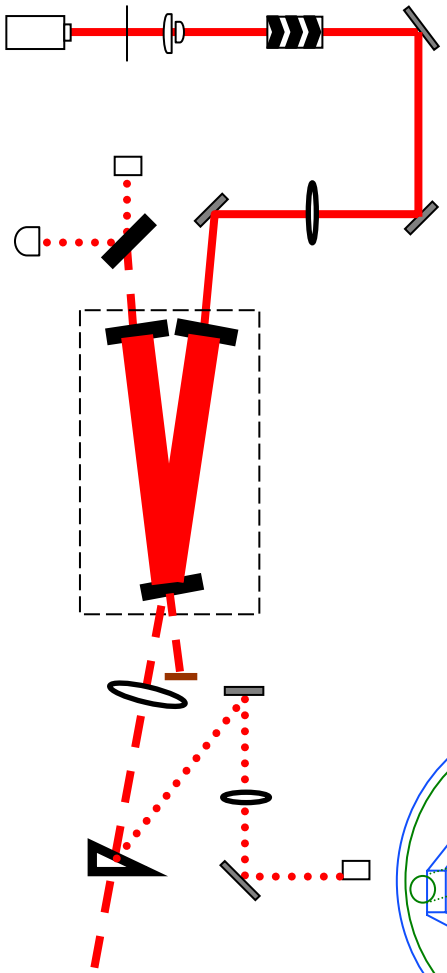
- Optimisation produces the mesa beam

$$U(D,r) = \int_{C_D} \exp\left[\frac{-[(x-x_0)^2+(y-y_0)^2][1+i]}{2b}\right] dx_0\, dy_0$$

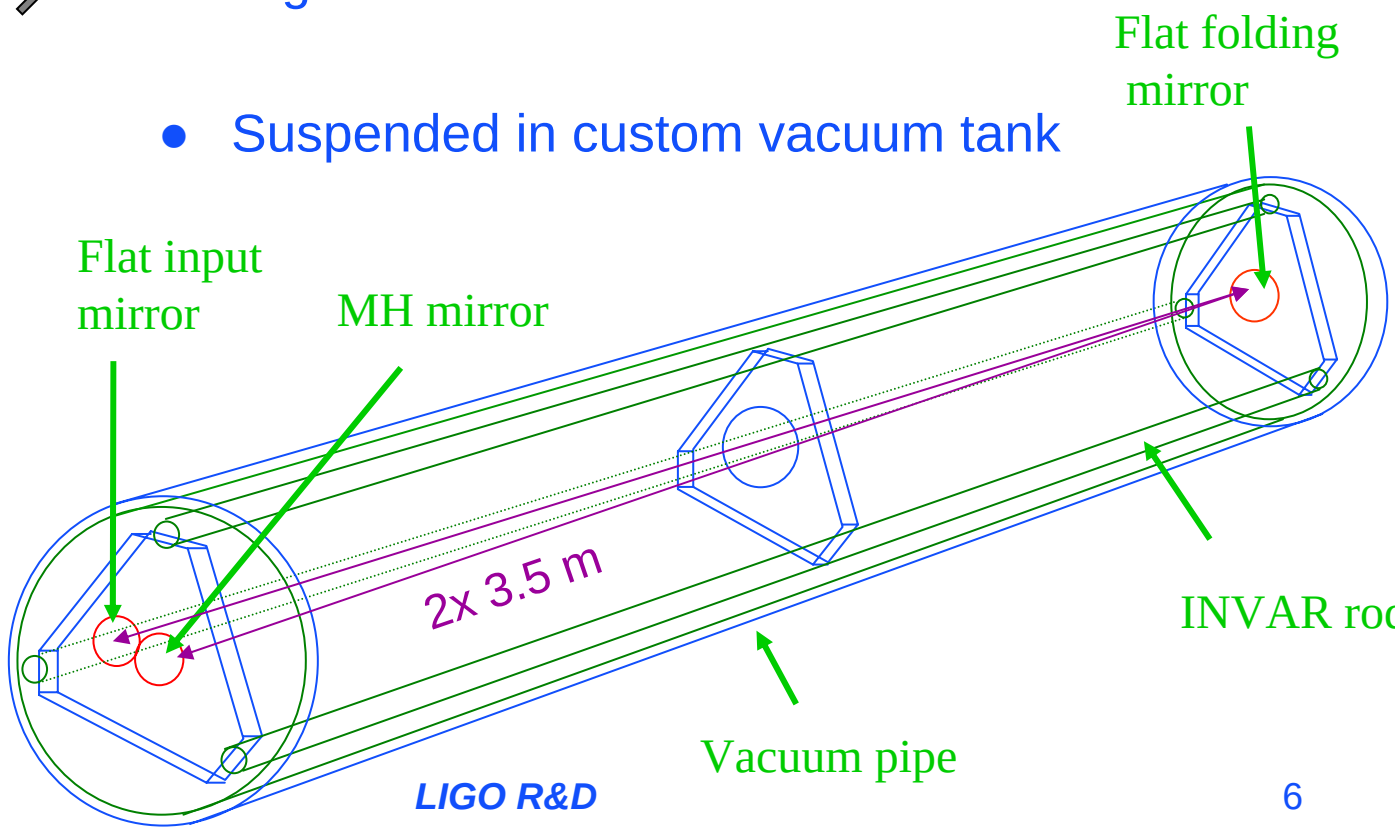




Cavity



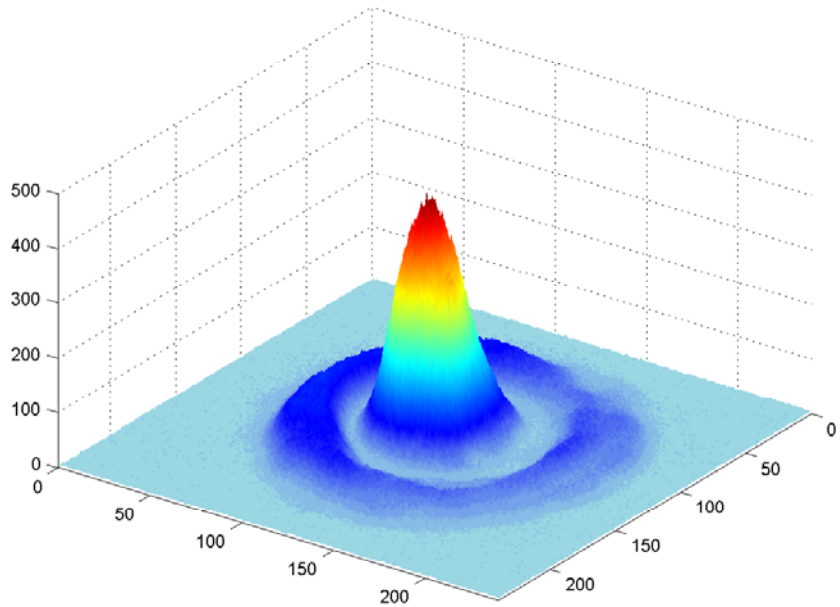
- 7.32 m folded cavity
- Rigid structure
- Suspended in custom vacuum tank

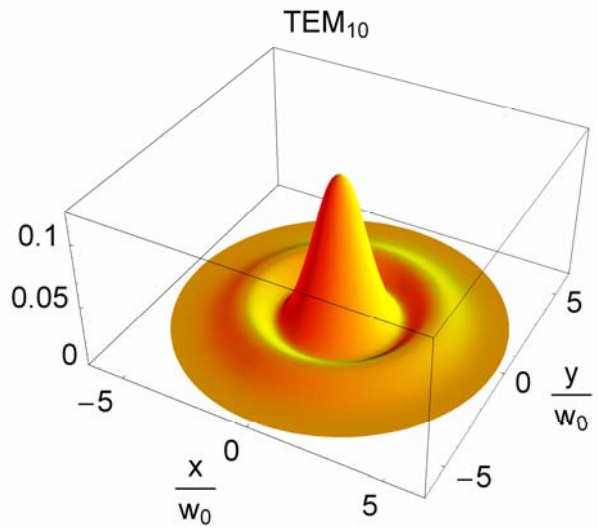


Results

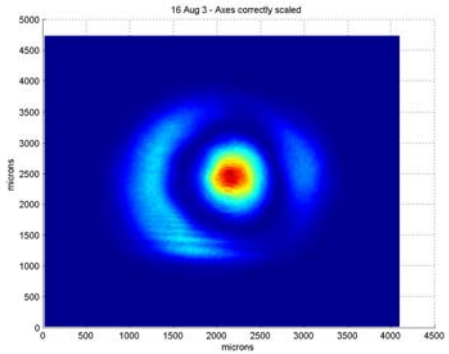
- We have been able to lock to higher order modes
- These modes exhibit good agreement with theory

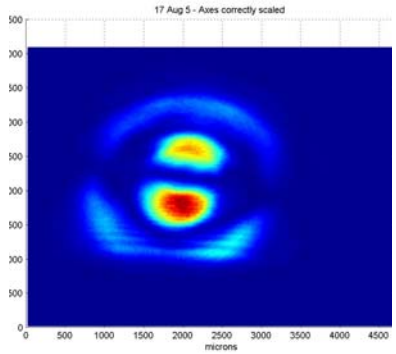
TEM_{10}

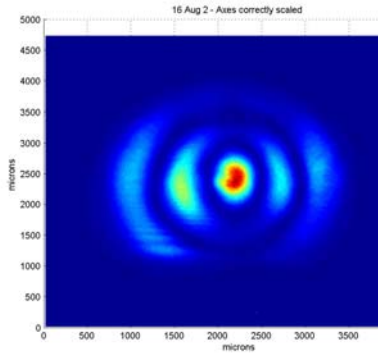


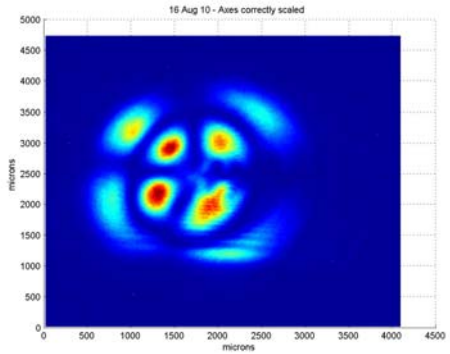


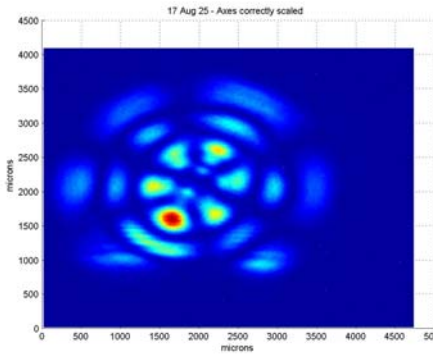
Results - HOM

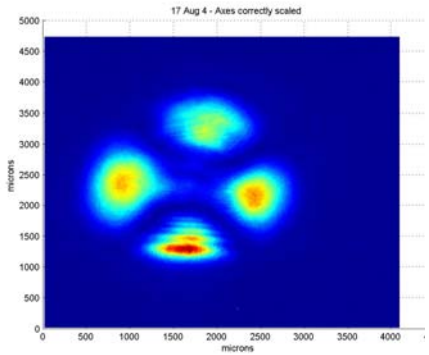


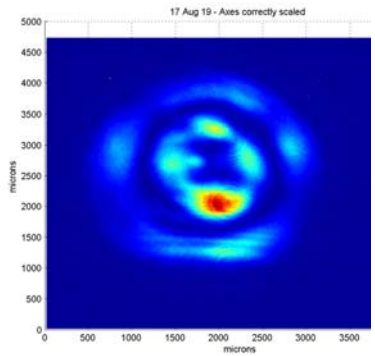


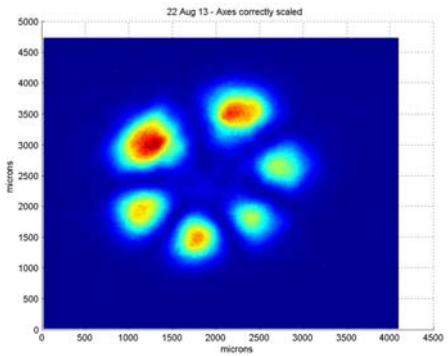








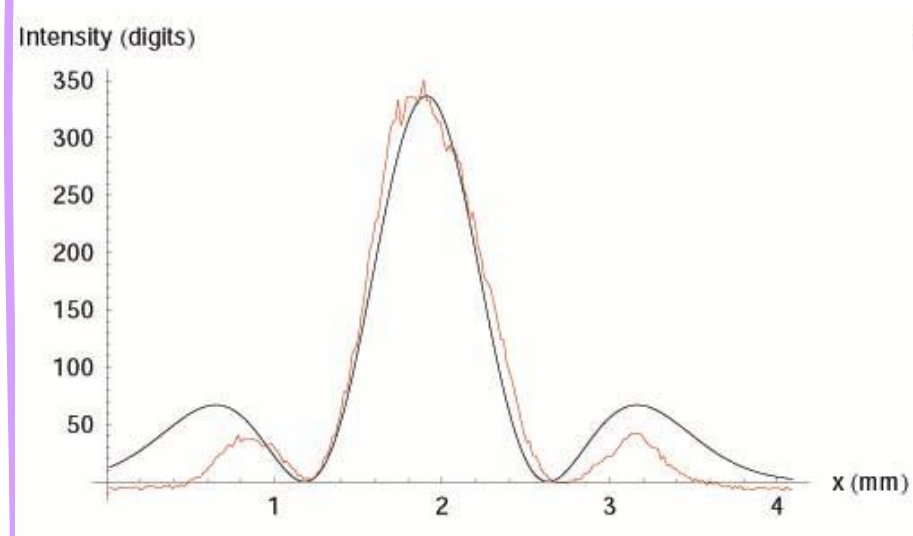




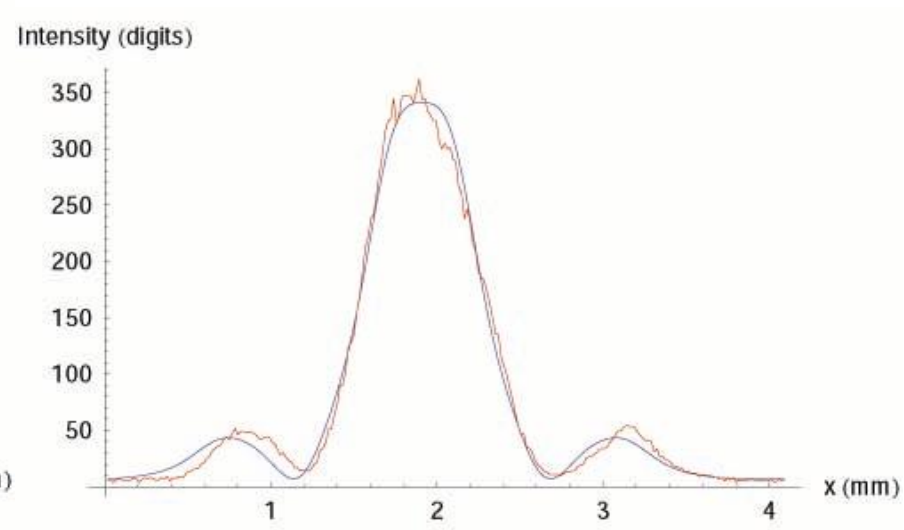
Diffraction around beam baffle eliminated

Gaussian?

- Modes resemble HG and LG sets



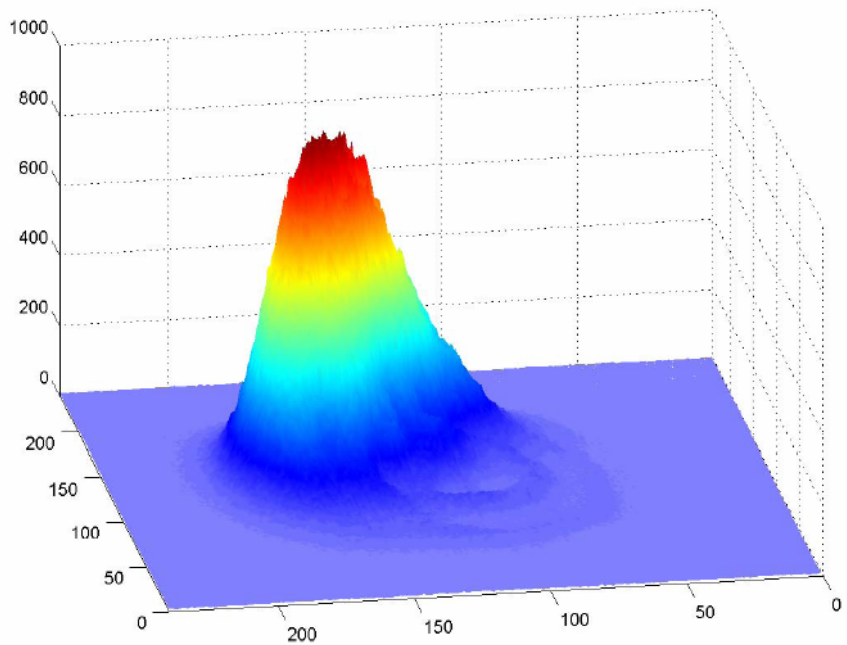
- LG_{10} fit



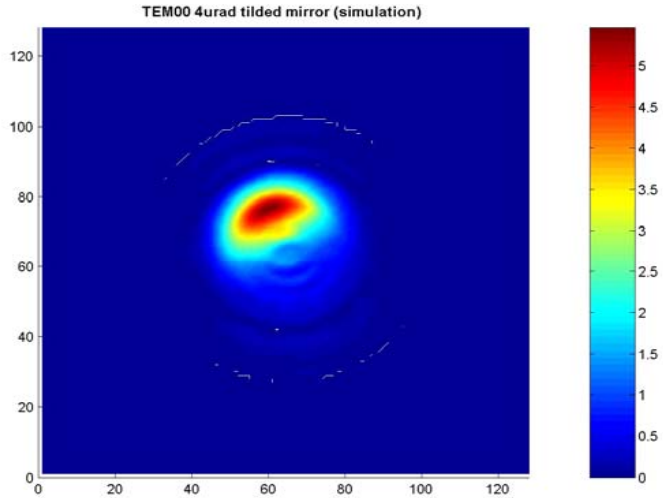
- MH_{10} fit

The Fundamental?

- Alignment is taxing
- Long periods were spent aligning input optics and cavity mirrors

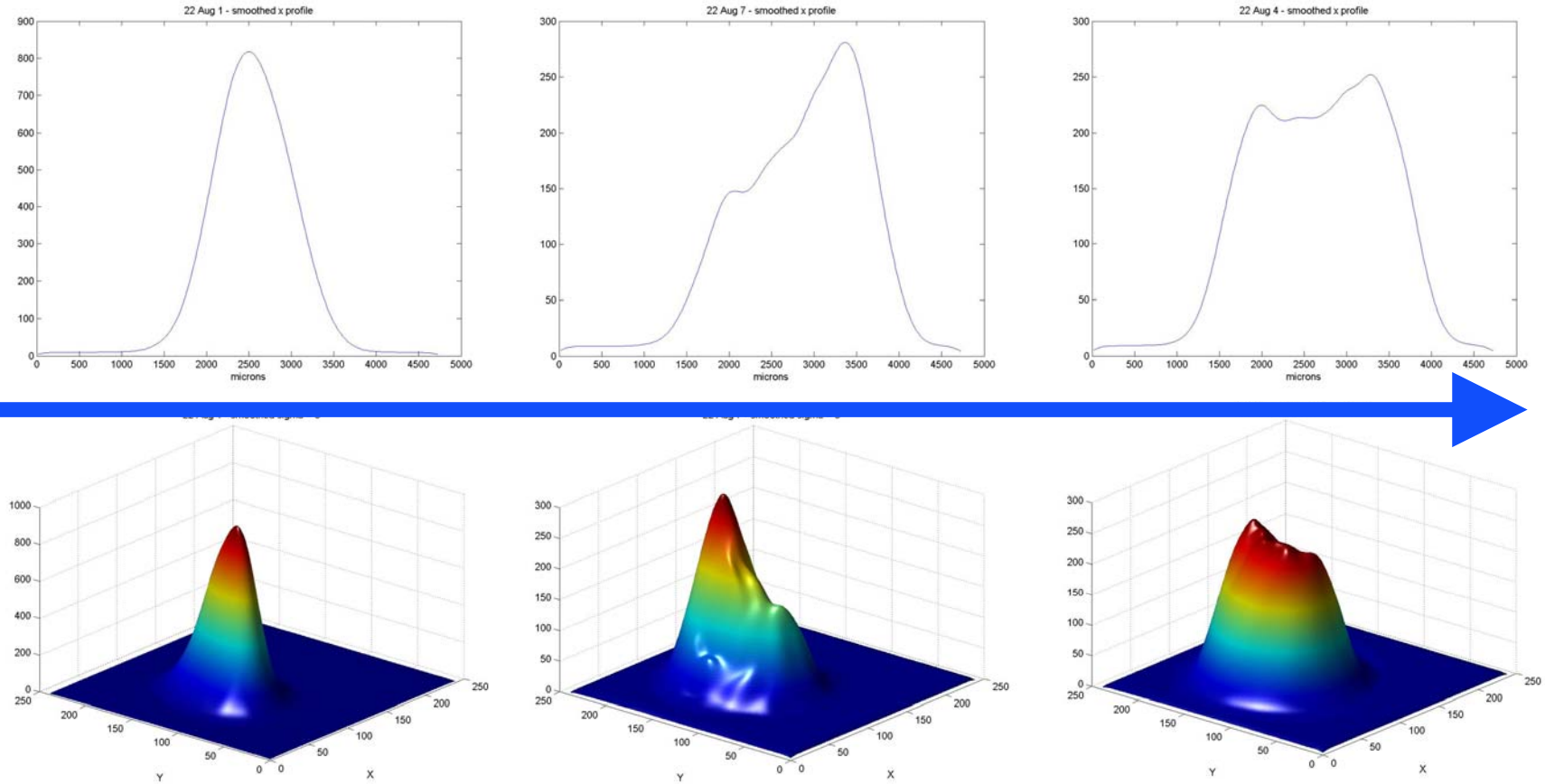


4μrad tilt

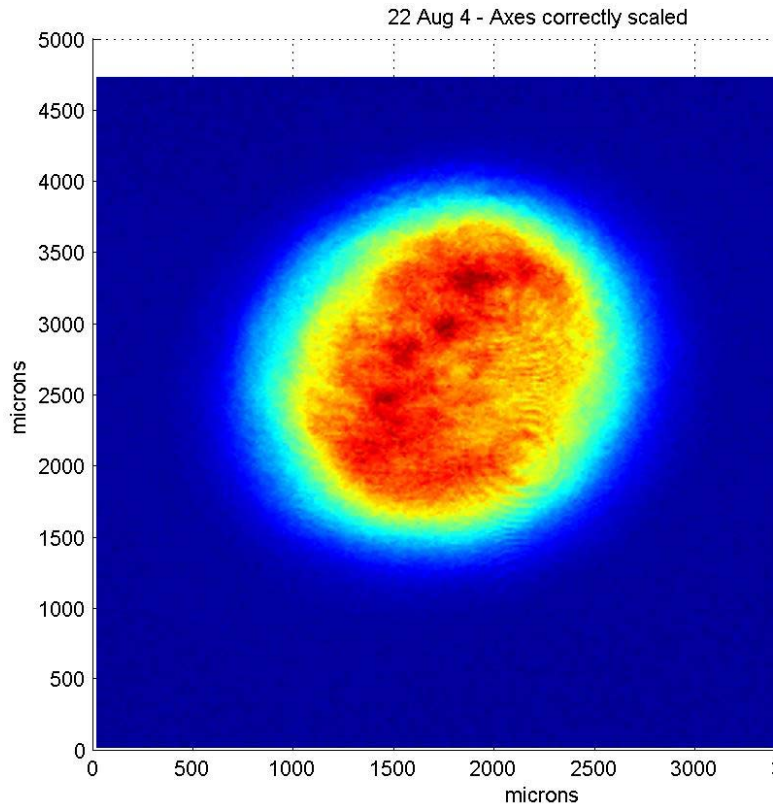


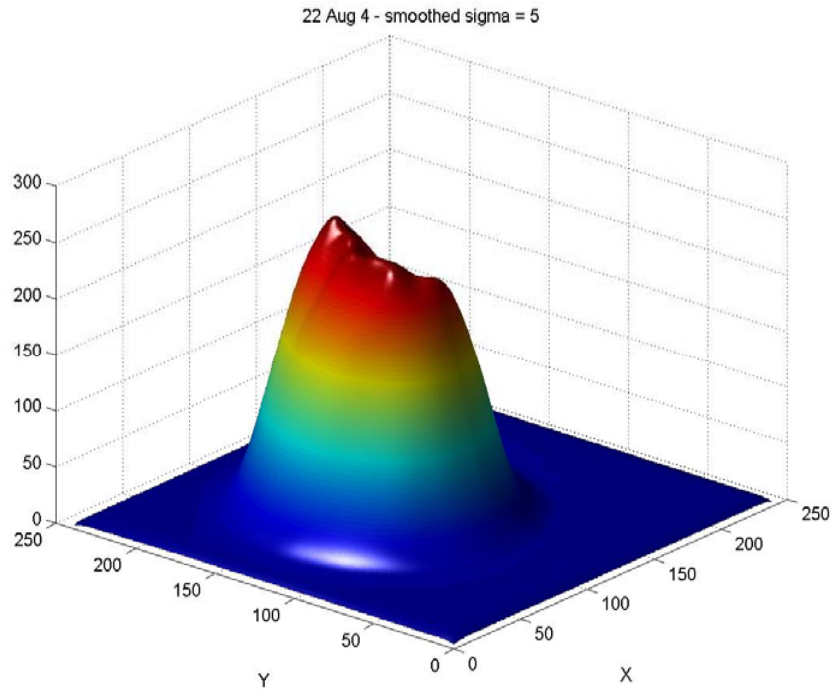
Improving Alignment

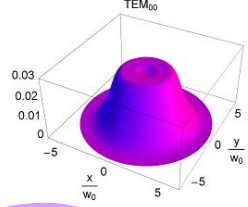
- The reference during alignment was changed from the intensity profile to the transverse mode spectrum



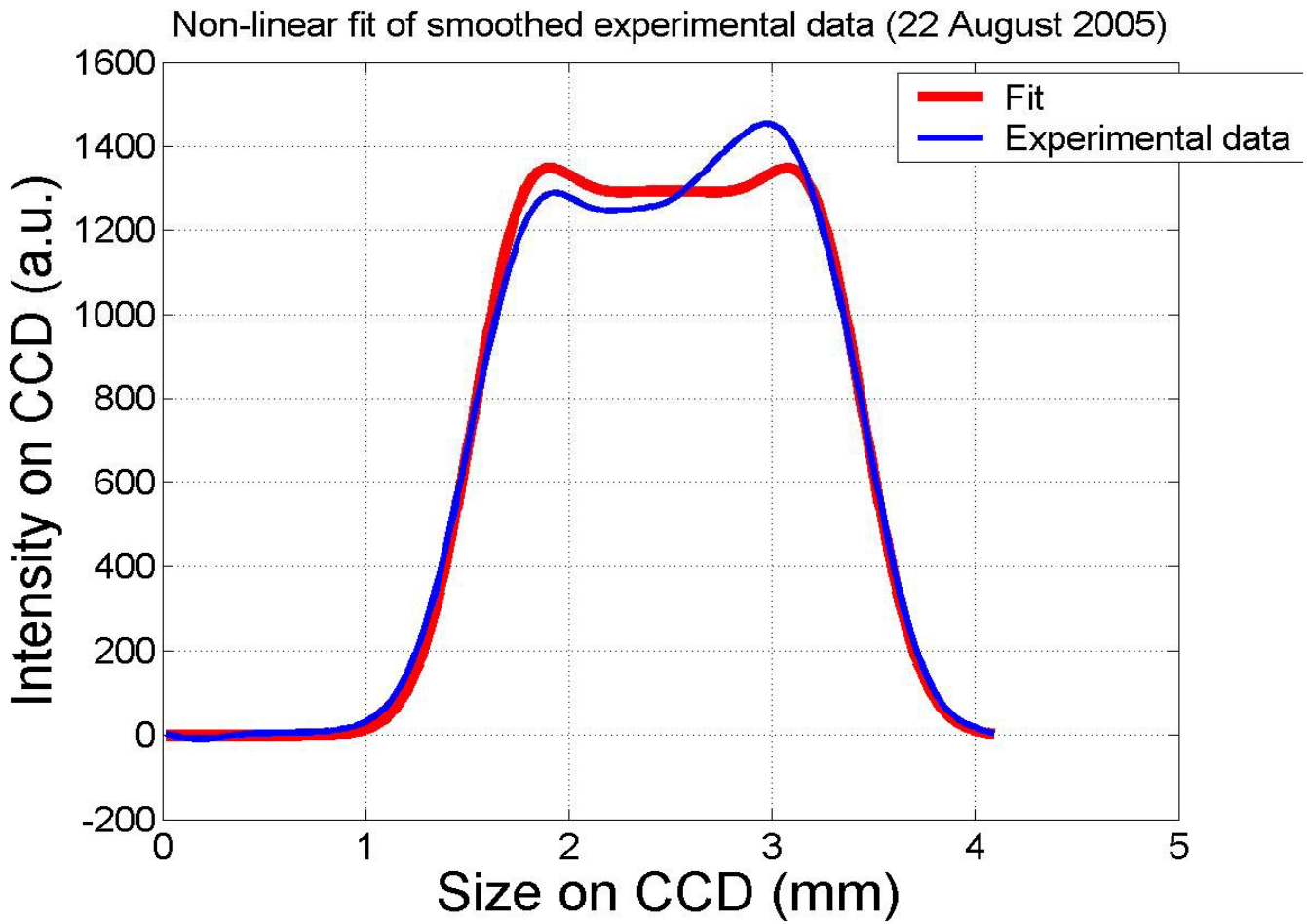
The First Mesa Beam



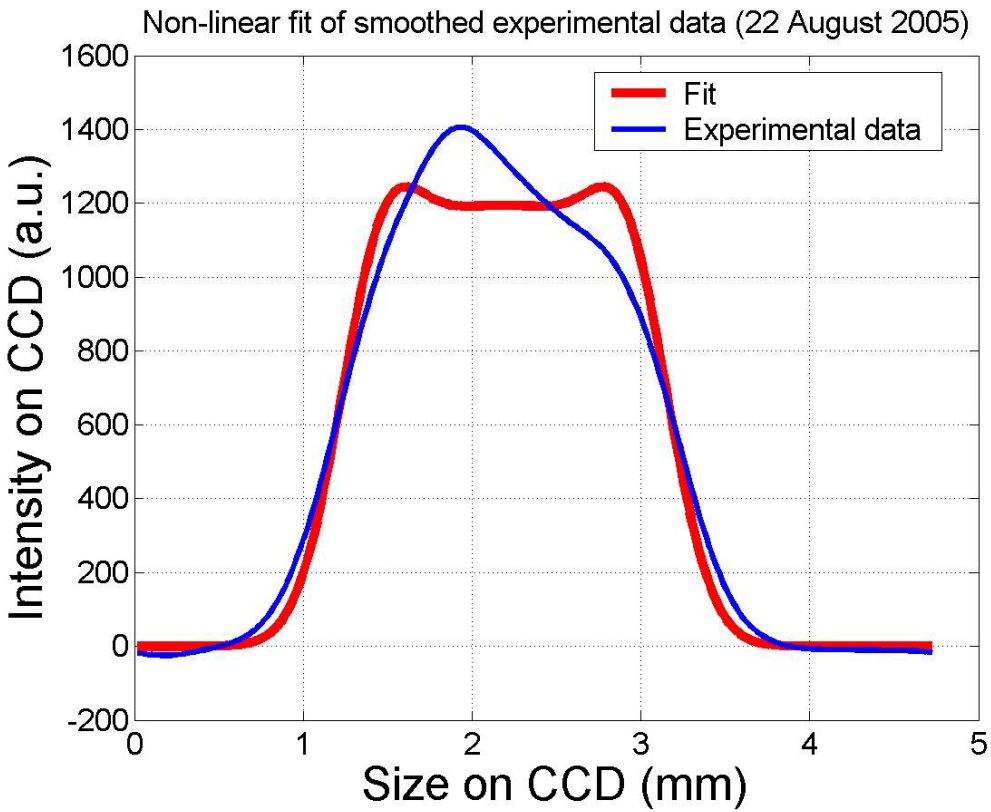


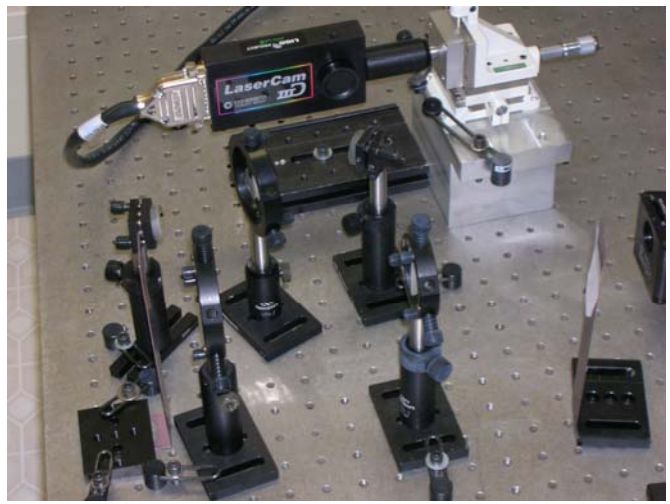


Non-Linear Fit X



Non-Linear Fit Y

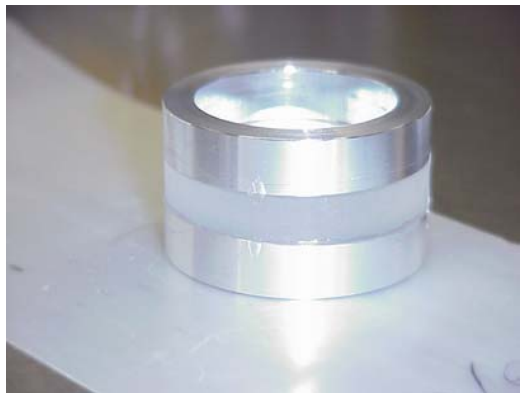




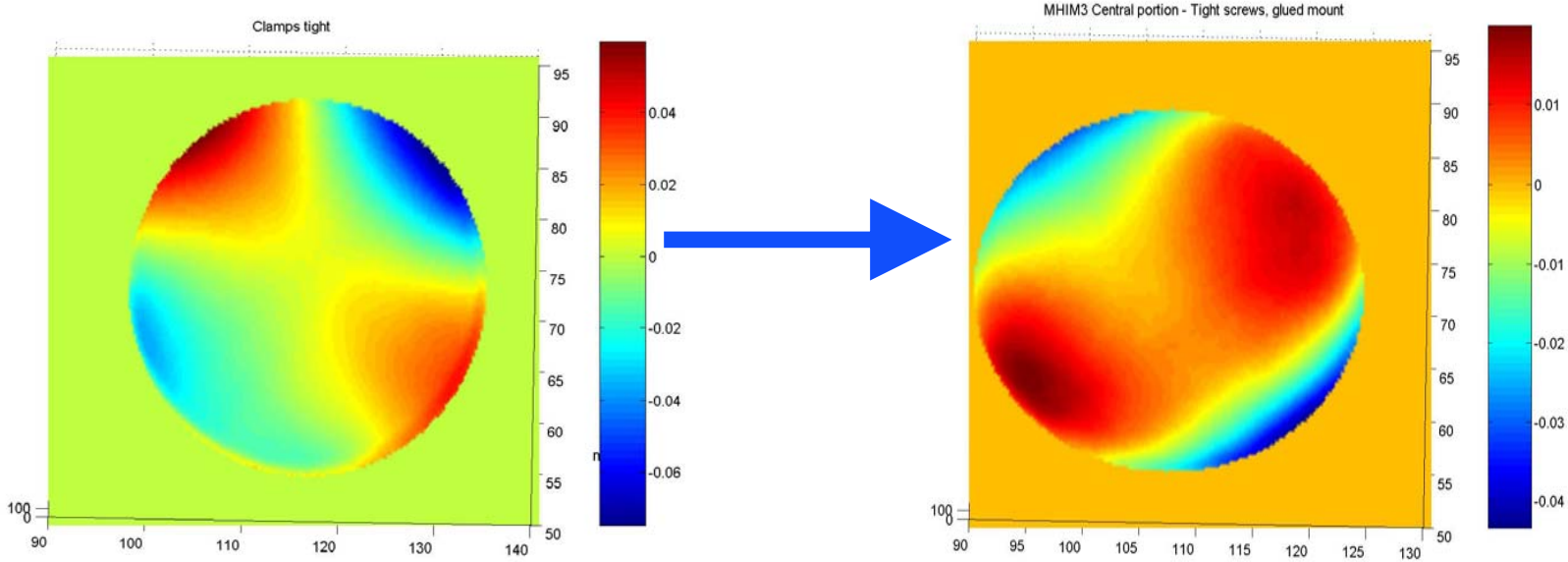
$$w_{theory} = 6.68mm$$

$$w_{experiment} = 7.60 \pm 1.19mm$$

How Was This Achieved?

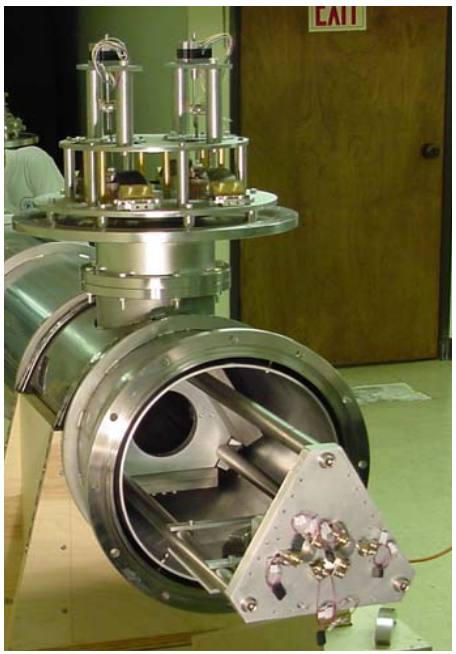


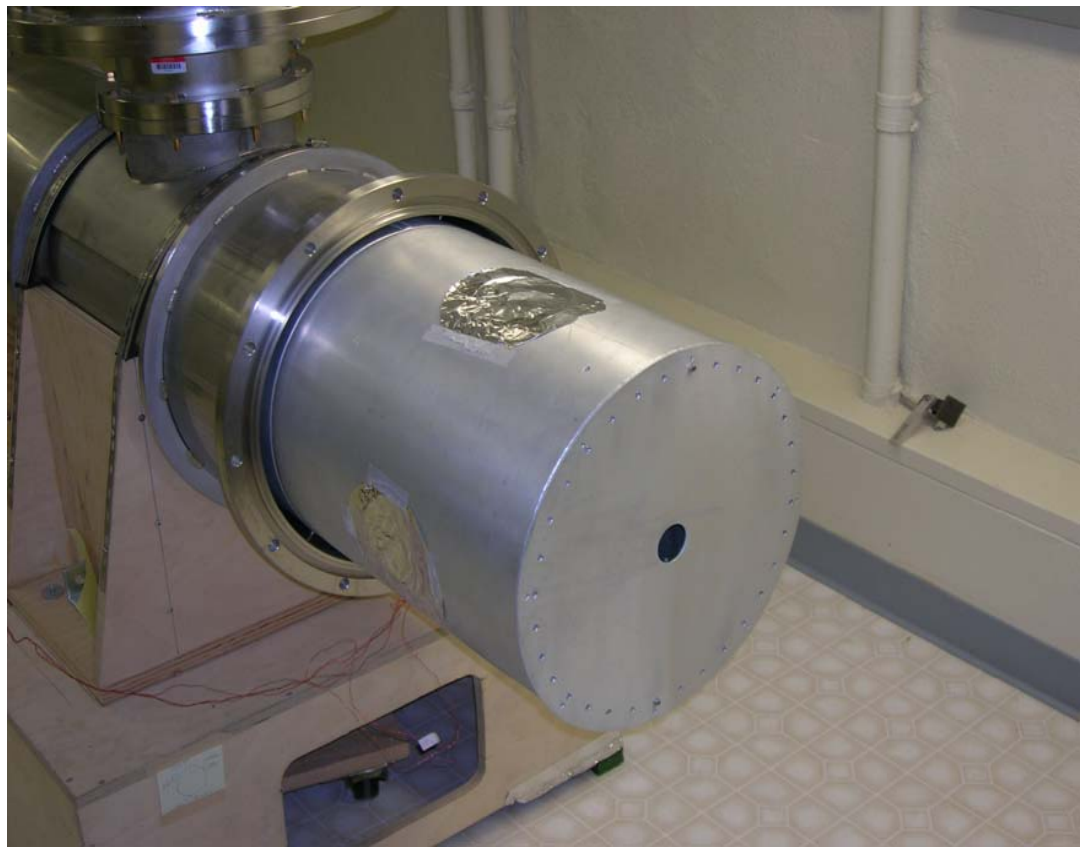
- We have reinforced flexible mirrors with aluminium rings
- Thicker substrates have been ordered



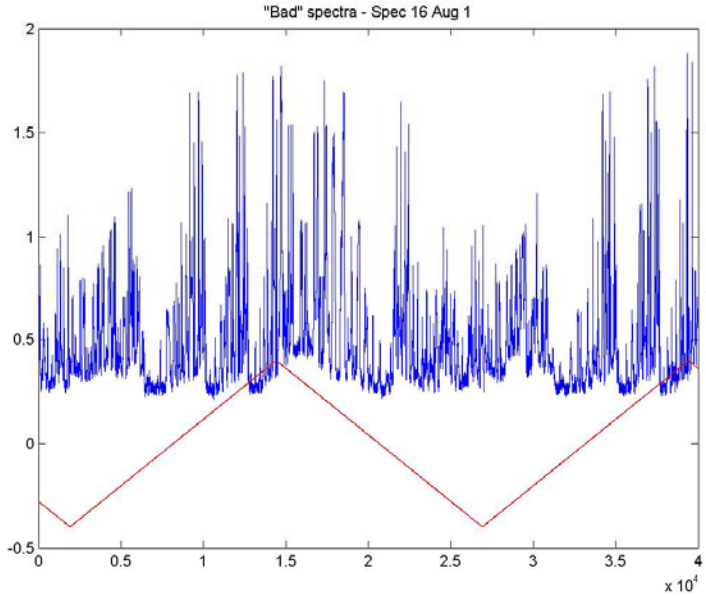
How Was This Achieved?

- Improved atmospheric isolation
- Better stability ‘in lock’



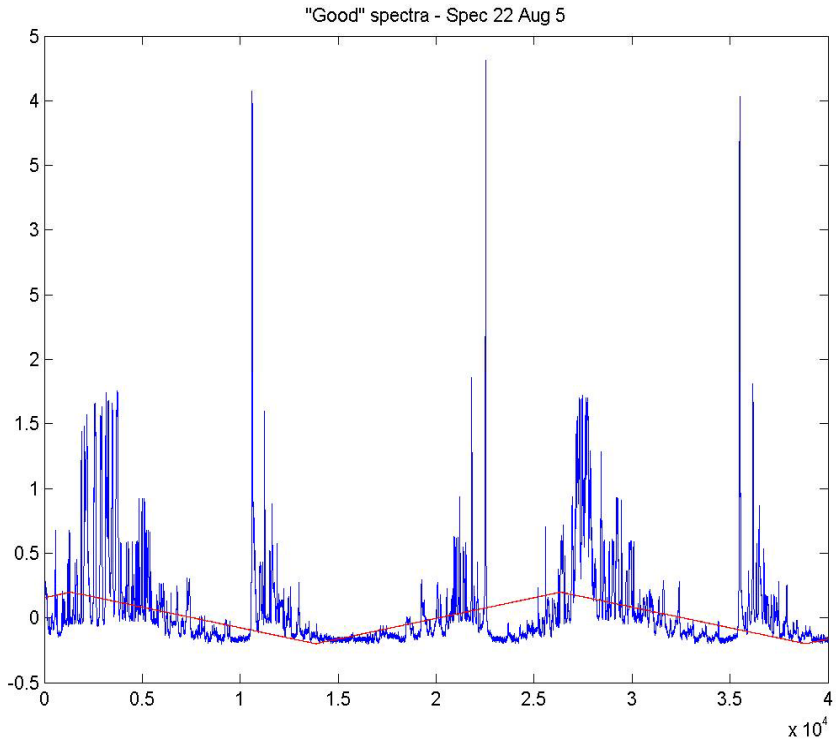


How Was This Achieved?

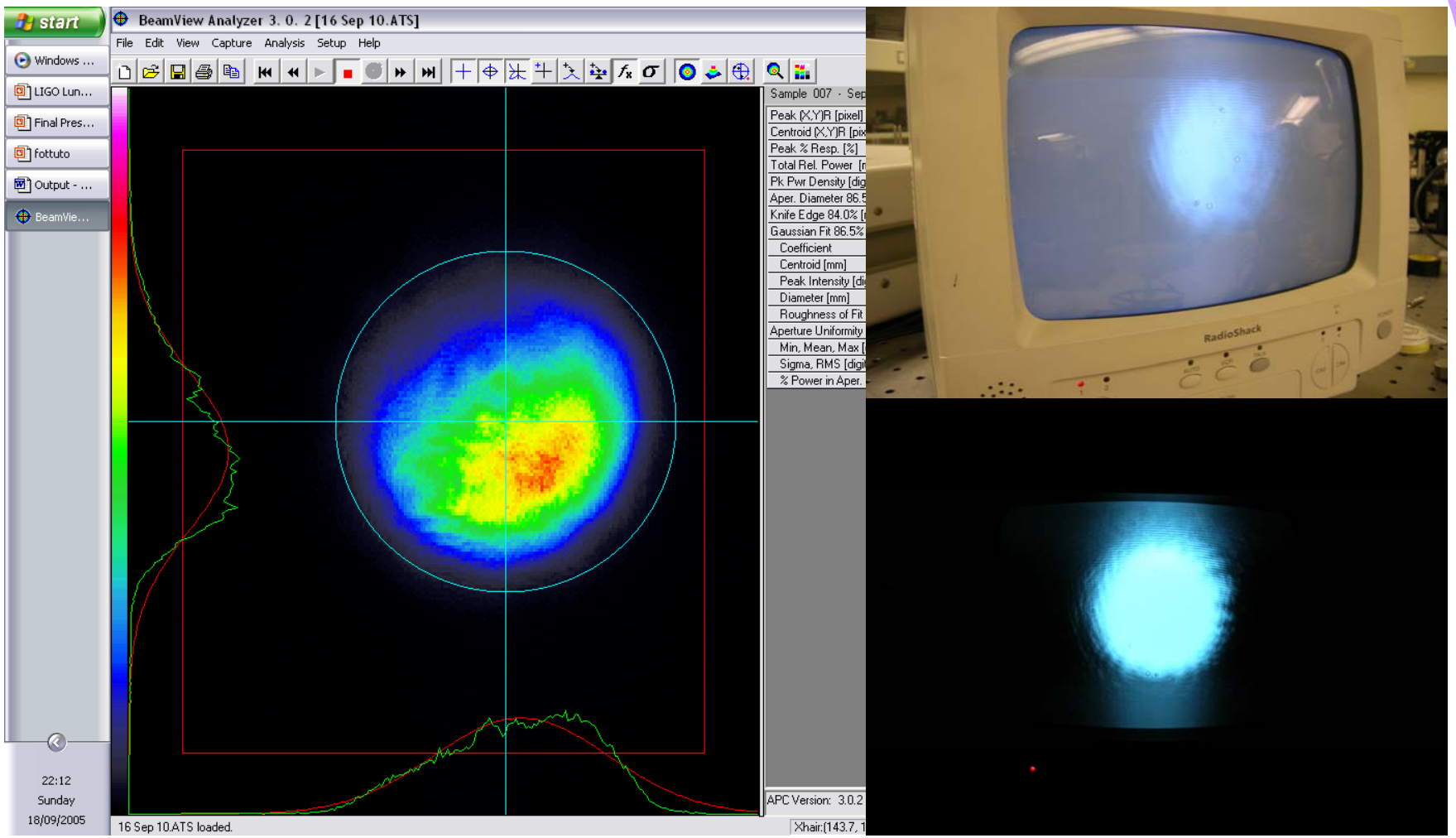


- More power in the fundamental mode

- Improved spectrum



Alignment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Knife Edge 84.0% [
Gaussian Fit 86.5%
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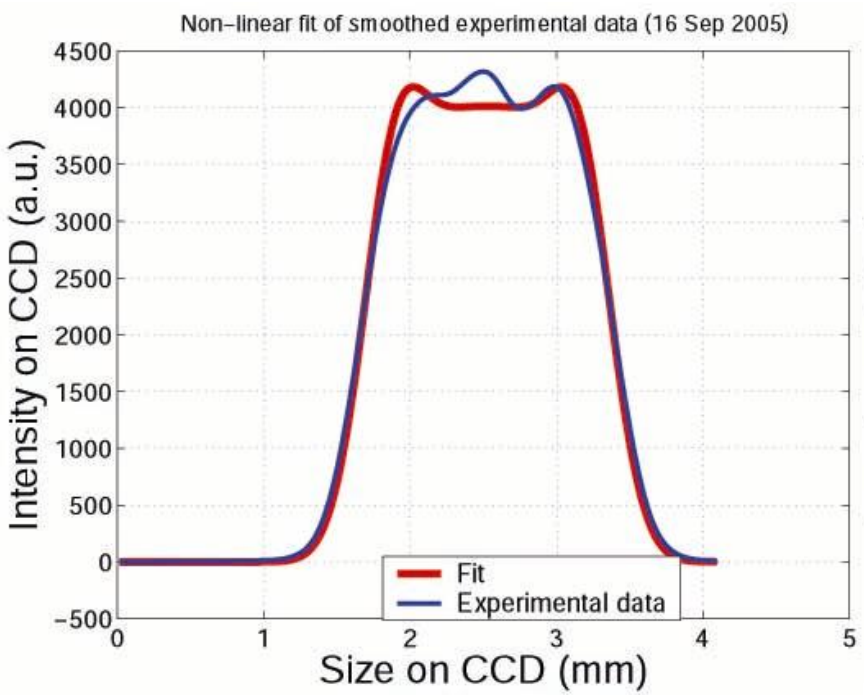
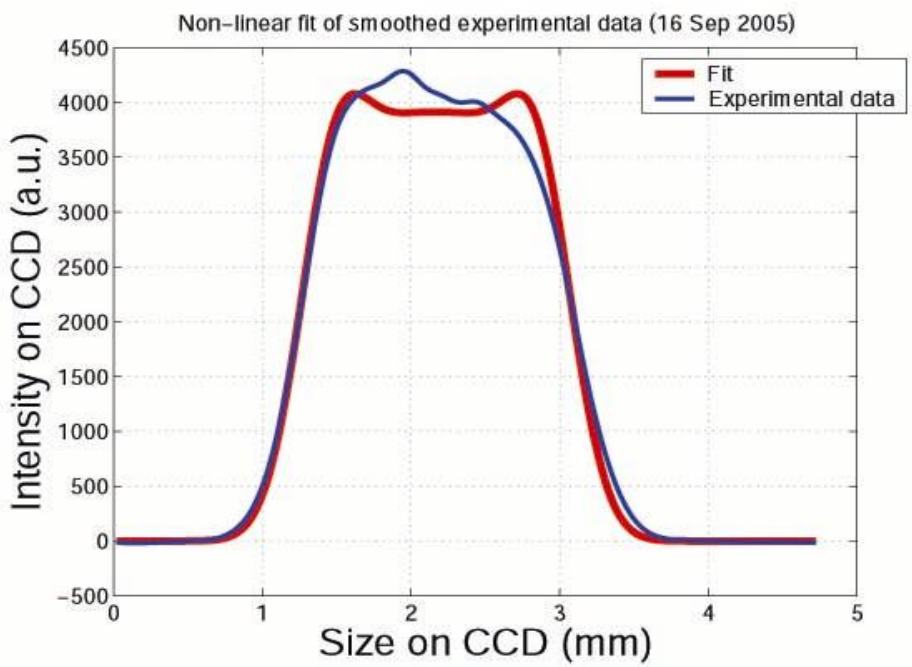
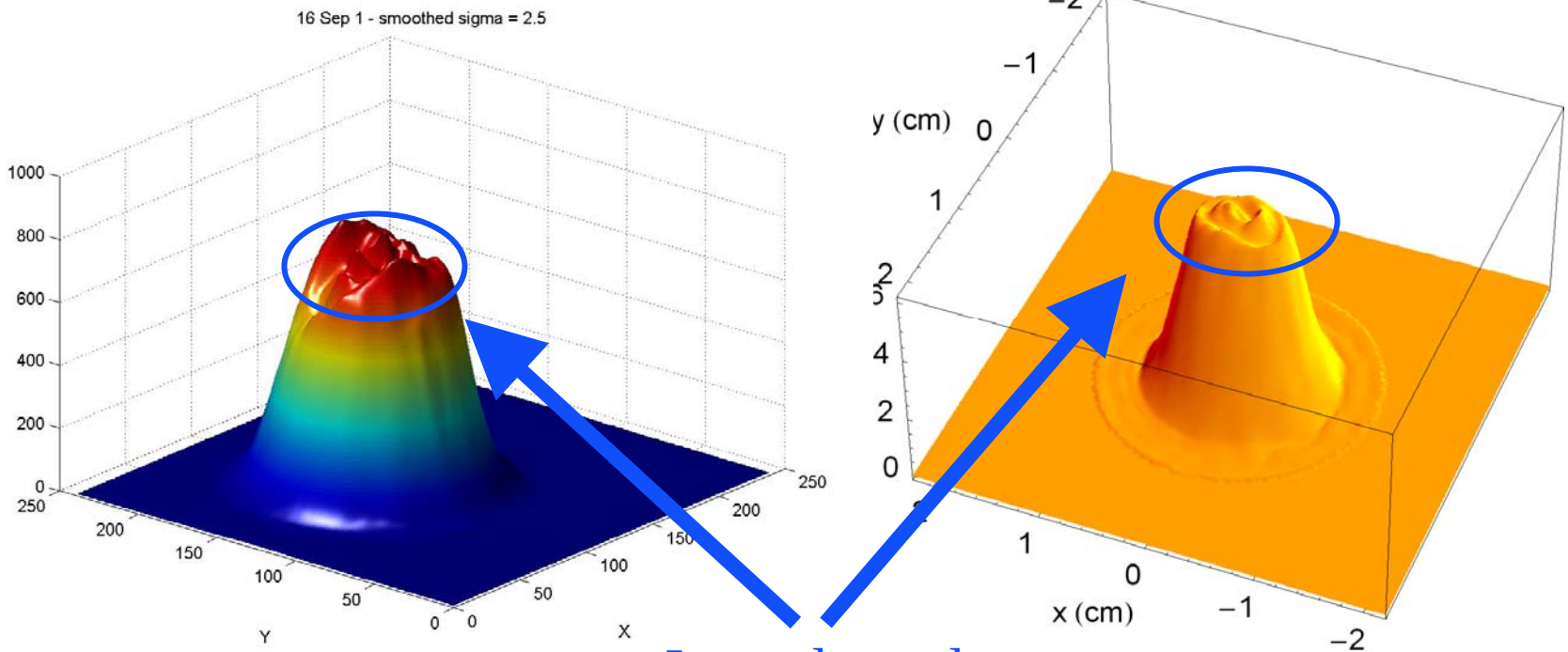
Best Mesa Beam





- Rsq = 0.996
- Rsq = 0.992

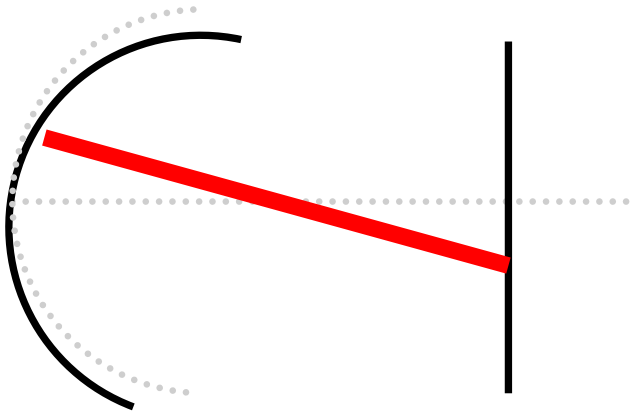
Best Mesa Beam

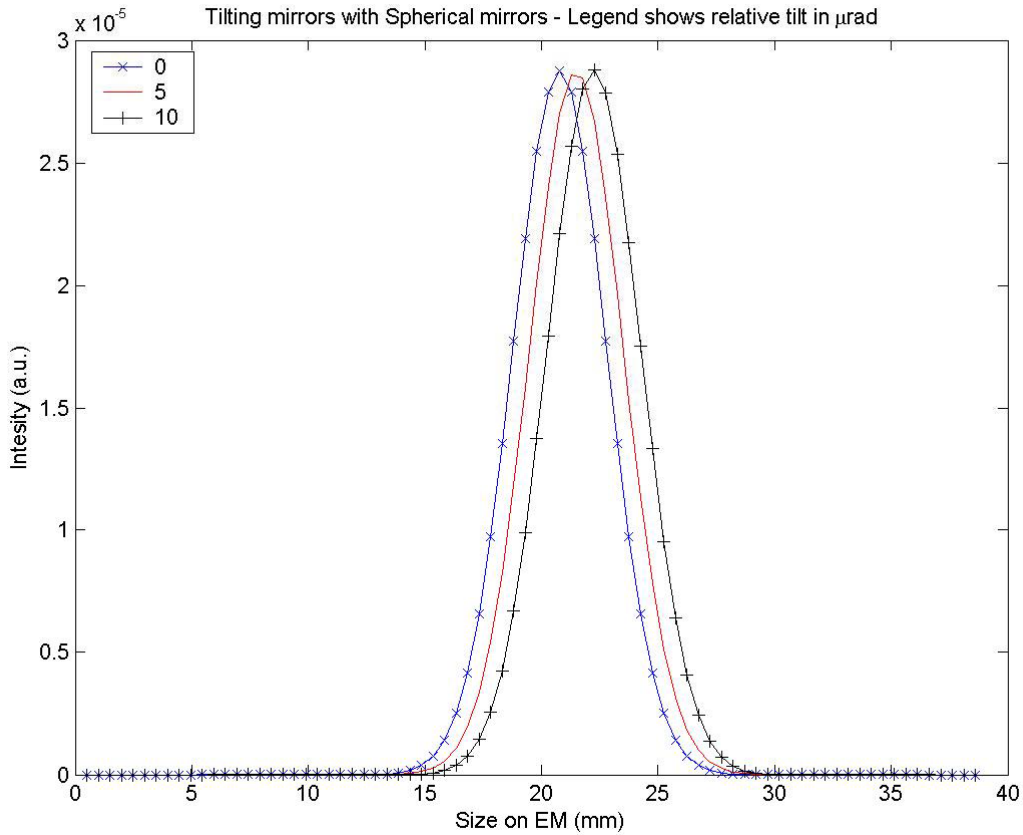


Jagged top due to imperfect mirrors

Tilts of Spherical Mirrors

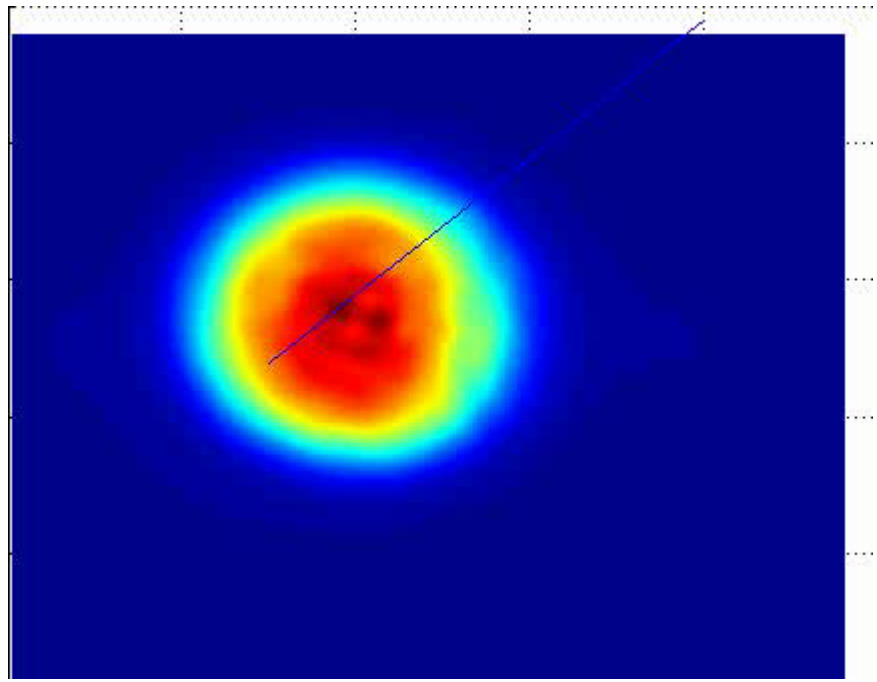
- Tilts of spherical mirrors translate optical axis





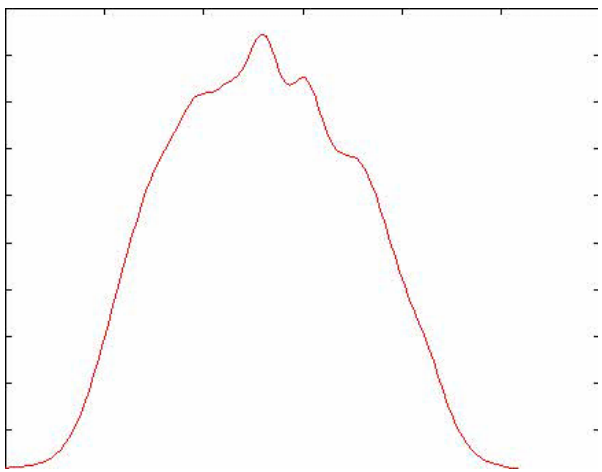
Tilt Sensitvity

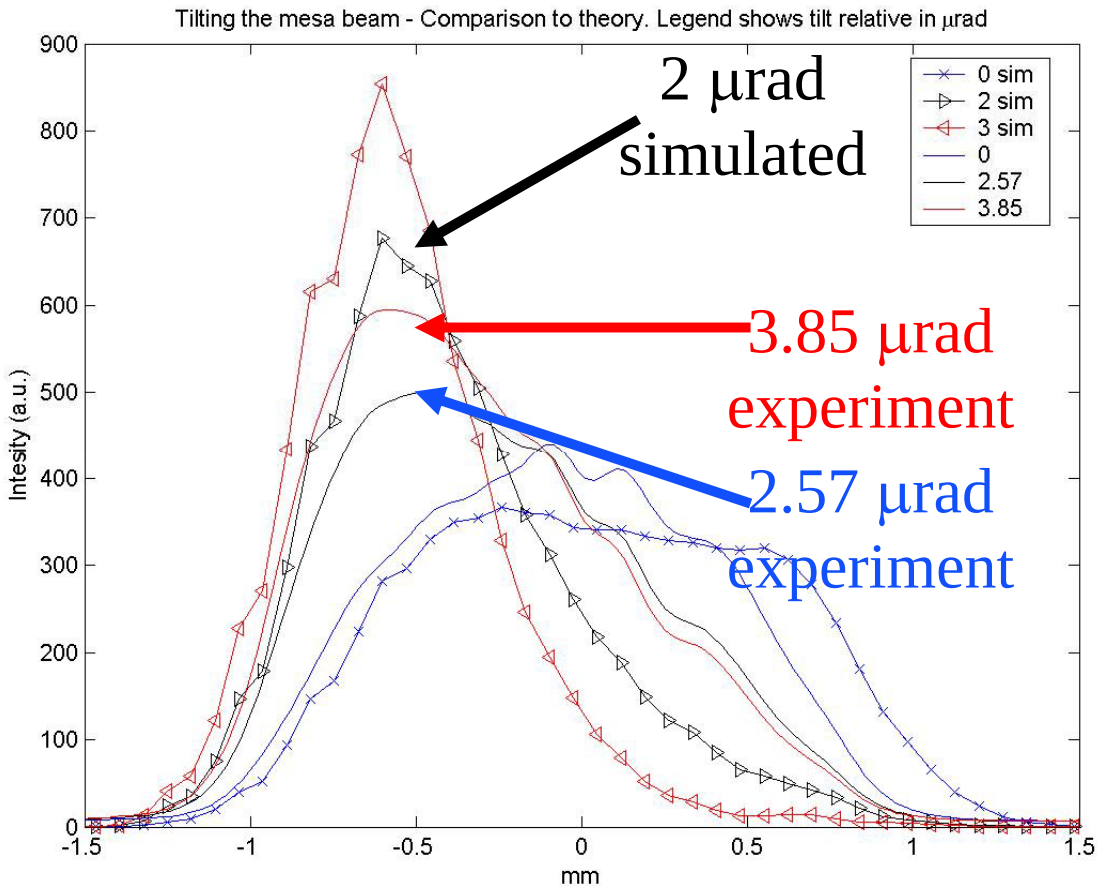
- Controllability of beam is key
- Decided to first investigate tilt sensitivity
- Tilt MH mirror about a known axis



Profiles

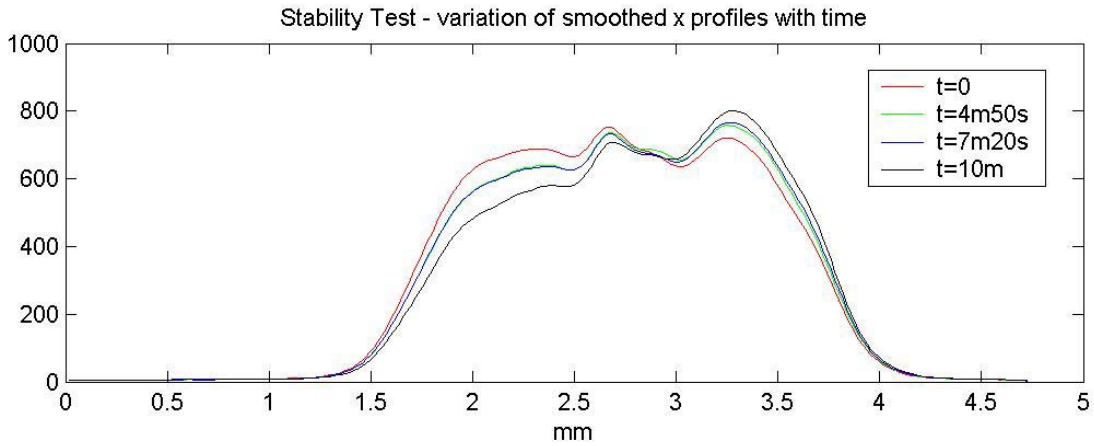
- Profiles along axis

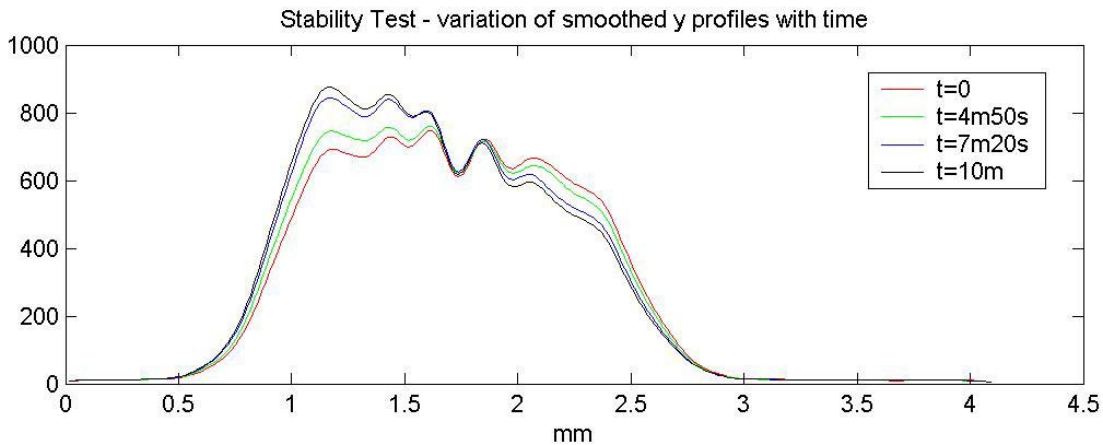


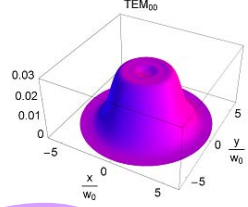


Excuses

- Lack of temporal stability
  - » vacuum?
- Stiction
- PZTs are bad



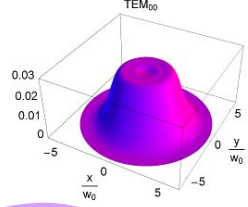




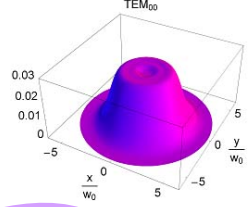
Summary

- We are able to produce acceptable flat-topped beams with imperfect optics
- We have begun to make a quantitative analysis of mesa beam
  - » Beam size appears correct
  - » Tilt sensitivity shows correct trends

Further Work With This Set Up



- Improve profile using new flat mirrors
- Repeatability/ stability – vacuum operations
- Complete tilt sensitivity measurements
- Test other two MH mirrors – mirror figure error tolerances
- Long term – design and build half of a nearly concentric MH Cavity



Grazie

- Riccardo DeSalvo
- Phil Willems
- Mike Smith
- GariLynn Billingsley
- Marco Tarallo
- Juri Agresti
- Chiara Vanni