Thermal Compensation Installation at LIGO HANFORD OBSERVATORY

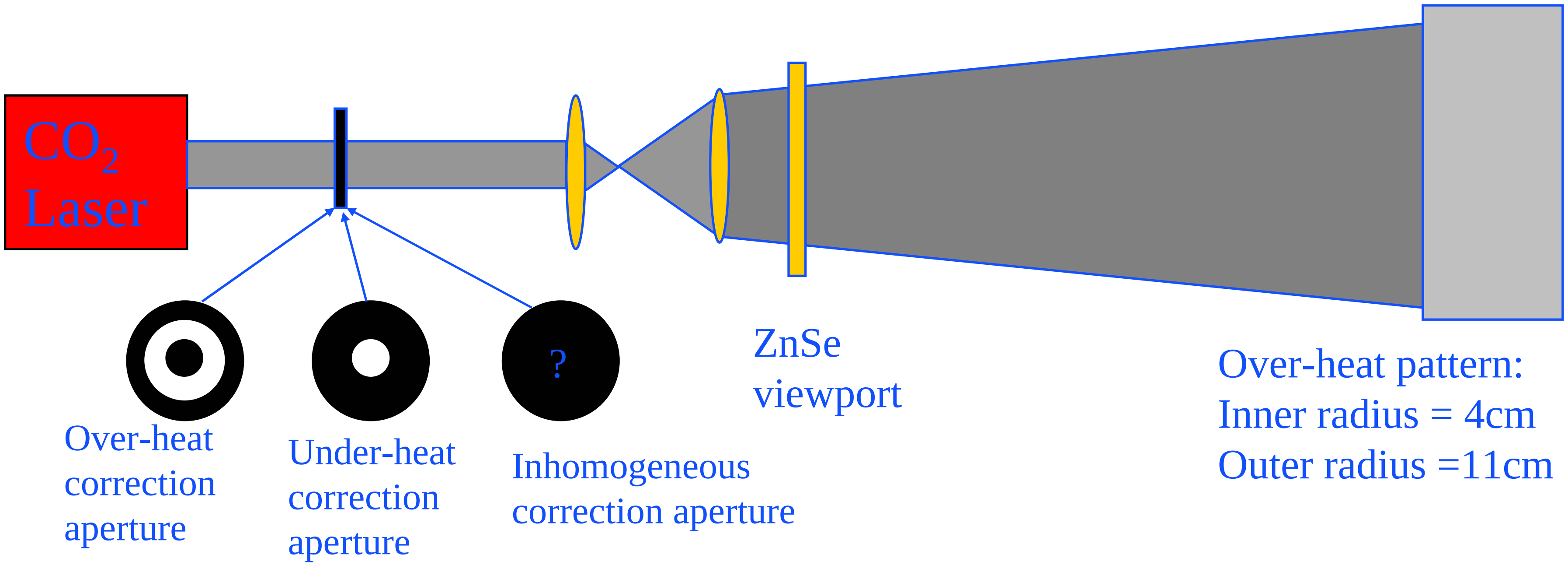
Dave Ottaway, Ken Mason, Stefan Ballmer- MIT

Mike Smith, Phil Willems- Caltech

Cheryl Vorvick, Gerardo Moreno, Daniel Sigg- LHO

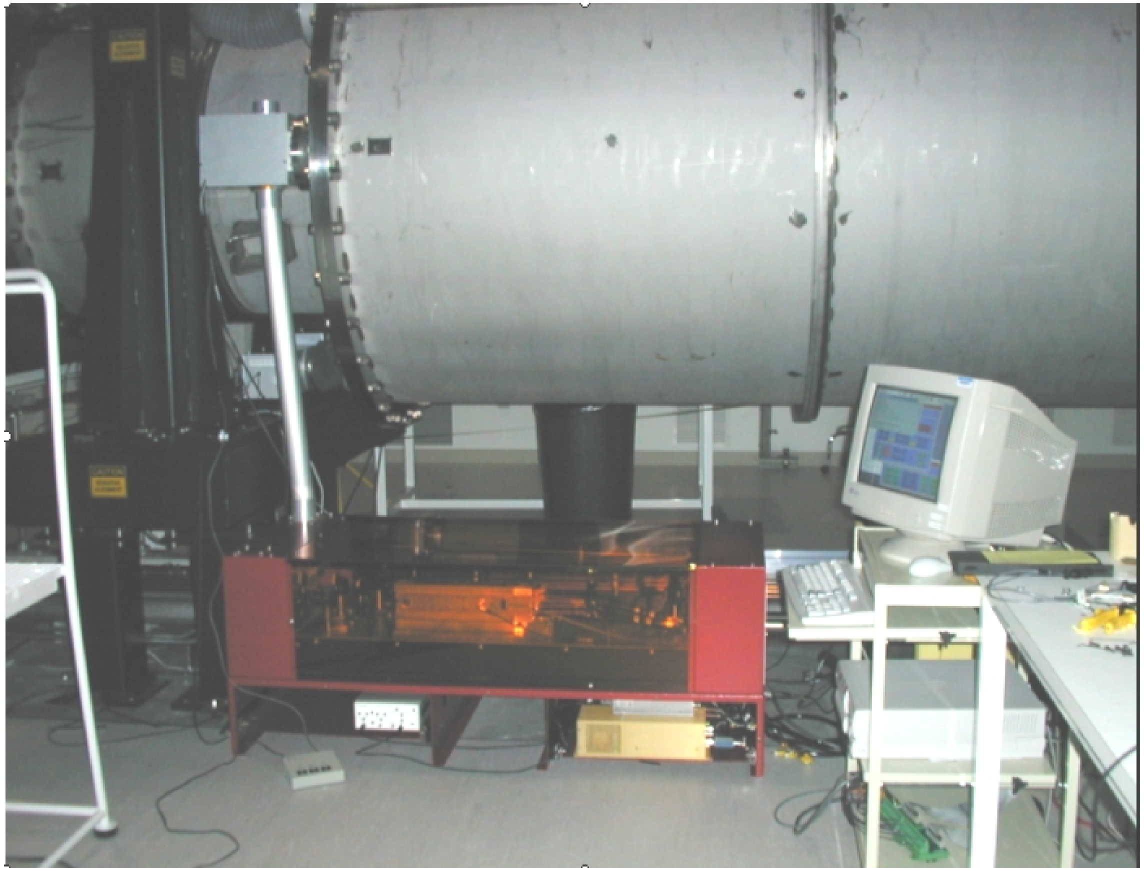
GR17, July 18-23, 2004, Dublin Ireland

Initial LIGO Thermal Compensation Concept

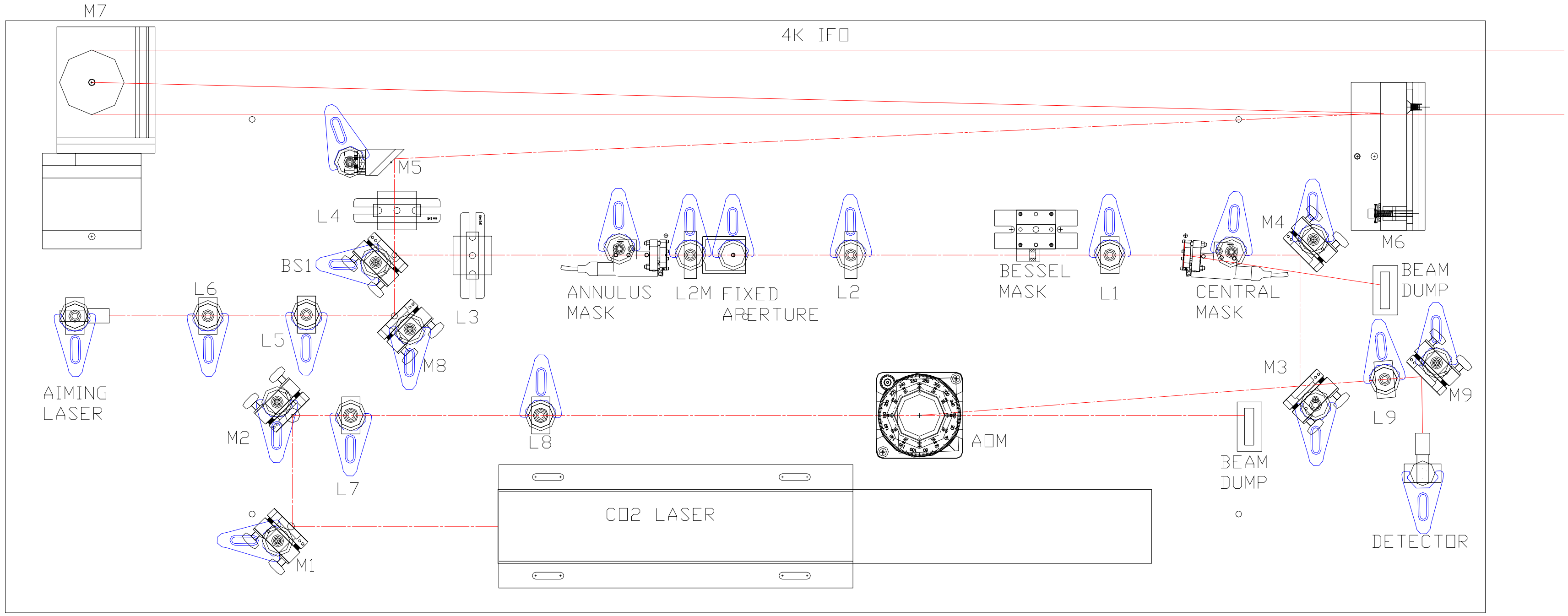


- Imaging target onto the TM limits the effect of diffraction spreading
- Modeling suggests a centering tolerance of 10 mm required to maintain good correction

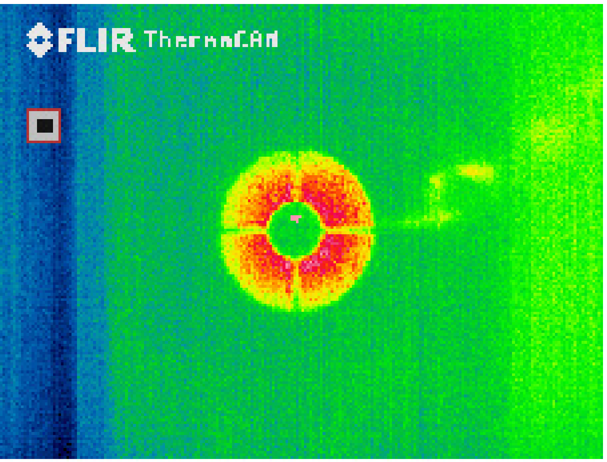
Thermal Compensation Implementation



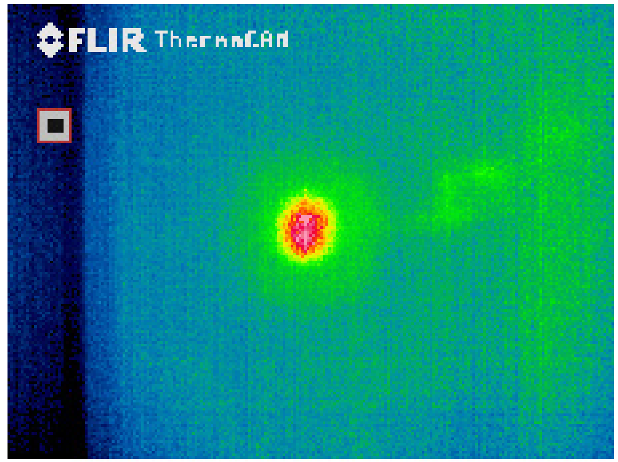
Thermal Compensator Layout



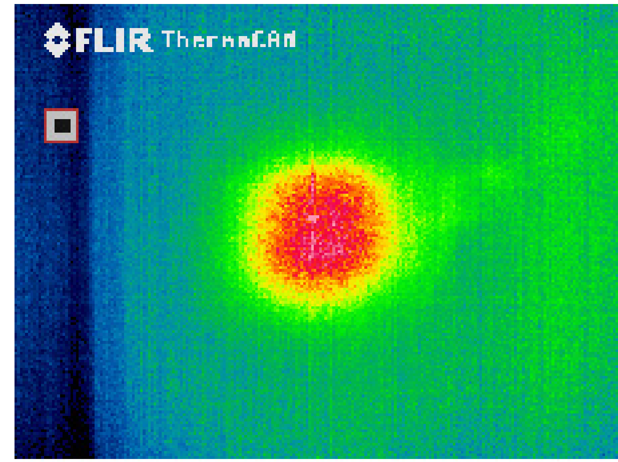
Thermal Compensation Heating Pattern



Annulus Mask



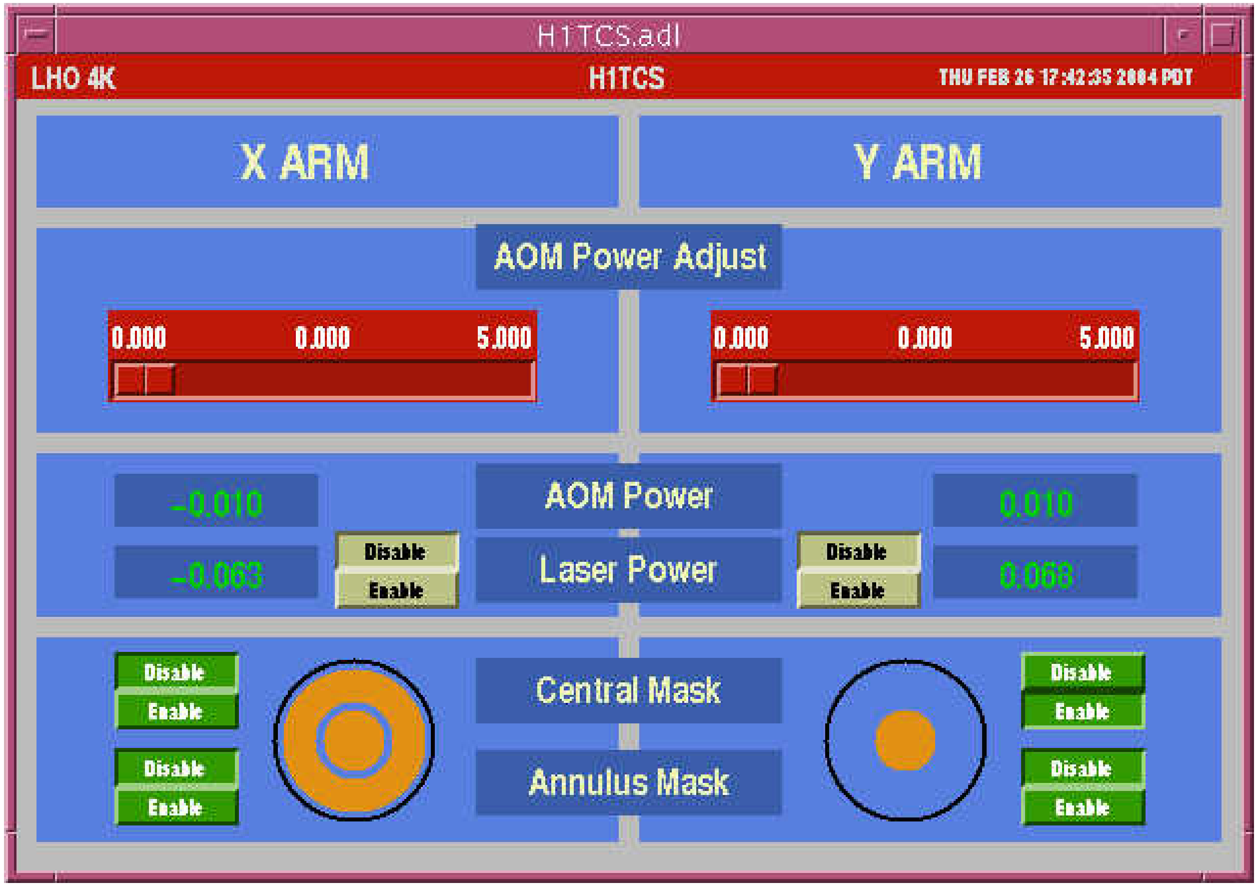
Central Heat Mask



No Masks

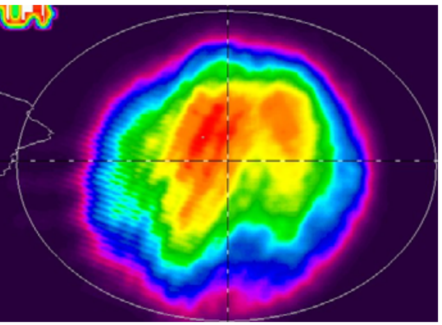
- Intensity variations across annulus image due to small laser spot size
- Modeling suggests that this should not be an issue
- Projection optics work well
- AOM distortion above 3W causes intensity centroid shift (these images all taken at 1 Watt CO_2 laser power exiting AOM)

Thermal Compensation Controls

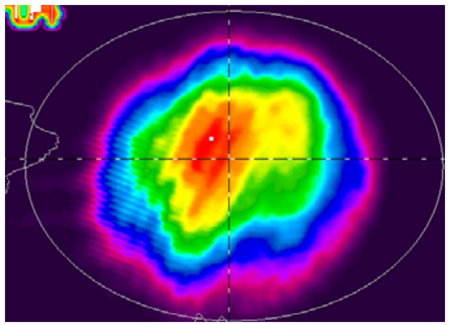


PRM Results – Mode Images at AS Port (both ITMs heated)

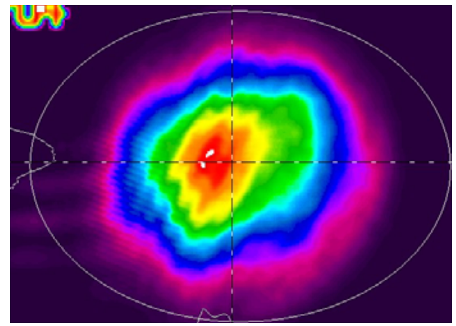
RF sidebands--->|



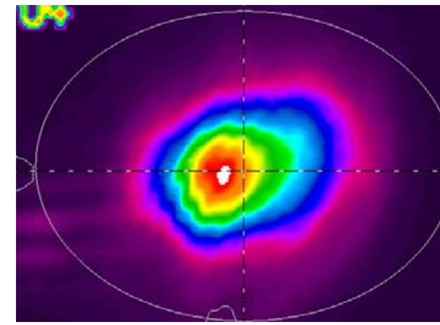
no heating



30 mW

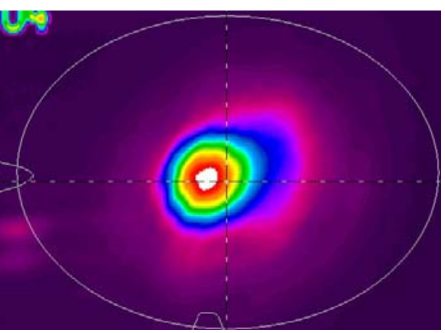


60 mW

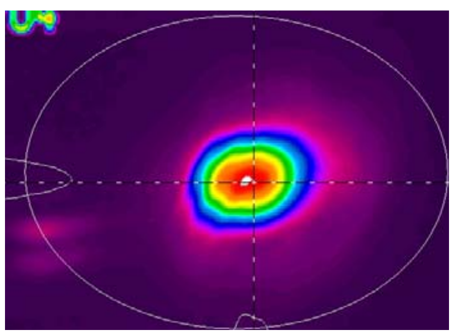


90 mW

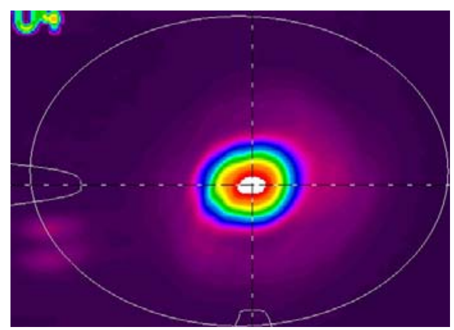
RF sidebands-->|



120 mW

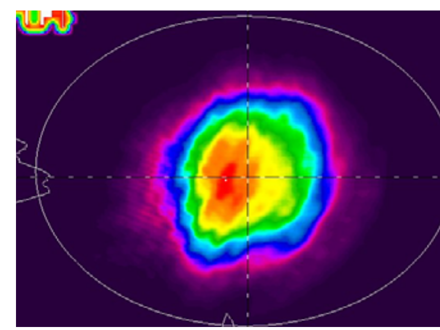


150 mW



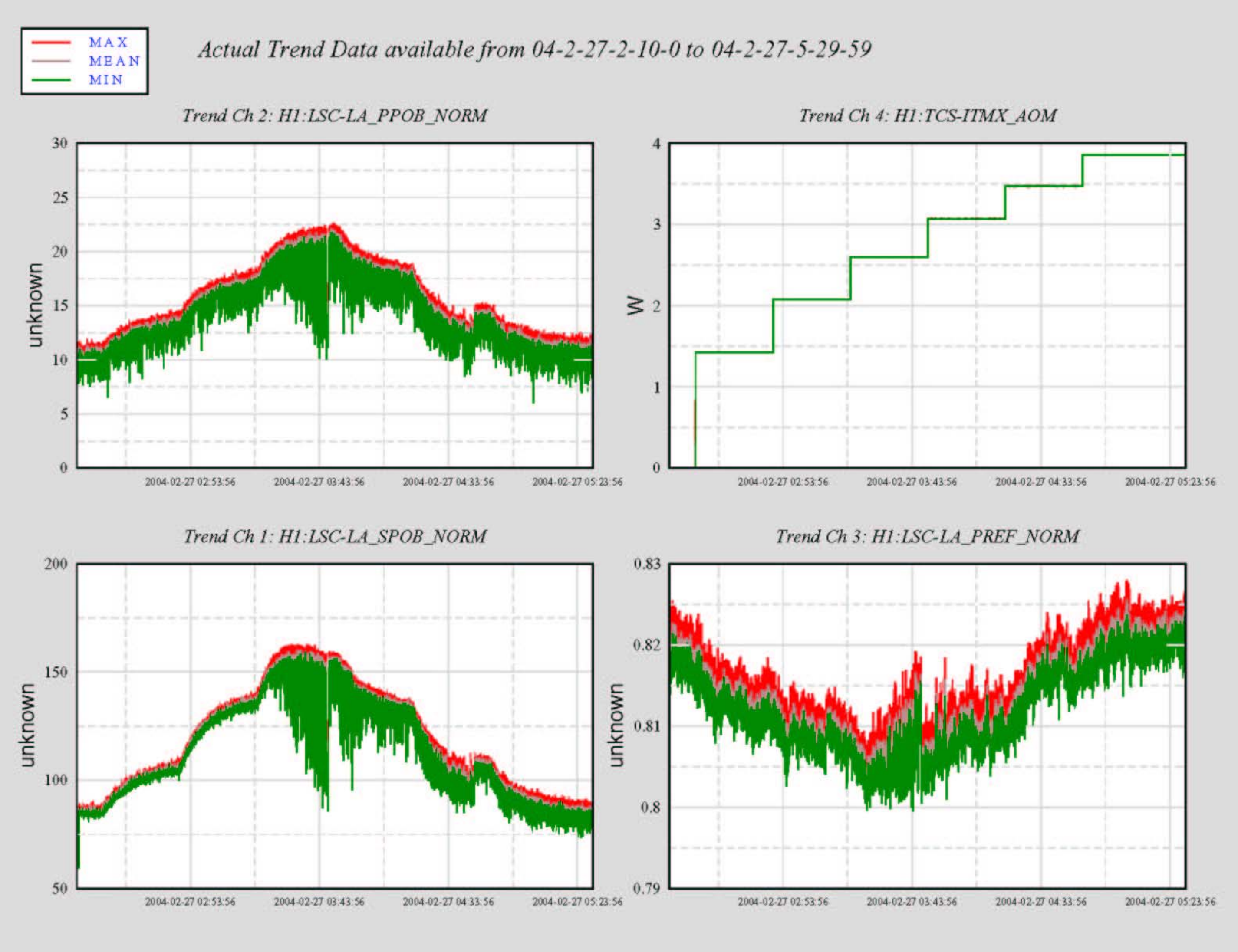
180 mW

Carrier



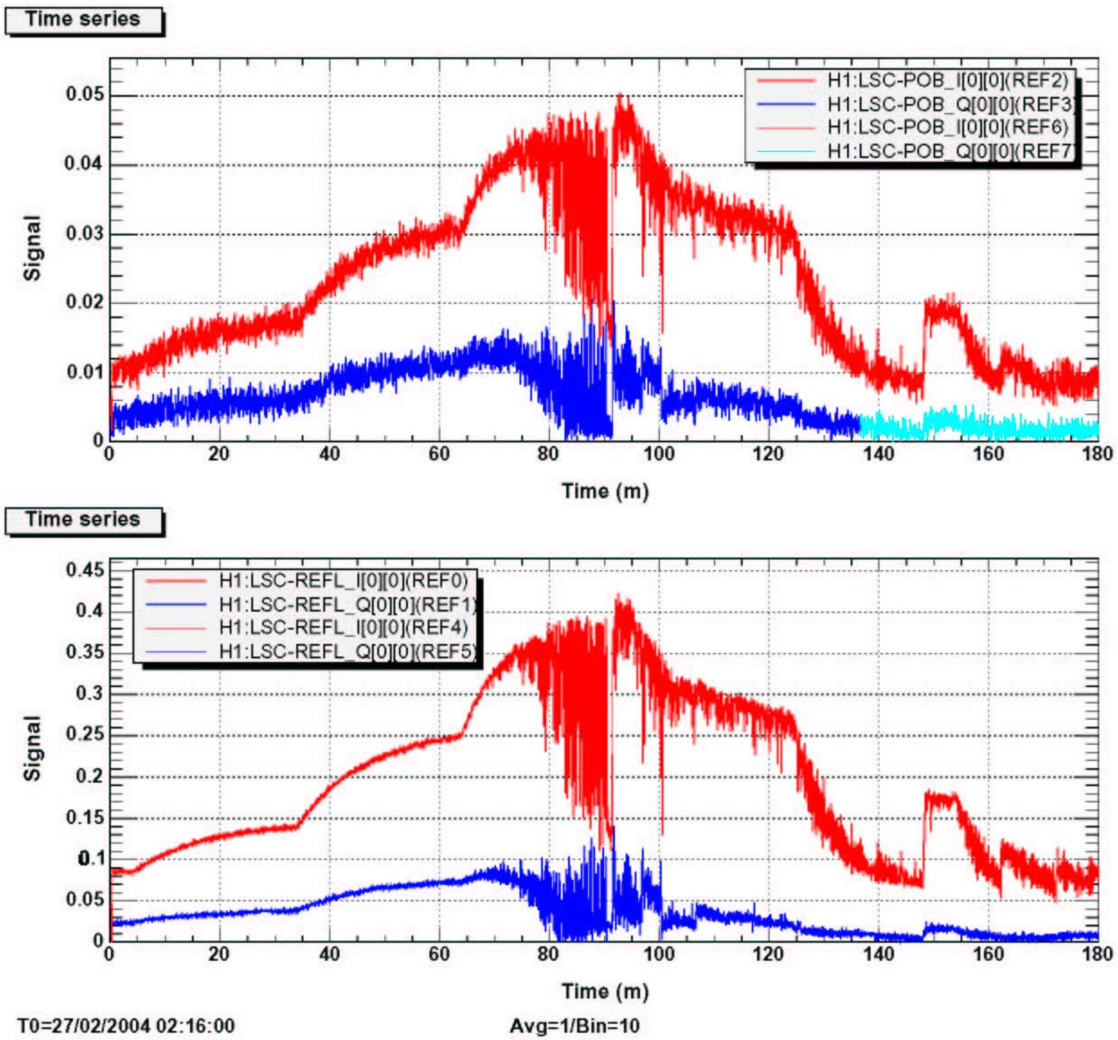
(thru unlocked IFO)

PRM Results –Sideband Buildup



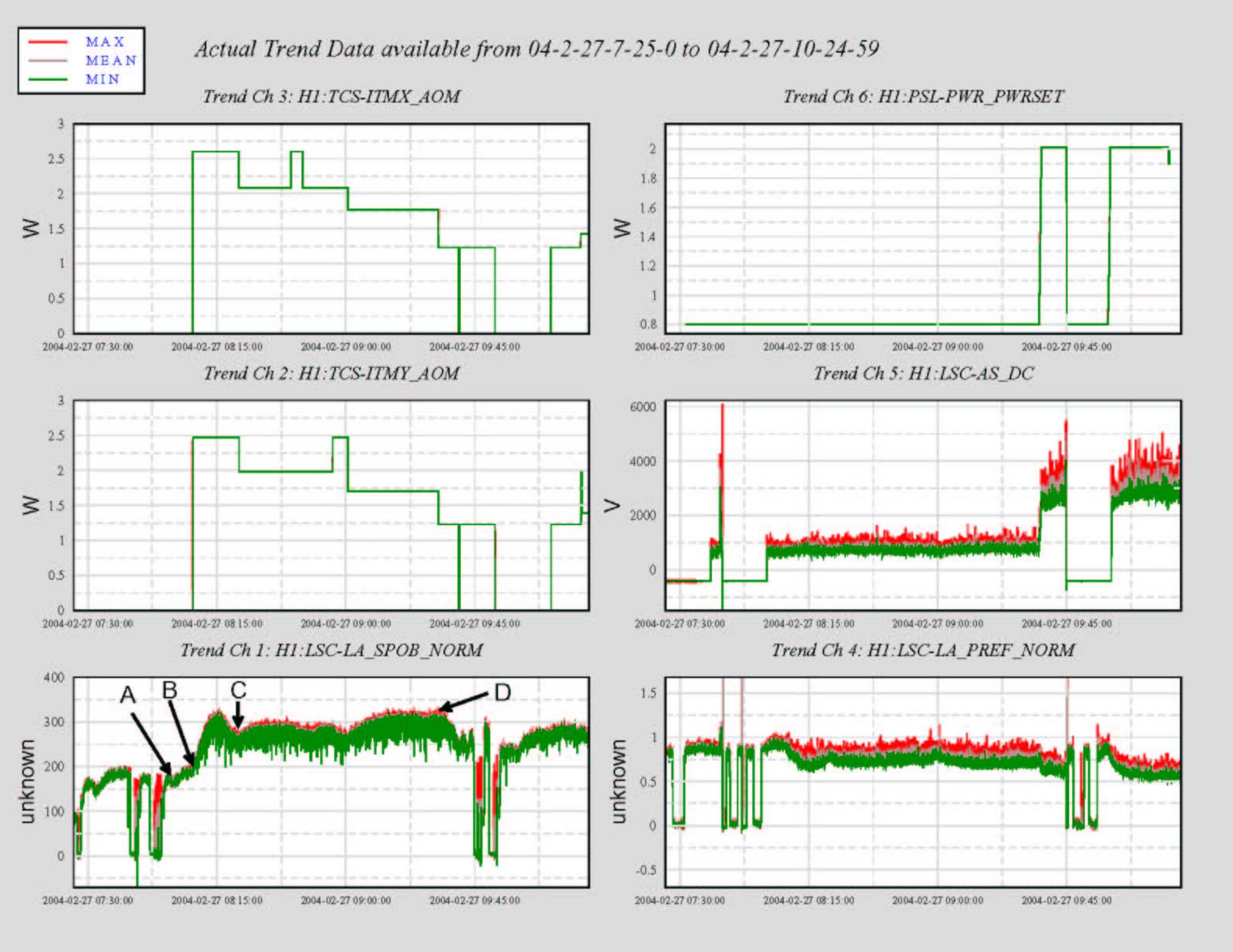
- Max buildup at ~90 mW TC
- TC increased in 30 mW steps
- IFO is sideband locked PRM with wavefront sensing

PRM Optical Gain during heating



- Maximum gain at ~90 mW central heating
- Same heating optimizes RF sideband buildup
- Same heating makes RF sideband mode resemble carrier mode

Full Interferometer Results



A. Interferometer locked at 0.8 Watt

B. 90 mW central heating applied to both ITMs

C. Central heating reduced

D. Maximum power with 45 mW heating

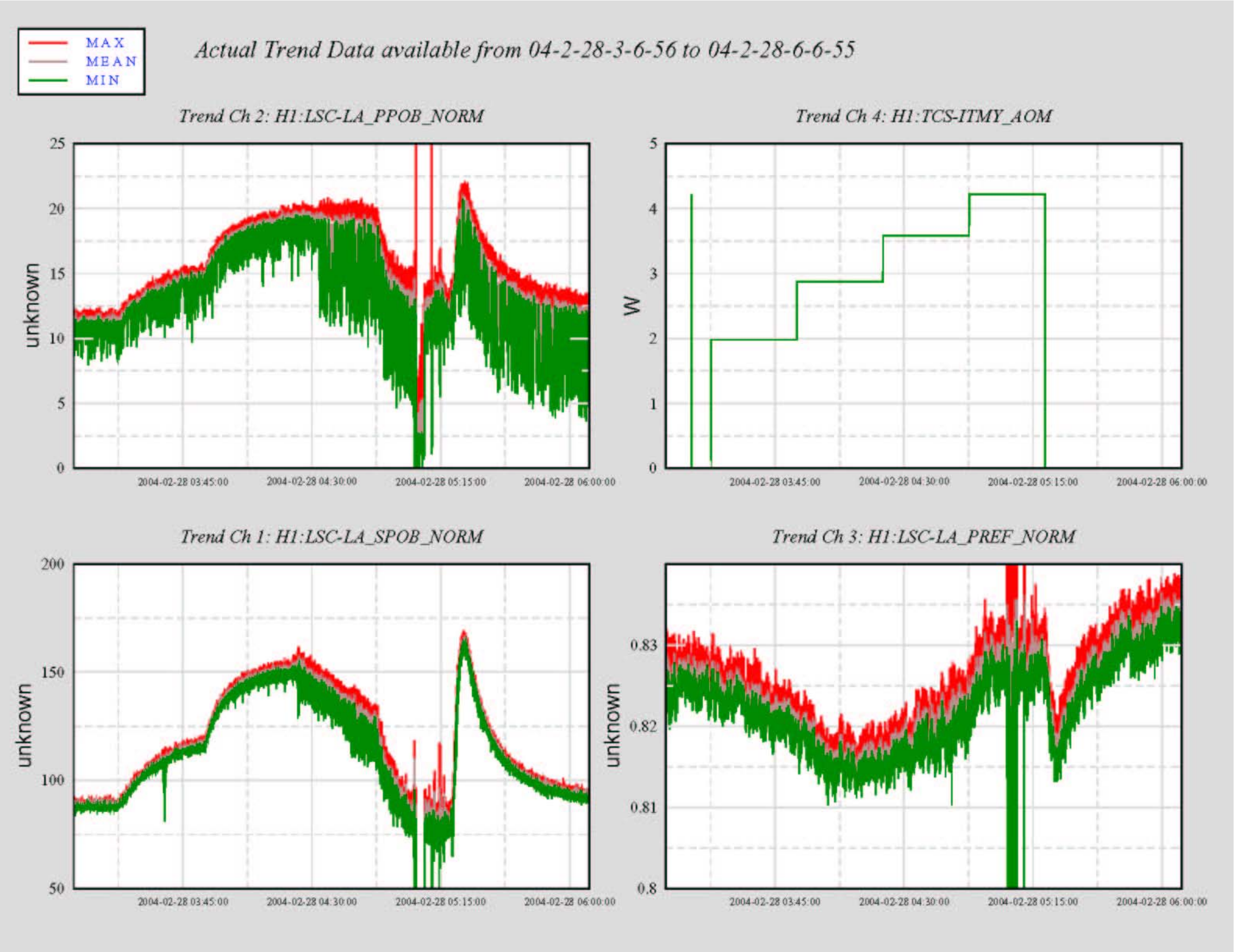
?? No change in AS_DC throughout

Summary of Results

State	SPOB	GSB
State 2 cold	85	7.0
State 2 hot (90 mW CO_2)	152	12.5
State 2 max (tRM / (1 - rRM rM rITM))^2		14
State 4 cold	160	13
State 4 warm (0.8W input)	190	16
State 4 hot (2.3W input, no TCS)	240	20
State 4 hot (0.8W input, 45mW CO2)	320	26.5
State 4 max (tRM / (1 - rRM rM))^2		30

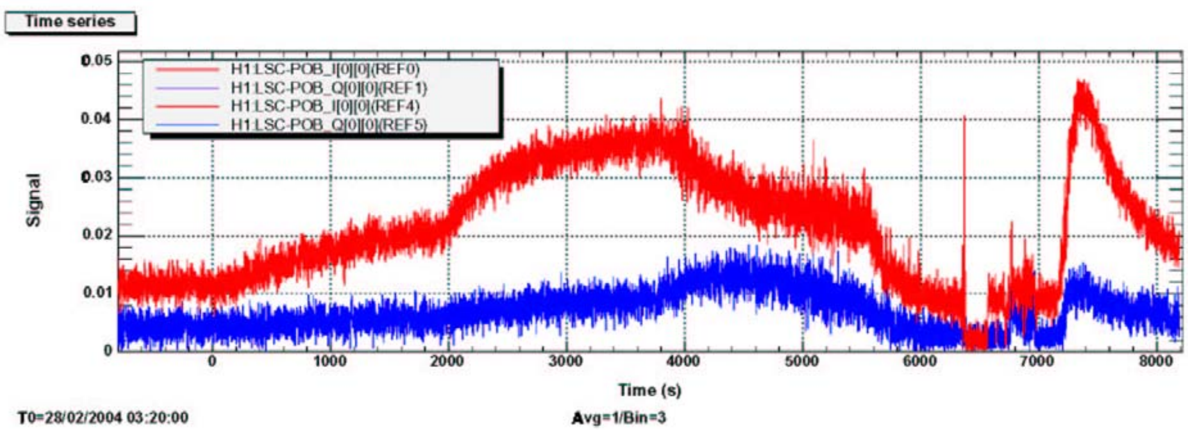
LIGO

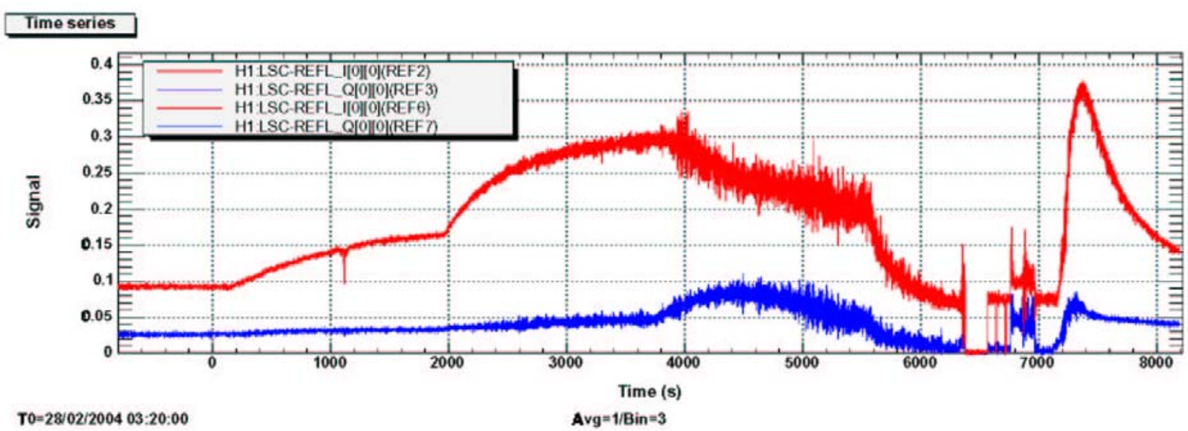
PRM Asymmetric Heating



- Maximum achieved with 120 mW on ITMy only
- SPOB build-up is the same gotten with common heating
- ITMx requires 200 mW to maximize SPOB to lower value; some asymmetry observed in mode structure

PRM Asymmetric Heating – Optical Gain





Issues to Resolve

- Different behavior of ITMx and ITMy
- Optimum compensation occurs with 90mW central heating, yet models predict less than half this
  - » Tests show 90% of CO_2 laser power is absorbed by ITM
  - » Misalignment of CO_2 laser beam cannot explain discrepancy