LOS Absorption Presentation for TCS Group

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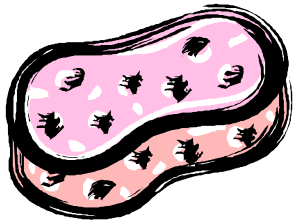
Outline

- Motivation
- Theory
- Procedure
- Data
- Result

Motivation

- Question:

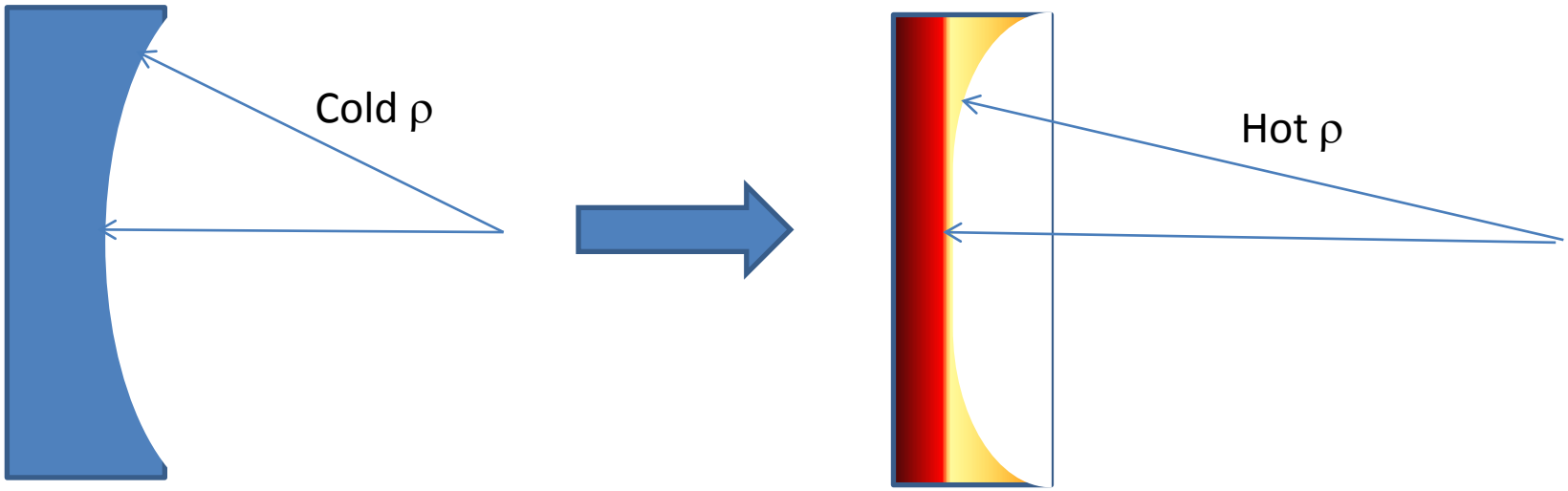


- 1) What do we care about the absorption of the large optics?
- 2) What is the absorption value?

- Answer: Silica mirrors inside IFO unfortunately absorb resonant laser power.

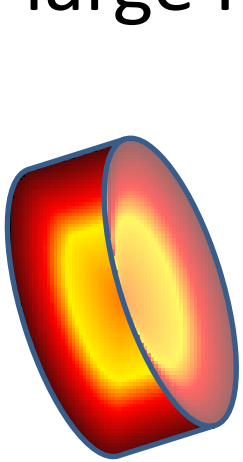
Motivation

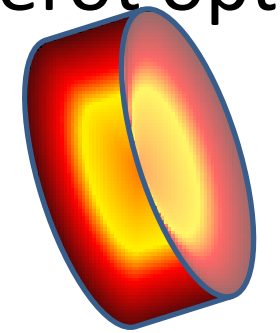
- Ans (con't): Mirrors expand due to temperature changes. Depending on absorption coefficient, mirrors may distort beyond or below design optimum.

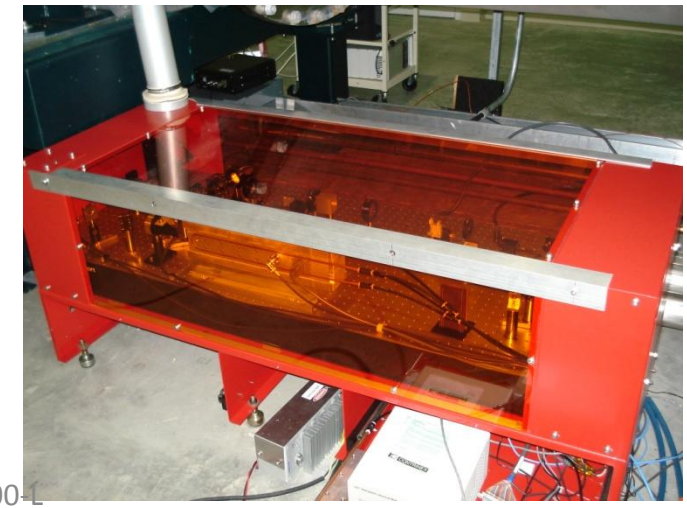


Motivation

- Measuring absorption (especially the ITMS) allows TCS team to build effective absorption models (Mathematica, Matlab, Finesse, SIS)
- Correct setup scheme for Enhanced TCS.
- So…We need the absorption values of the large Fabry-Perot optics.







Theory

- Crude theory
  - Mirrors have body modes
    - Finite temperature ⟹ Brownian motion
  - Frequencies are thermally dependent
    - Due to Young's modulus having a Y(T).
  - Track body mode frequency evolutions due to ΔT
  - Δf yields power absorption

Theory

- Crude theory

$$\frac{\Delta f}{f_0} = \left(7.5\times10^{-5}\,\frac{1}{K}\right)\times\left(\frac{P_{abs}}{7390\,\frac{J}{K}} + \Delta T\right)$$

- Better theory

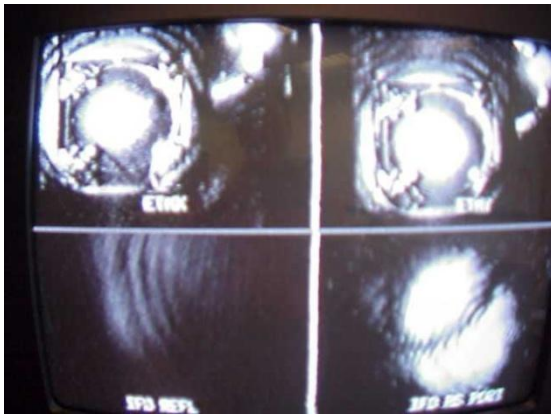
$$\frac{\partial f}{f}(t) = \int_{-\infty}^{t} \frac{10.5\times10^{-5}}{K}\times T(t')\frac{e^{\frac{-(t-t')}{17000s}}}{17000s}$$

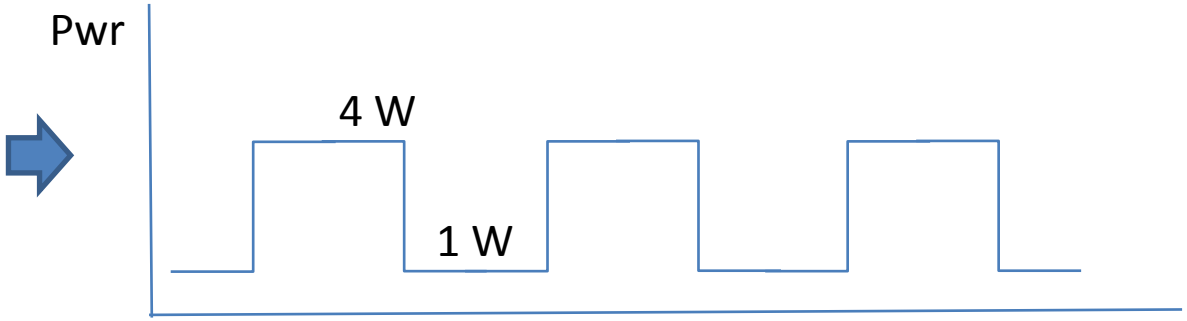
- We need f and Δf to determine α^*

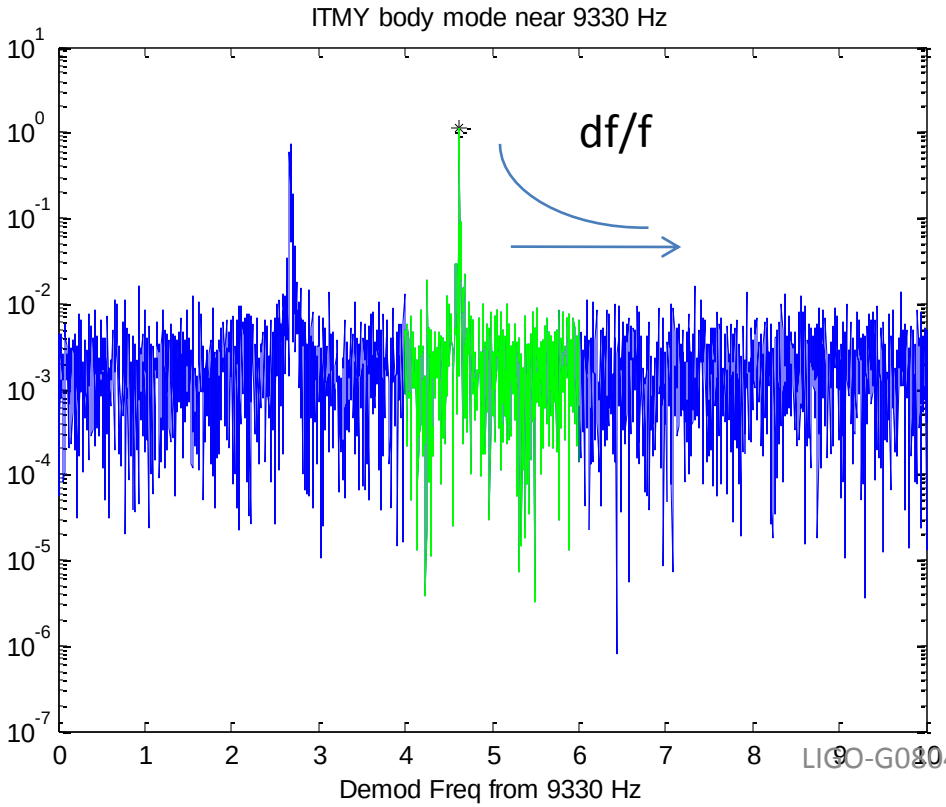
Procedure

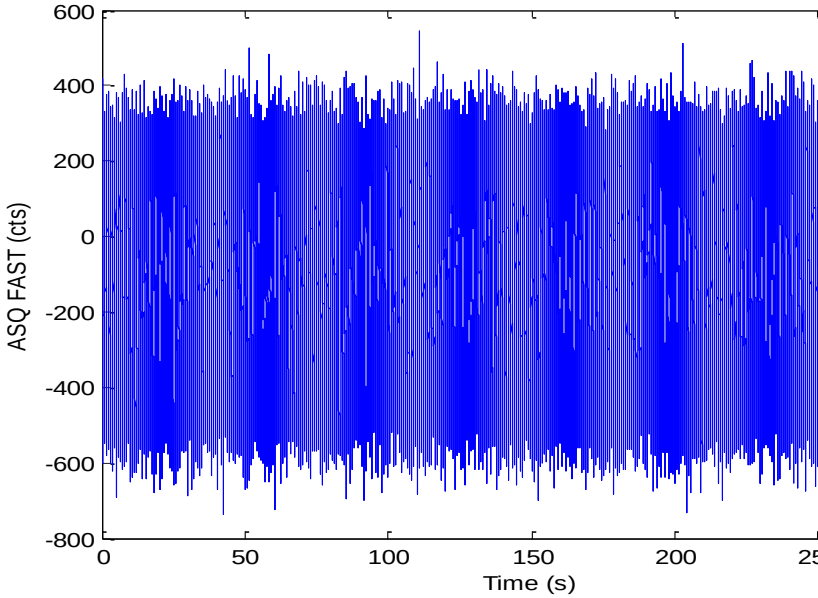
- Power Cycle IFO during fully locked state.
  - Do this over several hours
- Save data from fast ASQ sample channels and temperature sensors.
- Download GBs of data from LDAS and analyze.

Procedure



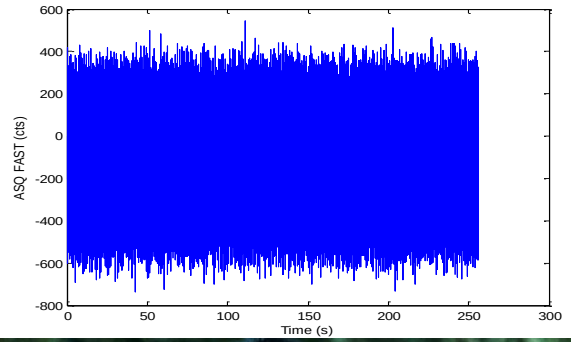

Pwr
4 W
1 W
t

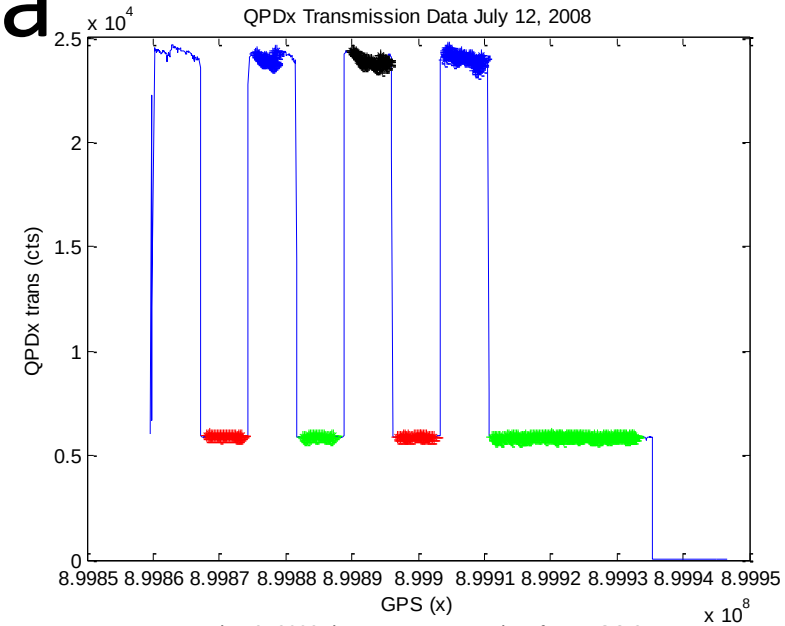

ITMY body mode near 9330 Hz
df/f
Demod Freq from 9330 Hz

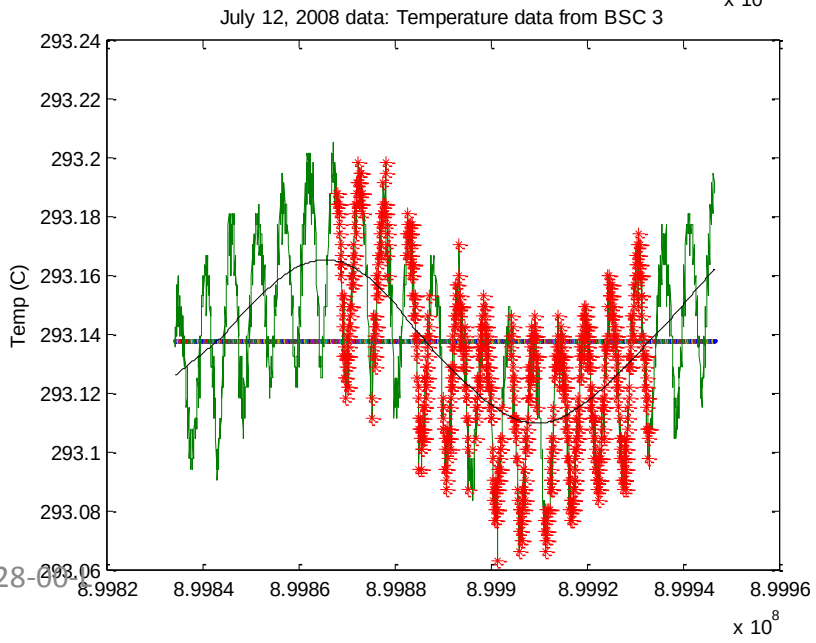

ASQ FAST (cts)
Time (s)

Data

- Lock data from 899867714 s

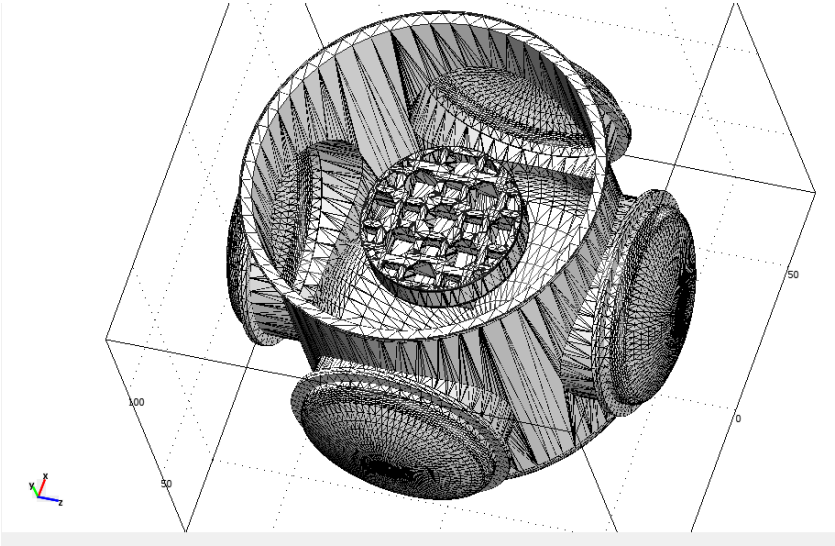






Thermal Resistances and Sources

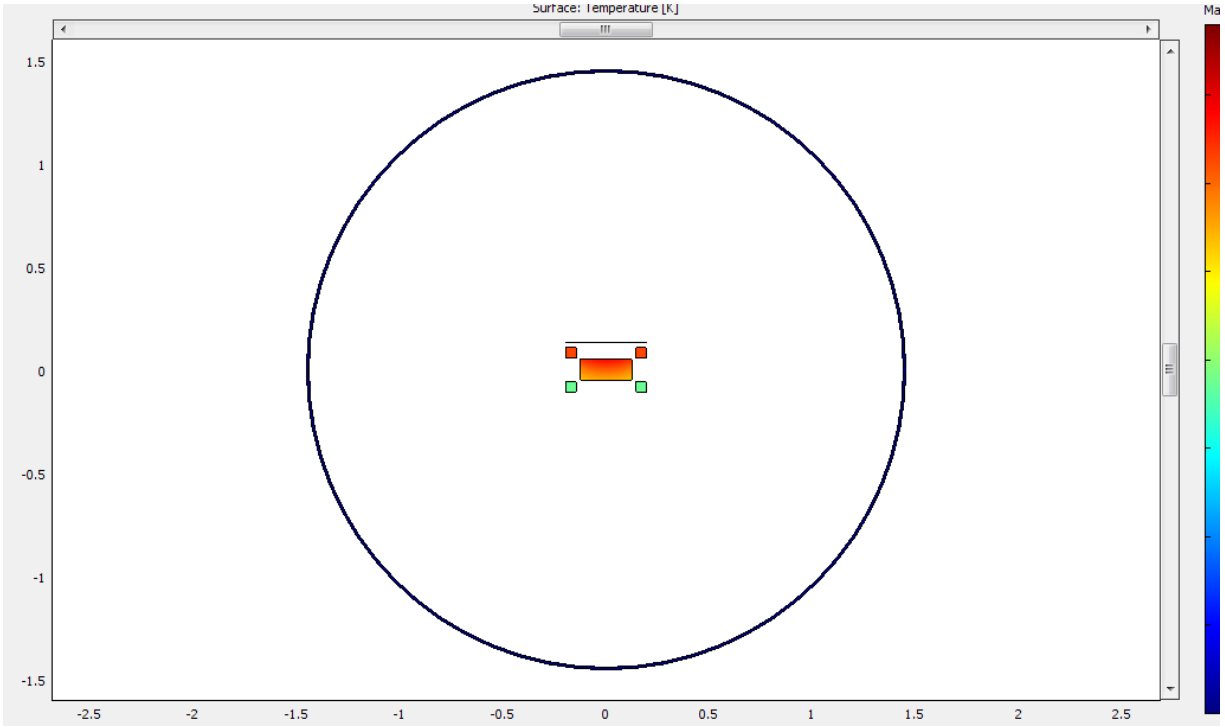
- BSC and contents slow LVEA to ITM interaction time.



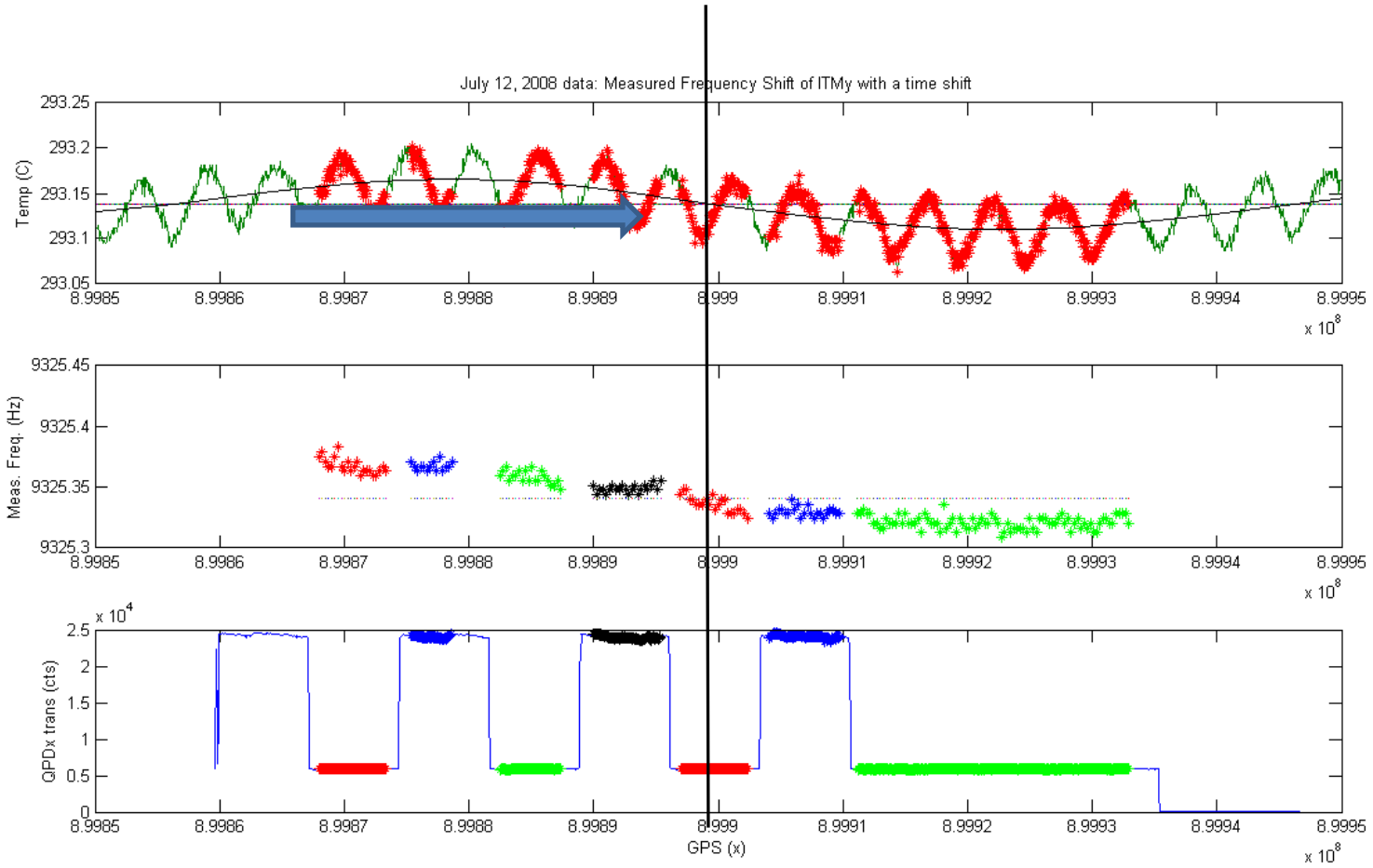
- Beam tubes: heat source but negligible

Thermal Resistance

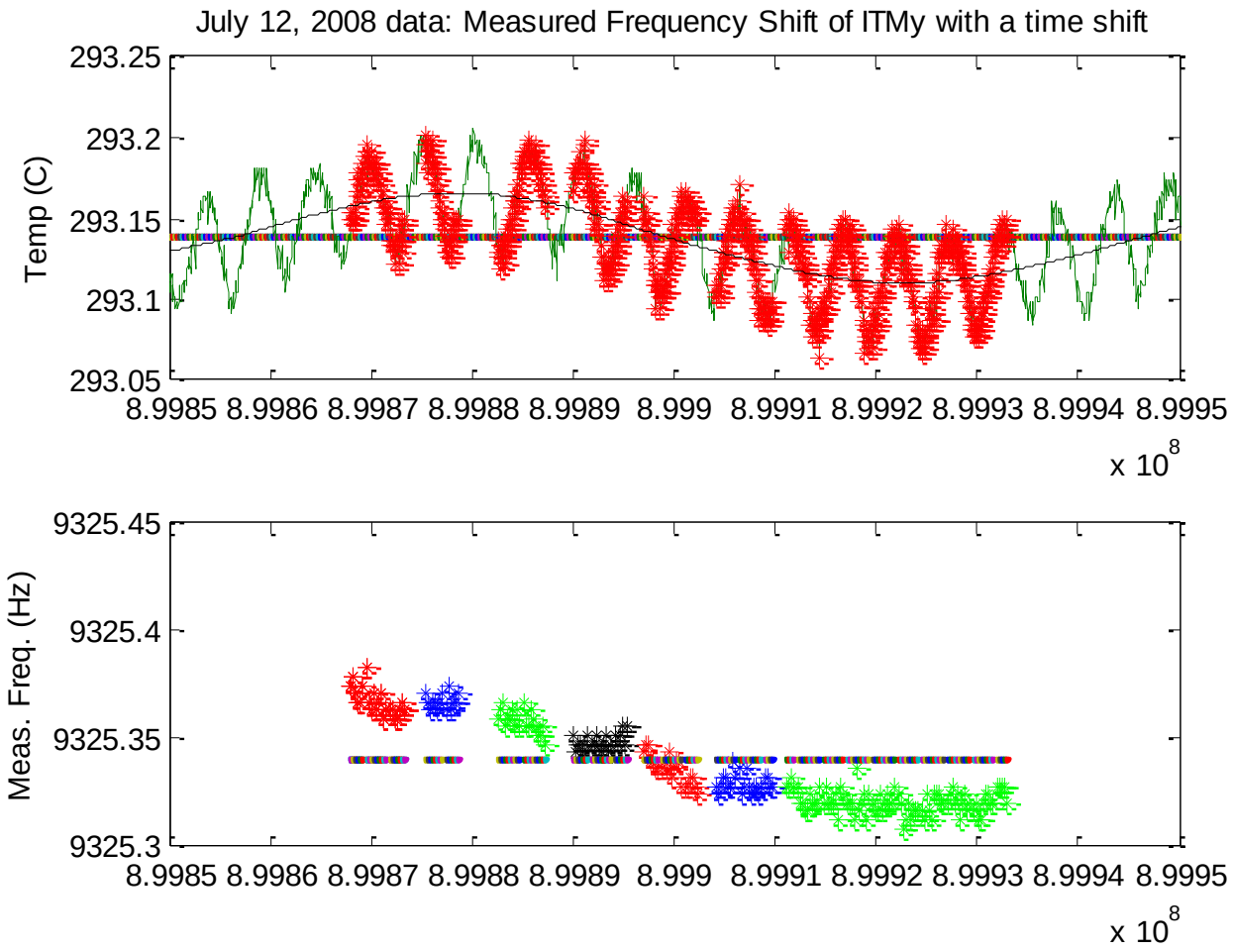
- Simulation of TM interaction with BSC. Small perturbations lead to simulation problems.



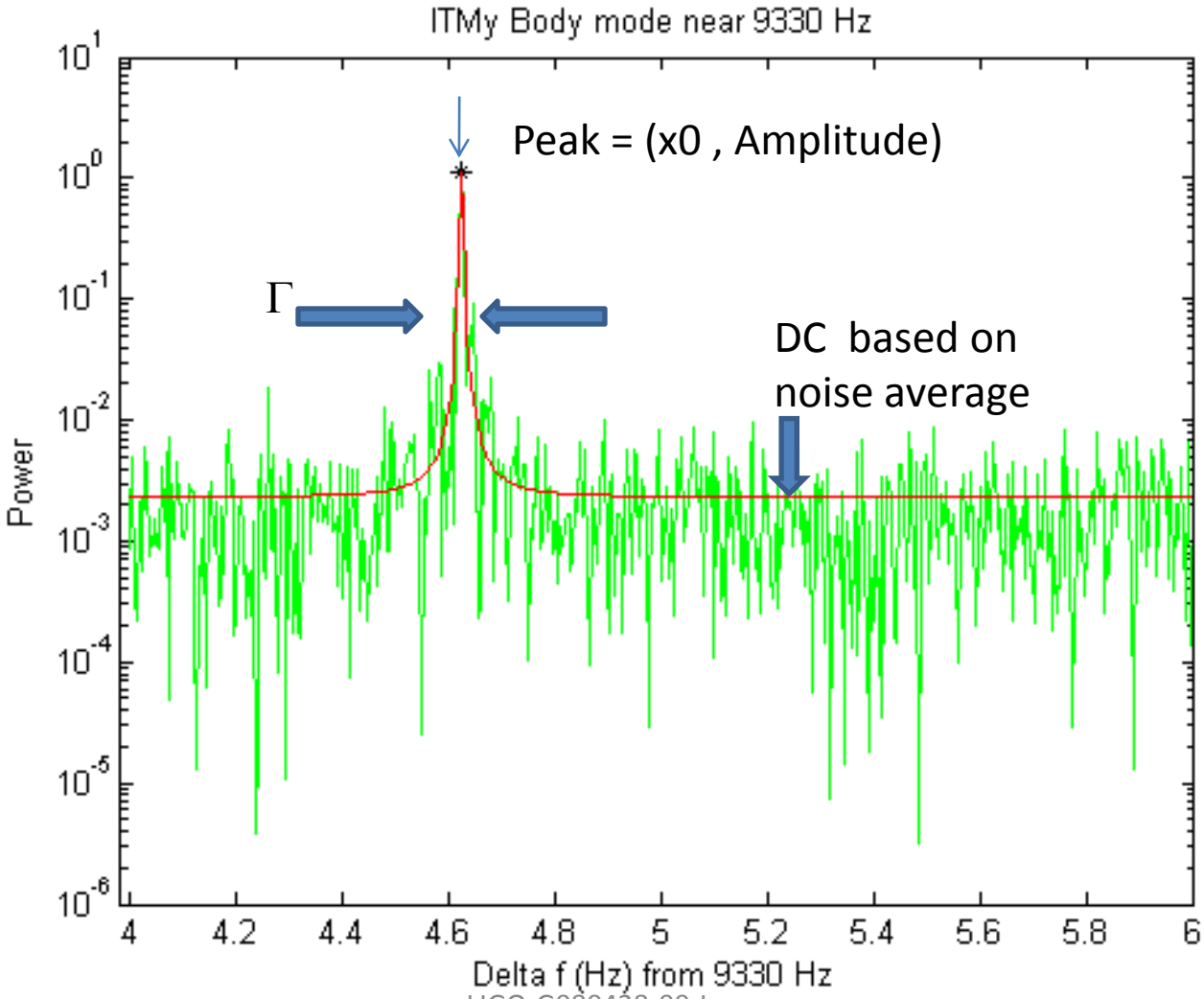
Analysis using raw data



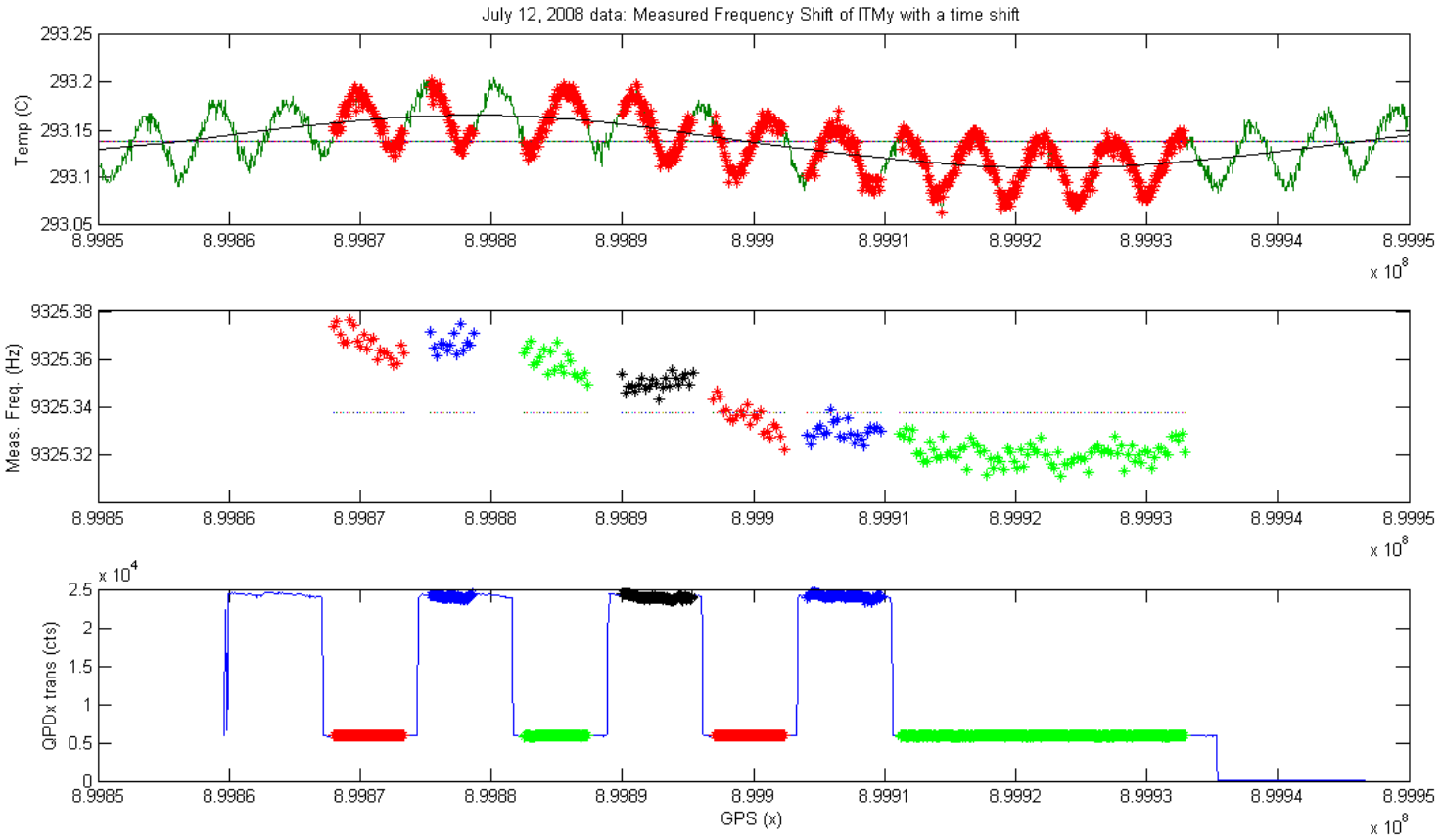
Raw Data (noisy)



Fitting Data

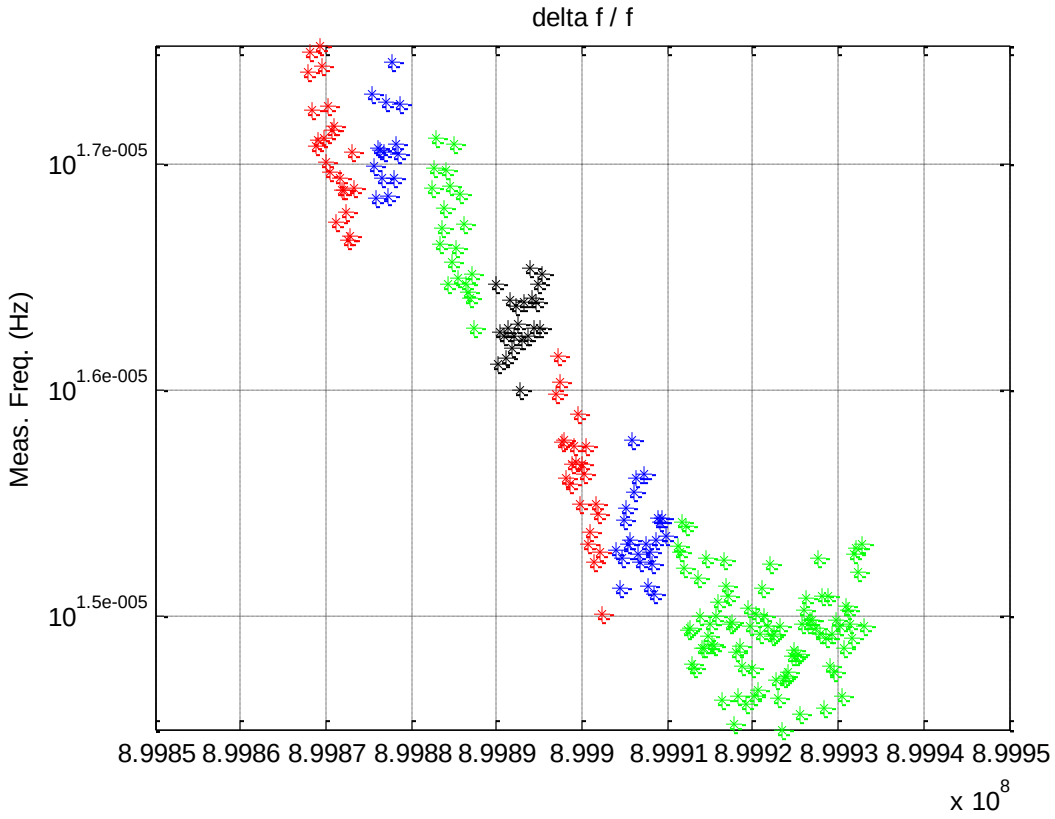


Analysis using fitted data



Analysis

- Δf/f for ITMy

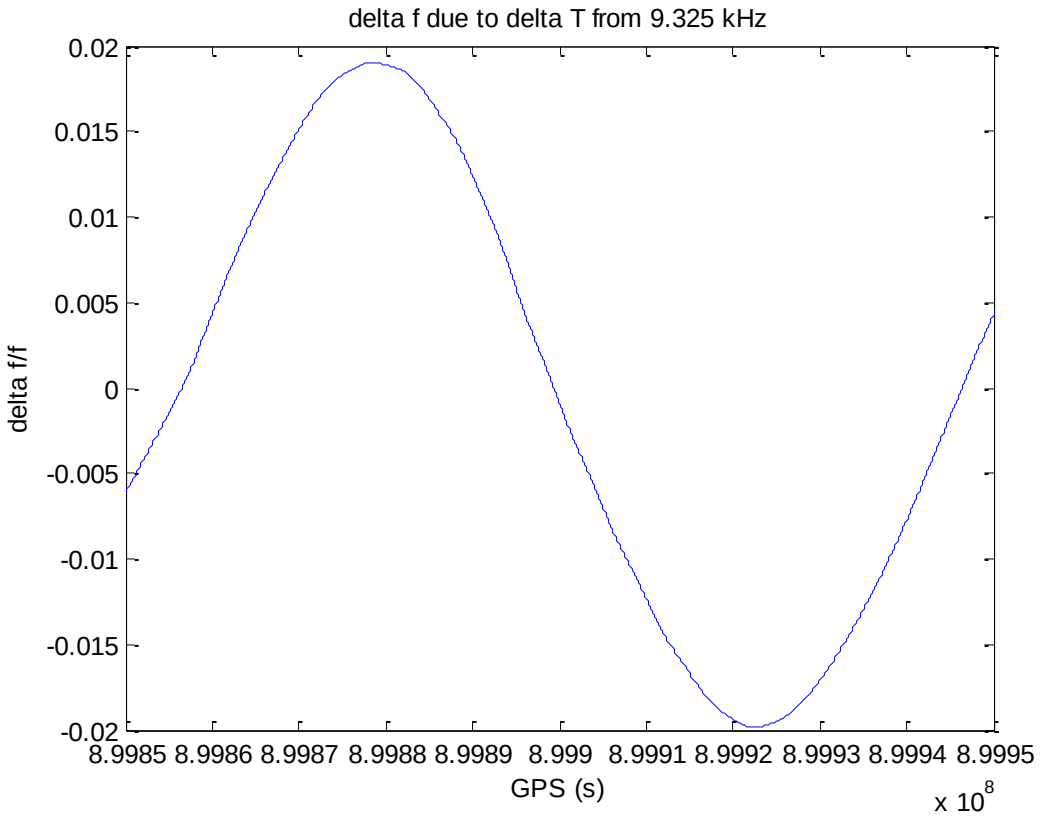


Results

- Total uncorrected slope = 1.3(3)e-6+/- 1.3e-6 Hz/s
- Uncorrected for high power = 4.(43)e-7+/- 3. e-7 Hz/s
- Crudely Corrected slope = ?
- Refined df/f = Need to do

Ambient temperature f-drift

- Crude shift due to temperature fluctuations



Questions?

- 1) What is your purpose?
- 2) What is your favourite color?