Angular Fluctuations

Biplab Bhawal (LIGO-Caltech), Gabriela González (Penn State),
Dave Ottaway (LIGO-Hanford), Tiffany Summerscales (Penn State)

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Presenter: Tiffany Summerscales

Detector Characterization Session

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Goals

- Estimate the angular motion in the mirrors

- Analyze the influence of the control signals fed back to the mirrors in the angular motion of those mirrors

- Analyze the effect of mirror angular motion in the interferometer performance

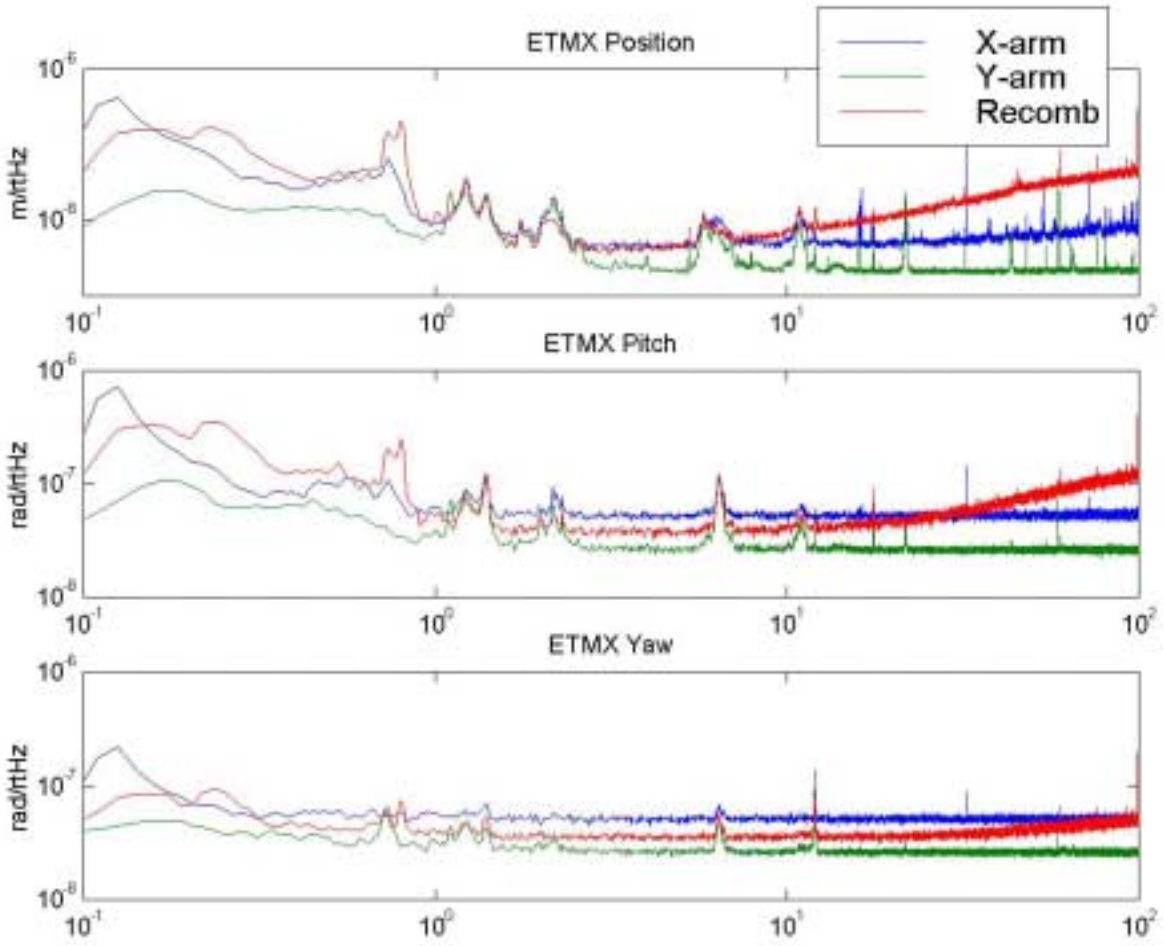
E2 Channels Used

- BS, ETMX, ETMY, ITMX, ITMY, FMX, FMY
- Optical Levers (Pitch Yaw)
- Local Sensors (LL, LR, UL, UR, Side)

Problems:

- Some Optical Levers had lower hardware sampling rates (ETMs, BS, FMs) than the data acquisition sampling rate.
- Antialiasing Filters not set for 256 Hz Local Sensor sampling rate. (However, ETMX, BS, and FMs accidentally sampled at 2048 Hz)
- ETMX Optical Lever pitch and yaw are switched
- ETMY LL sensor was dead
- ITM Optical Lever signals were not properly saved for recombined times and null when arm was unlocked.
- Moral: we need to check for the status of signals before the data is acquired! (we did this for E3).

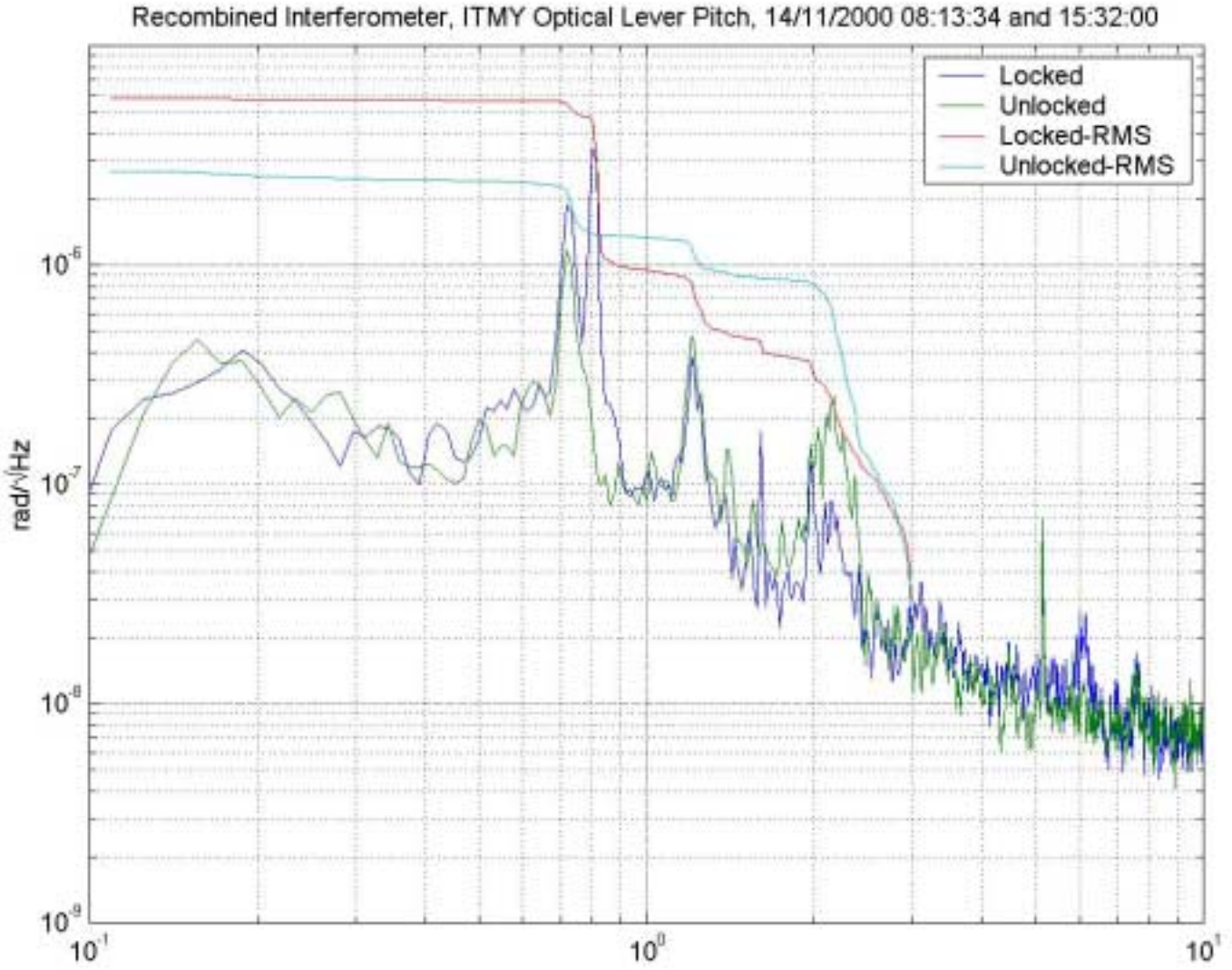
ETMX



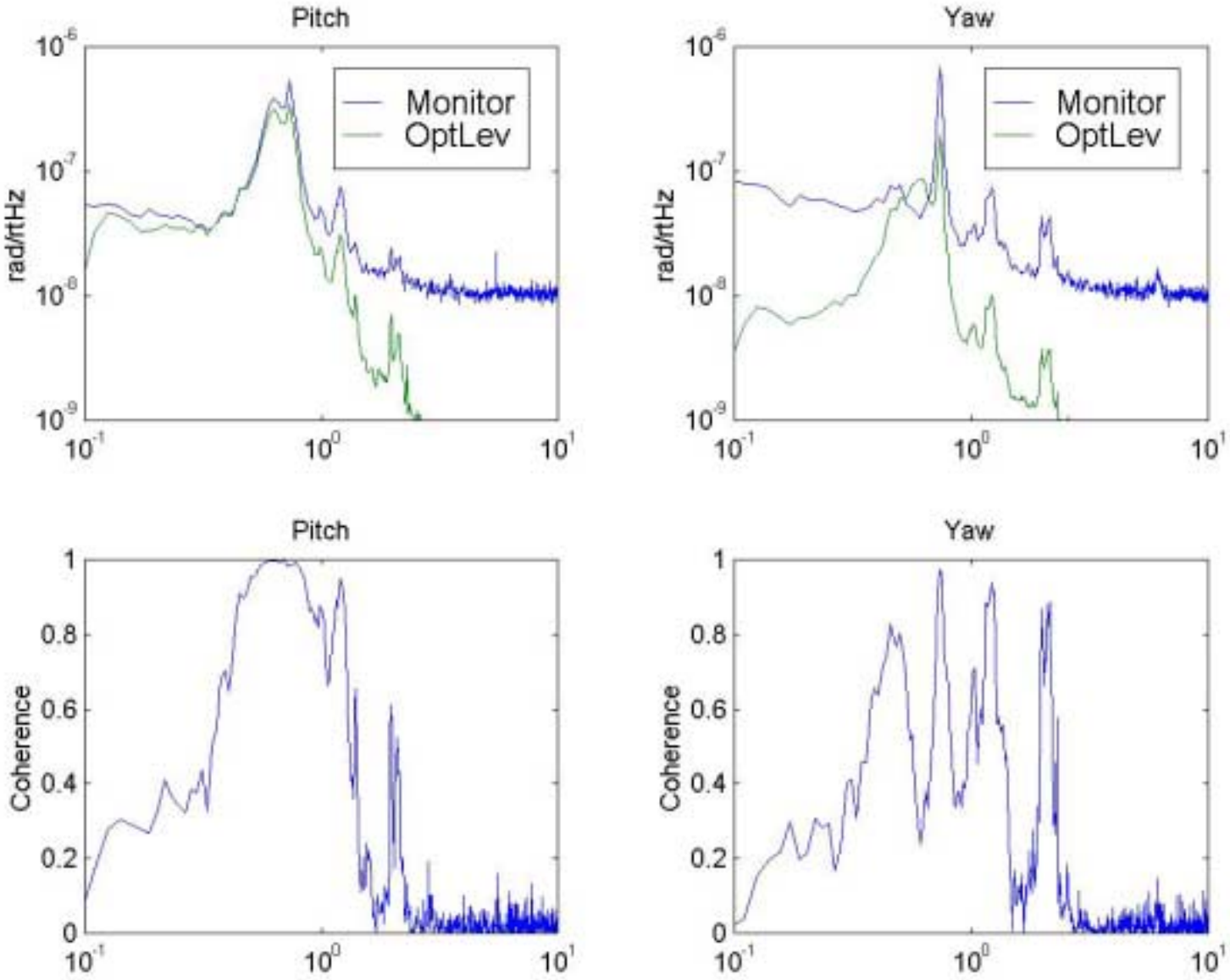
RMS Pitch
Y-arm = 0.5 μrad
X-arm = 1.1 μrad
recomb = 1.6 μrad

RMS Yaw
Y-arm = 0.37 μrad
X-arm = 0.48 μrad
recomb = 0.77 μrad

ITMY


Recombined Interferometer, ITMY Optical Lever Pitch, 14/11/2000 08:13:34 and 15:32:00
Locked
Unlocked
Locked-RMS
Unlocked-RMS
rad/√Hz
10^-6
10^-7
10^-8
10^-9
10^-1
10^0
10^1

ITMX


Pitch
Monitor
OptLev
rad/rtHz
Yaw
Monitor
OptLev
rad/rtHz
Pitch
Coherence
Yaw
Coherence

Yaw: $(f/0.6Hz)^2$

Pitch:

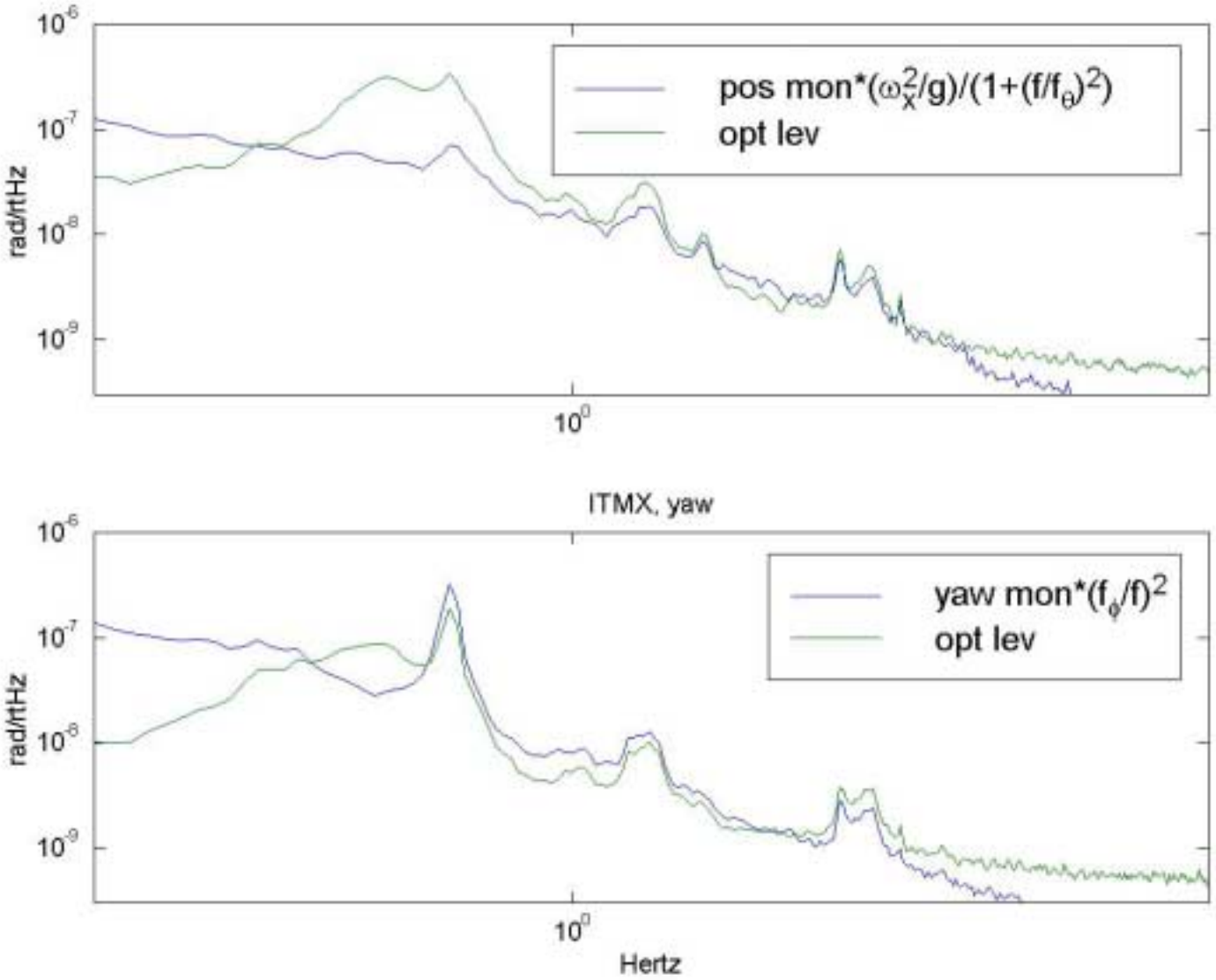
θ = Mirror pitch x = Mirror Translation X = Frame Translation

$$\frac{\theta}{X} = \frac{\omega^2/g}{(1+(\frac{f}{f_\theta})^2)(1+(\frac{f}{f_x})^2)} \qquad \frac{x}{X} = \frac{1}{(1+(\frac{f}{f_x})^2)}$$

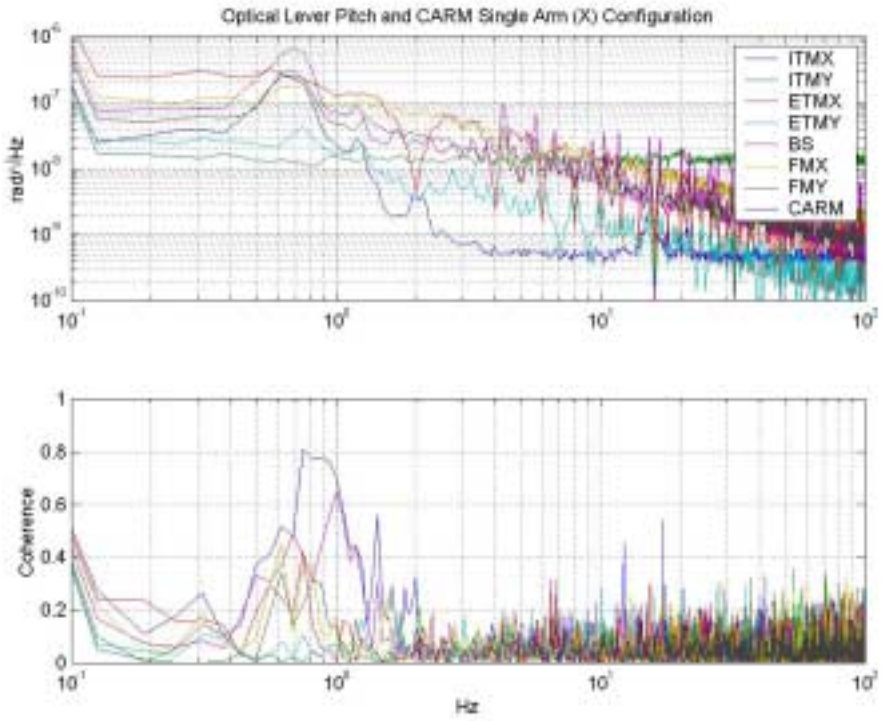
M_x= position monitor = x-X

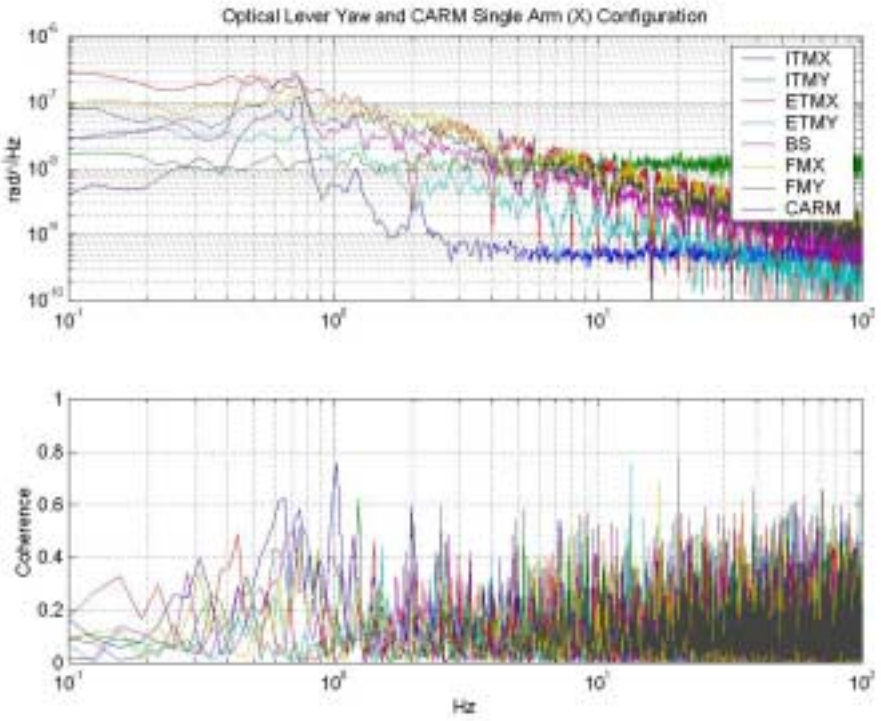
$$x = M_x(\frac{f}{f_\theta})^2 \qquad \theta = \frac{M_x(\frac{\omega^2}{g})}{(1+(\frac{f}{f_\theta})^2)}$$

ITMX


pos mon*(ω_x^2/g)/(1+(f/f_θ)^2)
opt lev
rad/rtHz
10^-6
10^-7
10^-8
10^-9
10^0
ITMX, yaw
yaw mon*(f_ϕ/f)^2
opt lev
rad/rtHz
10^-6
10^-7
10^-8
10^-9
10^0
Hertz

Mirror motion and detector performance





Conclusions

• Angular Motion is on the order of about 1 μrad in pitch and tenths to one μrad for yaw

• Control signal feedback tends to increase angular motion by a factor of ~ 2.

• Angular Motion is coherent with CARM ： the mirrors are moved in angle due to forces cross-coupled into torques.