E2e modeling of MC

S. Yoshida[1], J. Quave[1], and H. Yamamoto[2]

1. Southeastern Louisiana University
2. Caltech LIGO

LSC August 2006 meeting

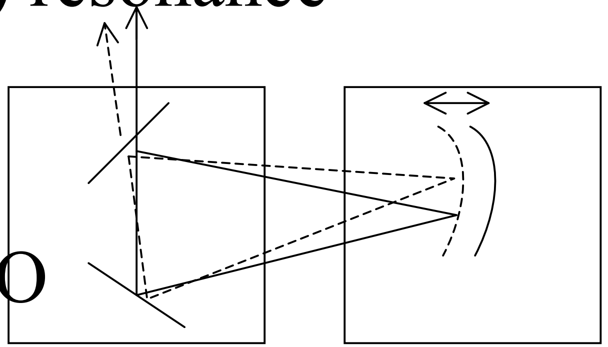
LIGO-G060476-00-Z

Motivation

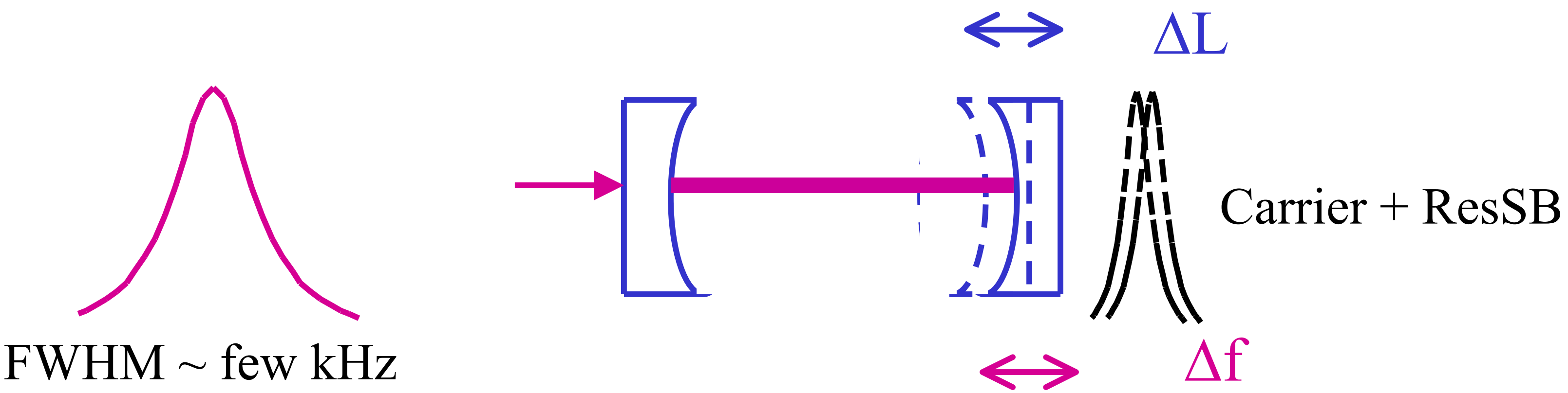
- Frequency noise due to MC length fluctuation
- Test/learn from LIGO I and apply to AdvLIGO

Outline

- MC Opt - trans light Pitch/Yaw show peaks & high coherence at HAM stack (U-U, V-V) resonance
- MC LSC - MC trans light Pitch/Yaw show high coherence at HAM stack (U-U, V-V) resonance
- Modeling table Yaw: $\frac{1}{2}(\frac{\partial u}{\partial y} - \frac{\partial v}{\partial x})$
- LIGO I MC simulation results
- Plan/status on modeling for AdvLIGO



MC frequency fluctuation and AS-Q



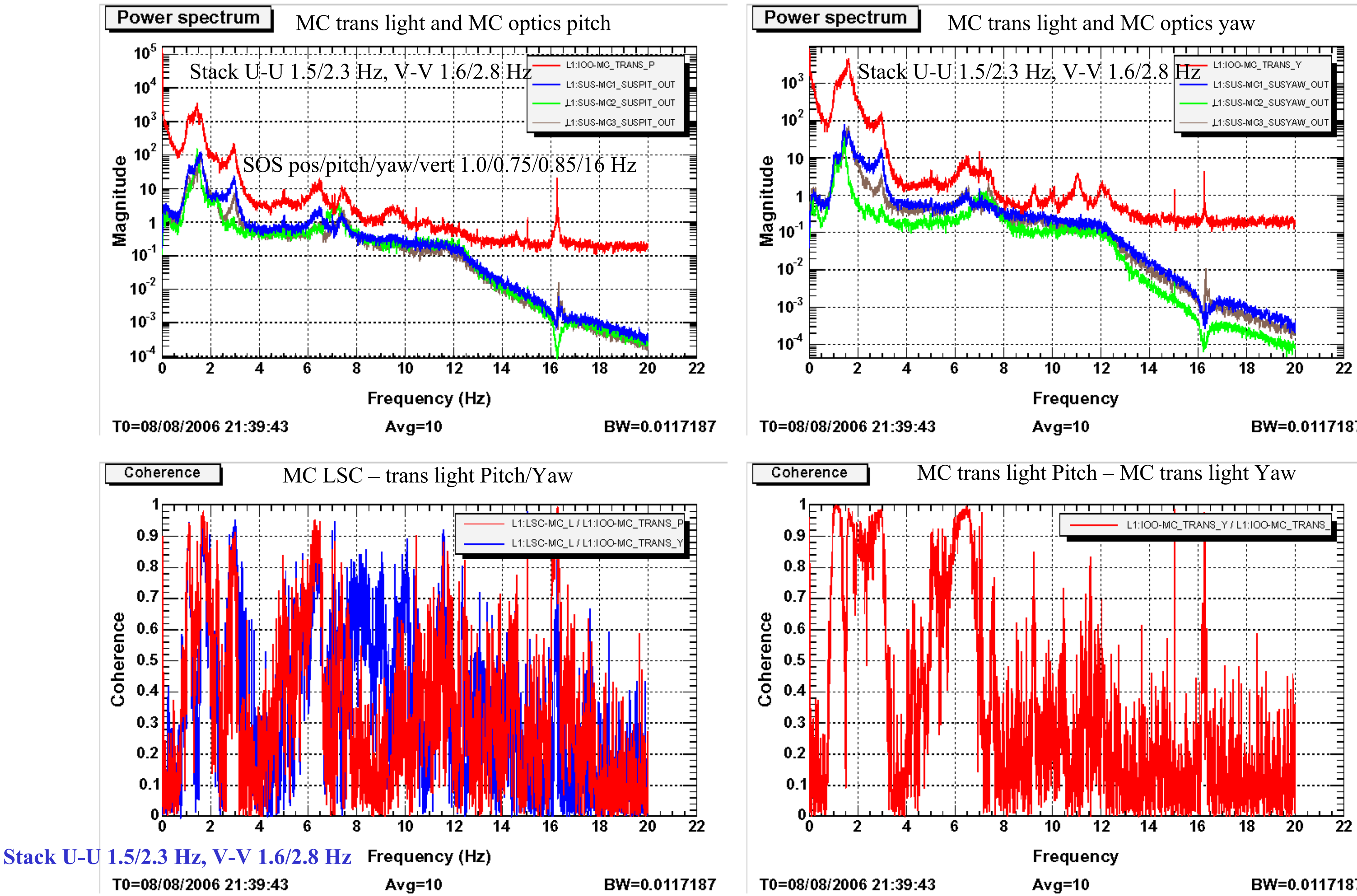
Frequency fluctuation by MC length affects ASQ by X/Y arm asymmetry (Leakage from COM to DIF by asymmetry) Freq fluctuation appears as if arm length change*.

(1) Different reflectivity on ITMX and Y
(2) Difference in cavity pole
(3) Snupp's asymmetry

*R. Adhikari

MC trans light and Optics' Pitch/Yaw (0 – 20 Hz)

- peaks at stack resonance -



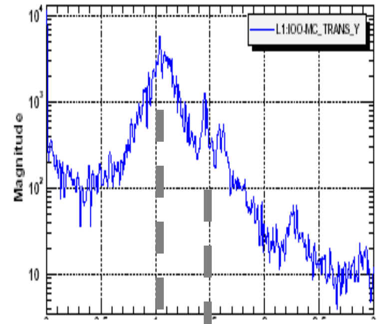
MC trans Pitch/Yaw and Optics Yaw (0 – 5 Hz)

High correlation at stack resonance between MC trans and opt yaw

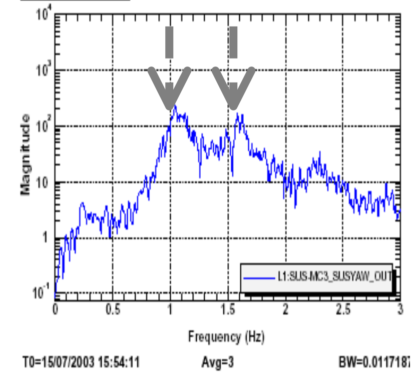
High Opt Yaw peak in 2003

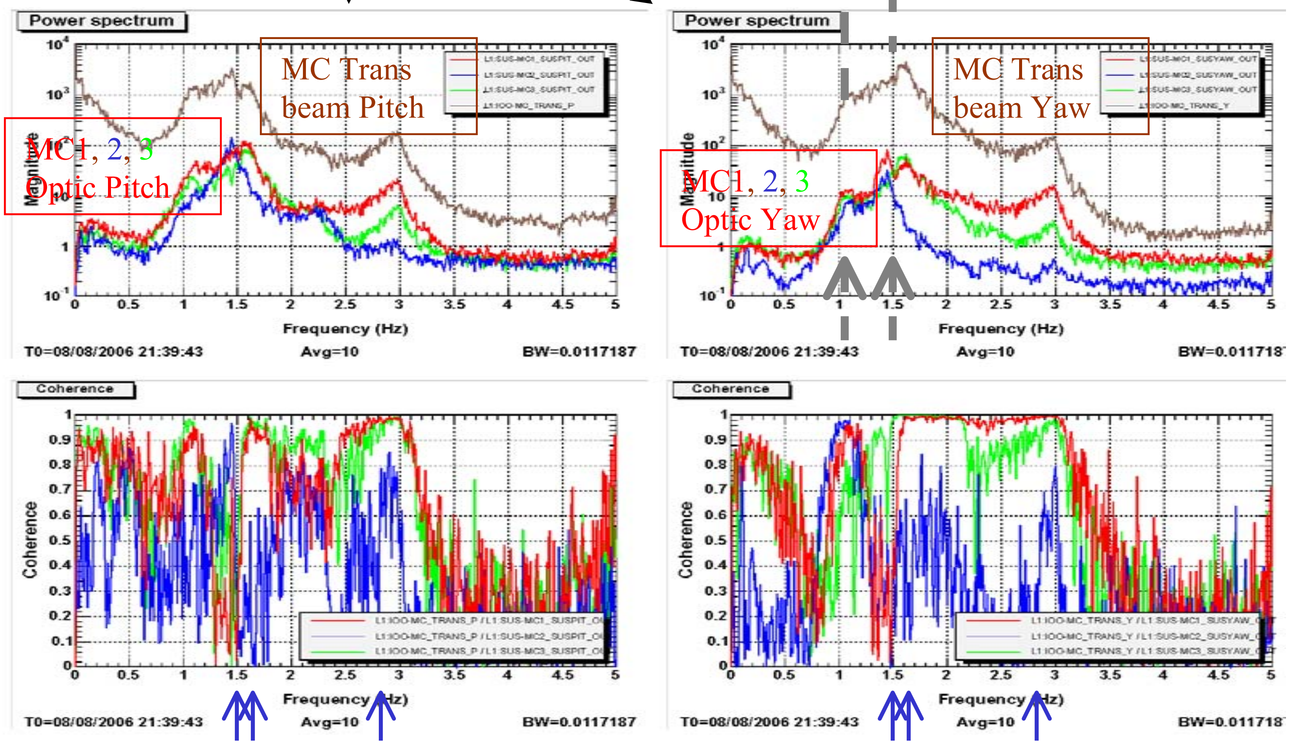
Low Opt Yaw/Pitch peak in 2006

MC_trans Yaw (2003)



MC3_Opt Yaw (2003)



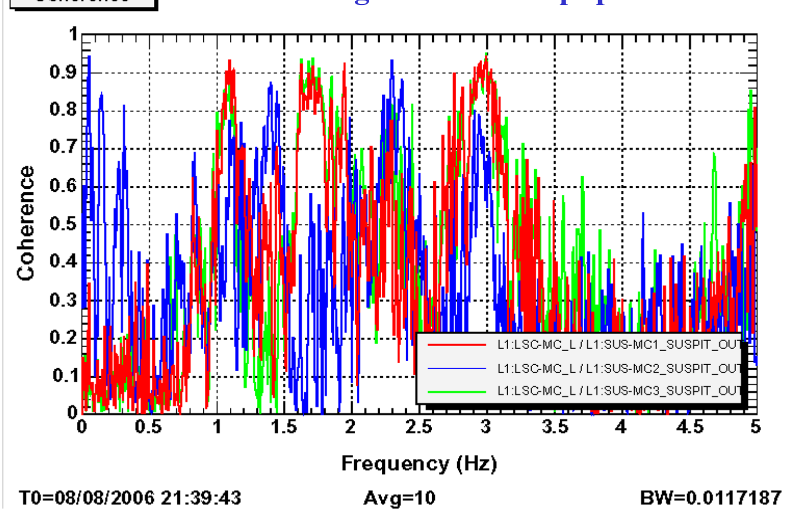


Stack U-U 1.5/2.3 Hz, V-V 1.6/2.8 Hz

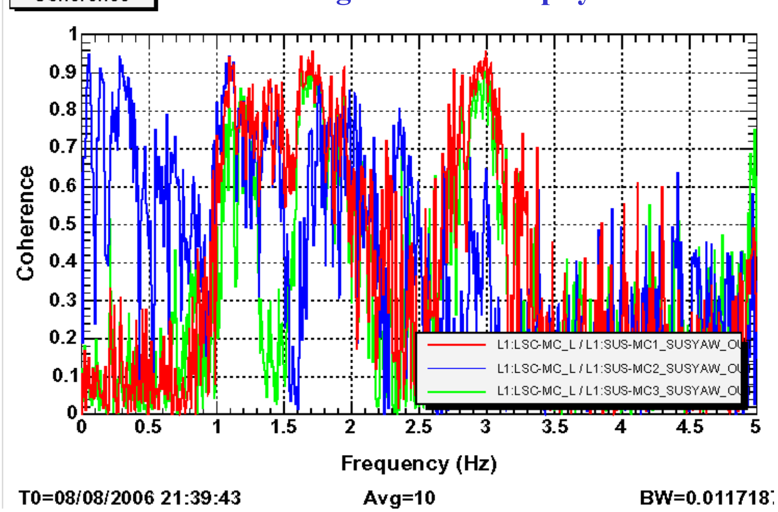
Stack U-U 1.5/2.3 Hz, V-V 1.6/2.8 Hz

MC Length Control and MC Pitch/Yaw
- strong correlation at stack resonance -

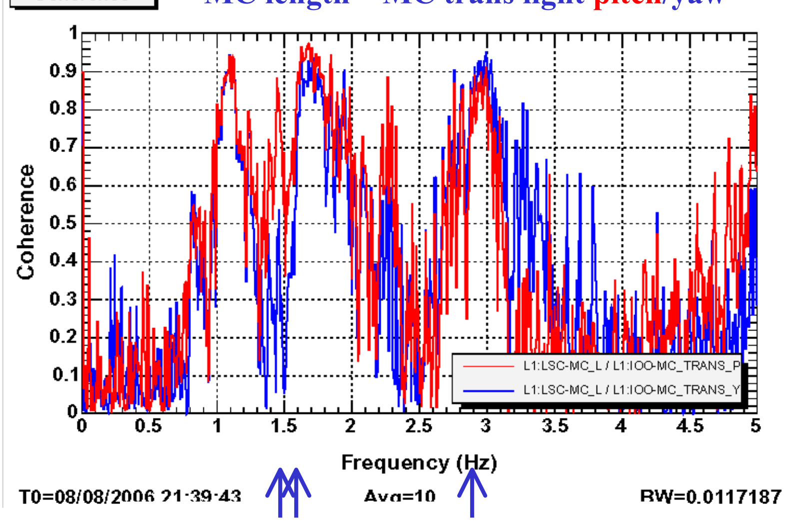
MC length – MC1-3 Opt pitch



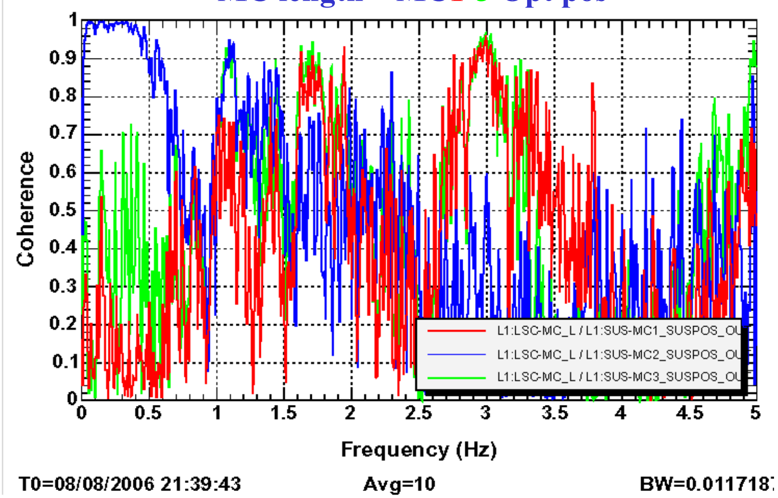
MC length – MC1-3 Opt yaw



MC length – MC trans light pitch/yaw



MC length – MC1-3 Opt pos



Stack U-U 1.5/2.3 Hz, V-V 1.6/2.8 Hz

LIGO I HAM and ground/table Yaw

$$\text{Ground yaw} = \frac{1}{2}\left(\frac{\partial u}{\partial y} - \frac{\partial v}{\partial x}\right)$$

$$= \frac{1}{2}\{ik_1\, u(y,t) - ik_2\, v(x,t)\}$$

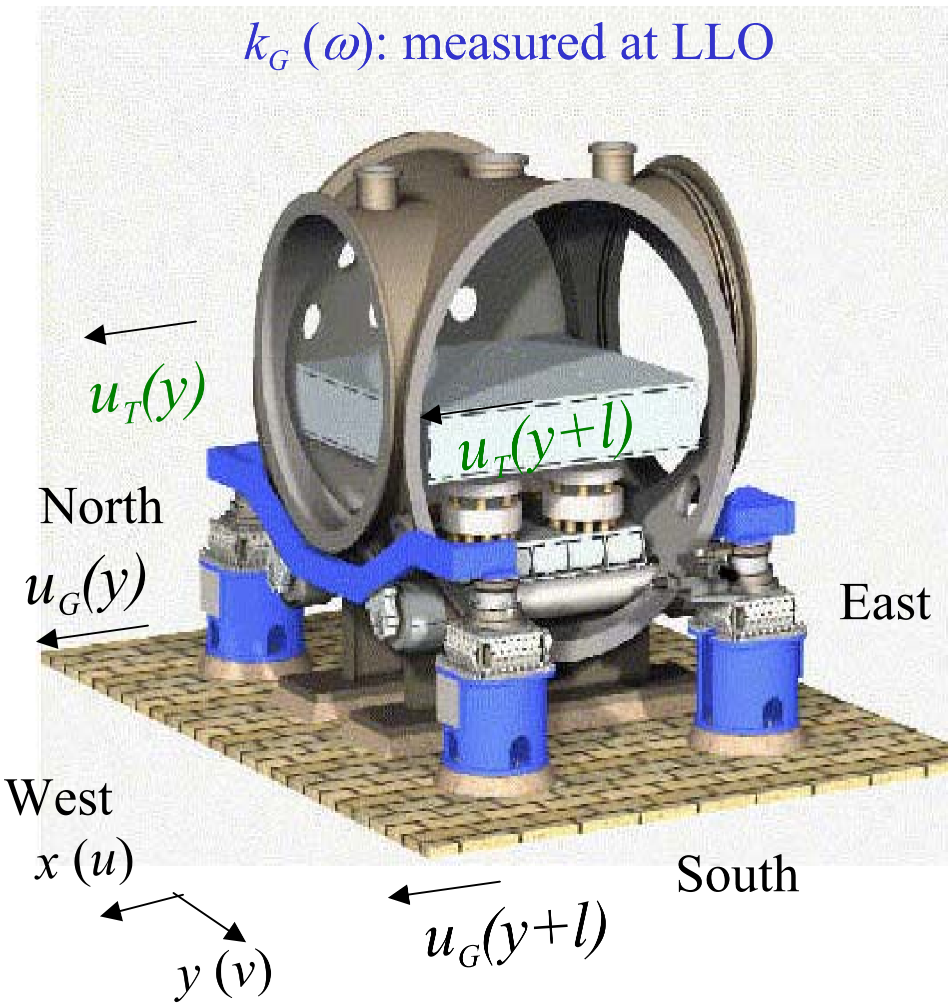
$$= ik_G\{\, u(y,t) - v(x,t)\}$$

u_G-u_T xfer → $i\phi_1 u(y,t)$

v_G-v_T xfer → $i\phi_2 v(y,t)$

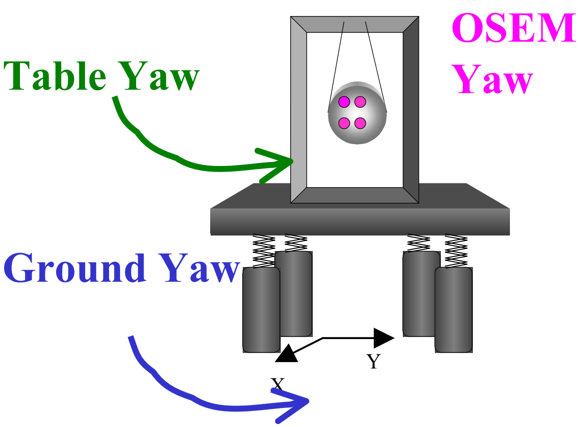
ϕ_1 , ϕ_1: additional phase delay due to different u-u (v-v) transfer rate between north and south (east and west)

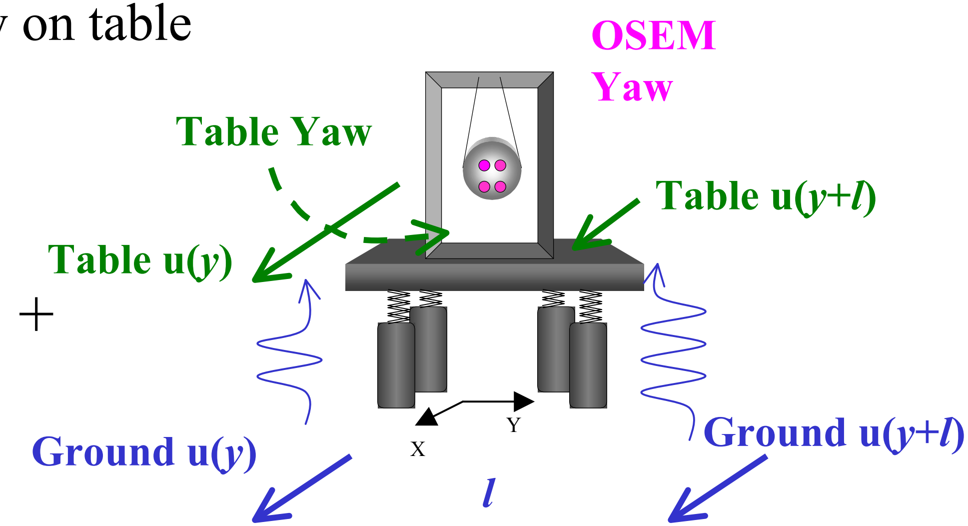
Table yaw = $ik_{T1}\, u_T\, (y,t)$ - $ik_{T2}\, v_T\, (x,t)$



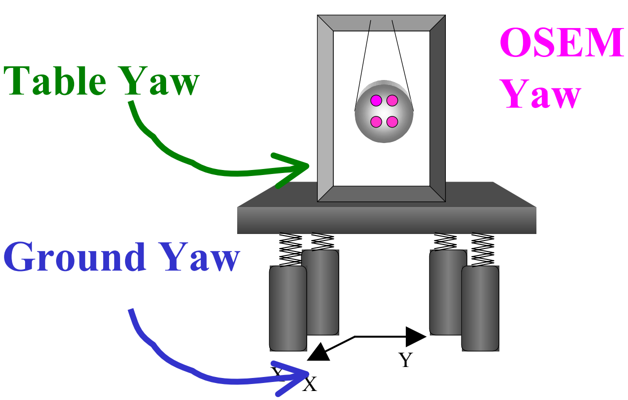
Two scenarios for table Yaw

Case 1: Yaw to Yaw + additional Yaw on table



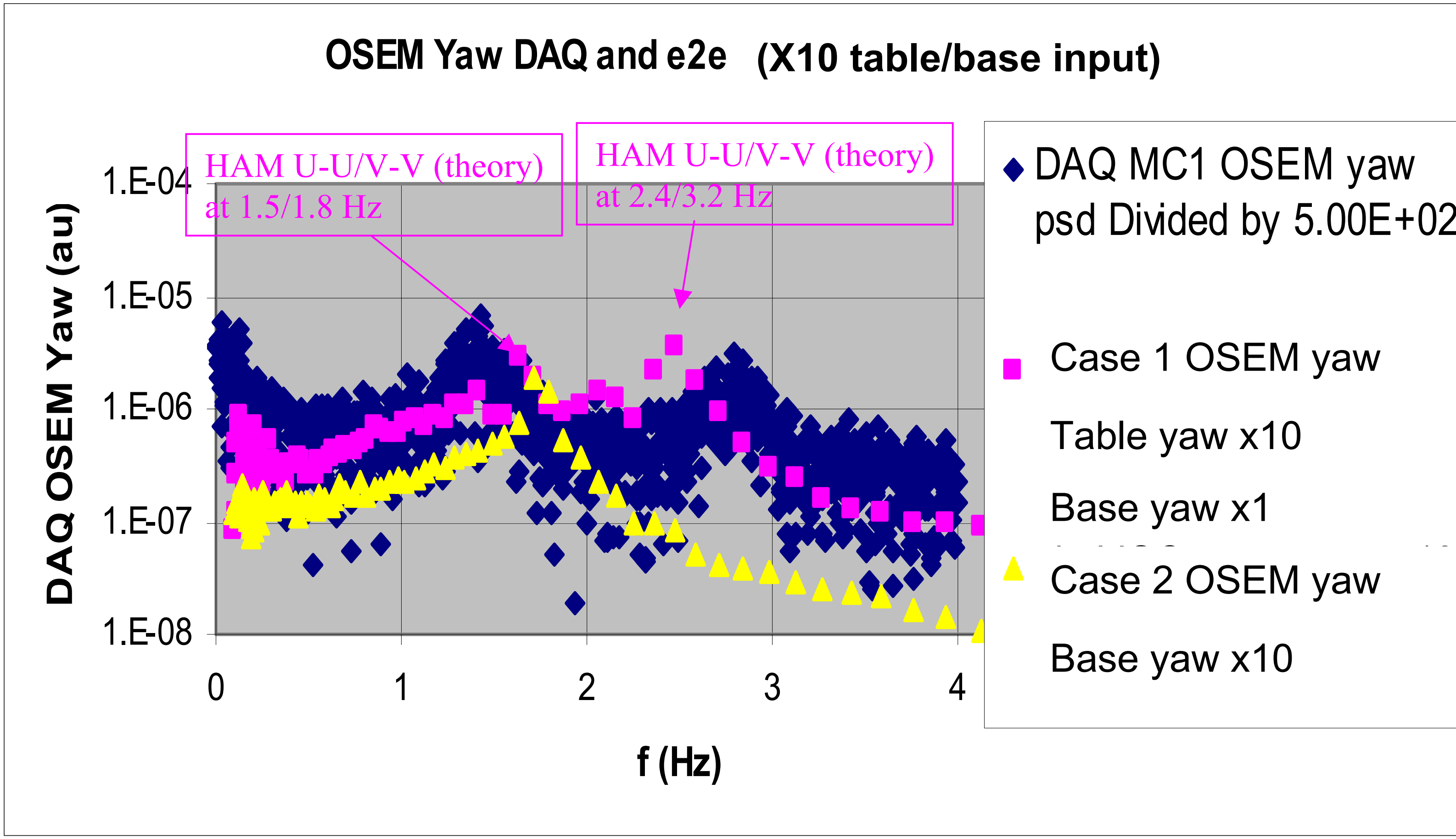


Case 2: Yaw to Yaw only

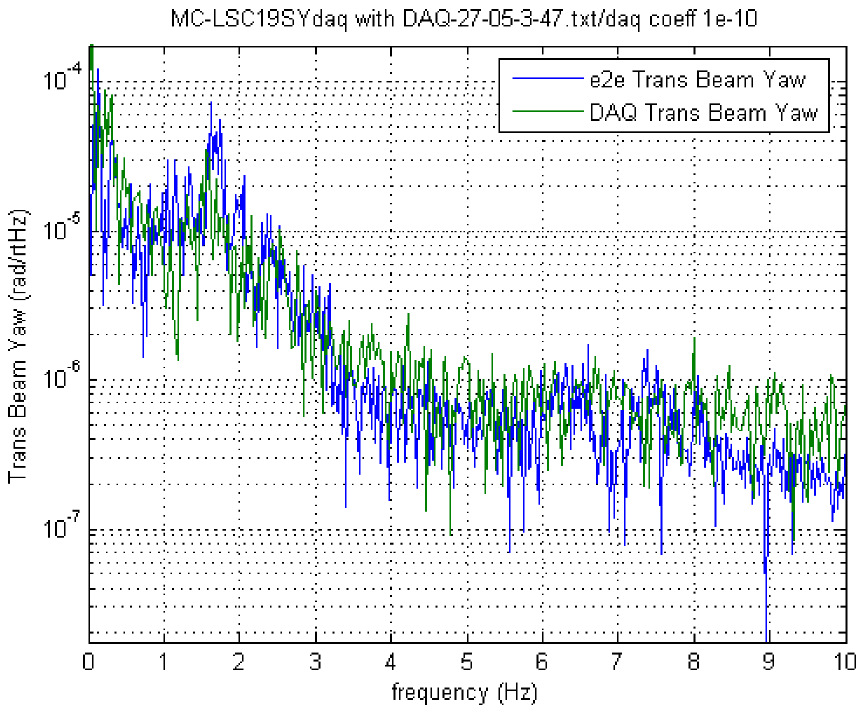


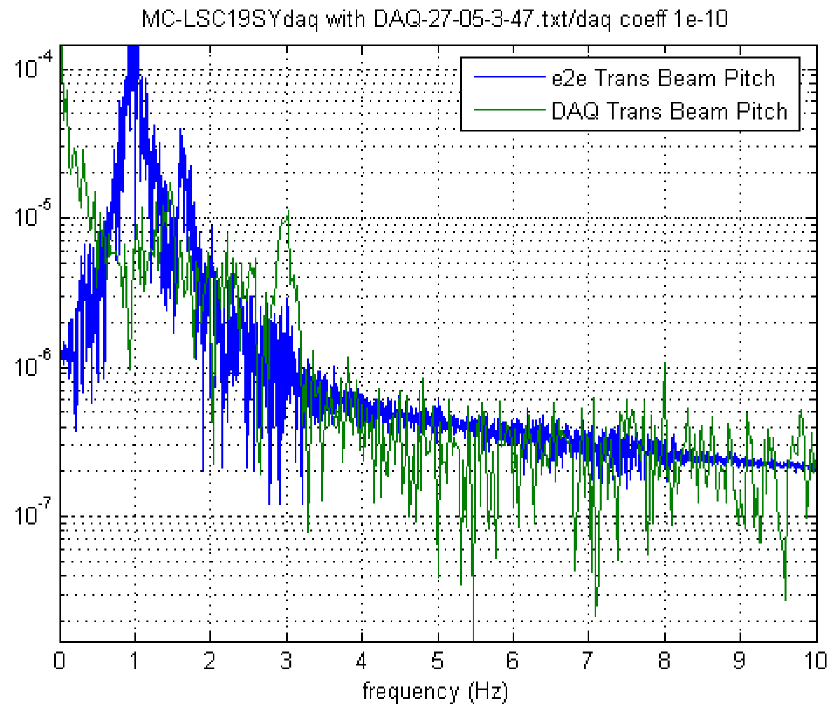
Compare resultant SOS OSEM yaw with DAQ OSEM yaw

OSEM Yaw DAQ and e2e (2)

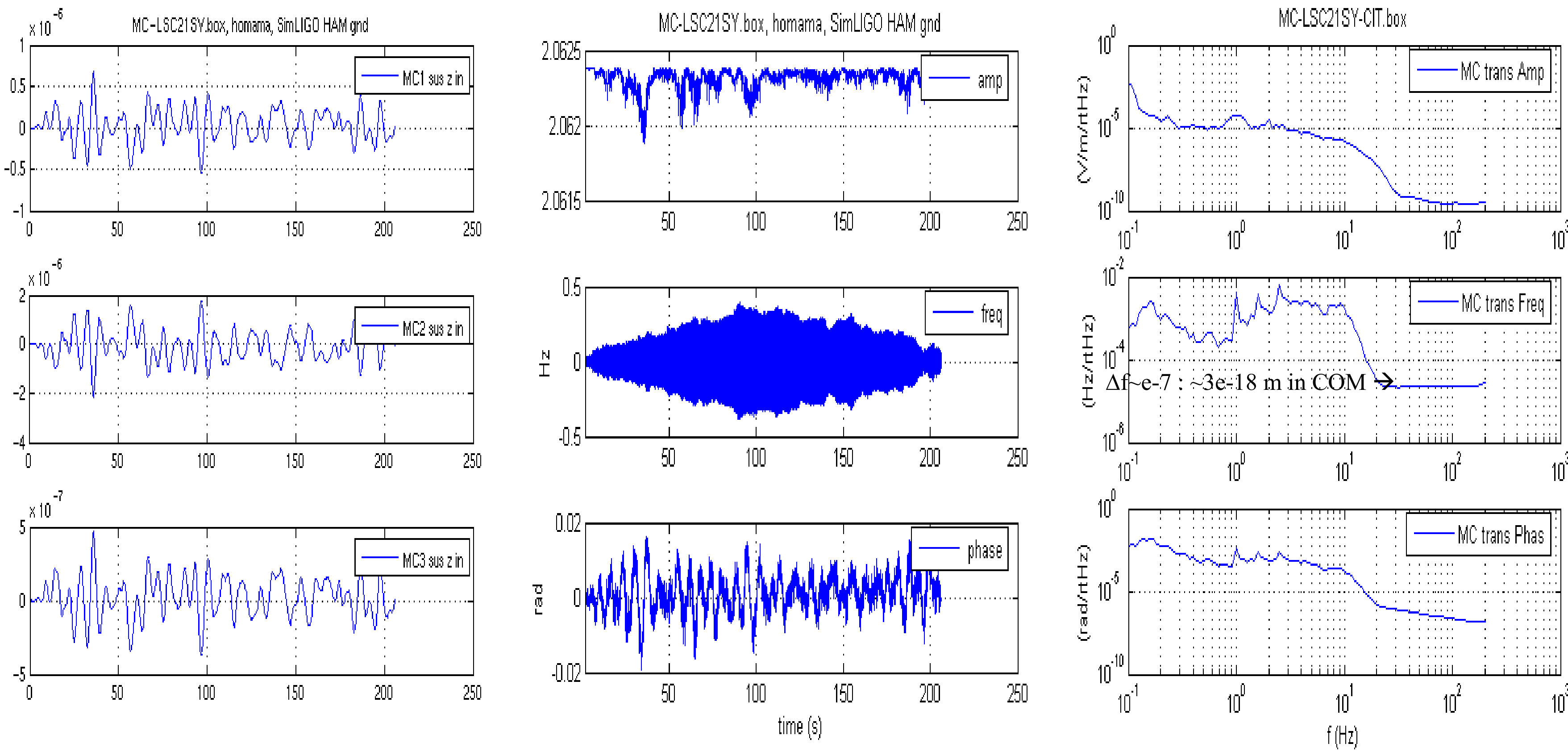


E2e and DAQ MC Yaw/Pitch





Fluctuation in MC transmitted beam (e2e)

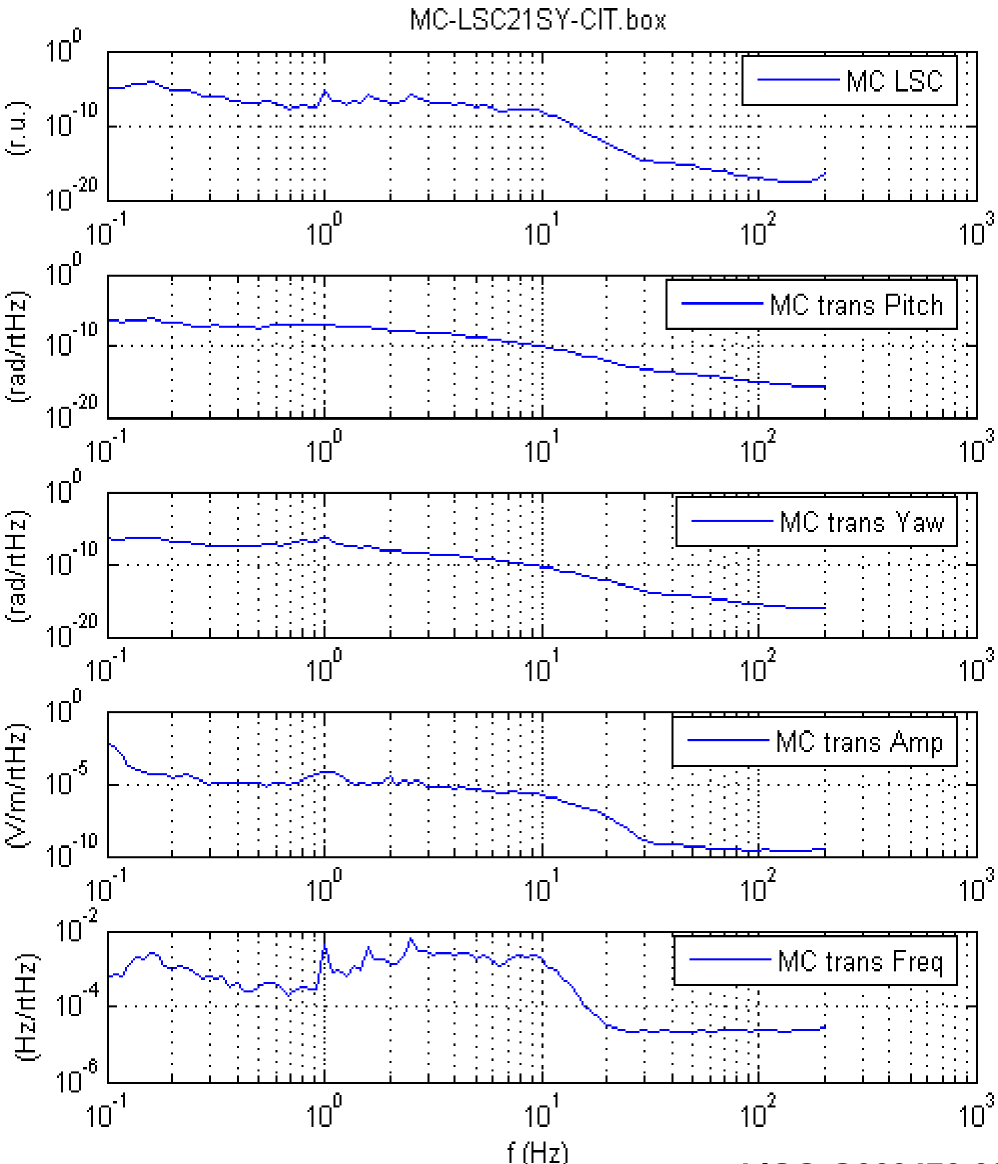


Sus point displacement input

MC trans light fluctuation (time)

MC trans light fluctuation (freq)

MC transmitted beam freq fluctuation and MC LSC



cf. LIGO I f noise requirement at Input to MC

40<f<=100 Hz → 0.1x(100/f)^2.5 Hz/rtHz
100<f<1kHz→ 0.1x(100/f) Hz/rtHz
1 kHz<f<10 kHz → 0.01 Hz/rtHz

100 Hz : 0.1 Hz/rtHz

cf. AdvLIGO f noise requirement at Input to MC

10<f<=20 Hz → 1Hz/rtHz
20<f<1kHz → 20/f Hz/rtHz
f>=1 kHz → 20e-3 Hz/rtHz

100 Hz: 0.2 Hz/rtHz

Status for AdvLIGO

	Available	Under development
HAM	- simple parameterized model	-Soft HAM model by HAM SAS group - State Space matrix being made -Active HAM model by Stanford group - State Space matrix will be made
Triple sus (MC) Mass= 2.9 Kg	-E2e model w/ and w/o violin modes (M. Barton)	- Local damping being considered

Plan

- Continue LIGO I MC e2e analysis
- Continue AdvLIGO HAM e2e model
- Local damp/LSC for AdvLIGO MC model