G020409-E

Characterization of MMT3's motion

- measurement of HAM1 motion and e2e -

S. Yoshida[1], R. Dodda[1] and H. Yamamoto[2]

1. Southern Louisiana Univ. 2. Caltech / LIGO Lab

LSC meeting at LHO on Aug.21, 2002

The beginning…

Yamamoto

Interested in comparing the mechanical simulation (stack motion, mirror motion, coherence…) of e2e and the real data.

Yoshida

Interested in studying the effect of the input optics (Mode cleaner, MMT, …) motions to the signal.

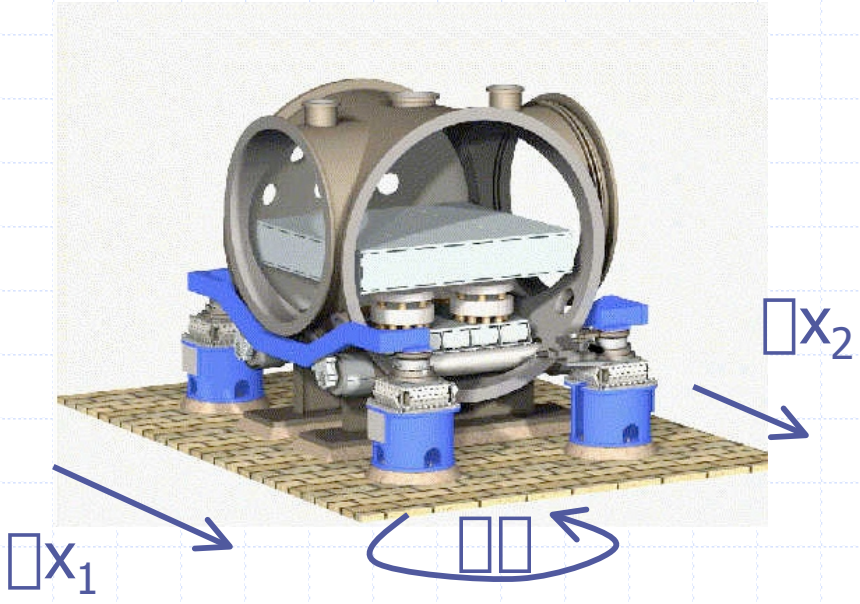
motions in e2e

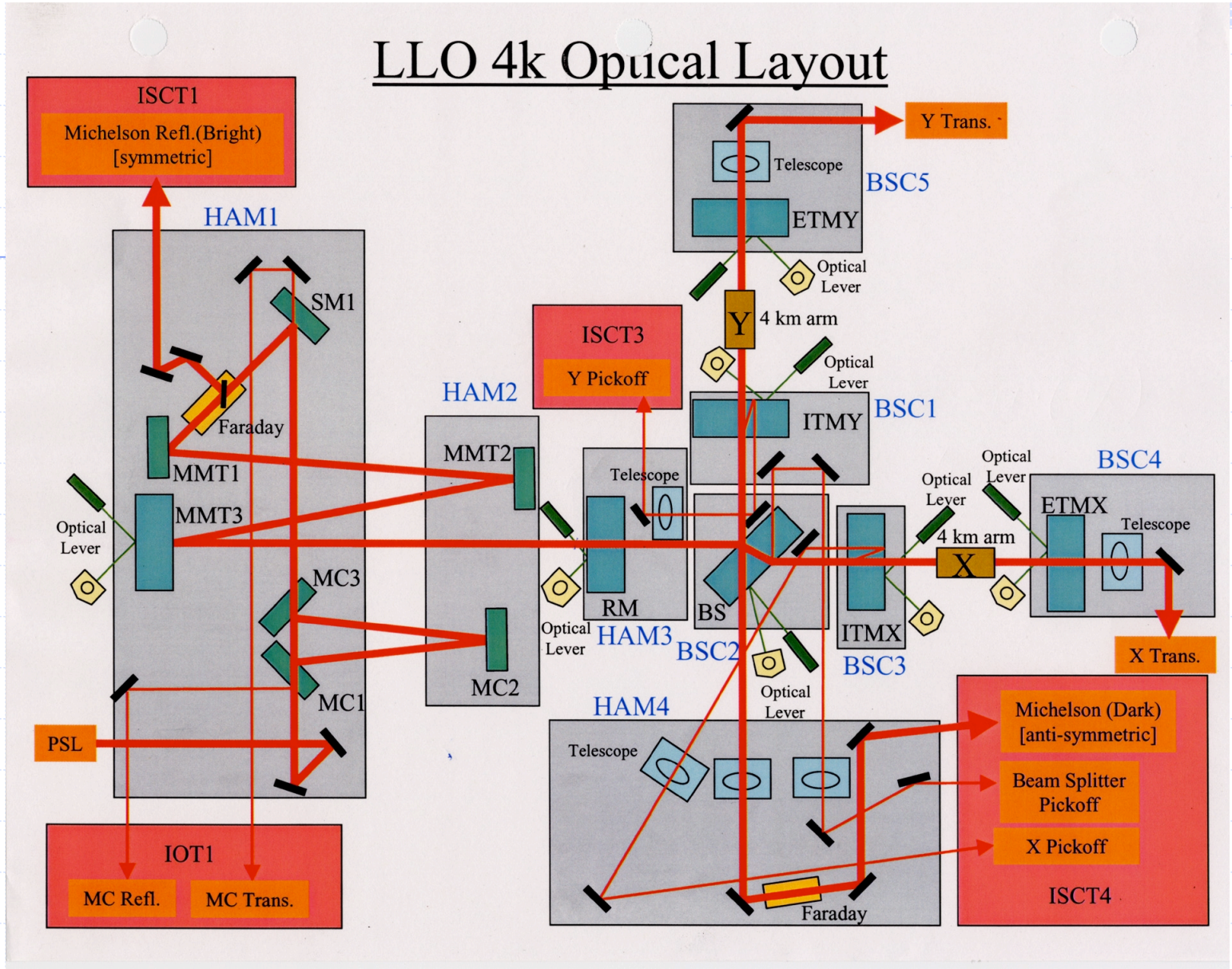
e2e simulation :

(1) fields and optics + (2) mechanical motions +
(3) electronics +
(4) input data (seismic motion, frequency noise, etc)

table top motion (displacement 3, rotation 3) =
ground motion (6) x stack transfer function (6x6)

□□ = (□x_1 - □x_2) / L ?

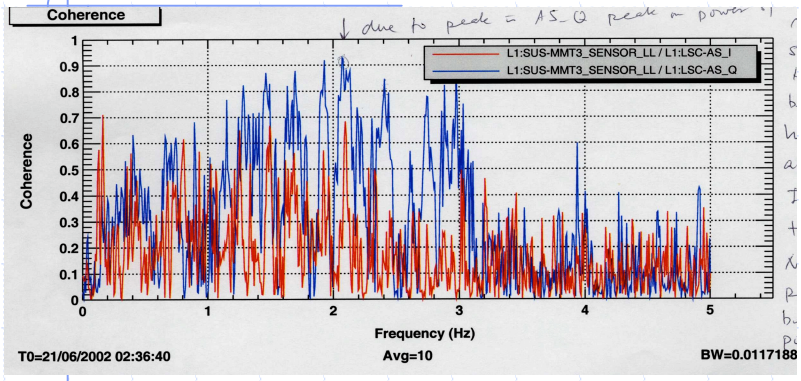




Pendular	0.762Hz	Side	0.732	HAM U-U	HAM V-V	HAM y-v
Pitch	0.627	Vertical	12.32	1.5	1.6	7.2
Yaw	0.506			2.3	2.8	8.0

Observation

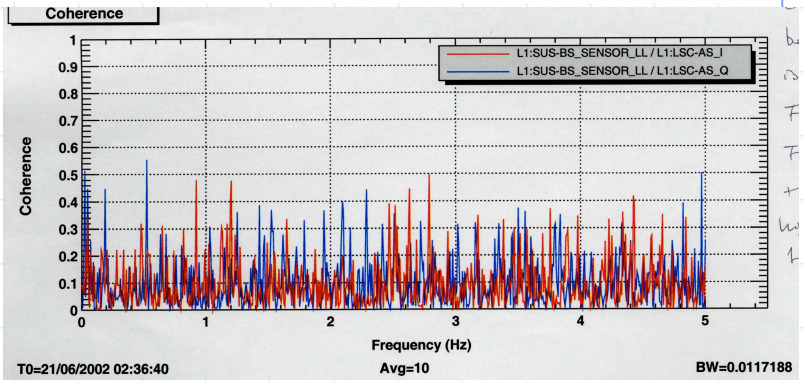
- Coherence between MMT3 and AS_Q observed



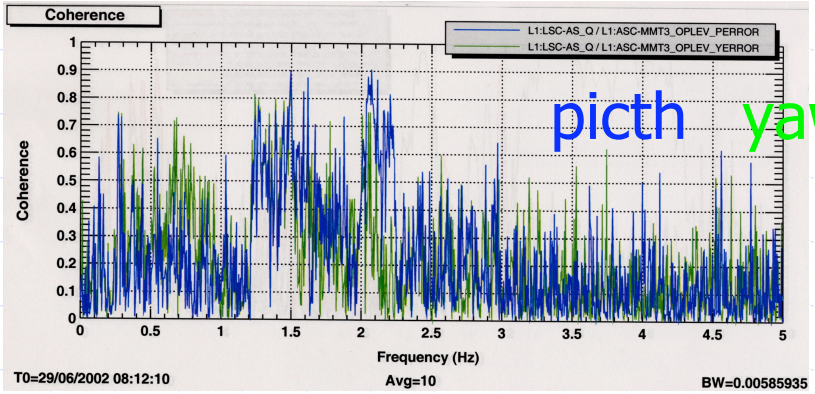
AS_Q

AS_I

MMT3_LL vs AS

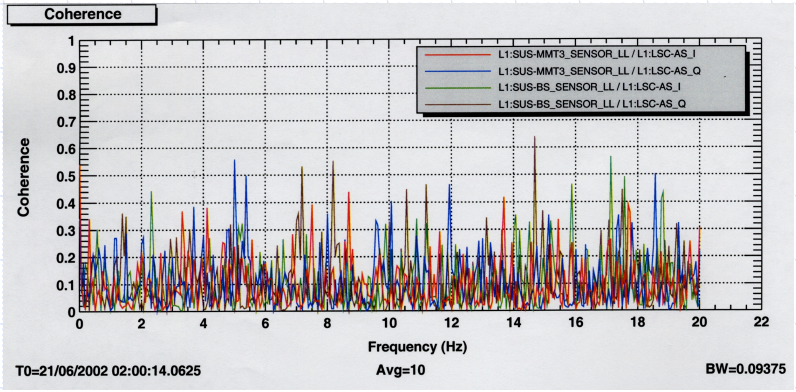


BS_LL vs AS



picth yaw

MMT3_OptLev vs AS_Q



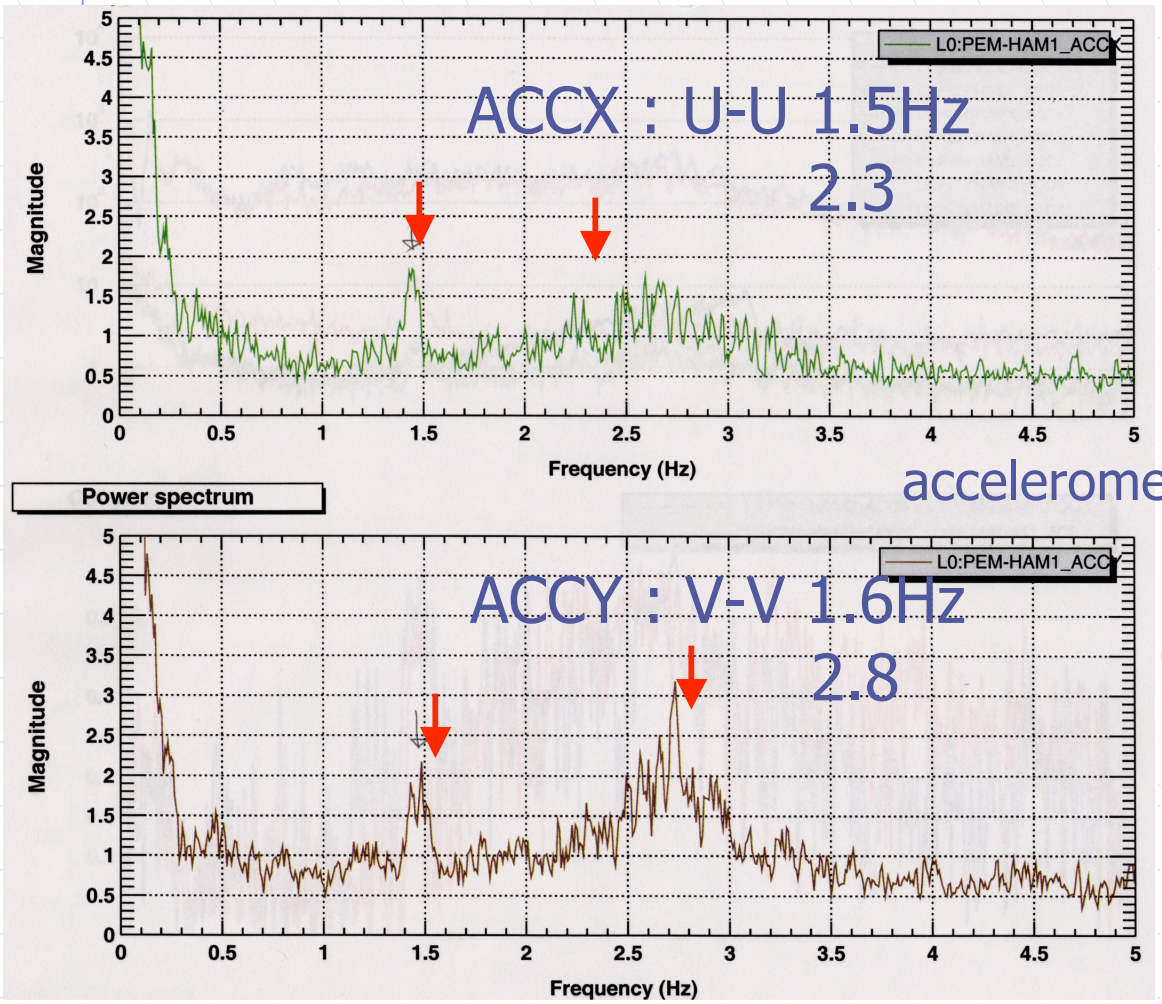
BS/MMT3_LL vs AS

Arms not locked due to train

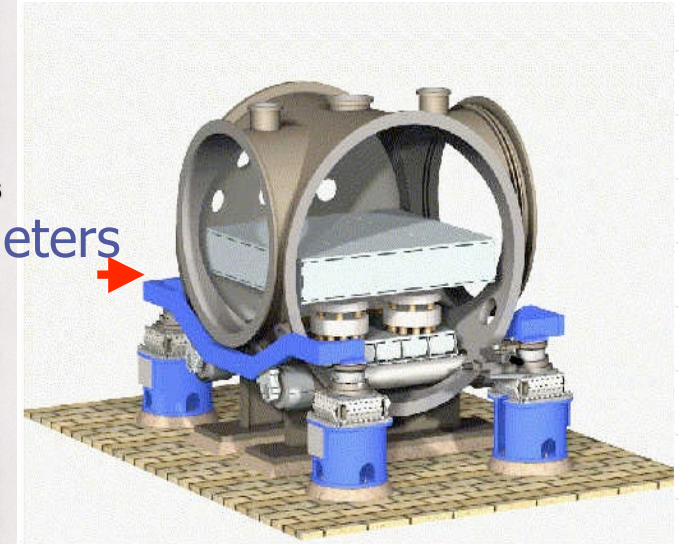
Analysis

- Estimate the HAM1 motion, translational (U,V) and rotational (yaw), from data of multiple mirrors
  - -Seismic motion, Table top motion, mirror motion
  - -e2e model used to validate the method
- Make e2e simulation setup of HAM with SOS and LOS
  - -Seismic motion input -> HAM table motion output
    - ›rotation consistent with data ?
  - -HAM table motion -> mirror motion
- Beam jitter data and effect on signal

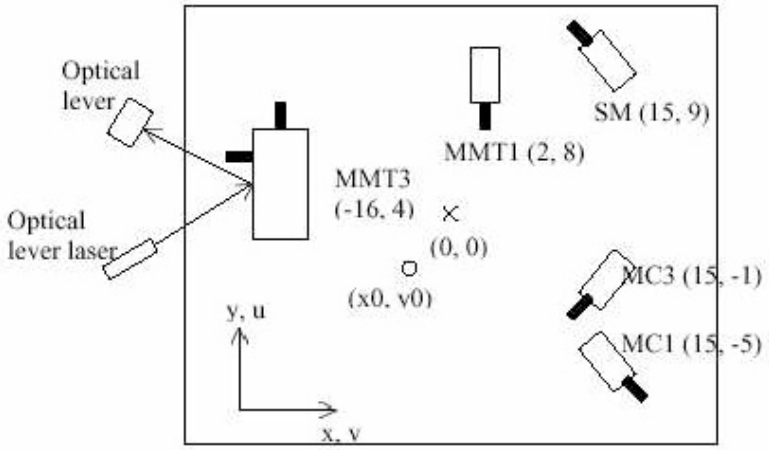
- Peaks in the same region are seen in HAM1 table accelerometer readings as well, suggesting HAM table's translation motion in U,V directions.
- This motion will also produce an yaw to HAM table. Could this yaw be causing an motion of the mirror, particularly, the yaw motion ?



accelerometers



HAM table motion

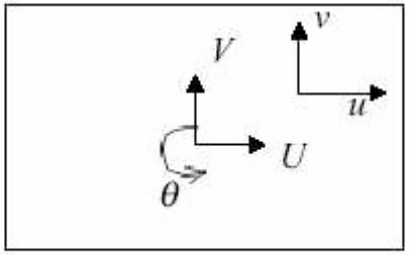


$$u = U - x\theta$$
$$v = V + y\theta$$

U : Table's center of mass motion

V : Table's center of mass motion

θ : Table's yaw motion



(1) HAM table yaw

$MC1+SM = \{(y_1 - y_3)\theta + (x_1 - x_3)\theta\}/\sqrt{2}$, where, $x_1 = x_3$. So, $\theta = \sqrt{2}\dfrac{(MC1+SM)}{(y_1 - y_3)}$

(2) HAM table U

(2.1) $SM + MC3 = \{2U - (y_3 + y_2)\theta + (x_2 - x_3)\theta\}/\sqrt{2}$. So, $U = \dfrac{SM + MC3}{\sqrt{2}} + \dfrac{(y_3 + y_2)}{2}\theta$

(2.2) $MC3 - MC1 = \{2U - (y_2 + y_1)\theta + (x_2 - x_1)\theta\}/\sqrt{2}$. So, $U = \dfrac{MC3 - MC1}{\sqrt{2}} + \dfrac{(y_2 + y_1)}{2}\theta$

where $x_1 = x_2 = x_3$ is used.

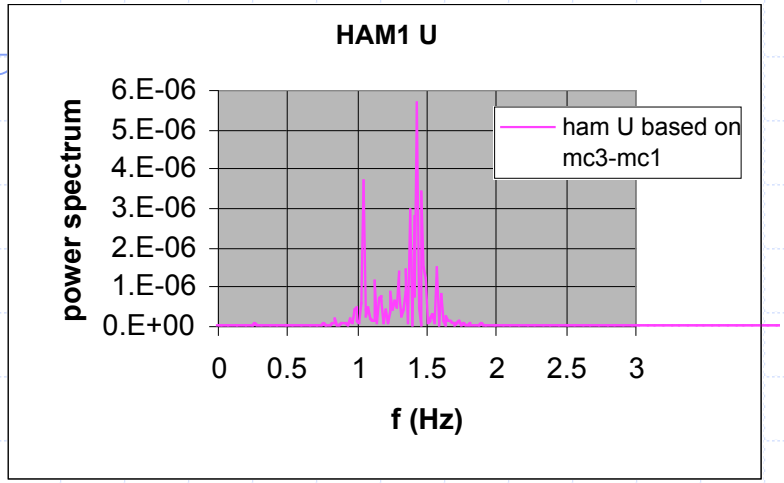
(3) HAM table V

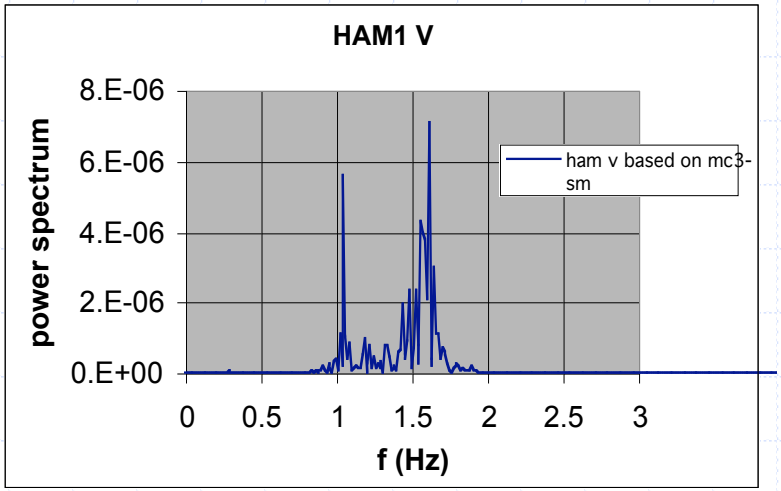
(3.1) $MC3 - SM = \{2V + (y_3 - y_2)\theta + (x_3 + x_2)\theta\}/\sqrt{2}$. So, $V = \dfrac{MC3 - SM}{\sqrt{2}} + \dfrac{(y_2 - y_3) - (x_2 + x_3)}{2}\theta$

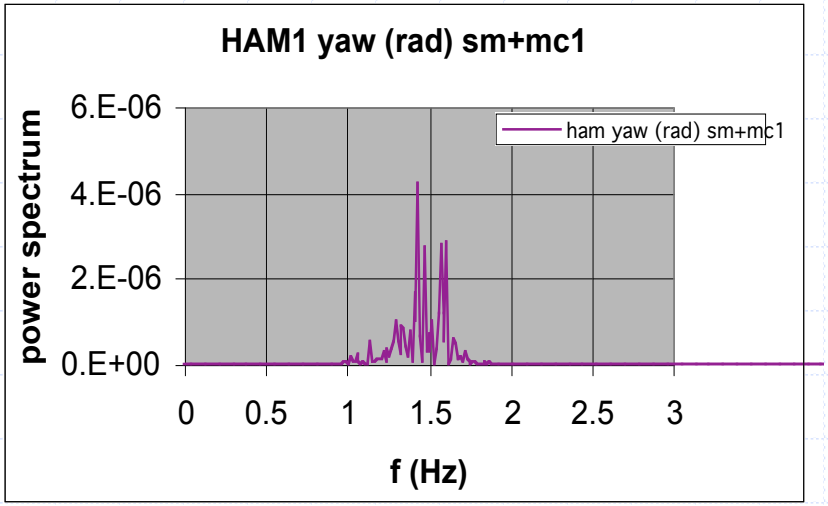
(3.2) $MC1 + MC3 = \{2V + (y_1 - y_2)\theta + (x_1 + x_2)\theta\}/\sqrt{2}$. So $V = \dfrac{MC1 + MC3}{\sqrt{2}} + \dfrac{(y_2 - y_1) - (x_2 + x_1)}{2}\theta$

(3.3) $MMT1 = V + x_4\theta$. So, $V = MMT1 - x_4\theta$

HAM1 table motion estimated by SOS
7/24/02 19:38:18 UTC (= 14:38:18 CT)







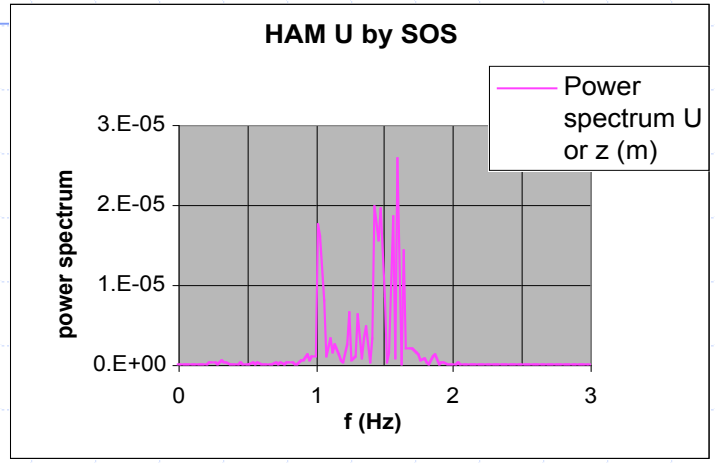
U- U transfer resonance: 1.45 Hz

V-V transfer resonance: 1.6 Hz

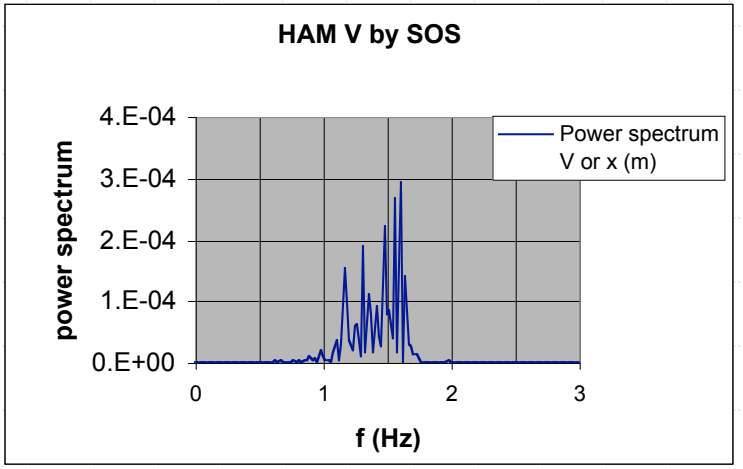
HAM yaw caused by U and V

HAM1 table motion estimated from SOS 7/31/02 15:04:48 UTC (= 10:04:48 CT)

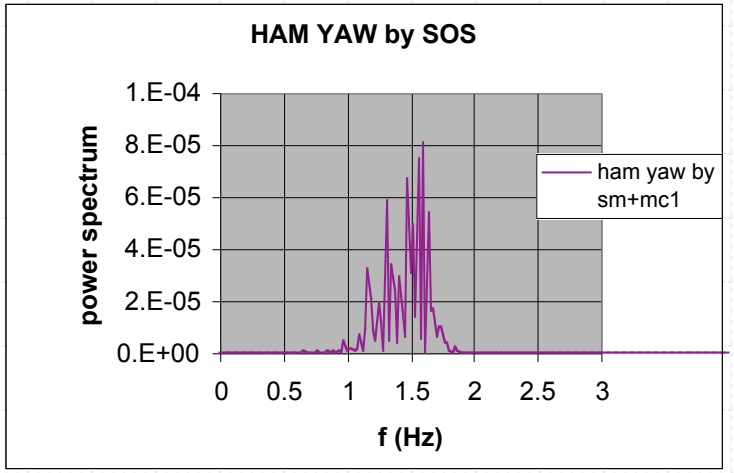
U: Center of mass translational motion



V: Center of mass translational motion



HAM yaw: Rotational motion about vertical axis



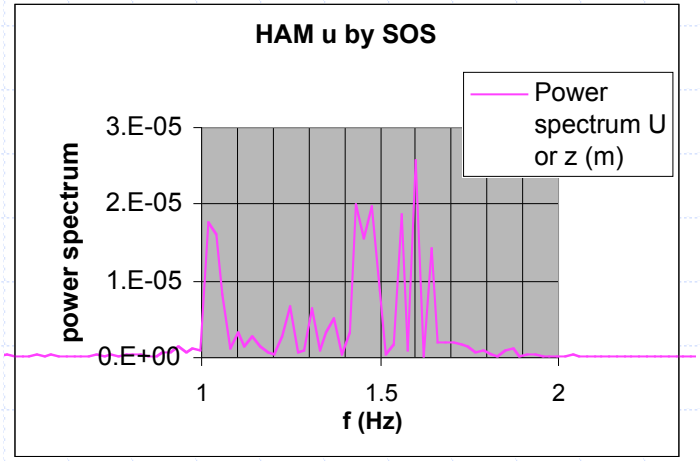
U- U transfer resonance: 1.45 Hz

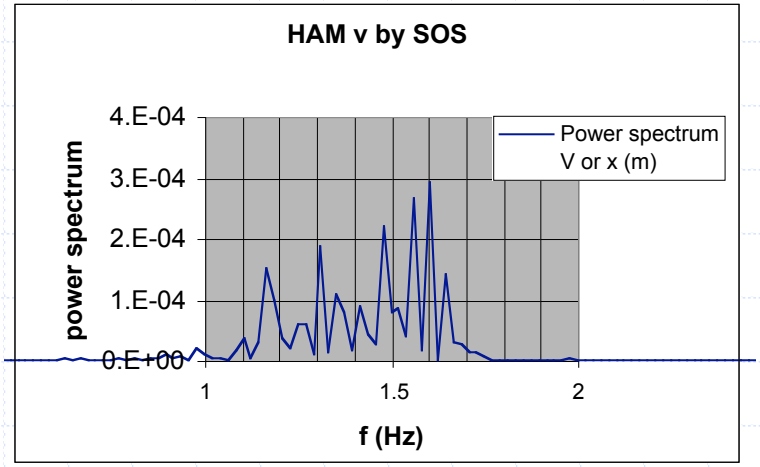
V-V transfer resonance: 1.6 Hz

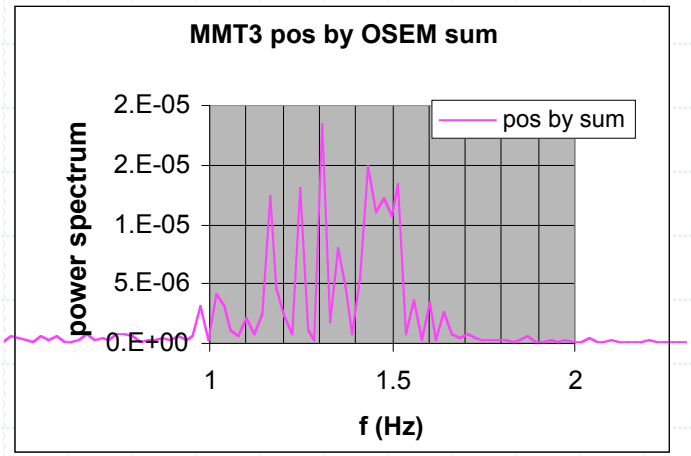
HAM yaw caused by U and V

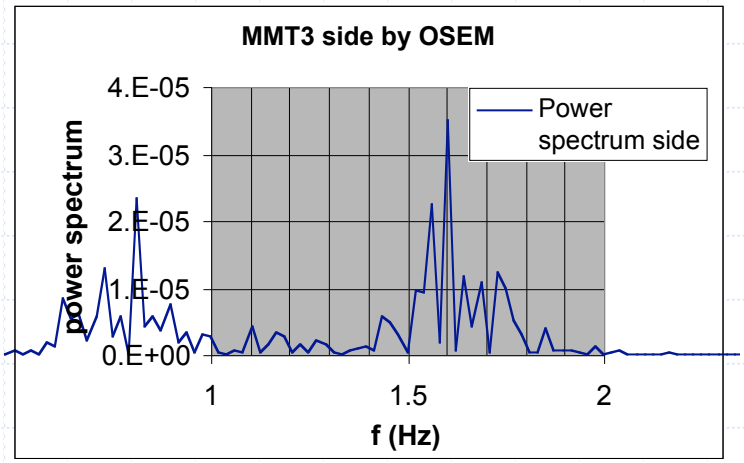
Power spectra of measured HAM and MMT3 OSEM

HAM translational motion (u and v) at MMT3 based on above HAM motions estimated by SOS (upper graphs) and MMT3 pos and side measured by MMT3 OSEMs (lower graphs)



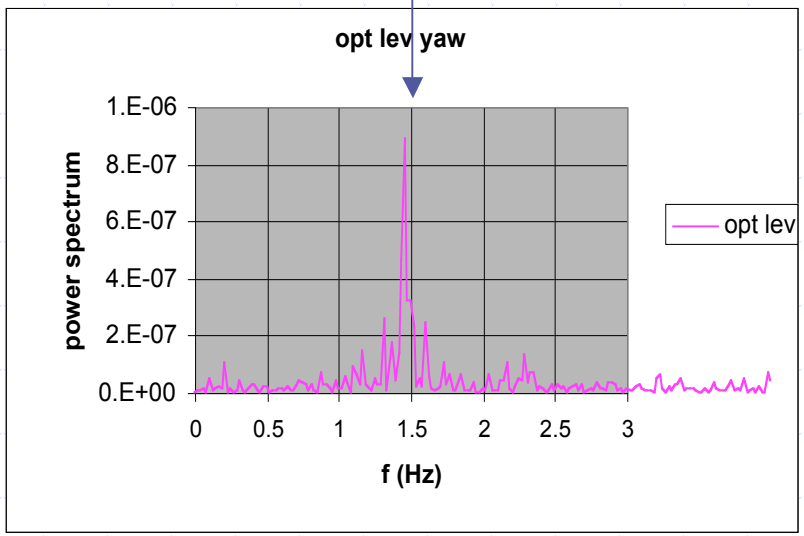




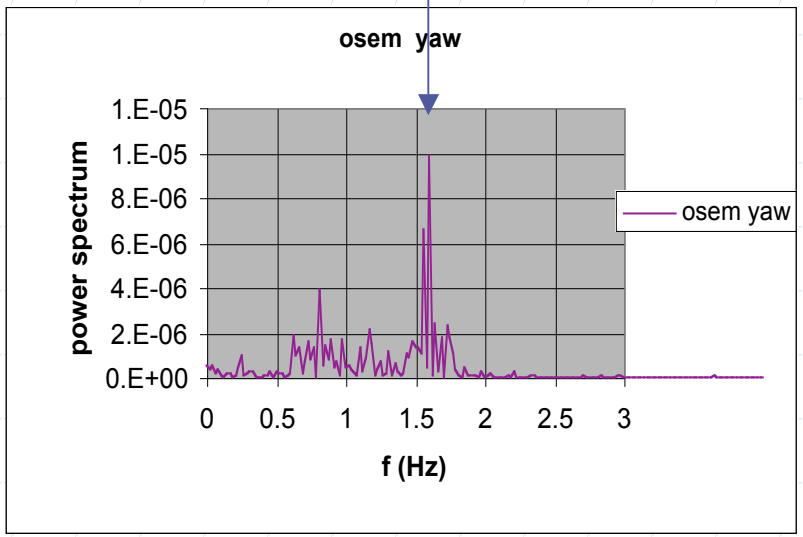


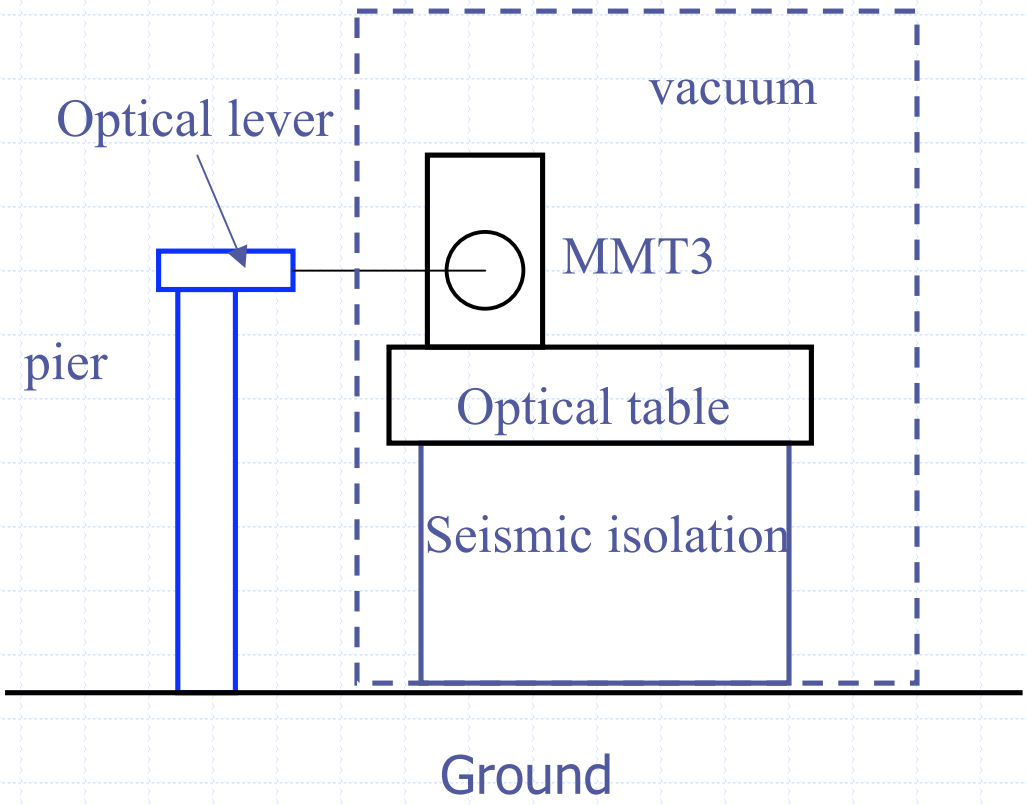
Power spectra of MMT3 Optical lever yaw (left) and MMT3 OSEM yaw (right)

Pier U motion



HAM yaw motion




vacuum
Optical lever
MMT3
pier
Optical table
Seismic isolation
Ground

Yaw Transfer function from suspension point to MMT3

OSEM YAW = Optics Yaw - tower yaw=Optics Yaw - HAM YAW

$= \theta_{Grd} * \theta_{Grd->Ham} * \theta_{Ham->sus\ pnt} * \theta_{sus\ pnt->optic} - \theta_{G} * \theta_{Grd->Ham}$

$= \theta_{Grd} * \theta_{Grd->Ham} * (\theta_{sus\ pnt->optic} - 1)$ $(\theta_{Ham->sus\ pnt} \approx 1)$

So,

OSEM YAW / HAM YAW

$= \theta_{Grd} * \theta_{Grd->Ham} * (\theta_{sus\ pnt->optic} - 1) / \theta_{Grd} * \theta_{Grd->Ham}$

$= \theta_{sus\ pnt->optic} - 1$

Future Work

(1) Compare measurement and computation in HAM to optic transfer function

- Complete MMT3 e2e box that takes HAM motion as input to suspension point.
- Obtain transfer function from suspension point to optics motion and compare with transfer function obtained by measured HAM motion and OSEM signal.

(2) Compare measurement and computation in ground to HAM transfer function

- Make and test MMT3 e2e box that takes LLO ground noise input.
- Make ground noise measurements.
- Obtain transfer function from ground to HAM and compare with transfer function computed by e2e