Study of AdvLIGO Input Mode Cleaner - effect of HAM correlations on MC length -

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#### MC and arm length fluctuations

MC length noise = MC mirror noise  $\times \sqrt{3} \times (1 \text{-coherence}) / (1+G) \propto \text{arm length noise}$ SEI & MC mirror noises 10<sup>-6</sup> 10<sup>-6</sup> coherence meters//Hz or rad//Hz 0, 0, 0, 0, Х 1-coherence 0 10 SEI displacement longitudinal f(Hz) pitch yaw 10 10<sup>0</sup> 10<sup>1</sup> 10 Frequency (Hz) Stabilized MC length noise 10<sup>-9</sup> Bode Diagram 10<sup>-10</sup> ຮຼິ 10<sup>-11</sup> ໄດ 10<sup>-12</sup> 140 meters/√Hz or m/sec/√Hz --> 10<sup>-13</sup> 10 10<sup>-15</sup> MC length 10<sup>-16</sup> ---- MC length rms Equiv. arm velocity 0.1 10 1 - Eq. arm vel. rms f(Hz)  $10^{-1}$ 10<sup>°</sup> 10<sup>1</sup> Frequency (Hz)

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#### HAM1 – HAM2 correlation and MC frequency noise



Gnd motion at HAM1

Gnd motion at HAM2

## e2e model MCs on HAMs



- J Table's center of mass motion
- V Table's center of mass motion
- $\theta$  Table's yaw motion





MC length change

#### e2e model of Triple suspension on HAM Opt motion output Sus pt input TP model Local damping control State Space Opt actuation force input (M. Barton) e2e Single Stage HAM Table top model (with control) output State Space model HEPI (FIR) (Stanford Group) Ground motion (Stanford Group)

## HAM1 X with/without HEPI



e2e result

SWG result (LSC March 2007 meeting) G-070110-00.pdf

# e2e model of Adv MC



MC Length fluctuation  $\rightarrow$  Frequency noise of MC trans light

## HAM1 – HAM2 correlation measurement



Х

 $S_1 = MC1 DAQ pos + MC3 DAQ pos \propto HAM 1 table X$  $S_2 = MC2 DAQ pos \propto - HAM 2 table X$ 

#### $S_1$ - $S_2$ coherence $\propto$ HAM1 - HAM2 coherence

## MC OSEM sensor coherence (recorded June 2004 at LLO with MCs free hanging)



Upper: (mc1 pos + mc3 pos) vs mc2 pos coherence

Lower: mc 1 pos spectrum



LLO floor coherence measured with two seismometers (sensitive to x component), d (m) apart along X-axis

$$\begin{array}{c} d = 0 \ (m) \\ d = 2.7 \ (m) \\ d = 5.4 \ (m) \end{array}$$

#### MC OSEM sensor phase (recorded June 2004 at LLO with MCs free hanging)



Upper: (mc1 pos + mc3 pos) vs mc2 pos coherence

Lower: mc 1 pos spectrum

DAQ (mc1+mc3) pos and -mc2 pos phase (upper) and phase difference (lower). Note: DAQ positive defined reference to suspension, mc2 suspension facing negative ground X, MC1 & MC3 facing ground<sup>1</sup>+X.

## Effect of coherence on MC length fluctuation



#### Frequency noise due to length fluctuation



Fig.5 Sample e2e computation of AdvMC frequency noise due to length fluctuation

## Summary

- MC locations on HAM table, HEPI model included in e2e Adv MC model
- Substantial effect of HAM1 HAM2 correlation on MC length fluctuation

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