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Date:	11/7/08	Refer to:	T080325-v1
Subject:	Earthquake Stop Scatter		
To:	LIGO Systems Group		
From:	Name: Michael R. Smith	Tel: 626-395-2062	

Purpose:

The purpose of this note is to estimate the scattered light noise in the Advanced LIGO IFO due to scattering from the ITM and ETM earthquake stops.

Analysis:

The earthquake stops for the ITM and ETM suspensions are mounted to the quadruple suspension structure and intrude inside the arm cavity baffle hole above the HR surface of the COC, as shown in Figure 1.

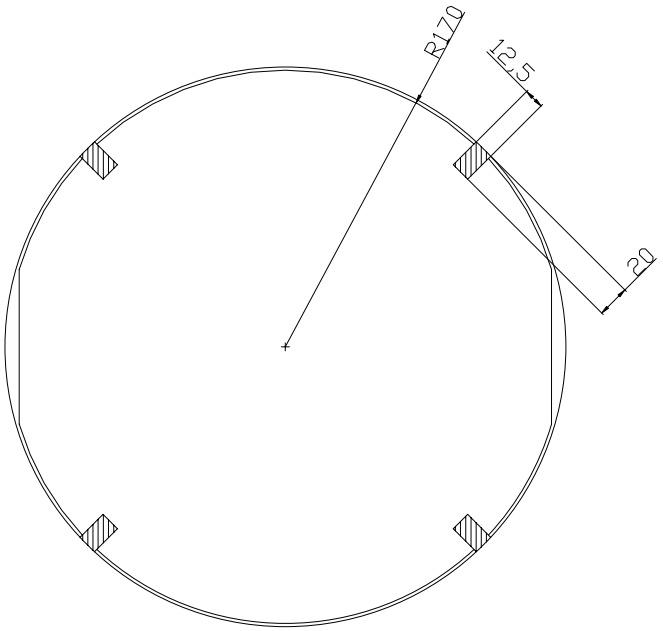

Figure 1: Geometry of the earthquake stops

The arm cavity beam and the scattered light from the far end COC will hit the surface of the earthquake stops and scatter light back into the interferometer mode.

The area of each earthquake stop is approximately 250 mm^2. The total light power incident on each earthquake stop is estimated to be approximately 40 mW.

$$P_{EQm} + P_{EQ} = 0.039$$

The power scattered into the interferometer mode from sixteen earthquake stops is given by the following expression

$$P_{EQs} := \sqrt{16} \cdot \left(P_{EQm} + P_{EQ}\right) \cdot BRDF_{EQ} \cdot \frac{\pi \cdot w_{ifo}^{2}}{L^{2}} \cdot BRDF_{1}\left(\theta_{coc}\right) \cdot \Delta_{ifc}$$

See T080210-00, SLC Conceptual Design for an explanation of these terms.

If the earthquake stop has a shiny surface and is normal to the incident beam, the BRDF (sr^-1) of the surface could be quite large. For the purpose of this calculation we will assume that

$$BRDF_{EQ} := 100$$

With that BRDF, the power in Watts scattered into the IFO mode is

$$P_{EQs} = 1.5021 \times 10^{-15}$$

The quad SUS is mounted to the BSC optical table, which has a seismic motion (m/rtHz) at 100 Hz of

$$x_{bsc} = 3.1 \times 10^{-14}$$

The displacement noise at the DARM signal is given by the following expression

$$DN_{EQ} := TF_{itmhr} \left(\frac{P_{EQs}}{P_{psl}}\right)^{0.5} \cdot x_{bsc} \cdot 2 \cdot k$$

And, the transfer function at 100 Hz for scattering directly into the arm cavity was calculated by Hiro to be

$$TF_{itmhr} = 1.1 \times 10^{-9}$$

Then, the displacement noise (m/rtHz) at 100 Hz is estimated to be

$$DN_{EQ} = 1.3961 \times 10^{-24}$$

This is about three orders of magnitude lower than the AOS requirement for total scattered light noise.

Conclusion:

The scattered light noise from the exposed earthquake stops will <u>not</u> cause excessive scattered light displacement noise. However, as a safeguard to avoid a possible glint into the IFO, the earthquake stop surface should have a mat finish, which will reduce the BRDF < 1.