SCATTERED LIGHT CONTROL
in
ADVANCED LIGO

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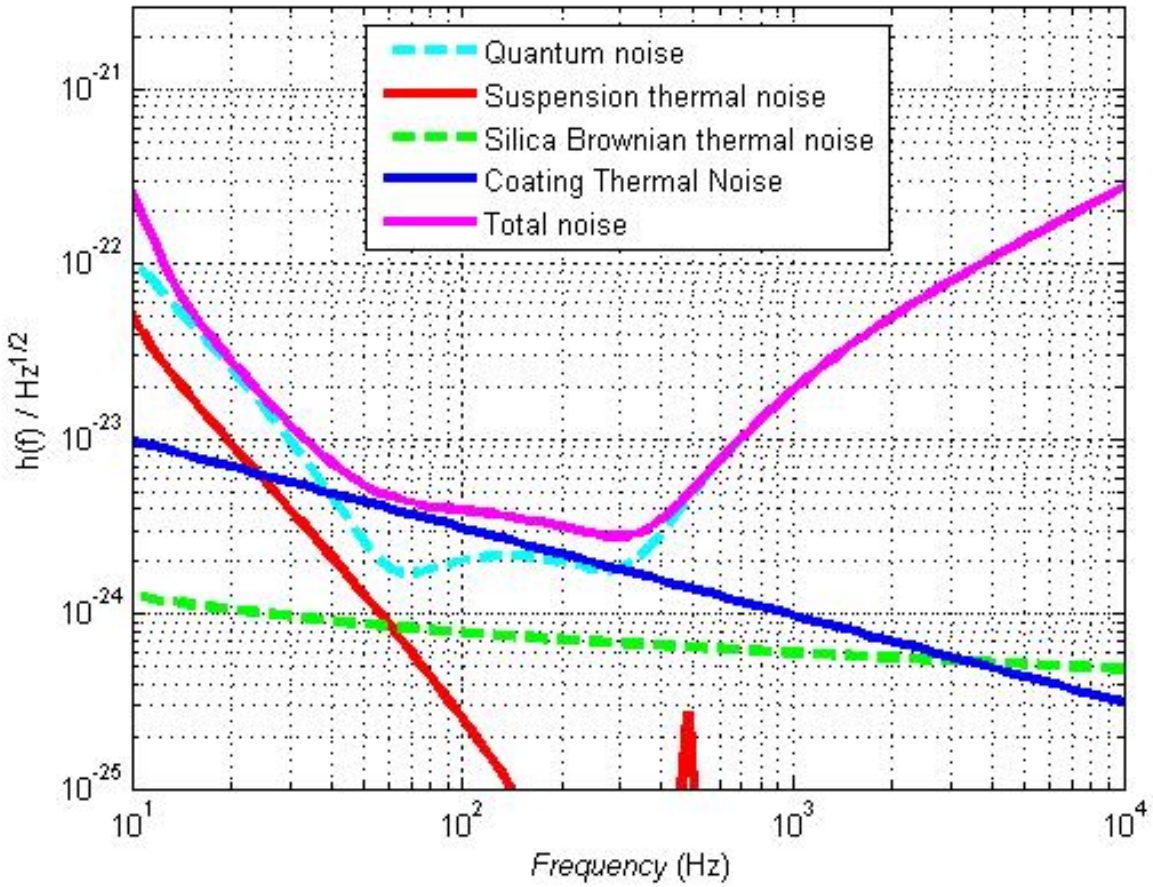
Scattered Light Displacement Noise Theory

- Min Gravity Wave Signal $V_{signal} := DARM \cdot L \cdot h_{min} \cdot \sqrt{P_0}$
- Scattered Light
  - » Noise $V_{noise} := SNXXX \cdot \delta_{SN} \cdot \sqrt{P_{SNi}}$
  - » Phase Shift due to motion of surface $\delta_{SNi} := \frac{4 \cdot \pi \cdot x_s}{\lambda}$
- Requirement: $SNXXX \cdot \delta_{SN} \cdot \sqrt{P_{SNi}} < \frac{1}{10} \cdot DARM \cdot L \cdot h_{min} \cdot \sqrt{P_0}$

Stray Light Design Requirement

- <1/10 of the thermal noise limit strain



Total Scattered Light Displacement Noise from Multiple Sources, m/rtHz

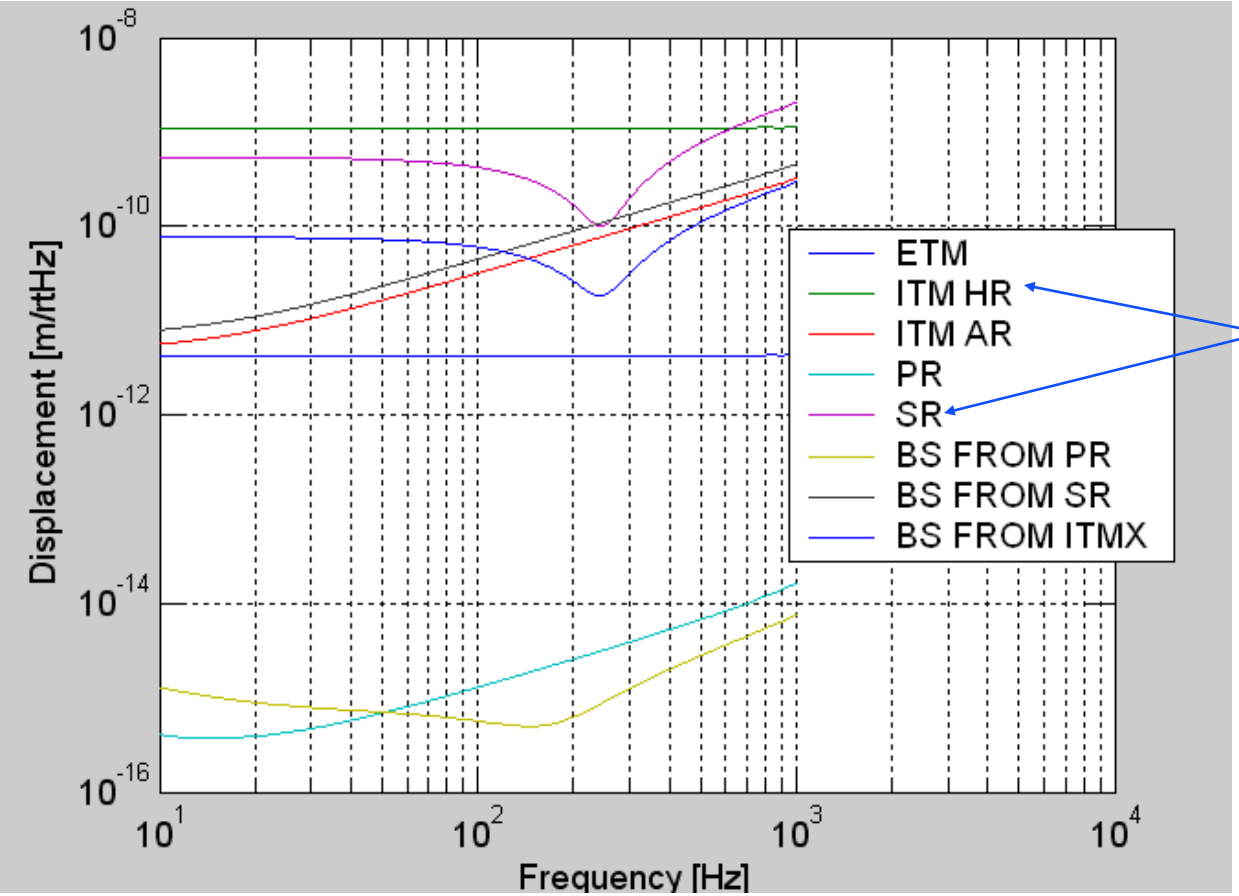
- Sources Are Random, Add in Quadrature

$$\sqrt{\sum_{i=1}^{n}\left(\frac{SNXXX}{DARM}\cdot\frac{4\cdot\pi\cdot x_s}{\lambda}\cdot\sqrt{\frac{P_{SNi}}{P_0}}\right)^2} < \frac{1}{10}\cdot L\cdot h_{mir}$$

- Scattered Light Transfer functions

$$TF := \frac{SNXXX}{DARM}$$

Scattered Light Transfer Functions from FFT simulation



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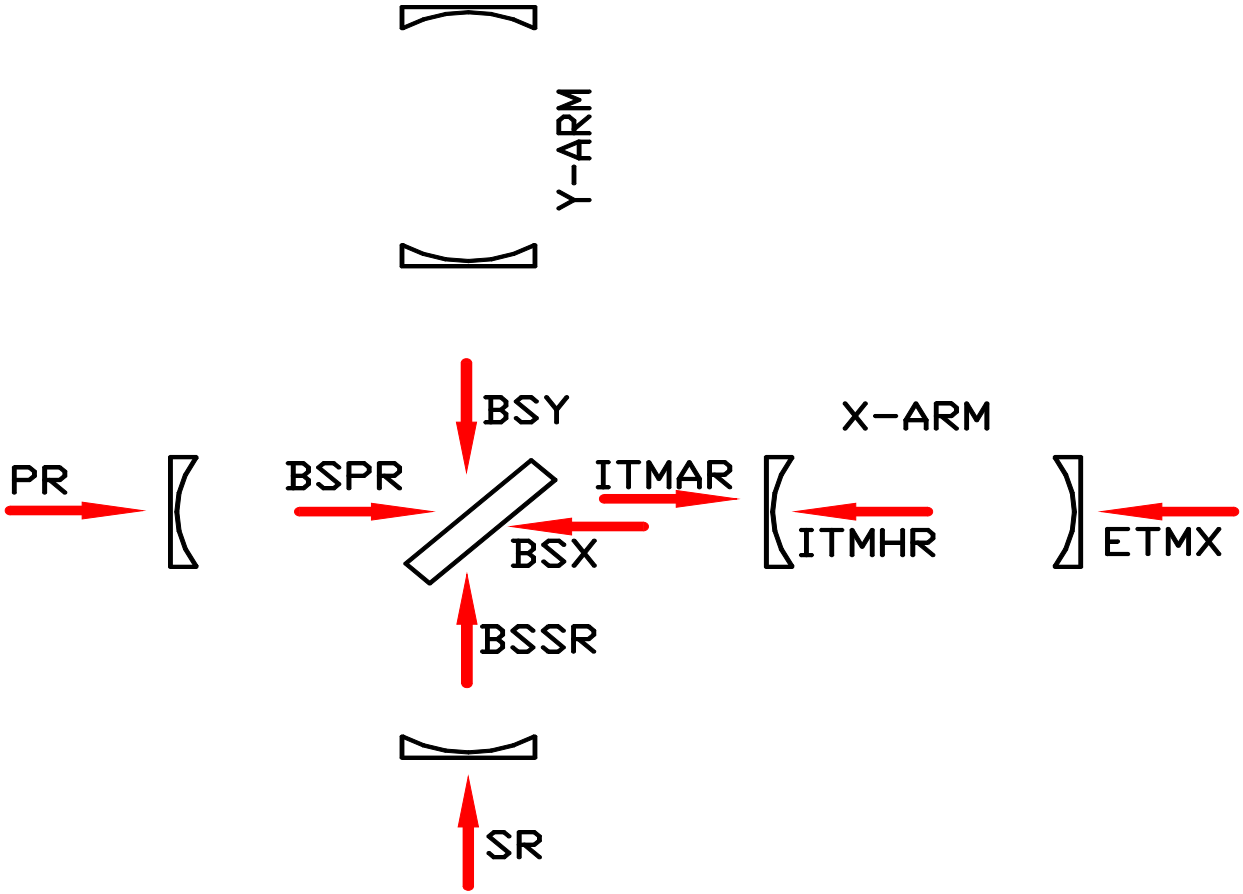
Scattered Injection Points



Scattered Power into IFO

- Scattered power depends upon:
  - » Incident power hitting scattering surface, W
  - » Bidirectional Scatter Distribution Function of scattering surface, BRDF, sr^-1
  - » Solid angle subtended by the mode inside IFO arm, sr
  - » Relative area ratio of IFO mode area to the area of incident beam waist
  - » Transmissivity of optical path from scatter surface to the injection point

$$P_{SNi} := P_{in} \cdot BRDF \cdot \Delta\Omega \cdot \frac{w_{IFO}^{2}}{w_{SN}^{2}} \cdot T$$

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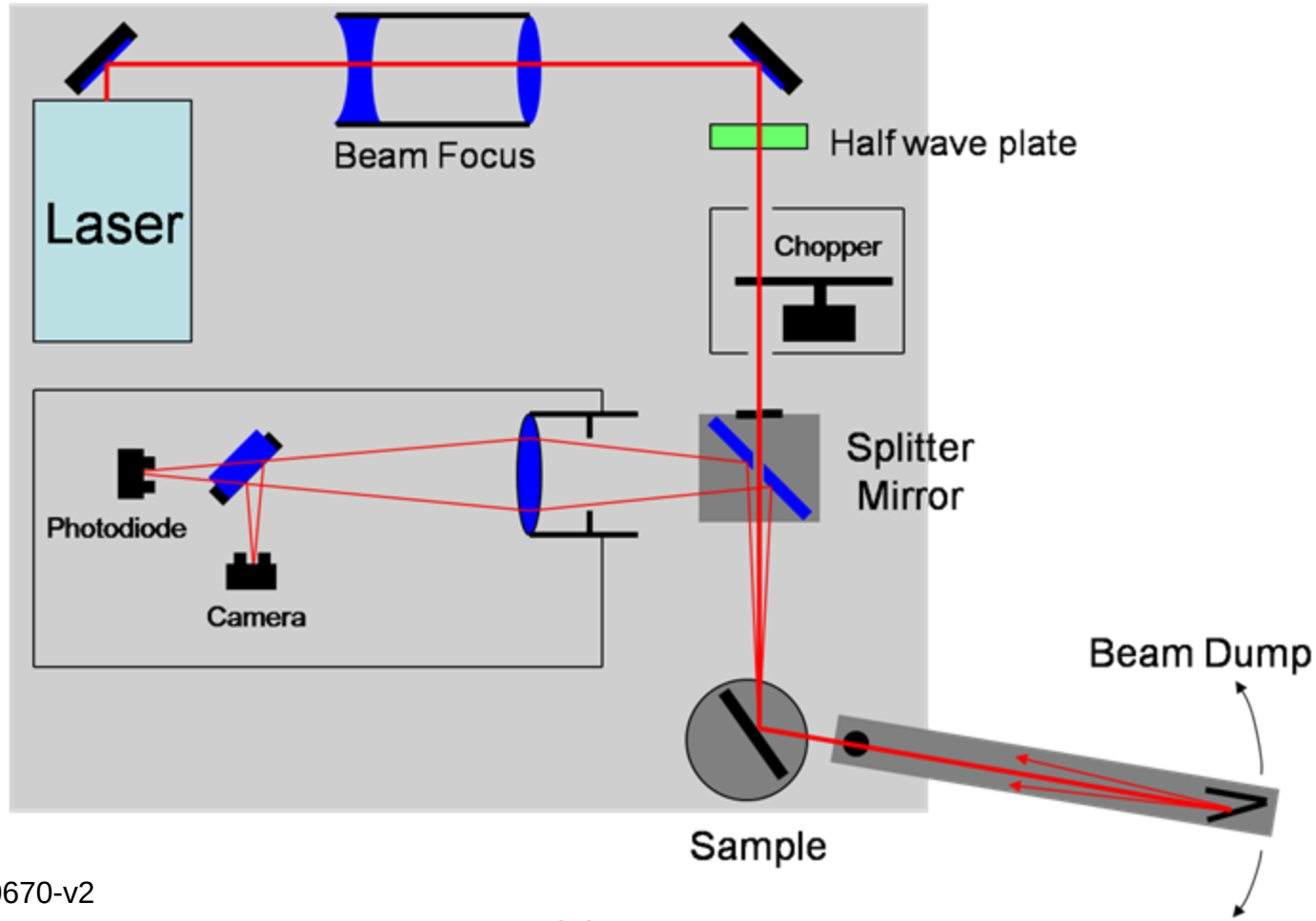
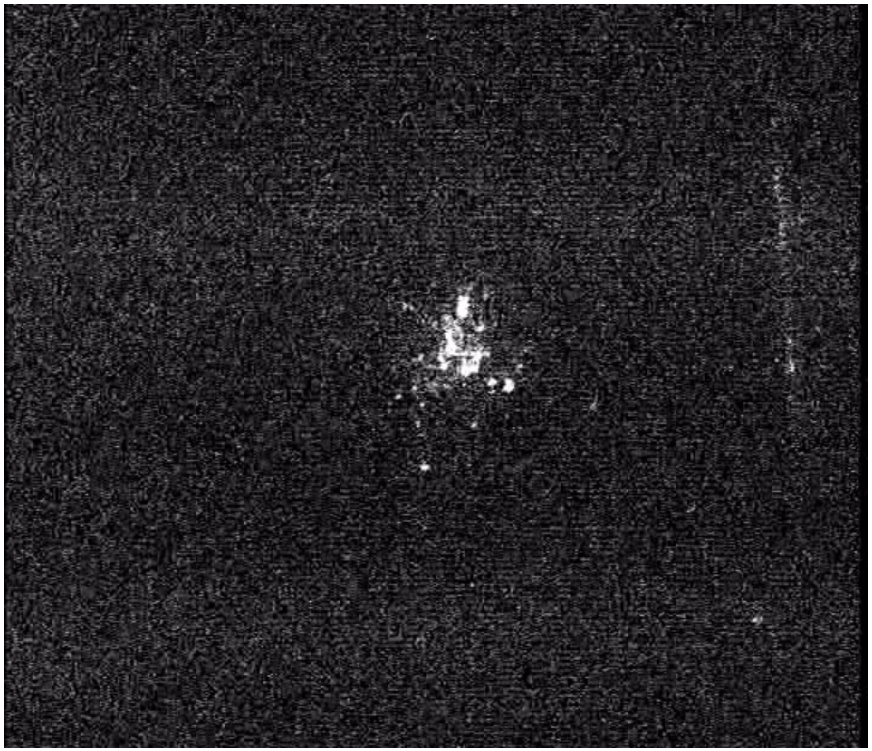
Measuring BRDF

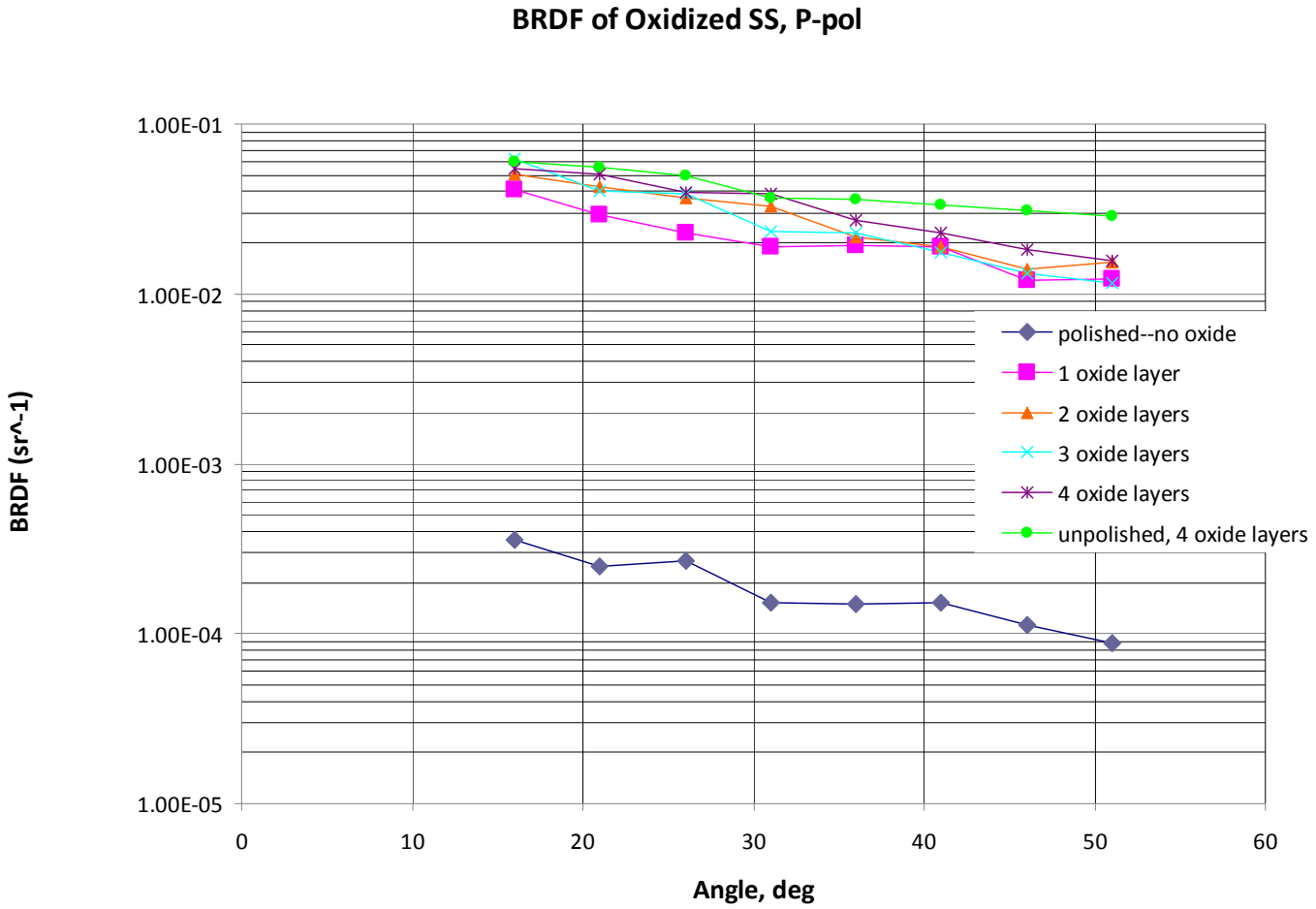


Cleanliness Is Next To Godliness

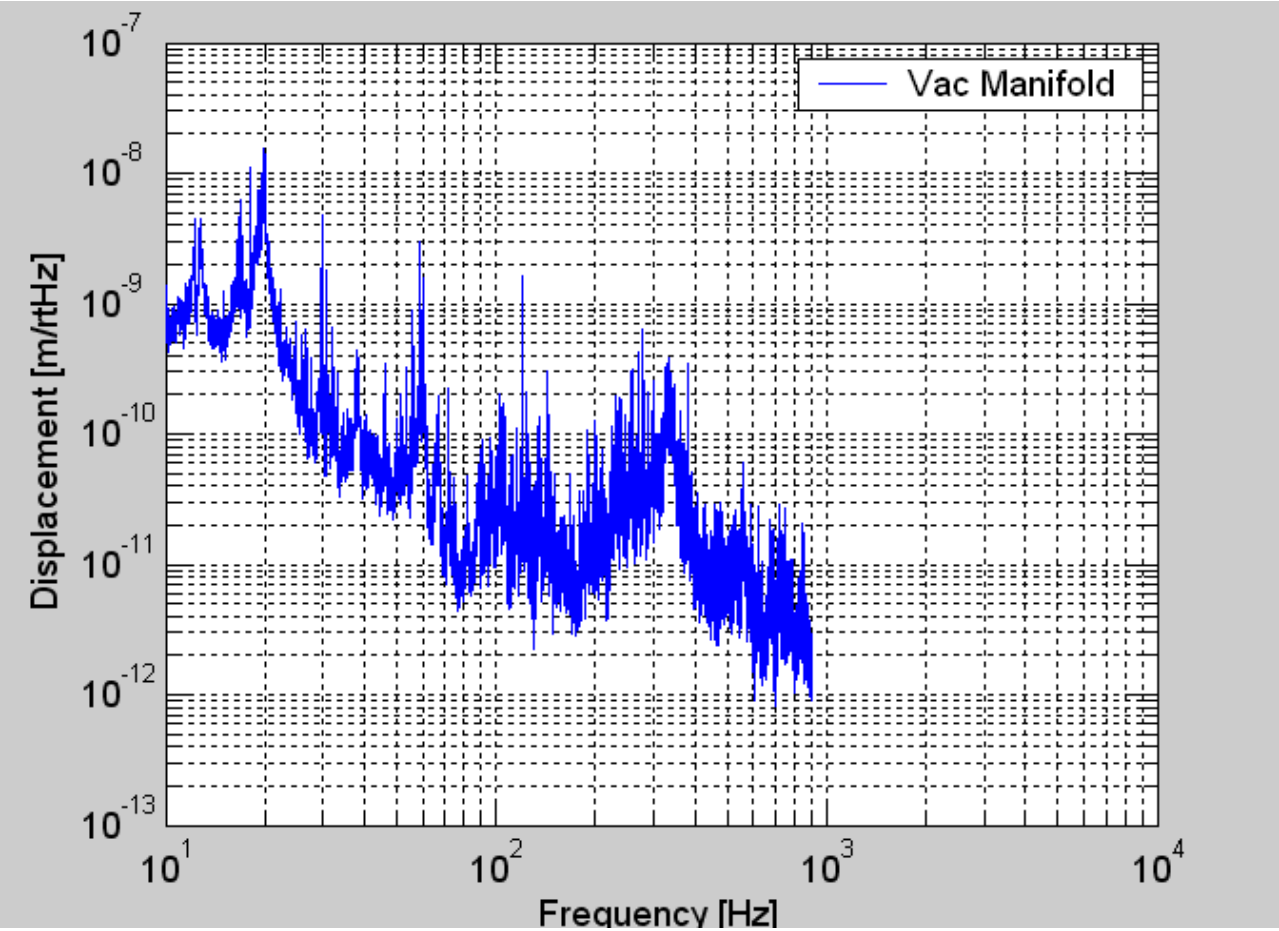
- Dust particles scattering light on the sample surface!



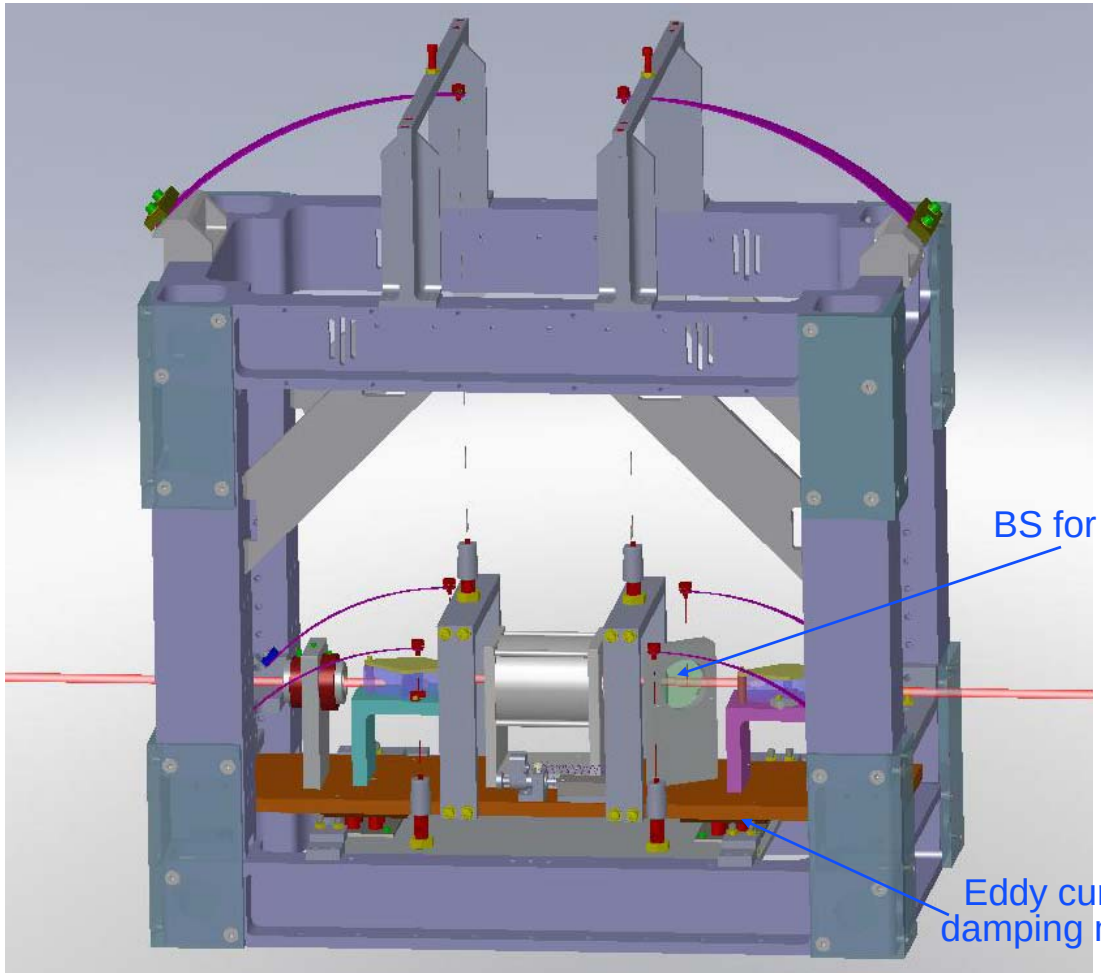
Example Of BRDF Data



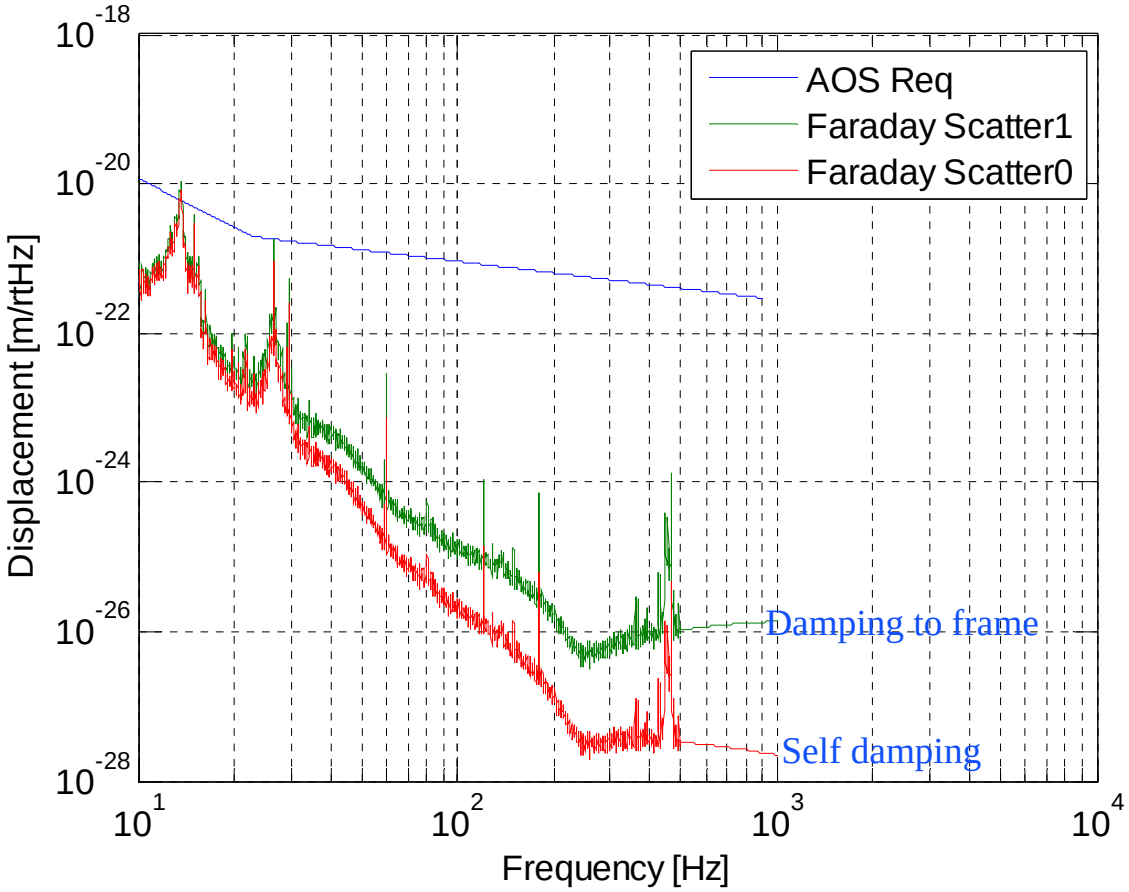
Motion Of Scattering Surface, m/rtHz



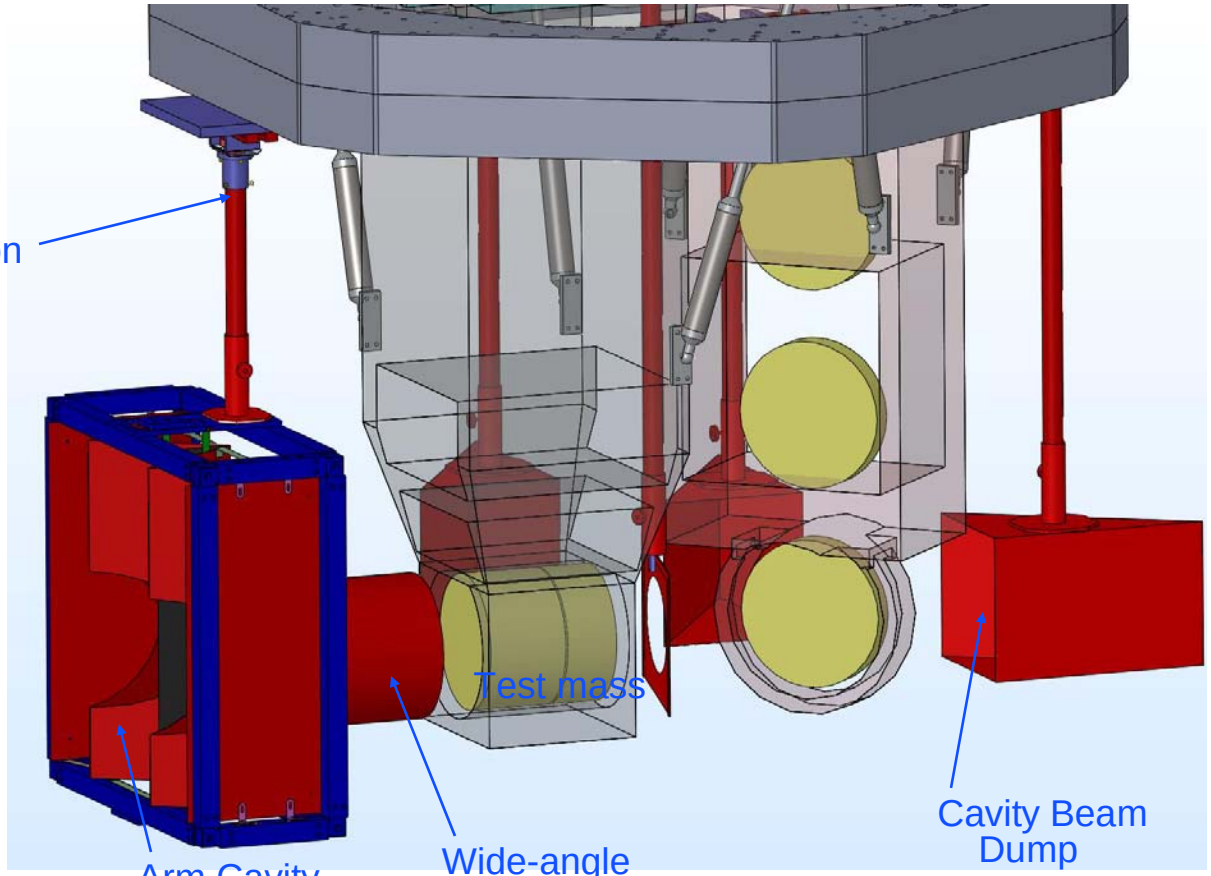
Scattered Light Control
Suspended Output Faraday Isolator



Output Faraday Isolator Scatter Displacement Noise



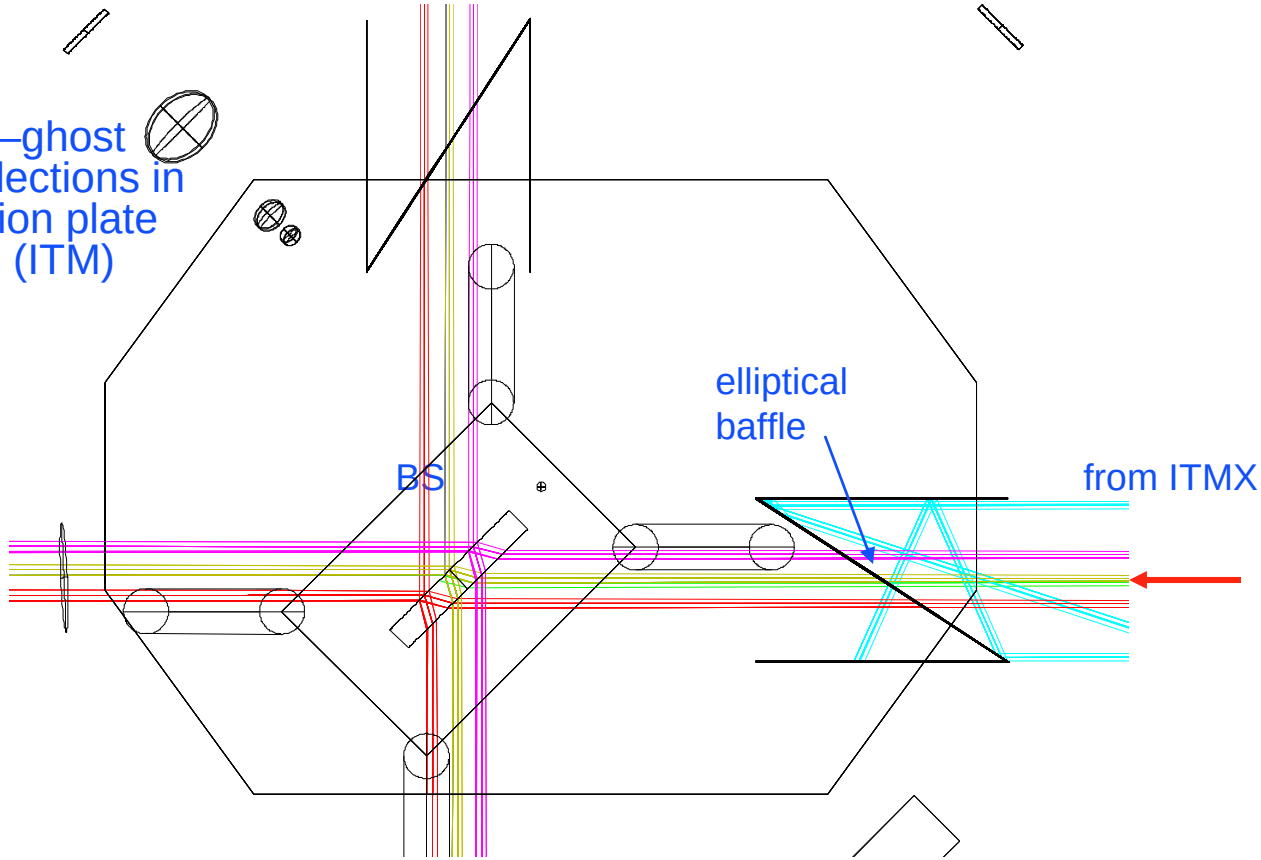
Other Examples



Modeling Of Ghost Beams

Modeling with ZEMAX:

- beam splitter chamber—ghost beams from internal reflections in the wedged compensation plate next to Input Test Mass (ITM)



Putting It All Together

Scattered Light Meets Requirement!!