A study of radiation pressure effect on ASC in H1 & H2

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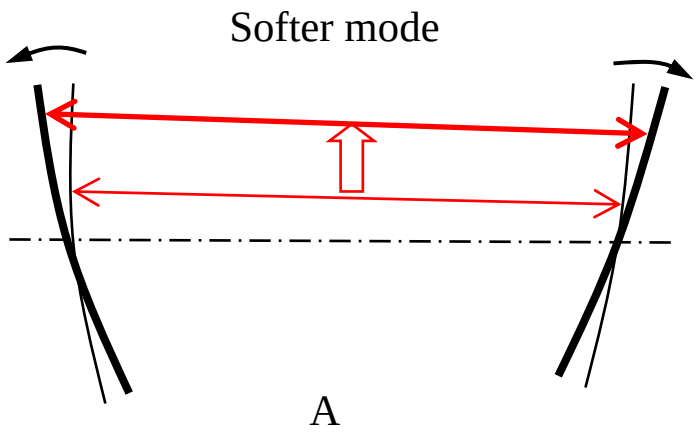
Summary

- First measurement of radiation pressure effect on ASC (“Sigg’s effect”) in LIGO
- Good agreement between measurement and model
- Both H1 & H2 seem to be already in naturally unstable region at full power (system itself is stable due to servo)

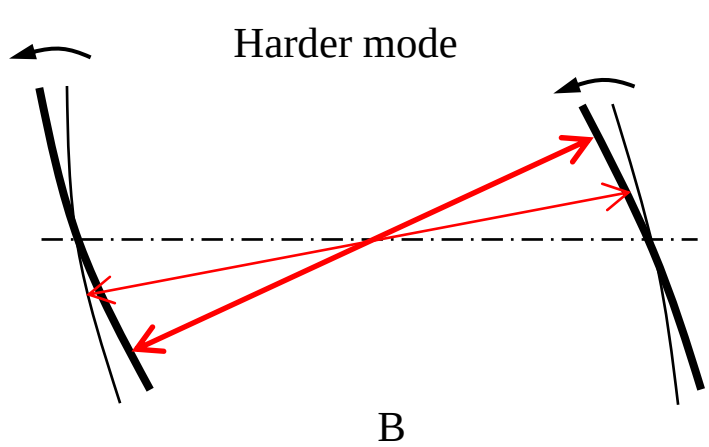
Outline

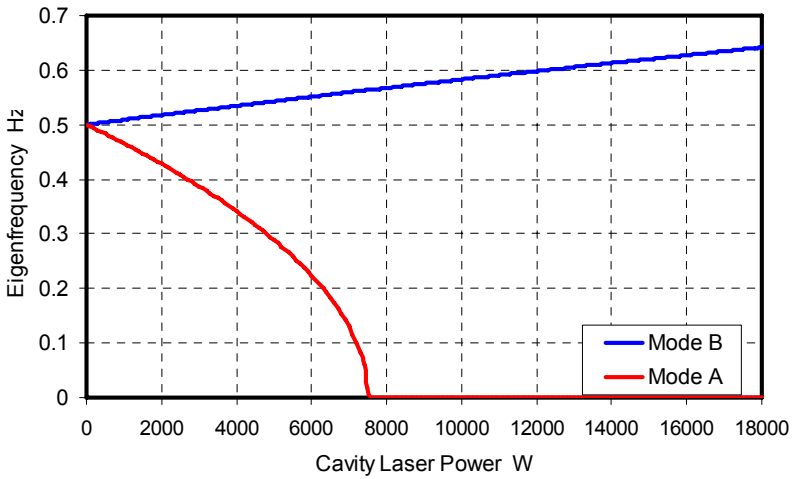
- Review of Sigg's instability
- Measurement
- Modeling (Simulink®)
- Estimation of cavity laser power
- Behavior at higher laser power
- Conclusion

Sigg's instability



$$\tau = \frac{2P\Delta}{c}$$



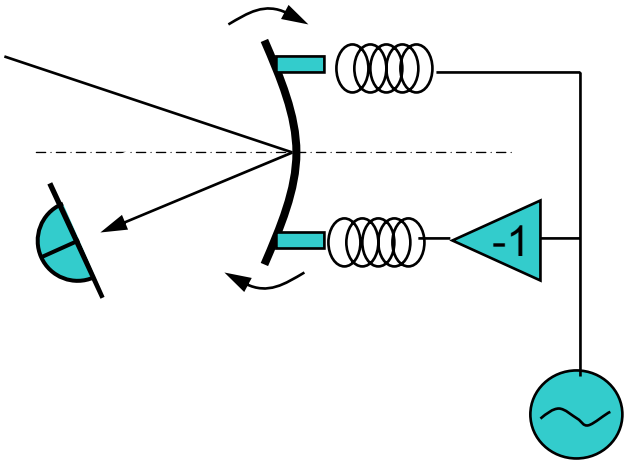


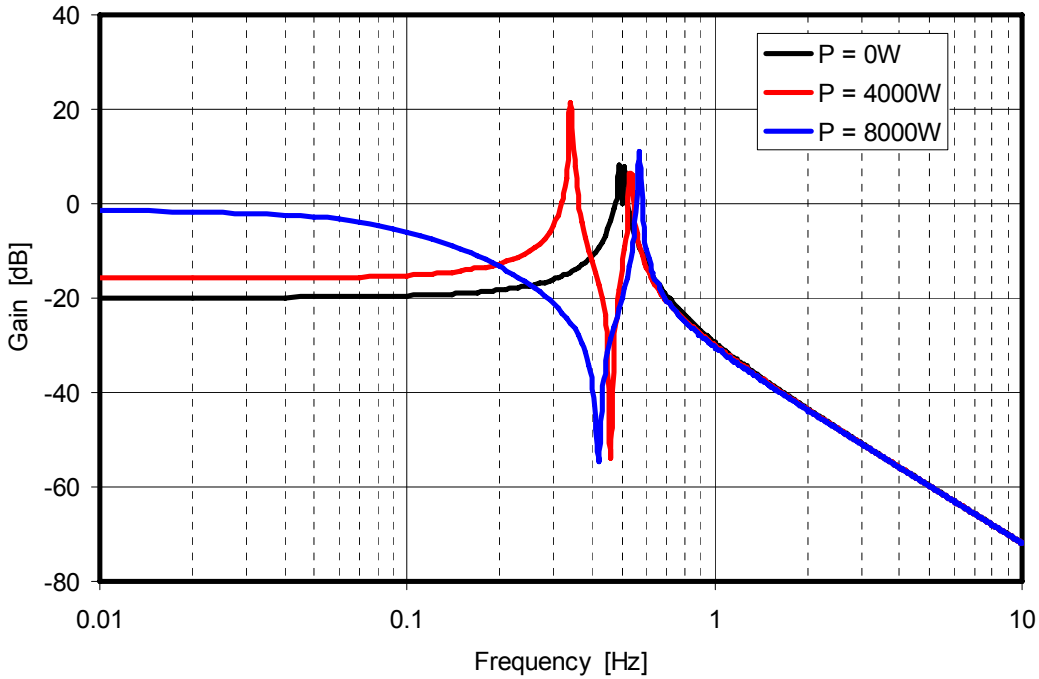
Opto-mechanical coupling between the TMs

$$L = \frac{1}{2} I_1 \dot{\theta}_1^{\,2} + \frac{1}{2} I_2 \dot{\theta}_2^{\,2} - \frac{1}{2} \mu_1 \theta_1^{\,2} - \frac{1}{2} \mu_2 \theta_2^{\,2}$$
$$+ \frac{P}{c} \frac{g_2 L}{1 - g_1 g_2} \theta_1^{\,2} + \frac{P}{c} \frac{g_1 L}{1 - g_1 g_2} \theta_2^{\,2} + \frac{2P}{c} \frac{L}{1 - g_1 g_2} \theta_1 \theta_2$$

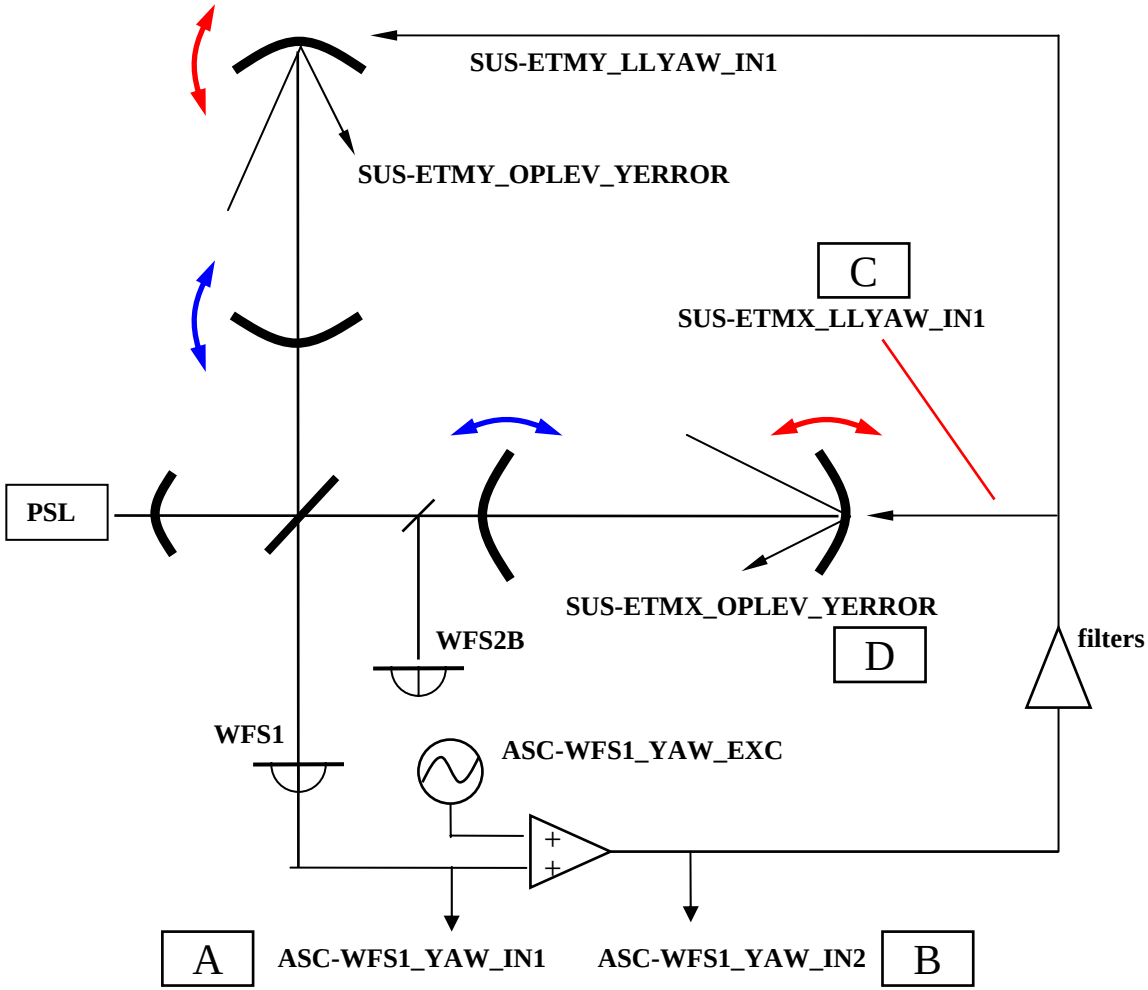
Zero "spring constant" for A at critical power.
(No catastrophe AFA the servo can take it.)

Opt – Mechanical TF

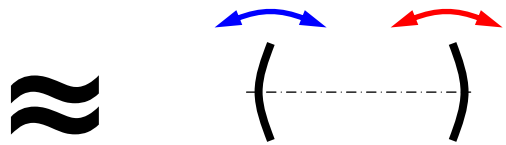




How the measurement was done



Look at WFS1 and WFS2B
(only two WFS for diff mode)
System is simplified as a 2DOF system



$$OLTF \equiv \frac{A}{B}$$

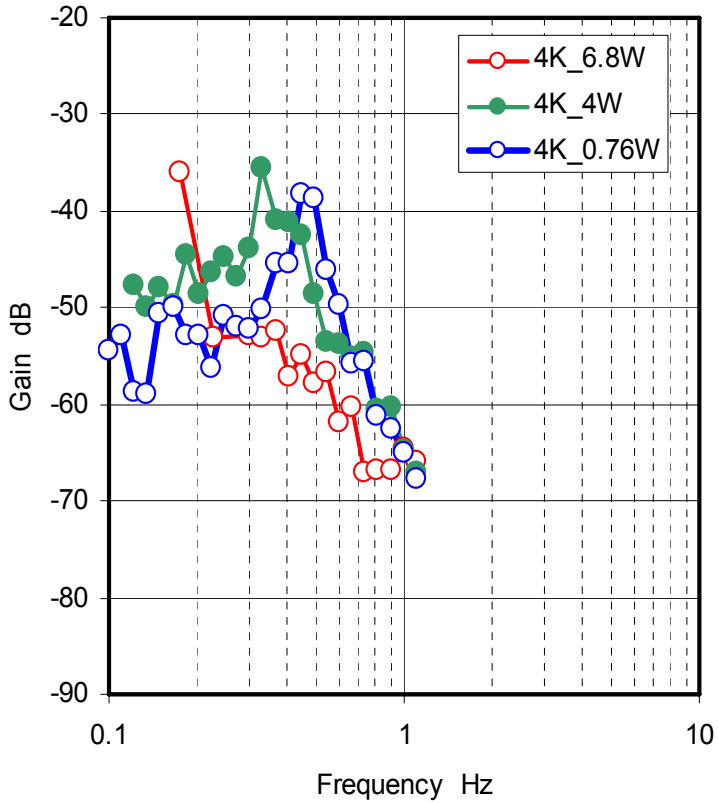
In-loop: WFS TF

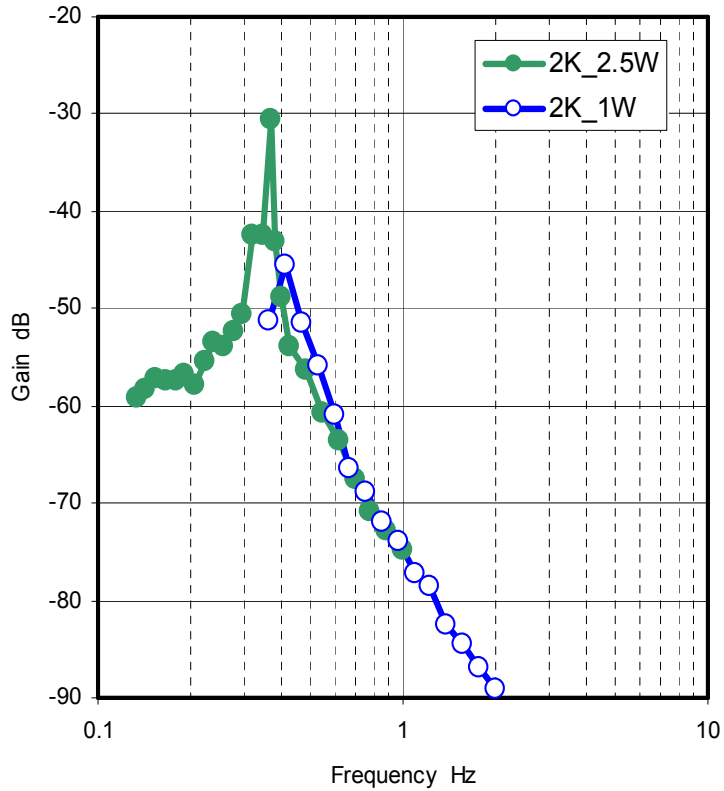
Out-of-loop: OPLEV TF

$$OPLEV \equiv \frac{D}{C}$$

Should extract opt-mechanical motion…

Didn’t make sense…

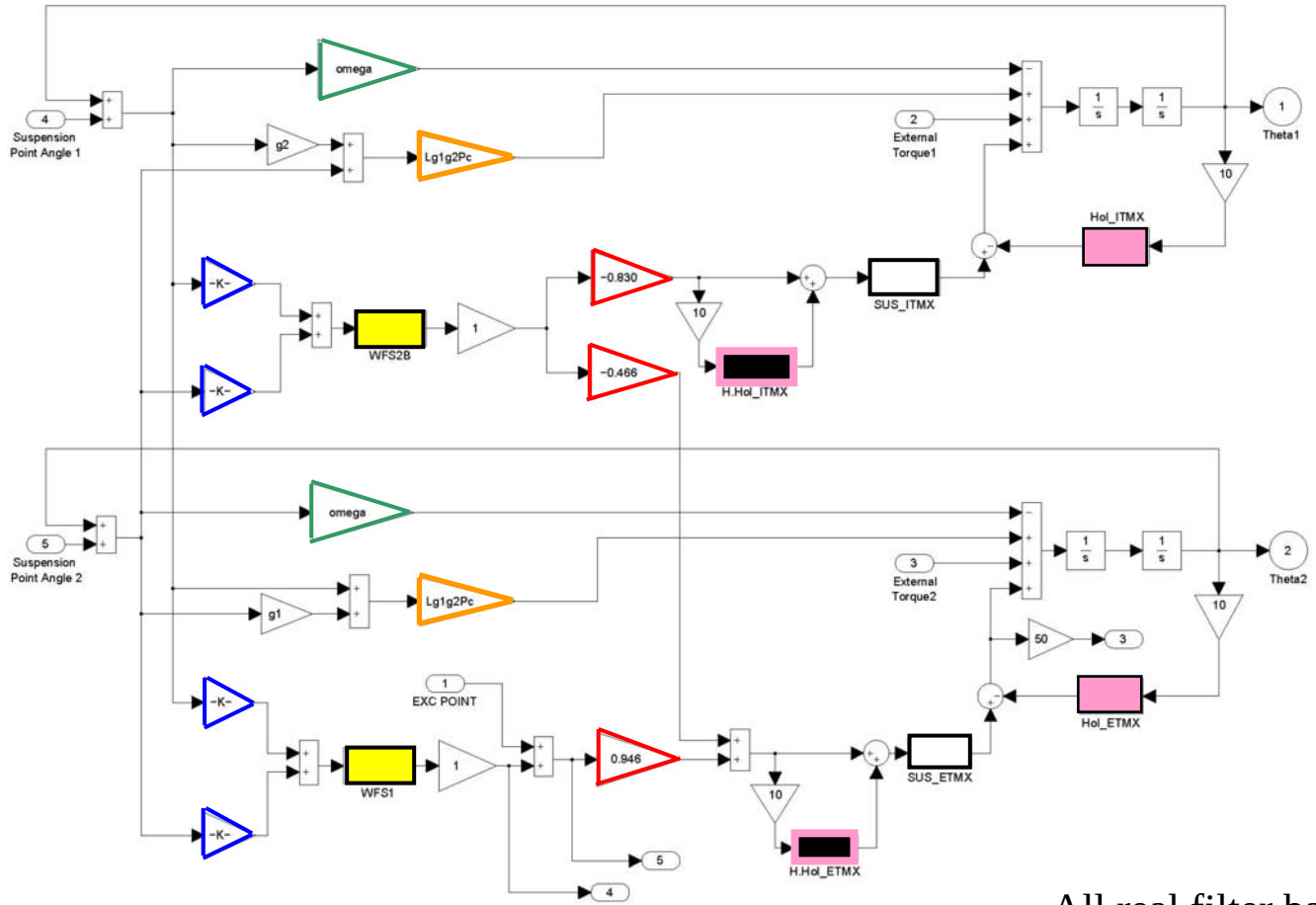




· Peak shifts as P goes up

· No harder mode observed

Model-based analysis

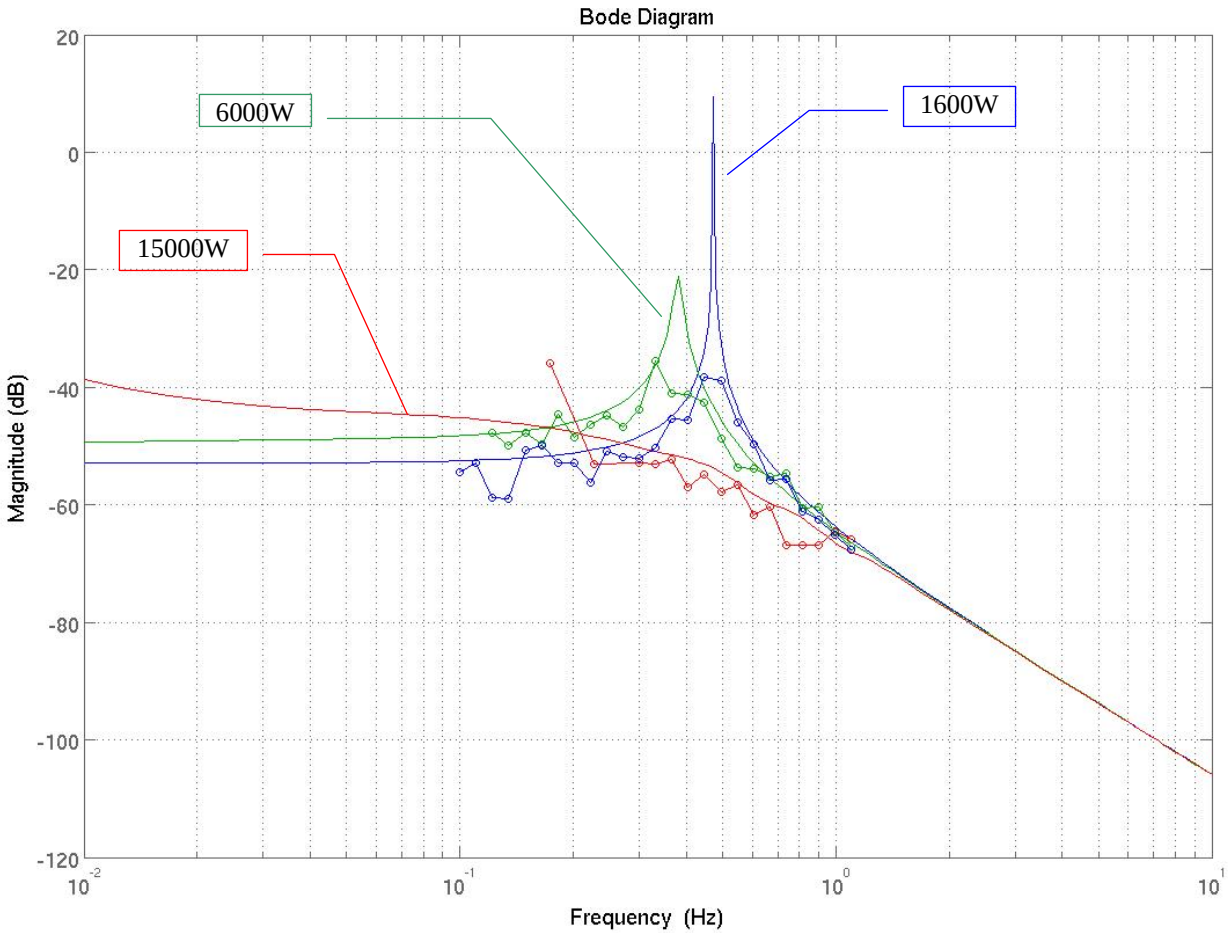


θ_1 ITMX | ITMY

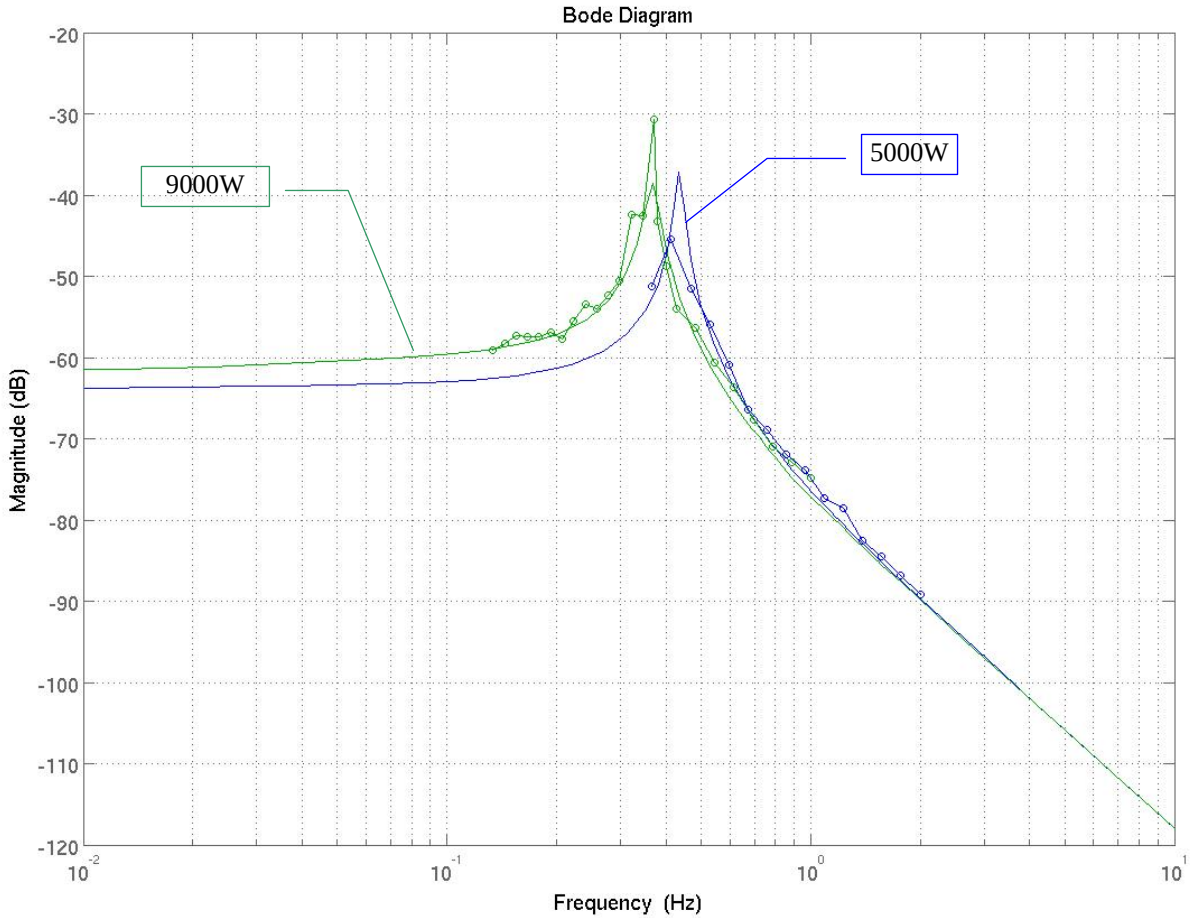
θ_2 ETMX | ETMY

All real filter bank used

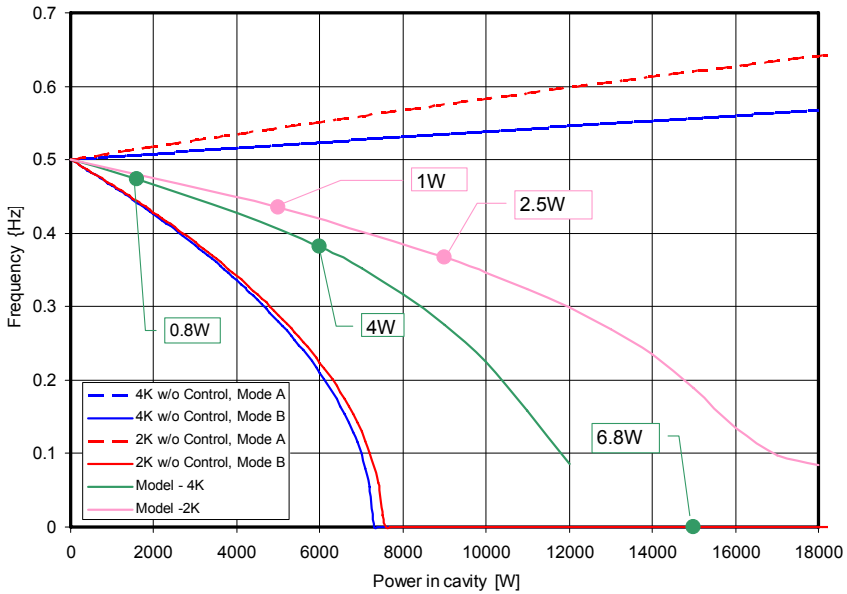
Simulation 4K

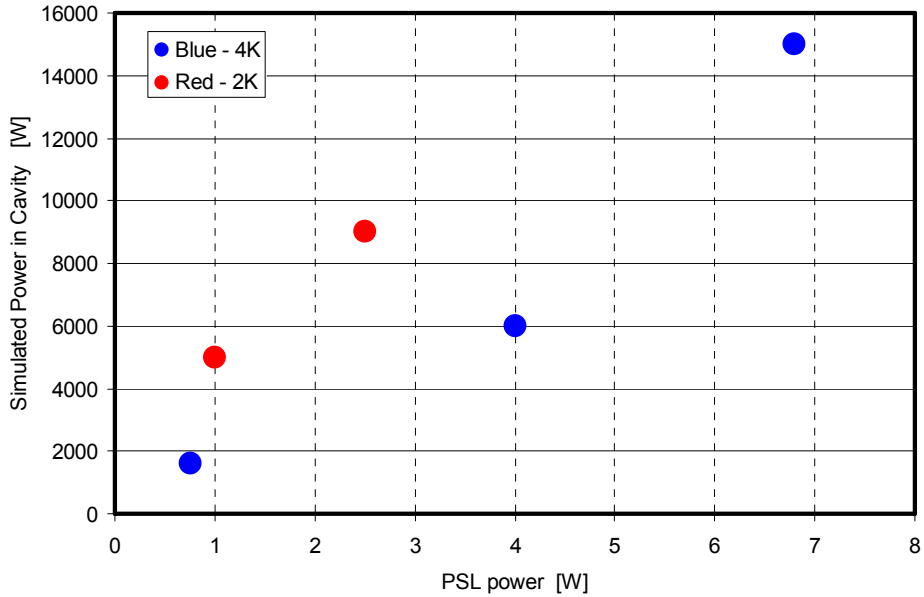


Simulation 2K

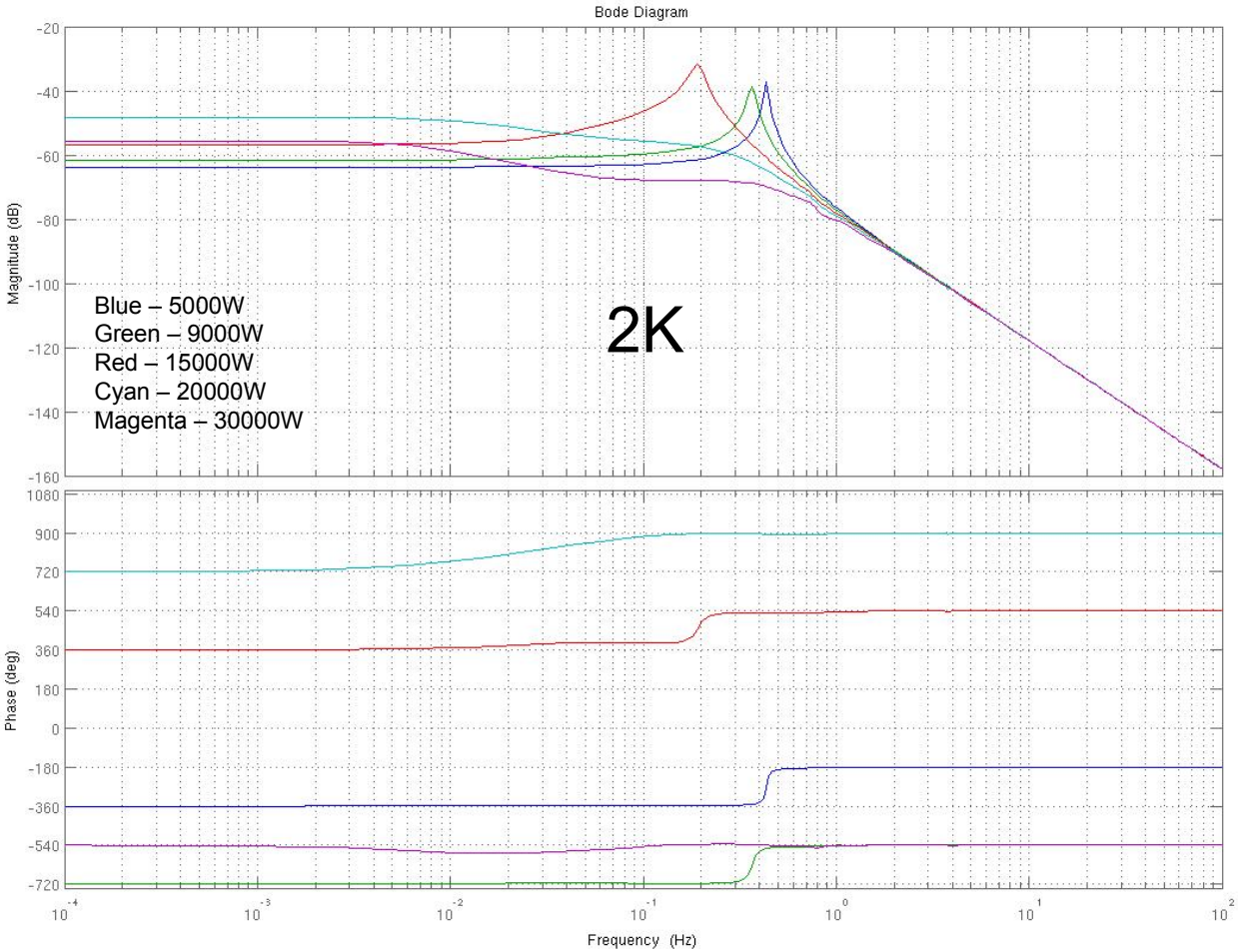


Preliminary arm power estimation

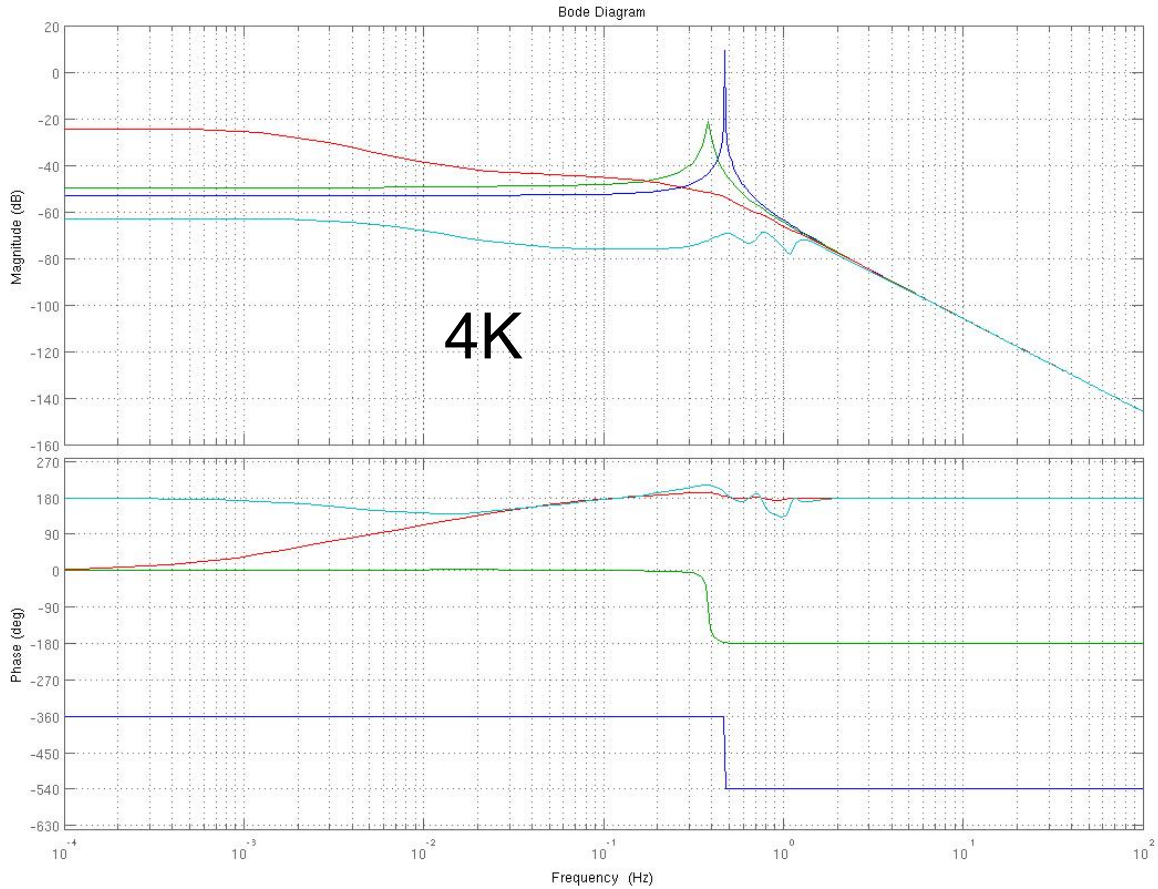




Behavior at higher power



Behavior at higher power



Conclusion

- Radiation pressure effect on ASC measured
- Good agreement bet. measurement and model
- Learning a lot about what is going on inside real IFO, which should help designing mLIGO ASC
  - Hopefully AdLIGO too

- Acknowledgements

  Rana Adhikari

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