A Systems Approach to Evaluating the Status of ET-LF Seismic Attenuation Proposals

Nathan A. Holland on behalf of

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Nikhef

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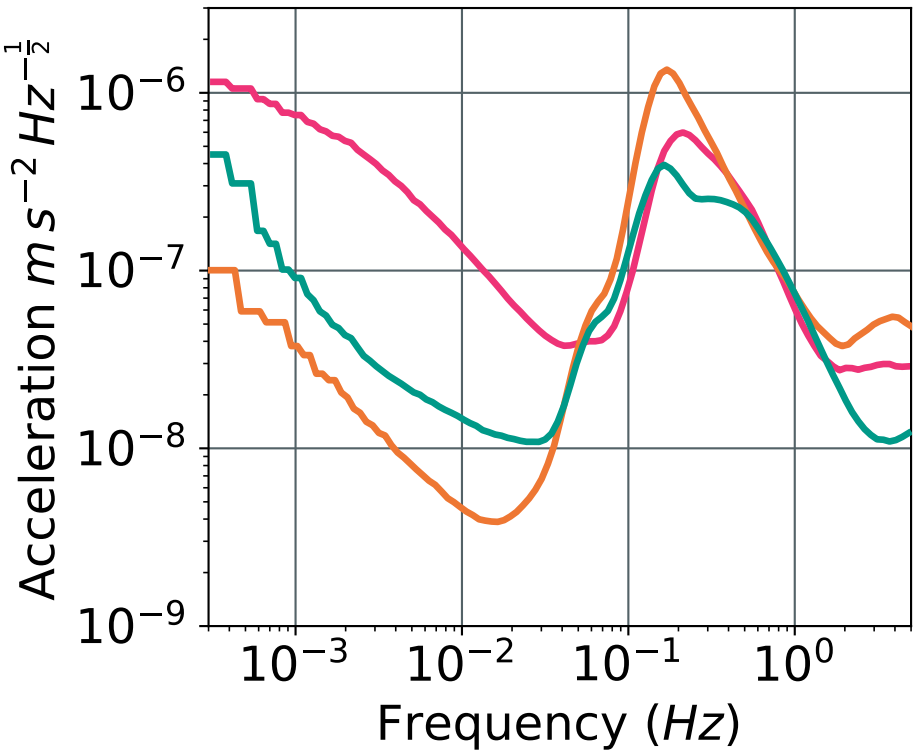
VU VRIJE UNIVERSITEIT AMSTERDAM

SEI Motion – Ventilated Caverns

LNGS Terzeit Sos Enatos



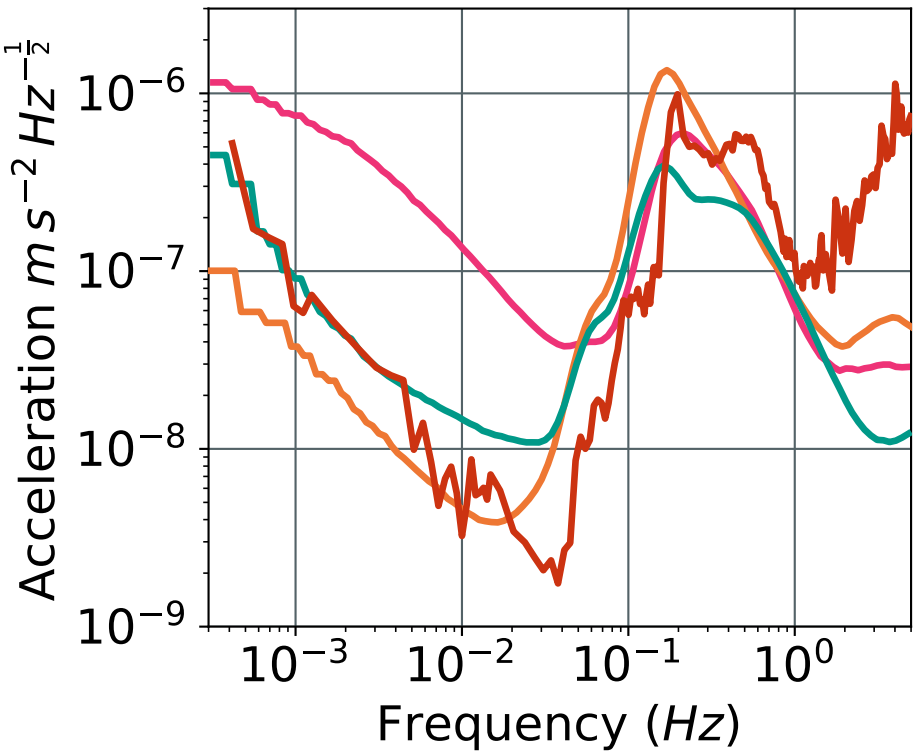
From; C. M. Mow-Lowry, et. al., 13th ET Symposium, May 2023.

- Boreholes/seismic vaults are NOT representative of SEI spectra for large ventilated caverns.
- Here we will use LNGS data.

We're looking into getting low-F Kamioka (KAGRA) spectra.

SEI Motion – Ventilated Caverns

LNGS Terzeit Sos Enatos Hanford (no wind)



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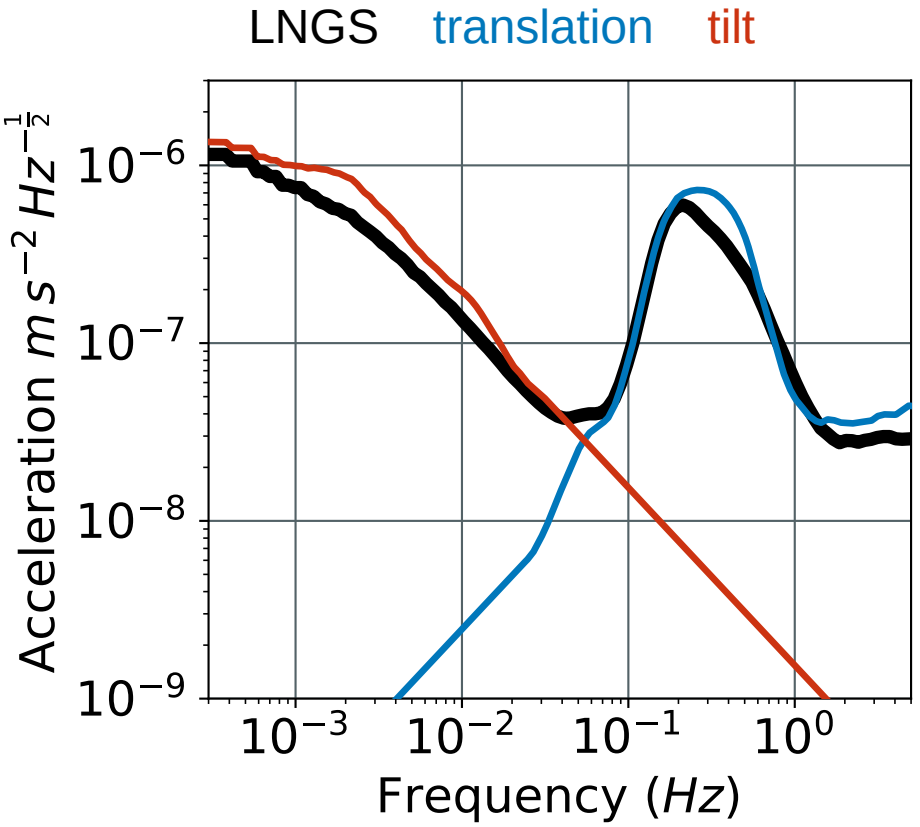

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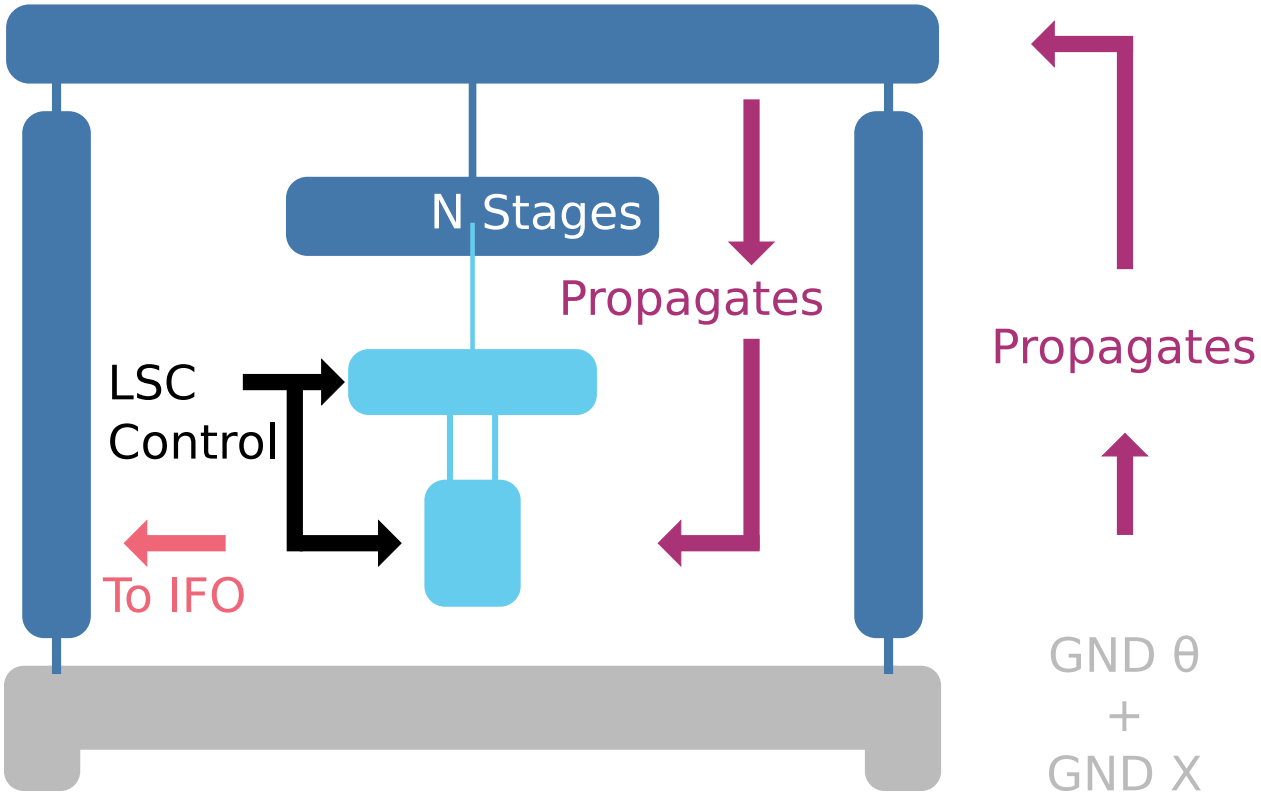
System

- LNGS GND spectra.
- 2 Stage (0 & 1) payload.
- 3 SAT options:
  - 9m Virgo.
  - 12m ET.
  - 17m ET-LF.
- Baseline proposal.



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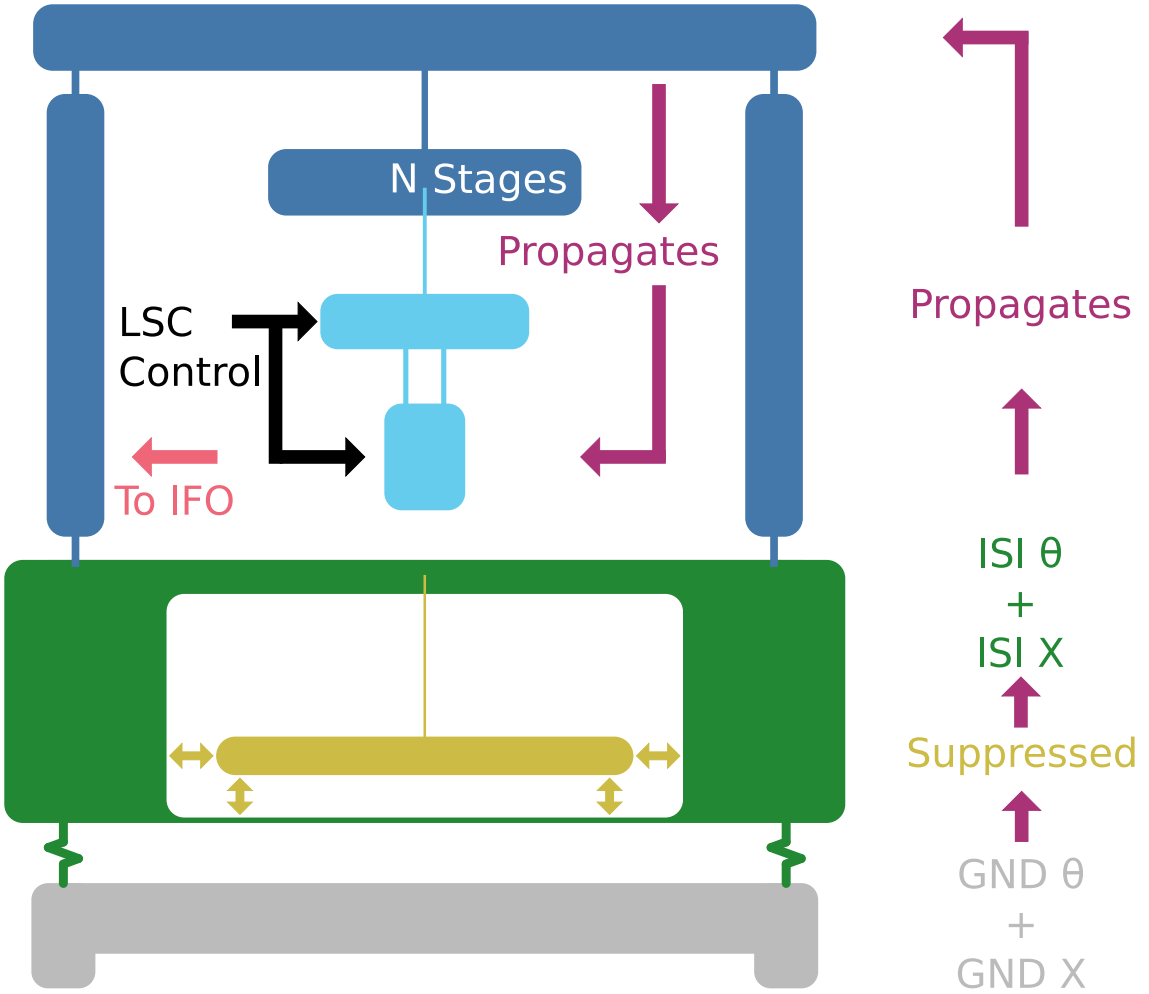
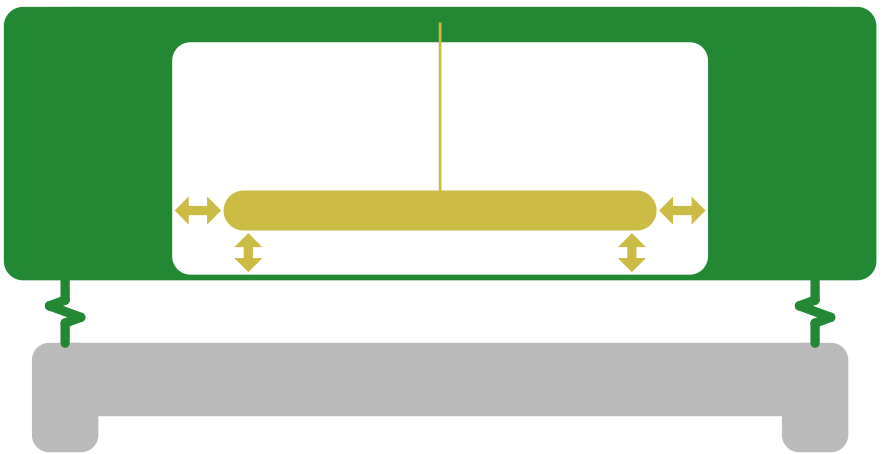


OmniSens – Seismic PreIsolation

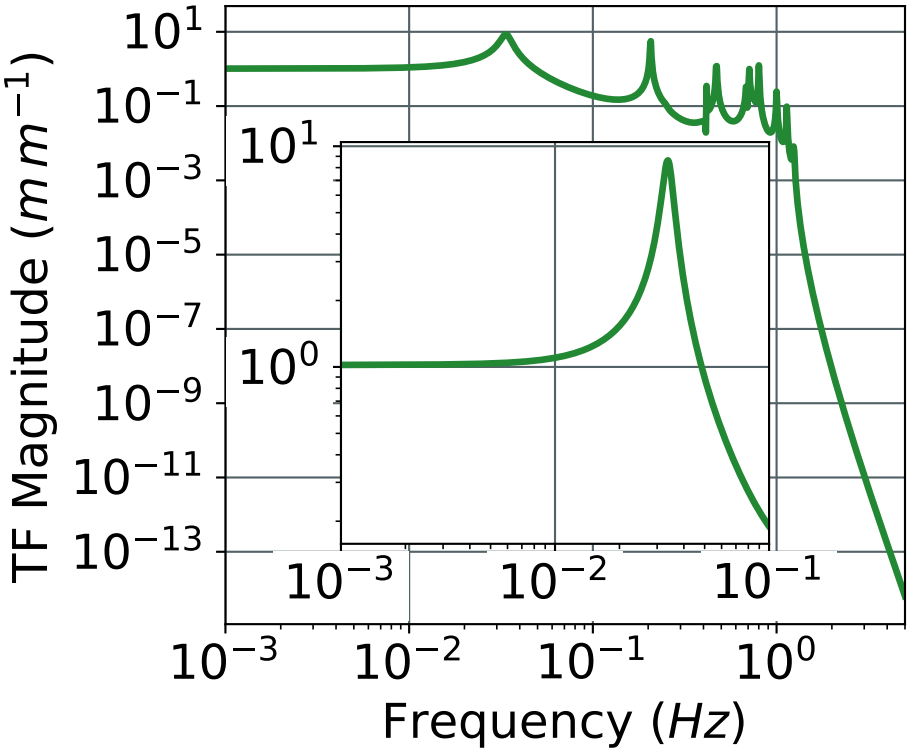


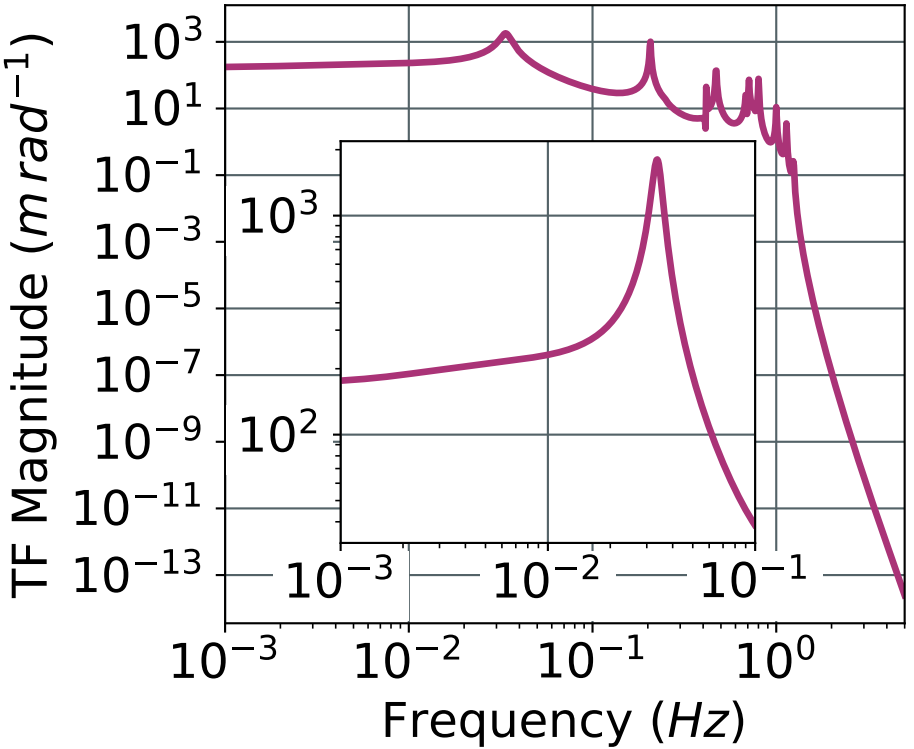
Ground
Internal Seismic Isolation (ISI)
Reference Mass

- Reference ISI table to highly isolated, tilt stable reference mass.

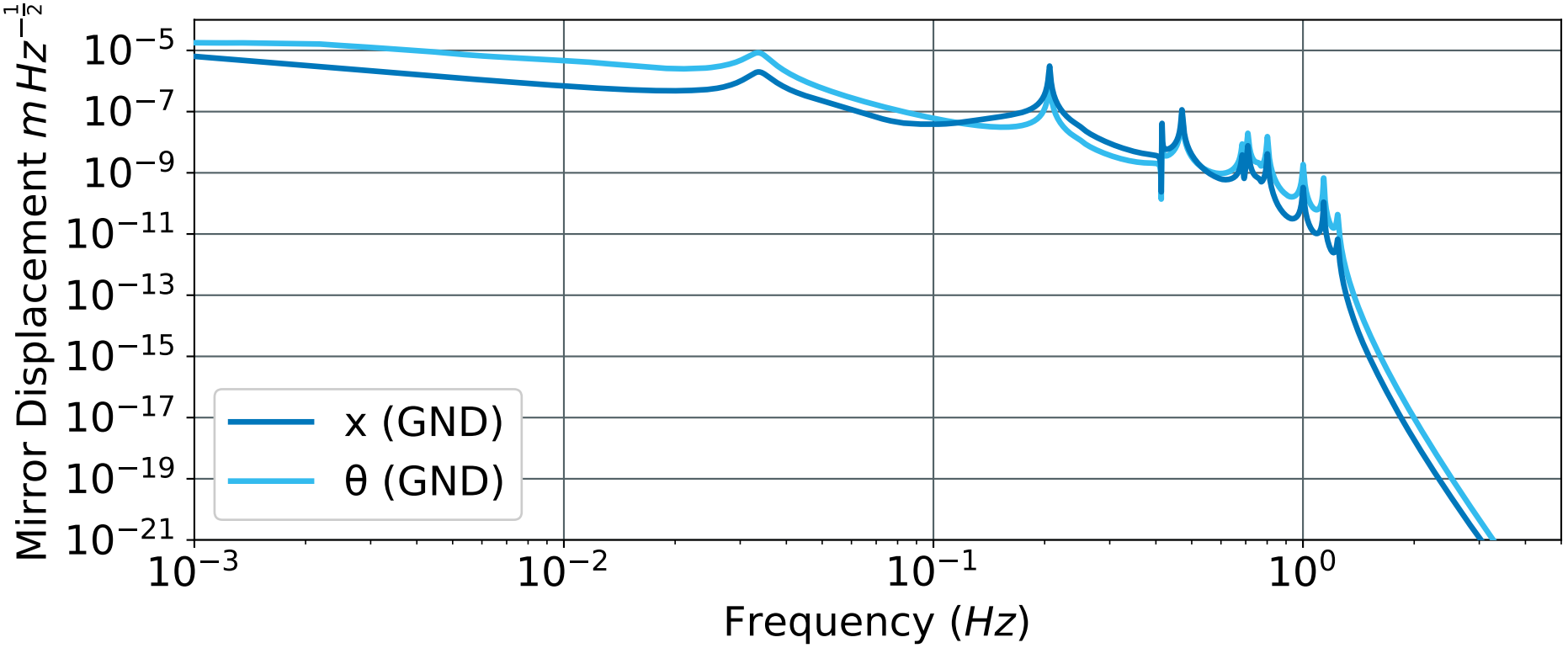
1. Stabilise ground tilt with active control.
2. Residual tilt feeds into translation sensing.
3. Stabilise translation with active control.
4. Residual tilt and translation are new *ground* inputs.

SAT TF – 17m ET-LF Baseline





Input Displacement to Optic - X_{res}



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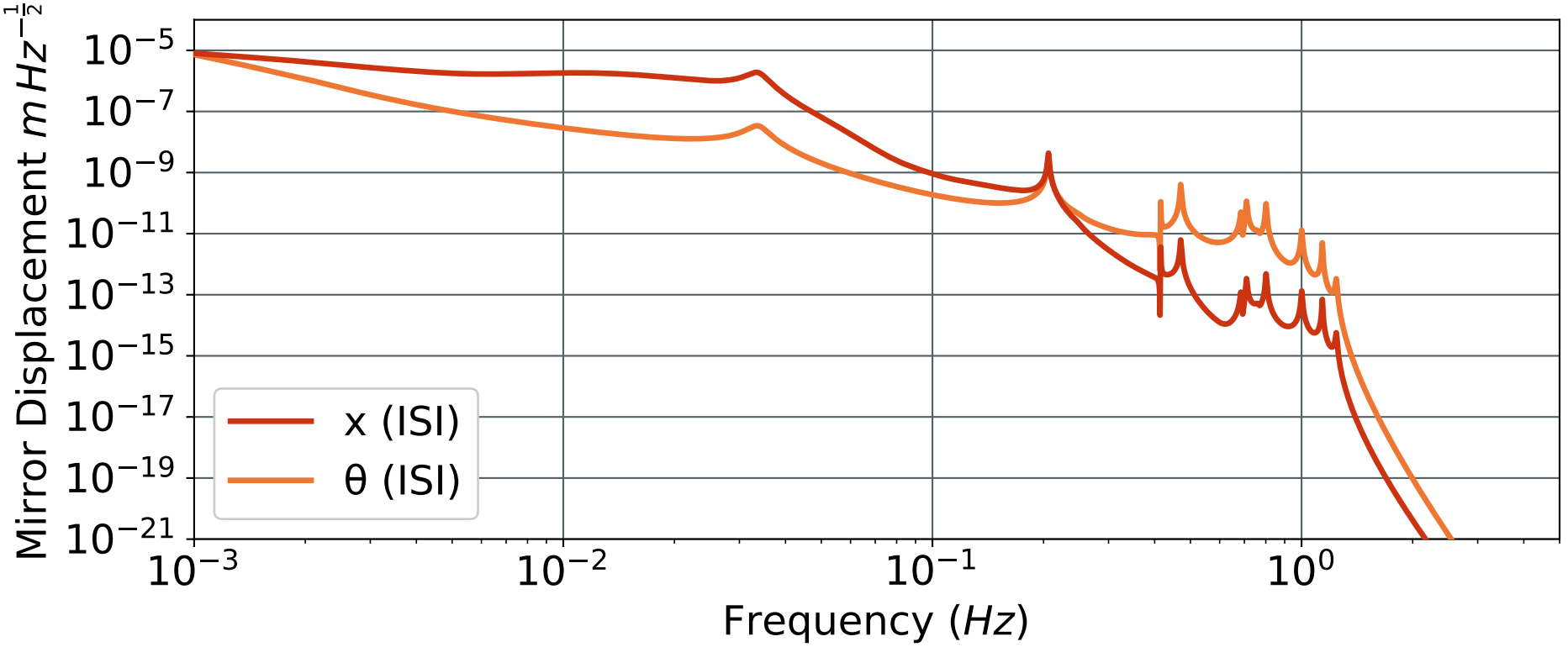

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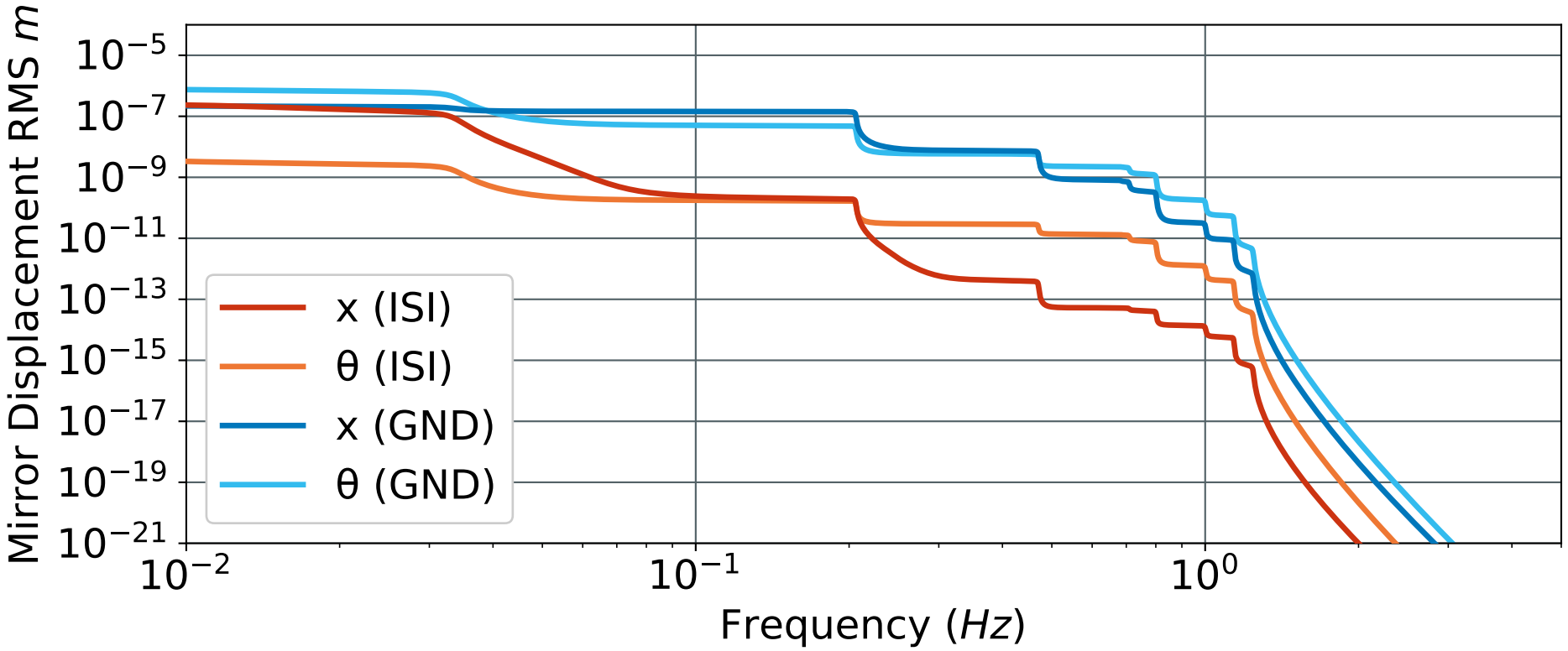
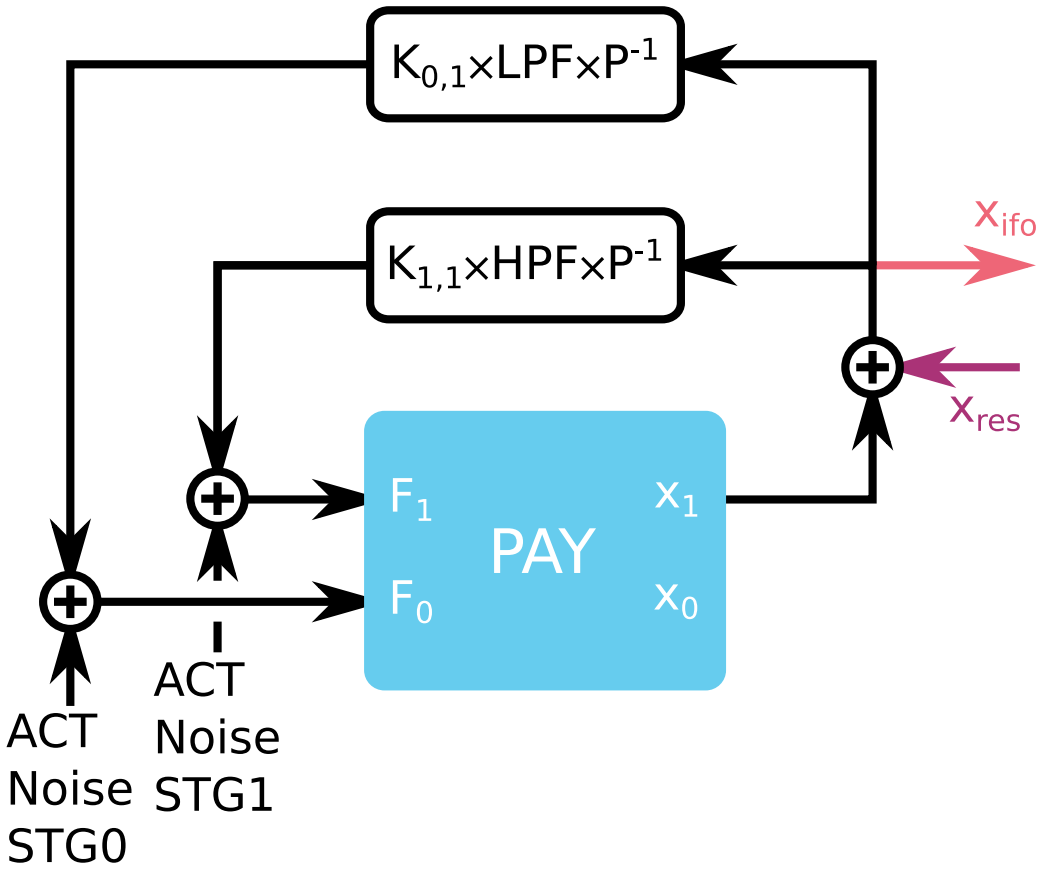
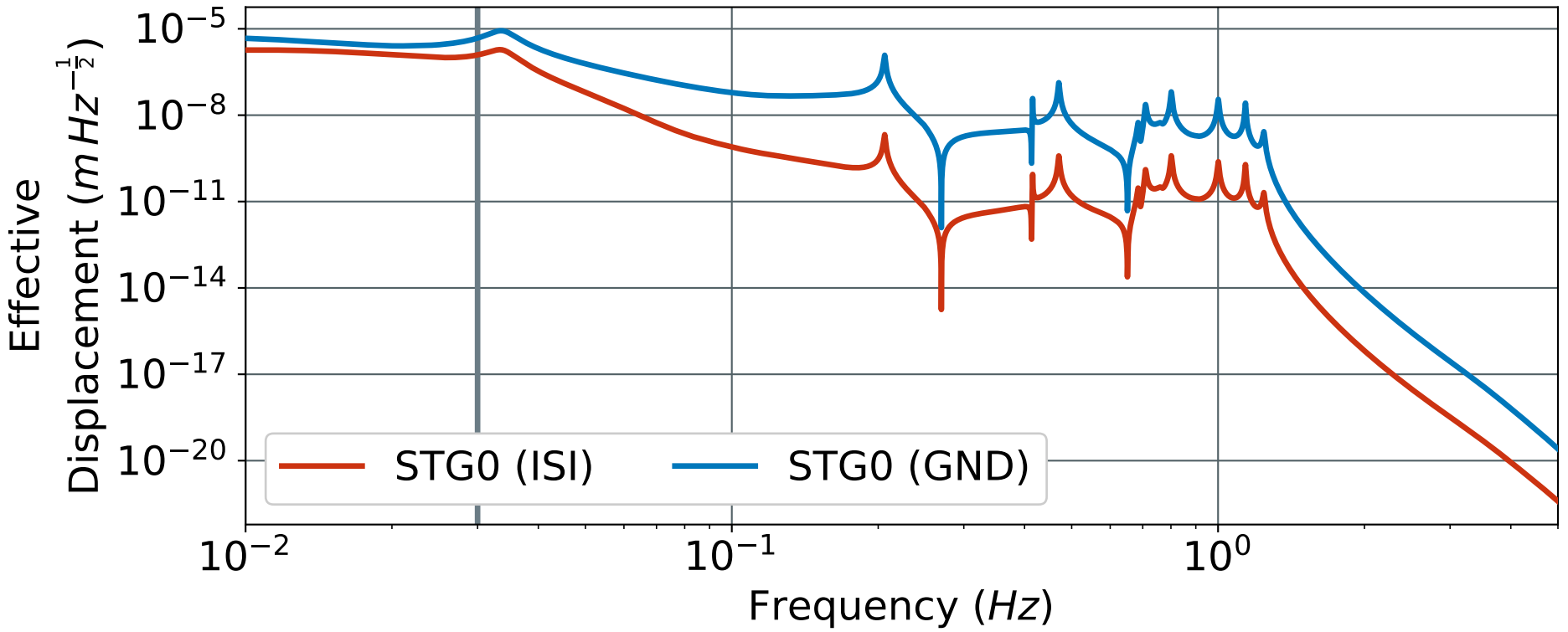


PAY

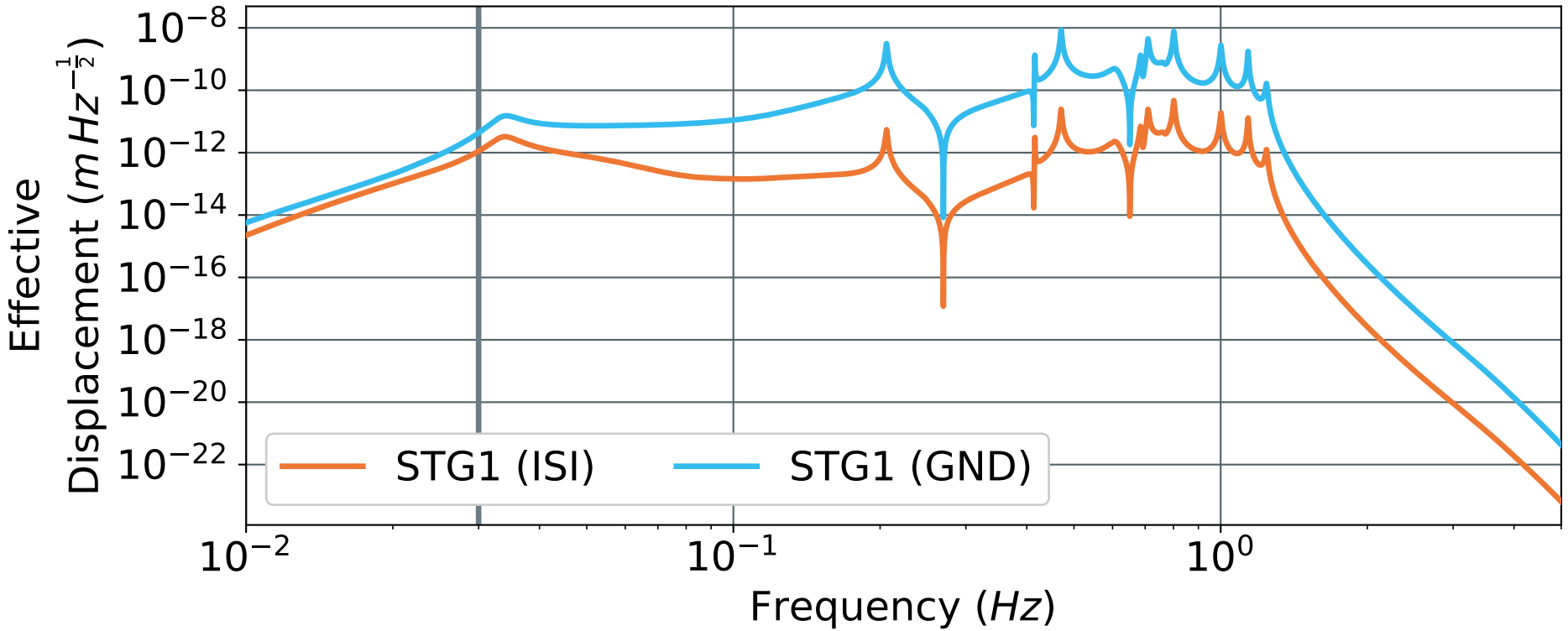


- Design taken from *ET-0028A-20* and *ET-0106C-10*.
  - Slightly modified to remove RM, and maintain critical coupling.
- Simple 2-D system.
- Drive heavily distributed up to stage 0.
- No detailed ET-LF PAY design.

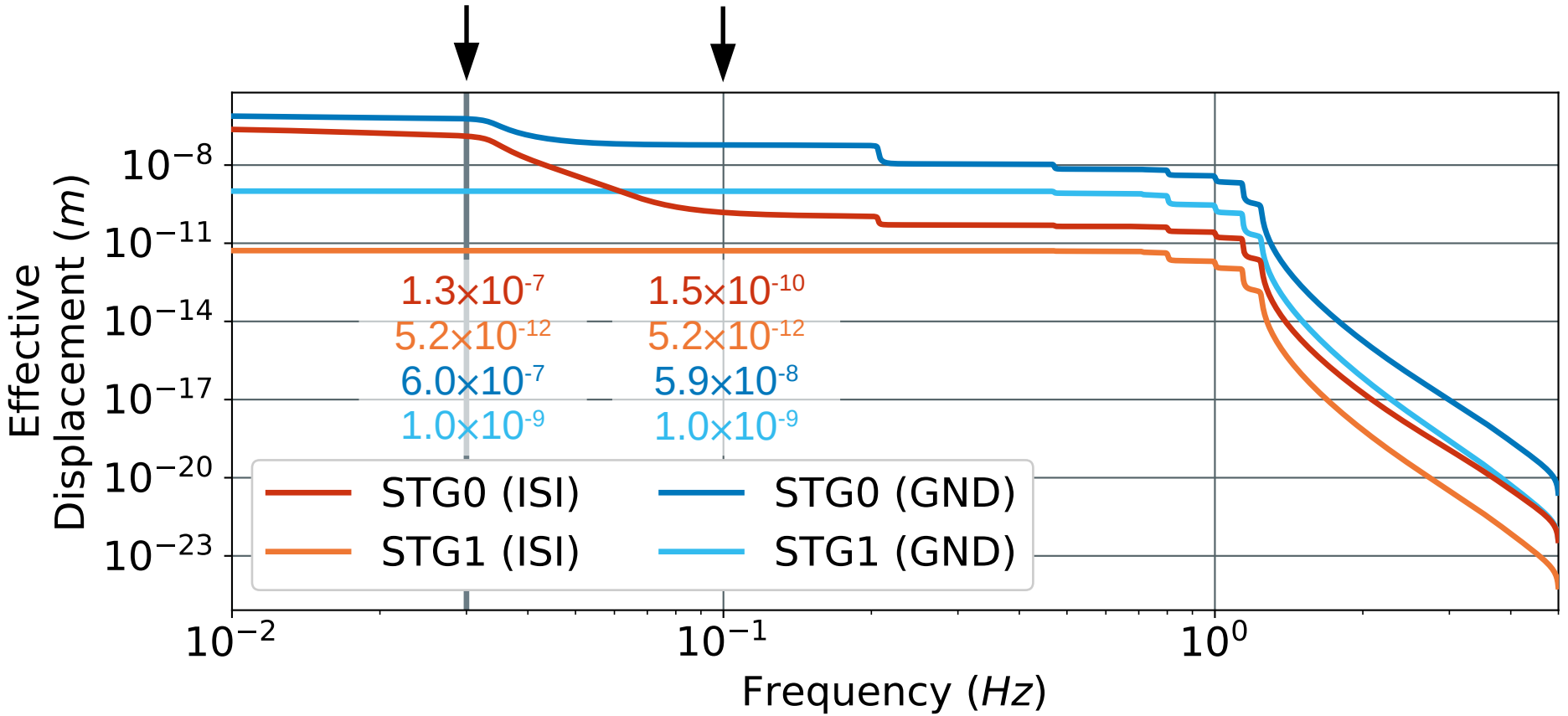
PAY Drive – Marionette



PAY Drive – Test Mass



PAY Drive – RMS



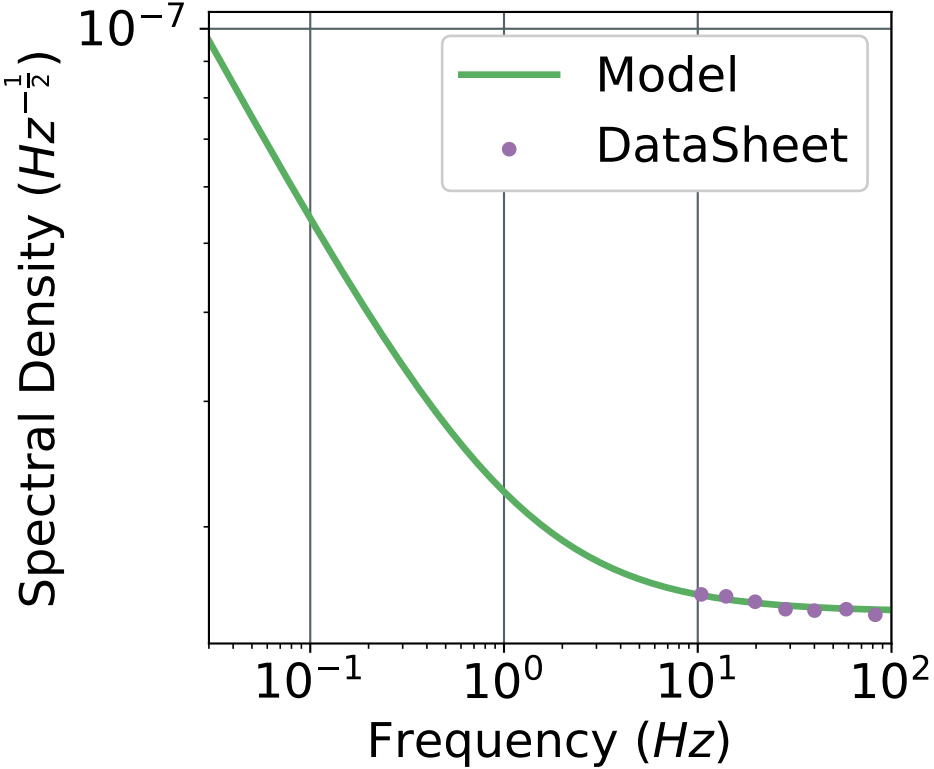
Actuation Noise Recipe

Virgo Recipe [Ruggi, ET-ISB workshop, ET-0303C-21]:

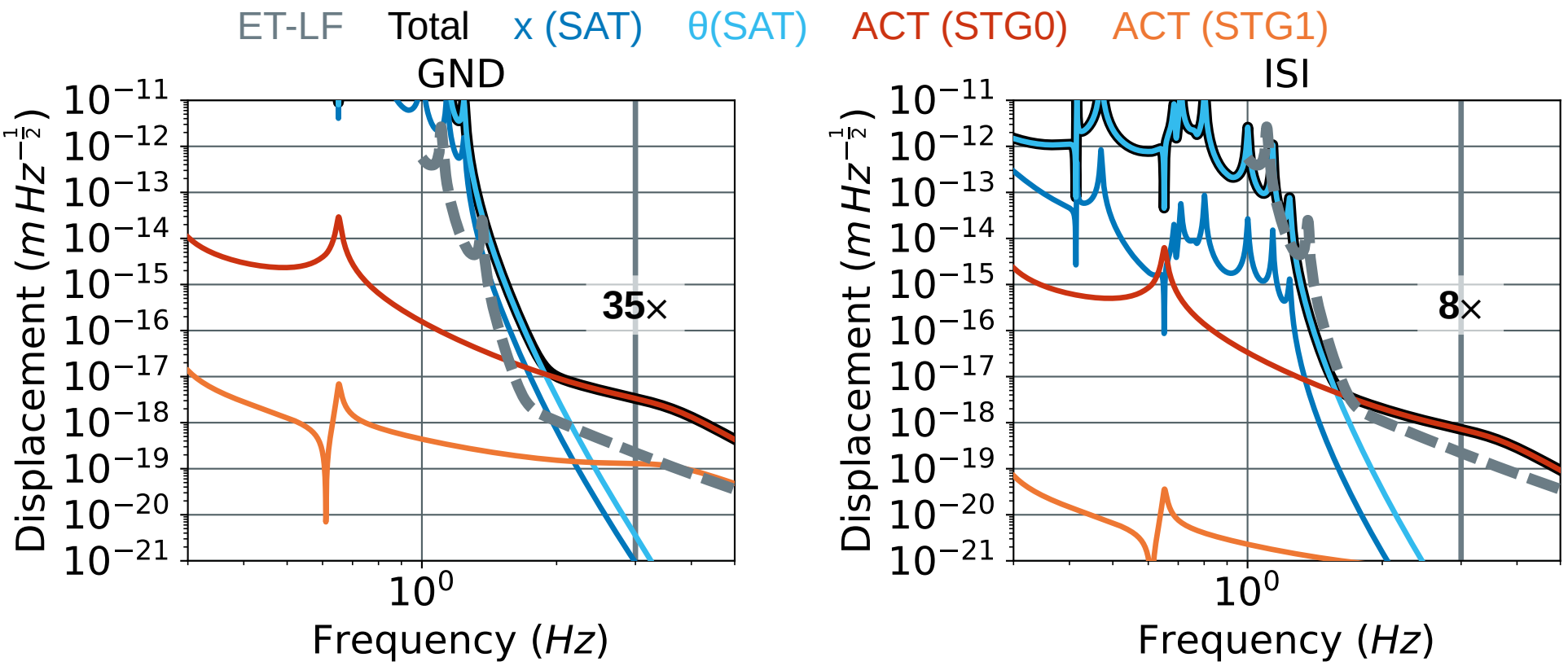
Max Disp × Dynamic Range × Mech TF

- Max Disp – from SAT × (ISI) × GND
- Dynamic Range – from DAC, voltage reference (LTC6655).
- Mech TF – from PAY model.

This model is very optimistic.

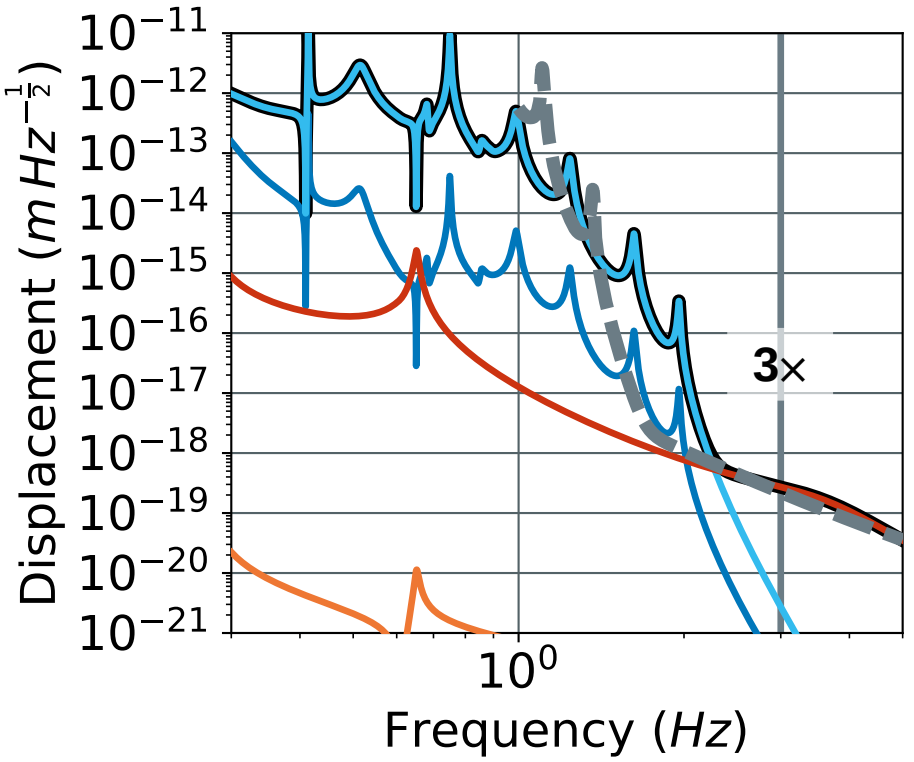


Pulling it all together – ET-LF



Damped Virgo SAT

- Damped Virgo SAT on an isolated ISI.
  - More realistic.
- Still **fails to meet ET-LF requirements.**
- Definitely worth further investigation.
  - e.g. redistribute drive.
  - Damp other SAT designs.



Conclusions

- This is **starting** to pull design solutions, and reflect them back onto design requirements.
  - How much actuation, and where, can we tolerate in ET-LF?...
- Optimistic current models **fail by > 10**×.
- Still more to improve, in this work; e.g. compare other large ventilated caverns, different control strategies for ISI/GND.
- SAT control makes a significant difference – a MIMO, SAT model is required.
- SAT will need to accommodate control at multiple stages.
  - Damping will have to be better than AdVirgo and aLIGO.