Study on the Vertical Separation between Suspension Points & Center of Mass
(in Type-B Suspension System, for Recycling Mirrors)

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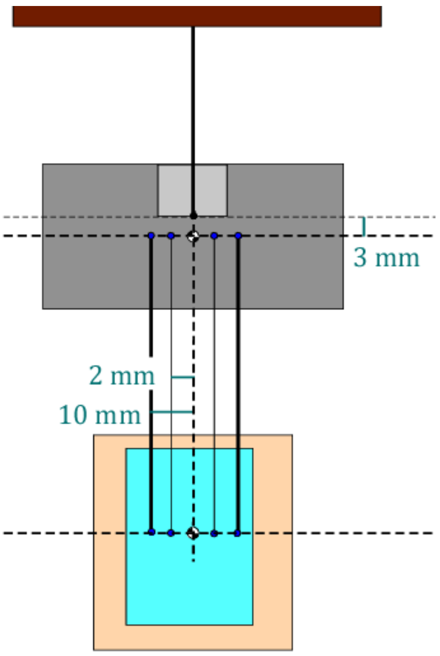
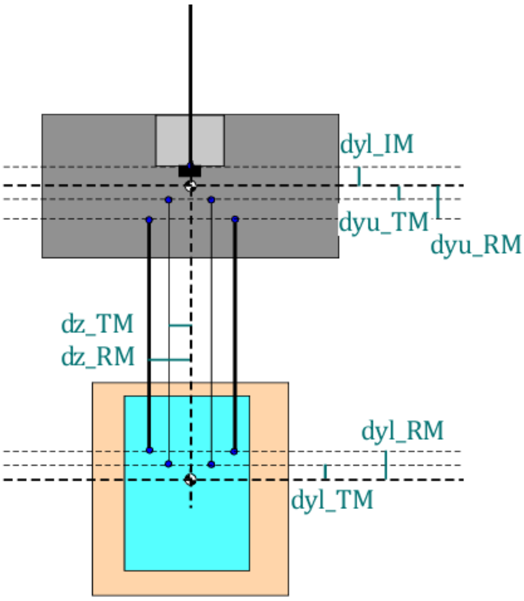
1. Payload Part (IM+RM+Mirror)





"Default" design :

dyl_IM=3 mm

dyu_TM=dyu_RM=dyl_TM=dyl_TM=0 mm

dz_RM=10 mm, dz_TM=2mm

wire thickness (diameters):

dw_IM=0.80 mm, dw_RM=0.60 mm, dw_TM=0.20mm

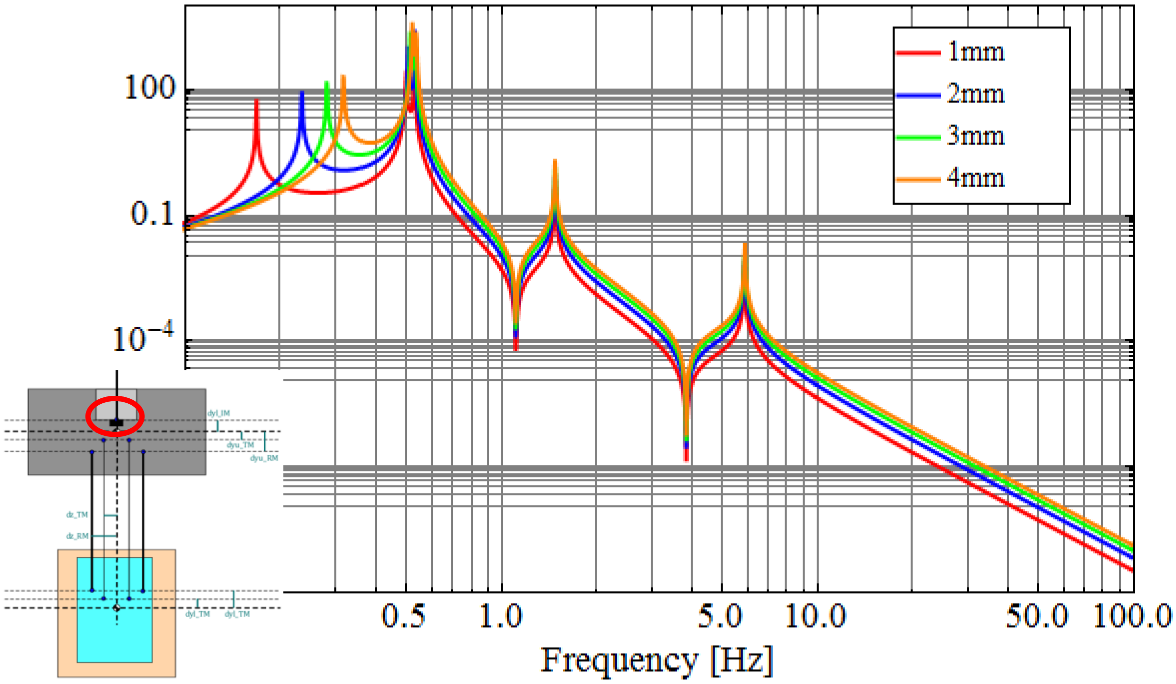
wire length:

lw_IM=lw_RM=lw_TM=500 mm

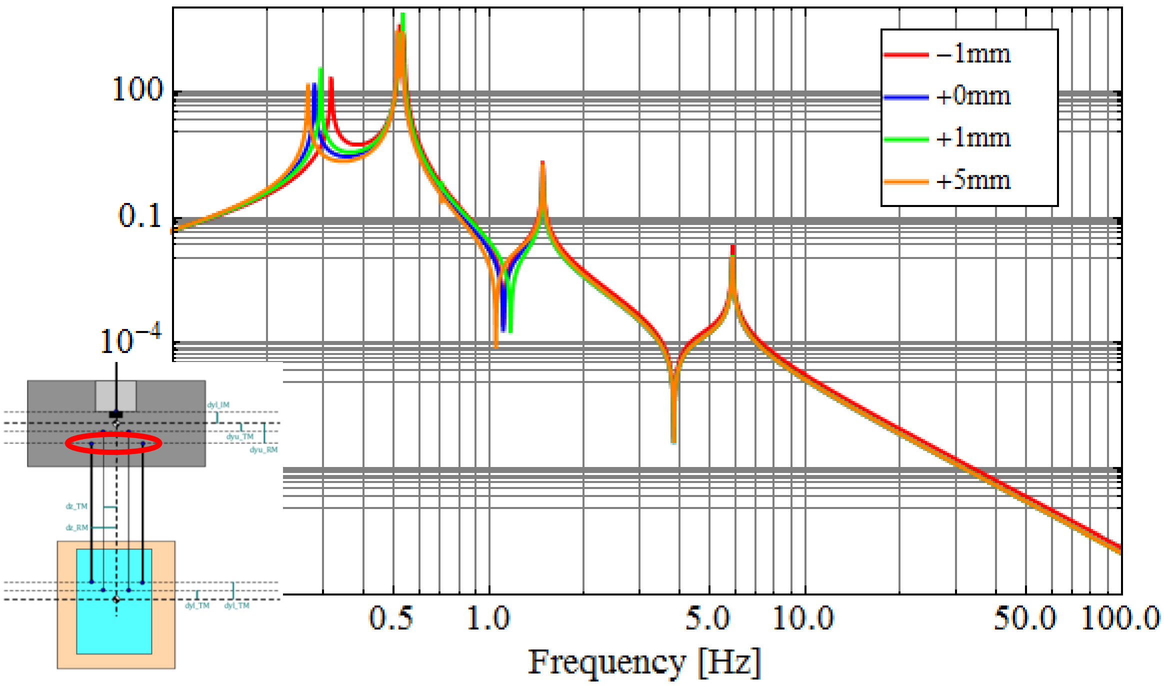
(Note: in the above definitions, suspension point = bending point of the wire)

The following plots are the transfer functions, from the top motion (in longitudinal direction) to the mirror pitch motion (z_ground → tx_mirror).

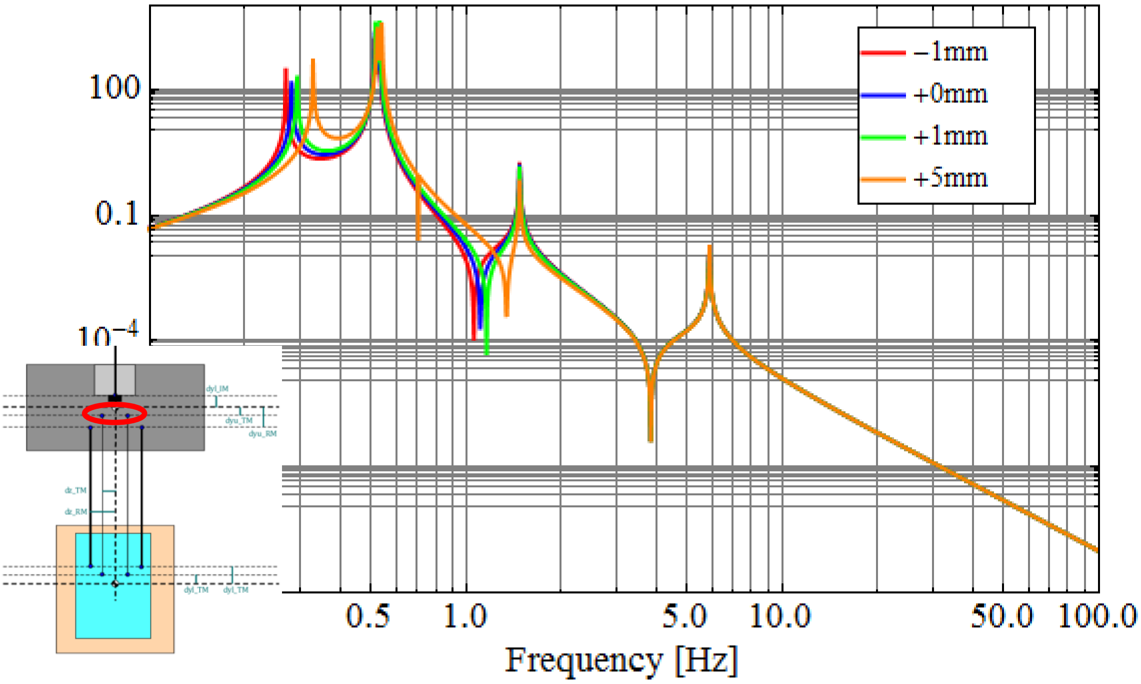
(1) dyl_IM dependence



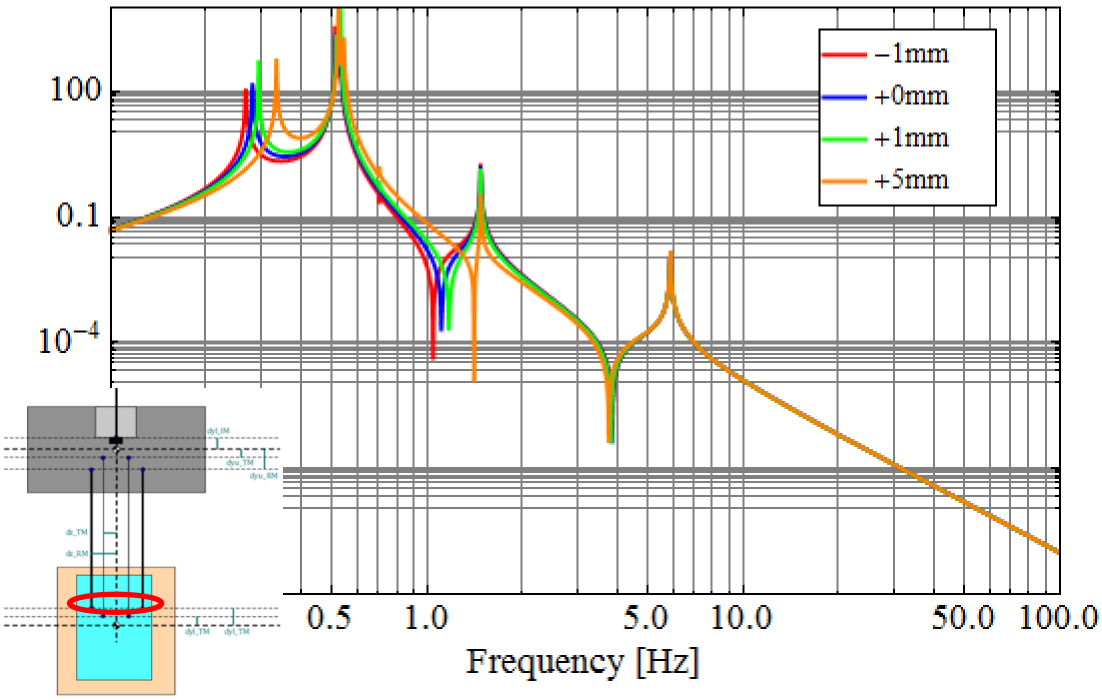
(2) dyu_RM dependence



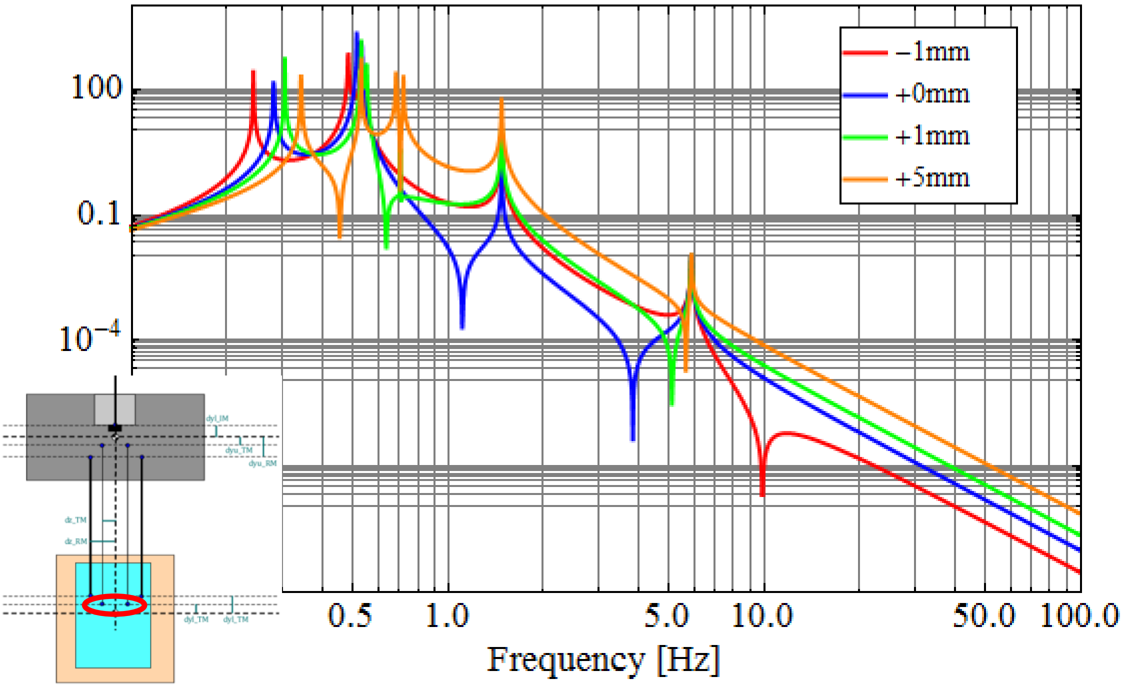
(3) dyu_TM dependence



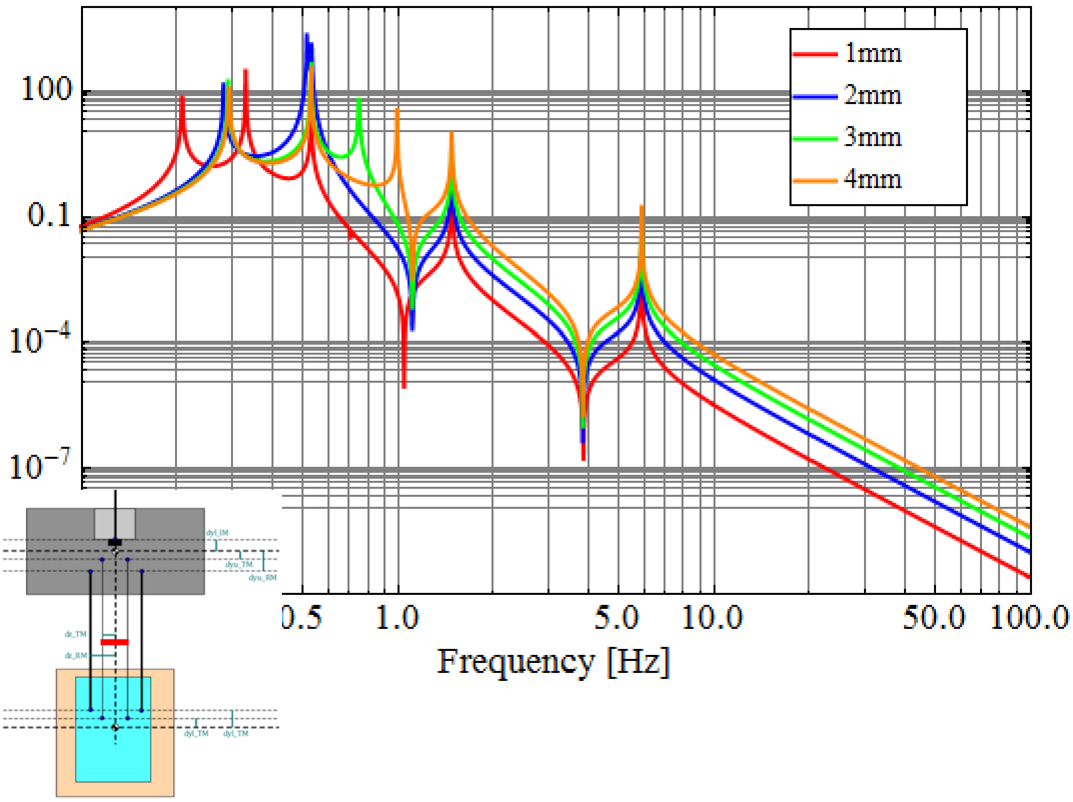
(4)dyl_RM dependence



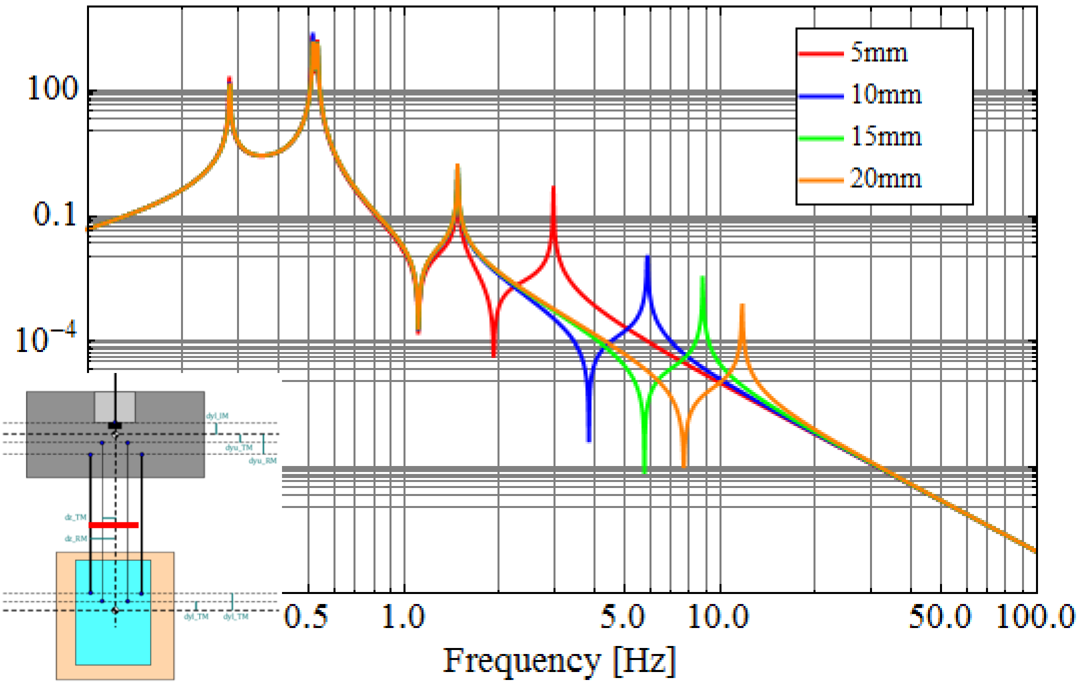
(5)dyl_TM dependence



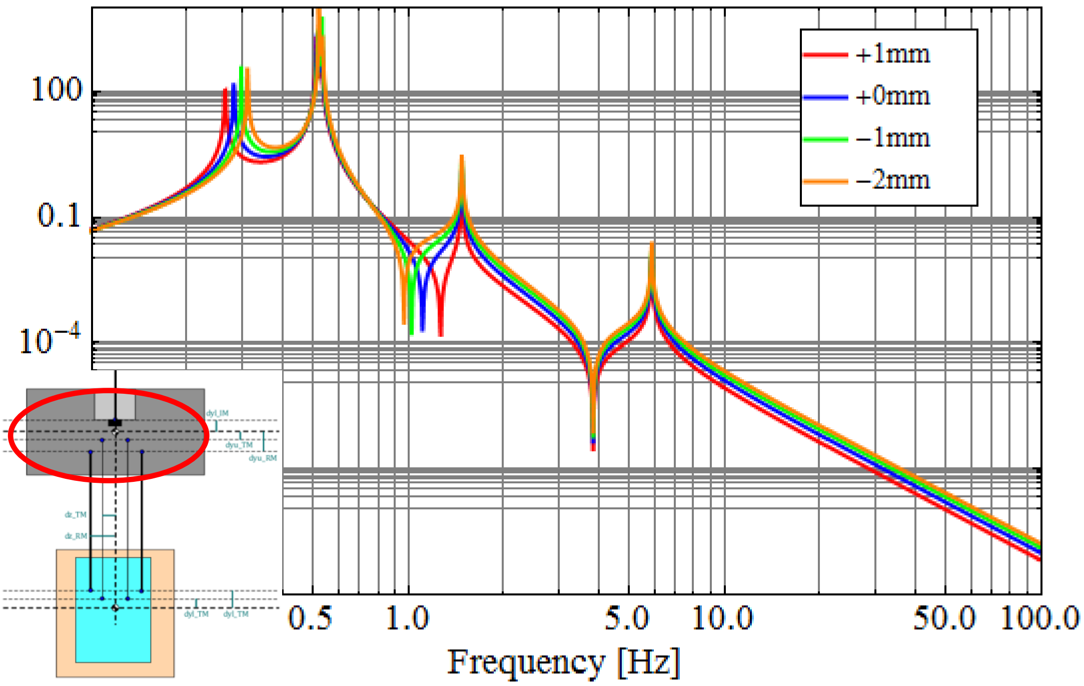
(6) dz_TM dependence



(7) dz_RM dependence



(8) Vertical position of CoM of IM

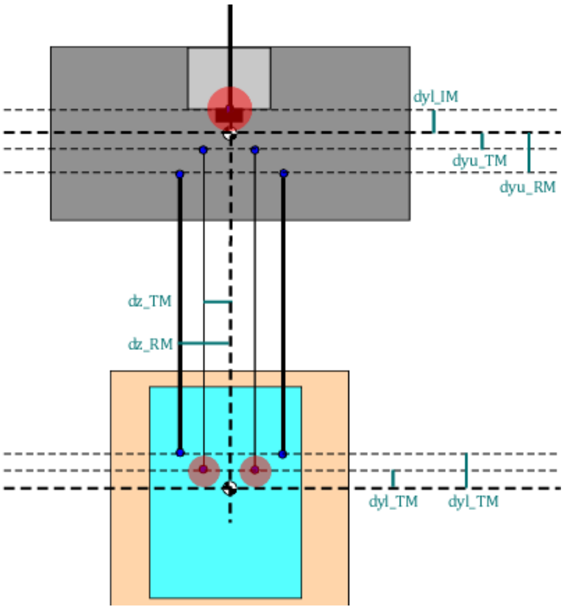


Discussion

Sensitive parts to the longitudinal-pitch transfer function are:

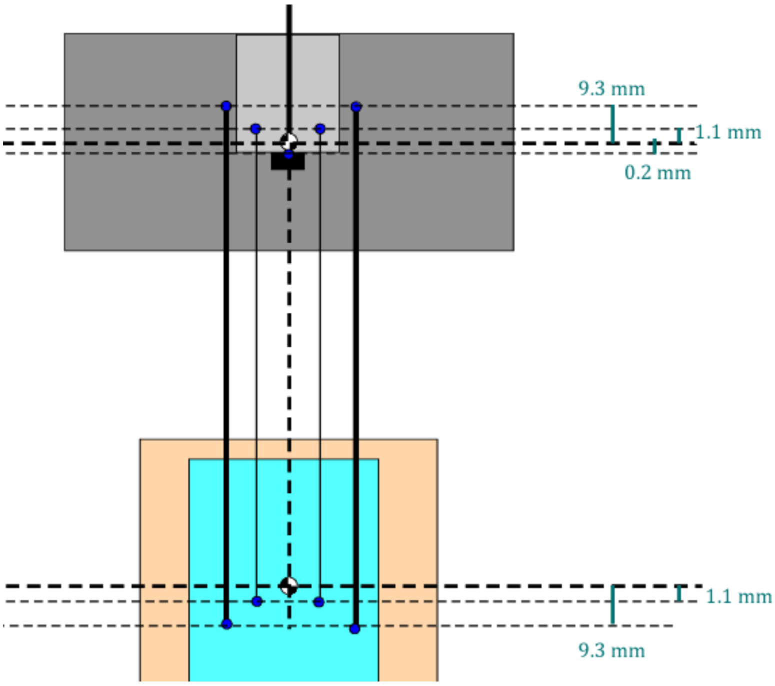
* Upper suspension point @ IM
* Suspension points @ Mirror

These parts must be carefully designed and tuned.

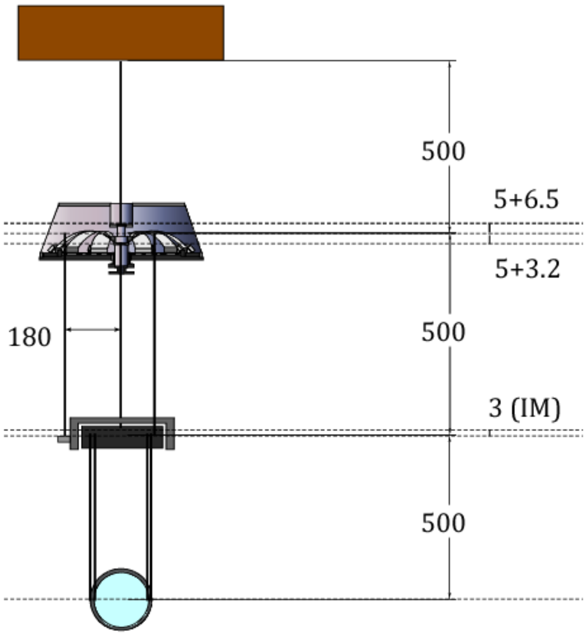


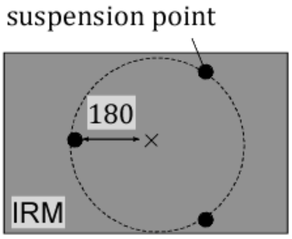
Due to the elasticity of wires, the suspension point and the effective bending point were separated by Sqrt[EI/T]. (E: Young's modulus, I: second moment of area, T: tension) After this compensation, the default design is corrected as:

dyl_IM=-0.2 mm
dyu_TM=dyl_TM =-1.1mm
dyu_RM=dyl_TM=-9.3 mm



2. IRM suspension





Default design:

dyl_F2=11.5 mm, dyu_IM=8.2mm, dyl_IM=3.0 mm,

dyu_IRM=dyl_IRM =0 mm

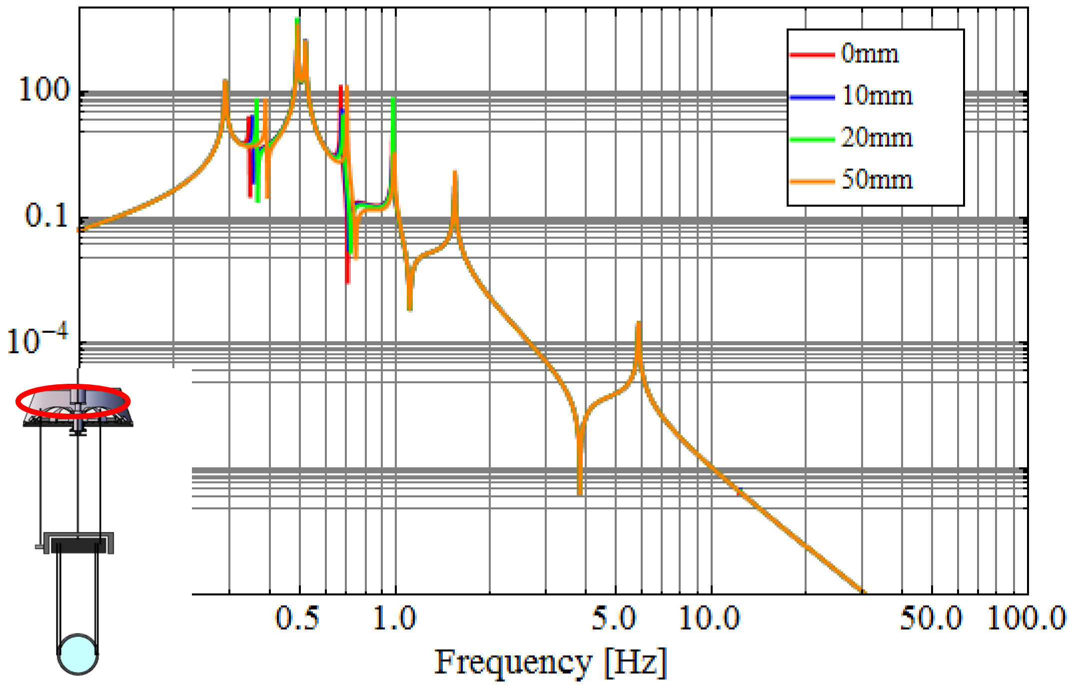
(Note: suspension point = bending point of the wire)

The intermediate recoil mass is suspended by three wires.
The horizontal distance between a wire and the center of mass is 18 cm.
(In the top view, the suspension points are on the corners of a regular triangle)

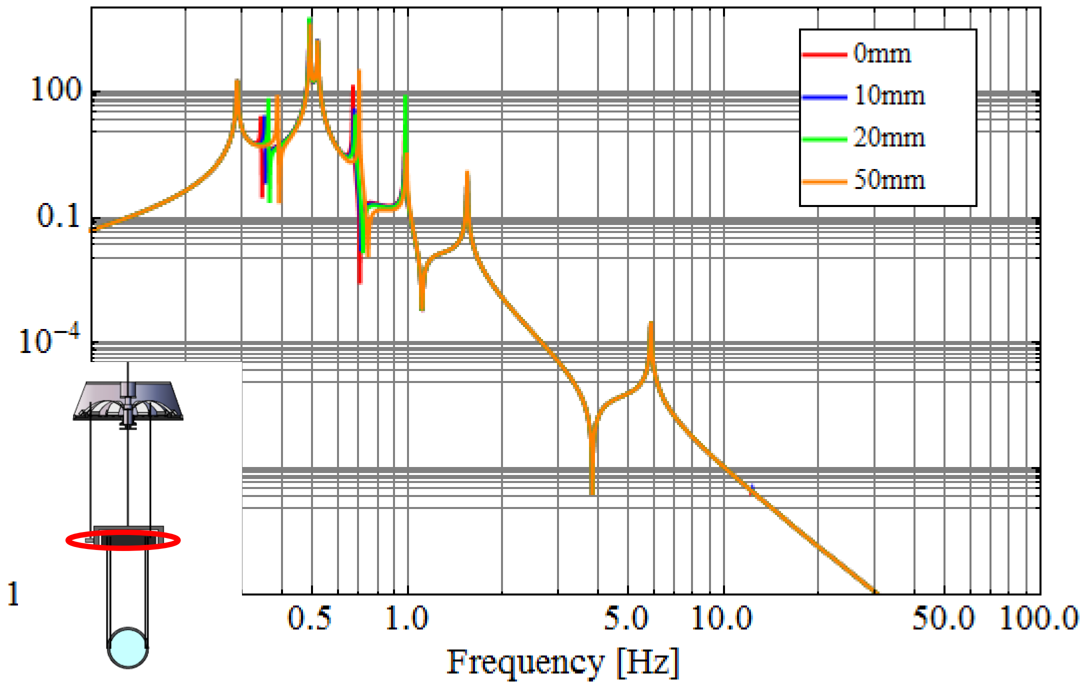
I assume 10 mm separation between the suspension points in the GAS filters. In the above design, the CoM of the filter is positioned at the center of the two suspension points. Due to the elasticity of the wires, the separation between the bending points of the wires is larger than 10 mm.

The following plots are the transfer functions, from the top motion (in horizontal direction) to the mirror pitch motion (z_ground → tx_mirror).

(1) dyu_IRM dependence



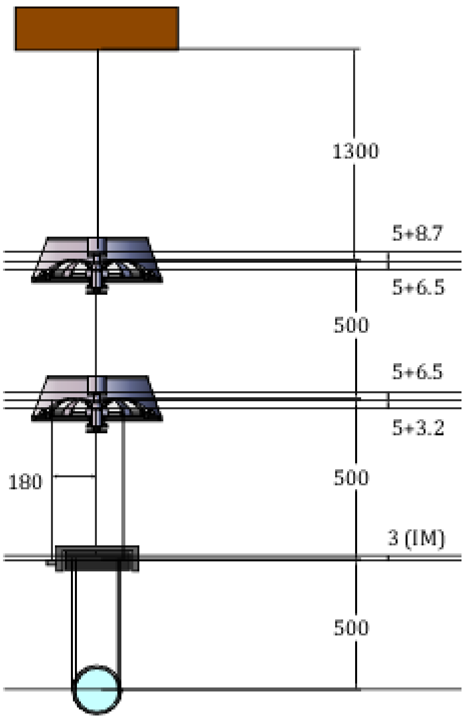
(2) dyl_IRM dependence



Discussion

Changes in vertical positions of the suspension points on the IRM suspension do not change the performance of SAS so much.

3. GAS Filters

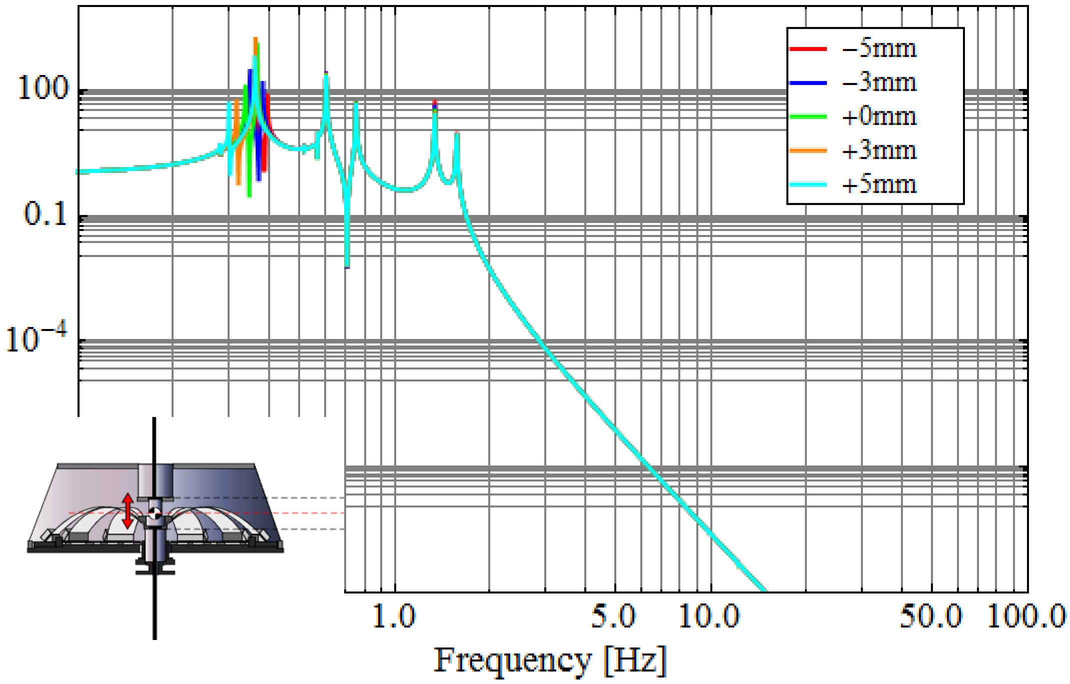


Default design:

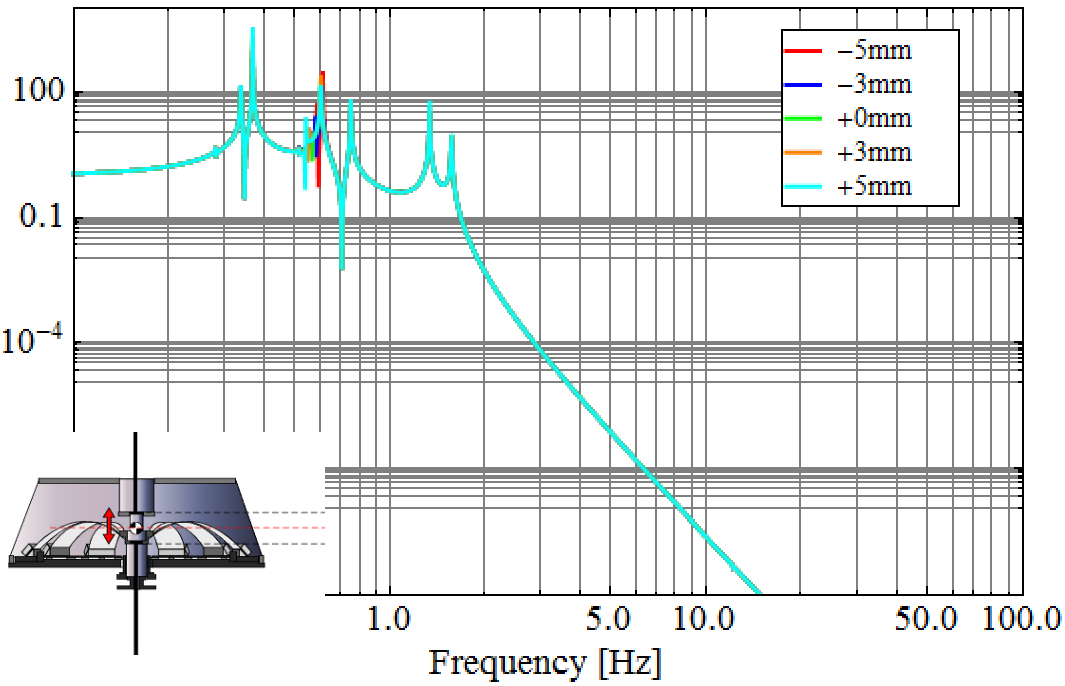
dyl_F2= dyu_F2=11.5mm, dyl_F1=13.7mm

Transfer functions, from the ground longitudinal motion to the mirror longitudinal motion (z_ground → z_mirror)

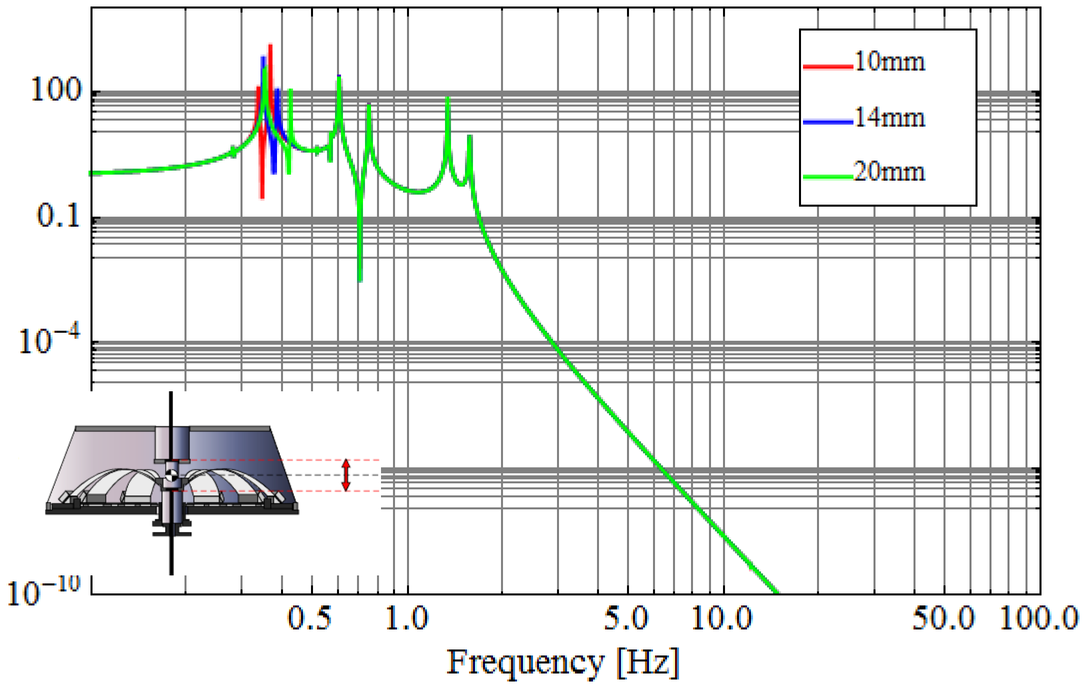
(1) Vertical position of CoM at F2



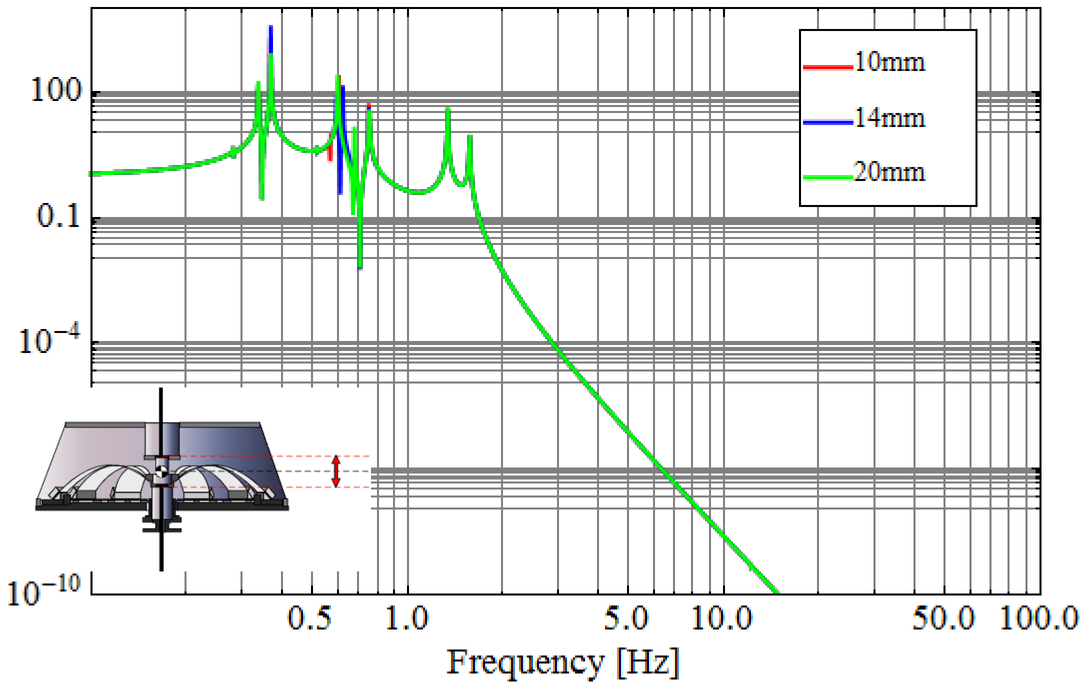
(2) Vertical position of CoM at F1



(3) Separation between two suspension points at F2

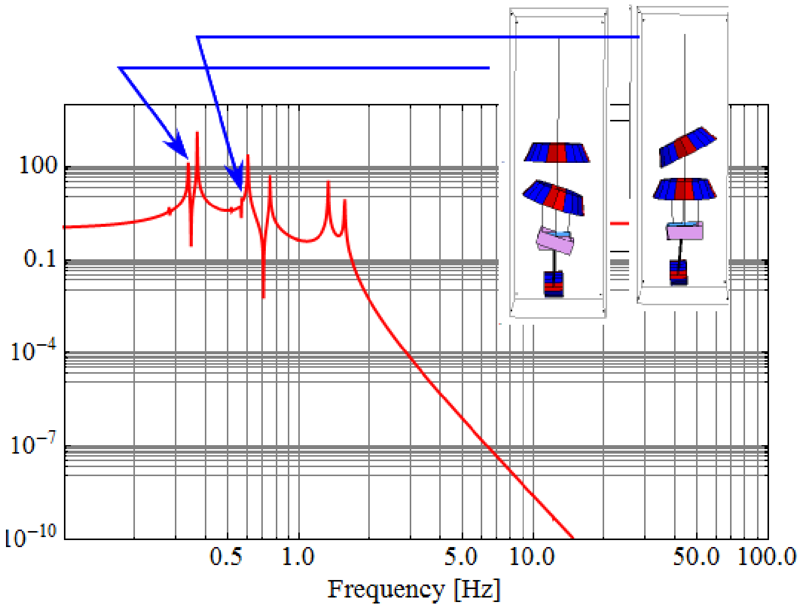


(4) Separation between two suspension points at F1



Discussion

The vertical position of CoM and the distance between two suspension points in a GAS filter, determine the resonant frequency of the pitch mode of the GAS.



These resonances produce peaks and notches in transfer functions, but they are not harmful if the peaks are not sharp.

The pitch resonance of the bottom filter may be damped by an active control, using sensors and actuators on IM & IRM.