Performance test of the type B suspension payload prototype for KAGRA

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Outline

- Goal of the presentation.
- The payload.
- The displacement sensor and actuators (OSEMs).
- Assembly of the prototype and changes to the design.
- First measurements.
- Conclusions and future work.

Goal of the presentation

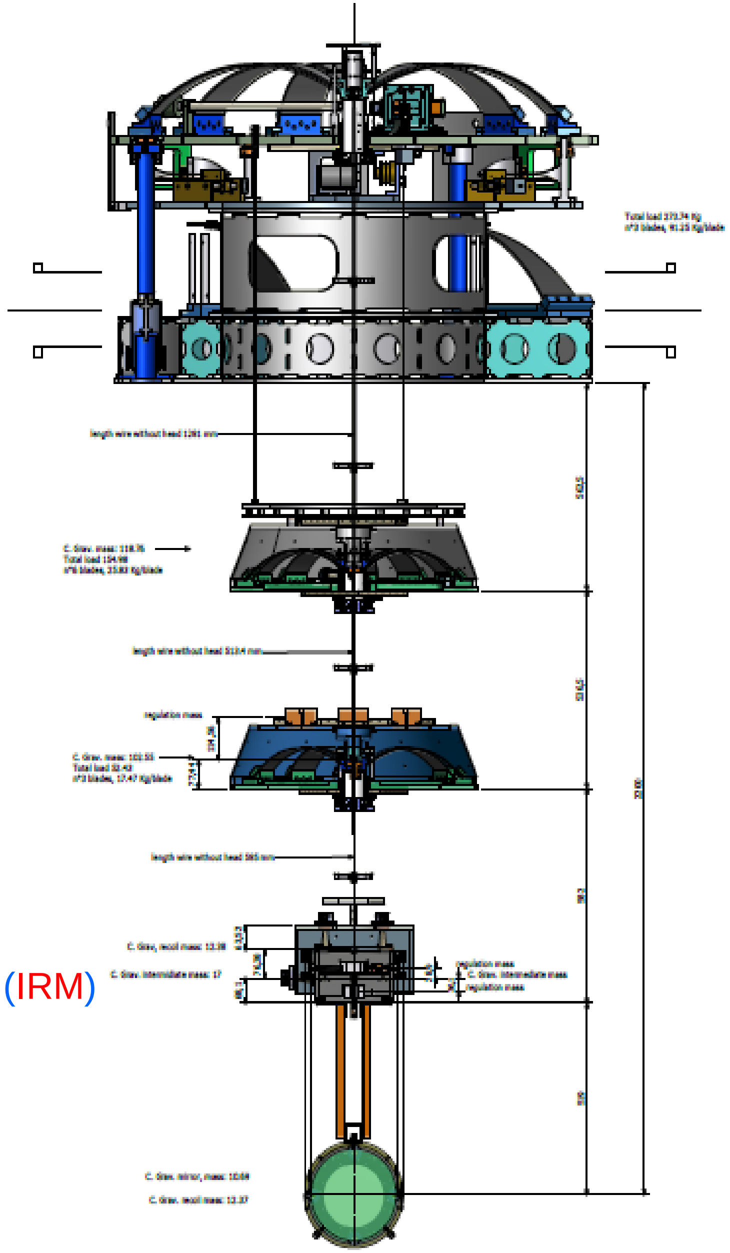
- An overview of a stage between placing the components in their nominal positions and making them work together as a single machine.
- This stage mainly comprises assembly and changes to the mechanical design.

Seismic Attenuation System SAS (Type-A/B)

Pre-isolator (PI)
- Top Filter (TF)
- Inverted Pendulum (IP)

Filter chain
- Standard Filter (SF)
  Filter1~3 in Type-A
  Filter1 in Type-B
- Bottom Filter (BF)

Payload (PAY)
- Intermediate Mass (IM)
  Intermediate Recoil Mass (IRM)
- Test Mass (TM)
  Recoil Mass (RM)

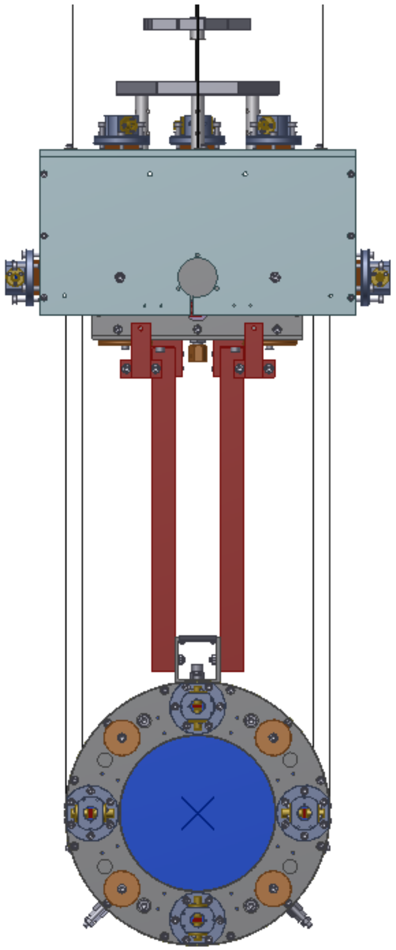


The payload

- Test mass
- Recoil mass
- Intermediate mass (marionette)
- Intermediate recoil mass
- 10 OSEMs

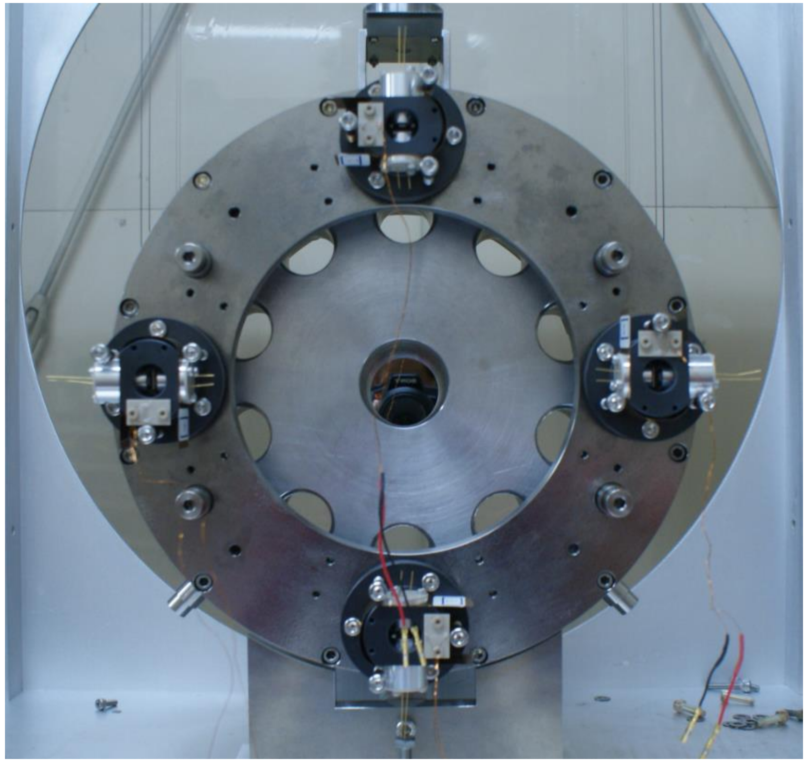
Test mass: 200 µm steel wire.

Recoil mass: 600 µm tungsten wire.

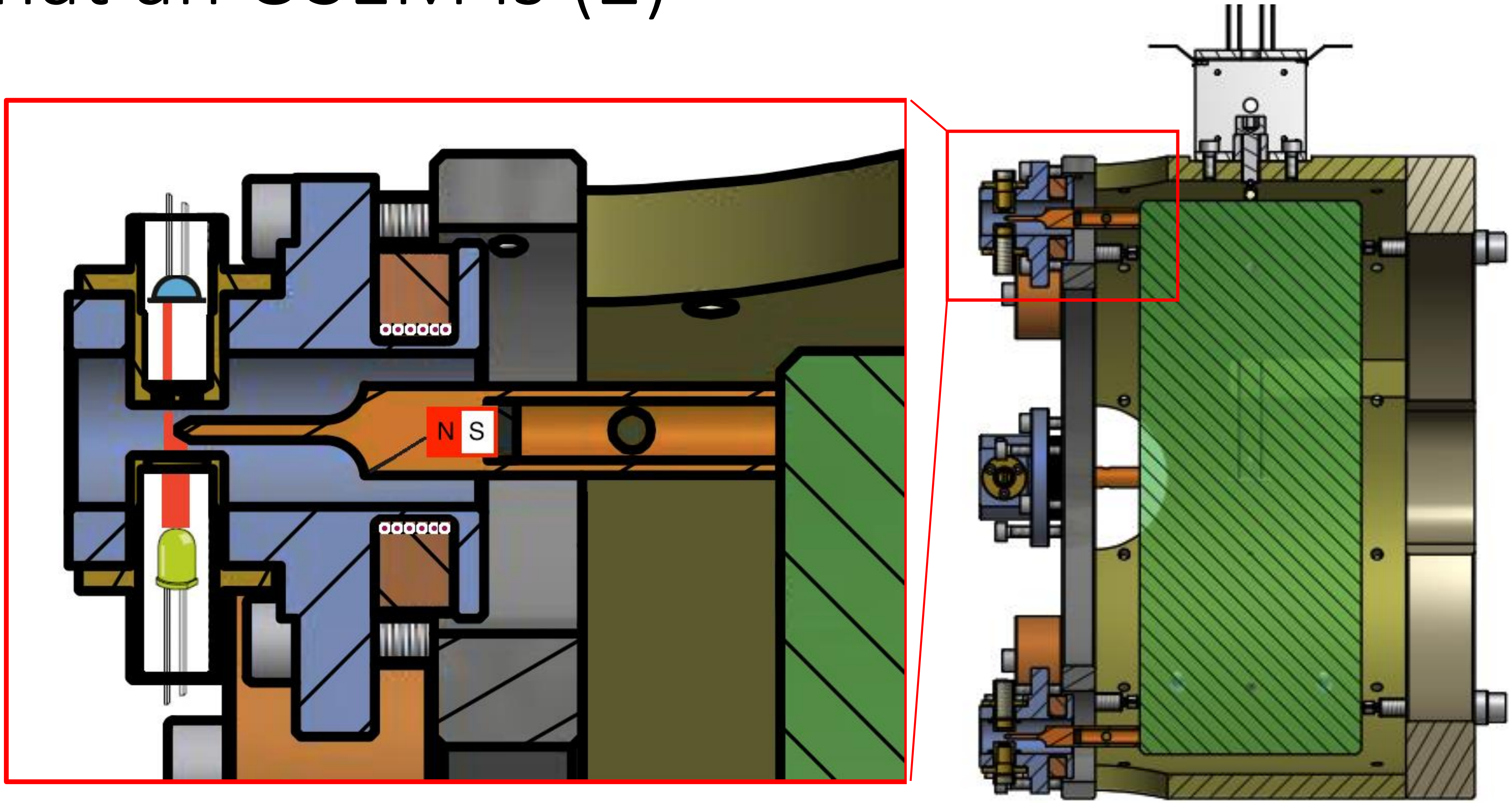


What an OSEM is (1)

- The position of the TM with respect the RM is measured with displacement sensors called OSEMs.
- The displacement measurement is achieved with a shadow sensor.
- Forces are applied using a coil magnet actuator.
- OSEM stands for Optical Sensor and ElectroMagnetic actuator.

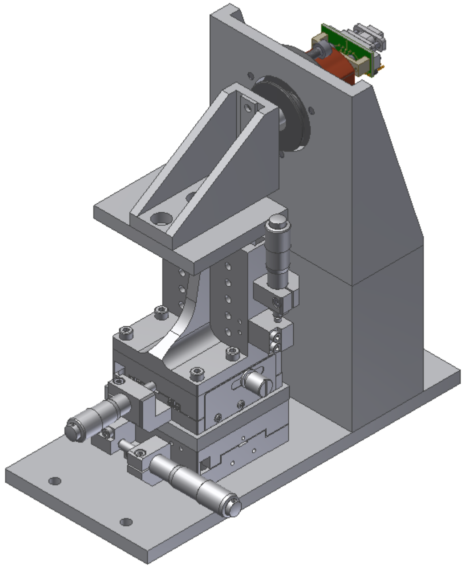


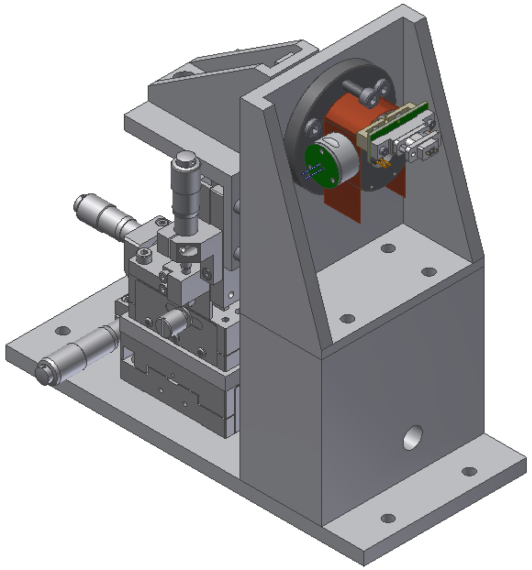
What an OSEM is (2)

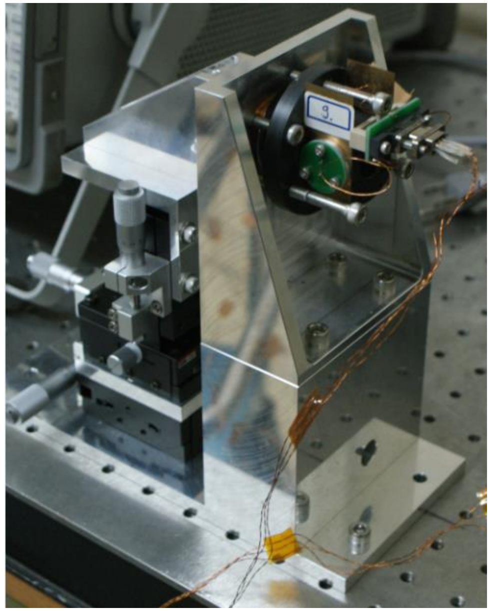


OSEM Calibration (1)

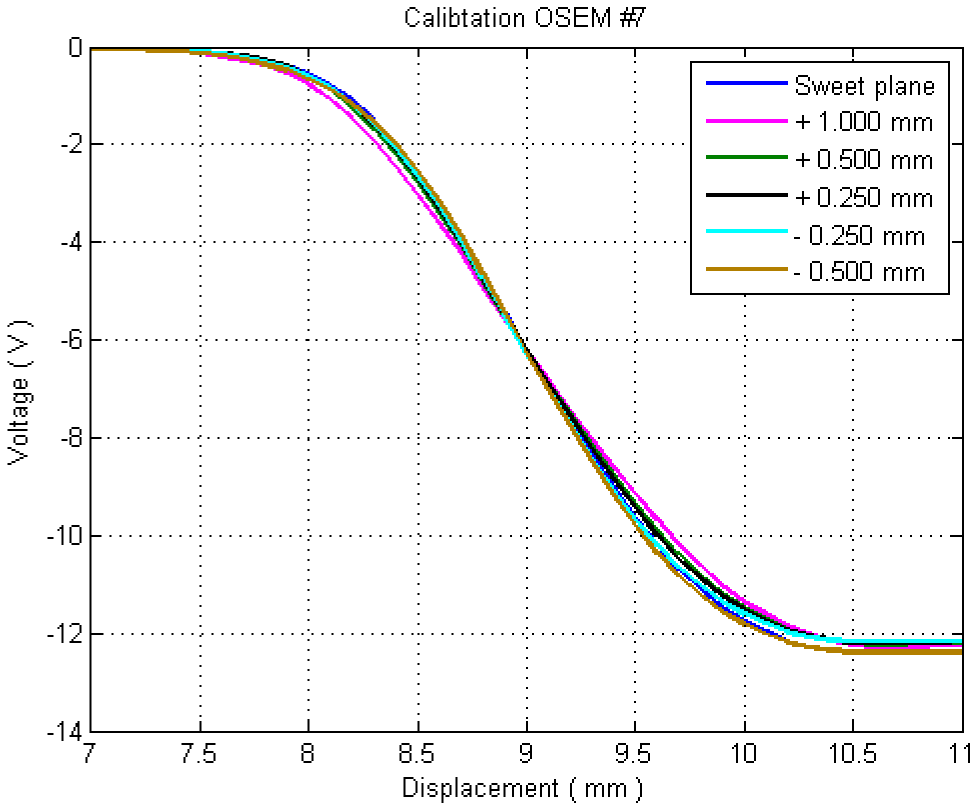
3 DOF calibration stage



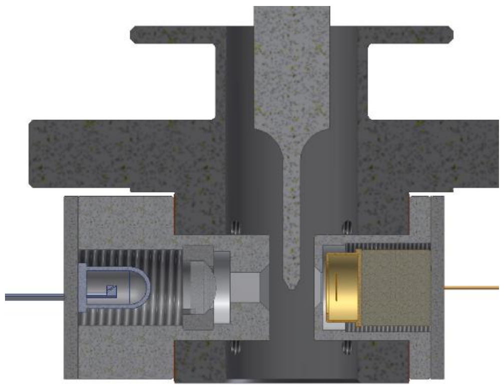




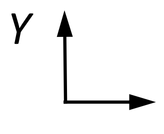
OSEM Calibration (2): OSEM #9 as an example



For three different position of the flag along the ***X*** direction (0 and ± 400 μm), three different calibration curves were generated by moving the flag along the ***Y*** direction.



Y: displacement during operation
X: set during alignment

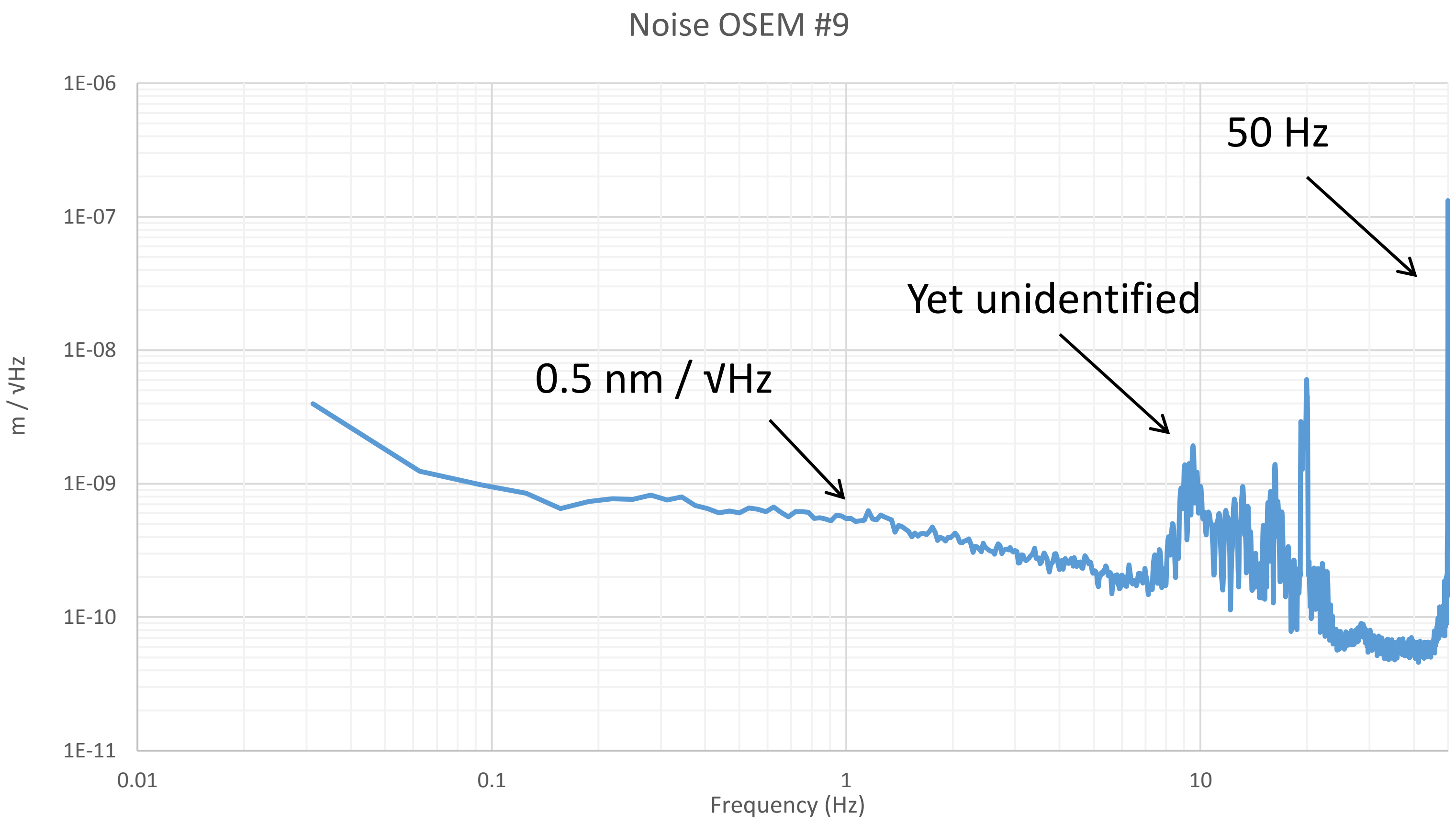


Calibration factor: **-6.737 V/mm**.

Displacement range (linear regime along *Y*): **1 mm**.

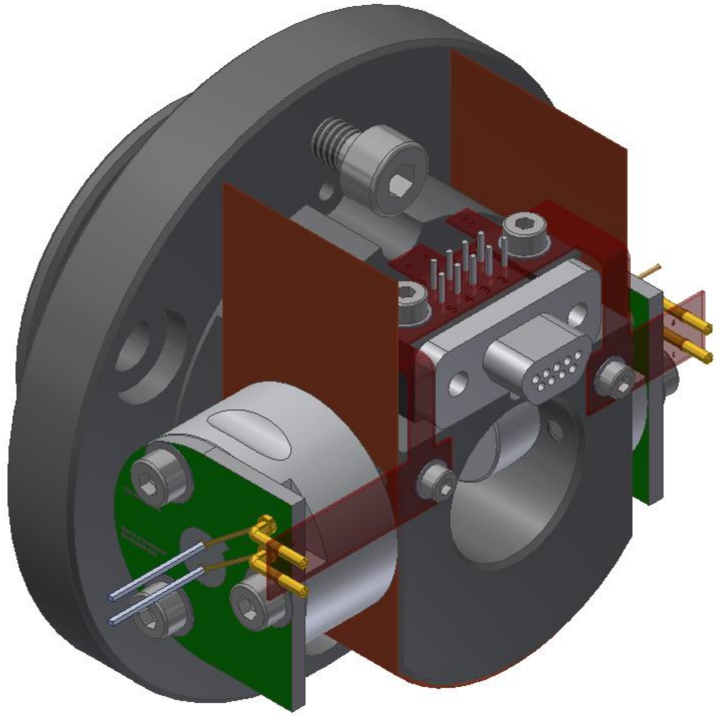
Alignment range (along *X*): **± 400 μm** with a **±3.8%** error.

OSEM Sensitivity: preliminary data



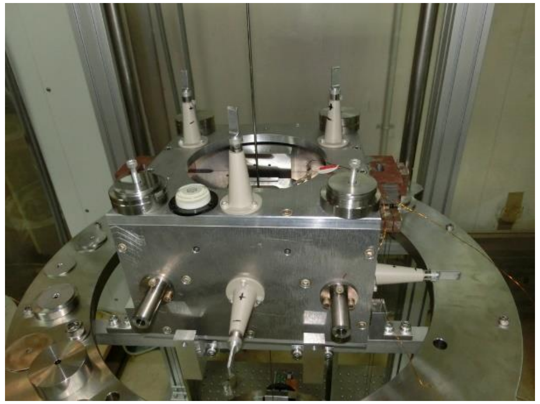
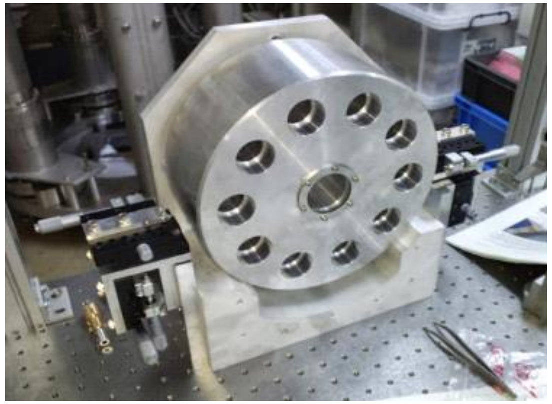
Current status

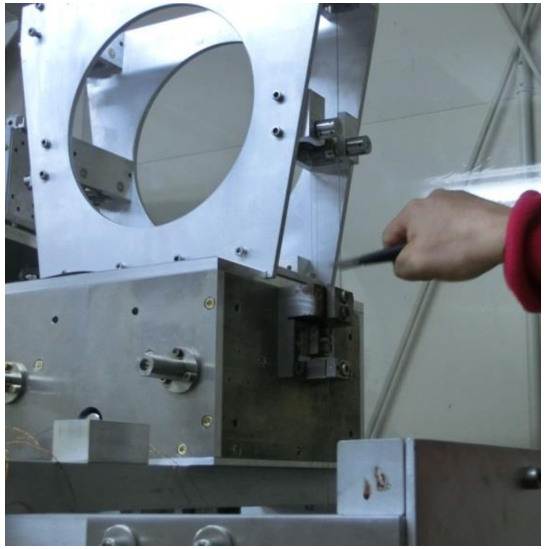
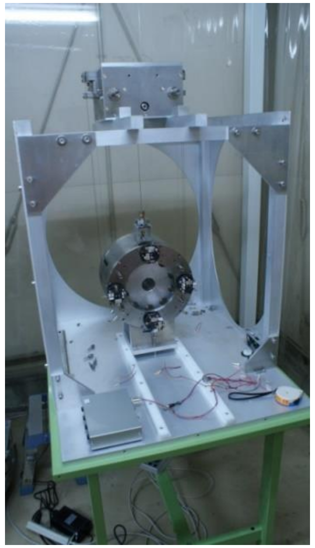
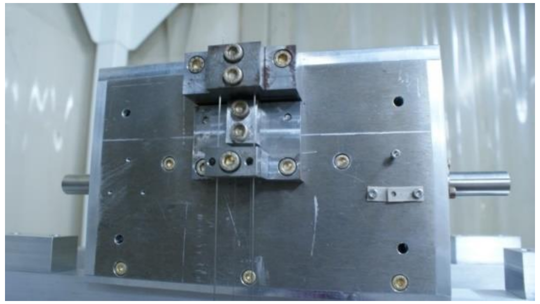
- Measurement range 1 mm.
- Error in calibration factor: 5% within ±400μm.
- Noise: 0.5 nm/√Hz at 1 Hz
- Un upgraded version has been designed.
- OSEM body is in production now.
- We are in the process of improving the electronics.
- Estimation of the noise budget.



New version of the OSEM

Assembly of the payload

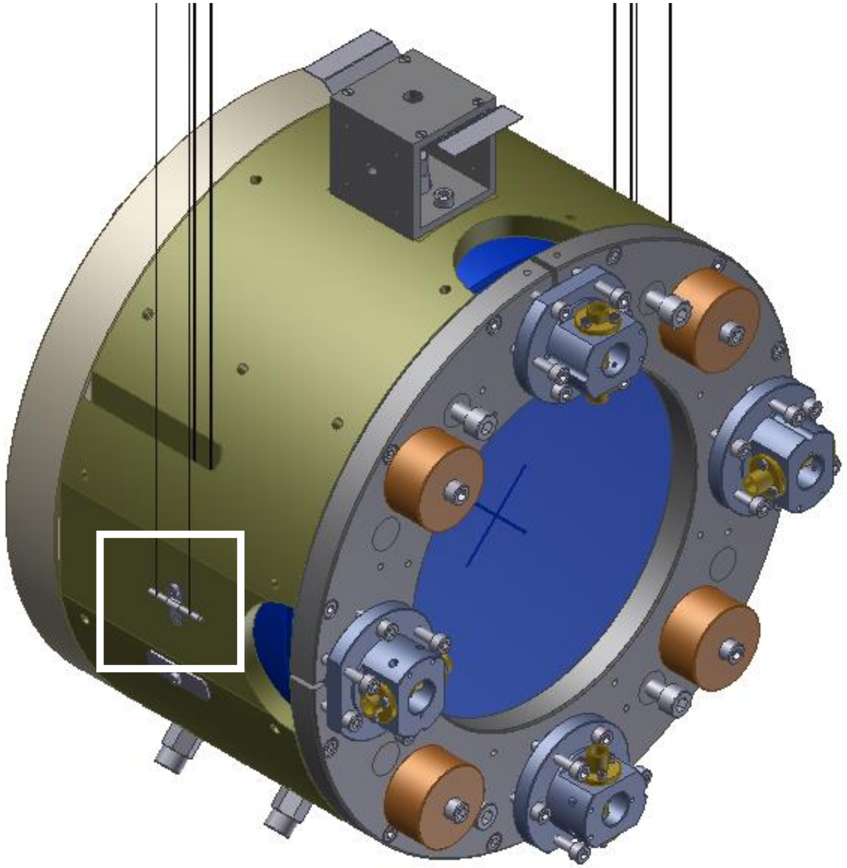





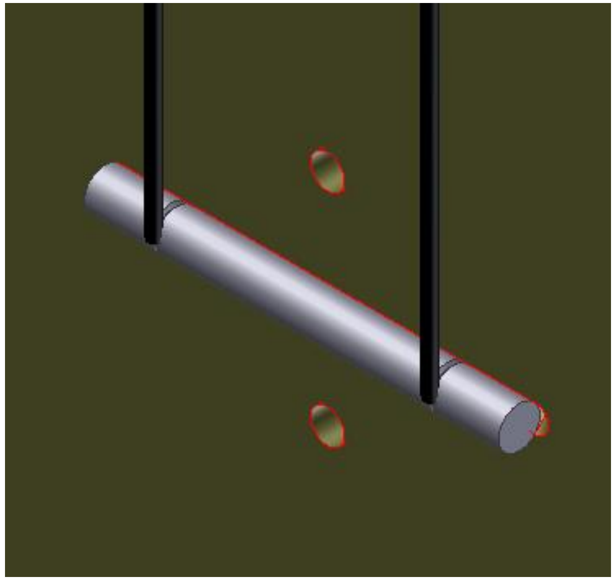
Problems with the payload

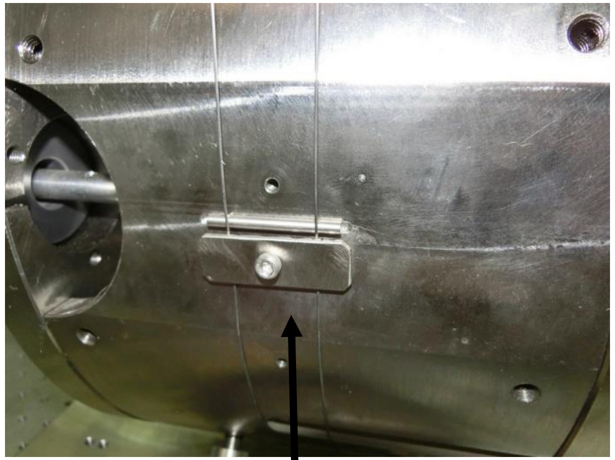
- The suspension wires of the RM easily went off the wire breakers, making the system unstable.
- The center of mass regulation masses within the IM was subject to too much friction.
- Every time we removed the suspension wire from the IM we had to adjust the center of mass again.
- The IRM is very hard to align: ± 400 μm in six degrees of freedom.

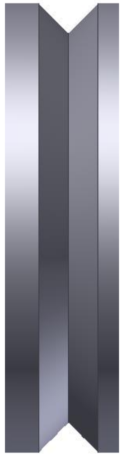
Wire breakers

- Upon a small roll of the RM the wires tended to go off the hosting grooves of the wire breakers, making the system unstable.
- New wire breakers have been designed.





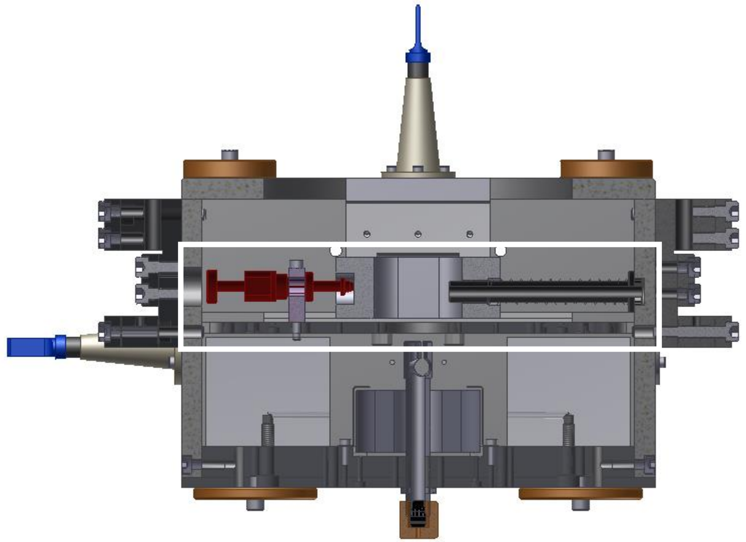


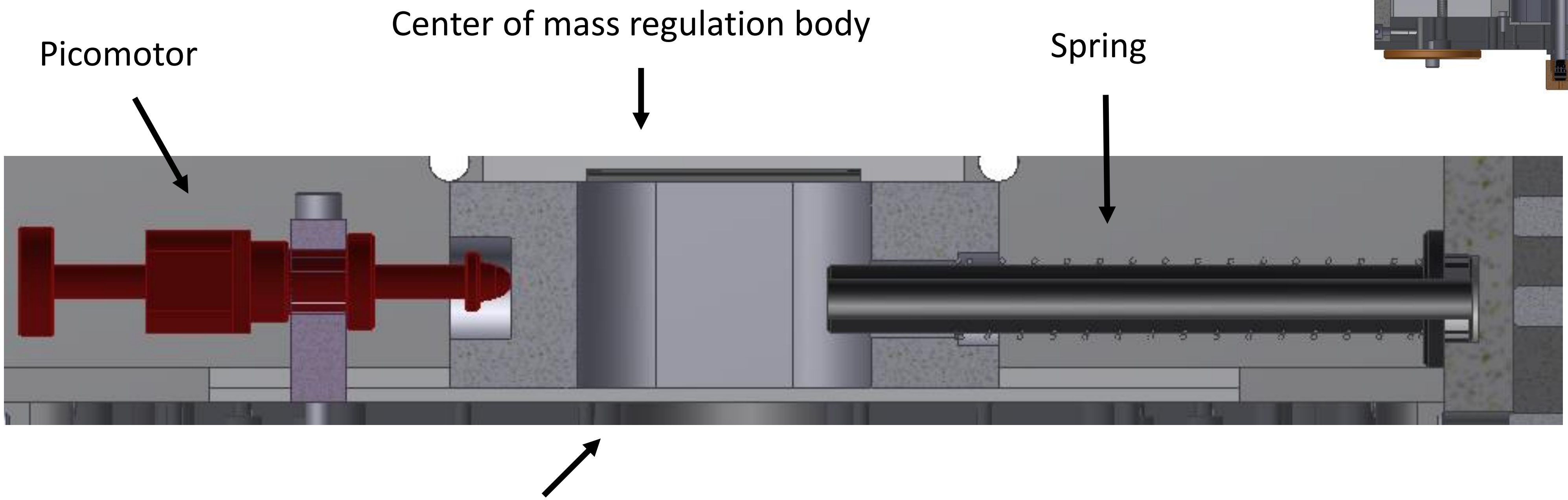


Depth of only 200 µm for a wire of 600 µm

We put a clamp under the wire breaker

Centre of mass regulation system



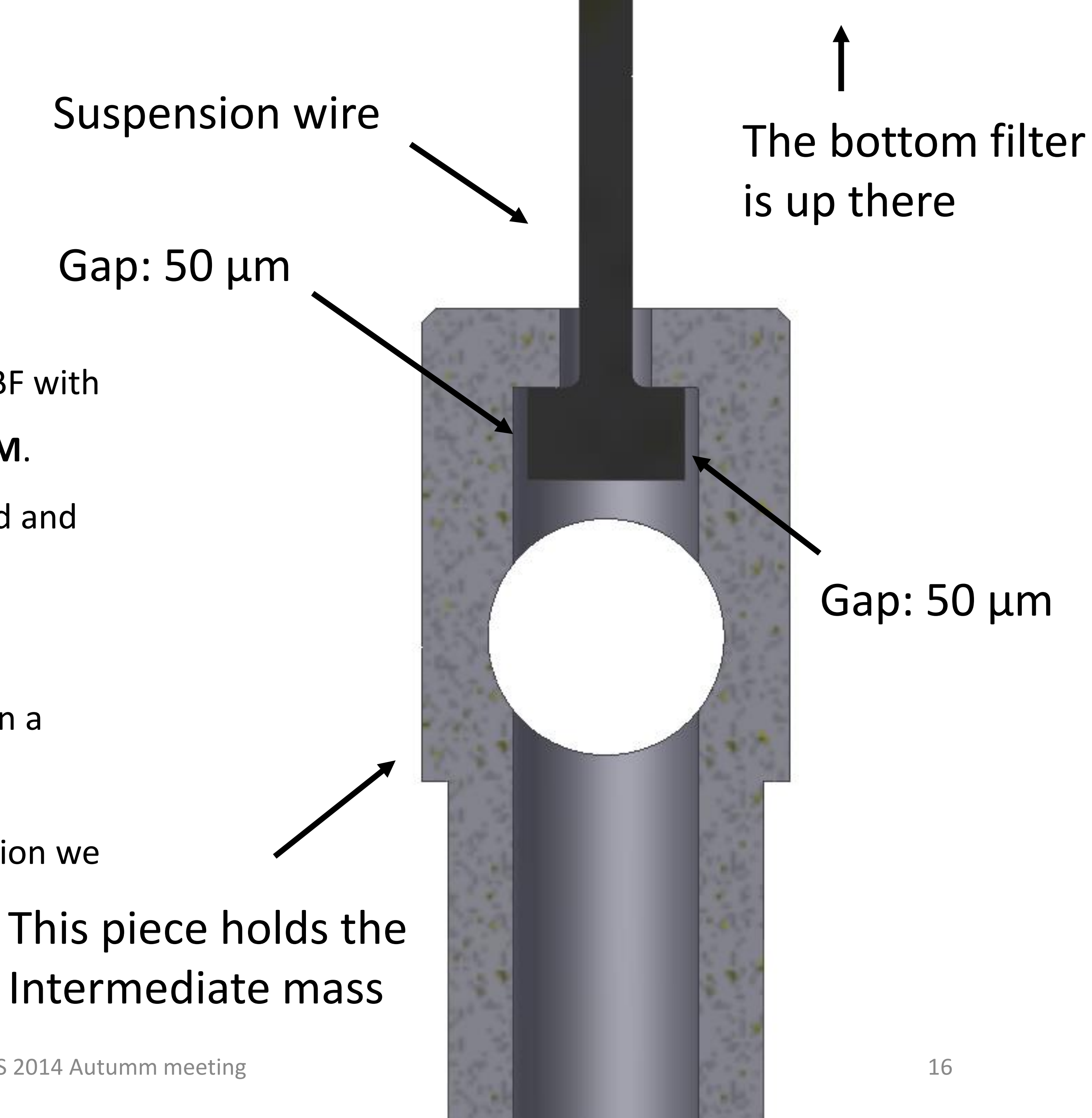


Too much friction between the regulation body (900 gr. of AISI 304) and the supporting plate (Al).

We put vacuum compatible grease in the prototype, but we will use peek supports in the final version.

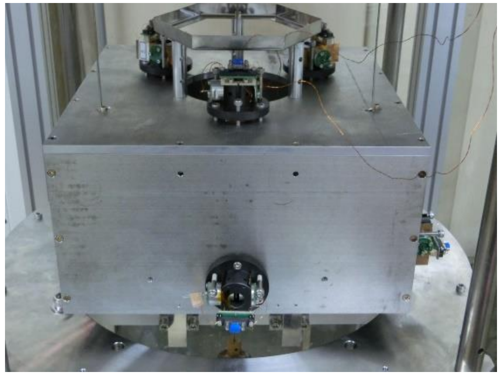
Hooking device

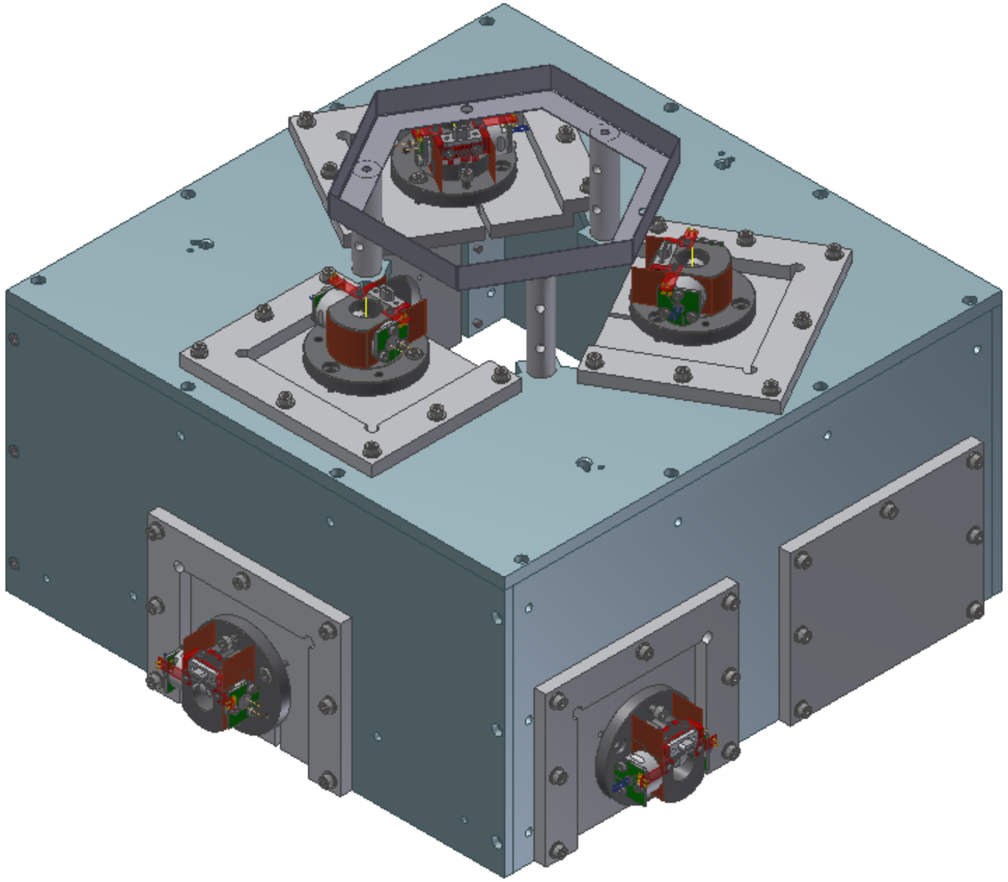
- The IM loses balance upon recoupling with the BF with the wire. **This is a problem when putting the IRM**.
- There is a gap of ±50 µm between the wire head and the cavity of the piece that hooks to it.
- Upon reassembly the head is always in a slightly different position rendering the centre of mass in a different place, producing thus a tilt.
- We should reduce the gap. As a temporary solution we put kapton tape around the head.



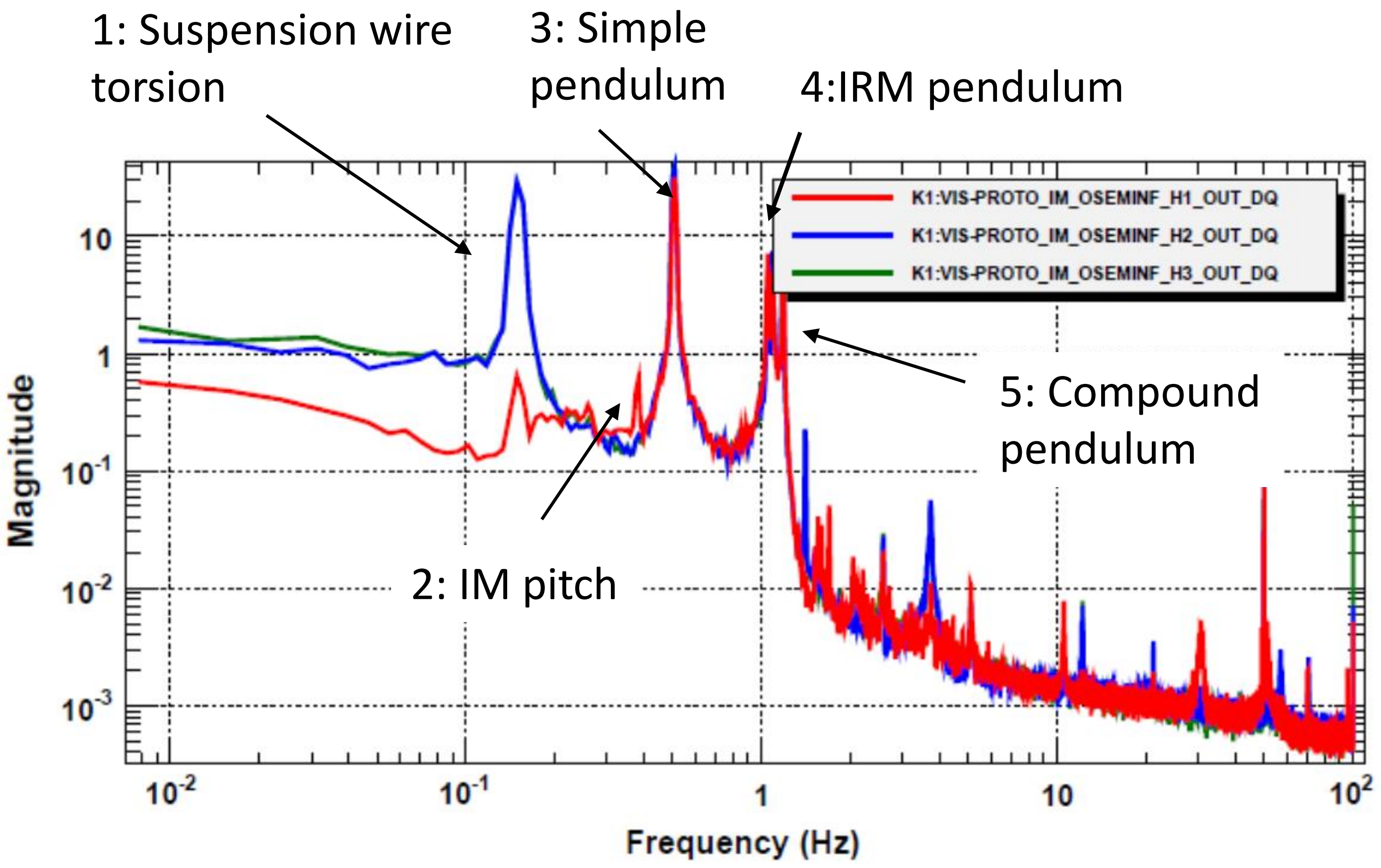
Intermediate recoil mass new design

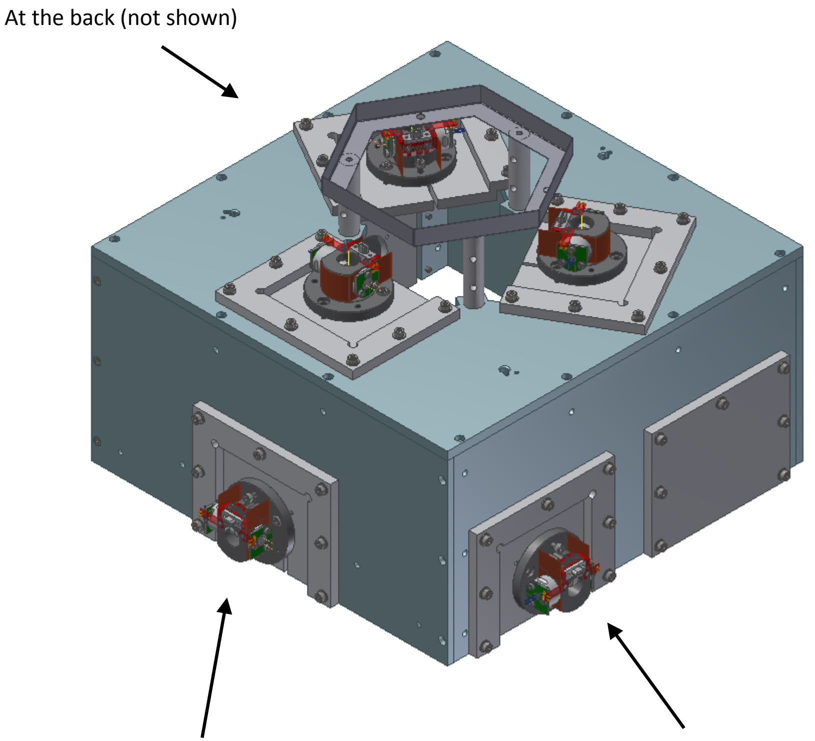
- The IRM is very hard to align: **± 400 µm in six degrees of freedom**.
- Each OSEM will be mounted on its own support and will be adjusted individually.
- The IRM must be initially aligned within **± 1.5 mm** from its nominal position.





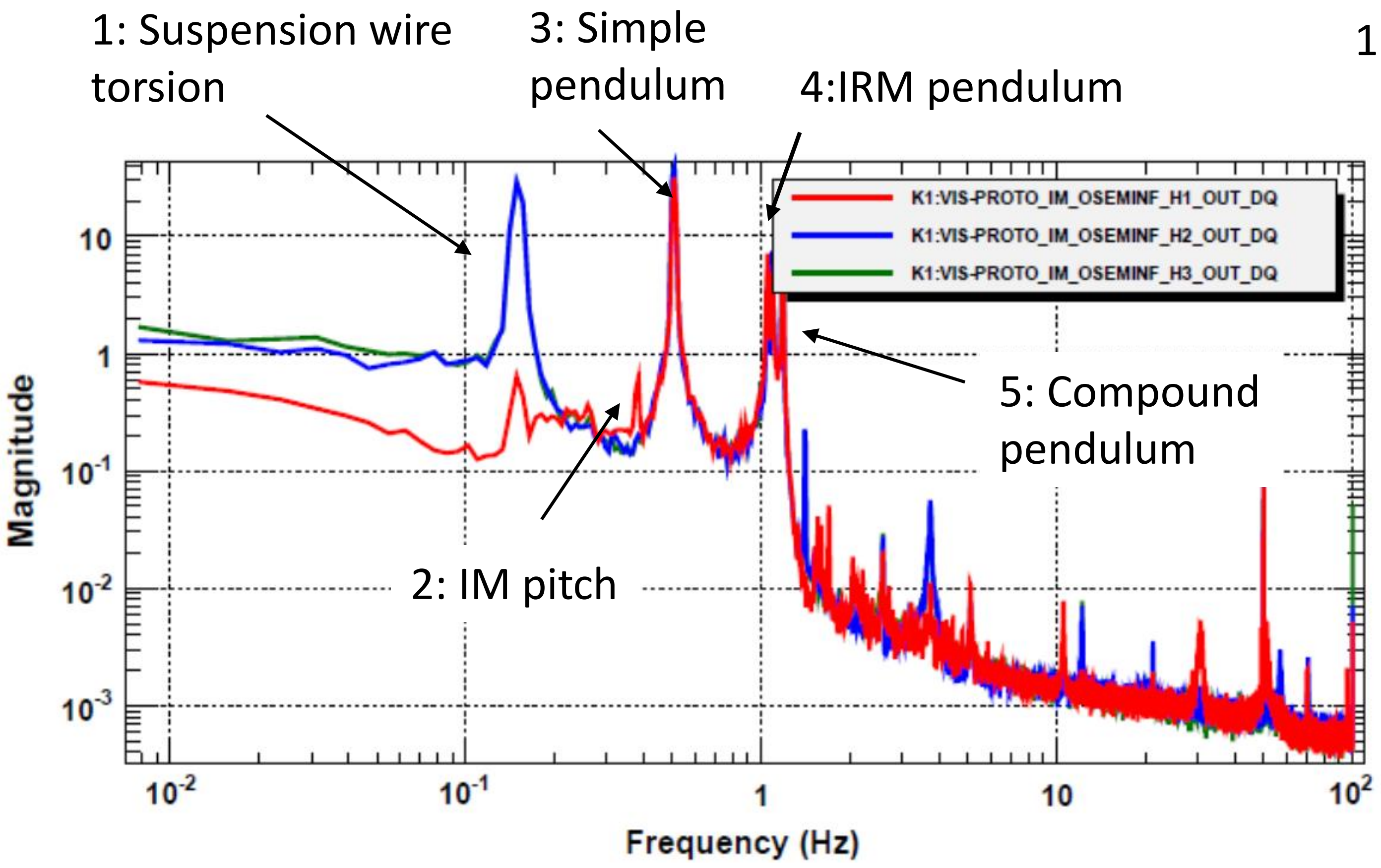
Preliminary measurements with the OSEMs (1)

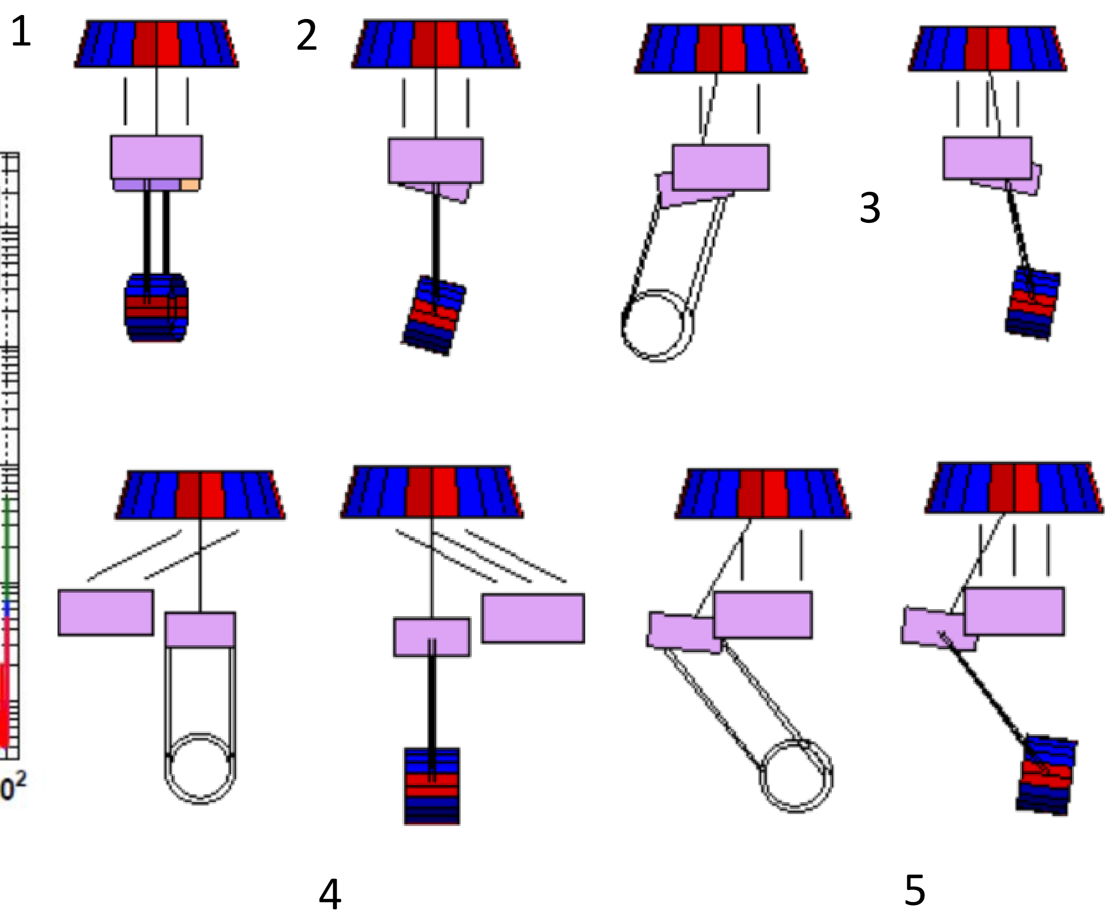




Measurements taken with three side OSEMs of the IRM

Preliminary measurements with the OSEMs (2)





Conclusions and future work

- OSEM: ±1 mm range, error in calibration factor of 5% within ±400μm, 0.5 nm/√Hz at 1 Hz.
- Mechanical changes:
  - We will increased the stability of the RM by modifying the wire breakers,
  - We increased the stability of the IM when moving the center of mass,
  - We increased the stability upon reassembly of the suspension wire in the IM,
  - We increased the alignment tolerance of the IRM from ± 400 μm to ± 1.5 mm.
- We have taken the first measurement and identified some of the predicted normal modes.
- Future (immediate) work: diagonalization of the degrees of freedom, active damping strategies using the OSEMs.