An Active Platform for the Inverted Pendulum of the Superattenuator

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Introduction

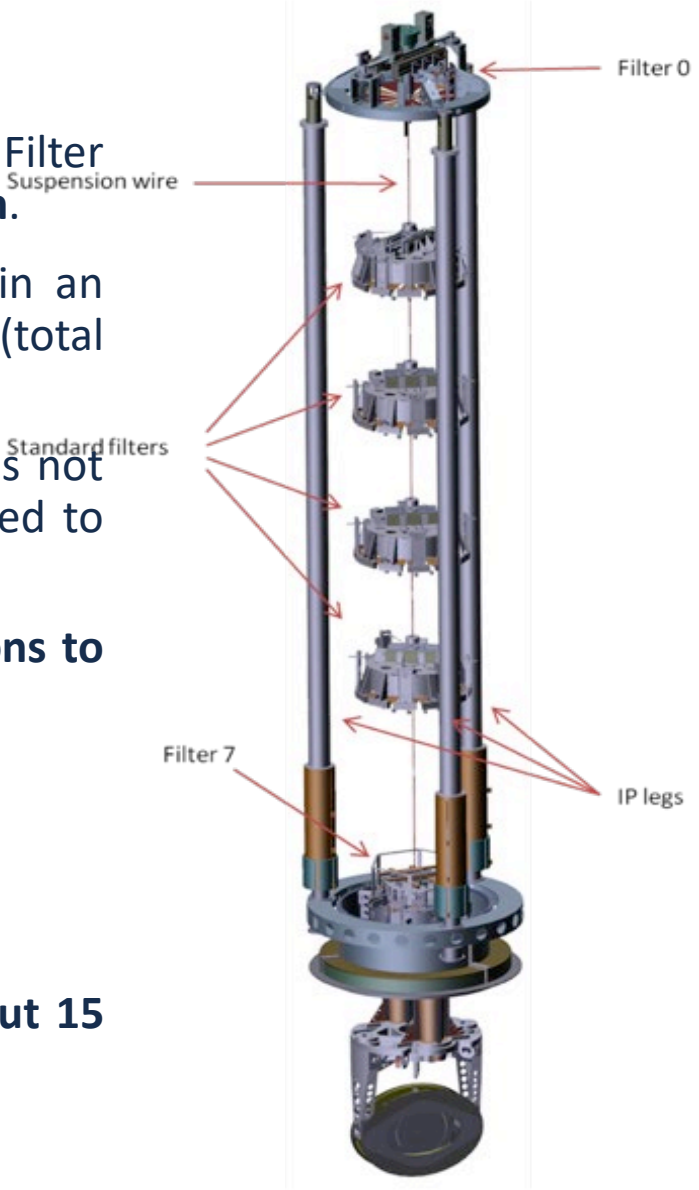
- The "traditional" research line based on the AdV Superattenuators (Inverted Pendulum, Filter Chain, Payload) is currently considered the **reference solution in the ET Conceptual Design**.
- For the High Frequency Interferometer (HFI), the AdV Superattenuator with 6 filters in an "equal spaced" configuration is considered compliant with the ET requirements (total pendulum length of about 9 meters);
- For the Low Frequency Interferometer (LFI), the Superattenuator proposed for the HFI is not sufficient to meet the ET requirements: the total pendulum length needs to be increased to approximately 17 meters with the intent to extend the detection bandwidth down to 3 Hz;
- **Experimental activities are in progress at INFN Pisa Laboratory to test technical solutions to be used in the final design of the Superattenuator:**

  - New magnetic Anti-Spring

  - New active platform – IP bottom-ring

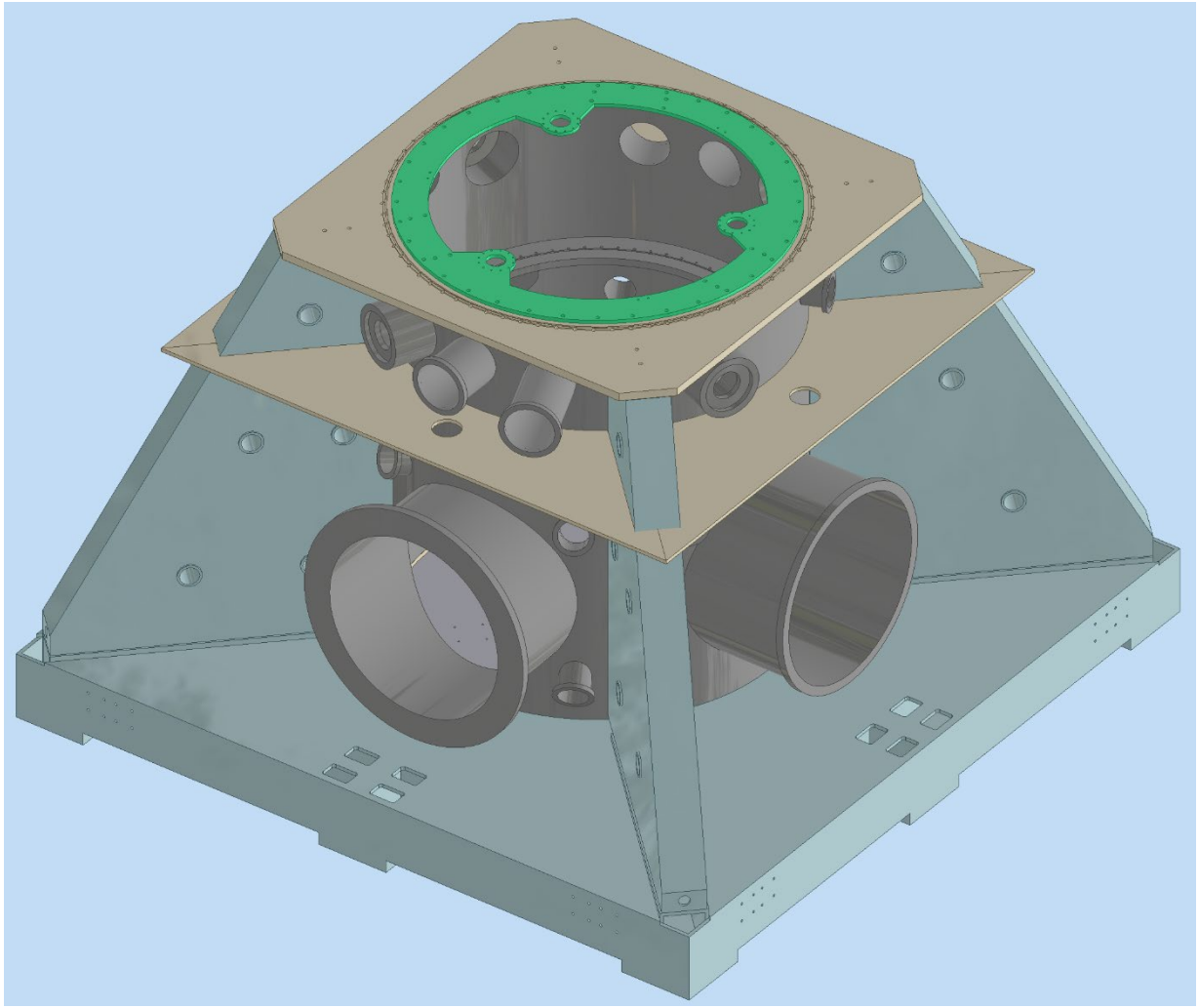
  - New Filter0/Disk0 on top of the structure

  - CAOS facility as fundamental test-bench for 2 AdV based Superattenuators about 15 m hight, supporting a Fabry-Pérot optical cavity for ET research developments.



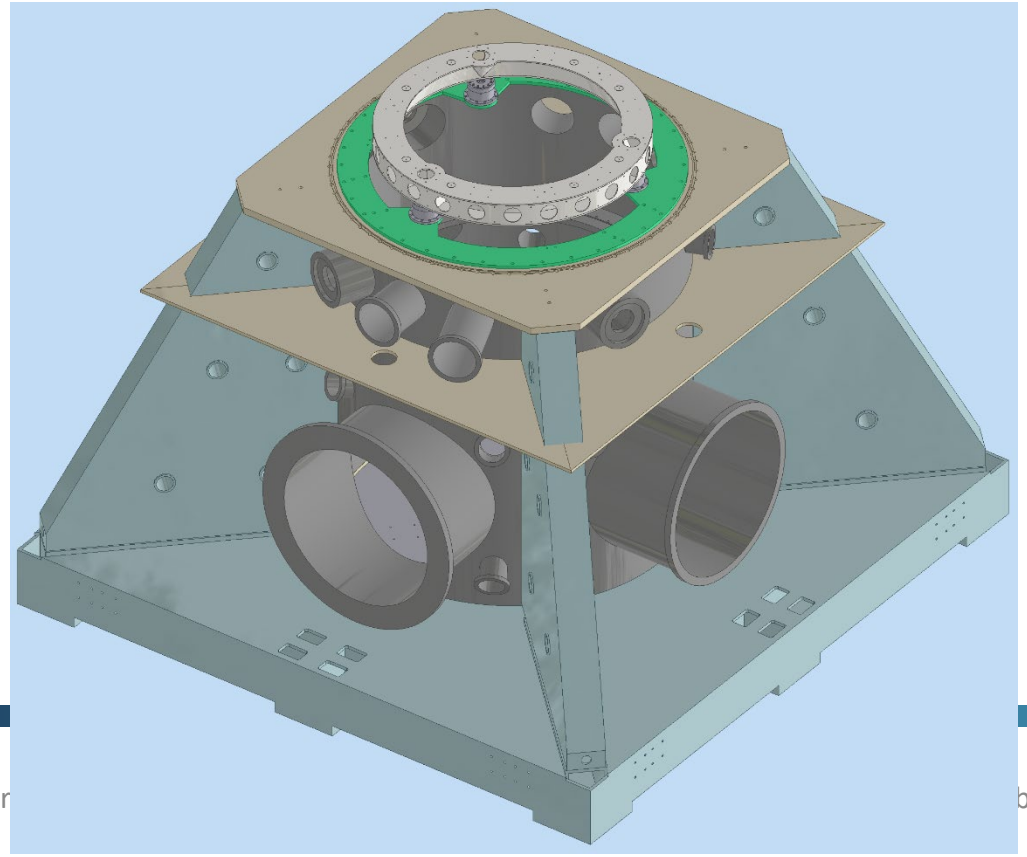
The IP and the Vacuum System

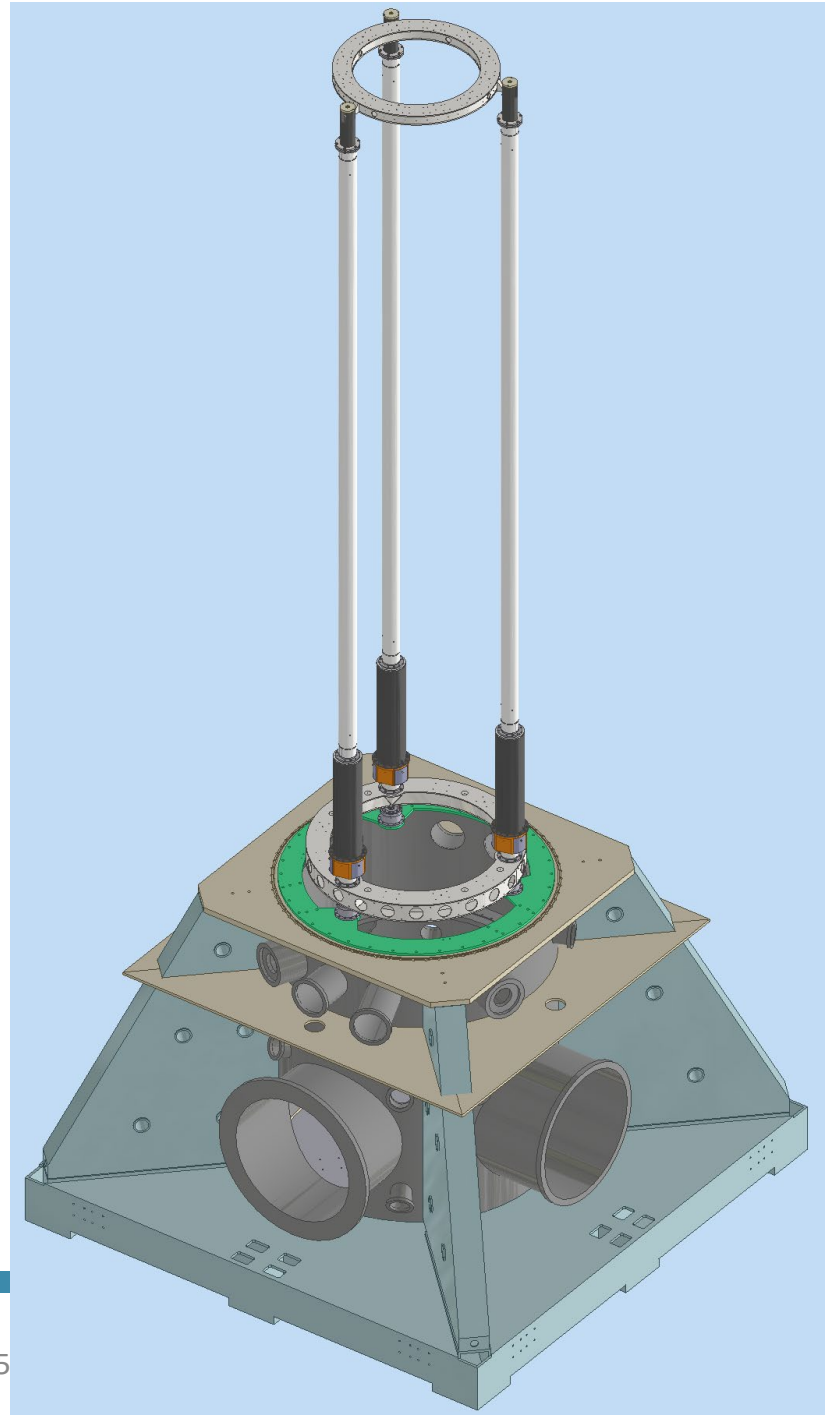
- Following the AdV approach, the **bottom-ring** of the **Inverted Pendulum, is the interface with the vacuum system;**
- The base-tower is an open volume towards the tower upper part where the Superattenuator is installed;
- The Payload is confined into the base tower vacuum chamber;
- Particular care is due to the LFI where the presence of cryostat demands an adequate material selection close to the interface: **Maraging alloy can not be used in cryogenic environment for machining thin suspension wires.**



The IP assembling procedure

- The **bottom-ring of the IP** is bolted to the base tower/cryostat representing the ground reference for the whole Superattenuator
- The bottom-ring is equipped with **vertical actuators** (PZT) to compensate the ground motion-tilt (3D) if an adequate tilt sensor will be available (sensitivity of the order of 10^{-8}mrad/sqrt (Hz)@50 mHz)

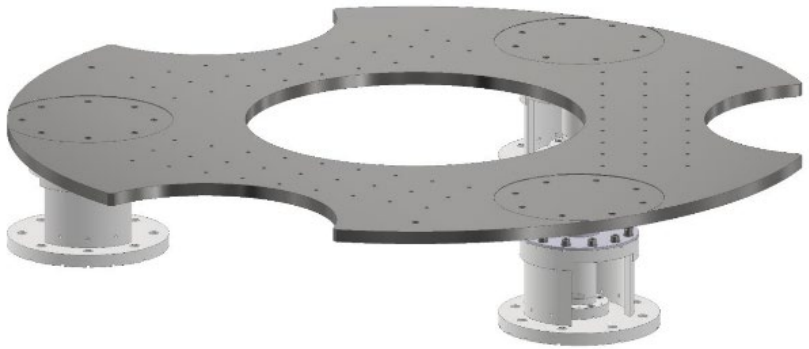




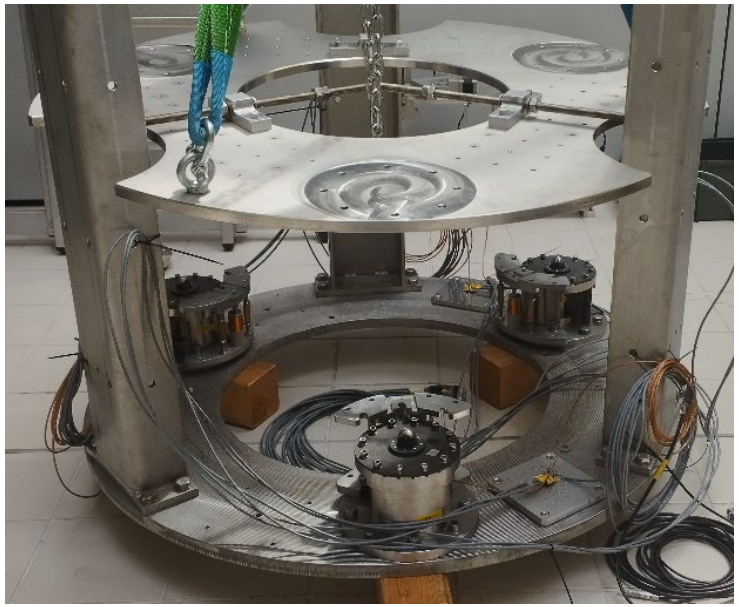
Activity in progress: Active Platform

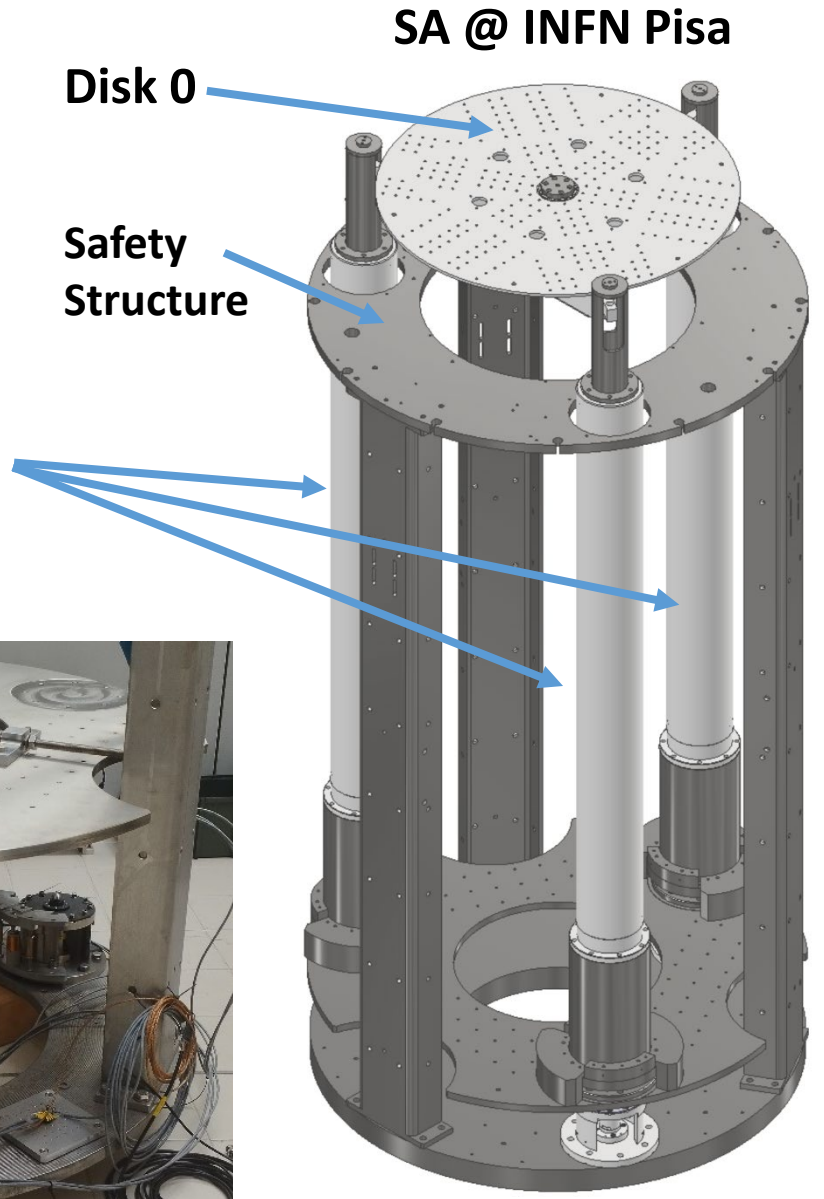
- Some studies are in progress at INFN Pisa Laboratory: a SA 2 m high with 1 m diameter is used as prototype to test
  - Safety Structure (SS), **Active Platform** , Inverted Pendulum
  - **Disk0** prototype just installed: test campaign to be defined
  - Filter with new Magnetic Anti-spring (**new crossbar design**)

Goal: development of an Active Platform with the possibility to include **horizontal feedback action** for future application



Active Platform and feet equipped with PZT





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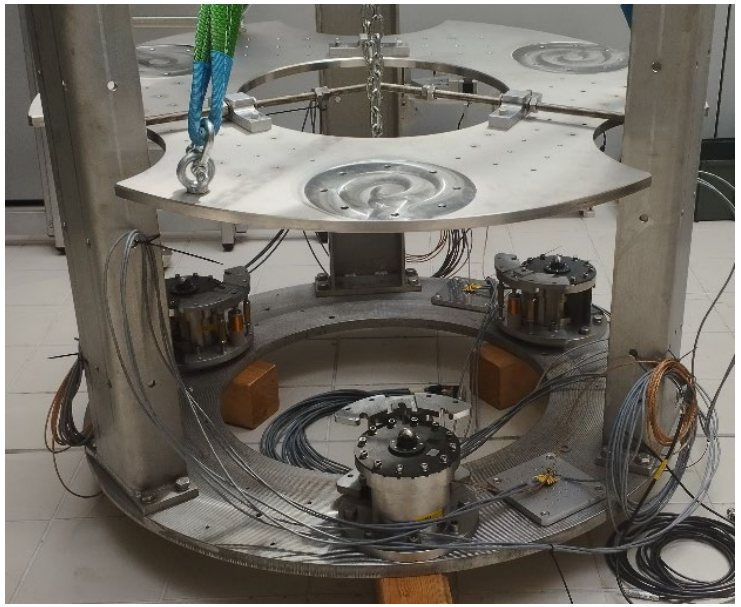
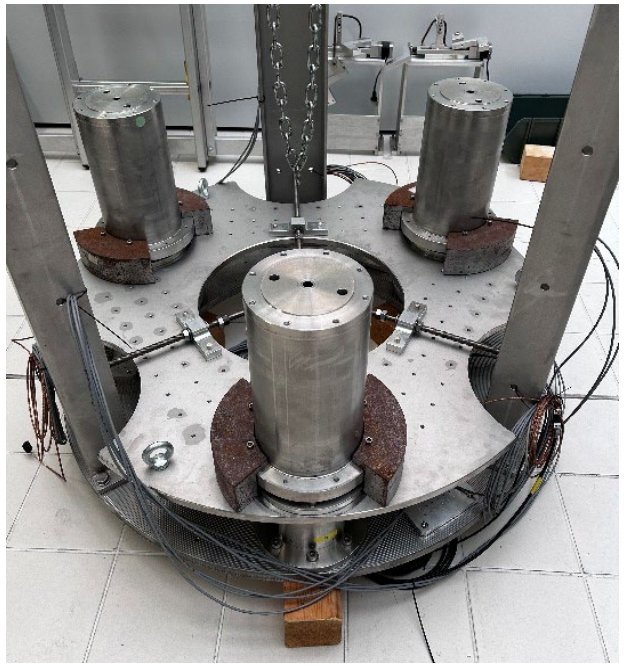
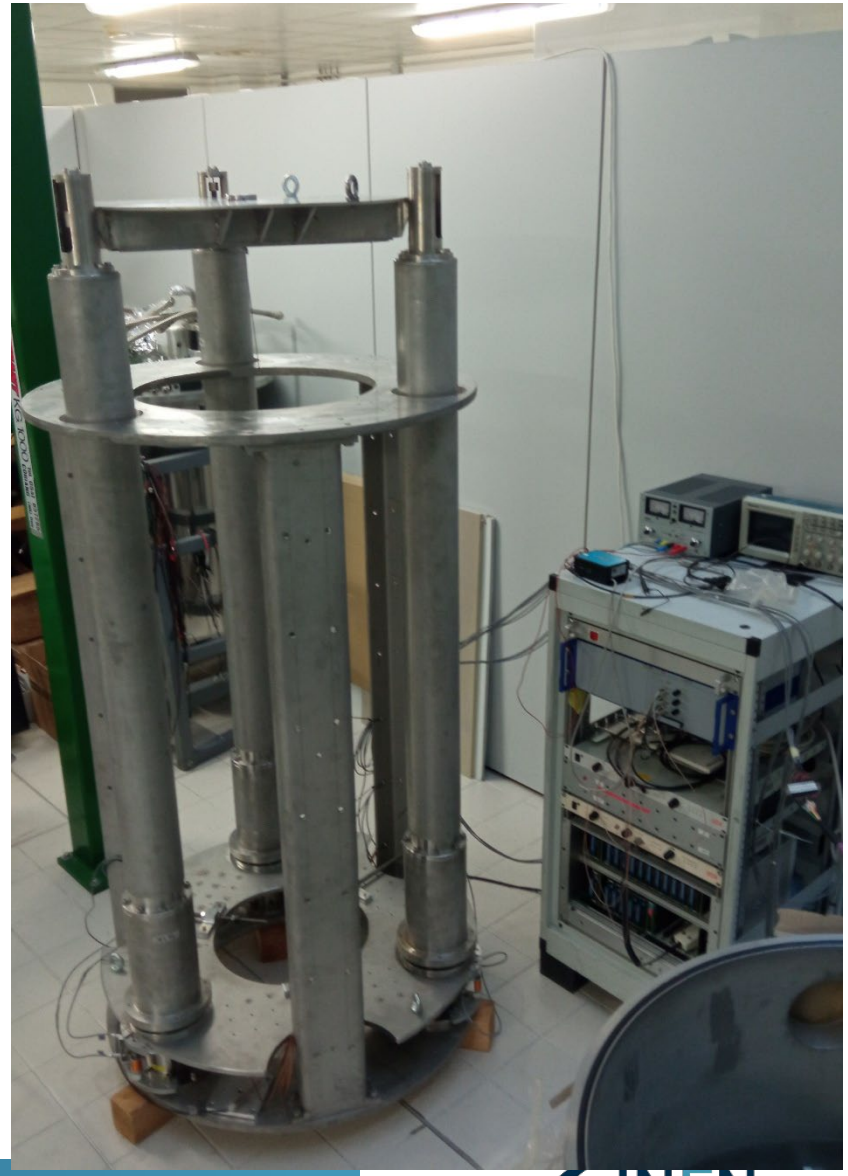
Tests of the Active Platform and Disk0 @ INFN Pisa

- A small SA 2 m high with 1 m diameter is used as prototype to test:
  - Safety Structure (SS), **Active Platform** , Inverted Pendulum
  - **Disk0** prototype just installed: test campaign to be defined
  - A commercial accelerometer (tri-axial TITAN Accelerometer) is used in the laboratory test together with 3 displacement sensors (LVDT) close to PZTs







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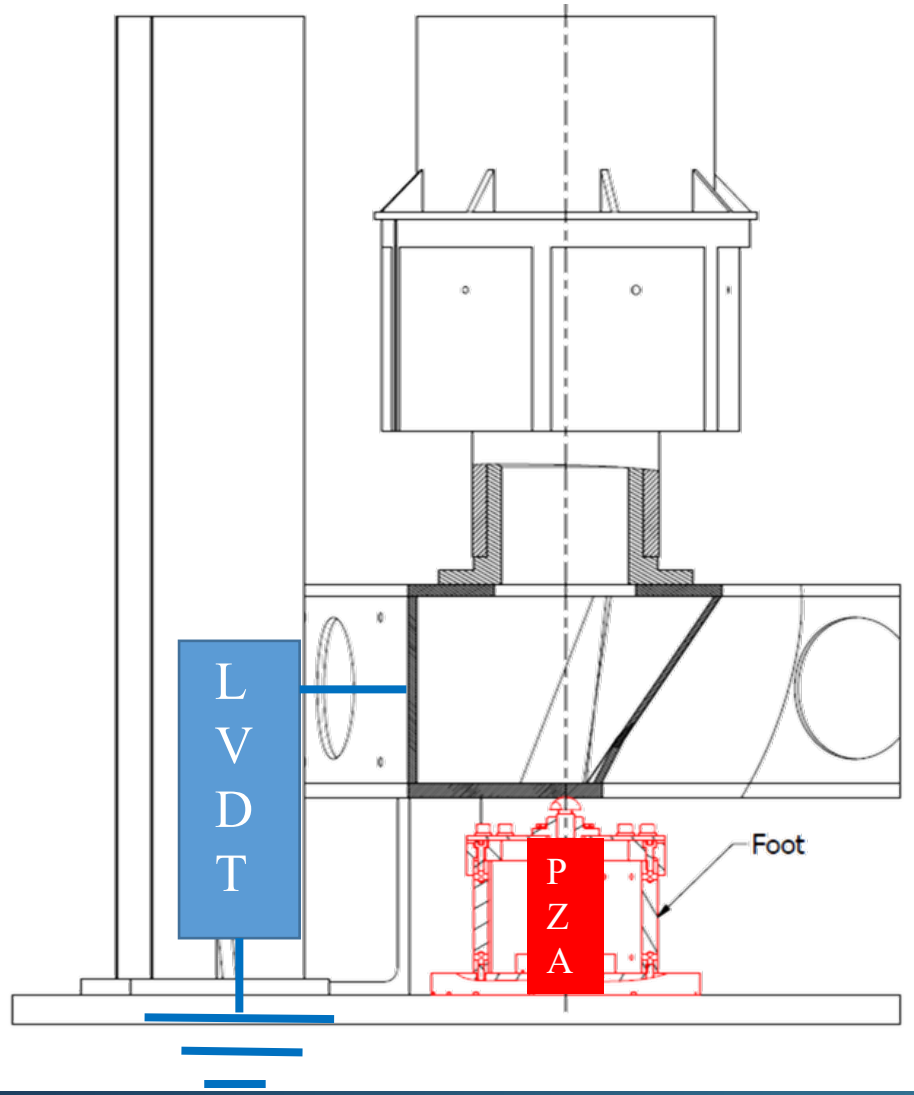
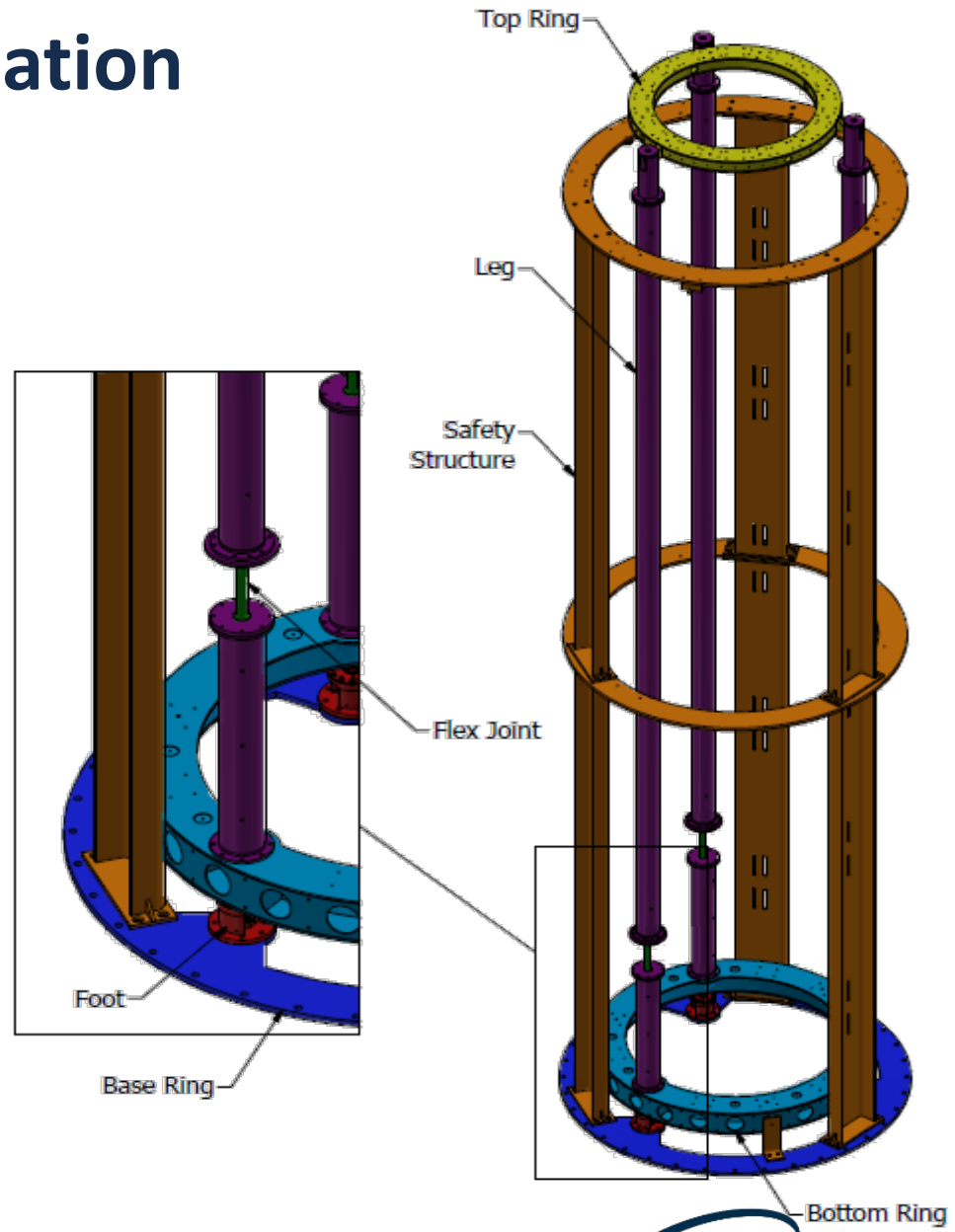
Inverted Pendulum: details on Vetical actuation





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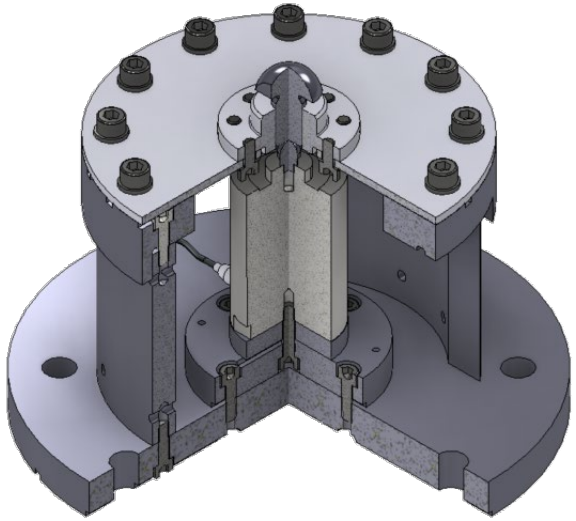
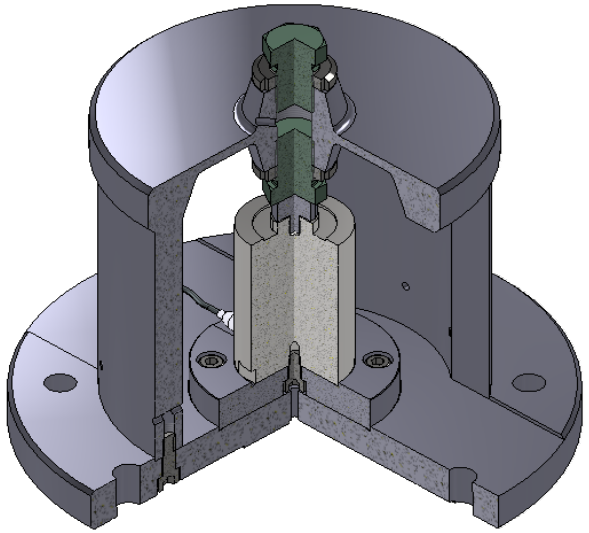
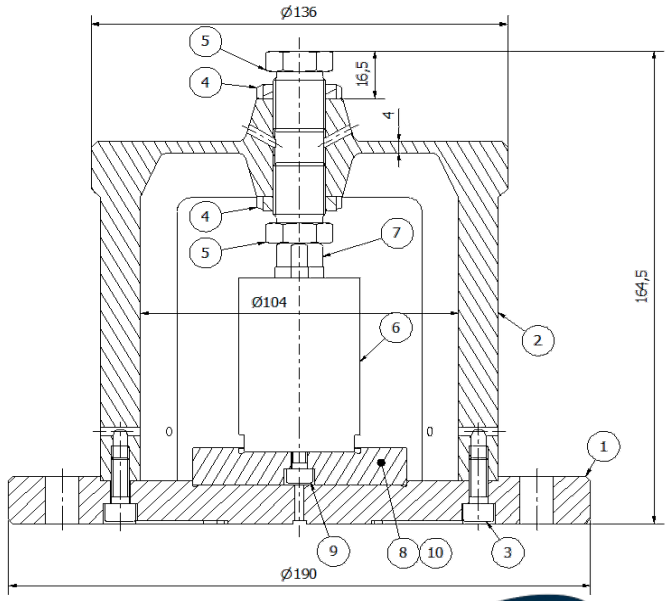
Foot re-design



Re-design



- A detailed study on the foot structure used in AdV Superattenuators has been done:
  - **FEM simulation** and **experimental measurements** on foot response by using a compression machine (available at INFN Pisa Lab) has been carried out;
  - It has been put in evidence some critical points of the mechanical structure together with the materials choice



Credits: Buggiani-Lucchesi

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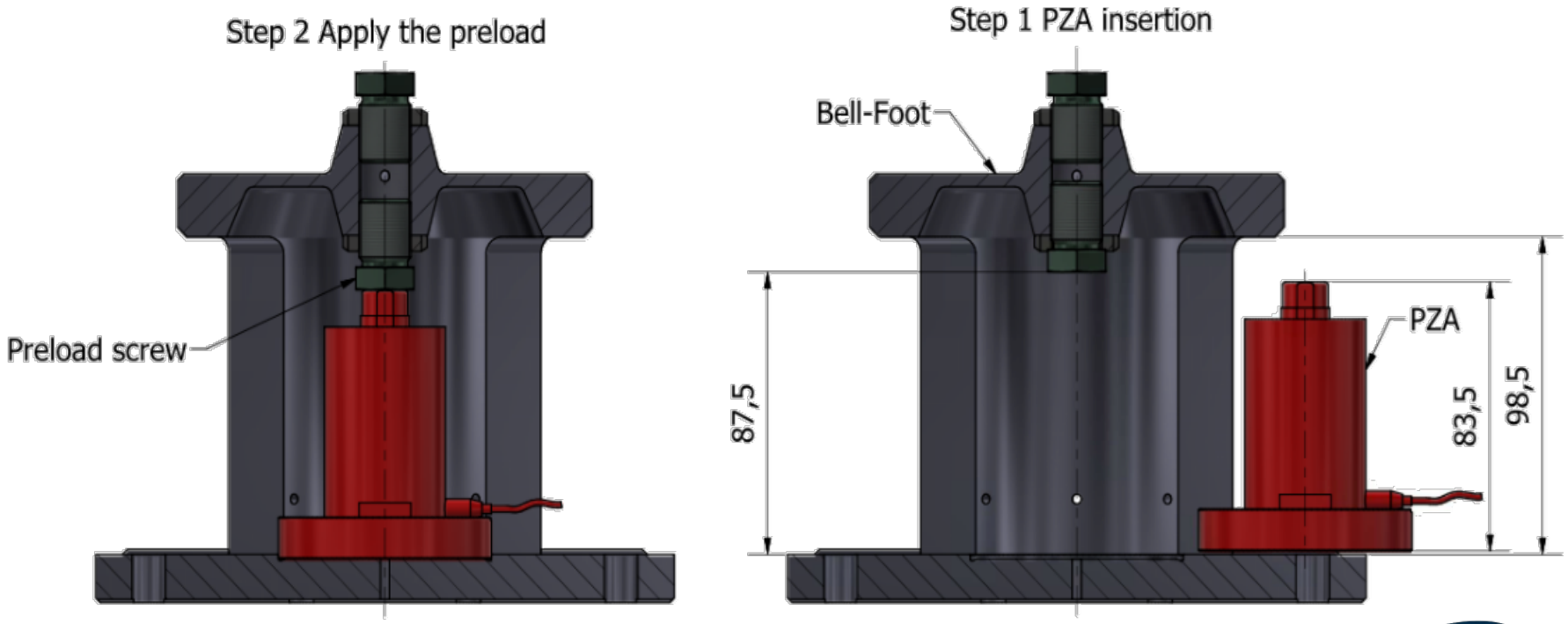
The new foot for future application

- Thanks to the studies carried out on the AdV set-up, a **new monolithic foot** has been conceived (**removing some criticalities**);
- An assembling sequence of the mechanical structure and the actuator (PZA) has been defined too;
- **A protype (available at INFN Pisa laboratory) will be tested and characterized soon**.



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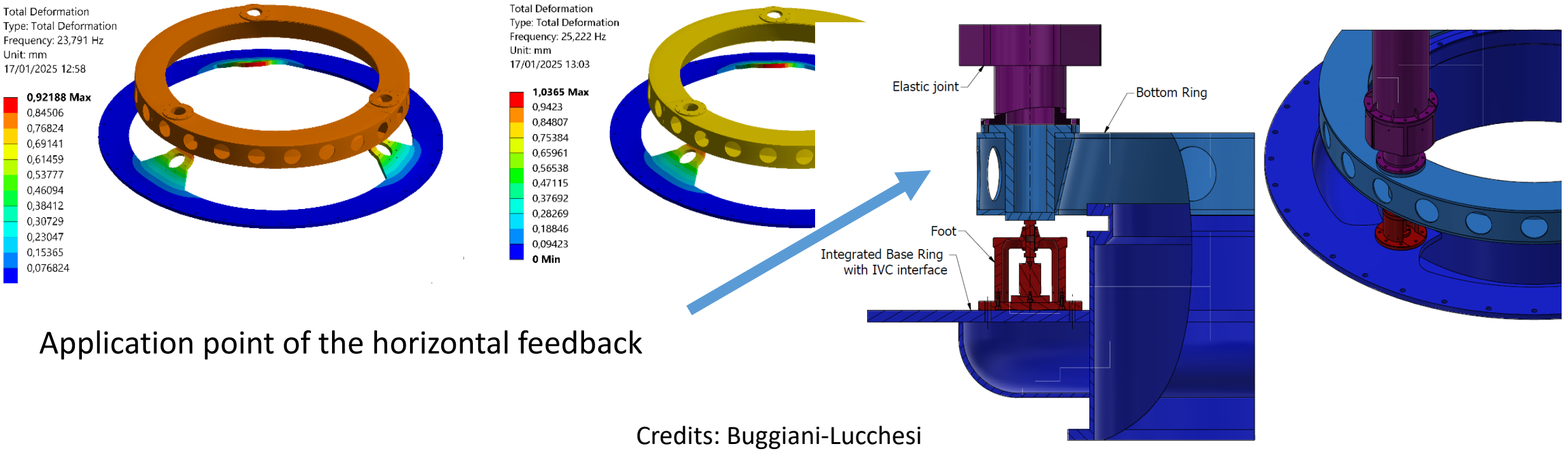
Future developments

- A detailed study of the **bottom-ring** mechanical structure is started (FEA simulation). The intent is the improvement of its rigidity to be implemented into the Seismic Isolation System for ET;
- Measurement campaign for testig and characterizing the new geometry of the foot;
- Construction of a complete set of monolithic feet (3) for the acceptance test on our (small dimension) Active Platform (feedback control activity)



Application point of the horizontal feedback

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Final Considerations

- The AdV Superattenuator is the starting point of our R&D activities (**NGSA** and **CAOS**) for the Seismic Isolation System of ET. The intent is the improvements of filtering performance of the mechanical system with the possibility to extend the detection bandwidth down to 2 Hz;
- An **Active Platform** with vertical and horizontal feedback action is under study;
- The mechanical structure of the **single IP** is under revision to improve the **bottom-ring rigidity** including space for **horizontal actuators** (vertical PZT actuators within a new geometry of the feet is present);
- Construction of **IP with increased dimensions of the legs** (diameter pipe and length) following the results of the experimental test carried out at EGO site in 2011-2012. To be used on **CAOS Facility**.