First assembly of the LCGT Top Filter and Inverted Pendulum prototype.

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The top filter and inverted pendulum design is shown in figure 1.
A prototype was built and assembled to verify the design.
The design defects were reported in redline drawings

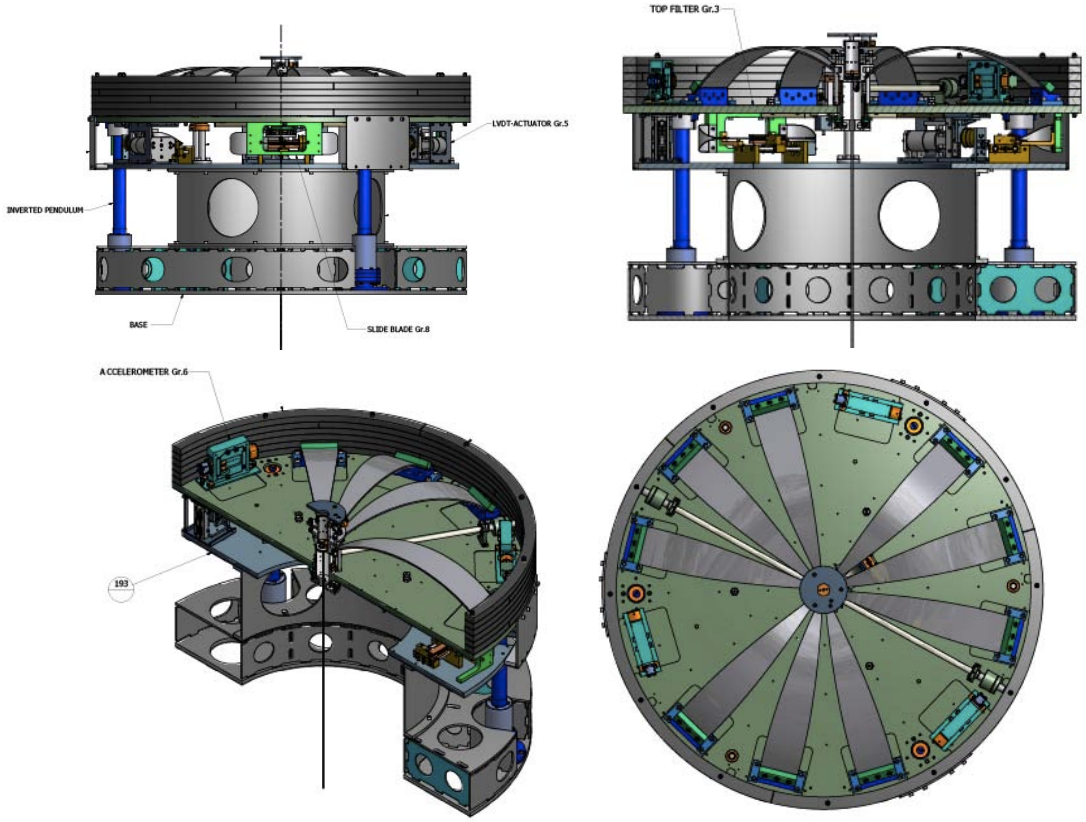


Figure 1: views of the LCGT Top Filter and Inverted Pendulum unit.

Several minor errors and a serious one were found, several small improvements, especially to ease clean room assembly, were identified and incorporated in an updated design.
As soon as the assembly was started we realized that the welds of the spacer (188) between the base platform (101-106) were not UHV compatible, see also figure 2.
We had specified UHV tank weld, and not for inside UHV. As a result instead of full penetration welds as implemented in the base, a continuous internal weld in the inner side, with stiffener stitches on the outer side. As the result the volume between and below the stitches was not cleanable and in the followup surface machining filled up with machining oil.
A replacement was rapidly ordered and manufactured.
The first filter assembly (with the wrong spacer) is shown in figure 3.

The minor mistakes and improvements are specified in the redlines. Unfortunately, for our laziness and convenience, we wrote them mostly in Italian. Most of them are self evident, despite the language. Please ask if you have any doubt.
All modifications are implemented in the updated design. All relevant modifications were implemented in the prototype.

Figure 2: Assembly of the base, spacer, sensor plate, please note the difference in weld style between the base structure (UHV compatible), and the spacer, which is continuously welded inside and stitch welded outside without the cleaning clearances clearly visible in the base structure below.

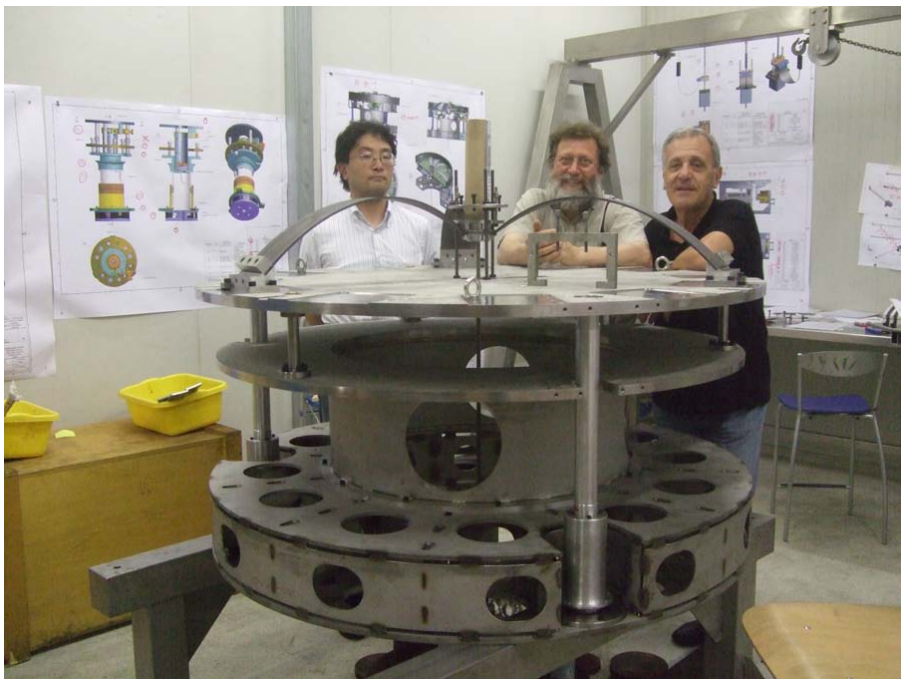


Figure 3: First assembly of the Top Filter unit.

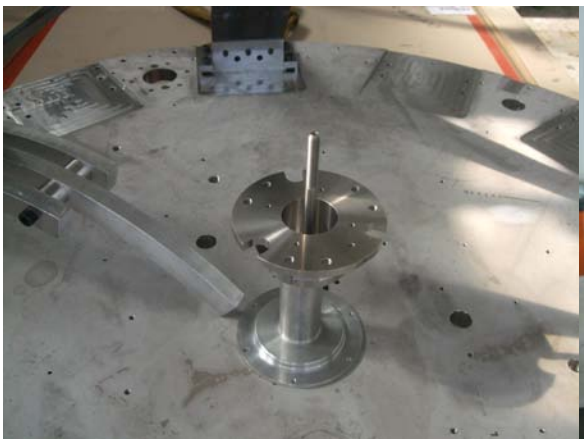
The blades of the Top filter lift about 100 kg each, they cannot be pulled by hand anymore. A special screw driven tool was designed.

The blade is first attached to its clamp and to a pre-stressing arch. A threaded rod attached to a homo-kinetic joint is attached at the tip of the blade


A nut is mounted at the other end of the threaded rod, and pulled with the help of a hand drill and a long tube wrench. Alcohol is used as lubricant because of the clean room requirements


The last few cm the nut is pulled by hand, then the tipoff the blade is fastened to the stressing arch.


The pulling nut is released and the blade clamp is released from its table support.
The pre-stressed blade is then ready to be mounted on the filter plate
The table support is designed to accept both blades from the Top Filter and from the Standard filter with the same pulling mechanism.




To mount the blades on the filter, a mushroom tool holding the filter's keystone is used. The mushroom tool mounts below the filter's plate and locks the keystone with an m12 threaded rod. Three blades are then presented to the keystone. For added safety the keystone endstop is mounted as well.


The filter has 120^{o} symmetry, therefore three at a time are mounted to null the transversal stress on the keystone, the nose of the blades is bolted to the keystone. The blade clamp is then bolted to the filter's base plate.


At this point the clamps holding the tip of the blades to the stressing arch are released, the load is transferred to the endstop plate by means of three limiting screws, and the mushroom tool is removed. At this point the filter is ready to be

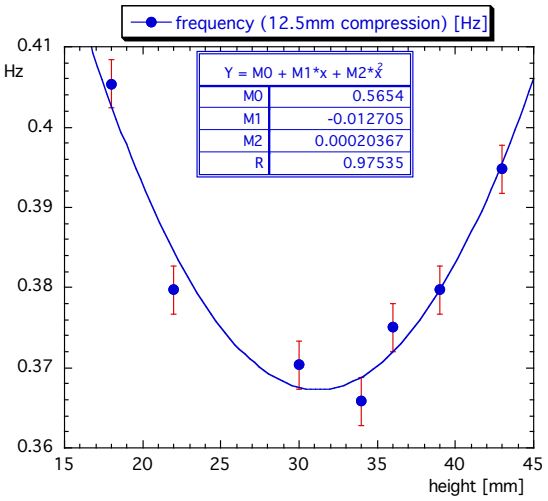
loaded with its payload, or to receive three more blades. Up to 9 blades can be mounted, blades of different width are used to lift the desired payload.


The filter is positioned on a suitable stand. Special extension tubes have been thought to mount on the inverted pendulum range limiter to help aligment while lowering the top filter.

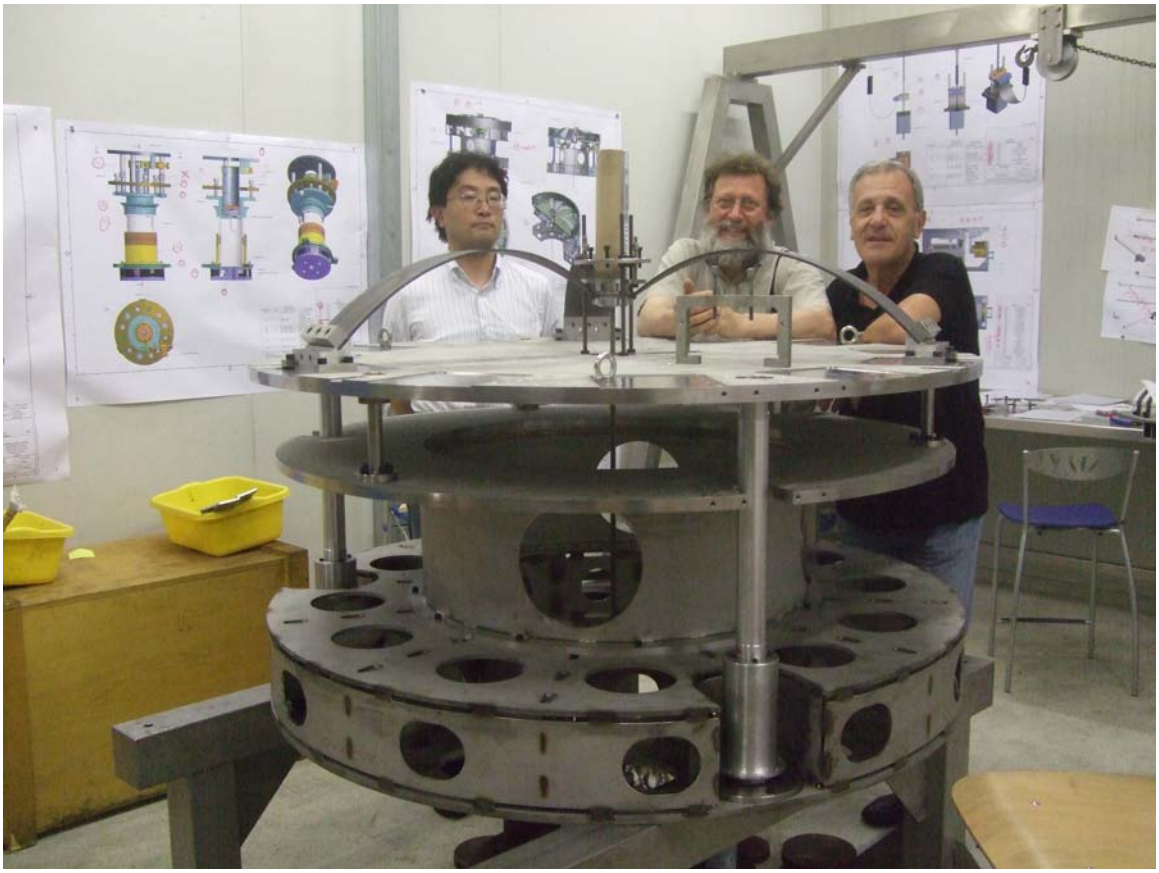

A payload, of about 300 kg in this case, is procured


A threaded rod is attached to the keystone, and the payload to the threaded rod

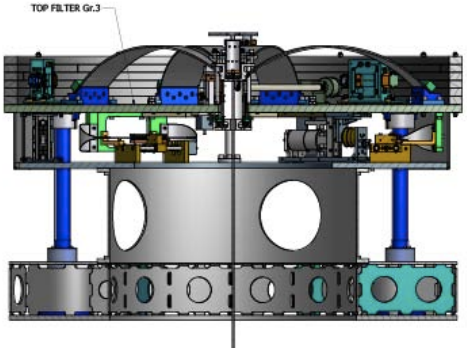
The payload is changed in increments of 0.5 kg with ½ liter water bottles and the measurements recorded on computer.



The blade's radial compression can be changed by means of this tool. Two screws take the radial load, the clamps are released, the screws are used to push in, the clamps are tightened back. A typical compression of at least 12 mm from the back of the clamp is necessary for low frequency operation of the filter. A typical measurement with tuning at 370 mHz is shown as well



This figure shows the Top filter first assembly and a happy crew

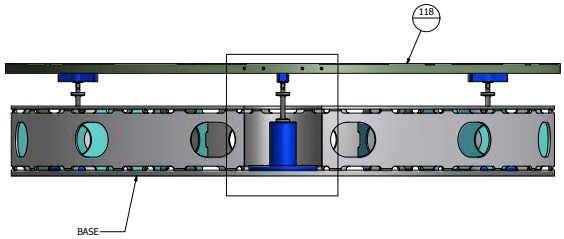


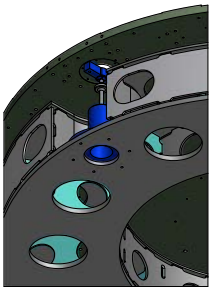
The tuning of the inverted pendulum is made with ballast mass, in the form or ribs, bolter on the periphery of the Top filter. These ribs are obtained by rolling flat stainless steel bars, the top and bottom surface is re-machined, then holes are drilled

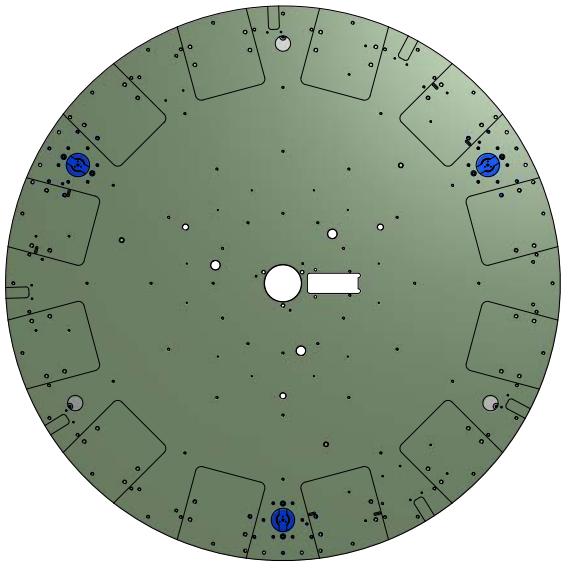
Figure 5L : The tuning masses are 120^{o} arches with 40 mm 20 mm, 10 mm and 5 mm thickness, that can be bolted on the outer rim of the filter to form whatever load mass necessary to tune the Inverted pendulum at the desired frequency.
Figure 5R: Cable passage slot to bring the cables to the sensors and actuators operating on the top filter.

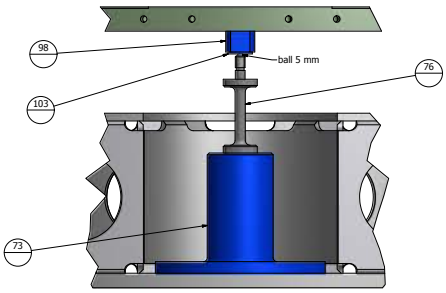
The inverted pendulum base, with its flezure and the Inverted pendulum leg base are then mounted on the base structure, then the leg's counterweight bell is installed.

The three inverted pendulum footing are mounted and the Inverted pendulum endstop bars, then the IP legs get installed.
At this point the system is ready to lower the top filter on the inverted pendulum legs.
There is a step that needs to be performed before mounting the top filter on the legs. For proper operation is necessary that the inverted pendulum legs be perfectly parallel. The parallelism is obtained by aligning the bridges (98) receiving the leg's top flexure to the leg's bottom, main, flexure (76).

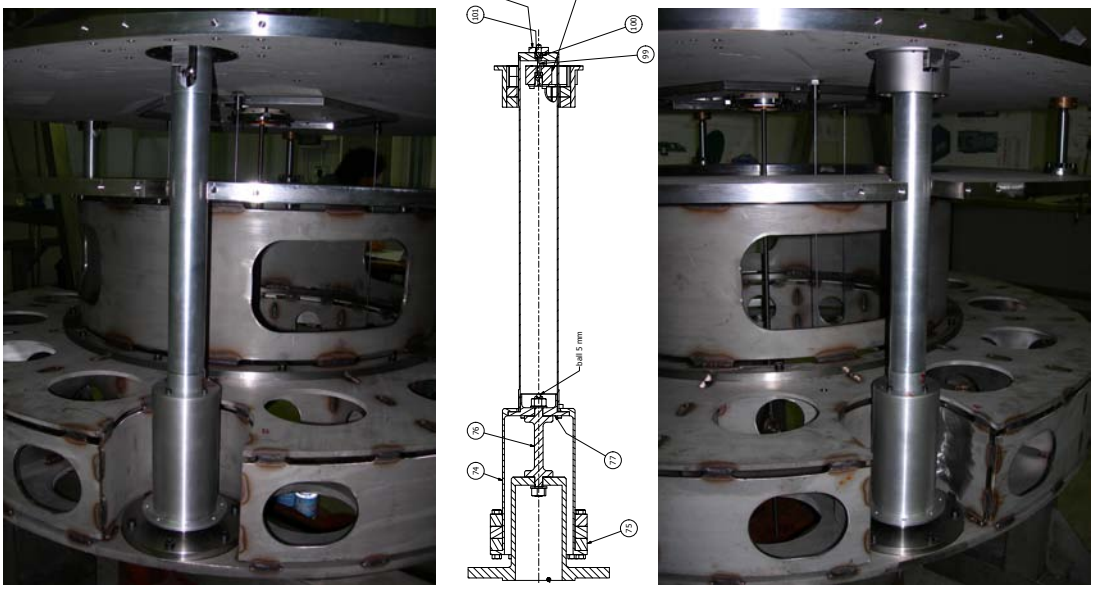








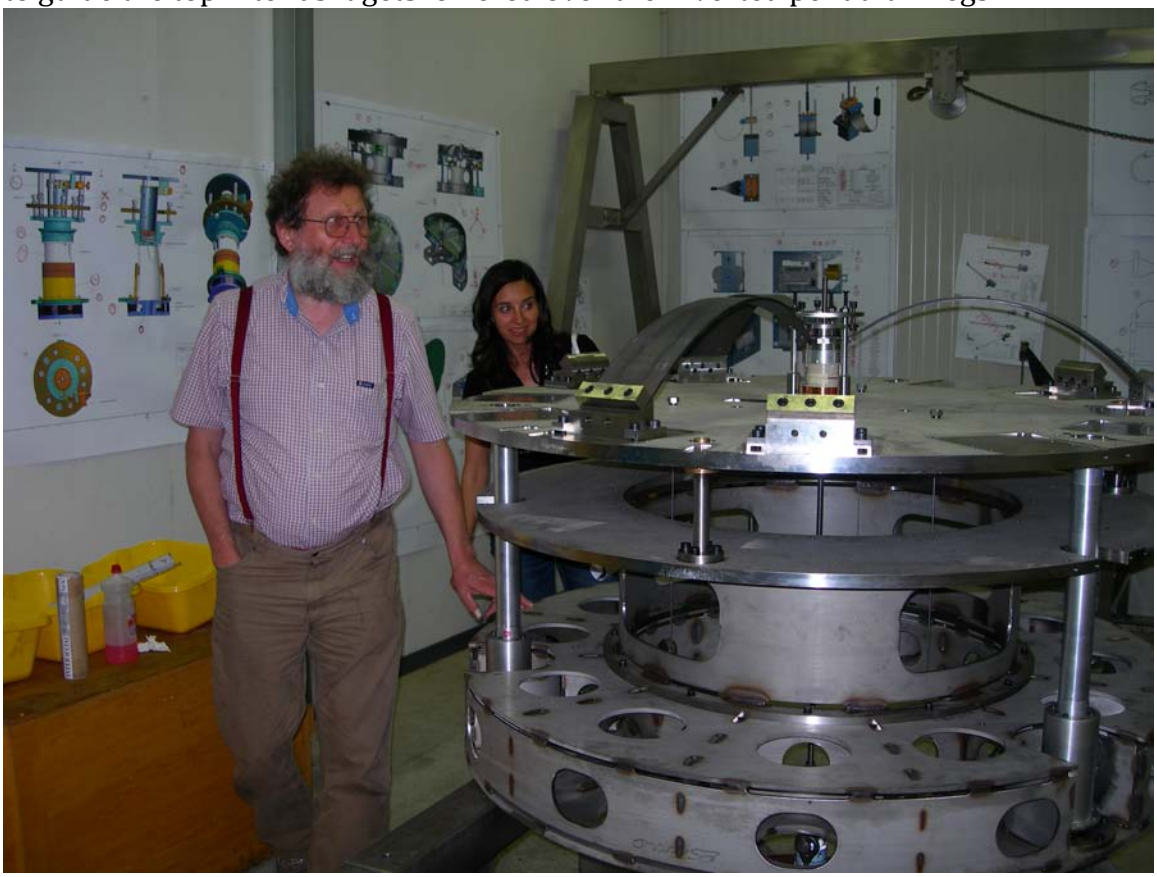
The alignment of the bridges is made before installation of the inverted pendulum legs and of the mechanical structure. It is achieved by lowering the top filter, with the bridges (98) bolted loose on the plate (118) directly over the inverted pendulum flexures (76) already well fastened on the base. The alignment is obtained by placing of three bearing steel balls on the conical ends of the flexure . The bridges (98) are provided with their covers (103), each provided with matching conical receptacle. The balls position the bridges, which are then bolted tight.



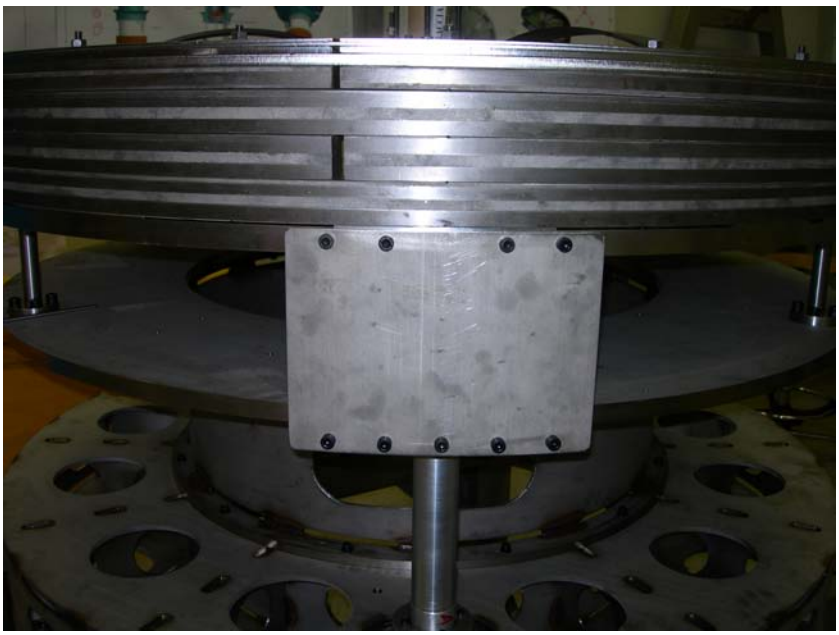
After the filter has been lowered on the legs, the damping magnet shell is mounted around the leg's head

The damping magnets shell is shown open, around the leg's head and the inverted pendulum bridge. The inverted pendulum batting center counterweights are mounted on the counterweight bell at the bottom of the leg. These counterweights have still to be determined.

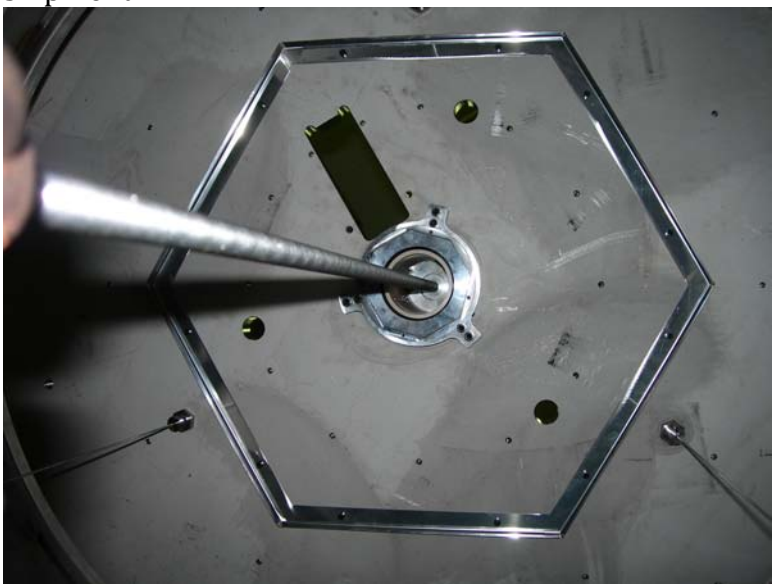

The inverted pendulum endstop rods limit the x-y-ϕ movement. They are provided with brass cones that can be lifted to immobilize the inverted pendulum movement altogether. These cones can also be provided with extension tubes, which are useful to guide the top filter as it gets lowered over the Inverted pendulum legs.

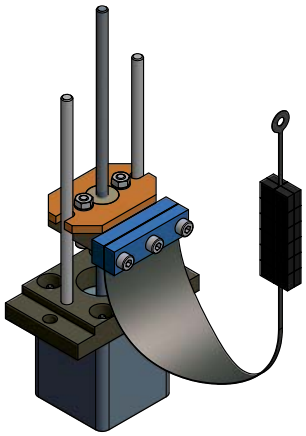


Visible here is the almost complete filter inverted pendulum unit, waiting for its instrumentation.



Transport plates between the top filter and the base structure can be bolted on for shipment.

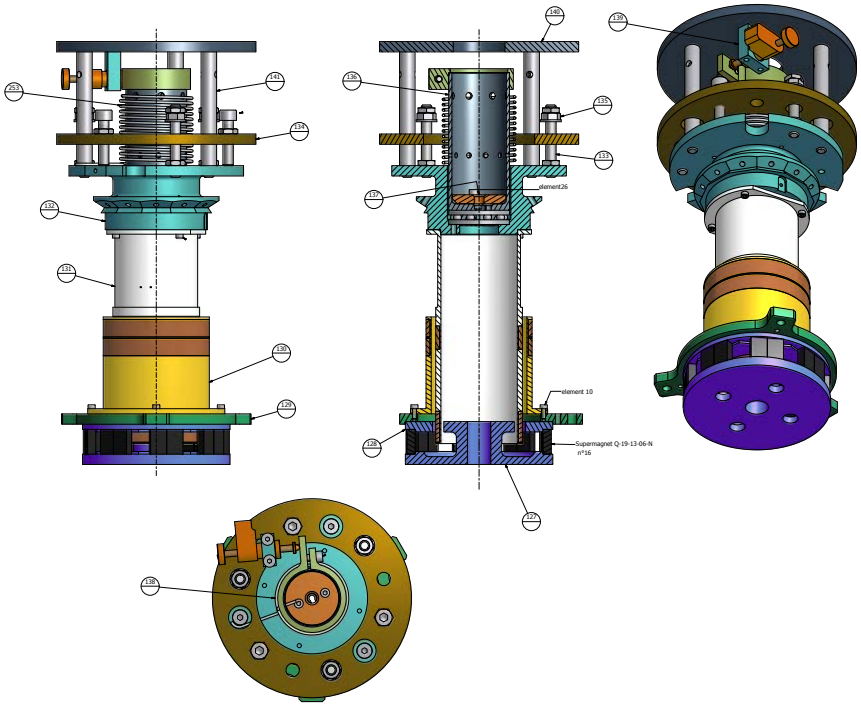




Looking up from below the top filter one sees the hexagon for electrical wiring, The electrical wire will be kapton coated and kapton tied ribbons, each will be clamped to the lip of the hexagon with an “ASCO-like” clip.
At a larger diameter one can see two of the three wires supporting the magnetic damper tray. Inside the hexagon, off-axis, there is the rectangular window of the stepper motor tuneable spring, designed to register the top mirror working point (see insert on the right). Around the temporary load threaded rod part of the magnetic actuator, and of the LVDT are visible.

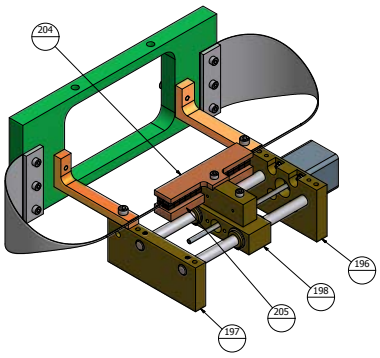
The next step is to mount the LVDT-Actuator group, and the ire rotation mechanism. Not all the parts were ready,therefore this assembly was delayed.

The voice coil magnet and the LVDT secondary are mounted from below on the filter base plate.The coil of the actuator and the LVDT primary are bolted on the underside of the filter's keystone. Inside the keystone there is a thrust roller bearing, supporting a tumbler-like object. At the center of the tumbler there is the keyhole wire connection that supports the entire payload. A flag clamp is mounted at the top rim of the glass. An helical spring applies a torque on the tumbler and force it against a picomotor, which is supported on a platform mounted on the roof of the keystone.

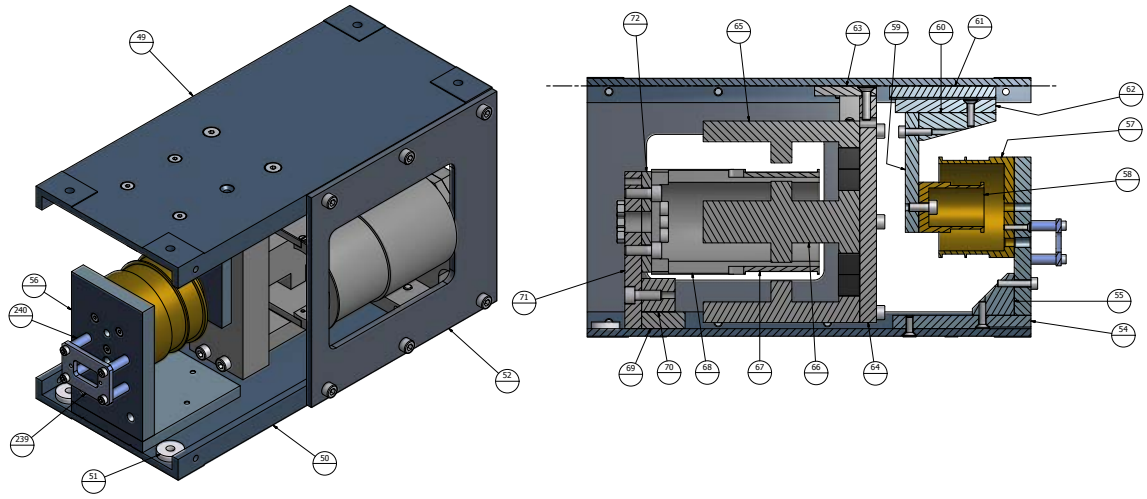


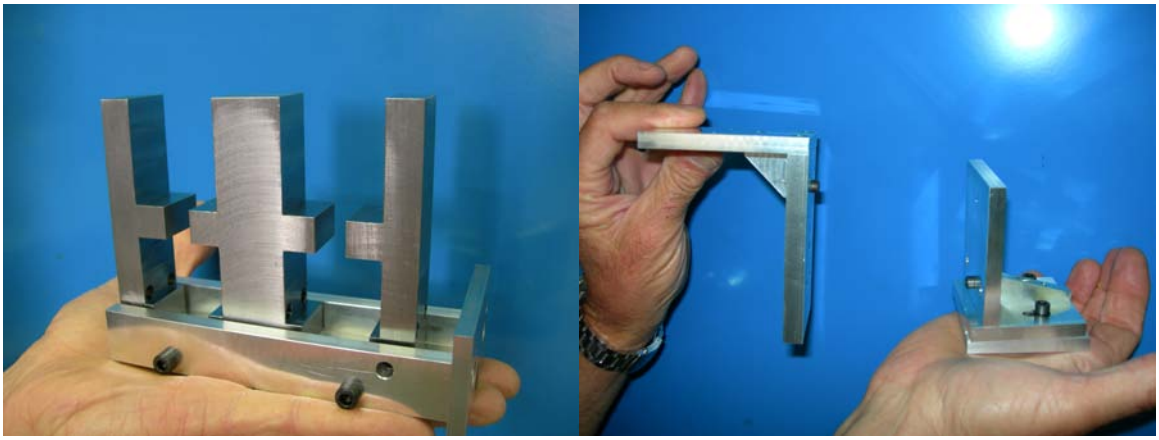
The top filter keystone is sitting against its range limiter disk. The payload id taken out and the load threaded rod is removed. The LVDT primary and secondary were positioned. Because the working point was 15 mm higher than expected, in the prototype an aluminum extender was used. In future a suitably longer coil support will be designed.

The suspension wire is inserted in the cup, the wire safety is put in position above it, and the tumbler is ready for installation on the Keystone bearing, then the picomotor stand is mounted on the keystone. No picomotor was available at the time. The helical spring is also still in production.



The three horizontal tuneable springs were only partially available, the motors were not available at the time. The assembly scheme was tested with the motor and the spring plates, as well as the two transport brackets.





Only some of the components of the horizontal LVDT-Voice-coil actuators were available, the top and bottom plates were missing.
It was found that several parts were designed in a much too complicated manner, several components were re-designed or eliminated, while keeping full functionality.

The latter parts of this report will be replaced as prototype test assembly will be completed.