New IMC dihedron: a must for Virgo

Problems

The current dihedron (see Figure 1, in the previous bench) is indicated as the culprit of some of the bad features found in Virgo.

First the support of the dihedron is realized with a design that don't guarantee the stability of the position after shocks applied to the bench. Every tower aperture we had small but annoying displacements of the dihedron position.

Looking at the sensitivity curve in Figure 2, there are structures at 80Hz that correspond to the rotational modes of the dihedron support (see http://www.roma1.infn.it/people/puppo/Virgo/Diedro/VirgoNoteDiedro.doc).

These structures are more evident in the transfer function measurement (see Figure 3).

It is important to recall that the IMC length noise enters also in the Virgo spectrum through the frequency noise that is a limiting noise at high frequency (see http://www.ego-gw.it/ILIAS%2DGW/WP1docs/evans_131106.ppt) and it will be useless to increase the laser power if we don't reduce it.

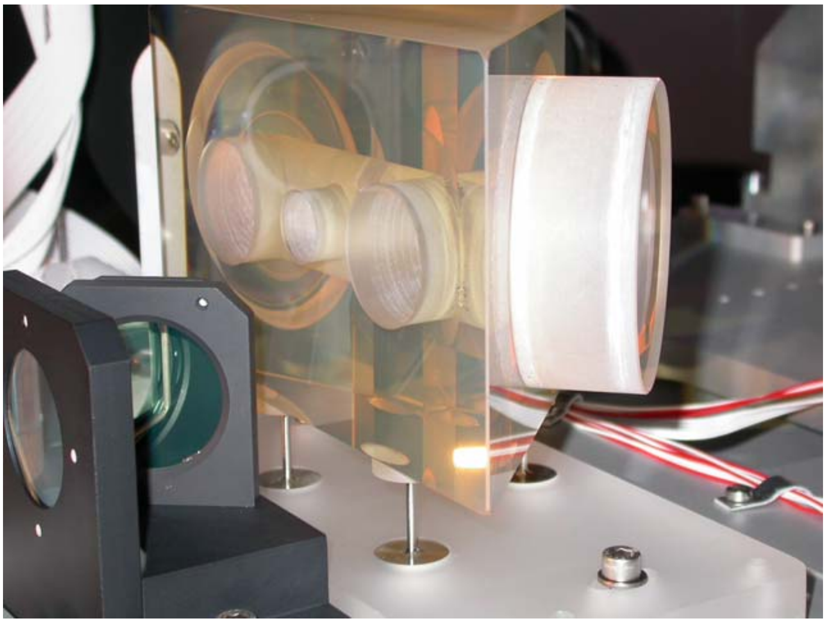

Figure 1 - the dihedron

The clear aperture is at the limit of the golden rule (>5 times the waist), because of the small holes in the dihedron itself. Furthermore the 45° incidence angle and the thickness of the mirrors (3 cm) decrease the clear aperture.

In addition to these problems there is the poor quality of the current substrates that requires a replacement of the mirrors.

Ideas

How to solve these problems? Currently we have no solutions but some ideas. There are three possibilities, ordered from the simpler to the more complex.

1. **replace the dihedron with a larger one, clamp it to the bench**
    a. **benefits**: very simple solution
    b. **drawbacks**: we go back to a solution already adopted and replaced in Virgo. The end mirror of the IMC were clamped to a bench and we had to suspend it because of the transmission of all the resonant modes of the bench to the mirror. Some difference are in the current setup, but we have to understand the importance of this effect. Thermal lensing effects more complex mainly with the Virgo+ injected power.

c. **Actions**: perform a FEM study of the transfer of the bench vibration to the dihedron. Adopt the available clamp or design a new one

2. **replace the dihedron with a larger one, suspend it**
   a. **characteristics**: suspended from the marionette, actuators in the bench. Sensing and control system completely to be designed.
   b. **benefits:** maintain the current geometry. Reduced degree of freedom respect to a independent mirror suspension. Suspending from the marionette a better seismic noise reduction is available.
   c. **Drawbacks:** complete control system to be designed and verified to be noise compliant. Radiation pressure issues to be evaluated. Thermal lensing effects more complex mainly with the Virgo+ injected power. Recoil of the injection bench.
   d. **Actions:** realize a FEM model. Realize a prototype of a suspended marionette+bench+dihedron. Design and test the control system in the prototype.
3. **Replace the dihedron with two independent and suspended mirrors**
   a. **characteristics**: two larger mirrors are suspended from the marionette and controlled with coils mounted on the bench (or through reference masses?)
   b. **benefits**: Virgo knowledge on the control issues. Better seismic noise reduction
   c. **Drawbacks**: more actuators, more noise. Radiation pressure issues very relevant. Thermal lensing "simple" but tobe considered.
   d. **Actions**: Design the suspension. Realize a prototype of a suspended marionette+bench+dihedron. Design and test the control system in the prototype.

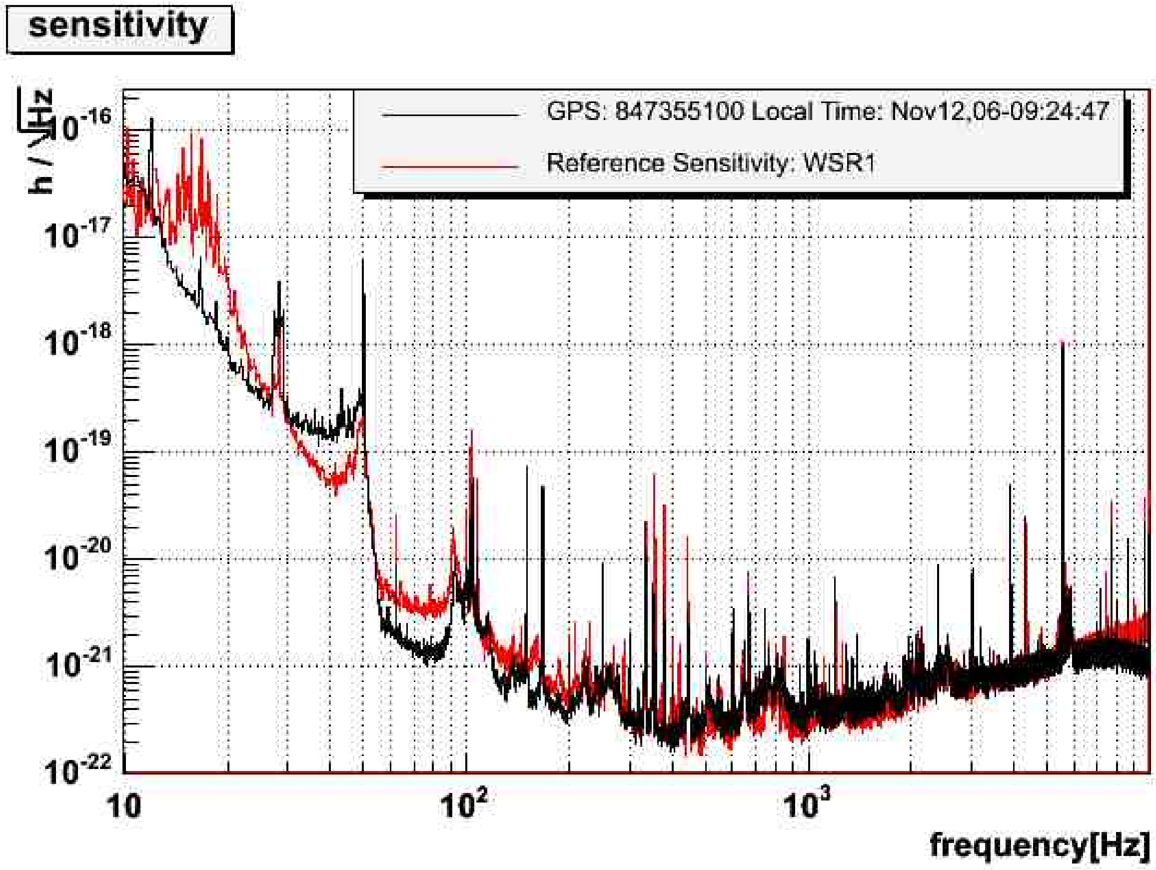

Figure 2 - recent sensitivity curve

Interest for the group involved in the study

The realization of a fully suspended IMC should be of interest not only for the Virgo collaboration, but also for the grown of the group involved in the and realization. In fact the design of a similar component of Virgo requires the acquisition of a know-how in the control problems, that is one of the two major issues in the Interferometric GW detectors. Low noise controls are at the basis of the low frequency performances of the ITF and the knowledge acquired in this field can be spent in the commissioning of the future versions (+ and Advanced) of Virgo. Furthermore, the needed collaboration with the optic experts at the site will permit a further knowledge transfer.

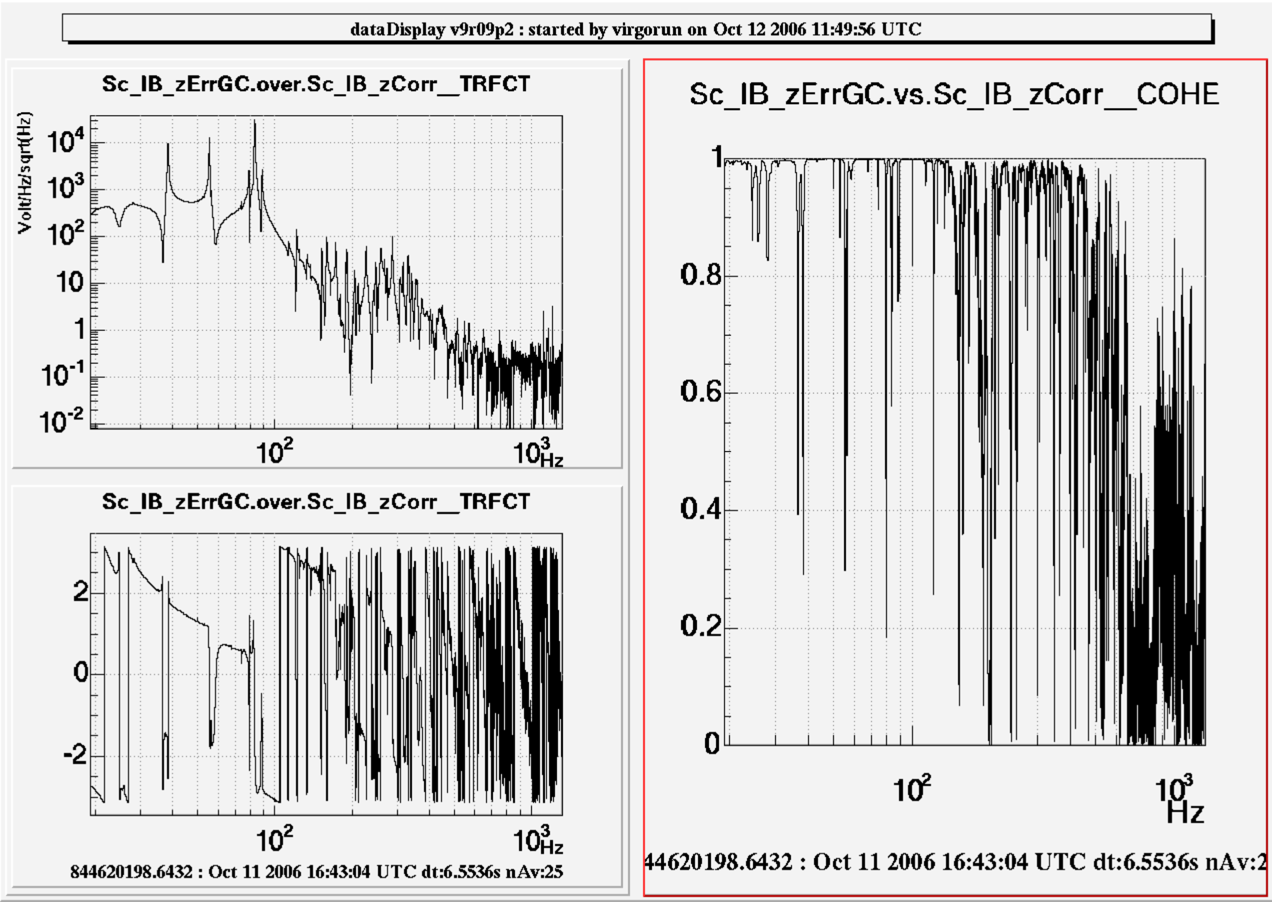

Figure 3 - Injection bench transfer function measurement

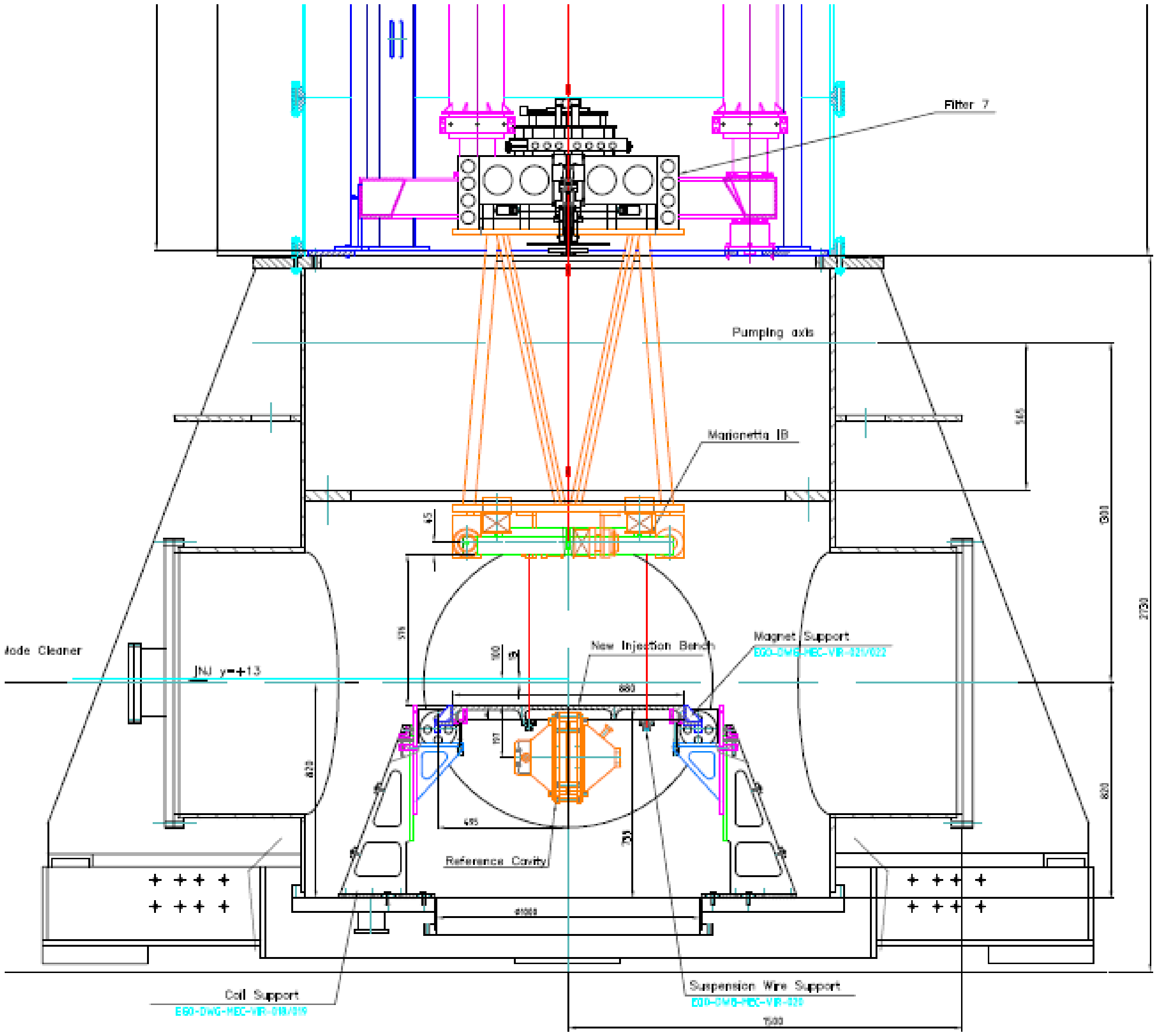

Figure 4 - Scheme of the suspended injection bench