

DESIGN AND CONSTRUCTION OF A PW EXPERIMENTAL SYSTEM OF HV CHAMBER ADAPTABLE, MODULAR AND STABLE

A. Carballedo^{1†}, J. Hernández-Toro², C. Colldelram¹, R. Monge¹, L. Nikitina¹, J.R. García¹, L. Roso²

¹ALBA-CELLS Synchrotron, 08290 Cerdanyola del Vallès, Spain

²Centro de Láseres Pulsados, CLPU, Parque Científico, 37185 Villamayor, Salamanca, Spain

Abstract

In the recent years, the number of high power lasers devoted to particle acceleration has increased in Europe. Additionally to this, some synchrotrons and accelerators are integrating these lasers in its lines, increasing the scientific synergies. The HP laser must be transported in HV. The use of HV also permits good cleanliness in the optical setup. As addition, is necessary to create an adaptable and modular design where several chambers could be assembled together. One additional constrain is the stability. A new model of HV chambers is presented. These consist in a frame where the walls are exchangeable panels, which make easier the introduction of a new configuration of ports. The system was designed as construction blocks. For a proper connection of the chambers a new interior fixation and pushers system was designed. Thanks to this, coupling new HV chambers, the volume total can be also easily modified. Finally, a third generation decoupled system is integrated inside, consisting of a stable breadboard, this supported by six columns that implement a preloaded kinematical mount, providing both an outstanding stability and a fine regulation (1st RM: 77Hz).

INTRODUCTION

This project is the result of the collaboration between ALBA-CELLS and CLPU in order to promote the Mechanical engineering related with the high power laser. CLPU (Ultra-short Pulsed Laser Center) is a facility specialized in femtosecond laser pulses with peak powers at Gigawatt, Terawatt and Petawatt levels. Previous collaborations have given the 200TW and 1PW laser compressors. The protagonist of this article is the third one, the 1PW Experimental system consisting in a HV modular vacuum chamber and a stable breadboard for the optical equipment.

MAIN CONCEPT

The functionality of this chamber is as interaction chamber, where the target of the laser and the focus system are mounted. Due to the laser is a high power laser, after the laser is compressed, this cannot be transported in air because the laser properties are deteriorated and a complete HV system ($<5 \cdot 10^{-6}$ mbar) is required. Further-

more, this also reduces the presence of hydrocarbon contamination on the system.

REQUIREMENTS

A new paradigm of HV chambers is presented. It is necessary to create an open and adaptable design with the following requirements:

- The vacuum chamber should be modular and allow easily modifications in the ports distribution.
- As different experimental setups might need of different optical equipment distribution, a decoupled system is integrated inside the chamber, based in the experience of the two previous laser compressor chambers.

DESIGN

Vacuum Chamber. Modularity

The Experimental vacuum chamber is designed plate-to-plate in a rectangular configuration. Each plate has rectangular ports for lateral covers. Due to the modularity of its design, faces are identical two by two. It implies that the large lateral covers and the short lateral covers are equal respectively. This fact allows not only using a same design of lateral cover for each experimental chamber but also interconnect different vacuum chambers between each other (Figure 1).

Vacuum chamber is made of AISI 304L stainless steel with the exception of AL 6082 aluminium lateral covers, and can be divided on four main parts: bottom cover, walls, top cover and lateral covers. The global dimensions of the chamber are 3000 mm x 1900 mm x 1500mm.

In order of ensure the tightness a system of double joint with different size was designed. This permits either to fix one lateral cover or another vacuum chamber in the same port.

Furthermore, an internal matrix of holes was added to each port in order to allow the connection between chambers.

Due to the big weight of the chamber a complete system of pushers was added. Low friction intermediate plates are placed between chamber and its support to

† acarballedo@cells.es

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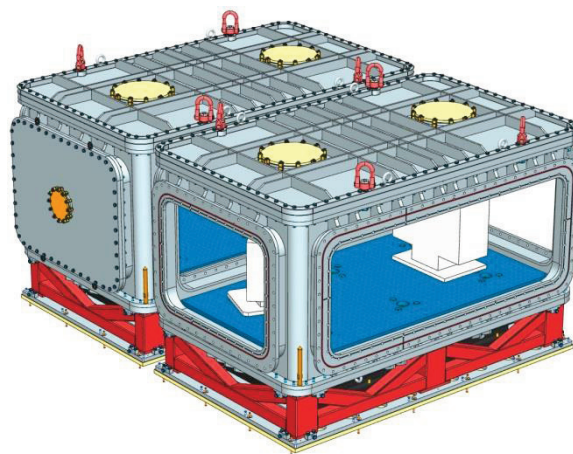
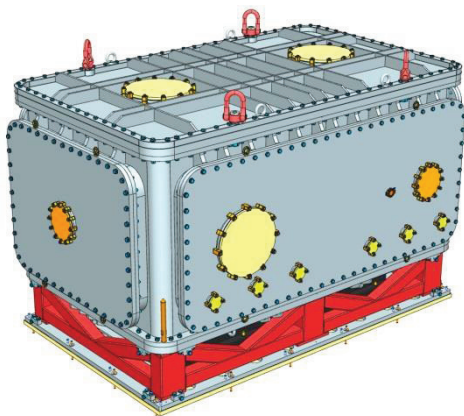


Figure 1: Experimental vacuum chambers. Individual assembly and two chambers connected.

soften the movement the chamber in 2 axis and make the connection easily (Figure 2).

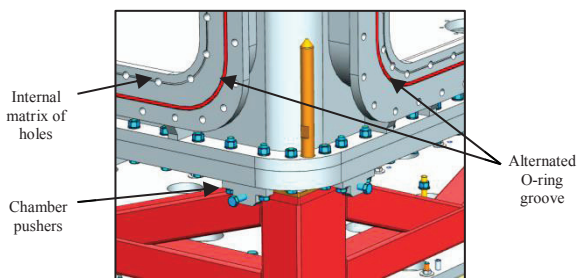


Figure 2: Detail of alternated O-ring grooves, internal matrix of holes and chamber pushers.

Different calculations by means of FEA have been done in order to achieve the standards of safety and technical specifications. The modularity of the design has made necessary to check that in any possible configuration the vacuum chamber would achieve these standards. The resulting maximum deformation and stress for an individual chamber were 0.84 mm and 78.5 MPa respectively. Regarding to two chambers together, deformation and stress was of 1.1 mm and 101 MPa (Figure 3). The values obtained from the modal analyses for both configurations are showed in Table 1.

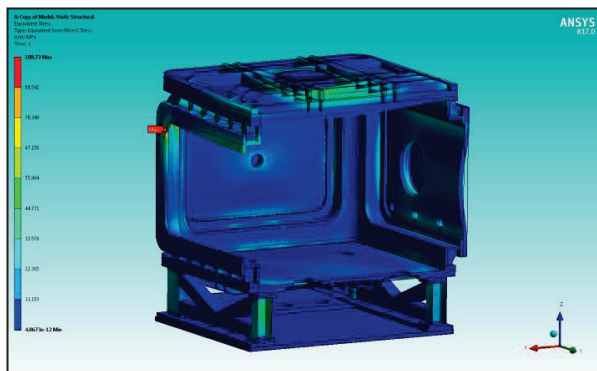
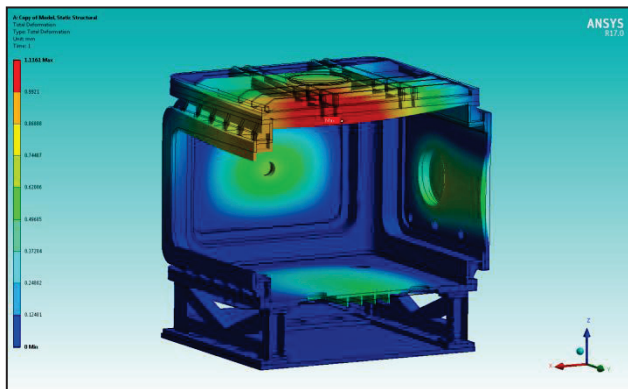


Figure 3: Expected deformation and stress results for two chambers together.

Table 1: Vacuum Chamber Resonance Modes.

Mode	Frequency [Hz]	
	One chamber	Two chamber
1	57.2	61.2
2	80.4	64.9
3	82.5	76
4	105.4	93
5	116.7	101
6	147.8	121.7



Breadboard System: Stability

The Breadboard is a flat, rigid and stable surface (AL 6082) mounted on six pedestals above six blanking flanges (AISI 304 and AISI 420B) and a granite block. The granite rests on a base plate made of conventional steel S-235 and this plate rests on an epoxy layer. Breadboard system is disengaged from the vacuum chamber by means of hydroformed bellows so no vibration is transmitted between both subsystems.

On the six columns, a preloaded kinematical mount is implemented (cone, V slot and four planes). These contacts allow vertical fine regulation (linear resolution of 50 μm) with angular relieving (pitch and roll) thanks to the presence of spherical washers (Figure 4).

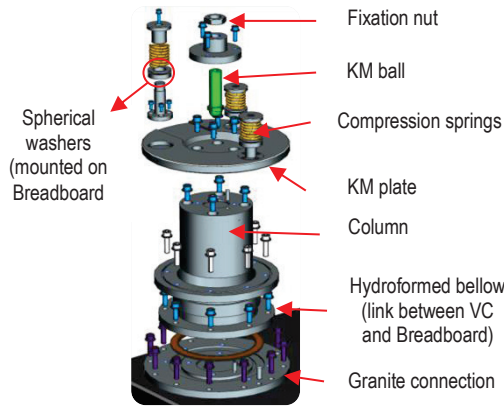
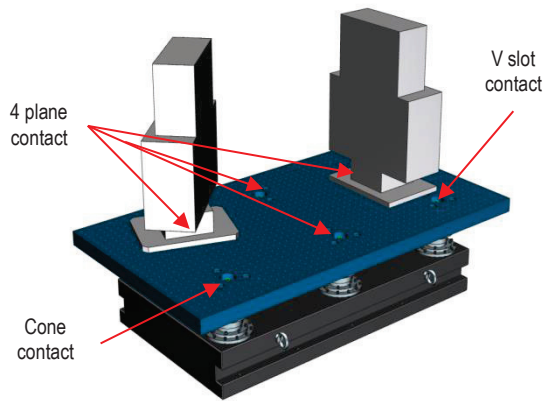


Figure 4: Breadboard assembly and conical KM contact detail.

Different FEA calculations studying the free vibration behaviour were done (Table 2). Figure 5 shows the breadboard deformation and first resonance mode. Maximum expected deformation of 0.004 mm and 1st RM of 76.8 Hz.

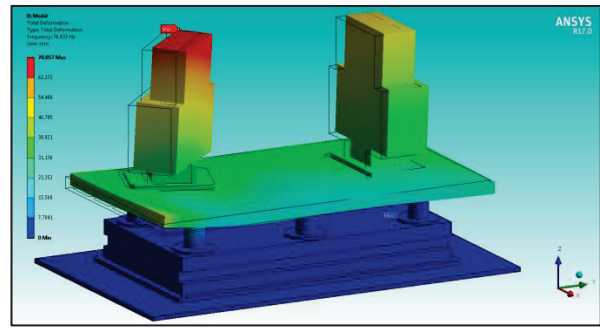


Figure 5: Expected deformation and RM results.

Table 2: Breadboard Resonance Modes.

Mode	Frequency [Hz]
1	76.8
2	115.8
3	126.3
4	141.7
5	143.2
6	168.8

CONCLUSION

As a conclusion, the collaboration between CLPU and ALBA-CELLS has result in a third generation vacuum chamber and breadboard design applied to high power laser plants.

Without refusing to the achievements accomplished of low deformation and stability of the two previous laser compressor chambers (Def.≤1mm and 1st RM>50Hz), the new Experimental vacuum chamber adds the flexibility and modularity needed in any scientific facility who constantly faces new challenges with a limited budget.

The chamber, which is under construction currently, should be tested and installed during this month.

ACKNOWLEDGEMENT

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