CIEMAT activities in CALICE SDHCAL: Mechanics

X Meeting of the Future Linear Colliders Spanish Network

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1. Goal.

The aim of the project we are development here is to participate in R&D activities. It is a continuity of the work developed by the CIEMAT group in the past years but represents a step forward to address the issues related to build a real detector. We must show that the SDHCAL technology is viable, not only in terms of physics performance and operation but also we should demonstrate the feasibility of a compact integrated detector design fulfilling the demands of compactness and hermeticity and the viability of its construction.

The goal of the SDHCAL for the next few years is to build few larger GRPC chambers with the final dimensions of the biggest one (~290x90 cm2) foreseen for ILD, equip them with a new version of electronics and insert them in an absorber mechanical structure, built with the same procedures than the final one, capable to host 4 or 5 of them. The chambers will be tested with beam particles at CERN to confirm that they have the same performance than the 1x1m2 used for the 1m3 prototype.

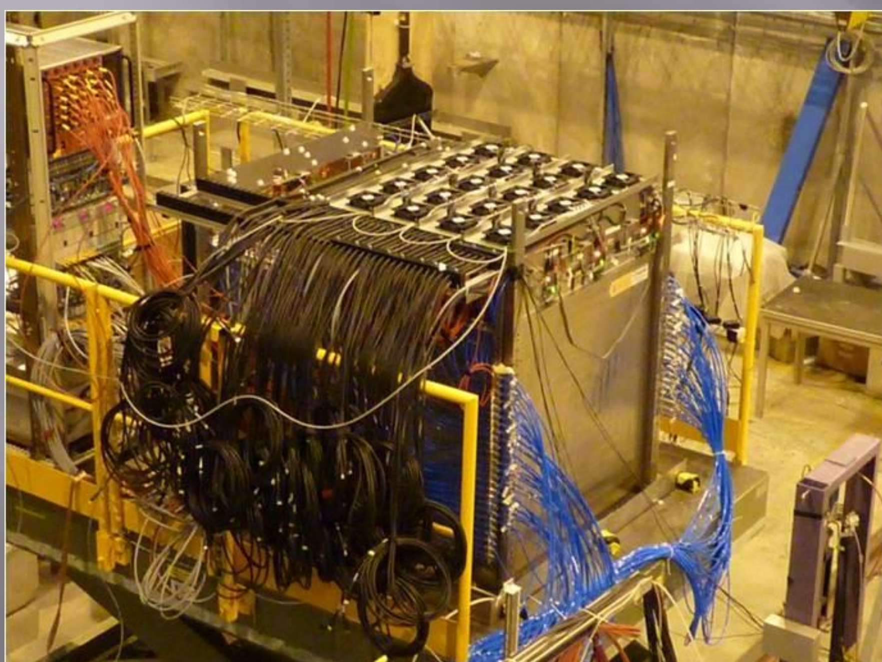
The CIEMAT group will lead the SDHCAL mechanics R&D activities.

2. Previous Ciemat prototype.

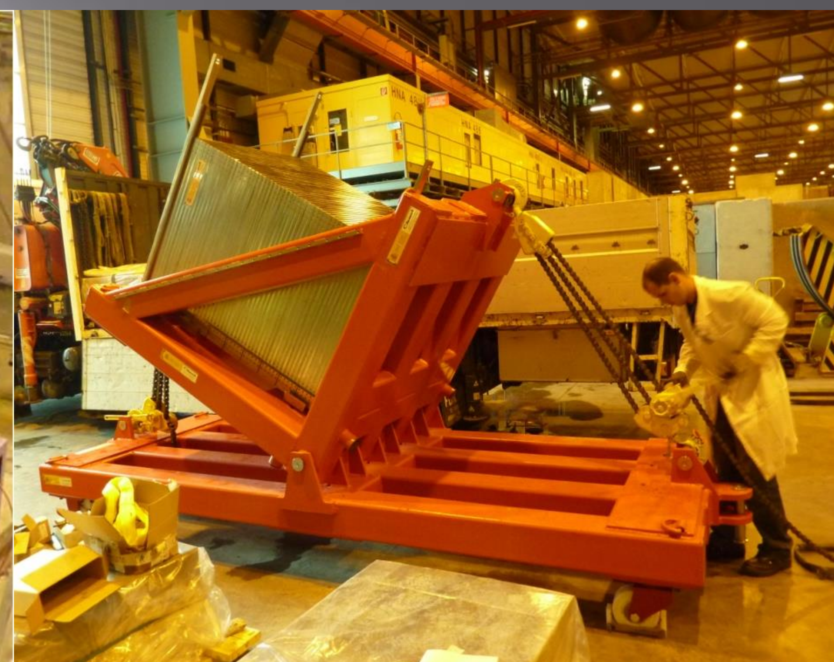
- **<u>The M^3 SDHCAL prototype</u>** concept:

Is a sampling calorimeter with stainless steel as absorber, a gas detector (Glass Resistive Plate Chamber (GRPC)) as active medium and 1x1 cm2 readout electronics segmentation. Each layer is compound of 20 mm absorber + 3 mm GRPC + 3 readout electronics + 2 mm tolerances.

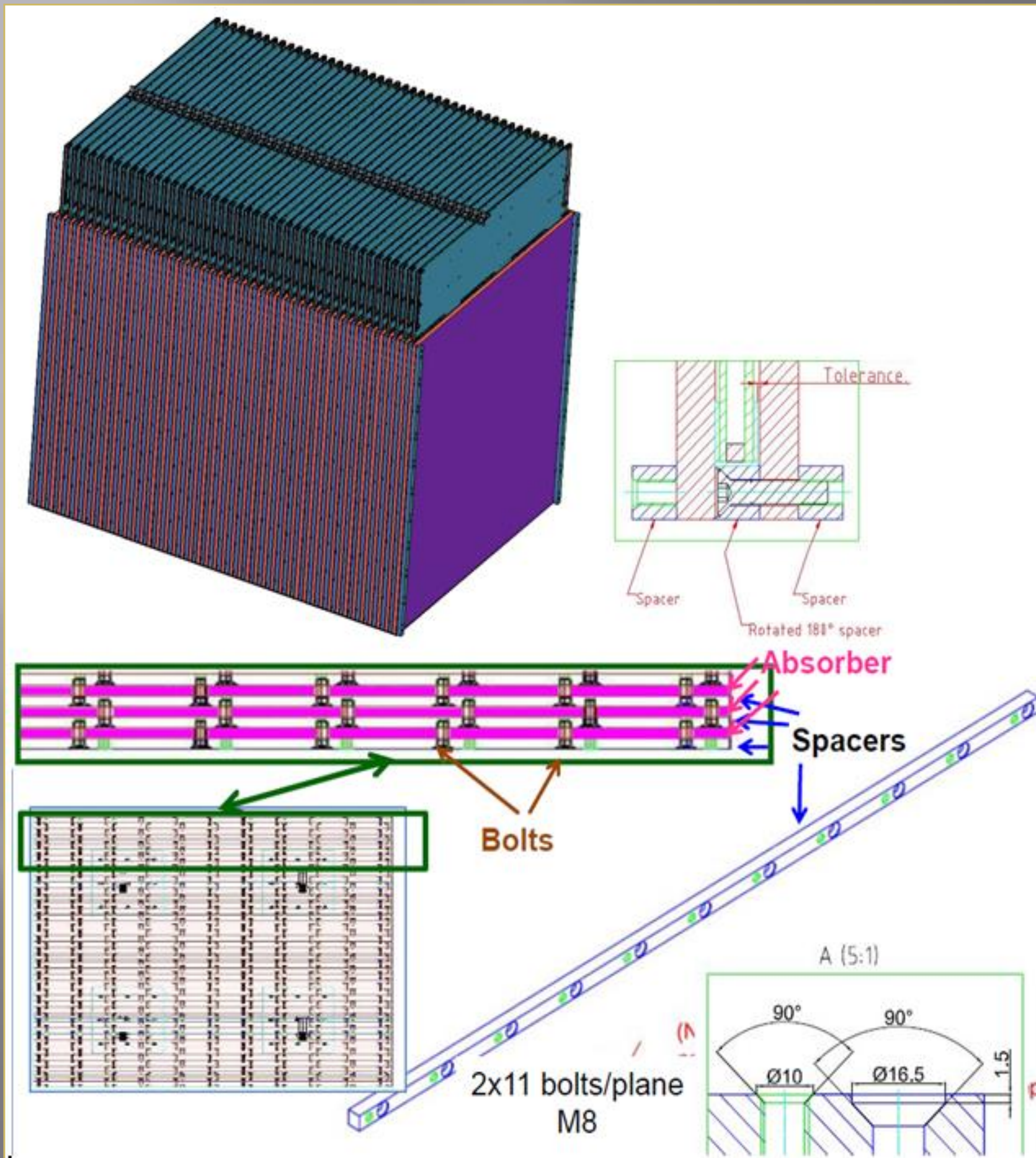
The prototype module is a self-supporting structure with 50 layers of stainless steel plates with dimensions 1010x1054x15 mm3. The gas detectors are assembled in independent readout cassettes and inserted in between the plates.



M^3 SDHCAL prototype at CERN test beam.

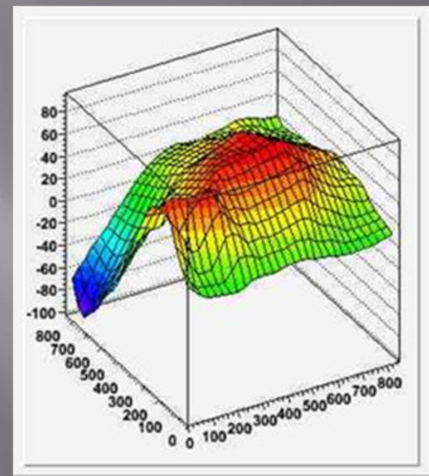


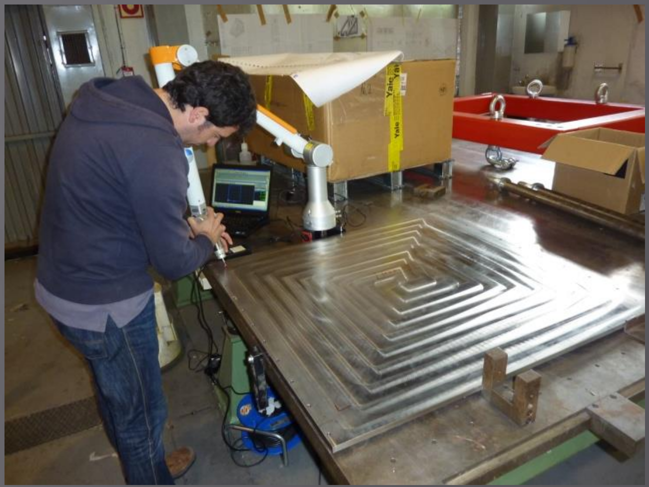
Using both hand Pull-Lift together we can rotate the module with the rotation tool.



The mechanical structure is made of 51 stainless steel plates assembled together using lateral spacers fixed to the absorbers through staggered bolts. The thickness tolerance is 0.05mm and a surface planarity below ~500 microns was required. The spacers are 13mm thick with 0.05mm accuracy. The excellent accuracy of plate planarity and spacer thickness allowed reducing the tolerances needed for the safe insertion (and eventual extraction) of the detectors. This is important to minimize the dead spaces and reduce the radial size view of a future real detector where the calorimeter will be located inside the coil.

- The design of this structure, machining of the spacers and pieces, final assembly and quality tests has been done at CIEMAT. This required also the design and construction of a precise assembling table and different tooling.





(Left-top) Measurement of a plate planarity using a laser interferometer system.

(Center-top) Planarity over the surface of a plate

(Rigth-top) Measurement of the plate using a CMM arm.

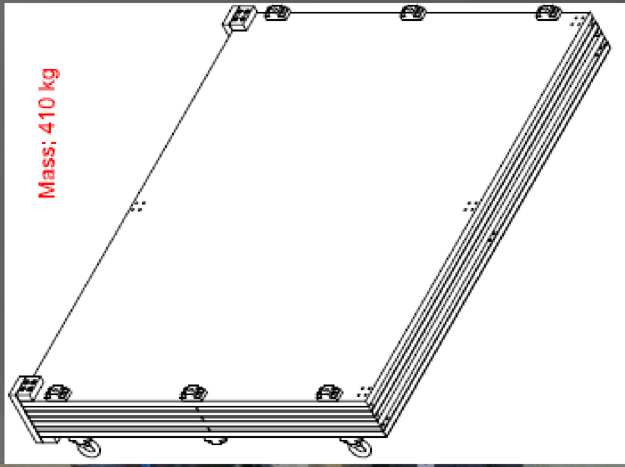
(Left-Bottom) Measurement of the m^3 prototype using the CMM arm on the assembly table.

(Center-Bottom) Using the lifting tool.

(Right-Bottom) Assembly table.

3. PROTOTYPES UNDER FABRICATION.

The plates of the 1m3 were assembled together with the spacers using bolts, but in the final module we plan weld them to reduce the lateral dimensions of the spacers to decrease the dead space. The welding can introduce deformations and increase the depth due to the extra tolerances needed. Electron beam welding is probably the best but need vacuum conditions and could be not affordable for a big module, the Laser welding could be a better option. Standard, Electron beam and Laser welding will be tested at CIEMAT and external companies or CERN.
Quality tests as the planarity or position precision will be performed by using a 3D articular precision arm already used for the 1m3 prototype tests and the reference tables.



- Machining Test for a small prototype (Ciemat workshop)

+A small machined and welded module structure compose of several layers:

-4 Plates of Inox AISI 304 of ~1000x800 and 15 mm thickness.

-Several spacers.

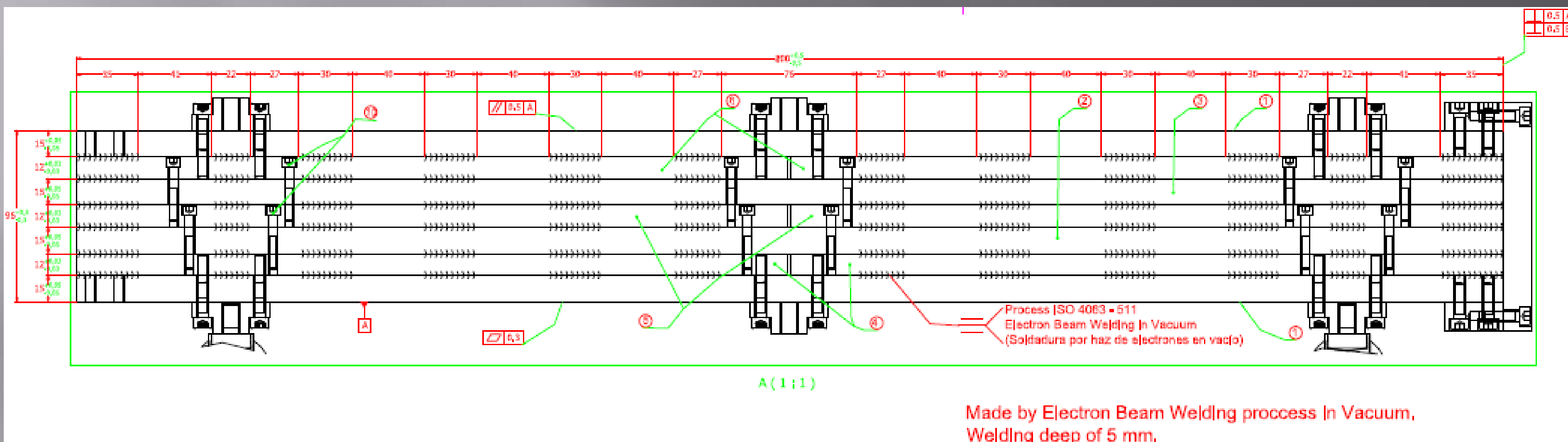
-Auxiliar pieces.

+Operational tool.

+Verification tool.

- <u>Welding Test for the small prototype (CERN workshop)</u>

+The small machined prototype will be welded by electron beam welding (EBW) process in vacuum at CERN.



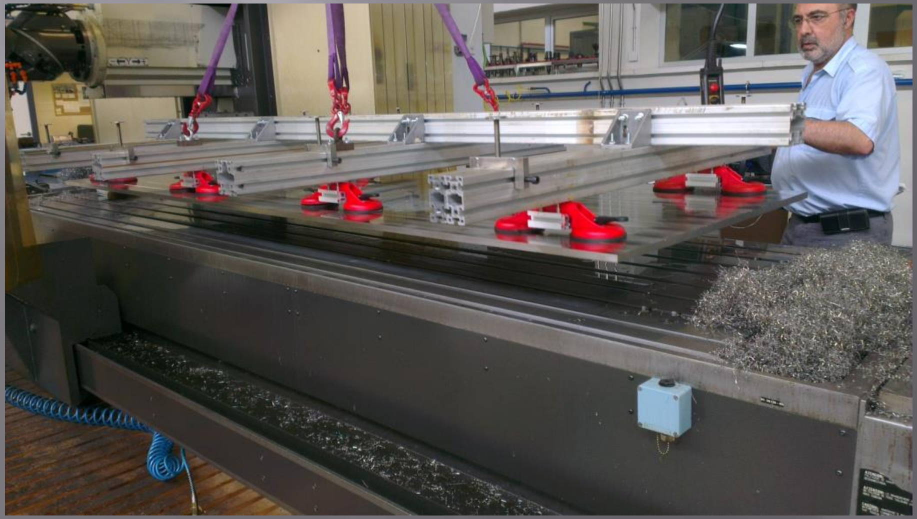
- Machining test for the large prototype (Ciemat workshop)

The planarity required for the final prototype is <1mm, larger than we required for the 1m3 prototype but more difficult to obtain in a surface three times bigger

+to produce one plate of Inox AISI 304 of 3000x800 and 15 mm thickness.

+Operational tool.

+Verification tool.



4. Ciemat infraestructures.

- The **Ciemat main <u>Workshop</u>** has several working lines that include different fabrication technologies. This unit has about 25 people.

The most relevant machines are:

-Several CNC machine centers and Milling machines, until 4x1x1 m3 working range.

-CNC turning and turning machines until 0.9 m diameter and 3 m length working range.

- Electrical discharge machines.

-Plane surface CNC grinder.
-Several metal forming machines, 1 CNC bending and forming machine of 3 m range, CNC punching machine of 2x1.5 m2 range, Hydraulics cutting shears of 3 m range.
-Several welding process machines how Shielded Metal Arc Welding (SMAW), Tungsten inert gas welding (TIG), Metal inert gas welding (MIG), metal active gas welding (MAG), oxyacetylene welding.

-Coordinate-measuring machines (CMM), to verify the tolerances of the pieces.

-The CIEMAT equipment includes also large assembly hall already used for the assembly of LEP and LHC detectors and CALICE prototype. The equipment includes 2 cranes (1.6t and 3.2t), compressed air, big assembling tables, a laser interferometer, a 3D articulated precision arm and gas system distribution.

5. NEXT.

- Machining and Welding Test for a smaller prototype (Ciemat workshop)

+A smaller machined and welded module structure compose of several layers. By standards welding process and using methods to minimize deformations, this should be the cheaper welding process:

-4 Plates of Inox AISI 304 of ~1000x400 and 15 mm thickness.

-Spacers and auxiliary pieces.

+Operational tool.

+Verification tool.

- Laser Welding Test for a smaller prototype (CERN or external company)

+If with the standard welding we can't obtain the required tolerances, to reduce production costs of the EBW, we will do a test with a smaller machined module structure , but with laser welded process.

-4 Plates of Inox AISI 304 of ~1000x400 and 15 mm thickness

-Spacers and auxiliary pieces.

- <u>Survey market for the roller leveling</u>

+ The roller leveling is essentially a bending process. The out of flat part of the plate is deformed by a series of alternating bends. These alternating bends are created by passing the plate between upper and lower sets of leveling rollers. The leveling rollers are offset by half of the roller pitch in the direction of the travel. As a result, the sheet metal takes a wave-like path through the precision leveler. This wave should be greatest at the entry into the machine and smallest at its exit (comparable to a decaying sinusoidal curve). The elastic-plastic alternating bends and the constant decline of bending intensity thereby produce flat and nearly stress-free plates.

+ We are doing that from time ago, but not easy, because the companies aren't interested in small quantities like our devices.

-test for two plates of Inox AISI 304 of 3000x800 and 15 mm thickness.

- <u>Design and construction of a mechanical structure to host 5 GRPC with the largest dimensions of a ILD SDHCAL</u>

+Design of the final mechanical structure.
+Produce a machined/roller leveling and welded module structure compose of several layers:
 -6 Plates of Inox AISI 304 of ~ 3000x800 and 15 mm thickness.
 -spacers and auxiliary pieces for this structure.
 -reinforces.

+Operational tool.
+Verification tool.

- Next step is to build few GRPC chambers with the final dimensions of the biggest one foreseen for ILD, equip them with the new electronics and insert them in a mechanical structure produced with the final procedures.