# The CALICE SemiDigital Hadronic CALorimeter (SDHCAL)

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**VI Jornadas sobre la participación española en futuros aceleradore lineales**

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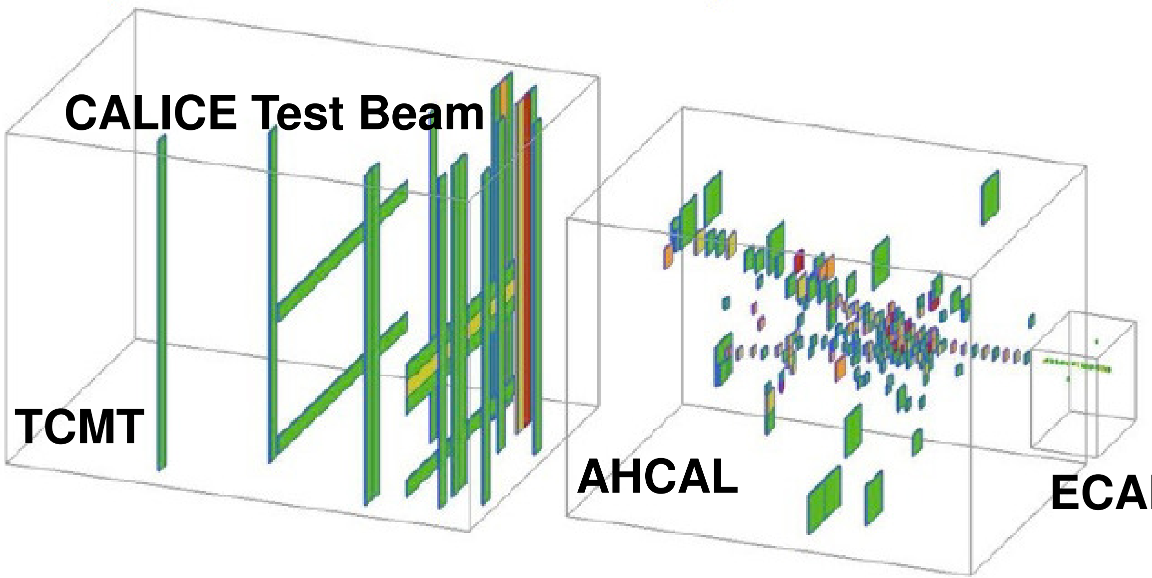
Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas



# The CALICE Collaboration

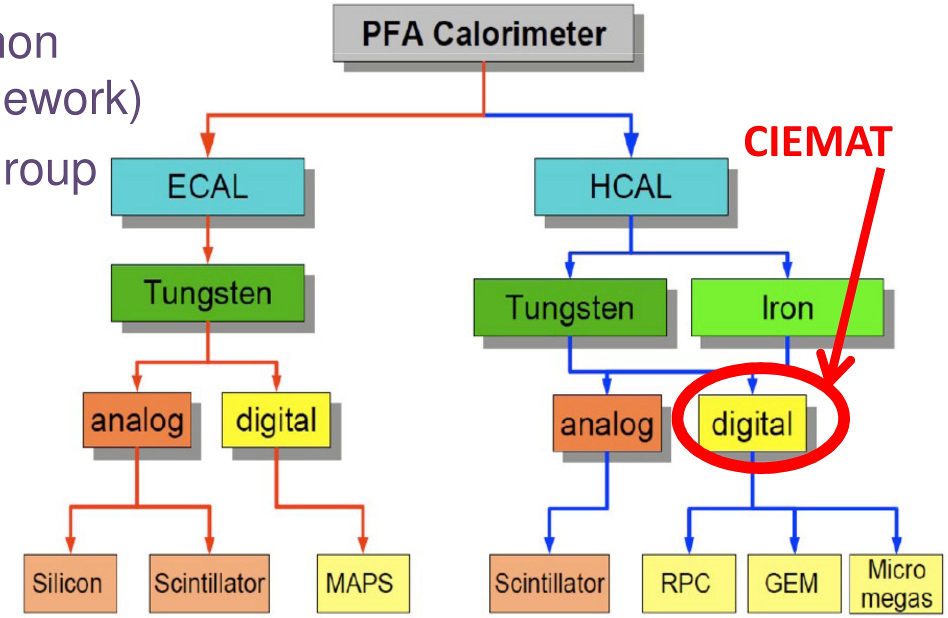
https://twiki.cern.ch/twiki/bin/view/CALICE/CaliceCollaboration

**Goal**: Development of highly granular "imaging" calorimeters to find the "best" calorimeter to deliver the future Linear Collider physics, requirements motivated by Particle Flow for jet reconstruction.

336 physicists/engineers from 57 institutes and 17 countries coming from the 4 regions (Africa, America, Asia and Europe)

**Different technologies** under development with common efforts (infrastructures, testbeams, DAQ, analysis framework)

The work is not for any specific ILC detector concept group




## Two generations of prototypes

**Physics(1st generation) prototypes**
Evaluate technologies; identify problem areas.
Validate Monte Carlo simulations, especially for hadronic showers, so that results can feed into full detector simulations.

**Technological (2nd generation) prototypes**
The goal of the technical prototypes is to demonstrate the possibility to build imaging calorimeters with fully integrated electronics using also similar mechanics, electronics, DAQ, etc to proposed calorimeters. To get experience not only on the operation and performance but on integration and technical issues of building an ILC-like module

In spring 2012 CALICE is expected to present proposals for technology baselines to concepts

# Calorimetry & Particle Flow Algorithms (PFA)

**GOAL: Excellent jet energy & di-jet mass resolution**
**A factor 2 better than the actual calorimeters**

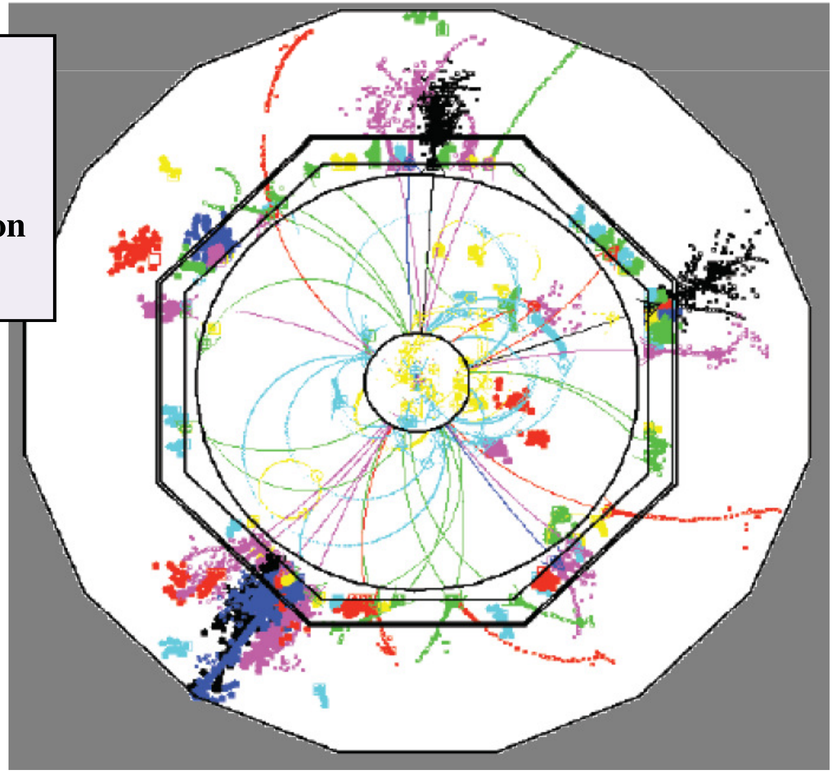
$$\sigma(E) \approx 30\% \sqrt{E(GeV)}$$

$E_{jet} = E_{charg\ trk}$ (Tracker) $+ E_{\gamma}$ (ECAL) $+ E_{h^0}$ (ECAL+HCAL)

fraction: 65% | 26% | 9%

$\sigma^2_{jet} = \sigma^2_{ch.} + \sigma^2_{\gamma} + \sigma^2_{h^0} + \sigma^2_{confusion}$

resol: $\Delta p/p \sim$ few $10^{-5}$ | $\Delta E/E \sim 12\%$ | $\Delta E/E \sim 45\%$



**PFA**

- Charged energy (65%) measured in tracker
- Photons measured in ECAL
- Neutral particles measured in ECAL+HCAL

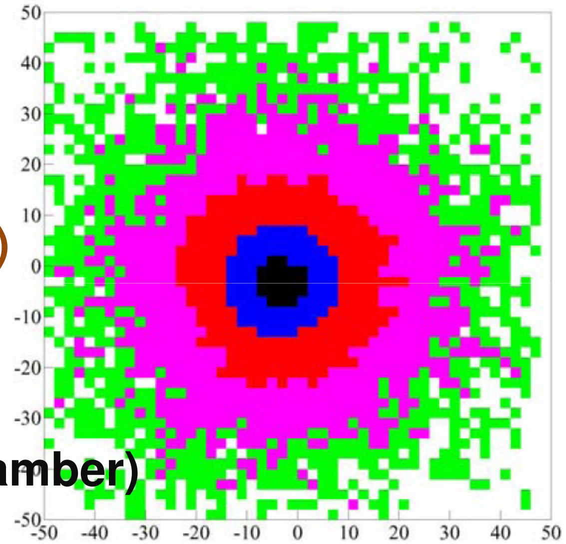
## Pattern recognition on Calorimeters

- Reconstruct each visible particle individually
- Associate charged particles with calorimeter clusters
- Granularity (transversal & longitudinal) more important than resolution in calorimeters

# SemiDigital Hadronic Calorimeter (SDHCAL)

**Groups**: **CIEMAT**, Gent, IPNL, LAL, LAPP, LLN, LLR, LPC, IHEP Protvino, Tsinghua,

CALICE Calorimeter for ILC
Ciemat




**100 GeV pion**

**Sampling calorimeter**

- **Absorber: Stainless steel (2cm width)**
- **Active medium: Gaseous detector, pads 1x1 cm$^2$ (~0.6cm width)**
  - **Gaseous detectors are homogenous, cost-effective, and allow high transverse and longitudinal granularity**
  - **BaseLine ➔ GRPC (Glass Resistive Parallel Chamber)**
  - **(Also considering MICROMEGAS)**

**Semidigital Readout :**

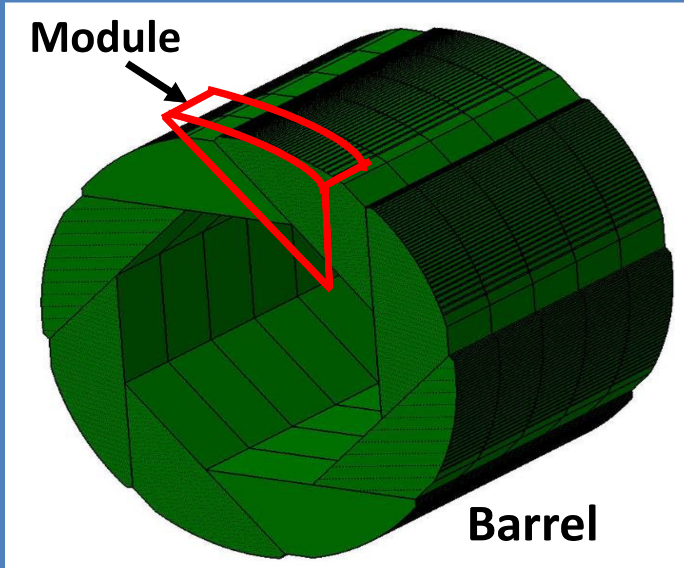
- **Use number of hits instead of deposited energy**
  - **➔ How many & which pads over a threshold**
  - **(A semi-digital readout (2-bits) improves the resolution at high energies)**

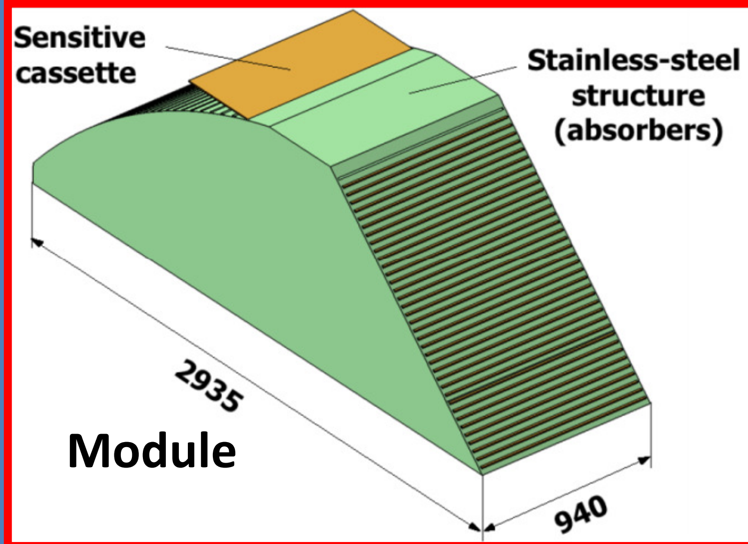
**Simpler electronics (just a comparator)**

- **Simplifies requirements on uniformity of the active medium, reduces costs of electronics**

**But, price to pay higher granularity 1x1cm$^2$ ➔ 70-80 millions of channels**

ILD - SDHCAL LOI design




## The technological prototype

**We intend to validate the SDHCAL concept by building a prototype which is as close as possible to the proposed SDHCAL for ILD**

**1- Large detector with almost no dead zones**
**2- Large electronics board**
**4- One-side services**
**5- Self-supporting mechanical structure**
**6- Power-pulsed electronics**
**7- New generation of DAQ system**

Size: 51 stainless steel plates + 50 detector cassettes ~ $1m^3$ ~500K channels

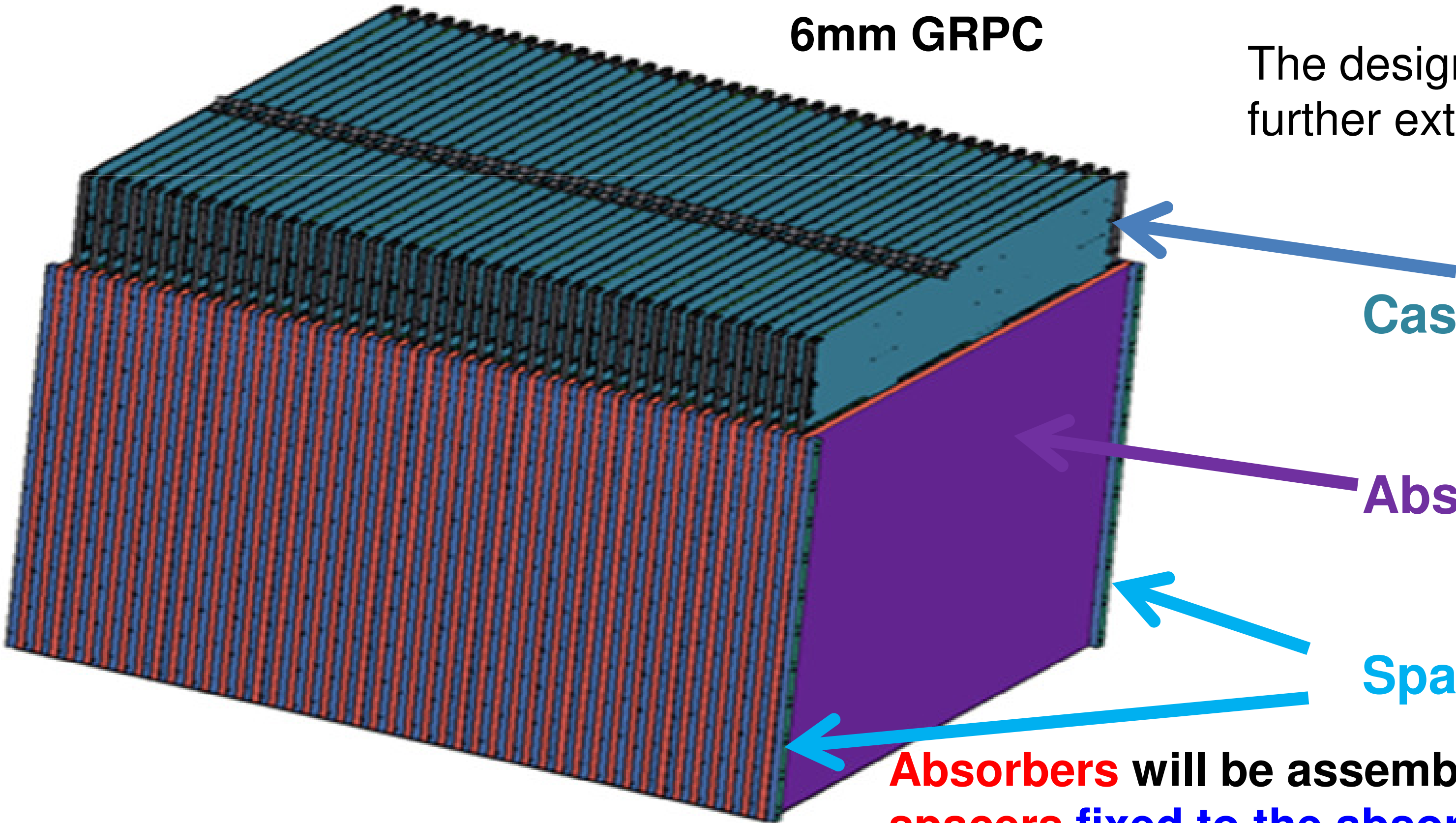
# Towards a Technological Prototype

**Technological prototype :** **48-50 detector plans of 1m$^2$ :**

**20mm stainless steel (absorber + cassette support)**

**6mm GRPC**

The design allows the insertion and further extraction of the cassettes



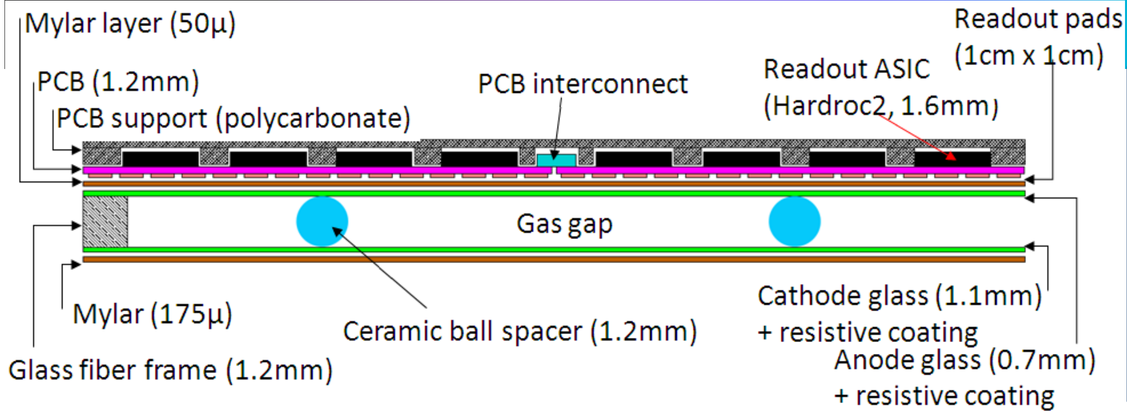

**Absorbers will be assembled together using lateral spacers fixed to the absorbers through bolts.**

The dead spaces have been minimized as much as possible taking into account the mechanical tolerances (lateral dimensions and planarity) of absorbers and cassettes to ensure a safe insertion of the cassette.

Design independent of the detector technology to be used (RPC and MICROMEGAS)

# The Detectors
# Glass Resistive Plate Chamber (GRPC)

# GRPC Chambers & Electronics

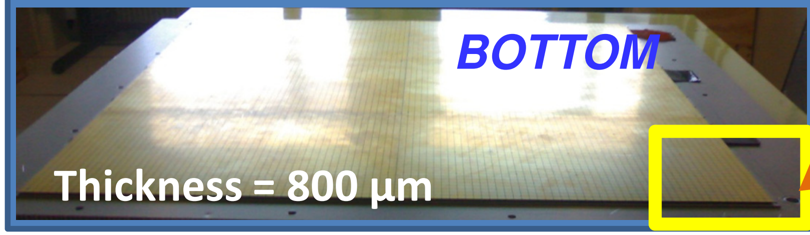


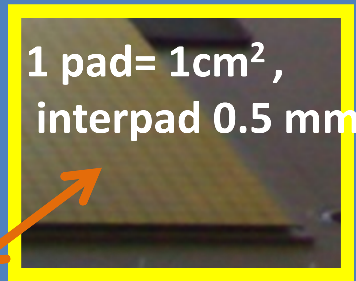

**ASIC: HARDROC**
- 64 channels ,
- 2-bit readout (3 thresholds)
- Digital memory: 128 events,
- Power pulsing system
- Large dynamic gain

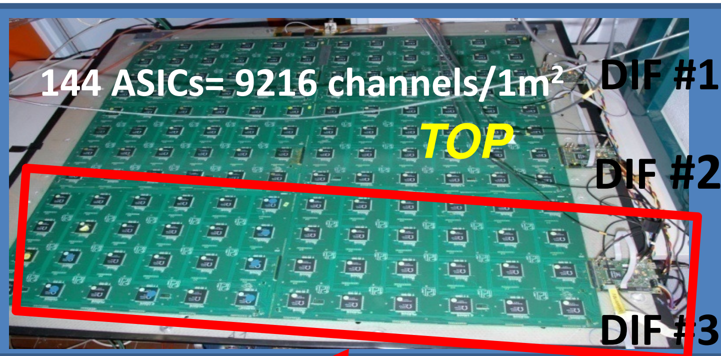
**Large number of readout channels (~4x10$^5$ for 1m$^3$) the readout electronics embedded in the detector**

**The HARDROCs are hosted in a Printed Circuit Board (PCB)➔ ASU (Active Sensor Unit)**
**It provides the connection between adjacent chips and link the first to the readout system and contains in the opposite face the 1x1cm$^2$ copper pads for the GRPC readout**

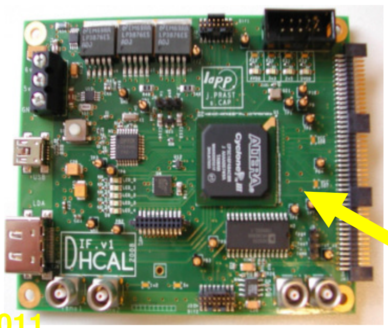
**1m$^2$ board fabrication too difficult**
**➔ 6 ASUs hosting 24 ASICs**

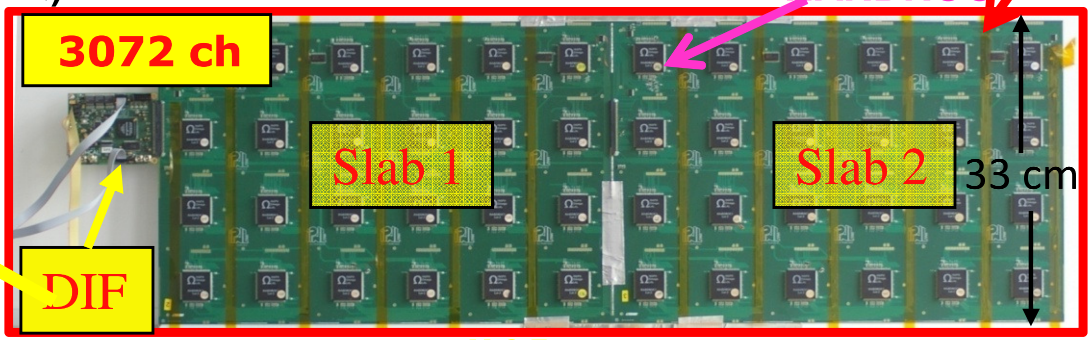


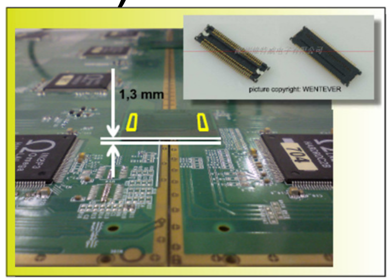




**Every two ASUs connected to each other and connected to one DIF (Detector InterFace) card.**
**3 DIFs (connect to the DAQ) for a 1m$^2$**

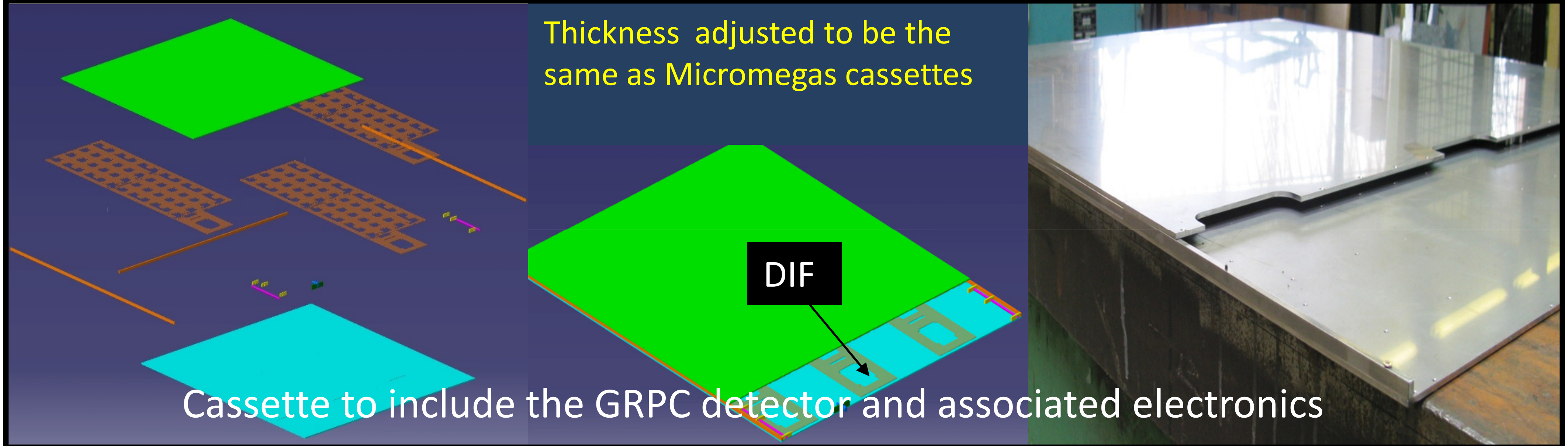


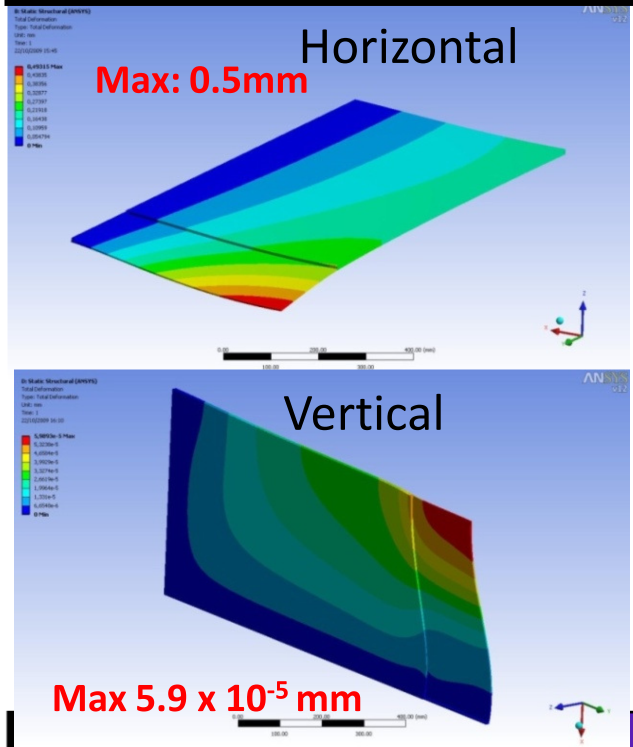




**ASU to ASU connector allows the continuity of the GND soldering**

# GRPC Chambers.
# Mechanic structure: Cassette



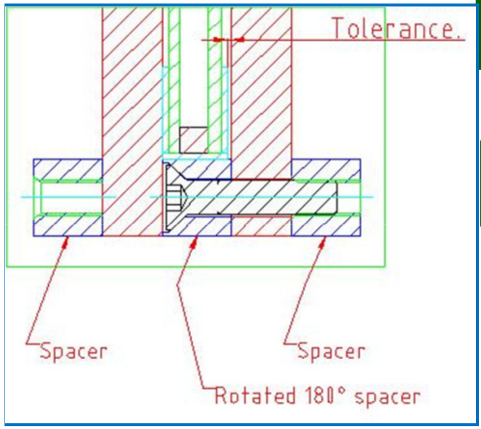



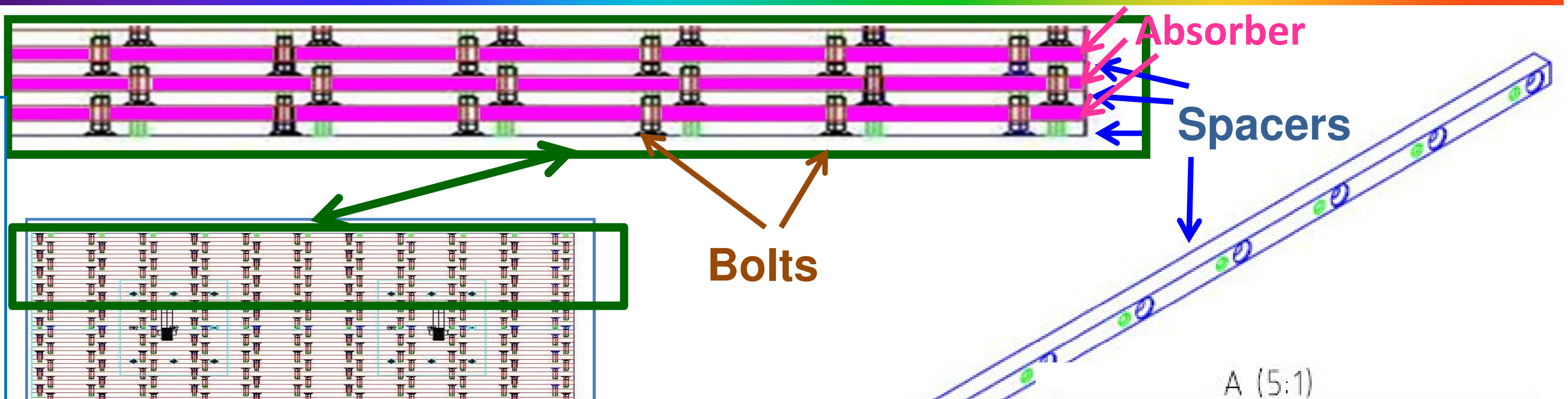

- 2x SS plates 2.5mm thick
- Contribute to absorber layers (15mm + 5mm)
- PCB supports in polycarbonate cut with water jet
- PCBs fixed to support using M1.6 screws

**Deformation under its own weight as a function of storage orientation**

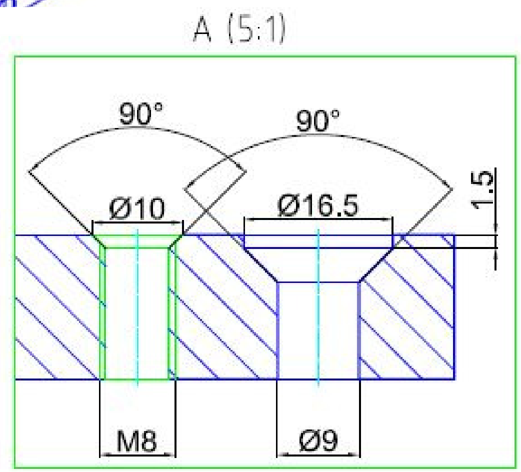
# The mechanical Structure (Dessigned & Built @ CIEMAT)

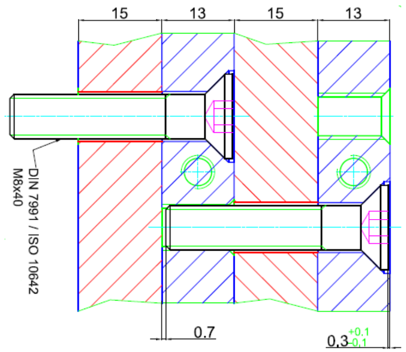
# Absorber Mechanical structure – Details

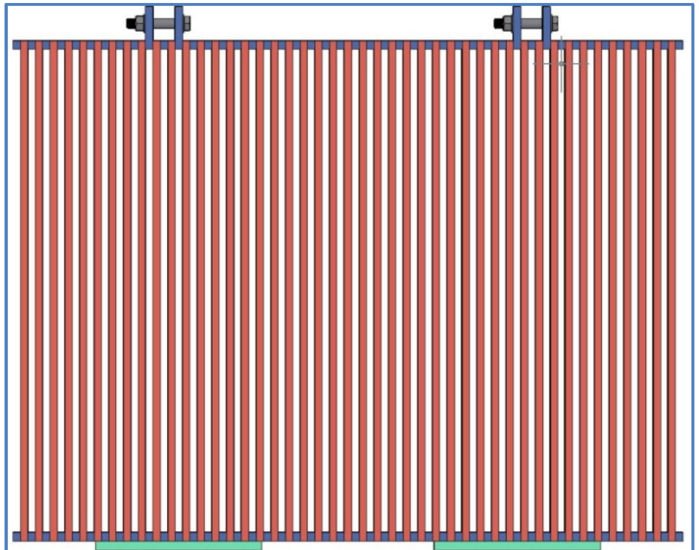



2x11 bolts/plane
M8



**Absorber Plates:**

**1011 x 1054 mm² lateral dimensions**

**15 ± 0.05 mm thick**

**Surface Planarity < 500µm**

**Spacers: 13 mm thick**

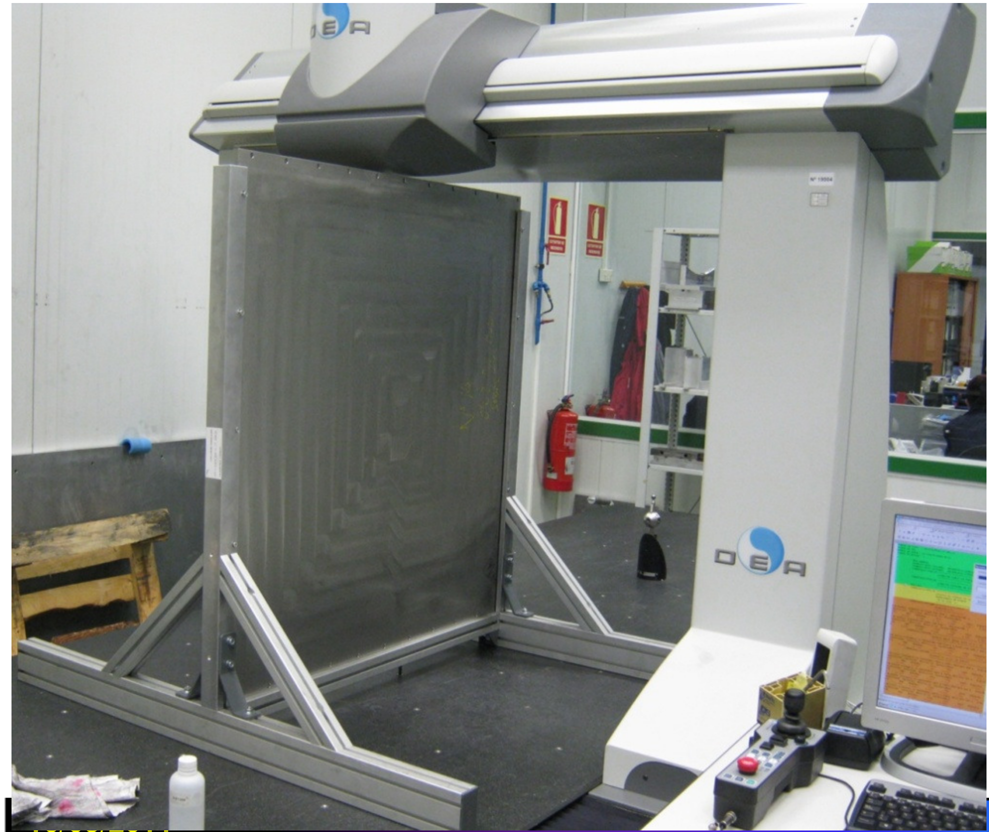
**Material: Stainless steel 304L (permeability , as measured, 1.5**

**➔ it allows to use it in B=4T)**

# Plates & Quality Control

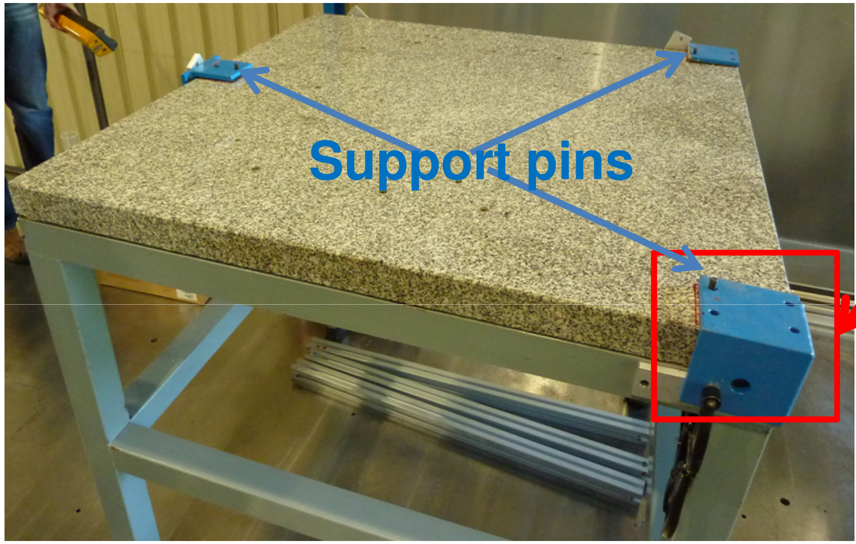
To reduce the gaps it is needed a good planarity of the absorbed plates.
The tolerances of the standard market are higher (several mm) than our needs(hundred of microns), the plates need to be further machined to achieve the precision we are interested in
It is not easy to achieve the precision.
Tests done at different companies to find a supplier that guarantees our needs.

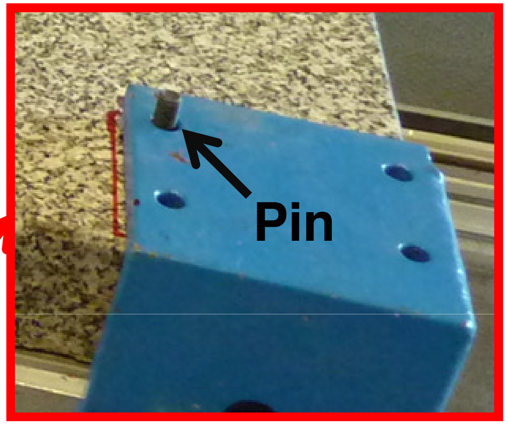
Quality control during the mass production of the plates will include verification by the company, both of the thickness and the planarity, and then a crosscheck will be performed at CIEMAT by using a laser interferometer system (Precision 30-40 μm for the planarity measurement)..




Planarity and thickness measurements (#49 points) performed by the company in vertical on both sides

# Plates - Planarity measurement procedure



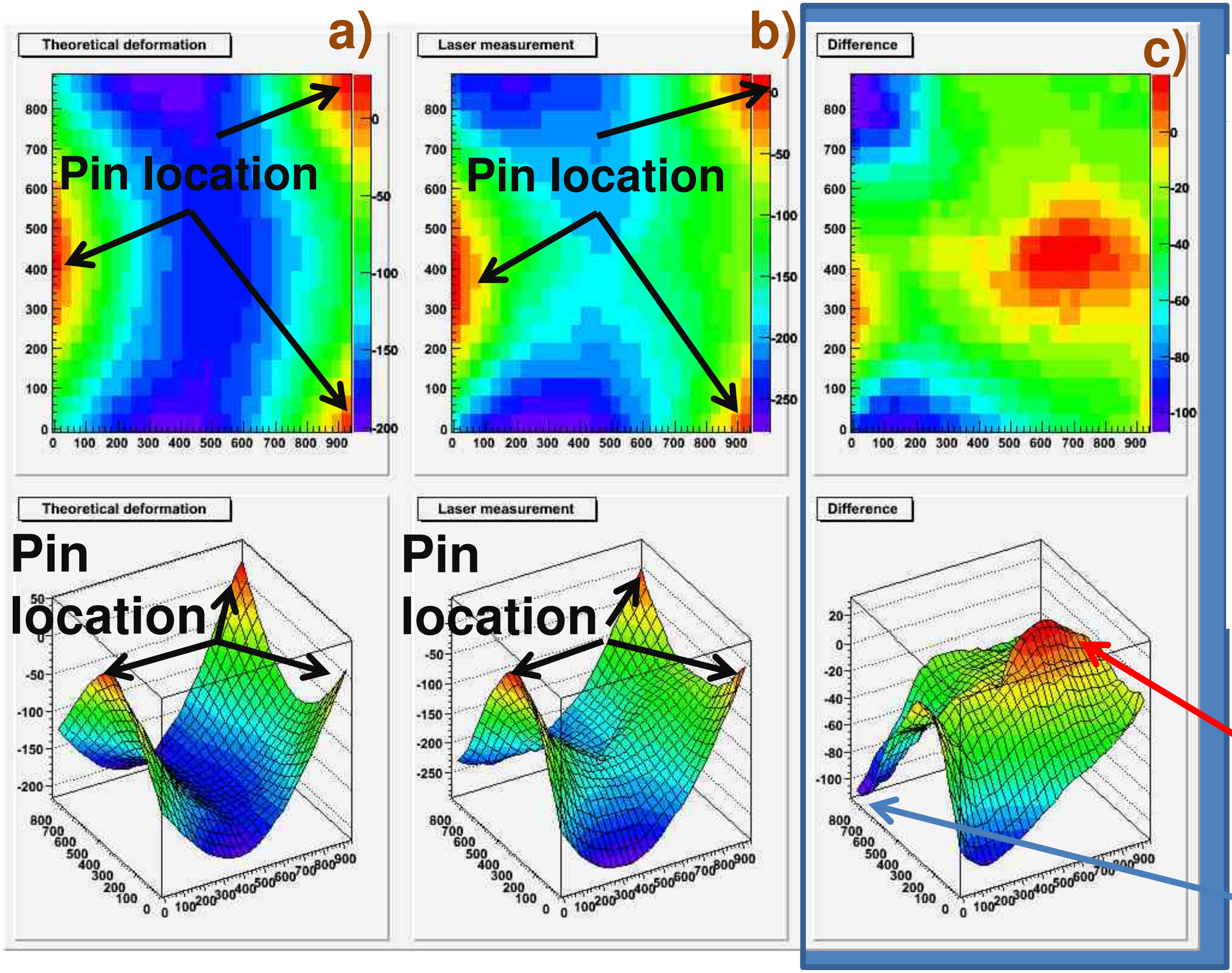




3 pins support the plate

In order to disentangle the planarity measurement from the table shape

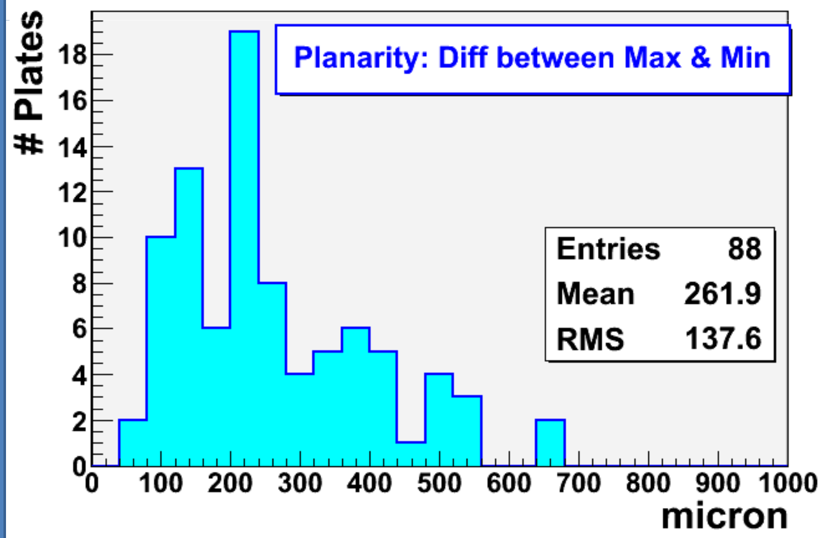
# Plates - Planarity measurement results

a) Theoretical deformations computed for the plate supported by the three pins.
b) Laser measurements of the surface of a real plate
c) Surface plate planarity computed as b) – a)



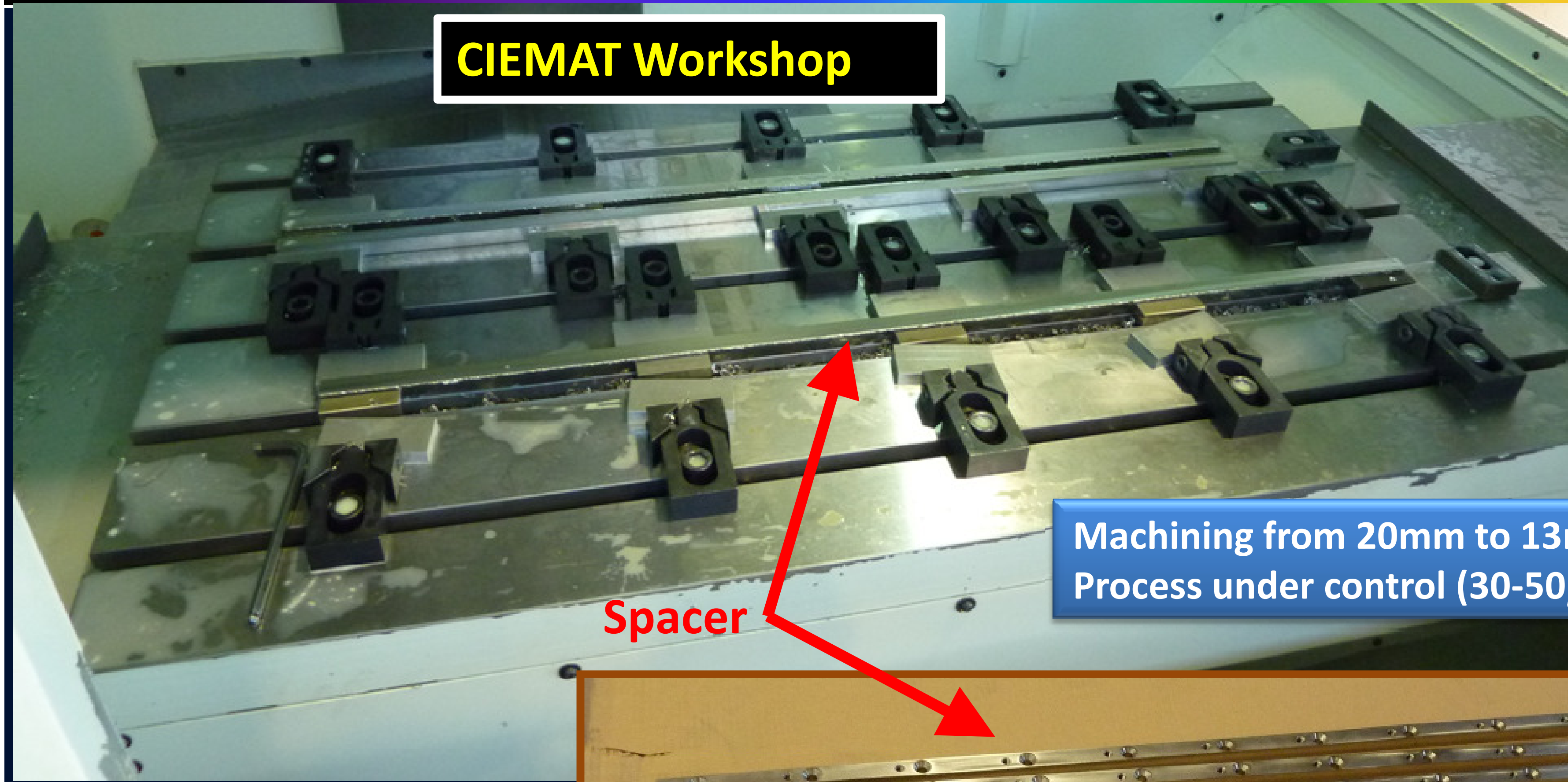

Maximum

Minimum



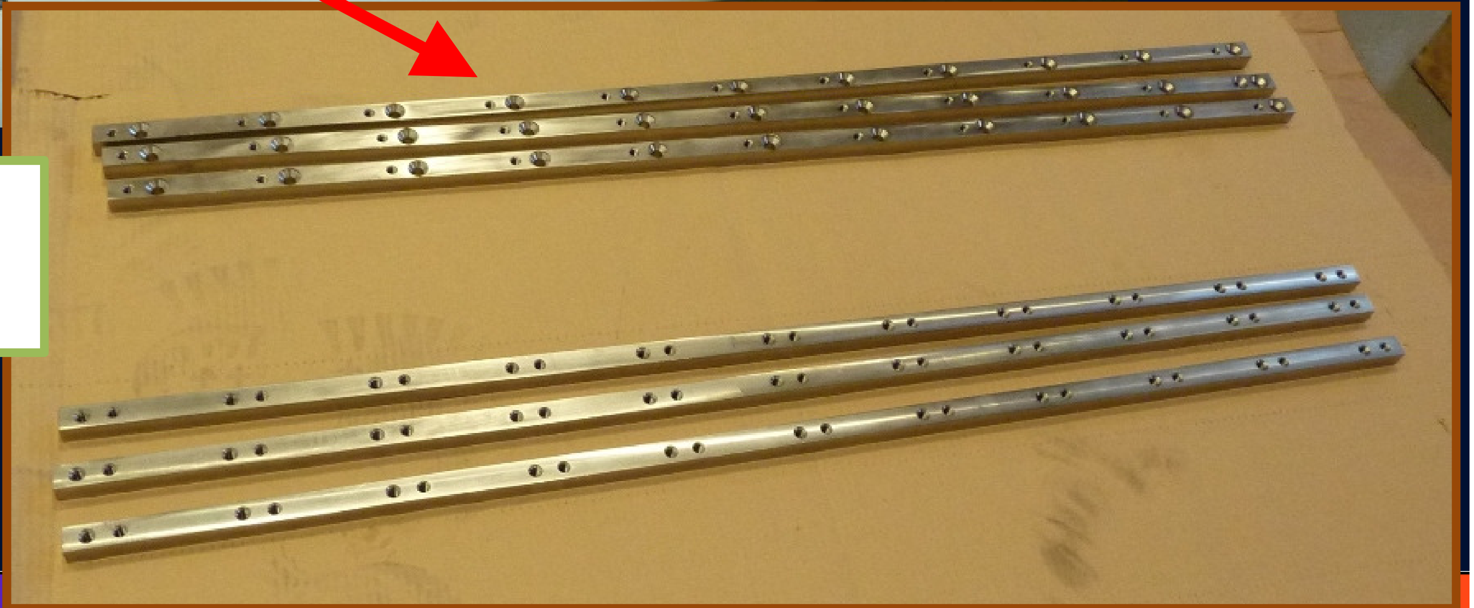

**Planarity values**

# The Spacers

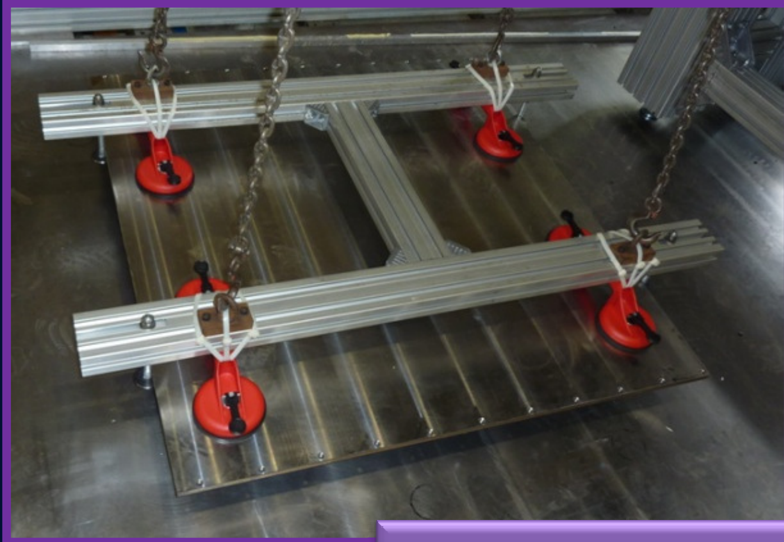



Machining from 20mm to 13mm
Process under control (30-50μm accuracy)

Absorbers assembled together using lateral spacers fixed to the absorbers through bolts.

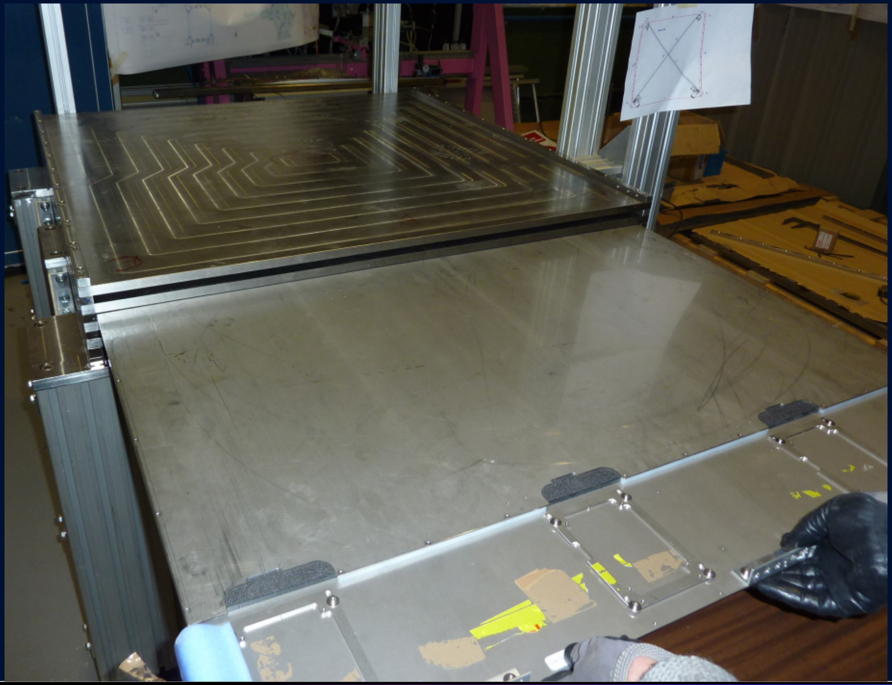


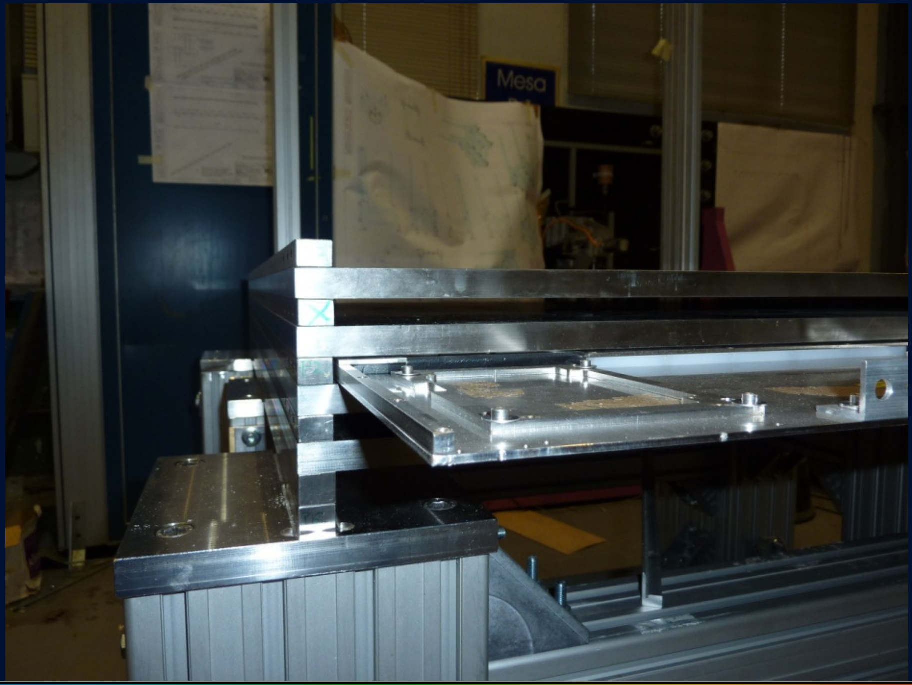
# Assembly Tools

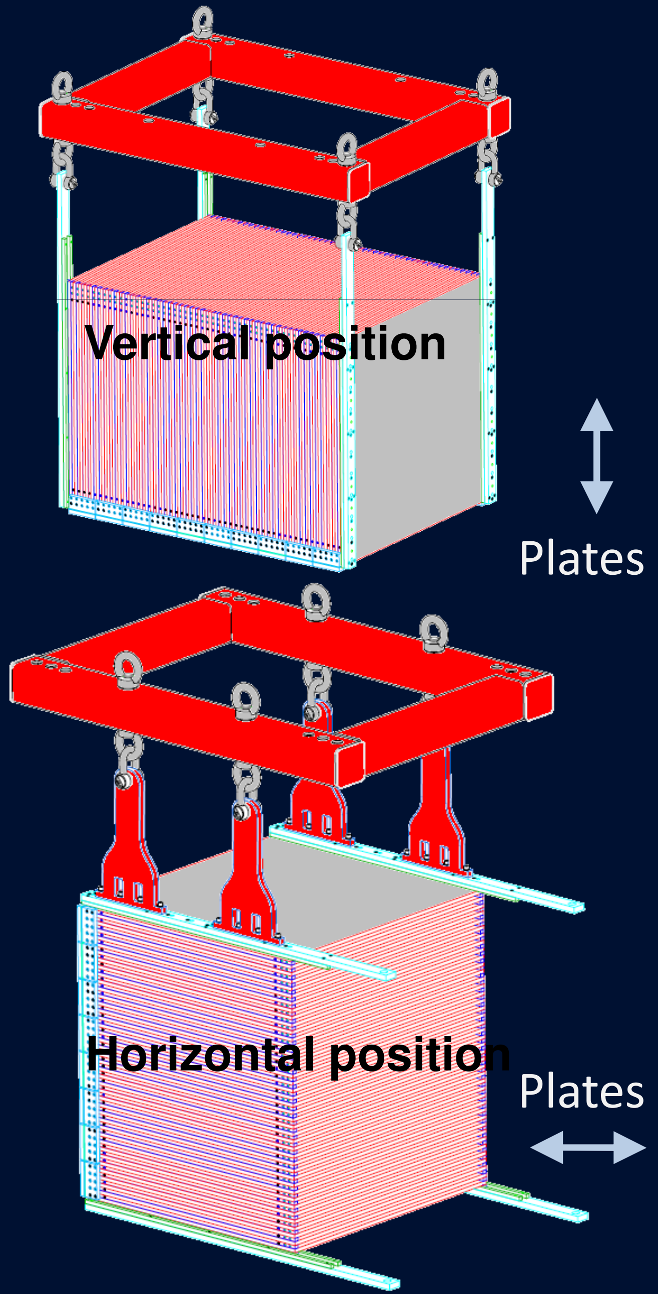

# Prototype Assembly

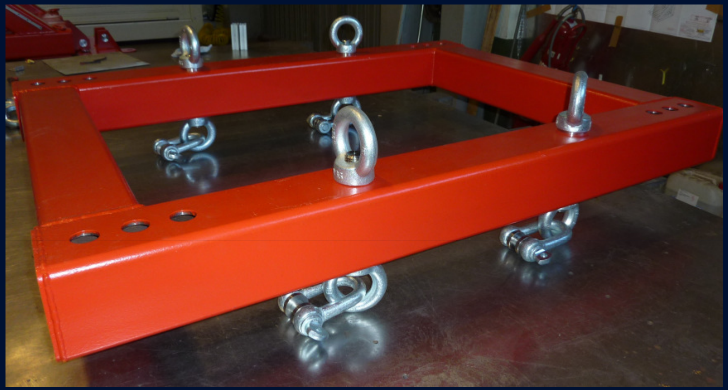

# Cassette insertion tests

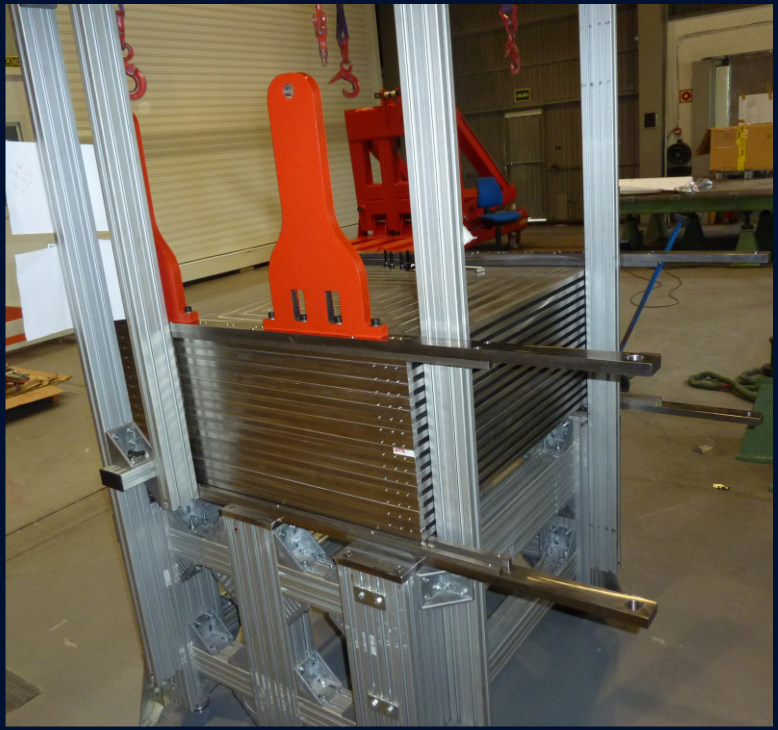




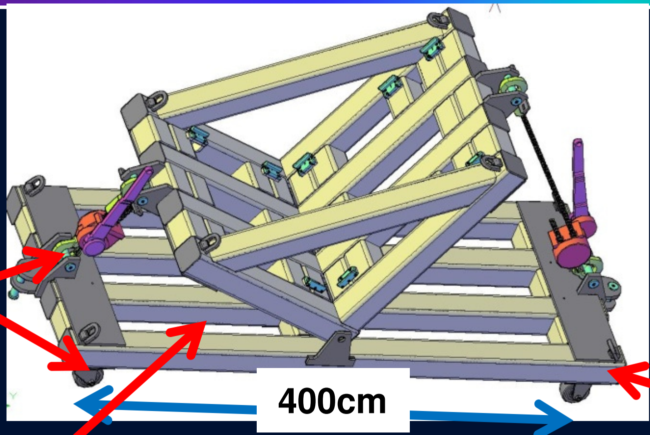
# Tools for handling the prototype

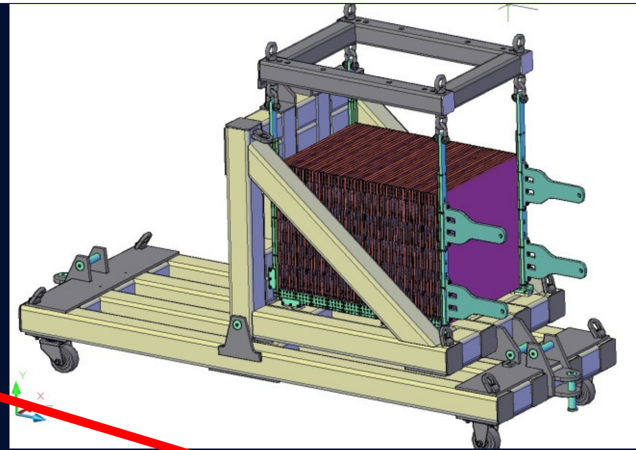




# Rotation tool assembly (mainly welding)

Mechanical structure assembled with plates in horizontal.

Test beam → Vertical plates

Cosmic tests → Horizontal plates

# First rotation test

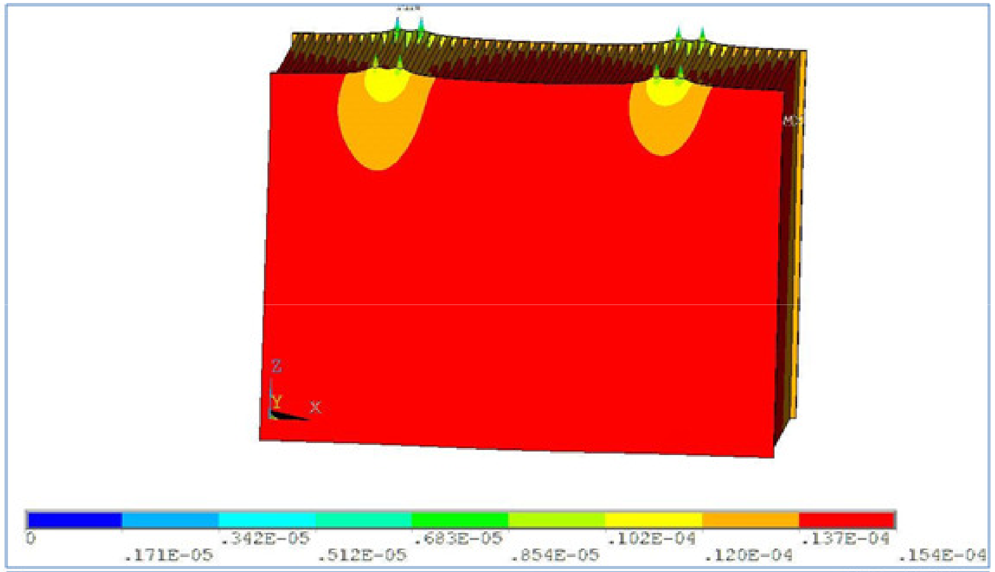
# Simulations

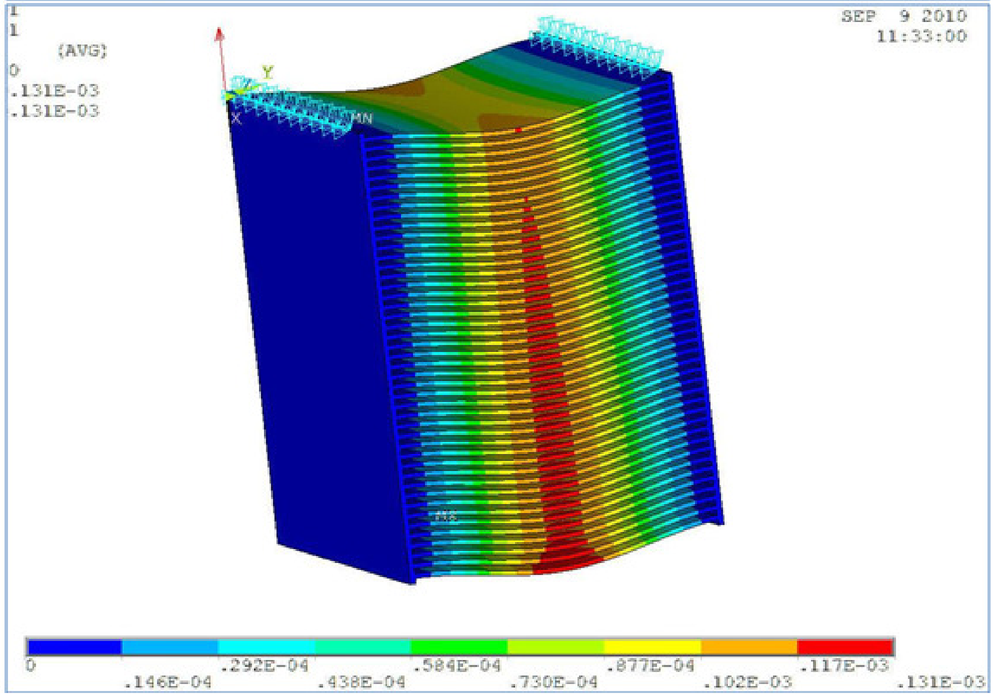
Detailed study has been made to evaluate the robustness of this structure in different positions.
It is important to evaluate the deformations and the stress that the structure can suffer when moving and rotating, the deformations will be also transferred to the GRPC detector

ANSYS numerical simulations performed on the deformation and stress

**Max. deformations don´t exceed 150 microns.**
**The punctual max. stress it is only 74 Mpa,**
**well away from the elastic limit of the material**

**The max. reactions on the M8 bolts are:**
**Fx= +/- 17955 N, Fy= - 694 N, Fz= +/- 2249 N**
**M8 bolt have the elastic limits, function of the material, between about 10000 N to 40000 N.**
**This is the situation more adverse for the M8 bolts.**



# Short term plans

**Second half of May:**

**Once the mechanical structure will be finished the final rotation test with will be performed.**

**Checks of the final geometry and deformations induced during the rotation**

**Begin of June:**

**Assembly of cassettes inside the mechanical structure ( at CERN)**

**Mid of June:**

**Test beam at CERN**

## Articulated arm for final geometry measurements

**Tested recently (measurement of the planarity of plates)**