CALICE SDHCAL Status

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CIEMAT

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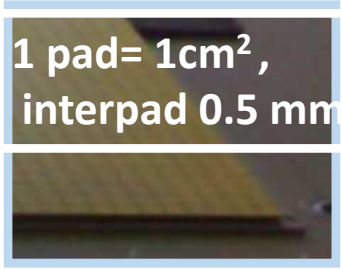
Semi-Digital Hadronic Calorimeter (SDHCAL)

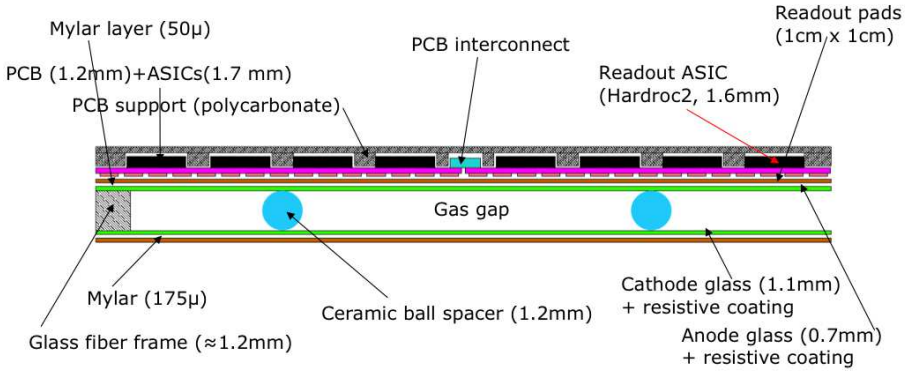
Absorber: **Steel** (20 mm)

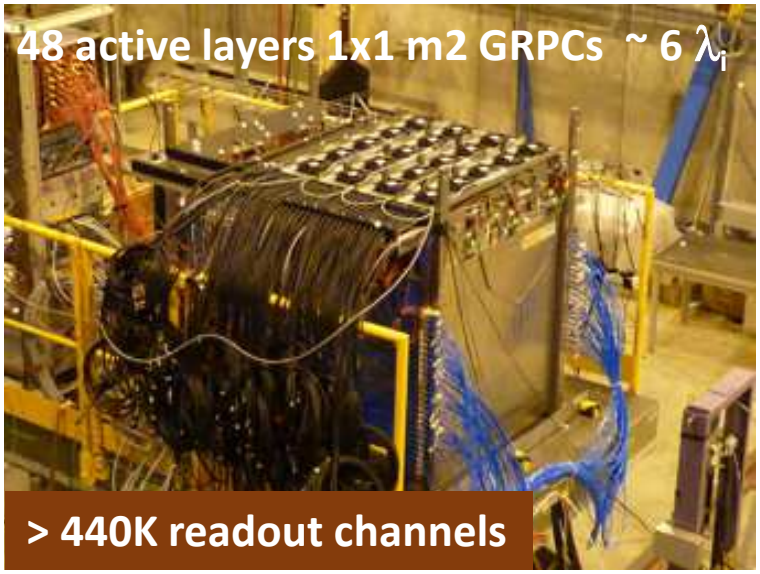
Detector: **GRPC (Glass Resistive Plate Chambers)** operating in **avalanche mode**

1x1 cm^2 pads. **Semi-Digital Readout** (**which and how many pads with signal over a threshold**), 2bits **- 3 thresholds**

Technological prototype

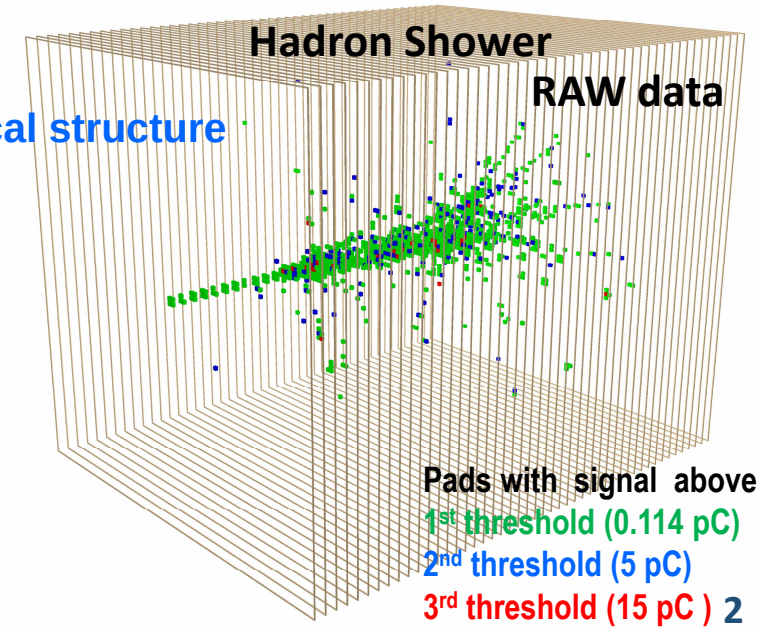






- **Large detector (1x1 m^2) with almost no dead zones**
- **Large electronics board**
- **One-side services**
- **Self-supporting mechanical structure**
- **Power-pulsed electronics**

Absorber plates
Planarity < 500 µm
Thickness tolerance 50µm



SDHCAL Energy calibration

Triggerless acquisition mode ➔ **Time Clustering for event building**

It includes also cosmics. **Particle identification** (muons, electrons, pions) is applied

Energy Reconstruction – Binary mode

$N_{tot} = N1 + N2 + N3$ Number of pads with signal

$$E_{reco} = (C + D\,N_{tot})\,N_{tot}$$

Allows restoring linearity

N1 = Nhits crossing only the first (lower) threshold
N2 = Nhits crossing the 2nd threshold but not the 3rd
N3 = Nhits crossing the 3rd (higher) threshold

C=0.0543, D=0.09x10 $^{-4}$ Determined from data (Ebeam vs Nhit)

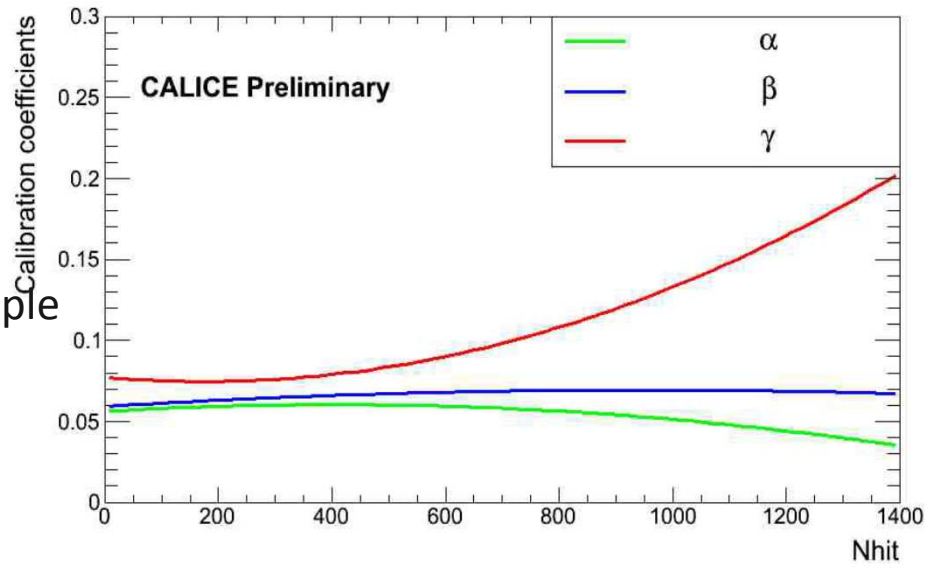
Energy Reconstruction – Multithreshold mode

$$E_{reco} = \alpha\,N1 + \beta\,N2 + \gamma\,N3$$

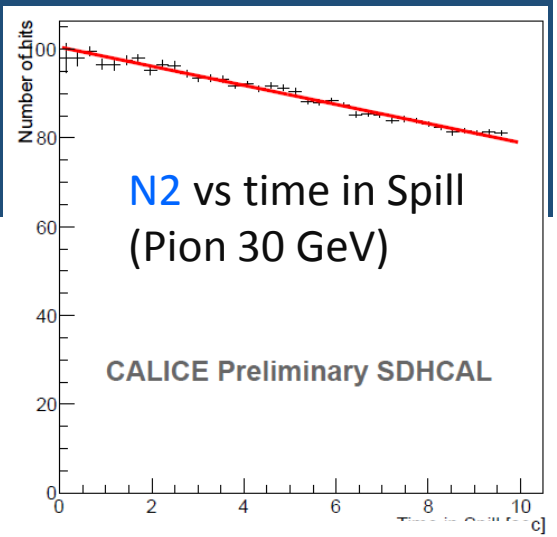
$\alpha, \beta, \gamma = f(N_{tot})$ (Quadratic function)

α, β, γ are obtained by minimizing from a data subsample

$$\chi^2 = \sum_{i=1}^{N} \frac{\left(E^i_{beam} - E^i_{reco}\right)^2}{E^i_{beam}}$$



SDHCAL Energy calibration



Time Spill correction

GRPC efficiency decreases at high rate. Efficiency decrease with time in spill due to charge accumulative effects. This can be corrected

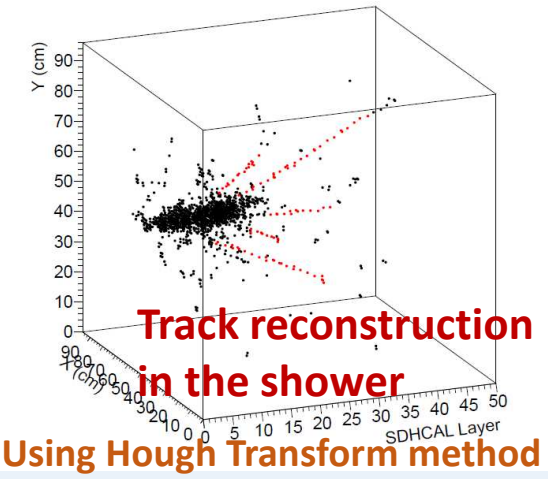
$$N_{TOTcor} = N1 - Slope1 \times Time + N2 - Slope2 \times Time + N3 - Slope3 \times Time$$

Track hits correction.

Single tracks can produce a signal bigger than 2nd or 3rd threshold and can bias the measurement

Identifying those tracks, removing the hits belonging to them from N1,N2,N3 and giving them the same weight can improve the results

$$E_{reco} = \alpha\, N1' + \beta\, N2' + \gamma\, N3' + c\, N_T$$



Density weighting

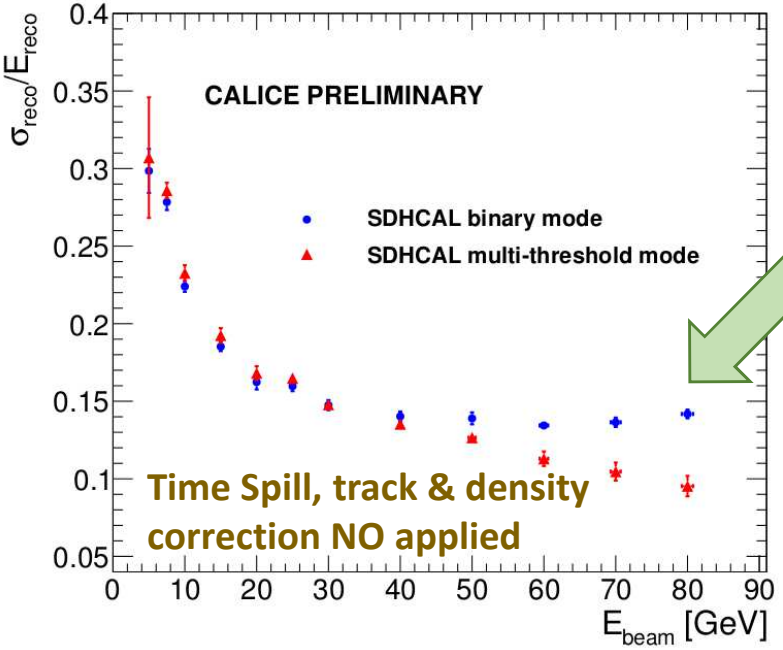
Separate the hits in **high-density** (e.m) and **low-density** (had) and give different weights

Density computed in a volume 1.5(x) x 1.5 (y) x 3.1 cm^3 **>9 ➔ High density**

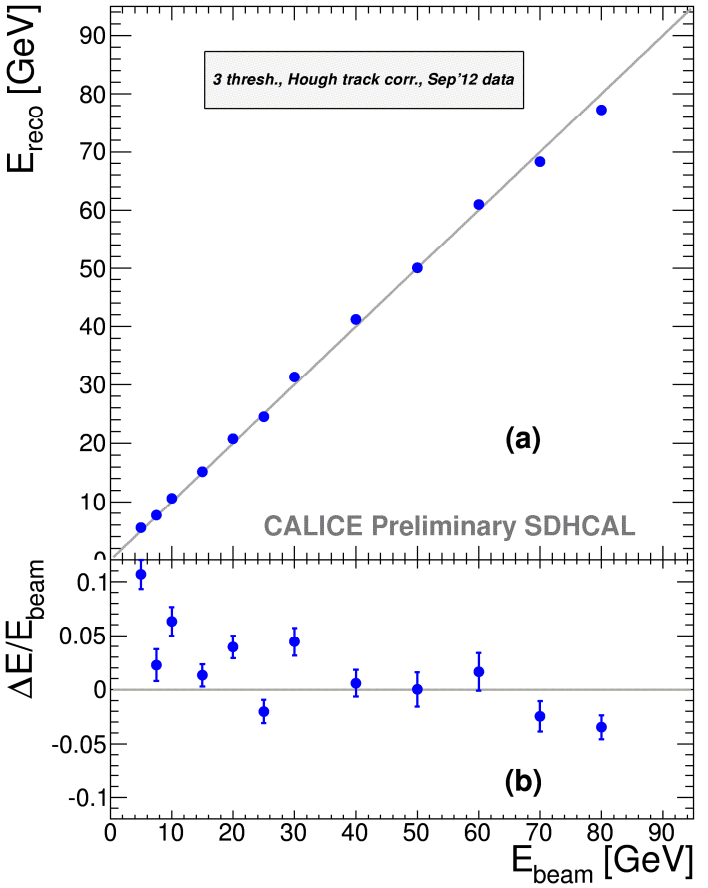
High density part	Low density part	Track

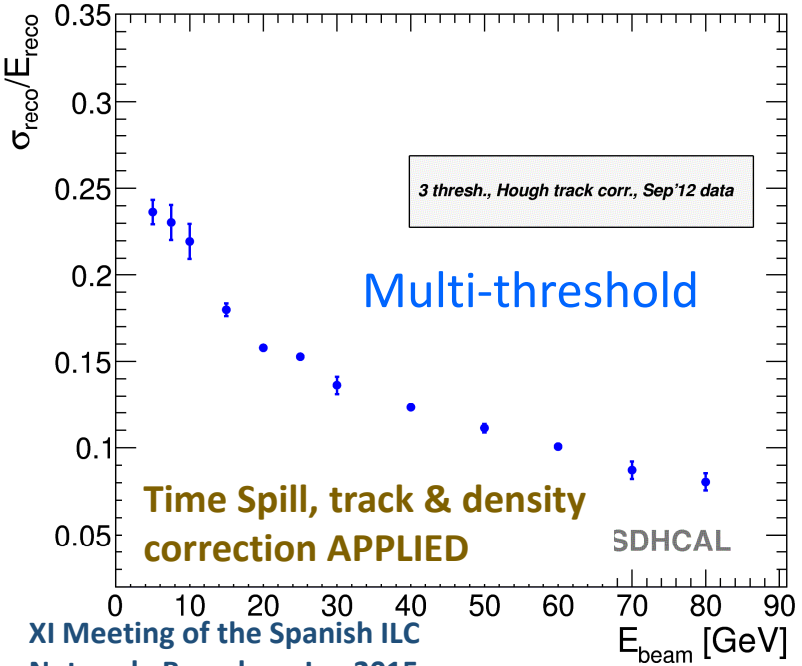
$$E_{reco} = \alpha_h\, N1_h + \beta_h\, N2_h + \gamma_h\, N3_h + \alpha_l\, N1_l + \beta_l\, N2_l + \gamma_l\, N3_l + c\, N_T$$

SDHCAL Performance



Multi-threshold mitigate the saturation effects at higher energies and improve the resolution respect to binary.





Corrections improve the resolution

New test beam @ SPS in Dec 2014

Pion & electron energy scan
Using Cherenkov information
Should help with the PID

2014 TB Data analysis just starting

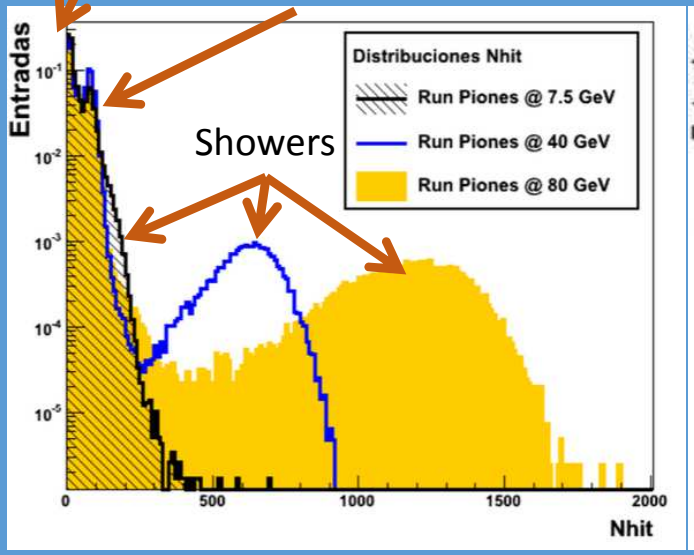
2012 Data (Cherenkov not available)

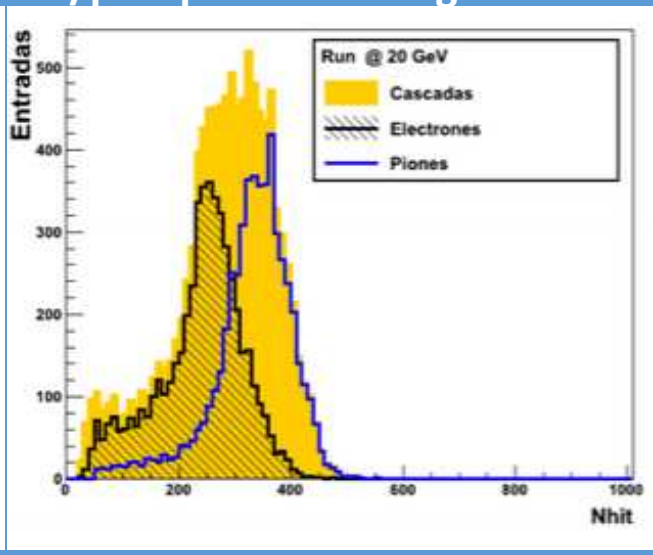
Cosmics

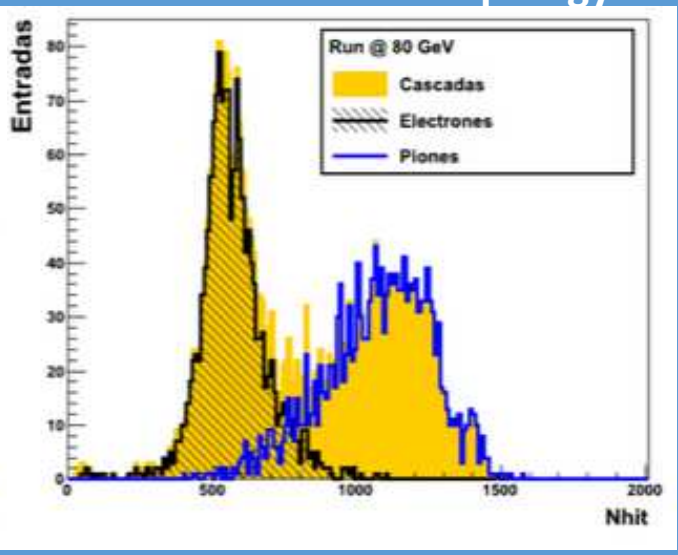
Beam muons

Showers

e/pi separation using software cuts based on shower topology



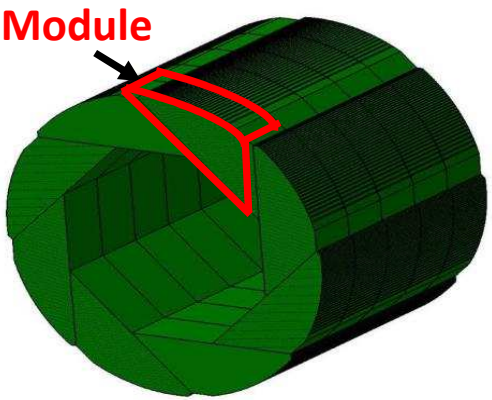




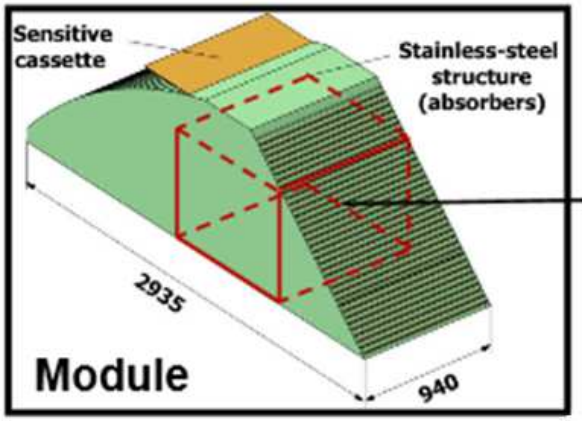
New test beam data periods foreseen for 2015

Towards real scale prototypes

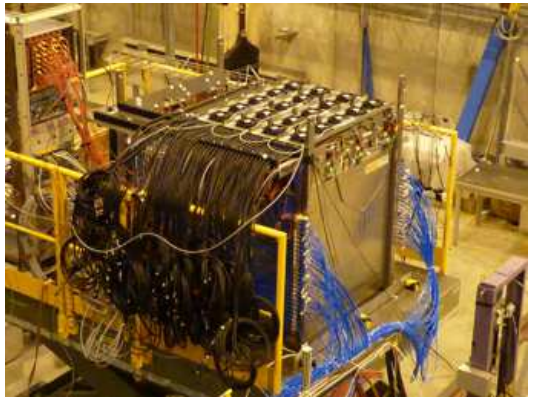
SDHCAL ILD barrel



SDHCAL ILD module



SDHCAL 1m3 prototype



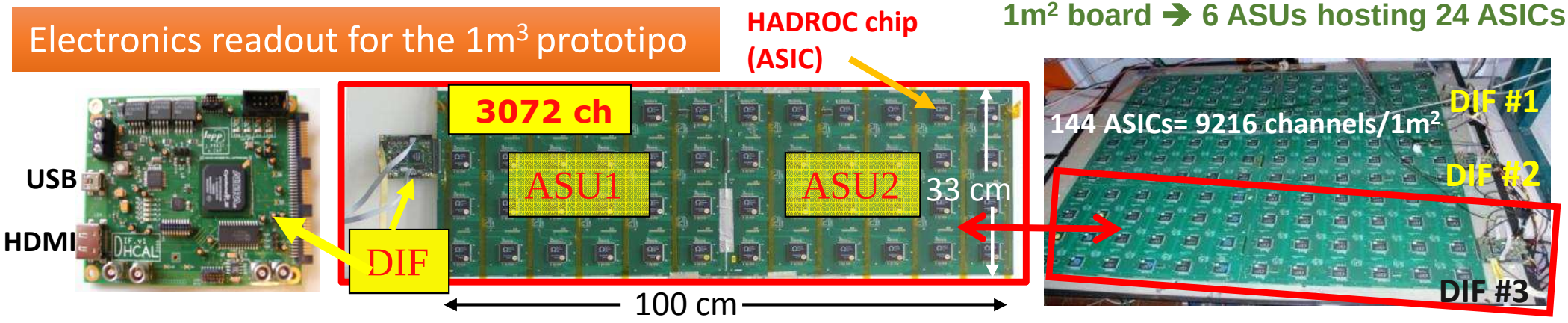
ILD SDHCAL
- Plates up to ~3x.9 m2
- Welding?

1m3 SDHCAL prototype
- Plates ~1x1 m2
- Bolted

R&D on
- Larger GRPC chambers
- Electronics
- Mechanics

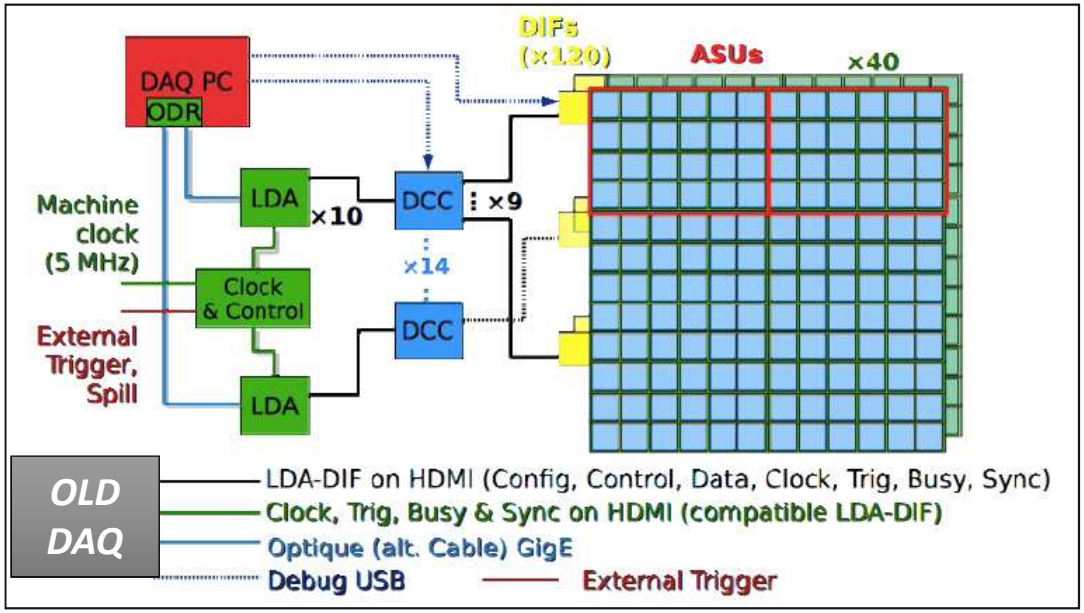
1m3 Prototype Electronics

Electronics readout for the 1m^3 prototipo



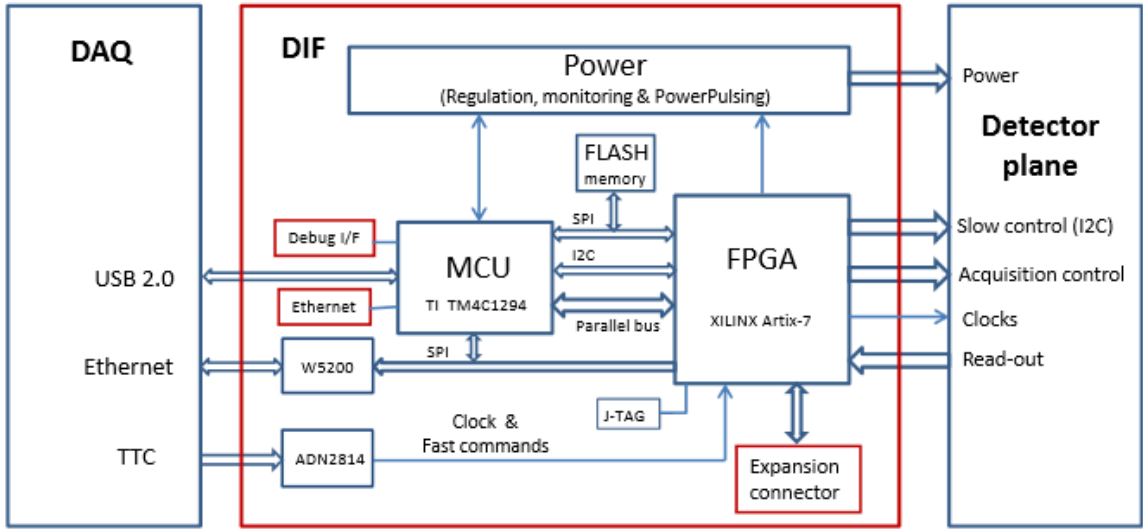
Not possible to produce 1m2 PCB (rigidity & planarity conditions needed)
6 smaller boards (ASU-Active Sensor Unit) used
2 ASUs interconnected to form a slab
Each slab connected to a DIF

DIF sends DAQ commands (config, clock, trigger) to front-end and transfer their signal data to DAQ. It controls also the ASIC power pulsing

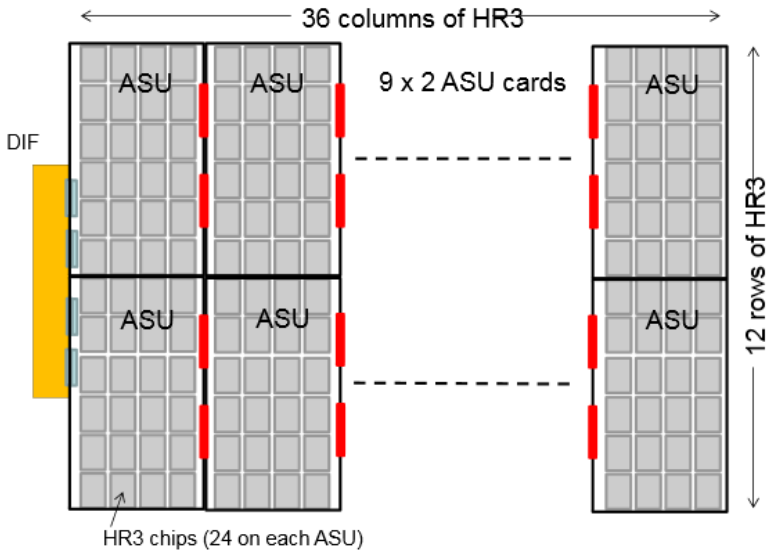


New Electronics

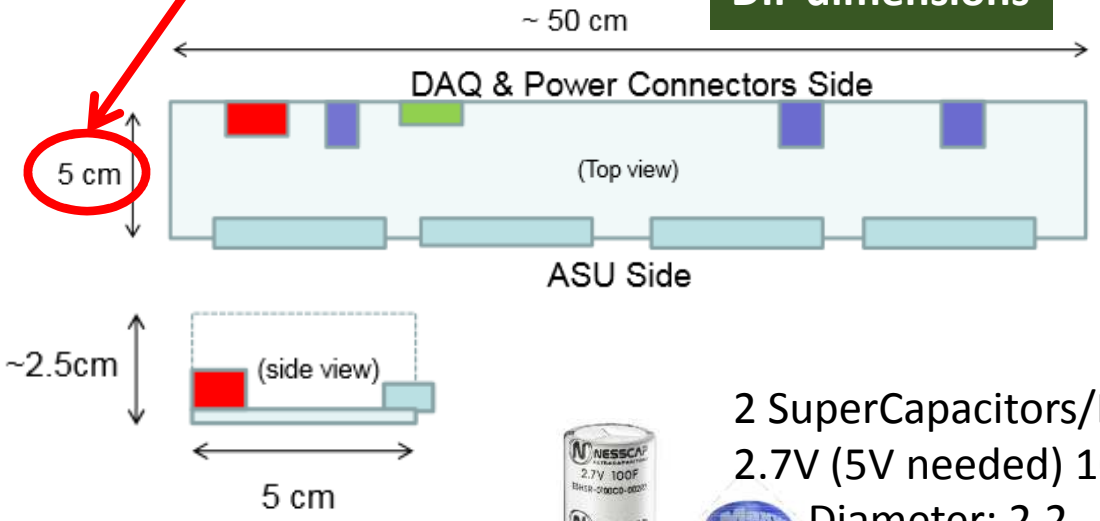
- New HARDROC3 (HR3) front end chips
- New DIF **(developed @ CIEMAT)**
- Only one DIF per plane
- Slow control through the new HR3 I2C bus
- Slow Control & Readout by Ethernet
- Clock and Synchronization by the TTC system used in LHC experiments



Only 1 DIF per plane with small dimensions to fit in the small space available at the final detector

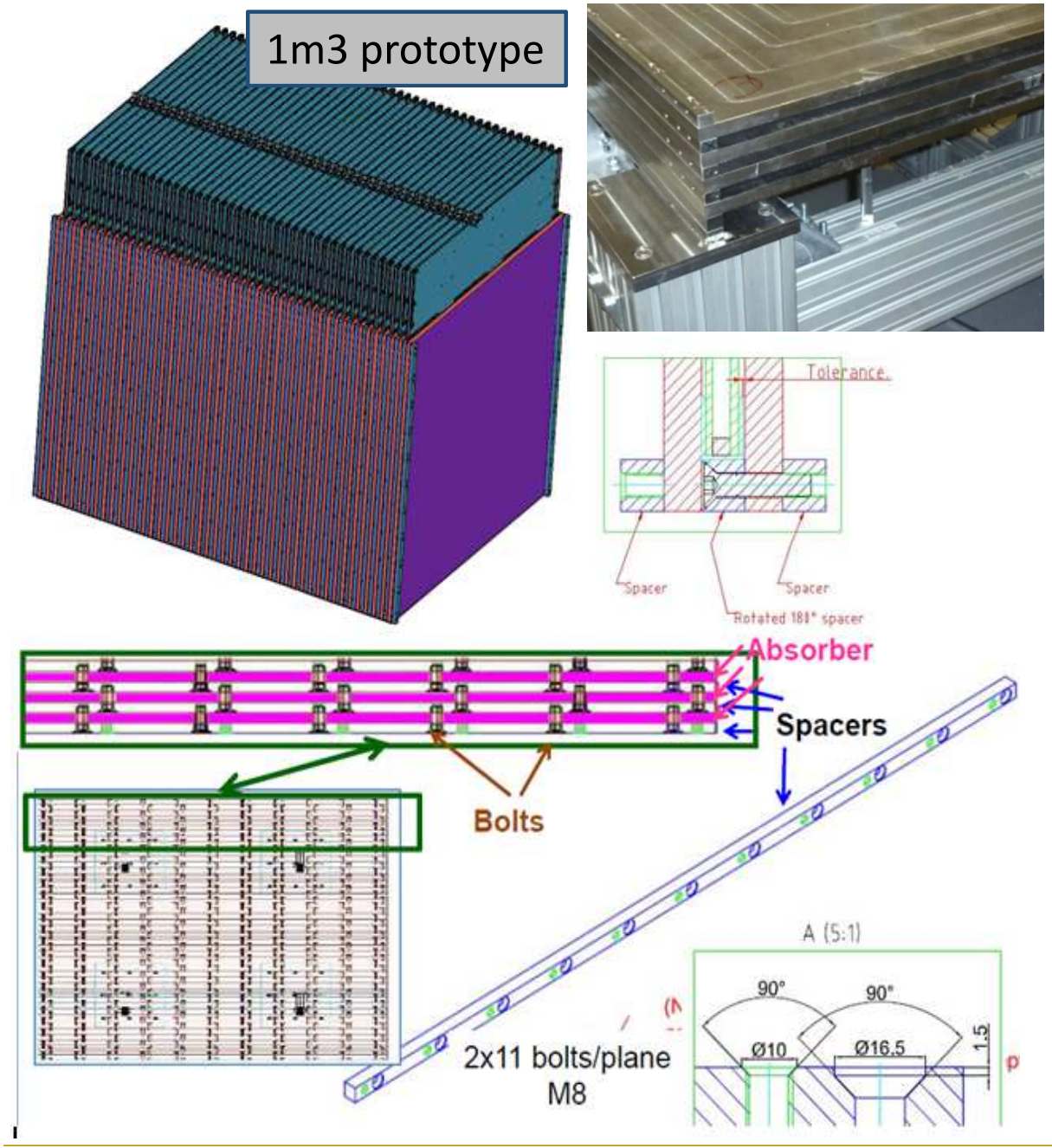


DIF dimensions



2 SuperCapacitors/DIF
2.7V (5V needed) 100F
Diameter: 2.2
Length: 4.5

Absorber mechanical structure



The 1m³ mechanical structure was made of 51 stainless steel plates assembled together using **lateral spacers fixed to the absorbers** through **staggered bolts.**

Thickness tolerance 0.05mm
Surface planarity < 0.5 mm
➔ **< 1mm for the big plates**

For the **final structure**
➔ **Welding instead of bolts**

Allows to **decrease the lateral size of the spacer**
➔ **Less dead zone**

Could introduce **deformations**

Absorber mechanical structure - Welding

Standard welding:

Could introduce **deformations** ➔ **Tests to be done @ CIEMAT**

Electron beam welding:

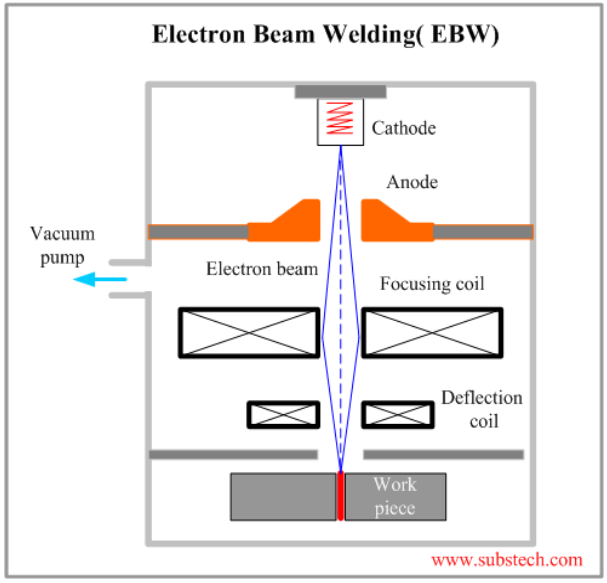
The **best** but **need vacuum conditions** and could be not affordable for big modules

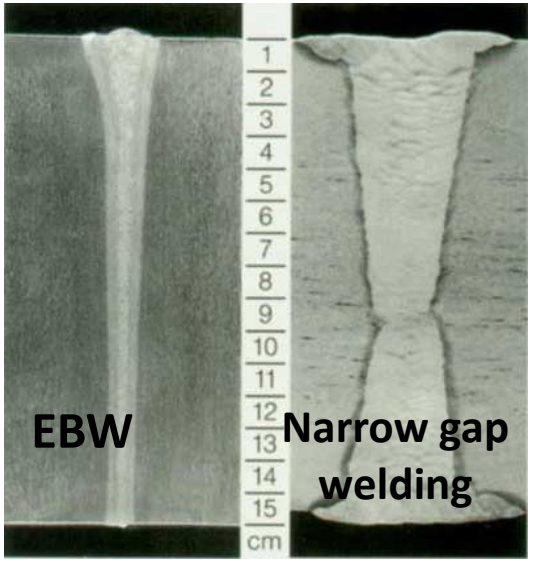
➔ **First test done at CERN**

Laser welding:

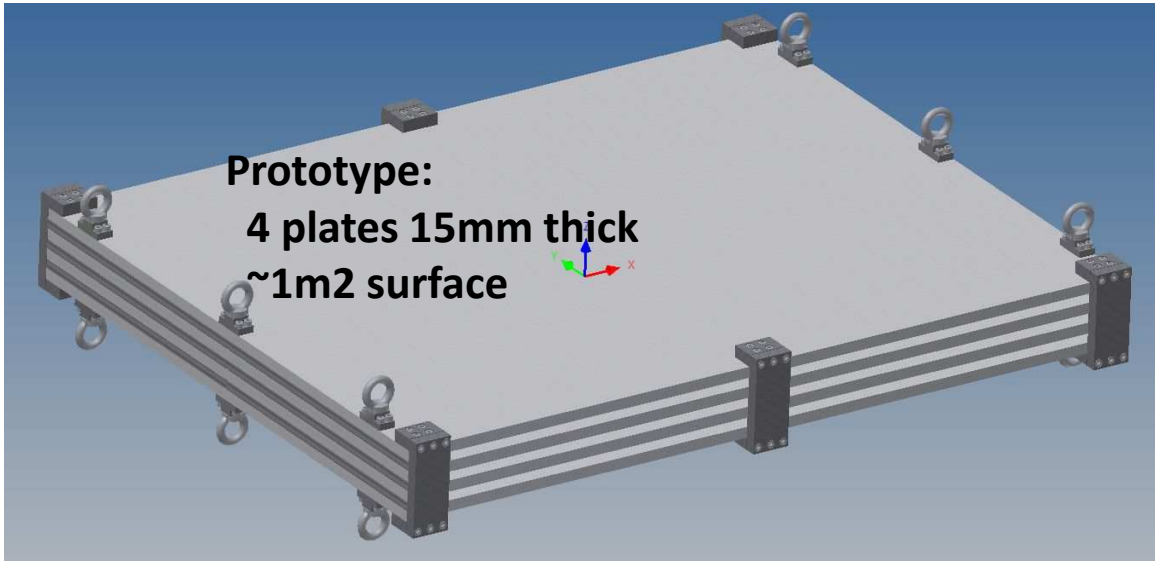
Could have **reasonable deformations** and is **easier (and cheaper) than electron beam welding**

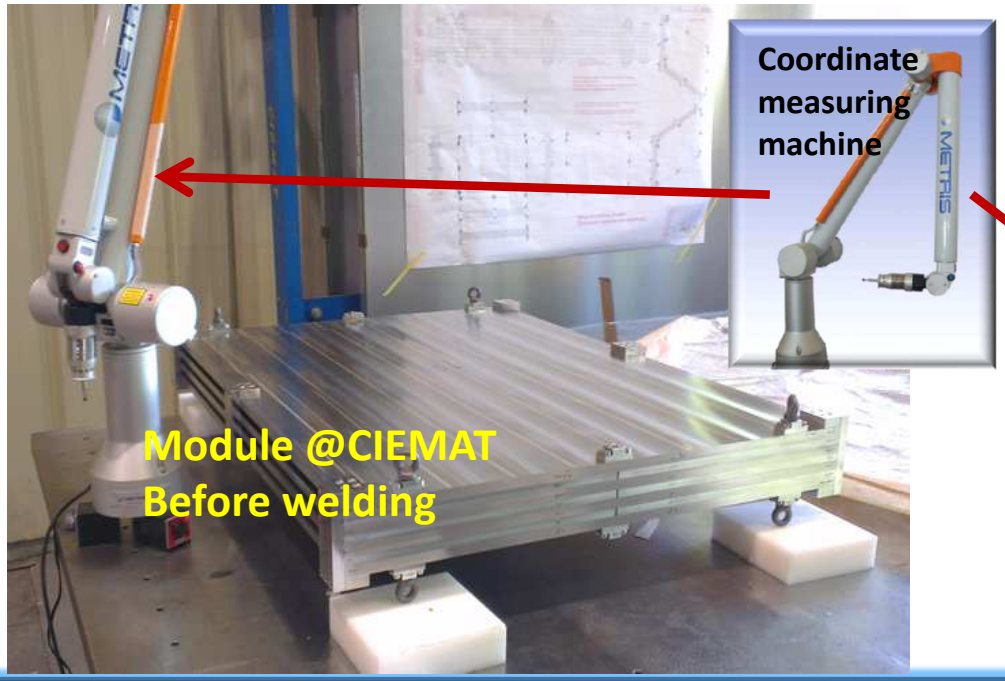
Electron beam welding

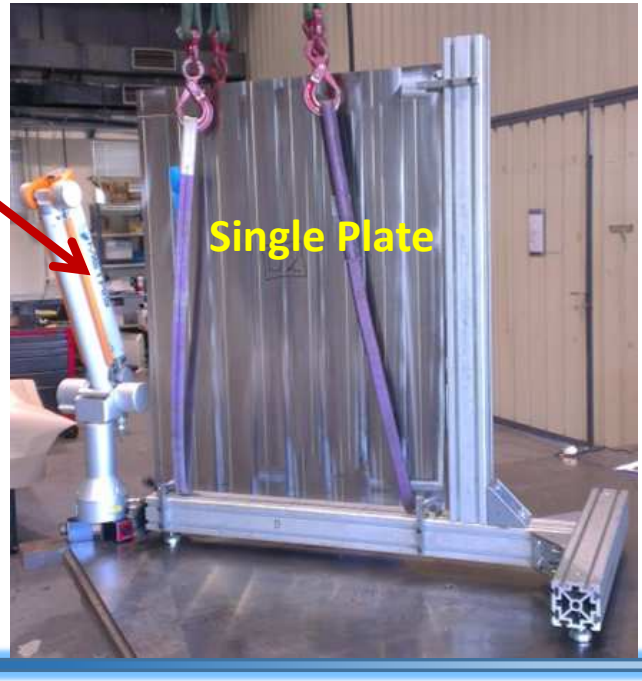




EBW: Prototype assembly & verification @ CIEMAT



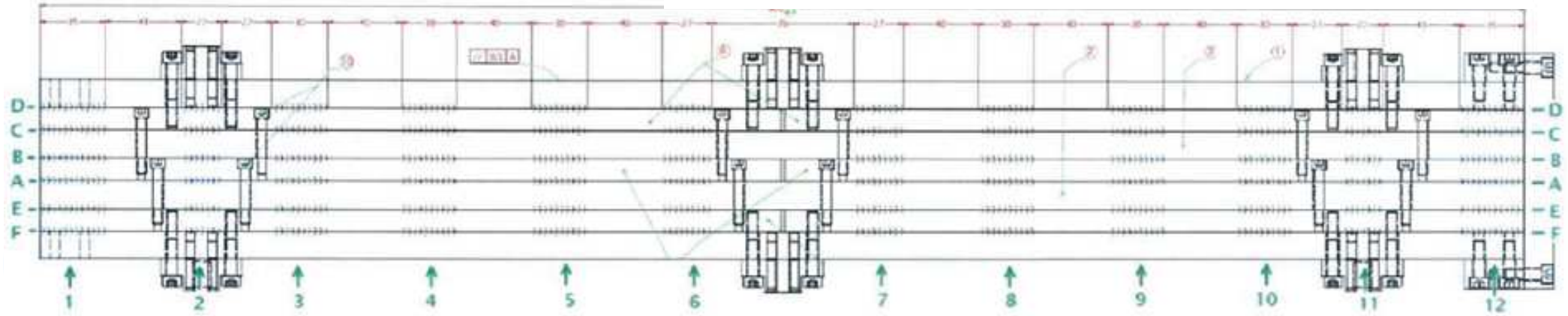




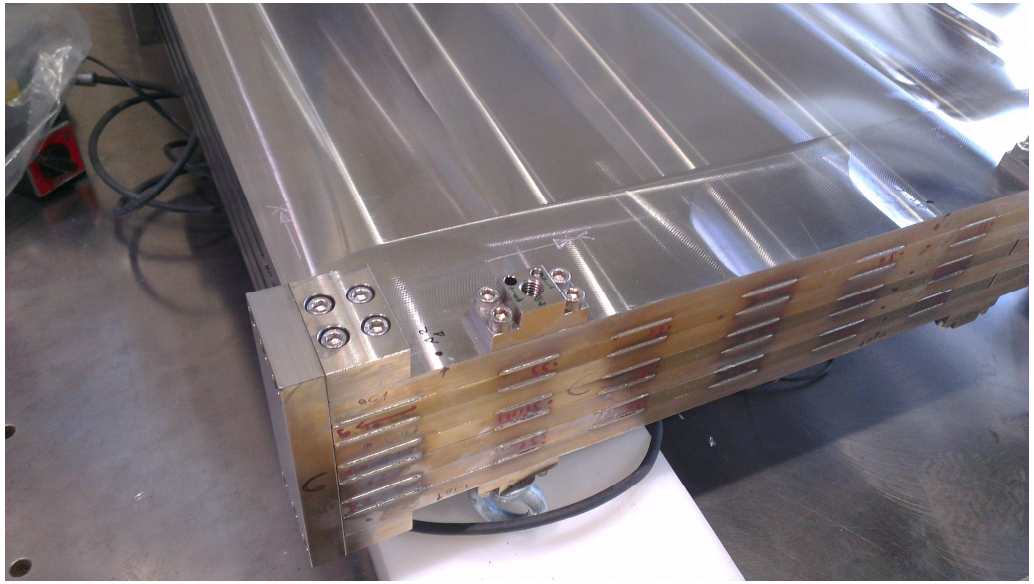
Welding @ CERN

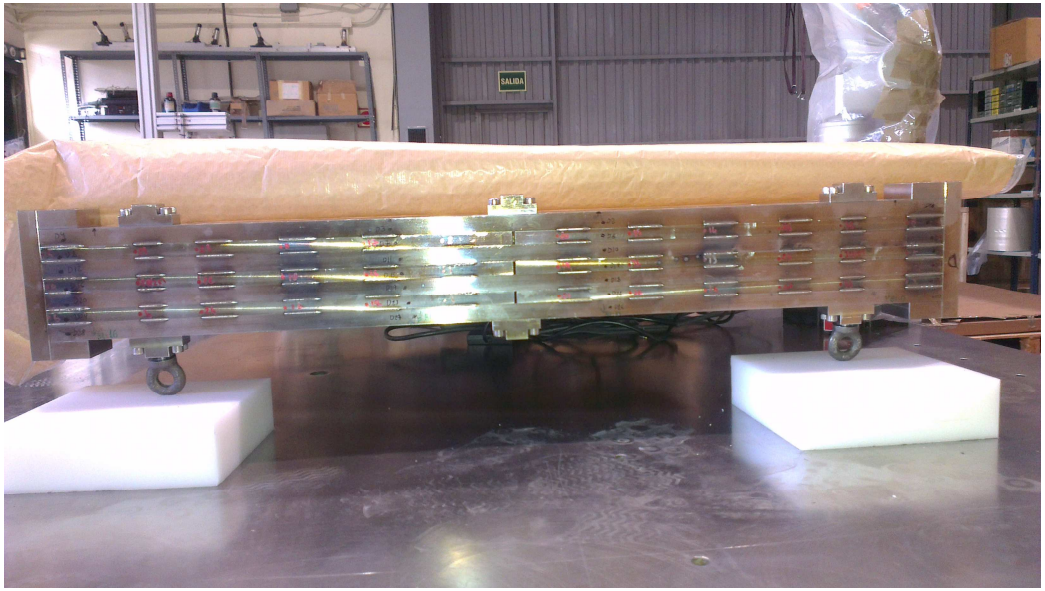
The welding sequence has been the following:

1. Side A – Tack welding, penetration 2mm: 6, 1, 12, 4, 9.
2. Side B – Tack welding, penetration 2mm: 6, 1, 12, 4, 9.
3. Side B – Welding, penetration 5mm: 5, 7, 3, 10.
4. Side A – Welding, penetration 5mm: 5, 7, 3, 10, 2, 11, 8, 6, 1, 12, 4, 9.
5. Side B – Welding, penetration 5mm: 2, 11, 8, 6, 1, 12, 4, 9.



Results after welding





Deformation verification measurements after welding are still ongoing but **preliminary results show deformations below 100 microns in most of cases**. One value of ~400microns should be understood and **some measurements are still pending.**

Summary

- The 1 m3 prototype shows a good performance that has been improved after applying new energy calibrations:
  - Spill time correction
  - Track correction
  - Density correction

  New beam tests foreseen on 2015

- R&D for larger modules and towards a final calorimeter is ongoing

  - A new Detector Interface (DIF) board being developed at CIEMAT
    Waiting for the new PCB design (french responsibility)

  - Welding tests ongoing at CIEMAT
    Electron beam welding test performed. Quality control verification on going