The 1m^3 SemiDigital Hadronic CALorimeter prototype (SDHCAL)

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SDHCAL Group: CIEMAT, Gent, IPNL, LAL, LAPP, LLN, LLR,LPC,Protvino,Tsinghua,Tunis

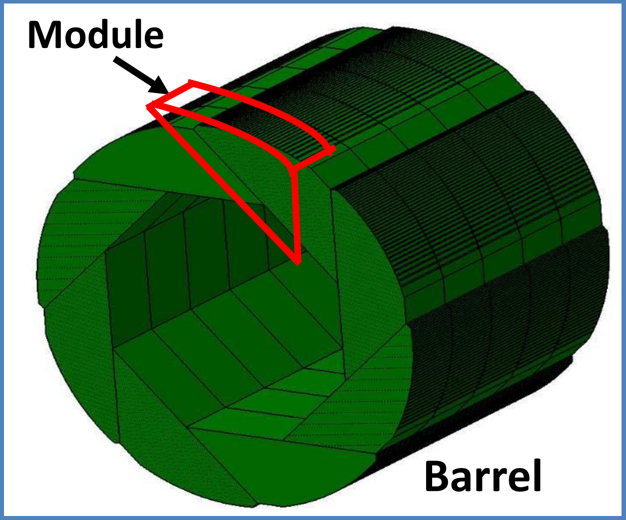
GOBIERNO DE ESPAÑA | MINISTERIO DE CIENCIA E INNOVACIÓN | Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

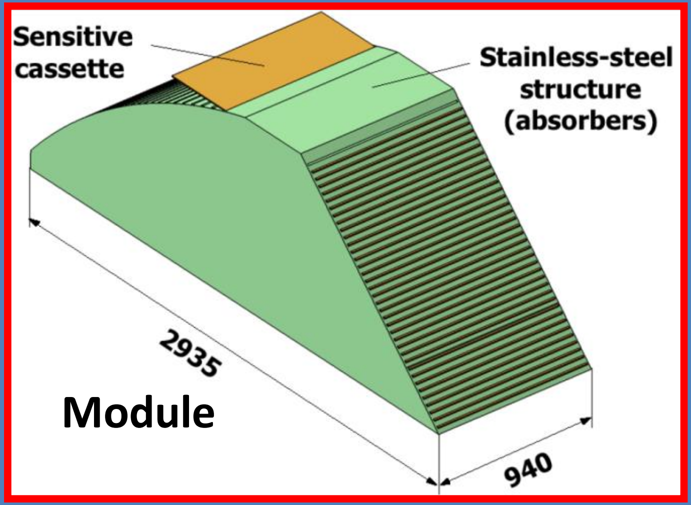
CALICE Calorimeter for ILC

LCWS11

Granada, September 2011

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 to understand key issues of integration and operation

1- Large detector with almost no dead zones
2- Large and embedded electronics board
4- One-side services: HV, LV, gas, readout
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

SDHCAL Technological Prototype

~1m^3 ~6 λ_I
~450K readout channels

Up to 50 GRPC detector plans of 1m^2

20mm stainless steel (absorber + cassette support)

6mm GRPC (Glass Resistive Plate Chamber), readout pads 1x1cm^2 (huge granularity)

Semi-digital Readout

Use **number of hits instead of deposited energy**

➔ **How many & which pads over certain thresholds**

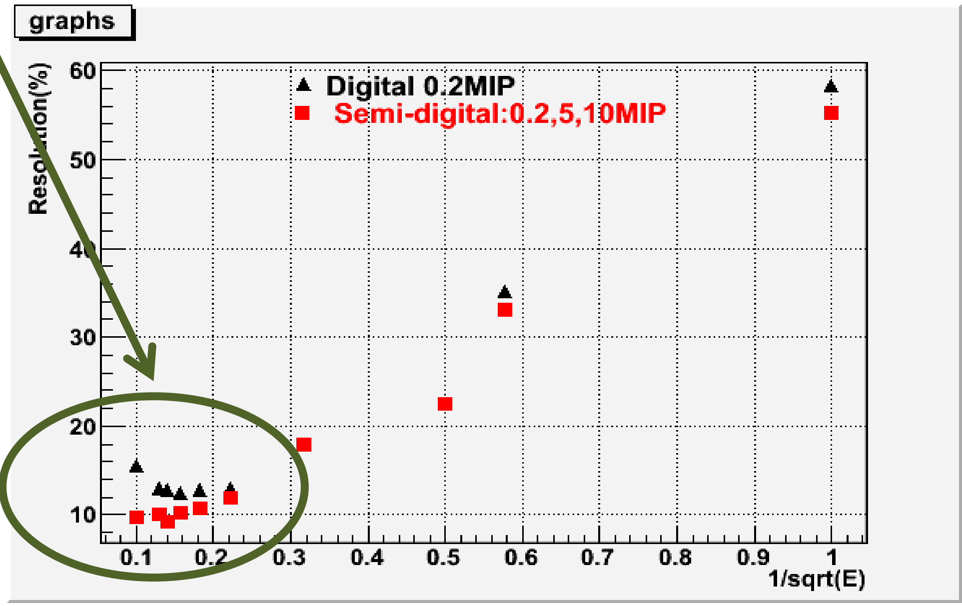
A semi-digital readout (2-bits) **improves** the **resolution** at high energies with respect to digital (saturation effect)

Advantage of digital or semi-digital

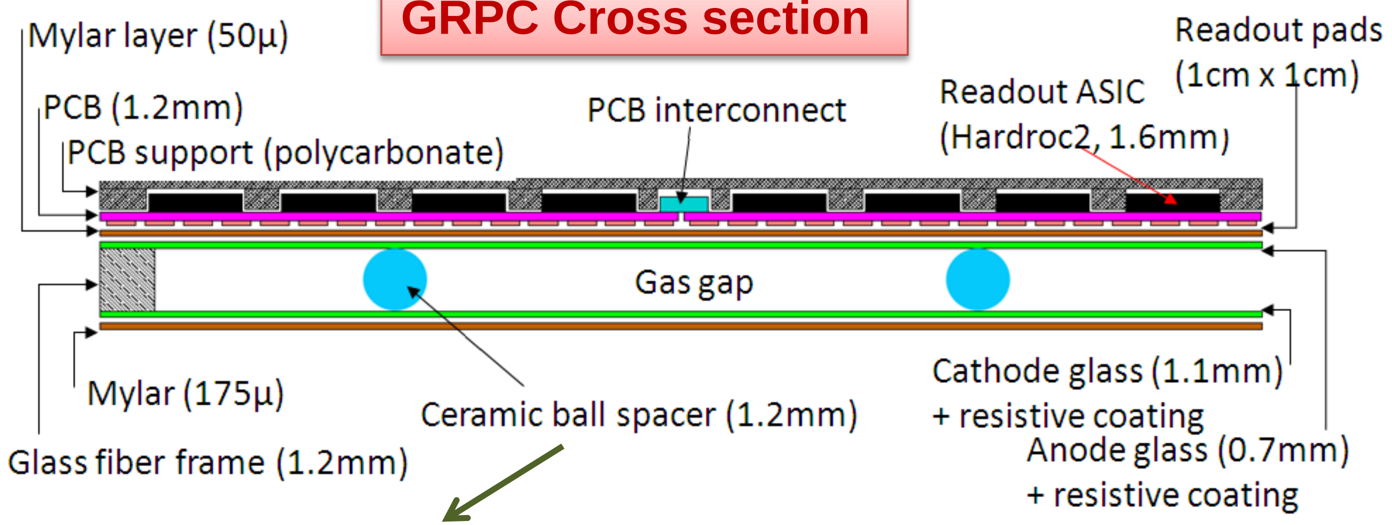
Simpler electronics (just a comparator)

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

But, **price to pay higher granularity** 1x1cm^2 (➔ **> 50 millions of channels for a full detector)**



The SDHCAL's GRPCs



Ceramic balls reduce dead zones and noise with respect to use fishing lines

Total thickness: 6.025mm
Gas Gap: 1.2 mm

Main characteristics

Gas: **TFE/i-C4H10 (or CO2) /SF6 (93-94.5) / 5 / (2-0.5)**

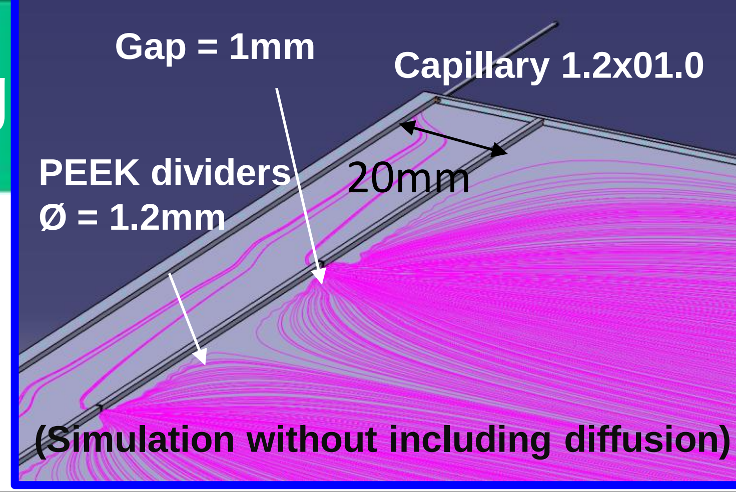
HV: **~7.4 kV Avalanche mode (➔2-4 pC , rate up to 100Hz/cm^2)**

Efficiency **>95%,**

Multiplicity: **1.4-2 pads/mip**

Homogeneous, easy/low-cost to build, robust

GRPC Chambers: Gas & coating

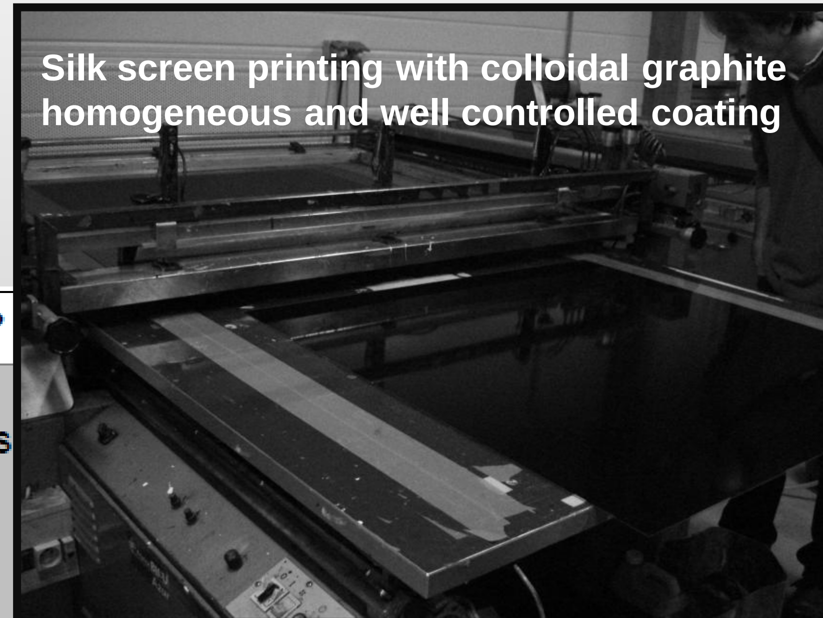


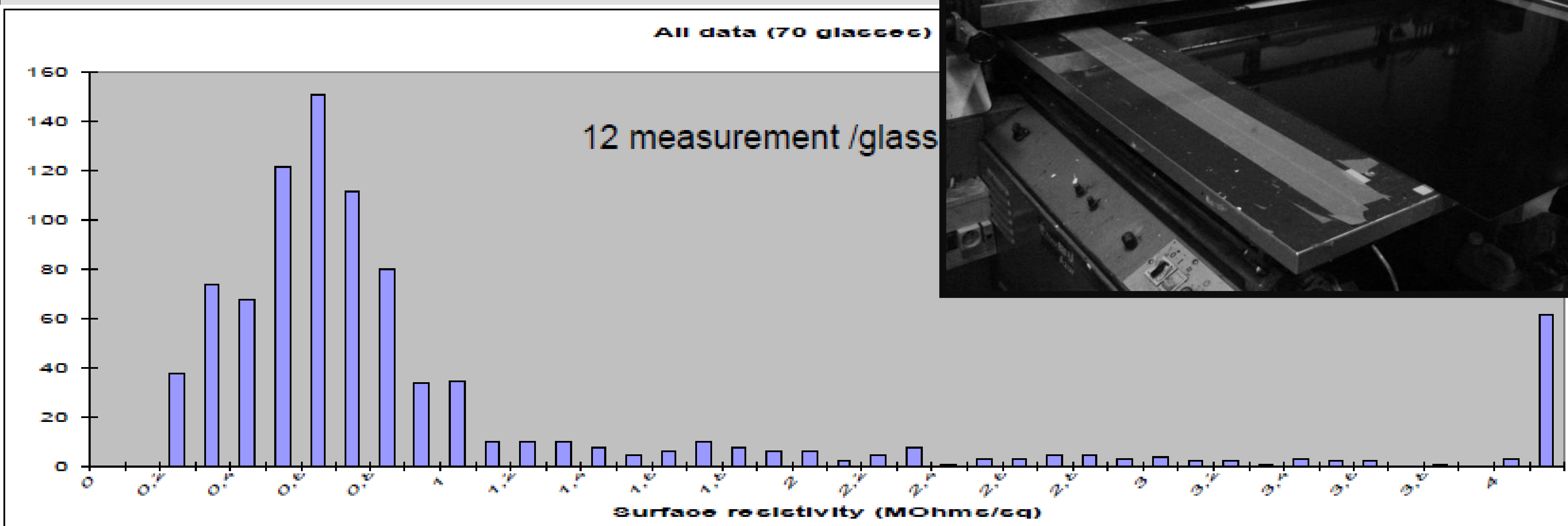
To guarantee the same performance all along the GRPC surface the gas and the electrode resisitivity must be homogeneous.

A good **gas distribution** within chamber is needed
Large area($1x1m^2$) and very thin (1.2mm)

Multiplicity depends on the coating resistivity
- ➔ higher resistivity lower multiplicity
- ➔ Lower resistivity higher rate capability

Different **coatings** tested on different chambers.
The best one was **colloidal graphite**



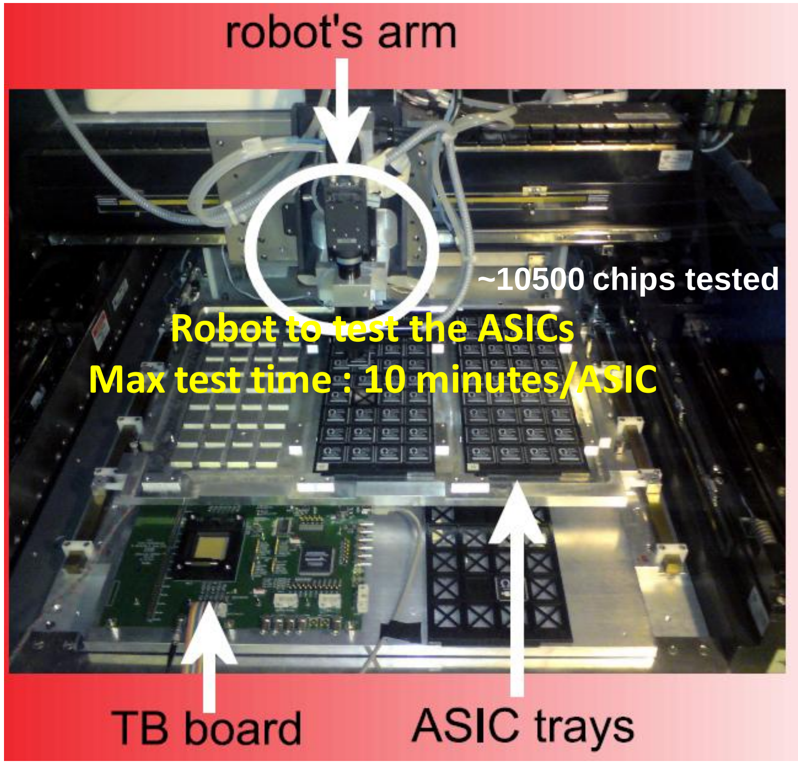


GRPC chambers – Electronics: ASIC

Due to the large number of readout channels (~4x10^5 for 1m^3) the readout electronics must be embedded in the detector, possible thanks to the chip miniaturization.

ASIC: HARDROC
- 64 channels
- 2-bit readout (3 thresholds)
- Digital memory: 128 events
- Power pulsing system.
- Crosstalk <2%
- Large dynamic

Test bench @ Lyon



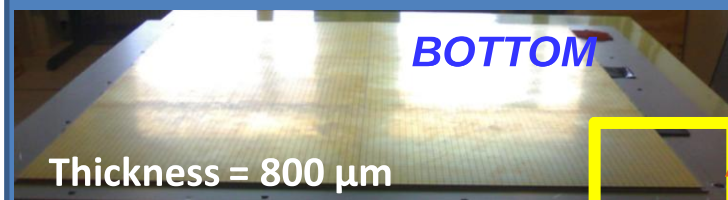
~10500 chips tested with a dedicated test bench using Labview based application:

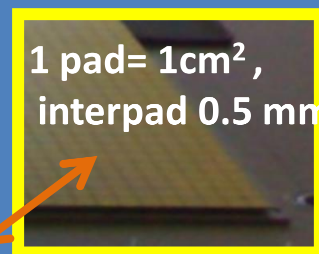
- ✓ **Measurement of the DC levels and power consumption**
- ✓ **Test of the Slow Control loading**
- ✓ **Memory test**
- ✓ **DAC linearity**
- ✓ **Trigger efficiency measurement**
  - Pedestal for the 3 shapers
  - 100 fC trigger efficiency measurement for fsb0 + gain correction for each channel
  - 1 pC trigger efficiency measurement for fsb1 and fsb2

GRPC chambers – Electronics

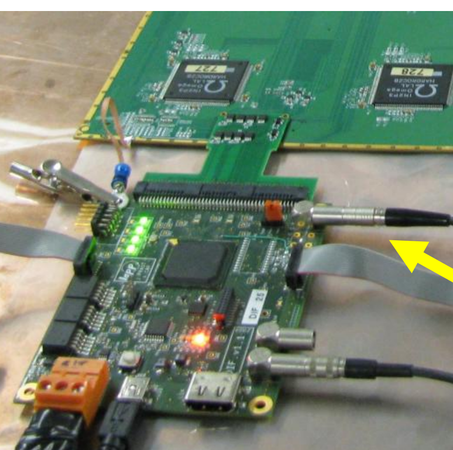
The HARDROCs are hosted in a Printed Circuit Board (PCB)➔ ASU (Active Sensor Unit)
It provides the connection between adjacent chips and links the first to the readout system and contains in the opposite face the 1x1cm^2 copper pads for the GRPC readout

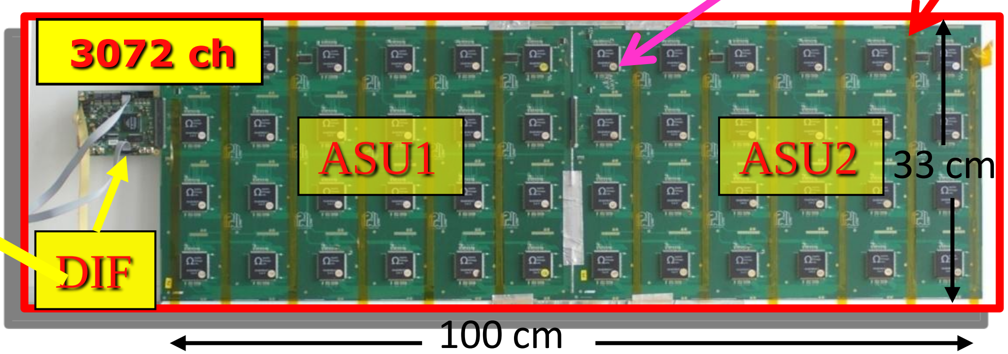
1m^2 board fabrication too difficult ➔ 6 ASU hosting 24 ASICs

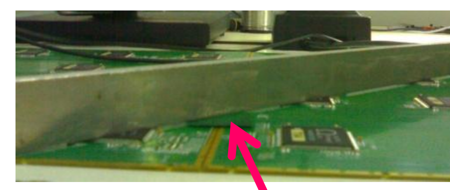




Every two ASUs connected to each other and connected to one DIF
3 DIFs (connect to the DAQ) for a 1m^2



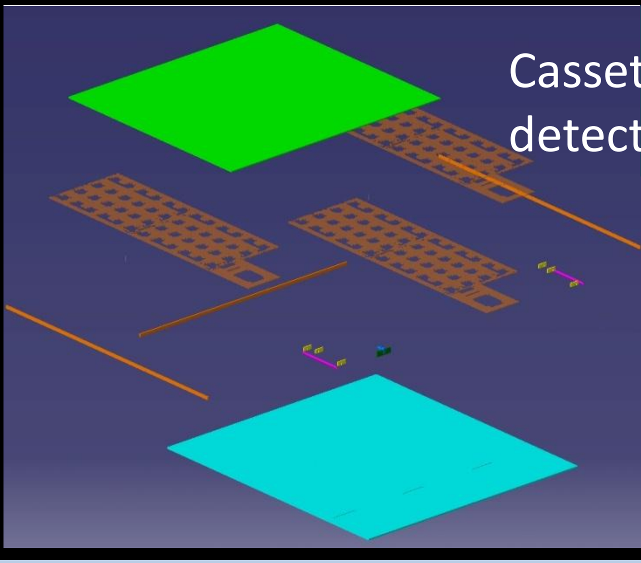


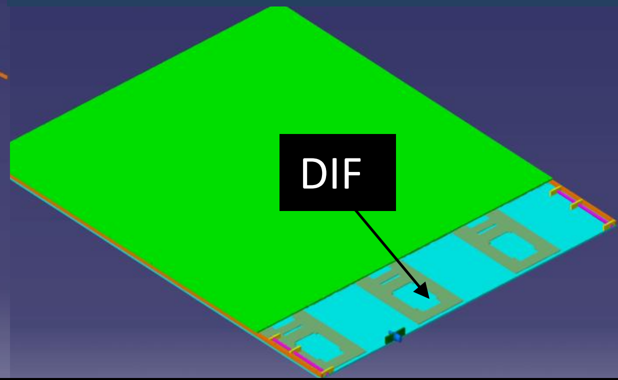


Thin ASU to ASU connector

GRPC Mechanic structure - Cassette

Cassette to include the GRPC detector and associated electronics



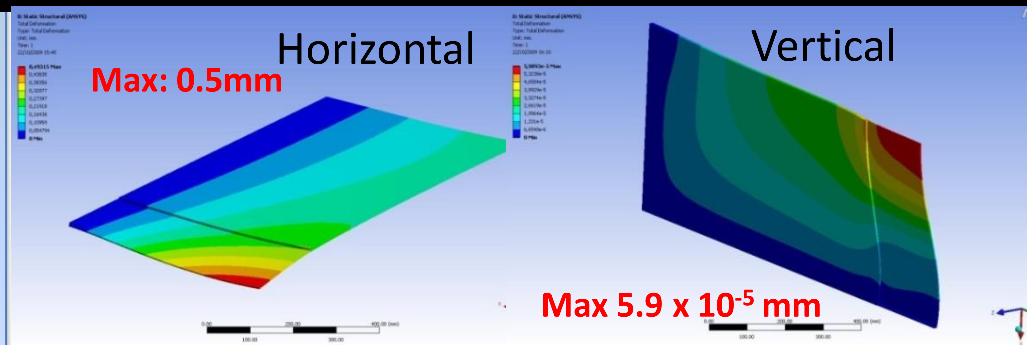


Box: 2 stainless steel plates 2.5mm thick
6x6 mm^2 stainless steel bars

PCB supports in polycarbonate
(cut with water jet)

PCB fixed to plate using 1.6mm screws
PCB fixed on the detector using 3mm screws

Mylar foil (175μm) separates detector from box



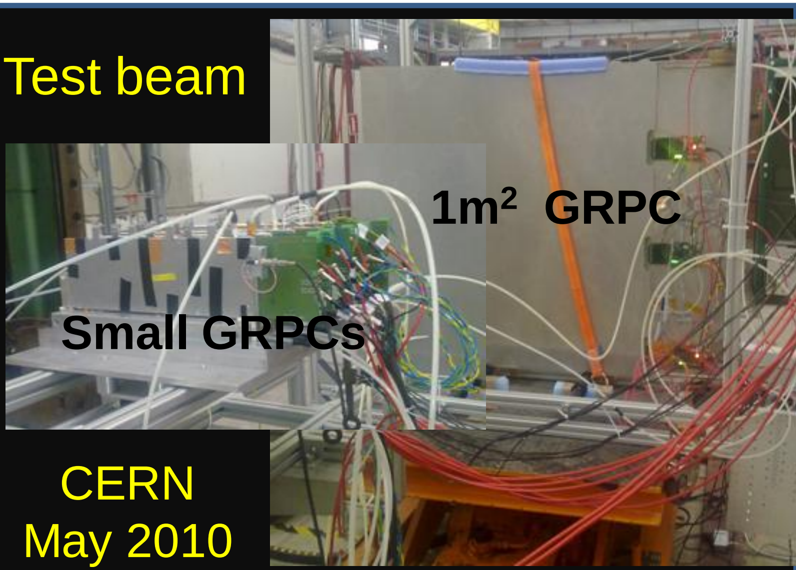
Deformation under its own weight as a function of storage orientation

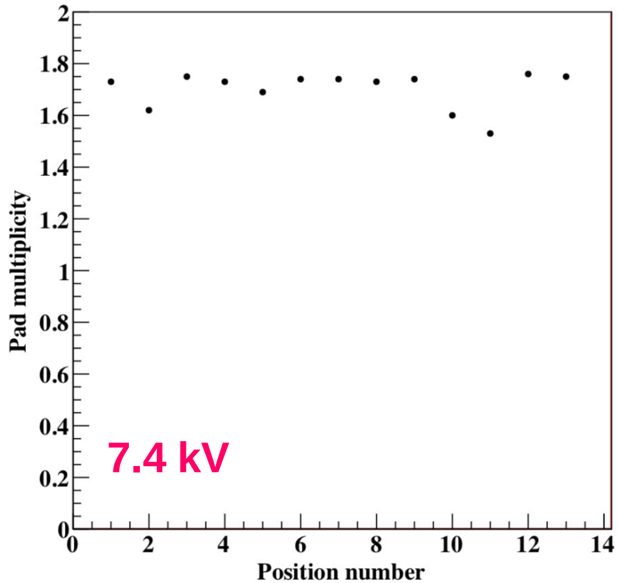
GRPC beam tests

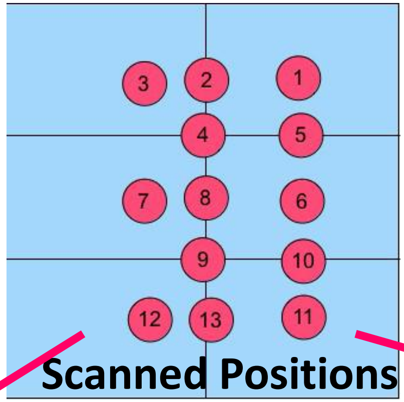
Beam Line	Date	Aim
CERN PS T10	July 2008 (7 days)	Small chambers Studies
CERN PS T9	August 2008 (6 days)	Mini SDHCAL setup
CERN PS T9	Nov. 2008 (5 days)	Small chambers Coating tests
CERN PS T9	June/July 2009 (22 days)	Large Chamber + Small chambers High rate
CERN SPS H4	August 2009 (7 days)	Large chamber studies
CERN PS T9	May 2010 (11 days)	Large chamber homogeneity
CERN SPS H2	June 2010 (7 days)	PowerPulsing
CERN SPS H4	Sept 2010 (10 days)	Large chambers tracking

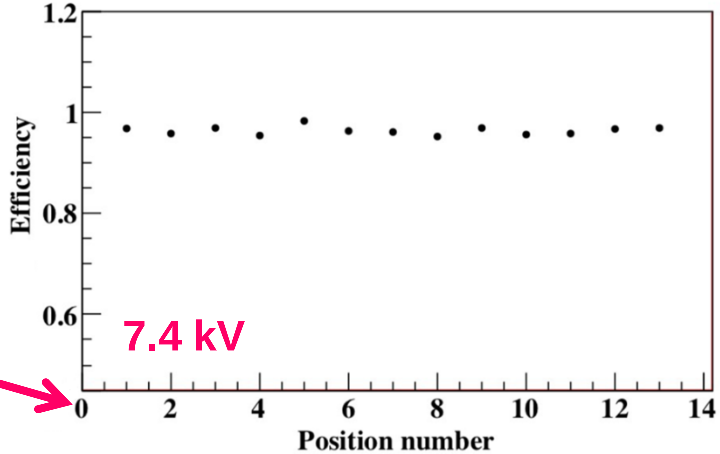
Test beam

CERN May 2010

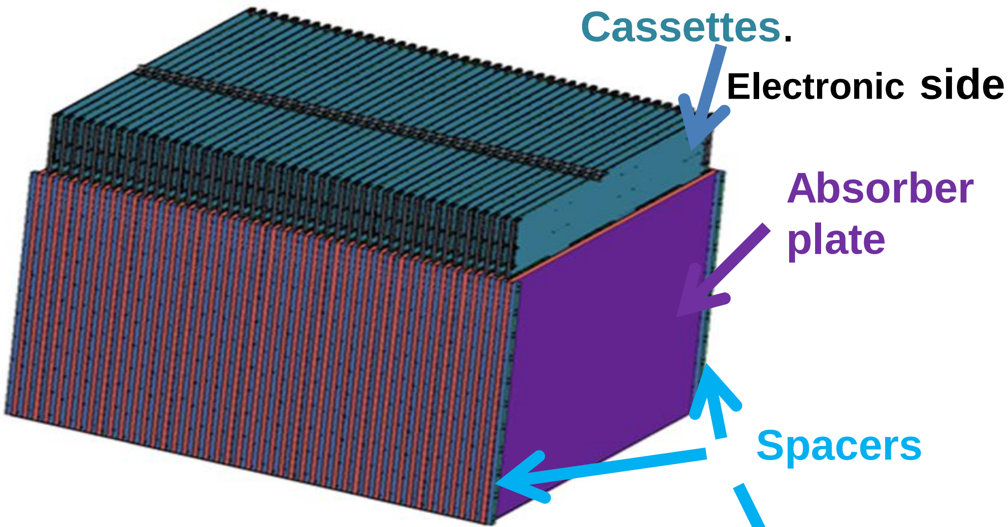








Design of the 1m^3 SDHCAL prototype



The design allows the insertion and further extraction of the cassettes.

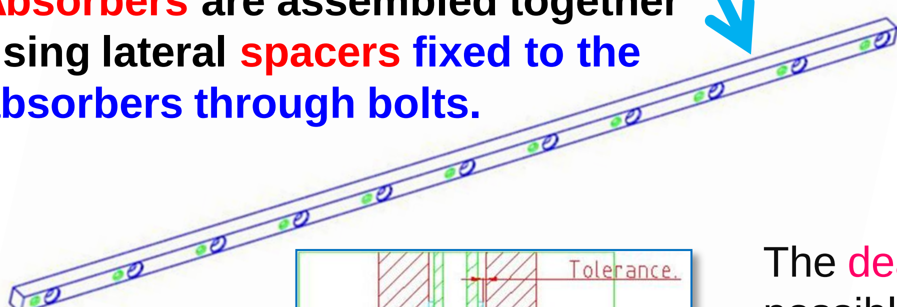
Absorber Plates:

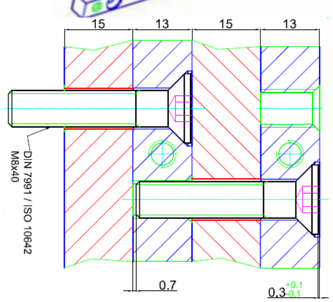
- **1011 x 1054 mm^2 lateral dimensions**
- **15 ± 0.05 mm thick**
- **Surface Planarity < 500μm**

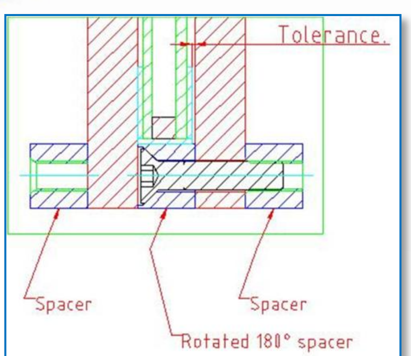
Spacers: 13 mm thick (30-50μm accuracy)

Material: Stainless steel 304L (low permeability ➔ it allows to use it in B=4T)

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



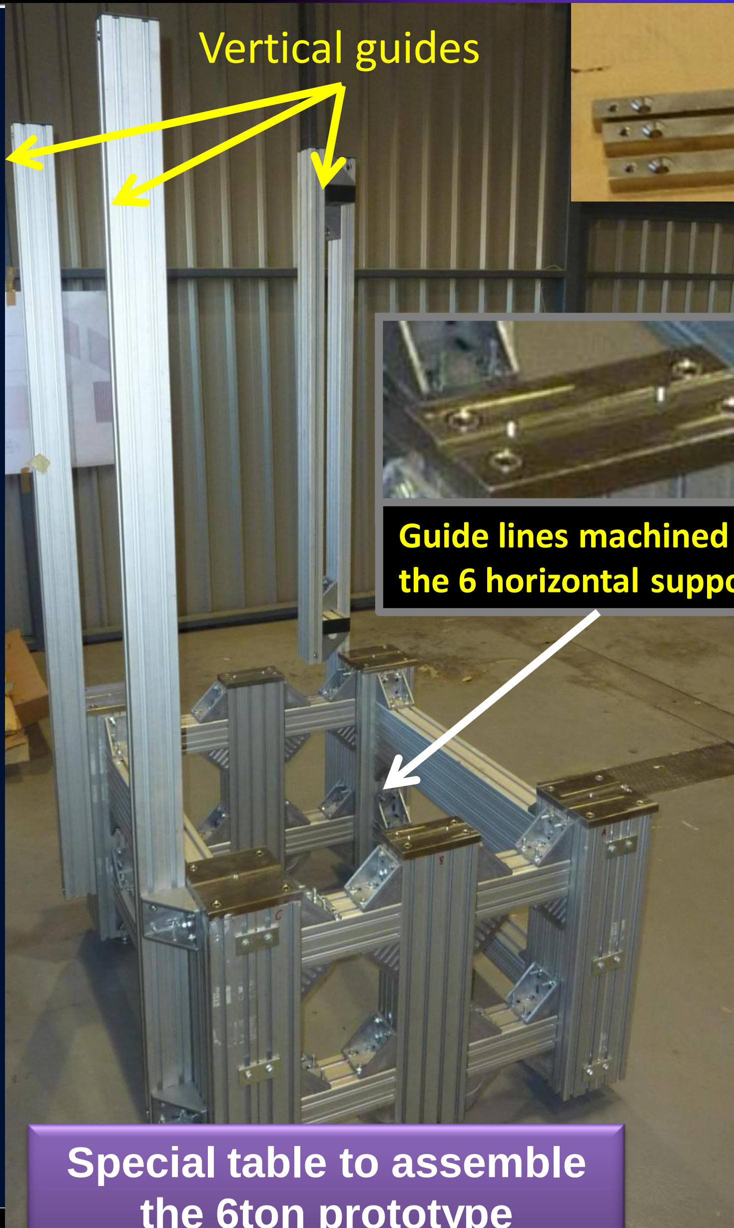




The dead spaces have been minimized as much as possible taking into account the mechanical tolerances (lateral dimensions and planarity) of absorbers and cassettes to ensure a safe insertion of the cassette.

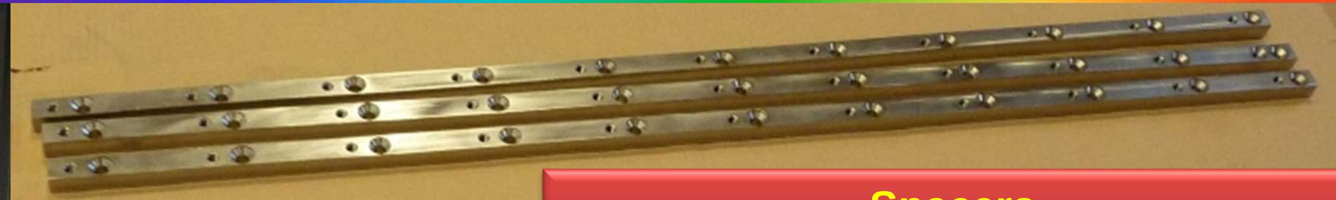
The design also allows interchange the GRPC by MICROMEGAS

Mechanical assembly



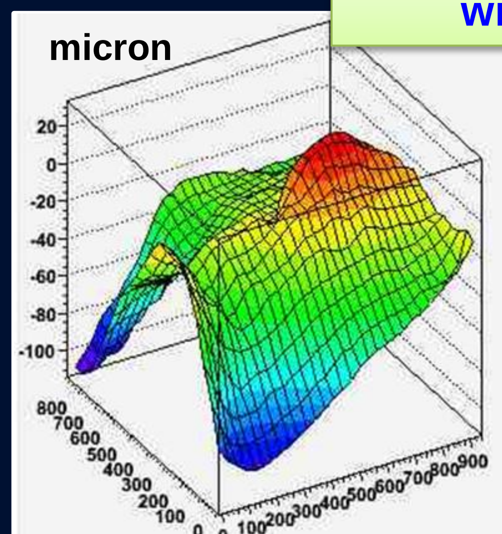
Guide lines machined in the 6 horizontal supports

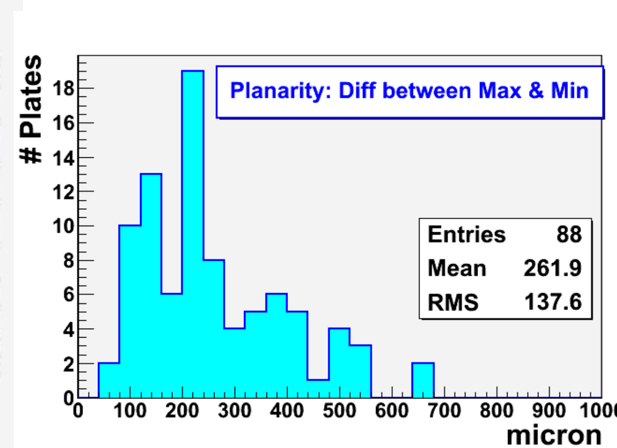
Special table to assemble the 6ton prototype



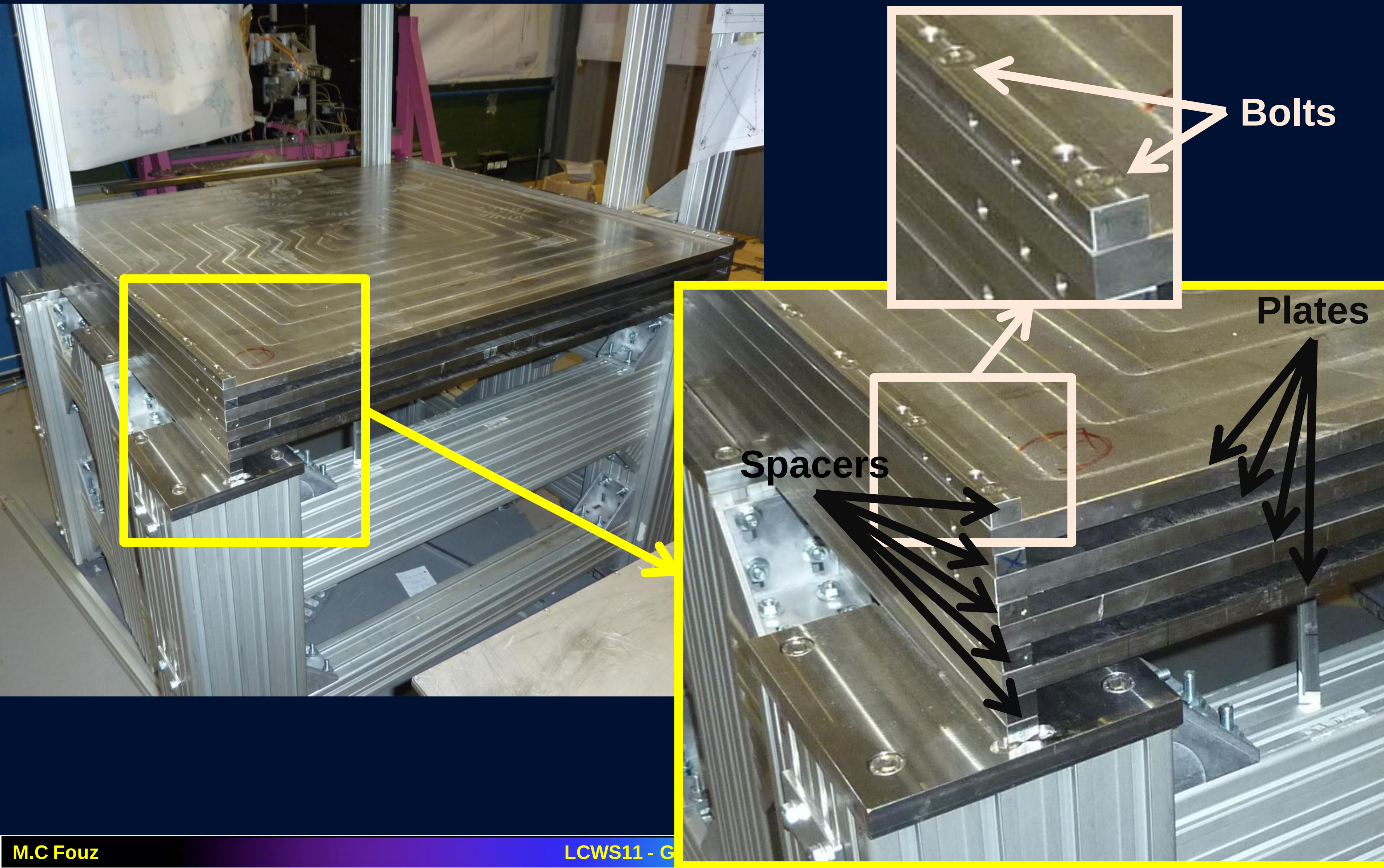
Spacers
Thickness 13mm (30-50 μm accuracy)

Plate planarity verified with laser interferometer



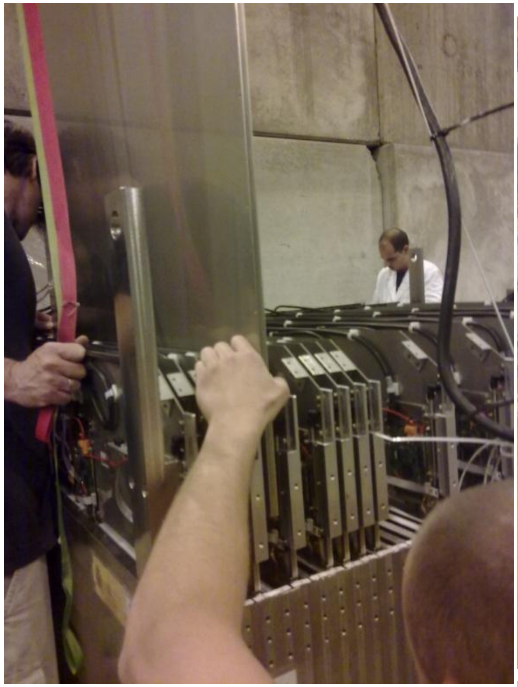


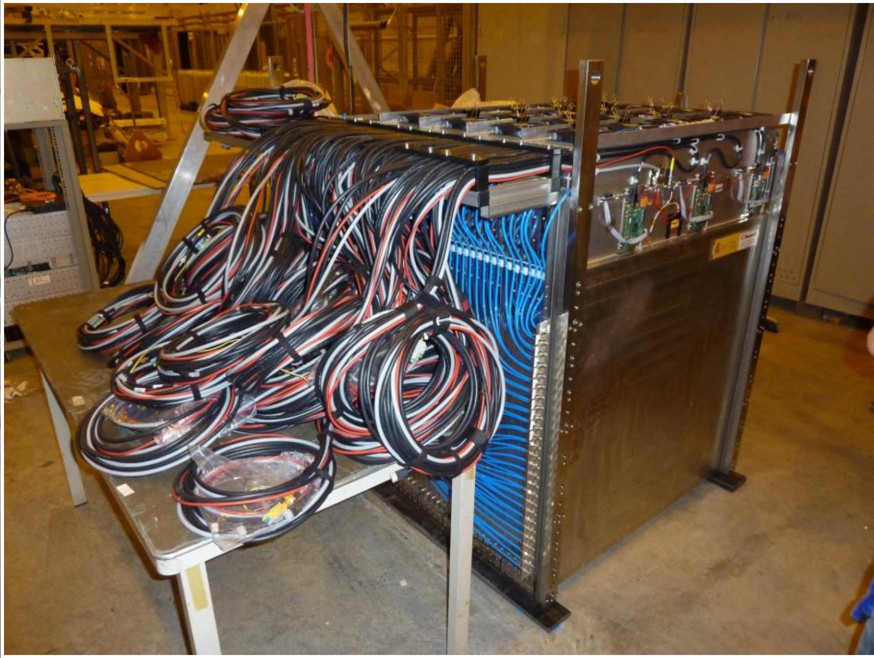
Mechanical assembly @ CIEMAT

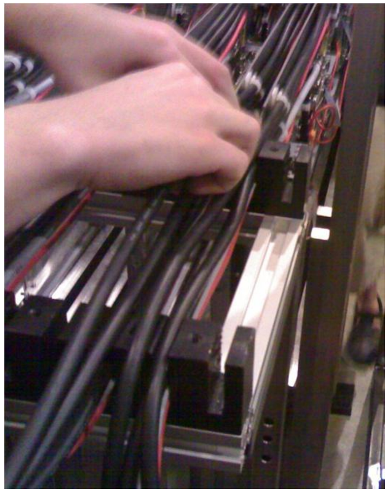


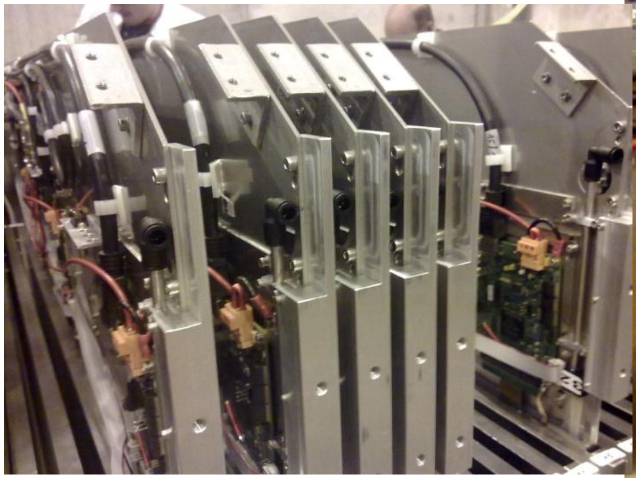
Mechanical assembly @ CIEMAT

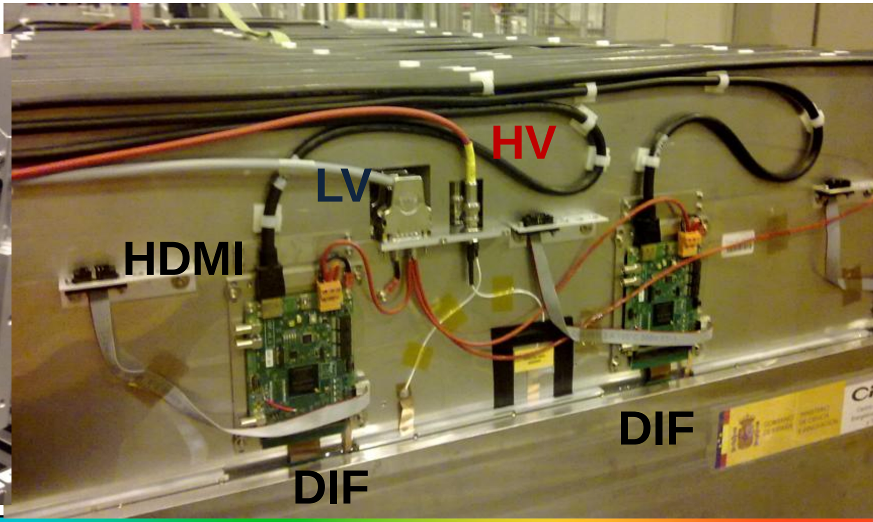
GRPC Insertion & cabling @ CERN











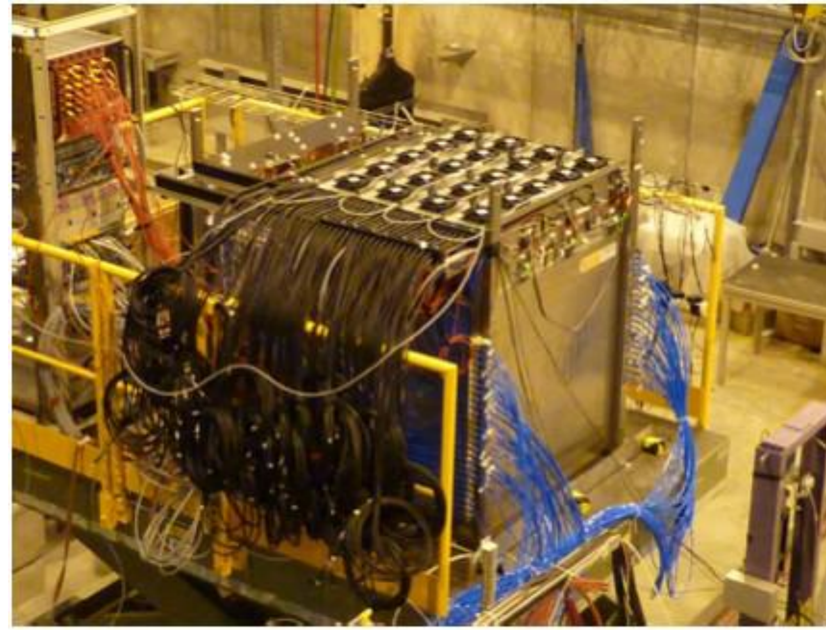
First attempt to show that both, detectors & electronics were performing well

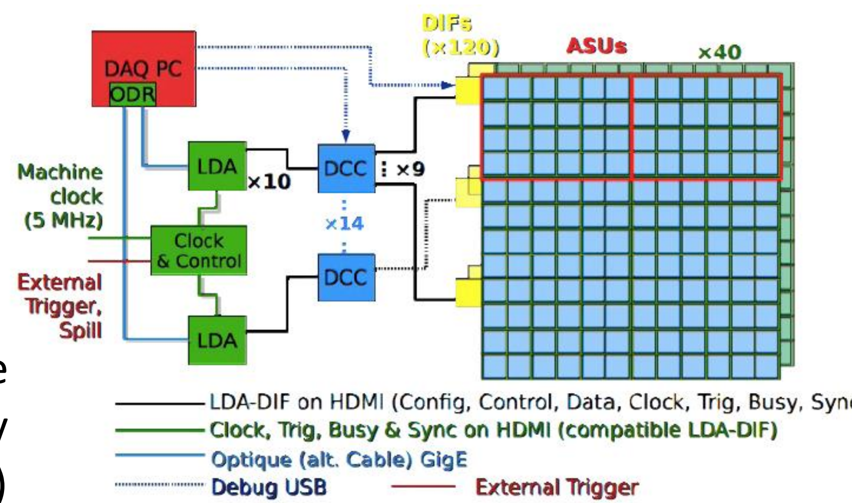
Unfortunately the new DAQ generation wasn´t yet ready by June .

But by using the USB DIF readout we were able to take a very small amount of data

USB readout is not designed for the prototype:

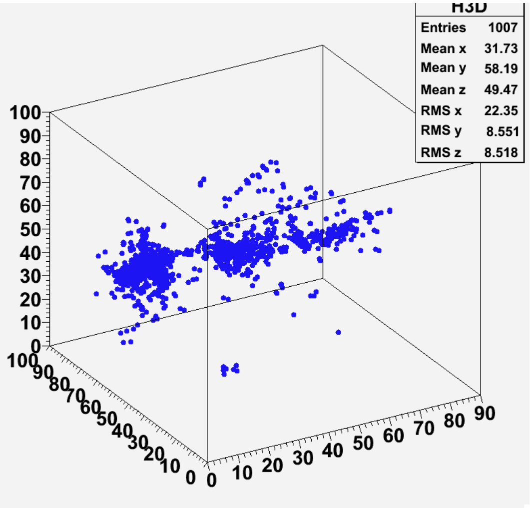
- ➔ Extra cabling
- ➔ Synchronization very difficult
- ➔ Very slow readout

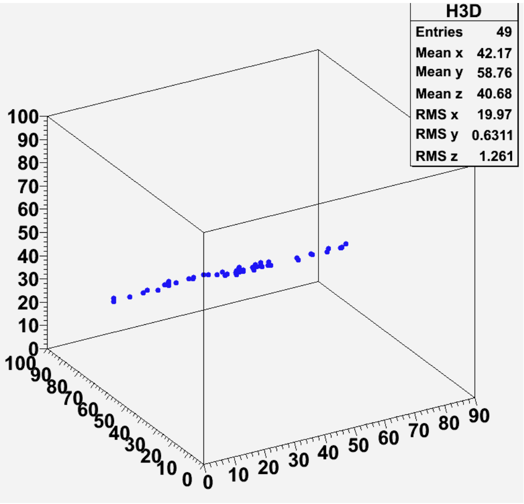


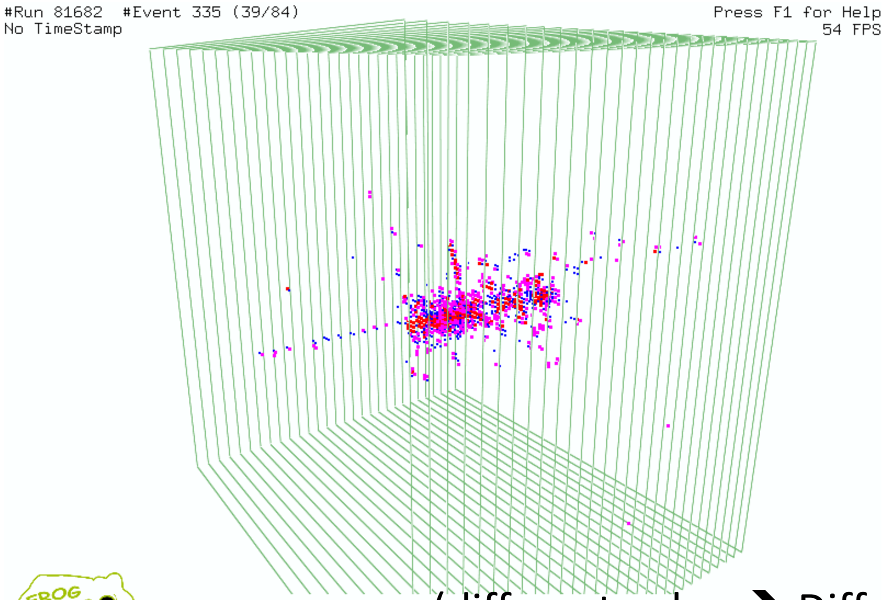


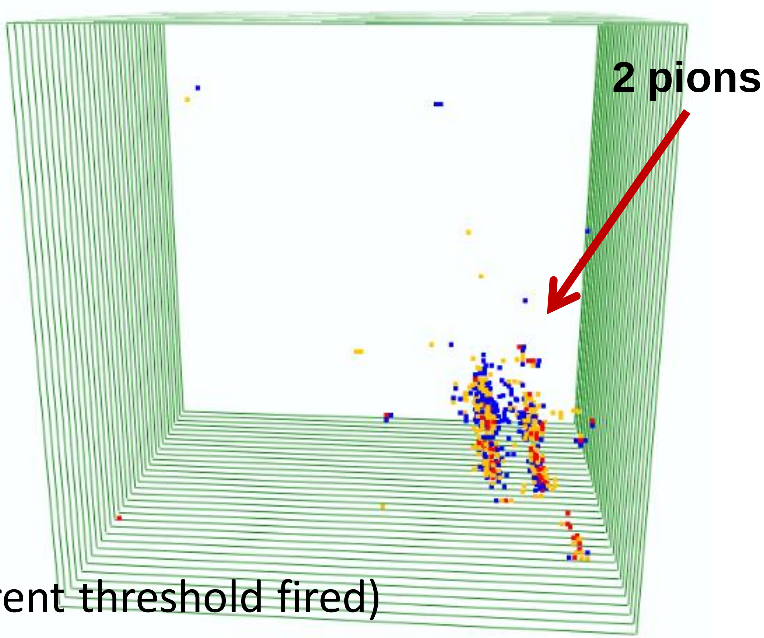
DAQ system scheme
(see V.Boudry´s talk on thursday
Second Generation DAQ for CALICE beam)

June test beam – Event displays



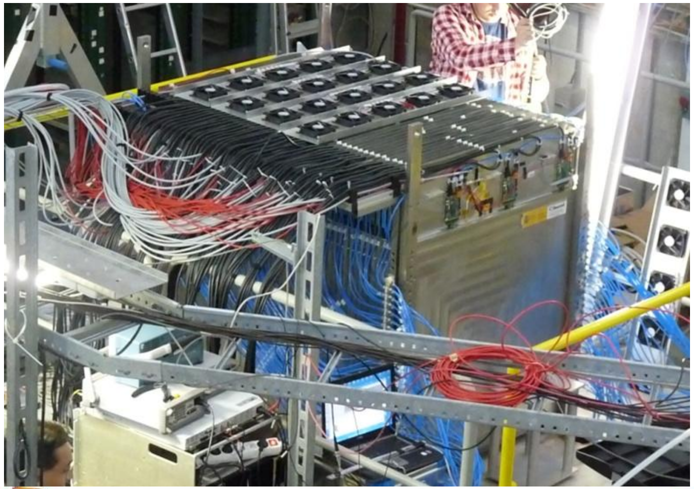






(different color ➔ Different threshold fired)

PS @ CERN September test beam



More GRPC chambers being inserted → 47 GRPC

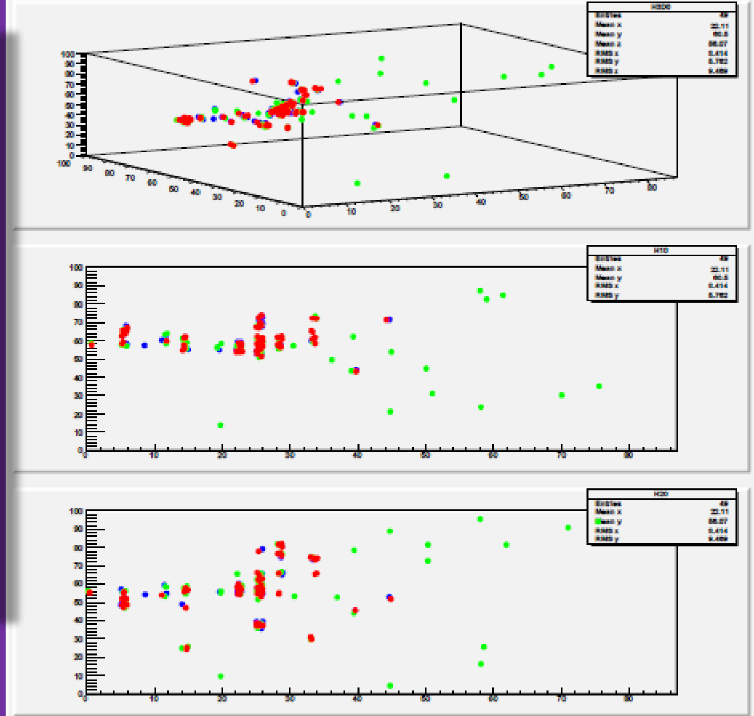
Final DAQ being commissioning

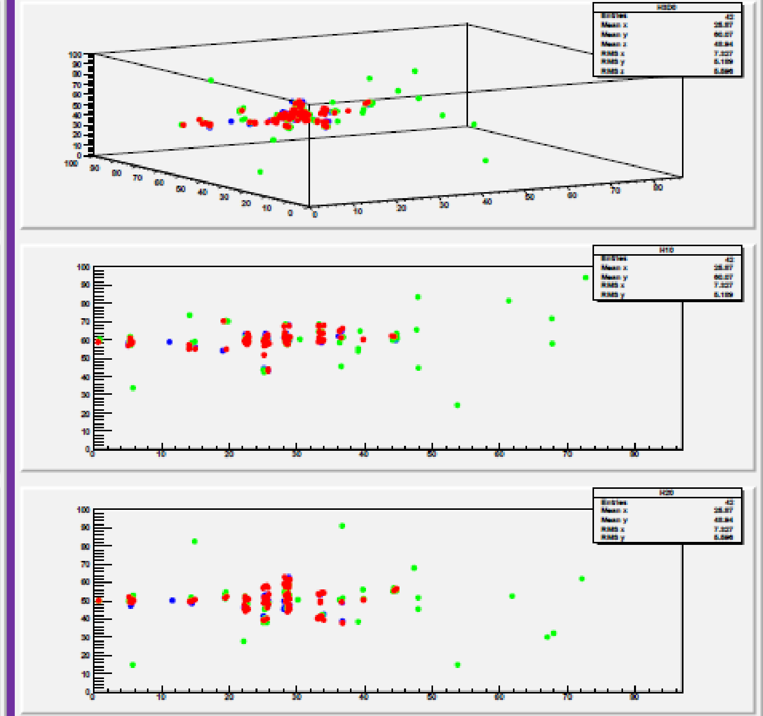
PS test beam Event displays

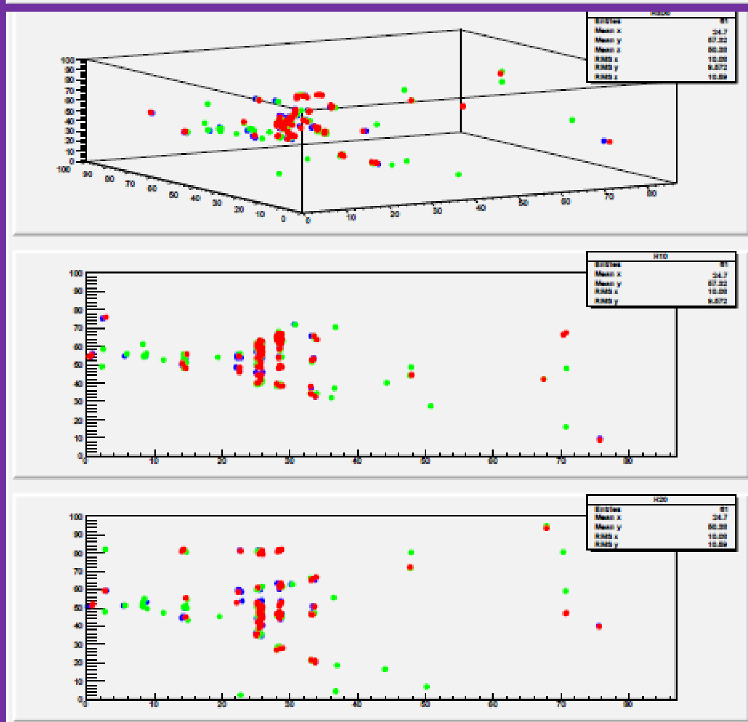
New DAQ Readout:
28 GRPC

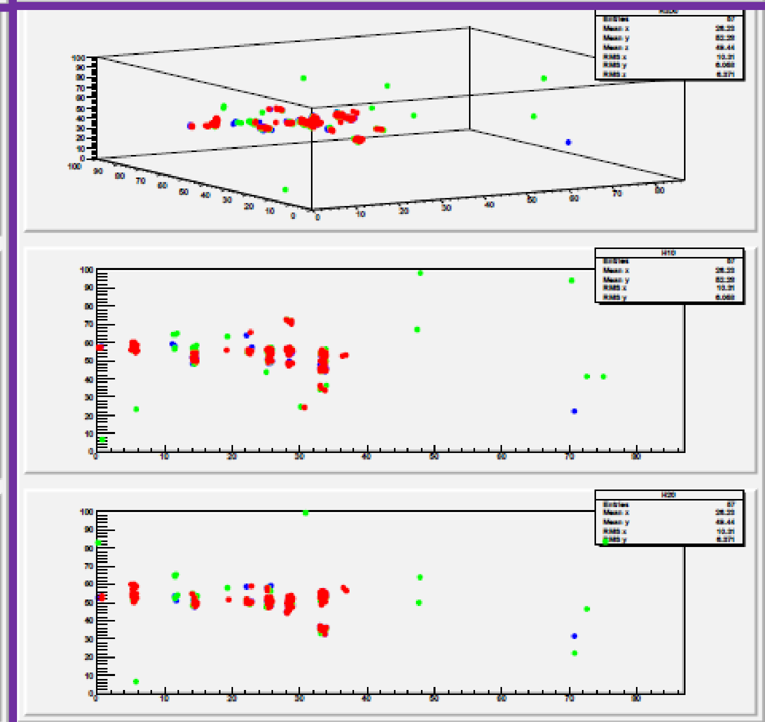
Thr0 (250 fC)
Thr1 (1 pC)
Thr2 (5pC)

RAW Data from PS test beam (25th Sep)









Summary & plans

A technological ~1m^3 SDHCAL has been built.

➔ Extensive GRPC (chambers & electronics) R&D during last years

➔ Design & construction of a technological prototype

➔ Reduced dead zones, self-supporting mechanical structure, embedded electronics, power-pulsed, one-side services.

➔ Construction of the mechanical structure (51 plates)

➔ 47 GRPC built, tested and integrated in the mechanical structure.

Cabling and first test with beam particles at SPS on June

New DAQ version being commissioned now with the prototype at PS, CERN

Test beam @ H2 SPS CERN October 2011 (9 days)

➔ **First tests for physics**

But not enough to perform a full study.

Several months of test beam are needed at SPS CERN in 2012