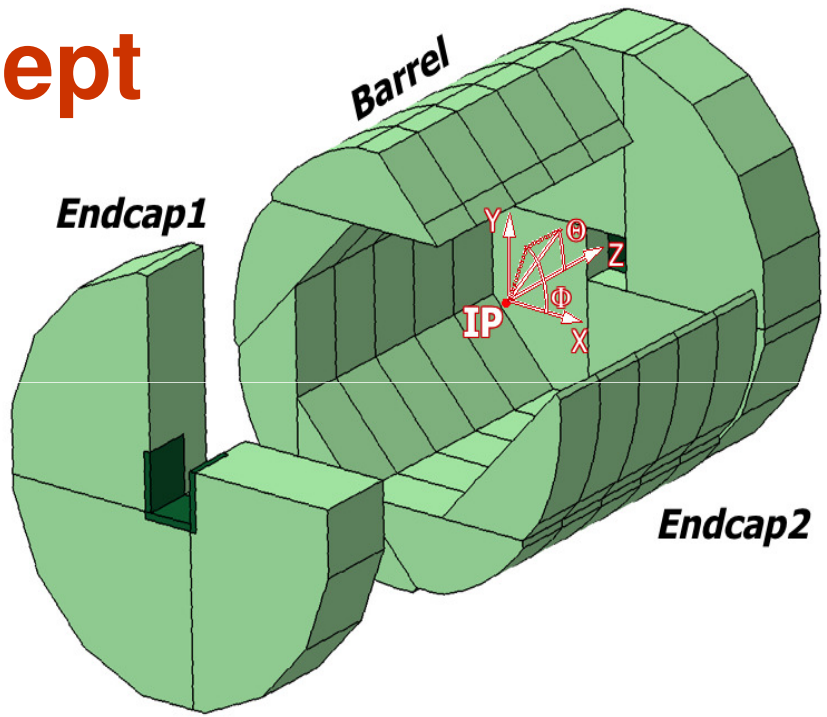
DBD documents
SDHCAL

outline

- SDHCAL concept
- Technological prototype
- Test Beam results
- Next Steps

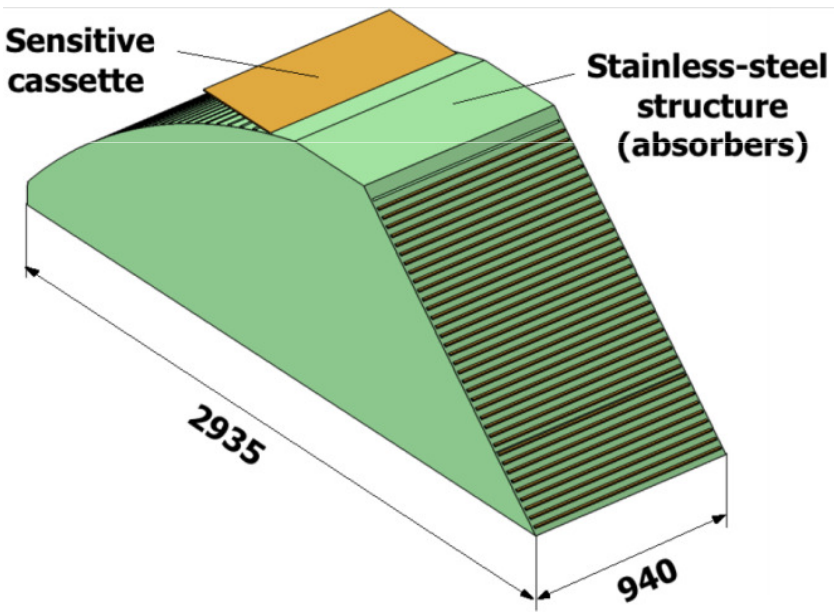
Semi-Digital HCAL Concept

SDHCAL is one of the two HCAL options of the ILD project.
It is proposed with a genuine mechanical structure with no projective cracks and no dead zone between the Barrel and the Endcaps since services are on the periphery



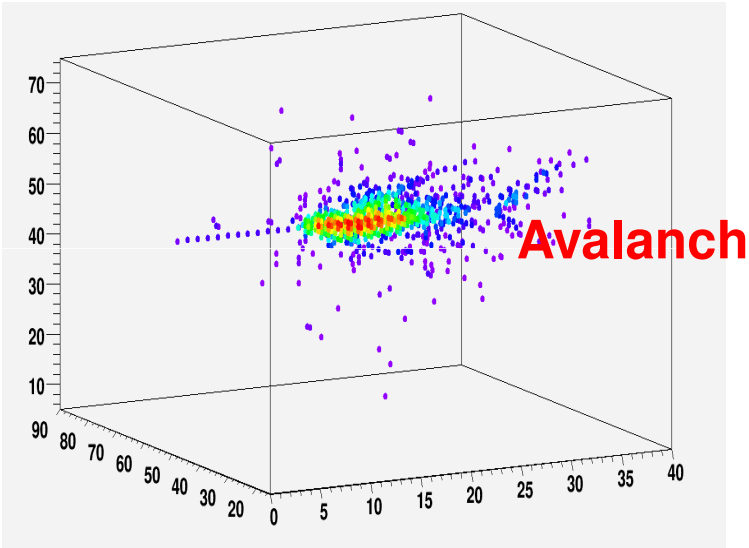
Challenges

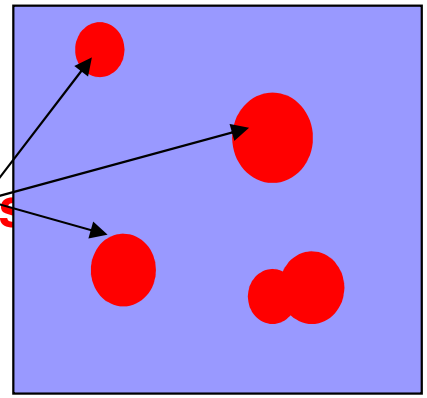
-homogeneity for large surfaces
-Thickness of only few mms
-Services from one side
-Embedded power-cycled electronics
-Self-supporting mechanical structure



Semi-Digital HCAL Concept

Ultra-granular HCAL can provide a powerful tool for the **PFA** leading to an excellent Jet energy resolution.





It is based on two points:

1- Gaseous Detector

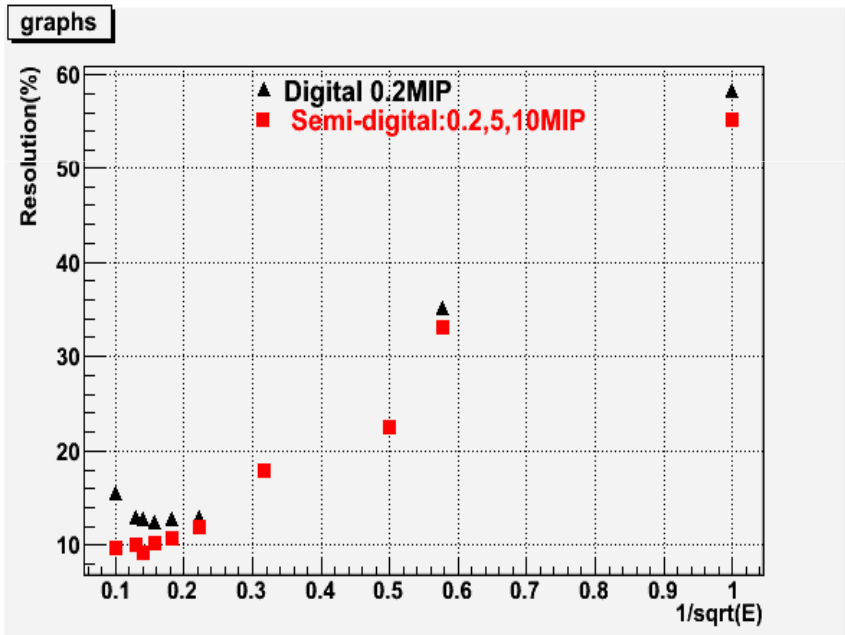
Gaseous detectors like **GRPC** are homogenous, cost-effective, and allow high longitudinal and transverse segmentation.

2- Embedded electronics Readout

A simple binary readout leads to a very good energy resolution

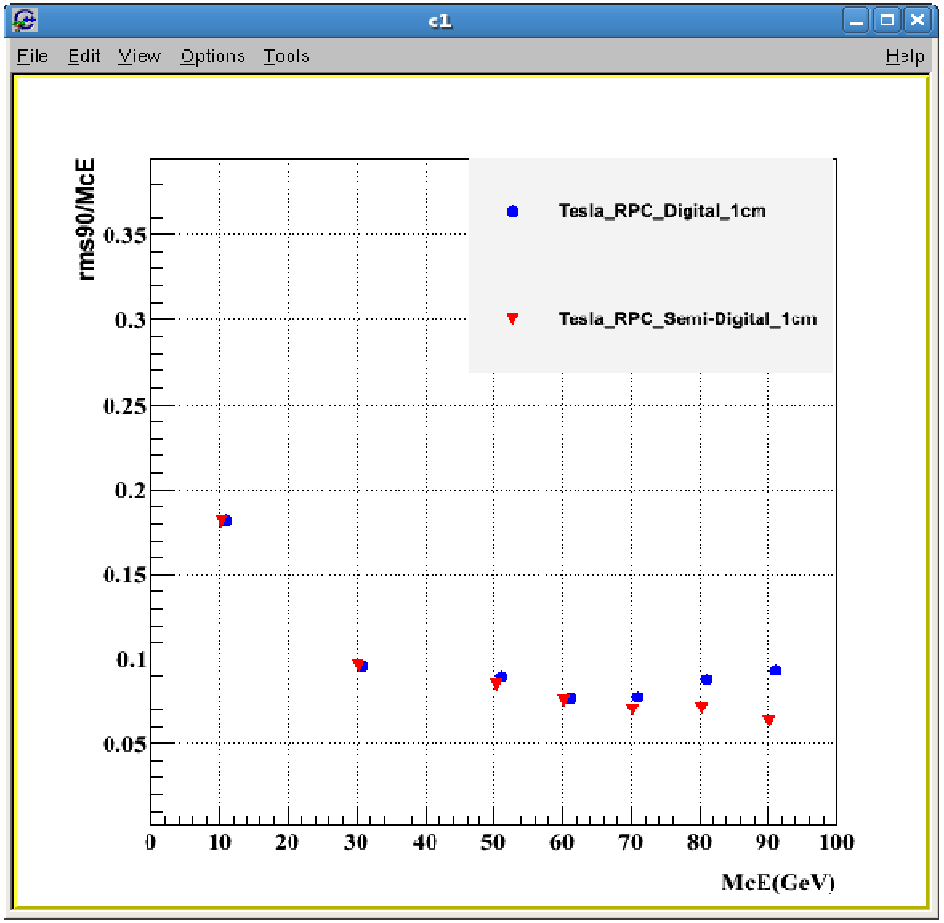
However, at high energy the shower core is very dense and saturation shows up

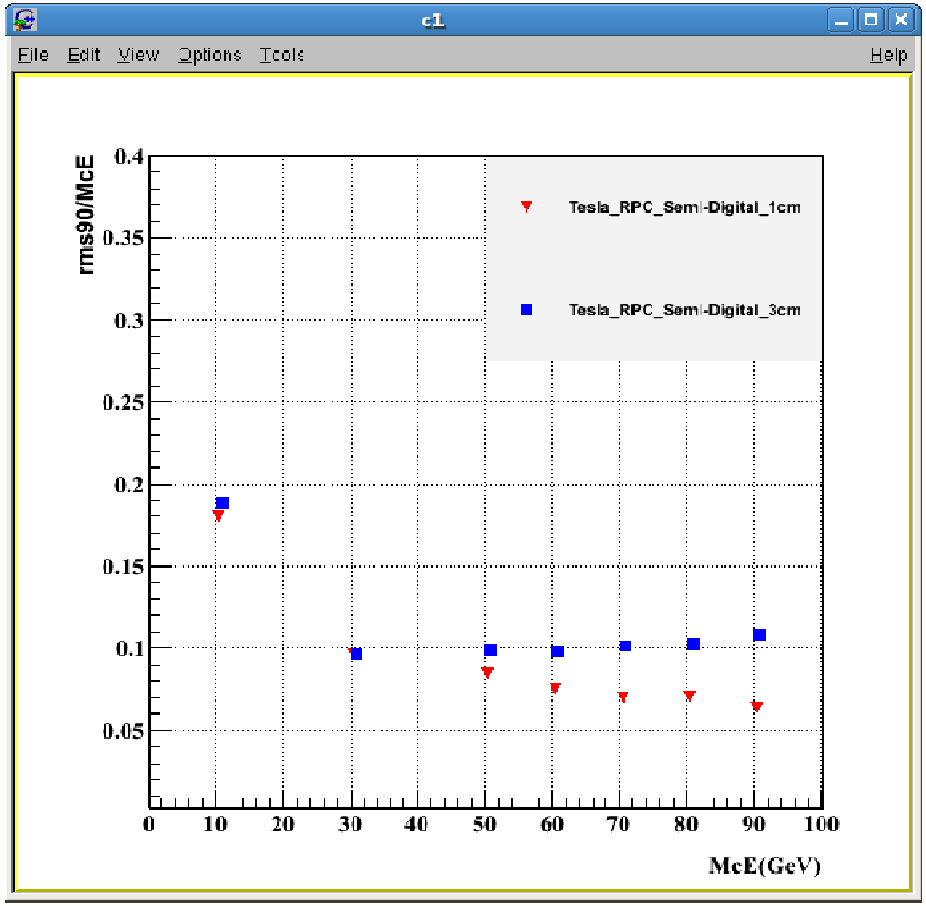
→ 2-bit readout improves on energy resolution at energies> 30 GeV



ILD SDHCAL Simulation

SDHCAL option was fully simulated with both TESLA and Videau geometry options. Granularity and DHCAL vs SDHCAL was studied but also SDHCAL vs Analog HCAL. All these results were presented in ILD meetings.





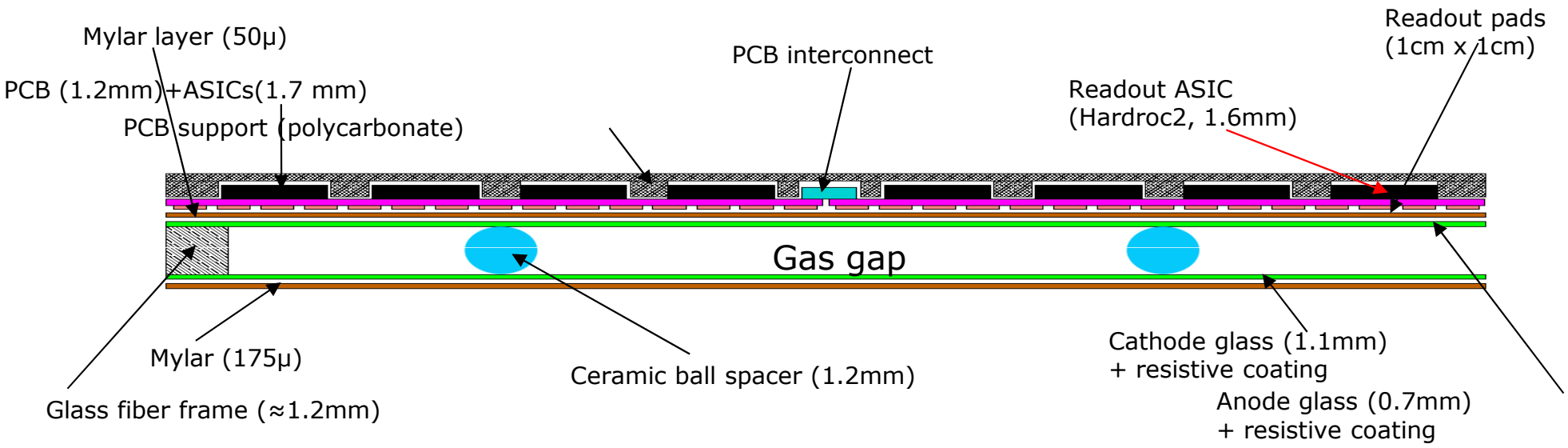
Study realized using K0 in a TESLA geometry ILD SDHCAL

Semi-Digital HCAL Technological Prototype

The technological prototype is intended to be as close as possible to the one proposed in the ILD LOI.

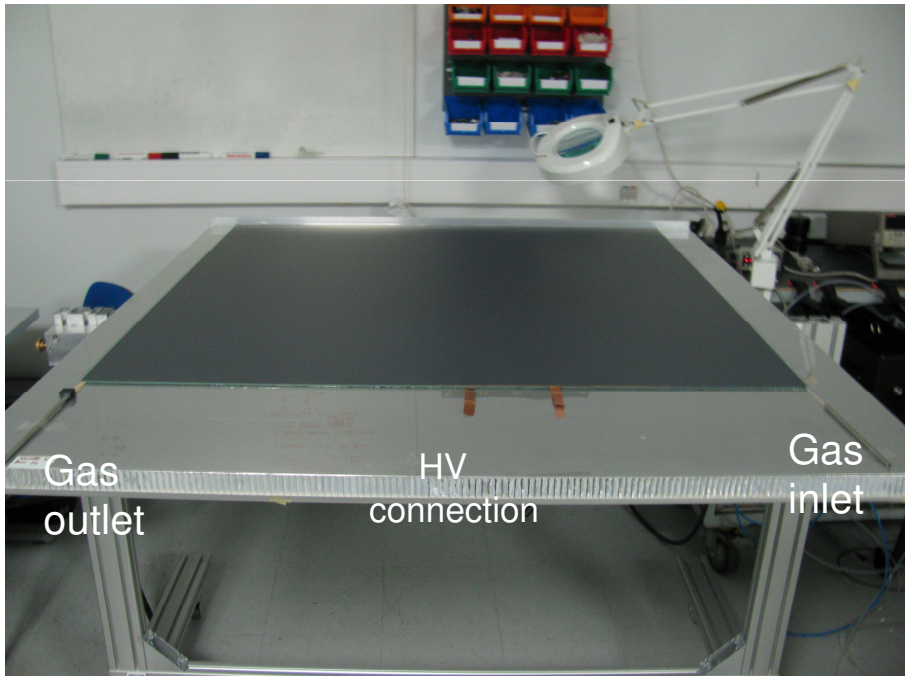
- Efficient, robust and large GRPC detectors with negligible dead zones
- Embedded readout electronics satisfying ILC requirement of compactness and low energy consumption (Power-Pulsed in our case)
-Self-supporting mechanical structure
- Compactness with services from one side

Structure of an active layer of the SDHCAL



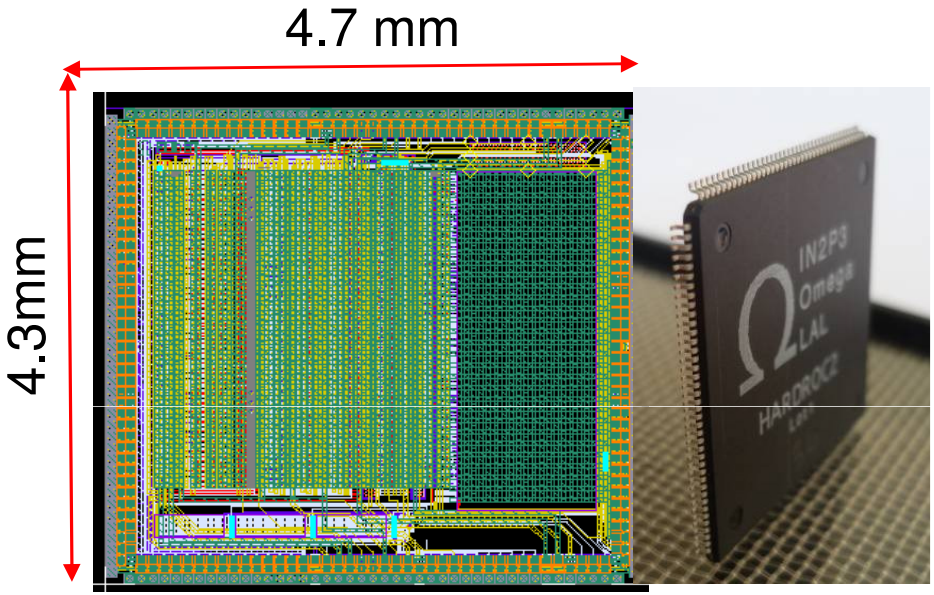
Large GRPC R&D

- ✓ Negligible dead zone (tiny ceramic spacers)
- ✓ Efficient gas distribution system (channeling gas inlet and outlet)
- ✓ Homogenous resistive coating (special paint mixture, silk screen print)



Electronics readout system R&D

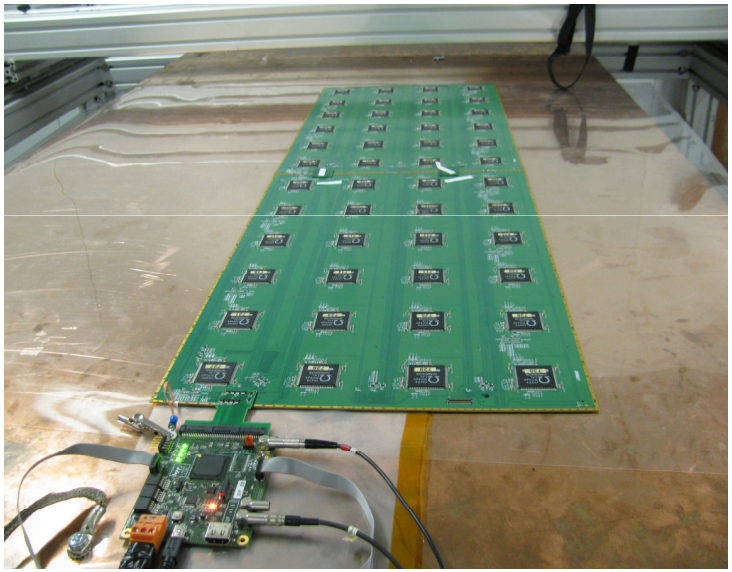
ASICs : HARDROC2
64 channels
Trigger less mode
Memory depth : 127 events
3 thresholds
Range: 10 fC-20pC
Gain correction → uniformity
Power-Pulsed (7.5 μW in case of ILC duty cycle)



Printed Circuit Boards (PCB) were designed to reduce the x-talk with **8-layer** structure and buried vias.

Tiny connectors were used to connect the PCB two by two so the 24X2 ASIC are daisy-chained.

DAQ board (DIF) was developed to transmit fast commands and data to/from ASICs.



Cassette R&D

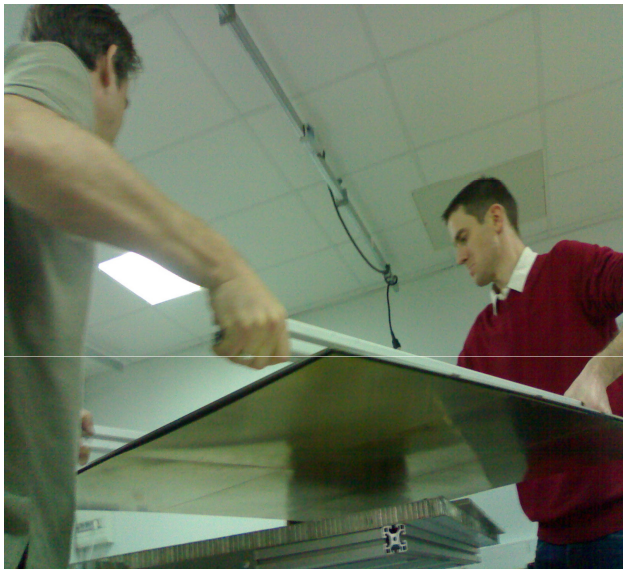
Cassettes were conceived

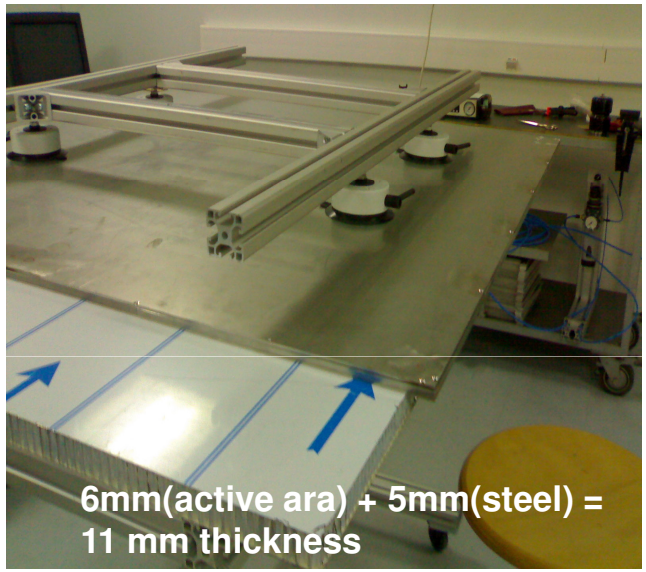
✓ To provide a robust structure.

✓ To maintain good contact between the readout electronics and the GRPC.

✓ To be part of the absorber.

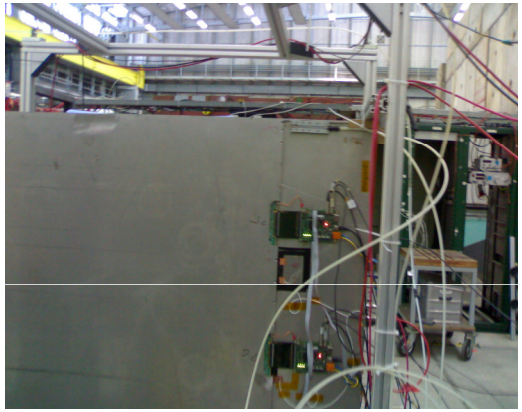
✓It allows to replace detectors and electronics boards easily.

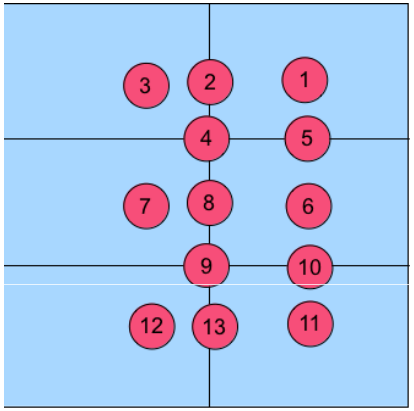




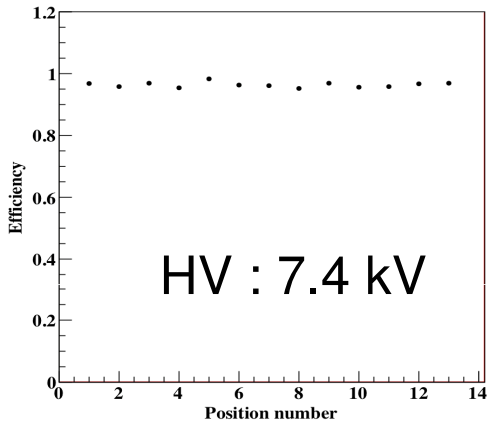
The cassettes are built of no-magnetic stainless steel walls 2.5 mm thick each
→ Total cassette thickness = 6mm (active layer)+5 mm (steel) = 11 mm

The homogeneity of the detector and its readout electronics were studied (CERN TB)

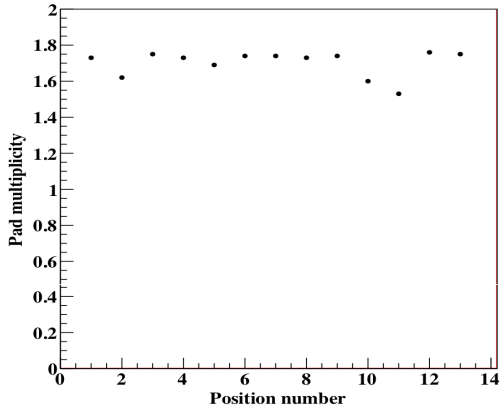




Beam spot position



Efficiency

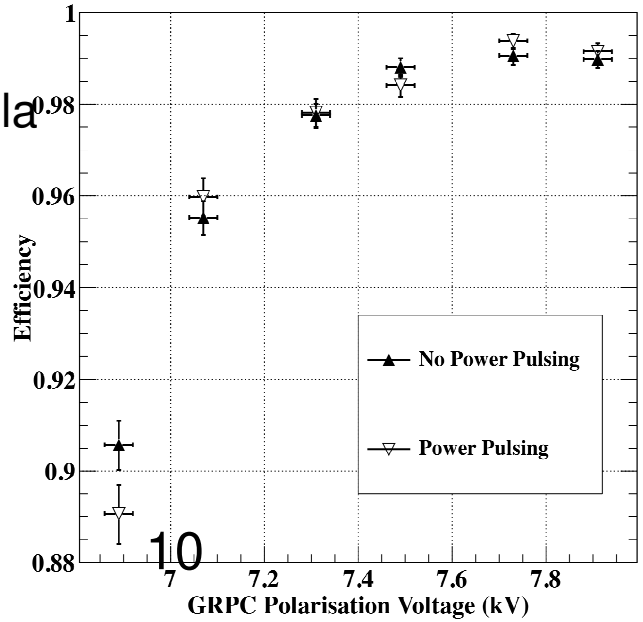


Multiplicity

Power-Pulsing mode was tested in a magnetic field of 3 Tesla

The Power-Pulsing mode was applied on a GRPC in a 3 Tesla field at H2-CERN
(2ms every 10 ms)
No effect on the detector performance

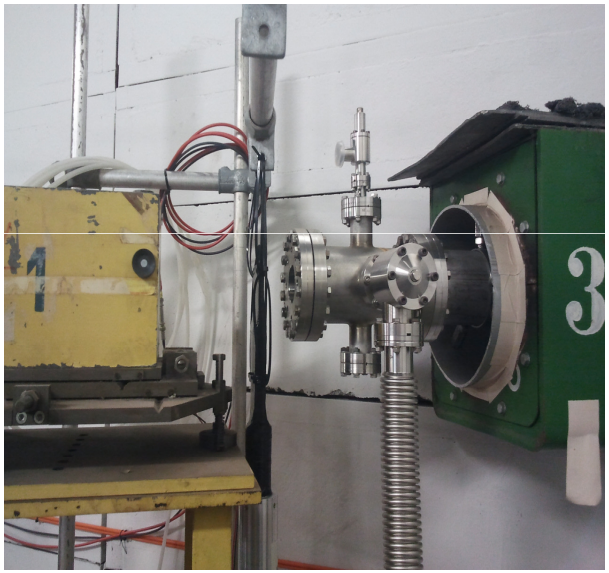
ILC duty cycle :
1ms (BC) every 200 ms



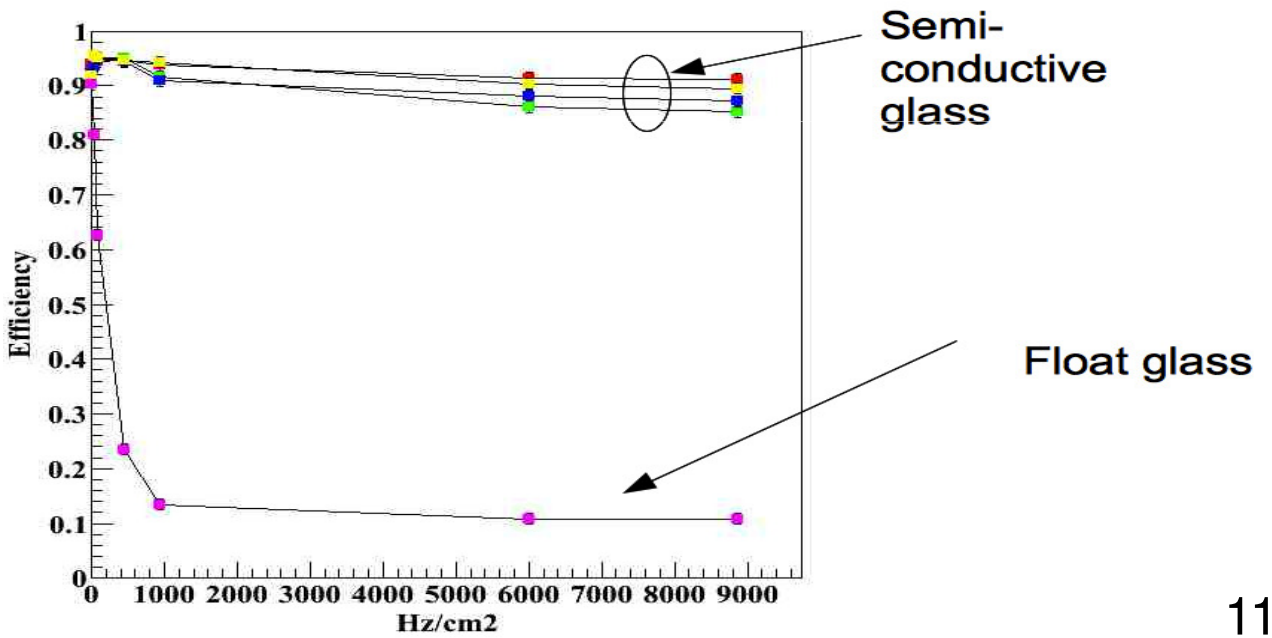
High-Rate GRPC

High-Rate GRPC may be needed in the very forward region

✓Semi-conductive glass (10^{10} Ω.cm) produced by our collaborators from Tsinghua University was used to build few chambers.
✓4 chambers were tested at DESY as well as standard GRPC (float glass)

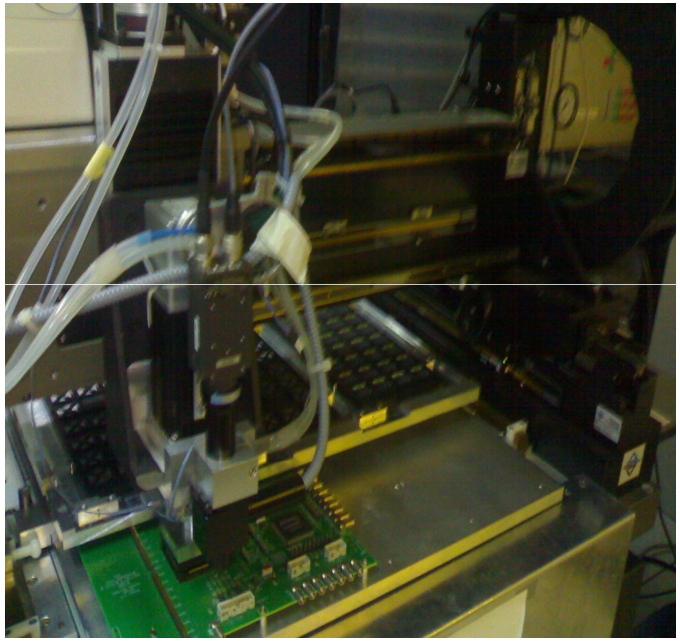


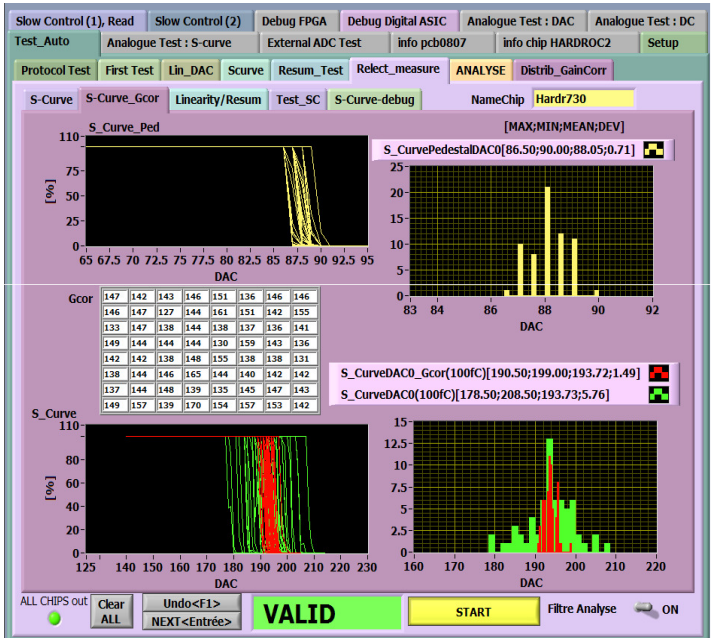
Performance is found to be excellent at high rate for GRPCs with the semi-conductive glass and can be used in the very forward region if the rate > 100 Hz/cm^2



SDHCAL prototype construction

✓ 10500 ASIC were tested and calibrated using a dedicated robot(93% layout)
✓ 310 PCBs were produced, cabled and tested according to strict quality control rules

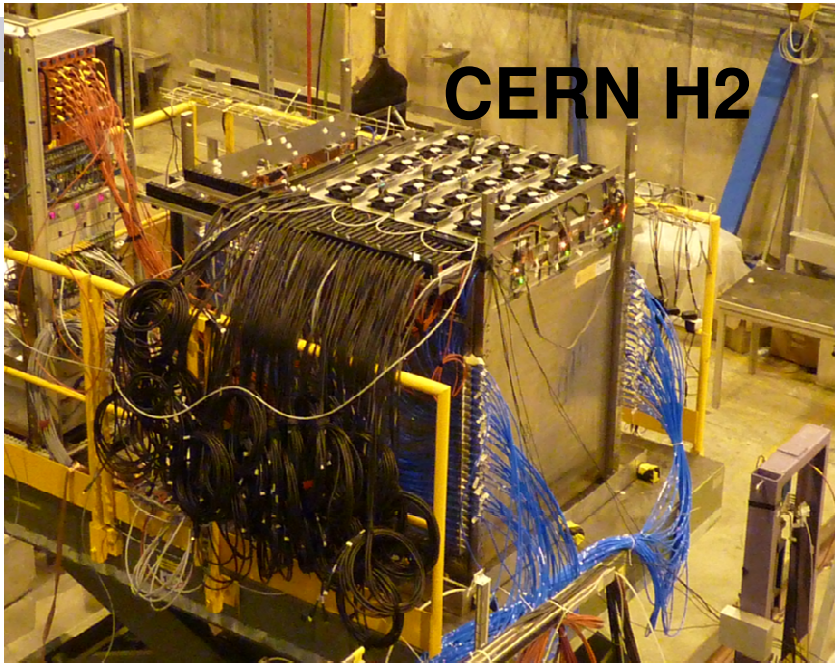




✓ self-supporting mechanical structure was conceived and built.

✓ 51 stainless steel 15mm thick plates with planarity <500 µm were machined and tested

SDHCAL TestBeam



TB of the SDHCAL took place in 2011 and 2012

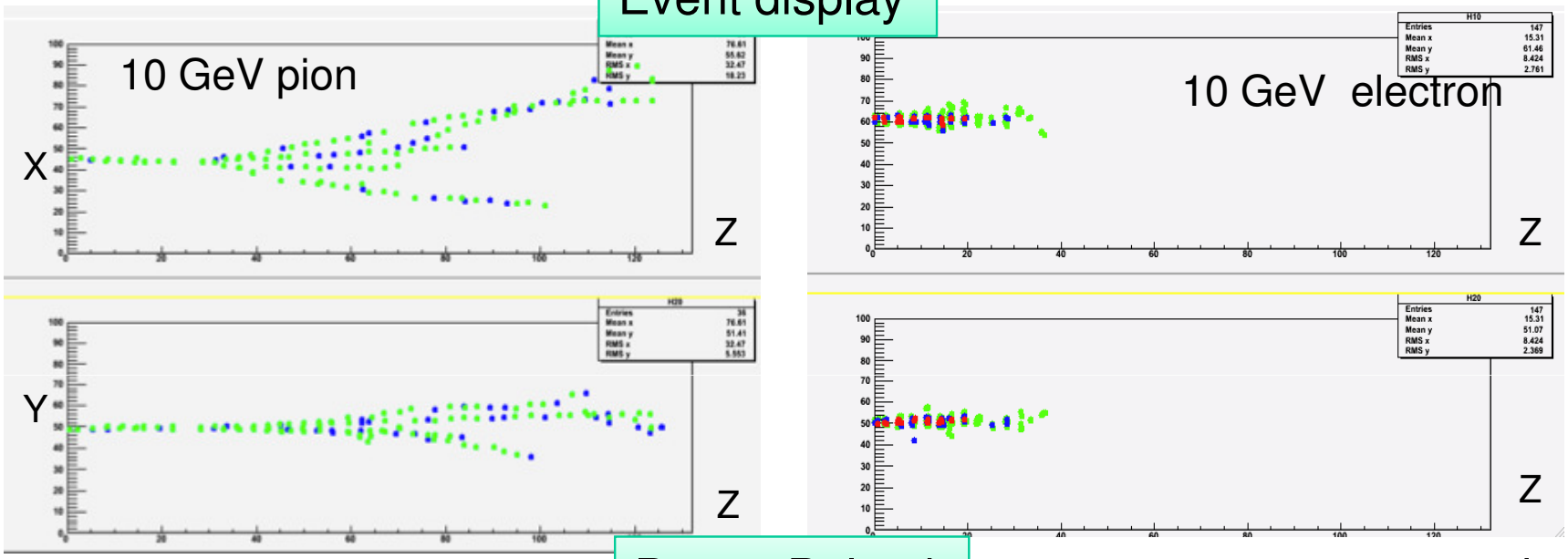
In 2011:
40 layers were used for tests at PS and SPS. Attempts to run the 40 layers using the CALICE DAQ2 were unsuccessful but were useful to diagnose the problems and to propose a solution based on a hybrid HDMI-USB DAQ.

In 2012:
TB at PS and SPS were very successful. Power-Pulsing was applied with a great benefit on the detector behaviour (heating, noise,….). Only simple cooling system was used.

Gas tightness was a problem in the first TB because of old CERN gas connections. This was fixed by using our own system. Isobutane was not used at all and definitely replaced by CO2

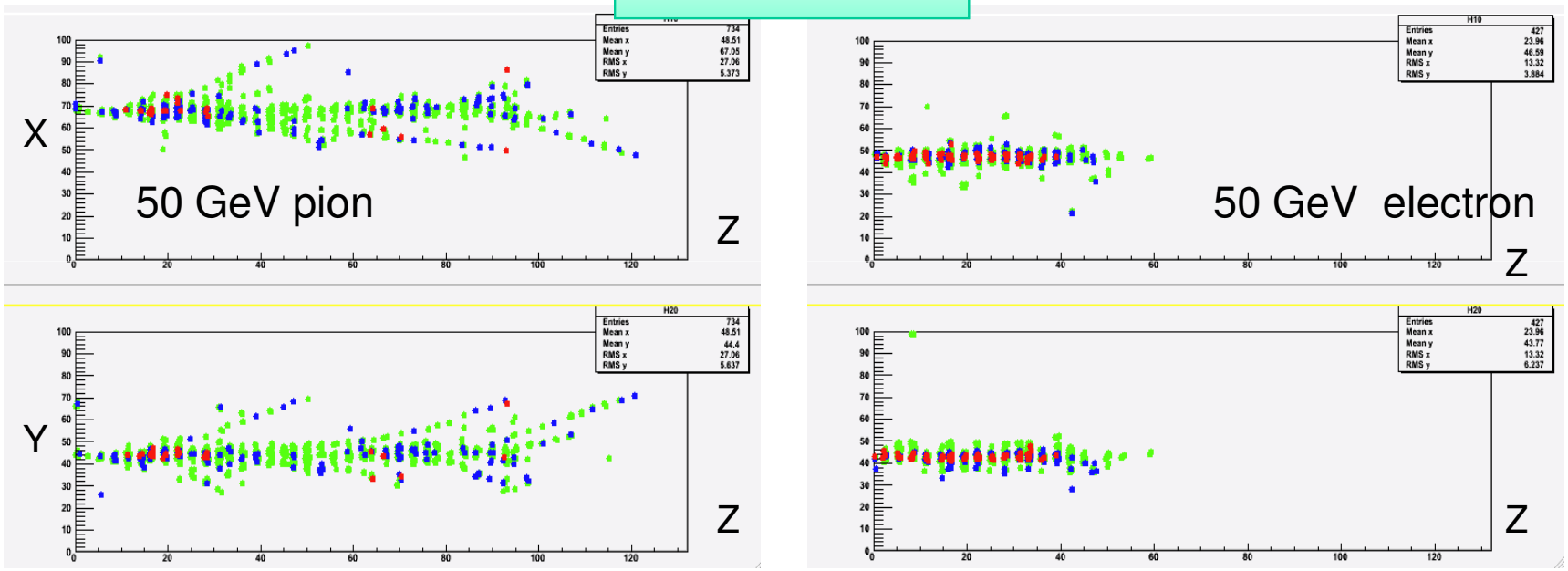
Data quality can be seen from the hadronic shower and muons events recorded during the 2012 TB.

Event display



Power-Pulsed

units in cm



Colours correspond to the three thresholds: Green (114 fC), Blue (5 pC), Red (15 pC)

Raw data, no treatment except time hit clustering

SDHCAL TestBeam

TB 2012

May and August TB were performed with no gain correction and the results were obtained with no correction of any kind

Some data runs of May suffered from high intensity beam (saturation effect easily detected by estimating the efficiency of tracks)

In August a good understanding of the beam optics allowed to enlarge the beam size and to take more data.

No intervention during the August period. Detector is very stable

In august “We reached the phase of boring shifts”

SDHCAL TestBeam

Analysis tools were developed to allow on-line control of data quality and fast analysis.

Different groups started to look at the data with the aim to validate and cross-check the results.

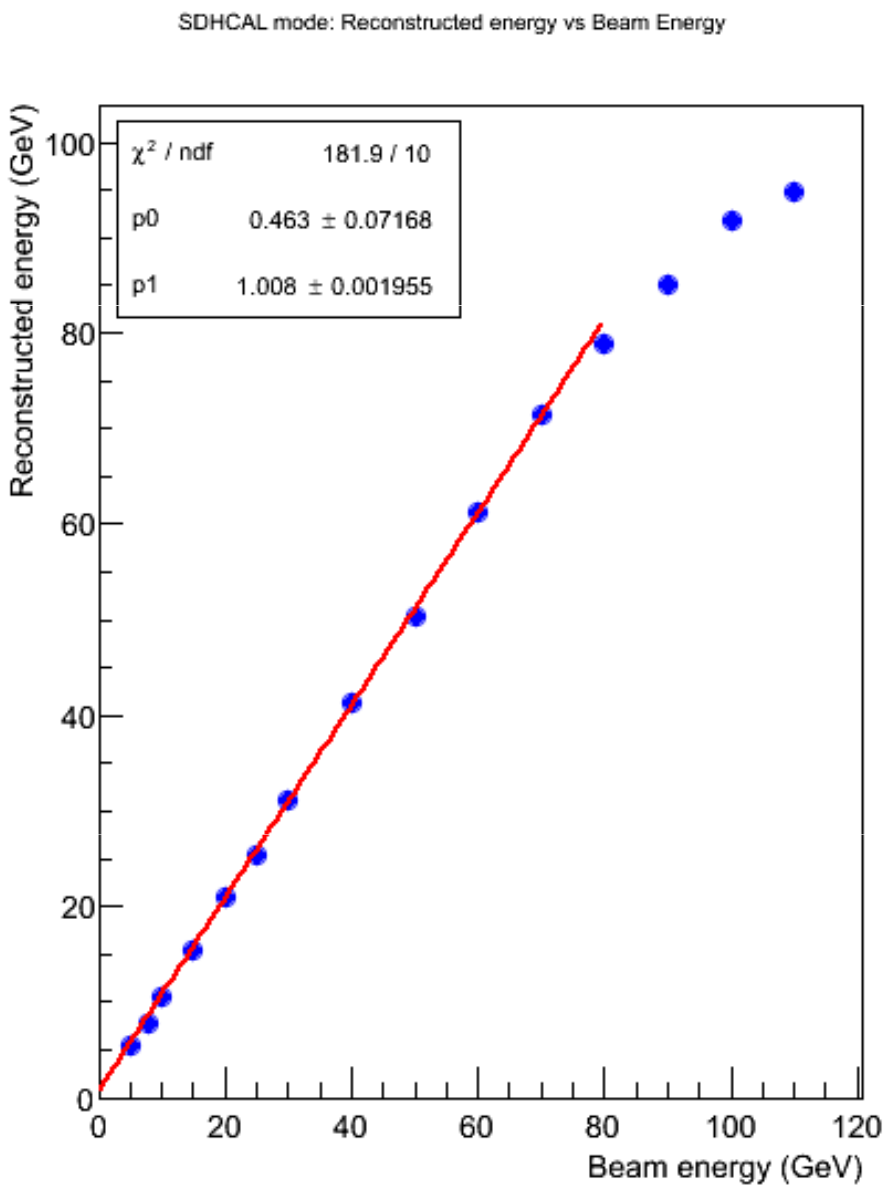
Many results were presented in the two previous days using different approaches. This allows to reduce biases as much as possible

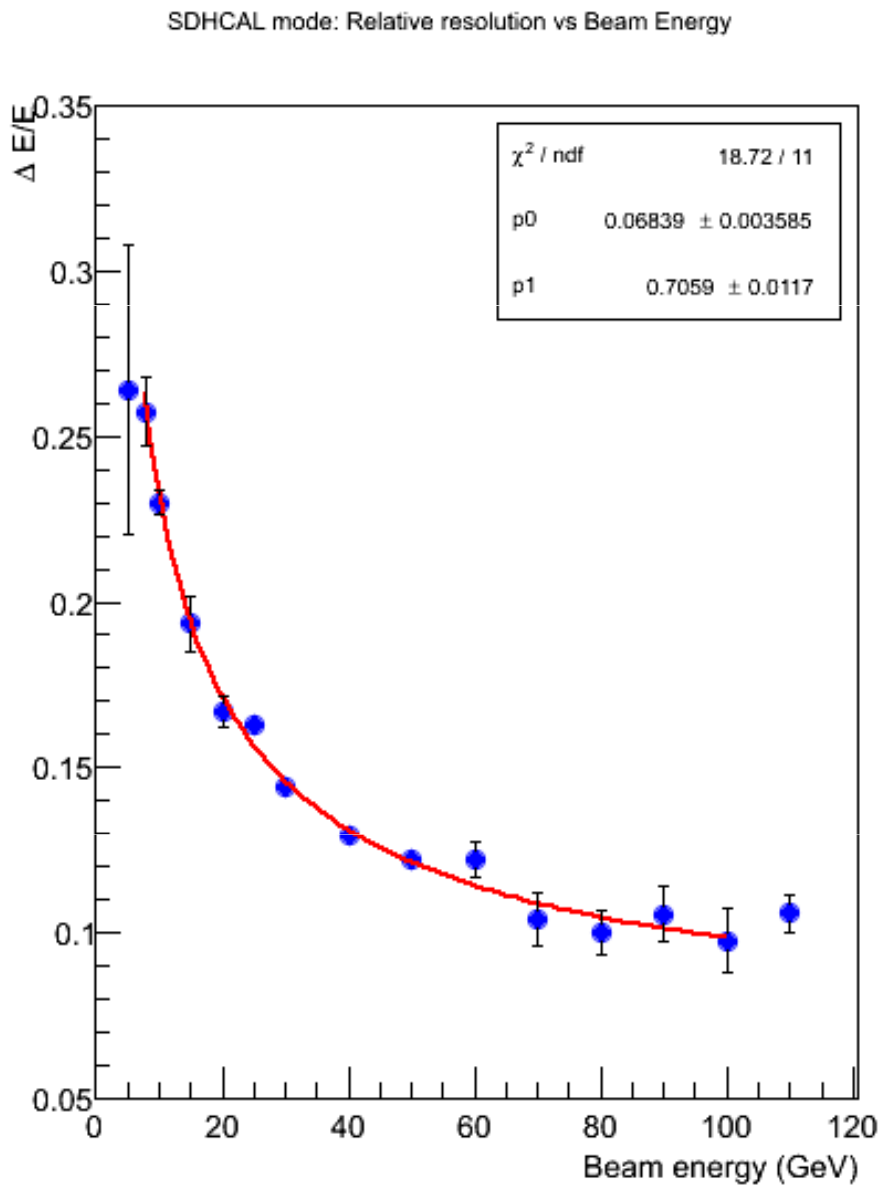
The SDHCAL-GRPC data are open to everybody in CALICE.
available on the CALICE Grid:

/grid/calice/SDHCAL/TB/CERN/PS_April2012
/grid/calice/SDHCAL/TB/CERN/PS_April2012/SPS_May2012
/grid/calice/SDHCAL/TB/CERN//SPS_AugSep2012

A note including the most significant results will be written after this CALICE meeting. **We would like to include the resolution results in the DBD document.**

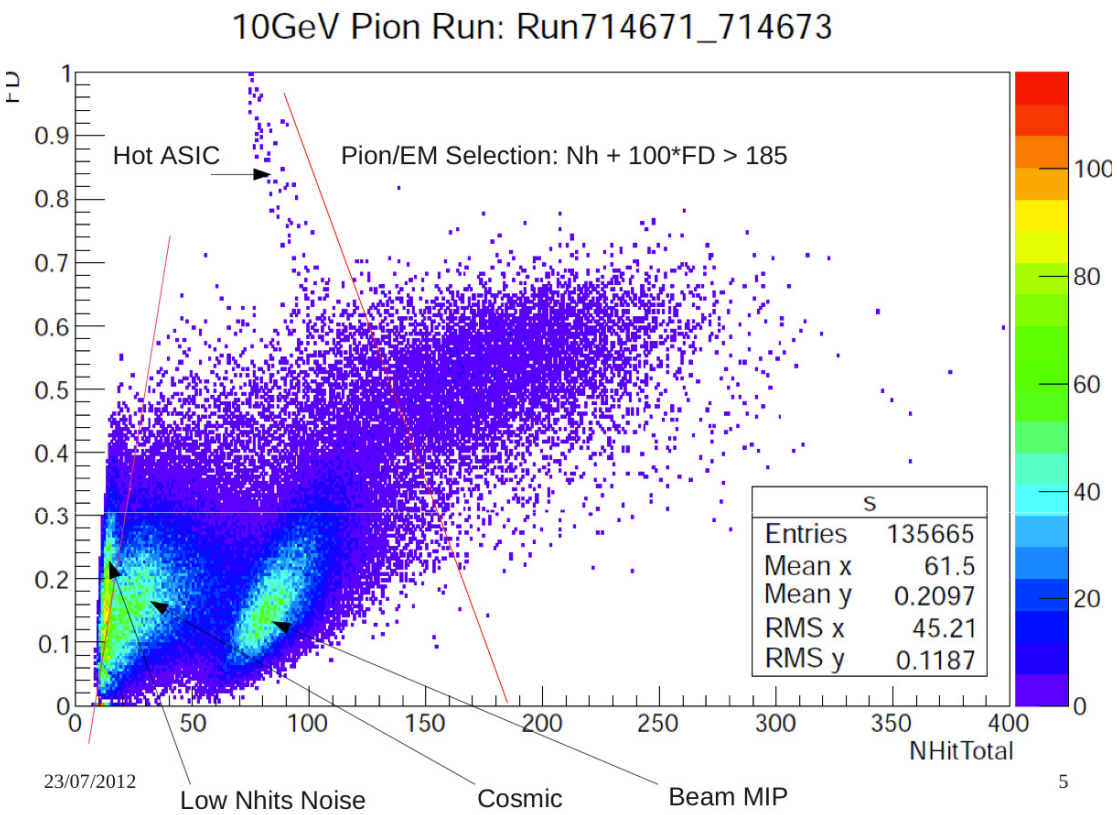
And in a further step the resolution results including local corrections (electronic gain, efficiency, multiplicity, dead channels) and


SDHCAL mode: Reconstructed energy vs Beam Energy
χ² / ndf 181.9 / 10
p0 0.463 ± 0.07168
p1 1.008 ± 0.001955
Reconstructed energy (GeV)
Beam energy (GeV)
0
20
40
60
80
100
120

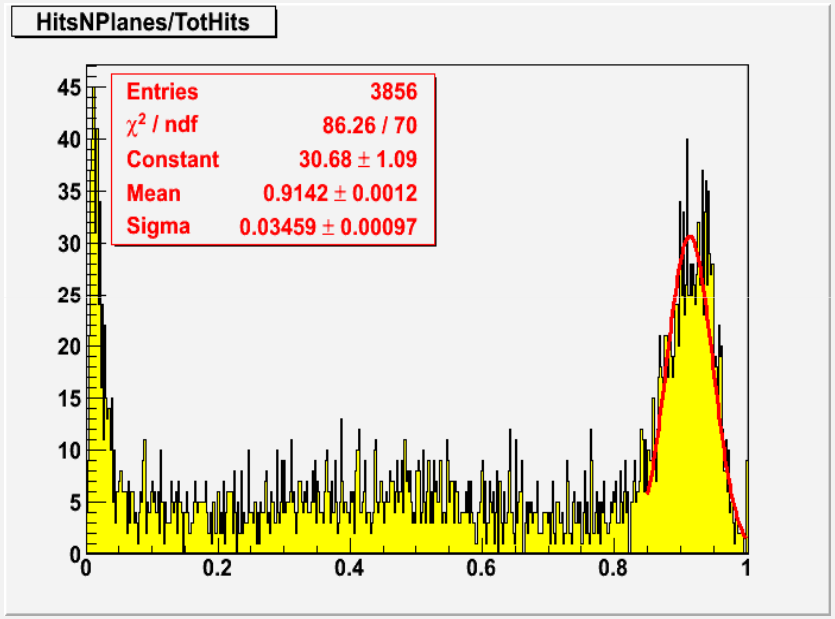

SDHCAL mode: Relative resolution vs Beam Energy
χ² / ndf 18.72 / 11
p0 0.06839 ± 0.003585
p1 0.7059 ± 0.0117
Δ E/E
Beam energy (GeV)
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0
20
40
60
80
100
120

SDHCAL TestBeam

In second phase we would like to introduce the results obtained with electron/pion separation and

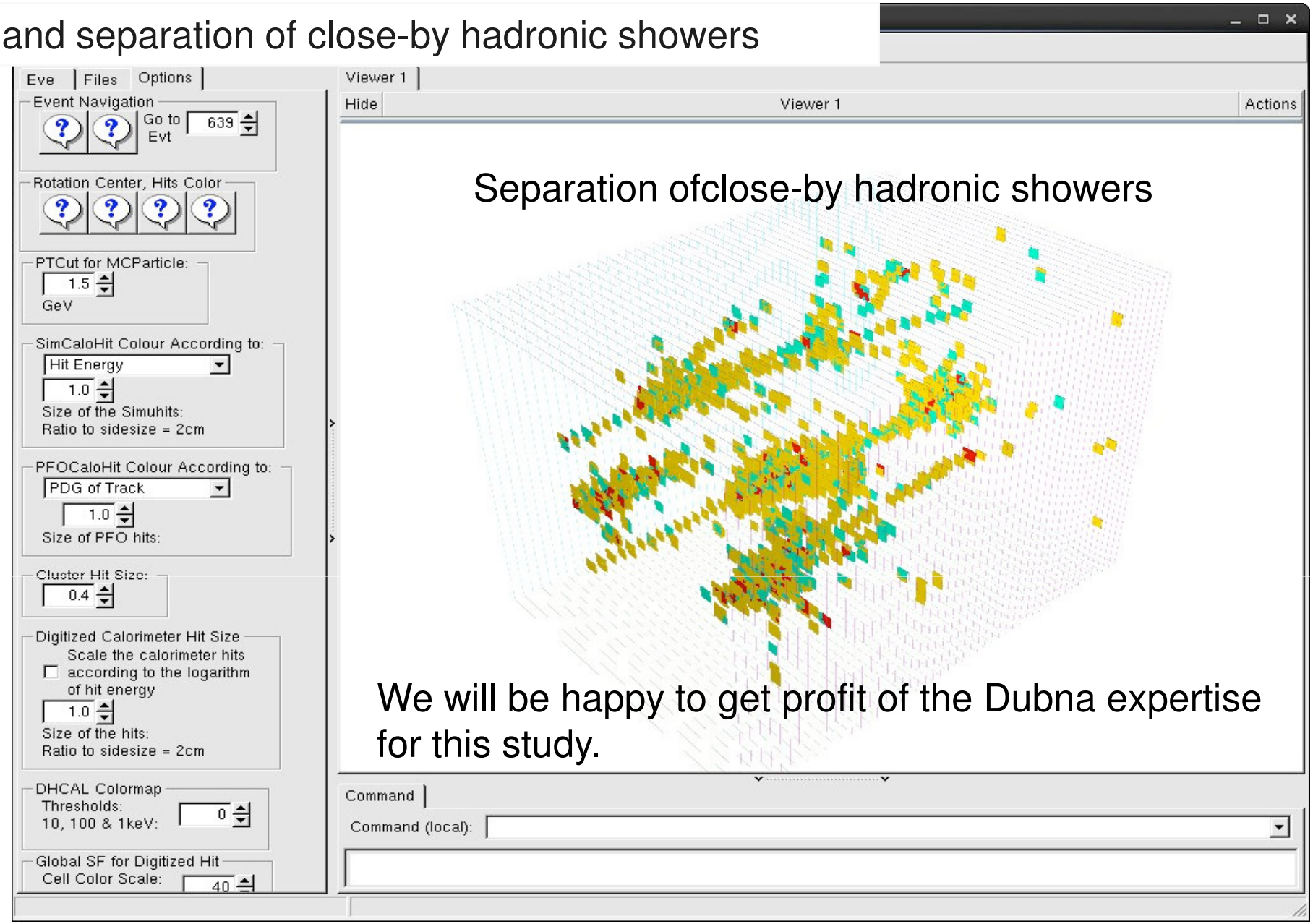


Longitudinal Cut distribution using N=14
electron – pion run of 80 GeV
The peak on the right corresponds to electrons



SDHCAL TestBeam

and separation of close-by hadronic showers



SDHCAL next steps beyond the DBD and towards ILD

Hardware development :
We intend to start building large GRPC (2-3 m^2) equipped with the third generation of HARDROC.

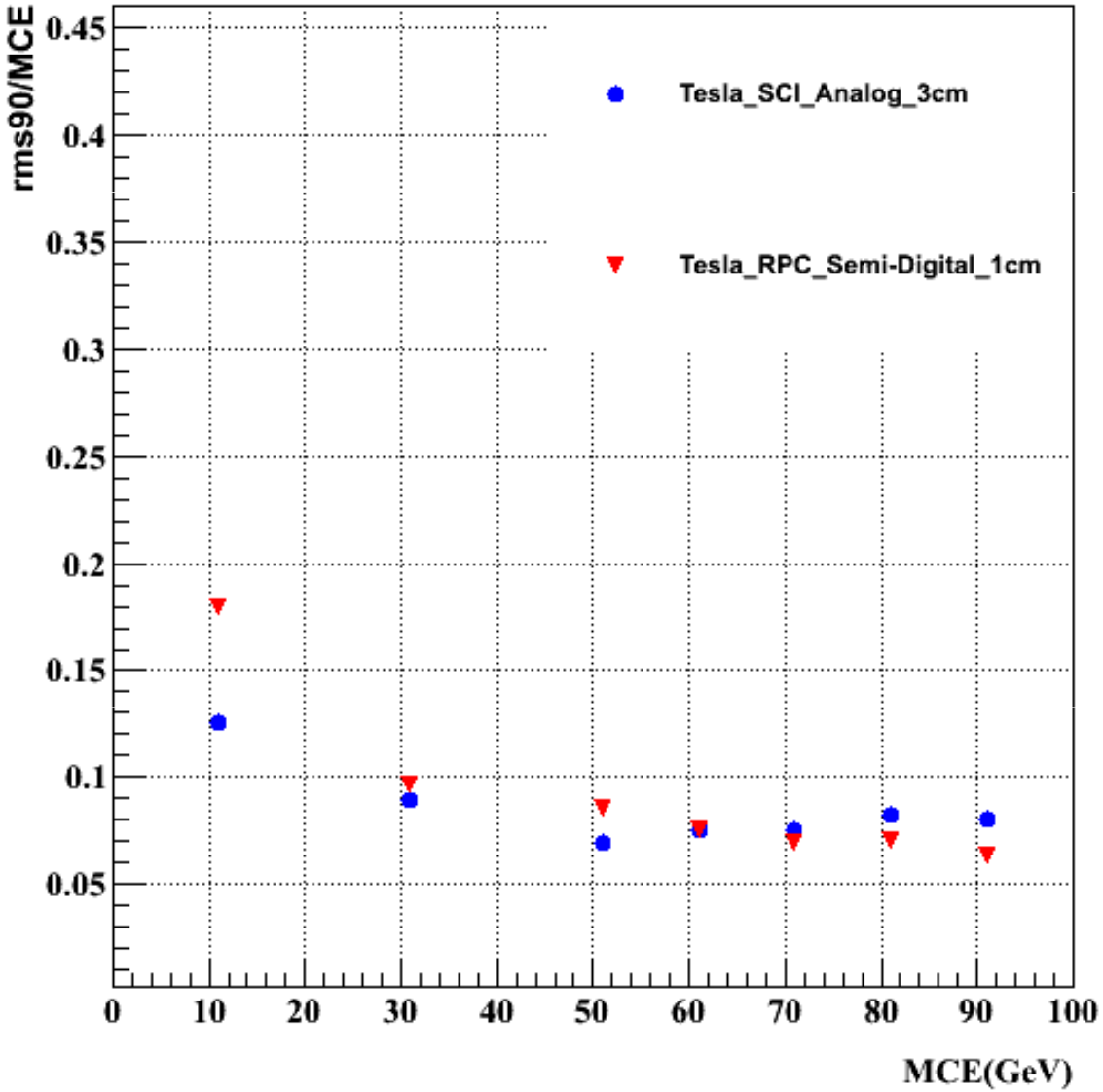
Appropriate PCB and compact DAQ acquisition boards will be developed to complete as a full demonstrator for ILD SDHCAL.

Software and analysis development :

We intend to complete the study on the digitization and provide the needed tools for physics analysis.

Different physics channels (like e e -> WW with jets in final states) will be studied using the SDHCAL.

Backup


rms90/MCE
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
10
20
30
40
50
60
70
80
90
100
MCE(GeV)
Tesla_SCI_Analog_3cm
Tesla_RPC_Semi-Digital_1cm