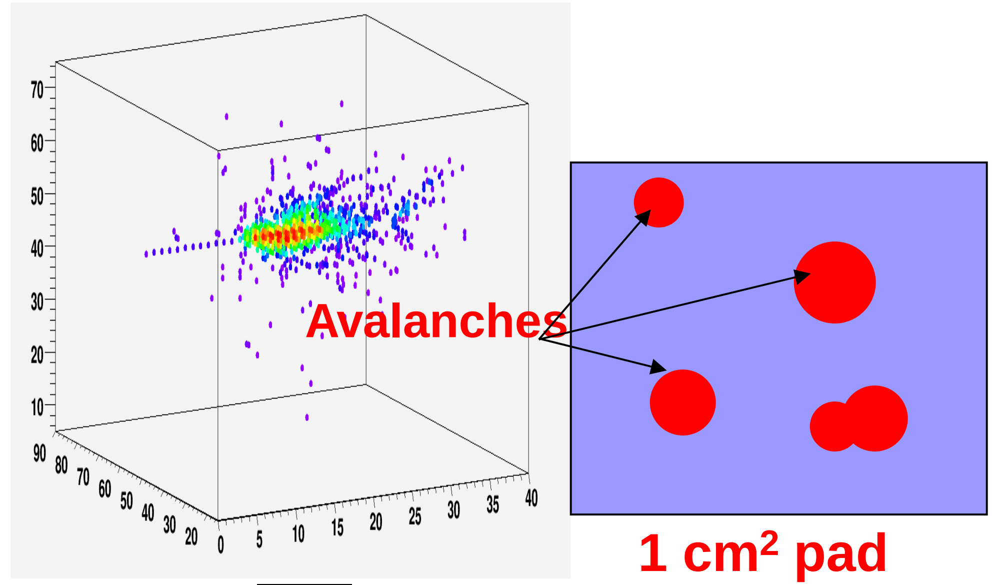
GRPC development in Lyon

Imad Laktineh

ILC

Semi-Digital HCAL Concept



1 cm^2 pad

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

How to obtain ultra-granularity?

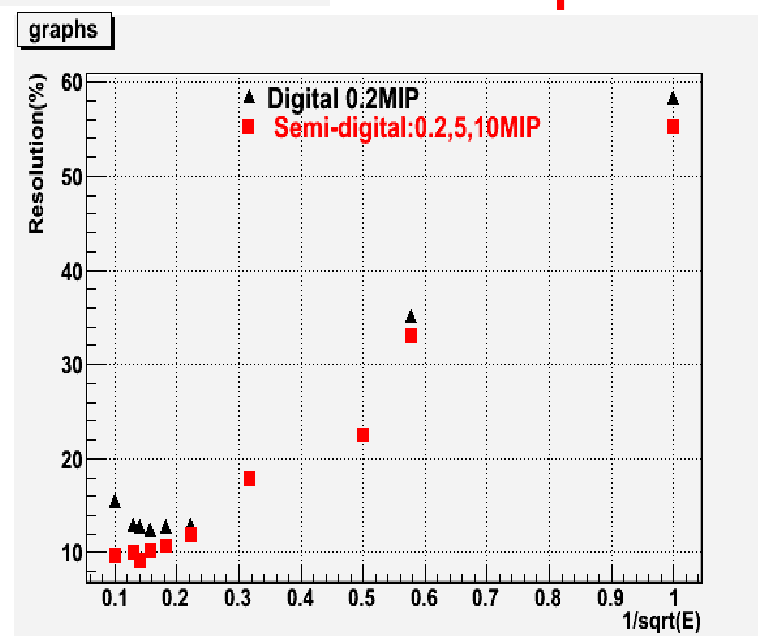
1- Gaseous Detector

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

2- Electronics Readout

A transverse granularity of (1cm2) with a binary readout leads to a very good energy resolution However, at high energy the shower core is very dense and the simple binary readout will Suffer saturation effect

Semi-digital readout (**2-bit**) should improve the energy resolution by better counting the particles of the shower



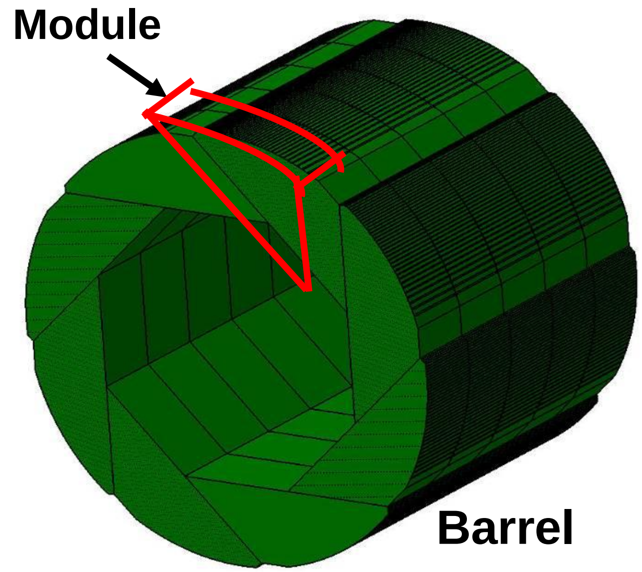
SDHCAL technological proto

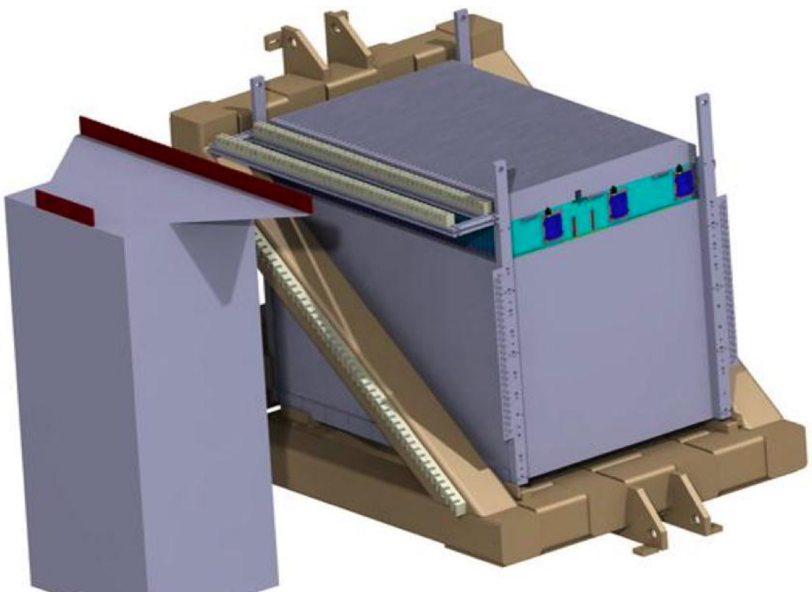
-For PFA, higher granularity is essential.
1cm2 lateral segmentation is a good compromise

GRPC was chosen as the baseline :
-Cost-effective
-High efficiency
-Adequate resolution

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

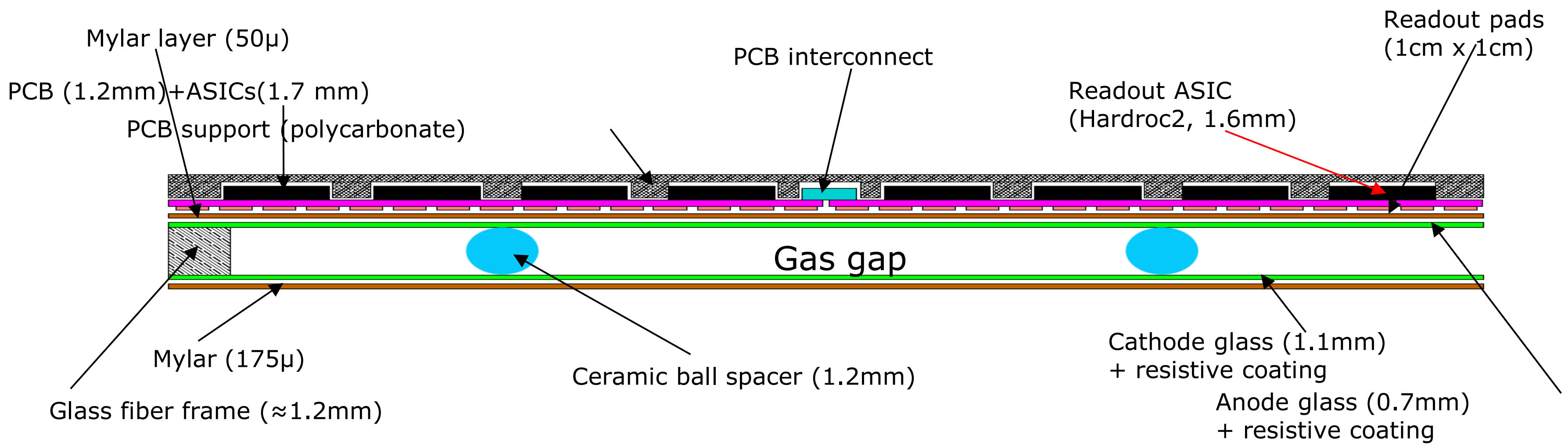
To succeed the technological SDHCAL prototype construction is an essential element to pretend to figure in the DBD





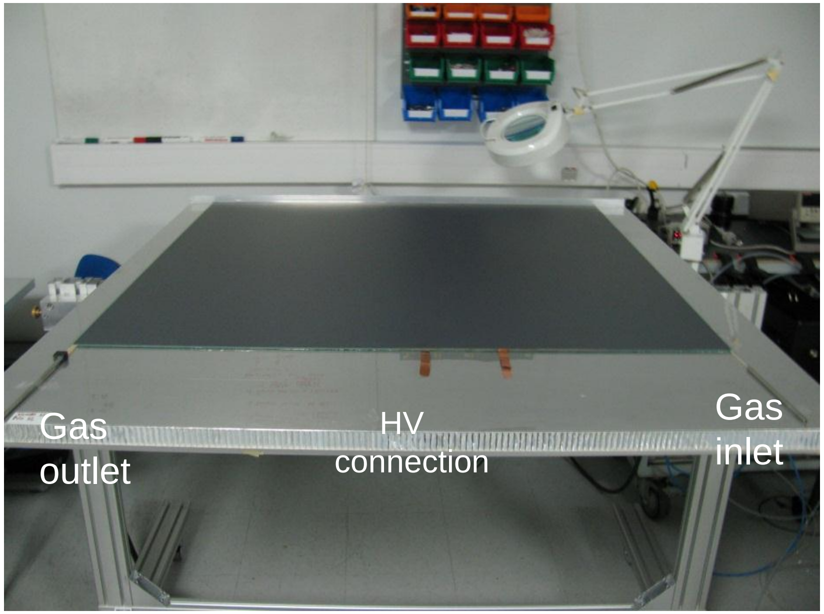
A prototype with 48 GRPC of 1 m2 is conceived as a demonstrator

Structure of an active layer of the SDHCAL



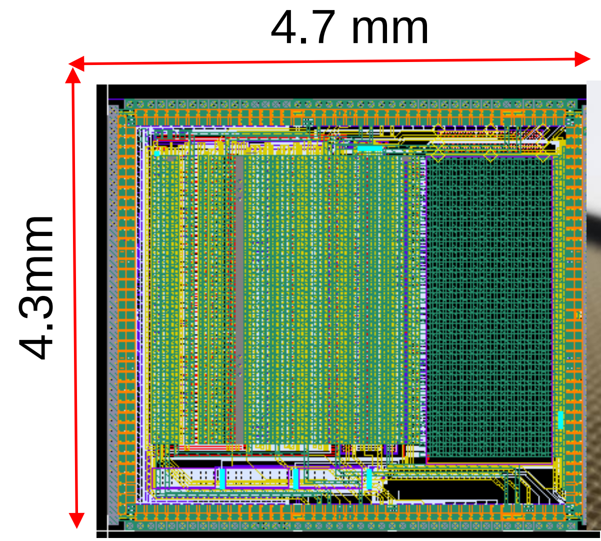
Large GRPC R&D

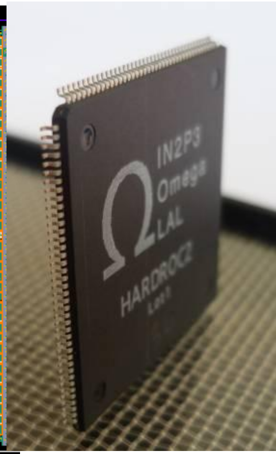
- ✓ Negligible dead zone (tiny ceramic spacers)
- ✓ Efficient gas distribution system (channeling gas inlet and outlet)
- ✓ Homogenous resistive coating (special paint mixture, silk screen print)



Electronics readout system R&D

ASICs : HARDROC2
64 channels
Trigger less mode
Memory depth : 127 events
3 thresholds
Range: 10 fC-15 pC
Gain correction → uniformity
Power-Pulsed (7.5 μW in case of ILC duty cycle)

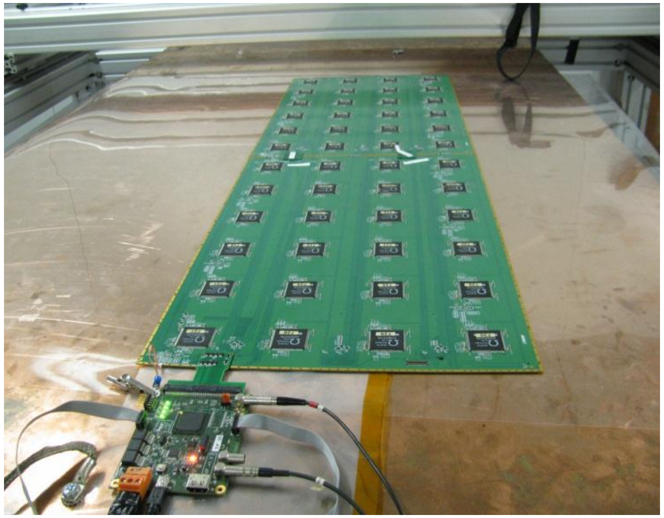




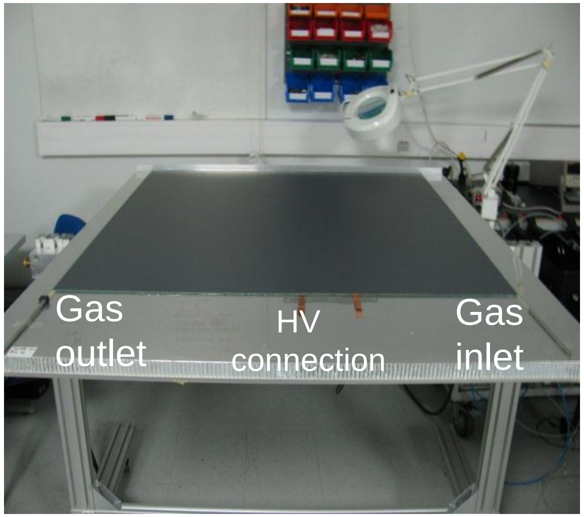
Printed Circuit Boards (PCB) were designed to reduce the x-talk with 8-layer structure and buried vias.

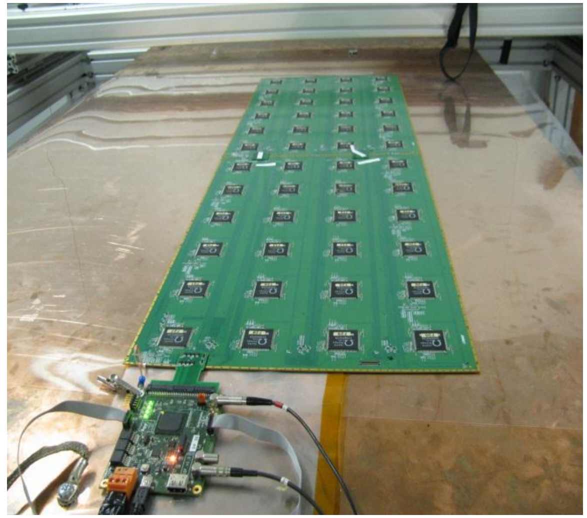
Tiny connectors were used to connect the PCB two by two so the 24X2 ASIC are daisy-chained.

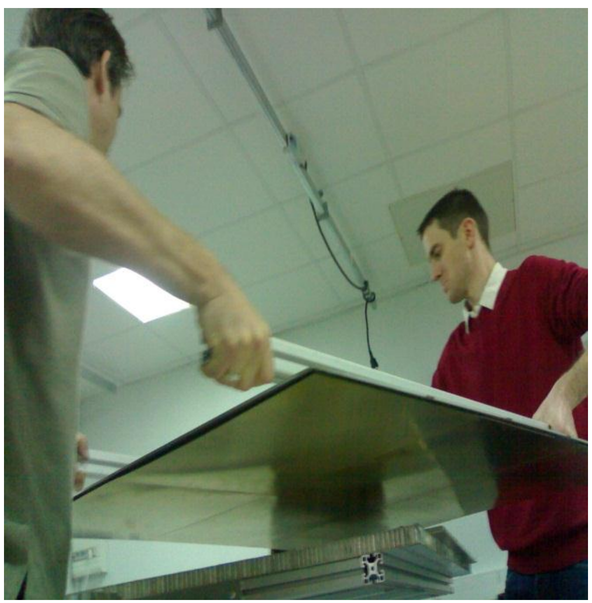
DAQ board (DIF) was developed to transmit fast commands and data to/from ASICs.

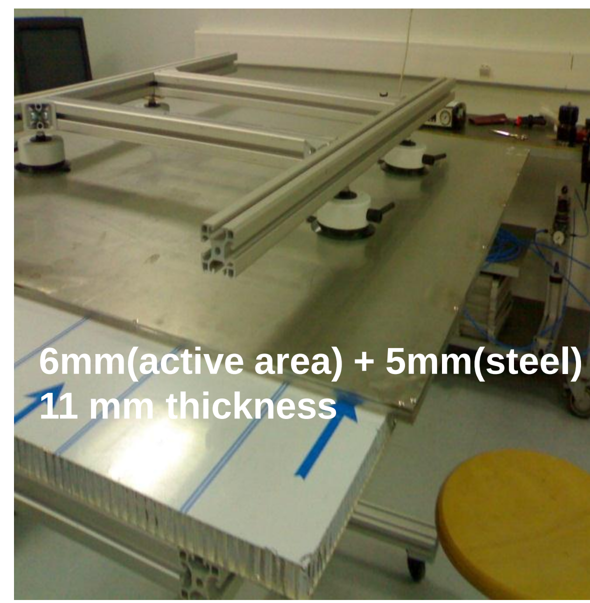


Construction of one unit of the SDHCAL prototype

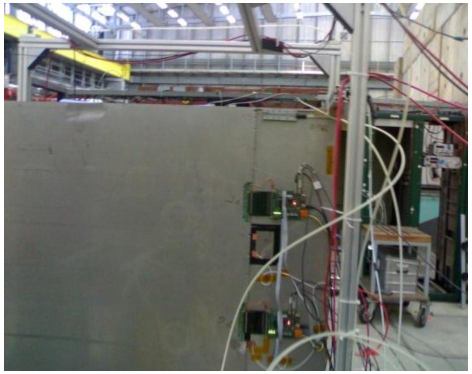


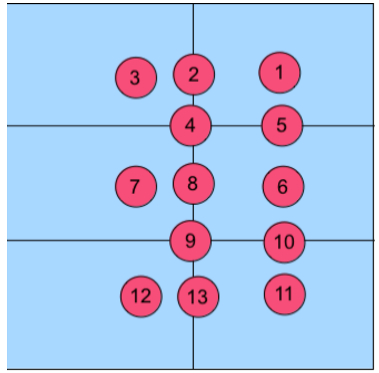




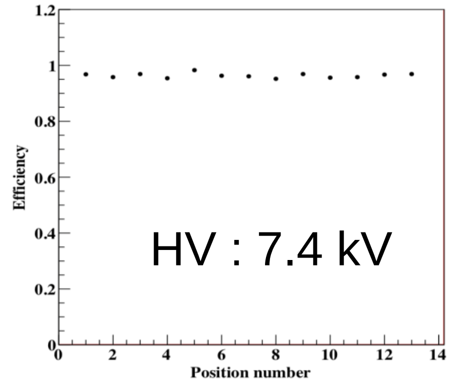


The homogeneity of the detector and its readout electronics were studied

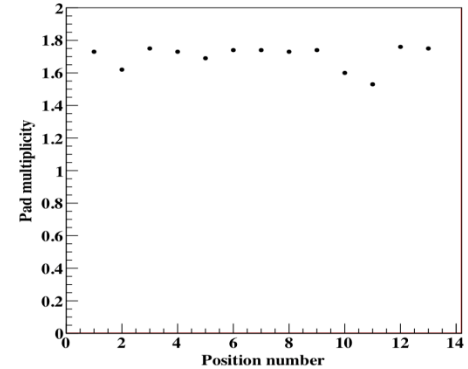




Beam spot position

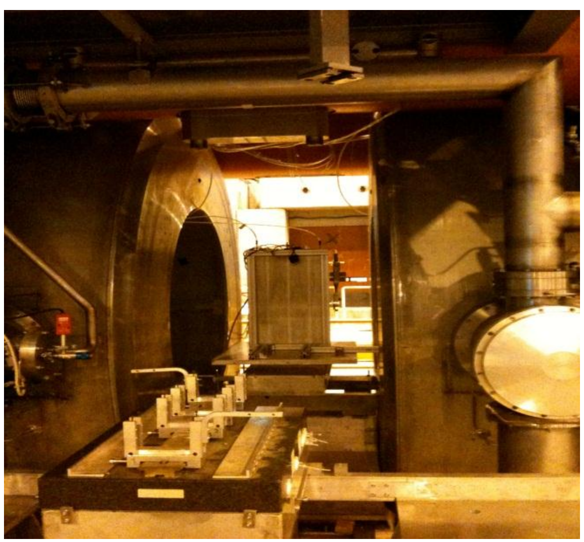


Efficiency

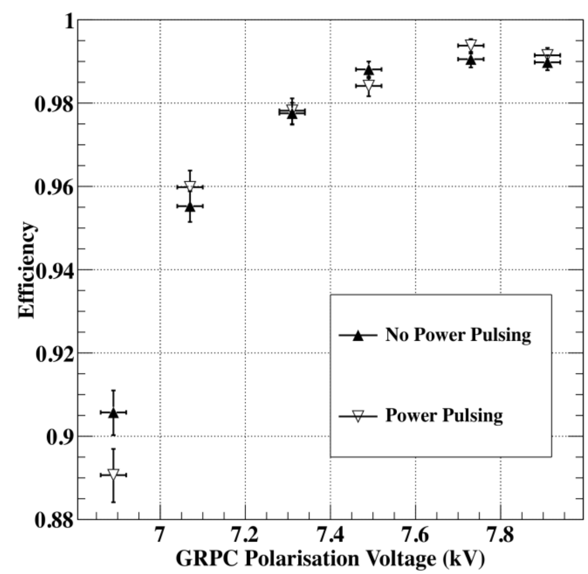


Multiplicity

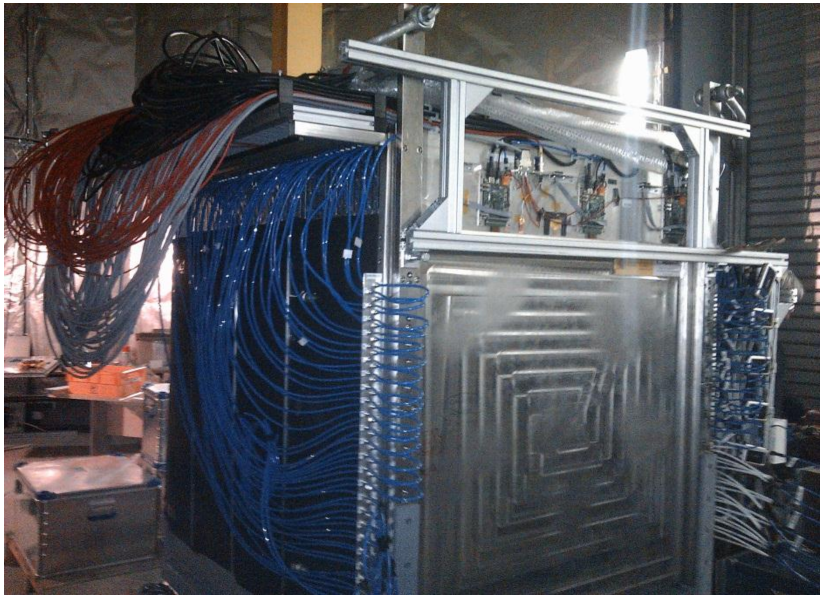
Power-Pulsing mode was tested in a magnetic field of 3 Tesla

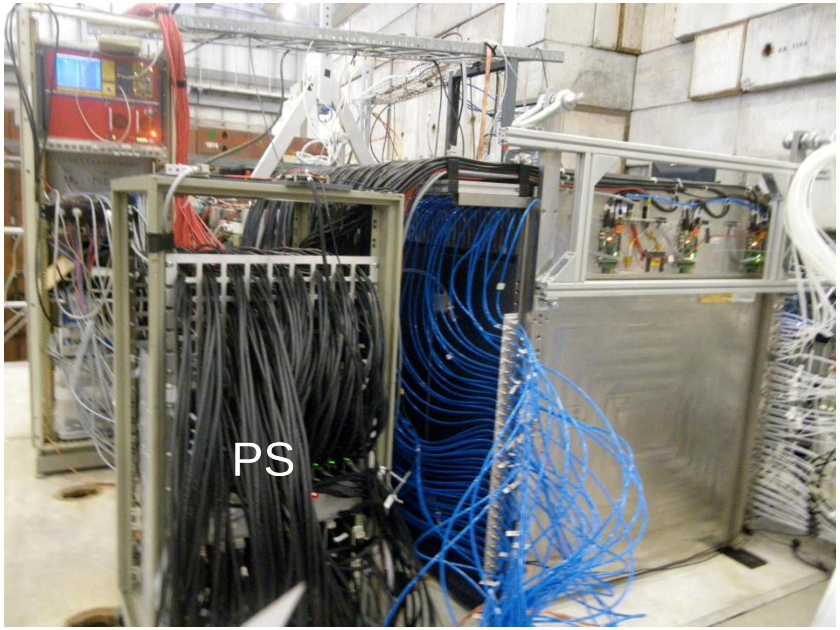


The Power-Pulsing mode was applied on a GRPC in a 3 Tesla field at H2-CERN
(2ms every 10ms)
No effect on the detector performance

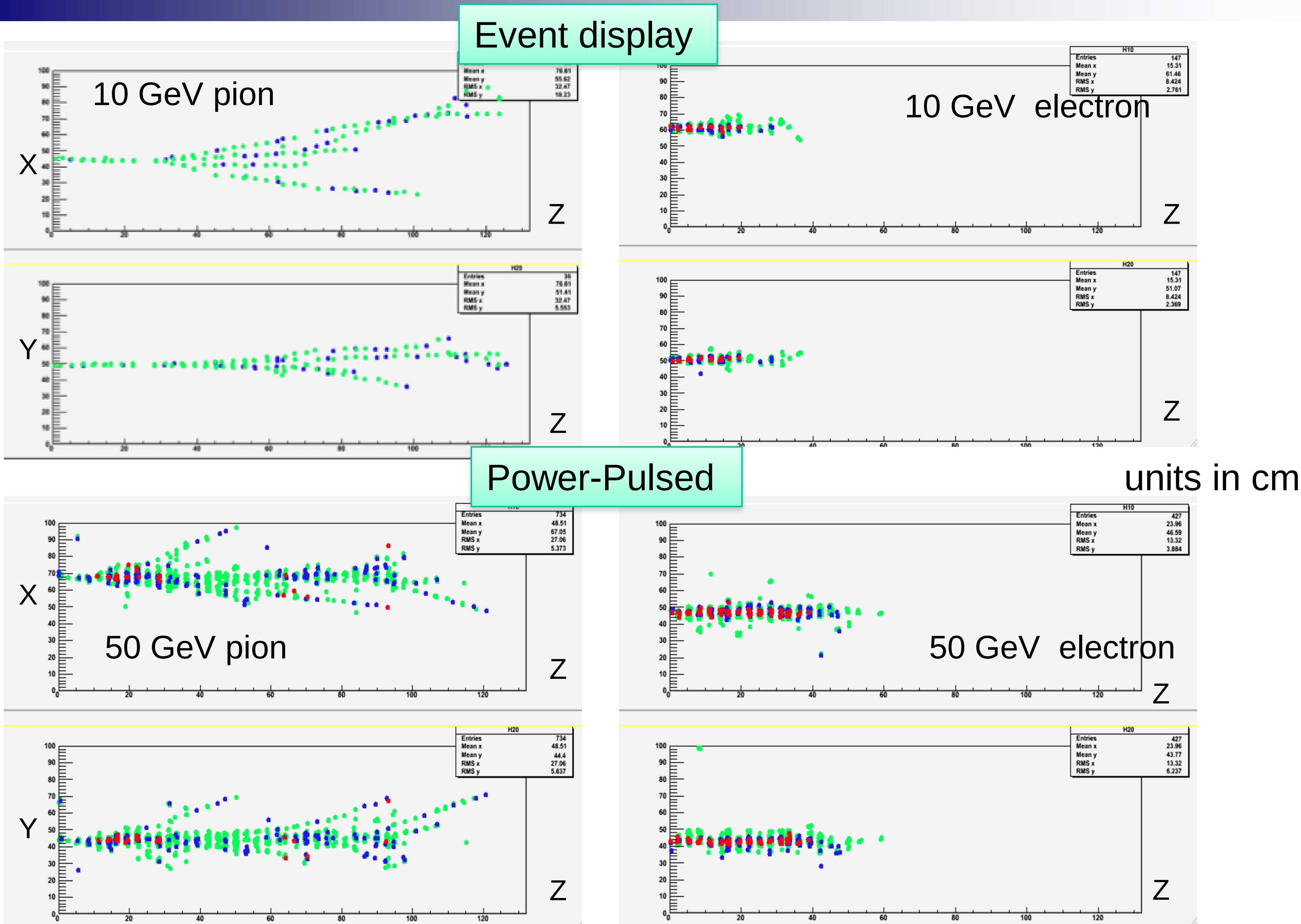


50 Chambers are built and will be used in the SDHCAL prototype in the coming days..



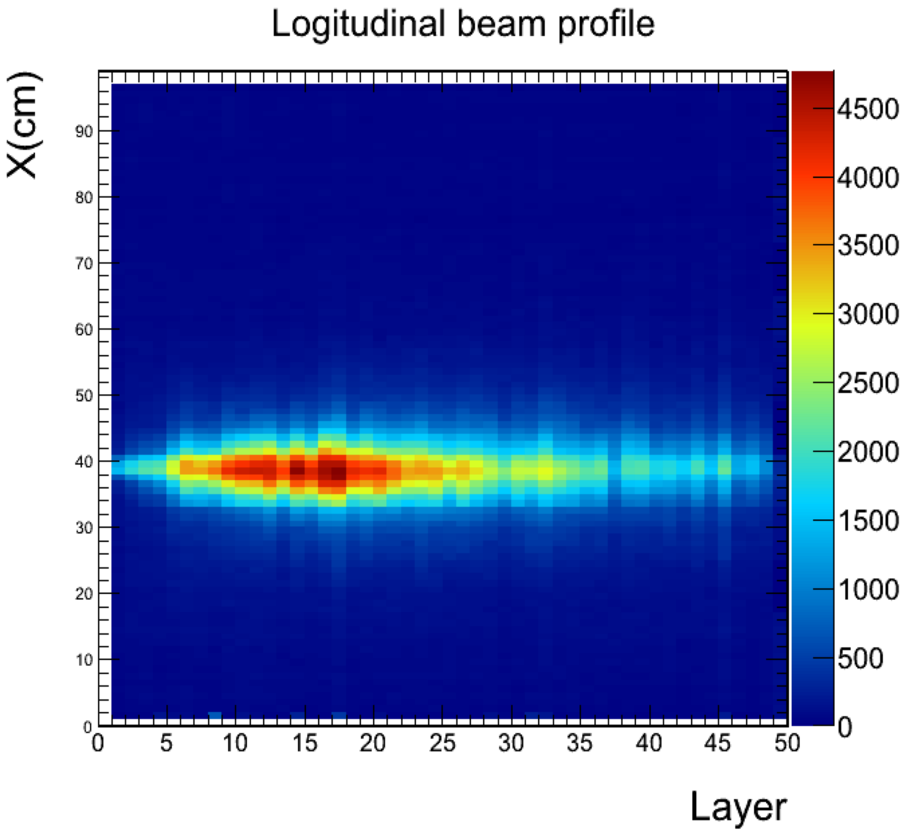

PS

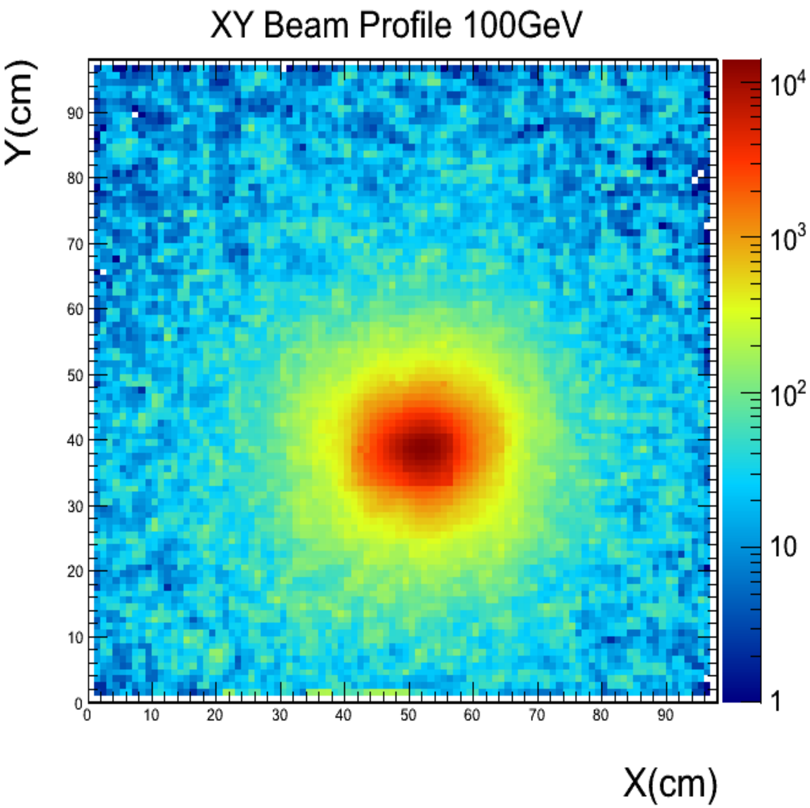

SPS



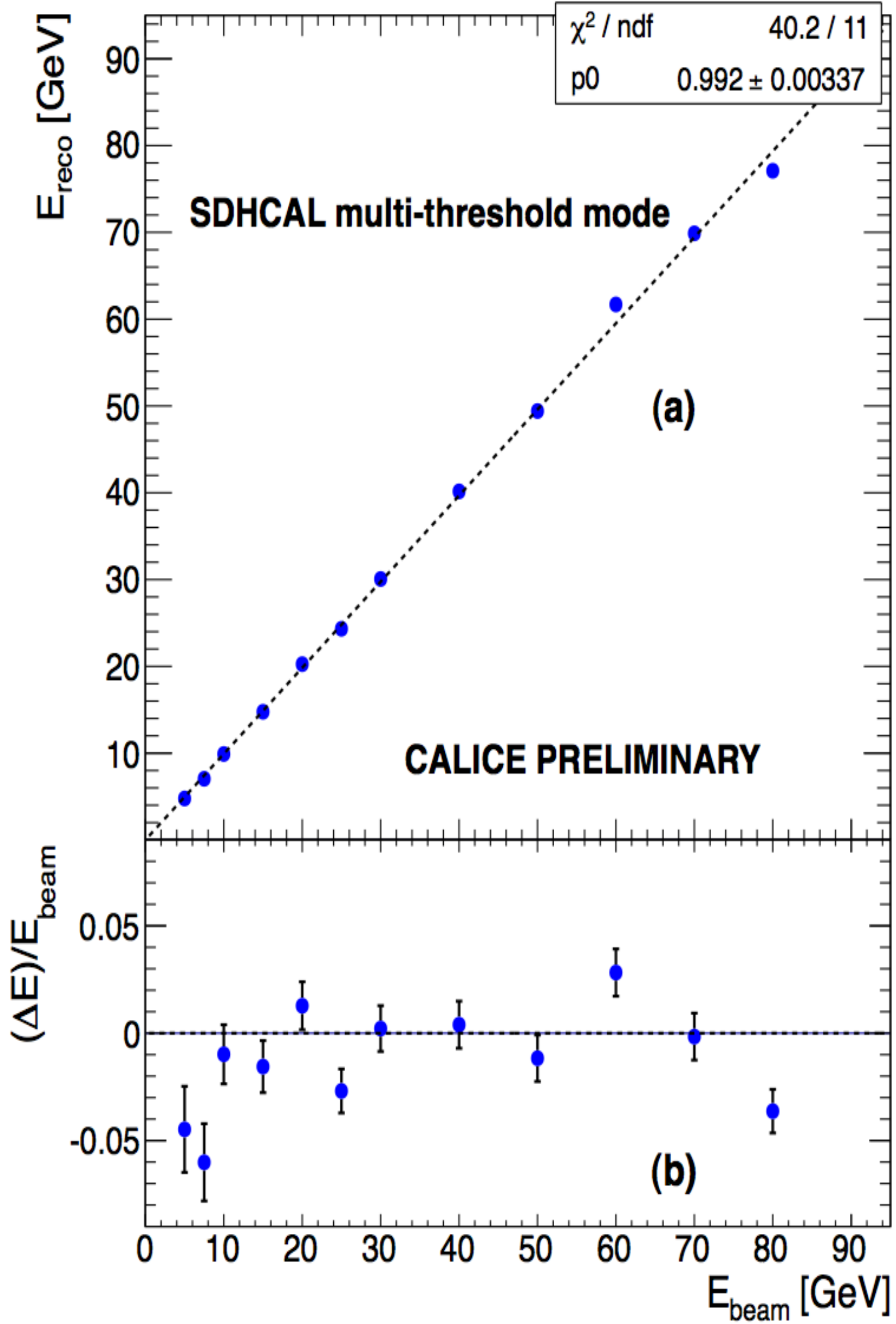
Colours correspond to the three thresholds: Green (100 fC), Blue (5 pC), Red (15 pC)

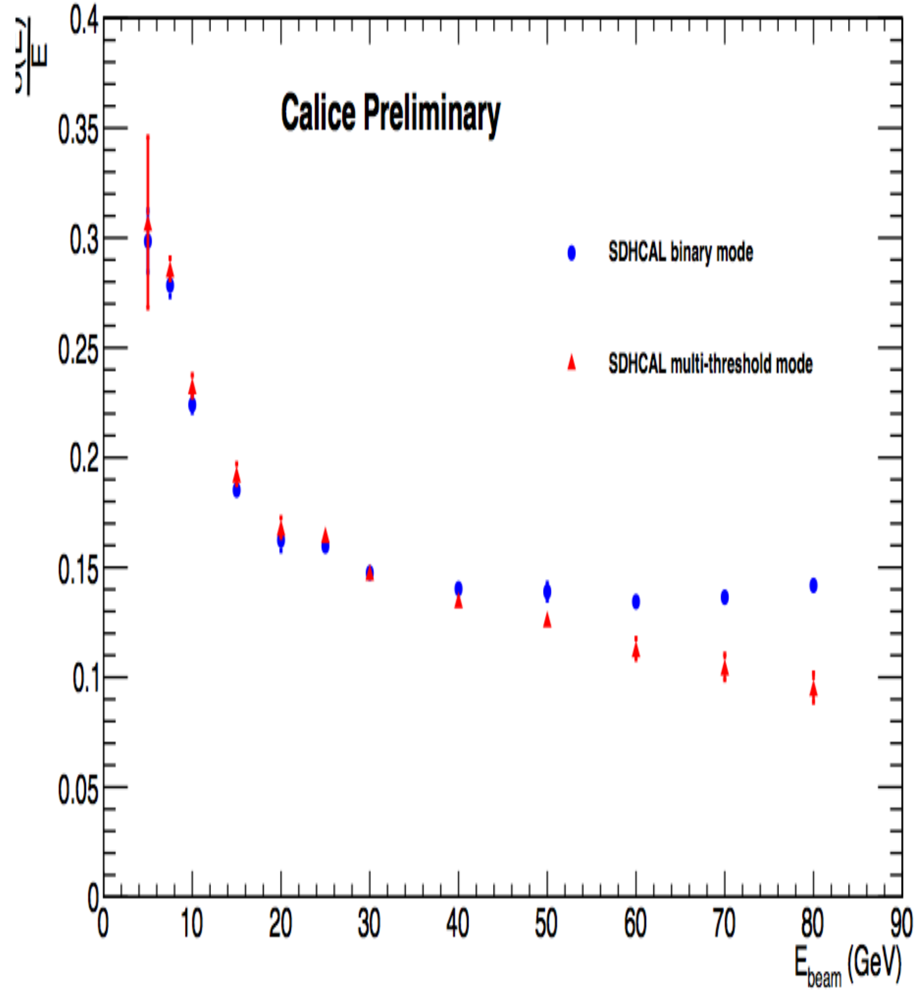
Raw data, no treatment except time hit clustering





100 GeV pions

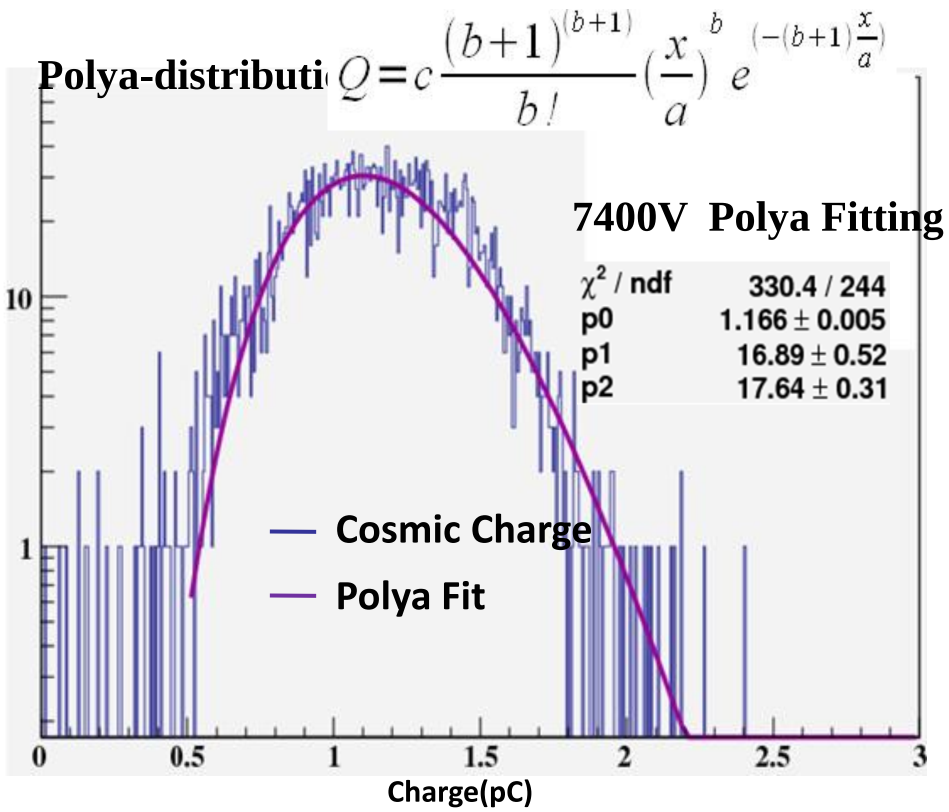

χ² / ndf 40.2 / 11
p0 0.992 ± 0.00337
SDHCAL multi-threshold mode
(a)
CALICE PRELIMINARY
E_reco [GeV]
(ΔE)/E_beam
(b)
E_beam [GeV]


Calice Preliminary
SDHCAL binary mode
SDHCAL multi-threshold mode
E_beam (GeV)

Digitisation

First step:

Measure GRPC analog signal with cosmic muon



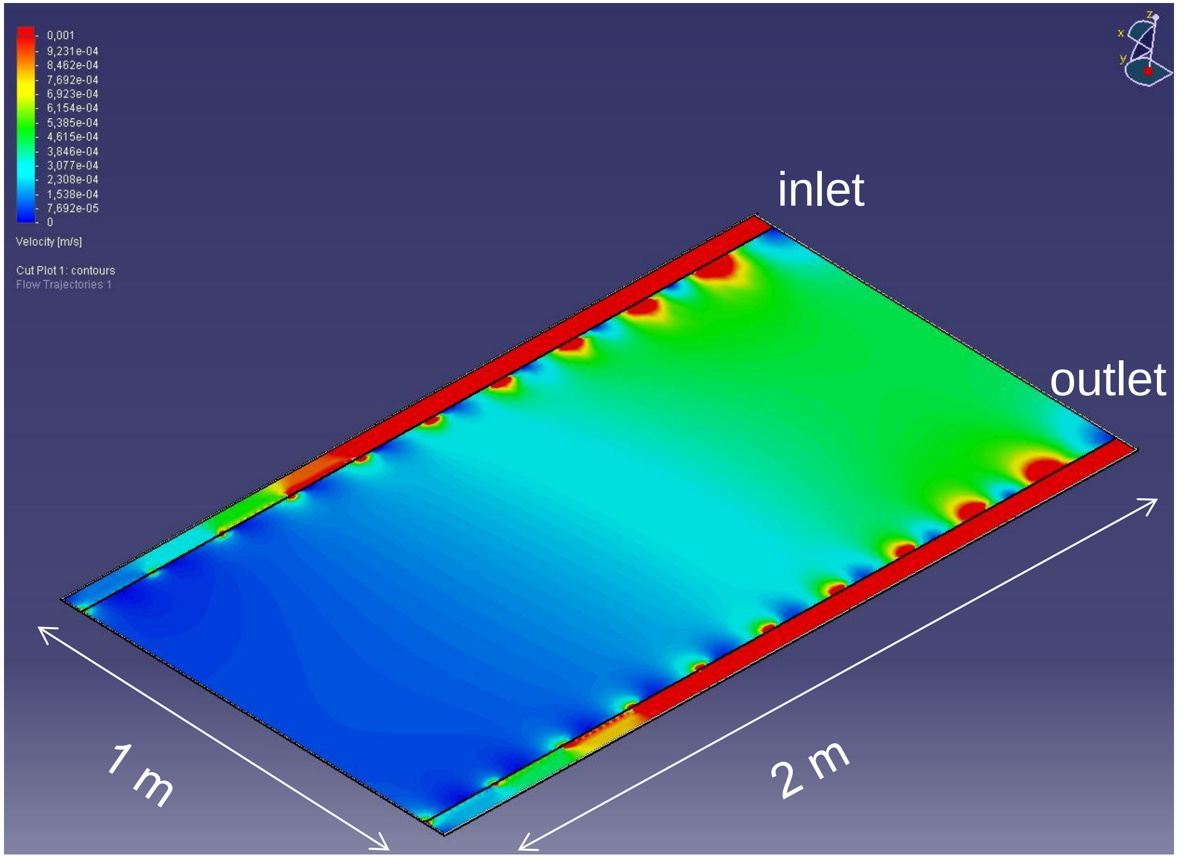
1- Build few very large GRPC detectors (2-3 m2) : Gas circulation system, thickness…
2- Improve on the readout electronics (I2C, roll mode..)
3- Design a new ASU capable to read the large GRPC (up to 3 m^2)
4- Develop a new DIF (low consumption, reduced size, new functionalities)
5- Build a small mechanical prototype to host the few large chambers

Large GRPC for ILD:

GRPC with a surface
≤ 3 m^2 are needed.

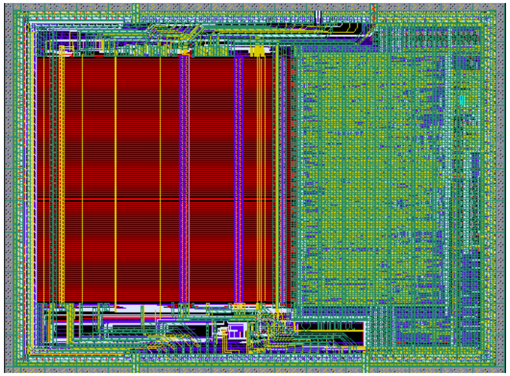
We intend to build
a $2m^2$ GRPC.

We are currently studying
the gas distribution system
to ensure a good gas
renewal.



HARDROC3

- **64 independent channels**
- **I2C link (@IPNL)**
- PLL: integrated before in a builiding block, first measurements are very good
    - Input frequency 2.5 MHz =>output frequency: 10, 20, 40, and 80 MHz available
- Bandgap: new one with a better temperature sensitivity, tested in a building block
- Temperature sensor: tested in a building block, slope – 6mV/°C
- Die size ~30 mm2 (6.3 x 4.7 mm2)
- To be packaged in a TQFP208
- Test board to be designed
- submitted at the end of Feb 2013 (SiGe 0.35µm), expected in June 2013

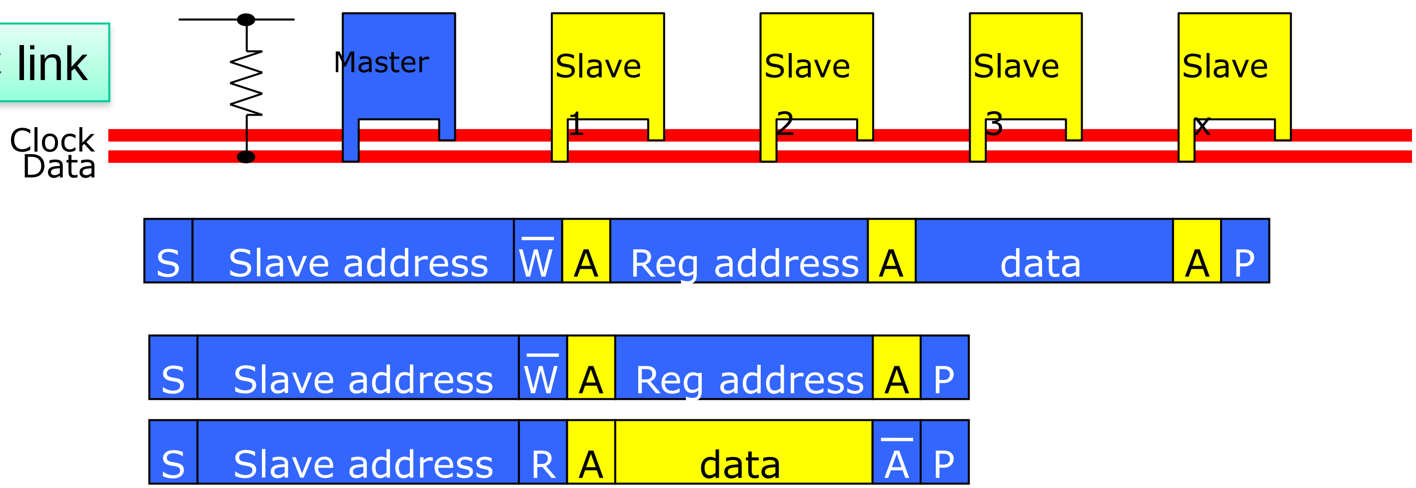


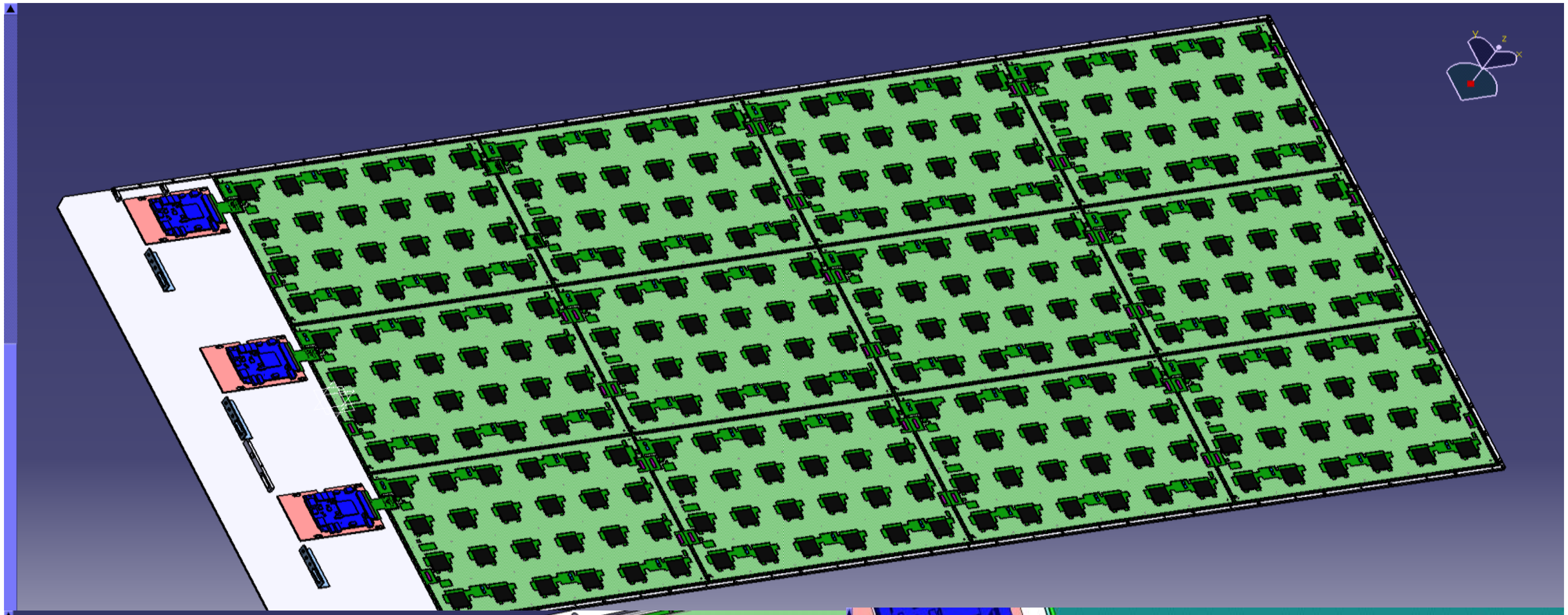
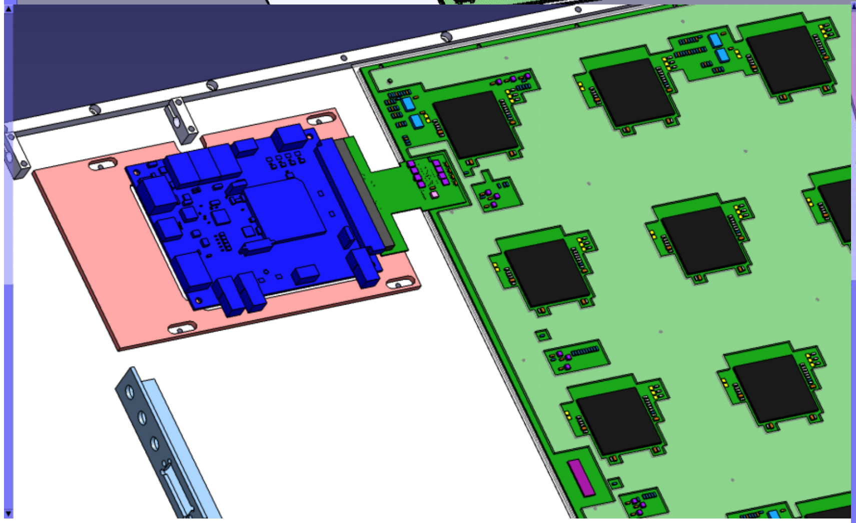
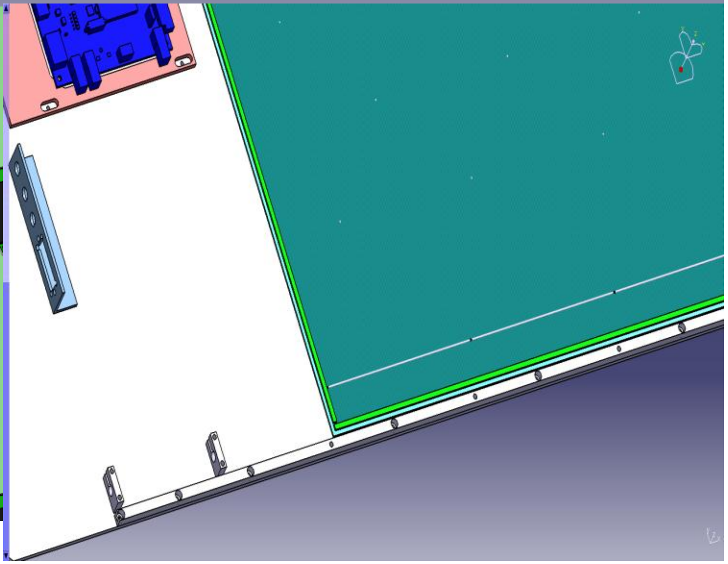
- 3rd generation ROC chip
  - **Independent channels (= Zero suppress)**
    - 64/36 address pointers
    - ReadOut, BCID

    ⇒ **Digital part much more complicated**

    ⇒ Possibility to use "Roll mode" by Slow Control: circular memory very useful for Testbeam
    - New TDC with no dead time
    - **New Slow Control** (Triple voting) using **I2C link** (while keeping the « old SC » system)

I2C link



CMS

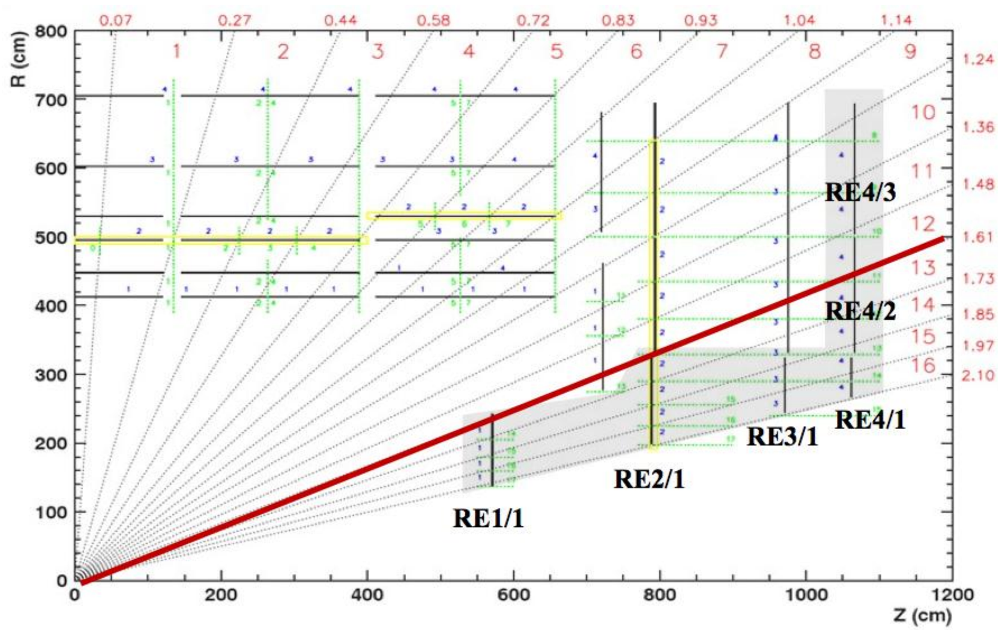
CMS

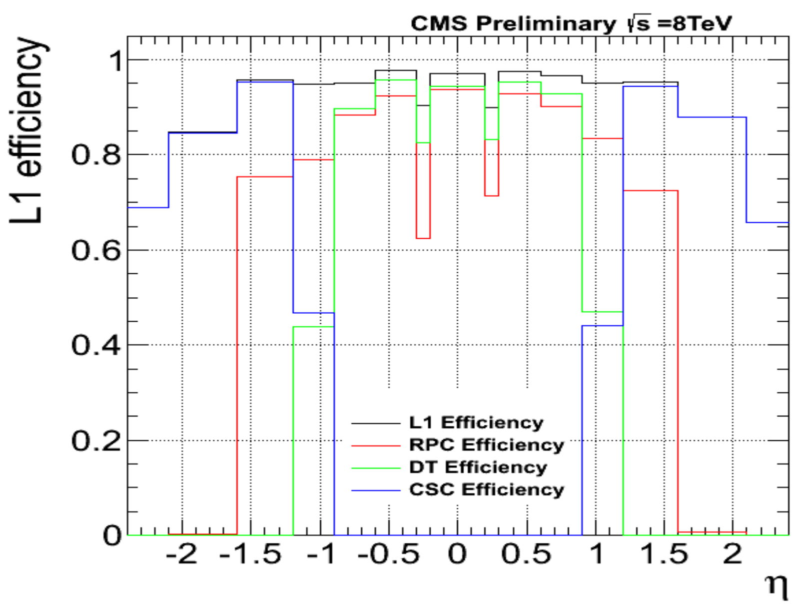
-Absence of RPC in the
 high η region because of
 high rate (> 1000 Hz/cm2)

This leads to a low trigger efficiency.

Solution :

Equip with GEM or
New GRPC detector using
low-resistivity glass

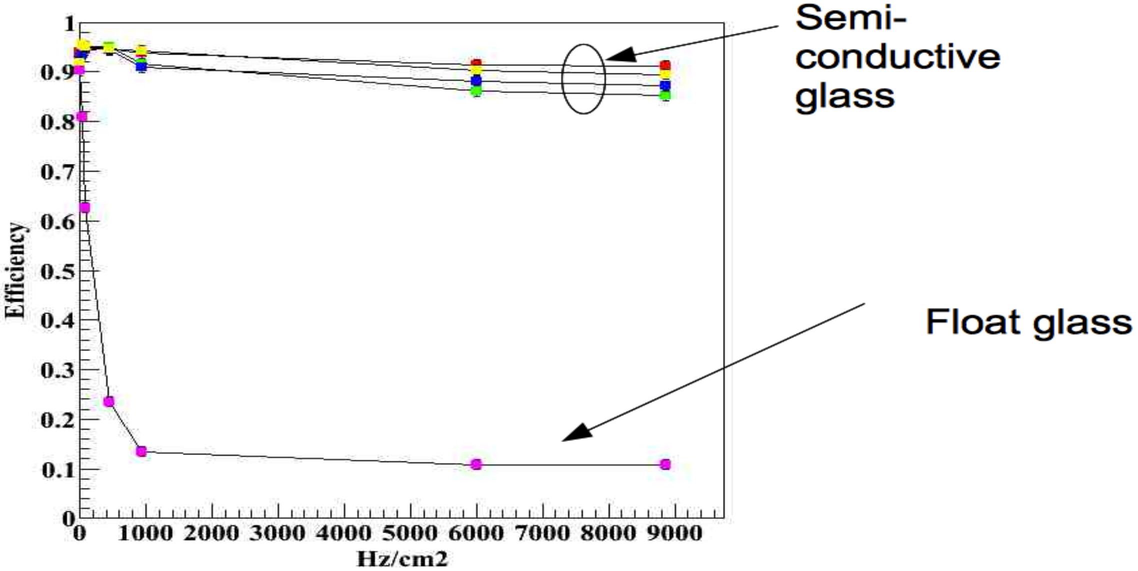




High-Rate GRPC

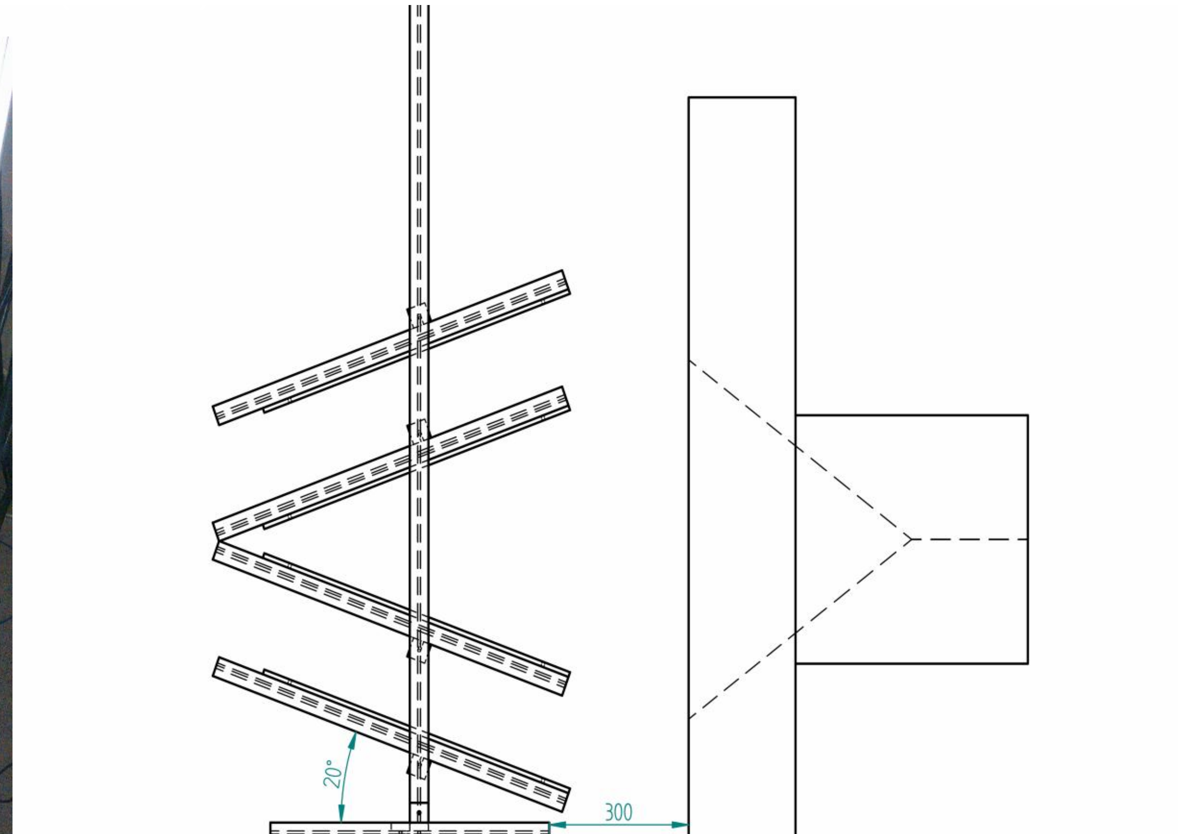
Semi-conductive glass (10^{10} Ω.cm) produced by our collaborators from Tsinghua University was used to build few chambers. They were tested at DESY

Performance is found to be excellent at high rate so no problem with GRPC in the very forward region



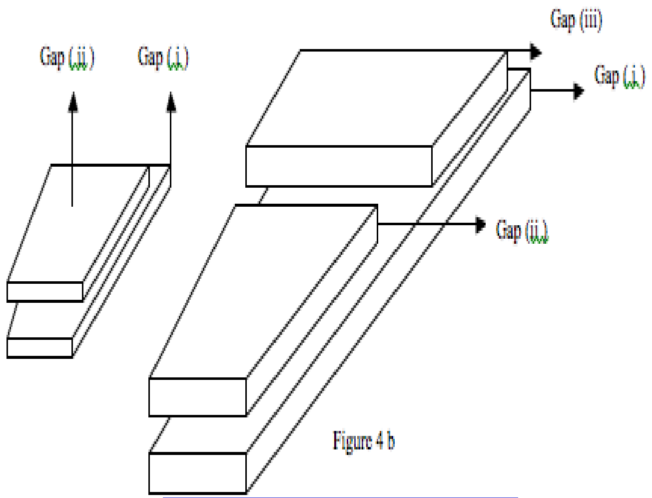
Irradiation and aging tests + efficiency monitoring

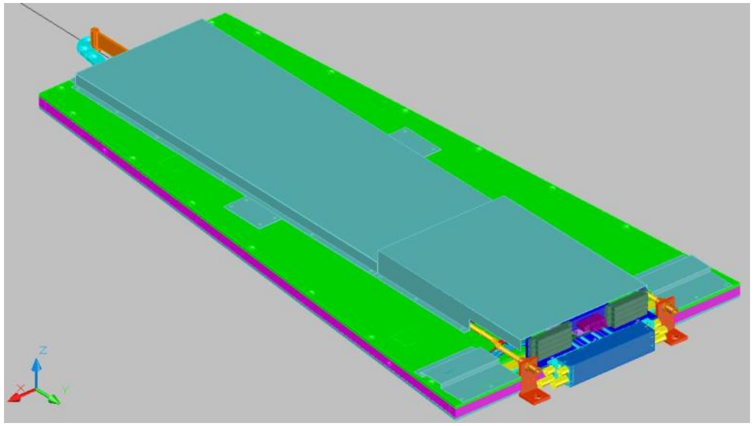
A set-up to host 4 small (30x30 cm^2) high rate GRPC was built.
This will allow to expose the chambers to the GIF source at small distance and check the efficiency using the GRPC tracks.

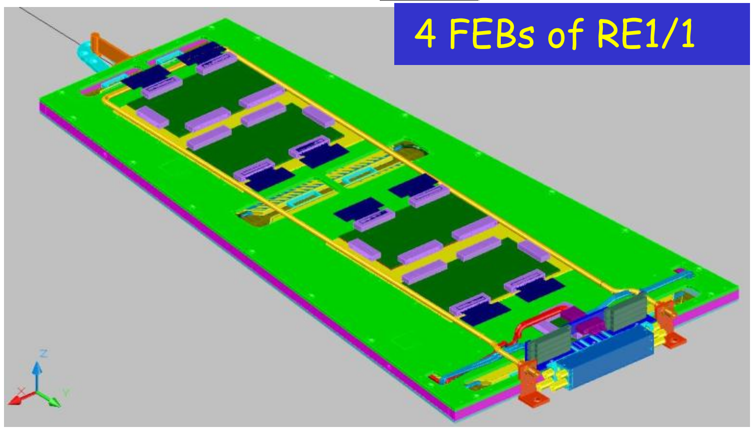


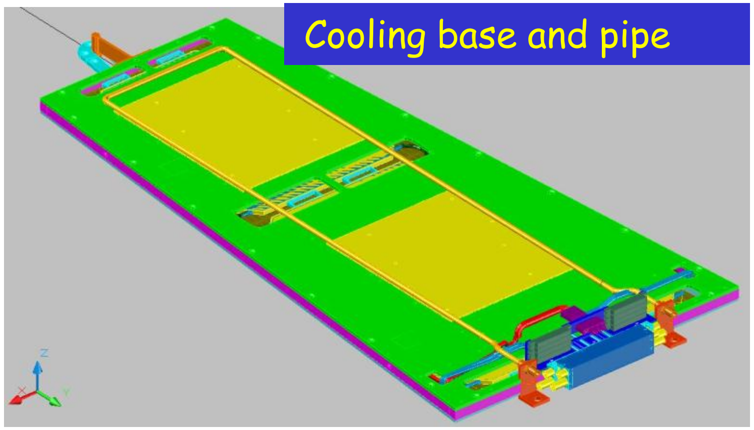
Construction of RE X/1 GRPC

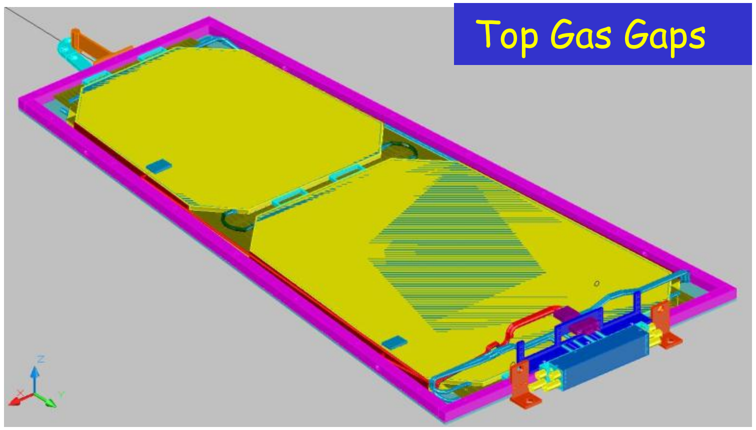
RPC in the stations RE X/1 were foreseen in the CMS TDR.
The cassettes were designed.
Few HPL units were built by SKODEL.



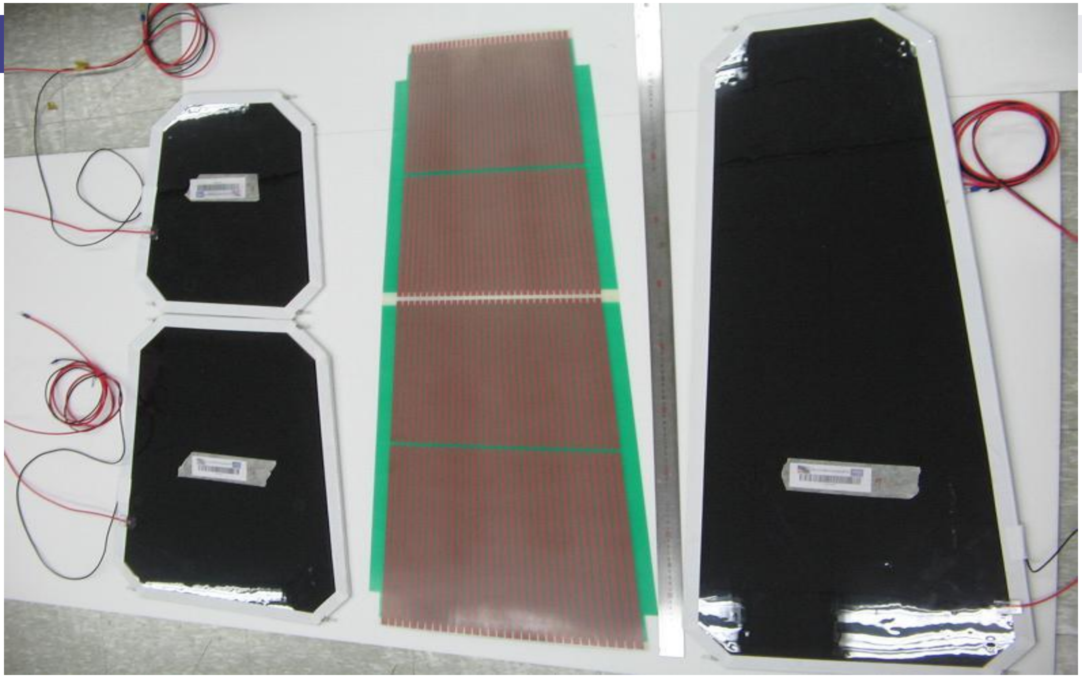




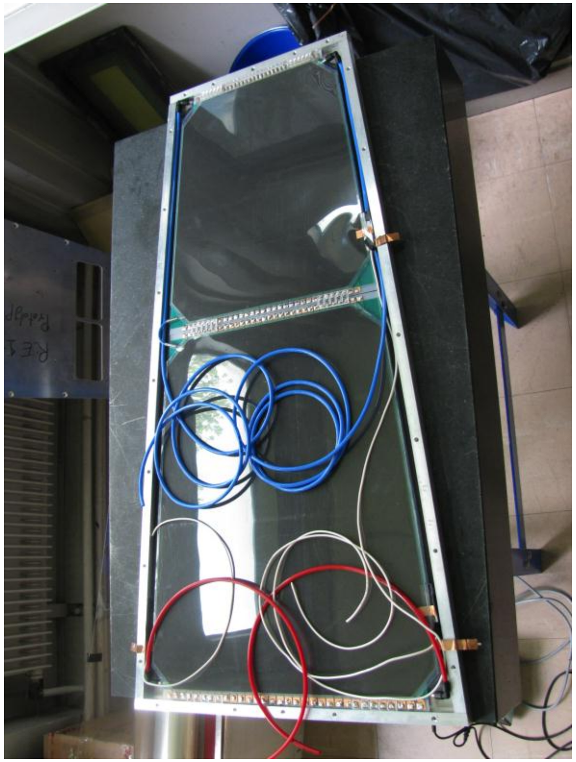




HPL



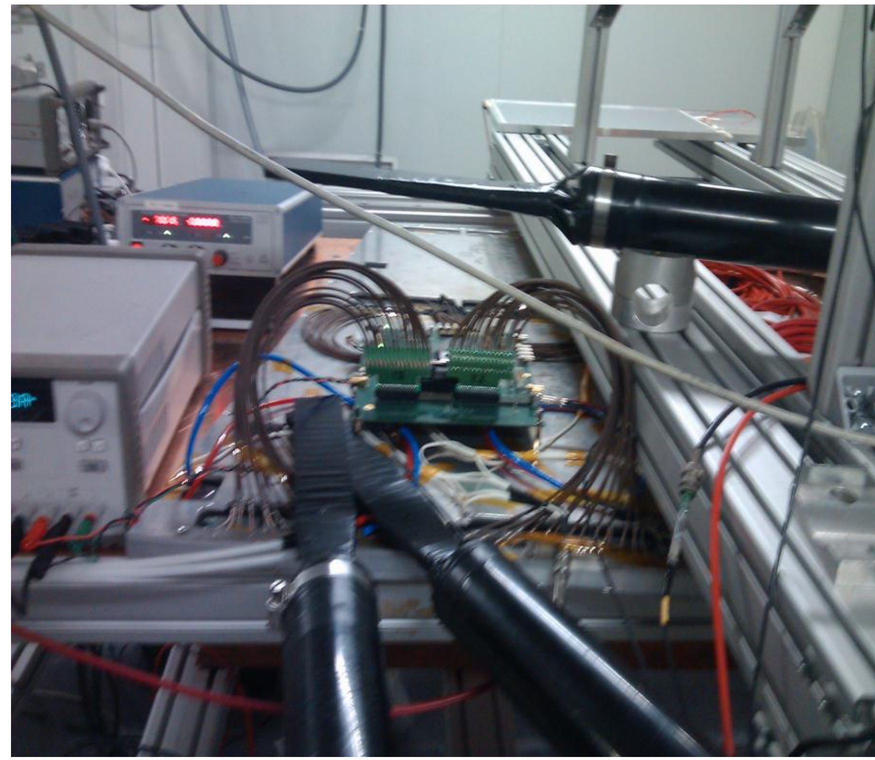
GRPC

→RE1/1 GRPC chamber construction using Float Glass is completed

→ Semi-conductive glass to build high rate RE1/1 GRPC chamber is being produced.

To test the new chamber without conceiving new electronics, a HARDROC test board was used. 63 strips of the RE1/1 chamber could be read. One channel is used to record the Scint-PM signal



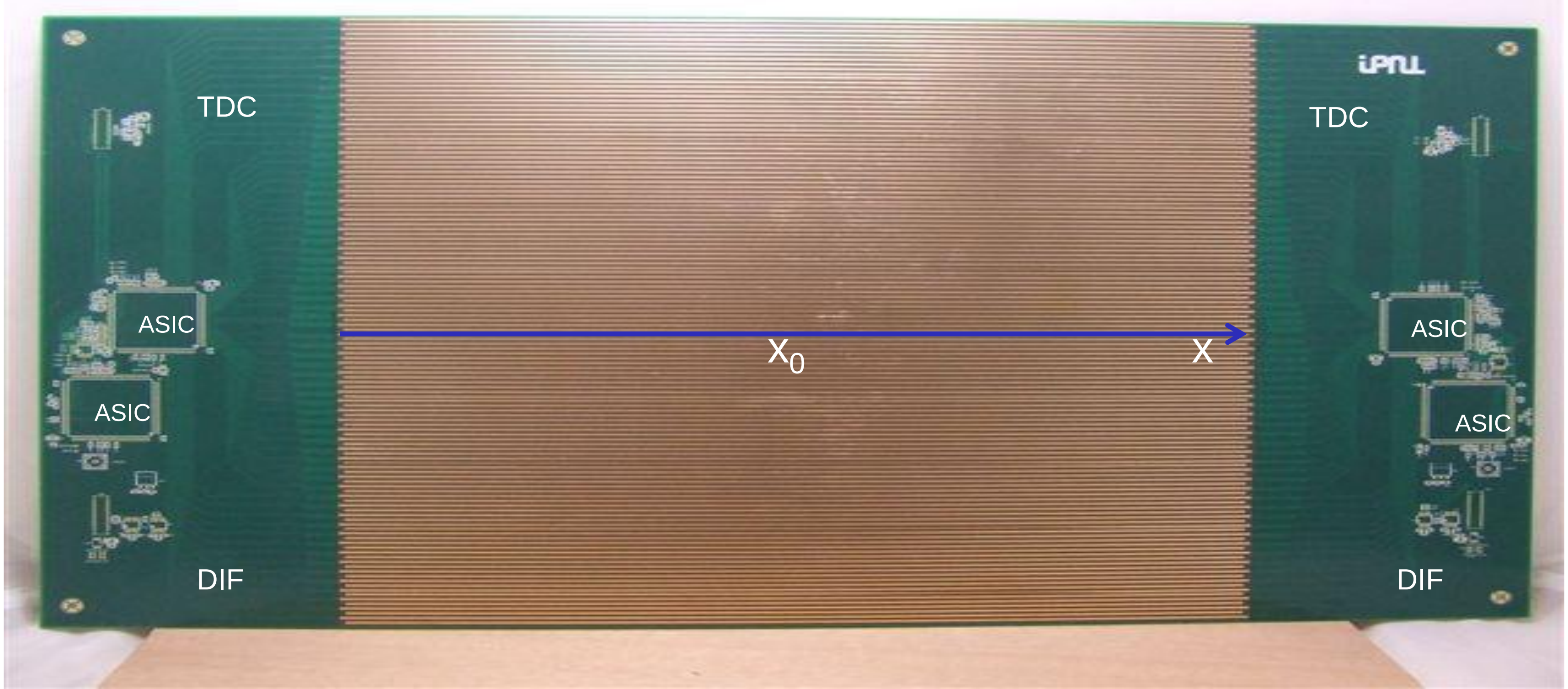
The GRPC is being studied (efficiency vs HV…)

R&D for single gap and < 1 ns time resolution

The readout electronics used to study the single gap GRPC was updated by adding a **TDC** to measure the time resolution and a new PCB with strips was designed and produced.

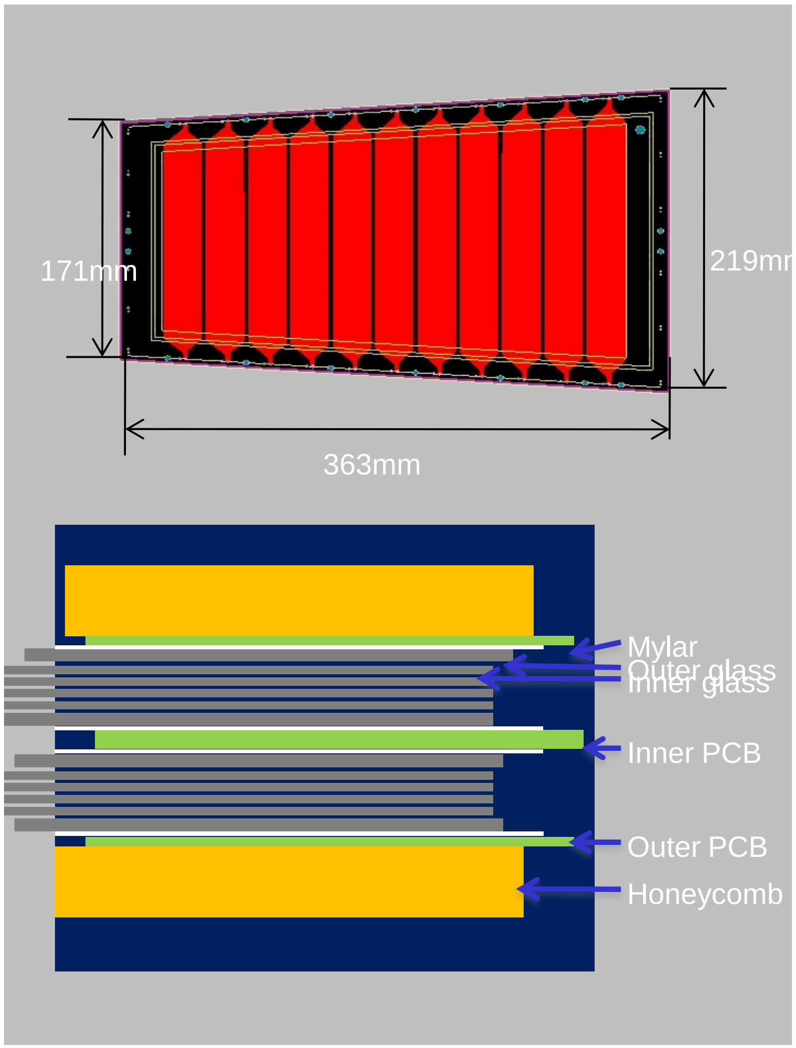
The strips are **2mm** wide and they cover the two PCB faces with **2.5 mm pitch**. A relative shift of 0.5 mm between the strips of the two faces
This will allow to study the spatial resolution one can attain.

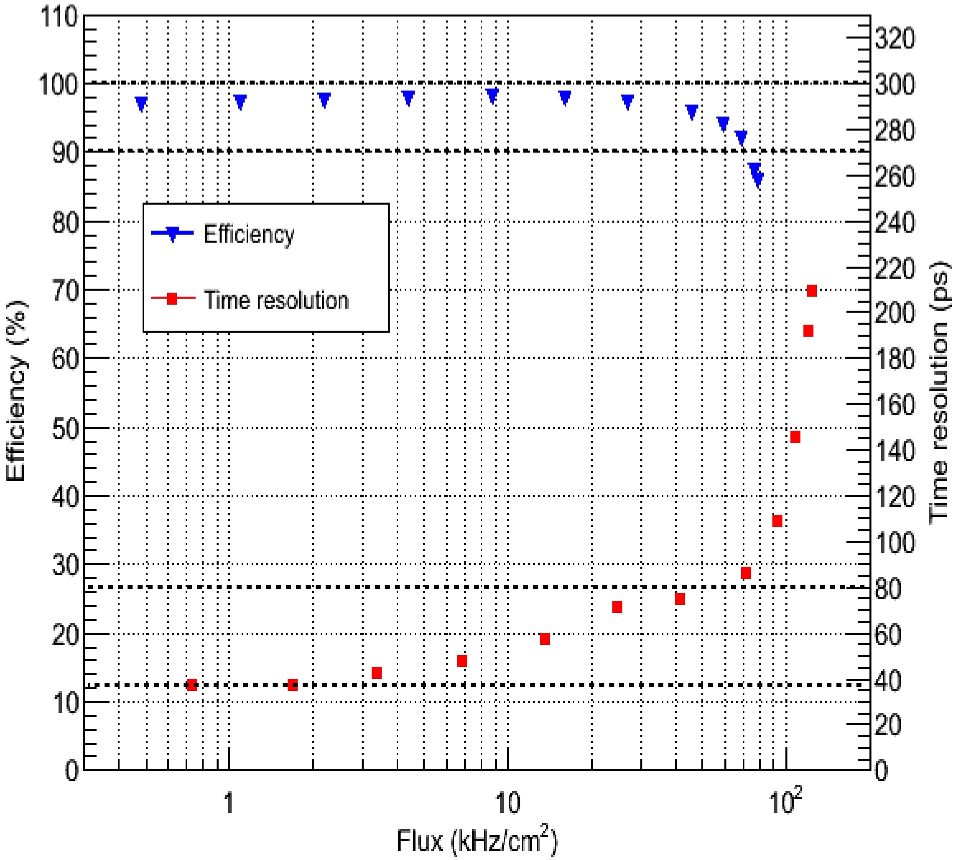
The strips are read out from one side but two neighbor strips are read from two opposite sides. This will provide time and x position information :
$\mathbf{x\text{-}x_{mid}= (t_2\text{-}t_1)/2v}$. Time resolution can be measured : $\mathbf{(t_1+t_2)\text{-}\ L/v}$



However one can obtain a wonderful time precision when multi-gap is used

Beam Test@HZDR June, 2012

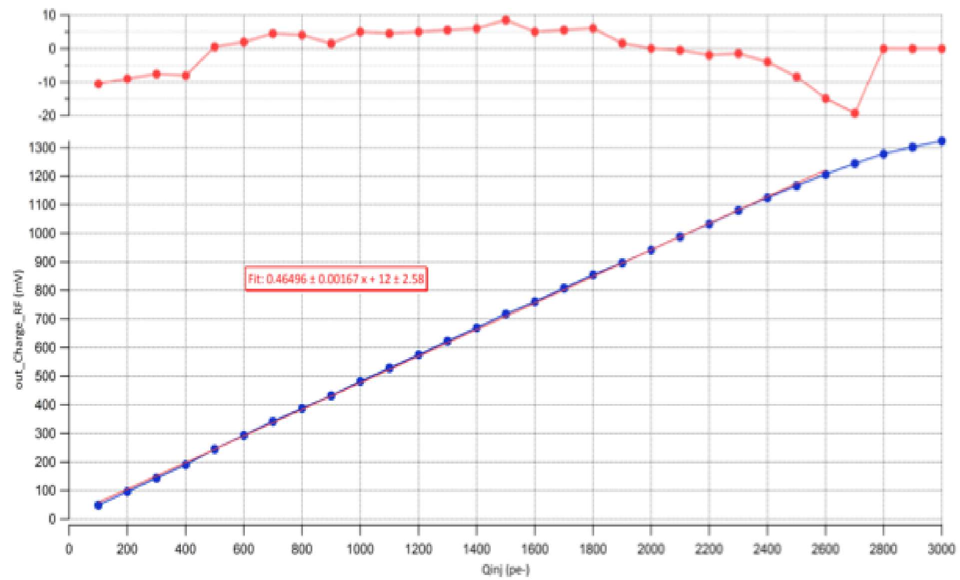




-Use the **16**-channel **PETIROC** ASICs developed by OMEGA :
High bandwidth preamp (GBWP> 10 GHz), <3 mW/ch, **dual time and charge** measurement up to 2500 pe, **jitter < 10 ps rms**

- Use a **TDC with 25 ps time resolution** (developped by Tsinghua) per ASIC (use the ∪16 available signal)
- Design new PCB with pick-up strips with ASICs and TDC are on the same PCB (on the edge)
  the two strip's ends are read out with two different ASICs
- The final size of the PCB will be that of RE1/X detector.

First results before end of 2013.

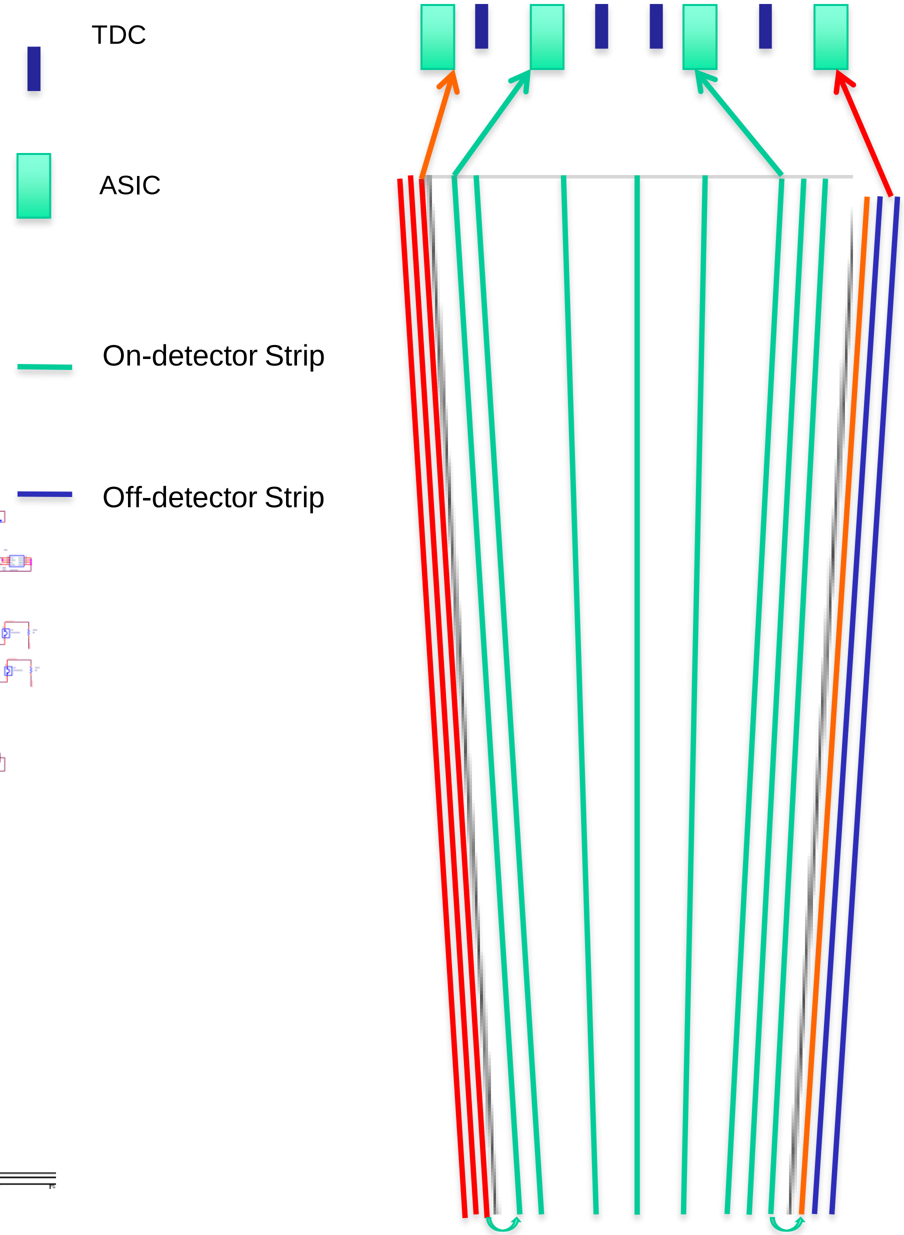


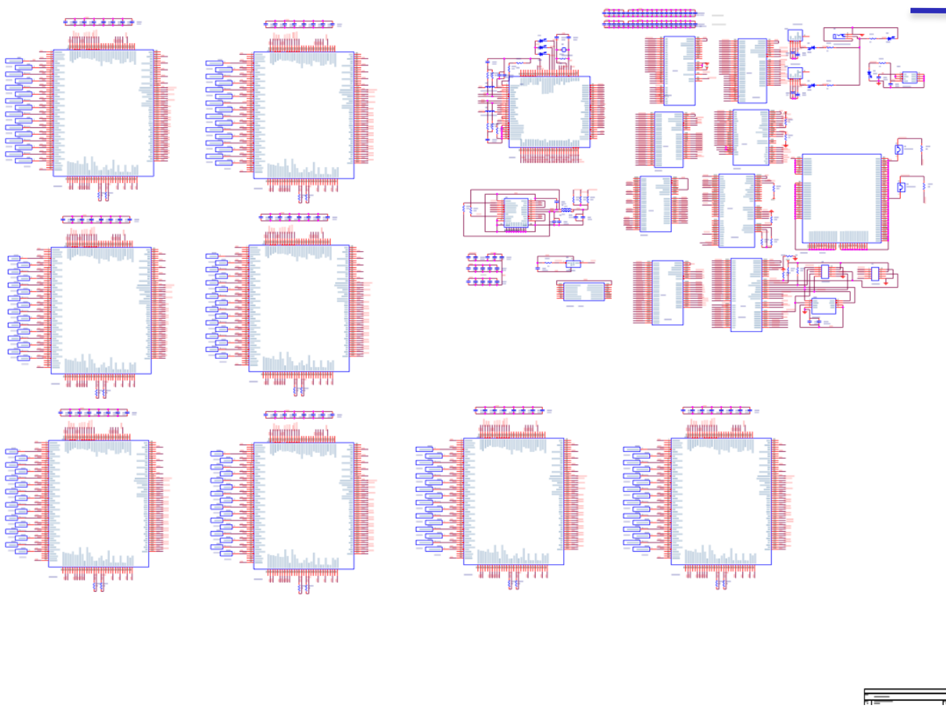
→Strips are read out from both sides to get position and time measurement

→The off-detector strips are on the edges (5-10 mm on each side?) and out of the detector

→ Strips are buried in an insulator layer

→ ASICs and TDCs on one side





Conclusion

GRPC for ILC: development will be soon completed

GRPC for CMS : development underway. Excellent timing and high rate to be achieved.