Development of large GRPC with a very fine segmentation readout electronics

I.Laktineh

IPN de Lyon

Outline

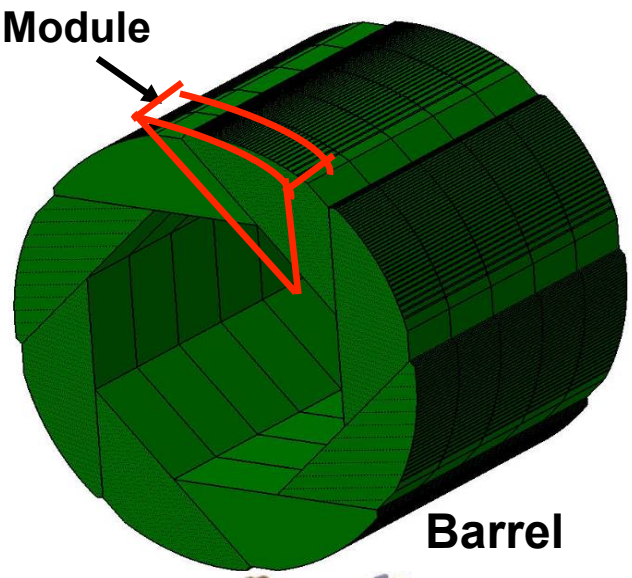
- Motivation
- Design and constraints
- Technical issues
- Test Beam and cosmics results
- Conclusion

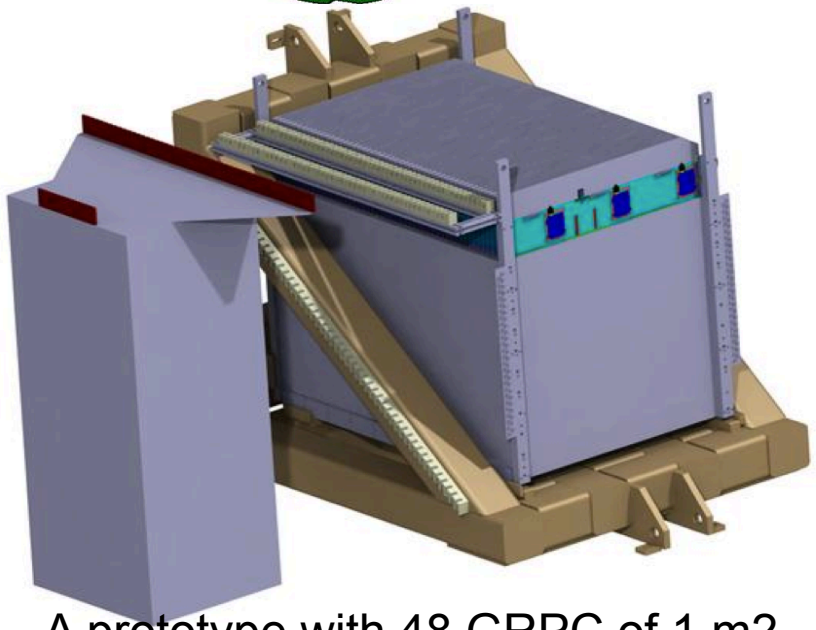
Motivation

-The Semi-Digital HCAL is one of two options proposed in the ILD LOI. It uses gaseous detectors as sensitive medium with embedded readout electronics providing 1cm2 lateral segmentation.
-A genuine mechanical structure is proposed for the SDHCAL.

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 electronics





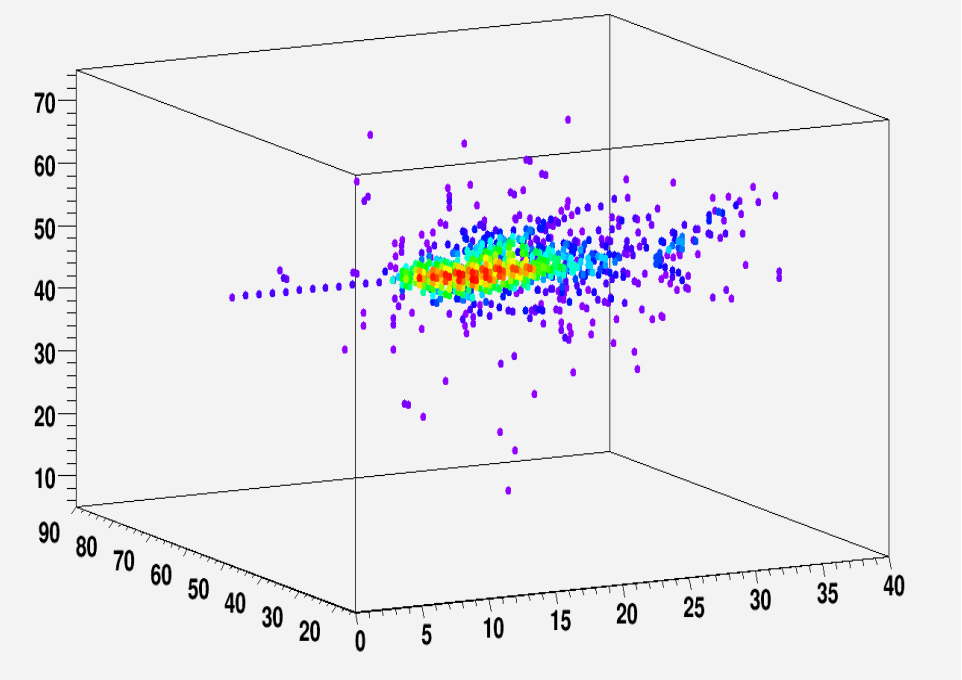
A prototype with 48 GRPC of 1 m2 was conceived as a demonstrator

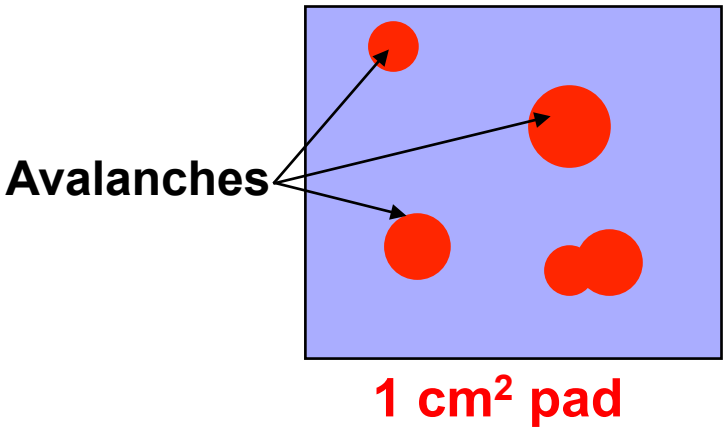
Motivation

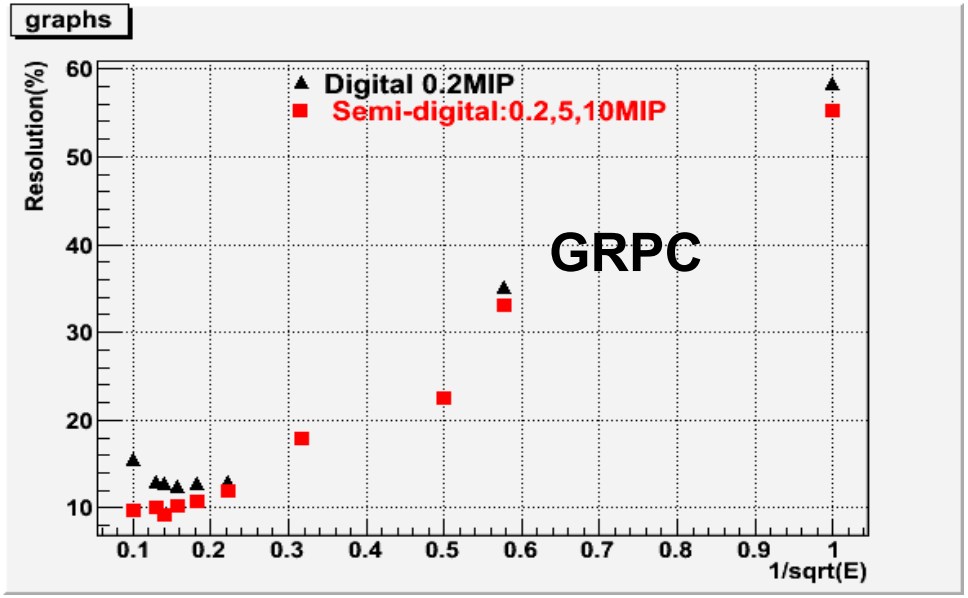
Electronics readout choice

At high energy the shower core is very dense→ simple binary readout will suffer saturation effect

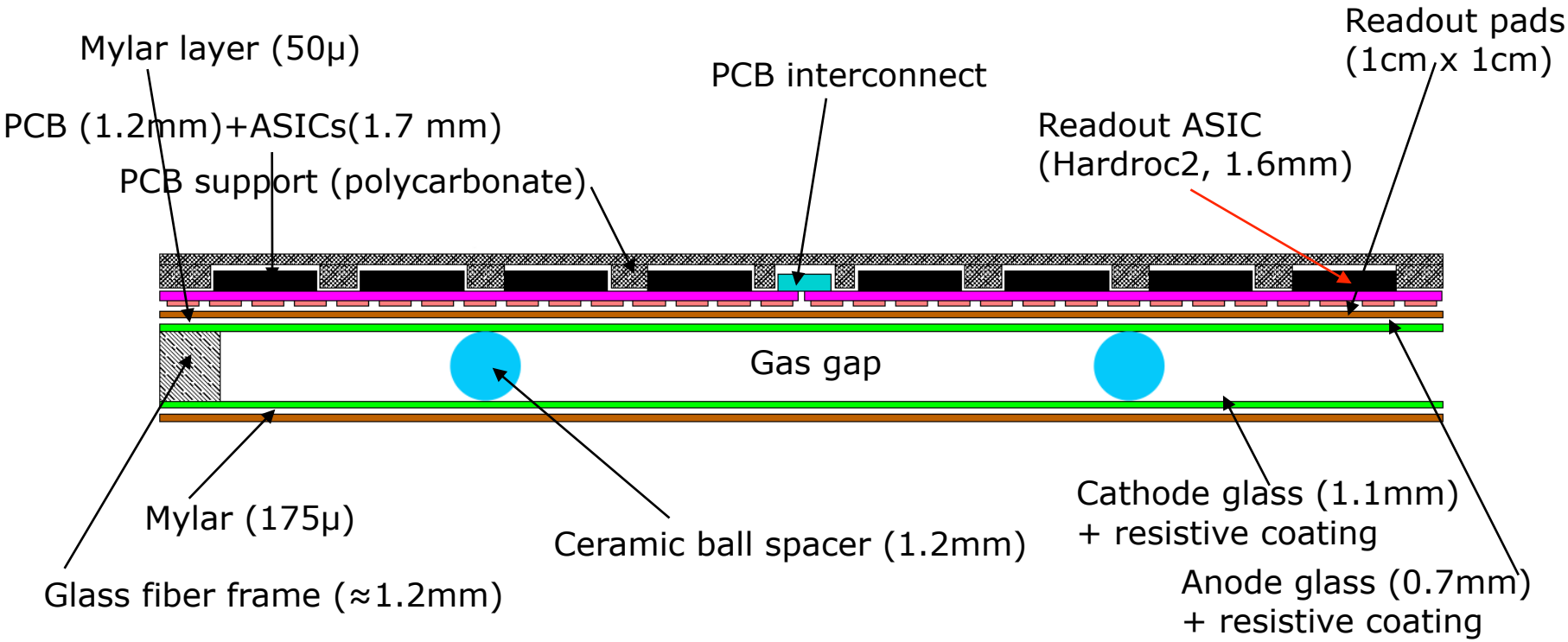
→ semi-digital readout (2-bit) can improve the energy resolution.







Cross-section of SDHCAL 1m^2 glass RPCs

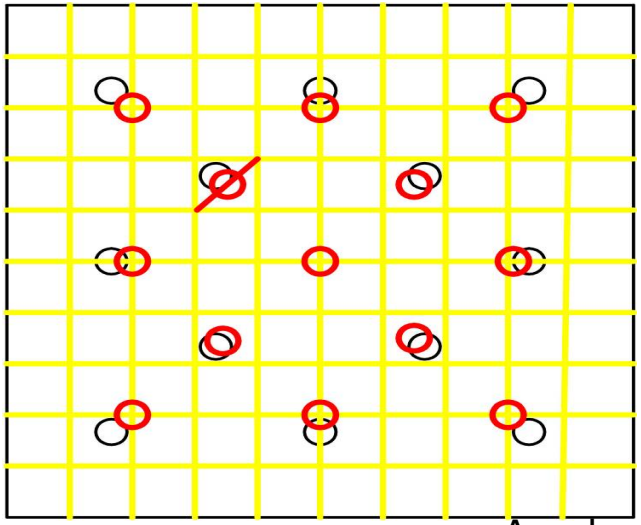


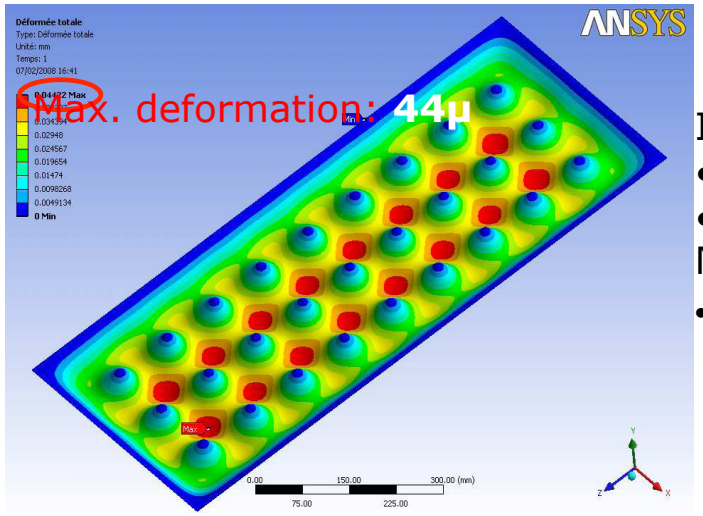
Total thickness: 6.0mm

The choice of ceramic balls rather than fishing lines aims at reducing both dead zones and noise.

Homogeneity study

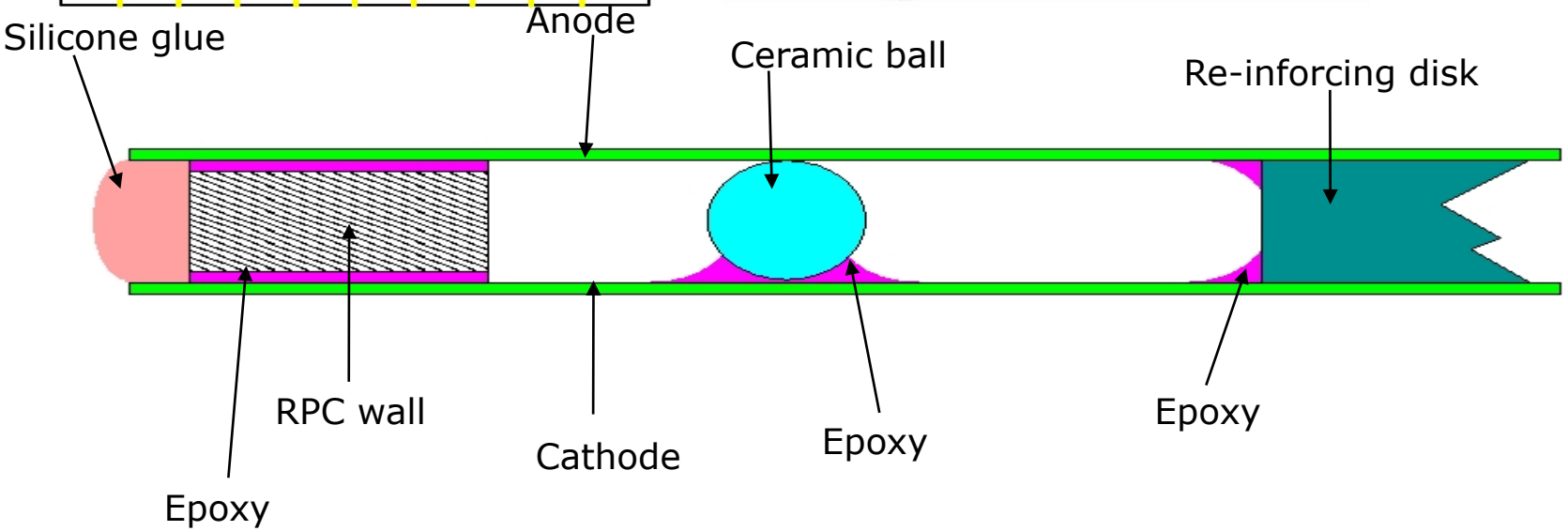
To maintain the same distance between the two glass plates, spacer are used every 10 cm : 68 ceramic balls+ 13 fiber glass disks.





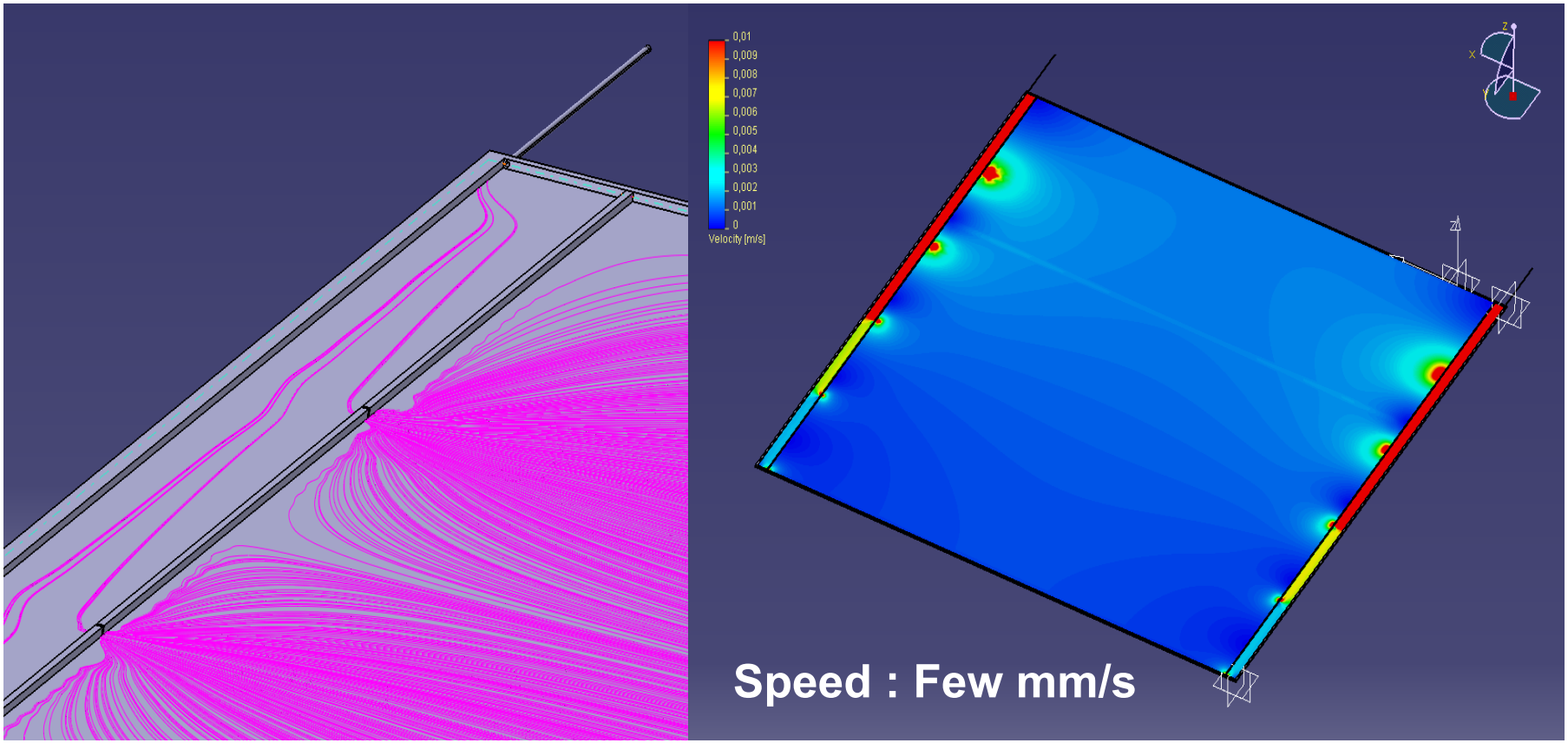
Included
- glass weigh
- electrostatic force

Not included
- Gas pressure



Gas distribution system

The services being on one side of the detector, a new gas distribution design is used. It allows to distribute the gas uniformly in the large chamber.



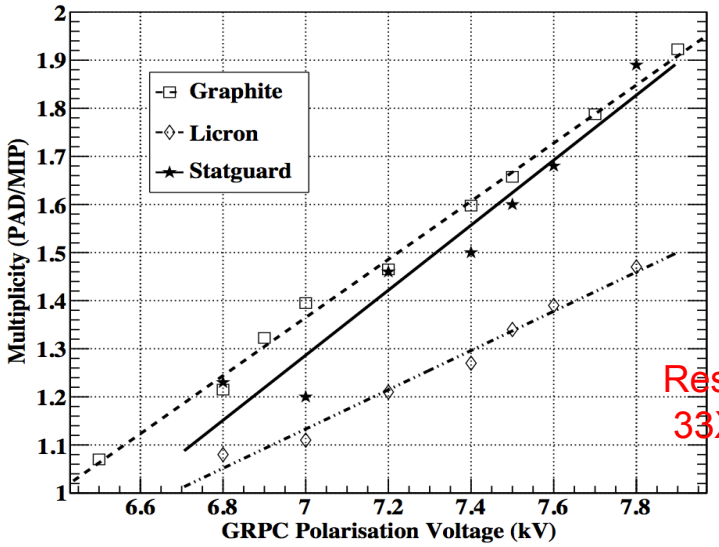
When diffusion is included→ Homogeneity is expected to be even better

A test using Kr83m radioactive gas is scheduled to monitor online the gas distribution

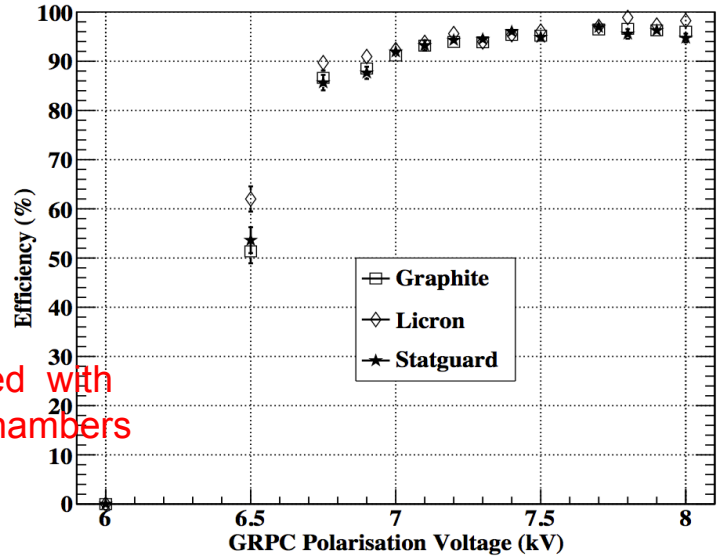
Resistive coating study

The resistive coating is needed to apply the HV on the two glass plates (electrodes). The resistivity value of this coating plays an important rôle of the pad multiplicity. The higher the resistivity the lower the multiplicity
Three kinds of coatings were tested :

	Licron	**Statguard**	**Colloidal Graphite type I**	**Colloidal Graphite type II**
Surface resistivity (MΩ/□)	~20	1-10	~0.5	Depends on mix ratio; choose ~0.7
Best application method	Spray	Brush	Silk screen printing	Silk screen printing



Results obtained with 33X8.3 cm2 chambers

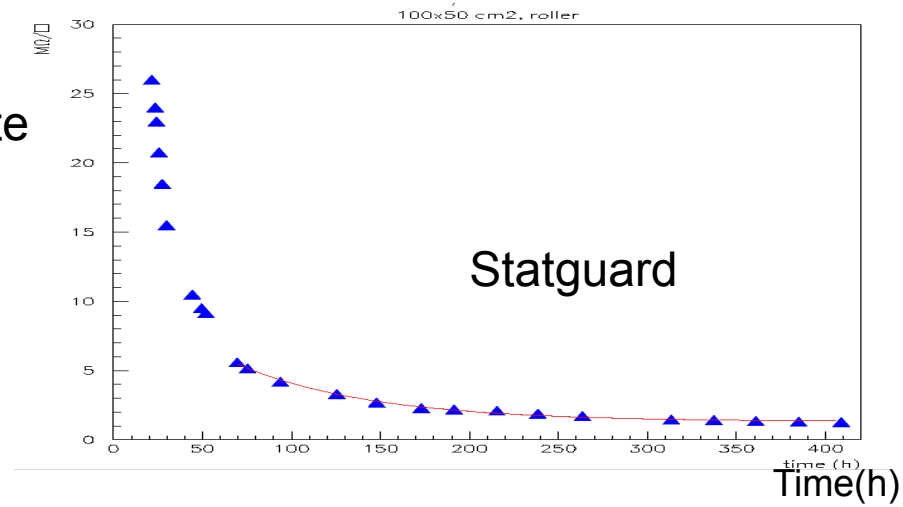


Resistive coating study

Licron and Statguard are more appropriate for low pad multiplicity. However :

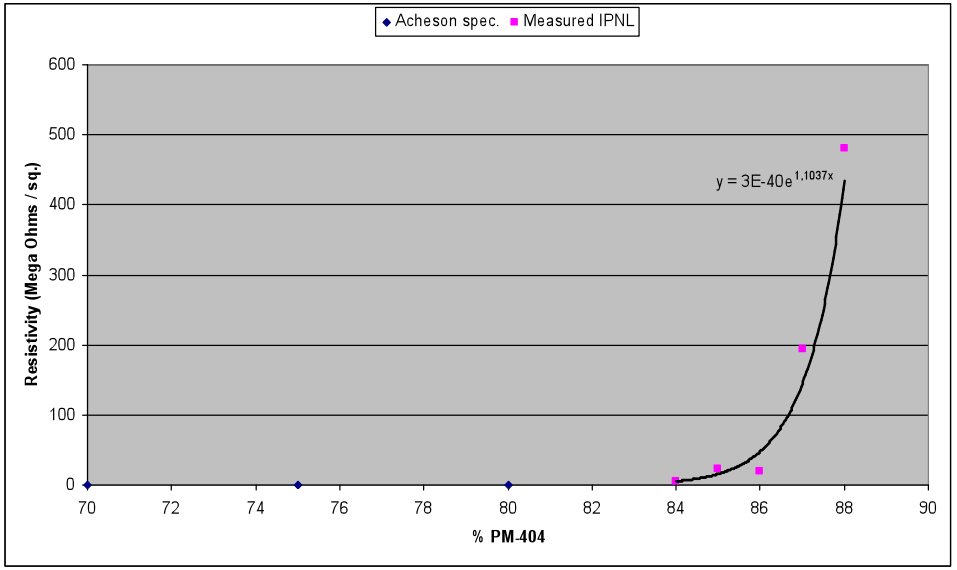
Licron : Loss of HV connection over time (1-2 months)

Statguard : long time constant for stable resistivity (2 weeks), poor homogeneity

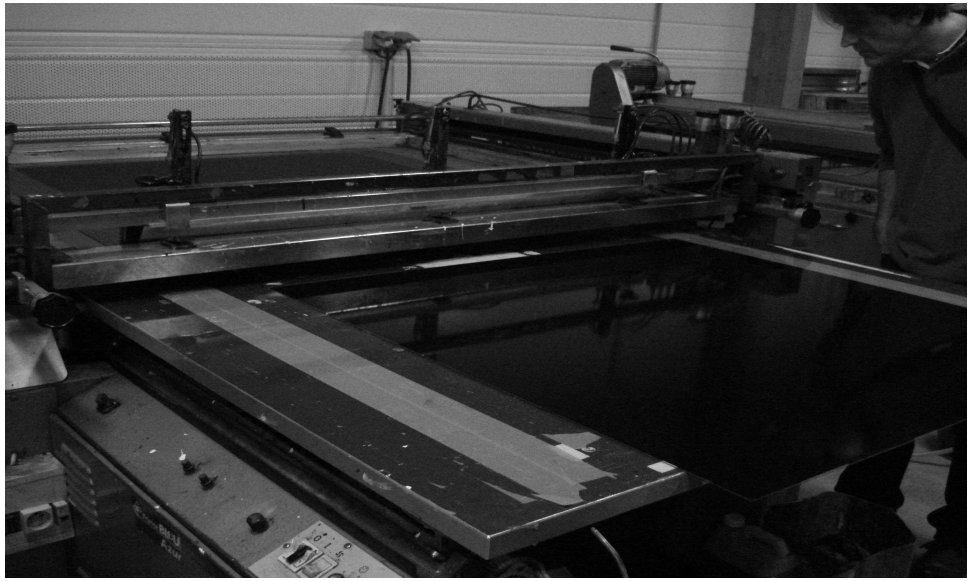


Time(h)

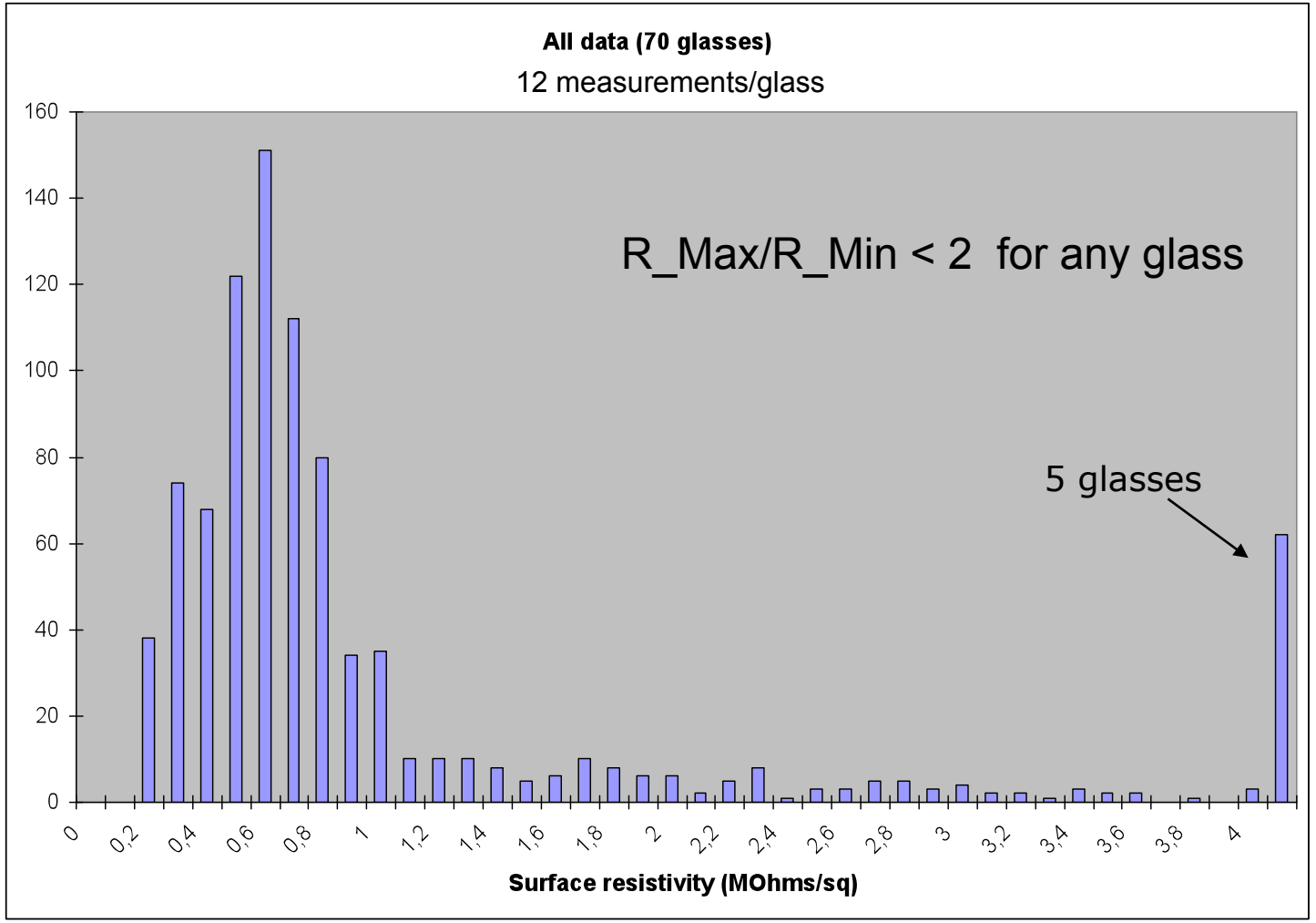
The colloidal graphite of type II is less expensive and allows to choose the needed resistivity even if this is a delicate operation



Measured resistivity as a function of the mix ratio

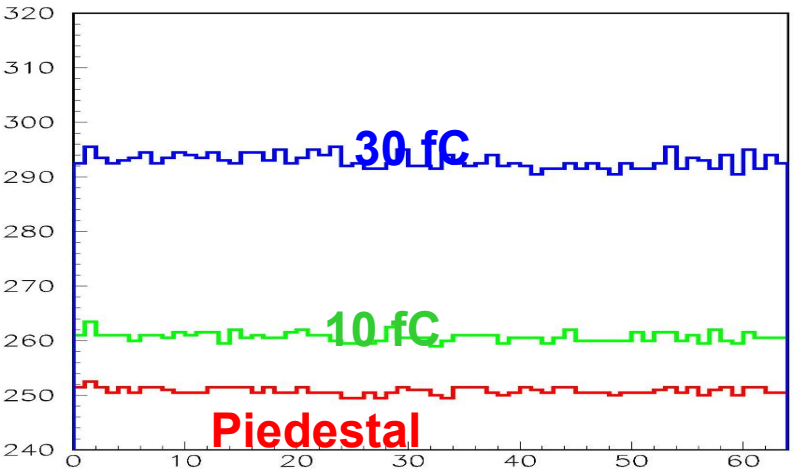


Silk-screen print method provides very good uniformity

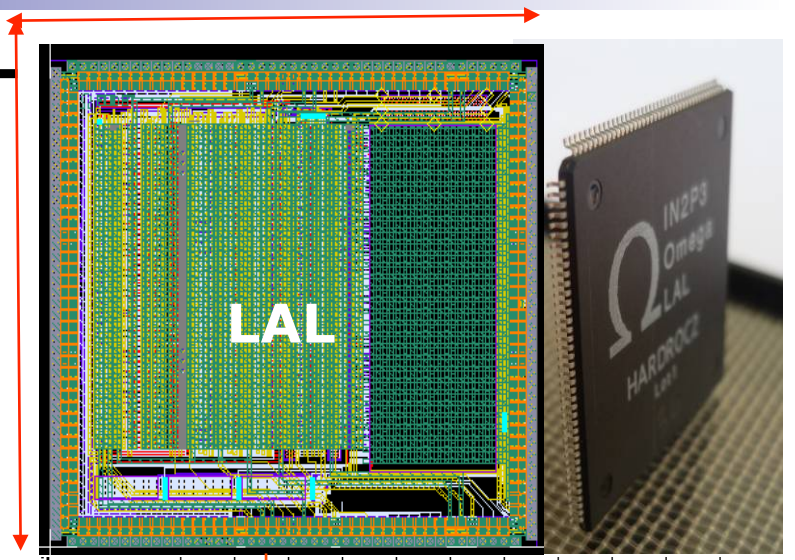

All data (70 glasses)
12 measurements/glass
R_Max/R_Min < 2 for any glass
5 glasses
160
140
120
100
80
60
40
20
0
0
0,2
0,4
0,6
0,8
1
1,2
1,4
1,6
1,8
2
2,2
2,4
2,6
2,8
3
3,2
3,4
3,6
3,8
4
Surface resistivity (MOhms/sq)

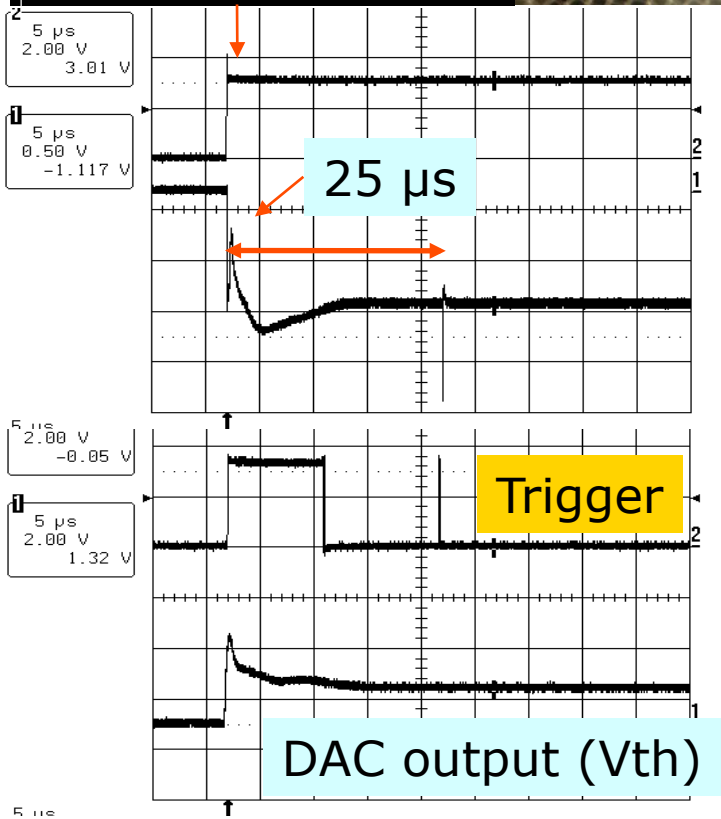
Electronics for GRPC-SDHCAL

ASICs : HARDROC2
64 channels
Triggerless mode
Memory depth : 127 events
3 thresholds
Range: 10 fC-30pC
Gain correction → uniformity



Power-pulsed→ consumption< 10µW/ch
(0.5% duty cycle), X-talk < 2%



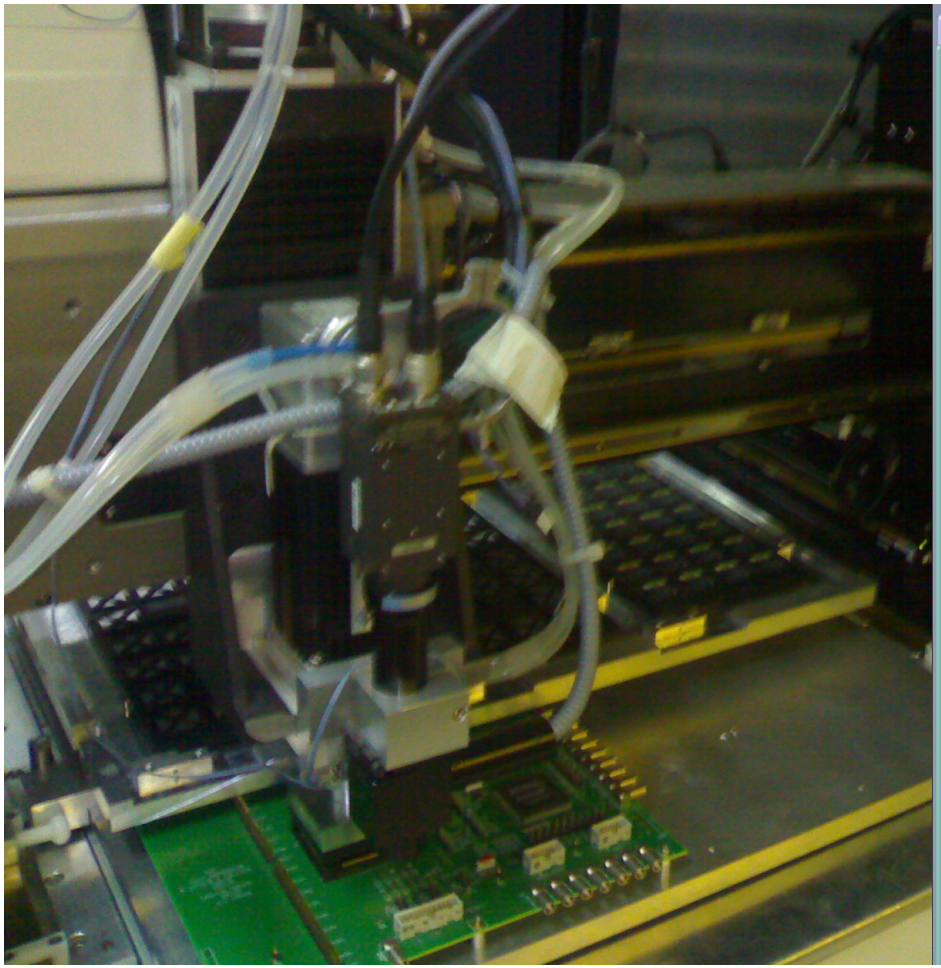


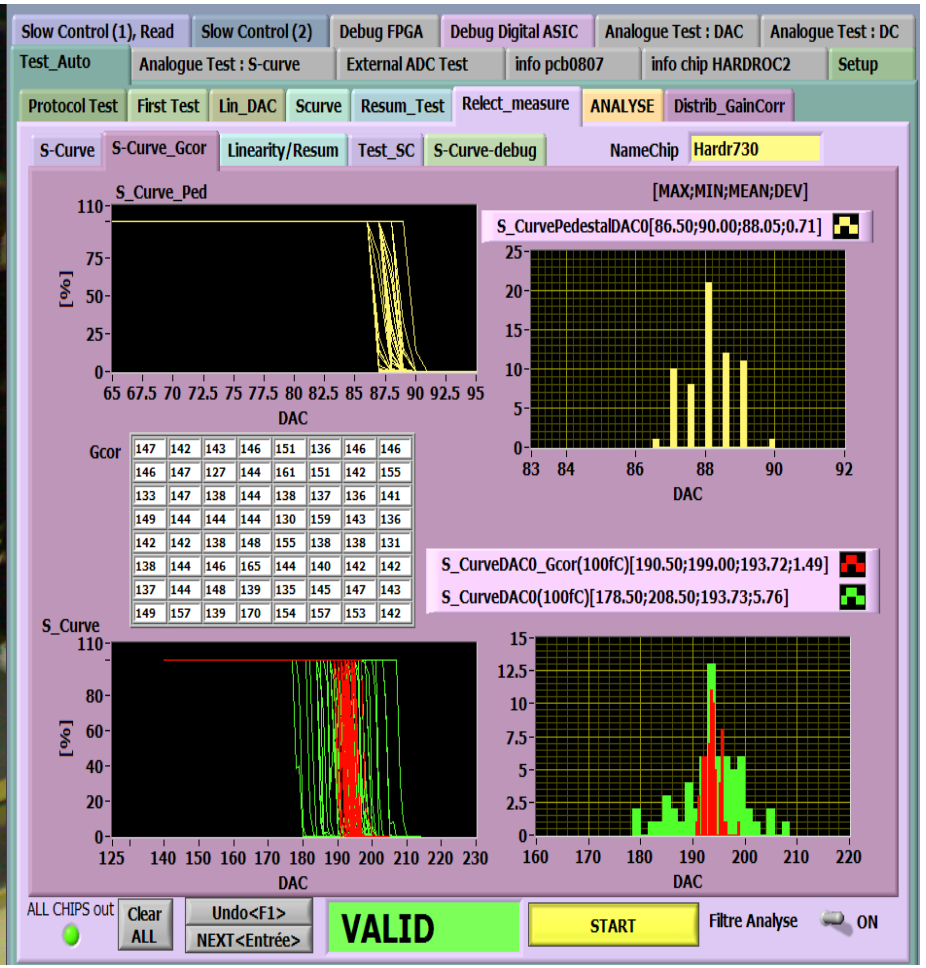
Electonics: ASICs stand test

A robot was used to test the 10500 ASICs

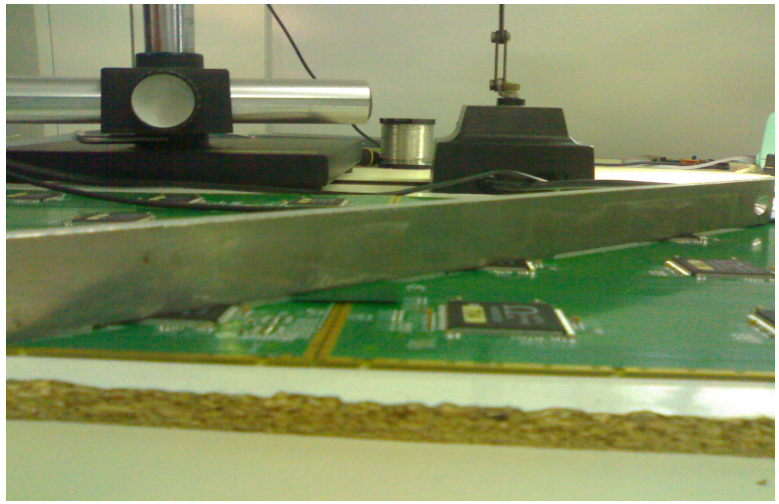
The procedure allows to select the good ASICs and calibrate them

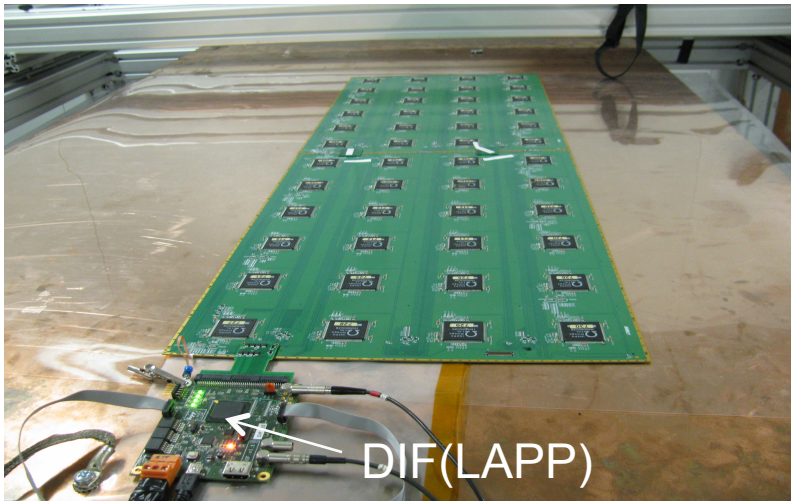
Yield 93%

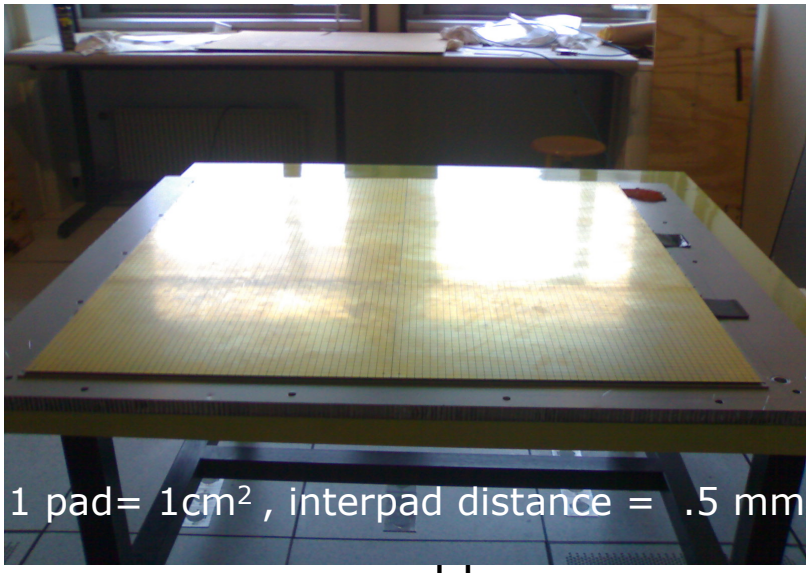


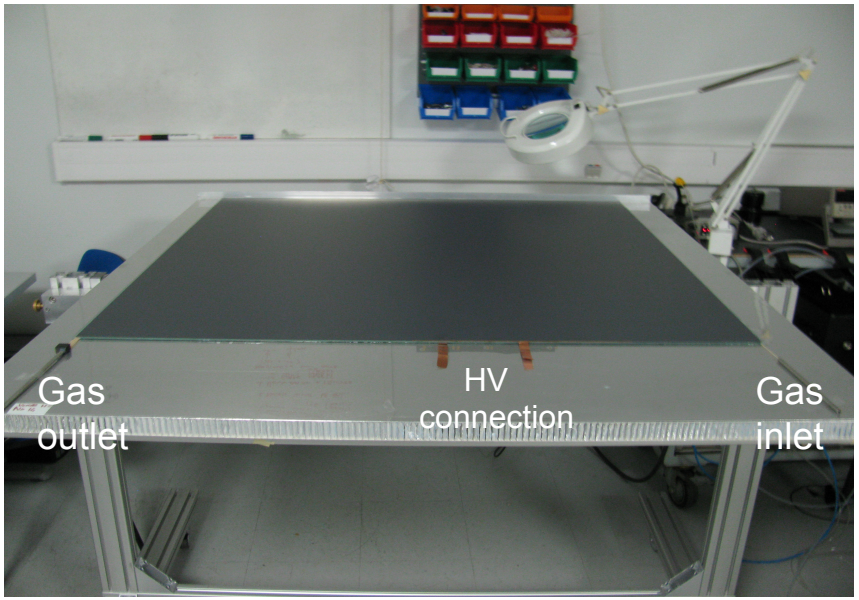


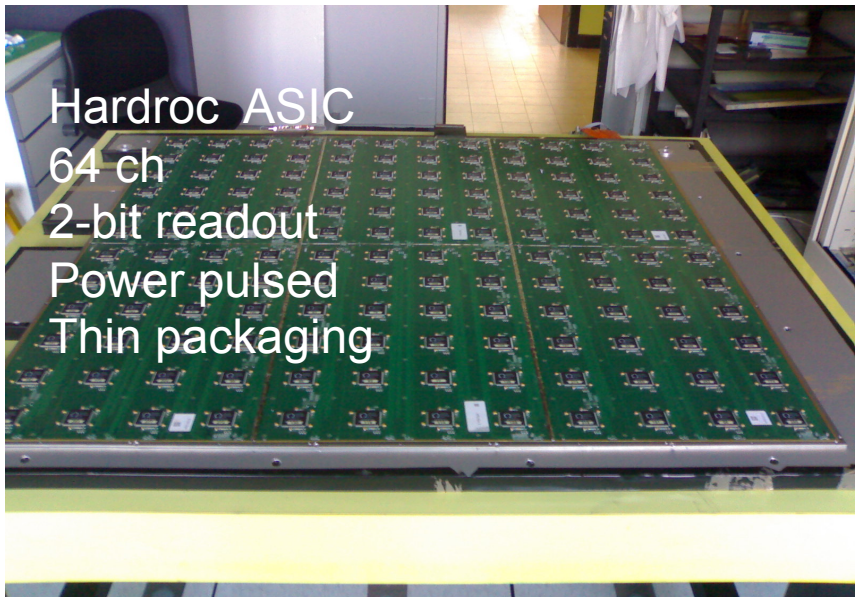
Electronics boards of 1 m^2 using new generation of connectors were developed to host the readout electronics.



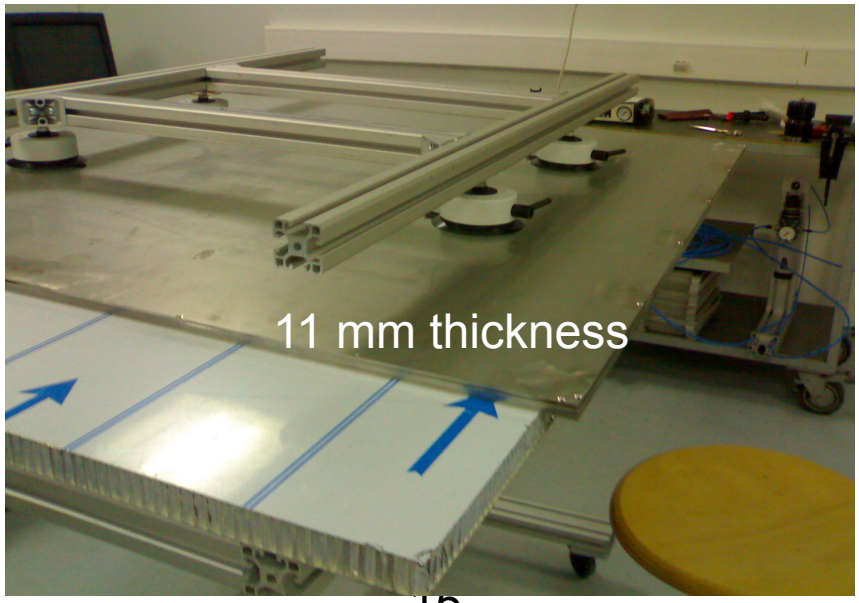





Gas
outlet
HV
connection
Gas
inlet

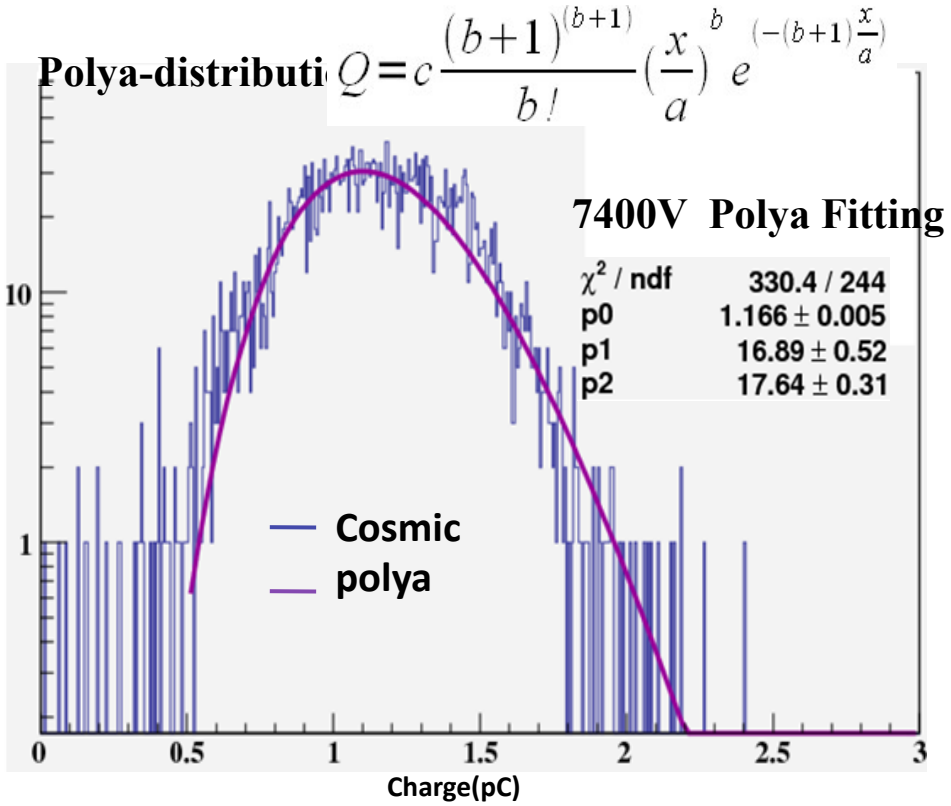

Hardroc ASIC
64 ch
2-bit readout
Power pulsed
Thin packaging


9216 ch/m2


11 mm thickness

Validation

Charge spectrum of our detector was carefully studied and understood. Polya distribution is successfully used to describe the data



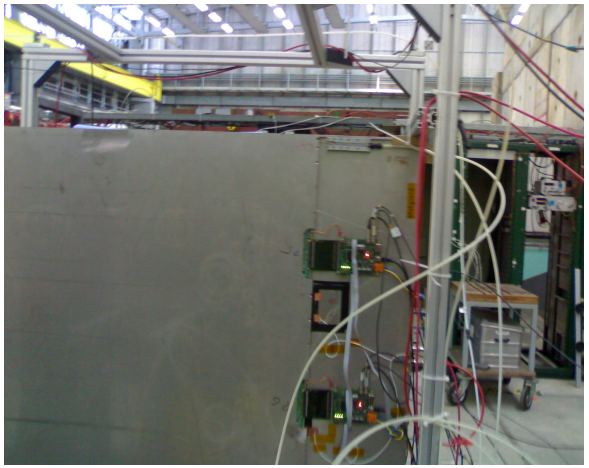
Charge Spectrum Cosmic Test Set Up (analog readout)

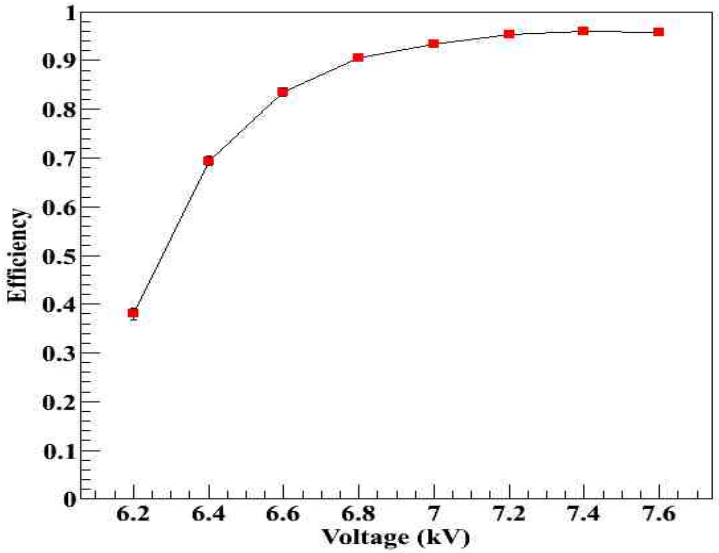
Validation

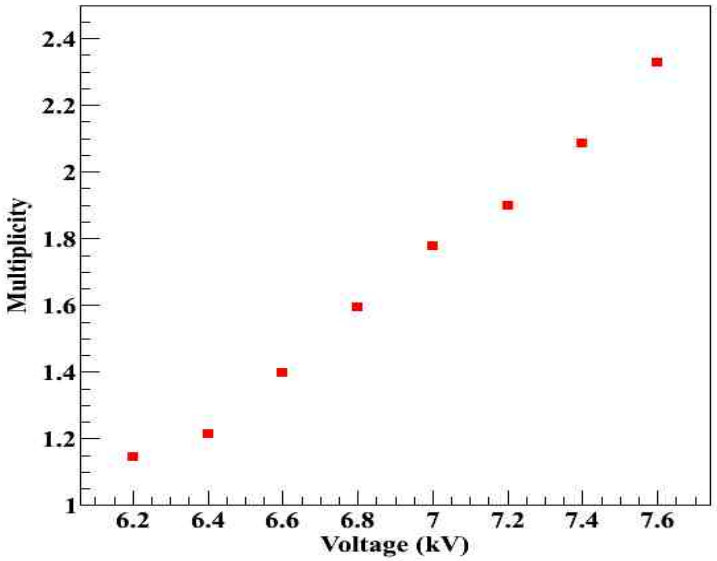
A full cassette was tested
at H4-SPS in September 2010
to validate the concept and to study
the GRPC performance.

Gas mixture :
TFE :93.5 %
CO2 : 5 %
SF6 : 2 %

Charge threshold : 100 fC



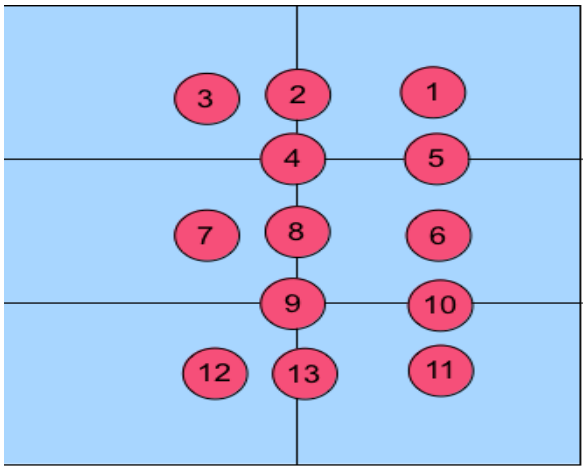


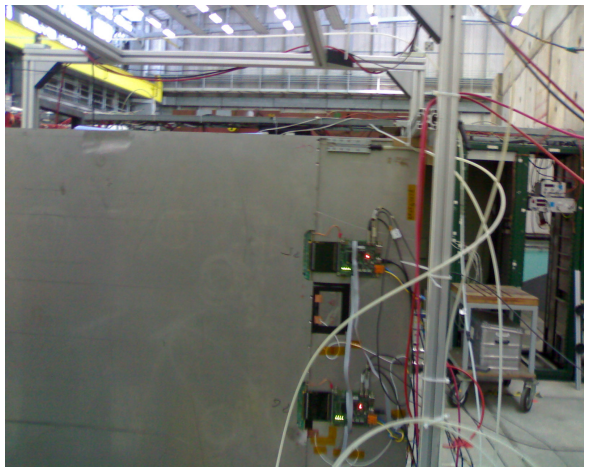


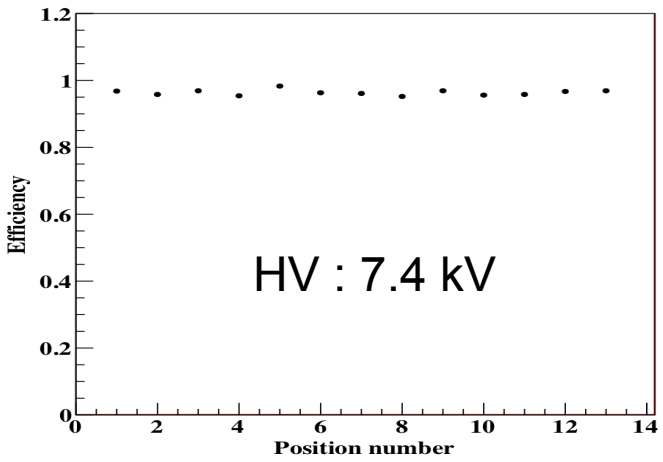
Z

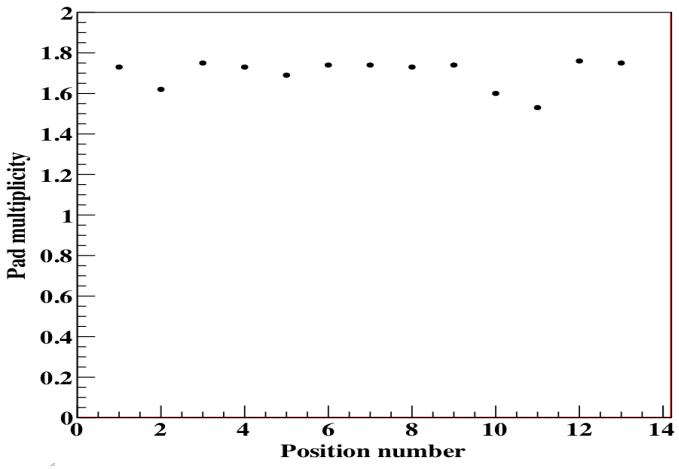
Validation

The homogeneity of the detector and its readout electronics were studied.



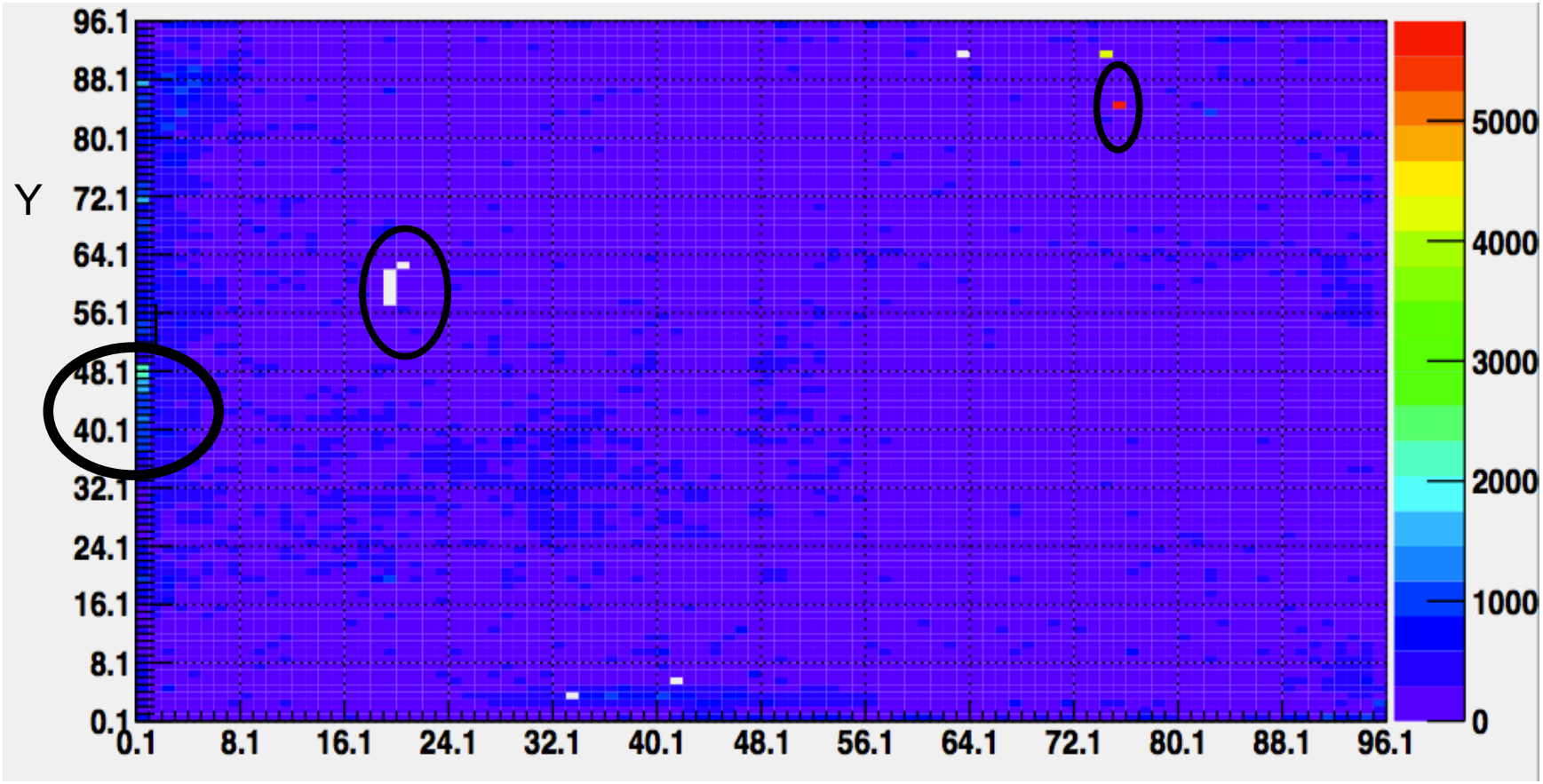






Validation

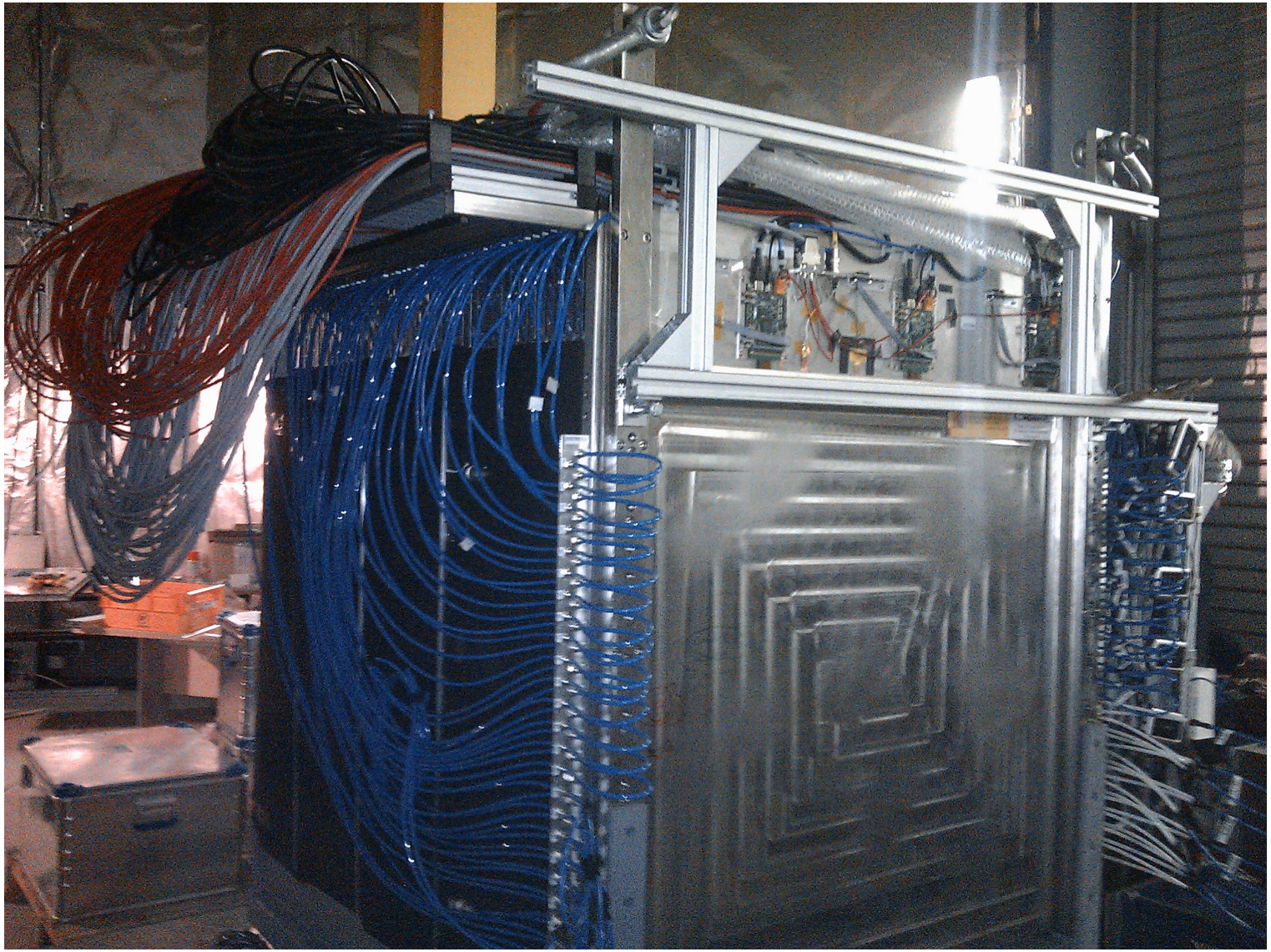
Noise was measured and found to be < 1 Hz/cm2 outside the channeling tubes and HV connection zones



Noise Map

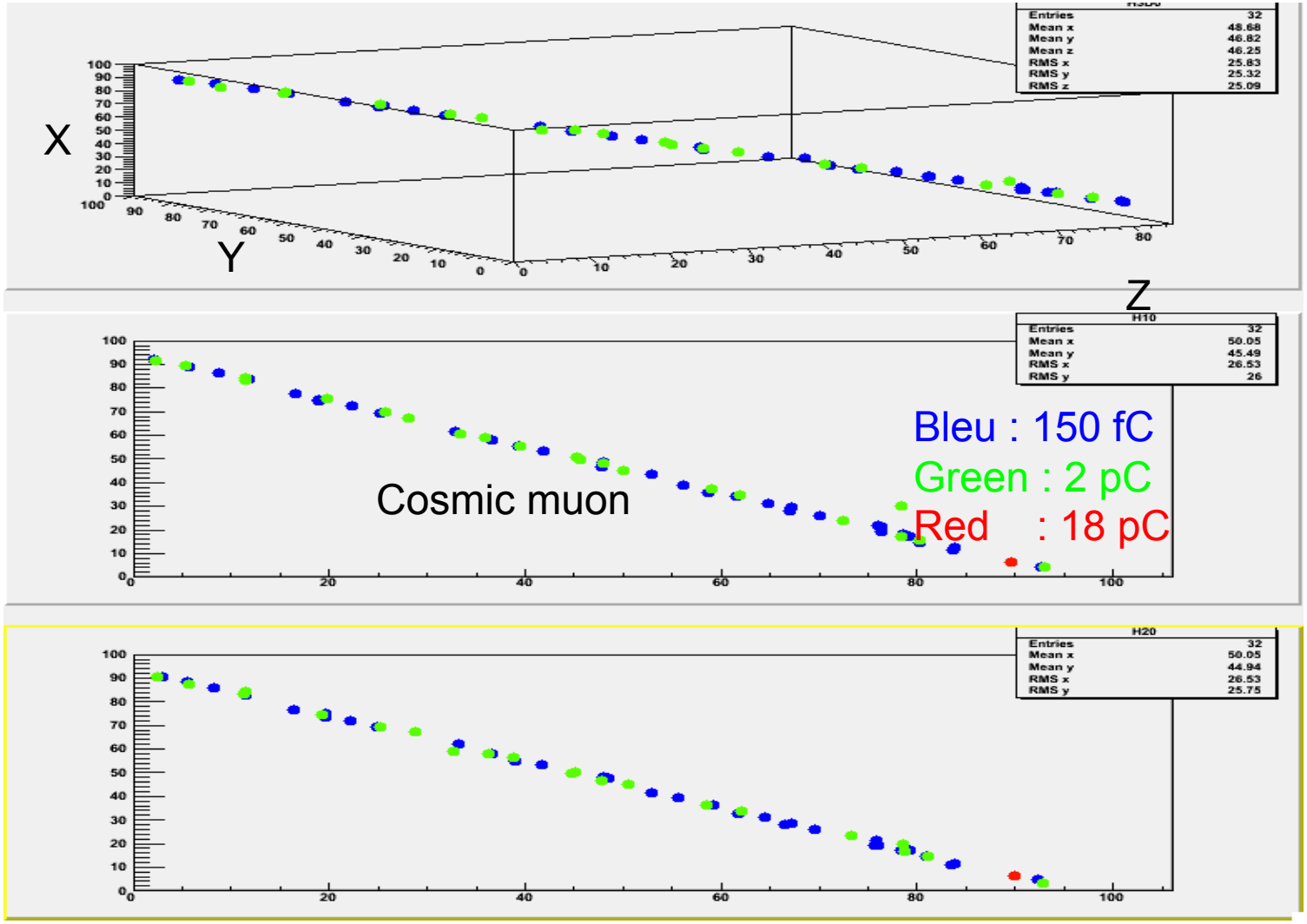
X

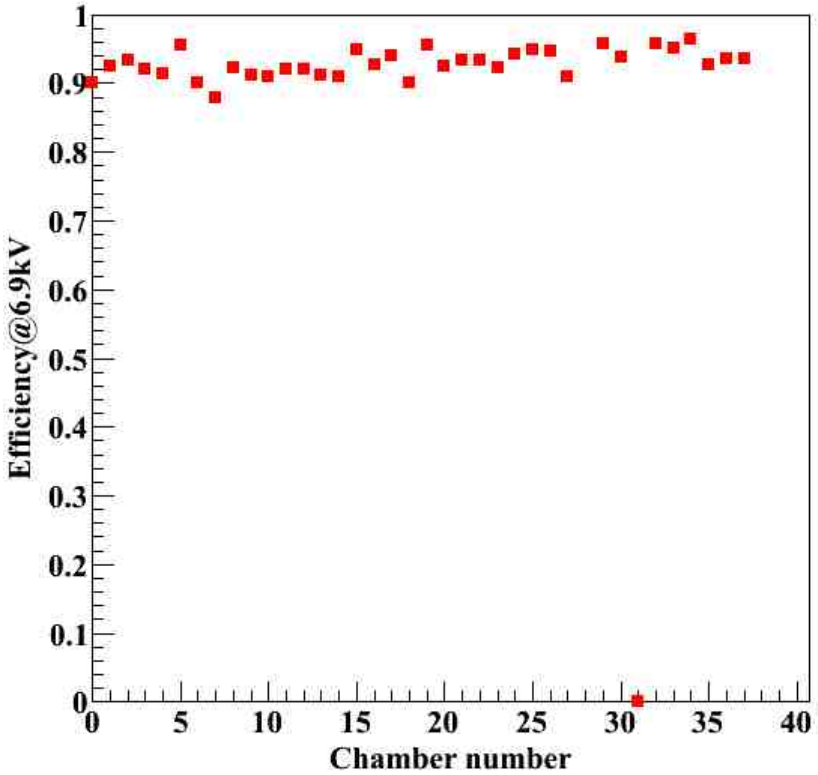
50 Chambers are built and will be used in the SDHCAL prototype in the coming days..

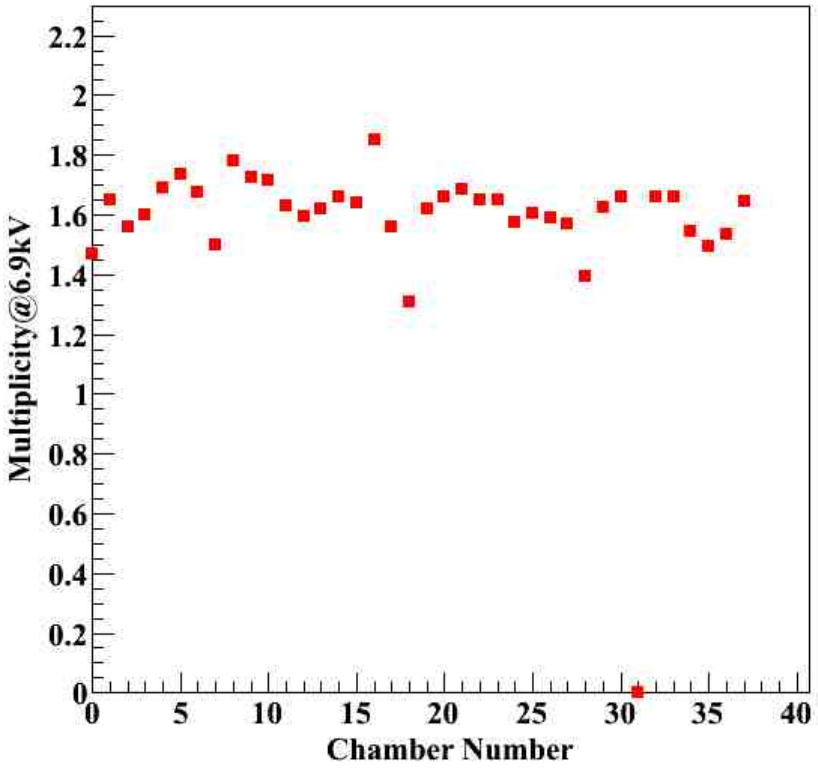


The GRPCs with their electronics in the cassettes are installed

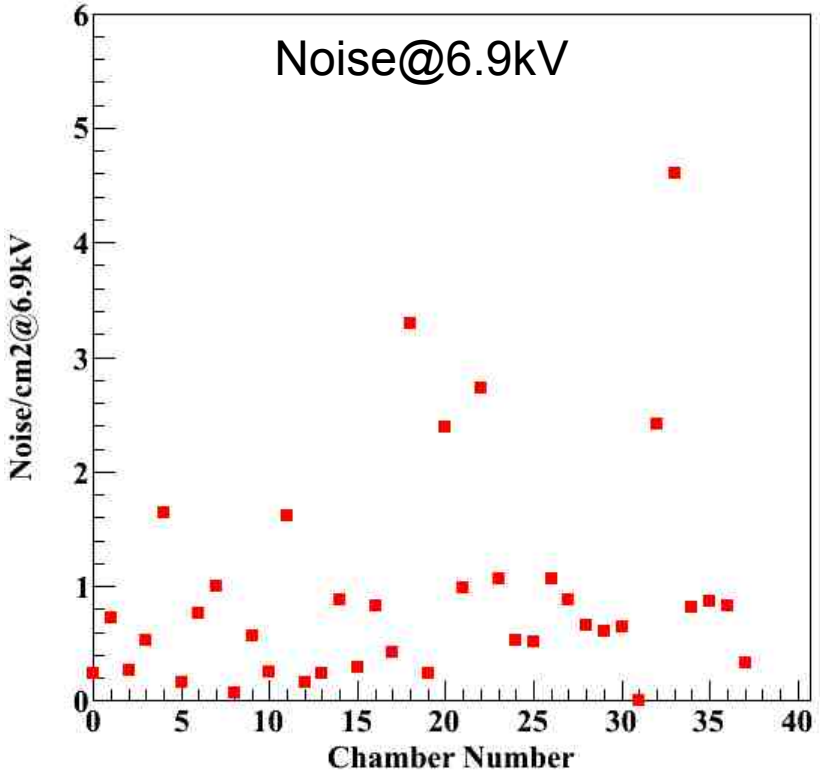
The cosmic rays were used to study the performance of the GRPC detectors





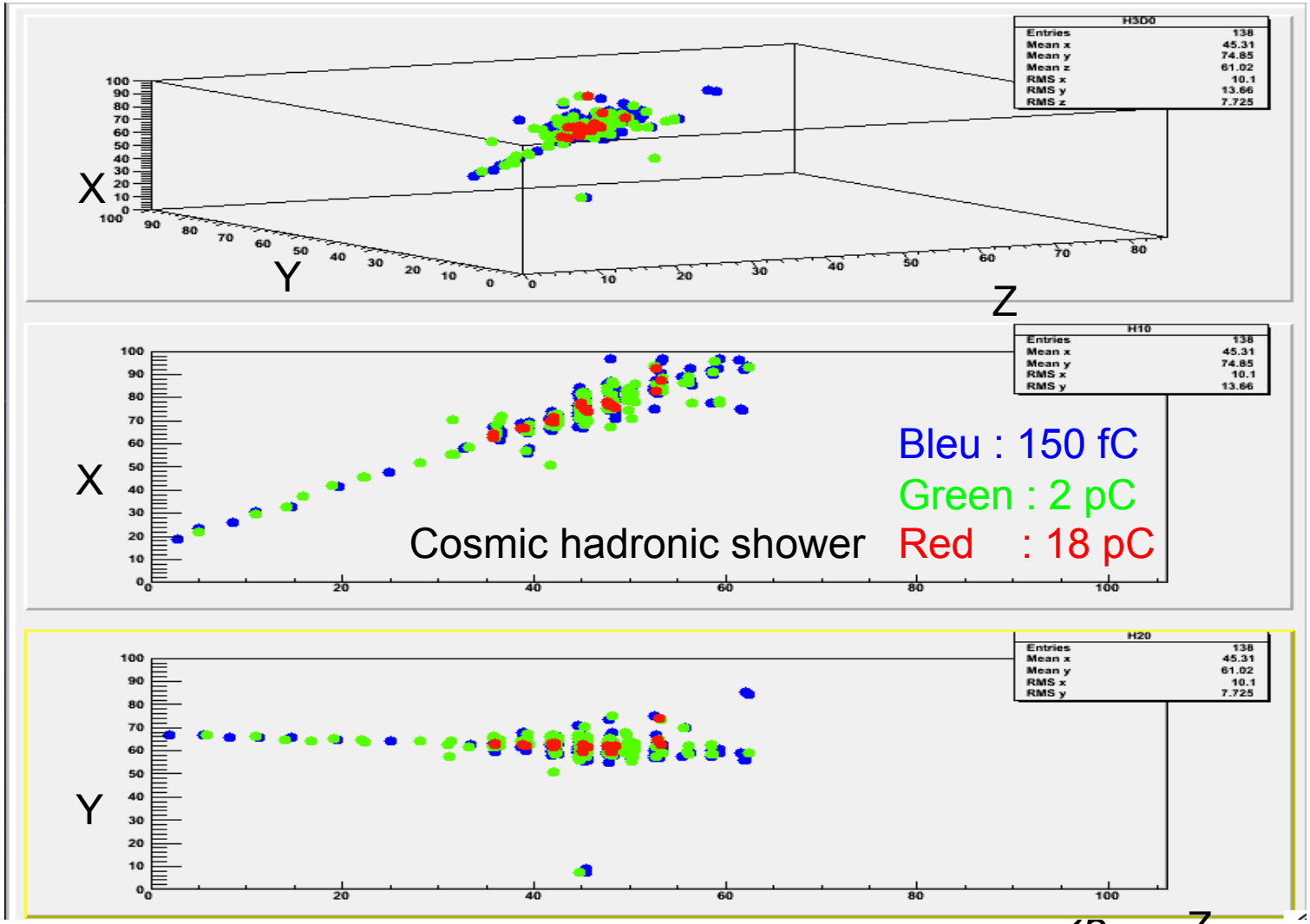


Efficiency and multiplicity(6.9kV)



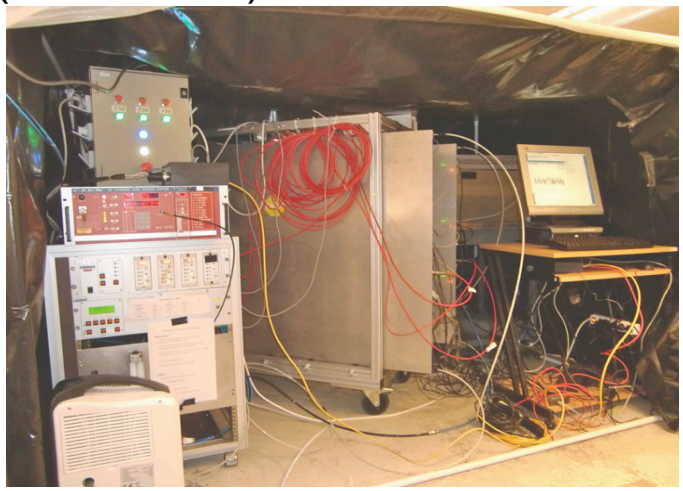
Noise in some chambers is essentially due to higher electric field
In the edges where the gas gap is less than the nominal one.
This could be corrected by reducing the electronics gain to compensate

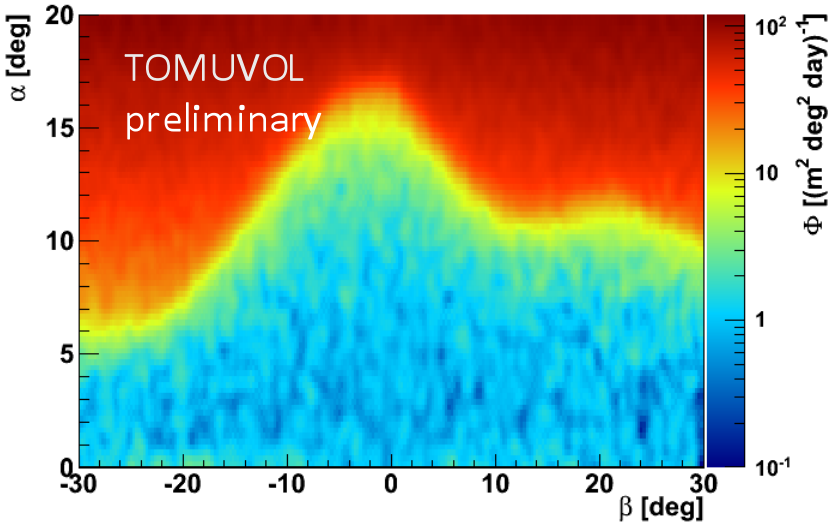
The interest of the the semi-digital readout electronics is not yet demonstrated in TB. However this can already be seen from hadronic showers of some cosmics

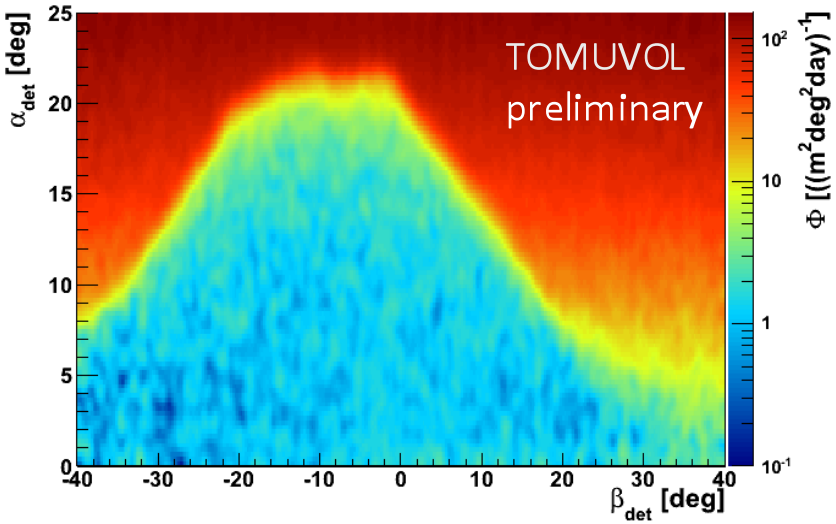


GRPC@TOMUVOL

The same GRPCs we developed for the SDHCAL were used in the TOMUVOL (cf V.NIESS)







Conclusion&Prospects

→ Development of large and thin GRPC for the Semi-Digital Hadronic CALorimeter was successful.

→GRPC provides high efficiency and good resolution and are excellent cosmic rays detectors. The SDHCAL prototype will be used for systematic study of cosmic rays in the future

→The TOMUVOL project will use GRPCs based on the development achieved previously.