Development of large GRPC for a Semi-Digital Hadronic Calorimeter for ILC

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On behalf of the SDHCAL-CALICE group

CIEMAT, Ghent, IPNL, LAL, LAPP, LLN, LLR, LPC, Protvino, Tsinghua, Tunis

Output

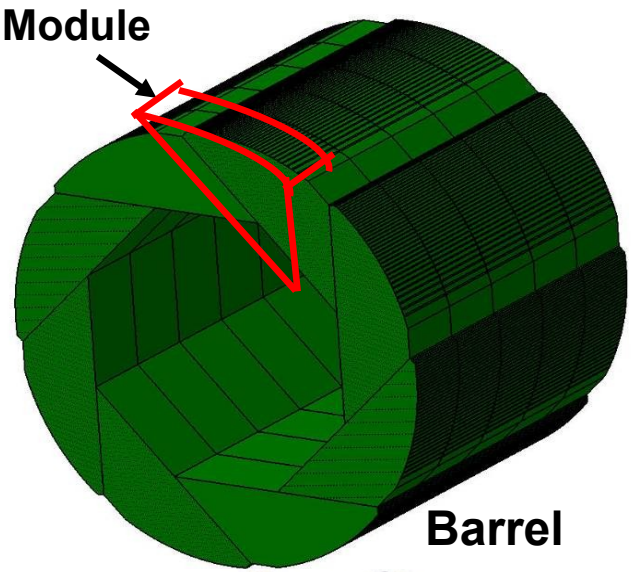
- Motivation
- Design and constraints
- Technical issues
- Prototype construction
- Conclusion

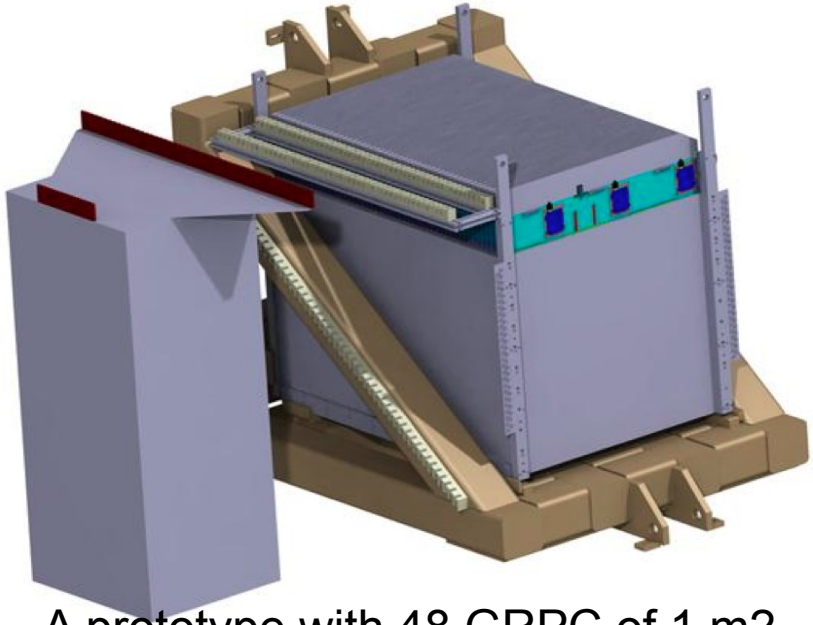
Motivation

-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





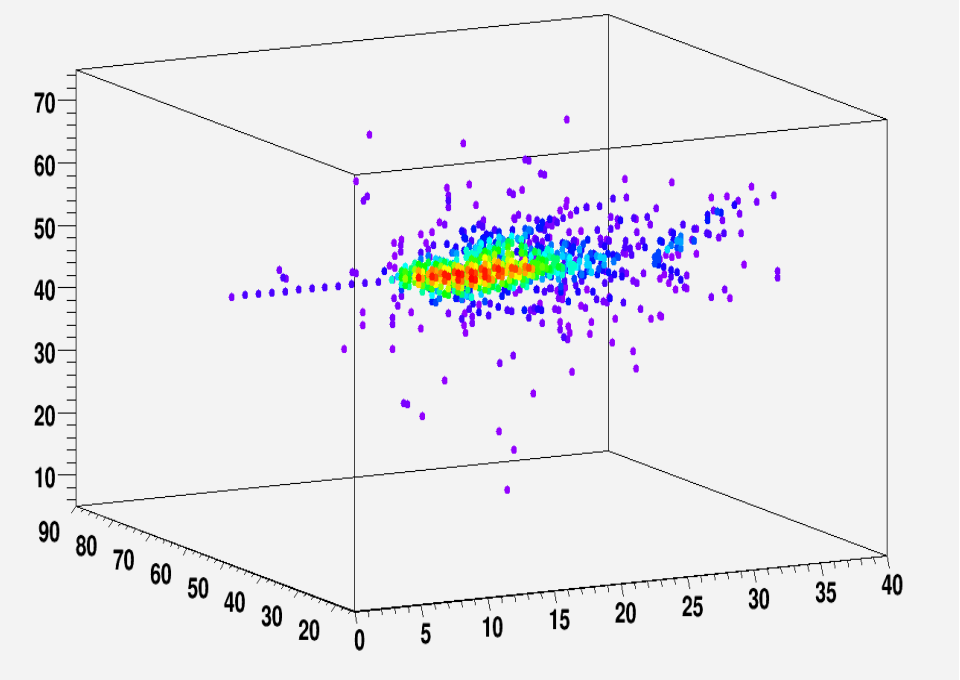
A prototype with 48 GRPC of 1 m2 was conceived as a demonstrator

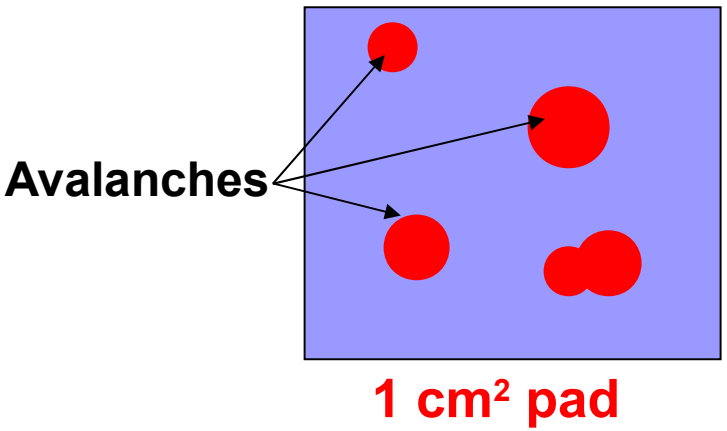
Motivation

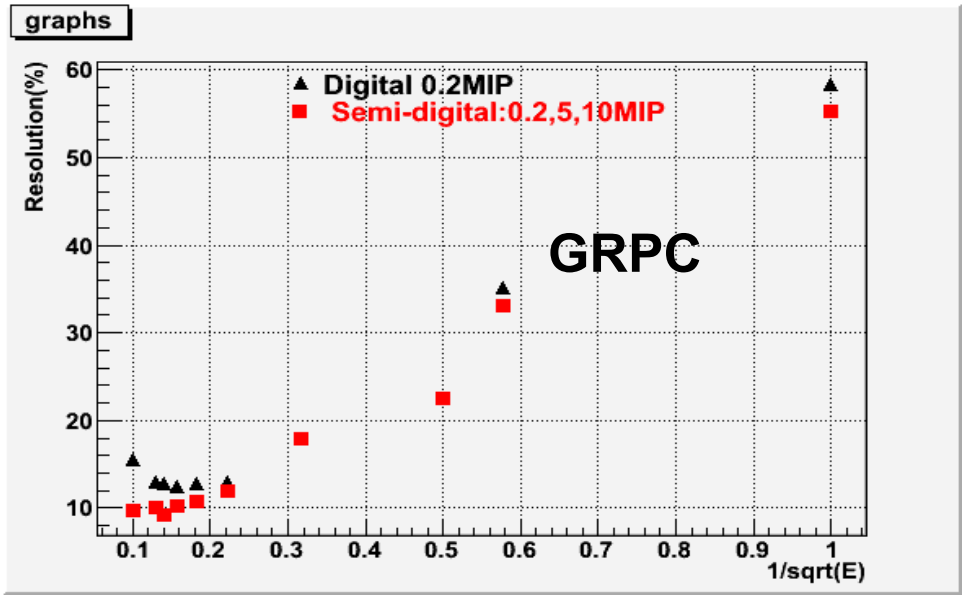
Electronics readout choice

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

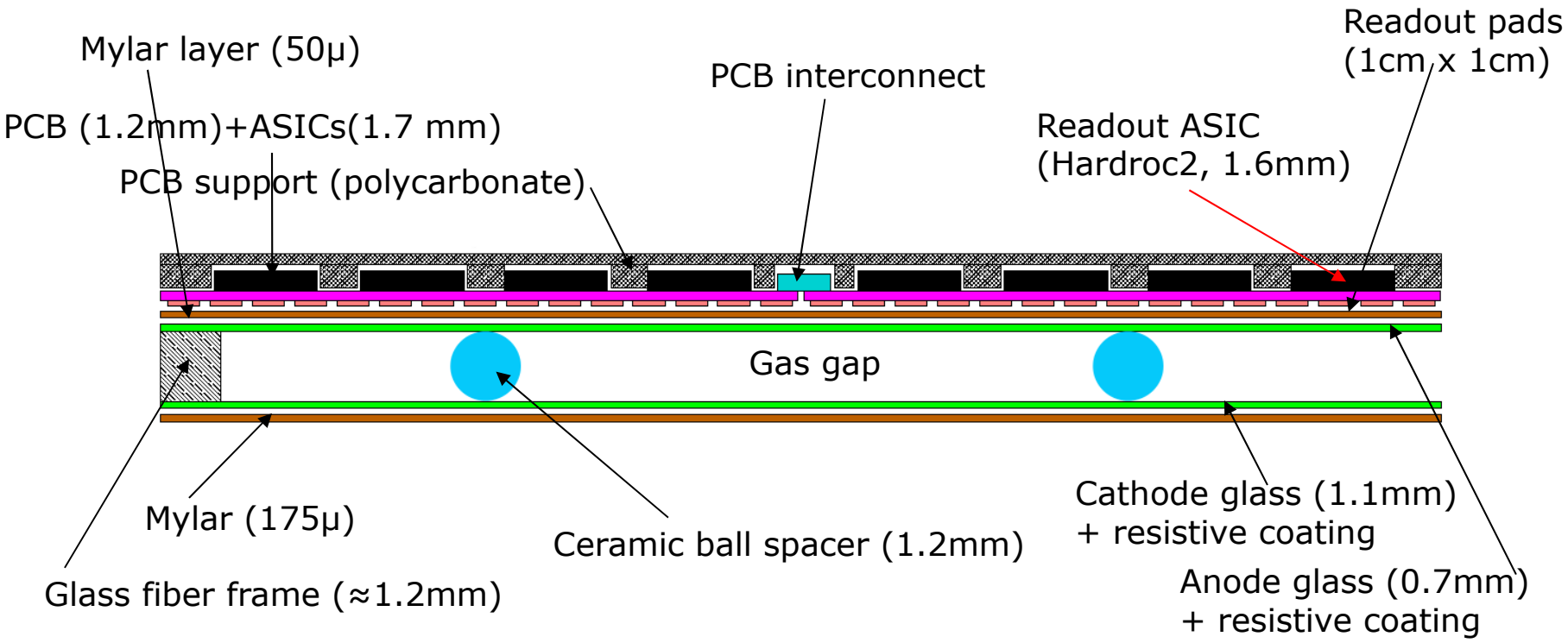
→ semi-digital readout (2-bit) can improve the energy resolution.







Cross-section of Lyon 1m^2 glass RPCs

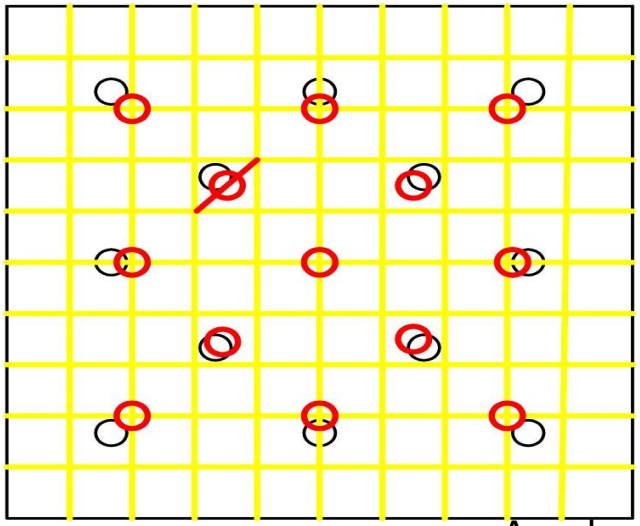


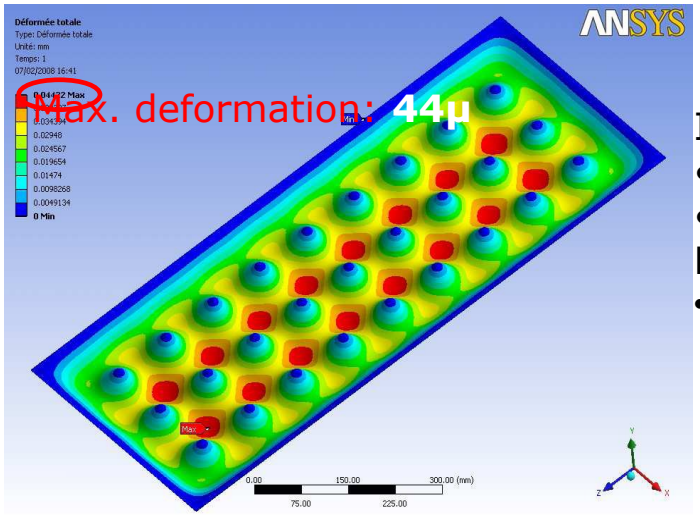
Total thickness: 6.0mm

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

Homogeneity study

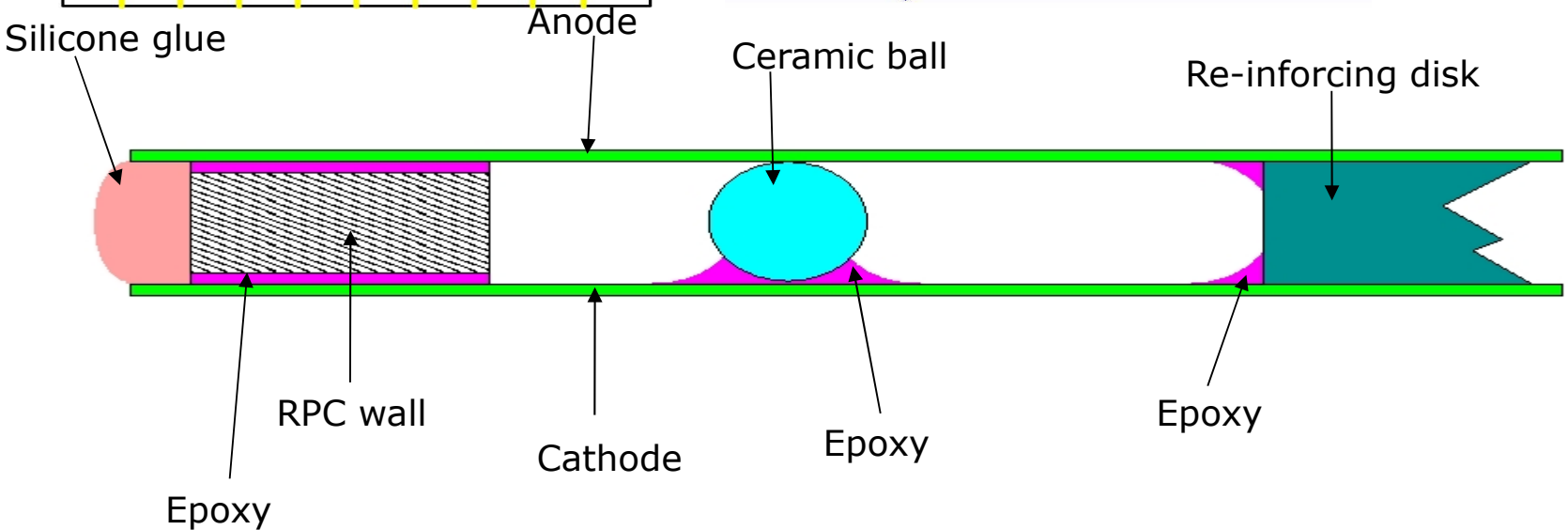
To maintain the same distance between the two glass plates, spacer are used every 10 cm : 68 ceramic balls+ 13 fiber glass disks.





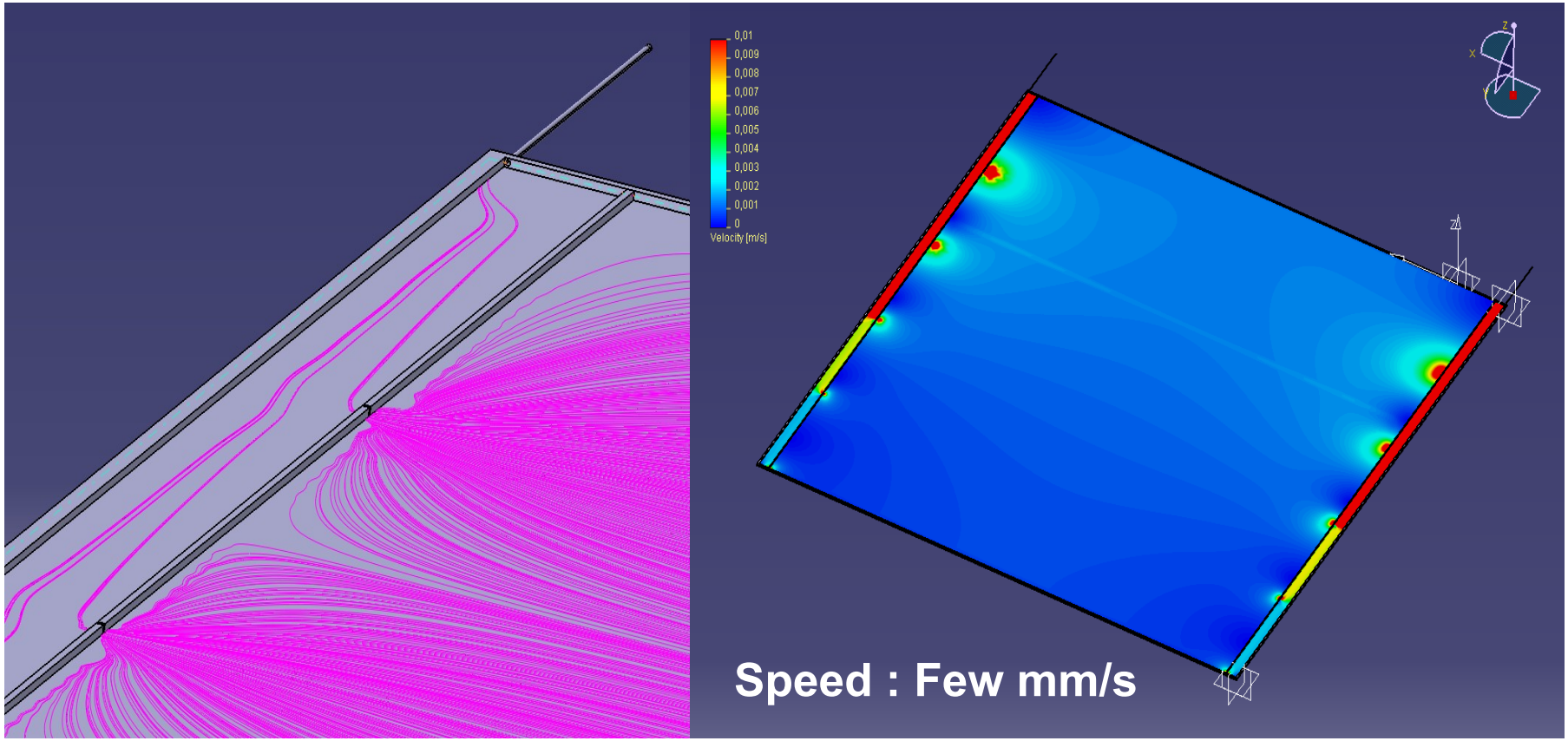
Included
- glass weigh
- electrostatic force

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.



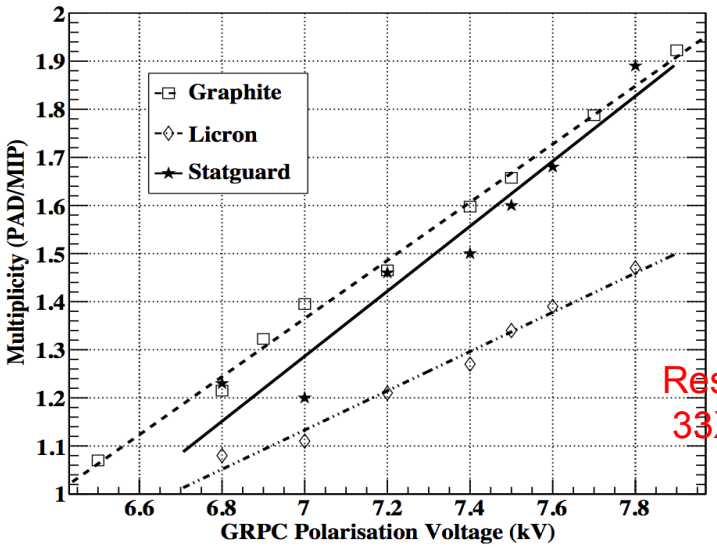
When diffusion is included→ Homogeneity is expected to be even better

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

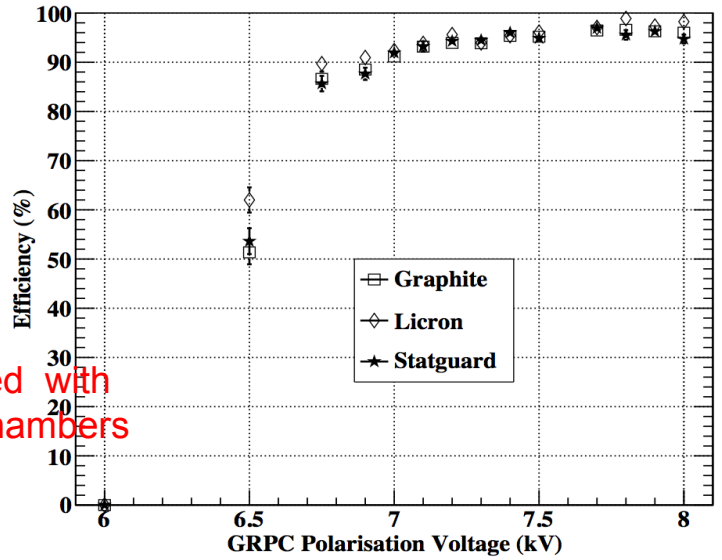
Resistive coating study

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

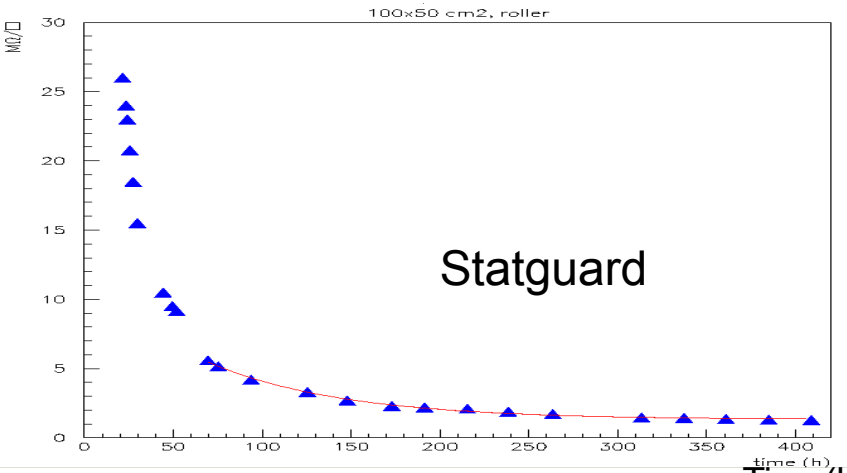


Resistive coating study

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

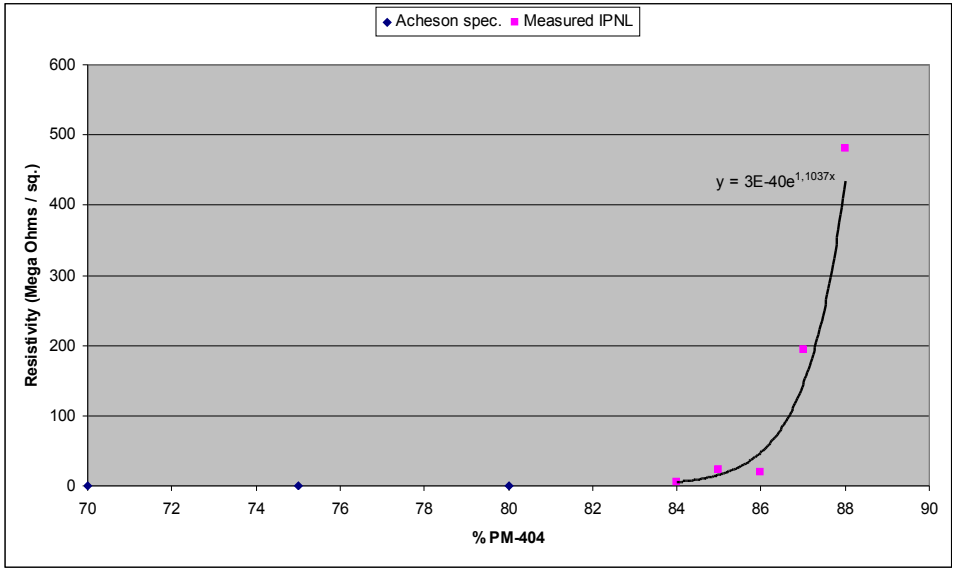
Licron : Loss of HV connection over time (1-2 months)

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

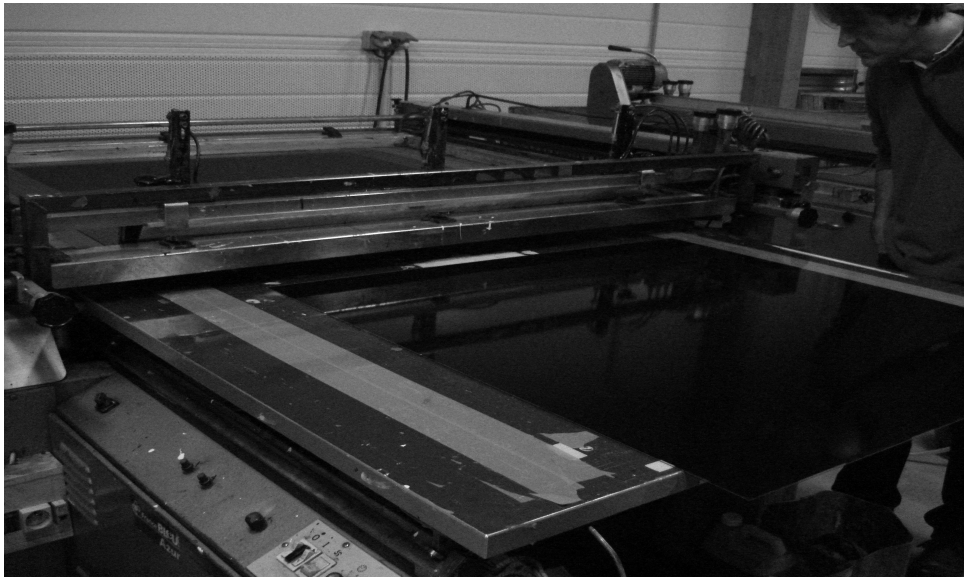


Time(h)

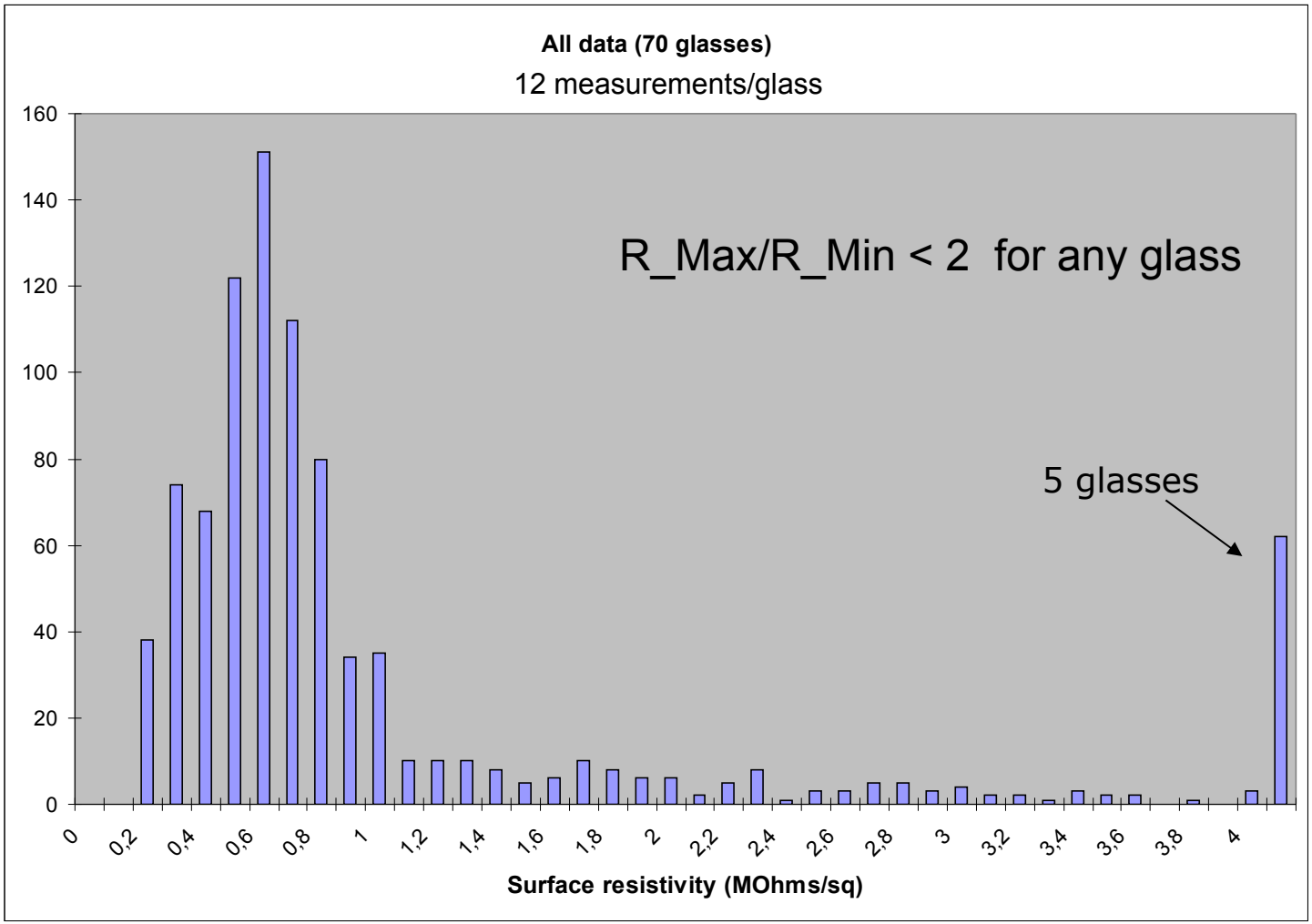
The colloidal graphite of type II is less expensive and allows to choose the needed resistivity even if this is a delicate operation



Measured resistivity as a function of the mix ratio

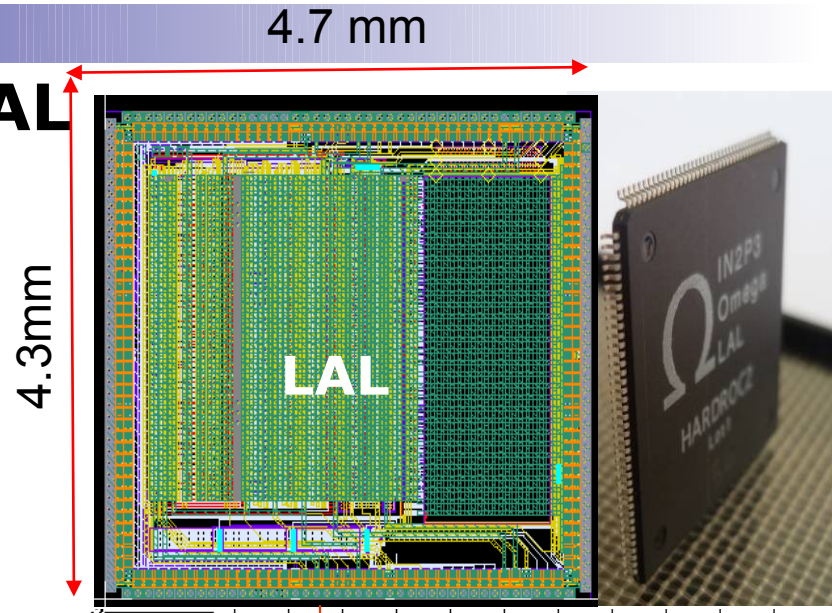


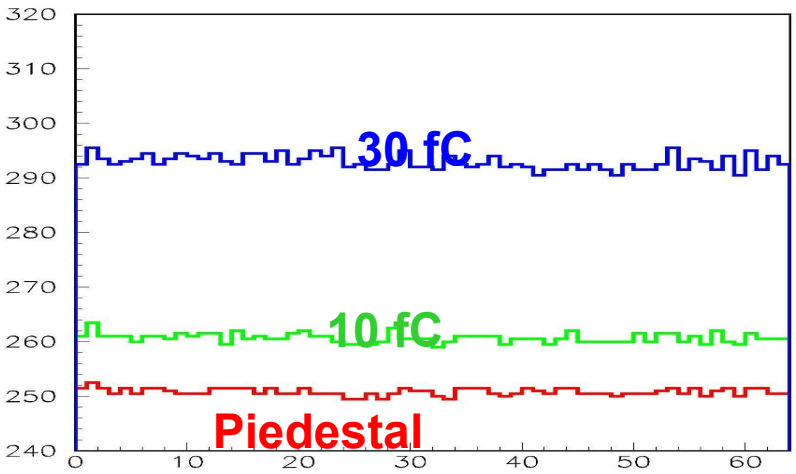
Silk-screen print method provides very good uniformity

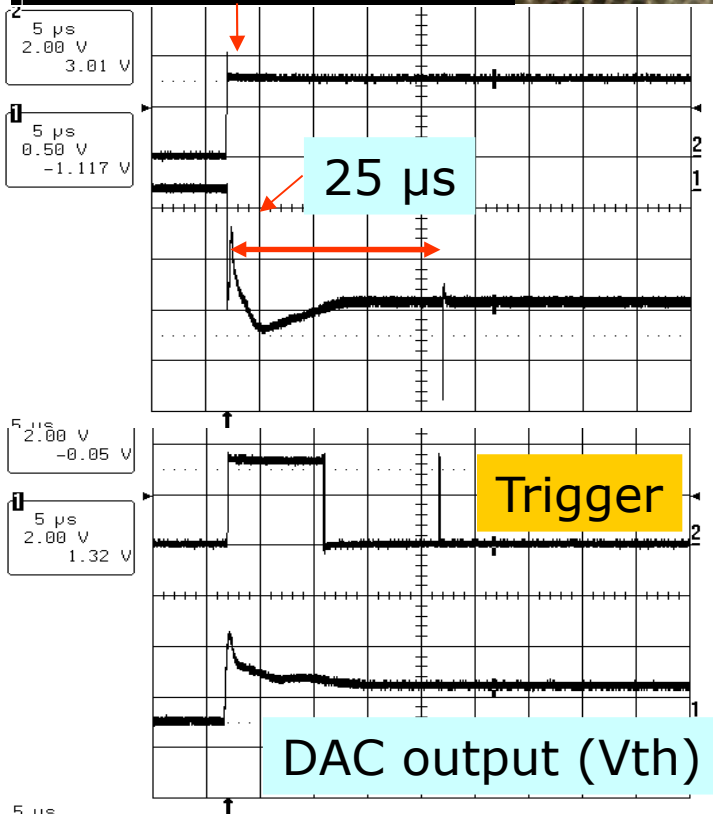

All data (70 glasses)
12 measurements/glass
R_Max/R_Min < 2 for any glass
5 glasses
160
140
120
100
80
60
40
20
0
0
0,2
0,4
0,6
0,8
1
1,2
1,4
1,6
1,8
2
2,2
2,4
2,6
2,8
3
3,2
3,4
3,6
3,8
4
Surface resistivity (MOhms/sq)

Electronics for GRPC-SDHCAL

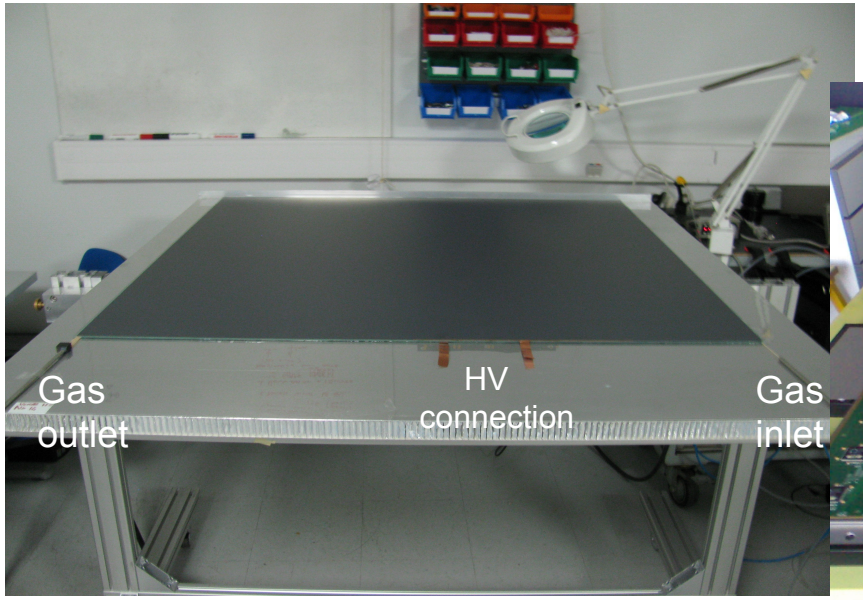
ASICs : HARDROC2
64 channels
Triggerless mode
Memory depth : 127 events
3 thresholds
Range: 10 fC-30pC
Gain correction → uniformity

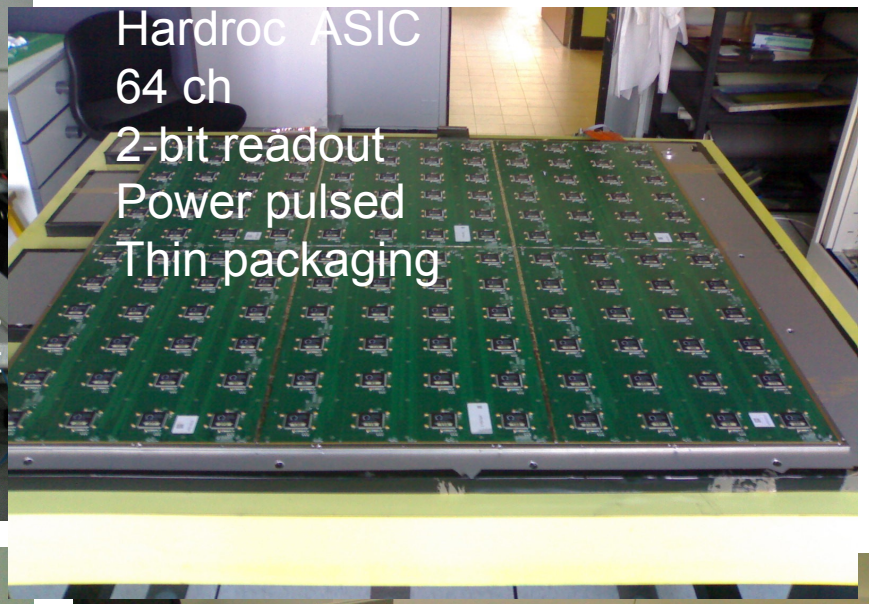




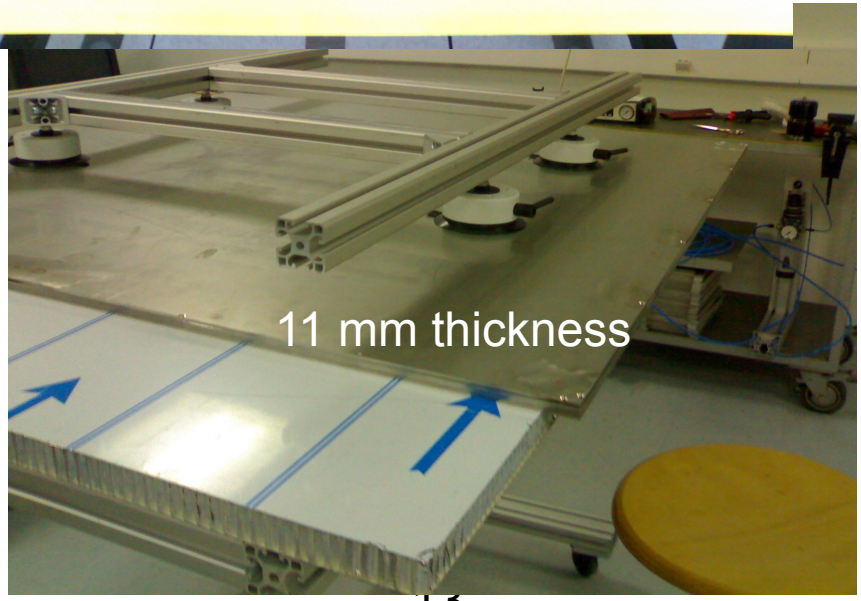


Power-pulsed→ consumption< 10µW/ch
(0.5% duty cycle), X-talk < 2%


Gas
outlet
HV
connection
Gas
inlet

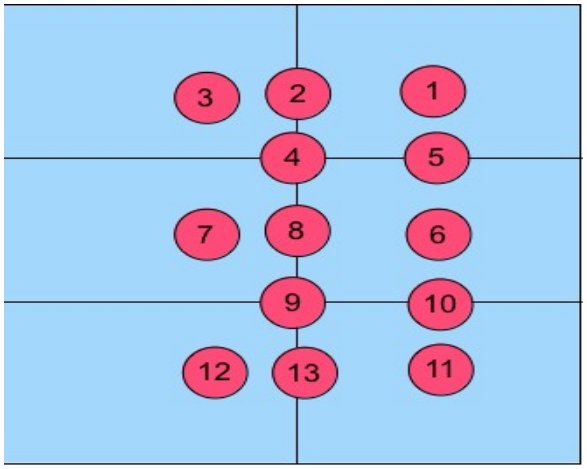

Hardroc ASIC
64 ch
2-bit readout
Power pulsed
Thin packaging

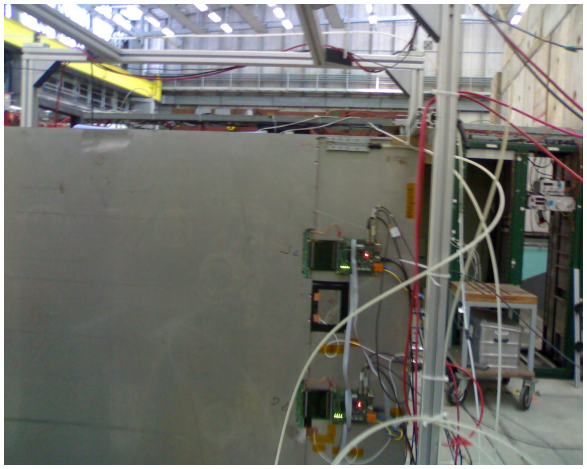

9216 ch/m2


11 mm thickness

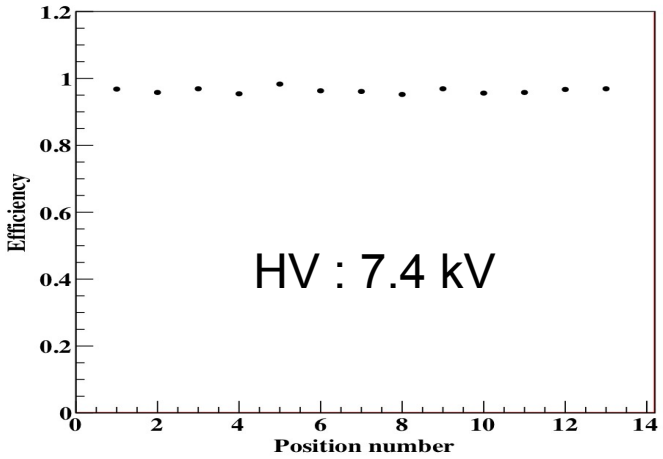
Validation

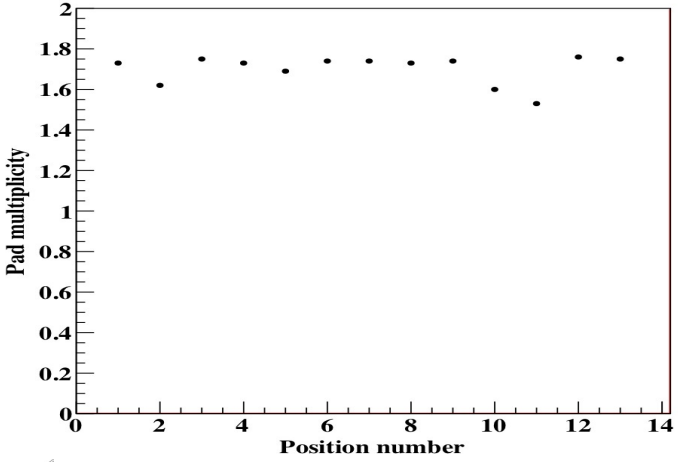
A full cassette was successfully tested at T9-PS May 2010
and H4-SPS in September 2010





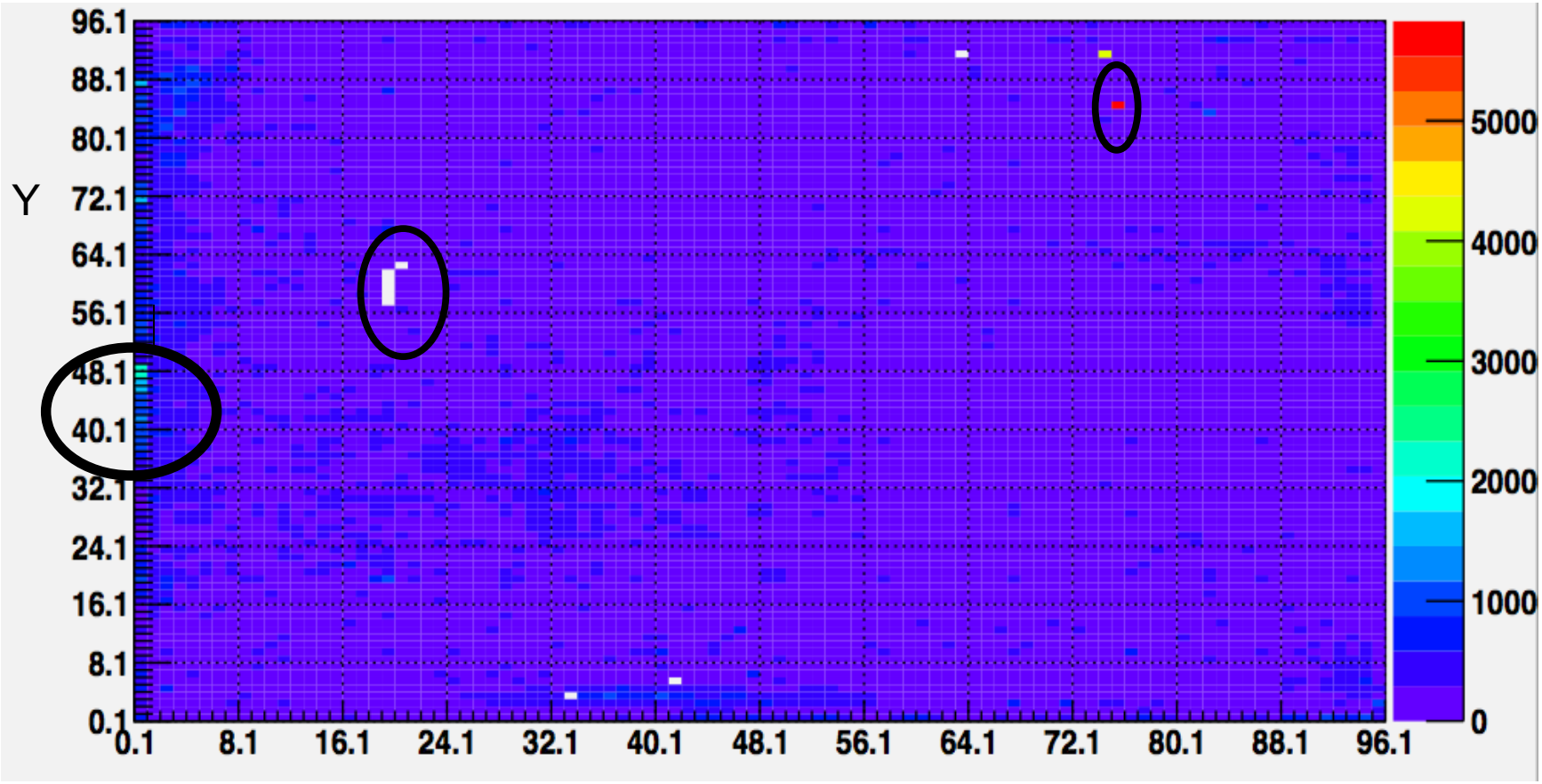
Gas mixture
TFE :94.5 %
Isobutane : 5 %
SF6 : 0.5 %





Validation

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

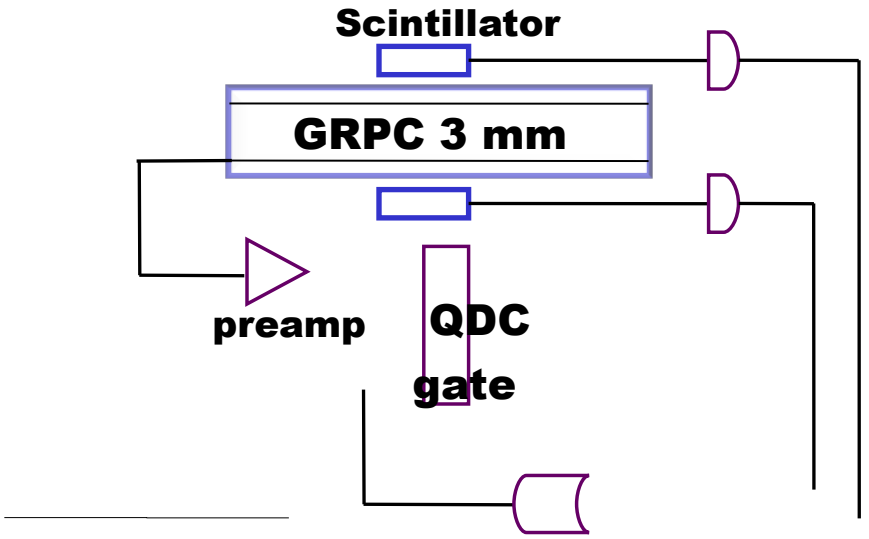


Noise Map

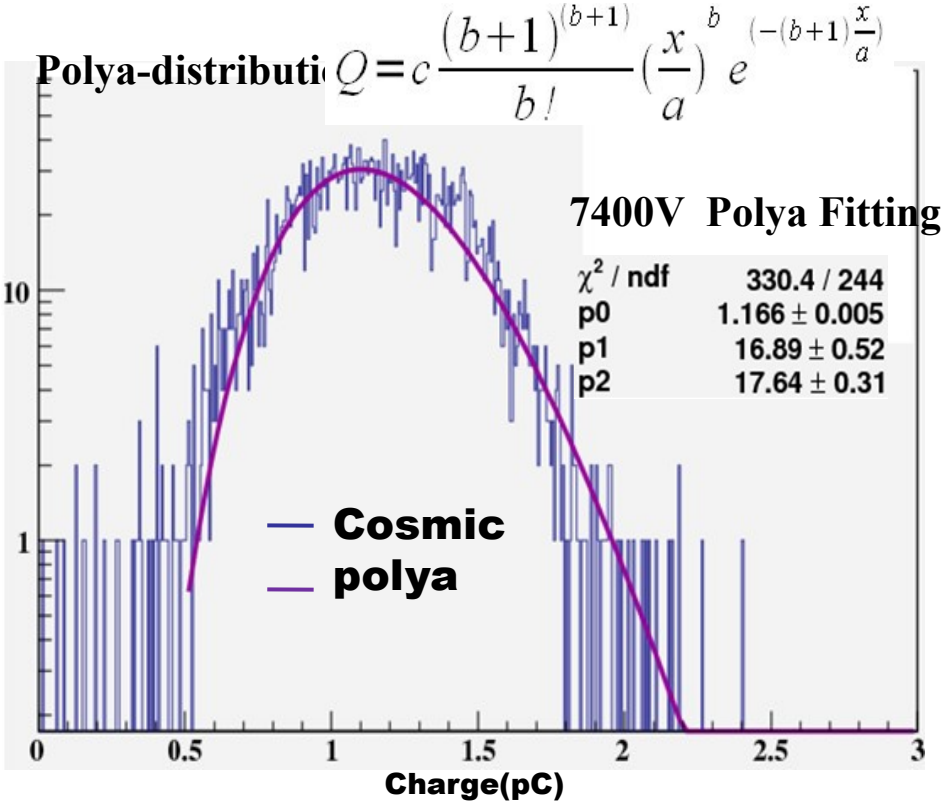
X

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)

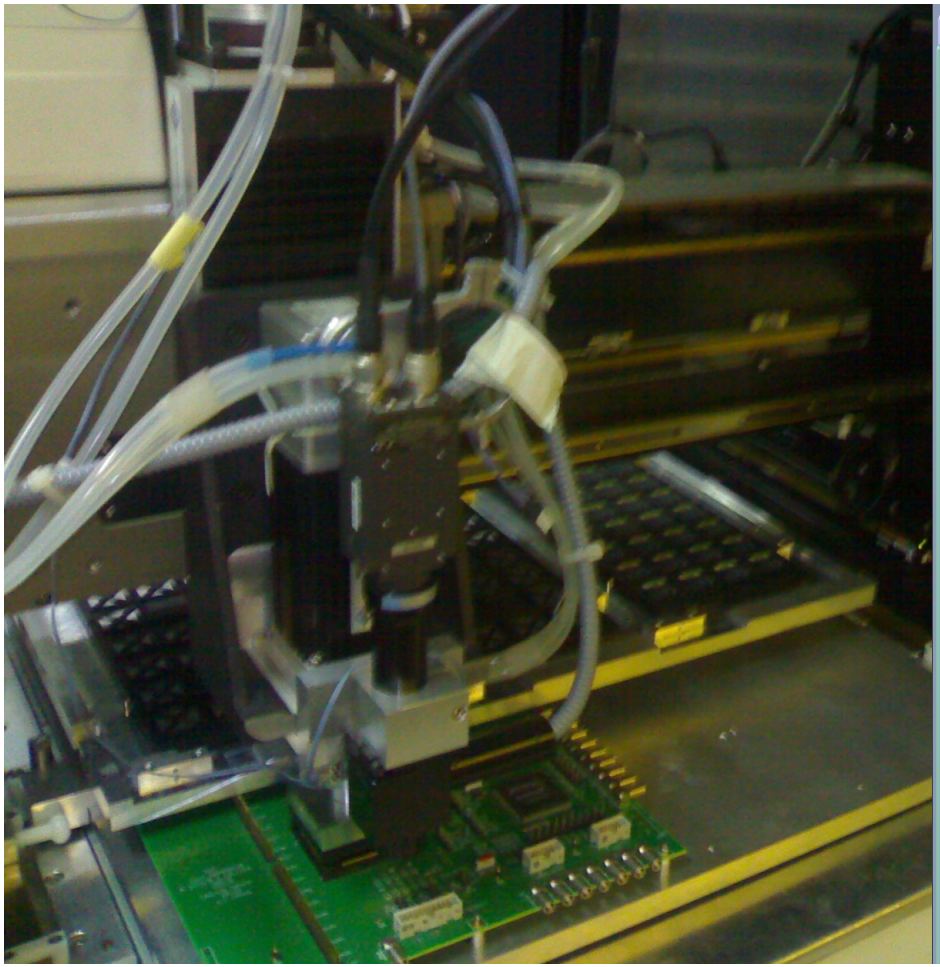


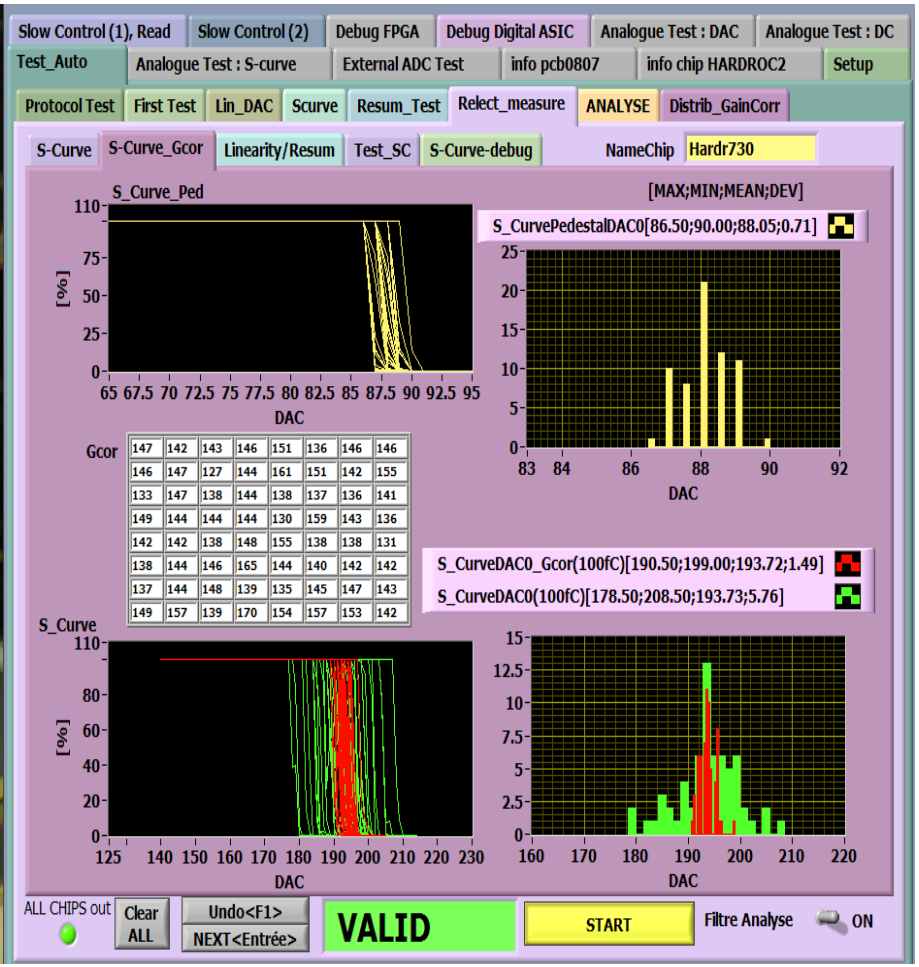
Electonics: ASICs stand test

A robot was used to test the 10500 ASICs

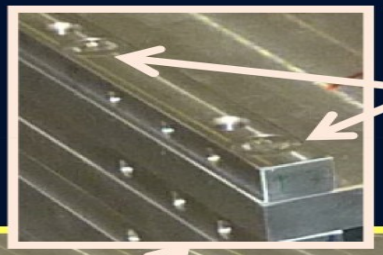
The procedure allows to select the good ASICs and calibrate them

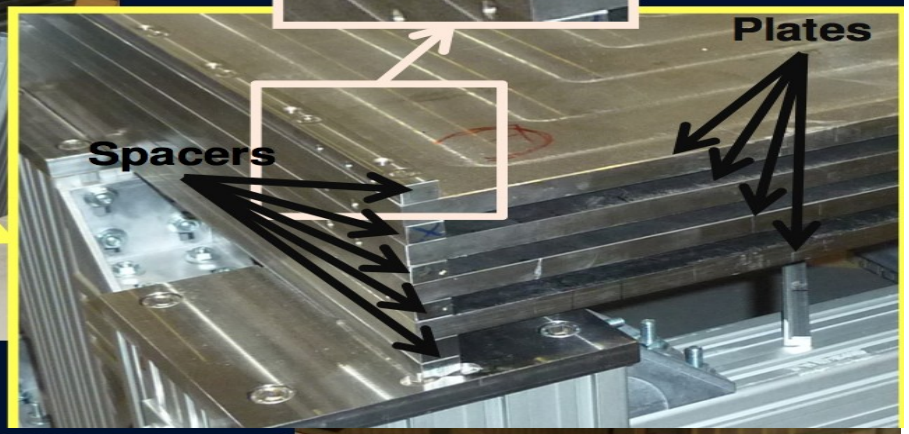
Yield 93%



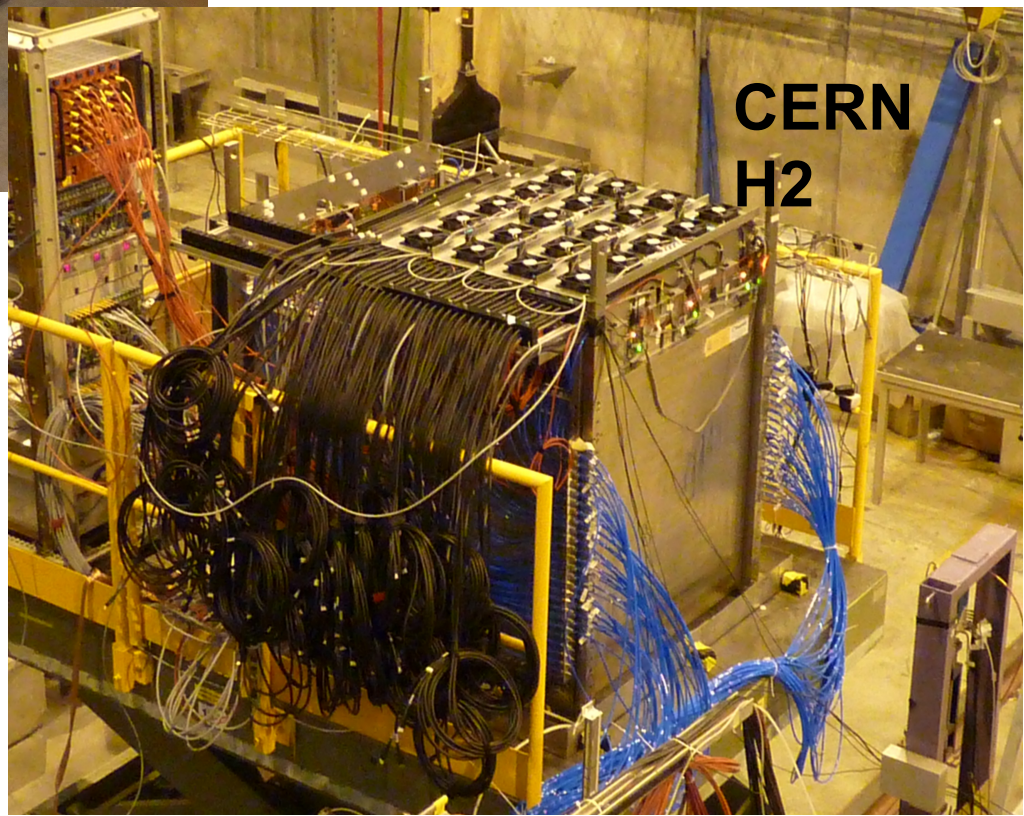


50 Chambers are built and will be used in the SDHCAL prototype in the coming days..


Bolts


Plates
Spacers

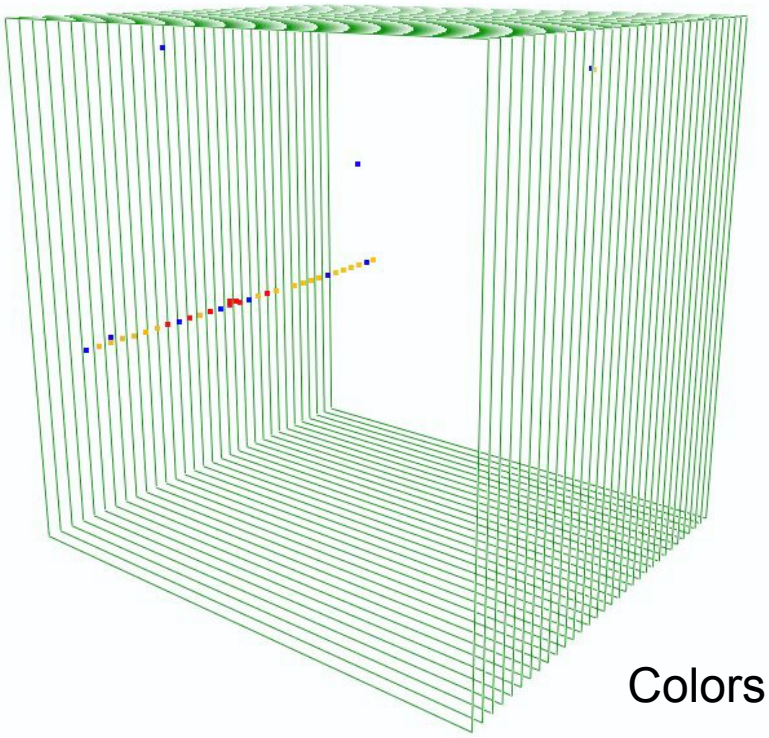

Planarity Verification



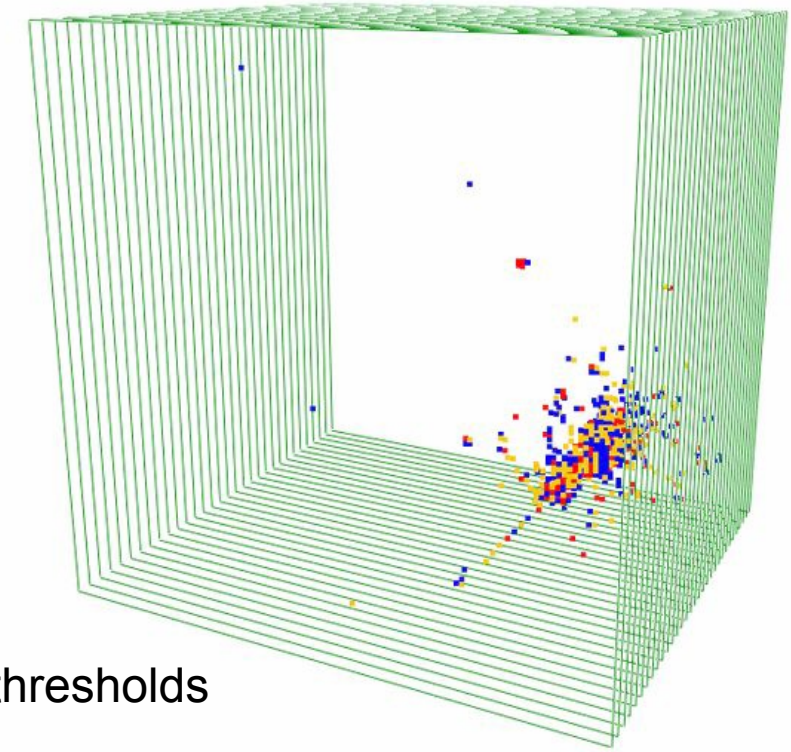
The SDHCAL prototype was assembled at CERN and then exposed to pion beam at H2-SPS in June 2011

First commissioning Test Beam at CERN in June 2011 SPS-H2 beam line

Using USB-based DAQ: very slow and problem with synchronization



Colors : 3 thresholds

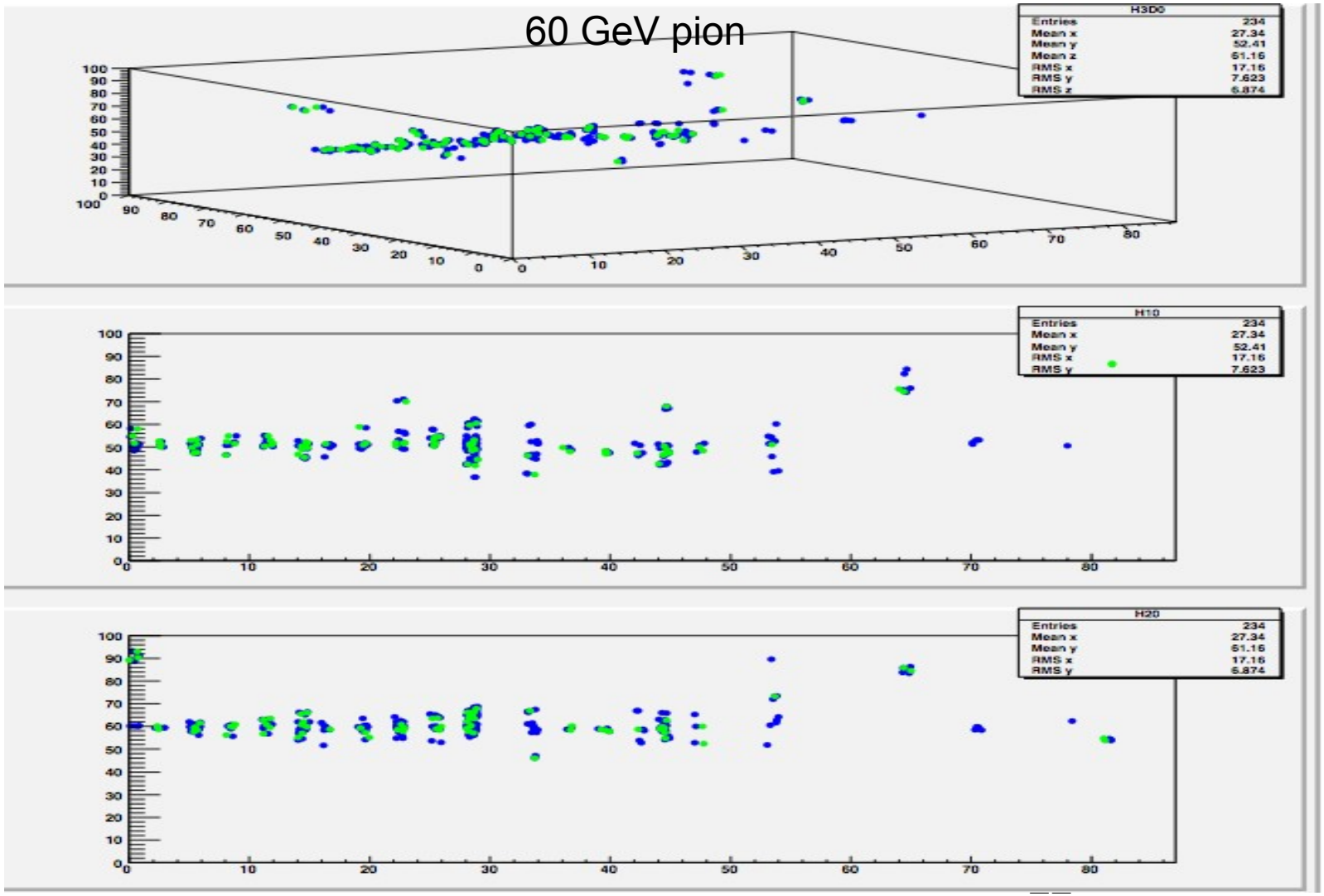


Muons (150 GeV)

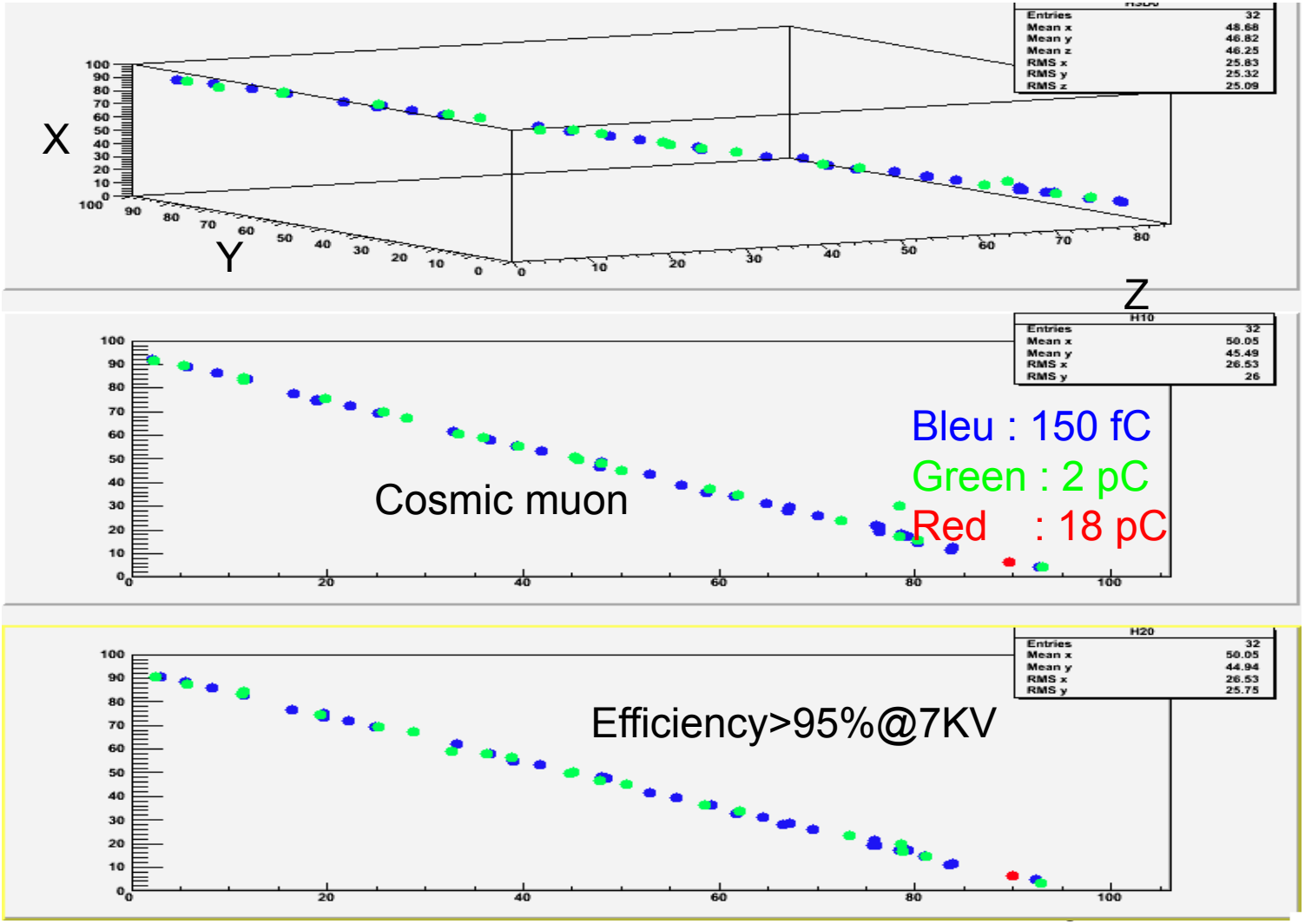
Pions

Second commissioning Test Beam at CERN in October 2011 H8 beamline

Using CALICE HDMI-base DAQ : instability, problem with the DAQ boards and loss of data.



New DAQ system has been developed waiting for the final DAQ.
It uses the HDMI protocol for the synchronization and the USB to read the recorded data in the ASIC memory and it works.....



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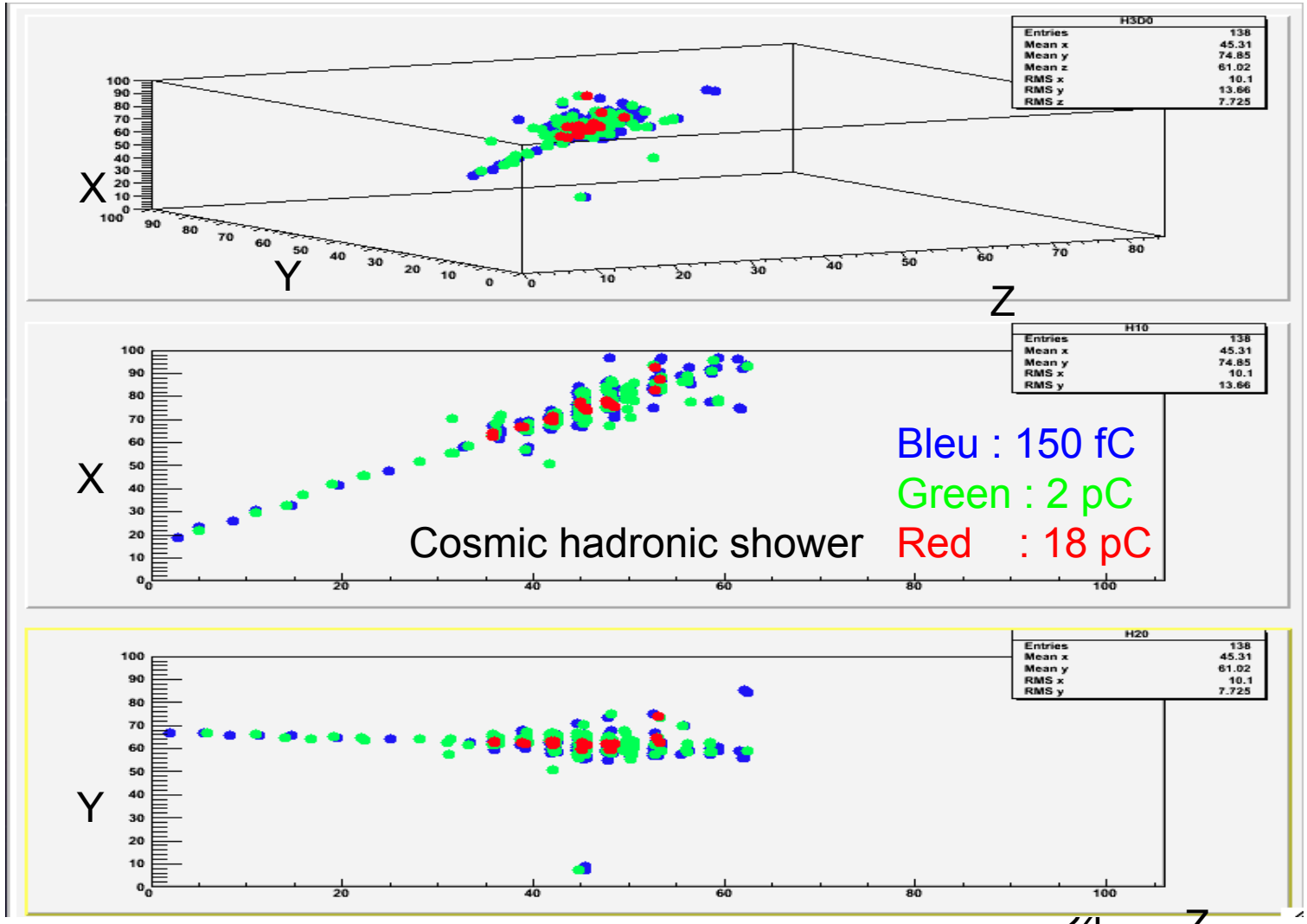


Conclusion&Perspectives

- An extensive development of GRPC as a sensitive medium for a Semi-Digital Hadronic CALorimeters has been conducted.

-A new design of spacers reducing both dead zones and noise is proposed. A scheme of gas distribution is designed. Resistive coatings are carefully studied and adequate products found.

-50 detectors following the previous scheme are built and equip a prototype of > 1m3.

-New DAQ system will be used in spring TB at CERN to validate the SDHCAL principle.

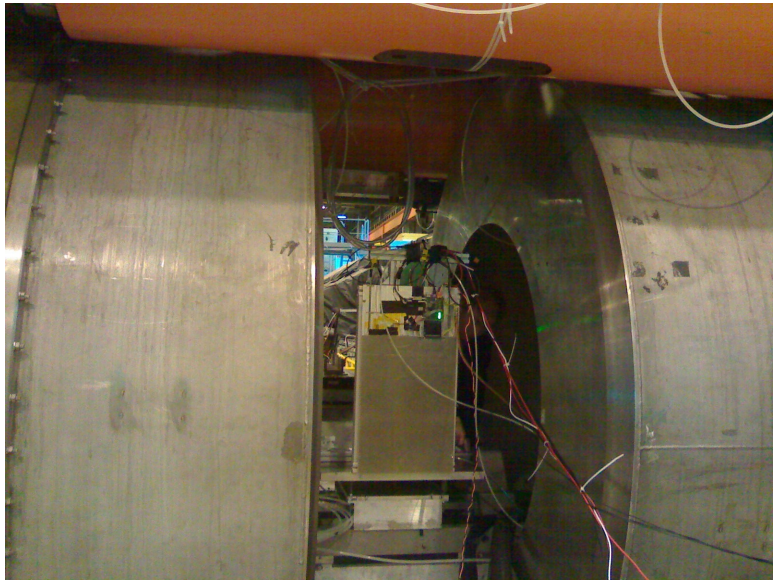
-A dedicated study using a radioactive gas (Kr83) will be conducted to confirm the gas circulation simulation in large chambers

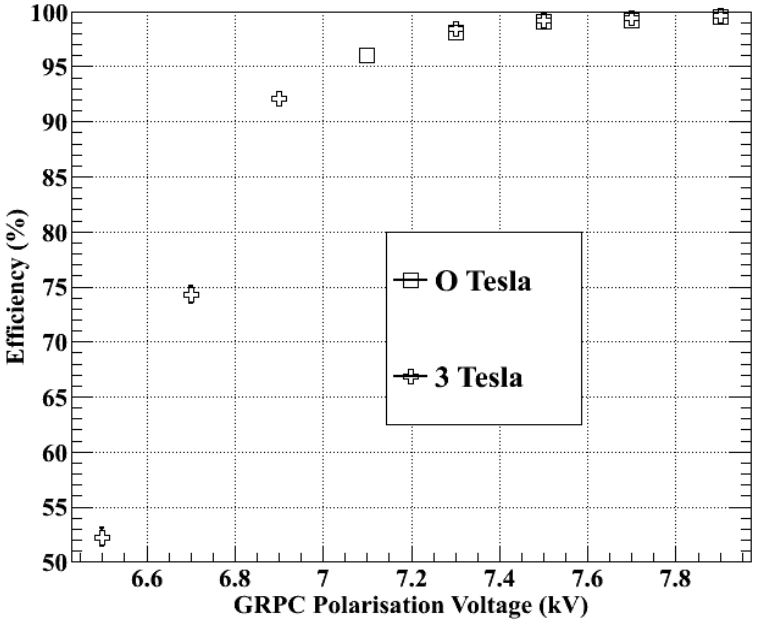
- Larger GRPCs (2m3, 3m2) will be built and tested using the same readout electronics

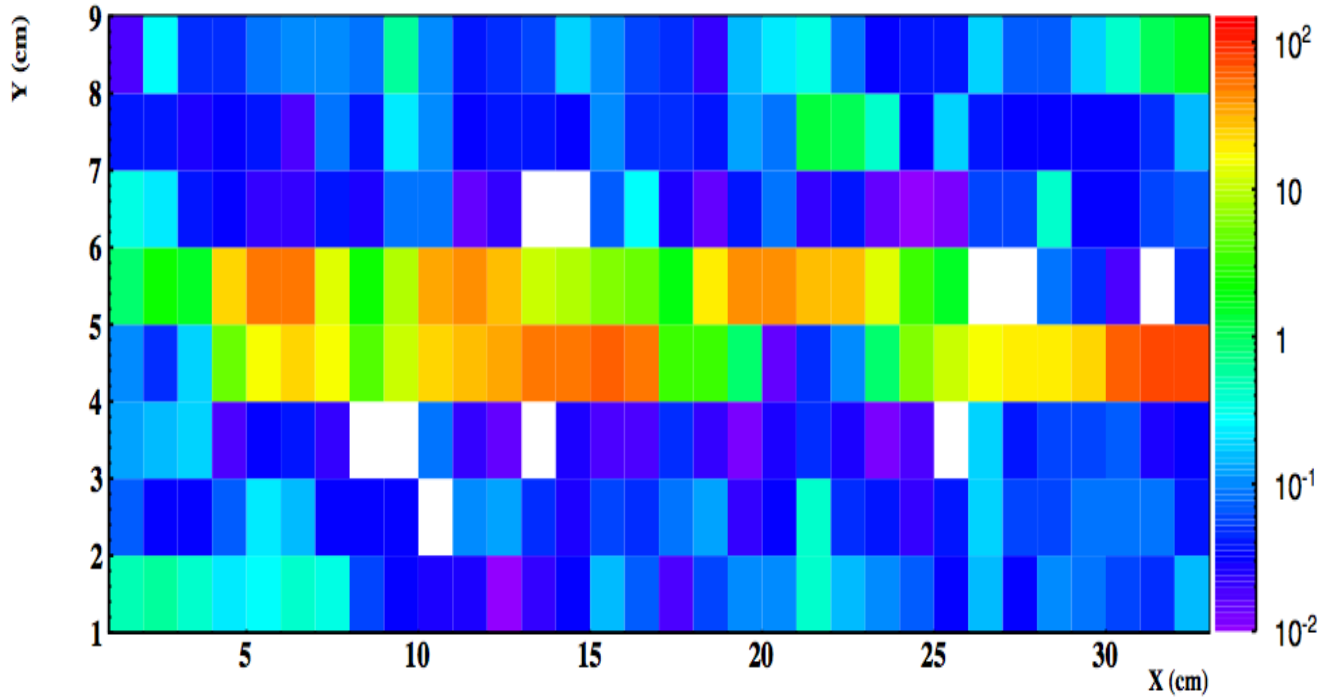
BACKUP

Validation

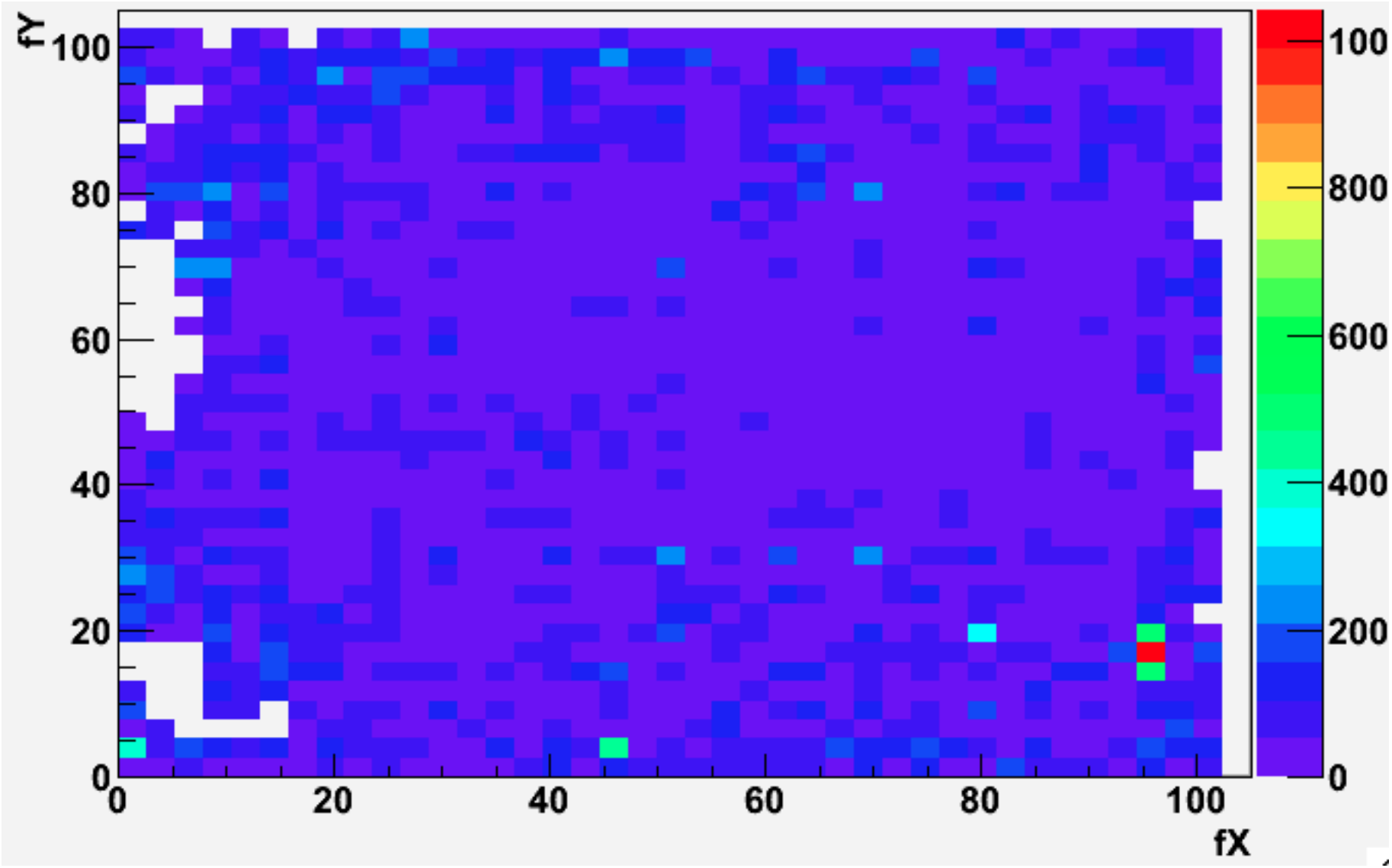
A GRPC (33X50 cm2) was tested using the same readout electronics in a 3-Tesla magnet in the H2-SPS beam line. No effect was found.







Noise map of a 33X8.3 cm2 GRP with a fishing line in the middle



Noisy zones can be masked by software