High rate high granularity GRPC SDHCAL

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Abstract

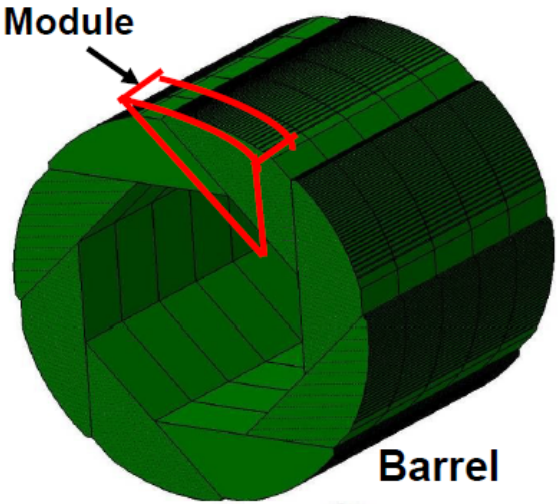
- **Motivation**
- **Prototype of 1m^2 of glass RPC**
- **Beam test results**
- **High rate GRPC**
- **Conclusions**

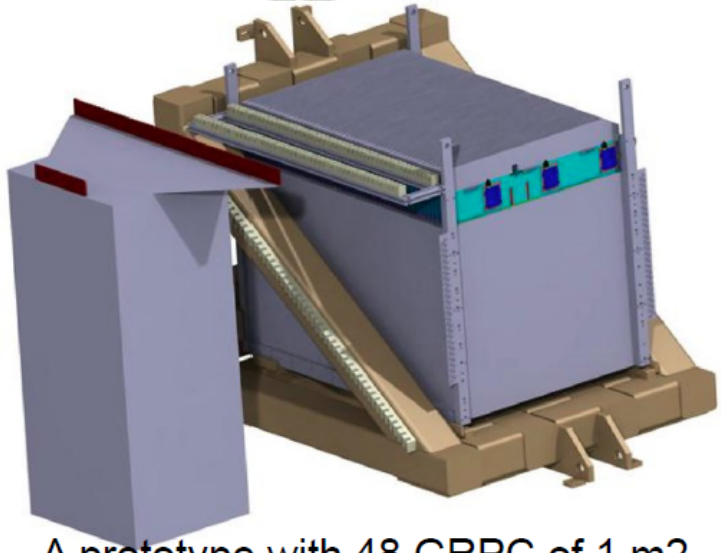
Motivation

-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





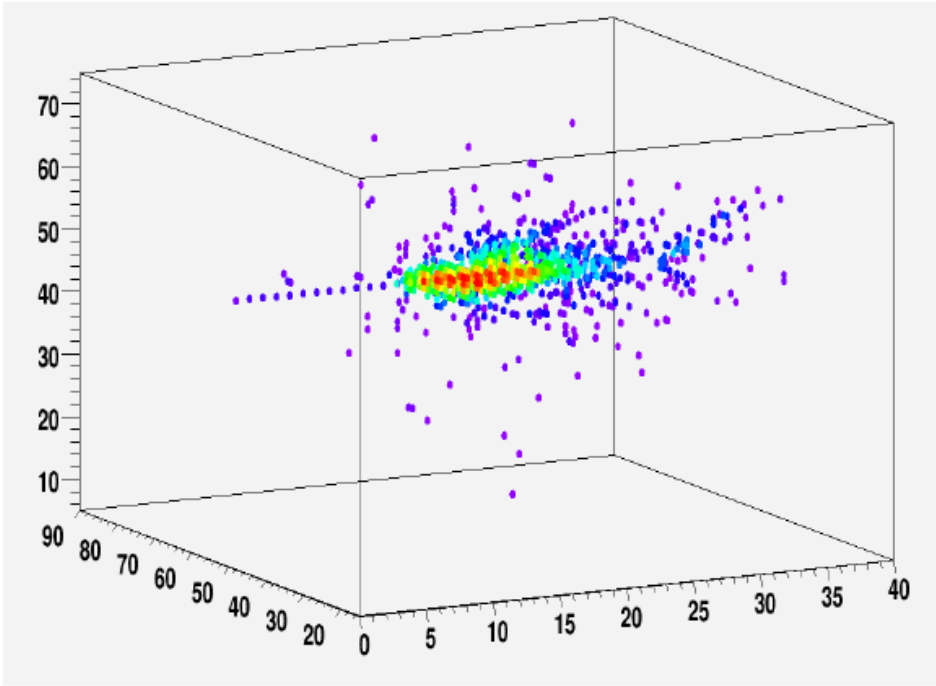
A prototype with 48 GRPC of 1 m2 was conceived as a demonstrator

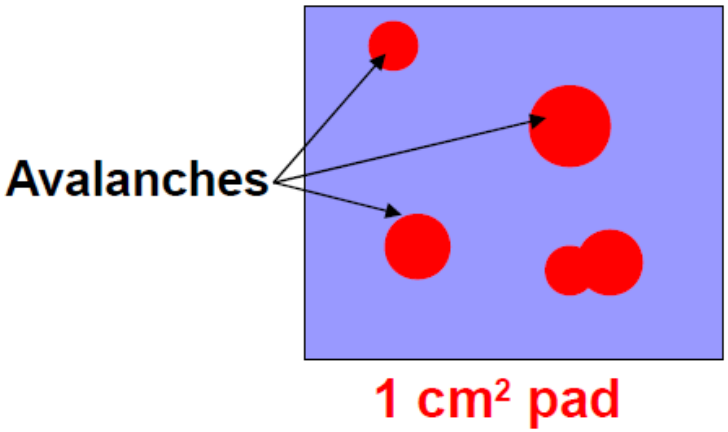
Motivation

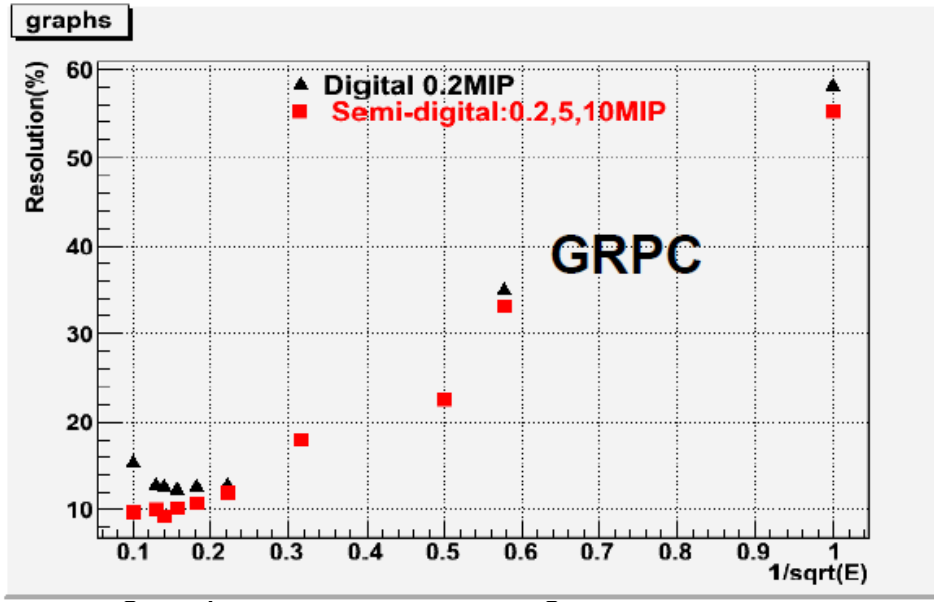
Electronics readout choice

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.







Challenges

To build a **technological prototype** one needs:

1- Large detector ($1m^2$) with almost no dead zones :

2- Large and thin embedded electronics board

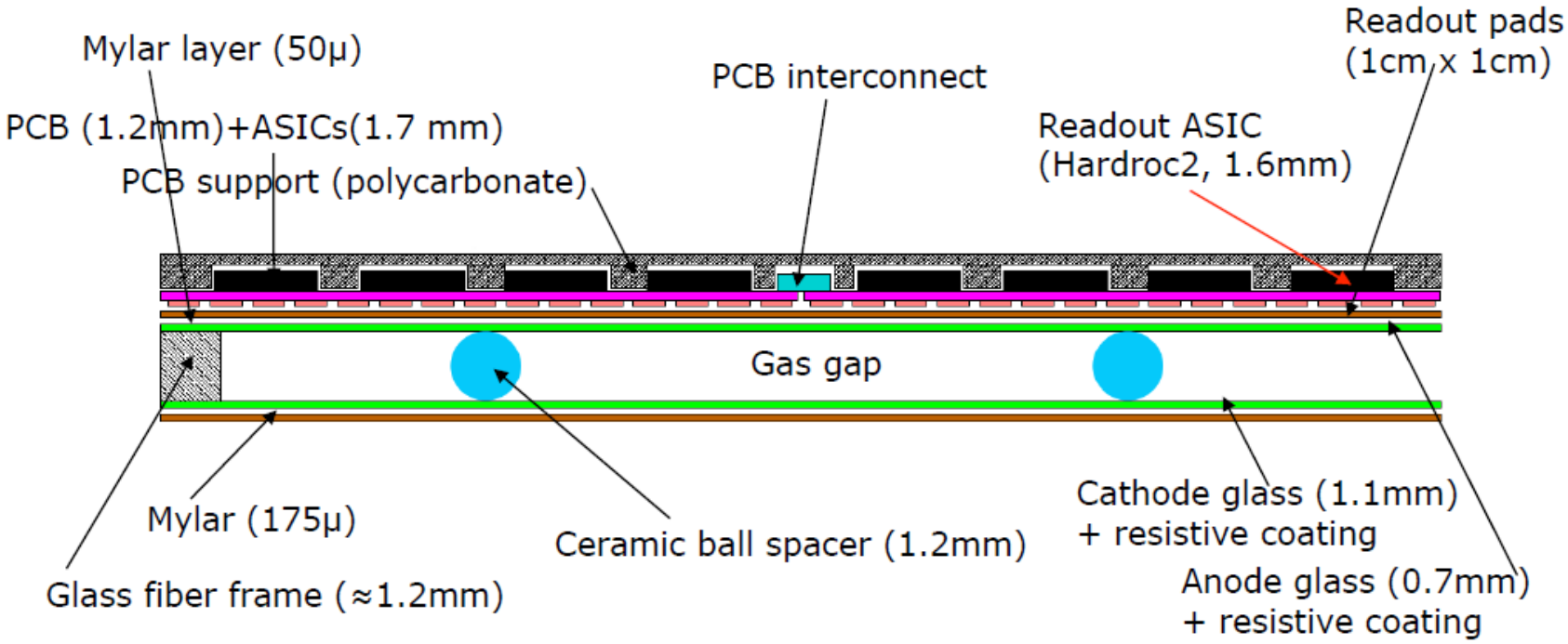
4- One-side services : readout, gas outlets..

5- Self-supporting mechanical structure

6- Power-pulsed, 2-bit electronics

7- New generation of DAQ system

Prototype of 1m^2 glass RPC

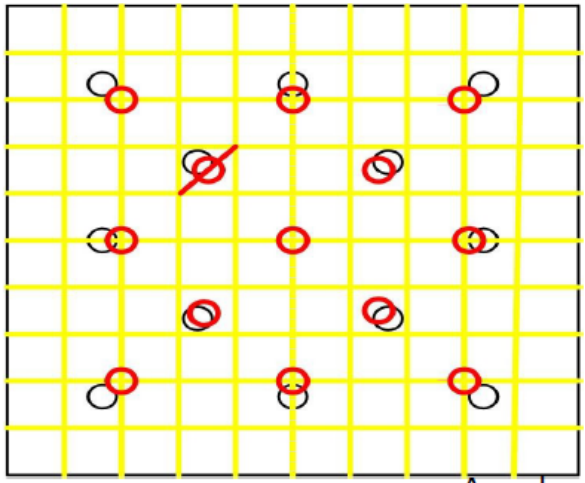


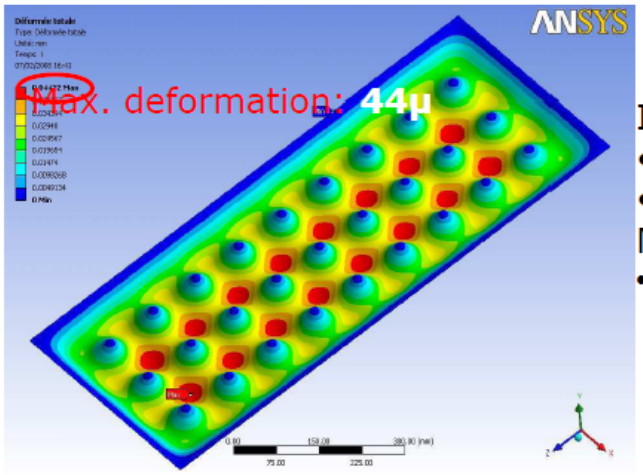
Total thickness: 6.0mm

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

Homogeneity study

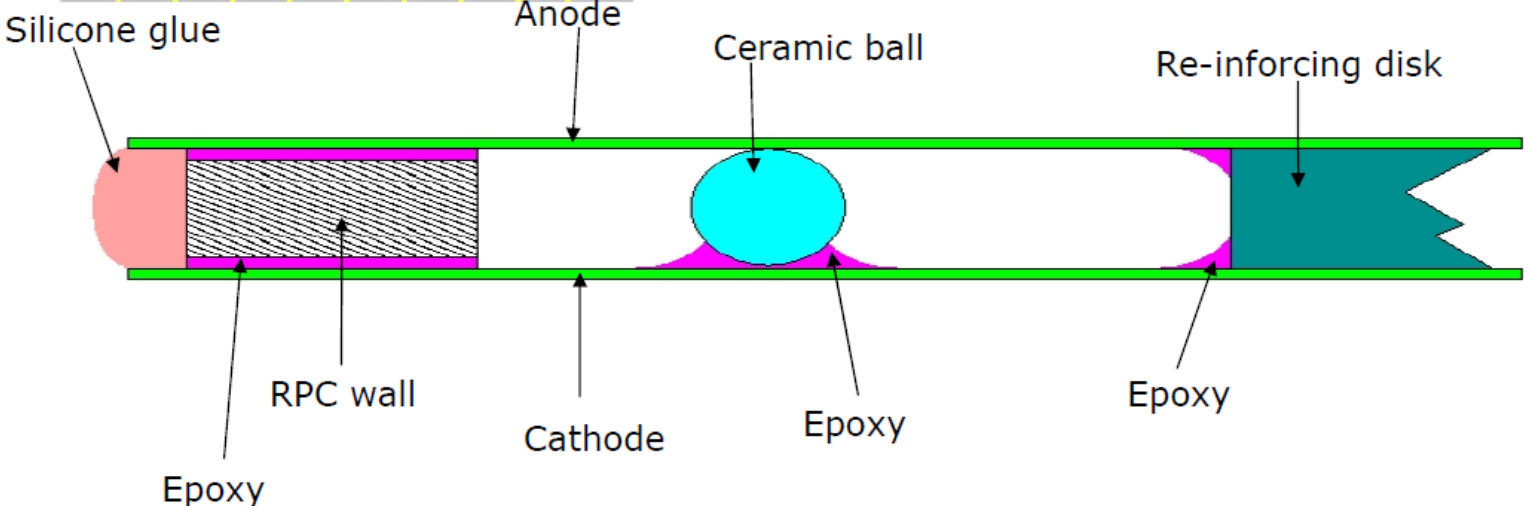
To maintain the same distance between the two glass plates, spacer are used every 10 cm : 68 ceramic balls+ 13 fiber glass disks.



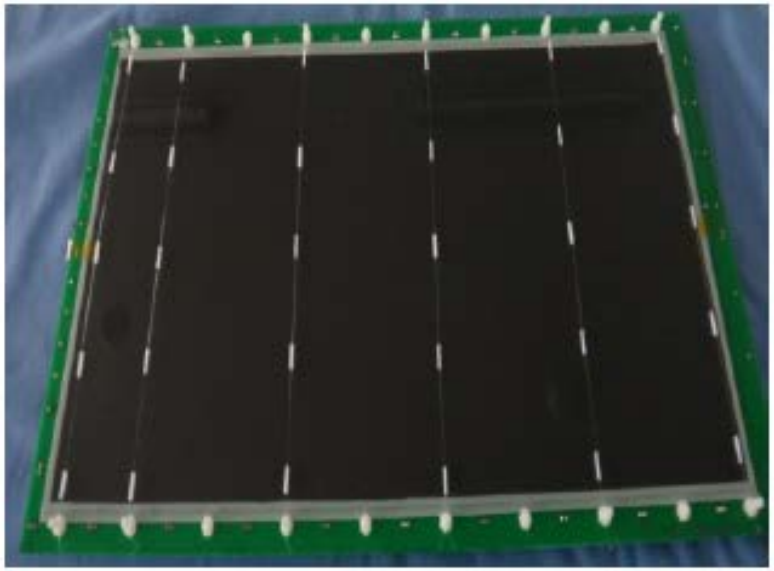


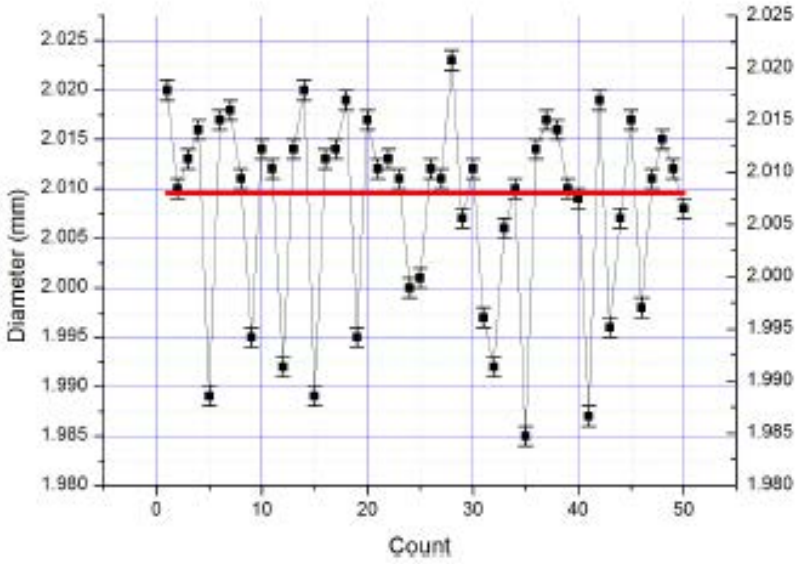
Included
- glass weigh
- electrostatic force

Not included
- Gas pressure



Necklace spacer

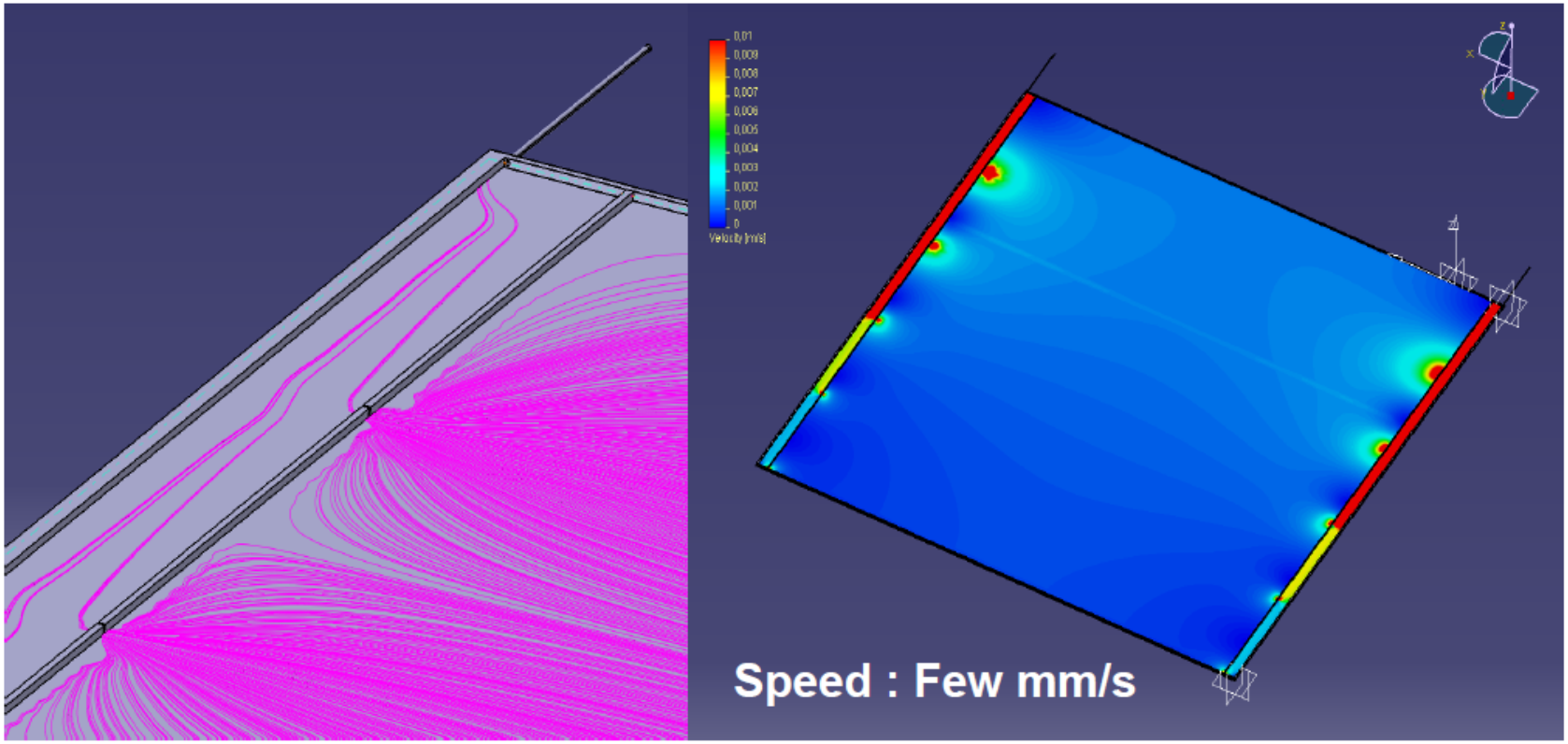




- ✓ The spacer is ϕ2mm PTFE tube. Its uniformity is excellent and commercially available. Dead area is smaller than cylindrical spacer.
- ✓ There is no glue on spacer and will not cause extra noise.

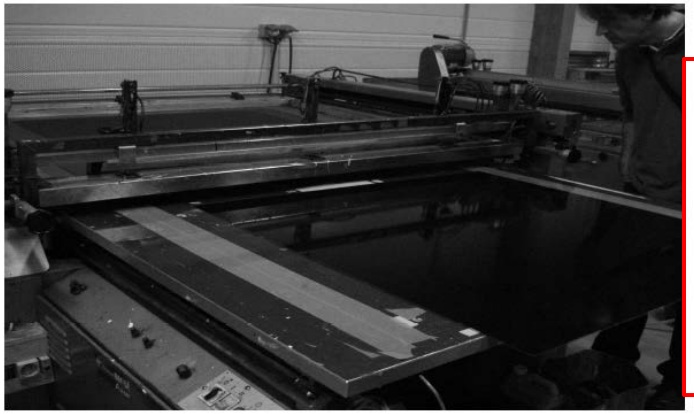
Gas distribution system

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

Resistive coating

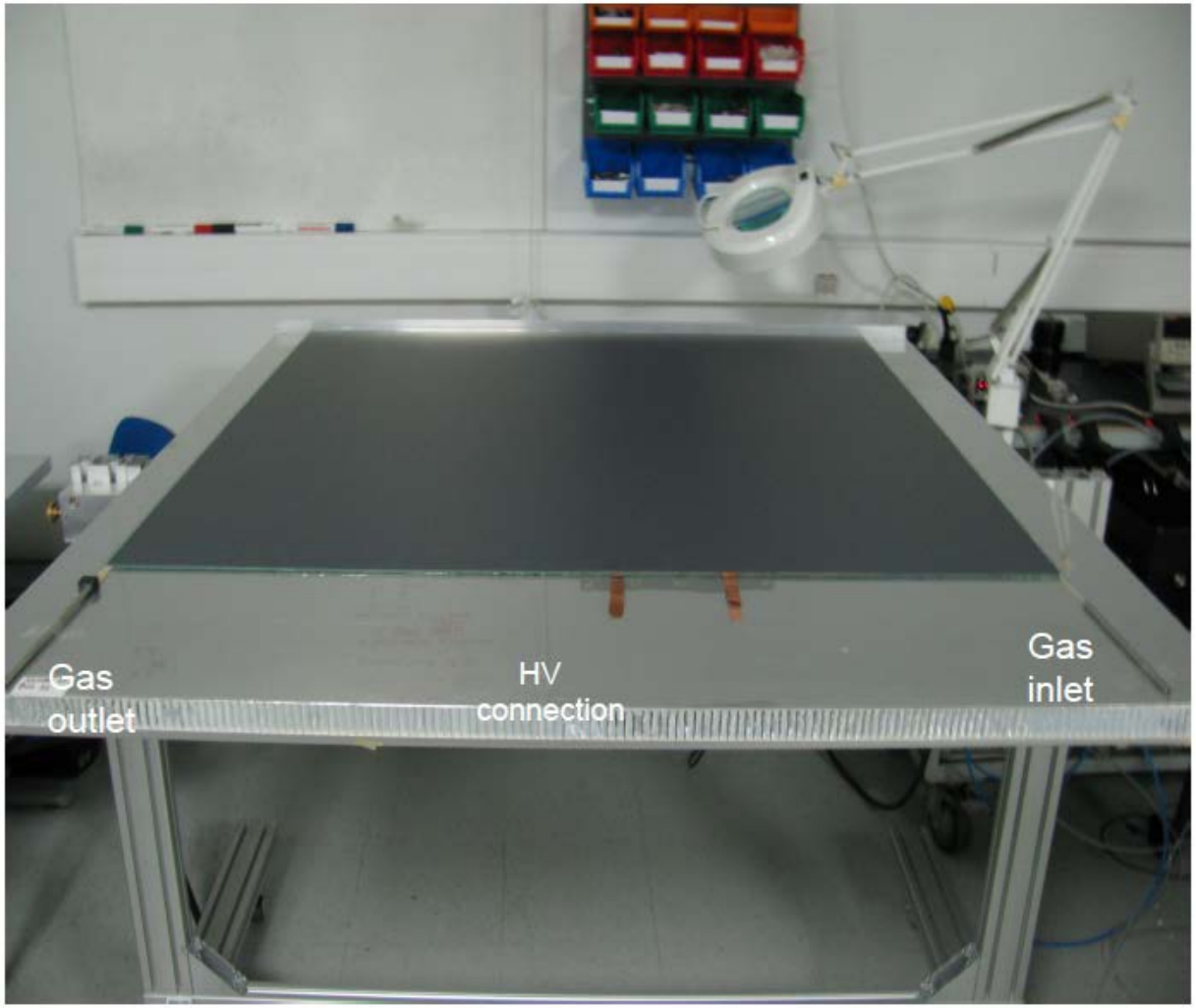


	Colloidal Graphite Type II	Chinese Colloidal graphite
Surface resistivity (MΩ/□)	~0.7	1~10
Application method	Silk screen	Spray printing

Silk-screen pint @Lyon

Colloidal graphite spray @Tsinghua

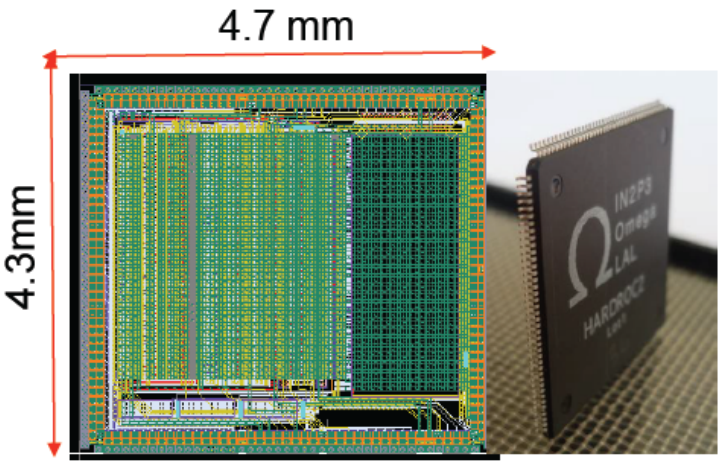
Prototype of gas gap



Readout electronics

Electronics readout system R&D

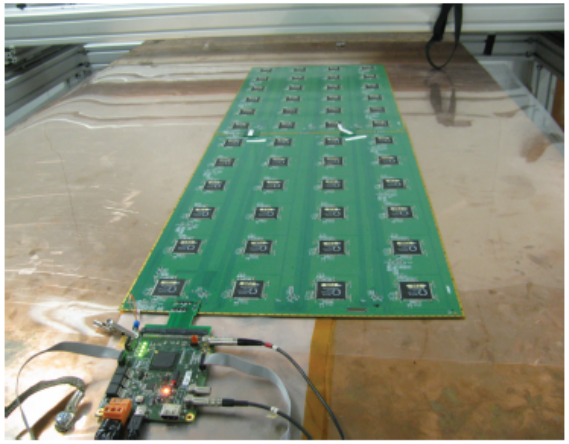
ASICs : HARDROC2
64 channels
Trigger less mode
Memory depth : 127 events
3 thresholds
Range: 10 fC-15 pC
Gain correction → uniformity



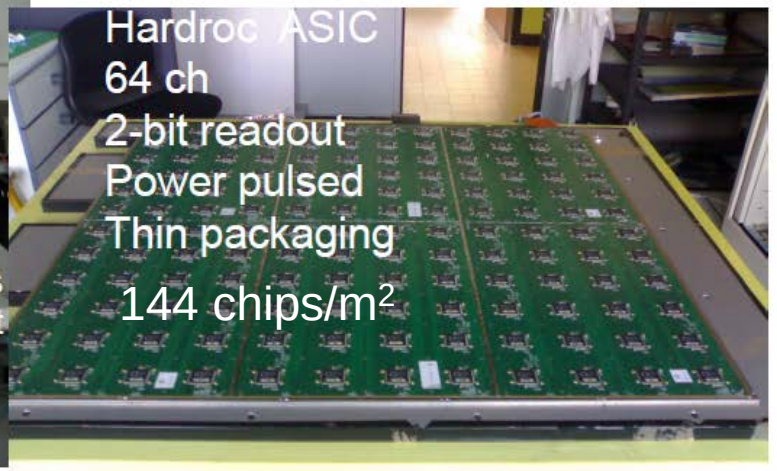
Printed Circuit Boards (PCB) were designed to reduce the x-talk with 8-layer structure and buried vias.

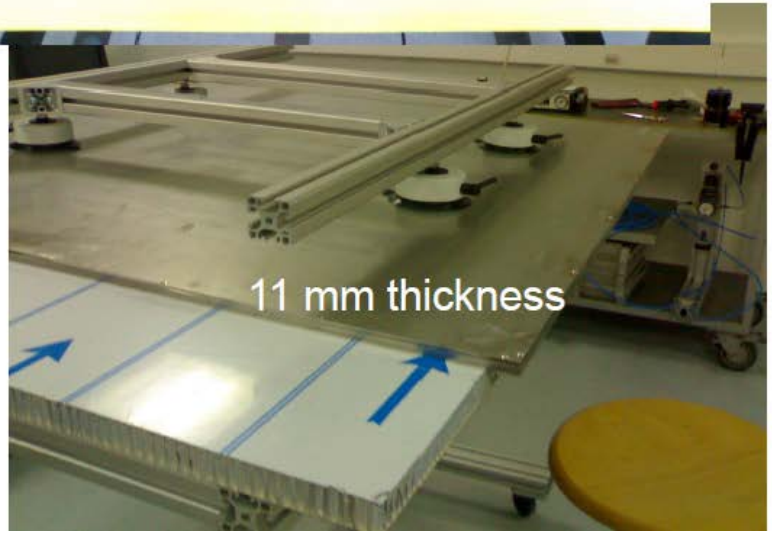
Tiny connectors were used to connect the PCB two by two so the 24X2 ASIC are daisy-chained.

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

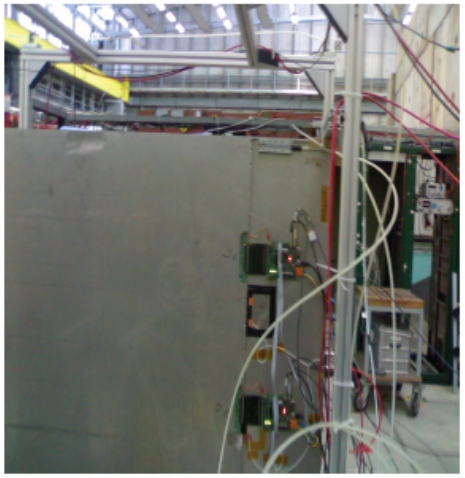


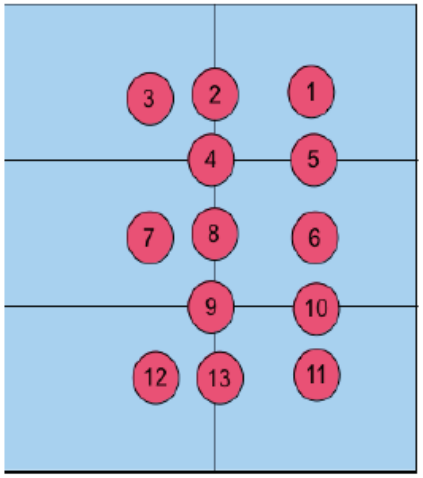
Readout electronics



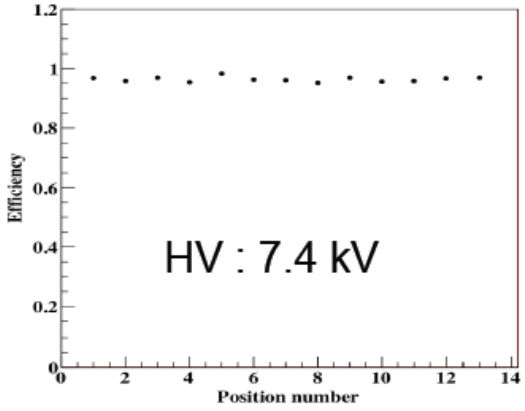


Validation of homogeneity of the detector

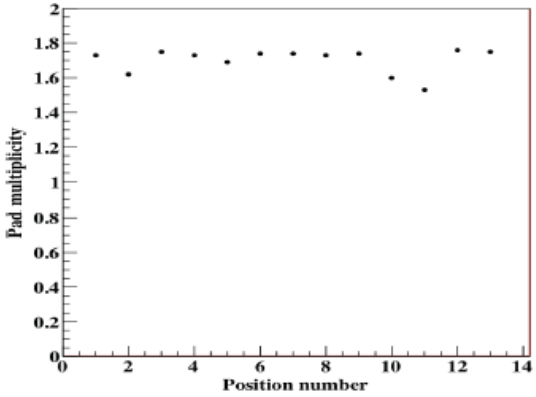




Beam spot position



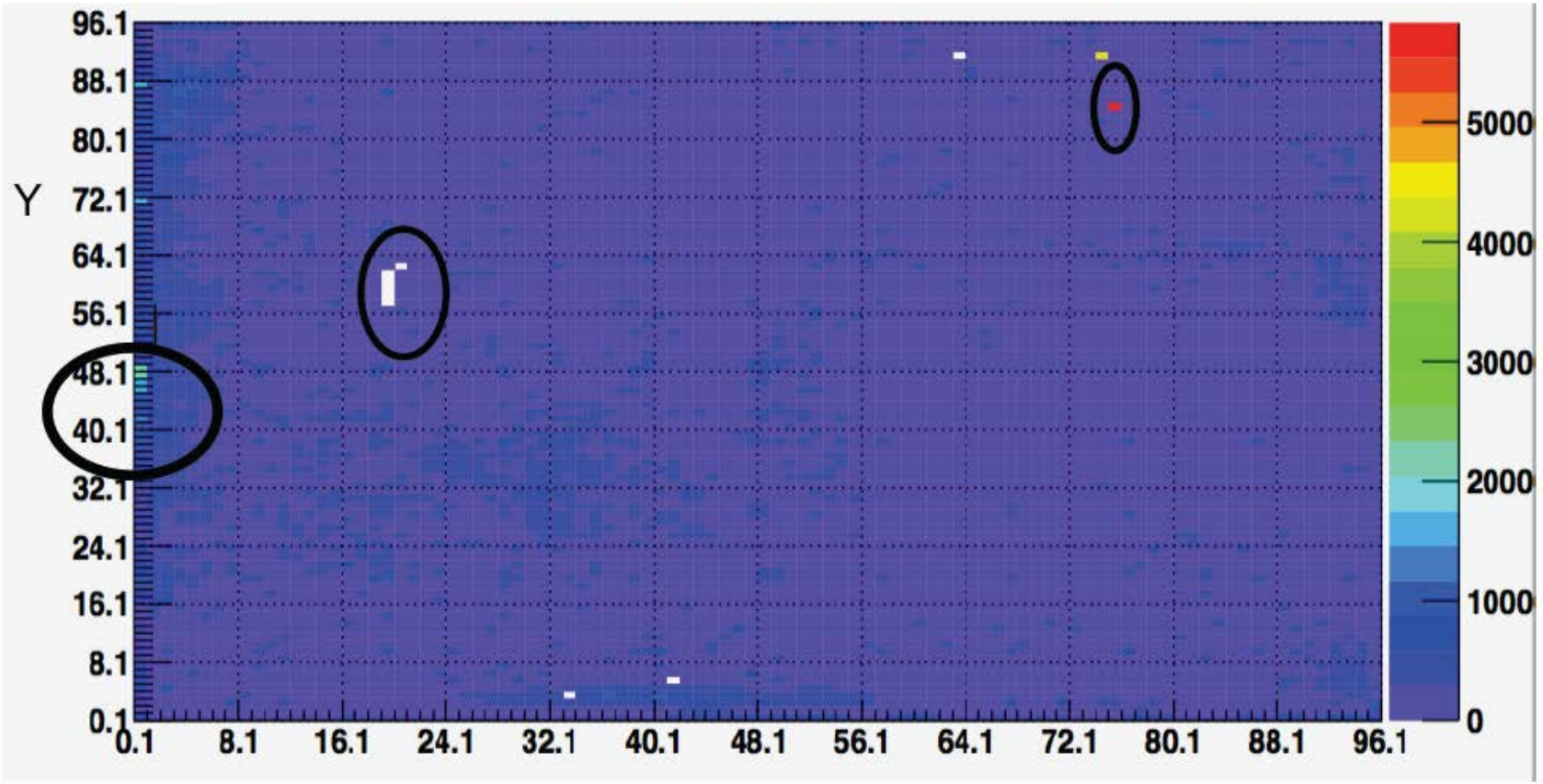
Efficiency



Multiplicity

Detector noise

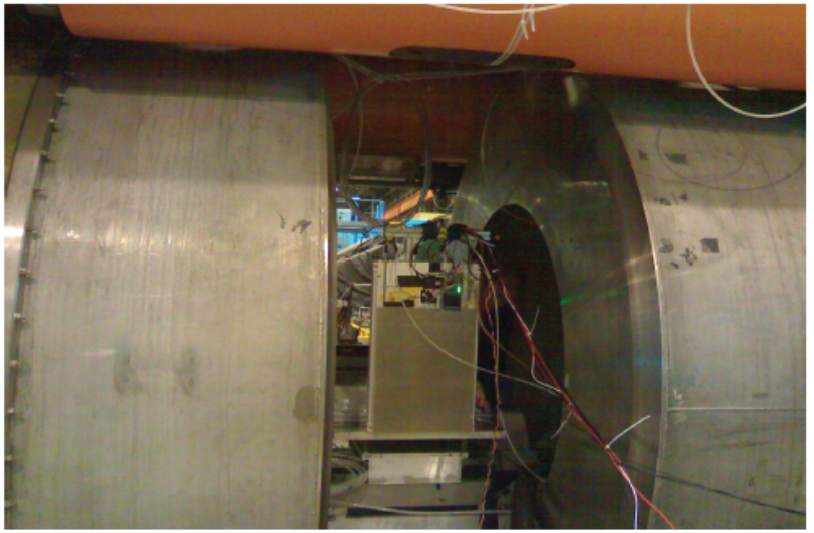
Noise was measured and found to be < 1 Hz/cm2 outside the channeling tubes and HV connection zones

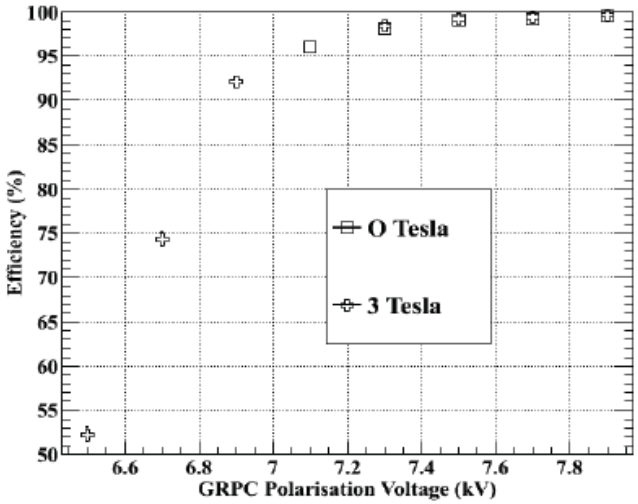


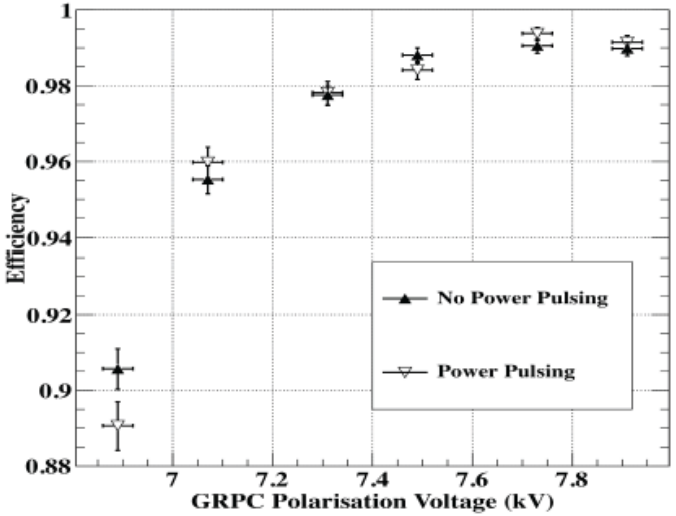
Tested in a magnetic field of 3 Tesla

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

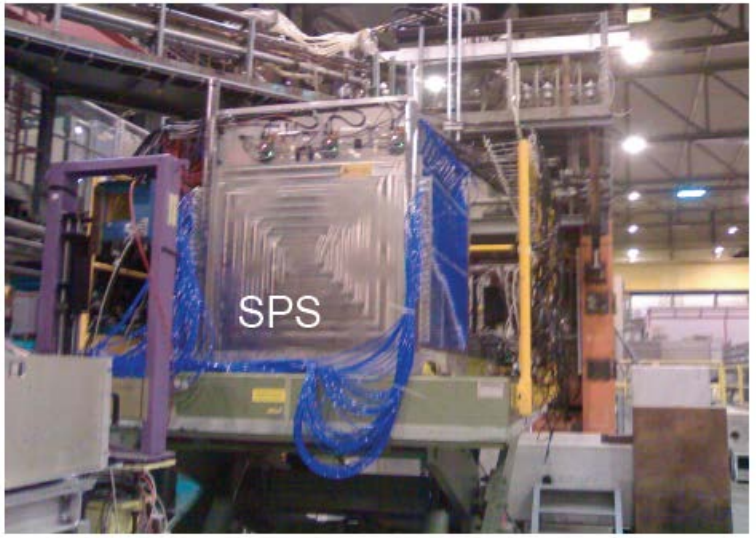


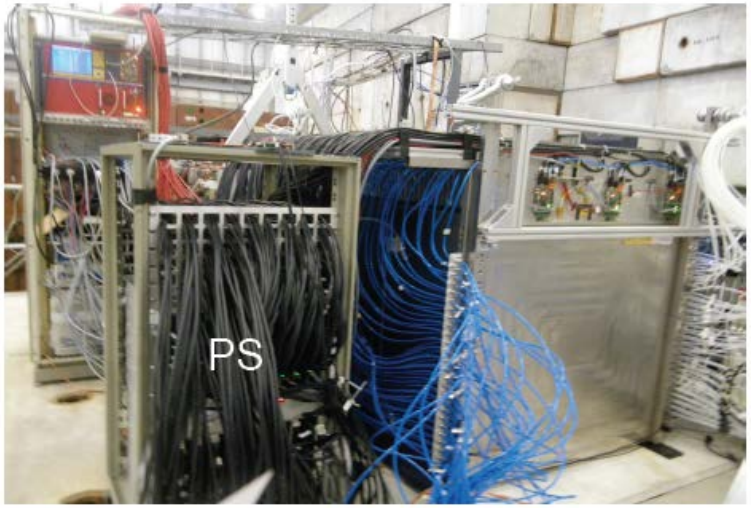


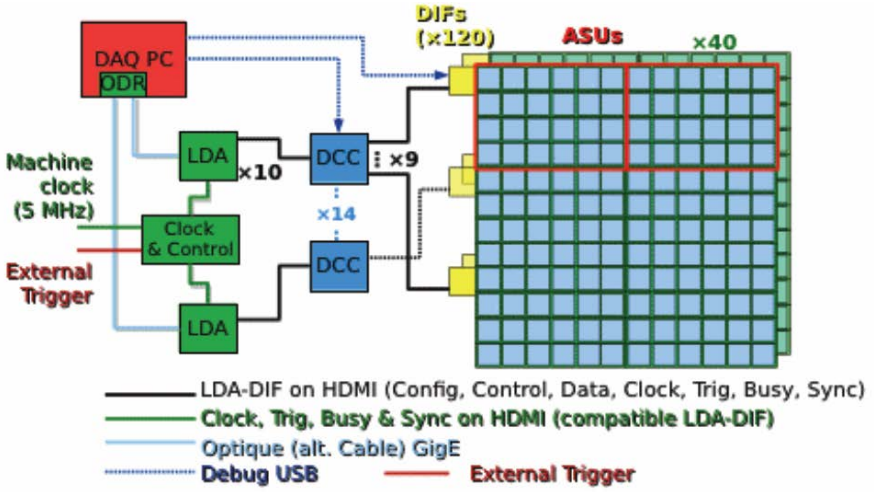


Prototype integration and test

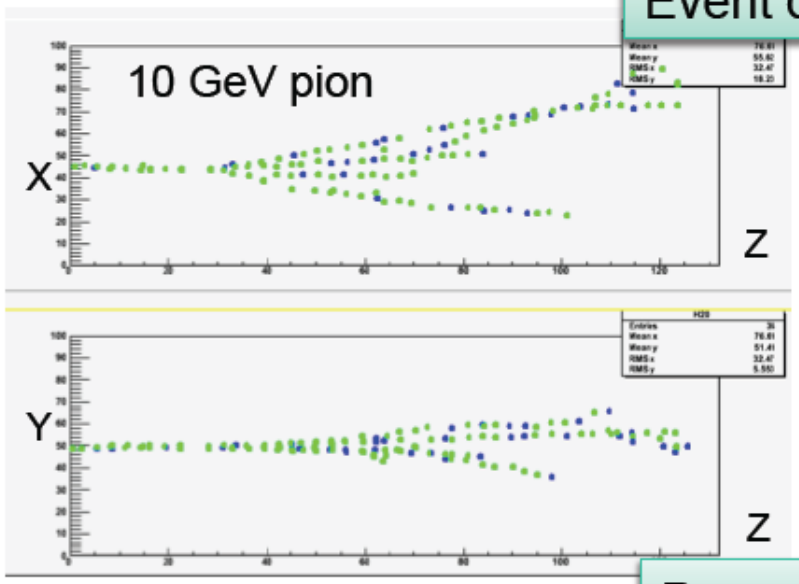
50 chambers

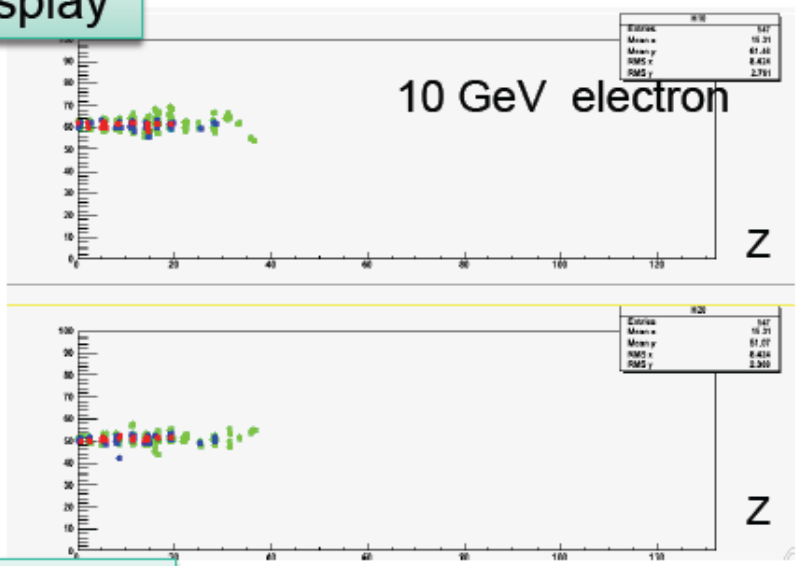






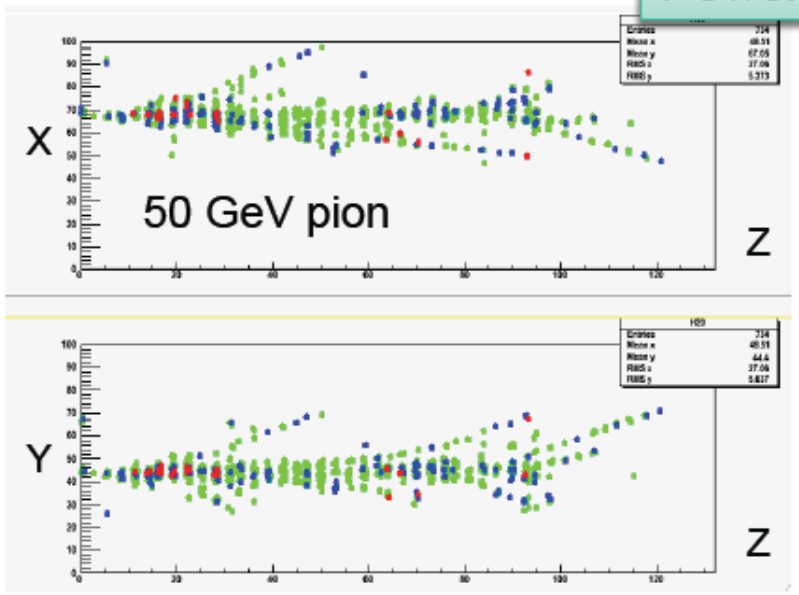
Event display

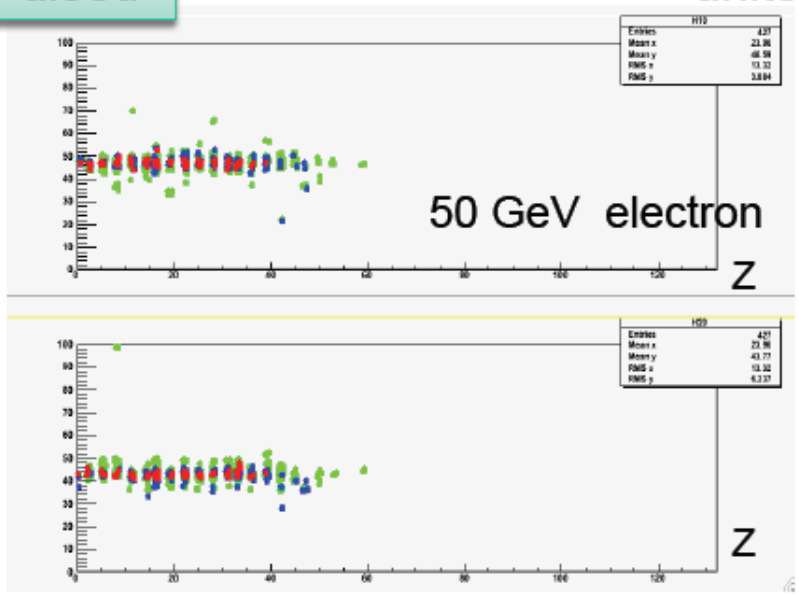




Power-Pulsed

units in cm



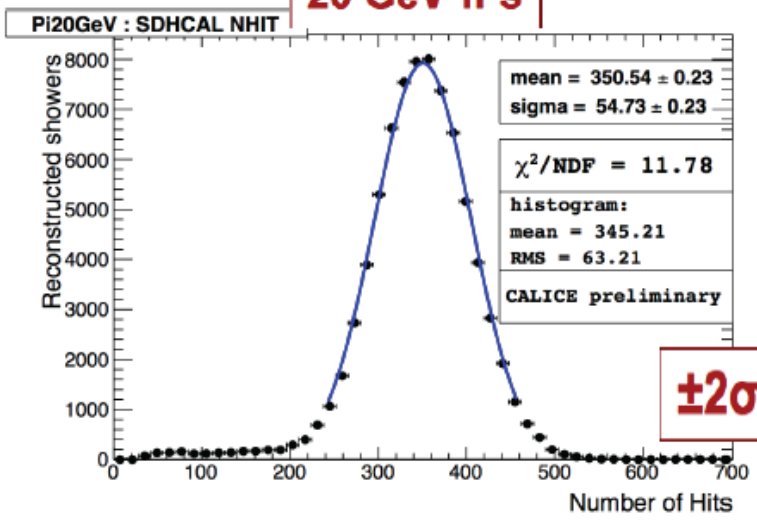


Colours correspond to the three thresholds: Green (100 fC), Blue (5 pC), Red (15 pC)

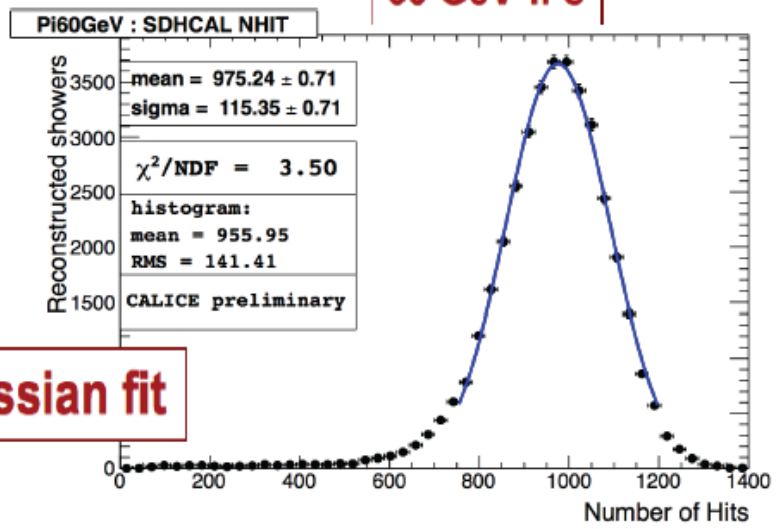
Raw data, no treatment except time hit clustering

Results

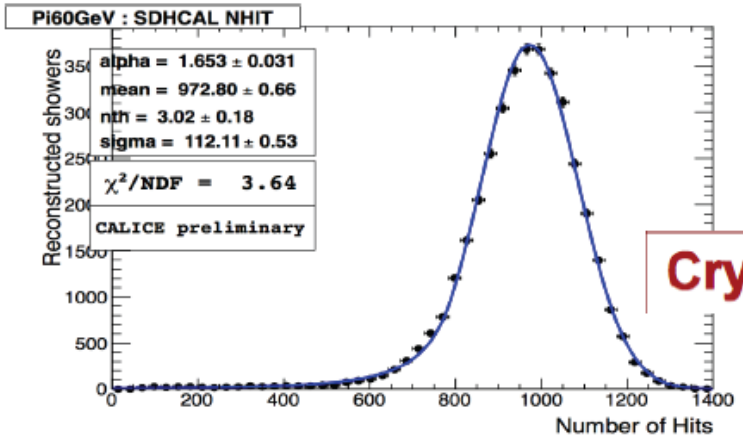
20 GeV π's



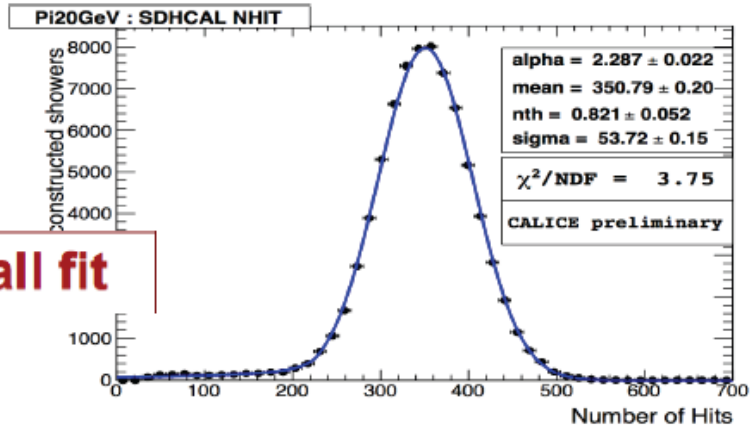
60 GeV π's



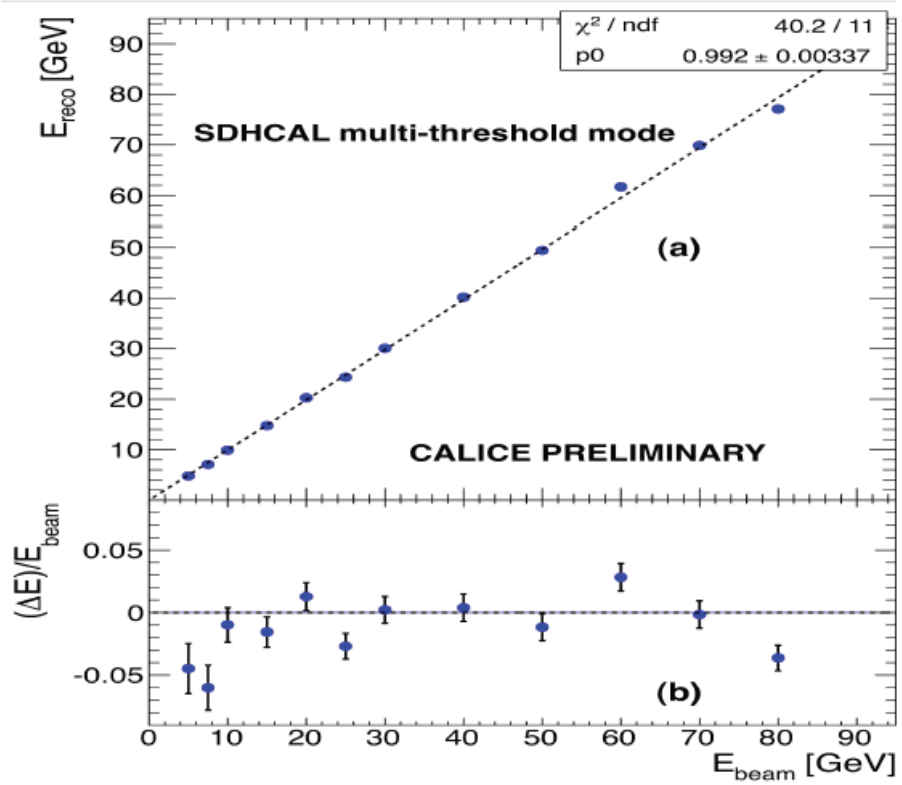
±2σ Gaussian fit

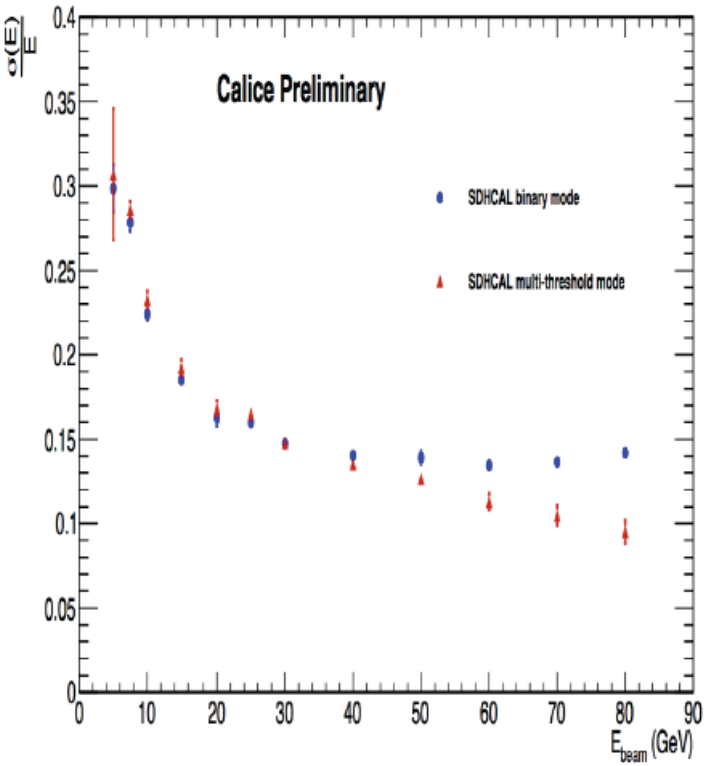


Crystal Ball fit



Results: Energy resolution



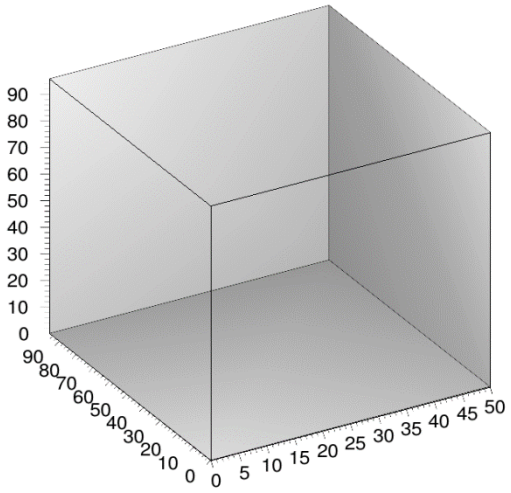


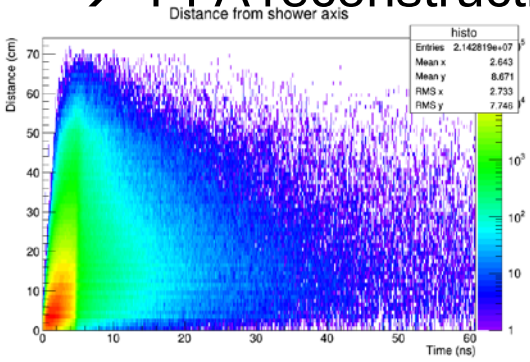
Timing in SDHCAL

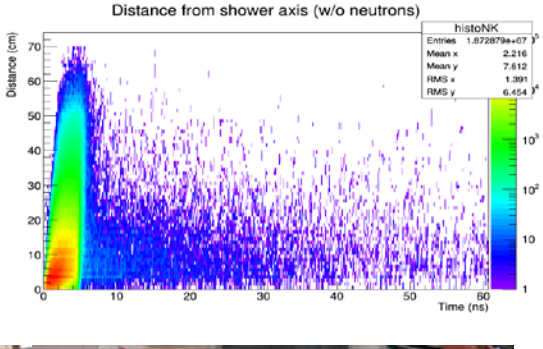
RPC are excellent fast timing detector

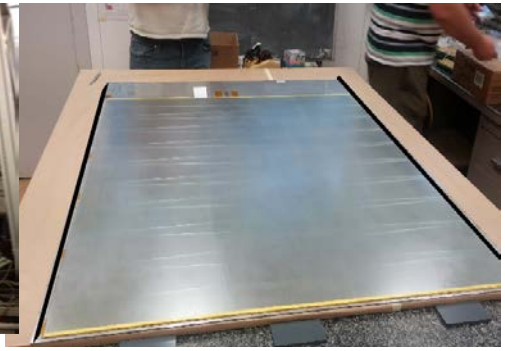
→ Delayed Neutrons

→ PFA reconstruction







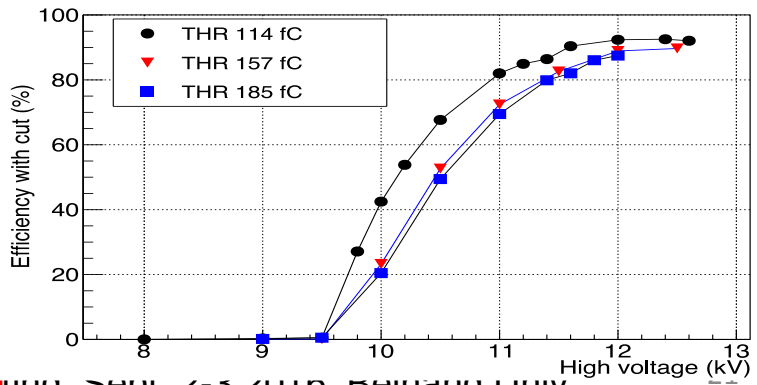


→ Studying the **MRPC** option to investigate **the hadronic shower timing structure (< 100 ps resolution is achievable)**

→ **Design and construction of large MRPC (4gap) realized in 2015. SDHCAL electronics and structure**

→ **Efficiency is as high as for single gap**

→ **Next step to use PETIROC + TDC**



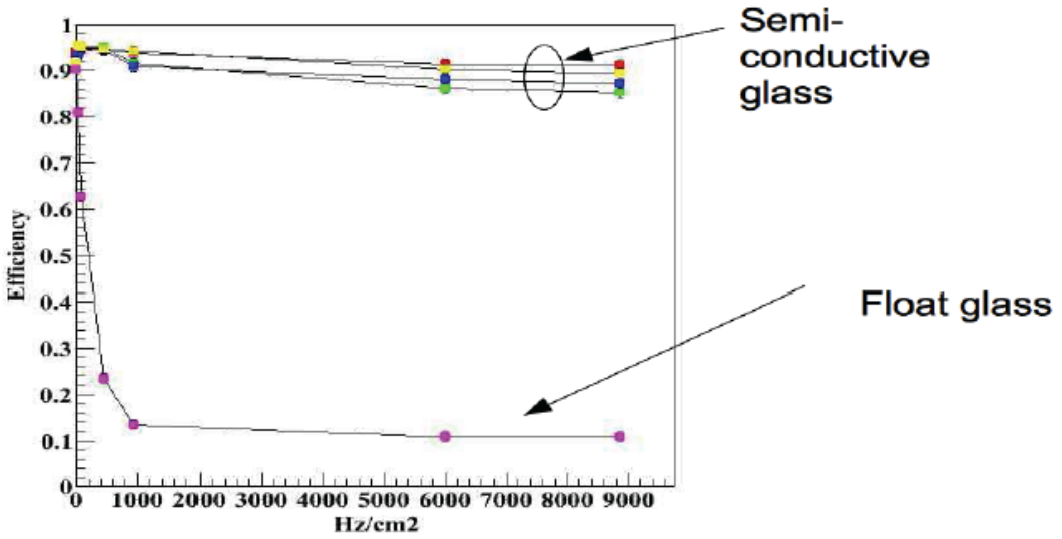
High-Rate GRPC

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

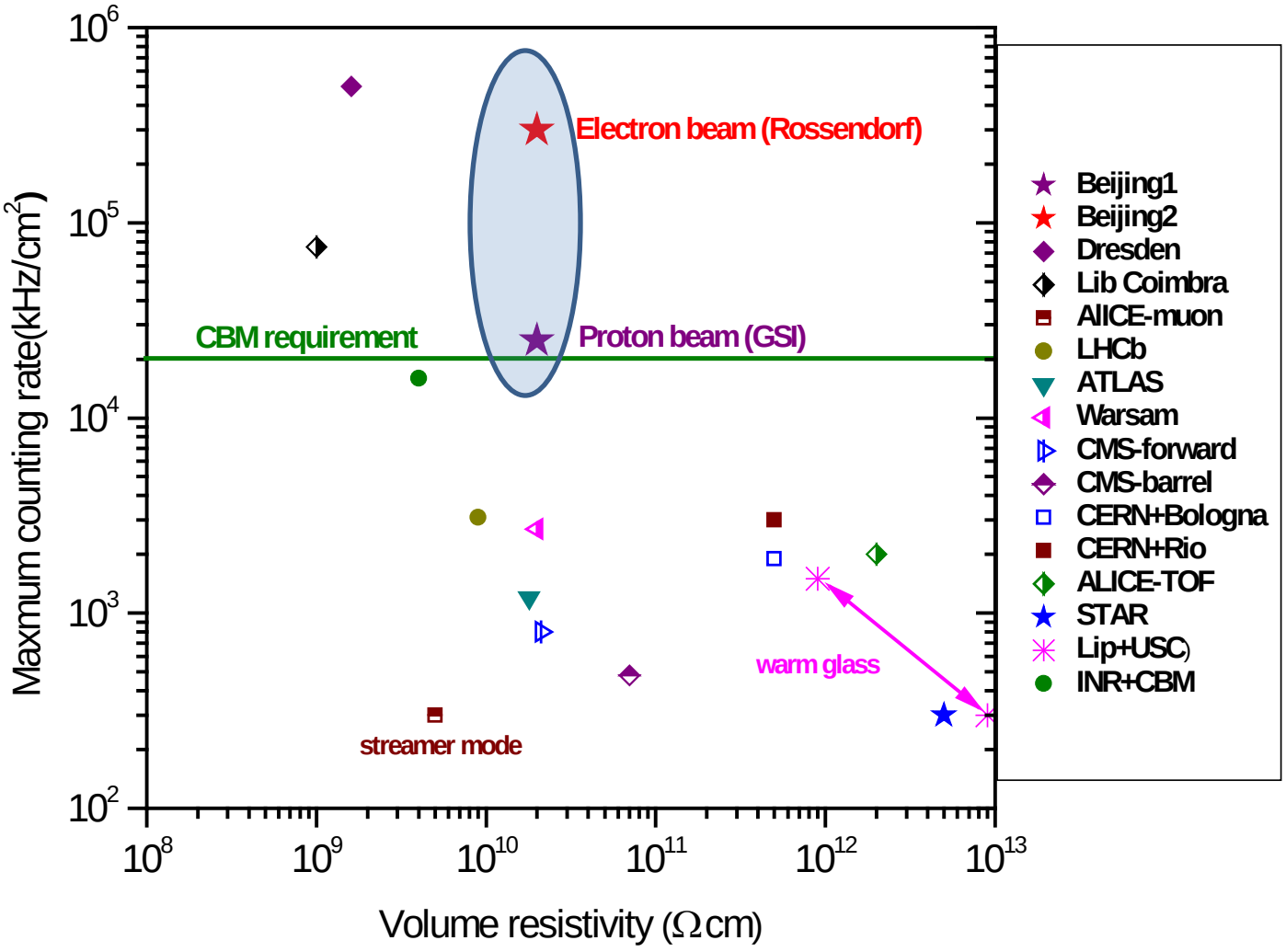
✓Low resistive glass ($10^{10}\Omega$.cm) developed by Tsinghua was used to build few chambers .

✓4 chambers were tested at DESY as well as standard GRPC(float glass)

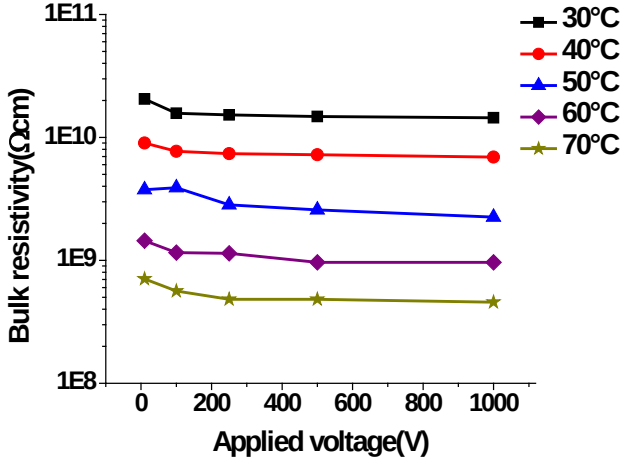
Performance is found to be excellent at high rate for GRPCs with the semi-conductive glass and can be used in the very forward region if the rate > 100 Hz/cm²



World map of MRPC's rate capability

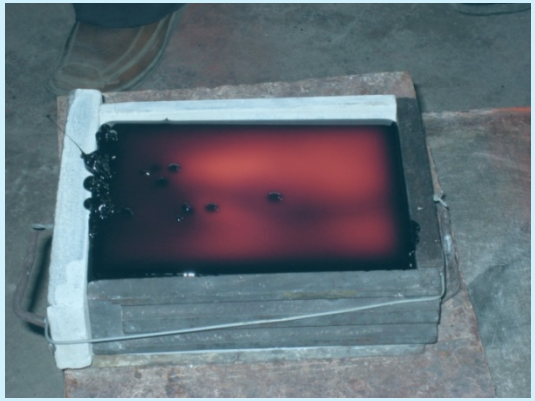


Low resistive glass

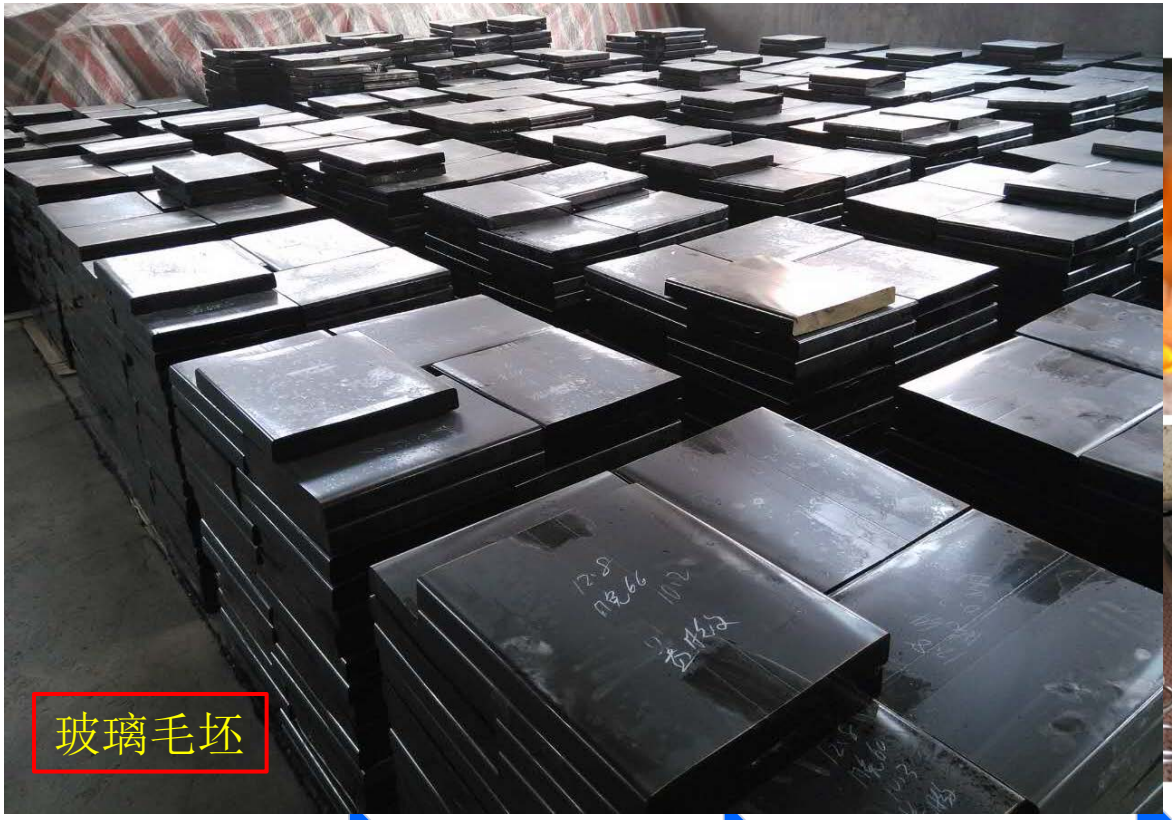


Dimension	33 x27.6cm^2
Bulk resistivity	~$10^{10}\Omega$cm
Standard thickness	0.7, 1.1mm
Thickness uniformity	20μm
Surface roughness	<10nm
Dielectric constant	7.5 - 9.5
DC measurement	Ohmic behavior
	stable up to 1C/cm^2

Mass production of low resistive glass

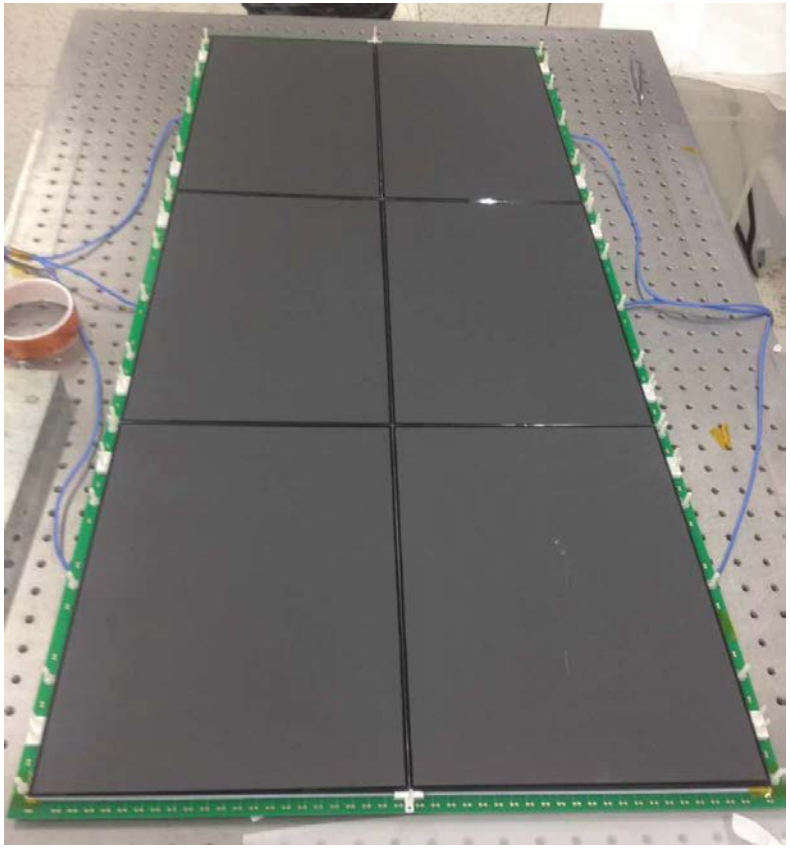


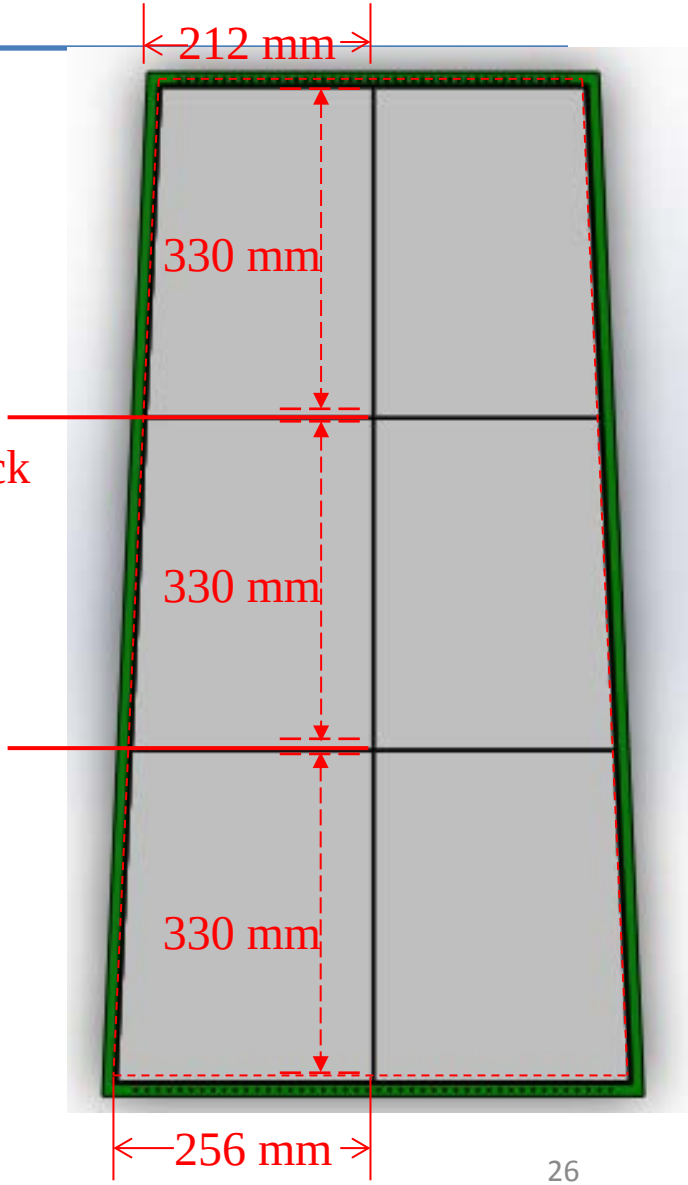
玻璃研发时的工艺



Continuous melting → Continuous pouring → Continuous annealing

Development of high rate big module





Conclusions

- ✓A prototype of $6\lambda_I$ was built using GRPC as active layers.
- ✓The quality of the collected data is very satisfactory.
- ✓ First results on energy resolution are very promising
- ✓Study high time resolution high rate SDHCAL
- ✓We intend to produce large high rate GRPC detectors (>1m) with a more sophisticated electronics (HR3) to validate completely the SDHCAL option.

Thanks for your attention!