Construction of the Semi-Digital Hadronic CALorimeter Technological Prototype

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

Outline

-Semi-Digital Hadronic Calorimeter :

Concept and objectives

-R&D, results

-Construction

-Sino-French collaboration

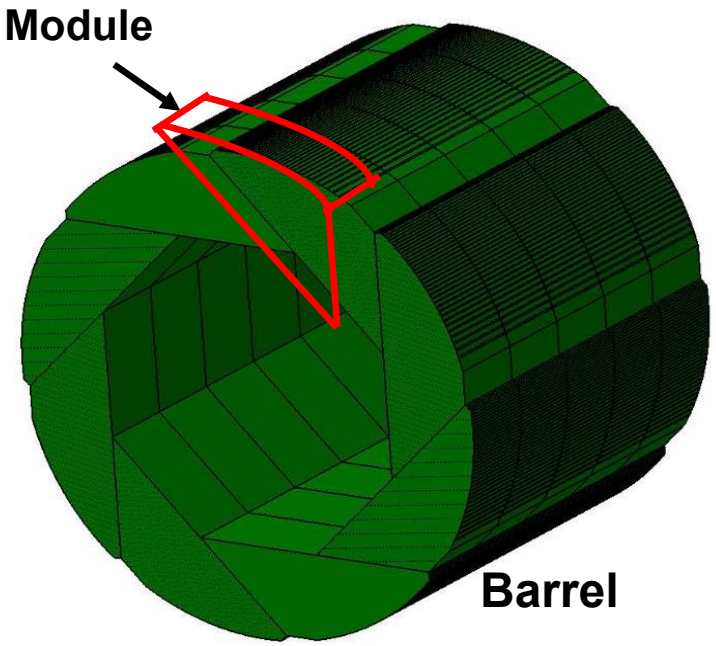
-Future

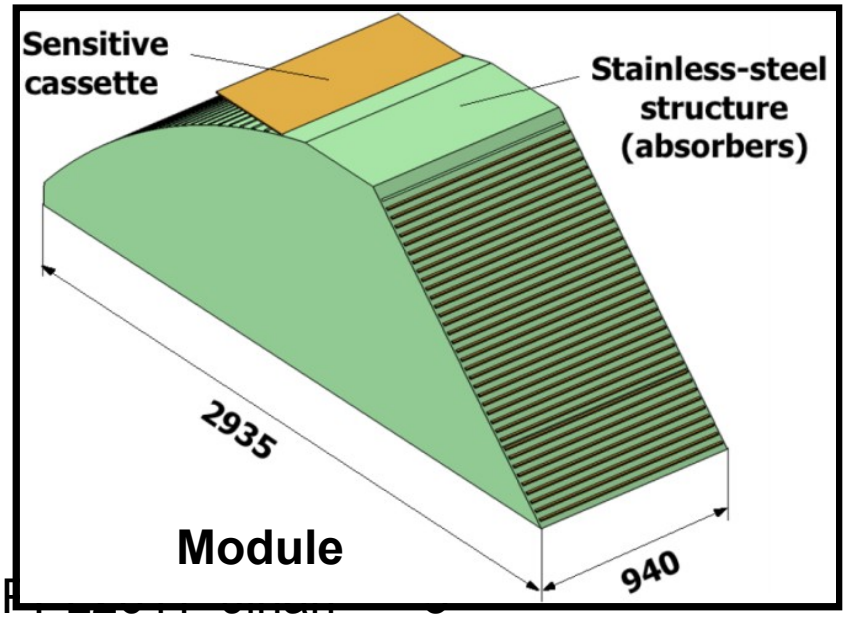
Objectives

The very granular (1 cm2 lateral segmentation)Semi-digital GRPC-based HCAL was proposed and accepted as one of the two HCAL possible options in the **ILD L**etter **O**f **I**ntent

A genuine mechanical structure was also proposed

- It is self-supporting
- Has negligible dead zones
- Eliminates projective cracks
- Minimizes barrel / endcap separation (services leaving from the outer radius)





Objectives

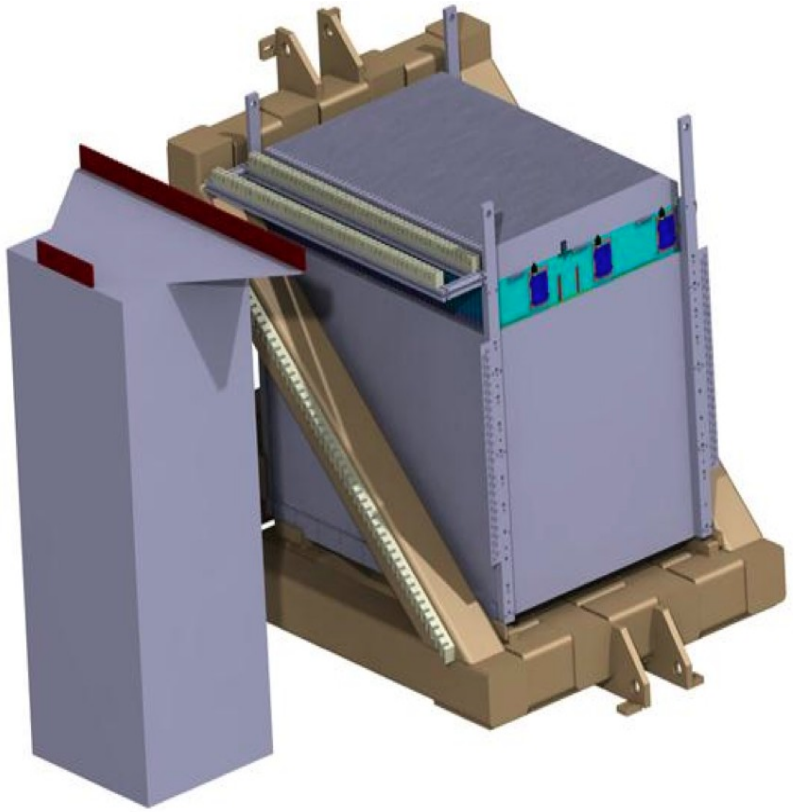
We intend to validate the **SDHCAL concept** by building a prototype which is **as close as possible to the proposed SDHCAL for ILD to understand key issues of integration and operation :Technological prototype but also hadronic shower behavior : Physics prototype**

- → **Self-supporting mechanics**
- → **Minimized dead zone**
- → **Minimized thickness**
- → **One-side services**
- → **Power pulsed electronics**

The prototype will be made of 48 units. Each unit is made of :

2 cm absorber
+ **0.6 cm sensitive medium**
1 cm^2 transversal granularity

This is about **$6\lambda_I$**
and **442368** channels



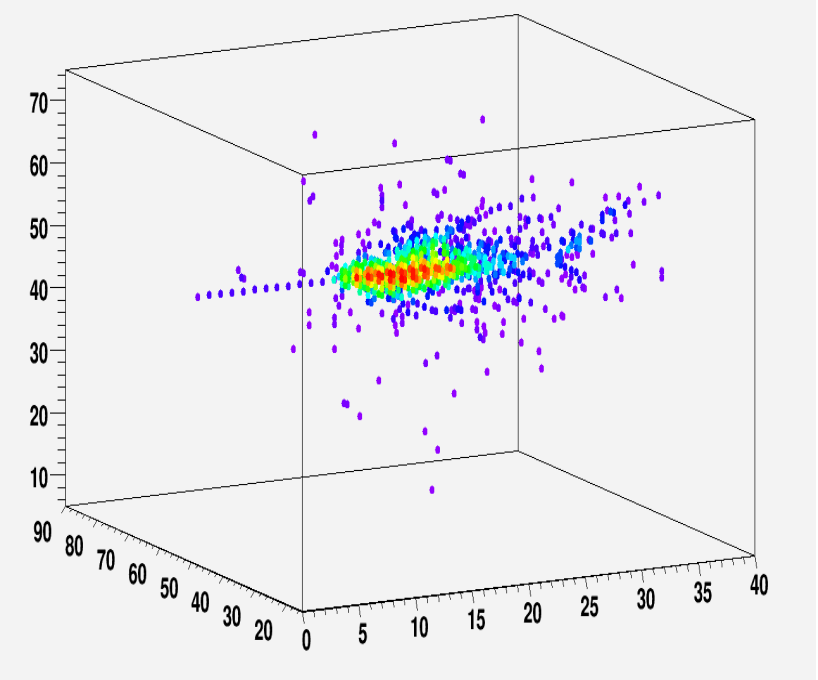
2-bit Readout Electronics

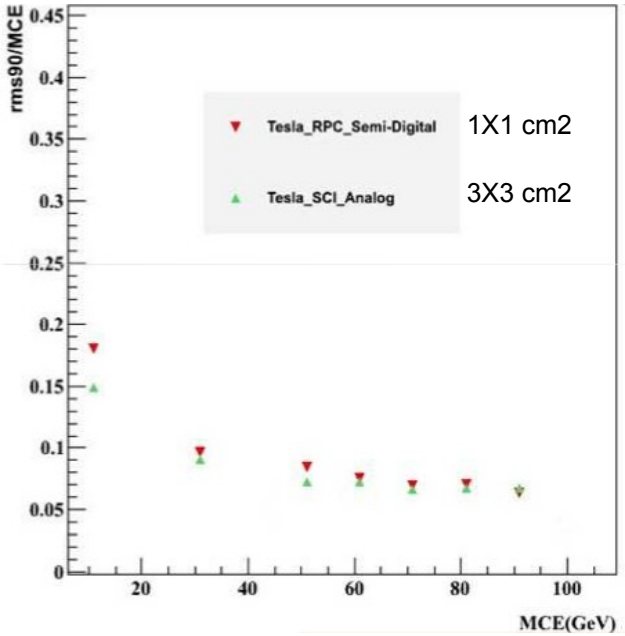
Electronics readout and granularity choice

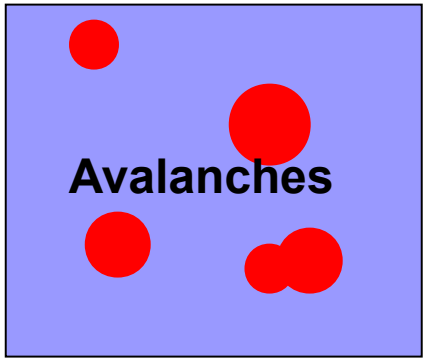
At high energy the shower core is very dense (up to 50 pc/cm^2)

→ simple binary readout will suffer saturation effect

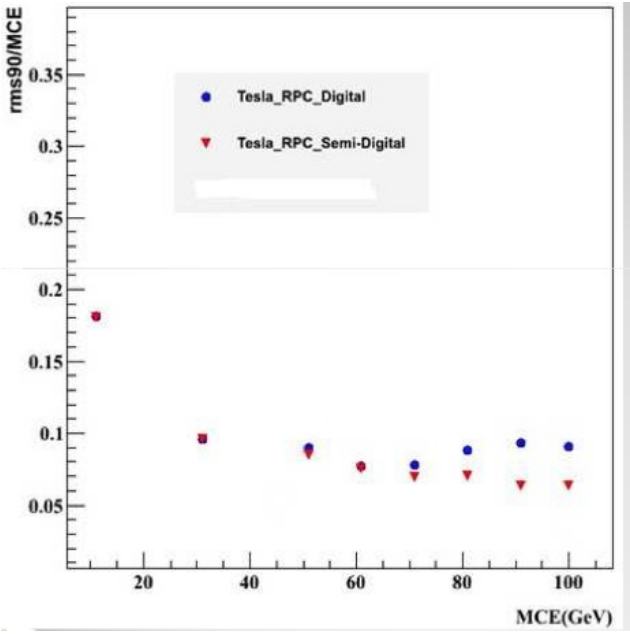
→ semi-digital readout (2-bit) can improve the energy resolution at high energy by improving counting capability







1 cm^2 pad



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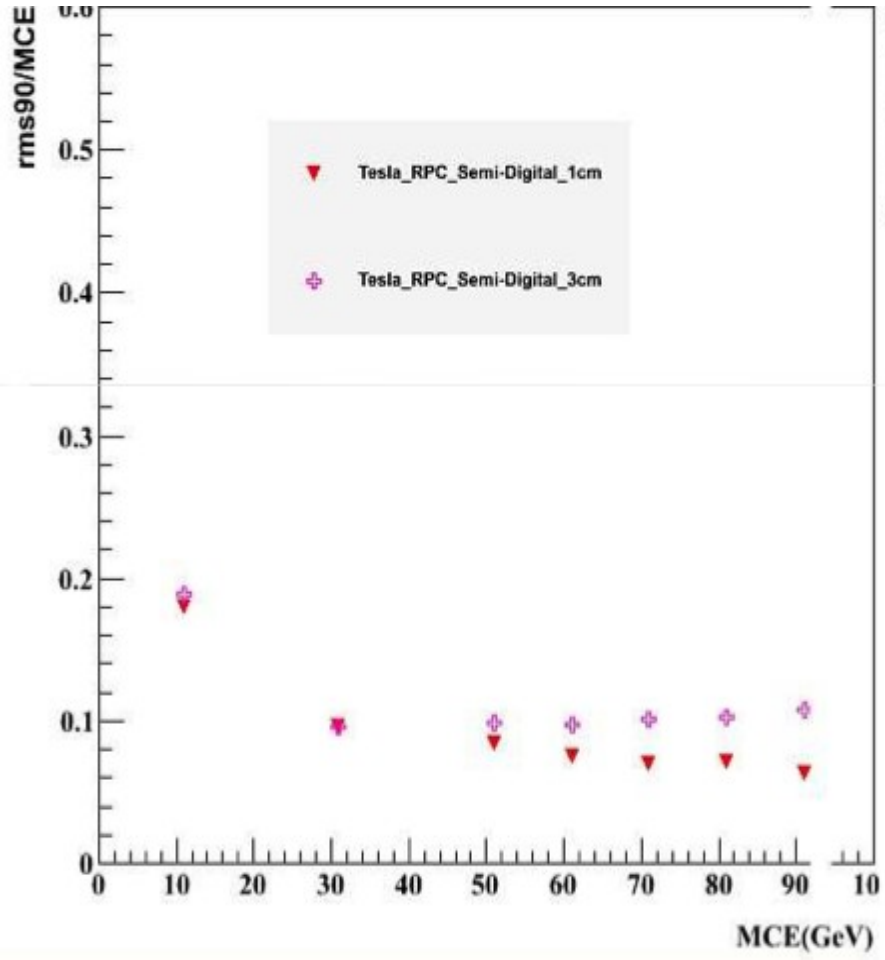
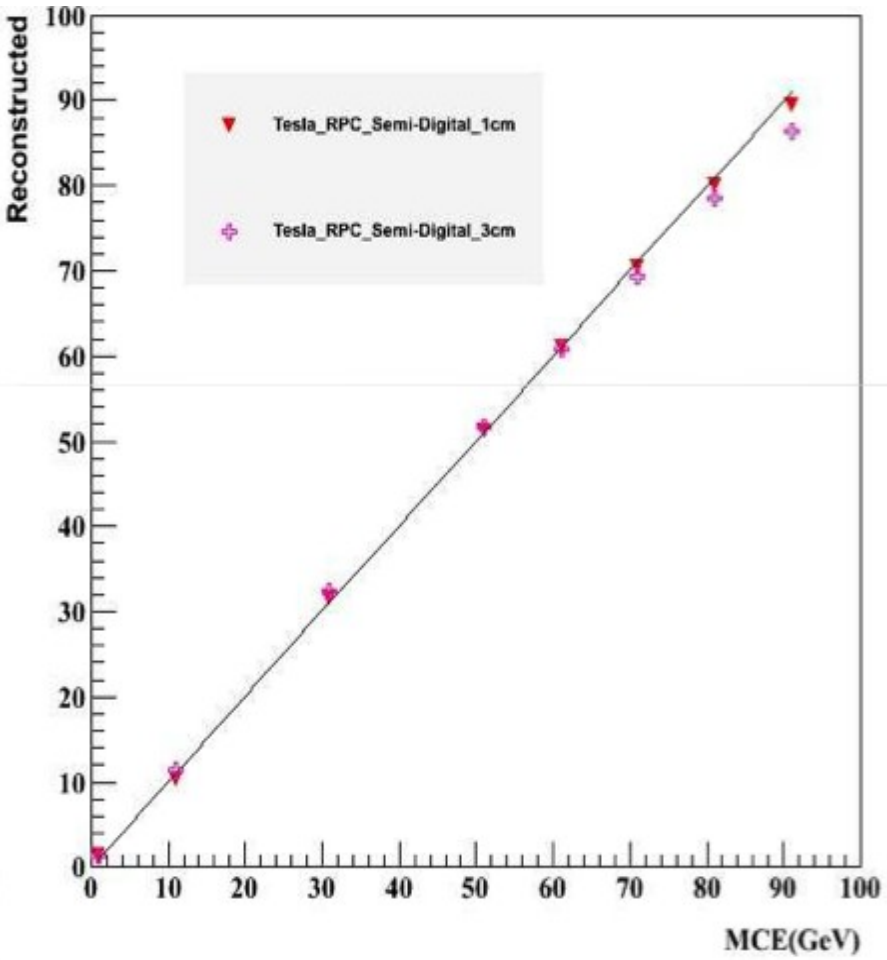
1cm2 granularity





Challenges :

To build a **technological prototype** we need to achieve the following :

1- Large detectors with almost no dead zones :

2- Large and thin embedded electronics board

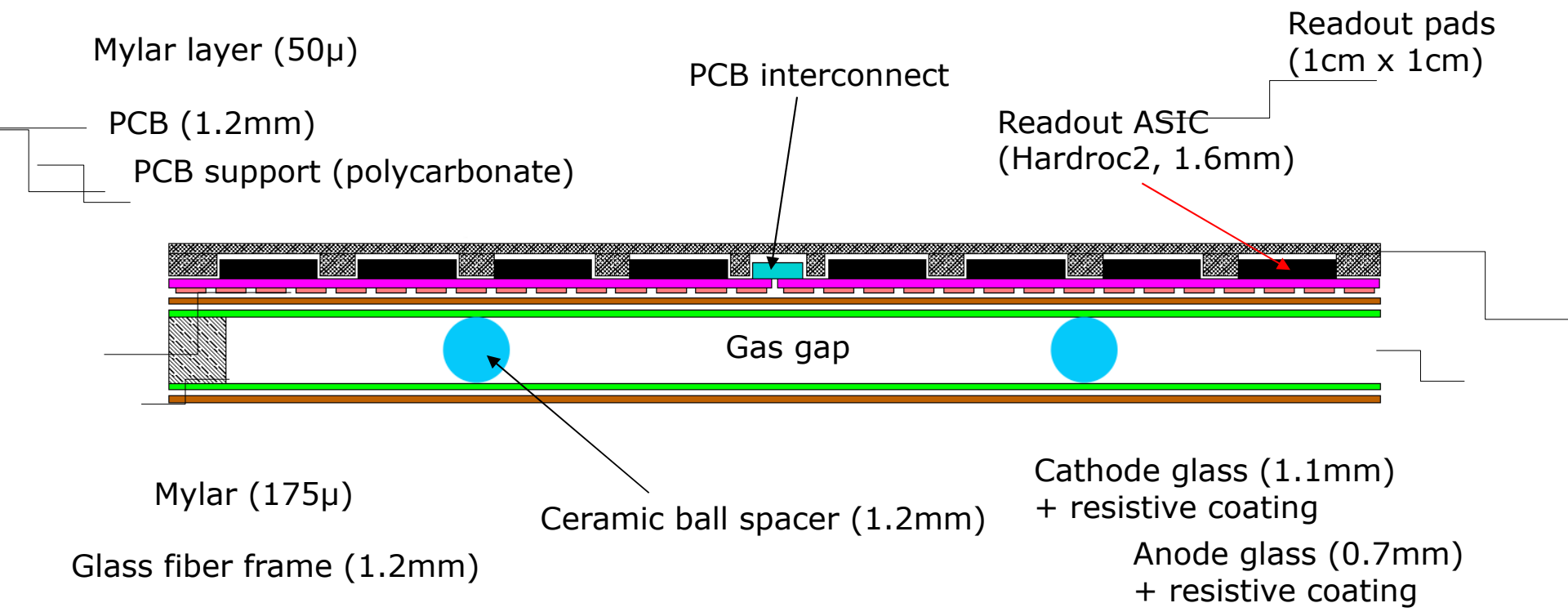
4- One-side services : readout, gas outlets..

5- Self-supporting mechanical structure

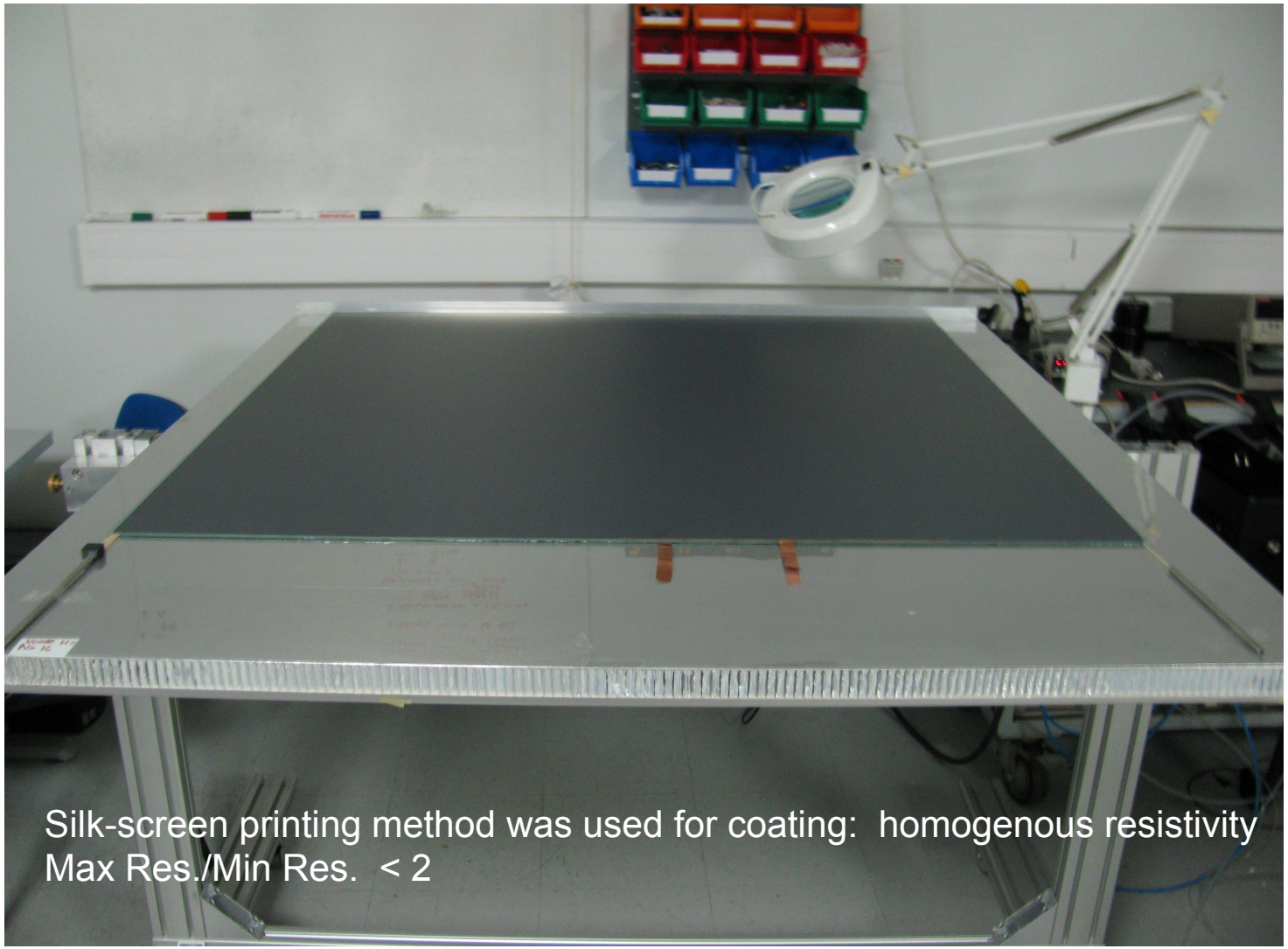
6- Power-pulsed, 2-bit electronics

7- New generation of DAQ system capable of dealing with more than 400000 channels.

Cross-section of 1m² glass RPCs

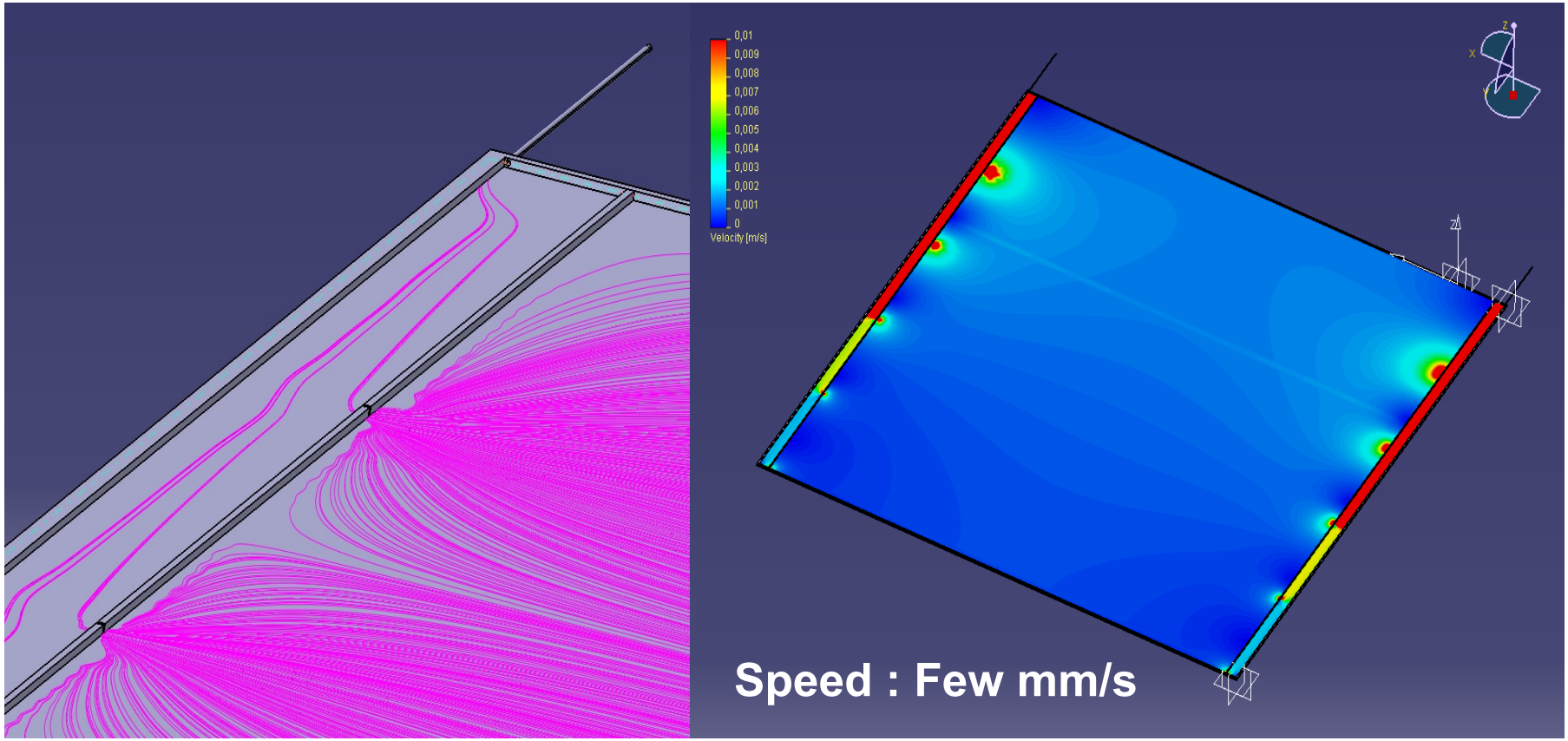


Total thickness: 6.025mm


Silk-screen printing method was used for coating: homogenous resistivity
Max Res./Min Res. < 2

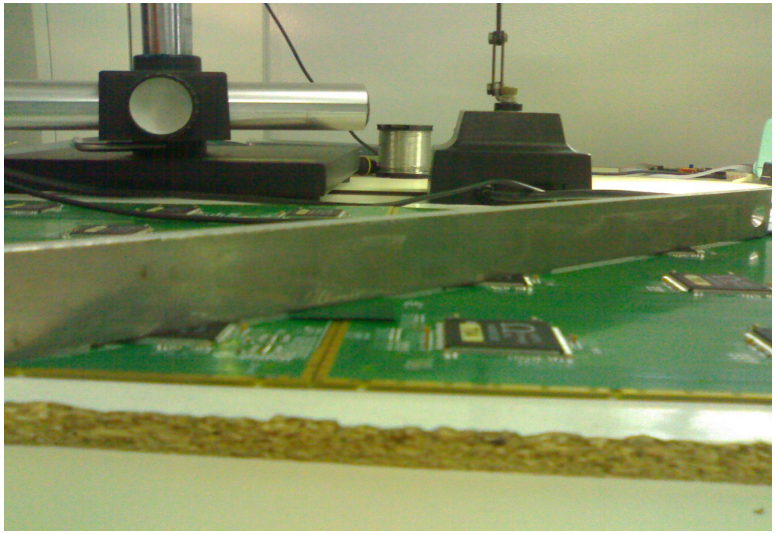
1m2 GRPC

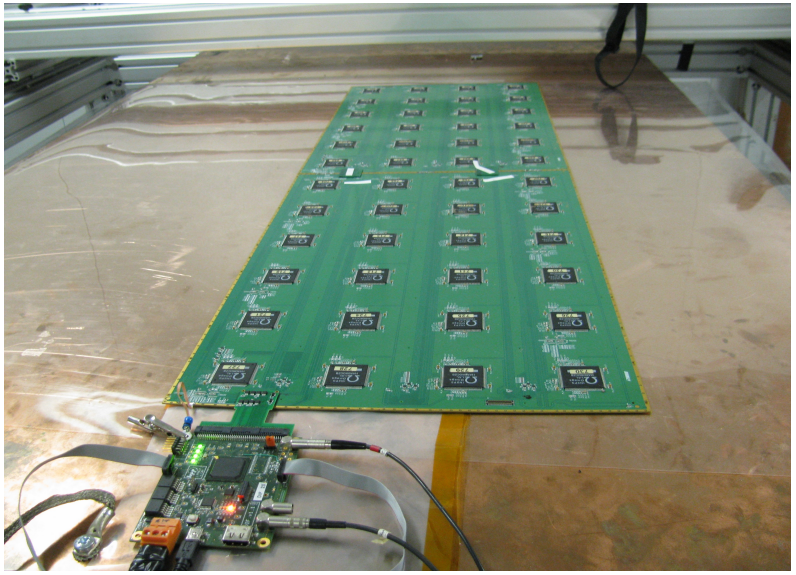
New gas circulation system was conceived and checked with sophisticated simulation tools with the aim to reduce gas consumption and to guarantee a well distributed gas

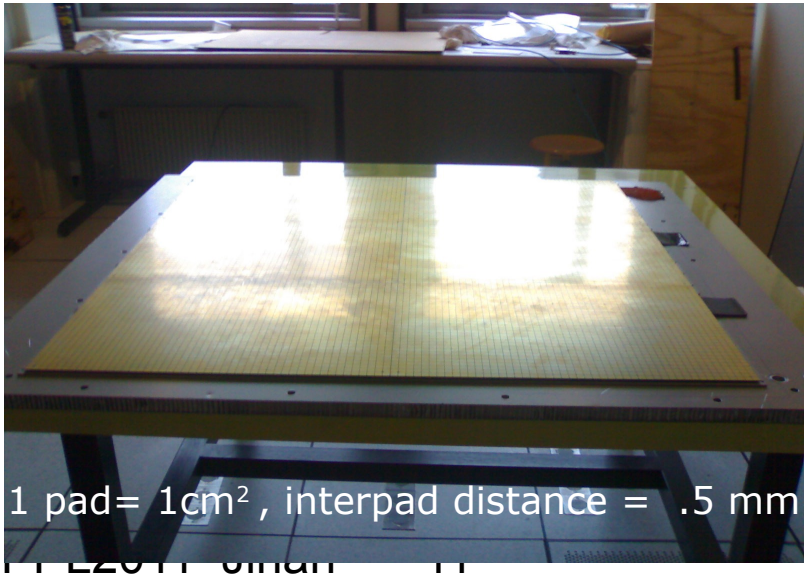


When diffusion is included→ Homogeneity is better

Final version of electronics using new generation of connectors



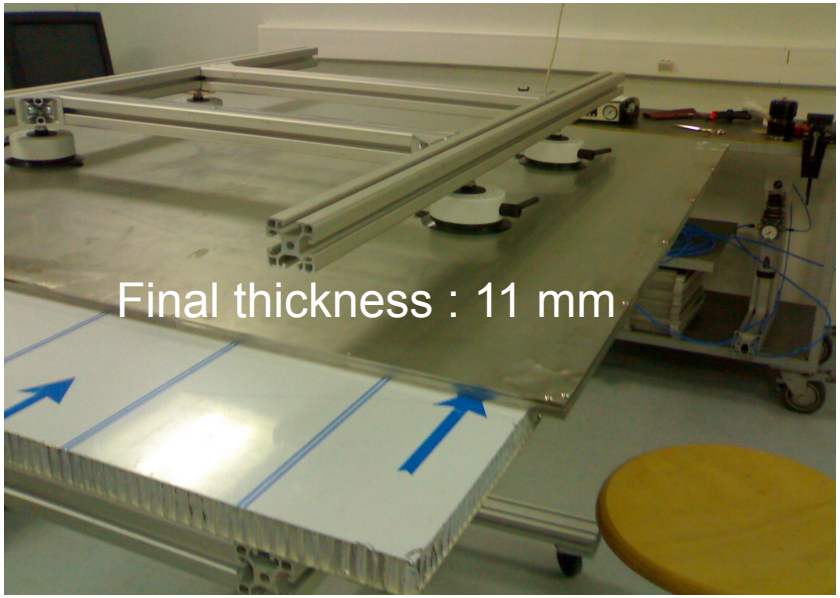




144 ASICs= 9216 channels/1m²

1 pad= 1cm² , interpad distance = .5 mm

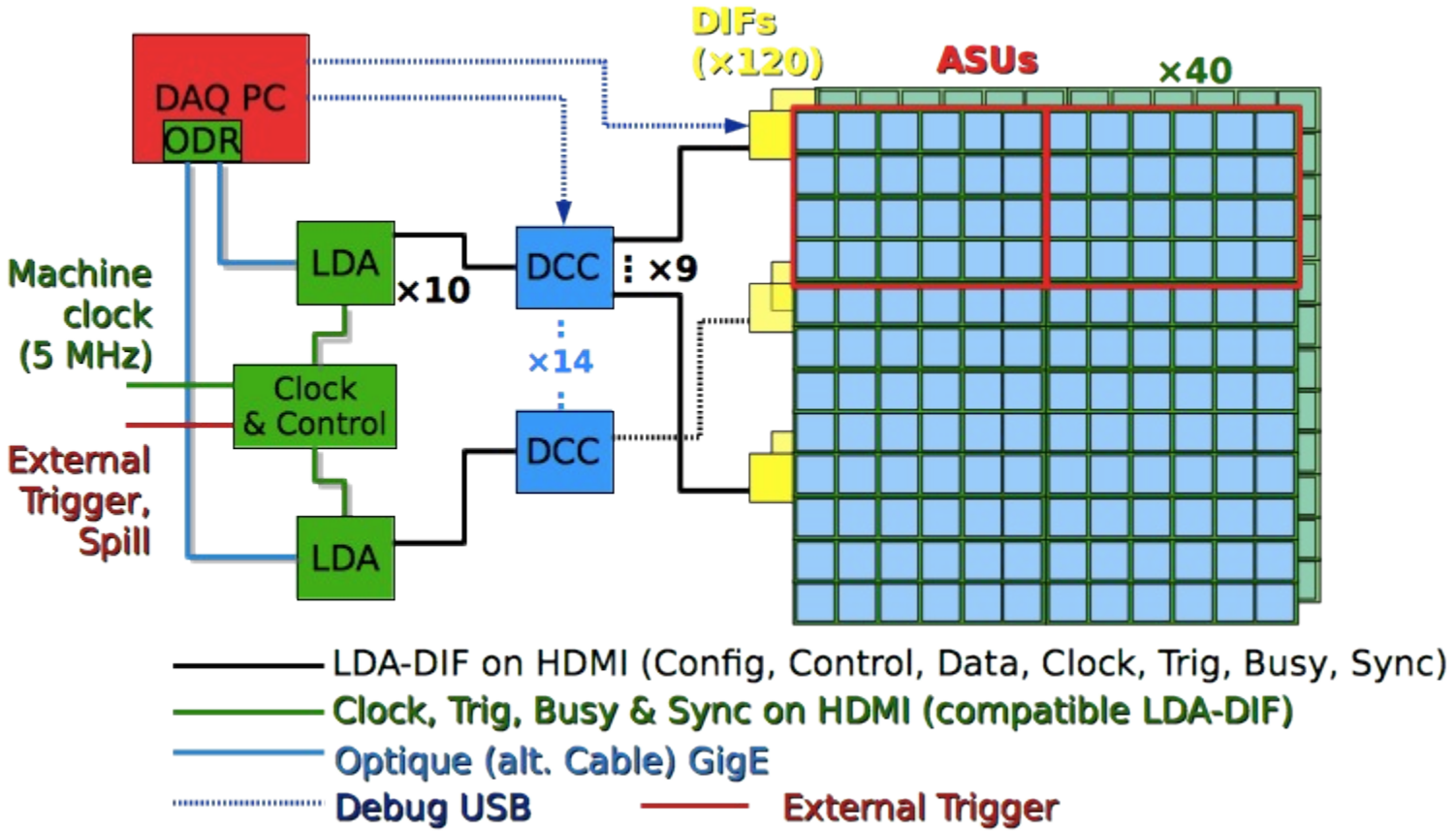

Assembling procedure


Final thickness : 11 mm

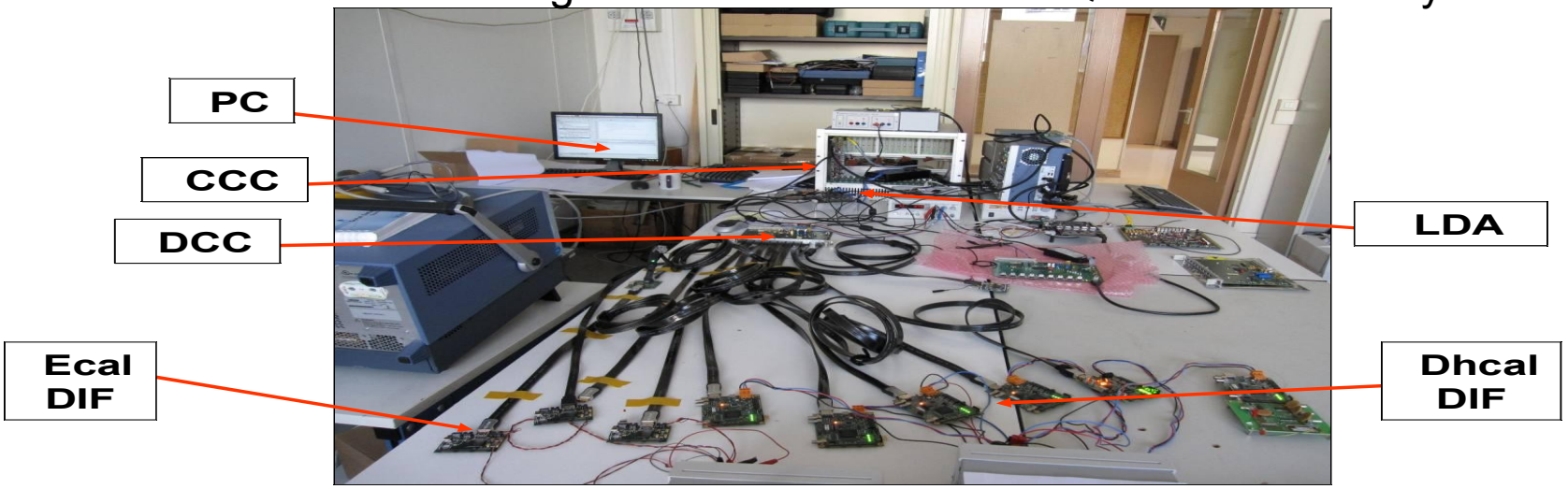

Mesa
P-1

Acquisition system

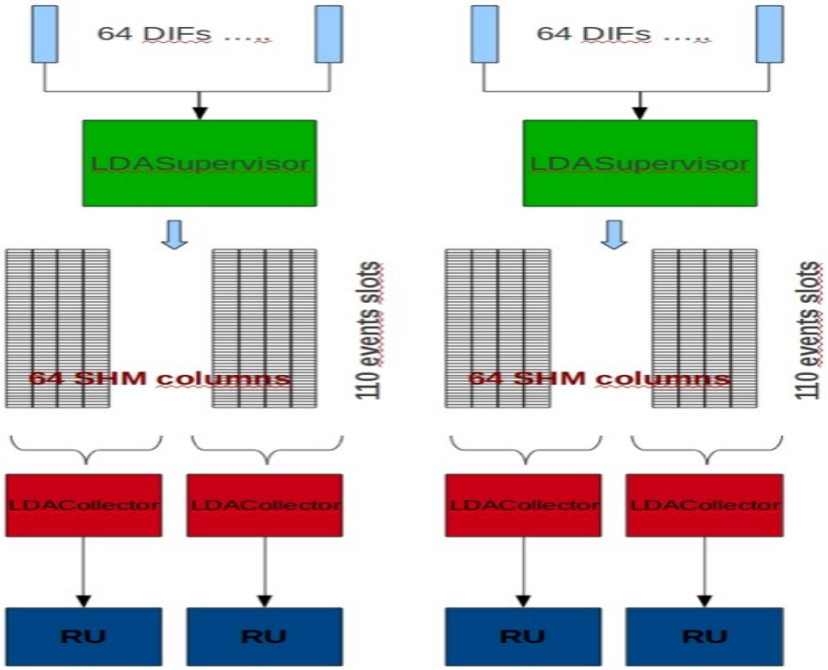
An acquisition system developed within CALICE collaboration will be used



The full chain of the new generation of CALICE DAQ was successfully tested

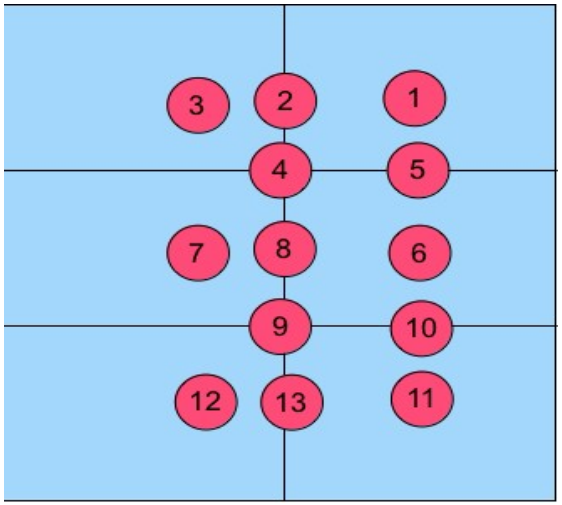


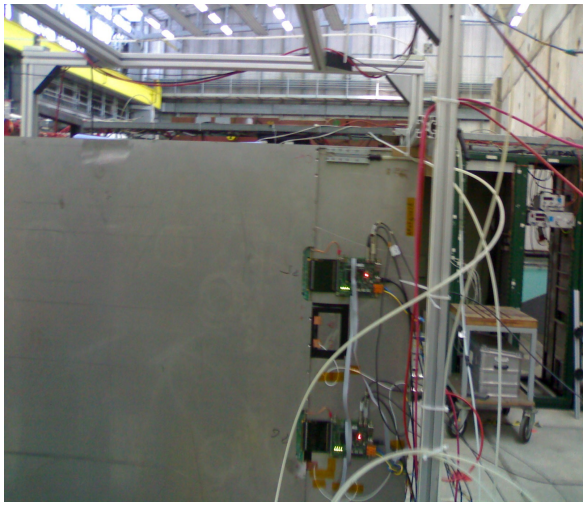
Software based on the Xdaq of CMS tracker is used :

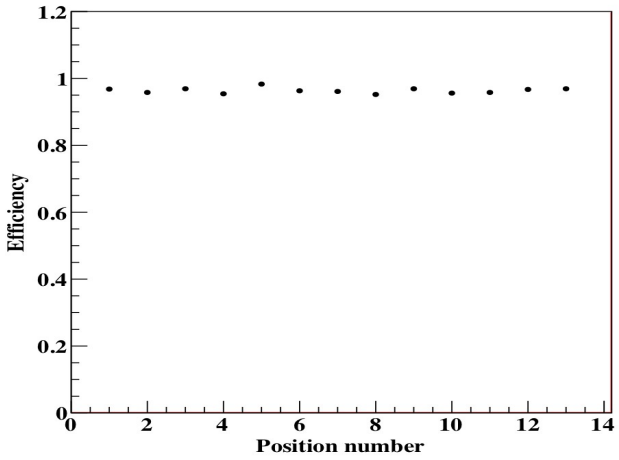


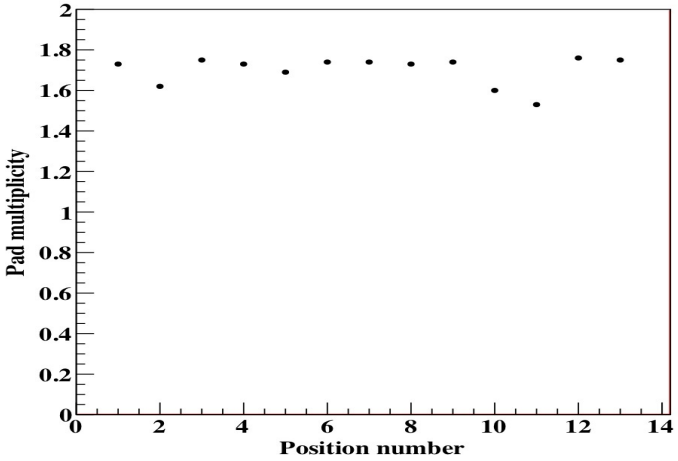
TestBeam Validation

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

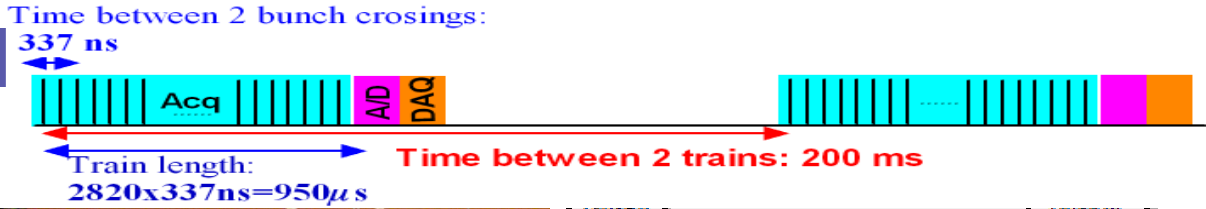


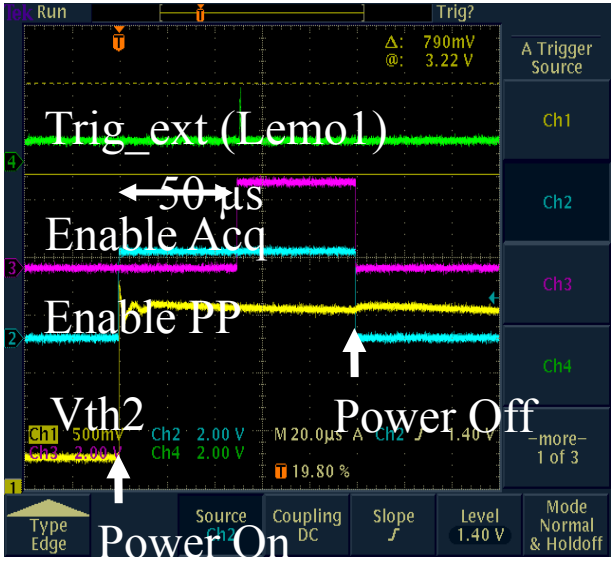


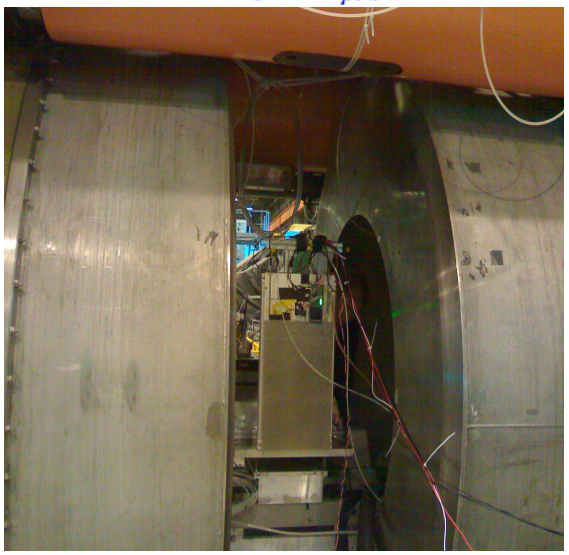


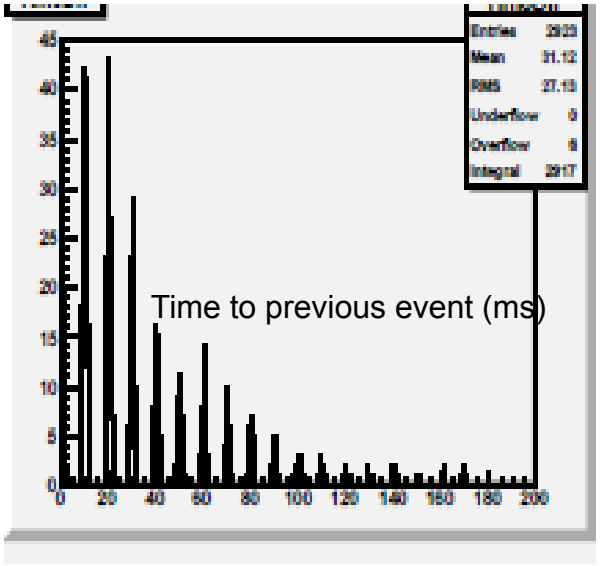


Power-pulsing test

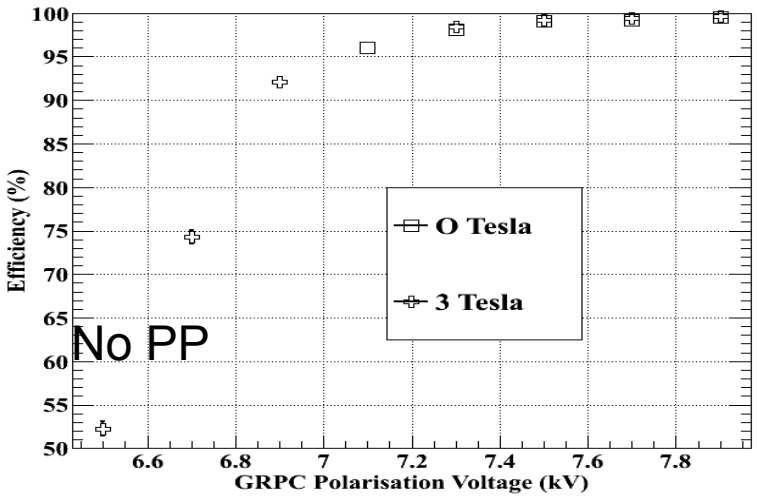


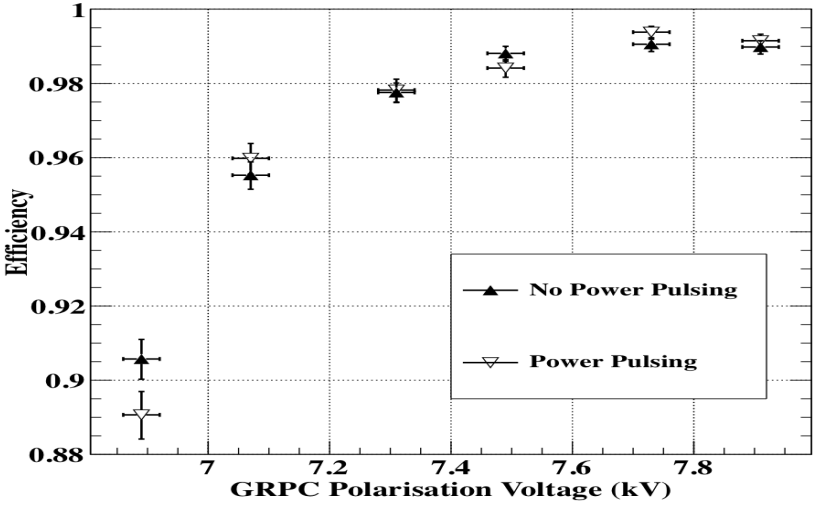






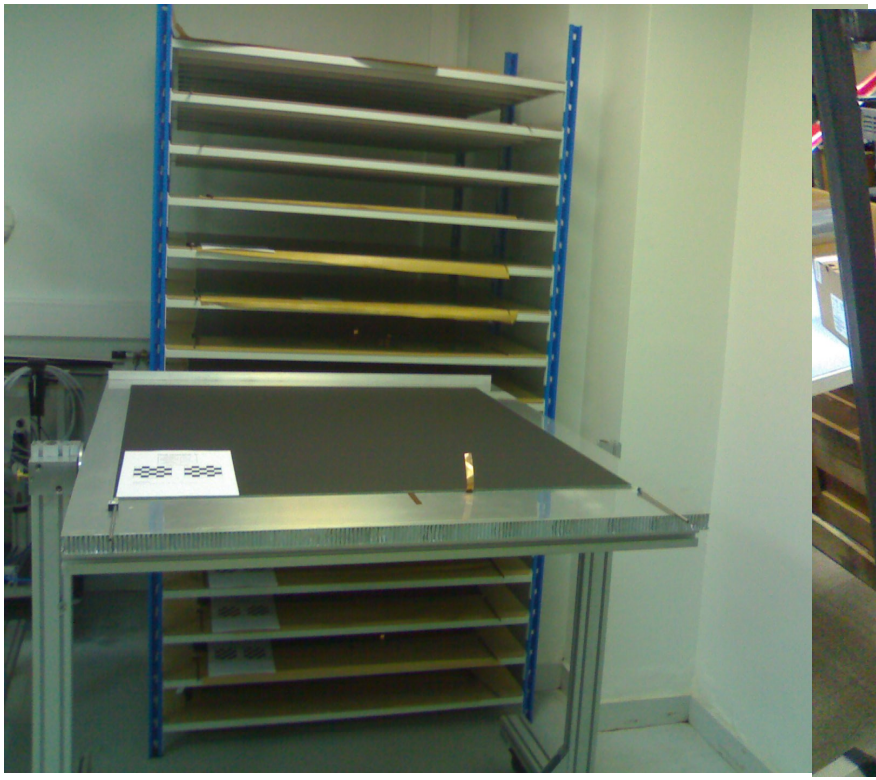
PP is on during 2 ms every 10 ms rather than every 200 ms for ILC





Prototype construction: GRPCs, cassettes

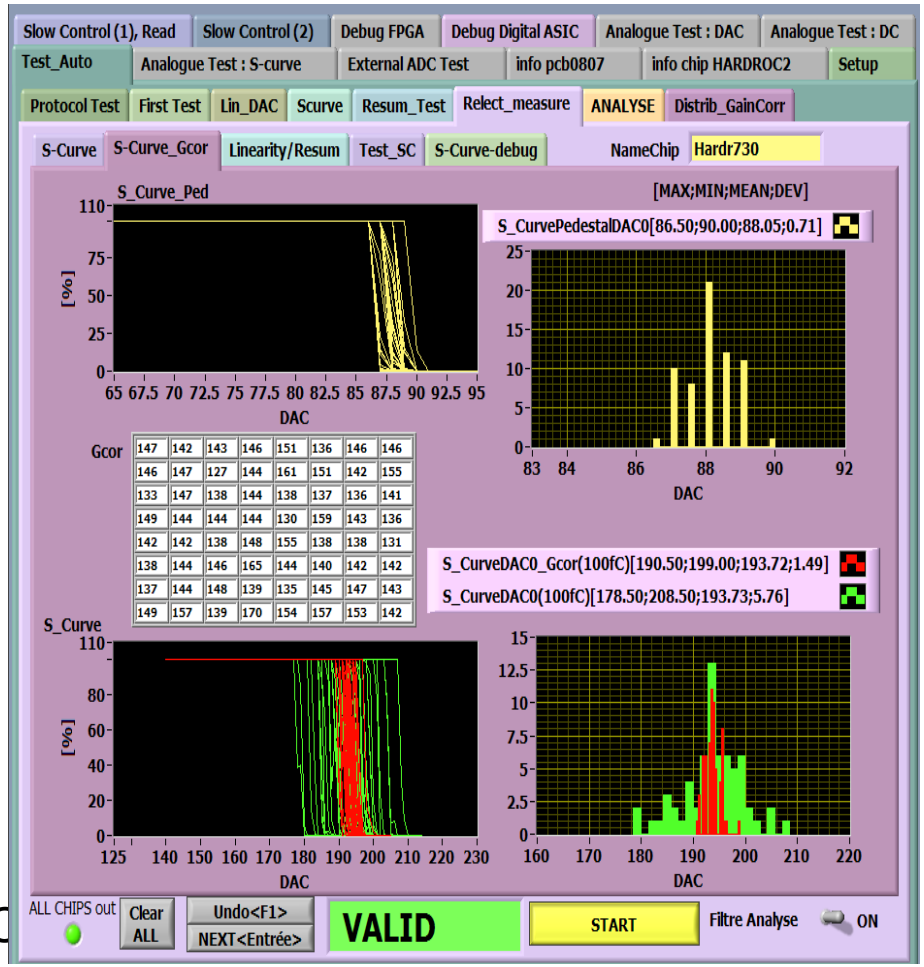
34 GRPCs were built up to now (2 detectors/week)
50 cassettes were produced and being assembled with the GRPCs
Construction will be completed by May



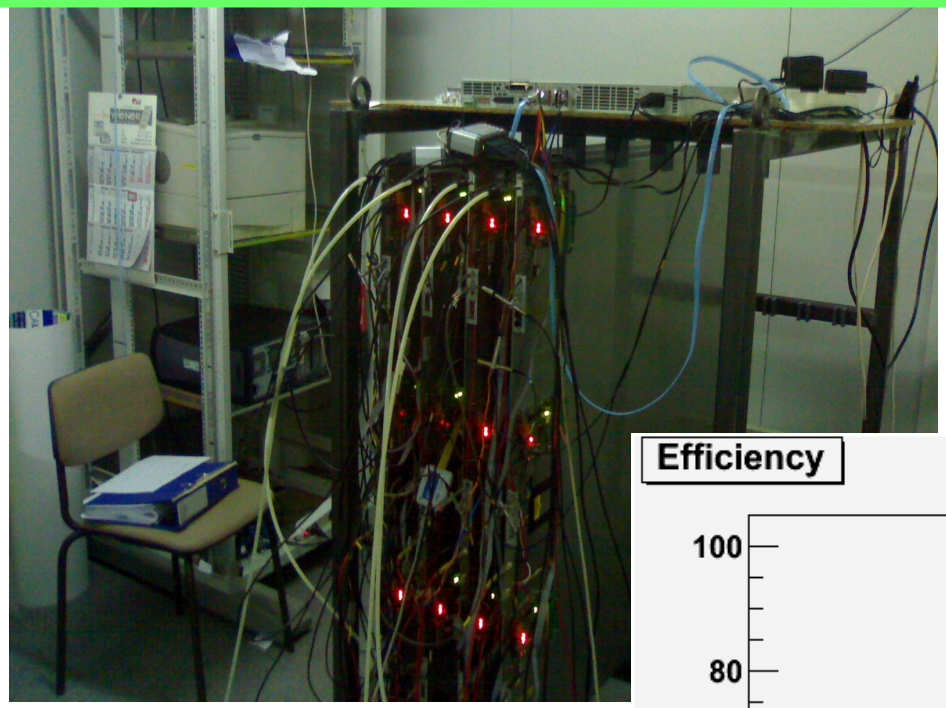
Cassette and GRPCs ard assembled

Prototype construction: Electronics

A robot was used to test the 10500 ASICs (64 ch, 3 thresholds)
The procedure allows to select the good ASICs and calibrate them
Yield 93%. Electronics boards are being produced



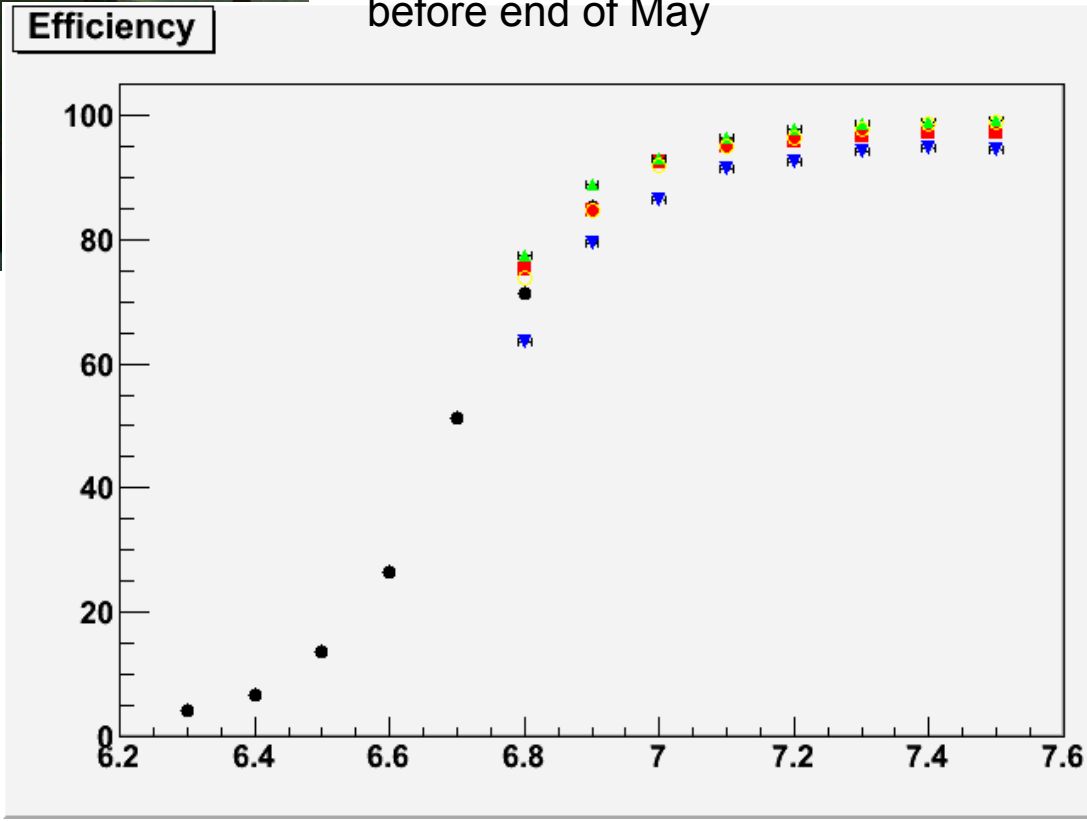
Prototype construction: Acquisition



6 fully equipped 1m2 GRPC were produced up to now. They were used to validate the whole system and more particularly the DAQ.
3 of them are currently used for the TOMUVOL project (volcanic muons)

The remaining part will be produced before end of May

The GRPCs are being tested in vertical position using cosmic rays



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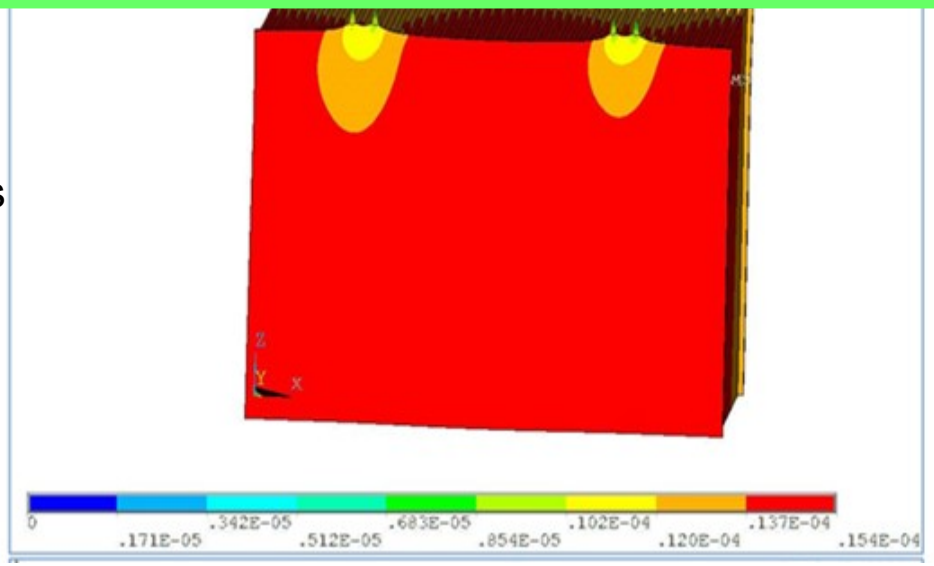
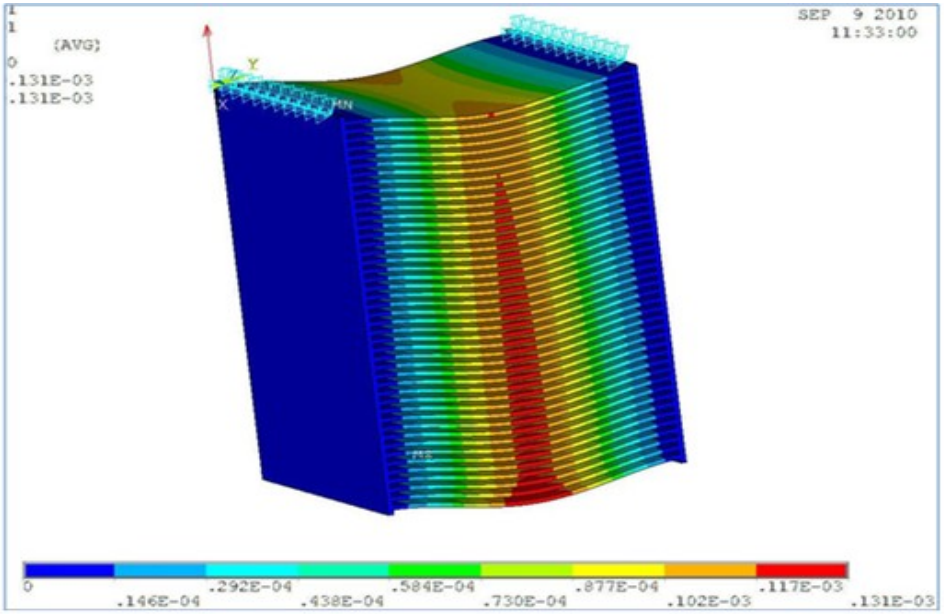
Prototype construction: Mechanical structure

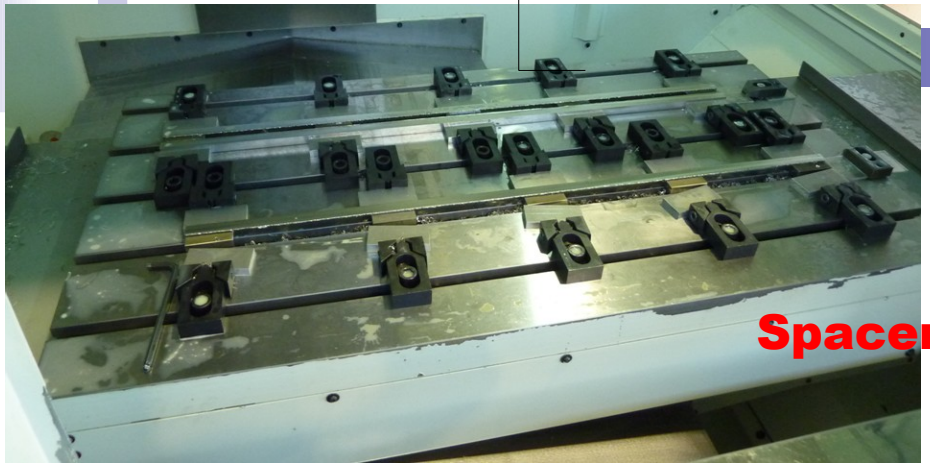
The self-supporting mechanical structure was conceived to be modular. Spacers with bolts used to assemble the absorbers

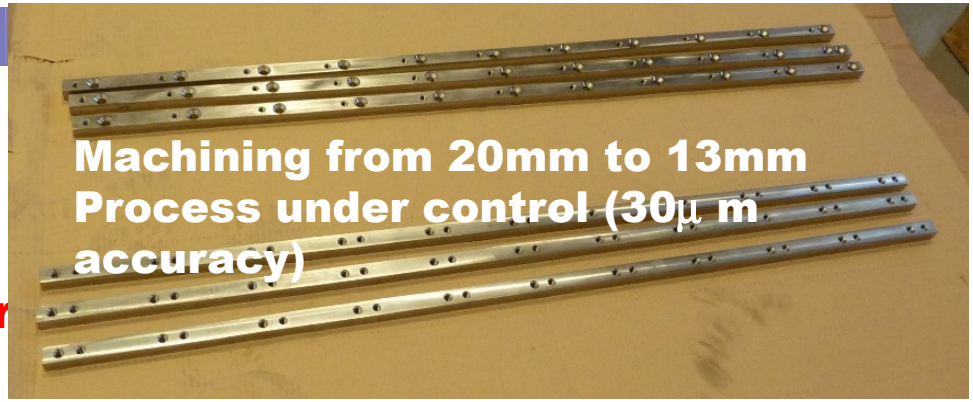
Detailed mechanical deformation study was performed in different configurations of the prototype.





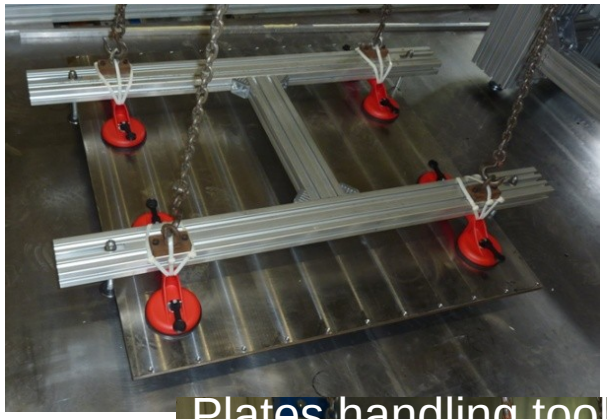
Maximum deformation was found To occur during manipulation (rotation, transport) but still with no effect on the cassettes.
A rotation tool will allow to use the prototype to study cosmic rays... tests will be conducted during assembling to check this possibility.





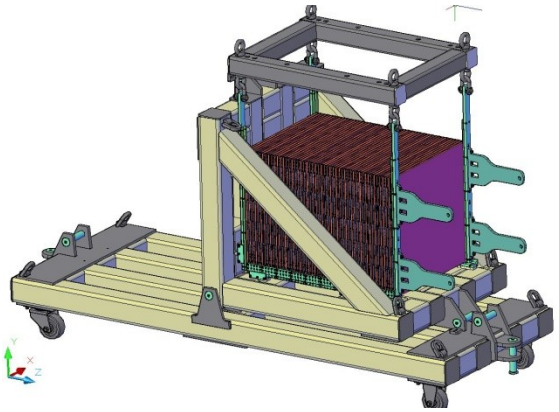
Absorbers assembled together using lateral spacers fixed to the absorbers through bolts.

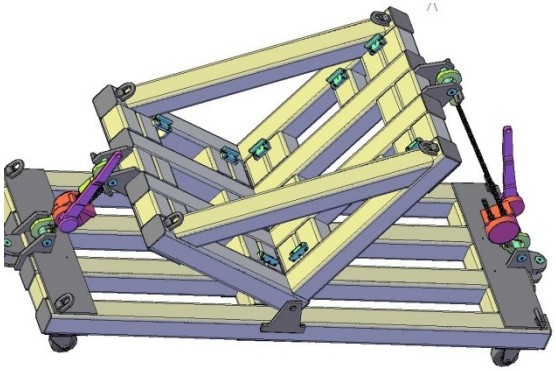
Assembling the mechanical structure

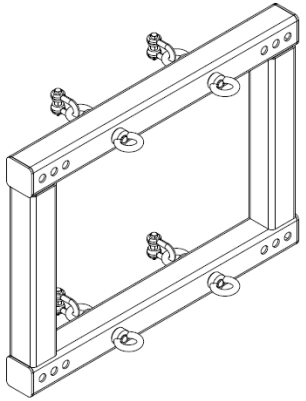


Special table to support the 8-ton prototype

Rotation tool







Sino-French collaboration

Lyon and Tsinghua groups are part of the SDHCAL project but in addition

1- Work on high rate GRPC is ongoing using the semi-conductive glass developed by Tsinghua group. Tests with small chambers were very successful detector efficient at very high rate (>90% at rates >20 kHz/cm2).

Plates of 50X50 cm2 are being prepared. Success of the new tests will encourage us to propose the GRPC to equip the very forward region of CMS and the update of both CMS and ATLAS.

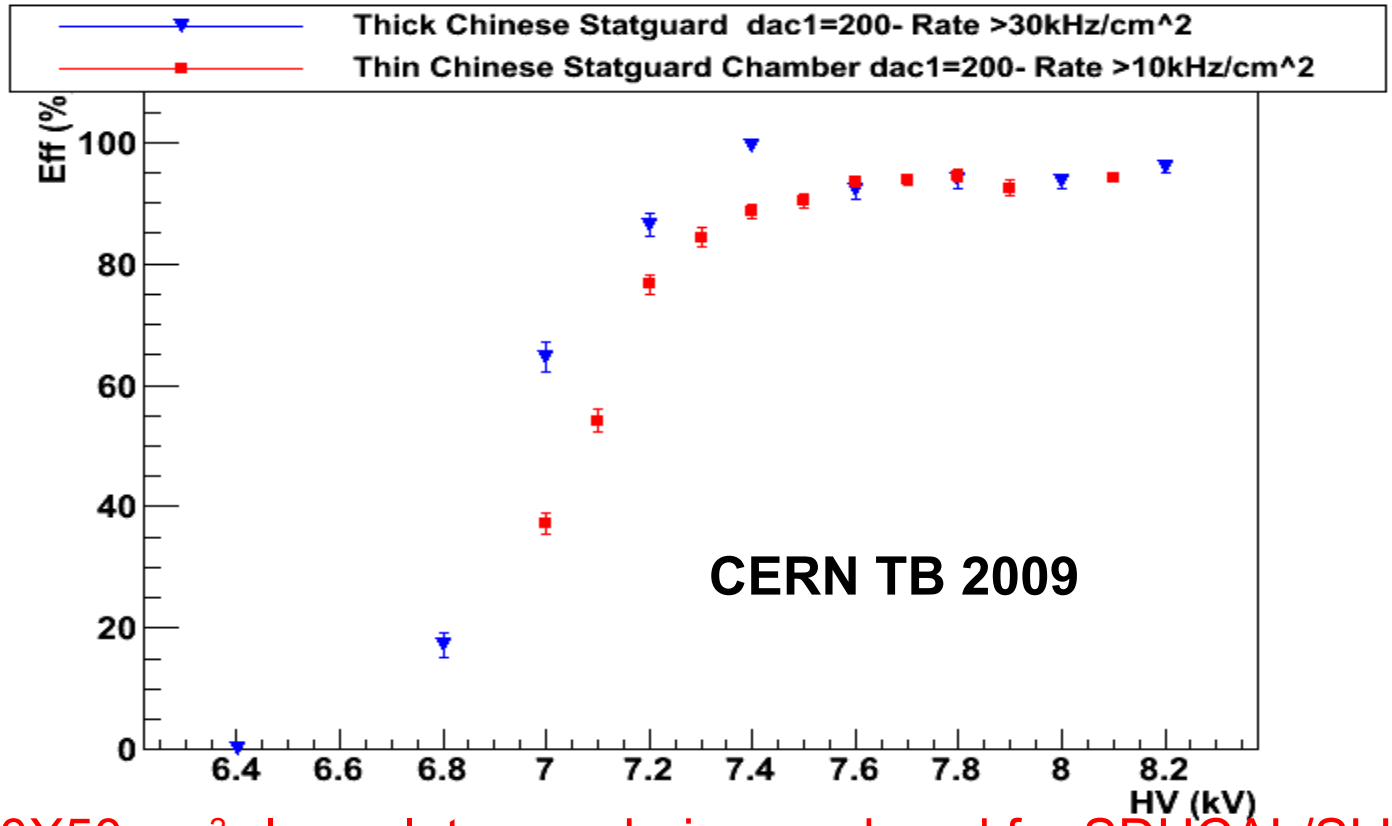
Weicheng Deng stay in Lyon in 2010 (3 months)

GRPC : At high rate standard GRPC becomes blind

(time needed to absorb charges accumulated on the glass)

Semi-conductive glass resistivity 10^{10} Ω.cm was developed and produced by **Tsinghua** group

(to be compared with 10^{13} Ω.cm for float (standard) glass)



50X50 cm^2 glass plates are being produced for SDHCAL/SLHC

Collaboration France-China

2- Study of the avalanche behavior in the GRPC chambers :

Comparison between data and simulation : Effect of different gas mixture on the detector performance.

Jingbo Wang stay in Lyon in 2011(3 months)

Townsend parameters

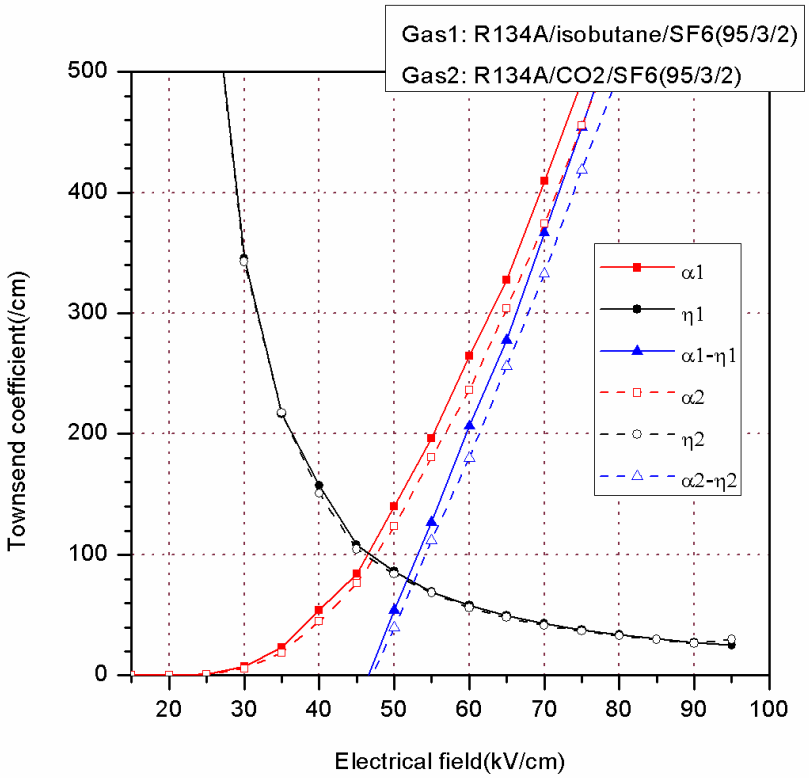
Jingbo Wang work

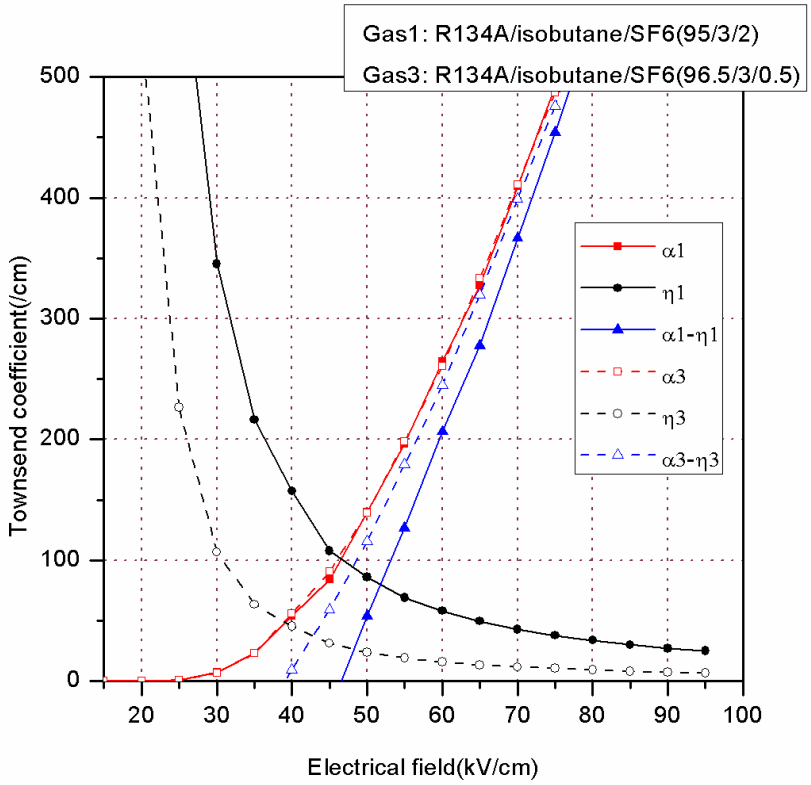
- Gas1: Freon/iso-butane/SF6 (95/3/2) Solid line !
- Gas2: Freon/CO2/SF6 (95/3/2),
- Gas3: Freon/iso-butane/SF6 (96.5/3/0.5),

- α multiplication
- η attachment
- α–η effective multiplication

Replace iso-butane with CO2

Decrease the fraction of SF6





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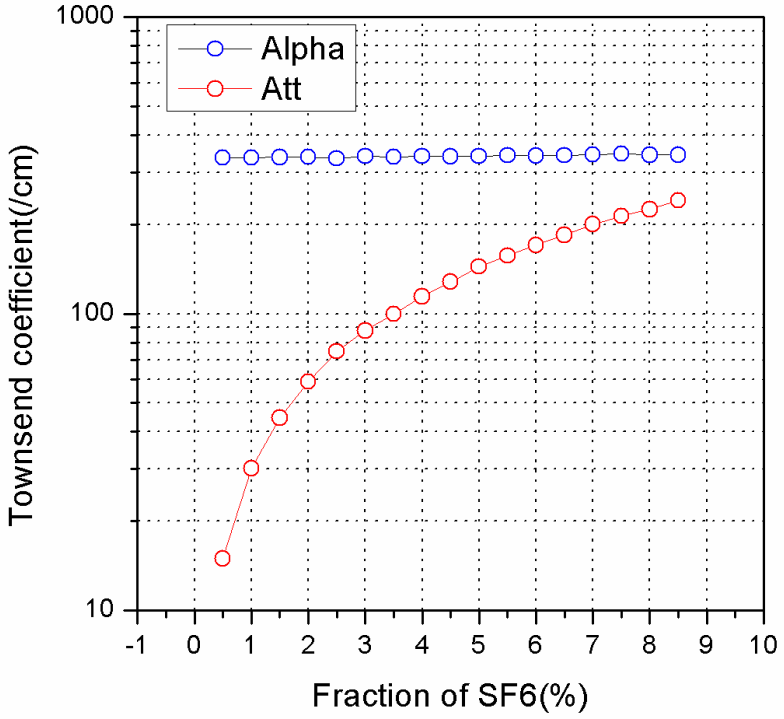
- **SF6 is an electron-negative gas with strong attachment**

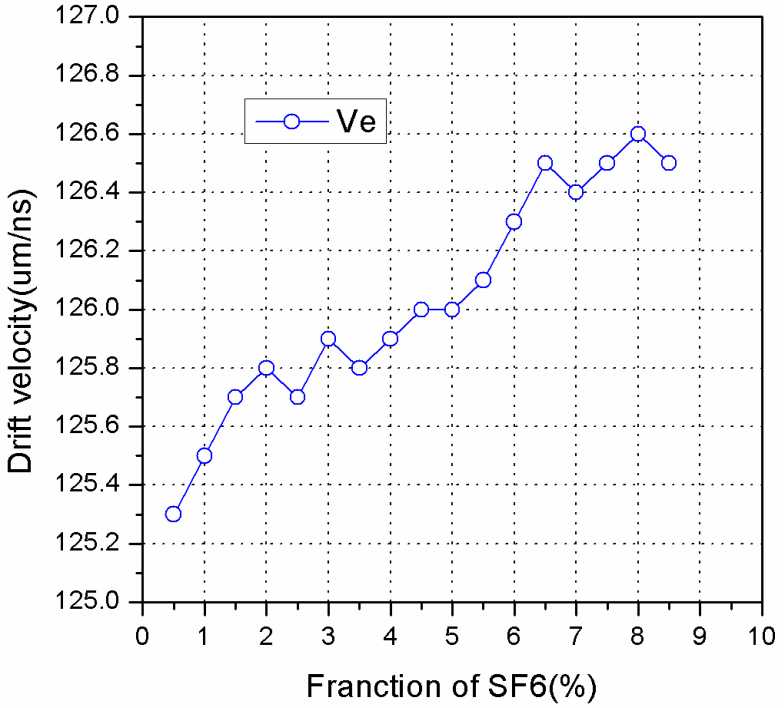
Magboltz, Version 8.9.3

Effect of the SF6 ratio

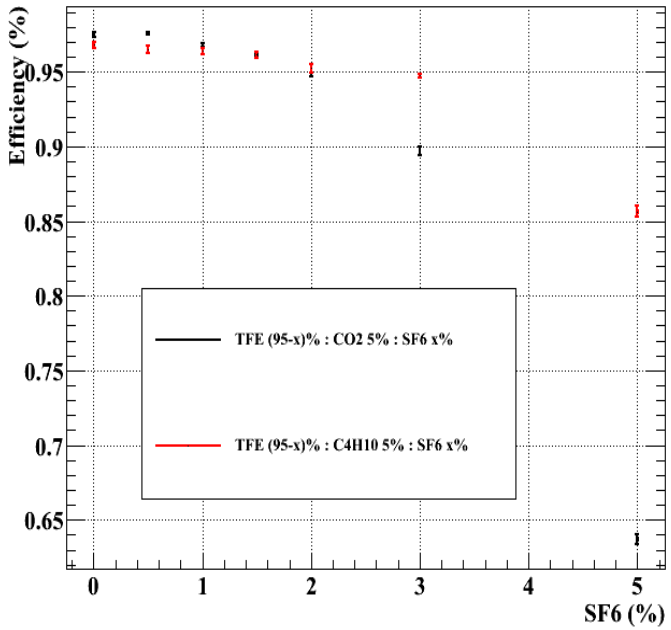
Jingbo Wang work

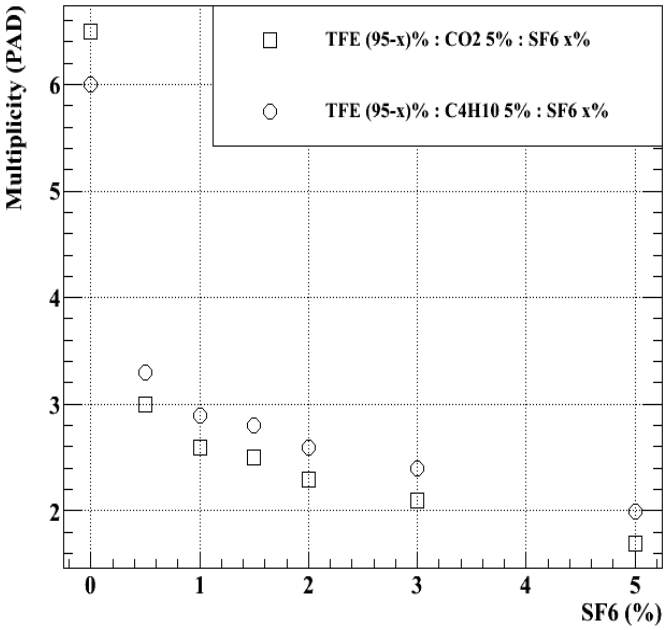
- Freon/iso-butane/SF6 (95-x/5/x)
- E = 7.5kV/1.2mm = 62.5 kV/cm





SF6 doen‘t influence the multiplication but the attachment!





Experimental verification with the large GRPC detector

Future

Next step will be the construction of very large chambers (>2 m2) with higher granularity. Glass manipulation may be a concern.
New bakelite plates used for Daya-Bay experiment can be of interest.

A small RPC (33 cm X50cm) was built by IHEP group for us on purpose. it is being studied on C.R test bench and will be tested with beam in the next TB.

We would like to collaborate with the IHEP to investigate the possibility to build large chambers using next generation of electronics.

Conclusion

-Collaboration between IPNL group and Tsinghua group is very fruitful. It contributes to the success of the technological prototype and its exploitation.

-New collaboration with IHEP has started and will certainly leads to nice results.

-This R&D is mainly orientend towards ILC but it is not limited to. Contributions to SLHC and neutrino physics are being considered. In addition Spin-offs are already there (volcanic muons) and many others to come...