Frontier Detectors for Frontier physics

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High Rate GRPC

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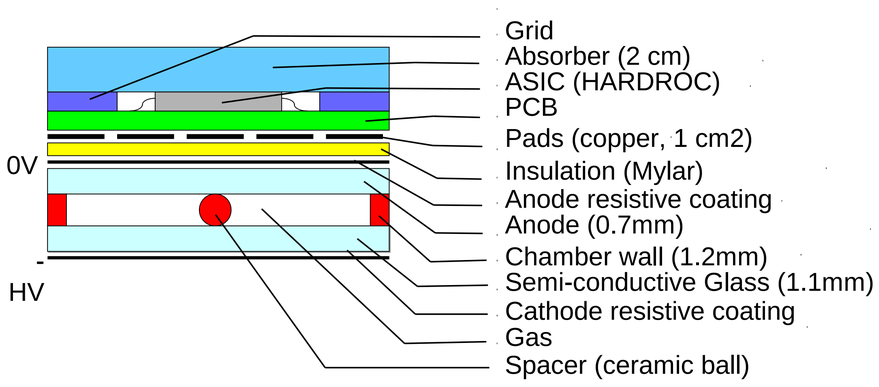
High Rate Glass RPC

GRPC are powerful detectors used in many HEP physics experiments. Their high time resolution and efficiency, in addition to their simplicity and low cost manufacturing make them excellent candidates for very large area detectors. The high resistivity of glass plates helps preventing discharge damages in these detectors, but this feature represents a weakness when it comes to their use in high rate environments. A Semi-Conductive Glass RPC is the solution to overcome this issue. The low resistivity of its doped glass accelerates the absorption of the avalanche's charges created when the charged particles cross the RPC. The recent beam test @DESY with a high rate electron beam constitutes a validation of this new concept.

Working principle of a GRPC



A charged particle passes through the detector ionizing the gas mixture (93%TFE, 5%CO2 , 2%SF6) contained in a 1.2 mm gap between 2 glass plates.

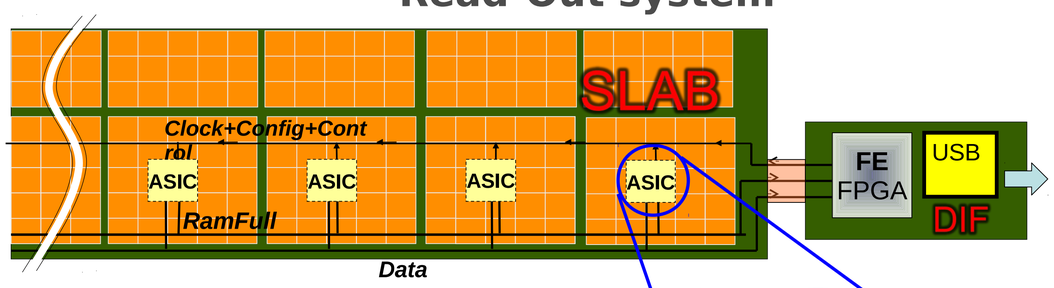
High voltage (6.5-8 kV) applied on the glass plates through a resistive coating produces charge multiplication in the gas gap (avalanche mode).

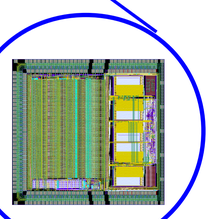
After a short time (few ns), the moving charges on the gas gap induce signal on the copper pads of the readout PCB.

Semi-conductive Glass

- Resistive material coatings:
  Colloidal graphite : ≈ 1 MΩ/□
- Glass plates: doped glass, low resistivity:
  10^{10} Ω.cm to be compared with the resistivity of float glass currently used : 10^{13} Ω.cm
- Plates thickness:
  Cathode 1.1 mm/ Anode 0.7 mm
- Gas distribution: Capillary tubes drive gas into channeled inlet.
- Spacers: 1.2 mm ceramic balls for spacers.
  GRPC size : 30X30 cm2
- GRPC thickness : 6 mm
- Spatial resolution: 4 mm

Read-Out system





HARDROC

SLAB :

- Semi-digital ASICs: 2-3 thresholds.
- One ASIC manage 8x8 (64) 1cm² sensitive PADs.
- Low consumption, power pulsed ASICs (< 10 µW/ch).

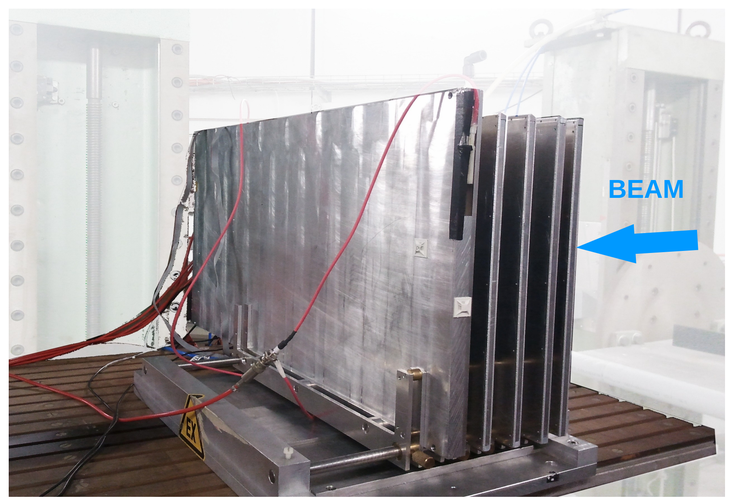
DIF:

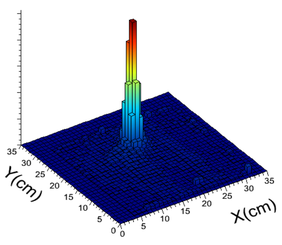
- FPGA-based DAQ talking through USB with Xdaq.
- Manage ASICs through daisy chain scheme.

TEST BEAM @ DESY

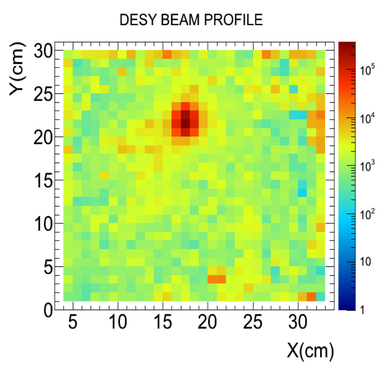
A beam test done on January 2012 with 4 semi-conductive GRPC + 1 float GRPC.

- Continuous electrons beam with very high intensity. (> 8 KHz)
- Energy of the beam : 1-6 GeV
- Very Concentrated beam is used (2cmx2cm)





Beam profile



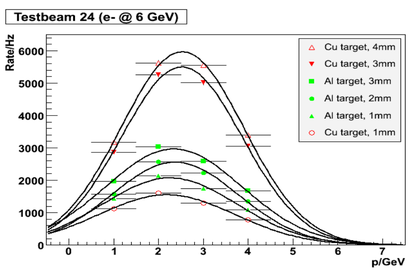
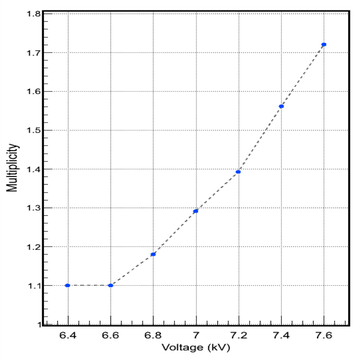
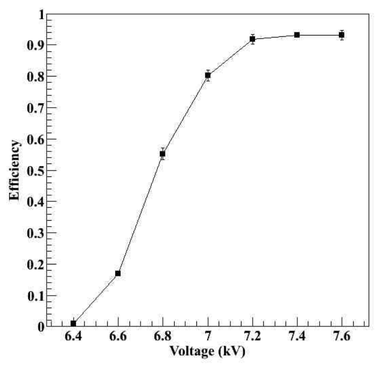


Fig.Rate vs p for Testbeam 24:about 14*10e9 electrons @ 6 GeV, one carbon wire, different targets.

RPC performances

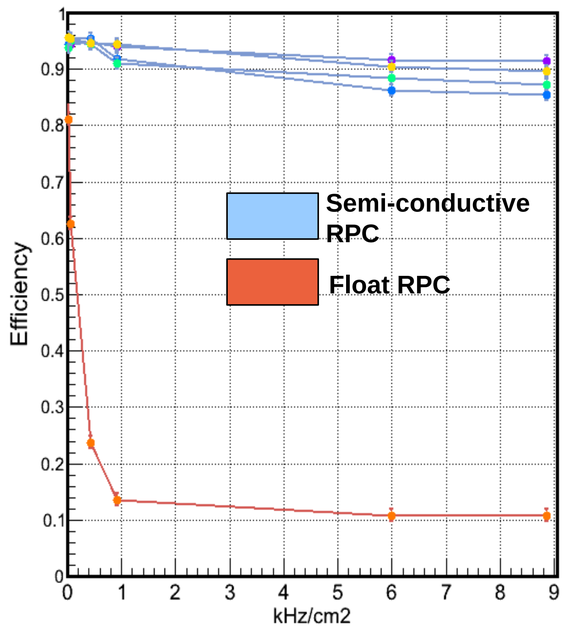




- Working point : 7.2 kV
- Very high efficiency > 95% @low rate
- Low Multiplicity ~ 1.4

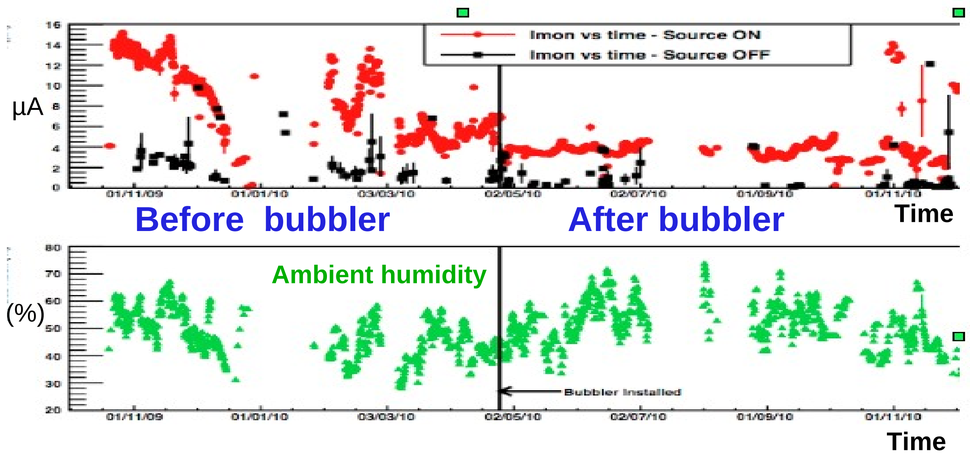
Semi-Conductive GRPC Efficiency @ High rate beam

- The particle tracks are used to measure the efficiency of each chamber by reconstructing the track using other chambers (without the studied chamber) .
- The efficiency is the probability to find hit near the reconstructed track.
- The multiplicity is the cluster size.
- For this study only the tracks with one cluster in each chamber with size < 4 pads are taken.
- Float RPC (in red) become very inefficient at very high rate beam.
- The Semi-conductive RPC have good efficiencies at High rate beam ~90% with rate ≈ 9 KHz



Aging effect

- Stable current with no aging effect in high rate condition during 6 mounts after bubbler installation.
- Other tests coming soon.



References :

[1] - Study on the performance of high rating MRPC, Y. Wang. Nucl. Instr. and Meth.
[2] - I. Laktineh, Development of a semi-digital hadronic calorimeter using GRPC, Nuclear Instruments and Methods, ISSN 0168-9002, 10.1016/j.nima.2010.02.205.
[3] - M. Bedjidian, J.-P. Ianigro, R. Kieffer, I. Laktineh, N. Lumb, S. Vanzetto, Glass resistive plate chambers for a semi-digital HCAL, Nuclear Instruments and Methods, ISSN 0168-9002, 10.1016/j.nima.2010.02.168.