Sampling Calorimetry with Resistive Anode Micromegas (SCREAM)

Test plans in RD51 beam line

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Resistive Micromegas for Particle Flow (sampling) calorimetry

→ at future linear colliders (ILC, CLIC)

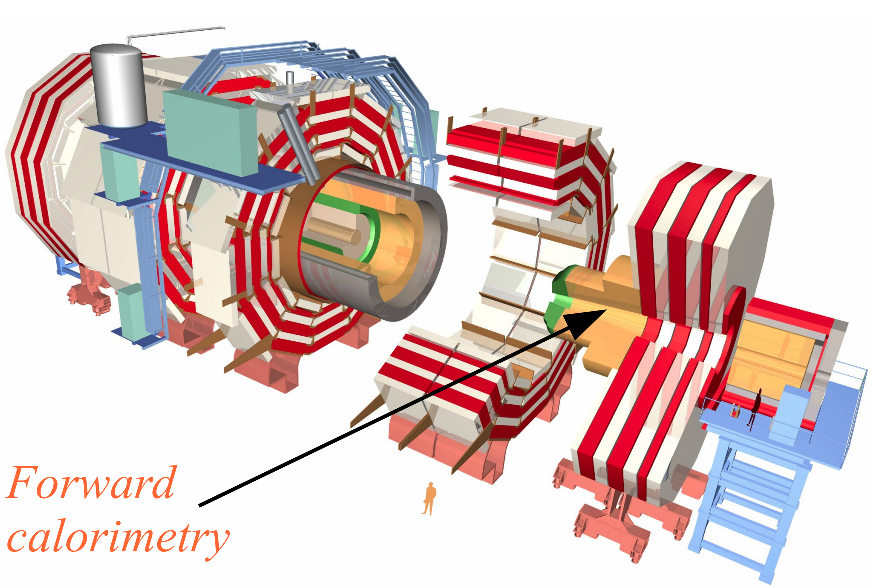
HCAL with 1x1 cm2 pads, 4-5 lambda, 40 layers, W or Fe absorbers
Constrains on power-consumption (power pulsing), low noise (self-triggering)
High channel density (ASIC on PCB), active layer thickness (< 1 cm)

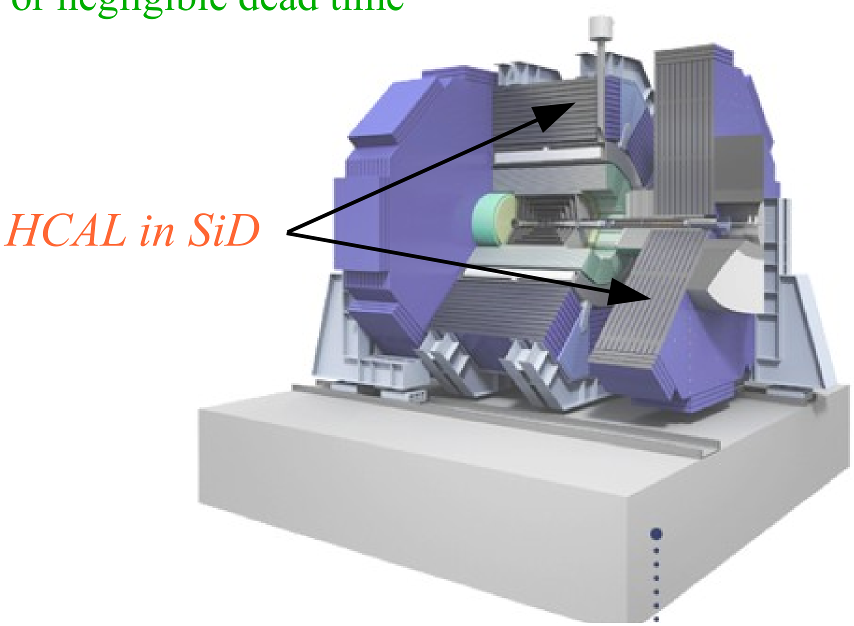
Advantage of resistive layer: removes spark protection diodes on PCB (→ cf. existing prototypes next slide)
(simpler design, more reliable, probably more cost effective)

→ at high-luminosity LHC (CMS)

Tail catcher of calorimetric system in forward region (completes Si-W ECAL+HCAL), upgrade for 2022 running
Constrains on rate capability, ageing, radiation hardness

Advantage of resistive layer: suppress or attenuate sparks, no or negligible dead time





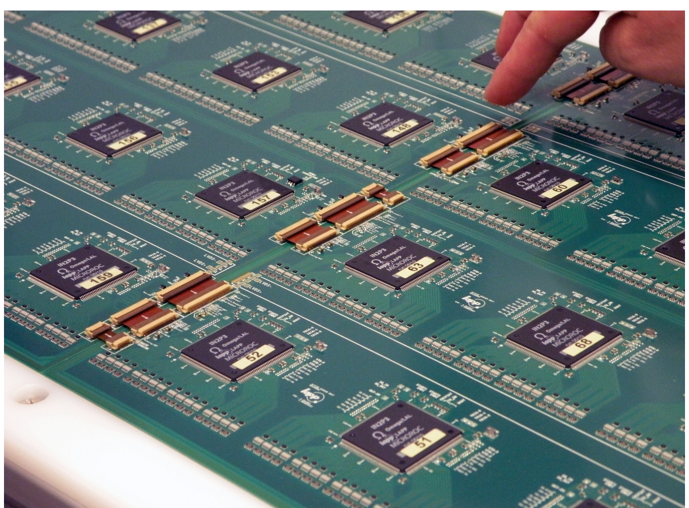
Prototypes for a LC

Large-area Micromegas with integrated front-end electronics

1x1 m2 prototype based on 6 boards
Each boards houses a Bulk Micromegas, 32x46 pads of 1x1 cm^2 and 24 MICROROC ASIC (1536 channels)
Non-resistive, ASIC are protected from sparking by diode networks on PCB

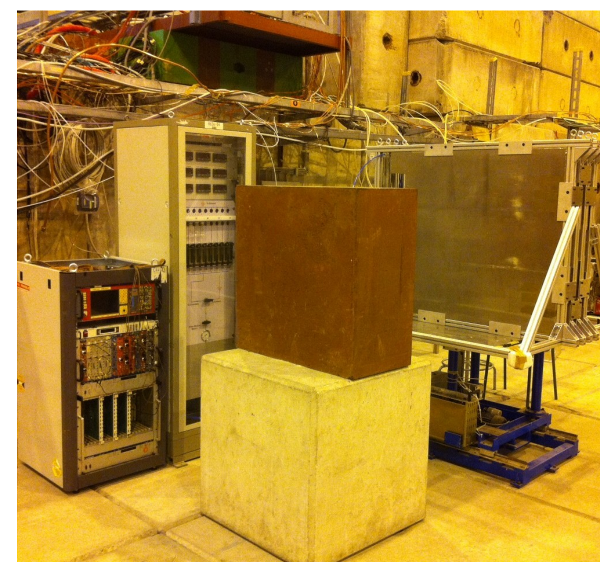
4 prototypes were build and extensively tested in beam (RD51 and CALICE)
2 publications reporting on construction (NIM A729 (2013) 90) & operating characteristics (A763 (2014) 221)

Setup in H4 RD51 beam line (2012)
At next testbeam, the setup will be similar, but smaller

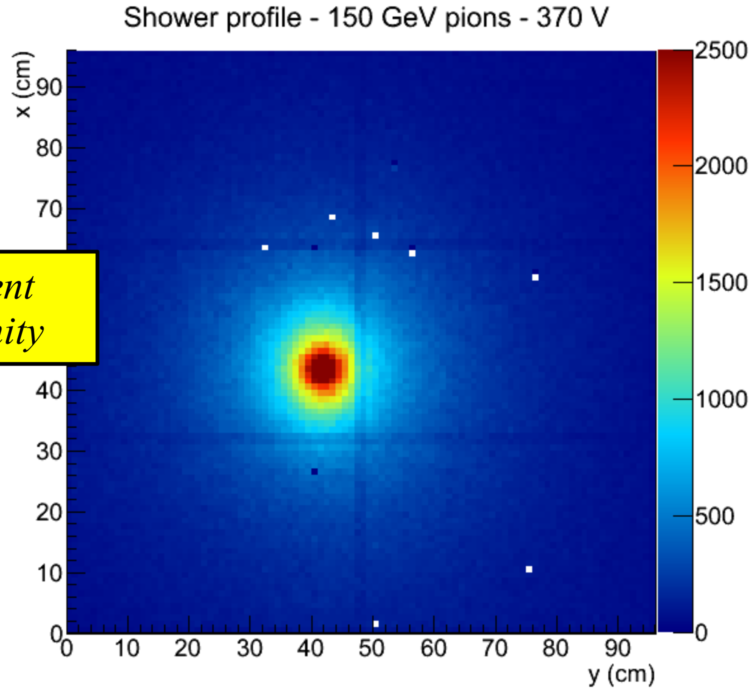


PCB with ASIC & diodes (recto)

6 Bulks in 1 chamber (verso)

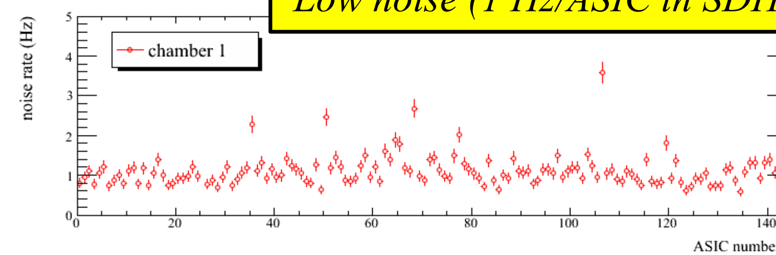


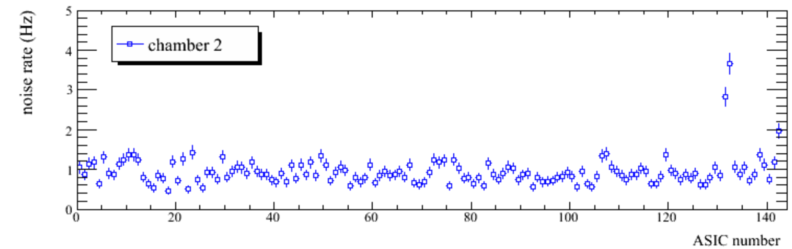
Highlights of testbeam results (LC-prototypes)



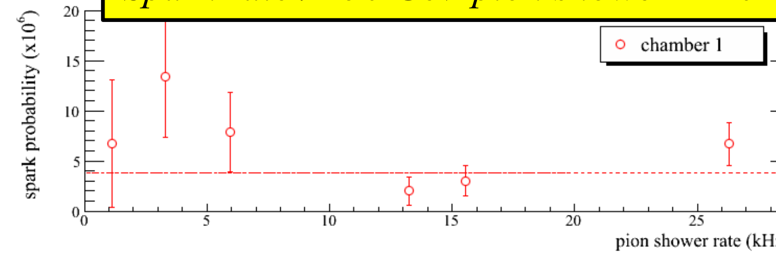
Excellent uniformity

Low noise (1 Hz/ASIC in SDHCAL)

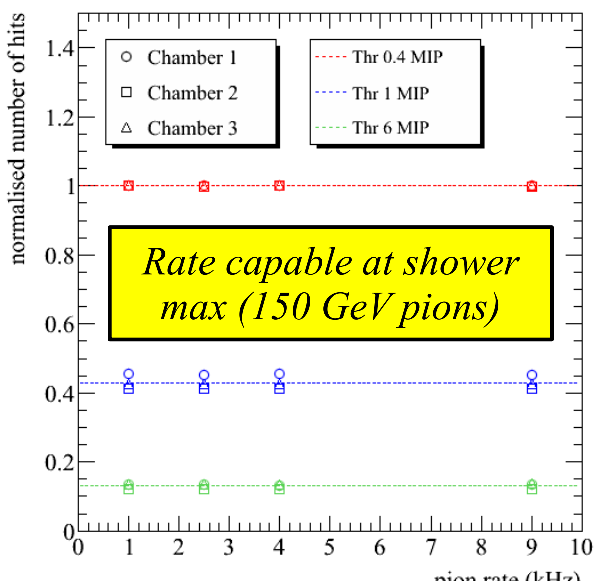




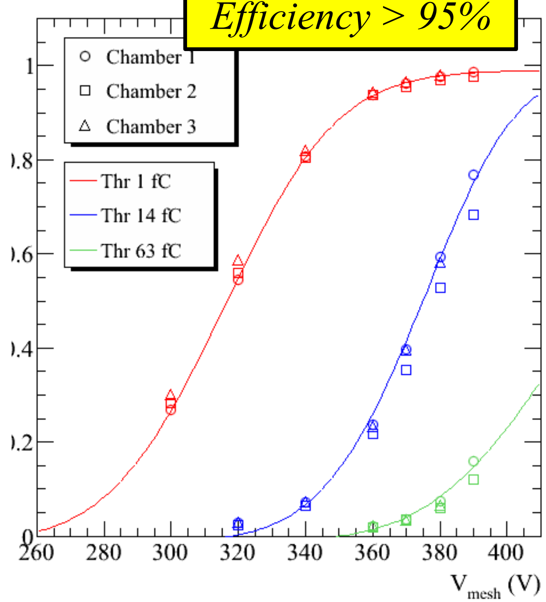
Spark rate / 150 GeV pion shower < 10^{-5}



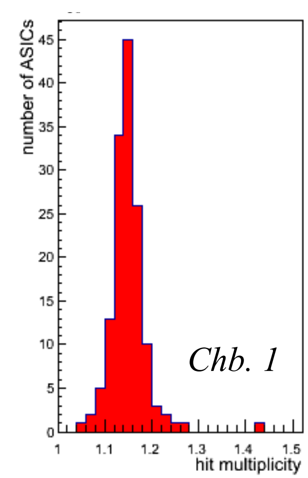
Rate capable at shower max (150 GeV pions)

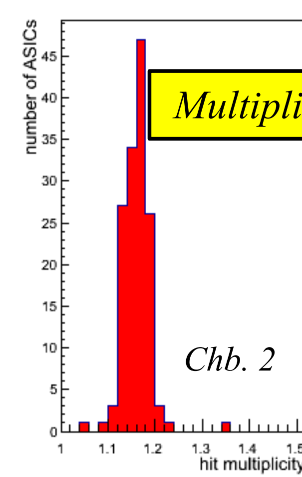


Efficiency > 95%



Multiplicity ~ 1.15



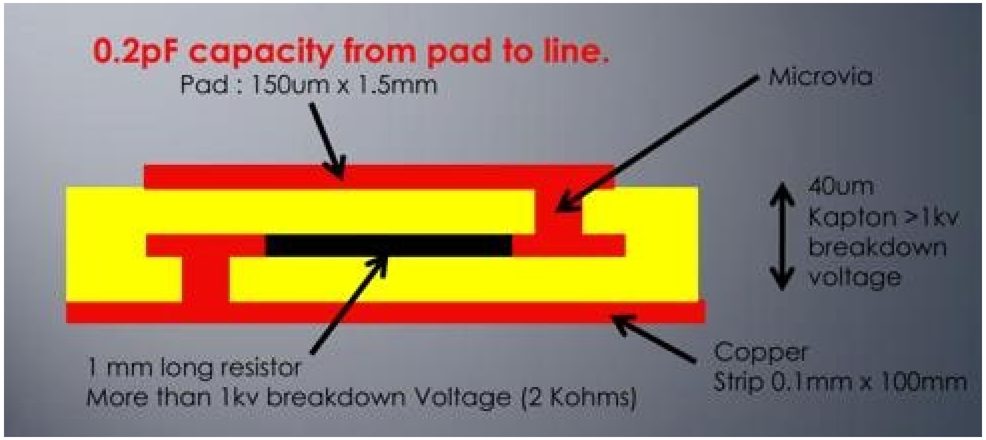


Requirements and R&D

What kind of resistive coatings?

Scalable to large area
→ charge evacuation to ground through the pad and not on the side → buried resistor
In this scheme, resistive and readout pads are connected by a resistor and separated by an insulator.

Fast evacuation of charge
→ small RC constant
R is the sheet resistance of the resistive pad
+ the buried resistance
C is controlled by the insulator thickness
and the pattern & size of the pad



What will we investigate?

Signal linearity will eventually determine the response of a sampling calorimeter
→ **effect of rate but also of energy deposit** (dE/dx) on gas gain

How is sparking affected
→ Careful monitoring of the mesh voltage & current

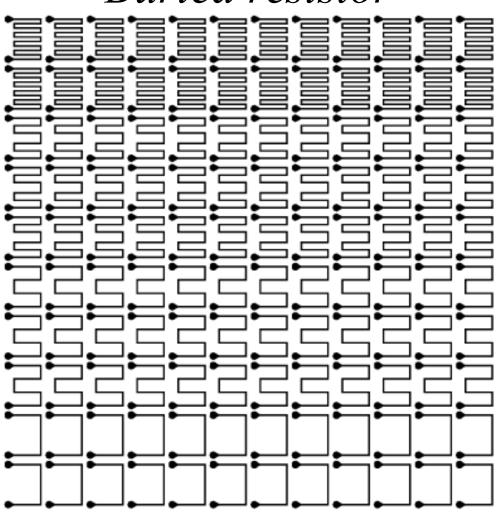
Resistive prototypes (1/2)

Study different configurations of buried resistors with small prototypes
Then, build a large-area prototype with the best configuration

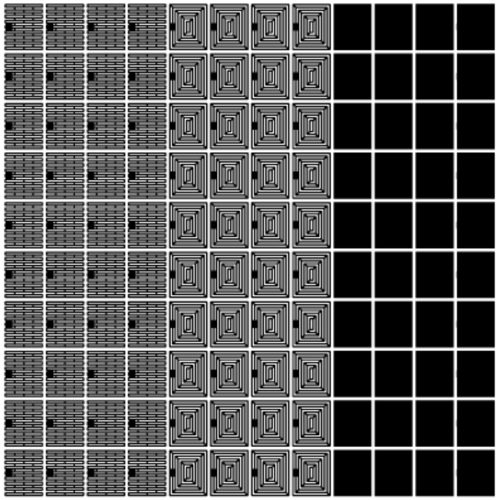
Use simple PCB + re-use existing hardware (JINST 4 (2009) P11023)
Design of 10x10 cm^2 with 1x1 cm^2 pads
External electronics (Gassiplex), VME module -based DAQ, Labview sotfware

We first produced a prototype with different R-patterns
then prototypes with the same pattern over the pad matrix

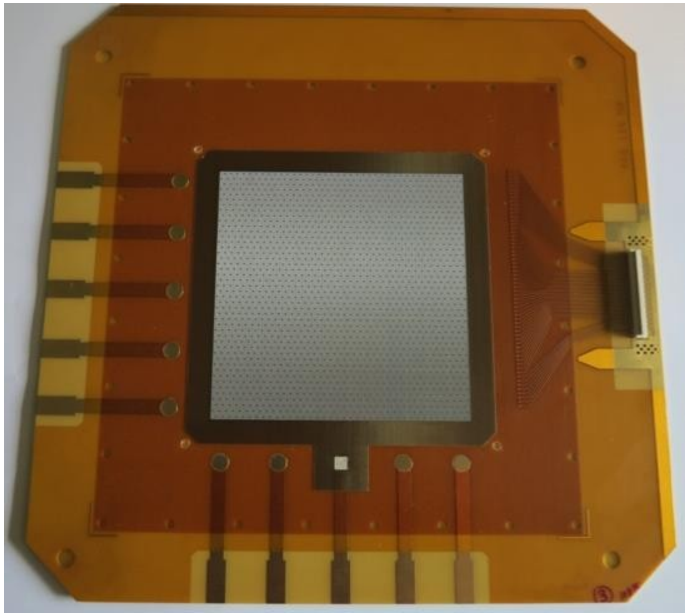
Buried resistor



Resistive pad



Rpad + Bulk



Resistive prototypes (2/2)

Study different configurations of buried resistors with small prototypes
Then, build a large-area prototype with the best configuration

Use simple PCB + re-use existing hardware (JINST 4 (2009) P11023)
Design of 10x10 cm^2 with 1x1 cm^2 pads
External electronics (Gassiplex), VME module -based DAQ, Labview sotfware

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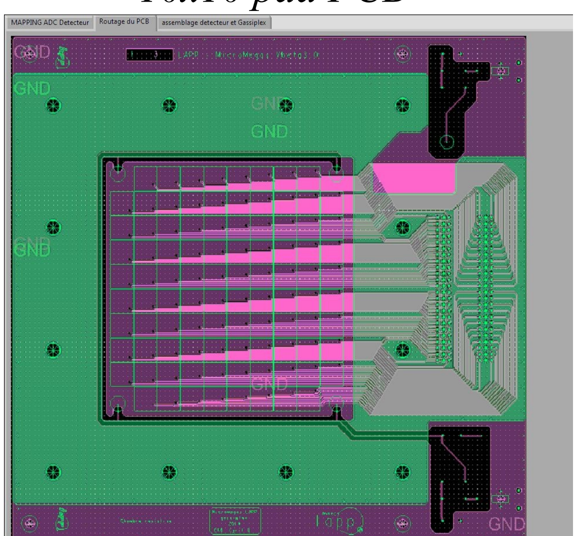
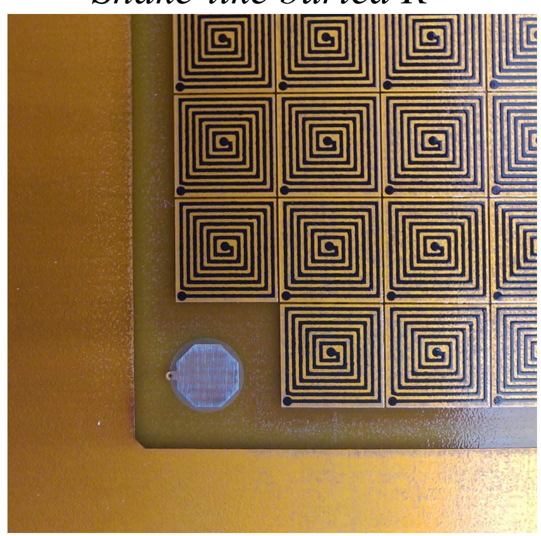
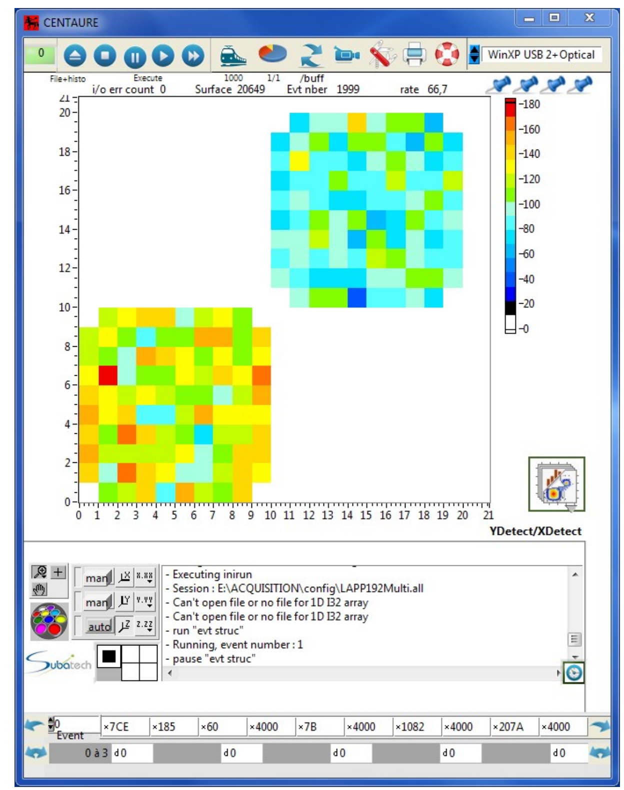
10x10 pad PCB



Snake-like buried R





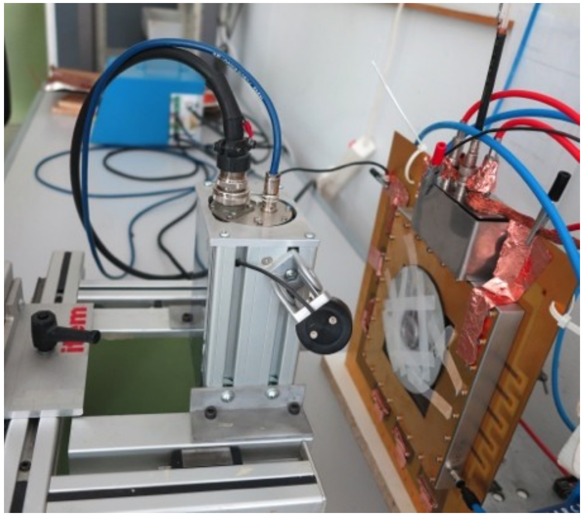
On-going measurements

Prior to the testbeam, we are checking the performance of all prototypes
At this moment, 5 prototypes were build, including a non-resistive as reference.

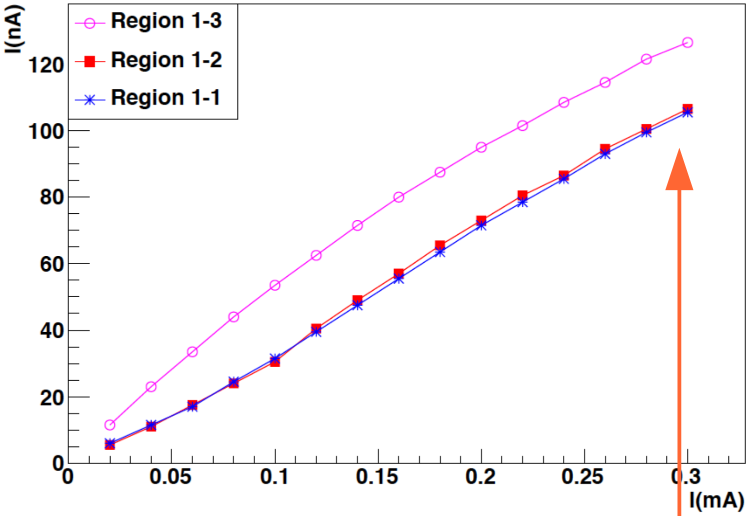
Rate scan
X-gun at Demokritos (3 keV, <11 MHz/cm^2 in detector) to be continued in the RD51 lab at CERN

dE/dx scan
Use GEM foil as charge injector, dedicated chamber @ LAPP

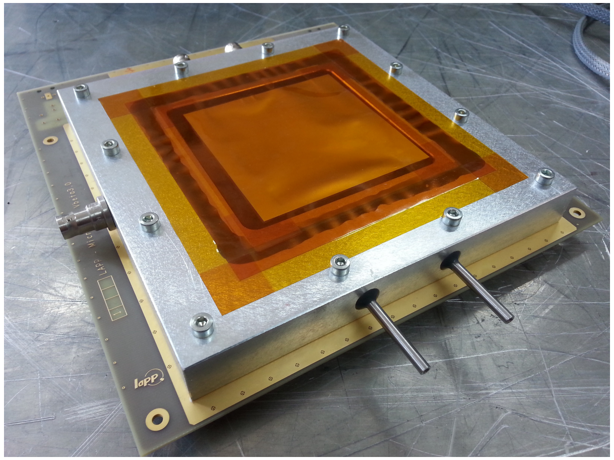
Xgun @ Demokritos



Mesh current VS Xgun current



Chamber with GEM+Bulk



For some patterns, linearity is preserved up to 11 MHz/cm^2!
Will it still be the case in hadron showers...

RD51 Testbeam

Main goal: test prototypes in high-energy, high-rate, hadron showers

Setup (downstream of other setups)

2 scintillators + PMT + trigger electronics

1-10 steel absorber layers (30x50 cm^2, 2 cm thick), can be removed in < 15 minutes

Detector stack: 2 non-resistive prototypes and 3-4 resistive prototypes (use non-R as telescope)

1 rack with VME modules for ASIC control & signal digitisation

2 PC (remote desktop from control room)

Gas: Ar/CO2 93/7 (2 bottles)

Beam 1: Muons

Detector calibration, single particle response

Beam 2: Pions (with & without absorbers)

Rate scan: 100 Hz to 100's of kHz

Energy scan: 10 to 100's of GeV

→ we will change the beam quite a bit!

What we would need from RD51: slow-control system for CAEN HV-unit (SY2527, 10 channels)

Crucial to study sparks