Pixellized Micromegas detector for the COMPASS experiment

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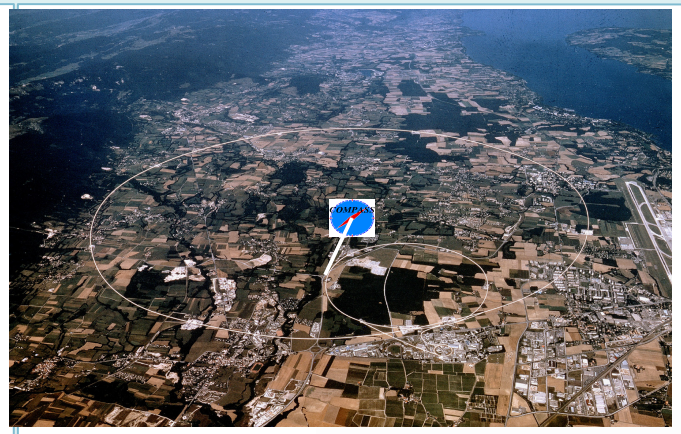
Principle of the project

Activities in 2011

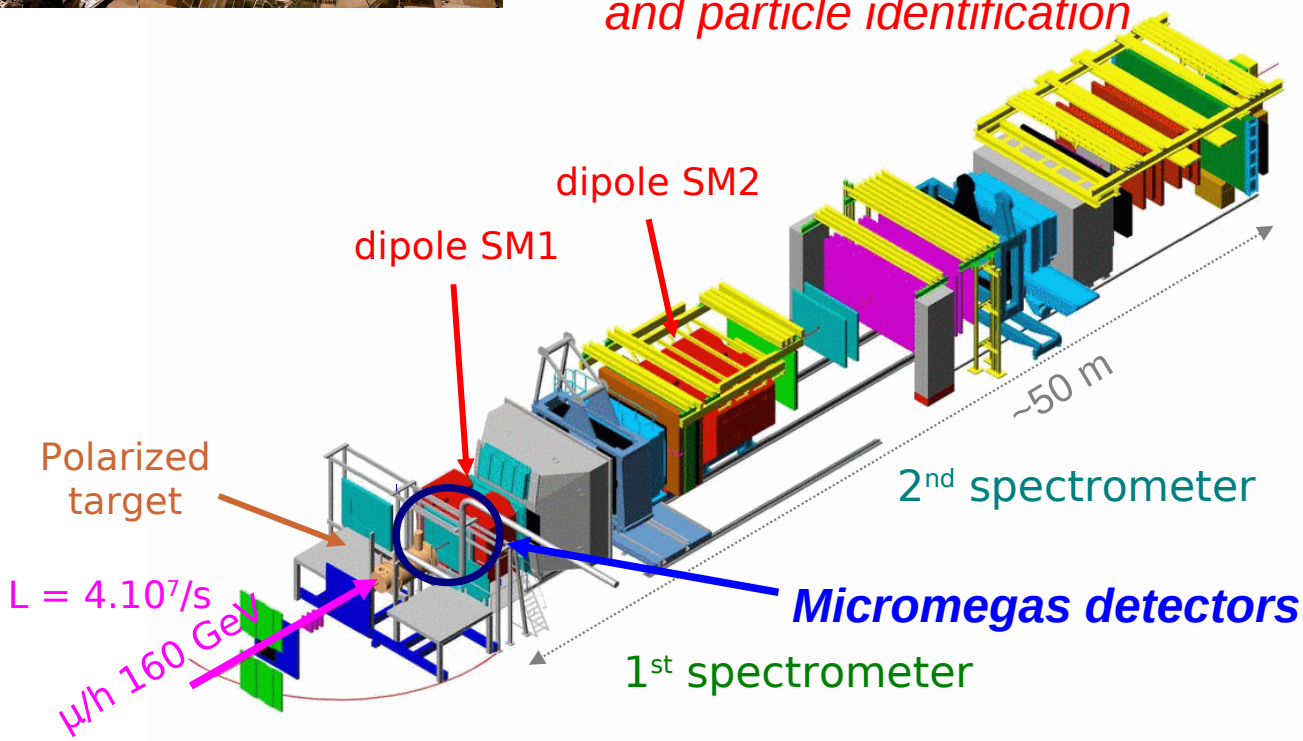
Preliminary results from 2011 pixellized prototypes

Future plans

The COMPASS experiment at CERN



Dedicated to nucleon structure and spectroscopy studies
High resolution spectrometer at small and large angles
High statistic experiment (30kHz trigger rate)
Very good spatial resolution (<100µm) required at small angle for kinematics and particle identification



Present COMPASS Micromegas detectors

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Main characteristics

Large size 40x40 cm² with deported electronics

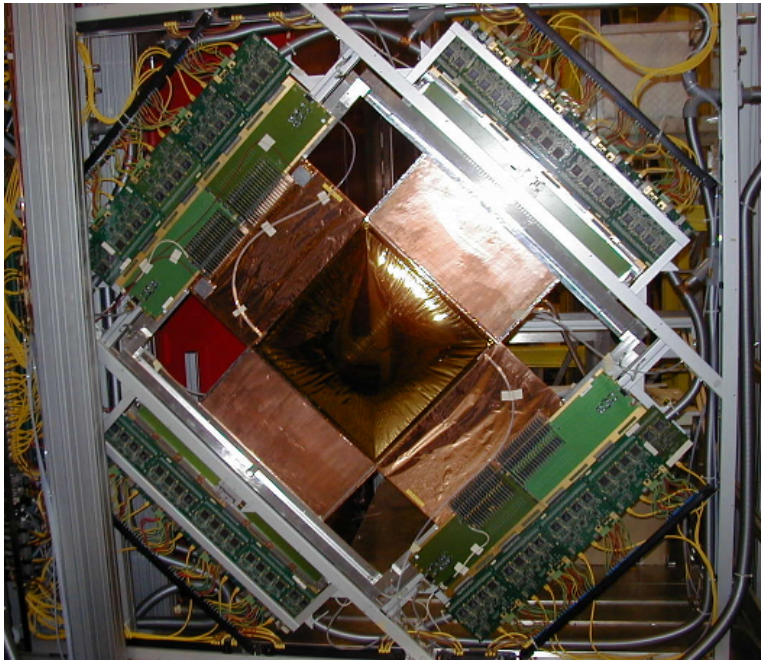
Reduced discharge rate with light gas and low noise electronics

Very good performances (70-100µm, 10ns resolution)

Room for improvements

Blind center (5cm diameter disk, beam area)

Discharge rate in amplification gap is limiting factor with hadron beam



Pixellized MM project

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Main objectives of the project

Less discharge → stand 5 times higher flux hadron beams

Detectors active in beam area

New MM detector to design with:

10 to 100 times less discharges compared to present MM

Read-out with pixels in the detector center (beam area)

Integrated electronics (APV25 chips)

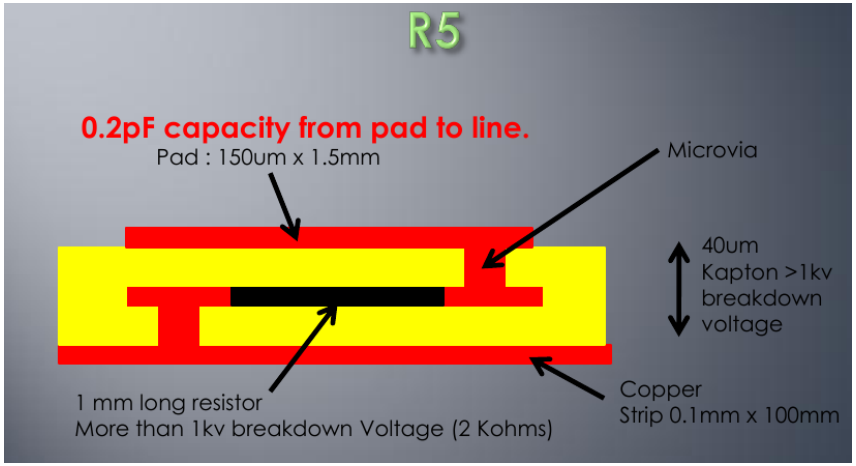
Robustness improved (bulk technology)

Two solutions to reduce discharge rate

Resistive Micromegas

« Standard » resistive schemes no more considered

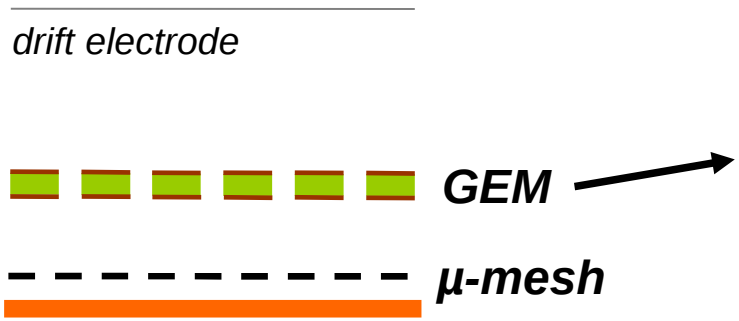
***Buried resistors** scheme proposed by R. de Oliveira et al. still under study*

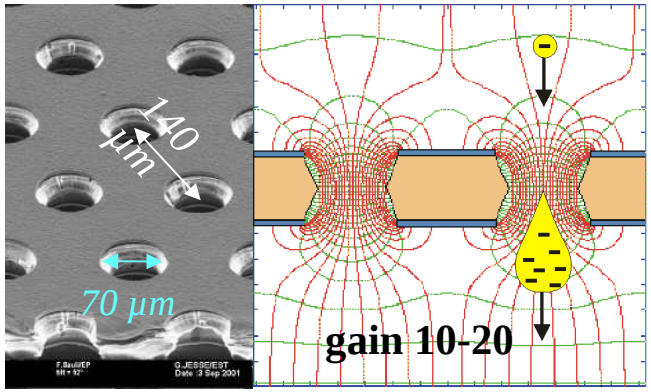


Micromegas + 1 GEM foil

Preamplification with a GEM foil (gain 10-20)

Micromegas stage at lower gain → less discharge





Spark probability of MM+GEM (2010 PS tests)

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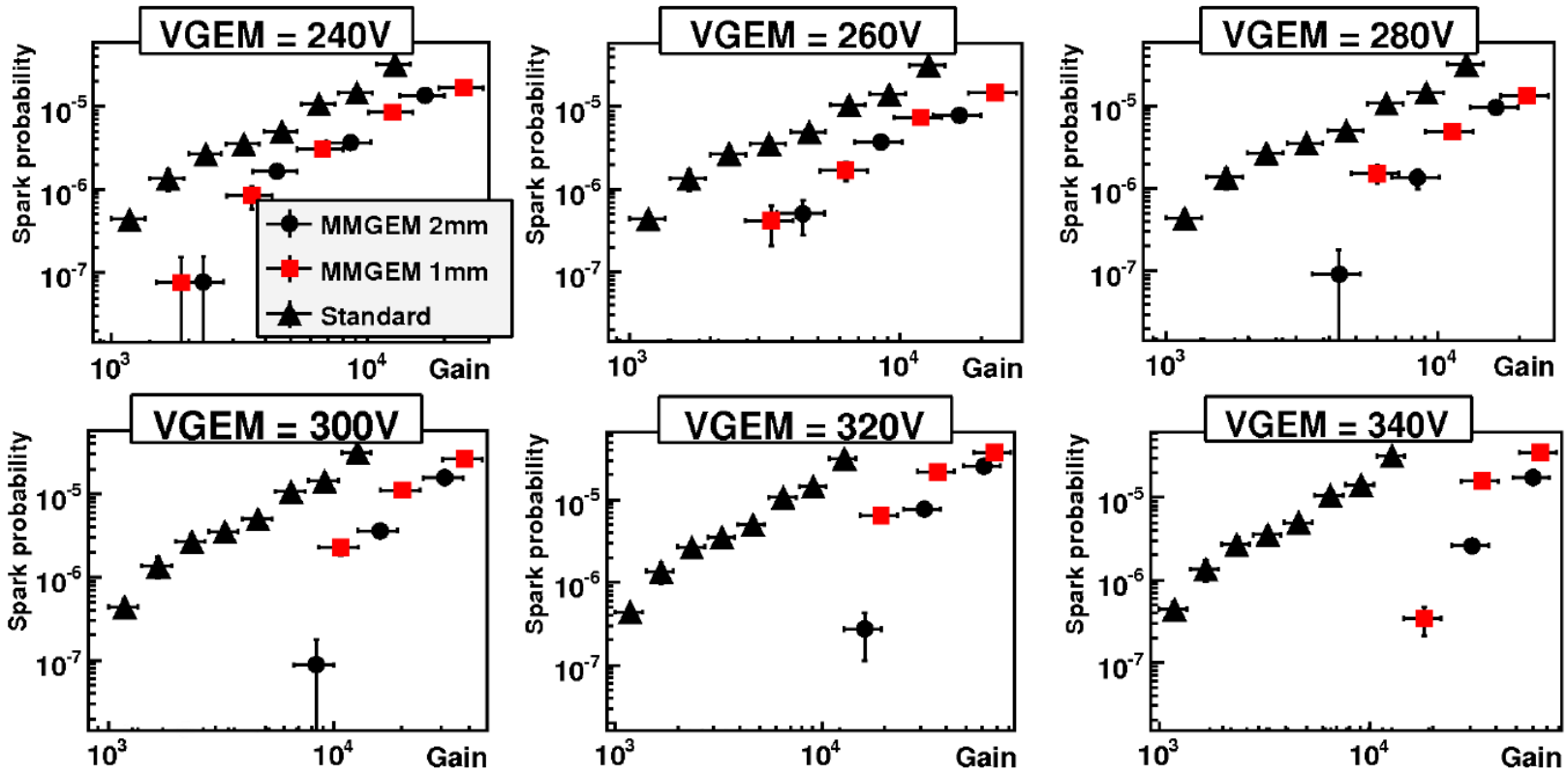
2 MM+GEM prototypes

1 and 2mm distance between mesh and GEM foil



please refer to M. Vandenbroucke and S. Procureur talks

Large size detectors for COMPASS

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Large prototypes

Design close to final one

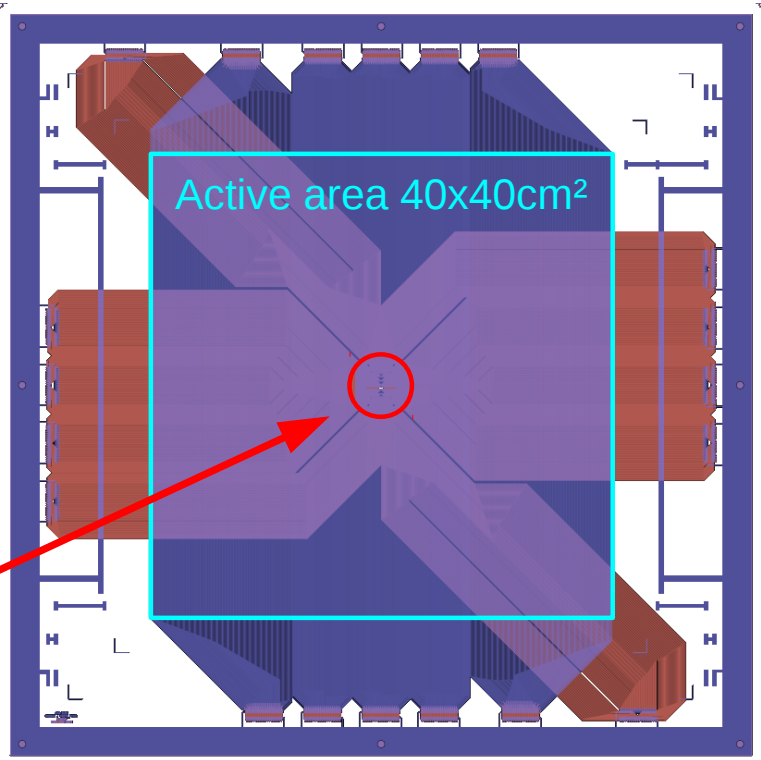
Material budget similar to present MM

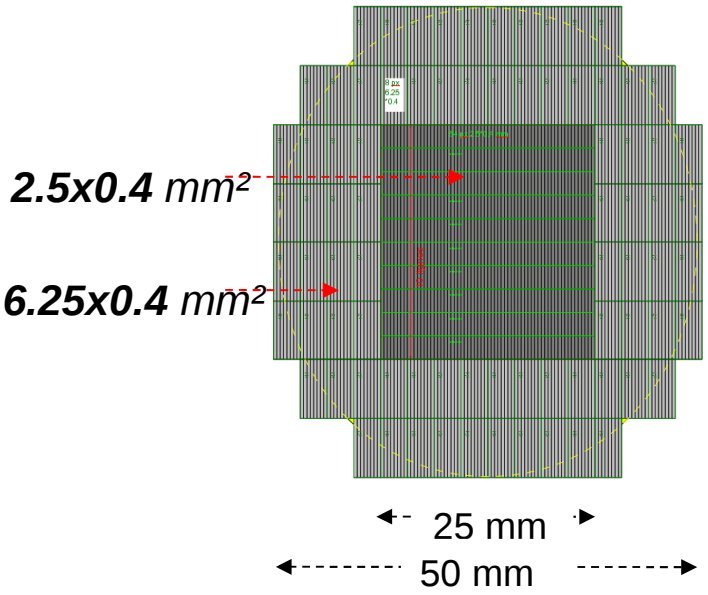
40x40cm² active area, MM bulk technology

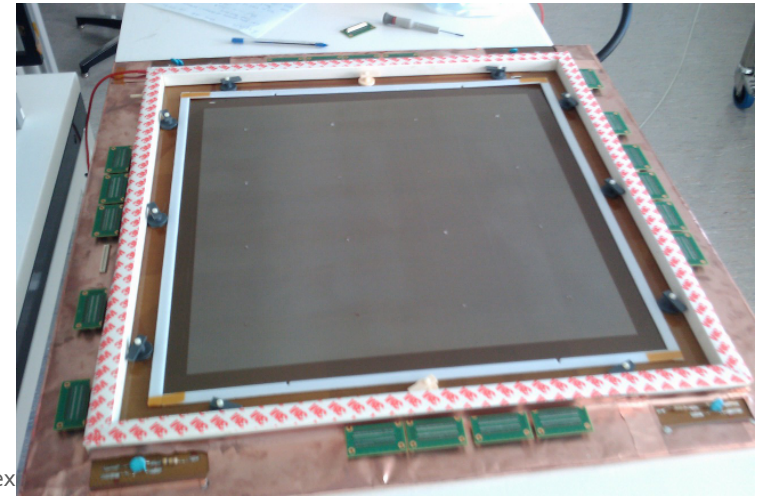
400µm pitch strips

5cm diameter pixel area in center

1280 + 1280 channels







About material budget

Material budget without GEM foil similar to MM

Board: 0.205% X0

Mesh: 0.05% X0

Drift: 0.027% X0

Gas mixture and enclosure: 0.037% X0

Total: 0.319% X0

Present MM: 0.287% X0

Budget of GEM foil or resistive layer

Standard GEM foil: 0.067% X0

Copper thickness can be reduced to 2µm → 0.035% X0

Resistive layer: 0.084% X0, mostly due to silver paste in vias

Read-out with APV25 chips

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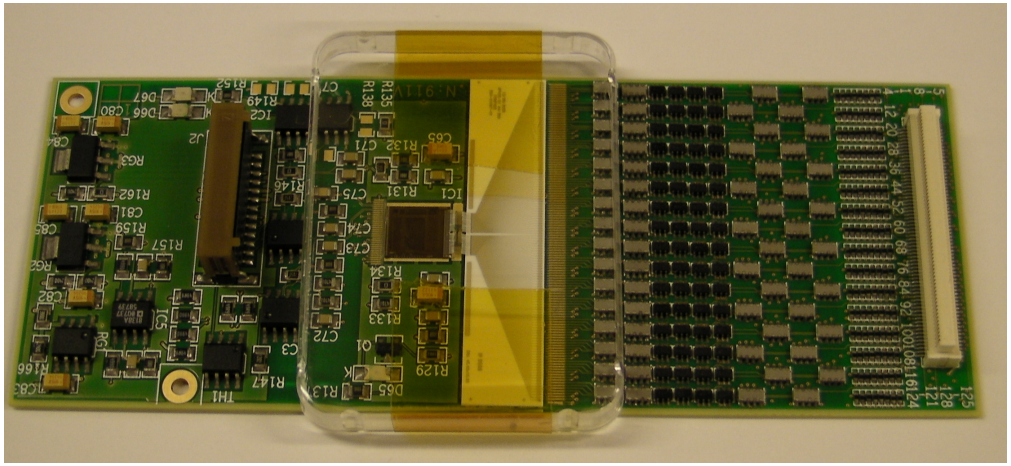
Integrated electronics based on APV25 chips

Already existing design (TUM Munich) adapted to MM (protection circuit with strips decoupling) + tuning of APV configuration

Integrated in standard COMPASS DAQ

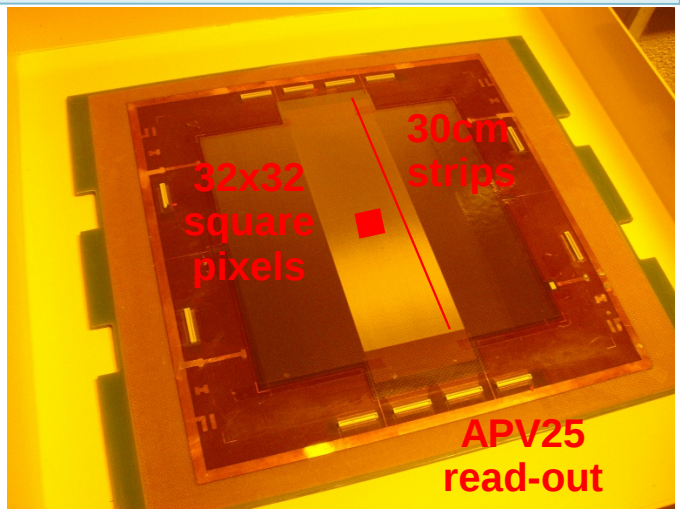


Large size prototypes

First prototypes in 2009

Square pixels in the center, APV read-out with MM detectors

Comparisons bulk / non-bulk



Large size prototype in 2010

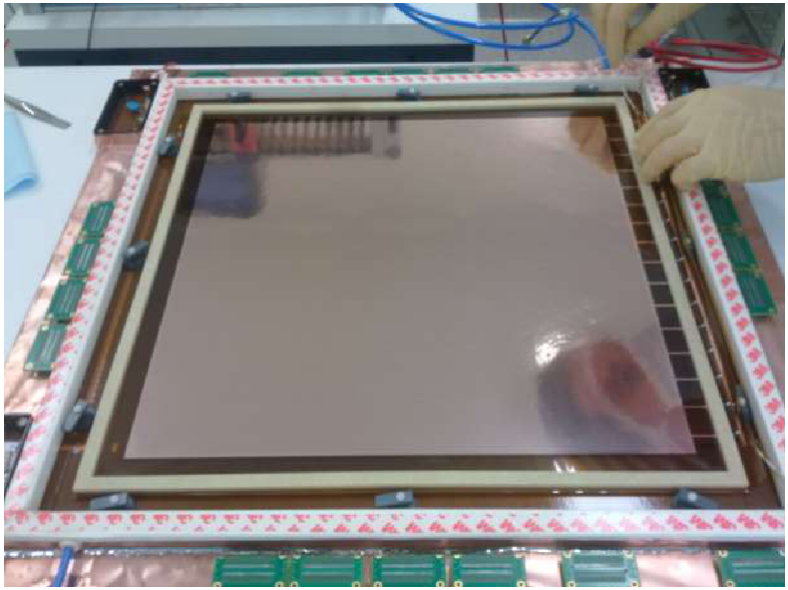
Validation of geometry

2 large size MM+GEM detectors in 2011

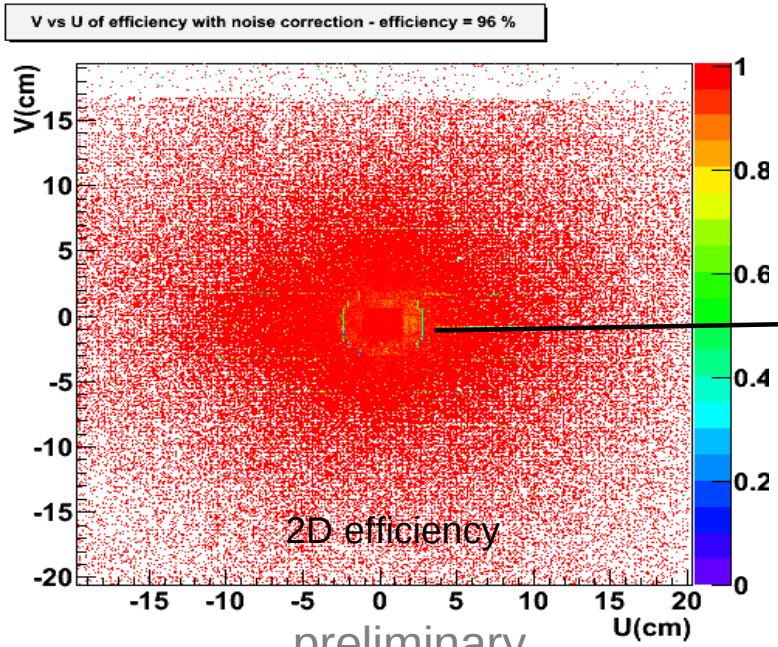
First large size MM+GEM detectors installed in COMPASS muon beam

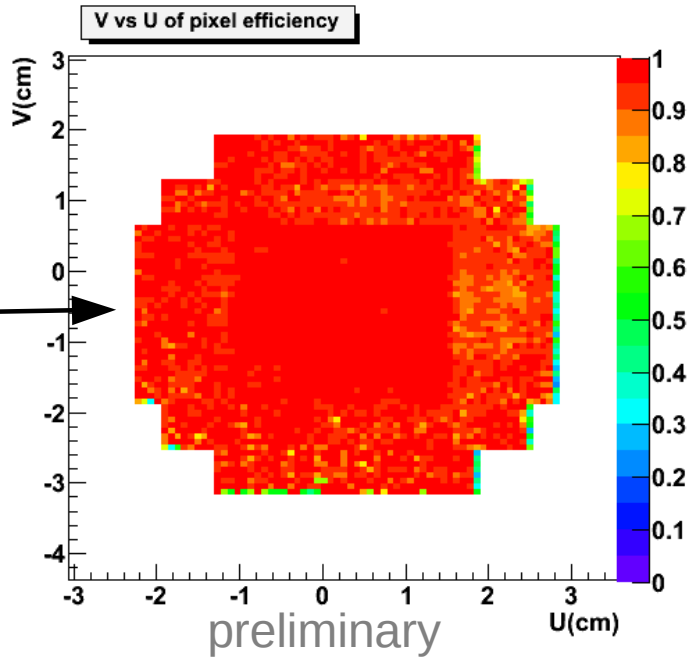
Performances measurements in progress

Large size buried resistor prototype under production

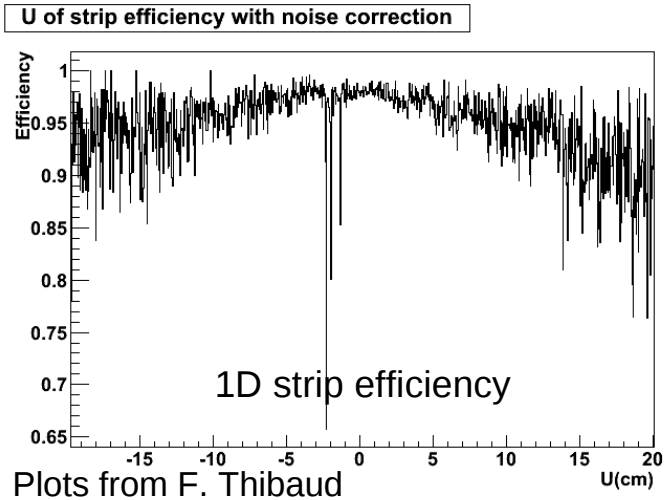


Preliminary results from 1st prototype: efficiencies

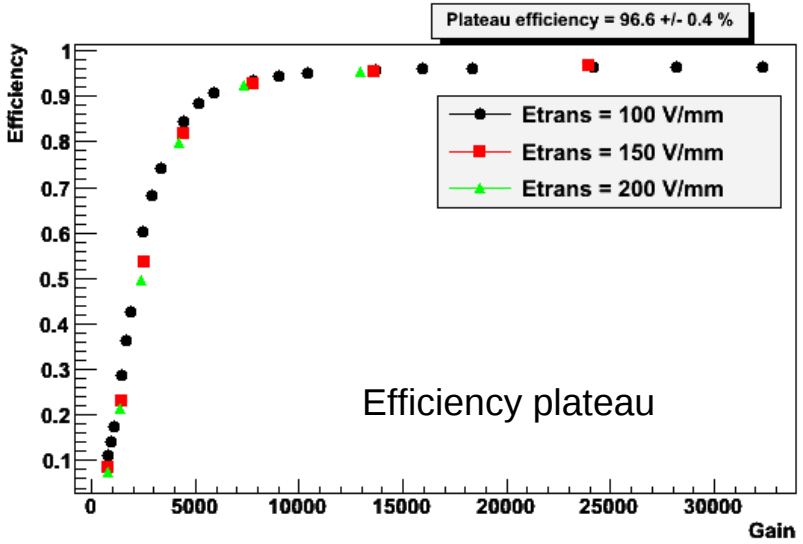




plateau run
HV_{mesh} 340V
HV_{GEM} 300V



Plots from F. Thibaud



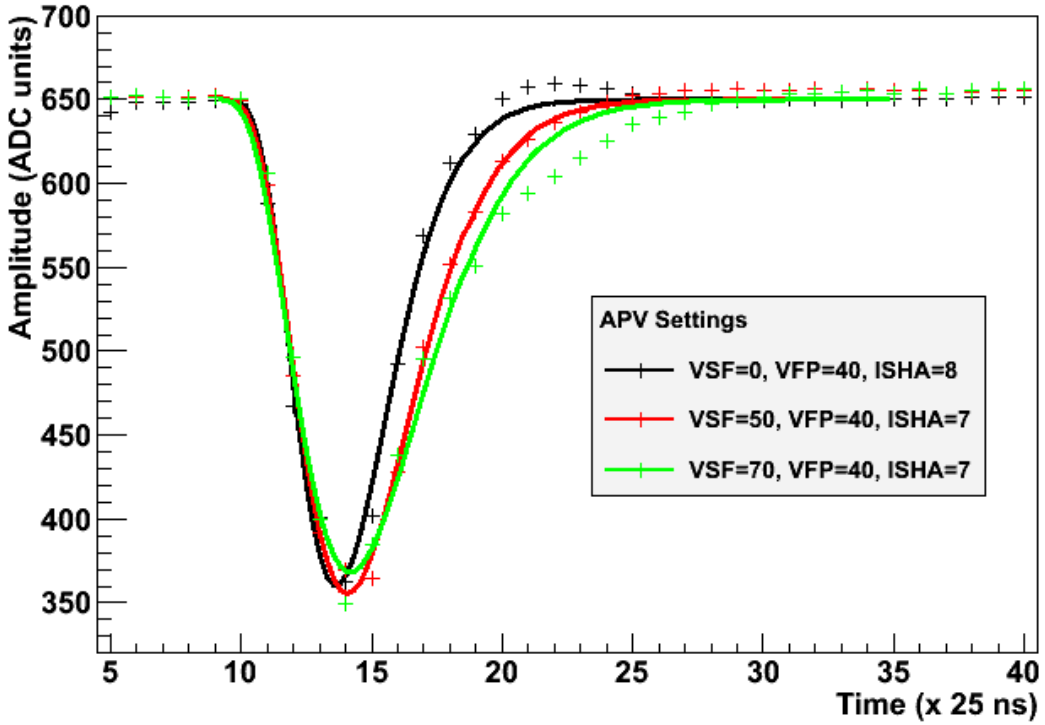
APV shaping to be improved

Electronics occupancy → impact on efficiencies

Lower efficiencies for long pixels → APV shaping to be shortened

*Constraints on shapes: **long peaking time** for MM signal integration (~100ns), but **short signal time** for occupancy*

A few shapes selected with non-null ballistic deficit, to be tested in September



Preliminary results from 1st prototype: residuals

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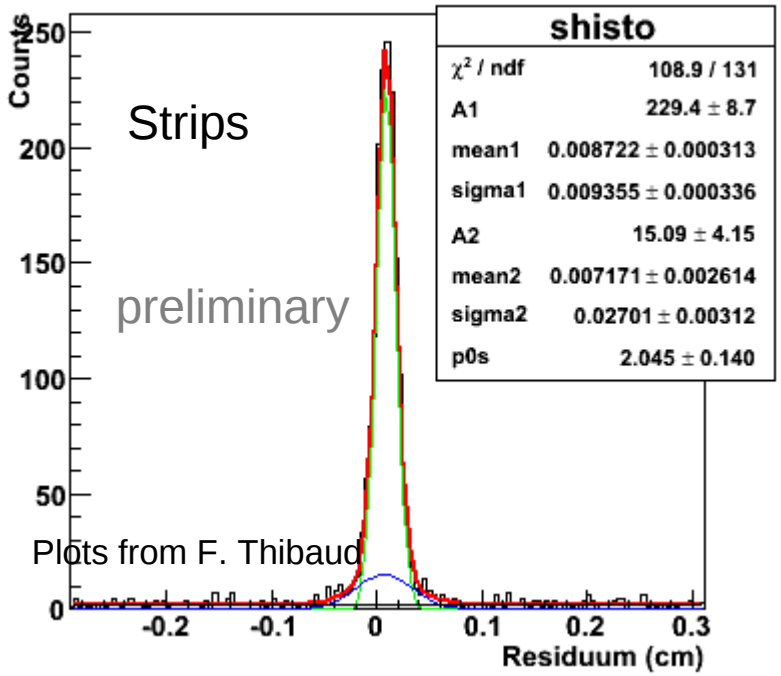
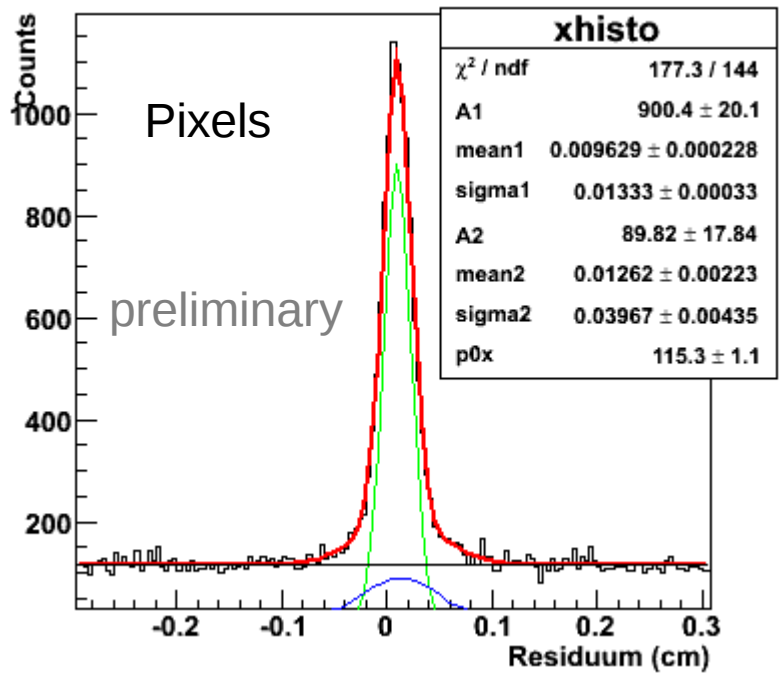
plateau run
HV_{mesh} 340V
HV_{GEM} 300V

Residuum (Strips) : σ = 122 μm



Plots from F. Thibaud

Residuum (Pixels) : σ = 194 μm



Residuals

Double gaussian distributions → tracking to be improved

Quite good residuals: <100μm for strips, ~135μm for pixels

Time line

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2011: Characterization of large size pixelized MM+GEM and buried resistor detectors

COMPASS nominal conditions with muon beam

MM+GEM pixel detectors almost validated

Hopefully buried resistor prototype tested at COMPASS before the end of the beam period...

Choice on technology end of the year

2012: 2 pixelized detectors to be installed at COMPASS

Will replace 2 standard MM detectors

2011-2012: R&D on production

Optimization of the board design to simplify production (shorter width)

Collaboration with CNRS and CIREA company (PCB producer) for thin PCB and bulk production (grant from ANR financing agency to the project)

R&D on buried components with CIREA

Final goal: 12 detectors (+spares) installed for the 2014 run

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Spares

Preliminary results on MM+GEM prototype: pixels

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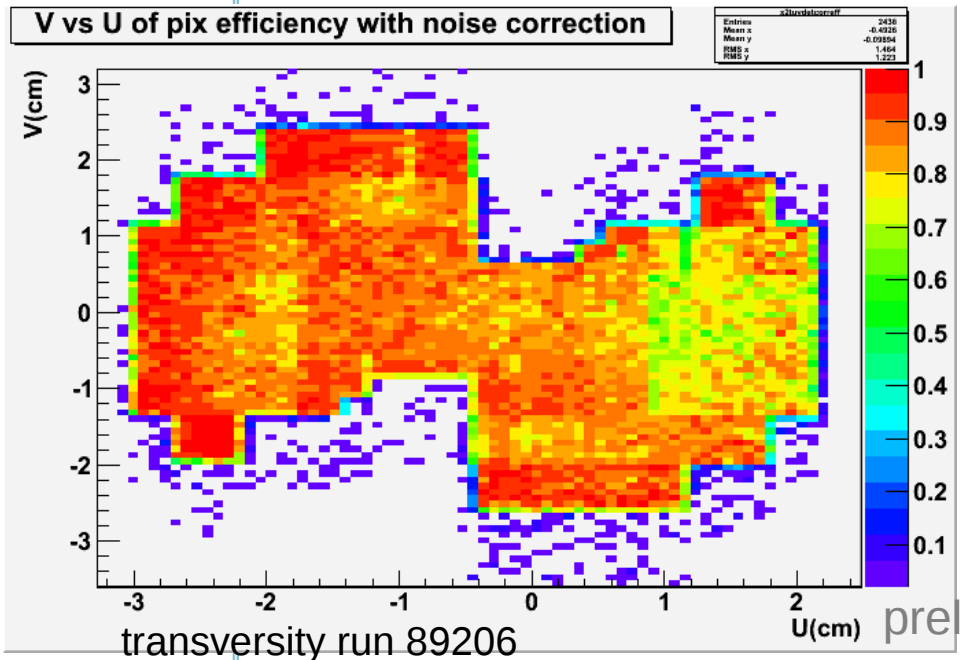
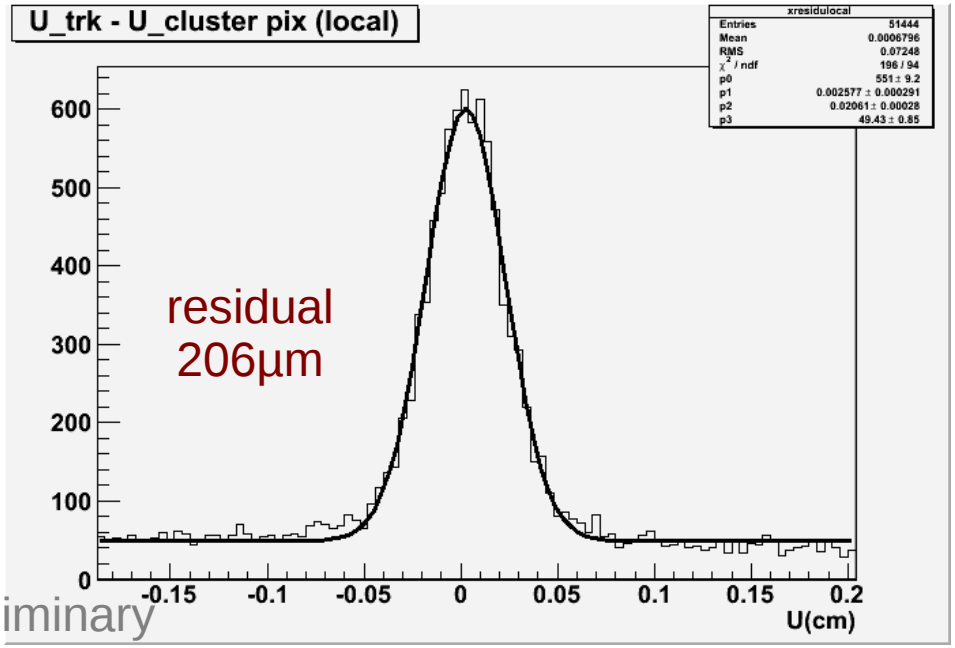




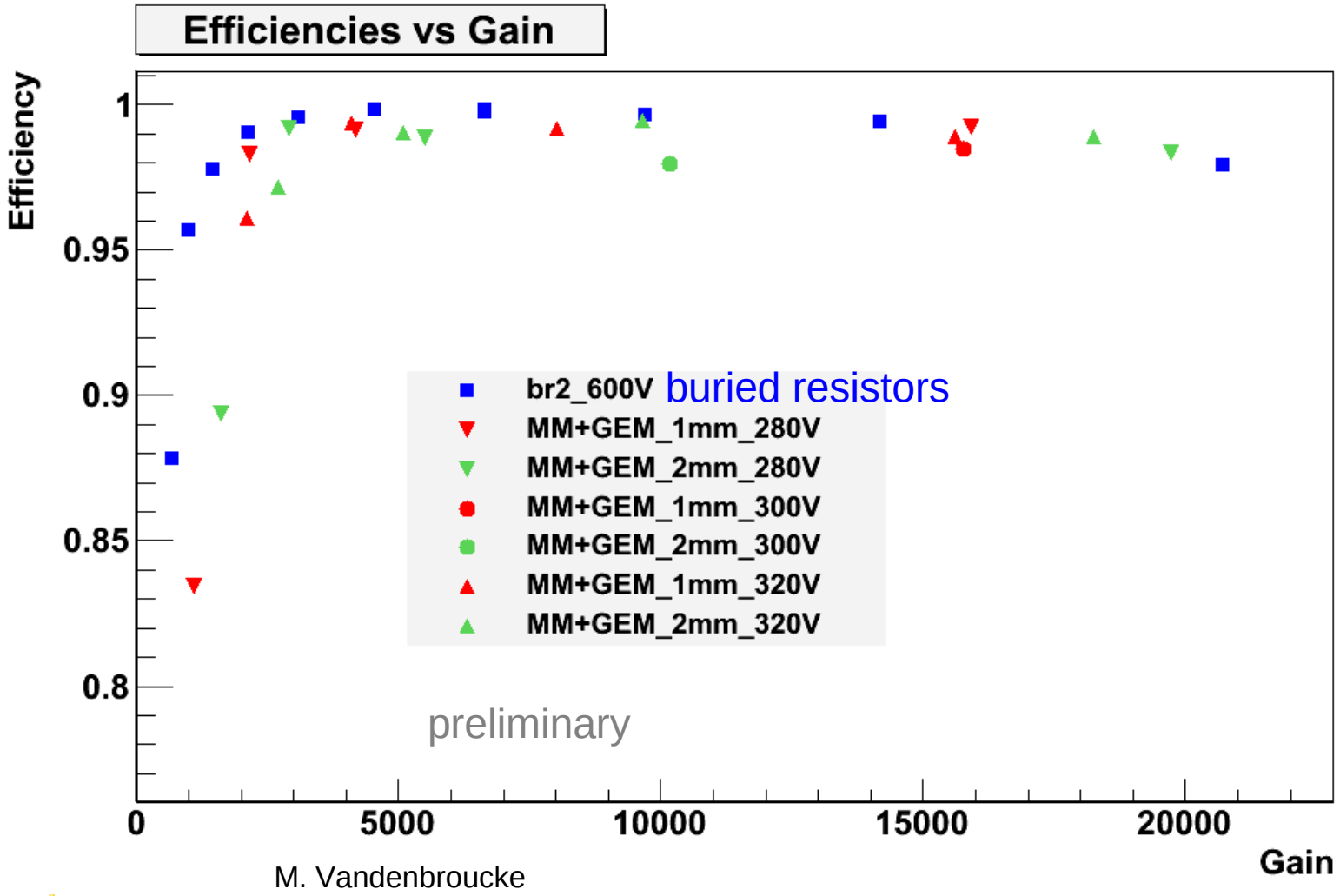
Not so good efficiency, limited by missing channels (>5%) and electronics occupancy (shaping time >500ns)

→ cluster time reconstruction and selection to be improved, APV shaping to be shortened

Large residual → cluster position algorithm to be improved

Efficiencies MM+GEM and resistive (2010 SPS tests)

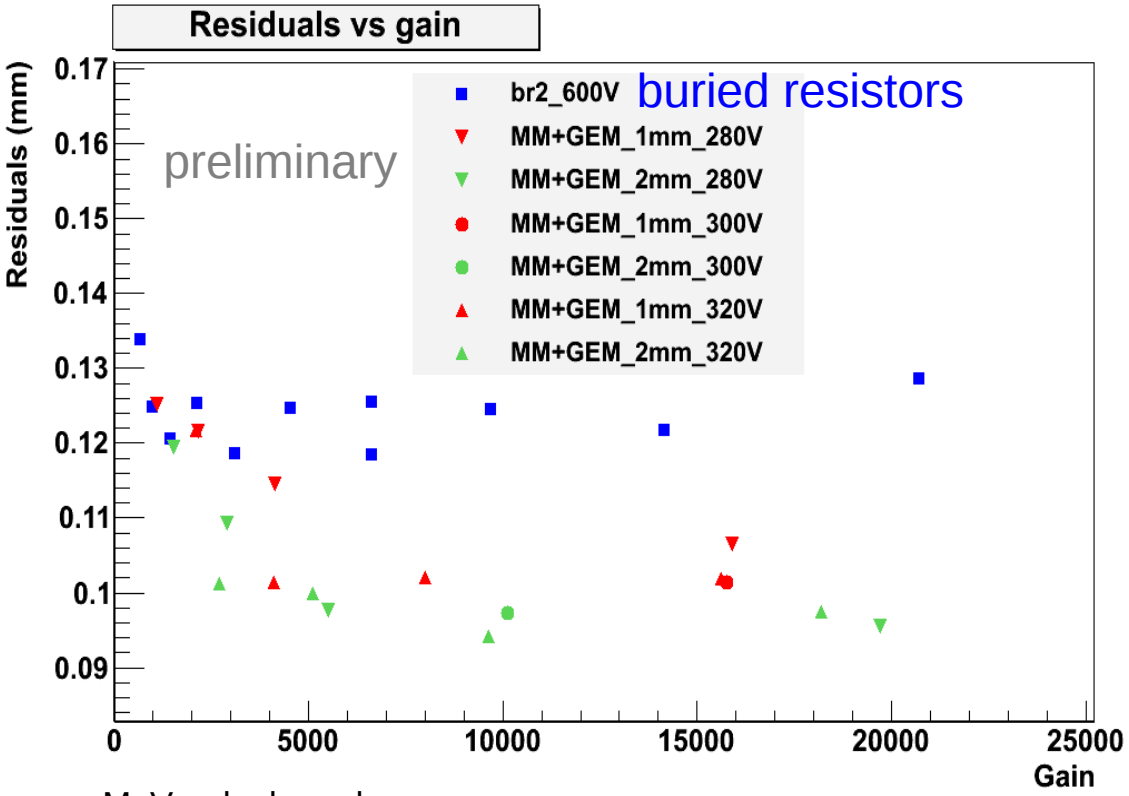
Tests with muon+hadron beam (RD51 tests)



M. Vandenbroucke

Residuals MM+GEM and resistive (2010 SPS tests)

Tests with muon+hadron beam (RD51 tests)



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MM+GEM is a solution

- discharge rate decreased by factor >>10
- efficiencies and spatial resolution ok

Buried resistor promising solution, further studies needed on:

- spatial resolution
- gain at high flux
- production of large size detectors

MM protection circuit