MPGD-NEXT – Task 3 :
High Performance Micromegas

M. Iodice for the INFN Roma Tre and Napoli Groups

March 23rd, 2017

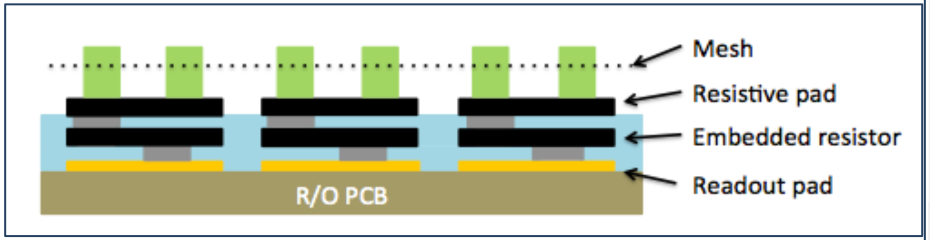
MPGD-NEXT WP3: Small Pads Resistive Micromegas

Small Pad Resistive Micromegas.

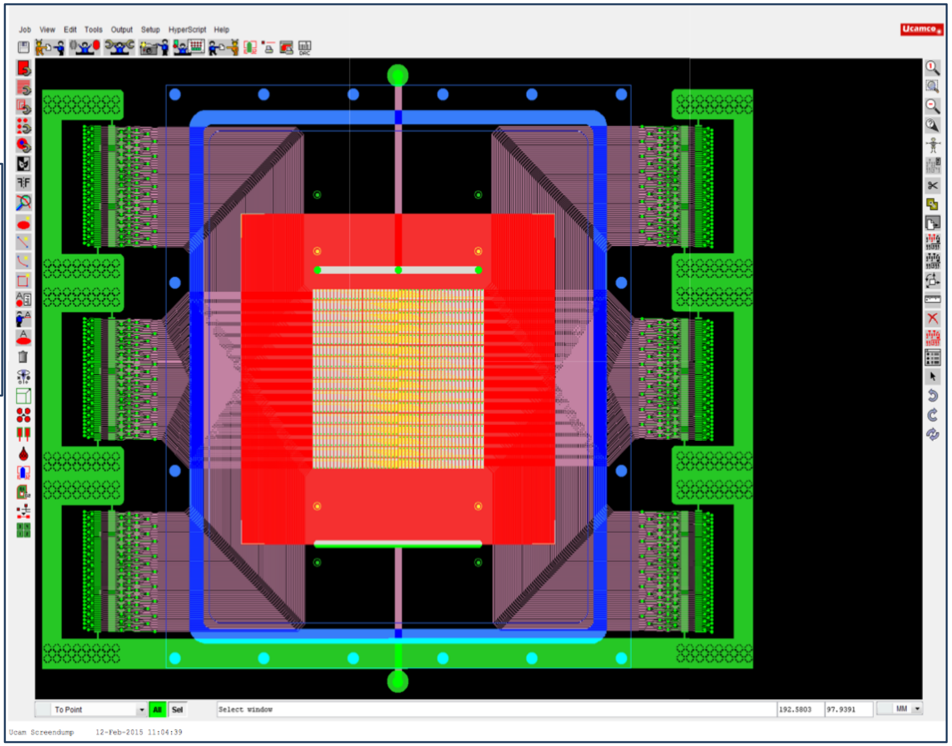
- GOAL: Development of improved Resistive MicroMegas (MM) detectors with small pad read-out, aimed at operation under high rate (>1 MHz/cm^2)
- From existing R&D we aim at reducing the pad size from ~1cm^2 to < 3mm^2.
- Ongoing R&D
- Possible application: ATLAS very forward extension of muon tracking (Large Eta Muon tagger)

Small Pad pattern with EMBEDDED resistors.

Technical solution inspired by a similar R&D by COMPASS.



- First design of a small size prototype
- Matrix of 48x16 pads
- Each pad: 0.8mm x 2.8mm (pitch of 1 and 3 mm in the two coordinates);
- Active surface of 4.8x4.8 cm^2 with a total of 768 channels



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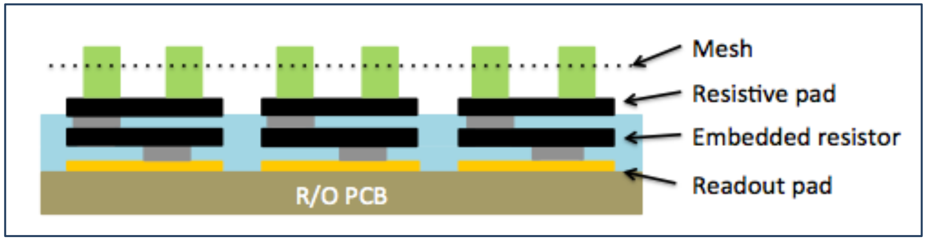

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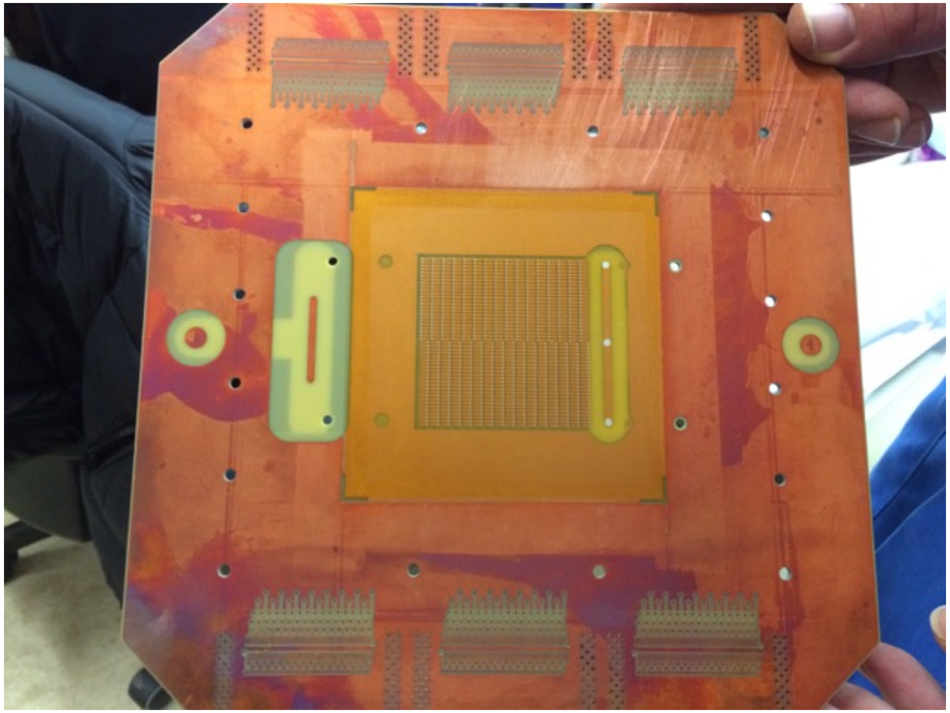


Project Timeline

Main objectives in a three year R&D project:

1. **Optimize the design of resistive micromegas with small size pad readout;**
2. **Optimize the construction;**
3. Optimize the parameter of construction **(resistivity**,…) and operations (gas mixture,…);
4. **Establish the optimal trade-off between dimensions and channel routing to read-out electronics;**
5. Establish safe operation up to a rate of O(1MHz/cm^2)
6. Construct a medium/large size prototype (~40x40 cm^2)
7. Start a process of technology transfer to industries.

PROJECT TIMELINE

Main objectives in a three year R&D project:

✔ **1. Optimize the design of resistive micromegas with small size pad readout; [successful]**

✔ **2. Optimize the construction; [Two prototypes built. → Successful]**

2017

3. Optimize the parameter of construction **(resistivity**,…) and operations (gas mixture,…);

4. Establish the optimal trade-off between dimensions and channel routing to read-out electronics; [ONGOING]

5. Establish safe operation up to a rate of O(1MHz/cm^2) **[ONGOING]**

6. Construct a medium/large size prototype (~40x40 cm^2)

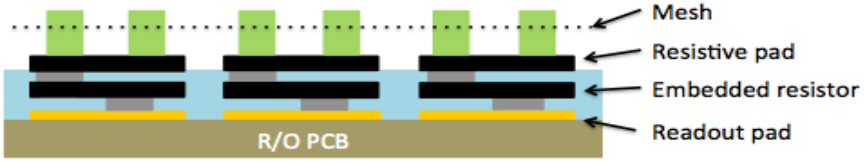
7. Start a process of technology transfer to industries.

CONSTRUCTION OF PROTOTYPES

TWO Prototypes built so far (Paddy1 and Paddy2)

- Both with the same layout: Matrix 48x16 – 1x3 mm^2 pads – 768 channels
- The construction technique was different in the two cases

  1. Full screen printing: stack of all layers, including the insulator, all deposited by screen-printing. A simple, cost effective technique **but subject to HV instabilities** (seems that we are not able to avoid pin-holes in the insulator)



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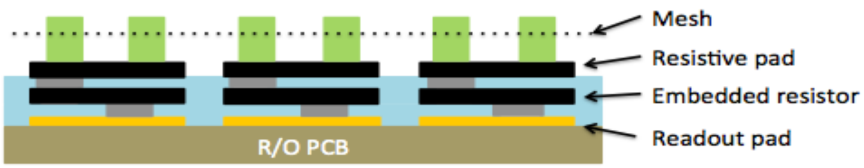
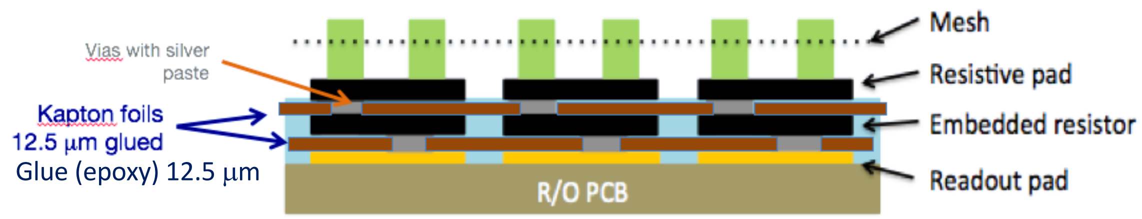


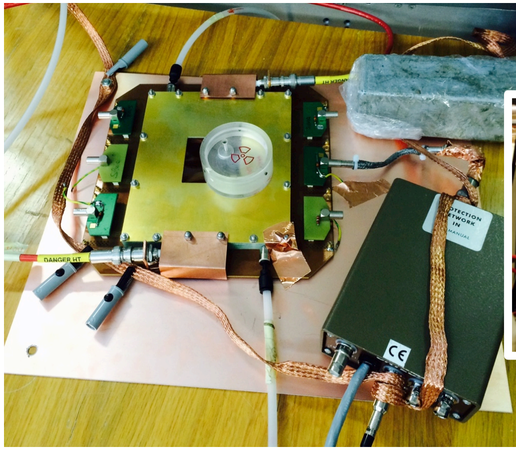
    2. Standard Kapton insulating foils. Vias are filled with silver epoxy paste deposited by screen printing followed by a planarization step.

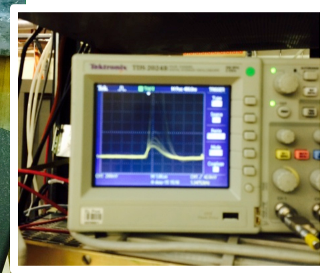
Before pressing the Kapton:

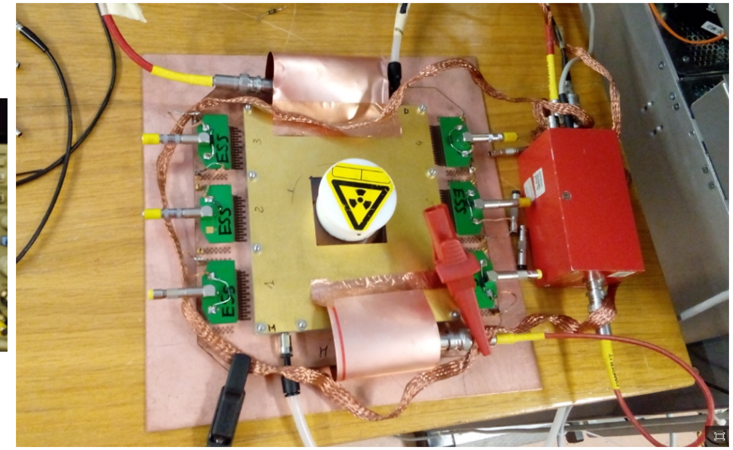
- Laminate the 12 μm glue on the back of the 12 μm Kapton
- Drill all the vias
- Then proceed with the gluing/press step

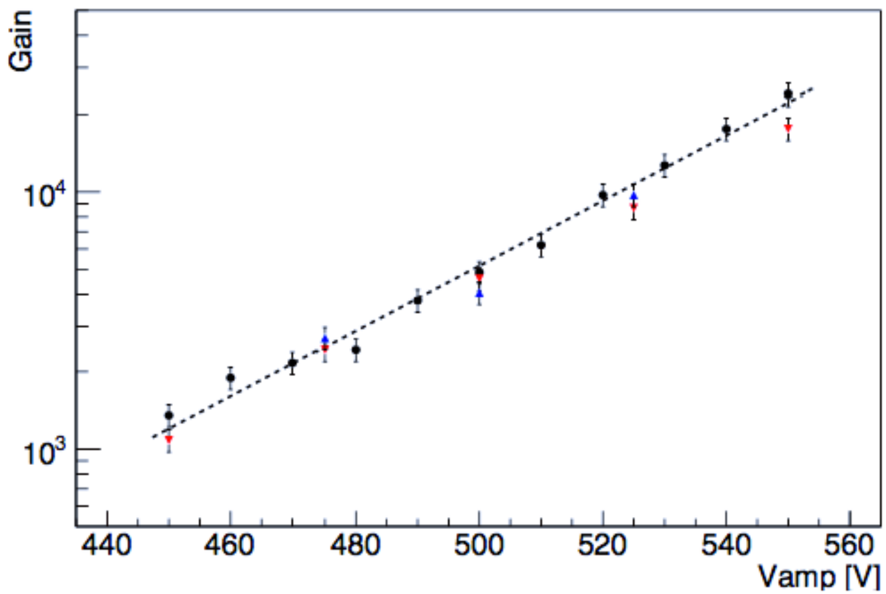


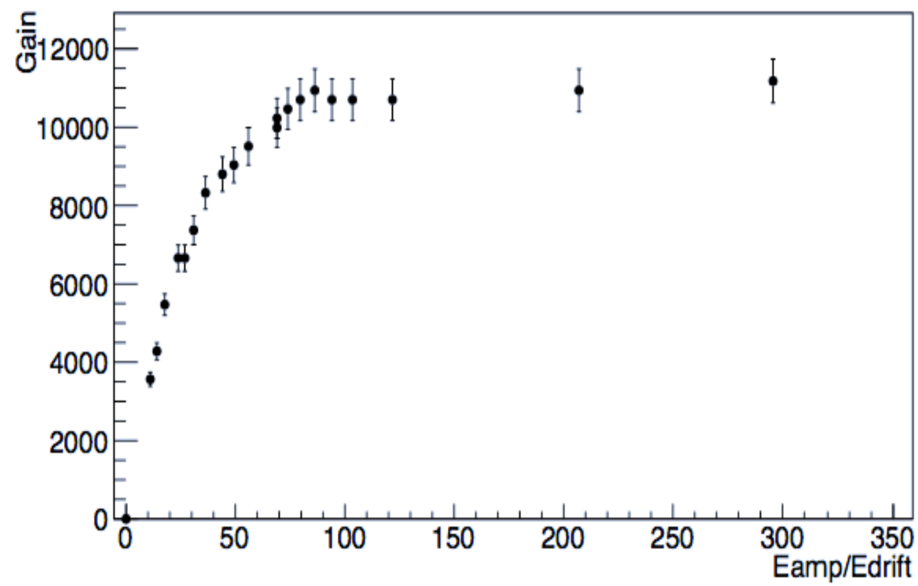
Gain Results with ^{55}Fe source in the Lab











- Very good performance. Gain curves compatible with “standard” bulk strips micromegas
- No HV instabilities with the second prototype

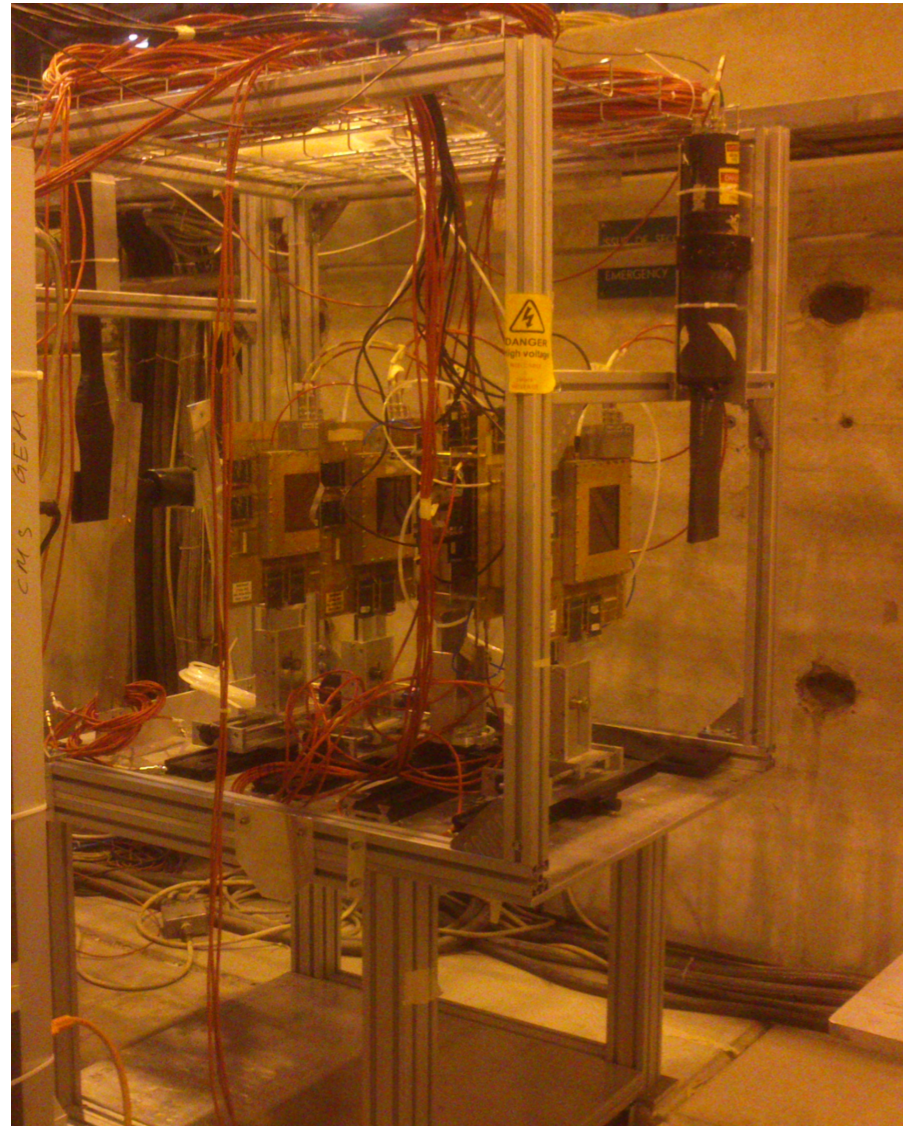
Test beam @ CERN

Test Beam at the SPS H4 CERN Experimental area

- High energy muons/pions beam
- Test Setup:
  - Small-pads MM
  - Three double readout (xy) small size bulk micromegas as reference
  - Ar/CO_2 93/7 pre-mixed gas
  - DAQ: SRS+APV25

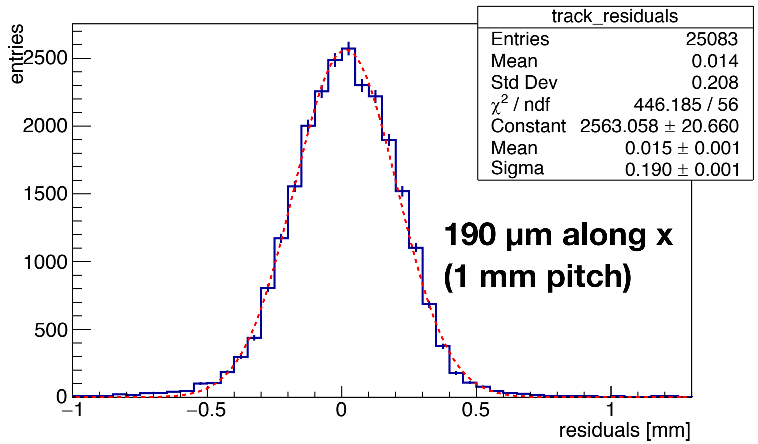
Measurements:

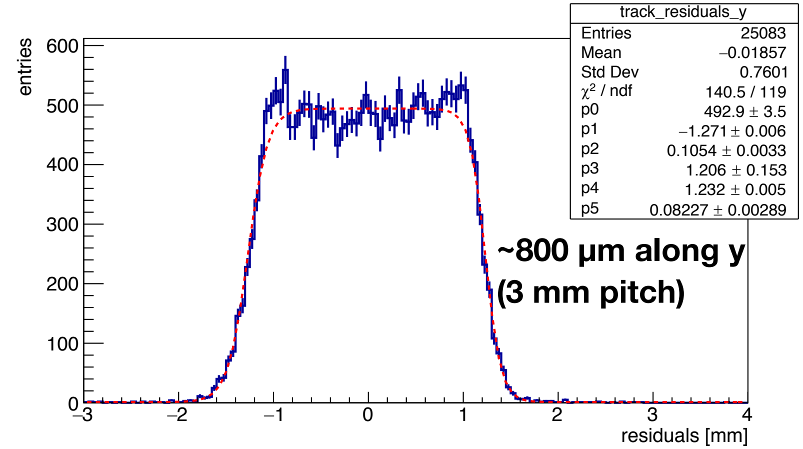
- Efficiency Vs HV
- Spatial resolution
- Drift HV scan
- X-Y scan (very limited – the detector is ~50x50 mm^2)
- Inclined tracks

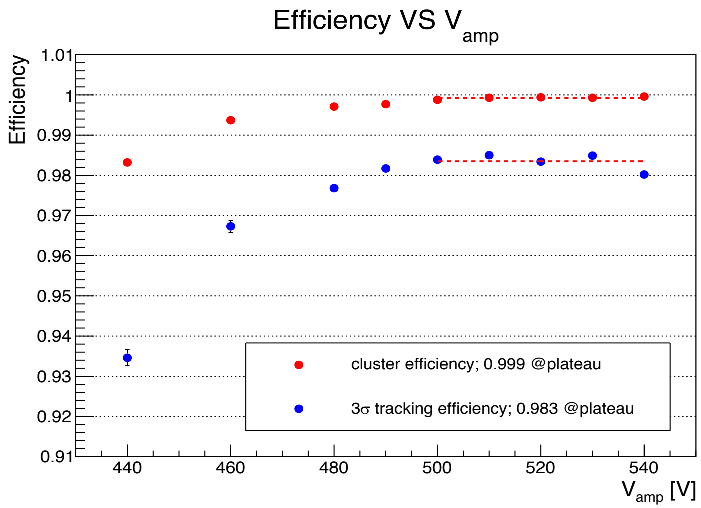


MAIN TEST BEAM RESULTS

The Position resolution is obtained by the difference btw the position measured from Paddy and that extrapolated by the Tmm tracks.







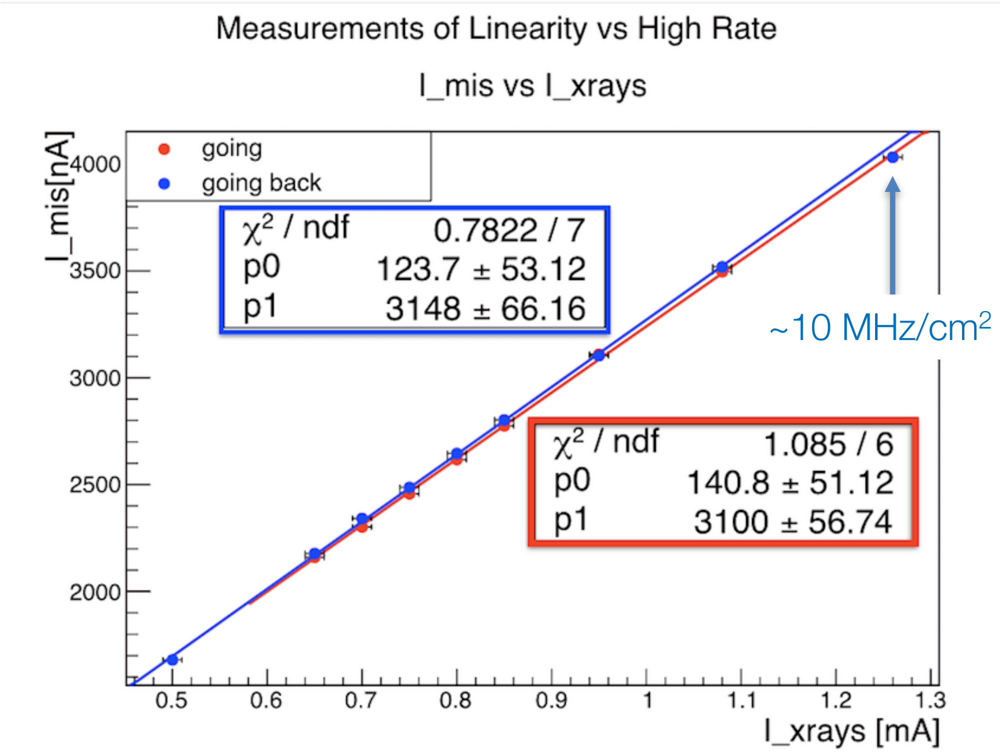
The "turn-on" efficiency curve is obtained:

1) By finding a cluster anywhere in the detector for any reference track → ~100%
2) By finding a cluster within 3sigma from the extrapolated impact point of the reference track → > 98%

ONGOING TESTS WITH X-RAYS

PRELIMINARY analysis of the data taken few weeks ago

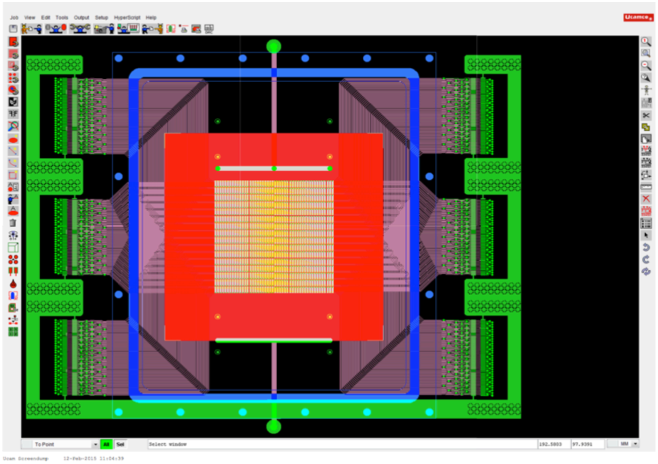
- Detector current in the amplification gap VS current of the (Cu) X-Ray gun
- Many checks still ongoing (i.e. Linearity of the X-ray gun Vs Rates, X-ray spot-size, etc...)



- Preliminary results are very promising showing no drop in current (i.e. Gain) at rates > 10 MHz/cm^2

WHAT'S NEXT: LARGE SIZE PROTOTYPES

Layout not scalable for large dimensions (very dense routing)

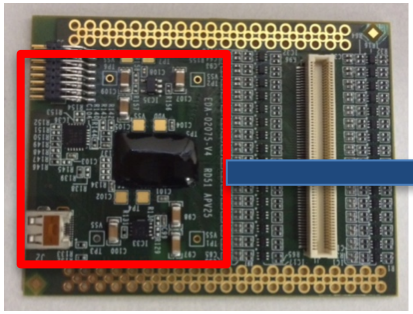


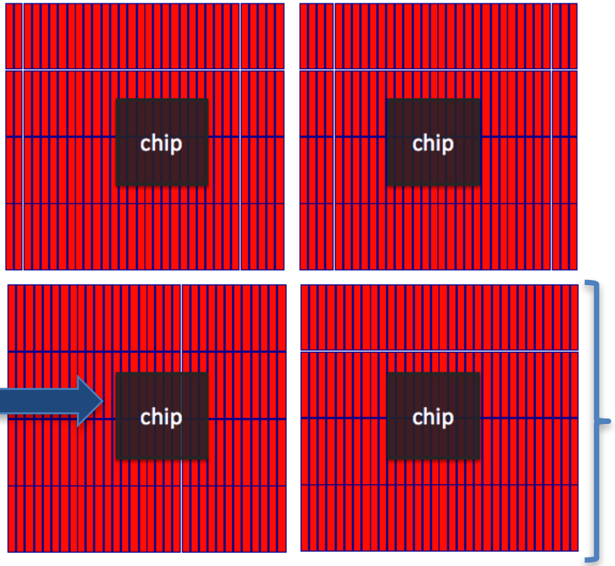
New R&D on MM small-pad Detectors WITH EMBEDDED electronics (back wire-bonded) .

DESIGN OF A FIRST PROTOTYPE :

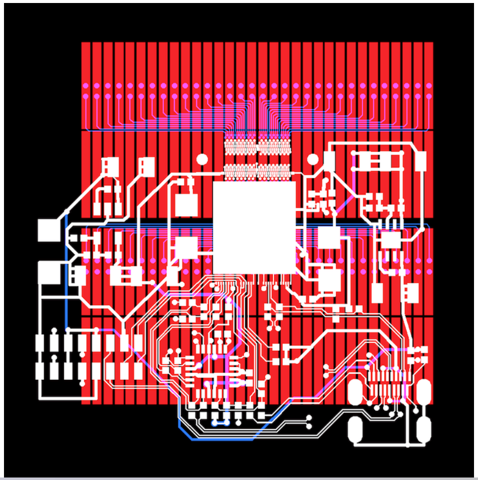
- 4 regions with 32x4 mini-pad
- Pitch 1x8 mm2
- Each region can be readout by a back embedded APV25 chip with associated Front-end electronic reassembled on the detector board

The RD51 front-end board with APV25

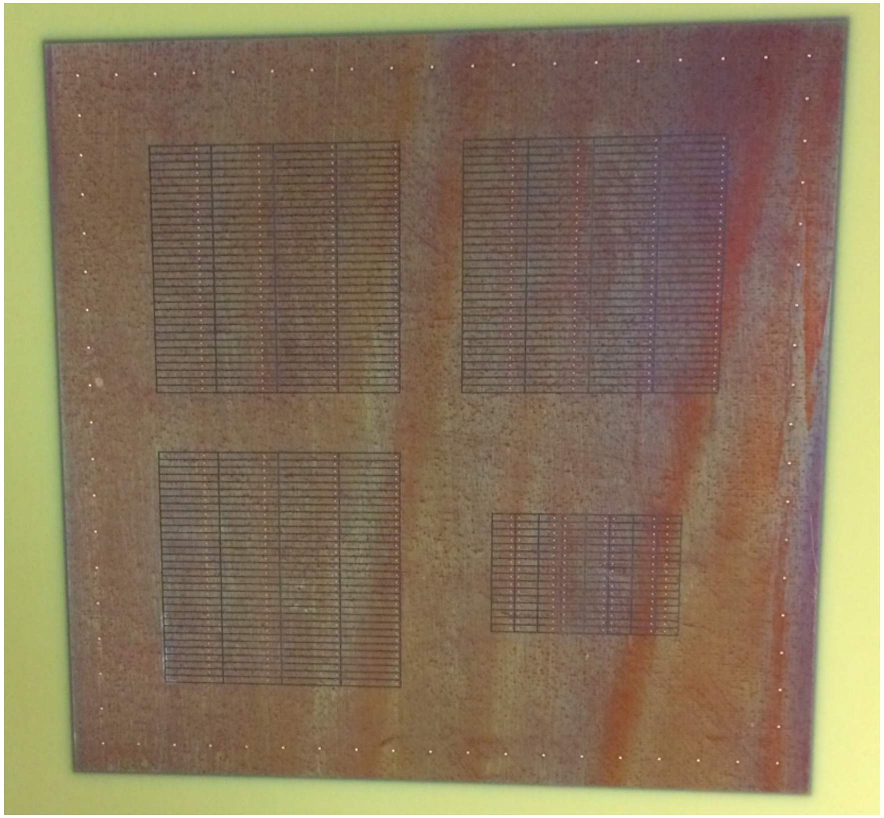




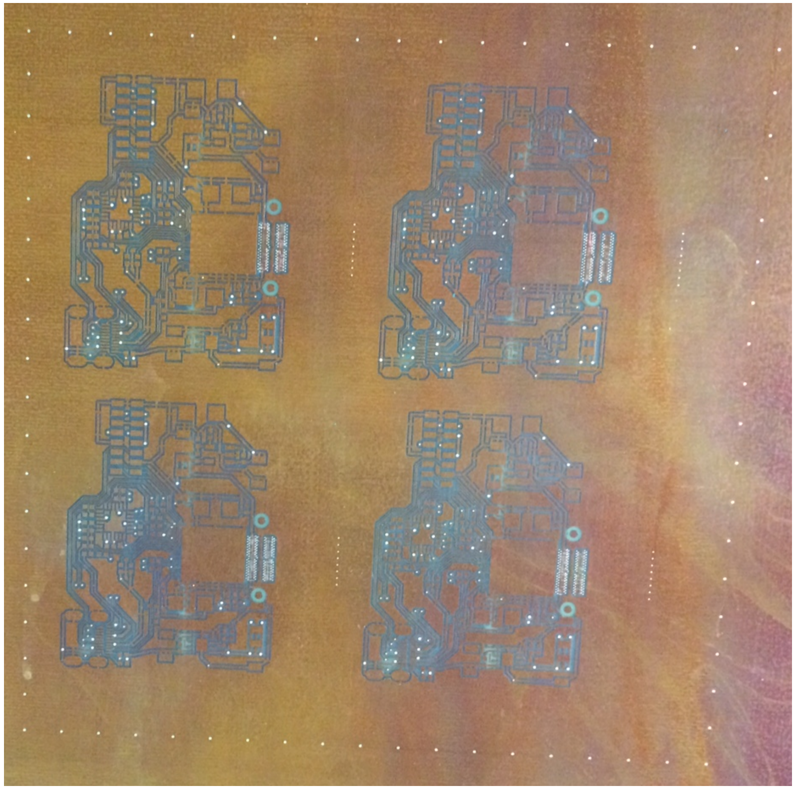
Here a single region. It will be repeated x 4



CONSTRUCTION OF SMALL-PADS MM WITH EMBEDDED ELX



Front:
3 minipad regions with pitch 8x1 mm
1 minipad regions with pitch 3x1 mm
(same as prevoius prototypes)



BACK:
Layout of the 4 regions for the assembly of the front-end electronics and the 4 APV25 chips (In Progress NOW)

Project Profile

&

Milestones 2017

PROJECT PROFILE

GANTT CHART as of July 2016 -- REVISED

activity	2016				2017				2018			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Simulation and Design of MM with pixelated anode												
Construction and tests of the first small prototype (10x10 cm2)												
Construction and TESTS of an improved small size prototype												
Design, construction and test of second generation small prototype (new Resistive Layout												
Design and Construction of MM with EMBEDDED ELECTRONICS for Large Size Detectors												
Construction of large size prototype (~40x40 cm2) and cosmics tests												
Test-beam and High Irradiation Tests												

Updates from the original planning:

- The first MM mini-pad Prototype has shown some limitations. A second small size prototype with a different construction technique has been built in 2016 and SUCCESFULLY tested
- Construction already started

MILESTONES 2017

1. Further performance studies with the second small size prototype with high/low intensity test beams and under high irradiation (X-rays)

2. **Construction and test of the Small-Pad MM with Embedded Readout Electronics**

MILESTONE !

3. Design and construction of a new small size small-pads prototype for resistivity optimization studies (a configuration different from the "embedded resistor" is also under study).

Anagrafica Roma Tre e Napoli - 2017

Preventivi 2017 > CSN V > MPGD_NEXT > Roma III > Modulo EC/EN 7

Modulo EC/EN 7

A cura di: Mauro Iodice

Ricercatori						
	Nome	Età	Contratto	Qualifica	Aff.	%
1	Biglietti Michela		Dipendente	Ricercatore	CSN I	10
2	Iodice Mauro		Dipendente	Ricercatore	CSN I	20
3	Petrucci Fabrizio		Associato	Prof. Associato	CSN I	20
				Numero Totale Ricercatori	3	FTE: 0.5

Preventivi 2017 > CSN V > MPGD_NEXT > Napoli > Modulo EC/EN 7

Modulo EC/EN 7

A cura di: MASSIMO DELLA PIETRA

Ricercatori						
	Nome	Età	Contratto	Qualifica	Aff.	%
1	Alviggi Maria Grazia		Associato	Prof. Associato	CSN I	20
2	Canale Vincenzo		Associato	Prof. Associato	CSN I	20
3	Della Pietra Massimo		Associato	Prof. Associato	CSN I	20
4	Di Donato Camilla		Associato	Prof. Associato	CSN I	20
5	Sekhniaidze Givi		Dipendente	Ricercatore	CSN I	20
				Numero Totale Ricercatori	5	FTE: 1.0

BACKUP

SITUAZIONE 2016 E RICHIESTE 2017

TASK 3			INFN unit NA			INFN unit Roma3		
			2016 Rich.	2016 Ass.	2017 Rich.	2016 Rich.	2016 Ass.	2017 Rich.
	Consumables	Resistive MM with pixeled readout	4	4	10	4	4	8
		Gas	1	1	2	0	0	1
		Fe electronics	3		4	0	0	0
		Small Items	2		3	0	0	1
		total	10	5	19	4	4	10
	Equipment	DAQ system				10	0	
		total	0	0	0	10	0	0
	Travelling	MPGD-NEXT annual meeting	0	1	0	1	1	1
		test beam activity	3	1 (s.j.)	3	2	1 (s.j.)	2
		total	3	1	3	3	1	3
	Grand Total		13	6	22	17	5	13