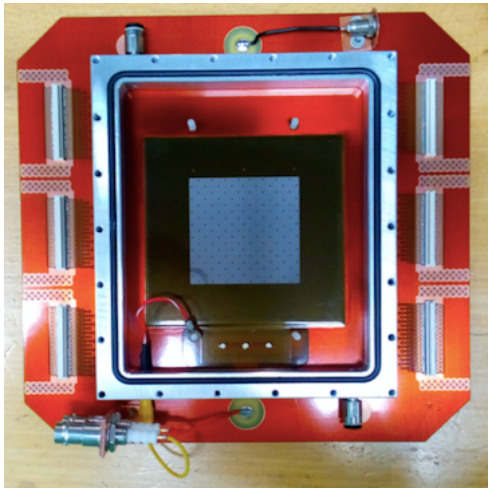
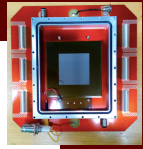


RHUM
Resistive
High granUlarity
Micromegas

CdS Roma Tre - Discussione Preventivi CSN5

RHUM



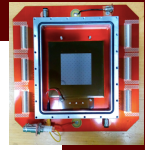
- A **"~new"** proposal
- Natural continuation of the R&D within the MPGD_NEXT project in INFN CSN5 (2016-2019 "High Performance Micromegas" workpackage).

- **Main goals:**
  - Establish resistive Micromegas MPGD as precision, radiation tolerant detectors for high (up to 10 MHz/cm^2 and more) particle rates;
  - low occupancy, high granularity read-out based on small size pads with size $\mathcal{O}$(mm^2);
  - Prove the scalability to large size detectors.

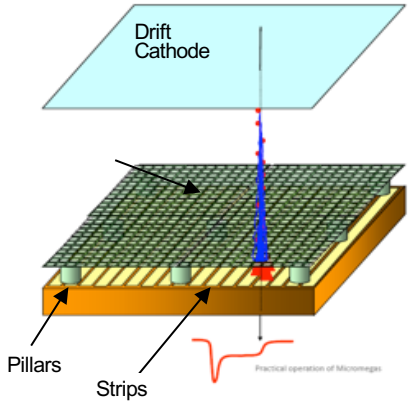
Use cases for this technology:

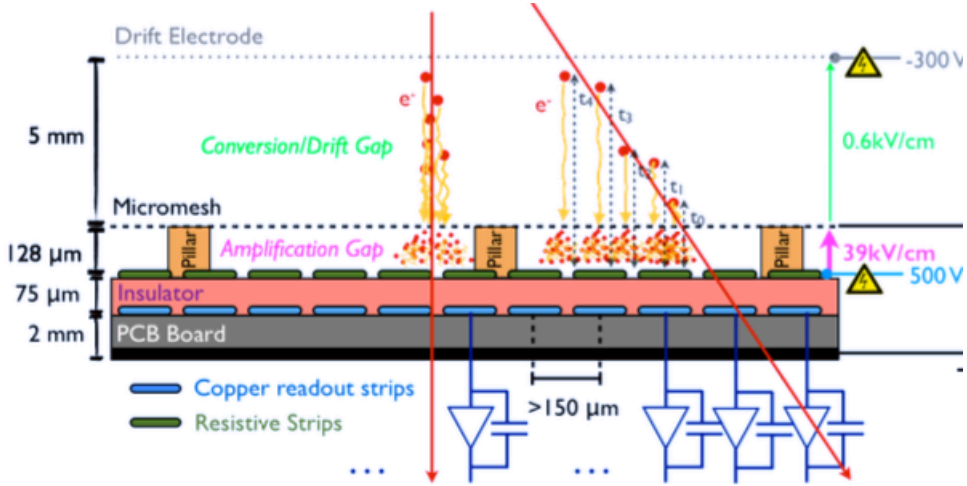
- Upgrades of present accelerator experiments (Large Hadron Collider at CERN)
- Detectors for high energy and very high intensity new particle accelerators (FCC-ee/hh, EIC, …)
- Large area fine tracking and trigger with high rate capability
- Forward Muon tagging detector (e.g. ATLAS High Eta Muon tagger)
- Pre-shower for an electromagnetic calorimeter
- Readout layer of a Time Projection Chamber

Resistive Micromegas

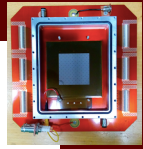


- Now a mature technology for HEP experiments also taking advantage of the intense phase of R&D for the ATLAS Experiment were resistive strips MM will be employed in the New Small Wheel upgrade of the Muon Spectrometer
- Resistive anode strips to suppress the intensity of discharge
- Large area: total surface of ~1200 m^2 of gas volumes
- Operation at moderate hit rate up to ~15 kHz/cm^2 during the phase of High-Luminosity-LHC





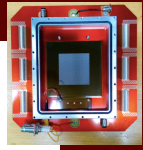
RHUM



- Achievements within the MPGD_NEXT project are the starting point.

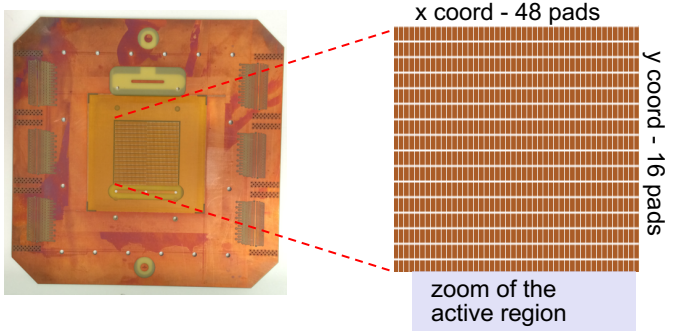
- **Project main objectives:**
  - Validate the full functionality of the small dimensions Small Pad Micromegas prototype with embedded electronics currently under construction;
  - Design and build a 400cm^2 active area detector fully assembled with embedded electronics;
  - Study its performances in a high rate environment using different gas mixtures;
  - Optimize detector stability at high gains;
  - Study a possible alternative for the read-out front end chip (currently the APV25 chip is being used);
  - Pursuit technological transfer in view of entrusting companies for large scale detector production.

Achievements within MPGD_NEXT (I)



Read-out pad layout:

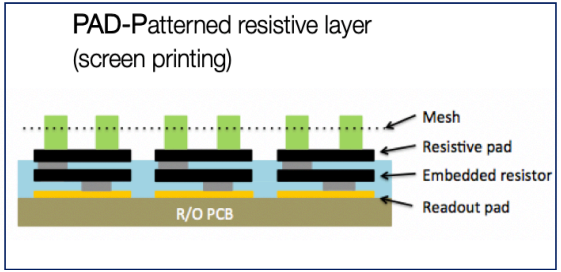
- Matrix of 48x16 pads – 768 channels
- Each pad: 0.8mm x 2.8mm - pitch of 1x3 mm^2
- Active surface of 48x48 mm^2

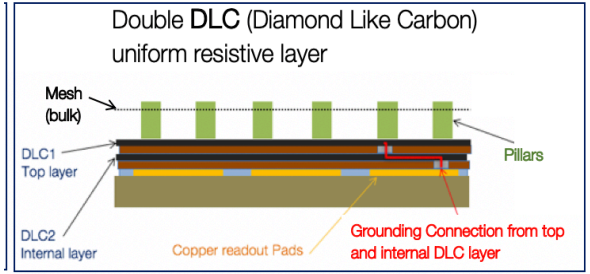


Resistive protection layouts:

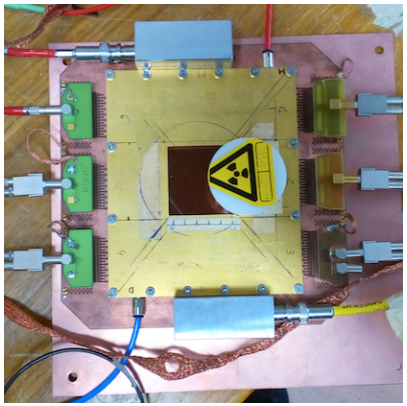
5 different prototypes

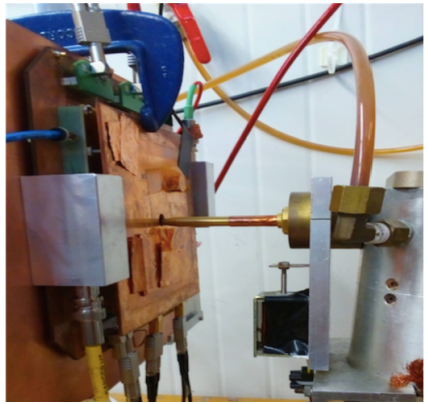
- **PAD-P**: Embedded resistor, mean value of the embedded resistors ≈ 3-7 MW
- **DLC20, DLC50**: 'standard' DLC, sputtered on kapton
  - surface resistivity: 20 MW/□ (DLC20) or 50-70 MW/□ (DLC50)
  - two regions, with conductive vias every 6 and 12 mm
- **SBU1, SBU2**: Sequential Build Up of DLC foils copper cladded on both sides
  - easier photolithographic construction process
  - improving of the alignment of vias and centering of the pillars with the silver vias (every 6 mm)
  - 1st layer (nearest to the pads) resistivity 35 MW/□ , 2nd layer 5 MW/□ (lower than requested)





Achievements within MPGD_NEXT (II)



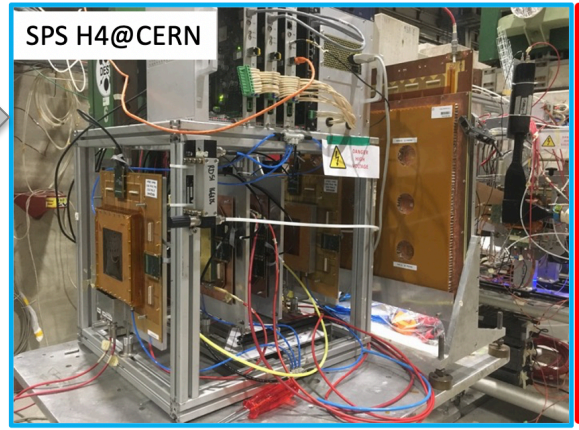


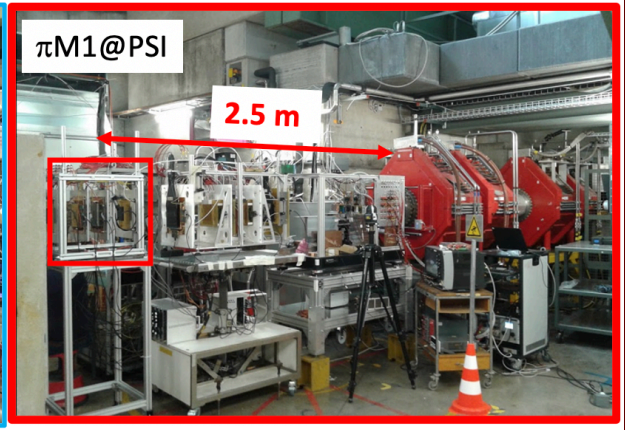
CERN GDD Lab:

- ^{55}Fe sources with 2 two different activities (measured rates ~1 kHz and ~100 kHz)
- 8 keV Xrays peak from a Cu target with different intensities varying the gun excitation current

Test Beams

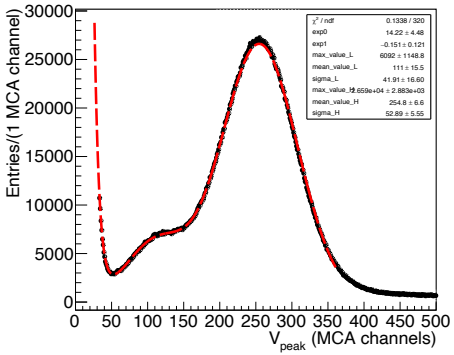
2016/17	2018	2019
SPS H4@CERN μ, π at 150 GeV/c low/high rate	SPS H4@CERN μ, π at 150 GeV/c π at 80 GeV/c	πM1@PSI π at 300 MeV/c p cont. ~7%
PAD-P, DLC50	DLC50, DLC20	PAD-P, DLC20, SBU1&2

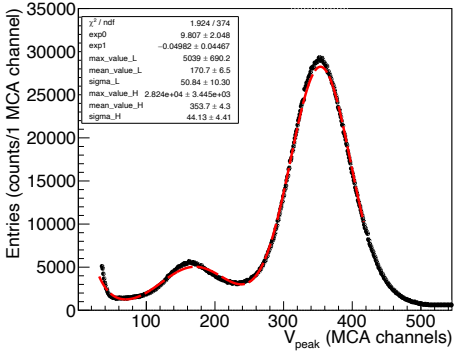


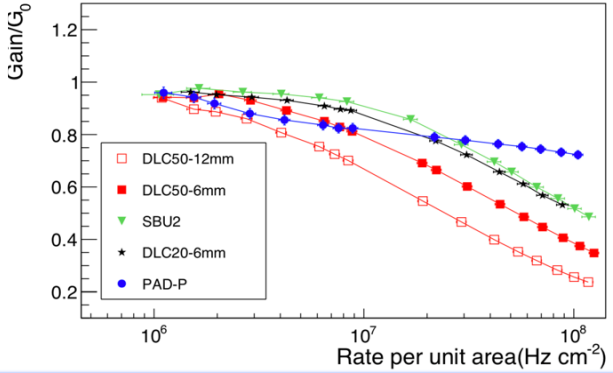


Achievements within MPGD_NEXT (IV)

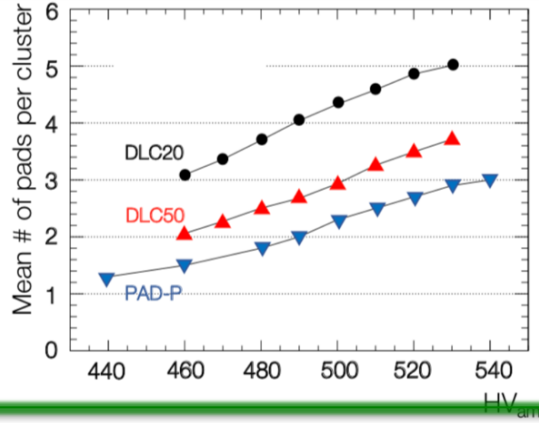
Detector characterization

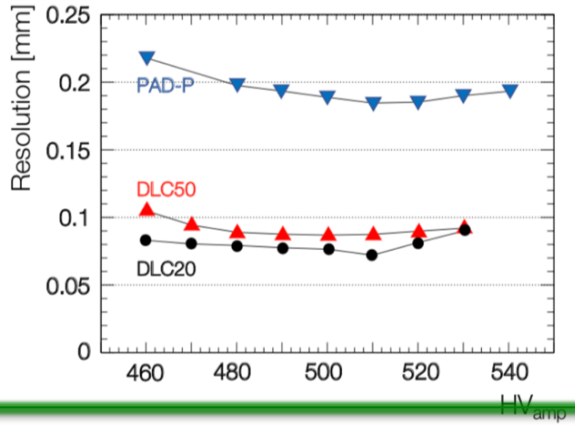


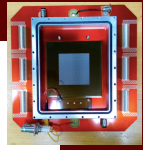




Test Beam Results







Achievements within MPGD_NEXT (V)

PAD PATTERNED and DLC based resistive scheme have been compared in similar conditions:

Gas mixture (possibly not the best) chosen to be on the safe side for ageing: Ar/CO2 93/7

Comparison in similar conditions: GAIN ~ 6500 – 7000 (most of the measurements with X-rays → ionisation >> MIP)

PAD PATTERNED PROTOTYPE

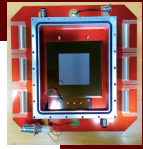
- Quite significant charging-up that nevertheless saturate at $\mathcal{O}$(1MHz/cm^2)
- ~20% gain drop at 20 MHz/cm^2
- No dependence on the irradiated area
- Very stable up to gains >> 10^4
- Degraded performance on energy and spatial resolution compared to DLC
- A new prototype has been built and is currently being tested for further checks of the results

DLC PROTOTYPES

Best performance with the "low resistivity" DLC (~20 MW/□) and with fine network of grounding vias (~6 mm)

- Gain reduction with rates dominated by ohmic voltage drop
- gain reduction is ~20% at 20 MHz/cm2 when irradiated on a 1 cm spot (as for PADP); it increases to ~30% for larger areas.
- Excellent energy and spatial resolution
- Robustness not yet at the level of PAD-P → the DLC-SBU technique promising but not yet conclusive

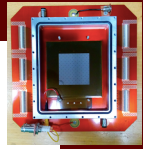
Group composition



The group composition is similar to the one of the MPGD_NEXT WP3

- **Roma Tre (1 FTE):**
  - **Michela Biglietti 0.1**
  - **Maria Teresa Camerlingo 0.2**
  - **Roberto Di Nardo 0.2**
  - **Mauro Iodice 0.3**
  - **Fabrizoi Petrucci 0.2**
- Napoli (>1FTE)
  - M. Alviggi, V. Canale, M. Della Pietra, G. Sekhniaidze
- Non-INFN: P. Iengo (CERN)
- Support of the RD51 Collaboration at CERN
  - general support + test beams organization
  - Project Funding on RD51 Common Funds: *"Pixelated resistive bulk Micromegas with integrated electronics"* - Project cost: 26keuro, **RD51 granted 13k euro**
- CERN GDD Lab for MPGD tests

Activities and manpower



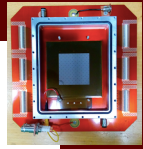
WBS and Gantt chart

WP#	Activity	2021 Q1	2021 Q2	2021 Q3	2021 Q4	2022 Q1	2022 Q2	2022 Q3	2022 Q4	2023 Q1	2023 Q2	2023 Q3	2023 Q4
1	Full validation and functionality checks of the MPGD_NEXT small-size prototype with integrated electronics												
2	Optimisation of the FE elx based on APV25 for pixelised layout												
3	Design and construction of the first large-size detector with reduced readout area.												
4	Design and construction of the final large size (> 20x20 cm2) Small Pad Micromegas detector and fully integrated electronics												
5	Fulll characterization of prototypes with radioactive sources and Test-Beams												
6	Stability and Discharges - gas studies												
7	Irradiation tests - ageing												
8	transfer of technology for the industrialization of pixelated Micromegas												
9	Studies on possible alternatives to the use of the APV25 chip												
10	Simulation Studies for resistive MPGD												

MANPOWER (Person Months)

WP#	2021	2022	2023	NOTES
1	6	0	0	
2	6	1	0	Manpower will include the Electronics Workshops at Rm3 and Naples
3	3	6	0	Year-2 Manpower mostly from MPT Lab at CERN (Rui De Oliveira)
4	0	2	8	
5	0	3	5	
6	2	3	3	
7	2	3	3	
8	2	2	2	Will include the involvement of Rui De Oliveira from CERN MPT Lab
9	1	1	1	with the additional manpower from the electronics workshops
10	1	1	1	with the additional manpower from students
TOTAL Person Months	23	22	23	
TOTAL FTE	1,9	1,8	1,9	

Project costs



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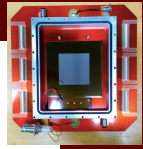
9	Studies on possible alternatives to the use of the APV25 chip												
10	Simulation Studies for resistive MPGD												

COSTI [STIMA GLOBALE - insieme Rm3+Na]

2021	2022	2023	NOTES
6	0	0	+ 6 s.j. Test Beam
6	2	0	TEST Layout con elementi passivi embedded (resistenze e capacita')
4	7	0	Test Elettronica ??? + Rivelatore + Missioni per Test + Materiale per Test **PER IL 2022 ALTRI 13 kE cinanziati da RD51**
0	0	20	Test Elettronica ??? + Rivelatore + Missioni per Test + Materiale per Test
0	6	6	+ 6 s.j. Test Beam (2022) 6 s.j. Test Beam (2023)
4	2	2	sensore umidita e GAS
4	4	4	
2	2	2	Missioni presso ELTOS (nostre + Rui)
0	2	2	Acquisto Demo board chip VFAT/Tiger/ABCstar
0	0	0	
26	25	36	TOTAL COST 87 +18 s.j

Roma Tre Financial requests for 2021



- Missioni (6 kE +3 s.j.):
  - 3 kE CERN
  - 3 kE test GIF
  - + 3 kE s.j. Test Beams

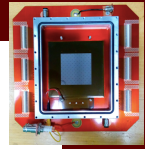
- Inventariabile (2 kE):
  - Umidity sensor (Gas-Group CERN Like) 2 kE

- Consumo: (2 kE)
  - gas 2 kE

- *6 kE Costruzione prototipi di PCB con elementi passivi embedded (resistenze e capacita')*
- *4 kE Compomenti per assemblaggio elettronica + readout (SRS ADC/FEC)*

→ Actual costs and sharing (RM3 or NA) to be determined

Rome Tre other requests



Richieste sui servizi:

- Reti e Calcolo 0
- Elettronica 3 m.u.
- Officina Meccanica 1 m.u.

THANKS!