Development and test of the Micromegas detector prototype and its readout electronics for the AMBER experiment at CERN

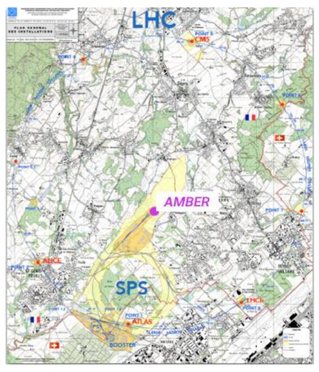
C. Alice on behalf of the working group

AMBER — Apparatus for Meson and Baryon Experimental Research

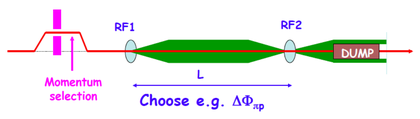
INFN

UNIVERSITÀ DI TORINO

The AMBER experiment at CERN



AMBER Collaboration:
13 countries + JINR (Dubna),
33 institutions, ~ 200 members.



$\Delta\Phi = 2\pi\ (L\ f\ /\ c)\ (\beta_1^{-1} - \beta_2^{-1})$ with $\beta_1^{-1} - \beta_2^{-1} = (m_1^2 - m_2^2)/2p^2$

Conventional muon/hadron M2 beams

Run 3 — Run 4

Phase-1 ✓

Proton Radius Measurement
Antimatter production cross section
Pion and kaon structure (PDFs and PDAs) via DY and J/Psi production

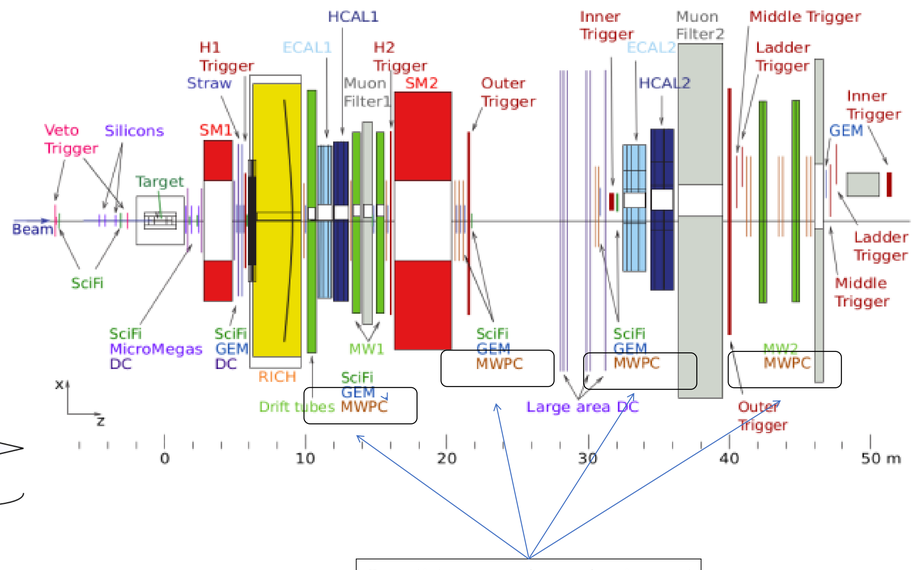
Phase-1: Proposal approved by RB on 02/12/2020

Phase-2

High precision strange-meson spectrum
Kaon and pion charge radius
Kaon induced Primakoff reaction
Gluonic content of kaon via prompt photons production

Phase-2 Proposal submission in the middle of 2023

2025 Drell-Yan setup

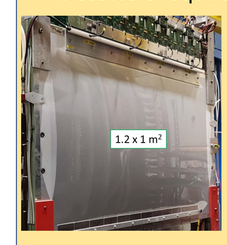


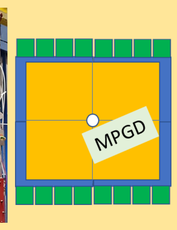
Candidates to be substituted

An MPGD detector with the new triggerless RO could find its first application during the Drell-Yan Pilot Run which is currently scheduled to the end of 2025.

MM development

- Detectors requirements:





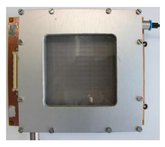
- ❑ Active area – up to 180x150 mm²
- ❑ Rates - ~150kHz/mm² (centre), 1-2 kHz/mm² (periphery)
- ❑ Thickness – 0.3-0.5 %/plane
- ❑ Possibly, proven design

To achieve that we would like to rely on a proven technology, a group with expertise and possibly a production site

Micromegas — JINR group involved in the ATLAS NSM project with a production site

- Prototyping timeline:

2022

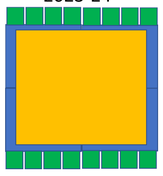


- 8x8 cm²
- TIGER ASIC
- New TIGER FE

2023

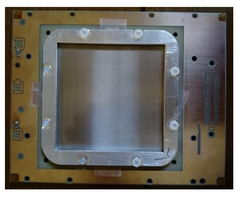
- 50x60cm²
- TIGER ASIC
- New MM ASIC

2023-24

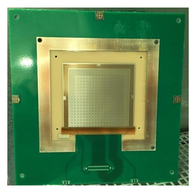


- 4x50x60cm²
- New MM ASIC

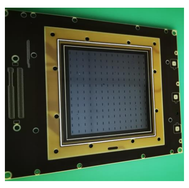
- Building technologies:



Floating Mesh



Bulk

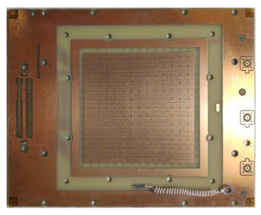


Resistive

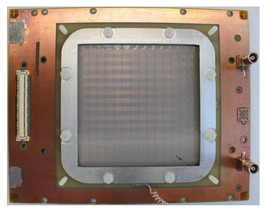
Our prototype: non-resistive floating mesh MM

- Active area: 6,8 x 6,8 cm²
- Amplification gap: 128 µm
- Conversion gap: ~ 5 mm
- Strips width: 400 µm
- Pitch: 550 µm
- Holes: 45 x 45 µm²
- Wires diameter: 18 µm

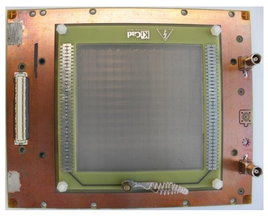
Anode PCB



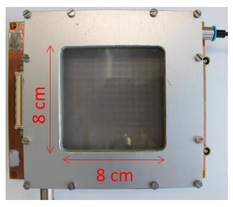
Mesh electrode

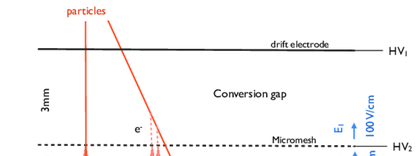


Drift electrode

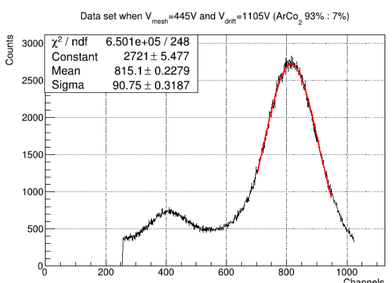


Gas vessel

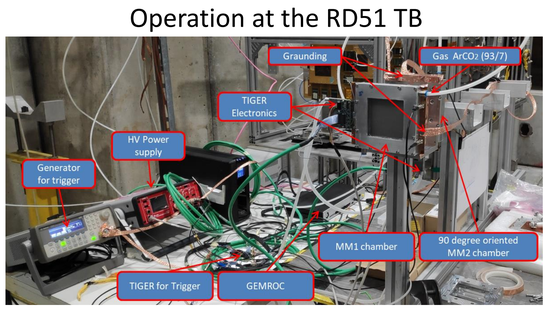


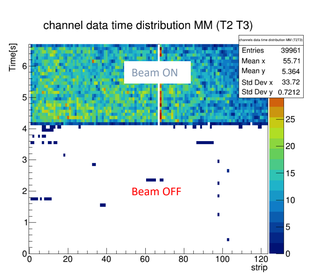


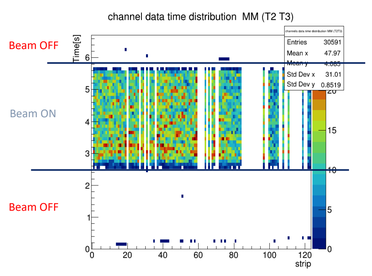
Fe55 laboratory test with MCA



Operation at the RD51 TB







Possblie collaboration for a Pixelated Resistive MM detector with the ATLAS INFN-Roma3 group

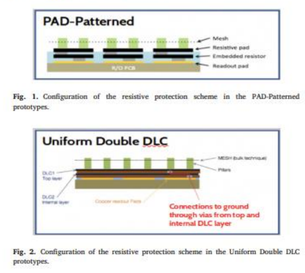
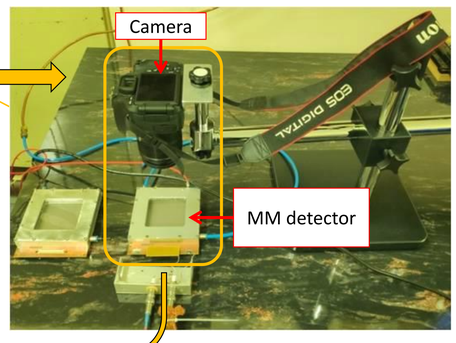


Fig. 1. Configuration of the resistive protection scheme in the PAD-Patterned prototypes.

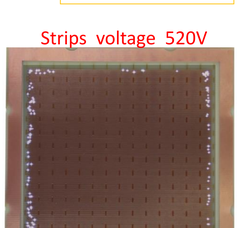
Fig. 2. Configuration of the resistive protection scheme in the Uniform Double DLC prototypes.

Quality check of the production

An optical system to analyse the anode defects has been implemented

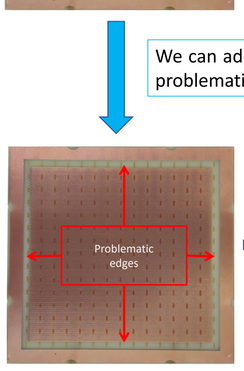


Strips voltage 520V



Video frames merged to obtain the discharges distribution

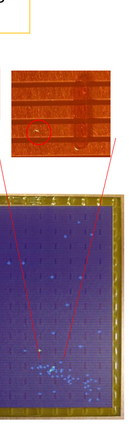
We can address the problematic areas



Kapton tape added

We have removed the problematic areas

Only local defects of the Cu on the strips



Strips voltage 590V

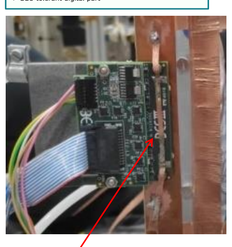
JOINT INSTITUTE FOR NUCLEAR RESEARCH

Initial digital RO chain

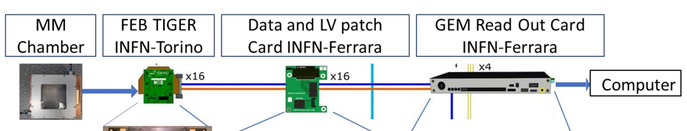
TIGER ASIC
(Torino integrated Gem Electronics for Read-out)

The ASIC speicification:

-> 64 channels with up to 60kHz/ch rates
->12 mW/ch power evelop
-> Analog charge measurement up to 50fC
-> ENC noise below 2000 e⁻ rms for strip capacity < 100pF
-> Time-over-Threshold charge measurement possibility
-> 4 TAC on T and Q branch of every channel
-> SEU tolerant digital part



The GND is provided by soldering of a trace, not through the connector



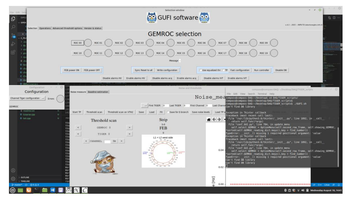
OFF-DETECTOR electronics: GEMROC based RO (Fe&To INFN)

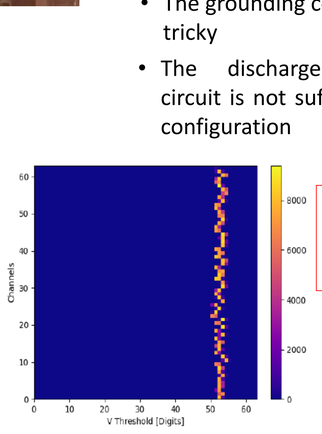
ON-DETECOR electronics: TIGER ASIC based FE card

DAQ software: GUFI DAQ software (To INFN)

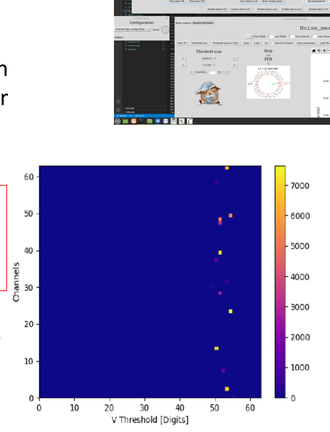
Two issues were identified

- The grounding could be tricky
- The discharge protection circuit is not sufficient in our configuration





After 1 day on beam, most of the channels are damaged



FE challenges

A new specific dedicated ASIC for MPGD detector is under development by INFN-Torino

New ESD protection circuit have been designed in order to face up the MM detector discharges

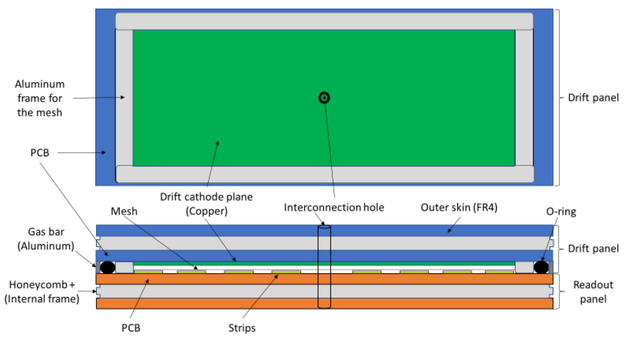
CGEM ESD circuit

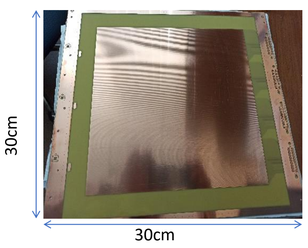
NEW ESD circuit

The new protection circuit will allow for an individual channel quenching.

Simulations with different capacitor values

Mechanical challenges





1) Study of the bigger surface behaviour during the production

2) Mechanical structure adapted for bigger prototype size

Software challenges

The online monitoring software still under development.