



Micropattern Gaseous Detectors and Imaging Applications prospects at INPP - Demokritos

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Detector Development and Data Acquisition, Monitoring & Analysis lab (DAMA)

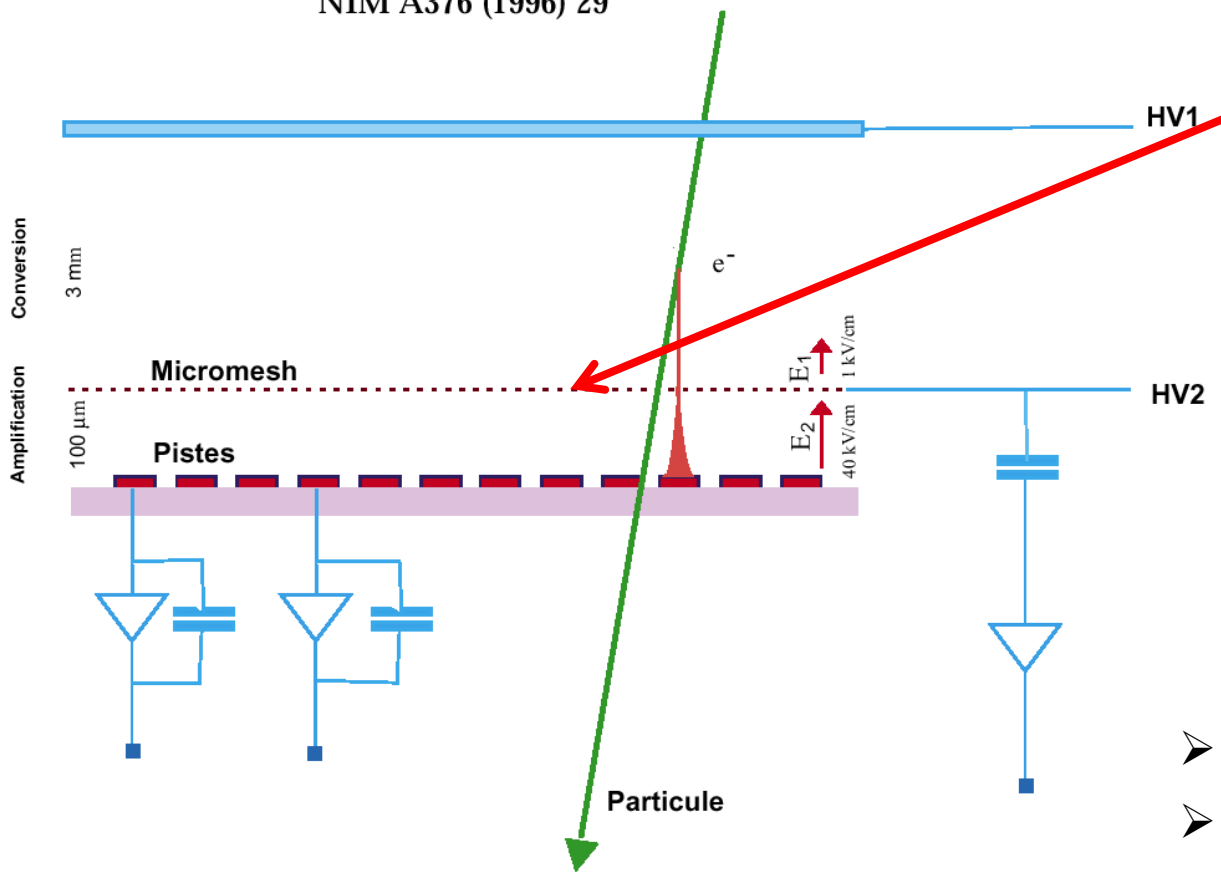
DAMA Laboratory projects

- ❖ Detector Instrumentation (Micropattern Gaseous detectors)
- ❖ Data Acquisition
- ❖ Triggering and FE electronics
- ❖ Detector Data Analysis
- ❖ R&D in Micromegas Detectors in the framework of experimental activities (CAST, RD51, ATLAS, CMS, IAXO, srEDM etc)

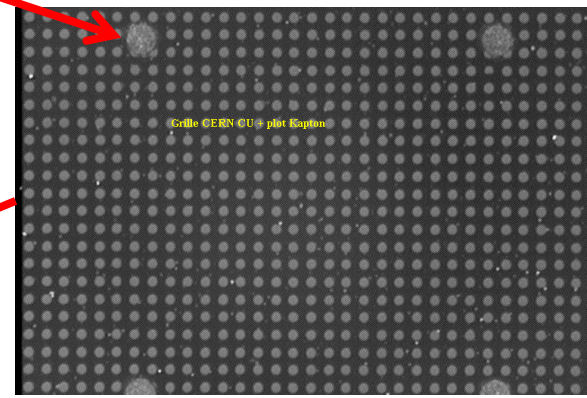
Micromegas – principle

MICROMEAS

Y.Giomataris, Ph. Rebourgeard, J.P Robert and G. Charpak
NIM A376 (1996) 29



Spacers
 $h=50\mu\text{m}$



Hole diameter=50 μm , pitch=100 μm

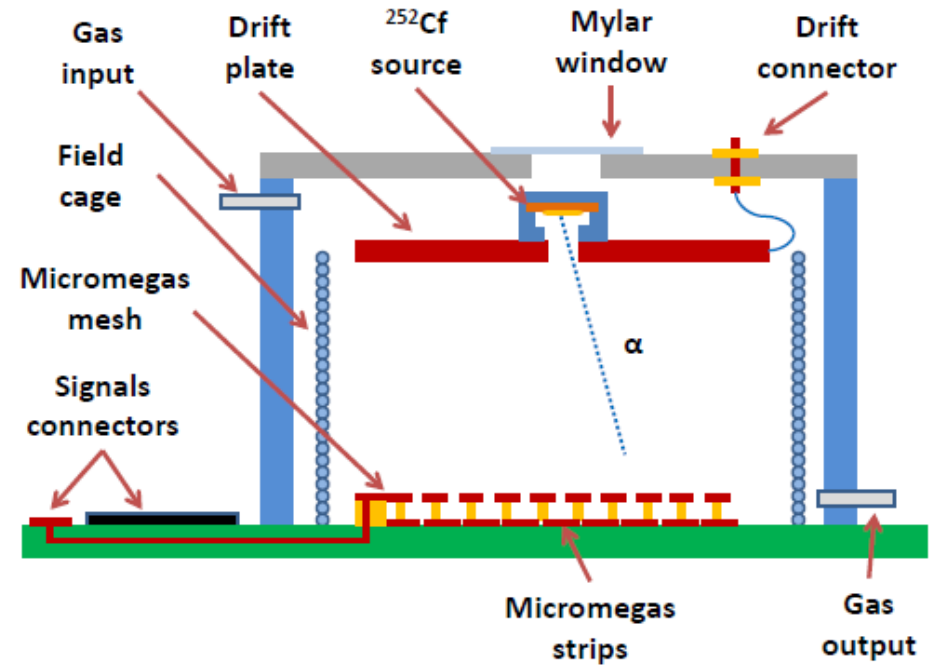
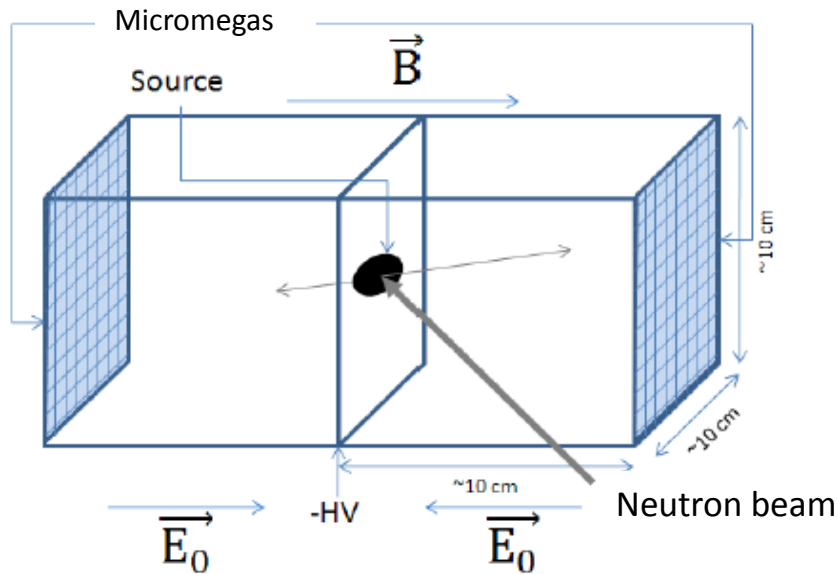
Manufacturing variations

- Bulk Micromegas
- Microbulk Micromegas
- Resistive (bulk) Micromegas

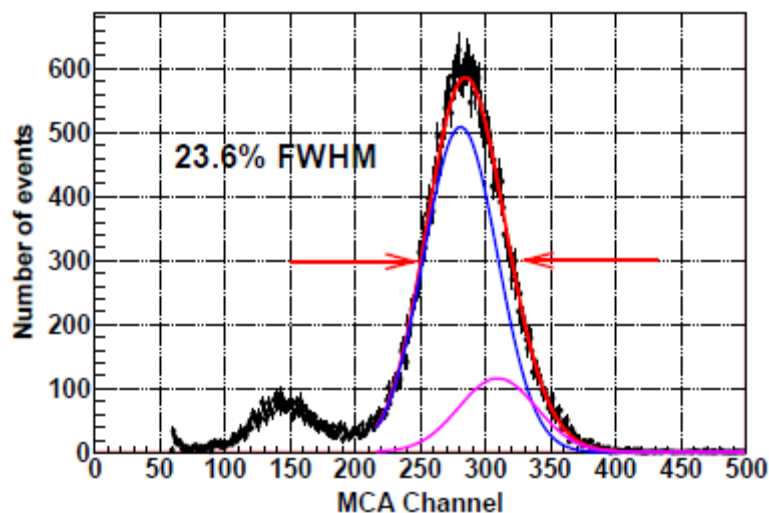
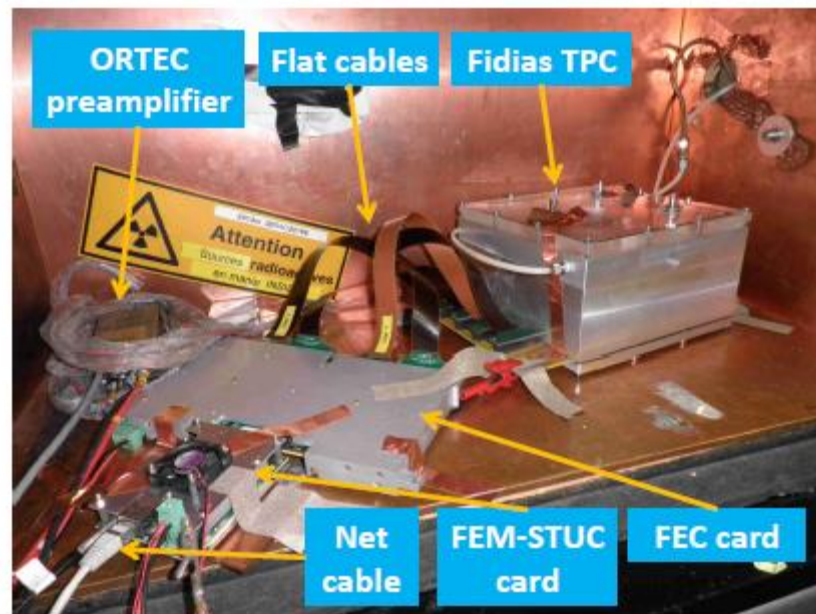
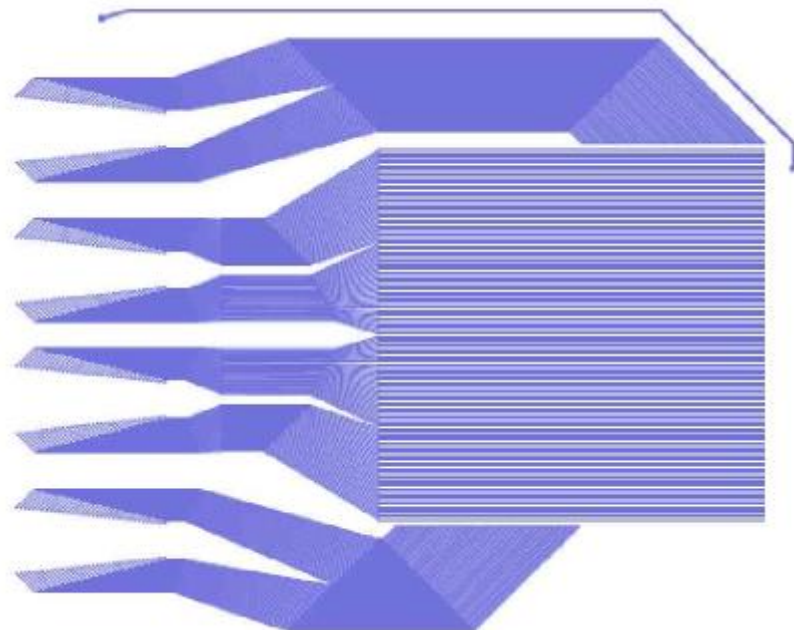
Micromegas: MICRO MESH Gaseous Structure detector

★ Nuclear TPC – Fission project FIDIAS (Demokritos – Saclay)

Purpose: to develop a Micromegas detector for detailed studies of nuclear fission and nuclear reactions

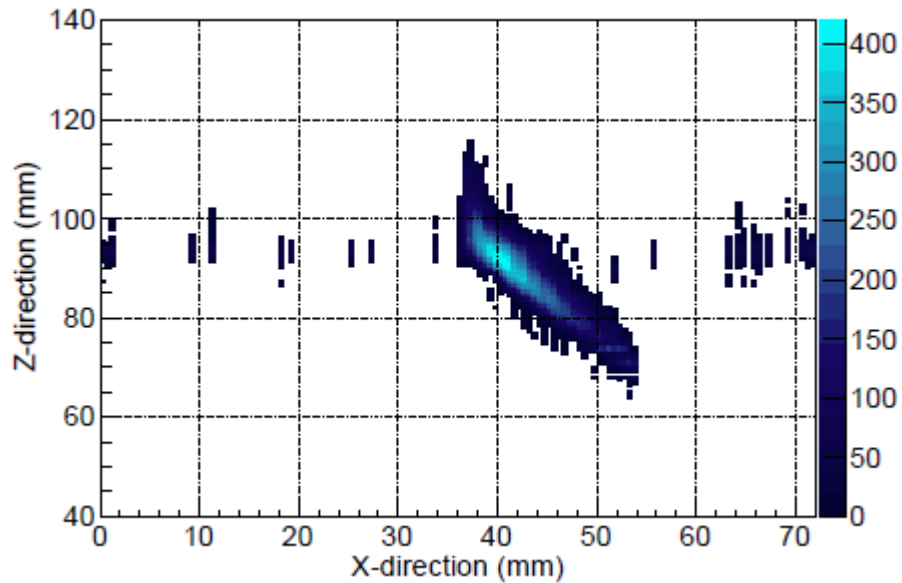
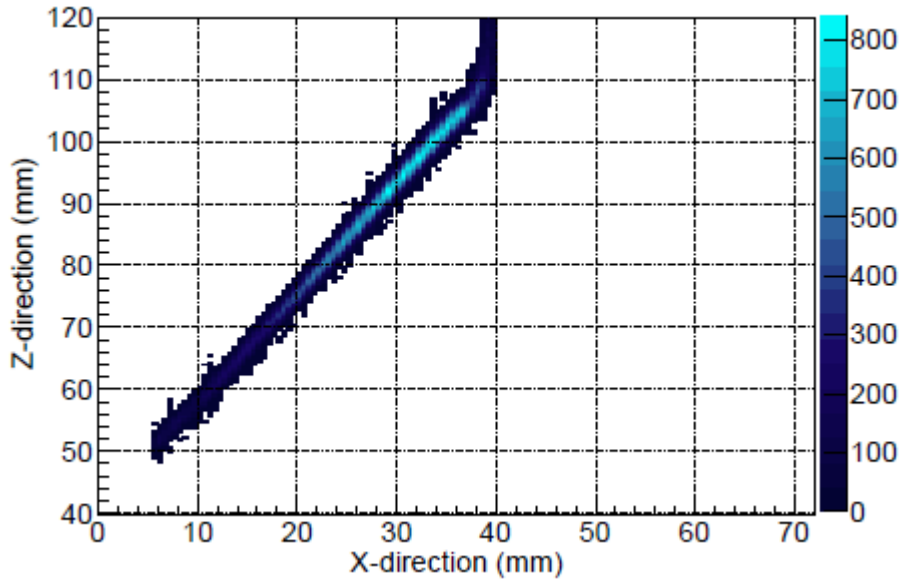


Design at Demokritos/CERN - Measurements done at Saclay with ^{55}Fe and ^{252}Cf sources and various gasses

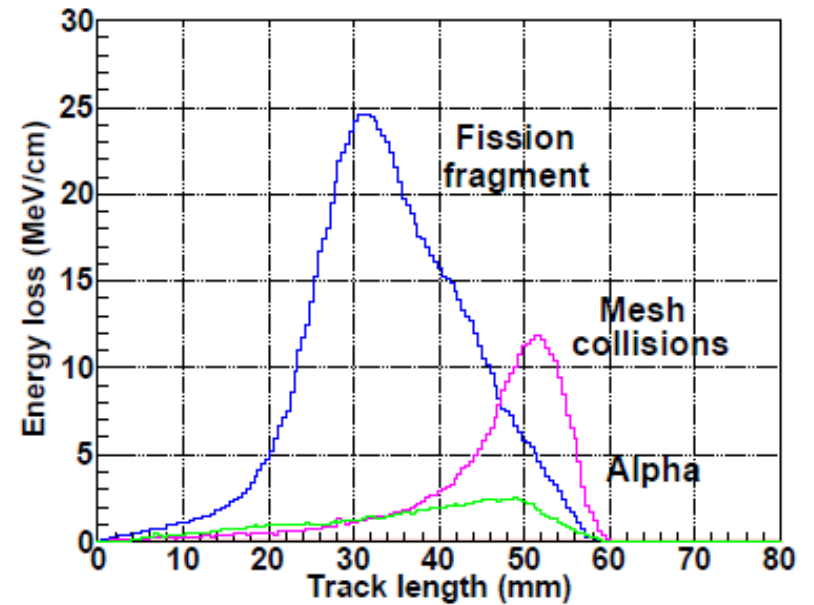


Energy resolution with 5.9 keV ^{55}Fe and 6.1 MeV alphas

Gas mixture	Energy resolution (% FWHM)	
	5.9 keV	6.1 MeV
Ar+5%iso	23.6 ± 0.4	9.9 ± 0.1
Ne+5%iso	21.7 ± 0.3	12.4 ± 0.2
He+5%iso	23.6 ± 0.4	—



Fission fragments in He +5% isobutane,
and in Ne+5% isobutane

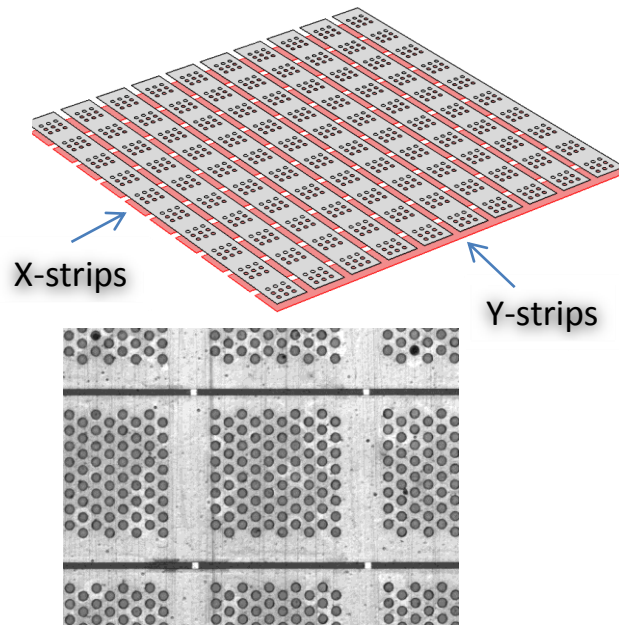


Reconstructed energy loss along a track
for a fission fragment in Ne+5%
isobutane



Segmented Mesh Microbulk Micromegas: (Demokritos – Saclay – Zaragoza)

Aim of the project →



To develop microbulk Micromegas detectors with segmented mesh

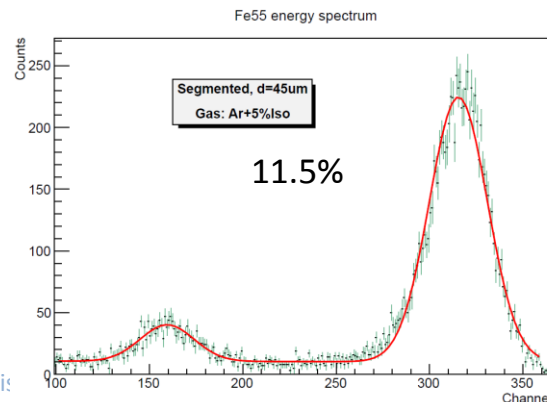
- 1) Real x-y structure
- 2) Mass minimization
- 3) Production Simplification
- 4) Large surface detectors

RD51 Common Fund Project

Collaborating groups

- NCSR Demokritos (Leading Institute)
- IRFU Saclay
- Univ. of Zaragoza
- CERN

Excellent Energy resolution achieved



1) Rare searches (axion, dark matter)

Microbulk background $\sim 10^{-6}$ cnts/keV cm²/s

Segmented background $\sim 10^{-7}$ cnts/keV/cm²/s

2) Neutron Beam profiler (nTOF)

Desirable due to very low material Budget:

5 μ m + 5 μ m of Cu

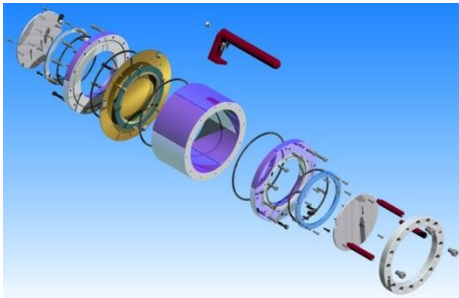
Emerging applications

Rare searches (axion, dark matter)

Microbulk background: $\sim 10^{-6}$ cnts/keV/cm²/s

**The segmented microbulk can further push
the background $\rightarrow \sim 10^{-7}$ cnts/keV/cm²/s**

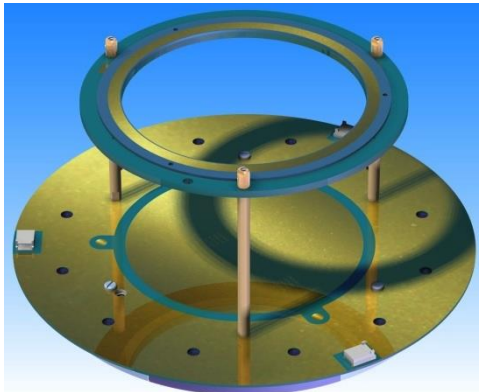
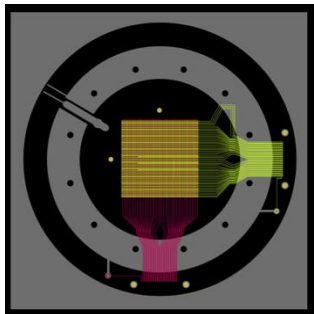
Neutron Beam profiler (nTOF)



**Very adequate due to very low material budget
5 μm + 5 μm of Cu only**

IRFU Saclay

**has a design for nTOF
of a neutron profiler
using segmented Micromegas.**



For the International Axion Observatory (IAXO)

The name of the game is to reduce all background sources and obtain a Micromegas detector with 10^{-7} - 10^{-8} cts/keV/cm²/s



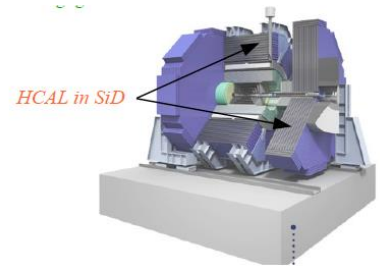
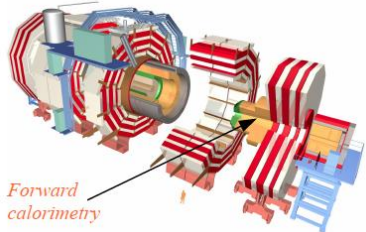
**Work in collaboration with Zaragoza and Saclay.
Focused to: Develop new microbulk Micromegas – e.g. segmented Micromegas**



★ Resistive Bulk Micromegas for Particle Flow Calorimetry Demokritos – LAPP Annecy

Resistive Micromegas for Particle Flow Calorimetry at ILC, HL-LHC and The Future Circular Collider (FCC)

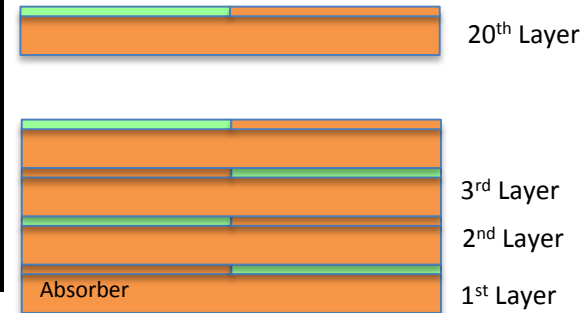
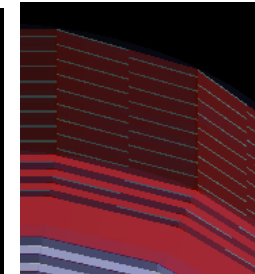
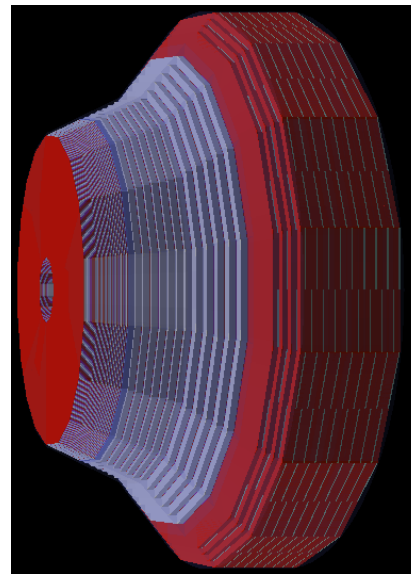
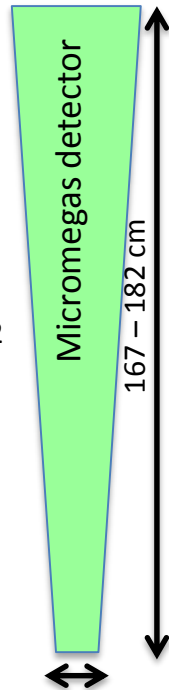
Required: High rate capability, radiation tolerance, stability, High granularity, industrialized production



36 – 40 cm

CMS Phase II Upgrade HCAL end cap upgrade option

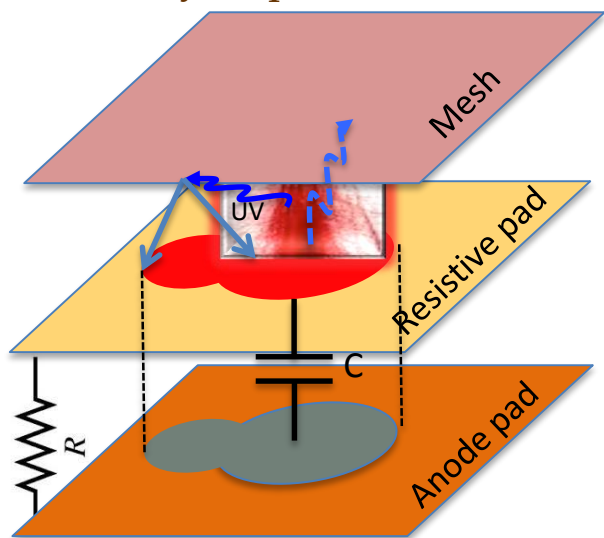
- 150 m² / end cap
- Total Detector Surface : ≈300 m²



36 – 40 cm

Resistive Bulk Micromegas for Calorimetry

Resistive layers prevent streamers to develop to sparks by quenching it at an early stage



R: Resistance to ground

C: Capacitance between resistive coating and ground

It depends on the extend of the cascade ($\sim 100 \mu\text{m}$) that is a function of the transverse diffusion (gas, drift length, HV) given the thickness and the material of the dielectric

RC: gives typical time of the charge evacuation

High charge deposition deforms locally the E field \rightarrow lower Gain

\rightarrow Quench spark \rightarrow loss of linearity

τ : time of cascade development $\sim 10 \text{ ns}$

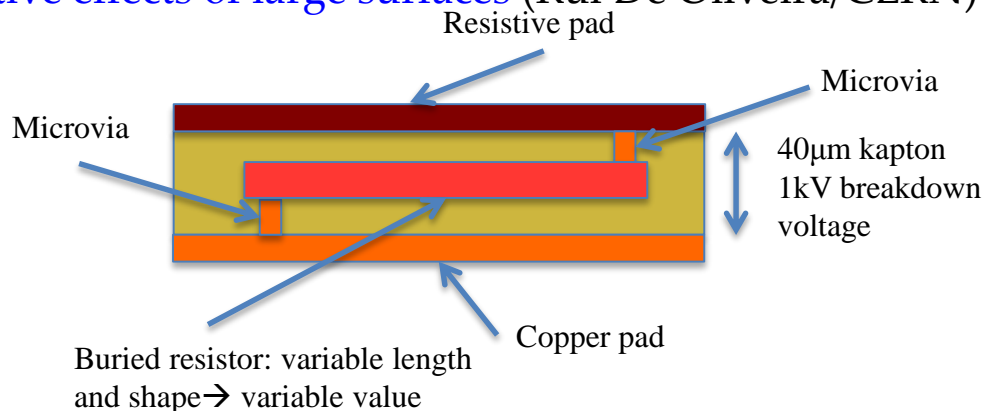
$RC > \tau \rightarrow$ Spark quenching

$RC \sim \tau \rightarrow$ Spark develops

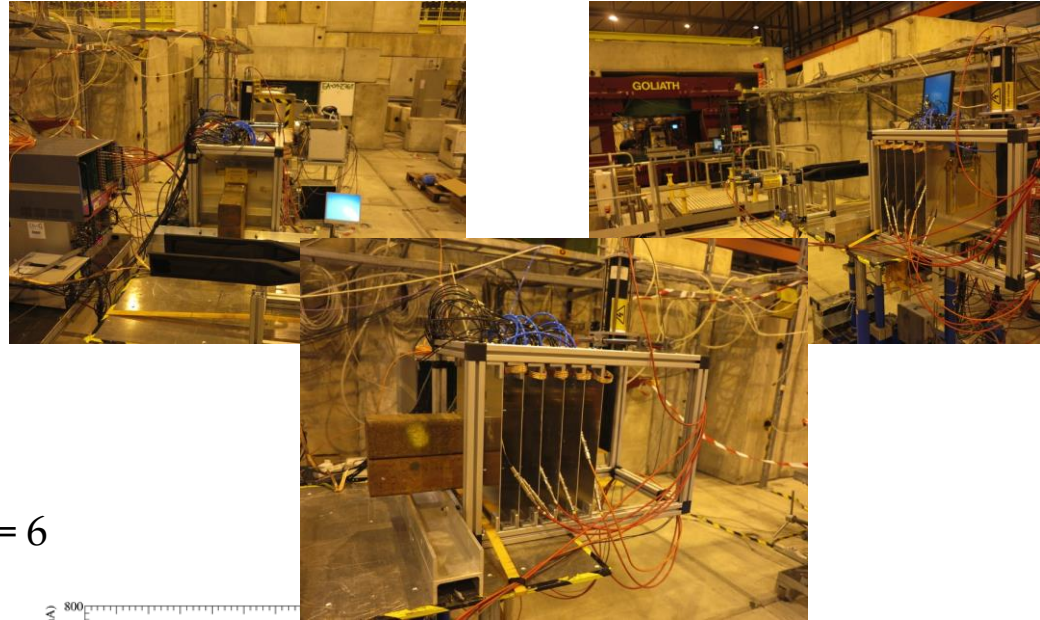
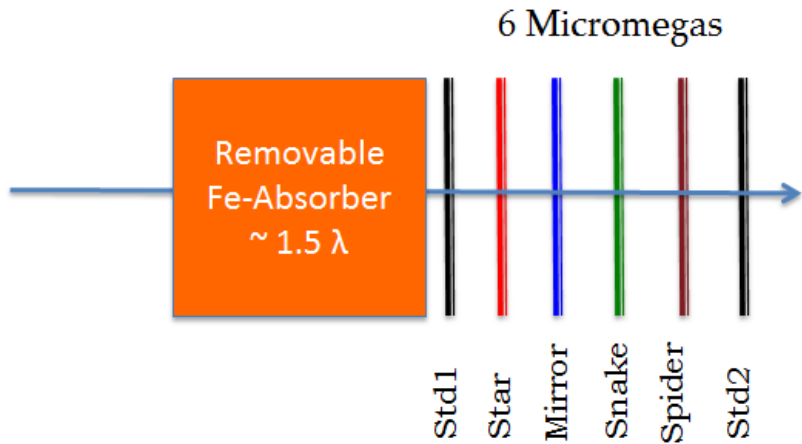
Our study: Vary RC (effectively vary R) and study response linearity and discharge rate.

Charge evacuation:

- Sideways, horizontal evacuation of charge not adequate for large surfaces and high rates due to development of steady state charges
- Individual surface resistivity for every pad with buried resistor to ground, limits cross talk and cumulative effects of large surfaces (Rui De Oliveira/CERN)

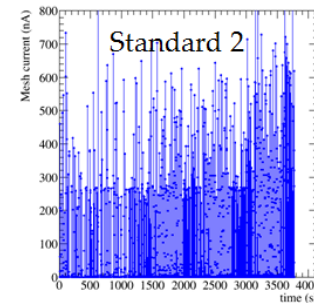
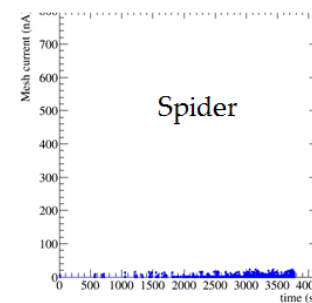
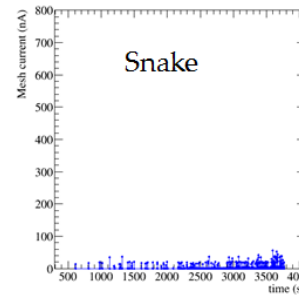
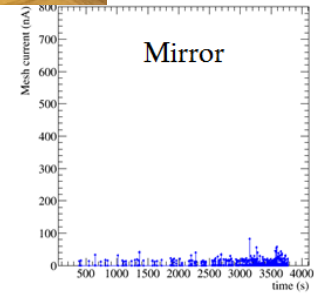
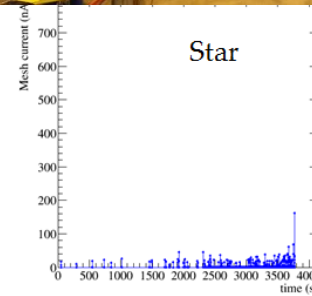
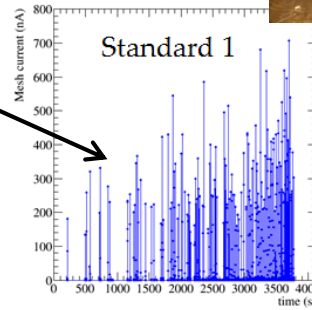
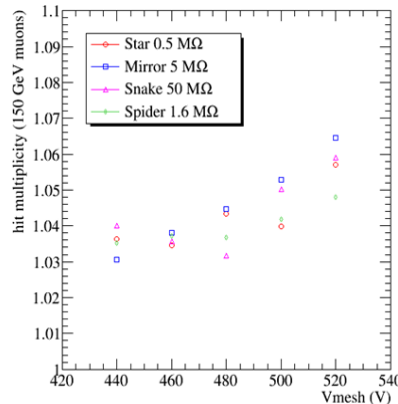
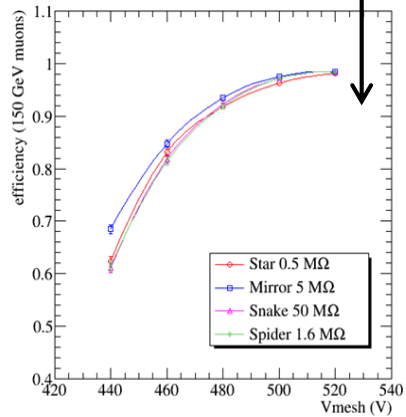


Common tests at H4 beam at CERN: Demokritos – LAPP Anecy



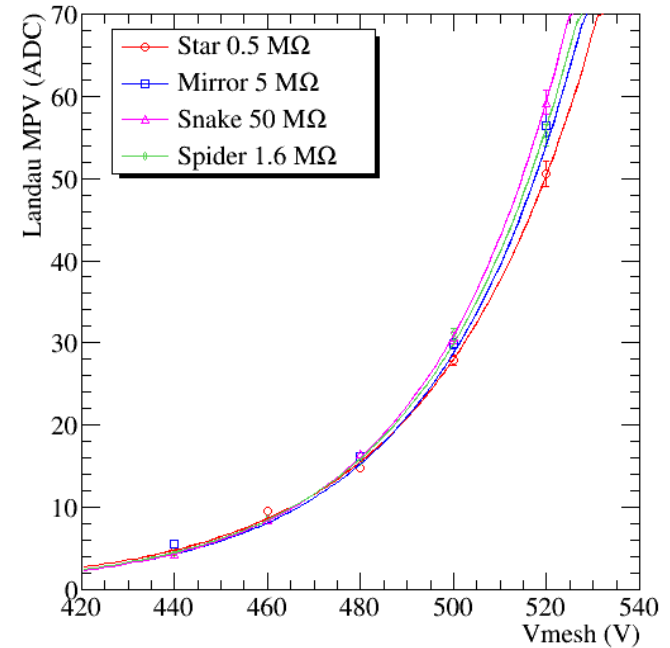
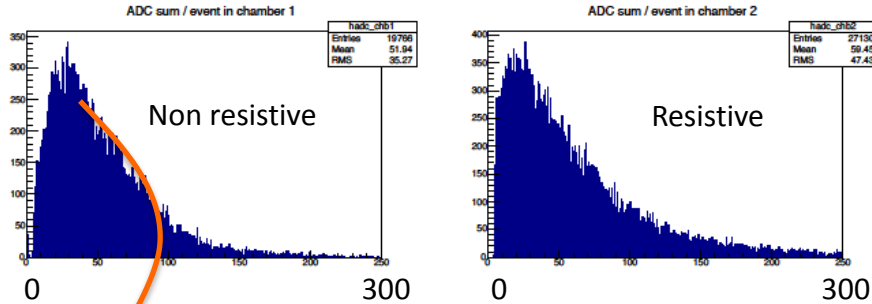
Spider: Region 3-1 ($R_{buried}=1.6 \text{ M}\Omega$, $R_{surface}=6 \text{ M}\Omega$) \rightarrow Build MM with uniform resistivity

- Mesh current with pions (2-400 kHz)
- Efficiency and Hit multiplicity

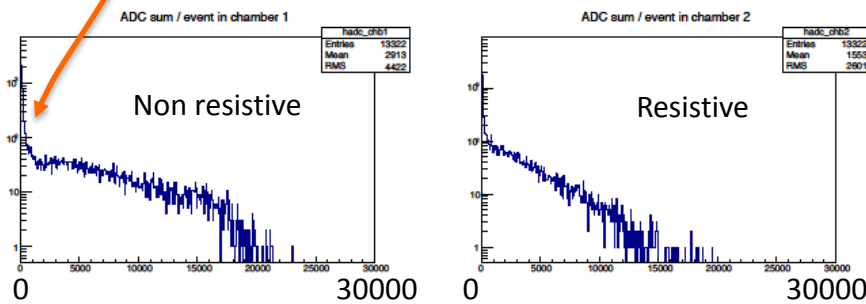


Energy distributions – Beam profile

Landau distribution for mips (muons at 150 GeV)

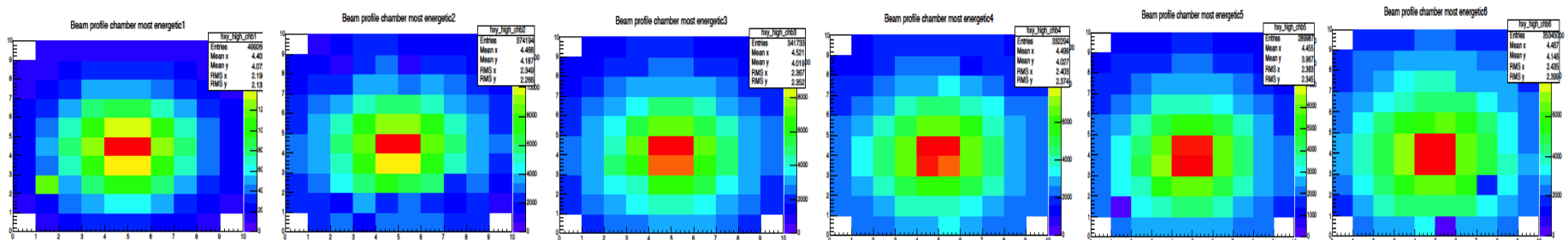


Energy distribution for pions at 150 GeV with absorber



Possibility to calibrate with mips

Beam spot in all detectors: π beam at 150 GeV with Fe absorber

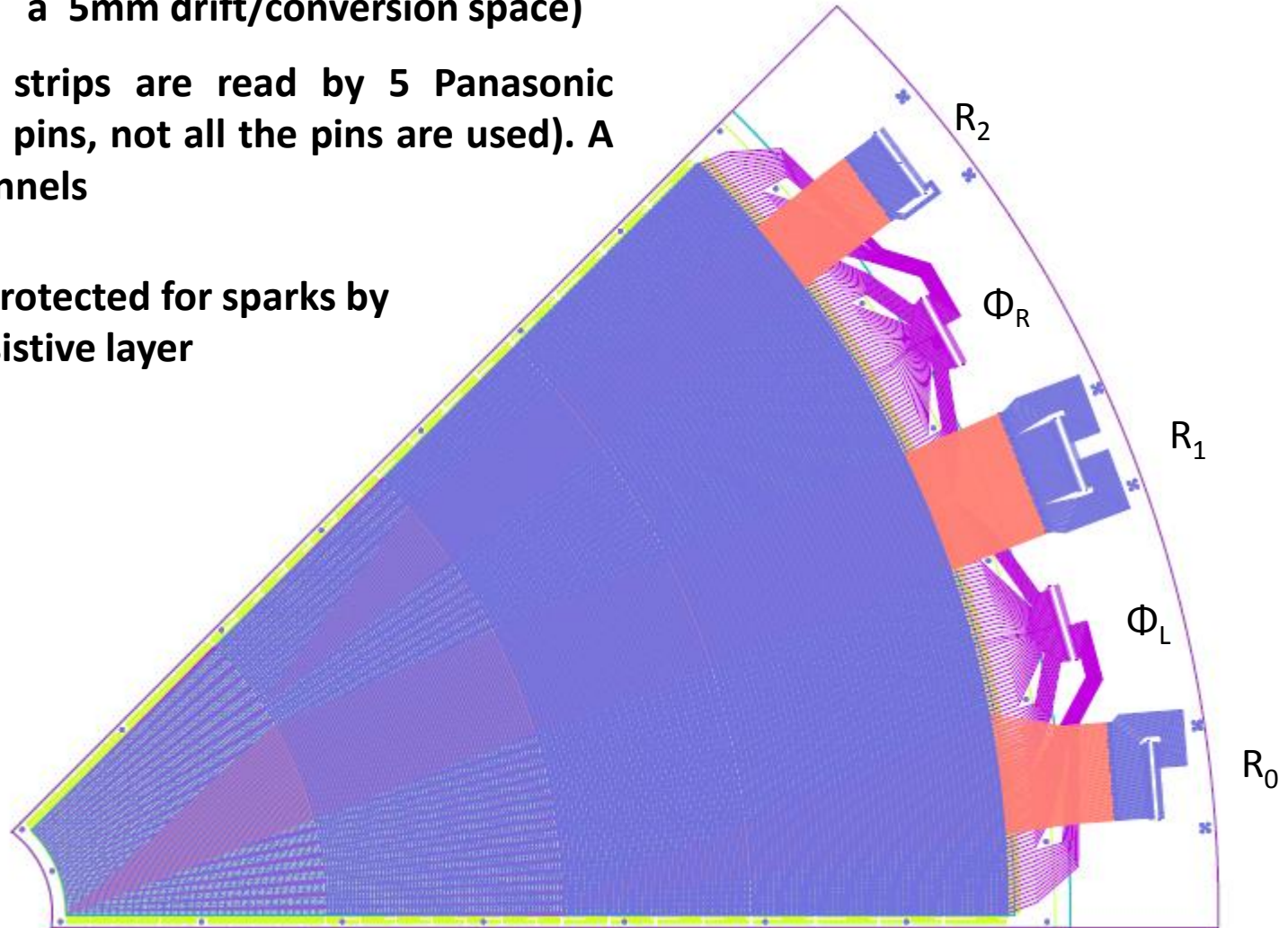


★ R-Phi Micromegas octant – segmentation and connectors (Demokritos-HOU)

Configured as normal tracking chambers for testing purposes with
a 5mm drift/conversion space)

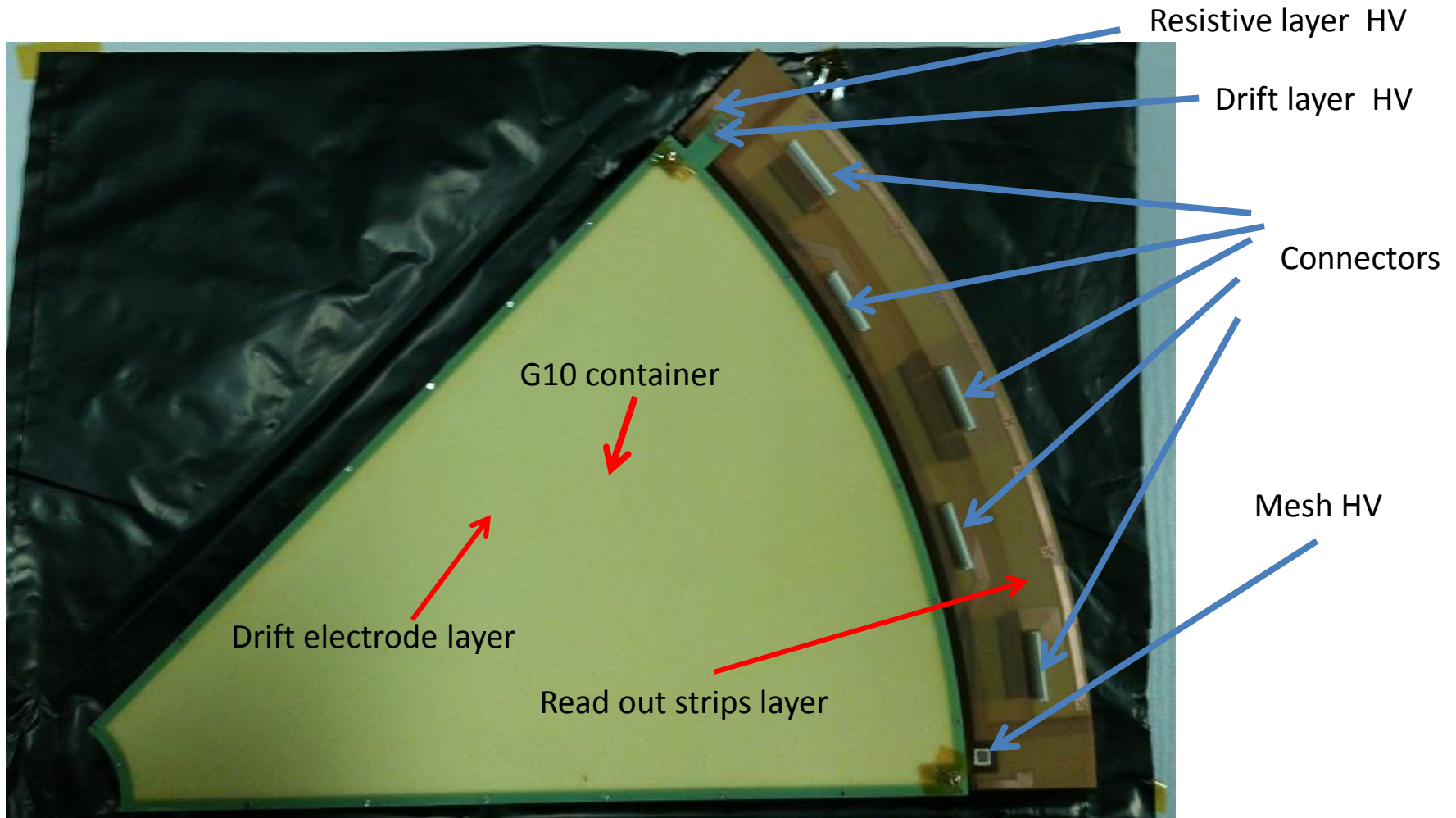
The r and phi strips are read by 5 Panasonic
connectors (130 pins, not all the pins are used). A
total of 444 channels

The readout is protected for sparks by
a resistive layer



Implementing the prototype octant

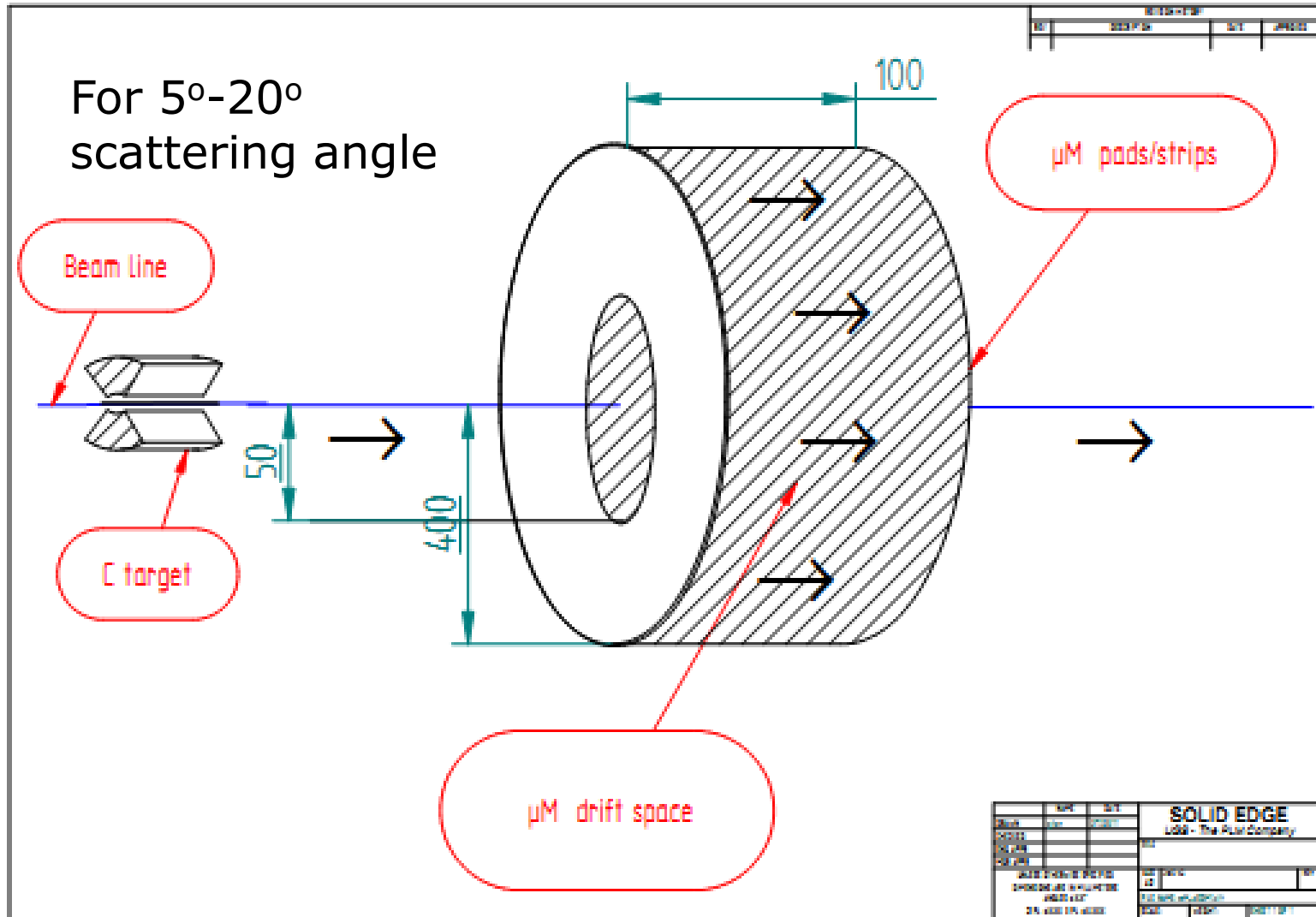
Two r-phi prototype octants have been ordered and constructed in the electronics lab of CERN. One with a 10 MOhm/sq and one with a 100MOhm/sq resistivity of the resistive layer, to test the behavior in various beam density situations (fast or less fast operation).



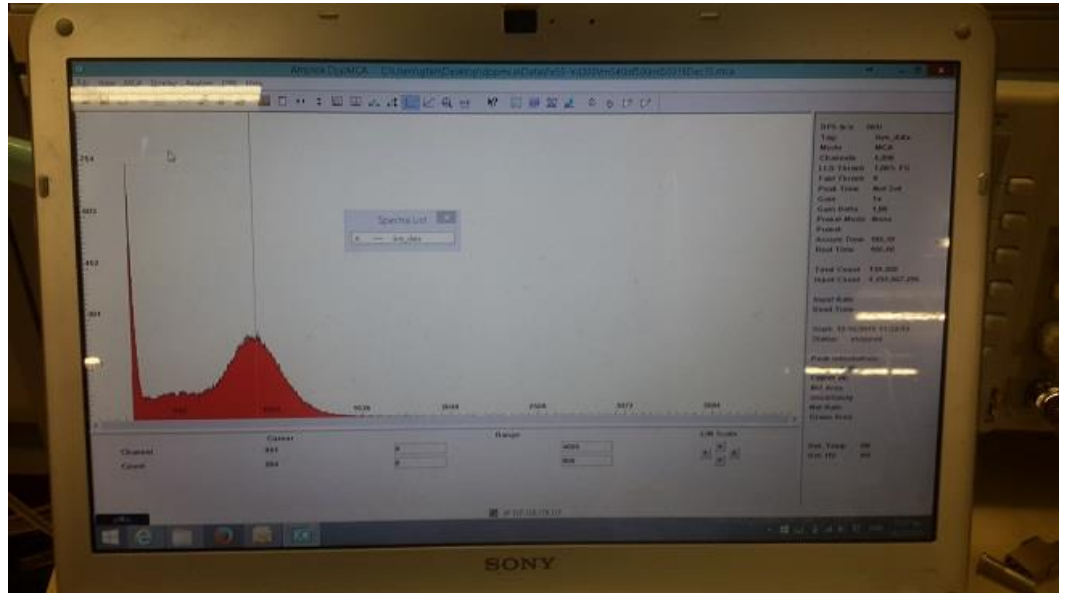
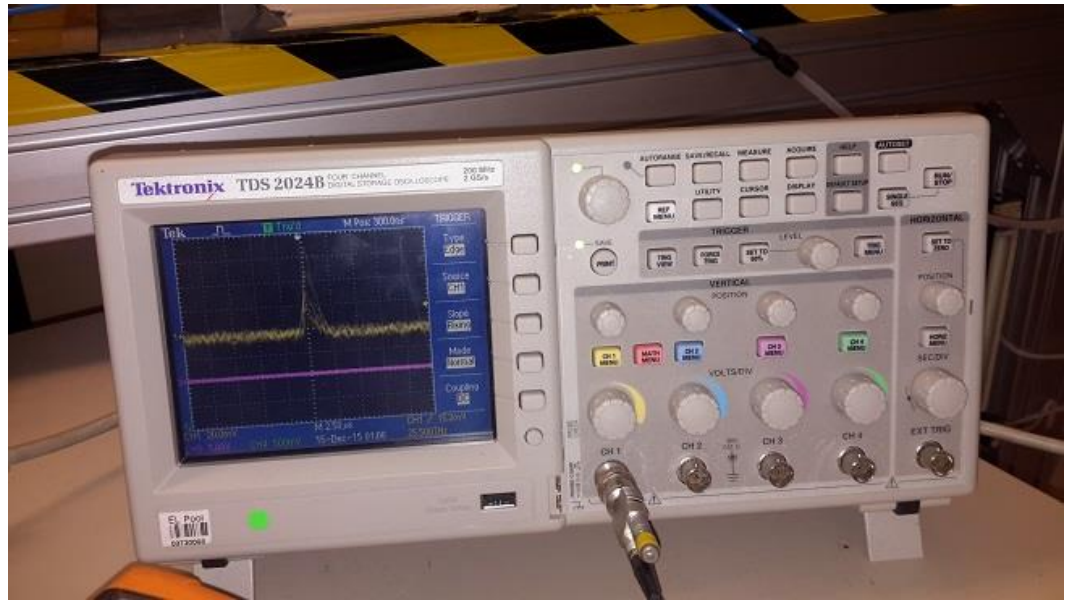
Sketch of a MM TPC polarimeter design

for use in the srEDM experiment

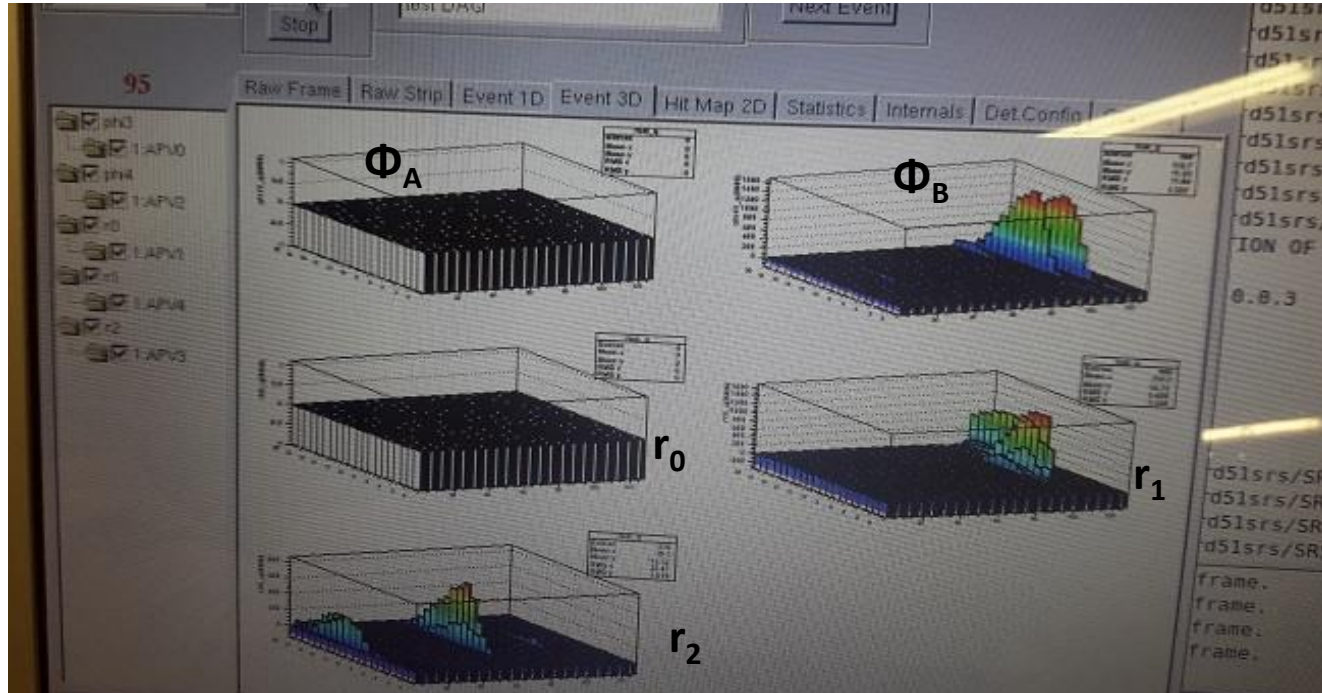
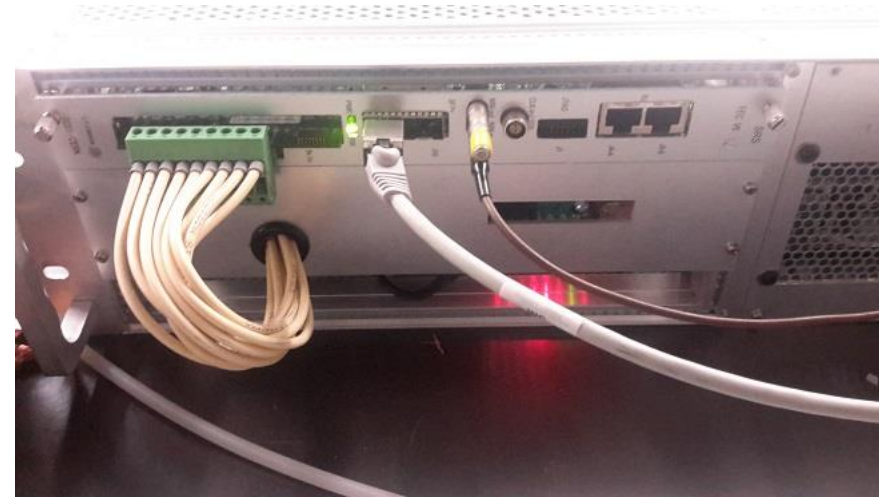
Units in mm - not to scale



R-Phi Micromegas octant – reading the mesh (^{55}Fe – Ar/ CO_2 93/7)



R-Phi Micromegas octant – reading with SRS and APV's



- Φ_A Left phi
- Φ_B Right phi
- r_0 3-4th Outer R
- r_1 Inner R
- r_2 2nd Outer R

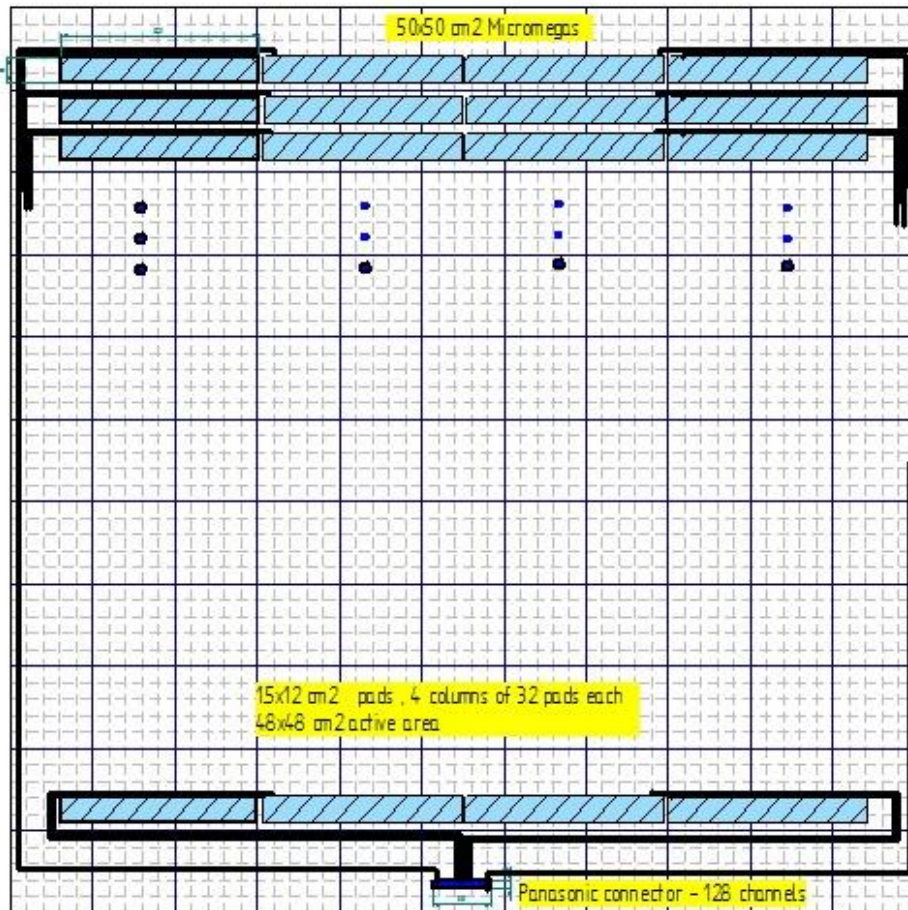


ASTRONEU Thalys project design and construct 50x50 cm² mM chambers (Demokritos-HOU)

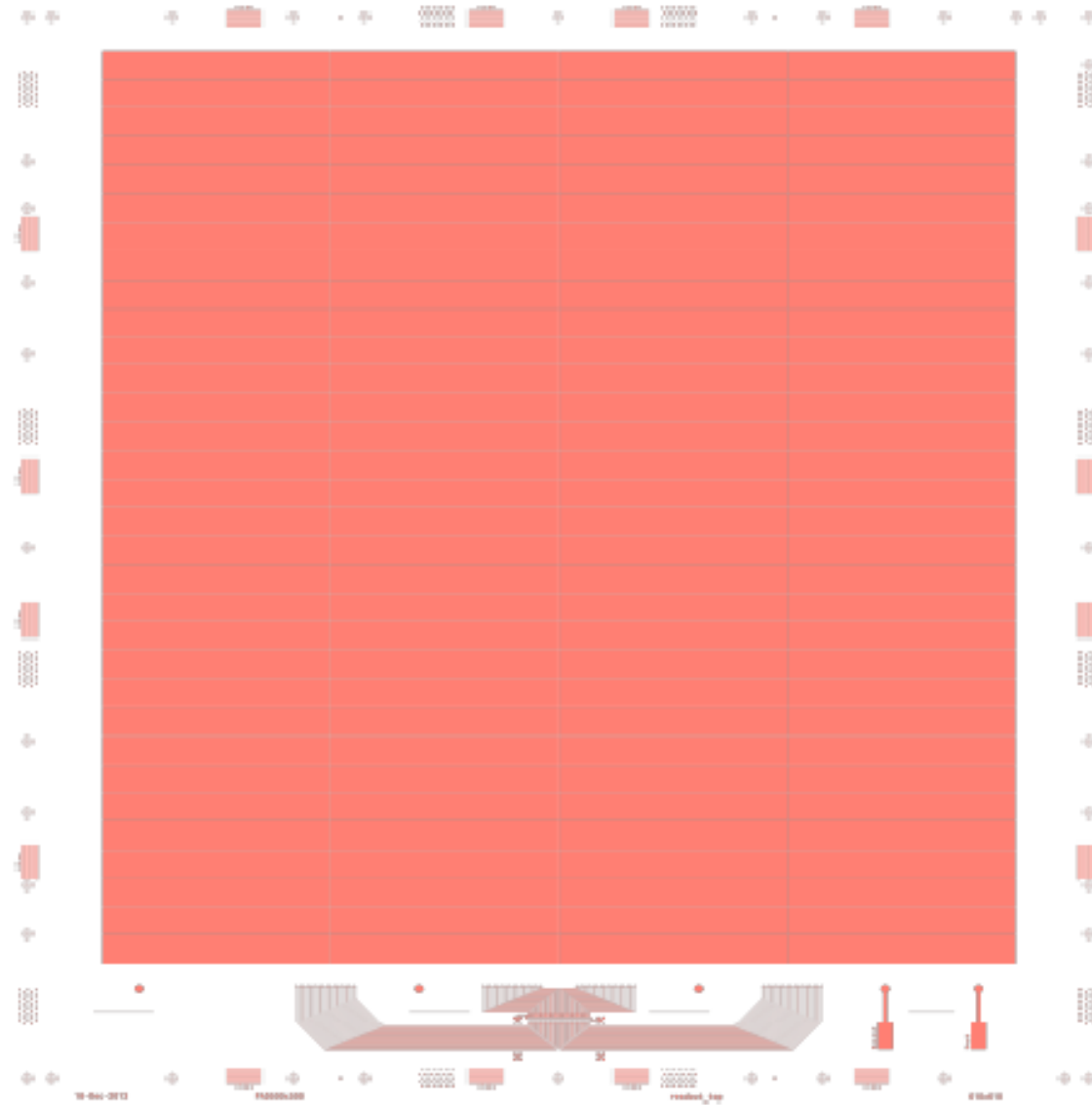
There is need of detectors able to record cosmic ray showers for use as calibration and veto systems for a deep underwater neutrino telescope.

Can be used in muon tomography

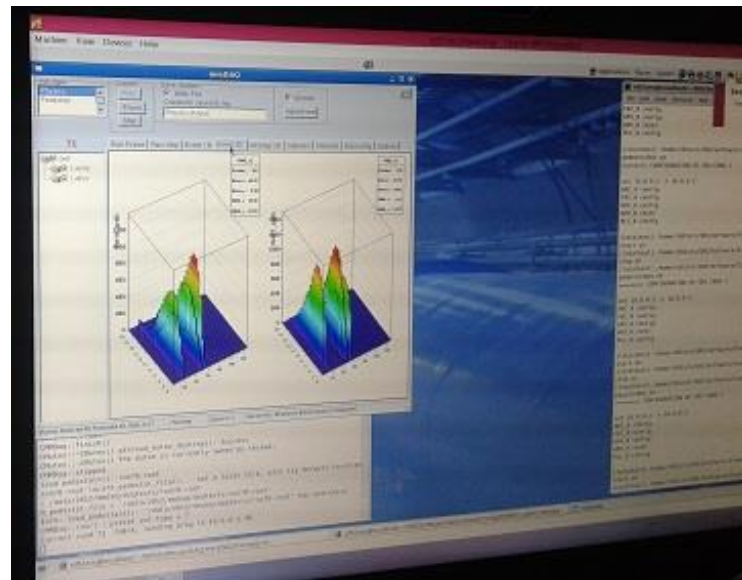
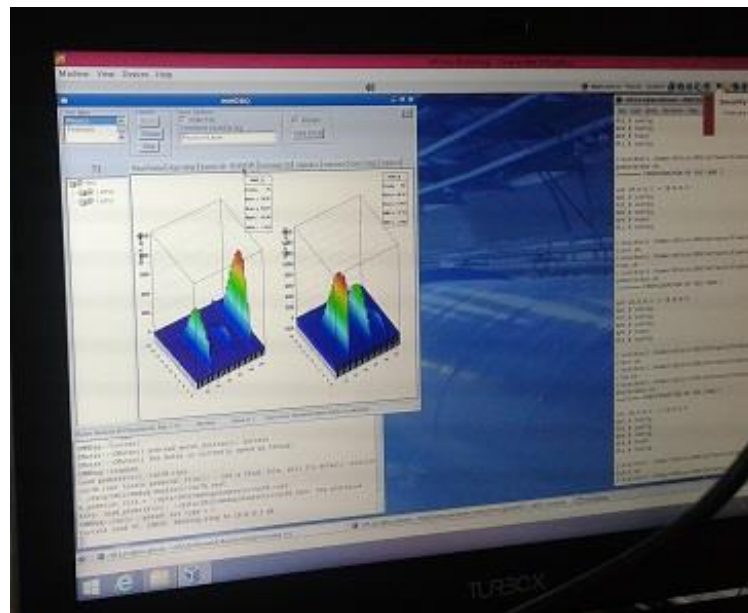
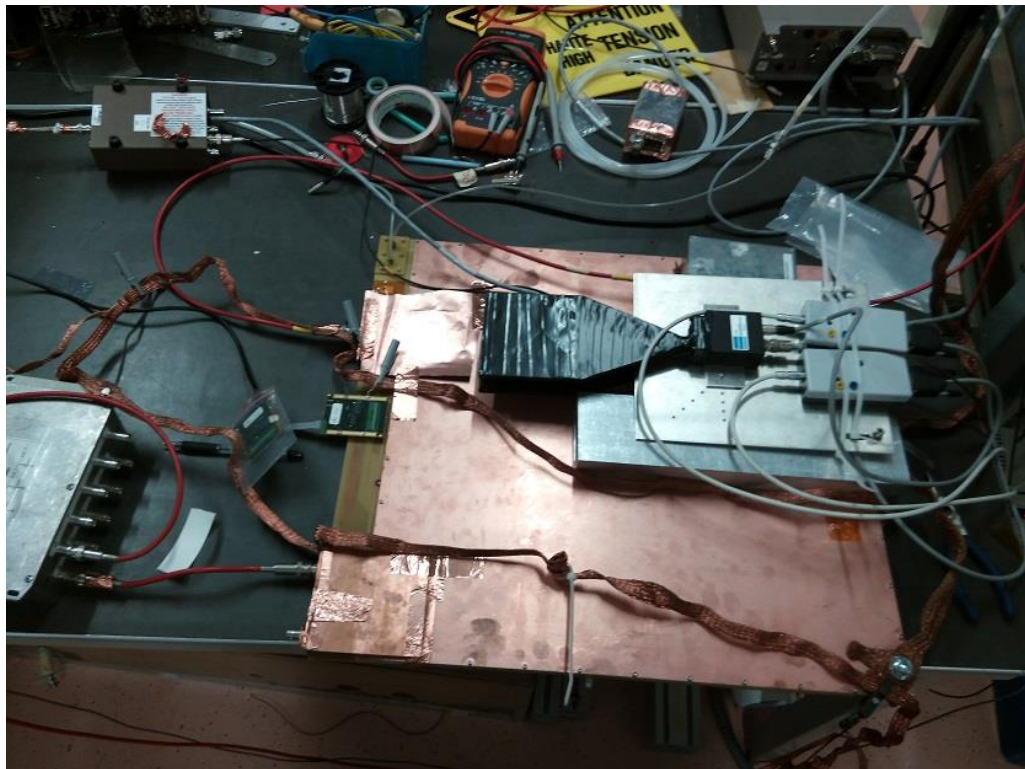
Testing prototype – opened for inspection



MegaμMegas design



MegaμMegas lab tests with cosμics



Summary

Several designs of Micromegas detectors being developed at the DAMA Laboratory of INPP - Demokritos

- ❖ A bulk Micromegas TPC for Nuclear applications (Nuclear interaction imaging)
- ❖ Segmented mesh microbulk Micromegas for low material, low background applications.
- ❖ Resistive bulk Mikromegas for calorimetry.
- ❖ R- Φ bulk Micromegas TPC for the srEDM polarimeter
- ❖ Mega-microMegas large area bulk Micromegas chambers for cosmic ray showers/tracking (can be used for muon tomography)