CHARACTERIZATION OF A LOW-PRESSURE MICROMEGAS-LIKE GASEOUS DETECTOR WITH LOW ENERGY X-RAY SOURCES

Istituto Nazionale di Fisica Nucleare
Sezione di Pisa

C. AVANZINI[a], G. BALESTRI[a], R. CAROSI[a], R. DELL'ORSO[a], F. FRASCONI[a], C. MAGAZZU'[a], M. MASSA[a], A. MOGGI[a], F. MORSANI[a,*], F. PILO[a], G. TERRENI[a]

[a] SWEATERS TEAM, INFN Pisa, CSN5

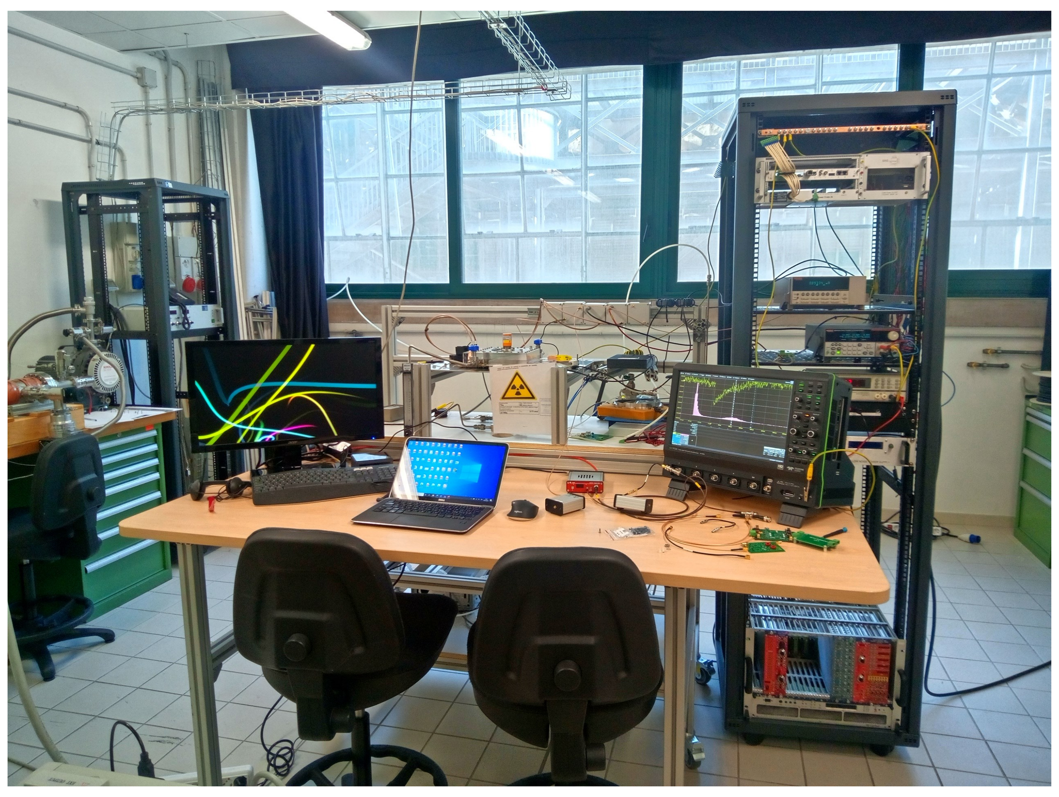
INTRODUCTION

Within the family of the Micro Strip Gas Detectors (MSGD), the intrinsic characteristics of the bulk Micro-Megas (MM) device represent the most promising features for the construction of a new instrument to be operated as a TPC gas chamber in a low-pressure regime. In this study, we present the main properties of a low-pressure MM detector in which the amplification gap was slightly increased to improve the gas gain. Two configurations have been deeply studied: the first one with a gap of 128 µm and a second one with 192 µm gap, both filled and operated with a gas mixture (Ar-Co_2; 93:7) at pressures below 100 mbar. The dependence of the gain and the energy resolution on the amplification field, gas pressure and drift field have been evaluated. The main goal of this experimental activity is the operation of a well consolidated detector technology for studying and monitoring low energy ionizing particles in the range 1-100 keV.

TEST BENCH

Dedicated to:

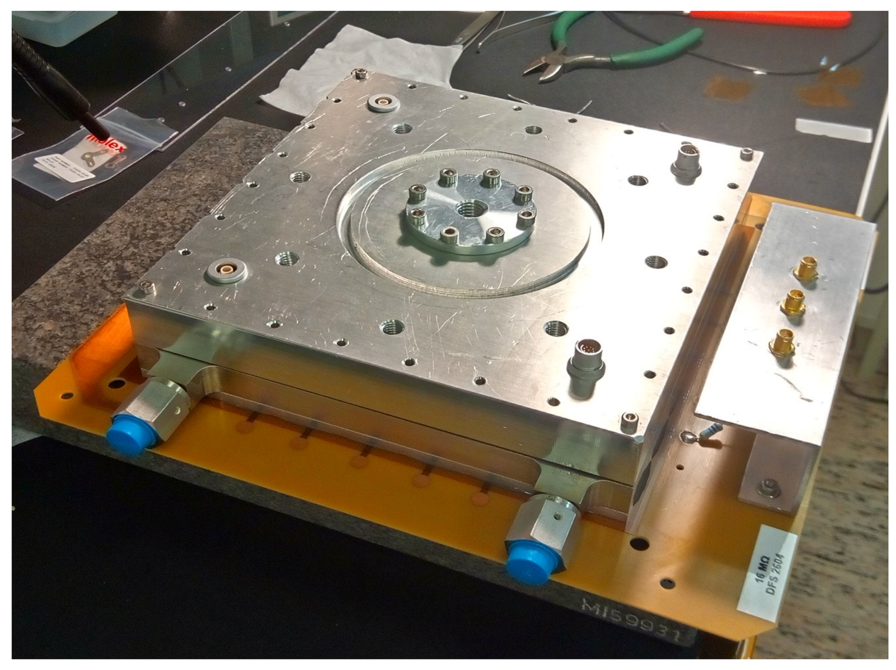
- the studies of radiation/matter interaction with ^{55}Fe source (X-ray source);
- detector performance characterization measurements (gain, energy resolution, relative mesh transparency, etc.);
- detector performance in new experimental set-up for low energy (below 100 keV) ionizing particles;
- performance and long term reliability detector studies;
- filling gas mixture (Ar-Co_2; 93:7) maintained at low pressure below 100 mbar;
- tests and performance characterization of read-out system and support sub-systems.



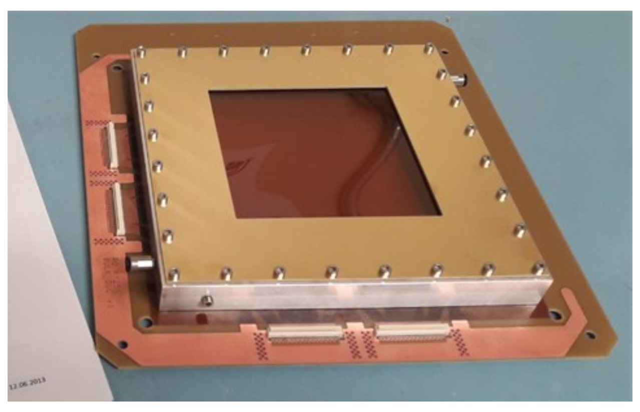
Test bench installed in the INFN Pisa lab.

SUPPORT MECHANICS

- According to the MM technology literature [1], the detector performance are highly influenced by the presence of oxygen in the gas mixture: oxygen contamination must be kept below 0.1% [2];
- For our application, a dedicated frame design has been developed to operate the detector at low pressure;
- Using indium sealing the MM leak rate is kept below 10^5 mbar·l/sec;
- Combining a low leak level rate with a constant gas mixture flux, even at low pressure, we improved a lot the detector performance.



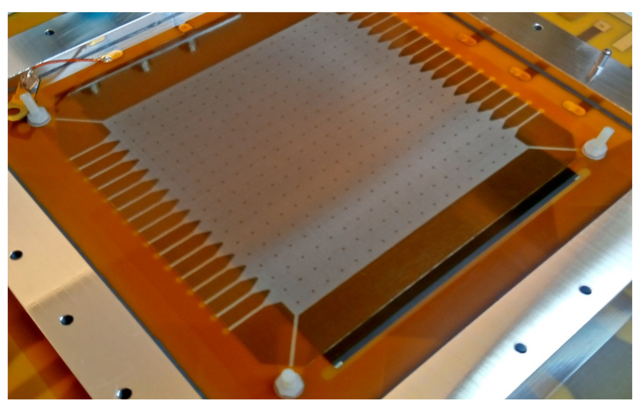
DETECTORS CHARACTERIZATION @ NTP CONDITION



Bulk Micro-Megas with 128 µm gap XY (R&D for ATLAS NSW upgrade [3])

Designed and manufactured @ Micro-Pattern Technologies Workshop - CERN in 2013

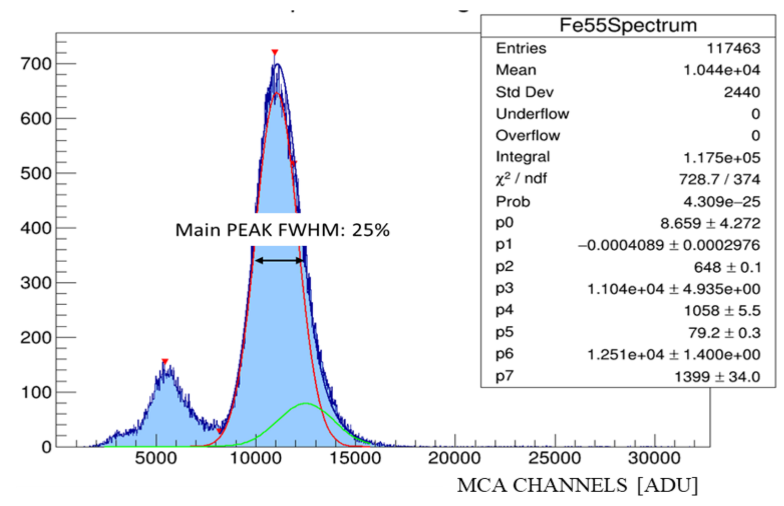
- Bulk technology: mesh is trapped by pillars made of a photo-imageable cover lay / Active area: approx. 100x100 mm^2
- XY strips with 250 um pitch —> 100 mm spatial resolution using µTPC techniques
- Resistive strips layer —> rate capability of 15 kHz/cm^2
- **DRIFT REGION 5 mm HEIGHT**

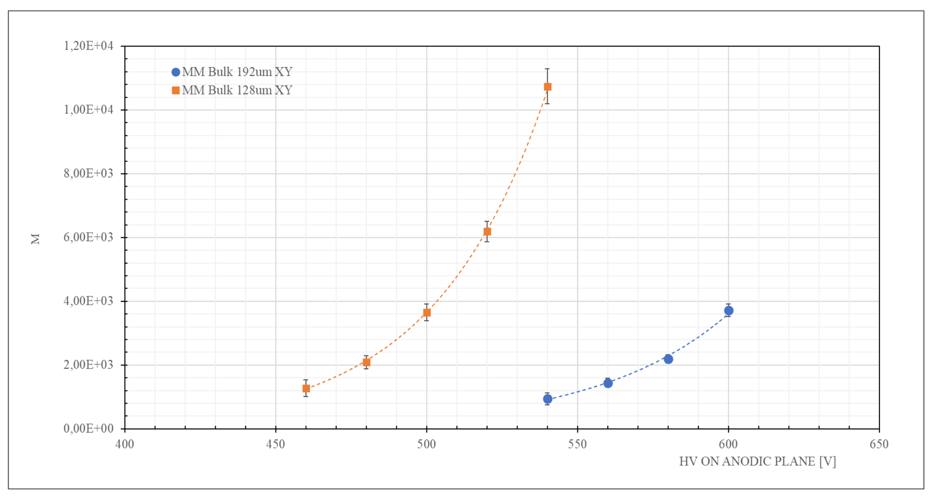


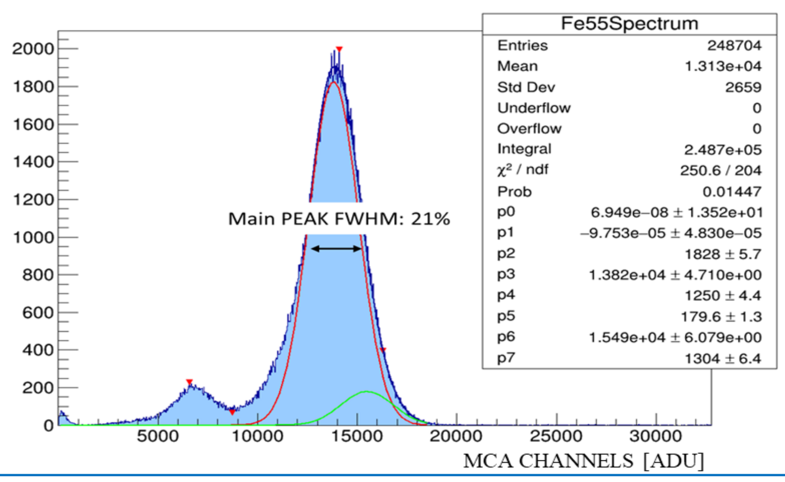
Bulk Micro-Megas with192 µm gap XY

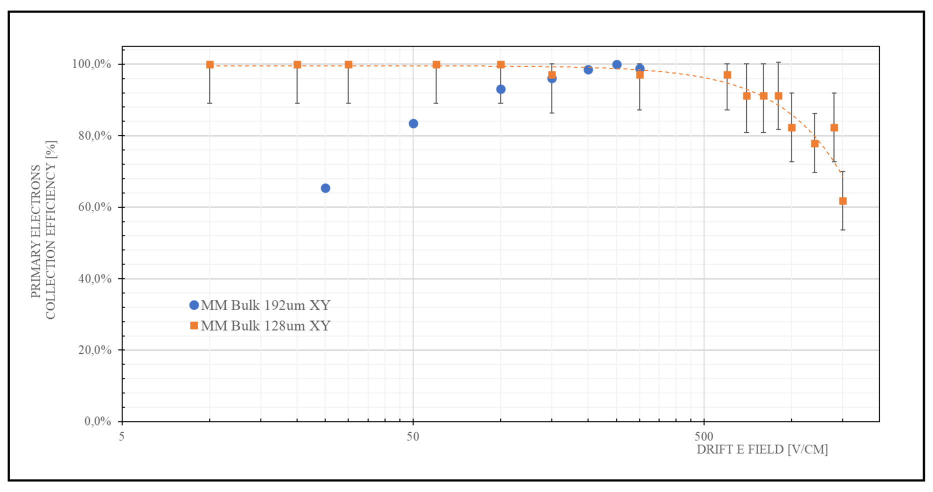
Designed and manufactured @ Micro-Pattern Technologies Workshop - CERN in 2021

- Bulk with increased avalanche region height / Active area: approx. 100x100 mm^2
- XY strips with 400 um pitch / Active area: 100x100 mm^2
- Resistive layer
- **DRIFT REGION 20 mm HEIGHT**

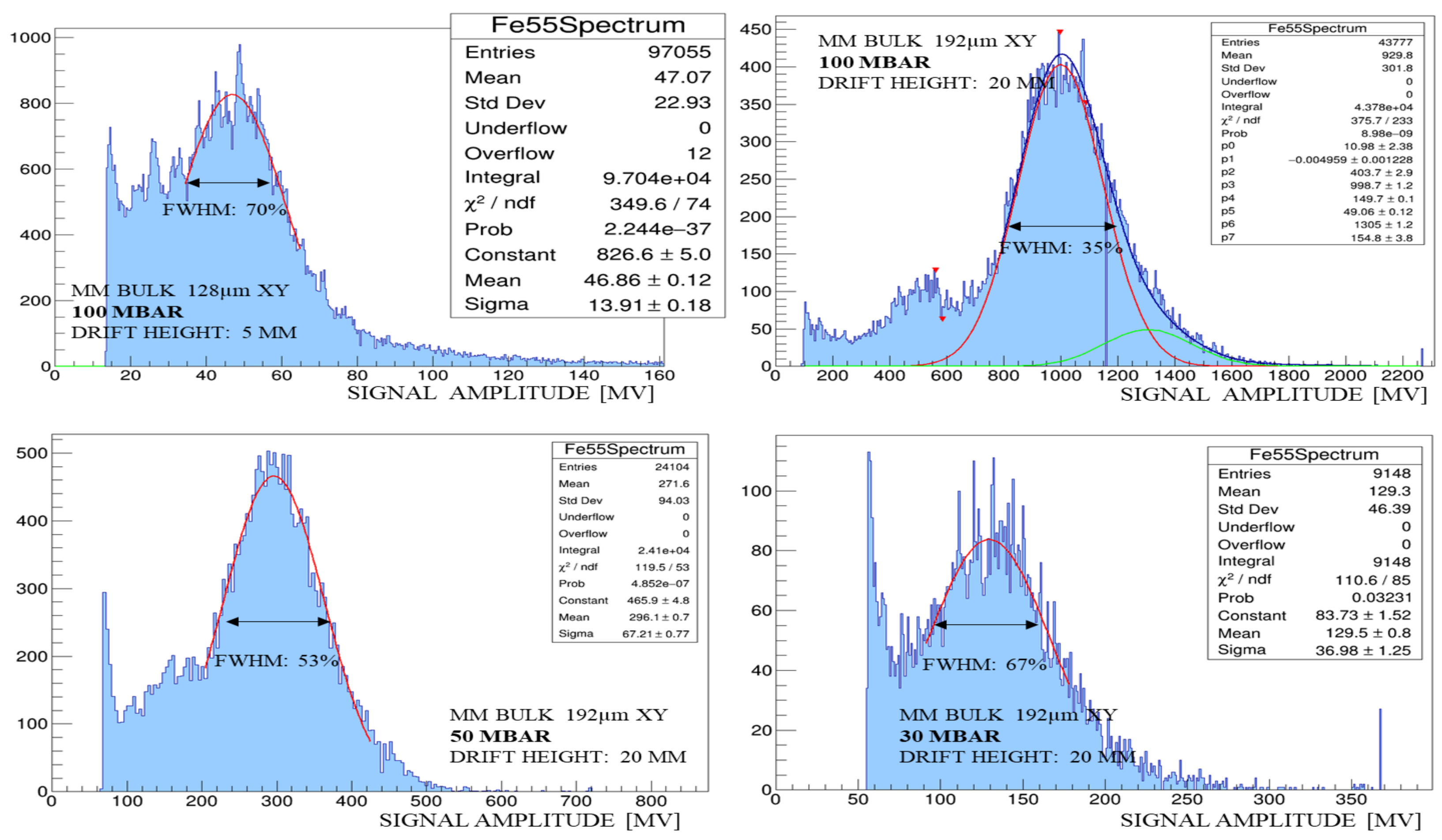




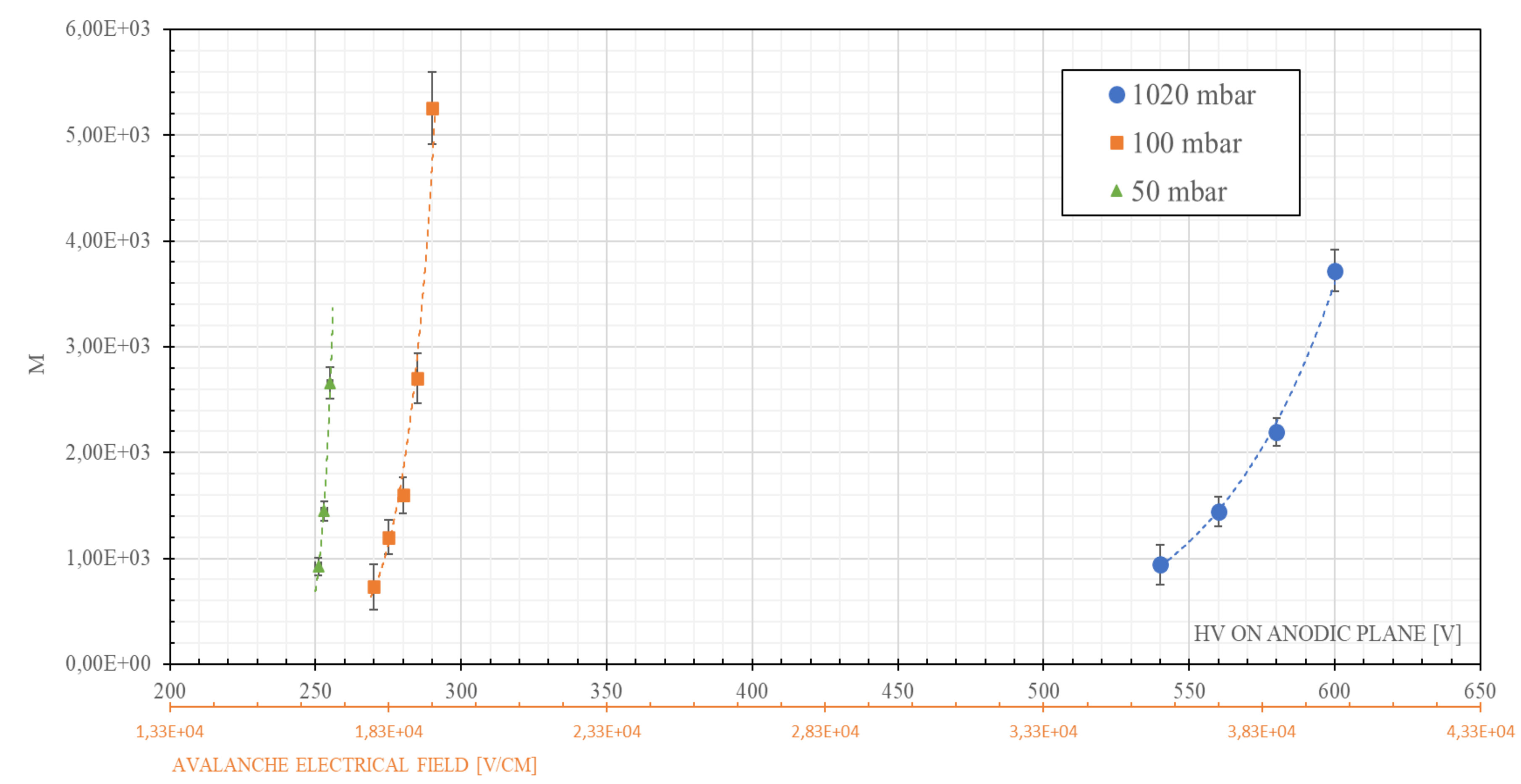




REFERENCE SPECTRA @ LOW PRESSURE



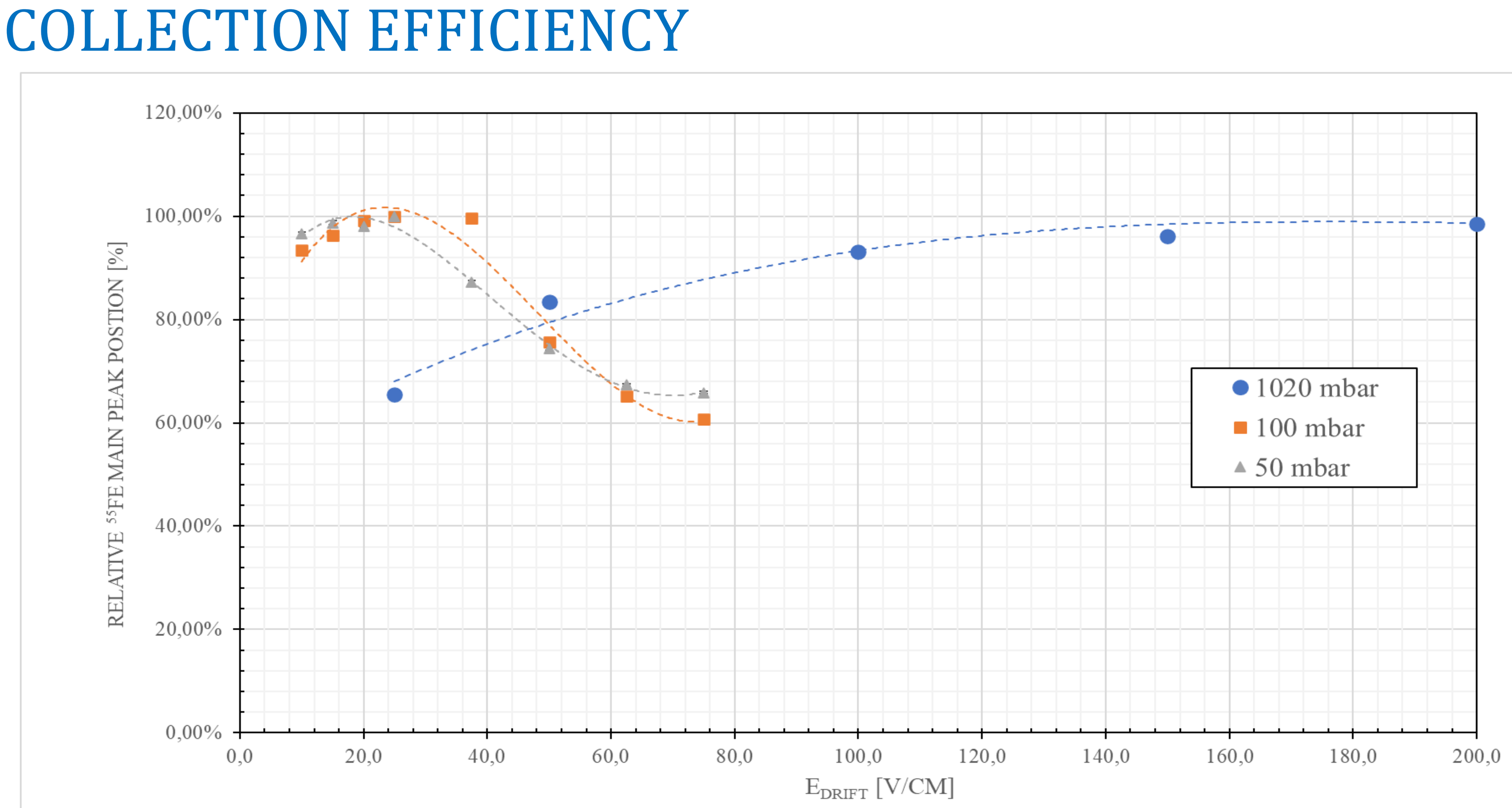
ABSOLUTE GAIN @ LOW PRESSURE



PRIMARY CHARGE COLLECTION EFFICIENCY

Primary charge collection efficiency in gaseous detectors, can be deteriorated through different charge absorption/recombination phenomena at the level of the interaction radiation-matter. In MM device an additional contribution comes from the electrons absorption during their transition through the micro mesh.

The primary charge losses, as a function of the drift electric field, has been estimated measuring the position of the ^{55}Fe main peak in the spectra. From our measurements, only a global effect has been evaluated: by using our experimental set-up was not possible to distinguish if the reduced primary collection efficiency is due to the oxygen contamination or to a real reduced mesh transparency.



FINAL CONSIDERATIONS

The reliability of the measured performance, combined with the simple and robust structure of the detector even with an increased length of amplification gap, make Micro-Megas (MM) an attractive choice for applications where track length of low energy particles is detected by using a low-pressure filling gas.

ACKNOWLEDGMENTS

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REFERENCES

[1] Y. Giomataris, et al., Nuclear Instruments and Methods in Physics Research Section A, 376 (1996), p. 29

[2] Kuger F., et al., Mesh geometry impact on micromegas performance with an exchangeable mesh prototype, Nucl. Instrum. Methods A, 824 (2016), pp. 541-542, 10.1016/j.nima.2015.11.011

[3] M. Vanadia, "Study of the Performance of the Micromegas Chambers for the ATLAS Muon Spectrometer Upgrade," in IEEE Transactions on Nuclear Science, vol. 64, no. 2, pp. 867-873, Feb. 2017, doi: 10.1109/TNS.2017.2649880.

* Corresponding author at: INFN, Pisa, Italy.
E-mail address: federico.pilo@pi.infn.it (F. Pilo).