# Non-standard GEM foils for gaseous detectors*

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Gas Electron Multiplier (GEM) technology is widely used in many experiments in nuclear and particle physics. There is the need to develop new gaseous detectors with propitious spatial resolution, high rate capability, sizeable sensitive area, operational stability and radiation hardness. In this contribution, a brief overview of gaseous detector development at the University of Warsaw will be presented, as well as basic concepts, operation and performance of the gas amplifier structures based on standard and non-standard GEM foils.

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## 1. Introduction

Gas Electron Multiplier (GEM) [1], introduced by Fabio Sauli in 1997, constitutes a powerful contribution to the family of micro-pattern gaseous detectors. GEM foils were originally developed for particle physics experiments, nevertheless thanks to the excellent amplification potential, good spatial resolution, high rate capability, sizeable sensitive area, operational stability and radiation hardness they found applications in gaseous detectors for nuclear physics [2].

## 2. Gas Electron Multiplier

### *2.1. Basic concept*

The standard CERN GEMs consist of an insulator made of a Kapton foil of the thickness of the order of 50 $\mu$m coated on both sides with thin, 5 $\mu$m copper layers. This structure is perforated with high density and tiny holes. Between the two copper coatings, a voltage of a few hundred volts is applied, which results in high gradient electric field inside each tiny hole. The electric

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field strength can reach several dozens of kV/cm, which is high enough for the gas amplification. It is possible to achieve a charge amplification up to ten thousand with a single GEM foil, but usually, an amplification setup consists of two or three successive GEM foils, to achieve high gains with stable operation. The performance of GEM foil was widely studied over the years; more details can be found in Reference [3].

### *2.2. GEM applications at Faculty of Physics, University of Warsaw*

At the Faculty of Physics, the University of Warsaw, GEM technology has been employed in a several developments of Time Projection Chamber (TPC) like detectors, dedicated to studies of two proton radioactivity and $\beta-$delayed multi-particle emissions studies [4, 5].

The ELITPC – an active target TPC dedicated to measurements of nuclear reactions of astrophysical relevance is currently developed for nuclear photo-disintegration experiments at ELI-NP and Higs [6, 7].

## 3. Non-standard GEM development

### *3.1. Motivation*

The reaction of present-day astrophysical interest is burning helium: $C(\alpha, \gamma)^{16}O$, in order to understand carbon-to-oxygen ratio in the Universe. The direct study of this reaction is unattainable in the laboratory, hence the approach of the reverse reaction, the oxygen photo-disintegration reaction, was proposed. For this purpose, the low-pressure active-target drift detector (AGT-TPC), allowing for measuring the kinematics of low-energy charged particles, was designed.

The AGT-TPC aims to work with a gas mixture based on $CO_2$ at an absolute pressure in the range of 50-200 mbar, which is going to serve as the reaction target and allow for measuring charged products of a reaction with energies of few MeV. Working at low gas medium density means reduction of maximal gas gain due to rising discharge probability and on feedback effects for standard GEM technology. In order to minimise harmful secondary effects whilst meeting the requirement of the high gas amplification capabilities, one may employ the non-standard GEM foils in the low-pressure TPC.

The special GEM foils were produced at CERN for our tests. The thickness is 125 $\mu$m instead of the standard 50 $\mu$m, and the perforation pith and hole diameter density were 280 $\mu$m and 140 $\mu$m respectively – slightly larger than for standard GEM foils. The design and manufacturing procedure of the non-standard, thicker, GEM are the same as in the case of the standard GEM foil.

### *3.2. Test-bench detector*

The thicker GEM operation was tested, for the first time, at the Faculty of Physics, University of Warsaw, in a test-bench low-pressure small-volume TPC, as shown in figure 1. The active volume of the detector is filled with

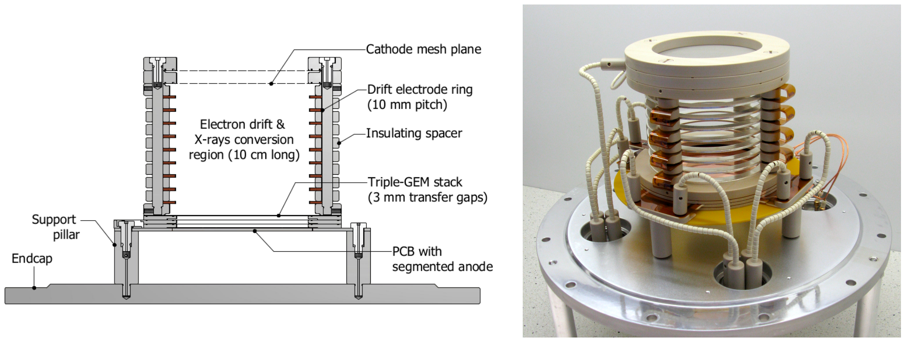


Figure 1. The scheme (*left*) and the photo (*right*)of the test-bench detector.

pure carbon dioxide at an absolute pressure in the range of 50-1000 mbar. As the ionisation source, the X-ray lamp (Amptek Mini-X generator with XRF fluorescence filters) is used. The source generates a quasi-monochromatic X-ray spectrum with a maximum at the energy of 4.9 keV (peak FWHM %9).

### *3.3. Results*

In such set-up, the measurements of the effective gas gain capabilities with using the stack of 3 standard GEM foils, as well as stacks of 3 and 2 thicker GEM foils as a charge amplification structure were performed. The results are presented in figure 2. Using thicker GEM foils in the low-pressure TPC, in both cases: double and triple stack, allowed to obtain almost two orders of magnitude higher gas gain with respect to triple-stack of standard GEMs and operating without discharges.

## 4. Summary

The results on the gas gain capabilities using GEM electric of 125 $\mu$m thickness are promising, and the R&D of non-standard GEM foils application in nuclear reaction physics as well as particle physics, in the context of the future sub-detectors of Multi-Purpose Detector (MPD) at Nuclotron-based Ion Collider (NICA), is ongoing.

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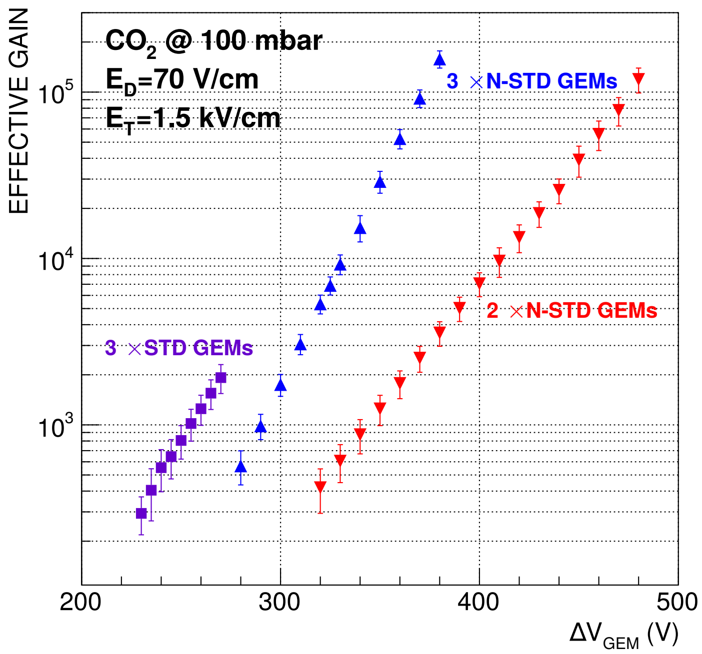


Figure 2. Effective gas amplification gain of: triple standard GEM (STD GEMs) stack (*squares*), triple thicker GEM (N-STD GEMs) stack (*triangles pointing up*) and double thicker GEM (N-STD GEMs) stack (*triangles pointing down*).

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## References

[1] F. Sauli, Nucl.Instrum.Meth. A386 (1997) 531-534
[2] F. Sauli, Nucl.Instrum.Meth. A805 (2016) 2 - 24
[3] http://gdd.web.cern.ch/GDD/
[4] M. Ćwiok et al., IEEE TNS 52 (2005) 2895
[5] K. Miernik et al., Nucl.Instrum.Meth. A581 (2007) 194
[6] O. Tesileanu et al., Romanian Rep. in Phys. 68 Supplement (2016) S699
[7] M. Ćwiok, Acta Phys. Pol. B 47 (2016) 707