AIDA-2020-MS84

AIDA-2020

Advanced European Infrastructures for Detectors at Accelerators

Milestone Report

Protocol and specifications for MPGD production and quality control

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26 June 2018

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MILESTONE REPORT

PROTOCOL AND SPECIFICATIONS FOR MPGD PRODUCTION AND QUALITY CONTROL

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Abstract:

MPGDs are becoming the most common gaseous detectors used in High Energy Physics and Nuclear Physics. They have promising applications in Medicine, Security, Geology, Cultural Heritage Imaging, power generation, and many other domains of societal applications. Thus the issue of manufacturing MPGDs in industry is becoming decisively needed. In the last 3-4 years, we ordered sets of various kinds of MPGD detectors to industries equipped for various operations as hole drilling (for Thick GEMs), laminating coverlays or meshes (for Micromegas), photo-imaging and others, which are needed in the process of MPGD fabrication. We then tested the products, defining criteria for Quality Control. We report here on this experience.

For more information on AIDA-2020, its partners and contributors please see www.cern.ch/AIDA2020

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Delivery Slip

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Executive summary

This report summarizes the efforts pursued in the last 3 years towards industrialization of MPGD detector parts, mainly with the ELTOS and ELVIA companies. A few tens of squared meters of THGEMs or LEMs have been produced at ELTOS and the process is getting mature. Several thousands of square meters of resistive Micromegas of various kinds have been made in both companies, but more protocols have to be defined to improve their stability and reliability. New structures are being developed in several places, as Microbulk, µRWELL, and piggyback for instance. Intellectual Property for some sub-processes added by the industries, meant as improving the production, might complicate the technology transfer.

1. INTRODUCTION

In AIDA, the gaseous detector work plan included the upgrade of the CERN MPGD workshop with new and larger machines to make large size MPGDs for prototyping. It was clear from this time, however, that industrial units would be necessary for the large series production. To encourage industrial companies equipped with the relevant tools to be ready to fulfil the needs, and to ease the dissemination of the MPGD technologies, the AIDA 2020 Integrated Activity defined a task entitled: 'Preparation for large series production: standard production protocols of optimized MPGD components to ease technology dissemination.

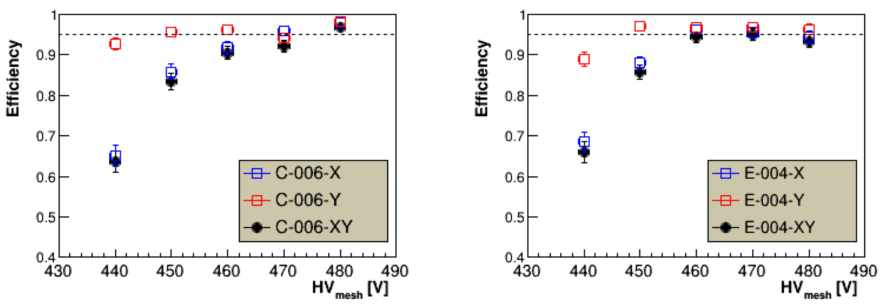


Fig. 1. Compared performance of CERN (left-hand side) and ELVIA (right-hand side) bulk Micromegas detectors in November 2015.

Note that intense efforts for GEM industrial production started in 2014, and are about to converge, though present large-surface GEM projects (CMS GE1/1 muon chambers and ALICE TPC) still use the CERN workshop for manufacturing the base GEMs. The next large-surface projects will be subcontracted in industry. These applications are out of the scope of this report. We concentrate here on MPGD technology transfer which developed in the AIDA-2020 era, namely THGEMs/LEM, Large surface Micromegas, and some more futuristic designs.

2. LARGE AREA RESISTIVE MICROMEGAS

Large-area Micromegas already found many applications in the sector of High Energy Physics and in societal applications : ATLAS muon chambers at LHC, muon densitography with applications to geology, construction, prospection, homeland security and cultural heritage. The ATLAS New Small Wheel [1] project is in progress in five assembly locations at CERN, in France, Germany and Italy. It consists of 1200 m² of resistive Micromegas. A thorough Quality Control / Quality Assurance process is carried out in the production sites and is continuously revised and improved. The importance of a dust-free environment and a controlled humidity is recognized, and procedures to condition the detectors in the commissioning phase are under development. It consists of a washing and drying procedure and a progressive increase of applied High Voltage according to a well-defined - though still evolving - protocol.

NSW construction relies on Industry for the base materials: the large PCBs are manufactured at ELTOS in Italy and ELVIA in France, and, after a rather long training period, they now produce each half of the needed panels. They are all gathered at CERN, together with the screen-printed resistive foils made by a Japanese company. The patterned resistive foils are laminated at CERN onto the base panels, they undergo a detailed quality check at building 188, and the material is sent to the 4 assembly sites in Germany, France and Italy. After assembly, with a removable mesh, the modules undergo a functional test (High Voltage holding and cosmic-ray tests).

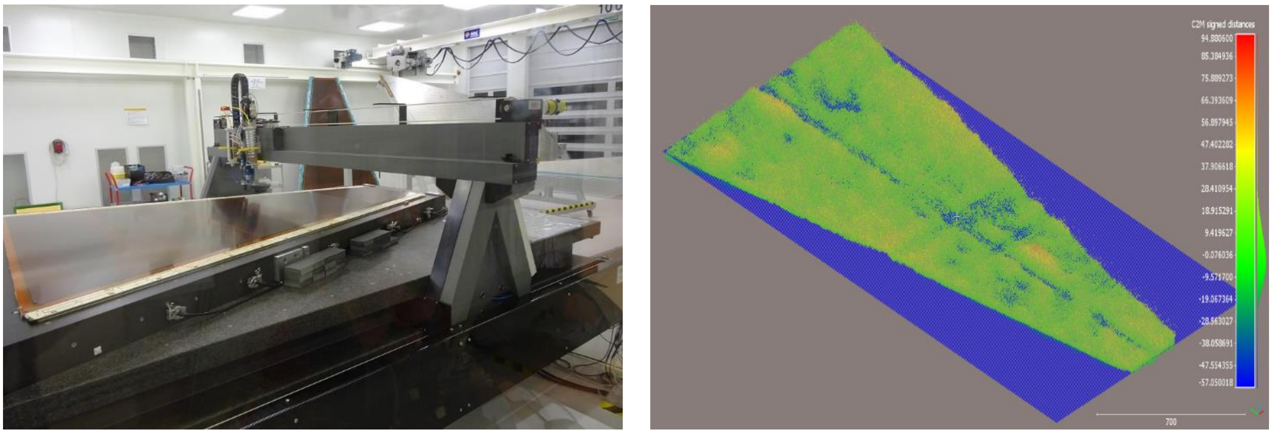


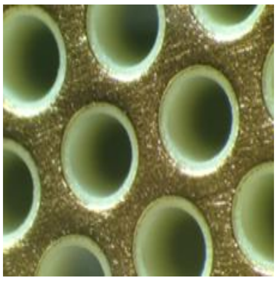
Fig. 2. Left: the granite flatness-measurement table used to detect down-to 1 micrometer defects in the detector panels; right: a colour-scale picture of the measured roughness and waviness of an equipped panel.

Large muon detectors are also used in a number of societal applications. 50 x 50 cm² detectors have been produced at CERN and in industry, under the supervision of CEA Saclay. In 2016 and 2017, 40 detectors have been produced, 20 at CERN and 20 at ELVIA, leading to a steady improvement of the quality at ELVIA. In 2018, 40 new detectors are being produced at ELVIA, 20 with screen printing and 20 with Diamond-Like Carbon foils. These detectors have been used in the ScanPyramid project, which announced a hint for a so far unknown void in the Cheops pyramid at Giza, Egypt.

Another possible application is a Large TPC for an e^+e^- collider. Modules of the 'bulk' type have been produced and tested with success, both with Carbon-Loaded Polyimide and Diamond-Like Carbon. The Near Detector of the long-baseline neutrino experiment T2K also considers using this technique for the upgrade of its Micromegas TPC. Several Nuclear Physics experiments are also considering this kind of detectors. For these applications, the 'bulk' concept is used, where the mesh is not removable [2].

Building a large surface of stable and robust resistive Micromegas detectors requires a very careful observance of cleaning procedure. Specifically, it requires working in a low-dust atmosphere, which is difficult to obtain in an industrial context where drilling and sawing is done in the same premises.

3. LEMS AND THGEMS



Large Electron Multipliers (LEMs, also called Thick GEMs or THGEMs) are being considered for the next world-wide Collaboration for the long baseline neutrino experiment DUNE [3]. The principle of operation is similar to GEMs (two conductive planes separated by an insulator with holes in which the electrons undergo multiplication). They however differ by the base material (simple Printed Circuit Board instead of kapton sandwiched between copper foils) and the technique for making the holes: drilling instead of chemical etching. An important feature of this technique is the need for a rim around the holes, wide enough to prevent discharge, and narrow enough not to affect the amplification field inside the hole.

Also, a careful sanding down is necessary to obtain a suitable surface finish to avoid triggering discharges.

The manufacture in Industry of this kind of technology was pioneered by the Trieste group of the COMPASS RICH experiment since 2010, and lead to the production of about 20 m² of thick GEMs.

CEA/ Irfu is in charge of procurement and validation of half of the 144 LEMs necessary for the 6x6x6 m^3 prototype of Dune WA105. All the infrastructures necessary for the preparation and tests are available at Saclay (cleaning, baking, polymerization, metrology, etc…)

A crucial step was taken in 2017 by moving from 10x10 cm² detectors to 50x50 cm². Stability problems occurred, which were solved by redesigning the edges of the detectors. A comparison of these two at 1 bar and 1.5 bar is shown in Fig. 2, for both ELTOS and ELVIA test productions.

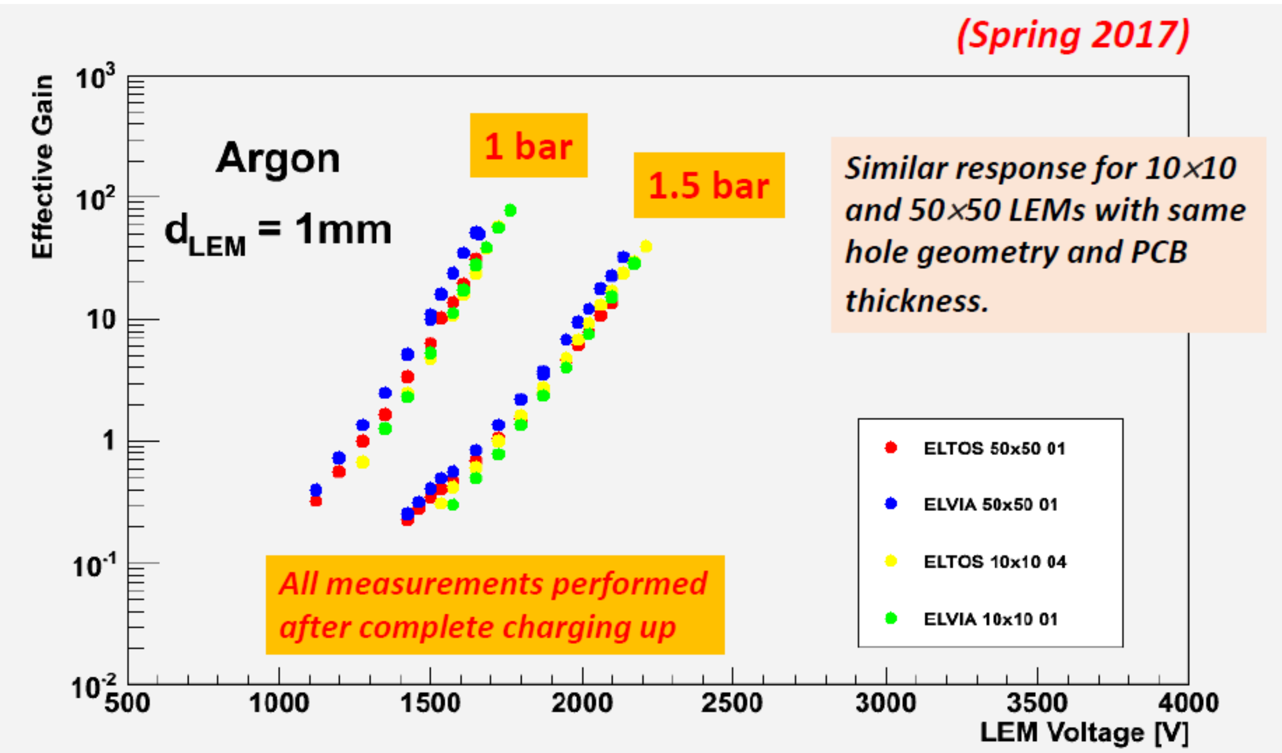


Fig. 3. Gain curves of ELTOS and ELVIA large and small LEMs, at atmospheric pressure and at 1.5 atmospheres.

A high-pressure chamber has been built to perform LEM tests in argon at the same gas density as in the experiment (3300 hPa at room temperature). LEM production started in July 2017 (contract with ELTOS for 78 50x50 cm² LEMs).

4. NEW STRUCTURES

In the course of this project, it was realized that screen printing of patterned conductive, insulating and resistive materials would allow to make all kinds of protection and filtering circuits on the detector board itself. A number of new structures are being tested at CEA/Irfu Saclay, as Piggyback for instance (capacity-coupled detector with independent readout electronics).

A new grounding scheme, with the micromesh at ground and the encapsulated resistive anode at High Voltage is being developed. It is expected to be less sensitive to radiated noise and to suppress possible distortions on the module edges.

5. REFERENCES

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ANNEX: GLOSSARY

Acronym	Definition
GEM	Gaseous Electron Multiplier
LEM	Large Electron Multiplier
MPGD	Micro-Pattern Gaseous Detector
Micromegas	Micromesh gaseous chamber
PCB	Printed Circuit Board
NSW	New Small Wheel, the upgraded ATLAS muon detector