Michał, Babij[3]; Jarosław, Bąkała[1]; Piotr, Bielowka[3]; Małgorzata, Chojnicka-Oleszko[3]; Mateusz, Czok[2]; Arkadiusz, Dąbrowski[2]; Szymon, Gburek[1]; Jacek, Głowinkowski[4]; Laura, Jaisńska[2]; Michał, Jędzierowski[3]; Mariusz, Kasprzyk[3]; Katarzyna, Kijewska[3]; Milena, Kiliszkiewicz[2]; Mirosław, Kowaliński[1]; Karol, Malecha[2]; Katarzyna, Mikuła[1]; Witold, Nawrot[2]; Piotr, Podgórski[1]; Marek, Siarkowski[1]; Bogusz, Stępak[4]; Marek, Stęślicki[1]; Daniel, Ścisłowski[1]; Piotr, Wilk[4]; Tomasz, Witwicki[3].

[1]*Zakład Fizyki Słońca, Centrum Badań Kosmicznych PAN - Solar Physics Division, Space Research Centre Polish Academy of Sciences,*
[2]Politechnika Wrocławska - Wrocław University of Science and Technology,
[3]Technology Transfer Agency Techtra Sp. z o.o., [4]Wrocławski Park Technologiczny S.A. - Wroclaw Technology Park S.A.

Modularne Detektory GEM
Modular GEM Detectors (MGEM)

Projekt dofinasowywany przez Narodowe Centrum Badań i Rozwoju - NCBiR. Project supported by The National Centre for Research and Development.
Project number POIR.04.01.02-00-0080/17.

Subtitle: GEM detector for **CubeSat** technology. Design, construction and tests.

Introduction

The MGEM Project is aimed at providing a models of innovative GEM (Gas electron multiplier) detectors for measurements of electromagnetic and corpuscular radiation. The Project is performed by the Consortium. Member institution of the Consortium are mentioned in the title section of this contribution.

These detectors will find applications in spectrometers, imaging systems and devices which allow for spectrometry and imaging simultaneously. Such instrumentation is widely used in industry and scientific laboratories as well as in space instrumentation. In addition it is likely that the detector will be capable of measuring degree of polarization of incoming radiation.

At the end of the Project two types of the detector will be assembled and tested. One for on-ground applications and the second one for application in space. Both types of detectors will be able to work in harsh environmental conditions and will have identical functionality.

Measurement capabilities of the detector will be tested. After the Project life cycle a complete models of the detector will be delivered including all subsystems vital for its operational performance. The detectors will be mechanically robust, immune for acoustic shocks, radiation hard and easy in service and customization to the end-user needs.

In what follows we focus on the type of detector for space mission.

This Detector will be designed to fit the CubeSat technology. This technology is in a fast, dynamic progress at present and allows to develop compact, low–weight space experiments in a modular way. Detector will have modular construction which will allow to join together single detection units in order to increase effective area. Basic assumption is that the detector must fit in 1U (one unit) CubSat structure which is a metal box of dimensions 10x10x10 cm (see Figure 1). Functional block diagram of the detector is shown in Figure 2. The detector mechanical construction (CAD drawing) is shown in Figure 3.

Figure 1. One unit CubeSat on a space mission (artist impression).

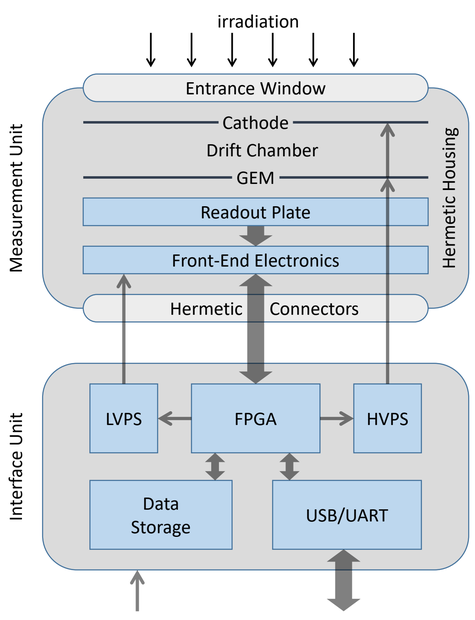

Figure 2. Block diagram of MGEM detector.

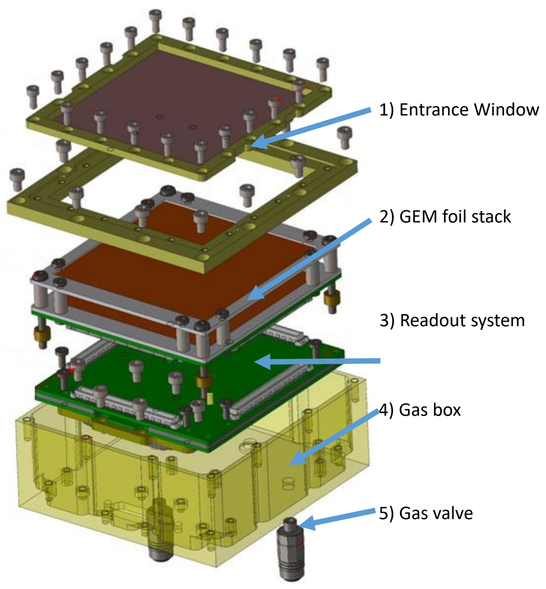

Figure 3. Exploded CAD drawing of the MGEM detector. Intrface unit is not shown here. After integration of the detector all components 1), 2) 3) will be placed inside the gas box 4) and gas valves 5) assembled to it.

Detector design, construction and properties

Mechanical design is compatible with PC/104 widely used CubsSat standard.

All elements of the detector except the Interface Unit will be placed in aluminum gas box equipped with temperature and pressure sensors and necessary electrical interfaces.

The present version of the detector is optimized to measure X-rays in energy range ~5 up to few tens keV. However the detector is customizable. One can change entrance filters, gas mixture, HV setting on GEM foils thus making possible measurements in different energy ranges for various types of radiation.

The main signal amplifying element of he detector is a stack of GEM foils (up to three foils can be used). The frame of the stack is made from Low Temperature Cofired Ceramic (LTCC) with discrete elements such as resistors for HV divider and capacitors buried in it.

The detector can use 2D cartesian (XY) strips or pixelated readout system. Both types of readout system have been already developed and tested. XY readout system will contain elements manufactured from LTCC ceramics.

Also simulations of detector performance are carried out during the Project using GEANT4 platform. These simulations will gain the insight in the physical processes occurring in the detector.

The detector will be sensitive enough to measure strong fluxes of radiation such as the Sun in particular during solar flares. For observations of faint objects e.g. distant astrophysical sources the detector will need to be placed in a focal plane of focusing optics.

Dedicated software and firmware is under development for monitoring the detector systems and data processing.

Interface Unit

Interface unit is an electronic board with all subsystems required for interfacing measurement unit with control computer. It provides complete powering for measurement unit by several low voltage DC/DC converters (LVPS) as well as high voltage DC/DC converter for detector bias (HVPS). Only two power rails are required for operate MGEM: +3.3V and +12V, which are widely used in CubeSat systems. Main interface function i.e. data acquisition, formatting and transmission to control computer are implemented in Artix-7 FPGA. The board are equipped with High Speed USB 2.0 interface for interfacing with standard PC computer and simple UART for interfacing with other controllers e.g. CubeSat onboard computer. Interface unit also contains nonvolatile data storage based on two micro-SD cards, so that the user can mount required amount of memory or save the costs if the buffer is not necessary. There are three operation modes possible:

- real time data acquisition through USB 2.0 High Speed connection (PC computer),
- data buffering in nonvolatile data storage and low speed data transmission through Universal asynchronous receiver-transmitter (UART)
- stand-alone operation – data are stored in in nonvolatile data storage and then can be read after connecting to control computer (no controller required during measurement).

The Interface unit is stacked at the back side of the measurement unit. Both components have the same form factor consistent with PC/104 modules. This makes MGEM mechanically compatible with typical CubeSat structures.

Tests

All the detector components undergo a series of tests to check their physical parameters, mechanical robustness, vacuum compatibility thermal properties and radiation hardness. In the upcoming months the tests of the entire, assembled detectors are planned. All tests are performed using equipment available in MGEM Consortium laboratories. These include thermal – vacuum chambers, various meters and radiation sources.

Among these appliances a unique and most advanced one is industrial linear accelerator (LINAC) in underground bunker of Non-Destructive Testing Laboratory* (NDT Lab) at Wroclaw Technology Park SA (see Figure 4 and Figure 5). LINAC is used to testing the detector, its parts and structures for reliability and resistance to ionizing radiation in electron and gamma rays beams. After each test the elements internal structure is inspected using computerized X-ray tomograph also available at NDT Lab (see Figure 6)

The tests which have been performed to date were successful. No destructions of tested elements or changes in their mechanical and physical parameters were observed.

Figure 4. Underground industrial accelerator station at NDT Lab. The blue arrow points to LINAC. The red arrow points to the positioning table which has maximum load of 5t.

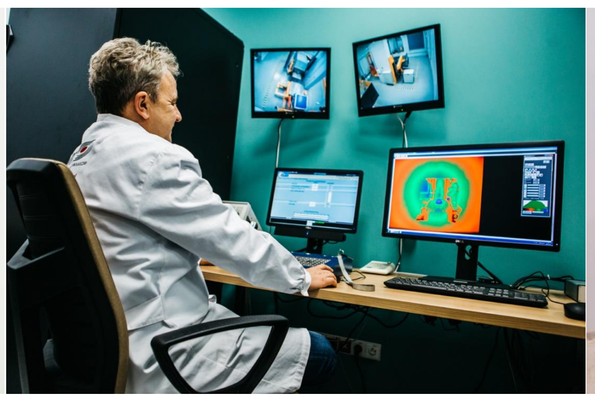

Figure 5. LINAC control center at NDT Lab.

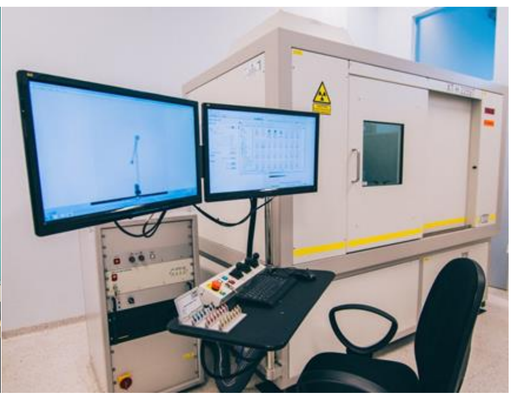

Figure 6. X-ray tomograph and its control center at NDT Lab.

Summary

Iinnovative GEM detectors are under development in Wrocław, Poland within a framework of MGEM Project supported by the Polish National Centre for Research and Development. Each detector module will be compatible with CubeSat technology and thus can be implemented even in small satellites. The detector will be a component suitable for ballooning, rocket and space mission instrumentations. Detector will be commercially available. Some elements of the detector can be customized. It is expected that the detector will be finally assembled in the end of 2022.For more information on the detector components, their construction and test procedures see the parallel poster.

* https://www.technologpark.pl/en/wptoffer/laboratories-and-protoype-workshops/laboratory-of-non-destructive-research/