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].

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Modularne Detektory GEM
Modular GEM Detectors (MGEM)

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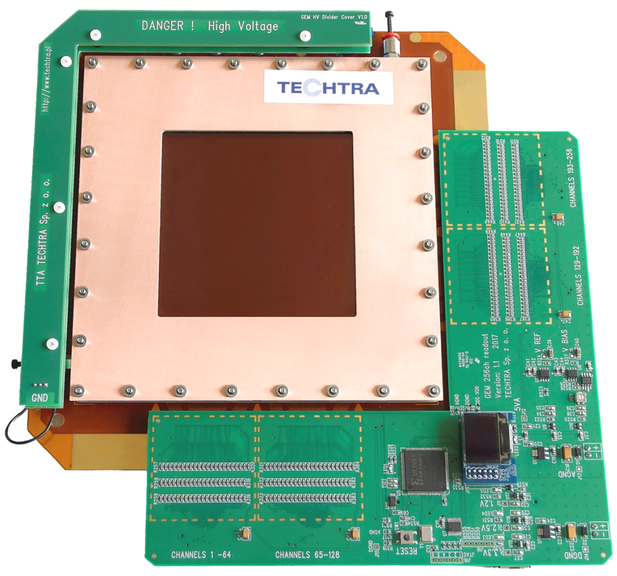
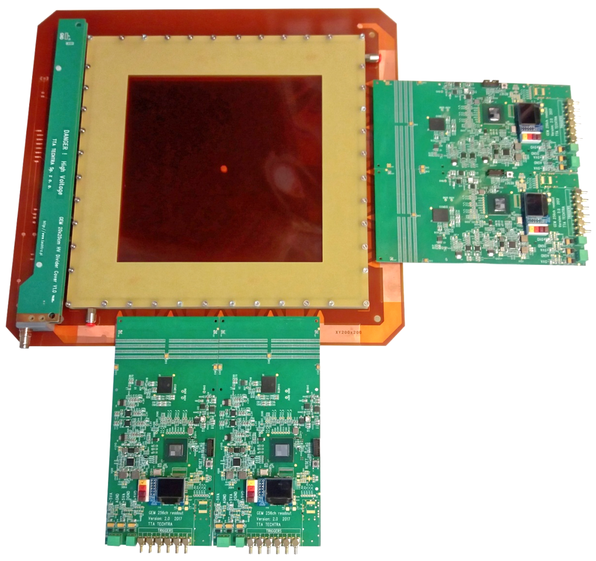
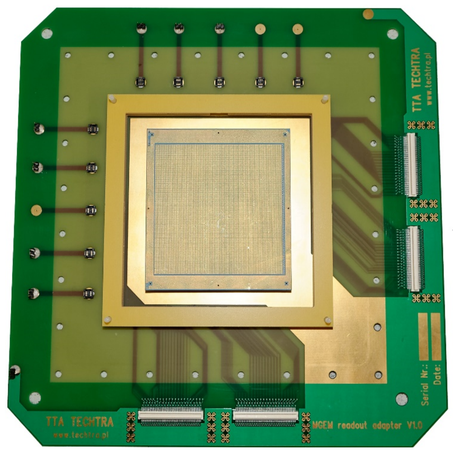
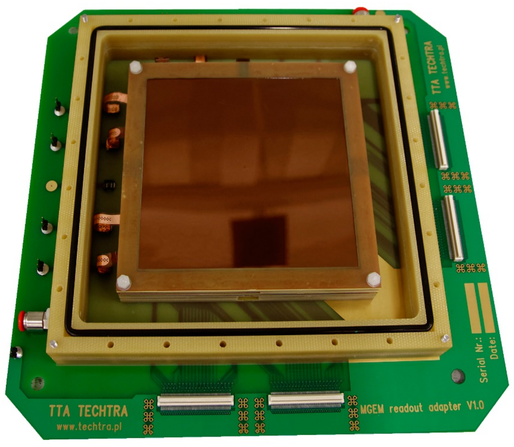
Gas Electron Multiplier detectors are well suited for photon detection. When the cathode is covered with a photosensitive layer, the electrons are knocked out by photons and will be driven towards the GEM for further amplification. Such a detector combines a wide dynamic range, good spatial resolution, high gain, and radiation hardness. They have also proved robust, light, and offer excellent performances and reliability suited for use in harsh environments.







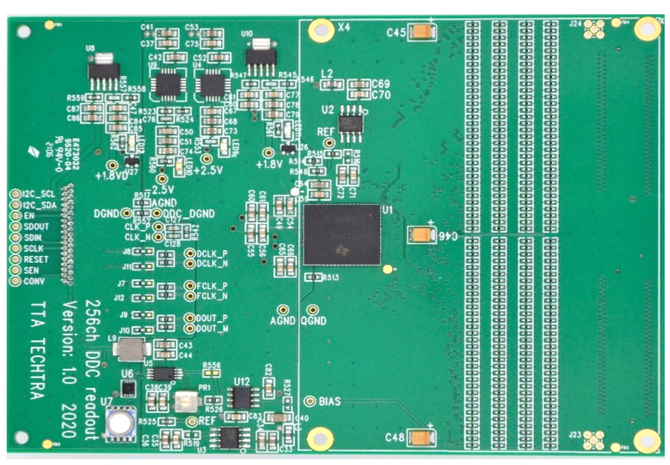
The prototype LTCC readout is placed on the testing board



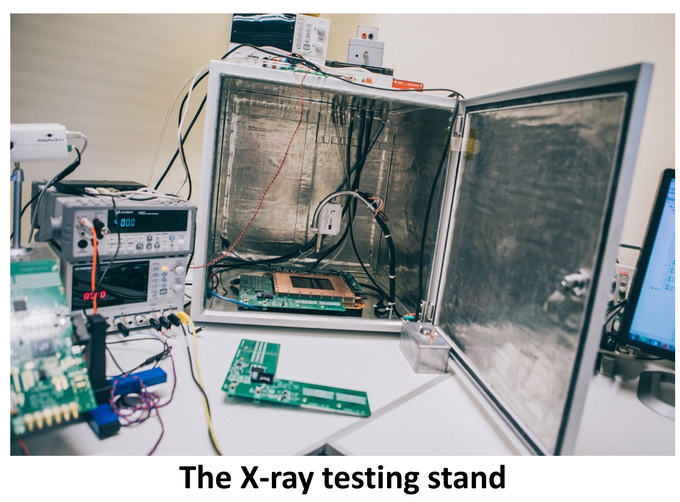
The prototype LTCC readout is placed on the testing board, covered by GEM and drift foils

v2.0 readout board

- Channels: 256 per strips
- Sampling rate: 17 kHz
- ADC resolution 24-bit
- Minimal ADC range: 6.25 pC
- Noise level: about 1 fC peak-to-peak
- Modular design
- 100Mbit Ethernet communication
- As the new DAQ is much faster, higher count-rate X-ray sources can be used
- Digital triggering and data processing inside FPGA



The DAQ system dedicated to the MGEM project



The X-ray testing stand

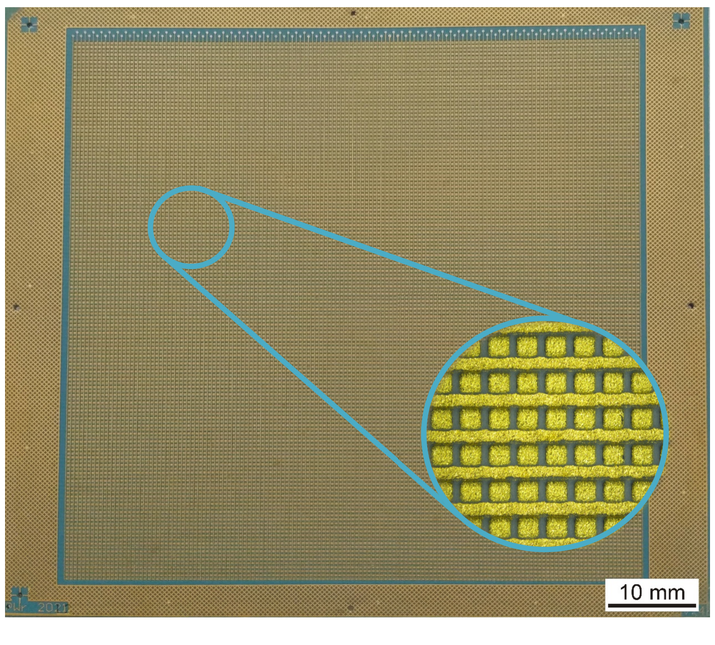
The electrode array for the detection of the electrons in the system was developed using the Low Temperature Co-fired Ceramic and thick film technology. It allows for high durability and reliability, as well as low outgassing, which are crucial for space applications. The performance and lifetime of a hermetically sealed GEM detector, used for example in space, strongly depend on gas purity. Therefore, the utilization of materials with a very low outgassing ratio is critical for the application. The state-of-the-art GEM foils and readouts are made from polymer or epoxy-based materials, which outgassing ratio is higher than in metals or ceramics.

Two variants of a detection plate were developed:

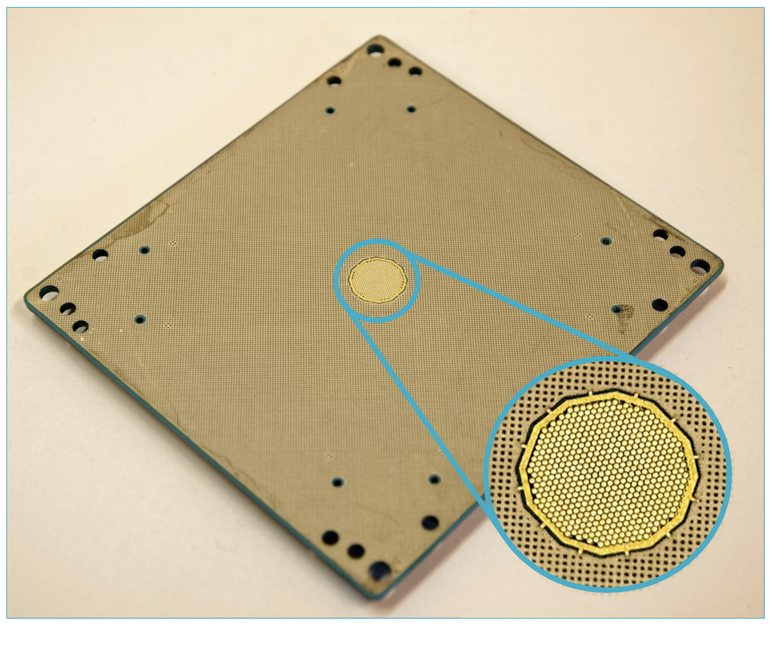
- for XY coordinate detection – two layers of parallel strip lines allow to detect the shape of detected radiation. This approach allows to manufacture large detection plates. The entire process can be carried out using only the screen printing method, which a very inexpensive solution. Alternatively, a multilayer LTCC approach can allow for an increased resolution.
- for polarimetry – a small detection area consists of electrodes ca. 300 µm wide, each with a separate connection to the readout system, enhancing the capabilities. It requires a high interconnection density that can be obtained in the LTCC, beyond the capabilities of PCBs.

Scalability of the solution

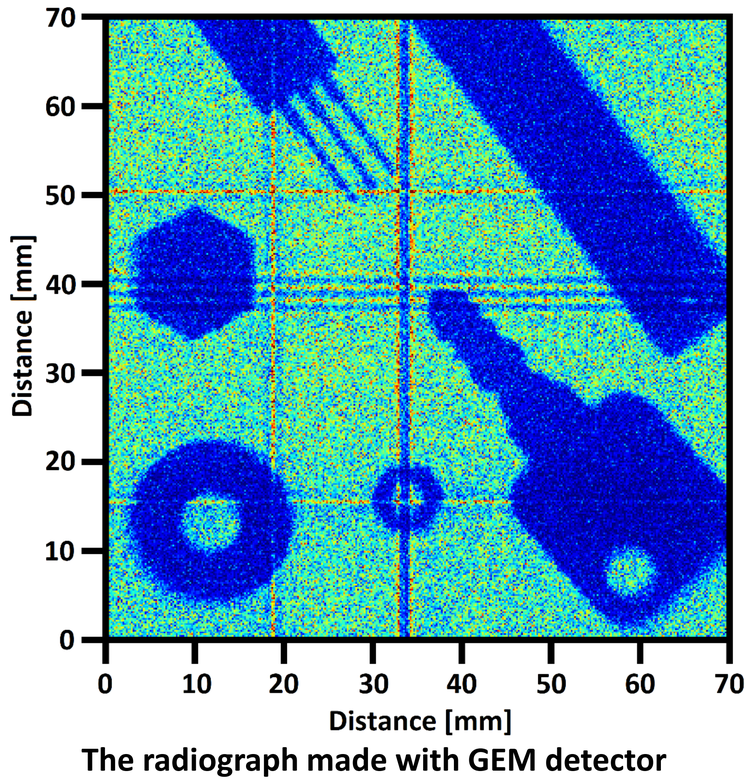
Strip detectors with an active area of at least 70 × 70 mm^2 were developed. Due to the precise manufacturing of the LTCC technology, they have improved resolution. Even larger boards could be manufactured for other applications. Alternatively, more flexible and cheaper modular designs can be obtained. Several components can be mounted very close together using BGA connections, with no bezels around the active area, creating a larger panel.



The stips readout board made of Low Temperature Co-fired Ceramic



The pixel readout board made of Low Temperature Co-fired Ceramic



The radiograph made with GEM detector and Low Temperature Co-fired Ceramic readout