

X-RAY SOURCE IMAGING USING GAS ELECTRON MULTIPLIER DETECTOR SYSTEM

Kristupa Šeškauskaitė¹, Algirdas Lazauskas¹, Muhammad Usman Uraf Ishafaq^{1,2}, Sigitas Tamulevičius^{1,2}, Brigita Abakevičienė^{1,2}

¹Kaunas University of Technology, Institute of Materials Science, Kaunas, Lithuania

²Kaunas University of Technology, Faculty of Mathematics and Natural Sciences, Kaunas, Lithuania
kristupa.seskauskaite@ktu.edu

A fully integrated Gas Electron Multiplier (GEM) detector system was used for high-resolution X-ray imaging. The detector employs a triple-GEM foil structure with a 100 cm² active area enclosed in a sealed gas chamber. Each copper GEM foil contains a dense matrix of identical microscopic holes that enable electron avalanche multiplication under applied high voltage. Using a triple-GEM configuration provides high gain, low ion backflow, and excellent spatial resolution.

The detector features a Kapton entrance window and a drift cathode that generate a uniform electric field across the drift region, guiding primary ionization electrons toward the GEM stack. After amplification through the three foils, the electrons are collected on a readout plate, yielding accurate spatial information about the incident radiation.

Signal processing is performed by a custom 256-channel readout board developed by Techtra and connected to the detector via four Panasonic connectors. The board incorporates four Texas Instruments DDC264 ADCs, each providing 64 current-input channels with 20-bit resolution. Adjustable full-scale charge ranges from 12.5 pC to 150 pC and integration times between 160 μs and 1 s allow precise current measurement across a wide dynamic range.

The analog front end includes precision reference sources, low-pass filtering, and a biasing circuit capable of supplying a constant current to support negative-polarity input signals. A Xilinx FPGA manages timing, data acquisition, and communication. Digitized data are serialized and transferred to a PC over a 100 Mbit/s Ethernet interface, where TCP is used for system control and UDP for high-rate data streaming. The system operates at a 6.25 kHz sampling rate and is supported by software enabling real-time monitoring, visualization, and data storage.

The detector operates with an Ar/CO₂ (70/30) gas mixture and is powered by a Caen DT5470N high-voltage supply capable of delivering up to -5 kV at 200 μA. High voltage is routed to the GEM foils through a dedicated connector and cable. The assembly is housed in a gas-tight enclosure equipped with interfaces for gas inlet and outlet, HV distribution, and signal readout, ensuring stable performance within controlled gas condition.

To evaluate the detector's imaging performance, a COOL-X miniature X-ray source was used. This solid-state device employs a pyroelectric crystal to generate electrons, which then produce X-rays when accelerated into a copper target. The source delivers peak intensities of approximately 10⁸ photons per second, with endpoint energies reaching up to 35 keV, providing a compact and reliable excitation source for characterization of the GEM-based imaging system.

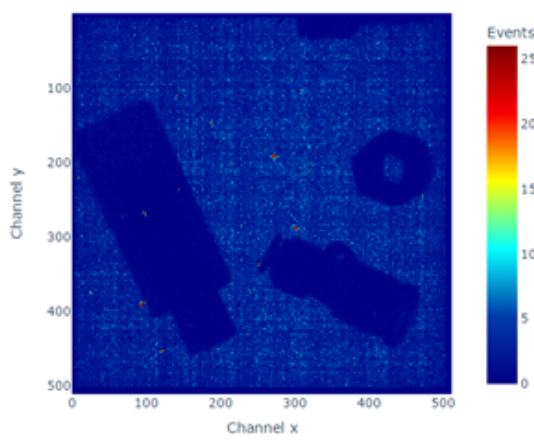


Fig. 1. Final reconstruction showing high-contrast, position-sensitive X-ray imaging achieved with the GEM detector

Acknowledgements

This work was supported by the project No. S-CERN-24-8, funded by the Research Council of Lithuania under the programme Prospective R&D Projects for Lithuania's Membership at CERN.

Keywords: GEM, X-ray, imaging, detector