FPGA and Embedded Systems based Fast Data Acquisition and Processing for GEM Detectors

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GEM detectors [1] are widely used for detection of ionizing radiation. When used in the proportional mode they provide information about the time, location, and energy of the detected particle [2].
Modern technologies allow full utilization of detector properties, by acquiring the waveform of the output current pulses and processing them using the sophisticated DSP algorithms. The current pulses must be digitized at high speed (up to 125 MHz) with high resolution (up to 12-bits).
Due to the high volume of the produced data, it is necessary to provide the high-performance data acquisition system (DAQ) to transmit the data to the processing units.
Efficient processing of the GEM data requires distributed parallel processing system to perform multiple tasks [3]:

- Filter out the background and transmit only the hit related data.
- Extract the parameters of the hit, describing the time and charge (related to energy).
- Estimate the hit position by combining the information from multiple strips.
- In case of 2D GEM detectors, correlate the pulses received from X and Y stripes or X, U and V stripes.
- Separate the hits overlapping in space or in time (if possible) to support detector operation at higher rates.

The above functionalities may be achieved in different hardware architectures. The typical hardware platforms include FPGA chips, standard or embedded computer systems, DSP processors, SoC (systems on chip) [4]. The presentation shows possible solutions and discusses their advantages and disadvantages.

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