Gas Pixel Detectors

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Abstract

We discuss a new class of Micro Pattern Gas Detectors, the Gas Pixel Detector (GPD), in which a complete integration between the gas amplification structure and the read-out electronics has been reached. Three generations of an analog Application-Specific Integrated Circuit (ASIC) built in deep sub-micron technology have been developed to realize a monolithic device that is, at the same time, the pixelized charge collecting electrode and the amplifying, shaping and charge measuring front-end electronics. The CMOS chip has the top metal layer patterned in a matrix of 50 μm pitch hexagonal pixels, each of them directly connected to the underneath full electronics chain which has been realized in the remaining five layers of the 0.18μm VLSI technology. The chip integrates more than 16.5 million transistors and it is organized as a 15mm_15mm active area. It is subdivided in 16 identical clusters, each one with an independent differential analog readout buffer. Each cluster has a customizable internal self-triggering capability with independently adjustable thresholds. An internal wired-OR combination of each cluster self-triggering circuit holds the maximum of the shaped signal on each pixel. The self-triggering function also includes an on-chip signal processing for automatic localization of the event coordinates. In this way it will be possible a significant reduction of readout time and data volume by limiting the signal output only to the pixels belonging to the region of interest.

Results from tests of a first prototype with 22k pixels and a full scale version with 105k pixels are presented. The device was coupled in this case to a fine pitch Gas Electron Multiplier. The application of this detector for Astronomical X-Ray Polarimetry is discussed. The experimental detector response to polarized and unpolarized X-ray radiation is shown. Results from a full MonteCarlo simulation for two astronomical sources, the Crab Nebula and the Hercules X1, are also reported.

Obviously, depending on type of electron multiplier, pixel and die size, electronics shaping time, analog vs. digital read-out, counting vs. integrating mode, many other applications can be envisaged for this device.