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Development of the GEM-TPC X-ray Polarimeter with the Scalable Readout System

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We have developed a gaseous Time Projection Chamber (TPC) containing a single-layered foil of a Gas Electron Multiplier (GEM) to open up a new window on cosmic X-ray polarimetery. The GEM-TPC polarimeter works as a highly sensitive tracker for photoelectrons whose initial direction is sensitive to linear polarization of incident X-rays. The GEM foil is used to increase signal-to-noise ratio of photoelectron track images by a few thousand-fold.

A prototype of the flight polarimeter has been built and evaluated in USA/NASA, while a spare for ground tests has been developed in Japan/RIKEN. The main difference between the two polarimeters is a signal readout system: the prototype uses the APV25 ASIC controlled by a NASA-programmed FPGA to read out signals from 128 one-dimensional strips, while the spare utilizes the Scalable Readout System (SRS) developed by CERN/RD51. In the conference, we will present the design and fabrication of the spare with the APV25-SRS electronics and its polarization performance.

In order to test the spare polarimeter, it was irradiated with monoenergetic and linearly-polarized X-rays from the BL32B2 beamline at the SPring-8 synchrotron radiation facility in December 2014. The polarized X-ray data were acquired by scanning with 5 mono energies from 4.5 to 7.5 keV. In addition, at each energy, the polarimeter was scanned with well-collimated beams in 6 different detector positions along the applied electric field.

The derived analyzing power (or modulation factor) for linear-polarized X-rays on the optical axis is approximately 40% at 4.5 keV and increases up to 50% with the beam energy. Moreover, the analyzing power increases by approximately 10% per cm with decrease in the electron drift length because of less image blurring caused by electron diffusion. These results show that the spare polarimeter has a comparable sensitivity to the flight prototype.

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