Contribution ID: **76** Type: **Poster**

Calibrating the photometric performance of a high-time-resolution photon-counting imager for optical astronomy

Wednesday 20 November 2024 19:32 (5 minutes)

Optical observations with high time-resolution should be a key to understand the origin of sub-millisecond time-scale astronomical phenomena such as giant radio pulses from the Crab Pulsar. We have developed a high-speed imaging system, Imager of MPPC-based Optical photoN counter from Yamagata (IMONY), using a customized Multi-Pixel Photon Counter (MPPC) as a sensor. This sensor is designed to read out signals from all the 8x8 pixels independently and to work as an imager of Geiger-mode avalanche photodiode array. We installed IMONY on the 3.8 m aperture Seimei Telescope in Okayama, Japan. We have successfully detected the 34-ms period of the Crab pulsar and imaged stars in the sensor's field of view. However, we have also found a small fraction of the pixels showed double or multiple pulses that used for the photon arrival timing. This situation should be due to circuit noise and unfortunately may result in overestimating the number of photons detected. In order to precisely estimate the photon flux of targets or the sky background, calibration of such over-counts is important. We measured the number of detected photons relative to the light intensity of each pixel in a laboratory environment. The number of overestimated counts is estimated based on the Poisson distribution of the time lag between each hit pulse. After applying the calibration to the observed data, we confirmed the linearity that is the correlation between magnitude and the number of detected photons. We will present the calibration and evaluation of the IMONY's photometric performance.

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Session Classification: Poster Session

Track Classification: Applications: Astroparticles, Astrophysics and Astronomy