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Application of Richardson-Lucy deconvolution to images obtained from GEM scintillation readout by a commercial Hamamatsu S13361-3050 SiPM unit

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Micropattern gas detectors (MPGDs) have been applied in many high-energy physics (HEP)experiments. The primary ionization signal generated by radiation in the sensitive volume is amplified through electron charge avalanches produced in the gas, under the high electric fields established across the micropattern elements. The avalanche electrons are, then, read out at the anode electrode. Imaging of the radiation interaction position is achieved by using pixelated anode electrodes, read out by a suitable electronic signal readout system. Besides HEP other specific applications include applications to medical and/or cultural heritage imaging and Homeland security.

The readout of gas scintillation produced in the electron avalanches as a mean for primary ionization signal amplification presents advantages over the charge readout. The mechanical and electrical decoupling of the signal readout system from the charge amplification region renders improved immunity to high-voltage problems and to electronic noise. In addition, the extra gain from the photosensor allows obtaining signals with higher amplitude and reduced signal-to-noise ratio. These advantages justify the increasing use of optical-TPCs to different applications.

Nevertheless, for imaging applications, the diffusion of the ionization electrons during electron drifting in the gas and the isotropic emission of the gas scintillation in the charge avalanches contribute to the degradation of the position resolution that can be obtained in optical detectors. In gaseous detectors the interaction position of the radiation interaction in the gas is usually obtained through the centre-of-gravity of the produced spatial charge or scintillation distribution at the readout plane. Nevertheless, the images are contaminated by blurring and noise. However, this degradation can be mitigated with deconvolution. For example, the Richardson-Lucy deconvolution algorithm has been routinely employed in many scientific and engineering fields to reduce image blurring.

In our experimental setup, the scintillation produced in GEM charge avalanches is read out by a commercial Hamamatsu S13361-3050 SiPM photosensor, which consists of an 8×8 array of 3x3 mm2 SiPMs. This readout unit allows large coverage areas due to its large pixel size, trading of with the position resolution. Nevertheless, since a data acquisition and imaging display unit is commercially available for this model of SiPM array, this photosensor is a strong option for scintillation readout.

In this work, we present our ongoing efforts to improve the imaging quality obtained in our setup. After subtracting noise background, imaging processing was performed using the interpolation method and, subsequently, applying a Gaussian filter. Clean images can be obtained, but the achieved position resolutions are larger than the pixel size. The image quality could be further significantly improved by applying the Richardson-Lucy deconvolution algorithm, which allows reversing the blurring induced by electron diffusion and isotropic scintillation light production in our gas chamber. With the application of the Richardson-Lucy deconvolution algorithm it was possible to achieve clean images with position resolutions well below the pixel dimensions of the readout unit.

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