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Optical readout of MPGDs: Techniques and applications

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High position resolution, insensitivity to electronic noise and intuitive interpretation of results without the need for extensive data processing are among the key advantages of optical readout of MPGD-based detectors. Together with the high gain factors achievable by technologies such as GEMs, this allows for sensitive 2D detectors taking advantage of inexpensive and commercially available CCD or CMOS cameras. Selected gas mixtures such as Ar/CF₄ with secondary scintillation in the visible wavelength regime allow for a direct recording of the light emitted during avalanche multiplication and enriching the 2D optical readout with timing information enables full 3D reconstruction of particle tracks.

X-ray imaging, fluoroscopy and fluorescence measurements acquired with an optically read out GEM are presented, highlighting the possibility for energy resolved images by single-photon sensitivity. For applications requiring high interaction probabilities and consequently thick drift regions, a planispherical GEM detector is shown, which minimises parallax-induced broadening by radially focused drift field lines. This preserves the position resolution required for applications such as X-ray crystallography or fluorescence.
Augmenting 2D images obtained from cameras by optical readout of MPGDs with timing information from a tagging signal or a fast photon detector such as a PMT, full 3D track reconstruction is achievable. An optically read out GEM-based TPC combining information from primary and secondary scintillation to 3D reconstructed representations of alpha tracks has been constructed and operated and is shown as an example of the track reconstruction capabilities of optical readout.
Owing to the low-material budget of gaseous detectors, optically read out GEMs are an attractive candidate for online beam-profile monitoring. While the adjustable gain of GEMs allows for tuneable sensitivity and operation in a wide range of beam parameters, the immediate availability and intuitive interpretation of images acquired by a camera make optical readout a high-potential technology in high energy physics and radiotherapy instrumentation.
Exploring the possibility of portable detectors based on optically read out MPGDs, sealed mode stability measurements are presented along with gas purity and spectroscopic investigations related to the light yield achievable in GEM-based detectors.

The advances in imaging sensors and state-of-the-art CCD and CMOS cameras have facilitated the utilisation of optical readout of MPGD-based detectors for a variety of applications ranging from highly sensitive and energy-resolved imaging to particle track reconstruction and high-resolution beam monitoring. Application-specific techniques such as the usage of radially focussed drift field lines or low-material budget detectors promise a versatile readout approach for scintillation-based detectors and pave the way for employing optically read out MPGDs in future devices and experiments.

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