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High-granularity optical and hybrid readout of gaseous detectors: developments and perspectives

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Modern imaging sensors and ASICs allow for high-sensitivity pixellated readout of gaseous detectors with good spatial resolution. Advances towards ultra-high-speed imaging sensors, low noise characteristics and internal amplification in combination with increasing pixel counts make scintillation light readout well-suited for the most demanding applications ranging from radiation imaging and beam monitoring to track reconstruction techniques including hybrid approaches with optical and electronic readout.

Building upon high-resolution imaging with optically read out gaseous detectors using different MicroPattern Gaseous Detector (MPGDs) technologies, developments towards a low material budget beam monitoring detector will be presented. This development takes advantage of intuitive pixellated readout enabled by imaging sensors and the possibility to guide light with optical elements and mirrors to locate readout devices outside of the beam path for minimising radiation exposure and material budget.

While frame rate capabilities have previously limited optical readout to low event rates or integrated imaging, novel ultra-fast CMOS sensors offer unprecedented readout speeds at moderate resolution. This not only enables rapid fluoroscopy limited only by incident radiation flux and the high rate capabilities of MicroPattern Gaseous Detectors, but may also be used for recording image sequences resolving drift time differences along tracks in TPCs. Developments towards direct 3D track reconstruction in optical TPCs with ultra-fast CMOS readout will be shown along perspectives for negative ion optical TPCs for superior depth resolution.
In addition, alternative hybrid TPC readout approaches combining detailed 2D imaging with timing information from fast photon detectors such as SiPMs or transparent electronic readout electrodes are presented.

The combination of the flexibility of gaseous detectors including different target densities and large detection areas with state-of-the-art pixellated sensors offers unprecedented possibilities for rare event searches, beam monitoring and rapid, high-resolution imaging.

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