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THE ROLE OF MPGD-BASED PHOTON DETECTORS IN RICH TECHNOLOGIES

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Gaseous Photon Detectors (PD) have played/are playing a major role in establishing and operating Ring Imaging CHerenkov (RICH) counters, thanks to their specific characteristics, some of them unique: they represent the most cost effective solution for what concerns the coverage of large detector areas, and they offer the minimum material budget, a feature relevant when the photon detectors have to sit in the experiment acceptance. Moreover, the gaseous PDs can operate in presence of magnetic field.

The successful operation of gaseous PDs imposes to overcome two major challenges. **(i) Selection of the photonconverter** - The photoconverting vapours, initially used, require either extended conversion volumes (TMAE), that results in parallax errors and wide ranges of electron drift time, or very far UltaViolet (UV) detection domain (TEA). Feedback photons from the multiplication process can generate spurious hits wherever in the converting volume. They have been progressively abandoned. Among the standard solid state photoconverters commonly used in vacuum-based detectors, only CsI can be reliably used in gaseous atmosphere thanks to its relatively high work function: it can tolerate some bombardment by the ions generated in the multiplication process, where the maximum integrated bombardment before observing Quantum Efficiency (QE) degradation is of the order of 1mC/cm^2 [1]. **(ii) Photoelectron extraction** - In gas atmosphere, the extracted photoelectrons can be elastically back scattered by the gas molecules and be reabsorbed in the photoconverter. Effective photoelectron extraction requires specific gas atmospheres and high electric field in front of the photoconverters [2]. MultiWire Proportional Chambers (MWPC) equipped with CsI photocathodes [3] have been successfully operated, for instance in HADES, COMPASS and ALICE RICHes, even if at low gain in order to limit the ion bombardment and the photon feedback. In these detectors, where the signal is due to the ion motion, low gain results in slow operation.

MPGD technologies offer natural answers to ion back flow and photon feedback suppression and much faster operation, as tested by successful applications:

- the **PHENIX HBD** with triple GEM PDs [4]
- the **COMPASS RICH upgrade** with Hybrid (THGEMS and MICROMEGAS) PDs [5]
- the **windowless RICH prototype** and test beam with quintuple GEM PDs [6]
- the **TPC-Cherenkov (TPCC) tracker prototype** with quadruple GEM PDs [7].

In multiple layer GEM PDs, where the top layer is coated with a CsI film and acts as photocathodes, the photon feedback is stopped by the limited optical transparency of the stack of GEMs, while the ion backflow is reduced because part of the ions are trapped in the intermediate detector layers. In a hybrid detector including two THGEMs and a MICROMEGAS, the first THGEM is the photocathode substrate and the feedback photon are stopped as in the GEM detector. The intrinsic ion blocking characteristics of the MICROMEGAS makes possible photon feedback rates at a few percent level. These detectors can be used in focusing and proximity focusing RICHes.

The major element of interest for future applications of MPGD-based PDs is in **developing the concept of compact RICH for PID of high momentum particles**, that would empower the application at colliders with hermetic coverage detectors and, therefore, is **a must at the EIC**. In fact, RICHes for PID at high momenta require gaseous radiators, as only small-value refractive index give access to PID at high momenta. The radiator must be long to ensure the required Cherenkov photon yields. Higher photon rates can be obtained in the far UV domain, around 120-140 nm. Access to this wavelength range can be obtained by a windowless RICH [6], where **the radiator gas is also the PD gas**. This poses specific requirements to MPGD-based PDs. FluoroCarbons (FC) are mainly used as radiator gasses thanks to their high density, that ensures good Cherenkov photon rates, and their low chromaticity, that make possible fine resolution, a need for PID at very high momenta. The FC Global Warming Potential (GWP) is extremely high and, therefore, their use is subject to increasing restrictions, also effecting procurement possibilities. A proposed alternative is by pressurized (at a few bar) noble gasses able to mimic FC in terms of density and chromaticity. MPGDs operation in FC atmosphere has been proven [6], while their ability to operate in high pressure noble gasses has to be established, in spite of some positive hints from literature [8]. Another need for the compact RICH concept is the **fine pixelization**, required to preserve the fine resolution with shorter lever arm imposed by the compactness requirements.

The possibility to identify **novel solid-state photoconverters** providing higher QE and adequate for operation in gaseous PDs has to be pursued: it is beneficial for the compact RICH concept and, more in general, for all the applications of gaseous PDs. Hydrogenated nanodiamond powders have been proposed [9] and initial studies are ongoing [10], while further investigation is needed, with dedicated attention to novel C-materials.

In conclusion, MPGD-based PDs are an option for further developments in the Cherenkov imaging techniques and, in particular, for the needed concept of compact RICHes, essential at the EIC and that, more in general, can open the way to a wider use of RICHes in collider environments.

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