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ELITPC - a TPC detector for photonuclear reaction studies using intense, monochromatic gamma-ray beams at the ELI-NP facility

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A newly built Extreme Light Infrastructure –Nuclear Physics (ELI-NP) facility in Bucharest-Magurele, Romania will provide monochromatic, high-brilliance gamma-ray beams that will allow one to study key nuclear reactions in modern astrophysics by means of the inverse photo-dissociation process [1]. Such inverse reactions exhibit larger cross sections due to detailed balance principle and have smaller experimental backgrounds in comparison with direct measurements. In particular, Oxygen-16 photo-dissociation process plays a key role in explaining carbon-to-oxygen abundance ratio observed in the Universe. In order to measure this and other (gamma, alpha) or (gamma, p) reactions of astrophysical interest, an active-target gaseous Time Projection Chamber (ELITPC) is being developed by the University of Warsaw, IFIN-HH / ELI-NP and the University of Connecticut [2].

The ELITPC detector has active volume of about 35 cm x 20 cm (readout area) by 20 cm (drift length) that is centered around the axis of the gamma beam. The working gas mixture, rich with target nuclei to be studied, is kept at a lower-than-atmospheric pressure (~100 mbar) in order to optimize three-dimensional kinematical reconstruction of the events. The ionization electrons from tracks of charged particles emerging from photo-dissociation reactions drift in a uniform electric field towards several Gas Electron Multiplier (GEM) structures before reaching the segmented readout anode. The whole internal structure is embedded in a vacuum vessel equipped with gamma-beam windows, gas and high-voltage ports as well as analogue signal feedthroughs. The ELITPC detector is complemented by: low-pressure generation and recirculation gas system, electron drift velocity monitoring and real-time gamma-beam intensity diagnostics.

The detector will employ fast digitizing front-end electronics developed by the Generic Electronics for TPCs (GET) collaboration for nuclear physics experiments [3]. The readout anode is constituted from interconnected pads that are arranged in three arrays of strips, which form a redundant three-coordinate u-v-w system. About 1000 electronic channels are envisaged in the full-scale ELITPC detector.

A scaled demonstrator detector operating at atmospheric pressure was constructed and tested with an alpha-particle beam at the IFIN-HH Tandem facility Romania [4]. The beam-induced experimental background for the expected gamma-ray intensities and energies has been simulated using Monte Carlo. The current R&D program focuses on testing thicker versions of GEM foils that will be more suitable for operation at low gas densities, further development of FPGA-based DAQ electronics, optimizing segmentation of the readout strips and number of electronics channels and optimizing composition of the working gas mixture (e.g. He + CO2). A brief status of these developments will be presented in the talk.

[1] D. Filipescu et al., "Perspectives for photonuclear research at the Extreme Light Infrastructure - Nuclear Physics (ELI-NP) facility,"European Physical Journal A, 51, 185 (2015).
[2] O. Tesileanu et al., "Charged particle detection at ELI-NP,"Romanian Reports in Physics, 68, S699 (2016).
[3] E. Pollacco et al., "GET: A Generic Electronic System for TPCs for Nuclear Physics Experiments,"Physics Procedia, 37, 1799 (2012).
[4] M. Cwiok, "Nuclear reactions at astrophysical energies with gamma-ray beams: a novel experimental approach,"Acta Physica Polonica B, 47, 707 (2016).

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