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Pixelated AC-LGAD sensors for the Electron-Ion Collider (EIC): read-out performances with EICROC0_v0 ASIC

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Finding the answers to the long-standing questions, such as, emergence of mass and spin of the proton from partons, saturation of gluon density, and gluon momentum distribution inside the proton and nuclei, motivated the EIC [1] under construction at Brookhaven National Laboratory, USA. The first EIC detector, ePIC (electron Proton-Ion Collision experiment), consists of a central barrel detector, as well as extensive beamline detectors in the outgoing electron (far-backward) and hadron (far-forward) beam directions. The far-forward (FF) detectors include Roman pots, which are placed inside vacuum and are intended to detect protons and ions scattered at very small angles (˜ 5 mrad) in the forward direction, at ˜30m downstream from the interaction point. The main goal of the FF detectors is to tag exclusive and diffractive events and to reconstruct their transverse momentum with a resolution of ˜ 10 MeV/c. This is obtained relying on a new generation of 4D tracking sensors, pixelated AC-LGADs (capacitively-coupled Low-Gain Avalanche Diode, pixel of 500×500 μm^2) [2][3] capable of providing the required spatial (less than 50 μm from charge sharing among neighboring pixels) and timing (˜ 30 ps) resolutions. To read-out these novel LGADs exploiting their charge sharing capability, an optimized read-out large scale chip, EICROC (32×32 pads), is being designed at OMEGA. The first ASIC prototype, EICROC0_v0 (4x4 pads) [5], is a system-on-chip with analog and digital processing including for each of the 16 channels a fast low-noise trans-impedance preamplifier, followed by two paths: a fast path with a discriminator connected to a 10-bit Time-to-Digital Converter (CEA/Irfu) for time measurement (ToA) with a 25 ps accuracy; and a slow path with shaper connected to an 8-bit 40 MHz successive approximation Analog-to-Digital Converter (AGH Krakow) providing amplitudes. The performance results obtained at IJCLab with pixelated AC-LGAD sensors read out by the EICROC0_v0 ASIC, including preamplifier response and digital data from the TDC and ADC, will be presented. These results rely on measurements performed using the internal charge injection system, a beta source, and an infrared laser. Special emphasis will be placed on quantifying the charge-sharing ratio between adjacent pixels, together with evaluating the timing and spatial resolutions achievable with the EICROC0_v0 ASIC. Perspectives of next EICROC0 chip iterations will also be discussed.

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References:

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