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A Low-Noise Pixelated ASIC for the Readout of Micro-Channel Plates

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In the field of astronomy, photon counting detectors based on micro-channel plates (MCP) are commonly used for UV detection and their characteristics often limit the overall instrument performance. In particular, UV spectroscopy is adopted in solar physics and for the investigation of planetary exospheres. The PLUS (PLanet extreme Ultraviolet Spectrometer) Project aims at developing a spectrometer in the 55-200 nm range leveraging a dual channel (VUV/EUV) architecture and high-efficiency optical components individually optimized for each channel. Within this context, we present the first version of a new ASIC custom-designed for MCP readout. The ASIC will be able to detect the electrons cloud generated by each photon interacting with the MCP, sustaining high local and global count rates to fully exploit the MCP intrinsic dynamic range with low dead time The main rationale that guided the electronics design is the reduction of the input equivalent noise charge (ENC) in order to reduce the gain of the MCP, thus, enlarging its lifetime, crucial for long missions.
The readout chain (Fig. 1) is composed of the low-noise charge sensitive amplifier (CSA), a filtering stage with selectable analog processing time (125 or 250 ns, Fig. 2), a discriminator with a 5-bit selectable threshold, a charge-sharing compensation logic (CSCL) offering two arbitration modes and, finally, two 17-bit counters alternating in parallel and, thus, granting zero dead time in the serial digital readout. The frame rate is 1 Hz and the maximum count rate per pixel is 100 kcps. The maximum collectable charge at the anode is 6000 e- with an ENC of only 25 e-. This value can be compared with 72 e- of MEDIPIX 3 (55 µm pixel [1]) and 84 e- of CHASE Jr. (100 µm pixel [2]).
The charge cloud on the array of collecting anodes is expected to spread at maximum among 4 adjacent pixels. In the basic arbitration mode, the event is assigned to the pixel with the highest detected charge. Instead, to address conditions of equally partitioned charge, in the advanced mode (an evolution of the MEDIPIX 3 approach), the cluster that received the highest charge is identified by the summing nodes between pixels and then the winning pixel is identified by vertical and horizontal comparisons.
A scaled 65-nm CMOS technology has been selected in order to achieve a compact pixel size (35 ×35 µm2 with an anode size of 20 ×20 µm2 for a 32% fill factor), providing high spatial resolution which is a key characteristic for the spectrometer under study, but which also makes the device suitable for different photon-counting (spectroscopic or imaging) applications. The first prototype of the ASIC contains an array of 32 × 32 pixels for a total chip area of 2 ×2 mm2, including several pads for diagnostics and characterization. Analog and digital block are carefully separated in a super-pixel configuration (Fig. 4).

Authors: Mr FABBRICA, Edoardo (Politecnico di Milano and INFN); CARMINATI, Marco (INFN - National Institute for Nuclear Physics); Mr QUARTERONI, Luca (Politecnico di Milano and INFN); MOHAMMAD ZAKI, Alireza (Politecnico di Milano); BUTTA, Davide (Politecnico di Milano); Dr USLENGHI, Michela (INAF); FIORINI, Mauro (INAF); Dr CORSO, Alain J. (CNR-IFM); Prof. PELIZZO, Maria Guglielmina (CNR-IFM); FIORINI, Carlo (Politecnico di Milano - INFN Milano)

Presenter: Mr FABBRICA, Edoardo (Politecnico di Milano and INFN)

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