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Scalable Control Systems for Vertex Detector utilizing Single Photon Counting Readout

I report the design and operation verification of two control systems for vertex detector dedicated for beam particle trajectory tracking. Both of the presented systems are designed to control and perform acquisition from the detector made of two layers of single photon counting hybrid pixel detectors (called later sensors). The alignment and synchronization of two sensors allows for particle transition registration and further calculation of the angle of incidence based on the timestamp and transition points.

The sensor chosen for the application is UFXC32k [1], designed at the AGH-UST in Cracow, made of 256 x 128 matrix of 75 um side square-shape pixels. The sensor is capable to operate in so-called zero dead-time mode enabling continuous streaming of sequential images. Using FPGA as the heart of the controller, the systems provide high speed data streaming allowing for up to 50 kfps data acquisition.

The two presented systems are build based on:
1st case: two NI sbRIO 9651 system on modules from National Instruments –the low-cost devices that enables building small and embedded detectors
2nd case: two NI FlexRIO Controllers with NI 7972R FPGA cards from National Instruments –powerful Kintex FPGA cards that allow achieving higher throughput

Due to compact nature of the devices and the fact that they are fully programmable in the same LabVIEW environment (both FPGA, RTOS and Host) the systems are highly scalable in terms of adding additional layers in the vertex detector as well as adding new functionality to the acquisition or data analysis process.

Both systems has been proved to work synchronously and are capable of registering ionizing beam particles [2].

[1] P. Grybos, P. Kmon, P. Maj, and R. Szczygiel, "32k Channel Readout IC for Single Photon Counting Pixel Detectors with 75 μm Pitch, Dead Time of 85 ns, 9 e- rms Offset Spread and 2% rms Gain Spread,"IEEE Trans. Nucl. Sci., vol. 63, no. 2, pp. 1155–1161, 2016, doi: 10.1109/TNS.2016.2523260.
[2] A. Koziol et al., "High rate proton detection with single photon counting hybrid pixel detector,"Nucl. Instruments Methods Phys. Res. Sect. A Accel. Spectrometers, Detect. Assoc. Equip., vol. 956, 2020, doi: 10.1016/j.nima.2019.163333.

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