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# MiniPIX Timepix3 –a miniaturized radiation camera with onboard data processing for the online measurement of particle fluxes and dose rates in mixed radiation fields

The MiniPIX TPX3 is a miniaturized, low-power radiation camera (see Fig. 1) based on the Timepix3 64k active pixel sensor, providing imaging, spectral and tracking information of individual particles in mixed-radiation fields. Timepix3 [1] is a high-granularity 256 × 256 pixel array of pitch 55 µm, with two per-pixel signal chain electronics. The hybrid architecture supports the use of different sensor materials (e.g., Si, CdTe, GaAs) of varying thickness (typically in the 100 µm –2000 µm range).

The high data rate performance makes use of the USB 2.0 readout port and operation by a PC/laptop computer. It utilises the PIXET software tool [2] which provides control, data acquisition and online visualization of single particle tracks. The maximum data and frame rate is 2.3 M hit pixels per second and 16 fps, respectively. The power consumption is in the range 1–2 W depending on the radiation field, intensity and resulting data rate. Raw data is readout and stored on an external PC/laptop where pre-processing can be performed by extended plug-in tools in the PIXET package. Steps performed include identification of single events registered in the form of pixelated cluster tracks (clustering) and application of the per-pixel energy calibration. Extensive data processing is performed offline for high-resolution, wide-range data evaluation and precise data products; such as selective particle fluxes, dose rates, LET spectra, deposited energy spectra, angular distributions, spatial- and time-distributions and charged-particle radiographs. High-resolution particle tracking coupled with advanced pattern recognition analysis of the single particle tracks provides enhanced resolving power of particle-type composition [3] for detailed analysis of radiation fields. A heuristic empirical approach, based on wide-range of calibrations of the Timepix detector in well-defined radiation fields, provides particle-type discrimination of up to 8 classes [3].

Onboard processing operation is enabled by firmware reconfiguration and the embedded microcontroller in the readout electronics. Control and communication is via the SPI port. A low power (0.5–1.5 W) mode is intended for space applications such as ESA's MIRAM payload intended for LEO and GEO orbit deployment [4]. Data processing can be performed to a limited extent for an online response. A detailed event-by-event mode provides position, timing, dose, deposited energy and LET data of single events for radiation field fluxes up to 105 cm-2s-1. An integrated summed mode suitable for high intensity radiation fields (up to 107 events cm-2s-1) provides integrated limited information of total particle flux and total dose rate. Both modes provide basic particle-type discrimination (3 main classes are resolved –see Fig. 2).

[1] T. Poikela et al., Timepix3: a 65k channel hybrid pixel readout chip with simultaneous ToA/ToT and sparse readout, J. of Instrum. JINST 9 (2014) C05013
[2] D.Turecek et al, USB 3.0 readout and time-walk correction method for Timepix3 detector, J. of Instrum. JINST 11 (2016) C12065
[3] C. Granja et al., Resolving power of pixel detector Timepix for wide-range electron, proton and ion detection, Nucl. Instrum. Meth. A 908 (2018) 60-71.
[4] S. Gohl et al., A miniaturized radiation monitor for continuous dosimetry and particle identification in space, contribution to this conference.

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