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Study of temperature influence on Timepix2 energy measurements

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Timepix2 [1] is a hybrid pixel detector developed by the Medipix2 collaboration as the successor to Timepix [2]. Its introduction brought significant advancements, including the simultaneous measurement of Time-over-Threshold (ToT) and Time-of-Arrival (ToA), as well as new capabilities such as adaptive gain mode and pixel disabling to reduce power consumption. These features, combined with the detector's compact size and occupancy trigger, make Timepix2 well-suited for space dosimetry applications. In such environments, high-energy heavy ions—such as Galactic Cosmic Rays—can deposit substantial radiation doses in both biological tissue and electronics, potentially leading to functional upsets. The enhanced pixel-level energy measurement capabilities of Timepix2 also enable a more accurate dE/dX spectroscopy in space. However, temperature variations can impact the absolute energy calibration and degrade the energy resolution of the Timepix2 detector.

In this contribution, we present a study of the temperature dependence of a Timepix2 (v1) detector (256 × 256 pixels, 55 µm pixel pitch) coupled to a 500 µm thick silicon sensor. Measurements were performed using X-rays (up to 60 keV) and alpha particles (5.5 MeV) in both air and vacuum across a range of stabilized temperatures from 10℃ to 80℃. The separation of the readout electronics from the readout chip minimizes the influence of temperature-dependent variations in the clock frequency generator, thereby allowing to investigate the stability of the Timepix2 itself.

In normal gain mode, the detector demonstrated excellent stability in energy measurements using the ToT mode, achieving absolute energy determination within ±0.2 keV for temperatures from 10 to 70℃. At the same time, the threshold level increased by approximately 2 keV as the temperature rose from 30℃ to 80℃. Measurements of the DAC voltages revealed a significant temperature dependence of the Ikrum DAC, which compensates for the threshold shift and enables accurate ToT measurements. In adaptive gain mode, a systematic shift in the absolute ToT measurement accuracy of approximately 0.6% per 10℃ temperature increase was observed. A mitigation technique for this behavior was identified and will be presented.

References:

[1] W.S. Wong et al., 2020 Radiat. Meas. 131 106230.
[2] X. Llopart et al., NIM A 581 (2007) 485–494.

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Workshop topics

Detector systems

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