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Characterization of a Timepix3 quad for space application in the penetrating particle analyzer (PAN)

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A Timepix3 [1] quad module (262,144 pixels, pixel pitch 55 μm) was developed for application in the penetrating particle analyser (PAN), i.e. a magnetic spectrometer for the measurement of galactic cosmic ray fluxes, their kinetic energies and to study the antimatter content in deep space [2]. The pixel detector therein provides accurate measurement of particle position and the energy left in the thin silicon sensor (dE/dX). Their low material budget is essential to reduce the impact of multiple low angle scattering on particle energy determination. However, the use of Timepix3 devices in space comes with challenges for carrier board, readout electronics and firmware design. For example, operation in vacuum requires proper cooling schemes; printed carrier boards and mechanics should be light weight while providing enough strength to survive vibration and shock; limited resources on the spacecraft impose strict limits on power consumption; and low downlink rates require data pre-processing capabilities. These issues are addressed in the present contribution.

A redesign of the Katherine [3] readout was used to study the Timepix3 tracking module's response to a 120 GeV/c hadron beam at the Super-Proton-Synchrotron (SPS) at CERN and to protons of 100-230 MeV at the Danish Center for Proton Therapy (DCPT). "Low"power operation was achieved by changing the internal DAC settings of Timepix3 and reducing the matrix clock (see [4]). We present a comprehensive study of the impact of the changes on the particle tracking performance, as well as the energy and time resolutions. The power consumption of 6 W with standard settings was reduced to 4 W by changing the Timepix3 DACs. While these changes did not affect the energy measurement resolution, the time stamping precision was reduced from 1.7 ns to 12.4 ns (Figure 1). Further reduction of the power consumption was achieved by reducing the matrix clock. Using a matrix clock of 5 MHz, we achieved a power consumption of 1.6 W. Moreover, the energy device performance (energy resolution) was studied in vacuum conditions and at different energies in a thermal chamber.

[1] T. Poikela et al., JINST 9 (2014) C05013.
[2] X. Wu et al., Advances in Space Research, 63 (2019), Issue 8, pp 2672-2682.
[3] P. Burian et al., JINST 12 (2017) C11001.
[4] P. Burian et al., JINST 14 (2019) C01001

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