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Radiation hardness of the ITkPixV1 and RD53A chips

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The ITkPixV1 chip is the pre-production pixel readout chip for the Phase-2 Upgrade of the ATLAS experiment at the HL-LHC. The harsh environment of HL-LHC, including a peak luminosity of 5x10ˆ34cm-2s-1 and an estimated total ionising dose (TID) of more than 500 Mrad throughout its lifetime is placing strong requirements on the radiation tolerance of the chip. This contribution outlines investigations into the radiation tolerance of ITkPixV1. The impact of TID damage to the digital and analog front-end up to total doses of 1 Grad (at dose rate 4 Mrad/h) is reported.

Summary (500 words)

The ATLAS experiment at the LHC will upgrade its entire tracking system around 2026 in preparation for the High Luminosity LHC (HL-LHC). This includes a new system of five layers of silicon pixel detectors, which will face the challenges of an increase in pile-up and luminosity by an order of magnitude. The new inner tracker (ITk) will consist of hybrid pixel detectors with smaller pixel pitch to provide higher granularity and better resolution. It will also include a novel readout chip with increased bandwidth and improved radiation hardness. The chip is designed by the RD53 collaboration, with the latest prototype of the ATLAS readout chip being ITkPixV1, which has 50 x 50 μm pixel pitch and a total of 384 x 400 pixels.

The radiation tolerance of ITkPixV1 can be studied in irradiation campaigns. The chip is equipped with ring oscillators to characterise the radiation damage on digital circuits. In this contribution, the TID damage to the ring oscillators up to total doses of 1 Grad at a dose rate of 4 Mrad/h is discussed, as measured in irradiations using X-rays with energies between 10 and 30 keV. The irradiations are performed at a temperature of -10 C, and no annealing is considered, as the chip is kept cold. Results from low dose rate irradiations using X-rays and electrons from Kr-85 are also presented. The impact of metallisation layers on the chip on the delivered dose is discussed. The effect of radiation damage on the analog front-end is also reported, by studying the threshold dispersion with irradiation and the performance of the analog front-end at 400 Mrad and 1 Grad.

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