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P2.15: The impact of individual cosmic rays on a DEPFET spectroscopic X-ray imager for space telescopes

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For the Wide Field Imager of the Athena X-ray space telescope, a DEpleted P-channel Field Effect Transistor (DEPFET) sensor was chosen. In a dedicated development phase, the DEPFET has been optimised for the mission objectives. ESA's Athena mission has been designed to investigate the hot and energetic universe, represented by the large-scale structures of galaxy clusters and the densest objects of the universe, black holes. Athena comprises two scientific instruments—provided by the European X-ray astrophysics community. A cryogenic integral field unit, the X-IFU, provides an excellent energy resolution of a few eV over the entire energy range of 200 eV to 15 keV. Wide field imaging capabilities are added by the WFI instrument with its large detector array consisting of four 512 × 512 pixel sensors with pixels of 130 µm edge length. The chosen DEPFET active pixel sensor enables significantly higher readout speeds compared to previous missions that had similar detectors using pnCCDs while conserving the Fano-limited spectral performance. The sensor bases on a fully depleted silicon bulk. It enables a high quantum efficiency for X-ray photons even at an energy of 10 keV and above. A field effect transistor is the first amplification and readout node. Below its transistor channel, a potential minimum for electrons is implemented. Electrons generated by an incident photon are collected there and influence the conductivity of the transistor channel proportional to their number. This is why it is called Internal Gate. The change in the transistor current is a measure for the energy of the incident photon. The measurement is non-destructive. Afterwards, the collected charge can be removed via clear contacts at both sides of the DEPFET gate.

While the detection of photons in the energy range of 200 eV to 15 keV is the purpose of the sensor, the harsh environment of space creates additional challenges for radiation detectors to be operated there. High energetic particles not only degrade the sensor performance over time. Individual particles create effects that need to be considered. Large amounts of charge carriers may switch on a DEPFET pixel unintendedly. Due to the limited resources on a space observatory, a rolling shutter readout has been chosen for the Wide Field Imager. In this row-wise readout, a switched on pixel may affect an entire sensor column. To investigate the immediate influence of high energetic particles, we irradiated the sensor with different sources. With an infrared LED, the capacity and the temporal behaviour of an Athena WFI DEPFET pixel
was examined. To get a more realistic representation, alpha particles from an americium source and protons measured in the non-clinical research program of MedAustron were investigated. The results of these measurement programs will be presented in this work.

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