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Mapping High Energy Particle Population in Earth's Magnetosphere Using Augmented Star Trackers

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The ESA Swarm mission, launched on 22 November 2013, consists of three spacecraft each equipped with a Micro Advanced Stellar Compass (μASC) designed and validated by the Technical University of Denmark (DTU). Each Star Tracker features three Camera Head Units (CHUs) orientated orthogonally to avoid simultaneous blinding. The CCD sensor inside the star tracker is sensitive to energetic particle irradiation which appear as transient bright pixels dubbed 'hot spots' on the source images.

Conventionally hot spots are removed to support nominal attitude operation, however in February and March 2018 software was uploaded to the μASCs on-board Swarm, which in addition to using the hotspot measurements to improve the star tracking is moving the measured hotspot data to the telemetry to ground. This added functionality, enables detection and monitoring of high energy particles.

In this work we present processes and analysis of the high energy radiation data obtained from the Micro Advanced Stellar Compass (μASC) on board ESA's Swarm mission, from February 2018 to end of 2021. Taking advantage of three years of data, high sample rates (1-2 Hz), the beneficial orientation of the camera heads and simultaneous measurements from all three spacecraft it is possible to determine spatial and temporal derivatives of the electric and magnetic fields. Furthermore, since the Swarm spacecraft are in near-polar orbits at an altitude of 450-510 km above Earth's surface the spacecraft continuously monitor and map high energy particles at the South Atlantic Anomaly (SAA) of relevance for future mission planning as well as provide detailed time-radiation relations from charge injection processes from e.g. CMEs.