The Swarm mission high energy particle flux investigation

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Introduction

Swarm mission constellation, launched into orbit on November 22, 2013, consists of three satellites that precisely measure magnetic signal of the Earth using the ASM and VFM, integrated with three Advanced Stellar Compass star trackers cameras. By using a minimum of magnetic material close to the magnetometer sensors (optimal for the magnetic measurements), the resulting shielding is insufficient to stop the more energetic part of the particle flux encountered in the Swarm constellation orbit, where protons above 60 MeV and electrons above 10 MeV may penetrate to the focal plane detectors.

To eliminate the ASC cameras sensitivity to passing energetic particles, the ASC employ a suite of morphological filters removing the effects from such particles before the stars observed are matched to the onboard catalogue. The efficacy of these filters is high enough to ensure full performance even during the most intense CMEs, moreover, the measured rate of these penetrating particles, effectively monitors the high energy particle flux. Since May 2018, the spacecraft thus have sent the measured fluxes to ground, enabling very precise map of this part of the energetic flux.

Ionizing particles in the Swarm orbits

- Silicon carbide structure and metal CHU housing provides shielding length of >35 mm Al eq. in all directions except through the lens
- Lens shield length is 23-35 mm Al eq.
- < 100 MeV omnidirectional sensitivity
- Particles > 150 MeV penetrates omnidirectionally

Particles flux for Swarm spacecrafts

- Swarm mission profile: Two spacecraft at ~450 km (A and C) and one at 530 km (B) to provide lateral and radial gradients
- Solar quiet times flux: Few protons and no electrons fluxes with penetrating energies, except from over the South Atlantic Anomaly
- Shielded flux for 20 mm Al Shielding (from SPENVIS), incl. trapped and solar protons, <10 p/cm²/s
- Field of view (in steradians) should be taken into account. Quiet time flux will result in a few p/cm²/s
- Peak flux conditions several thousand times higher

Swarm Integral Proton Flux East-West gradient

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- Swarm mission high energy particle flux investigation

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micro Advanced Stellar Compass μASC

- Designed and produced by the Measurement and Instrumentation (DTU)
- To date one of the most successful star tracker worldwide
- Autonomous calculates attitude based on all bright stars in the CHUs
- Running a single CHU, μASC can provide 22 true solutions per second
- Absolute accuracy of < 1 arc second
- Operating on many satellite missions without a single hardware or functional failure

Highlights

- Global map of p in 40 MeV to 100 MeV
- The radial and East-West particle flux gradient
- Seasonal variations in high energy flux
- Scatter times of protons migrating from trapped to SAA loss cone

References