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Publication date: 2018

Document Version
Publisher's PDF, also known as Version of record

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Citation (APA):

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The high energy particle flux distribution of Jupiter measured by the ASCs of the Magnetometer Investigation

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Introduction
The Juno mission offers an excellent opportunity to study the flux and distribution of very high energy particles moving in the Jovian magnetosphere. The Magnetometer Investigation is equipped with two star trackers collocated with each of the two vector magnetometers at the end of one of the solar panels. The primary objective for the star cameras is to provide accurate attitude recovery data for the magnetic mapping mission. The star trackers were provided with limited shielding, which in turn result in sensitivity to >1 MeV electrons and 85 MeV protons.

The star trackers, reporting the number of particles penetrating to the CCD at 4Hz, thus realize a very high energy particle detector.

Micro Advanced Stellar Compass µASC
- Designed and produced by the Measurement and Instrumentation Systems (DTU)
- one of the most successful star tracker worldwide
- autonomously calculates attitude based on all bright stars in the CHUs Field of View
- provides 22 true solutions per second with one single CHU
- absolute accuracy of < 1 arc second
- operating on many satellite missions without a single hardware or functional failure

Calibration
The µASC response to the high energy irradiation is fully calibrated using 1-2 MeV electron and 30-200 MeV+ proton irradiation with varied incidence angle, flux, dose rate, temperature, TID, and DDD doses.

Calibration test setup mounted inside the thermal chamber consist of a pre-irradiated notateable CCD under test, the star stimulator optics and grating, and a movable Sr90 e source.

The shield-depth of the CCD sensor onboard Juno is analyzed using a Monte Carlo simulator. Here red rays show where materials are traversed.

Image analysis. Deposited energy
A track left by an energetic particle that hit the CCD is ~50 pixels long (~0.7 mm or 160 mg/cm²) and has 4 or 5 splits due to recoil nuclei produced by the incident particle in silicon.

Estimation of the primary energy of a particle that could traverse at least 0.7 mm in Si behind the heavy shielding will involve the transport flux modelling for the µASC, the calibration curves of the CCD and infilt image analysis.

Moons and Radiation
The flybys of Juno orbiting Jupiter in highly elliptical have a period of about 53 days (left, in J2000). The Juno orbit in SII coordinates (right) shows the effect of Jupiter’s rotation period (~10h).

Juno’s crossing of the magnetic field lines which intersect the Jovian moon orbits is shown. These crossings are correlated with observations of the µASC particle counter.

Jovian magnetic field
Jupiter’s magnetic field model (JRM09) by Connerney (2018) describes the field with spherical harmonics up to degree 10. It is based on measurements performed near Jupiter by the Juno mission. The JRM09 model shows a more complex Jovian magnetic field in comparison to earlier models (eg, VIP4), and a clear asymmetry within the northern and southern hemispheres. For larger distances to the planet (>10RJ), the magnetic field can be represented well by a 10.5" tilted magnetic dipole and there is no apparent differences wrt VIP4 model.

Discussion
We have calibrated and demonstrated the use of the µASC as a high energy particle detector in the Jovian magnetosphere. As the forthcoming Juno flybys will cover more spatial regions near Jupiter, we expect to build a model of the high energy electron radiation environment near the planet solely based on the data from the star trackers.