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MARIE Solar Quiet Time Flux Measurements of H and He Ions below 300 MeV/n

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The Martian radiation environment has been directly observed by the MARIE charged particle spectrometer aboard the 2001 Odyssey spacecraft. Odyssey left Earth April 7th, 2001, arrived at Mars on October 23rd, 2001, and was placed in a stable circular orbit in March 2002. The MARIE instrument took data from April 23rd, 2001 until August 11th, 2001 when an anomaly occurred. The instrument was recovered in March 2002, and resumed taking data until late October 2003, when the Halloween SPE, is presumed to have caused the instrument to fail. Since then, the entire quiet time data set has been analyzed, and a summary of the MARIE measured fluxes of the H and He ions will be presented.

1. Introduction

Cosmic rays (CR) present one of the most challenging problems to overcome in human space flight safety. Given the current NASA goals it is a problem that must be understood for each destination that humans will explore. The MARIE instrument was designed to measure the radiation from charged particles in Mars orbit. MARIE was launched aboard the 2001 Odyssey spacecraft on April 7th, 2001. The first phase of operation from late April to early July was an engineering phase of adjusting the operational parameters in order to meet required data rate constraints. In mid-August an anomaly occurred which locked the instrument, and kept it from responding to commands. The instrument was turned off until the Odyssey spacecraft reached its 400 km altitude circular orbit about Mars, in March 2002. MARIE gathered data from March 2002 through October 2003, when the large Halloween solar particle event (SPE) is suspected to have caused irreversible radiation damage.

The MARIE instrument is a silicon detector telescope with a geometry factor of 3.2 cm^2-sr, which is defined by the trigger detectors A1 and A2. These A detectors are 30 mm square by 1 mm thick and are positioned as shown in Figure 1. There are also four B detectors (B1, B2, B3, B4), which are 5 mm thick cylindrical lithium drifted silicon detectors with a physical diameter of 63.5 mm and an active diameter of 58.4 mm. The information provided by these six detectors are all that was used in this analysis. The MARIE instrument is described in greater detail in [9].

2. Discussion

In this paper, we are interested in presenting the H and He fluxes, as measured by the MARIE instrument in Mars orbit, during solar quiet times. Therefore, the time periods when there were flux enhancements, due to SPEs, were removed from this analysis. These time periods were selected by using ACE and MARIE, data [2]

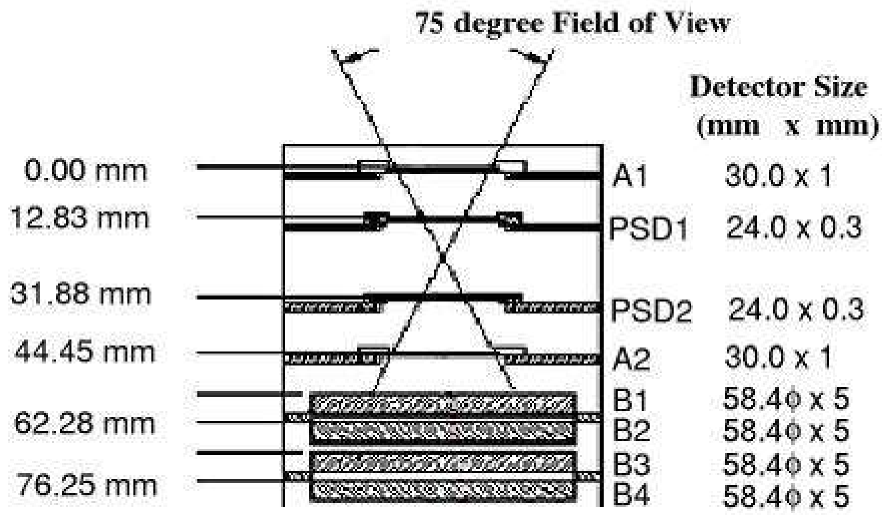

Figure 1. The MARIE detector stack.

and are listed in Table 1. Particles that arrive from a backward moving direction (traveling from B4 up toward A1) were also removed from this data set.

Table 1. List of selected as solar quiet times.

Year	Day of Year Range
2002	126-140
2002	162-182
2003	1-75
2003	80-96
2003	100-110
2003	120-147
2003	176-230
2003	233-294

The particle flux ϕ for an energy range ΔE is

$$\phi(\Delta E) = \frac{N_D(\Delta E)}{G_F t \Delta E} \frac{1}{\epsilon_s \epsilon_t} \tag{1}$$

where $N_D(\Delta E)$ is the number of ions in the data within the energy range ΔE, G_F is the geometry factor, t

is the time over which the measurement was made, ϵ_s is the data selection efficiency determined from a full FLUKA [4, 5] Monte Carlo simulation, and ϵ_t is the dead time correction [7, 6].

The resulting proton and He fluxes are shown in Figure 2. The first five energy bins are defined by the geometry. That is the energy at which each ion stops in A2, B1, B2, B3, and B4 respectively. The following energy bins are each 10 MeV/n wide. The A detector data are only used for particle identification for the first two bins.

Also shown in Figure 2 are the ACE/SIS helium data [1] over the same time period listed in Table 1, with the solar enhancement time periods removed. The updated Badhwar-O'Neill model [8] predictions, for the near Earth radiation environment, are shown as solid lines on the same figure for the time period of March 21,2002 through October 31, 2003.

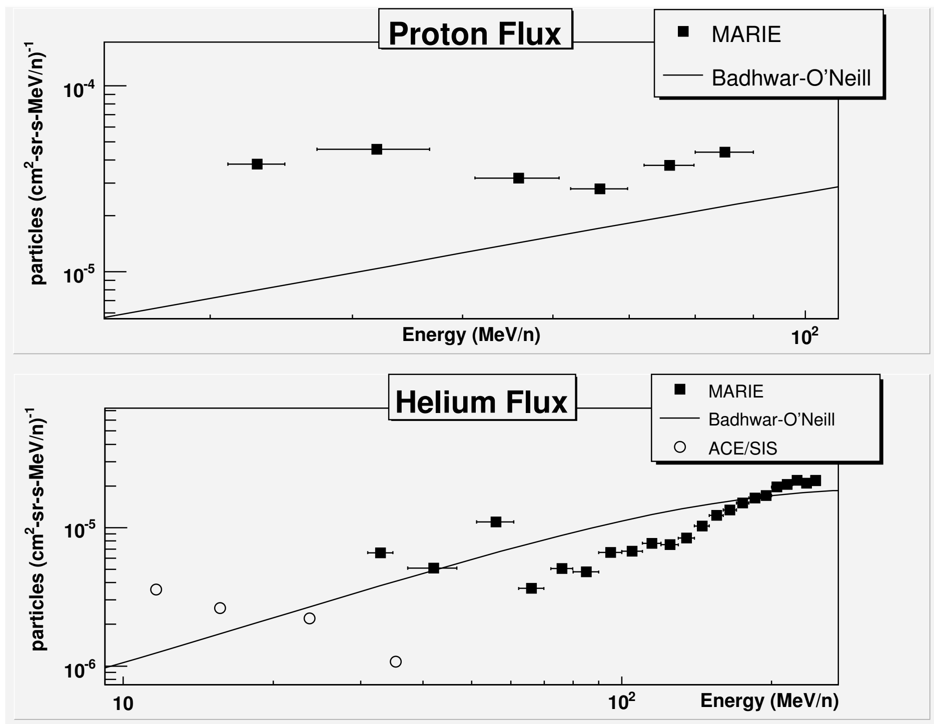

Figure 2. H and He particle fluxes measured by MARIE.

3. Conclusions

The MARIE data set has been analyzed during solar quiet times, and the H and He ion fluxes have been presented. The proton flux measured by MARIE is about a factor of two higher in Mars orbit versus the Badhwar-O'Neill model predictions for low-Earth orbit (LEO). The MARIE He flux is slightly higher than the ACE/SIS data, at the energies the two data sets overlap, and the Badhwar-O'Neill model is fairly consistent with the He data. The up-turn at the lower energy may be due to secondaries as shown in [3], but further investigation is needed to be certain. We do not expect the ACE or the Badhwar-O'Neill model to match the data exactly, but it is a good check to ensure the flux measurements are reasonable.

4. Acknowledgements

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