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Update of the radiation environment measurement results aboard ExoMars TGO in May 2018-June 2020

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Abstract

The dosimetric telescope Liulin-MO [1] for measuring the radiation environment onboard the ExoMars TGO is a module of the Fine Resolution Epithermal Neutron Detector (FREND) [2].

Here we present recent results from measurements of the charged particle fluxes, dose rates and estimation of radiation quality factors and dose equivalent rates at ExoMars TGO science orbit (circular orbit with 400 km altitude, 74^0 inclination, 2 hours orbit period), provided by Liulin-MO dosimeter from May 01, 2018 to June 10, 2020.

Since now the dosimeter has measured the dosimetric parameters of the galactic cosmic rays (GCR). Solar particle events were not registered. The measurements were taken during the declining and minimum of the Solar activity in 24^{th} Solar cycle.

Compared are the time profiles of particles and neutron detections from Liulin-MO, FREND/TGO and HEND/Odyssey [3] measured for the period May 2018 –December 2019.

Liulin-MO contains two dosimetric telescopes arranged at two perpendicular directions [1]. The parameters, provided by Liulin-MO simultaneously for two perpendicular directions have the following ranges: absorbed dose rate from 10^{-7} Gy h^{-1} to 0.1 Gy h^{-1}; particle flux in the range 0 - 10^4 cm^{-2} s^{-1}; energy deposition spectrum and coincidence energy deposition spectrum in the range 0.08 - 190 MeV.

Similar to FREND, HEND/Odyssey is a neutron spectrometer based on ^{3}He proportional counters but with smaller sensitivity and without collimation as in FREND [3], [4].

The fluxes and dose rates recorded in the perpendicular detectors B(A) and D(C) of Liulin-MO and count rates of Oulu neutron monitor (http://cosmicrays.oulu.fi/) for the period from 1 May 2018 to 10 June 2020 are shown in Figure 1. An increase of all quantities – flux, dose rate and Oulu count rate due to solar cycle modulation is observed. In this period in two perpendicular directions B(A) and D(C) the average values are: dose rate 14.8±1.5/15.4±1.5 microGy h^{-1}, planar flux 3.11/3.21 cm^{-2} s^{-1}, quality factor Q 3.5±0.26, dose equivalent rate 1.61±0.33/1.66±0.34 mSv d^{-1}.

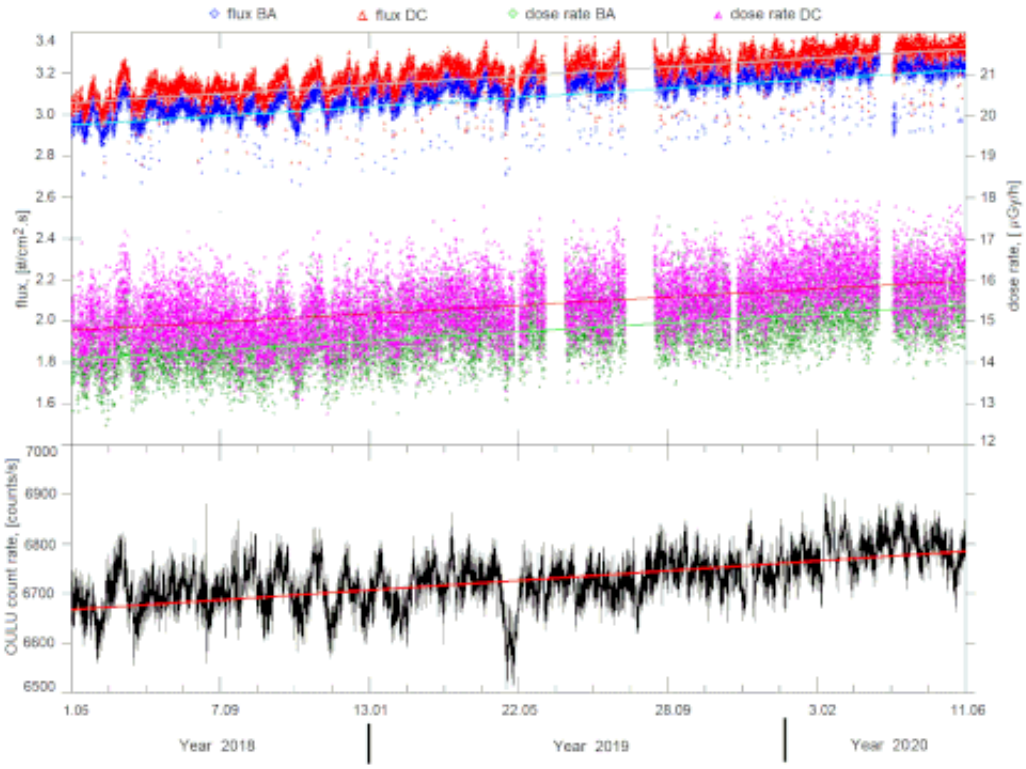

Figure 1. Overview of GCR fluxes (top) and dose rates (middle) measured by Liulin-MO in Mars science orbit and Oulu neutron monitor count rates (bottom) in the period 01.05.2018 – 10.06.2020

In Figure 2 is shown the comparison between the normalised (relatively to the mean daily value for the full period) daily mean Liulin-MO data and HEND data accumulated in energy channels 1 – 8, most sensitive to the charge particles of GCR. These profiles demonstrate good correlation both on a short time scale (days) and long term scale (months). The total amplitude of variations observed during 20 months of TGO mapping is about 8%. Figure 3 presents the comparison between the normalised FREND total counts rate and HEND data accumulated in the energy channels 9 – 16, mostly populated with counts from Martian neutron albedo (which is produced by GCR by interaction with matter in the shallow subsurface). These curves also show high correlation with each other both on short and long term scales.

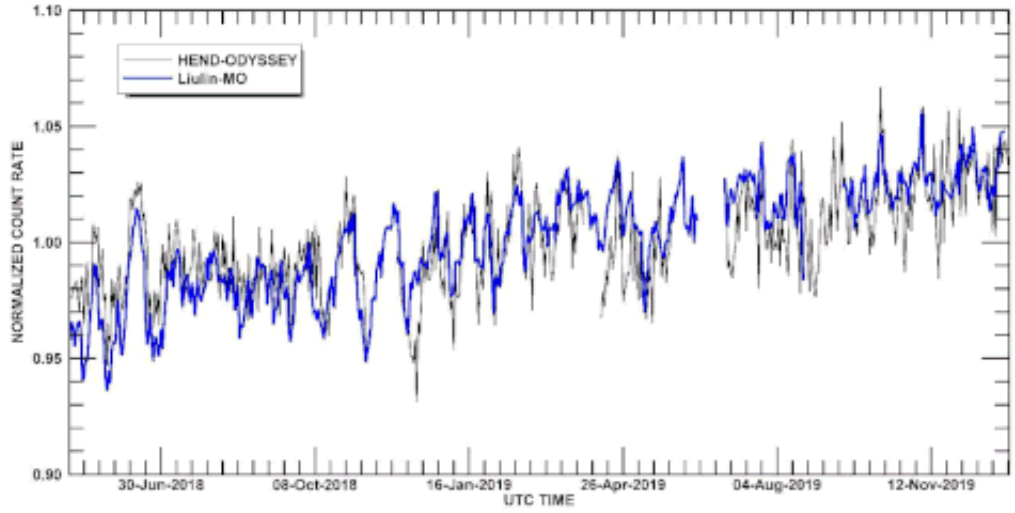

Figure 2. Time profiles of GCR daily variations measured by Liulin-MO and HEND/Mars Odyssey during May 2018 – December 2019

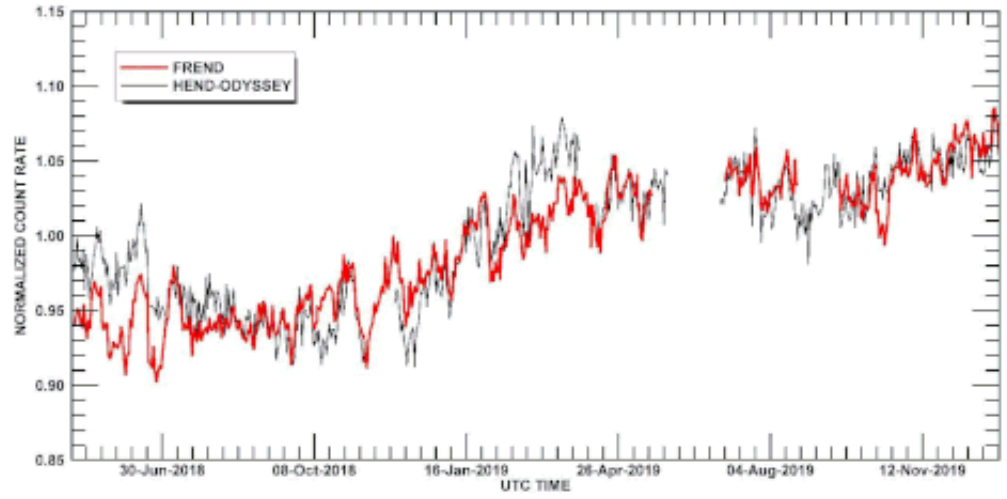

Figure 3. Time profiles of Mars neutron albedo variation measured by FREND and HEND/Odyssey during May 2018 – December 2019

The obtained data from May 2018 to April 2019 show that 1) An increase of the dose rates and fluxes is observed from May 2018 to March 2020 which corresponds to the increase of GCR intensity during the declining of the solar activity. From March to June 2020 the measured values are practically equal, corresponding to the minimum of the solar activity; 2) The time profiles of GCR daily variations measured by Liulin-MO and HEND demonstrate good correlation. The comparison between the normalised FREND total counts rate and HEND data accumulated in the energy channels mostly populated with counts from Martian neutron albedo also show high correlation with each other. The difference in the long term variations between the profiles of GCR and neutron albedo might be addressed to how the solar modulation changes directly the GCR flux and how it changes emission of neutron albedo by interaction with a matter in the Martian shallow subsurface.

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