Space Weather

Supporting Information for

Long-Term Observations of Galactic Cosmic Ray LET Spectra in Lunar Orbit by LRO/CRaTER

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Introduction

As Supporting Information for the above paper, we present the cuts devised as discussed in Section 2.2 to subtract out-of-aperture background from the observations of the LET spectrum for GCR ions passing through the CRaTER detector stack from D1 through D6. These are spelled out in Text S1 as logic statements ("IF D4 > 1.7 AND…") that select the particle events accepted for inclusion in the LET spectrum, so that readers of the paper have a record of the cuts that were applied to simulated particle events in Section 2.2 and to sensor data in Section 3.

We also include Movie S1, which animates the changes in the observed LET spectrum over the complete solar activity cycle that has elapsed from the start of the LRO mission in 2009 to this writing in 2020. Each frame of the movie shows the spectrum for one six-month period, with the corresponding time highlighted in an accompanying plot of the 27-day averaged sunspot number extracted from NASA/GSFC's OMNI dataset through OMNIWeb. Spectra are multiplied by the square of the abscissa to compress the dynamic range and make changes more readily visible; units are labeled "LET" rather than "normalized energy deposit" as in the main text, to facilitate reuse without having to quote the explanation of the latter term given in Section 1.

Text S1.

The following is an enumeration, for the record, of the cuts that were used in this work to select particle energy-deposit events that should be counted in the LET spectra, phrased as logic statements the aggregate result of which must be TRUE in order for an event to be accepted. In what follows, Dn refers to the normalized energy deposit in detector n for each recorded particle event, in units of keV/μm as used throughout the Figures.

For the D5 portion of the LET spectrum, which we used above 20 keV/μm (the subset of the cuts in *italics* is that illustrated in Figure 3):

(
    (
        (D5 < 10 OR D4 > 1.7)
        AND
        (D5 < 25 OR D2 > 4)
        AND
        (D5 < 100 OR D2 > 15)
)
    OR
    (D5 > 10 AND D4 < 1.7 AND D2 < 0.6)
)
AND
(D2 > 10 OR 3 * D2 + 4 > 2 * D4)

For the D6 portion of the LET spectrum, which we used below 20 keV/μm:

(
    (
        D2 > 4
        OR

```
            D6 < 10 * D2 - 27.5
            OR
            2 * D6 < 5 * D2 – 4
            OR
            D6 < 4
            OR
            D6 + 10 * D2 < 22.5
            OR
            D2 < 1.6
        )
        AND
        D2 > 0.45
        AND
        (D2 > 4. OR D6 < 13)
        AND
        (D2 > 0.9 OR 10 * D2 > D6 + 6 OR D6 < 2 OR 5 * D2 + D6 < 4.75)
        AND
        (D2 > 10 OR 3 * D2 + 4 > 2 * D4)
        AND
        (D2 < 2.5 OR D4 > 3 OR D2 < 12 * D4 - 9.5)
        AND
        (D4 < 3 OR D6 > 4 OR 9 * D6 > D4 + 6)
)
OR
(
        D2 < 0.45
        AND
        (D4 < 0.7 OR D4 + D6 < 2.7)
)
```

Movie S1.

Animation of the changing LET spectrum observed by CRaTER over a complete solar activity cycle. Each frame of this movie corresponds to one of the six-month periods in Figure 6. The background-subtracted LET spectrum for that period is shown at right, while at left the same period is highlighted in a time series of the 27-day averaged sunspot number. As in Figure 7, the LET spectra are multiplied by the square of the abscissa to compress the dynamic range. The three time periods whose spectra are shown in Figure 7 are highlighted in the same colors as in that Figure, showing the extremes of spectral variation over the solar cycle.