The Lunar Lander Neutrons & Dosimetry (LND) Experiment on Chang’E4

1. Abstract

The Lunar Lander Neutrons & Dosimetry experiment (LND) is part of the payload of the next Chinese lunar mission, Chang’E 4, which will land on the far side of the Moon towards the end of 2018. The mission consists of a lander, a rover, and a communication relay. The LND instrument will be accommodated on the Chang’E 4 Lander and has two major science objectives: 1) dosimetry for human exploration of the Moon and 2) to contribute to heliospheric science as an additional measuring point. To achieve the first objective, LND is designed to measure time-averaged dose rate and of linear energy transfer (LET) spectra in the complex radiation field of the lunar surface. For the second objective, LND is capable to measure particle fluxes and their temporal variations and thus will contribute to the understanding of particle propagation and transport in the heliosphere. Its stack of 10 silicon solid-state detectors (SSDs) allows to measure protons from 10-30 MeV, electrons from 10-30 MeV, and heavy ions from 15-40 MeV/n. In addition, LND can measure fast neutrons in the energy range from 1-20 MeV and, using two Gd-sandwich detectors, measures fluxes of thermal neutrons, which are sensitive to subsurface water and important for understanding lunar surface mining processes.

2. Instrument Concept

The zenith-pointing LND is mounted inside the payload compartment of the Chang’E 4 lander and consists of a thermally decoupled sensor head and an electronics box (see Figs. 1 and 2). The sensor head consists of a stack of 10 SSDs (Fig. 4) as well as two Printed Circuit Boards (PCBs). One PCB is used to pre-activate the signal detectors, while the other PCB contains shaper circuits and the Analog to Digital Converters (ADCs). These digitized signals are sent from the sensor head to the electronics box via a coaxial cable. The data from the electronics box is recorded using a TAOS-4800 and is received on the lander using a 650 s relaxation time. The raw data of LND is processed by LND on board and telemetered to Earth via an Earth-Moon L2 relay satellite. LND data products and their metadata will be provided to the lunar regolith science, as well as heliophysics.

3. Measuring fast neutrons

Fast neutrons are generated by the interaction of the galactic cosmic rays with the lunar regolith and are an important source of the radiation dose received by the crew and the equipment existing in an astronaut’s body. LND uses three segmented Si SSDs which are combined as two detection planes. One SSD is for cosmic-ray background rejection, the other two SSDs detect fast neutrons. The innermost segment of the C detector in Fig. 3, C1, measures neutral radiation in anti-coincidence with all outer segments (B1, B2, B3), LND’s response to neutral radiation (n, γ) is shown in Figs. 7 and 8.

4. The Sensor Head Design

LND is largely based on developments which were made for the Ionizing Radiation Sensor (IRAS) in an early phase of Exomars. As shown in Fig. 4, LND is basically a telescope consisting of three segmented SSDs (A-J). Three detectors (B, C, and D) are packed as close together as possible to measure neutrons in the energy range 1.20 MeV (see section 3). The lower six detectors (E-L) are mounted in two different sandwich configurations: in each sandwich, the Gd foils are placed from above, respectively below. The Gd-based sandwich is a copy of the IRAS BC-sandwich and serves as the final detector in the stack. J detector serves as an anti-coincidence telescope to discriminate neutrons from above and penetrating particles from below. The opening angle of the LND FOV is determined by the inner segments of detectors A and B and the outer segment of detector J as sketched in Fig. 4. Geometry factors for various detector combinations are included below.

5. Geant4 Simulations

As discussed in section 3 LND measures fast neutrons by using an anti-coincidence of C1 with B1, B2, B3, and D. This, if only the C1 segment is triggered, this was due to a neutron or gamma, because both of them interact weakly with the Si-nuclei in the detector compared with charged particles, e.g., protons and electrons. The expected spectrum of neutral radiation energy deposits in C1 shown in Fig. 6 was obtained using a GEANT4-model of the lunar surface neutron and gamma spectra folded with the LND IRF. It is dominated by neutrons for energy deposits above 1 MeV.

6. Data Products

The raw data of LND is processed by LND on board and telemeasured to Earth via an Earth-Moon L2 relay satellite. LND data products and their metadata will be provided to the lunar regolith science, as well as heliophysics. After receipt on ground, instrument response functions will be applied to the data, and visualizations will be performed at CAU and NISSE. LND data will be made available to the scientific community via the usual channels.

Acknowledgments:

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