NILS Mission Science Data User Guide

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CHANGE RECORD

Version		Date	Changed Paragraphs	Remarks
Issue	Rev			
1	0	2025-02-11		New document
1	1	2025-04-03	4	Landing coordinates and attitude added.

DISTRIBUTION

Abbreviation	Full name
ESA	European Space Agency, The Netherlands
IRF	Swedish Institute of Space Physics, Sweden

TABLE OF CONTENT

1 INTRODUCTION

This document describes the science data obtained by the Negative Ions on the Lunar Surface (NILS) Proto-Flight Model for the Chang'e 6 lander.

2 REFERENCES

[R1] NILS instrument description: R. Canu-Blot, M. Wieser, M. K´er´enyi, S. Barabash, X.-D. Wang, T. Maynadi´e, A. Zhang, W. Wang, N. Melville, Q. Wang, Y. Zou, H. Dou, H. Zhu, V. Alatalo, A. Edstr¨om, L. Kalla, S. Karlsson, M. Oja, J. Olsen, J. Peterson, D. St˚alnacke, and D. Upton. The Negative Ions at the Lunar Surface (NILS) instrument on the Chang'E-6 mission. Research Square, 2024. Preprint at https://doi.org/10.21203/rs.3.rs- 4718105/v1 (urn:esa:psa:ce6_nils:document:nils_instrument_description)

[R2] Wieser, M., Zhang, A. and the NILS team. (2025). Negative ion mass spectrum from observations by the Negative Ion at the Lunar Surface (NILS) instrument onboard of the Chang'E-6 lunar lander. (Version 3) [Dataset]. Institutet för rymdfysik. https://doi.org/10.5878/v4sy-3t95

3 INSTRUMENT DESCRIPTION

NILS is a time-of-flight based negative ion mass analyzer. An angular deflection system allows to steer the field-of-view of the single viewing direction in a vertical plane relative to the lunar surface. Electrons and negative ions can be separated by their time-of-flight and using a programmable electron suppression magnet.

A detailed instrument description can be found in [R1].

4 OPERATIONS

Chang'E-6 landed on the lunar surface on 2024-06-01 at 153.978°W, 41.638°S based on Chang'E-2 derived coordinates or 153.986°W, 41,638°S based on Lunar Reconnaissance Orbiter derived coordinates.

After landing, the instrument attitude was within +/-2°almost perfectly both vertically and horizontally aligned with the insruments +x axis pointing to nadir and the +z axis horizontal.

The instrument bore-sight (viewing direction alpha = 0° and theta = 0°, see [R1]) is pointing to local North within +/- 2°.

NILS operated for a total of about 300 min on the lunar surface on 2024-06-02 to 2024-06-03. Operations were split in several segments (Figure 1), mainly driven by instrument temperature.

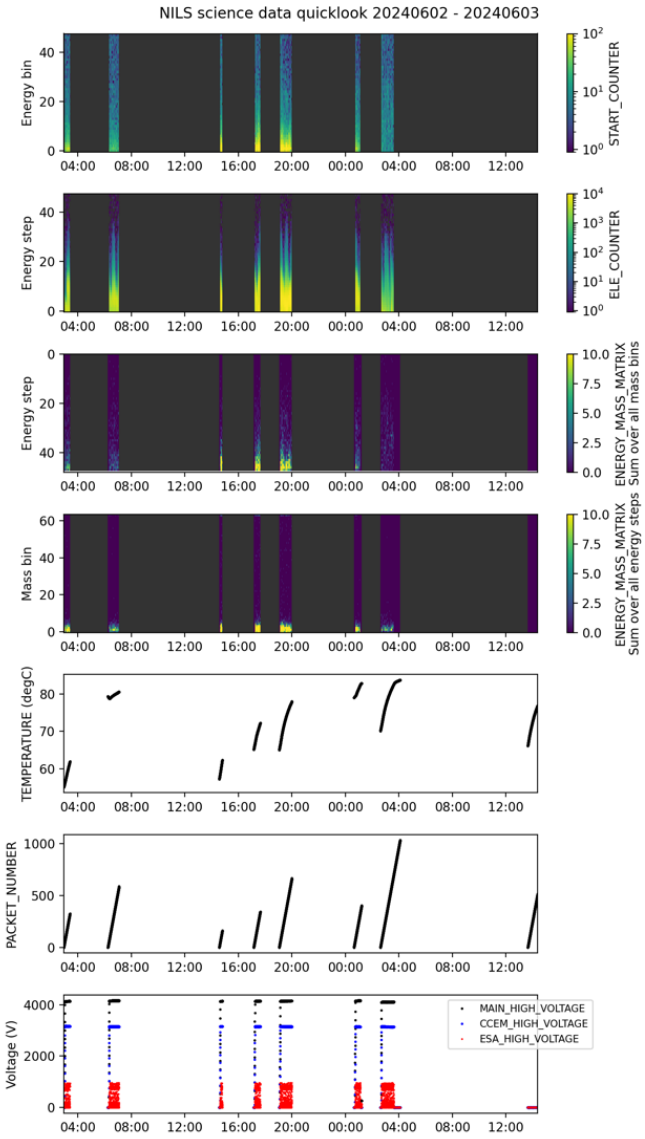

Figure 1 NILS data overview showing all operational segments.

5 DATA

NILS data consists of times series and time independent data. The time independent data (e.g. energy tables, geometric factors, angular viewing directions or mass response functions) are described in [R1]. Where possible, the time series data was processed to physical units. The exception is the particle data itself that is expressed in counts per integration interval - this to enable statistically proper treatment of small signals.

The time dependent data is organized by measurement cycles. The cyclogram is shown in Figure 2 (from [2]). Each cycle covers a single elevation direction (or elevation step) and contains an energy sweep with the electron suppression magnet off (e) and an energy sweep with the electron suppression system on (i).

Mass resolved negative ions and electron data is contained in the variable ENERGY_MASS_MATRIX (see Table 1 below). The separation into different masses is not straight forward due to the overlapping of the individual mass responses and the low count rates. The observed mass spectrum can be interpreted as is a linear combination of the mass responses for the different components. The mass responses are described in [R1].

Example code in python to process these data can be found in [R2].

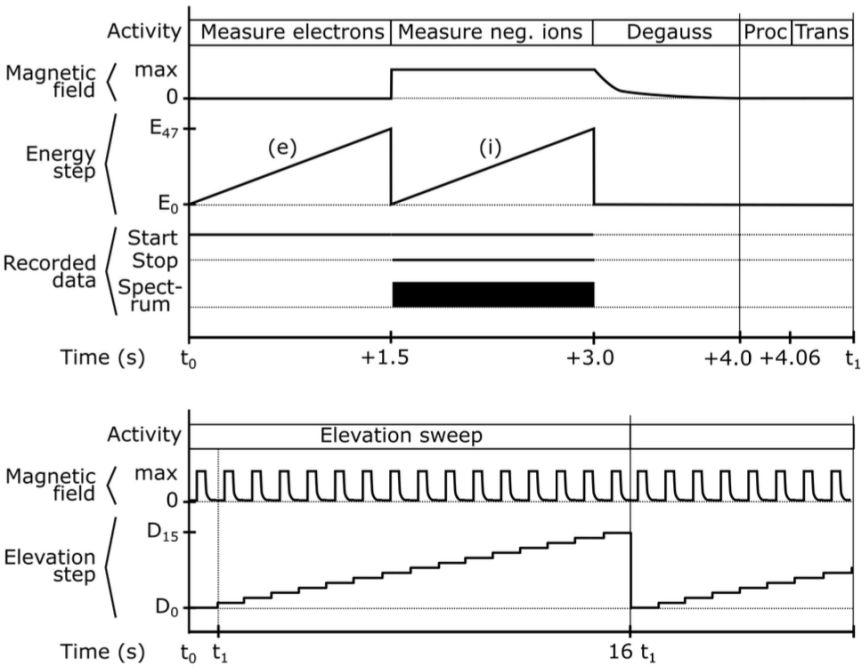

Fig. 2 NILS operation cyclogram. Top panel: Measurement sequence for a single elevation step. During the energy sweep (e) electrons are measured and during the energy sweep (i) the instrument records negative ions. A one second long degaussing sequence for the magnet is followed by 60 ms of data processing and typically one to two seconds of data transmission controlled by the spacecraft data handling unit. Bottom panel: The sequence in the top panel is repeated for each of the 16 elevation steps. The time needed for a complete elevation sweep of $16t_1$ depends on the timing of the data requests from the spacecraft.

5.1 Variables

The data set contains the following time dependent variables. All variables share the same time vector.

Variable name	Type	Unit	Description
DATETIME_UTC	Time	-	Start of data acquisition in UTC for a measurement cycle. This value is based on both NILS internal clocks and spacecraft time synchronization. Estimated accuracy is about 0.5 sec.
PACKET_NUMBER	Integer	-	Data packet number for this measurement cycle. Increases monotonically from zero when NILS is restarted. Decreases in this value indicate a sensor reboot. Increments usually by one but larger increments are also possible.
MODE	String	-	Instrument mode. Always "EXM".
INTEGRATION_TIME	Float	Second	Integration time per energy step. Always 31.25ms per single energy step. This means an single energy spectrum is acquired in 48 * 31.25ms.
DIRECTION_STEP	Integer	-	Direction step number. Each measurement cycle covers a different viewing direction. Possible values are 0 to 15. For mapping of the direction step number to viewing angle see [R1, 4.4.1 Elevation scanning constant].
MAIN_HIGH_VOLTAGE	Float	Volt	Main high voltage in Volts. Data acquisition produces valid results if this value is > 2000V
CCEM_HIGH_VOLTAGE	Float	Volt	Ceramic channel electron multiplier bias high voltage in Volts. Data acquisition produces valid results if this value is > 2000V
ESA_HIGH_VOLTAGE_RAW_REFERENCE	Integer	-	One of the reference values programmed to the electrostatic analyzer high voltage system during the energy sweep. The corresponding energy step is chosen quasi randomly but it matches the energy step from which the ESA_HIGH_VOLTAGE monitor value is obtained. Programmed analyser high voltage raw reference. Physical value = b·x+c Where x = raw value [0x0000; 0x0FFF], b = 0.02345, c = -44.711 The true physical value may drift a few volts due to temperature.
ESA_HIGH_VOLTAGE	Float	Volt	One of the monitor values measured from the electrostatic analyser high voltage during the energy sweep. Unit is Volts. The corresponding energy step is chosen

Variable name	Type	Unit	Description
			quasi randomly but it matches the energy step from which the ESA_HIGH_VOLTAGE_RAW_REFERENCE value is obtained.
TEMPERATURE	Integer	degC	Instrument temperature. The temperature sensor is located about in the middle of the electronics box.
nE	Integer	-	Number of energy bins, always 48
nM	Integer	-	Number of mass bins, always 48.
ENERGY_MASS_MATRIX	Integer [nE * nM]		Energy-mass matrix (coincidence event matrix) with dimension [nE * nM]. For each time-of-flight coincidence event a corresponding mass bin is computed onboard and the corresponding element in this matrix is incremented. The electron suppression magnet is ON when recording these data.
START_COUNTER	Integer [nE]		Start counter matrix with dimension [nE]. Values of the time of flight start counter for each energy step while the electron suppression magnet is ON.
STOP_COUNTER	Integer [nE]		Stop counter matrix with dimension [nE]. Values of the time of flight stop counter for each energy step while the electron suppression magnet is ON.
OVER_COUNTER	Integer [nE]		Over counter matrix with dimension [nE]. Values of the time of flight over counter for each energy step while the electron suppression magnet is ON. The over counter increments when the time-of-flight is longer than 1.6us and no mass bin can be computed.
ELE_COUNTER	Integer [nE]		Start counter matrix with dimension [nE]. Values of the time of flight start counter for each energy step while the electron suppression magnet is OFF. In this configuration mainly electrons are recorded - the contribution from negative ions to the value of this counter is negligible.