Apollo 14 Charged Particle Lunar Environment Experiment (CPLEE)

Instrument Overview

The Apollo 14 Charged Particle Lunar Environment Experiment (CPLEE) was designed to measure the energy spectra of low-energy charged particles striking the lunar surface. It measured the fluxes of electrons and ions with energies from 40 eV to 20 keV. The primary purpose of the experiment was to examine plasma particles originating from the Sun and the low-energy particle flux in the magnetic tail of the Earth. The CPLEE had a mass of 2.7 kg, a stowed volume of 2540 cubic cm, and used 3.0 W power normally and 6.0 W at night when the survival heater was on.

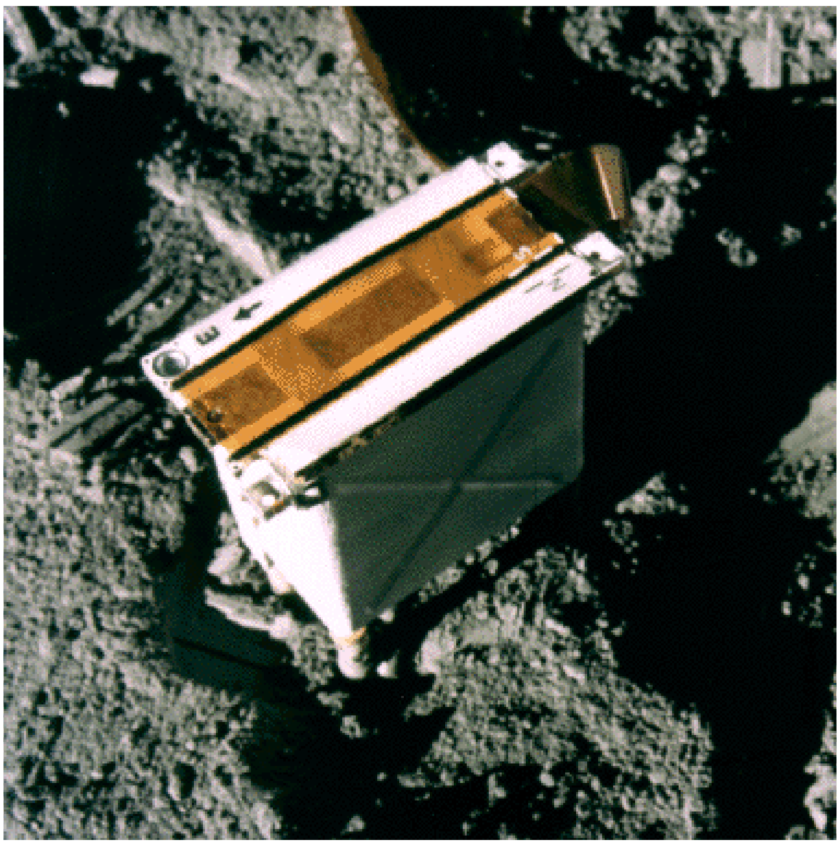

Figure 1 - The CPLEE deployable detector unit

Instrument Description

The CPLEE (Figure 1) consists of box a supported by four legs. The box contains two similar physical charged-particle analyzers, two different programable high-voltage supplies, twelve 20-bit accumulators, and appropriate conditioning and shifting circuitry.

Each physical analyzer contains five C-shaped channel electron multipliers with a nominal aperture of 1 mm each and one helical channel electron multiplier with a nominal aperture of 8 mm. These are shown schematically in Figure 2.

The channel electron multiplier is a hollow glass tube, the inside surface of which, when bombarded by charged particles, ultraviolet light, etc., is an emitter of secondary electrons. In the CPLEE, the aperture of each electron multiplier is operated nominally at ground potential (actually at 16 V), while a voltage of 2800 or 3200 V (selected by ground command) is placed on the other (i.e., anode) end. Thus, if an incident particle enters the aperture and secondary electrons are produced, these are accelerated and hit the walls to generate more secondary electrons, so that a multiplication to an order of 107 is achieved by the time the pulse arrives at the anode. After conditioning, pulses from each electron multiplier are accumulated in a register for later readout as described in the following paragraphs.

As shown in Figure 2, incident particles enter an analyzer through a series of slits and then pass between two deflection plates across which a voltage can be applied. Thus, at a given deflection voltage, the five small-aperture electron multipliers make a five-point measurement of the energy spectrum of charged particles of a given polarity (e.g., electrons), while, simultaneously, the large-aperture multiplier makes a single wideband measurement of particles with the opposite polarity and of simultaneous multiple-spectral samples are considerable in studies of rapidly varying particle fluxes.

In the CPLEE, the deflection-plate voltage in the normal mode is stepped in the sequence shown in Figure 3. As a consequence, the energy passbands shown in Figures 5 and 6 are sampled. Although data acquired by the six sensors are not transmitted simultaneously, the six sensors are connected to six accumulators for exactly the same time (viz, 1.2 sec) and the contents transferred to shift registers for later sequential transmission.

Two analyzers, A and B, point in the directions shown in Figure 4; one analyzer looking in the local vertical direction and one at 60 degrees from vertical toward lunar west. The same deflection voltage is applied to each analyzer simultaneously, with counts from 1.2-sec accumulation time of analyzer A being transmitted while counts from analyzer B are accumulating. Thus, each voltage is normally on for 2.4 sec with the result that the total cycle time is 19.2 sec (fig. 2), when allowance is made for two sample times when the deflection voltage is zero. On one of those two occasions, counts are accumulated as usual to measure background or contaminating radiation. On the other occasion, a pulse generator of about 375 kHz is connected to the accumulators to verify operation.

The command link with the ALSEP provides a variety of options for CPLEE operation. Aside from the usual power commands common to all ALSEP experiments, three commands are provided that allow the normal automatic stepping sequence to be modified. The sequence can be stopped and then the deflection plate supply can be manually stepped to any one of the eight possible levels. This is done to study a particular phenomenon (e.g., low-energy electrons) with higher time resolution (2.4 sec). A second set of commands allows the electron-multiplier high-voltage supply to be set at either 2800 or 3200 V. The higher voltage is used in the event the electron-multiplier gains decrease during lunar operations. A third pair of commands allows the normal thermal control mode to be bypassed in the event of failure of the thermostat, thus offering manual control of the heaters.

The CPLEE apertures are covered with a dust cover to avoid contamination during deployment and, particularly, during LM (Lunar Module) ascent. The dust cover was made doubly useful because a 63Ni radioactive source was placed on the underside over each aperture. Thus, the sensors were proof calibrated on the Moon, and the data compared with measurements made in the same way with the same system when the unit was last calibrated on Earth.

CPLEE was deployed on the lunar surface at lunar coordinates 3° 40' south latitude and 17° 27' west longitude on February 5, 1971. Leveling and east-west orientation to with ± 1° were accomplished by means of a bubble level and sun compass. Analyzer A, therefore, points toward the local lunar vertical and Analyzer B point 60° from vertical toward lunar west. For a first approximation, the detectors may be considered to be pointing in the plane of the ecliptic.

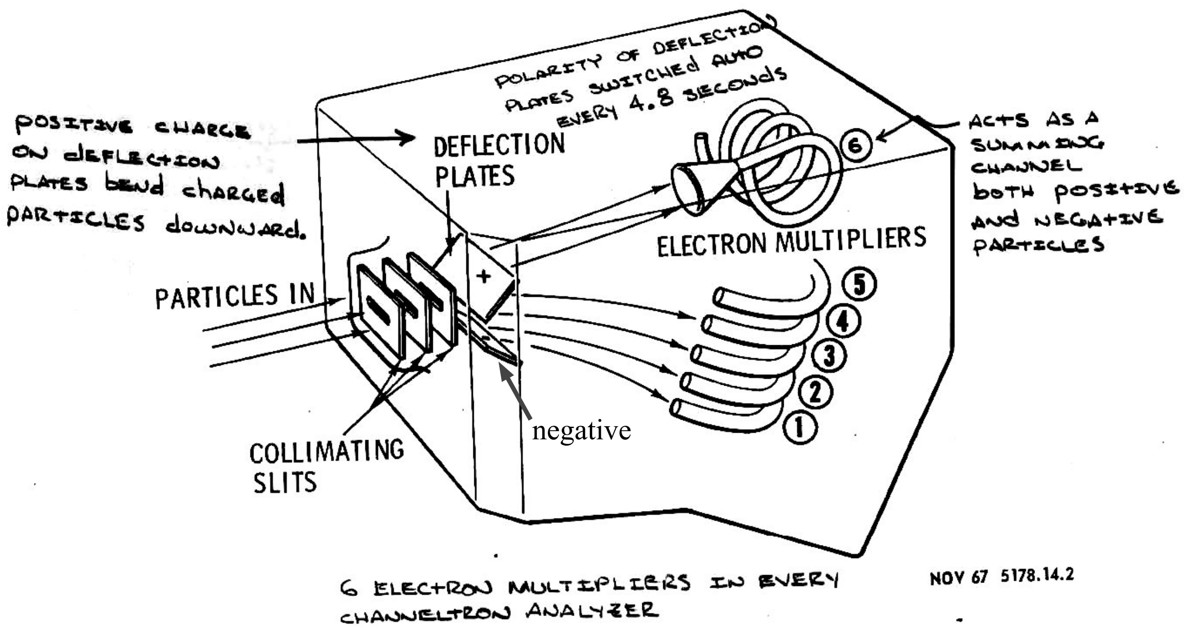

Figure 2: CPLEE Physical Analyzer

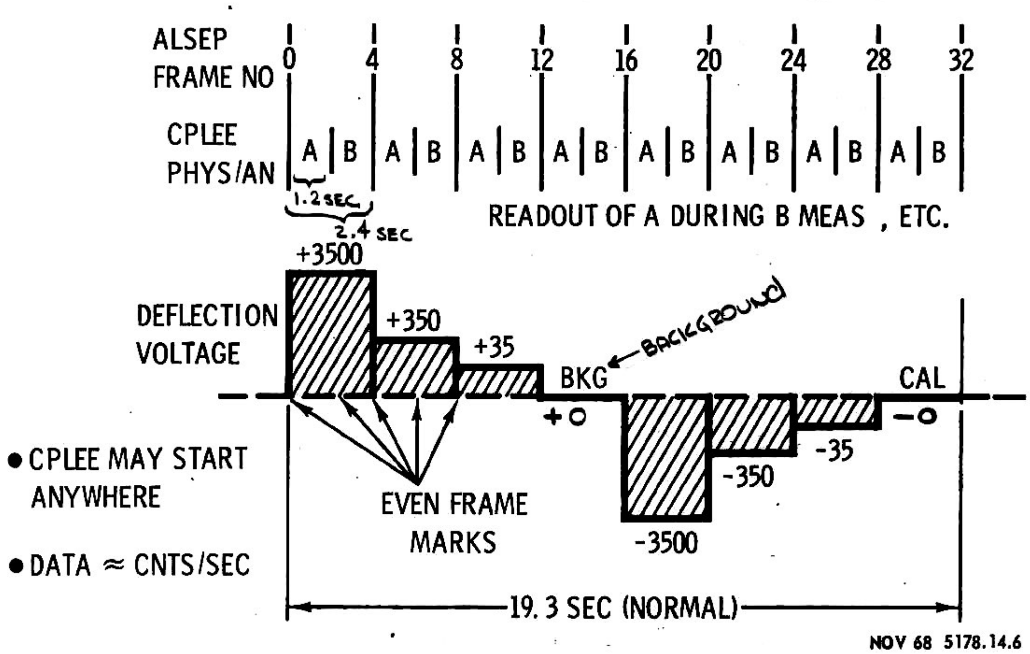

Figure 3: CPLEE Timing Sequence; Data $\approx$ Counts/1.2 seconds

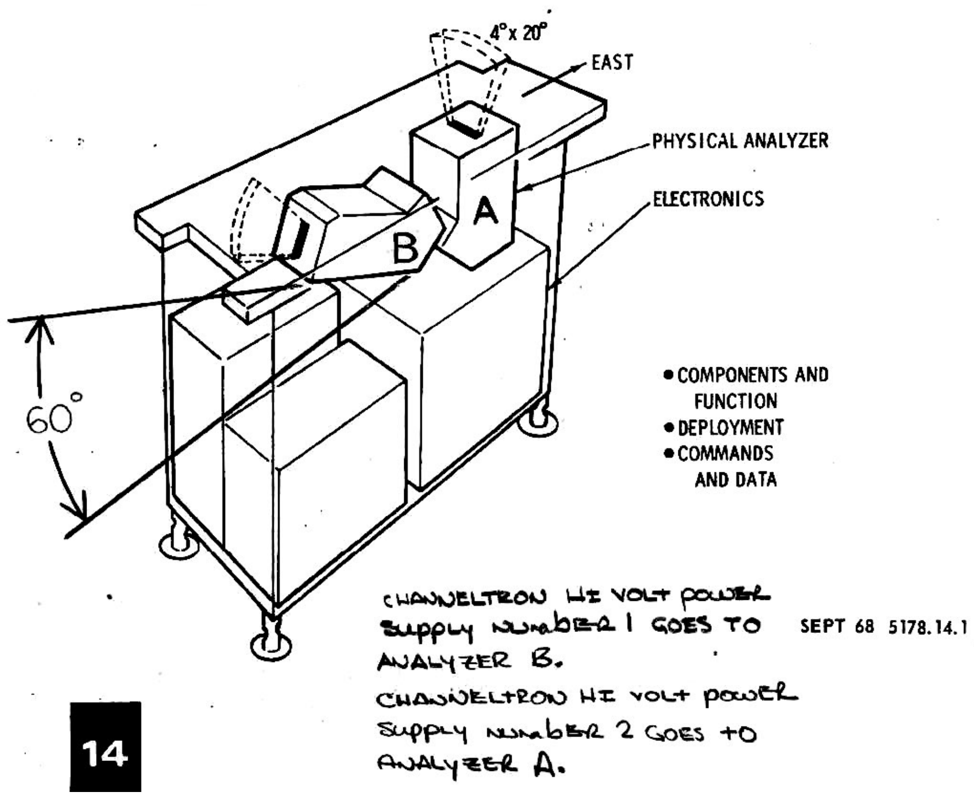

Figure 4: CPLEE Subsystem

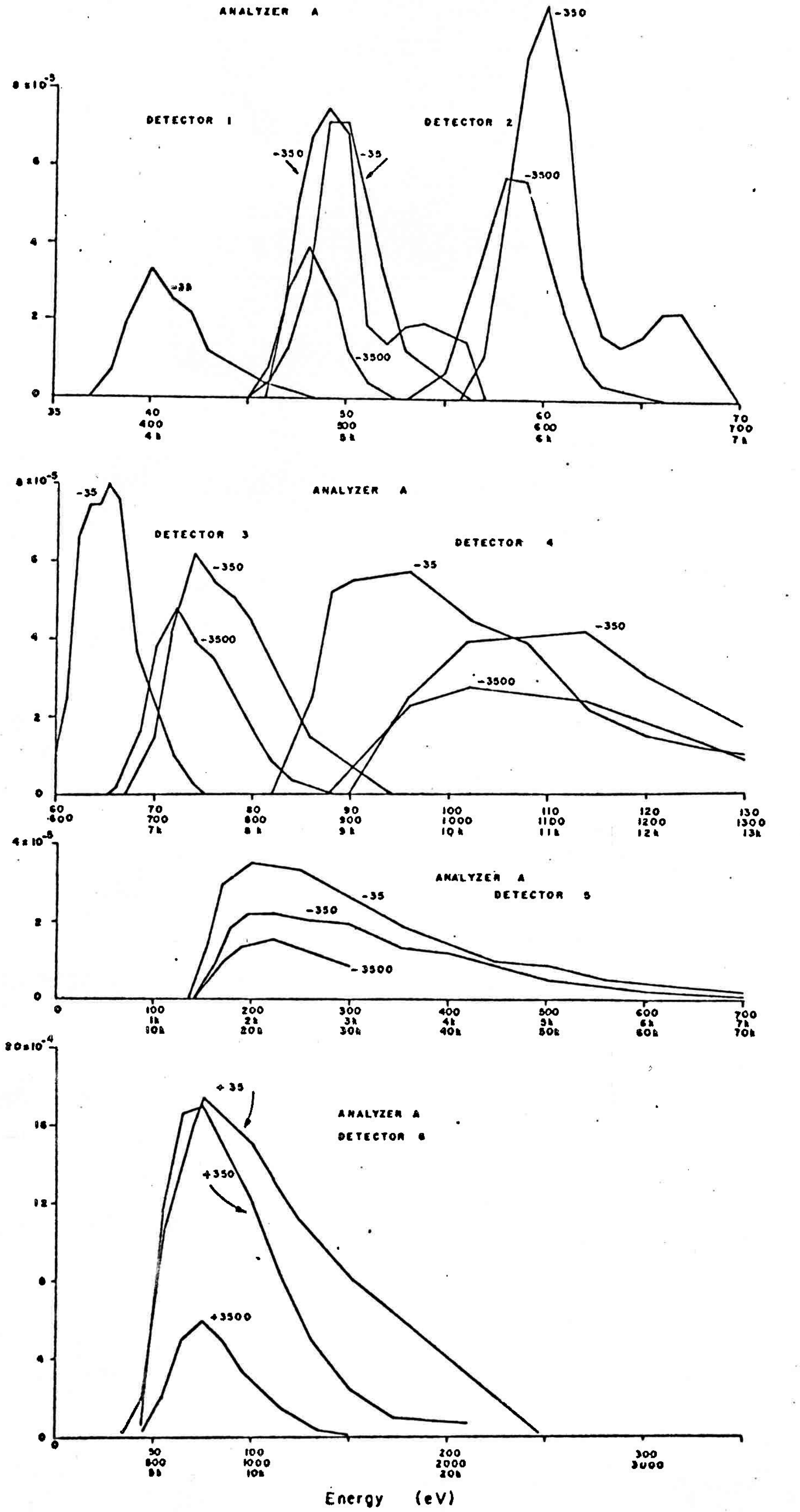

Figure 5: CPLEE energy passbands

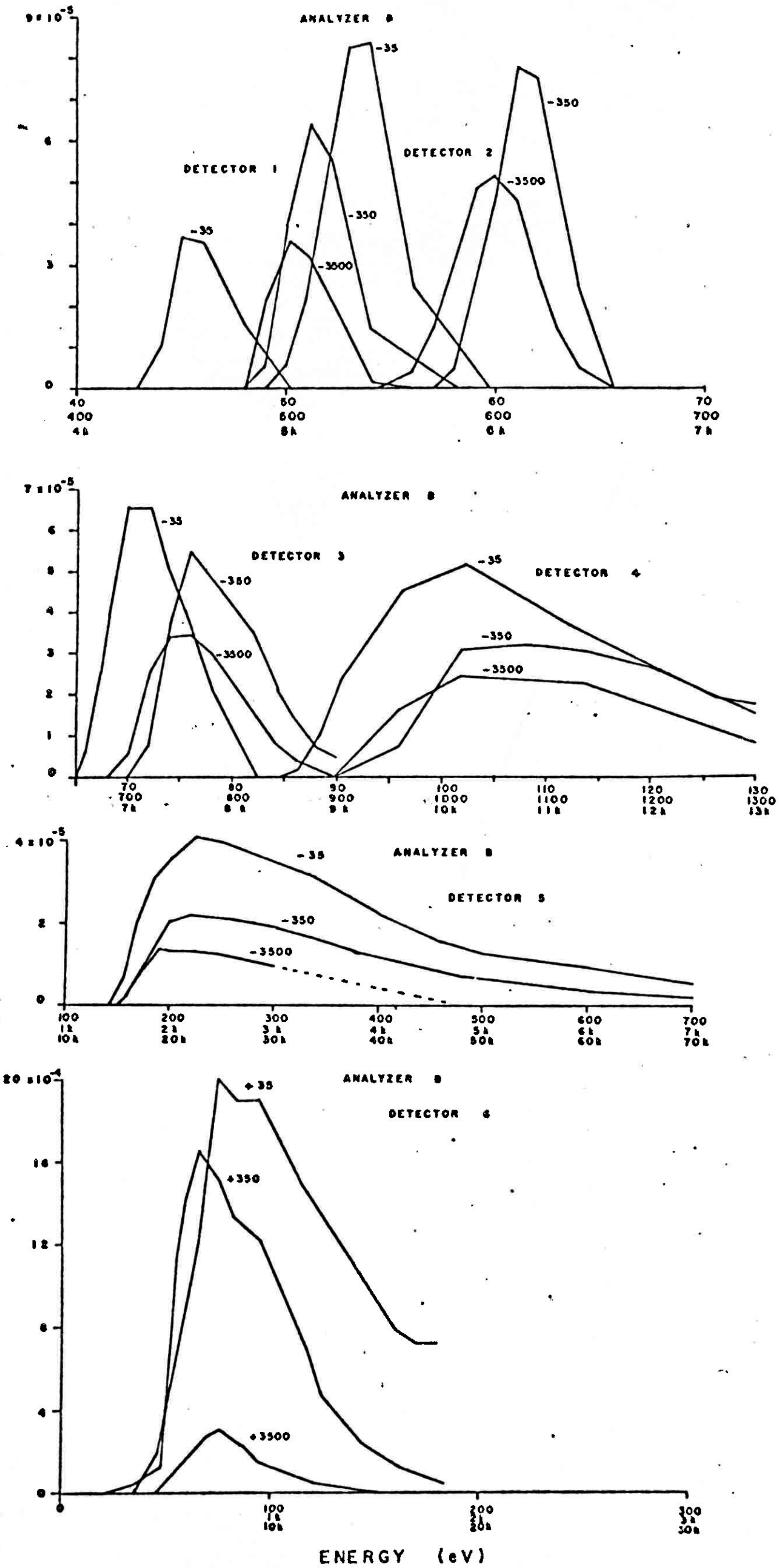

Figure 6: CPLEE energy passbands

Operational History

The ALSEP central station was located at 3.6440 South latitude, 17.4775 West longitude. The CPLEE instrument was deployed approximately 3 meters northeast of the central station. Leveling to 1.7 degrees, tipped to the east, was accomplished with a bubble level and east-west alignment to within 1 degree with a Sun compass. The instrument was deployed at approximately 18:00 UT on 5 February 1971 and commanded on at 19:00 UT for 5 minutes of functional tests. A checkout procedure was conducted on 6 February from 4:00 to 6:10 UT. Following LM ascent on 6 February at 18:49 UT the dust cover was commanded to be removed at 19:30 UT. The experiment worked normally from deployment until April 8, 1971, when the power supply for the analyzer pointing away from lunar vertical (analyzer B) failed. The other analyzer continued to function normally until June 6, 1971, when a partial failure of the power supply occurred. Operation of this analyzer was intermittent for the rest of 1971. During most of 1972, operation was continuous during lunar night and intermittent during lunar day because high temperatures caused a low voltage condition in the power supply. From December 1972 to February 1973 operation was continuous, after which time the voltage problems occurred again. The Apollo 14 central station signal was lost on 1 March 1975 and reacquired on 5 March. Command uplink capability was lost on 18 January 1976 and regained on 19 February 1976. Loss and reacquisition of signal happened sporadically until termination of the ALSEP experiment. Although telemetry and data downlink continued over most of this time, operation was affected because commands could not be sent. Loss-reacquisition of signal occurred in 1976 on 17 March - 20 May, 8 June - 10 June, 9 October - 12 November and in 1977 on 30 July - 4 August. The CPLEE experiment was in standby mode when the ALSEP stations were turned off on 30 September 1977.

References

Apollo Lunar Surface Experiments Package Systems Handbook, ALSEP 4, Unnumbered, Flight Control Division, NASA Manned Spacecraft Center, Houston, Texas, 1970.

Apollo Scientific Experiments Data Handbook, NASA Technical Memorandum X-58131, JSC-09166, NASA Johnson Space Center, Houston, Texas, Aug. 1974, revised Apr. 1976.

O'Brien, B. J. and D. L. Reasoner, "10. Charged-Particle Lunar Environment Experiment (CPLEE)", Apollo 14 Preliminary Science Report, NASA SP-272, pages 193-213, NASA, Washington, D.C., 1971.

Reasoner, D. L., "Charged Particle Lunar Environment Experiment (CPLEE)" in Data Set Catalog 226 for "Apollo 14 CLPEE Count Rate Data", Dataset id. SPHE-00017, NASA Space Science Data Coordinated Archive, Goddard Space Flight Center, 1972.

Source

The NASA Space Science Data Coordinated Archive (NSSDCA, formerly NSSDC) provided this description including Figure 1 and the Operational History section. Figures 2-4 are from the Apollo Lunar Surface Experiments Package Systems Handbook, ALSEP 4 (Apollo 14). Figures 5-6 and the content in the Instrument Description section are from Reasoner (1972).