The Resource Prospector Neutron Spectrometer System: RP's Bloodhound

The primary goal of the Resource Prospector Neutron Spectrometer System (NSS) is to locate and characterize hydrogen-bearing volatile deposits, especially subsurface ice, that may exist at the lunar poles. A key objective is to detect water-equivalent hydrogen concentrations of 0.5 wt% or greater while on a moving rover. A second objective is to determine approximate burial depth of enhanced hydrogen-bearing materials up to 1 meter below otherwise dry regolith. The instrument will be carried aboard a landed mobility system at the lunar poles. The instrument operates by measuring the changes in the leakage flux of low energy neutrons out of the regolith. These neutrons are produced by galactic cosmic rays, which are so energetic that they shatter the nuclei in surface materials. The neutrons interact with other nuclei and lose energy, becoming thermalized in the process. Hydrogen is most efficient at thermalizing neutrons owing to protons' similar mass – statistically, neutrons lose half their energy per collision with protons. With hydrogen in the soil, leakage fluxes of neutrons in the 0.5 eV to 500 keV energy range are reduced. A concentration of only1-2 wt% water-equivalent hydrogen results in a decrease in epithermal leakage flux of a factor of two. The leakage flux of thermal neutrons, from 0 to 0.5 eV in energy, can either increase or decrease depending on the hydrogen abundance and stratigraphy. As with the highly successful Lunar Prospector Neutron Spectrometer, the RP NSS detects both thermal and epithermal neutrons by using two helium-3 gas proportional counters, one covered by cadmium and the other uncovered. The former detects only epithermal neutrons with energies above ~0.5 eV, the latter detects both thermal (<0.5 eV) and epithermal energies (>0.5 eV). When a neutron enters the detector tube and interacts with a helium-3 nucleus, the resulting reaction produces an energetic proton and triton that ionize the gas. The resulting electrons are accelerated toward a high-voltage anode and cascade, amplifying the net charge, which is collected at the anode. The number of electrons produced is proportional to the energy that the triton and proton deposit in the gas. A charge sensitive pre-amplifier converts the total charge to a step voltage output. A shaper amplifier then shapes this step into a uni-polar waveform with peaking time appropriate for the detection depending on the event rate. The integrated shaped waveform, representing the deposited triton/proton energy, is then measured. A histogram, or pulse height analysis, is performed to record the main capture peak and wall effect pulses. A threshold for detection is also required to limit the low amplitude counting rate such as noise floor. The system electronics consists of 2 modules – the Sensor Module (SM) front-end and the Data Processing Module (DPM) back-end circuits. SM is designed as a light-weight and low power front-end housing the two helium-3 proportional counter detectors, preamp and HVPS. It is mounted external to the rover body to detect the thermalized neutron flux with a minimum of host background. The DPM is located inside the rover; it digitizes the SM signals, performs pulse height analysis and accumulates the count rate for each spectral channel. The DPM controls high voltage and thresholding, and sends the science data to the host craft via an RS422 serial asynchronous protocol. The payload host provides all thermal management and control for the SM and DPM.

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