THE LOS ALAMOS NEUTRON SPECTROMETER FOR THE LUNAR SCOUT-I MISSION; George Auchampaugh, Bruce Barraclough, Roger Byrd, Darrell Drake, William Feldman, Calvin Moss, and Robert Reedy, Space Science and Technology Division, Los Alamos National Laboratory, Los Alamos, NM 87545.

We review the current status of the Los Alamos program to develop a neutron spectrometer for the Lunar Scout-I mission, which is the first of two such missions to obtain global compositional, gravity, topography, and image maps of the lunar surface during nominal one-year missions. The neutron spectrometer will measure fast and slow (epithermal and thermal) neutrons in the ranges of 0.5 MeV to 25 MeV and 0.01 eV to more than 1 keV, respectively. The neutron spectrometer will consist of two independent instruments, a fast-neutron one and a thermal and epithermal one. The measured neutron fluxes are very sensitive to hydrogen in the top meter of the lunar surface and provide additional information about lunar composition.

The concept of using cosmic-ray-produced neutrons that escape from the Moon to study lunar surface composition dates back to Lingenfelter *et al.* [1], who in 1961 noted that hydrogen modifies the ratio of thermal and epithermal neutrons and proposed an experiment to measure lunar thermal and epithermal neutrons. Better sensitivity for detecting lunar hydrogen can be obtained by adding a sensor for detecting fast neutrons [2]. Using neutrons measured in three energy ranges (fast, epithermal, and thermal) also removes many ambiguities in the two-energy-range neutron system and provides additional information on lunar composition, such as a measure of the abundances of elements in the top meter of the lunar surface like Fe, Ti, Gd, and Sm that strongly absorb thermal neutrons [2]. No experiment to measure neutrons has flown in lunar orbit. The Mars Observer Gamma-Ray Spectrometer has the capability of detecting martian thermal and epithermal neutrons [3] and will be used to map hydrogen and carbon in the martian surface after the Mars Observer goes into orbit in August 1993.

The fast neutron sensor consists of four boron-loaded plastic scintillator rods, optically coupled to photomultiplier tubes. The boron in the scintillator provides a unique way to unambiguously identify a fast neutron. When such a neutron interacts with the plastic and is subsequently captured by ^{10}B, two pulses of light are created, a prompt pulse and a delayed pulse, which are separated in time by the neutron moderation time of the scintillator. The neutron moderation time is 2.2 μs and is governed by the amount of ^{10}B loaded into the scintillator, which is approximately 1% by weight ^{10}B for our scintillators. The prompt pulse provides a measure of the total energy released by the neutron as it slows down in the scintillator. A correction must be made to account for the energy that does not result in a detectable light pulse. The amplitude of the delayed pulse, which is governed by the 2.78-MeV Q-value for the ^{10}B(n,α) reaction, provides a unique way to identify a neutron. Gamma rays in coincidence with a prompt pulse would have random amplitudes. An event is tagged by three pieces of data: the prompt pulse amplitude, the delayed pulse amplitude, and the time interval between them. The data are stored in several formats: (a) single events, where the pulse heights in each rod are recorded; (b) 1-rod events; (c) 2-rod events; and (d) 3&4-rod events. Calculations show that the directional information provided by the four rods can be used to correct the data for cosmic-ray-generated spacecraft neutron background, thereby eliminating the need for a boom. The instrument has energy resolution of about 30% for 5-MeV neutrons, gamma-ray rejection comparable to that obtainable using pulse shape discrimination with liquid scintillators, and previous flight heritage. See reference 4 for more details on the operation of the instrument.

Thermal and epithermal neutrons will be measured with ^{3}He gas proportional counters. The epithermal counter will be wrapped with cadmium and the "thermal" neutron counter with tin. The thickness of tin is chosen so that the epithermal response of the "thermal" counter matches that of the epithermal counter. In this way, a thermal neutron flux is obtained by a difference between the "thermal" and epithermal count rates. The counters can be effectively shielded from the thermal/epithermal spacecraft neutron background with little weight penalty, thereby also eliminating the need for a boom. Similar counters have been flown in Earth orbits.

We will report on neutron science issues relating to the Lunar Scout-I mission and on the current configurations, potential weight, power and telemetry rates of these instruments.

References: [1] Lingenfelter R.E., Canfield E.H., and Hess W.N. (1961) *J. Geophys. Res.*, **66**, 2665. [2] Feldman W.C., Reedy R.C., and McKay D.S. (1991) *Geophys. Res. Lett.*, **18**, 2157. [3] Boynton W.V. *et al.* (1992) *J. Geophys. Res.*, **97**, 7681. [4] Feldman W.C., Auchampaugh G.F., and Byrd R.C. (1991) *Nucl. Instrum. & Methods*, **A306**, 350. * Work done under the auspices of the US DOE.