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Study of a fast neutron telescope for remote planetary neutron spectroscopy

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Neutron spectroscopy has been largely used as a powerful remote technique to characterise chemical composition in the uppermost decimetres of planetary surfaces (average density, content of light elements such as hydrogen, eventual layering, etc.). The technique used so far is based on the thermalisation and final capture of fast neutrons and lacks good spatial resolution and, to a lesser extent, good energy resolution. We present here a novel concept of instrument for planetary fast neutron spectroscopy in the energy range from 0.5 to 20 MeV, able to provide significantly improved performance. Such an instrument has been studied, developed, and tested at the University of New Hampshire (Durham, NH, USA) for general purposes as well as for space-borne solar physics. Based on the detection of double neutron-proton elastic scatters, the instrument provides measurement of the time of flight, and of the recoil proton energy deposits and locations, which allows to constrain the direction of incidence to an event circle and to determine the total energy of the incident neutron with good resolution. We report on the simulated performances of such an instrument for planetary exploration and compare them to those of classically used fast neutron detectors. Results are illustrated in the context of a Moon exploration mission. A discussion is also given on the ability of the instrument to detect moderated (or epithermal) neutrons.