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A Compact Gamma-Ray and Neutron Detector for Abundance Mapping on the Moon

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Neutron detection, as well as gamma-ray spectroscopy are powerful tools for in-situ resources utilization. They allow for characterizing the abundance of hydrogen and elemental composition of the top meter of moons, airless planets, or asteroids. Compact instruments can be deployed both on orbiters and landers/rovers for either mapping larger areas or narrowing down locations with targeted materials. A more specific application is the abundance mapping of water in the lunar polar regions. To improve the Lunar Prospector resolution maps, a satellite in a low altitude orbit, below 30km, of the lunar surface is needed. This can be accomplished by a small satellite, like a CubeSat.

We propose a hybrid gamma-ray and neutron detector based on scintillator technology for space exploration, sensitive to gamma-rays in the spectral range of 30keV to 8MeV as well as to thermal and epithermal neutrons. The detector consists of an array of CLLBC scintillators that are read out by silicon photomultipliers attached to partially space-qualified read-out electronics provided by IDEAS. In the targeted configuration, the compact instrument will have the size of tow CubeSat units (2U), where one unit is covered in Cd to allow for the distinction between epithermal and thermal neutrons.

A good understanding of the targeted radiation environment is vital for simulating and characterizing the instrument's performance before deployment. We performed an environmental analysis for the Moon that provides the input parameters for detector response simulation in GEANT4. With the detector response simulation, the detector design can be optimized, and characterization measurement data from the physical instrument can be verified.

In this paper, we present the mechanism behind the detection of targeted elements, such as hydrogen, KREEP, Fe, Ti and Sm, the results from the lunar radiation environment simulation and first results from the detector response simulation. A demonstrator instrument was assembled and tested in a laboratory, the first results look promising, showing that the targeted energy range for gamma-ray and neutrons can be detected. The performance of the lab demonstrator will be presented, as well.