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A HYBRID GAMMA-RAY AND NEUTRON DETECTOR FOR IN-SITU RESOURCE UTILIZATION

Abstract

Gamma-ray spectroscopy, as well as neutron detection (GRND) are powerful tools for mapping available resources both remotely and in-situ. GRND allows us to characterize the abundance of hydrogen and elemental composition of the top meter of airless celestial bodies , or asteroids. Compact instruments can be deployed on orbiters, landers or rovers for either mapping larger areas or narrowing down locations with targeted materials. For instance, Lunar Prospector (LP) quantified the abundances of ice water at the lunar polar regions during the last decade of the previous century. To achieve better resolution than these maps a satellite in a low altitude orbit or low periselene, below 30km, from 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 both gamma-rays in the spectral range of 30 keV to 8 MeV and thermal to 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 developed by Integrated Detector Electronics AS (IDEAS). In the targeted configuration, the compact instrument will have the size of less than two CubeSat units (2U), where one unit is covered in Cd to allow for the distinction between epithermal and thermal neutrons.

An understanding of the targeted radiation environment is vital for optimizing the instrument's design parameters before assembly. We report an environmental analysis for the Moon with the detector response simulated in GEANT4. With the detector response simulation, the detector design can be finalized, and characterization measurement data from the physical instrument can be verified.

In this paper, we present preliminary results for the simulated detector response and compare them with measurements taken by a laboratory demonstrator, which was assembled and tested in a laboratory in 2023. First results look promising, showing that the targeted energy range for gamma-ray and neutrons can be detected. The performance of a monolithic prototype instrument will be elaborated and design decisions as well as the roadmap for the exploration instrument will be discussed.