PLANETARY GAMMA RAY SPECTROSCOPY WITH STRONTIUM IODIDE

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Introduction. The chemical composition of solar system bodies can be determined from gamma ray spectra measured by an instrument deployed on an orbiter, lander, rover, or sonde. Gamma rays are produced by the decay of natural radioelements and, for bodies with thin or no atmosphere, by the interaction of galactic cosmic rays with the regolith. The leakage spectrum of gamma rays can be analyzed to determine the concentration of specific elements, such as H, C, O, Mg, Al, Si, S, Cl, K, Ca, Ti, Fe, Ni, Th, and U. The elemental data is needed to understand chemical and physical processes underlying planetary formation and evolution.

Gamma ray spectroscopy is well established for planetary remote sensing. The elemental composition of surface materials on Mercury, Venus, the Moon, Mars, the near-Earth asteroid 433 Eros, the main belt asteroid 4 Vesta, and the dwarf planet 1 Ceres was determined from passive gamma ray measurements [e.g. 1]. Although some information can be obtained during a close flyby, precise measurements require lengthy accumulation at low altitude (<1 body radius). Future missions may use active interrogation with a pulsed neutron generator or isotopic neutron source for high-throughput, in situ measurements.

Requirements: Sensors with large active volumes made from materials with high density and atomic mass are required to measure gamma rays in the target energy range: a few hundred keV to 10 MeV. High-energy resolution is desired; however, other factors such as payload limitations (mass, volume, power), thermal environment, susceptibility to radiation damage and backgrounds must be considered. For example, sensors optimized for the exploration of main belt asteroids may be poorly suited for a mission to the surface of Venus.

Strontium Iodide: Europium-doped strontium iodide, SrI_2(Eu), is an ultra-bright scintillator with a factor of two to four times better energy resolution at room temperature than scintillators with flight heritage. Improved resolution will enable accurate analyses of elements with gamma rays in the densely populated region below 3 MeV (Fig. 1). Large, single crystals can be manufactured, obviating the need for arrays required for other sensor technologies (e.g. CdZnTe). The scintillation emission spectrum is well matched to the photon detection efficiency of solid-state optical sensors, such as silicon photomultipliers, leading to compact, low-power spectrometers (Fig. 2). These factors combined

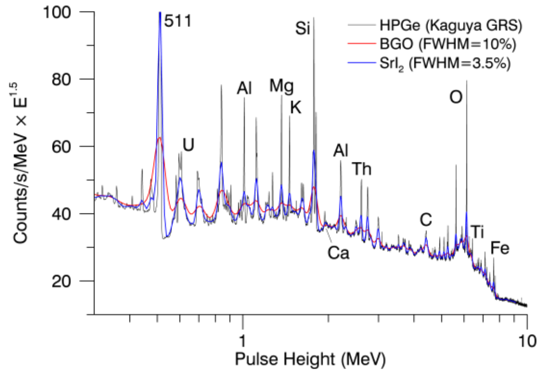

Figure 1. The average lunar spectrum acquired by JAXA/Kaguya (HPGe) was adjusted to illustrate the potential performance of a SrI_2 gamma ray spectrometer.

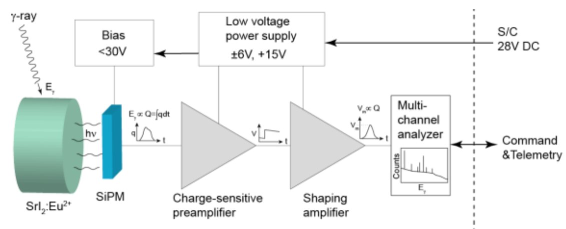

Figure 2. Block diagram for a gamma ray spectrometer with a SrI_2 crystal and silicon photomultiplier (SiPM).

with the potential for scalability of crystal size and absence of self-activity make SrI_2 an excellent choice among competing scintillators such as $CeBr_3$ and $LaBr_3$ [3].

Next steps in the development of SrI_2 for planetary applications include optimizing crystal growth, packaging and readout of large-volume crystals; evaluating radiation damage effects for SrI_2 crystals and optical sensors; determining the response of sensors to energetic particles; and identifying potential sources of background. Successful development will lead to a new generation of high-performance spectrometers that can be deployed on a variety of platforms [e.g. 4] to targets large and small in the inner and outer solar system.

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