A FIRST LOOK AT THE FLIGHT DATA OF THE KPLO GAMMA-RAY SPECTROMETER.

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Introduction: The Korea Pathfinder Lunar Orbiter (KPLO) was launched from Cape Canaveral by a SpaceX Falcon 9 rocket on Aug. 4, 2022 to orbit and investigate the Moon. It was inserted to the lunar orbit in Dec. 2022. We aim to investigate the elemental composition of the lunar surface using the gamma-ray spectrometer (GRS), which has a unique energy range of observation where new information is expected, especially for volatile and rare earth elements [1]. The knowledge of the elemental distributions give insights into lunar geology as well as future resource utilization [e.g., 2,3].

During the cruise phase to the Moon, the GRS on board the KPLO acquired data to characterize the background gamma-ray emission from the spacecraft. Because the main detector of the KPLO GRS is known to contain radioactive nuclides, it is crucial to precisely measure the background gamma rays prior to the orbit insertion to separately analyze gamma rays emerging from the Moon [e.g., 4].

Instrument: The KPLO GRS employs a $LaBr_3$ scintillator to measure intensities of lunar gamma rays, whose energies are characteristic of surface elements. It should cover an energy range of 30 keV through 10 MeV [5]. Surrounding the main detector is a boron-loaded plastic shield to reject charged particle events. The variations in signals from the shield detector will also be used to search for water in the polar regions [1].

Data: A total of five days of the GRS spectrum data during the cruise phase, acquired on Aug. 11 and 26, Sep. 24, Oct. 21, and Nov. 25, 2022, was provided for analysis, as well as the structure details of the detector crystals and the enclosure. Here, the spectra from the main detector in anti-coincidence with the shielding detector were mainly analyzed. After a brief check for consistency, 34,496 spectra were analyzed. Each spectrum has an accumulation interval of 10 s.

Results: *Modeling of the detectors.* The sensitivity of the spectrometer to the lunar gamma rays was evaluated by numerically modeling the detectors. Our preliminary estimate of the efficiency-area product shows that KPLO GRS would have ample efficiency for measurement of gamma rays produced by cosmic ray interactions with the lunar surface and the decay of natural radioelements, per the comparison with the Kaguya GRS [6]. The full-energy, single and double escape efficiencies are plotted in Fig. 1.

Spectral analysis. Spectrum features including peaks and edges due to detector's internal activities were confirmed. Among those are the 789 keV and 1.4 MeV peaks, that are attributed to radioactive ^{138}La [7]. The contributions from the actinium series, a known contaminant of lanthanum halide crystals [e.g., 8], are significant. Many gamma-ray peaks as well as alpha-ray peaks were observed, which are dominant especially in the 2-3 MeV region of the spectrum.

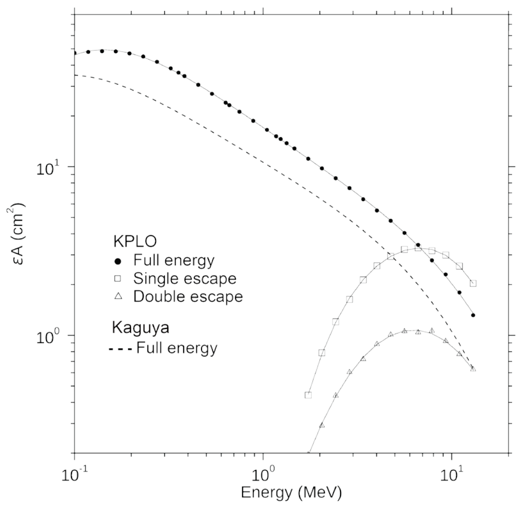

Figure 1 Efficiency-area product of the KPLO GRS, in comparison with the Kaguya GRS.

A significant gain shift was also observed during the cruise, as expected. To quantify the gain shift, we derived the centroid positions of the peaks at 511 keV and 1.4 MeV for every single spectrum following the methods by [9]. It turned out that the KPLO GRS lost its gain by 5% in one day on Aug. 11, and by 25% over the course of ~4 months (see Fig. 2a). The decrease in gain is most likely attributed to the change in the crystal temperature and counting rates. This will be verified once the corresponding counter and house-keeping data become available for analysis.

Because each individual gamma-ray spectrum has poor statistical precision, we need to accumulate many spectra to produce a high-quality data set suitable for science investigations. Therefore, the centroid positions of the peaks and their known energies are used to derive the gain and offset for each spectrum to put it on the same energy scale, in a similar way to those employed by other planetary gamma-ray observations such as those of the Dawn and Kaguya missions [10,11]. The spectra before and after such gain corrections are shown in Fig. 2.

Discussion: The day-by-day gain-corrected high-gain spectra of KPLO GRS are shown in Fig. 2. The peak positions, peak widths, and the net counts are

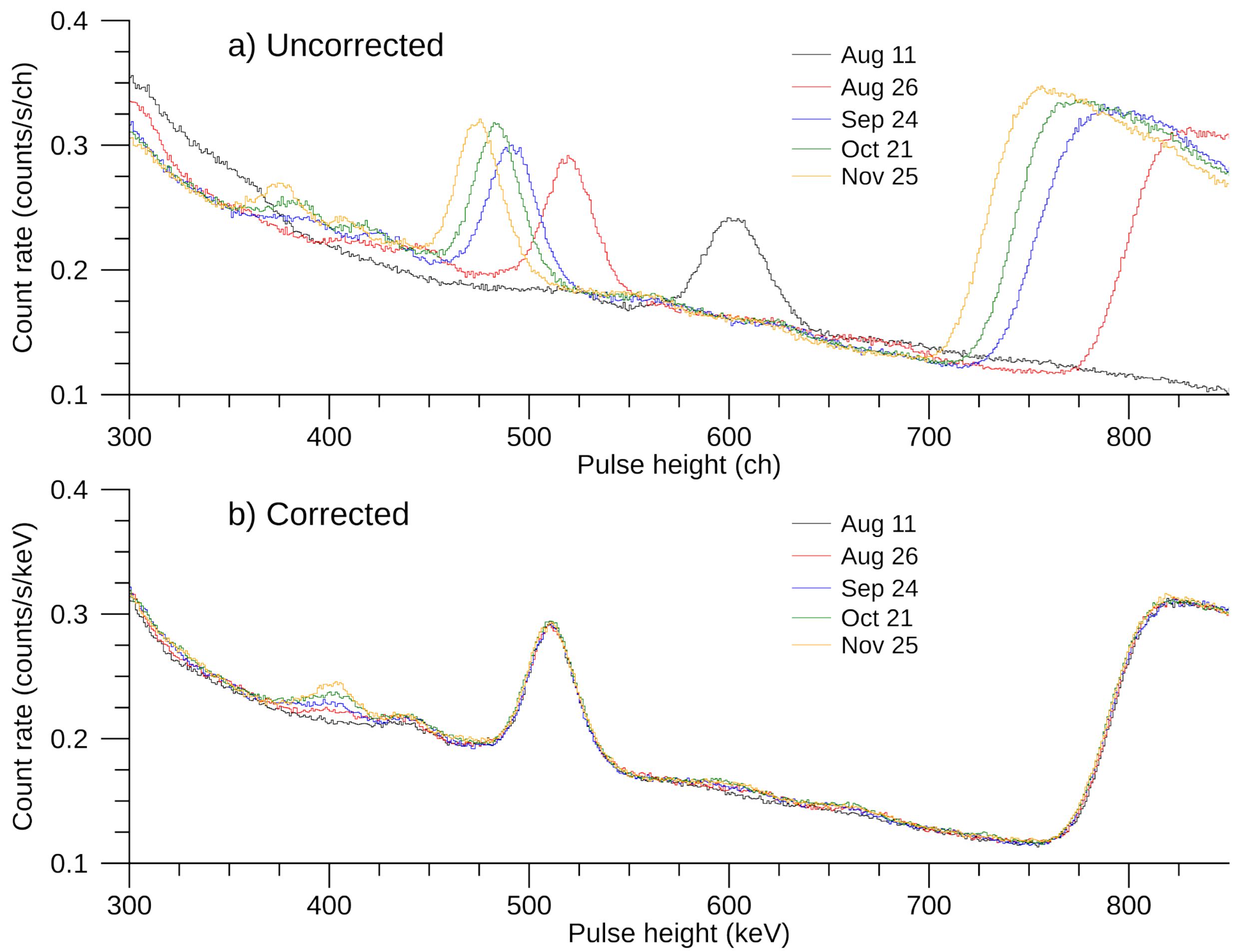

Figure 2 Energy spectra of gamma rays acquired by the gamma-ray spectrometer on board the Korea Pathfinder Lunar Orbiter during the cruise phase. High-gain, anti-coincidence spectra from the $LaBr_3$ main detector were accumulated day by day (see text). Raw, uncorrected spectra (a) and partially processed gain-corrected spectra (b) are shown for comparison in the regions including an annihilation gamma-ray peak at 511 keV.

consistent throughout the cruise phase, a consequence of the gain correction (Fig. 2b). For the sum of the five days of data, the energy resolution was determined to be 4.8% full width at half maximum at 662 keV. Notably, there are a few temporal changes in the spectrum. Namely, the intensities of the peaks at approximately 400, 600, and 660 keV increase with time (Fig 2b). These are most likely attributed to the activation of the surrounding materials. Identification of the source elements is underway.

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