ONBOARD SOFTWARE ANALYSIS OF SELENE XRS. T. Arai[1], Y. Yamamoto[2], T. Okada[2], K. Shirai[2], K. Ogawa[3], K. Hosono[4], and M. Kato[2], [1]*Institute of Space and Astronautical Science, School of Physical Sciences, The Graduate University for Advanced Studies (SOKENDAI), Sagamihara 229-0006, JAPAN, (arai@planeta.sci.isas.jaxa.jp)*, [2]*Department of Solid Planetary Science, Japan Aerospace Exploration space Agency (ISAS/JAXA), Sagamihara 229-0006, JAPAN*, [3]*Department of Earth and Planetary Sciences, Graduate School of Science and Engineering, Tokyo Institute of Technology, Ookayama, Meguro-ku, Tokyo 152-8551, JAPAN*, [4]*Department of Earth and Planetary Sciences, Graduate School of Science and Engineering, The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113-0033, JAPAN.*

Introduction: SELENE is a lunar polar orbiter satellite that will be launched by H-IIA rocket 2006 in JAPAN. An X-ray fluorescence spectrometer (XRS) onboard SELELE will quantitatively determine major elemental compositions of the lunar surface such as Fe, Mg Al Si, Ca, Ti, $\cdots$.

The XRS is composed of lunar surface detectors (XRF-A) and solar monitors (SOL-B and SOL-C). XRF-A includes 4 CCDs sensor units ($\times$ 4) have high-energy resolution enough to separate K (L) line X-ray emissions of major elements (FWHM : under 180eV at 5.9keV). The total effective area is 100cm^2 (16 CCDs) and FOV is $3.5^\circ \times 3.5^\circ$. SOL-B includes two Si-PIN photodiodes to use monitoring the solar X-ray activity directly. SOL-C includes 1CCD chip same as XRF-A and standard sample allows for comparative analysis. All specifications are introduced in [1][2][3].

The primary objective of the XRS is to make global map of major elemental compositions of the lunar surface with high-spatial resolution (under 30$\times$30km). It requires high-performance sensor and accurate analysis. In this study, we introduce observation data analysis by using software process of onboard computer.

Data Processing: Onboard hardware (FPGA) and software (CPU) combinations perform data reduction and analysis of observation data (this is improved technologies of HAYABUSA XRS[4]). Maximum telemetry rate of XRS is fixed in 32 kbps (bits per seconds) at day-side observations (3.2 kbps at night-side). Because the image data size of CCD (1024$\times$1024 effective pixels) is 2MBytes, the XRS is unable to send all the data to the Earth-station. Therefore, the XRS extracts X-ray event data only from CCD image by using hardware process.

The hardware extracts an incident X-ray event I as pulse height (ADU), if value of I is larger than that of dark-frame D plus event threshold (parameter). Then, the hardware updates D as background in real-time by following,

$$D_{new} = D_{old} + \frac{I - D_{old}}{h},$$

where h is called a history parameter which is concerned with relaxation time of background. The backgrounds make it possible subtract hot pixels from event data. The pulse height values of extraction pixel and neighboring pixels are stored First-in First-out (FIFO) memory, and the data are added event information as, CCD-ID, event counter, horizontal pixel coordinate, vertical pixel coordinate, neighboring pixel (left pixel), event pixel (center pixel), neighboring pixels (2 right pixels), and background pixel with event pixel.

The software performs to analyze the data, and makes data packets. The onboard computer of the XRS includes high-performance Reduced Instruction Set Computer (RISC) type CPU (60MIPS at 60 MHz) $\times$ 3 allow for flexible analysis of observation data.

Onboard Analysis: The XRS will use 7 observation modes that are controlled by software process shown in Table1.

Table 1: Observation Mode

Observation mode	Data format
Event mode	1$\times$5 pixels data
Spectrum mode	Histogram data
Intelligent mode	*Event mode* $\leftrightarrow$ *Spectrum mode*
Frame mode	Raw image data
Dark-Frame mode	Background image data
PIN mode	Histogram data
Stand-by mode	Idling

Event mode makes a data packet (8kbits/packet) of 1$\times$5 pixels $\times$ 63 events (optional: *eventRaw*), or makes a light data packet which consists of effective pixels only (optional: *eventLight*). Furthermore, this mode makes background data packets (optional: *bgPlus*). The bit rate will be roughly 25 kbps when B class flare burst occurs.

Spectrum mode makes an analyzed data packet which is transformed to a histogram from *Event mode* data. The histogram is cropped 1000 channels (ADU) from dark level (about 0-10keV range), and performs the grade method as XIS of Astro-E2[5]. The integration time is constantly 16 seconds to resolve lunar local area as central peak of crater for well spatial resolution under 30$\times$30km. The bit rate is constantly 17 kbps.

Intelligent mode is autonomous observation mode to avoid packet saturations. The mode exchanges *Event mode* and *Spectrum mode* with monitoring X-ray flux every 160 seconds (optional: *modeChange*). If the bit rate of flux is larger than 32kbps, the mode changes *Spectrum mode* from *Event mode*. Furthermore, this mode reduces the effective area 25cm^2 from 100cm^2 according to drive off 12 CCDs among 16 CCDs (optional: *driveOff*). It allows for fast readout even if solar colona burst occurs.

Frame and Dark-Frame mode makes raw or background (dark) image packets. It will be used health check of effective pixels, and monitored charge traps due to radiation damages. The bit rate is constantly 1Mbits/frame.

PIN mode makes a histogram packet of SOL-B. The bit rate is 0.5/1.0/2.0 kbps in sync with the integration times.

Stand-by mode does not make packet. It will be waiting until the next command received.

Pre-launch Performance: We have demonstrated pre-launch tests in *ISAS/JAXA* for calibration of sensor and logic tests of the hardware and software. The sensors performance were very well, and the hardware and software operated correctly. Fig.1 shows XRF-A response K line emissions to Fe excited by W X-ray tube. Because the XRS response separates the Fe-Kα and Fe-β lines, the energy resolution is well.

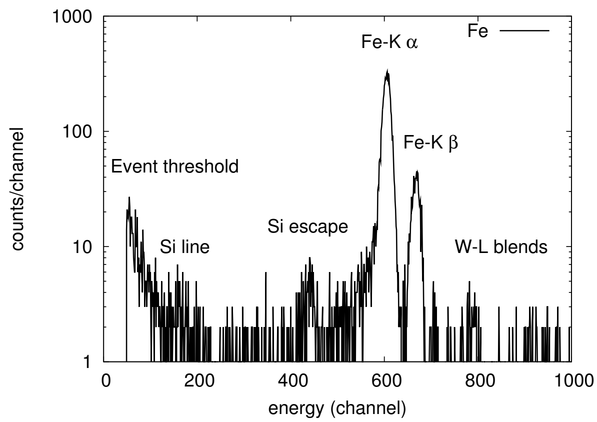

Figure 1: XRF-A response K line emissions to Fe excited by W X-ray tube (20kV 0.5mA). The grade mode is 0 (single pixel events extraction), Then the integration time is 1800 seconds, the temperature is -50 degree Celsius. Fe-Kα/β lines are separated clearly.

Summary and Discussions: The hardware and software processes of the onboard computer perform data reduction and analysis. The hardware process is to extract the X-ray events from raw image data. The software process is to analyze the data and to make data packets. These combinations of onboard process have operated well in pre-launch tests, and sensors performance are also well.

The sensors have characteristics that are written by response-function. Because the response-function varies according to observation mode, optional mode, or parameter, we require constructing their accurate response-functions in pre-launch tests. Now, we have calibrated all the sensors, and constructs improved response-functions for quantitative analysis.

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