PRELIMINARY RESULTS FROM THE HAYABUSA NEAR INFRARED SPECTROMETER (NIRS) OF ASTEROID (25143) ITOKAWA. M. Abe[1] , Y. Takagi[2], K. Kitazato[1,3], T. Hiroi[4], S. Abe[5], F. Vilas[6], B. E. Clark[7], P. A. Abell[8], S. M. Lederer[9], K.S. Jarvis[8,10], T. Nimura[1,3], Y. Ueda[3], and A. Fujiwara[1], [1]Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency (3-1-1 Yoshinodai, Sagamihara-shi, Kanagawa-ken 229-8510, Japan; abe@planeta.sci.isas.ac.jp, kitazato@planeta.sci.isas.ac.jp, minura@planeta.sci.isas.ac.jp, fujiwara@planeta.sci.isas.ac.jp), [2]Toho Gakuen University (3-11 Heiwagaoka, Meito-ku, Nagoya 465-8515, Japan; takagi@toho-jc.ac.jp), [3]University of Tokyo (7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan; yueda@space.eps.s.u-tokyo.ac.jp), [4]Brown University (Providence, RI 02912, USA; takahiro_hiroi@brown.edu), [5]Graduate School of Science and Technology, Kobe University (1-1 Rokkodai, Nada, Kobe 657-8501; avell@kobe-u.ac.jp), [6]MMT Observatory (P.O. Box 210065, University of Arizona, Tucson, AZ 85721, USA; fvilas@mmto.org), [7]Ithaca College (267 Center for Natural Sciences Ithaca, NY 14850-7288 USA; bclark@ithaca.edu), [8]National Aeronautics and Space Administration (Lyndon B. Johnson Space Center, Houston, TX 77058, USA; paul.a.abell1@jsc.nasa.gov, kandy.s.jarvis1@jsc.nasa.gov), [9]Deprtment of Physics, CSUSB (5500 University Parkway, San Bernardino, CA 92407, USA; slederer@csusb.edu), [10]Jacobs Sverdrup, ESC Group (2224 Bay Area Blvd., Houston, TX 77058, USA).

Introduction: NIRS is a near-infrared spectrometer on-board the spacecraft HAYABUSA, which rendezvoused with the near-earth asteroid, (25143) Itokawa in September through November 2005. HAYABUSA was launched by a Japanese M-V-5 rocket on May 9, 2003 [1]. After the Earth swing-by on May 19, 2004, the spacecraft successfully arrived at the Gate Position approximately 20 km from the asteroid on September 12, 2005. During the rendezvous phase with the asteroid, NIRS obtained more than 80,000 spectra of Itokawa. NIRS has a 64-channel InGaAs photodiode array detector and a grism grating system [2]. The relation between observation wavelength and pixel number of the detector is: Wavelength [nm] = 2271.44 – 23.56 x (Pixel Number). However, the observational limit at the long wavelength end was determined by the cutoff wavelength of the InGaAs photodiode array at roughly 2100nm. The short wavelength cutoff is 763.60nm. The NIRS field of view (0.1 x 0.1 degrees) was aligned with the LIDAR and the AMICA field of view before launch. During the cruise phase before arriving at Itokawa, NIRS observed some bright stars and planets [2],[3]. At the Earth swing-by, NIRS obtained the spectrum of the Moon and the Earth. NIRS has a calibration lamp and LED, which are used in order to monitor the response and possible variations between the channel number and observed wavelength over time. NIRS' characteristics and prelaunch calibration results were summarized in a previous paper [3].

Operations of NIRS during the rendezvous: The first spectrum from Itokawa was obtained by NIRS on September 10, and the distance at that time was 50 km from the asteroid. During mission operations, NIRS spectra were obtained at solar phase angles ranging from near 0 degrees up to 38 degrees, and footprint sizes ranging from 6 to 90 m excluding the Touchdown phase of the mission. After successfully arriving at the Gate Position at approximately 20 km from the asteroid on September 12, we started continuous observations with asteroid tracking using ONC-W on September 15, simultaneous observations with AMICA 7-color observations on September 17, and one-dimensional scan observations by slewing the altitude of the spacecraft on September 24. After switching to the Home Position at an altitude about 7 km from the asteroid on September 30, we moved the spacecraft to change the observation aspect angle and solar phase angle to obtain spectra of the polar regions under different lighting conditions. We observed almost the whole surface of Itokawa during the rendezvous phase of the mission. During the Touchdown Rehearsal phase, which started on November 4, NIRS successfully detected the reflectance of the LIDAR signal from the surface of Itokawa. From these data, we confirmed that the co-alignment of NIRS with the LIDAR has not changed since the launch of Hayabusa. We performed the acquisition of the on-board calibration lamp and LED data on September 4, October 30, and November 24, which was before the arrival at the Gate Position and before/after the first Touchdown operation on November 20 respectively. From this operation, we confirmed that the overall response and relationship between the channel and observed wavelength had not changed during the rendezvous phase of the mission. During the Touchdown phase, the temperature of the detector was successfully maintained to within 1 degree, at approximately -15 degrees centigrade using the optical bench heater and electric cooler under the detector.

Data Set: Data transmitted to the Earth were the average of 32-512 stacked output voltage from the InGaAs array. The onboard computer also calculated

the deviation of output voltage during the stack. The total deviation values were also transmitted. The maximum and minimum voltages of each channel during the stack were also transmitted before the failure of 2nd. momentum wheel of the spacecraft. A total of 42,000 data sets with average, deviation, maximum, and minimum values were obtained. Another 139,000 data sets include only the average and deviation values. However, about a half of the 181,000 data sets were obtained when NIRS did not point at Itokawa's surface. The number of effective spectra obtained is 80,000. Figure 1 shows an example of an obtained average and a standard deviation. The figure indicates that the S/N ratio in the range of 0.8 – 2.1 micron is larger than 100.

Preliminary results from NIRS: Figure 2 shows an obtained spectrum of NIRS on September 17 at a distance of 17 km from the asteroid. This observation was performed simultaneously with AMICA 7-color observation. The footprint is at the north side of MUSES Sea, where one of the smooth terrains on the surface of Itokawa is located (Figure 3). The footprint size of NIRS during this time is about 30 m. The spectrum of Itokawa obtained by NIRS compares well with ground-based disk-integrated spectra [4],[5]. NIRS found that there are variations in albedo, changes in depth of the absorption bands, and spectral slope differences among the spectra of Itokawa due to the specific lighting conditions and/or surface properties of the different surface locations. Even with these differences, preliminary analyses of NIRS data suggests that Itokawa is an object that contains a significant amount of olivine and pyroxene on its surface. These and other NIRS results will be presented and discussed.

References: [1] Kawaguchi J. et al. (2003) *Acta Astronautica* **52**, 117-123. [2] Abe M. et al. (2004) *LPS XXXV*, Abstract #1724. [3] Abe M. et al. (2005) *LPS XXXVI*, Abstract #1604. [4] Binzel R. P. et al. (2001) *MAPS*, 36, 1167-1172. [5] Abell A. P. et al. (2006) *MAPS*, in revision.

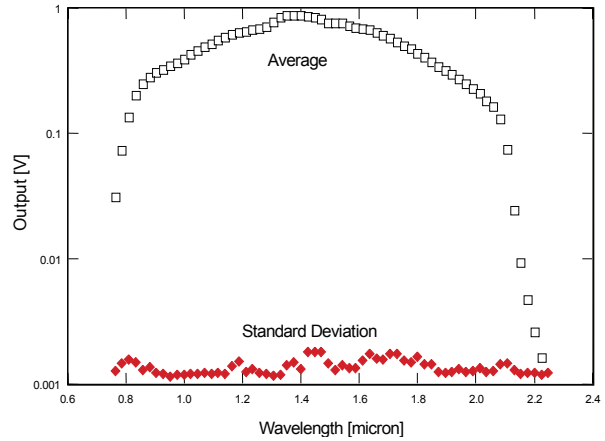

Figure 1. An example of output from NIRS.

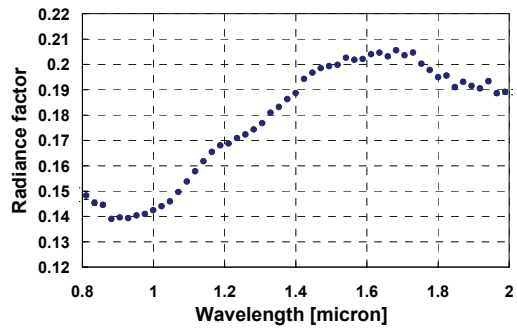

Figure 2. Near infrared spectrum of 25143 Itokawa obtained by NIRS on September 17.

Figure 3. AMICA image during simultaneous observation with NIRS on September 17. The red square is NIRS' footprint. This image is provided courtesy of the AMICA team.