

**GAMMA-RAY AND NEUTRON SPECTROMETER FOR STUDYING OF PHOBOS REGOLITH ONBOARD “PHOBOS-GRUNT” MISSION.** A.S. Kozyrev<sup>1</sup>, M.L. Litvak<sup>1</sup>, I.G. Mitrofanov<sup>1</sup>, A.A. Rogozhin<sup>2</sup>, A.B. Sanin<sup>1</sup>, R. Schulz<sup>4</sup>, V.N. Schvetsov<sup>3</sup>, V.I. Tretyakov<sup>1</sup>, C. D’Uston<sup>5</sup>, <sup>1</sup>Institute for Space Research, 84/32 Profsojznaja str., Moscow 117997, Russia, [kozyrev@mx.iki.rssi.ru](mailto:kozyrev@mx.iki.rssi.ru); <sup>2</sup>All-Russia Scientific Research Institute of Mineral Resources named after N.M. Fedorovsky, 31 Staromonetnyi per., Moscow 119017, Russia; <sup>3</sup>Joint Institute for Nuclear Research, Joliot-Curie, 141980, Dubna, Russia; <sup>4</sup>ESA/ESTEC, Noordwijk, The Netherlands; <sup>5</sup>CNES, France.

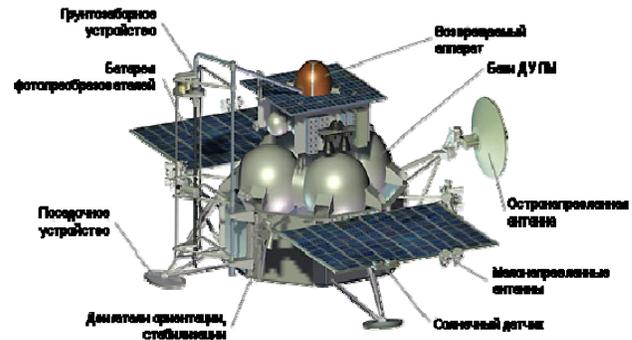
**Introduction:** The Neutron Spectrometer HEND (NS HEND) has been proposed for studying elemental composition of Phobos (the Mars’s moon) regolith by “Phobos-Grunt” mission (see Figure 1). NS HEND have been selected by the Federal Space Agency of Russia for the Lander of the “Phobos-Grunt” mission scheduled for launch in 2009 (Figure 1).

The shallow subsurface of Phobos might be studied by observations of induced nuclear gamma-ray lines and neutron emission. Secondary gamma-rays and neutrons are produced by energetic Galactic Cosmic Rays within 1-2 meter layer of subsurface. The knowledge of the spectral density of neutrons in addition to measurements of nuclear gamma lines allows to deconvolve concentrations of soil-forming elements. That is why nuclear instruments include both the segment for detection of gamma ray lines and segment of neutron spectrometer for the measurement of the neutron leakage spectra. Moreover, measurements of neutrons and 2.2 MeV line will also allow to study the content of hydrogen within subsurface layer about 1 meter deep.

**Instrument design:** The concept of NS HEND instrument is based on HEND instrument onboard NASA’s Mars Odyssey mission launched in 2001 year, which is successfully operating on Mars orbit [1]. Additional element of NS HEND instrument in comparison with HEND is gamma-ray spectrometer, which allows to measure gamma-ray lines together with neutrons from the surface of Phobos. NS HEND will be proto-flight instrument for the Mercury Gamma and Neutron Spectrometer MGNS, which is under development now for ESA’s BepiColombo mission to Mercury scheduled in 2013 [2].

Concept design of NS HEND is presented in Figure 2). The total mass for this instrument is less than 3.8 kg and the power consumption is less than 8.0 W.

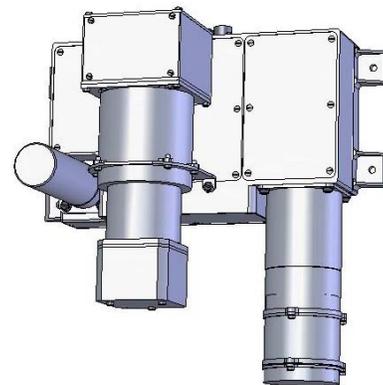
Instrument NS HEND includes the set of three <sup>3</sup>He proportional counters inside polyethylene and cadmium enclosures for measurements of thermal and epithermal neutrons, scintillation stilben crystal for measurements of fast and high energy neutrons with energies from 0.5 MeV up 10 MeV and scintillation crystal of LaBr<sub>3</sub> for measurements of gamma-ray lines with energy resolution better than 3% at 662 keV.



**Figure 1.** The concept design of landing module for Phobos-Grunt mission.

**Conclusion:** At present, development of NS HEND instrument is at the stage of manufacturing of Engineering Unit. Structural and thermal prototype units are already delivered to the industry. The flight units of NS HEND instrument will be manufactured and tested towards in 2008 years.

This instrument, as the part of “Phobos-Grunt” mission, will be able to provide observational data for composition of Phobos regolith and content of natural radioactive elements K, U and Th, and also for content of hydrogen or water in the Phobos subsurface.



**Figure 2.** The mechanical design for NS HEND instrument.

#### References:

- [1] I. G. Mitrofanov et al., Science, vol. 297, Issue 5578, pp. 78-81, 2002; [2] A.S. Kozyrev et al., Lunar and Planet. Conf. XXXVIII, abstract # 1589, 2007.