ADRON instrument for future missions to Moon and Mars: active gamma-ray sensing of shallow subsurface.

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Abstract: The series of ADRON instrument (ADRON-LR and ADRON-EM) are developed in Russian Space Research Institute (IKI) for Russian Luna-25, Luna-27 and Roscosmos-ESA ExoMars-2022 landers. The main goal of this experiment is studying of elemental composition of the lunar sub-surface down to 1 m. Using pulsing neutron generator and observing albedo after-pulse neutron and gamma rays emission from the soil, one can detect layering stratification of hydrogen and other elements.

Both instruments consist of two blocks: 14 MeV pulsing neutron generator PNG with pulse duration ~1 μs, and detector block with neutrons and gamma detectors based on 3He counters and CeBr3 scintillator, respectively (Figure 1). 3He counters allow to detect thermal and epithermal neutrons, which are the most sensitive to hydrogen in underlying soil, and gamma-ray detector allows to detect nuclear lines at the energy range from 200 keV to 10 MeV. Readout and digital electronics are designed to minimize the dead-time of signal processing. It allows to accumulate the after-pulse profiles of emission of neutrons and gamma-rays with very good time (less than 2 μs) and spectral resolutions (better than 4.5% for 662 keV). So, more detailed information of instruments design and measurements will be presented.

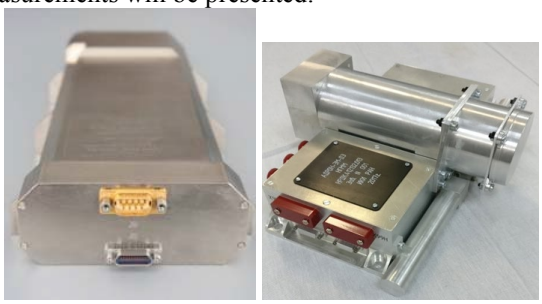

Fig.1. ADRON Instrument: PNG (left) and detectors block (right)

The results of laboratory measurements and numerical simulations will also be presented for post-pulse emission of neutrons and gamma rays. As an example, Figure 2 shows a number of counts for hydrogen gamma-ray line at 2.22 MeV in LaBr3 detector of ADRON depending on water content in lunar soil in the time window of 0.1-1 millisecond time after a PNG pulse, as calculated for 1 irradiated 14 MeV neutron.

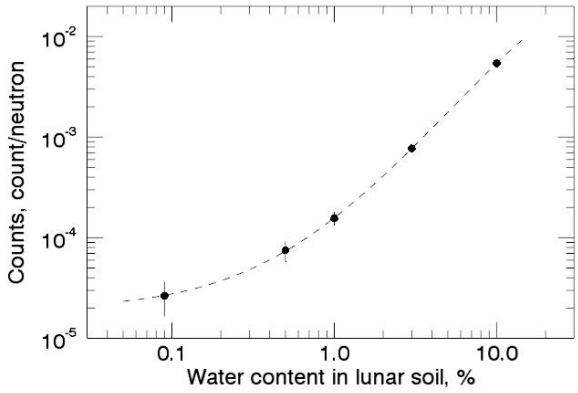

Fig.2. Total counts for gamma-ray line 2.22 MeV in LaBr3 detector of ADRON-LR depending on water content in lunar soil in time window 0.1-1 millisecond after PNG pulse for 1 irradiated 14 MeV neutron.