EXPERIMENT OF DYNAMIC ALBEDO OF NEUTRONS (DAN): SEARCHING FOR WATER-RICH SPOTS FROM THE ROVER ON THE SURFACE OF MARS. M.L. Litvak[1], I.G. Mitrofanov[1], A.S. Kozyrev[1], A.B. Sanin[1], V.I. Tretyakov[1], V.I.Ryzhkov[2] and V.N.Shvetsov[3], [1]Space Research Institute, RAS, Moscow, 117997, Russia, imitrofa@space.ru, [2]Science and Research Center for Automatics, TBD, [3]Joint Institute for Nuclear Research

Introduction. After global neutron mapping of Mars by Odyssey from the orbit [1-4], the next step of shallow water detection should be measurements of neutrons directly on the surface. If the orbital measurements present the global picture of shallow water distribution on Mars with resolution of 200-300 km, the surface data may provide the spatial resolution of 1-3 meters both along the surface and into depth, and therefore may support the direct access to water bearing soil and/or to water ice. The technical condition for these searching for water is the surface mobility, which could be provided either by future NASA Martian Science Laboratory of 2009, of by another future Rovers on the surface of Mars. The concept of the experiment of Dynamic Albedo of Neutrons (DAN) on the Mars rover is presented below, and expected results of these measurements are discussed.

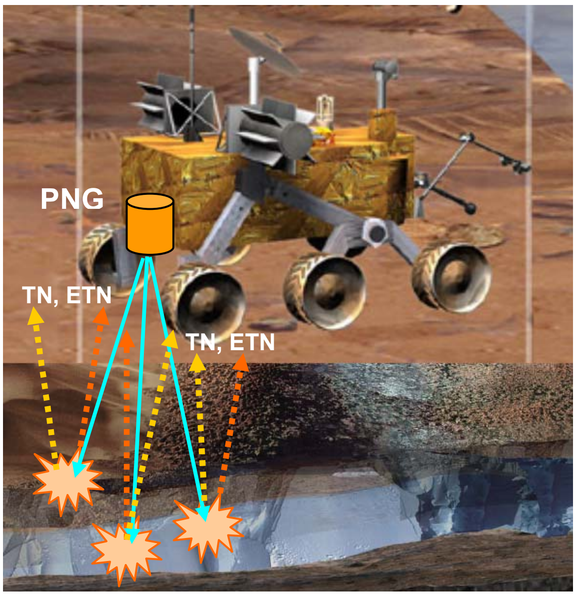

Figure 1. The concept of DAN measurements on the Rover. PNG is pulsing neutron generator, which radiate high energy neutrons (bright blue). Epithermal and thermal neutrons (ETN and TN) of dynamic albedo are shown by red and yellow, respectively.

Concept of DAN experiment. The main element of DAN instrument is the Pulsing Neutron Generator (PNG, Figure 1), which produces 1-2 μsec pulses of high energy neutrons at 14 MeV with the frequency f_{PNG} about 10 Hz or lower. The flux of neutrons at each pulse is about 10^7 particles. These high energy neutrons propagate to the subsurface below the Rover down to the depth and produce the leakage flux of epithermal and thermal neutrons (ETN and TN), which die away during the time about several msec (Figure 1).

The measurements of dynamic albedo of epithermal and thermal neutrons allow to identify the structure of subsurface, the major elements of the soil, and, the most important, the content of shallow water at about 2-3 meters around the Rover. These neutrons are detected by two separate Sensors of Thermal and Epithermal Neutrons (STN and SETN), which measure time lags of counts with resolution of 3 μsec in respect to moments of neutron pulses from PNG. Die away time profiles of albedo emission of thermal and epithermal neutrons depend both on composition and on layering of subsurface.

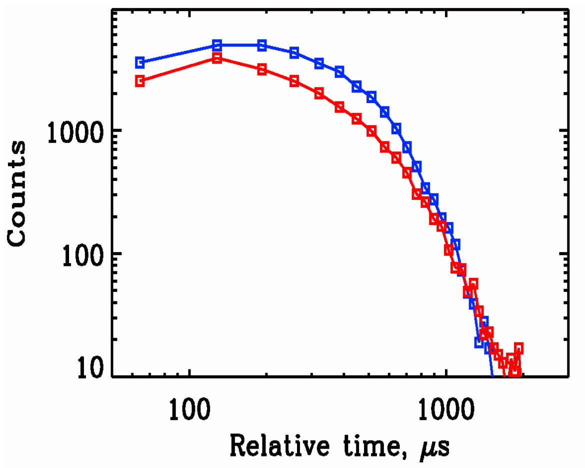

Figure 2. Laboratory measurements of die away curves for dynamic albedo of thermal neutrons for dry SiO_2 soil (red) and for SiO_2 with 30 wt% of water (blue).

According to numerical simulation, sensors of thermal and epithermal neutrons STN and STNS of DAN with effective cross-section S_{eff} will measure about

$$\sim 10^3\ (f_{PNG}/10\ \text{Hz})\ (S_{eff}/1\ \text{cm}^2)\ (d/3\ \text{m})\ (V/6\ \text{cm/s})$$

neutrons along the path of about 3 m, which Rover covers with the maximal velocity V of 6 cm/s. This statistics is high enough to detect variations of neutron albedo with the accuracy of about 3 %. If the average content of shallow water were about 10 wt% (e.g. see HEND data for Arabia [5,6]), this accuracy would be sufficient to measure the variation of water content about 3 wt% along the Rover trace.

Conclusions. Experiment DAN with pulsing activation of subsurface provides very high sensitivity for measurements of subsurface water content along the Rover trace. The measurements of passive neutron albedo due to activation by galactic cosmic rays or by radio-isotopic generators (RTGs) on the Rover (e.g. see [7]) do not provide so large statistics of counts as DAN does, and, even more important, the passive activation does not allow to measure die away curves of thermal and epithermal neutrons, which is the most sensitive nuclear method for detection the layered structure and composition of subsurface.

Figure 2 presents two die away curves of thermal neutrons, which were measured in the laboratory by DAN laboratory prototype at 10 cm above SiO_2 soil (red curve) and soil with 70 wt% of SiO_2 and 30 wt% of water. The difference factor ~2 between these two curves demonstrate the "power" of DAN for detection of water in the subsurface.

DAN provides very useful flexibility of operations with different sensitivity and power consumption depending on frequency of pulses and on the Rover velocity. There are different regimes of measurements for high-speed motion, special regimes for low-speed back-forward mapping of some local spot, and special regime for Rover parking conditions.

References:

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