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Active Neutron Spectrometer (ANS) for on-board un-distractive screening of water-rich samples for Lunar Sample Return missions

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Introduction

Return of samples of lunar surface in 70-th years of past century has made very significant progress to understanding of geology and evolution of the Moon. At the last decade of that century the US missions Clementina and Lunar Prospector have provided the observational data, which indicated on the possibility of water ice deposits at bottoms of permanently shadowed craters at lunar poles (e.g. see [1-2]). Instruments of NASA's Lunar Reconnaissance Orbiter have to perform the conclusive testing of the presence of polar water ice on the Moon [3]. Either in positive or negative case, laboratory studies of lunar samples with enhanced content of hydrogen and/or water shall be the next important step of lunar exploration.

That means that instruments for on-board un-destructive screening of samples for return are necessary for future lunar robotic missions. Similar instruments could be useful as well for future sample return missions from Mars.

Instrumentation

The concept of ***Active Neutron Spectrometer (ANS)*** is based on the well-known method of neutron logging for geological applications. However, instead of putting the instrument into the well, we propose to screen all samples delivered from the well onboard the lander to measure the average content of hydrogen (i.e. hydrogen equivalent water) in each sample. Samples with high enough content of water could be selected for return them to the Earth.

Experimental results

Pulsing Neutron Generator (PNG), which has been developed for DAN instrument onboard the NASA's Mars Science Laboratory [4], and special Detection and Electronic Unit (DEU) with 3He counter are used to measure induced emission of thermal and epithermal neutrons from a tested sample (Figure 1). This laboratory set-up is the full-scale prototype of ANS instrument.

Aluminum tubes 10 cm long and 3 cm in diameter were filled by sand with different content of water or water-substitute material (polyethylene). Total mass of each sample was about 100-150 g. These samples were irradiated by neutrons prom PNG at 14 MeV during total exposure of 5 minutes, and die-away emission of moderated thermal neutrons from these samples was measured by DEUles.

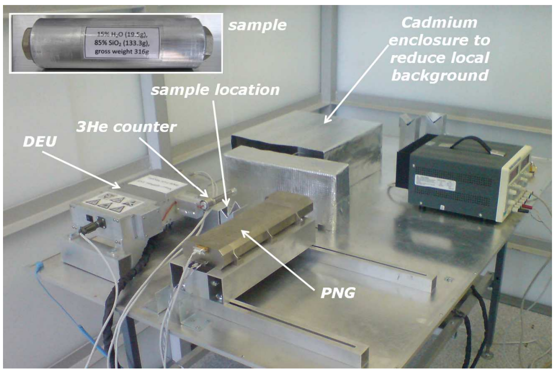

Figure 1: Laboratory prototype of ANS instrument. Example of a soil sample is shown in at left-top corner.

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Figure 2 shows the measured time profiles of die-away emission of secondary thermal neutrons for three tested samples with 100, 15 and 5 wt% of water. The difference between time profiles for different samples is very large. The measurements of this difference allow to estimate the content of hydrogen/water in the soil of these samples with the accuracy better than 1 wt% during exposure time of several minutes.

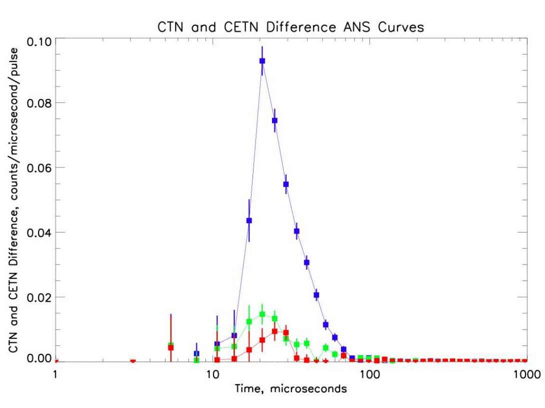

Figure 2: Time profiles of die-away emission of thermal neutrons from samples with 100 (blue), 15 (green) and 5 (red) wt% of water in the mixture with sand.

Conclusion

ANS instrument is based on available heritage of design of DAN, and it has very high technology readiness level. The mass of ANS is about 6 kg and total consuming power is about 16 W.

ANS is proposed for future robotic landers of lunar sample return missions. This instrument will allow to perform non-destructive screening of water-rich samples.

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