NEUTRON DETECTORS ON MARS: FROM HEND ONBOARD MARS ODYSSEY TO ADRONS ONBOARD EXOMARS-2022. MAJOR RESULTS, FIRST DATA AND UNRESOLVED ISSUES. A. V. Malakhov[1], I. G. Mitrofanov[1], M. L. Litvak[1], A. B. Sanin[1], S. Y. Nikiforov[1] and D. V. Golovin[1], [1]Space Research Institute, Profsoyuznaya st. 84/32, 117997, Moscow, Russia.

Introduction: Neutron planetology methods involving neutron and gamma-ray detectors operating on orbit or from the surface of a celestial body are known and implemented for several decades and yielded important scientific results. On Mars, many instruments investigated the planet using these techniques and several are currently in commissioning and development.

Current results: For instance, High Energy Neutron Detector (HEND), part of the Gamma-Ray Spectrometer instruments suite onboard 2001 Mars Odyssey orbiter is actively operating for more than 16 years [1]. It produced a map of soil hydrogen variability and was able to observe its seasonal variations. HEND was the first to discover huge permafrost areas around Martian polar ice caps.

On August 6, 2012 the Dynamic Albedo of Neutrons (DAN) instrument onboard the Curiosity rover landed in Gale crater of Mars [2]. It is the first scientific space instrument featuring a pulse neutron generator that allows to screen the subsurface for hydrogen-bearing materials from a lander vehicle on Mars. The neutron generator emits 10 pulses per second of 10^7 neutrons with 14 MeV energy. This produces much stronger neutron flux than Galactic Cosmic Rays can, thus usage of this artificial source of neutrons as part of the instrument allows DAN to perform measurements in a matter of minutes instead of several hours. Furthermore, the active neutron pulsing technique allows for detection of layered hydrogen structure in situ.

After 5 years of operation, measurements of DAN instrument are not in line with the data from HEND orbital measurements, which presents an unresolved issue to the question of hydrogen deposits in Gale crater [3]. There are several theories that can resolve this question, but they need to be confirmed by new data.

Fine Resolution Neutron Detector (FREND) instrument onboard the Trace Gas Orbiter (TGO) of the ExoMars mission already arrived in the Martian orbit and is currently finalizing aerobraking that will bring the mission to the final circular orbit in April 2018 [4]. FREND's main feature is its collimator that allows for neutron detectors' very narrow field of view – up to 28 km radius spot. This will allow for new hydrogen deposition maps to be of a much higher spatial resolution than that of HEND: an omnidirectional detector's field of view is from horizon to horizon, which, in case of Mars Odyssey orbit is around 200 km radius. A finer resolution of hydrogen deposition maps would allow, possibly, to resolve the problem of HEND and DAN data discrepancies. In any case, this new knowledge would allow for finer selection of prospective landing sites and help understanding the geology of Mars better.

Future missions: Part of the second launch of the ExoMars programme, ADRON-RM [5] and ADROM-EM instruments onboard the Pasteur rover and the landing platform, respectively, are being developed. The landing platform instrument contains a pulse neutron generator, identical to that of DAN. Pasteur rover instrument is a passive detector only – however it will be able to work in sync with the generator onboard the landing platform while it is in the vicinity. These two instruments will provide further hydrogen characterization of the landing site and rover path, and provide another cross-check between HEND and FREND orbital and ExoMars-2022 in situ data.

Conclusion: We summarize that the neutron spectroscopy instruments are very common on Mars, allowing for characterization of hydrogen deposition in the soil of the planet from orbit and in landing locations. These data provided for a number of discoveries and new knowledge of the planet's history and present state, including the search for life. Future missions will widen this knowledge and, partnered with other instruments onboard space missions, will help understand further the past and present of Mars.

References: [1] Mitrofanov I. G., Litvak M. L. et al. (2004) *Solar System Research, 38,* 253-257. [2] Mitrofanov I. G., Litvak M. L. et al. (2012) *SSR, 170,* 559-582 *JGR, 90,* 1151–1154. [3] Mitrofanov I. G., Litvak M. L. et al. (2014) *JGR, 119,* 1579-1596. [4] Mitrofanov I. G., Malakhov A. V. et al. (2017) *EGU, 19,* 14685. [5] Mitrofanov I. G., Litvak M. L. et al. (2017) *Astrobiology, 17, 585-594.*