MSL DAN Science Investigation: Physical Simulation of DAN

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Outline

- Overview of DAN
- the proposed investigation
  - Investigation 1 – Library and algorithm
  - Investigation 2 – Impact of the MMRTG neutrons
  - Investigation 3 (Optional) - Secondary neutrons at the surface
- Path-forward plan
MSL DAN Overview

Location of DAN DE and PNG on rover

MMRTG

14 MeV neutrons

Albedo neutrons

This document has been reviewed and determined not to contain export controlled technical data.
DAN Measurements

- DAN measures the abundance of H and OH bearing materials (e.g., adsorbed water or hydrated minerals)
  - Active neutron spectroscopy with pulsed 14 MeV neutrons or passive
  - Creates profiles along traverses and with depth to 1 m
  - Resolves time decay curve and energy spectrum of returned pulse
  - Accuracy of 0.1-1% by weight of water (or water-equivalent hydrogen) depending on observation type
DAN Operational Schemes

Operational Regimes of DAN measurements

Regime (1) – Monitoring during a motion (PNG is off or works with low frequency)
Regime (2) – Studying of a Target (PNG works with frequency up to 10 Hz)
Regime (3) – Studying of hydrogen profile along a motion (PNG works with frequency up to 10 Hz)
Regime (4) – 2D Studying of hydrogen content at a Location (PNG works with frequency up to 10 Hz)
Regime (5) – Passive measurements during studying a Target (PNG is off)

This document has been reviewed and determined not to contain export controlled technical data.
The main objective of the proposed investigation is to study the characteristics (i.e., hydrogen content, soil composition, layer-structure, etc.) of subsurface and the surface radiation (neutron in particular) environment:
Investigation 1

• How do we identify scientifically interesting target or region in near-real time to maximize the science return?

Develop numerical approaches to simulating active DAN measurements over a range of rock/regolith compositions and layer structures.

Develop an algorithm that can be used to producing quick turn-around analysis of active DAN data to identify likely composition or layer structure of sub-surface.

Generate an extensive database (or library) of expected DAN measurements for a wide range of hydrogen contents, chemical composition, and layer-structure of sub-surface.

Validate the library and algorithm with the data from field or lab tests.

(Surface Operation) Determine the characteristics of sub-surface in near-real time using the algorithm with the library developed.
Simulation Results (Examples)

No rover structure included

**Simulated die-away curve of thermal neutrons with different water contents** (homogeneous soil model)

**Comparison of simulated die-away curves of thermal neutrons with for different soil composition (Mars vs. Venus) without water**
Investigation 2

• What would be the impact of neutrons from MMRTG to DAN measurements?

Perform careful analysis of estimating MMRTG neutron’s impact to the DAN measurements

Remove the background noise floor

Table 1-2. Neutron spectrum from the MSL RTG [Kang and Jun, 2005].

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Investigation 3
(If time permitted and collaborating with RAD)

- What would be the GCR- or SEP-induced secondary neutron environment at the surface?

Study GCR- or SEP-induced secondary neutron environments at the surface through extensive radiation transport simulations during passive DAN mode.

Use radiation transport tools to estimate the spectrum of secondary neutrons at the surface given the atmospheric condition and spectra of GCR and SEP

Measure the spectrum of secondary neutrons at the surface resulting from GCR or SEP interactions with Martian atmosphere and soil

Figure 1-4. Estimated neutron flux enhancement of Martian neutrons (two data points were taken at periapses #48 and #49) from the Mars Odyssey HEND instrument during the extreme SEP event in November 23-26, 2001, compared with the average neutron flux at an altitude of 700 km [Mitrofanov, 2005].

determined not to contain export controlled technical data.
Plan Toward the Landing Day

- Initiate numerical simulations with different:
  - Soil compositions
  - Water contents
  - Sub-surface layer structures

- Study effect of the followings on the neutron counts:
  - CO2 atmosphere
  - Rover structure

- Develop and validate an algorithm

- Investigate the sensitivity of GCR- or SEP-induced neutron environment at the surface due to variation of atmospheric conditions

- Collect the information from IKI (see next chart)

- Any other requests from the DAN science team or any theme group?

Any suggestions from the DAN science team for me to start?
Information Needed from the IKI DAN Team

• Geometry and materials of PNG and detector assembly for detailed numerical simulations
• Detector response function (i.e., efficiency curve)
• Format of the passive and active DAN measurement data (e.g., energy boundaries)
• Any data from field or laboratory tests