# MSL DAN Science Investigation: Physical Simulation of DAN

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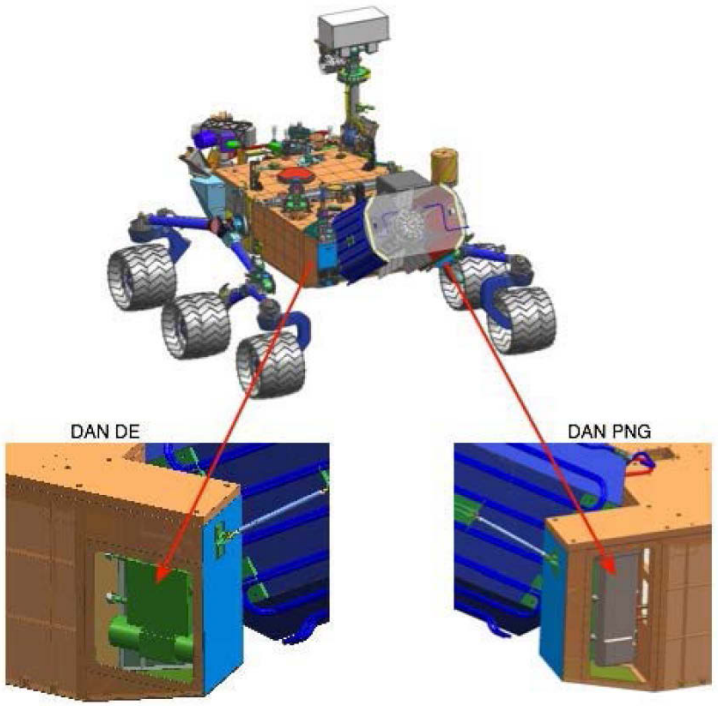
# Outline

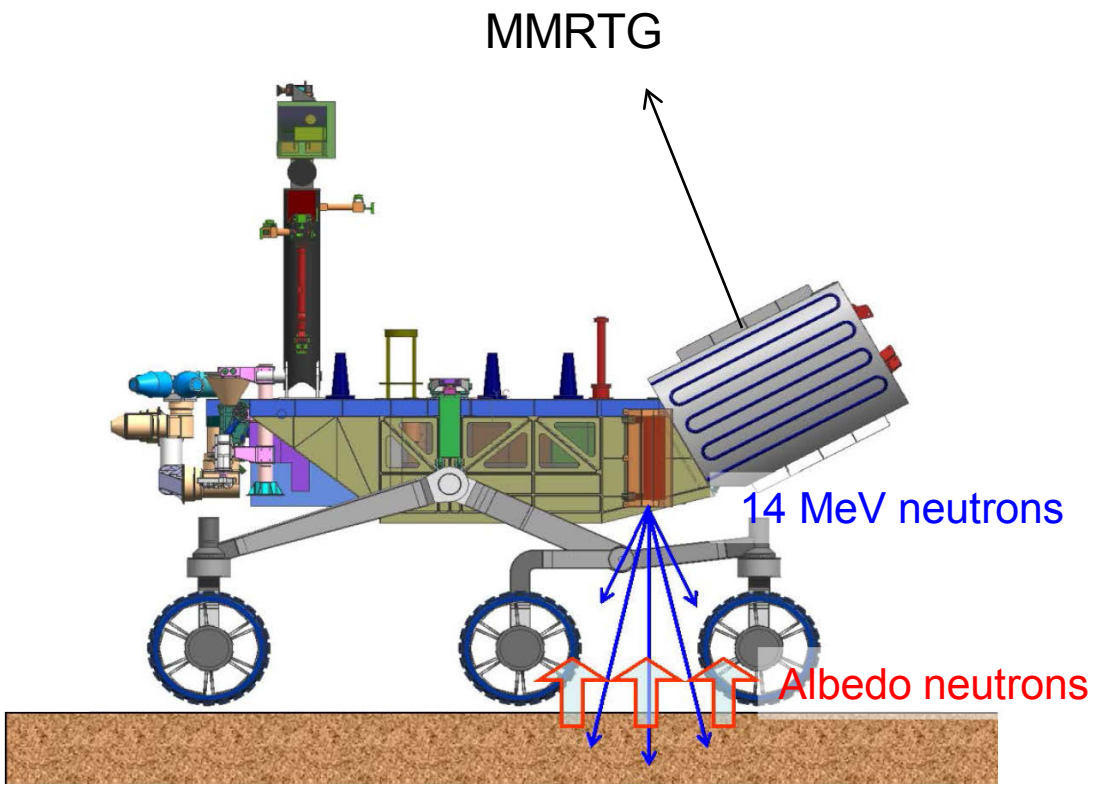
- Overview of DAN
- the proposed investigation
  - Investigation 1 – Library and algorithm
  - Investigation 2 – Impact of the MMRTG neutrons
  - Investigation 3 (Optional)- Secondary neutrons at the surface
- Path-forward plan

# MSL DAN Overview



## Location of DAN DE and PNG on rover



# 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



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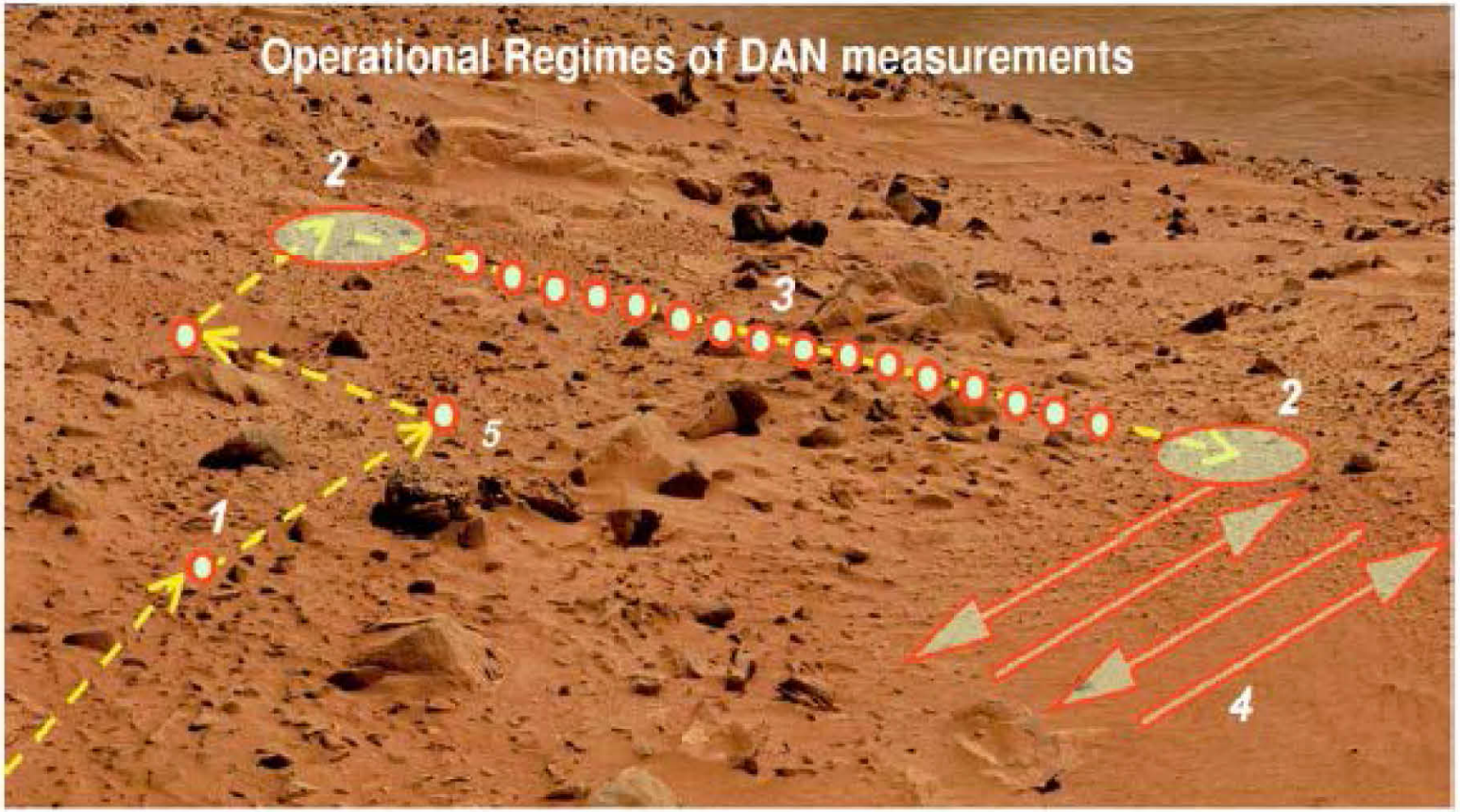



Regime (1) – Monitoring during a motion (PNG is off or works with low frequency)
Regime (2) – Studying of a Target (PNG works with frequency up to 10 Hz)
Regime (3) – Studying of hydrogen profile along a motion (PNG works with frequency up to 10 Hz)
Regime (4) – 2D Studying of hydrogen content at a Location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

The main objective of the proposed investigation is ***to study the characteristics (i.e., hydrogen content, soil composition, layer-structure, etc.) of sub-surface 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***

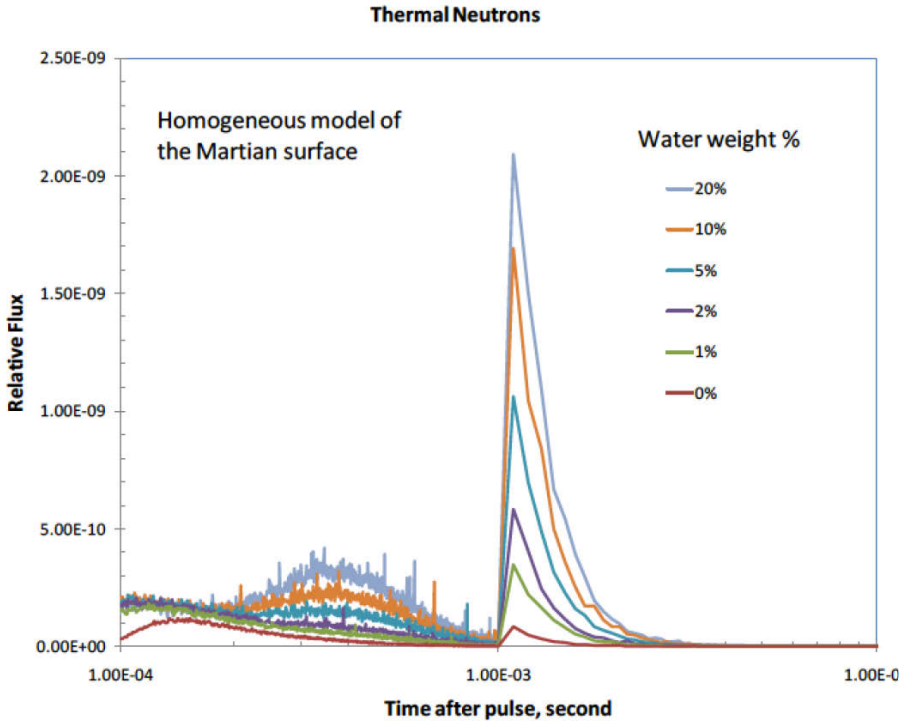
***Validate the library and algorithm with the data from field or lab tests***

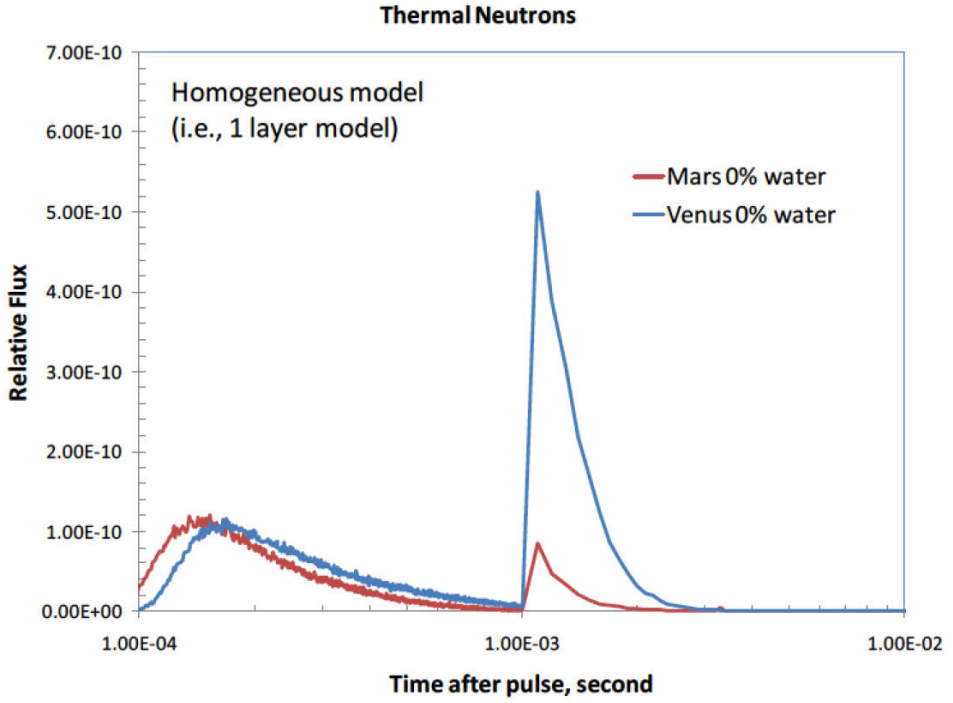
***(Surface Operation) Determine the characteristics of sub-surface in near-real time using the algorithm with the library developed***

# 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].

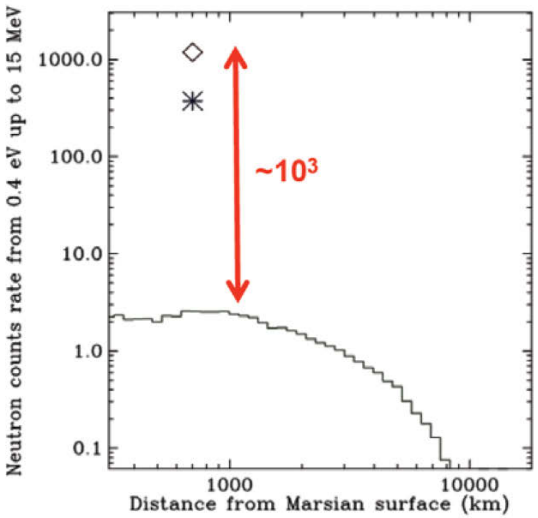
| Energy Bin | | |
|---|---|---|
| Elow, MeV | Ehigh, MeV | #n/s/g-of PuO2 |
| 2.50E-08 | 1.07E-07 | 6.31E-08 |
| 1.07E-07 | 3.00E-06 | 7.82E-06 |
| 3.00E-06 | 3.00E-05 | 2.39E-04 |
| 3.00E-05 | 5.55E-04 | 1.94E-02 |
| 5.55E-04 | 1.70E-02 | 3.49E+00 |
| 1.70E-02 | 4.49E-02 | 1.18E+01 |
| 4.49E-02 | 1.22E-01 | 4.90E+01 |
| 1.22E-01 | 2.01E-01 | 6.62E+01 |
| 2.01E-01 | 3.31E-01 | 1.22E+02 |
| 3.31E-01 | 5.46E-01 | 2.28E+02 |
| 5.46E-01 | 7.02E-01 | 1.75E+02 |
| 7.02E-01 | 9.00E-01 | 2.24E+02 |
| 9.00E-01 | 1.16E+00 | 3.02E+02 |
| 1.16E+00 | 1.49E+00 | 4.22E+02 |
| 1.49E+00 | 1.91E+00 | 6.63E+02 |
| 1.91E+00 | 2.45E+00 | 1.11E+03 |
| 2.45E+00 | 3.14E+00 | 1.39E+03 |
| 3.14E+00 | 4.04E+00 | 9.10E+02 |
| 4.04E+00 | 4.46E+00 | 1.15E+02 |
| 4.46E+00 | 5.18E+00 | 7.44E+01 |
| 5.18E+00 | 6.66E+00 | 6.87E+01 |
| 6.66E+00 | 8.55E+00 | 2.76E+01 |
| 8.55E+00 | 1.00E+01 | 6.56E+00 |
| 1.00E+01 | 2.00E+01 | 3.73E+00 |
| | | |
| | TOTAL | 5.97E+03 |

# 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 peri-apsises #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

***Any suggestions from the DAN science team for me to start?***

- 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?

# 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