ANALYZING THE PRESENT-DAY MARTIAN RADIATION ENVIRONMENT WITH MSL/RAD - IMPLICATIONS FOR DIFFERENCES IN THE EARLY-MARS PERIOD Bent Ehresmann[1], D.M. Hassler[1], R.F. Wimmer-Schweingruber[2], C. Zeitlin[1], S. Boettcher [2], S. Burmeister [2], J. Koehler [2], C. Martin [2], D. Brinza [3], S. Rafkin [2], the RAD team, the MSL team, [1]Southwest Research Institute, Boulder, CO 80302 USA; ehresmann@boulder.swri.edu; [2]Christian-Albrechts-Universitaet zu Kiel, Kiel Germany; [3] JPL/Nasa, Pasadena, CA 91011 USA

Introduction: The Radiation Assessment Detector (RAD) on NASA's Mars Science Laboratory (MSL) mission aims to characterize the radiation environment on the surface of Mars, measuring charged and neutral particles [1]. These include both primary particles from galactic cosmic rays (GCRs) and Solar particle events (SEPs), and secondaries created by the interaction of these particles with the molecules of the Martian atmosphere and soil.

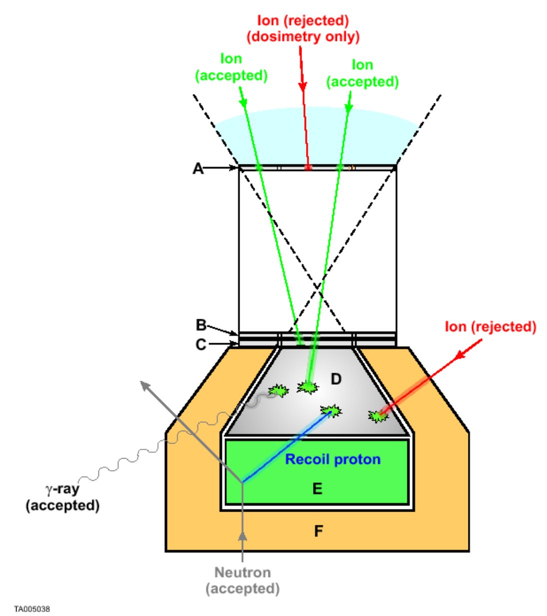

Figure 1: Schematic of the RAD sensor head. Allowed flight paths for stopping charged particles in green, rejected paths in red.

A schematic of the RAD sensor head, as well as allowed and rejected flight paths of charged and neutral particles, can be seen in Fig. 1.

One of the main science objectives of RAD is to assess the measured surface radiation environment in terms of health risks for humans on future manned missions to Mars. Furthermore, such a radiation environment can also prove hazardous for any potential simple (e.g., bacterial) life forms residing subsurface in a dormant state. Here, the RAD measurements can aid in gaining knowledge of chemical alterations of the regolith due to the interactions with space radiation.

Present-day radiation environment: The present-day radiation environment on the Martian surface mainly stems from GCRs and their interactions with the molecules in the atmosphere and in the soil. The surface fluxes of these primary and secondary particles are significantly higher than found on the Earth's surface. This is because Mars, in comparison, has a much thinner atmosphere, allowing energetic particles to propagate much deeper in the atmosphere, even all the way to the ground. Fig. 2 shows simulation results of how such a surface radiation field induced by GCRs might look like.

There are other contributing factors to the radiation environment, such as the natural background radiation due to the decay of unstable radionuclides found in the ground. Interactions of Solar energetic particles (SEPs), ejected from the Sun during Solar events, with the Martian atmosphere can also lead to a high, if short-lived, contribution to the surface radiation environment.

Early Mars: While the present-day surficial and environmental conditions on Mars do not seem to be well-suited for a potential presence of life, there is evidence that the early Mars possessed a much more convenient environment for an emergence of life. It is assumed that in the Noachian period ($\sim$ 4 Ga ago), Mars sustained larger bodies of liquid surface water [3, 4]. This in turn leads to the conclusion that Noachian Mars must have had a considerably denser atmosphere. As can be seen on Earth, denser atmospheres most probably yield much lower surface radiation fluxes and, thus, creating a better suited environment for life viewed from a radiation standpoint. The exact magnitude of the postulated higher Noachian surface pressure is yet unknown, but model calculations place the necessary amount of CO_2 pressure between 0.6 - 5 bar [5, 6]. As can be seen in Fig. 3, these estimated CO_2 levels would place the resulting surface radiation exposure in the order of magnitude of the absorbed dose encountered under present-day terrestrial conditions.

Measurements with RAD: Before the MSL mission and the RAD instrument there existed no measurements of the Martian surface radiation field. So, researchers had to rely on particle-propagation models, such as GEANT4 [7] and its application Planetocosmics [8], to investigate the Martian radiation environment. A disadvantage of these codes is that they have to make certain assumptions about environmental conditions and are dependent on the quality of their underlying physics models.

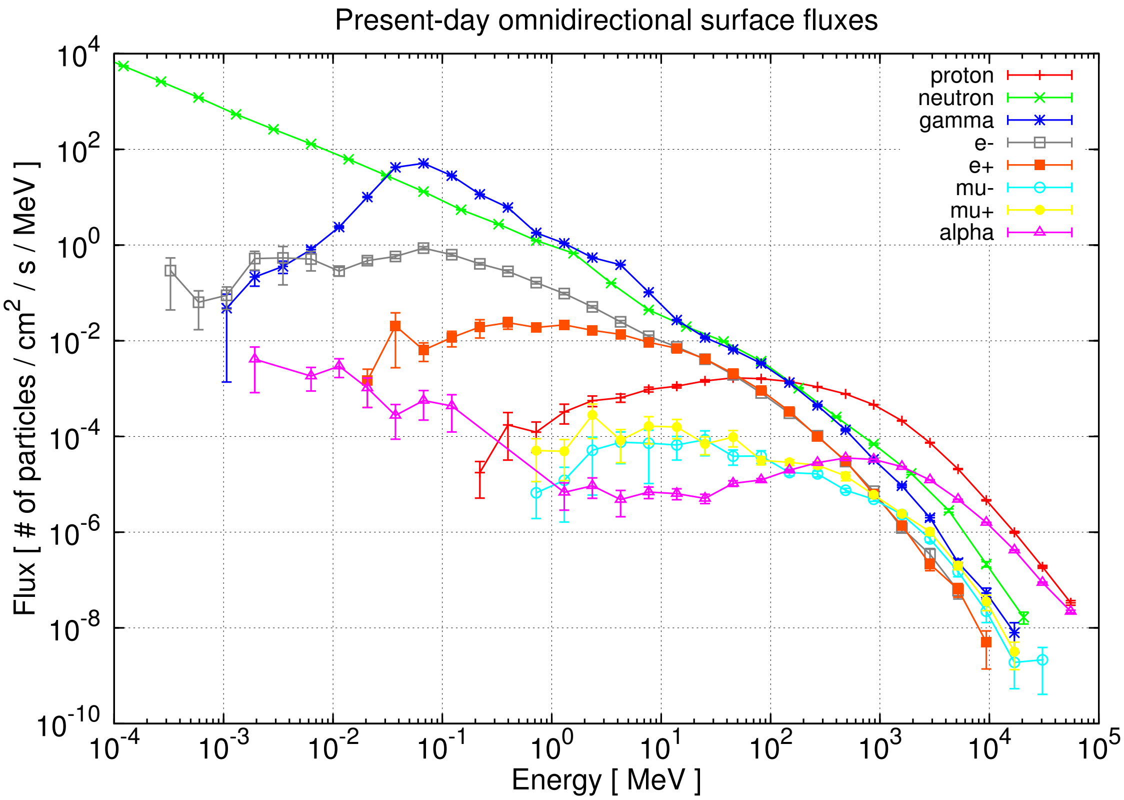

Figure 2: Exemplary present-day omnidirectional fluxes on the Martian surface, calculated with Planetocosmics. From [2].

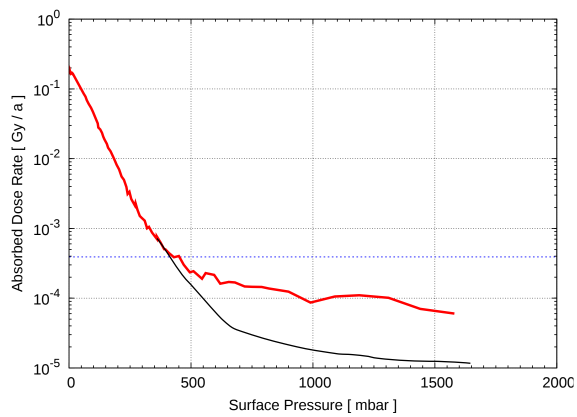

Figure 3: Calculated absorbed dose rates on the Martian surface for different surface pressure levels (red). The black line shows an extrapolation accounting for uncertainties in the model. Shown in blue is the average GCR-induced dose rate on the Earth's surface during present-day. From [2].

The RAD analysis will be a valuable tool for validating these propagation codes by comparing measurements and simulations of the surface radiation. Furthermore, as RAD was already operating during the cruise phase, the results can also help to validate free-space models of the galactic cosmic radiation.

Conclusions: In this presentation, we will present RAD measurements of charged particle fluxes during cruise and on the surface and compare them with expected results derived from simulations. Furthermore, we will give modeled estimates of the present-day and Noachian radiation environments on Mars and their implications for a possible emergence and sustainment of life on Mars, as well as place these model results in context with findings from the MSL/RAD mission.

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