The Radiation Assessment Detector (RAD) on the Mars Science Laboratory (MSL). D. M. Hassler[1], J. Andrews[1], M. Bullock[1], D. Grinspoon[1], K. Neal[1], A. Posner[1], S. Rafkin[1], Y. Tyler[1], M. Vincent[1], E. Weigle[1], C. Zeitlin[1], R. Beaujean[2], E. Boehm[2], S. Boettcher[2], S. Burmeister[2], O. Kortmann[2], C. Martin[2], R. Muller-Mellin[2], R.F. Wimmer-Schweingruber[2], G. Reitz[3], D. Brinza[4], F. Cucinotta[5], and T. Cleghorn[5], [1]Southwest Research Institute, 1050 Walnut St., Boulder, CO 80302, [2]Christian-Albrechts-Universitaet, Kiel, Germany, [3]DLR, Koln, Germany, [4]Jet Propulsion Laboratory, Pasadena, CA, [5]NASA Johnson Space Center, Houston TX.

Introduction: The Radiation Assessment Detector (RAD) will detect and analyze the most hazardous energetic particle radiation on the surface of Mars as a key element of the Mars Science Laboratory (MSL) mission. Fully characterizing and understanding the radiation environment on the Martian surface is fundamental to quantitatively assessing the habitability of the planet (both past and present), and essential for future manned Mars missions. As part of the MSL investigation, RAD will address the radiation effects on biological potential and past habitability, as well as keys to understanding the chemical alteration of the regolith due to impinging space radiation.

RAD Primary Science Objectives: The primary science objectives of RAD are:

- To characterize the energetic particle spectrum at the surface of Mars, including direct and indirect radiation created in both the atmosphere and the regolith. This includes contributions from Galactic Cosmic Rays (GCR), Solar Particle Events (SPEs), and secondary neutrons created in both the atmosphere and the regolith,
- To determine the radiation dose rate and equivalent dose rates for humans on the surface of Mars,
- To enable validation of Mars atmospheric transmission models and radiation transport codes,
- To provide input to the determination of the radiation hazard and mutagenic influences to life, past and present, at the Martian surface,
- To provide input to the determination of the chemical and isotopic effects of energetic particles on the Martian surface and atmosphere.

Radiation Environment and Habitability: RAD is the primary instrument for assessing the contribution of the radiation environment to sterilization on and below the Martian surface. Characterizing the radiation environment and its variations (diurnal, seasonal, solar cycle) on the surface of Mars, will allow calculations of the depth in rock or soil for which there is a lethal dose of radiation for biological organisms. From this we can learn how deep life would have to be today for natural shielding to be sufficient. These depths can be compared to calculations of diffusion depths of strong oxidizers which destroy organisms near the surface and then judge whether radiation or oxidizing chemistry will determine the minimum depth needed to drill to look for extant life on Mars. Complimentary to these measurements, and RAD's assessment of surface sterility, Complimentary ultraviolet (UV) radiation measurements will be provided by the REMS instrument on MSL, and will contribute to RAD's assessment of surface sterility.

RAD will also address questions related to the radiation effects on Mars surface chemistry and geology. Does radiation enhance or add to the aqueous weathering processes observed in the top-most dust layers? Water, wind, and exposure to the atmosphere are the primary influences of weathering. However, given the relatively poor shielding properties of the Martian atmosphere to radiation, and the demonstrated ability of radiation to alter the chemistry and appearance of surfaces (i.e. airless bodies such as the moon and asteroids), the role of radiation must be considered. RAD will measure the radiation at the surface of Mars with sufficient breadth to include radiation effects in models of weathering and chemistry of Martian rocks and regolith.

RAD measurements of the Mars surface radiation (both albedo & natural radiation) will also help characterize local geology and geochemistry. RAD will contribute to the detection of hydrogen-rich deposits indicative of water or water-ice (through measurements of the neutron albedo spectrum), as well as potential signatures of aqueous processes in early Mars.

The RAD Instrument: RAD is a lightweight (1.56 kg) energetic particle analyzer designed to characterize the full spectrum of energetic particle radiation at the surface of Mars, including both charged particles ($1 \leq Z \leq 26$) and neutral particles (neutrons, gamma rays) from 10 to >100 MeV/nuc. The RAD instrument (Figure 1) consists of a charged telescope comprised of three planar silicon PIN-diode detectors (SSDs, referred to as the A, B, and C detectors), a cesium iodide calorimeter (D), and a neutron-sensitive plastic scintillator (E). A coincidence logic system using the dE/dx method is used to identify charged particles. An anti-coincidence shield constructed out of a scintillating plastic (F), completely surrounds the D and E detectors, so that these detectors can be used to measure neutral particles. The RAD instrument itself is composed of the RAD Sensor Head (RSH) and the RAD Electronics Box (REB), shown in Figure 1.

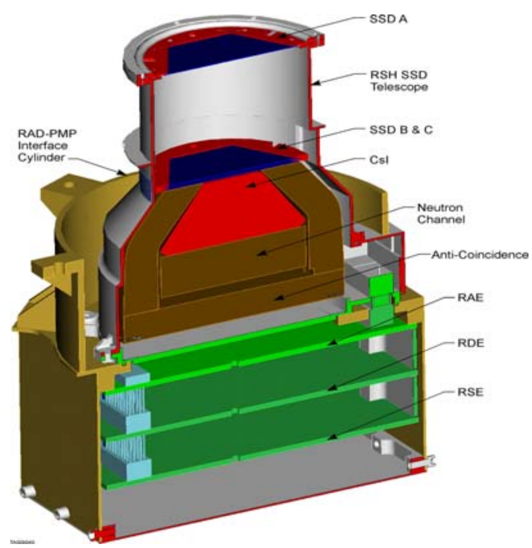

***Figure 1**. Cross section view of the RAD instrument.*

The outputs of the solid-state detectors and photodiodes are converted to digital or pulse height discriminated signals for further processing. The digital logic includes an embedded micro-controller to bin and format the data.

The RAD instrument can be used throughout the mission, including cruise phase, to characterize the radiation environment of MSL. The nominal observation cadence of RAD while on the Martian surface is roughly 1 hour, sufficient to characterize the onset of solar particle events when they occur.

RAD Calibration & Test Program: RAD has gone through an extensive calibration and test program to fully characterize its sensitivity and performance to each of the different particle radiation types. Charge particle calibration and characterization of the RAD Flight Model and Flight Spare have been carried out at the NASA Space Radiation Laboratory (NSRL) at Brookhaven national Laboratory (BNL), and will be carried out for the Flight Spare at HIMAC in Japan. Neutral particle calibration and characterization has been carried out for the EM and FM Sensor Head and EM electronics at iThemba in South Afric, PtB in Germany and CERN/CERF in Switzerland. Selected results from these calibration campaigns will be presented at the meeting.

RAD Instrument Status: Both the RAD Flight Model (FM) and Flight Spare (FS) have successfully completed environmental testing (Figure 2), and the RAD Instrument Delivery Review was held at SwRI in December 2008. The RAD FM model is ready to be shipped to JPL for temporary integration checks with the rover before being returned to SwRI for storage in preparation for final delivery to JPL and final integration with MSL in 2010.

***Figure 2**. Photo of the RAD Flight Model prior to environmental testing.*

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