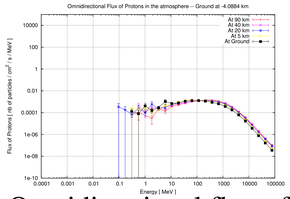
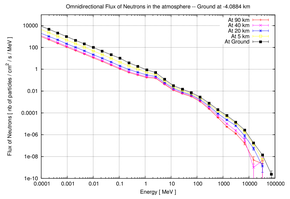
Cosmic Rays in the Martian Atmosphere and Implications for the Habitability of Mars

Robert F. Wimmer–Schweingruber, Bent Ehresmann, Cesar Martin, Eckart Boehm, Stephan Boettcher, Onno Kortmann,
Institute for Experimental and Applied Physics, Christian–Albrechts–University Kiel, Germany
Don Hassler, Cary Zeitlin, Scot Rafkin,
Southwest Research Institute, Boulder Office, Boulder, CO
Arik Posner
NASA HQ, Washington DC

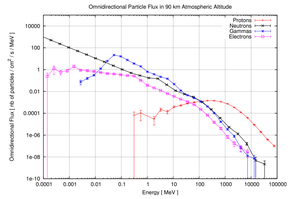
The thin atmosphere and nearly absent magnetic field provide only very weak shielding of the Martian surface from cosmic rays in the heliosphere, resulting in a much harsher radiation environment on Mars than on Earth. The maximum ionization rate lies near the Martian surface and even the topmost layers of soil do not provide the same protection against radiation hazards as at Earth. This is especially important for the habitability of Mars, even for primitve life forms which would very likely require sunlight as an energy source.



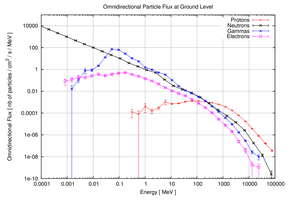
Omnidirectional flux of protons through the Martian atmosphere. The attenuation of the practically undisturbed GCR spectrum at 90km altitude is minimal, even at ground level.



In fact, the increased omnidirectional flux of secondary neutrons increases the flux of ionizing radiation.

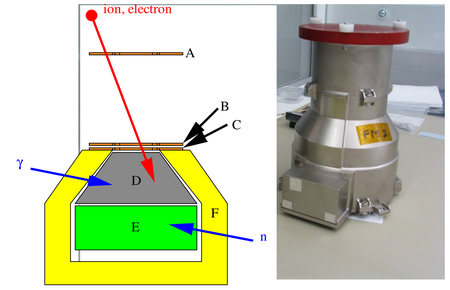


Indeed, comparison of fluxes of different particle species at 90km altitude already shows that below 100 MeV neutral ionizing radiation dominates.



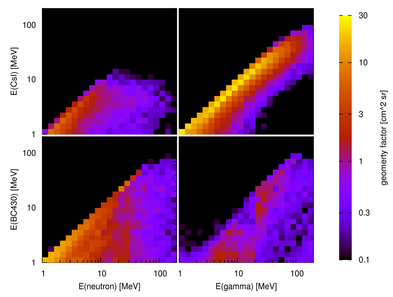
This situation is only barely altered at ground level, where neutral particles dominate below ~250 MeV.

Future MSL/RAD measurements

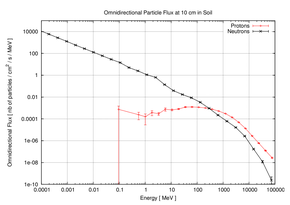


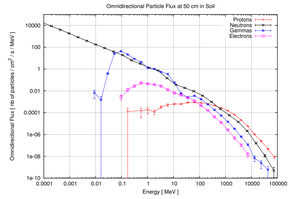
The Radiation Assessment Detector (RAD) instrument on NASA's Mars Science Laboratory (MSL mission will measure the radiation levels and their variations on Mars. Launch is foreseen for 2011.)
A combination of Si detectors and a CsI(Tl) and a plastic scintillator will allow determination of both the fluxes of charged and neutral particles.

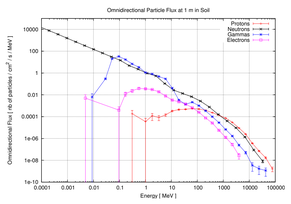
A statistical inversion will allow us to discriminate between neutrons and gamma rays. The method exploits the different energy deposits of neutrons and gamma rays in CsI(Tl) and the plastic scintillator, BC–432m.

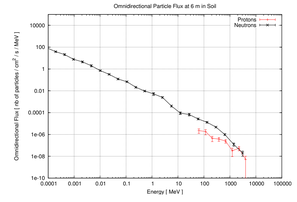


At and below ground level, the radiation is dominated by neutral particles. The following figures show the contributions of various particles at different depths below the topsoil:



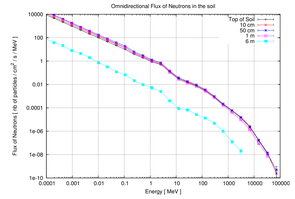






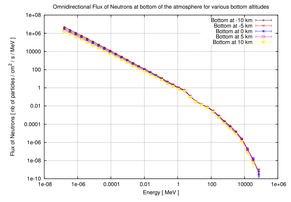
The radiation environment does not change appreciably in the top meter or so.

The small change of the radiation exposure in the top meter of soil is clearly seen in neutrons. Their omnidirectional flux only decreases appreciably when going about 6m deep.



What is the influence of location?

The small effect of atmospheric shielding means that it does not matter whether an organism were to live in a deep or an elevated area.



Next steps:

Produce a map of radiation exposure on present–day Mars.
Investigate influence of water in various forms, as well as a denser atmosphere and the presence of a large–scale magnetic field.

This work was supported in parts by DLR grant QX–0701.