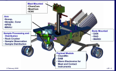
The Mars Science Laboratory (MSL) Radiation Assessment Detector (RAD)

Robert F. Wimmer-Schweingruber[1], R. Beaujean[1], E. Böhm[1], S. Böttcher[1], S. Burmeister[1], K. Herbst[1], O. Kortmann[1], C. Martin[1], R. Müller-Mellin[1], L. Seimetz[1], S. Kolbe[1], G. Reitz[2], D. Hassler[3], J. Andrews[3], M. Bullock[3], D. Grinspoon[3], M. Epperly[3], A. Posner[3], S. Rafkin[3], K. Smith[3], F. Cuccinotta[4], T. Cleghorn[4]

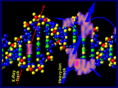
[1]Institute for Experimental und Applied Physics, CAU Kiel, Germany, [2]DLR Cologne, [3]Southwest Research Institute, Boulder and San Antonio, [4]Johnson Space Center

ESWW3, Brussels, November 16, 2006

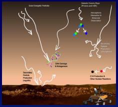
The MSL Radiation Assessment Detector (RAD)



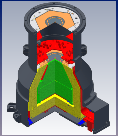
Mars Science Laboratory (MSL)



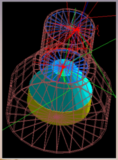
Charged particle - matter interaction



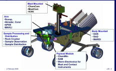
Radiation Assessment Detector (RAD) Science



RAD Sensor Head (RSH) Design

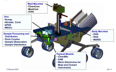


RSH modeling and calibration results

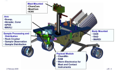


Mars Science Laboratory

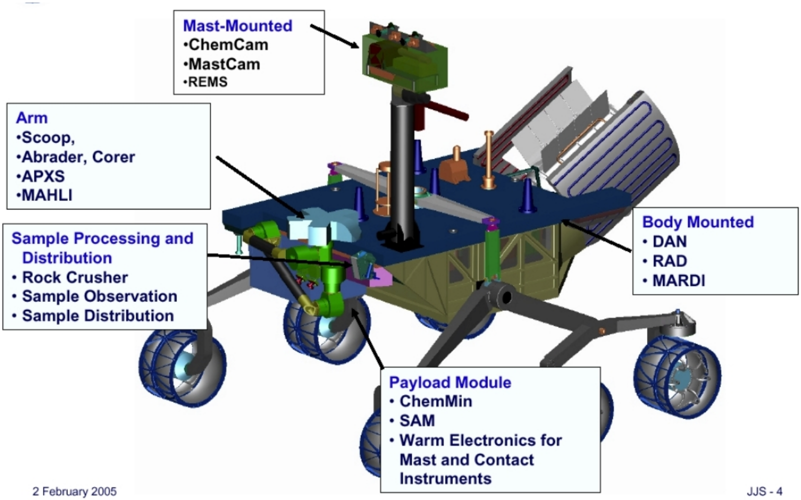
- Exploration of a Martian region as a potential habitat ("past or present")
- Biological potential of the region
- Geology and geochemistry of the region (from μm to m)
- Identification of relevant planetary processes for habitability
- Characterisation of the broad particle spectrum on the Martian surface including neutrons and γs $\longrightarrow$ **RAD**

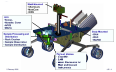


Assess a Martian Region as a Potential Habitat

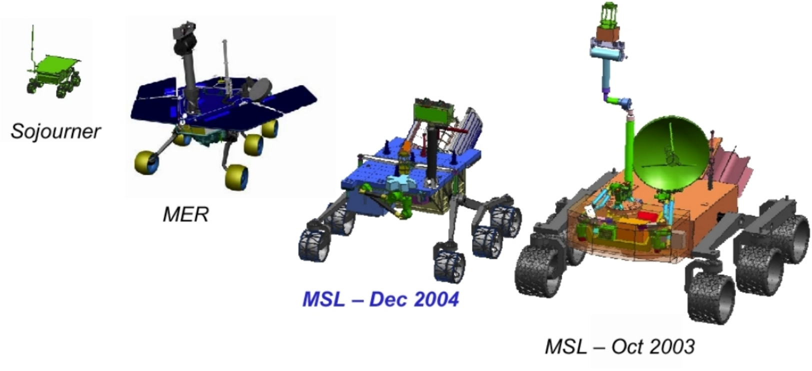


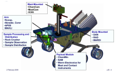
MSL Payload


Mast-Mounted
•ChemCam
•MastCam
•REMS
Arm
•Scoop,
•Abrader, Corer
•APXS
•MAHLI
Sample Processing and Distribution
• Rock Crusher
• Sample Observation
• Sample Distribution
Body Mounted
• DAN
• RAD
• MARDI
Payload Module
• ChemMin
• SAM
• Warm Electronics for Mast and Contact Instruments
2 February 2005
JJS - 4

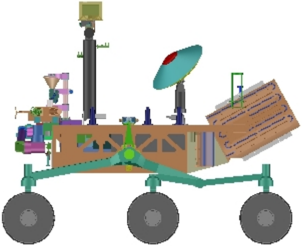


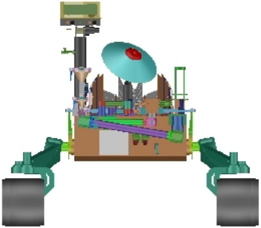
MSL Rover

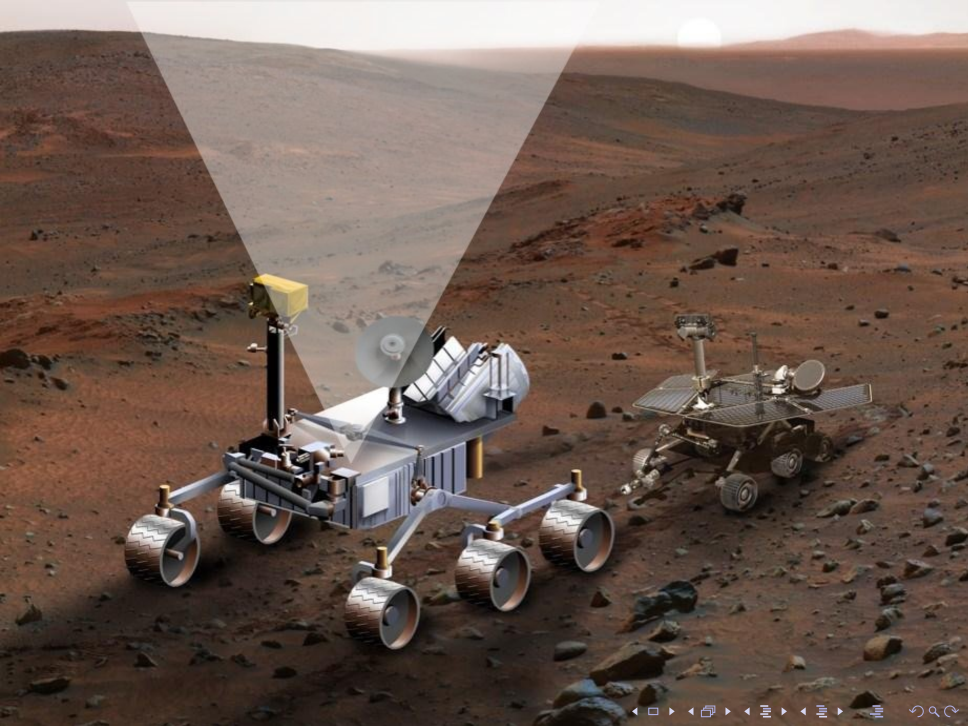


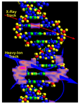


MSL Rover



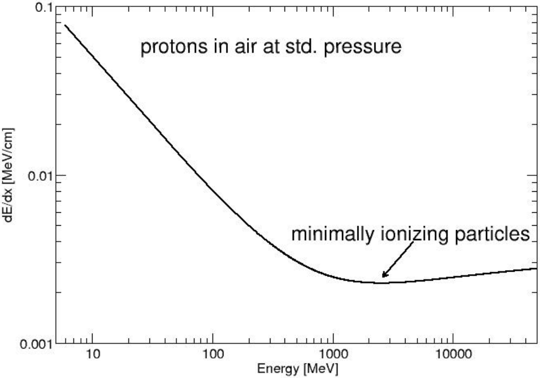


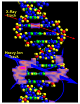




Energetic charged particles ionize target material

$\frac{\mathrm{d}E}{\mathrm{d}x} \sim Z_p^2 \rho / E \ldots$ (Bethe-Bloch)





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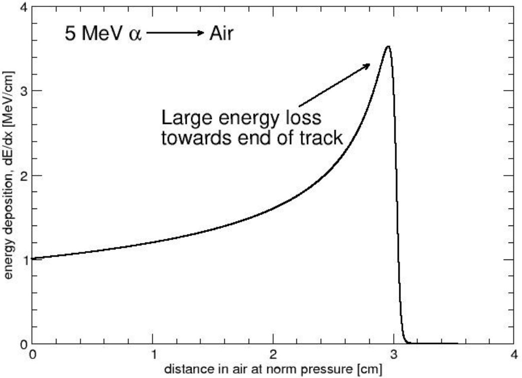
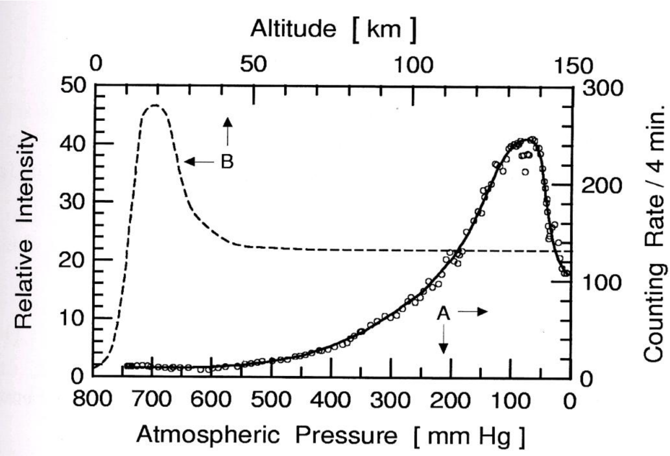


Pfotzer Maximum

at 20 km altitude on Earth,



Pfotzer Maximum

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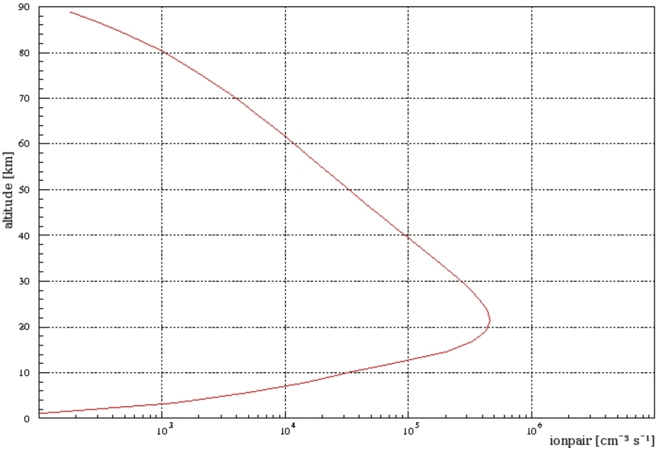
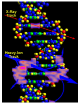
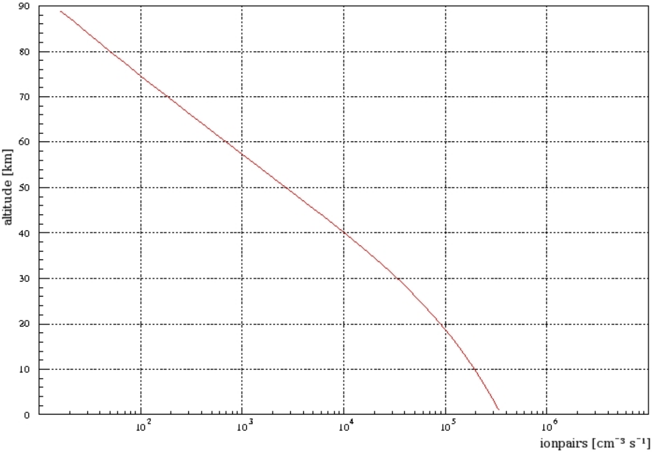
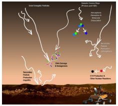




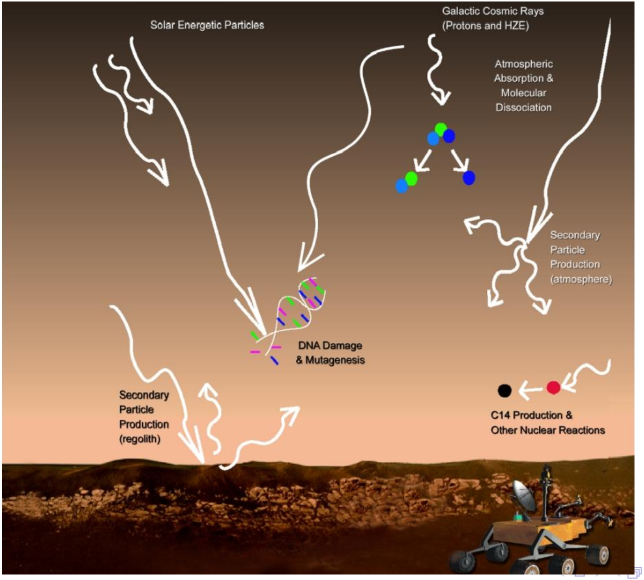
Pfotzer Maximum

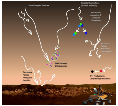
at 20 km altitude on Earth, but at Martian surface!





Radiation Assessment Detector Science





Radiation Assessment Detector Science

MSL RAD Scientific Objectives

To characterize fully the broad spectrum of radiation at the surface of Mars.

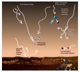
Characterize the energetic particle spectrum incident at the surface of Mars, including direct and indirect radiation created in the atmosphere and regolith.

Determine the radiation Dose rate and Equivalent Dose rate for humans on the Martian surface.

Validate Mars atmospheric transmission models and radiation transport codes.

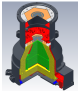
Determine the radiation hazard and mutagenic influences to life, past and present, at and beneath the Martian surface.

Determine the chemical and isotopic effects of energetic particles on the Martian surface and atmosphere.

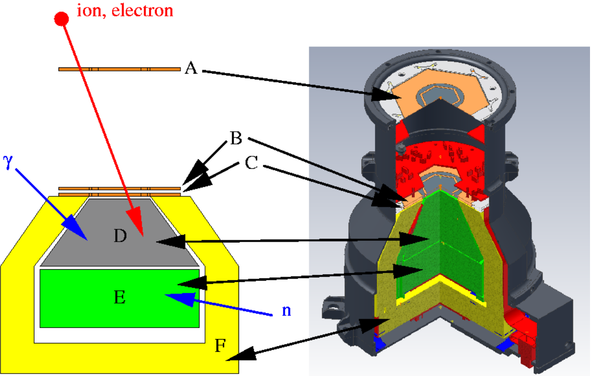


RAD Measurement Requirements

1. Energetic charged particles ($1 \leq Z \leq 26$) up to 100 MeV/nuc
2. Neutral particles (γs and neutrons) up to 100 MeV
3. Electrons up to 10 MeV
4. Dose and LET spectra
5. Resolution sufficient to resolve low-Z (p, He) from medium-Z (C, N, O,...) and high-Z (up to Fe) elements
6. Time resolution sufficient to resolve solar particle events

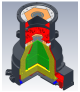


RAD Sensor Head (RSH) Implementation



Combination of telescope and calorimeter

Measure GCR, SEP, n, γ	
Energy range:	
Ions	5 - 270 MeV/amu
p, α	5 - 100 MeV/amu
e^-	150 keV - 15 MeV



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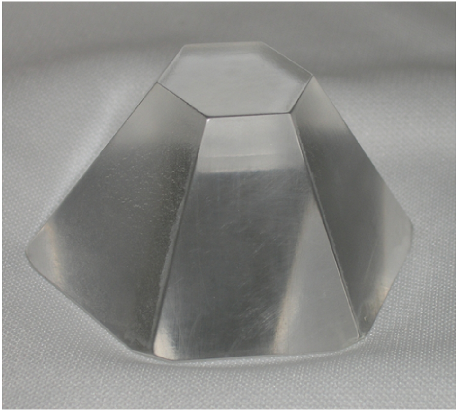
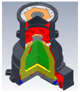


CsI crystal for γs and as calorimeter

Measure GCR, SEP, n, γ	
n	2 - 100 MeV
γ	$>$ 1,5 MeV

CsI stops 100 MeV/amu p



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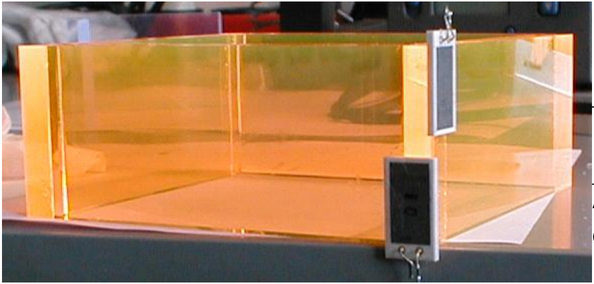
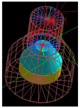


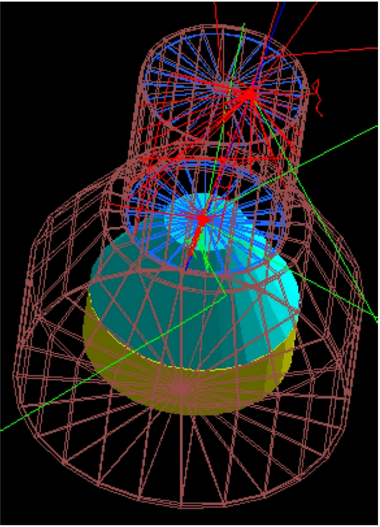
Neudos anticoincidence

Measure GCR, SEP, n, γ	
n	2 - 100 MeV
γ	$>$ 1,5 MeV

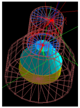
Anti-coincidence 99.98% efficient



RAD Sensor Head (RSH) modeling indicates that RAD will perform as expected

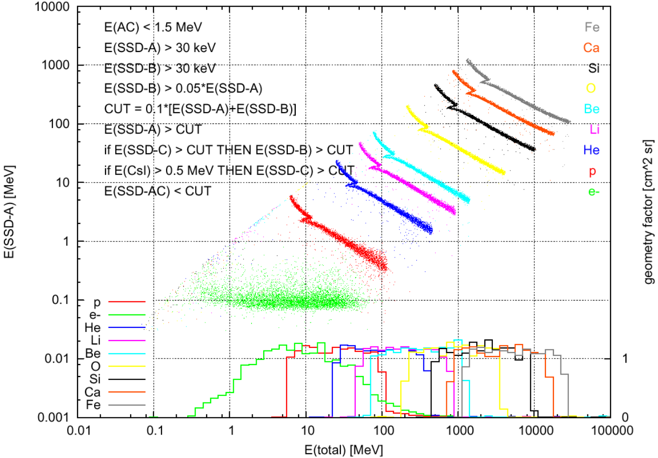


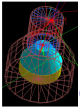
Use Geant4 Monte-Carlo model of RSH to simulate instrument performance. Model does not yet include detector and FEE response and direct Si hits.



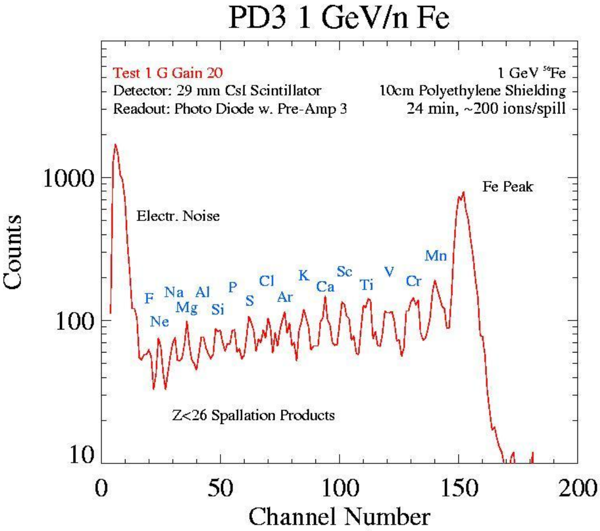
Detection of stopping particles

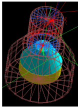
dE/dx (SSD-A) and geometry factor versus total energy deposit





Calibration shows expected results

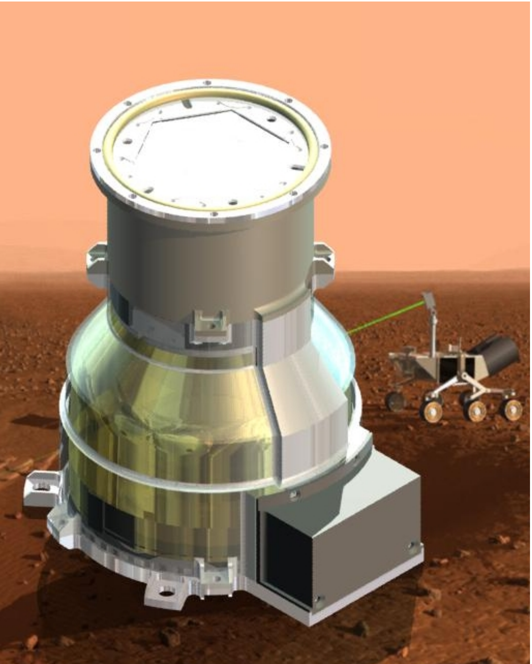




Expected Performance

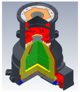
radiation (particle)	count rate (per second)	uncertainty (%/6 months)	model uncertainty
p	0.25	0.1	20%
e	0.02	0.35	20%
CNO	$5{\cdot}10^{-3}$	0.7	20%
Fe	$3{\cdot}10^{-4}$	3	20%
n	20 – 200	0.25 – 0.75	100%
dosimetry	25	0.7 (per hour)	–

Conclusions

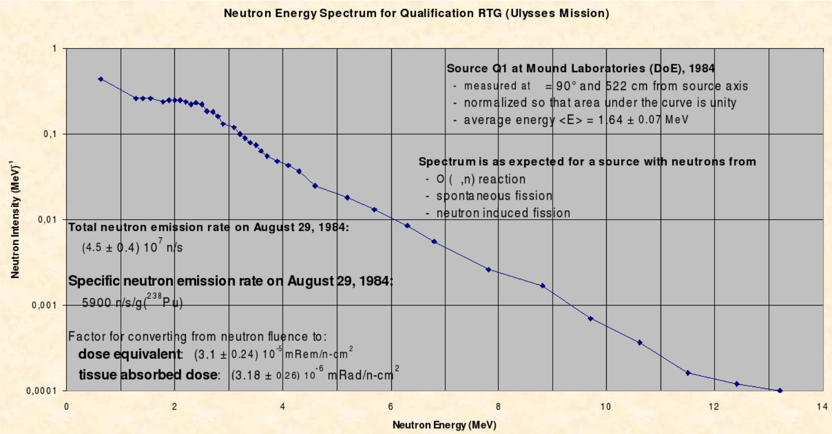


RSH will determine the broad spectrum of surface radiation using a novel combination of detection techniques

Backup Slides



Neutron and γ background from RTG and DAN



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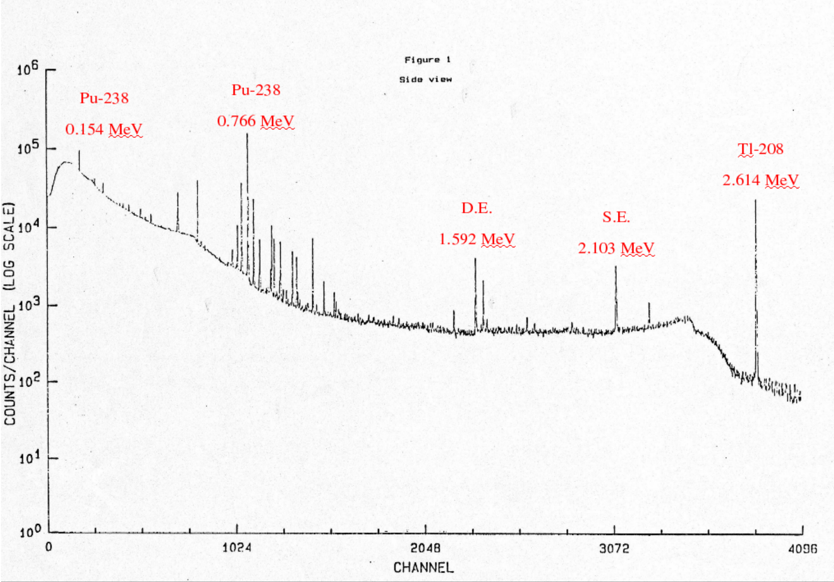
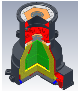
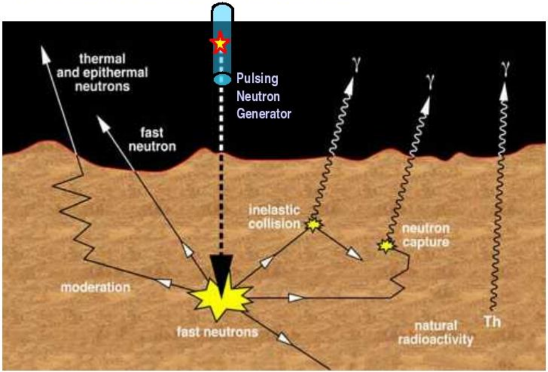
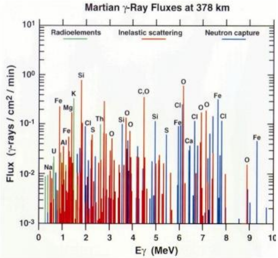


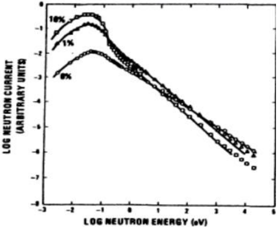


Neutron and γ background from RTG and DAN

Neutrons and gamma-rays from Mars may be also produced by Pulsing Neutron Generator

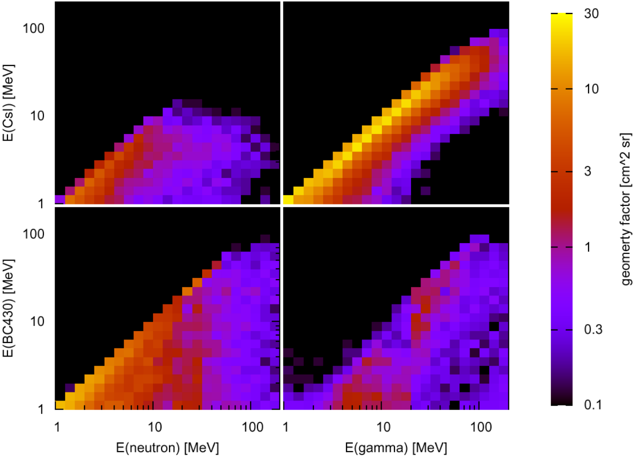


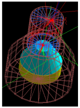




Statistical neutron and γ separation

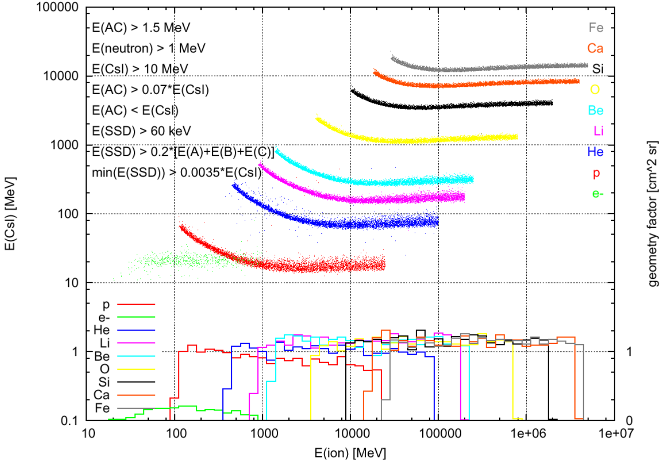
Detected energy vs particle energy matrix





Detection of penetrating particles

Energy loss and geometry factor of penetrating charged particles



MSL/RAD-Insitutions

Southwest Research Institute Don Hassler, PI	**PI-Institution** Project management Electronics Geology, atmosph. transport Astrobiology
University of Kiel Bob Wimmer, Lead-CoI	**Lead-CoI Institution** Sensorhead, FEE data analysis Modeling
DLR Cologne Günther Reitz, Lead-CoI	Calibration, Dosimetry Astronaut Safety
Johnson Space Flight Center Frank Cuccinotta, Lead-CoI	Astronaut Safety