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RADIATION DOSE MAPPING IN THE EUROPEAN COLUMBUS LABORATORY OF THE INTERNATIONAL SPACE STATION

Christina Hofstätter[1], Michael Hajek[1], Thomas Berger[2], Christine Hill[2], Günther Reitz[2]

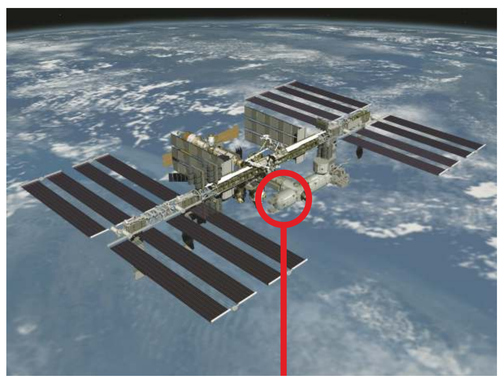
[1]Institute of Atomic and Subatomic Physics, Vienna University of Technology, Stadionallee 2, 1020 Vienna, Austria
[2]Institute of Aerospace Medicine, German Aerospace Centre, Linder Höhe, 51147 Cologne, Germany

Introduction and Objectives

Cosmic radiation and its secondaries created in interactions with spacecraft structures are one of the most important hazards associated with human spaceflight. DOSIS is an international dosimetry programme to determine the nature and map the distribution of the radiation environment in the European Columbus laboratory of the International Space Station (ISS).

A comprehensive set of active and passive instrumentation accounted for the cosmic-ray charge and energy spectrum. Within two stages, dosemeter badges measured absorbed dose and linear energy transfer (LET) spectra at eleven sites throughout Columbus.

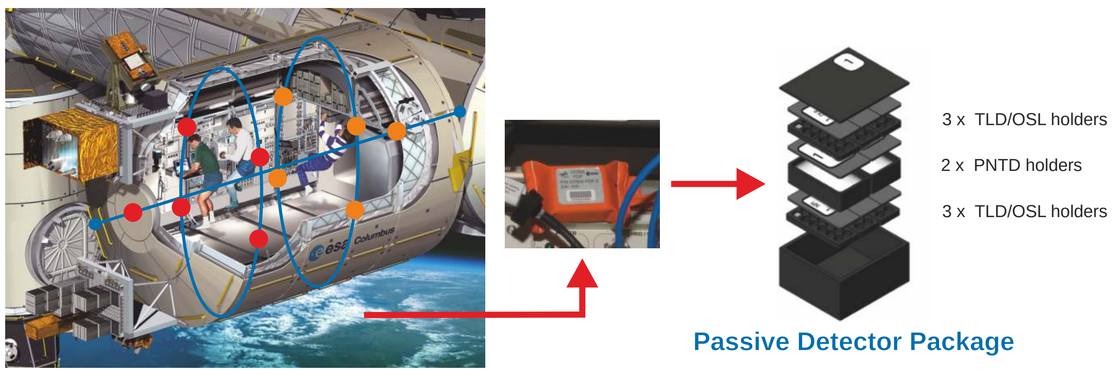
07/2009	08/2009	09/2009	10/2009	11/2009	12/2009	01/2010	02/2010	03/2010	04/2010	05/2010
DOSIS Active										
DOSIS-1 Passive (136 days)										
				DOSIS-2 Passive (191 days)						



Columbus laboratory of the ISS

Passive detector packages (PDP) comprised thermoluminescence (TLD) and plastic nuclear track detectors (PNTD).

Discussion focuses on TLD results but strives convolution of TLD and PNTD data to derive dose equivalent and evaluate the significance of the high-LET (≥10 keV/µm) contribution in uncorrected TLD doses.

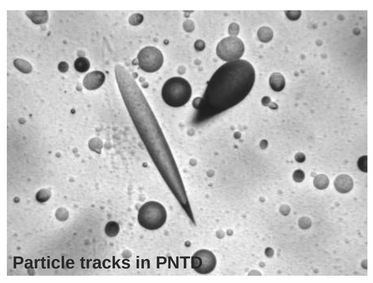


Passive Detector Package

Materials and Methods

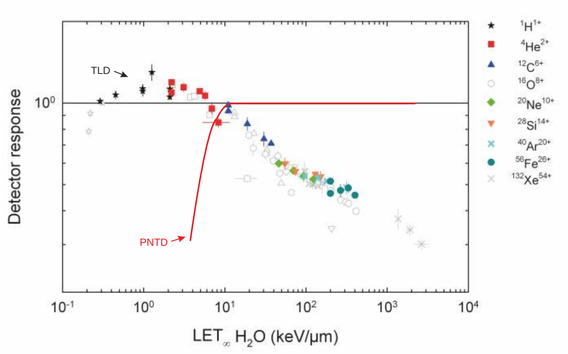
TLD sets included phosphors of different response to the space radiation environment:

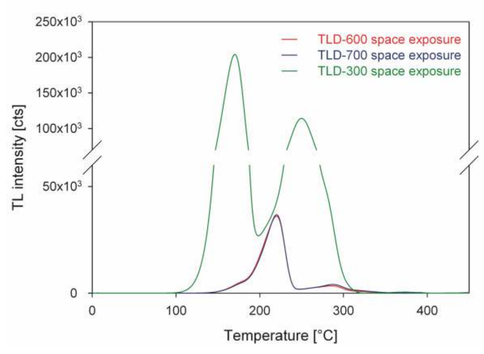
Phosphor	Trade name	Annealing cycle
CaF_2:Tm	TLD-300	1.5 h at 400°C, slow cooling
^{6}LiF:Mg,Ti	TLD-600	1 h at 400°C, slow cooling
^{7}LiF:Mg,Ti	TLD-700	1 h at 400°C, slow cooling



Particle tracks in PNTD

TLD and PNTD response complements each other to cover the cosmic-ray spectrum:





Conclusions

DOSIS-1 mission:

- Mission-integrated absorbed dose rate: 260 ± 21 µGy/d (TLD-300, TLD-700)
- Spatial variation: ± 13%

DOSIS-2 mission:

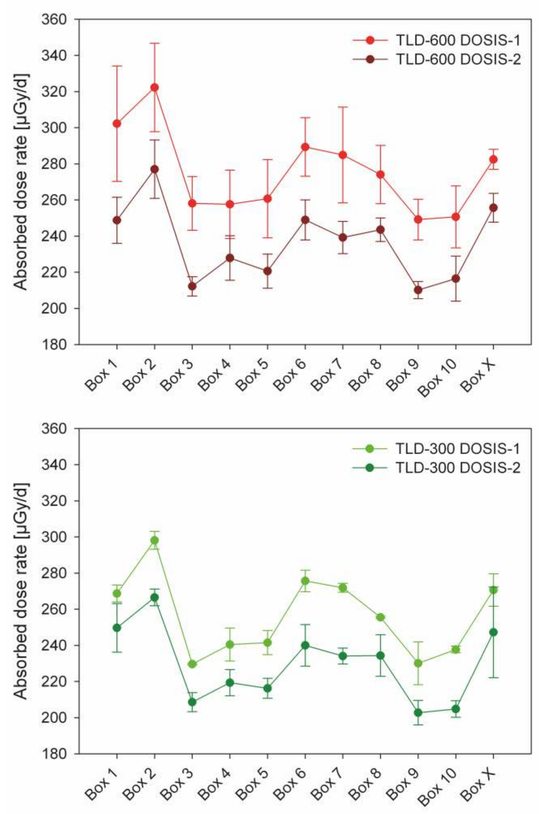
- Mission-integrated absorbed dose rate: 223 ± 19 µGy/d (TLD-300, TLD-700)
- Spatial varation: ± 11%

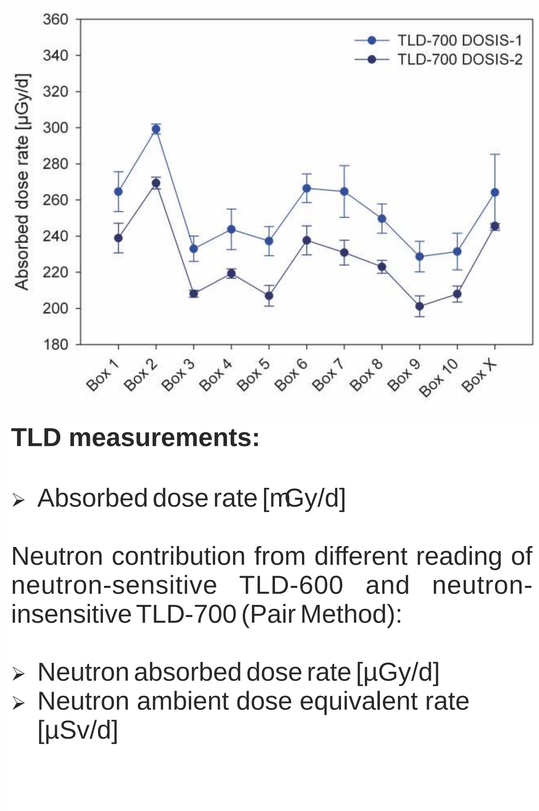
Comparison of DOSIS-1 and DOSIS-2 mission:

- Obtained radiation maps show same pattern of dose distribution for DOSIS-1 and DOSIS-2
- Dose rate measured for DOSIS-2 on average 16% lower than for DOSIS-1, reflecting primarily increasing solar activity
- Minor neutron contribution
- Experimental data evaluated by different groups largely consistent within statistical uncertainties
- High-LET (≥10 keV/µm) contribution in uncorrected TLD doses ~ 10%

Results and Discussion

Comparison of experimental data of DOSIS-1 and DOSIS-2:





TLD measurements:

- Absorbed dose rate [mGy/d]

Neutron contribution from different reading of neutron-sensitive TLD-600 and neutron-insensitive TLD-700 (Pair Method):

- Neutron absorbed dose rate [µGy/d]
- Neutron ambient dose equivalent rate [µSv/d]

Convolution of TLD and PNTD data:

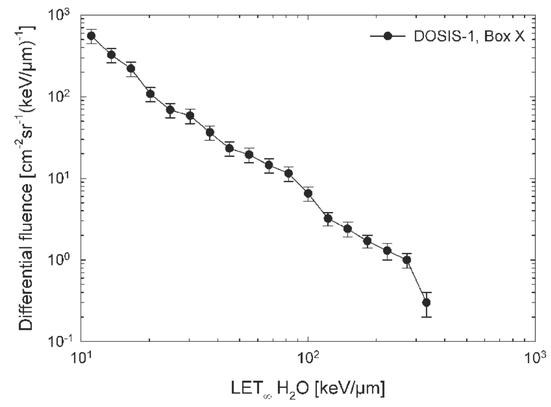
- LET spectra were evaluated from PNTD measurements for $10 < \mathrm{LET} \leq 366$ keV/µm.
- Convolution of TLD and PNTD measurements compensates for the shortcomings of both detectors by separating absorbed dose into low- and high-LET portions:

$$D(L < 10\ \mathrm{keV/\mu m}) = D^{\mathrm{TLD}} - \Sigma_i\, \eta_{\mathrm{HCP,\gamma}}(L_i)\, D^{\mathrm{PNTD}}(L_i)\, \Delta L_i$$

- TLD efficiency with respect to gamma-rays is close to unity for low-LET (< 10 keV/µm) irradiation, but decreases rapidly with LET for particles of higher charge.

PNTD measurements in Box X:

- Absorbed dose rate ≥10 keV/µm (PNTD):
  - DOSIS-1: 45 ± 8 µGy/d
  - DOSIS-2: 38 ± 2 µGy/d
- Absorbed dose rate (all LET, TLD * PNTD):
  - DOSIS-1: 276 ± 7 µGy/d
  - DOSIS-2: 267 ± 1 µGy/d
- Quality factors (all LET):
  - DOSIS-1: 3.3 ± 0.1
  - DOSIS-2: 3.1 ± 0.1



Acknowledgements

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