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

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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, dosimeter badges measured absorbed dose and linear energy transfer (LET) spectra at eleven sites throughout Columbus.

Materials and Methods

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

<table>
<thead>
<tr>
<th>Phosphor</th>
<th>Trade name</th>
<th>Annealing cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaF₂: Tm</td>
<td>TLD-300</td>
<td>1.5 h at 400°C, slow cooling</td>
</tr>
<tr>
<td>LiF: Mg, Ti</td>
<td>TLD-600</td>
<td>1 h at 400°C, slow cooling</td>
</tr>
<tr>
<td>LiF: Mg, Ti</td>
<td>TLD-700</td>
<td>1 h at 400°C, slow cooling</td>
</tr>
</tbody>
</table>

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 variation: ± 11%

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

Results and Discussion

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%

Convolution of TLD and PNTD data:
- LET spectra were evaluated from PNTD measurements for 10 < LET < 2 MeV/µm
- Convolution of TLD and PNTD measurements compensates for the shortcomings of both detectors by separating absorbed dose into low- and high-LET portions:

\[ D(L < 10 \text{ keV/µm}) = D_2^i - \sum \eta_{D_2} (L) D_1^{pop}(L) dL \]

- 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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