DLR and ESA Human Space Dosimetry – Current experiments and the future

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Institute of Aerospace Medicine, Cologne
MATROSHKA

EuCPD

Future....
MATROSHKA

MATROSHKA (MTR) Facility is designed to determine the radiation exposure of an astronaut / cosmonaut during an extravehicular activity (EVA) (MTR-1) and during his stay inside the International Space Station (MTR-2 A/B).

Radiation exposure is measured in a Phantom simulating an Human Upper Torso shielded with a Carbon Fibre structure simulating the EVA suit.

Active and Passive Radiation Detectors are distributed over the whole body to determine skin and organ doses.

MATROSHKA inside ISS January 2004
MATROSHKA

- MATROSHKA-1 was the first long duration phantom experiment positioned outside a Space Station (Duration of ~ 600 days)
- MATROSHKA-2 A/B will measure the dose distribution of an astro – and cosmonaut inside the ISS
- The combination of MTR-1 and MTR-2 will for the first time allow the comparison of skin- and depth dose measurements performed with the same facility in and outside the ISS
- Results will give the dose distribution inside a Human Phantom for a better correlation between skin and organ dose and for better risk assessment in future long duration space flight
International Contribution:
19 Institutes for MATROSHKA
The MATROSHKA Facility

Phantom Torso + Poncho + Container + MLI (MTR-1)
The MATROSHKA Facility – Active radiation detectors

DOSTEL
(Dosimetric Telescope)

SSD
(Silicon Scintillator Device)
- Eye
- Lung
- Stomach
- Kidney
- Intestine

TEPC
(Tissue equivalent proportional counter)
The MATROSHKA Facility – Passive radiation detectors

Thermoluminescence detectors (TLDs) and Nuclear Track Etch detectors
Total Number: ~ 6000
## MATROSHKA-1 Timetable

<table>
<thead>
<tr>
<th>Event</th>
<th>Dates and Details</th>
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<tbody>
<tr>
<td>Launch of MATROSHKA</td>
<td>29. January 2004 with PROGRESS</td>
</tr>
<tr>
<td>Docking with ISS</td>
<td>31. January 2004</td>
</tr>
<tr>
<td>EVA</td>
<td>26. February 2004 performed by expedition 8 crew Alexander Kaleri Michael Foale</td>
</tr>
<tr>
<td>Activation of the active instruments</td>
<td>16. April 2004</td>
</tr>
<tr>
<td>EVA</td>
<td>18. August 2005 performed by expedition 11 crew Sergei Krikalev and John Phillips</td>
</tr>
<tr>
<td>Dismounting of the passive detectors</td>
<td>14. September 2005 performed by expedition 11 crew Sergei Krikalev and John Phillips</td>
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<tr>
<td>Detector download</td>
<td>11. October 2005 with Soyuz</td>
</tr>
</tbody>
</table>
MATROSHKA-1

MATROSHKA mounted outside the ISS February 2004 – August 2005
MATROSHKA-1 Science (active DOSTEL)

- Radiation exposure during an EVA: 1.3 mSv/day
- Radiation exposure inside the ISS: 0.4 mSv/day

Countrate of DOSTEL over a period of 16 days
MATROSHKA-1 Science (passive TLDs)

Dosemeter positions

Dose (mGy)

1 2 3 4 5 6 7 8 9

Slice # 1
Slice # 5
Slice # 9
Slice # 17
Slice # 21
Slice # 23
Slice # 25
Slice # 29
Slice # 31

Dose (mGy)

100 120 140 160 180 200

Dosemeter positions

1 2 3 4 5 6 7 8 9
### MATROSHKA-2 Timetable

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Date/Details</th>
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</thead>
<tbody>
<tr>
<td>Integration of the passive detector set into the MATROSHKA Facility</td>
<td>05. January 2006 performed by expedition 12 crew William McArthur and Valery Tokarev</td>
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<tr>
<td>Exposure time for MATROSHKA-2 Phase A</td>
<td>~ September 2006</td>
</tr>
<tr>
<td>Start of MATROSHKA-2 Phase B (passive and active)</td>
<td>Autumn 2006 (6 months)</td>
</tr>
<tr>
<td>Start of MATROSHKA-2 Phase C (2\textsuperscript{nd} outside exposure)</td>
<td>Spring 2007</td>
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</tbody>
</table>

MATROSHKA-2 Detector mounting

MATROSHKA-2 Phase A passive detector mounting January 2006
MATROSHKA-2 Exposure Inside ISS

MATROSHKA-2 Phase A ISS exposure in the docking compartment (DC-1)
MATROSHKA

Passive dosimetry
Combination of TLD/ OSL with CR-39 detectors for the determination of
- absorbed dose
- LET spectra / Quality factor
- dose equivalent
- neutron dose

Active dosimetry
- Tissue equivalent proportional counter
- Silicon telescope
- Plastic scintillator
  - LET spectra / Quality factor … Neutron component
EuCPD
European Crew Personal Dosemeter

Starting with STS-121 … STS-116…
EuCPD

European Crew Personal Dosemeter

Light weight (~ 30g) passive dosemeter system

- Thermoluminescence Detectors (TLD´s)
- CR-39 Nuclear Track Etch Detectors
- PADC Neutron Detector

Personal Dosemeter for European Astronauts (inside (IVA) and outside (EVA) the ISS)
EuCPD
European Crew Personal Dosemeter

- 48 x TLD´s
- 2 x CR-39
- 1 x PADC
EuCPD

European Crew Personal Dosemeter

- Personal Crew Dosemeter

  → Passive Systems (easy to handle)

  → Development of a small active device
    (based on Silicon detectors)
ALTCRISS
DOSIS

Dose Distribution Inside ISS

- Dosimetric Mapping Experiment
- Dosimetry inside the ISS using active and passive devices
Columbus
Columbus

- Permanent Dosimetric Mapping
  Inside the Columbus module

- Outside: Dosimetry on EuTEF
  and on Expose
Columbus / EuTEF

EuTEF – Active dosimetry

Expose – Passive dosimetry
Columbus / EuTEF

EuTEF → DOSTEL (active)
Expose / Expose-R

Passive Dosimetry
FOTON – Biopan Missions

Dosimetry for very low shielding thicknesses
ExoMars

Dimensions: Ø 58 mm, Height 55 mm
Mass: ~ 500g
Power consumption: 600mW
MSL
Timeline:

<table>
<thead>
<tr>
<th>Year</th>
<th>Project</th>
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<tbody>
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<td>2006</td>
<td>MATROSHKA</td>
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<tr>
<td></td>
<td>Altcriss</td>
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<td>2008</td>
<td>EuCPD</td>
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<td>Foton/Biopan</td>
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<tr>
<td>2009</td>
<td>EuTEF</td>
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<td></td>
<td>Dostel/Expose</td>
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<tr>
<td>2010</td>
<td>Expose-R</td>
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<tr>
<td>2011</td>
<td>Columbus</td>
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<tr>
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<td>Dosimetric</td>
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<td>Mapping</td>
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<tr>
<td>2012</td>
<td>MSL</td>
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<td>ExoMars</td>
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