Radiation survey in USLab and first measurements in Columbus with the ALTEA detector

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Mitigation of radiation risks is a needed step for human exploration

A detailed knowledge of the radiation environment is required:

- for **accurate risk assessments**
- for **developing countermeasures**
- to **validate models** for future extrapolations in outer space.

**Detailed characteristics** of the radiation are needed for all objectives.
• The detector and the data handling

• New measurements:

  - 3D Survey of the USLab {ALTEA – DOSI, NASA; ALTEA – shield / survey, ESA}

  - March 2012 SPE

  - Measurements in Columbus {ALTEA – shield / shield, ESA}
    (first baselined detailed space measurements of Polyethylene and Kevlar radiation shielding effectiveness)
ALTEA: the detector

With the current parameters:

3 keV/µm < LET(Si) < 800 keV/µm
ALTEA: the configurations

Many other configurations are possible with the new mounting system.
ALTEA in 2009 (Lab1P1)  \{DOSI\}
ALTEA in 2011-2012 (Lab1S6) \{shield-survey & DOSI\}
ALTEA in 2012 (Columbus) \{shield-shield\} NOW
ALTEA: real time in Rome DFURTV - UHB
ALTEA: real time in NASA - JSC

ISS Altea 24-Hour Display

Cumulative Dose (rad)

- ALTEA-SDU1
- ALTEA-SDU2
- ALTEA-SDU3
- ALTEA-SDU4
- ALTEA-SDU5

Update Plot

Growth Rate (rad/day)

Current

- SDU1: 137,222,42.55
- SDU2: 137,222,42.55
- SDU3: 137,222,42.55
- SDU4: 137,222,42.55
- SDU5: 137,222,42.55

View Enlarged Chart

View Entered Image

Memorandum of AGREEMENT BETWEEN NASA AND THE AGENZIA SPAZIALE ITALIANA (ASI)

On Ground Segment Infrastructure and Joint Operations
Support for the instrument - Anomalous Long Term Effects in Astronauts (ALTEA)
ALTEA: real time in NASA – GSFC [iSWA – web]

Data Sharing Agreement Between ESA’s ALTEA-shield experiment andASI’s ALTEA experiment with NASA GSFC Space Weather Laboratory

PUBLIC:
http://iswa.ccmc.gsfc.nasa.gov:8080/iswaSystemWebApp/index.jsp?i_1=388&l_1=4&t_1=27&w_1=1239&h_1=614&s_1=0
ALTEA: running times

Light Flashes sessions

2006
- Lab1P1
- Aug 2006

2007
- Lab1P2

2008

2009
- Lab1P1

2010
- Lab1O2
- ALTEAshield/shield (ESA sponsored)

2011
- Lab1P4
- Lab1S6
- ALTEAshield/survey (ESA sponsored)

2012
- Col
- ALTEAshield/shield (ESA sponsored)
# Experiments 2006 – 2012: Integrated Results Summary

<table>
<thead>
<tr>
<th>year</th>
<th>location</th>
<th>experiment</th>
<th>approximate duration (d)</th>
<th>Flux (n/(s , cm^2 , sr))</th>
<th>Dose rate (nGy/s)</th>
<th>Dose Eq rate (nSv/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006 – 7</td>
<td>Lab1P1-2</td>
<td>ALTEA-DOSI (ASI)</td>
<td>224</td>
<td></td>
<td></td>
<td></td>
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<td>2009</td>
<td>Lab1P1</td>
<td>ALTEA-DOSI (ASI-NASA)</td>
<td>180</td>
<td>0.00355</td>
<td>0.205</td>
<td>1.15</td>
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<td>Lab1P1</td>
<td>ALTEA-DOSI (ASI-NASA)</td>
<td>47</td>
<td>0.00347</td>
<td>0.199</td>
<td>1.08</td>
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<td>2010</td>
<td>Lab1O2</td>
<td>ALTEA-DOSI (ASI-NASA)</td>
<td>23</td>
<td>0.00344</td>
<td>0.202</td>
<td>1.17</td>
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<td>2010</td>
<td>Lab1S1</td>
<td>ALTEA-shield/survey pos 1 (ESA)</td>
<td>15</td>
<td>0.00390</td>
<td><strong>0.239</strong></td>
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<td>2010</td>
<td>Lab1O2</td>
<td>ALTEA-shield/survey pos 2 (ESA)</td>
<td>42</td>
<td><strong>0.00328</strong></td>
<td>0.200</td>
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<td>2011</td>
<td>Lab1P4</td>
<td>ALTEA-shield/survey pos 3 (ESA)</td>
<td>90</td>
<td>0.00331</td>
<td><strong>0.185</strong></td>
<td><strong>0.941</strong></td>
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<td>2011</td>
<td>Lab1S6</td>
<td>ALTEA-shield/survey pos 4 (ESA)</td>
<td>136</td>
<td>0.00342</td>
<td>0.194</td>
<td>1.10</td>
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<td>2012</td>
<td>Lab1S6</td>
<td>ALTEA (ASI-NASA)</td>
<td>128</td>
<td><strong>0.00409</strong></td>
<td>0.226</td>
<td>1.20</td>
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<td>2012</td>
<td>Col</td>
<td>ALTEA-shield/shield [Poly] (ESA)</td>
<td>62</td>
<td>0.00373</td>
<td>0.225</td>
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<td>2012</td>
<td>Col</td>
<td>ALTEA-shield/shield [Kevl] (ESA)</td>
<td>17</td>
<td>0.00383</td>
<td>0.229</td>
<td><strong>1.71</strong></td>
</tr>
</tbody>
</table>

* Averaged over the three directions / whole period, errors ≈≤ 1 %
The detector and the data handling

New measurements:

- 3D Survey of the USLab {ALTEA – DOSI, NASA; ALTEA – shield / survey, ESA}

  - March 2012 SPE

  - Measurements in Columbus {ALTEA – shield / shield, ESA}
    (first baselined *detailed* space measurements of Polyethylene and Kevlar radiation shielding effectiveness)

Preliminary drafted results
ALTEA: USLab survey

Errors on flux values along y and z: few ‰
The ISS .. And its very complex shielding
ALTEA DOSI & shield/survey – 3 years 3D monitoring

Flux

Dose

Dose Eq.
ALTEA DOSI & shield/survey – 3 years 3D monitoring

Flux

Lab1P1

Lab1O2

Lab1S1

Lab1O2

Dose

Dose Eq.
ALTEA DOSI & shield/survey – 3 years 3D monitoring

Flux

Lab1P4  Lab1S6

Lab1S6  Columbus

Flux

Dose

Dose Eq.
ALTEA shield/survey – 3D monitoring {small FOV}

Field Of View (FOV) with a single SDU: 90° X 129°
Field Of View (FOV) with a double SDU: 39° X 72°

Double SDUs permit better nuclear identification capability {analysis still in progress}
ALTEA shield/survey – 3D monitoring {small FOV}

[Graph showing particle counts vs. LET (keV/μm) for different elements such as C, O, Ne, Mg, Si, and Fe at positions Pos 1 Lab1S1 and Pos 2 Lab1O2.]
ALTEA shield/survey – 3D monitoring {small FOV}
ALTEA shield/survey – 3D monitoring {small FOV}

Flux

Dose

Dose Eq

Mean Q
• The detector and the data handling

• New measurements:

  - 3D Survey of the USLab {ALTEA – DOSI, NASA; ALTEA – shield / survey, ESA}

  - March 2012 SPE

  - Measurements in Columbus {ALTEA – shield / shield, ESA}
    (first baselined detailed space measurements of Polyethylene and Kevlar radiation shielding effectiveness)

Preliminary drafted results
March 2012 SPE particle flux

directionality
ALTEA: March 2012 SPE
March 11 2012
ALTEA: March 2012 SPE – Forbush decrease

Pamela data preliminary and confidential

> 2 weeks

Pamela data preliminary and confidential
Forbush decrease – protons, electrons and positrons

Confidential From Pamela Collaboration
• The detector and the data handling

• New measurements:
  - 3D Survey of the USLab {ALTEA – DOSI, NASA; ALTEA – shield / survey, ESA}
  - March 2012 SPE
  - Measurements in Columbus {ALTEA – shield / shield, ESA}
    (first baselined detailed space measurements of Polyethylene and Kevlar radiation shielding effectiveness)

Preliminary drafted results
ALTEA in Columbus: shield - shield

- Yellow: saturation, only ion counting
- Blue: nuclear discrimination

Diagram showing dimensions and components of ALTEA.
ALTEA in Columbus: shield - shield

2012 ... now running

Polyethylene  Kevlar

June 8th – Aug 9th  Aug 8th – Oct 10th

2 shielding values: 5 g/cm² and 10 g/cm²
ALTEA in Columbus: shield – shield {Polyethylene}

- No shield
- 10 g/cm²
- 5 g/cm²

Elements: B, C, O, Ne, Mg, Si, Fe
ALTEA in Columbus: shield – shield \{Kevlar, to Aug 18\textsuperscript{th}\}
ALTEA in Columbus: shield – shield

Nuclear Identification

Polyethylene

Kevlar
ALTEA in Columbus: shield – shield

Nuclear Identification

Compare the ratios of the measurements with the tiles to the reference measurements (no tiles)
Summary conclusions / comments

1) Radiation environment in the ISS depends strongly on directions and on position

   Differences can be as large as one order of magnitude

   Further measurements, CAD models, info on racks configurations must be used to study in detail the data

   Columbus in the site and direction measured appears to have a different radiation quality then USLab (*very Preliminary*)

2) Details of the dynamics of the radiation field during the March 2012 SPE are under analysis

   Clear Forbush decrease, lowering the dose for about two weeks following the March 2012 SPE, have been measured (same dynamics shown by Pamela measurements). Further analysis is in progress. Possibly more SPE in the ISS must be studied to provide information on countermeasures development

3) Preliminary analyses show similar effectiveness of Polyethylene and Kevlar, reaching a reduction of about 25% in Dose and almost 50% in Dose Equivalent (10 g/cm$^2$)

   We need models to compare our data with and info from radiation biology suggesting the degree of details the data analysis (and consequently the models ..) must reach

   We need to compare our data with the data coming from other available similar instrumentation

   We need concurrent measurements inside – outside the ISS to correctly provide tools for model validation

   Only detectors that can provide trajectory and nuclear identification (such as ALTEA) can provide the entire set of the needed experimental info
ALTEA the international team

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Lawrence Berkeley National Laboratory, CA, USA
Loma Linda University, CA, USA
Cole Eye institute, The Cleveland Clinic, Cleveland, OH, USA
Wyle Laboratories, TX, USA
Eril Research, CA, USA

+ others joining in
Thank you for your attention
ALTEA: iron oversimulation

Di Fino et al Rad. Res 2011