ALTEA

multiple approach program for studying the ionizing radiation effects on the Central Nervous System (CNS)

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…. understanding ..

…. the radiation functional risks for the Central Nervous System during space voyages, with a specific regard to

i) long permanence in space

ii) missions outside the protective Earth magneto-shielding

Cornelius A. Tobias

Radiation Hazards in High Altitude Aviation

“It is conceivable that very densely ionizing tracks would produce small flash-like light sensations”
Background

• Reports from space
  - An unusual flashes of light have been first reported from the Apollo 11 crew (July 1969)
  - Following Apollo flights (12-17, to the Moon)
  - Skylab missions
  - Apollo - Soyuz
  - MIR
  - ISS
  - Shuttle flights

• Ground experiments in the 70’s
• Astronaut Survey (Fuglesang et al.)
Background - 2

Clear findings:
- latitude effect
- heavy ions, high LET as primary source
  ... many open issues

Hardware issues
- solid angle coverage
- single ion - Electrophysiology linking
- visual system monitoring
ALTEA - space: the hardware

- large-solid angle, silicon detector system (SDS), to be positioned around the Astronaut’s head
- EEG system
- visual stimulator unit (VSU)
- Push Button (PB)

**NOTE:**
all hardware can be used in any combination
ALTEA - space: the protocols

• measure:
  i) the particles passing through the Astronauts’ brain/eyes
  ii) their electrophysiological brain dynamics
  iii) the visual system status
  {protocol CNSM: Central Nervous System Monitoring, 7 - 8 sessions}

• measure the radiation environment in the ISS
  {protocol DOSI: Dosimetry, 12 months of measurements}
ALTEA - space: the SDU

- The large-solid angle, silicon detector system is composed by six Silicon Detector Units (SDU) mounted on an helmet shaped holder (geometrical factor: 1071 cm²/sr)
ALTEA - space: the SDU - 2

- The Silicon Detector Unit (SDU)
  (geometrical factor: 250 cm²/sr)
• The Silicon Detector Unit (SDU) - characteristics:

SDU reads from $^4$He $>$ 25 MeV/n to $^{96}$Mo $>$ 1 GeV/n

Two operational modes:
- Normal
- Full

SDU: Silicon Detector Unit

DETECTORS: 6 double strip silicon layers arranged alternately along X and Y directions
Plane area: $2 \times (6 \times 8)$ cm$^2$
Thickness: 380 µm
Distance X-Y planes: 3.75 cm
Maximum error of angular reconstruction: 1.8°
Geometric Factor (bidirectional): 250 cm$^2$ sr

PERFORMANCES:
Threshold: 3.33 MIP
Saturation: 2400 MIP
(1 MIP = 109 KeV/plane)
ADC: 12 bit

DAU SOFTWARE PARAMETERS:
Resolution: 0.64 MIP/ADC ch
Maximum Acquisition Rate: 700 Hz
Autotrigger (logic OR or logic AND of X planes, software switchable)
ALTEA - space: SDUs tests (at GSI)

- linearity

![Graph showing linearity with MIP (simulation) on the y-axis and ADC channels on the x-axis. The graph includes data points for different materials (C, Ti) and镖s1 MIP = 0.64 ADC ch and R² = 0.9998.](image)
ALTEA - space: SDUs tests at GSI - 2

- nuclear recognition

Ti 600 Mev/n
6 mm Al
• the Bragg curve
ALTEA - space: final acceptance and schedule

• the PTCS at KSC (from March 2005 in the MPLM)

• manifested on the next Shuttle flight
  (STS121 - ULF1.1) \{summer '06\}
ALTEA - space: accepted protocols

• DOSI
  - SDS tilted to minimize protrusion
  - Running throughout the increment(s)
  - Real Time data Downlink
  - Real Time partial analysis on ground
- The astronaut wears the EEG cap..
- .. slides into the SDS..
- .. close the VSU and start dark adaptation
- The assistant starts the automatic procedure:
  SDS always ‘on’
  EEG always ‘on’
  VSU (at the beginning) delivers the stimulation paradigm
  The astronaut signal the LF perception with the PB
ALTEA - space: data transfer

• **DOSI:** Real Time data downlink
  - maximum rate \( \approx 0.64 \text{ Mbps} \)
  - (corresponding to \( \approx 600 \text{ Hz} \) in *normal* mode)
  - average foreseen rate \( \approx 60 \text{ kbps} \)

• **CNSM:** Storaged on Lap Top HD, downlinked Off Line
  - \( \approx 1.5 - 2 \text{ GB/session} \)
The data downlink route

- **White Sand Complex**
- **JSC**
- **MSFC**
- **ISS**
- **DomSat**
- **DOI**
- **Univ. of Rome Tor Vergata User Home Base**
- **TPC**
- **Net Control Center Telespazio Fucino**
- **ASI-USOC User Support Operations Center**

**Networks and Relays**

- TDRSS
- Tracking and Data Relay Satellites System
- KuBand
- S band over IONet
- VPN over Internet
• The User Home Base

Data is going to be easily available for the scientific community
ALTEA - space: Real Time Analysis

- Real time trace display

- Software for real time trace recognition is under development
ALTEA - space: interactive data display

- Software for the visualization of Particle and EEG data
The scientific strategy: follow up

- extend measurement validity on other vessels & outside magnetosphere
- propose shielding material(s) to minimize risks
- test on ground and in space such shielding material(s)

ALTEA - shield (ESA)

2 increments after ALTEA - space
ALTEA - shield

- working hypothesis:

3D survey detectors

- to be started in incr. 15?
  (spring 2007)

“shield” configuration
The scientific strategy: follow up 2

• ALTEA - 2 is in the process of being designed ....
The ALTEA team

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DISM-Univ. of Genoa, Genoa
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ALENIA spazio - Laben
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+ others joining in

Radiation Detection and Dosimetry Workshop - Houston, Tx April 6 - 7, 2006
Thank you for your attention
ALTEA - space: EEG VSU and PB

**EEG**
32 channels
128 - 16384 Hz per channel

**PushB.**
Three independent pushbuttons

**VSU**
Two color LCD-TFT oculars
XGA, 1024 x 768 pixels at 60 Hz
Field of view: 35° diagonal (21° V 28° H)
Luminance 5-50 FL Contrast 40:1
256 colors out of a 16 million colors palette
Video memory: 2 MB
ALTEA - space: the EEG

- EEG cap and electrodes
ALTEA - space: the Visual Stimulator

- visual stimuli

Astronaut Jeff Williams during BDC
ALTEA - space: the Push Button

- three independent buttons
ALTEA - space: BDC

- protocol

  - the same protocol that will be performed in space:
    - Contrast gratings
      12 combination of
      spatial freqency and contrast
    - Flashes
      press the pushbutton at the rare event (Low Right Flash)

- BDC already performed:
  - Bill McArthur (complete)
  - Jeff Williams (complete)
  - Sunita Williams (partial)
  - Clay Anderson (partial)
ALTEA - space: BDC - 2

• results: Reaction Time

Results in the MIR station

Reaction time (s) for 5 astronauts:
- 0.42 ± 0.10
- 0.42 ± 0.08
- 0.43 ± 0.10
- 0.37 ± 0.05
- 0.39 ± 0.07