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# The ALTEA facility on the International Space Station

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*Abstract*

The ALTEA project studies the problems related to possible functional damage to the Central Nervous System (CNS) due to particle radiation in space environment.

The project is a large international and multi-disciplinary collaboration. The ALTEA instrumentation is an helmet-shaped multi-sensor device that will measure concurrently the dynamics of the functional status of the visual system and the passage of each particle through the brain within a pre-determined energy window.

ALTEA is scheduled to fly in the International Space Station in February 2003. One part of the multy-sensor device, one of the advanced silicon telescopes, will be launched in the ISS in early 2002 and serve as test for the final device and as discriminating dosimeter for the particle fluences within the ISS.

KEYWORDS: Space radiation, electrophysiology in space, light flashes, long manned flights.

## 1. Introduction

In the next few years the question of the safety about long manned spaceflight will raise to paramount importance. Operations of increasing complexity and duration will be requested in the future to crewmembers and scientists in orbital flight. Effects on the Central Nervous System (CNS) were overlooked in the past missions in the absence of detectable long-term or irreversible symptoms. They should now be revisited and studied in view of longer missions, focusing on possible harmful cumulative effects. Large particle flux and microgravity are among possible causes of modifications in the normal functioning of the astronauts' CNS, however their long term effects are not yet fully studied.

This program is then aimed at the determination of the possible Anomalous Long Term Effects in the Astronauts' CNS.

The visual system will be used as a 'probe' because of its sensitivity to space environment. This has been demonstrated since when, while awake in the darkness, astronauts on Apollo missions 11 through 17 and Skylab 4 [1-3], and more recently, MIR Station crewmembers [4] observed phosphenes appearing as light flashes in the shape of sharp lines, clouds, bars, thin or thick streaks, single or multiple dots,etc.

To assess the LF phenomenon correctly is extremely important to determine simultaneously time, nature, energy and trajectory of the particle passing through the cosmonaut's eyes, as well as the cosmonaut's LF perception time. These findings and several experiments performed in ground laboratories in the 70s [4-11] appear to link such APP phoenomenon to the passage of heavy nuclei through the astronauts' head, most probably through their retina. The specific mechanism governing this interaction, as well its site, remain still unclear. Functional CNS changes may go undetected by the astronauts if not resulting in subjective percepts. The same could be recognized using electrophysiological studies. These appear mandatory when planning long space permanencies either in orbit (International Space Station) or outside the protective earth magnetic shield (Mars missions).

Sensory systems are just the most immediate targets of our investigation: higher cognitive functions may as well be affected by particle radiation, that could produce undetected anormalities, for example in latency and discriminative power.

## 2. Description of the System

The ALTEA experiment should give an answer to these problems. It has been financed by the Italian Space Agency (ASI) and by the National Institute for Nuclear Physics (INFN) and rated "Highly recomended" by the European Space Agency (ESA). It has a flight opportunity on the ISS for February 2003. The device will allow indipendent monitoring of cosmic ray flux and brain activity.

The detector system consists of an helmet shaped mechanical structure holding 12 Advanced Silicon Telescopes to monitor incoming comic rays, an ElectroEncephaloGrapher (EEG) to monitor brain activity and a Visual Stimulator, to determine the functional status of the visual system and study its dynamics. The silicon detectors will be positioned over the whole cerebral cortex (see Figure 1).

Each detector is made of three silicon strip sensors. The basic sensor is obtained assembling back to back two chips with ion implanted resistive strips, $8 \times 8$ cm$^2$ of sensitive area, 300 μm thick, strip pitch of 2.4 mm. To allow both × and y coordinate measurement the strips of the two detectors are perpendicular.

The distance between the chips of each detector will be 15 mm. The EEG system will measure the concurrent changes in the cortical bioelectrical activity. Electrodes will be placed on an elastic cup.

Studies about new materials for these electrodes are in progress. Polimeric conductive gels, soft enough to adapt on the head and hair of people without loosing the contact over time are being considered. The Visual Stimulator will permit to perform suitable stimulation routines, to determine

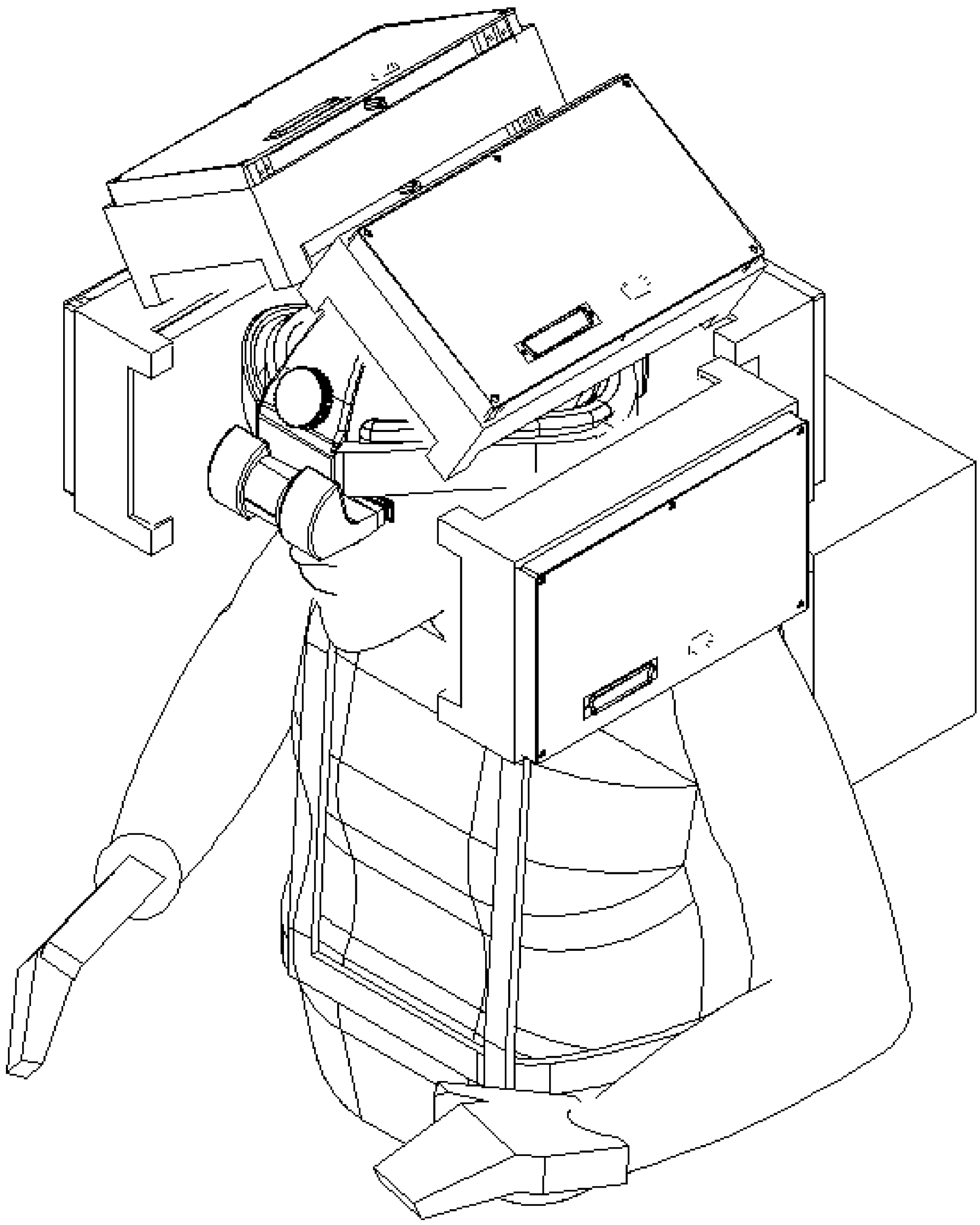

Fig. 1 – A schematic view of the astronaut with the ALTEA system (frontal Silicon Telescopes box not shown).

the status of the visual system. Two push-buttons will be used by the astronaut to mark the perception of a light flash. All information will be stored together via an integrated data handling system that will also allow transmission of the data to ground.

A particle telescope equal to those of ALTEA device plus an EEG will be launched on the ISS (Russian Segment) in the early 2002.

## 3. Procedures

A typical schedule of the experiment is:
A) *Astronauts Training.* B) *Ground measurements* (prior to launching): i) Set-up testing; ii) Electrodes positioning (10 min); iii) Stimulation paradigm (5 min). C) *Onboard measures*: i) Set-up testing; ii) Electrodes positioning (10 min); iii) Stimulation paradigm (5 min); iv) Dark adaptation (15 min); v) electrophysiological recording and particle assessment during a full orbit (90 min). D) *Ground measurements* (after landing): i) Set-up testing; ii) Electrodes positioning (10 min); iii) Stimulation paradigm (5 min). Measures will be repeated on board in different moments of the orbital permanence of the astronaut to follow the dynamics of the CNS status.

ALTEA as a facility will permit to set up experiments asking for simple or complex visual and/or auditory stimulation with concurrent EEG acquisition/particle detection. As an example, experiments aimed at assessing cognitive performance levels during long flights might be designed.

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