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Experiment ALTEA for the International Space Station

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Abstract

Project Flashes/ALTEA (Anomalous Long Term Effects in Astronauts) is aimed at the understanding of the causes for the anomalous light flash perceptions (phosphenes) reported by astronauts in orbit, and, more ingeneral, at monitoring the visual system status in microgravity conditions and during cosmic ray passages through visual cortices/retina.

1 Introduction:

The foreseen prolonged human permanence in space either in the International Space Station, or during manned Mars missions, opens new questions about the health hazards in space enviroment. While attention has been given to the possible risk of cell damage due to the cosmic ray flux, and to the cumulative effects from long exposure to microgravity at skeleton or muscolar level, studies on the functional anomalies of the Central Nervous System (CNS) caused by the combined effects of all space environmental parameters, has been almost totally neglected, probably due to the absence of clearly evident syntoms in the astronauts after the missions. However *i)* the large increase of the average human permanence in space in the near future, especially due to the operation of the International Space Station, *ii)* the quite important and sensitive issues connected with possible transient impairment of even limited parts of the CNS during flights and, *iii)* last but not least, the clear evidence of anomaluos functioning of the visual system offered by the phosphene perceptions reported by dark adapted astronauts in orbit since Apollo missions, are demanding a most detailed investigation of the interaction of microgravity conditions and impinging particles with the CNS.

Anomalous phosphene perceptions has been related in the past with particle interaction with the retina. Experiments were performed irradiating the experimenter's eye with a "proper" particle flux in controlled conditions in accelerator beams (Budinger et al.1971, McNulty 1971, McNulty et al. 1972, McNulty et al. 1975, Budinger et al. 1972, McNulty et al. 1978, McAulay 1971, Charman and Rowlands 1972, Charman et al.1971, Tobias et al.1971). The experimenters reported phosphene similar to what described by the astronauts. The possibility that the particles could interact directly with the visual cortex had not been given adequate credit. Also these experiments performed in ground laboratory, assumed that the anomalous phospenes phoenomenon was a due to a visual activation at the start of the physiological mechanisms of transduction of external events into neuronal functions, driven by the passage of "anomalous" HZE particles. The possibility that the phoenomenon could be a consequence of stimulation of retinal or cortical neurons through mechanism that are not physiological in normal (ground based) conditions, but possible in a visual systems with alterated parameters due to the space environment, has been disregarded.

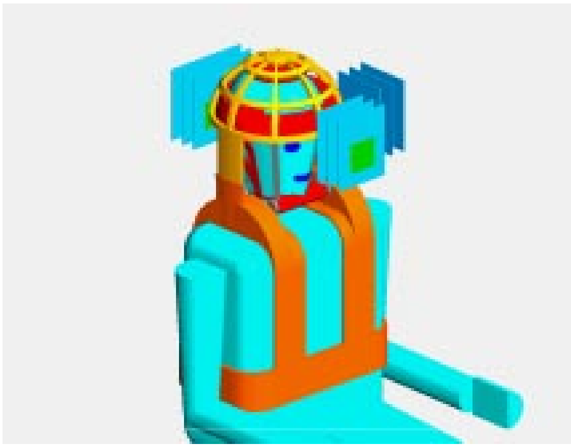
First results obtained in our experiments on board of the MIR Space Station (experiment SilEye) have shown that HZE particle flux is correlated with phosphene perception (Galper et al. 1997, Bidoli et al 1999a).

ALTEA (Bidoli et al 1999b) is an improvement of project SilEye, with a larger telescope and, most important, featuring the concomitant use of electroencephalography and visual stimulation. This will allow us to monitor the visual system status and to detect electrophysiological signatures of particle passages. Preliminary experiments on rodents, electrophysiologically monitored while irradiated with HZE particle flux in accelerators, will provide a useful animal model for the flight experiment. The experiment will benefit of the ongoing collaboration between Italian and Russian institutions, it has been founded by the Italian Space Agency and have flight opportunity on board of the Russian modulus of the International Space Station.

2 Experimental Set Up and Data Analysis:

The rationale of the experiment is to monitor the dynamics of visual system status through a measurement of the ElectroEncephaloGraph of the astronauts both while resting and under suitably chosen luminance and contrast stimulation. Concurrently a series of active silicon particle telescopes, positioned over the eye and visual cortices areas, will provide information about the impinging particles (trajectory, type, deposited energy).

A first schematic of the silicon detector,of the EEG system and of their integration in the system has been produced (see Figure).



The detector system is constituted by a mechanical structure devoted to interface an helmet, three silicon detectors, the EEG and the stimulator. The silicon detectors will be positioned in front of the astronauts eye, in the temporal region and over the occipital region.

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 (6x6 cm^2) of sensitive area, 200 µm thick, strip pitch is 3.6mm. To allow both x and y coordinate measurement the strips of the two detectors are perpendicular.

The basic detector in the occipital region is obtained connecting electrically and mechanically two chips with parallel strips to form a unique plane of 12x6 cm^2 .

The distance between the chips of each detector will be 15 mm.

The EEG system, shall measure the concurrent changes in the cortical bioelectrical activity. The helmet-like integrated system will be worn easily and comfortably by the astronauts during data acquisition. Electrodes will be placed on an elastic cup. Studies about new materials for these electrodes, conductive and soft enough to adapt itself on the head and hair of people without loosing the contact over time are in process. Candidate materials are conductive polymeric gels with intelligent properties, which might modify their structure under the influence of external stimuli (such as electrical impulse, temperature, or pH).

The whole apparatus foresees also the presence of a couple of push-buttons so that the astronaut can mark the light flash. This information is stored from data acquisition system with the other information relative to the silicon detector and the EEG.

A data handling system constituted by a Laptop computer allows the storage and transmission of the data to ground.

The stimulator, not shown in the figure, will be driven by a dedicated card and provide both luminance and contrast stimulation..

2.1 Animal Model: The old accelerator beam experiments did not provide any concurrent electrophysiological information. The repetition of those experiments on humans while acquiring EEG is excluded for ethical reasons. Therefore we decided to use an animal model and perform the experiments on rodents. Transfer of electrophysiological procedures from humans to rodents and normative electrophysiological procedures on visually stimulated rodents have been started. Visual evoked potential (VEP) experiments have been carried out in free-moving mice and also after anaesthesia with equitesin or with urethan. Equitesin induced strong increase (+10 +50% delay) in the latency of waves, diminution of amplitude, and increase of luminance detection threshold, versus the same parameters of unanaesthetized animals. These alterations reached a maximum 60 min after treatment, and returned to near-to-normal values 2 hours later. Urethan induced analogous qualitative changes, but of smaller intensity. Elettroretinograms (ERG) were also recorded in anaesthetized mice. A relationship luminance/effect was recorded also in this case (i.e., more intense light flashes induced increased waveforms amplitudes and lower latency for ERG and oscillatory potentials. The experimental conditions that will allow testing and recordings of animals exposed to subatomic particles under accelerator are being verified on mice and rats. We expect to obtain information on electrophysiological correlates of controlled particle flux through cortex/retina, needed to set the parameters for the final flight experiment and for the interpretation of the normative and flight data

2.1 Data Analysis: In order to provide the needed constructive parameters for the silicon particle detector we are now analysing data from our SiEye2 experiment.

We found a candidate particle for anomalous perception of a phosphene. This particle precede a phosphene of about 220 ms and deposited a total energy of 0.5 GeV in our detector. Of all energetic particles (11 had an energy that exceeded 400 MeV) is the only one followed by a phosphene but also the only one featuring an entrance angle less than 7¡ (insuring the passage through the eye bulb).

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