University of Rome
“Tor Vergata”

ALTEA and Alteino: studying the ISS radiation environment and its effects on the Central Nervous System

a program to study the neuronal risk from space radiation

Livio Narici

Department of physics, University of Rome “Tor Vergata” and INFN - Roma II

University of Genoa

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Lawrence Berkeley National Laboratory

Rationale

- Long space missions require investigation of the transient/long-term functional effects of space environment and cosmic radiation on the Central Nervous System (CNS).

- Anomalous Light Flash perceptions suggest that abnormal (though possibly transient) CNS functional states may result.

- If visual pathways are affected, other cortical areas may as well be.

⇒Need to study the possible cortical ***functional*** alteration due to particle passages in microgravity conditions.

Funded by ASI and INFN

Background

- Tobias prediction (1952)

- Apollo and other 60’s and 70’s space missions

- Laboratory and space experiments in the 70’s

- MIR (our experiments SilEye)

Nature 2003, 422:680
Acta Astronautica 2002, 81:511-525
J.Phys. G27, 2001:2051-2064

ALTEA program: a multiple approach

Experiment in Space
On board ISS

ALTEA-space

ISS - Take off in Early 2005?

Alteino
On board ISS since April 2002

ALTEA
L.F. questionnaire
In preparation

Controlled, laboratory based experiments

ALTEA-MICE
GSI-BNL
Started 2001

ALTEA-biophys
GSI-BNL
Started 2003

ALTEA-HIT
GSI
Starting 2003

Alteino

Take off (Baikonur)
April 25th 2002, 08:26

Based on SilEye (MIR): ALTEA precursor

Scientific goals:

- help in the definition of the ALTEA's experimental parameters

- First cortical electrophysiological measurement linked to LF

- First measurement of nuclear abundances in the ISS.

Alteino

AST: Advanced Silicon Telescope

8 silicon strip detectors planes
each 8 x 8 cm^2, 380 µm thick

32 strip per plane
2.5 mm pitch

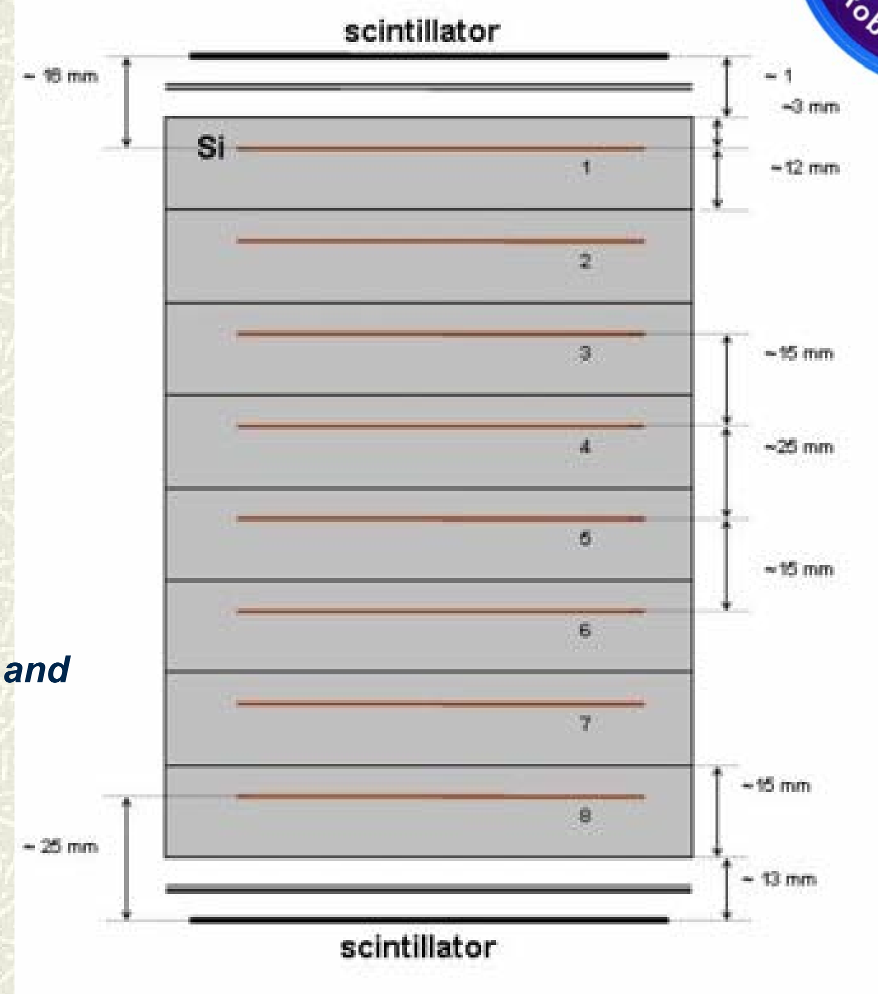
Planes along X & Y view alternately

Two scintillators (1mm thick each) at the top & bottom of silicon stack to provide improved triggering capabilities

Scintillators covered by 50 µm Mylar foil and an Al (70 µm) and Mylar (50 µm) foils

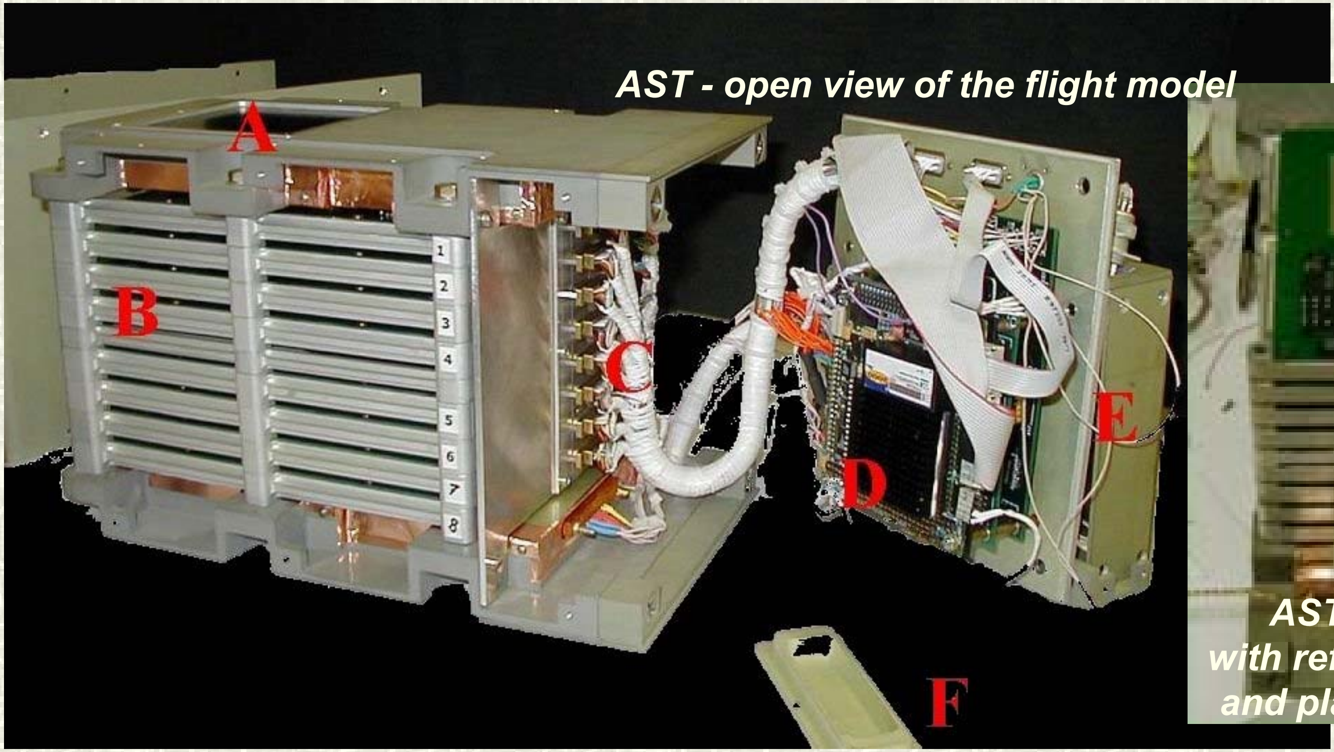
Threshold: 2 MIP; saturation: 1200 MIP

Geometrical factor 2 x 23.8 cm^2 sr



Take off (Baikonur)
April 25th 2002, 08:26

Alteino



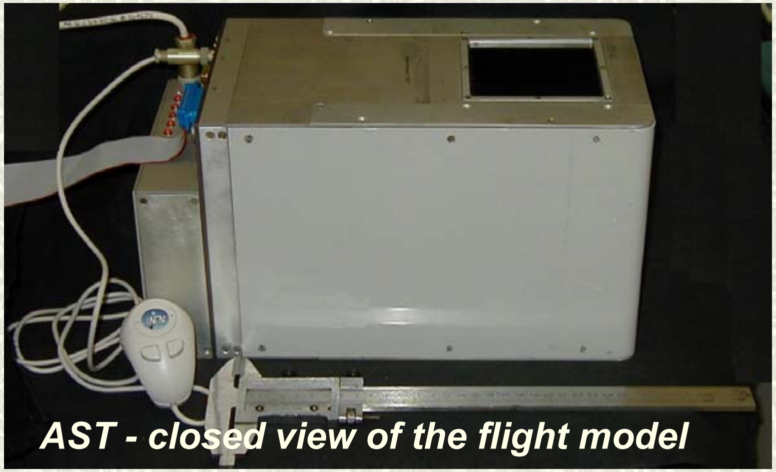
AST - open view of the flight model

AST - top view
with reference system
and plane numbering

A: acceptance window
B: boards
C: digital signal connectors
D: processor
E: power supply
F: light tight cover for PCMCIA slot


Take off (Baikonur)
April 25th 2002, 08:26

Alteino


AST - closed view of the flight model

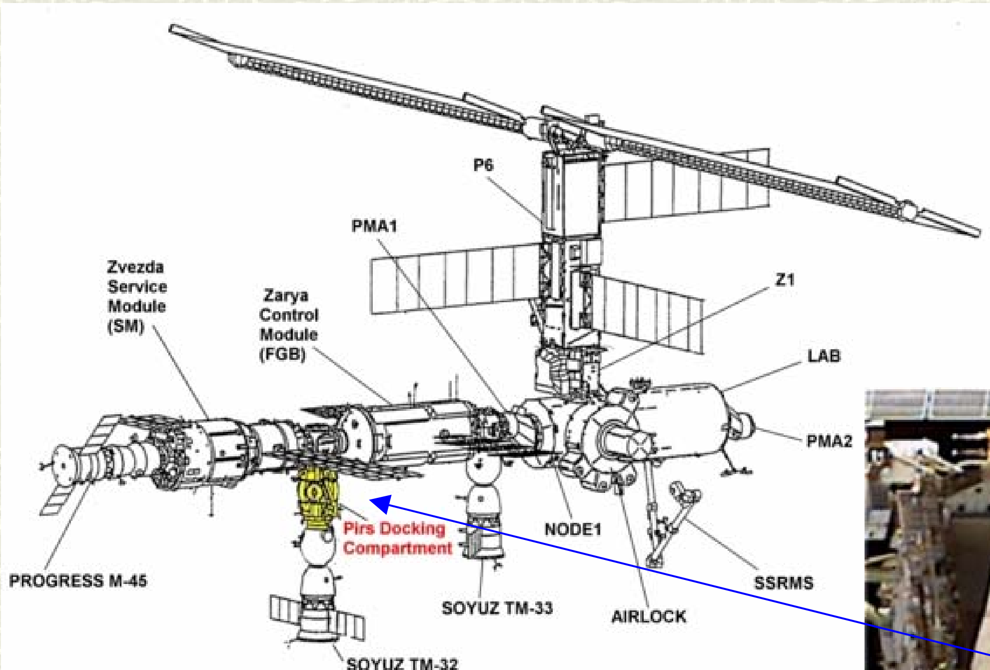

Alteino instrumentation before launch

AST + EEG + pushbutton

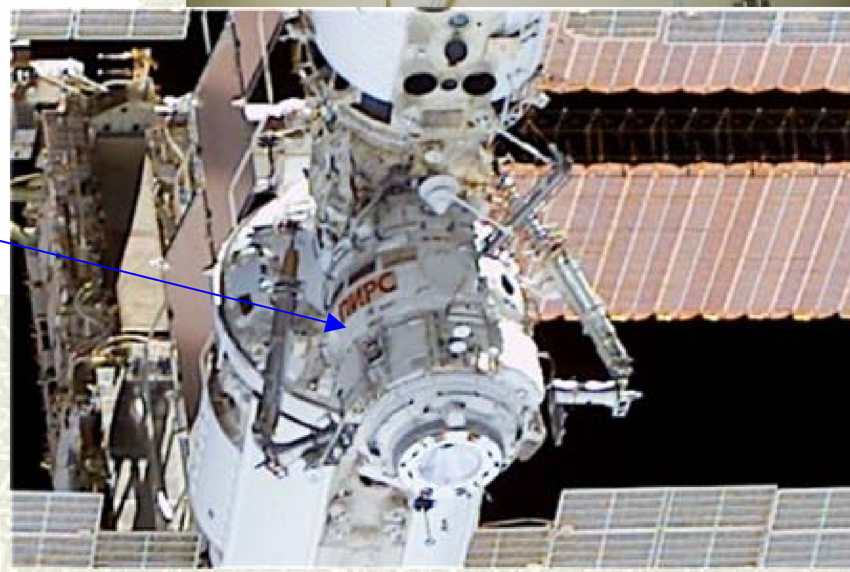
Alteino

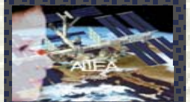

Take off (Baikonur)
April 25th 2002, 08:26

The location in the ISS




The Alteino detector
(AST) on board the ISS





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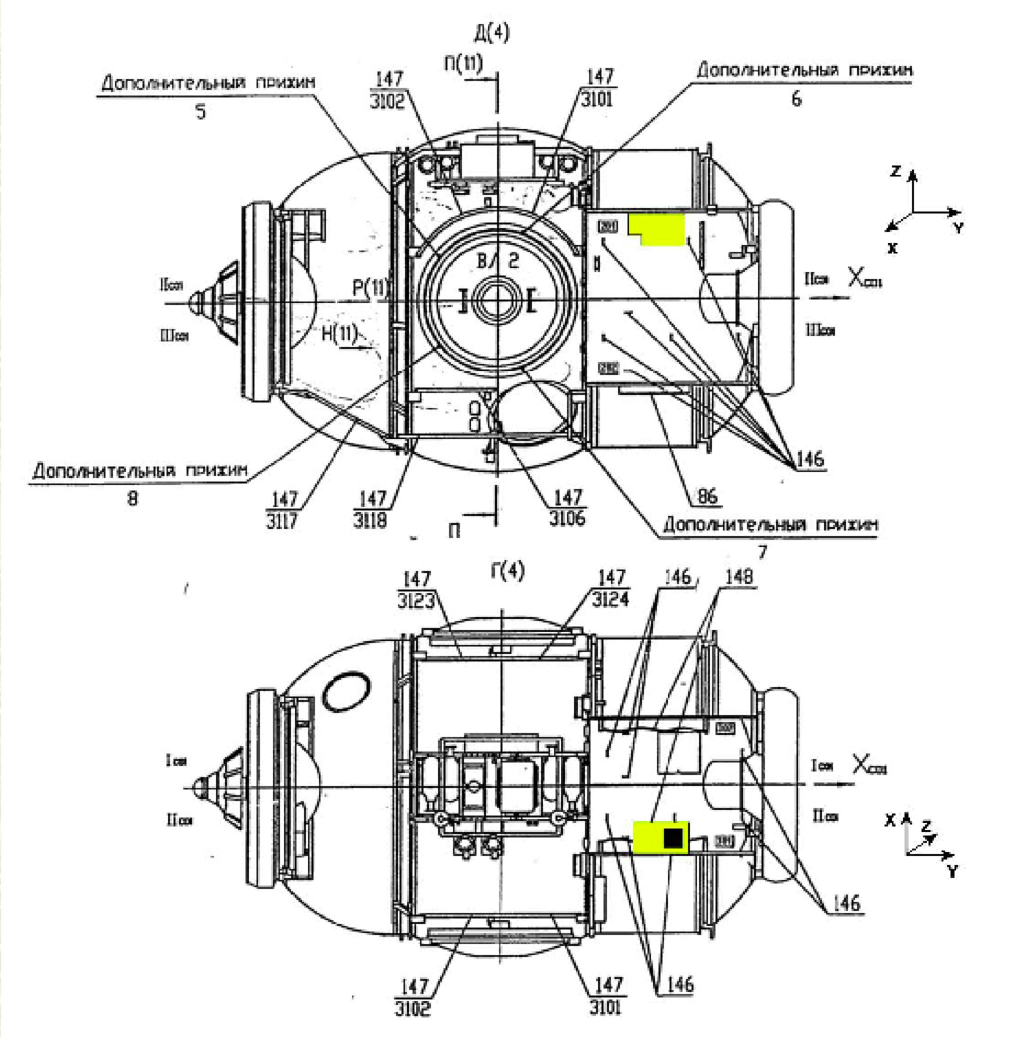
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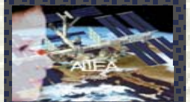

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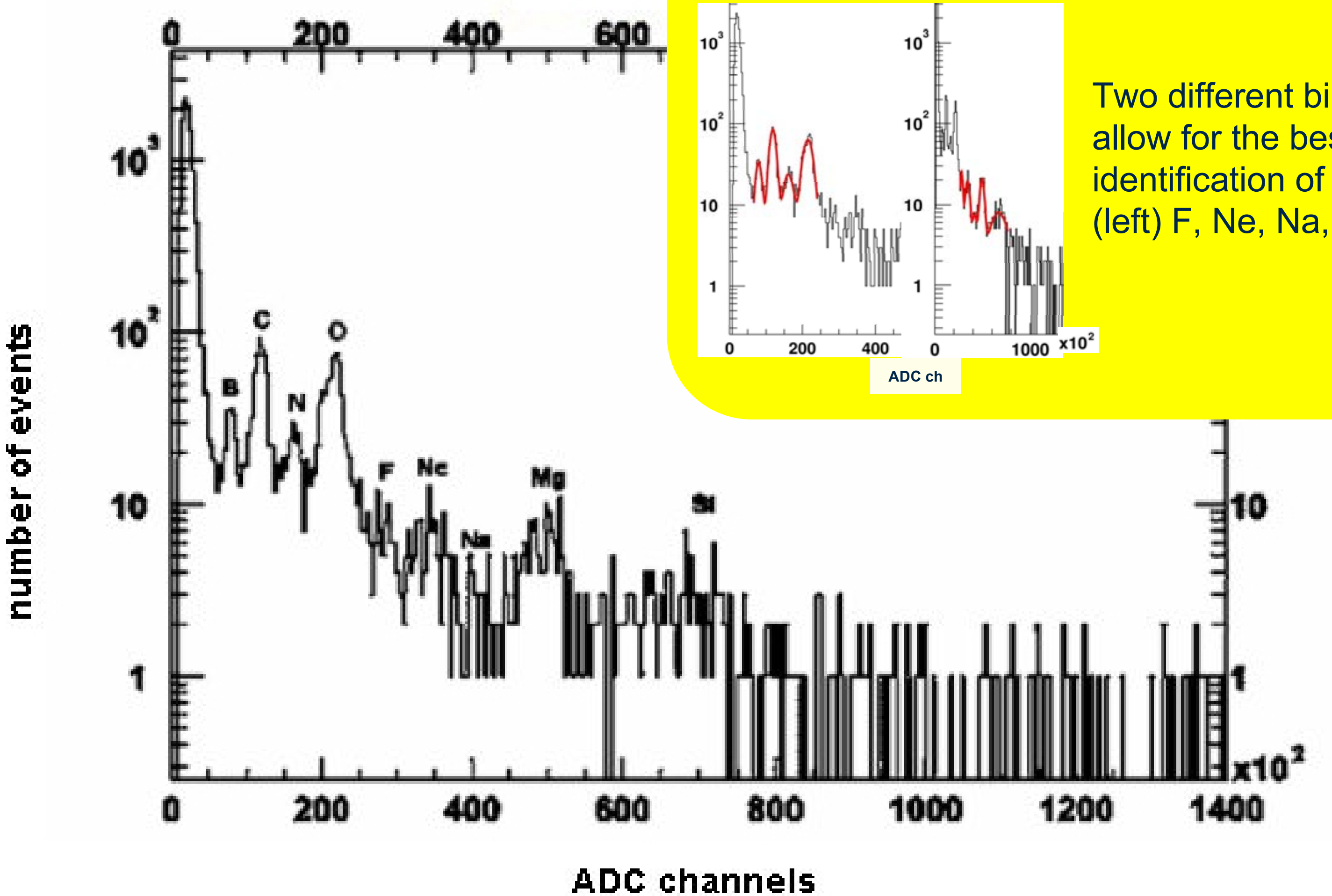


131 h particle data acquisition

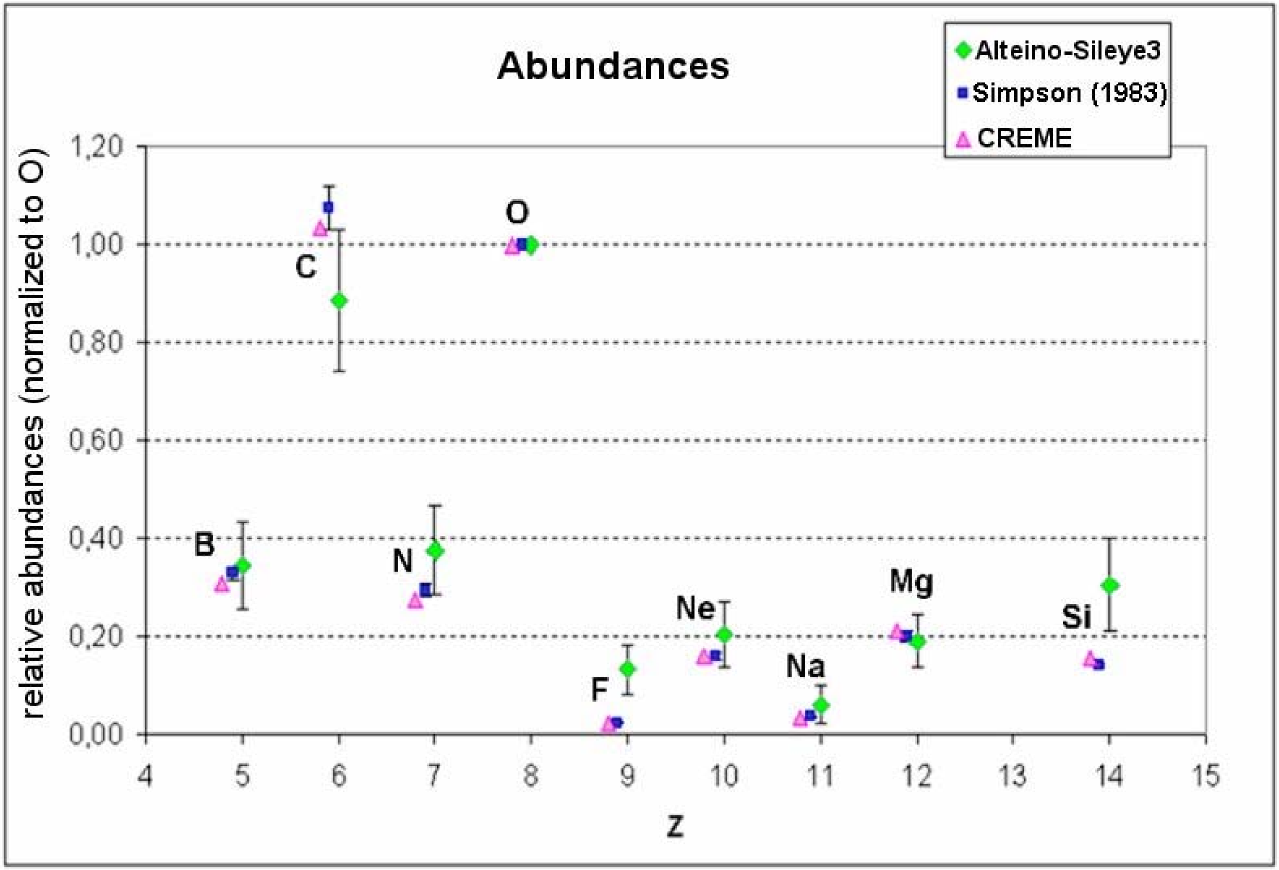
ADC ch

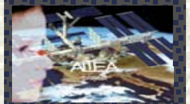
Two different bin choices allow for the best identification of B, C, N, O (left) F, Ne, Na, Mg (right)

Alteino

Marco Polo

Roberto Vittori





Alteino

Alteino has been also the first attempt to correlate brain electrophysiological activity (as measured by EEG) with LF perceptions and particle fluxes

The astronaut wear the electrode cap and position his head in the proximity of the AST holding the pushbutton to signal the perception of a light flash.

Dark adaptation was performed at the beginning of the session

A typical EEG - AST session lasted for one orbit (90 m)

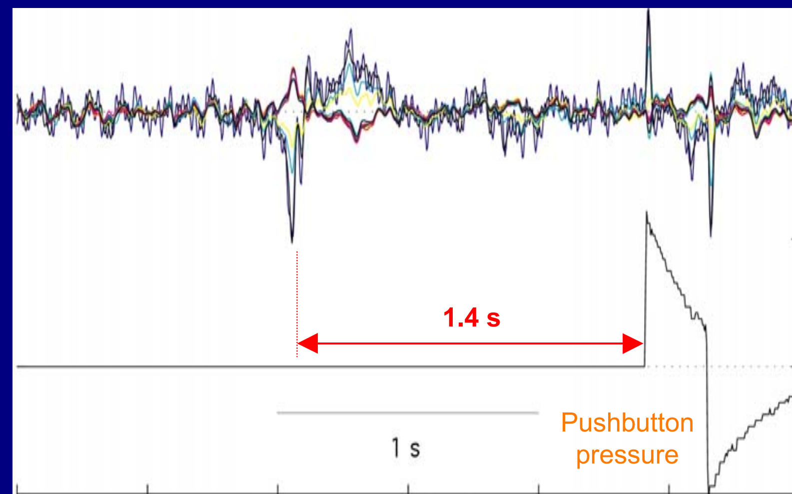
6 sessions have been performed

Alteino

7 h 41 min in 6 sessions (44 Light Flashes)

Day	Start h:min:s	Duration h:min:s	No. of LF	period (min)
April 28	16:30:40	01:00:00	7	9
April 29	09:59:39	00:56:50	3	19
April 30	16:03:02	01:30:00	7	13
May 01	16:54:23	01:30:00	4	23
May 02	10:01:00	01:14:30	9	8
May 03	15:11:42	01:30:00	14	6
TOTAL		07:41:20	44	10

.. what we are looking for as candidates for electrophysiological events:



Alteino

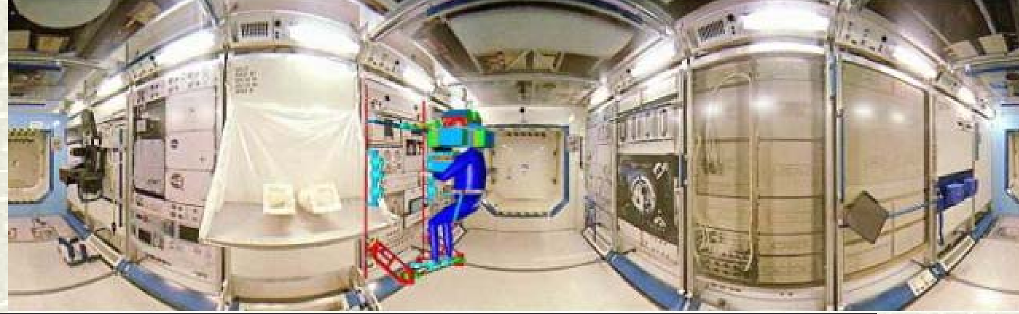
Expected number (CREME simulation) of ions passing through a 1 cm radius sphere in the total time of Light Flashes observation (7h 41m 20s).

AST findings do not disagree with this result

		Expected number of nuclei	
Element	**Atomic number**	**1-2000 MeV/n**	**1-10000 MeV/n**
H	1	1.2×10^6	1.2×10^6
He	2	1.1×10^3	2.0×10^3
	Z > 2	90	160

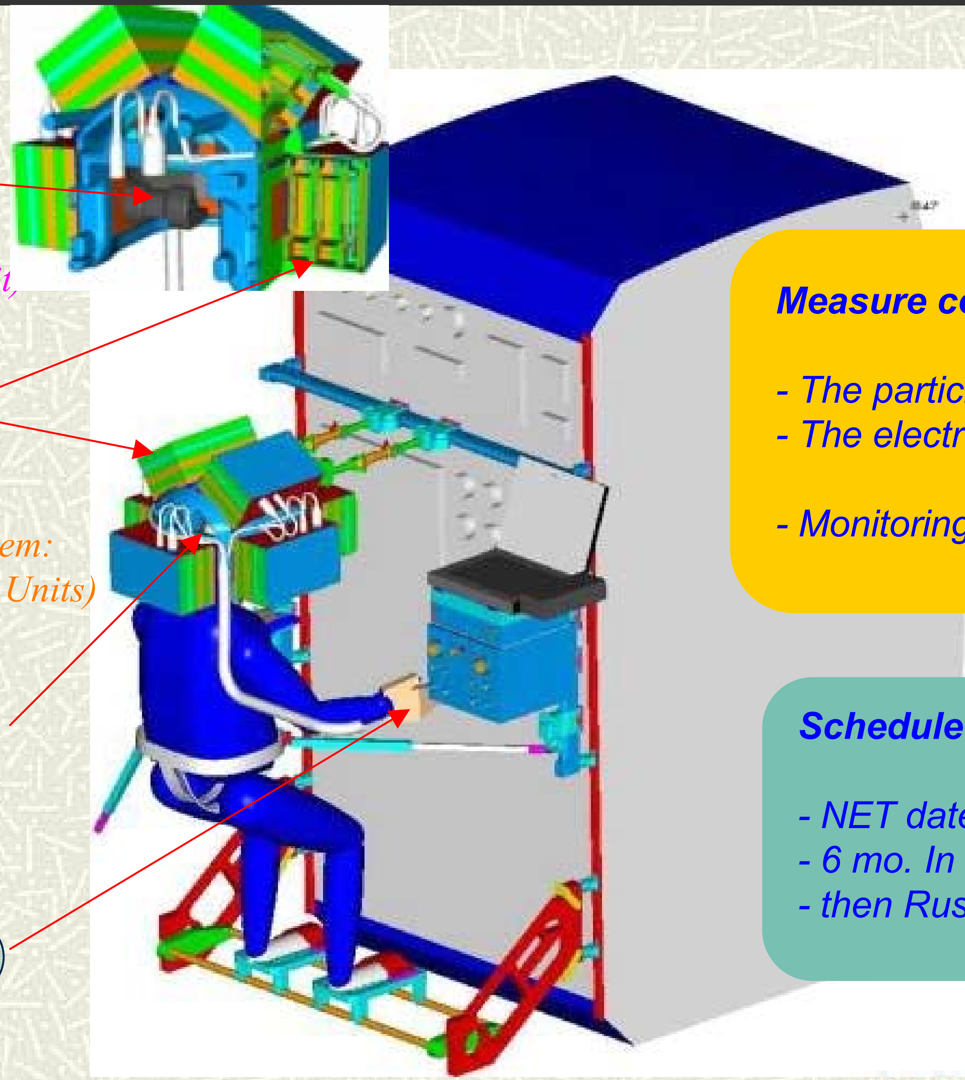
To compare with the number of observed Light Flashes: 44

ALTEA - space



- ***Measure particle trajectories in the brain:*** ***- more angular covering***
  - detectors around the head
- ***Better electrophysiological tools***
- ***Monitor the visual system status***
- ***Use Alteino experience***
- ***Build a multipurpose facility***

ALTEA - space



VSU

(Visual Stimulator Unit)

SDS

(Silicon Detector System:
*6 **SDU**, Silicon Detector Units)*

EEG

PushB.

Measure concurrently:

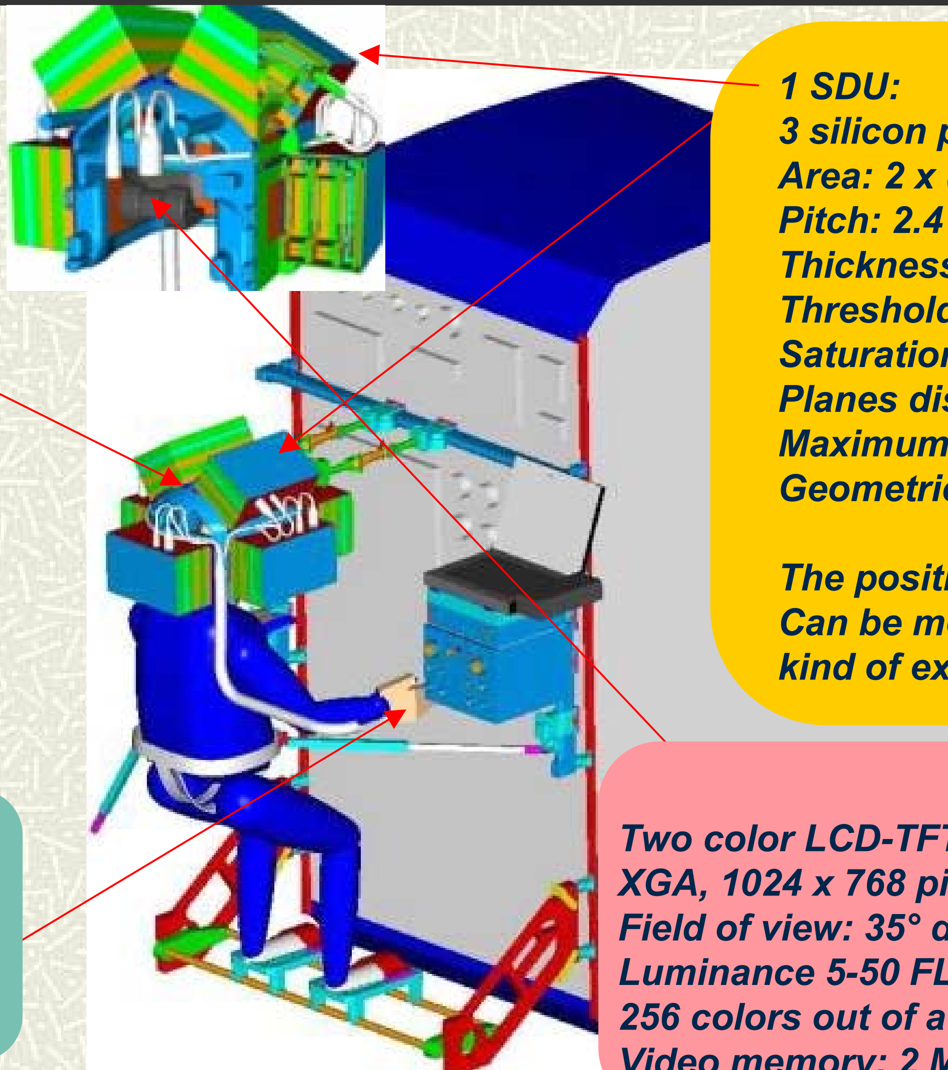
- The particles passing through the head
- The electrophysiological dynamics

- Monitoring the visual system status

Schedule:

- NET date: Feb 17 2005
- 6 mo. In US LAB
- then Russian Modulus (TBC)

ALTEA - space



SDS

1 SDU:
3 silicon planes with double detectors, view X & Y
Area: 2 x (8 x 8) cm2
Pitch: 2.4 mm
Thickness: 380 µm
Threshold: 5 MIP
Saturation: 2400 MIP
Planes distance: 3.75 cm
Maximum error of angular reconstruction: ±1.8°
Geometric factor: 160 cm2 sr

The position of the 6 SDUs
Can be modified to accommodate for different kind of experiments

EEG

32 channels
128 - 16384 Hz per chan

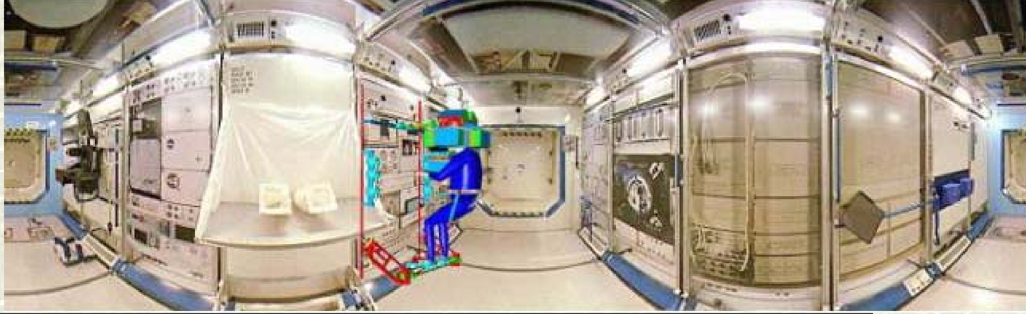
PushB.

Three independent pushbuttons

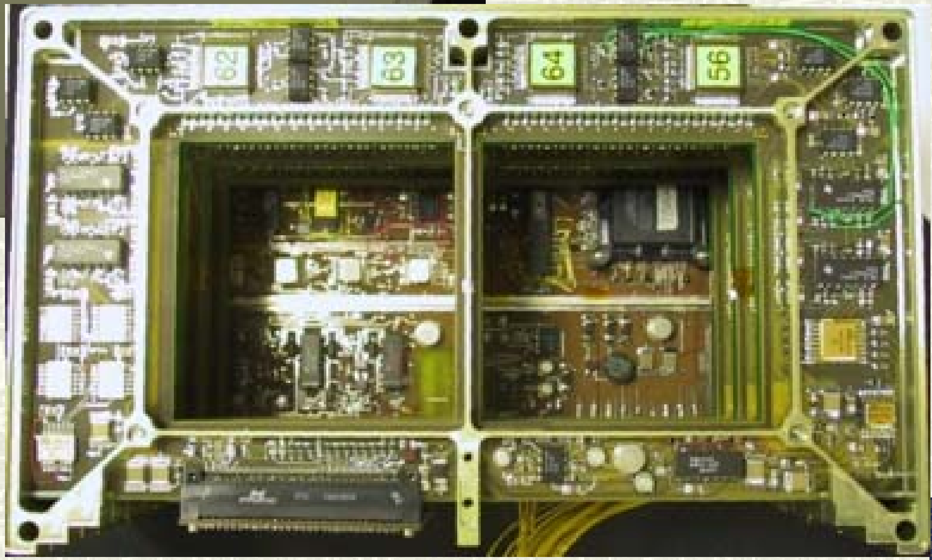
VSU

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

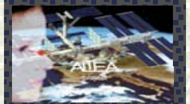
ALTEA - space



SDU during construction - closed view



The SDU open, seen from above
With silicon not yet bonded



ALTEA - space

The ALTEA experiment

Two protocols:

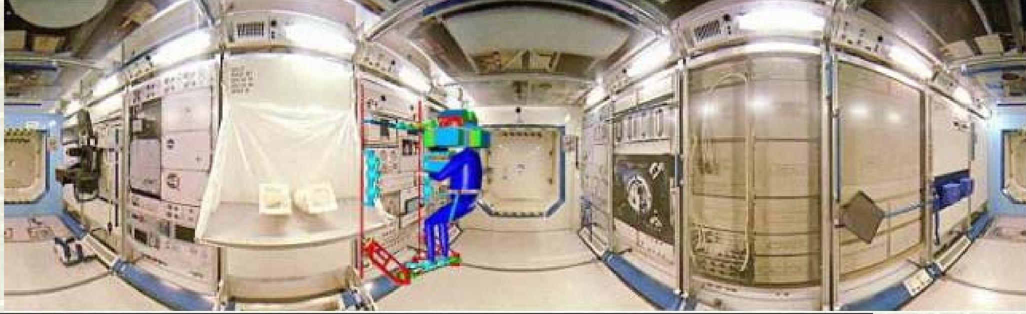
- ***DOSI:*** ***unmanned***
  the SDS is tilted 90° downwards to minimize protrusion
  the SDS is 'on' continuously. Data is downlinked in real time

- ***CNSM:*** ***manned; 6 sessions approximately 1 month apart to each other***
  the astronaut:
  - ***wears the EEG cap with the electrodes and check their impedances***
  - ***'wears' the helmet and restraints himself***
  - ***close VSU, start dark adaptation and stimulation procedure***
  - ***start session (1 orbit)***

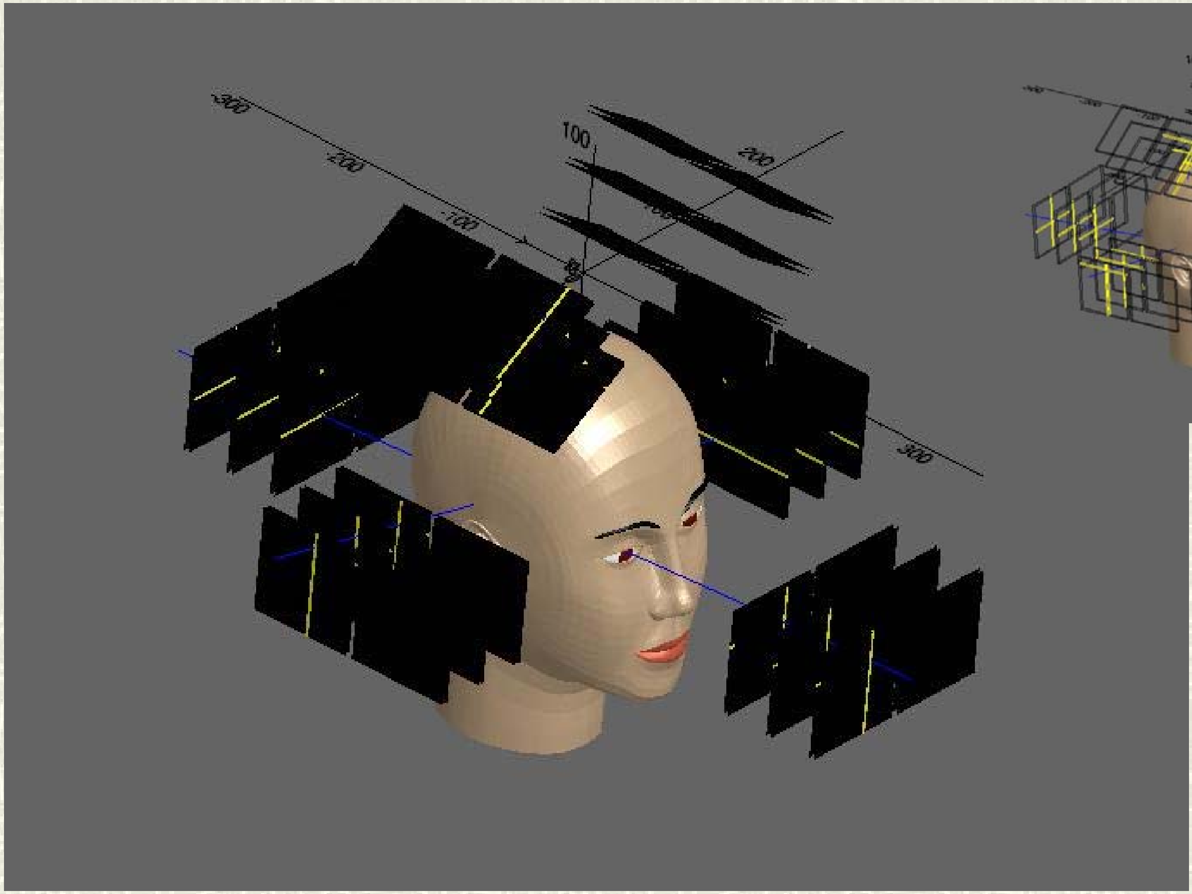
The ALTEA facility

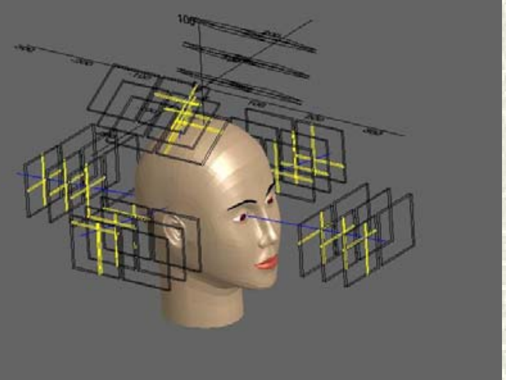
The three subsystems can work in any combination.
The SDS can be re-positioned
Possible experiments in particle physics, dosimetry, psychophysics, electrophysiology, etc.

ALTEA - space



An example of the particle data presentation in ALTEA (.. under construction ..)





Summary

Our approach to the Light Flashes phenomenon, and to the other interactions between cortical functions and cosmic particles

1995 - 97	***SilEye 1*** *(MIR)*		correlation between HZE and LF
1997 - 00	***SilEye 2*** (MIR)		energy discrimination and nuclear species
1998 -	***ALTEA:***		
	2001 -	***ALTEA-MICE***	laboratory animal model
	2002 -	***Alteino***	particle fluxes in the ISS
	2003 -	***ALTEA-biophys***	insight to the mechanism models
	2003 -	***ALTEA-HIT***	controlled approach on humans
	2005 -	***ALTEA-space***	correlation particle - electrophysiology

Acknowledgements

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Royal Institute of Technology, Stockholm, Sweden

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Institute for BioMedical Problems, Moscow, Russia.

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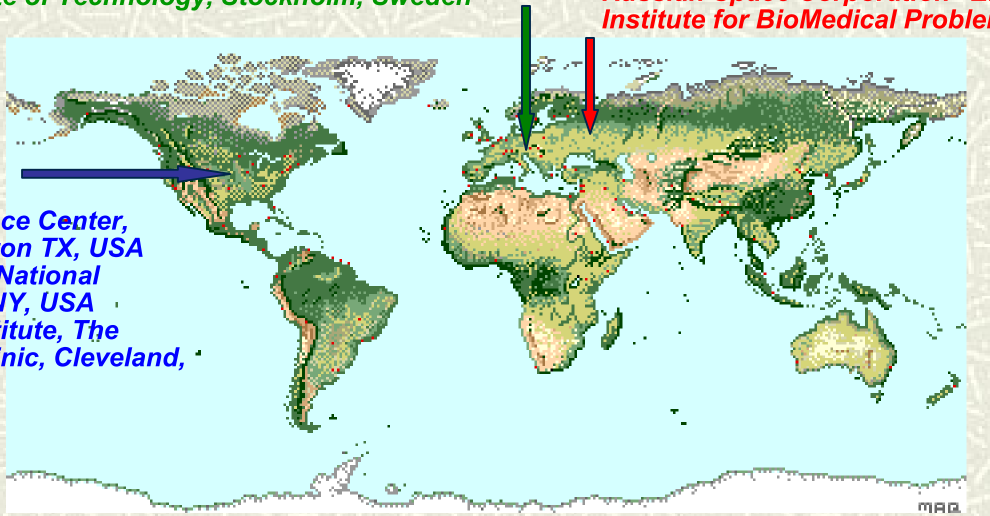
Brookhaven National Laboratory, NY, USA
Cole Eye institute, The Cleveland Clinic, Cleveland, OH, USA



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thank you for your attention