ALTEA

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

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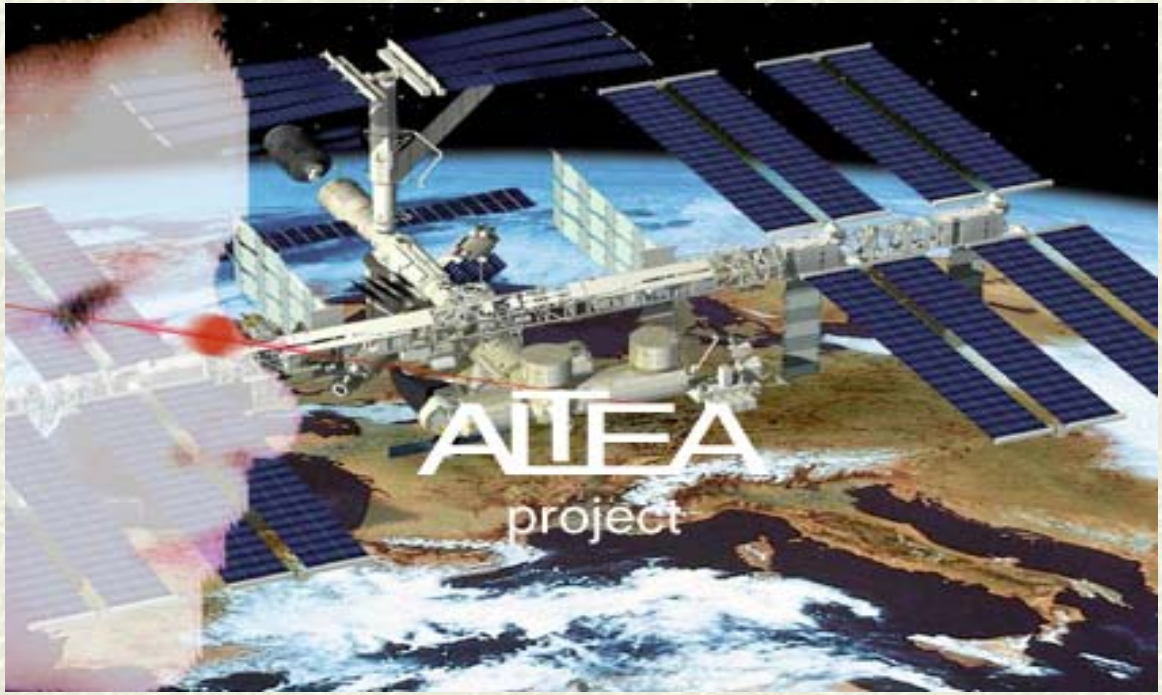

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Radiation Detection and Dosimetry Workshop - Houston, Tx April 6 - 7, 2006

…. understanding ..

…. the radiation functional risks for the Central Nervous System during space vojages, 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

Journal of Aviation Medicine 23, 345-372, ***1952***

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

Background

- Reports from space
  - Anusual 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

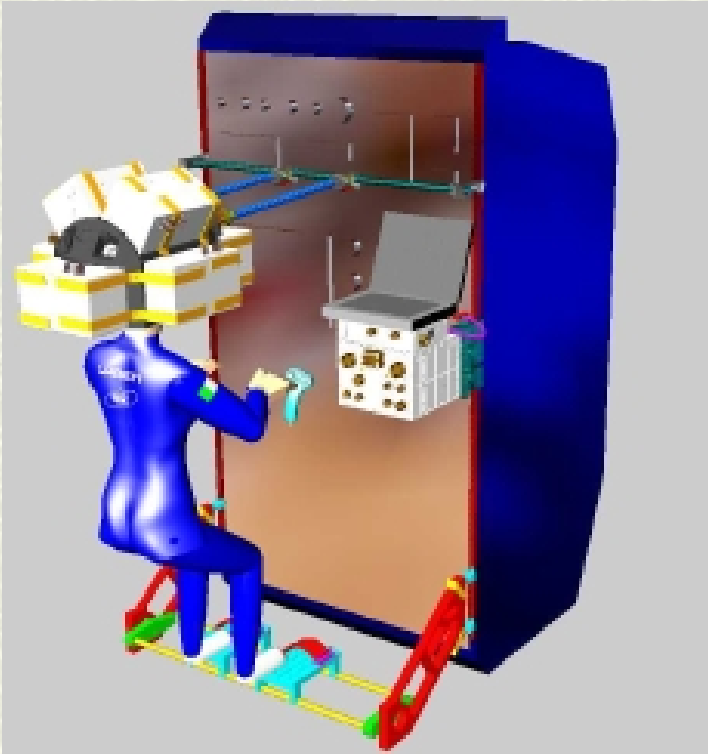
… many open issues

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}

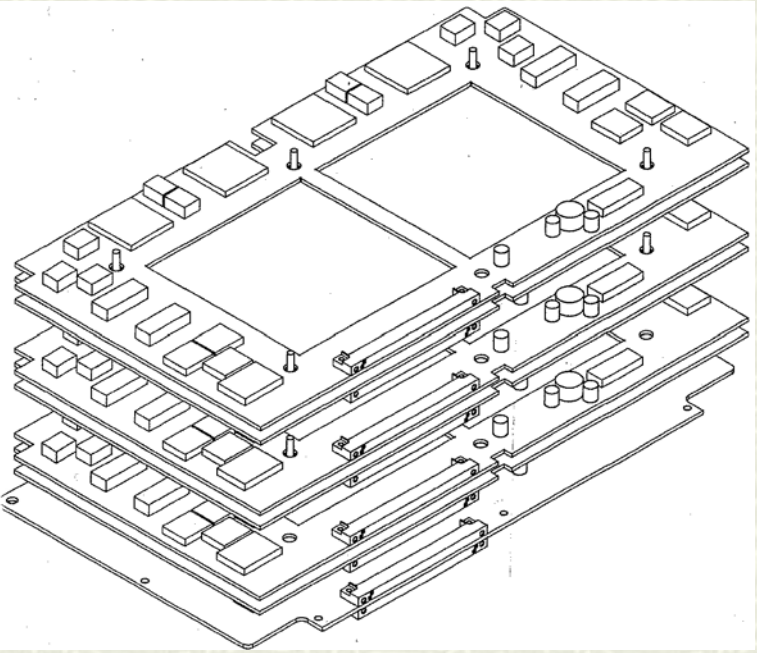
ALTEA - space: the SDU

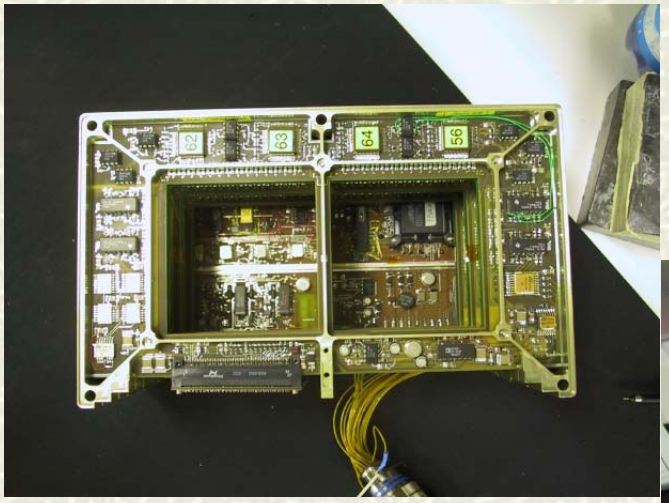
- The large-solid angle, silicon detector system is composed by six Silicon Detector Units (SDU) mounted on an helmet shaped holder (geometrical factor: 1071 cm^2/sr)

ALTEA - space: the SDU - 2

- The Silicon Detector Unit (SDU)

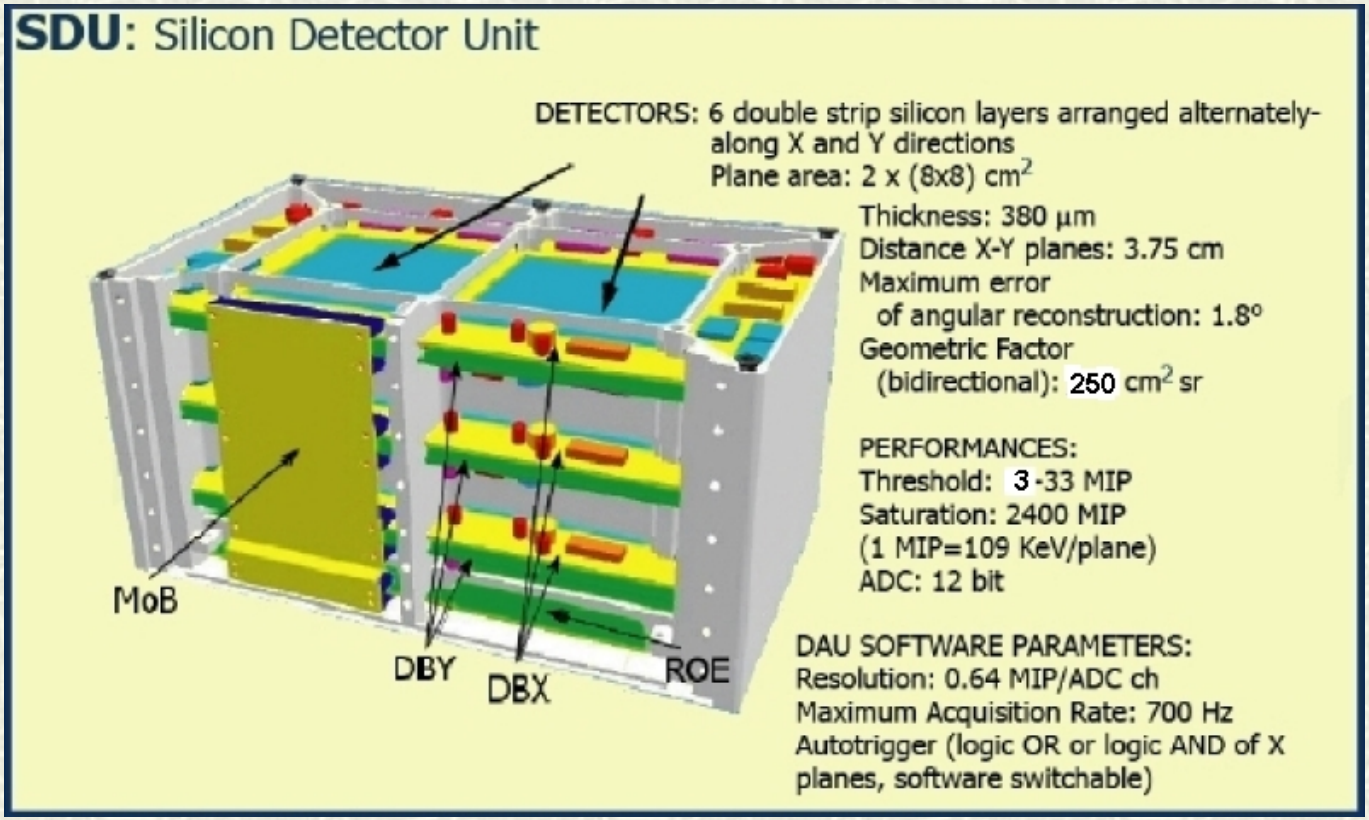
(geometrical factor: 250 cm^2/sr)





ALTEA - space: the SDU - 3

- The Silicon Detector Unit (SDU) - characteristics:

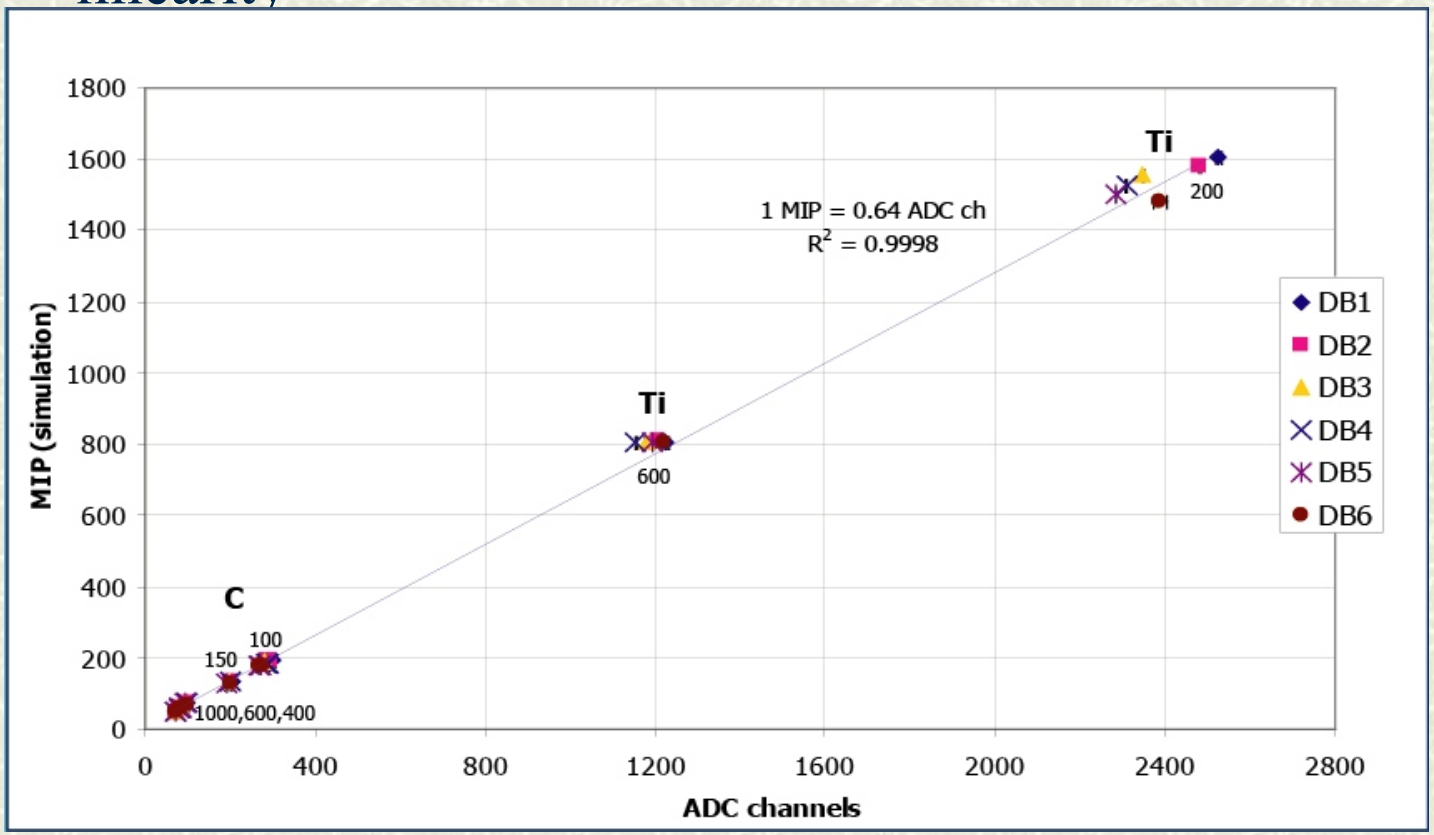


SDU reads from ^{4}He > 25 MeV/n To ^{96}Mo > 1GeV/n

Two operational mode:
-Normal
-Full

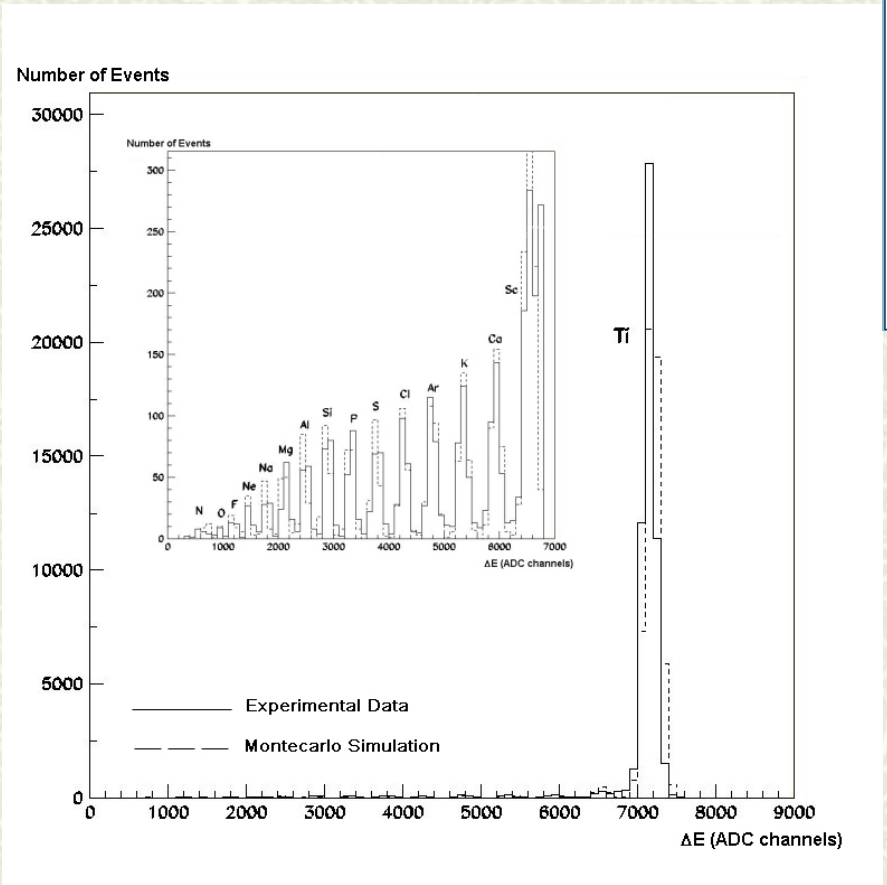
ALTEA - space: SDUs tests (at GSI)

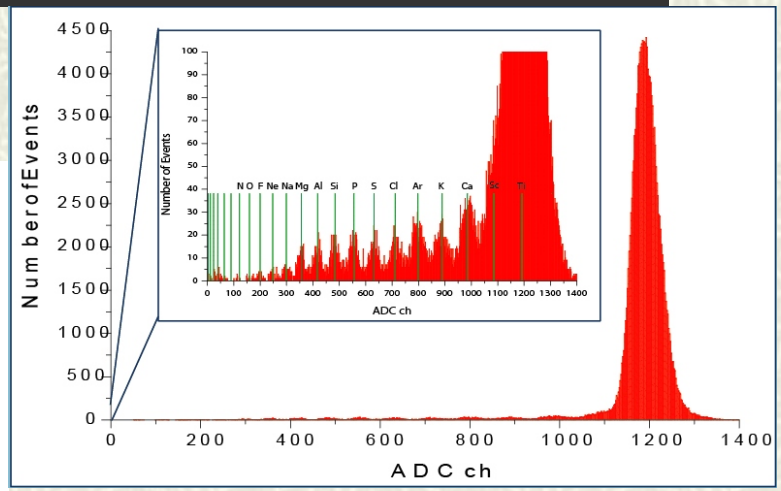
- linearity



ALTEA - space: SDUs tests at GSI - 2

- nuclear recognition

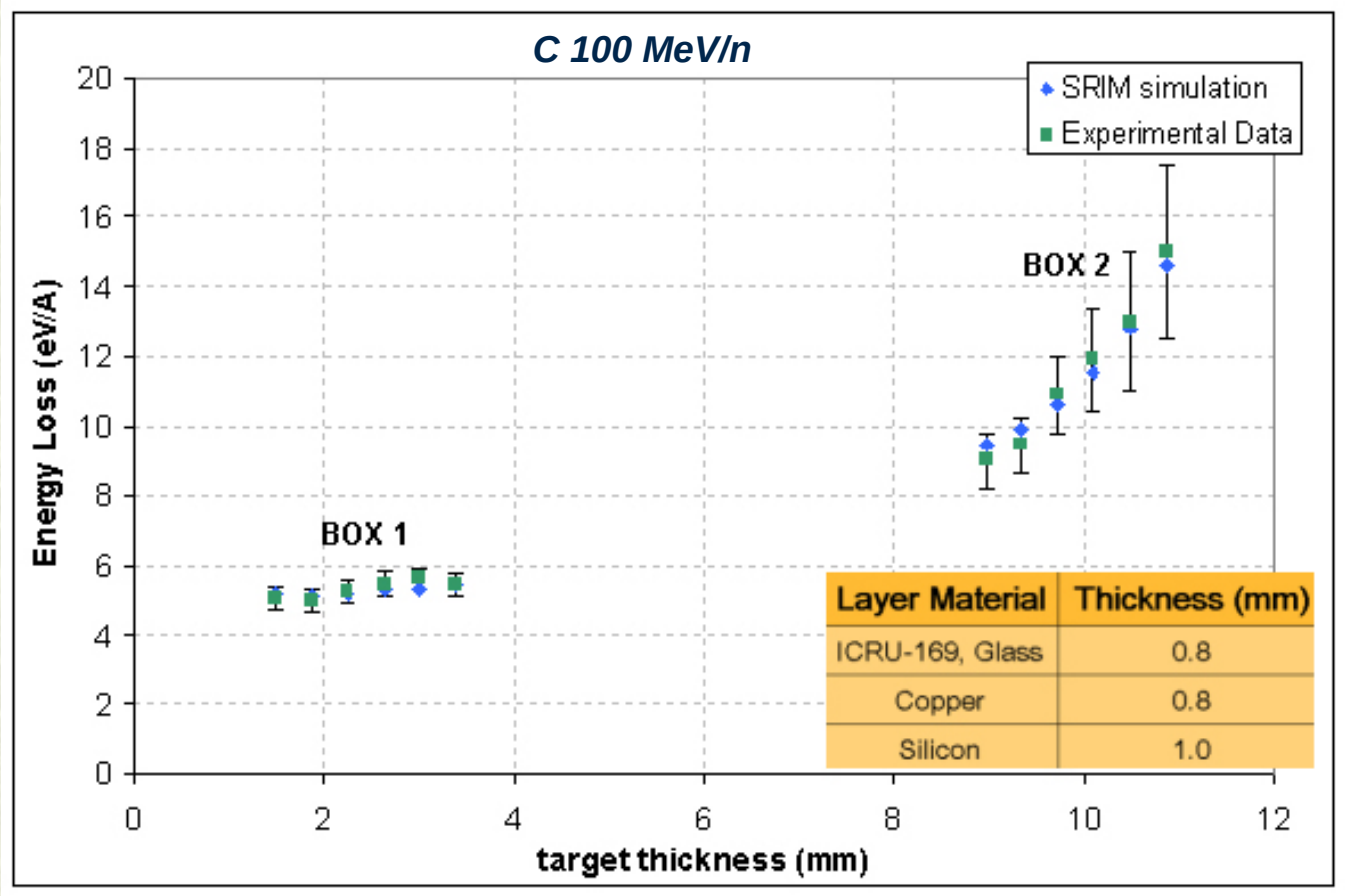




Ti 600 Mev/n
6 mm Al

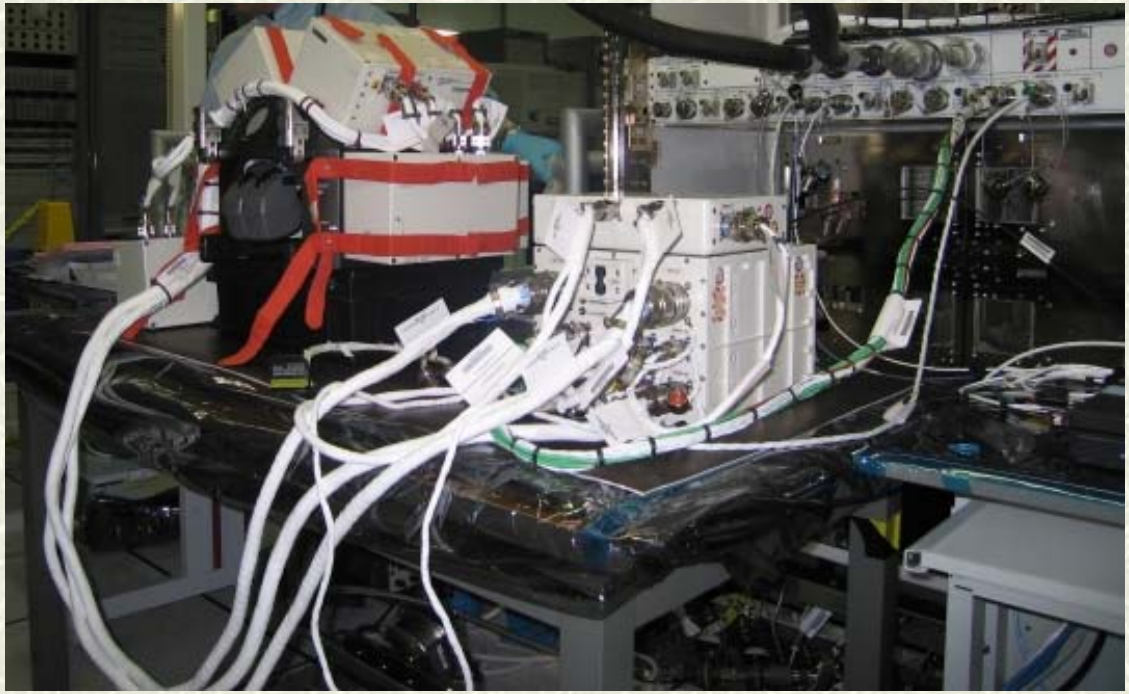
ALTEA - space: SDUs tests at GSI - 3

- the Bragg curve



ALTEA - space: final acceptance and schedule

- the PTCS at KSC (from march 2005 in the MPLM)

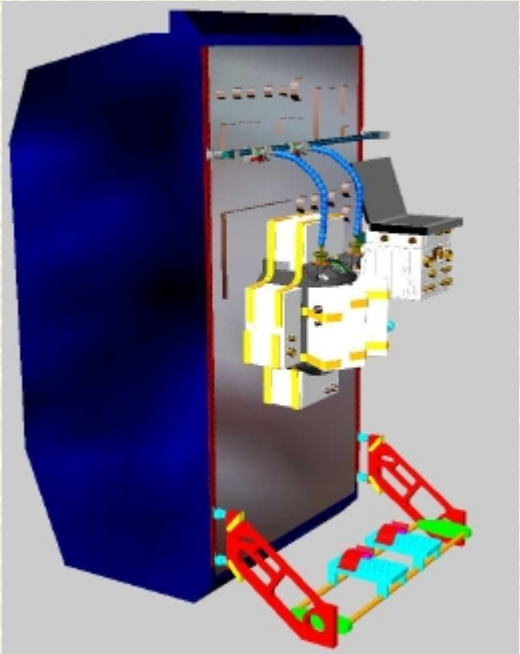


- manifested on the next Shuttle flight

(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



ALTEA - space: accepted protocols - 2

- CNSM

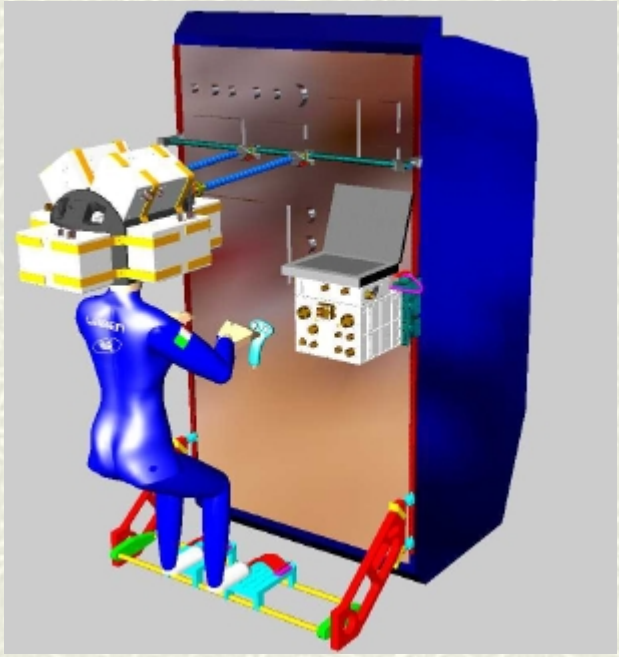
  - The astronaut wears the EEG cap ..
  - .. slides into the SDS ..
  - .. close the VSU and start dark adaptation
  - The assistant starts the automatic procedure:

    SDS always ‘on’

    EEG always ‘on’

    VSU (at the beginning) delivers the stimulation paradigm

    The astronaut signal the LF perception with the PB



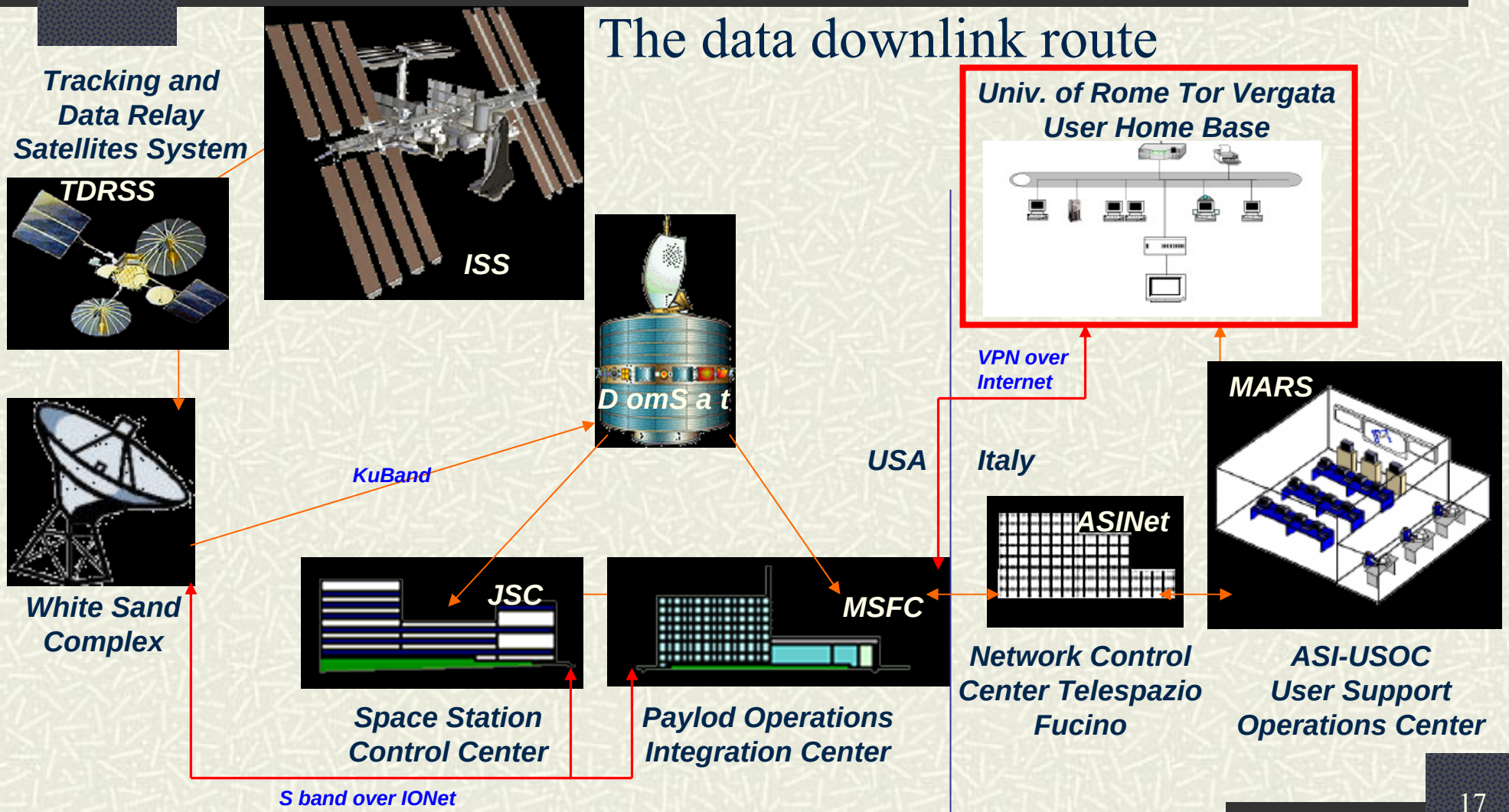
ALTEA - space: data transfer

- DOSI: Real Time data downlink
  maximum rate ≈ 0.64 Mbps
  (corresponding to ≈ 600 Hz in *normal* mode)
  average foreseen rate ≈ 60 kbps

- CNSM: Storaged on Lap Top HD, downlinked Off Line
  ≈ 1.5 - 2 GB/session

ALTEA - space: data transfer - 2

The data downlink route



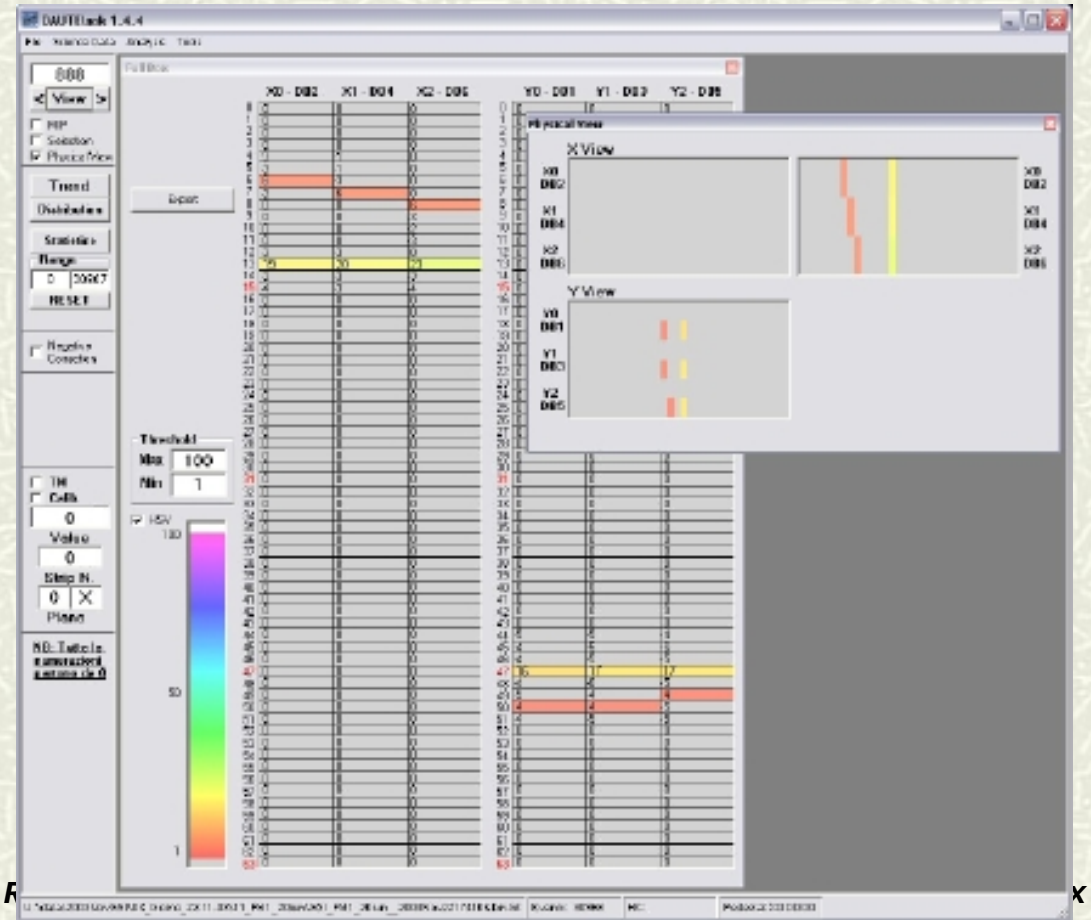
ALTEA - space: data transfer - 3

- The User Home Base

Data is going to be easily available for the scientific community

ALTEA - space: Real Time Analysis

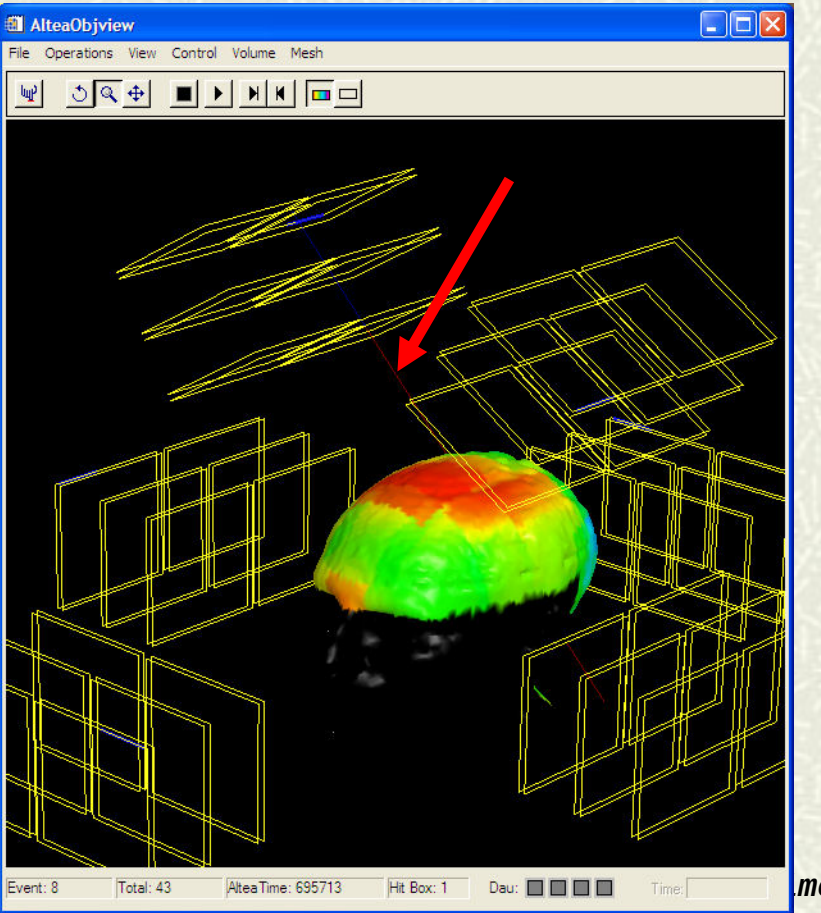
- Real time trace display

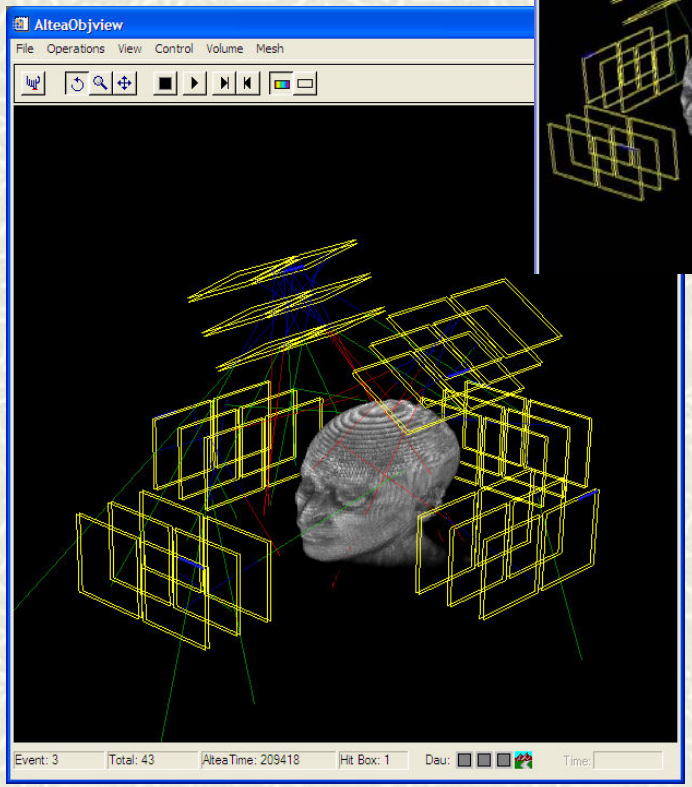


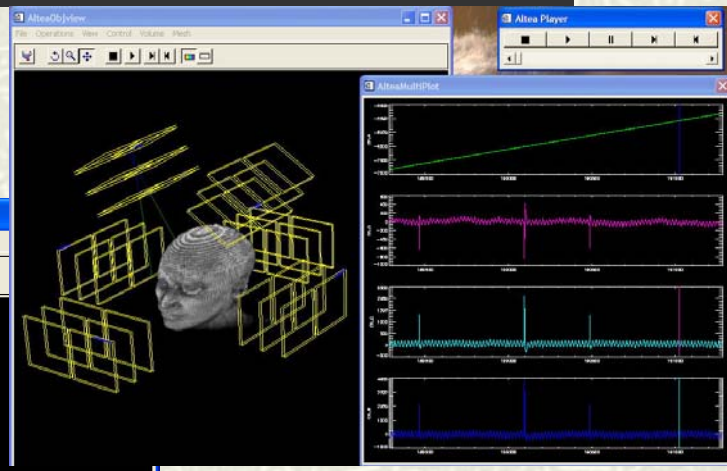
- Software for real time trace recognition is under development

ALTEA - space: interactive data display

- Software for the visualization of Particle and EEG data







The scientific strategy: follow up

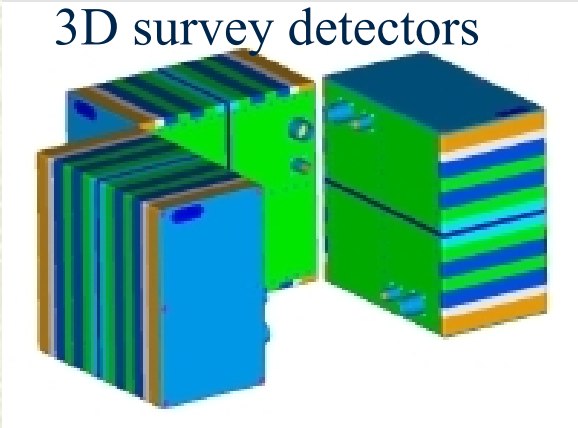
- extend measurement validity on other vessels & outside magnetosphere
- propose shielding material(s) to minimize risks
- test on ground and in space such shielding material(s)

ALTEA - shield (ESA)

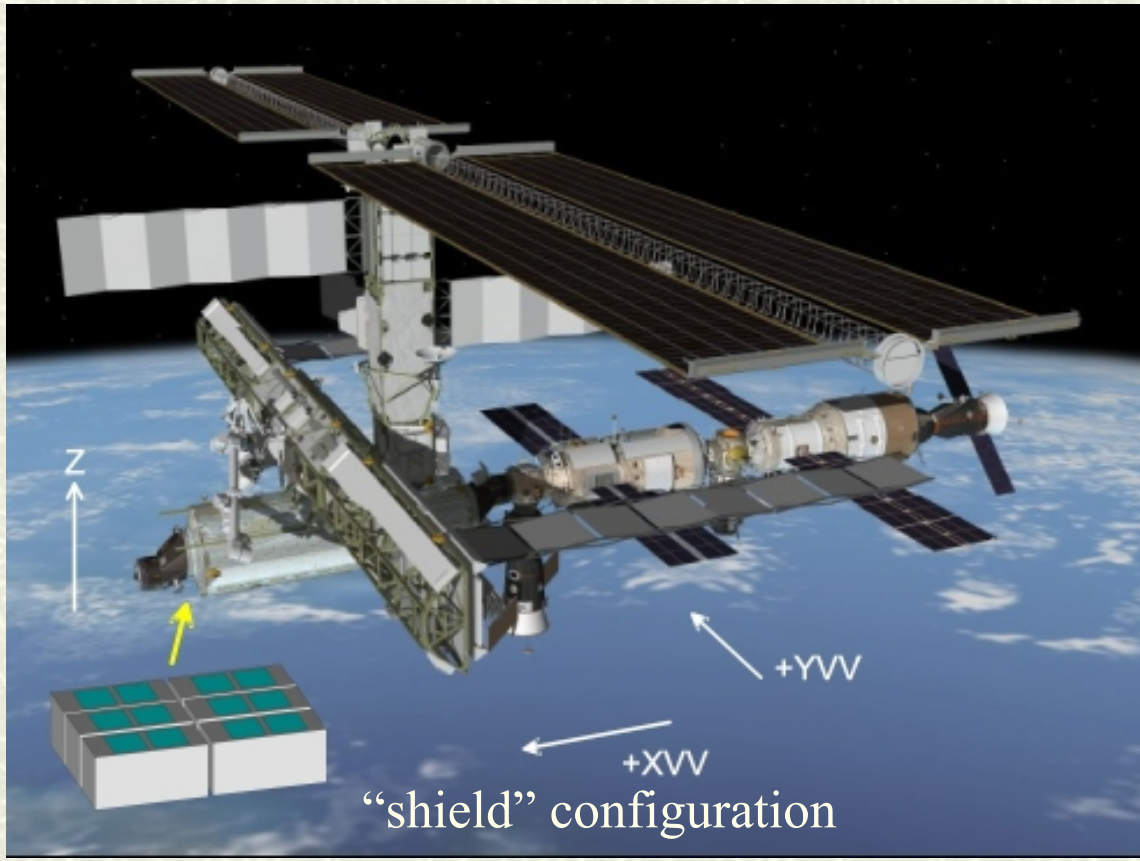
2 increments after ALTEA - space

ALTEA - shield

- working hypothesis:



- 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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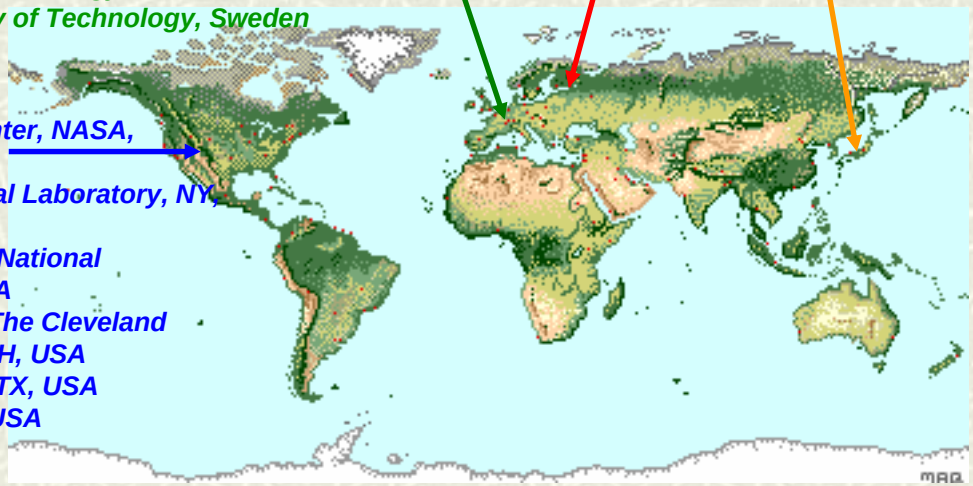
Italian Space Agency (ASI) - Rome
Dept of Physics, Univ. of Pavia, Pavia
Dept of Physics, Univ. of Milan, Milan
DISM-Univ. of Genoa, Genoa
L.N.F. - INFN, Frascati (Rome)
ALENIA spazio - Laben
CERN - INFN
Dept. of Physics,Univ. e Sect. INFN of Trieste, Perugia, Firenze
Dept. of Sc. and Chemical Tec., Univ. of Rome "Tor Vergata"
Dept. of STB - Univ. of L'Aquila, L'Aquila
GSI - Biophysik, Darmstadt, Germany
Royal Institute of Technology, Stockholm, Sweden
Chalmers University of Technology, Sweden

Institute for BioMedical Problems, Moscow, Russia.
Russian Space Corporation "Energia" by name Korolev, Korolev, Moscow region, Russia
Moscow State Engineering Physics Institute, Moscow, Russia

JAERI, Japan



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Brookhaven National Laboratory, NY, USA
Lawrence Berkeley National Laboratory, CA, USA
Cole Eye institute, The Cleveland Clinic, Cleveland, OH, USA
Wyle Laboratories, TX, USA
Eril Research, CA, USA

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Vacchi A.
Vavilov N.
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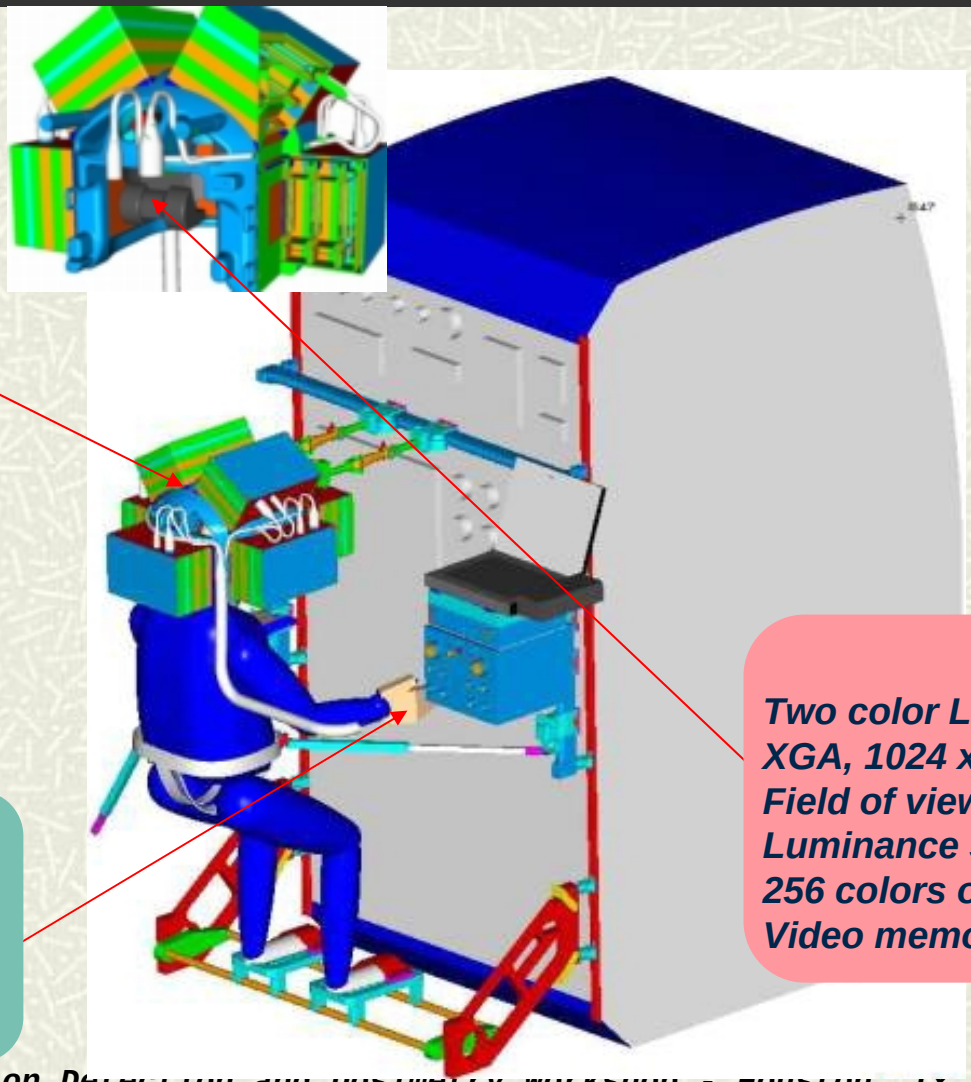
Villari S.
Vittori R.
Zaconte V.
Zampa N.

+ others joining in

Thank you for your attention

ALTEA - space: EEG VSU and PB



EEG

32 channels
128 - 16384 Hz
per channel

PushB.

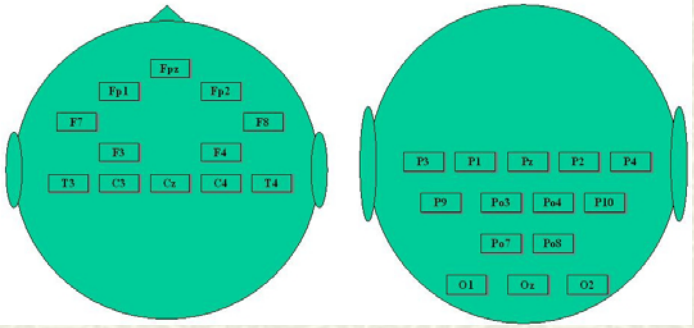
Three independent pushbuttons

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

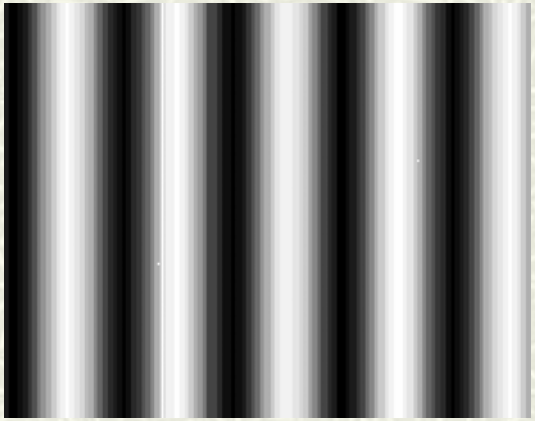


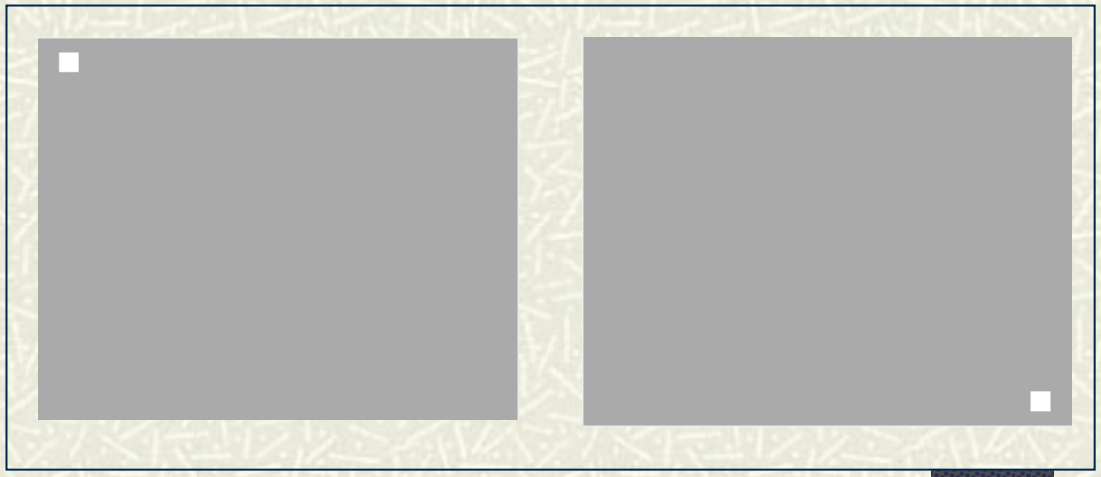
Astronaut Jeff Williams during BDC

ALTEA - space: the Visual Stimulator

- visual stimuli

Astronaut Jeff Williams during BDC





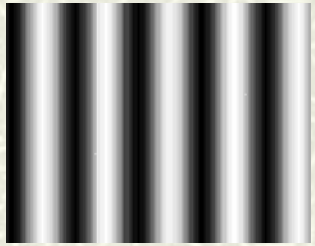
ALTEA - space: the Push Button

- 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

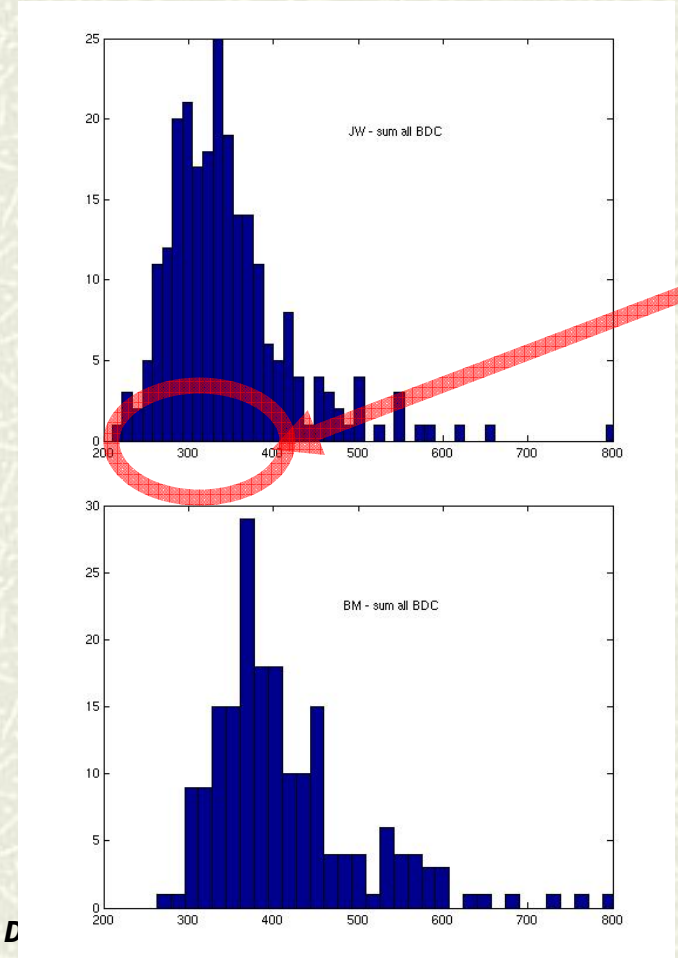
      press the pushbutton at the rare event (Low Right Flash)

Astronaut Sunita Williams during BDC

- 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

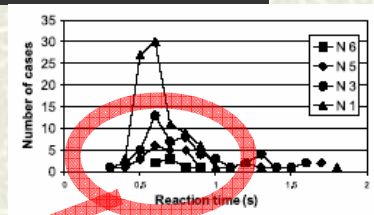


Fig. 10. Reaction time of four subjects to dark adaptation signals.

Reaction time (s)
5 astronauts

0.42 ± 0.10
0.42 ± 0.08
0.43 ± 0.10
0.37 ± 0.05
0.39 ± 0.07