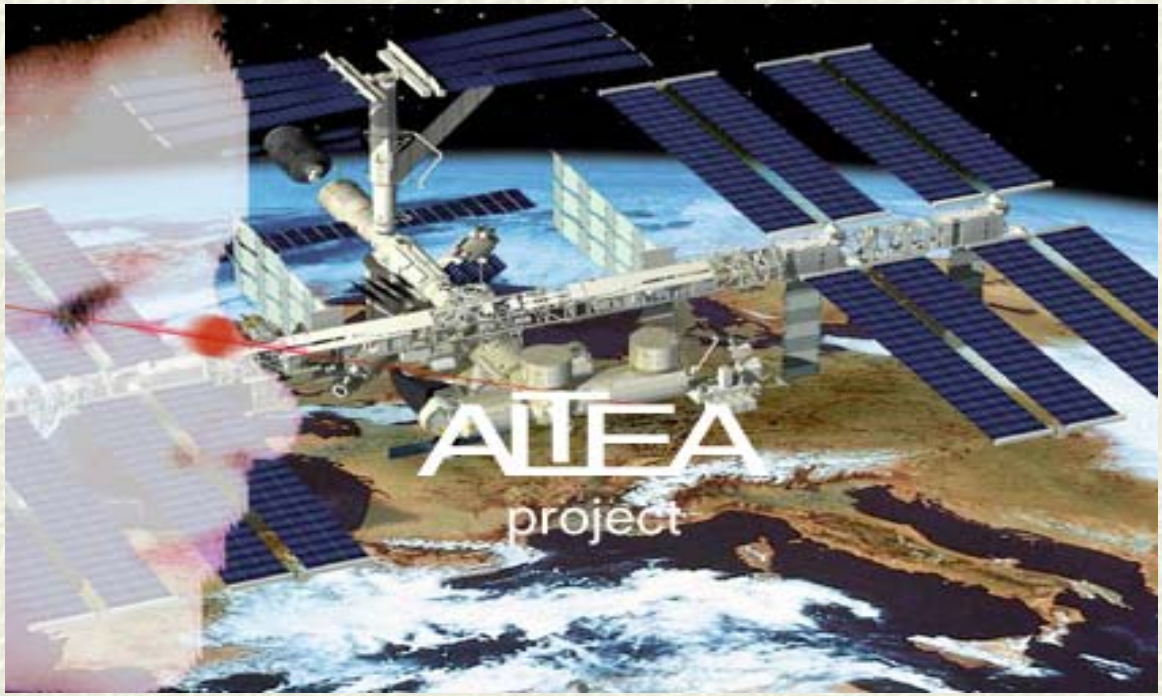
# ALTEA

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

*Livio Narici*
*Department of Physics, University of Rome and INFN 'Tor Vergata', Rome, Italyy*




University of Rome "Tor Vergata"

University of Genoa

narici@roma2.infn.it

# …. 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

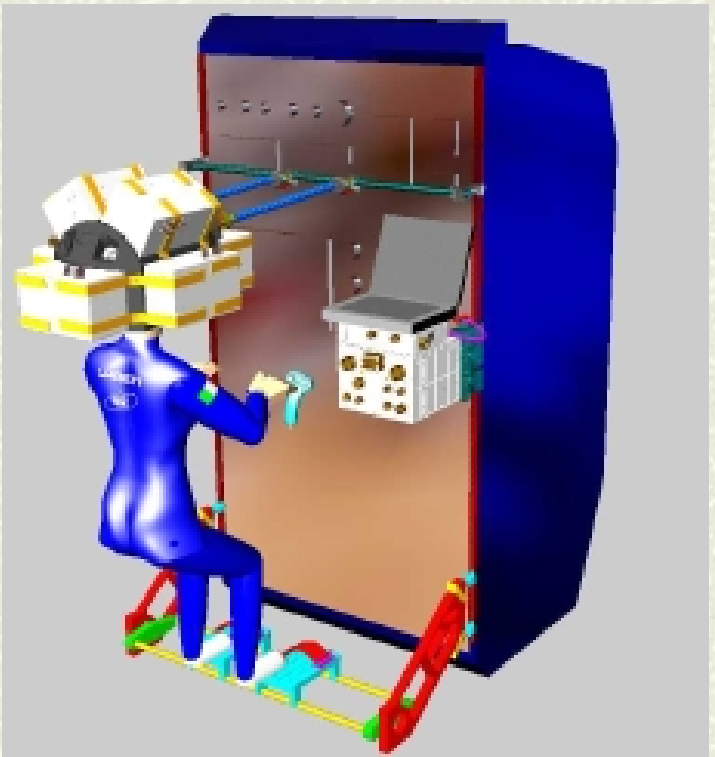
Hardware issues

- 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}

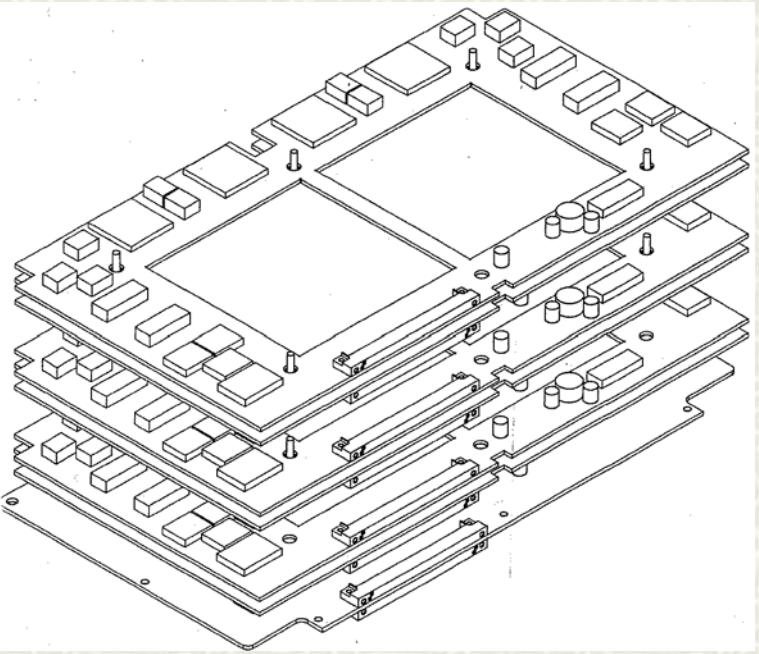
# ALTEA - space: the SDU

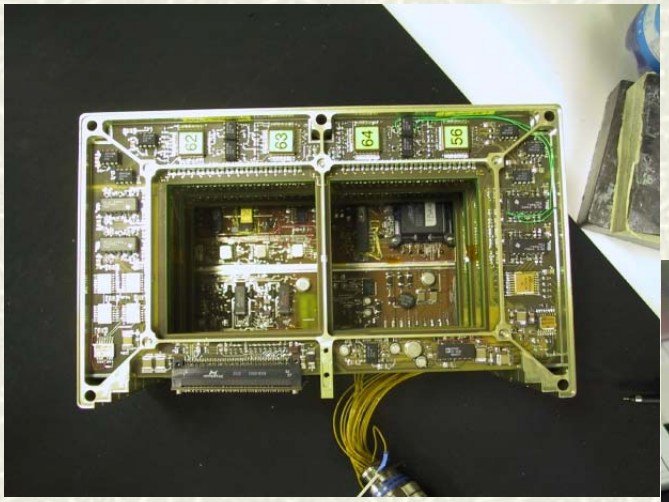
- The large-solid angle, silicon detector system is composed by six Silicon Detector Units (SDU) mounted on an helmet shaped holder (geometrical factor: 1071 $cm^2/sr$)

# ALTEA - space: the SDU - 2

- The Silicon Detector Unit (SDU)

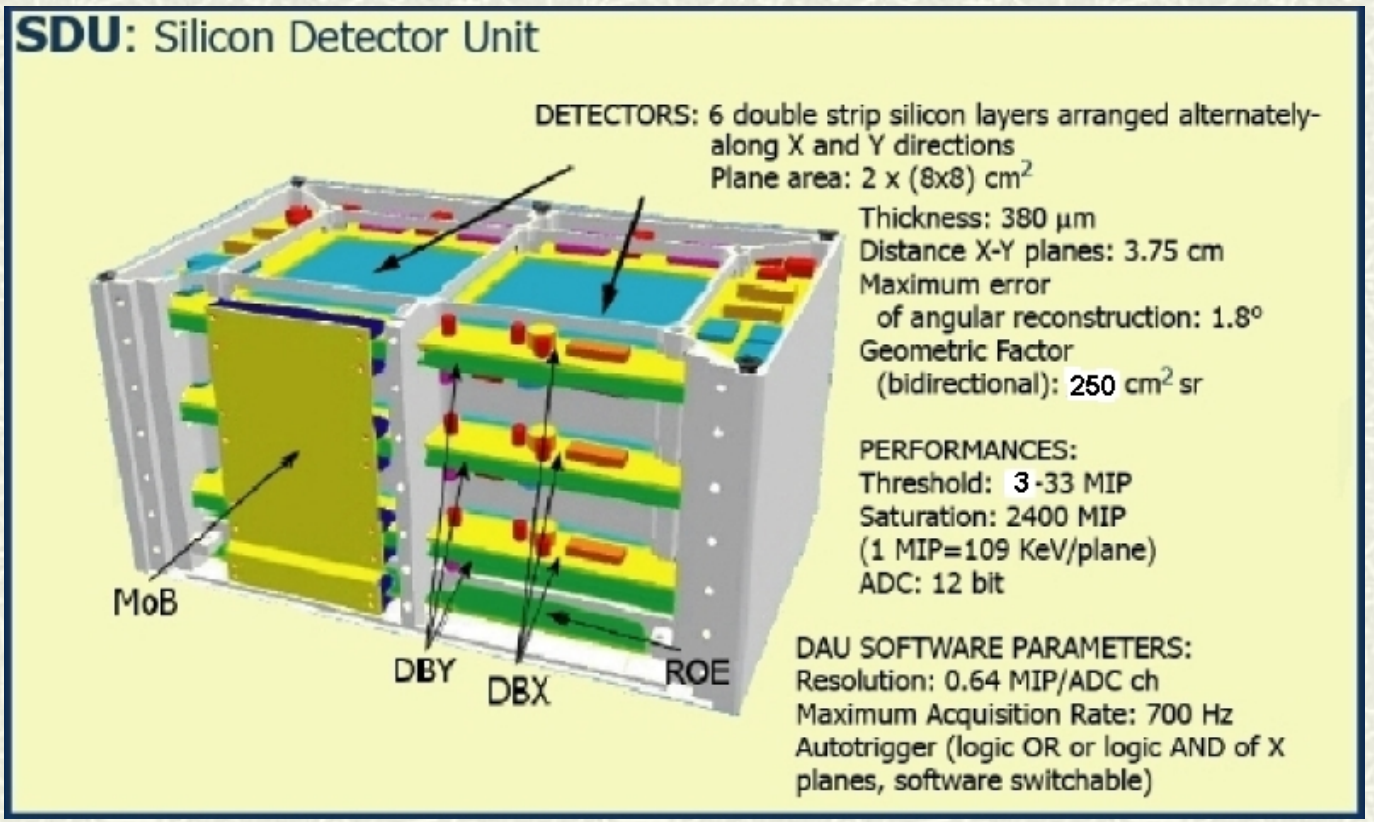
(geometrical factor: 250 $cm^2/sr$)





# ALTEA - space: the SDU - 3

- The Silicon Detector Unit (SDU) - characteristics:

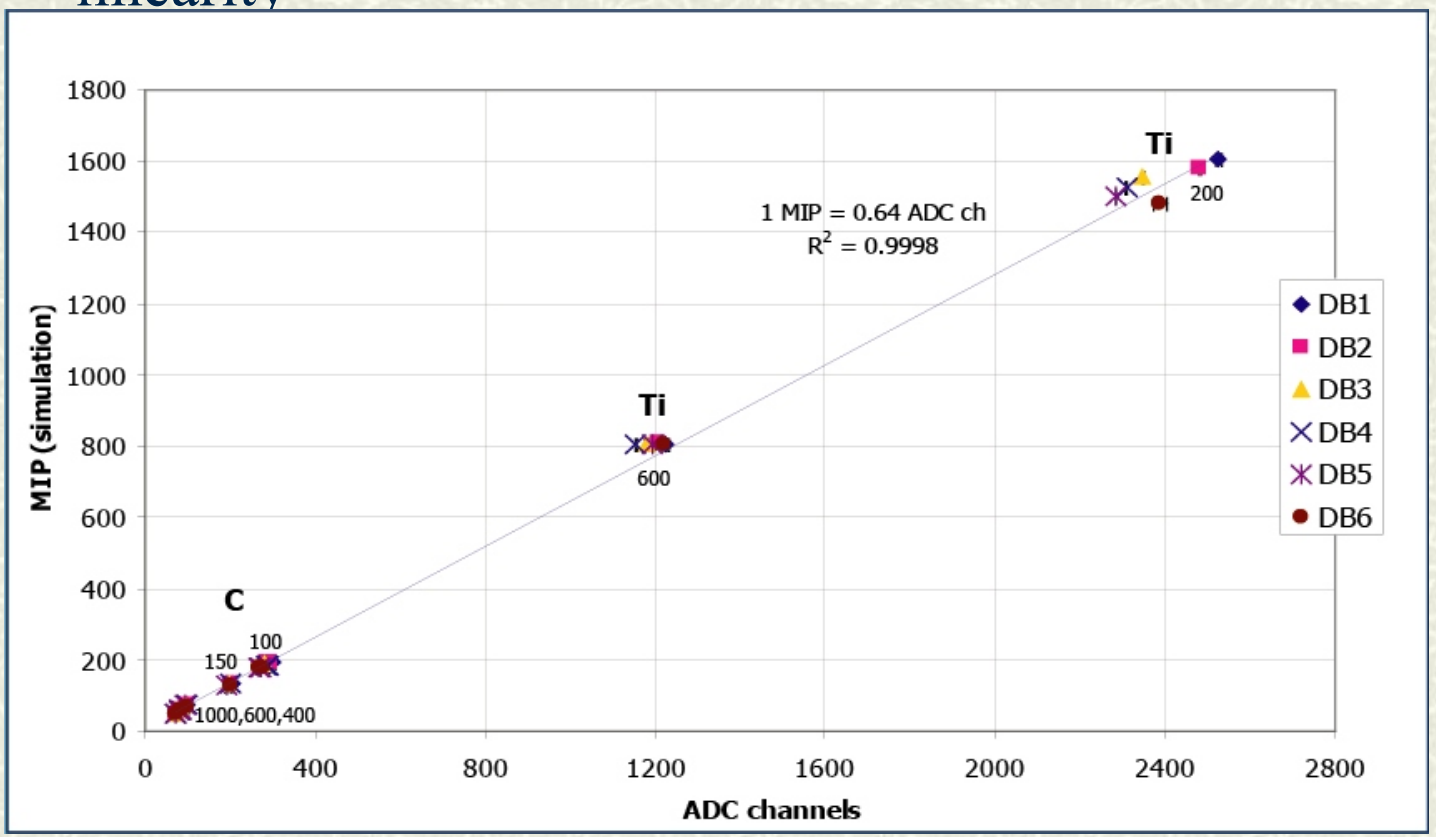



***SDU reads from $^{4}He$ > 25 MeV/n To $^{96}Mo$ > 1GeV/n***

***Two operational mode:***
***-Normal***
***-Full***

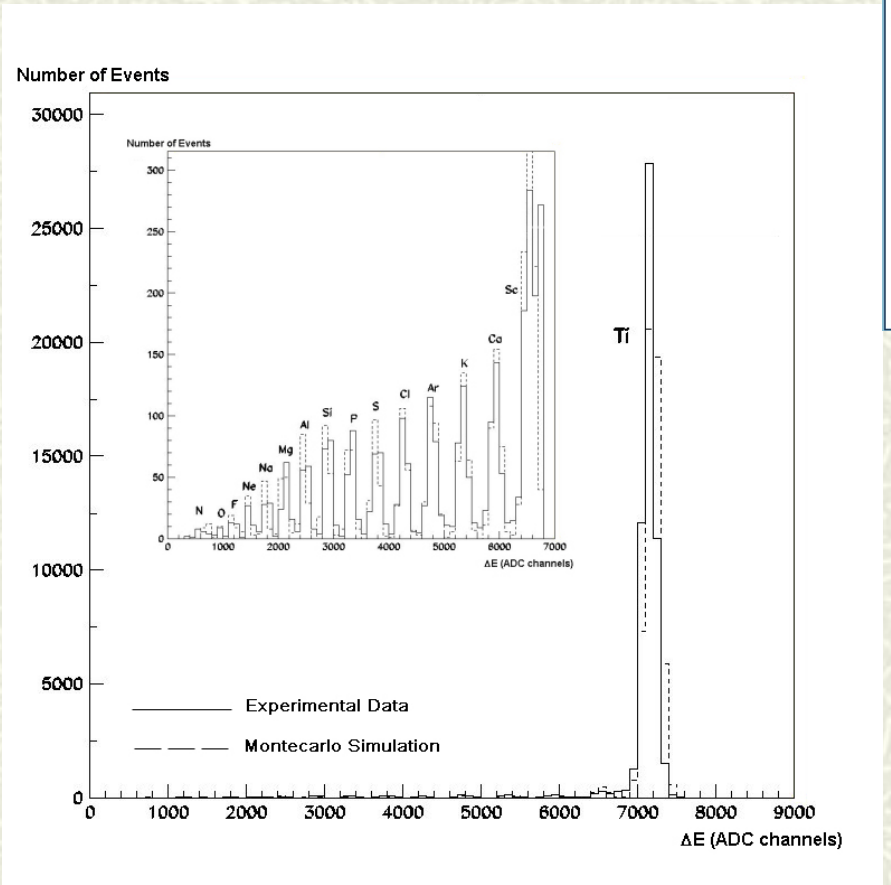
# ALTEA - space: SDUs tests (at GSI)

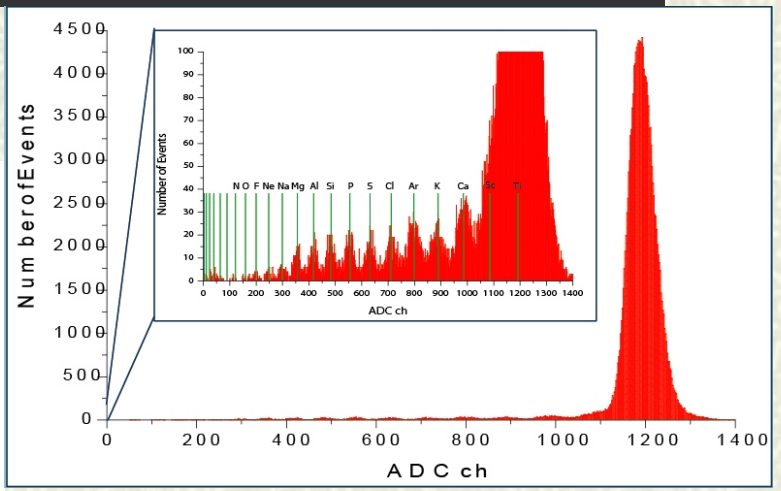
- linearity



# ALTEA - space: SDUs tests at GSI - 2

- nuclear recognition

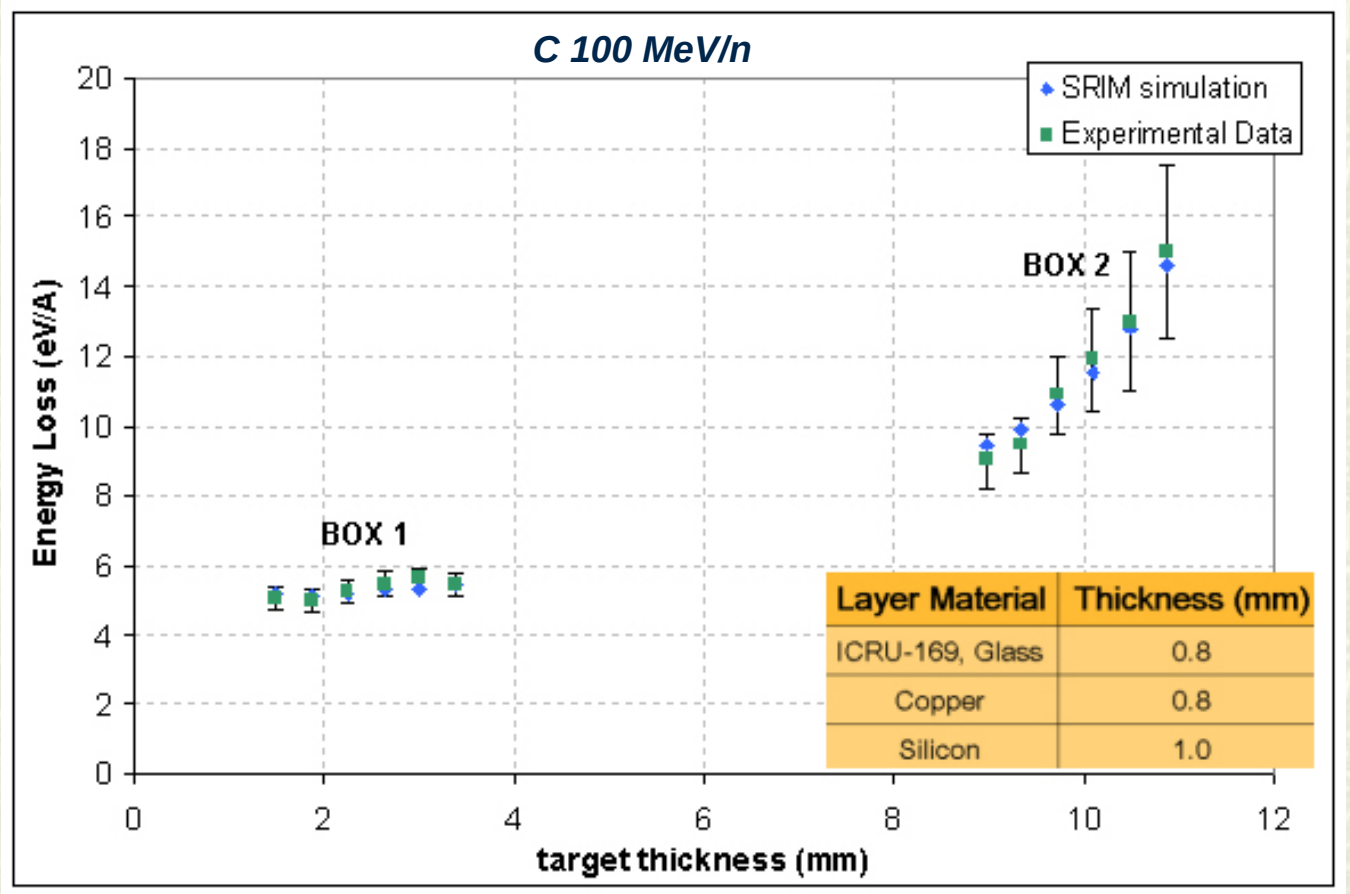



***Ti 600 Mev/n***
***6 mm Al***

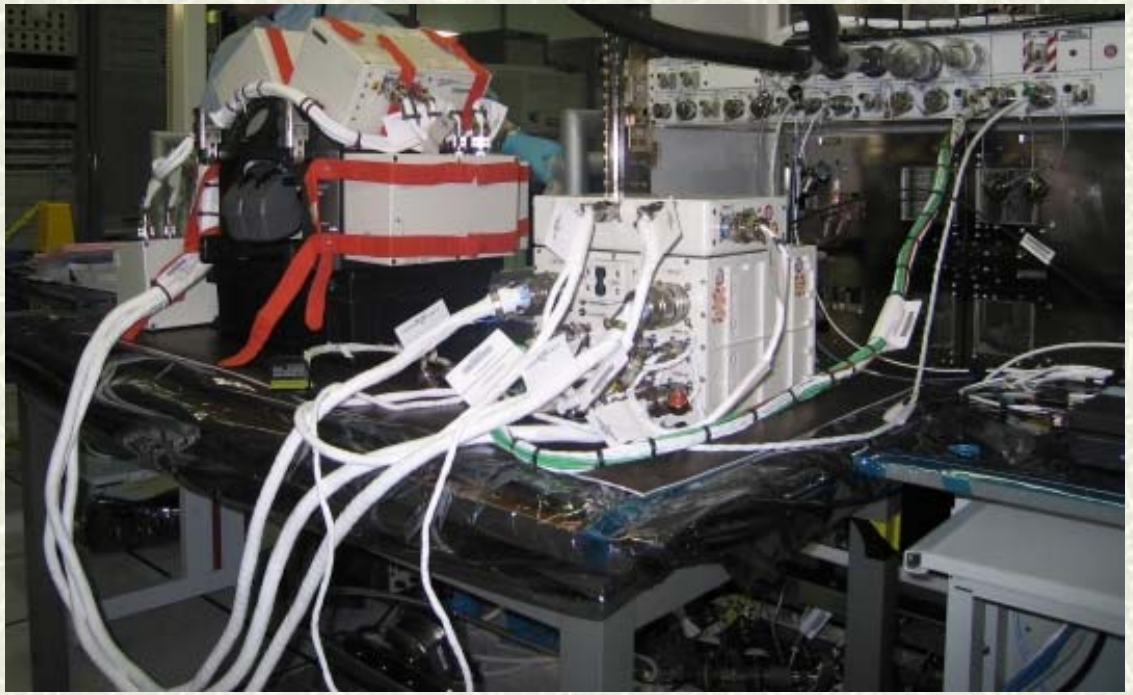
# ALTEA - space: SDUs tests at GSI - 3

- the Bragg curve



# ALTEA - space: final acceptance and schedule

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

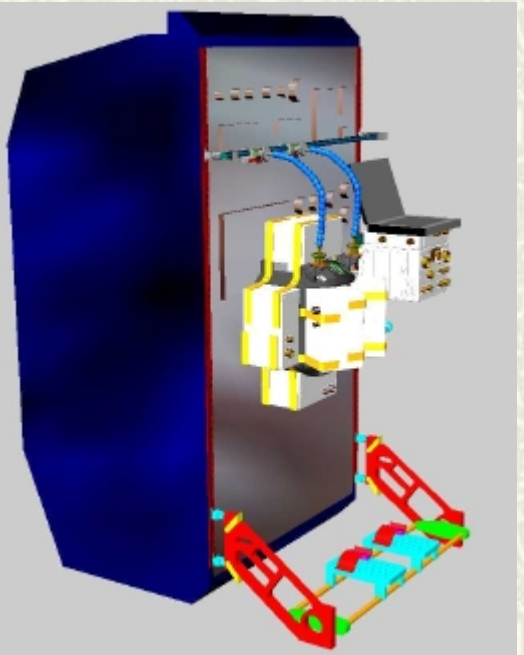


- manifested on the next Shuttle flight

( STS121 - ULF1.1 ) {summer 06}

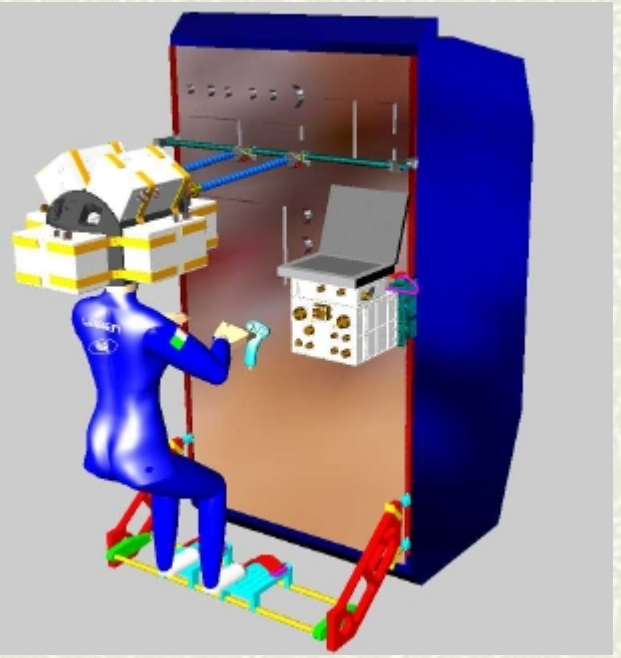
# ALTEA - space: accepted protocols

- 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

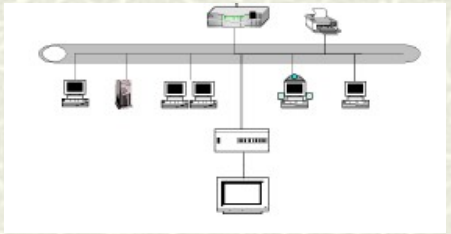
- CNSM: Storaged on Lap Top HD, downlinked Off Line
  ≈ 1.5 - 2 GB/session

# ALTEA - space: data transfer - 2

## The data downlink route

Tracking and Data Relay Satellites System

Univ. of Rome Tor Vergata User Home Base



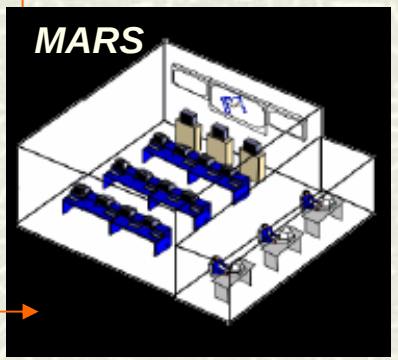
VPN over Internet

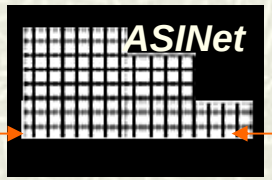
KuBand

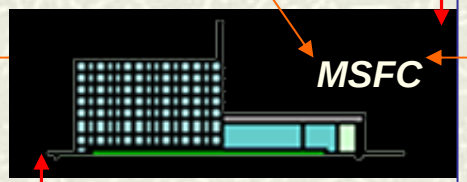
White Sand Complex

USA

Italy






Space Station Control Center

Paylod Operations Integration Center

Network Control Center Telespazio Fucino

ASI-USOC User Support Operations Center

S band over IONet

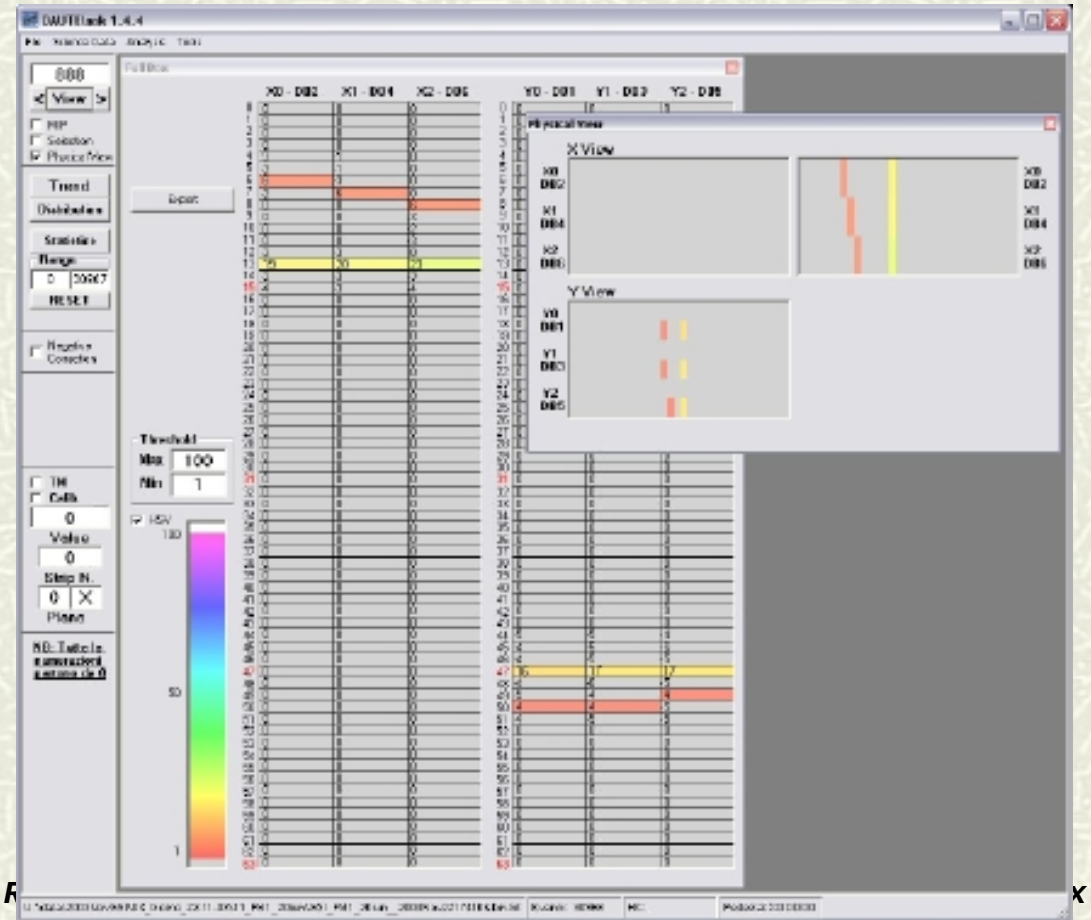
# ALTEA - space: data transfer - 3

- The User Home Base

Data is going to be easily available for the scientific community

# ALTEA - space: Real Time Analysis

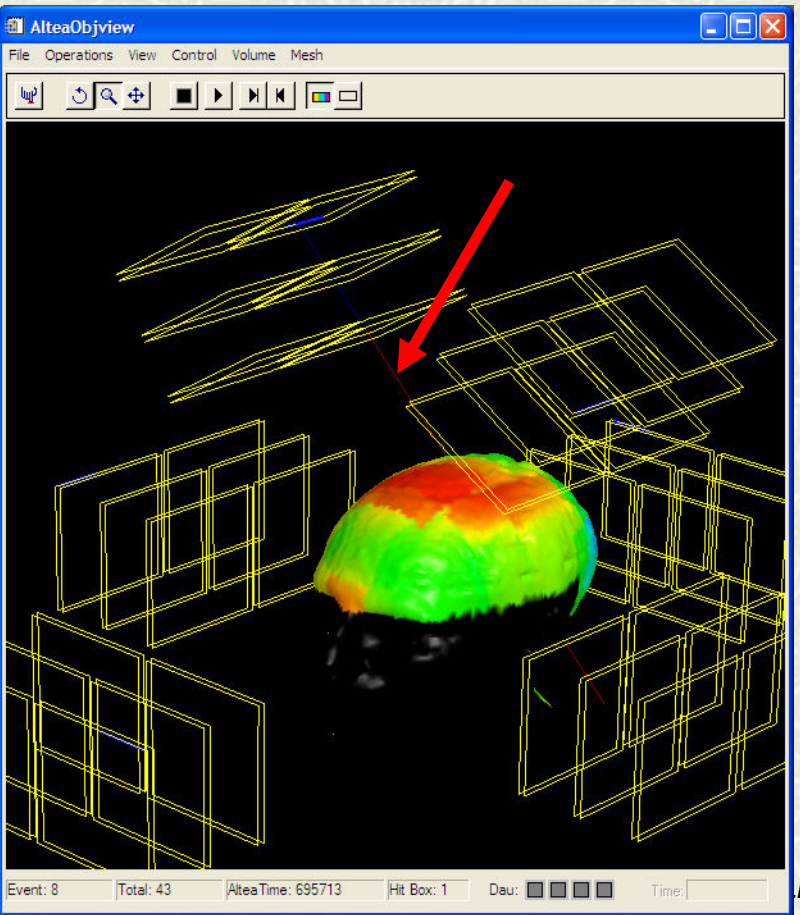
- Real time trace display

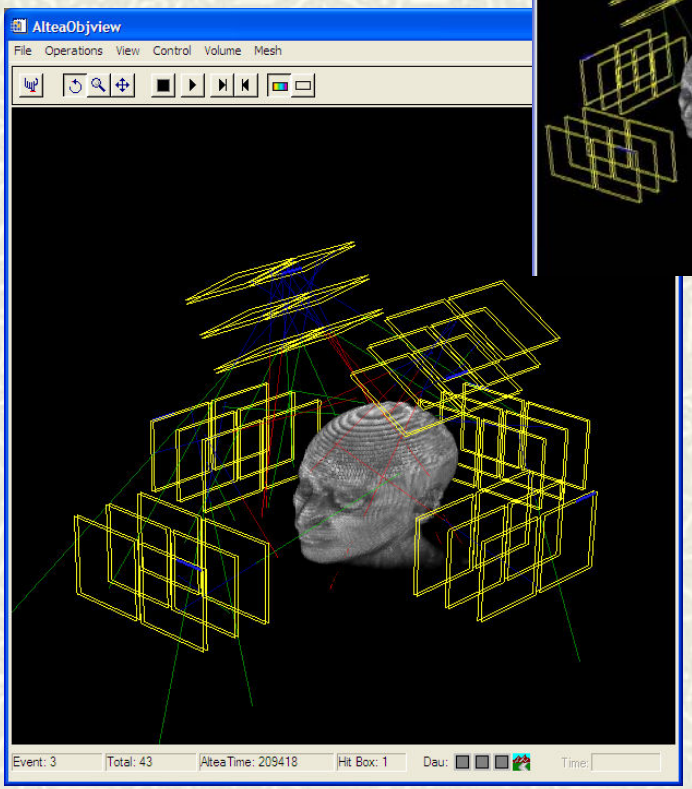


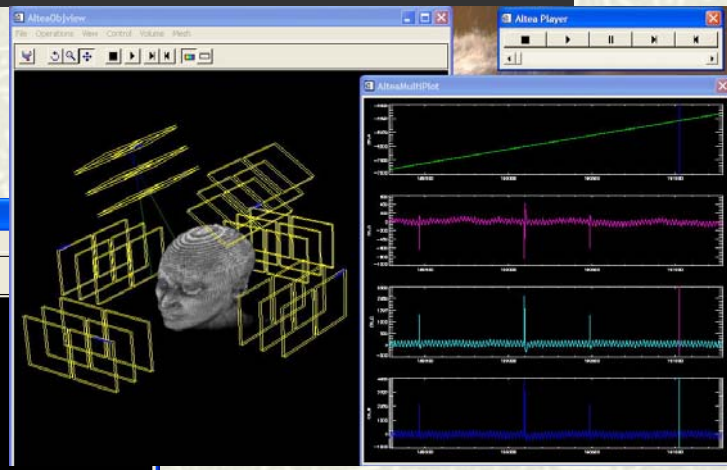
- Software for real time trace recognition is under development

# ALTEA - space: interactive data display

- Software for the visualization of Particle and EEG data



# The scientific strategy: follow up

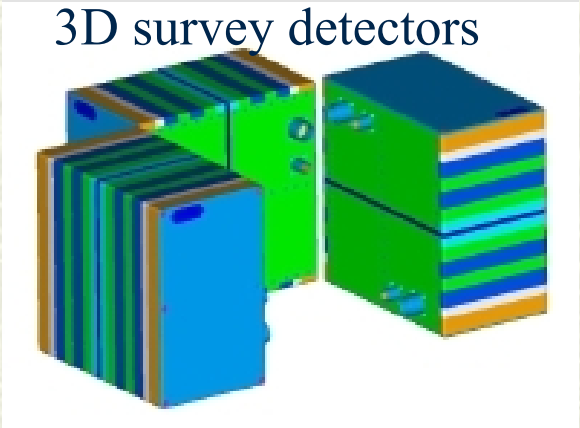
- extend measurement validity on other vessels & outside magnetosphere
- propose shielding material(s) to minimize risks
- test on ground and in space such shielding material(s)

ALTEA - shield (ESA)

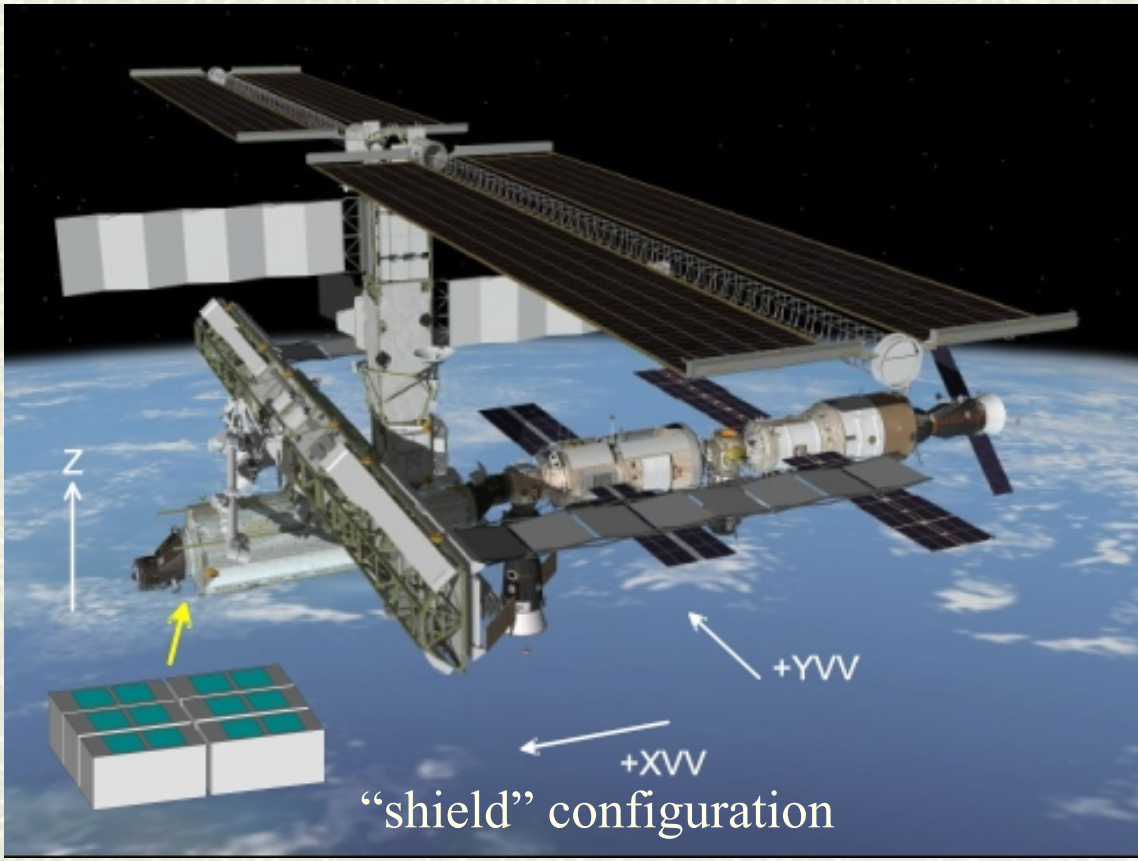
*2 increments after ALTEA - space*

# ALTEA - shield

- working hypothesis:




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



# The scientific strategy: follow up 2

- ALTEA - 2 is in the process of being designed ….

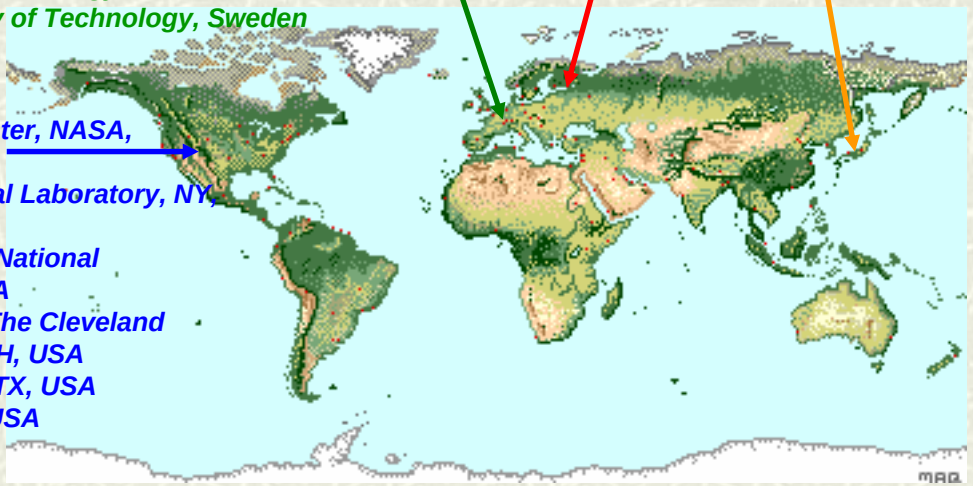
# The ALTEA team

*Dept. di Physics, Univ. of Rome "Tor Vergata" and INFN Sect. Roma2 , Roma*
*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

*Johnson Space Center, NASA, Houston TX, USA*
*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*

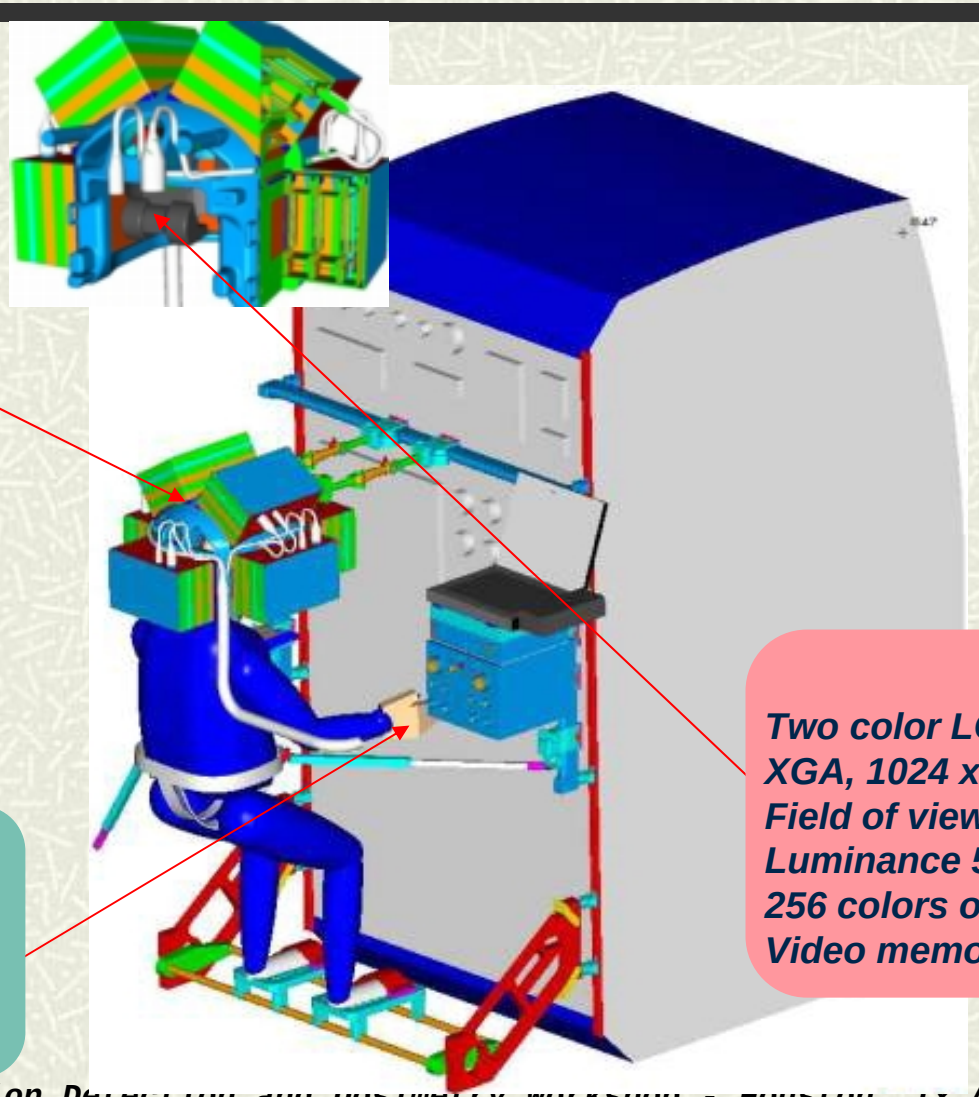


Altamura F
**Avdeev S.**
Ball S.
Ballarini F.
Battistoni G.
Belli F.
Bencardino R.
Bengin V.
Benton E.
Bidoli V.
Bisti S.
Boezio M.
Bonvicini W.
Carlson P.
Carozzo S.
Casolino M.
Castellini G.
Cotronei V.
Cucinotta F.
De Martino A.
DePascale M.P.
Di Fino L.
Ferrari A.
**Fuglesang C.**
Furano G.
Galper A.
Gianelli G.
Khodarovich A.
Korotkov M.G.
Iwase H.
Licoccia S.
Maccarone R.
Mazzenga G.
Miller J.
Morino V.
Morselli A.
Narici L.
Negri B.
Ottolenghi A.
Paci M.
Peachey N.S.
Petrov V.P.
Picozza P.
Popov A.
Reali E.
Ricci M.
Rinaldi A.
Romagnoli P.
Ruggieri D.
Salnitski V.P.
Sannita W.G.
Sato T.
Schardt D.
Shavers M.
Shevchenko O.I.
Shurshakov V.A
Sihver L.
Sparvoli R.
Spillantini P.
Trukhanov K.A.
Vacchi A.
Vavilov N.
Vazquez M.
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*

**VSU**

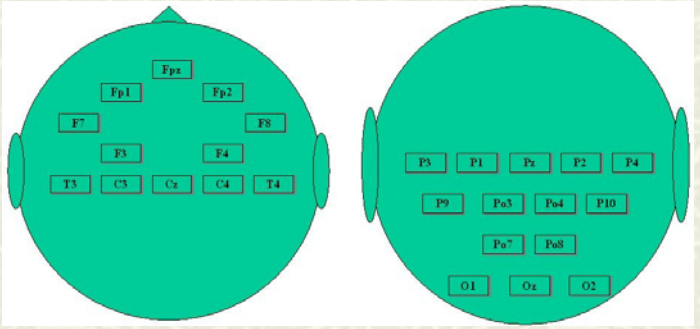
*Two color LCD-TFT oculars*
*XGA, 1024 x 768 pixels at 60 Hz*
*Field of view: 35° diagonal (21° V 28° H)*
*Luminance 5-50 FL Contrast 40:1*
*256 colors out of a 16 million colors palette*
*Video memory: 2 MB*

**PushB.**

*Three independent pushbuttons*

# ALTEA - space: the EEG

- EEG cap and electrodes

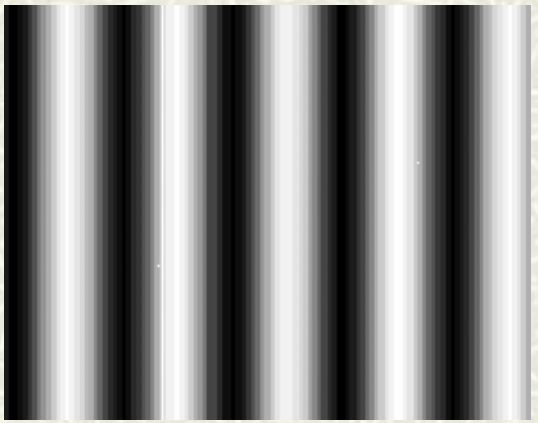


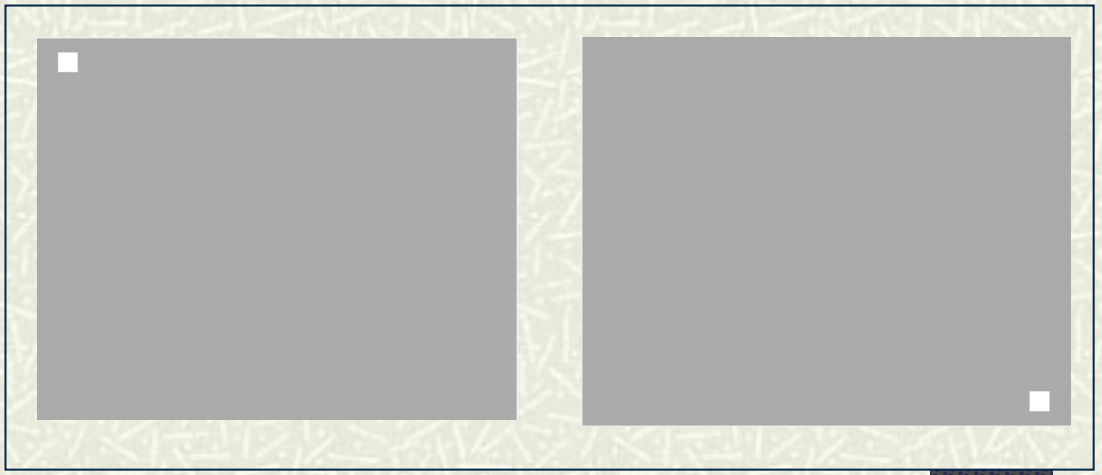
Astronaut Jeff Williams during BDC

# ALTEA - space: the Visual Stimulator

- visual stimuli

*Astronaut Jeff Williams during BDC*





# ALTEA - space: the Push Button

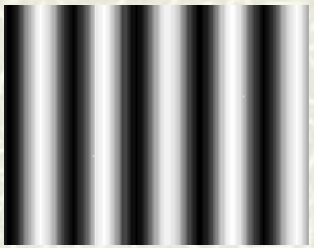
- three independent buttons

# 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)

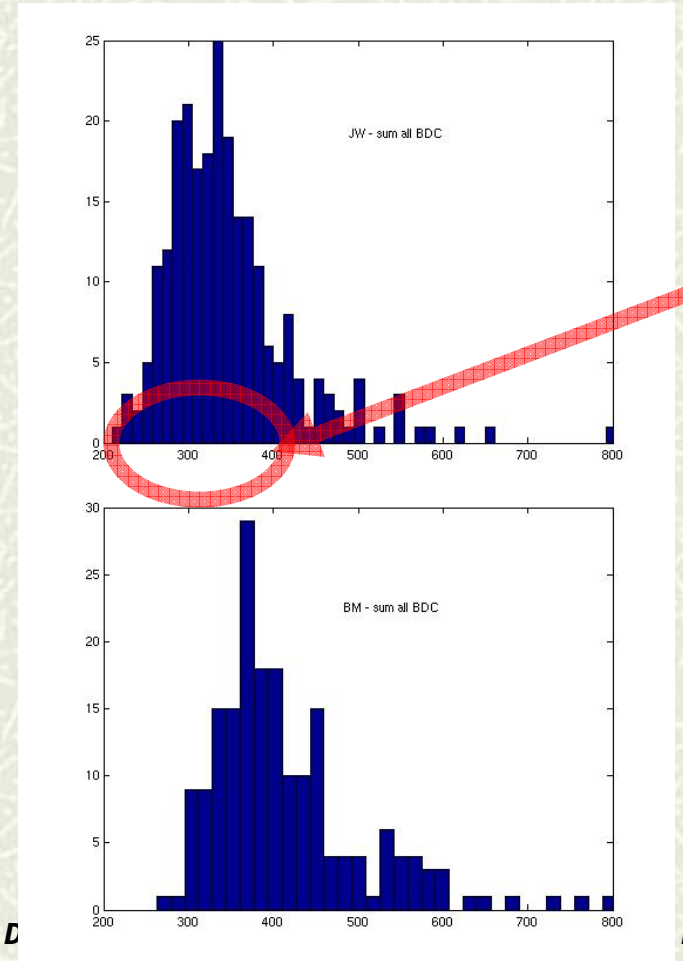


*Astronaut Sunita Williams during BDC*

- 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***

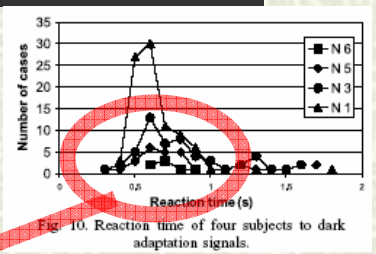


Fig. 10. Reaction time of four subjects to dark adaptation signals.

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 |