



WRMISS September 2007 Stillwater OK - USA

ALTEA Status and (4D) Perspectives

Livio Narici

(for the ALTEA collaboration)

University of Rome 'Tor Vergata' & INFN, Rome, Italy

ALTEA: a program for

- *the study of the radiation environment in the ISS*
- *the understanding and characterization of the interactions between ionizing radiation and Central Nervous System functions*



The ALTEA program

Several experiments in space and on ground aimed at the study of the influence that radiation in space has on CNS functions.

(example : the anomalous phosphene perceptions reported by astronauts)

- Investigate radiation environment in the ISS
- Find the ions (energies) with the highest interaction probability with CNSM functions
- Propose CNS functions - risk parameters
- Validate models and extrapolate results in different external conditions (such as interplanetary missions) using the simulations
- Test different materials as shields for such ions (energies)
- Understanding the basic mechanisms for the interactions
- Propose countermeasures.



ALTEA program: a multiple approach (Financed by ASI and INFN)

SilEye
MIR

ASI
SRAG-NASA
agreement

Experiment in Space on ISS

Controlled, laboratory
based experiments

Alteino/ALTCRIS
On board ISS
since April 2002

ALTEA-space



ISS - July 4th 2006

ALTEA-shield
2007 - 2010



ALTEA
shield
ground
exps.

ALTEA-MICE
GSI-BNL
Started 2001

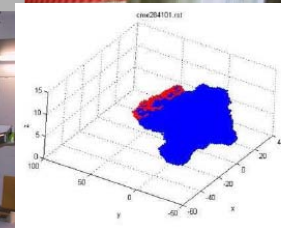
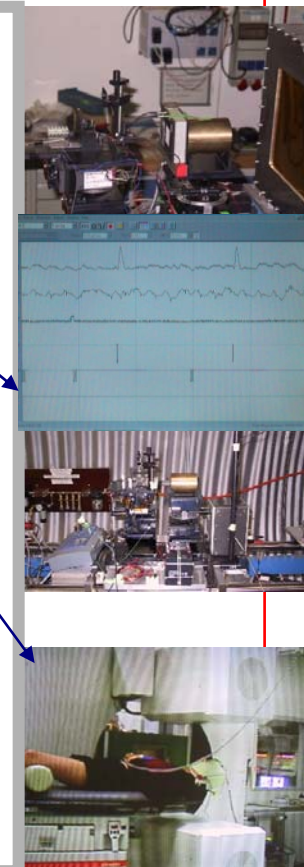
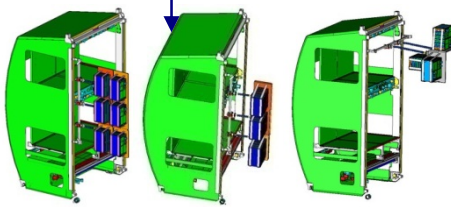
ALTEA-HIT
GSI
Started 2004

ALTEA-biophys
GSI-BNL
Started 2003

ALTEA
L.F. questionnaire
Published 2006

ASTRONAUT LIGHT FLASH SURVEY

C. Fuglesang
European Astronaut Centre, ESA, Cologne, Germany
L. Narici and P. Picozza
Dept. of Physics, University of Rome "Tor Vergata" and INFN Sezione di Roma 2, Rome, Italy
W.G. Sannita
DISM - Univ. of Genova, Genova, Italy and Dept. of Psychiatry, SUNY, Stony Brook, NY, USA





ALTEA program: a multiple approach

- **ALTEA - space / shield**

DOSI / survey: measures radiation environment (survey: in different ISS sites)

CNSM: (CNS monitoring) measures the astronaut's electrophysiological activity, his/her visual system status, the ions through their brain and the time when they perceive phosphenes (*1 measurement session: 1.5 h*)

Shield: measures the shielding effectiveness of different materials

ALTEA has been launched with STS121 on July 4th 2006

DOSI operation started on Aug 17th 2006 ended July 27 2007

data taking will be resumed in Rome and at JSC-SRAG (ASI-NASA collaboration) as soon as porting of the sw is completed

CNSM operations started on Dec 17th 2006 (7 sessions completed)



ALTEA program: a multiple approach

- **ALTEA - MICE**

Studies the electrophysiological responses of mice under irradiation with very short ion bursts

- **ALTEA - HIT**

Investigates the electrophysiological responses of patients undergoing Heavy Ion Therapy for brain tumors, when they perceive anomalous phosphenes

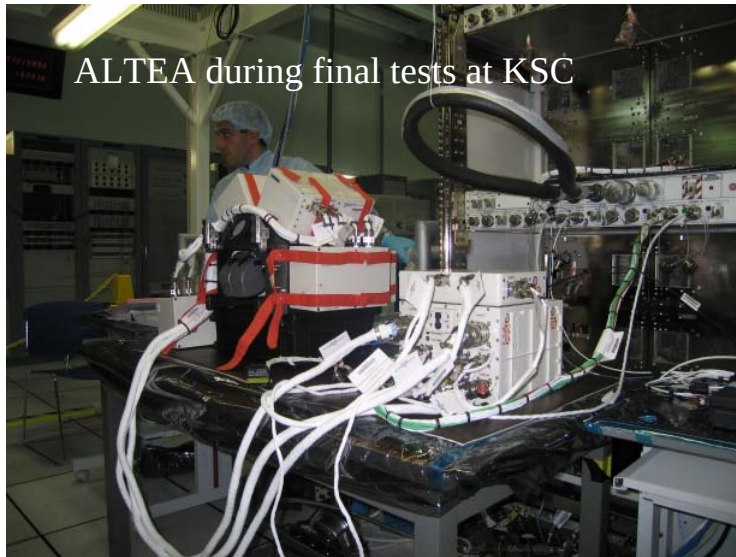
- **ALTEA - biophys**

Studies the possible interaction between ionizing radiation and CNS structures. First investigation is aimed at rhodopsin



ALTEA - space

ALTEA: photos of the hardware



ALTEA during final tests at KSC



ALTEA ready for CNSM in the ISS

ISS013E65565



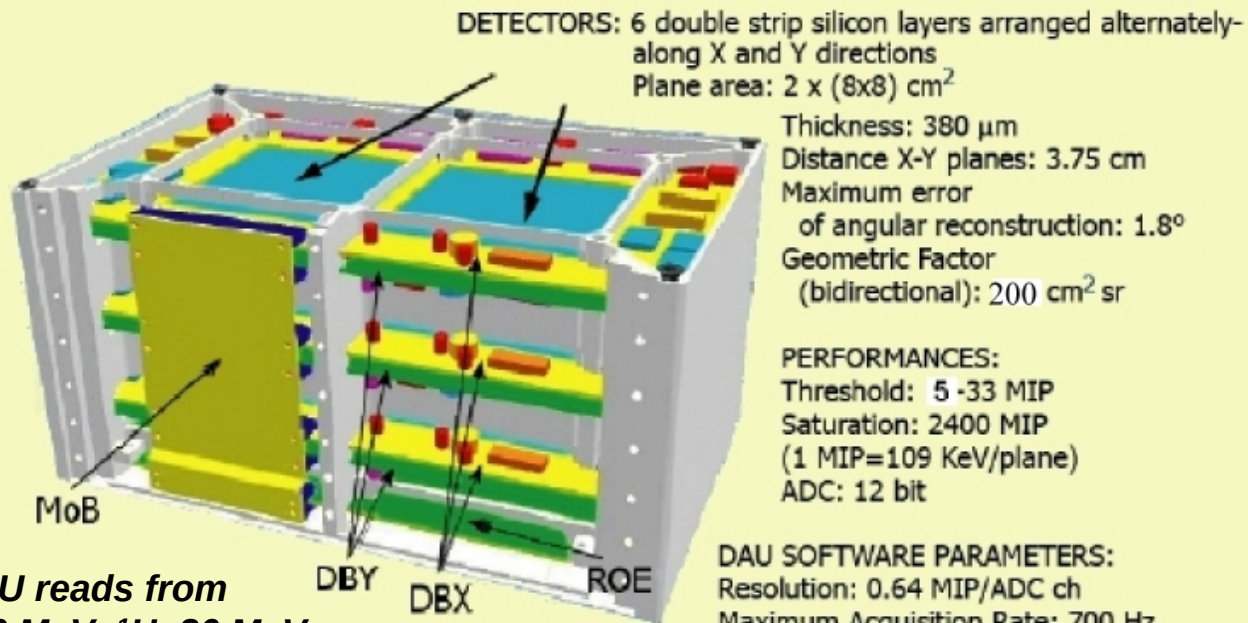
ALTEA during CNSM in the ISS

ISS014E16208



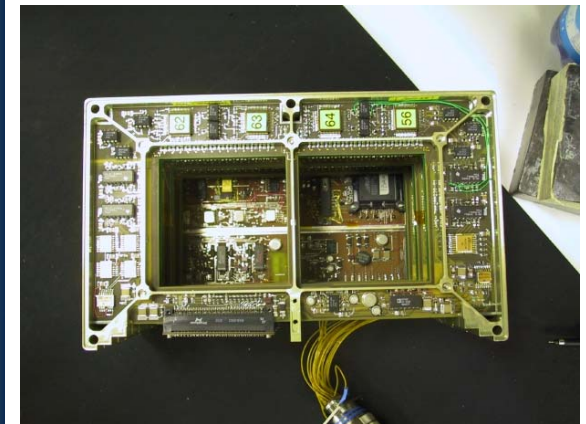
ALTEA - space

SDU: Silicon Detector Unit



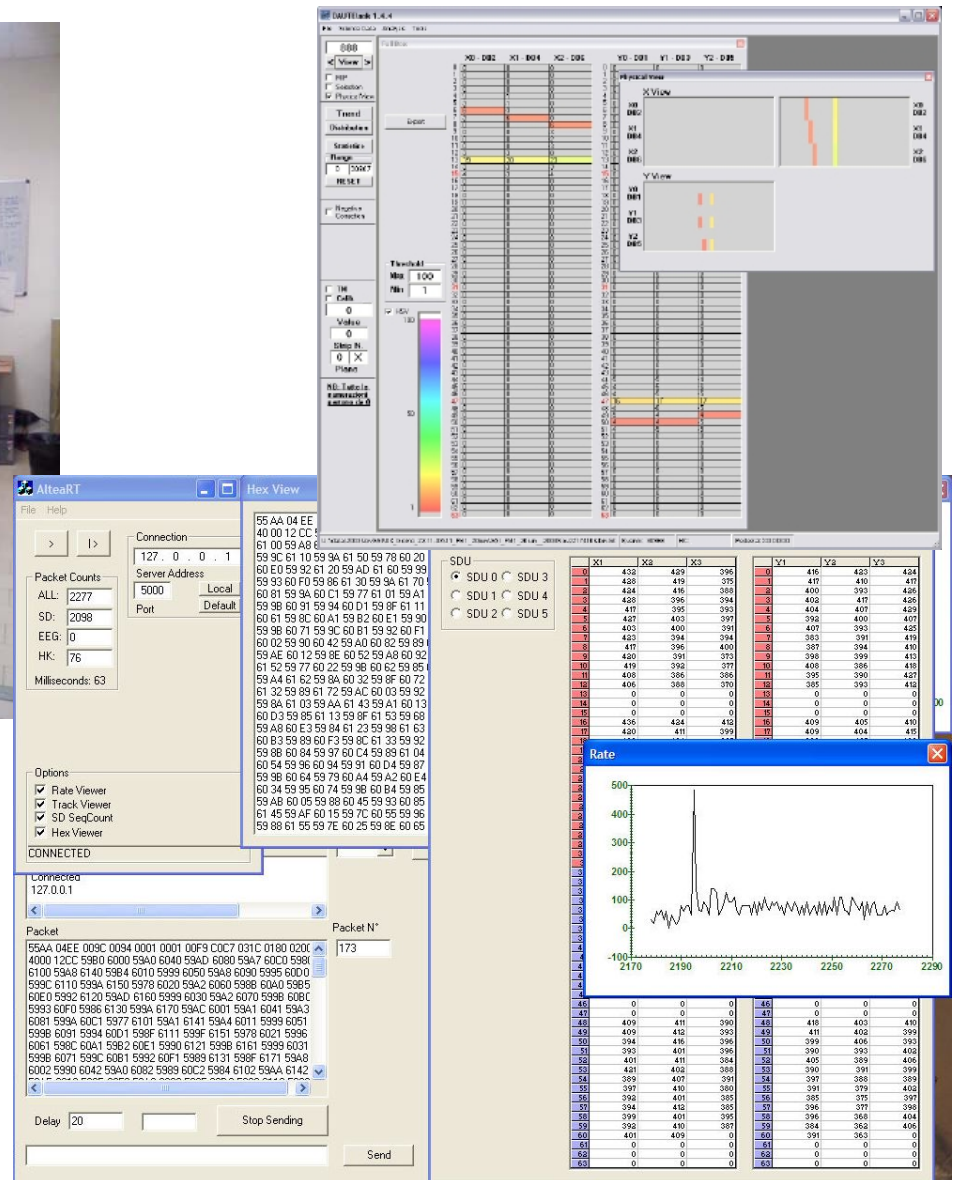
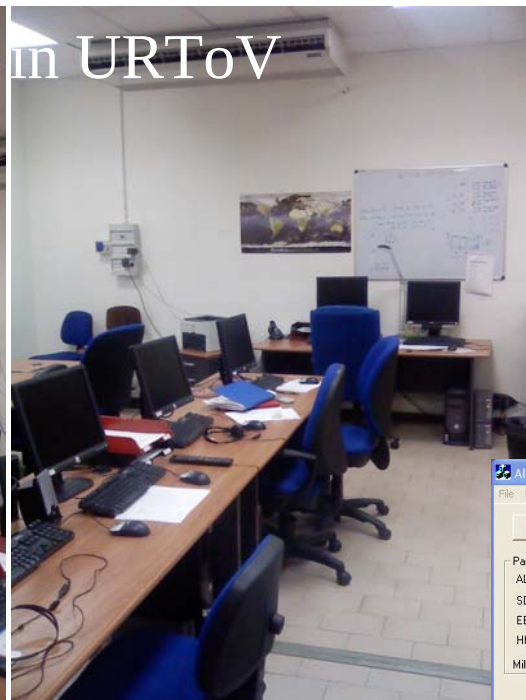
SDU reads from
 $200 \text{ MeV} < E < 30 \text{ MeV}$
 To $^{96}\text{Mo} > 1 \text{ GeV/n}$

Photos of TM model





ALTEA - space

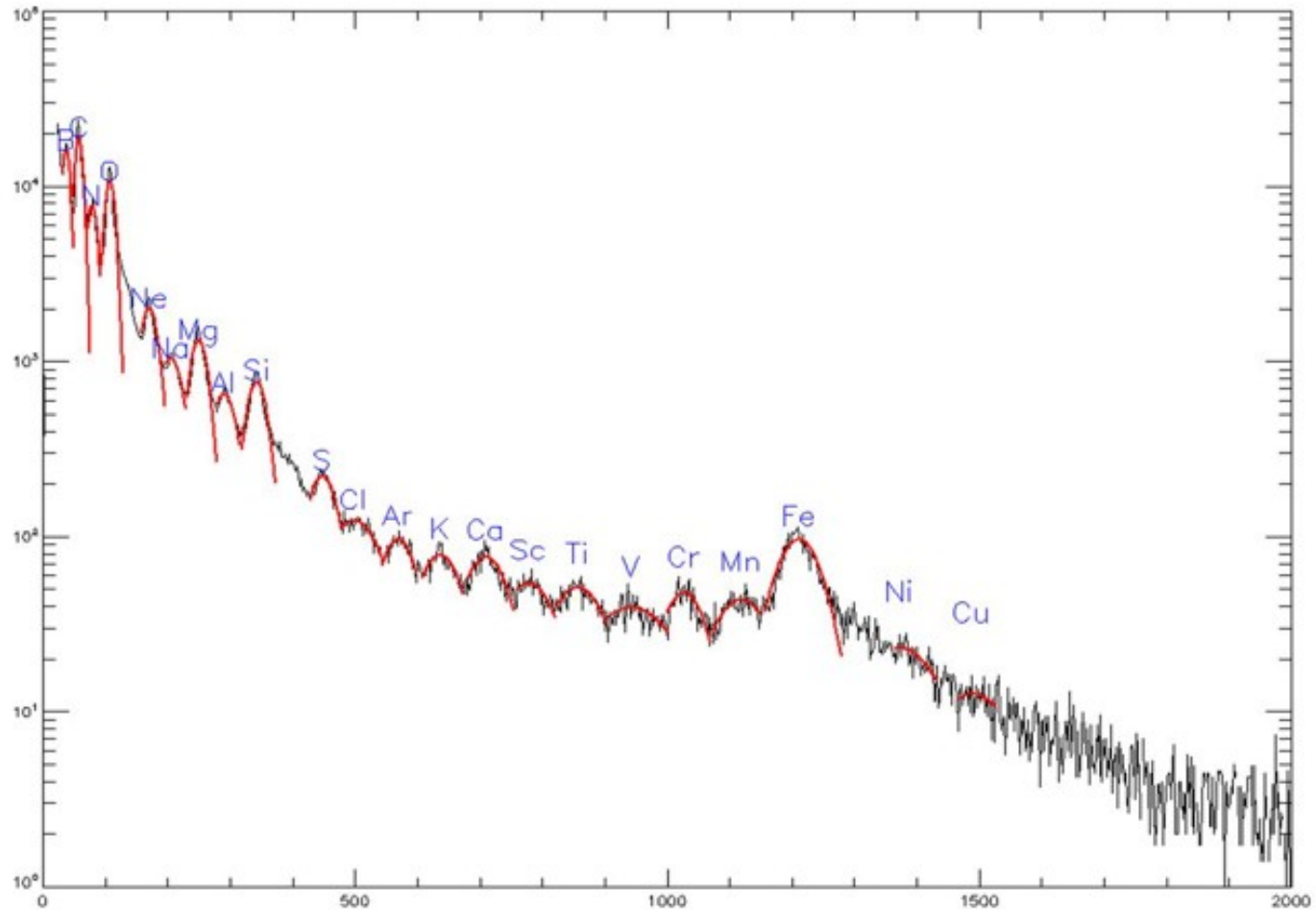


Examples of the many screens for the on line acquisition / analyses / monitoring



ALTEA - DOSI

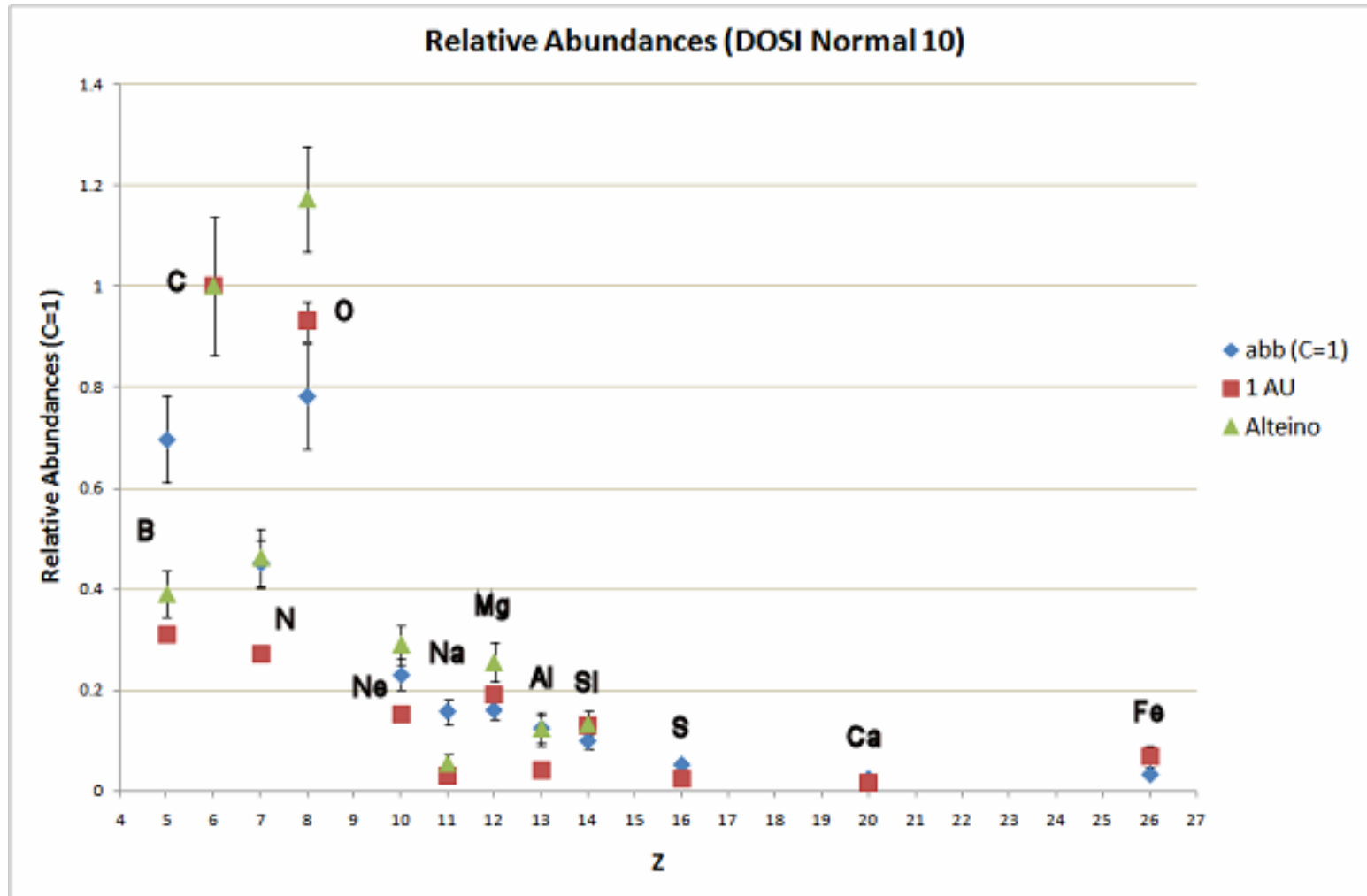
Spectrum of the relativistic ions (about 6 months)





ALTEA - DOSI

Relative abundances: Comparison with outer space and with Alteino (PIRS module)

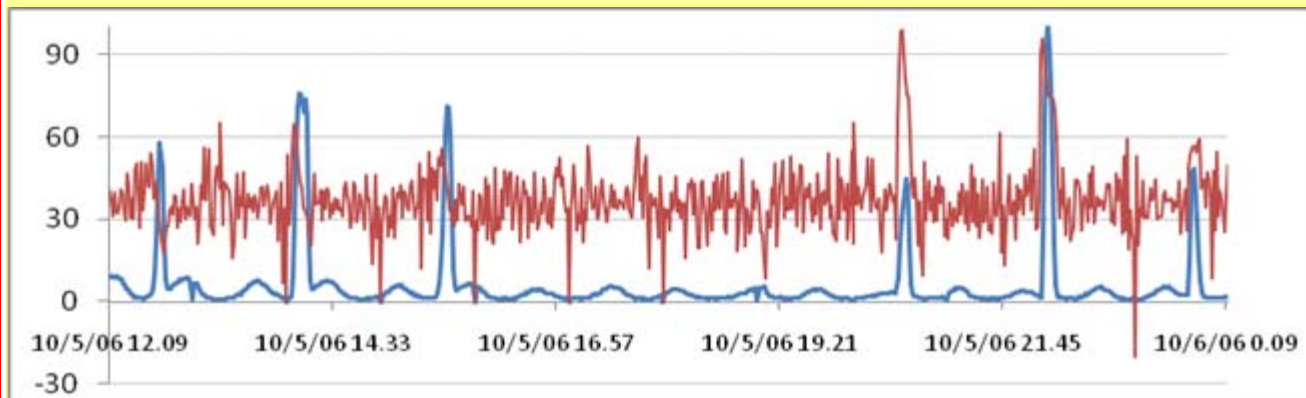
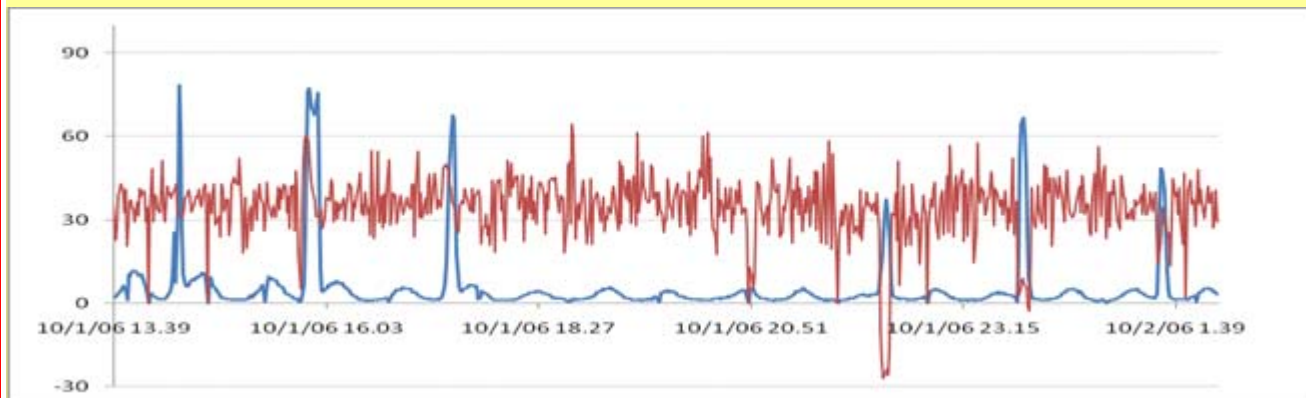




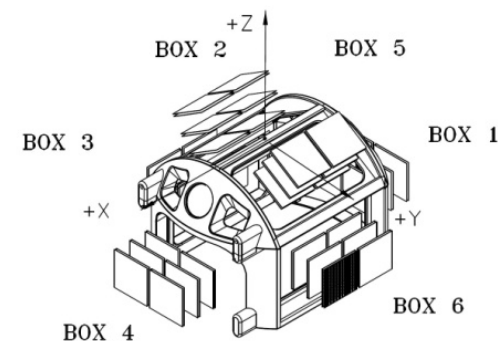
ALTEA - DOSI 3D capabilities

Off line work just started

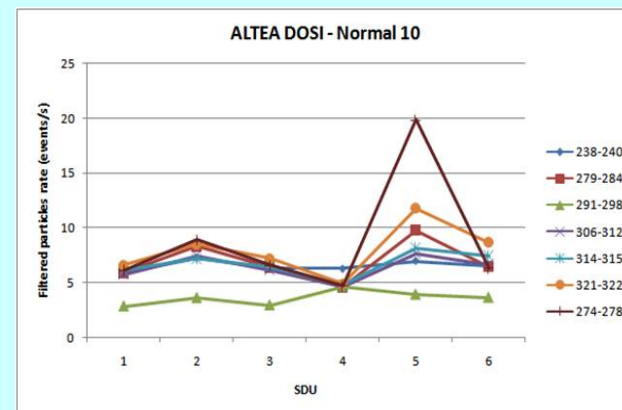
- counting differences



$$\text{relative counting difference} = ((\text{SDU1} + \text{SDU4}) - (\text{SDU3} + \text{SDU6})) * 100 / \text{TOT} + \text{offset}$$



- measuring single SDU rates



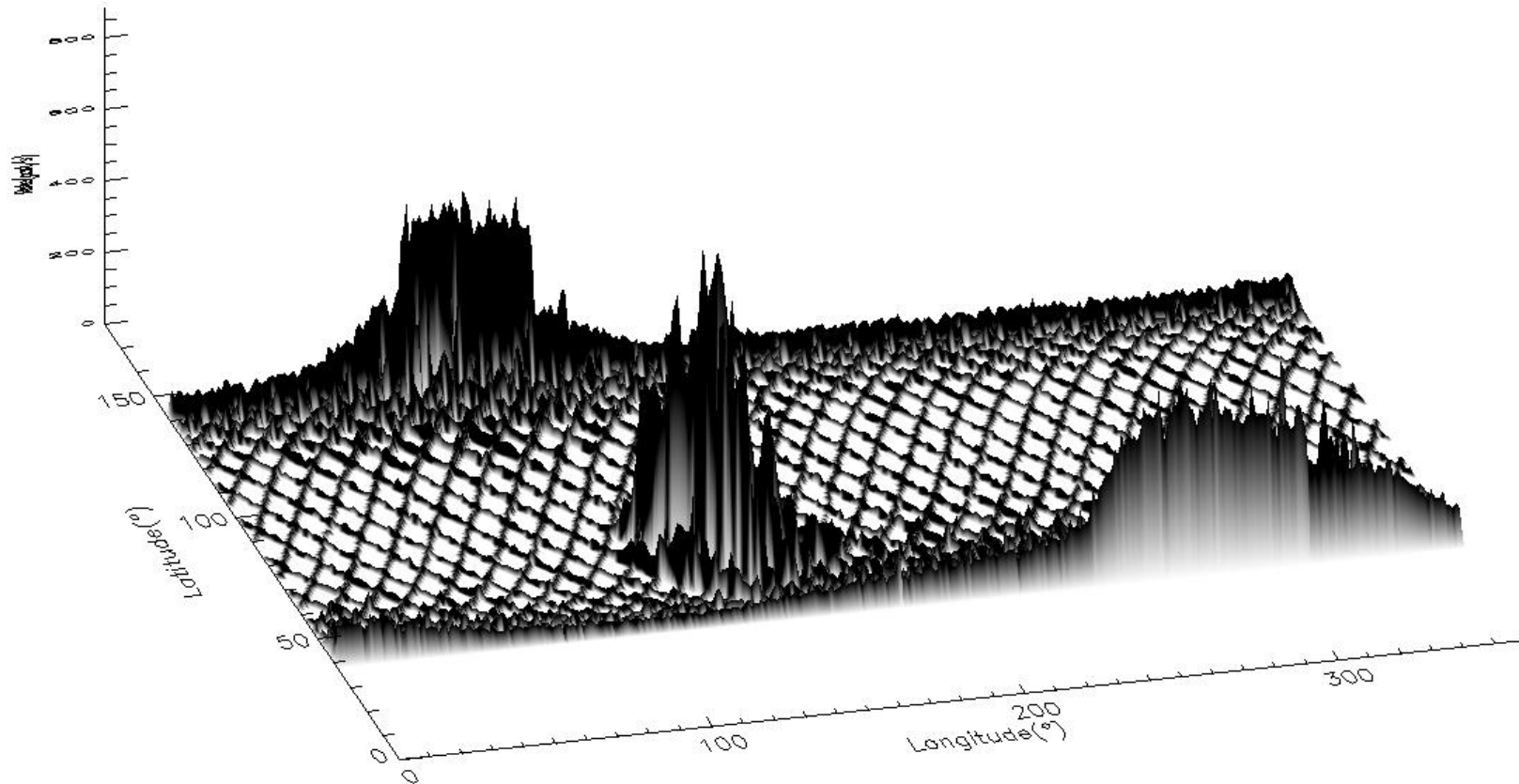


ALTEA - DOSI



Measurements of radiation flux during the Dec. 2006 solar flare

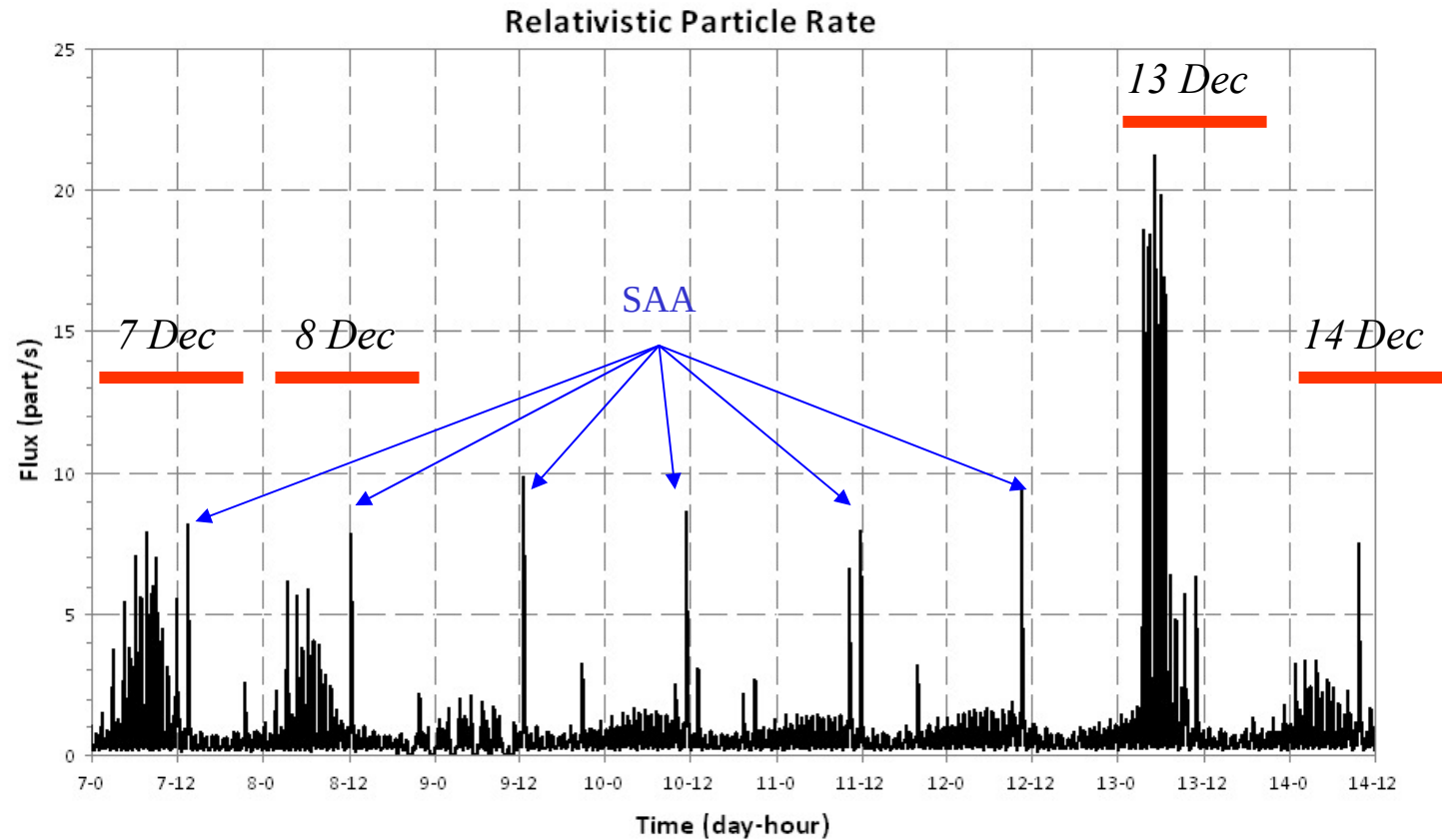
ALTEA DOSI 7–14 Dic 2006: Particle Countings





ALTEA - DOSI

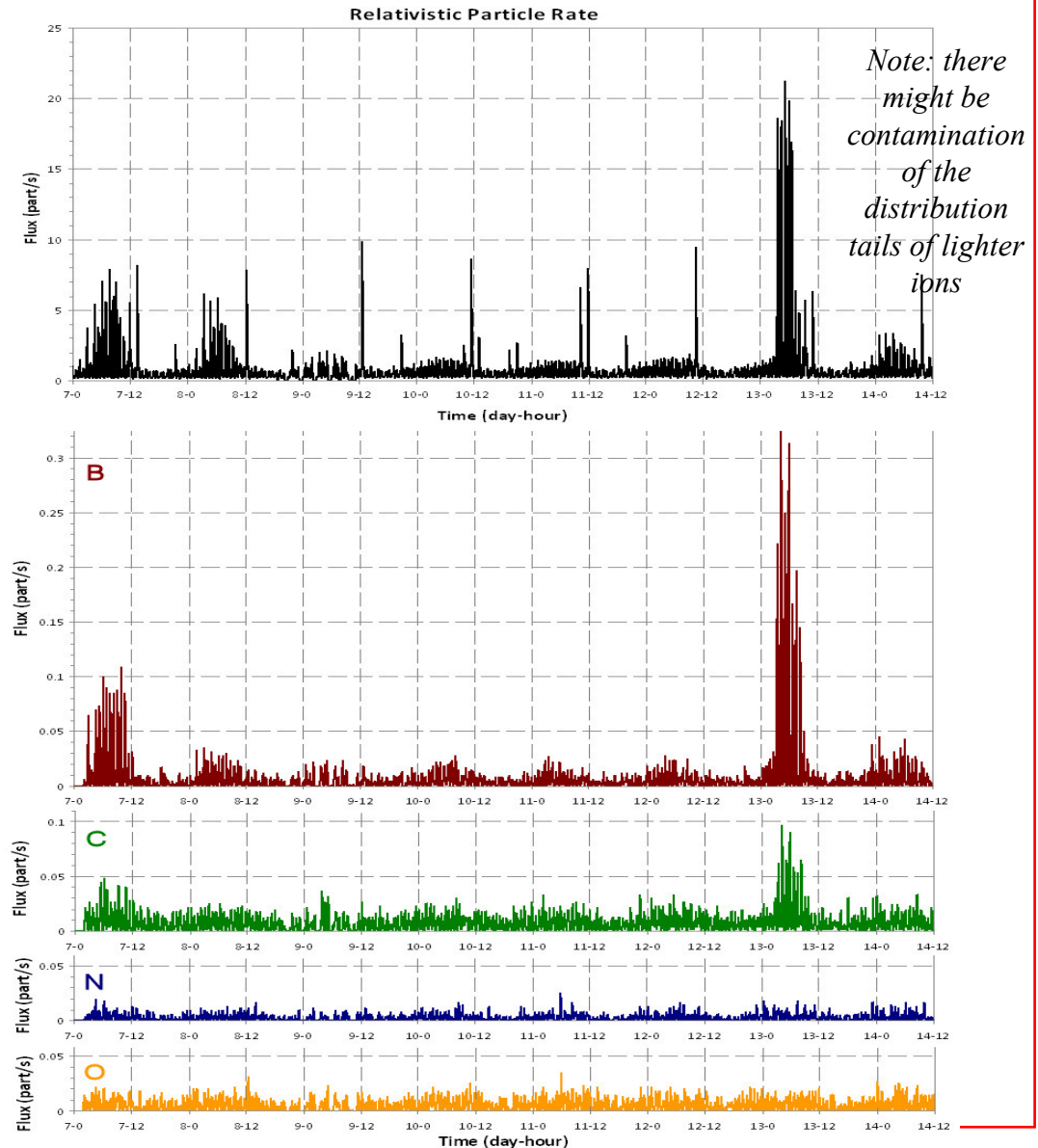
Measurements of radiation flux during the Dec. 2006 solar flare





ALTEA - DOSI

Measurements of
radiation flux during the
Dec. 2006 solar flare
for some relativistic ions
(B, C, N, O)

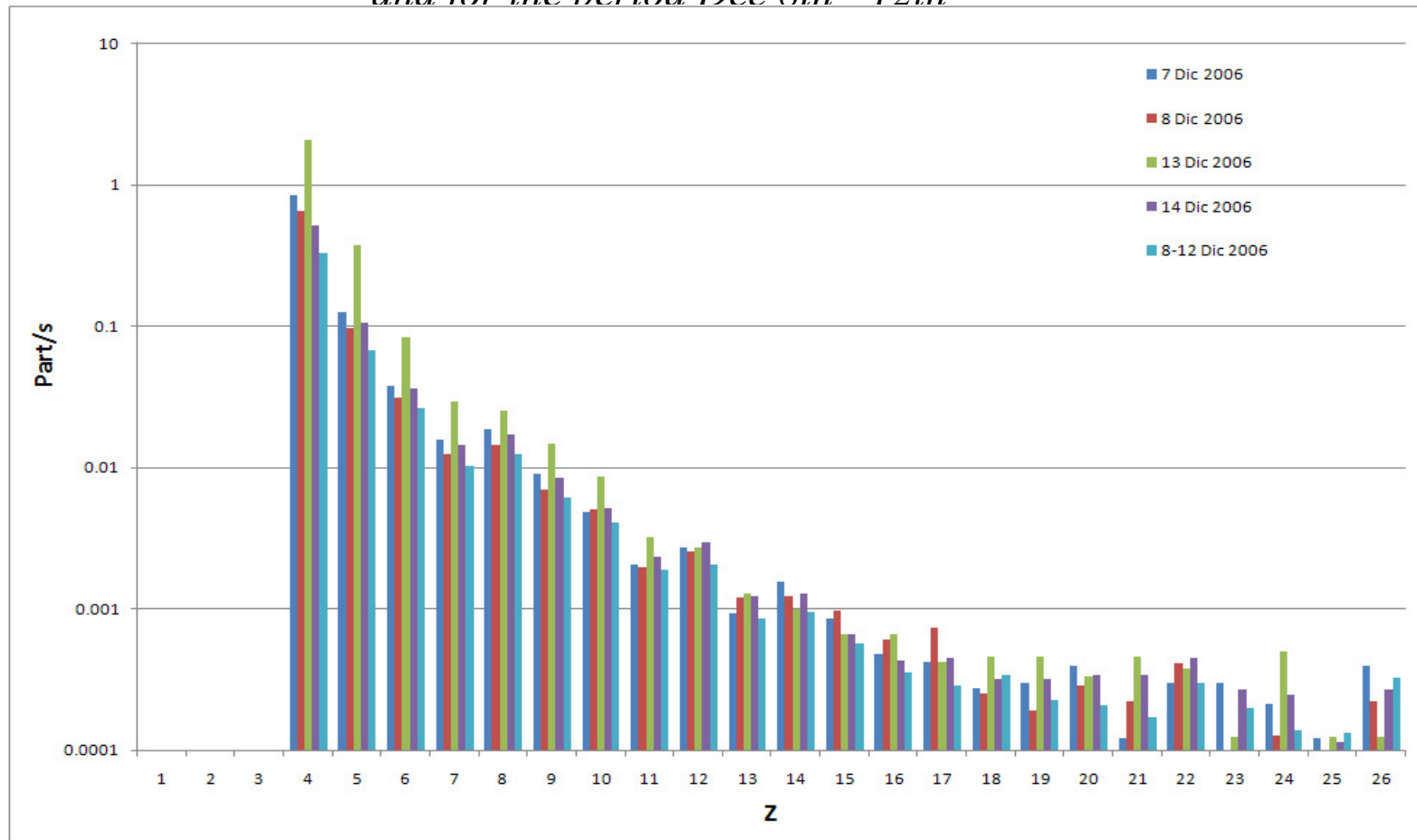




ALTEA - DOSI

Measurements of radiation flux during the Dec. 2006 solar flare

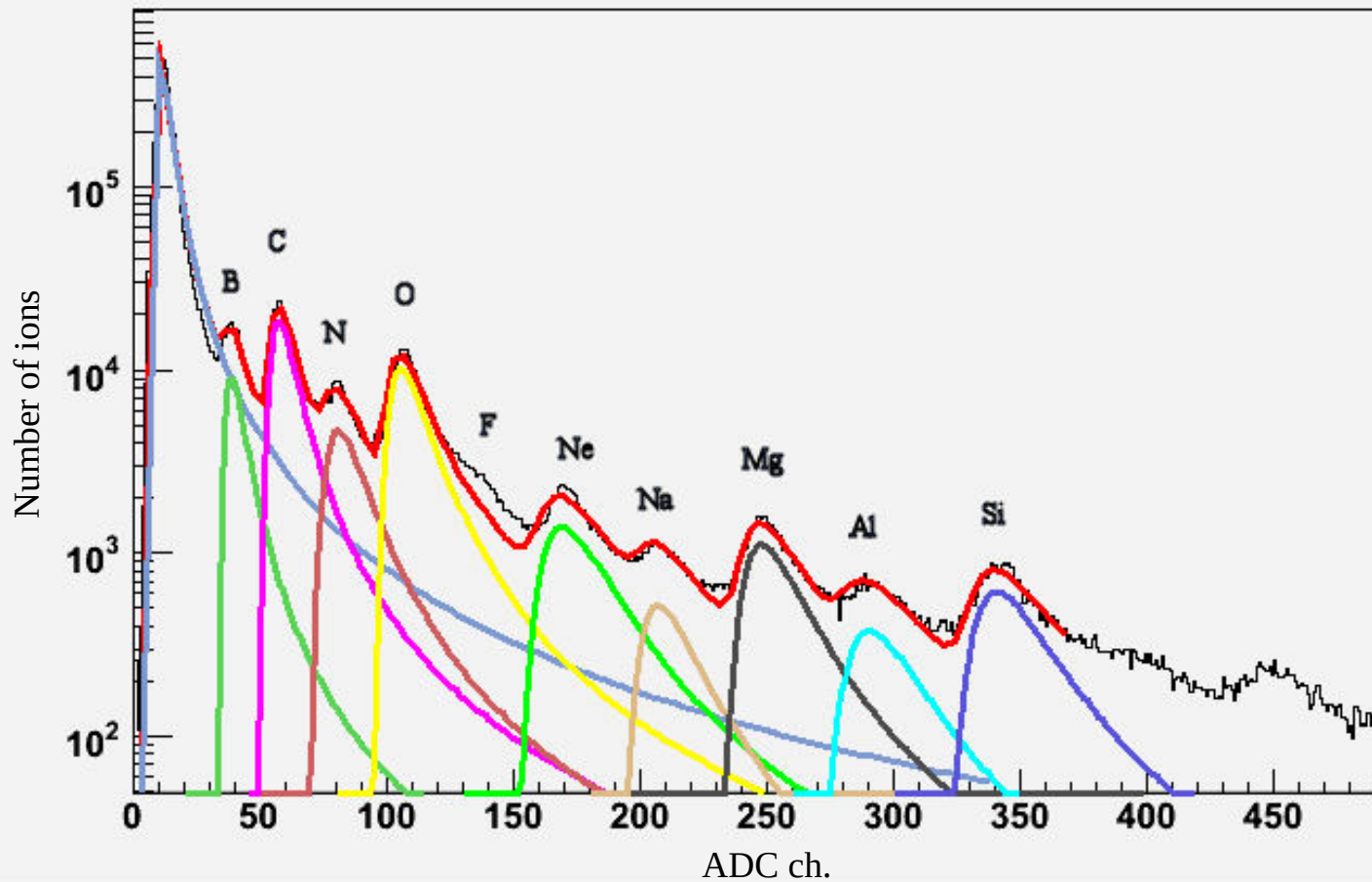
*Spectrum for $Z = 4 - 26$ for the 4 periods of intense solar activity (Dec 7th, 8th, 13th, 14th)
and for the period Dec 8th - 12th*





ALTEA - DOSI

Landau fitting of the data (*work in progress*)





ALTEA - CNSM

CNSM sessions performed

ASTRONAUT	DATE	Phosphenes perceived
Christer Fuglesang	2006: GMT351 (Dec. 17th)	12
Mike Lopes Alegra	2007: GMT066 (March 7th)	4
Sunita Williams	2007: GMT067 (March 8 th)	1
Mike Lopes Alegra	2007: GMT079 (March 20th)	0
Sunita Williams	2007:GMT080 (March 21th)	1
Mike Lopes Alegra	2007: GMT095 (April 5th)	1
Mike Lopes Alegra	2007: GMT108 (April 18th)	1



Sunita Williams during a CNSM session

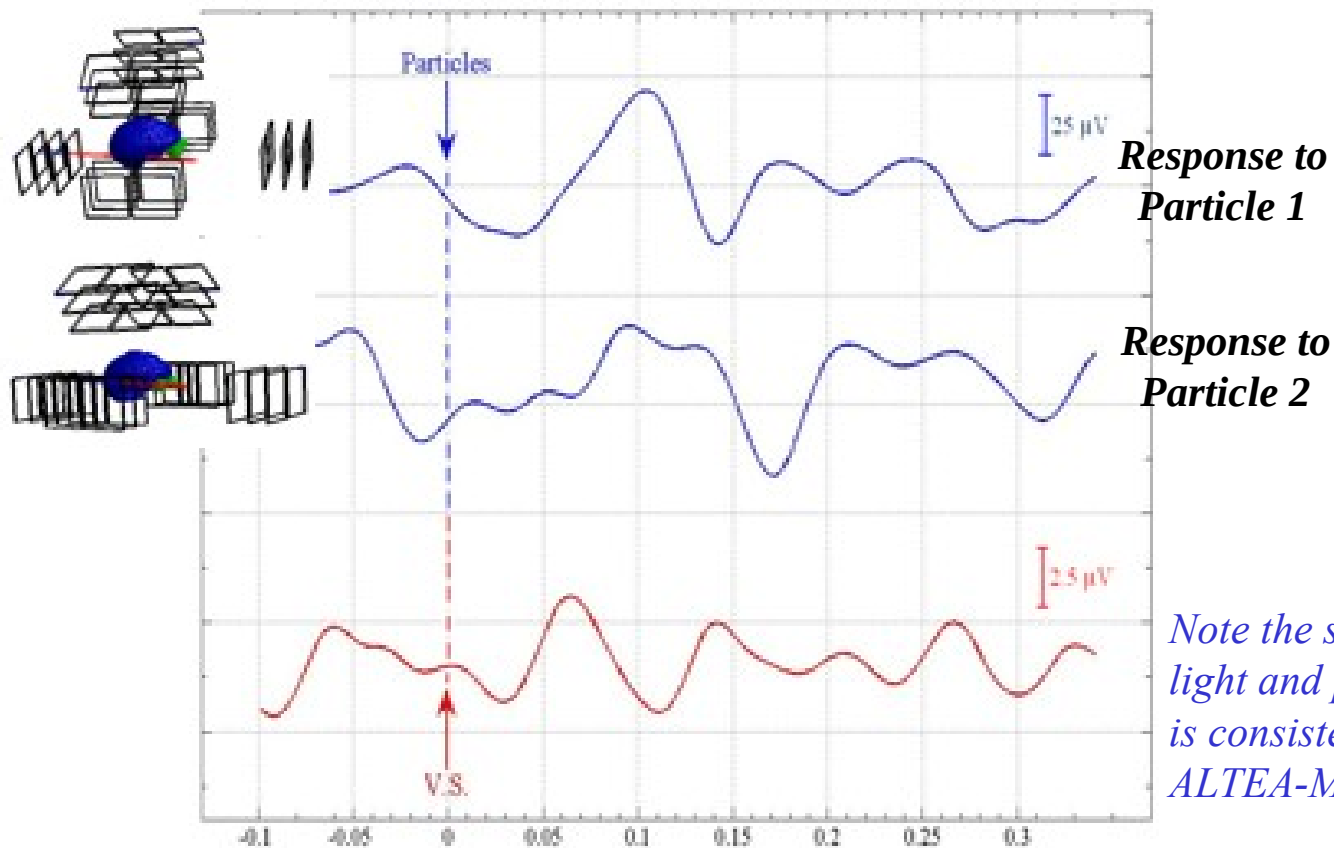


ALTEA - CNSM

QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.



ALTEA - CNSM



Subject 1		
	Pb latency(s)	Estimated Z
Particle 1	0.74	5 (B)
Particle 2	0.90	4 (Be)

Latency between the particle candidates and Push Button (PB)

Estimated Z of the impinging particles

Note the shift in latency between light and particle responses which is consistent with the one found in ALTEA-MICE

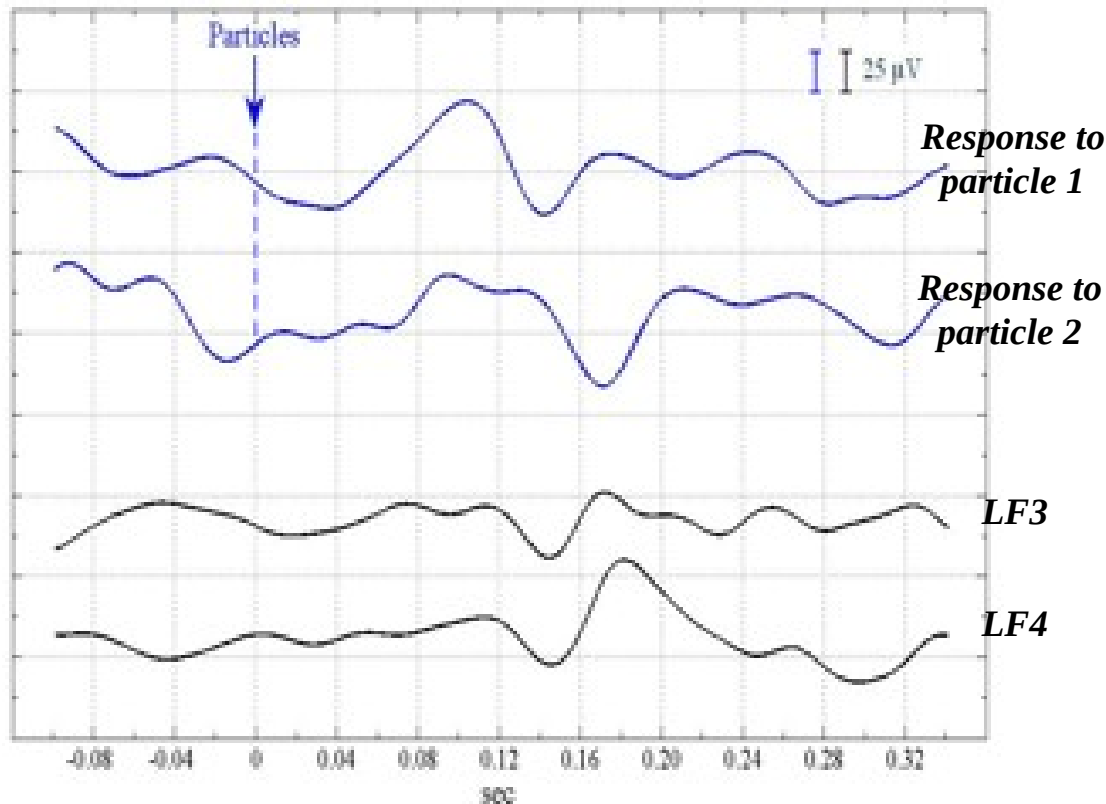
Responses from Retina (subj 1)

Bottom (red): averaged response from Visual flash Stimuli (VS) from a LED.

*Top (blue): two **candidate responses** from relativistic particles traveling through the right eye (see trajectory sketches, in red, on the top left)*



ALTEA - CNSM



Responses from Retina (subj 1)

Top (blue): candidates responses as on previous figure
Bottom (black): two possible responses (Light Flashes, LF) with a non-detected particle, aligned on the possible response peak.

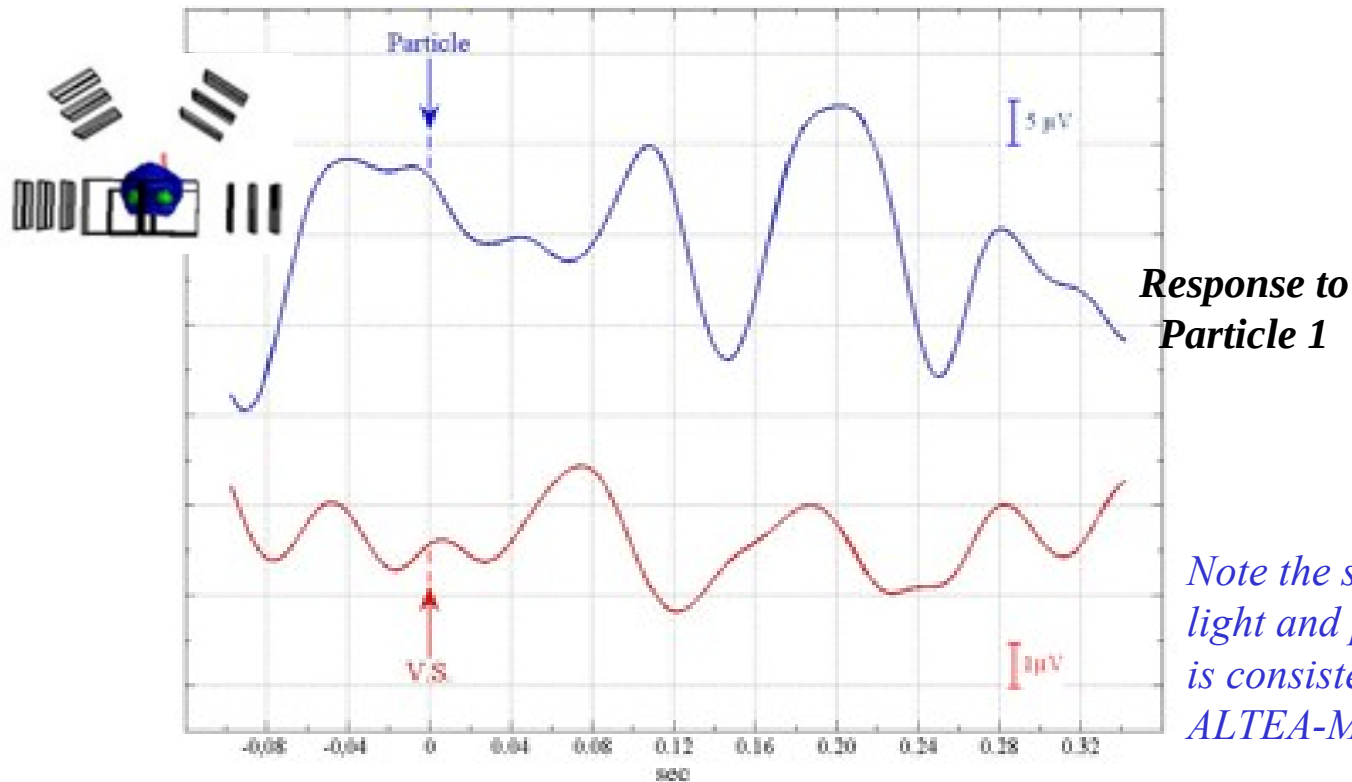
	Pb latency(s)
Particle 1	0.74
Particle 2	0.90
LF3	0.97
LF4	0.67

Latency between the estimated time of the non-detected particle ('0' point in the figure) and the Push Button (PB). Note the consistency of these data with the measured ones in the previous figure reported also in the first two shaded lines

NOTE: we do not expect to detect all particles causing phosphenes (Light Flashes) perceptions due to the still not complete coverage of the head of the ALTEA detector



ALTEA - CNSM



	Pb latency(s)	Estimated Z
Particle 1	0.65	4 (Be)

Latency between the particle candidate and Push Button (PB)

Estimated Z of the impinging particle

Note the shift in latency between light and particle responses which is consistent with the one found in ALTEA-MICE

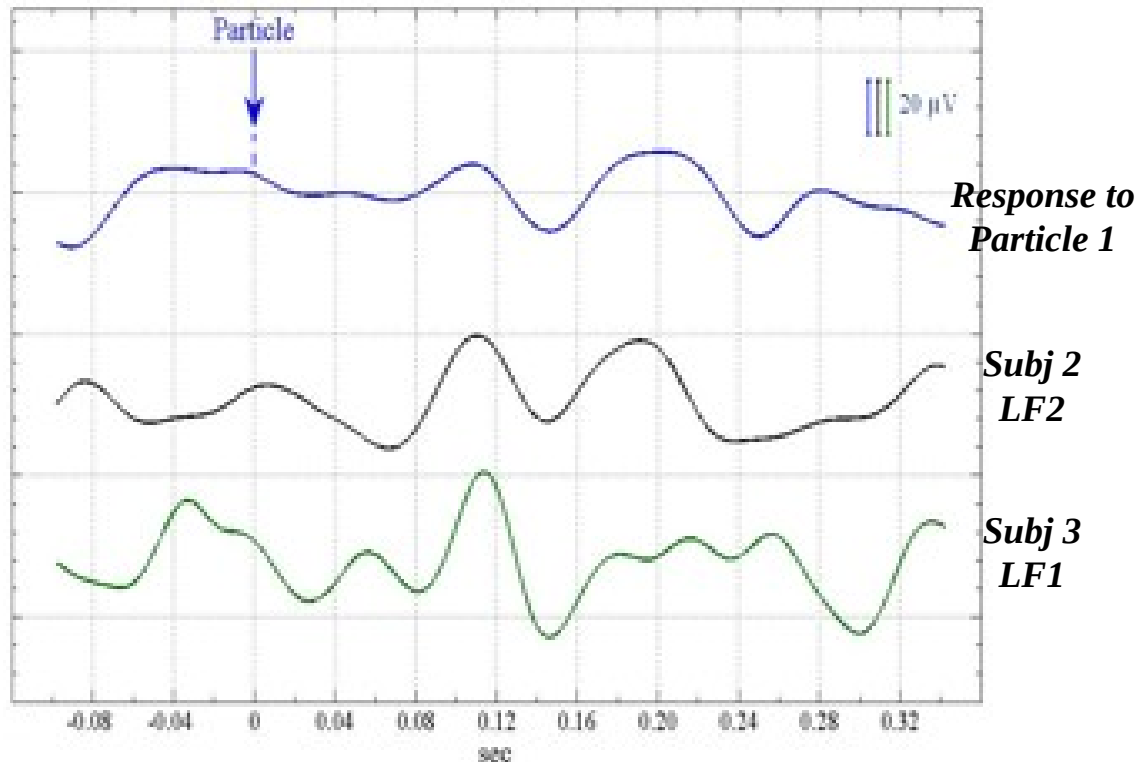
Responses from Retina (subj 2)

Bottom (red): averaged response from Visual flash Stimuli (VS) from a LED.

Top (blue): candidate response from a relativistic particle. The particle hits the astronaut's low posterior head, but depending on head's inclination it could pass through the eye (see trajectory sketches, in red, on the top left)



ALTEA - CNSM



Responses from Retina (subj 2 & 3)

Top (blue): candidate response as on previous figure

Center (black): a possible response with a non-detected particle, aligned on the possible response peak.

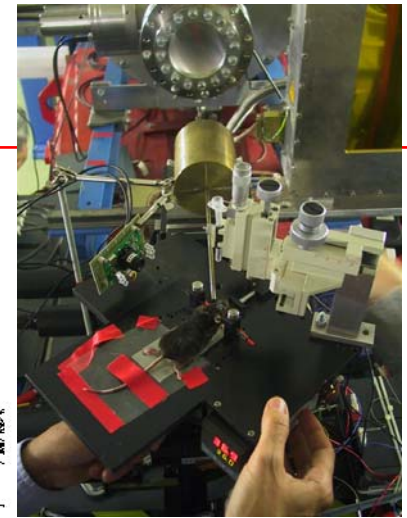
Bottom (green): another possible response with a non-detected particle, aligned on the possible response peak, for subj 3

Subject 2	
Pb latency(s)	
Particle 1	0.65
LF2	0.87
Subject 3	
LF1	1.06

Latency between the estimated time of the non-detected particle ('0' point in the figure) and the Push Button (PB). Note the consistency of these data with the measured one in the previous figure reported also in the shaded line

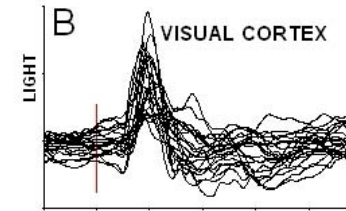
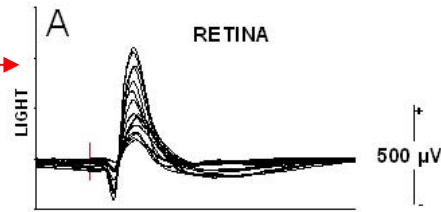


ALTEA-MICE (ground)

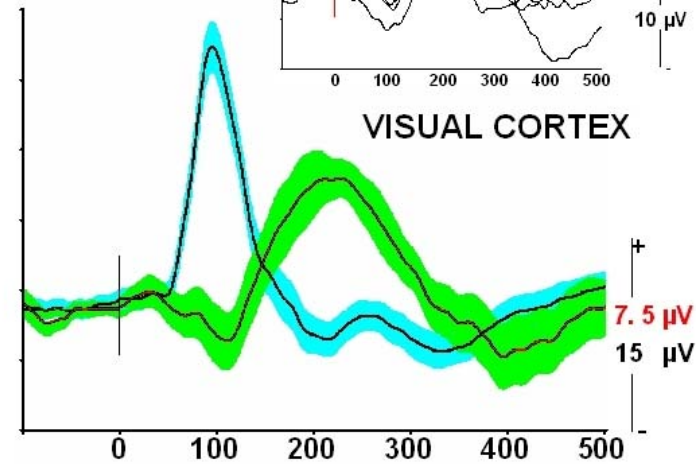
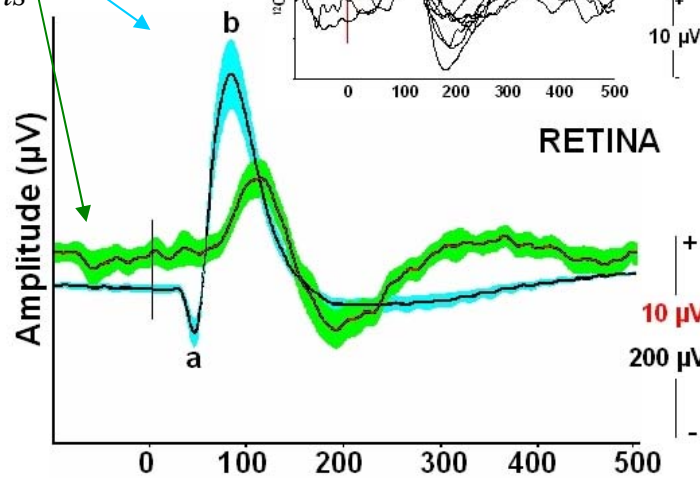
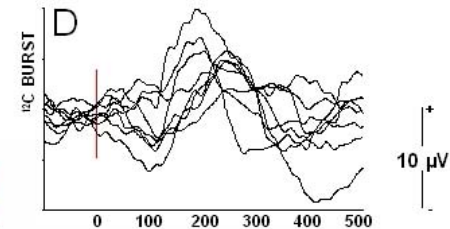
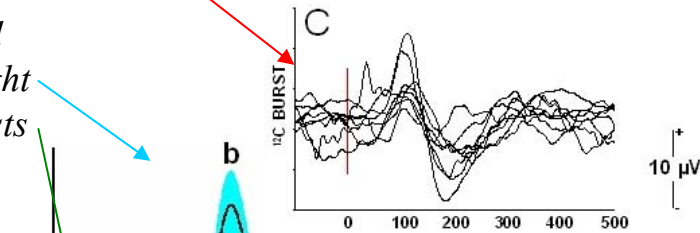


Responses following ^{12}C bursts over the retina

Individual mice responses



Averages + sd
From light
From ^{12}C bursts



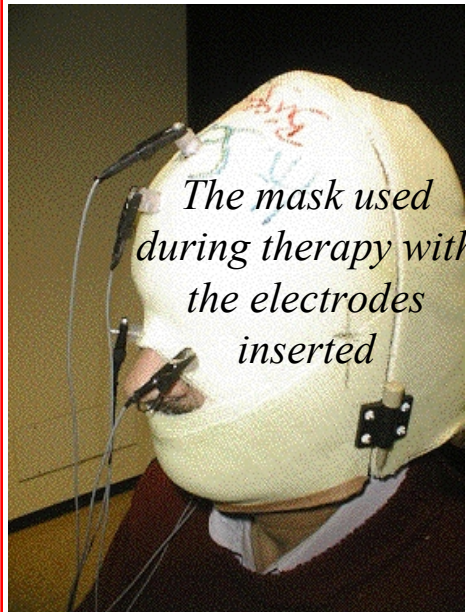
Time from light or ^{12}C burst (ms)

Electrophysiological responses of the mouse retina to ^{12}C ions
Sannita et al. Neuroscience Lett. (2007).



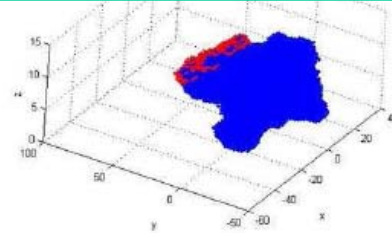
ALTEA-HIT (ground)

- During Heavy Ion Therapy at GSI (FRG) many patients reported perceiving phosphenes.
- We measured electrophysiological responses from these patients.



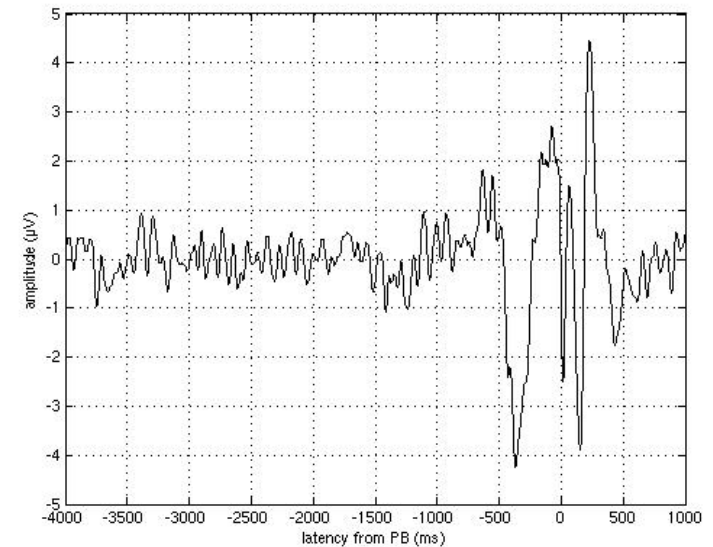
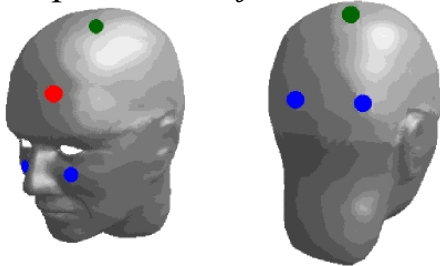
The mask used during therapy with the electrodes inserted

Always the same region (in red) is irradiated when the phosphene is perceived (PB pressed)

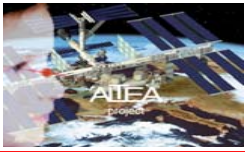


A patient undergoing therapy during ALTEA-HIT acquisition

The positions of the electrodes



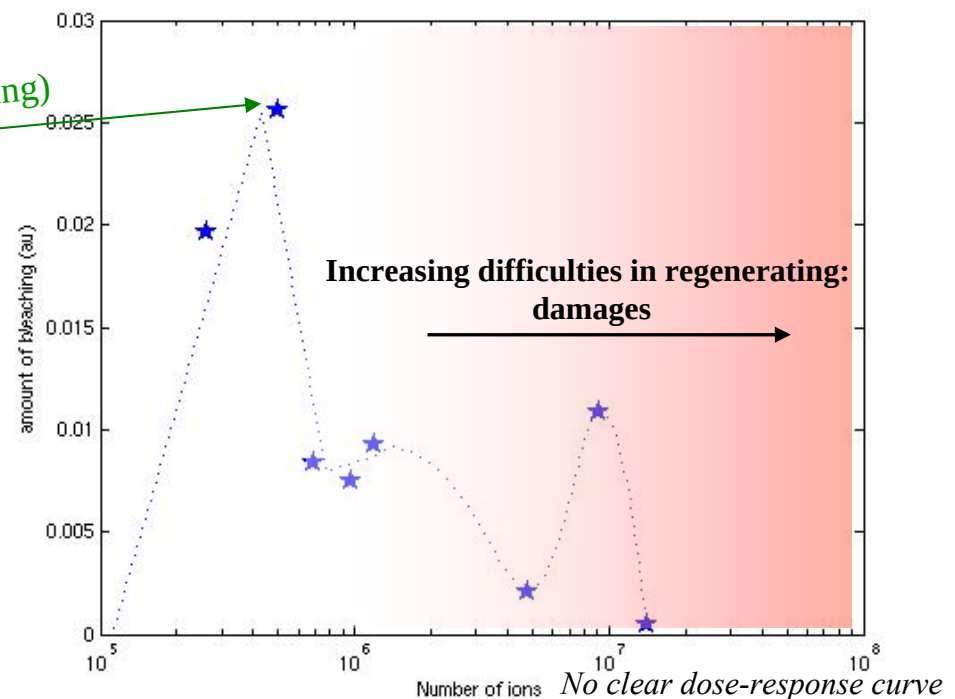
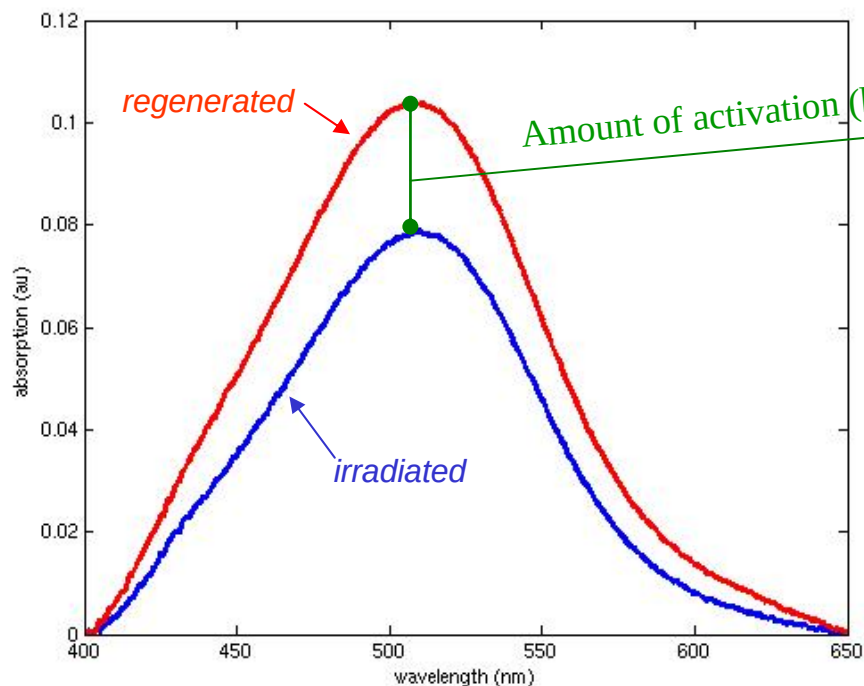
A possible candidate response: an averaged electrophysiological signal about 400 ms before the PB



ALTEA - biophys (ground)

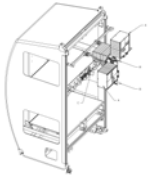
- Experiments aimed at studying the interaction mechanism(s) between radiation and CNS
- First experiment aimed at rhodopsin (at the start of the photo-electronic cascade in the visual pathway): activation (bleaching) of rhodopsin with different doses

Radiation activates rhodopsin



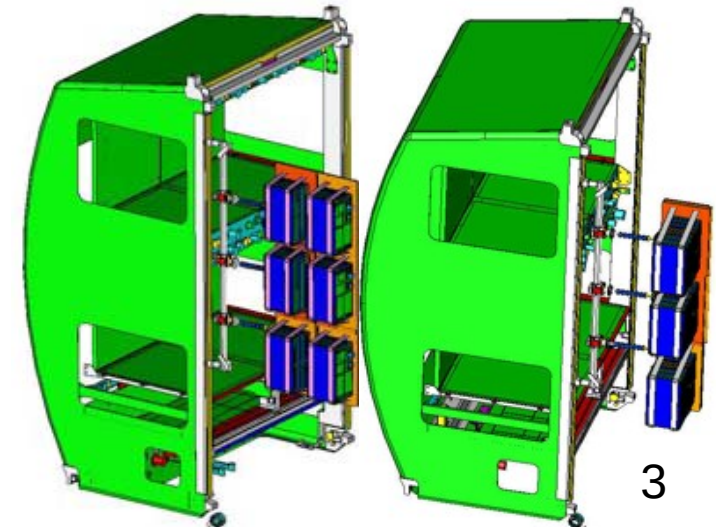
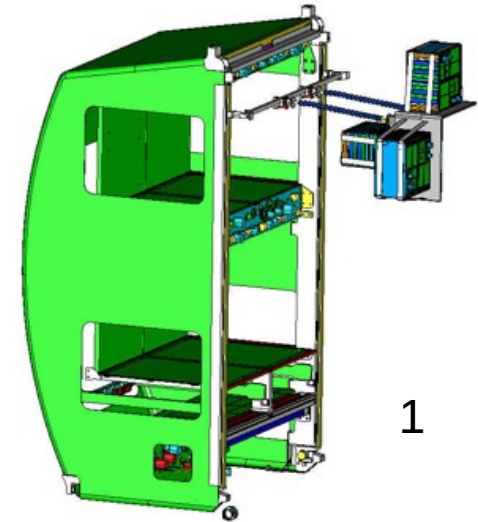


ALTEA - shield



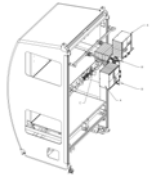
ALTEA - shield uses the ALTEA hardware with different holders and harness, it may be divided in 4 steps

1. Survey: survey the radiation environment within the habitable volume of the ISS
 - identification of hot and cold spots for CNS functional risks
 - validation of computer models that will provide description of the radiation flux, transport through the spacecrafts materials, shielding efficiency, interactions and dose deposited in the human brain.
2. Ground base tests of shielding materials (irradiation measurements & mice EEG measurements)
3. Shield: ISS-based tests of above shielding
4. CNSM with shielding

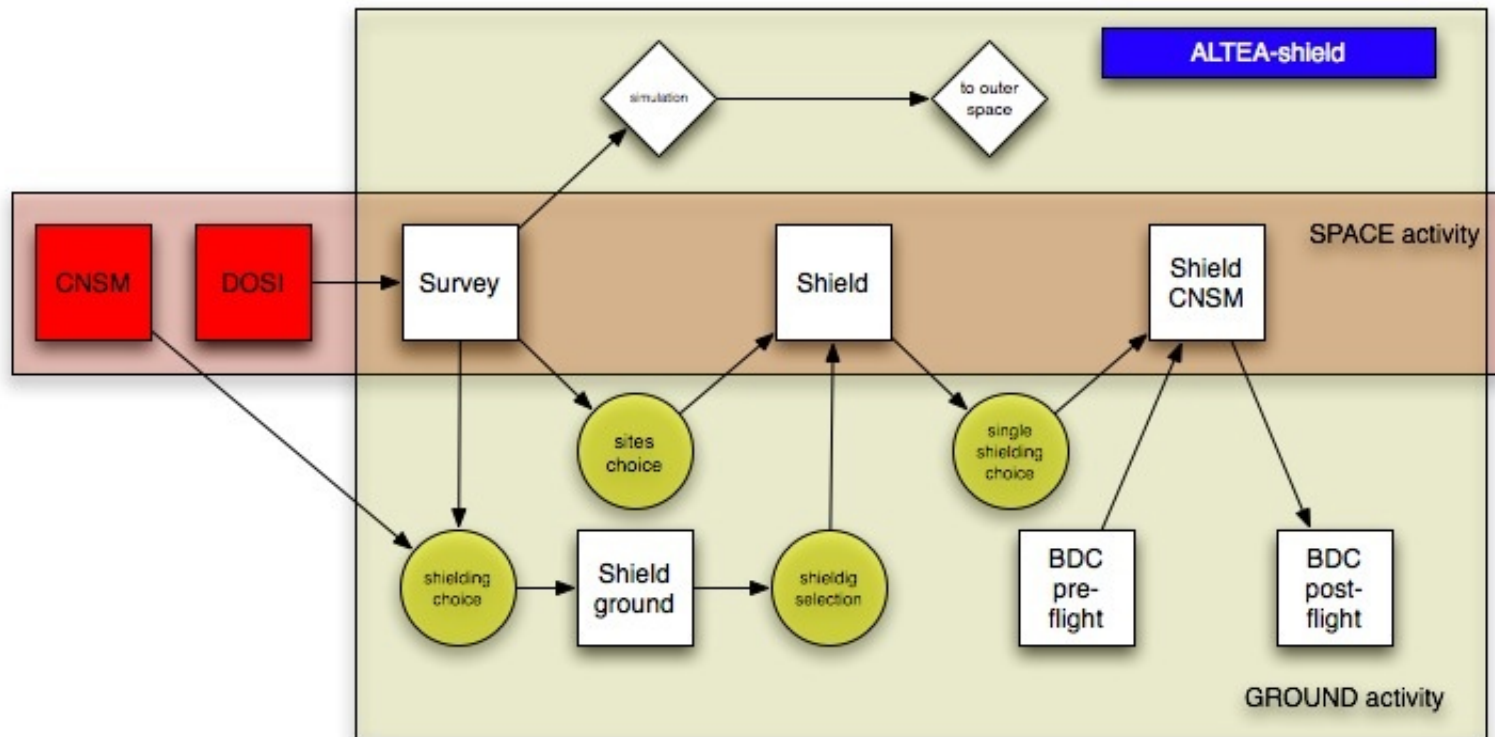


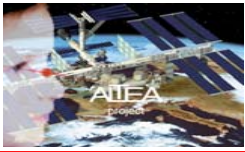


ALTEA - shield



ACTIVITIES flux diagram (no time scaled)





ALTEA data- status and perspective in space

We have ≈ 1 year of DOSI data + 7 CNSM easily accessible

Late 2007 / Early 2008:

DOSI ops up again

Late 2008:

shield starts (survey)

shield

shield-CNSM

ALTEA reflight

ALTEA2



The ALTEA international collaboration

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

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)

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



+ others joining in

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.

Ciccotelli A.

Cotronei V.

Cucinotta F.

De Martino A.

DePascale M.P.

Di Fino L.

Ferrari A.

Fuglesang C.

Furano G.

Galper A.

George, T.

Gianelli G.

Khodarovich A.

Korotkov M.G.

Iwase H.

Lee, K.

Licoccia S.

Lo Schiavo V.

Maccarone R.

Marchetti M.

Mastrangeli F.

Mazzenga G.

Miller J.

Morino V.

Morselli A.

Narici L.

Negri B.

Notaro G.

Ottolenghi A.

Paci M.

Peachey N.S.

Petrov V.P.

Picozza P.

Popov A.

Procaccini M.

Realì E.

Ricci M.

Rinaldi A.

Romagnoli P.

Russo M.

Ruggieri D.

Salnitski V.P.

Sannita W.G.

Sato T.

Schardt D.

Semones E.

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.

Zapp, N.



Thank you for your attention