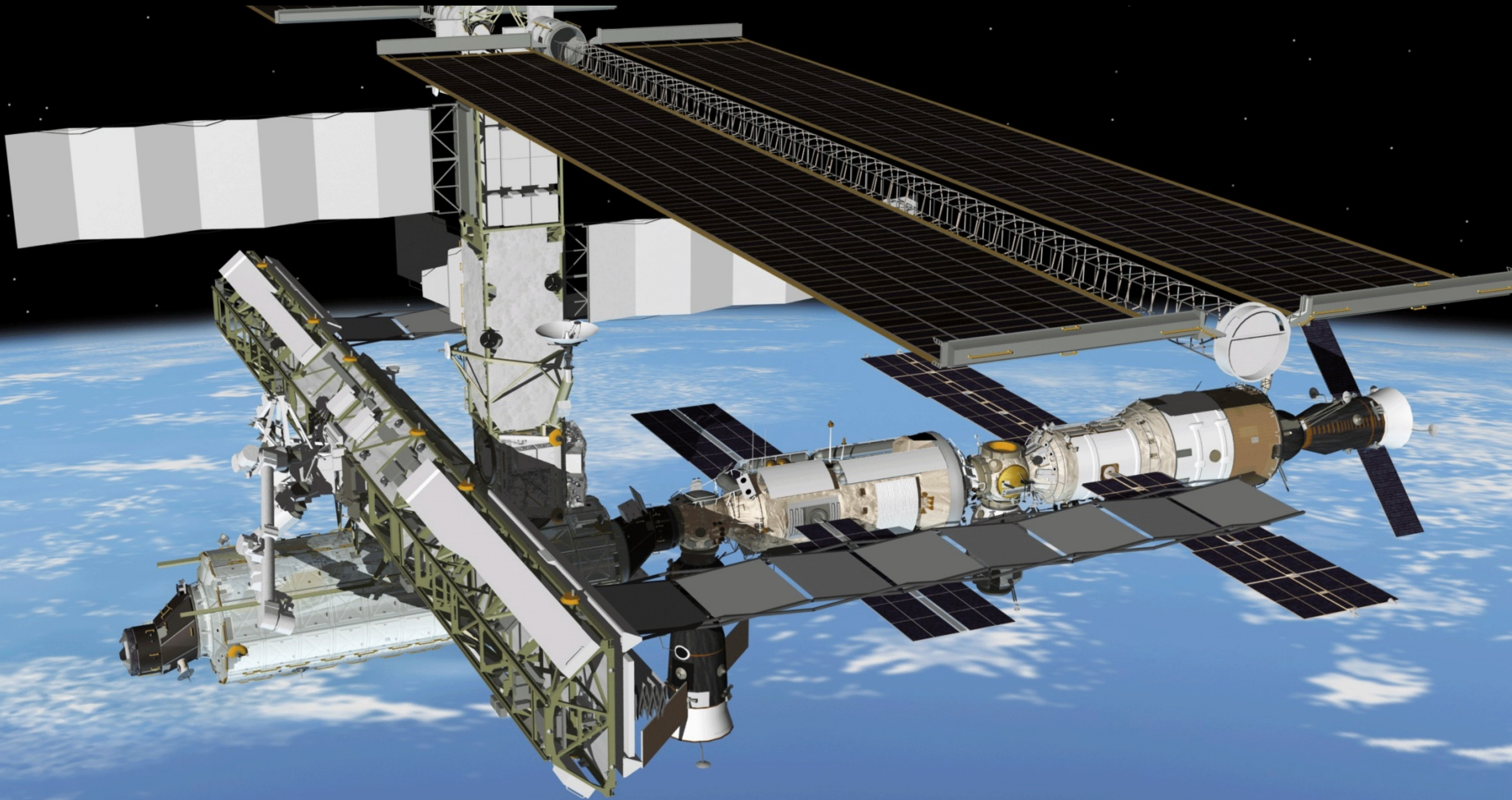
ALTEA measurements in 2006-7 and during the December 2006 SPE. Results of the latest analysis



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INFN Istituto Nazionale di Fisica Nucleare

13th WRMISS - Krakow, 8-10 September 2008

Summary

- Overview of the ALTEA-*Space* experiment
  - Energy Loss Spectrum (2006-2007 data)

- Solar Flares Introduction
- December 2006 SPE recorded by ALTEA-*Space*
  - Particle Rate
  - Energy Loss Spectrum
  - Landau fit and results
  - Fluxes comparison

- Conclusions

ALTEA-*Space* experiment

ALTEA-*Space* is the main on-space experiment of the ALTEA project, aimed at studying the cosmic radiation and its effects on astronauts during space missions, with a focus on the

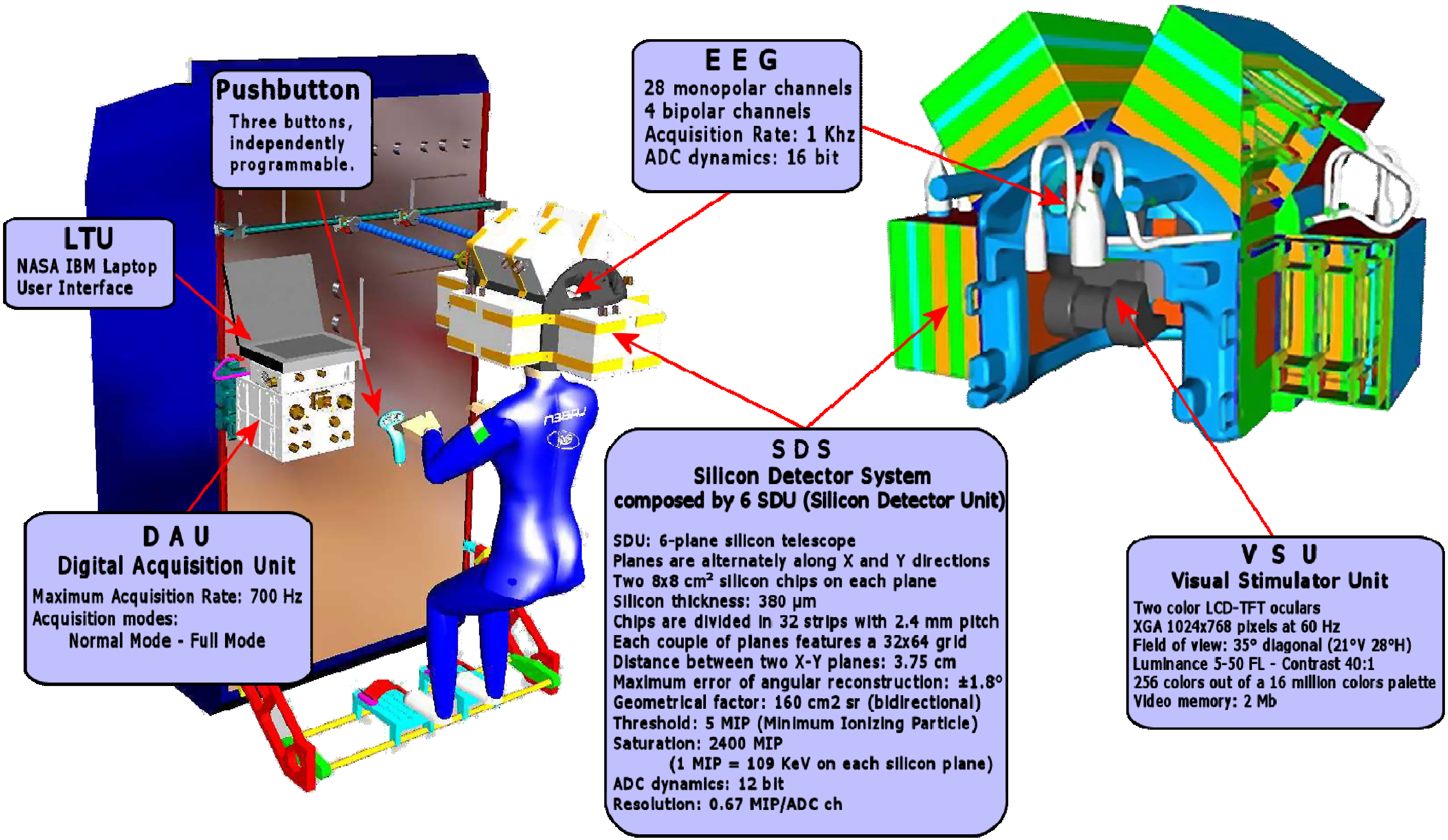
Light Flash phenomenon

- Composed by six silicon telescope particle detectors arranged on a 3D (helmet-shaped) structure

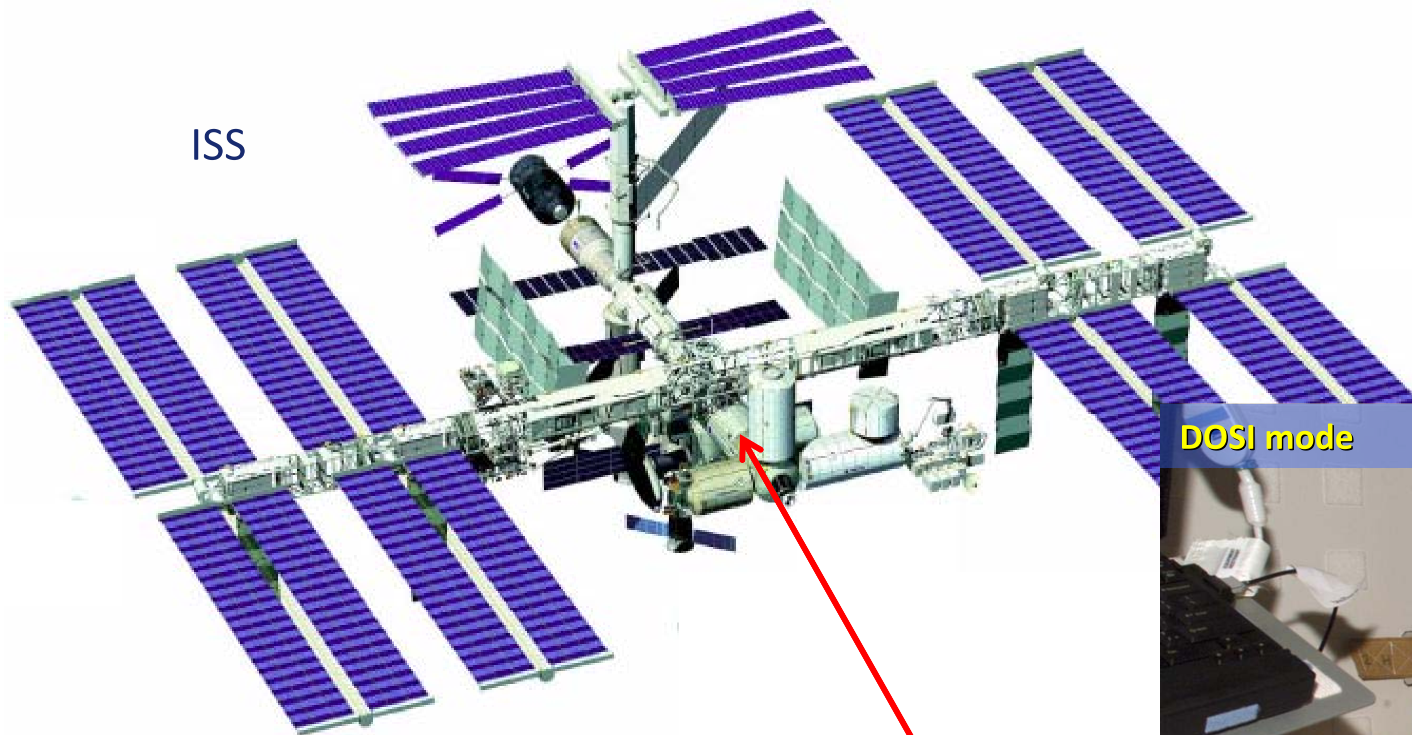
- Characterized by two main operative configurations:
  *C*entral *N*ervous *S*ystem *M*onitoring and *DOSI*metry

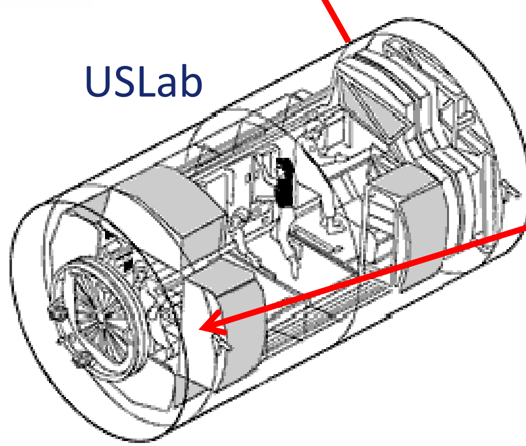
  - *CNSM* sessions: in collaboration with astronauts for the Light Flashes perception
  - *DOSI* mode: measurements of the radiation field composition inside the ISS

ALTEA-*Space* architecture



ALTEA-*Space* facility on board ISS

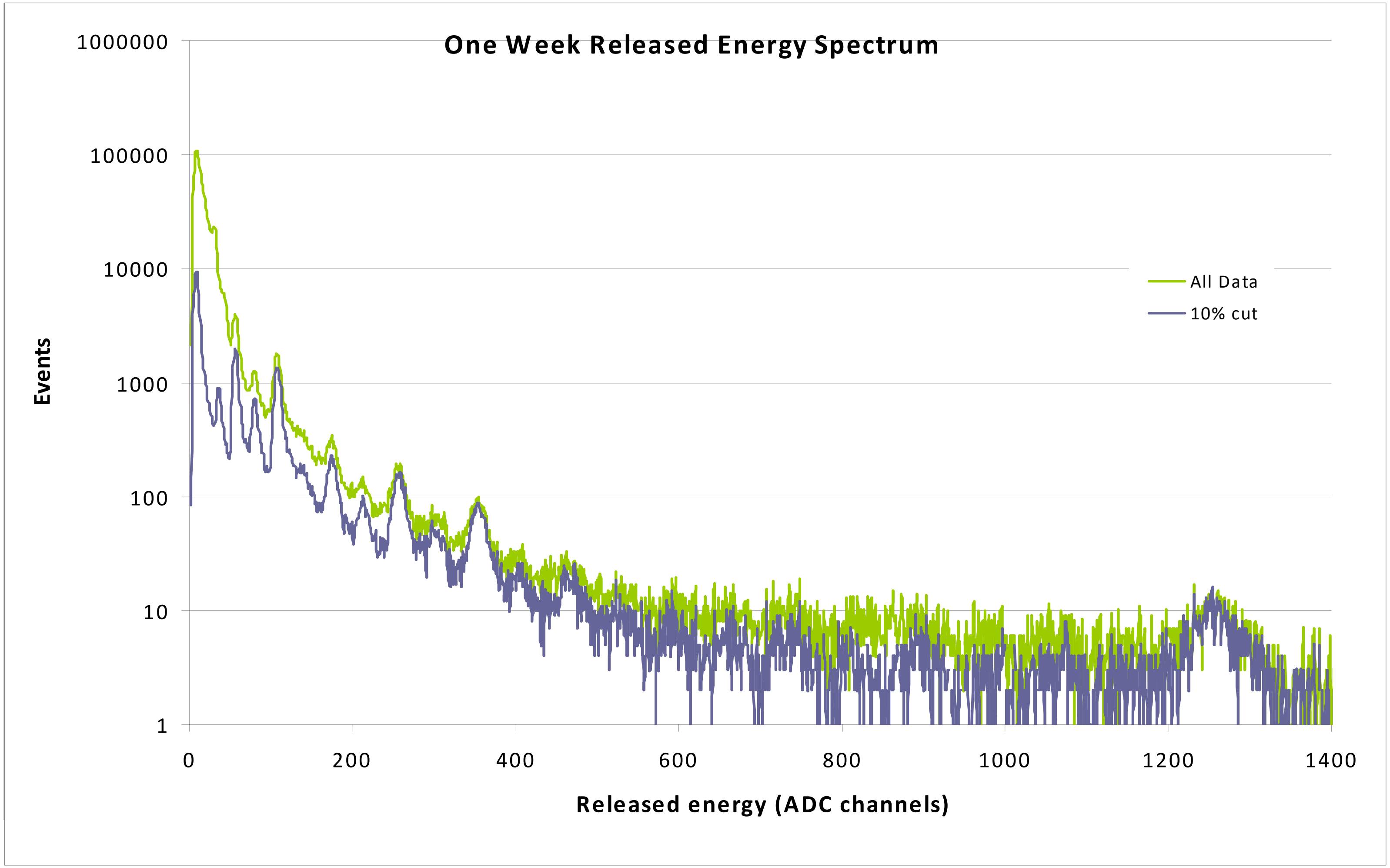




- Onboard ISS since July 2006
- Operative between August 2006 and July 2007
  ~ 180 000 000 events
- ALTEA will be reactivated on February 2009

Energy Loss Spectrum

- Unfiltered Energy Spectrum
- **After Data Processing**



• more than 3M events

Data Analysis

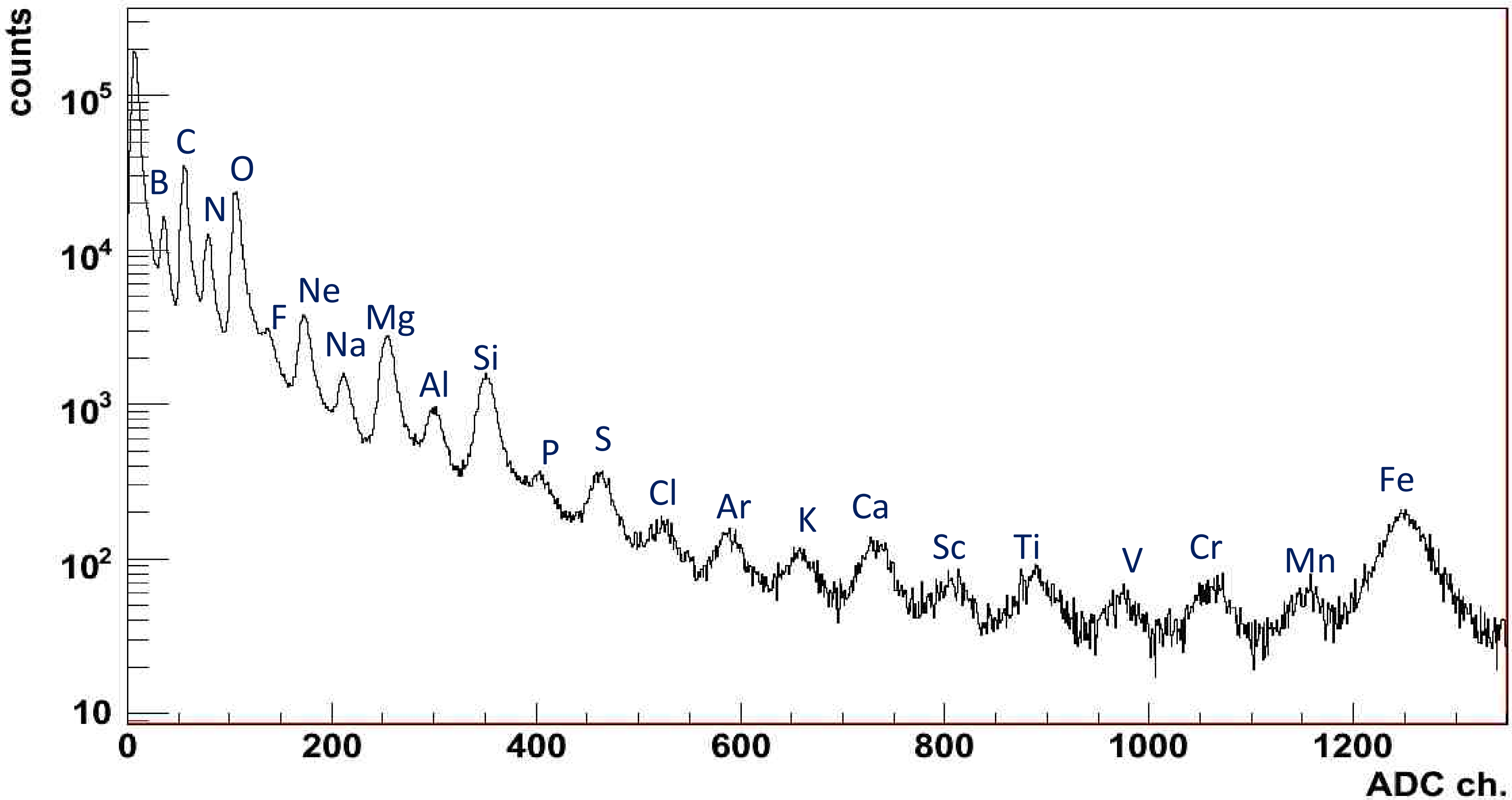
- data analysis procedure:
  - dynamical pedestal subtraction
  - maximum energy loss per plane
  - alignment check and angular correction
  - fast event selection rule :

$$[(\Delta E_0+\Delta E_1) - (\Delta E_4+\Delta E_5)] \,/\, \max[(\Delta E_0+\Delta E_1), (\Delta E_4+\Delta E_5)] \leq R$$

where ΔE_n is the energy loss value in the plane n

$R = 0.1$

2006-7 Energy Loss Spectrum
Fast Particles



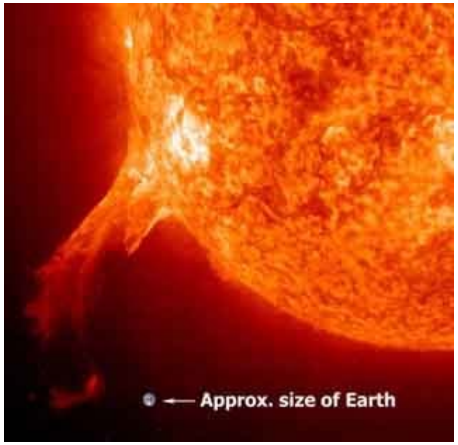
- mean energy, 6 SDUs, about 300 days of data acquisition
- filtered spectrum
- more than 4M of particle events

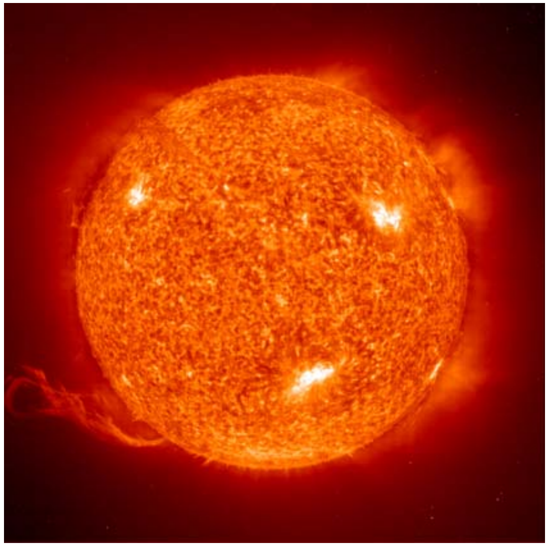
December 2006 Flare

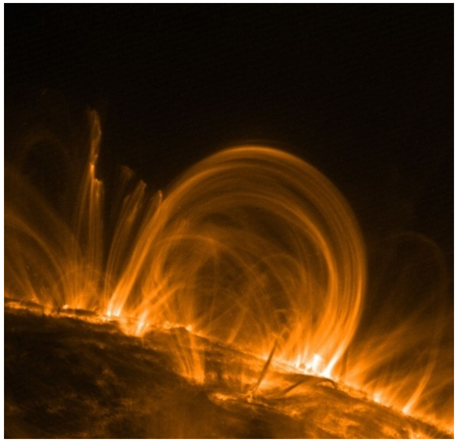
- A Solar flare occurred in the period between 5 and 16 December 2006.
- ALTEA was active inside the USLab until 14 December and recorded the SPE dynamics.
  - Observation time during the flare: 631560 s
  - Detected ions : 2031954

Solar Flares

They appear as sudden and intense brightenings in the solar atmosphere caused by violent explosions in the chromosphere, lasting from minutes to hours. They occur near sunspots when magnetic energy built up in the solar atmosphere is suddenly released (energy emissions up to 10^{25} J). As the magnetic energy is released, particles (including electrons, protons and heavy nuclei) are heated and accelerated.

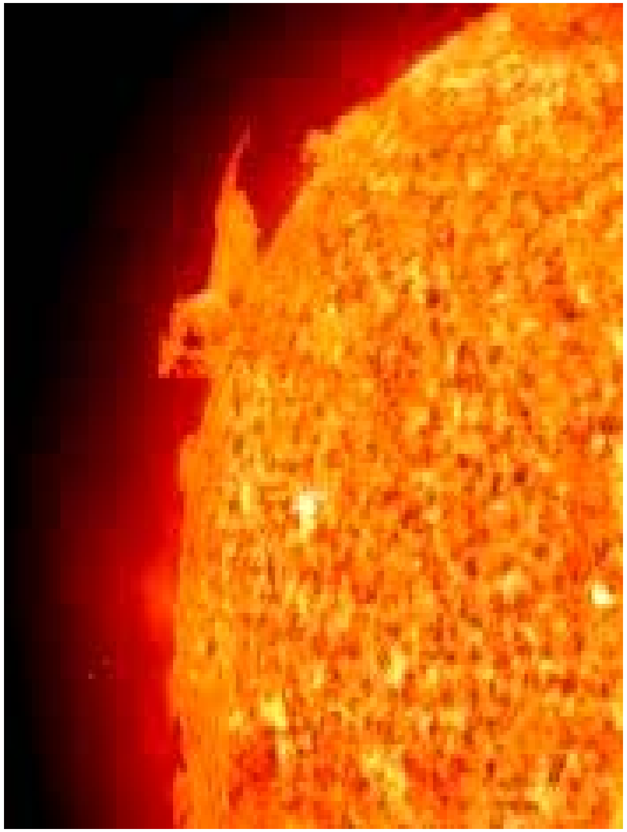






Understanding the influence of a SPE on the radiation environment inside the ISS plays a relevant role in the estimate of the risk for astronauts

Solar Flare



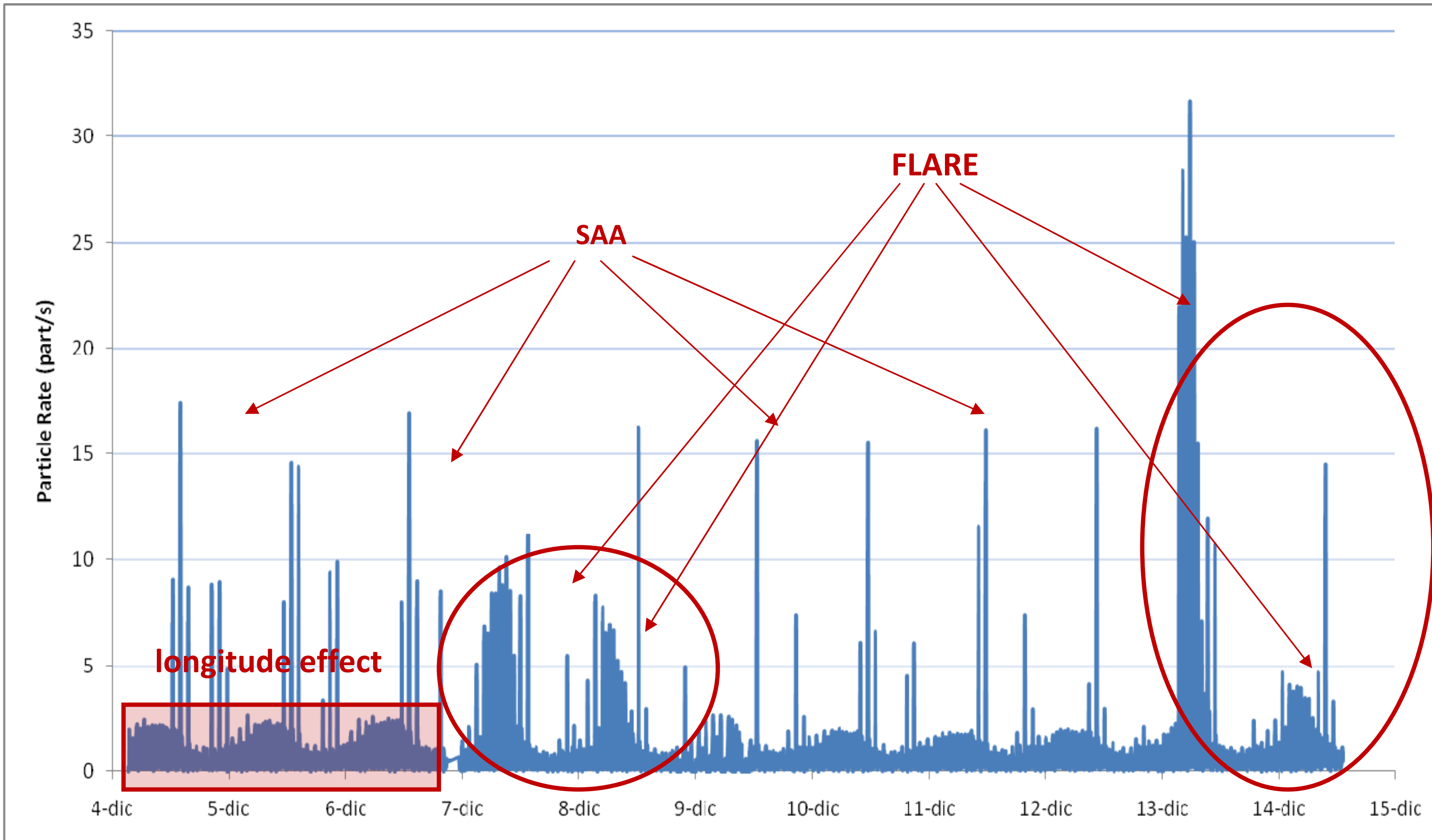
•Solar Flare typically occur near sunspots, usually along the dividing line (neutral line) between areas of oppositely directed magnetic fields

•The key to understanding and predicting solar flares is the structure of the magnetic field around sunspots. If this structure becomes twisted and sheared then the magnetic field line can cross and reconnect with the exsplosive release of energy.

•There typically is a correlation between the frequency of flares and the number of sunspots on the Sun.

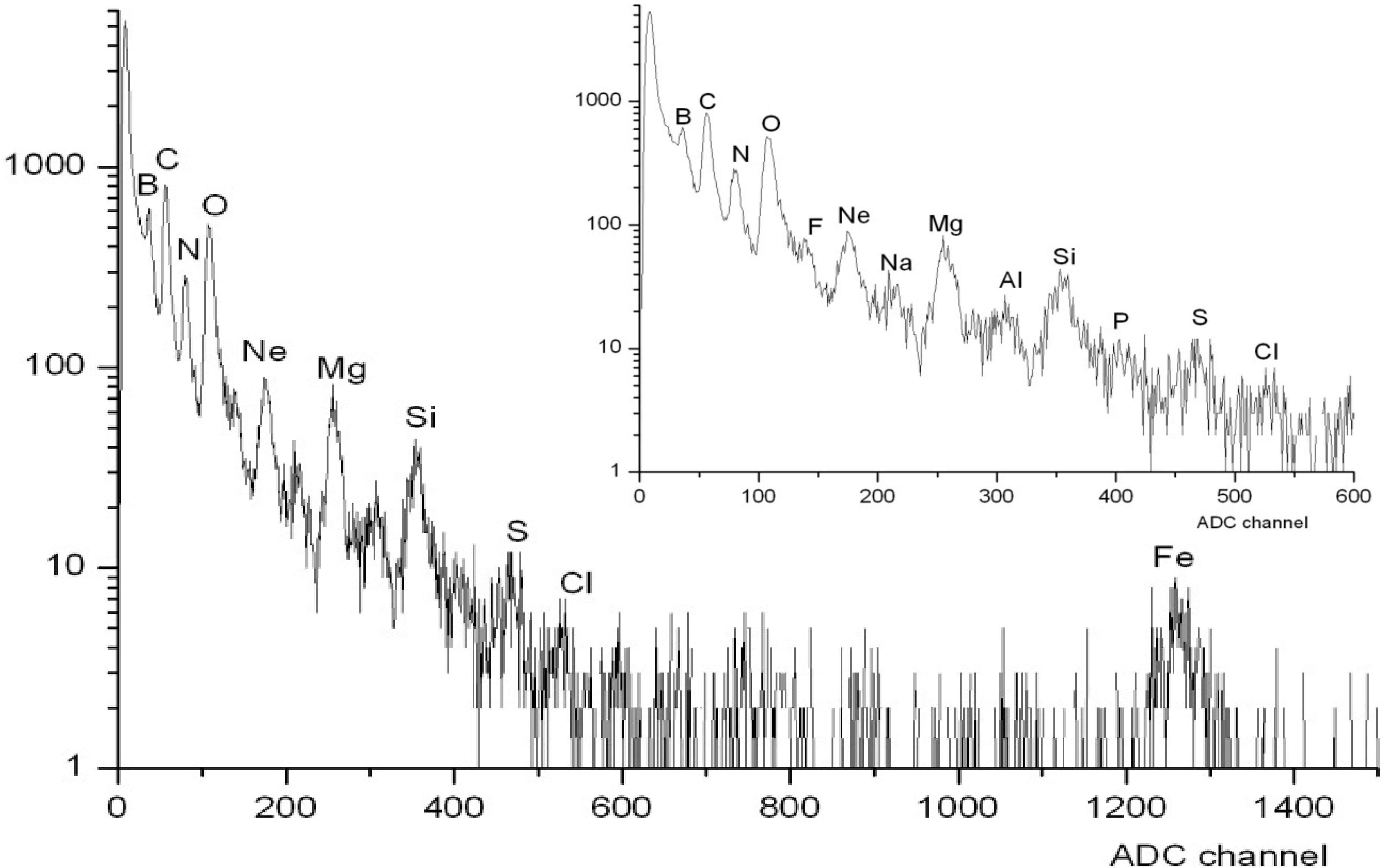
•Solar activity varies with a 22-year cycle (the Solar Cycle). At the peak of the cycle there are typically more sunspots on the Sun, and hence more solar flares.

Solar Flare Particle Rate

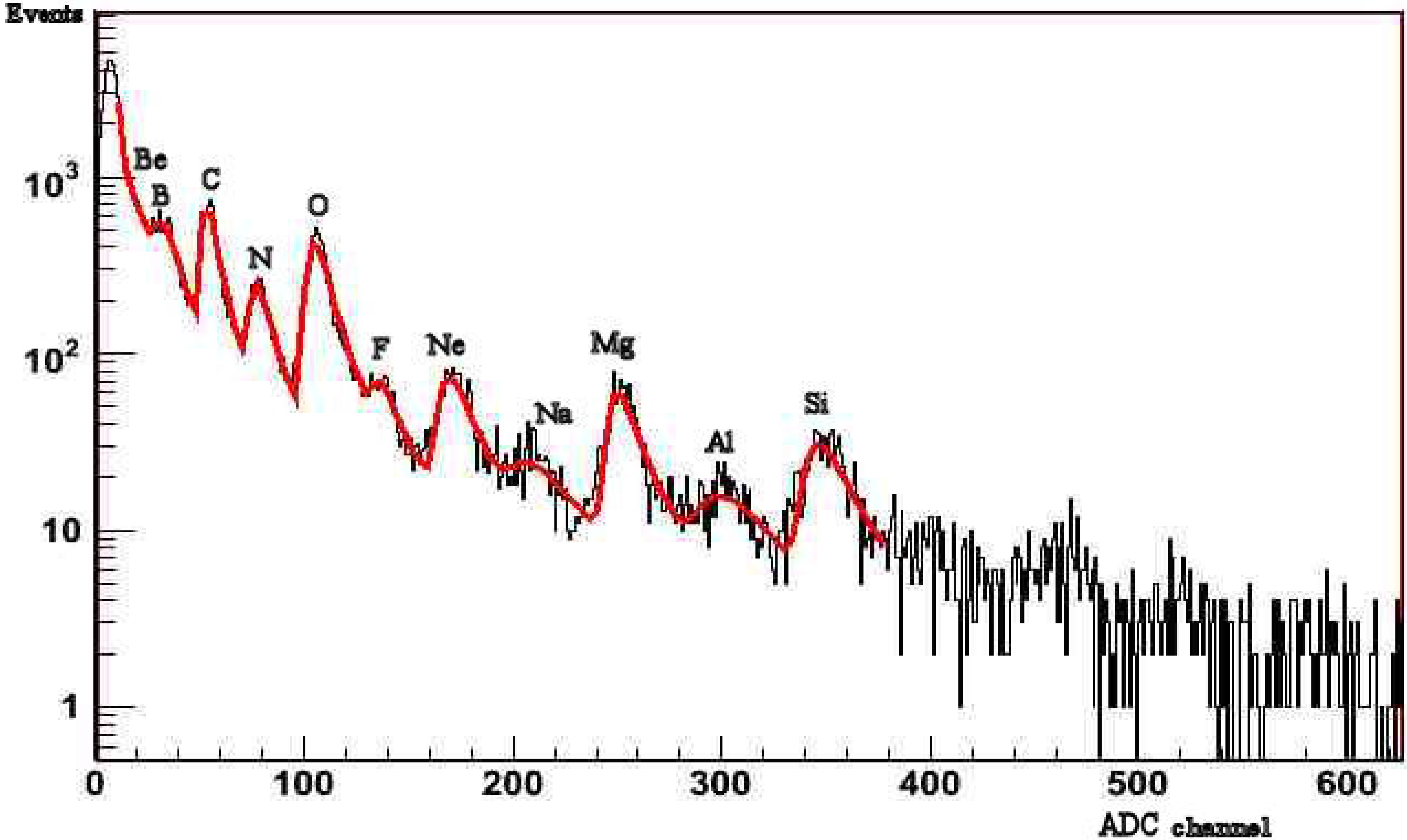


- ALTEA (1 SDU) Particle Rate

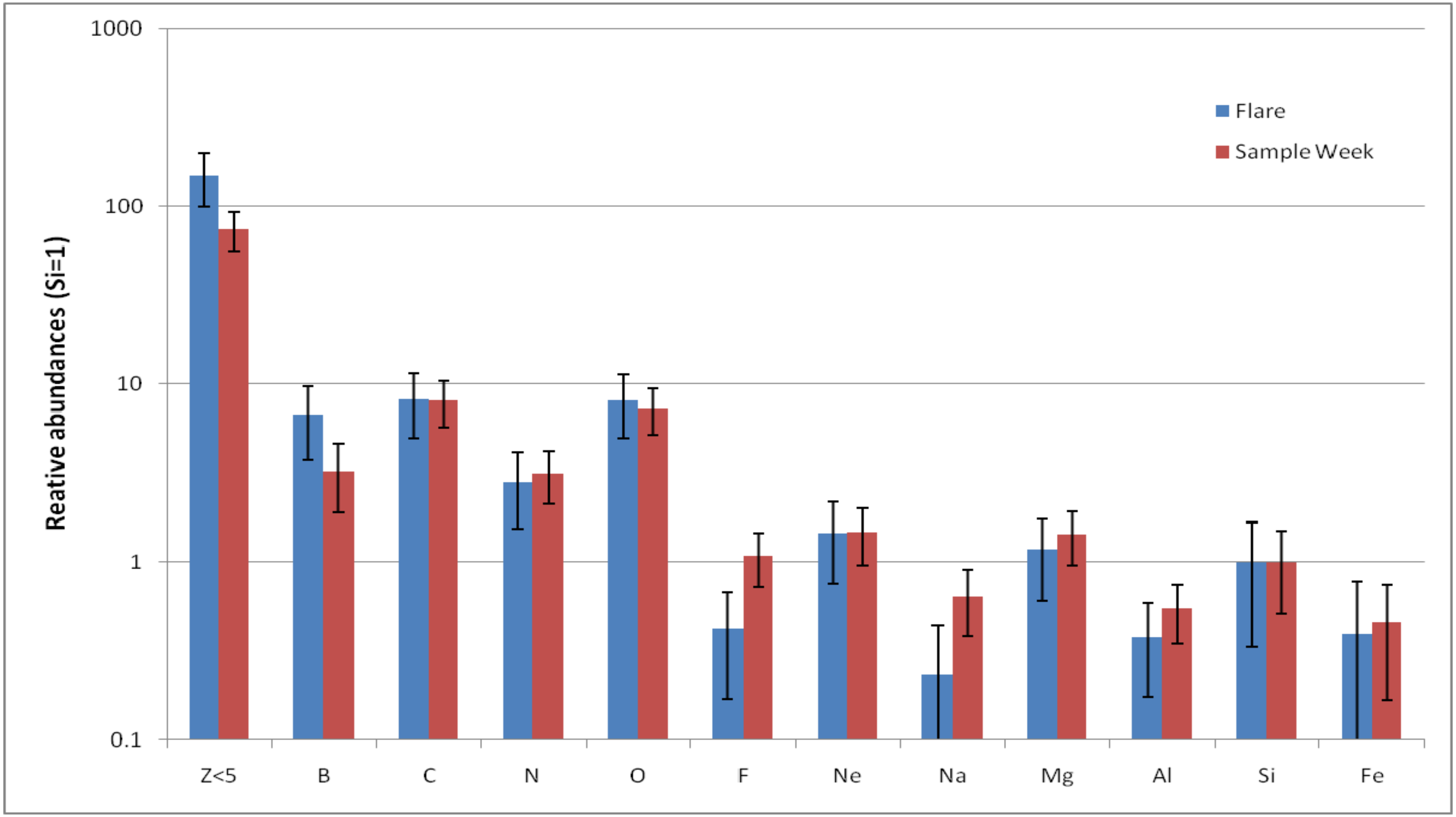
Energy loss spectrum for fast particles



Landau fit of energy loss spectrum



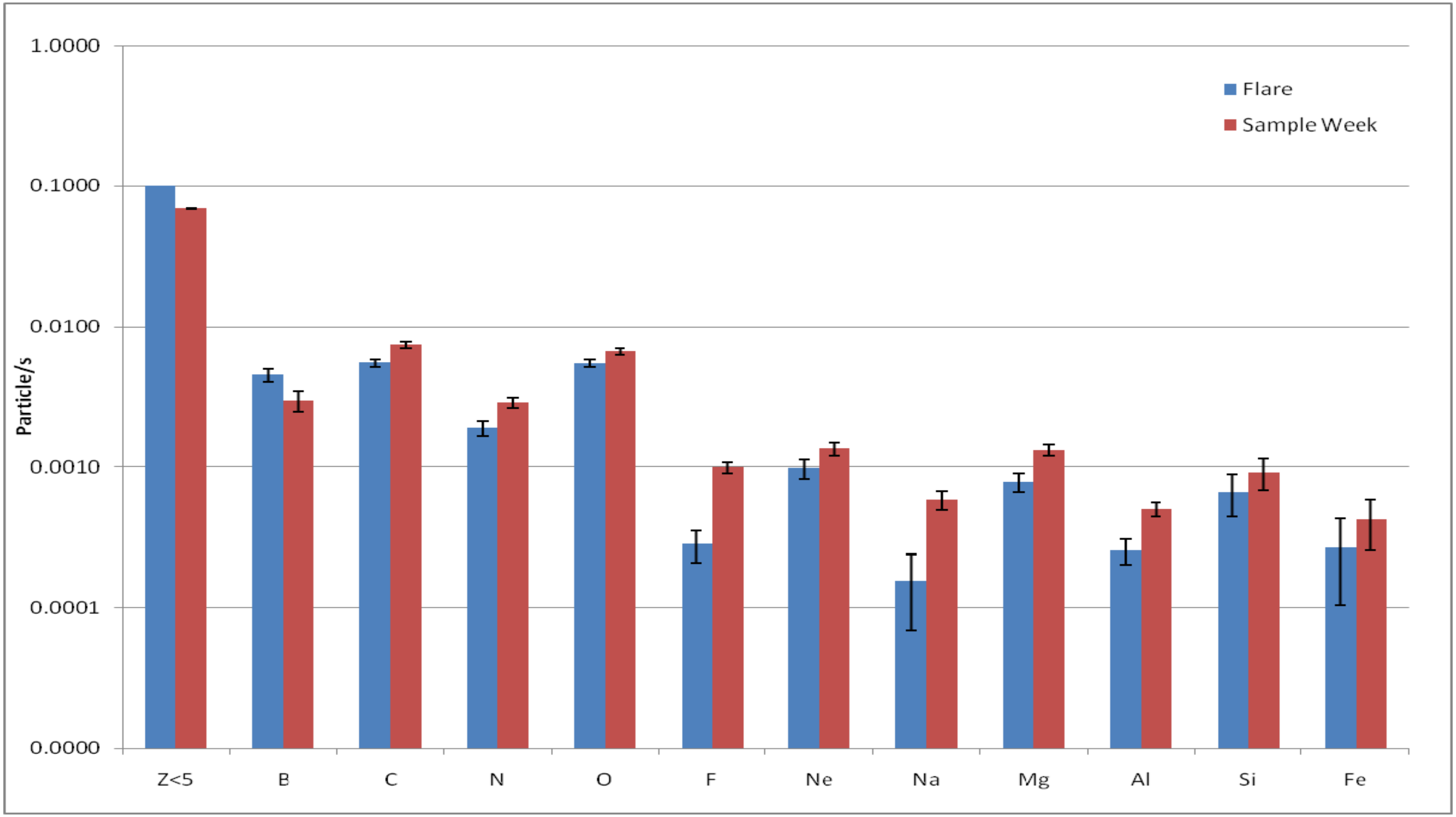
Relative Nuclear Abundances



There is no significant difference in the relative nuclear abundances of the flare compared to a sample week in november

… but

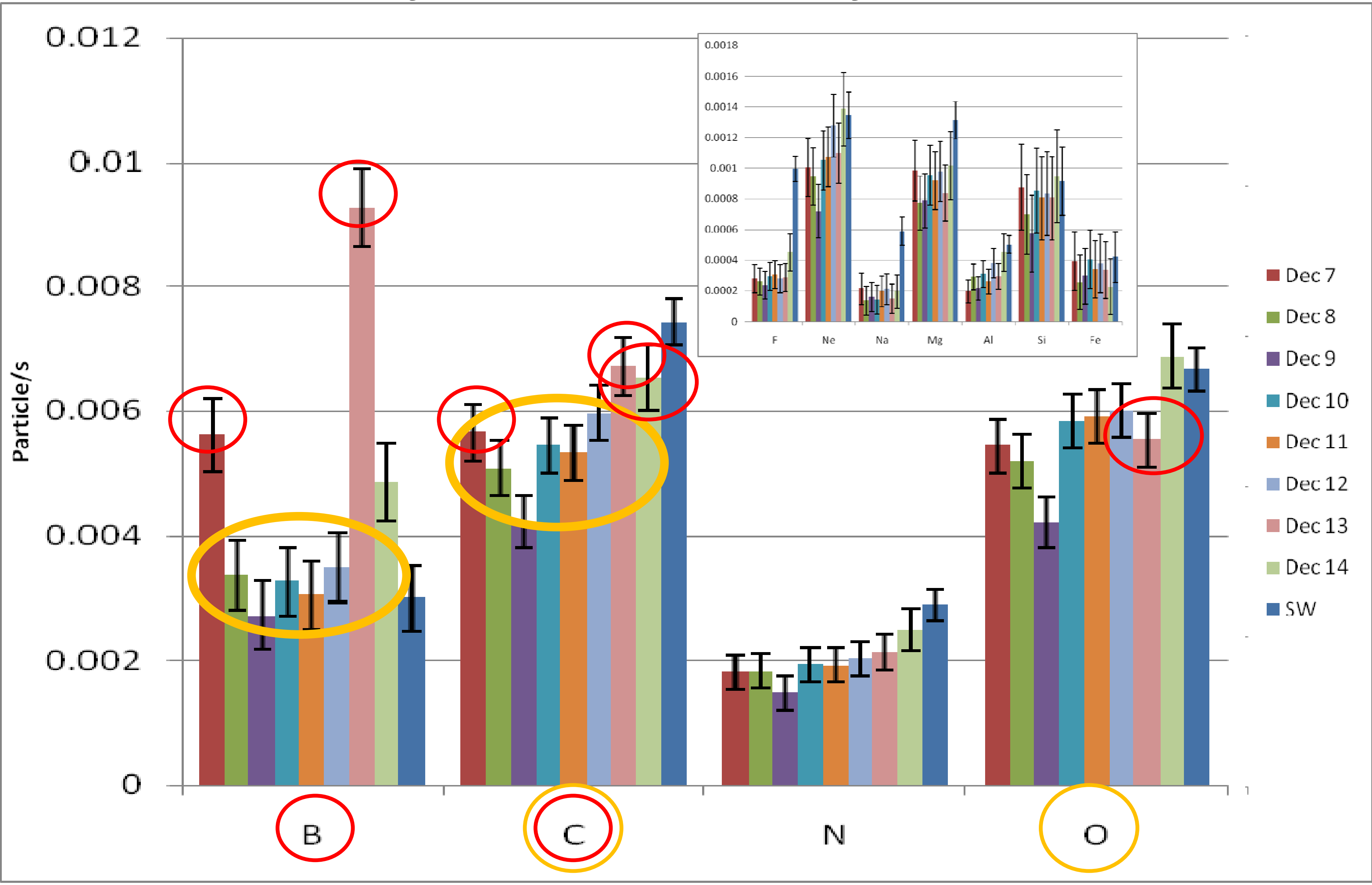
Nuclear Particle Rate



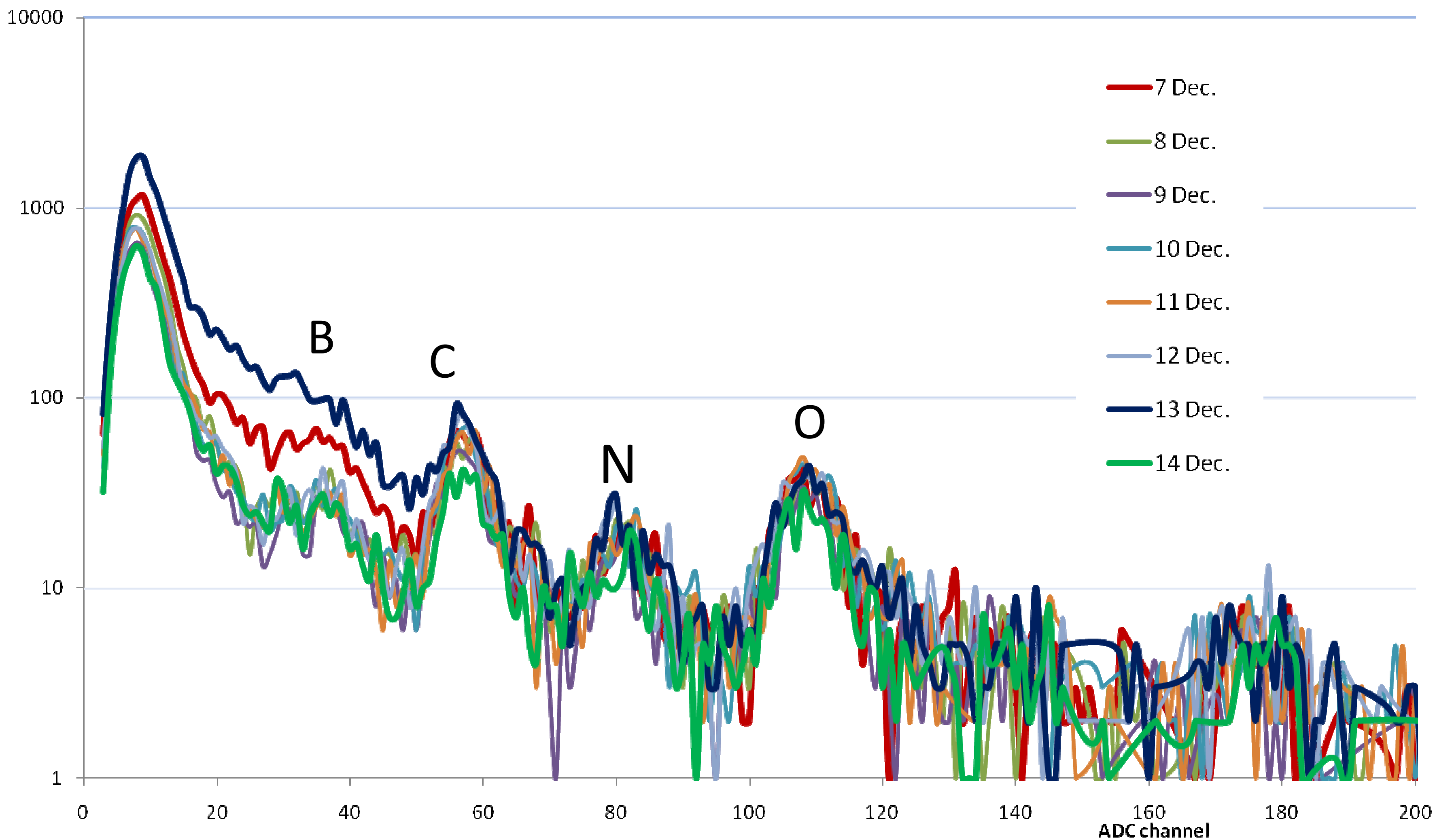
There is a significant difference in the nuclear rates:

- Increase of ion rates for ions with Z<=5
- Decrease of ion rates for ions with Z>5

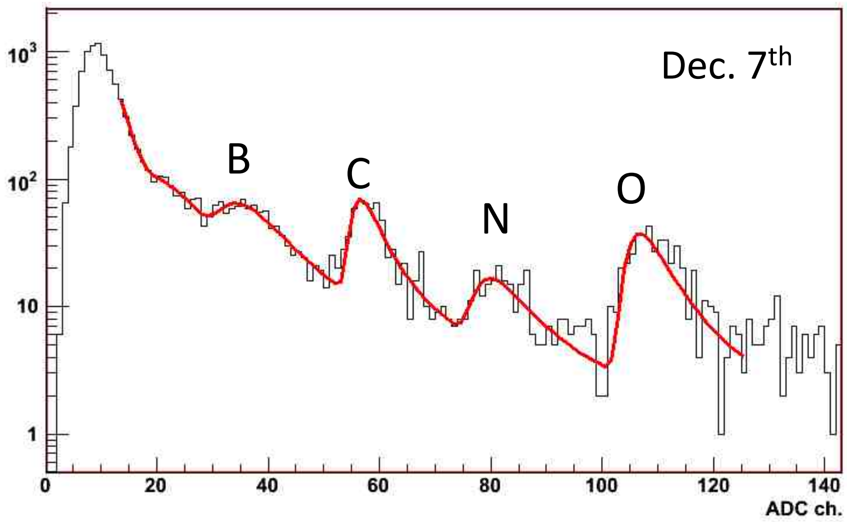
Flare dynamics: daily ion rates

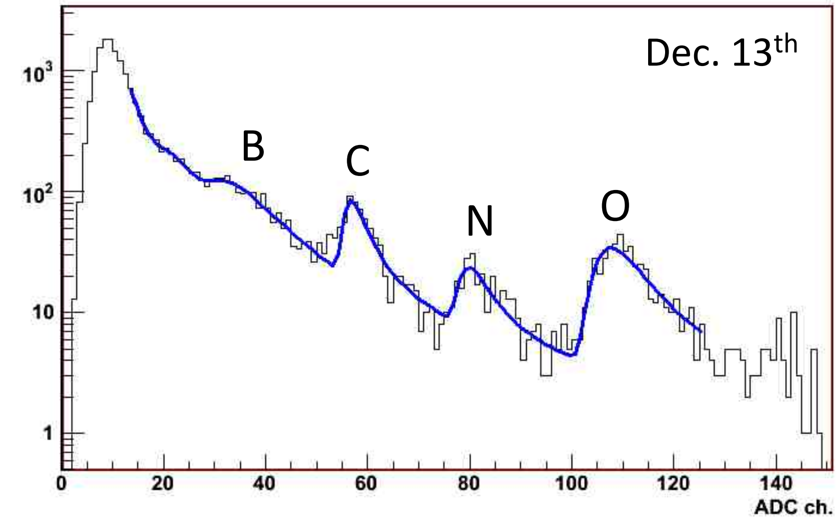


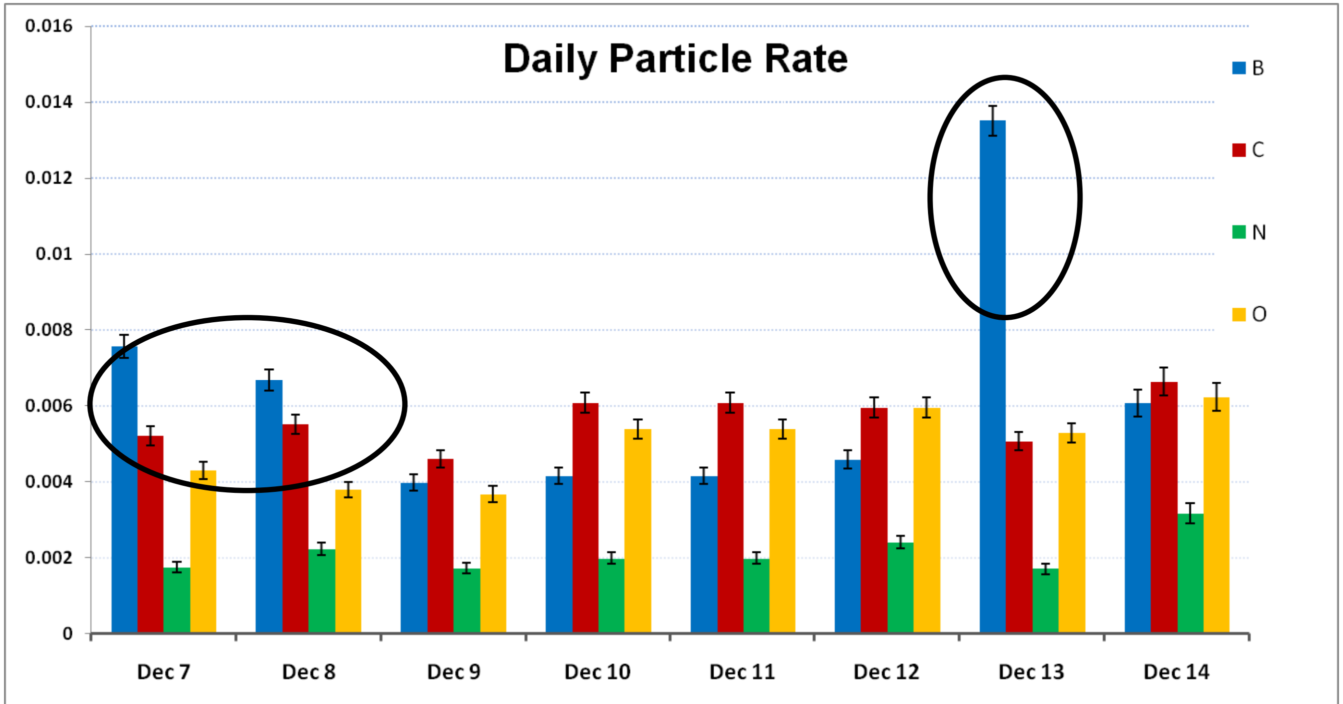
Daily energy loss spectra



Daily Landau fits





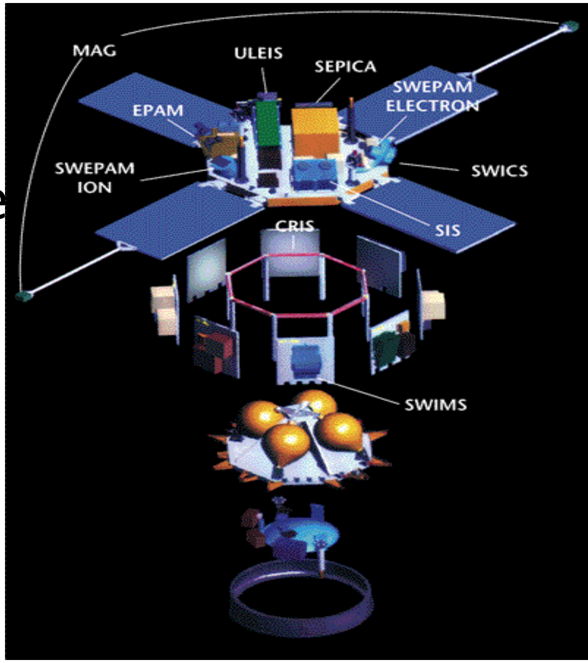


Comparison with ACE
(**A**dvanced **C**omposition **E**xplorer)

- Samples low-energy particles of solar origin and high energy galactic particles
- Provides near-real-time continuous coverage of solar wind parameters and solar energetic particle intensities
- Carries 9 scientific instruments

 - the Solar Isotope Spectrometer (*SIS*) designed to provide high resolution measurements of the isotopic composition of energetic nuclei

but



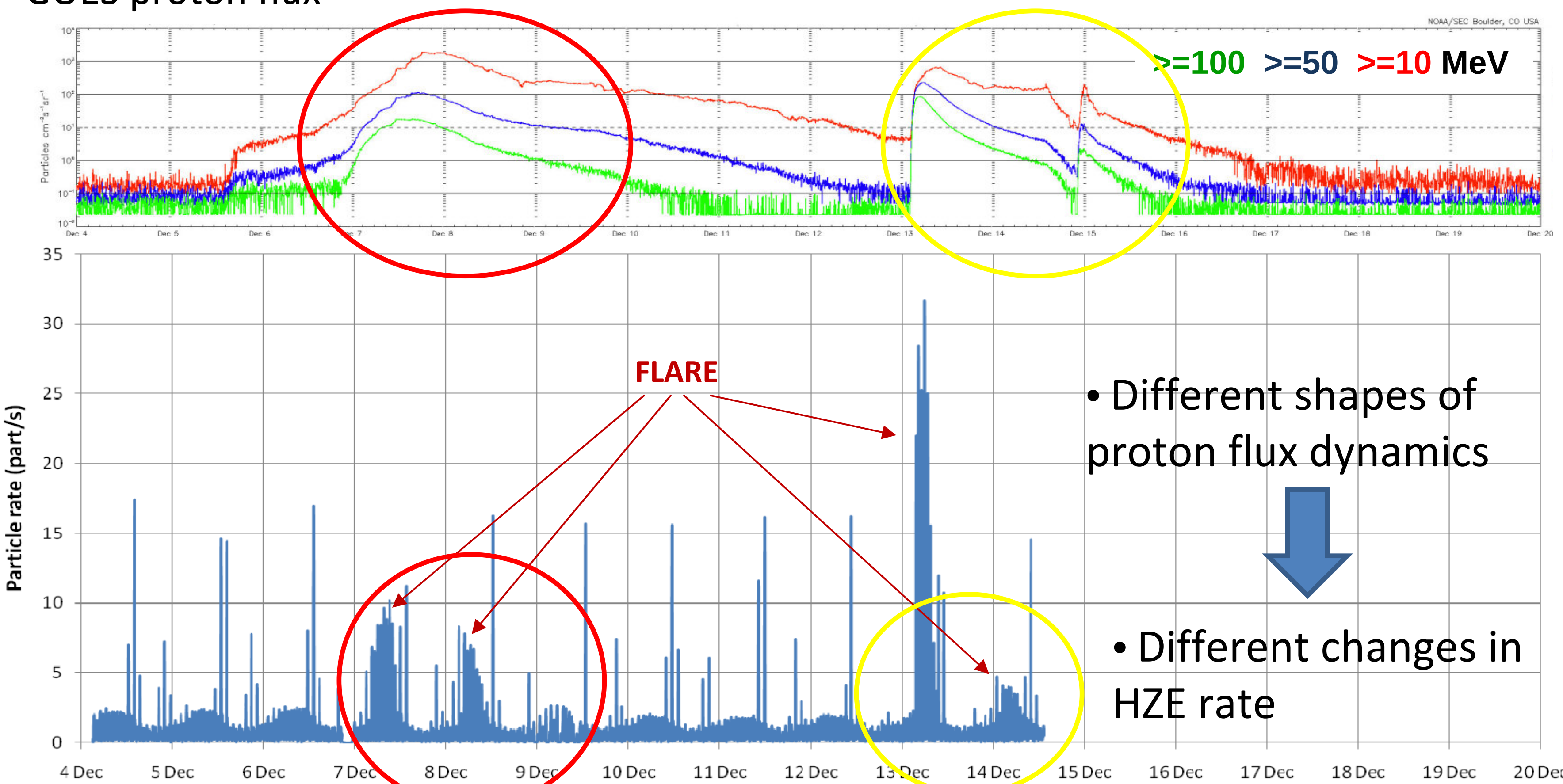
– Few energy ranges to compare with
– Boron not included

- **Introduction**

- The Solar Isotope Spectrometer (SIS) is designed to provide high resolution measurements of the isotopic composition of energetic nuclei from He to Ni (Z=2 to 28) over the energy range from ~10 to ~100 MeV/nucleon. During large solar events, when particle fluxes can increase over quiet-time values by factors of up to 10000, SIS will measure the isotopic composition of the solar corona, while during solar quiet times SIS will measure the isotopes of low-energy Galactic cosmic rays and the composition of the anomalous cosmic rays which are thought to originate in the nearby interstellar medium. The solar energetic particle measurements are useful to further our understanding of the Sun, while also providing a baseline for comparison with the Galactic cosmic ray measurements carried out by CRIS. SIS has a geometry factor of ~40 cm^2-sr, which is significantly larger than previous satellite solar particle isotope spectrometers. It is also designed to provide excellent mass resolution during the extremely high particle flux conditions which occur during large solar particle events.

Comparison with GEOS proton flux

GOES proton flux



- Different shapes of proton flux dynamics
- Different changes in HZE rate

ALTEA (1SDU) particle rate

Conclusions and future work

ALTEA-*Space* measures

- Increasing rate for ions with Z <= 5
- Decreasing rate for ions with Z > 5

- Nuclear absolute fluxes
- Study of "slow" particles using recognition methods
- Improvement of the filter on fast particles
- Correlation with ISS attitude

ALTEA: the international team

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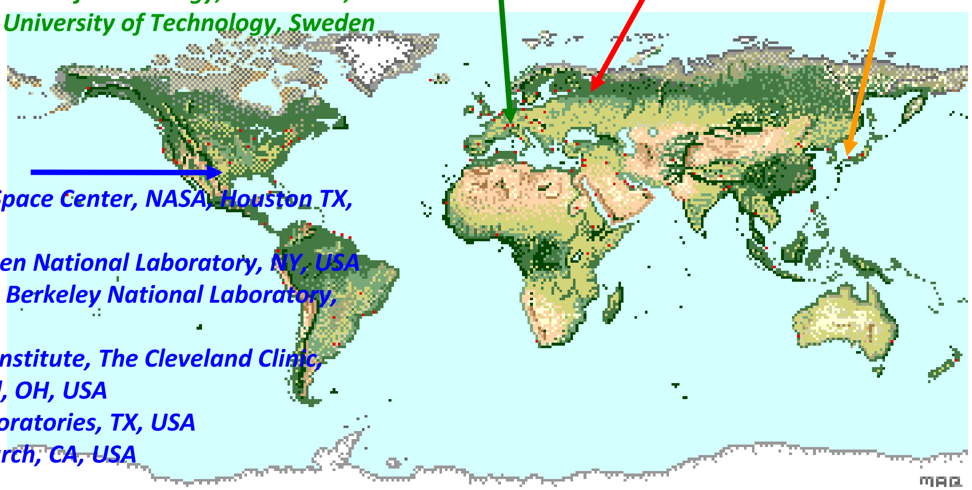
Dept of Physics, Univ. of Milan, Milan
DISM-Univ. of Genoa, Genoa
L.N.F. - INFN, Frascati (Rome)
CERN - INFN
Dept. of Physics,Univ. e Sect. INFN of Trieste, Perugia, Firenze
Dept. of Sc. and Chemical Tec., Univ. of Rome "Tor Vergata"
Dept. of STB - Univ. of L'Aquila, L'Aquila
GSI - Biophysik, Darmstadt, 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



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Wyle Laboratories, TX, USA
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Vittori R.
Zaconte V.
Zampa N.
Zapp N.

+ others joining in

Thank you for your attention

Detectable Ion Energy Range

	Minimum energy (MeV/n)	Maximum energy (MeV/n) threshold	
		10 MIP	**5 MIP**
H	25*	45	100
He	25*	250	> 2000

* is for Bragg peak…
** is for saturation…

…in the last of the six silicon planes

	filter threshod (MeV/n)		filter threshold (MeV/n)
H	42	Si	122
He	42	P	125
Li	48	S	134
Be	57	Cl	135
B	65	Ar	135
C	75	K	140
N	83	Ca	149
O	90	Sc	146
F	95	Ti	148
Ne	100	V	150
Na	105	Cr	160**
Mg	112	Mn	170**
Al	117	Fe	187**