Relative Nuclear Abundances Measurements Inside Mir And ISS With Sileye-2 And Sileye-3 Experiments

Marco Casolino[1], Vittorio Bidoli[1], Luca Di Fino[1], Gianluca Furano[1], Mauro Minori[1], Aldo Morselli[1], Livio Narici[1], Maria Pia De Pascale[1], Piergiorgio Picozza[1], Enzo Reali[1], Adele Rinaldi,[1] Roberta Sparvoli[1], Veronica Zaconte[1], Christer Fuglesang[2], Walter Sannita[3], Per Carlson[4], Guido Castellini[5], Arkady Galper[6], Mikhail Korotkov[6], Alexander Popov[6], Nikita Vavilov[6], Sergei Avdeev[7], Victor Benghin[8], Victor Salnitskii[8], Olga Shevchenko[8], Mirko Boezio[9], Walter Bonvicini[9], Andrea Vacchi[9], Gianluigi Zampa[9], Nicola Zampa[9], Giuseppe Mazzenga[10], Marco Ricci[10], Piero Spillantini[11] and Roberto Vittori[12]

(1) Dept. of Physics, Univ. of Roma 'Tor Vergata' and INFN-Roma2, Rome, Italy. casolino@roma2.infn.it
(2) European Astronaut Centre, ESA, Cologne
(3) Neurophysiopathology-DISMR,Univ. of Genova, Genova, Italy and Dept. of Psychiatry, SUNY, Stony Brook, NY, USA
(4) Royal Institute of Technology, Stockholm, Sweden
(5) IROE, CNR, Florence, Italy
(6) Moscow State Engineering Physics Institute, Moscow, Russia
(7) Russian Space Corporation "Energia" by name Korolev, Korolev, Moscow region, Russia
(8) Institute for BioMedical Problems, Moscow, Russia
(9) Dept. of Physics, Univ. and INFN, Trieste, Italy
(10) LNF-INFN, Frascati, Italy
(11) Dept. of Physics, Univ. and INFN, Florence, Italy
(12) INFN Perugia, ESA - European Space Agency

Abstract

In this work we present measurements of cosmic ray nuclear abundances above 100 MeV/n inside Mir and the International Space Station (ISS). Observations inside Mir Space Station were performed with SilEye-2 experiment, a 6 plane silicon strip detector telescope designed to measure environmental radiation and investigate on the Light Flash (LF) phenomenon. A total of 100 sessions comprising more than 1000 hours of observation was performed in the years 1998-2000. ISS data have been taken in 2002 with Sileye-3/Alteino (an 8 plane, 32 strip silicon detector) device during the Soyuz-34 flight. We report on SilEye-3/Alteino relative abundances from Boron to Silicon measured in Pirs module of ISS and on the comparison with Sileye-2 results.

pp. 4245–4248

1. Introduction

The SilEye project is devoted to the investigation of LF phenomenon[9], the study of astronaut brain activity in space when subjected to cosmic rays [7], and a detailed measurement of radiation environment and nuclear abundances inside Mir and ISS. In space the absorbed and equivalent doses depend basically from two parameters: 1. from the cosmic ray flux, depending on long and short term solar phenomena such as solar cycle and Solar Particle Events respectively; 2. from the construction (hull shielding) and orbit of the spacecraft.

Cosmic ray flux and composition is the subject of extensive studies for the importance they play in different fields of physics, ranging from the cosmological implications of the antimatter component of cosmic rays [8], to solar physics and solar-terrestrial phenomena [6].

2. The Sileye-2 and Sileye-3/Alteino devices

Sileye-3/Alteino [4, 6] is composed of two distinct devices: the cosmic ray advanced silicon telescope (AST) and an electroencephalograph . AST consists of 8 silicon strip detector planes (4 oriented along X direction and 4 along Y direction), resulting in a geometric factor of 24 cm^2 sr. Sileye-3/Alteino was placed on board the ISS on April the 27^{th} 2002 in the framework of the Soyuz-34 taxi flight mission. The cosmic ray detector was active for the whole duration of the mission, which lasted until May the 5^{th}. SilEye-2 [2,3] consists of a silicon detector telescope coupled to a 'helmet' with an eye mask, and worn by the astronaut to carry out LF observations[1]. Both devices can be operated as stand-alone cosmic ray detectors without the presence of the cosmonaut; in this acquisition mode they could monitor in real time the environmental radiation inside the stations. For both devices each particle event is defined by the energetic and topological information coming from the strips hit by incoming particle(s).

In Fig.1 it is possible to see good nuclear discrimination capabilities (for particles with energy above 100 MeV) of Sileye-3. This allows to determine instrument linearity (fig.2) and measure relative nuclear abundances on board ISS.

3. Results and Conclusions

Fig. 3 compares nuclear abundances normalized to C inside Mir (in Kristall and Priroda modules) and ISS (in Pirs module, between panels 301 and 201) with theoretical calculations on outer space taken from [10] and using Creme model [12]. It is possible to note some differences between Mir and ISS data: for instance Oxygen and Silicon are more abundant in respect to Carbon on ISS than on Mir and outside values. This is probably due to the the higher shielding material present on Mir than on Iss (the Pirs module is the airlock where Soyuz docks and is orthogonal to the main body of the station). It is also possible to see F abundance increase most probably due to spallation of the more abundant even-numbered nuclei. Current observations are however limited by statistics; a long term operation of the instrument is currently under consideration.

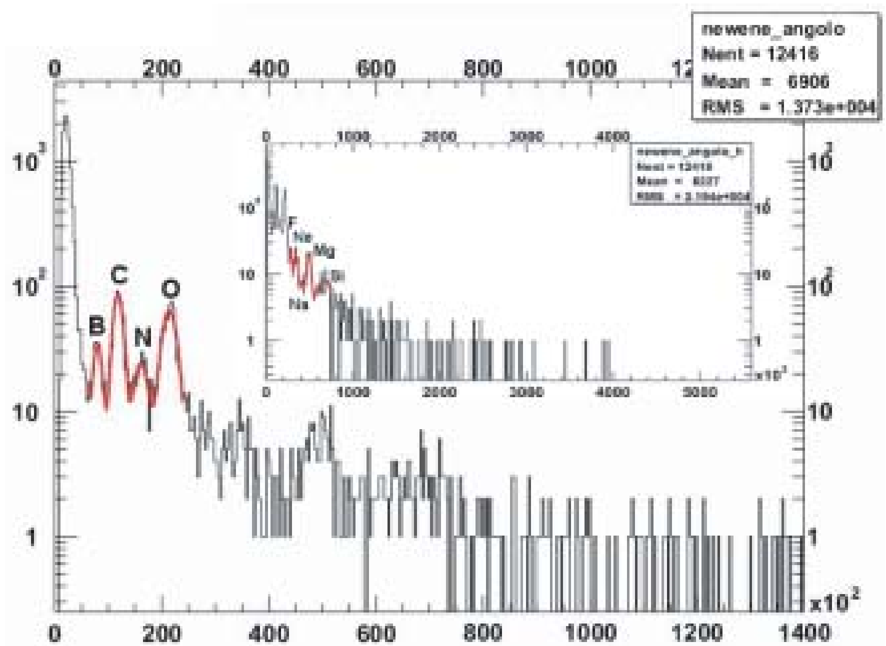

Fig. 1. Histogram of the number of entries as a function of energy deposited in the detector for high energy particles. The continuous lines represent fits with gaussian distributions for the BCNO elements in the main picture, and for elements from F to Si in the inset.

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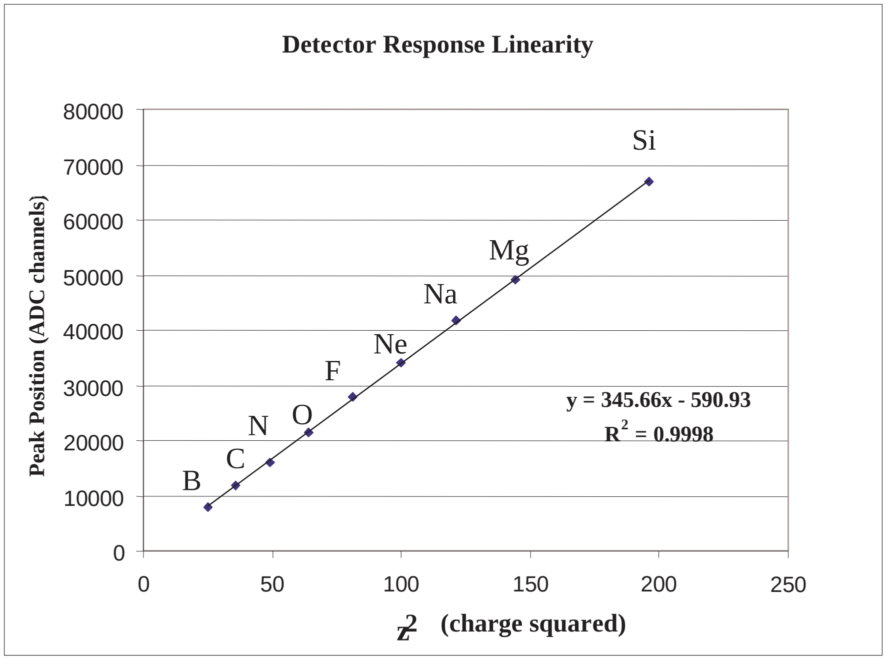

Fig. 2. Detector linearity for Sileye-3: peak positions of various nuclei (in ADC channels) are plotted as function of the square of their charge.

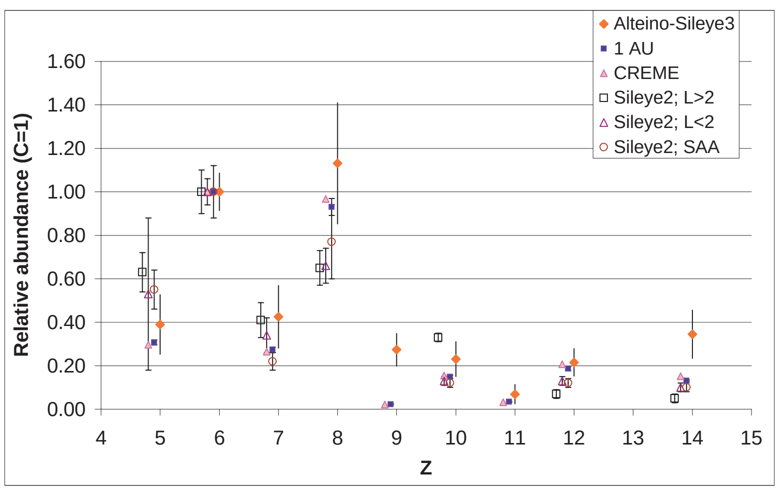

Fig. 3. Comparison between abundances measured with Sileye-2 on MIR (divided according to the geomagnetic cutoff and the geomagnetic field in three regions) and Sileye-3 on ISS and those evaluated using [10] and [12].