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Launch in orbit of the NINA-2 apparatus aboard the satellite MITA.

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Abstract. The satellite MITA was launched on July the 15^{th}, 2000 from the cosmodrome of Plesetsk (Russia) with a Cosmos-3M rocket. MITA carries the payload NINA-2 for the study of solar and galactic cosmic rays. The detector used in this mission is identical to the one already flying on the Russian satellite Resurs-O1 n.4 in a 840 km sun-synchronous orbit, but makes use of the extensive computer and telemetry capabilities of MITA bus to improve the active data acquisition time. The scientific objectives of NINA are the study of cosmic nuclei from hydrogen to iron in the energy range between 10 MeV/n and 1 GeV/n during solar maximum period. The device is capable of charge identification up to iron with isotope sensitivity up to oxygen. The 87.3 degrees, 460 km altitude polar orbit allows investigations of cosmic rays of solar and galactic origin as well as the trapped component. In this work we present preliminary results concerning particle identification capabilities and nuclear differential spectra for helium, carbon and oxygen in the energy range between 10 and 50 MeV/n.

1 Introduction

The cosmic ray detector NINA-2 was launched on the the Italian satellite MITA (**M**inisatellite **I**taliano a **T**ecnologia **A**vanzata - *Italian Advanced Technology Minisatellite*) with a Cosmos rocket from the cosmodrome of Plesetsk on July the 15^{th}, 2000.

NINA-2 is the sole scientific payload of MITA and continues the observations begun with the first NINA telescope, launched in 1998 on board the Russian Resurs-O1 n.4 satellite. These detectors were realized and launched in space by the WiZard - RIM international collaboration, composed by INFN (Italian National Institute of Nuclear Physics), MEPHI (Moscow Engineering Physics Institute), and other universities and institutions. In parallel to the NINA launches, two devices employing the same detector technology - RIM/SilEye experiments (Bidoli et al., 2000; Casolino et al., 2001) were placed on board the MIR Space Station to study radiation related effects in that environment.

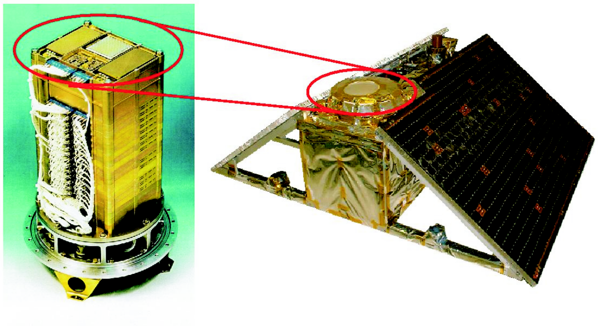

Fig. 1. The NINA-2 detector (left - height: 48 cm, diameter: 28 cm) and its accomodation within MITA satellite (right). MITA is three-axis stabilized with the detector pointing toward the zenith.

The design of NINA-2 is identical to the first detector: however, the use of the extensive computer and telemetry capabilities of MITA allow an improved data acquisition. NINA-2 can detect charged cosmic ray particles between 10 and 200 MeV/n (contained particles) and up to 1 GeV/n (outside containment), working during maximum solar activity.

2 NINA-2 and MITA satellite

The MITA satellite is first platform built by ASI (Italian Space Agency)for low cost Earth: its main characteristics are shown in Table 1. MITA represents a new generation of satellite architecture based on modular criteria that allow to build up a mission in short periods ($\sim$ 2 years), at low costs.

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Mass	170 Kg
Dimensions	$180 \times 160 \times 84$ (cm)
Average (peak) power cons.	85 (120) W
Attitude Control System	3 axis stabilized, Earth point.
Attitude Accuracy	$\pm 1^o$ / axis
Communications	S-Band
Telemetry	512 Kbps - ESA Standard
Telecommand Uploads	4 Kbps
Mass Memory	64 MBytes
Payload Mass	30 Kg
Payload Power Budget	40 W

Table 1. MITA bus characteristics summary.

The satellite was launched in a circular polar orbit of 460 km height and 87.3 degrees of inclination. A picture of NINA-2 and its position within MITA is shown in Figure 1.

There are two main computer systems on board: the OBDH (On Board Data handler) and the PL/C (PayLoad Computer). The OBDH is linked to all spacecraft systems such as the telemetry frame formatter, the interface with the active control systems, the sensors and actuators, the engineering and scientific data readout. Data from the detector are read out from the Payload Computer which performs all tasks of data readout, reduction, second level triggering and active acquisition mode switching. This architecture allows good development flexibility and a relatively simple integration of the scientific payloads. Work on NINA-2 begun in 1997; the integration phase included beam tests of the detector at the accelerator facilities of GANIL (France), GSI (Germany) and Uppsala (Sweden).

3 Detector Characteristics

The NINA-2 detector is composed of 16 X-Y planes, each consisting of two n-type silicon detectors, 60×60 mm^2, divided in 16 strips and connected to a supporting ceramic frame under lateral strips (1 and 16). The geometric factor of the instrument ranges from 8.6 cm^{2}sr for low energy particles to 1 cm^{2}sr for particles crossing whole detector. The thickness of the detector is $(2 \times 150 \pm 15)$ μm for the first plane, and $(2 \times 380 \pm 15)$ μm for the remaining 15 planes: the active part thus amounts to 11.7 mm. Interplanar distance is 1.4 cm for planes 2-16 and 8.5 cm for plane 1-2 in order to improve determination of the particle incident angle. Preamplifiers are placed on the side of the detector: the signal is then sent, via a multiplexer, to a 12 bit ADC and then to the OBDH via a FIFO (ADC and FIFO electronics board are placed under the 16 planes stack). ADC dynamic range corresponds to about 300 MeV of released energy; the resolution is 73 KeV/ch. The whole structure is surrounded by a cylindrical aluminum vessel of 284 mm diameter and 480 mm height and 2 mm thick (aside from the aforementioned 300 μm thick window placed in front of the detector). For a full description of the instrument and its characteristics see Bakaldin et al. (1997); Bidoli et al. (1999). All satellite and detector systems have their cold redundant counterpart with the exception of the silicon detector which has a functional redundancy in the multiplicity of the strips and the different triggers which allow to cope with eventual malfunctions. Indeed, second level triggers allow to discard broken strips or planes and substitute anticoincidence vetoes. The system performs automatic calibrations and checks of the dark current noise at intervals during acquisition; this allows to take into account possible shifts of the detector pedestals or variations of the amplification chain gain. According to the trigger configuration, the detector can vary its observational characteristics in order to focus the acquisition of different particles and energy ranges. The PL/C can vary the trigger configuration as a result of telecommands sent from ground station or automatically adjust the trigger configuration to cope with increased particle flux.

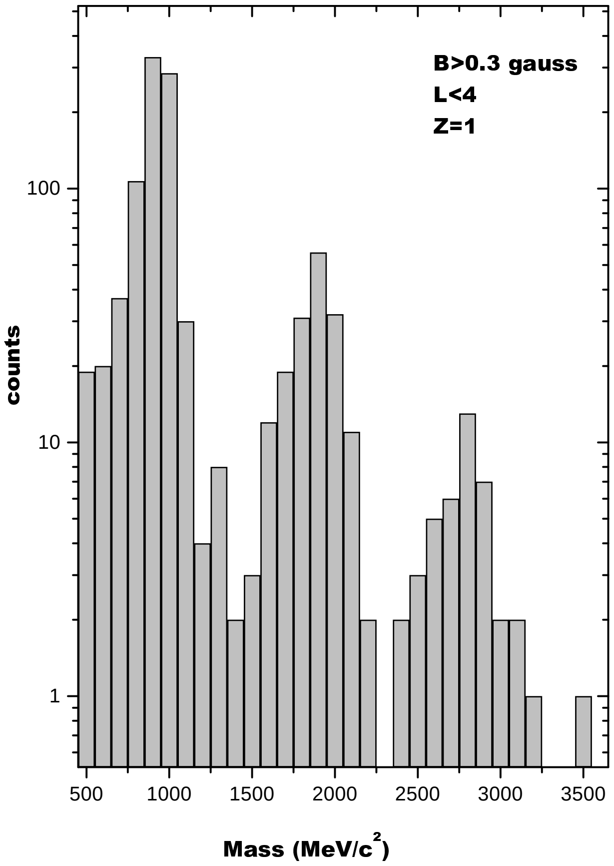

Fig. 2. Hydrogen isotopic discrimination capabilities.

The segmented nature of the detector allows a very precise measurement of the Bragg curve of the incoming particle. In this way it is possible not only to perform particle and energy classification according to dE/dx methods for particles contained into the calorimeter (up to $\sim$ 200 MeV/n) but also to identify particles not contained in the device (albeit with a reduced discrimination) thus extending the acceptance energy range to 1 GeV. An example of the

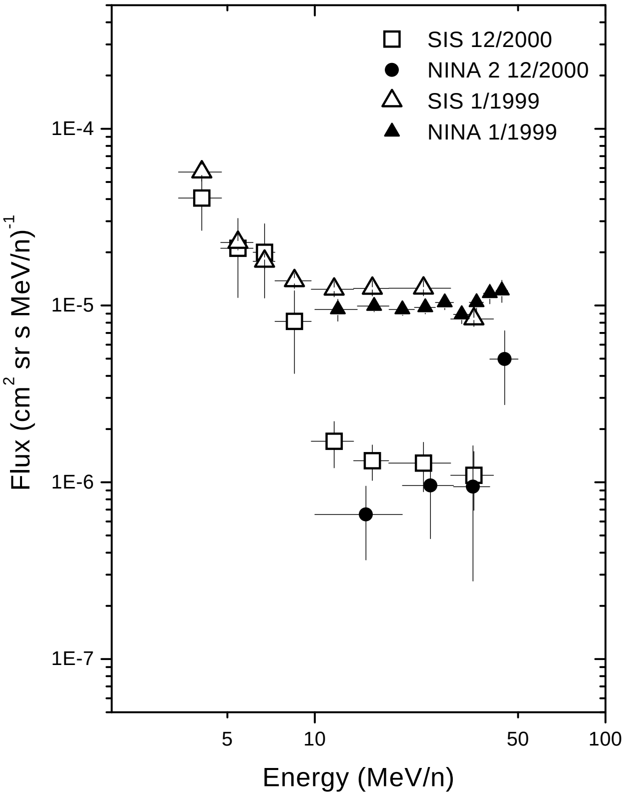

Fig. 3. Helium differential flux measured in solar quiet condition with NINA-1, -2 and SIS at before (1999)and at Solar Maximum (2000).

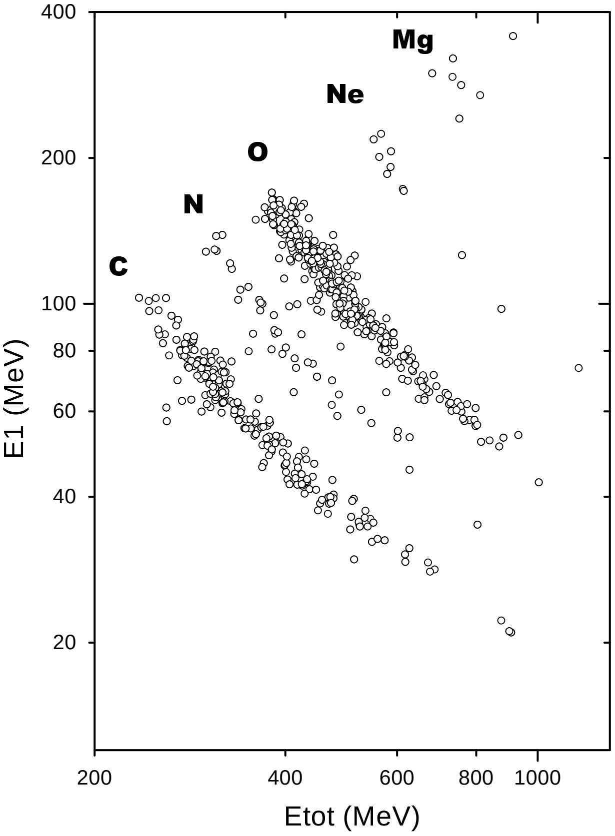

Fig. 4. NINA-2 nuclear identification capabilities. Data refer to November, the 9^{th} 2000 SEP event.

isotopic identification capabilities of the device for Hydrogen is shown in Figure 2.

4 Scientific objectives

NINA-2 continues the observations begun in 1998 with NINA(Bidoli et al., 2001): they include the study of cosmic ray nuclei from hydrogen in the energy range between 10 MeV/n and 1 GeV/n. The detector characteristics, its high inclination orbit (see Table 1) and the period of observation (beginning at solar maximum) allow to address several scientific items related to cosmic rays physics:

- **Galactic (GCR) and Anomalous (ACR) Cosmic Rays.** Data acquired at high geomagnetic latitudes represent a sample of the galactic cosmic ray component, which has a long term modulation due to the solar cycle. Therefore, in addition to studies of the nuclear component of GCR, solar modulation phenomena will be considered. Detailed knowledge of the phenomena and processes behind the modulation and the interaction between the out-flowing solar material and the incoming galactic cosmic rays are still under study and await new data. ACRs are more dependent on solar activity than GCRs for their production and propagation mechanisms (Fisk et al., 1974), being greatly reduced at solar maximum. In Figure 3 we show the comparison between NINA and SIS results before (1999) and at Solar Maximum (end of 2000). In both bases there is a good agreement between measurements taken by SIS on board ACE(ACE Level 2 Data, 2000) outside Earth's magnetosphere and the two NINA devices in polar regions. It is possible to see the solar modulation effect below 50 MeV/n.

- **Solar Energetic Particles (SEP).** In addition to long term modulation effects, the heliosphere is often perturbed by a number of transient phenomena due to the solar activity, such as solar flares and coronal mass ejections. Each solar event has its own characteristics which have been proved quite challenging for acceleration and propagation models. Multi-spacecraft studies with different instruments are again of critical importance toward a deeper understanding and classification of different solar events. In this case NINA-2 capability to perform isotope studies in particular in relation to ^{3}He/^{4}He ratio and the increased abundance of various elements in SEP events will complement the results obtained

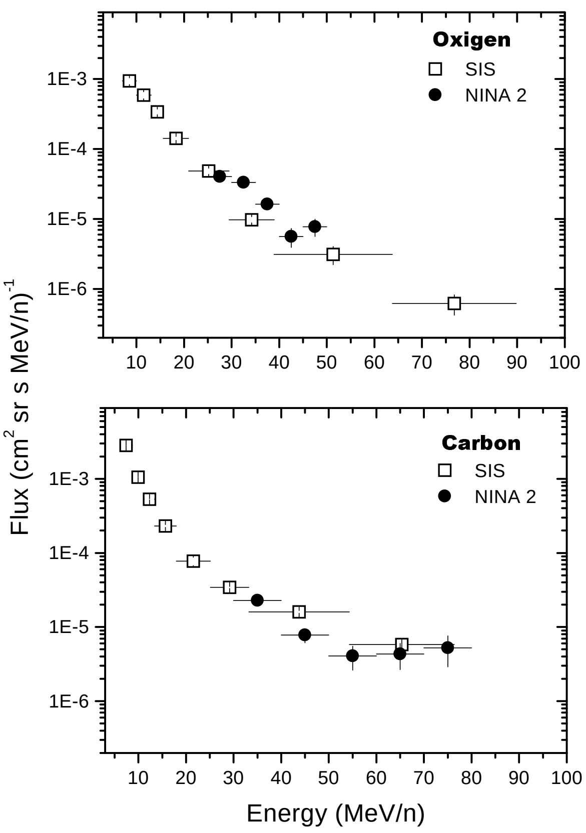

Fig. 5. Comparison of differential fluxes for O and C measured with NINA-2 and SIS (SEP of 10-20/11/2000).

with NINA-1(Sparvoli et al., 2001). The nuclear identification capabilities of NINA are shown in Figure 4 where nuclei detected during the SEP of 9-10/11/2000 are shown. Up to now more than 10 SEPs were detected and analysis is currently in progress. In Figure 5 we show Carbon and Oxygen differential flux below 80 MeV/n compared with SIS(ACE Level 2 Data, 2000) for the SEP of 10-20 November 2000. It is possible to see the good agreement between data.

– **Geomagnetically trapped and albedo particles.** High energy cosmic rays intercating with the upper strati of the Earth's atmosphere can produce secondary particles such as - for instance - hydrogen and helium isotopes. Particles not absorbed by the atmosphere can move along geomagnetic field lines between mirror points drifting longitudinally around the Earth for at least one orbit. Their lifetime may therefore by of several seconds before being lost in the atmosphere(Hess, 1968). The downward flux of these particles can be detected with NINA-2 in an analogous way to NINA-1. A preliminary measurement of Hydrogen isotopes at geomagnetic shell $L < 4$ is shown in Figure 2. The good isotopic discrimination of the instrument allow the observation of deuterium and tritium of this nature. A detailed study of the composition and energy spectra of this component is currently in progress in order to improve our knowledge of the propagation and interaction processes of cosmic rays in the Earth's vicinity.

  Of equal importance is the analysis of the particle component trapped by the geomagnetic field. In this case too, these particles are produced with the interaction with the atmosphere although production and trapping processes are very different(Roederer, 1970). Recent measurements have shown a very complex structure due to light isotopes and the trapped anomalous cosmic rays (Grigorov et al., 1991; Looper et al., 1996; Selesnick and Mewaldt, 1996). NINA-1 results in this field are presented in this conference in Bakaldin et al. (2001); NINA-2 data are currently under analysis. The increased telemetry allow us study light isotopes in a wider energy range.

5 Conclusions

NINA-2 was put into orbit in the second half of year 2000. The detector has been working correctly and according to specifications. Data received up to now on cosmic rays of solar, galactic and trapped nature are currently under analysis are will contribute to the understanding of the current solar cycle. For further information and current status of the mission you are welcome to our web page: http://wizard.roma2.infn.it

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ACE level 2 data can be found at: http://www.srl.caltech.edu/ACE/ASC/level2

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