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Launch in orbit of NINA detector for cosmic ray nuclei study

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Abstract

The apparatus NINA, on board the Russian satellite Resurs-O1 n.4, is in orbit since July 10th, 1998. Its scientific scope is to study the low energy component of cosmic ray nuclei. The polar orbit of the satellite allows the telescope to detect particles of different nature during its revolution: galactic cosmic rays, solar energetic particles, trapped and untrapped anomalous cosmic rays. We report here about the launch phase and present some preliminary results obtained with the first months of life in space of the detector.

1 Introduction

The Wizard-RIM (Russian Italian Mission) program is devoted to the study of cosmic rays using space borne apparatus over a range of several orders of magnitude (~10 MeV/n to ~100 GeV/n). The SilEye detector (Furano et al., 1999, Bidoli et al., 1997), devoted to the study of radiation environment on board space station MIR from 1995, is the first of these experiments. It was followed by NINA, the first satellite borne detector, part of the Russian Resurs-O1 n.4 satellite. Future work includes NINA-2, featuring a second detector, identical to the first one, placed on the Italian MITA satellite (Casolino et al., 1999 (1)) to be launched by the base of Plesetsk by the end of 1999. Other activities also involve antimatter component in cosmic rays (PAMELA).

The space telescope NINA, launched in 1998, is a silicon detector devoted to the study of cosmic rays of Solar and Galactic origin in the energy range 10-200 MeV/n at 1 AU. It is capable of nuclear identification up to Iron and isotopic discrimination up to Nitrogen, allowing the addressing of important space physics issues such as the composition and energy spectra of galactic and solar particles (including Solar Energetic Particles). The importance of such measurements is underlined by the unprecedented number of probes which are studying the heliosphere in different points of the Solar System to understand particle production and propagation mechanisms (Baker et al, 1993, McDonald, 1998, Simpson et al, 1992, Stone, E., et.al, 1998, von Rosenvinge, et. al., 1995).

In this article we describe the apparatus and the first measurements performed with NINA; some of the first physics results obtained are described in Sparvoli et al., 1999 and Casolino et al., 1999 (2).

2 Description of the apparatus

NINA is composed of four subsystems: detector, power supply, data analysis computer and interface computer. The silicon detector (Bakaldin et al., 1997) consists of 32 sensitive planes arranged in couples of X-Y readout planes: each plane has an active area of 60×60 mm^2 area and is divided in 16 strips of 3.6 mm pitch. The thickness of each detector is 380 microns (except for the first pair which are 150 microns thick). The lateral strips 1 and 16 of each detector are used as lateral anticoincidences (ACs); the strips of plane 16 or 15 may be used as bottom ACs in order to reject registration of particles not stopping in the calorimeter. The whole structure is housed in a special container filled up by nitrogen at normal pressure. The container has a 2 mm thickness except on top of the detector, where it is 300 μm thick in order to decrease the minimum energy of detectable nuclei. The detector registers an incoming particle as two (X and Y) independent tracks, recording the energy released in each strip resulting in the Bragg curve of the particle as it stops in the detector. Energy range is about 10-100Mev/n. Geometric factor is about 10 cm^2sr for low energy particles. The removal of the bottom ACs from the trigger allows an increase of NINA energy range by a factor 10 (up to about 1 GeV/n) albeit at a reduced nuclear and energetic discrimination capability.

In addition to the physical data coming from energy released in the Silicon strips, a series of housekeeping data to monitor and calibrate the behavior of instrument as function of time, temperature, and trigger rate are used. They include power supplies, silicon detector currents (in all planes), single plane trigger rate and temperatures (in critical parts of the detector box).

The detector and data handling computer systems were built by Laben Italia; the power supply and interface computer were realized by VNIIEM (Russia), the same company which realized the satellite Resurs-O1. Several integration and beam tests in PSI (Zurich) and GSI (Darmstadt) laboratories were performed prior to installation with the satellite (Bidoli et al.,1999).

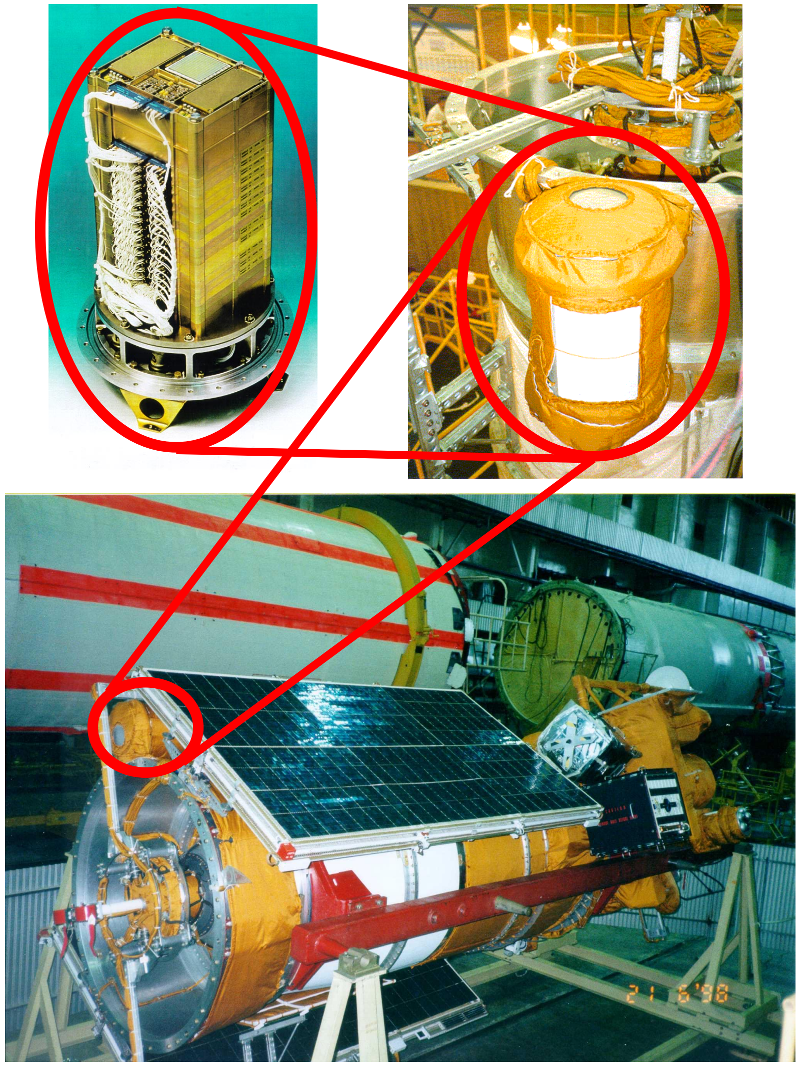

Figure 1. NINA apparatus. Top left - The Silicon detector tower without cover. Top right - the detector with cover (note the round acceptance window) being assembed on Resurs. Bottom - the telescope before launch. On the back it is possible to see the Zenit rocket . rocket.

3 Launch and first results

On July, the 10th 1998, the Resurs-O1 n.4 satellite was launched in orbit. The detector of NINA is placed, as shown in Figure 1 on top of the satellite and points toward the zenith, whereas the other three systems are housed in the interior of the Resurs-O1. The satellite has a polar circular orbit with an altitude of 835 km, an inclination of 98^0, and a period of about 6100 s, corresponding to about 14 revolutions per day. After the launch and the initial satellite orbital adjustment phase, the instrument started operations on August, the 31st 1998.

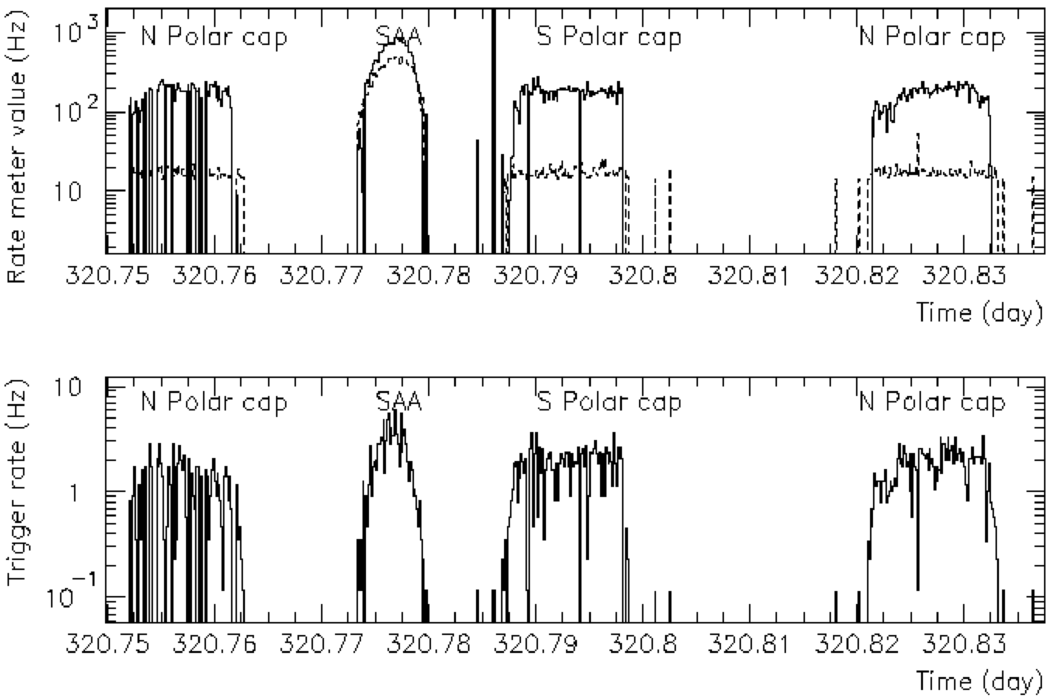

Figure 2. Response of the apparatus in the magnetosphere: it is possible to see how Rate Meter (top) and trigger counting (bottom) rate increases during passage in the polar caps (in this case detected flux is higher due to the presence of solar flare particles) and in the SAA. The rate meter shown are those corresponding to plane 1 (straight line) and 5 (dotted line). Note how the particle ratio measured by the rate meters is significantly different for polar and SAA conditions due to the different particle composition and energy spectrum.

The control of the instrument in flight is performed with 24 telecommands (TLC's); they allow the satellite to communicate with ground during passages over the receiving stations. Some of the TLC's are dedicated to operations like power switching ON/OFF, data transferring and instrument calibration. Others allow to change the trigger logic or the detector threshold. A special onboard device allows to use combinations of TLC's acting in specific points of the orbit; these programs permit to make instrument calibrations over the equatorial regions, or to stop data acquisition in regions of very high counting rate. There are 10 onboard programs for NINA on the satellite computer.

The average volume of data transferring is 2 MB/day, transmitted twice (corresponding to more then 20000 events). NINA has a 14 MB mass memory; since the average mass memory occupation in solar quiet periods is around 1.5 MB/day, there is the possibility to accumulate data for a few days, or for solar flares events, for a later transmission.

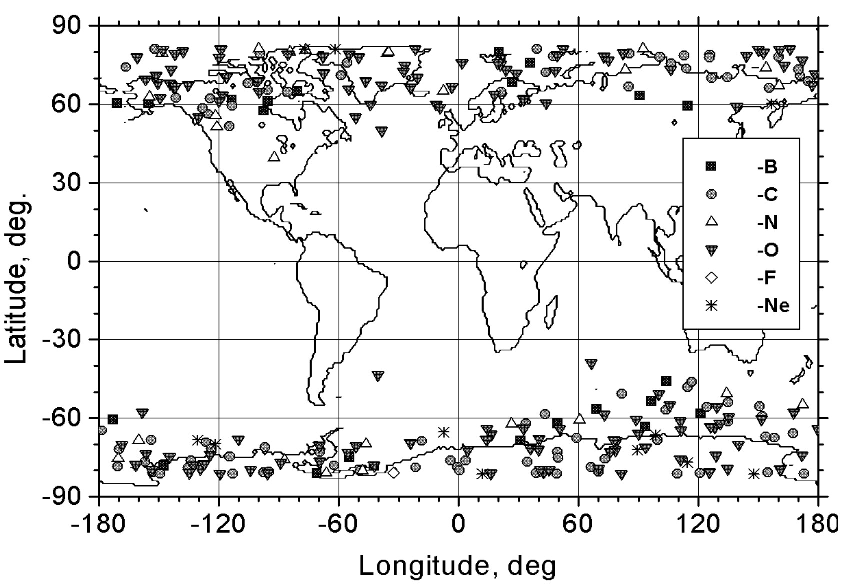

Figure 3: Map of nuclei detected by NINA during December 1998-March 1999 solar quiet period

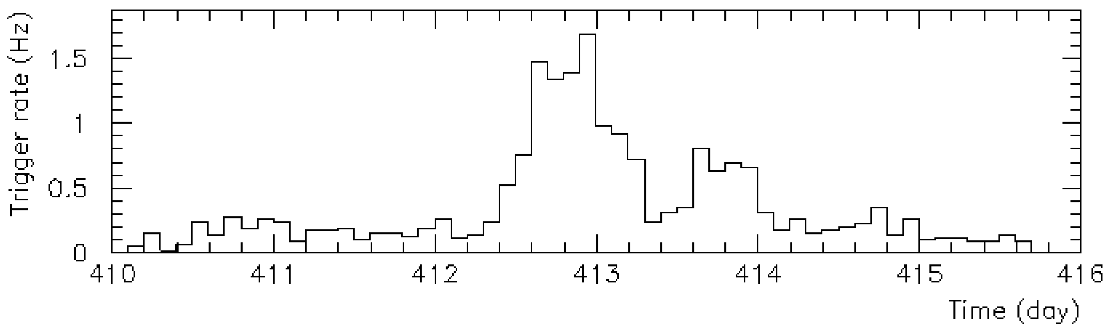

Figure 4: Detection of a solar flare by NINA. Data are restricted to particles detected in polar regions. It is possible to see the flux increase associated to the arrival of the flare at 1AU on day 412.4 (February 16) and the subsequent return to quiet time values in the following days.

The sun-synchronous polar orbit allows short and long term monitoring cosmic rays of trapped and untrapped nature. Due to the high count rate, work in the core of SAA (South Atlantic Anomaly) quickly saturates the available memory: to avoid this effect the default working condition is selected to exclude from the trigger most of the Hydrogen nuclei. A monitoring of counting rate and behavior of the radiation belts in high rate condition is however ensured by housekeeping signals. Indeed the trigger rate measured on different planes of NINA (at different thickness) allows monitoring of the amount and type of radiation impinging on the detector. Indeed the first plane, which is shielded from the top side only by the 300 micron Al window, is able to monitor also the passage in electron belts. Figure 2 shows count rate of NINA along the orbit for rate meters of plane 1 and 5 compared with trigger rate. It is possible to see how the former easily reaches many kHz during passage in SAA or polar caps, whereas the latter is much lower and of the order of some Hz rate is main trigger and low detectors threshold.

Figure 3 shows type and position of a sample of detected nuclei. Selecting particles measured at high geomagnetic latitude it is possible to measure composition and energy spectra untrapped cosmic rays of solar and galactic origin (Sparvoli et al, 1999).

As shown in Figure 4, the instrument is also capable of detection of solar flares. Up to now several such events have been detected and their temporal and nuclear behavior is being analyzed; some results are obtained are presented in Casolino at al. 1999 (2).

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