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Study of November 1998 Solar Particles Events with NINA instrument

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Abstract

Some characteristics of the 6th and 14th November 1998 Solar Particles Events, observed at 1 AU with the detector NINA, aboard the Russian satellite Resurs-01 n.4, are presented. NINA is in orbit since July 1998. The data selection involves particles detected during passages over the polar regions (L>6). The helium isotopic abundances and energy spectra between 10 and 50 MeV/n of the 6th November flare, and the abundant high Z particle acquisition of the 14th November flare, are presented.

1 Introduction

Among the most interesting features of the flares of Solar Energetic Particles (SEP) is their isotope composition which varies notably from flare to flare. Indeed, the registration of similar events with their mass composition can give important information on the processes of generation of SEP's and on the interaction of these particles with the interplanetary environment at their propagation from the Sun to the Earth (Kahler et al., 1985, McGuire et al., 1986, Mazon, 1987, Reames et al., 1990, Miller, \& Vinas, 1993). Unfortunately the detection of such events is not easy, therefore each observation has its significant scientific interest.

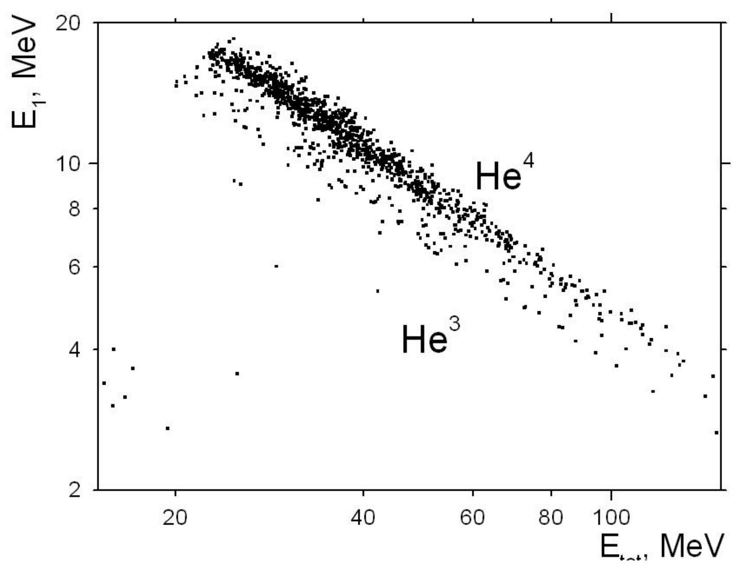

Figure1. dE/dx – E (E_1-E_{tot} for NINA detector) diagram for Z=2 particles during the 6th November 1998 flare

On June the 10th ,1998 the satellite Resurs-01 n.4 with on board the instrument NINA was launched in orbit with a Zenith launcher. The satellite has a circular polar orbit with 98° of inclination,835 km of altitude and a period of about 6100 s. The active part of NINA is the telescope consisting of 16 silicon detectors 60×60 mm^2 wide, each one consisting of two layers divided in 16 orthogonal strips (Bakaldin et al., 1997). The geometrical factor of the instrument is ~10 cm^2 sr for low energy particles.

In this paper we report about observations of solar flares in November 1998 using NINA instrument. Four solar flares were detected in this month. We will report in detail only about two of them: the one of 6th-8th November, where there was a significant increase in the detection of ^{3}He nuclei, and the one of 14th-19th November, during which the nuclear abundance of particles with Z≥2 increased over the typical values (see also M. Casolino et al., OG 4.2.07, R. Sparvoli et al., SH 3.5.01, this conference).

Data analysis

Nuclear identification in NINA, for particles stopping inside the detector, is based on the measurement of the ionisation losses dE/dx of the particle in each of the 16 silicon detectors. The telescope allows to identify isotopes of hydrogen and helium with a resolution of 0.15 amu, and of nuclei up to Z~10 with a resolution not worse then 0.5 amu. The charge and mass resolution capabilities of the instrument were studied by simulations, and tested at the GSI heavy ions accelerator in 1997 (Bidoli et al., 1999).

Due to the polar orbit of the satellite, observations of SEP's in the vicinity of the Earth occur when passing over the polar areas. Only in these regions the Earth's magnetic field allows low energy particles to reach the instrument and be stopped inside the detector. In our analysis we applied the selection L>6 on the L shell in order to detect particle fluxes with kinetic energies E≥10 MeV/n.

In November 1998 NINA worked mainly in high-threshold mode, which implies registration of almost only Z≥2 nuclei; this is the usual trigger mode which is adopted in order to reduce the onboard memory occupation. In such configuration, the observable energy window for He is 10-50 MeV/n in NINA, while the one for Z=1 particles is very narrow (12-15 MeV/n, 7-14 MeV/n, 6-13 MeV/n for ^{1}H,^{2}H,^{3}H respectively).

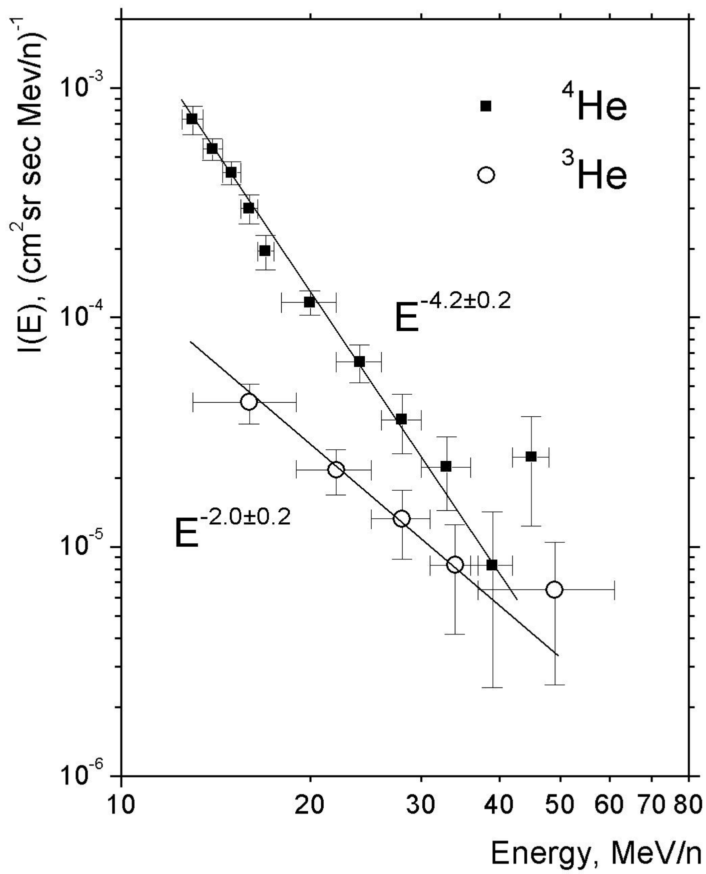

Figure 2. Differential energy spectra for the ^{3}He and ^{4}He component for the 6th November 1998 flare.

For the final estimation of the abundance ratios and the flux intensities we have taken into account the geometrical factor of the instrument, its efficiency, the efficiency of the track selection, and the exposure time. The track selection requires particles to cross at least 4 silicon layers (2 planes), not to hit the lateral strips, and eliminates double and upward going tracks. The exposure time is calculated considering the time of observation of the detector in the polar areas (L>6), which varies from 10 to 15 minutes for every passage, and the dead time of the instrument. The subtraction of the galactic background from the flare data has not been carried out so far.

3 Results of the observations

During the 6th November flare, a strong increase in the detection of Z=1 and Z=2 particles was observed, while no significant acquisition of heavy nuclei was registered. This situation is reported in Figure 1, where the dE/dx-E (E_1-E_{tot} for NINA) diagram for the helium nuclei during the flare is shown. E_1 is the energy released by the particles in the first silicon plane (two layers) of the detector, and E_{tot} is the total energy released in the whole instrument. In this figure the ^{3}He and ^{4}He nuclei are clearly identified. The counting rate ratio ^{3}He/^{4}He varied during the flare; the maximum value was reached on November 7th and it was 0.23 ±0.04. Figure 4(top) presents a reconstruction of the two isotope masses, with a resolution of the order of 0.15 amu.

The differential energy spectra for the ^{3}He and ^{4}He components are shown in fig. 2. The energy spectrum for ^{3}He is significant flatter than the one for ^{4}He. The spectra were both fitted with a power law function $E^{-\gamma}$. The spectral index γ for ^{3}He is $\gamma = 2.0 \pm 0.2$, while for ^{4}He is $\gamma = 4.2 \pm 0.2$.

The differences in the inclination of the spectra have as a result that the ratio ^{3}He/^{4}He increases with energy. A similar behaviour of these spectra was observed in early measurements on IMP-5 in the energy interval E ~ 10-100 MeV/n (Dietrich, 1973) and on CRRESS for the interval E~ 50-110 MeV/n (Chen, Gusik, \& Wefel, 1995).

In particular, in (Dietrich, 1973) results of observations of two enriched ^{3}He were described. Spectral indexes γ equal to $\gamma = 3.5 \pm 0.2$ and $\gamma = 3.15 \pm 0.2$ for ^{4}He and $\gamma = 1.9 \pm 0.6$ and $\gamma = 2.1 \pm 0.8$ for ^{3}He were obtained.

However the ratio ^{3}He/^{4}He in these measurements did not exceed a few percents. In the flare of 6th November 1998, instead, the intensities of ^{3}He and ^{4}He are practically comparable at E ~ 40 MeV/n. The ratio ^{3}He /^{4}He exceeds of almost one order of magnitude the ones observed on the IMP-5 and CRRESS satellites at the same energy.

On November the 14th a second solar event was observed. This flare differed from the previous one for its enrichment of heavy ions.

In figure 3 the diagram dE/dx-E (E_1-E_{tot} for NINA) for Z≥6 nuclei detected in this flare is presented. The picture shows a qualitative conformity of the flare elemental composition to the one of the solar corona.

In this flare the acquisition of ^{3}He seems to be lower than the one of the 6th November flare,

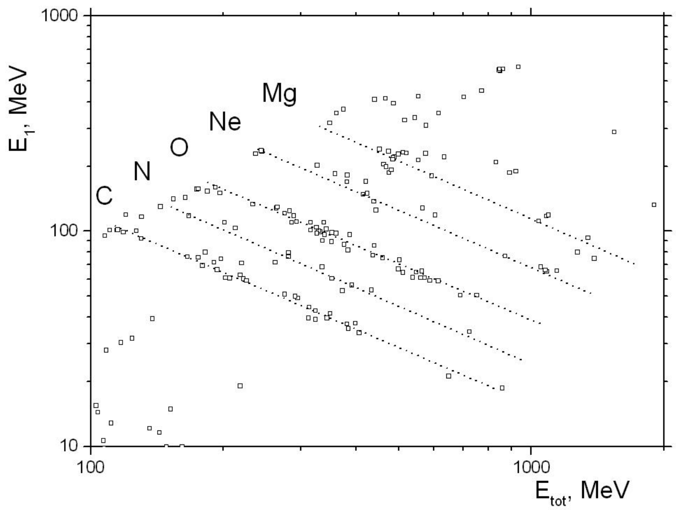

Figure 3. dE/dx-E (E_1-E_{tot} for NINA) diagram for Z≥6 particles during the 14th November 1998 flare.

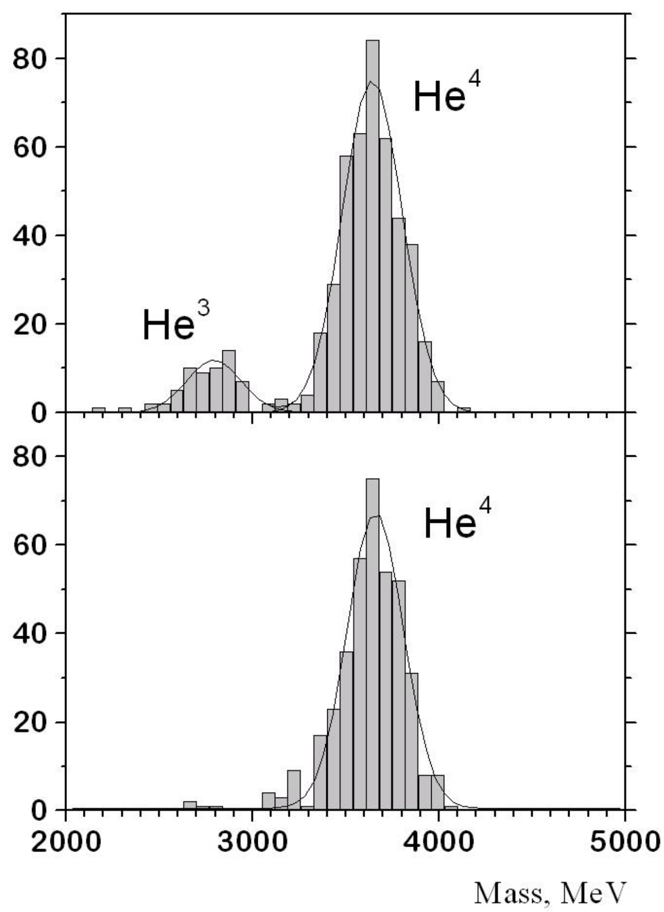

Figure 4. Mass reconstruction for Z=2 particles during the 6th November 1998 (top) and 14th November 1998 (bottom) flare. Number of events on Y axis.

as figure 4 (bottom) shows.

Figure 5 shows the mass distributions for the hydrogen isotopes for the two flares in the narrow energy interval allowed by the trigger configuration. We note the practical absence of heavy hydrogen isotopes in both events.

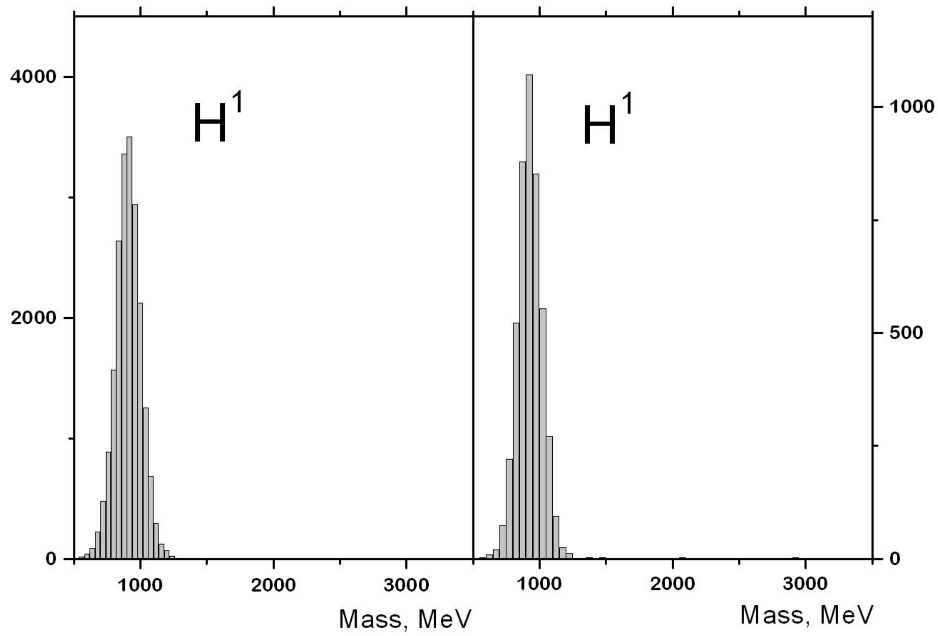

Figure 5. Mass reconstruction for Z=1 particles during the 6th November 1998 (left) and the tail of 14th November 1998 (right) flare.

4 Conclusions

In November 1998 the telescope NINA, onboard the Russian satellite Resurs-01 n.4, detected several solar flares.

The flare of 6th November presents a high enrichment of the ^{3}He isotope for energies up to 40 MeV/n. On November the 14th a flare enriched of high Z particles was detected and investigated as well. Some characteristics of both flares have been presented in this paper; the analysis of these and the other events of solar nature detected by NINA instrument is actually in progress. A detailed study of these flares in correlation with other radiation bands, and in conjunction with data of the interplanetary environment, will provide new hints about the nature of similar events.

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