

**2. The results of scientific research on completed space missions obtained
by Russian scientists in 2014-2015**

**Fe ion spectra measured in solar cosmic ray events of 1989 and 2003
(PLATAN experiment)**

A series of experiments PLATAN (PLASTic Track ANalyzer) was carried out on board of orbital stations Salyut, Mir, and ISS from 1978 to 2004. The aim of experiments was the study of heavy particle component of solar and galactic cosmic rays (SCR and GCR) with low energies (from tens to hundreds MeV/nucleon). Chambers consisting of sheets of solid state track detectors were exposed on the outer surface of orbital stations.

Large solar particle events were recorded by the PLATAN equipment in September-October 1989 (Mir station, PLATAN-3 chamber) and in October-November 2003 (ISS, PLATAN-M chamber).

In Fig.1 the charge distributions of heavy nuclei measured in PLATAN-3 (a) and PLATAN-M (b) experiments are shown. Nuclei with even charges from Ar ($Z=18$) to Fe ($Z=26$) appear as distinct peaks in the distribution where the major contribution make Fe ions of the SCR. Charge resolution obtained in the PLATAN experiment allows reliably separate the Fe peak for the energy spectrum calculation.

For the large SCR events of 1989 and 2003 energy spectra of Fe ions were measured in the energy ranges 5–200 MeV/nucleon (1989, Fig 2a) and 25–90 MeV/nucleon (2003, Fig. 2b). Using the model of charged particle penetration to the near-Earth orbit (NIIYaF MSU, R.A. Nymmik) the measured spectra were transformed to the interplanetary space outside the magnetosphere of the Earth

(Figs. 2a, b). The spectra were approximated with good accuracy by the power functions of energy with spectral indices -3.26 ± 0.03 (1989) and -4.04 ± 0.09 (2003) (Table 1).

Comparison of spectral indices for Fe ions and protons (OMNIWEB) in the events of 1989 and of 2003 shows the strong Fe enrichment of the elemental composition for the SCR event of 1989 (Table 1).

The results of the PLATAN-3 experiment transformed into the near-Earth space were compared with the data obtained outside the magnetosphere of the Earth by the VLET and CRT instruments on IMP-8 (Fig. 3a). General coincidence of the results obtained by different measurement techniques can be seen. There is some discrepancy between VLET and CRT spectra arising possibly due to calibration errors. In Fig. 3b the PLATAN-M data transformed to the interplanetary space are compared with the results obtained outside the magnetosphere of the Earth by the SIS instrument (ACE spacecraft). General coincidence of the results obtained at the two space stations can be seen. However some of the SIS energy channels display spread of flux values which can be explained by the measurement errors. Especially large outlier was observed at the energies $E \sim 90$ MeV/nucleon.

Conclusions

Energy spectra of Fe ions in the 1989 and 2003 events were measured by the PLATAN chambers in details and with good accuracy for the energy range from tens to several hundreds MeV/nucleon. The PLATAN data were transformed from the near-Earth orbit to the interplanetary space. Results of these calculations show a good agreement with the data obtained outside the magnetosphere of the Earth.

Energy spectra of large events of 1989 and 2003 can be accurately approximated as a power function in the considered energy range. The events of the year 1989 significantly exceed in Fe flux those of the year 2003. Strong Fe enrichment of the elemental composition is observed for the SCR event of 1989.

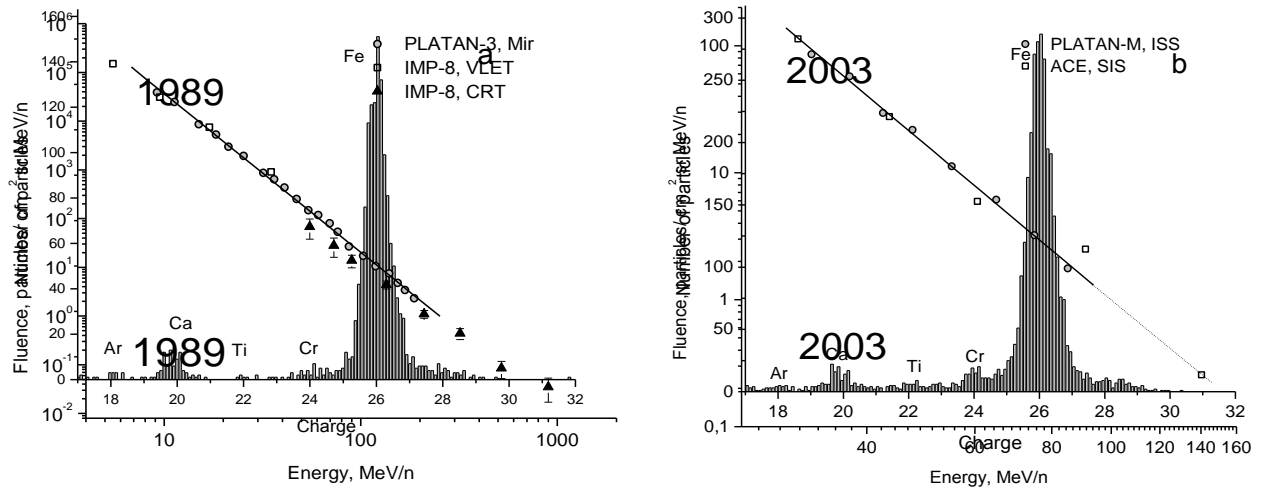
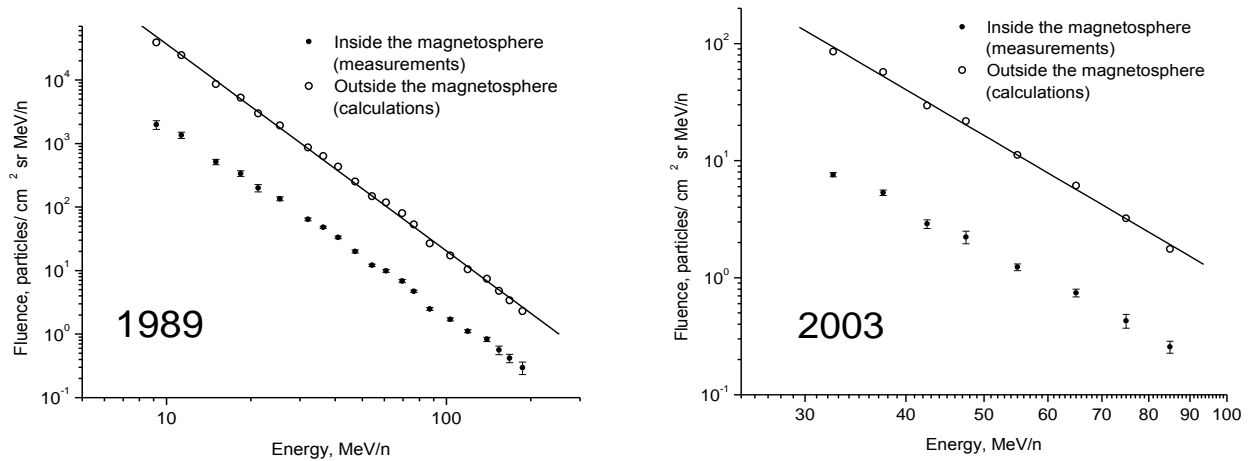


Fig. 1 Charge composition of particles measured in experiments PLATAN-3 (a) and PLATAN-M (b).



The major contribution to the charge spectrum make Fe ions of the SCR.

Fig. 2 Fe ion spectra of the SCR measured on the orbital stations in experiments PLATAN-3 (a) and PLATAN-M (b) inside the magnetosphere of the Earth. Measured spectra were transformed to the interplanetary space using NIIYaF MSU model (R.A. Nymmik). The spectra outside the magnetosphere were approximated by the power function of energy.

Fig. 3 Comparison of the Fe spectra of SCR measured outside the magnetosphere of the Earth with the data of PLATAN-3 (a) and PLATAN-M (b) experiments transformed to the interplanetary space. General coincidence of results obtained by different measurement techniques can be seen.

Table 1. Spectral indices of the Fe ions (PLATAN experiment) and protons (OMNIWEB) in large SCR events of 1989 and 2003.

SCR events	Spectral index Fe	Spectral index p
September October 1989	-3.26 ± 0.03	-4.01 ± 0.18
October November 2003	-4.04 ± 0.09	-3.77 ± 0.65

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