

# A real-time cosmic ray monitoring at the Antarctic station Mirny

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**Abstract.** We depict the Antarctic cosmic ray station Mirny, which has been modernized to meet the requirements of the modern cosmic ray monitoring. There is given a description of the subsystems of registration, acquisition, and a subsequent real-time transmission via satellite of the cosmic ray intensity data with a 1 minute temporal resolution. Also, a quality estimation for the last observation period is shown.

**Keywords:** Neutron Monitor, Cosmic Ray Variations, Data Acquisition

## I. INTRODUCTION

Because of a non-uniformity of the detector points of the global neutron monitor network, every cosmic ray station in the South hemisphere is of an especial importance. Besides, the high-latitude detectors of cosmic radiation possess a number of unique properties: their threshold being defined exclusively by the atmospheric absorption, all the high-latitude neutron monitors situated at the sea level have a nearly identical energy sensitivity. This is a great advantage for the study of cosmic ray anisotropy, because there is no need to make any corrections for variation of the cut-off rigidity at different stations. Another preference of high-latitude stations is connected with their excellent directional sensitivity, in contrast to the middle- and low-latitude ones. In fact, at high latitudes the cosmic ray particles experience a strong focusing influence when approaching the Earth's surface; as a result, only the particles moving inside the very narrow (of some degrees) "acceptance cone" have appropriate initial conditions to be able to achieve the surface without mirroring back. Hence, the network of polar stations permits to gain a "snapshot" of the three-dimensional flow of cosmic rays, much more complete and distinctive, than any satellite-based observation could be.

## II. GENERAL DESCRIPTION OF THE MIRNY STATION

The standard 12NM64 type neutron supermonitor of the Mirny cosmic ray station was re-activated in the beginning of 2007 year, where a full modernization of its whole electronics has been done. The monitor is equipped with a data registration and data acquisition system on the basis of the industrial counter/timer card *Advantech PCI-1780U*. This system satisfy all the modern claims of cosmic ray monitoring: it ensures a necessary operation speed, its temporal resolution is of the order of 1 minute and higher, it has a possibility of a

real-time transfer of measurement data and their online publication with the use of the satellite system *Iridium*. For correction of the local computer's time, the system is equipped with a GPS receiver, it includes also a high-sensitive digital barograph for precise registration of atmospheric pressure (with an accuracy of 0.2 mb), the sensors of outdoor temperature and speed of wind. All the accompanying environmental information, so as the monitoring results of the intensity of neutron component, are written with a 1-min temporal resolution. The control software of neutron monitor installation works under the *Windows* operation system, it may be downloaded by internet address [ftp://cr0.izmiran.rssi.ru/NMDB\\_doc/RegistrationSystems\\_MARS/\(PCI-1780\)/](ftp://cr0.izmiran.rssi.ru/NMDB_doc/RegistrationSystems_MARS/(PCI-1780)/), and its more detailed description may be found in [1].

The neutron supermonitor of the Mirny station, so as the building where it is hosted, are shown on photos of the figure Fig. 1. The main characteristics of the cosmic ray station are listed in Table I.

TABLE I: Characteristics of the cosmic ray station Mirny.

Detector	12NM64
Altitude a.s.l.	30 m
Overlap thickness	10 g/cm <sup>2</sup>
Average count rate	130 s <sup>-1</sup>
Geographic coordinates	66.55S, 93.02E
Standard pressure	1030 mb
Accuracy of pressure measurement	0.2 mb
Accuracy of time correction	1 ms

In Table II are presented the response coefficients of the North-South anisotropy  $C10$ , diurnal variation  $A11$ , and the asymptotic latitude of particle arrival  $P11$  for the neutron supermonitor at Mirny, together with some other polar stations. These parameters are calculated for the variation spectrum index of the first harmonic  $\gamma = 0$ ,  $R_u = 100$  GeV, and for a minimum of solar activity. It is seen, that the Mirny station has an intermediate location, while the most appropriate for the study of the North-South asymmetry is the station McMurdo, with its minimal module of the  $C10$  coefficient, and its lowest sensitivity to diurnal variation.

## III. THE REAL-TIME DATA TRANSMISSION

The Antarctic stations are situated mostly at a margin of the receiving zone of the majority of satellite networks. The only exception is the network *Iridium* which consists of 66 satellites on the near-polar orbits, ensuring a reliable communication with the high-latitude



Fig. 1: The neutron supermonitor at the Antarctic station Mirny.

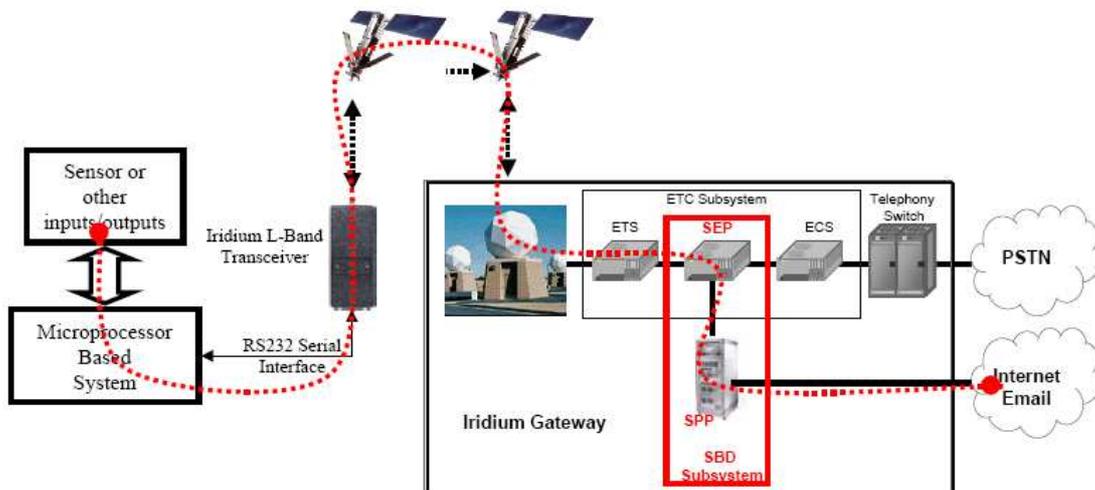


Fig. 2: Schematic of the data transfer via the *Iridium* network. (*SBD* — Short Burst Data; *SPP* — SBD Post Processor; *ETC* — Earth Terminal Controller; *ECS* — ETC Communications Subsystem; *ETS* — ETC Transmission system; *SEP* — SBD ETC Processor; *PSTN* — Public Switched Telephone Network).

TABLE II: Parameters of the polar cosmic ray stations (see text).

	Mirny	Terra Adele	Sanae	Vostok	Thule	South Pole	McMurde	Mawson
C10	-0.6057	-0.7221	-0.2964	-0.8547	0.7740	-0.7501	-0.7981	-0.4839
A11	0.5220	0.3610	0.6850	0.2840	0.2340	0.4350	0.1180	0.6230
P11	-7.85	-18.72	20.42	-55.58	26.86	-8.56	106.61	-5.54

stations with an efficiency about 100%. Also, this system supports the short burst data operation mode (SBD) which is ideal for the real-time data transfer sessions [2], [3] and may be a favorable low-cost solution. In the figure Fig 2 is shown a principal scheme of the data transfer at Mirny station, starting from the primary detector, and up to the final mail server we use. As a transceiver at Mirny is used the SBD-9601 type modem.

The data flow of Mirny cosmic ray station is organized as following: a short data file with a size about 30 bytes (it contains a 4-byte time mark and 12 two-byte measurements of neutron intensity) is sent as a mail message; accepted by the mail server; decoded; and loaded into a database. If some failure occurs, the message may be

stored at intermediate servers until the recovery of the information channel; the procedure of database renewal in this case takes into account additional time delay and restores the correct order of data packages. Operation of this system is extremely stable: during the 4-month long test period no packages has been lost, and the mean temporal delay of data arrival was about some minutes (see the figure Fig 3).

#### IV. DISCUSSION OF THE RESULTS

The data being accepted from Mirny station, are accumulated in the database of IZMIRAN (<http://cr0.izmiran.rssi.ru/mrny/main.htm>) and simultaneously transmitted to the European high-resolution real-time database NMDB (<http://db01.nmdb.eu/phpmyadmin>). The data

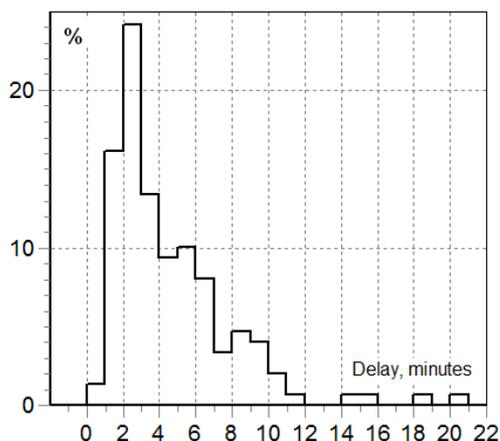


Fig. 3: Distribution of temporal delays in arrival of data packages from Mirny station.

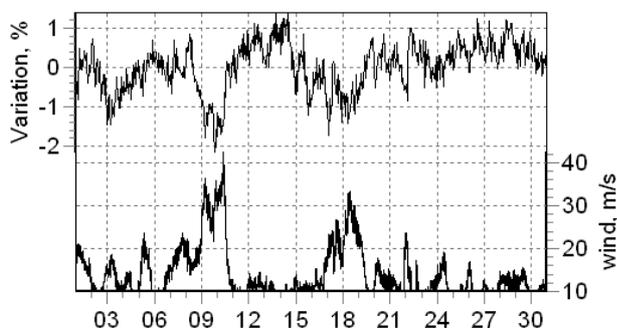


Fig. 4: Typical variations of the counting rate of neutron component (not corrected to Bernoulli effect), and the wind velocity at Mirny station in June, 2007.

acquisition procedure, as a whole, succeeds in a real time. This procedure includes, in particular, a necessary correction of neutron intensities for the variable thickness of the snow [4] and for the Bernoulli effect. At Mirny station, there are not particular problems with snow blanket, but the influence of Bernoulli effect is very considerable, the wind velocity often rising up to 20 – 40 m/s [5], [6], [7]. Because of this influence, the pressure estimations at ground level occur something lower, than the weight of the air column which defines the barometric effect in cosmic ray intensity. In the figure Fig 4 are shown the typical variations of the counting rate of neutron component and of the wind velocity at Mirny station during a winter month.

In [8], an estimation is drawn for the efficiency of neutron detectors in comparison with the epoch of 2008. For that purpose, there were used two different methods: (1) the one based on a variation model, when any discrepancy between the model predictions and experiment are totally related to a change of detector efficiency; (2) another one, when the efficiencies of the neighboring stations with similar cosmic ray variation are defined as a relation between their measurements.

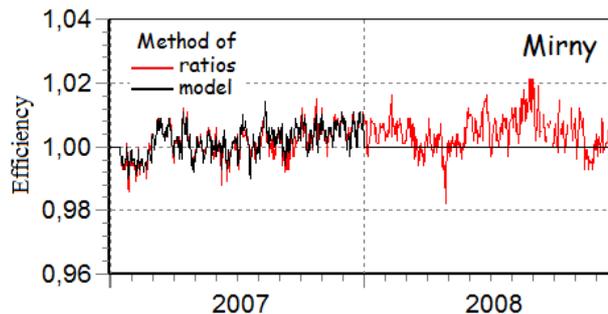


Fig. 5: Efficiency estimation for the Mirny station drawn by the model method (black curve) and by the method of relations (see text). The efficiency values are normalized to the level of February, 2008.

If both independent methods give a similar result, this is a correctness evidence of the used approach. Such estimations for the Mirny station are presented in figure Fig 5. Thou the observation period here is not very long, with exception of the winter season of 2008 year, the trend of detector efficiency does not exceed 0.01.

#### V. CONCLUSION

A two-year exploitation of the modernized cosmic ray station Mirny has shown a reliability of the data registration and acquisition system even with a non-ideal power feeding under expedition conditions. Also, a steady operation reliability has proven the satellite system *Iridium*, which ensures a real-time transfer and Internet publication of the data of Mirny cosmic ray station with a minute resolution.

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