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Continuous monitoring of environmental radiation in the Arctic

D. Cattani[1], **S. Cecchini**[2], **M. Galli**[1], **G. Giovannini**[1], **G. Longo**[1], **A. Pagliarin**[1], **and M. Trabisondi**[3]

[1]Dipartimento di Fisica dell'Universita', 40126 Bologna, Italy
[2]Istituto TeSRE/CNR, 40129 Bologna, Italy
[3]Via Misa 7, 40138 Bologna, Italy

Abstract. For more than one year a detector for environmental radiation (airborne radionuclides and cosmic rays) has been operated at the Italian base in the Arctic. We report here on time variations of the cosmic ray component in the energy range 3-18 MeV and compare them with observations made by neutron monitor stations at different latitudes.

1 Introduction

The systematic study of time and spatial variations of the Environmental Radiation (ER), i.e. cosmic rays (CR) and radioactivity gamma's with E > 50 keV, was firstly developed in the framework of the ENEA-PNRA project with special regard to the Antarctic environment. Following the two latitudes surveys of the ER in 1995 and 1996 winters (Galli et al., 1997) one of our standard detectors was put in operation at the Italian Antarctic base at Baia Terra Nova (74º.7 S,164º.12 E) since Dec. 7th 1997. It registered data almost continuously with few interruptions for more than 1.5 year (M. Brunetti et al., 1999b). Meanwhile several measurement campaigns (Brunetti et al., 1999a; Aglietta et al., 1999; Longo et al., 2001) have been carried out in order to study the dependence of ER properties on the different locations.

Antarctic environment immediately appeared as a special observatory for ER and so we decided it would be interesting to compare simultaneous ER observations at two high latitude sites. We put into operation a standard detector at the Italian base in the Arctic (Ny Alesund, Norway 79º N, 11º E) since September 1998. The base is accessible any time during the whole year, so that colleagues from other permanent bases can have access at the detector and check the status of the data acquisition. For this reason the interruptions are usually short in time and the recovery of the data occur regularly. This is not the case of the Antarctic base that is not permanent and is closed at the end of the austral summer - usually by the end of February each year. Unfortunately the detector located in Antarctica started to malfunction soon after the base was closed by the end of February 1999 and finally the acquisition stopped due to the breaking of the personal computer.

Here we present some results concerning the observations of the cosmic ray component with energy in the range 2.8-18 MeV and compare them to the observations of a neutron monitor station at a similar latitude.

2 The detector and data acquisition

The standard scintillation detector based on a NaI(Tl) monocrystal has been already described in Galli et al. (1997a). The acquisition system has been changed and it is based on the Genie2k computer card (Canberra manufactured) with 2048 channels. A software program DAQ has been developed for the purpose of registering data with pre-selectable time interval (>1min) for a certain number of measurements. A separate software allow to obtain a quick-look of the stored data. In this way it is possible to reconstruct the time history of counts accumulated in different channel band/range (up to 11) from the last completed measure. The choice of the bands is made in order to isolate photopeaks of interesting radionuclides (airborne or local) - e.g. Radon daughters, Thoron daughters, ^{137}Cs, ^{40}K, ^{214}Pb etc.- and cosmic ray components (ultrasoft, 3-8 MeV and soft, 8-18 MeV). An example of the time history plots for 3 bands, is shown in Fig. 1.

Due to the limited space of the data storage device and in order to limit the number of interventions, the sampling time was 15 min. The average counting rate of total cosmic ray component is 6500 counts/15min. At present we are implementing a remote control of the system via Internet.

Correspondence to: cecchini@bo.infn.it

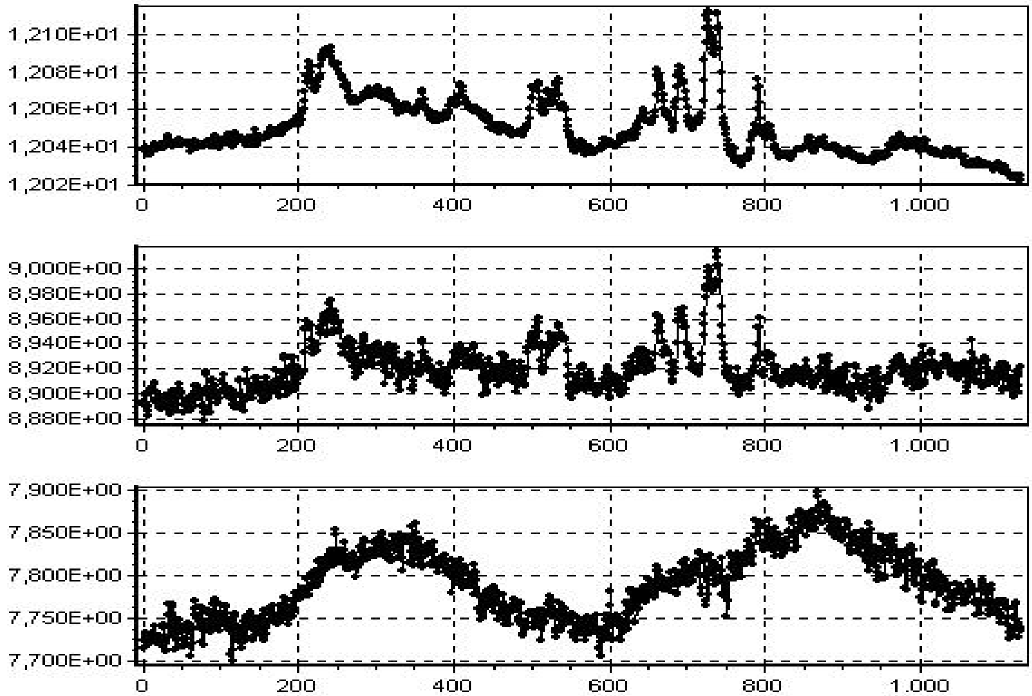

Fig. 1. Plot of the data acquisition quick look for the period 11/03/2000 - 7:32:00 UT to 23/03/2000 - 4:11:00 UT. Here only three times series of the logarithm of the counting rates with 4 min. sampling time are presented: upper plot - total spectrum; middle plot - Bi^{214} in the band 550-640 keV; bottom plot- cosmic ray component in the band 3-10 MeV.

3 Pressure and temperature effects

It is well known that cosmic ray components undergo time variations as a consequence of changes of atmospheric conditions (Dorman, 1974). The two main meteorological effects affecting the observed counting rates are due to atmospheric temperature and pressure. We calculated the temperature and pressure coefficient via linear regression using the data of the AWI station in Svalbaard available at the Internet address http://www.awi-bremerhaven.de. For the pressure, the value results

$$\beta_p = -(0.34 \pm 0.02)\ \%/\text{mbar}$$

which is in agreement with what already reported by Galli et al. (1997a) and Brunetti et al (1999a) and Dorman (1974).

For the temperature we used only the ground temperature values (also from the same source) and in this case the coefficient resulted

$$\alpha_t = (0.057 \pm 0.003)\ \%/\ °C$$

Even in this case the value agrees with what found by Brunetti et al (1999a).

4 The observations

Here we present the data record of July 2000 when a significant Forbush decrease (FD) occurred. The record of the 3-hourly NyA data, corrected for temperature and pressure, is presented in Fig. 2 together with the data recorded by the Oulu neutron monitor station (65°.01N, 25°.50E). Fig. 3 shows the ratio of the Oulu to NyA counting rate.

From the last figure it is clear that with respect to the pre-FD, the relative pre-increase [day 11-13 July] is more pronounced in our data; the decreases of day 13 and day 15 July are larger in NyA detector, while the GLE observed the July 14^{th} is very much reduced compared to what observed by Oulu station. Finally the diurnal variations occurring during the recovery phase of the decrease appear to be larger in NyA detector. The latitude effects observed by our detectors during two latitude surveys (Galli et al., 1997) seems to indicate that it is responding to primary cosmic ray with rigidity in between the neutron monitors and the meson monitors. Few others event of this kind have been recorded since the beginning of data taking. The behaviour is very similar in the majority of cases. It is clear that it is necessary to compare the our data with the data collected in the same periods by neutron and meson monitors in the

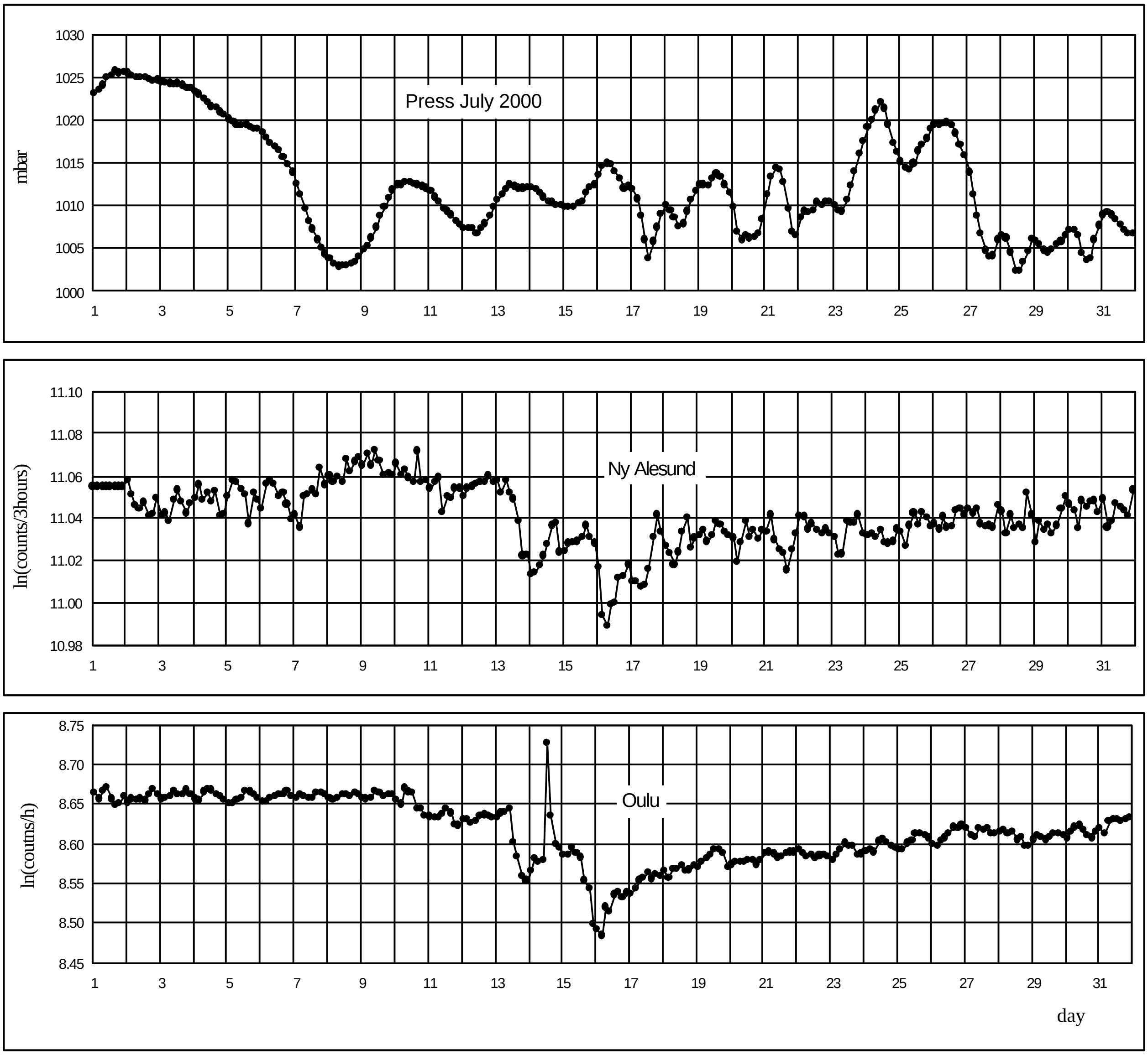

Fig. 2. 3-hourly data records of July 2000. Top panel: atmospheric pressure; middle panel : corrected cosmic ray component registered by the ER scintillation detector at Ny Alesund; bottom panel corrected cosmic ray data registered by Oulu NM stations.

world wide network to fully understand the observed behaviour and the spectral and directional variations of cosmic ray intensity at the occurrence of transient interplanetary phenomena. At present we are collecting this data and information on the IMF at the time of the events.

5. Conclusions

A new detector for the study of soft cosmic ray component has been put in acquisition at very high latitude. Its main characteristics are easy transportability and compactness. Its capacity typical counting rate can allow the study of primary cosmic ray variations being sensitive to rigidities in between the neutron monitors and the meson monitors. It will be a useful tool for the understanding of cosmic ray modulation mechanisms in occasion of transient phenomena.

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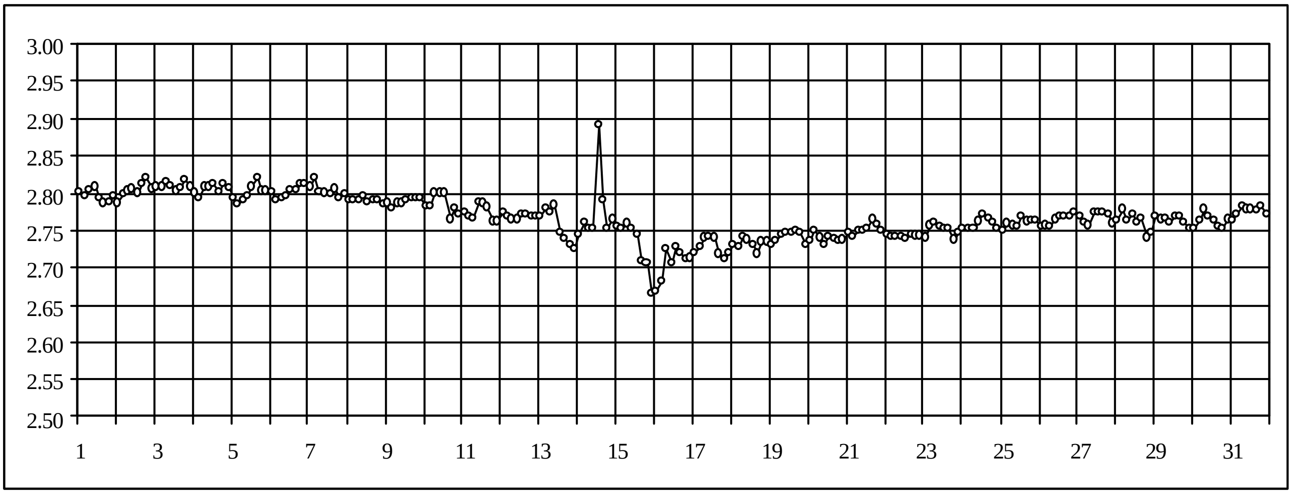

Fig 3. Ration between the 3-hourly percentage variations of Oulu neutron monitor and comic ray component of NyA detector.