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Monitoring the environmental radiation at the Chacaltaya Cosmic Ray Laboratory(*)

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Summary. — After a brief summary of the results obtained up to now by a world wide survey of the Environmental Radiation, we discuss the possibility of operating a compact scintillation NaI(Tl) detector at the Chacaltaya Cosmic Ray Laboratory in order to monitor with continuity the low energy secondary cosmic radiation and radioactivity, airborne and from environment matter.

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1. – Scientific motivations

In the last few years we have shown the convenience of monitoring on minute and hourly basis the *Environmental Radiation* (ER: cosmic rays and airborne radioactivity with energy greater than 50 keV) by means of a large NaI(Tl) scintillation detector (10 cm $\times$ 20 Ø cm), with the possibility of separating the two components and identifying the nature of the radio-nuclides [1, 2]. With such detectors, duly standardized, we have studied, beginning from 1995, the latitude and altitude variations of the ER with expeditions from Italy to Antarctica through the Indian Ocean (three years) [1-7], at Gran Sasso (970 and 2000 m a.s.l.) [8-10], at the Ev-K2-CNR "Piramide" Laboratory (Nepal), at 5000 m altitude [5, 6, 9, 10], on board of an aeroplane at 7000-8000 m altitude and at Cheko Lake (Siberia) [11].

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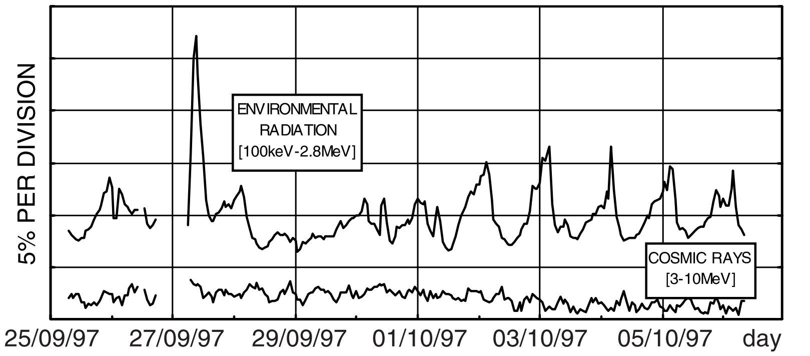

Fig. 1. – Minute counting rate in the 0.1–5 MeV energy range (upper curve) and cosmic ray component in the range 3-10 MeV (lower curve) recorded at the "Piramide" Laboratory of the Ev-K2-CNR Project (5005 m a.s.l.).

Many interesting new phenomena have been observed. Among them we would like to recall:

i) very sharp discontinuities in the X-ray counting rate in the energy band 50 keV–3 MeV, when the ship approached the harbour from sea and viceversa, during the expeditions Italy to Antarctica and return, originating from the different concentrations of uranium and thorium daughters over the sea and in land [1, 2];

ii) enhancements of short duration (a few hours), called *Radonic Storms*, in the level of radon daughters observed at sea and probably due to the wind flowing from land and transporting radioactive aerosol [1-4];

iii) minute range bursts of gamma rays up to 10 MeV that have been detected in association with perturbed weather conditions (thunderstorms) during the Gran Sasso campaign; for the first time it has been possible to reveal on ground high energy gamma radiation unequivocally produced during thunderstorm activity and this deserves further research [8-10];

iv) in Nepal, a fairly regular diurnal wave, of amplitude 5–10% , in the counting rate corresponding to the radon daughter concentrations [5, 6, 8, 9], see fig. 1.

As a consequence of our previous experiences we consider of great interest the possibility of running one of our standard detector at the Chacaltaya Cosmic Ray Laboratory (5230 m a.s.l.). Due to its position, it can offer unique opportunities for studying the different component of the ER and their temporal variations. In particular:

a) variations of the low energy component (3–10 MeV) of cosmic radiation, which is about 10 times more abundant at this altitude than at sea level, see fig. 2;

b) the relation between variations of US cosmic rays either due to direct emission of CR from the Sun or to the solar modulation that in the period 2000-2001 will reach the maximum of the present cycle;

c) with a particular arrangement it should be possible to monitor also the neutron component that at the laboratory altitude is measured to be 20–30 times higher than at sea level and especially to monitor the direct emission of neutrons by the Sun; in fact the place is privileged (due to the low latitude and high altitude) as by more than the 25% of the time the Sun is above the horizon viewed with a slant depth of less than 1000 g/cm^2;

d) seasonal and diurnal variation of the ER connected to local weather conditions and the atmospheric transport of radionuclides in a region never explored before;

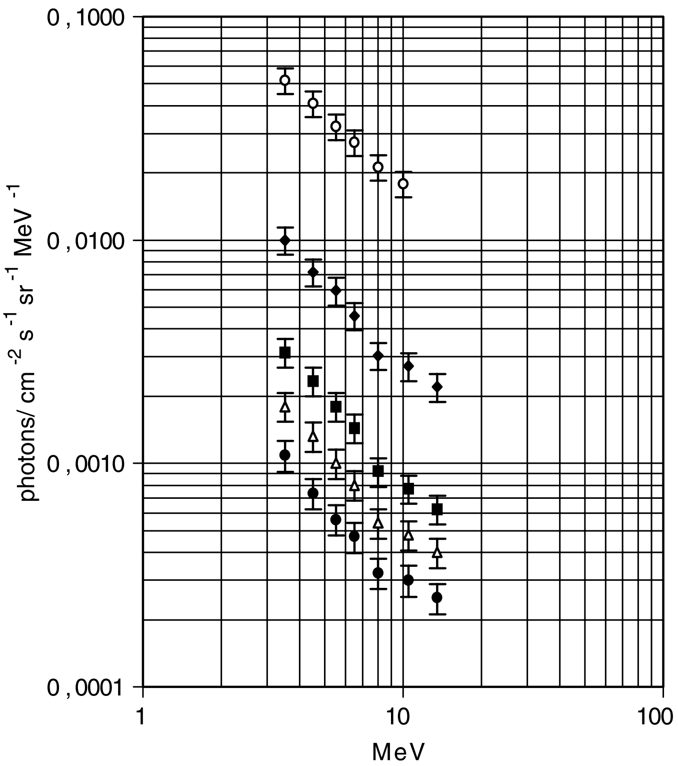

Fig. 2. – Comparison of the differential energy spectra recorded at different altitudes: •, sea level, 1030 g/cm^2; △, Laboratorio Nazionale del Gran Sasso, 915 g/cm^2; ■, EASTOP Laboratory, 845 g/cm^2; ♦, "Piramide" Laboratory, 550 g/cm^2; ○, aeroplane, 340 g/cm^2. The attenuation length resulted of (173 ± 8) g/cm^2 which is consistent with the value of (188 ± 12) g/cm^2 obtained by Ryan *et al.* [12] from balloon experiments in the same γ-ray energy range.

e) rapid variations (on the minute scale) of the gamma component with $E > 1$ MeV during perturbed weather conditions (thunderstorms) and their association with the development of air showers;
f) to study possible correlation between variations of cosmic ray flux and atmospheric ozone.

Finally the observations of the ER can provide useful information for the studies of human physiology at great altitude and the influence of the environment on men.

2. – The detector

The detector is an improved version but with minor changes with respect to the one described in Cecchini *et al.* [1]. It is based on a NaI(Tl) mono-crystal having the dimensions (10cm × 20Ø cm) and 1 cm of Pb, 0.1 cm of Cu and 0.3 cm of Al shaped around the crystal (see fig. 3). It is provided with wheels for easy movement on a smooth surface. It can be easily dismounted and assembled. The upper shield surrounding only the NaI crystal can be easily removed. The PMT HV supplied by the new ACQ card coupled to a PC is very stable. It can accumulate 2048-channel spectra every minute (or

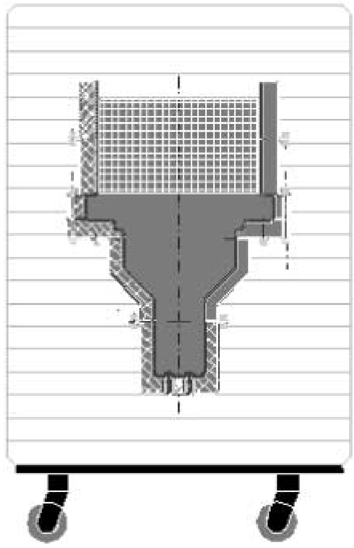

Fig. 3. – Drawing of the new version of our standard detector. The NaI(Tl) mono-crystal, together with its PMT is embedded in a box of thermal insulator.

more) with tunable energy resolution. Online programs allow a quick-look analysis and graphical inspection of the data collected in different pre-set energy bands (see fig. 4).

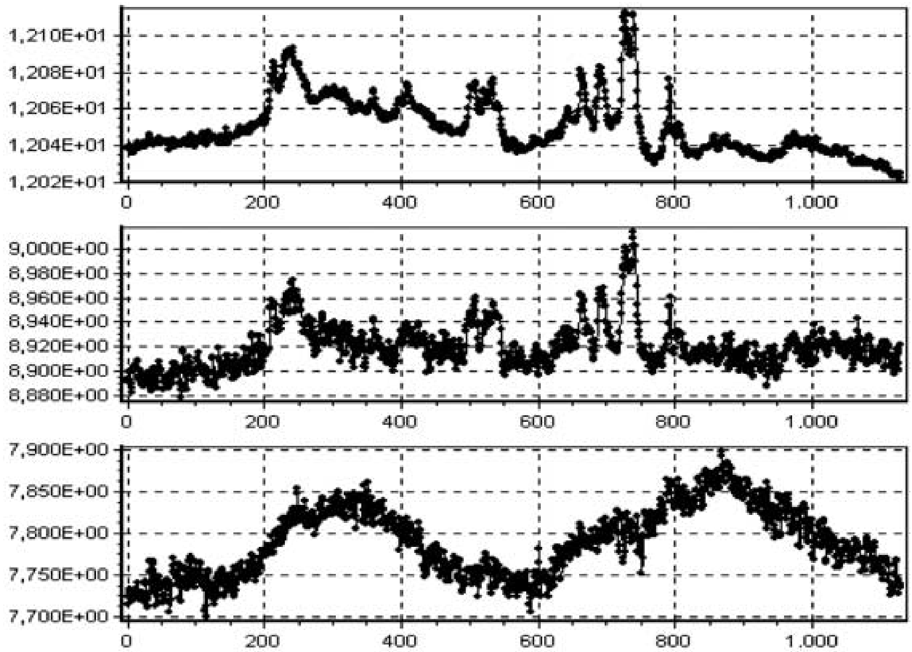

Fig. 4. – Plot of the data acquisition quick look for the period 11/03/2000 - 7:32:00 UT to 23/03/2000 - 4:11:00 UT. Here only three times series of the logarithm of the counting rates with 4 min. sampling time are presented. Upper curve: total spectrum; middle: ^{214}Bi in the band 550–640 keV; lower: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

3. – Conclusions

In view of the just mentioned favourable conditions of the Chacaltaya site it is desirable to have one of our detectors functioning by the Cosmic Ray Laboratory and acquiring data continuously for a period not inferior to six months, possibly one year, in order to cover the maximum phase of the present solar cycle and to unravel short and long duration variations in the ER. As other experiments for EAS are also operating at the same locations it would be possible to study the correlation of short time events recorded by different detectors.

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