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Neutron Flux Meter at Basic Environmental Observatory Moussala

ALEXANDER MISHEV[1], ALEXANDER BOUKLIYSKI[1], LORENZO VISCA[2], OSCAR BORLA[3], JORDAN STAMENOV[1], ALBA ZANINI[3]
[1]*Institute for Nuclear Research and Nuclear Energy-Bulgarian Academy of Sciences, Bulgaria*
[2]*Torino University Experimental physics department, Italy*
[3]*Instituto Nazionale di Fisica Nucleare section of Turin, Italy*
mishev@inrne.bas.bg

Abstract: The final design of neutron flux meter based on gas-filled SNM-15 detectors is presented as well several preliminary experimental and Monte Carlo results. The aim of the complex is to provide with high statistics and precision measure of the absolute secondary neutron cosmic ray flux. The scientific potential of detector complex is described.

Introduction

The Basic Environmental Observatory (BEO) Moussala is located on the top of the highest mountain at Balkan Peninsula, precisely at 2925m above sea level. During the last several decades the high mountain observatories have been exploited not only for cosmic ray and astroparticle studies but for environmental studies and observations of the Sun-Earth system. In the last years one of the most existing topics in the area of Sun-Earth system investigations is the possible influence of cosmic ray on terrestrial atmosphere, especially the connection between low energy cosmic ray and the Earth atmosphere. As example the variations of the cosmic rays may be responsible for the changes in the large-scale atmospheric circulation associated with solar activity phenomena [1]. Presently several arguments claims that the Solar activity affects the global climate in different aspects and timescales. One possibility is based on climate response to changes in the cosmic ray flux and radiative budget. Among the existing techniques for investigation of cosmic ray variations the registration of secondary neutron component is very convenient. This is the main reason to develop a neutron flux meter at BEO Moussala. According the initial design the principal aim of the device is to provide long term records with high accuracy of absolute neutron flux from secondary cosmic ray.

Detector design

The neutron flux meter represents complex of six gas filled detectors type SNM-15, divided in two modules of 3 detectors. The working gas is BF_3 enriched to 90% with B^{10}. The detectors are situated under the roof of the main building of BEO Moussala. The moderator of the detector complex is glycerin. The moderator tank represents a cylinder with 40 cm diameter and 2.5m length. The detector complex area is 5.28 m^2 including the moderator tanks. The estimation of the moderator layer of glycerin is carried out using Monte Carlo simulations with MCNP(x) code and using the measured at Testa Griggia neutron spectrum [2] as input. In this case was used a simplified geometric model of the detector (planar geometry) and uniform spherical neutron source. The results as a neutron current trough the detector surface as a function of the moderator layer are presented in Fig.1 and Fig.2.). The proposed 12.5 cm moderator of glycerin permits us, first of all, to avoid the registration of neutrons resulting from reaction in the detector complex surroundings. Secondly the proposed moderator layer permits to obtain relatively high counting rate and thus to assure good statistic of the measurements. The front panel of the first module is presented in Fig.3. It is possible to see the signal, power supply cables, the covers of electronics and the filling system. The data acquisition system is very similar to the

Lomick Stit neutron monitor with several differences. First of all the parallel port of a PC, in fact the data registers is used for 6 channel counting i.e. a software counting is provided. An additional circuit for providing the interface between the power supply and data acquisition block and the PC is developed in INRNE-BAS. The scientific potential and detector complex simulations are described in details in [3].

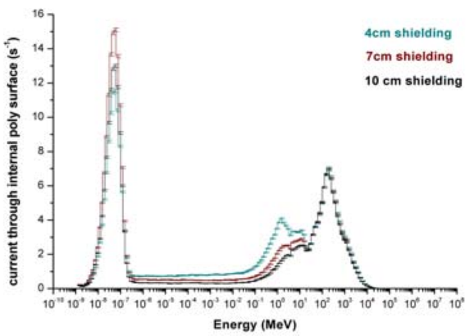

Figure 1: Neutron current as a function of moderator thickness for single detector simulated with MCNP(x) code

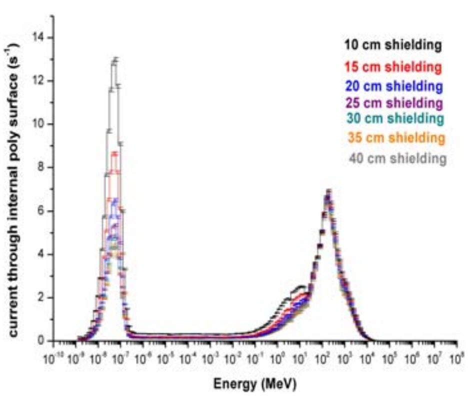

Figure 2: Neutron current as a function of moderator thickness for single detector simulated with MCNP(x) code

Detector response

During the detector completion several additional simulation are carried out. The aim is to obtain precisely the detector response and counting rates at Moussala observation level of 725 g/cm^2. In this case a realistic geometry model is used. The cylinder shape of the moderator tank is taken into account, the thickness of the tank wall as well and finally the stainless steal of the SNM-15 detectors.

Figure 3: Front panel of the first module of the neutron flux meter at BEO Moussala

The results are presented in Fig. 4. Additionally is compared the detector response for different moderators (glycerin and polyetilen) and the impact of the stainless steal.

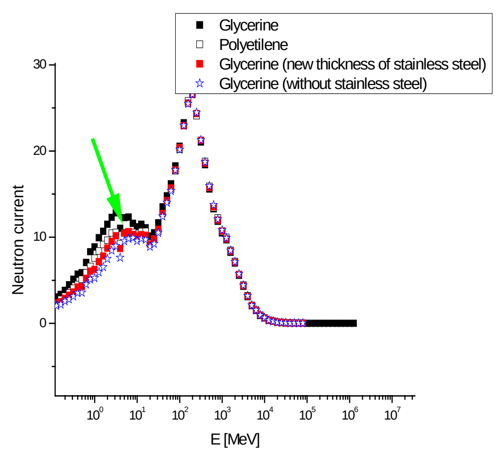

Figure 4: Neutron current as a function of moderator thickness for single detector simulated with MCNP(x) code

The detailed picture of the detector response in the range of thermal neutrons is presented in Fig.5. The results of Fig. 5 permitted after integration of the current to estimate the expected counting rate of the detector complex [3]. The detector efficiency is estimated with cross measurements with He^3 detectors and using neutron source. The estimated detector efficiency varies between 3% and 0.5 % for the different detectors which is below of the technical specification of the detectors (between 6 and 8 %). The preliminary measurements at Sofia observation level – 550 m above sea level, which corresponds to 970 g/cm^2 and Moussala observation level taking into account the estimated detector efficiency shows very good coincidence of the measured and simulated counting rates. The estimated from the simulations counting rate for Sofia observation level is around 1.5 neutrons/s (for single detector).

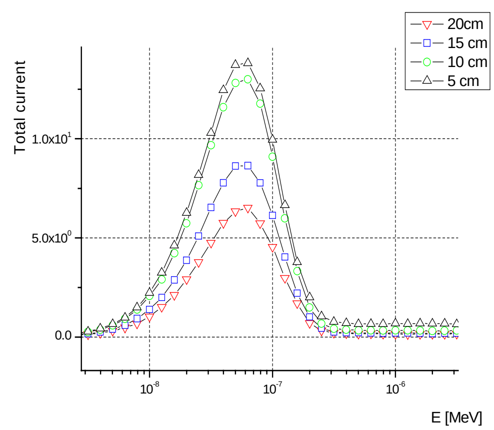

Figure 5: The simulated neutron current as a function of moderator thickness for single detector simulated with MCNP(x) code –detailed view

The expected counting rates for Moussala are around 5000 counts in 10 min. for the whole complex.

First measurements and scientific potential

As was mentioned above the first measurements with single detector at Sofia observation level confirmed the expected counting rates. Presently the detector complex is mounted at BEO Moussala and it is operational since the 1 of April 2007. The results of these preliminary measurements are presented in Fig. 6.

One observes the variation of the secondary cosmic ray neutron flux. The first estimation connected with barometric influence shows the expected anti correlation with the barometric pressure.

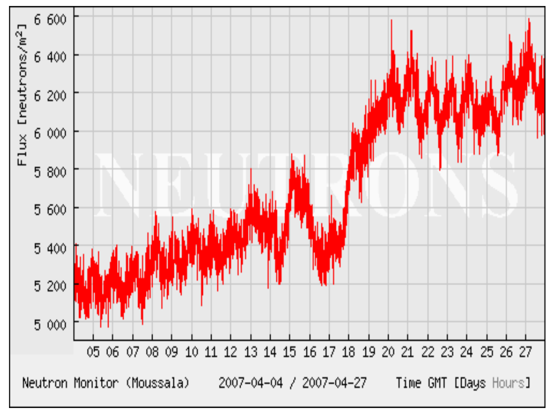

Figure 6: Preliminary measurements with neutron flux meter at BEO Moussala for month of April 2007

In general the scientific potential of the flux meter is promising. Taking into account the large detector surface it is possible to measure with high statistics and accuracy the secondary cosmic ray neutron flux. Afterwards it is a topic of reconstruction strategy and models to estimate the obtained dose rate at high mountain altitude. This is very important in attempt to propose a model for dose rate distribution as a function of the altitude. As was mentioned above one of the most exciting topics in the area of Sun-Earth system research is the possible influence of cosmic rays on terrestrial atmosphere, especially the connection between low energy cosmic rays and the Earth atmosphere [4]. Several characteristic signatures in cosmic rays may be used for space weather applications [5] on the basis of secondary cosmic ray neutron data. Good examples are the solar proton events [6] and geomagnetic storms [7]. One of the most significant points is related to the atmospheric transparency and cloud formation. The variations of the cosmic rays of solar and galactic origin may be responsible for the changes in the large-scale atmospheric circulation. Such type of phenomena may be associated with solar activity and especially with cosmic ray particles in the energy range 0.1-1 GeV [8] and [9].

Conclusion

In this work is described the present status including the detector design, detector response and first measurements of the neutron flux meter at BEO Moussala.

The geomagnetic and radiation storms are significant elements of space weather. The forecasting of such type of events is very important for orbiting flights. In fact the geomagnetic storms are driven by magnetized plasma clouds. They reach the Earth from few hours till several days. During their propagation they interact with galactic cosmic rays. The result is the modulation of galactic comic rays till energies of thousands of GeV. As was mentioned above the change of the intensity is possible to detect by surface detectors (neutron monitors, neutron flux meters, muon telescopes, muon hodoscopes).

Acknowledgements

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