Neutron monitor prototype for measurement of cosmic ray

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1. Introduction

The cosmic rays (both galactic and solar) play important role in the interplanetary and extraterrestrial space. At the same time they can affect the human activity [1,2]. A modern and interesting topic is related to space weather studies. The space weather refers to the dynamic, variable conditions on the Sun, solar wind and Earth's magnetosphere that can diminish the performance and reliability of spacecraft and ground-based systems [3]. Therefore study of cosmic rays, especially the variation of cosmic ray flux is very important [4].

2. Methods and Results

Despite several decades of tradition, ground based neutron monitors remain the state-of-the-art instrumentation for measuring cosmic-ray, and they play a key role as a research tool in field of space physics, solar-terrestrial relations, and space weather applications. They are sensitive to cosmic rays penetrating the Earth's atmosphere with energies from about 0.5-20 GeV, i.e. in an energy range that cannot be measured with detectors in simple, inexpensive, and statistically accurate way. For the purpose of cosmic-ray flux measurements, the ^{3}He gas detector was selected for cosmic-ray neutrons monitoring in this study because the neutron cross section of the ^{3}He gas is significant higher than that of other materials in thermal region.

2.1 Design of a neutron monitor prototype

Neutron monitors consist of special gas-filled proportional counters surrounded by a moderator, a lead producer, and a reflector. The incident nucleon component (protons and neutrons) of the secondary cosmic ray flux causes nuclear reactions in the lead, and evaporation as well as low-energy neutrons are produced. These MeV-neutrons are slowed down to thermal energies by the moderator and finally detected by the proportional counter tubes.

In this study, ^{3}He tube has a diameter 5 cm, a length of 30 cm and 5 atm and is surrounded by a polyethylene moderator, a 10 cm lead producer and 7.5 cm polyethylene reflector. The material and geometry of the system were determined by referring standardized detector 'NM64' type[5]. To improve counting efficiency of the system, the optimized thickness of moderator surrounding the gas detector was designed by using MCNPX and GEANT4 Monte Carlo simulation codes, in which the incident of neutron spectrum of cosmic-ray that reaches the surface of the Earth was obtained by using Excel-based Program for calculating Atmospheric Cosmic-ray Spectrum (EXPACS) code. The optimized moderator thickness is 4 ~ 5 cm, as shown in Fig.3.

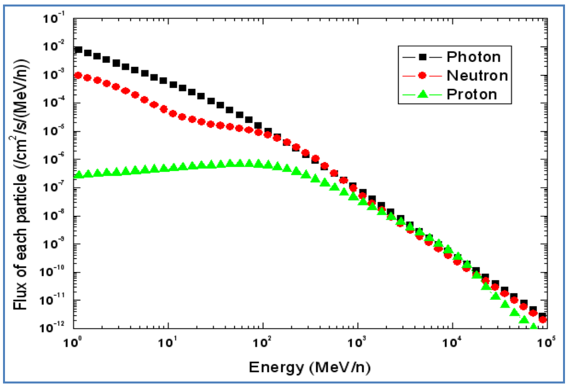

Fig. 1. The cosmic ray spectrum data at 1 m from the ground level

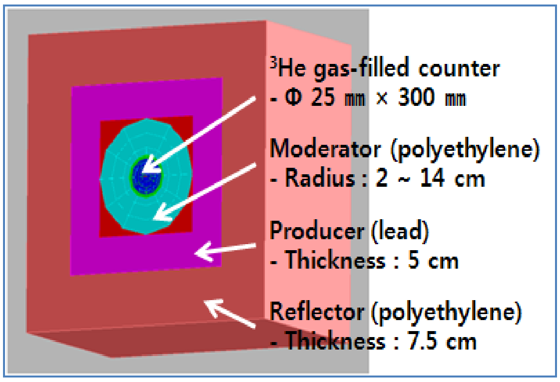

Fig. 2. The neutron monitor prototype geometry in Monte Carlo simulation code

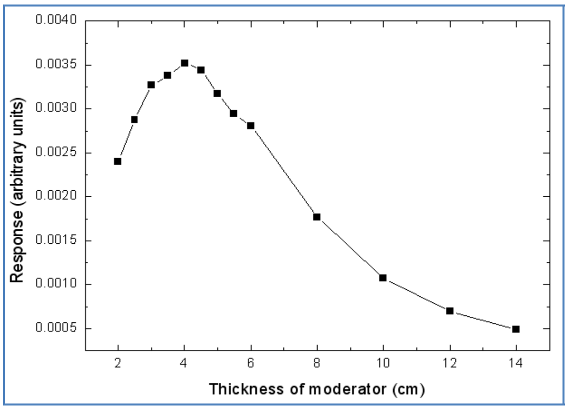

Fig. 3. The response of prototype calculated using Monte Carlo simulation for a moderator of 2 ~ 14 cm

2.2 Performance of a neutron monitor prototype

To separate cosmic ray neutron region from neutron/gamma mixed fields, performance evaluation test of the ^{3}He detector was conducted. Fig. 4 compares the spectrum for cosmic ray and the spectrum for cosmic ray and gamma sources(^{137}Cs, ^{60}Co). Fig. 6 shows the cosmic ray monitoring data from March 27 to April 2, 2010. The detection threshold value is about 4 V.

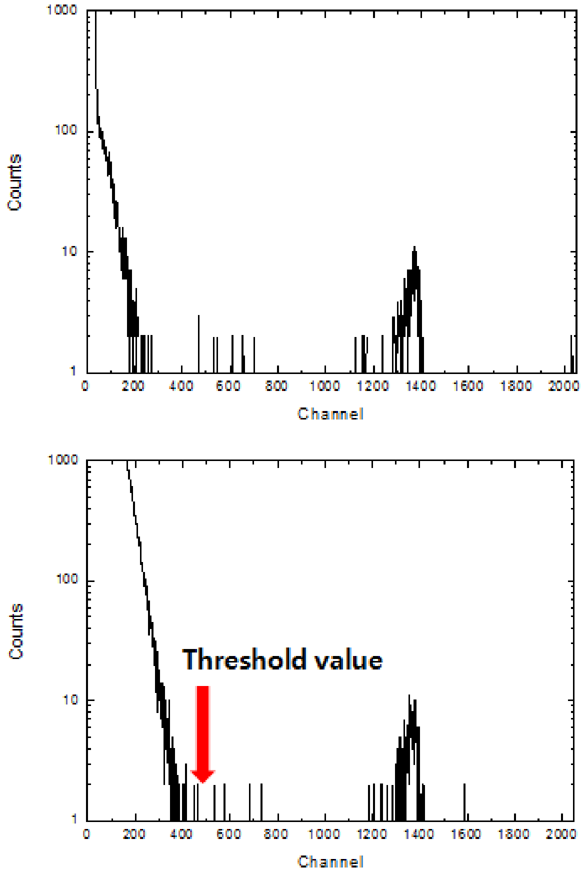

Fig. 4. The spectrum for cosmic ray with ^{3}He detector(up), the spectrum for cosmic ray and gamma source(^{137}Cs, ^{60}Co) with ^{3}He detector(down)

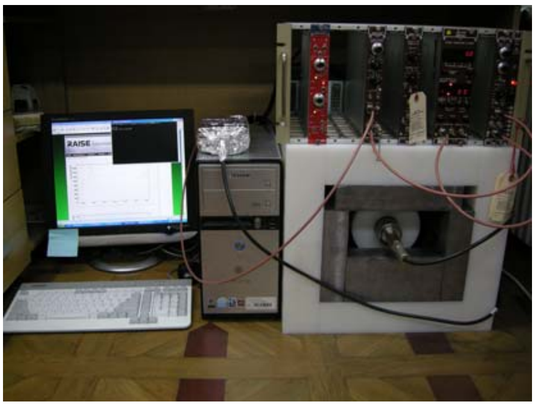

Fig. 5. The manufactured neutron monitor prototype system

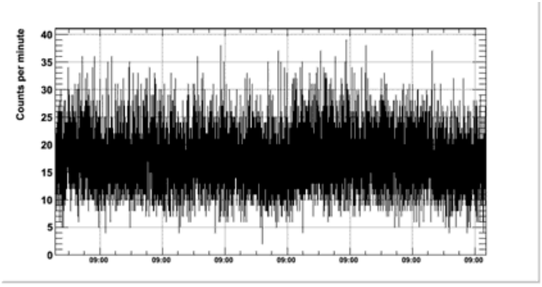

Fig. 6. The measured cosmic ray monitoring data with prototype system from 2010.03.27 to 2010.04.02

3. Conclusions

By using the Monte Carlo simulation code, the design of the neutron monitor prototype was determined. The prototype system was manufactured for the cosmic ray monitoring. The cosmic ray fluctuation rate will be analyzed with cosmic ray monitoring data. Our studies will help to figure the cosmic ray fluctuations level of Korea.

Acknowledgment

This work was supported by the Basic Atomic Energy Research Institute (BAERI), nuclear R&D program of MEST, Korea and partially supported by the Ministry of Knowledge Economy (2008-P-EP-HM-E-06-0000).

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