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ABSTRACT

We report on a measurement of thermal neutrons, generated by the hadronic component of extensive air showers(EAS),by means of a small array of EN-detectors developed for the PRISMA project(PRImary Spectrum Measurement Array),novel devices based on a compound alloy of ZnS(Ag)and 6LiF. This array has been operated within the ARGO-YBJ experiment at the high altitude Cosmic Ray Observatory in Yangbajing(Tibet,m a.s.l.).

1. INTRODUCTION

The cosmic ray energy spectrum spans over many decades from about 10^6 eV to beyond 10^{20} eV.It consists of different regions with power law behavior and changes in the power law index.In the high energy range above 100 TeV two features are known since a long time,that is a steepening of the spectrum,named the knee,at about 3-5$\times10^{15}$ eV and a hardening,named the ankle,at about 3-5$\times10^{18}$ eV.Other peculiar features have been observed in this energy interval by the KASCADE-Grande experiment.

$$< n >= 36E^{0.56} \tag{1}$$

This is my equation:"$F(x) = \int f(x)\mathrm{d}x = \int x^2\mathrm{dx} = x^3/3$"equation

$$F(x) = \int f(x)\mathrm{d}x = \int x^2\mathrm{dx} = x^3/3 \tag{2}$$

2. THE EN-DETECTOR

The EN-detector is based on a special phosphor,which is a granulated alloy of inorganic ZnS(Ag) scintillator added with LiF enriched with the isotope up to 90%.One captures one thermal neutron via the reaction α ith cross section of 945 barn.The phosphor is deposited in the form of a thin one-grain layer on a white plastic film, which is then laminated on both sides with a thin transparent film.The scintillating compound grains used are of 0.3-0.8 mm in size.The effective thickness of the scintillator layer is 30 mg/cm^2 .Light yield of the scintillator is 160,000 photons per neutron capture.The structure of a typical EN-detector is shown in Fig.1,right. The scintillator of 0.36m^2 area is mounted inside a black cylindrical polyethylene (PE) 300-l tank which is used as the detector housing. The scintillator is supported inside the tank to a distance of 36 cm from the photomultiplier (PMT) photocathode.A 6-PMT (FEU-200) is mounted on the tank lid. A light reflecting cone made of foiled PE foam of 5-mm thickness is used to improve the light collection.As a result,100 photoelectrons per neutron capture are collected.The efficiency for thermal neutron detection in our scintillator was found experimentally by neutron absorption in the scintillator layer to be about 20%.To determine it,we measured the counting rate of our scintillator layer,then we put another similar layer under the first one (with a black paper between them) as an absorber and measured again.Then we compared the results and calculated the scintillator efficiency.Similar efficiency was also obtained by simple Monte-Carlo simulation using GEANT4 code.As an example,we show in Fig.2 the response of the detector illuminated with a low activity source of thermal neutrons (1 Bq of 252 Cf).

$$\begin{aligned} F(x) &= \int f(x)\mathrm{d}x \qquad (3) \\ &= \int x^2\mathrm{dx} \\ &= \frac{x^3}{3} \qquad (4) \end{aligned}$$

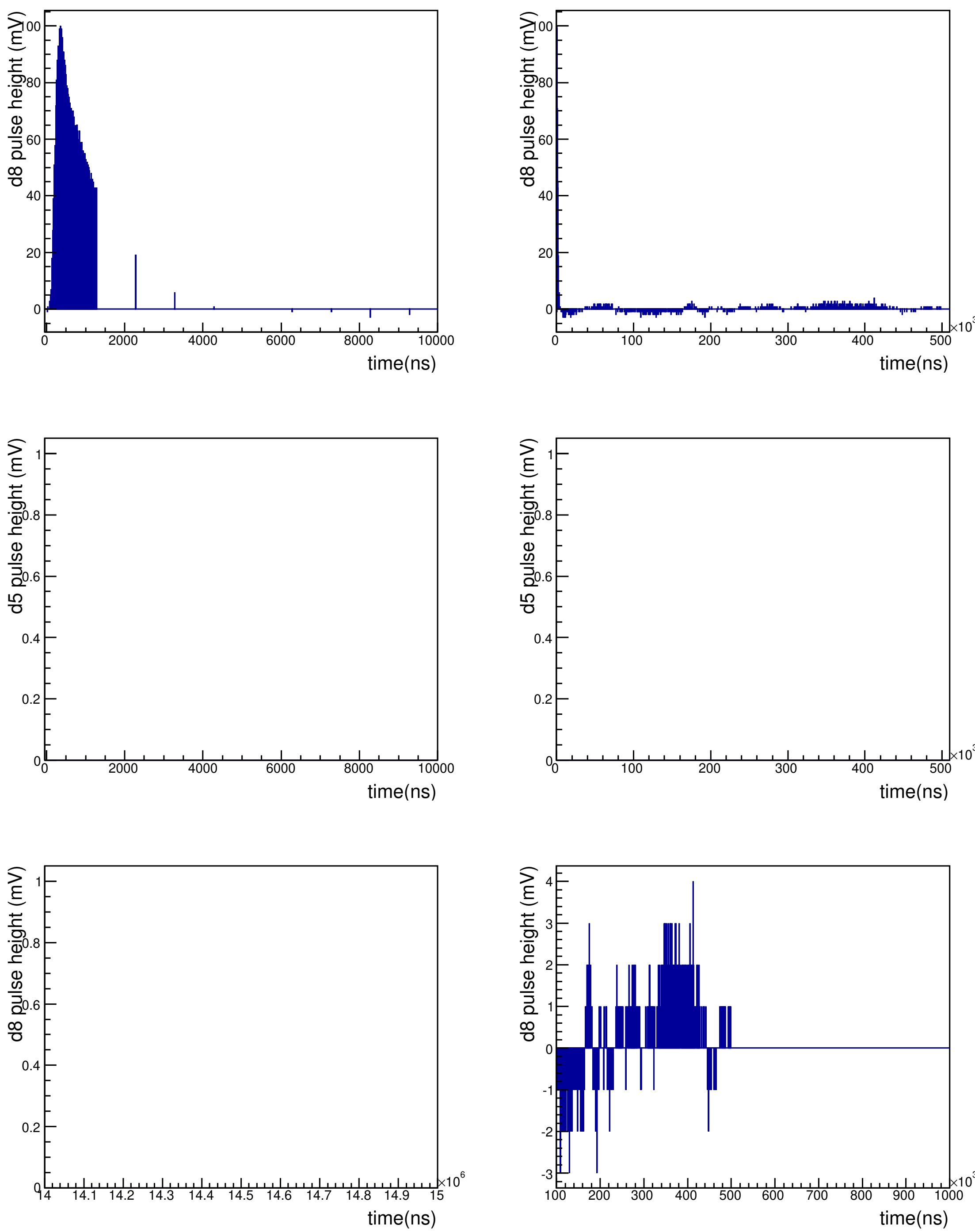

Figure 1. scan 20190615 evt865 1.

Table 1. Detector events

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Detector	Events
$No.33$	439
$No.34$	1202
$No.35$	897
$No.36$	1038

IP11 events of six days