Muon Studies by means of ELEGANT V

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ELEGANT V is the high sensitive and ultra low background detector which was designed to search for $\beta\beta$ decay, dark matter and so on [1]. ELEGANT V is located at Oto Cosmo Observatory(1200 m.w.e.) in order to avoid the cosmic muon. The cosmic muon is one of the serious background origin for this kind of measurements, therefore it is very important to estimate the muon flux correctly.

On the other hand, it is also interesting to deduce the information as follows;

- The origins of muons in the underground are almost the cosmic muons but a few muons induced by the atmospheric neutrinos. The down-ward going muon is the cosmic muon, and the up-ward going one is the neutrino-induced muon. Therefore if these components are distinguished clearly, it is possible to extract the information about the atmospheric neutrinos [2] [3].
- The seasonal variations in the underground muon intensity are concerned with the temperature variations in the atmosphere. From this relation, it is possible to extract the information about the muons whether coming from pion decays or kaon decays component [4].

At present, it has been accomplished to evaluate the muon flux with angular distribution and study up-ward going muon, and it has been carried out to evaluate the seasonal variations of the muon flux by means of ELEGANT V.

ELEGANT V consists of 3 drift chambers, which have total 15 layers, on central position sandwiched by 16 modules of the plastic scintillators and 20 modules of the NaI(Tl) scintillators, and the thin films of ^{100}Mo, which is $\beta\beta$ decay source, are put between the drift chambers. The direction of the muon was determined by hit position and ID of the plastic scintillators, and hit ID of NaI(Tl) scintillators as shown in Figure 1. The detection efficiency with the zenith angles were determined by Monte Carlo simulation, GEANT 3.21 [5]. Energy threshold is about 0.4 GeV which is the total energy of the minimum ionization to penetrate Pb and Cu shields, upper plastic and NaI(Tl) scintillators, and lower plastic and NaI(Tl) scintillators. It is determined by the hit time of upper and lower plastic scintillator whether the muon is up-ward going or down-ward going one.

Figure 2 shows the distribution of muon flux with the zenith angle in the laboratory ELEGANT V located. The integrated value over all zenith angles is $(8.4\pm0.2)\times10^{-7}$cm^{-2}sec^{-1}, which is about four times higher than Kamioka Underground Lab., where ELEGANT V was located before. This detailed information for the muon distribution is valuable for the analysis of $\beta\beta$ decay, dark matter and so on.

In Figure 3, the velocity distribution of the muons is presented as $1/\beta$ distribution, where β is the fraction of the speed of the light. In case of $\beta < 0$, the muons must be up-ward going ones and distributed around $\beta = -1$. On the other hand, in case of $\beta > 0$, the muons must be down-ward going ones and distributed around $\beta = +1$. Unfortunately, these components could not be distinguished clearly in this analysis. This is because the uncertainty of hit time, thus the position(∼3cm), of plastic scintillators and the geometrical uncertainty of width of the scintillators (less than ∼10.4cm). It is possible to extract the more correct information about the directions of the muons, 1∼2cm of the position resolution on the source plane, if using the data of the drift chambers. On the other hand, it is difficult to improve the time resolutions of the plastic scintillators any more, therefore it is not realistic to evaluate the up-ward going muon, that is, atmospheric muon neutrino, by means of ELEGANT V. In addition, even if these components could be distinguished clearly, only one event for one year live time is expected by the Monte Carlo evaluation. This event rate is too small to evaluate the up-ward going muon.

Finally, the investigation of the seasonal variation of the muon intensity is on-going program. It will be reported soon that the relation of the seasonal variation of the muon intensity and atmospheric temperature.

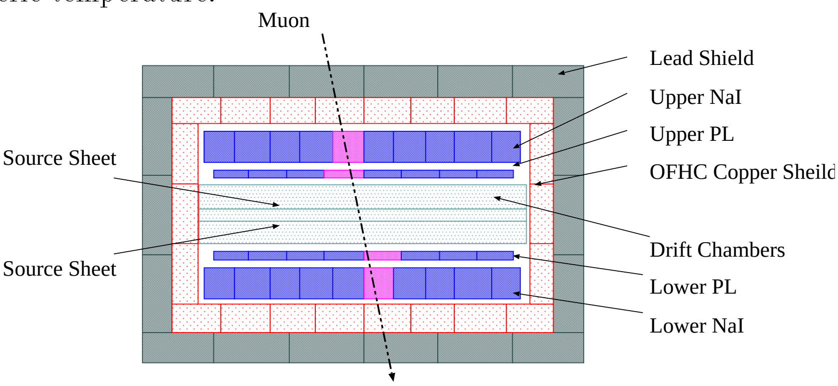

Figure 1: Schematic view of typical muon detection by means of ELEGANT V

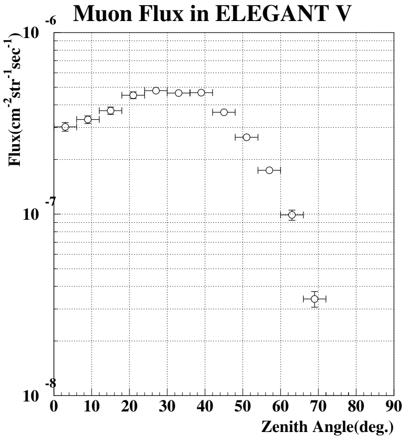

Figure 2: The muon flux with zenith angle in ELEGANT V

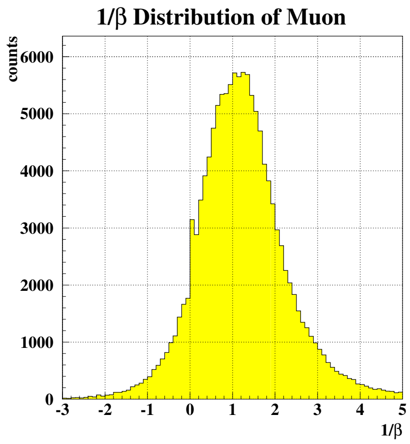

Figure 3: $1/\beta$ distribution of the muons in ELEGANT V

References

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