Geophysical Research Abstracts
Vol. 13, EGU2011-2932, 2011
EGU General Assembly 2011

Newly Developed Multi-Layered Muon Detection System for the Next Generation of Muon Radiography

Hiroyuki Tanaka (1), Tomohisa Uchida (2), and Manobu Tanaka (2)

(1) University of Tokyo, Earthquake Research Institute, Japan (ht@postman.riken.jp), (2) Institute of Particle and Nuclear Studies, High Energy Accelerator Research Organization (KEK), Japan

Conventionally, muon radiography has been performed by employing a two-layer muon detector [e.g. 1-2]. These detectors are limited in that they can only measure small scale volcanoes or sections of volcanoes such as small lava domes or summit regions. Objects with larger volume, such as a deeper region of a volcano, would require a detector with a larger observation area. However, if the level of the background noise exceeds the muon signal, this enlargement would not work. False muon tracks can occur in the detector when 2 particles accidentally hit two counter planes at the same time. After counting the muons that successfully pass through a gigantic object, these false muon tracks can cause severe background noise, effecting the resulting image. This problem will not be solved when simply enlarging the detection area. The ratio between the number of total muon tracks and false muon tracks decreases, making it increasingly difficult to separate the real muon events from the false muon events. In order to address this issue of background noise in the form of false muon tracks, we developed a multi-layer muon detector. In addition to the conventional multiplicity analysis method, a linear analysis method is used, coordinating three or more extra detector planes. Taking advantage of the fact that the false muon tracks rarely travel in a straight line through three or more counters, we can reduce the number of these fake muon tracks by checking the angles of the trajectories that are produced in any two counter planes in the detector. Synchronized multiple muon read out modules have been developed as part of a data acquisition system for this purpose. By utilizing this new data acquisition system, the technique of muon radiography can be applied to a larger range of subjects. Each muon read out module [3] records the combination of the counter strips in each detector plane and measures the timing when a signal occurs within a counter plane. A data processing software accesses the muon readout modules via an Ethernet cable to down load such information to reproduce the muon trajectory. On the data processing software, the trajectory reproduced within any two layers can be compared each other. These trajectories can be visually monitored so that we can confirm if we select the most muon-like events from the background trajectories. After applying the linear analysis in addition to the conventional multiplicity analysis, we found that the background signal was reduced by 90%. This value was obtained in the laboratory experiment without an existence of a gigantic muon absorption target. In order to further reduce the systematic errors, we developed a rotational muon detection system. This system recurrently obtains the reference data by periodically rotate the muon detector so that we can normalize the detection efficiency with the least temporal variations. Together with this system, we anticipate that the multi-layered muon detector will further improve the radiographic image of a larger volcano or a deeper region of a volcano.

References

[1] H.K.M. Tanaka et al., Geophys. Res. Lett., 36 L17302 (2009).
[2] H.K.M. Tanaka et al., Geophys. Res. Lett., 36, L01304 (2009)
[3] T. Uchida et al., Earth Planets and Space, 62, 2, 167 (2010)