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多層型ミューオン検出器システムの開発-ミューオグラフィー適用可能範囲の拡大を目指して-
Development of a multifold segmented muon detection system to improve the maximum resolvable distance of muography

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In order to perform cosmic-ray muon radiography to image a volcano with a thickness of more than 1 km, a detector with a large active area is necessary to collect the sufficient number of muon events since the penetration flux of cosmic-ray muons is reduced steeply as a function of the thickness of the target of which the muon traverses. However, the size of the active area is not a unique factor to improve the measurement. The signal-to-noise (S/N) ratio also decreases seriously as the size of the target becomes larger, and thus the density distribution cannot be accurately measured. The background (BG) noise that reduces the S/N ratio mainly consists of the fake tracks that are generated by the accidental coincidence of the vertical electromagnetic (EM) shower particles. In order to solve this problem, we developed a novel muon detection system that consists of many layers of position sensitive detectors (PSDs) in conjunction with a new analysis method to effectively reduce the BG noise. In this method, the EM shower-originated fake tracks are rejected by requesting a linear trajectory for a muon event (linear cut method) since vertical EM showers randomly hit each PSD layer and make a non-linear trajectory in the detection system. The developed detection system was tested by imaging the internal density structure (the spatial distribution of the density) of Usu volcano, Hokkaido, Japan. In this measurement, we used a muon detection system that consists of 7 layers of PSDs. One PSD layer consists of x- and y- arrays of scintillator strips to make an active area of 1.21 m^2 with a segmented area of 10x10 cm^2. The angular resolution is +/-3 degrees. The measurement duration was 1977 hours (82 days and 9 hours). This measurement yielded the following results: (A) by analyzing the region that has a thickness of more than 1000 m, we confirmed that our detection system is sensitive to a density variation of 10% in 1300-m rock; and (B) we found that there are high- and low-density anomalies beneath between Oo-Usu and Usu-Shinzan, which is consistent with the magma intrusion and the resultant fault generation suggested by Yokoyama and Seino (2000) and Ogawa et al. (1998).

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