Geosci. Instrum. Method. Data Syst. Discuss., 5, C102–C105, 2015
www.geosci-instrum-method-data-syst-discuss.net/5/C102/2015/

Geoscientific Instrumentation Methods and Data Systems Discussions

Interactive comment on "Development of the very long range muographic imaging technique to explore the internal structure of an erupting volcano, Shinmoe-dake, Japan" *by* T. Kusagaya and H. K. M. Tanaka

T. Kusagaya and H. K. M. Tanaka

kusagaya@eri.u-tokyo.ac.jp

Received and published: 22 October 2015

We thank the referee for the valuable comments. Please see the following answers.

Assuming they would have access to whatever detector they would need, what would be the detector improvement that they would mostly benefit from?

→It would be the large active area of the detector to obtain the sufficient number of muons for a short time that is necessary to image dynamics of magma in conduits of a

volcano.

As the authors state in the text, imaging from such large distances greatly reduces the solid angle for the volcano observation. Likely a better angular resolution would be useful. How would your conclusions change assuming the position resolution to be 1cm instead of 10cm?

→Energy estimation of detected particles would be made by analyses of scattering angles.

The density reconstruction suffers from low statistics. How longer should your detector acquire the data on site in order to solve this problem? Do you have an estimate on the level of systematic uncertainties affecting the density measurement?

→It should need at least twice as long as the measurement duration in this study. During the measurements, 7-day variations of the number of open-sky muons ranged between 800 and 860 counts, however, the value of chi-square with 6 degrees of freedom was 5.15. Therefore, the variation of muon flux was considered to be negligible.

Section 2.2.2 The authors rightly point out that the horizontal low energy electromagnetic flux (10 MeV to 1 GeV) is of the order of magnitude of the horizontal muon flux. However the impact of these electrons and positrons on the muographic measurement is very much dependent on quality of the telescope used to perform the muographic measurement. If the position and angular resolution of the telescope is good, the electrons and positrons will be tagged since they scatter much more than the muons in the detector shielding. It might be therefore hazardous to infer the level of contamination from the electromagnetic component of the air showers in a general case without being specific on the detector used.

→The sentence "If the angular resolution of a muography telescope is not enough to distinguish these components from muons, these electrons and positrons scatter in the air, change direction, and become a possible source of background events." was

added at Line 153.

Section 3.2.1 The tracking procedure is unusual. I would expect the angular resolution might be improved if the differed detection layers are used more uniformly in the fit procedure. How well the chi2 distribution of the fitted tracks reproduces the theoretical chi2 distribution? Did you estimate the energy threshold for muons being accepted by your tracking and selection procedure?

→The significance level of fitted tracks is ∼0.8. The energy threshold was estimated to be ∼5 GeV for accepting 95% of muons with the detector shielding.

Section 3.2.2 In order to estimate the amount of scattering the muons undergo in the telescope, the authors simulated 0.5 Million muons with zenith angles between 60 and 70 degrees. Since the scattering depends mostly on the muon momentum, it would be useful to state the lowest muon energy considered by simulations.

→The sentence "The lowest muon energy considered in the simulation was 1 GeV that corresponded to the cutoff energy derived from the detectors and the shields." was added at Line 294.

A fast estimation based on the geometry of the detector shows that the angular acceptance of the detector extends from about 63deg to 90deg. Could you explain the angular range of 60 to 70 deg that you used in order to simulate the muons?

→The open-sky flux of muons were dominant for scattering, and thus we used those angular range.

The flux and energy dependence of the nearly horizontal muons is very badly known. What would be the incertitude you would quote on the scattered muon fluxed in paragraph 10? I would expect the figures 11 and 12 to be highly dependent on the model you assume for the energy and angular spectrum of the horizontal muons. Maybe it should be safer to state in the text that those are likely orders of magnitude estimates ?

→The incertitude would be ∼10% that derived from the residual between the fitted flux model of muons based on Matsuno et al.(1985) and the data from Jokisch et al.(1979). And the sentence "These are likely orders of magnitude estimates" was added at Line 301.

Section 4.1 Could you explain also the meaning of the red and blue dots in Fig 4? It is difficult to judge the level of agreement between the short range and low range muographic measurements on the logarithmic scale, but the long range measurement seems to be systematically higher than the short range one. Could you comment on it?

→The sentences "Satsuma-Iwojima (blue dots in Fig.14)" and "Shinmoe-dake (red dots in Fig.14)" were added at Line 325. It might be regional effect. The surrounding of muography telescope was flat area at Satsuma-Iwojima while it was slant area at Shinmoe-dake. Less obstacles at Shinmoe-dake might have caused those differences.

Interactive comment on Geosci. Instrum. Method. Data Syst. Discuss., 5, 207, 2015.