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Interactive comment on "The effect of rock composition on muon tomography measurements" *by* A. Lechmann et al.

Anonymous Referee #2

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The paper is very interesting, well organized and pleasant to read. The authors aim to quantify one of the systematic errors of muography which comes from the chemical composition of rocks. To extract this uncertainty, a novel approach is applied, which is based on the calculation of mineral composition of different rock types and volumetric averaging of energy loss processes. The expected fluxes are calculated based on a muon spectra model and compared to the expected flux after the so-called "standard" rock. The systematic error is found to be less than 2.5 % under the rock thickness of 300 m, where the ionization energy loss process is dominating and it tends to increase with the increase of rock thickness because of the increasing contribution of stochastic energy loss processes.

The scientific comments are summarized in the following points:

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Discussion paper

1. The main comment is that the systematic uncertainties of the calculations are not presented in the present version of manuscript. This paper presents a novel approach to derive the expected flux and it investigates more rock types to compare with earlier studies, such as [1]. It is suggested to compare the new calculations with another calculations or with GEANT4 simulation. Furthermore, it is suggested to use different flux models, such as [2] or [3], to extract the uncertainty of the calculations.

2. The paper is lack of experimental data taken after rock with known chemical composition. If the authors has any experimental data collected after known rock composition, the calculations should be verified for at least one rock type.

3. The paper could provide more useful information to the muography research community if the authors could extend the study to low-density rocks and soil structures. It is suggested to collect composition information about the different muography targets (underground laboratories, volcanoes) and include them to present study. Furthermore, the extension of the thickness range of flux comparison is suggested up to 3000-3500 meter-standard-rock equivalent.

Further comments are listed here:

Line 33: "recent years this has been done for various volcanoes in Japan (Nishiyama et al., 2014; Tanaka et al., 2005, 2014),": In the recent years the Shinmoe-dake volcano (2015) [4], Unzen lava dome (2016) [5], and most recently (2017-) the Sakurajima volcano [6] have been investigated in Japan. Furthermore, there are ongoing muography experiments at different Italian volcanoes, such as at Etna [7] or Stromboli [8].

Line 38: "500m" -> "500 m" or "500 metres".

Line 105: "I" denotes integrated flux in Eq. (1) and later the mean excitation energy the Appendix B. Maybe it is better to use "F" instead of "I" to denote the integrated flux in Equations (1) and (6).

Line 173: "2.5%" -> "2.5 %" or "2.5\,%"

Line 184: "+/-" -> "$\pm$"

line 210: "600m" -> "600 m" or "600 metres".

Line 226: If my understanding is correct the Avogadro number is used in Eq. A1, however it is defined after Eq. B4.

Line 249: Eq. B2 is suggested to be explained in more details here. All the parameters have to be defined around it.

- The units, e.g. g/cm3 , somewhere written with italic letters, somewhere written with normal letters. It is suggested to unify the written of units.

References:

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[3] Alfred Tang et al.: Muon simulations for Super-Kamiokande, KamLAND, and CHOOZ, Phys. Rev. D 74, 053007, https://journals.aps.org/prd/abstract/10.1103/PhysRevD.74.053007

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[6] L. Oláh et al.: High-definition and low-noise muography of the Sakurajima volcano with gaseous tracking detectors http://www.nature.com/articles/s41598-018-21423-9

[7] D. Lo Presti et al.: The MEV project: design and testing of a new high-resolution telescope for Muography of Etna Volcano, https://arxiv.org/pdf/1805.11612.pdf

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