

# Monitoring of mass density variation inside active volcanoes with cosmic-ray muography

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Muography is an innovative imaging technique for investigation of large-sized natural and human-made objects based on the measurement of absorption rate of cosmic-ray muons [1]. The monitoring of mass density variation occurred during volcano eruptions is a possible applicability of muography. The first large-sized, high-resolution muography observatory is under development based on Multi-Wire Proportional Chamber technology (MMOS) for monitoring of mass density variations in the vicinity of Minamidake crater of Mt. Sakurajima [2,3]. An automated analysis framework provides real-time data and allows analysis and visualization of the variations of muon flux and average mass density across the crater regions via a web-server [4]. The MMOS system consists of five tracking systems with the total surface of 4 square meters is operated at a distance of 3 kilometers from Showa crater in South-West direction since October 2018. The track rates are found stable within 3 % from the backward-direction, which demonstrates that the MMOS system is applicable to detect the average density variation well below the practical limit of about 5 %. We observed a decrease in average density across the West side of Minamidake crater during the ongoing data taking period, which suggests that the amount of material has decreased due to the consecutive occurred eruptions between 30th November 2018 and 11th of January 2019. The extension of MMOS system is scheduled up to the sensitive surface of 20 square meters between 2017-2021. The density-length variation of 5 (10) % is expected to be detected within 5-20 (2-8) days with 68 % confidence level with the designed muography observations system.

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