Intense RISE report

Secondment from Wigner RCP to University of Tokyo, 2019 august

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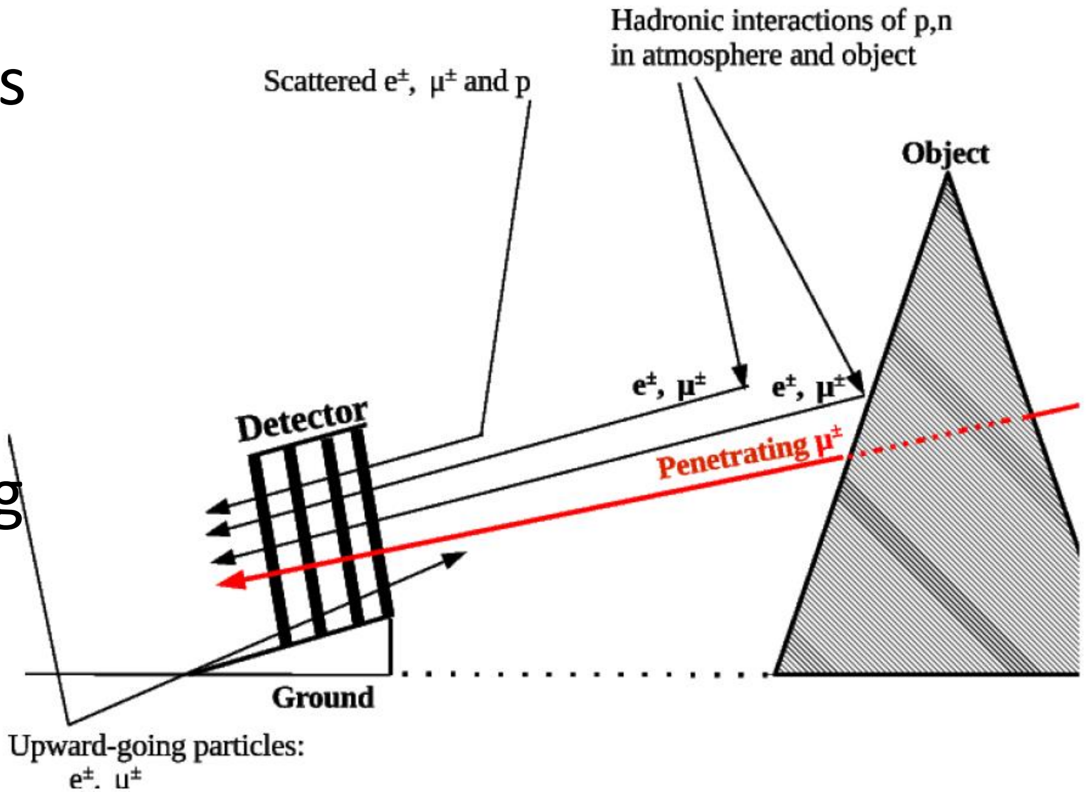
H2020-MSCA-RISE-2018 – Grant Agreement N° 822185

Objectives

- Meetings, discussions and knowledge exchange with the colleagues of the University of Tokyo (UT) about muography
- Software development and simulations for muography projects
- Field experience about the local detector installations and operation

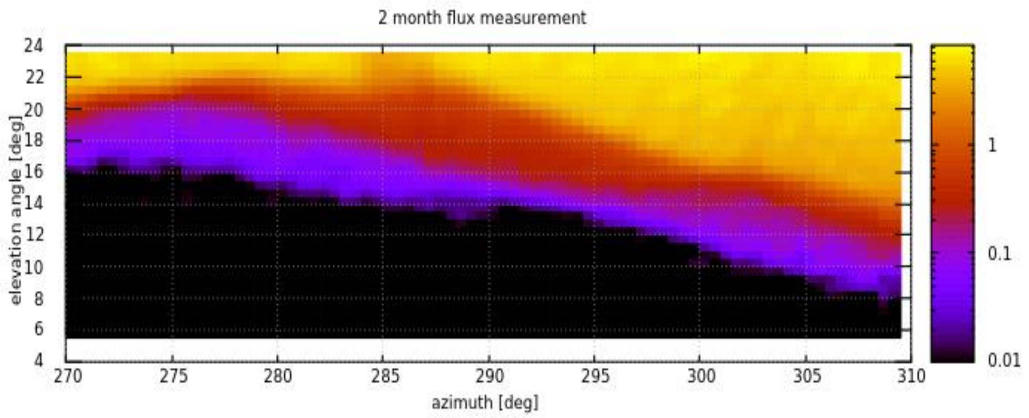
Muography

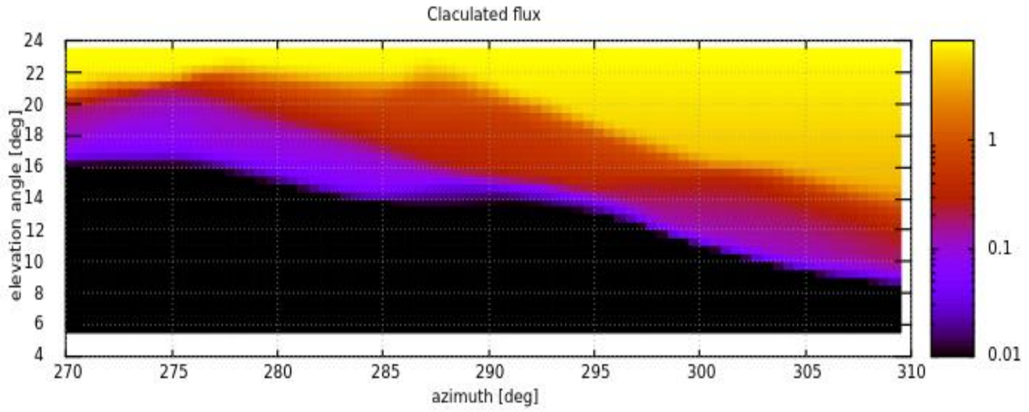
- Muon-Tomography: imaging large objects with the penetrating muons
- Source is cosmic ray, deep penetration, high energy
- Muon flux in a given direction depends on the density and rock length -> imaging
- Example of use:
  - volcanology
  - archeology
  - reactor inspection
  - underground structures, cave research
  - etc...



Software tool for calculating muon flux

- To find a density anomaly, we need to calculate the muon flux and compare it to the measurement
- My software generates from point cloud altitude data a rock length map from a given detector position
- Rock length map is converted to flux by the modified Gaisser method[1]





Example measurement of János mountain (Budapest)

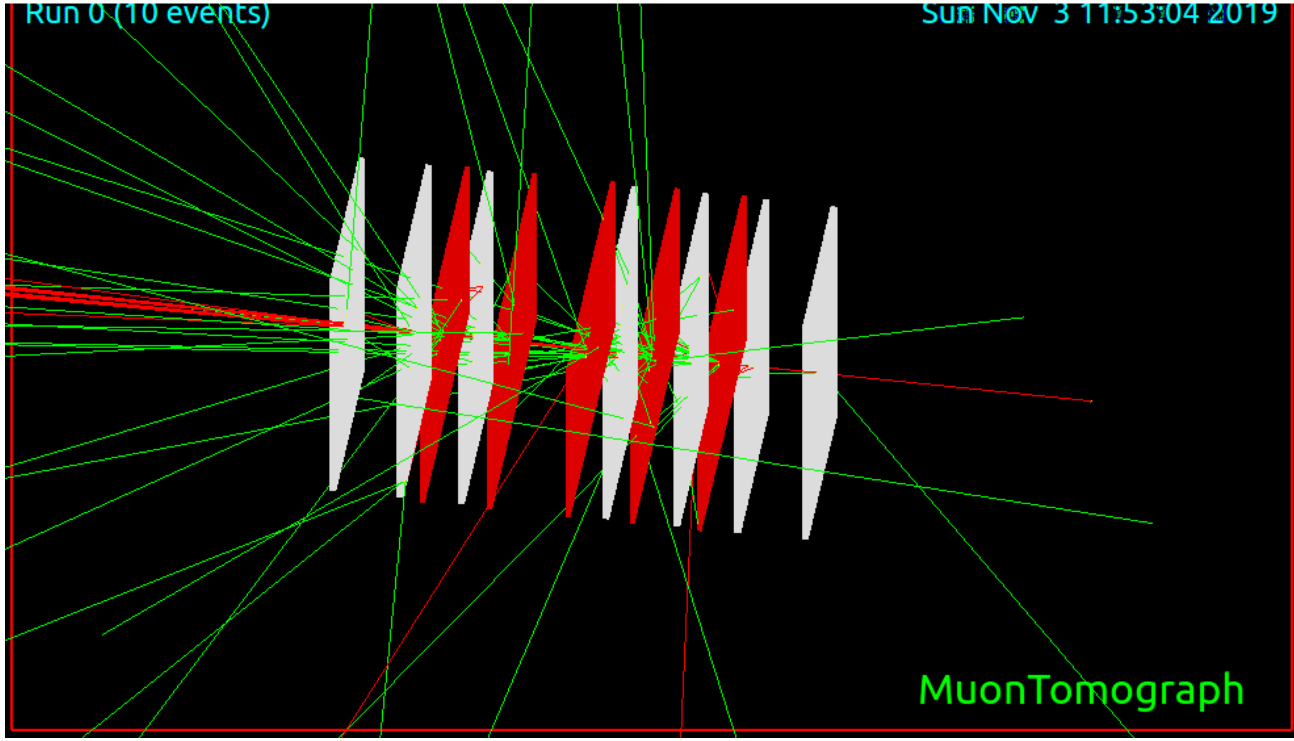
[1] https://arxiv.org/pdf/0706.1110.pdf

From Gábor GALGÓCZI
Geant4 simulation of the MMOS setup

- MMOS: MWPC-based Muographic Observation System
- In order to surpress low energy muons, lead absorbers added between the detectors
- Current setup:
  - 7 detectors
  - 5 lead absorbers (150 kg each)
- Lead is not that cheap… → How can we optimize the geometry to achieve given SNR with the given material?
- Last but not least we can understand where the background (e.g. EM showers in the lead) comes from

From Gábor GALGÓCZI
Geant4 simulation of the MMOS setup

- A dedicated Geant4 simulation was developed
- The detectors:
  - Include copper and epoxy layers
  - are voxalized into sensitive gas volumes with size of 1.2x1.2x2 cm^3

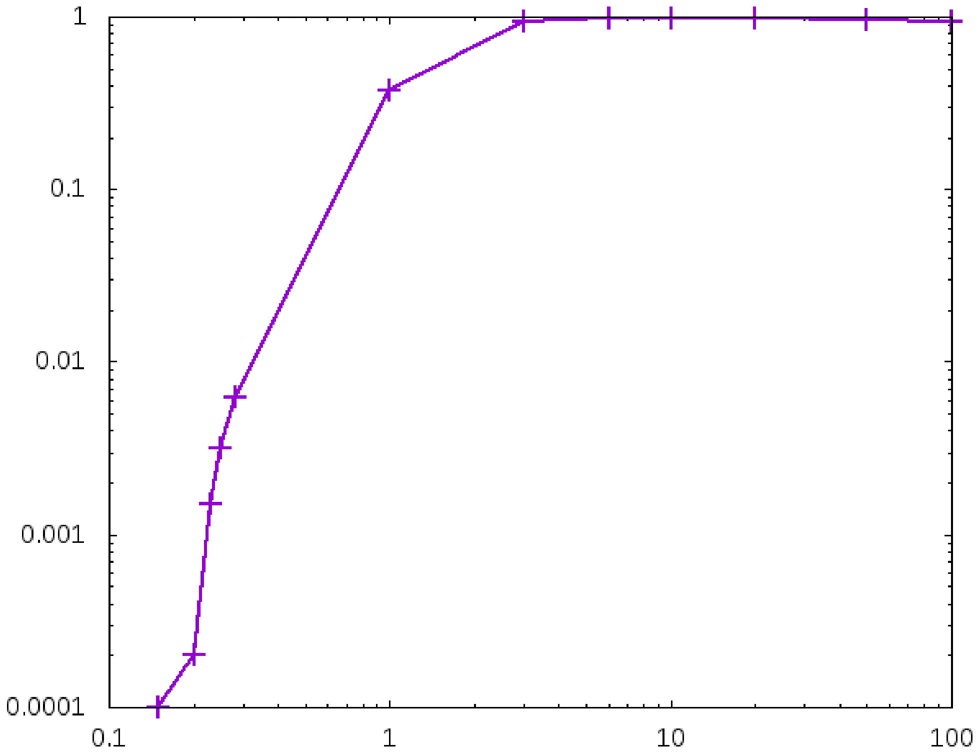


From Gábor GALGÓCZI
Output of the simulation

- The simulation was designed to have the same output style as the actual measurements do
- The detector in the simulation triggered just as in the experiments
- The output of the simulation is processed by the same algorithm that is used in the experiments
- χ^2 distribution is calculated to predict “efficiency” of the detector

From Gábor GALGÓCZI
An example

- Pencil muon beam
- Cumulative χ^2 distribution of 10000 events produced by fitting a track for the hits by the analysis
- The χ^2 cut was defined for this geometry so that for 10 GeV muons 95% of the tracks are identified



Detection efficiency on different muon energy

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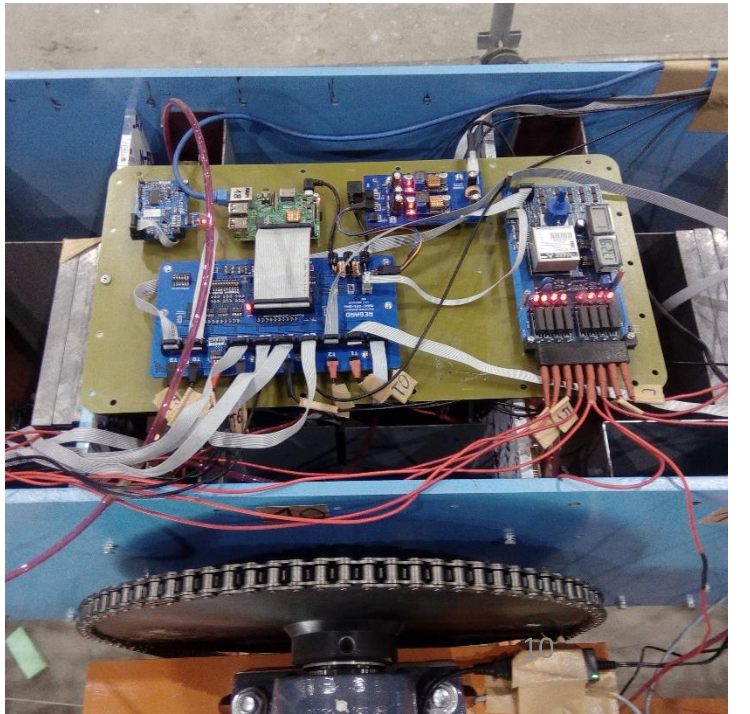
To be done

- Validate simulation with measurements
- Simulate different geometries to find the detector with the highest SNR (still keeping as many muons as possible!)
- Check which physical processes create detections thrown away by the analysis (e.g. EM showers)

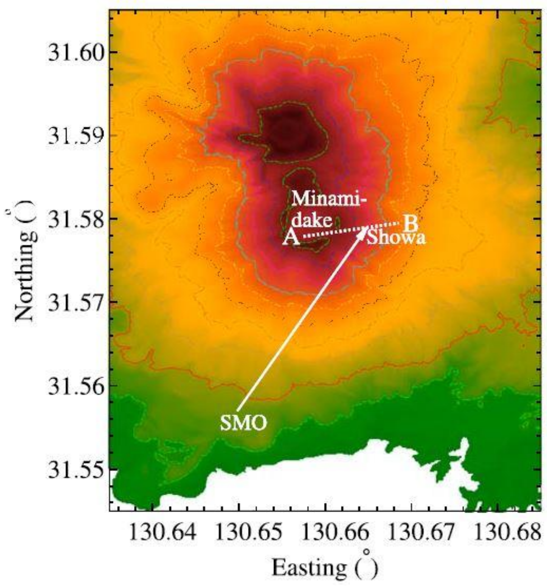
The NEWCUT upgrade

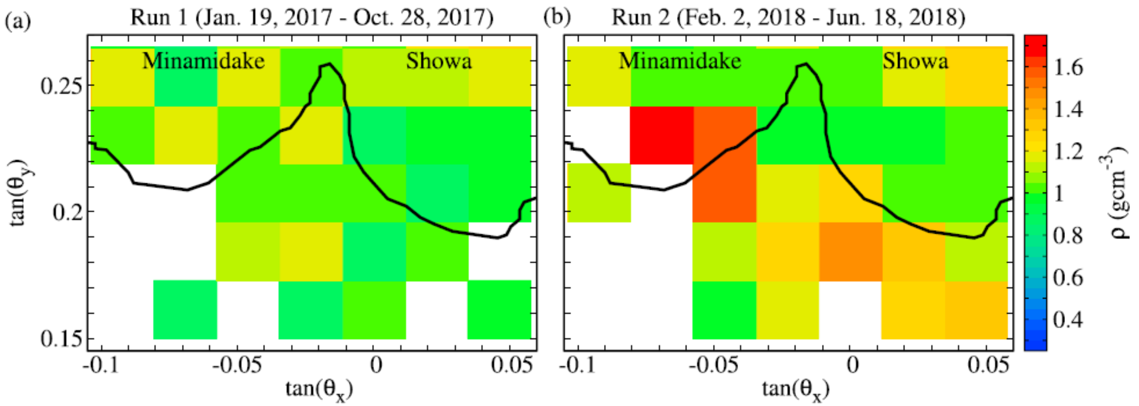
- Supervisors:
  Dr. László OLÁH,
  Prof. Hiroyuki TANAKA
- Measuring muon spectra in different zenith angles, with high precision
- 40 cm x 40 cm MWPC detectors and lead absorbers along a 5 m long layout
- Upgraded to 19 detectors (from 13) for better resolution



The Sakurajima MMOS upgrade

- Supervisors:
  Dr. László OLÁH,
  Prof. Hiroyuki TANAKA
- Measuring the density change of the Sakurajima volcano
  (for volcanic eruption forecast)
- Launched in 2017 and continuously expanding
- MWPC detectors[1] with reasonable resolution[2]





[1] doi.org/10.1016/j.nima.2018.11.004
[2] dx.doi.org/10.1098/rsta.2018.0135

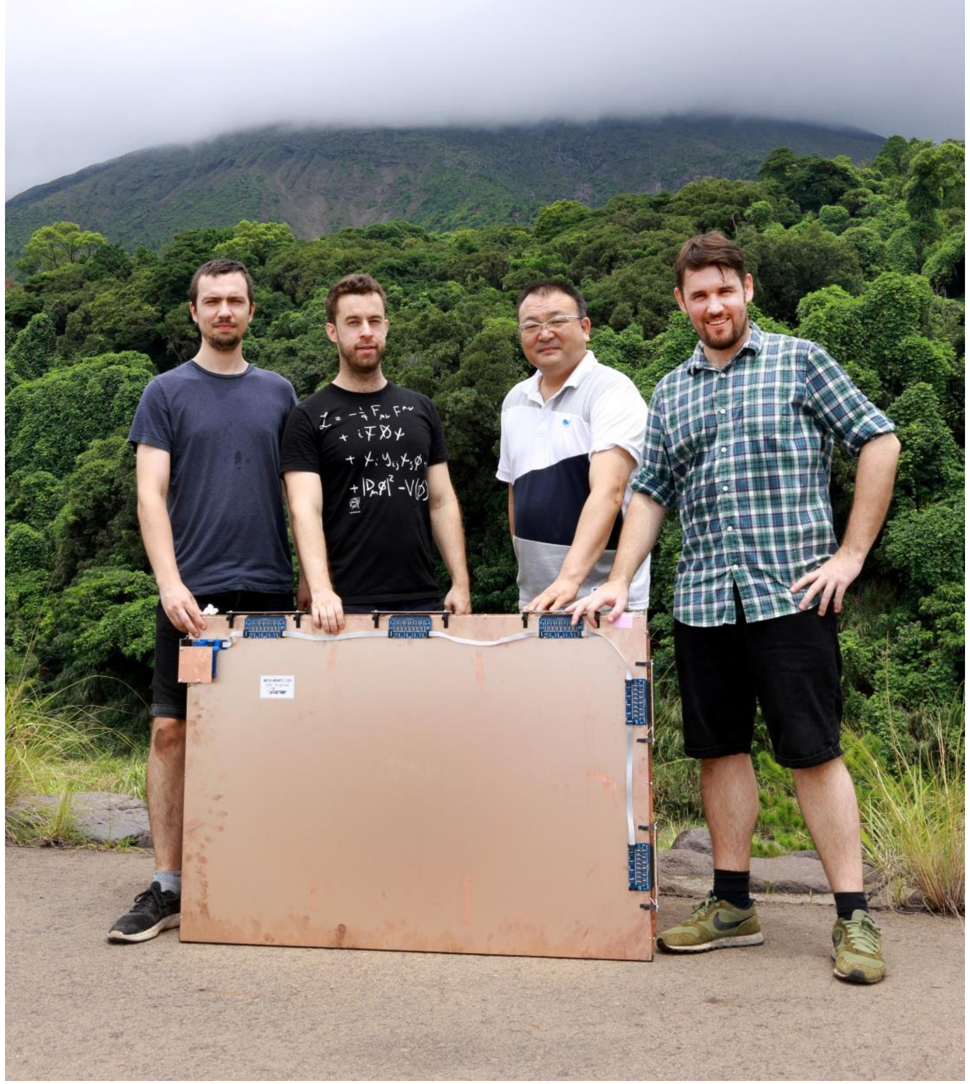
2019 L. Oláh et.al.: Plug Formation Imaged Beneath the Active Craters of Sakurajima Volcano WithMuography, DOI: 10.1029/2019GL084784

The Sakurajima MMOS upgrade

- Active area upgraded to 8 m^2 (from 5,5 m^2)
- Two 120 cm x 80 cm and one 80 cm x 80 cm detector system has been installed
- Each system consists 8 layers of MWPC chambers and 5 layers of lead wall
- Field work: inserting detector layers, calibrations, gas- network- and power-supply setup, starting and checking measurement

Summary

- Two PhD students from Wigner RCP to UT for one month in August
- Sofware tool and simulation developments
- Scientific networking and knowledge exchange
- Field experience in detector installation
- We are looking forward to the next secondment in spring,
  to continue this work



Thank you for your attention