Density Imaging of an Active Hydrothermal System With Atmospheric Muons

Master 2 Research Internship at Laboratory of Physics of Clermont (LPC)
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DIRE (Data integration from multiprobe sensor networks to assess risk scenario's at volcanic hydrothermal ecosystems) is an interdisciplinary project that will use Vulcano (Eolian Islands, Italy) as a testbench for assessing risk scenario's at volcanic hydrothermal systems from surface (temperature, gas, deformations) and in depth (muographic imaging) monitoring of the volcano, using deep learning algorithms. The project was funded by ANR in 2020 for a four-years duration and brings together particle physicists from LPC Clermont, data scientists from LIMOS/Clermont, volcanologists from LMV Clermont, INGV-Catania and Palermo and risk experts from Geneva University.

The LPC group is in charge of the muographic imaging within DIRE. Muography is a novel imaging technique using the attenuation of the atmospheric muon flux propagating through a volcano to infer its inner (density) structure. For the first time, a dynamic imaging will be attempted to monitor real-time changes in the structure induced by meteoric water movements within the structure. To this end, the muographic inverse method needs to be statistically optimized to offer the best sensitivity in the regions of interest.

Starting from an existing algorithm that reconstructs the density within a given (pixelized) direction from the number of recorded muons, the trainee is expected to develop an algorithm that optimizes the density contrast against the spatial resolution. This requires implementing image processing algorithms to uniformize the number of muons across the volcano, but also estimating in a robust way the uncertainties affecting the density reconstruction and the correlations between different pixels.

The trainee will work closely with a 3rd year PhD student in charge of the muon simulations and of the density reconstruction. Previous knowledge of ROOT and C++, expertise in data analysis are required. Good communication and team-work skills are necessary. A good English or Italian command is a plus.

A successful internship can be continued with a PhD.