Nuclear emulsions techniques for muography

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Introduction

The nuclear emulsions technology has recently entered the field of muon radiography of volcanic edifices and faults. The historically first muographic image of a volcano was indeed generated by using this nuclear emulsion technology. In earlier times, large-scale application was limited by the readout time and manpower needs as the emulsion films had to be scanned by eye; modern fast automatic microscopes solved both issues, and the readout and analysis speed increased by several orders of magnitude, allowing larger statistics for muographic data samples.

Nuclear emulsions are usually cast in the shape of thin films (thickness in the range of 20-100 micrometers) coating transparent plastic bases. Even a single film can provide 3D tracks marking the passage path of ionizing particles, when observed by a dedicated microscope. Normally emulsions films are exposed in stacks, piling several sheets, so that a single particle, after development, leaves several aligned tracks, one in each film. This allows not only precise directional measurements (resolution of the order of few milliradians), but also particle identification; the latter is crucial to discriminate hard muons from softer particles from muon-induced showers in the rock, which may bias track counting and the related density estimates.

The ongoing progress of faster and cheap film readout systems is quickly improving the data-taking speed and hence the attainable statistics. Muon radiography triggered the development of specific data analysis procedures, aimed at maximizing the signal/noise ratio in detectors made of several multiplets of films used as tracking devices. Dedicated software is also being developed to simulate the passage of high-energy muons through thick rock layers: this allows comparing results of data acquisition campaigns to the expectations of reference models of volcanoes or faults.