R&D on nuclear emulsion detectors for muon-radiography of large structures

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The development of novel detection systems based on nuclear emulsion films and very fast advanced automated read-out microscopes could allow an unprecedented performance in the investigation of large structures (glaciers, volcanoes or civil engineering constructions) by cosmic-muon stereo-radiography, opening the way to novel studies in many different fields. A full 3D density map of the structure under investigation can in fact be obtained by merging the information from several muon detectors measuring cosmic-muon flux from different directions.

Emulsion films represent a suitable detector for such a study for many reasons: their unbeatable spatial and angular resolution (less than 1 μm and a few mrads, respectively); their detection and data storage capabilities; their passive nature not requiring power supply and radio-transmission of data; their mechanical robustness. The use of an emulsion tracker is ideal for muon-radiography also for the rather simple implementation in harsh environmental sites, as for practical geological applications.

On the other hand, a rather long exposure time is required for any reasonable detector surface, and a quasi-real time analysis of the emulsion data is quite impossible due to the time needed by the optical microscope scanning of the emulsions.

A major R&D activity is then required for exploiting at best the high potentiality of an emulsion-based detector for muon-radiography purposes, in particular by developing and employing custom emulsion films of specific features, and realizing a new generation of automated microscopes, faster than the current devices.

LHEP in Bern is one of the largest emulsion scanning laboratories in the world, where six state-of-the-art high-speed automatic scanning microscopes are presently installed and routinely operating: five microscopes are running for the OPERA experiment on neutrino oscillation research; one of them is fully devoted to other applications, among which muon-radiography. In this framework, an emulsion film production and development facility has recently been established in an underground laboratory at LHEP, with the purpose of producing high sensitivity and high angular resolution emulsion detector, which can also be read out quickly. At this facility, set-up in the framework of the Innovative Nuclear Emulsion Technologies (INET) project, financed by the Switzerland-Russian Scientific and Technological Cooperation Programme, the R&D activity on emulsions has started and several tests are ongoing with the aim of producing suitable emulsion films for muon-radiography. The new high sensitivity films have been exposed to high-energy beam at CERN to study their detection performances. The status and perspectives of this activity will be presented.