

# **Development of nuclear emulsion technologies for cosmic-ray muon radiography**

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Nuclear emulsion is high sensitive photographic film used for detection of three-dimensional trajectory of minimum ionizing charged particles like cosmic ray muon. These trajectories are recorded as tracks consist of a lot of developed silver grains. The size of the silver grain is about 1 micron, so that nuclear emulsion has very high spatial resolution. In addition, nuclear emulsion doesn't need electric power supply, the size is compact and the weight is light. These properties have advantages in the out-door observation for the measurement of geoscience object, archeological object, or in the disaster area. In principle, resolving power of muon radiography is increased by enlarging detector area. It's possible to enlarge detector area to 10-100m<sup>2</sup> by installing small area (~100cm<sup>2</sup>-1m<sup>2</sup>) detectors side by side. Time information can be added by addition of moving mechanism, called "emulsion shifter". As described above, nuclear emulsion is very unique and powerful tool for cosmic-ray muon radiography.

We are developing the nuclear emulsion in our laboratory at Nagoya University by introducing emulsion gel production machine. By using this machine, we can control the silver bromide crystal size and its sensitivity in order to optimize for various purposes. We are also developing nuclear emulsion production techniques (gel production, coating and packing) for mass production. In this way, we are preparing the framework, which performs all processes of nuclear emulsion production at a university. Until now, we have already produced about 50m<sup>2</sup> nuclear emulsions by our laboratory and used 10m<sup>2</sup> for cosmic-ray muon radiography experiments. These nuclear emulsions were used for the test observation for Fukushima Daiichi Nuclear Power Plant, archeological application, civil engineering application.

We are also developing new read-out system of nuclear emulsions built with optical microscope system "Hyper Track Selector (HTS)", which read-out speed is 1m<sup>2</sup>/hour. This scanning system is under development.

We will present these topics and future prospects of technological progress and applications.