

# **Muonic X-ray measurement system for historical-cultural heritage samples in J-PARC.**

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Negative muon elemental analysis, which can measure elemental compositional distribution in the depth direction from 100 nm to several centimeters in a cm-order area with a depth resolution on the order of  $\mu\text{m}$ , is a revolutionary technology that enables nondestructive analysis of samples that previously could only be cut and analyzed in cross-section. In recent years, this technique has begun to be applied to historical cultural heritage, and has already been carried out on Japanese archaeological heritage, beginning to provide new insights into Japanese archaeological research. We have been developing a negative muon X-ray measurement system for elemental analysis of historical cultural heritage at the KEK Muon Science Laboratory (MSL) in the Japan Proton Accelerator Research Complex (J-PARC). At MSL, machine time is very limited and fast measurement of archaeological samples is required. For this purpose, it is essential to increase the detection efficiency of the high-purity germanium semiconductor detectors (HP Ge), which can obtain energy spectra of negative muon X-rays over a wide energy range with high resolutions. Especially, for the pulsed muon source at J-PARC, the Ge detector can detect only one photon or less per pulse. Hence, the use of multiple Ge detectors is essential to obtain high detection efficiency. In our present system, totally 9 Ge detectors with small crystal (1cc) have provided the energy spectra with a high signal-to-noise ratio (S/N) and increased detection efficiency by about 10 times compared to conventional systems.