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Developments on muonic X-ray measurement system for historical-cultural heritage samples in Japan Proton Accelerator Research Complex (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 μm, 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. In this talk, we will report on the development of 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. Therefore, we are developing a system to measure negative muon X-rays from archaeological samples at high speed. For this purpose, it is essential to improve the detection efficiency of the detector. Since the analysis of negative muon X-rays requires obtaining energy spectra over a wide energy range with high resolution, high-purity germanium semiconductor detectors (HP Ge) are used; 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 addition, to obtain a high signal-to-noise ratio (S/N), noise sources must be identified and suppressed. By increasing the number of detectors and suppressing noise sources, we have succeeded in increasing detection efficiency by about 10 times compared to conventional systems.

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