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Advanced Non-Destructive Element-Sensitive 3D Tomography Using Muon-Induced-Xray-Emission (MIXE)

Muon-Induced X-ray Emission (MIXE) [1-4] is a non-destructive analytical technique that leverages negative muons to probe elemental and isotopic compositions by detecting characteristic muonic X-rays emitted during atomic cascades and gamma rays from nuclear capture processes. By controlling the muon beam momentum, MIXE enables depth-resolved analysis, spanning microns to centimeters, making it ideal for studying compositional variations in fragile, valuable, or operando samples. Significant advancements in MIXE technology have been achieved at the Paul Scherrer Institute (PSI) [5-7], facilitated by the high-rate continuous muon beam.

To establish a universal tomographic approach, additional muon tracking was incorporated using a twin GEM-TPC tracker, originally developed for heavy-ion detection at FAIR [8]. This enabled precise reconstruction of muon trajectories and correlation with emitted X-rays, yielding three-dimensional, element-specific information. The resulting technique, MIXE Tomography (MIXE-T), offers high-resolution, depth-resolved elemental analysis for a broad range of applications.

[1] Taylor et al., Observation of Muonic X-rays from Bone, Radiat. Res., 1973, 54, 335-342.

[2] Hutson et al., Tissue chemical analysis with muonic x rays, Radiology, 1976, 120, 193-198.

[3] Köhler et al., Application of muonic X-ray techniques to the elemental analysis of archeological

objects, Nucl. Instrum. Methods Phys. Res., 1981, 187, 563-568.

[4] Reidy et al., Use of muonic x-rays for nondestructive analysis of bulk samples for low Z constituents, Anal. Chem., 1978, 50, 40-44.

[5] Biswas S. et al. The non-destructive investigation of a late antique knob bow fibula (Bügelknopffibel) from Kaiseraugst/CH using Muon Induced X-ray Emission (MIXE), Herit Sci, 2023, 11, 43.

[6] Beda A. Hofmann et al., An arrowhead made of meteoritic iron from the late Bronze Age settlement of Mörigen, Switzerland and its possible source, J. Archaeol. Sci., 2023, 157, 105827.

[7] Q. Edouard et al., Overcoming the probing-depth dilemma in spectroscopic analyses of batteries with muon-induced X-ray emission (MIXE), J. Mater. Chem. A, 2025, 13, 2275-2284.

[8] F. García et al., A GEM-TPC in twin configuration for the Super-FRS tracking of heavy ions at FAIR, NIM-A, 2018, 884, 18-24.

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