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Muon-Induced X-ray Emission (MIXE) at PSI

Monday, 29 August 2022 17:00 (20 minutes)

The Muon-Induced X-ray Emission (MIXE) technique, first developed in the 1980's mostly for studying fundamental science, has recently seen a wide usage in the field of applied sciences, which includes archaeology, battery research, meteorites, ancient paintings etc.
Probing deep inside the material (up to a few mm) and being non-destructive, this technique is sensitive to all the elements of the periodic table, except hydrogen.
The continuous muon source at Paul Scherrer Institute (PSI) along with the newly in-house made instrument is one of the most powerful setups for an efficient usage of this technique.
We present here recent developments of this dedicated detector setup for MIXE at PSI, used at the πE1 beamline, which can deliver negative muon rates between $\sim$1.5 kHz and $\sim$100 kHz for a momentum range between 20 MeV/c and 45 MeV/c, respectively.
This setup presently consists of 11 HPGe detectors, with an overall absolute efficiency of $\sim$5\% and a resolution of $\sim$1 keV (FWHM) for muonic X-ray energies at $\sim$100~keV.
In addition to the HPGe detectors, there are two scintillator detectors, utilized to detect the muon entrance time and as veto counter.
By making use of the continuous-wave character of the PSI beam, a clear distinction between X-rays, produced during the muon cascade, and γ-rays produced after the capture of the muon by the nucleus, is possible hence providing a second route for the elemental and isotopic determination.
This setup enables the determination of the quantitative elemental composition within $\sim$1 h of DAQ time.
A proof-of-principle experiment, using a simple three-layered sandwich sample has been recently published [1].
Several other experiments on precious objects from archaeology and meteorites along with operando battery samples have been performed and the analysis is in progress.

[1] S. Biswas, L. Gerchow et al., App. Sci. 2022, 12(5), 2541.

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