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Simultaneous measurement of U and Pu isotopes in environmental samples using large collector array MC-ICP-MS in support of nuclear safeguards

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The International Atomic Energy Agency (IAEA) collects environmental swipe samples from nuclear facilities to verify declarations in support of safeguards. With the anticipated increase in nuclear facilities from the adoption of small modular reactors, the number of environmental samples analyzed by the Network of Analytical Laboratories (NWAL) is expected to increase significantly in the coming years. To accommodate this increase there is a need for improved sample throughput and reduced data reporting timelines.

This work aims to reduce analytical timelines while maintaining the precision of isotopic analyses conducted by NWAL by developing front-end sample preparation and analysis techniques for advanced mass spectrometry. We report the development of a simplified chemical separation scheme, using UTEVA resin, that allows for co-collection of U and Pu from environmental swipe samples with sufficient purity for analysis by MC-ICP-MS. Furthermore, we leverage PNNL's recently installed Nu Instruments Sapphire 1700 MC-ICP-MS to simultaneously measure U and Pu isotopes in purified samples. The Sapphire 1700 is equipped with a large collector array comprised of twelve full-size, discrete dynode SEMs (interspersed with Faraday cup detectors for larger analyte ion beams, such as ^{238}U) that allows ion counting at 12 masses between 230 and 244 amu. This novel large detector array allows for simultaneous collection of ^{244}Pu, ^{242}Pu, ^{241}Pu, ^{240}Pu, ^{239}Pu, ^{238}U, ^{236}U, ^{235}U, ^{234}U, and ^{233}U. The combination of a streamlined sample preparation procedure (co-collection of U and Pu) and analytical routine (simultaneous U and Pu isotopic analysis) can significantly reduce total timelines, which corresponds to a significant increase in sample throughput. More broadly, this work demonstrates the unique capabilities potentially afforded by next-generation large collector array equipped MC-ICP-MS instruments.