Laboratory-based High-Resolution X-ray Absorption and Emission Spectroscopy for Nuclear Science and Radiochemistry Research and Education

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ABSTRACT:

The objective of this project is to acquire a radiological laboratory-based high-resolution hard X-ray spectrometer that can perform both X-ray absorption spectroscopy (XAS) and X-ray emission spectroscopy (XES). This instrument will greatly upgrade the technical capability of Washington State University (WSU) for nuclear-related and radiochemical research and teaching, allowing for enhancement of WSU's capacity to attract high quality students interested in nuclear science. Additionally, ready access to this instrument will strengthen the radiochemistry and materials science research programs at WSU, and enable more collaborative work among top scientists in the field of radiochemistry, actinide science, and nuclear materials science. The very recent availability of this type of instrument has the promise of transforming analytical chemistry and materials science, removing access barriers traditionally imposed by specific missions of synchrotron beamlines. Currently available lab-based systems enable the attainment of high quality quantitative X-ray absorption near edge spectroscopy (XANES) and emission spectroscopy (XES), and qualitative extended X-ray absorption fine structure (EXAFS) data. These data were previously only obtainable on synchrotron beamlines, whereas now the data quality from commercially viable lab-based systems is comparable to synchrotron data. XAS measurements allow for accurate quantification of oxidation state, coordination, and bonding information, which are essential for research in *i*) chemistry of lanthanides, actinides, and transition metals, such as in nuclear fuels and nuclear waste forms; *ii*) transuranic elements, including speciation and local chemistry; and *iii*) molten fuel salts, with actinide and fission product components.

The lab-based X-ray spectrometer will greatly extend the *Light Source* capability in the Nuclear Science User Facilities (NSUF) to enable faster cycles of Nuclear Fuels and Materials Characterization and support the Post-Irradiation Examination (PIE) mission. The instrument will also accelerate the education and training of the next generation researchers on this state-of-art spectroscopic technique with in-depth understanding on actinide chemistry, preparing them to utilize national synchrotron user facilities and work in DOE national laboratories.