DOE-ID NEPA CX DETERMINATION
Idaho National Laboratory

CX Posting No.: DOE-ID-INL-21-079

SECTION A. Project Title: LDRD Photonuclear

SECTION B. Project Description and Purpose:

Laboratory Directed Research and Development (LDRD) 18P37-031P,"Expanding photo-nuclear data via high-energy Linear Accelerator (LINAC) coupled with real time gaseous mass separation," proposed modifying a commercial isotope separator to separate short-lived isotopes irradiated in-situ in the ion source of the isotope separator. Separated ions are implanted into separate metal foils permitting each isotope to be counted individually. This approach simplifies gamma spectra for measuring weak photonuclear cross sections of very short-lived isotopes (half-life <2 hours). Originally, this work was to be performed using a LINAC purchased by Idaho National Laboratory (INL), constructed at Idaho State University (ISU), tested at ISU, and then relocated to INL to support the photonuclear production of isotopes for the Department of Energy (DOE) National Nuclear Security Administration (NNSA) and Department of Defense Programs. The LINAC was not relocated to INL, is currently operated at ISU under ISU's Nuclear Regulatory Commission license. Due to limitations at ISU, in-situ irradiation using the isotope separator is not proposed.

Instead, the project proposes to demonstrate this concept using isotope separation to measure weak or short-lived nuclear transitions using isotopes of Neodymium (Nd). The isotopes of Nd will be separated in a commercial isotope separator developed for in-situ irradiations. This separator will only handle stable isotopes. The separated isotopes will be implanted into foils; the foils will be transported to ISU for irradiation; and then the isotopes and foils will be transported back to INL for non-destructive gamma spectrometry. Loading and counting targets will be performed at the INL Research Center (IRC). The samples may be dissolved and analyzed by mass spectrometry at IRC to determine the amount and isotopic composition of Nd implanted on each foil.

Neodymium has eight natural isotopes: 142Nd, 143Nd, 144Nd, 145Nd, 146Nd, 148Nd, and 150Nd. The proposed action evaluates gamma-neutron (g,n) reactions that form 141Nd and 147Nd and 149Nd; these isotopes have half-lives of 2.49 hours, 10.98 days, and 1.73 hours respectively.

The Nd samples will remain radioactive for some time due to the decay daughter of 147Nd, namely Promethium-147 (T1/2 = 2.6 years). Neodymium metal foils may be irradiated to determine irradiation conditions. Neodymium oxidizes in air rapidly; therefore water should be avoided unless it is being dissolved. The Nd foils and separated isotopes can be re-irradiated for future experiments or dissolved and used for test samples as a low-level radioactive test material for rare earth reclamation (electrorefining), chemistry (rare earth separations), or measurements standards (Nd fission product measurements).

The isotope separator is a high vacuum system operated with inert gas such as argon. Xenon is often used to measure the isotope separation efficiency. There will be air emissions from argon and stable Xe solid samples, which are placed in the ion source to be atomized and ionized. A positive potential (kilovolts) will be applied to the ion source relative to the extraction cone to extract the samples. A magnetic field will separate the extracted ions which will then be implanted onto Faraday cups constructed of high purity aluminum foil. The foils containing implanted isotopes will then be removed from the instrument. Ion source components will be plated with the sample (>99.99) during the ion extraction process; afterwards they will be removed and disposed of. The Faraday cup foils containing the samples (typically 10's of micrograms Nd) will be transported to ISU, irradiated, and transported back to INL for gamma spectrometry. After the measurements are completed, the samples will be disposed as low-level radioactive waste (LLW). Stable and Radioactive isotope separations will be performed at Materials Fuels Complex (MFC), and the Xe Isotope separation will be performed at IRC in the A wing.

A higher resolution calibration is necessary for each photon energy used in the irradiation with conditions specific to the sample and sample holder. To do this, gold (foil or wire) will be irradiated under conditions identical to those of the sample. Samples of gold and high purity copper will be used to characterize the photon flux and spectral characteristics of the LINAC. These samples will be prepared at INL, transported to ISU, irradiated, and transported back to INL for gamma counting. Due to the short half-lives of the gold and copper isotopes formed during photonuclear irradiation (196Au T1/2 = 6.18 days; 64 CuT1/2 = 12.7 hours and 62Cu, T1/2 = 9.7 minutes), these samples will be stored and permitted to decay and reused for future irradiations.

The experiment will conduct irradiations for six gold foils at end -point test energies of 10-,12-,14-,16-,18-, and MeV. The number of samples that will be produced are estimated to be eight to 10 samples, each containing approximately 39 milligrams of gold. Each sample will be irradiated for five minutes.

Photonuclear irradiations and gamma counting with mass spectrometry will be done routinely.

Purchased materials for the experiment are Nd foils, gold foils, aluminum foils, vacuum hardware for mass separator, aluminum to make holders for irradiation, an oil-less vacuum pump, and a turbo-pump.

SECTION C. Environmental Aspects or Potential Sources of Impact:

Air Emissions

The project will generate stable Xe and Argon air emissions from the isotope separator. Other air emissions include nitric oxides from the nitric dilution of 16 Molar acid to 3 Molar acid. The dilution will be less than 10 milliliters of 16 Molar acid.

Discharging to Surface-, Storm-, or Ground Water

N/A

Disturbing Cultural or Biological Resources

N/A

Generating and Managing Waste

Generation of waste will consist of Nitric acid (<100 mL if leached Nd off of the foils). The Nd implanted on the aluminum faraday cup foils will be disposed of as LLW.

Releasing Contaminants

Whenever chemicals are used there is a potential for spills and releases.

Using, Reusing, and Conserving Natural Resources

Waste shall be diverted from the landfill whenever practicable. Aluminum holders are to be recycled and reused. Gold and Nd will be repurposed for other experiments.

SECTION D. Determine Recommended Level of Environmental Review, Identify Reference(s), and State Justification: Identify the applicable categorical exclusion from 10 Code of Federal Regulation (CFR) 1021, Appendix B, give the appropriate justification, and the approval date.

For Categorical Exclusions (CXs), the proposed action must not: (1) threaten a violation of applicable statutory, regulatory, or permit requirements for environmental, safety, and health, or similar requirements of Department of Energy (DOE) or Executive Orders; (2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment or facilities; (3) disturb hazardous substances, pollutants, contaminants, or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-excluded petroleum and natural gas products that pre-exist in the environment such that there would be uncontrolled or unpermitted releases; (4) have the potential to cause significant impacts on environmentally sensitive resources (see 10 CFR 1021). In addition, no extraordinary circumstances related to the proposal exist that would affect the significance of the action. In addition, the action is not “connected” to other action actions (40 CFR 1508.25(a)(1) and is not related to other actions with individually insignificant but cumulatively significant impacts (40 CFR 1608.27(b)(7)).

References:
10 CFR 1021, Appendix B to subpart D, items B3.6, "Small-scale research and development, laboratory operations, and pilot projections," and B3.10 "Particle accelerators."

Justification:
The proposed R&D activities are consistent with CX B3.6, "Siting, construction, modification, operation, and decommissioning of facilities for small-scale research and development projects; conventional laboratory operations (such as preparation of chemical standards and sample analysis); small-scale pilot projects (generally less than 2 years) frequently conducted to verify a concept before demonstration actions, provided that construction or modification would be within or contiguous to a previously disturbed area (where active utilities and currently used roads are readily accessible). Not included in this category are demonstration actions meaning that they are undertaken at a scale to show whether a technology would be viable on a larger scale and suitable for commercial deployment,”

and CX B3.10, "Siting, construction, modification, operation, and decommissioning of particle accelerators, including electron beam accelerators, with primary beam energy less than approximately 100 million electron volts (MeV) and average beam power less than approximately 250 kilowatts (kW), and associated beamlines, storage rings, colliders, and detectors, for research and medical purposes (such as proton therapy), and isotope production, within or contiguous to a previously disturbed or developed area (where active utilities and currently used roads are readily accessible), or internal modification of any accelerator facility regardless of energy, that does not increase primary beam energy or current. In cases where the beam energy exceeds 100 MeV, the average beam power must be less than 250 kW, so as not to exceed an average current of 2.5 milliamperes."

Is the project funded by the American Recovery and Reinvestment Act of 2009 (Recovery Act) ☐ Yes ☒ No

Approved by Jason Anderson, DOE-ID NEPA Compliance Officer on: 05/28/2021