NATIONAL ISOTOPE DEVELOPMENT CENTER

Managed by the U.S. Department of Energy's Office of Nuclear Physics

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NIDC Newsletter #9

In This Issue

How to Make a Super Heavy Nucleus

Just how massive can a nucleus become? Is there a limit to the number of protons and neutrons in a nucleus? These questions lie at the heart of super heavy element research.

Nuclear stability decreases significantly with increasing atomic number after the element plutonium, and no element above element number 82 (lead) has stable isotopes. These heavier nuclei cannot withstand the Coulomb repulsion among the protons, so that adding more protons to a heavy nucleus simply makes it less stable. However, nuclear theorists predicted in the 1960s that an island of super-heavy nuclei with potentially long lifetimes might exist in the range of proton number Z=114 to 120 and neutron number N=184. A quantum many-body shell effect is believed to be responsible for this stabilization. In order to verify theoretical predictions, experimentalists bombard actinide targets with neutron-rich nuclei to produce new super-heavy nuclei. The discovery of element 117 – for which ORNL received considerable attention in the scientific community and popular media – and independent verification of elements 114 (flerovium) and 116 (livermorium) have provided significant validation for the experimental technique.

Much of the super-heavy research occurred through multi-year collaborations between scientists in the United States (Lawrence Livermore National Lab, Oak Ridge National Lab, University of Tennessee, Vanderbilt, and the University of Nevada) and scientists in Russia who focused on discovering and understanding these super-heavy nuclei. The Russian Principal Investigator, who has made this his life's work, is Professor Yuri Oganessian, a Russian nuclear physicist of Armenian descent. Professor Oganessian is a scientific leader of the Flerov Laboratory of Nuclear Reactions at the Joint Institutes for Nuclear Research (JINR) in Dubna, Russia. For over a decade, in collaboration with United States scientists, Oganessian has pursued this science at the local cyclotron facility of the Flerov Laboratory. The United States' unique contribution to this effort, aside from the scientific effort, has been the provision of target material, produced most recently by the DOE Isotope Program at the High Flux Isotope Reactor (HFIR) at ORNL. HFIR produces neutrons that irradiate heavy curium targets for several reactor cycles. The irradiation principally produces ^{252}Cf and ^{249}Bk as a byproduct. In June 2009, 22.2 mg of ^{249}Bk was collected and used to produce six targets that were employed in the discovery of element 117.

Berkelium used for the synthesis of element 117

How to Make a Super Heavy Nucleus (continued)

Today, a new opportunity exists to advance super-heavy research and expand the periodic table through deploying unique decay-enriched californium target material. The research is made possible by the DOE Isotope Program's provision of californium using the transcurium production, separation, and purification capabilities of ORNL's Radiochemical Engineering Development Center (REDC) and its ability to provide key materials and fabricate the desired actinide sources and targets. During previous hot fusion experiments, four events were assigned to the isotope $^{294}(118)$, which represent the only evidence so far for the synthesis of the heaviest element, Z=118. Three short decay chains were observed among the products of the $^{249}Cf+^{48}Ca$ reaction at JINR, one event resulted from the reaction of a ^{48}Ca beam on ^{249}Cf produced in beta decay of ORNL-made ^{249}Bk during the experiment detecting mostly Z=117 isotopes. ORNL's advanced digital detection technology recently increased the discovery potential of these experiments by extending observational capabilities to shorter half-lives, reducing random event rates, and improving energy resolution. New discoveries will be enabled by the development of targets containing heavier californium isotopes, ^{250}Cf and, in particular, long-lived ^{251}Cf ($T_{1/2}$=898 years). The synthesis of new super-heavy nuclei of element 118 and a search for a new element Z=120 will be undertaken by studying fusion- evaporation reactions between ^{251}Cf target nuclei and beams of ^{48}Ca and ^{50}Ti projectiles. These experiments should result in the creation of the heaviest nuclei ever synthesized. Experiments with ^{251}Cf targets will provide powerful tests of the validity of nuclear theories at extreme nuclear masses and help to define the properties of the island of enhanced stability for super-heavy elements.

Funding to develop the ^{251}Cf targets was provided by the DOE Isotope Program, the Nuclear Physics Research Program, and ORNL Laboratory Directed Research and Development funds for initial proof of principle target designs.

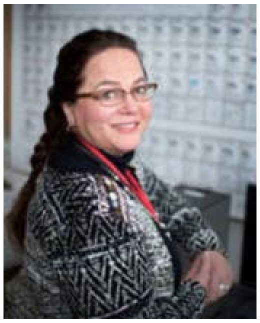
Isotope Program Distributed Sr-89 Samples for Evaluation

The DOE Isotope Program recently produced samples of strontium-89 (Sr-89), an isotope used for the palliation of pain associated with cancer that has metastasized to bone. The Isotope Program will engage in routine production if there is sufficient demand. The National Isotope Development Center shipped out millicurie quantities of non-GMP Sr-89 solution for evaluation by potential users.

Specifications for the sample material were:

Preparation:	strontium chloride ($SrCl_2$)
Radionuclidic purity:	>99%
Radioactive concentration:	>10 mCi/mL
Sr content:	<100 mg/mL
Solution:	0.1 *M* HCl
pH:	1-2
Specific activity:	>0.1 Ci/g
Total gamma-ray impurities:	<1% (Eu-154, Eu-155, Co-60 <$1x10^{-3}$%)
Total content of Sr-90:	<$2x10^{-4}$ %

Meet an Isotope Program Member



Recently Cathy Cutler joined the Department of Energy's Isotope Program at Brookhaven National Laboratory. Cathy came to the Collider-Accelerator Department as the new Director of the Medical Isotope Research and Production program (MIRP). Cathy comes to us from the University of Missouri, where she very successfully directed the radiopharmaceutical laboratories of the University of Missouri Research Reactor. The primary mission of the Brookhaven National Laboratory (BNL) Medical Isotope Research and Production Program is to prepare certain commercially unavailable radioisotopes to distribute to the nuclear medicine community and industry, and to perform research to develop new radioisotopes desired by nuclear medicine investigators. In conjunction with this mission, the group also performs irradiations for non-isotope applications, sells by-products, and explores opportunities for new products and radioisotope applications as needed.

The DOE Office of Science Graduate Student Research (SCGSR) Program is Now Accepting Applications

The Department of Energy's (DOE) Office of Science is pleased to announce that the Office of Science Graduate Student Research (SCGSR) program is now accepting applications for the 2016 Solicitation 1. **Applications are due 5:00 p.m. ET on Wednesday, May 11, 2016.**

Starting from 2015 Solicitation 2, the SCGSR program is open to graduate students with Permanent Resident status, in addition to U.S. Citizens, who meet all other eligibility requirements. Detailed information about the program, including eligibility requirements and access to the online application system, can be found at: http://science.energy.gov/wdts/scgsr/.

The SCGSR program supports supplemental awards to outstanding U.S. graduate students to conduct part of their graduate thesis research at a DOE national laboratory in collaboration with a DOE laboratory scientist for a period of 3 to 12 consecutive months—with the goal of preparing graduate students for scientific and technical careers critically important to the DOE Office of Science mission.

The SCGSR program is open to current Ph.D. students in qualified graduate programs at accredited U.S. academic institutions, who are conducting their graduate thesis research in targeted areas of importance to the DOE Office of Science. The research opportunity is expected to advance the graduate students' overall doctoral thesis while providing access to the expertise, resources, and capabilities available at the DOE laboratories. The supplemental award provides for additional, incremental costs for living and travel expenses directly associated with conducting the SCGSR research project at the DOE host laboratory during the award period.

The Office of Science expects to make approximately 50 awards in 2016 Solicitation 1, for project periods beginning anytime between November 1, 2016 and February 28, 2017.

The 2014 program solicitation and the 2015 Solicitation 1 have resulted in awards to a total of 112 graduate students from more than 50 different universities to conduct thesis research at 15 DOE national laboratories.

The DOE Office of Science Graduate Student Research (SCGSR) Program is Now Accepting Applications (continued)

The SCGSR program is sponsored and managed by the DOE Office of Science's Office of Workforce Development for Teachers and Scientists (WDTS), in collaboration with the six Office of Science research programs offices and the DOE national laboratories, and the Oak Ridge Institute of Science and Education (ORISE).

For any questions, please contact the SCGSR Program Manager, Dr. Ping Ge, at sc.scgsr@science.doe.gov.

National Isotope Development Center (NIDC)

Purpose

The National Isotope Development Center (NIDC) interfaces with the User Community and manages the coordination of isotope production across the facilities and business operations involved in the production, sale, and distribution of isotopes. A virtual center, the NIDC is managed by the Isotope Development and Production for Research and Applications (IDPRA) subprogram of the Office of Nuclear Physics in the U.S. Department of Energy's Office of Science.

NIDC Supporting Staff

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