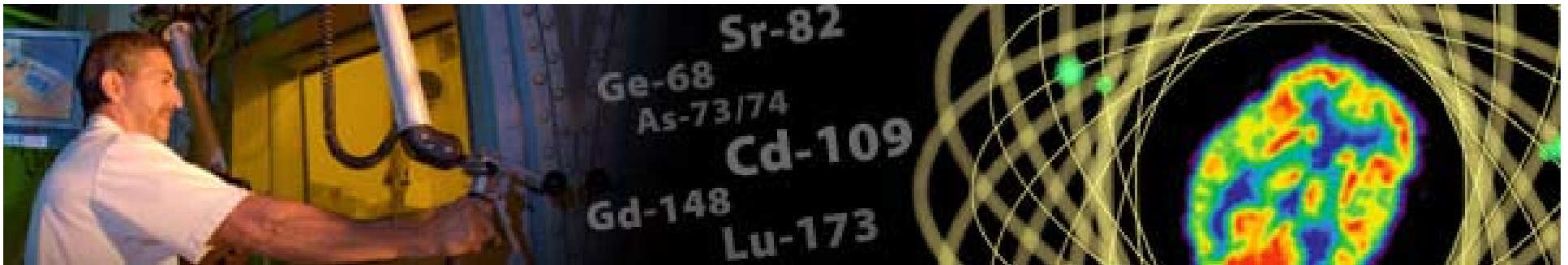




U.S. DEPARTMENT OF
ENERGY

OFFICE OF
SCIENCE

Status of Isotope Program Office of Nuclear Physics



NSAC

March 2, 2011

Jehanne Gillo

*Division Director, Facilities and Project Management
Office of Science, U.S. Department of Energy*



Isotope Program Mission

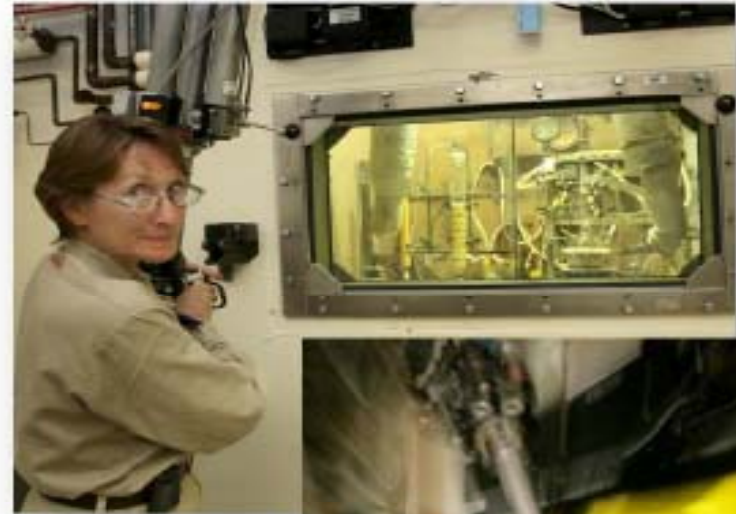
The mission of the DOE Isotope Program is threefold:

- Produce and/or distribute radioactive and stable isotopes that are in short supply, associated byproducts, surplus materials and related isotope services.
- Maintain the infrastructure required to produce and supply isotope products and related services.
- Conduct R&D on new and improved isotope production and processing techniques which can make available new isotopes for research and applications.



Isotope Program

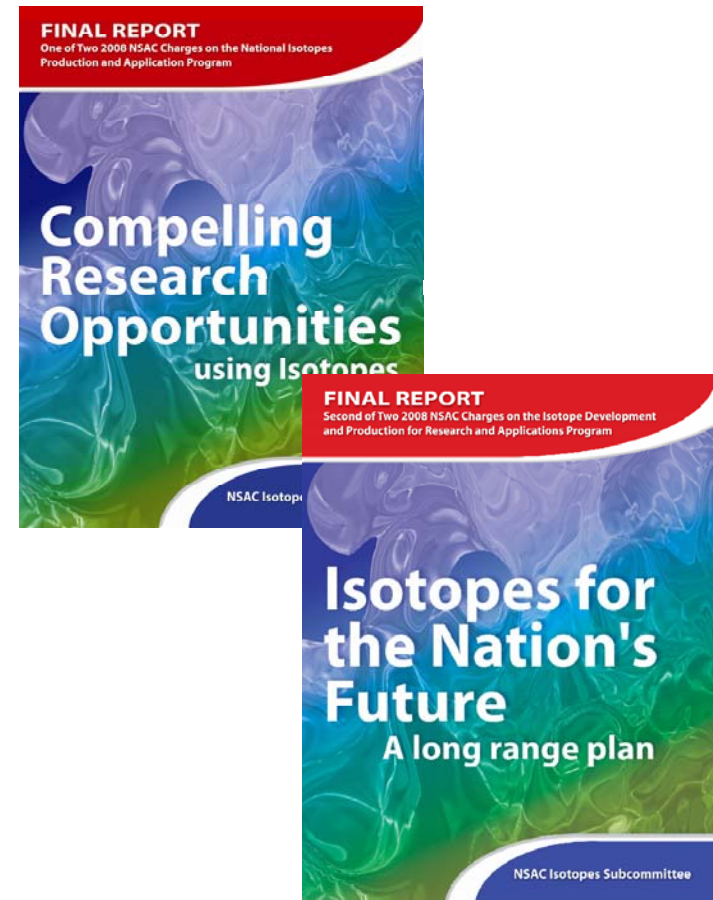
- Transferred from the Office of Nuclear Energy to NP with the 2009 Appropriation.
- Continues to produce, process, package and deliver isotopes for those isotopes not produced commercially.
- Re-established research and development of isotope production techniques and the production of research isotopes
- Serves a broad community of Federal agencies in addition to DOE—NIH, NIST, EPA, NNSA, DHS...
- Funding is from a combination of appropriations and sales—funds are deposited into the revolving fund which is externally audited annually.



OAK

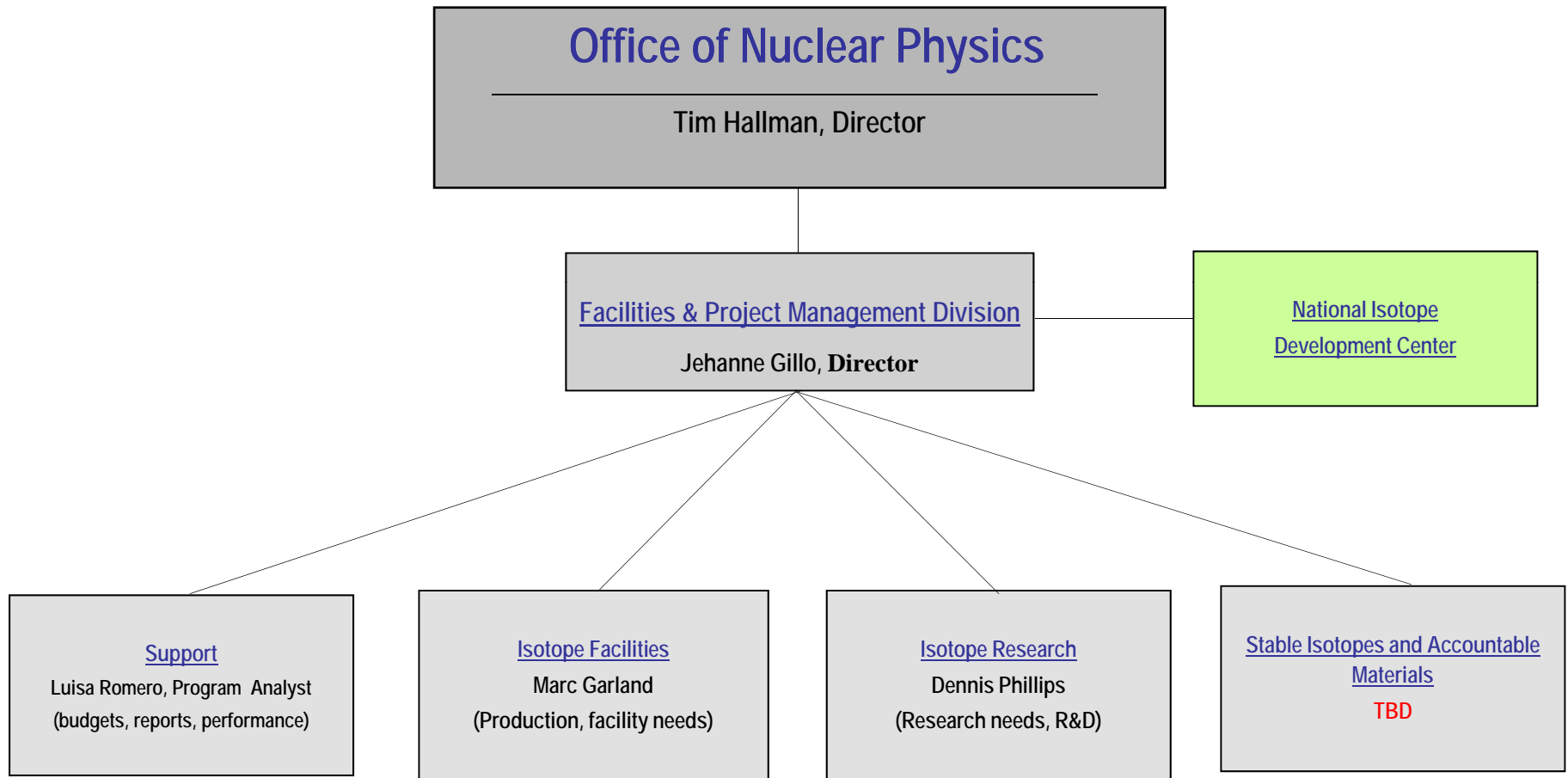
The changes to the program have been substantial

- Created Research and Development Program for new and improved isotope production techniques
- Introduced peer review into mode of operations
- Restructured the federal organization of the program
- Created the National Isotope Development Center
- Charged NSAC to set priorities for research opportunities and to develop a long-term strategic plan for isotope production and development.





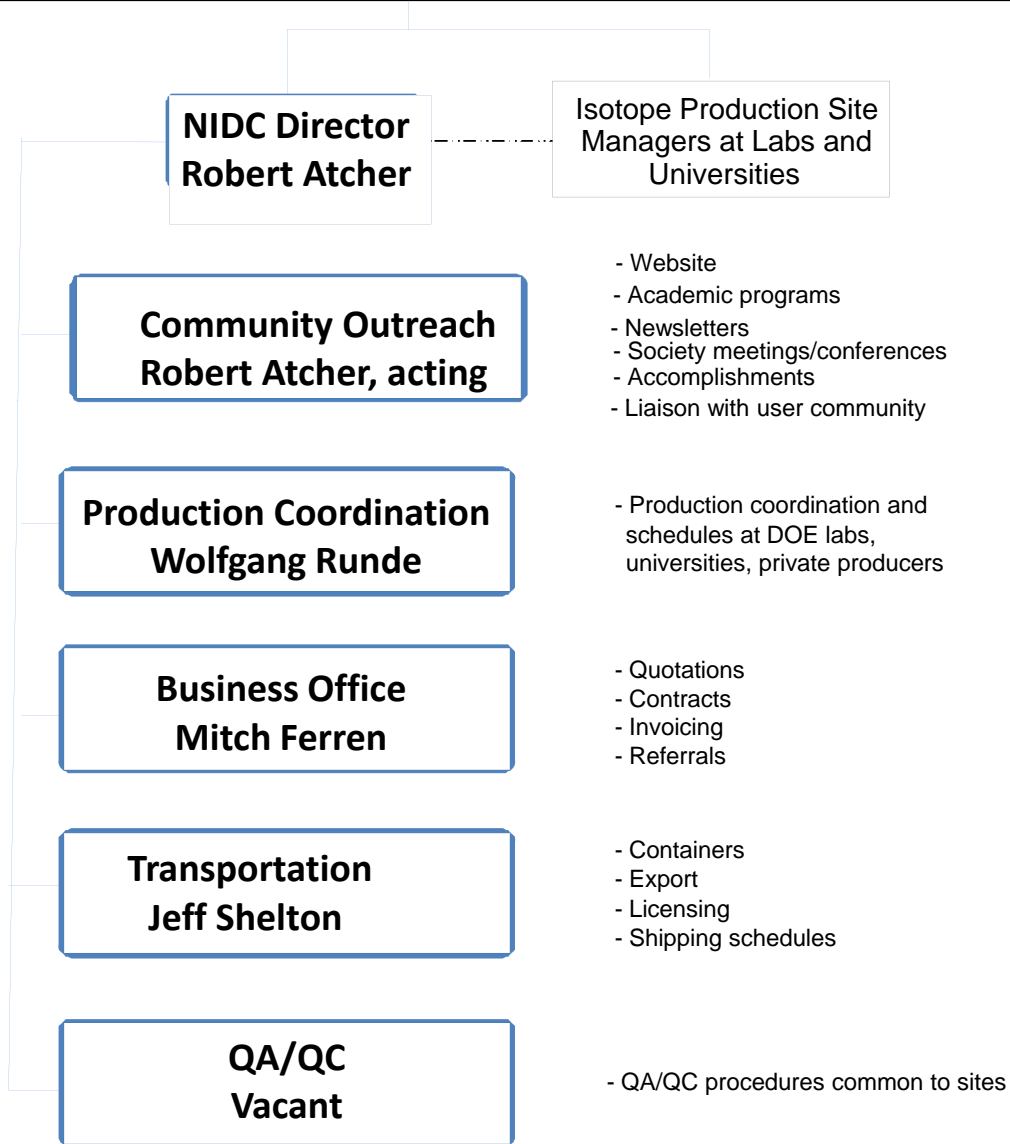
New Isotope Program Organization





Office of Nuclear Physics Isotope Production and Applications

New National Isotope Development Center Organization





NSAC Research Isotope Recommendations

Compelling Research Opportunities using Isotopes

- Invest in new production approaches of alpha-emitting radionuclides, e.g. Ac-225, At-211.
- Invest in coordination of production capabilities and supporting research.
- Produce isotopes of the heavy elements, e.g. Cf, Ra, TRU.
- Focused study and R&D on new or increased production of He-3.
- Re-establish domestic production and supply of stable isotopes.
- Robust investment into education and training.



Initiated R&D effort on the development of new and improved isotope production techniques for research and applications in FY 2009; guided by NSACI recommendations

- FY 2009 FOA and FY 10 awards
 - Awards: \$15.2 M in FY 2009 and 2010
 - ARRA Funds: \$8.6 M
 - 10 Laboratory Grants
 - Program funds FY09: \$3.6 M
 - 4 Laboratory; 6 University; 1 industrial
 - Program funds FY10:: \$3.0M
 - 1 Lab; 3 University
 - Alpha emitters (At-211, Ac-225)
 - Diagnostic dosimetry for therapeutic agents (Cu-64, Y-86)
 - Therapeutic (Cu-67)
 - Educational programs/development
 - Stable isotope enrichment

- FY 11 IDPRA Research FOA (DE-FOA-0000448)
 - Deadline April 18
 - Up to ~ \$3M in FY11 and same in FY 12

Alpha-Emitter Production for Targeted Radiotherapy

■ Actinium-225

- Continue to process the Th-229 for Ac-225; up to about 360 mCi per year.
- ORNL is conducting R&D to assess alternative accelerator and reactor methods for the production of parent-isotopes for alpha-emitting radionuclides (Th-229, Th-228, Ac-227, Ra-228) . ORNL is also assessing the use of ionic liquids as solvents for improved production of radioisotopes.
- LANL is conducting R&D to provide excitation function data for proton accelerator-based direct production Ac-225.
- R&D conducted by NorthStar is being supported for production of Ac-225 via high energy proton induced spallation.

■ Actinium-227

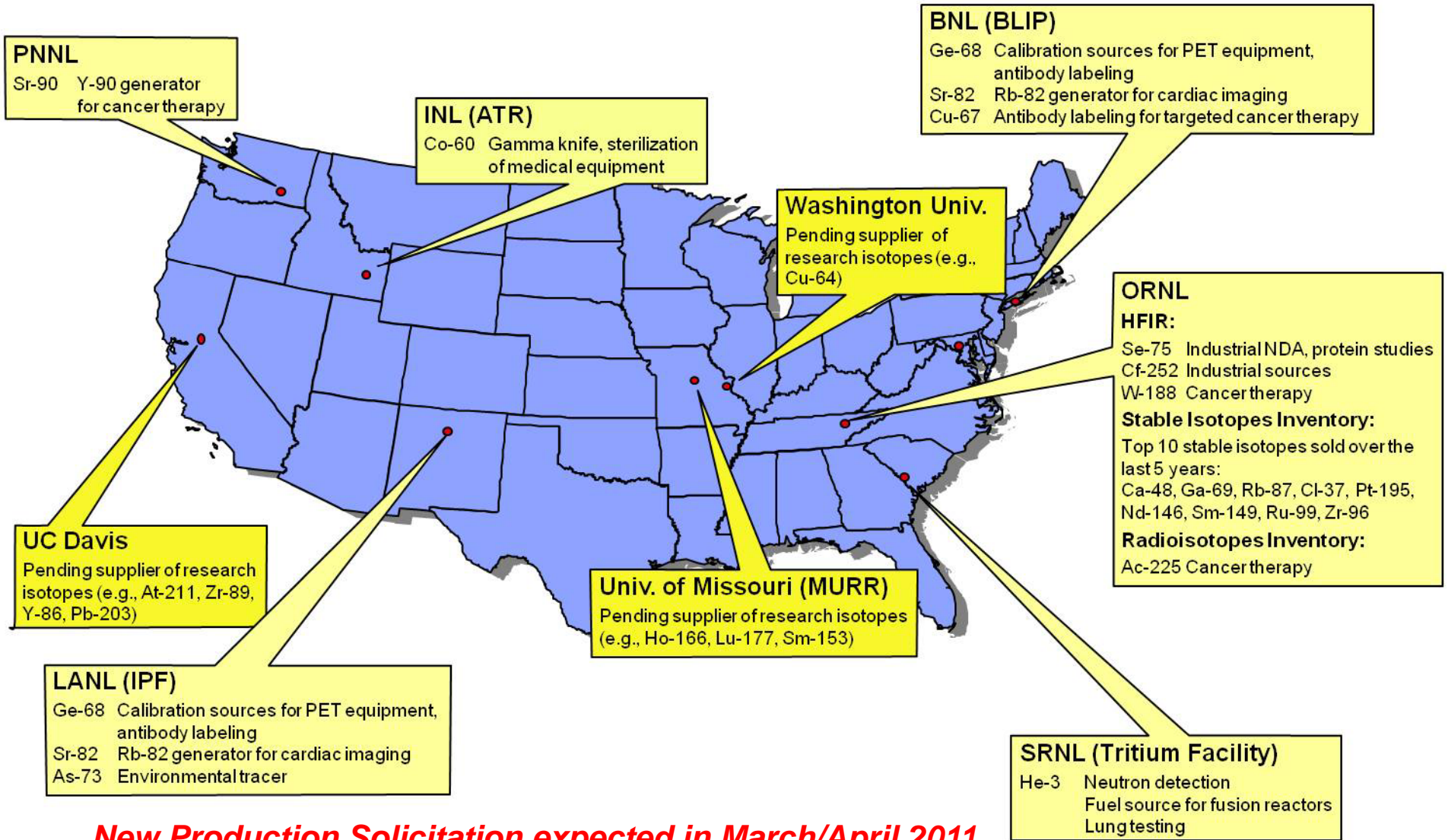
- R&D to separate and purify Ac-227 from surplus actinium-beryllium neutron sources at ORNL and other from legacy Ac-227 at PNNL. When completed, the Ac-227 can be used as a source (cow) for the decay production of very high purity Th-227 and Ra-223, important alpha-emitting isotopes for medicine.

■ Astatine-211

- R&D effort to obtain methods and materials at the University of Washington to routinely supply radiopharmaceutical grade At-211 to researchers.



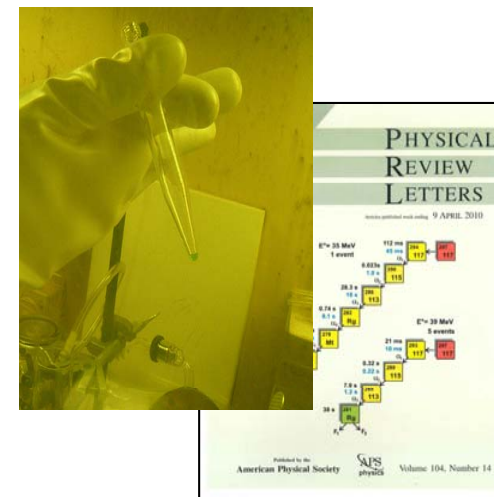
Invest in coordination of production capabilities and supporting research



New Production Solicitation expected in March/April 2011

Produce Elements of the Heavy Isotopes

- NP is the sole provider of research isotopes for super heavy element discovery research
 - 22 mg of berkelium-249 produced as by product of californium production for collaborative experiment between U.S. and Russia leading to the discovery of element 117
 - NP is supporting production of ~ 25 mg of Bk-249 for follow-up search to discover element 119 and 120
- Established reliable supply of Cf-252 for Nation
 - Supplies 97% of domestic market
 - Developing plan for ensuring feedstock supply of curium, including some acquisition
- Re-establishing domestic Am-241 production for industry and research



Focused study and R&D on new or increased production of He-3

■ Helium-3 Shortage

- Established Integrated Project Team in March 2009
 - Working Groups: Demand, Supply, Alternative Technologies (neutron detection); and Policy.
 - Guided by the steering group chaired by the EOP National Security Council.
 - Prioritized and allocated some He-3 in FY 2009; FY 2010 and FY 2011.
 - In June 2009 a He-3 workshop to explore alternatives to He-3 for neutron detection technologies was hosted by the Savannah River National Laboratory on behalf of the NNSA Network of Senior Scientists.
- Strategy to Reduce/Manage Demand
 - Pursue and employ alternative technologies for neutron detection. American Association for the Advancement of Science (AAAS) workshops: <http://cstsp.aaas.org/Helium3.html>.
 - Prioritize use of the existing supply of He-3.
 - Prioritize upcoming projects that would be big users of He-3.
- Increase Supply
 - Seek He-3 supply from foreign countries.
 - Encourage He-3 recycling and reuse.
 - Investigate techniques to increase He-3 extraction efficiency.
 - Possible new He-3 production.



Re-establish domestic production and supply of stable isotopes

- **Stable Isotope Purchase**
 - ORNL stable isotope purchase to replenish inventory of research isotopes such as Lu-176, Mo-100, Ni-62, W-186, and others.

- **R&D Concepts for Modern Stable Isotope Separation Technology**
 - ORNL is conducting R&D on technology for integrating gas centrifugation and electromagnetic isotope separation for preparation of stable isotopes.
 - New concepts in Plasma Enrichment
 - Other concepts for smaller scale enrichment of specific isotopes (e.g V-51) for research
 - Open competition for proposal is planned for the future



Education in Nuclear Chemistry and Radiochemistry

- Collaborative project between LANL and the University of Missouri to do research in the production and application of radioisotopes
 - Gives undergraduate, graduate, and post-doctoral opportunities to use unique isotope facilities at MURR and LANL
 - Production Se-72/As-72 generator system and synthesis of potential As-72 labeled radiopharmaceutical agents
 - Production and separation of medically useful lanthanide radioisotopes (Gd-153, Nd-140)
- Project at Pennsylvania State University to support re-establishment of a thriving graduate program in nuclear and radiochemistry
- Summer Schools in Nuclear Chemistry and Radiochemistry
 - NP provides funding to ACS DNCT to support the schools at San Jose State and Brookhaven National Laboratory
 - Isotope Program facilities and staff are used extensively in the program at Brookhaven National Laboratory
- Sponsoring and Participating in Symposia in Isotope Production and Applications and Radiochemistry Education
 - Symposium in Division of Nuclear Chemistry and Technology: American Chemical Society Fall National Meeting, Boston, August, 2010
 - IMI Sub-topical meeting of the American Nuclear Society, Las Vegas, November, 2010
 - 7th Symposium on Targeted Alpha Therapy, Berlin, July, 2011

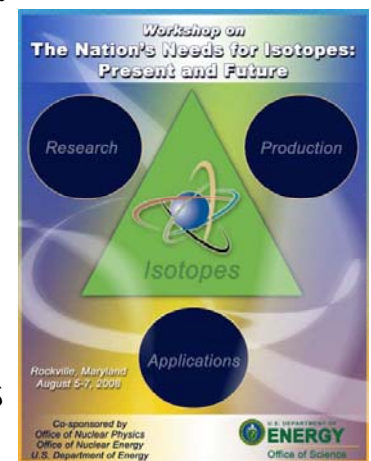
NSAC Long Range Plan Recommendations

Isotopes for the Nation's Future A Long Range Plan

- **Maintain a continuous dialogue with all interested federal agencies and commercial isotope customers to forecast and match realistic isotope demand and achievable production capabilities.**
- Coordinate production capabilities and supporting research to facilitate networking among existing DOE, commercial, and academic facilities.
- **Support a sustained research program in the base budget to enhance the capabilities of the isotope program in the production and supply of isotopes generated from reactors, accelerators, and separators.**
- **Devise processes for the isotope program to better communicate with users, researchers, customers, students, and the public and to seek advice from experts.**
- **Encourage the use of isotopes for research through reliable availability at affordable prices.**
- Increase the robustness and agility of isotope transportation both nationally and internationally.
- Invest in workforce development in a multipronged approach, reaching out to students, post-doctoral fellows, and faculty through professional training, curriculum development, and meeting/workshop participation.
- Construct and operate an electromagnetic isotope separator facility for stable and long-lived radioactive isotopes.
- **Construct and operate a variable-energy, high-current, multi-particle accelerator and supporting facilities that have the primary mission of isotope production.**

Improved Communication

- Workshop held August 5-7, 2008: The Nation's Needs for Isotopes: Present and Future
 - Assembled representative stakeholders- federal, research and industrial to identify needs and challenges.
- Establishing links of communications with federal agencies to understand needs and priorities
 - Federal Working Group to discuss medical isotopes etc. (DOE BER, DOE NP and NIH); establishing NIH prioritization mechanism
 - EOP Interagency Working Group to discuss He-3: NP/NNSA/DOD/DHS/CIA/FBI/Navy/Commerce/others
 - Solicits input from community in terms of needs
 - OSTP Working Group on Mo-99
- Charged NSAC to set priorities for research opportunities and to develop a long-term strategic plan for isotope production and development.
- National Isotope Development Center to improve public relations with stakeholders
- Involved in DOE strategic planning of accountable materials; frequent meetings with NNSA, NE
- Both DOE NP and NIDC hosting meetings with industry
- Planning a Federal Workshop in 2011 to identify long term agency needs





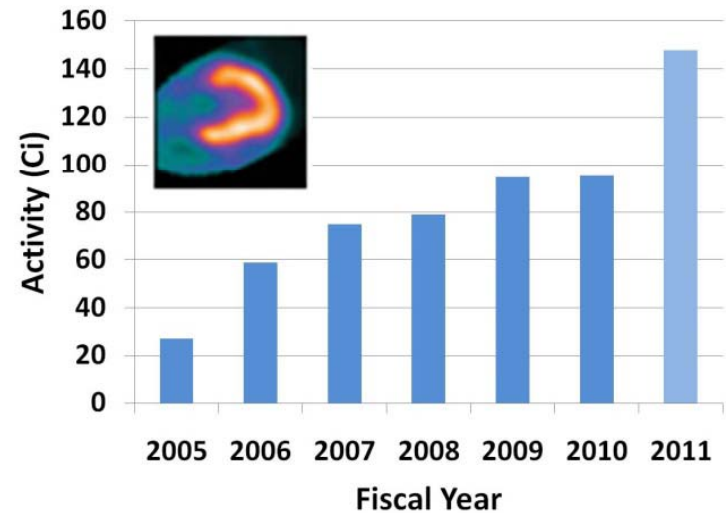
Availability of Research Isotopes

- Actinium-225
 - Arsenic-72
 - Arsenic-73
 - Berkelium-249
 - Beryllium-7
 - Bromine-86
 - Californium-252
 - Copper-64
 - Copper-67
 - Holmium-166
 - Iron-52
 - Lead-203
 - Lutetium-177
 - Magnesium-28
 - Samarium-153
 - Selenium-72
 - Silicon-32
 - Radium-223/Th-227
 - Rubidium-83
 - Tungsten-188/Rhenium-188
 - Yttrium-86
 - Zirconium-89
- Pricing policy has been revised: Unit cost instead of batch cost
 - Additional subsidization
 - Bottom-up cost estimates
 - Base research program at ORNL, LANL and BNL have been established



Other Isotopes

- **Actively working on/considering making other isotopes available in FY11**
 - High specific activity Gd-153
 - Ir-192
 - U-234
 - Am-241
 - Moving Co-60 production from INL to IP
 - Np-237
 - U-233
 - Sr-89
 - Additional quantities of Ra-226
 - Additional quantities of Ac-225
 - NP is Increasing strontium-82 (Sr^{82}) production for cardiac imaging in response to molybdenum-99 supply challenges
 - DOE supplies ~ 75% of domestic Sr^{82} market





Dedicated Facility

- Current two facilities stewarded primarily operate in parasitic mode
- NAS and NSAC both recommended dedicated facility
- Landscape is quickly changing
- Other Commercial entities are planning to build dedicated cyclotron facilities
- Isotope Program is being successful in broadening suite of facilities in cost-effective manner
- NP is encouraging development of proposals
- Multi-energy, Multi-particle Accelerator for radioisotope production (Conceptual Development)
 - ORNL: C70 Driver Cyclotron for radioisotope production and nuclear physics.
 - BNL: C70 Cyclotron for dedicated radioisotope production.
 - LANL: Run IPF at 40 Mev, 70 Mev, 100 Mev; MTS at 800 MeV.
- Considering partnerships with industry
- Need to complete cost-benefit analysis and study of potential business models
- Call for letters of interest anticipated in the summer



Conclusions

- **Isotope Program is synergistic with Nuclear Physics program**
- **Isotope Program is undergoing significant change in terms of management, mission, scope and capabilities**
- **There are continuous challenges that the program faces**
- **Much progress has already been made in addressing NSAC recommendations and more**
- **A high priority goal is to develop a coordinated, national strategy to meet present and future demand for isotopes in short supply for research and applications**



ORNL Proposal for Stable Isotope Production (R&D)

Focus on combining the best characteristics of gas centrifuge (high throughput) and electromagnetic separators (high purity) to create an efficient, cost effective process for stable isotope production.

The proposal has 3 primary aims:

- Investigate increased applicability of gas centrifuge technology to production of isotopes by exploring volatile analogs that would be compatible with the gas centrifuge process for a variety of elements.
- Acquire appropriately designed centrifuge(s) and install in a facility at ORNL with the goal of developing procedures for enriching the largest possible range of isotopes.
- Design and build an efficient, modernized electromagnetic separator that exploits the potential to use pre-enriched feedstock material from a gas centrifuge process and thereby reduce the total ion current required for isotope production compared to using a feedstock material with natural abundance of isotopes.