DOE Isotope Science and Technology Program and Facilities

SBIR/STTR Program

Cathy Cutler, BNL

DOE-NP SBIR/STTR Exchange Meeting

August 8, 2015

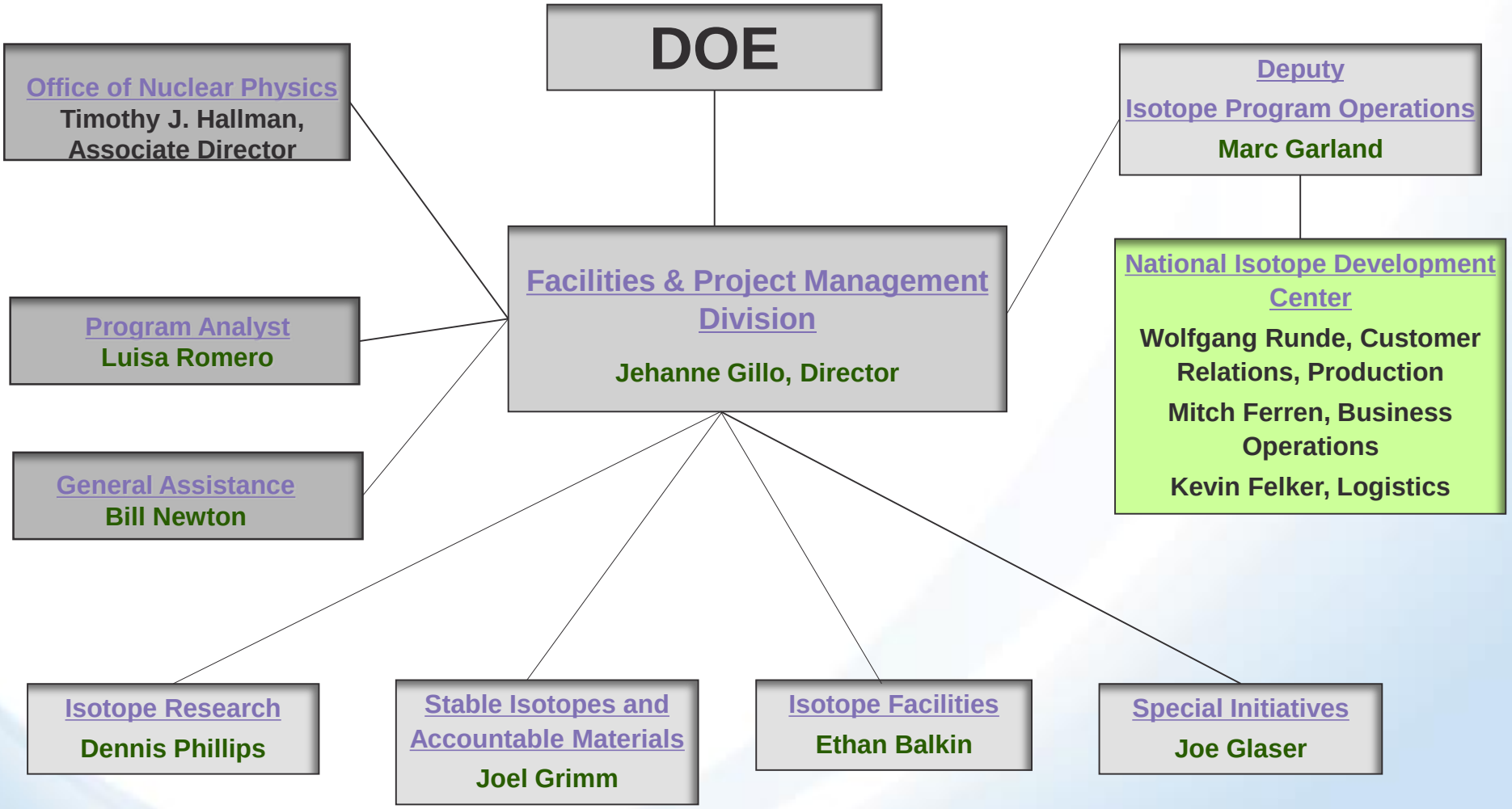
Outline

- Background
- Products, Services and Applications
- Facilities and Capabilities
- Isotope Program Development and Areas of Overlap with SBIR/STTR

Isotope Program Mission

- Produce and/or distribute radioactive isotopes that are in short supply, including valuable by-products, 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.
  - **Core R&D where there are Programmatically stewarded activities**
  - **Competitive R&D**
  - **SBIR/STTR, Early Career Award Program,**
  - **Nuclear and Radiochemistry Summer School, Workforce Development**

DOE Isotope Program Organization

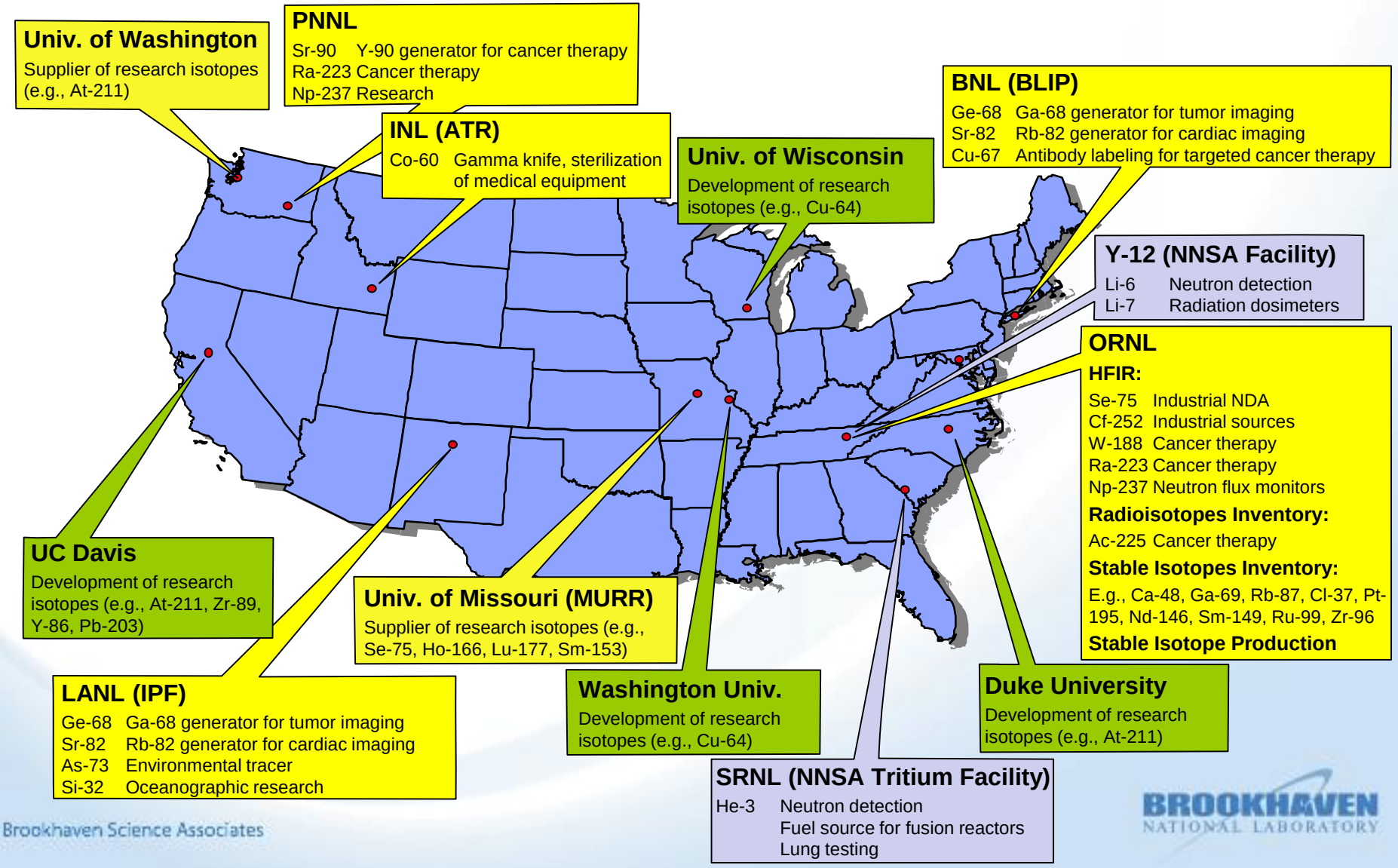


National Isotope Development Center

- The Department of Energy NIDC includes the Isotope Business Office located at Oak Ridge National Laboratory
- Coordinates the distribution of all DOE isotope products and services available from DOE facilities.
- All contractual discussions with customers.
- Responsibilities:
  - transportation
  - Q&A
  - public relations (website, newsletter, booth)
  - cross-cutting technical topics
  - marketing strategy
  - Assessments
- Customers maintain technical discussions with sites.

www.isotopes.gov

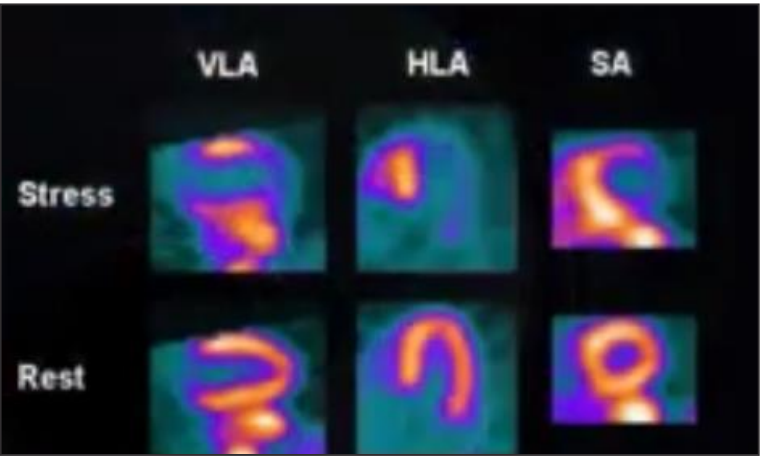
DOE Isotope Program Production and/or Development Sites



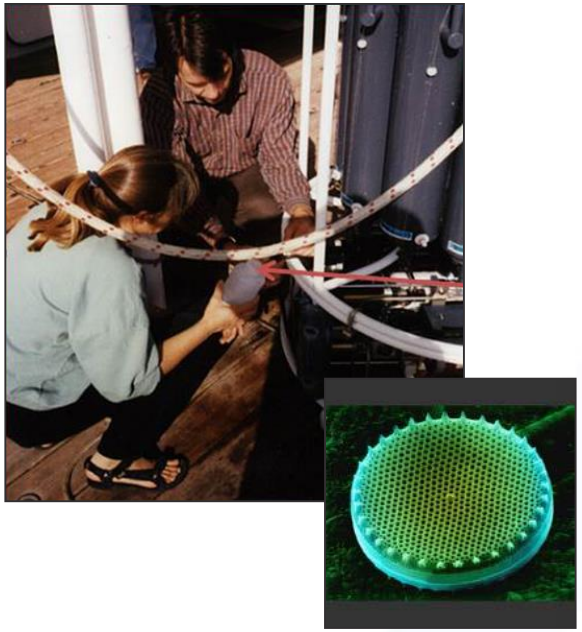
Products, Services and Applications

Applications – Accelerator Isotopes

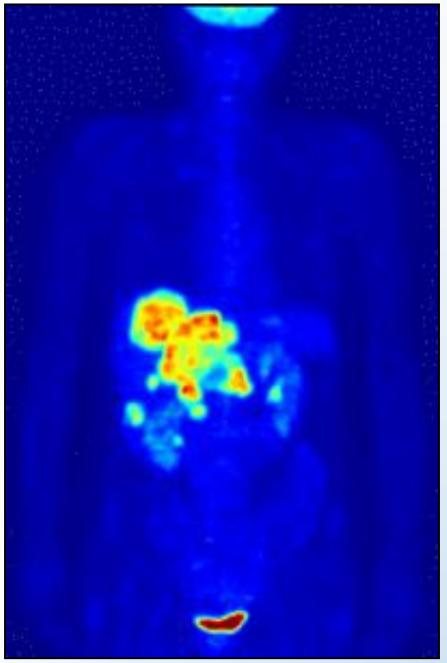
Sr-82/Rb-82:
Generator- cardiac imaging



Si-32: Environmental applications



Ge-68/Ga-68:
Generator-
cancer imaging



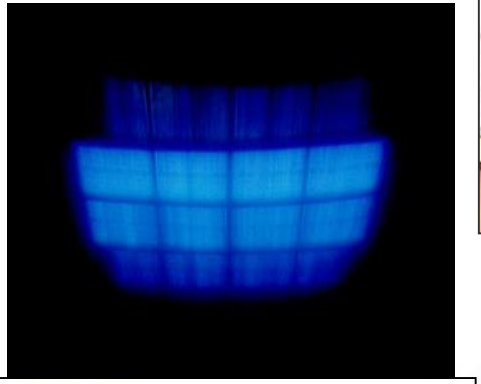
Na-22: Source for PET imaging

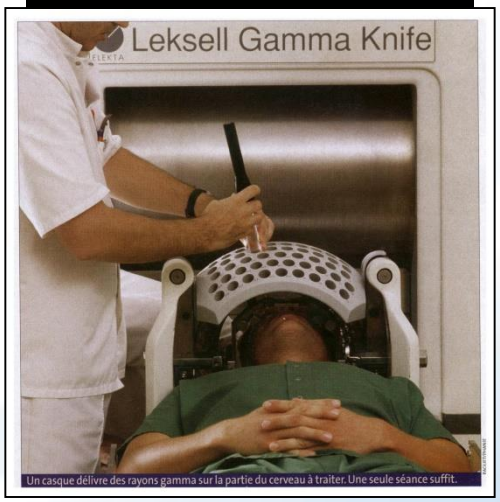
Cd-109: X-ray fluorescence source

Applications – Reactor Isotopes

Cf-252: Source – Oil Well Logging

Co-60:
Source – gamma sterilization
Gamma-Knife

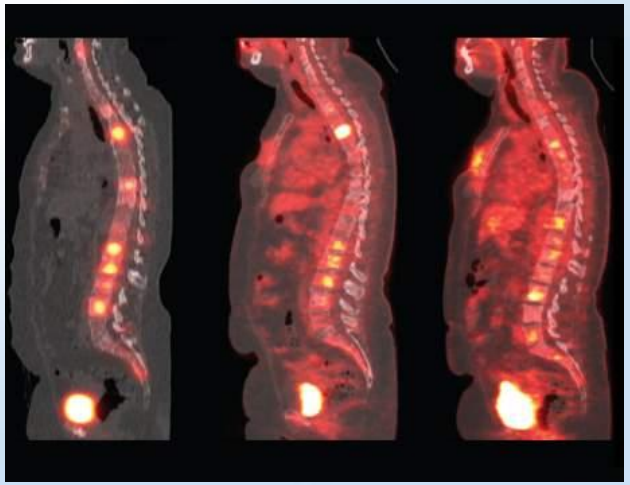




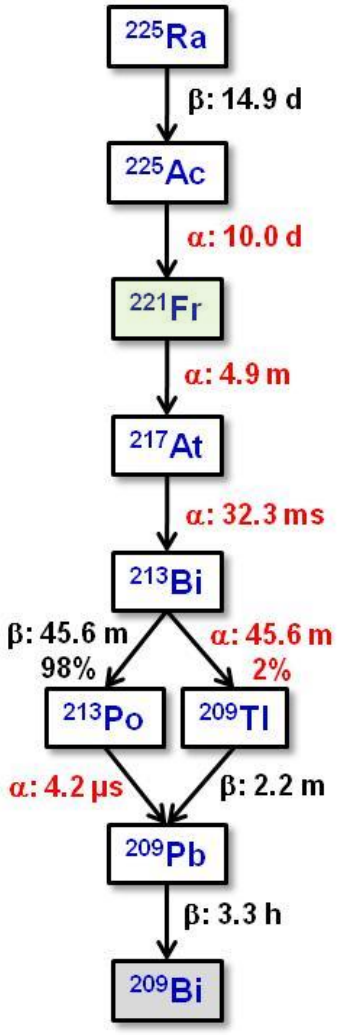
Se-75:
Source – medium energy gamma applications; non-destructive testing

W-188/Re-188: Generator – Cancer therapy applications

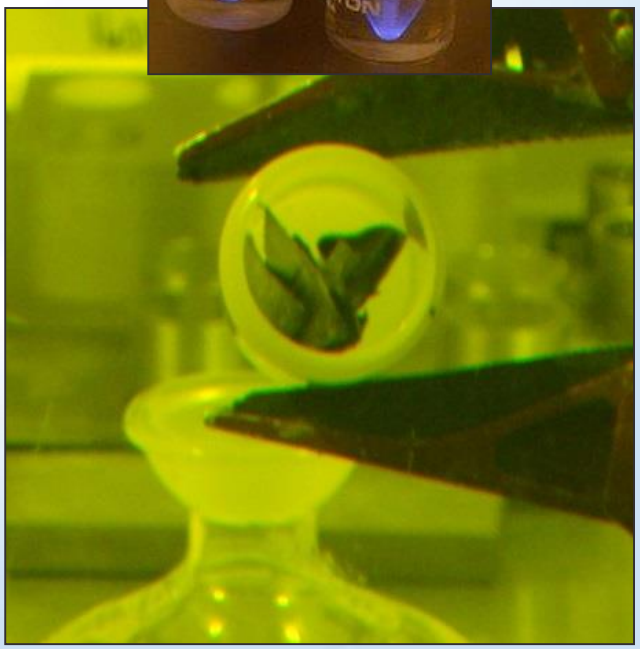
Ra-223: Cancer therapy applications



Accelerator-Produced Ac-225 for Targeted Therapy



- Clinical data suggests both α-emitting Ac-225 ($t_{1/2}$ 10 d) and its daughter, Bi-213 ($t_{1/2}$ 45.6 min) will be powerful isotopes for targeted alpha therapy for cancer
- Current world-wide, annual supply is 1.7 Ci/yr
  - 50+ Ci/yr required to support expanded clinical trials and drug development
- Developing novel accelerator-production method to address demand
  - Working with clinical sites to evaluate material



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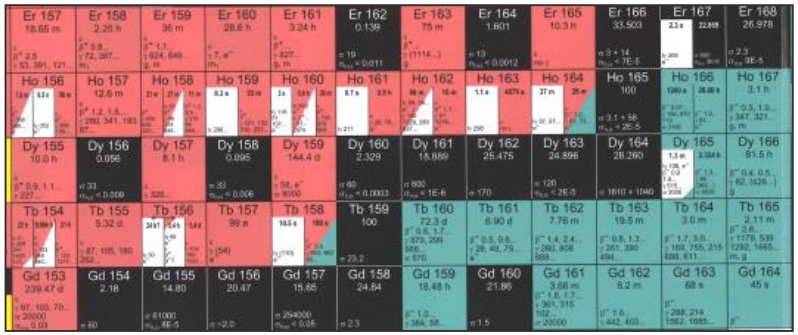
OAK RIDGE National Laboratory

Los Alamos NATIONAL LABORATORY EST. 1943

Applications- Stable Isotopes

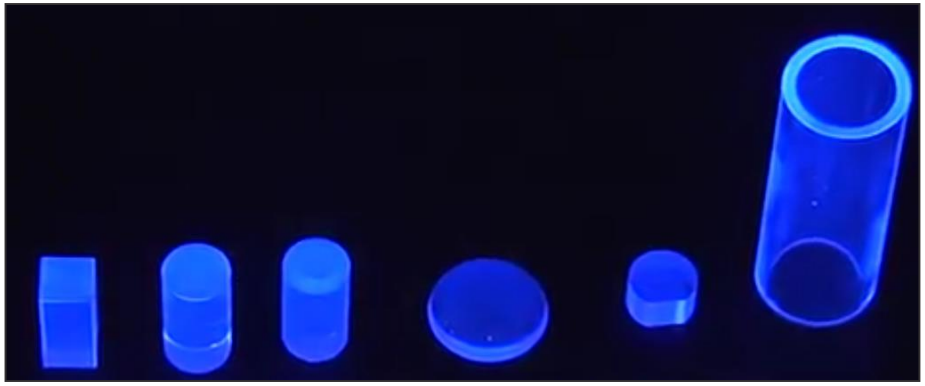
Stable isotope inventory maintained at ORNL for a variety of uses including industrial, medical, fundamental R&D and national security applications

Stable Lanthanides: Nuclear Data



Ca-42,44,46,48: Calcium metabolism

Stable Isotopes – Li-6



- Li-6 serves as a scintillation material for neutron detection used in portal, backpack and hand-held devices to prevent the elicit smuggling of special nuclear materials at ports and border crossings
- The Li-6 neutron detection technology is also used for oil and gas exploration when coupled to a neutron source such as Cf-252 or Am-241.

Y-12

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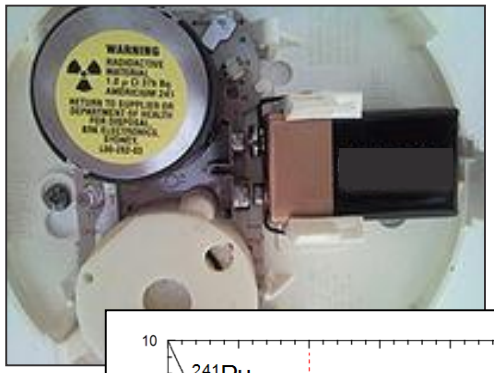
Re-establish Production of Enriched Stable Isotopes

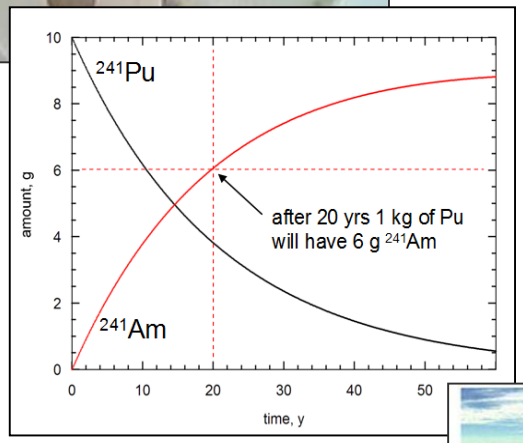
- Calutrons have not operated for over a decade.
- Isotope Program manages inventory – depleted/short for many isotopes in demand.
- Developing concepts for modern stable isotope separation technology: electromagnetic separation coupled with small configurable gas centrifuges.
- Smaller scale enrichment of specific isotopes for research
- ORNL 10 mA EMIS commissioned December 15, 2011
  - now developing 100mA ion source
- Construction of Pilot Production plant approved December 2013
  - FY2016 Finish

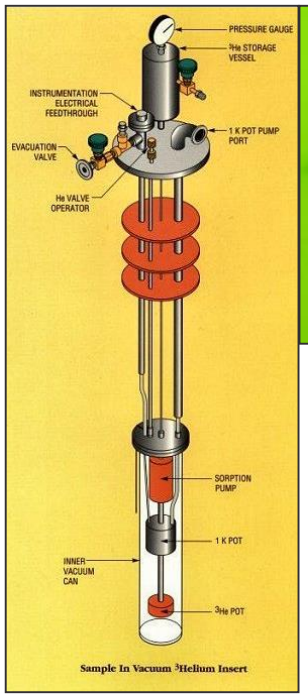
Stable Isotope Inventory at ORNL

OAK RIDGE National Laboratory

Isotopes From DOE's Nuclear Defense Mission



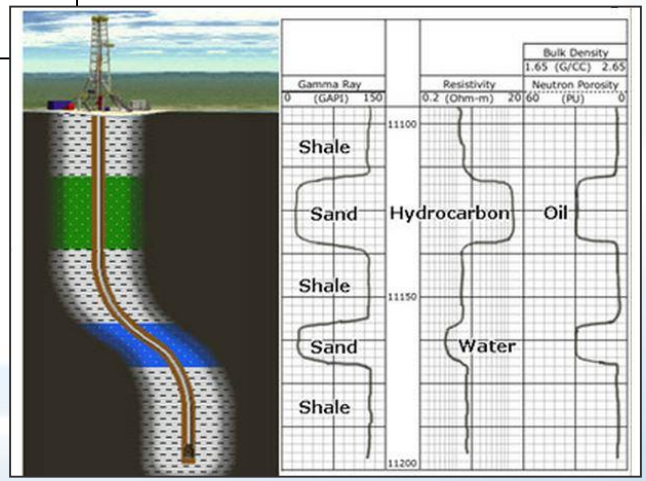




He-3 (beta decay tritium, SRNL): Neutron Detection (proportional counter tube), cryogenic systems (below 300 mK)

Li-7 (co-product from enriching Li-6, Y12): Pressurized water reactor

Am-241 (from Pu-241, LANL): Oil well logging, smoke detectors, moisture gauge in use for highway construction QC



Service Activities

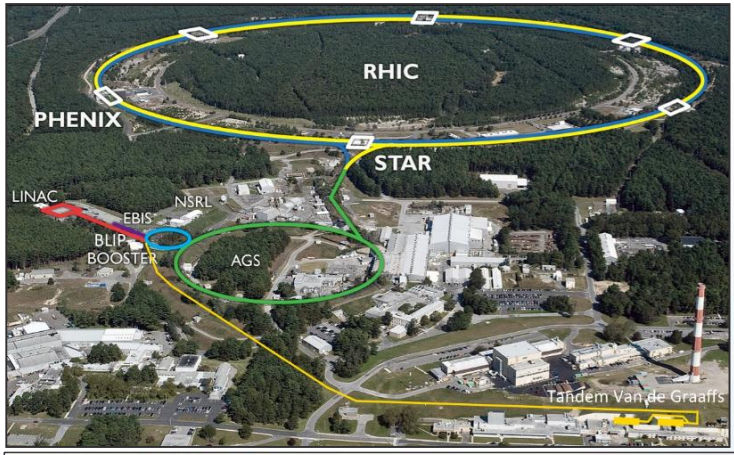
Laboratories at ORNL are available to provide unique services and dispense over 200 different isotopes in a wide variety of chemical and physical forms:

- Metallurgical, ceramic, and high vacuum processing methods
- Pyrochemical Conversion: oxide to high-purity metal
- Arc-melting and alloying
- Hot and cold rolling
- Preparation of cold-rolled foils from air-reactive metals
- Drop casting
- Wire rolling/swaging (hot or cold)

Thorium handling capabilities under development at LANL

Facilities and Capabilities

Brookhaven LINAC Isotope Producer (Cathy Cutler, Leonard Mausner)



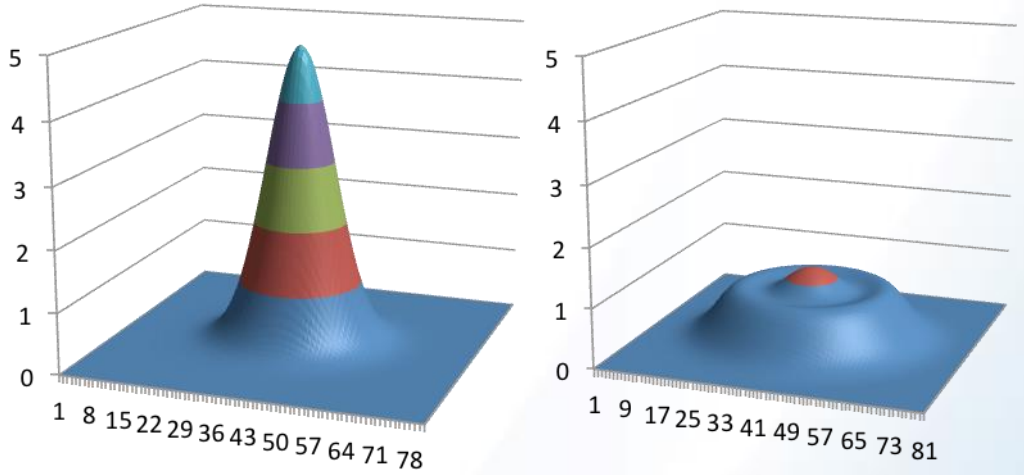
- BLIP utilizes the beam from the proton Linac injector for the Booster, AGS, and RHIC accelerator (nuclear physics)
- Excess pulses (~92%) are diverted to BLIP. Energy is incrementally variable from 66-202 MeV.
- The BLIP beam line directs protons up to 165µA intensity to targets; synergistic operation with nuclear physics programs for more cost effective isotope production.
- Key production isotopes Sr-82, Ge-68; R&D isotopes Ac-225, Sc-44, Cu-67, As-72, Re-isotopes

http://www.bnl.gov/cad/Isotope_Distribution/Isodistoff.asp

BLIP Beam Enhancements

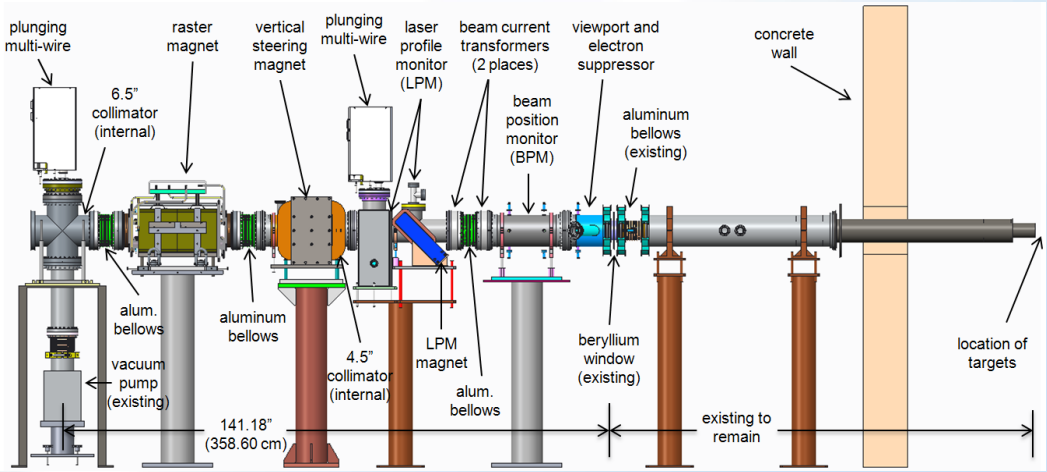
BLIP beam raster system

- Reduction in localized target heating
  - Enables increase in beam current from 100 µA to 125 µA (greater isotope yields)
  - Greatly lowers possibility of target failures



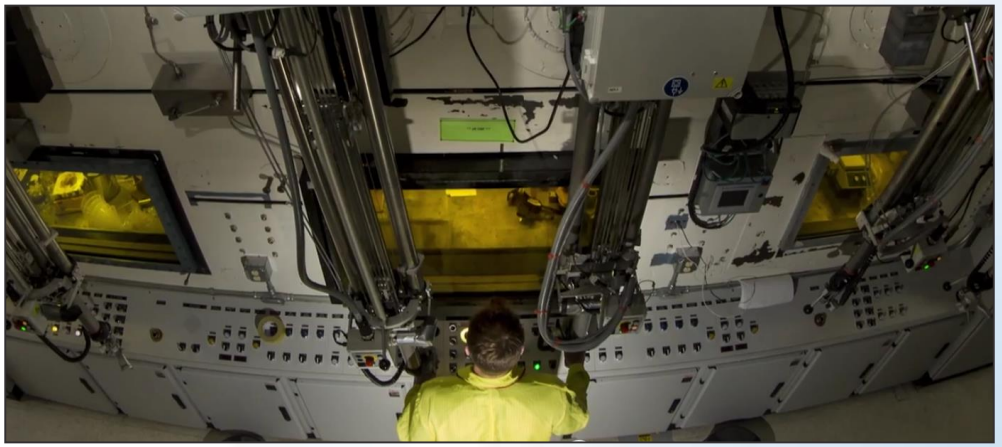
Linac intensity upgrade

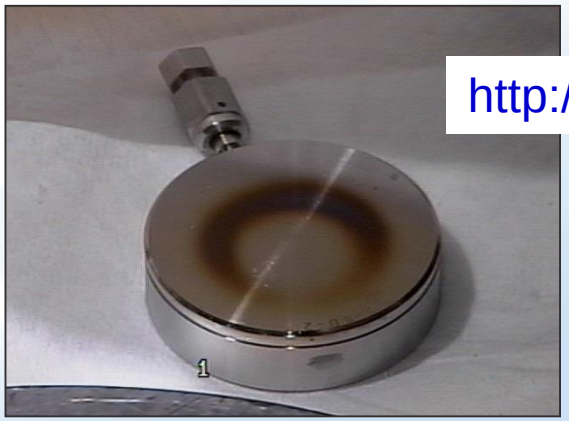
- Phase 1 (in progress) Changes pulse shape to effectively increase current from 125 µA to 140 µA
- Phase 2 (proposed) Increases current to 250 µA by increasing pulse length



LANL Isotope Production Facilities (Eva Birnbaum)

- IPF receives protons from the LANSCE accelerator at 100 MeV incident energy up to 250 mA for routine production.
- IPF targets are subjected to extreme conditions with up to 5-7 kW of power deposited in each target.
- IPF is the sole user of H^+ beam at LANSCE – overall parasitic operation with other NNSA programs at LANSCE.
- Hot Cell Facility (13 hot cells) with unique inert process capabilities as well as FDA-compliant infrastructure.
  - Key production isotopes: Sr-82, Ge-68, Na-22, As-73, Si-32, Y-88;
  - R&D isotopes Ti-44, Ac-225, U-230, Np-236, Sb-119.
  - Utilize secondary neutron flux for unique production opportunities.





http://isotopes.lanl.gov/

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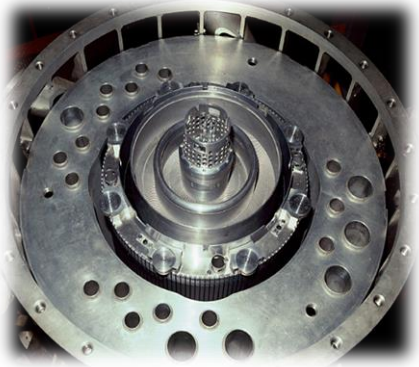
DOE Reactor Sites: HFIR (John Krueger) and ATR (Stephen Johnson)

High Flux Isotope Reactor (HFIR) at ORNL:

http://neutrons.ornl.gov/facilities/HFIR/

- High thermal neutron flux
- ($2x10^{15}$ n/cm^2 s)
- Hydraulic tube for short irradiations
- Several hot cell facilities
- Key Isotopes: Cf-252, W-188, Ni-63, Se-75



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Advanced Test Reactor (ATR) at INL:

http://www.inl.gov/research/advanced-test-reactor-research/

- Moderately high thermal neutron flux ($4x10^{14}$ n/cm^2 s)
- Hot cell facilities
- Key Isotope: Co-60
- Shuttle system for short irradiations

INL Idaho National Laboratory

PNNL Radiochemical Processing Capabilites (Gert Patello)

- DOE hazard category 2 facility for work with mg to kg of fissionable and non-fissionable radioactive materials (40,000 ft^2 of laboratory and more than 8,500 ft^2 of hot cell space (16 hot cells).
- Radiological facilities for work with trace quantities supporting work in detection.
- Extensive wet laboratories, shielded glove boxes, wet radiochemistry fume hoods, and a modern analytical lab.
- PNNL's radiochemistry capability includes staff with extensive experience in radiochemistry, separations, and actinide science that support clients in environmental management, nuclear energy, national security, homeland security and science.
    - Key isotopes Sr-90, Np-237, Ra-223, Th-227;
    - R&D with U. of Washington on At-211

Modular Hot Cell

Actinide Chemistry

Automated Radiochemistry

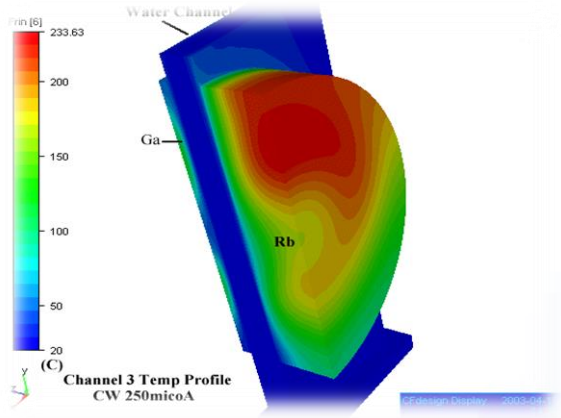
Pacific Northwest
NATIONAL LABORATORY

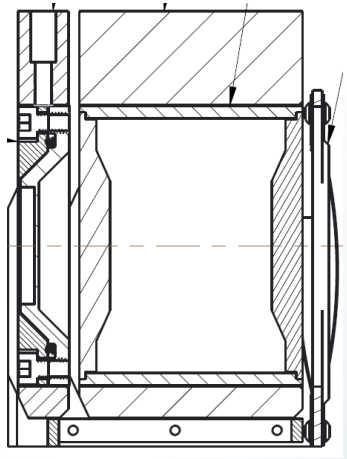
http://radioisotopes.pnnl.gov/

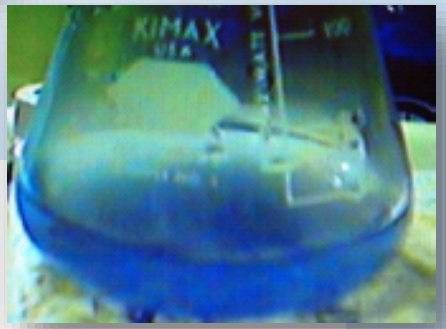
Isotope Program Development and Areas of Overlap with SBIR/STTR

SBIR and the Isotope Program

- **SBIR/STTR**
  - Support R&D toward commercialization of isotope products or services and process improvements with broad impact
  - Encourage collaboration between Labs and Industrial Partners
  - SPP (Strategic Partnership Project; replaces WFO), CRADA, IBO Contract
- **Expectations**
  - No adverse impacts on programmatic mission (facilities, personnel resources)
  - Development to commercialization primarily responsibility of the industrial partner
  - Private industry may not use Government facilities for commercial production



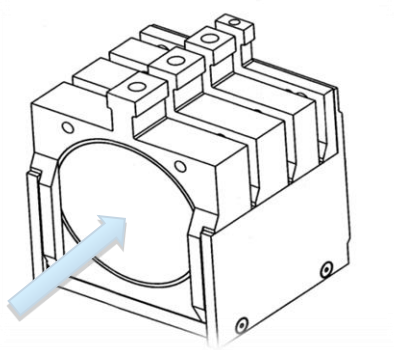


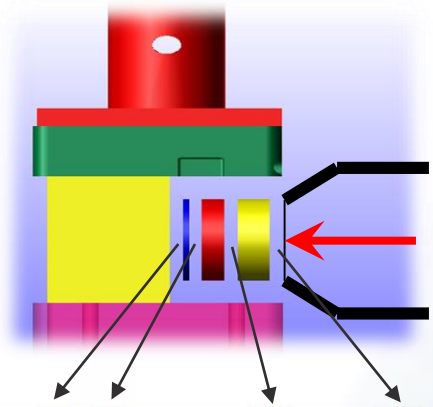


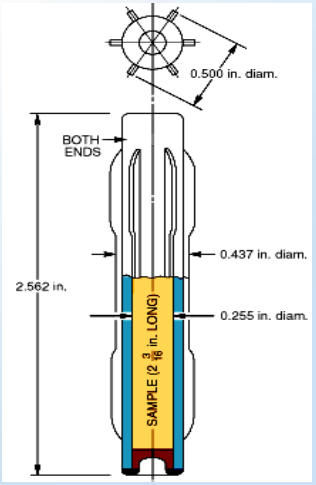
Fiscal Year	SBIR Phase	SBIR /STTR	Topic	Company	Title of work
FY 10	Phase I	SBIR	47 a	Manhattan Isotope Technology Llc	A New Evaluation of Recycling of the Cardiac Imaging Agent, **Strontium-82**,from spent Strontium-82/Rubidium-82 Generators
FY 11	Phase I	SBIR	43	Isotherapeutics Group Llc	High Specific Activity **Sm-153** By Post Irradiation **Isotope Separation**
FY 12	Phase I	SBIR	36a	Niowave, Inc.	Commercial Superconducting Electron Linac for **Radioisotope Production**
FY 12	Phase I	SBIR	36c	Alameda Applied Sciences Corporation	High Separative Power Vacuum Arc **Centrifuge**
FY 12	Phase I	SBIR	36b	Weinberg Medical Physics LLC	Semi-automated Lab-on-a-Chip for Dispensing **Ga-68** Radiotracers
FY 12	Phase I	SBIR	36b	Clear Vascular, Inc.	Production of Commercial High Specific Activity **Sn-117m** Radiochemical and Chelates
FY 12	Phase II	SBIR	46b	Isotherapeutics Group Llc	High Specific Activity **Sm-153** by Post Irradiation **Isotope Separation**
FY 13	Phase I	SBIR	43b	Alameda Applied Sciences Corporation, San Leandro, California	Staged, rotating plasma, stable **isotope separator**
FY 13	Phase II	SBIR	36b	Clear Vascular, Inc.	Production of Commercial High Specific Activity **Sn-117m** Radiochemical and Chelates
FY 13	Phase II	SBIR	36a	Niowave, Inc.	Commercial Superconducting Electron Linac for **Radioisotope Production**
FY 14	Phase I	SBIR	40b	IsoTherapeutics Group LLC, Angleton, TX	High Specific Activity **Sn-117m** by Post Irradiation **Isotope Separation**
FY15	Phase I	STTR	26	MuPlus, Inc., Newport News, VA	Energy-Recovery Linacs for Commercial **Radioisotope Production**

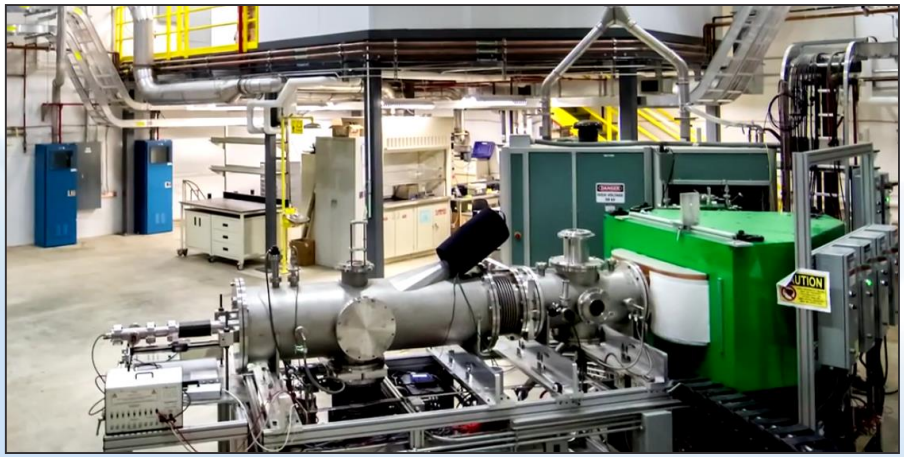
Programmatic Interests

- **Stable Isotope Enrichment**
  - High enrichment
  - High volume
  - Safe, secure operations
- **Accelerator and Reactor Radioisotope Production**
  - Targetry design, fabrication and thermal modeling
  - Accelerator/Reactor Technologies
  - Separations and purification
  - Automation and remote handling
  - Safe compliant transportation of radioactive products
  - Waste management
  - In situ target monitoring
  - Radiation resistant IX resins, sorbents and extractants









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Summary

Strong synergy with US Private Sector (Medical and Industrial Applications) – would like to see growth fostered by SBIR/STTR interactions

Variety of production capabilities (accelerator and reactor) and associated hot cell processing infrastructure

Potential areas of opportunity with SBIR/STTR:

Novel or Improved Production Technologies

- **Target Optimization – robust targets, new modeling capabilities, new materials and designs can be considered, novel fabrication techniques, recycling methods**
- **New technologies for production of enriched stable isotopes, electromagnetic isotope separation techniques**
- **General Equipment – areas related to improved accelerator and reactor technologies as well as stable isotope separation: general diagnostics**
- **New production methods for transuranic elements**

Improved Radiochemical Separation Methods for Preparing High-Purity Radioisotopes

- Automation for routine processing including radiation hardened semi-automated modules. Process Optimization – automation of process and associated activities (product dispensing) would be of great benefit to overall program; focus on developing transportation needs.
- Innovative separation technologies
  - Actinides and lanthanides
  - Higher binding capacity and selectivity, with ability to be scaled up
  - Radiation resistant materials
- Improved Radiochemistry methods
  - Improve separations
  - Improved ion-exchange materials
  - Diagnostics for the alpha emitters