The DOE Isotope Program: Introduction and Project Perspective

Khianne Jackson

Federal Program Manager

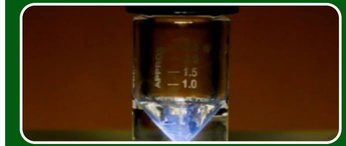
Office of Isotope R&D and Production, SC IRP

DOE Isotope Program, DOE IP

Outline

- Mission and Authority
- Organization
- Isotopes
- DOE IP Growth
- Isotope Priorities
- Projects and Initiatives
  - SIPRC – Stable Isotope Production and Research Center, ORNL
  - CARP – Clinical Alpha Radionuclide Producer Facility, BNL
  - RPF – Radioisotope Processing Facility, ORNL

DOE IP Mission



Produce and/or distribute radioactive and stable isotopes that are in short supply; includes by-products, surplus materials and related isotope services

Maintain the infrastructure required to produce and supply priority isotope products and related services

Conduct R&D on new and improved isotope production and processing techniques which can make available priority isotopes for research and application. Develop workforce.

Ensure robust domestic supply chains. Reduce U.S. dependency on foreign supply to ensure National Preparedness.

The DOE IP **does not compete with domestic industry** and sells isotopes at market price or full-cost recovery (“non-profit”). Aid in commercialization of isotope when market is robust. Must be prepared to “step away” when market is stable.

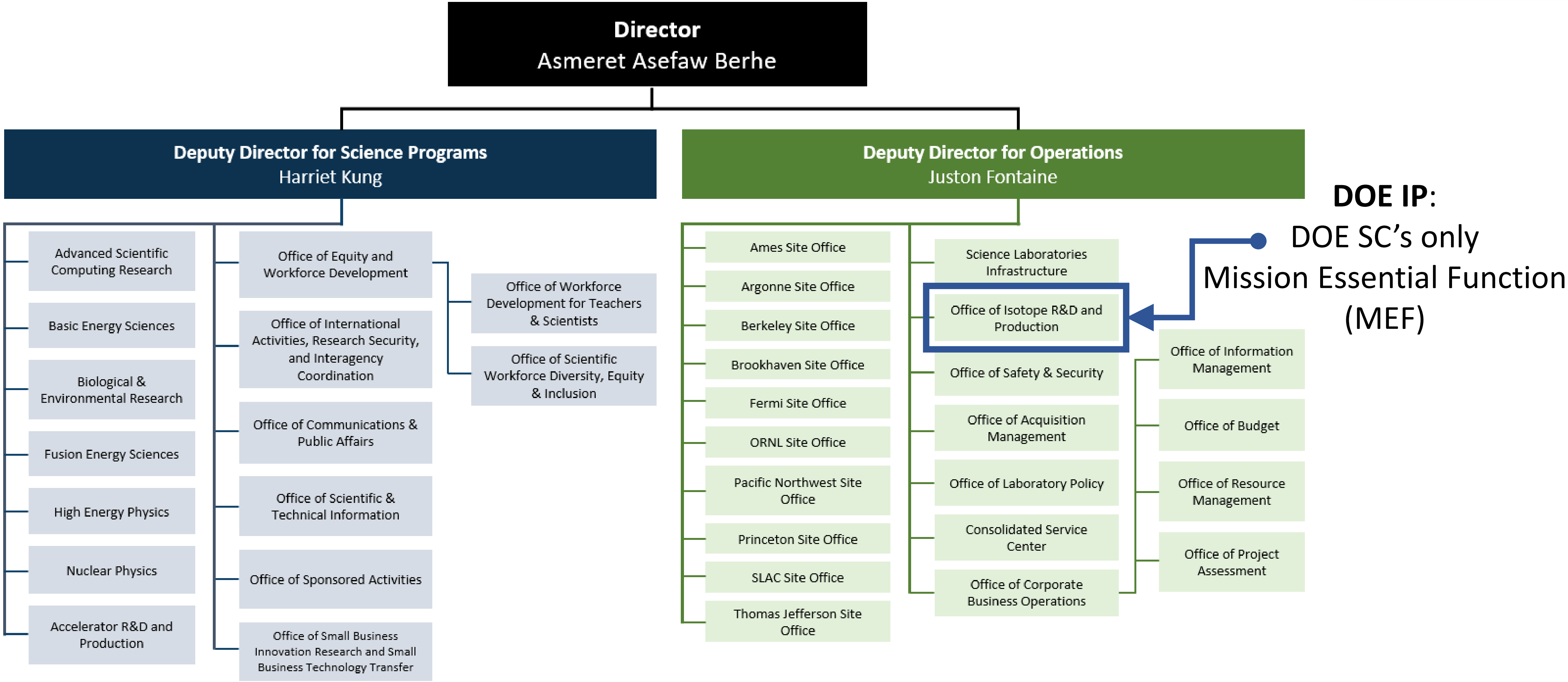
DOE IP Authority

- Atomic Energy Acts of 1946 and 1954 established U.S. policy of promoting R&D of nuclear materials for peaceful & military purposes.
  - Peaceful purpose includes production and sale of isotopes not produced or reasonably available from domestic private industry.

- DOE IP – Sole authority to produce isotopes for sale and distribution
  - **Produce over 80 radioisotopes and provide over 240 stable isotopes**
  - Labs may not embark on isotope production on their own
  - Sales through the National Isotope Development Center
    - Separate business arm of DOE IP.

**** DOE IP is not responsible for Mo-99 (NNSA), Pu-238 for NASA (NE), Special Nuclear Materials (SNM) for weapons (NNSA).**

Office of Science Organization Chart



Faces of the Office of Isotope R&D and Production

Jehanne Gillo
Director

Andrea Condrad
Financial Management Specialist
Budget Formulation

Deanna Ammons
Financial Management Specialist
Budget Execution

Ethan Balkin
Radioisotope Production R&D

Adewonuola Ademiluyi
Alternative Isotope Production

Kenneth Brooks
Isotope Program Operations (NIDC)

Arne Freyberger
Isotope Accelerator Facilities

April Gillens
Stable Isotopes

Khianne Jackson
Isotope Program Initiatives

Jon Neuhoff
Isotope Reactor Facilities

Julie Ezold
Technical Advisor

- Open Positions: Chief of Staff, Program Managers, Program Analyst, and Detailees

DOE IP – Current Organization

** Vacant Position
PM – Program Manager
Succession Planning in Progress

Director
Jehanne Gillo
Admin Assistant
(being filled)

Chief of Staff, Vacant

Andrea Condrad
Financial Analyst
Deanna Ammons
Financial Analyst

Program Analyst, Vacant

Isotope Operations (NIDC)
Ken Brooks, **PM**

Isotope Initiatives
Khianne Jackson, **PM**
Detailee, Vacant

Radioisotope Production R&D
Ethan Balkin, **PM**
Detailee, Vacant

Isotope Accelerator Facilities
Arne Freyberger, **PM**
Detailee, Vacant

Isotope Reactor Facilities
Jon Neuhoff, **PM**

Nuclear and Radiochemistry
Program Manager, Vacant

Stable Isotope Production R&D
April Gillens, **PM**

Stable Isotope Facilities
Program Manager, Vacant

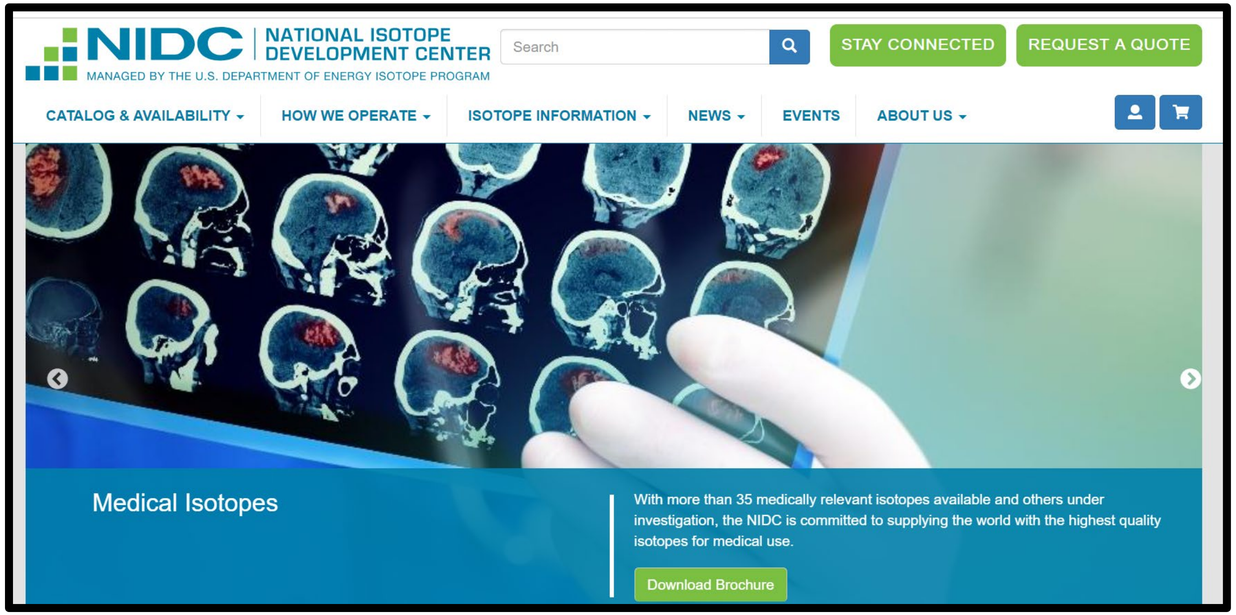
Alternative Isotope Production
Ade Ademiluyi, **PM**
Julie Ezold, **Technical Advisor**

**** Organizational structure as of April 2023**

National Isotope Development Center

The NIDC (Oak Ridge National Laboratory) is the business arm of DOE IP.

- Coordinates sale and distribution of DOE isotope products and services available from DOE facilities.
- Contractual discussions with customers.
- Transportation, Q&A, public relations, marketing strategy and assessments.



- www.isotopes.gov
- Sign up here for DOE IP newsletter

Isotope Landscape – What are Stable Isotopes?

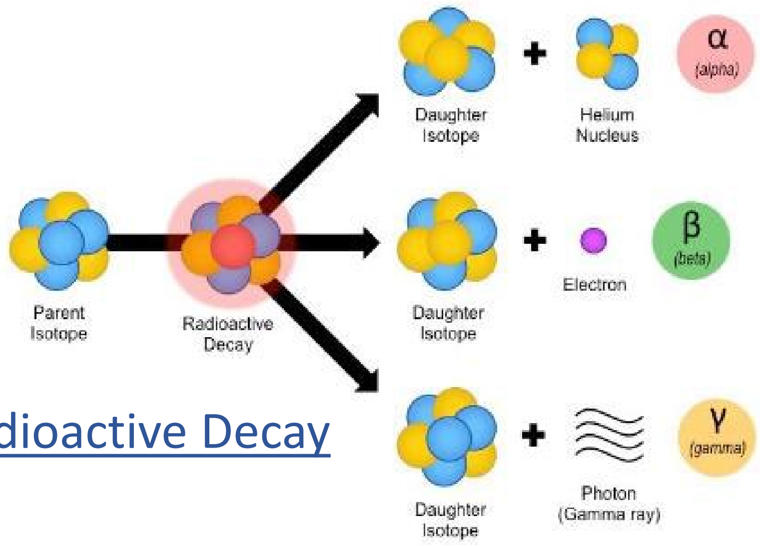
- Isotopes are atoms of a chemical element that have the same number of protons but different neutrons.
- **Stable isotopes** are found naturally and do not decay.
  - Enriched stable isotopes are used in a variety of applications as well as the production of radioisotopes.
  - Enrichment technologies include:
    - Distillation
    - Gas Centrifuge Isotope Separation (GCIS)
    - Electromagnetic Isotope Separation (EMIS)
    - Thermal Diffusion Isotope Separation (TDIS)
    - Atomic Vapor Laser Isotope Separation (AVLIS) – R&D

Manhattan Project calutrons that enriched uranium via electromagnetic separation (*defunct)*

Piketon Plant gas centrifuges (*defunct but capability being revived)*

Isotope Landscape – What are Radioisotopes?

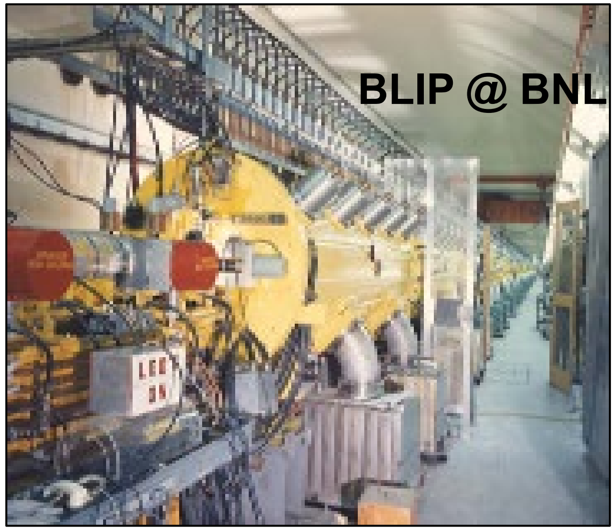
- **Radioisotopes** are unstable isotopes of a chemical element
  - Contain an unstable combination of neutrons and protons.
  - Decay to a lower energy daughter via alpha, beta, or gamma ray emission.
  - Occur naturally or are created in reactors, accelerators, and cyclotrons



Radioactive Decay

Reactors

Accelerators



Examples: Alternative Isotope Production

Y-12 National Security Complex

- Includes production of Li-6 (neutron detection) and Li-7 (dosimeters)
- Demo of high purity isotopes for NG reactors

Pacific Northwest National Laboratory

- Sr-90 power sources (terrestrial and space), reduces foreign dependence

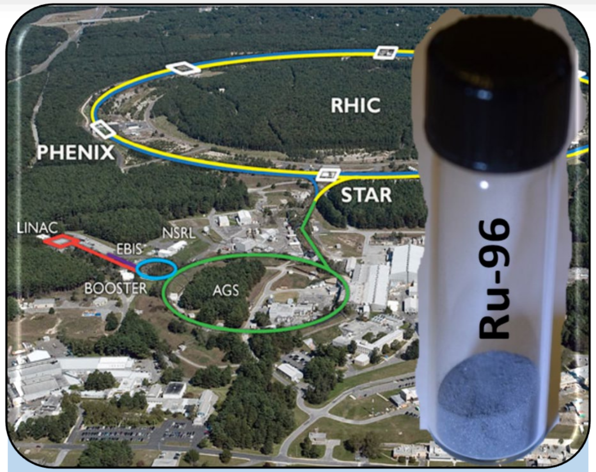
Los Alamos Plutonium Facility

- Am-241 from Pu waste streams (smoke detectors, power sources)

Savannah River Site (SRS)

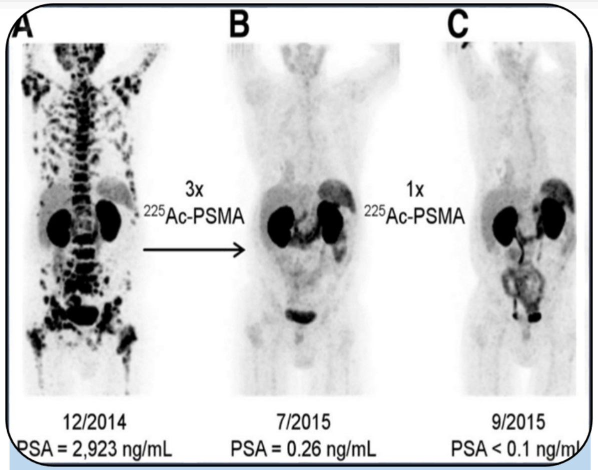
- He-3 extraction from NNSA tritium (cryogenics, national security, neutron detection)

Isotope Landscape – Applications



Basic Research

Physics
'New Element Discovery'
Chemistry
Materials
Quantum Computing
Analytical Chemistry
Geosciences

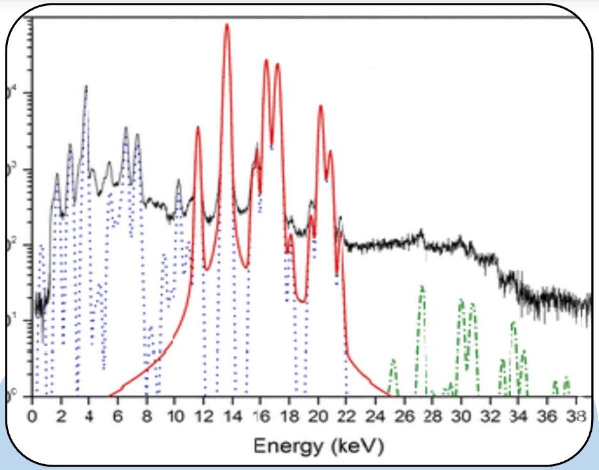


Medicine

Cancer Therapies
Imaging/Diagnostics
'Infectious Disease Treatment'
Drug Development
'Medical Device Calibration'
Research

Industry

Semi-conductors
Standards
Inspections
'Oil and Gas Exploration'
Batteries
Pesticides
Food Sterilization



National Security

'Satellite Communications'
Detection
Nuclear Batteries
'Global Positioning Sources'
Quantum-encryption
Space Exploration

Isotope Landscape – U.S. Production History

1946 – 1985

U.S. production increased and then leveled out

- National Labs produce isotopes for research and industry.
- Calutrons converted from uranium to stable isotope enrichment.

1986 – 2000

Foreign producers take advantage of losses in U.S. production capabilities

- Research reactor capacity reduced.
- Radioisotope processing facilities shut down late 1980s
- Fall of USSR in 1991. Russia enters the market.
- U.S. calutrons shut down - 1999

2001 – 2008

U.S. production is limited, and imports most bulk isotopes used in industry, research, and medicine

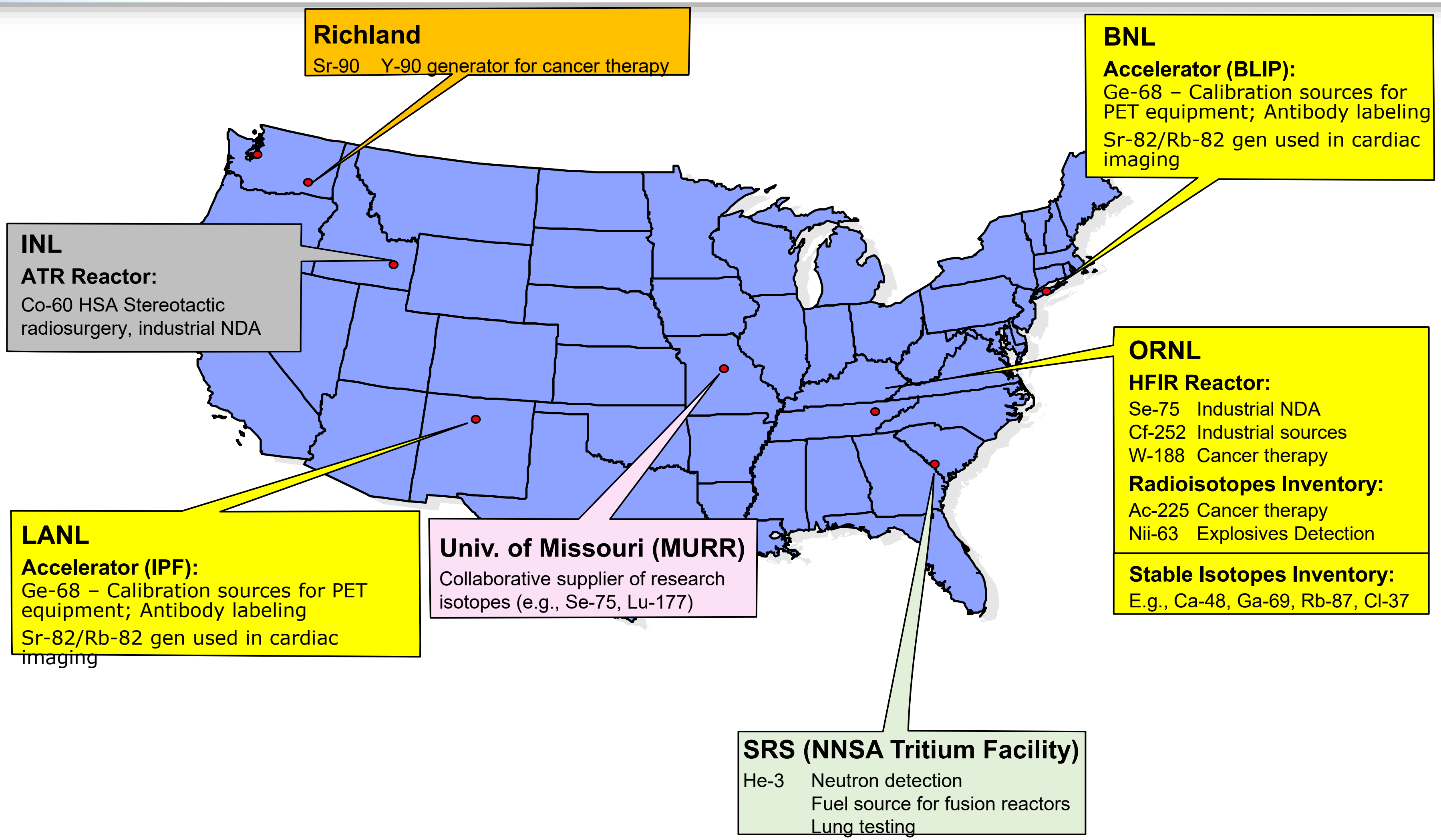
- U.S. relies on foreign sources for bulk isotopes.
- U.S. industry refines foreign-supplied isotopes into finished end-use products.
- 2003 – DOE no longer supports isotope R&D and production.

2009 – Present

U.S. production increases with new capabilities. U.S. still dependent on foreign supply for critical isotopes. Periodic shortages occur.

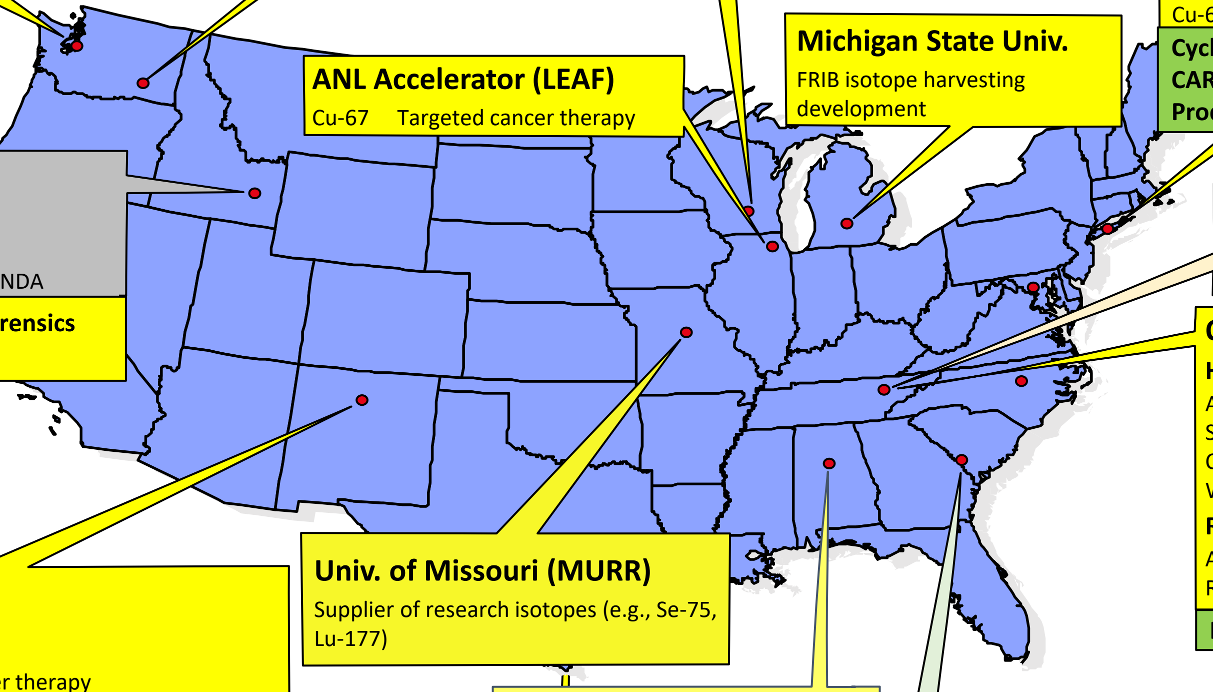
- Isotope R&D and production restarts
- DOE IP sites & University Network added
- Increased radiochemical processing capabilities
- Restart enriched stable isotope production and core competencies.

DOE IP Growth – Production Sites in 2009



- 2009 – Program transferred to the Office of Science

DOE IP Growth – Production Sites in 2023



Univ. of Washington
Supplier of research isotopes (e.g., At-211)

PNNL
Sr-90 Y-90 generator for cancer therapy

Univ. of Wisconsin
Supplier of research isotopes (e.g., Mn-52)

BNL

Accelerator (BLIP):

Ac-225	Targeted cancer therapy
Ti-44	Sc-44 generator for PET imaging
Y-86	PET imaging
Cu-67	Targeted cancer therapy

Cyclotron (TR-19)
CARP (Clinical Alpha Radioisotope Producer)

Michigan State Univ.
FRIB isotope harvesting development

ANL Accelerator (LEAF)
Cu-67 Targeted cancer therapy

INL

ATR Reactor:
Co-60 HSA Stereotactic radiosurgery, industrial NDA

Rad EMIS – nuclear forensics

Y-12 (NNSA Facility)

Li-6	Neutron detection
Li-7	Radiation dosimeters

Green boxes – under development

ORNL

HFIR Reactor:

Ac-227	Cancer therapy
Se-75	Industrial NDA
Cf-252	Industrial sources
W-188	Cancer therapy

Radioisotopes Inventory:

Ac-225	Cancer therapy
Ra-223	Cancer therapy

RPF (Radioisotope Proc. Fac.)

Stable Isotopes Inventory:
E.g., Ca-48, Ga-69, Rb-87, Cl-37

Stable Isotope Production:
ESIPP
SIPF
SIPRC

Univ. of Missouri (MURR)
Supplier of research isotopes (e.g., Se-75, Lu-177)

LANL

Accelerator (IPF):

Ac-225	Targeted cancer therapy
Ti-44	Sc-44 generator for PET imaging
Cd-109	X-ray fluorescence analyses
As-73	Environmental tracer
Si-32	Oceanographic research

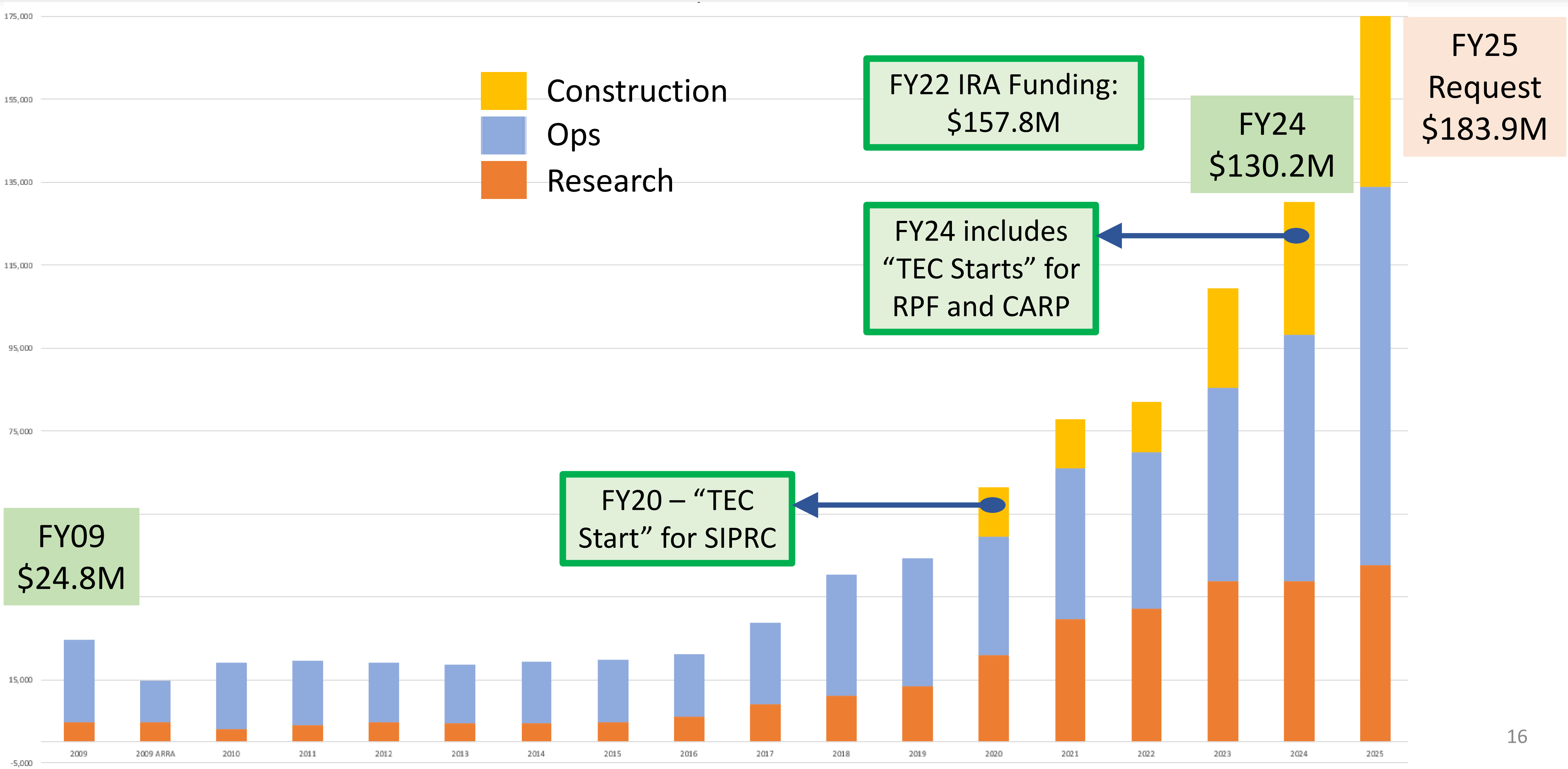
Plutonium Facility (PF-4):
Am-241 Oil and gas exploration

Univ. of Alabama Birmingham
Supplier of research isotopes (e.g., Mn-52)

Texas A&M Cyclotron
Supplier of research isotopes (e.g., At-211)

SRS (NNSA Tritium Facility)
He-3 Neutron detection
Fuel source for fusion reactors
Lung testing

DOE IP Growth – DOE IP Enacted Budget



DOE IP – Impact on Medical Isotopes

Available Medical Isotopes - isotopes in red made available within the past two years				
Ac-225/Bi-213	**Br-77**	Lu-177 c.a.	Rb-83	**Ti-44**
Ac-227	Cd-109	**Mn-52g**	Rh-103m	**V-48**
Al-26	**Ce-134**	**Mn-54****	Se-72	W-188/Re-188
As-73	**Ce-139**	Na-22	Se-75	**Y-86**
At-211	**Co-55**	**Pb-203**	Sn-117m (HSA)	Y-88
Au-199	Co-60 (HSA)	**Pd-103**	**Sr-85**	**Yb-176**
Ba-133	Fe-52	Pm-147	Sr-89	Zn-65
Be-7	Fe-55	Ra-223	Sr-90/Y-90	
Bi-207	He-3	Ra-224/Pb-212	Th-227	
Br-76**	**Ir-192**	**Ra-226**	Th-228	

Medical Isotopes Under Development			
As-72 /Se-72	Gd-153	Ru-106	Ti-44/Sc-44
C-14	Mo-98 &100	Sb-119	Xe-129
Co-57	Nb-90	Sc-43, 44, & 47	U-230/Th226
Cs-131	Pt-191,193m, & 195m	Tb-155 & 161	
Fe-59	Re-186 & 189 (HSA)	Te-119m/Sb-119	

R&D funded by DOE IP and executed through our National Laboratories, Universities and other institutions is **key** to the program's success

DOE IP – Assessment of U.S. Critical Needs

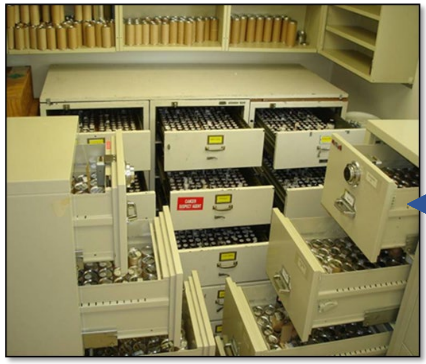
- Industry: Commercial stakeholder meetings twice a year and annual Industrial Surveys
- Biennial Federal Workshops and 5-year surveys
- Sponsorship of workshops, symposiums at conferences
- White House Working Groups
- Inter-agency Working Groups
- Community Meetings and Round Tables
- Professional Society Meetings and Exhibit Booths

Status of U.S. Capabilities & DOE IP Priorities

- Key technical abilities and core competencies lost
- Limited resources to provide critical isotopes for the Nation
- Unacceptable risks with dependence on sensitive countries

Priorities:

- U.S. economic resilience
- Emerging technology
- Life-saving medical treatments
- Scientific strength
- National security



Increase Mission Readiness

Increase isotope production core competencies

Increase radiochemical processing capabilities

Increase stable isotope inventory

Increase stable isotope enrichment capabilities

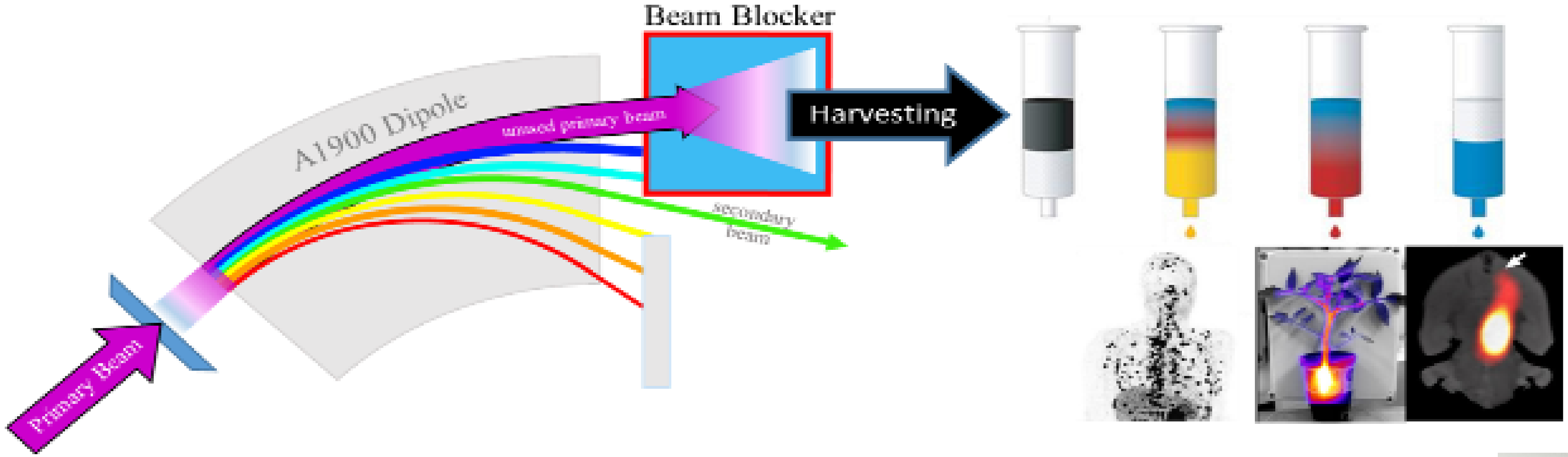
DOE IP LIC Projects and Initiative Priorities

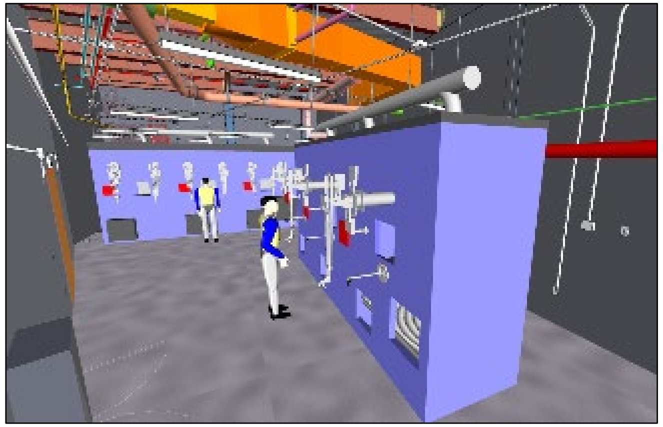
- **Isotope projects** and initiatives – core element of long-term plans for **expanding isotope production capabilities**
  - Re-establish core capabilities in the U.S for producing and enriching key isotopes and remove dependence on foreign countries.
  - Russian invasion of Ukraine highlighted U.S. vulnerabilities for isotopes.
  - Essential to maintain domestic security, health, and economic resilience.

- Initiatives – 'Projectized' critical R&D and operations to ensure deliverables within budget and schedule.

- Line-Item Construction Projects
  - **Stable Isotope Production and Research Center – SIPRC**
  - **Clinical Alpha Radionuclide Producer – CARP**
  - **Radioisotope Processing Facility – RPF**

FRIB Isotope Harvesting Facility (DOE IP Initiative)





The Isotope Harvesting Project ($13.2M) is a research initiative to enable harvesting of radioisotope from the FRIB beam dump. The effort will support the production of radioisotopes for research.

Conceptual and actual view of new hot cells for purifying and harvesting radioisotopes.

SIPRC @ ORNL

Stable Isotope Production and Research Center - $325M

- Production-oriented new facility with EMIS and GC technologies.
    - **Reestablishes large-scale stable isotope enrichment in the U.S.**
    - **Incorporates space for expansion.**
- Scope includes pre-CD-1 planning activities and 3 subprojects:
    - Subproject 1 (SP1) – Facility and EMIS
    - Subproject 2 (SP2) – Mo-100 Production Cascade
    - Subproject 3 (SP3) – Test Cascade Infrastructure

External Rendering - SIPRC

SIPRC @ ORNL

SIPRC Project

- CD-0 approved FY19
- CD-1 approved FY21
- CD-4: Q3 FY32 (Planned)
- Approved CD-1 TPC Range: $187M to $338M
- Current Total Point Estimate: $325M
- FY22 IRA Funding: $75M – significant impact and schedule risk mitigation.

Subproject 1: Facility and EMIS

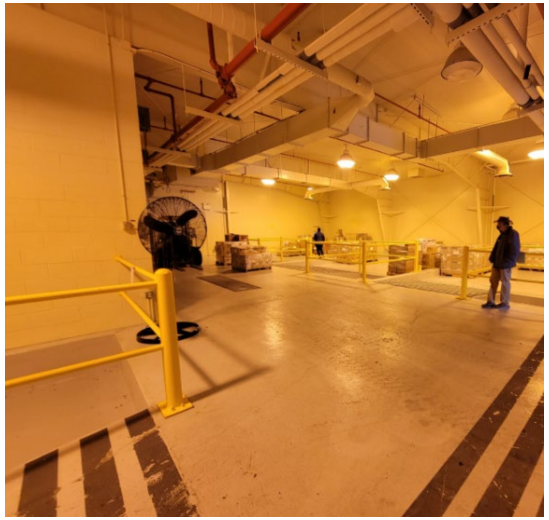
- SP1 CD-2/3 Approval: March 2024
- Baselined TPC and CD-4: $231.5M, Q4 FY30

External Rendering - SIPRC

CARP @ BNL

Clinical Alpha Radionuclide Producer (CARP)

- Added capability to process accelerator-based radioisotopes at BLIP – Brookhaven Linac Isotope Producer.
- Hazard Category 3 (HC3) Nuclear Facility – Repurposes an existing building at BNL (Bldg. 870). Relatively clean and operated as HC3 in the 80s.



Internal View – Bldg. 870

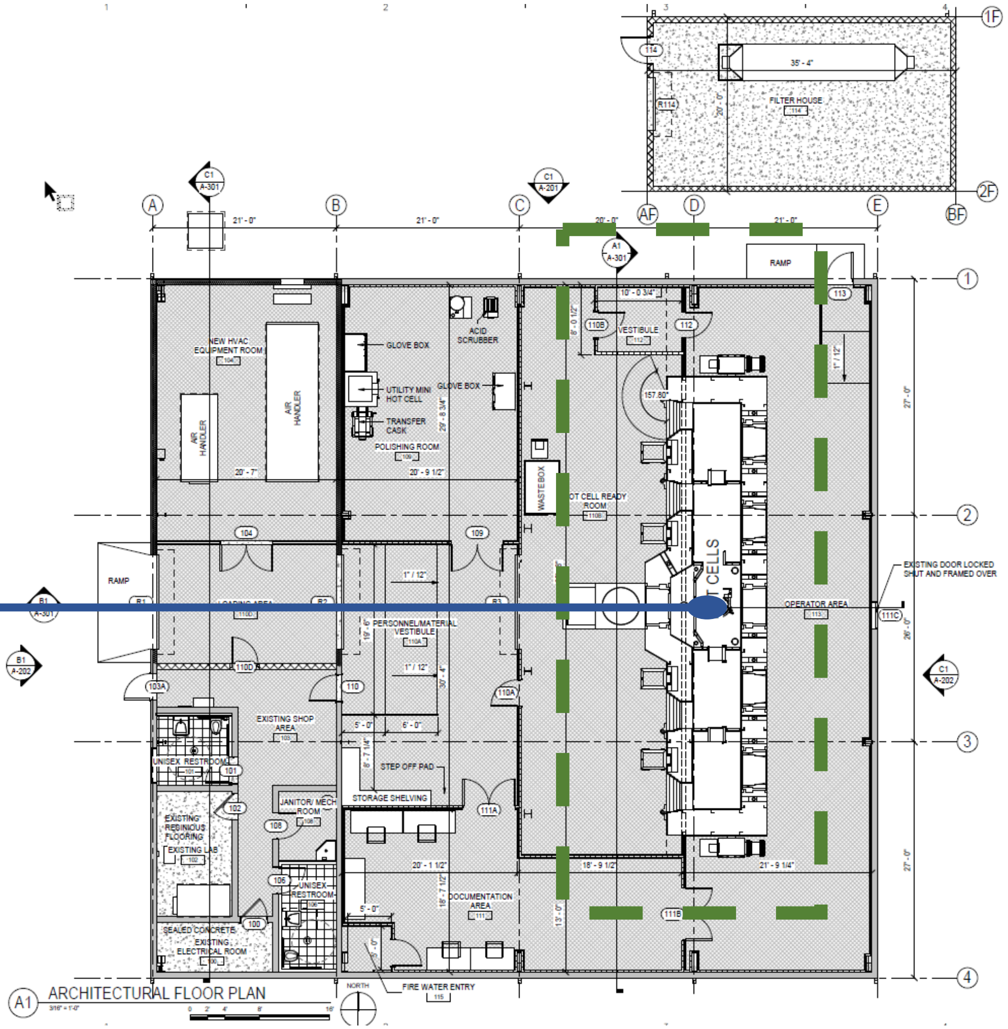
Scope:

- Modest building utility upgrades to bring it up to current HC3 requirements.
- Design, procurement, installation and commissioning of hot cells and radiochemical processing equipment and related support spaces.

CARP @BNL

- CD-0 approved December 2022
- CD-1 planned Q4 FY26
  - Constrained early funding
  - TEC start in FY24 Enacted Budget
- Approved CD-0 TPC Range: $60M to $80M
- CD-4: Q4 FY31 (Planned)

Proposed Hot Cells



Preconceptual Plan - CARP

- Funding as of end of FY23 – $585k
- FY24 Funding – $1.5M OPC, $1M TEC

RPF @ ORNL

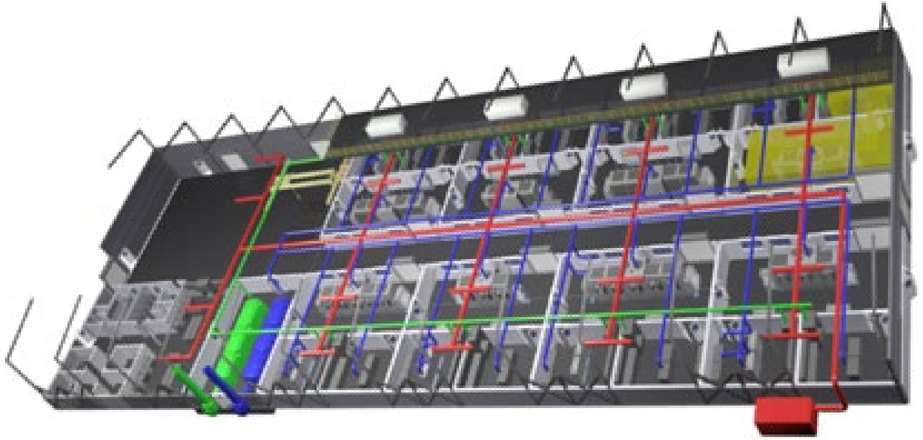
Radioisotope Processing Facility

- Hazard Category 2 (HC-2) Nuclear facility
- New facility with up to eight processing bays
    - Multiple combination of Modular Hot Cells, gloveboxes, and other radiochemical processing equipment hood to meet production needs.
    - Includes space for supporting laboratories and R&D

External Rendering - RPF

- Reduce U.S. dependence on foreign suppliers; particularly Russia
- Expand research, production and processing capacity for high priority radioisotopes
- Focus on HFIR irradiated targets
- Incorporates expansion for the future

RPF @ ORNL



Internal View - RPF

- CD-0 approved April 2021
- CD-1 planned Q3 FY24 (TBD)
  - TEC start in FY24 Enacted Budget
- Approved CD-0 TPC Range: $310M to $615M
- FY22 IRA Funding: $10.6M – Fully funded critical conceptual design activities
- CD-4: Q4 FY34 (Planned)

- Funding as of end of FY23 – $15.2M
- FY24 Funding –$8.5M TEC

Summary

- Isotopes are enabling and foundational. Disruptions in supply can be crippling to industry, national security, federal missions, discovery research, emerging technology.
- Demand for radioisotopes and stable isotopes will continue to quickly escalate.
- The U.S. has fallen significantly behind other world powers in its ability to produce isotopes. We lack the facilities and equipment, the core competencies, and the capabilities.
- DOE IP projects and initiatives that add needed capabilities are critical to the resilience of the U.S.

Thank You!

Questions?