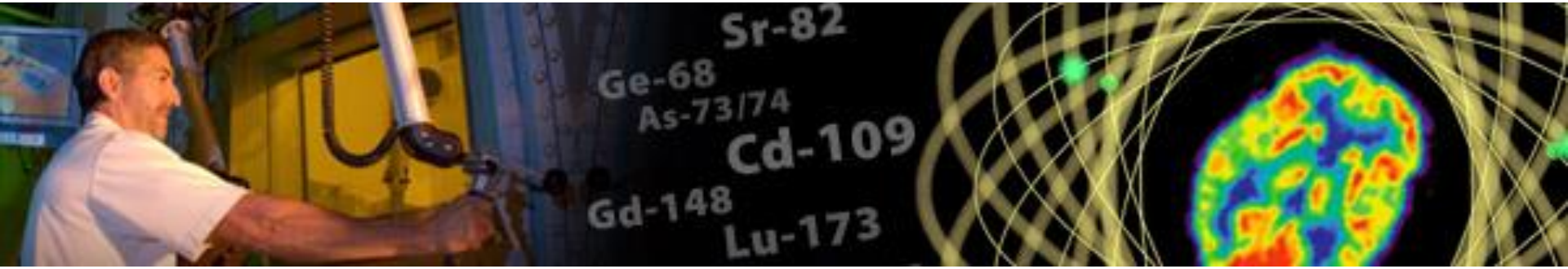
U.S. DEPARTMENT OF ENERGY

Launching Enriched Stable Isotope Production



DOE Isotope Program -- Federal Workshop

Joel Grimm, Program Manager
Stable Isotopes and Accountable Nuclear Materials
DOE Isotope Program
Office of Science, U.S. Department of Energy

November 2016

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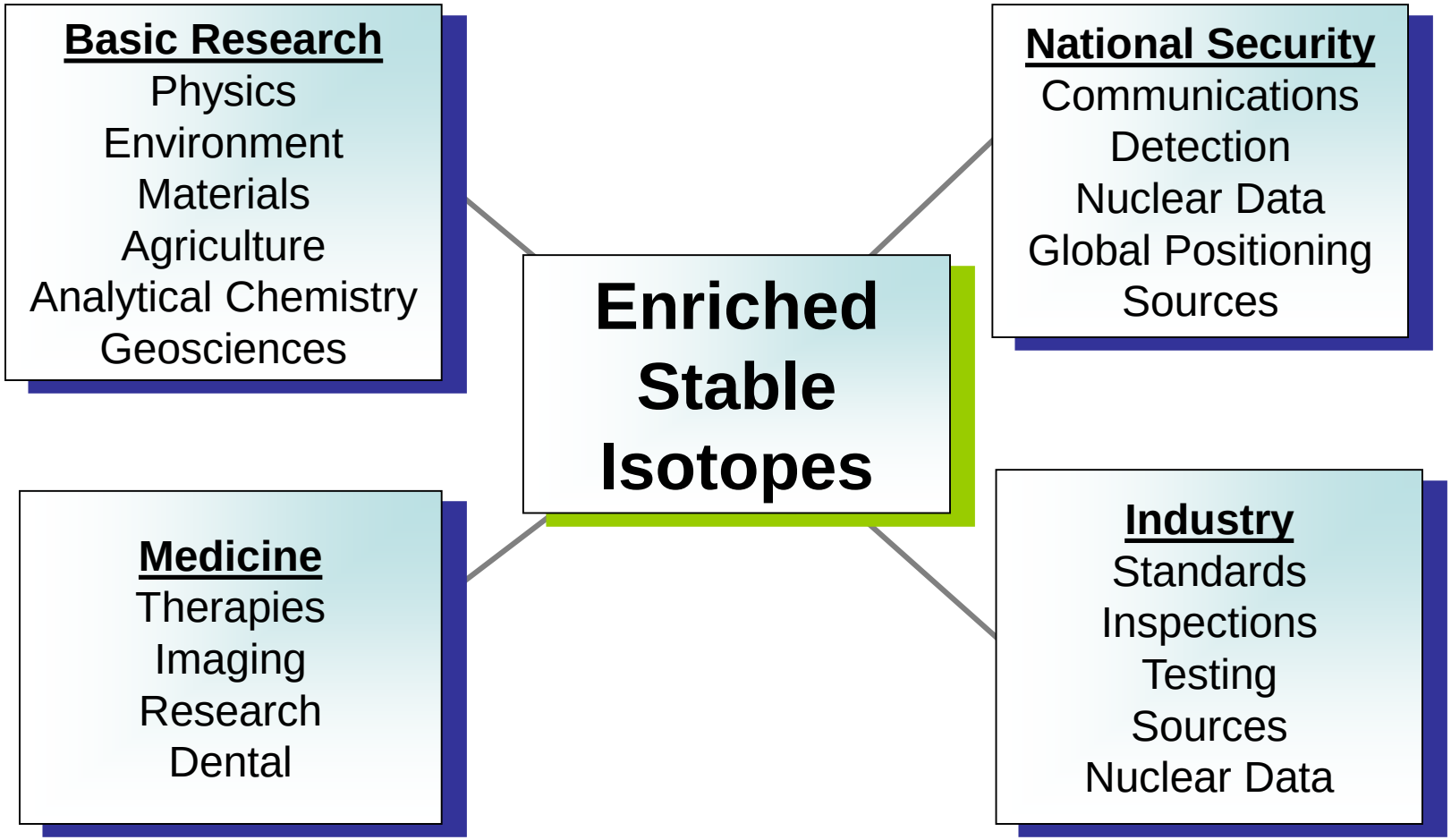
Stable Isotopes Uses



Stable Isotopes Inventory

Stable Isotope Operations at ORNL

- Enriched >230 stable Isotopes 1945 - 1998
- Unique materials with few other suppliers
- No existing domestic broad-scope enrichment
- U.S. dependent on foreign sources for new production
- Isotope Program manages national inventory
- Inventory of 11 has been exhausted
- Filled 147 isotope orders in FY 2016
- Dispensed more than 800 items

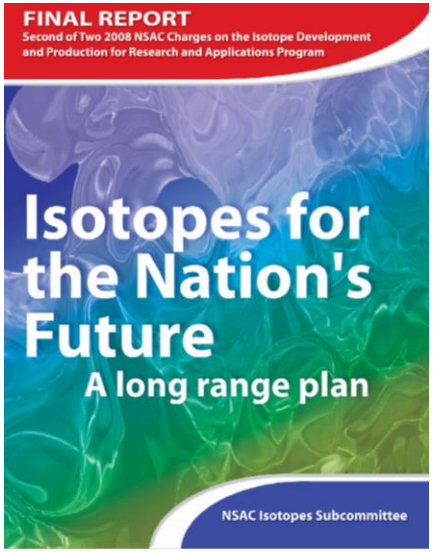
NSAC Recommendations

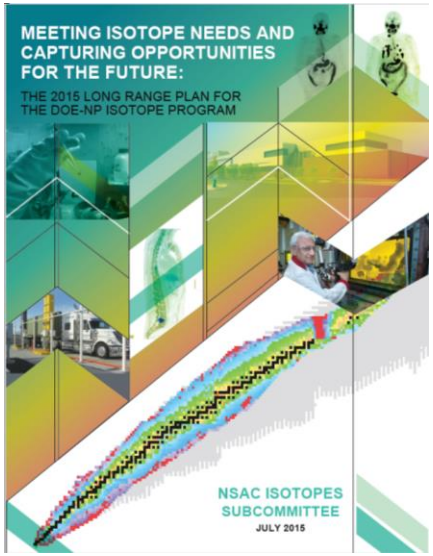
Strategic Planning for Isotopes Opportunities

- **The 220 stable non-gaseous isotopes are not currently produced domestically**
- **Most require separation and enrichment by either electromagnetic or gas centrifuge separators**

NSAC Recommendations:

- **Reestablish a Domestic Source of Mass-separated Stable Research Isotopes.**
- **Develop a Strategy to Re-establish a Separator for Radioactive Isotopes to Support Research**





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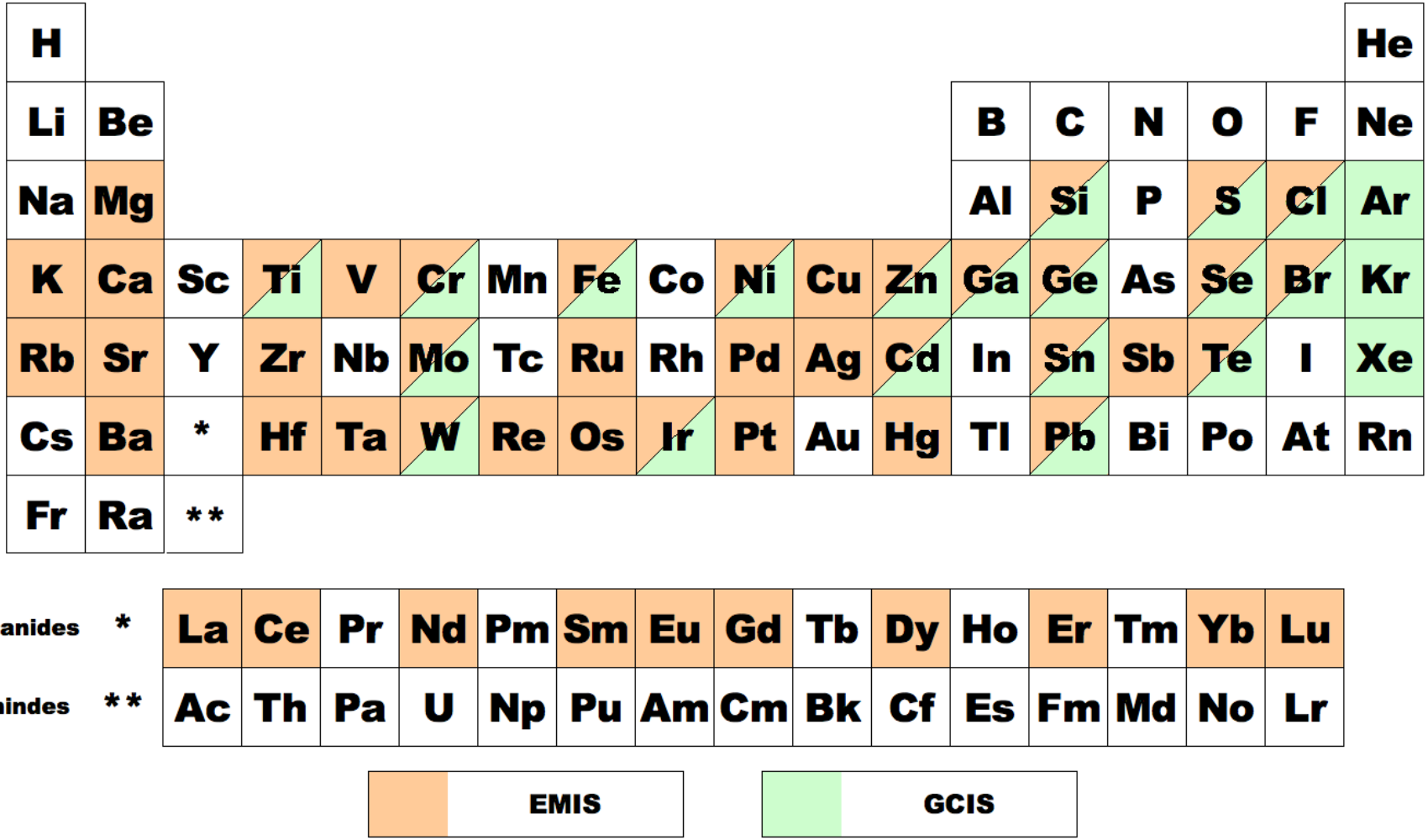
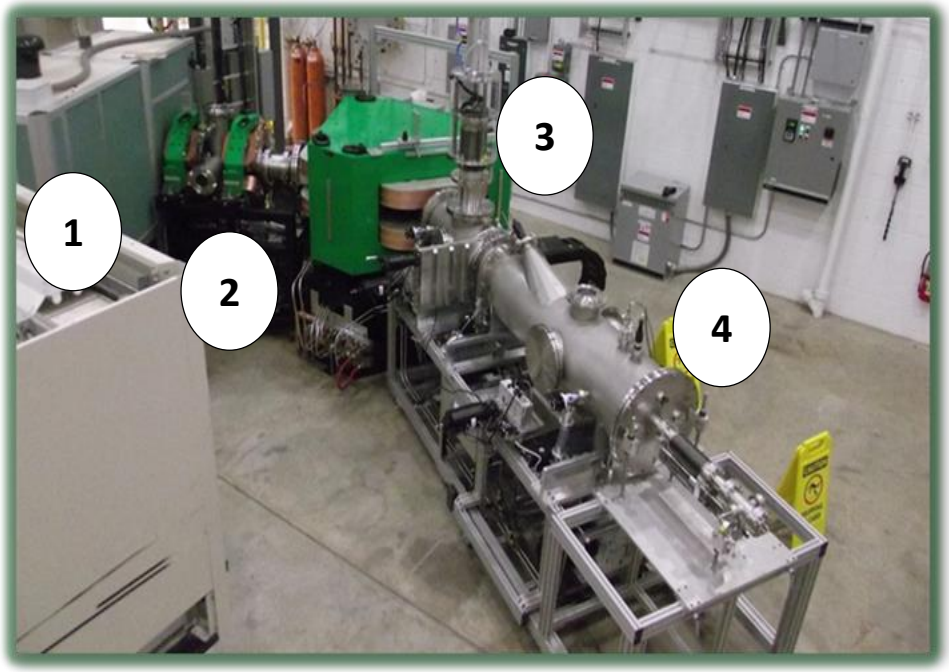
Enrichment Technology



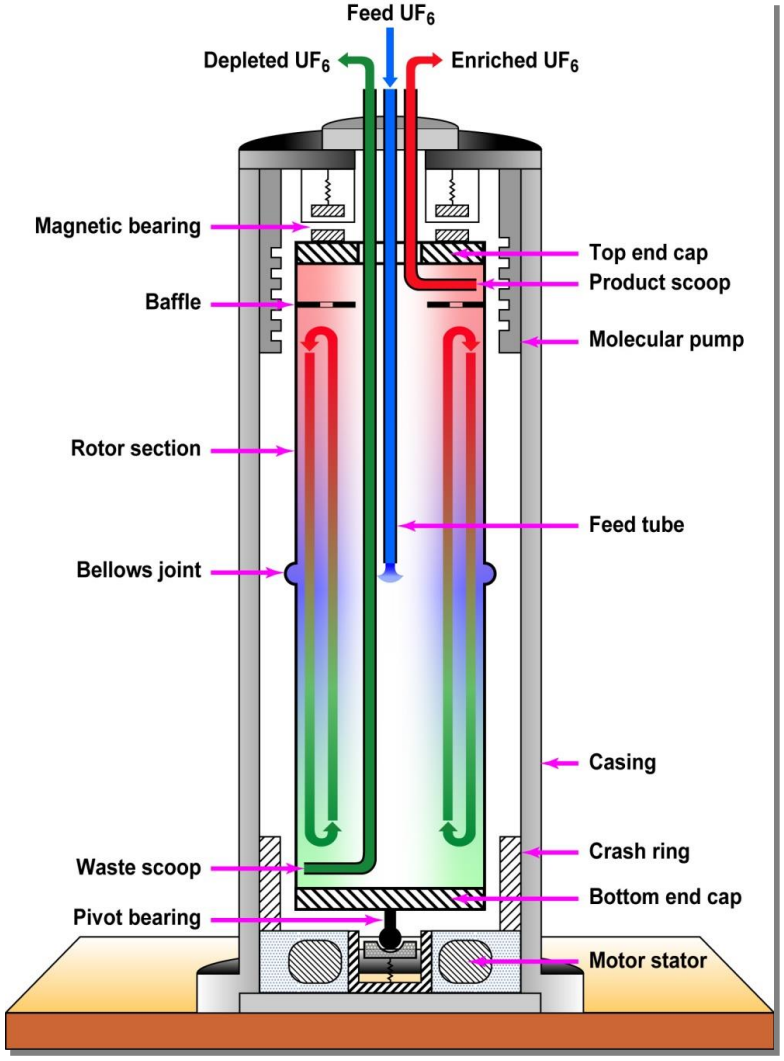
Enriched Stable Isotope Prototype Plant (ESIPP)

- **Developed New Stable Isotope Enrichment at ORNL**
- **Electromagnetic Separation Coupled with Gas Centrifuge Technology**
- **Investment of ~ $11M by DOE Isotope Program**
- **Construction and Development Completed in FY 2016**
- **Capability established by DOE Isotope Program for community**
- **Transitioning to small-scale production – 2017 (research quantities)**

1. Power supply and multiple ion source technologies
2. Magnetic quadrupoles for beam focus and diagnostics
3. 60-degree dipole sector magnet for separation
4. Isotope Collectors
   - Based upon Calutron designs
   - Re-useable with graphite liners
   - Viable for most stable elements



Gas Centrifuge Isotope Separation

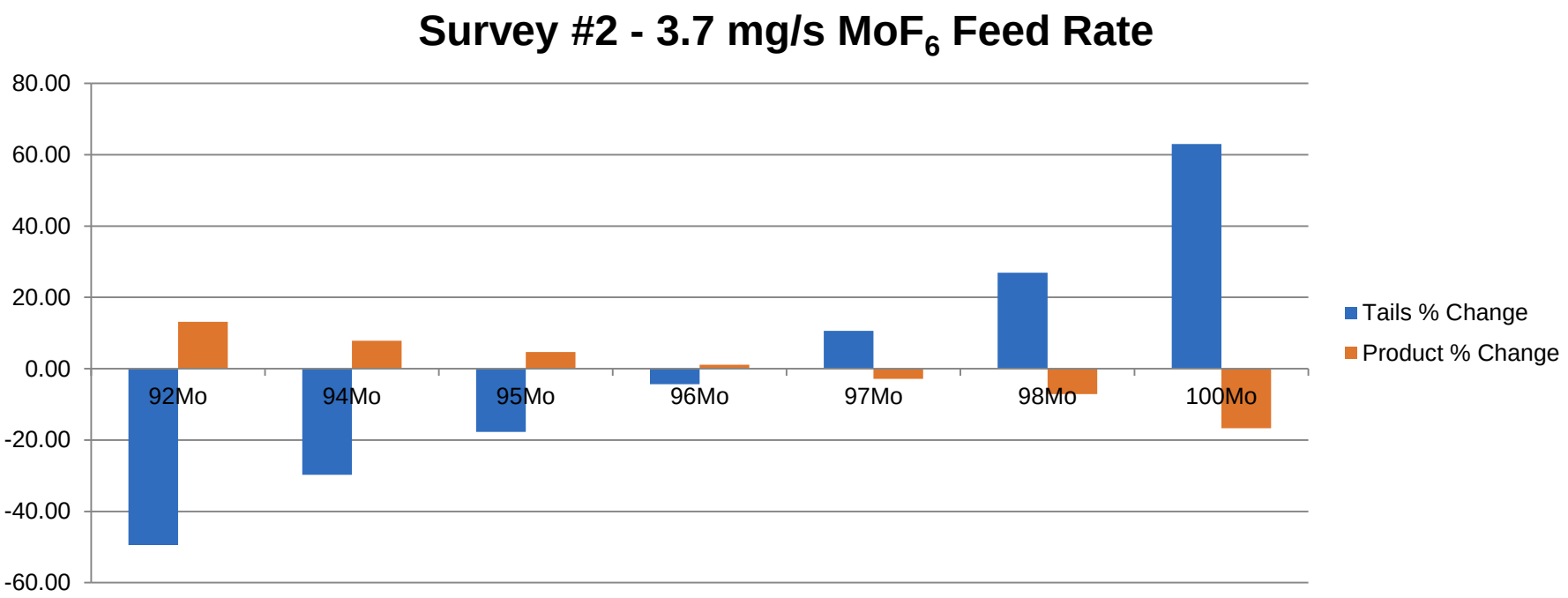


- **Higher Throughput**
- **Some Isotopes can be Fully Enriched (e.g. Ge, Mo)**
- **Provide Pre-enriched Feedstock Material for EMIS**
  - ✓ **Multiplies EMIS performance to help achieve g/year production**
  - ✓ **Reduces the number of EMIS machines needed**
- **Typically has Low Capital, Operating, and Facility Costs**

GCIS MoF_6 Test Data

New Small Centrifuge Performance

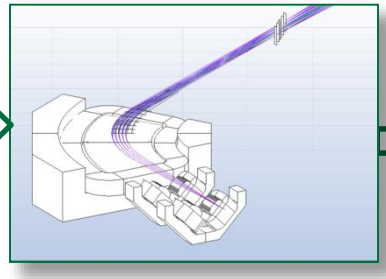
- Achieved Key Performance Parameter in 2016 Testing
- Molybdenum-100 Enrichment was Boosted 60 percent above natural abundance in a single pass



Pathways to Enrichment

Natural Material

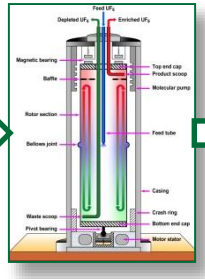
Electromagnetic Separator



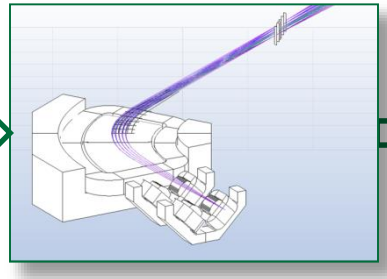
all elements, all isotopes
mg to g/yr, x10s enrichment

Isotopically Enriched Product

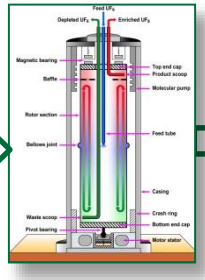
Gas Centrifuge



Electromagnetic Separator



Gas Centrifuge



select elements, one isotope
g to kg/yr, x2 to x5 enrichment

Enriched Stable Isotope Prototype Plant

Enriched Stable Isotope Prototype

Transition to Pilot Operations FY 2017

Currently producing Molybdenum-98 and -100 for feedstock for Mo-99 production (remove foreign dependence)

Production Priorities

- Ruthenium-96 (for physics research)
- Molybdenum-98 and -100
- Xenon-129 and -136 (for NIH to ensure adequate supply as transition away from He-3 for polarized lung imaging)
- Lutetium-176 (cancer therapy)
- Gadolinium-152 and -157 (target for medical isotopes; superconductors)

This capability is for you – let us know what you need.

Stable Isotope Production Facility

Next Step – Expand from a Prototype to Production Facility

- **Mission Need (CD-0) for Expansion is Approved**
- **Stable Isotope Production Facility**
- **Maximize Use of ESIPP Footprint**

- **Address higher research and commercial demand**
- **Candidates include Xenon, Germanium, Molybdenum**
- **Expand Operations in FY 2020**

Conclusion

- Addressed NSAC Recommendations
- Transition ESIPP to Operations for the Stable Isotope Community
- Input from the Community will Affect Priorities
- Next Steps?
  - FY 2017-18 Gram-scale Production
  - Mission Need for Expansion is Approved
  - Stable Isotope Production Facility
  - Maximizes Use of ESIPP Footprint
  - Kilogram-scale production achievable for selected isotopes
  - Radioactive Isotope Separator Development