Savannah River National Laboratory®

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Hydrogen Isotope R&D at SRNL

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Graduate Student Symposium

University of South Carolina at Columbia

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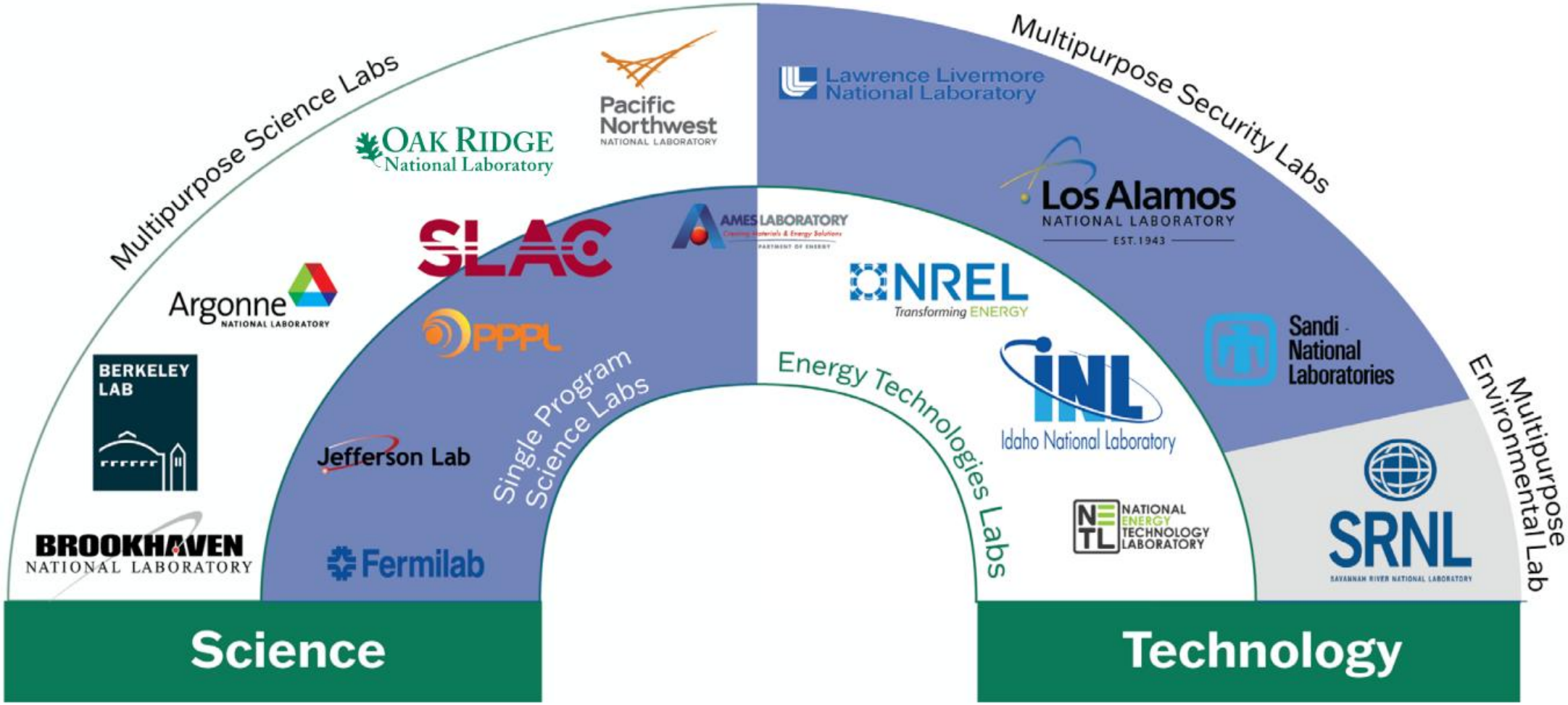
A Spectrum of Laboratories



Savannah River Site is BIG

- 310 square miles / 803 km^2
- Site budget over $2 Billion
- Site Workforce over 10,000
- Organizations at SRS:
  - Department of Energy
  - Savannah River National Laboratory
  - Savannah River Nuclear Solutions
  - Savannah River Mission Completion
  - Savannah River Ecology Laboratory

Provide risk-informed approaches that achieve sustainable regulatory end-states.

Enable NNSA success by supporting a robust weapons stockpile while reducing threats through advances in proliferation detection technologies.

Develop environmentally responsible and secure energy strategies through advanced engineering of materials and chemistry.

Enabled by a Workforce Development Initiative

Deliver the intellectual resources needed to execute the vision for the nation.

SRNL's Core Competencies

 Accelerating remediation, minimizing waste, & reducing risks	 Creating manufacturing & energy solutions for EM, NNSA, and other sponsors	 Enabling next-generation nuclear materials processing & disposition
 Assuring production & supply of strategic materials & components	 Sensing, characterizing, & assessing materials production & environmental impacts	 Securing connected control systems & associated data

SRNL Research Directorates

Global Security

Environmental and Legacy Management

Weapons Production Technology

Science, Engineering & Innovation

Hydrogen Isotope Research & Development at SRNL

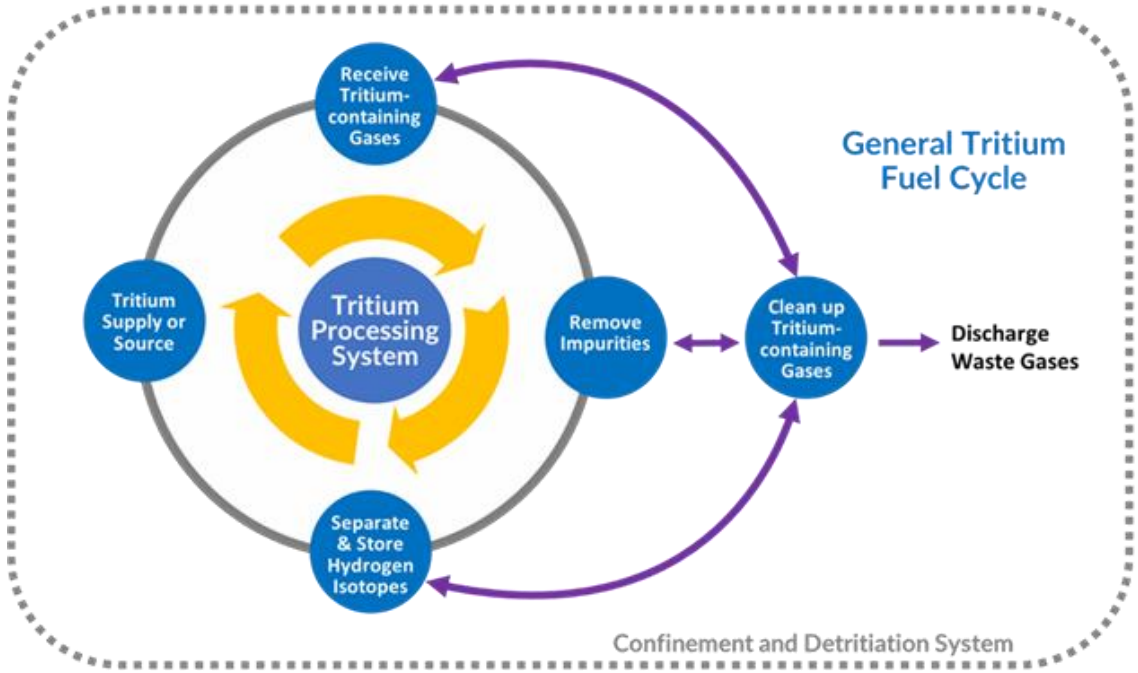
Tritium Process Development

- Tritium Processing is a complex chemical process – containment, separations, materials compatibility, and accountability.

- SRNL's unique tritium process development capabilities, established for Defense Programs, also support other federal and non federal applications.

- Tritium Processing R&D at SRNL is primarily performed at the Applied Research Center.

Tritium Gas Processing: Needs & Opportunities



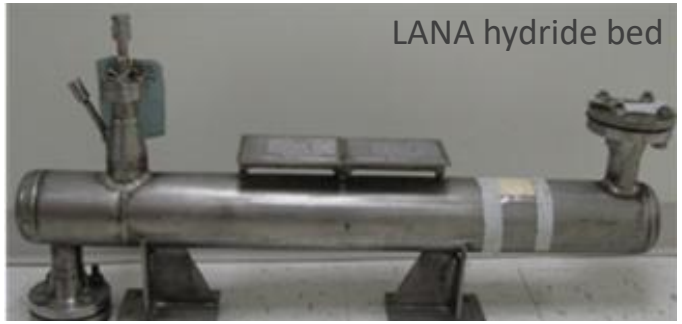
Increased Efficiency

In-process regeneration of current Lanthanum-Nickel-Aluminum (LANA) hydride storage beds would ***reduce large tritium heel***, lowering tritium Required Minimum Inventory (RMI), and extend bed life.

Obsolescence

Currently deployed Pd-Ag diffusers, used to separate hydrogen isotopes from inert and other non-hydrogen species, are prone to poisoning and ***vendor support is uncertain***.

Pd-Ag diffuser

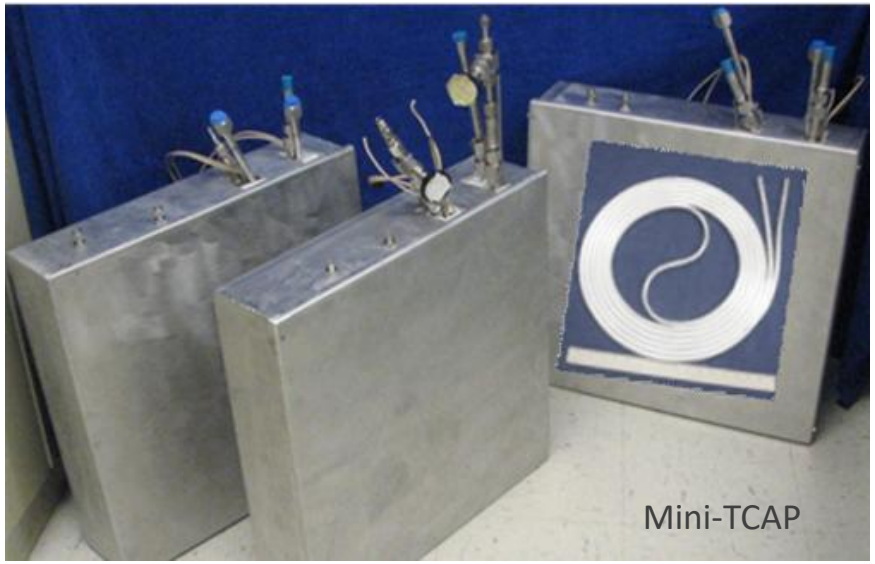


LANA hydride bed

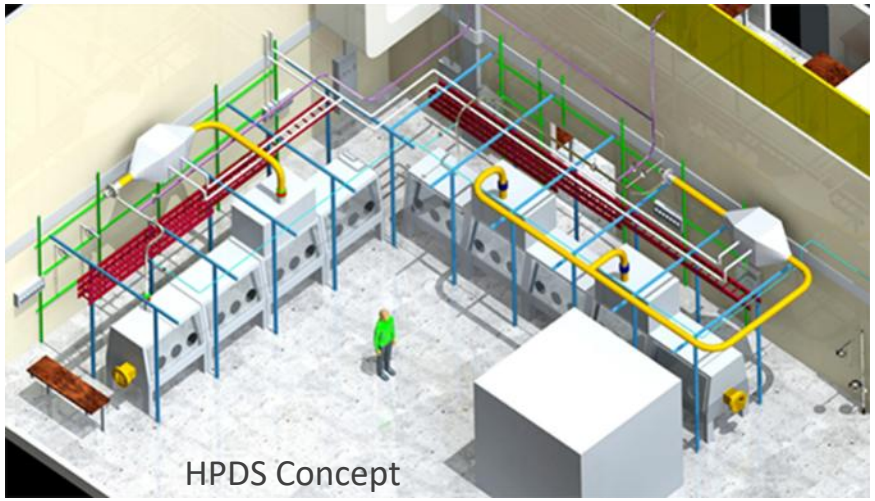
Tritium Gas Processing: Needs & Opportunities (Examples)

Increased Efficiency

Advanced design of the Thermal Cycling Absorption Process (TCAP), an SRNL-developed technology for the separation of hydrogen isotopes, occupies a significantly smaller footprint with ***double the throughput*** and 1/3 the tritium inventory of the currently deployed TCAP system.


Mini-TCAP

The Hydrogen Processing Demonstration System (HPDS) will provide non-rad R&D testing capabilities/infrastructure for individual components and integrated systems to ***accelerate technology maturation*** and support maintaining core competency.


HPDS Concept

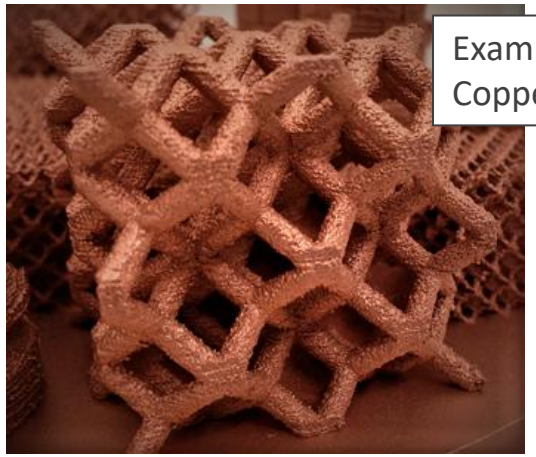
Hydrogen Storage

Redesign the current methods of storing, compressing, mixing, and transporting hydrogen isotopes.

Hydride Bed Development

Lanthanum-Nickel-Aluminum (LANA) Hydride Beds

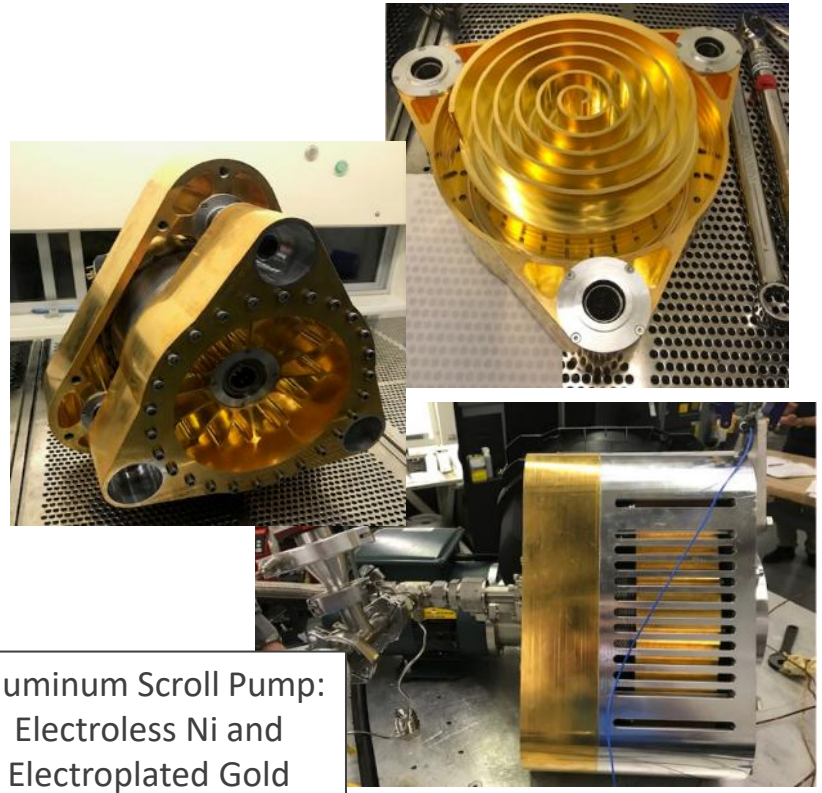
- In-process regeneration of current LANA hydride beds would ***reduce large tritium heel***, lowering tritium Required Minimum Inventory (RMI), and extend bed life.



Example of an Additively Manufactured (AM) Copper Cellular Structure for a hydride Bed

- Utilizing this specific hydride for tritium storage would **eliminate tritium heel**.
- Use of lattice structures to confine the hydride particles in a vessel would **allow flow-through operations**.
- The hydride does not retain ^{3}He.

Alternative Pumping Technologies



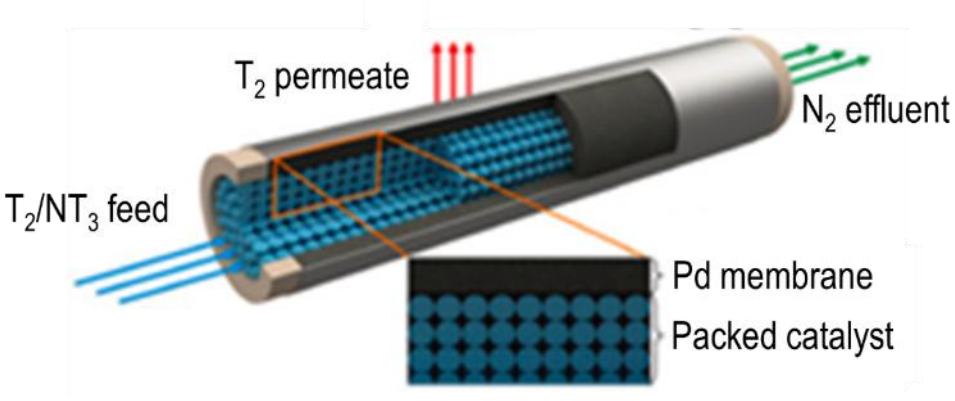
Aluminum Scroll Pump: Electroless Ni and Electroplated Gold

- Redesign components needed to make the pump **compatible for tritium service**.

Impurity Removal

Objective: eliminate/mitigate the issues caused by accumulation of gaseous impurities.

Ammonia Decomposition and Processing



Permeation Membrane Reactor (PMR) Packed With Ammonia Decomposition Catalyst.

- Development of novel trimetallic **catalysts for ammonia decomposition** could be used to re-design diffusers.
- As ammonia is cracked into tritium and nitrogen, tritium permeates out of the reactor through the palladium (Pd) walls for further purification.
- Nitrogen and tritium cannot recombine since the tritium is removed.

Tritiated Water Processing

- Development of **water vapor detritiation unit** for the passive (i.e., ambient condition) **recovery of accumulated tritium** present in the moisture of a glovebox atmosphere.

Impurity Trap Material Development

Cryocooler With Sample Loaded

- Development of **absorbent and cryogenic beds** to selectively **remove impurities** from a hydrogen isotope process stream.

Isotope Separations

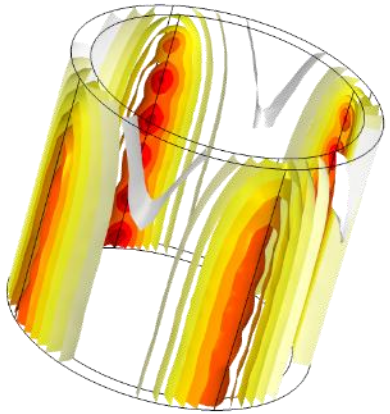
Objective: improvement and scale up of the Thermal Cycling Absorption Process (TCAP) technology.

Advanced HT-TCAP Development

Mini-TCAP System

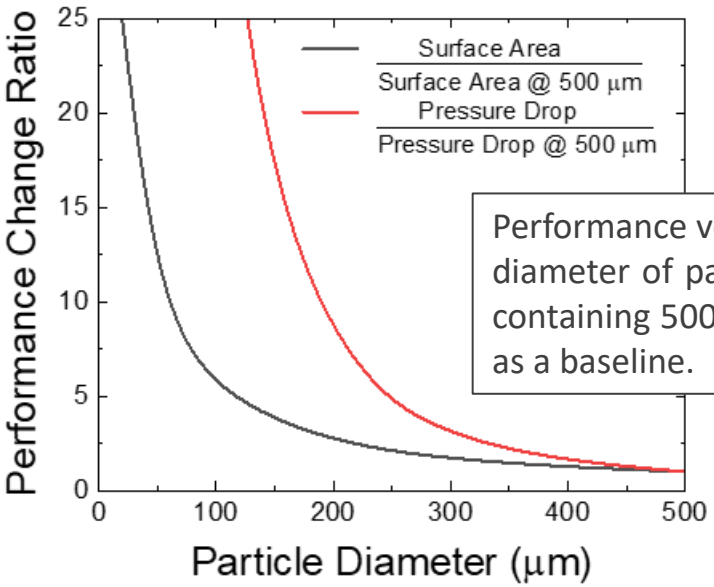
- Mini-TCAP design occupies a significantly **smaller footprint with double the throughput** and 1/3 the tritium working inventory of the currently deployed TCAP system.

Design and Modeling



- Development of a **scaled-up** version of the Mini TCAP due to the higher throughput needed compared to Mini-TCAP.
- Development of heating and cooling methods to **improve heat transfer**.

TCAP Column Material Development



Performance versus particle diameter of packed column containing 500 μm particles as a baseline.

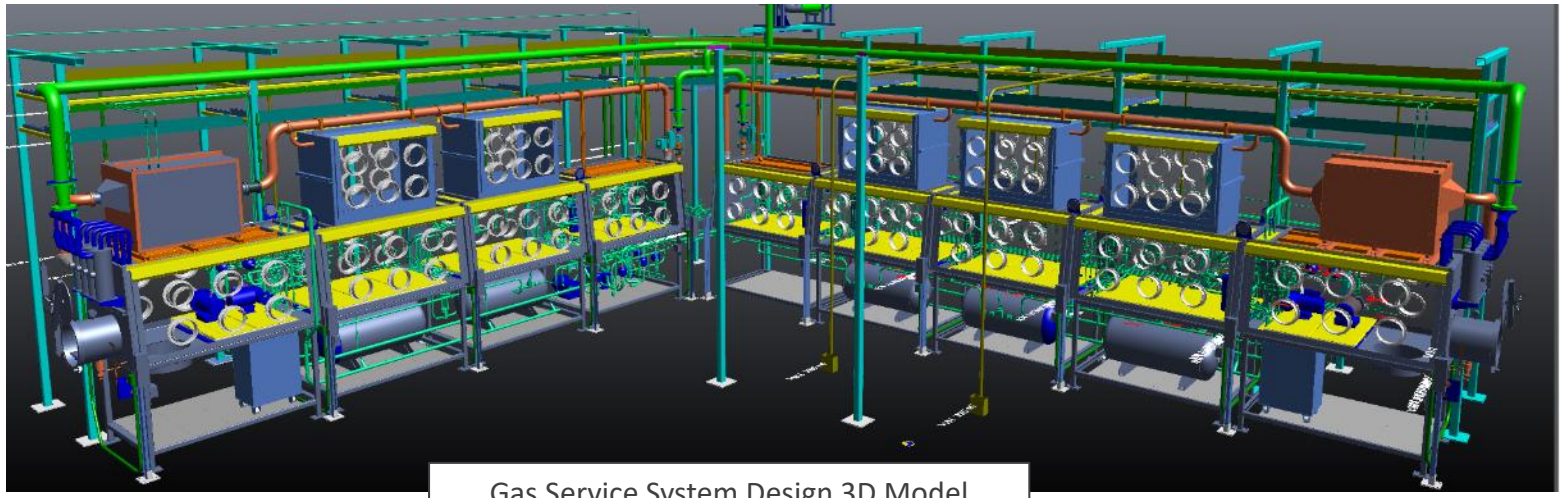
- Development of new Pd-based and other hydride and non-hydride materials to **improve absorption kinetics and mass transfer** in TCAP columns.

Integrated R&D Capabilities

The Integrated R&D Capabilities tasks cover radiological and non-radiological R&D capabilities required to address the risk of inserting new technologies into the Tritium Facility.

Hydrogen Processing Demonstration System (HPDS)

- HPDS would **facilitate tritium process research and maturation** efforts by integrating technologies prior to insertion into the Tritium Facility
- HPDS would provide valuable **hands-on training** for researchers/operators and **maintain/grow core competencies** and expertise in tritium processing.



Gas Service System Design 3D Model

Gloveboxes interior provide abundant space to test individual tritium processing components as well as integrated systems testing.

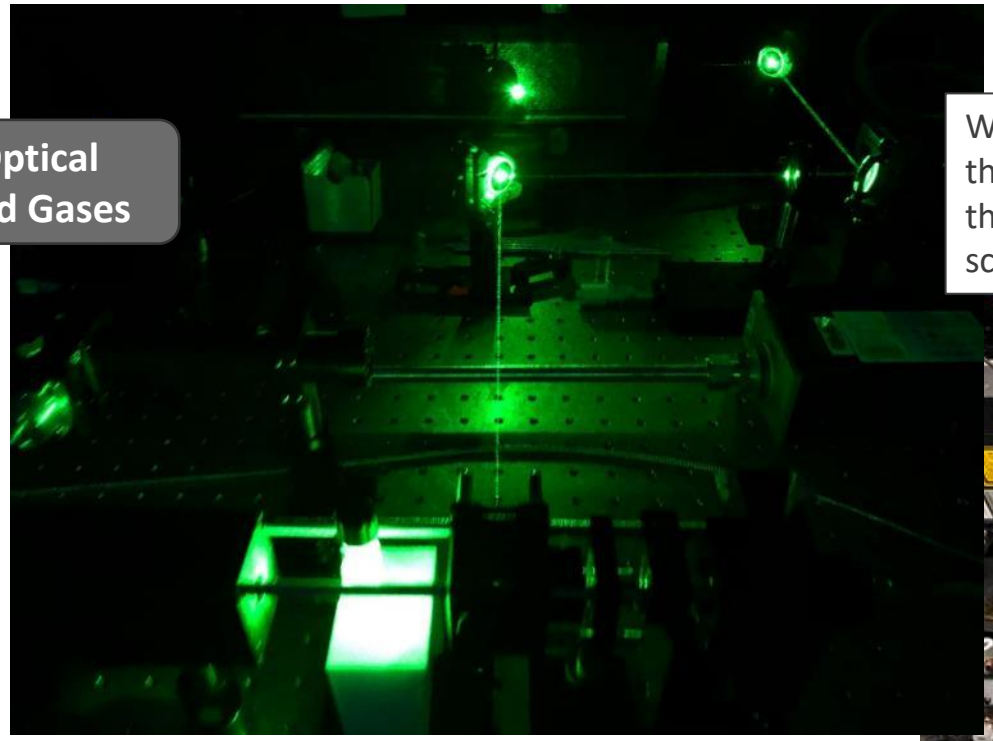
Tritium Laboratory

- Development and establishment of a capability to handle low amounts of gaseous tritium.

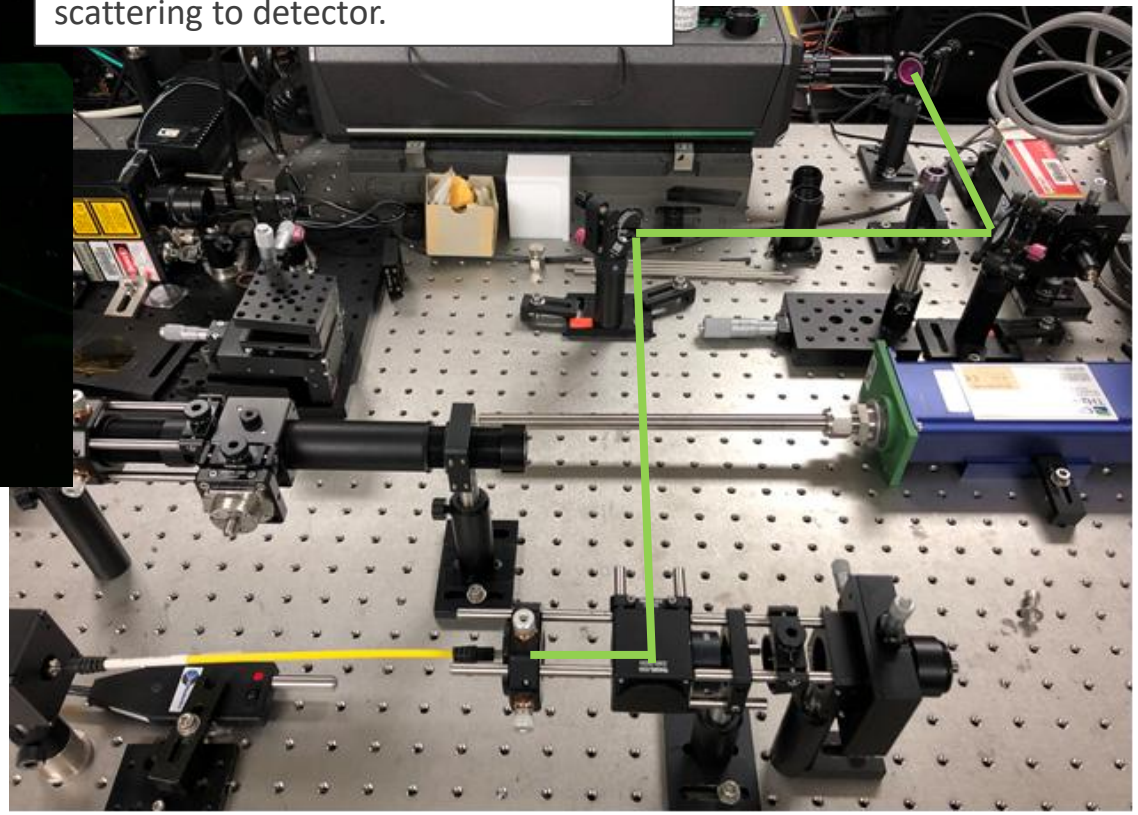
Supporting Systems

The Supporting Systems R&D tasks address factors regarding instrument design and operation for compatibility in tritium processing systems.

Next Generation Optical Detection of Tritiated Gases



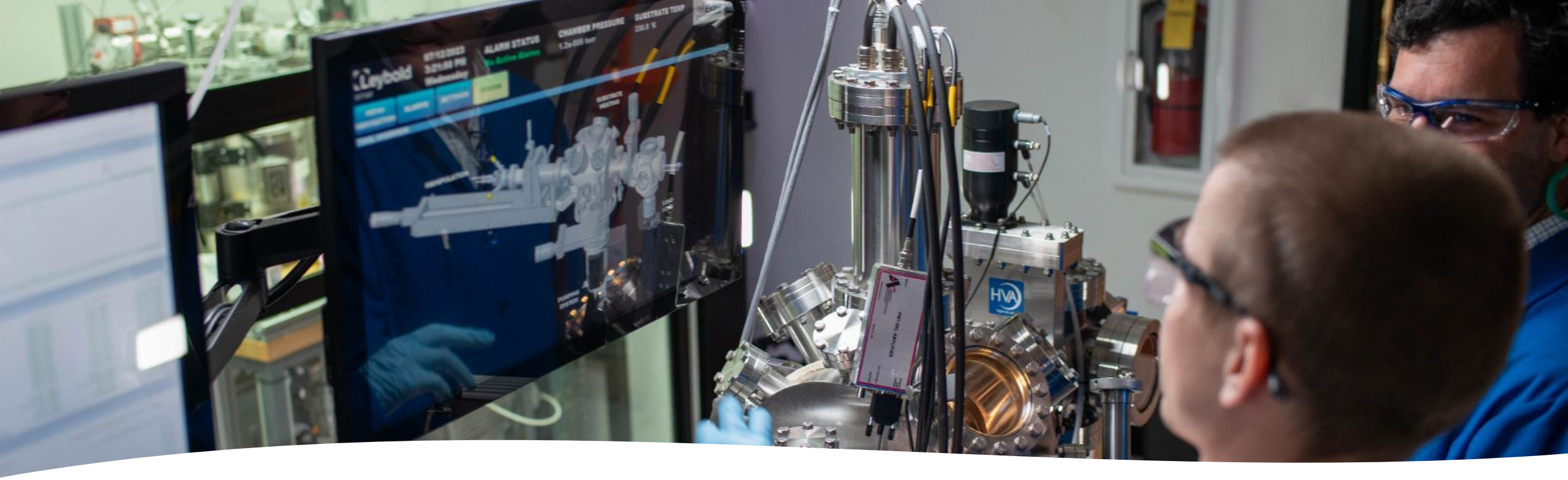
Waveguide of 1000 micron to minimize the interaction of the laser beam with the walls, but still funnel Raman scattering to detector.



- Development of waveguide-based Raman **monitoring system for X_2 and other tritium-containing trace gas species**.
- Raman spectroscopy using reflective waveguides can provide ~100 ppm sensitivity for X_2 isotopologues.

Summary and Conclusions

- SRNL is the nation's leader in tritium technology R&D
- We address the needs from early stages of development to full deployment.
- Expertise has been developed through more than 7 decades
- Leadings areas of research
  - Hydrogen Storage
  - Impurity Removal
  - Isotope Separation
  - Analytical Systems



Questions?