Overview of Tritium Activities at the Laboratory for Laser Energetics

W. T. Shmayda
University of Rochester
Laboratory for Laser Energetics

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Summary

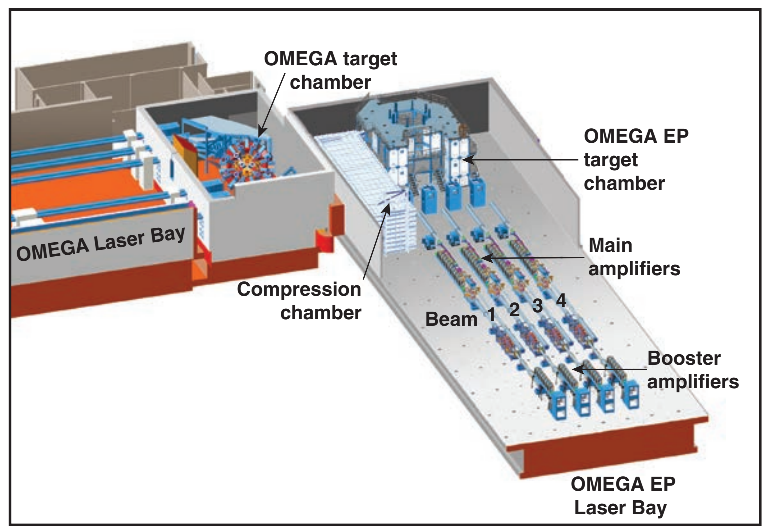
Tritium operations are an integral part of the Inertial Confinement Fusion Program at LLE

- LLE has operated a 1.5-g tritium facility since 2006 without a reportable incident
- Handling tritium gas over a 500°C temperature range and a 1000-atm pressure range poses unique challenges
- Volatile organic species and decay helium contaminate the DT fuel; a Pd permeator has been installed to remove these impurities
- LLE's tritium handling capabilities have expanded to address new programmatic needs:
  - DT layering studies
  - de-protination of the DT fuel
  - the study of DT fusion branching ratios

The Laboratory for Laser Energetics operates two of the world's largest lasers for high-energy-density-physics research

- Operate the National Laser Users' Facility
- Conduct research and development in high-energy-density phenomena
- Provide undergraduate and graduate education in electro-optics, lasers, plasma physics, and fusion technology
- Conduct experiments in support of the National Inertial Confinement Fusion (ICF) Program

- Faculty-equivalent staff: 112
- Professional staff: 167
- Associated faculty: 21
- Contract professionals: 10
- Graduate and undergraduate students: 127

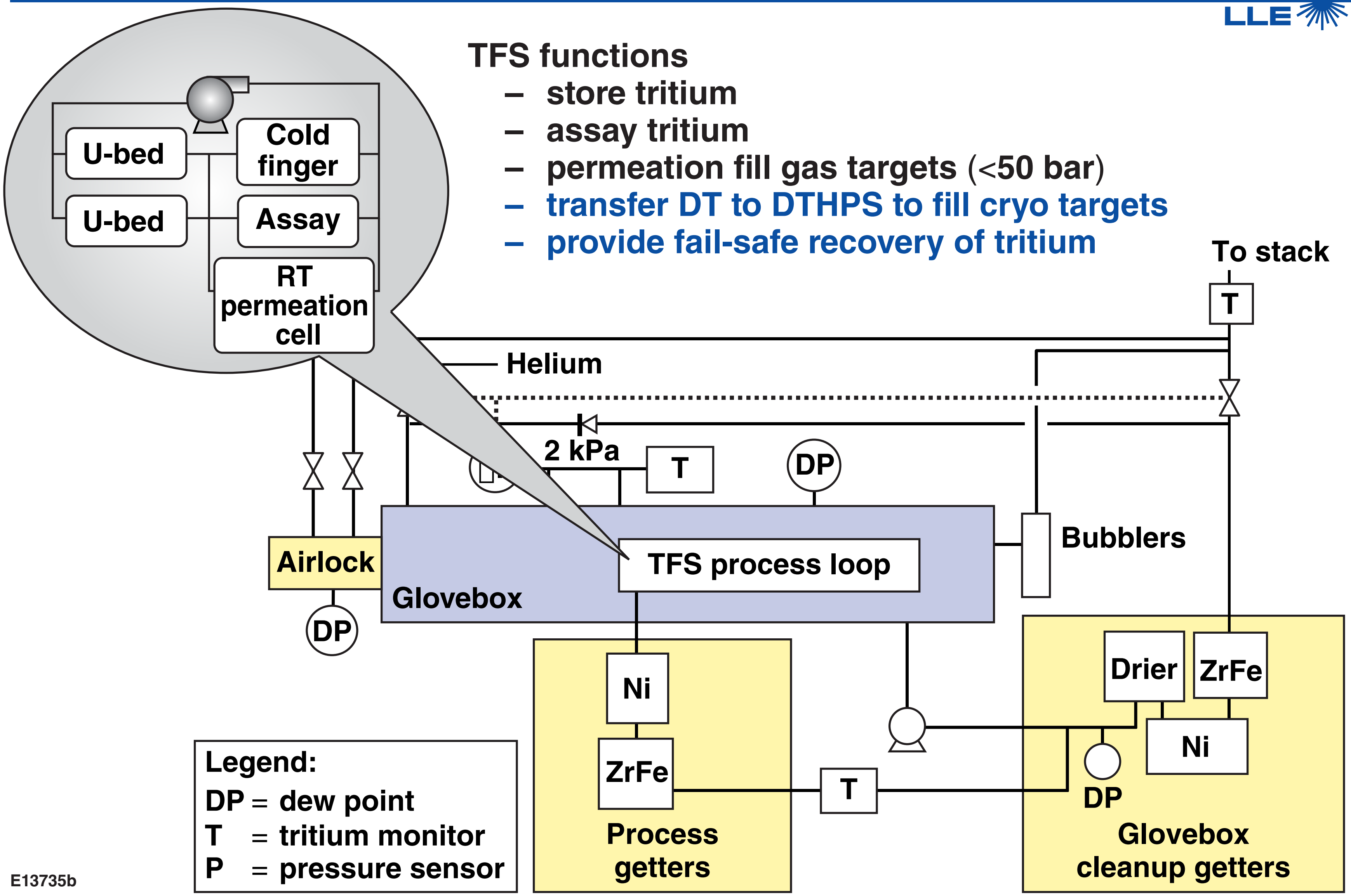


E19929c

In 1996 LLE commissioned the Tritium Fill System (TFS) to permeation fill *gas targets*; since 2006 the TFS also delivers measured aliquots of gas to the DT high-pressure system (DTHPS) for cryo targets

UR LLE

TFS functions
- store tritium
- assay tritium
- permeation fill gas targets (<50 bar)
- transfer DT to DTHPS to fill cryo targets
- provide fail-safe recovery of tritium



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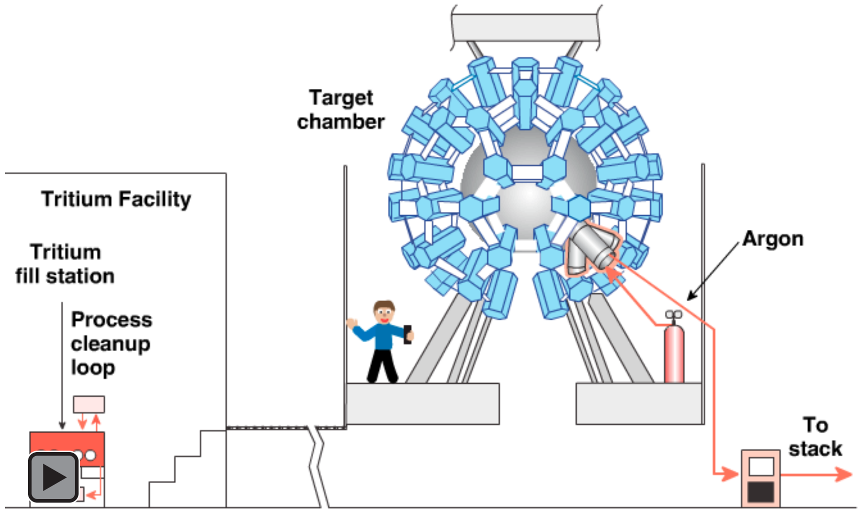
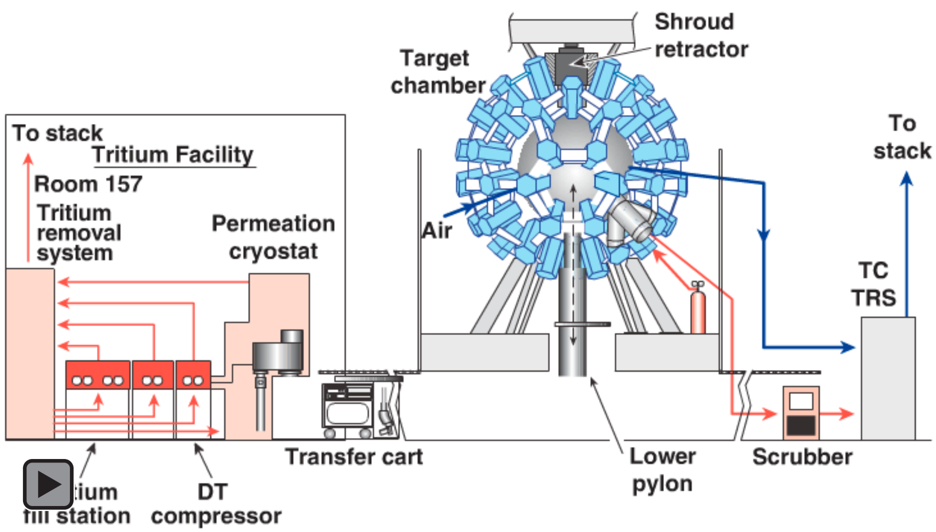
Targets filled with DT gas are routinely fielded to study the physics of DT implosions

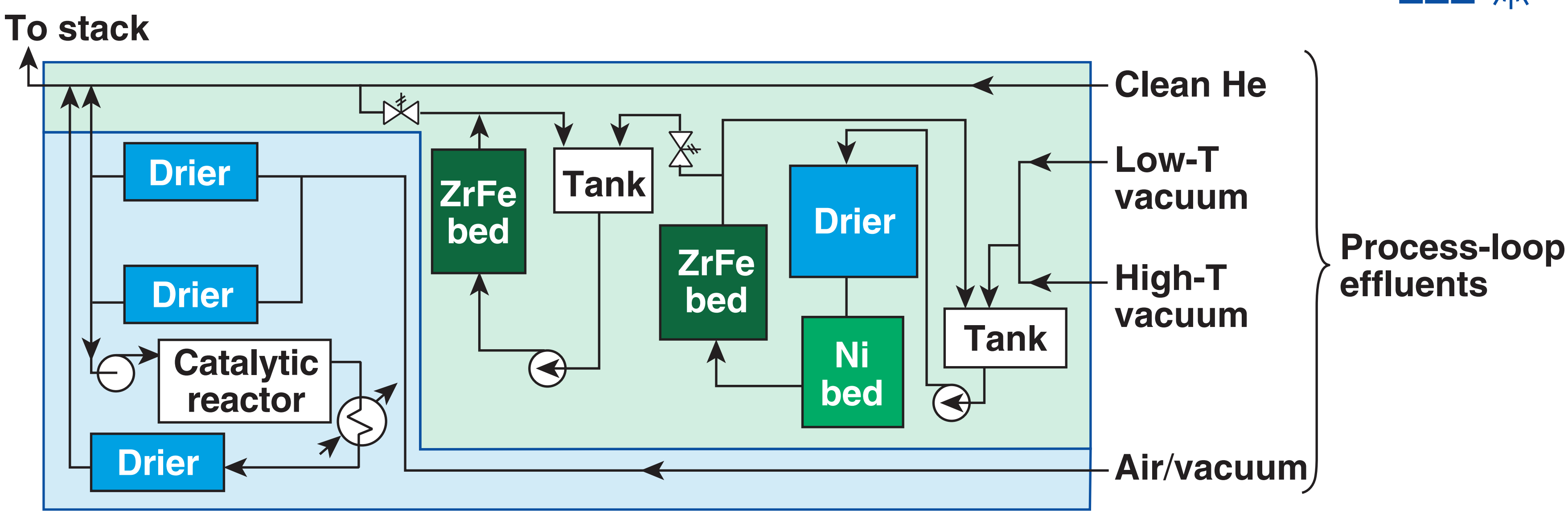




- Warm targets
  - diagnostic development
  - field 10 to 12 per campaign
  - 10 to 20 atm DT
  - <10 mCi per target
- Cryogenic targets
  - DT fusion reactions
  - field 4 to 5 targets per campaign
  - ~700 atm, 17 K DT ice
  - ~200 mCi per target
- Tritium Facilities
  - 1.5-g tritium inventory
  - released 0.6 Ci to the environment in 2012

E11597h

All effluent streams are scrubbed to ensure LLE does not exceed its 9.6-Ci emission limit

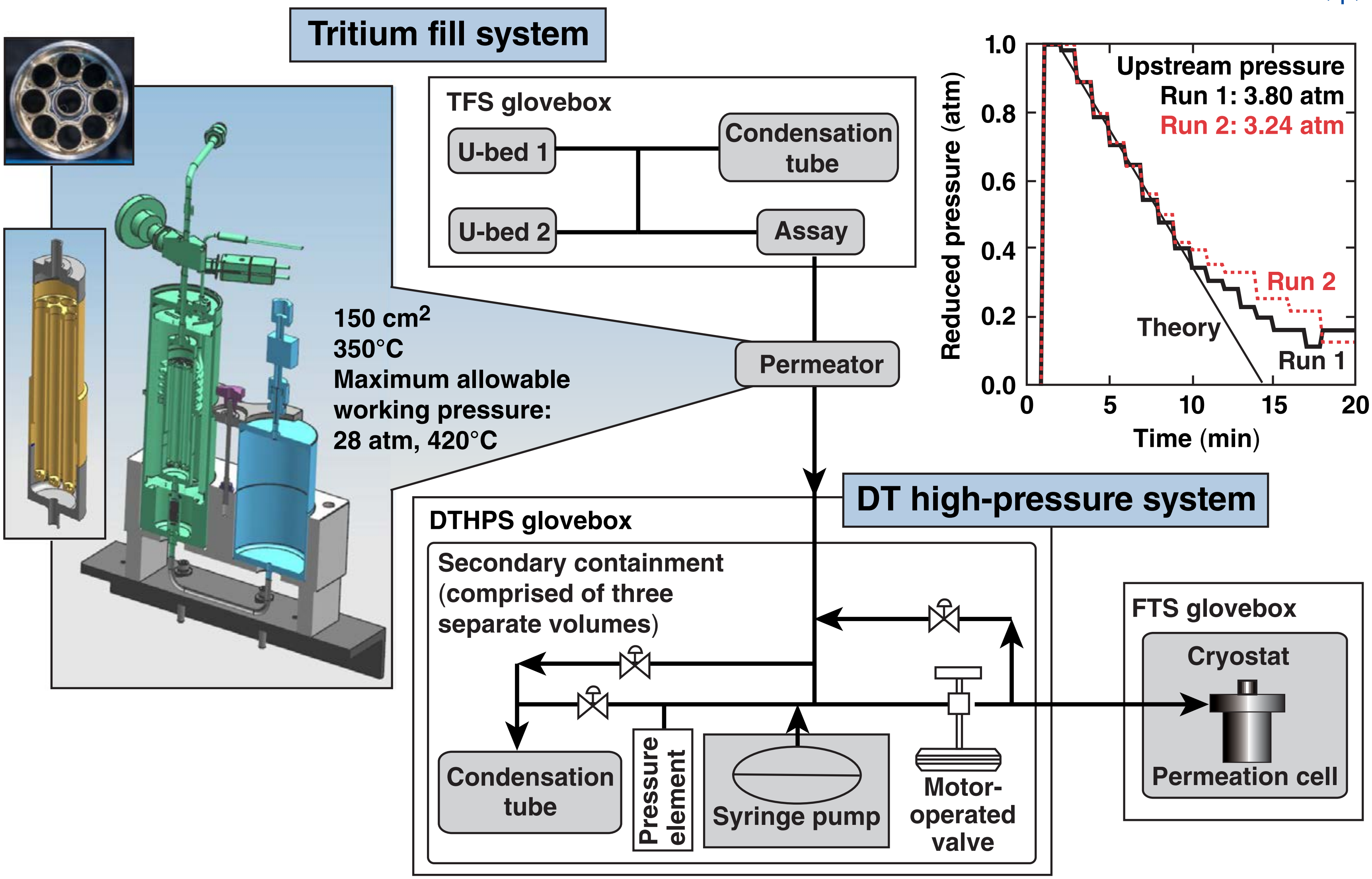


The presence of air determines which technology is deployed to remove tritium from the effluent stream.

Effluent–air mixtures	Effluent without air
– catalytic oxidation – drier	– drier to remove HTO – Ni to remove O_2 and crack organics – ZrFe to capture hydrogen gas

E16057a

A Pd/Ag permeator has been installed to remove organic impurities and decay helium from the DT fuel



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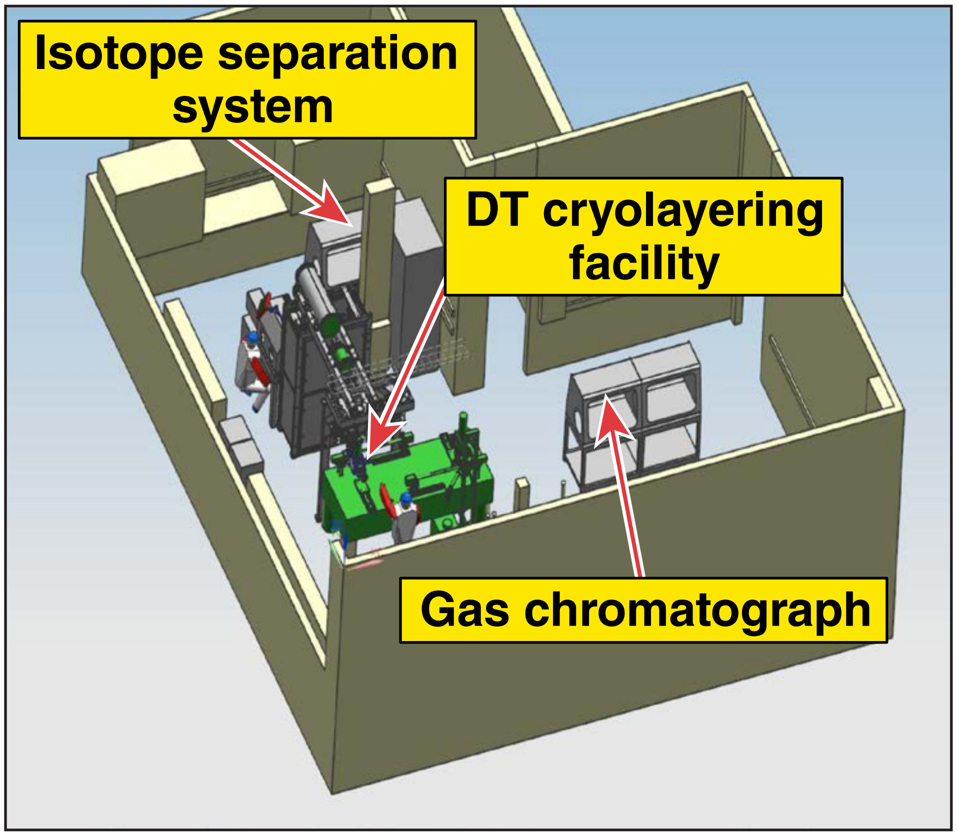
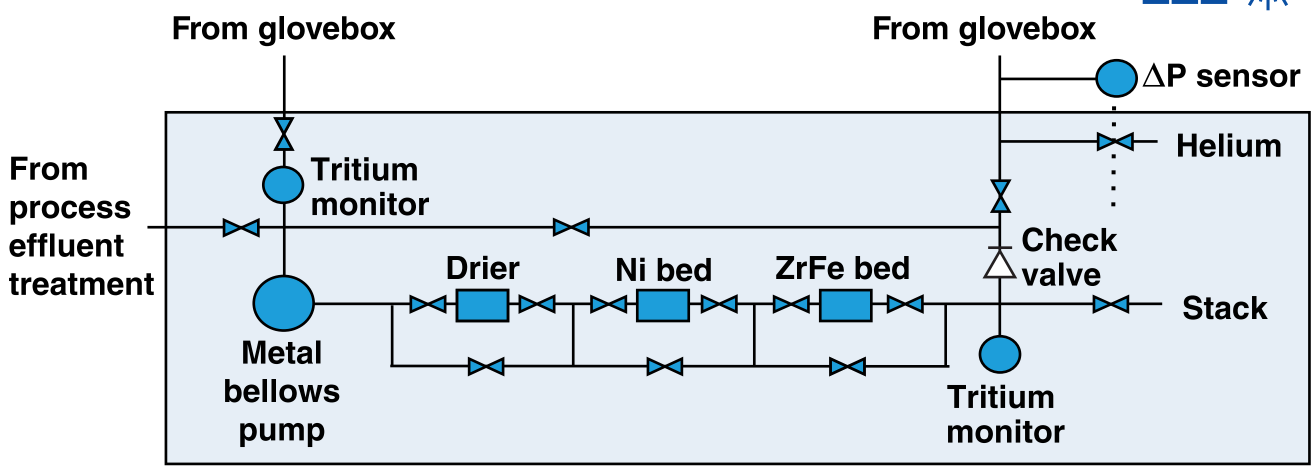
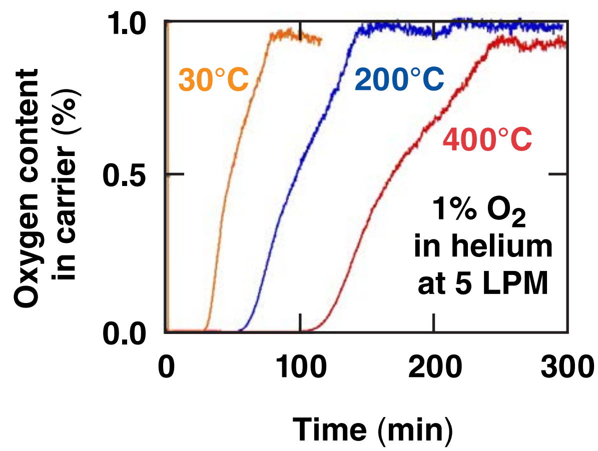
LLE has activated a new tritium laboratory to address expanding programmatic needs

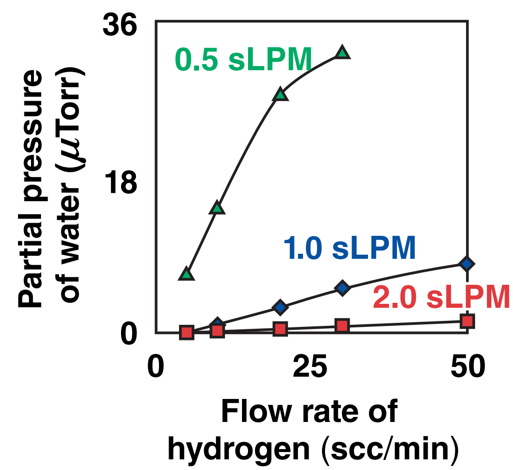


- 3.2-Ci release limit; real-time monitoring of T emissions
- Lab is 0.05-in. H_2O negative relative to adjacent labs; seven air changes per hour
- Primary-loop effluents treated by dedicated tritium capture equipment
- Treated primary-loop effluents discharged into attendant independent glovebox cleanup systems

The glovebox purification systems are integrated, rack-mounted, engineered systems



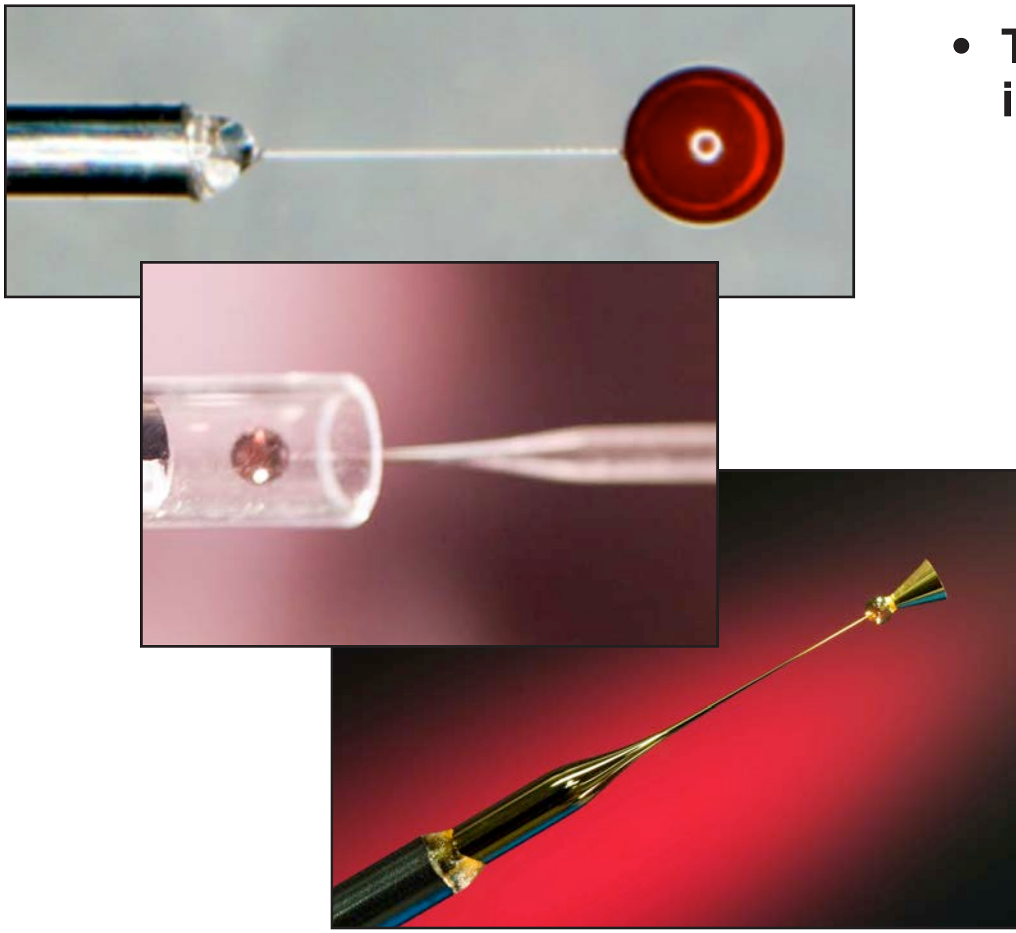




- The mass transfer zone and capacity for oxygen uptake increase with temperature; higher operating temperatures are preferred
- Increasing the hydrogen concentration in the carrier increases the nickel reduction rate linearly at higher flow rates

E21966

A DT cryolayering facility will study advanced cryogenic target designs to be fielded on the National Ignition Facility (NIF)

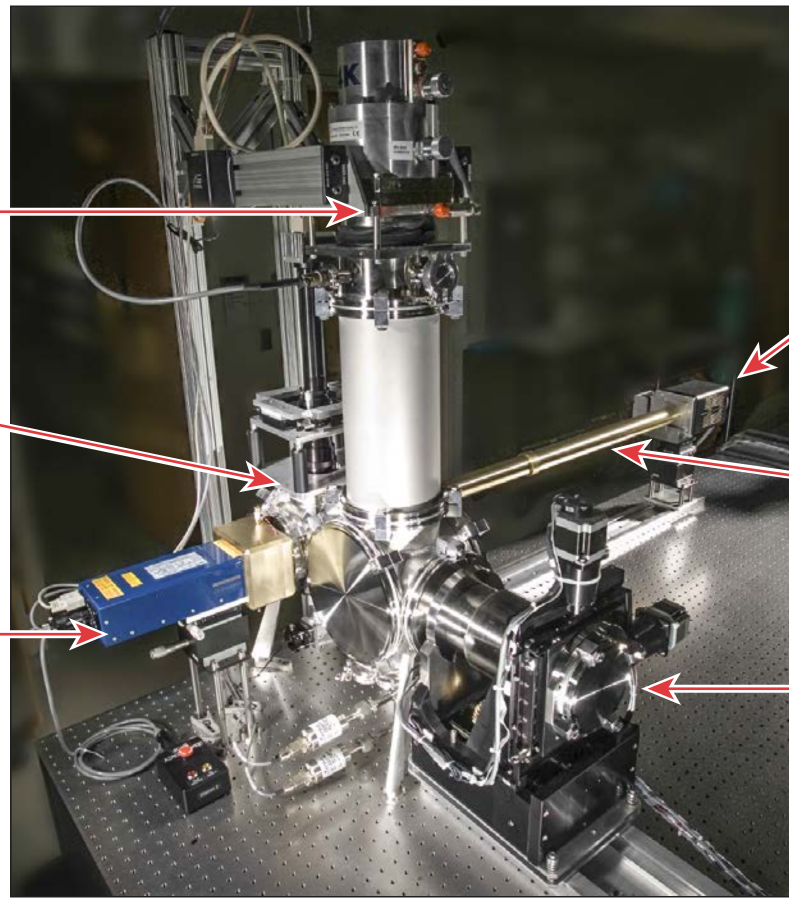


- Targets being examined include:
  - polar-drive targets
  - capsules in transparent hohlraums
  - cone-in-shell targets

NIF baseline: All cryogenic targets are fueled using a fill tube.

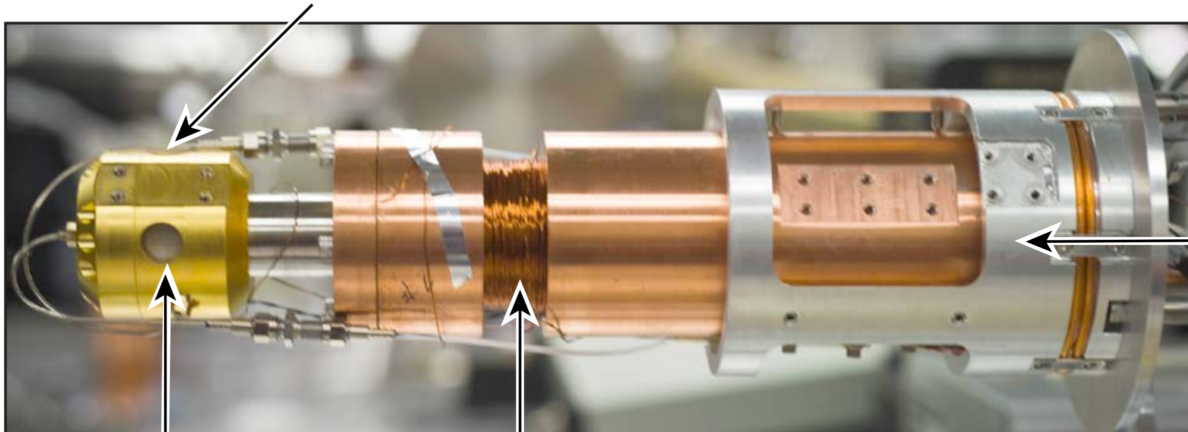
E21985

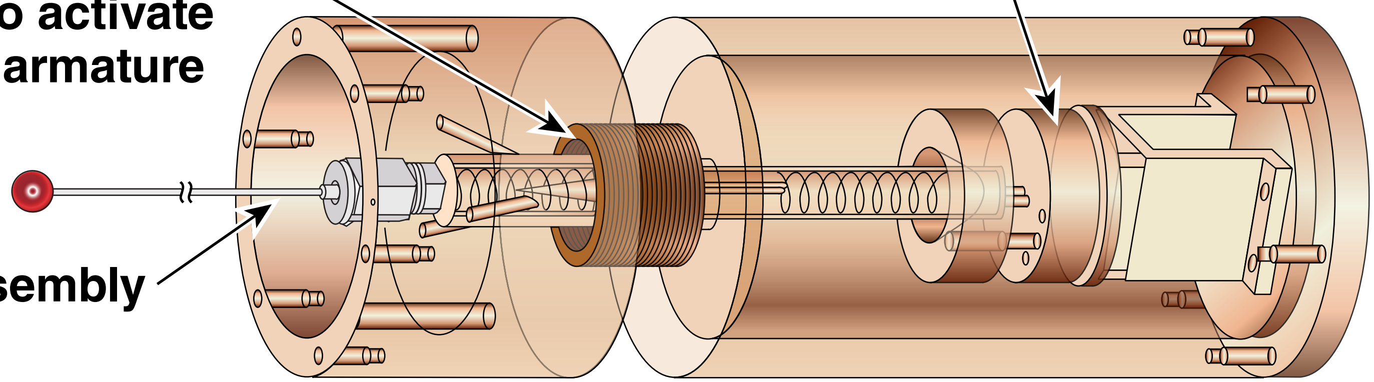
A test stand to produce and characterize the advanced cryogenic targets has been constructed and tested with D_2



- Optical and x-ray wavelengths are used to characterize targets

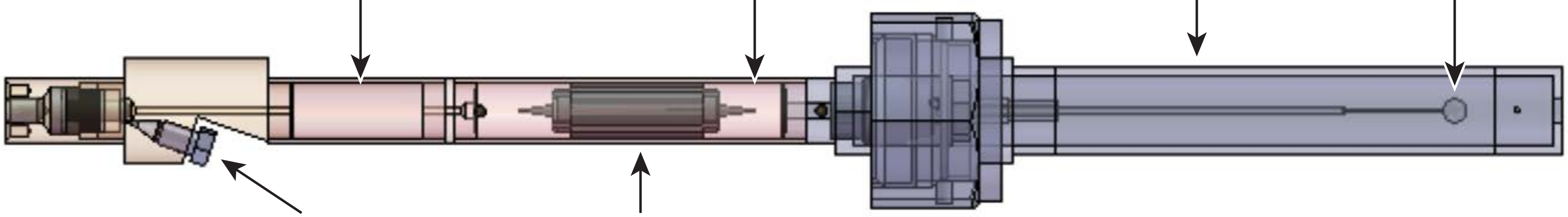
The layering sphere is thermally isolated, controlled separately, and provides primary containment for the DT





E21987

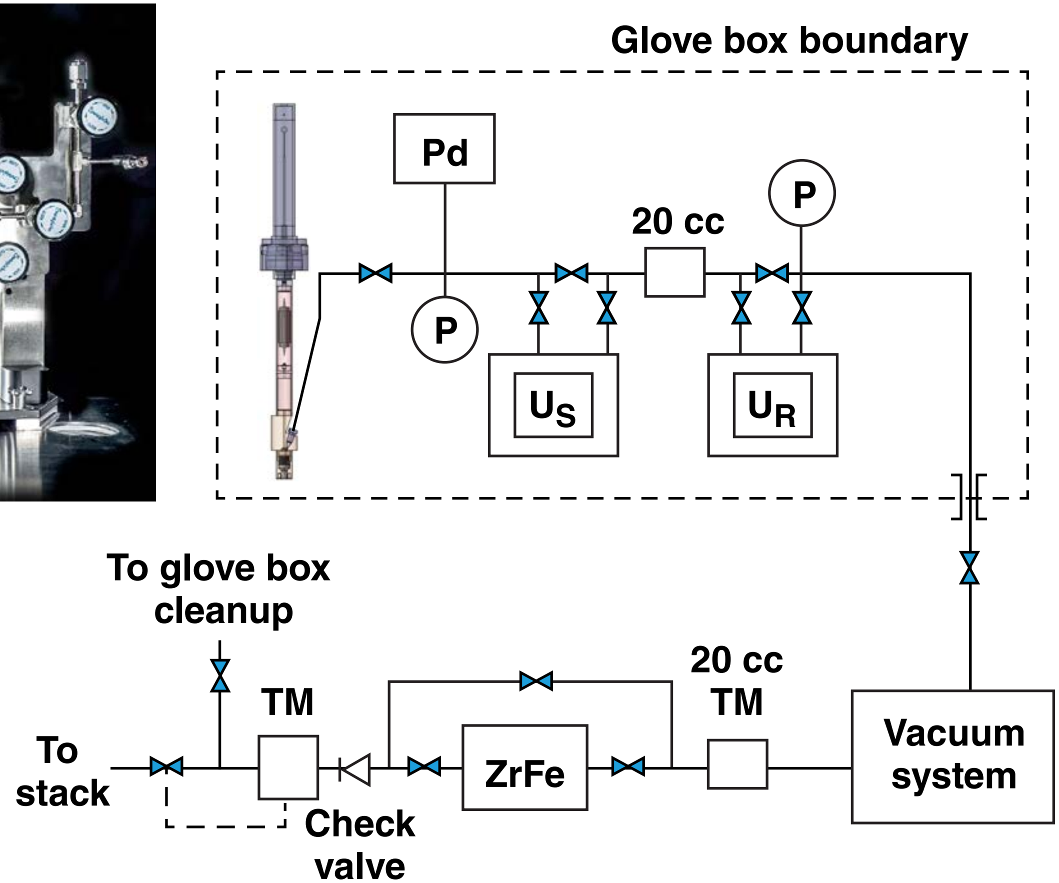
The target assembly comprises four gas compartments: D_2 and T_2 reservoirs, shell, and cover assembly

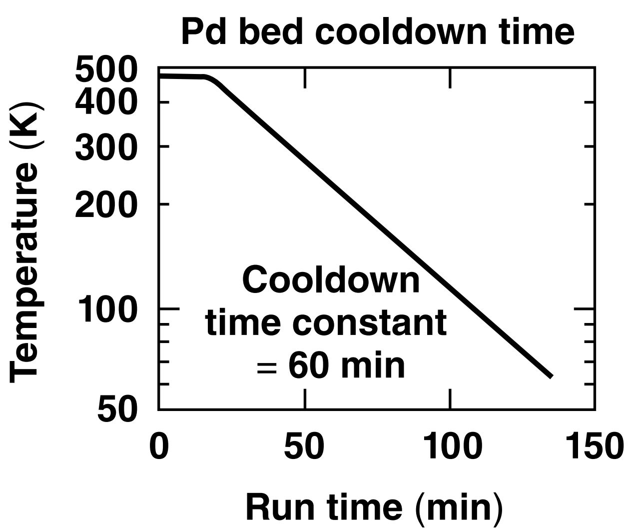


- The cover assembly provides containment for target transfer from T_2 dispensing loop to layering facility

Metal seals are used throughout. The leak rate between adjacent compartments and the exterior is $<10^{-8}$ sccm He.

The tritium dispensing loop uses a Pd bed for all dispensing and recovery operations; T_2 is stored on U



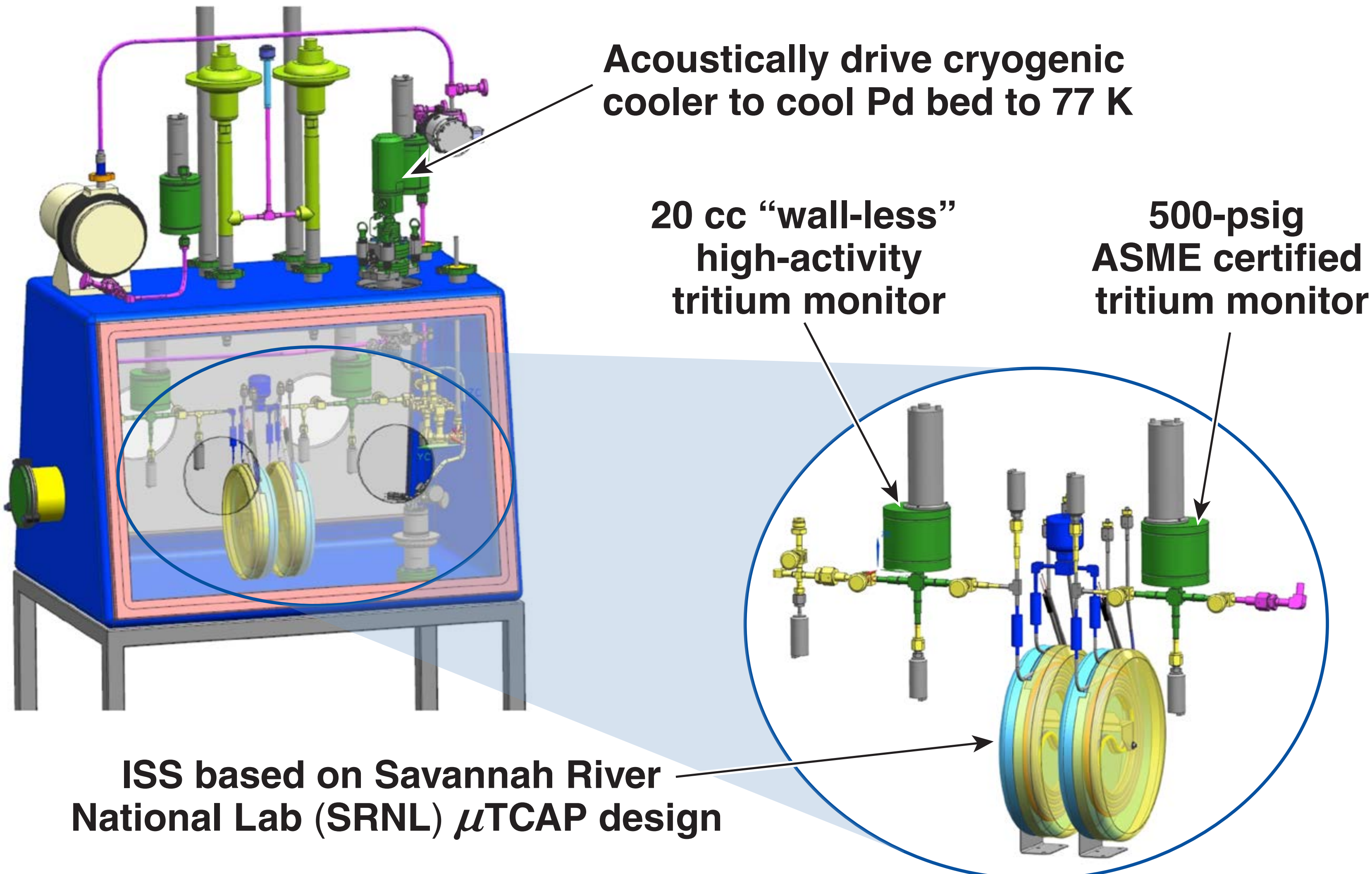


E21988

An isotope separation system (ISS) will provide LLE with a flexible tritium fuel supply

- Ensure the D/T ratio of the fuel supply meets LLE's baseline ICF program requirements
- Eliminate protium from the existing fuel supply
- Recover tritium from existing, unusable spent DT fuel
- Eliminate the need to ship tritium to/from external cleanup facilities
- Provide the ability to examine fusion reactions at variable D/T ratios

The ISS can process 5 L/day and supports several novel features



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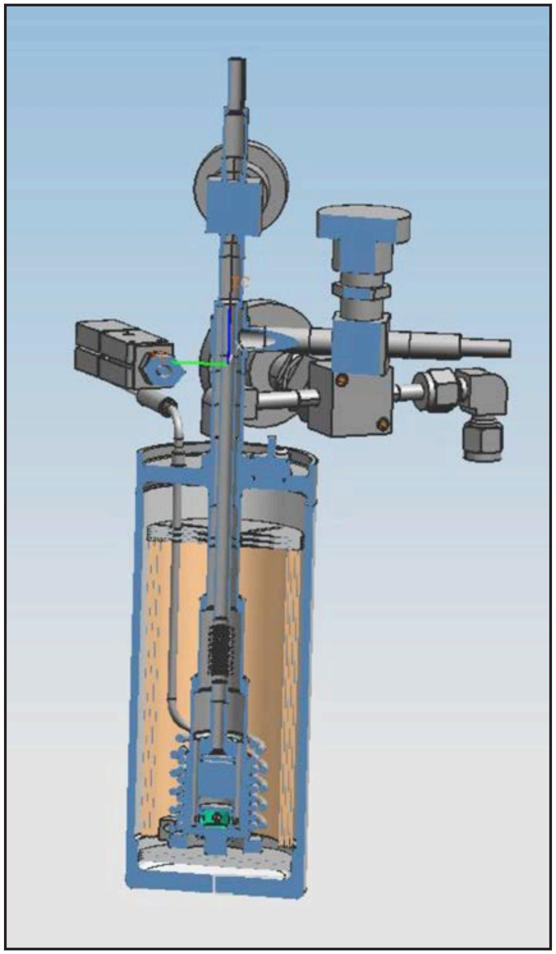
The gas handling system used to support the ISS comprises flow through uranium and palladium beds



Flow though U-bed cross section

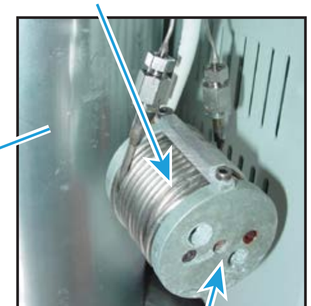
- Both beds have a maximum working inventory of 5 liters of hydrogen gas
- Beds have a secondary containment to capture permeant tritium and for thermal isolation
- Compact design to permit gas circulation through the "getter" medium
- The uranium bed will be used for tritium storage
- The palladium bed will be used to "pump" tritium inside the gas handling loop

E21972

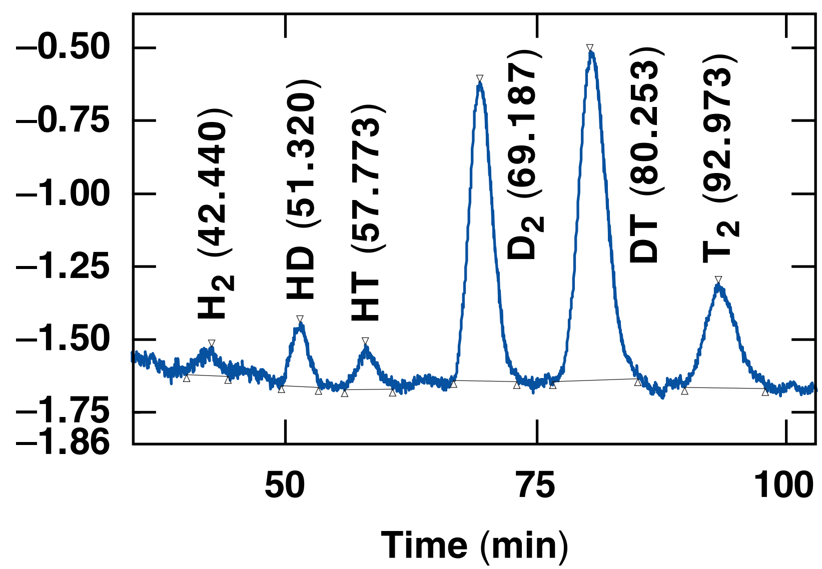
The gas chromatograph permits baseline separation of all six hydrogen isologues

Zr-Fe–based effluent collector

1/8-in.-diam nickel column contains Fe-doped Al_2O_3



Aluminum mandrel provides uniform temperature for the column



E14977b

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