Isotope Separation System and Gas Chromatograph Support Non-Standard Fills

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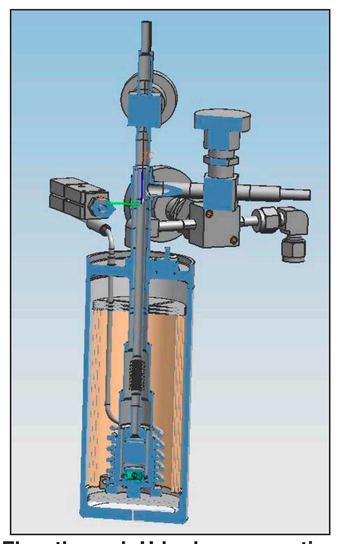
An Isotope Separation System (ISS) will provide LLE with a flexible tritium fuel supply

- Ensure the purity of the tritium fuel supply meets LLE's baseline ICF program requirements
- Recover tritium from existing, unusable spent DT fuel
- Eliminate the need to ship tritium to/from external cleanup facilities
- Provide LLE with the ability to examine fusion reactions at D–T ratios other than 1:1

E20949

The Gas Handling System comprises a uranium and a palladium storage bed


Flow through U-bed cross section

- Both beds have a maximum working inventory of 5 liters of hydrogen gas
- Beds have a secondary containment
- The bed design permits the option for circulating gas through the "getter" medium
- The uranium bed will be used for tritium storage
- The palladium bed will be used to move ("pump") tritium inside the gas handling loop
- The palladium bed will be used to separate decay helium from the tritium gas

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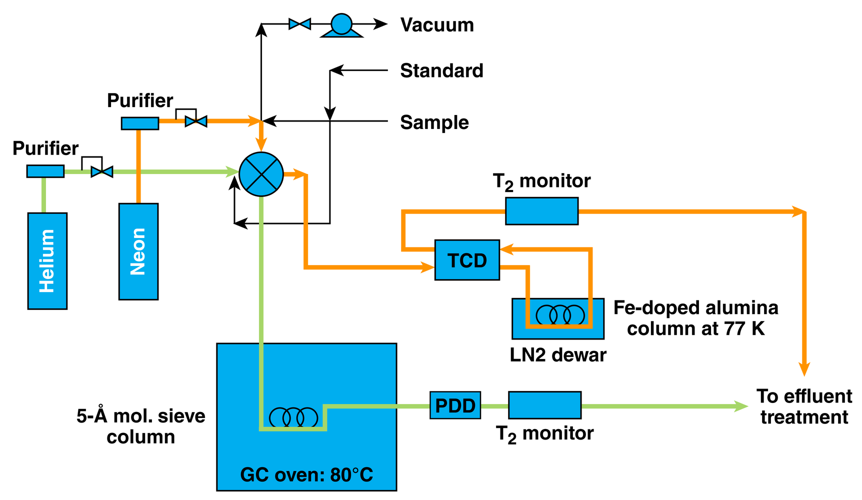
H, D, T, ^{3}He, and mixed isotopes are measured by gas chromatography at the μL aliquot level using two carrier streams



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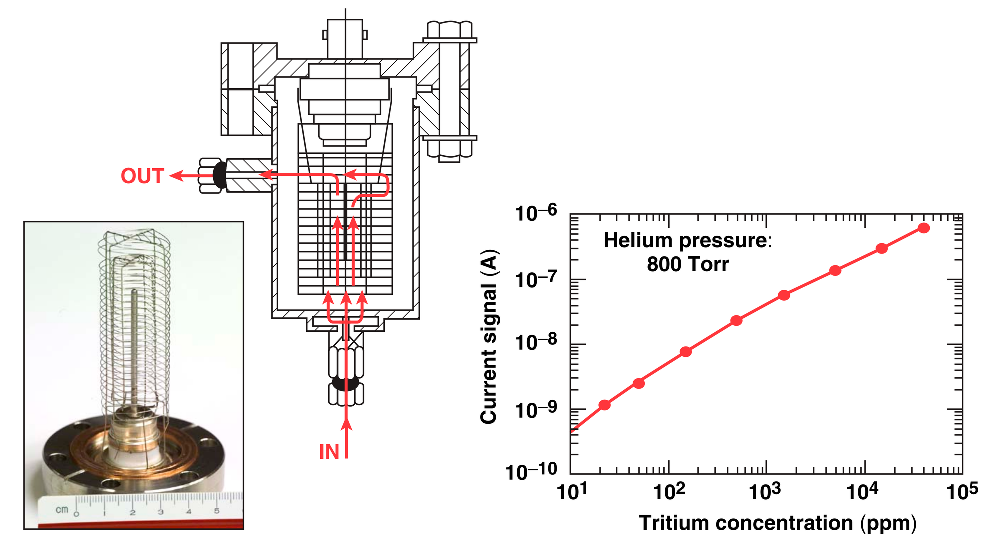
β detection relies on a unique "wall-less" 5-cc ionization chamber configured to encourage slug flow through the detection volume



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The ISS is designed to process up to 5 liters of gas per day and produce 99.2% pure tritium

There are four subsystems

1. The gas handling system feeds isotopically diluted tritium to the core system and provides temporary storage for purified tritium
2. The core system decomposes the mixed hydrogen isotopes (HT and DT) and separates them to isolate pure tritium gas
3. The glovebox cleanup system provides a secondary containment for any tritium in the ISS
4. Control system

E20950

The core system is used to separates the isotopes using the thermal cycling absorption process (TCAP)

- Two chromatography columns are separated by a remotely actuated valve. The columns are coiled SS316 tubing filled with
  - Pd/k: palladium metal coated on kieselguhr (finely divided diatomaceous earth)
  - MS (or Mol. sieve): 4-Å molecular sieve (zeolite)
- The columns are heated using embedded heaters, or cooled using liquid nitrogen
- The thermal cycling process is controlled by the PLC, which also monitors the temperature and pressure, and controls the LN2 feed and the interconnect valve
- The system is enclosed in a helium purged glovebox

E20954

Assay by gas-phase chromatography offers a good balance between required sensitivity, cost, and operational ease

- Separation of HT/D_2
- Detection of ^{3}He
- Avoids fragmentation to simplify signal deconvolution — No trimmers
- Very simple analysis of isotopic mixtures with low protium content
- Less expensive than mass spectrometry

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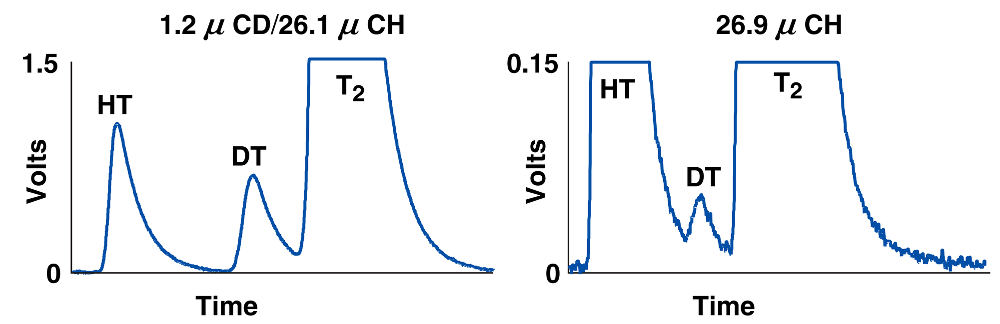
Near-baseline separation of the hydrogen extracted from the gas target can be achieved



	H	D	T
	Atom percent		
Pre-fill gas	0.16	0.165	99.67
27 days post fill	H	D	T
CH	5.9	0.13	93.97
CD/CH	2.9	1.90	95.20

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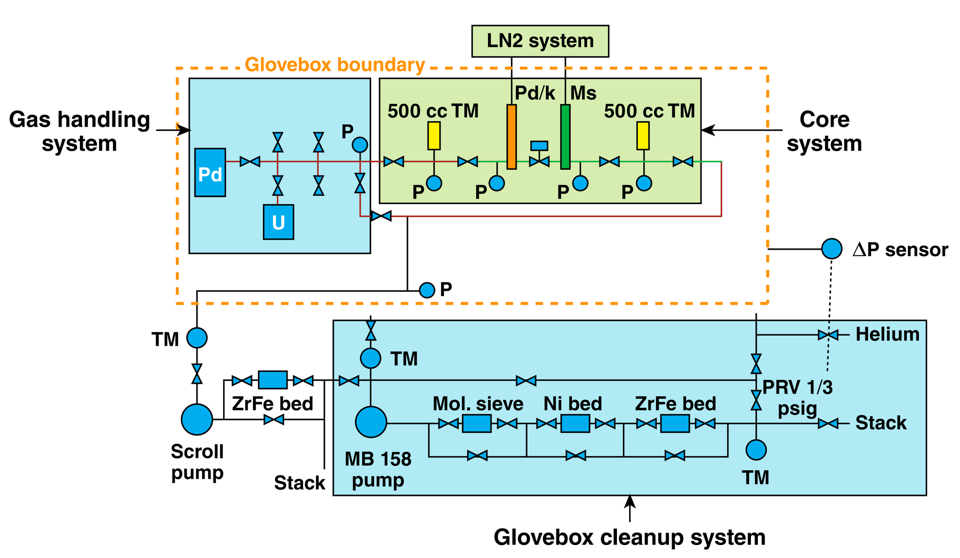
The ISS comprises four subsystems: gas handling, core system, LN2 cooling, and glovebox purification



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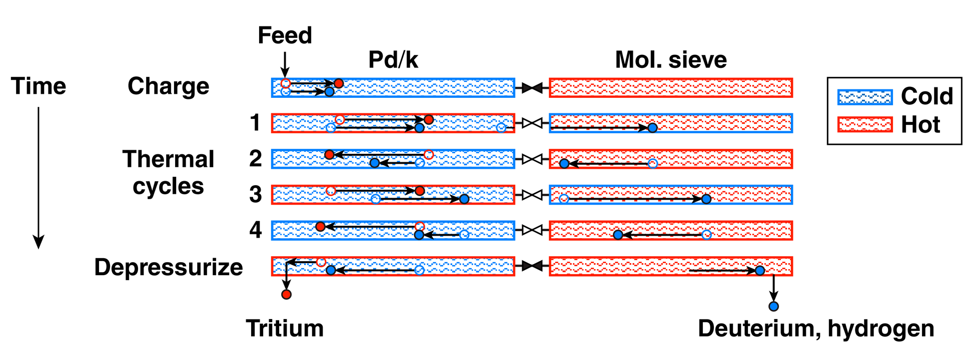
Both columns sort hydrogen isotopes according to mass but use different mechanisms

- Pd/k column separates and decomposes molecules based on differences in the hydrogen isotope isotherms
- Molecular sieve column separates molecules based on differences in the hydrogen isotope residence times on cold mole sieve



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The LLE Assay System relies on three diagnostics

- Thermal conductivity detector
  - H/D/T detector, ppm detection limit
  - dual filament, differential operation, flow through
  - neon carrier to increase sensitivity to hydrogen and allow ^{3}He detection
- Pulsed-discharge detector
  - trace impurity content of the hydrogen (air, organics, and helium)
  - ppb detection limit, helium carrier, operating temperature 100°C
- Wire-cage ionization chamber
  - active hydrogen species
  - calibrated to operate over a broad range: ppm to pure tritium
  - 5-cc detection volume, bakeable to 350°C

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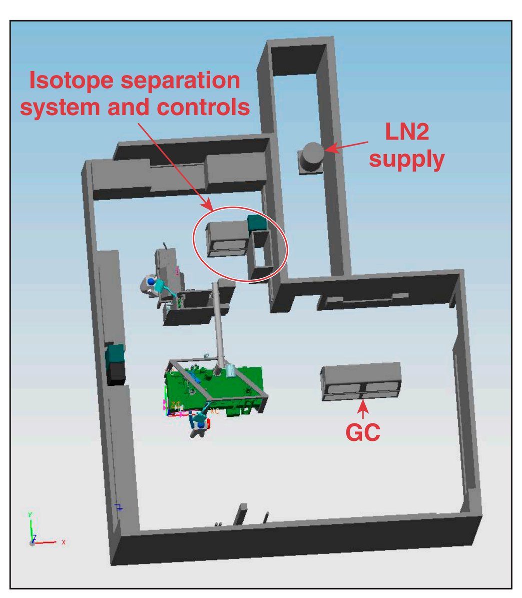
Key milestones for 2012

- ISS operational readiness tests — late Oct
- De-protonate primary fuel (50/50 DT) — mid Nov
- Recovery "T" from spent 10% T in DT — early Dec
- Purify pure tritium (98% → 99.2%) — mid Dec
- Fills using 99.2% T — Jan 2013

E20958

The ISS will reside in the Tritium Laboratory (Room 2838)



- Automated room monitor alarms for
  - tritium release
  - oxygen deficiency
- LN2 supply dewar will be ventilated to the environment
- Laboratory is 0.05-in. H_2O negative relative to adjacent labs
- 3.2-Ci release limit
- Real-time monitoring of laboratory air and stack effluent

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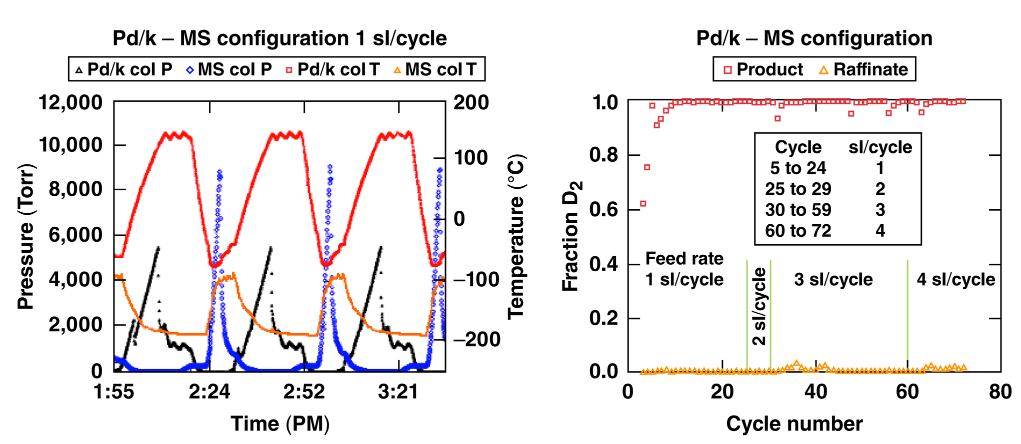
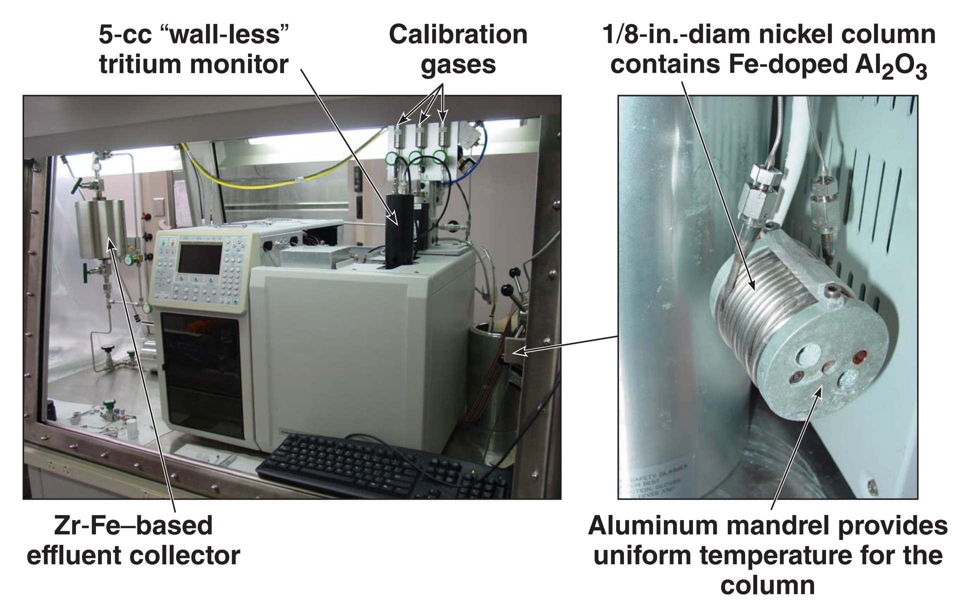
The separation of H_2/D_2 mixtures has been demonstrated using 3/8-in.-diam. columns



L. K. Heung, H. T. Sessions, and X. Xiao, "TCAP Hydrogen Isotope Separation Using Palladium and Inverse Columns," Fusion Sci. Technol. 60, (2011).

E20956

The GC is installed in an air-ventilated box and effluent is collected with a ZrFe getter



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