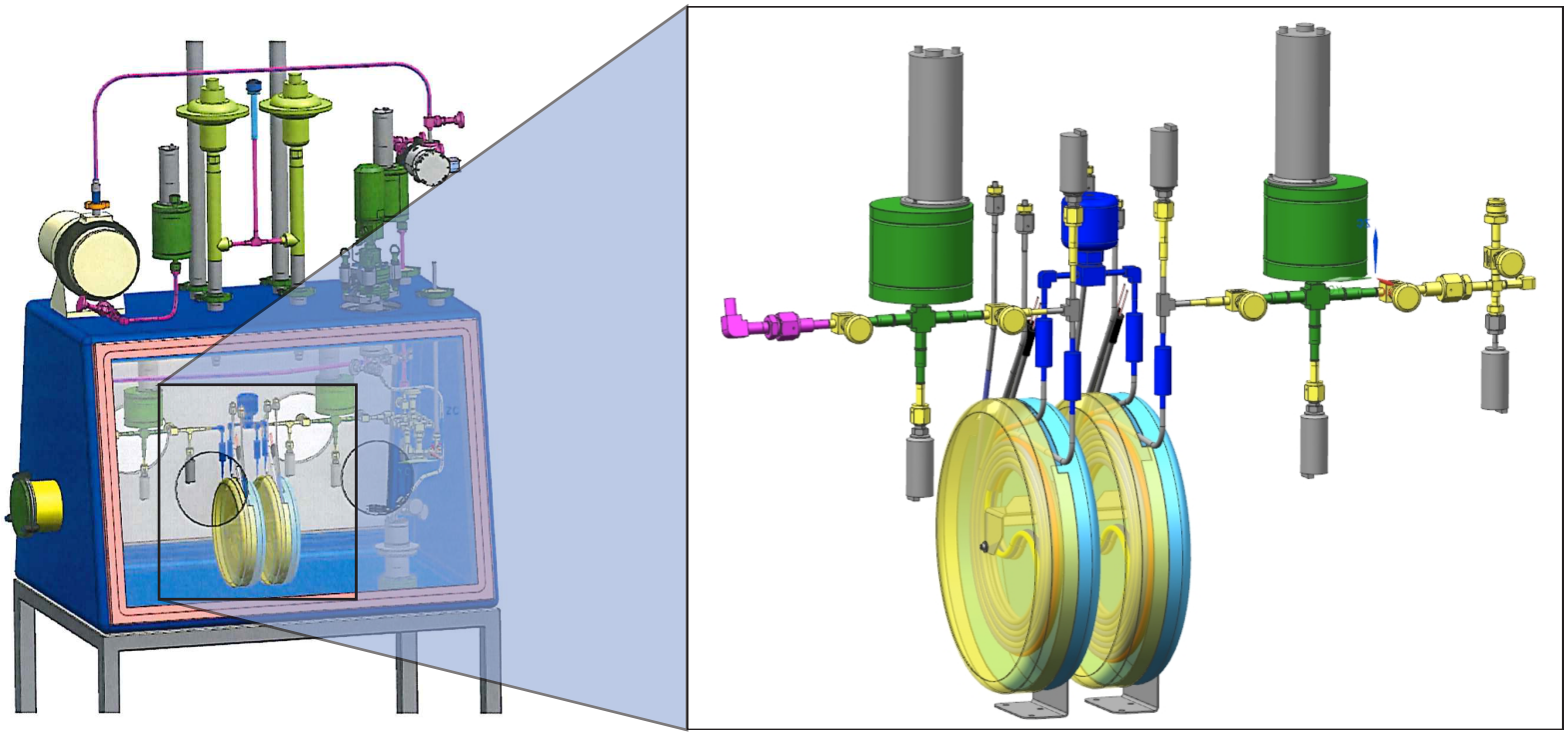
Initial Operation of the μTCAP Using H_2 and D_2



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Tritium Focus Group
Aiken, South Carolina
22–24 April 2014

Collaborators

- Development of the thermal cycling absorption process (μTCAP) was a collaborative effort between two NNSA funded facilities

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Motivation

Deuterium–tritium (DT) fuel purification is driven by several needs at the Laboratory for Laser Energetics (LLE)

- The primary tritium fuel supply is contaminated with 3% of hydrogen
- The T:D ratio of the fuel supply has dropped from a 50:50 ratio to 38:59
- A major tritium release can be recaptured but the fuel will be too heavily contaminated with hydrogen to be useful
- LLE possesses 1300 Ci of unusable ~10% T in D + H that is too expensive to dispose
- OMEGA users wish to examine fusion reactions at D–T ratios other than 1:1

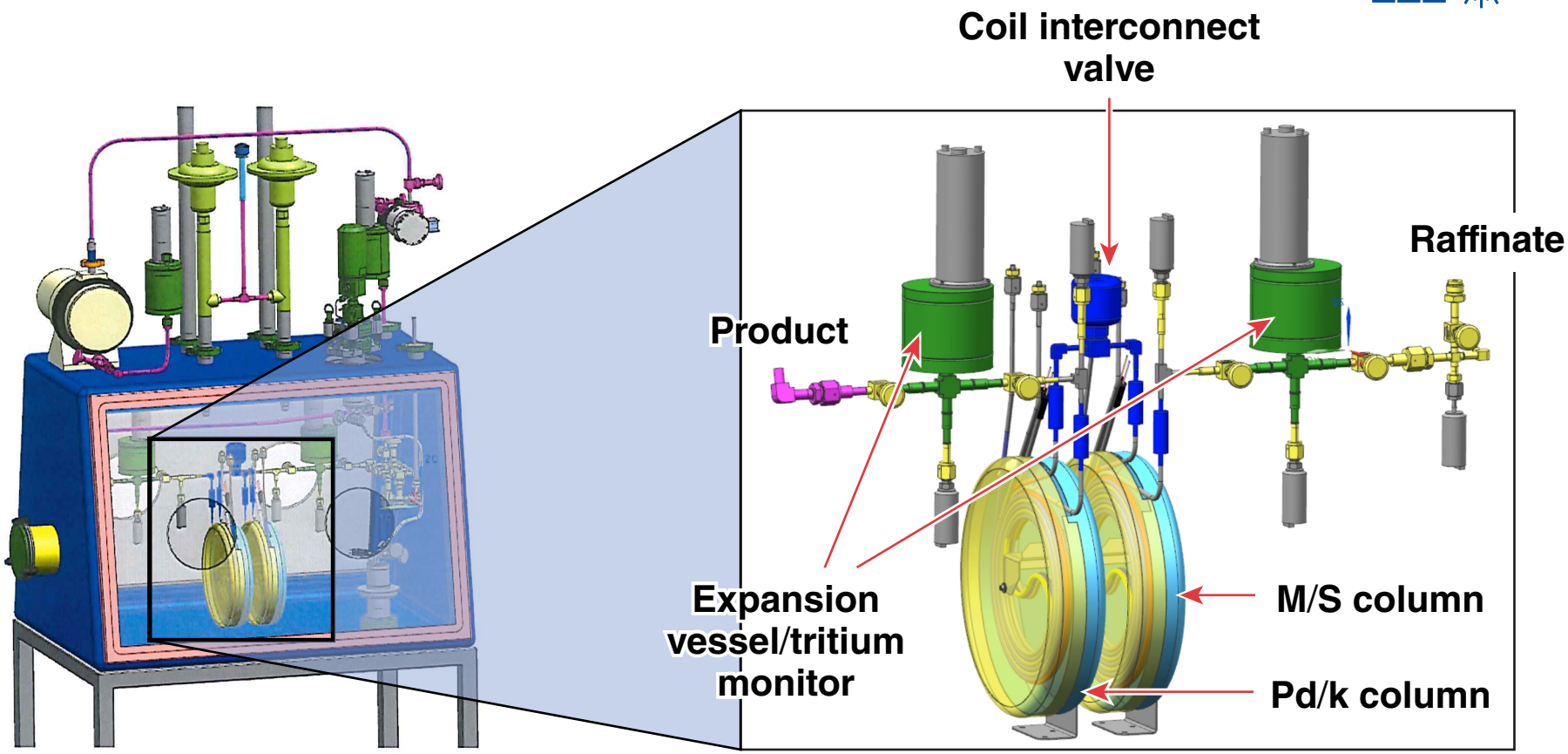
E22876

Purpose

Protium deuterium (H–D) mixtures were used to simulate tritium operations

- Characterize the performance of the Isotope Seperation System (ISS)
  - measure the maximum hydrogen capacity of the palladium-on-kesielghur (Pd/k) and the molecular sieve (M/S) coils
  - measure the level of purity achievable in the product (D_2) stream
  - explore the purity of the product versus total gas load and number of cycles
  - minimize the cycle period by tuning the temperature and pressure profiles
  - establish the minimum contamination level achievable in the effluent (residual D in H)
- Familiarize personnel with the nuances of operating the ISS
- Vet procedures in preparation for tritium operations

μTCAP comprises two columns separated by an automated interconnect valve



- The Pd/k coil dissociates molecules and sorts atomic hydrogen
- The M/S coil sorts molecular hydrogen isologues

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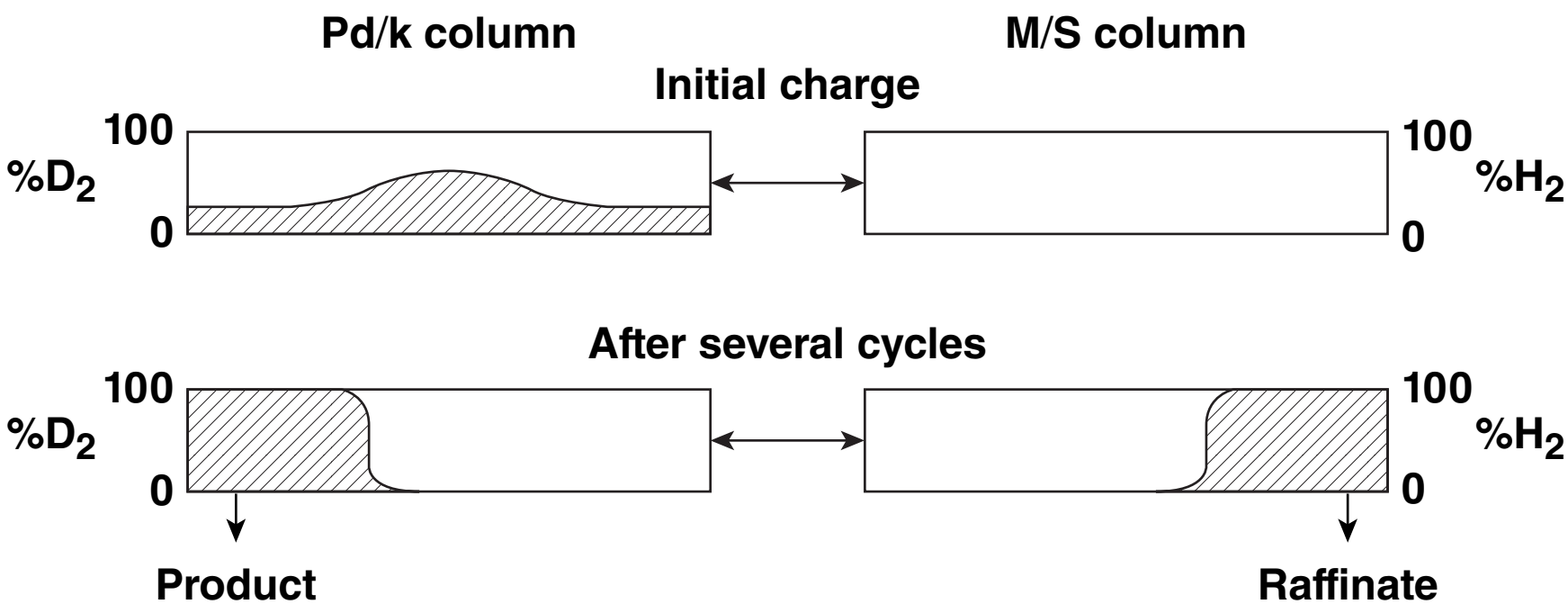
The Pd/k and M/S columns reinforce the isotopic separation in a complementary manner



The hydrogen molecules dissociate via chemisorption and the heaviest atoms concentrate at the product end of the Pd/k coil

The lightest hydrogen species concentrate at the raffinate end of the M/S coil

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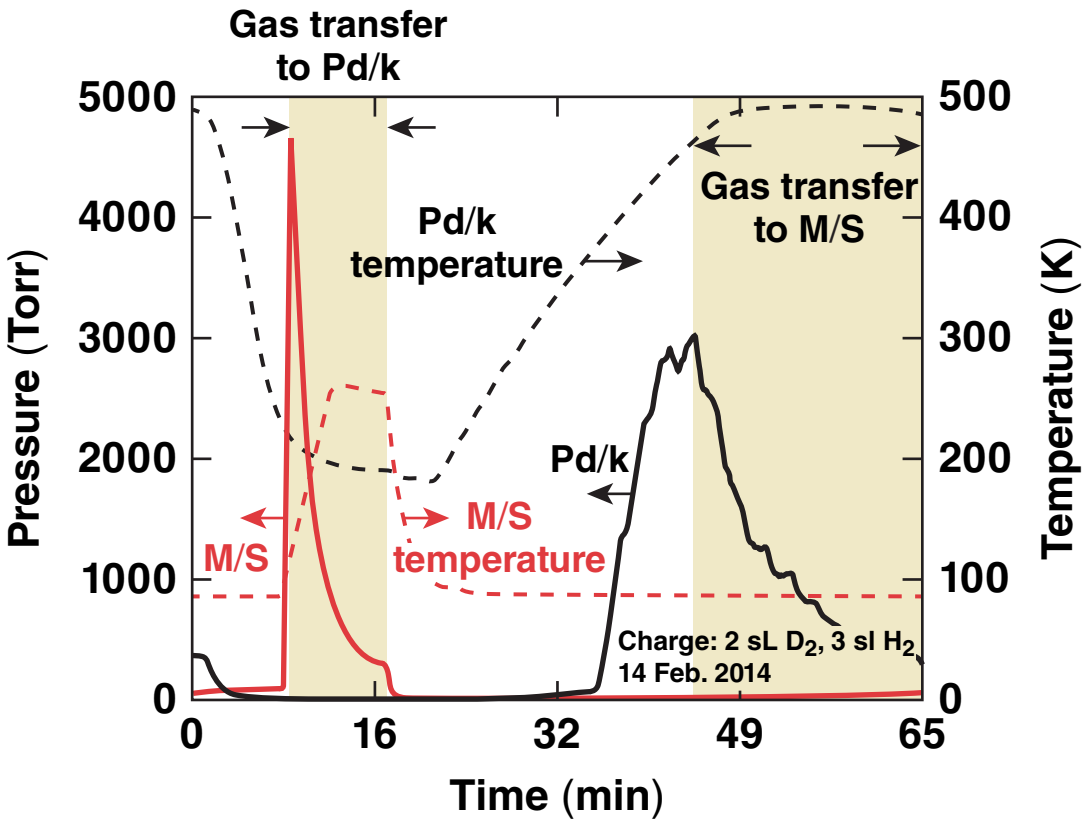
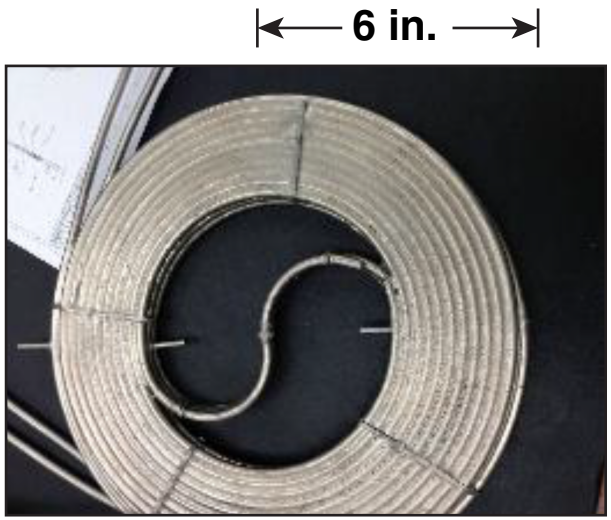
Isotope separation is based on shuffling hydrogen between Pd/k and M/S coils





Three coils are brazed together to form a compact column: heater, liquid nitrogen channel, and M/S or Pd/k coil

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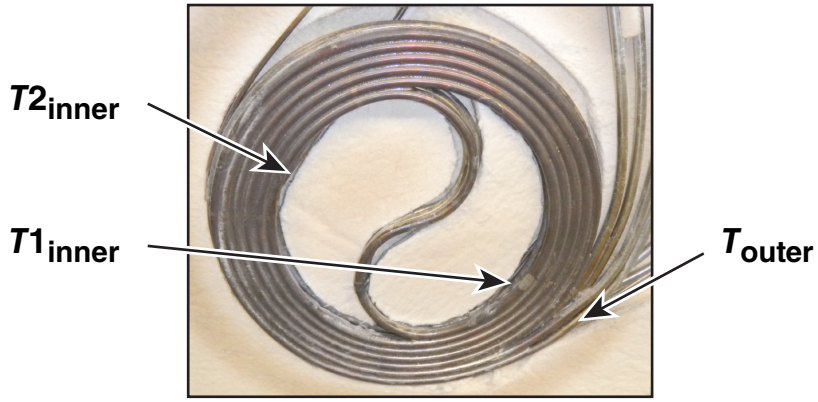
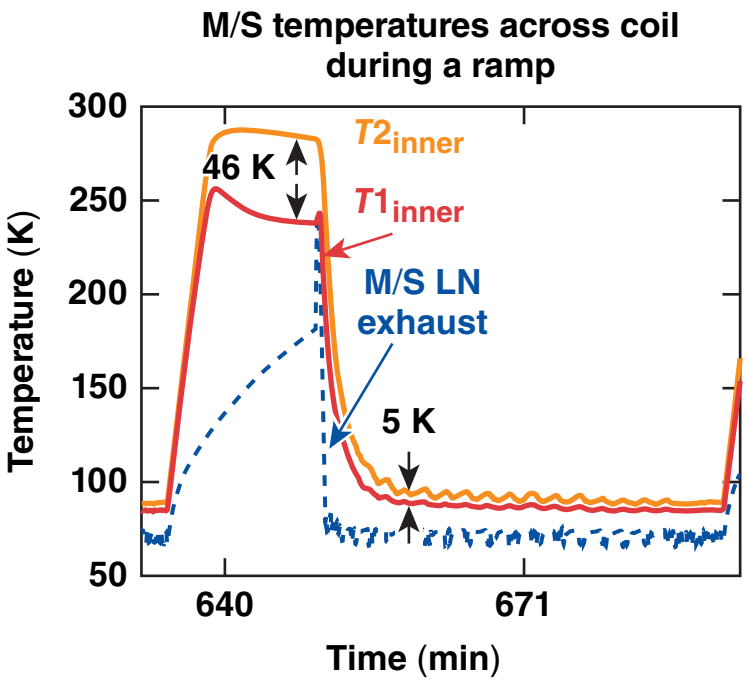
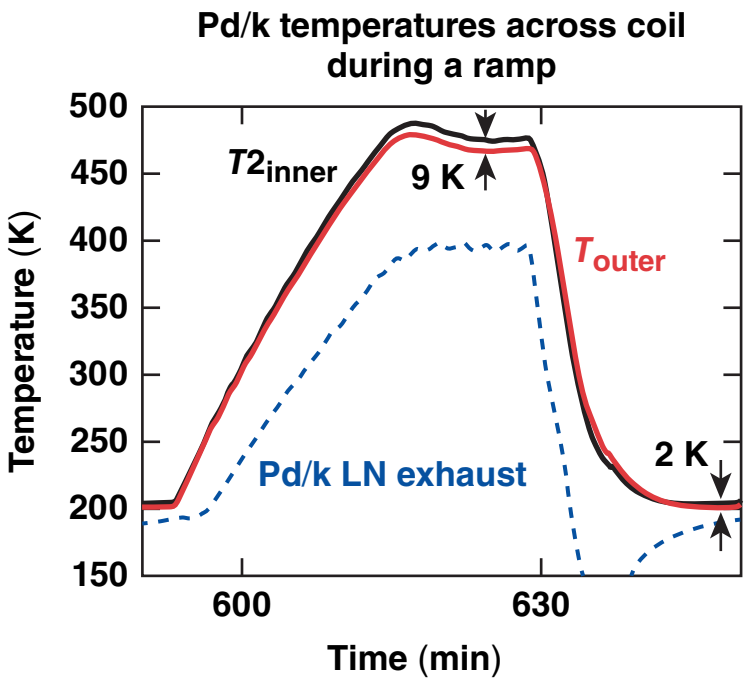
The temperature gradient across the counterflow heat exchanger is <5 K during the cooling cycle







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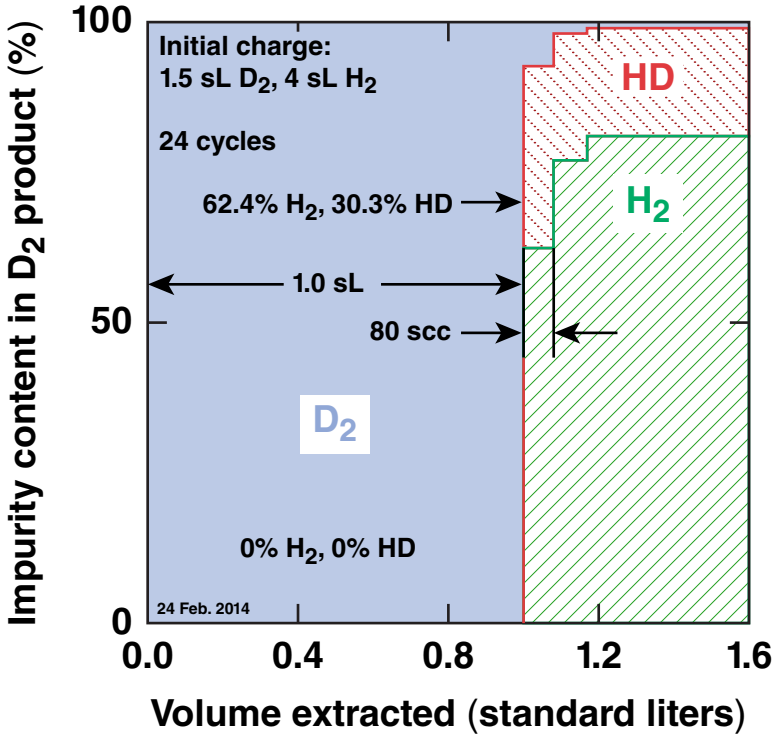
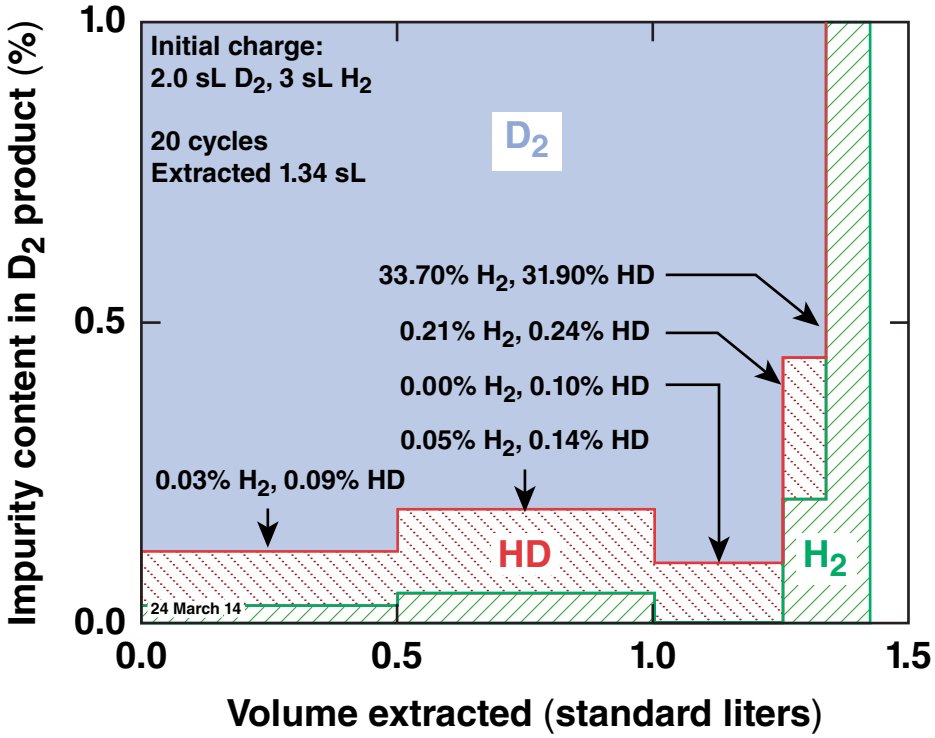
67% of the deuterium in a H_2/D_2 gas mixture can be extracted as >99.99% pure D_2

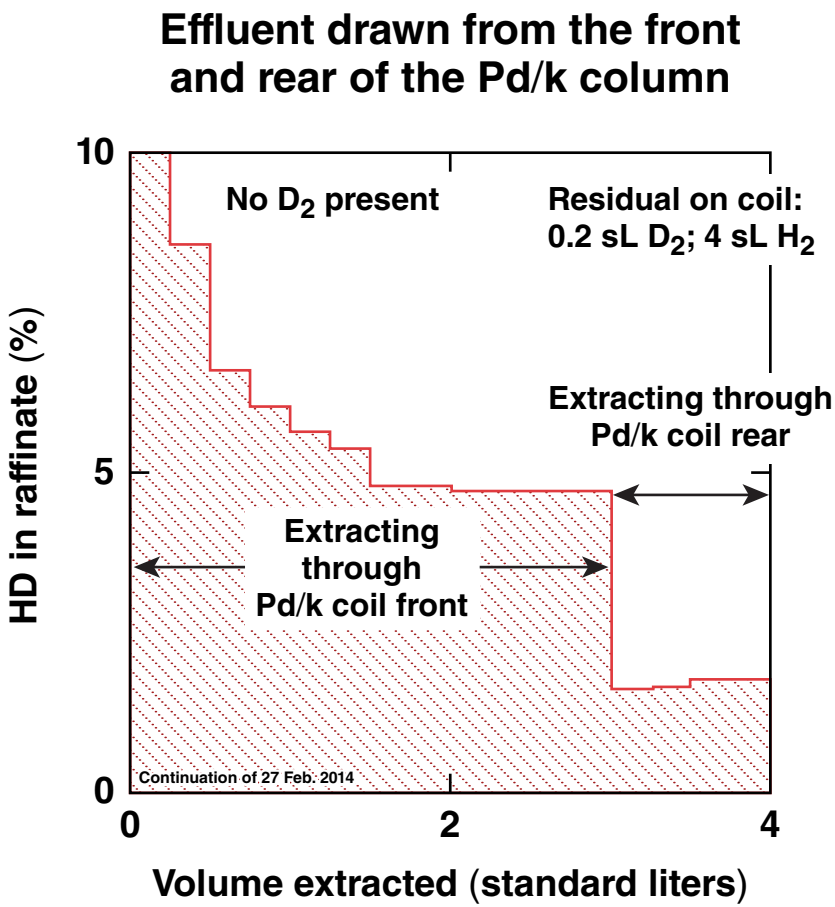


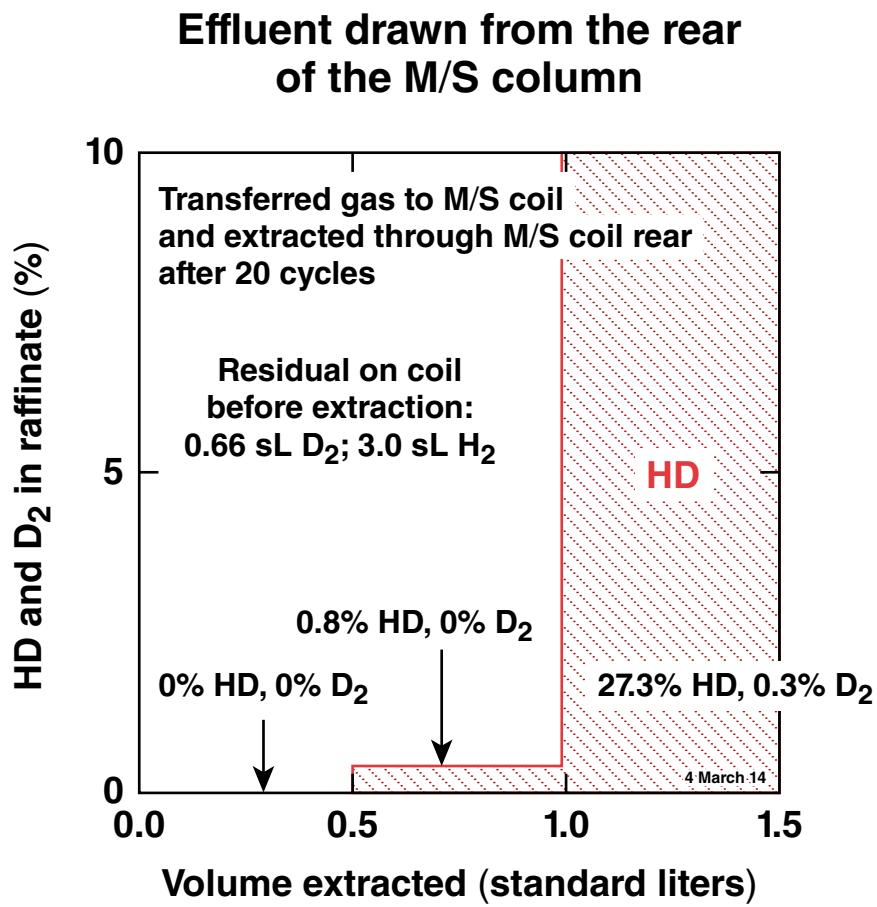


The transition from pure D_2 to clean H_2 is very sharp

E22881

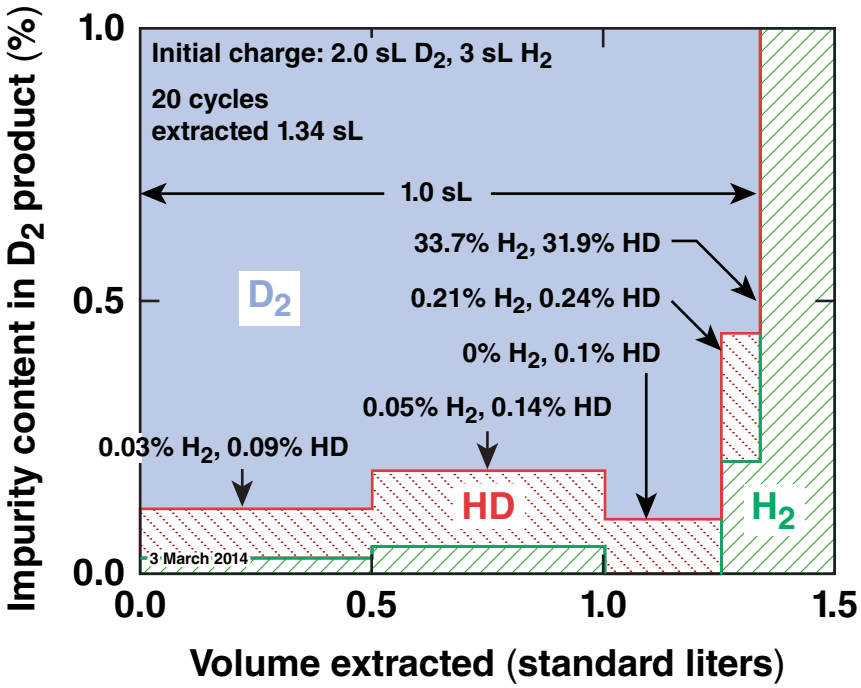
The effluent with the lowest D contamination is drawn as raffinate from the M/S column

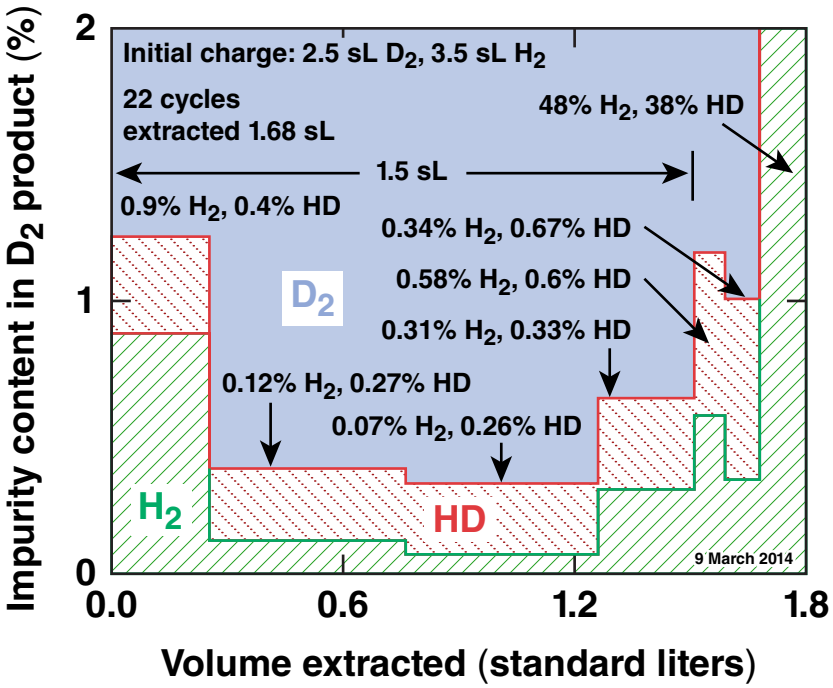




E22882

Higher product purity is obtained when working at ~85% of the system inventory



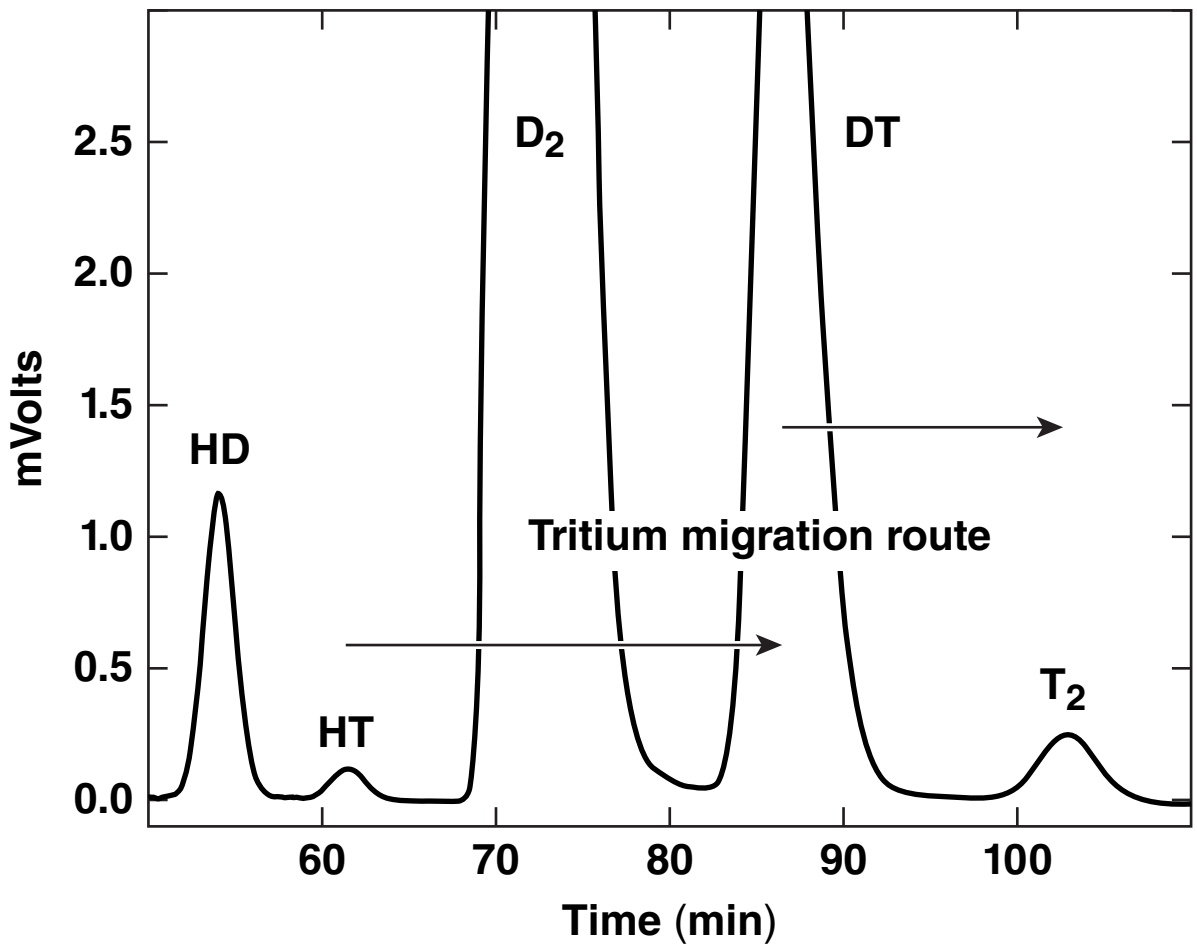


Working inventory = 83% of capacity

Working inventory = 98% of capacity

E22895

The tritium in lower-molecular-weight species will dissociate in the Pd/k coil and migrate to the higher-molecular-weight species



E22912

The ISS is designed to process up to 6 liters of gas per day and can produce 99.9% pure tritium

There are four subsystems:

1. The gas handling system feeds isotopically diluted tritium to the μTCAP and provides temporary storage for purified tritium

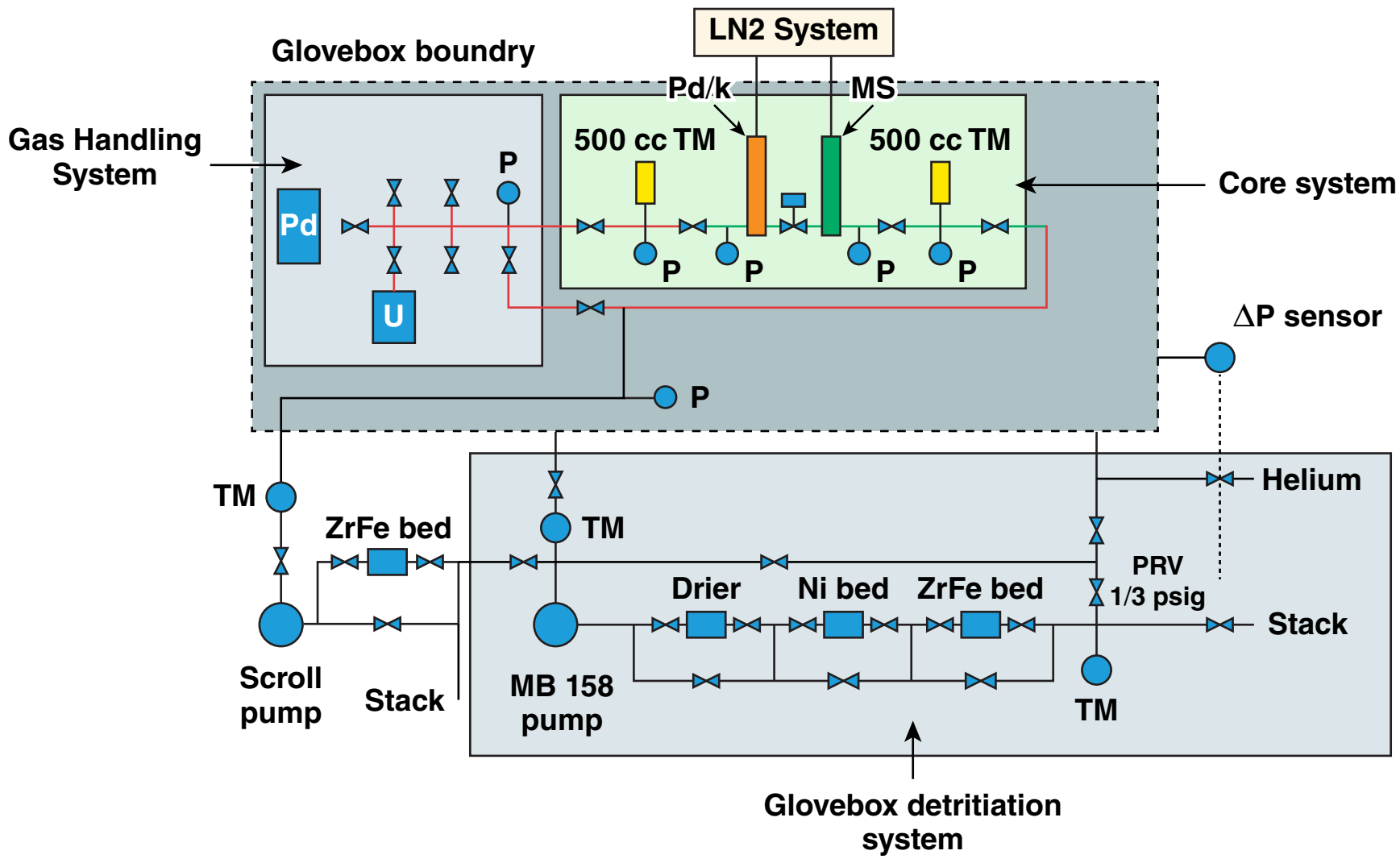
2. The μTCAP decomposes the mixed hydrogen isotopes (HT and DT) and separates them to isolate pure tritium gas

3. The glovebox cleanup system provides a secondary containment for the gas handling and μTCAP systems

4. The liquid nitrogen system provides cooling to the μTCAP

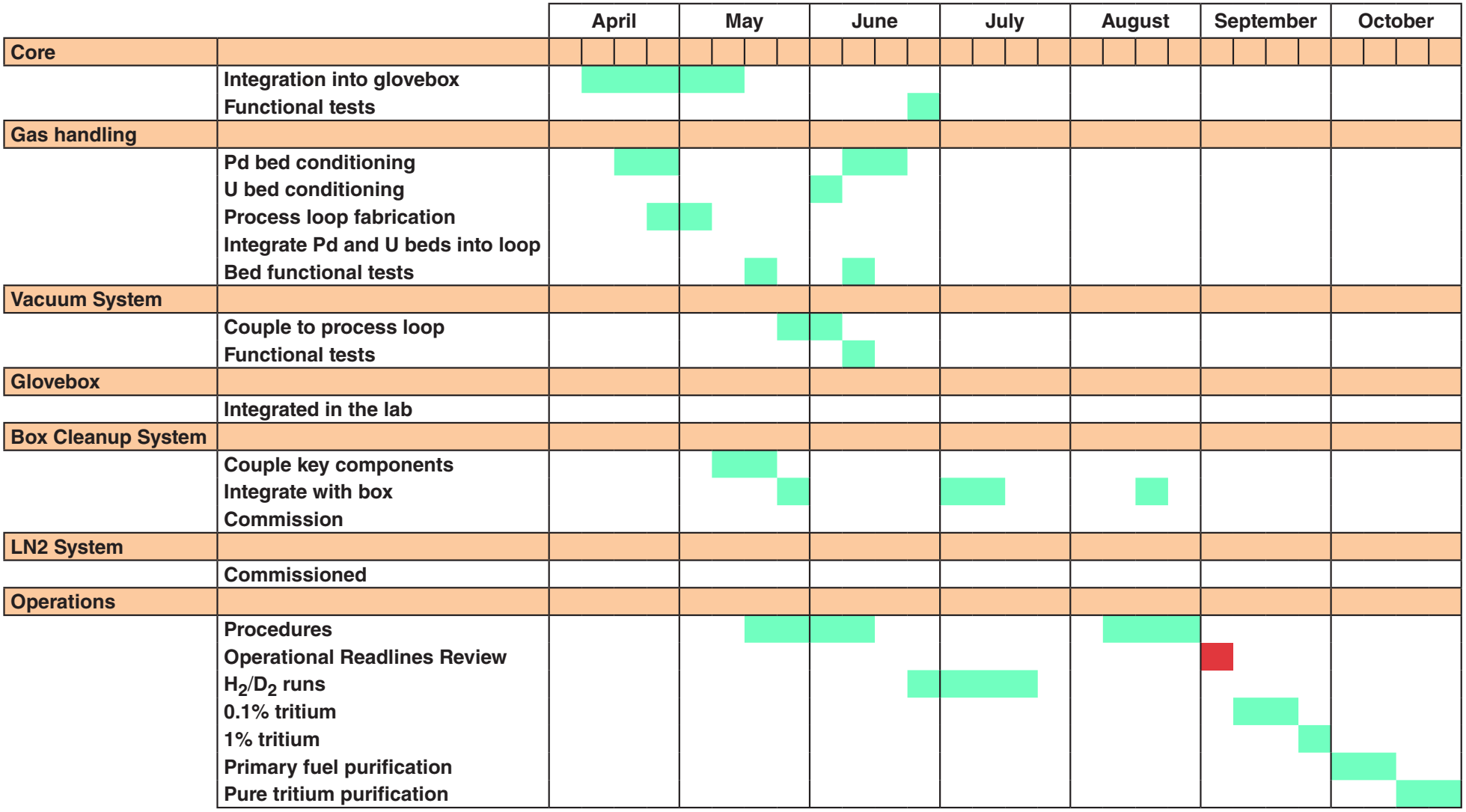
E22884

The ISS comprises four subsystems and is designed to process up to 6 liters of gas per charge



E22885

ISS is expected to be operational by October 2014



E22913

Summary/Conclusions

The Isotope Seperation System (ISS) will be used to isotopically purify the tritium fuel supply at LLE

- Protium must be removed from the DT fuel mixture
- The cost of disposing spent tritium favors purification of the existing stock versus replacement
- Pure tritium can be mixed with deuterium in ratios other than 50/50 to satisfy inertial confinement fusion (ICF) experimental requirements
- Initial testing of the ISS with protium–deuterium (H–D) mixtures resulted in >99.99% pure deuterium
- Tritium purification will begin later this calendar year

E22875a