Tritium Operation Improvements at the INL STAR facility

Tritium Focus Group Meeting
Princeton Plasma Physics Laboratory
Princeton, NJ
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INL Fusion Safety Program

Idaho National Laboratory

Idaho National Laboratory

Outline

- Brief overview of tritium operations at INL's Safety and Tritium Applied Research (STAR) facility
- Discuss ongoing improvements to tritium air monitoring for STAR
- Discuss improvements being made to two major experiments at STAR the use tritium during test campaigns

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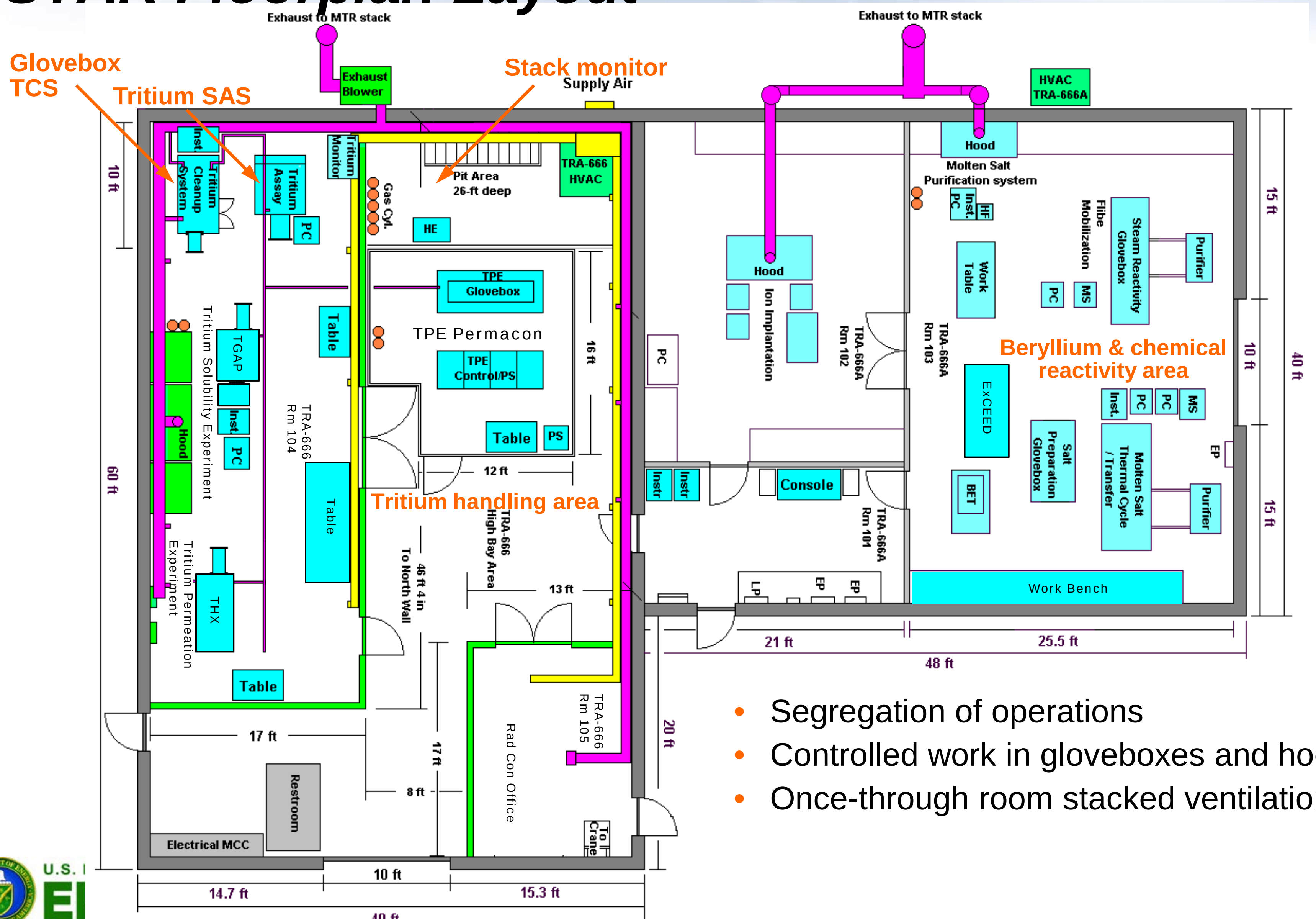
FSP's STAR Lab located at the INL Site…

- STAR designated as the Office of Fusion Energy Science (OFES) tritium materials research facility after the closure of TSTA at LANL.
- STAR Facility – DOE less-than Hazard Category 3 Radiological Facility
  - Allows handling of radioisotopes at low radiation levels (e.g., W, Ni, Mo, T_2) typically specified as either:
    - Maximum contact dose (< 1.5 mSv/hr at 30 cm, normally < 100 µSv/hr at 30 cm),
    - Annual maximum worker dose (< 7 mSv/yr or 700 mrem/yr)
    - Total inventory (1.6 g T_2 or 6.0×10^5 GBq)

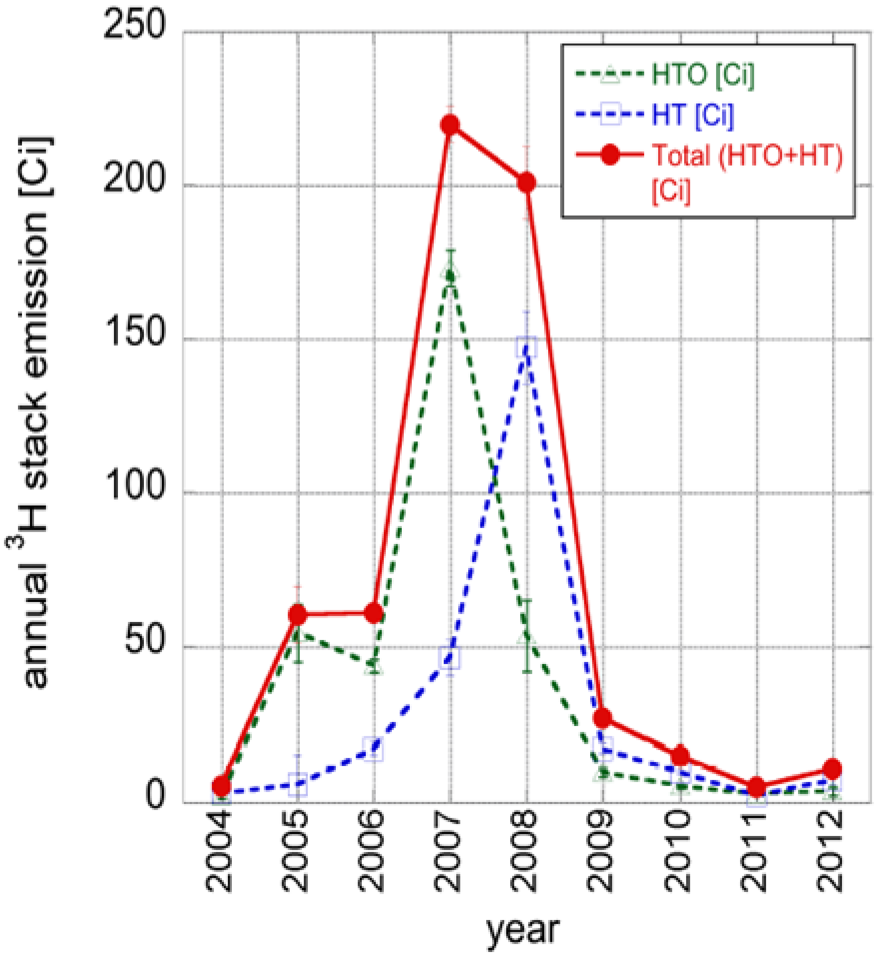
STAR Floorplan Layout



- Segregation of operations
- Controlled work in gloveboxes and hoods
- Once-through room stacked ventilation

Annual STAR Stack Release

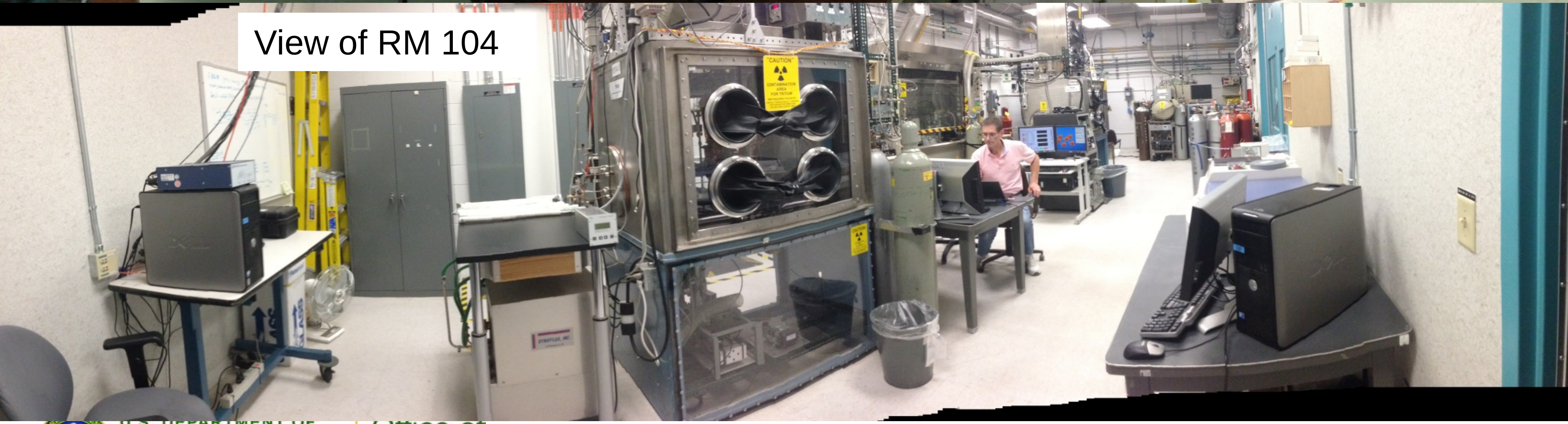
- 2004-2008 releases primarily represent the installation and startup of Tritium Plasma Experiment (TPE)
  - Off-gassing from TPE
  - Failed weld on TPE exhaust
  - Initial operation of Ubeds
- 2009-present releases dropped to 5-15 Ci/yr primarily due to changes in TPE operation
  - Ubeds used to pump and store during tritium plasma runs
  - Typical plasma operation requires ~ 200 Ci per 8 hours run even at only 4% tritium in plasma
  - In 2014, the annual stack emission dropped from ~5 Ci in 2012 to ~ 1 Ci



Reference: B. Pawelko

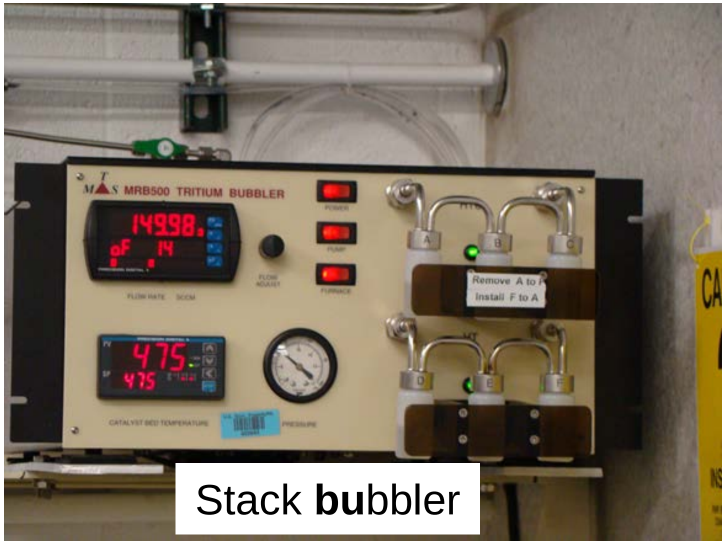

INL
Home of the STAR Facility at the
Idaho National Laboratory
W brush
samples
Temperature: 1100°C
Time: 340 minutes
Fusion Safety Chemical
Reactivity Experiments
Tritium Storage &
Assay System
Tritium Infrastructure
Systems
Dust/Debris Characterization
TFTR
DIII-D
C-MOD
Tore Supra
NOVA
Safety and Tritium
STAR
Applied Research
Tritium Gas Absorption Permeation (TGAP)
Experiment
Tritium Plasma Experiment
TPE Plasma
Neutron Irradiated Material
Ion Implantation Experiment (NIMIIX)
Be dust explosions

Interior View of STAR Tritium Areas

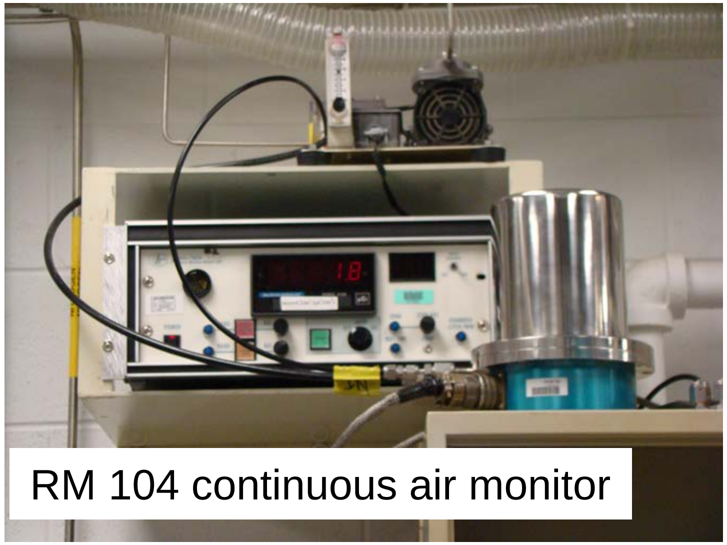


Present Tritium Monitoring at STAR

- MTS bubbler used to monitor stacked air to determine annual environmental tritium releases to satisfy reporting requirements (sampled weekly, resolution limit 1×10^{-10} μCi/m^3)
- FemtoTECH ion chambers are used to monitor the room air in the tritium experiment RM 104 and in TPE's PermaCon enclosure (< resolution 0.1 μCi/m^3, low level evacuation alarm at 25 μCi/m^3)
- Presently, STAR uses monthly bioassays of workers as the only means of identifying tritium exposure
- Frequency of bioassay is set to give near the minimum detection limit (MDL) of 3.15×10^{-06} μCi/sample in urine (0.1 mrem). This is 1 μCi uptake 30d. Also expected annual dose from an tritium air concentration < 0.01 μCi/m^3.
- Initial setup of the TPE experiment in 2002-2005 gave annual collective worker doses of 10-30 mrem. Since 2009, STAR personnel usually receive negative bioassays, with a collective dose of 0 to <10 mrem/yr.



Stack bubbler


RM 104 continuous air monitor

Ongoing Improvements to STAR Tritium Monitoring

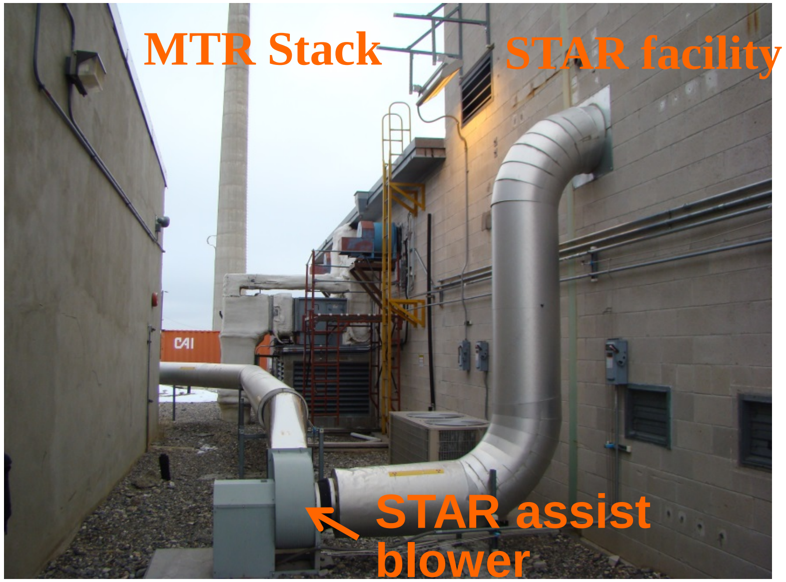
- DOE's occupational radiation protection system is dose-based. 10 CFR 835.209(b), also Appendix E of DOE-HDBK-1129-2008, address methods of internal dose assessment.

  "The estimation of internal dose shall be based on bioassay data rather than air concentration values **unless bioassay data are**: (1) unavailable; (2) inadequate; or (3) internal dose estimates based on air concentration values are demonstrated to be as or more accurate."

- Given the frequency of bioassays that return < MDLs, the goals of this project to improve STAR's air monitoring system are to:
  - Gain a better measurement of the background tritium concentration at STAR
  - Supplement /improve dose estimates from monthly bioassay
  - Detect possible increases in chronic low level tritium releases
  - Discriminate between HTO and HT in room air
  - Identify spurious tritium readings from other types of instruments
- This will be accomplished by adding three new bubbler units to determine tritium air concentrations in the PermaCon, High Bay and RM 104, and add a CAM system in the High Bay.

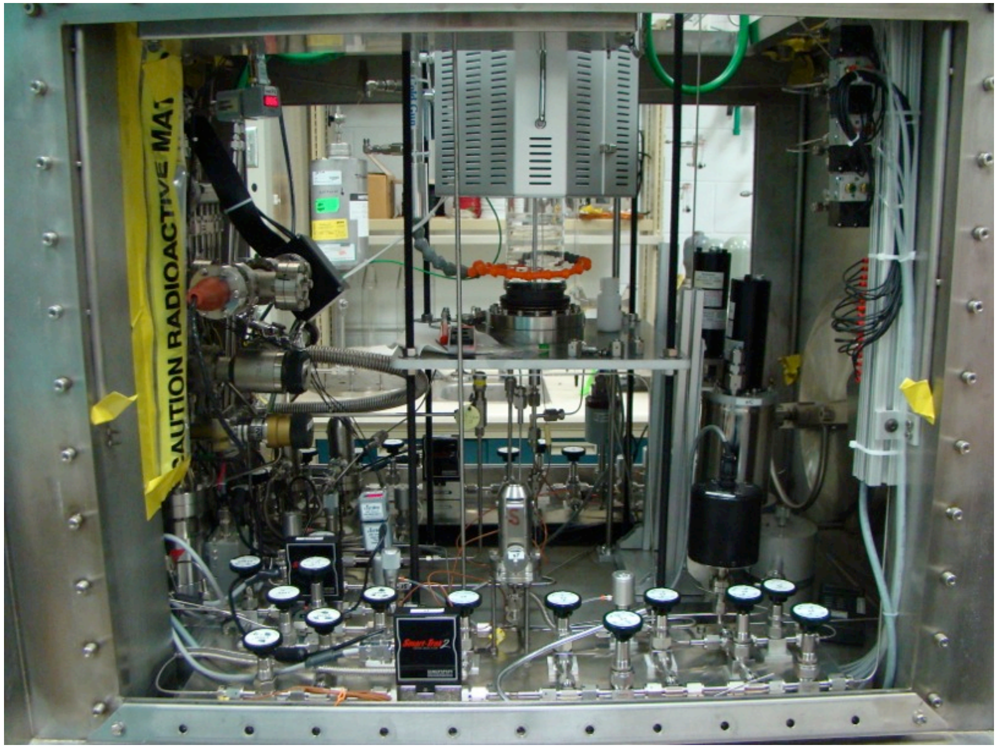
Facility Emergency Power Upgrade

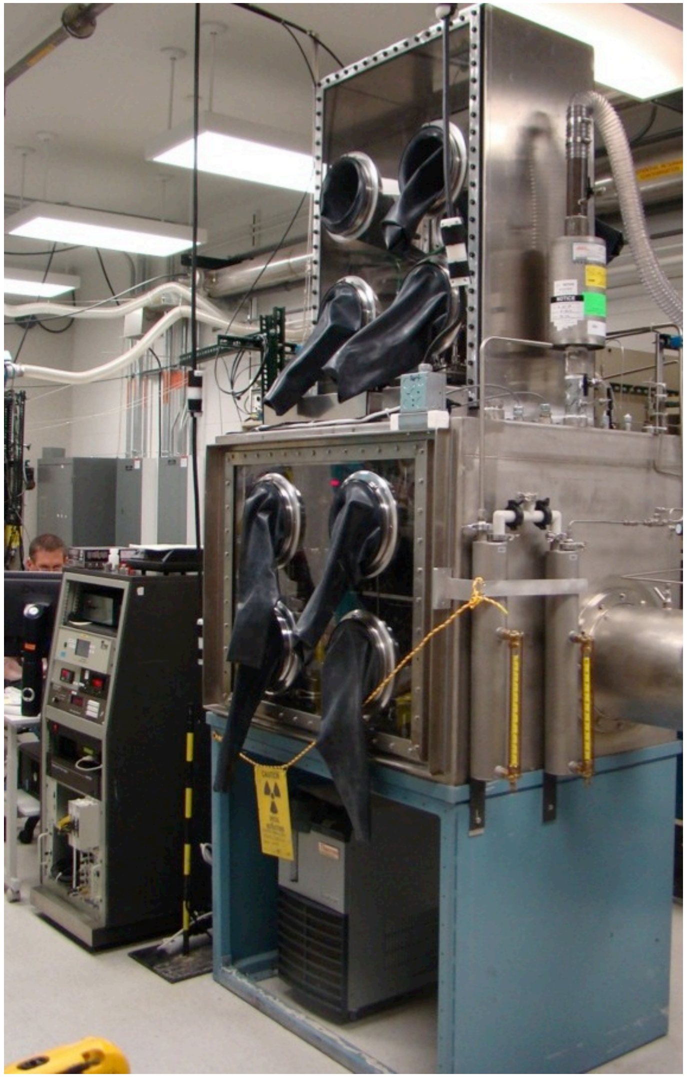
- A project is underway to bring emergency diesel power to the STAR facility for two reasons:
  - Support STAR's tritium confinement strategy of once through facility ventilation that is stacked during commercial power outages
  - Provide the power required for the upgraded tritium monitoring system to measure air concentrations even during commercial power outages
- STAR shares two stack blowers with another facility at the INL site. Only one of these stack blowers is on site emergency diesel power . Under commercial power, both blowers provide ~ 2450 CFM to STAR
- A smaller building assist blower provides an additional 1100 CFM
- The goal of this project is to supply emergency power to the assist blower and the tritium air monitoring system



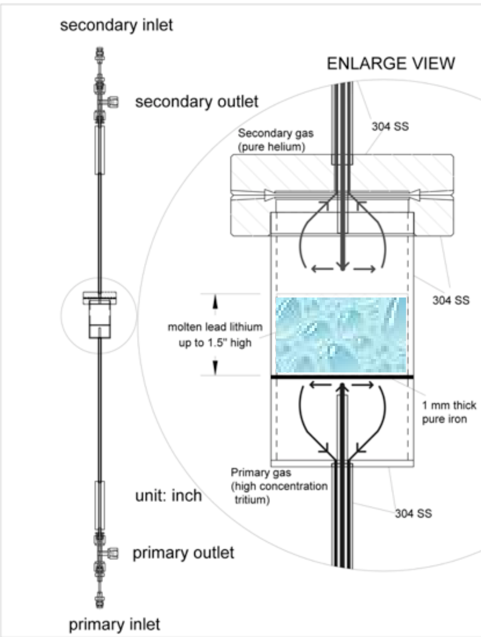
Tritium Gas Absorption Permeation (TGAP) Experiment

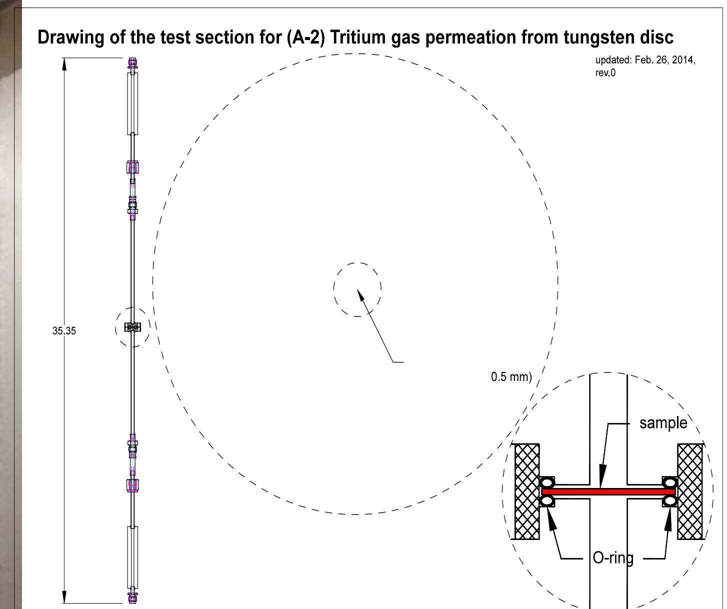
- This experimental apparatus studies pressure driven tritium permeation or absorption in materials. It is located inside Contamination Area (CA) for tritium (STAR RM 104)
  - Tube furnace in Ventilated Enclosure (VE)
  - Gas supply and exhaust clean-up systems will be located in a Fume Hood





TGAP Examines Tritium Permeation or Absorption & Release Through Test Section Replacement





Unique capabilities

- Designed to measure tritium transport properties (e.g. diffusivity, solubility, and permeability) in activated materials at realistic fusion sweep gas conditions (e.g. low tritium < 10 Pa & hydrogen partial pressures < 1000 Pa, moderate < 700 C to high temperatures < 1000 C)
- Capable of testing liquid or ceramic breeder materials (e.g. PbLi, FLiBe, Li_2TiO_3, etc.) and disc shaped metal specimens (W, RAFM steels, etc.)

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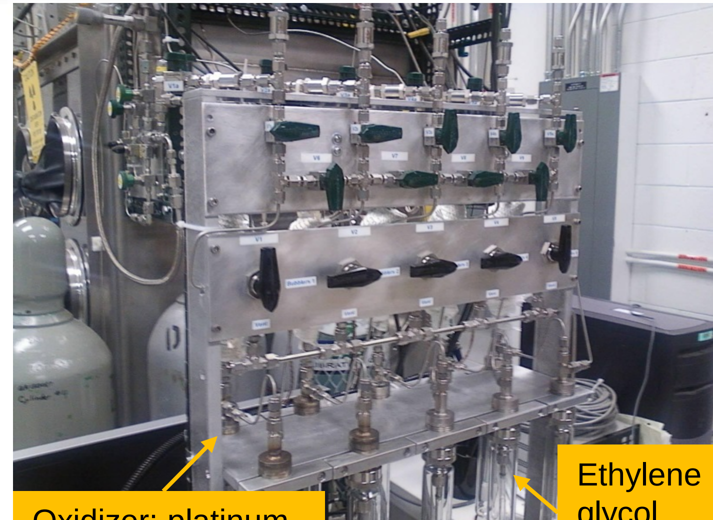
Ongoing TGAP Improvements to Achieve Blanket Purge Gas Flow Conditions

- TGAP's old exhaust cleanup system (2 catalyst + bubbler sets – flow capacity ~200 sccm) has been modified to process a throughput up to ~1500 sccm, and the modified exhaust cleanup (5 catalyst + bubbler sets) completed February 2015
- A new TGAP source supply system for primary sweep gases is being designed and built to allow the researcher to tailor the both the hydrogen (< 1000 ppm) and tritium (< 100 ppm) concentrations while reducing the quantity of at risk tritium (June 2015)
- TGAP present source gas (mostly depleted now) are pre-set mixed helium/tritium mixtures of 0.01 ppm, 1.5 ppm and 2.5 ppm tritium and at gas pressures of 5-10 atm

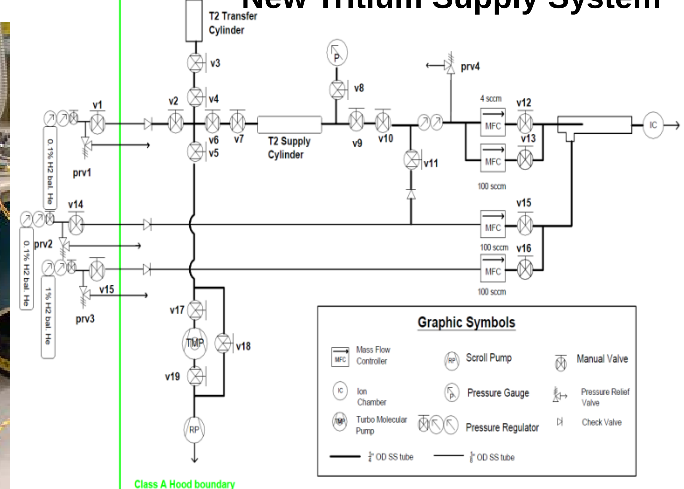


Oxidizer: platinum on alumina pellets

Ethylene glycol bubbler

Old Tritium Supply System

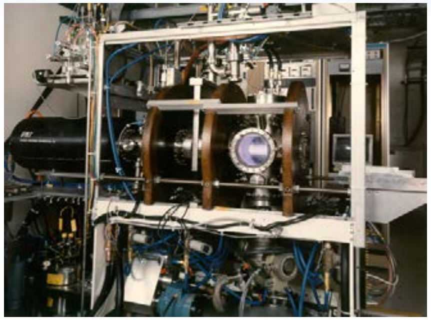
New Tritium Supply System



R. Pawelko

Tritium Plasma Experiment (TPE)

- A linear plasma device that can use tritium in its plasmas, doubly confined within a glovebox inside a PermaCon structure
- Neutron damaged materials (tungsten) irradiated to 0.3 dpa will be studied for tritium retention under the US/Japan TITAN collaboration to better understand inventories in, and releases from, fusion reactors
- TPE operating parameters - plasma flux on target $3x10^{22}$ $m^{-2}s^{-1}$, plasma heat flux ~5 MW/m^2, and plasma diameter of 5 cm
- Collaboration with SNL/CA produced a new TPE target holder that allows permeation tests up 1000 °C for PHENIX collaboration (neutron irradiated tungsten to 3 dpa)



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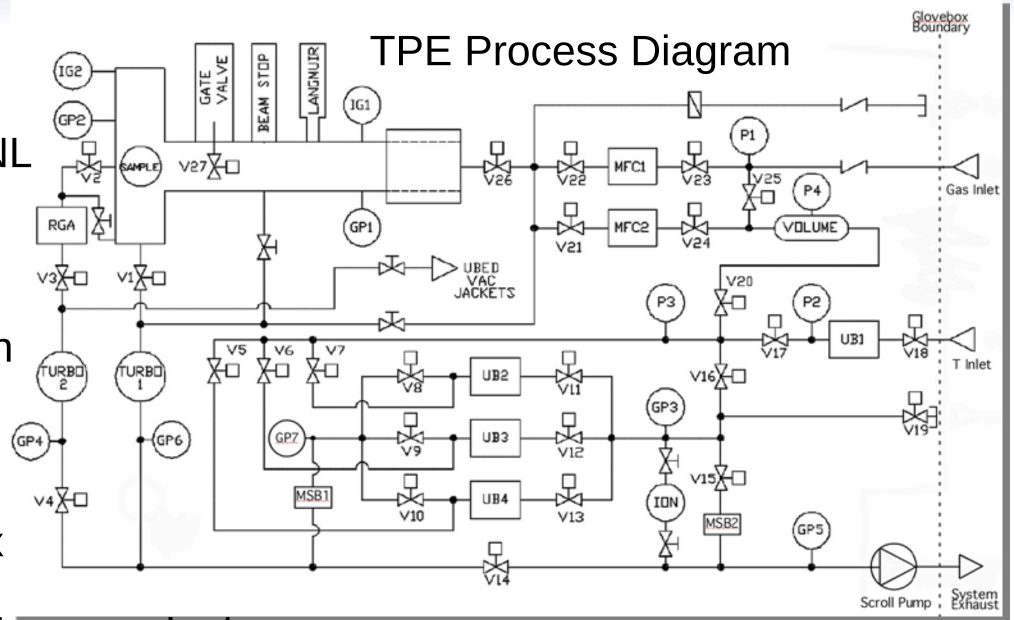
Future TPE Changes to Accommodate Efficient Tritium Operations

TPE Process Diagram



- The present configuration of TPE does not employ the roots blower used at LANL to drive TPE exhaust gases on to its Ubeds due to possible oil contamination to and replacement costs of the beds
- This limits tritium plasma operation to 2 h runs before impurity backflow requires plasma termination
- Has there been any progress on an affordable replacement for the Normetex scroll pump?
- In addition, because this pump was used to recycle the Ubeds inventory (presently ~4000 Ci) and the tritium cost of each 200 Ci run represents ~ $4000, we will be examining alternative operation options to recycle the tritium in TPE
- One alternative would be a high pressure turbo-pump and metal bellows pump in series upstream of Ubeds
- In the near-term, a regeneration chamber and non-metallic sealed dry scroll pump will be used to test once through Ubed extraction efficiency and Ubed gas composition

TPE 1.5 kg Ubeds

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Our website is at:
https://inlportal.inl.gov/portal/server.pt/community/fusion_safety