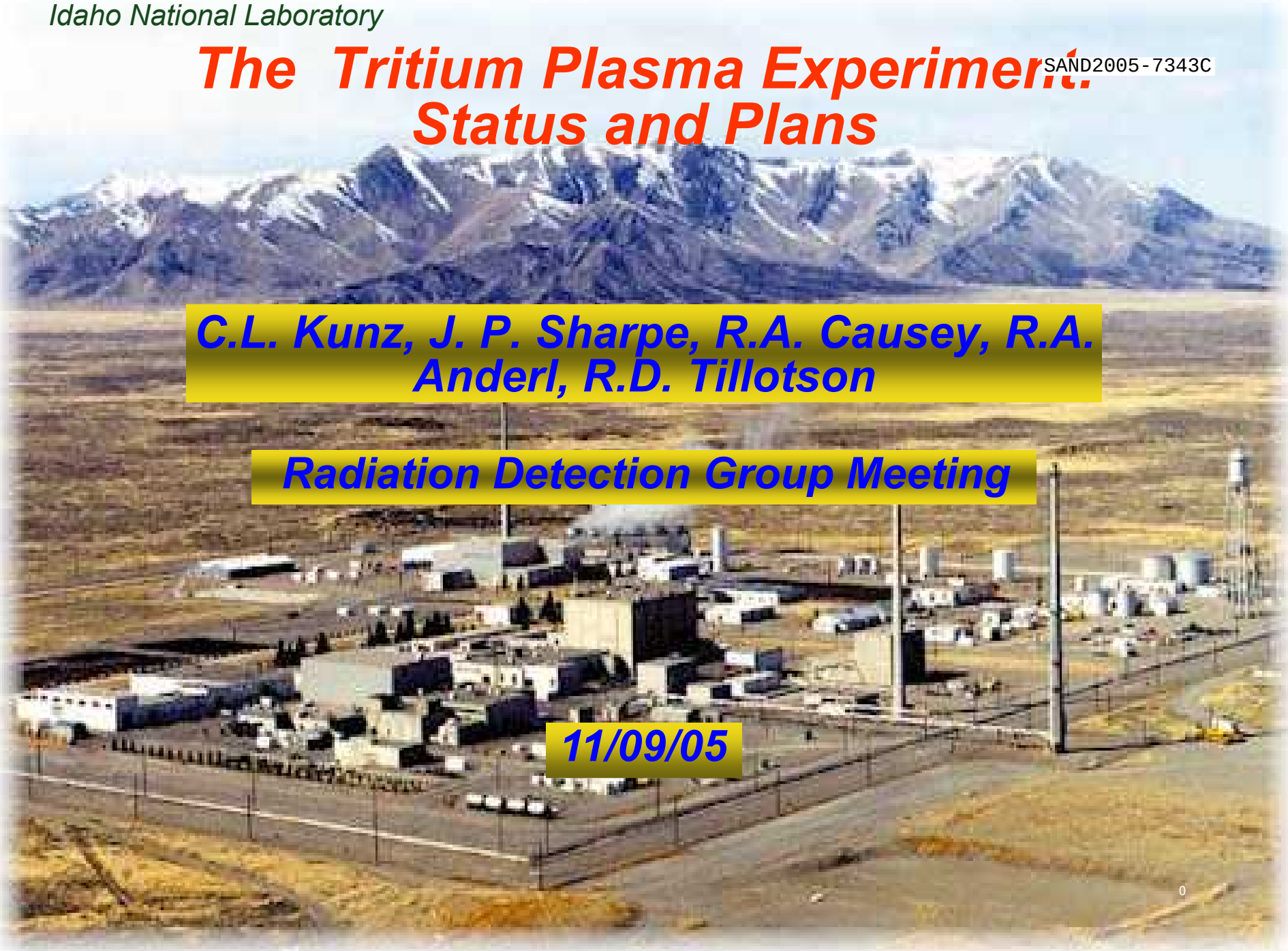
The Tritium Plasma Experiment: Status and Plans

SAND2005-7343C



C.L. Kunz, J. P. Sharpe, R.A. Causey, R.A. Anderl, R.D. Tillotson

Radiation Detection Group Meeting

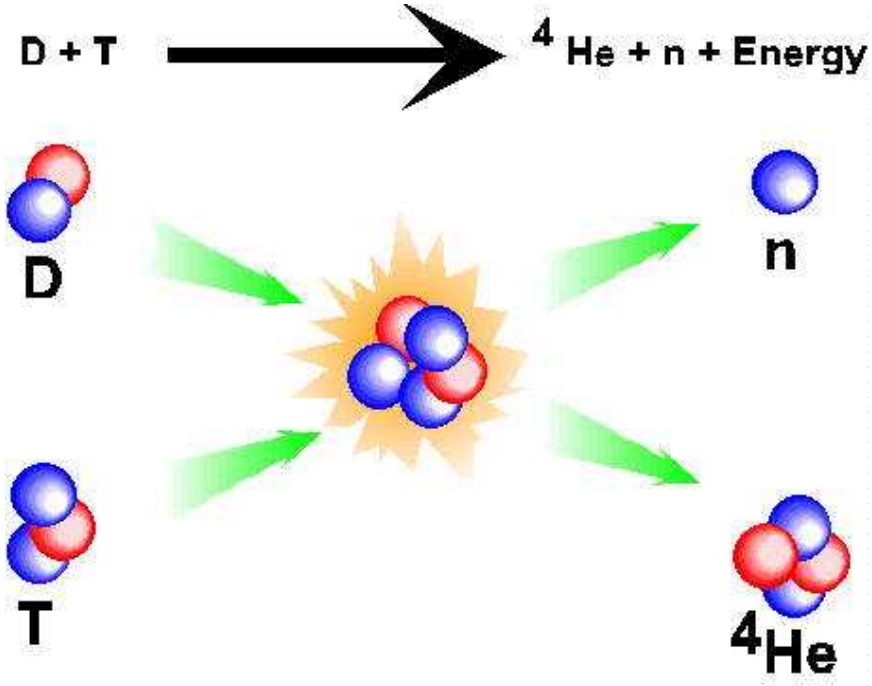
11/09/05

Outline

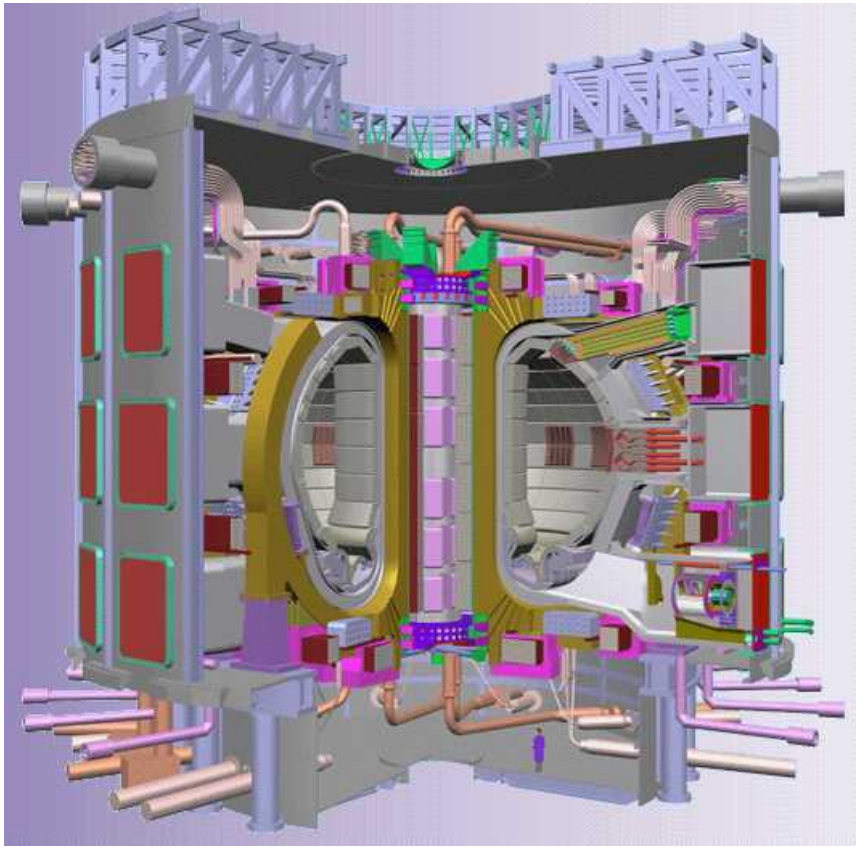
- Fusion Basics
- ITER
- TPE History
- New Home at INL's STAR Facility
- Reassembly Work
- Return to Experiments

Fusion Basics

- *Simplest fusion reaction is DT*
- *DT Fusion requirements*
  - *Plasma temperature (T)*
    - *100-200 million deg. C*
  - *Energy Confinement Time (t)*
    - *1-2 seconds*
  - *Central Density in Plasma (n)*
    - *2-3 x 10^{20} particles m^{-3} (approx. 1/1000 gram m^{-3})*



International Thermonuclear Experimental Reactor (ITER)



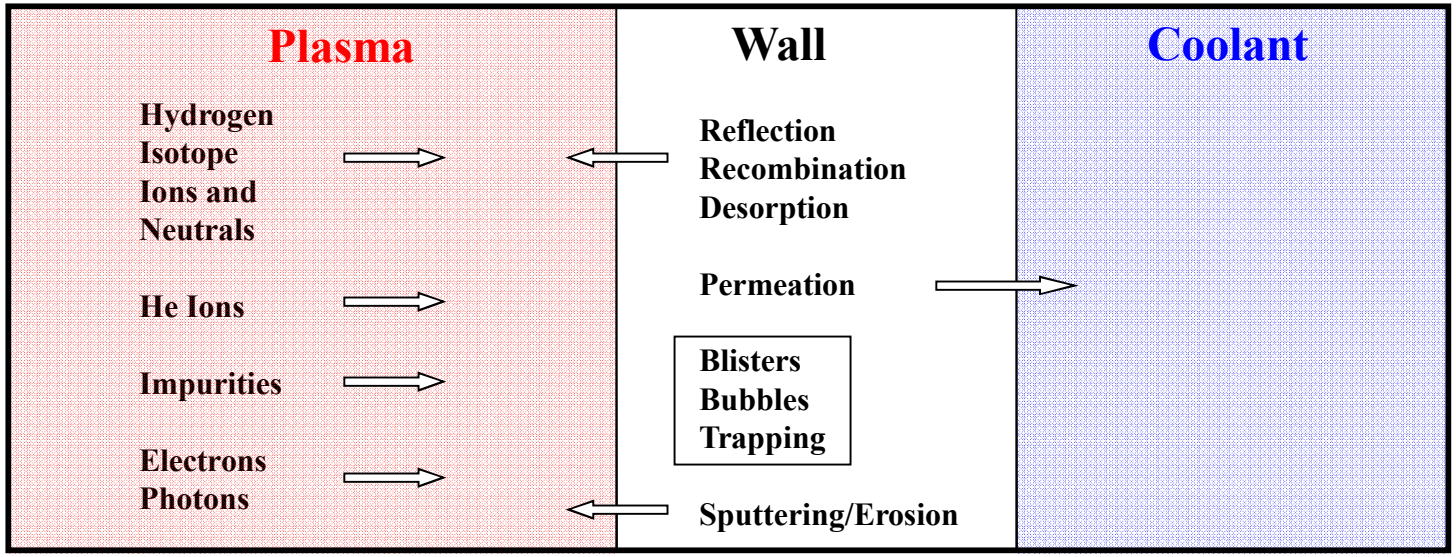
Soon to be built in Cadarache, France

Minor radius - 2 m
Major radius - 6 m
Magnetic field - 5.3 T
Current - 15 MA
Heating - 40 MW
Fusion power - 500 MW
Ion temperature - 8.1 keV

Cost - $2.8 B

Sandia/California Fusion Program

- *All of the fusion work at Sandia/California falls into the category of plasma surface interactions*
  - *Sputtering or erosion of materials by energetic particles from the plasma*
  - *Conditioning (impurity removal from plasma facing materials)*
  - *Hydrogen isotope retention and recycling*
  - *Plasma diagnostics*

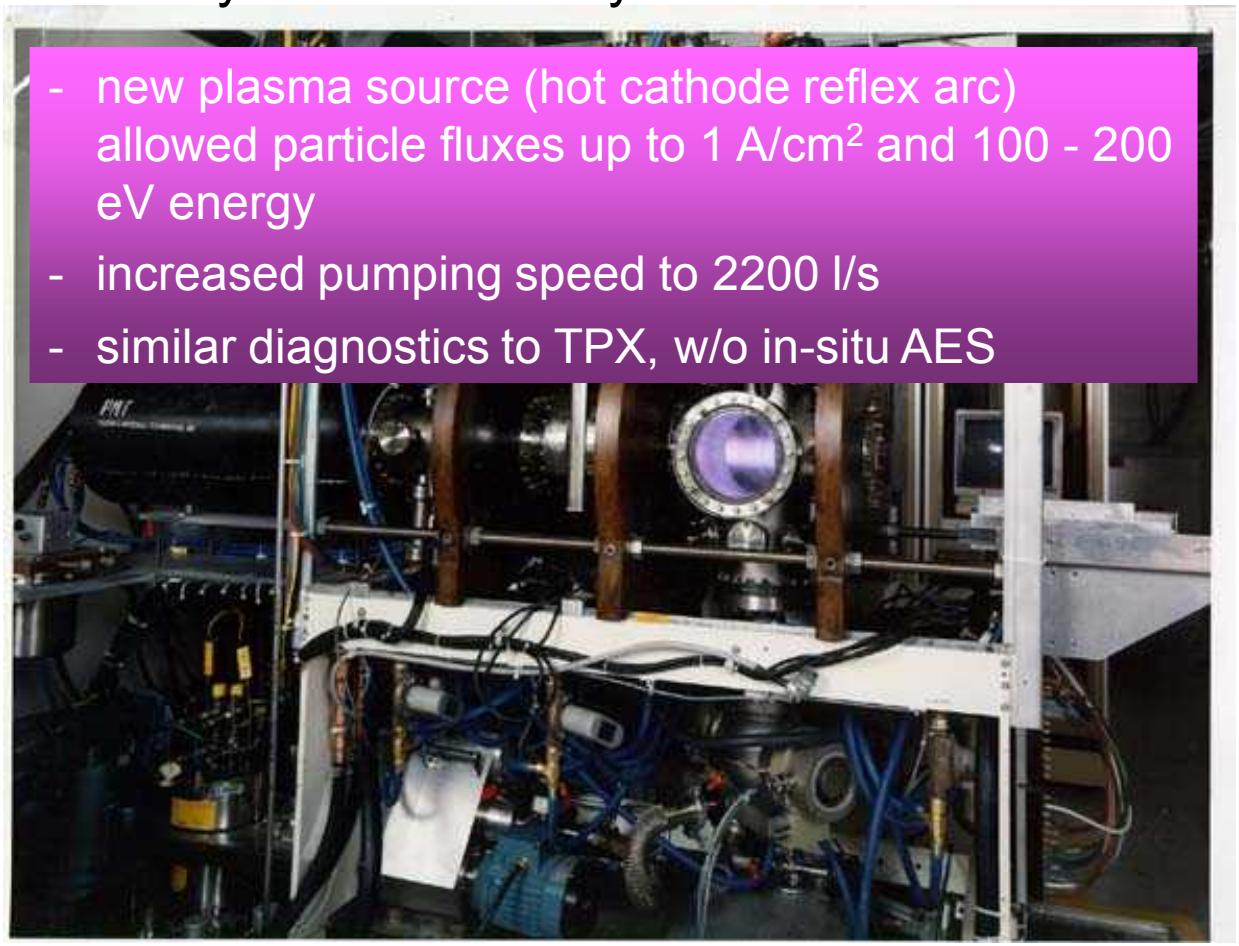


TPE History

- Established as the ***Tritium Plasma Experiment (TPX)*** in 1982 at the Tritium Research Laboratory at Sandia-Livermore; TPX operated for ~ 10 years
  - Uniquely capable of H-D-T plasmas for PSI studies, primarily measuring plasma-driven permeation behavior of metals and graphites
  - RF driven plasma (390 MHz) up to 200 W; axially magnetized to ~ 150 G
  - Plasma density ~3×10^{11} ions/cm^3, T_e ~ 10 eV, on-sample ion flux 10 mA/cm^2
  - T throughput ~ 0.1g/day; experiment placed in a high-velocity ventilation hood for T contamination control; pumping system exhausted to tritium recovery system
  - Diagnostics included Langmuir probes, QMS (plasma species and permeation species), in-situ Atomic Emission Spectrometer (AES)

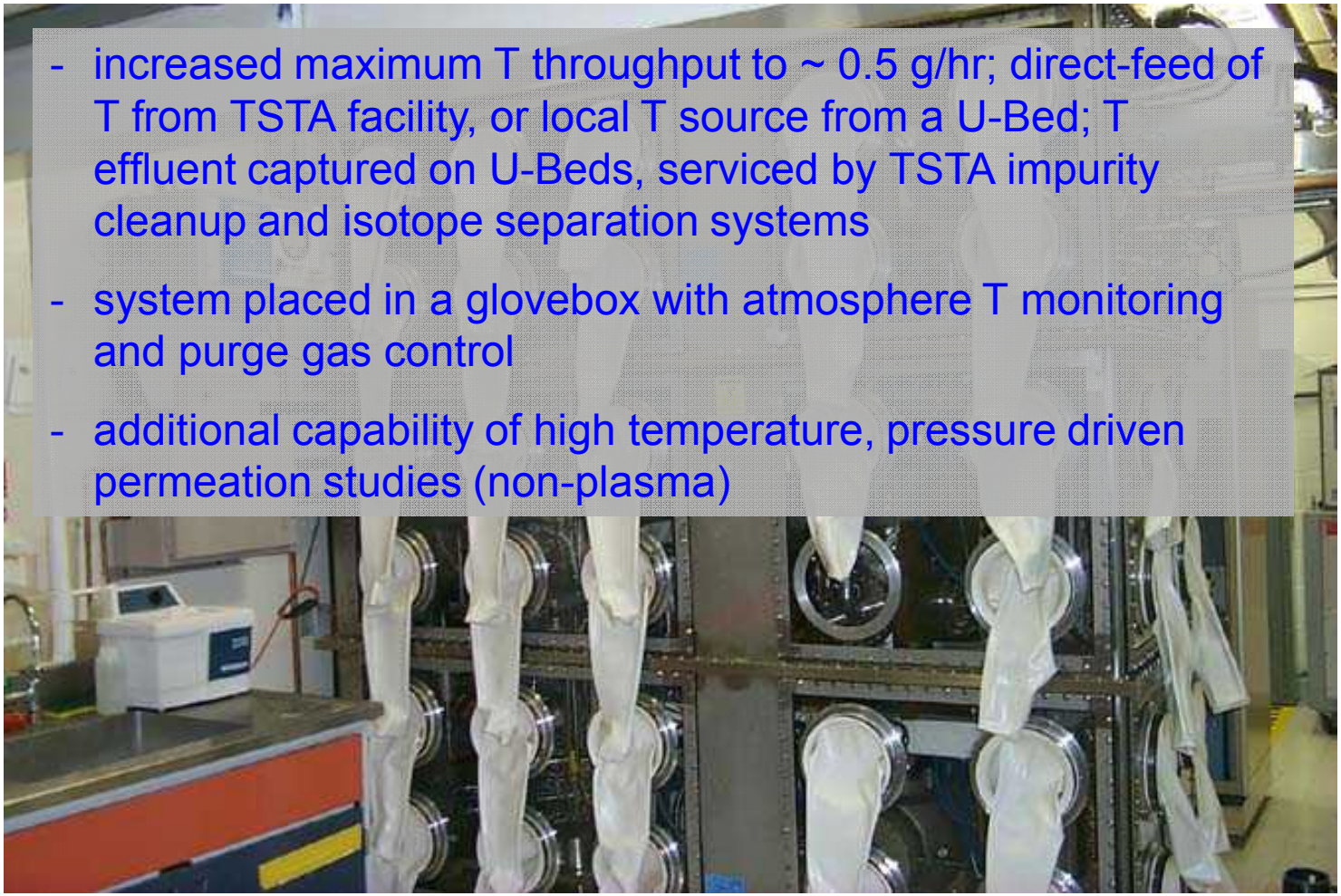
TPE History, cont.

- Experiment system upgraded and moved to the Tritium Systems Test Assembly at LANL in early 1990's



TPE History, cont.

- TPE returned to T operation in May 1995



- increased maximum T throughput to ~ 0.5 g/hr; direct-feed of T from TSTA facility, or local T source from a U-Bed; T effluent captured on U-Beds, serviced by TSTA impurity cleanup and isotope separation systems
- system placed in a glovebox with atmosphere T monitoring and purge gas control
- additional capability of high temperature, pressure driven permeation studies (non-plasma)

TPE History, cont.

- Decision in 2001 to close TSTA operations forced relocation of TPE

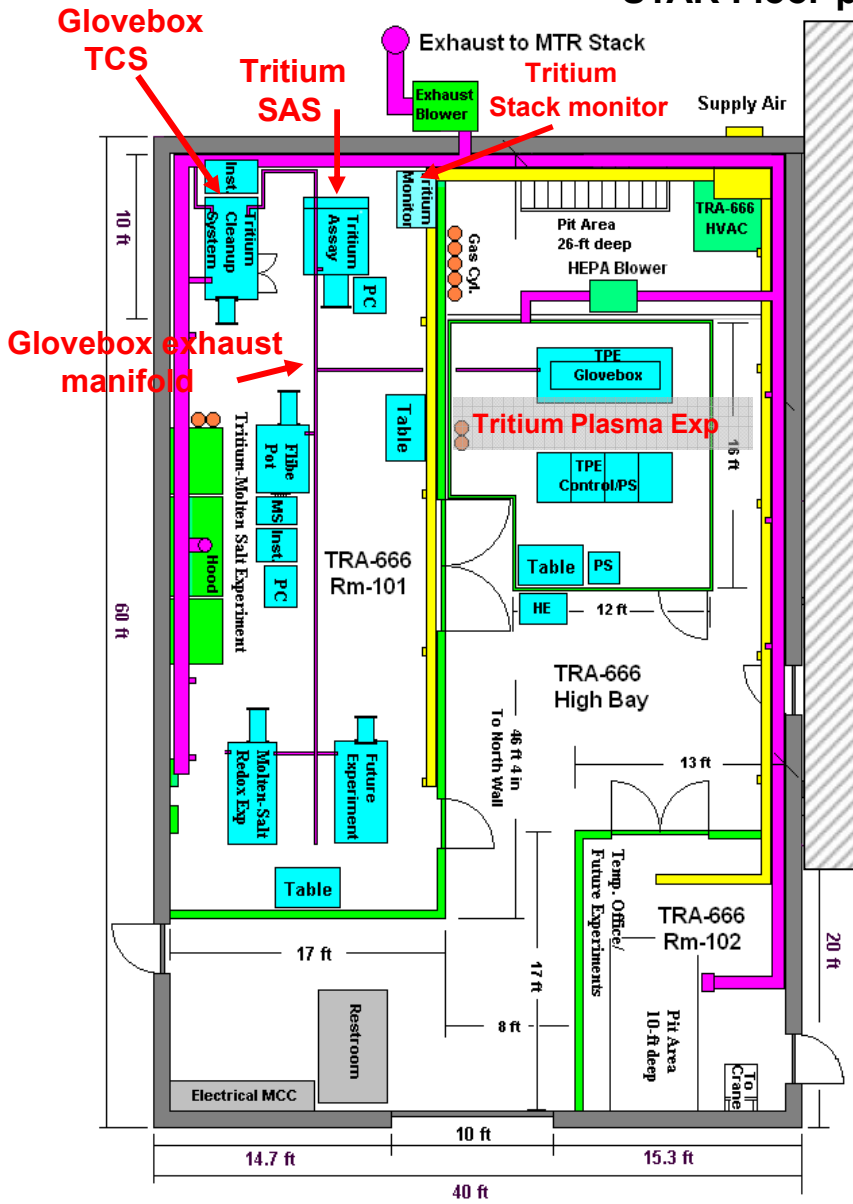
New Home at INL's STAR Facility

- TPE arrived at INL in April 2002

New Home at INL's STAR Facility, cont.

- Changed plans for experiment location due to high levels of T contamination
  - Levels as high as 300,000 dpm / 100 cm^2 located within instrument racks and power supply chassis (CA limit is 10,000 dpm / 100 cm^2)
  - Decontamination efforts unsuccessful at reducing levels below CA limit
  - TPE will have a dedicated room in the facility, minimizing contamination spread, and reducing impact on other STAR systems or experiments
  - Substantial facility modifications were required to enact changed plans: purchase and erect a PermaCon enclosure, re-route and expand electrical service, modify facility ventilation, extend the fire suppression system into the PermaCon

STAR Floor-plan Layout



15,000 Ci tritium limit
Segregation of operations/ventilation
Once-through room ventilation
Tritium cleanup system (TCS)
Tritium storage and assay system (SAS)

New Home at INL's STAR Facility, cont.

PermaCon enclosure housing TPE and ancillary equipment.

Anti-contamination gear

Reassembly Work

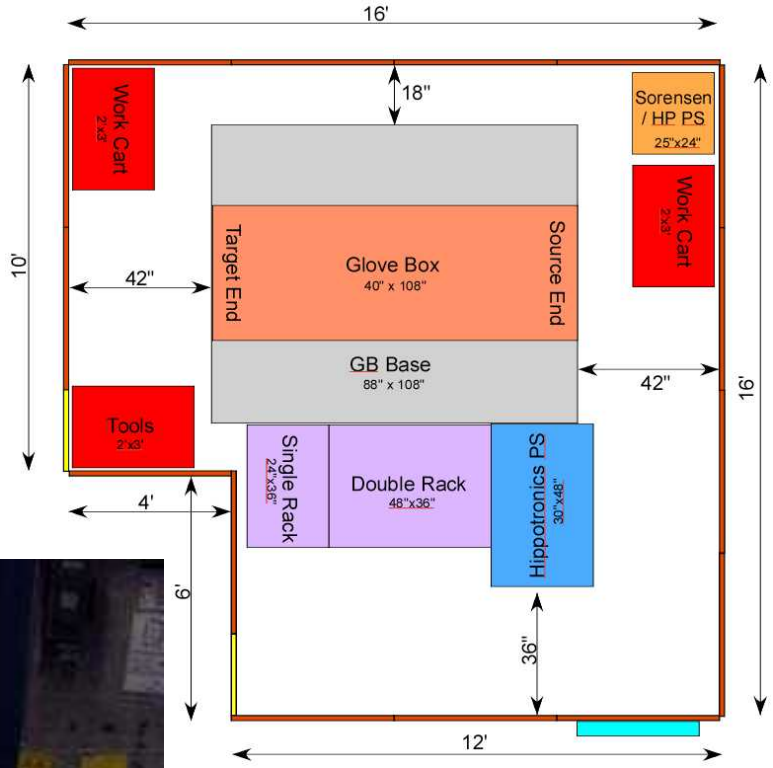
- Experiment systems to be reassembled and tested; activities include:

- Install electrical service for PermaCon and distribution switchgear
- Installation and checkout of cabling and power leads
- Configure and install cooling systems (external); checkout and purge cooling lines inside glovebox
- Evaluate condition and test out electro-pneumatic control valve system
- Install gas supply manifold to service plasma and glovebox systems
- Glovebox integrity testing, purge gas monitoring and control system installation, glove replacement
- Test vacuum system components, condition vacuum system (new TMP, roughing pump, and controls)
- Test I&C instrumentation (heaters, flow controllers, PS controllers, etc.)
- Refurbish plasma source
- Modify operations procedures, and write ES&H documentation

Reassembly Work, cont.

Room ventilation exhausted through the TPE glovebox.

Testing TPE I&C lines going to glovebox feedthroughs.

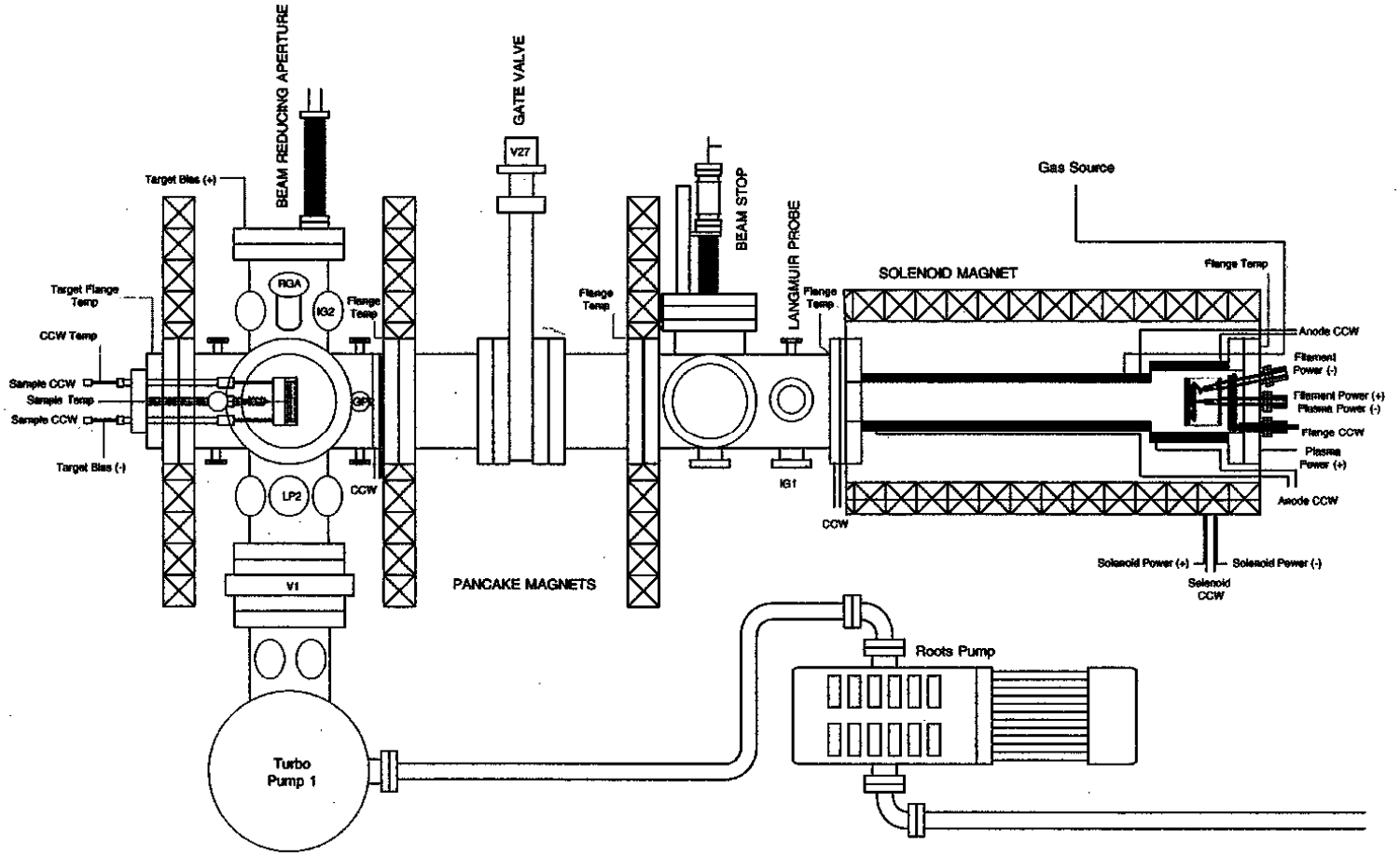


Equipment layout in the PermaCon.

Return to Experiments

- TPE will again be available for continued support of the PFC community
- Experiment conditions and diagnostics will not change, except T throughput will be much reduced (~0.1 g/day)
- Some of the near-term experiments include:
  - Re-investigation of T permeation in W
  - T uptake and retention in Be-W mixed materials
  - Other mixed materials work, possibly w/ carbon
  - Pressure-driven permeation studies of advanced materials/coatings

Misc. Pics: Inside the Glovebox

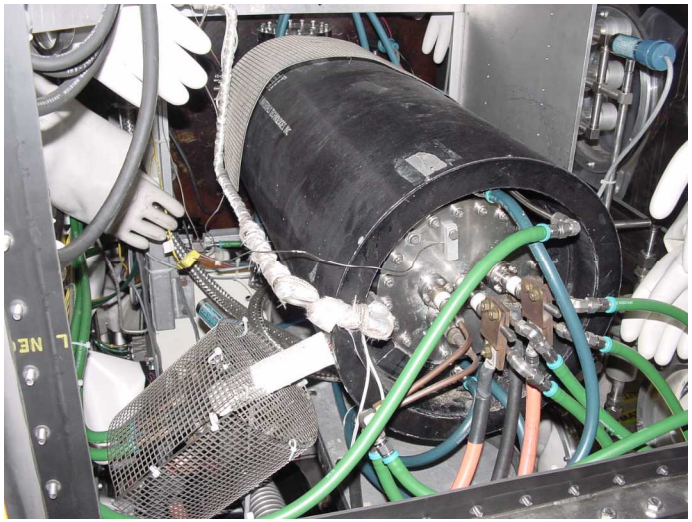


plasma system component layout

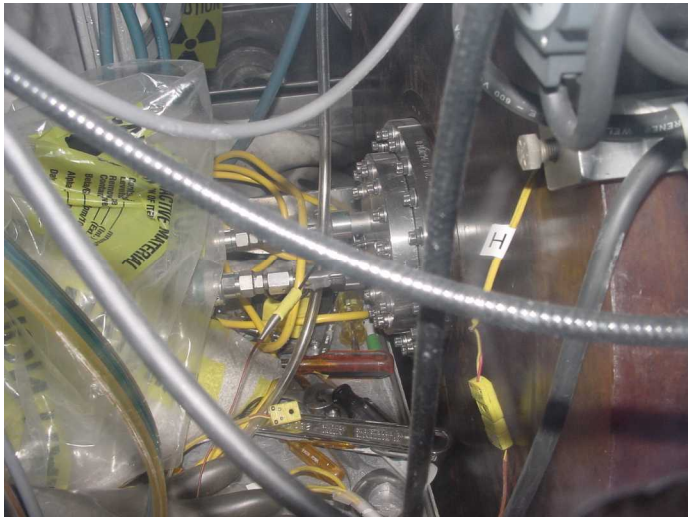
Misc. Pics: Inside the PermaCon

fruit of Chris' hard work

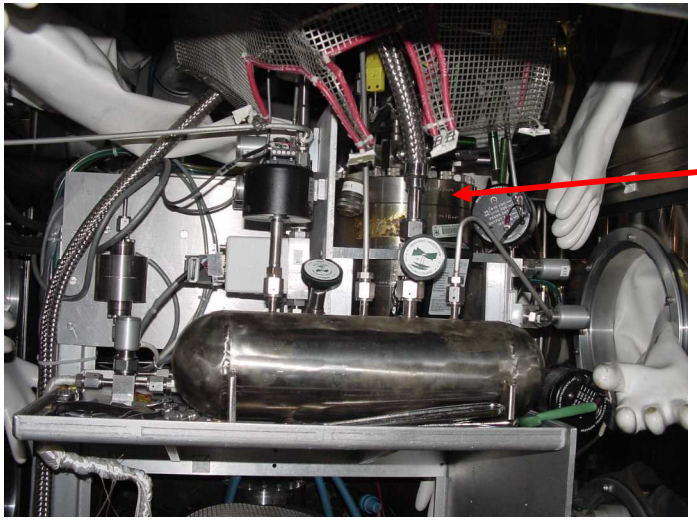
Misc. Pics: Inside the Glovebox



plasma source



target flange surrounded by pancake magnet



T storage (UBed-1) and supply plenum (3-liter volume)

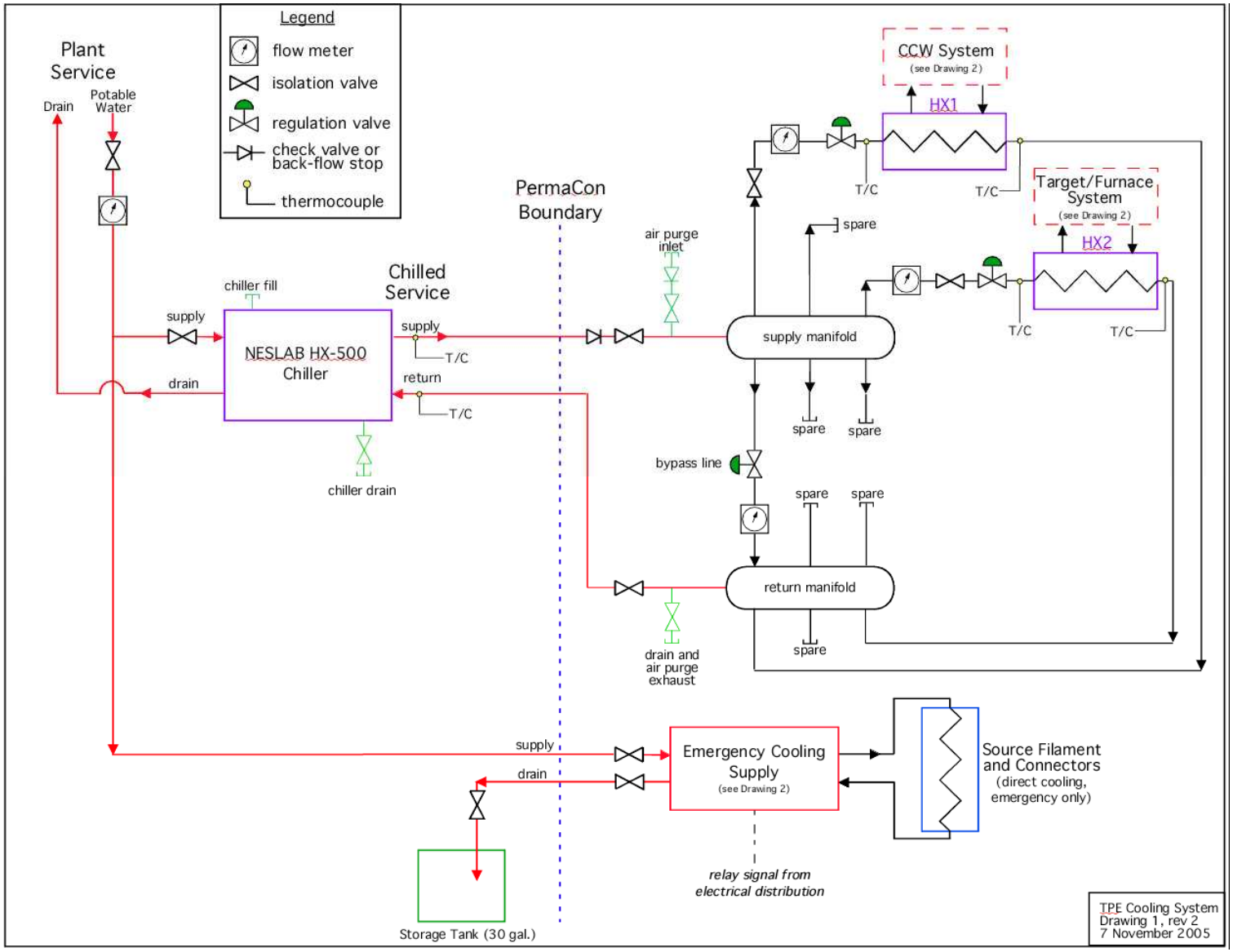
furnace for H/D/T permeation studies

Misc. Pics: Outside the PermaCon

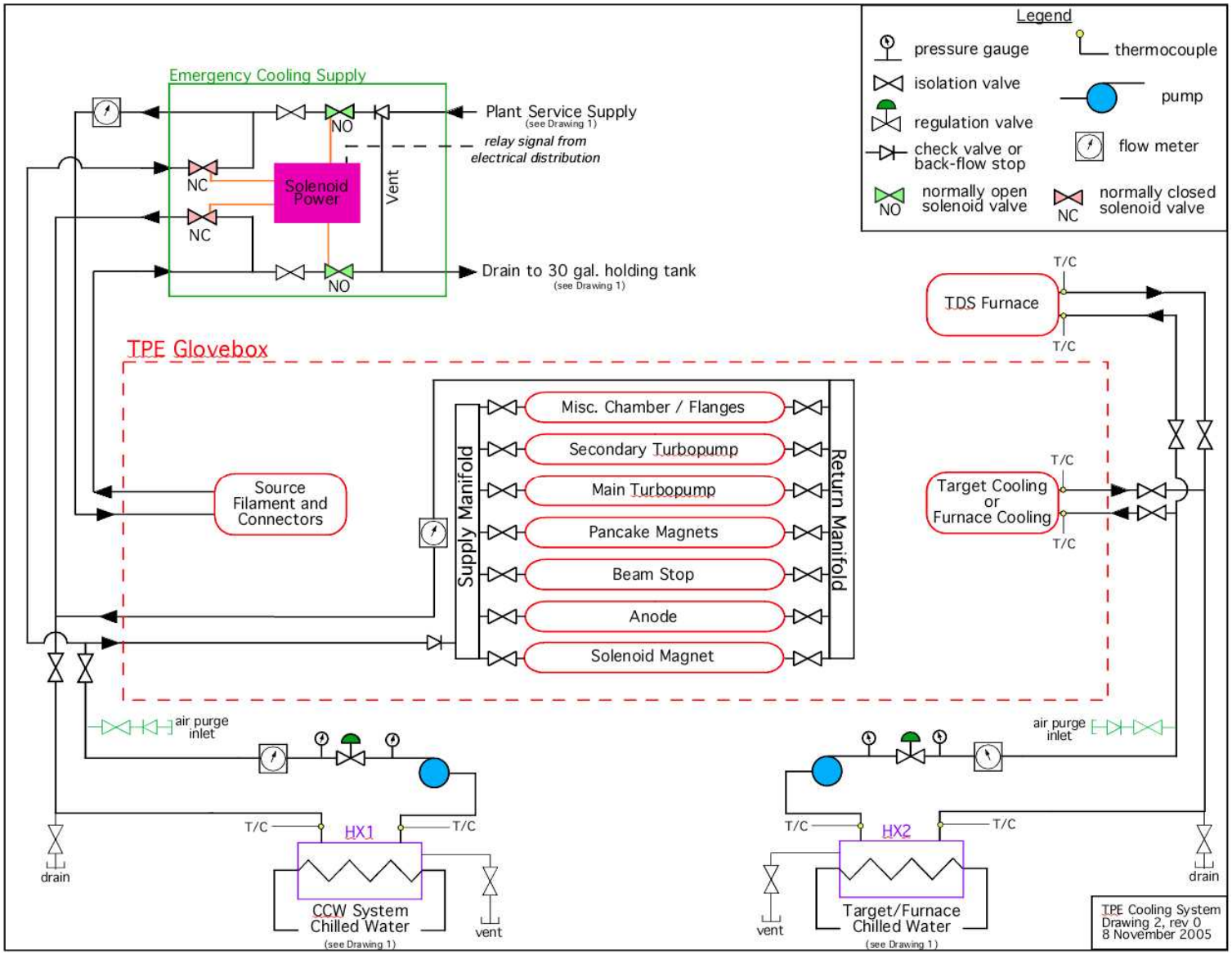
detector guys might like this picture :)

more fruit of Chris' hard work

Misc. Pics: System Diagrams- chilled water service



Misc. Pics: System Diagrams- CCW and Target/Furnace loops



Misc. Pics: System Diagrams- gas delivery system