Operational Experience using the Combined Electrolysis and Catalytic Exchange (CECE) Tritium Compatible Rig

Presented by: Todd Whitehorne

39th Tritium Focus Group Meeting, Oak Ridge, Tennessee
2018 May 15-17

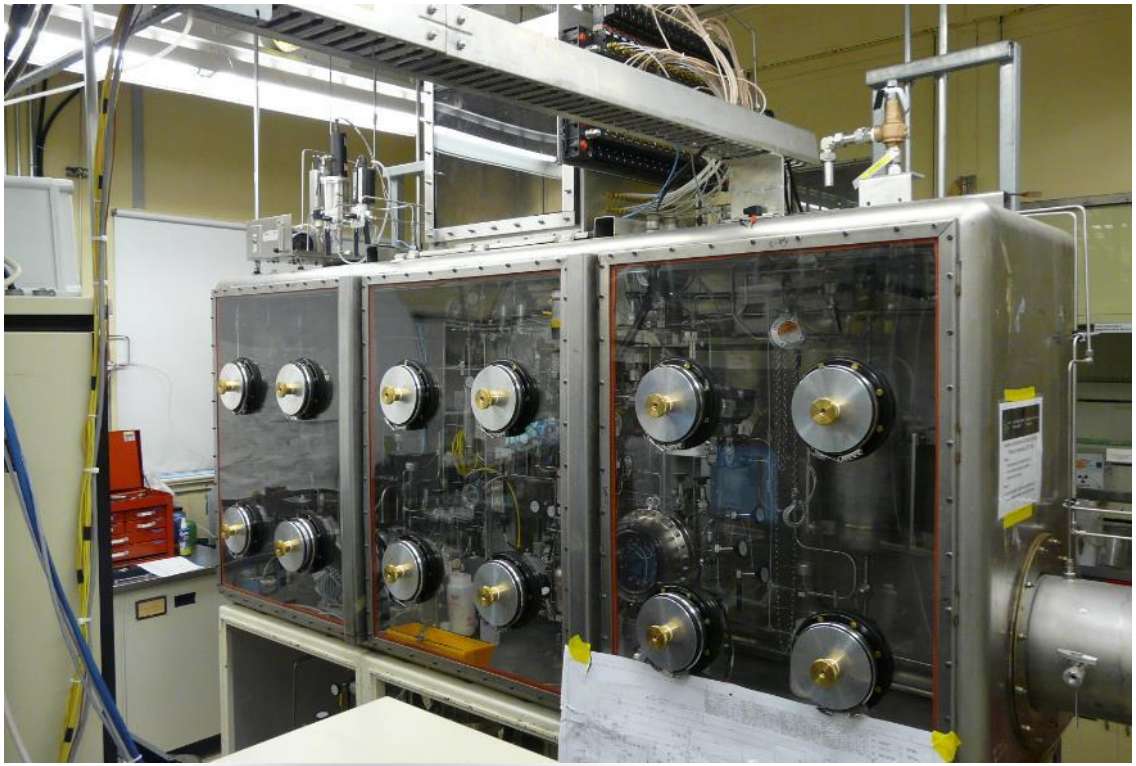
System Overview

Design Intent

- Operate a small scale Combined Electrolysis Catalytic Exchange (CECE) rig for active materials testing while under operational conditions.
  - Recombiner catalyst
  - LPCE catalyst
  - Cell materials
    - Proton Exchange Membranes, Electrode Catalysts
- Maximum concentration of 1000 Ci/kg water
- Small closed loop system

System Overview

Secondary Enclosure Glove Box



- Secondary Enclosure: Inert Atmosphere positive pressure Ar Glove Box
- Continuous moisture monitoring - dewpoint transmitter
- Continuous tritium measurements using 1L ion chamber
- Automated atmosphere control using a PLC

System Overview

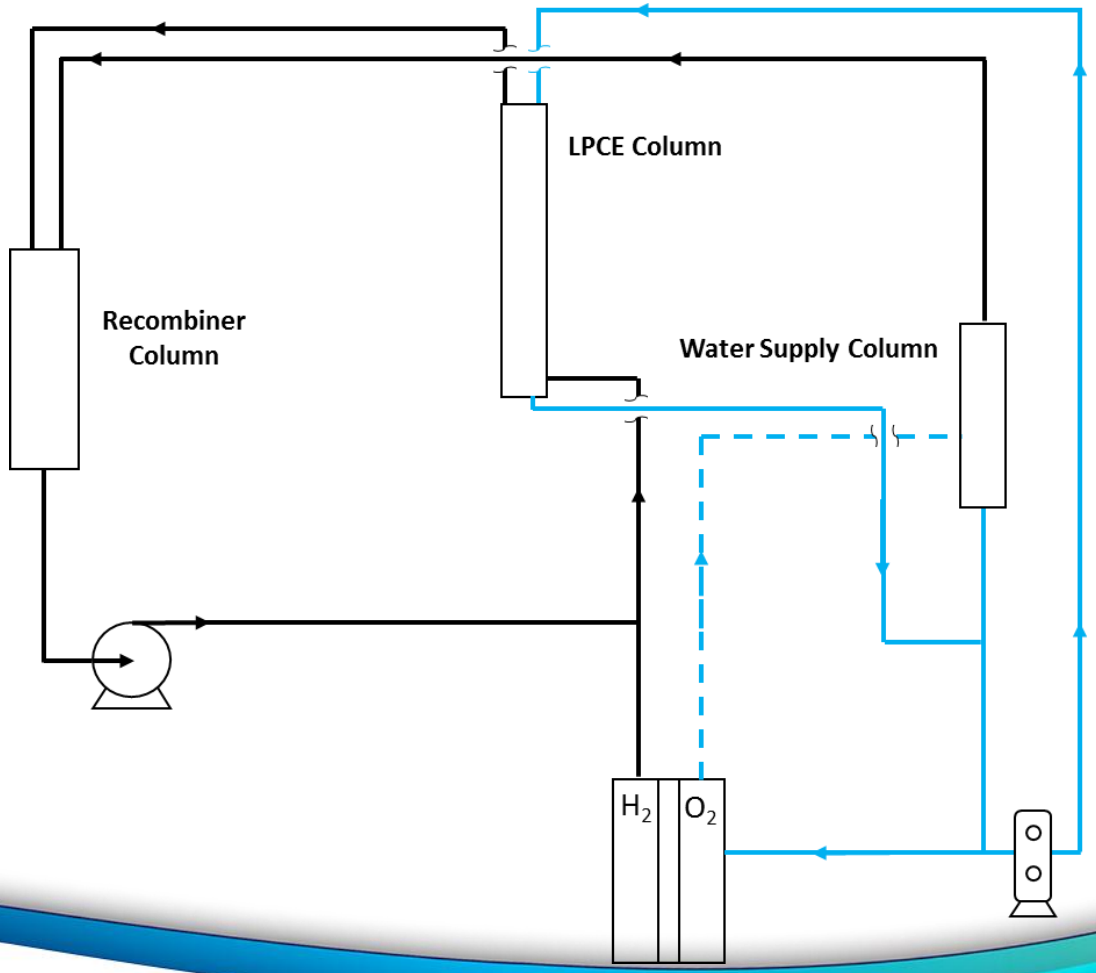
Secondary Enclosure Cleanup (SEC)

- Molecular Sieve bed
  - Cycles through to maintain a user defined dewpoint
- Ti bed
  - Cleanup of O_2 (decrease atmospheric formed HTO)
  - Cleanup of T_2 , N_2
- Ni bed
  - Cleanup of Organically Bound Tritium

System Overview

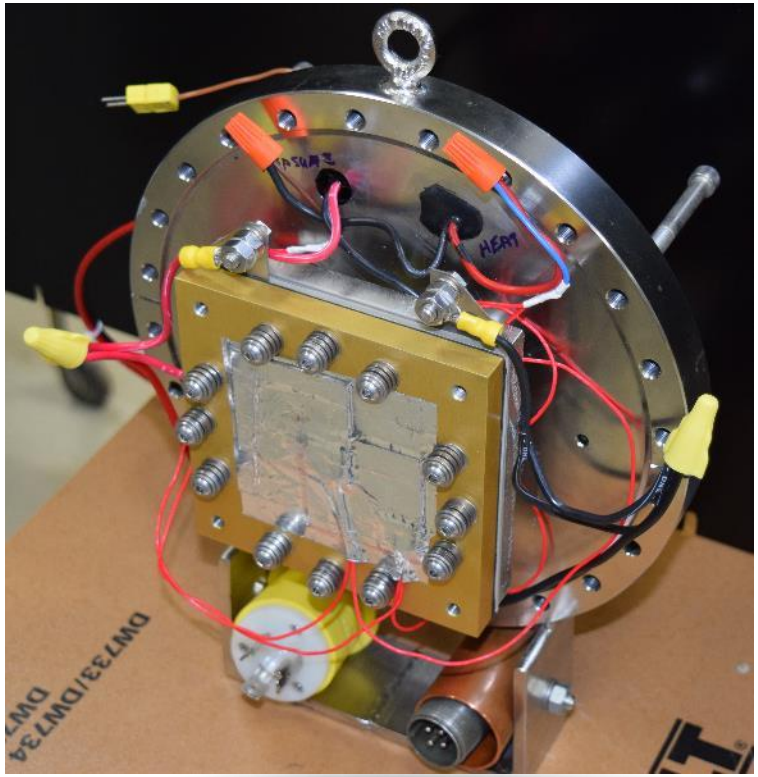
CECE-T Rig: Simplified

- Welded tubing with VCR connections where necessary
- Gravity fed water supply
- Tritium compatibility
- Metal bellows pump
- Closed loop system (cell«»recombiner)



System Overview

Electrolyser Cell



- Proton exchange membranes
  - Nafion® (reference material)
  - CNL Tritium Compatible Membrane
- Membrane Electrode Assembly (MEA)
  - CNL prepared electrode catalyst
  - MEAs pressed on site
- Cell operation @ 60 °C

System Overview

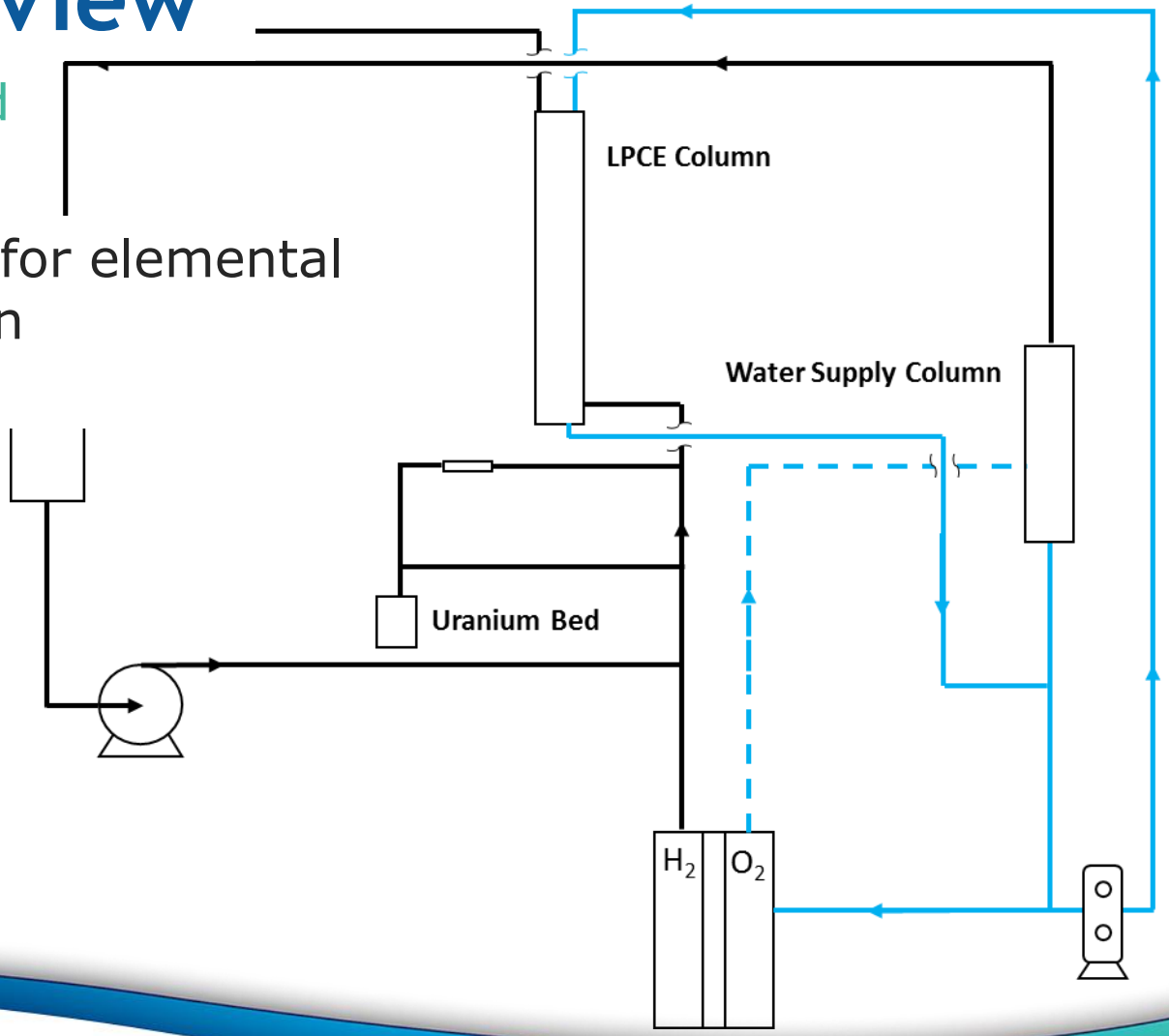
Electrolyser Enclosure

- Electrolyser is the most likely leak point within the rig
- Low point
- Enclosure allows for gas cycling through molecular sieve beds to trap tritiated water in the event of a cell leak/rupture

System Overview

Tritium Injection Method

- Uranium bed loop for elemental tritium introduction



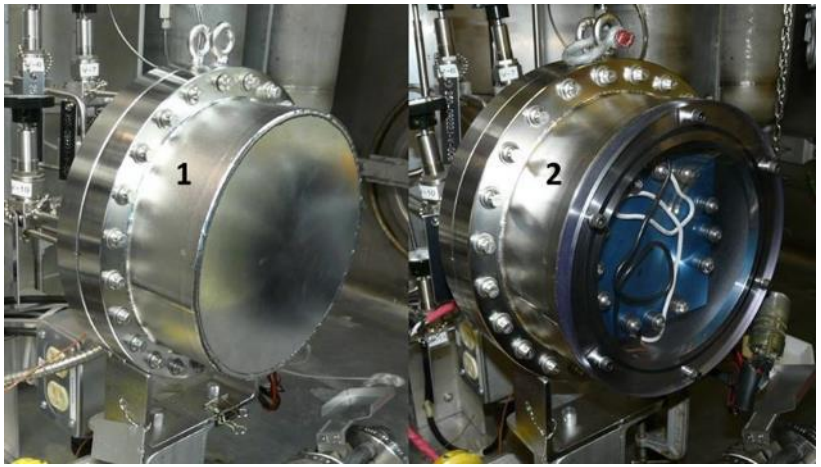
Inactive Commissioning Findings

Electrolyser Cell – Deficiency

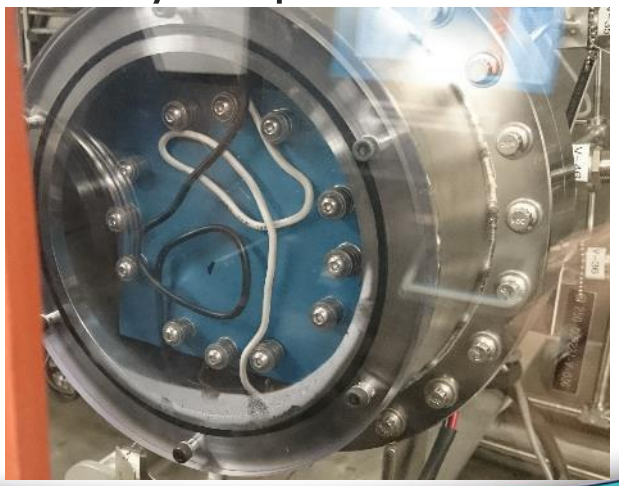
- Secondary cell enclosure does not allow for leak monitoring.
- Forced to monitor rig water levels for leaks.
- During inactive commissioning, found standing water inside the enclosure

Inactive Commissioning Findings

Electrolyser Cell – Solution



- Modified faceplate to clear polycarbonate with a gasket.
- Able to tighten cell components following cell conditioning.
- Able to visually inspect for leaks.

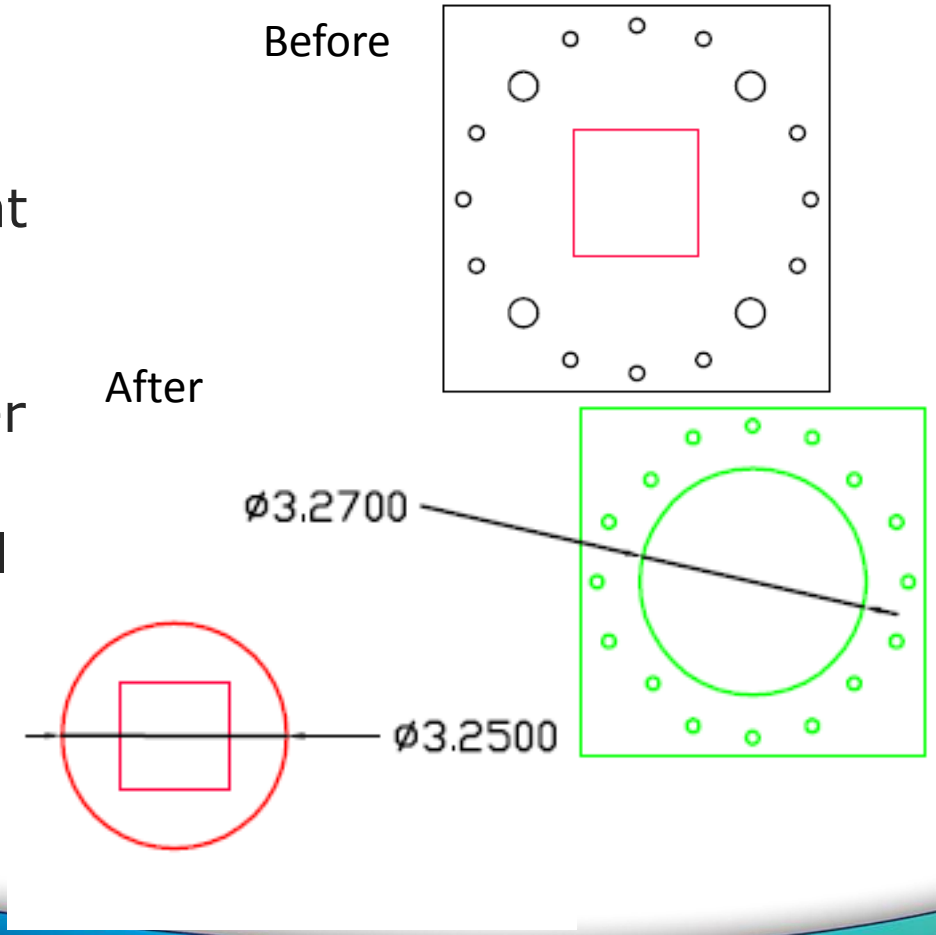


- Discovered water was diffusing slowly from the cell

Inactive Commissioning Findings

Electrolyser Cell

- PEEK capping layer
- Tight tolerances ensure a tight fit of fully hydrated MEA
- Thickness of PEEK film designed to be slightly smaller than a fully hydrated MEA
- In plane expansion is minimal



Inactive Commissioning Findings

Bellows Pump Vibration

- Pumps are solidly mounted on common base within the GB
- Results in excessive noise, and vibration to the rig
- Direct hard-pipe connections changed to flexible hose
- Rubber mounts installed on the base

Active Commissioning Findings

Tritium Injection Method

- To initiate active commissioning, a small amount of tritium was added from tritiated gas mix.
- Found this to be preferred tritium injection method.
- Elemental tritium introduced to the rig using a calibrated volume loaded with gas from tritium gas dispensing system. Fill to less than atmospheric pressure
- Removal of uranium bed/heater.
  - Remove the permeation hazard
  - Removed elemental tritium hazard

Active Commissioning Findings

Glove Atmospheric Conditions Assessment

- Removal of uranium bed, Ti, and Ni beds
- Hazard in the GB is HTO only, originating from the rig (very low elemental inventory - < 1 Ci)
- Knowing the concentration of HTO in the rig (1000 Ci/kg)
- The GB atmospheric HTO can be regulated by controlling the dewpoint. This controls the overall system emissions.

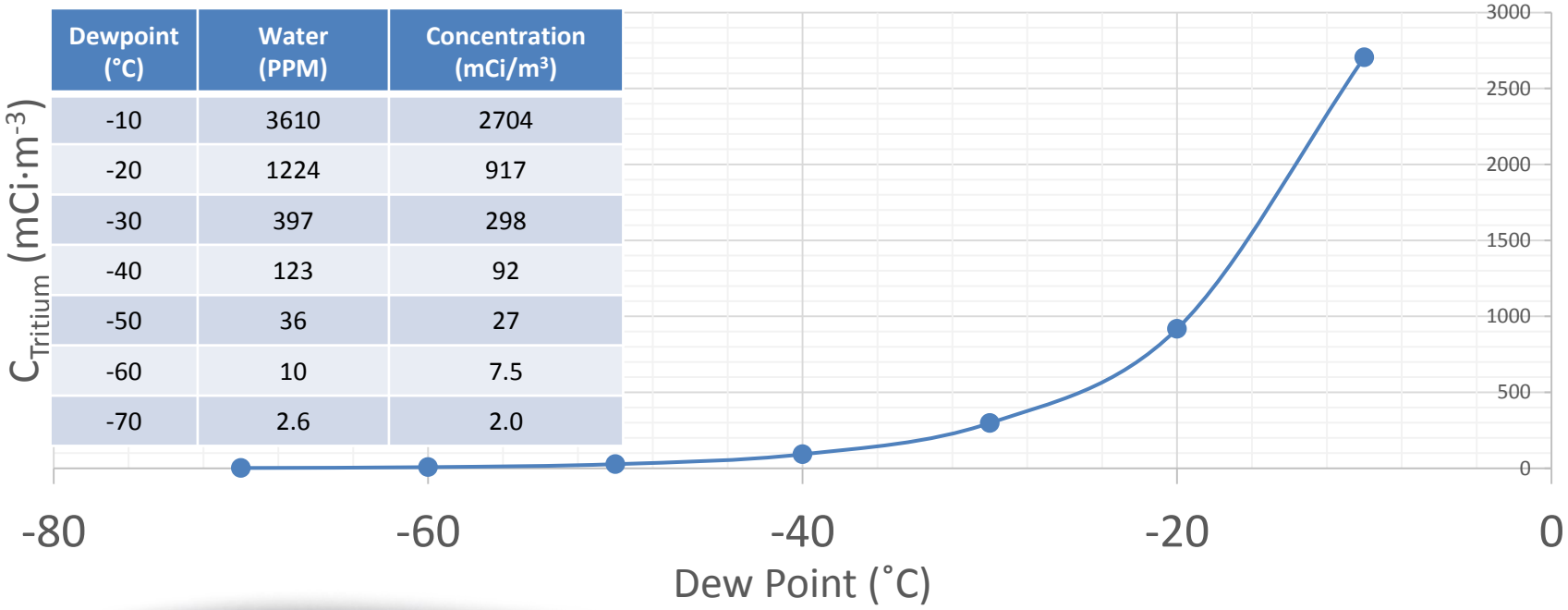
(Actual total inventory of tritium is ~200 Ci)

Active Commissioning Findings

Glove Atmospheric Conditions Assessment

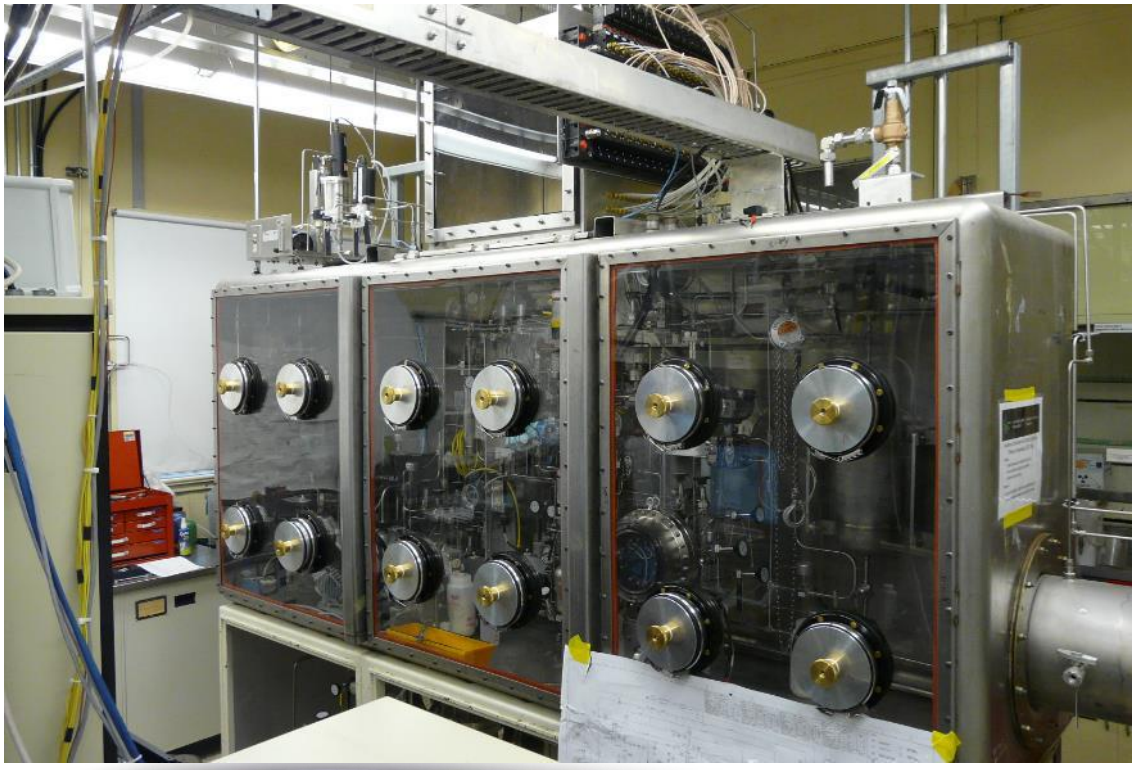
Calculated Atmospheric Tritium Concentration
vs. Dew Point Values

Dewpoint (°C)	Water (PPM)	Concentration (mCi/m³)
-10	3610	2704
-20	1224	917
-30	397	298
-40	123	92
-50	36	27
-60	10	7.5
-70	2.6	2.0



Continuing Work

CECE-T Rig



- Step up concentration to 1000 Ci/kg
- Materials testing of PEMs, and CNL proprietary membranes over long term

Thank you

Questions?

Contact Information:
Todd Whitehorne, PhD
CNL Tritium Facility R&D Scientist
E-mail: Todd.Whitehorne@cnl.ca
Phone #: 1-613-584-3311 ext: 46918