

PRad Target

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JLab Target Group

- Target Overview & Components
- Target Software
- Hazard Analysis and Mitigation
- Target Status, Performance & Remaining Work
- Installation Schedule

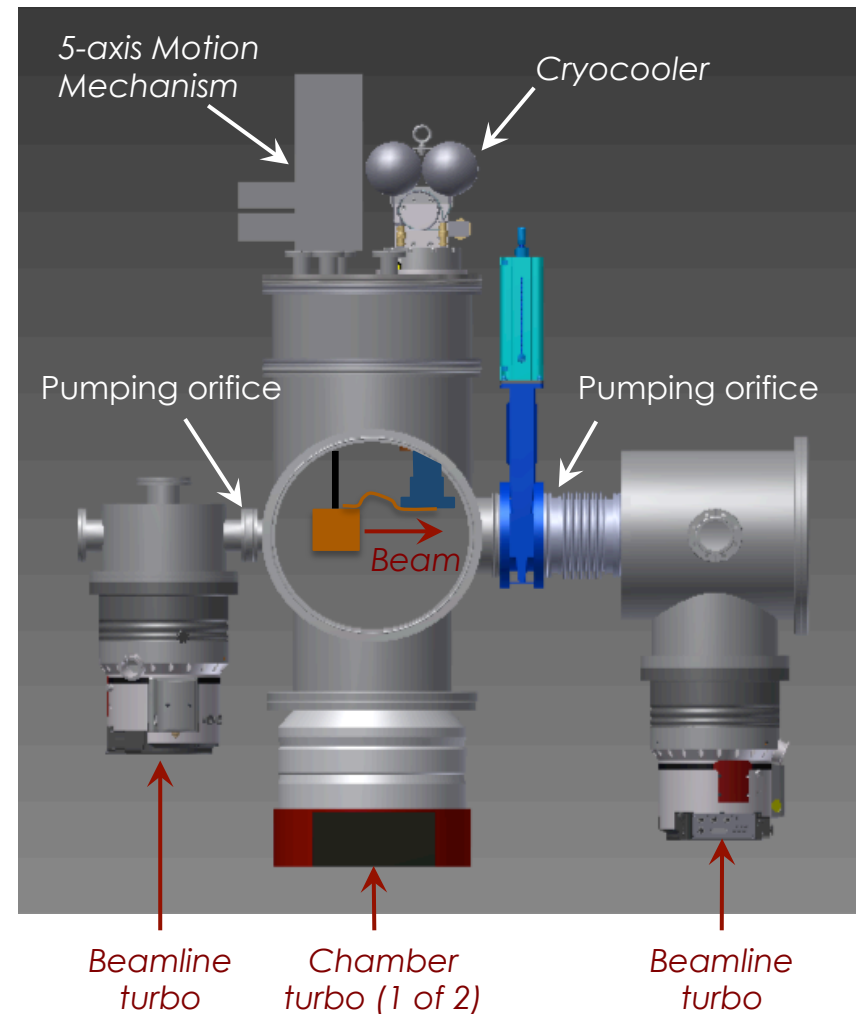
PRad Target: Description

A windowless, hydrogen gas-flow target

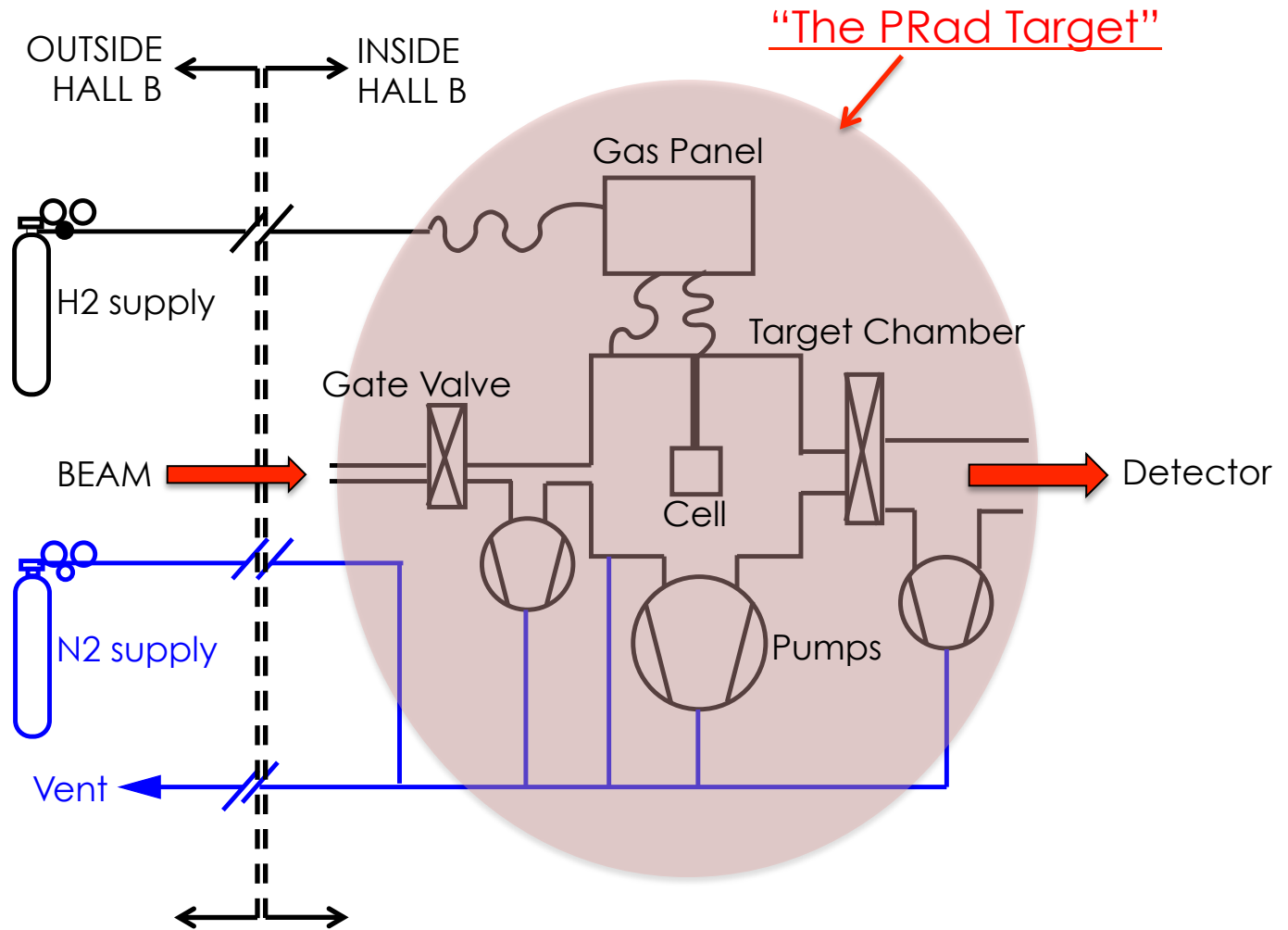
- Cold hydrogen gas flows (~1 slpm) through a cooled copper cell with beam-entrance and exit orifices
- Cell has thermometry and pressure tap to *estimate* gas density
- Large turbo pumps maintain target chamber vacuum $\sim 5 \times 10^{-3}$ torr
- Additional turbos up- & downstream maintain beamline vacuum $\sim 10^{-6}$ torr

Proposal Specs

- Cell length, 4 cm
- Cell Pressure, 0.6 torr
- Temperature, 25 K
→ 10^{18} H/cm²



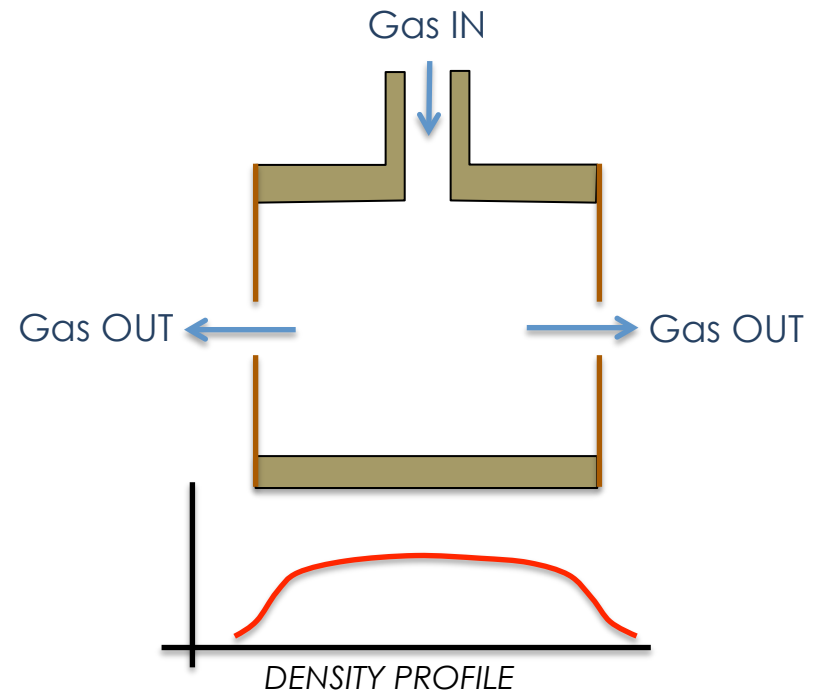
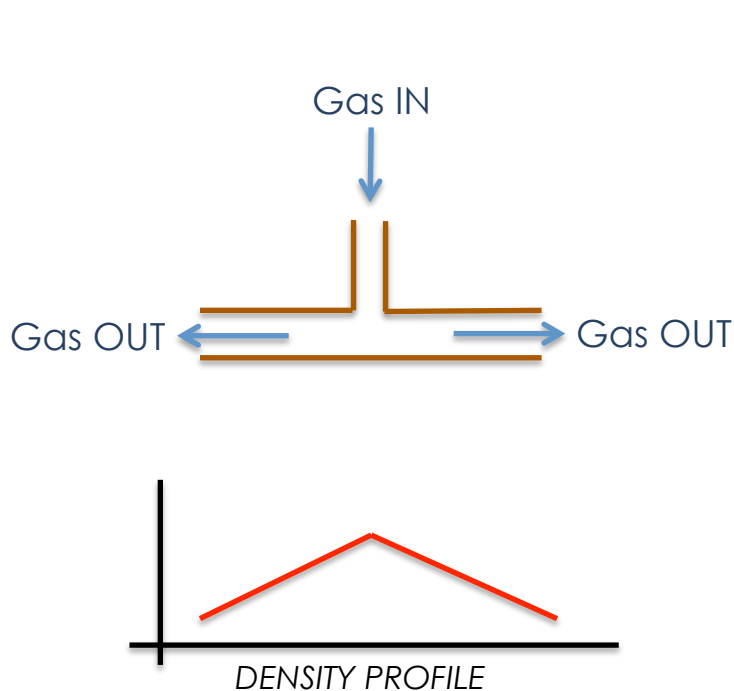
PRad Target: Definition



PRad Target: Components

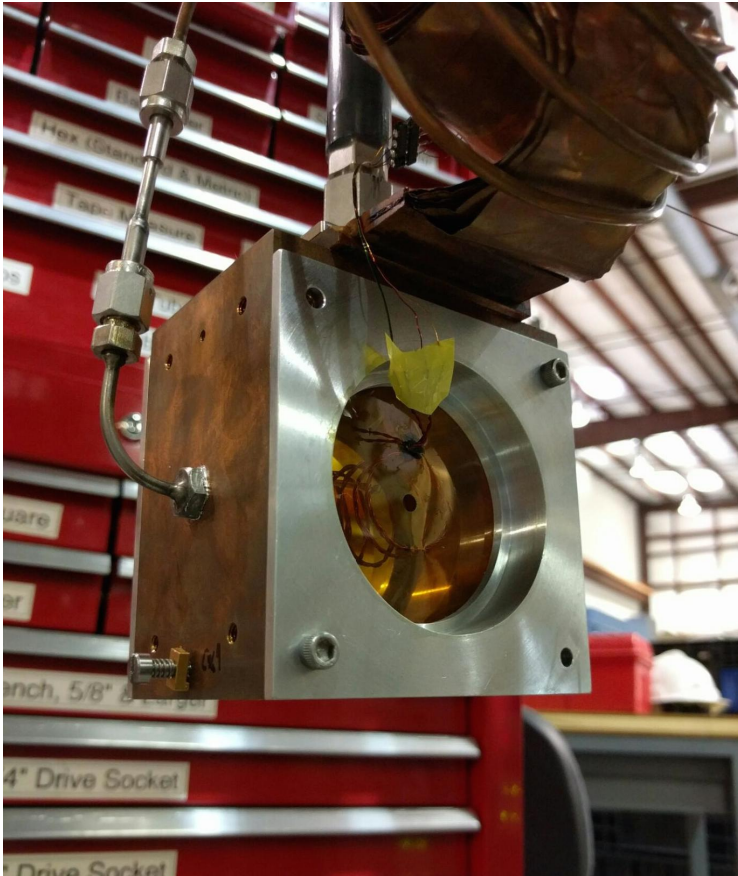
The original design from the PRad proposal (a “kapton straw”) has been replaced by a large copper cell with kapton windows (orifices for beam)

- 4 cm of kapton in beam halo
- Highly non-uniform density profile
- Non-adjustable dimensions
- 2 x 25 um of kapton in beam halo
- More uniform density profile
- Easy to adjust orifice dimensions

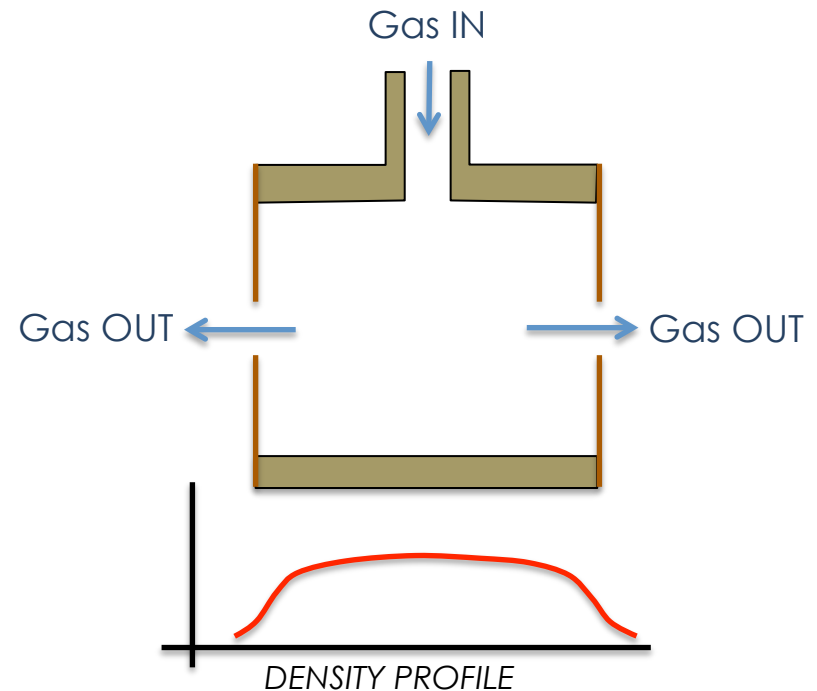


PRad Target: Components

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- 2 x 25 um of kapton in beam halo
- More uniform density profile
- Easy to adjust orifice dimensions



PRad Target: Components

The cell is suspended in the vacuum chamber from a carbon fiber tube, and positioned on the beam line by a modified, 5-axis motion mechanism.

Spares? No.



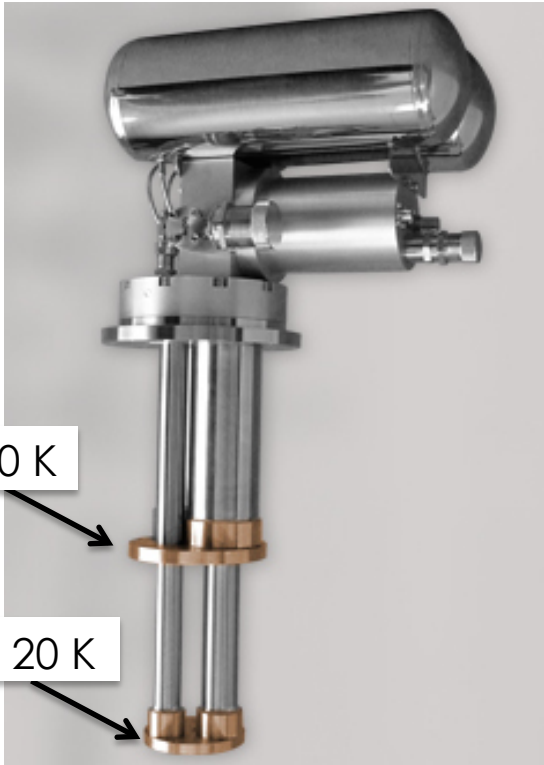
The hydrogen gas is metered into the cell (or directly to the chamber) by a precision mass flow controller, attached to the gas panel.

Spares? Yes.

PRad Target: Components

The hydrogen gas is cooled to 25 K by a temperature-controlled pulse tube cryocooler

CryoMech PT810



80 W @ 80 K

18 W @ 20 K

Spares? Sort of...

LakeShore Model 336

- 100 W + 50 W



Spares? Yes.

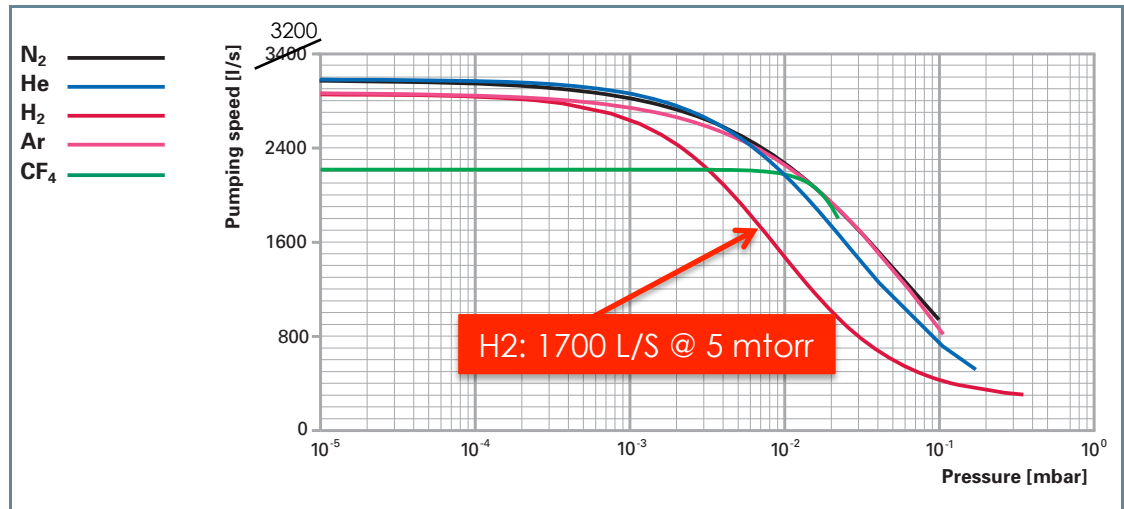
PRad Target: Components

The hydrogen gas is pumped from the vacuum chamber using TWO large turbomolecular pumps. Pressure goal is 5×10^{-3} torr.

Pfeiffer HiPace 3400



Pumping speed



HiPace™ 3400 MC

Slightly smaller turbos are used up- and downstream of the target chamber to keep the beamline vacuum $\sim 10^{-5}$ torr.

Spares? Sort of...

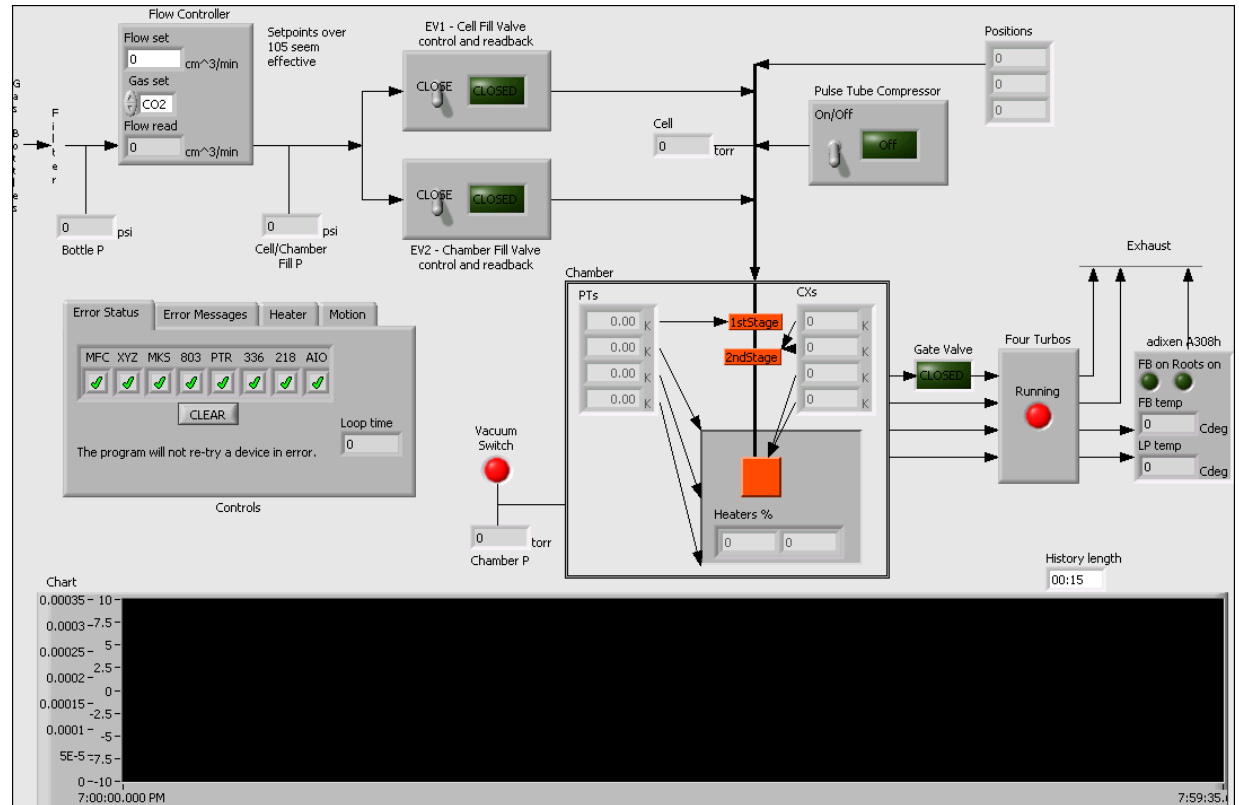
PRad Target: Control Software

CONTROL

- H2 flow
- H2 temperature
- Pulse tube on/off

READ

- Temperatures
- Pressures
- Error statuses



PRad Target: Hazard Analysis

- Magnetic Fields
- Oxygen Deficiency
- Vacuum/Thin Windows
- Cryogenic Materials
- Flammable Gas
- Pressure System Safety (Dave Meekins)
- Loss of Power

PRad Target: Hazard Analysis

Magnetic Fields

- The target does not generate any high magnetic fields
- There are no high fields in the vicinity of the target to affect field-sensitive components such as the turbo pumps for or the rotary valve motor for Pulse Tube Refrigerator
- All components inside vacuum chamber are non-magnetic

Consequence Level: Extremely Low

Probability Level: Extremely Low

Risk Code before Mitigation: Negligible

Mitigation: none required

PRad Target: Hazard Analysis

Oxygen Deficiency

- The target uses hydrogen gas as its operating fluid, ~ 1 liter.
- The pulse tube cryocooler contains about 81 liters of helium.
- Release into Hall B would decrease oxygen levels by less than 0.01%.

Consequence Level: Low

Probability Level: Low

Risk Code before Mitigation: 1

Mitigation: none required

PRad Target: Hazard Analysis

Vacuum/Thin Windows

- Volume of target chamber is less than 1 m³
(stored energy < 1000 ft•lbf)
- No thin windows on chamber

Consequence Level: Low

Probability Level: Low

Risk Code before Mitigation: 1

Mitigation: none required

PRad Target: Hazard Analysis

Cryogenics

- No cold components accessible by personnel (no PPE)
- No condensed gases in system

Consequence Level: Low

Probability Level: Low

Risk Code before Mitigation: 1

Mitigation: none required

Risk Code after Mitigation: 1

PRad Target: Hazard Analysis

Flammable Gas

- Target system contains about 0.09 g of hydrogen
- Qualifies as a “CLASS 0” installation (< 600 g)
- Hall B flammable gas monitoring
- Hydrogen vented out of hall via a dedicated, purged vent line
- Hydrogen service cylinder will be installed on the Hall B gas pad
- Inert system prior to any maintenance or repair

Consequence Level: High

Probability Level: Low

Risk Code before Mitigation: 3

Mitigation: NFPA code, ASME 31.12, minimization of ignition sources, VESDA, dedicated vent

Risk Code after Mitigation: 1

PRad Target: Hazard Analysis

Pressure systems

- Gas panel is only pressure system in the target
- Constructed according to ASME B31.3 (2012)
- Pressure relief handled at the gas cylinder, outside the experimental hall

Consequence Level: Medium

Probability Level: Low

Risk Code before Mitigation: 2

Mitigation: Compliance with ASME 31.3 (2012). Routine inspection, testing, and replacement of pressure system components.

Risk Code after Mitigation: 1

PRad Target: Hazard Analysis

Loss of Power

- The hydrogen supply valves to the target CLOSE
- Turbopumps stop, gate valves close
- The pulse tube cryocooler warms up, heater turns off
- Less than 30 milligrams of H₂ gas is trapped inside chamber, with no ignition sources energized.

Consequence Level: Medium

Probability Level: Medium

Risk Code before Mitigation: 3

Mitigation: Cryocooler shuts off, Hydrogen valves close, heater turns off.

Risk Code after Mitigation: 1

PRad Target: Status & Remaining Work

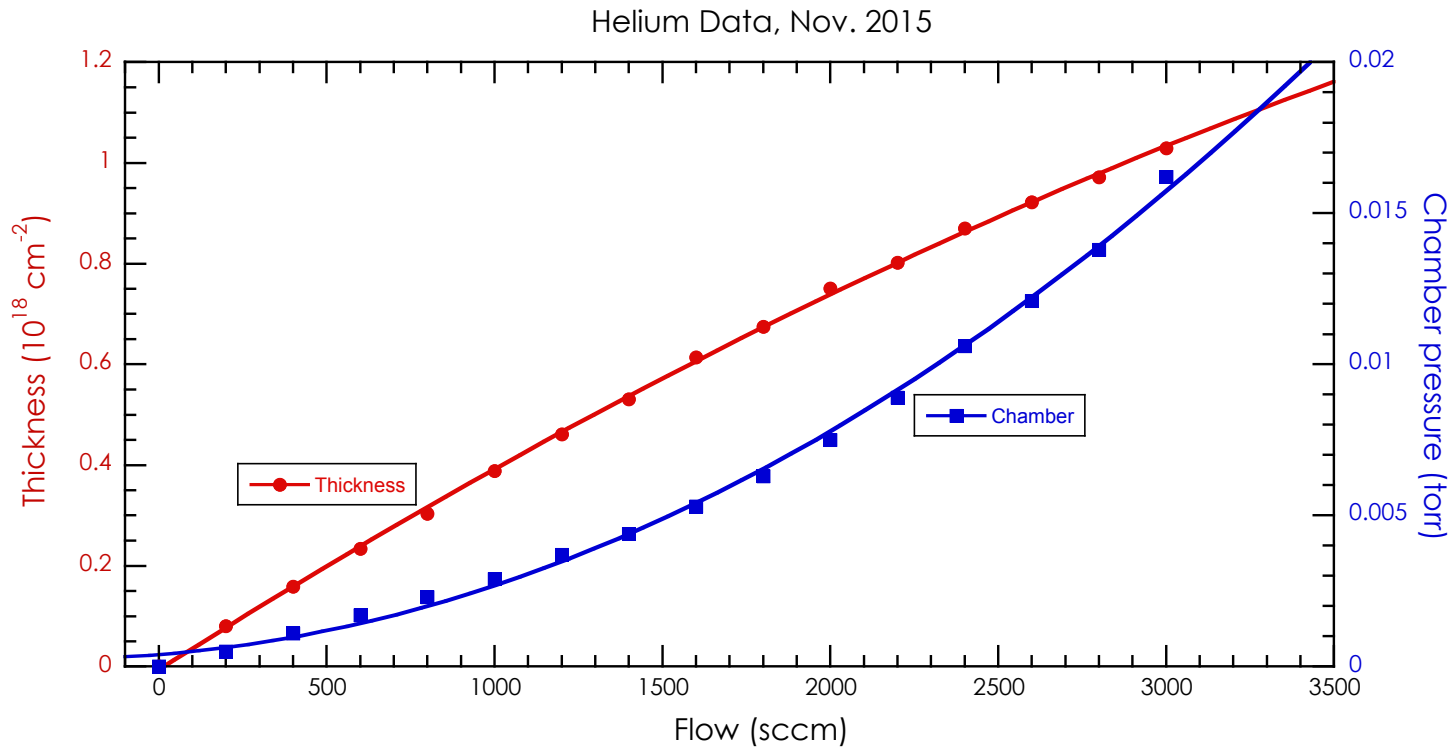
- Target system has been assembled and tested with helium gas in the EEL.
- No *major* problems to fix.

Remaining Work

- Fiducialize the target cell to survey markers on the target chamber.
- Develop an EPICS database for the target data
- Create a GUI and alarm handler for the Hall B counting house.
- Fabricate extension piping between H2 supply line and gas panel, and vent lines to Hall B vent header.



PRad Target: Performance



- Goal thickness of 10^{18} atoms/cm² (1 torr, 40 K) was achieved with 2600 sccm.
 - Chamber vacuum was a bit high, ~ 10 mtorr
 - Beamline vacuum also a bit high, $\sim 10^{-4}$ torr.
- ➔** Need to optimize pumping orifices between the chamber and beamline, and possibly add additional ones.

PRad Target: Installation schedule

A detailed installation schedule will require coordination with the Hall B work coordinator, Doug Tilles.

Estimated time required is ~ two weeks. May not be contiguous.

- JANUARY
- Transport components to hall (1 day)
 - Install chamber on beam line (1 day)
 - Install gas panel, chillers, etc in Hall B (2 days)
 - Reconnect system components(1 day)
 - New electrical & piping work (5 days)
 - Cool down and check out (1 day)

➔ PARK target during HPS...

- APRIL
- Survey and align (2 days)
 - Cool down (1 day)