PRad Target

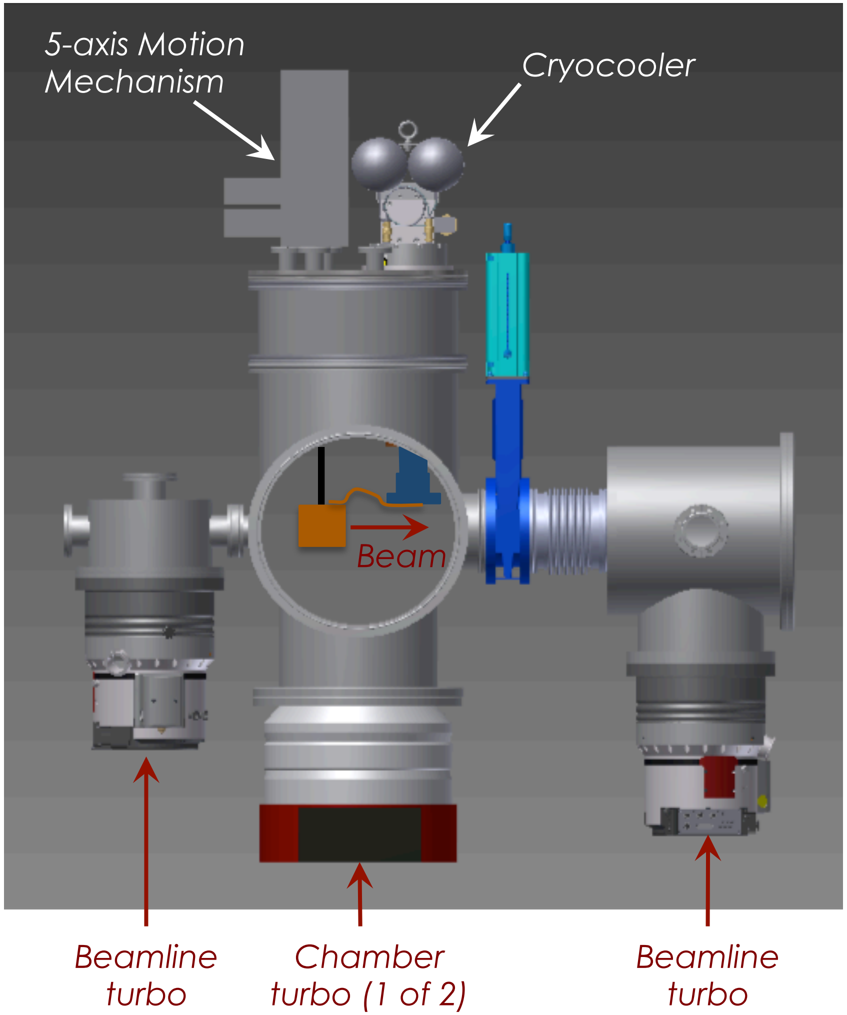
Chris Keith
JLab Target Group

- 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 ~5 x 10^{-3} torr
- Additional turbos up- & downstream maintain beamline vacuum ~10^{-6} torr

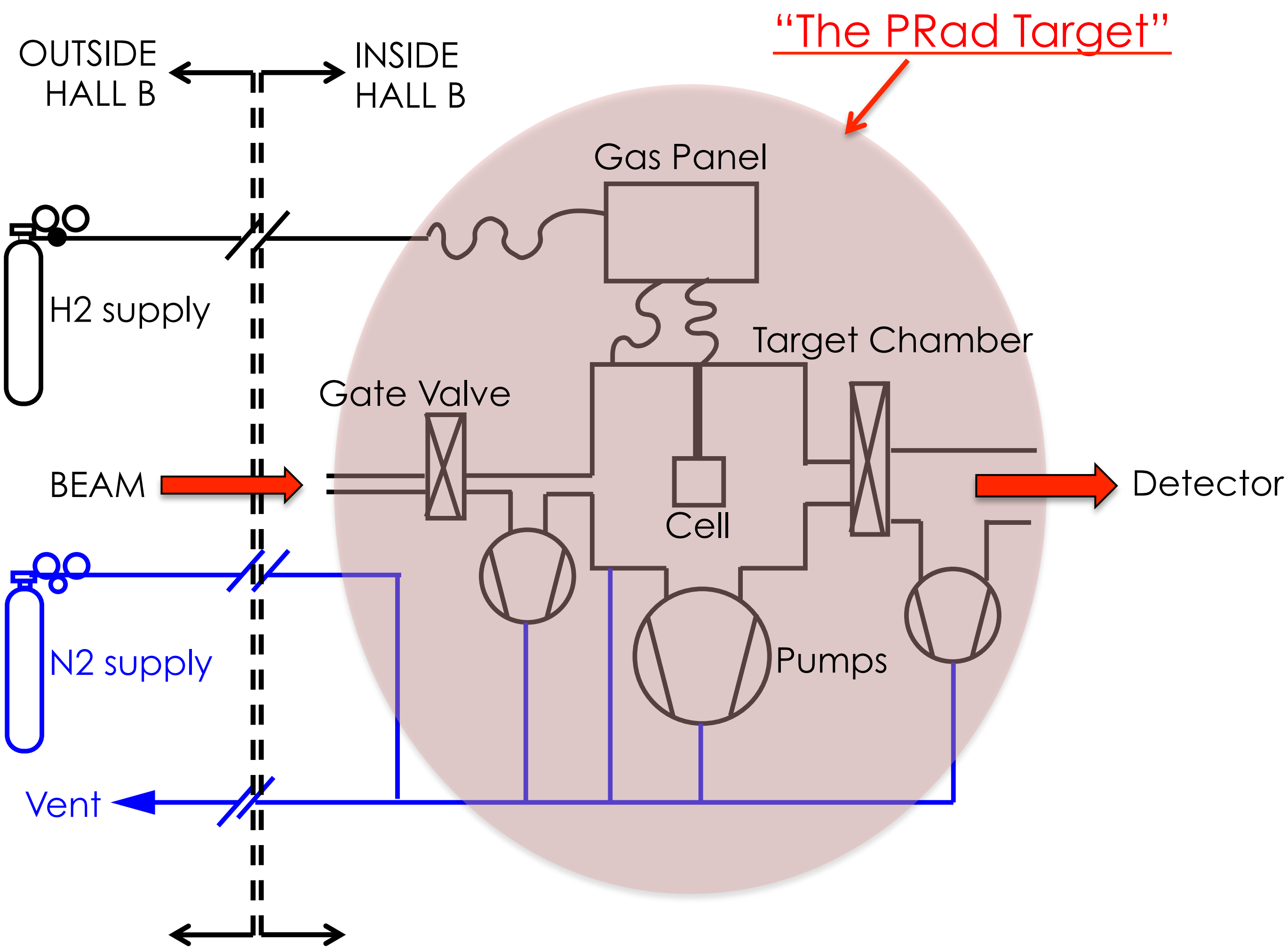


Proposal Specs

- Cell length, 4 cm
- Cell Pressure, 0.6 torr
- Temperature, 25 K

➔ 10^{18} H/cm^2

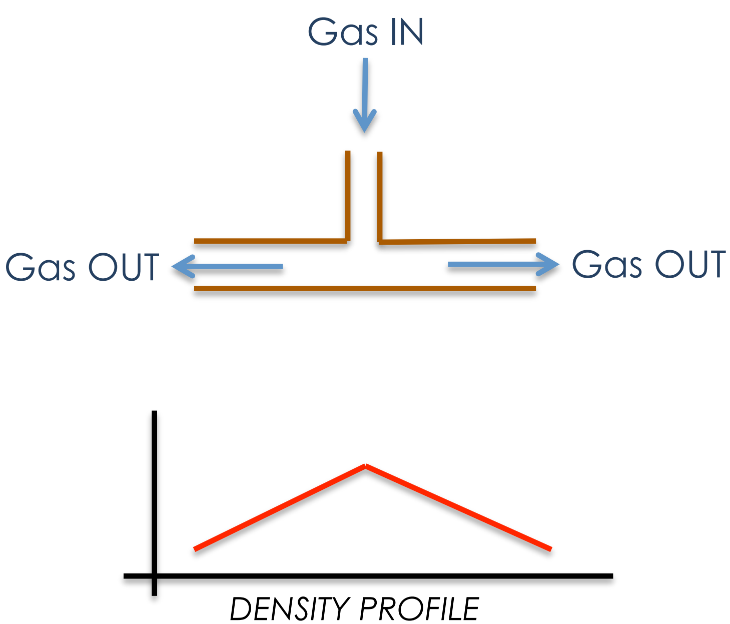
PRad Target: Definition



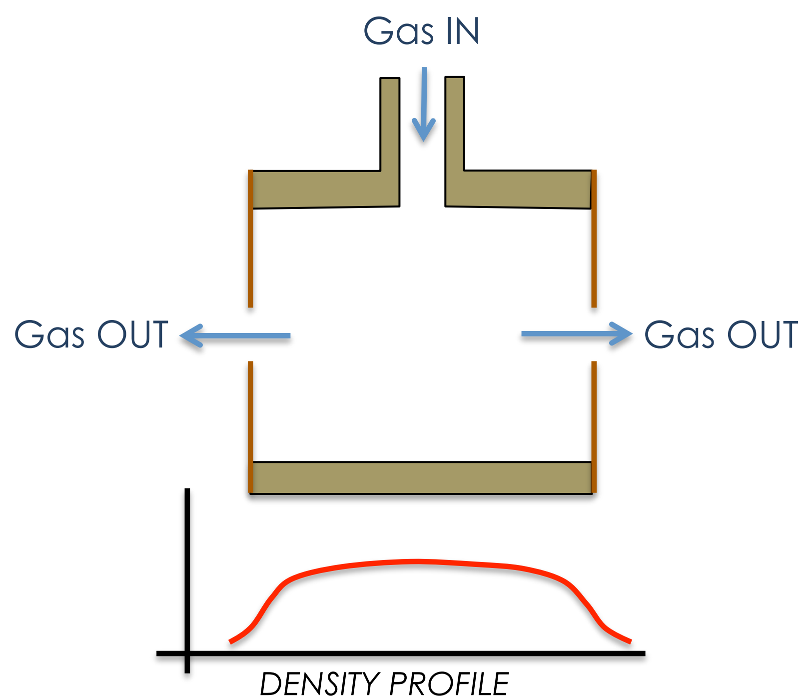
PRad Target: Components

The original design from the PRad proposal (a"kapton straw") has been replaced by a large copper cell with kapton windows (orifices for beam)

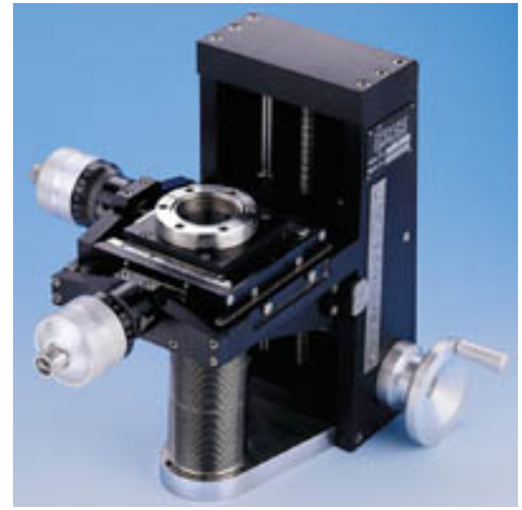
- 4 cm of kapton in beam halo
- Highly non-uniform density profile
- Non-adjustable dimensions



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



PRad Target: Components



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.

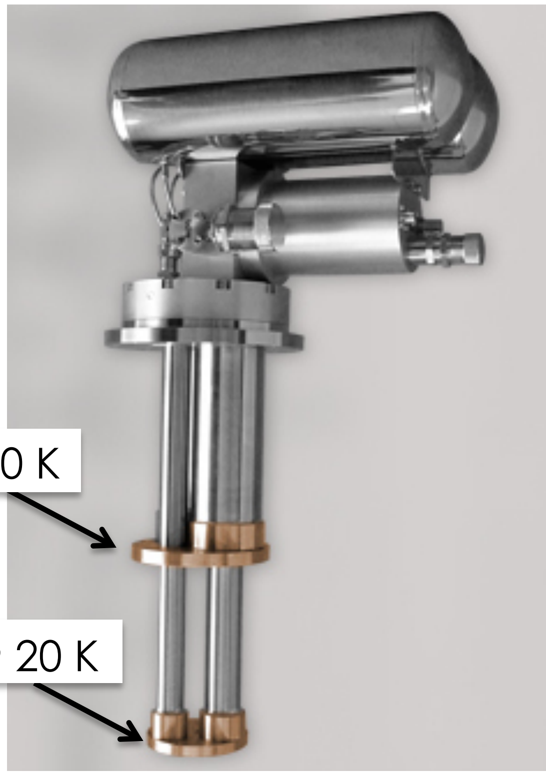
The hydrogen gas is metered into the cell (or directly to the chamber) by a precision mass flow controller, attached to the gas panel.

Spares? Yes.

PRad Target: Components

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

CryoMech PT810



Spares? Sort of…

LakeShore Model 336

- 100 W + 50 W

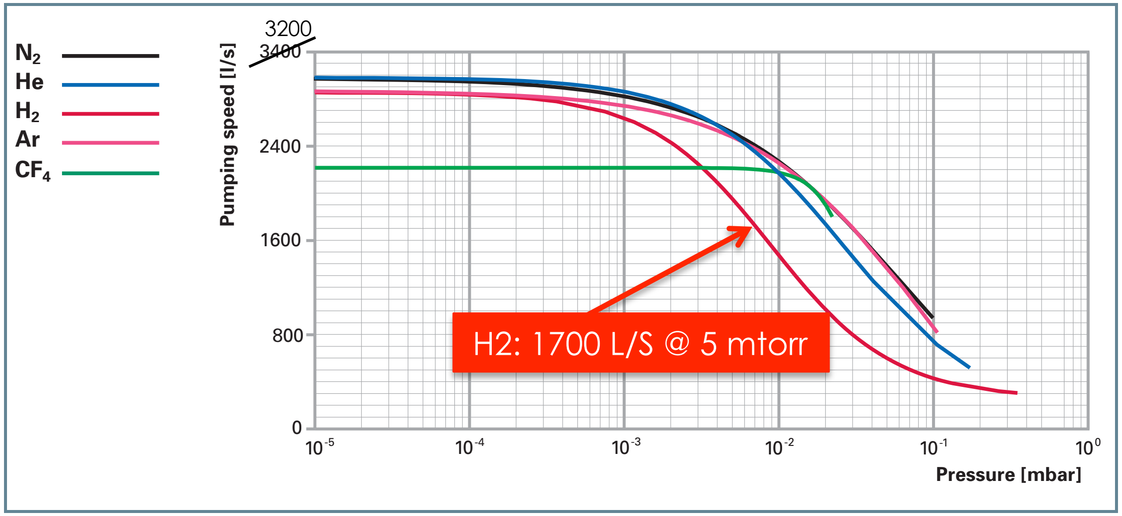
Spares? Yes.

PRad Target: Components

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

Spares? Sort of…

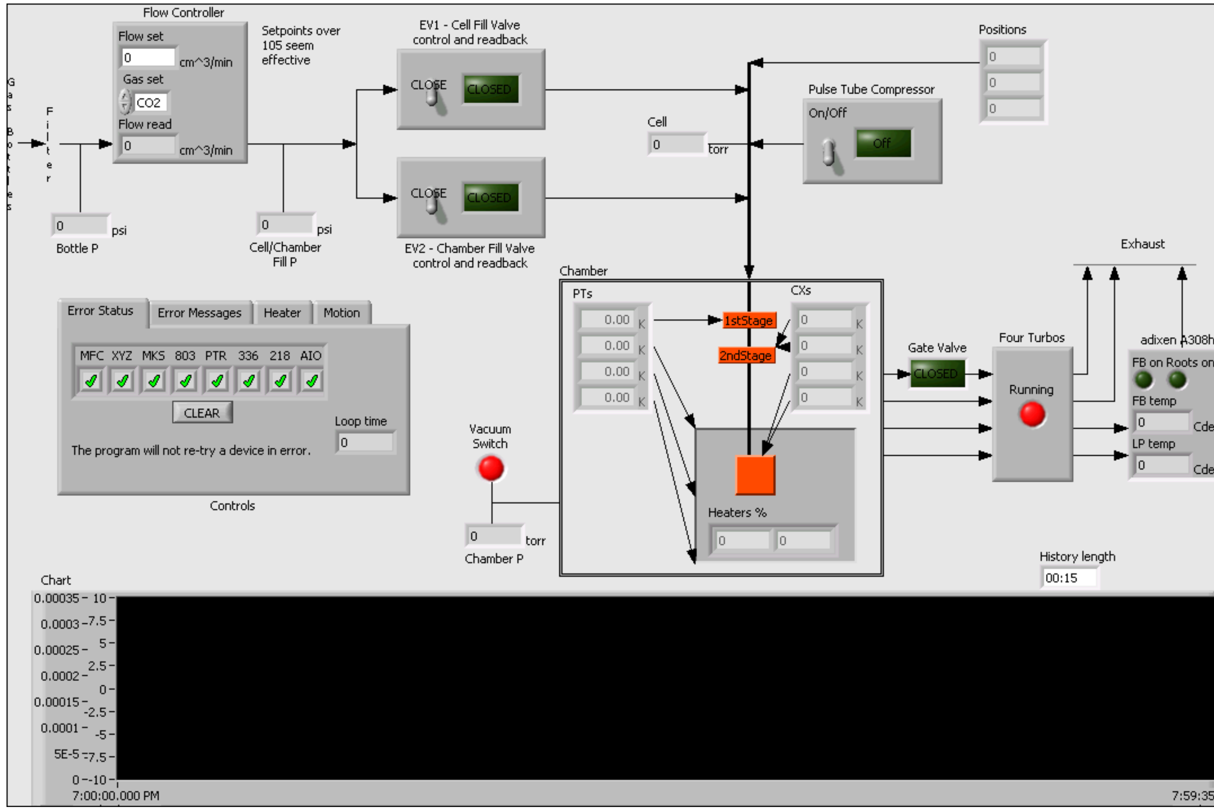
PRad Target: Control Software

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 m^3
  (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

Cryogens

- 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.

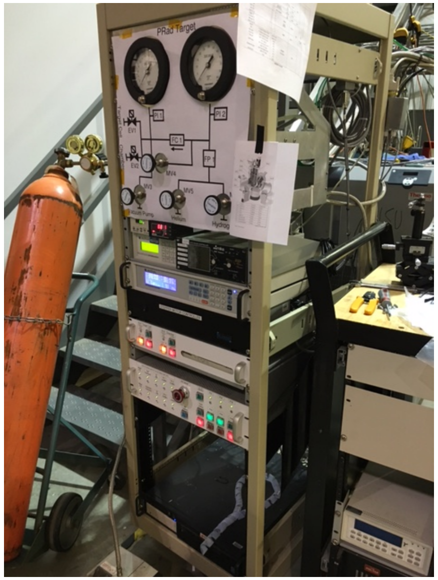
Consequence Level: Medium
Probability Level: Medium
Risk Code before Mitigation: 3
Mitigation: Cryocooler shuts off, Hydrogen valves close, heater turns off.
Risk Code after Mitigation: 1

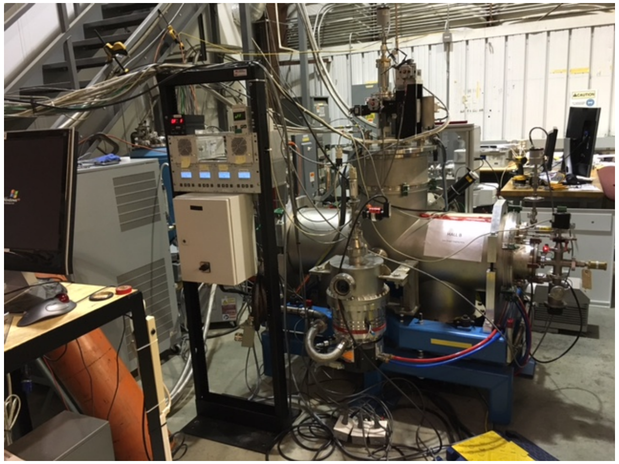
PRad Target: Status & Remaining Work

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

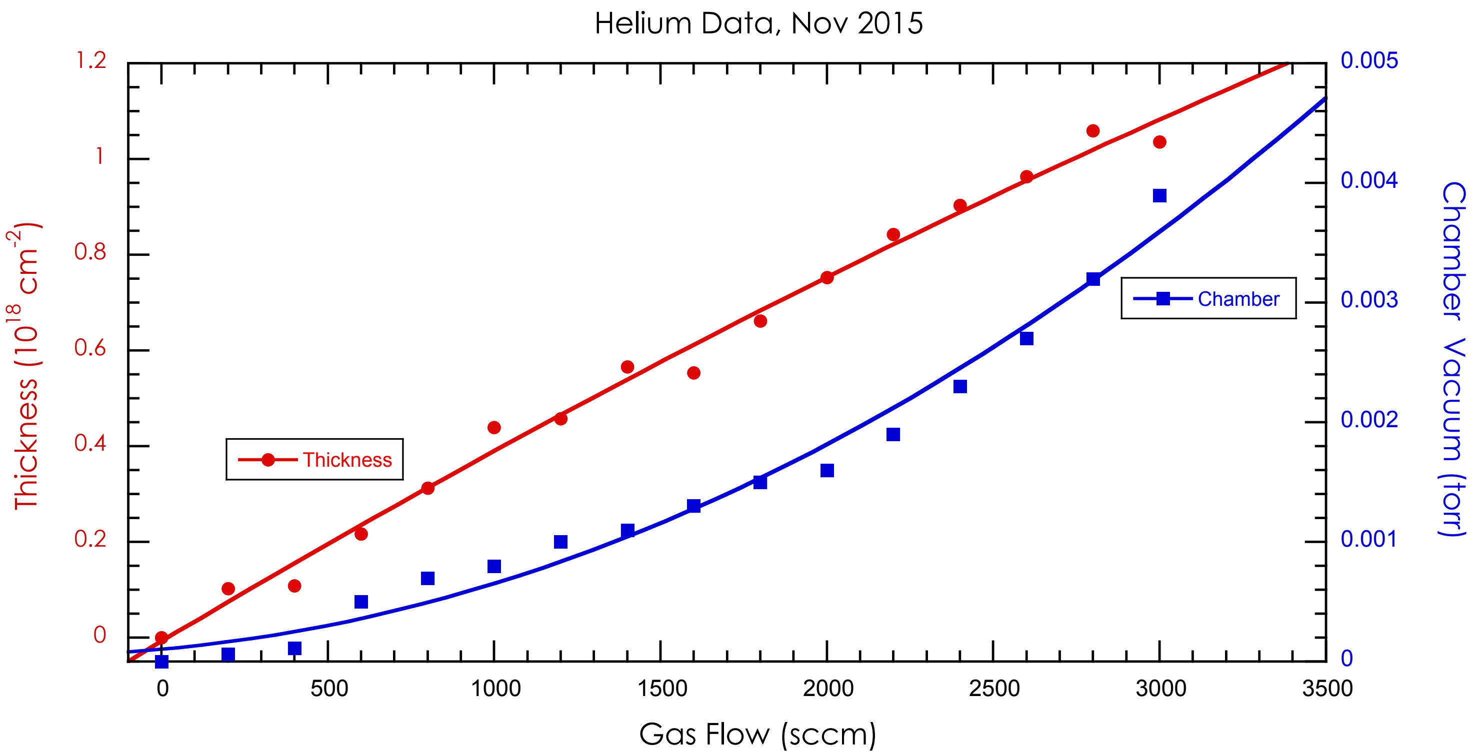
Remaining Work

- 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.





PRad Target: Performance



- Goal thickness of 10-18 atoms/cm2 was achieved with ~2600 sccm.
- Chamber vacuum was acceptably low at ~ $3 \cdot 10^{-3}$ torr
- Unfortunately, beamline vacuum > 10^{-4} torr.

➡ We will install pumping orifices between chamber and beamline.

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)