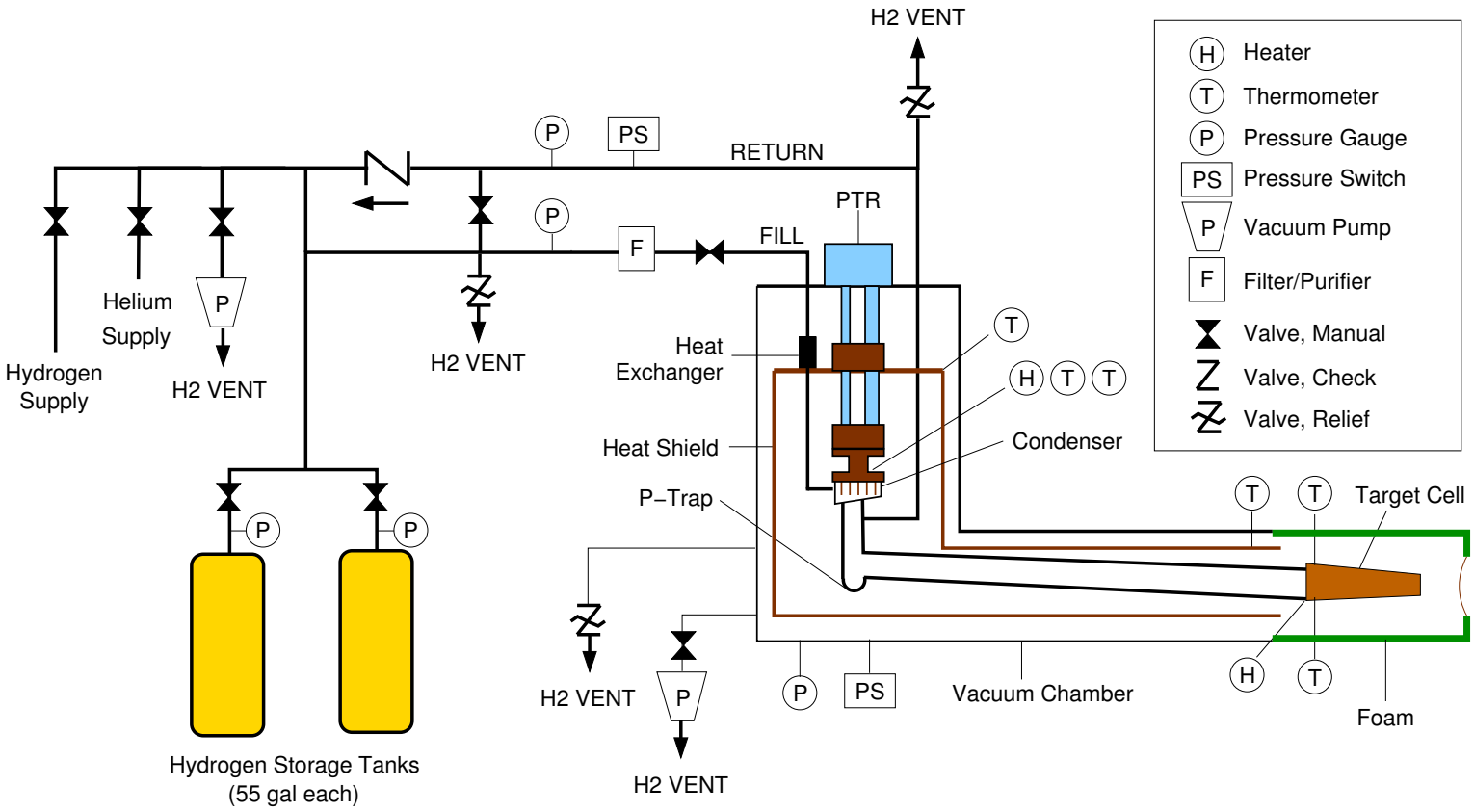
Hall D Cryotarget for Short Range Correlation Studies

Chris Keith
JLab Target Group

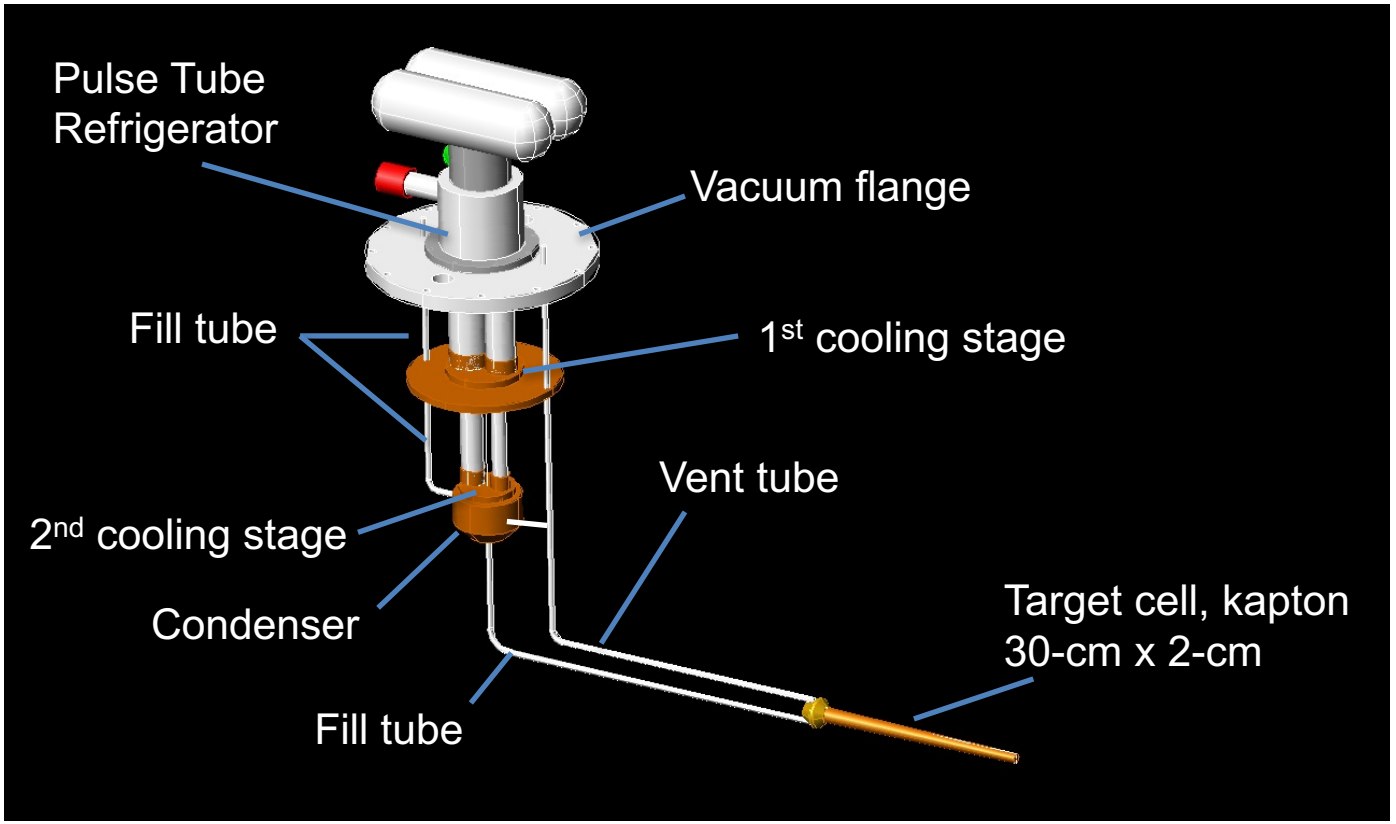
This presentation addresses Charge Item Two

Hall D Cryotarget: LH_2 & LD_2

GlueX Liquid Hydrogen Cryotarget



Hall D Cryotarget: LH_2 & LD_2



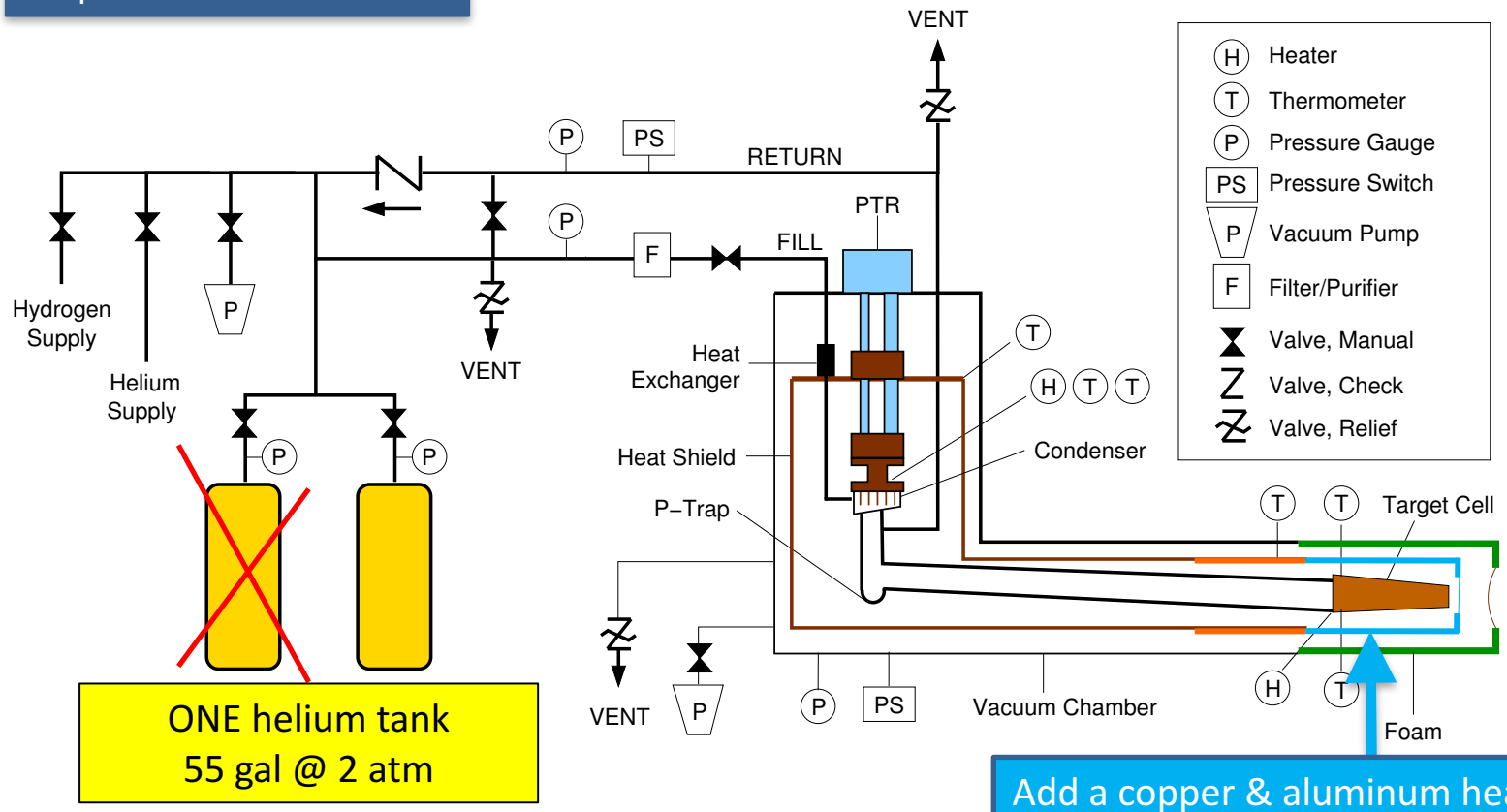
Liquid hydrogen (or deuterium) is condensed in the target cell, condenser, and fill & vent tubes.
The liquid is subcooled 1-2 K below the SVP curve to suppress boiling.

$\rho_{H2} = 71.2 \pm 0.3$ mg/cc

A similar accuracy is expected for D2

Hall D Cryotarget

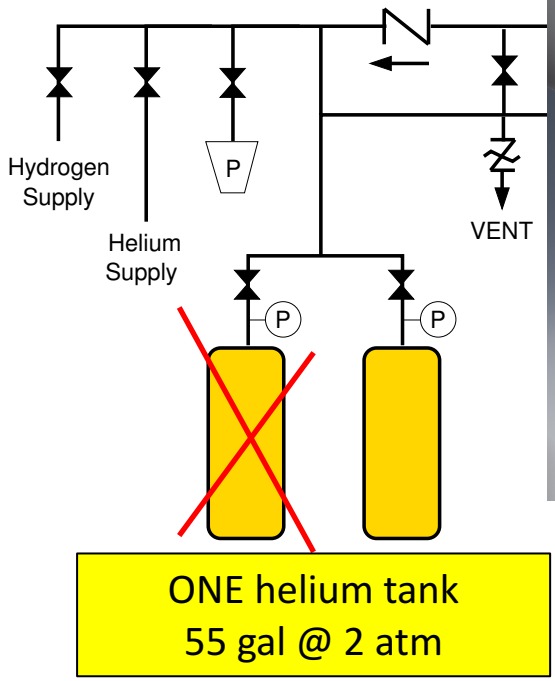
Modifications for Liquid Helium



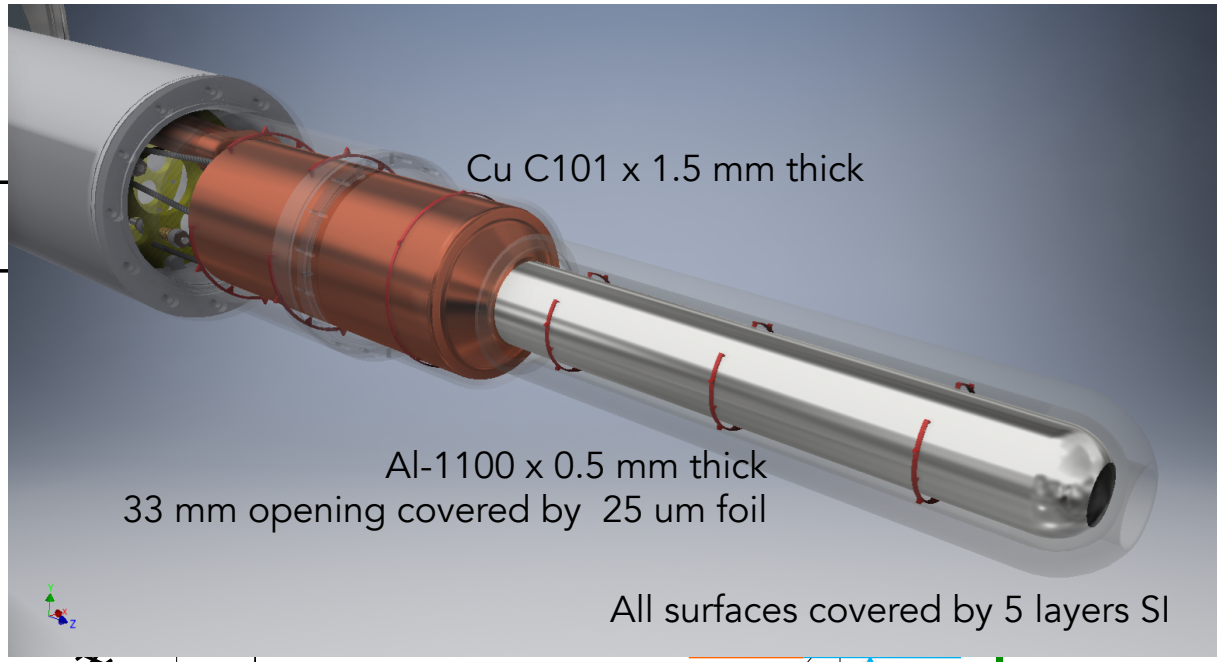
Add a copper & aluminum heat shield around the target cell.
To reduce overhead, the heat shield will also be in place during LD2 runs.

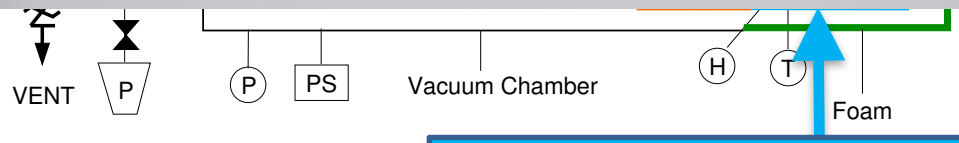
Hall D Cryotarget

Modifications for Liquid Helium



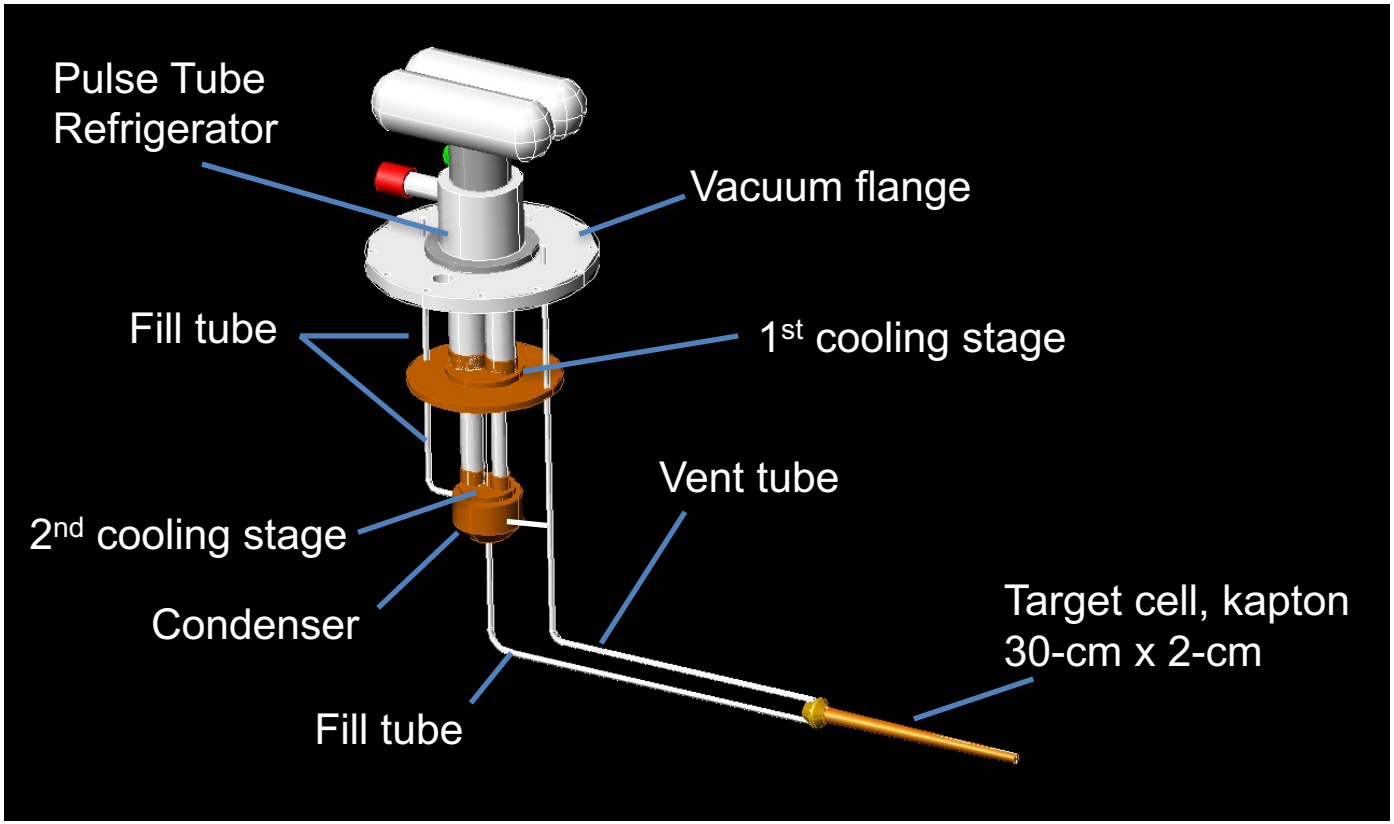
ONE helium tank
55 gal @ 2 atm





Add a copper & aluminum heat shield around the target cell.
To reduce overhead, the heat shield will also be in place during LD2 runs.

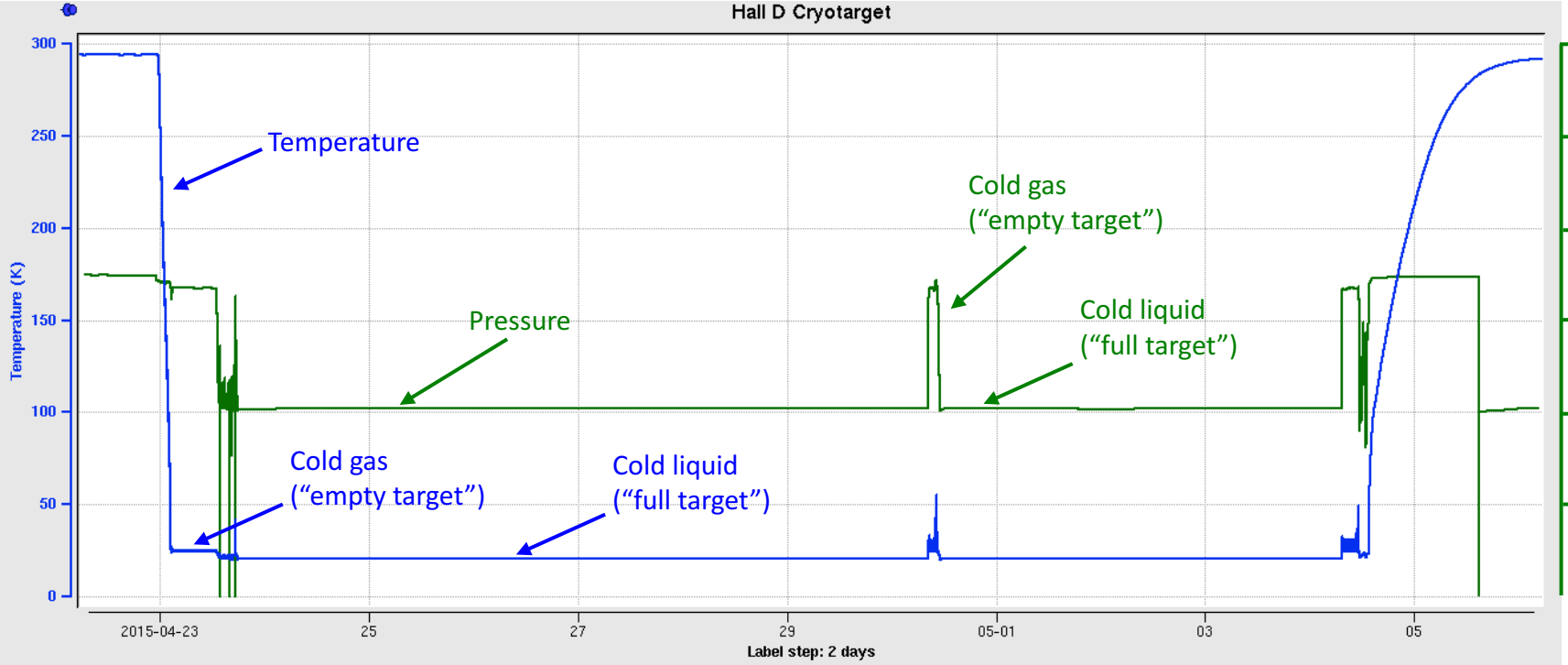
Hall D Cryotarget: LHe



In the case of LHe, only the target cell is filled with liquid.
Subcooling is not possible, and the liquid is on the SVP curve.
Some boiling is present.

$$\rho_{He} = 117 \pm 1 \text{ ? mg/cc}$$

Hall D Cryotarget: performance

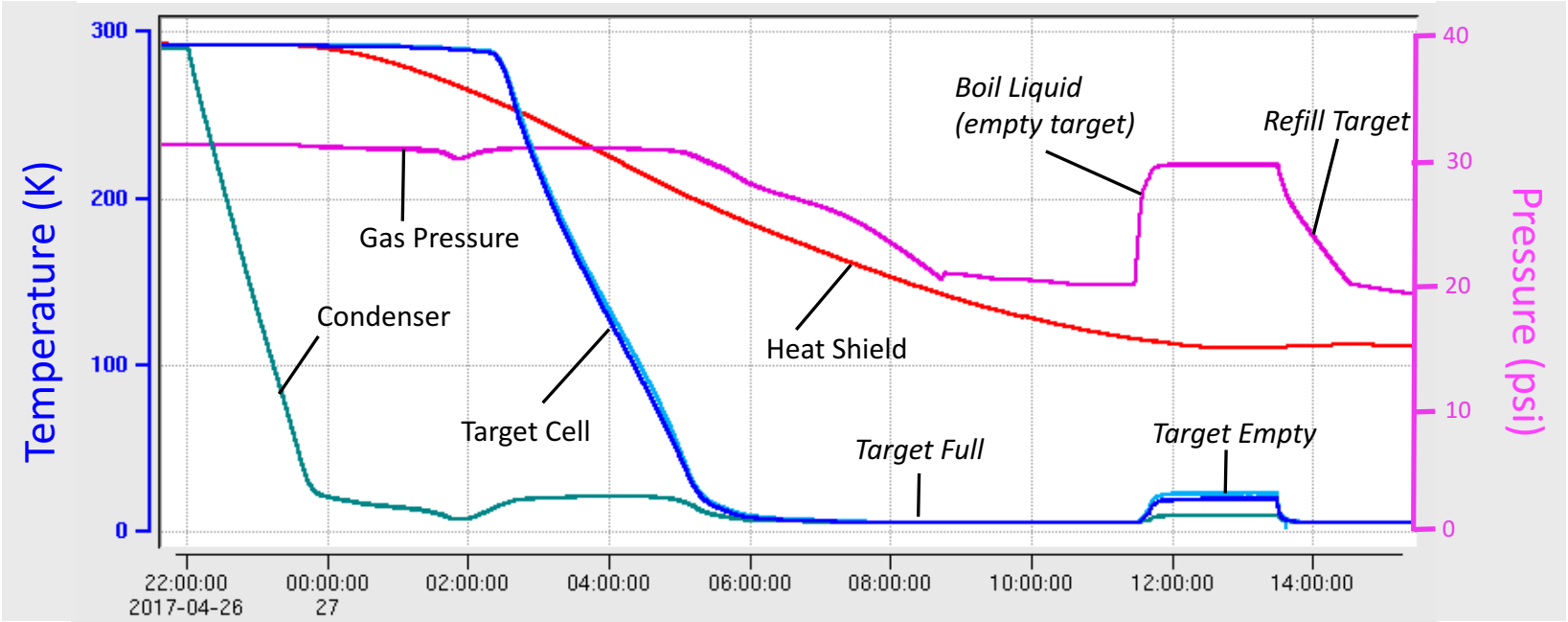


Liquid hydrogen

Cooling & filling target requires about 8 hours;
Emptying target takes ~15 minutes;
Re-filling target takes ~30 minutes;

Similar performance is expected for D2

Hall D Cryotarget: performance

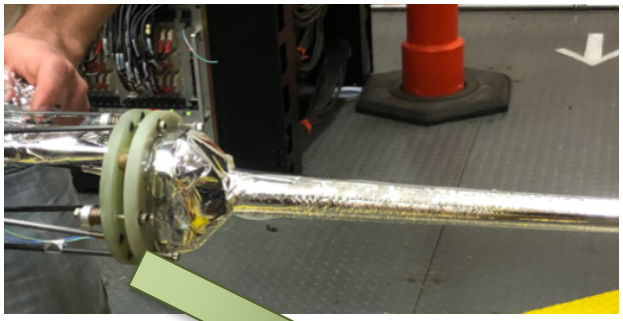


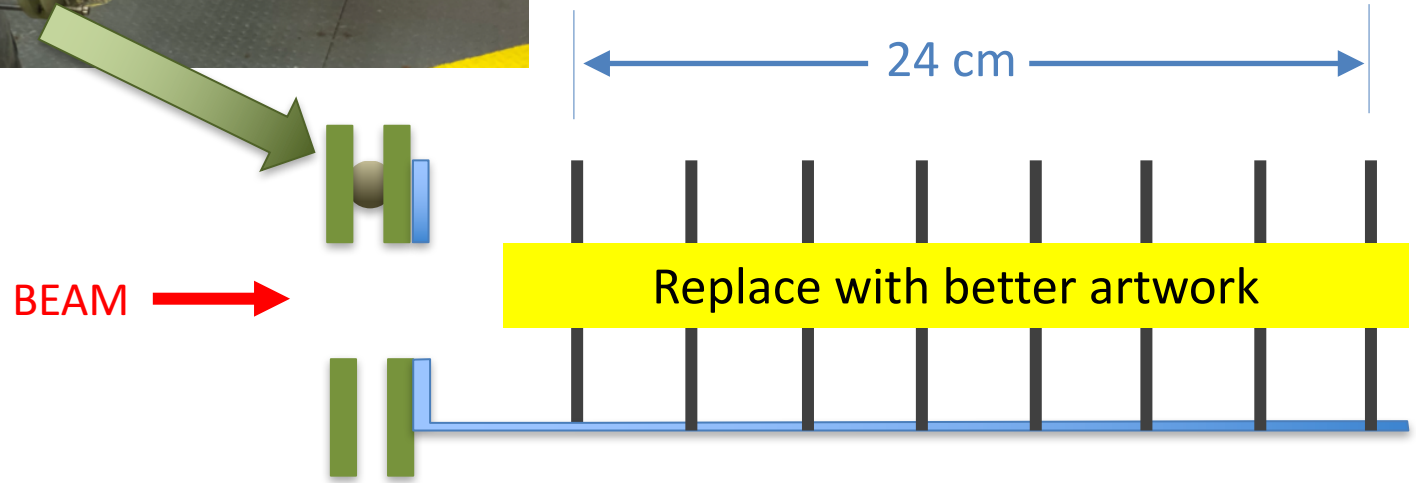
Liquid helium

Cooling & filling target requires about 12 hours;
Emptying target takes ~15 minutes;
Re-filling target takes ~45 minutes;

Hall D Cryotarget: carbon foil target

Alignment mounting & alignment fixture for cryotarget





Eight (3 cm x 3 cm) carbon foils, each 1.7 mm thick
(total RL ≈ 7%)

Hall D Cryotarget: safety considerations

The Hall D cryotarget has been approved for operation with hydrogen (GlueX) & helium (PrimeX)

- ASME B31.12 2011
- ASME BPVC VIII D1 2010
- ASME BPVC VIII D2-2013

Deuterium has same flammability properties as hydrogen

Deuterium has 17% higher expansion ratio than hydrogen

➢ storage pressure 32 ➞ 37 psia (OK, relief setting is 40 psi)

During Loss-of-Vacuum, deuterium has a lower pressure rise than H_2
(Relief calculation is on my inaccessible desktop PC)

Hand-waving argument:

Rate of gas volume (cc/s) generated during LoV

$$\dot{V} = \frac{\dot{Q}}{\mathcal{L}} \cdot \frac{R}{\rho_L}$$

Q = heat flux (W)
$\mathcal{L}$ = latent heat (J/g)
R = expansion ratio at SVP
ρ_L = density of liquid (g/cc)

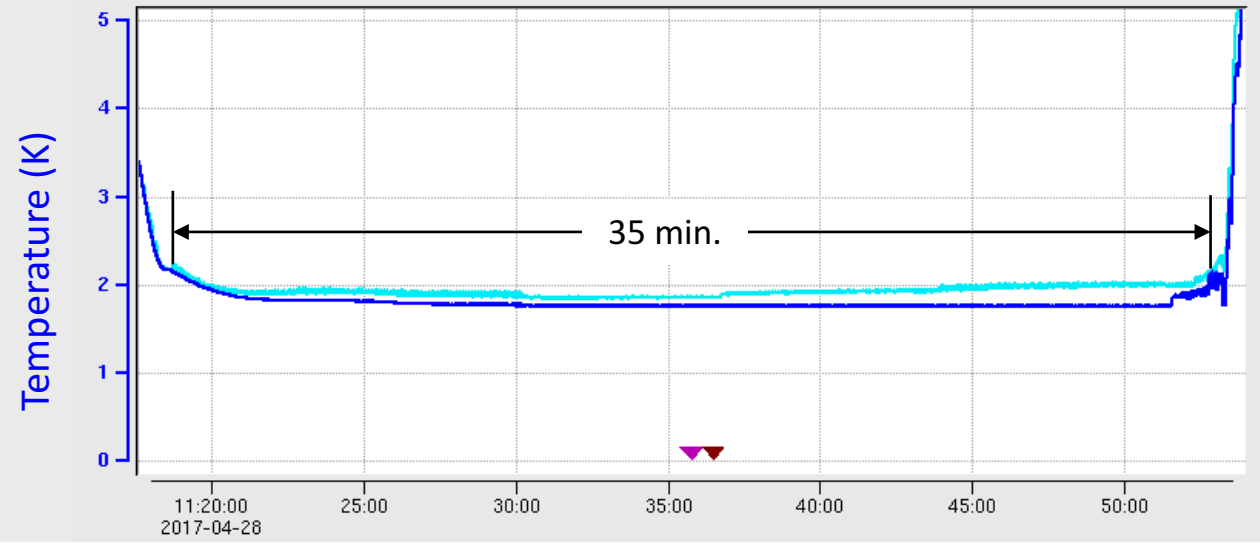
Hydrogen	Deuterium
0.68 cc/s per W	0.61 cc/s per W

Hall D Cryotarget for SRC

Summary

- The Hall D cryotarget has been approved and demonstrated work with both LH_2 and LHe
- It will also work with liquid deuterium (new alarm and heater settings)
- A simple array of carbon foils can be installed in the scattering chamber using the same mounting fixture as the cryotarget cell
- Remaining tasks:
  - Procurement of D2 gas (4 weeks)
  - Design, procurement, & assembly of carbon foil target (8 weeks)
  - Install & align carbon foil target (2 days)

A Helium Cryotarget for Hall D



Rough estimate of the density reduction from boiling

- 35 min. to pump 16 g of LHe from the cell ➡ boiling rate = 8 mg/s
- Latent heat $\mathcal{L}$(1.75 K) ≈ 23 J/g ➡ 0.18 W of heat
- Latent heat $\mathcal{L}$(4.55 K) ≈ 19 J/g ➡ 9 mg/s boiling rate @ 4.55 K
- The vapor density at 4.55 K is 23 mg/cm^3
- The vapor production rate is then 0.4 cm^3/s
- This means about 0.4% of liquid is displaced each second
- If bubbles stay in beam 1 sec, ~1% reduction of target thickness