Cryotarget Training

- Common Training for Hall A and C
- 12 GeV Era
Your Job (Do’s)

• Keep tgt safe & within specs
  – ~ 7 liters/loop of LH2!!!
  – ~ 2 MJ stored energy (cryogenic)
  – ~ 60 MJ chemical energy
• Monitor! Watch! Listen! Think!
• Service & log alarms
• Change targets (thru MCC)
• Respond to ESR changes with JT (page for big changes)
  – Keep 50-100 W reserve heater power for the PID
• Check raster, beam position, vacuum, cameras, etc.
• Log all target changes
• Target GUI screen captures to the logbook.
• Call target expert whenever you have a question!!
Don’ts

• Cooldown
• Warmup
  – unless asked to by an expert
• Manipulate gas panel
• Change alarm setpoints
  – Unless asked to do so by a tgt expert
• Leave tgt console unattended
• Fail to acknowledge alarms
• Let system go sub-atmospheric or more than 3 K below setpoint
• Move tgt while beam is on
• Fail to call an expert after a real problem
• Panic
# Experts

<table>
<thead>
<tr>
<th>Name</th>
<th>Work</th>
<th>Pager</th>
<th>Cell</th>
<th>Home</th>
</tr>
</thead>
<tbody>
<tr>
<td>J.P. Chen</td>
<td>7413</td>
<td></td>
<td>218-0722</td>
<td>867-7380</td>
</tr>
<tr>
<td>Greg Smith</td>
<td>5405</td>
<td></td>
<td>871-4371</td>
<td>565-9883</td>
</tr>
<tr>
<td>Silviu Covrig</td>
<td>6410</td>
<td>584-5411</td>
<td>(843) 697-1753</td>
<td></td>
</tr>
<tr>
<td>Dave Meekins</td>
<td>5434</td>
<td></td>
<td>968-9076</td>
<td>874-4750</td>
</tr>
<tr>
<td>Chris Keith</td>
<td>5878</td>
<td></td>
<td>746-9277</td>
<td>596-3002</td>
</tr>
<tr>
<td>Chris Carlin</td>
<td>5971</td>
<td></td>
<td>559-1269</td>
<td></td>
</tr>
</tbody>
</table>

If you need help, call on-call person 1st (posted in CR), then these people in the order listed. (use home # only as a last resort if off hours)
Basic Components

- LH2 & LD2 cells & re-circulation loops
- Re-circulation fan/pump (60 Hz)
- 1 kW (Helium) heat exchanger
  - He Supply ~ 14K, 12 atm
  - He Return ~ 20K, 3 atm
  - JT valve controls He flow
- 1 kW (max) heater (on PID)
  - replaces $P_{\text{beam}}$ & regulates LH2 temp
- T&P instrumentation
- Control System GUIs
- Gas Panel, Ballast tank, Electronics
- Motion System (vertical)
Loop Anatomy

- H2/D2 in/out
- HX
- He coolant in/out
- Fan
- JT Valve
- Heater
- Thermometer
- Pairs
- Beam
- ESR
- Upper cell blk (absent in ½ height cells)
- Cell/tuna can/tahini can
- Cell block (H2 manifold)
Target Specifications

LH2 (15 cm cell):

- $T = 19 \pm 0.01$ K
  ($T_F = 13.8$ K, $T_B = 22.2$ K)
- $P \sim 25 \pm 1$ psia
- $P_{\text{beam}} \sim 415$ W @ 80 $\mu$A
- Reserve power $\sim 75$ W
- Fan $\nu = 60$ Hz (25%)
- $\sim 2 \times 2$ mm$^2$ uniform raster (always on)
- $\rho = 0.0723$ g/cm$^3$
- $dE/dx \sim 4.8$ MeV/g/cm$^2$

LD2 (15 cm cell):

- $T = 22 \pm 0.01$ K
  ($T_F = 18.7$ K, $T_B = 25.3$ K)
- $P \sim 22 \pm 1$ psia
- $P_{\text{beam}} \sim 480$ W @ 80 $\mu$A
- Reserve power $\sim 75$ W
- Fan $\nu = 60$ Hz (25%)
- $\sim 2 \times 2$ mm$^2$ uniform raster (always on)
- $\rho = 0.167$ g/cm$^3$
- $dE/dx \sim 2.4$ MeV/g/cm$^2$
Parking

• 15K coolant sum rule:
  - \( \dot{m}_{Hall\,A} + \dot{m}_{Hall\,C} \leq 25 \, g/s \)

• You usually run 2 cryotargets *simultaneously*!
  - Only one is in beam at a time
  - So reduce power (park) the other!

• Parking means:
  - Reduce JT valve to minimize \( P_{tot} \sim 50\,W \)
  - Possibly also drop \( \nu_{fan} \) to 40 Hz
Useful Equations

\[
c_{p} \left( \frac{J}{gK} \right) = \frac{\Delta Q}{mT}
\]

\[
\Delta \rho / \rho \approx 1.5\% \Delta T \text{ (K)}
\]

\[
P_b (W) = I_b (\mu A) \ \rho (g/cm^3) \ t (cm) \ \frac{dE}{dx} (MeV/g/cm^2)
\]

\[
= 0.35 \ W/\mu A/cm \text{ (LH}_2\text{)}
\]

\[
= 0.40 \ W/\mu A/cm \text{ (LD}_2\text{)}
\]

(but add another \(~75\) W for reserve heater power)

<table>
<thead>
<tr>
<th></th>
<th>LH2 (19 K, 25 psia)</th>
<th>LD2 (22 K, 22 psia)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\rho ) \ (g/cm^3)</td>
<td>0.0723</td>
<td>0.167</td>
</tr>
<tr>
<td>(dE/dx) \ (MeV/g/cm^2)</td>
<td>4.8</td>
<td>2.4</td>
</tr>
<tr>
<td>(C_p) \ (J/g-K)</td>
<td>8.8</td>
<td>6.8</td>
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</tbody>
</table>
Bulk density reduction with $I_{beam}$ is real & must be measured.

New Covrig CFD-based cell design should help.

### Bulk Effect Slopes

<table>
<thead>
<tr>
<th>Target</th>
<th>Raster (mm x mm)</th>
<th>Fan Speed (Hz)</th>
<th>Slope (100 $\mu$A)$^{-1}$</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>$IH_2$, 4 cm ‘beer can’</td>
<td>1.1 x 1.1</td>
<td>60</td>
<td>-7%</td>
<td>Hall C, 1996 [7]</td>
</tr>
<tr>
<td>$ID_2$, 4 cm ‘beer can’</td>
<td>2.0 x 2.0</td>
<td>60</td>
<td>-4%</td>
<td>Hall C, 1996 [7]</td>
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<tr>
<td>$ID_2$, 4 cm ‘beer can’</td>
<td>2.4 x 2.4</td>
<td>60</td>
<td>-3%</td>
<td>Hall C, 1996 [7]</td>
</tr>
<tr>
<td>$ID_2$, 4 cm ‘beer can’</td>
<td>2.0 x 2.0</td>
<td>67</td>
<td>-2.4%</td>
<td>Hall C, 1997 [7]</td>
</tr>
<tr>
<td>$ID_2$, 12 cm ‘beer can’</td>
<td>2.0 x 2.0</td>
<td>67</td>
<td>-2.3%</td>
<td>Hall C, 1997 [7]</td>
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<tr>
<td>$IH_2$, 4 cm ‘beer can’</td>
<td>2.0 x 2.0</td>
<td>67</td>
<td>-1.1%</td>
<td>Hall C, 1997 [7]</td>
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<tr>
<td>$IH_2$, 4 cm ‘beer can’</td>
<td>2.0 x 2.0</td>
<td>40</td>
<td>-3.2%</td>
<td>Hall C, 1997 [7]</td>
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<tr>
<td>$IH_2$, 15 cm ‘beer can’</td>
<td>3.4 x 2.8</td>
<td>?</td>
<td>-5%</td>
<td>Hall A, 1997 [8]</td>
</tr>
<tr>
<td>$ID_2$, 15 cm ‘beer can’</td>
<td>3.4 x 2.8</td>
<td>?</td>
<td>-3%</td>
<td>Hall A, 1997 [8]</td>
</tr>
<tr>
<td>$ID_2$, 4 cm ‘tuna can’</td>
<td>2.0 x 2.0</td>
<td>60</td>
<td>-2.4%</td>
<td>Hall C, 1999 [9]</td>
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<tr>
<td>$IH_2$, 15 cm ‘cigar tube’</td>
<td>2.0 x 2.0</td>
<td>60</td>
<td>-19%</td>
<td>Hall C, 2001 [10]</td>
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<tr>
<td>$ID_2$, 15 cm ‘cigar tube’</td>
<td>2.0 x 2.0</td>
<td>50</td>
<td>-10%</td>
<td>Hall C, 2001 [10]</td>
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<tr>
<td>$ID_2$, 4 cm ‘cigar tube’</td>
<td>2.0 x 4.0</td>
<td>60</td>
<td>-7.2%</td>
<td>Hall C, 2000 [10]</td>
</tr>
<tr>
<td>$ID_2$, 4 cm ‘cigar tube’</td>
<td>2.0 x 4.0</td>
<td>60</td>
<td>-7.4%</td>
<td>Hall C, 2000 [10]</td>
</tr>
<tr>
<td>$ID_2$, 15 cm ‘cigar tube’</td>
<td>2.0 x 4.0</td>
<td>60</td>
<td>-12%</td>
<td>Hall A, 2002 [11]</td>
</tr>
</tbody>
</table>

Table 2: Bulk effect slopes: % change in apparent luminosity for a beam current change from 0 to 100 $\mu$A, from other JLab cryotarget studies.
Hall A Layout

Target gas panel

Beam

Target Electronics

Target
In the Hall

- Cryogen Temps
- Loop Temps
- JT control
- P readouts
Counting Room

• Target computer (controls, charts, etc.)
• TV cameras looking at tgt, Hall, tgt racks
• Manual heater controls
• Analog temperature & position readouts
• Target motion kill switches
• Documents (how-tos, phone #’s, etc.)
• Phone to call tgt expert
Counting Room Station

- New Temp readout (°K/10)
- New HPH Controls
- Low Pressure Alarms
- Emergency Lifter Crash
- Emergency HP Heater Shut Off
- Emergency JT Shut Off
Getting Started

Hall A:
- Log into poltarac.jlab.org as poltar. PW posted in CR.
- cd $GUI (／u/group/poltar/ctarg/Screens)

Hall C:
- Log into poltarcc.jlab.org as poltar. PW posted in CR.
- cd $GUI (／u/group/poltar/atarg/Screens)

Then in either Hall:
- Type ./tgtgui
- This will launch main GUI.
  - From main GUI, launch alh, strip charts, etc.
- Insure alh visible everywhere (each workspace), alh & logger running. Heartbeat OK?
  - Crack secondary GUIs from main GUI
**Adjusting the Heat Load**

- $P_{beam} \approx 450$ W at 80 $\mu$A, $P_{reserve} \approx 50-100$ W
  - For 15 cm LH$_2$ or LD$_2$
- With beam on, need $\approx 50-100$ W on HPH
- With beam off $\rightarrow$ 450+50=500 W on HPH
  - (if off a long time, can reduce)
- HPH power adjusted automatically
  - (in PID looking at $T_{loop}$ & $I_{beam}$)
- **To adjust, use JT:**
  - Open JT to increase HPH power
  - Close JT to lower HPH power
Changing Targets

- **Call MCC:** beam off, mask tgt motion FSD, explain which tgt you’re going to
- **From main GUI, click:**
  - *Target Motion,* then choose *Cryotarget Lifter*
  - Click on the chosen target button
  - Click on the *Move Target* button. Observe motion on TV. **Hit panic button if necessary.**
  - Note: light switch & dimmer pot on main console
  - Wait for green light to return, check position is OK.

- **Call MCC:** beam & FSD on, new $I_b$ & tgt
  - check $I_{beam}$ limit OK! Use operational restriction web page (link on cryotgt page)
- **Log configuration change**

**BDS positions** (~50k/mm)
Servicing Alarms

- Click on alh bar to open alarm tree GUI
  - Alarm OK?
    - Clear the alarm. Transients can happen.
  - Not OK?
    - May be telling you something (adjust JT?). Think!
    - If can’t understand why it’s alarming, call an expert.

- Log the event

- Change alarm limits only if asked to by an expert

- Alarm Colors:
  - RED: outside wide limits
  - Yellow: between narrow & wide limits
  - WHITE: Readout error
Alarm Handler GUI

File | Action | View | Setup
--- | --- | --- | ---

1. **General**
   - **Loop_Temps**
   - **MSC_Temps**
   - **Coolant**
   - **Pump**
   - **Heater**
   - **Pressures**

2. **QW-TARGET**
   - **General**
   - **Loop_Temps**
   - **MSC_Temps**
   - **Coolant**
   - **Pump**
   - **Heater**
   - **Pressures**

3. **QW-hp_power_R**
   - **LOLO**
   - **LOW**
   - **HIGH**
   - **HIHI**

**Execution Status:** Local Active

**Mask (CIMX):** Cancel,Disable,ndAck,ndAck1,ndLog

**Group Alarm Counts:** (ERROR,INVALID,MAJOR,MINOR,MONALARM)

**Channel Alarm Data:** Status,Severity,Unlock,Severity

**Filename:** ALH/queak,alhConfig

March 2014 | Hall A/C Tgt Training Talk
Check Logger/Archiver

- **Archiver** is a very useful tool for the TO:
  - [http://hallcweb.jlab.org/targetlog/](http://hallcweb.jlab.org/targetlog/)
  - Myaviewer in Hall A
  - List of EPICS variables on archiver startup screen
  - Check functionality at start of shift by plotting something like loop pressure

- **When making log entries, use keyword “target:”**

- **Query epics name:**
  - right-click in gui, choose “PV info”, then left-click on value wanted
  - Or use middle mouse button. Can drag name to striptool this way.
Rebooting the Target IOC

- Why? Heartbeat lost, stripcharts flat, white medm readouts, etc.
- Don’t panic. You can do this!
- Call MCC for beam off.
- Set manual HPH pot for appropriate power
- Monitor analog temps, fine-tune HPH, keep $|T - T_{goal}| < 1^\circ K$
- Reboot IOC from reboot GUI
- Wait 2 min. Check PID working again. Network up?
General advice for an off-normal event:

1. Think!
2. Don’t panic.
3. Respond if you think you understand what the problem is and what the proper response is.
4. You can almost always control the tgt manually with the manual heater, or the JTs, to keep it safe.
5. Reboot (rebooting solves many problems).
6. Call an expert unless you are 100% positive the problem has been dealt with successfully. For all but routine alarms, call expert anyway.
7. Log the problem.
High Loop Temperature Alarm

No real danger. Just delays.

1. Ask MCC to turn off the beam
2. Check other TS’s, & analog temp. r.o.
   1. If just PID TS → change PID TS
4. HPH should be @ 0W. If not turn it off.
5. SC vacuum OK?
   Turbopump tripped? Call tech-on-call (Hall A or Hall C)
6. Coolant $T_{\text{supply}}$ abnormally high?
   1. Close offending JT
   2. May be ESR/CHL or xfer line IV failing...
Low Loop Temperature Alarm

Danger: freezing the H2

1. Leave the beam on (OK if it trips off)
2. Check other TS's, & analog temp. r.o.
   1. If just PID TS → change PID TS
3. HPH should be railed.
   1. Check if HPH $P_{\text{max}}$ is set high enough (in GUI)
   2. Is Coolant (ESR) $T_{\text{supply}}$ abnormally low?
      1. This happens after an ESR compressor trip. Close JT some.
4. Is PID or HPH PS broken?
   1. Use manual HPH to restore Loop temps by hand
      1. Look at analog temp readout
   2. May need to slowly close JTs some.
Low Loop Pressure Alarm

1. Diurnal pressure variation?
   1. Check archiver to see recent history. (see next slide)

2. Gas panel problem? System can’t breathe:
   1. If SC vacuum also bad →
      1. Potential H2 leak. BAD. Call expert.
   2. If SC vacuum OK →
      1. Call expert to check valves or
      2. Call expert to add H2 to the system

3. Temps too low?
   1. See low temp procedures
Ballast tank is outside, and is affected by sun, $T_{\text{air}}$
- $P \propto T$.
- Ex: $\Delta T = 15\degree C$ (5%) $\rightarrow \Delta P = 1$ psi

Systematic effect on target $\rho$ negligible.

Questions? Use the archiver!

1000 gallon tanks
Warm storage pressure is ~50 psia

$y = -0.2495x + 76.507$
$R^2 = 0.9981$
High Loop Pressure Alarm

1. Diurnal pressure variation?
   1. Check archiver to see recent history.

2. Temps high? Turn off the beam.
   1. System is warming up.
   2. Warm (storage) pressure ~ 50 psia.
   3. See High temp alarm procedures:
      1. Probably a vacuum pump has tripped, or the LH2 pump has tripped.
      2. Call expert if problem or solution not obvious.

Danger: Bursting cell window
Vacuum Alarms

No Danger. Just delays & headaches.

1. Monitor vacuum stripcharts over ~ days.
   1. SC vacuum should be < 1x10^{-6} Torr

2. Turbopumps:
   1. Scatt chmbr, downstream beamline
   2. Can close beamline GVs to isolate & diagnose problem

3. If one tripped, reset ASAP (see cryotgt web page)
   1. Call Hall techs to reset
   2. GVs close automatically at ~ 5x10^{-5} Torr
   3. Can develop ice on tgt, bad for expt.
      1. May have to warmup to eliminate the ice

4. May be GVs on turbos closed: Open them.

5. Other possibility: H2 leak or o-ring leak.
   1. Call expert.
Non-Target fire in the Hall

Danger: Obvious

1. Sound the fire alarm & evacuate Hall.
2. Call 911.
3. Call 5822.
4. Call MCC.
5. Close GVs on both sides of the SC.
7. Call the target expert.
LH2 Pump Trip

1. **Turn off the beam immediately**
   1. To avoid overheating cell windows

2. **Expect T to drop at first, then rise**
   1. Thermal siphoning may help some

3. **Takes time (~20 min) to leave VP curve (phase transition)**

4. **Reset pump controller asap**
   1. Reset from GUI if possible.

5. **If pump reset fails, call an expert asap.**
   1. Reduce coolant flow to avoid freezing HX (D2 loop)

6. **If pump is toast (eg bearing failure) so are we.**
   1. Call an expert, warmup tgt.
Breach of system in the Hall
(H2 release into Hall)

Danger: System leak, hydrogen fire or explosion.
EXTREME HAZARD!

1. Evacuate the Hall
   1. Careful: H2 flame is colorless
2. Shut off pump and heater
3. Do not operate lifter, JTs, etc.
4. Call cryo to shut off coolant
5. Call experts to pump & purge system, ...
Power Failure

1. System is designed to handle this event safely, passively.
   1. Call tgt expert.
   2. GVs will close, generates an FSD, kills beam.
   3. Pump & heater will stop. Vacuum will begin to spoil.
      1. Use heater kill switch also
   4. TS’s, JT’s, & control computer are on UPS.
   5. Close JT’s. Very important if ESR still up & sending coolant to the target.
      1. If you can’t, call MCC to get cryo on call to stop coolant at source in case it has not already stopped.

Danger: Freezing H2, blocking relief path
Heater Failure

Danger: Could freeze H2/D2, & turn the HX into an ice cube.

1. There are two redundant relief paths:
   1. On either side of HX. Or pump.
2. PID problem? Reboot.
3. If heater PS fails, use secondary (manual) heater power supply (like you do for an IOC reboot)
   1. Power cycle the primary HPH PS- this usually fixes problem
4. If neither PS works, heater coil may be shorted.
5. Then reduce JT valves. Can control tgt temp with reduced JTs alone, without a heater (manually).
   1. Call expert. May have to warmup and repair.
1. Control room (GUI) computer fails:
   1. Monitor analog temp readout, use aux HPH if needed
      1. Log in to tgt computer in the hall & start GUIs
      2. Or, log in to another tgt computer in the counting room
   2. Reboot tgt computer (or power cycle it)
      1. Restart GUIs & strip charts.
      2. Tgt operation should be OK, you’re just blind while it’s down

2. Tgt IOC Fails: (white fields, flatlined charts):
   1. Check if network is up
   2. If it’s the IOC, follow IOC reboot procedure

Danger: You are blind, don’t know what is going on.
Target Training Requirements

• For all new TO’s:
  - **Oral Training course**
  - Practical:
    • training in CR with expert
    • ~ half shift practice in CR with a TO

• For already-trained:
  - Training course
    • recommend to attend oral training class
    • must at least read training slides online
  - Practical:
    • short training in CR with expert
Cryotarget Web Pages

Hall A:
http://halla.web.jlab.org/equipment/targets/cryotargets/Halla_tgt.html

Hall C: from Hall web page
http://www.jlab.org/Hall-C/

Target group:
https://userweb.jlab.org/~ckeith/

Contents:
• Control system guide
• How-tos
• Contacts
• FAQs
• This talk
• Goal parameters
• Thicknesses
• Documentation
• Etc.

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J e f f e r s o n  L a b  H a l l  A
Cryogenic Target System

Links to Hall C and Target group web sites:
- Hall C Cryotarget webpage
- Target group webpage

Hand A Cryotarget Operational Safety Procedure (OSP):
- Guide for Normal Running
- Safety Assessment Document
- User's Guide

How to become a Hall A/C cryotarget operator:
- If you have not been trained before, you need to
  1) take a training class, you can write to the target experts (J.P. Chen, Greg Smith, Silvia Covioli) to arrange a class;
  2) take a practical training with a target expert;
  3) practice for — half a shift with an experienced TO.

- If you have been previously trained,
  1) you are recommended to (but not required) take a training class. You must at least read the training slides.
  2) take a practical training with a target expert.

After completing the training, please send an email to notify the target experts.

Information for Cryotarget Operator (Updated 3/2014):
- Target Operator Training Slides
- Target Operator Responsibilities
- What Each Target Operator Should Know
- Whom to call for help
- Frequently asked questions
A Typical Shift
(what you’ll really wind up doing)

- Monitor tgt parameters
- Service the occasional alarm
- Log target parameters & changes
- Change targets
- Adjust JT in response to ESR changes
- Rare tgt IOC reboot

That’s all!
Done!

• Remember to get practical training with an expert and practice ~ half shift with a trained operator to complete your practical

• Then email jpchen@jlab.org, smithg@jlab.org and covrig@jlab.org that you have completed your training

• Read documentation available from the Cryotarget website

• Stay cool!