Target Training

1. Theory: This talk (~ 1½ h)
   • theory, basics, reference, bkg. Questions answered …

2. Practical: Sit ~½ shift with trained tgt operator
   • explore, find buttons, try things!

3. Email smithg@jlab.org that you have completed steps 1 & 2

4. Read How-tos, control system guide, etc.
   • http://www.jlab.org/~smithg/target/Hall_C_Cryotarget.html
Essential Responsibilities

• At start of your shift:
  – Verify power settings, configuration, program
  – Verify alarm handler & logger are functional
  – Make sure alh visible in all workspaces
  – Complete the checklist

• Log alarms, configuration changes

• Service alarms from lowest level in tree

• Contact MCC before & after tgt motion

• Know the essential “How-tos” at www.jlab.org/Hall-C/ in the Cryogenic Target link
Your Job (Do’s)

- Keep tgt safe & within specs (~8 litres of LH2!!)
- Monitor! Watch! Listen! Think!
- Service & log alarms
- Change targets (thru MCC)
- Respond to ESR changes with JT
  - Keep ~100 W reserve heater power for PID
- Log configuration changes, etc. Fill out the checklist.
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
  – At least email me about it
• Leave tgt console unattended
• Fail to acknowledge alarms
• Let system go sub-atmospheric or more than 3K below setpoint
• Move tgt while beam is on
• Panic
### Experts

<table>
<thead>
<tr>
<th>Name</th>
<th>Work</th>
<th>Home</th>
<th>Pager</th>
<th>Cell</th>
</tr>
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<tbody>
<tr>
<td>Greg Smith</td>
<td>5405</td>
<td>565-9883</td>
<td>584-5405</td>
<td>(yes)</td>
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<tr>
<td>Mike Seely</td>
<td>5036</td>
<td>223-1216</td>
<td>584-5036</td>
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<tr>
<td>Dave Meekins</td>
<td>5434</td>
<td>874-4750</td>
<td>584-5434</td>
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<tr>
<td>Chris Keith</td>
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<td>596-3002</td>
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<tr>
<td>Thia Keppel</td>
<td>7580</td>
<td>855-5883</td>
<td>584-7580</td>
<td></td>
</tr>
</tbody>
</table>

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**Target pager is 584-5543**

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If you need help, call these people in the order listed. (pager first if off hours)
Basic Components

- LH2 & LD2 cells & re-circulation loops
- Re-circulation fan/pump (60 Hz)
- 800 W (max) heater (on PID) to replace $P_{\text{beam}}$
- 800 W (Helium) heat exchanger
  - He Supply ~ 14K, 12 atm
  - He Return ~ 19K, 3 atm
  - JT controller on He Supply
- T&P instrumentation
- Control System
- Gas Panel, Ballast tank, Electronics
Gep Targets

• 20 cm LH₂ machined cell (X₀~2.3%)
  – Tgt center 1.5115” downstream of nominal/HMS center
    • Cell & entrance window longer than usual to provide 120° clearance
• 4 cm LH₂ machined cell (normal center)
• Optics tgts: 0.173 g/cm² ¹²C foils
  • One foil at z=0
  • Two foils at ±2 cm, 2 at ±3.8 cm, 2 at ±7.5 cm
  • 5 foils at z=0, ±3.8, and ±7.5 cm.
• Dummy targets: 0.263 g/cm² Al 6061-T6
  – One 20 cm dummy (matched to z-offset of LH₂ cell)
  – One 4 cm dummy
• Other tgts: BeO viewer, empty, and a thick (~4 mm) C.
• One spare loop with empty 4 & 20 cm cells
• For January ’08: One loop with two 15 cm cells, 1 of which with a Cu radiator ~1.2mm (X₀~8.4%)
Gep Cells made September, 2007
New Features

• 20 cm LH2 cell
  – Offset z
• New cell block design
  – Opens flow bottleneck
  – Should improve \( \frac{dp}{\rho(I_{\text{beam}})} \)
• Rebuilt fans
• Scattering chamber first used first last spring
## H Target Specifications

### LH2 (20 cm cell):

- **T = 19 ± 0.01 K**  
  \((T_F = 13.8 K, T_B = 22.2 K)\)
- **P ~ 24 ± 1 psia (9 psig)**
- **\(P_{beam} \sim 550 W @ 80 \mu A\)**
  - (110 W for the 4cm tgt)
- Reserve power ~ 100 W
- Fan \(\nu = 60 Hz (25\%)\)
- 2x2 mm\(^2\) uniform raster (always on)
- **\(\rho = 0.0723 \text{ g/cm}^3\)**
- **\(dE/dx = 4.84 \text{ MeV/g/cm}^2 (@ 4 \text{ GeV})\)**

### LD2 (20 cm cell):

- **T = 22 ± 0.01 K**  
  \((T_F = 18.7 K, T_B = 25.3 K)\)
- **P ~ 24 ± 1 psia (9 psig)**
- **\(P_{beam} \sim 630 W @ 80 \mu A\)**
- Reserve power ~ 75 W
- Fan \(\nu = 60 Hz (25\%)\)
- 2x2 mm\(^2\) uniform raster (always on)
- **\(\rho = 0.1674 \text{ g/cm}^3\)**
- **\(dE/dx = 2.42 \text{ MeV/g/cm}^2 (@ 4 \text{ GeV})\)**
Loop Anatomy

H2/D2 in/out

He coolant in/out

HX

Fan

Heater

Upper cell blk (absent in ½ height cells)

Cell/tuna can/taehini can

Thermometers

beam

Cell block (H2 manifold)
Fan & Heat Exchanger

10/17/2007
Spring-03
G. Smith: 12
Goal Parameters

- **H2**: $T=19.00 \pm 0.02$ K, $P\sim23 \pm 2$ psia
- **D2**: $T=22.00 \pm 0.02$ K, $P\sim23 \pm 2$ psia
- **ESR**: $T\sim14 \pm 1$ K, $P\sim12$ atm, $m\sim17$ g/s
  - Note $\Sigma(A+C) < 25$ g/s!
- **Fans**: 60 Hz (25%)
- **Heaters**: $P_{\text{tot}} = P_{\text{beam}} + P_{\text{reserve}} \sim 550 + 100 \sim 650$ W at 80 $\mu$A
Parking

• You are running 2 cryotargets simultaneously!
  – Only one is in the beam, so reduce power on the other!

• If you know one will not go in beam for at least a day → park it (reduces ESR load)

• Park means:
  – Close JT to minimize $P_{\text{reserve}} \sim 50W$
  – possibly also drop $\nu_{\text{fan}}$ to 40 Hz

Better not to mess with fans unless you absolutely have to!
## Basic Equations

\[
C_p = \frac{\Delta Q}{m \Delta T}
\]

\[
\Delta T = \frac{dE/dx (\text{MeV/g/cm}^2) I_b (\mu A)}{c_p (\text{J/gK}) d_{\text{raster}} (\text{cm}) v_s (\text{cm/s})}
\]

\[\Delta \rho / \rho \approx 1.5\% \Delta T\]

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

<table>
<thead>
<tr>
<th>Where:</th>
<th>LH2 (19K, 23 psia)</th>
<th>LD2 (22K, 23 psia)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\rho) (g/cm(^3))</td>
<td>0.07231</td>
<td>0.1674</td>
</tr>
<tr>
<td>(dE/dx) (MeV/g/cm(^2))</td>
<td>4.8 @ 3 GeV</td>
<td>2.4 @ 3 GeV</td>
</tr>
<tr>
<td>(C_p) (J/gK)</td>
<td>8.8</td>
<td>6.8</td>
</tr>
</tbody>
</table>
Note: Normally have an additional 50-100 W of reserve power.
Gep07
Cryostack

- Loop 1 (15cm, Cu rad)
- Loop 2 LH2 (4 & 20 cm) (spare?)
- Loop 3 LH2 (4 & 20 cm)
- Optics Sled
- Dummy Targets
- Solid Targets
Gep07
Solid Targets

Empty Frame

BeO

Cu

Thin C

Thick C

empty
Cryostat

JT’s, Gas & Coolant lines

Lifter Mechanism

Bellows

Scattering Chamber
- Lift/rot. controllers
- Loop 1 & 2 Temps
- Loop 3 Temps
- Cryogen Temps
- JT control
- Tachometers
- Fan controllers
- HPH power supplies
- P readouts
- Loop 1 & 2 Temps
- Loop 3 Temps
- Cryogen Temps
New Hall C Target (4/07)

• Completely new scattering chamber (~copy of Hall A):
  – Cryostack centered on S.C. axis
  – No separate solid tgt ladder or cryostack rotation
  – Pivot bored out to provide more vertical motion
  – Nominal S.C. i.d. 41”, 2” thick Al
  – HMS window:
    • 8” high, $5.5^\circ < \theta < 103^\circ$,
    • 0.016” thick at $r = 22.5”$
  – SOS window:
    • 15” high, $24^\circ < \theta < 101^\circ$,
    • 0.020” thick at $r = 23.75”$

• Completely new loop plumbing
  – but old cells, cell blk, fans, hx’s, etc.

• New octal Lakeshore temperature controllers
• Some changes to control guis
Ballast Tanks

H2
D2
G0
**Diurnal ΔP**

- Ballast tank outside, and $P \propto T$.  
  - Ex: $\Delta T=15^\circ C$ (5%) $\rightarrow \Delta P=1$ psi
- Systematic effect on target $\rho$ negligible:

![23 psia LH2 density vs temp](image)

- 23 psia
- 25 psia
- 27 psia
- Linear (23 psia)

$$y = -0.2495x + 76.507$$

$R^2 = 0.9981$
Archived $\Delta P$

- 5 days in December, G0 tgt
Recommended Studies

• Position scans
  – Horizontal (crucial!)
  – Vertical (less sensitive)
  – Move beam in small steps across the target

• Luminosity scans
  – Characterize boiling vs $I_{\text{beam}}$
  – Watch tracking efficiency (Eric)
  – Use cuts to define e’s in HMS cleanly
4cm Tuna Can Boiling

Hydrogen Target, 7/15/99

(Tuna/Tahini Can, E94-110, from E. Christy)

Slope = (-2.4 +/- 0.2)% / (100 uA)
Counting Room Station

- New HPH Controls
- Alarms
- Emergency lifter crash
- Tgt guis (jeffylab)
- FSD Status
- New Temp readout (°K/10)
- Loop1
- Loop2
- Loop3
- Panic buttons
- TV controls
Getting Started

• log into jeffylab.jlab.org as cvxwrks
  – PW is ____________
• cd $GUI  (/u/group/poltar/ctarg/Screens)
• 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
New Main GUI

Heartbeat

Alarm Handler

Secondary GUI buttons

Strip Charts
Alarm Handler

- Alarm Handler GUI must be visible in each workspace
- If not running, from main GUI click:
  - Charts & Alarms in upper right corner
  - Choose Start TCL Alarm Handler
  - Load appropriate alarm file (usually ctarg.alh)
- Alarm Colors:
  - Red: major, outside wide limits
  - Yellow: minor, outside narrow limits
  - White: readout error
- Alarm Color States:
  - Steady: alarm condition was transient
  - Flashing: alarm condition is active
Servicing Alarms

• Click on alh bar to open alarm tree GUI
• Click lit main branch (left side) text button
• Click lit sub-branch (right side) “P” button
• On this new GUI look at the alarming sub-branch. Shows current value and all the alarm limits.
  – OK? → click lit button left of sub-branch to 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 Handler GUI

1. [Diagram](image1)
2. [Diagram](image2)
3. [Diagram](image3)
0. [Diagram](image0)
StripTool

- Watch out: vertical scale only appropriate for selected color. Have to click on desired variable to see its scale!
- Horizontal Scale: Buttons in lower left corner of the graph
- If you zoom, you may also want to right justify!
- Vertical Scale: Right-click inside graph to bring up controls dialog
Cryostat & Loop GUIs
Check Logger

- From main GUI:
  - Type `ps -e | grep ArchiveEngine` on a control computer xterm
    - OK? Then 3 instances will be listed
    - Not OK? You get nothing back. This should never happen, since cron checks for it. But if it does:
      - Then, type `cd /Archives`
      - Then, type `/start_archiver`
  - When making hclog entries, use keyword “target:”
  - Archiver: [http://jeffylab.jlab.org/~cvxwrks/](http://jeffylab.jlab.org/~cvxwrks/)
    - Very useful to see history of any target parameter
    - Query epics name: right-click in gui, choose “PV info”, then left-click on value whose name you want
Checklist

• From main GUI, click the
  – chart/alarms/checklist button
  – Select Checklist
• This overwrites the file
  ~/Ctarg/Checklist
• Print the file with the command:
  /apps/bin/pdq –Pchchp2
  Checklist
  (from the appropriate
directory)
• Output look OK? Put into
  binder.

OR

• Use ksnapshot
to put a picture
of the main gui
and/or the
stripcharts into
hclog
Adjusting the Heat Load

- $P_{\text{beam}} \approx 150$ W at 100 $\mu$A, $P_{\text{reserve}} \approx 50-100$ W
  - For 4 cm LH2/LD2
- With beam on, need $\approx 50-100$ W on HPH
- With beam off should have $\approx 250$ W on HPH
  - (if off a long time, can reduce)
- HPH power adjusted automatically
  - (in PID looking at $T_{\text{loop}}$ & $I_{\text{beam}}$)
- To adjust, use JT:
  - Open JT to increase HPH power
  - Close JT to lower HPH power
Lifter, Heater, & JT GUIs

Note: It takes ~1/2 minute to see effects of a JT change

0 < Step ≤ 2%
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 the green light to come back, check you are where you should be. Tgt motion slower now.
  – Close the relevant GUIs

• Call MCC: beam & FSD on, new \( I_b \) & tgt
  – check \( I_{beam} \) limit OK! Use operational restriction web page (link on my cryotgt page)

• Log configuration change

BDS positions (~50k/mm)

10/17/2007 Spring-03 G. Smith: 42
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 pots for appropriate power
  – LH2 & LD2 will differ depending on which was in beam (beam power + reserve).
• Flip appropriate manual HPH switches on.
• Monitor temps via TV, fine-tune HPH pots.
  – TV image bad, so use DVMs in counting room!
HPH Pot Settings

![Graph showing HPH Pot Settings with a curve relating Pot Setting to Heater Power (W).]
Rebooting the Target IOC, ctd.

- On DAQ/CODA reboot GUI, enable buttons, then click on tgtIOC (hcvme4) reboot button. Wait ~2 min. until heartbeat, green lights, medm fields, etc. come back.
  - if network is down, IOC won’t come back! Keep trying every 5-10 minutes.
- Keep monitoring TV/DVM temps! Adjust pots as necessary, keep $|T-T_{\text{goal}}| < \sim 0.5^\circ \text{ K.}$
- PID OK? Then flip manual HPH switches back off. Check that PID is “pidding”. Heartbeat? Stripcharts? TV temps OK?
- Call MCC for beam back. Log event in hclog.
Temp., Press., & Fan GUIs

60Hz = 25%
Emergency Procedures

Why? ESR crash, power failure, LOV, etc.

• Ask for beam off if not already off.
• **Call an expert.** May advise controlled access.
• If T climbing, turn off heaters.
• Fan speeds to 20 Hz, then power off when T > 30K.
• Keep close eye on loop pressure, must not go sub-atmospheric. In certain situations, expert may ask you to hit the 2 panic buttons (HPH & JT).
  – Normally, after boil-off P rises to 40-45 psia.
  – You can’t save tgt by opening JT’s if the ESR has crashed. Let it go.
• Tgt expert may ask you to do a warm-up over the phone (together, & only thru MCC). See link in Cryogenic Target at www.jlab.org/Hall-C/
### $\rho (T, P)$

#### Hydrogen

<table>
<thead>
<tr>
<th>$T$ (K)</th>
<th>$P$ (psig)</th>
<th>$\rho$ (H2) (g/cm$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.5</td>
<td>8.22</td>
<td>0.07283</td>
</tr>
<tr>
<td>19.0</td>
<td>“</td>
<td>0.07231</td>
</tr>
<tr>
<td>19.5</td>
<td>“</td>
<td>0.07176</td>
</tr>
<tr>
<td>19.0</td>
<td>7.35</td>
<td>0.07230</td>
</tr>
<tr>
<td>“</td>
<td>8.22</td>
<td>0.07231</td>
</tr>
<tr>
<td>“</td>
<td>9.09</td>
<td>0.07231</td>
</tr>
</tbody>
</table>

#### Deuterium

<table>
<thead>
<tr>
<th>$T$ (K)</th>
<th>$P$ (psig)</th>
<th>$\rho$ (D2) (g/cm$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.5</td>
<td>8.3</td>
<td>0.16868</td>
</tr>
<tr>
<td>22.0</td>
<td>“</td>
<td>0.16743</td>
</tr>
<tr>
<td>22.5</td>
<td>“</td>
<td>0.16613</td>
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<tr>
<td>22.0</td>
<td>7.3</td>
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</tr>
<tr>
<td>“</td>
<td>8.3</td>
<td>0.16743</td>
</tr>
<tr>
<td>“</td>
<td>9.3</td>
<td>0.16744</td>
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# Energy Loss

<table>
<thead>
<tr>
<th>$P_e$ (GeV/c)</th>
<th>LH2 (MeV/g/cm$^2$)</th>
<th>LD2 (MeV/g/cm$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.63</td>
<td>2.32</td>
</tr>
<tr>
<td>2</td>
<td>4.74</td>
<td>2.37</td>
</tr>
<tr>
<td>3</td>
<td>4.80</td>
<td>2.40</td>
</tr>
<tr>
<td>4</td>
<td>4.84</td>
<td>2.42</td>
</tr>
<tr>
<td>5</td>
<td>4.88</td>
<td>2.44</td>
</tr>
<tr>
<td>6</td>
<td>4.90</td>
<td>2.46</td>
</tr>
</tbody>
</table>
Beam Currents

- Beam tuning: drop out of beam, $\leq 100 \, \mu A$
- Moeller runs: we won’t have any!
- LH2/LD2 runs: raster on, $\leq 140 \, \mu A$
- Dummy runs (optics): raster on, $\leq 40 \, \mu A$
- C runs: $\leq 100 \, \mu A$ raster on, 20 raster off
- Halo runs: raster on, $\leq 20 \, \mu A$ (careful!)

http://opweb.acc.jlab.org/internal/ops/ops_webpage/restrictions/ops_restrictions.php
Ortho-Para Conversion

\[ P = n^+ - n^- = \tanh(\mu H/kT) \]

With \( \mu_p = 8.8 \text{ eV/T}, k = 8.6 \text{ eV/K}, \)

\( T=19K, \) and \( B_\Phi \sim 0.5 \text{ G}, \)

\( P \sim 3 \times 10^{-9}. \)

But: at 19K, \( H_2 \) is 99.8 % para-\( H_2 \) (25% @ STP)

\( \Rightarrow \) Drops \( P_{\text{eff}} < 10^{-11}. \) Even if \( A=1, \) this drops below radar.

Note: ortho \( \Rightarrow \) para transition rate catalyzed by radiation & trace paramagnetic centers (pre-)existing in the SS tgt loop.
Cryotarget Web Page

From Hall C Web page:
www.jlab.org/Hall-C

Cryotarget link

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

10/17/2007
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 changes at ESR
• Occasional tgt IOC reboot

That’s all!
Done!

- Remember to sit ~½ shift with a trained operator to complete your practical
- Then email smithg@jlab.org that you have completed your training
- Read documentation available from the Hall-C Cryotarget website
- Stay cool!