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**

Don’ts

- **Cooldown**
- **Warmup**
  - **unless asked to by an expert**
- **Manipulate gas panel**
- **Change alarm setpoints**
  - **Unless asked to do so by a tgt exper**
- **Leave tgt console unattende**
- **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

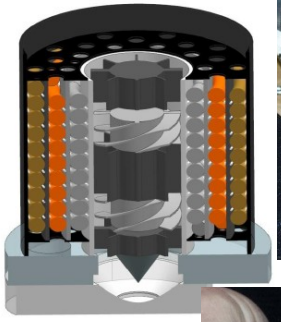
Name	Work	Pager	Cell	Home
J.P. Chen	7413		218-0722	867-7380
Greg Smith	5405		871-4371	565-9883
Silviu Covrig	6410	584-5411	(843) 697-1753	
Dave Meekins	5434		968-9076	874-4750
Chris Keith	5878		746-9277	596-3002
Chris Carlin	5971		559-1269	

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 loop
- 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_{beam} & regulates LH2 temp
- T&P instrumentation
- Control System GUIs
- Gas Panel, Ballast tank, Electronics
- Motion System (vertical)



Loop Anatomy

Target Specifications

LH2 (15 cm cell):

- T=19 ± 0.01 K
  (T_F=13.8K, T_B=22.2K)
- P~25 ± 1 psia
- P_{beam} ~ 415W @ 80 μA
- Reserve power ~ 75 W
- Fan ν=60 Hz (25%)
- ~2x2 mm² uniform raster (always on)
- ρ = 0.0723 g/cm³
- dE/dx ~ 4.8 MeV/g/cm²

LD2 (15 cm cell):

- T=22 ± 0.01 K
  (T_F=18.7K, T_B=25.3K)
- P~22 ± 1 psia
- P_{beam} ~ 480W @ 80 μA
- Reserve power ~ 75 W
- Fan ν=60 Hz (25%)
- ~2x2 mm² uniform raster (always on)
- ρ = 0.167 g/cm³
- dE/dx ~ 2.4 MeV/g/cm²

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} ~ 50W
  - Possibly also drop ν_{fan} to 40 Hz

Useful Equations

$$c_p\left(J/_{gK}\right) = \frac{\Delta Q}{\dot{m}T}$$

$$\Delta\rho/\rho \approx 1.5\%\ \Delta T\ (K)$$

$$P_b(W) = I_b(\mu A)\ \rho(g/cm^3)\ t(cm)\ dE/dx(MeV/g/cm^2)$$

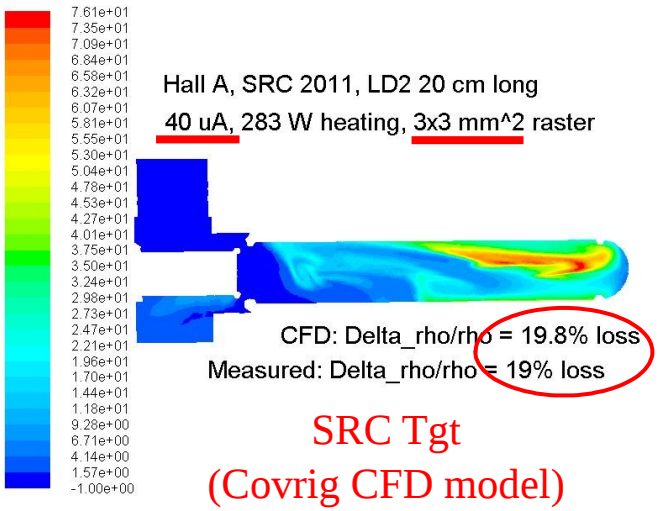
$$= \mathbf{0.35\ W/\mu A/cm\ (LH_2)}$$

$$= \mathbf{0.40\ \ W/\mu A/cm\ (LD_2)}$$

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

	LH2 (19 K, 25 psia)	LD2 (22 K, 22 psia)
ρ (g/cm^3)	0.0723	0.167
dE/dx (MeV/g/cm^2)	4.8	2.4
C_p (J/g-K)	8.8	6.8

Boiling



SRC Tgt
(Covrig CFD model)

Target	Raster (mm × mm)	Fan Speed (Hz)	Slope $(100\mu A)^{-1}$	Reference
lH_2, 4 cm 'beer can'	1.1 × 1.1	60	−7 %	Hall C, 1996 [7]
lD_2, 4 cm 'beer can'	2.0 × 2.0	60	−4 %	Hall C, 1996 [7]
lD_2, 4 cm 'beer can'	2.4 × 2.4	60	−3 %	Hall C, 1996 [7]
lD_2, 4 cm 'beer can'	2.0 × 2.0	67	−2.4%	Hall C, 1997 [7]
lD_2, 12 cm 'beer can'	2.0 × 2.0	67	−2.3%	Hall C, 1997 [7]
lH_2, 4 cm 'beer can'	2.0 × 2.0	67	−1.1%	Hall C, 1997 [7]
lH_2, 4 cm 'beer can'	2.0 × 2.0	40	−3.2%	Hall C, 1997 [7]
lH_2, 15 cm 'beer can'	3.4 × 2.8	?	−5 %	Hall A, 1997 [8]
lD_2, 15 cm 'beer can'	3.4 × 2.8	?	−3 %	Hall A, 1997 [8]
lD_2, 4 cm 'tuna can'	2.0 × 2.0	60	−2.4 %	Hall C, 1999 [9]
lH_2, 15 cm 'cigar tube'	2.0 × 2.0	60	−19 %	Hall C, 2001 [10]
lD_2, 15 cm 'cigar tube'	2.0 × 2.0	50	−10 %	Hall C, 2001 [10]
lD_2, 4 cm 'cigar tube'	2.0 × 4.0	60	−7.2 %	Hall C, 2000 [10]
lD_2, 4 cm 'cigar tube'	2.0 × 4.0	60	−7.4 %	Hall C, 2000 [10]
lD_2, 15 cm 'cigar tube'	2.0 × 4.0	60	−12 %	Hall A, 2002 [11]

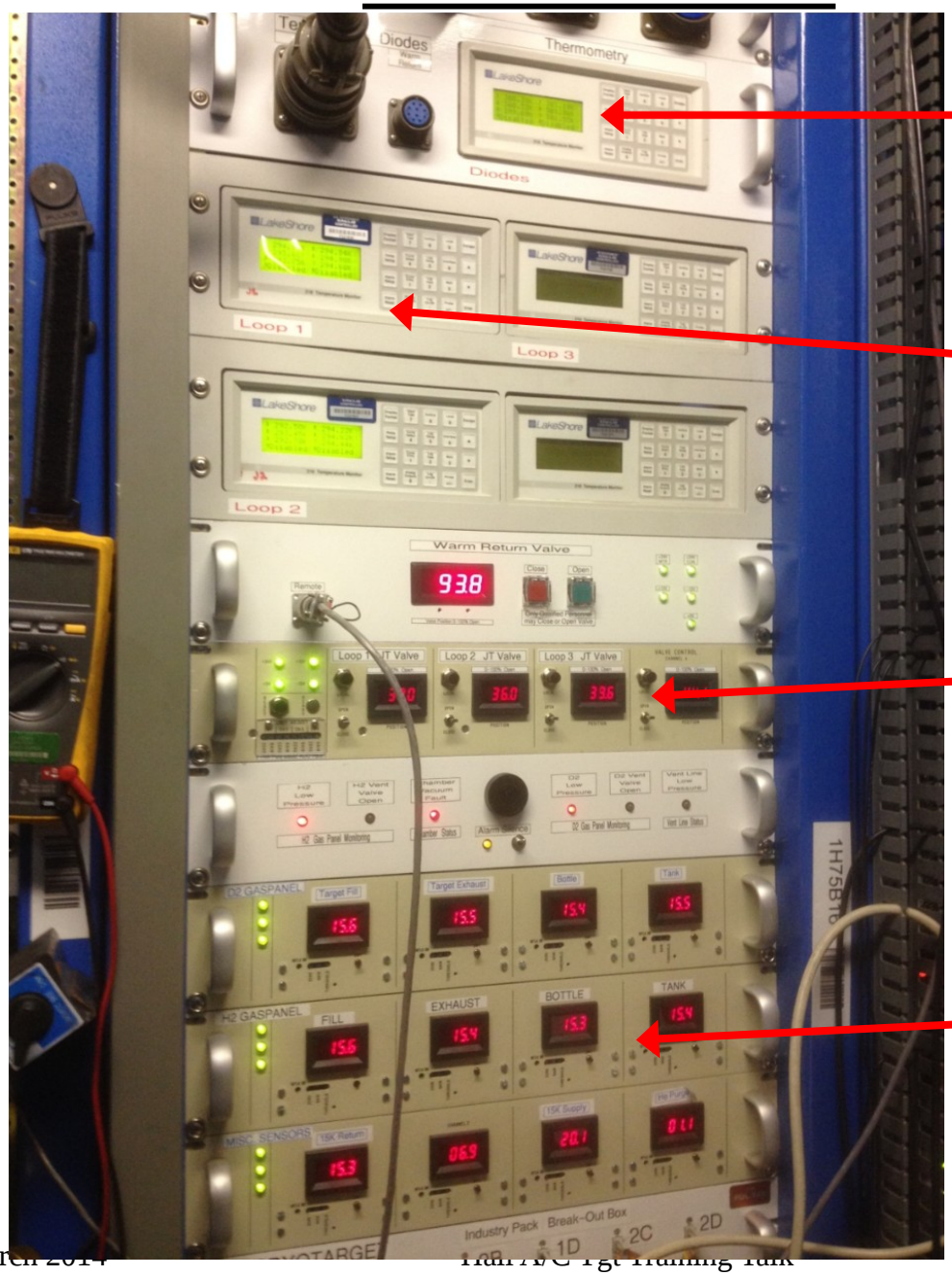
Table 2: Bulk effect slopes: % change in apparent luminosity for a beam current change from 0 to 100 μA, from other JLab cryotarget studies.

DA, RS, BM Boiling tech note (2003)

- Bulk density reduction with I_{beam} is real & must be msrd
- New Covrig CFD-based cell design should help

Hall A Layout

In the Hall



Cryogen Temps

Loop Temps

JT control

P readouts

Counting Room

- Target computer (controls, charts, alh)
- 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

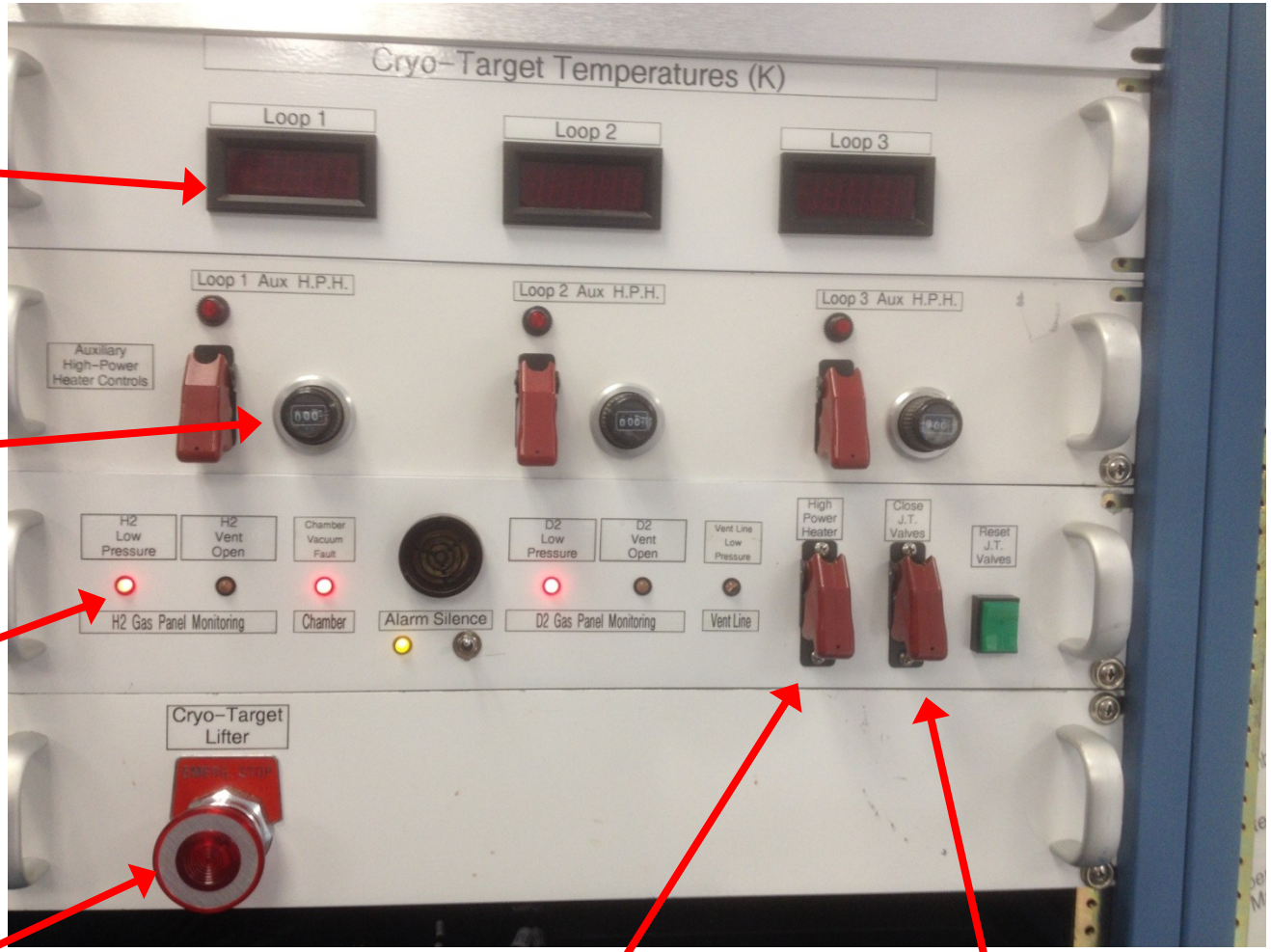
Counting Room Station

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 C:

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

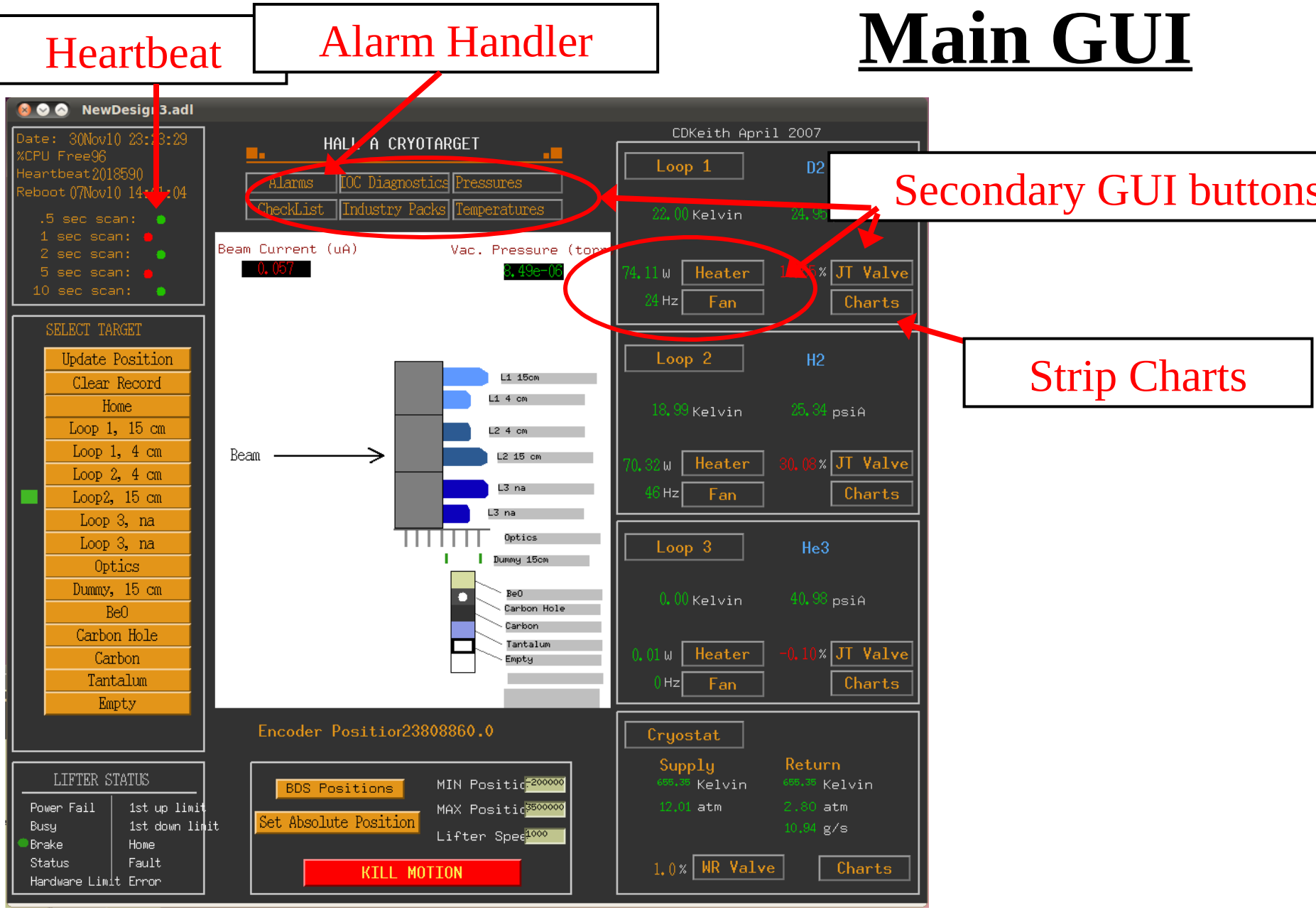
Hall A:

- Log into poltarac.jlab.org as poltar. PW posted in CR.
- cd Screens (/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**

Main GUI

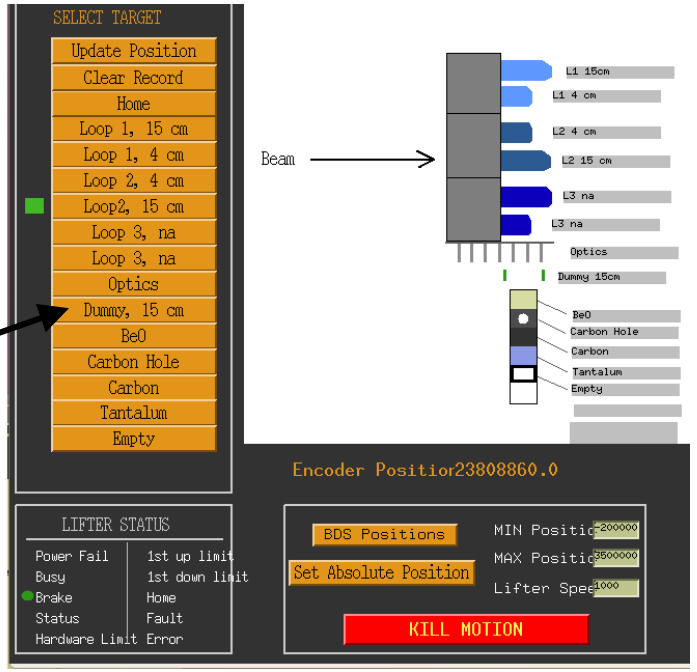

Heartbeat
Alarm Handler
Secondary GUI buttons
Strip Charts
NewDesig 3.adl
Date: 30Nov10 23:13:29
%CPU Free96
Heartbeat2018590
Reboot 07Nov10 14:11:04
.5 sec scan:
1 sec scan:
2 sec scan:
5 sec scan:
10 sec scan:
HALL A CRYOTARGET
Alarms
IOC Diagnostics
Pressures
CheckList
Industry Packs
Temperatures
CDKeith April 2007
Loop 1
D2
22.00 Kelvin
24.95
74.11 W
Heater
JT Valve
24 Hz
Fan
Charts
Loop 2
H2
18.99 Kelvin
25.34 psiA
70.32 W
Heater
30.08 %
JT Valve
46 Hz
Fan
Charts
Loop 3
He3
0.00 Kelvin
40.98 psiA
0.01 W
Heater
-0.10 %
JT Valve
0 Hz
Fan
Charts
Beam Current (uA)
0.057
Vac. Pressure (torr
8.49e-06
Beam
L1 15cm
L1 4 cm
L2 4 cm
L2 15 cm
L3 na
L3 na
Optics
Dummy 15cm
BeO
Carbon Hole
Carbon
Tantalum
Empty
SELECT TARGET
Update Position
Clear Record
Home
Loop 1, 15 cm
Loop 1, 4 cm
Loop 2, 4 cm
Loop2, 15 cm
Loop 3, na
Loop 3, na
Optics
Dummy, 15 cm
BeO
Carbon Hole
Carbon
Tantalum
Empty
Encoder Positior23808860.0
LIFTER STATUS
Power Fail
1st up limit
Busy
1st down limit
Brake
Home
Status
Fault
Hardware Limit
Error
BDS Positions
Set Absolute Position
MIN Positic-200000
MAX Positic3500000
Lifter Spee4000
KILL MOTION
Cryostat
Supply
Return
655.35 Kelvin
655.35 Kelvin
12.01 atm
2.80 atm
10.94 g/s
1.0 %
WR Valve
Charts

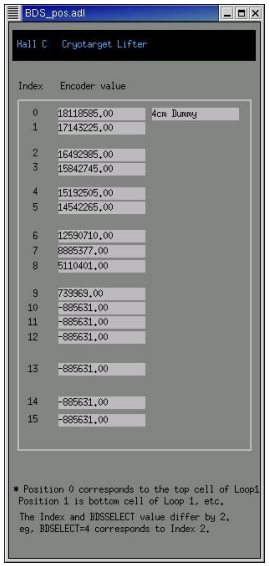
Adjusting the Heat Load

- P_{beam}~ 450 W at 80 μA, $P_{reserve}$~ 50-100 W
  - For 15 cm LH_2 or LD_2
- With beam on, need ~50-100 W on HPH
- With beam off ⎵ 450+50=500 W on HPH
  - (if off a long time, can reduce)
- HPH power adjusted automaticall
  - (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



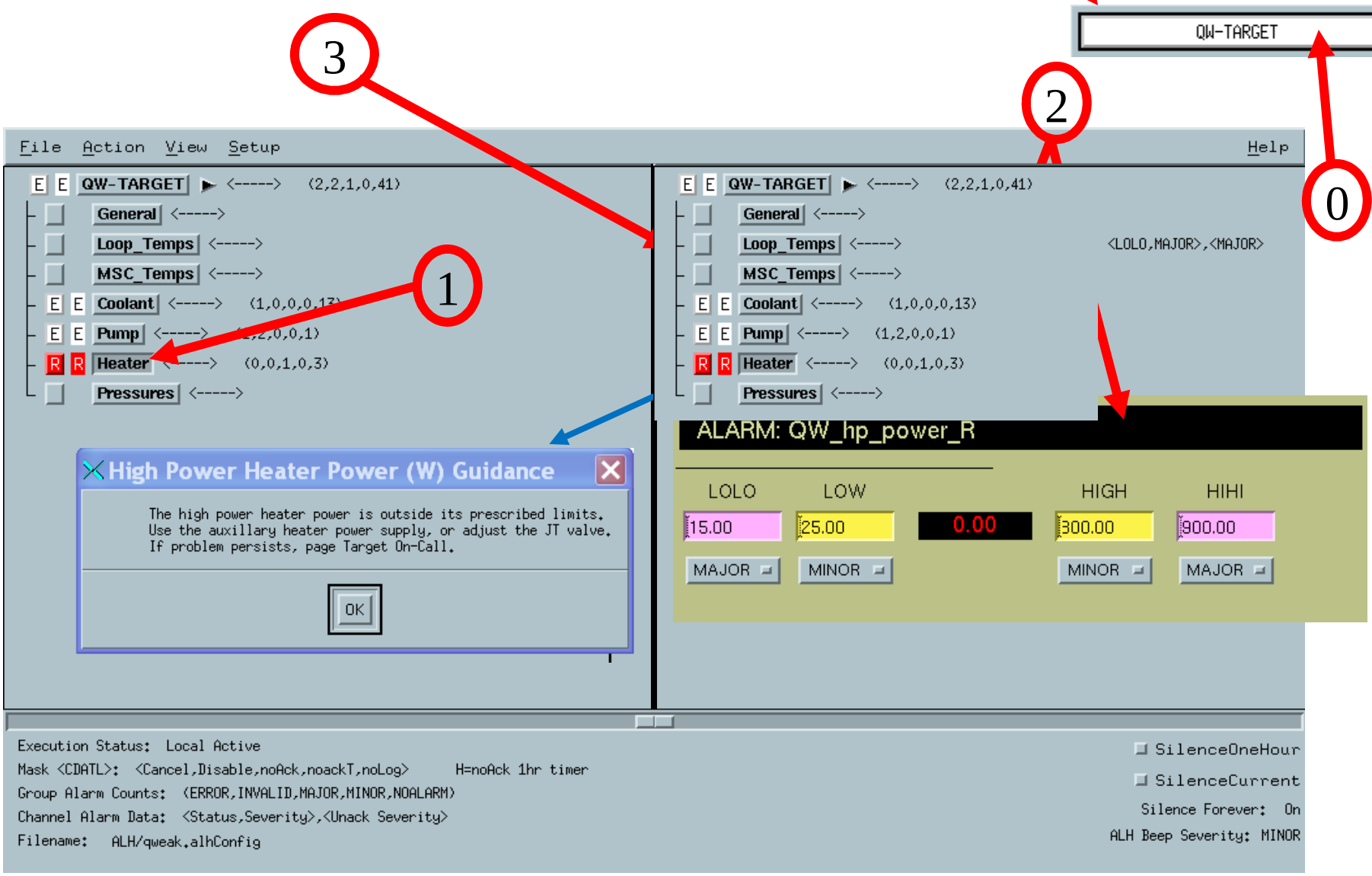


BDS positions (~50k/mm)

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**

Alarm Handler GUI



Check Logger/Archiver

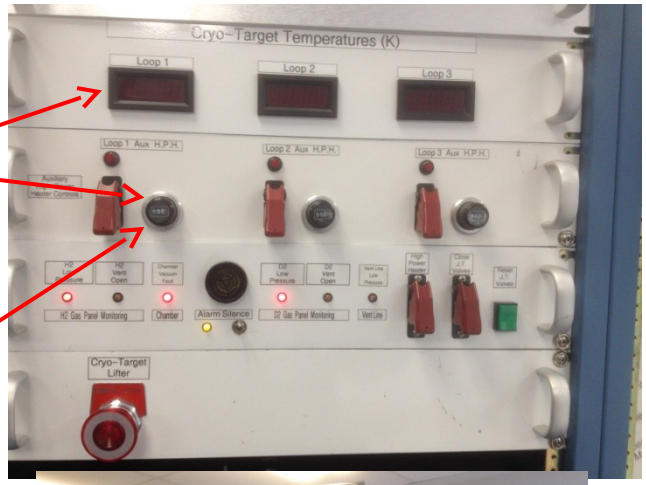
- Archiver is a very useful tool for the TO:
  - **http://hallcweb.jlab.org/targetlog/**
  - Myaviewer in Hall A
  - List of EPICS variables on archiver startup screen
  - Check functionality at start of shift by plotting something like loop pressure
    - Not OK? Page Steve Wood.
- When making log entries, 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.

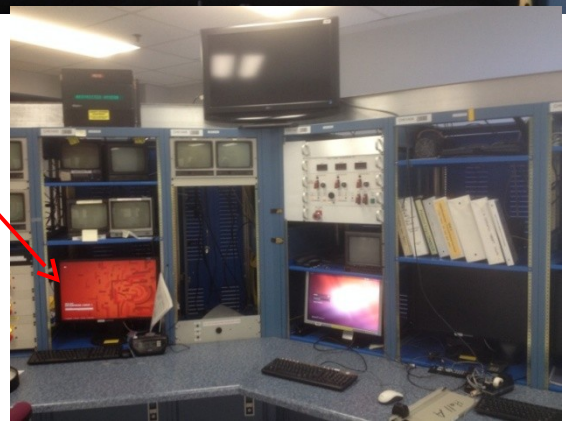
Rebooting the Target IOC

- 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-Tgoal| < 1º K
- Reboot IOC from reboot GUI
- Wait 2 min. Check PID working again. Network up?
- Turn off manual HPH. Still OK?
- Get Beam back. Log it.

Hall A: hacweb7 Hall C: hcvme4

username: hacuser



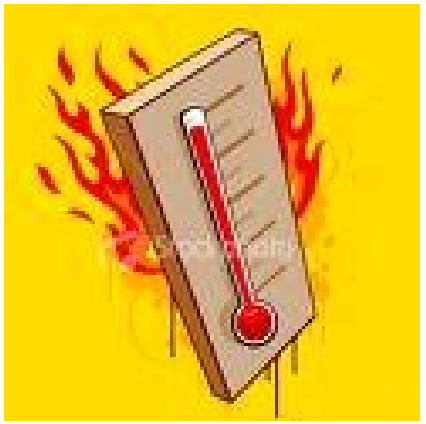


General advice for an off-normal event:

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.

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
3. LH2 Pump tripped? Restart.
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_{supply} abnormally high?
    1. Close offending JT
    2. May be ESR/CHL or xfer line IV failing…

Low Loop Temperature Alarm

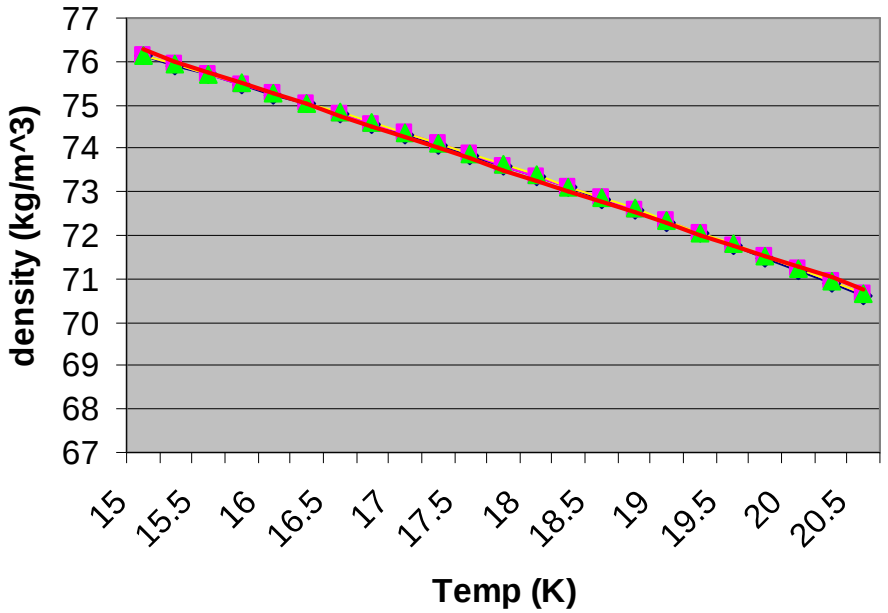
Danger: freezing the H2

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_{max} is set high enough (in GUI)
    2. Is Coolant (ESR) T_{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.

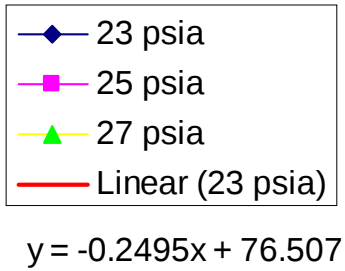
Low Loop Pressure Alarm

Danger: going sub-atmospheric & freezing air in relief path

1. Diurnal pressure variation?
    1. Check archiver to see recent history. (see next slide)
2. Gas panel problem? System can't bre[illegible]:
    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 syste[illegible]
3. Temps too low?
    1. See low temp procedures



23 psia LH2 density vs temp



$y = -0.2495x + 76.507$

$R^2 = 0.9981$

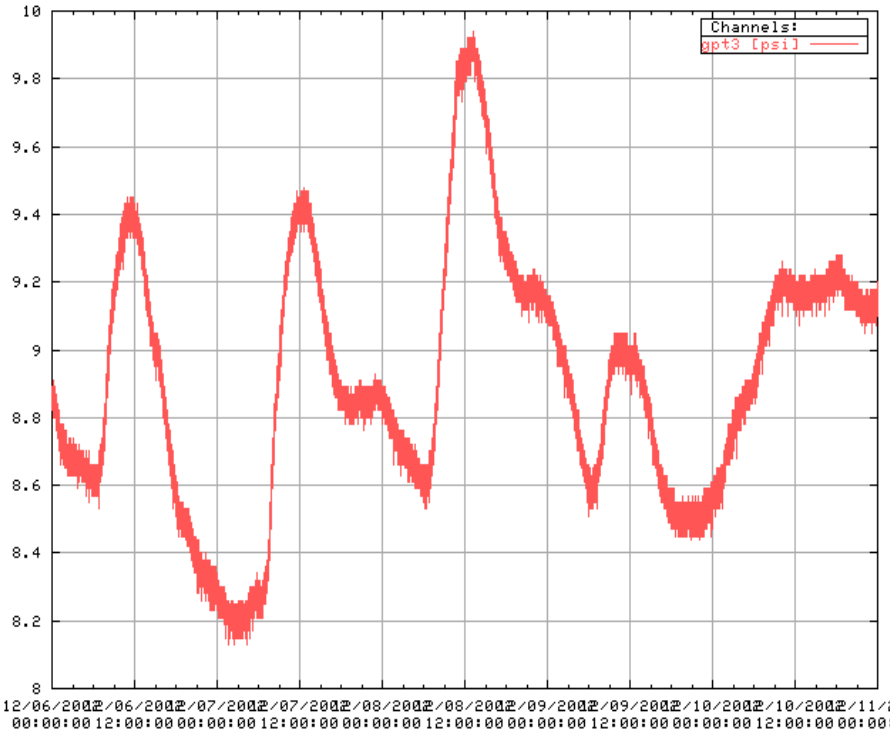
C

Hall A

0 gallon tanks

ge pressure is ~50 psia

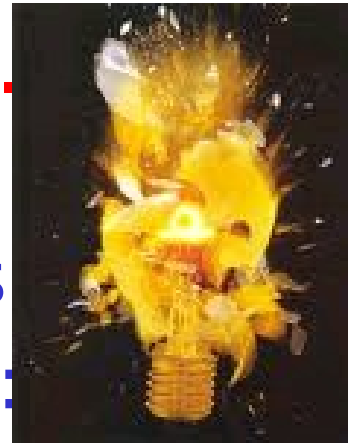
- Ballast tank is outside, and is affected by sun, T_{air}
  - $P \propto T$.
  - Ex: ΔT=15C (5%) $\rightarrow$ ΔP=1 psi
- Systematic effect on target p negligible.



High Loop Pressure Alarm

Danger: Bursting cell window

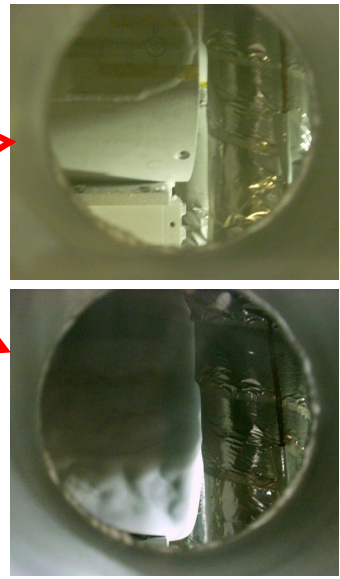
1. Diurnal pressure variation?
    1. Check archiver to see recent history.
2. Temps high? Turn off the beam.
    1. System is warming up.
    2. Warm (storage) pressure ~ 50 ps
    3. See High temp alarm procedures:
        1. Probably a vacuum pump has tripped, or the LH2 pump has tripped.
       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



Vacuum Alarms

No Danger. Just delays & headaches.

1. Monitor vacuum stripcharts over ~ days.
    1. SC vacuum should be < 1×10^{-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 ~ 5×10^{-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.
6. Close JT valves.
7. Call the target expert.

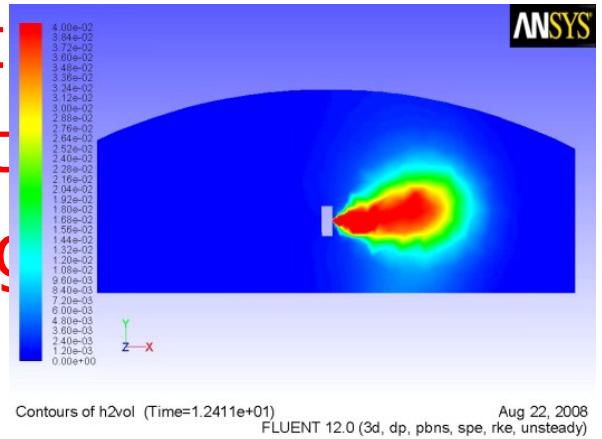
LH2 Pump Trip

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, et
4. Call cryo to shut off coolant
5. Call experts to pump & purg system, …



Power Failure

Danger: Freezing H2, blocking relief path

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 JTs. 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.

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

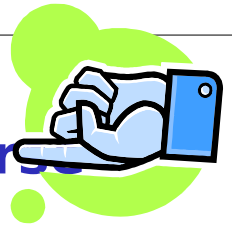
Computer failure

Danger: You are blind, don't know what is going on.

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

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

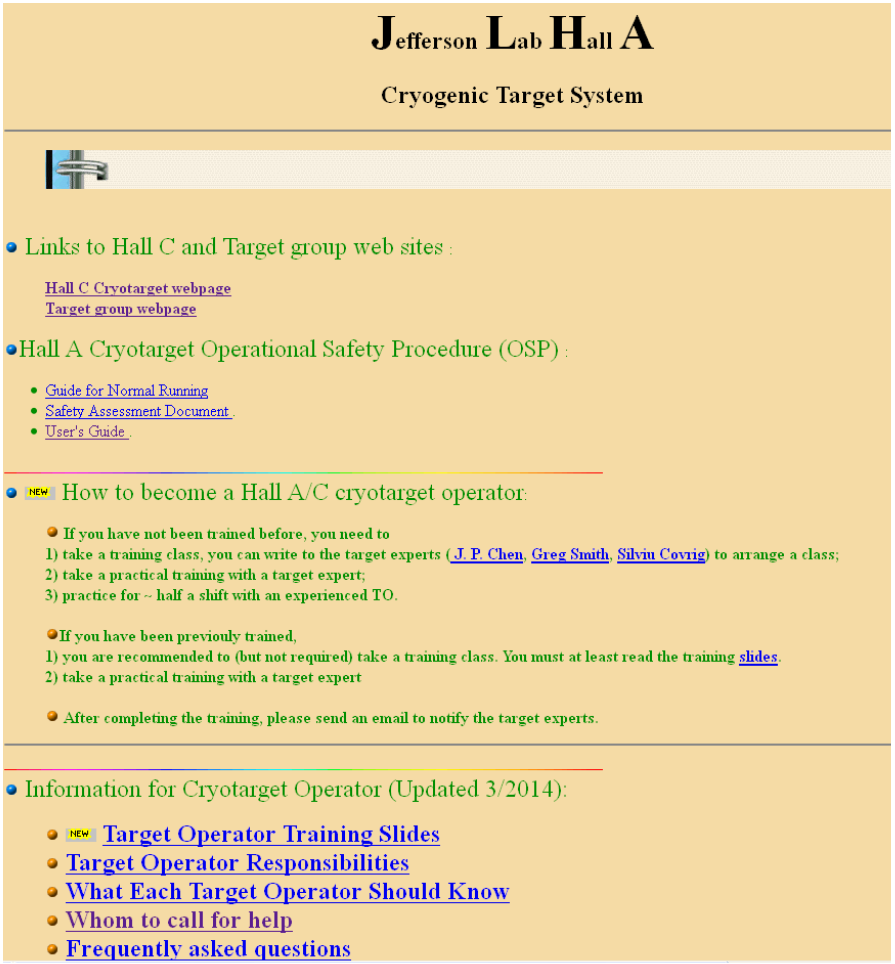


Cryotarget Web Pages

Hall A:
http://hallaweb.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-to
- Contacts
- FAQs
- This talk
- Goal parameters
- Thicknesses
- Documentation
- Etc.



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!