Manual for HPS ECal v1.5

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1 General description of the ECal

The electromagnetic calorimeter (ECal), installed downstream of the pair spectrometer dipole magnet (figure 1), performs two essential functions for the experiment: it provides the trigger signal and helps identify electrons and positrons. The ECal modules are based on tapered 160 mm long PbWO crystal with a 13.3x13.3 mm^2 (16x16 mm^2) front (rear) face wrapped in VM2000 multilayer polymer mirror film. The scintillation light, approximately 110 photons / MeV, is read out by a 10x10 mm^2 Hamamatsu S8664-1010 Avalanche Photodiode (APD) with 75% quantum efficiency glued to the rear face surface. The low gain of APDs (150 pC/pC) is compensated with custom-made preamplifier boards, which provide a factor of 225 amplification of the APD signal. In front of the crystals, LEDs are installed to send light into the crystals. These are used in order to check the proper functioning of the ECal and provides complementary information to evaluate gain variations in the various channels of the calorimeter (see figure 2).

The ECal is built in two separate halves that are mirror reflections of one another relatively to the horizontal plane. The 221 modules in each half are supported by aluminum frames and arranged in rectangular formation with five layers and 46 crystals / layer, except for the layer closest to the beam where nine modules were removed to allow a larger opening for the outgoing electron and photon beams (figure 3). Each half is enclosed in a temperature controlled box ($< 1°$F stability and $< 4°$F uniformity) to stabilize the crystal light yield and the operation of the APDs. Four printed circuit boards (referred as mother boards) mounted on the back plane penetrate the enclosure and are used to supply the ± 5 V operating voltage for the preamplifiers, the 400 V bias voltage to the APDs, and to read out signals from the APDs. Each half of the ECal is divided into 26 bias voltage groups formed in order to minimize the gain spread of the APD-preamplifier couples.

After a 2:1 signal splitter, 1/3 of an amplified APD signal is fed to a single channel of a JLab flash ADC (FADC) board. 2/3 of the signal is sent to a discriminator module before a TDC for a time measurement. The FADC boards are high speed VXS modules digitizing up to 16 crystal signals at 250 MHz and storing 4 ns samples with

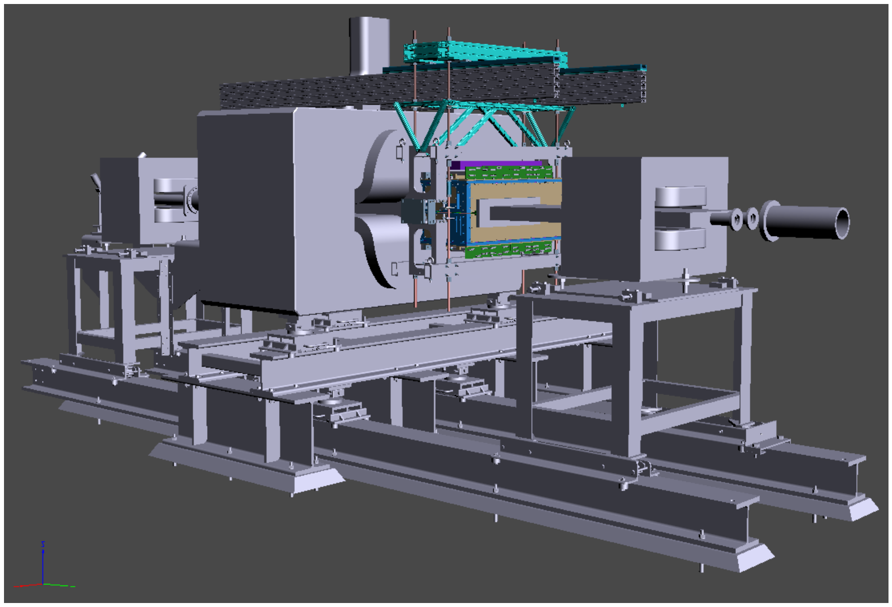


Figure 1: General view of the ECal (in color) suspended at the downstream end of the HPS analyzing magnet.

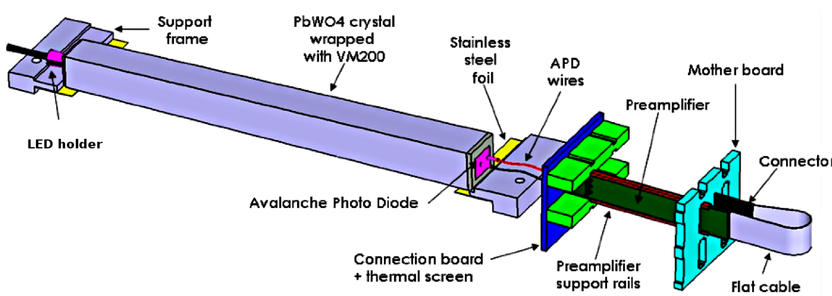


Figure 2: View of an ECal crystal and the amplification chain.

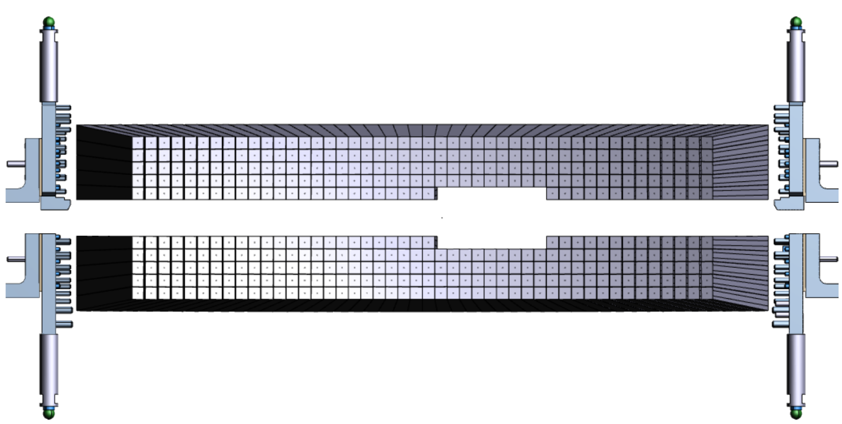


Figure 3: Front view of the ECal crystals layout.

12-bit resolution. When a trigger is received, the pipeline is read on these boards from 5 samples before and 30 after the trigger time (those values will be adapted during commissioning).

Part I
Shift Takers Instructions

Most ECal controls are accessible through EPICS, from the main window (figure 4). From there you can access **Temperature monitoring** in *Miscellaneous* then *ECal Temperature*, the **ECal chiller** in *Devices* then *Chiller (ECAL)*, the **Scalers** in *ECal Scaler GUI*, the **ECal high voltage** in *Voltages* then *ECal HV* and the **LED control panel** in *Devices* then *Flasher*.

If not already open, HPS's main EPICS window is opened as user `hpsrun` on `clonsl1`, `clonsl2`, or `clonsl3`, with the command

`hps_epics`

In general, all shift workers should be using user ***`hpsrun`*** *for instructions in this document.*

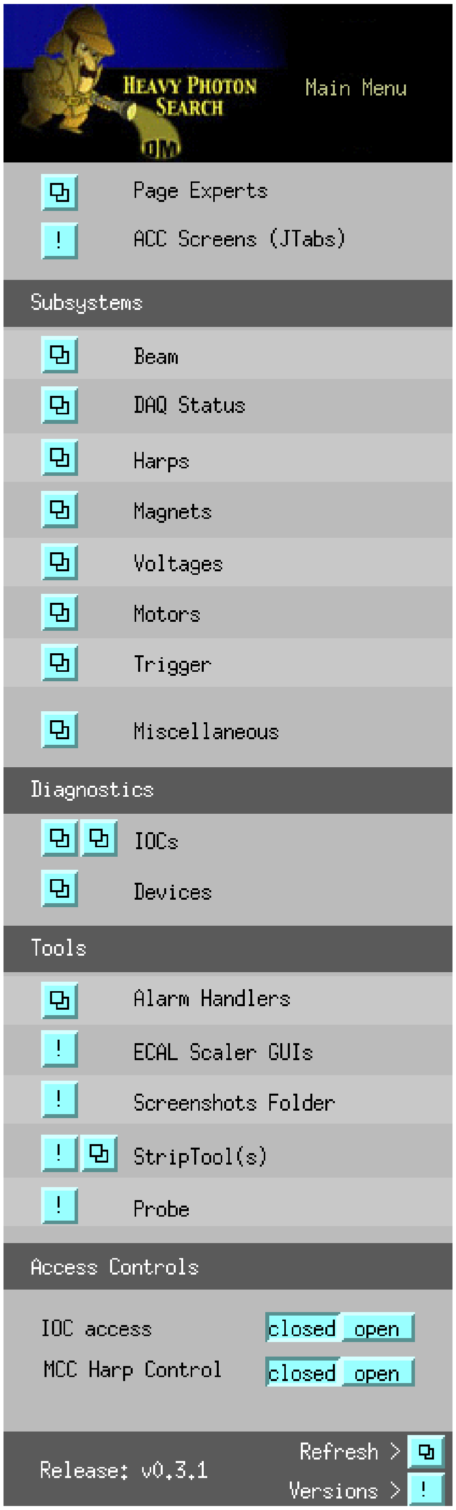


Figure 4: View of the Hall-B EPICS main window.

2 Temperature

The ECal temperature should remain as stable as possible in order to avoid gain variation in the system. Eighteen temperature sensors are placed in the ECal enclosure and should be monitored through EPICS (see figure 5 and 6). Variations of two degrees F or more during a shift should be reported to ECal expert on call and noted in the log book.

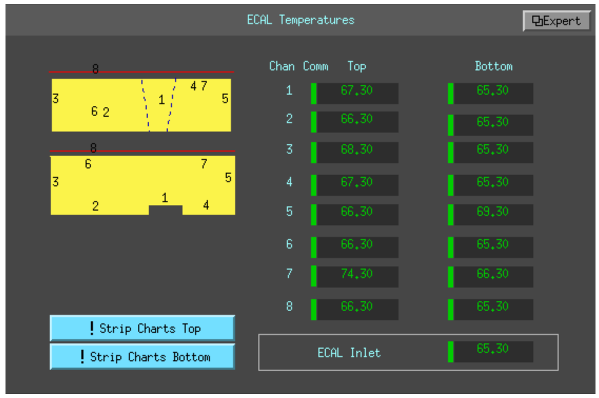


Figure 5: View of the EPICS temperature monitoring window.

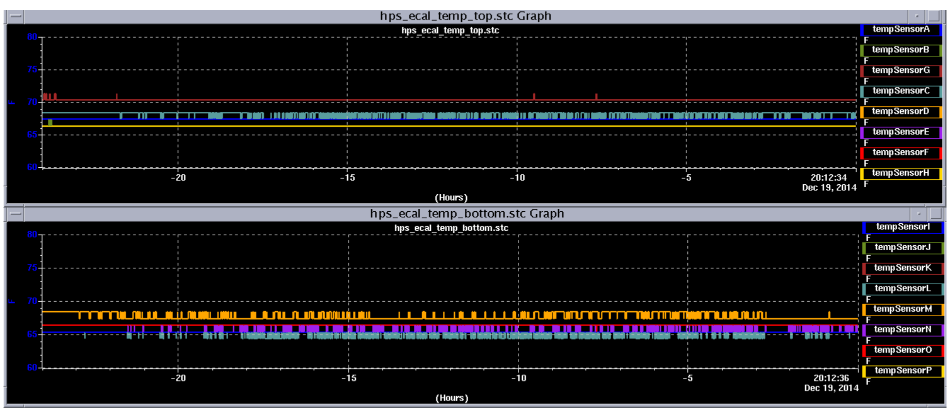


Figure 6: View of the EPICS temperature monitoring strip charts.

3 Chiller

The chiller allows to keep the calorimeter at the right temperature and should be ON and set at 17C at all times. The chiller can be monitored through its webcam (figure 7) or using its EPICS controls (figure 7). Shift takers should not attempt to change the chiller settings and call ECal expert in case of problem.

The webcam is accessible either by the url `cctv10.jlab.org` in a web browser, or via the "Monitoring" tab on the main **HPS Run Wiki**.

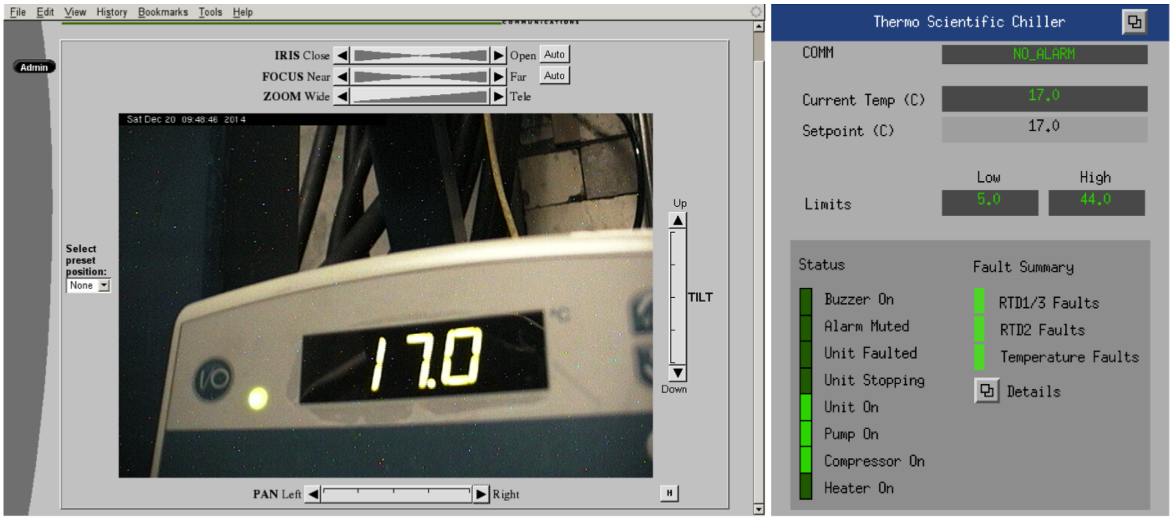


Figure 7: View of the chiller by webcam (`cctv10.jlab.org`) and its EPICS window in normal operation.

4 Voltages

4.1 Low Voltage Controls

The low voltage power supply must be on before HV is turned on. The LV supply is controlled manually in the hall and should be monitored using its webcam (figures 8). Call the ECal expert if this appears not to be ON or shows an abnormal current. Normal current is between 4.0 and 4.2 A.

A webcam is focused on the LV supply, accessible either by the url `cctv11.jlab.org` in a web browser, or via the "Monitoring" tab on the main **HPS Run Wiki**.

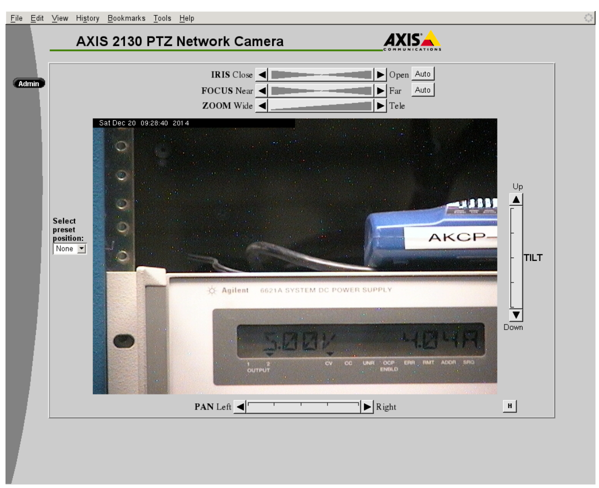


Figure 8: View of the LV screen by webcam (`cctv11.jlab.org`).

4.2 Turning ON/OFF High Voltages

The high voltage supply of the ECal is controlled and monitored using the EPICS application (see figure 9). It is accessible via the main EPICS window (`HV->ECal`), and has buttons to ramp up and down the entire calorimeter's high voltages, and open windows for individual channel control (figure 11).

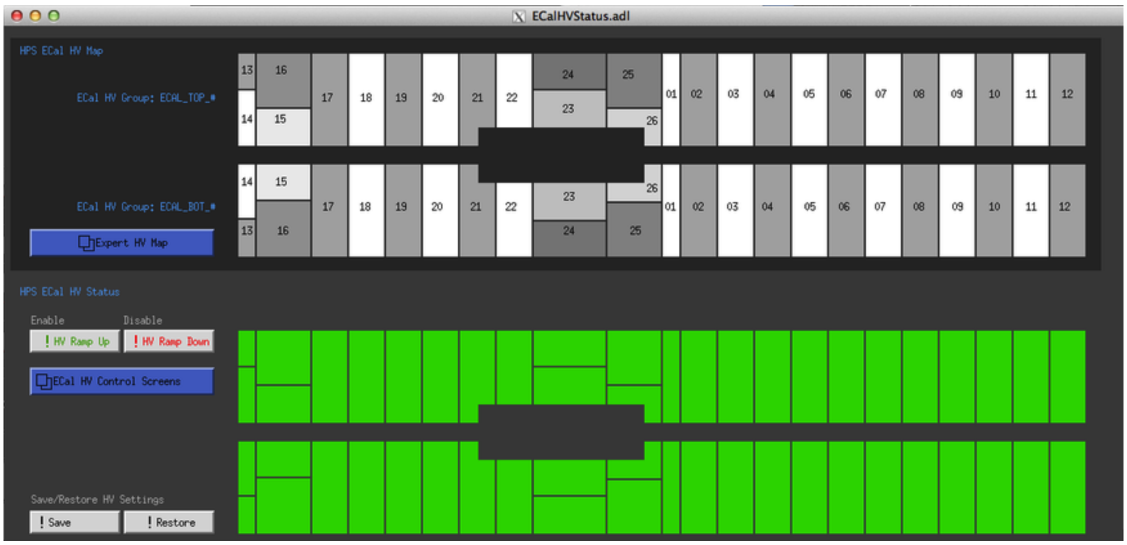


Figure 9: View of the EPICS ECal HV monitoring window.

4.3 HV Current Monitoring

Individual channels' currents can be monitoring in figure 11, and strip charts should be open for long term monitoring (accessible from the main EPICS GUI (figure 4) via the "Strip-Tool" button). An example is shown in figure 10. Jumps or drifts in current of more than 1 A should be noted in the logbook.

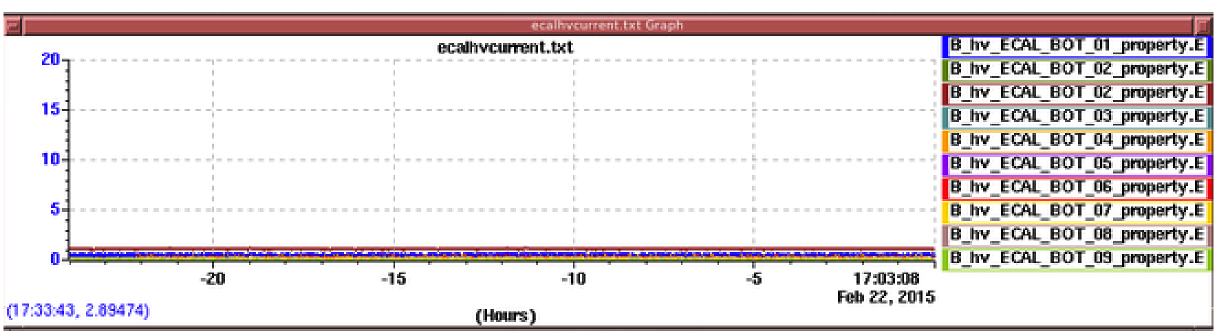
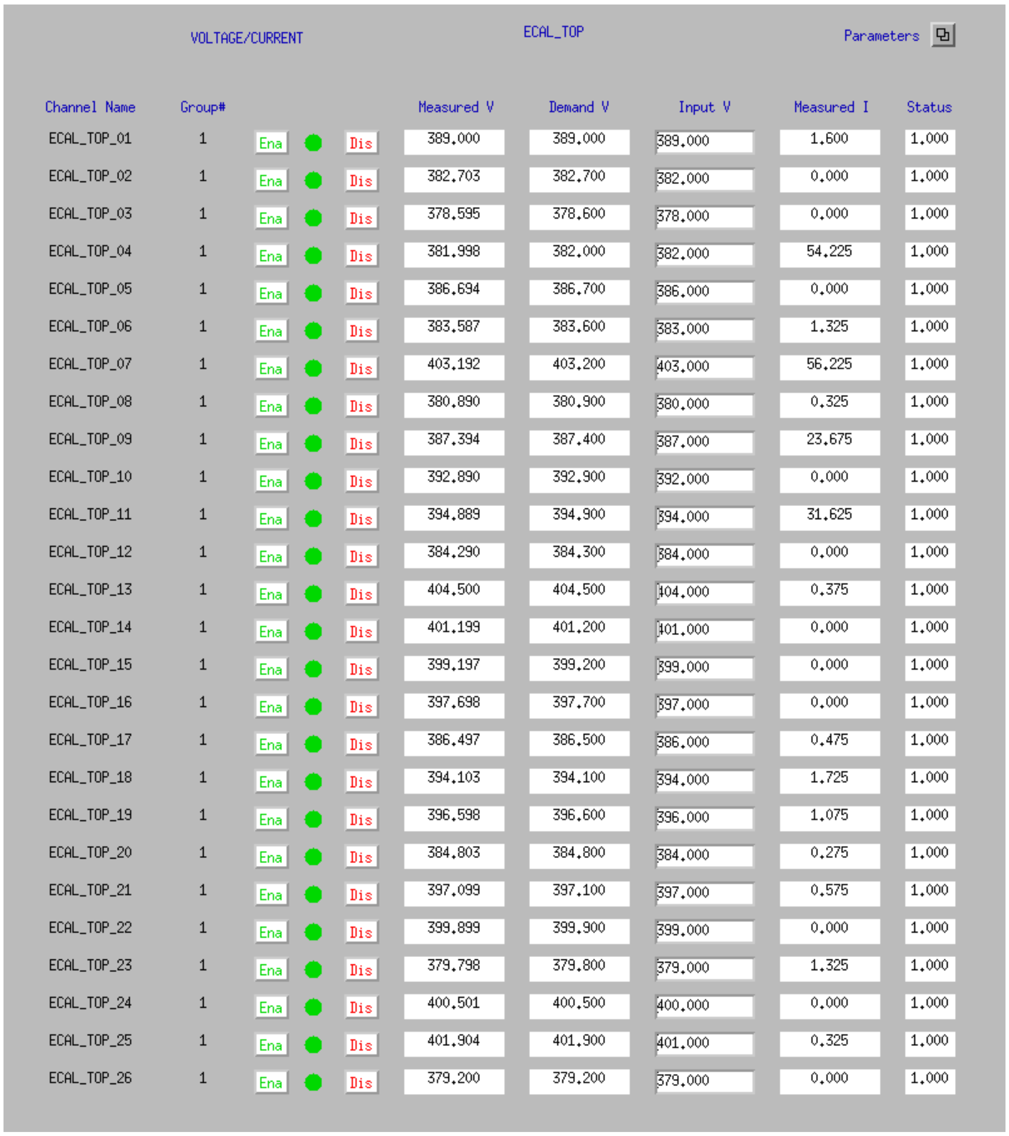


Figure 10: HV Current strip charts.

4.4 Responding to HV trips

HV problems, in particular trips, are indicated by a red group in the main EPICS GUI (figure 9). Record all HV trips in the log book with indication of the group and run number concerned. HV can be turned back on in the EPICS HV control screen (figure 11) accessed in the main EPICS GUI. N.B. The HV can take up to 3 minutes to turn back on so you should end the current run and begin a new one when the high voltage is back on. If you cannot get a HV group to work contact the ECal expert on call.

If you encounter more than two HV trips during your shift for the same group, you should notify the ECal Expert.



Channel Name	Group#			Measured V	Demand V	Input V	Measured I	Status
ECAL_TOP_01	1	Ena	Dis	389.000	389.000	389.000	1.600	1.000
ECAL_TOP_02	1	Ena	Dis	382.703	382.700	382.000	0.000	1.000
ECAL_TOP_03	1	Ena	Dis	378.595	378.600	378.000	0.000	1.000
ECAL_TOP_04	1	Ena	Dis	381.998	382.000	382.000	54.225	1.000
ECAL_TOP_05	1	Ena	Dis	386.694	386.700	386.000	0.000	1.000
ECAL_TOP_06	1	Ena	Dis	383.587	383.600	383.000	1.325	1.000
ECAL_TOP_07	1	Ena	Dis	403.192	403.200	403.000	56.225	1.000
ECAL_TOP_08	1	Ena	Dis	380.890	380.900	380.000	0.325	1.000
ECAL_TOP_09	1	Ena	Dis	387.394	387.400	387.000	23.675	1.000
ECAL_TOP_10	1	Ena	Dis	392.890	392.900	392.000	0.000	1.000
ECAL_TOP_11	1	Ena	Dis	394.889	394.900	394.000	31.625	1.000
ECAL_TOP_12	1	Ena	Dis	384.290	384.300	384.000	0.000	1.000
ECAL_TOP_13	1	Ena	Dis	404.500	404.500	404.000	0.375	1.000
ECAL_TOP_14	1	Ena	Dis	401.199	401.200	401.000	0.000	1.000
ECAL_TOP_15	1	Ena	Dis	399.197	399.200	399.000	0.000	1.000
ECAL_TOP_16	1	Ena	Dis	397.698	397.700	397.000	0.000	1.000
ECAL_TOP_17	1	Ena	Dis	386.497	386.500	386.000	0.475	1.000
ECAL_TOP_18	1	Ena	Dis	394.103	394.100	394.000	1.725	1.000
ECAL_TOP_19	1	Ena	Dis	396.598	396.600	396.000	1.075	1.000
ECAL_TOP_20	1	Ena	Dis	384.803	384.800	384.000	0.275	1.000
ECAL_TOP_21	1	Ena	Dis	397.099	397.100	397.000	0.575	1.000
ECAL_TOP_22	1	Ena	Dis	399.899	399.900	399.000	0.000	1.000
ECAL_TOP_23	1	Ena	Dis	379.798	379.800	379.000	1.325	1.000
ECAL_TOP_24	1	Ena	Dis	400.501	400.500	400.000	0.000	1.000
ECAL_TOP_25	1	Ena	Dis	401.904	401.900	401.000	0.325	1.000
ECAL_TOP_26	1	Ena	Dis	379.200	379.200	379.000	0.000	1.000

Figure 11: View of the EPICS ECal HV control window for individual channels.

5 LED Monitoring

5.1 System operations

The LED system is operated through an EPICS GUI accessible from the main HPS EPICS menu, through Devices, then Flasher (see Figure 12).

Shift takers are requested to operate the system in "Sequence mode" only. To do so, when requested, click on "Initialize Flasher", then verify the TOP frequency is 8000 Hz, and if necessary adjust it trough the proper drop-down menu. Finally, to start the sequence, click on "Start Blue Seq" (to use blue LEDs) or "Start Red Seq" (to use red LEDs). During such a run the DSC scaler screen allows to check the proper functioning of the channels (figure 13).

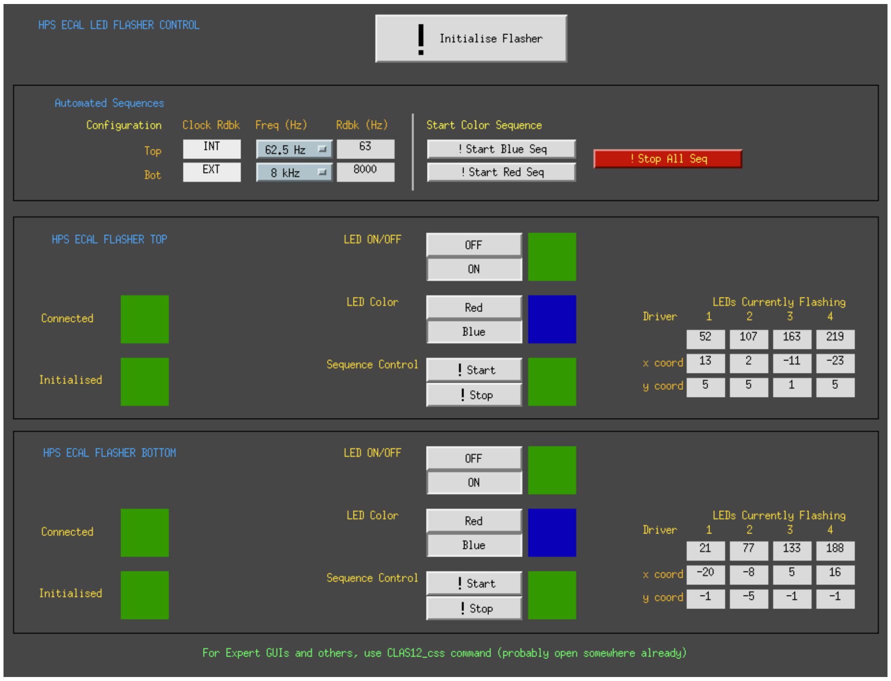


Figure 12: The HPS-ECAL Led monitoring system EPICS GUI.

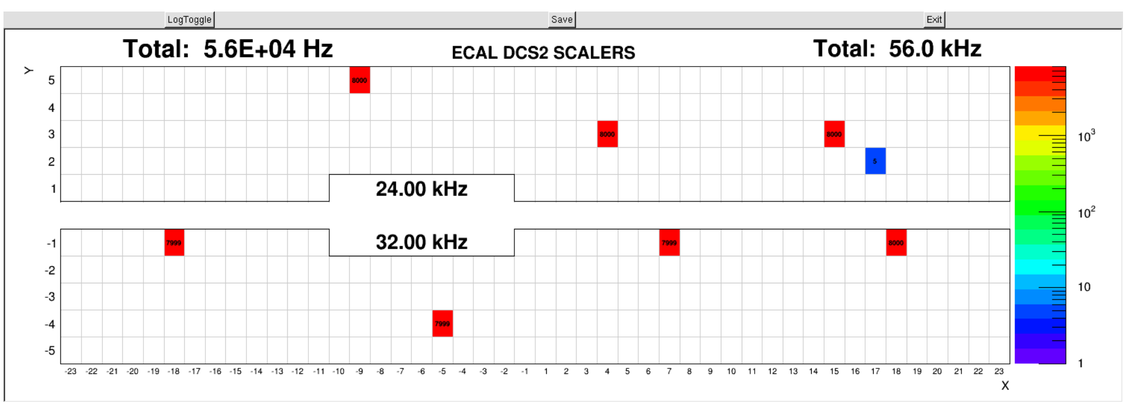


Figure 13: The HPS DSC scaler during a LED run.

5.2 Automatic LED Monitoring

A monitoring app is setup to record all channels successfully registered during an LED run. It should be started before the LED sequence is started and viewed afterwards, with the command:

$HOME/scripts/ECalLEDMonitor.sh

.

TODO: To Be Tested. Make app accessibble from EPICS gui.

6 Making a cosmic calibration run

In addition to the calorimeter, the cosmic PMTs should be powered on. Their HV control is under "beam" in the main EPICS gui's HV section. They are named `ECal_cosm1` and `ECal_cosm2`. The DAQ configuration should be set to

`hps_cosmic_mode1_thresh0.cfg`

It takes at least one full day of data to acquire sufficient statistics for a cosmic calibration.

7 Taking a Pedestal Run

Pedestals are calculated at running luminosity with DAQ configuration

`hps_ecal_pedestal_mode7_thresh50.cfg`

and monitored and analyzed with HPS's hps-java monitoring app via the command:

$HOME/scripts/ECalCalculatePedestals.sh

Once the user deems the statistics sufficient in the monitoring plots, the app should be disconnected from the ET-ring and then output will be files `fadc37.ped` and `fadc39.ped` in the current working directory. An expert should place them in the proper location for the DAQ to read.

? TODO: Make pedestal viewer app accessible from EPICS gui, and make it save ped files to an absolute path.

8 Scalers

Rates seen by the ECal are available in the EPICS (Fig 14), they represent the rates as seen from the FADC and TDC electronics. The difference is mainly due to their different thresholds. One can also see scalers from the DAQ GUI (figure 15), this indicates the rates of clusters reconstructed by the trigger electronics. These numbers should all remain constant within 10% during stable beam operation. A strong increase is the indication of bad beam conditions or is due to the presence of a new source of noise, in the latter case, please contact ECal expert on call.

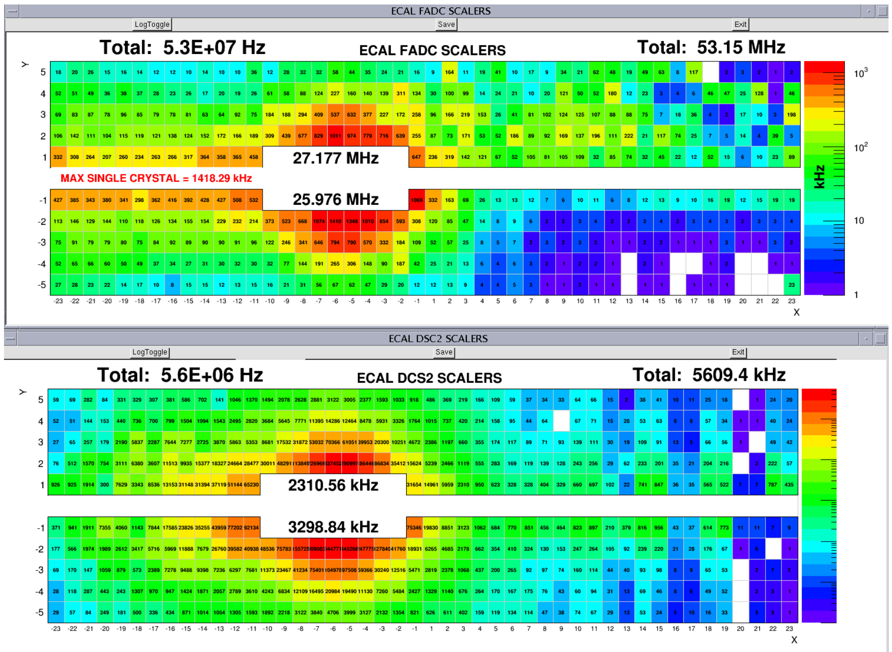


Figure 14: View of the EPICS FADC and DSC2 scalers window.

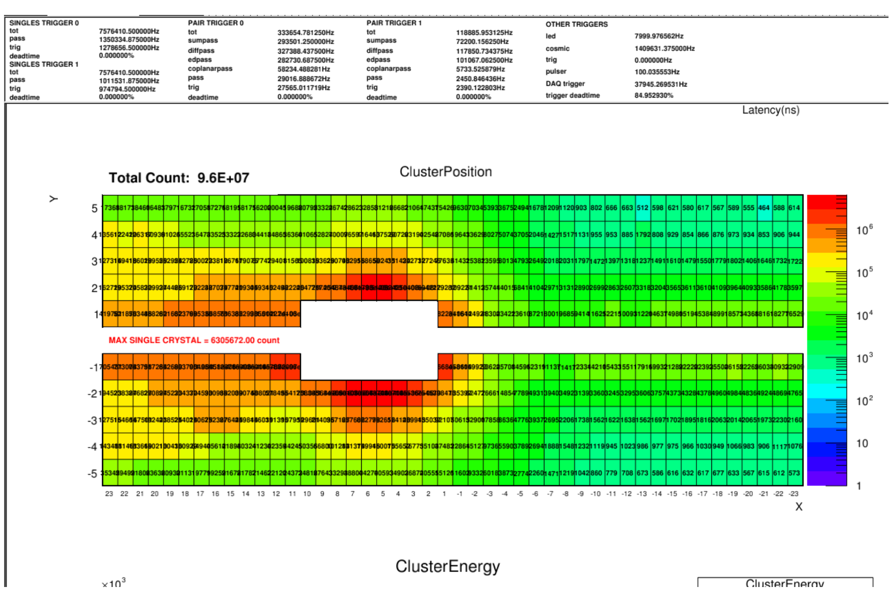


Figure 15: View of the DAQ scaler window.

Part II
ECal Experts Resources

9 Localization of ECal elements for experts

REMINDER: Since the ECal is within 3 feet of the beam line it needs to be surveyed by RADCON before any work can be done on it.

- The chiller is located beam-left just downstream of the calorimeter on the ground.
- The LED controllers are located at the top of the rack closest to the beamline in the Alcove.
- The TDC crates are in the rack closest to the beamline in the Alcove.
- The FADC crates and calorimeter signal splitters occupy the rack furthest from the beamline in the Alcove.
- The HV supply is on the Pie Tower in the rack closest to the beamline.
- The LV supply is on the Pie Tower at the top of the middle rack.

TODO: Add images.

10 Cooling system

The cooling system is using a Thermo Scientific chiller that can be controlled through EPICS (7). The setting should not be modified; the temperature setting should be fixed at 17 degrees Celsius. In case of problem with the chiller contact ??? (who can take care of these in Hall-B engineer group?). The manual for the chiller can be found here:
`http://www.nist.gov/ncnr/upload/Circulating-Bath_Thermo-Scientific_NESLAB-RTE-7.pdf`

10.1 Rebooting After Power Failure

If the chiller loses power while in local mode, the "power" button must be pressed manually to restart it after power is restored. In case it loses power while in remote mode, a procedure is necessary to reset it after power is restored:

1. Hold the "up" and "down" arrow buttons simultaneously for 10 seconds.
2. Press the "computer" button to go into local mode.
3. Press the "power" button to turn it off.
4. Press the "power" button to turn it on.
5. Press the "computer" button to return to remote mode.

11 Changing LV settings

Low voltage power supply should be set at ± 5V. The low voltage supply might have difficulties to get at this level because of the high current. If that was the case check, with all power supplies off, that all connection are goods. Then contact run coordinator to see if LV power supply addition is possible.

12 High Voltage

12.1 Restarting the IOC

Occaissonaly the soft IOC for the HV needs to be manually restarted. Symptoms of this condition include errors messages from EPICS when trying to turn on/off voltages and white blocks in the main HV screen (figure 9). The IOC always needs to be restarted if the mainframe is power cycled.

Currently, the HV IOC runs in a "screen" on `clonioc1`. To restart it, follows these steps:

1. '`ssh hpsrun@clonioc1`'
2. '`screen -ls`' to list running screens
3. '`screen -x ECALHVIOC`' to attach to the screen running the IOC
4. '`ctrl-c`' to kill the IOC
5. '`up-arrow ; return`' to restart the IOC
6. '`ctrl-a-d`' to detach from the screen

If for some reason this does not work (e.g. no screen named something like `ECALHVIOC` is listed in #2, or #5 does not start the IOC), you can start from scratch:

1. '`ssh hpsrun@clonioc1`'
2. '`screen -S ECALHVIOC`' to create and attach to a new screen named `ECALHVIOC`
3. '`cd /home/nerses/github_test/epics/apps/iocBoot/iocECal_Voltages`'
4. '`./st.cmd`' to start the IOC
5. '`ctrl-a-d`' to detach from the screen

Don't leave a terminal open connected to this screen.

12.2 Changing HV Settings

NOTE: Changing voltage settings should be taken care of in coordination with the ECal group (contact R. Dupre). Current setting can be increased in case of need, please document this change in the log book and notify the ECal expert on call.

NOTE: The ECal HV groups had to be renumbered in the EPICS, the correspondence map (figure 16) is available in the main ECal HV monitoring window with the Expert HV Map button.

If for some reason some channels were to drop in gain (or increase) or if the current drawn increases in a group, it might be necessary to change the HV settings in the expert ECal EPICS control (Fig. 17). A modification of the voltage will lead to a modification of the gain used by the trigger system, these values need to be updated at the same time!

12.3 HV Save/Restore

A system to save and restore the entire calorimeter's voltage settings is available via buttons in the main monitoring window. If the voltage setpoints are changed, a backup should be made of the new settings. This must be run as a user in group `clas-4`; user `hpsrun` does not have sufficient priveleges to save/restore voltage settings. An example of the restore window is shown in figure 18

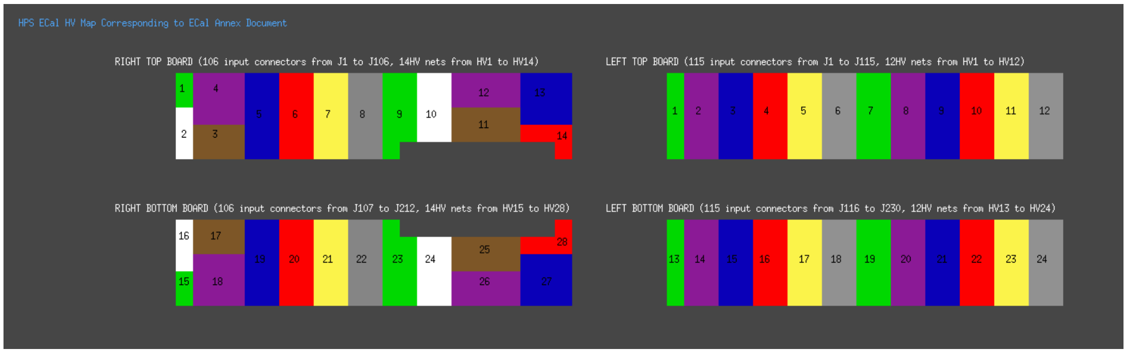
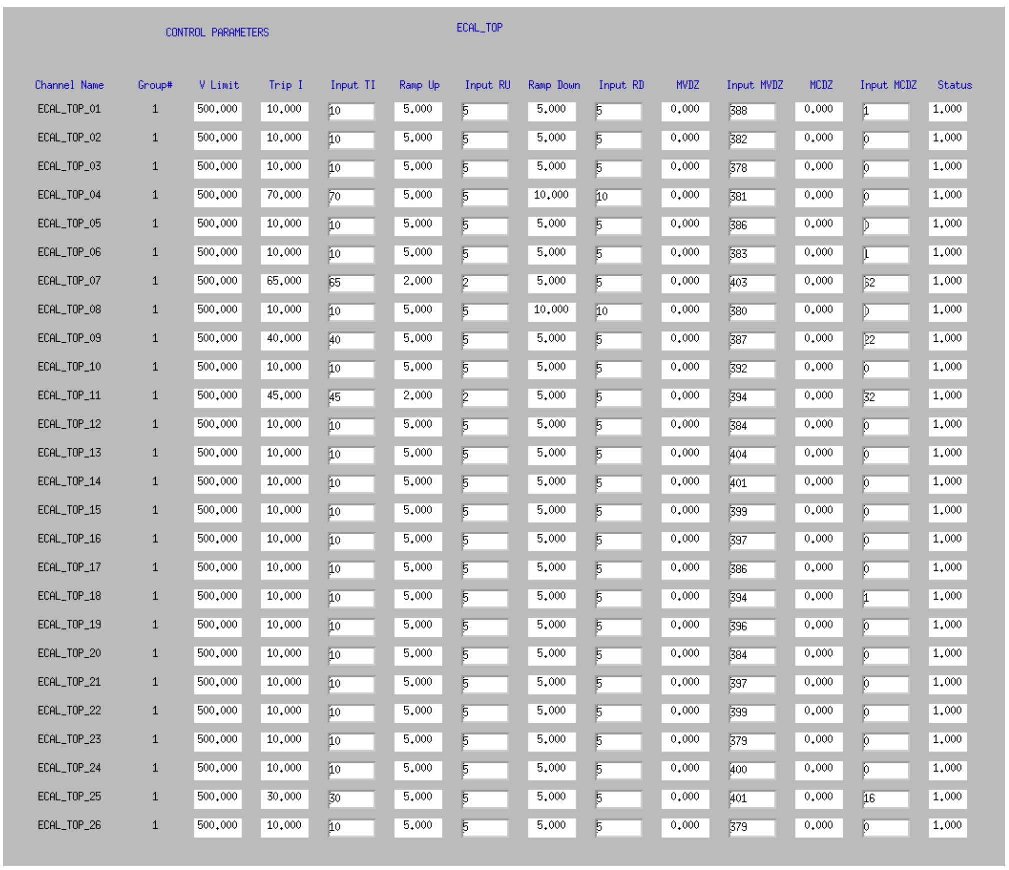


Figure 16: Expert HV channel map for reference.



CONTROL PARAMETERS ECAL_TOP

Channel Name	Group#	V Limit	Trip I	Input TI	Ramp Up	Input RU	Ramp Down	Input RD	MVDZ	Input MVDZ	MCDZ	Input MCDZ	Status
ECAL_TOP_01	1	500.000	10.000	10	5.000	5	5.000	5	0.000	388	0.000	1	1.000
ECAL_TOP_02	1	500.000	10.000	10	5.000	5	5.000	5	0.000	382	0.000	0	1.000
ECAL_TOP_03	1	500.000	10.000	10	5.000	5	5.000	5	0.000	378	0.000	0	1.000
ECAL_TOP_04	1	500.000	70.000	70	5.000	5	10.000	10	0.000	381	0.000	0	1.000
ECAL_TOP_05	1	500.000	10.000	10	5.000	5	5.000	5	0.000	386	0.000	0	1.000
ECAL_TOP_06	1	500.000	10.000	10	5.000	5	5.000	5	0.000	383	0.000	1	1.000
ECAL_TOP_07	1	500.000	65.000	65	2.000	2	5.000	5	0.000	403	0.000	62	1.000
ECAL_TOP_08	1	500.000	10.000	10	5.000	5	10.000	10	0.000	380	0.000	0	1.000
ECAL_TOP_09	1	500.000	40.000	40	5.000	5	5.000	5	0.000	387	0.000	22	1.000
ECAL_TOP_10	1	500.000	10.000	10	5.000	5	5.000	5	0.000	392	0.000	0	1.000
ECAL_TOP_11	1	500.000	45.000	45	2.000	2	5.000	5	0.000	394	0.000	32	1.000
ECAL_TOP_12	1	500.000	10.000	10	5.000	5	5.000	5	0.000	384	0.000	0	1.000
ECAL_TOP_13	1	500.000	10.000	10	5.000	5	5.000	5	0.000	404	0.000	0	1.000
ECAL_TOP_14	1	500.000	10.000	10	5.000	5	5.000	5	0.000	401	0.000	0	1.000
ECAL_TOP_15	1	500.000	10.000	10	5.000	5	5.000	5	0.000	399	0.000	0	1.000
ECAL_TOP_16	1	500.000	10.000	10	5.000	5	5.000	5	0.000	397	0.000	0	1.000
ECAL_TOP_17	1	500.000	10.000	10	5.000	5	5.000	5	0.000	386	0.000	0	1.000
ECAL_TOP_18	1	500.000	10.000	10	5.000	5	5.000	5	0.000	394	0.000	1	1.000
ECAL_TOP_19	1	500.000	10.000	10	5.000	5	5.000	5	0.000	396	0.000	0	1.000
ECAL_TOP_20	1	500.000	10.000	10	5.000	5	5.000	5	0.000	384	0.000	0	1.000
ECAL_TOP_21	1	500.000	10.000	10	5.000	5	5.000	5	0.000	397	0.000	0	1.000
ECAL_TOP_22	1	500.000	10.000	10	5.000	5	5.000	5	0.000	399	0.000	0	1.000
ECAL_TOP_23	1	500.000	10.000	10	5.000	5	5.000	5	0.000	379	0.000	0	1.000
ECAL_TOP_24	1	500.000	10.000	10	5.000	5	5.000	5	0.000	400	0.000	0	1.000
ECAL_TOP_25	1	500.000	30.000	30	5.000	5	5.000	5	0.000	401	0.000	16	1.000
ECAL_TOP_26	1	500.000	10.000	10	5.000	5	5.000	5	0.000	379	0.000	0	1.000

Figure 17: View of the EPICS HV expert control window. It is accessed from the parameters button in the ECal HV control screen 11

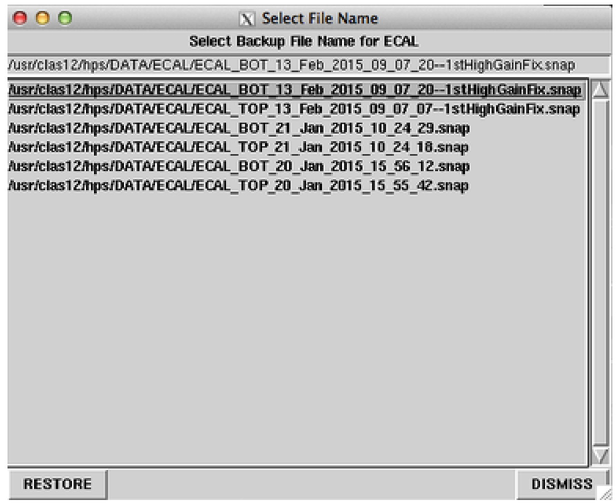


Figure 18: The gui interface to save/restore HV settings.

12.4 Long Term HV monitoring

An hourly snapshot of HV currents is stored by a cron job (and in the EPICs and MYA databases). Currently the easiest way to view it is as user `hpsrun` on `clonpcNN` by excuting the command:

```
$HOME/.ecalhv/plotEcalHV.py
```

The product should be a plot like figure 19.

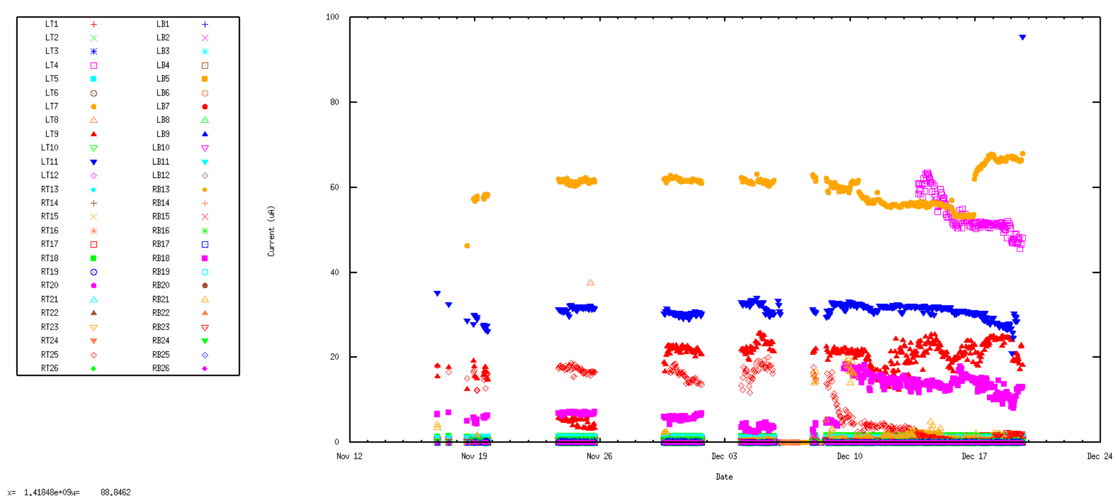


Figure 19: Expert HV current history.

13 Disconnection of a Channel and Preamplifier Replacement

In last resort, to recover a HV group that is tripping one can disconnect the faulty channel causing trouble. To do so, you need to find exactly which channel is involved!

It might be obvious from data, if the channel was already very noisy, else you will have to test the channels of the group one by one. This is a lengthy operation and should only be attempted with the authorization of the run coordinator and in coordination with the ECal Group. It necessitates that the Hall-B crew moves the ECal out of the beam line and to open it.

14 LED system for experts

This section has to be replaced with instructions to use the CLAS_css GUI.

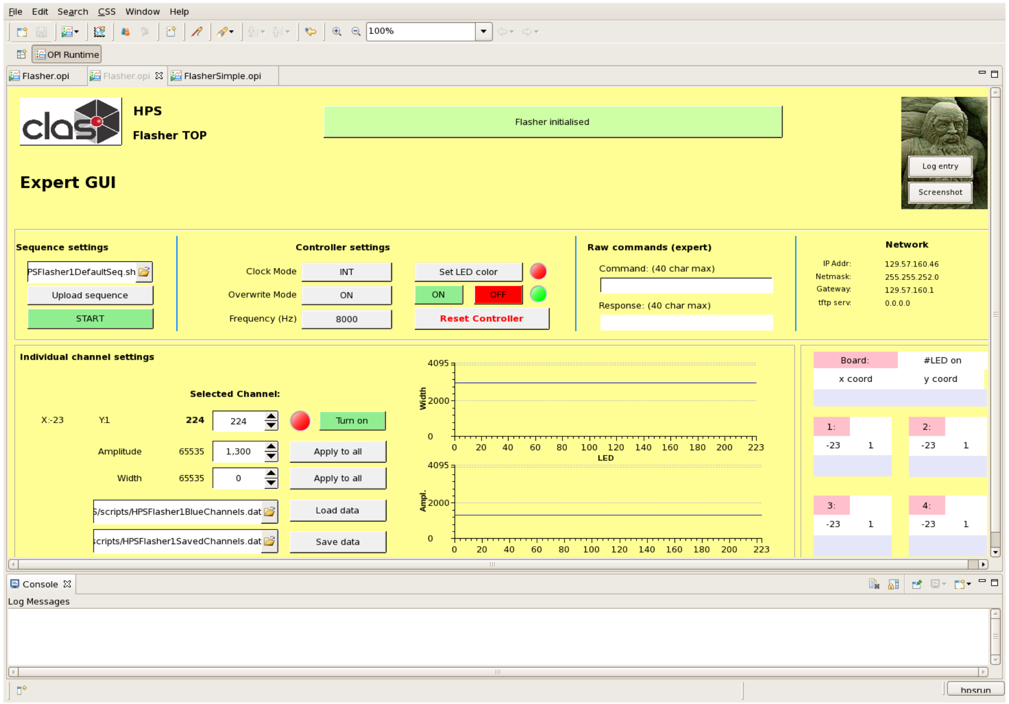


Figure 20: View of the LED expert controls.