Manual for HPS ECal v1.3

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January 7, 2015

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

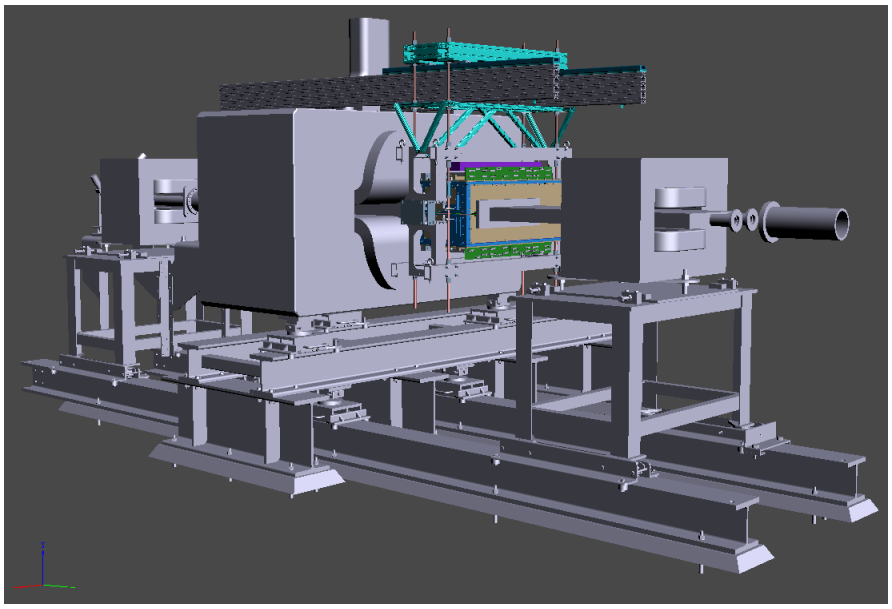


Figure 1: General view of the ECal (in color) suspended at the downstream end of the HPS analyzing magnet.

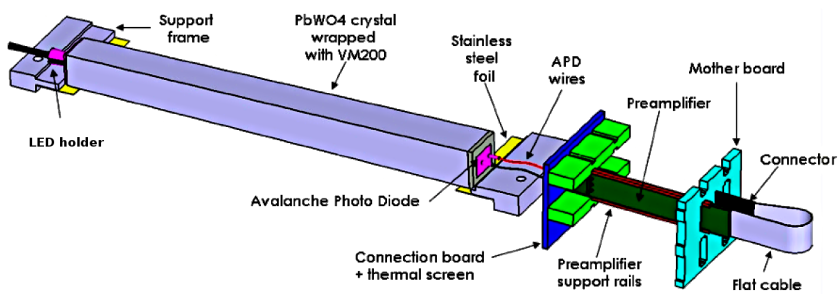


Figure 2: View of an ECal crystal and the amplification chain.

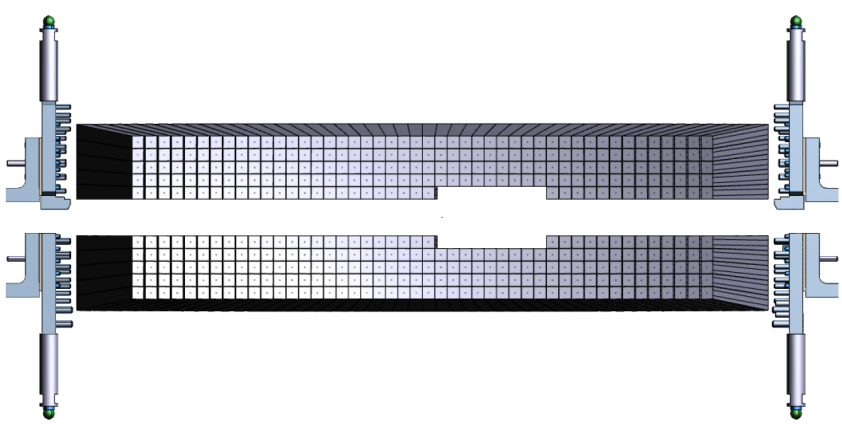


Figure 3: Front view of the ECal crystals layout.

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*.

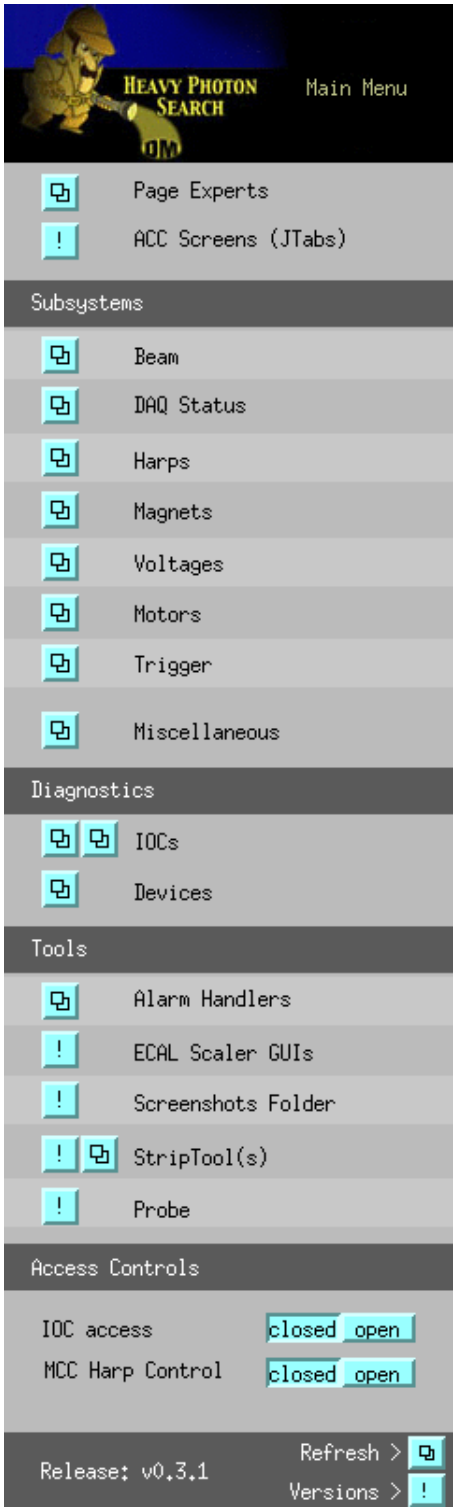


Figure 4: View of the Hall-B EPICS main window.

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.

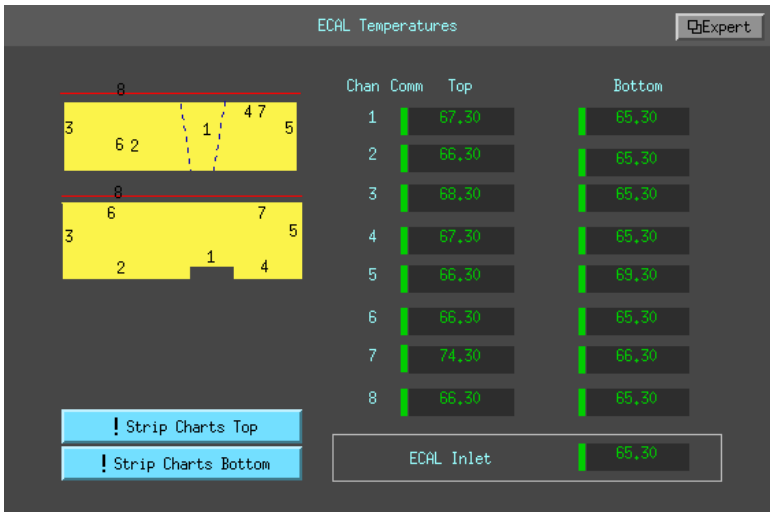


Figure 5: View of the EPICS temperature monitoring window.

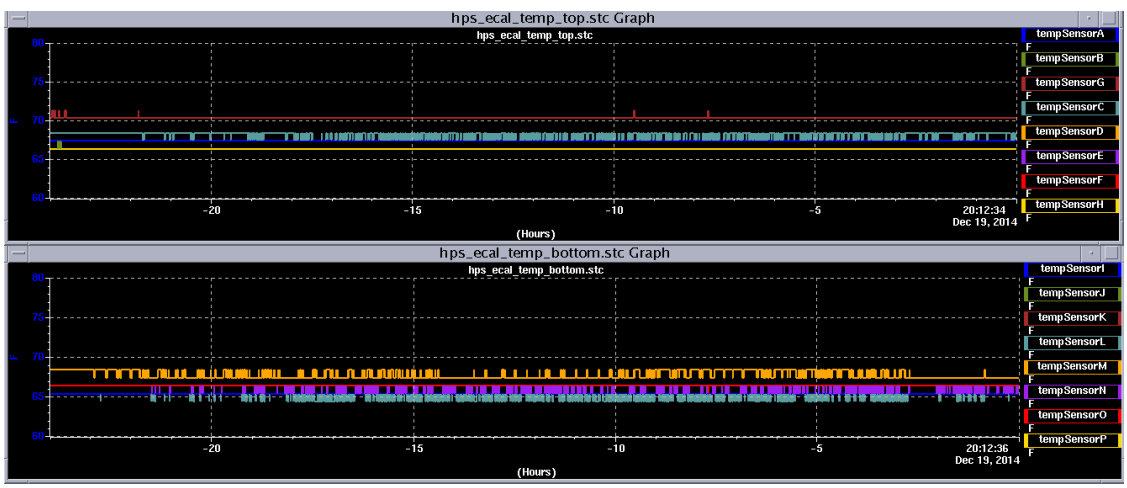


Figure 6: View of the EPICS temperature monitoring strip charts.

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 8). Shift takers should not attempt to change the chiller settings and call ECal expert in case of problem.

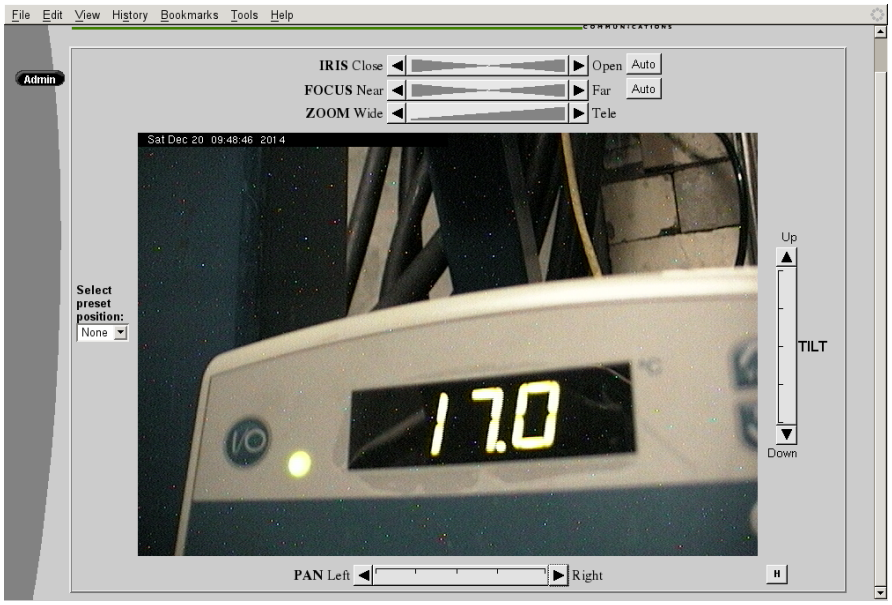


Figure 7: View of the chiller screen by webcam (cctv10.jlab.org).

4 Scalers

Rates seen by the ECal are available in the EPICS (Fig 9), 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 10), 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.

5 High Voltages

5.1 Low Voltage Controls

The low voltage power supply must be on before HV. It is controlled manually in the hall and should be monitored using its webcam (figures 11). Call the ECal expert if this appears not to be ON or shows an abnormal current.

5.2 Turning ON High Voltages

The high voltage supply of the ECal is controlled and monitored using the EPICS application (see figure 12).

5.3 Responding to HV trips

HV problems, in particular trips, are indicated by a red group in the main EPICS GUI (figure 12). 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

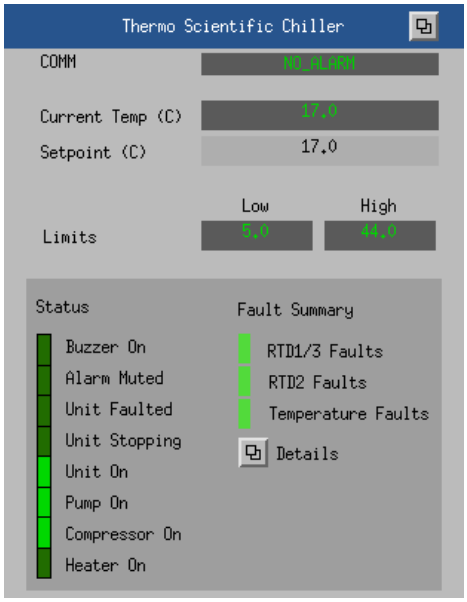


Figure 8: View of the EPICS ECal Chiller window.

(figure 13) 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.

6 LED Monitoring

6.1 System operations - EPICS GUI

The LED system is operated trough an EPICS GUI, that is accessible trough the main HPS EPICS menu, trough Devices, then Flasher (see Figure 14).

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 15).

7 Making a cosmic calibration run

To be added later.

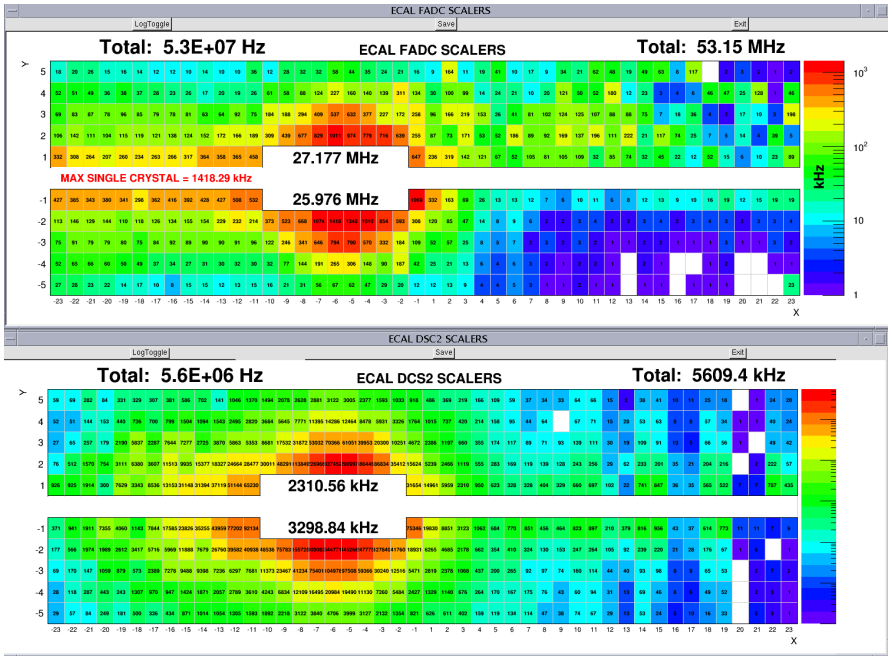


Figure 9: View of the EPICS FADC and DSC2 scalers window.

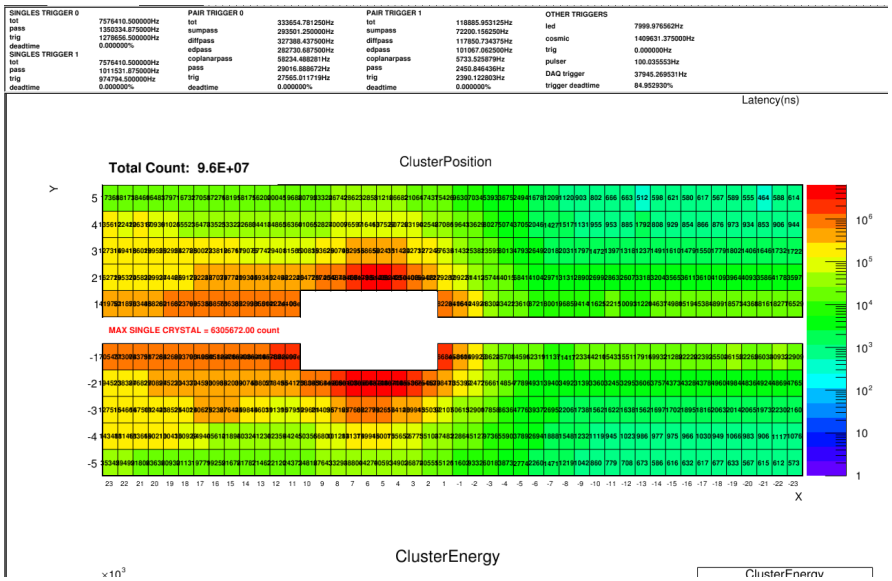


Figure 10: View of the DAQ scaler window.

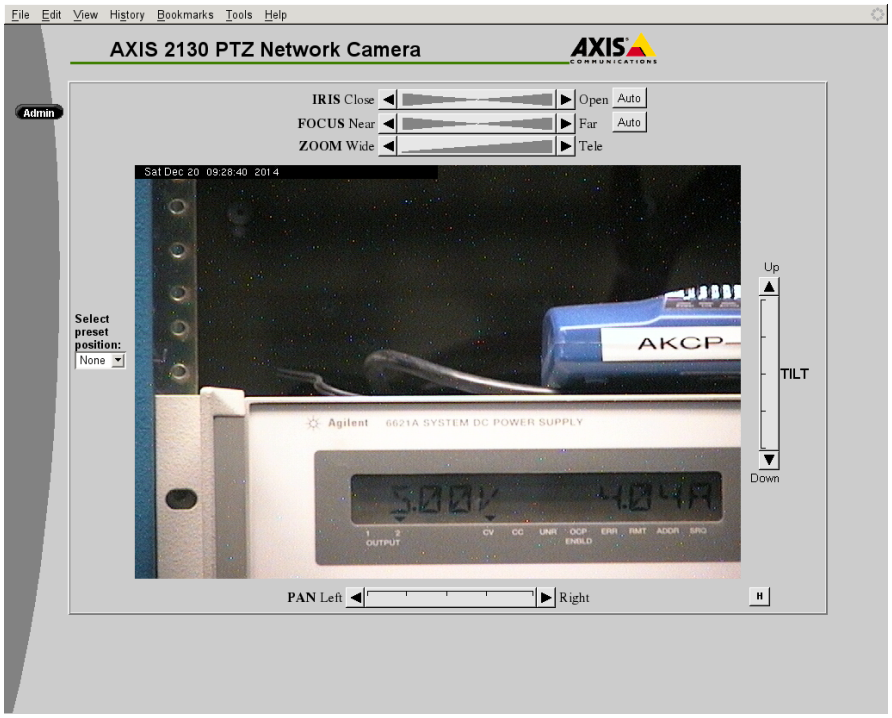


Figure 11: View of the LV screen by webcam (cctv11.jlab.org).

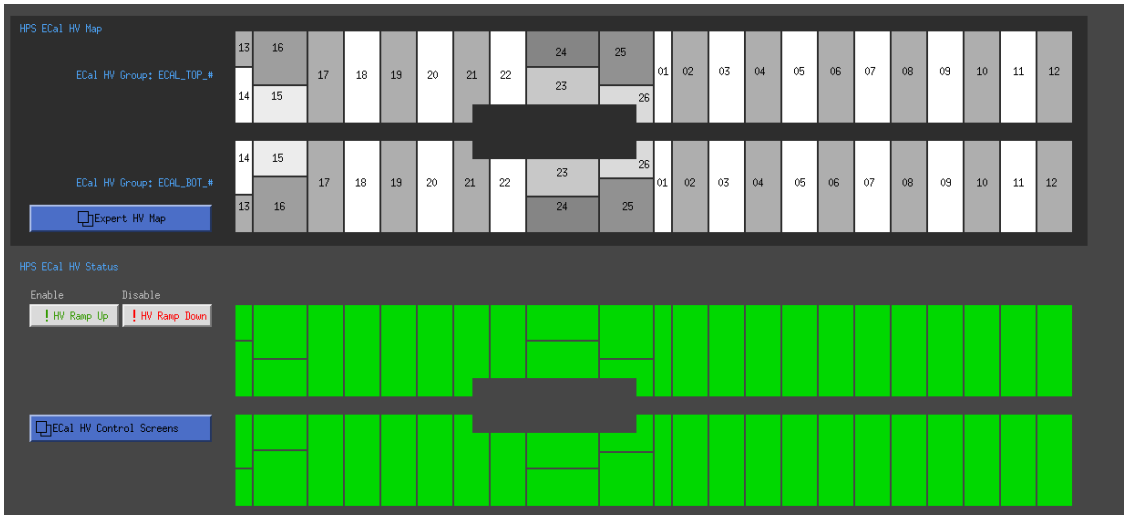
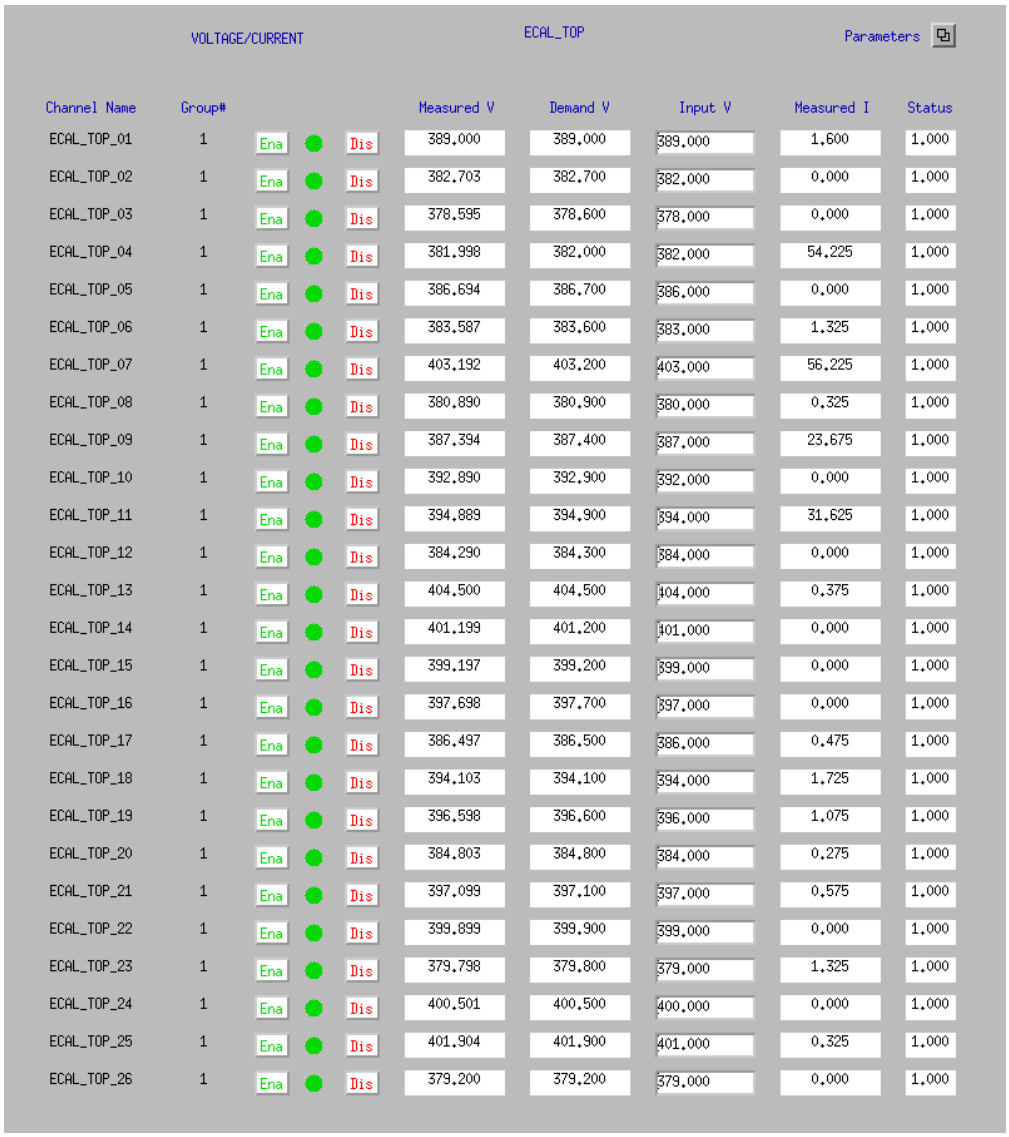


Figure 12: View of the EPICS ECal HV monitoring window.



VOLTAGE/CURRENT ECAL_TOP Parameters

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 13: View of the EPICS ECal HV control window.

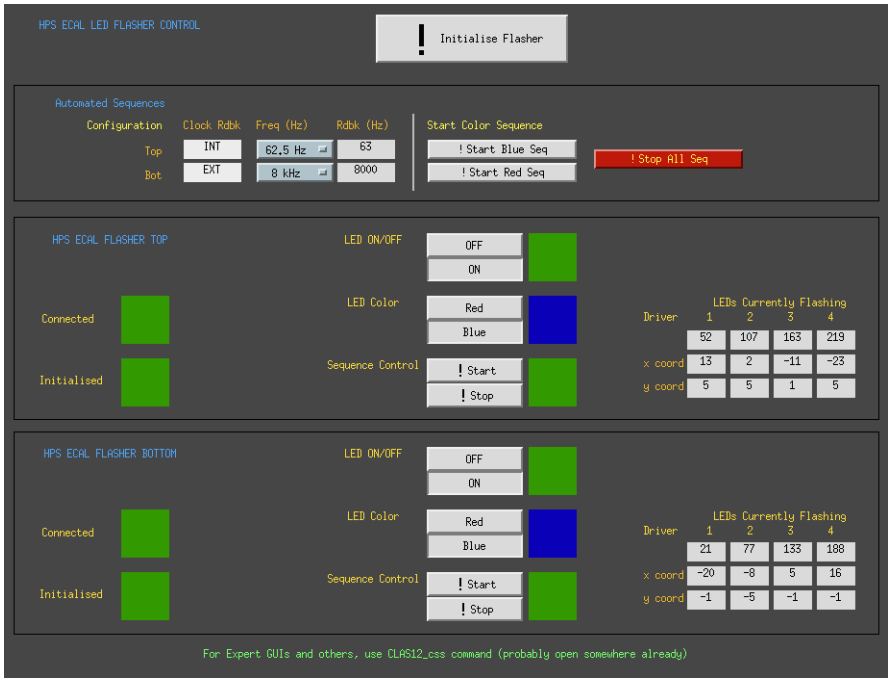


Figure 14: The HPS-ECAL Led monitoring system EPICS GUI.

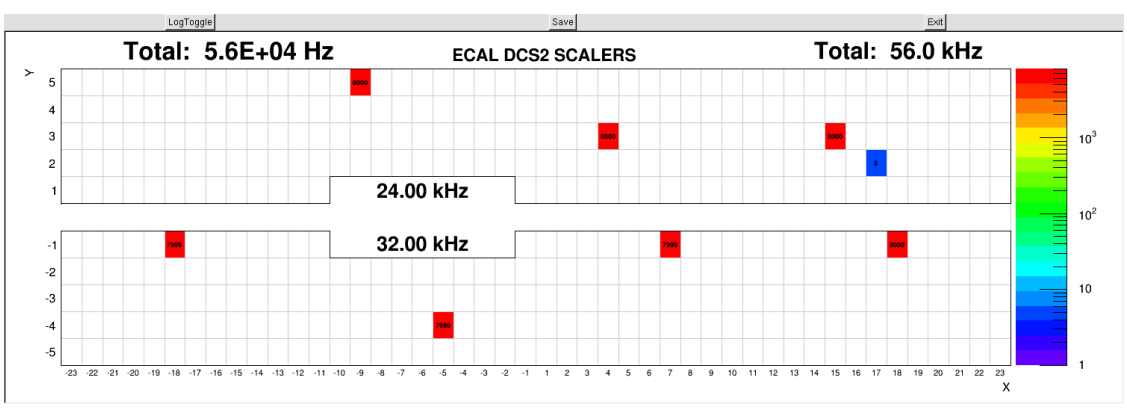


Figure 15: The HPS DSC scaler during a LED run.

Part II
ECal Experts Resources

8 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.

Location of elements (electronics, chiller...) in the Hall to be added with images.

9 Cooling system

The cooling system is using a xxxx chiller that is controlled through EPICS (Fig to be added). 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?).

Add basic information to reset the Chiller. Add link to manual.

10 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.

11 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.

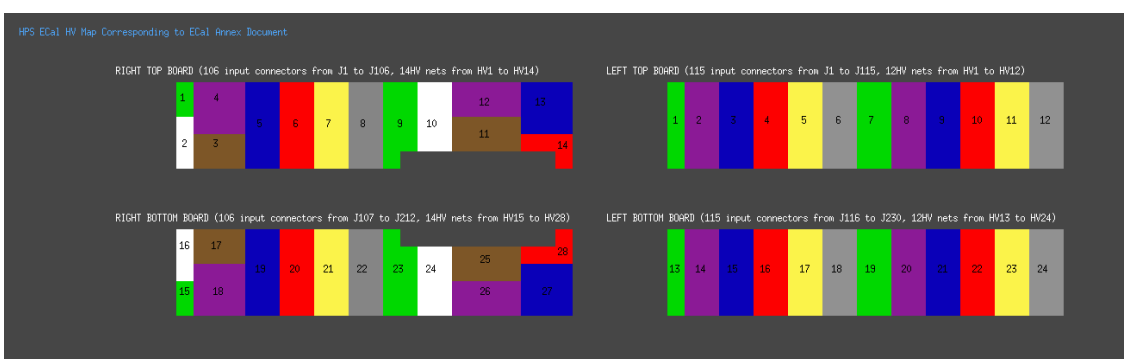


Figure 16: Expert HV channel map for reference.

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!

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	52	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 13

12 Long term HV monitoring

Add here commands to make current plot of fig 18

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

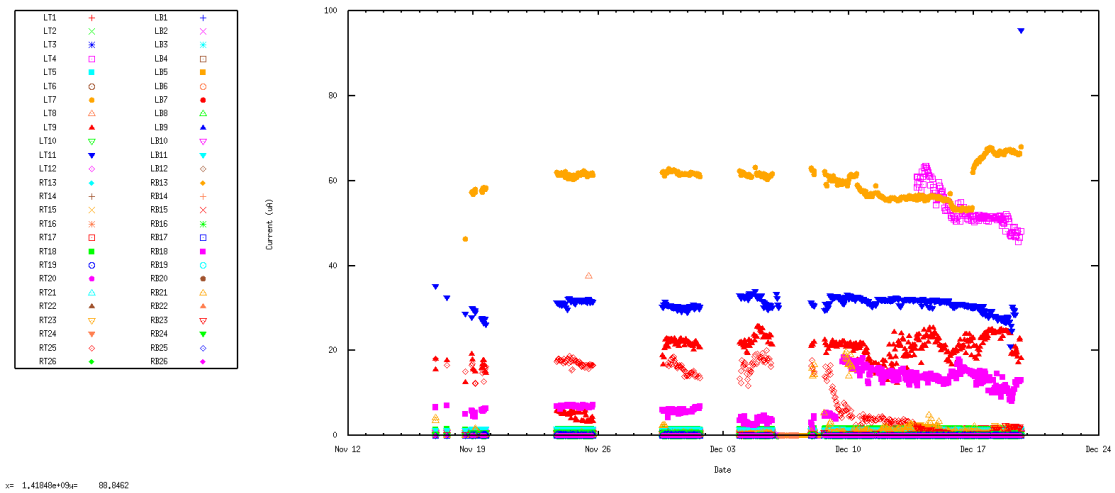


Figure 18: Expert HV current history.

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.

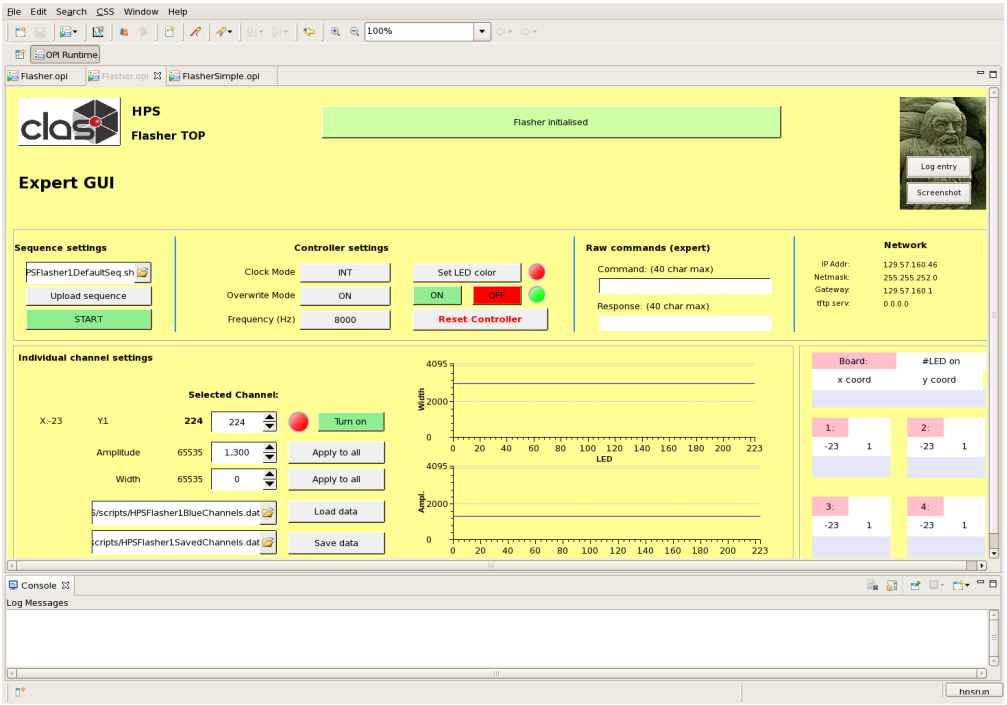


Figure 19: View of the LED expert controls.