

HPS-ECal commissioning with the LED monitoring system

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Abstract

This document describes the operations involved in the HPS-ECal commissioning employing the LED monitoring system. This will be the first step of the full commissioning process, before measurements with cosmic rays and with the beam will take place. For each task to be performed, the corresponding procedure is reported with full details, together with the requirements needed to complete it.

Introduction

The LED monitoring system will be used during the first phase of the HPS-ECal commissioning, before measurements with cosmic rays and with the beam will take place. The system will be mainly used to check the proper operation of each ECal channel, testing the corresponding signal processing chain, involving the APD, the amplifier, the DAQ system. Some tasks will be performed to characterize the LED system itself within the ECal setup. The tasks to be performed during the commissioning are the following:

- Verify the proper operation of all the ECal channels, from the APD to the DAQ system. Identify and correct cable-swaps (both for the signals and for the high voltage).
- Determine the working point for all the LEDs, for both colors.
- Measure the cross-talk for each channel.
- Align the ECal channels in time.
- Check the effect of the recovery mode on the LED response, to verify if there is an hysteresis.
- Measure the LED system stability.

To perform these tasks, some pre-requirements must be already satisfied. These are:

- **Calorimeter:**
 - The calorimeter has been installed in Hall-B.
 - The low voltage and the high voltage system have been connected to the calorimeter.
 - The output signals have been cabled to the DAQ system according to a definite map.
 - The cooling system has been installed and the temperature readout is working.
- **LED system:**

- The two controllers have been installed in the electronic racks in Hall-B and connected to the slow-controls Ethernet network.
 - The slow-controls (EPICS) software to control the system is installed and configured.
- **DAQ system:**
 - The DAQ system has been configured to acquire data from FADCs in RAW mode (i.e. full waveform) and in PULSE mode (i.e. pulse integral + pulse time).
 - The DAQ system has been configured to accept the trigger from the LED system master clock (TTL signal).
 - The DAQ system has been configured to save the ECal temperature in the output file periodically. To do so, a proper EPICS bank should be defined in the EVIO output file.
- **Software:** each task has specific software and analysis requirements, that are discussed case-by-case.

Task 1

Goal: verify the proper operation of all the ECal channels (APD, amplifier, cabling, DAQ system). Identify and correct cable-swaps (signals and HV).

Specific requirements:

- The map of the LED system must be known (i.e. which LED is coupled to which ECal channel). This has been checked during preliminary tests and is available in the HPS conditions database, and also in the HPS run Wiki page [1].
- A preliminary working point for each LED, resulting in a visible pulse at the amplifier output, should be available. A specific signal amplitude is not critical at this stage. This information is available in the HPS conditions database.

Procedure:

1. Turn on the DAQ system and start a run, with all channels enabled, configured to take data in RAW mode. The ET system should be up and running, but there is no necessity to save data to the disk.
2. Switch on the LED connected to the ECal channel under study, blue color, setting the preliminary working point.
3. Switch on the corresponding HV channel.
4. Verify that the output waveform, measured by the FADC, has a “proper” shape (see Fig. 1, left panel, for a “typical” good signal shape).
5. Switch off the corresponding HV channel and verify that the pulse is no longer visible.
6. Switch off the LED.

This procedure has to be repeated manually for all the 442 LEDs.

Time required: 2-3 days, including the time to identify and fix any problem found during the measurement.

Software: The online monitoring system included in the HPS software is used to perform this measurement, configured with the LCIO steering file “ECalLedCommissioning.lcsim”. The ECal event display is used to select the channel being measured, whose output waveform is displayed on a histogram in the main application canvas.

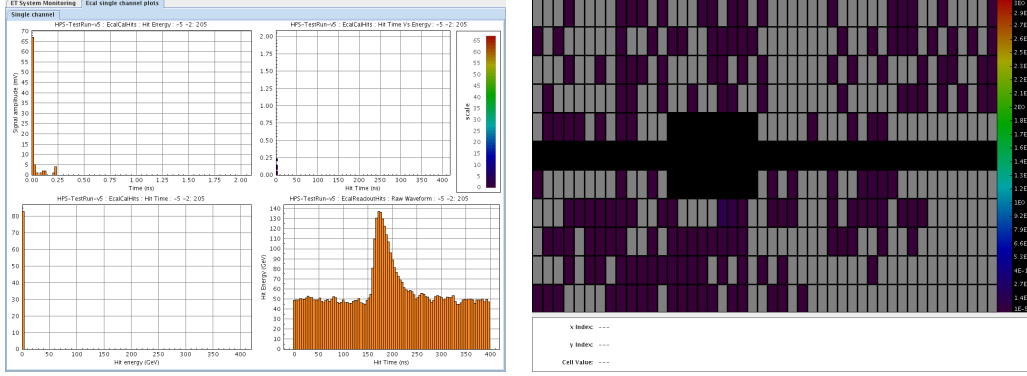


Figure 1: Left: The HPS monitoring application configured to show waveforms, using the steering file “ECaLedCommissioning.lcsim”. A typical waveform is shown in the bottom right panel. Right: The ECal event display.

Task 2

Goal: determine the working point of all LEDs, for both colors. This is required since the LED system is intrinsically non-linear. The preliminary working point used in the previous task, determined from an independent characterization of the system, can’t be extrapolated to the working point in the different HPS setup. The working point is used to accomplish the next tasks, in particular the cross-talk measurement, the time alignment, and the stability measurement. For each LED, it is desirable to identify 4 working points, 2 for each color. The first, referred to as “high setting”, corresponds to a large emitted pulse, resulting in an output signal amplitude of 1.8 V, and will be used to measure the calorimeter stability and evaluate the cross-talk. The second, referred to as “low setting”, corresponds to an output amplitude of the same order of magnitude of the signal produced by cosmic rays. These working points can be determined at different times. In particular, to proceed with the following tasks only the “high” working point is required.

Procedure: Ideally, we would have an automatic procedure that iteratively finds the LED working point, by starting from a certain configuration, taking data, measuring the resulting output amplitude, changing the LED working point (interacting with the LED system through EPICS), taking data again, ..., until convergence. However, if this automatic procedure is not ready before the commissioning starts, we identified the set of operations that must be performed manually to identify the working point. Here, we assume that Task 1 has already been accomplished.

1. Turn on the DAQ system and start a run, with all channels enabled, configured to take data in RAW mode. The ET system should be up and running, but there is no necessity to save data to the disk.
2. Switch on all the HV channels.
3. Switch on the LED corresponding to the ECal channel under study, blue color, setting the preliminary working point.
4. Measure the output signal amplitude (in mV). This information is available in the online monitoring application.

5. Change the LED working point until the amplitude is $1.8 \text{ V} \pm 10\%$. When done, write down the working point, and repeat these operations for the red color.

This procedure has to be repeated manually for all the 442 LEDs.

Time required: for each working point (determined for both colors), 5 minutes/LED are required. Having 442 LEDs in the system, this results in $\simeq 37$ hours to fully characterize the system. However, this time can be reduced if more people work in parallel, each person controlling a different LED system driver, and running a different instance of the monitoring application. The EPICs software already supports this.

Software: The online monitoring system included in the HPS software is used to perform this measurement, configure with the LCIO steering file “ECalLedCommissioning.lcsim”. The ECal event display is used to select the channel being measured, whose output waveform is displayed on a histogram in the main application canvas. The amplitude (in mV) is also shown in a histogram (see Fig 1, left panel).

Task 3

Goal: measure the cross-talk between the different ECal channels.

Specific requirements: the “high setting” of each LED should have been already determined (Task 2), at least for the blue color. Also, FADCs should have been configured to acquire data in PULSE mode, with proper values of the “NSB” and “NSA” parameters.

Procedure:

1. Turn on the DAQ system and start a run, with all channels enabled, configured to take data in PULSE mode, with the lowest readout threshold (compatible with the noise). Switch on all the HV channels, at the nominal HV value.
2. Start an LED sequence over all the LEDs, taking for each step data for 1 minute. In the sequence, switch on 8 LEDs at time with the blue color, 1 per driver. For each LED, the working point should be the “high setting” determined before.

Time required: $\simeq 1$ hour for the measurement, plus the analysis time.

Analysis/software: to compute the cross-talk induced by the LED n on the neighborhoods, the analysis should be performed as follows. First, the events with the LED n ON have to be identified. Then, the average pulse “energy” should be computed for both LED n and the neighborhoods. Finally, the cross-talk is measured taking the ratio of these values. This analysis can be performed before calibration constants are available, working on “raw” energies (i.e. directly on the pulse integral reported by the FADCs in “arbitrary” units). Later, the analysis can be repeated on the same data-set when calibration constants are available.

The software to perform this task is currently being developed, within the HPS software framework.

Task 4

Goal: align ECal channels in time. When a single event results in a deposition of energy in multiple ECal channels (for example, an electromagnetic shower), generally the measured hit times reported by the DAQ system are not synchronous. This is due to fixed, channel-by-channel, delays, caused, for example, by different cable lengths, different settings of the FADCs, ... The goal of this task is to measure and correct these delays, using the LED system.

Specific requirements and procedure: this task can be performed working on the same dataset measured in Task 3. The intrinsic time differences between each LED signal and the LED system master clock must be known. These have been measured during the preliminary system characterization, and are available in the HPS conditions database.

Analysis/software: the goal of the analysis is to measure, for each ECal channel n , the average hit-time T_n reported by the DAQ system with respect to the trigger signal, provided by the LED system master clock. To determine the intrinsic ECal delays, these measurements have to be corrected by the corresponding LED system delays.

The software to perform this task is currently being developed, within the HPS software framework. In particular, the same software will be used to perform Task 3 and Task 4.

Caveat: the accuracy of this procedure is $\simeq 1$ ns: this is the accuracy of the setup used to measure the intrinsic LED system delays.

Task 5

Goal: check the effect of the LED “recovery mode”¹. In particular, it is essential to determine if, for a certain LED working point, the signal amplitude is the same before and after the LED has been turned on continuously for a long time ($\simeq 1$ day), or if there is an hysteresis in the LED response.

Procedure:

1. Turn on the DAQ system and start a run with all channels enabled in PULSE mode. Start an LED sequence over all the LEDs, taking for each step data for 1 minute. Switch on 8 LEDs at time, 1 per driver, with the blue color, “high setting”. Then, repeat the sequence with the red color (using the corresponding “high setting”).
2. Switch the system to recovery mode for $\simeq 1$ day.
3. Repeat again the two sequences of the first step above.

Time required: $\simeq 2$ hours for the first 2 sequences + 1 day for the recovery mode + $\simeq 2$ hours for the last 2 sequences.

Analysis/software: the goal of the analysis is to determine, for each channel, if the output signal is the same before and after the recovery mode, for both colors. Therefore, for each channel n (and for both colors), the events with the LED n ON have to be identified, and the corresponding average pulse “energy” should be computed. This operation must be done for both the sequences taken before and after the recovery mode. The results should then be compared to see if there is a significant difference. This analysis can be performed before calibration constants are available, working on “raw” energies (i.e. directly on the pulse integral reported by the FADCs in “arbitrary” units).

The software to perform this task is currently being developed, within the HPS software framework.

¹When in “recovery mode”, the LEDs are switched on continuously, in DC mode, to inject an intense blue light in the crystals and recover radiation-induced damage.

Task 6

Goal: measure the LED system stability, before the calorimeter is exposed to the electron beam.

1. Turn on the DAQ system and start a run with all channels enabled in PULSE mode. Start an LED sequence over all the LEDs, taking for each step data for 1 minute. Switch on 8 LEDs at time, 1 per driver with the blue color, “high setting”.
2. When the sequence is finished (after $\simeq 1$ hour), start again a new iteration from the beginning. The LED system supports this option (the user has to specify how many iterations a sequence should be performed: -1 means *ad libitum*).

Time required: $\simeq 1$ hour for each sequence iteration. At least 20 iterations are required.

Analysis/software: the goal of the analysis is to isolate in the datastream the events corresponding to the channel i , iteration j , and to compute for these the average signal energy $E_{i,j}$. The dependence of $E_{i,j}$ on j (i.e. on the time) is then studied to evaluate the LED system stability, channel-by-channel, also in correlation with the temperature. Calibration constants are not necessary at this stage, the analysis can be performed working on “raw” energies (i.e. directly on the pulse integral reported by the FADCs in “arbitrary” units).

The software to perform this task is currently being developed. Since a similar standalone software already exists, developed for the FT-Cal detector, it will be adapted to the HPS setup to perform this task.

References

- [1] HPS Wiki run page: https://wiki.jlab.org/hps-run/index.php/The_HPS_Run_Wiki