Timing and signal strength calibrations for the High Threshold Cherenkov Counter

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Abstract

This document describes all the steps necessary to calibrate both timing and signal strength for the HTCC detector based on the experimental data.

1 Introduction

There are two key values to be calibrated for the High Threshold Cherenkov Counter: signal strength (in terms of the number of photoelectrons) and timing of the signal. Both of these calibrations are performed by using the HTCC calibration software package (which is undergoing a major upgrade right now). Results of this procedures are PMT-by-PMT correction coefficients for the signal strength (to be uploaded to the *ccdb*) and timing delays.
All these procedures are relevant to electrons only (as identified by the Event Builder Particle ID).

2 Using the code

To perform the calibration in the optimal manner one has to create hipo files corresponding to "htcc skim" (see bank structure in Table 1). Usually there is no issue with accessing lower (Ring1 and Ring2) PMTs closer to center, but Ring3 and especially Ring4 requires substantial statistics of order of 5M event.
One run the calibration code with the input file name as a input parameter

```
$COATJAVA/bin/run-groovy htccCalib.groovy filename
```

There is a shell script that sets all the environment variables. One need to edit it and add lines with input files names to make it go over many files

```
htccCalib.sh
```

0	HTCC::adc
1	HTCC::rec
2	REC::Cherenkov
3	REC::Event
4	REC::Particle
5	REC::Scintillator
6	REC::Track
7	RUN::config
8	RUN::rf

Table 1: Bank structure for the HTCC calibration output.

3 Signal strength equalization

In order to estimate and equalize the signal strength PMT by PMT one selects events corresponding to a single PMT hit (disregarding clusters where signal was split into several PMTs) and calculates average NPE for each of the channel. Correcting coefficient for each PMT is equal to ration of the signal in this PMT to the average value across all PMTs.
This correction value is applied to gain in the ccdb. Sample calibrated spectrum is presented in Fig. 1. This procedure of calculating of average is very robust and the only possible issue is not having enough statistics.

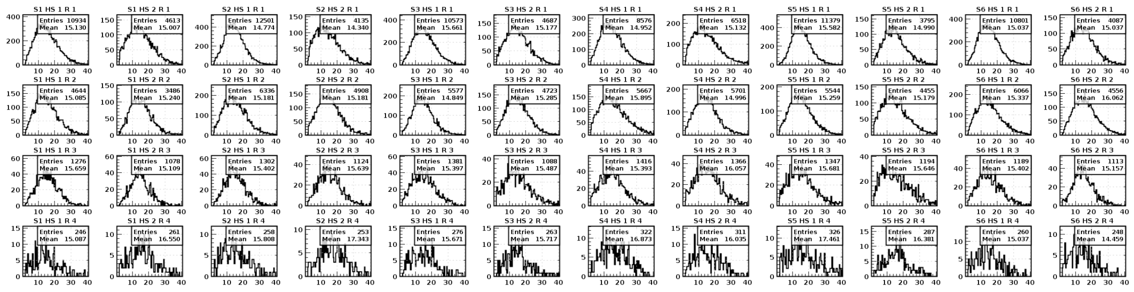

Figure 1: Example of the yield equalization for a single run, all 48 PMTs.

4 Timing calibration

In order to properly align timing between different PMTs one again selects single-hit events and calculate timing between the HTCC time and event start time at vertex. This time difference is later fit with gaussian and the position of this gaussian is used as a additional time shift. These time shift are to be uploaded to the ccdb and are later used during the HTCC signal reconstruction.

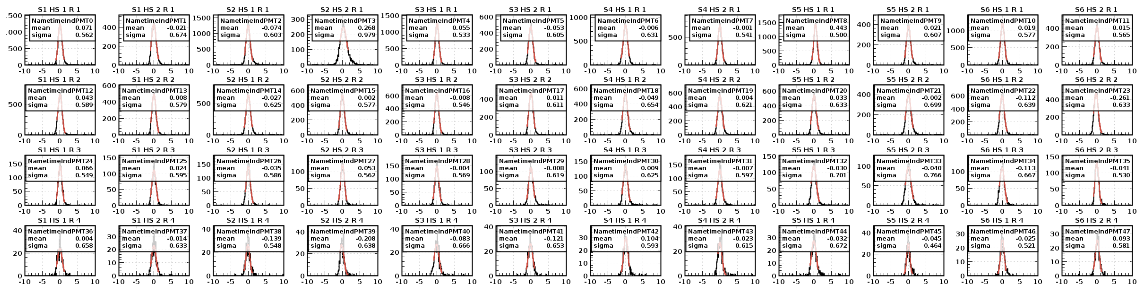
Figure 2: Integrated timing.

5 Diagnostics

While the resulting plots for the HTCC Calibrations (Fig. 1 and Fig. 2) are rather self-explanatory, it might be useful to have one summary plot for each of the calibrations. Example plots are presented in Fig. 3 and Fig. 4. While these distributions are of course heavily skewed by the largest statistics (low θ PMTs), they still are good summary of the HTCC performance and calibration.

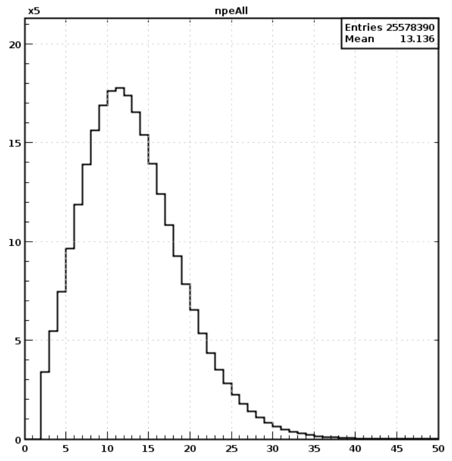

Figure 3: Integrated over 48 channels signal strength.

6 Interface with *ccbd*

Calibration code reads from the ccdb (default variation and current timestamp, which effectively reads the latest set of constants) gains and offsets and produces corresponding calibrated values (two output files, npePMT3219.dat and timePMT3219.dat) for both gain and timing. One has to use CLAS12 monitoring timelines to estimate ranges of applicability of constants (there is no automatization to this step). Constants of interests are loaded in the *ccdb* in the tables */calibration/htcc/time* and

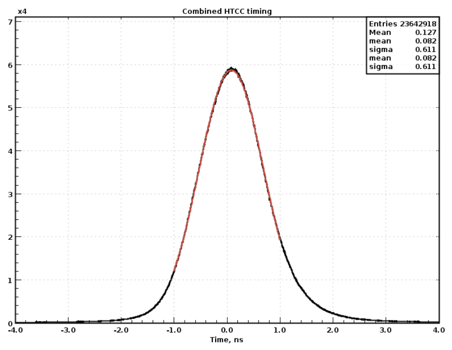

Figure 4: Integrated over 48 channels timing.

/calibration/htcc/gain (default variation). Example of the appropriate commands are presented below:

ccdb -c mysql://clas12writer:geom3try@clasdb/clas12 add /calibration/htcc/time -r 11093-11243 timePMT11158.dat

ccdb -c mysql://clas12writer:geom3try@clasdb/clas12 add /calibration/htcc/gain -r 11093-11243 npePMT11158.dat

7 Monitoring and procedures

In order to determine which runs to calibrate and which run ranges particular constants are applicable for, one starts from the CLAS12 monitoring timelines. Sample non-calibrated plot for RG-A Spring18 is presented in Fig. 5. One can clearly see distinct run ranges with similarly miscalibrated timing.

Zoom (fig. 6) shows that for example in the beginning of the run we have regions of (3210 - 3293, 3306 - 3474, 3480 - 3817) have similar miscalibration and each of them require one run to be properly calibrated. To select a proper run for each range, one should choose a regular production run with enough statistics ($>$ 10M events) and without major problems recorded in the logbook. Corresponding constants should be uploaded to ccdb for the appropriate run ranges. One can check if it was properly uploaded by visiting ccdb web interface.

Once required runs are calibrated and proper constants are uploaded to *ccdb*, another pass0 is run and new generation of monitoring plots are produced with updated constants applied. Fig. 7 shows results of the calibration. One can see that timing shifts are now well within 1 ns and at this stage calibration procedure can be stopped.

One must note that NPE plots are not as simple as timing due to the fact that trigger properties will affect monitoring plots in the timelines. Specifically, the peak position or mean value can change not due to the calibration differences but due to overall shape of the NPE distribution. One should look into individual PMT plots in order to determine the quality of gain calibrations.

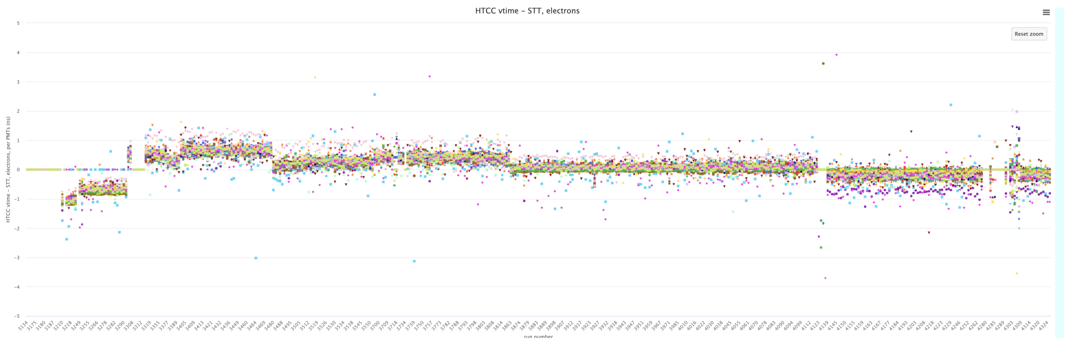

Figure 5: HTCC timing monitoring timelines before timing calibrations.

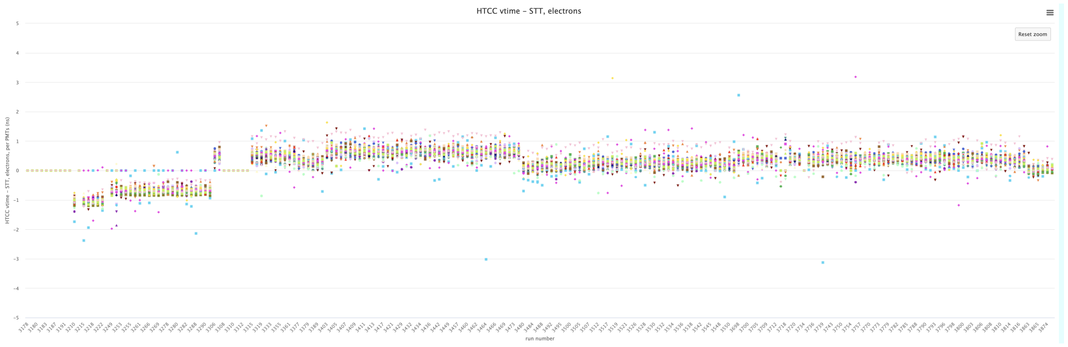

Figure 6: HTCC timing monitoring timelines before timing calibrations, zoomed in.

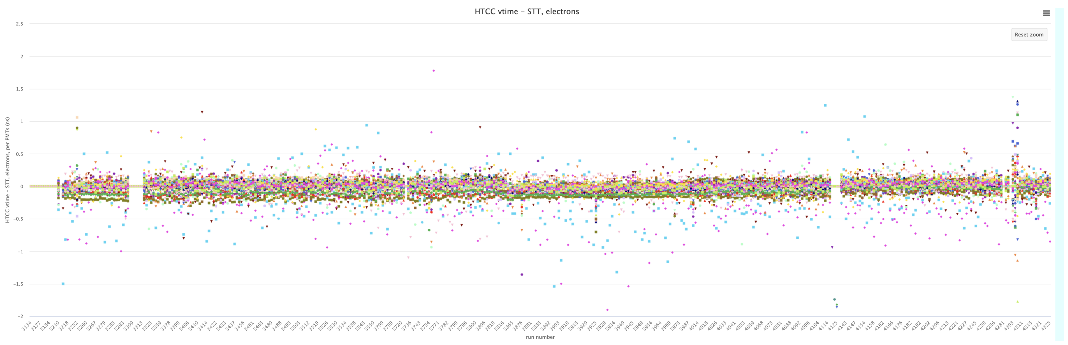

Figure 7: HTCC timing monitoring timelines after timing calibrations.