Tutorial for CLAS12 Central Neutron Detector Energy and Timing Calibration

Pierre Chatagnon, Institut de Physique Nucléaire d'Orsay, France
Gavin Murdoch, University of Glasgow, United Kingdom
Paul Naidoo, University of Glasgow, United Kingdom
Silvia Niccolai, Institut de Physique Nucléaire d'Orsay, France
Daria Sokhan, University of Glasgow, United Kingdom

June 9, 2020

Abstract: This document describes all the calibration steps of the CLAS12 Central Neutron Detector (CND). All the steps are fully explained, and typical results are shown in order to judge the quality of the results.

Contents

Part I
Introduction

The Central Neutron Detector (CND) is a scintillator barrel detector located in the CLAS12 Central Detector. It is used to detect neutrons at backwards angles ($40° < \theta < 120°$). The CND consists of 3 radial layers of 48 plastic scintillator paddles of trapezoidal shape. Adjacent paddles are coupled two-by-two at their downstream end with a "uturn" lightguide. Three pairs of coupled paddles are stacked up, one over the other, forming a sector. Overall there are 24 sectors of 6 paddles, for a total of 144 scintillators. The paddles are numbered by their sector/layer/component (S/L/C). There are 24 sectors, 3 layers and 2 components (Left or 1 and Right or 2). The scintillation light is guided from the upstream ends of the scintillators to the PMT through 1.5m-long lightguides. The readout is done by PMTs located at the end of the lightguides.

The calibration of the CND is done in two steps. The first step is the time-based calibration which calculate effective velocities and time offsets. This calibration is necessary to obtain timing and position information of CND hits. The second step is the energy calibration, in which attenuation lengths and energy conversion factors are calculated. There are 4 calibration steps and 7 sets of calibration constants (see Table 1). All of the constants need to be uploaded to the CLAS12 Database.

Step	Calibration Constant	Output	Number of Constants
1	LR (Left-Right) time offset	LR_{off}	72
2	Effective velocity	v_{eff}	144
	U-turn time loss	u_{tloss}	72
	Adjusted LR time offset	$LR_{off_{adj}}$	72
3	Global time offset	t_{off}	72
4	Attenuation length	Att_L	144
	Energy constants	MIP_D, MIP_I	144 each

Table 1: A list of the calibration constants, and the steps in which they are calculated.

In this document, every step of the calibration is presented with respect to its implementation in the calibration suite. A full description of the formulas used in the algorithms can be found in a separate, dedicated document [1].

Part II
CND Calibration Startup

1 Getting the code

The CND calibration suite is written in Java, and deployed as a *.jar* file. It can be executed on any machine that runs Java 1.8 or later. The source code can be found on the official JLab GitHub repository:

`https://github.com/JeffersonLab/clas12calibration-cnd`

The most recent versions will be tagged and available to download at:

`https://github.com/JeffersonLab/clas12calibration-cnd/releases/`

Questions or suspected bugs may be directed to: *p.naidoo.1@research.gla.ac.uk*

2 Running the code

There are two main options to run the CND calibration suite :

- In Unix systems one can run the code from the command line as: *java -jar CalibrationCND.jar*
- In any other systems one can run the code by right clicking the .jar file and choose *Run with Java* or similar

3 Calibration Suite GUI Layout

The GUI interface of the CNDcalibration suite is composed of two main windows. The first window is the Configuration window. It is opened when the suite is launched. The configuration window is illustrated in Figure 2. The second window is the Calibration window. It opens when the configuration has been completed and the configuration window closed. It is shown in Figure 1.

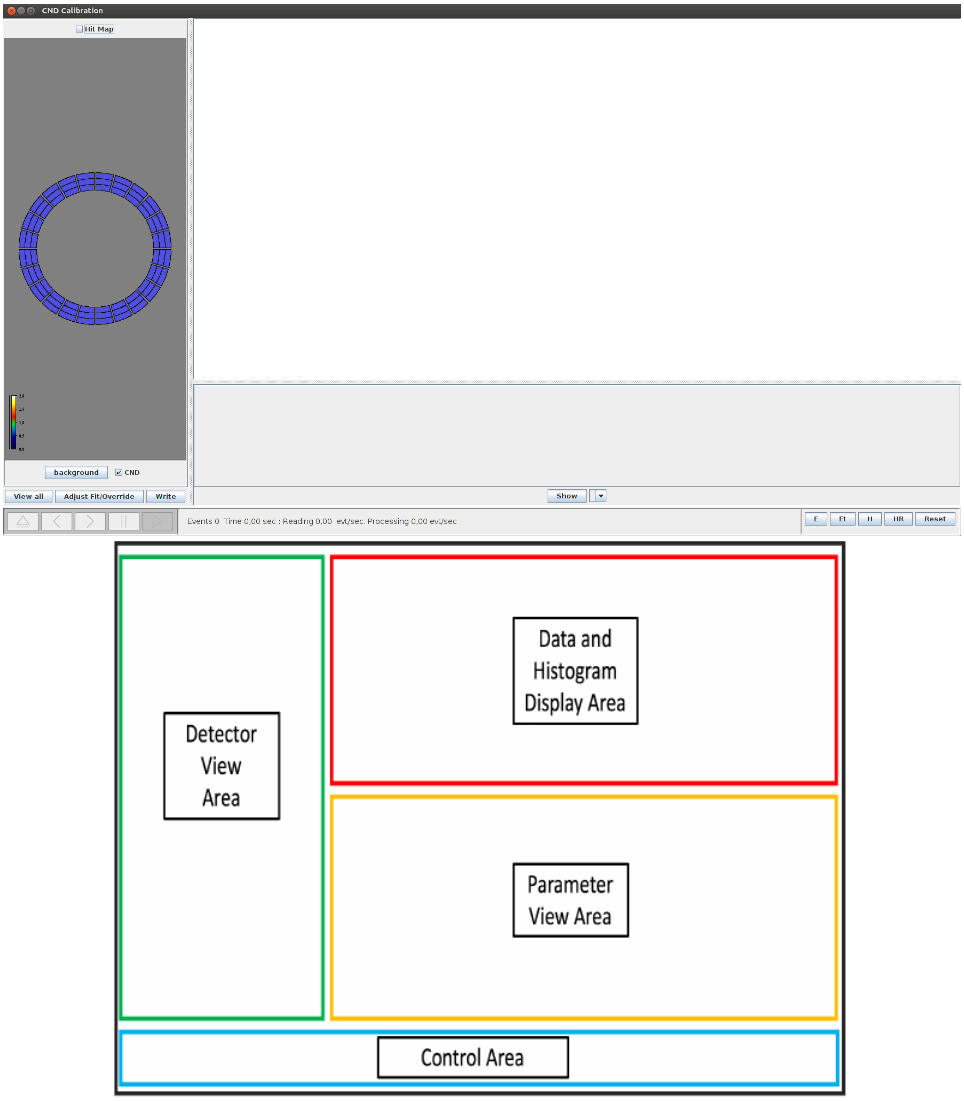

Figure 1: Top: the CND suite calibration window. Bottom: the different areas of the calibration window.

The Calibration window is composed of 4 main areas. The Detector View Area (in Green) is used to access summary plots. The Data Display Area (in Red) shows the current calibration histograms. The Parameter Area (in Gold) shows the currently extracted calibration values. The Control Area (in Blue) is used to import input files and process them. The complete function of each area is explained in details in this document.

4 Configuration of the calibration

Once the calibration suite is running and the configuration window is displayed, it is possible to configure the suite. The Configuration window is composed of 9 tabs

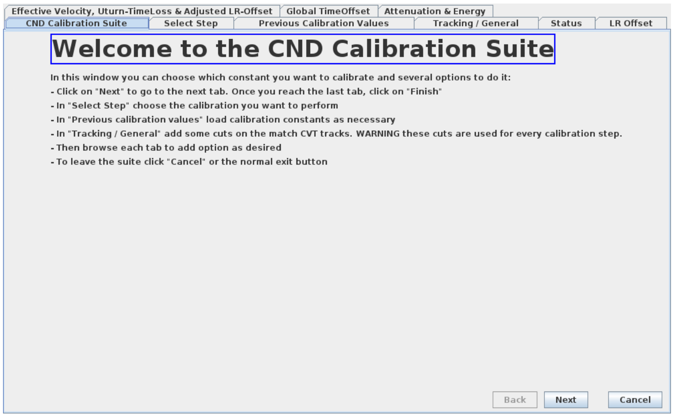

Figure 2: In the first tab of the configuration window, the CND calibration procedure is summarized. Users should read it once before using the calibration suite.

that allow the users to modify most calibration histograms parameters and apply some cuts on the input data. To access the tabs, click on the tabs at the top of the window or click *Next* on the bottom right corner of the window. To Exit the calibration suite, click *Cancel*. To go to the Calibration window, click *Finish* in the *Energy* tab. In the following sections each tab of the Configuration window is presented.

4.1 *CND Calibration Suite* tab

In this tab, the configuration procedure is presented and explained. Click *Next* to go to the next tab.

4.2 *Select steps* tab

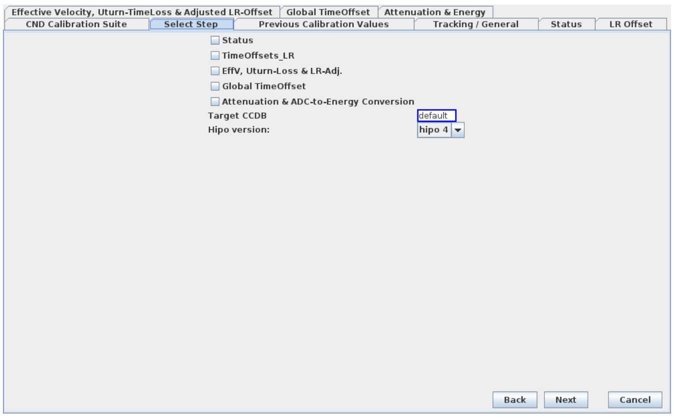

Figure 3: In the *Select steps* tab, users can tick the box corresponding to the calibration step they want to perform.

In this tab, one can choose which step will be performed by the calibration suite. The calibration steps have to be performed one at the time and in the specific order described in Section 6. Tick the desired box and click *Next* to go to the next tab.

Each run group has a target position defined in the CLAS12 database. In order to take into account of the position of the target, calibrators have to specify which entry in the target ccdb represents the geometry in the run being calibrated (eg. “rga_fall2018”). This must be entered into the “Target CCDB” field or the “default” values (target position set to 0cm) will be used.

The list of run group variations can be found here:

`https://clasweb.jlab.org/cgi-bin/ccdb/versions?table=/geometry/target`

In this tab the calibrator must also select the version of hipo which was used in the reconstruction of the file being calibrated. By default hipo4 is used.

In addition, users can click the Status tab to access raw data summary plots for CND. This step is not required to perform the calibration of the CND, and will produce an enormous amount of plots. It should be used only for debugging purposes.

4.3 *Previous calibration values* tab

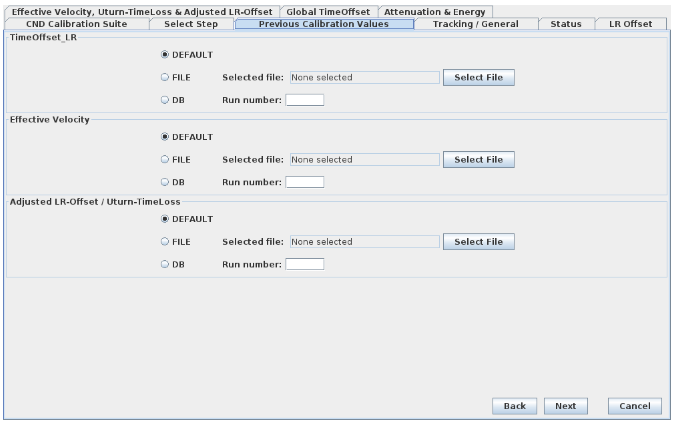

Figure 4: The *Previous calibration values* tab allows the users to upload the required calibration constants for a given step.

Constants	**Output Files Prefix to upload**	**Upload section**
LR_{off}	CND_CALIB_TIMEOFFSETS_LR	TimeOffset_LR
v_{eff}	CND_CALIB_EFFV	Eff. Velocity
$LR_{off_{adj}}$ u_{tloss}	uturn_LRad_CND_CALIB_UTURNTLOSS	Adj.LR_off/Uturn

Table 2: Output files prefixes, and upload fields for Previous Calibration Values.

In this tab users can upload the calibration values of LR_{off}, v_{eff} and u_{tloss} or $LR_{off_{adj}}$ needed to complete a given step of the calibration.

There are three options in this tab to provide calibration constants to the calibration suite:

The *File* option allows the user to provide the suite with a text file containing the calibration constants. The text file containing the constants has to have the same format as the output-file format of the suite. Click *Select File* and choose the appropriate file to upload. **This is the option which should typically be used.**

The *Default* option will provide the expected value of the given constant. This option should only be used for testing, or if there are no existing previous calibrations for a given run. If this is the case, the calibrator should perform multiple passes to improve the calibration of the quality of the calibration.

The *DB* option is not currently implemented and should not be used.

LR_{off} constants are uploaded in the *TimeOffset_ LR* section. v_{eff} constants are uploaded in the *Effective Velovity* section. u_{tloss} and $LR_{off_{adj}}$ are uploaded in the *Adjusted LR-offset/Uturn-TimeLoss* section using the u_{tloss} file, which contains both the u_{tloss} and $LR_{off_{adj}}$ constants. The prefix of the file to upload in each section and the associated calibration constants are summarized in Table 2 and the required constants for each given step can be found in Tables 5 & 6.

4.4 *Tracking/General* tab

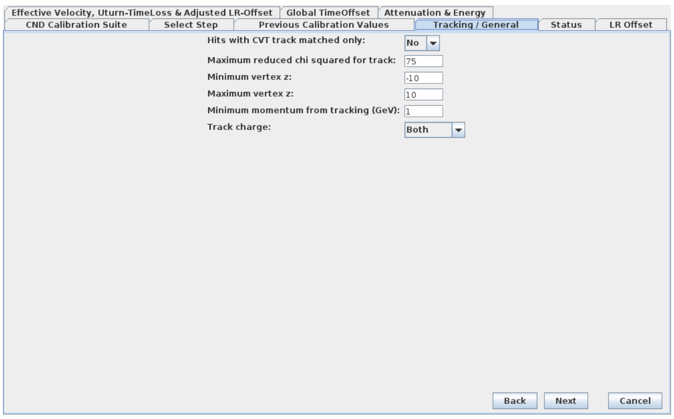

Figure 5: In the *Tracking/General* tab, users can add their own values to the cut applied to the calibrated data.

In this tab one can provide kinematic cuts on the data used in the suite. It is possible to:

1. use every CND hit or only the ones associated to a CVT track
2. require a cut on the chi square of the associated CVT tracks
3. cut on the position of the vertex (extracted from the DOCA of the track)
4. cut on the minimum momentum of the track
5. ask for positive or negative tracks

Note: there is no requirement to change these values for a typical calibration.

4.5 Calibration tabs

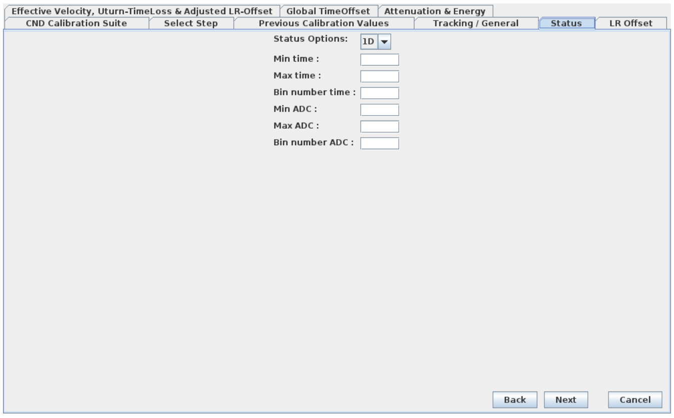

Figure 6: There is one calibration tab for each step. Each tab allows the user to modify plot ranges and the binning of the displayed plots.

The remaining 4 tabs are associated the four calibration steps. In each of these tabs one can define the range and the binning of the associated plots.

5 Importing and reading input files

5.1 Filtering the file to calibrate

The calibration suite is able to read hipo files. However such files can become very heavy if they record many banks per event. Besides, the CND calibration only requires a small amount of banks to run. Therefore, if the datafile being used has not already been filtered for you, you may desire to filter the input file before using it in the calibration suite. The CND calibration only uses the following banks:

- CND::Hits (ID 20321)
- CND::ADC (ID 20311)
- CND::TDC (ID 20312)
- CVT::Tracks (ID 20526)
- REC::Event (ID 330)
- RUN::config (ID 11).

In order to reduce the size of the input file it is possible to filter it with the following command line :

```
\$CLARA_HOME/plugins/clas12/bin/hipo-utils -filter  -l
   330:20321:20311:20312:20526:11
-e 20321 -merge -o outputfile.hipo list_of_file_to_filter
```

In order to produce good quality calibration constants, the file to calibrate should contain at least 20M CND events.

Once the CND file has be filtered, a further step of filtering can be applied to lower the weight of the file to process. Events with a negative tracks in the CVT are kept. To do so use the code located at JLab:

`/work/clas12/pierre/CNDCalibUtils`

To use the code copy the cndCalibFilter.class in your current folder. To run it use the following command line :

```
java -DCLAS12DIR="\$COATJAVA" -cp "\$COATJAVA/lib/clas
   /*:\$COATJAVA/lib/utils/*:." CNDCalibFilter [inputfile
   ] [outputfile]
```

This command will filter [inputfile] and keep negative tracks events, create the filtered file [outputfile] and write it in the current folder.

5.2 Importing and reading the input file in the calibration suite

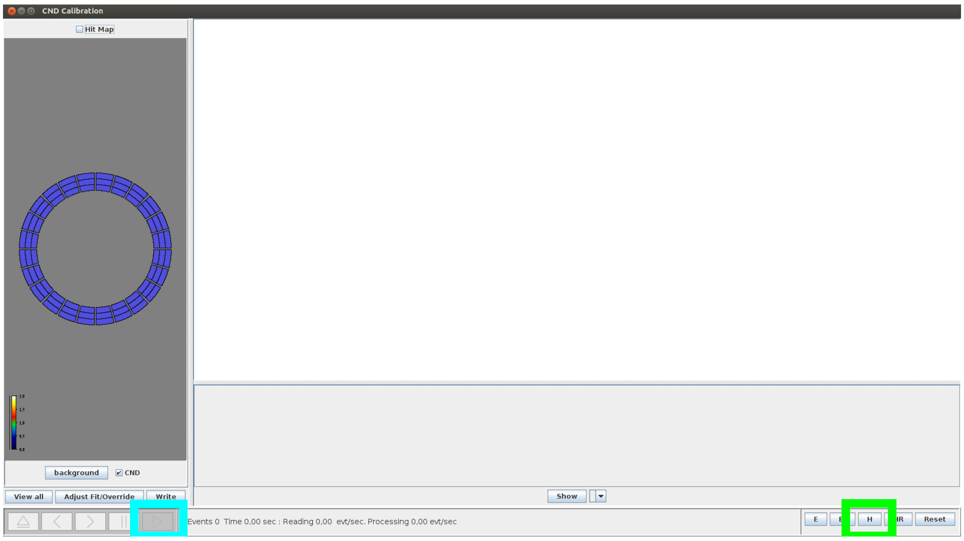

Figure 7: To import a file to calibrate in the suite, click on either the *H3* (hipo3) or *H4* (hipo4) button in green. Once the file is successfully imported, the *Play* (cyan) button will become clickable. Click this button and the calibration begins.

Once the configuration of the calibration suite is done, the Calibration window appears. Users then need to import the file, read it, and calibrate it. This is done by clicking one of the *H* buttons in the Control Area highlighted in green in Figure 7. Each button corresponds to a version of hipo. (ie. use the *H4* button if a hipo4 file is being used, and use the *H3* button if a hipo3 file is being used.) This will display a new window where it is possible to choose the input file. Click *Open* to import the file. Once the file is imported in the suite, the *Play* button will appear in the Control Area (see Figure 7, highlighted in cyan). Click the *Play* button and the file will be processed. The current event number will be displayed in the Control

Area. Clicking the *Pause* button will stop the reading of the file. The calibration plots and the fits are performed once the file has been fully read.

5.3 Calibration options

Once the file has been read the calibration algorithms determine the constants. This is explained further in the next section of this document. The user has to check the results of each calibration step according to the procedures described in Section 6. Here we explain the options available for the user during the calibration process.

5.3.1 *View all* button

This button is located in the left bottom part of the detector view area. It allows the user to display summary plots for each calibration constant of the current tab.

5.3.2 *Adjust Fit/Override* button

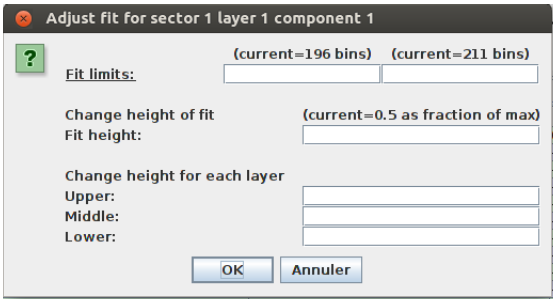

Figure 8: The *Adjust Fit/Override* window for LR_{off} step. In this window users can adjust the range (or the height) of the fit in order to improve their quality.

The *Adjust Fit/Override* button is important in the calibration process. It allows the user to change the conditions of the fit and, in case the fit doesn't work, to adjust the range (or height) of the fit by themselves to obtain the best possible value of the current calibration constant.

The *Adjust Fit/Override* button is located at the bottom of the detector view area. It will be required for all calibration steps. Once the user clicks on the button, a new window appears as shown in Figure 8. Users can adjust the fit conditions to improve it. Once the new constraints are set, click *OK*. Examples of these adjustments can be found in Figures 9 and 10.

5.3.3 *Write* button

Once the calibration has been performed, each fit has been assessed and each constant has been checked, users can produce the calibration constants file by clicking on the *Write* button. This will display a new window as in Figure 11, and write a text file in the current directory. This file can then uploaded to the CCDB, or used for the next calibration step/pass as appropriate.

The names of the produced file are as follow:

```
<prefix>_<date>.<version>.txt
```

where the various *prefix* are defined in Table 3, *date* is the current date, *version* is incremented from 0 if multiple files of the same constant are generated on the same date, whilst completing multiple passes.

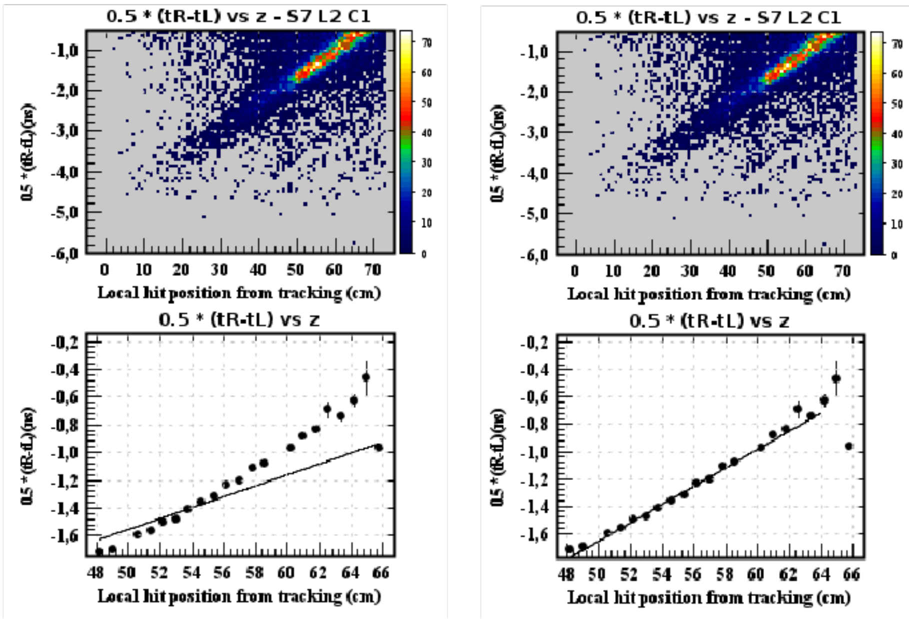

Figure 9: Fits of the $\frac{t_R - t_L}{2}$ vs z_{CND} distribution before (left) and after (right) the fit has been adjusted. The right fit is obtained by restricting the fit range to 64 cm.

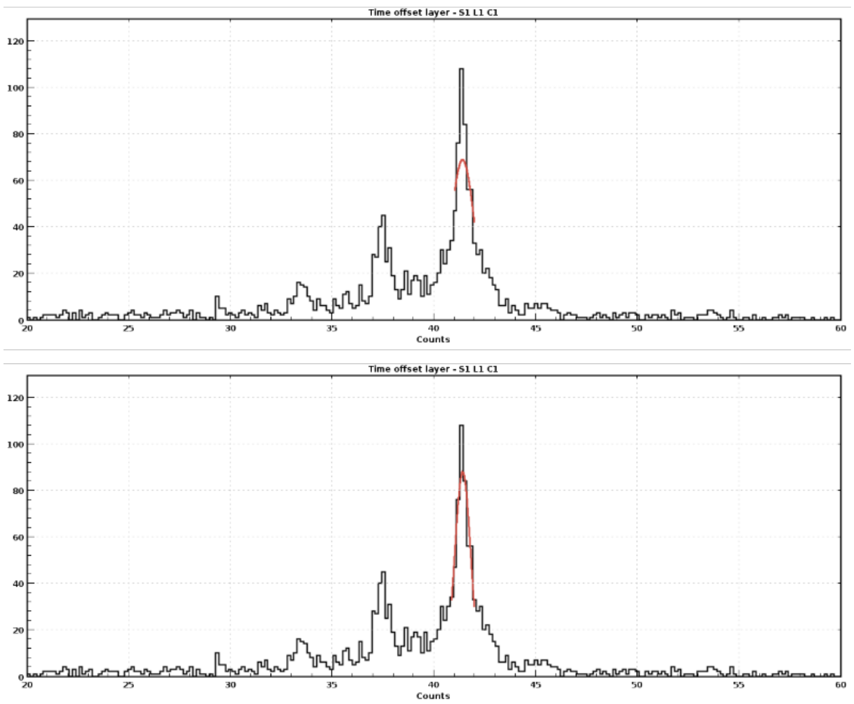

Figure 10: Fits of the t_{off} distribution before (up) and after (bottom) the fit has been adjusted. The bottom fit is obtained by restricting the fit range to the width of the peak at a 0.4 fraction of its maximum value.

Figure 11: This window appears when users click the *Write* button. It confirms that the current calibration values have been recorded in the given file.

Step	Calibration Step	Output Files Prefix
1	LR time off.	CND_CALIB_TIMEOFFSETS_LR
2	Eff. v	CND_CALIB_EFFV
	U-turn	uturn_LRad_CND_CALIB_UTURNTLOSS
	LR offset adj.	LRoffset_adjusted_CND_CALIB_UTURNTLOSS
3	Global t.offset	CND_CALIB_TIMEOFFSETS_LAYER
4	Att. length	CND_CALIB_ATTENUATION
	Energy	CND_CALIB_Energy

Table 3: Output file prefixes for each calibration step.

Part III

CND Calibration Steps

6 Calibration Constants and General Strategy

There are 4 steps in the calibration which produce 7 sets of calibration constants. Each step has to be performed in the order shown in Table 4. Note that there are two different Left-Right offsets. The first, LR_{off}, is a “raw” offset, and the second, $LR_{off_{adj}}$, is a “corrected” offset, which is used in the reconstruction of CND events.

Each step has to be performed individually. That is to say, the calibration suite must be closed, restarted, and options set up in the configuration window again for each step. The user must also ensure that the required constants have been chosen for the relevant calibration step. The required constants for each step are summarized in Table 5. The way constants have to be uploaded in the suite is detailed in Section 4.3. Table 2 summarizes where to upload the previous calibration constants files.

The CND calibration is an iterative process. Once the user has completed a full set of calibration constants it is possible to improve it, without recooking the data, by performing another pass. The process is similar to the first pass of calibration described above. However for further passes, the user has to make sure that the calibration suite uses the $LR_{off_{adj}}$ and v_{eff} values of the previous pass. This is done by uploading the files with prefix *CND_CALIB_EFFV* and *uturn_LRad_CND_CALIB_UTURNTLOSS* from the previous pass for step 2 of the next pass. These files contain the v_{eff} and $LR_{off_{adj}}$ values that will be used by the suite to improve the calibration by aiding in the process of selecting in which paddle an event occurred. Other than the inclusion of these extra files during set up, the calibration process is the same. The constants to be uploaded to the suite for pass i are described in Table 6. The full calibration process is described in Figure 12. It is advised that the user perform at least two passes of calibration before uploading the constants on the CCDB.

The following sections contain a largely qualitative description of how each calibration constant is obtained. Full details of the algorithms used in each section of the suite can be found in the document dedicated to these descriptions [1].

Step	**Calibration Constant**	**Output**	**Number of Constants**
1	LR (Left-Right) time offset	LR_{off}	72
2	Effective velocity	v_{eff}	144
	U-turn time loss	u_{tloss}	72
	Adjusted LR time offset	$LR_{off_{adj}}$	72
3	Global time offset	t_{off}	72
4	Attenuation length	Att_L	144
	Energy constants	MIP_D, MIP_I	144 each

Table 4: Calibration constants, and the steps in which they are calculated.

Step	**Calibration Constant**	**Required Constants**
1	LR time offset	none
2	Effective velocity U-turn time loss Adjusted LR time offset	LR_{off}
3	Global time offset	v_{eff}, $u_{tloss}/LR_{off_{adj}}$
4	Attenuation length Energy constants	v_{eff}, $LR_{off_{adj}}$

Table 5: Required previous constants for 1st pass calibration steps.

Step	**Calibration Step**	**Required Constants (Pass i)**
1	LR time offset	none
2	Effective velocity U-turn time loss Adjusted LR offset ad.	From pass i-1: LR_{off}, v_{eff}, $LR_{off_{adj}}$
3	Global time offset	From pass i: v_{eff}, $u_{tloss}/LR_{off_{adj}}$
4	Attenuation length Energy constants	From pass i: v_{eff}, $LR_{off_{adj}}$

Table 6: Required previous constants for ith pass calibration steps.

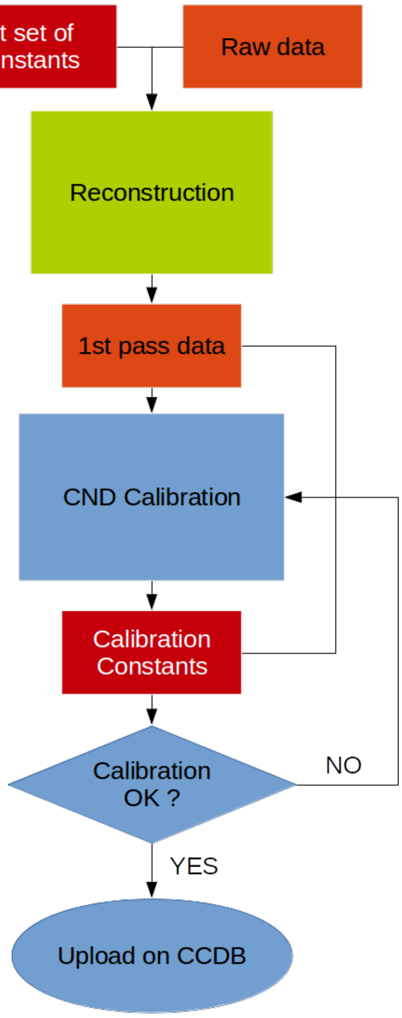

Figure 12: Flowchart of the CND calibration. The user retrieves pass0 data that have been processed by the reconstruction software once. Then the user processes this set of data through the calibration suite. If the calibration is good, constants can be uploaded to the CCDB. Otherwise the calibration has to be performed again using $LR_{off_{adj}}$ and v_{eff} constants from the previous pass.

Table 4 summarizes the order in which each step has to be performed and the calibration constants associated with these steps. Table 3 contains the file prefixes associated with the files produced by each calibration step. Table 5 shows the calibrated constants that are used for each steps. These constants have to be calibrated before the calibration of the given step.

6.1 Step 1: Left-Right Timing Offset

The goal of this step is to calibrate the "raw" time difference between two coupled paddles. The first calibration step of the LR time offset is done in two different ways depending on the experimental set up in in the run being calibrated. In both cases the raw time difference between two coupled paddle is plotted. If the run is done without any magnetic field, it is expected that the distribution will show a dip due to the fact that no hit will occur in the u-turn (see Figure 13). In the case of a run with magnetic field, the distribution will show a peak (see Figure 14). This peak is due to double hits (illustrated in Figure 15). The LR_{off} is defined as the position of the peak (or dip). This value gives an estimate of the time offset between two coupled paddles. *Note: this value does not take into account the difference in effective velocity between coupled paddles. The "true" time difference ($LR_{off_{adj}}$) is calculated as part of step 2·*

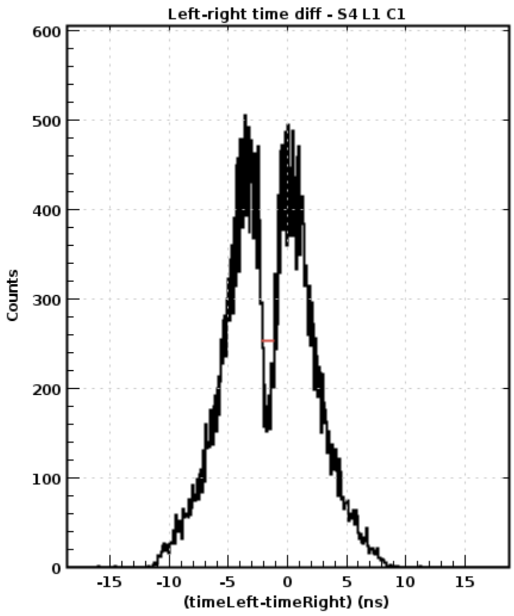

Figure 13: Left-Right time difference distribution when the magnetic field is off. The dip in the distribution is caused by the u-turn light guide.

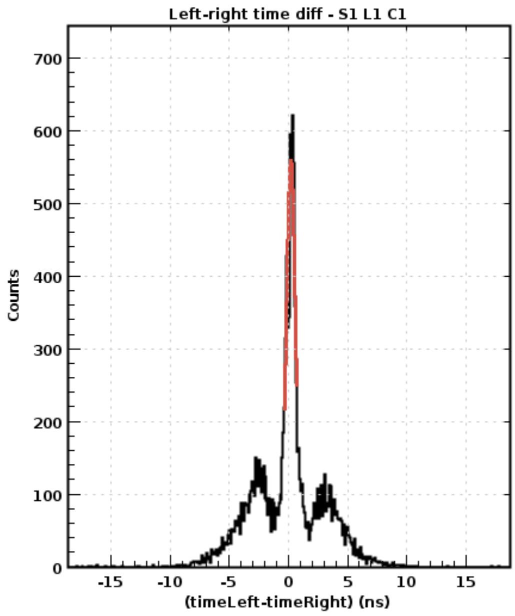

Figure 14: Time difference when the magnetic field is on. The peak is due to the double hits decribed in Figure 15

In the configuration panel, it is possible to choose between both magnetic field configurations. By default, the configuration is field ON. It is also possible to change the range of the plots.

Once the file to calibrate has been read and processed, users have to check the quality of the fits and adjust them as required. To adjust the fit in this step, it is recommended that the user gives the fraction of the peak (or dip) height at which the fit range stops. Examples of good fits are shown in Figures 13 and 14.

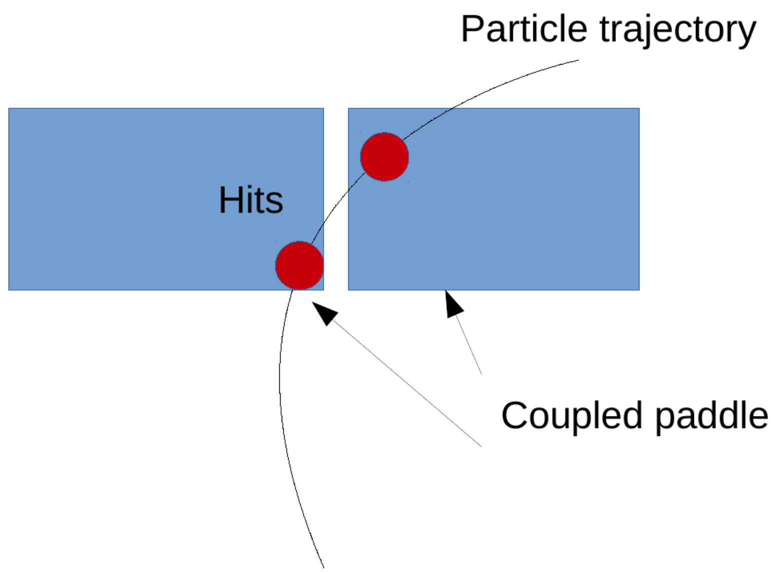

Figure 15: The CND double hits happen when a charged particle hits both coupled paddles. The two times associated with this hit are almost the same thus producing a peak in the time-difference distribution. This peak should be located at zero in the ideal case of zero time offset between the two paddles and equal effective velocities.

6.2 Step 2: Effective Velocity, U-turn Time Loss and Adjusted Left-Right Timing Offset

This step calculates three constants: the effective velocity of light in a scintillator paddle (v_{eff}), the time taken for light to travel through the uturn light-guide pairing two paddles (u_{tloss}) and an adjustment (detailed below) to the “raw” LR-offset calculated in step 1 ($LR_{off_{adj}}$).

This calibration step requires the LR_{off} values to be uploaded in the suite. When performing multiple passes, the $LR_{off_{adj}}$ and v_{eff} constants produced in the *previous pass* must also be included (see Section 4.3).

In the configuration panel, users can change the range and the binnings of the displayed plots. Once the file is processed, two distributions are plotted: $\frac{t_R - t_L}{2}$ vs z_{CND} , and a plot where the former is binned in z_{CND}, and the mode (or a Gaussian mean) value of $\frac{t_R - t_L}{2}$ is extracted. The latter is the plot which is fitted to extract the constants. Users have to assess the quality of the fit, and will most likely need to adjust the range for the fits by using the *Adjust fit* menu. An example of the produced plots are shown in Figure 16.

The *Write* button will produce three output files (see Table 3).

6.2.1 Effective Velocity

The effective velocity is calculated from the gradient of the fitted line. Each paddle has an associated Effective Velocity. Therefore there are 144 values of effective velocities.

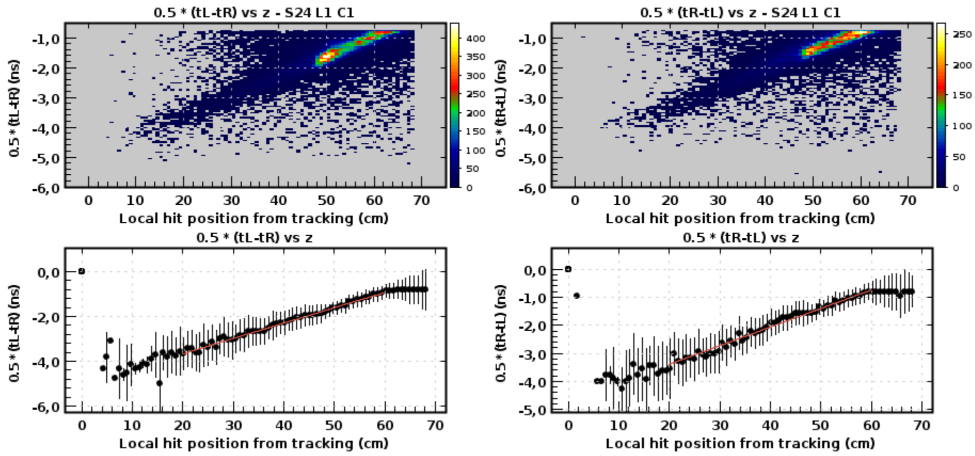

Figure 16: Plots displayed in the v_{eff}, u_{tloss} and $LR_{off_{adj}}$ step. The two top plots displayed the raw $\frac{t_R - t_L}{2}$ vs z_{CND} distribution for both coupled paddles. The two bottom plots show the positions of the peak of the Gaussian fit of each slice of the raw distribution. They also display the fitted lines that interpolate these points.

6.2.2 U-turn Time Loss

The u_{tloss} is calculated from the intercept of the fitted line from two coupled paddles. There are 72 u_{tloss} values, one for each uturn light-guide connecting paired paddles.

6.2.3 Adjusted Left-Right Timing Offset

$LR_{off_{adj}}$ is an adjustment on the LR_{off} (calculated in step 1) which takes into account the fact that the effective velocity of light may be different in two coupled paddles. There are 72 values, one for each paddle-pair. $LR_{off_{adj}}$ are also obtained from the intercepts of the fitted graphs, and are calculated at the same time as the u_{tloss} values are calculated.

Note that LR_{offadd} values are written into two files. Firstly, it is written into the file which contains only the adjusted LR time offset values (prefix: LRoffset_adjusted_CND_CALIB_UTURNTLOSS). Secondly, for the pragmatic reason of reading in both values from one file when required (see section 4.3), the values are also written into the final column of the file containing the u_{tloss} values (prefix:uturn_LRad_CND_CALIB_UTURNTLOSS). Both must be uploaded to the CCDB.

6.3 Step 3: Global Time Offset

This step aligns the vertex time measured by the CND and the vertex time measured using the CLAS12 start time. This steps requires all previous constants to be calibrated. It is very important to use $LR_{off_{adj}}$ values. For each CND hit with a negative charge associated, t_{off} is calculated. The obtained distribution is fitted with a Gaussian and the mean value defines the t_{off} value.

In the configuration panels, users can adjust binning and range of the time plots. Users can assess the fit and produce a better one by using the *Adjust fit* button. It is recommended that users adjust the fit via the fraction of the peak height (eg.

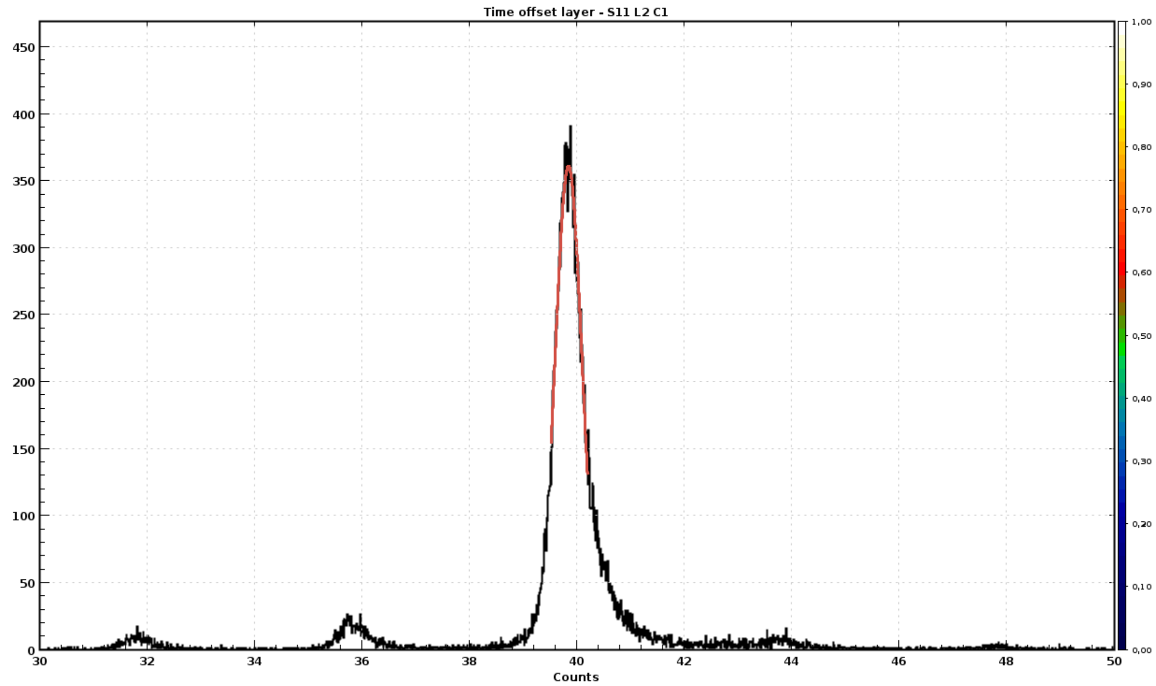

Figure 17: Vertex time distribution and the gaussian fit to extract t_{off}. The multiple peaks are due to mismatched RF times.

0.4) from which the fit range is calculated. An example of a good fit is given in Figure 17.

6.4 Step 4: Attenuation Length and Energy constants

Once the timing calibrations have been done, the final step in the calibration is to obtain the attenuation length and energy constants. This requires the v_{eff} and $LR_{off_{adj}}$ to be uploaded in the configuration step.

After the file is processed,two raw distributions are plotted: $ln(\frac{ADC_D}{ADC_R})$ vs z_{CND} and $\sqrt{ADC_D \cdot ADC_I} \cdot \frac{h}{path}$ Analogous to step2, the $ln(\frac{ADC_D}{ADC_R})$ vs z_{CND} distribution is binned in z_{CND}, and the the mode (or a Gaussian mean) value is extracted and fitted. An example of this is shown in Figure 18. The $\sqrt{ADC_D \cdot ADC_I} \cdot \frac{h}{path}$ is fitted with a Landau function, as shown in Figure 19.

Users have to check the quality of these fits and can adjust the range of the line fit.

In the configuration panel, it is possible to change the range and binning of all the displayed plots.

6.4.1 Attenuation Length

Att_L is the characteristic light attenuation length of each scintillator paddle. There is one Att_L value for each paddle, 144 in total. It is calculated using the gradient of the fitted $ln(\frac{ADC_D}{ADC_R})$ vs z_{CND} distribution.

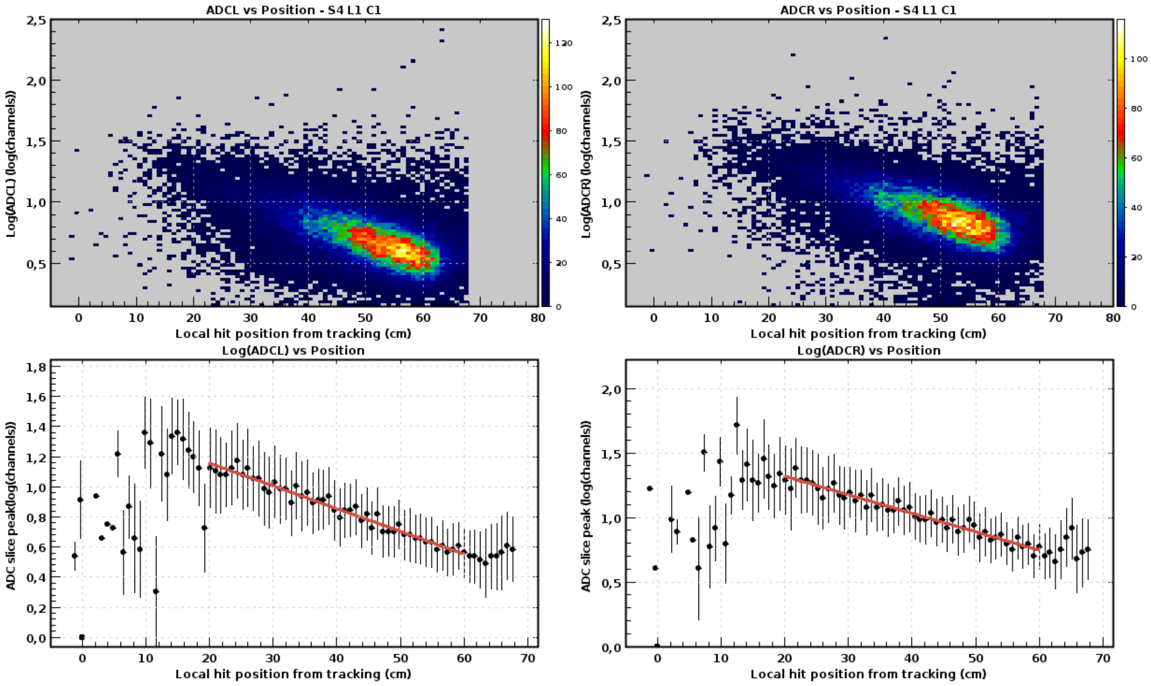

Figure 18: Plots displayed in the Att_L and MIP_D, MIP_I step. The two top plots display the raw $ln(\frac{ADC_D}{ADC_I}$ vs z_{CND} distribution for both coupled paddle. The two bottom plots show the positions of the maximum of each slice of the raw distribution. They also display the fitted lines that interpolate the points.

6.4.2 Energy constants

The energy constants are the constants required to perform the conversion of ADC-to-energy. MIP_D and MIP_I are calculated using the value for attenuation, and the fitted peak position of the $\sqrt{ADC_D \cdot ADC_I} \cdot \frac{h}{path}$ distribution. There is a MIP_D and MIP_I for each paddle, meaning each have 144 in total.

Part IV
Uploading calibration constants

Once every constant file has been produced, it has to be written in the CCDB. There are 6 files to be uploaded: v_{eff}, u_{tloss}, $LR_{off_{adj}}$,t_{off} , Att_L , $Energy$ (containing MIP_D and MIP_I constants). Each file has to be uploaded in its CCDB directory. The list of CCDB directory associated to each file is summarized in Table 7.

Before uploading the calibration file, users have to make sure that the common CLAS12 environment is set.

```
source /group/clas12/environment.csh
```

Users may want to change the CCDB_CONNECTION variable to:

```
mysql://clas12writer:geom3try@clasdb.jlab.org/clas12
```

Access the ccdb using the command:

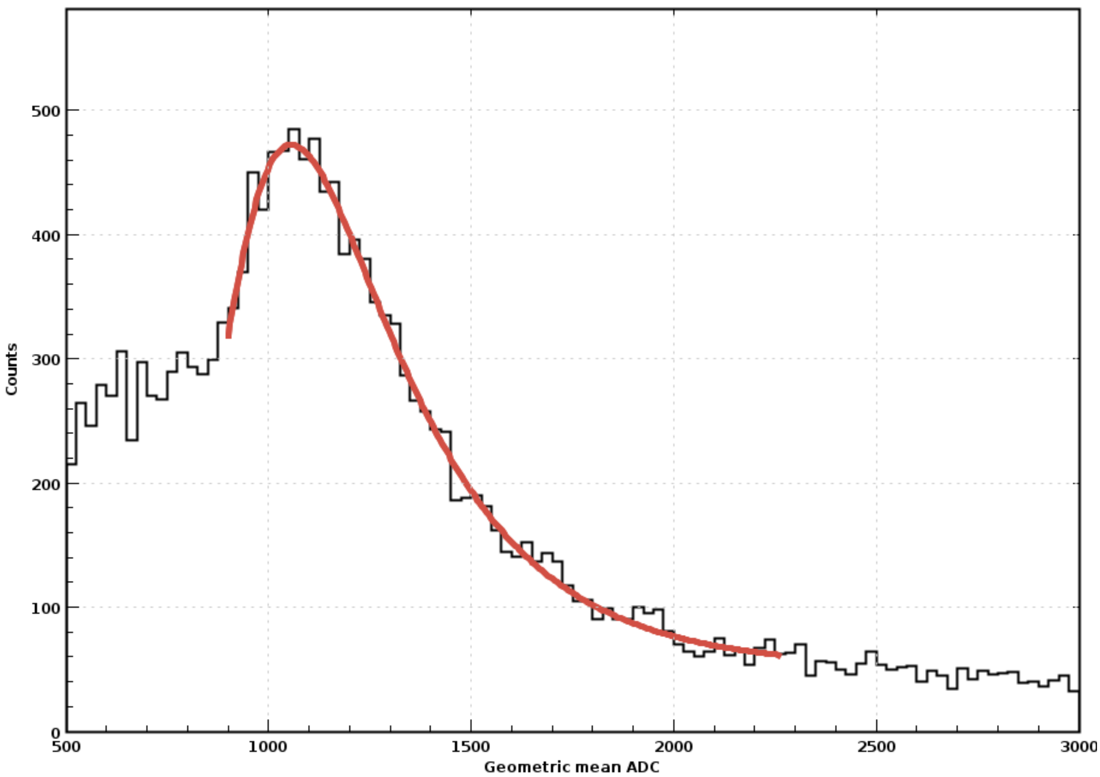

Figure 19: Raw $\sqrt{ADC_D \cdot ADC_I} \cdot \frac{h}{path}$ distribution and the Laudau fit that is displayed in the energy calibration step.

```
clas12-ccdb -i
```

Once in the CCDB interface, the user can add the calibration file with the following command:

```
add <table_path> -v <variation> -r <run_min>-<run_max> file_to_import
```

where *<table_path>* is the CCDB entry name listed in Table 7, *<variation>* is *default*, *<run_min>*-*<run_max>* is the run range for which the calibration is valid, and *file_to_import* is the calibration constants file.

Constants name	DB entry name
$LR_{off_{adj}}$	/calibration/cnd/TimeOffsets_LR
v_{eff}	/calibration/cnd/EffV
u_{tloss}	/calibration/cnd/UturnTloss
t_{off}	/calibration/cnd/TimeOffsets_layer
Att_L	/calibration/cnd/Attenuation
MIP_D, MIP_I	/calibration/cnd/Energy

Table 7: Calibration constants, their locations in the CLAS12 CCDB and the associated file prefix.

Constant name	Output Files Prefix
$LR_{off_{adj}}$	LRoffset_adjusted_CND_CALIB_UTURNTLOSS
v_{eff}	CND_CALIB_EFFV
u_{tloss}	uturn_LRad_CND_CALIB_UTURNTLOSS
t_{off}	CND_CALIB_TIMEOFFSETS_LAYER
Att_L	CND_CALIB_ATTENUATION
MIP_D, MIP_I	CND_CALIB_Energy

Table 8: Calibration constants and their associated file prefix.

References

[1] Pierre Chatagnon, Gavin Murdoch, Silvia Niccolai, and Daria Sokhan. Description of the calibration algorithms for the clas12 central neutron detector.