Calibration data taking in NEW detector

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1 Introduction

This document serves as a basic guide for the calibration of the 1792 SiPMs and the 12 PMTs of NEW. The aim of this calibration is to determine the conversion constants from ADC to photo electrons and their errors, calculate the pedestals, the pedestal sigmas and to check that the baselines are set properly for SiPMs. Additionally, expected dark current spectra must be generated for the Monte Carlo.

For the PMTs the aim is to determine the conversion from ADC to pes, the charge resolution and their errors, and to monitor the low frequency noise contribution to the baseline noise.

This document is also based on another one written by A. Laing.

2 Steps before start data taking:

- Stop the run and write down the current config.
- Notify Pau and the shifter.
- Notify on Slack (shifters channel).

3 SiPMs calibration runs:

- Switch OFF SiPMs (Anydesk).
- Switch OFF PMTs (Anydesk).

3.1 Electronics only:

This run is taken with the SiPMs OFF (SiPM bias OFF) in order to study the electronics noise.

JAVA configuration:

- **Mode of operation:** Test mode

- **Run code:** SiPM Calibration Dark Current
- **Circular buffer:** 800 μs
- **Pretrigger:** 400 μs
- **Trigger frequency:** 25 Hz
- **Trigger mask:** ON
- **External trigger:** ON
- **Auto trigger:** ON
- **Zero Suppression:** OFF
- **Presamples (in the ZS):** 0
- **Number of events:** 5.000 events

Once the JAVA is configured:

- Click all the "Config register" in the JAVA.
- In date (first tab), click Start Processes.
- In date click Start.
- In JAVA click Start Run.

In case the trigger is not working and events are not being registered, perform a Java RESET.

3.2 Dark current run:

Dark current runs are used to check connectivity by comparing with electronics only runs and to generate no-light pdf spectra for use in Monte Carlo simulations.

The conditions for the run are identical to those for the electronics only run (see section 3.1)., except with the SiPM bias ON. So, **switch ON the SiPMs**.

3.3 Nominal light

The LEDs used to calibrate the SiPMs are located in the energy plane and they need to be turned on in situ in the LAB. Beatriz has been the person in charge so far. She connects the pulse generator and switches the LEDs at the time we tell her. Instructions for the pulse generator handling are explained in the section 6.

The JAVA should be configured for external triggering with the following conditions:

- **Mode of operation:** Test mode
- **Run code:** SiPM Calibration Energy Plane LEDs active
- **Circular buffer:** 80 μs
- **Pretrigger:** 40 μs
- **Trigger frequency:** 100 Hz
- **Trigger mask:** ON
- **External trigger:** ON
- **Auto trigger:** OFF
- **Zero Suppression:** OFF
- **Presamples (in the ZS):** 0
- **Number of events:** 30.000 events

Usually, runs are taken with LEDs 2, 7 and 10.
Once the JAVA is configured:

- Click all the "Config register" in the JAVA.
- In date (first tab), click Start Processes.
- Tell the pulse generator user to turn on the LED.
- In date click Start.
- In JAVA click Start Run.

Before a complete run is taken, at least one run with few events is recommended to check that the pulse is visible
10 events is enough and the steps would be:

1. Data taking
2. Launch the decoder (in the third window of VNC):

   ```
   runDecoDaemon run_no
   ```

3. Plot the spectrum:

   ```
   plotrwf --file /analysis/run_no/hdf5/data/file_of_this_run.h5 -sipm --sum
   plotrwf --file /analysis/run_no/hdf5/data/file_of_this_run.h5 -pmt --sum
   ```

4 PMTs calibration runs:

The calibration of the PMTs uses LEDs embedded in the SiPM DICE boards and can be done remotely since they are controlled with the JAVA. The calibration should be performed without biasing the SiPMs. So if the calibration of the SiPMs has been performed before, switch OFF the SiPMs and switch ON the PMTs.

Nowadays all the LEDs are available, but we use to work with the ones of DICES 7, 11, 15, 19 and 27.

JAVA configuration:

- **Mode of operation:** Test mode
- **Run code:** PMT Calibration Tracking Plane LEDs active
- **Circular buffer:** 800 μs
- **Pretrigger:** 400 μs
- **Trigger frequency:** 25 Hz
- **Trigger mask:** ON
- **External trigger:** ON
- **Auto trigger:** ON
- **Number of events:** 5.000 events
- **LED conf:**
  - Click the *ON* buttom.
  - **Time Pulse ON:** Set the nominal value of the selected LED (every LED has its own recommended nominal value (see 1).
  - **Pulse period:** 50 μs

Please, do not forget to switch OFF the used LED after the calibration run. Remember to click the *load config* buttom.

LED DICE number	Recommended nominal value
LED 7	445 st
LED 11	456 st
LED 15	437 st
LED 19	429 st
LED 27	444 st

Table 1: LED tracking plane settings for PMT calibration

5 Processing data

Once the run has finished, it should be proccessed. In the case of the calibration runs of NEW, the procedure is the following:

- Decode the data and make the spectra:

```
runSensorCal sipm sipm_run1 sipm_run2 etc
runSensorCal pdf run_no
runSensorCal pmt pmt_run1 pmt_run2 etc
```

- The spectra will be located in:

```
/calibration/sipmCal
/calibration/pdfCal
/calibration/pmtCal
```

To continue with the steps to extract the calibration constants follow the instructions detailed here.

6 Pulse generation instructions

(taken from A. Laing)

The pulse generator should be set to provide a NIM pulse to the ATCA and the desired voltages etc to the LED. The NIM signal comes from ouput 1 of the pulse generator and should be set ready for use, in case it is not:

- **Square pulse**
- **Amplitude:** 1 Vpp
- **Offset:** -500 mV
- **Pulse width:** 100 μs
- **Lead edge = Trail edge:** 8.4 ns
- **Polarity:** inverted
- *Generator operation described below in more detail.*

The LEDs to be pulsed are then chosen manually using the switch board located next to the cable exit on the energy plane side of the lead castle. The LED power settings should be set using output 2 of the pulse generator in the following way:

1. Press the number two buttom below the adjustment knob and directly above the BNV connector.
2. Press the *parameters* buttom next to the screen.
3. Select the parameter to be adjusted. Normally only *pulse width* or *high level* will be adjusted.
4. Adjust to the desired level.
5. Repeat previous two steps as necessary to adjust all parameters needed.
6. Press the number two buttom again.
7. Press *parameters* $\Rightarrow$ *phase* $\Rightarrow$ *internal sync*
8. Press the number two buttom.

LED	Voltage	Pulse width
LED 2	10 Vpp	200 ns
LED 7	10 Vpp	250 ns
LED 10	10 Vpp	300 ns

Table 2: Energy PLane LED settings for SiPM calibration

Nominal settings are **PMT LED 2, 10 Vpp amplitude with 200 ns pulse width** and pulse every 1 ms. Once the pulse generator is ready, start the run. The user should then turn ON the pulse generator in the following way:

1. Select ouput 2.
2. Press the *output* buttom (the LED in the output 2 will be turn on).
3. Select ouput 1.
4. Press the *output* buttom.