PMT analysis – Update

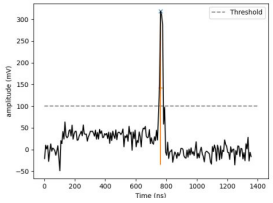
Cygno reco and analysis meeting - 28/04/2022

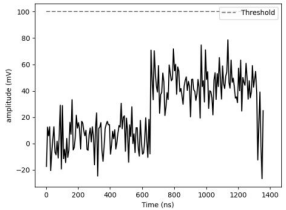
David Marques

Gianluca Cavoto

PMT analysis - ...previously...

1. Problems with data:
   a. High baseline
   b. Stepping baseline.





PMT analysis - Data correction

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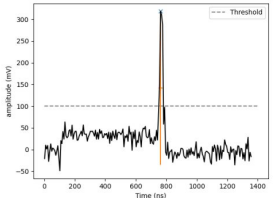
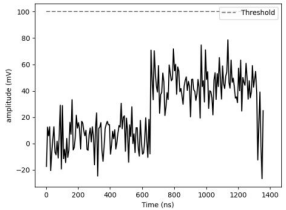
   b. Stepping baseline.





2. Solution: CAEN ***automatic*** data correction.
   a. Waveforms have 1024 cells.
   b. A correction table is applied point by point to each cell.

```
Calibration values from cell 0 to 1024 for channel 0:

 42  -40 82   -46 31  10  44  -21 cell = 0 to 7
 -7  -12 23   -17 45  -42 20  2   cell = 8 to 15
 18  -33 17   -23 81  -33 66  -21 cell = 16 to 23
 35  -28 57   -63 76  -35 33  -40 cell = 24 to 31
 54  0   86   3   47  15  20  -4  cell = 32 to 39
 13  -11 67   -1  51  26  54  -10 cell = 40 to 47
 30  -23 19   -23 77  -30 1   -16 cell = 48 to 55
 29  2   62   -4  55  -22 38  -37 cell = 56 to 63
 51  13  52   -50 37  32  74  -71 cell = 64 to 71
 33  -24 53   -25 32  23  55  25  cell = 72 to 79
 60  -2  94   4   56  -19 53  -18 cell = 80 to 87
 -5  20  48   52  27  1   64  21  cell = 88 to 95
 53  -36 29   -16 62  -5  72  -24 cell = 96 to 103
 32  1   73   -19 47  6   8   -23 cell = 104 to 111
 98  2   25   -15 45  10  35  -29 cell = 112 to 119
 -7  -27 88   -27 37  -31 28  13  cell = 120 to 127
 33  17  8    -30 50  21  61  14  cell = 128 to 135
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 44  9   71   18  12  -25 61  -20 cell = 160 to 167
 24  15  -12  3   62  -37 56  -17 cell = 168 to 175
 31  -9  48   -15 68  -9  49  -8  cell = 176 to 183
 48  3   61   -33 23  -47 61  -32 cell = 184 to 191
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```

```
st_ind =(uint16_t)(data->StartIndexCell);
for (i=0;i<MAX_X742_CHANNEL_SIZE;i++) {
    size1  = data->ChSize[i];
    for (j=0;j<size1;j++) {
        if (cellCorrection)
            data->DataChannel[i][j]  -=  CTable->cell[i][((st_ind+j) % 1024)];
        if (nsampleCorrection)
            data->DataChannel[i][j] -= CTable->nsample[i][j];
    }
}
```

CAEN Electronic Instrumentation

Cell Index Offset Correction

The analog capacitors of the DRS4 chip might have small differences between each other due to the construction processes. According to the cell index where the stop acquisition arrives, the same input signal can be reconstructed in different ways. For this reason it is required a cell amplitude calibration to compensate for the amplitude differences in the capacitors. The correction adjusts the baseline of the input (i.e. its offset).
Taking into account the internal noise of each channel, **Fig. 8.5** shows the sampled waveform on the left and the noise distribution histogram on the right, measured as the occurrence of the ADC counts. Plots are made before the correction. **Fig. 8.6** shows the same quantities after the correction. As expected, the noise in **Fig. 8.6** is flatter with no patterns, and its distribution has a smaller RMS.

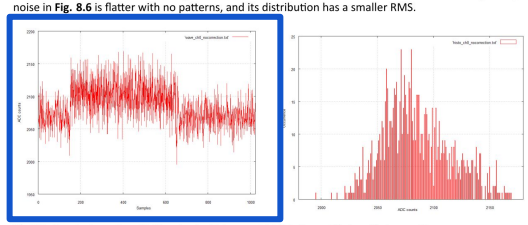

Fig. 8.5: Sampled waveform (left) and noise histogram (right) before cell index offset correction

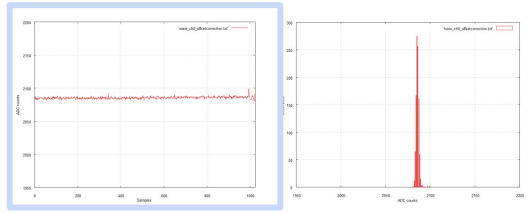

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Fig. 8.5: Sampled waveform (left) and noise histogram (right) before cell index offset correction

Fig. 8.6: Sampled waveform (left) and noise histogram (right) after cell index offset correction

PMT analysis - Data correction

What's the *Start Index Cell?*

Message from CAEN Support 08/04/2022 10:14:44

Dear Marques,

Thanks for clarification.
I'm sorry to inform you that **without the start index cell you can't apply the corrections needed to read the data**. This parameter **is not calculated**, it just indicated from which capacitor the measurement starts (that means **on which capacitor the read cycle was on when the trigger arrived**). Every capacitor has its own corrections, so, if you don't know which capacitor you were reading when the measurement starts, you can't correct the data.

Best regards,
Matteo

to each cell.


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PMT analysis - Data correction

Solution?

1. Discover the start index cell by brute force
    a. Test all the 1024 cell as being the start
    b. Choose the one with the cell RMS.
2. Data tested:
    a. MANGO fake data (because I had the corrected and uncorrected data available)

PMT analysis - Data correction

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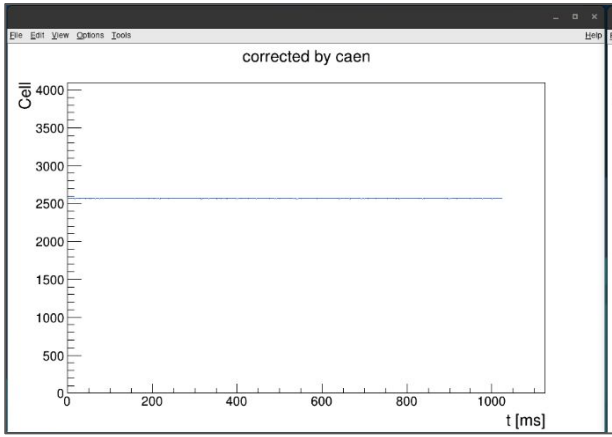
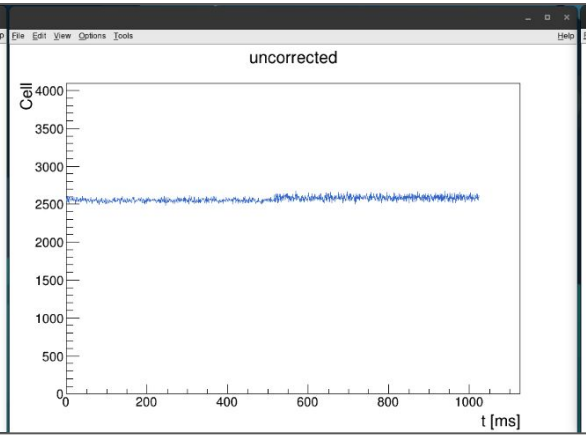
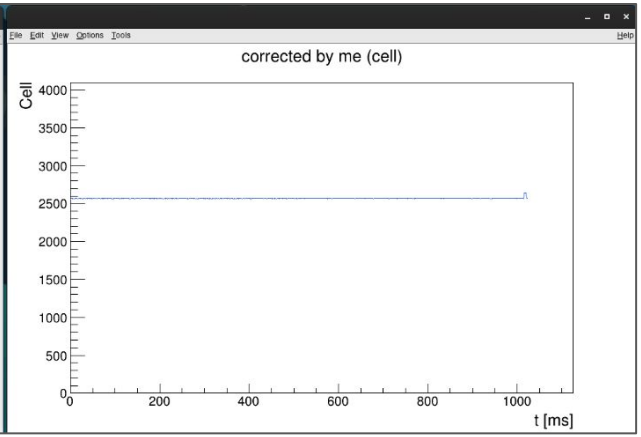
```
The RMS of the wf corrected by caen is :1.49449
The RMS of the wf uncorrected is :23.0888
Corrections opened: MANGO_X742Table_1GHz_gr0_cell.txt
Corrections opened: MANGO_X742Table_1GHz_gr0_nsample.txt
Corrections opened: MANGO_X742Table_1GHz_gr0_time.txt
The RMS of the wf corrected by me (only cell) is :1.40979
Start index cell found: 507 ...with an RMS of: 1.40979
```







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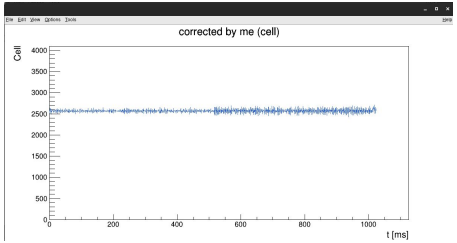
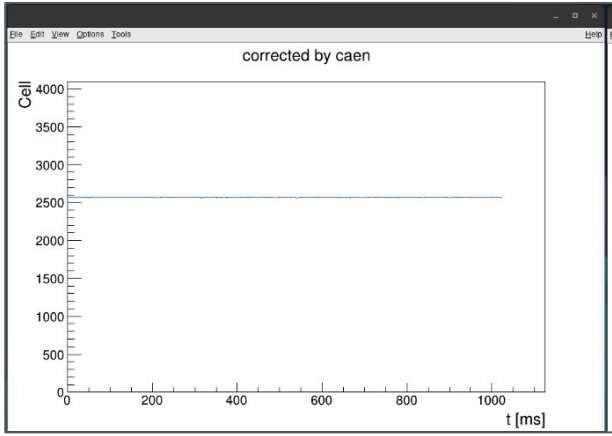
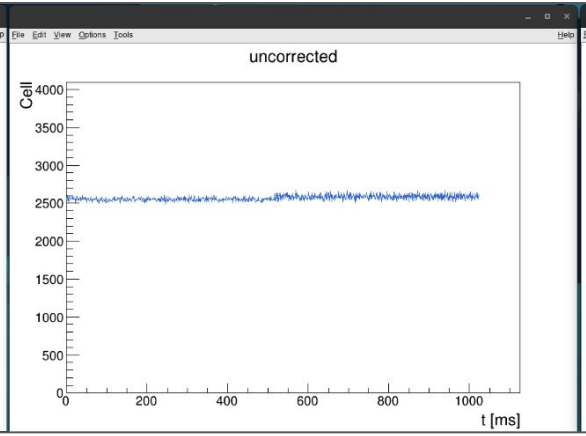
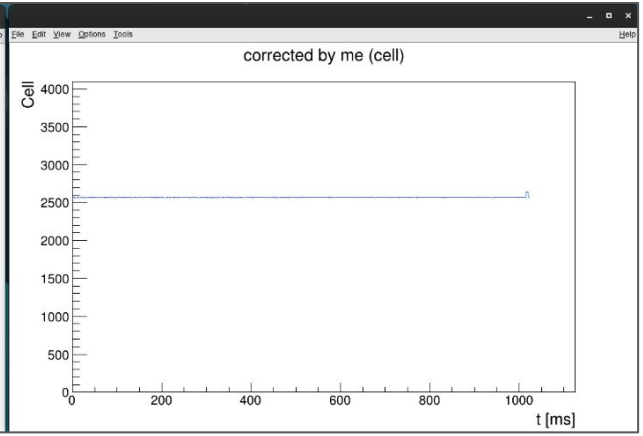
Example of waveform corrected with start index cell = 508, instead of 507 → **Clear difference**









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Outcome:

1. Ok, it works.

Next step:

2. Let's apply this to LIME data.

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```
File opened: test_histograms_Run0441.root
Corrections opened: MANGO_X742Table_750MHz_gr0_cell.txt
Corrections opened: MANGO_X742Table_1GHz_gr0_cell.txt
Corrections opened: MANGO_X742Table_2_5GHz_gr0_cell.txt
Corrections opened: MANGO_X742Table_5GHz_gr0_cell.txt
Channel: 0

*** RMS seems to big... Check please. ***

Start index cell found: 184 ...with an RMS of: 25.8476

*** RMS seems to big... Check please. ***

Start index cell found: 184 ...with an RMS of: 25.5263

*** RMS seems to big... Check please. ***

The RMS of the wf initial is :23.4892
```

Tested all the *frequencies*, *"channels"*, *"groups"*, and all the ***capacitors***.

–> Always find **higher RMS** that the original one == **corrections not working.**

PMT analysis - Data correction

Outcome:

1. Ok, it works.

Next step:

2. Let's apply this to LIME data.

```
File opened: test_histograms_Run04441.root
Corrections opened: MANGO_X742Table_750MHz_gr0_cell.txt
Corrections opened: MANGO_X742Table_1GHz_gr0_cell.txt
Corrections opened: MANGO_X742Table_2_5GHz_gr0_cell.txt
Corrections opened: MANGO_X742Table_5GHz_gr0_cell.txt
Channel: 0

*** RMS seems to big... Check please. ***

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Tested all the *frequencies*, *"channels"*, *"groups"*, and all the ***capacitors***.

–> Always find **higher RMS** that the original one == **corrections not working.**

What could be the issue?

1. Maybe digitizers were **swapped** (LNGS <-> Frascati)
   a. So I don't have the *correct* correction tables
   b. It's not so easy to get them now because they are performing software upgrades and not all the libraries are properly working.
2. But now all the digitizers are working properly, why not during last summer?
   a. Maybe there was some miss-calibration.
   b. It could mean the data might never be correctable…

PMT analysis - Data correction

Outcome:

1. Ok, it works.

Next step:

2. Let's apply this to LIME data.

```
File opened: test_histograms_Run04441.root
Corrections opened: MANGO_X742Table_750MHz_gr0_cell.txt
Corrections opened: MANGO_X742Table_1GHz_gr0_cell.txt
Corrections opened: MANGO_X742Table_2_5GHz_gr0_cell.txt
Corrections opened: MANGO_X742Table_5GHz_gr0_cell.txt
Channel: 0

*** RMS seems to big... Check please. ***

Start index cell found: 184 ...with an RMS of: 25.8476

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   a. Maybe there was some miss-calibration.
   b. It could mean the data might never be correctable…

What now?

➔ **Carry on the analysis** nonetheless. Maybe it's better to prepare the analysis for when better data arrives.

➔ If the data seems to much broken, try to manually fix it:

- ◆ With a man-made correction table (?)
- ◆ Bringing back the initial study with the moving average (?)