

UUB Charge and Peak histograms

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IIHE-ULB

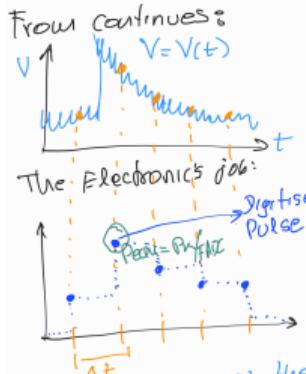
April 16, 2021



UUB Charge and Peak histograms

- ▶ Station studied: 863
- ▶ Data from CDAS.
- ▶ Software CDAS, pre-production version.

Some basics before to start



It needs of every Δt the voltage due to the current coming from PMT and passing through a resistance R .

From discrete:

$$\sum_i V_i \Delta t \rightarrow Q = \frac{1}{R} \sum_{i=0}^N V_i \Delta t$$

With N as number of bins, and V_i a number in FADC units, with, as instance:

$$1 \text{ FADC} = \frac{2 \text{ V}}{2^{10}-1} \approx 1.95 \text{ mV}$$

$$Q = \frac{1}{R} \sum_{i=0}^N (V_{\text{FADC}})_i$$

This means
Each point from the digitised pulse is the voltage of an instant of time.

So, because of $V = V(t)$

$$\Rightarrow V(t) = R I(t) = R \frac{dQ}{dt}$$

$$\Rightarrow \int dQ(t) = \frac{1}{R} \int_{t_0}^t V(t) dt$$

The ratio:

$$\frac{Q}{P_N} = \frac{\Delta t}{R} \sum_{i=0}^N (V_{\text{FADC}})_i / (V_{\text{FADC}})^{\text{FB}}$$

$$\text{If } (\text{AoS}) = \frac{\sum (V_{\text{FADC}})_i}{(V_{\text{FADC}})^{\text{FB}}}$$

$$\Rightarrow \frac{Q}{P_N} = \frac{\Delta t}{R} (\text{AoS})$$

Comparison $(\frac{Q}{P_N})^{\text{WB}}$ and $(\frac{Q}{P_N})^{\text{UB}}$

$$\Rightarrow \left(\frac{Q}{P_N}\right)^{\text{UB}} = \frac{(25 \text{ ns})}{R_{\text{UB}}} (\text{AoS})^{\text{UB}}$$

$$\left(\frac{Q}{P_N}\right)^{\text{WB}} = \frac{(8733 \text{ ns})}{R_{\text{WB}}} (\text{AoS})^{\text{WB}}$$

$$\text{So, if } R_{\text{WB}} = R_{\text{UB}}$$

$$\frac{\left(\frac{Q}{P_N}\right)^{\text{UB}}}{\left(\frac{Q}{P_N}\right)^{\text{WB}}} = \frac{(25 \text{ ns})(\text{AoS})^{\text{UB}}}{(8733 \text{ ns})(\text{AoS})^{\text{WB}}}$$

$$\frac{\left(\frac{Q}{P_N}\right)^{\text{UB}}}{\left(\frac{Q}{P_N}\right)^{\text{WB}}} = 3.0 \frac{(\text{AoS})^{\text{UB}}}{(\text{AoS})^{\text{WB}}}$$

If $(\text{AoS})^{\text{UB}} \approx (\text{AoS})^{\text{WB}}$

$$\Rightarrow \frac{\left(\frac{Q}{P_N}\right)^{\text{UB}}}{\left(\frac{Q}{P_N}\right)^{\text{WB}}} \approx 3.0$$

We know that $\left(\frac{Q}{P_N}\right)^{\text{UB}} \approx 3.5$

So,

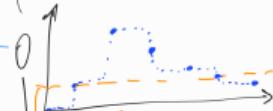
$$\left(\frac{Q}{P_N}\right)^{\text{WB}} \approx \frac{3.5}{3.0} \approx 1.17$$

Very similar to a delta to pulse.

So, from the data
 $(\frac{Q}{P_N})^{\text{WB}} > 1.17$
 $(\frac{Q}{P_N})^{\text{WB}} \neq (\frac{Q}{P_N})^{\text{UB}}$

So may be $(\text{AoS})^{\text{WB}} \neq (\text{AoS})^{\text{UB}}$
or $R_{\text{WB}} \neq R_{\text{UB}}$.

From digitised Pulse:



Baseline.

$$\text{So, } Q = \frac{\Delta t}{\sum_i^N} (V_i - B_L)$$

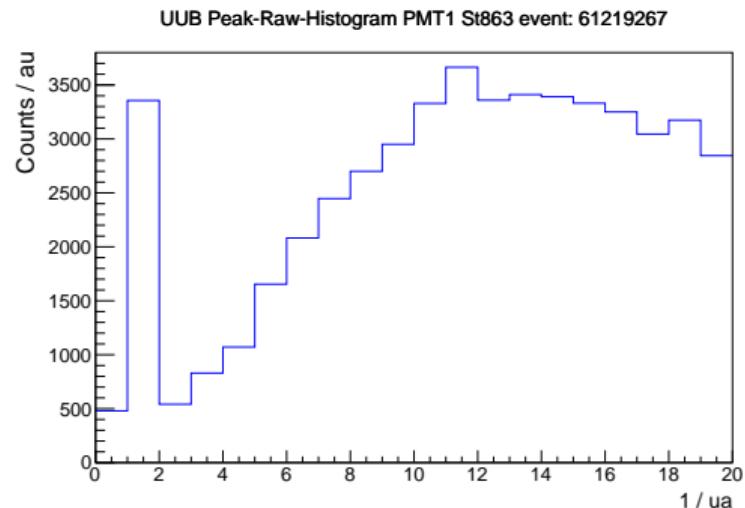
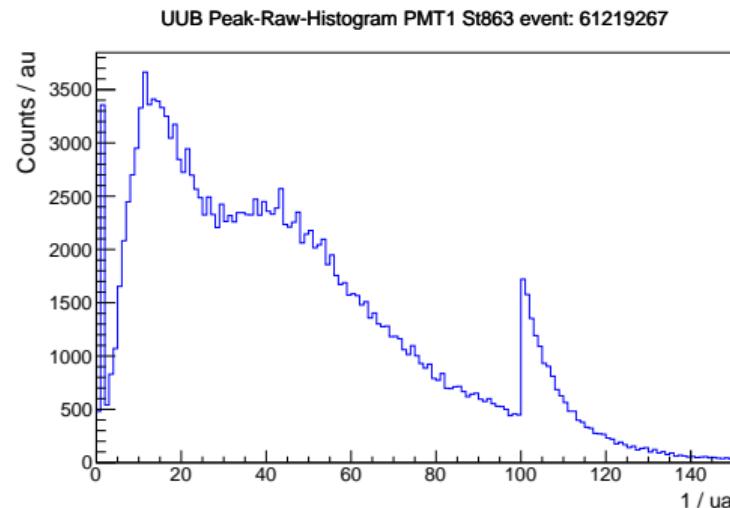
$$Q = \frac{\Delta t}{\sum_i^N} V_i - N(B_L)$$

Correction for baseline.

Assuming a constant baseline.

PMT 1: UUB Peak Histogram

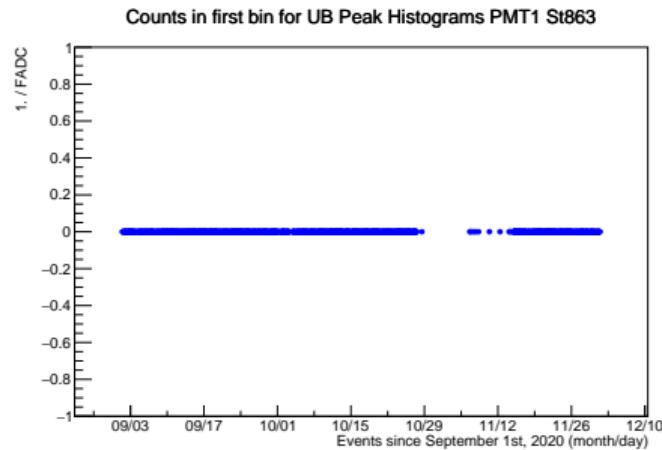
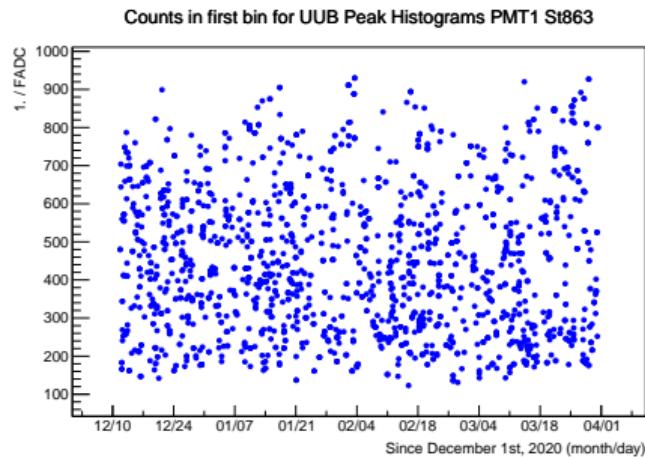
Raw UUB Peak Histogram



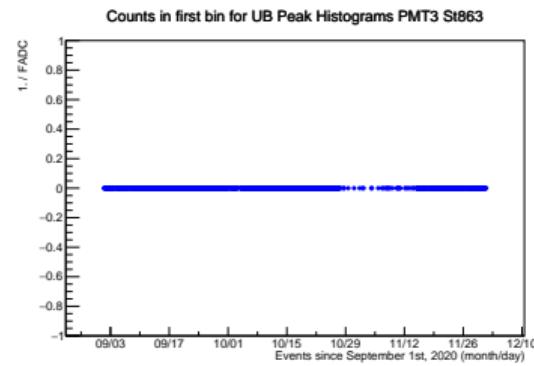
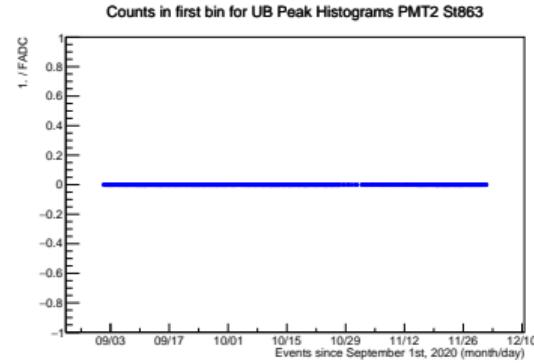
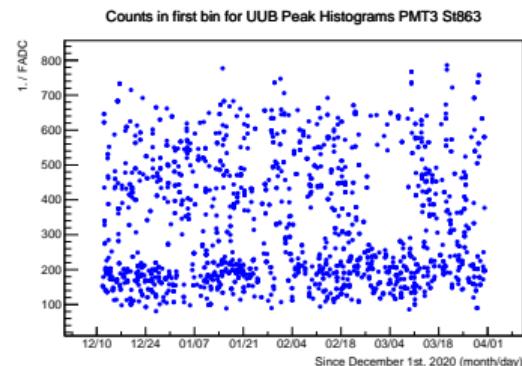
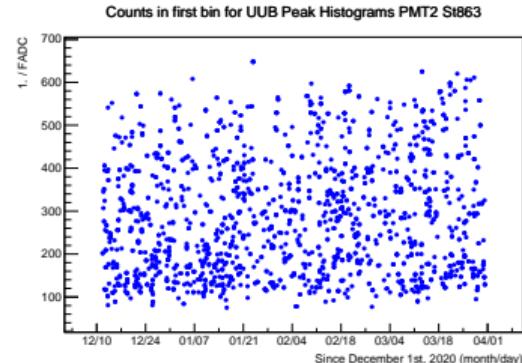
Not zero counts in the first bin

PMT 1: UUB and UB counts in the first bin in Raw Peak Histogram

IoSdHisto::Peak[pmtId][0]



PMT 1: UUB and UB counts in the first bin in Raw Peak Histogram IoSdHisto::Peak[pmtId][0]



Are we reading noise in first Peak histograms bins?

From UUB raw Peak histogram to the correct format

Applying `IoSdStation::HPeak` method

Each bin (j) of raw histogram is corrected as:

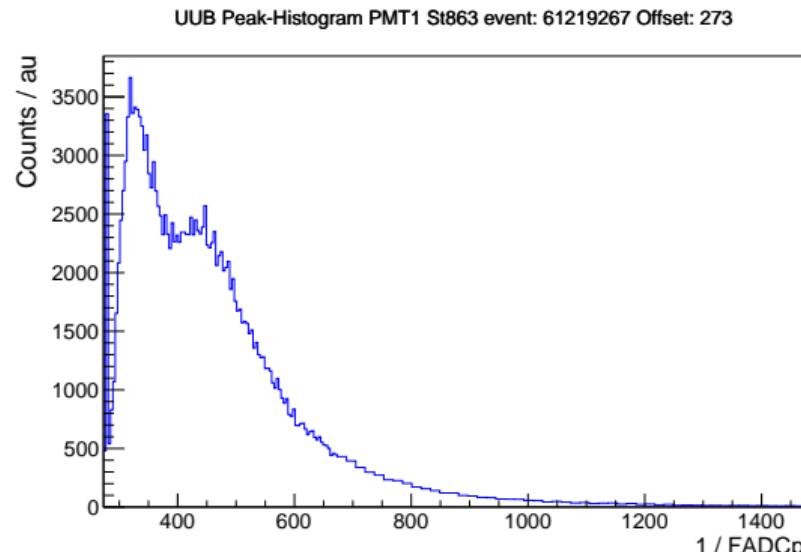
$$xp[j] = j * \text{mult} + \text{offset}; \quad xp[100 + j] = 100 * \text{mult} + \text{bigbins} * j * \text{mult} + \text{offset};$$

Here, *mult* and *bigbins* are constants and equal to 4; the *offset* is set for each event.

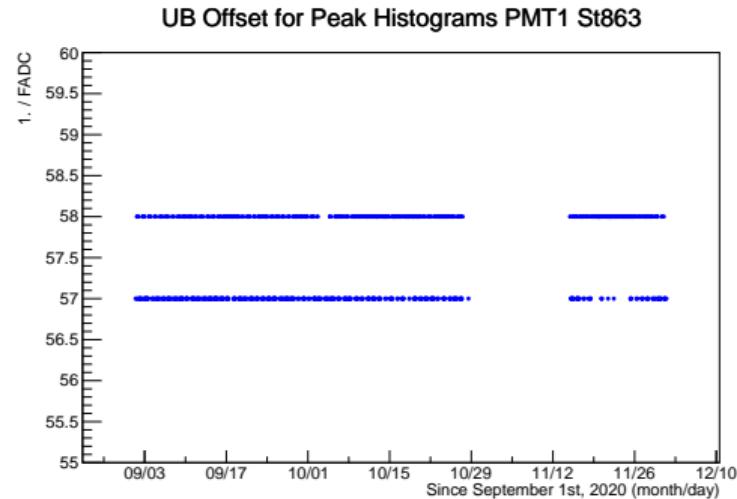
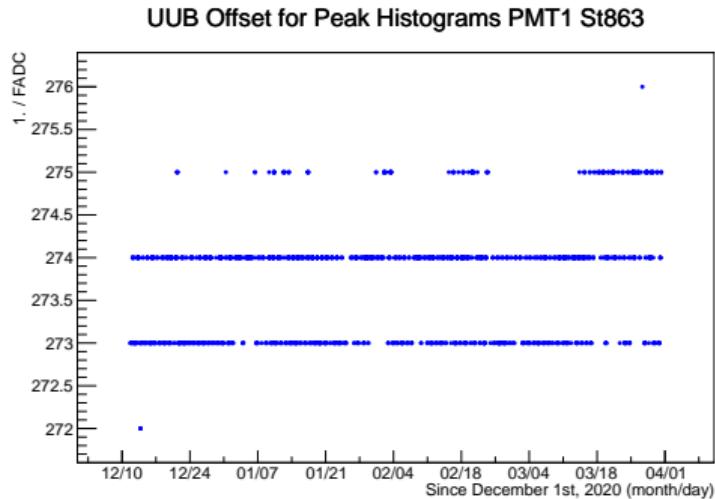
As an instance, for event 61219267 the first bin is set a 273 FADC. So, the baseline needs to be discounted.

First, the Offset variable is checked.

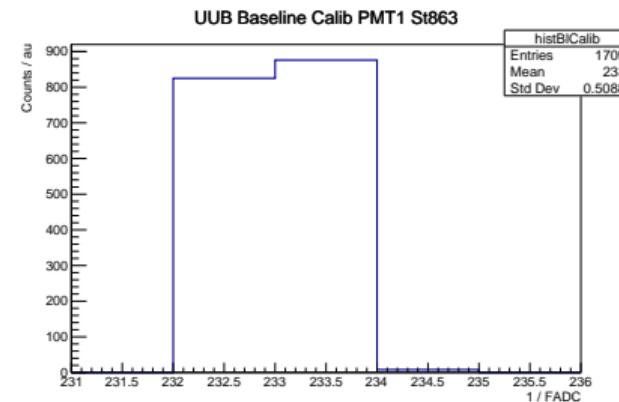
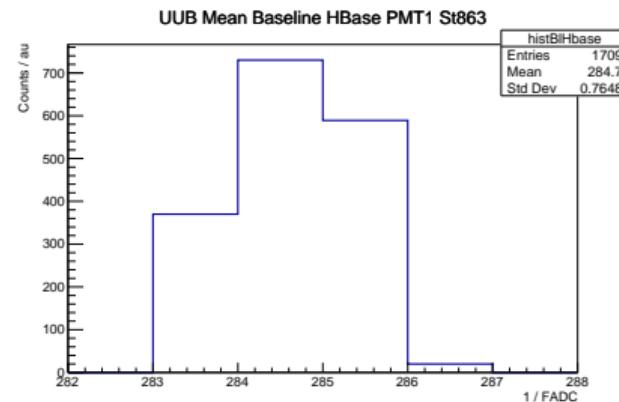
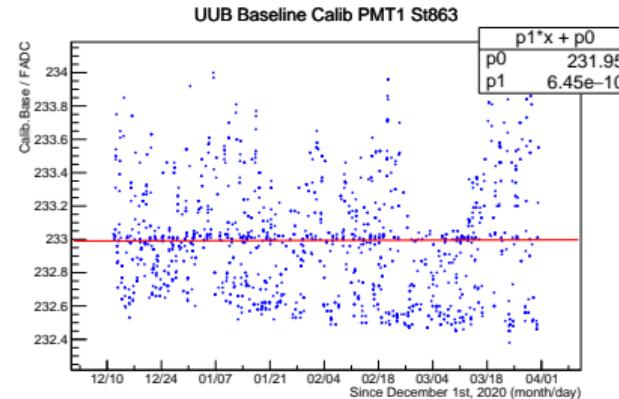
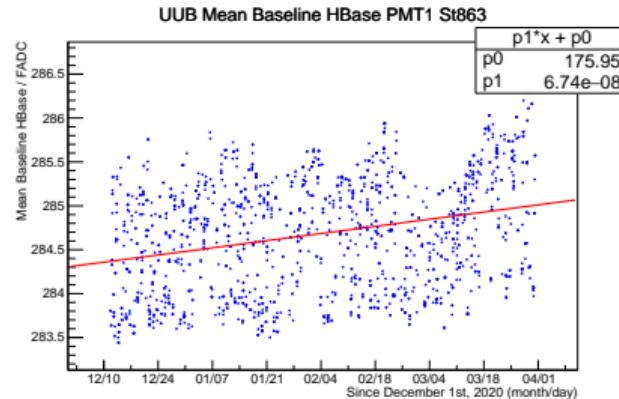
And, there are two methods to get the baseline: `IoSdStation::HBase` and `Calib->Base`.



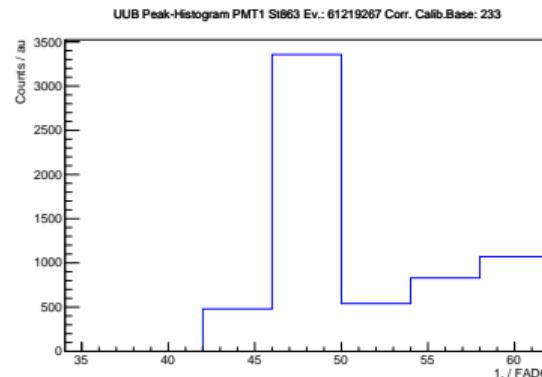
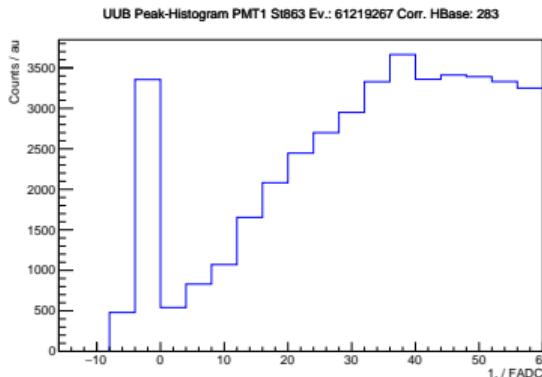
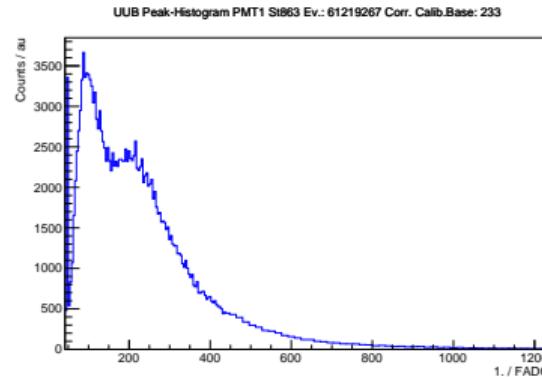
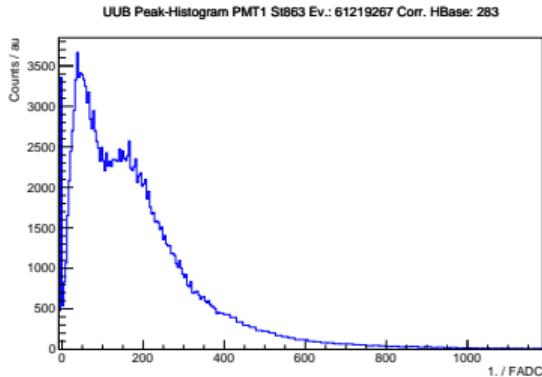
Checking Offset: comparison UUB and UB Peak histograms



Checking UUB Baseline: IoSdStation::HBase[pmt] and Calib.Base[pmt]



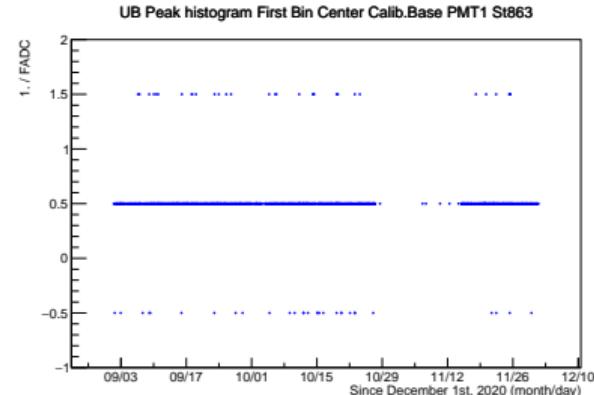
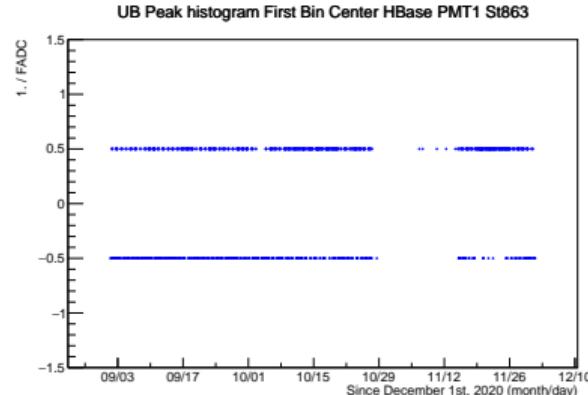
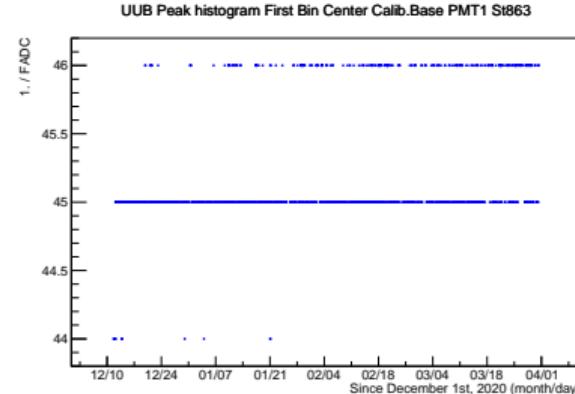
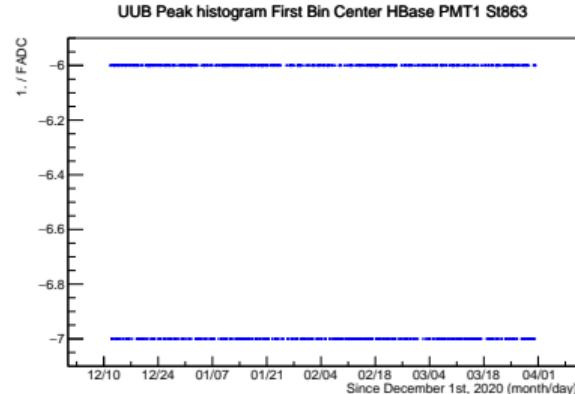
UUB Peak histogram correcting for baseline: HBase and Calib.Base



Is the correction using HBase producing negative bins?

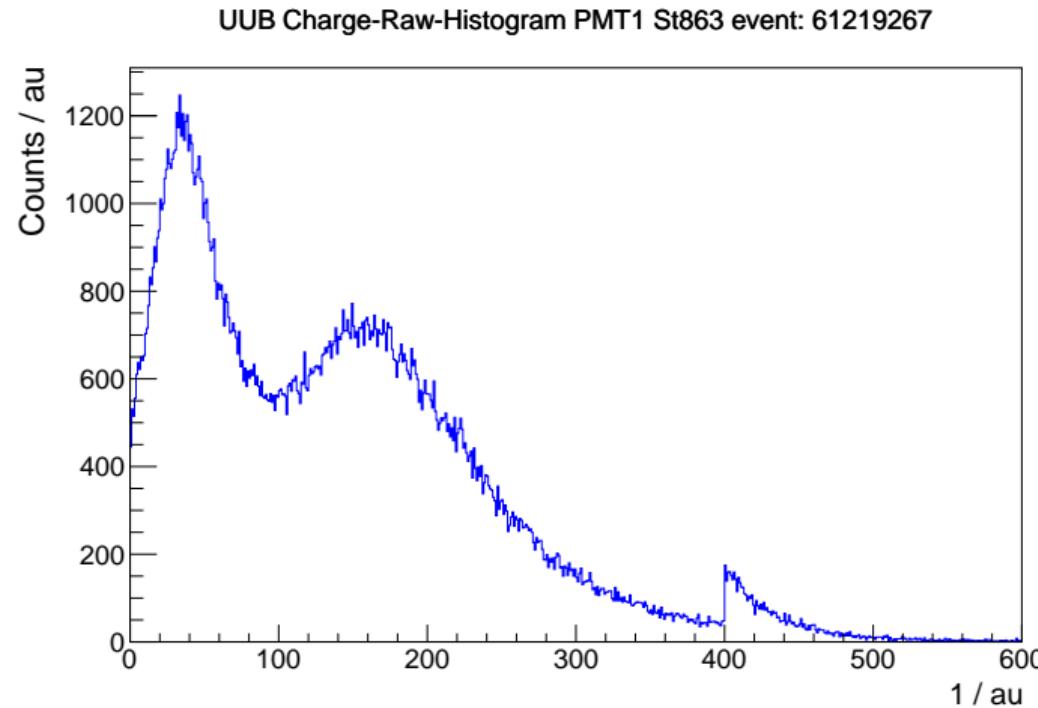
Comparison: UUB and UB Peak histogram First Bin center

Here, First Bin center: GetBinCenter(1).



Applying the previous steps to UUB Charge histograms

Raw UUB Charge histogram



From UUB raw Charge histogram to the correct format

IoSdStation::HCharge

Each bin (j) of the raw histogram is set as:

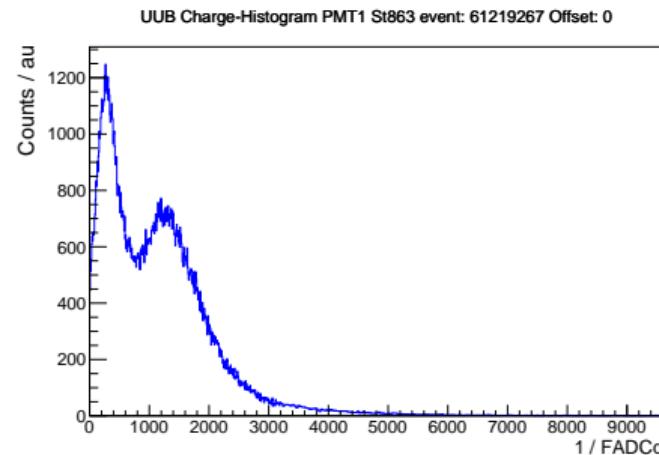
$$xc[j] = \text{mult} * j + \text{offset}; xc[400+j] = 400 * \text{mult} + \text{bigbins} * \text{mult} * j + \text{offset}$$

Here, $\text{mult}=8$ and $\text{bigbins}=4$, both of them constants;
the offset is set for each event.

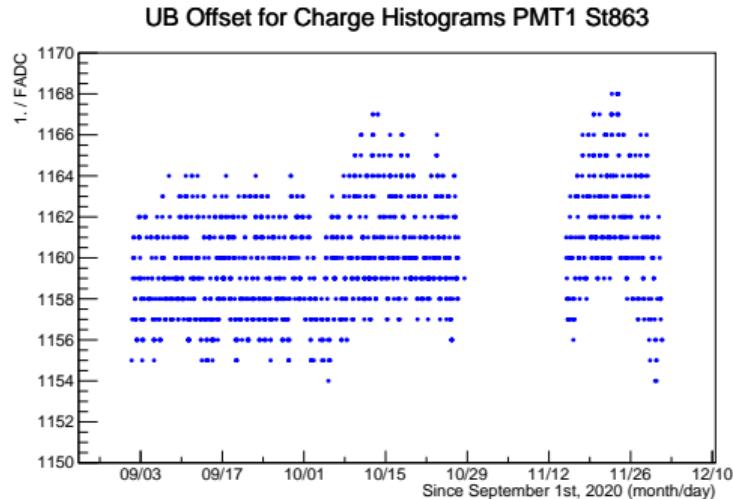
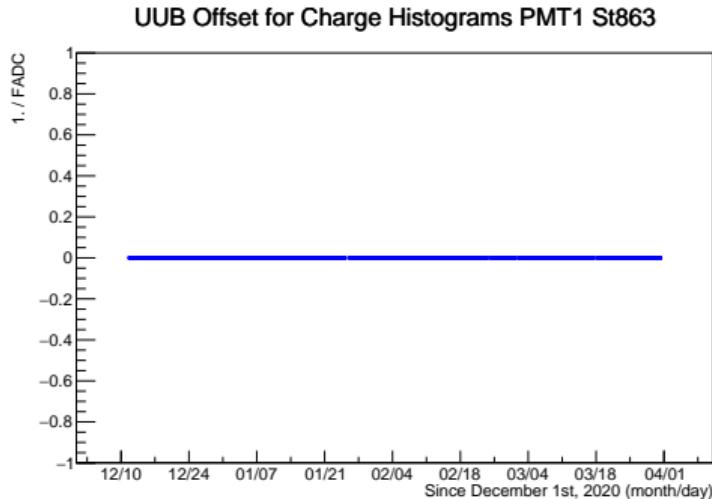
For event 61219267 offset = 0, with
a value of 0 for the first bin of the
UUB Charge histogram.

Is not needed a correction for baseline?

First, the Offset variable is checked.

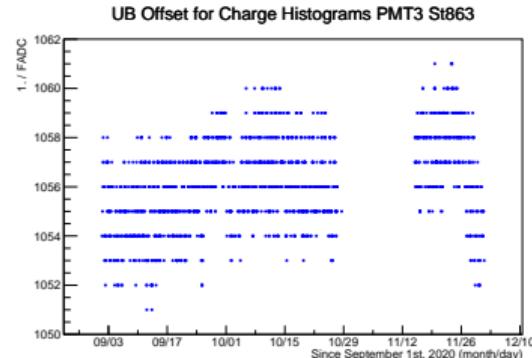
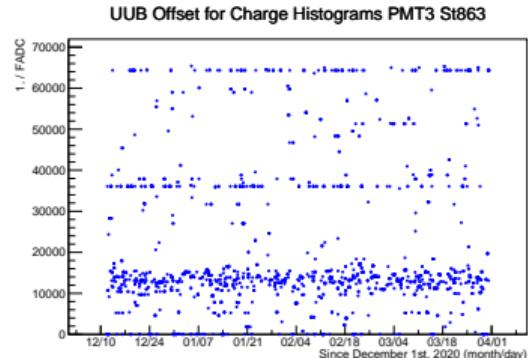
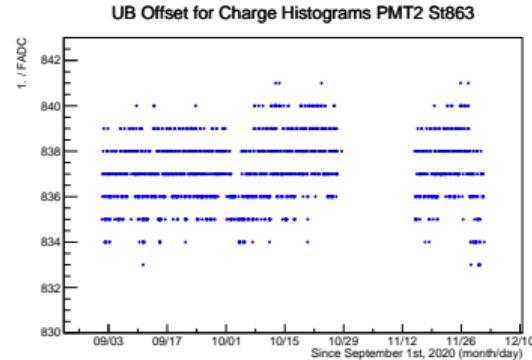
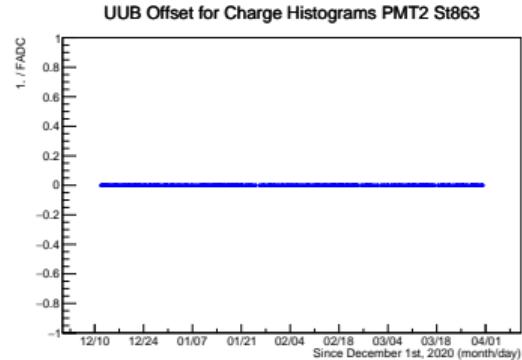


Checking Offset: UUB and UB for Charge histograms



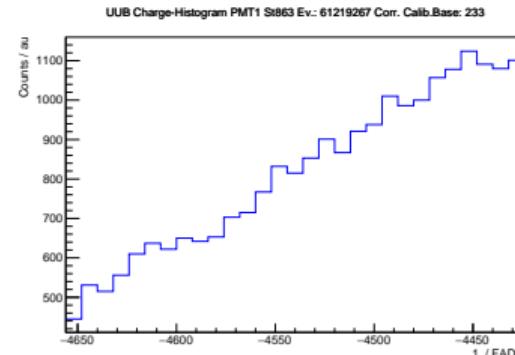
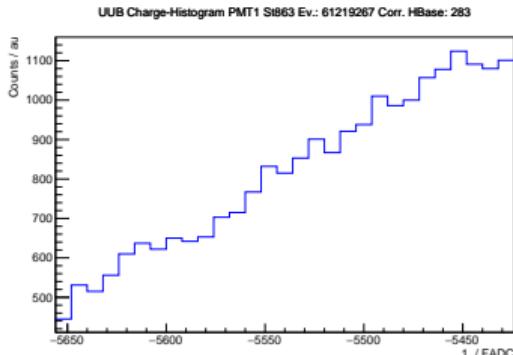
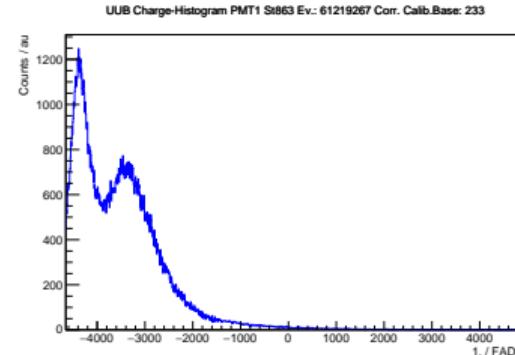
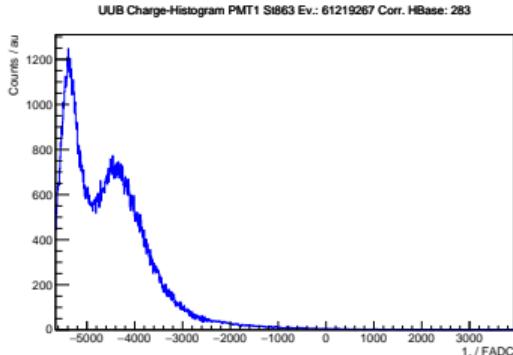
A very different behaviour for UUB respect to UB, the same for the others LPMT?

Comparison: UUB and UB Offset for Charge histograms



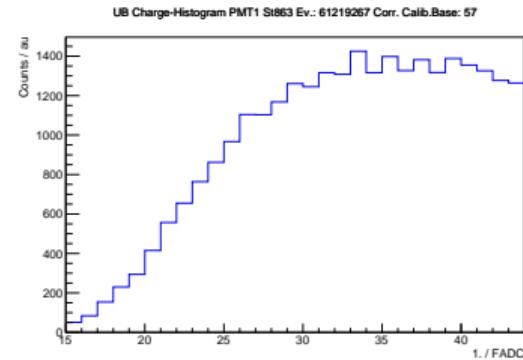
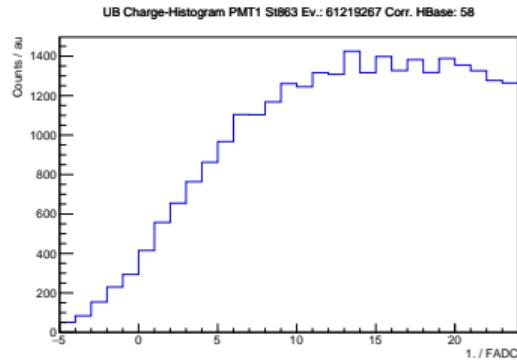
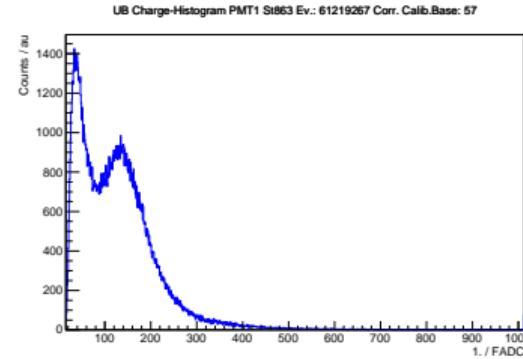
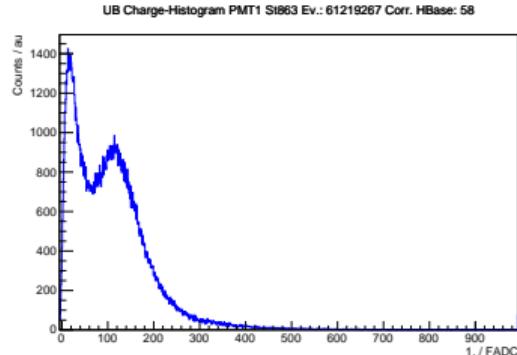
Offset for UUB LPMT3 is very different form LPMT1 and LPMT2, expected?

UUB Charge histogram Correcting for baseline



Does the Offset value of zero include the baseline correction?

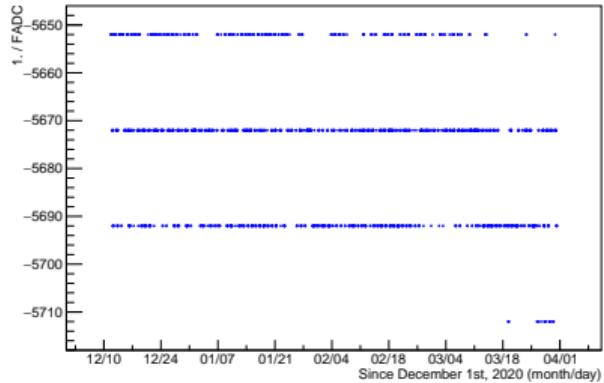
Comparison with UB Charge histogram Correcting for baseline



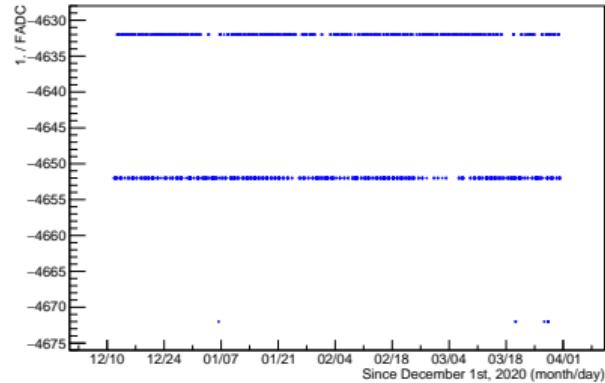
For UB the correction for baseline is needed.

Comparison: UUB and UB Charge histogram First Bin

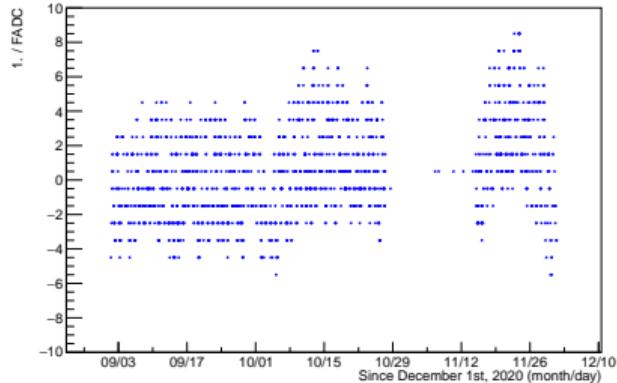
UUB Charge histogram First Bin Center HBase PMT1 St863



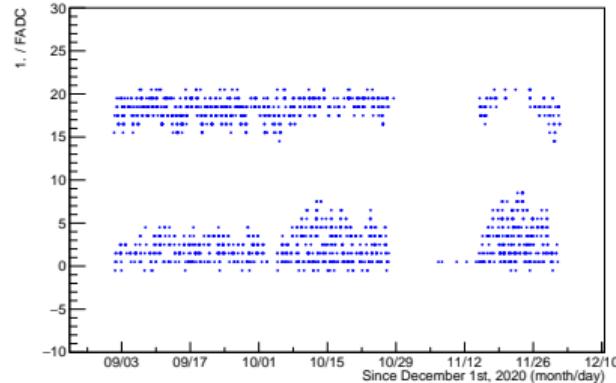
UUB Charge histogram First Bin Center Calib.Base PMT1 St863



UB Charge histogram First Bin Center HBase PMT1 St863



UB Charge histogram First Bin Center Calib.Base PMT1 St863

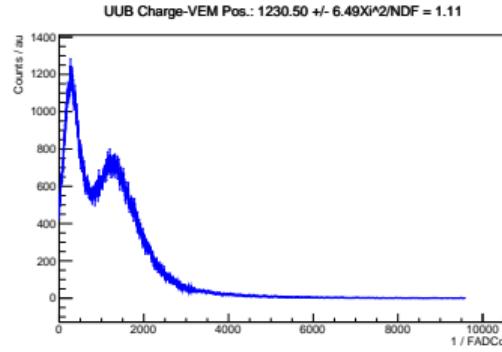
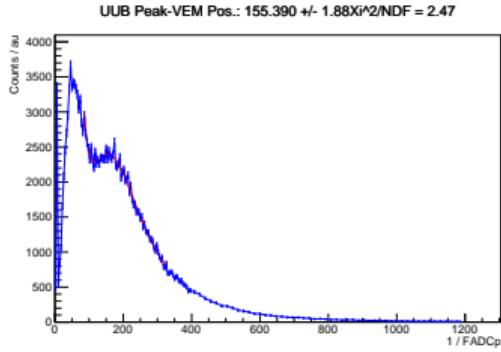


Brief summary

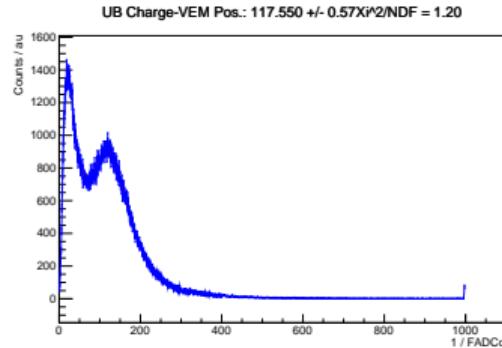
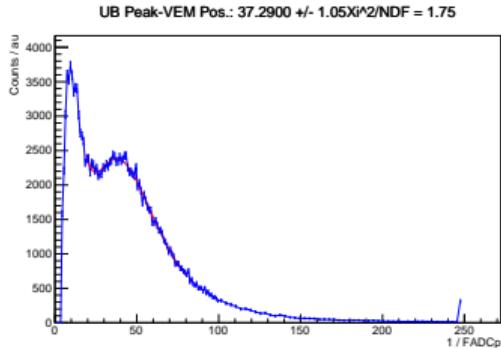
- ▶ **For Peak histograms:**
 - ▶ For UUB baseline, the bin center is most stable using HBase than using Calib.Base (slide 9); the same situation is for UB.
- ▶ **For Charge histograms:**
 - ▶ For UUB, from slides 14, 15 and 16 the correction for baseline has not sense for LPMT1 and LPMT2, but maybe if for LPMT3. Nevertheless, this correction has sense for UB (slide 17).
 - ▶ For UB, the bin center is most stable using HBase than Calib.Base.

Lets see what about the Area over Peak.

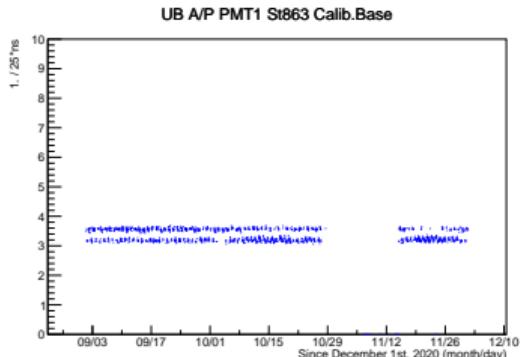
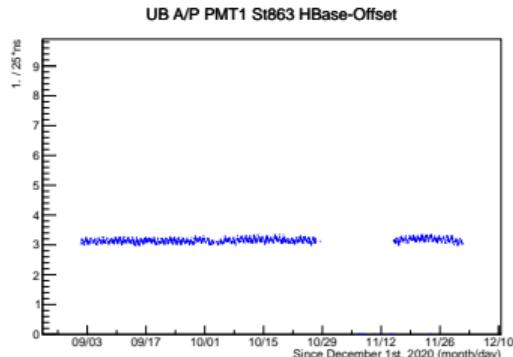
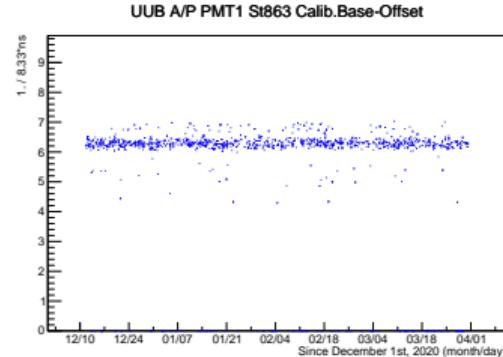
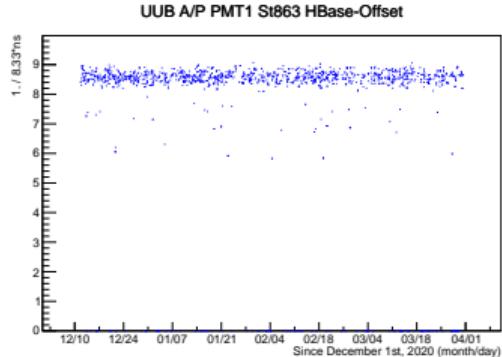
Area/Peak: Fitting histograms for UUB LPMT1



for UB LPMT1

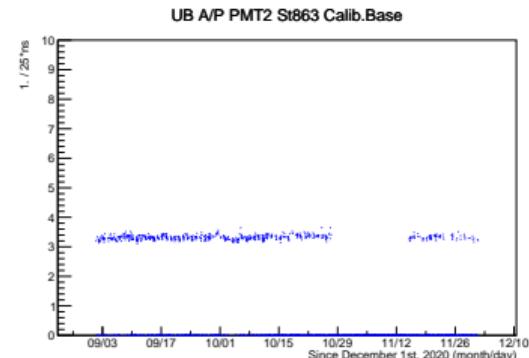
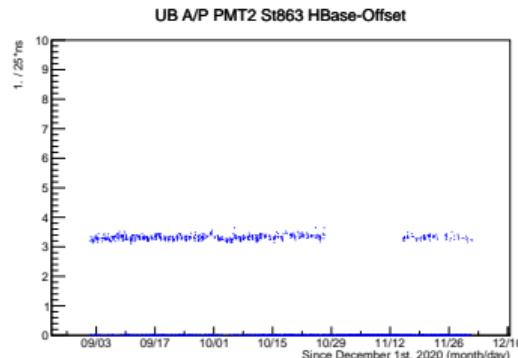
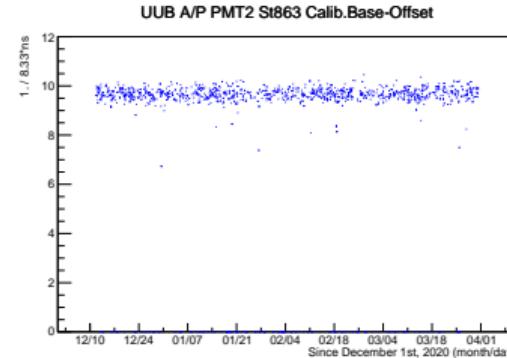
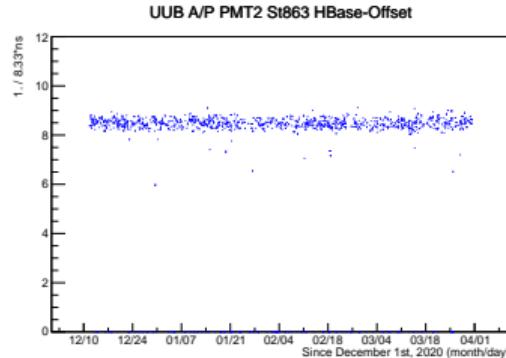


Area/Peak calculation: LPMT1



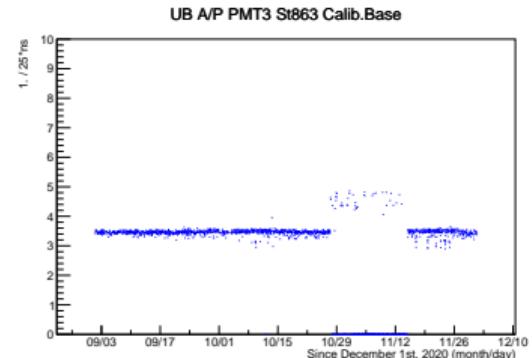
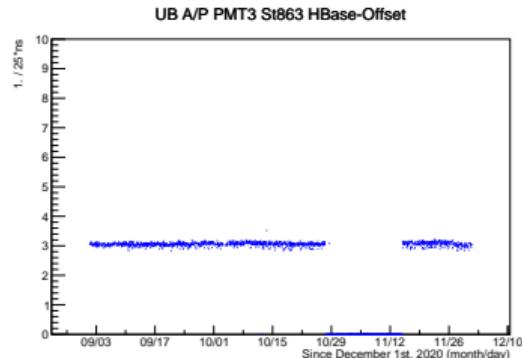
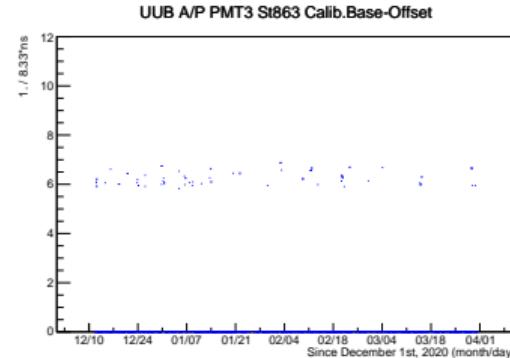
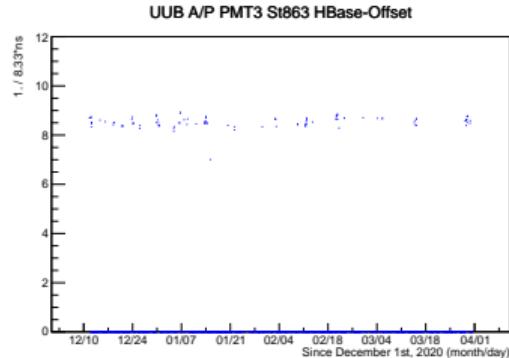
For UUB, the A/P using Calib.Base is $\sim 26.7\%$ different respect of using HBase.

Area/Peak calculation: LPMT2



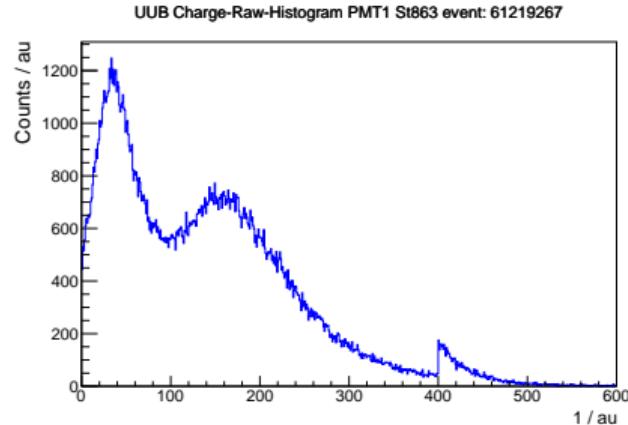
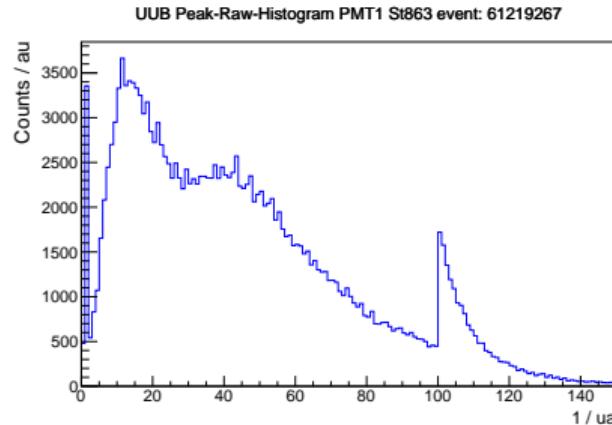
For UUB, the A/P using Calib.Base is $\sim -8.2\%$ different respect of using HBase.

Area/Peak calculation: LPMT3



For UUB, the A/P using Calib.Base is $\sim 29.4\%$ different respect of using HBase.

Final comments and questions



- ▶ In the Peak histogram is seen a peak before the EM one, this could be noise, but in the Charge histogram there is not evidence of this noise, i.e. if considering a noise as a pulse of one single bin, so its charge should be equal to the peak.
- ▶ Why is the Offset setting to zero for LPMT1 and LPMT2? Why is it not zero for LPMT3? How is the Offset getting its value? Why is not the same in UB?
- ▶ For UUB, why is so different the A/P value for HBase compares to Calib.Base?
- ▶ Could this Offset-issue affect the A/P calculation? How to be sure?

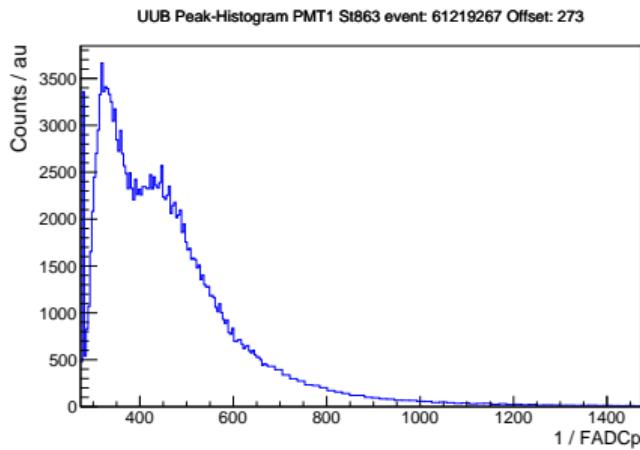
Next steps

- ▶ To Extend this study to the others stations

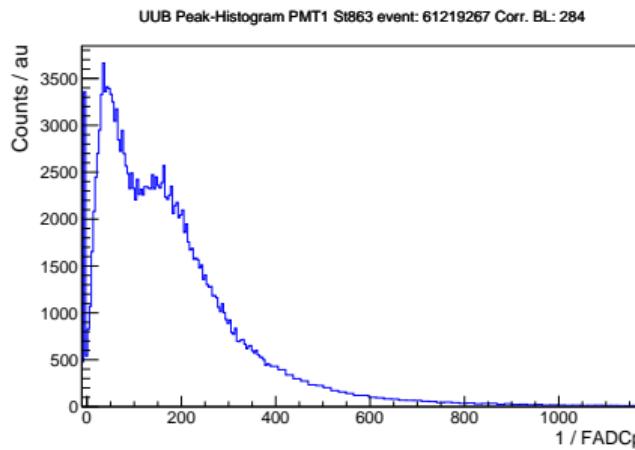
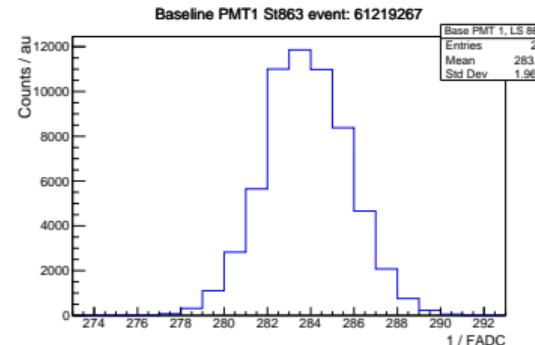
BACKUP...

UUB Peak histogram Correcting for baseline

Baseline histogram getting from
IoSdStation::HBase
 $xb[j] = j + \text{offset};$
 $yb[j] = \text{Histo} \rightarrow \text{Base}[\text{pmt}][j]$

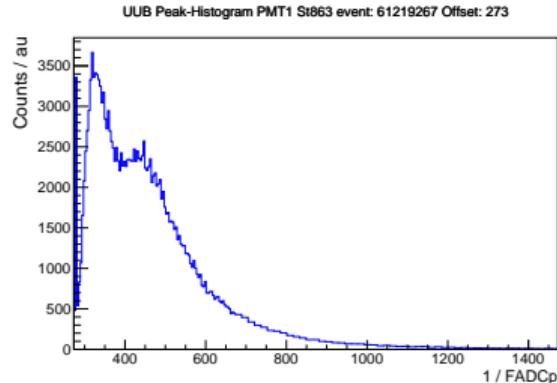


Not corrected

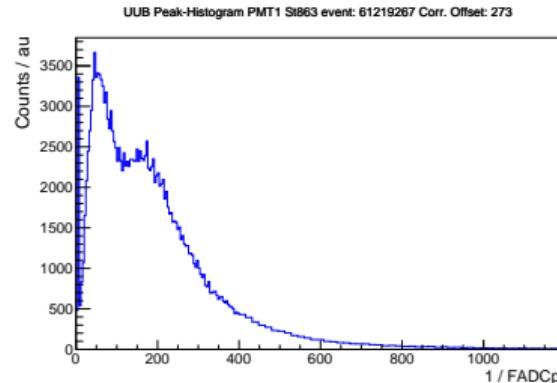


Corrected, but shows negative bins

UUB Peak histogram Correcting for Offset

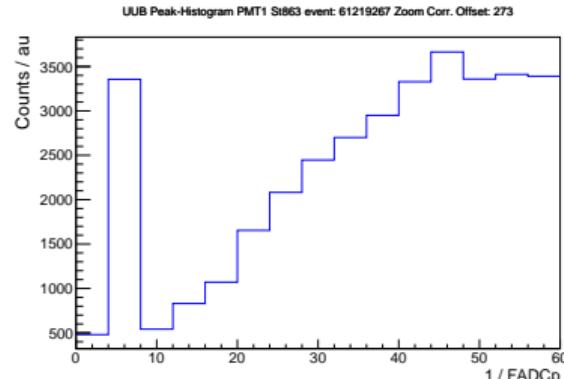


Not corrected



Corrected

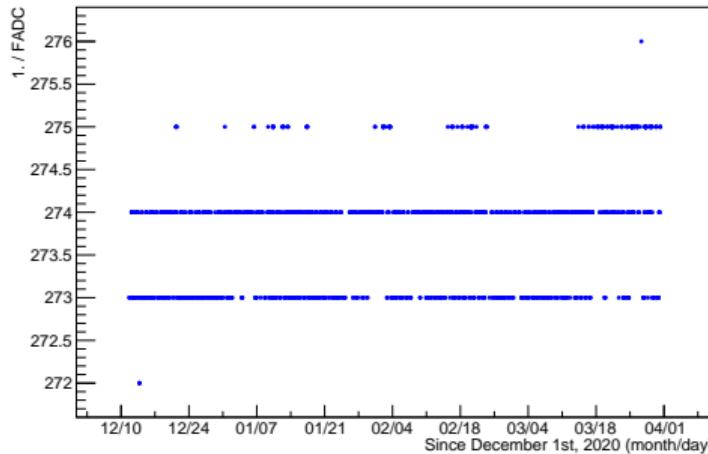
Zooming to check the threshold,
but no one can be seen.



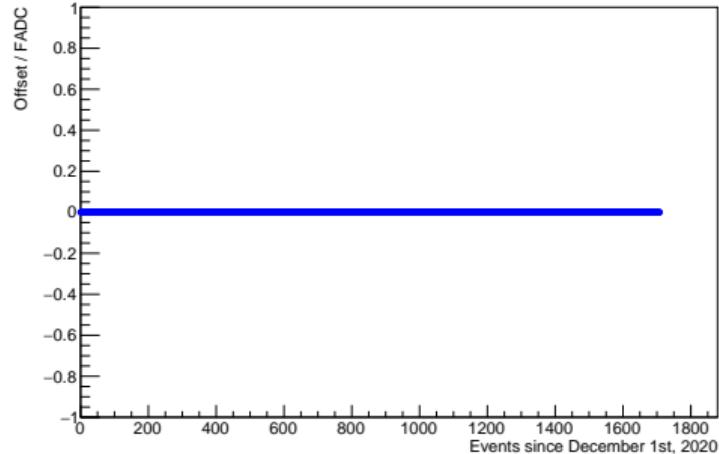
Offset values for UUB Peak histograms

For LPMT1

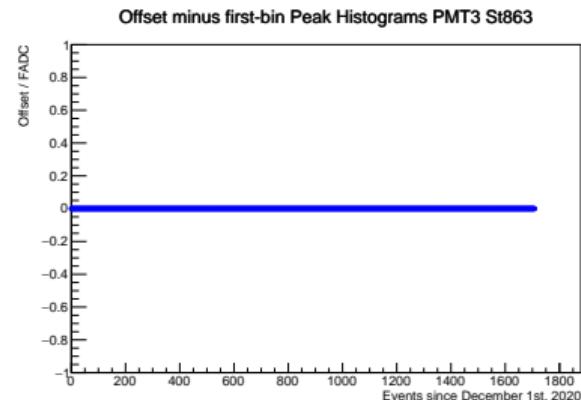
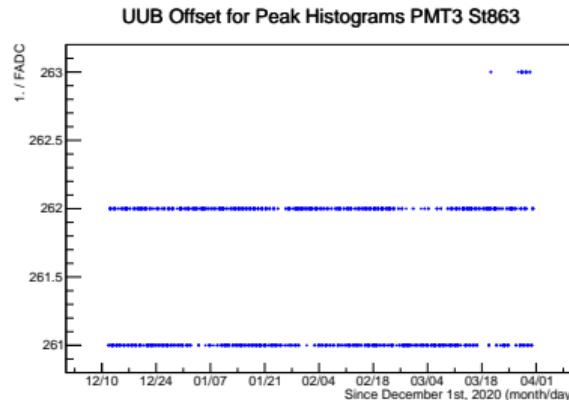
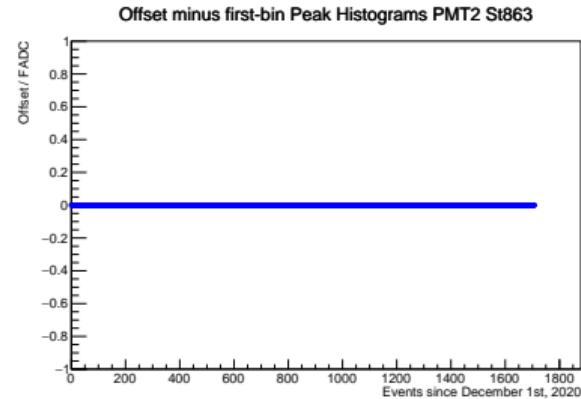
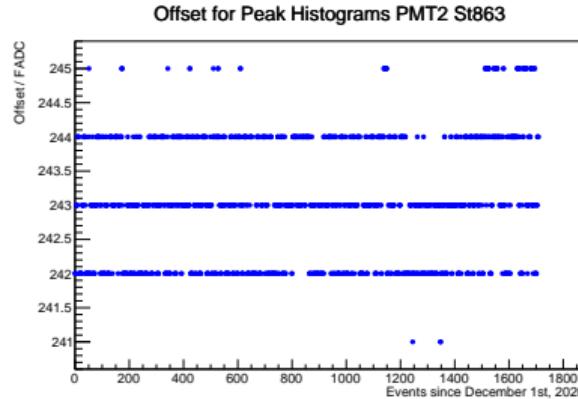
UUB Offset for Peak Histograms PMT1 St863



Offset minus first-bin Peak Histograms PMT1 St863



Offset values for UUB Peak histograms For LPMT2 and LPMT3



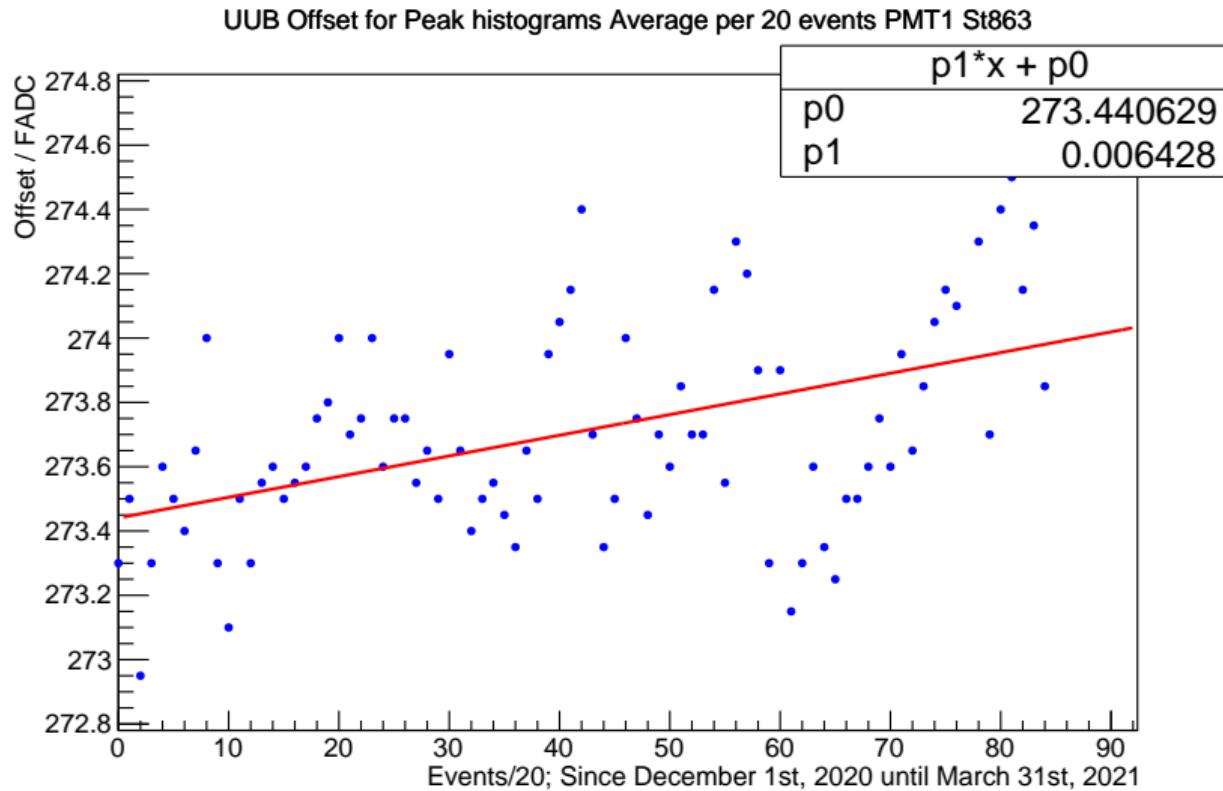
How to correct to obtain the right format?

Here, the correct format is one that shows some threshold.

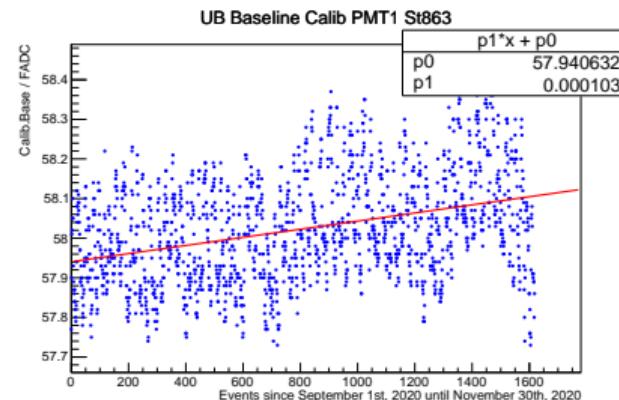
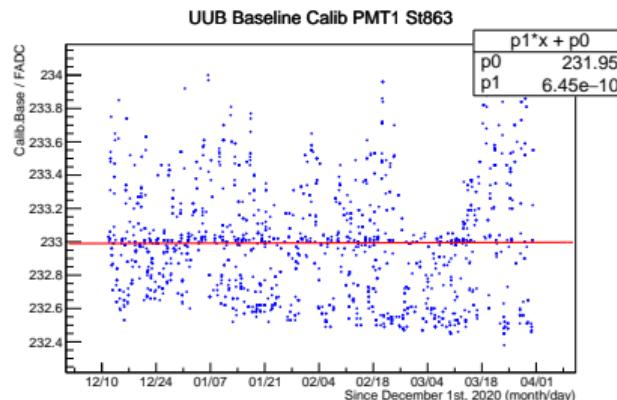
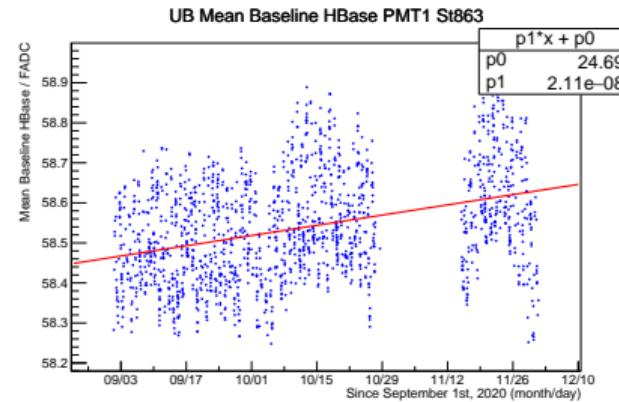
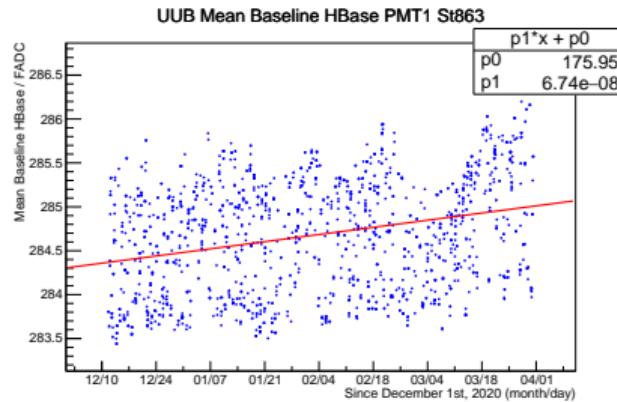
Two methos to check the baseline:

1. `IoSdStation::HBase[pmt]`, return a histogram with the baseline ditribution, according with: `histo->GetXaxis()->Set(20, offset, offset + 20)`; so, this method depends on the Offset.
2. `Calib->Base[pmt]` of the `IoSdCalib` class. This returns the value of the baseline, I guess it coming from some measurement performed at the WCD, but I am not sure.

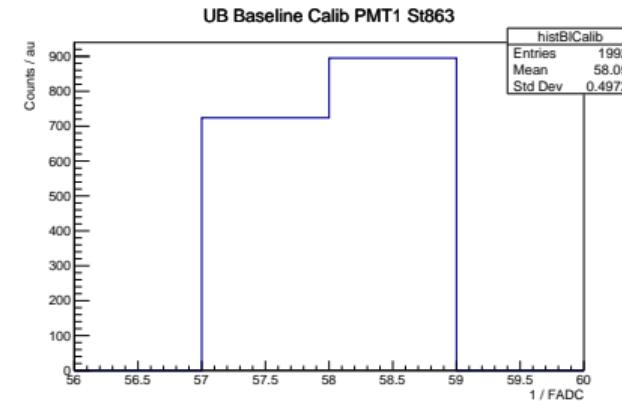
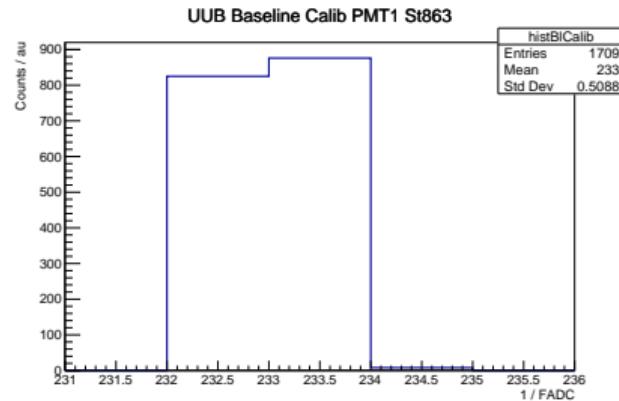
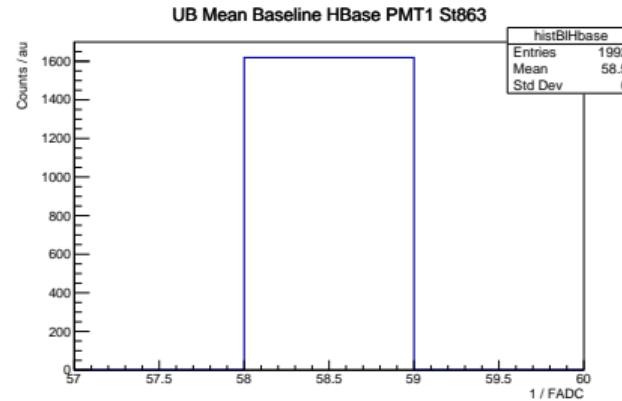
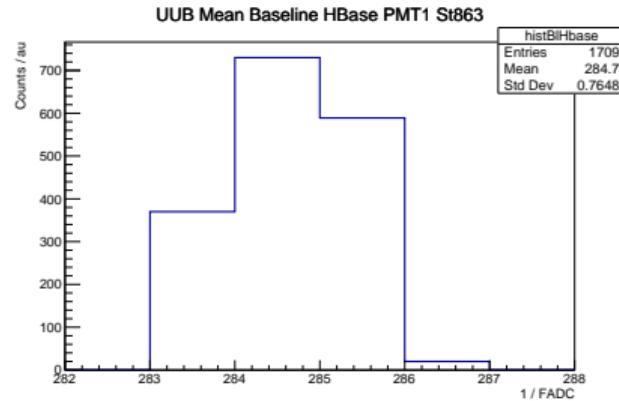
UUB Baseline values loSdStation::HBase[pmt] and Calib->Base[pmt]



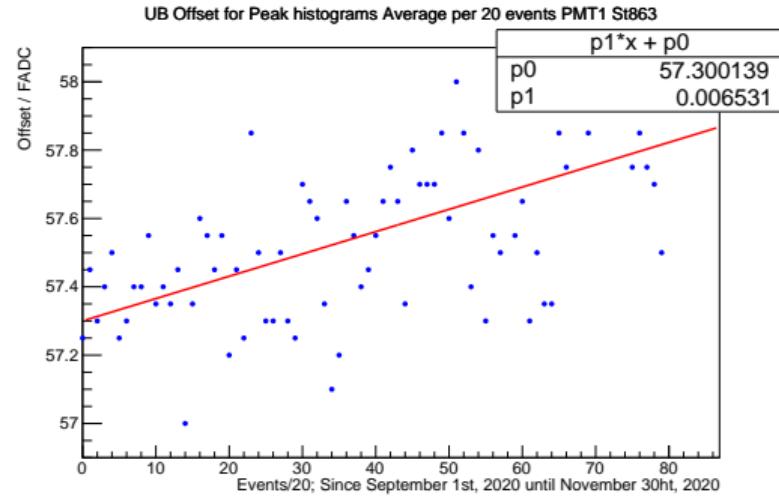
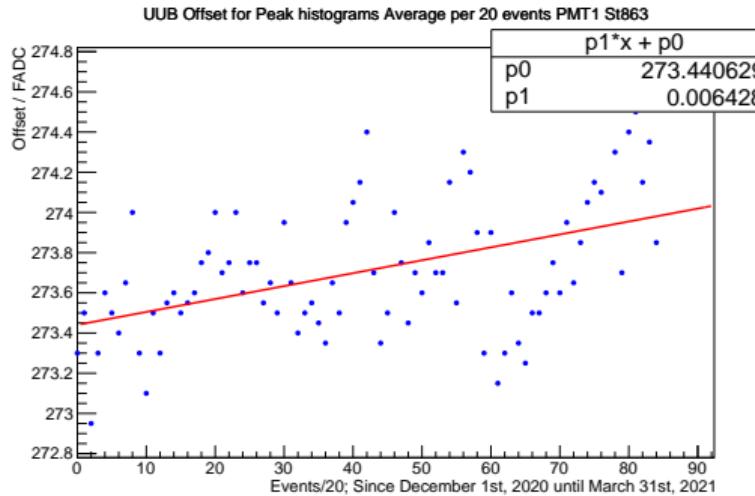
Comparison: UUB Baseline and UB Baseline



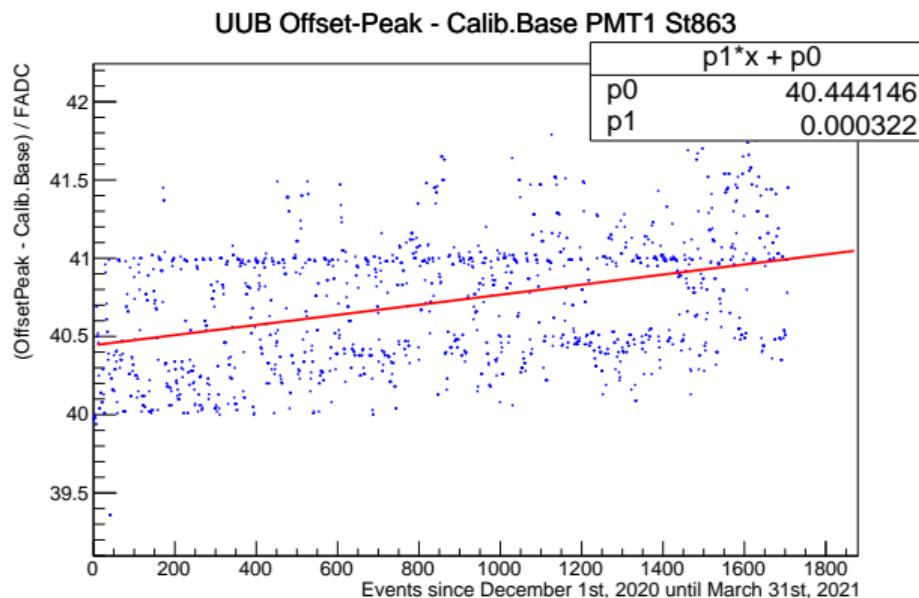
Comparison: UUB Baseline and UB Baseline



Comparison: UUB Baseline and UB Baseline

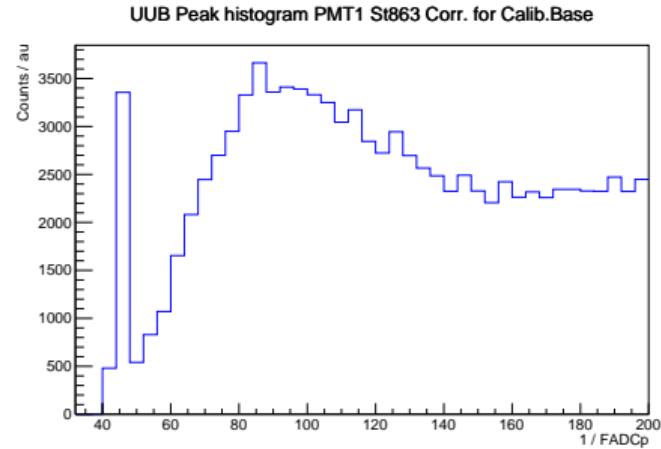
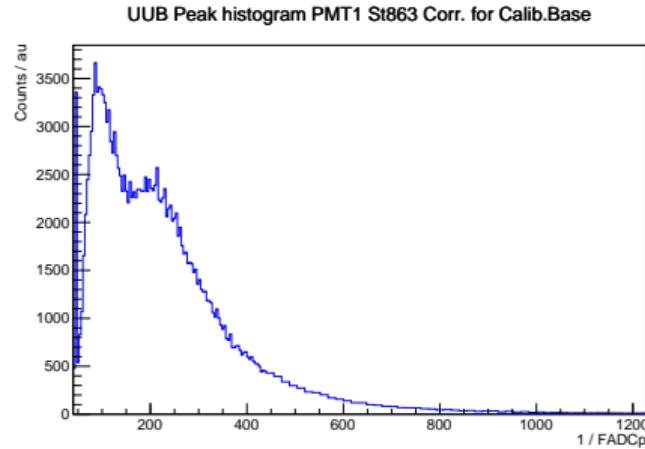


UUB Baseline values loSdStation::HBase[pmt] and Calib->Base[pmt]



The Offset is increasing with the time, so this explain why the baseline from HBase is increasing too.

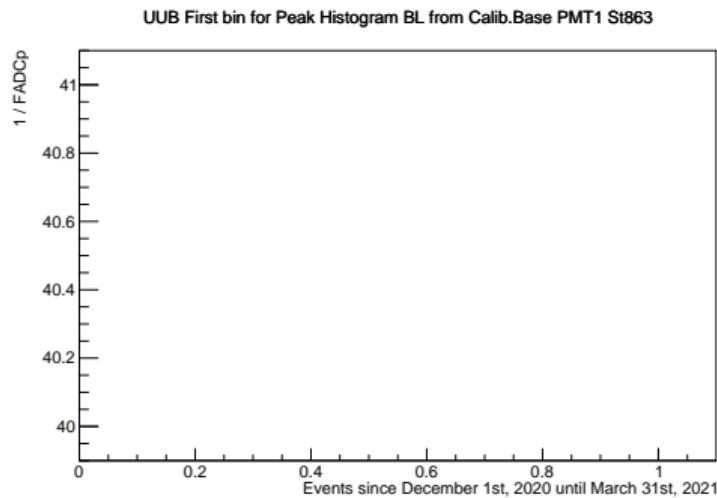
From UUB raw Peak histogram to the correct format, via Calib.Base[pmt]



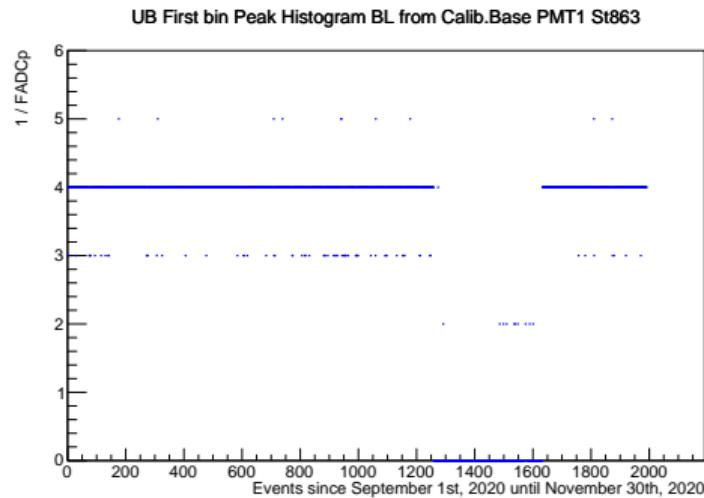
Now, a threshold is seen, the correct one?

From UUB raw Peak histogram to the correct format, via Calib.Base[pmt]

UUB first bin for peak histograms:



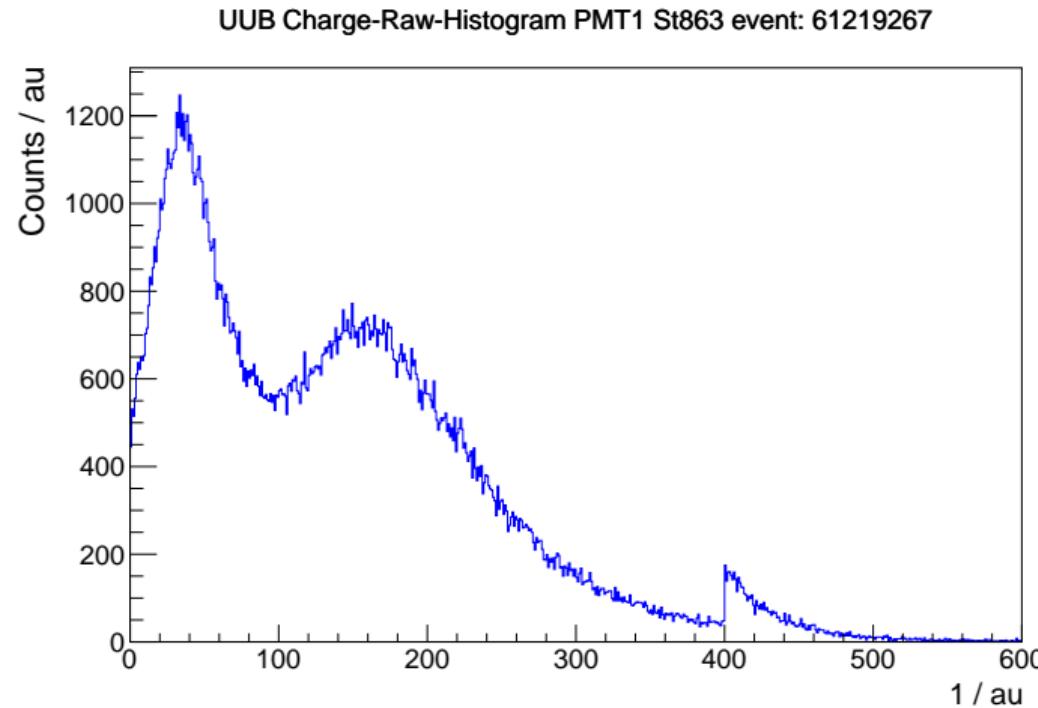
$$41 * (2\text{kV}/2^{12}) = 20.0\text{mV}$$



$$4 * (2\text{kV}/2^{10}) = 7.8\text{mV}$$

Applying the previous steps to UUB Charge histograms

Raw UUB Charge histogram



From UUB raw Charge histogram to the correct format

IoSdStation::HCharge

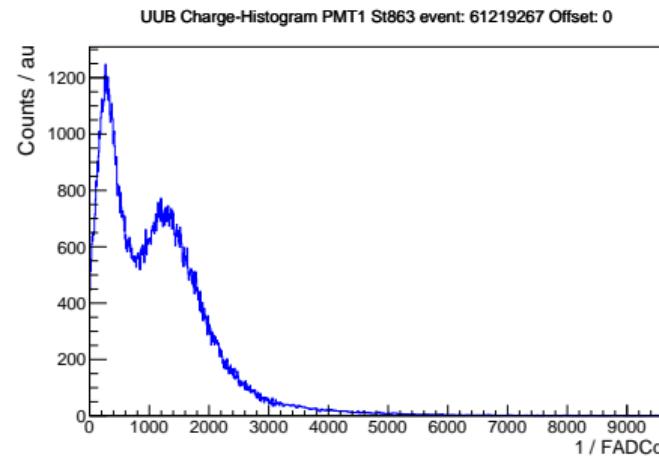
Each bin (j) of the raw histogram is set as:

$$xc[j] = \text{mult} * j + \text{offset}; xc[400+j] = 400 * \text{mult} + \text{bigbins} * \text{mult} * j + \text{offset}$$

Here, $\text{mult}=8$ and $\text{bigbins}=4$, both of them constants;
the offset is set for each event.

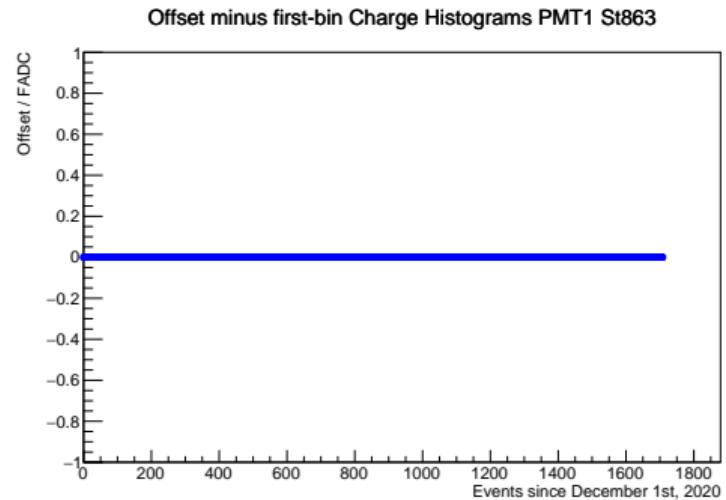
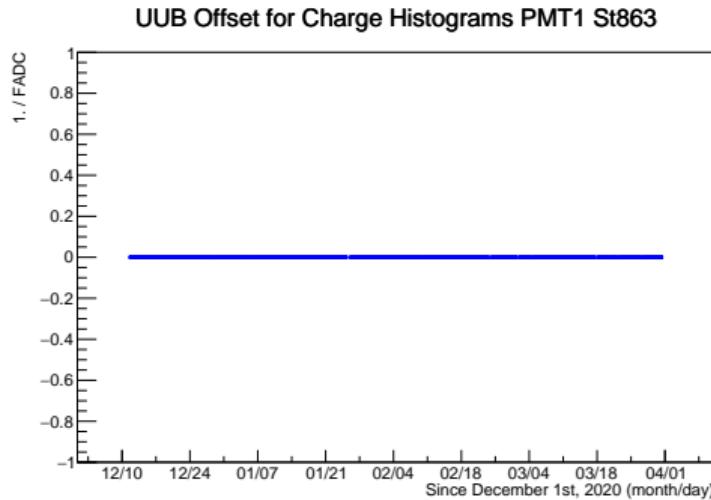
For event 61219267 offset = 0, with
a value of 0 for the first bin of the

UUB Charge histogram.
Not correction for baseline?

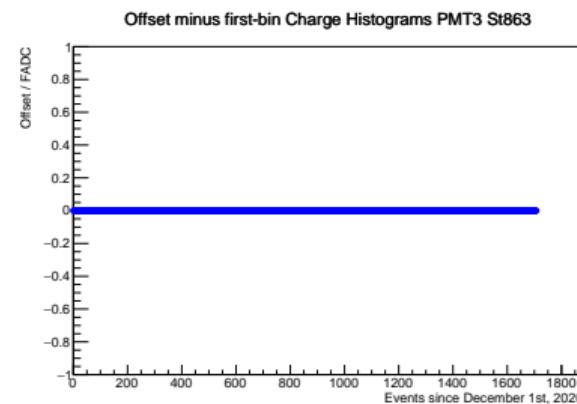
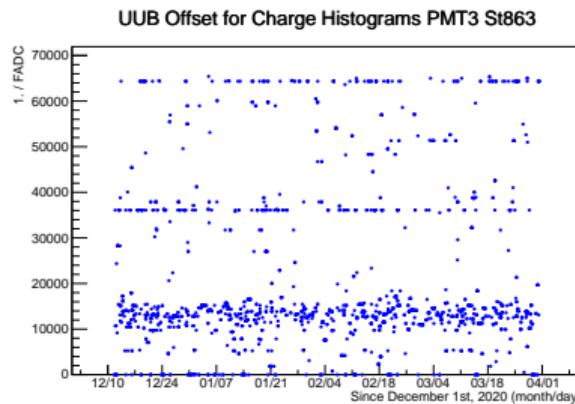
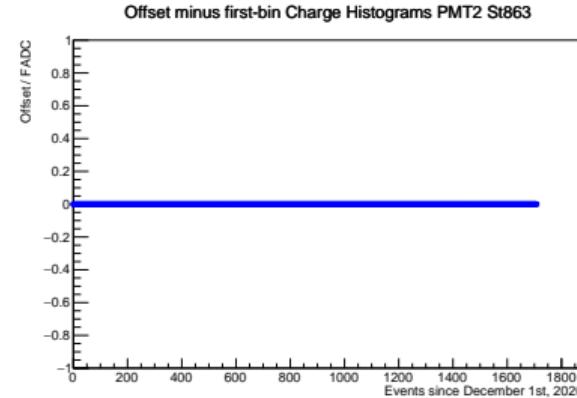
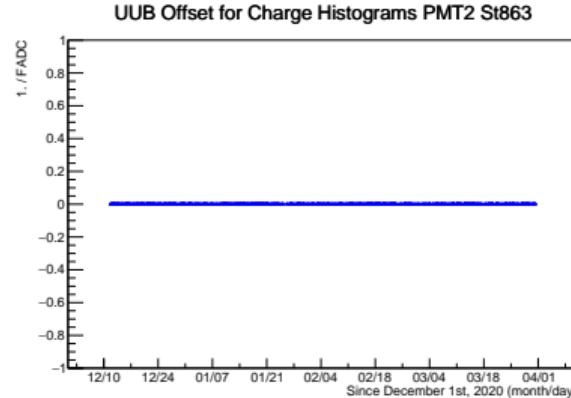


Offset values for UUB Charge histograms

For LPMT1

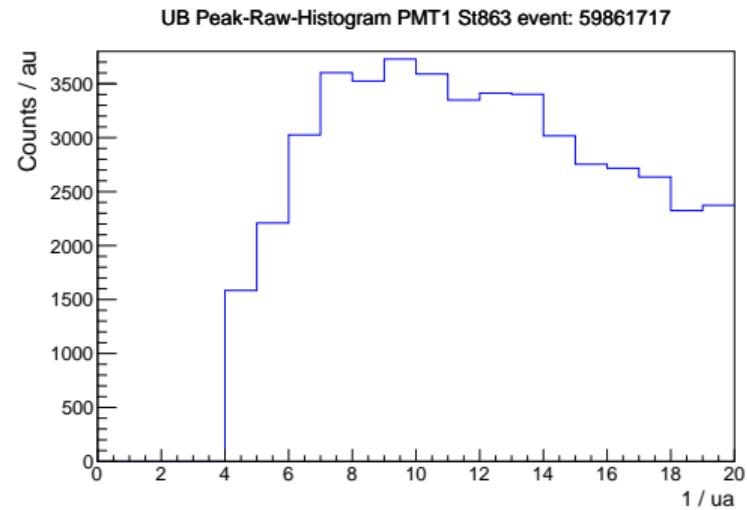
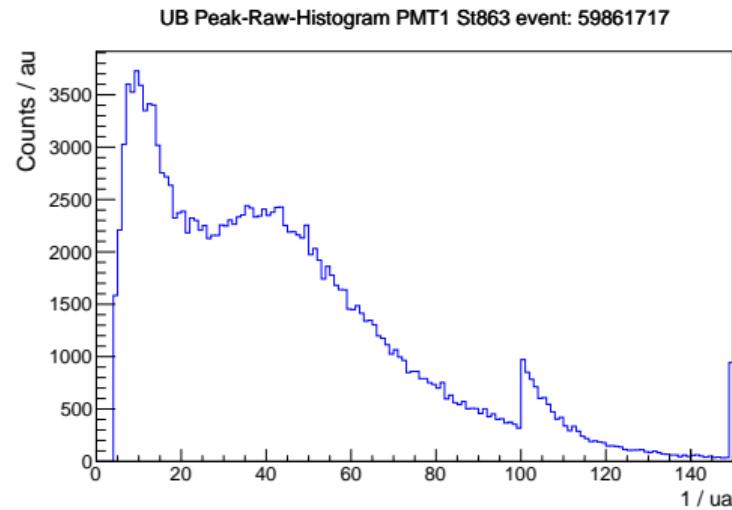


Offset values for UUB Charge histograms For LPMT2 and LPMT3



Comparison with UB version, same station

Raw UB Peak Histogram



From UB raw Peak histograms to the correct format

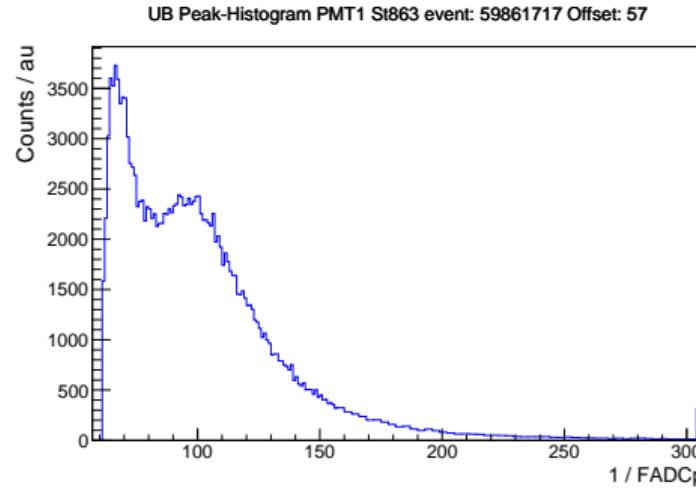
IoSdStation::HPeak

Each bin (j) of raw Peak histogram is set as:

$$xp[j] = j * \text{mult} + \text{offset}; \quad xp[100 + j] = 100 * \text{mult} + \text{bigbins} * j * \text{mult} + \text{offset};$$

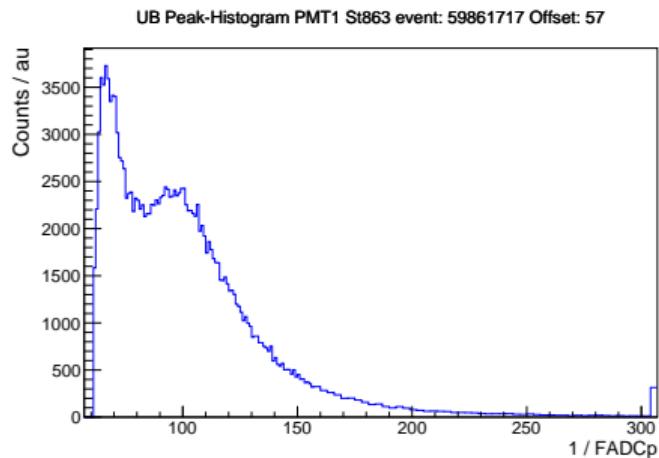
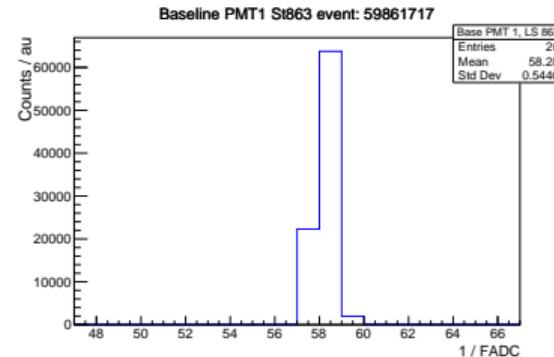
Here, *mult*, *bigbins*, and *offset* are constants and fixed in the code with values of:
 $\text{mult}=1$, $\text{bigbins}=3$ y $\text{offset} = 0$.

For event 61219267 offset = 57, with
a value of 57 for the first of the histogram.

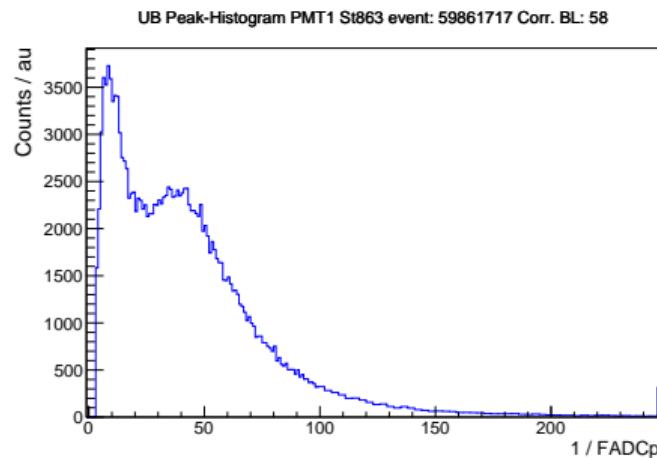


UB Peak histogram Correcting for baseline

Baseline from IoSdStation::HBase

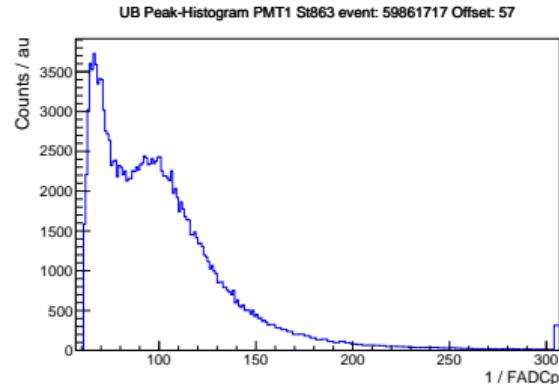


Not corrected

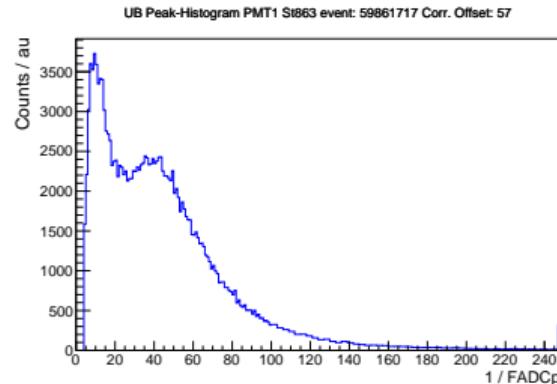


Corrected

UB Peak histogram Correcting for Offset

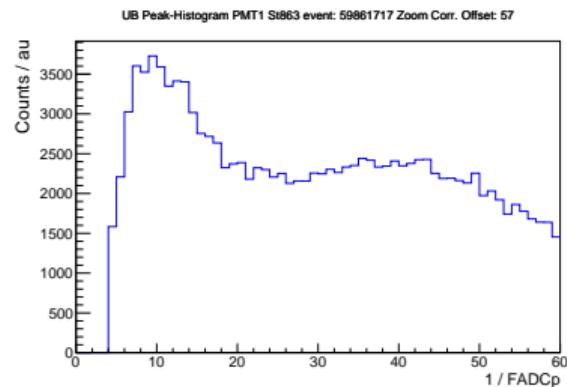


Not corrected



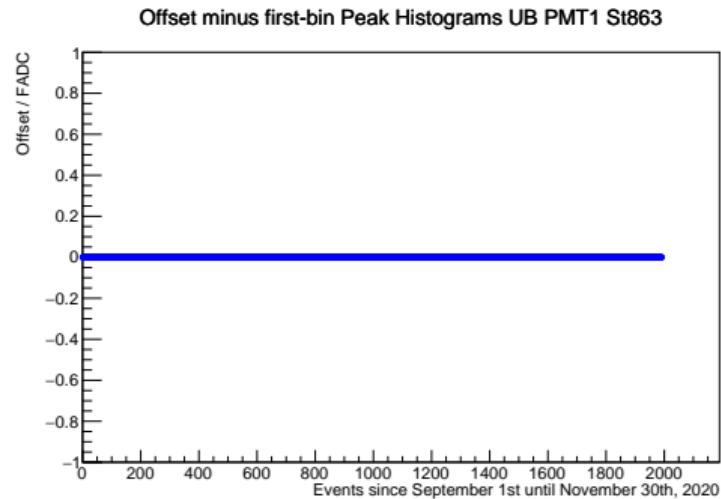
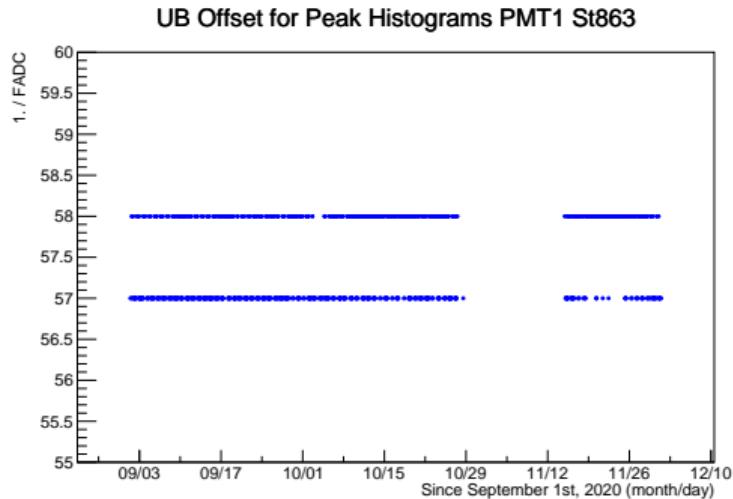
Corrected

Zooming to check the threshold



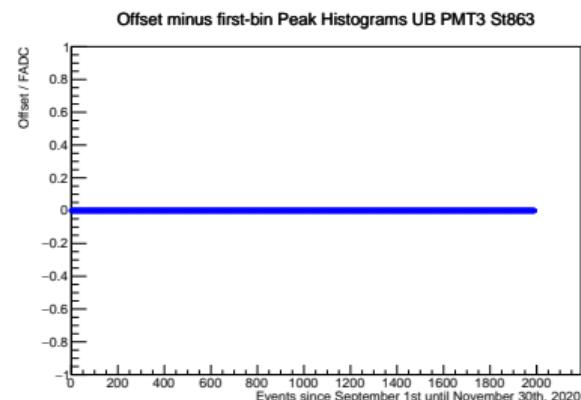
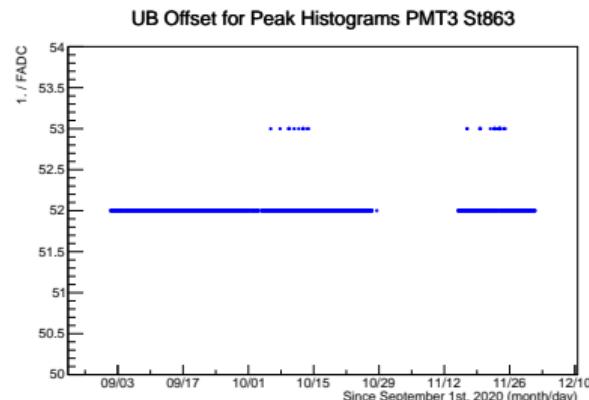
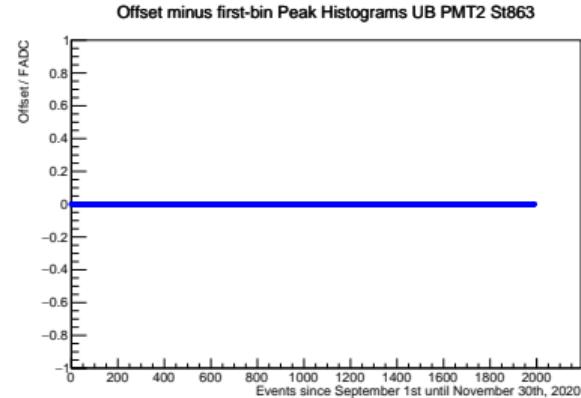
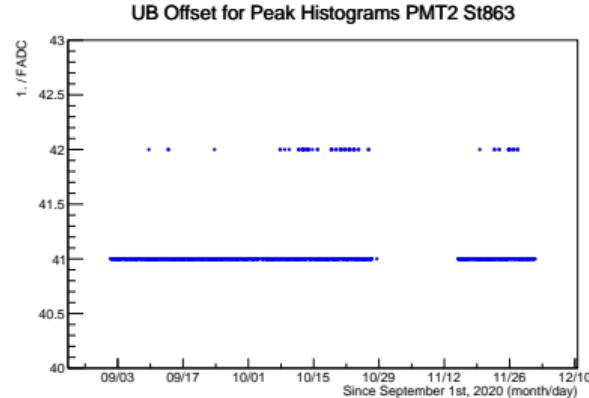
Offset values for UB Peak histograms

For LPMT1



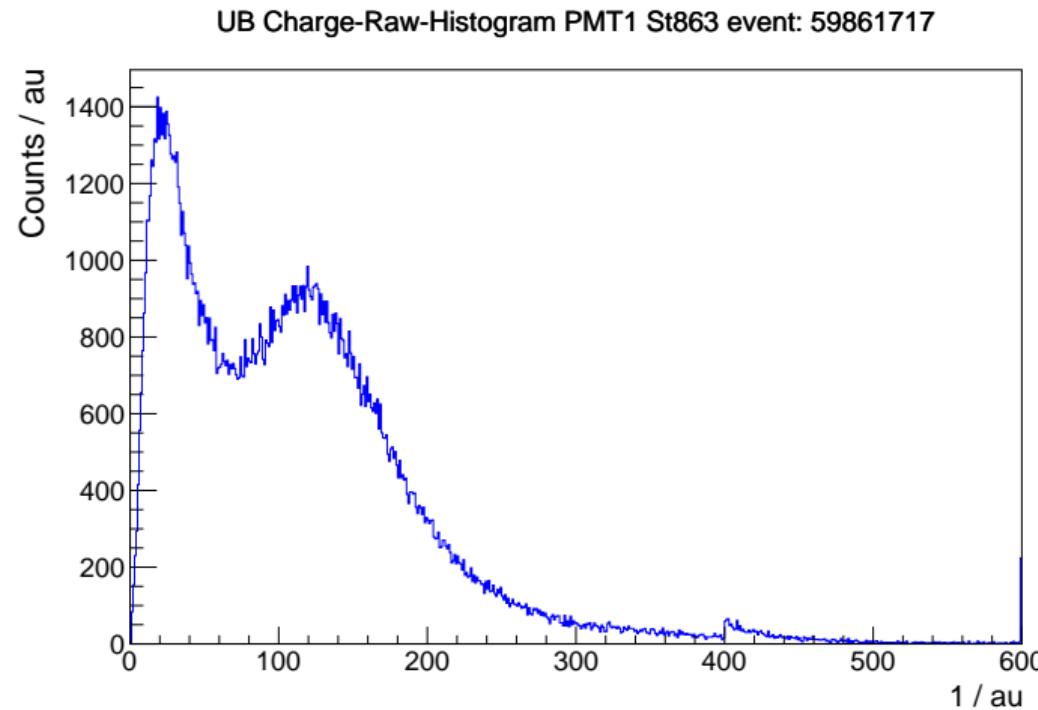
Offset values for UB Peak histograms

For LPMT2 and LPMT3



Applying the previous steps to UB Charge histograms

Raw UB Charge histogram



From UB raw Charge histogram to the correct format

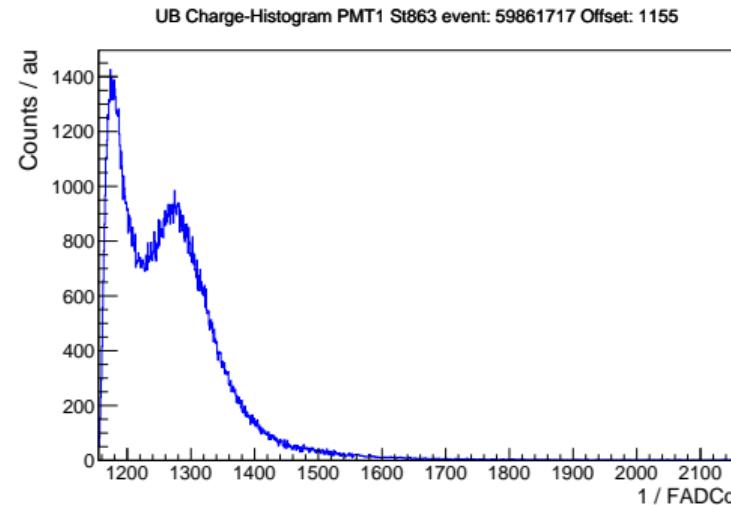
IoSdStation::HCharge

Each bin (j) of the raw Charge histogram is set as:

$$xc[j] = \text{mult} * j + \text{offset}; xc[400+j] = 400 * \text{mult} + \text{bigbins} * \text{mult} * j + \text{offset}$$

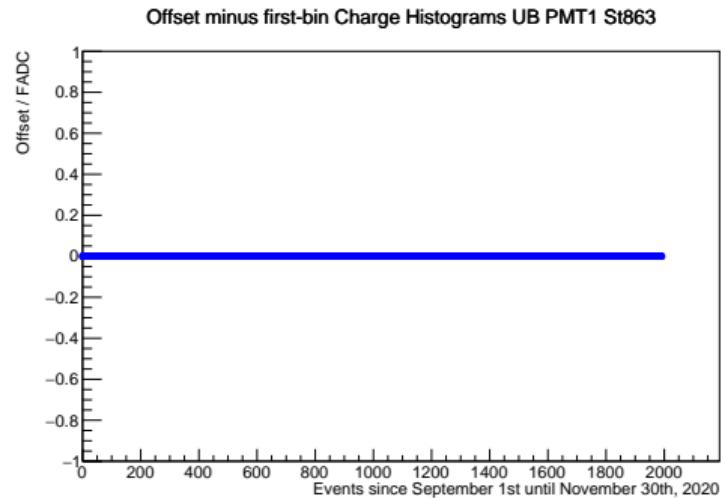
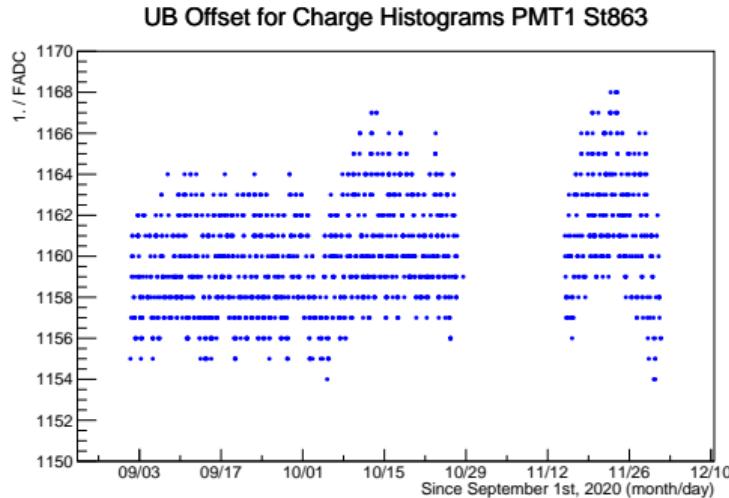
Here, *mult*, *bigbins* and *offset* are constants and fixed in the code with values of:
 $\text{mult}=1$, $\text{bigbins}=3$ y $\text{offset} = 0$.

For event 61219267 offset = 1155, with
a value of 1155 for the first bin of the
UB Charge histogram.



Offset values for UB Charge histograms

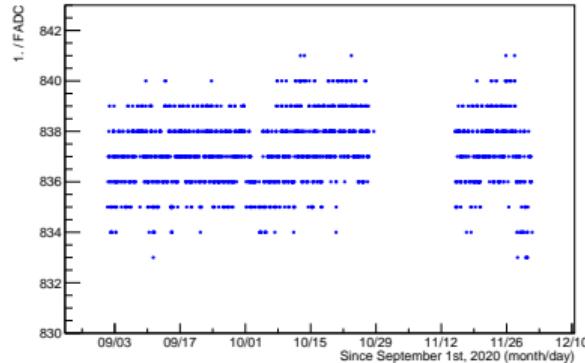
For LPMT1



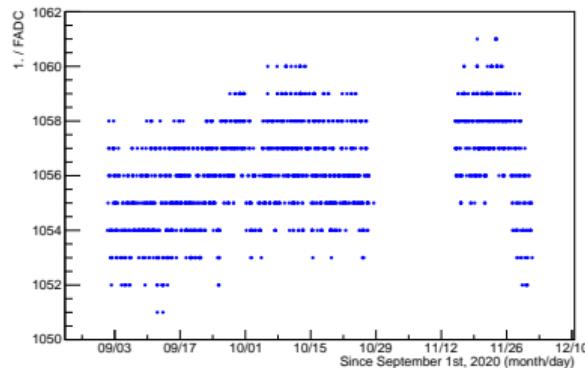
Offset values for UB Charge histograms

For LPMT2 and LPMT3

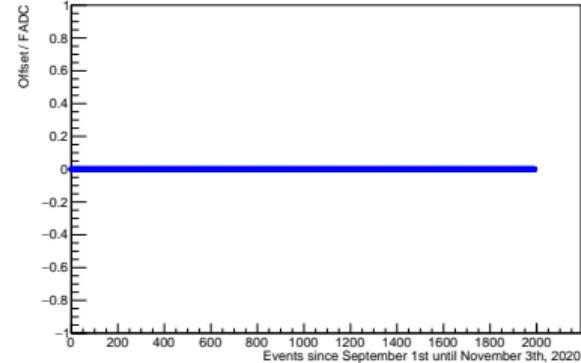
UB Offset for Charge Histograms PMT2 St863



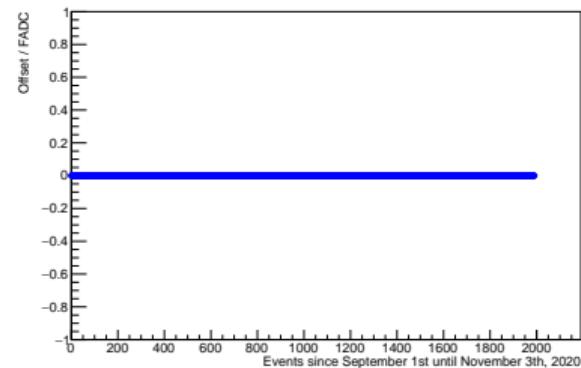
UB Offset for Charge Histograms PMT3 St863



Offset minus first-bin Charge Histograms UB PMT2 St863



Offset minus first-bin Charge Histograms UB PMT3 St863



Checking Offset differences for more UUB Satations

Stations to check:

0871 1224

0868 0804 1225

0859 0864 1220 1218

+0863 0866 +1222 +1219 +1211

+1740 +1743 +1221 +1223 +1217

=1747 =1741 =1745 =1818 =1851

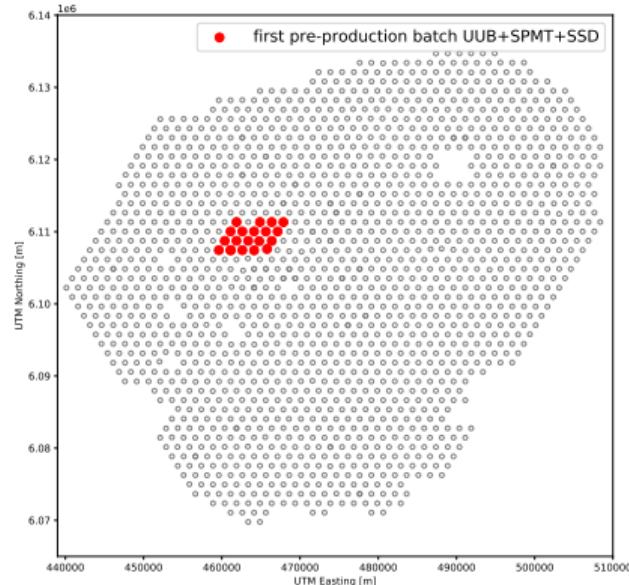
=1729 =1735 =1746 =1819 =1791

The stations installed are:

Dec. 07-11: "+"

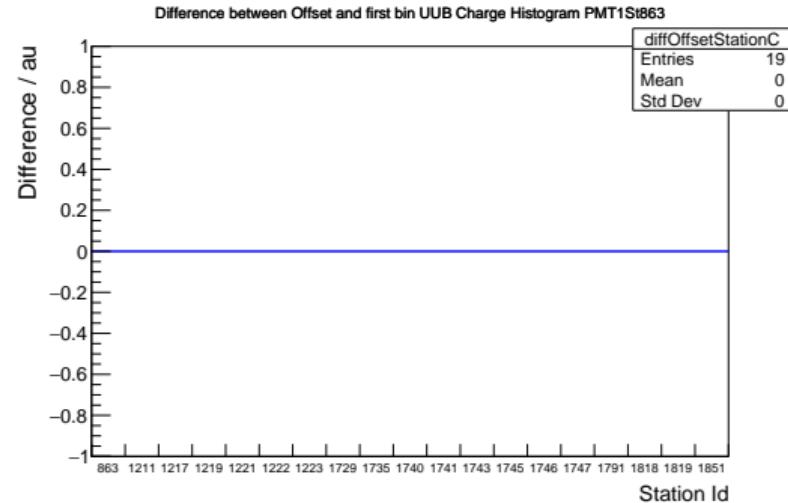
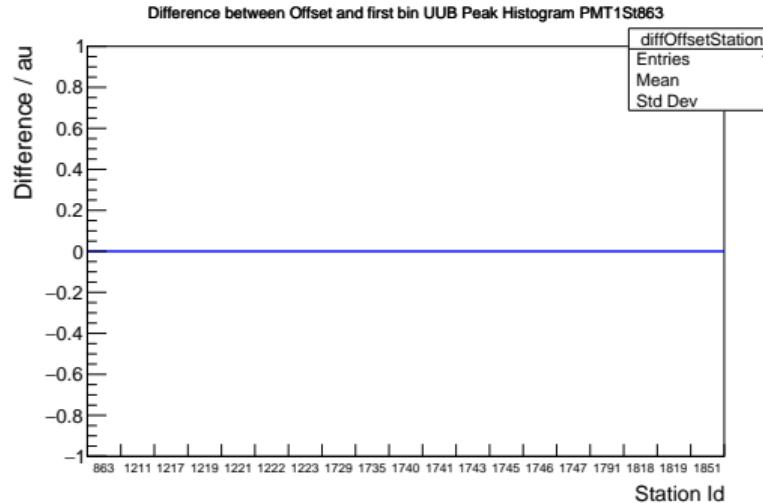
until Dec. 04: "="

The others which are not marked, still need to installed.



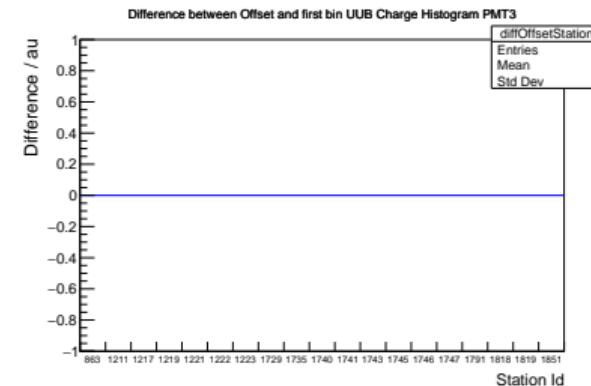
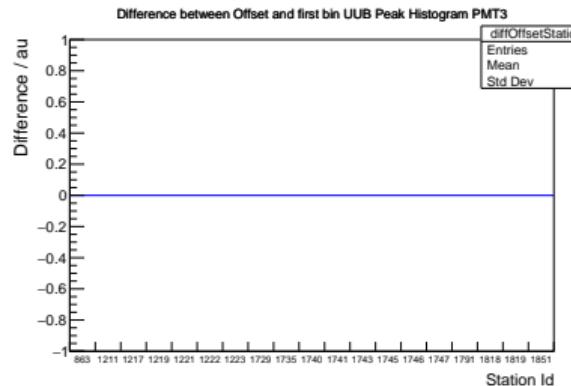
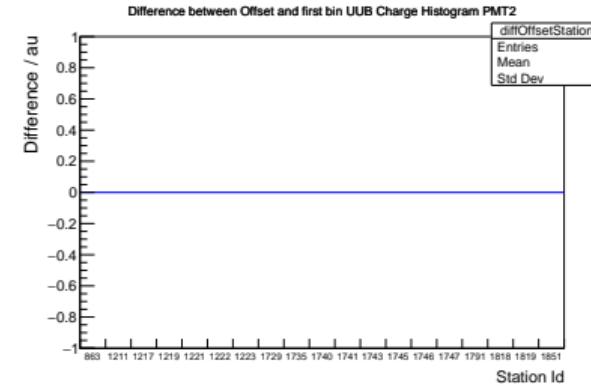
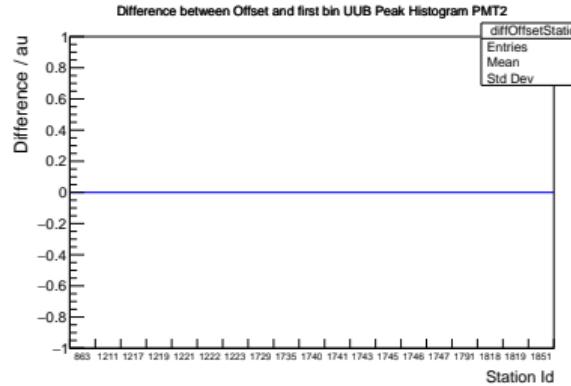
Checking Offset differences for more UUB Satations

Checking for LPMT1, Peak and Charge

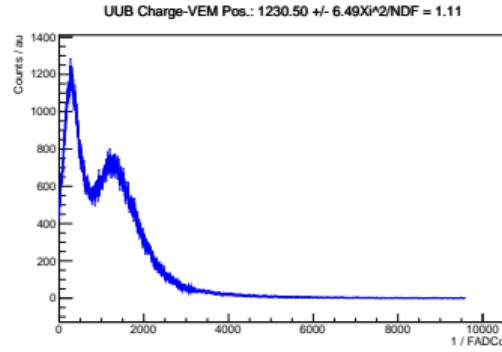
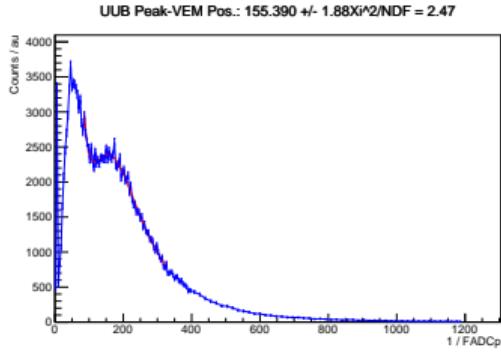


Checking Offset differences for more UUB Satations

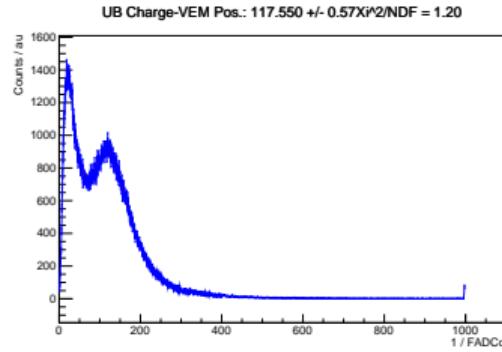
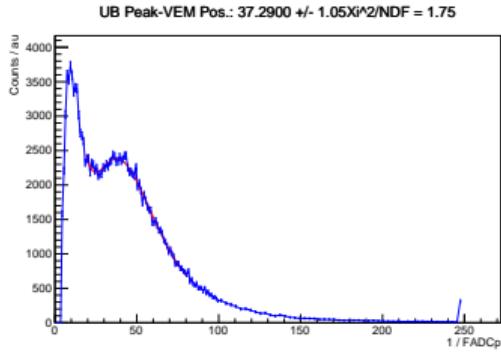
Checking for LPMT2 and LPMT3, Peak and Charge



Area/Peak: Fitting histograms for UUB LPMT1



for UB LPMT1



Area/Peak: Fitting histograms

