Stability Studies of the PPM-DU Calibration Process Using the Natural Background of ^{40}K Decays

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September 30, 2015

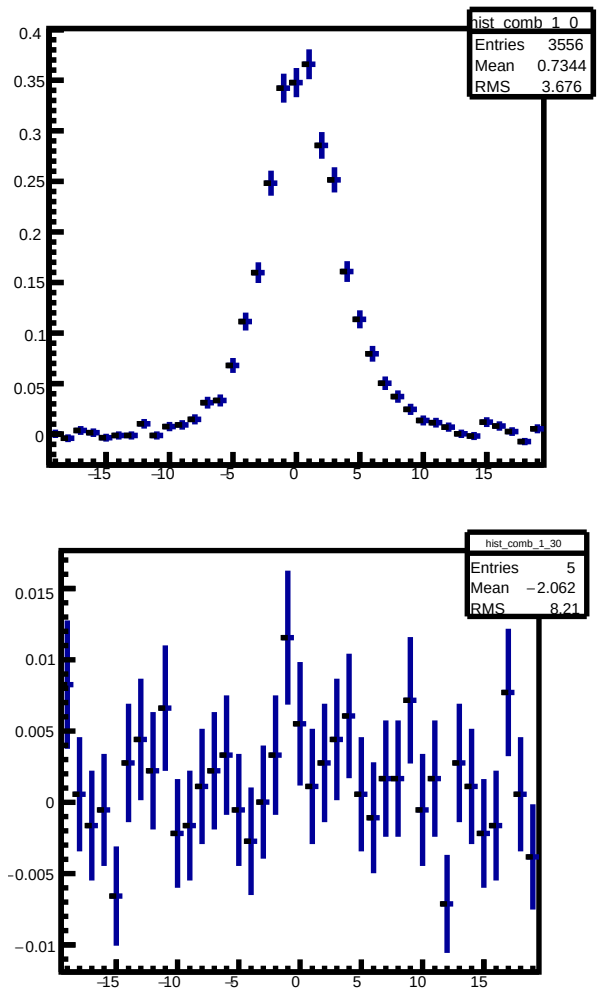
Overview

- Reminder: Calibration Routine
- Artifacts in Coincidence Plots
- Long Term Stability of Calibration / Timestreams

Calibration Routine

- Record L1 coincidences
- Histogram difference in hit time for each PMT combination
- Subtract combinatorial background
- Fit all histograms simultaneously with Gaussians to get
  - time offset (t0)
  - time spread (sigma)
  - efficiency (QE)

  for each PMT.

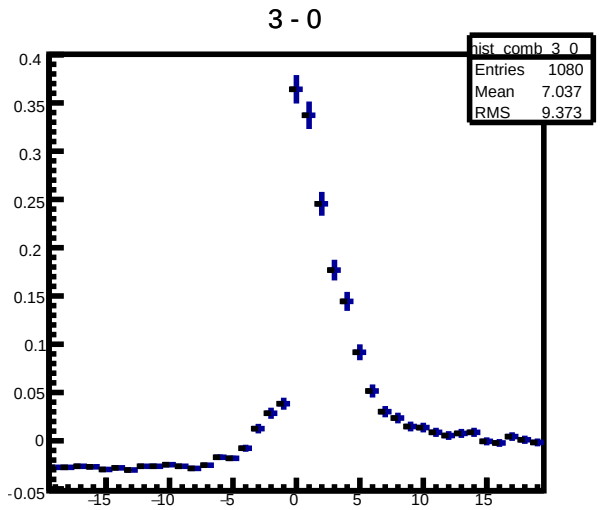


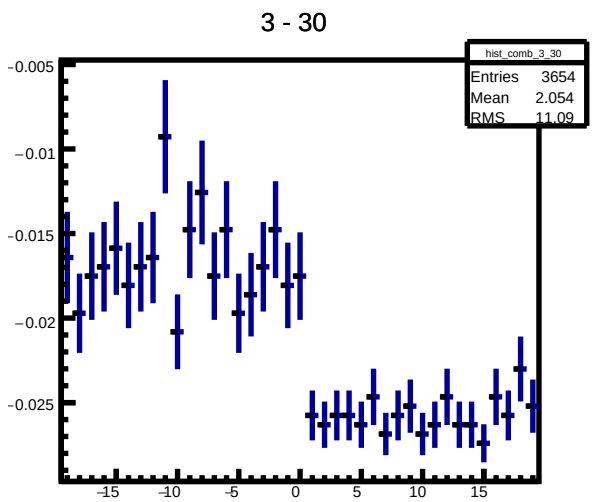
Artifacts in coincidence plots

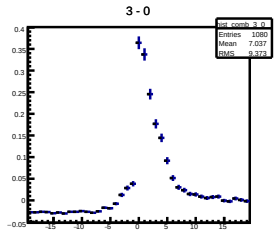
- One side of coincidence histogram higher than the other
- Does not appear when using snapshot hits

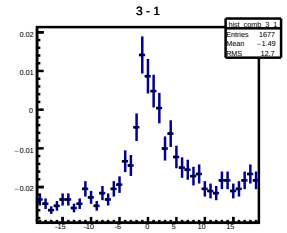
→ Error while writing L1 slices

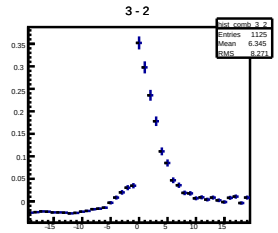
- Absent in more recent runs (1500+)
- Still: would be good to understand
- Thoughts?

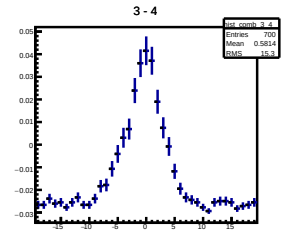


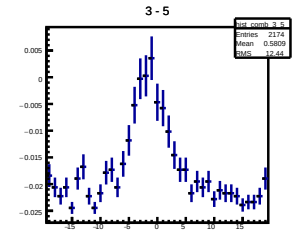


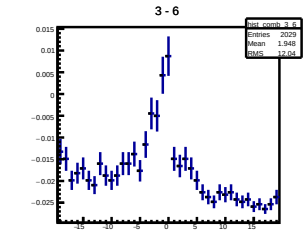

3 - 0
hist_comb_3_0
Entries 1080
Mean 7.037
RMS 9.373

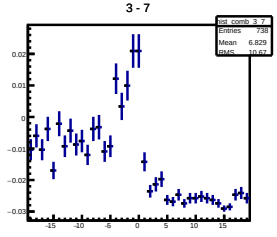

3 - 1
hist_comb_3_1
Entries 1677
Mean -1.49
RMS 12.7

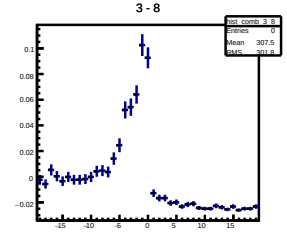

3 - 2
hist_comb_3_2
Entries 1125
Mean 6.345
RMS 8.271

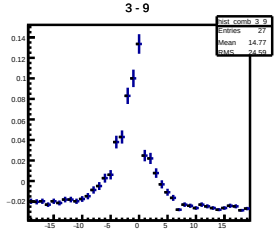

3 - 4
hist_comb_3_4
Entries 700
Mean 0.5814
RMS 15.3

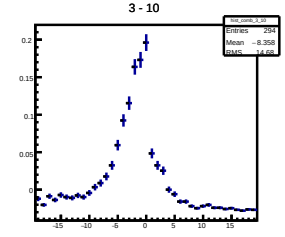

3 - 5
hist_comb_3_5
Entries 2174
Mean 0.9809
RMS 12.44

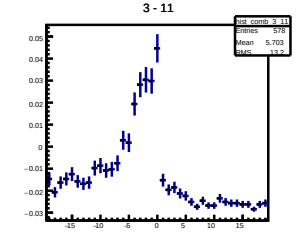

3 - 6
hist_comb_3_6
Entries 2029
Mean 1.948
RMS 12.04

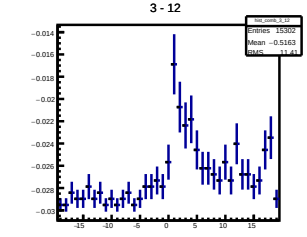

3 - 7
hist_comb_3_7
Entries 738
Mean 6.829
RMS 10.67

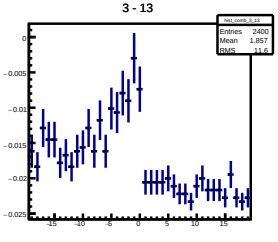

3 - 8
hist_comb_3_8
Entries 0
Mean 307.5
RMS 301.8

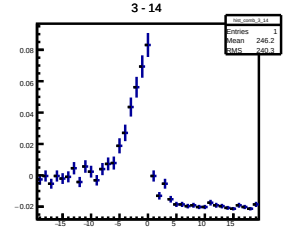

3 - 9
hist_comb_3_9
Entries 27
Mean 14.77
RMS 14.59

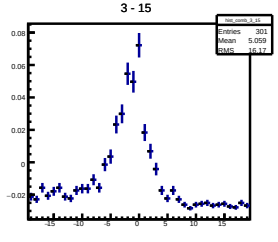

3 - 10
hist_comb_3_10
Entries 294
Mean -8.358
RMS 14.68

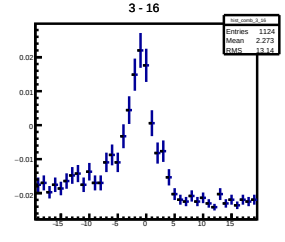

3 - 11
hist_comb_3_11
Entries 578
Mean 5.703
RMS 13.2

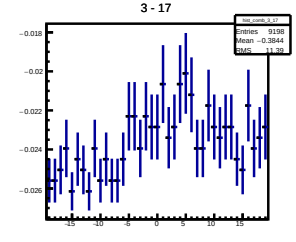

3 - 12
hist_comb_3_12
Entries 15302
Mean -0.5163
RMS 11.41

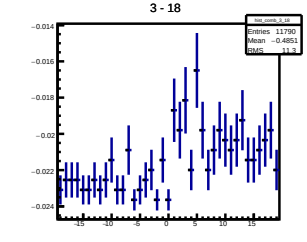

3 - 13
hist_comb_3_13
Entries 2400
Mean 1.857
RMS 11.6

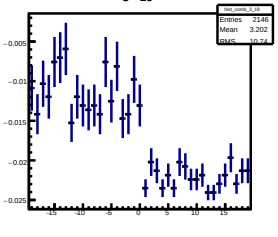

3 - 14
hist_comb_3_14
Entries 1
Mean 246.2
RMS 240.3

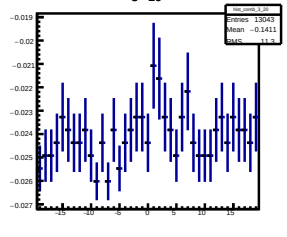

3 - 15
hist_comb_3_15
Entries 301
Mean 5.059
RMS 16.17

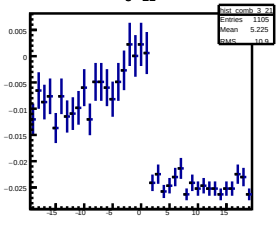

3 - 16
hist_comb_3_16
Entries 1124
Mean 2.273
RMS 13.14

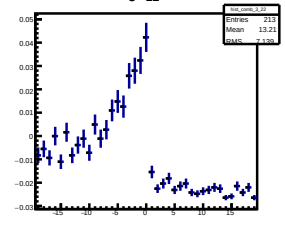

3 - 17
hist_comb_3_17
Entries 9198
Mean -0.3844
RMS 11.39

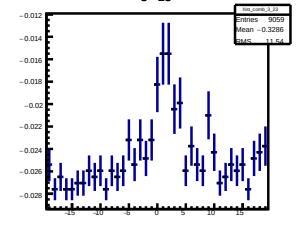

3 - 18
hist_comb_3_18
Entries 11790
Mean -0.4851
RMS 11.3

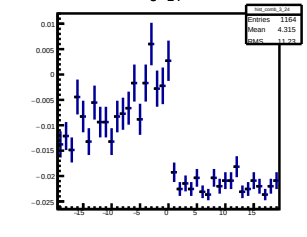

3 - 19
hist_comb_3_19
Entries 2146
Mean 3.202
RMS 10.74

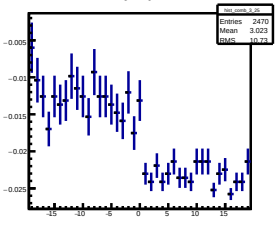

3 - 20
hist_comb_3_20
Entries 13043
Mean -0.1411
RMS 11.2

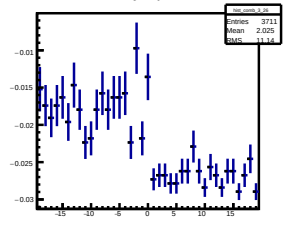

3 - 21
hist_comb_3_21
Entries 1105
Mean 5.225
RMS 10.9

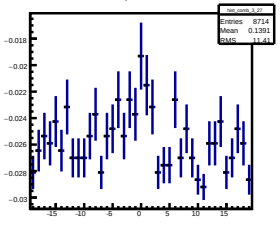

3 - 22
hist_comb_3_22
Entries 213
Mean 13.21
RMS 7.139

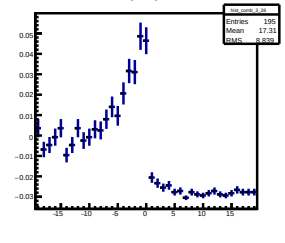

3 - 23
hist_comb_3_23
Entries 9059
Mean -0.3286
RMS 11.54

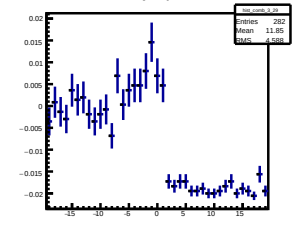

3 - 24
hist_comb_3_24
Entries 1164
Mean 4.315
RMS 11.23

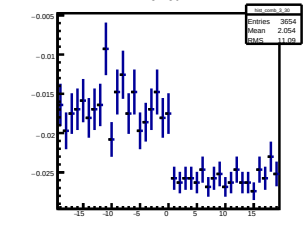

3 - 25
hist_comb_3_25
Entries 2470
Mean 3.023
RMS 10.73


3 - 26
hist_comb_3_26
Entries 3711
Mean 2.025
RMS 11.14


3 - 27
hist_comb_3_27
Entries 8714
Mean 0.1391
RMS 11.41

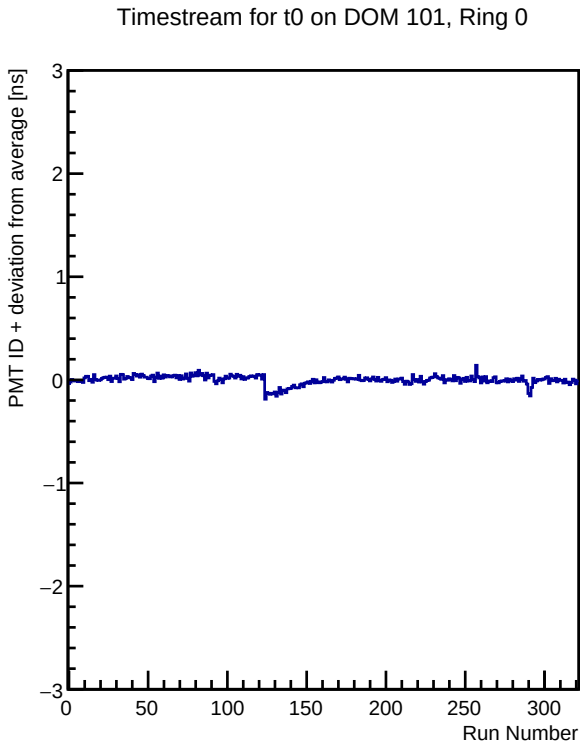

3 - 28
hist_comb_3_28
Entries 195
Mean 17.31
RMS 6.839

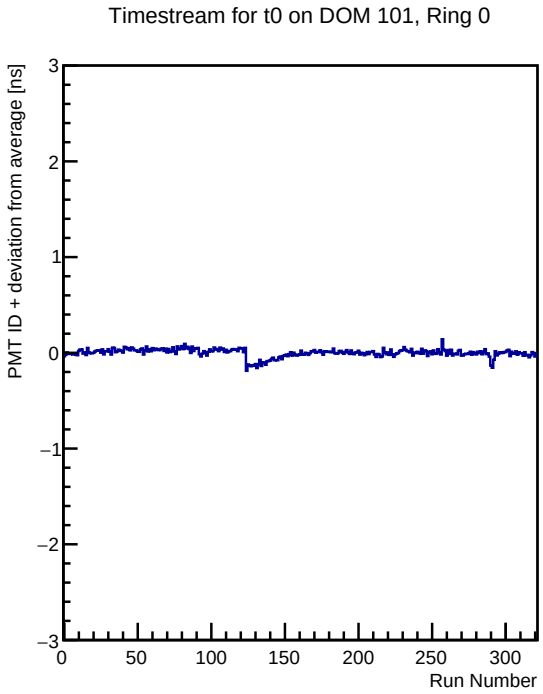

3 - 29
hist_comb_3_29
Entries 282
Mean 11.85
RMS 6.588

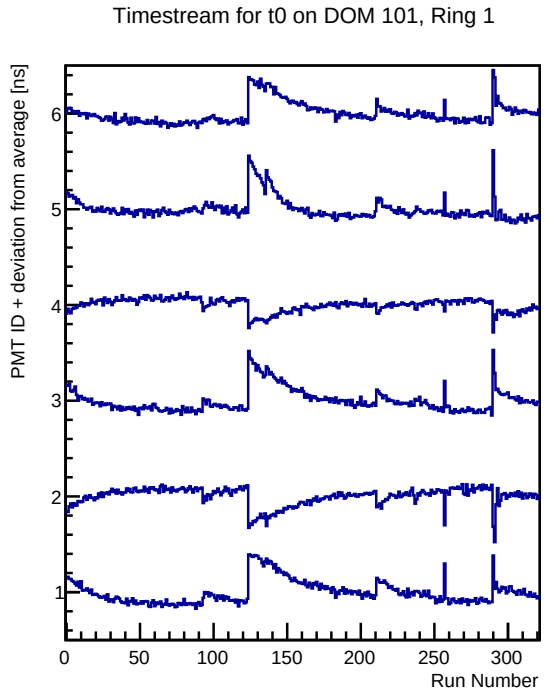

3 - 30
hist_comb_3_30
Entries 3654
Mean 2.054
RMS 11.06

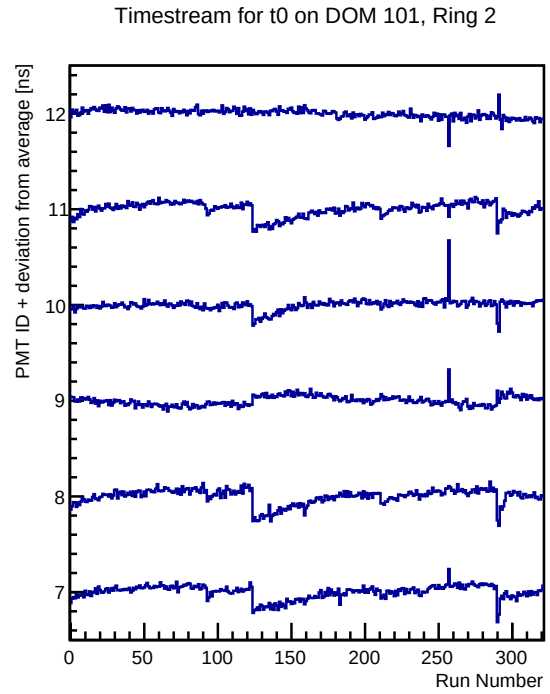
Long Term Stability

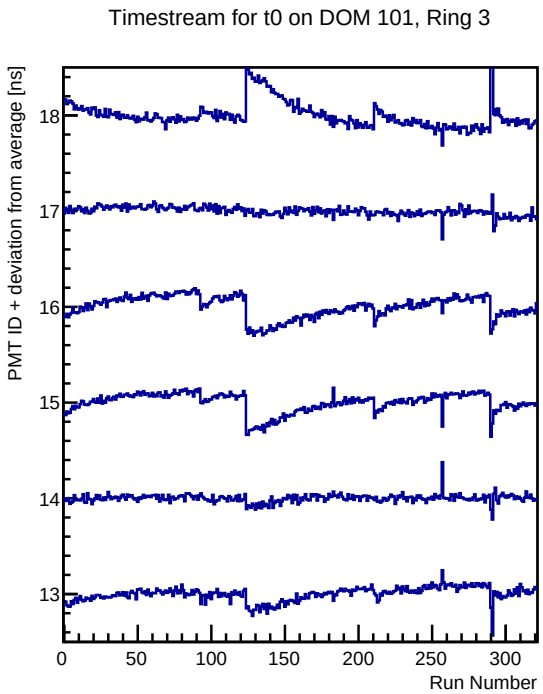
- Analyzed 300 consecutive runs
- For each PMT: Plotted deviation from average vs. run number
  - For t0, sigma: absolute deviation
  - For QE: relative deviation

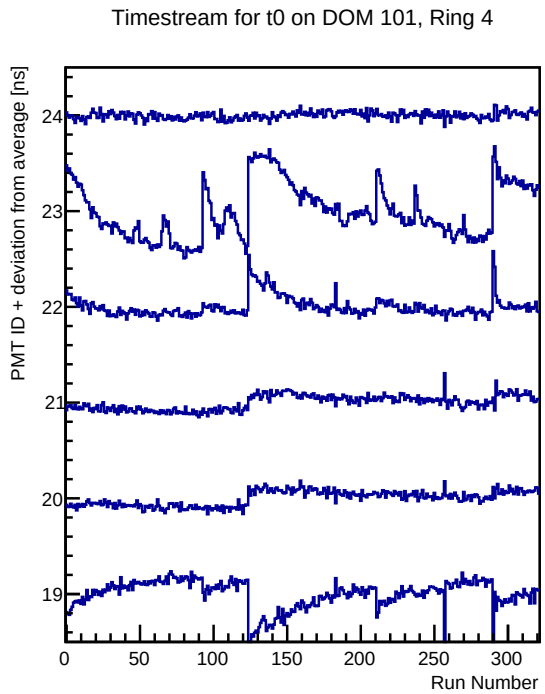


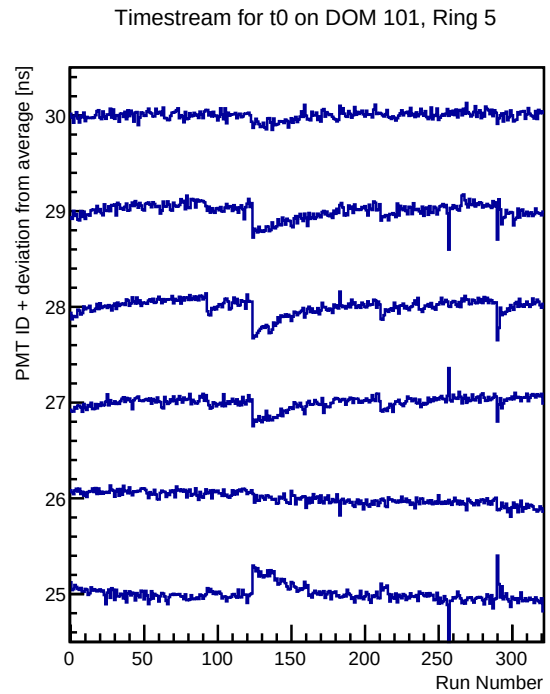

Timestream for t0 on DOM 101, Ring 0
PMT ID + deviation from average [ns]
Run Number


Timestream for t0 on DOM 101, Ring 1
PMT ID + deviation from average [ns]
Run Number

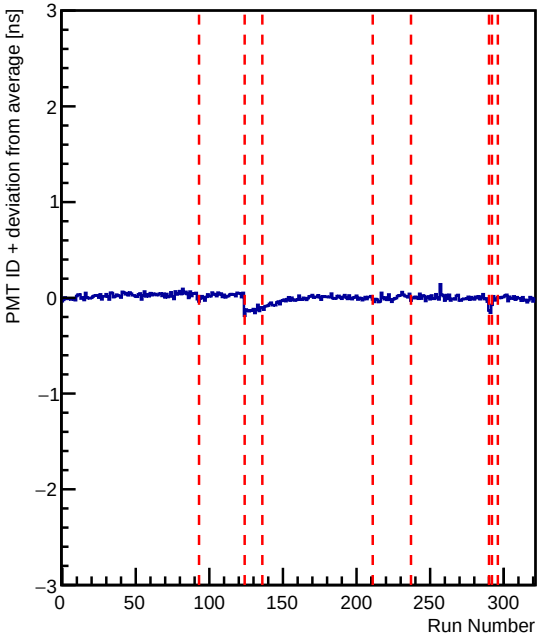

Timestream for t0 on DOM 101, Ring 2
PMT ID + deviation from average [ns]
Run Number


Timestream for t0 on DOM 101, Ring 3
PMT ID + deviation from average [ns]
Run Number

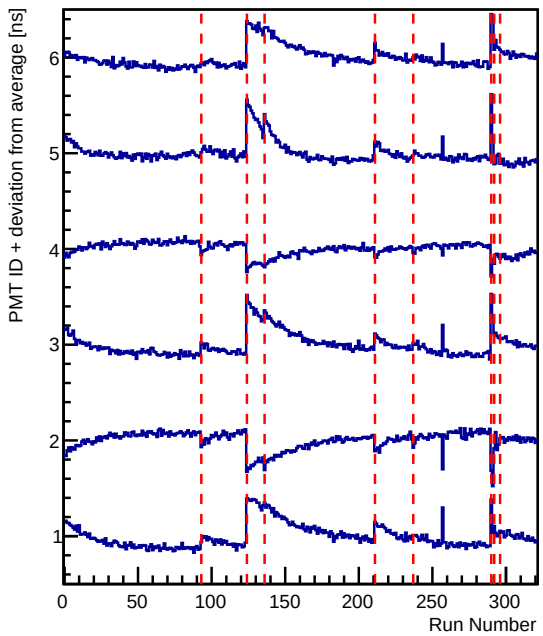

Timestream for t0 on DOM 101, Ring 4
PMT ID + deviation from average [ns]
Run Number


Timestream for t0 on DOM 101, Ring 5
PMT ID + deviation from average [ns]
Run Number

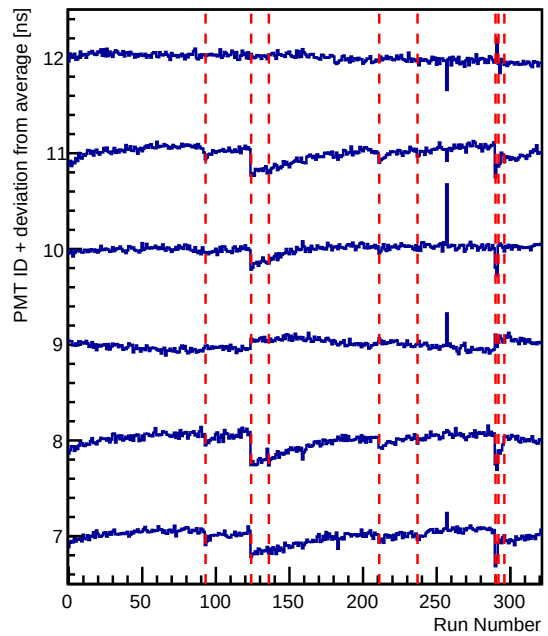
Timestream for t0 on DOM 101, Ring 0



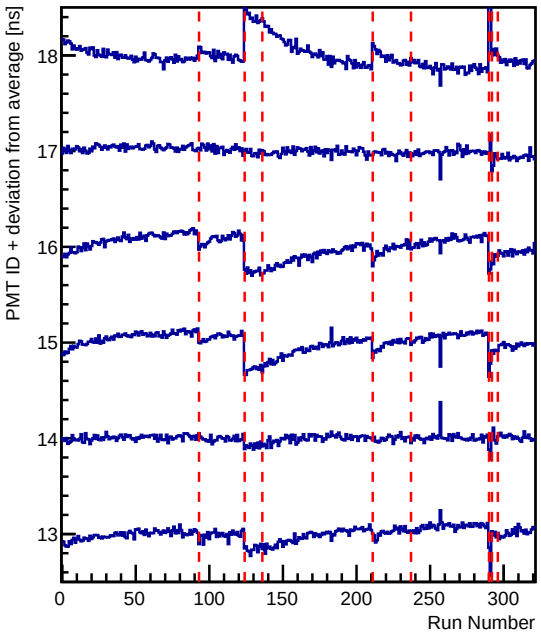
Timestream for t0 on DOM 101, Ring 1



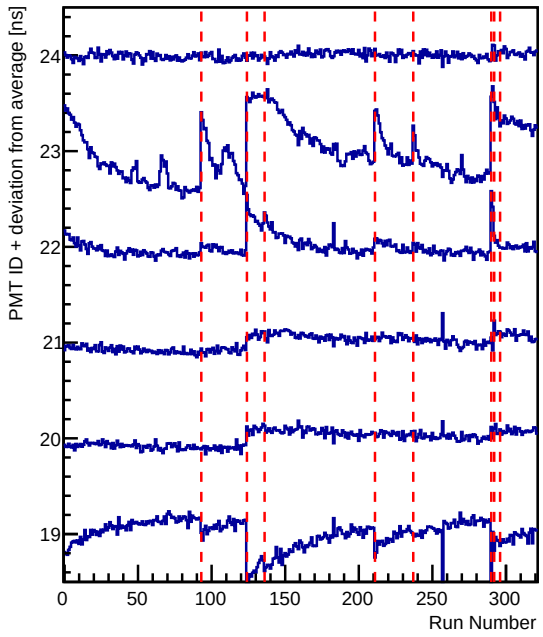
Timestream for t0 on DOM 101, Ring 2



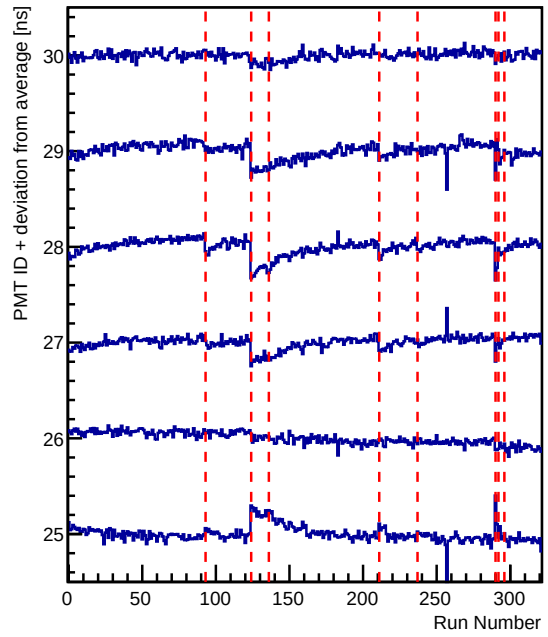
Timestream for t0 on DOM 101, Ring 3

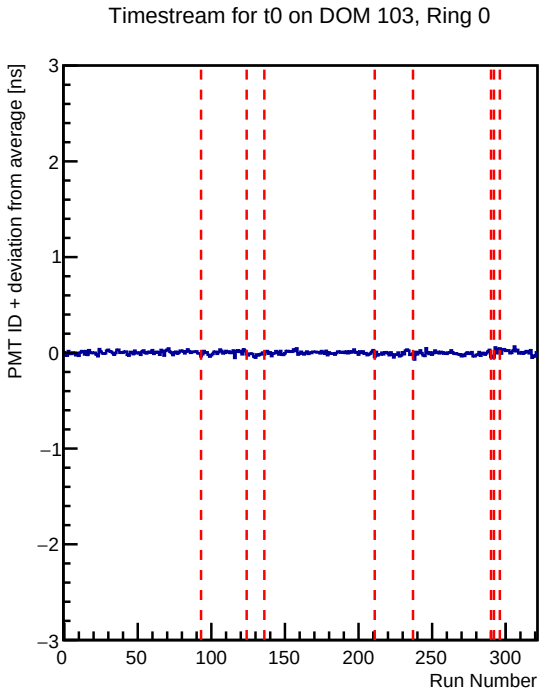


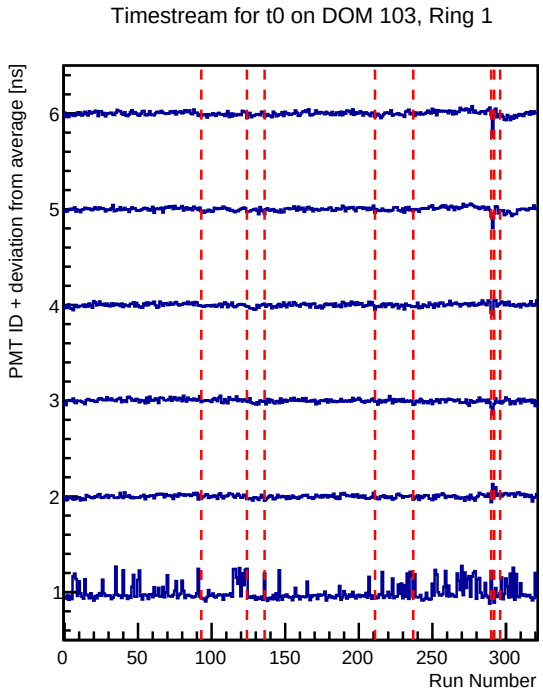
Timestream for t0 on DOM 101, Ring 4

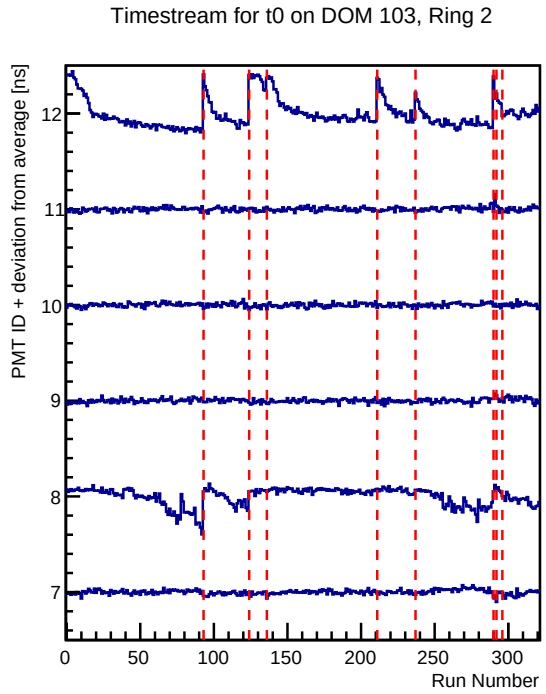


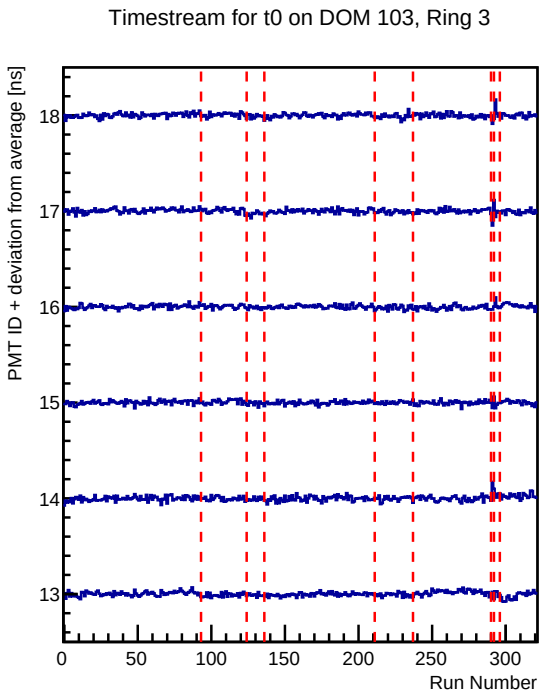
Timestream for t0 on DOM 101, Ring 5

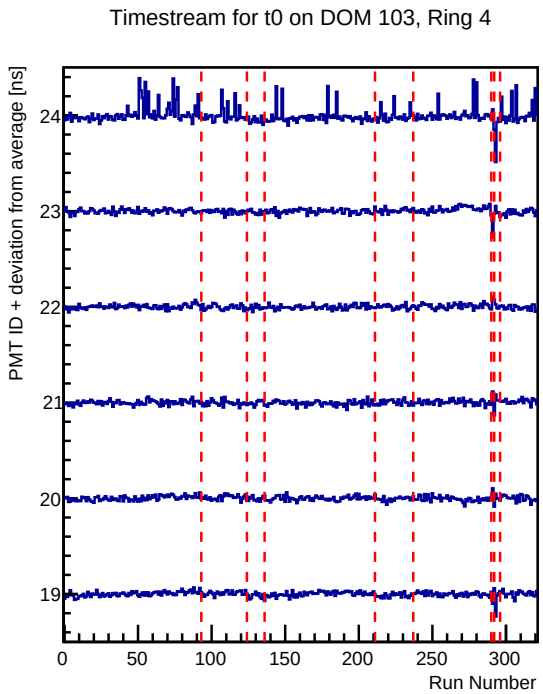


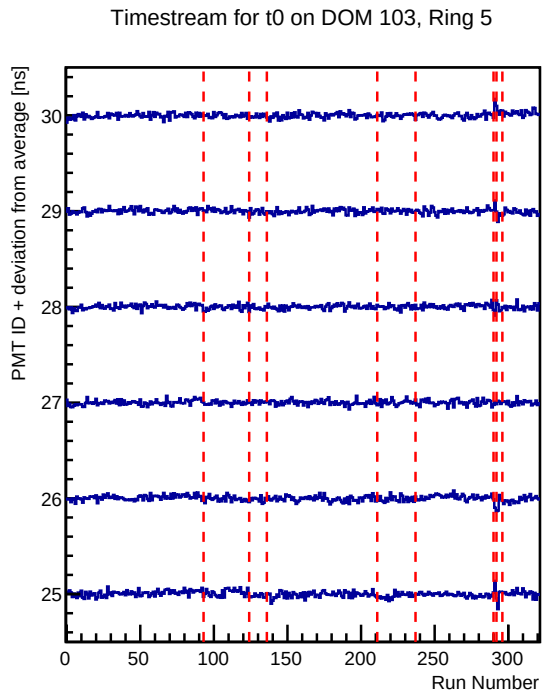

Timestream for t0 on DOM 103, Ring 0
PMT ID + deviation from average [ns]
Run Number


Timestream for t0 on DOM 103, Ring 1
PMT ID + deviation from average [ns]
Run Number

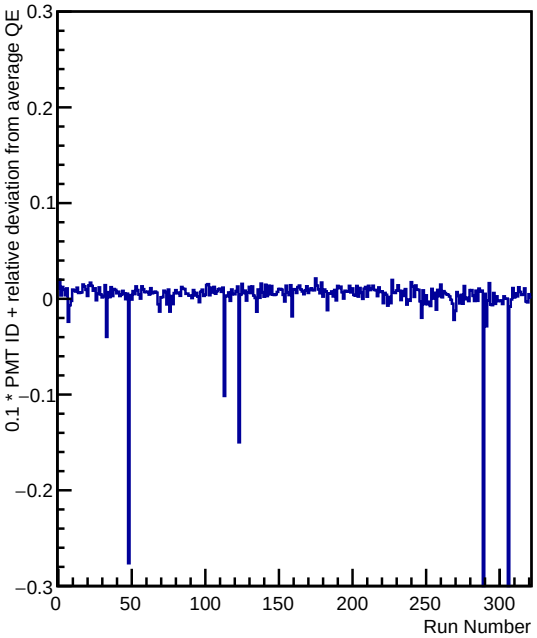

Timestream for t0 on DOM 103, Ring 2
PMT ID + deviation from average [ns]
Run Number


Timestream for t0 on DOM 103, Ring 3
PMT ID + deviation from average [ns]
Run Number

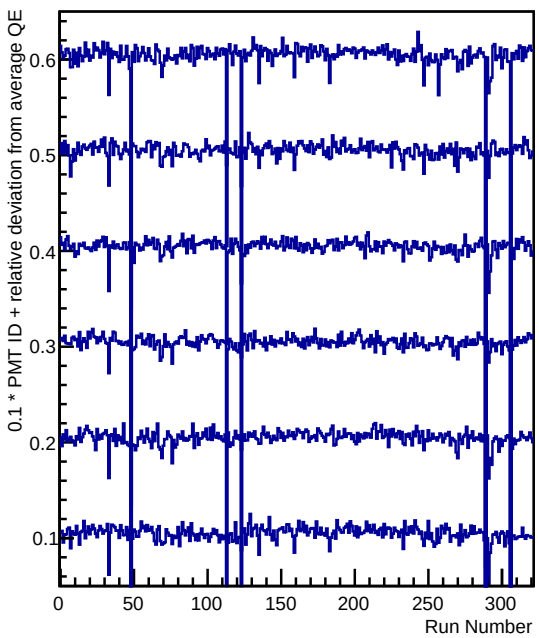

Timestream for t0 on DOM 103, Ring 4
PMT ID + deviation from average [ns]
Run Number


Timestream for t0 on DOM 103, Ring 5
PMT ID + deviation from average [ns]
Run Number

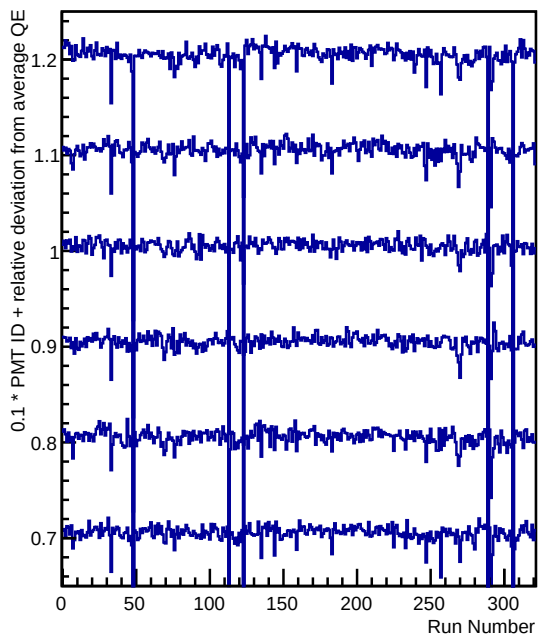
Timestream for QE on DOM 103, Ring 0



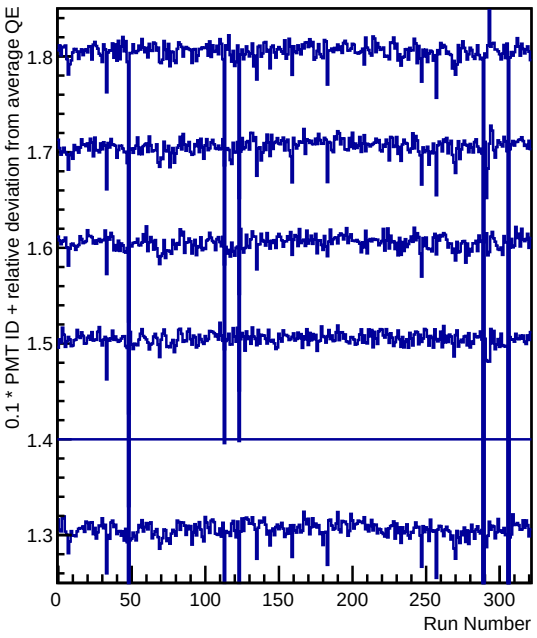
Timestream for QE on DOM 103, Ring 1



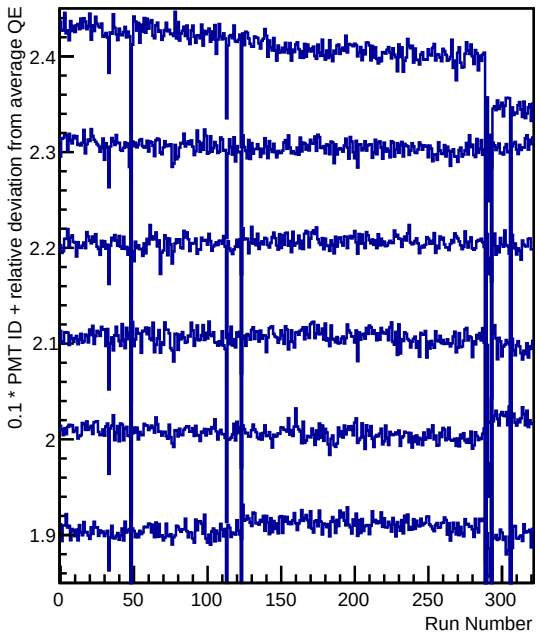
Timestream for QE on DOM 103, Ring 2



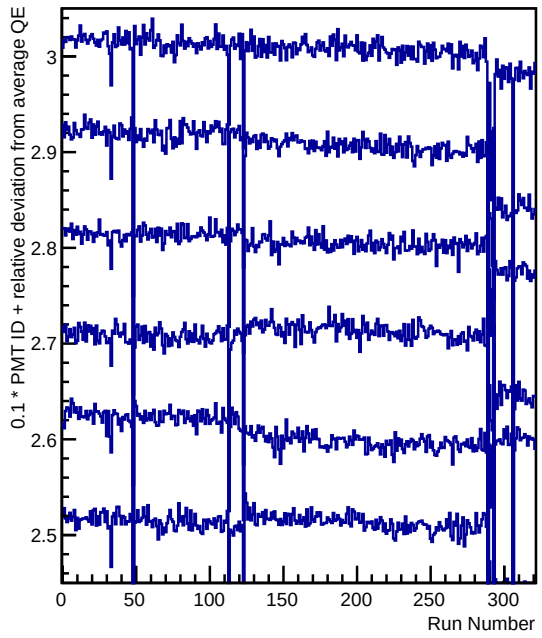
Timestream for QE on DOM 103, Ring 3

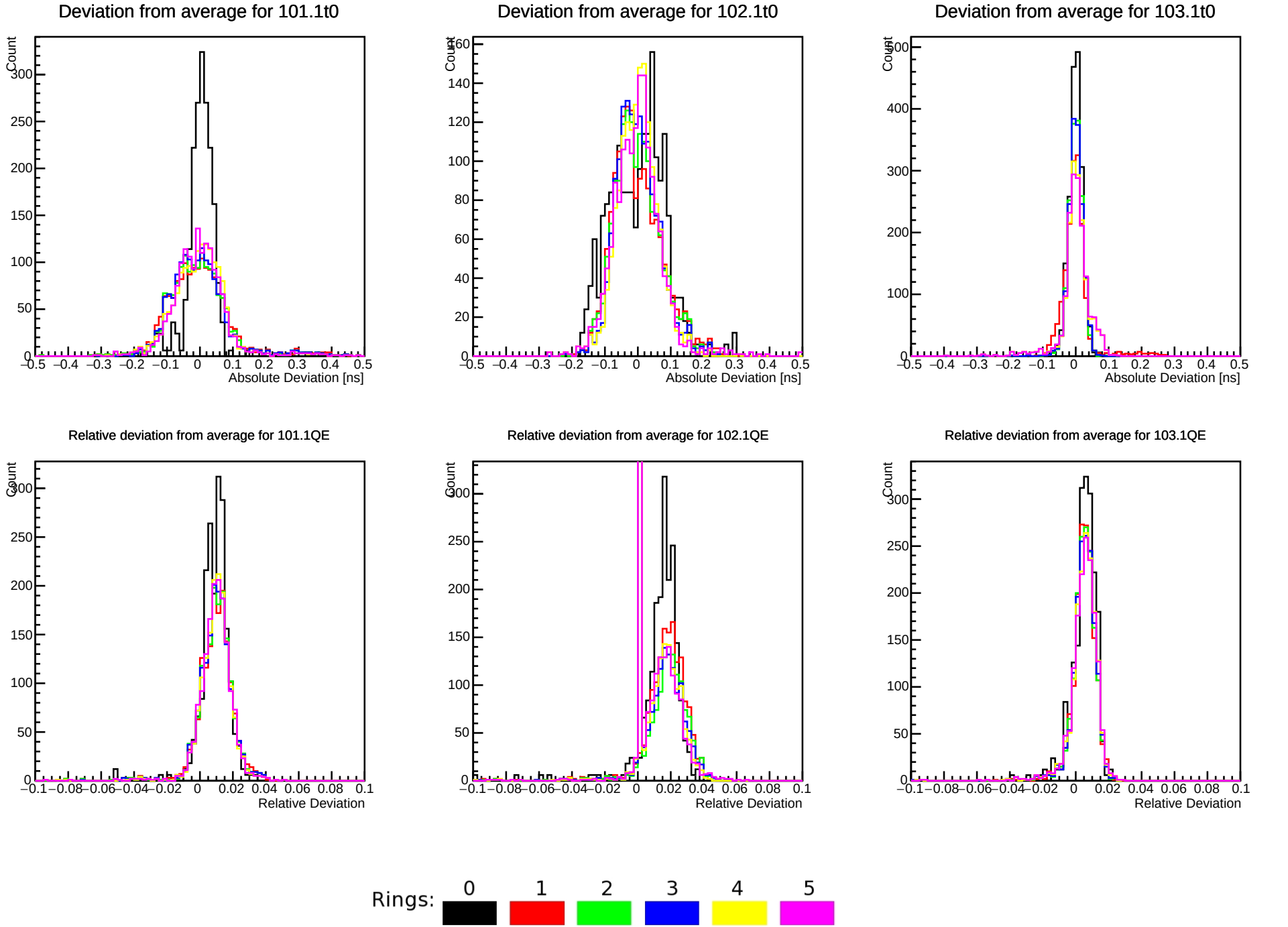


Timestream for QE on DOM 103, Ring 4



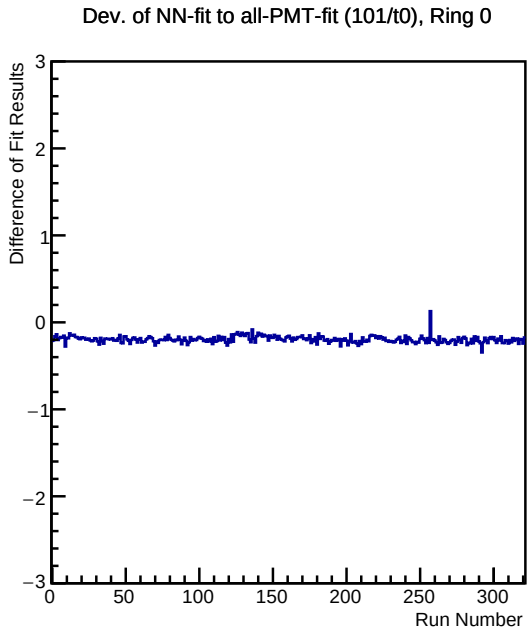
Timestream for QE on DOM 103, Ring 5

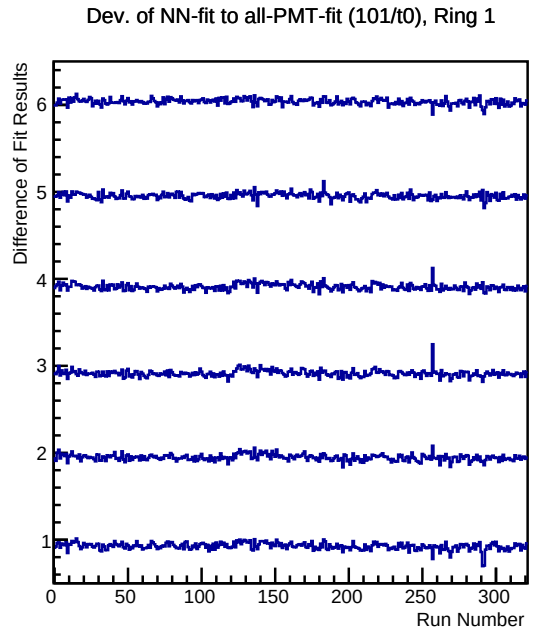


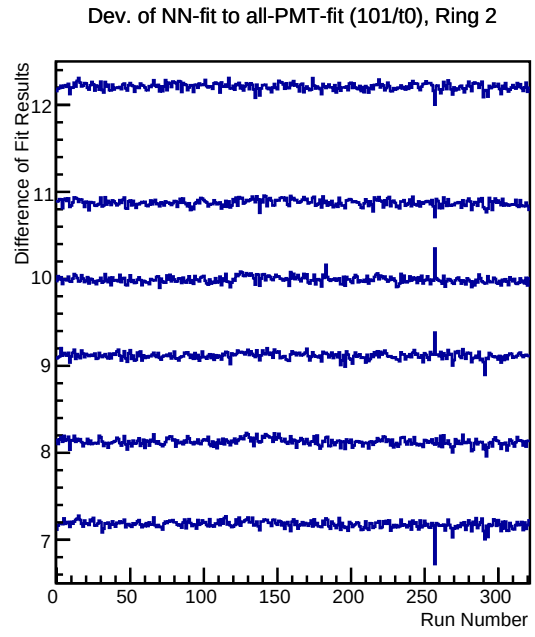

Deviation from average for 101.1t0
Count
Absolute Deviation [ns]
Deviation from average for 102.1t0
Count
Absolute Deviation [ns]
Deviation from average for 103.1t0
Count
Absolute Deviation [ns]
Relative deviation from average for 101.1QE
Count
Relative Deviation
Relative deviation from average for 102.1QE
Count
Relative Deviation
Relative deviation from average for 103.1QE
Count
Relative Deviation
Rings:
0
1
2
3
4
5

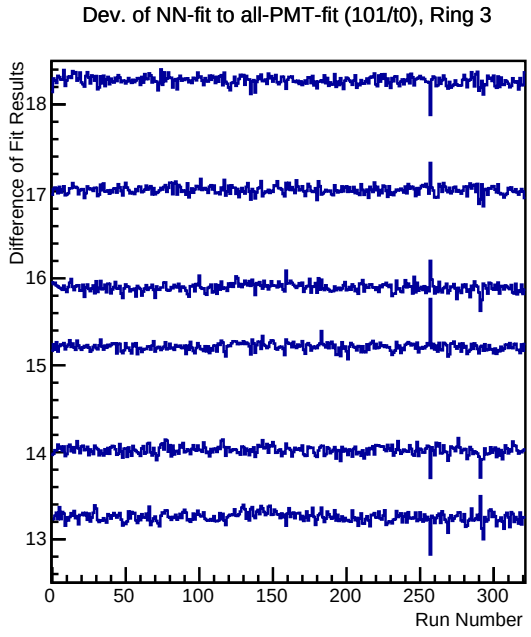
Calibration Fit and Angular Dependence Function

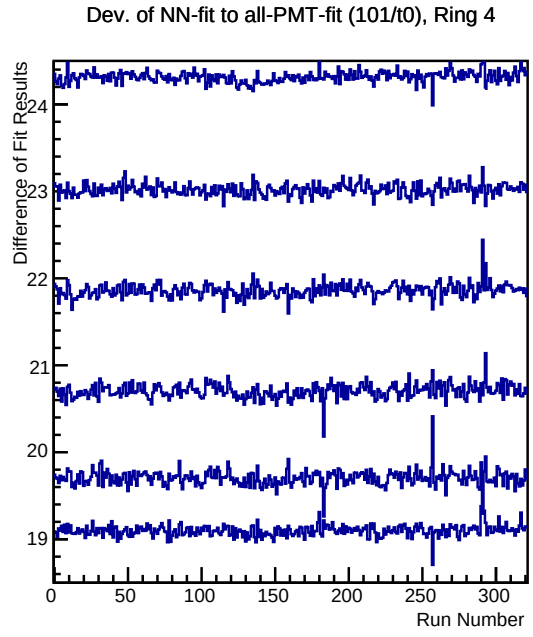
- Coincidence rate depends on angle θ between PMTs
- Calibration fit uses fixed (empirical) model of this dependence
  - $c_\theta = cos(\theta)$
  - $f(c_\theta) = \exp(p_1 + c_\theta(p_2 + c_\theta(p_3 + c_\theta(p_4 + c_\theta))))$
- What is the effect of this fixed model on fit results?
- Does a fit using only combinations of neighboring PMTs look different?

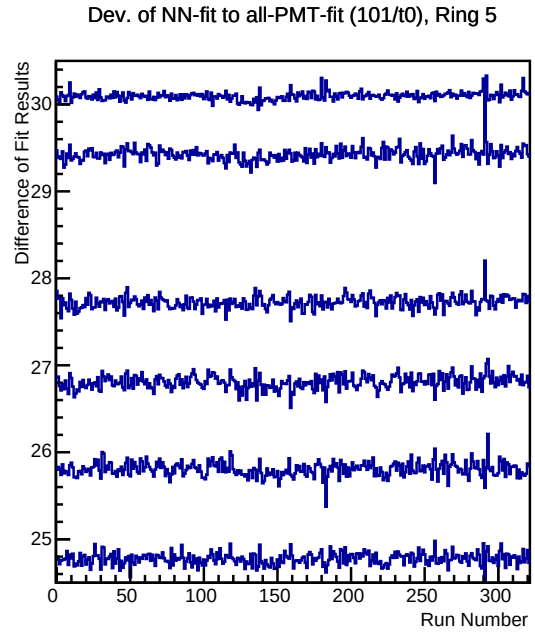

Dev. of NN-fit to all-PMT-fit (101/t0), Ring 0
Difference of Fit Results
Run Number


Dev. of NN-fit to all-PMT-fit (101/t0), Ring 1
Difference of Fit Results
Run Number


Dev. of NN-fit to all-PMT-fit (101/t0), Ring 2
Difference of Fit Results
Run Number


Dev. of NN-fit to all-PMT-fit (101/t0), Ring 3
Difference of Fit Results
Run Number


Dev. of NN-fit to all-PMT-fit (101/t0), Ring 4
Difference of Fit Results
Run Number


Dev. of NN-fit to all-PMT-fit (101/t0), Ring 5
Difference of Fit Results
Run Number

Fit Using Only Nearest Neighbors

- Stronger scattering in higher rings
- Constant offsets on highest rings: persistently differing fit results!
- Should investigate further:
  - Does fixing the angular dependence function introduce a significant bias?
  - Is there a difference between DOMs? (DOM 3 has different geometry)

→ Next step: fitting the angular dependence function for many runs.