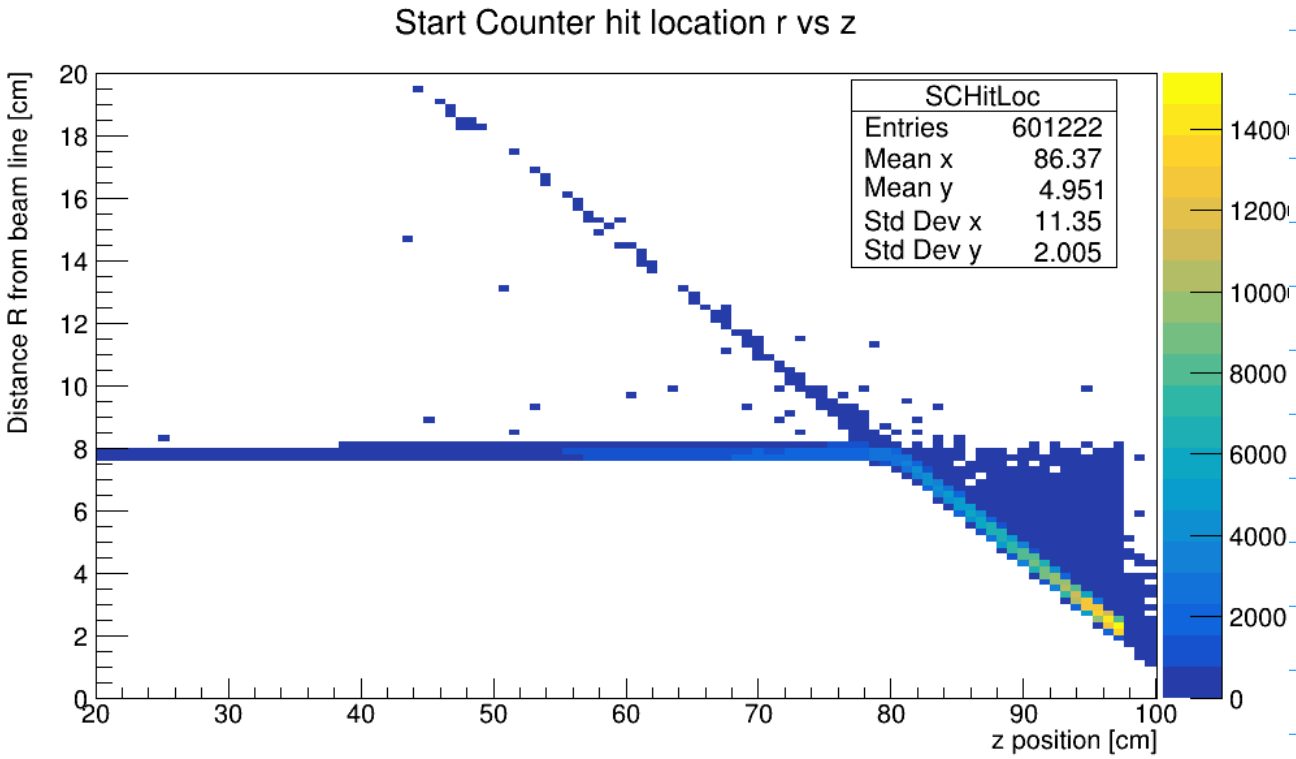
Start counter timing issues in run period fall2022

the time difference between SC time corrected for path length in counter and flight time of particle minus the rf time shows a very large width of order 1ns which is about a factor of 3 worse than seen in the past.

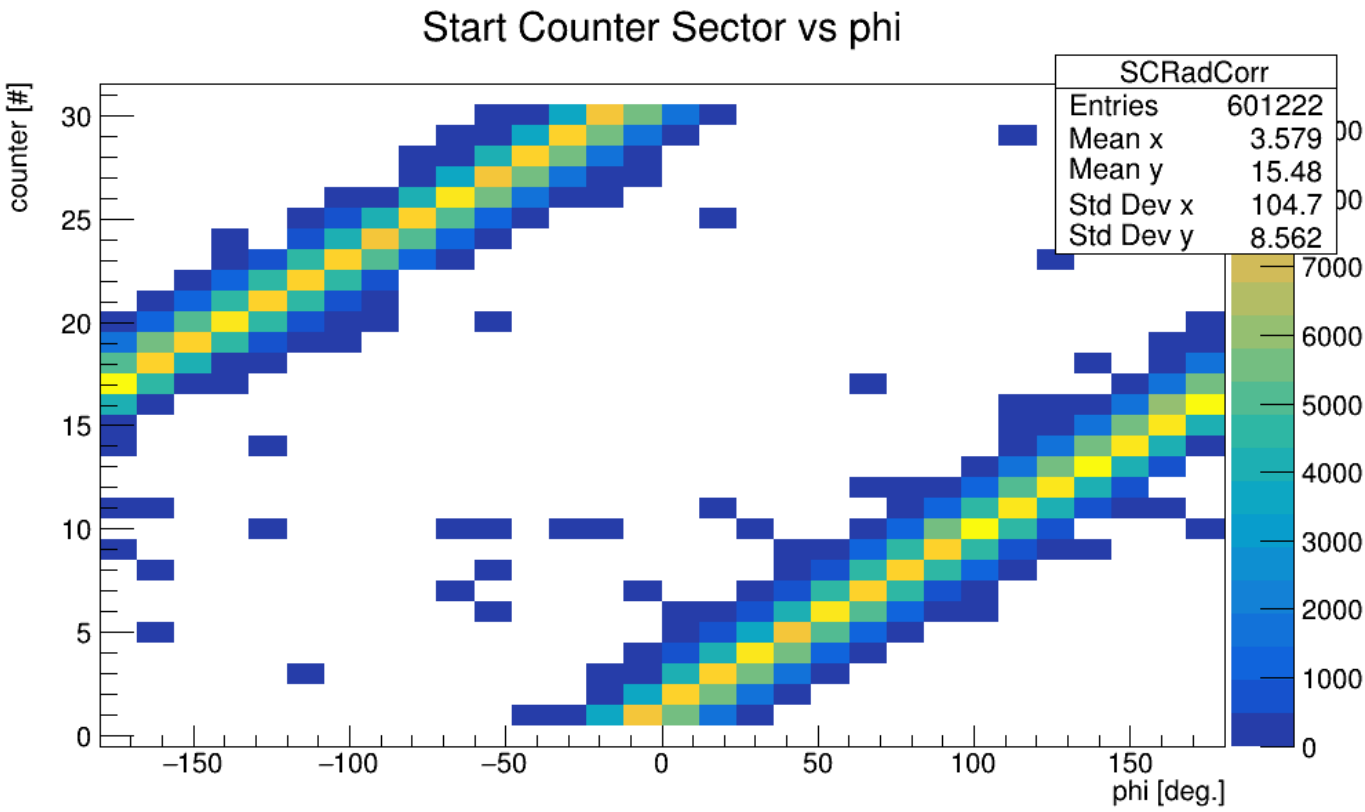
First finding: in the code JEventProcessor_HLDetectorTiming.cc
line 1109 the call to the method Cut_MatchDistance was commented out causing the variable locSCzIntersection to be left initialized to zero and is not updated by that function call! therefore the subsequent if statement locSCzIntersection < 83 will be always true.
this however will not change the issue as described above and the observed resolution is still the same.
Note, the commenting out of this part of the code happend already quite some time ago (sept. 2019).

further investigation step by step
a) first look at r vs z of the accumulated hits in the start counter:



this looks quite as expected with the majority of hits in the nose cone.

also the phi distribution of hits look reasonable:

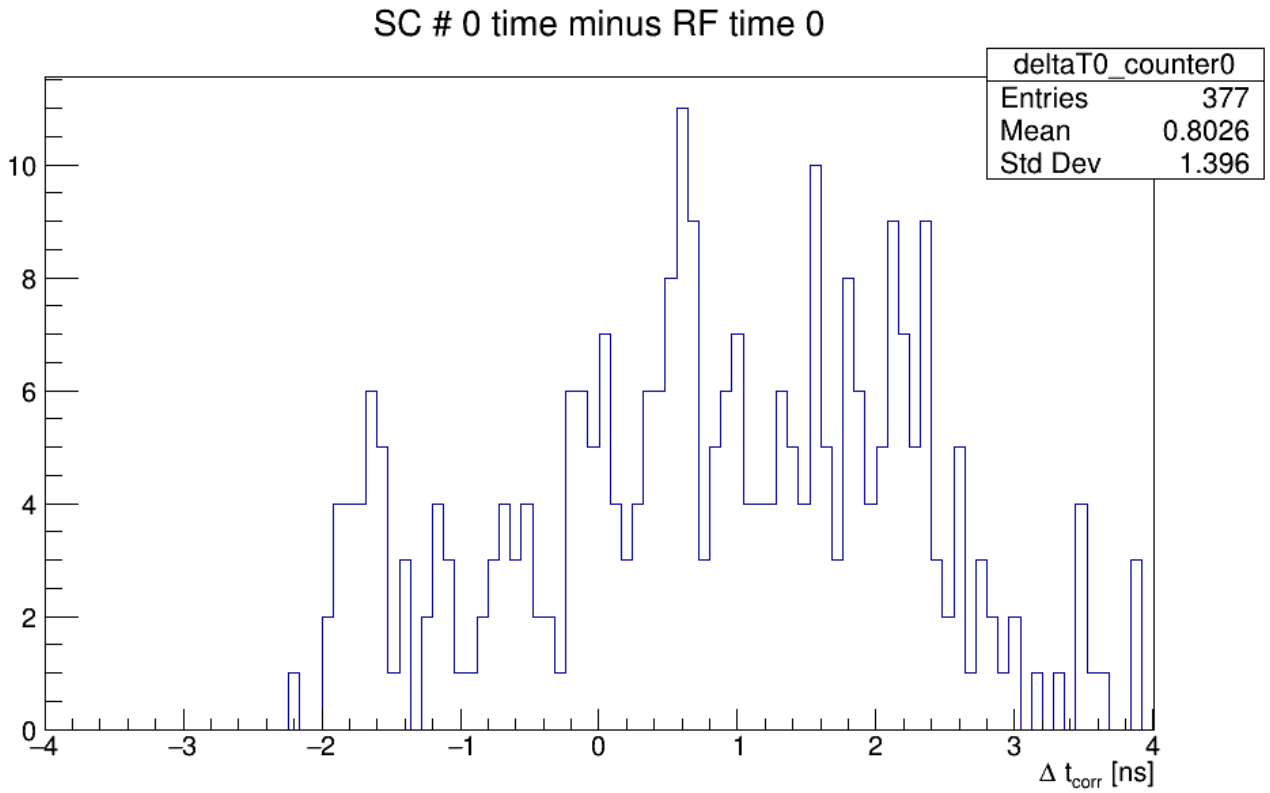


the vertical axis is the counter number while the horizontal axis is the phi angle.

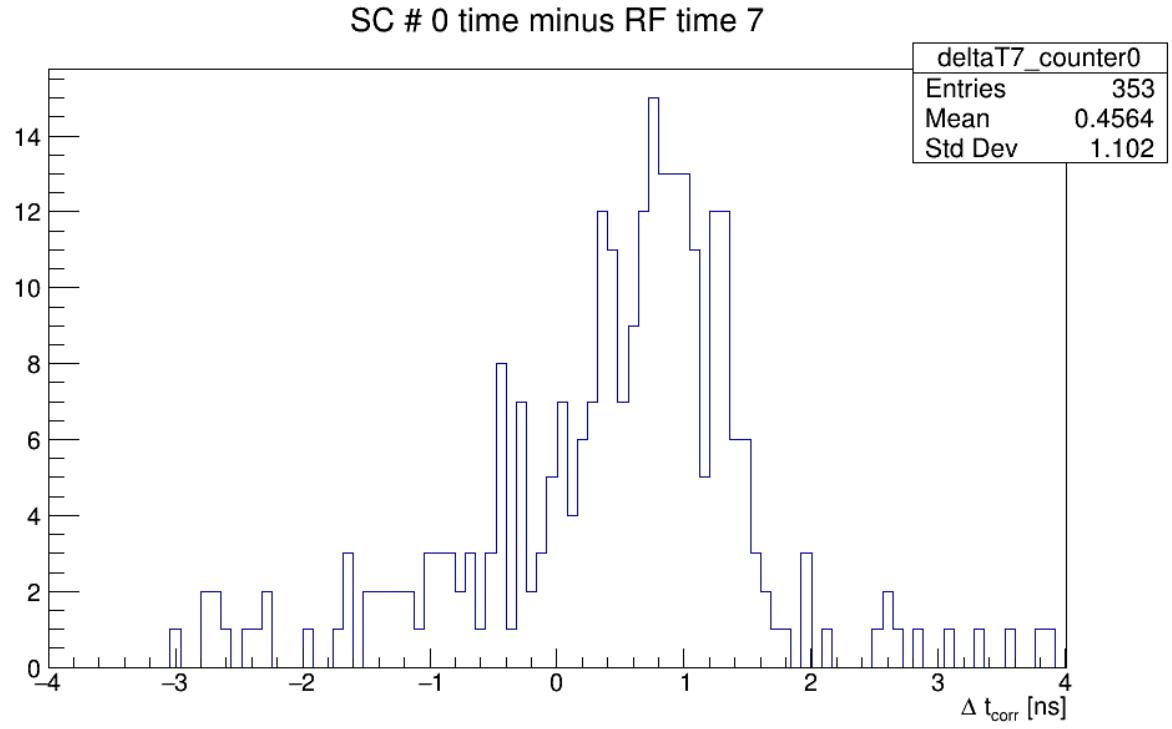
The timing of the start counter is assessed by looking at the time difference between the start counter time corrected for the flight time of the particle from the vertex to the start counter and the path length in the start counter to the SiPMT using an effective speed of light inside the plastic scintillator.

after initial test of integrating over all counters the code was split to look at individual counters as a function of the z hit location along the paddle.
the most upstream reagion shows timing difference distributions that are very broad and difficult to assess with limited statistics however at locations further downstream around 14 cm from the SiPMT readout the statistics is sufficient to identify a timing peak.

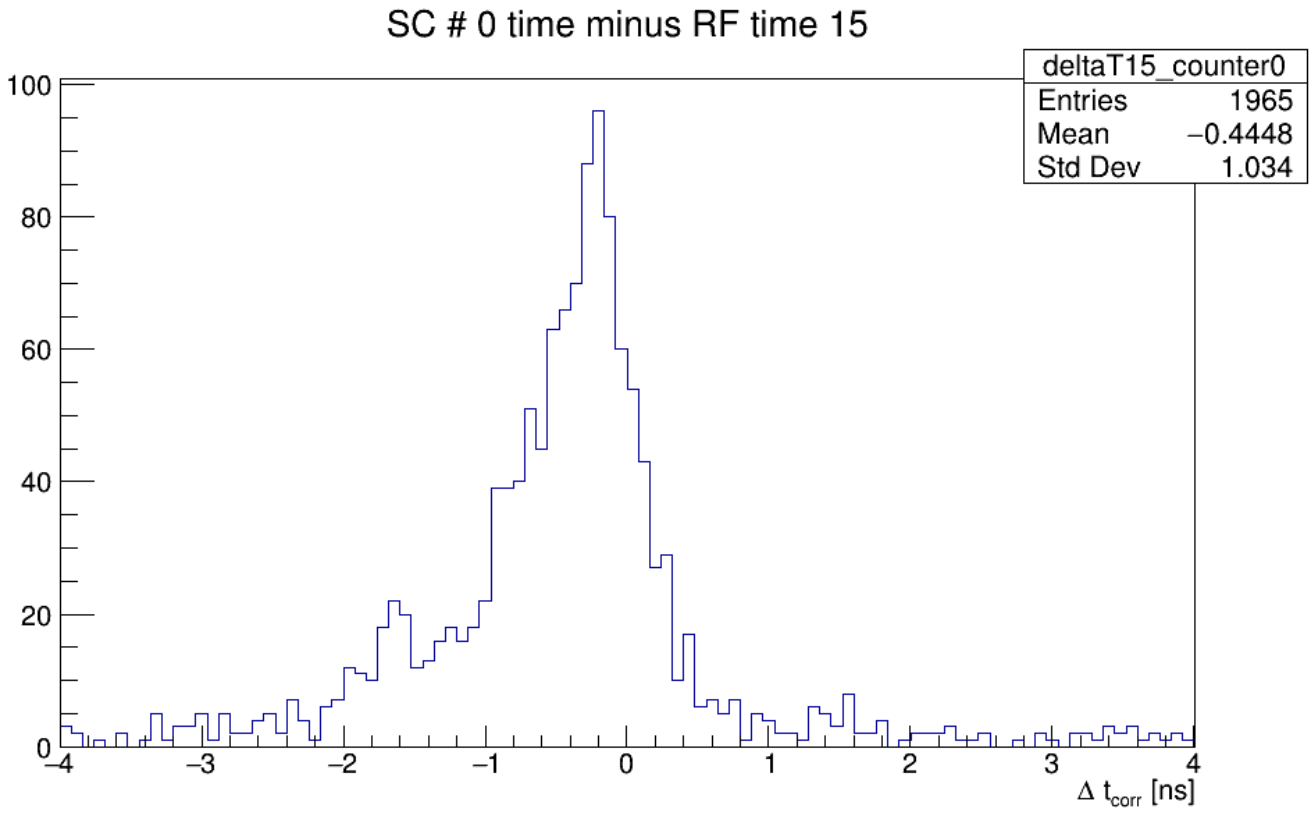
show first is the time difference at 1cm from the SiPMT z=21cm



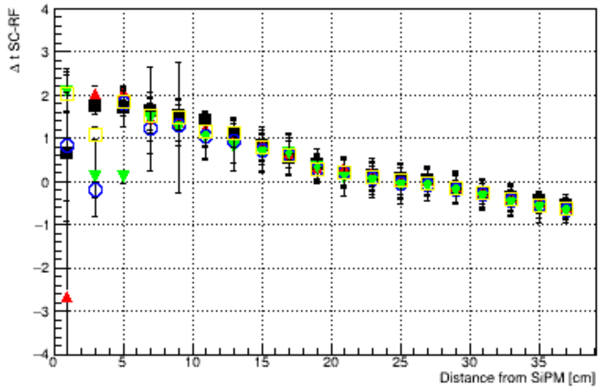
as one can see the timing distribtion is too broad and the statistics too low to identify a peak.
however furth downstream the statistics increases and a peak is clearly identifiable.

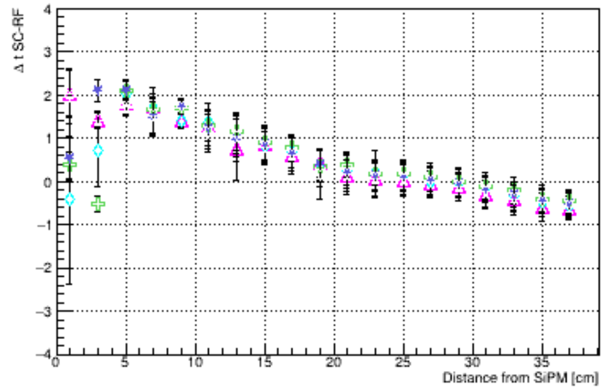


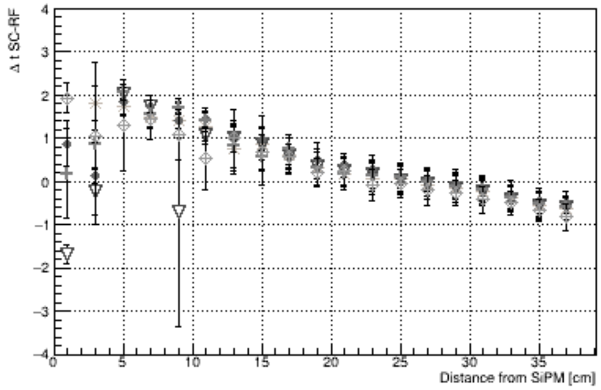
even further downstream where the statistics increases even more the peak is very obvious:

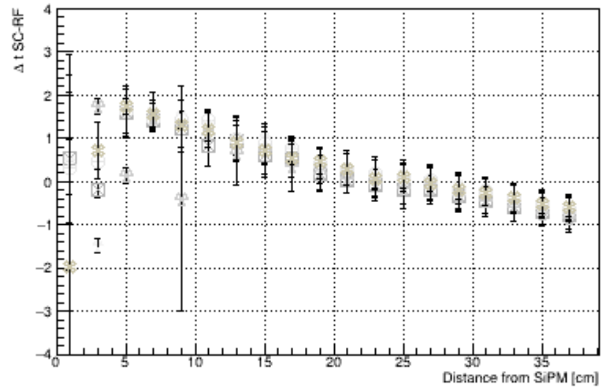


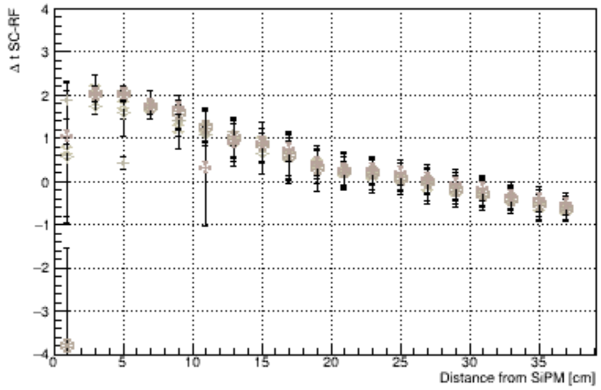
the peak location and width can be determined with a Gaussian fit and plotted as a function of z along the paddle.
this is done for each paddle separately and found they behave all the same and show a linear depencence which was expeced to be flat rather than having a slope.





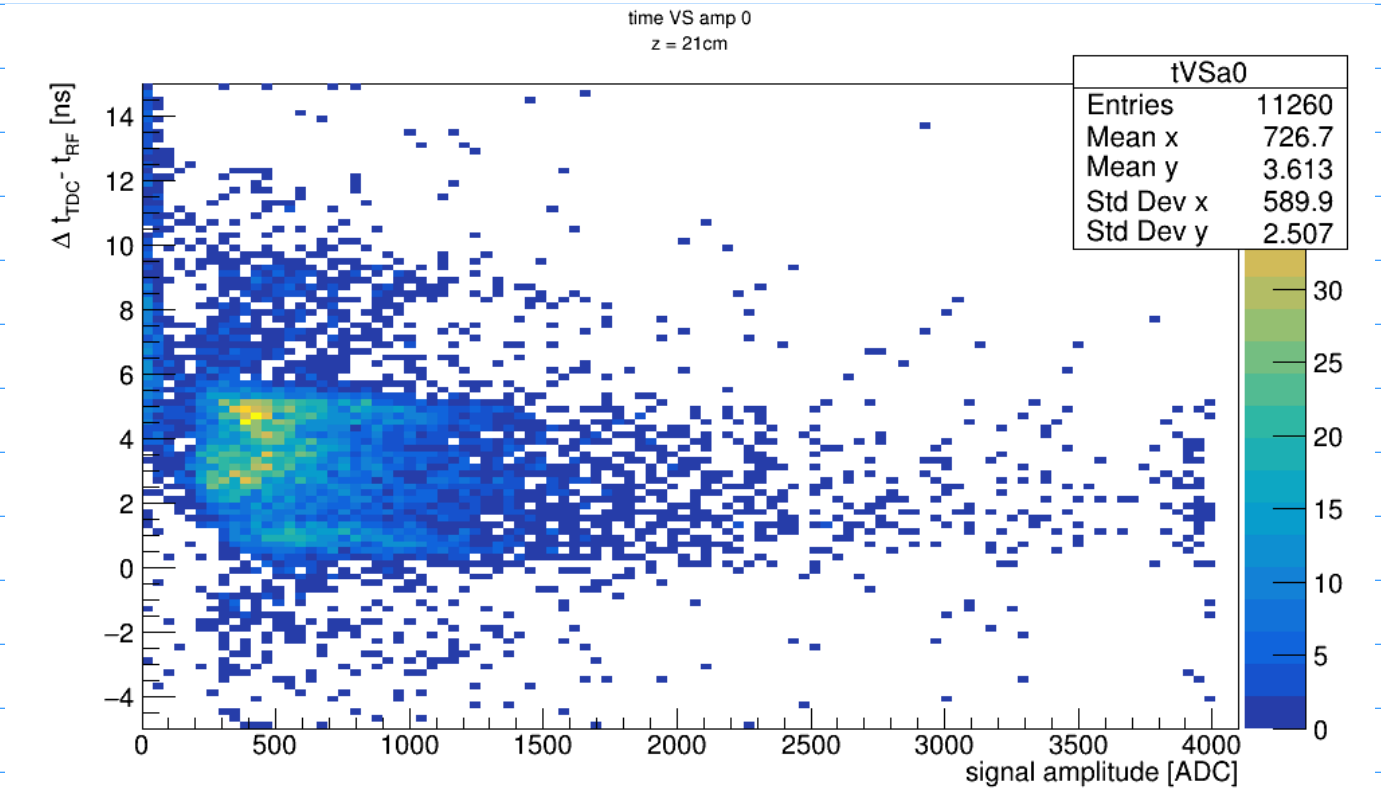






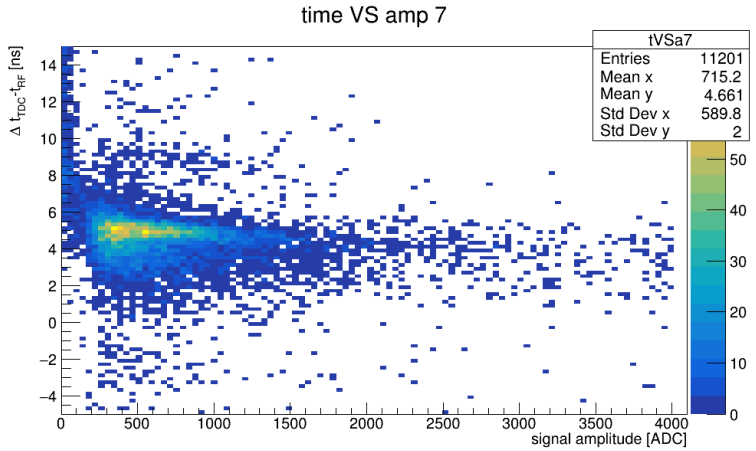
pretty much all paddles show a very similar slope and dependence on z. The horizontal axis here is the distance from the SiPMT readout.

Two more issues are seen in the start counter timing.
a) for the very upstream hits close to the SiPMT readout the time difference t_TDC minus t_RF is very broad and shows several "lines" as if some hits pick the wrong RF.

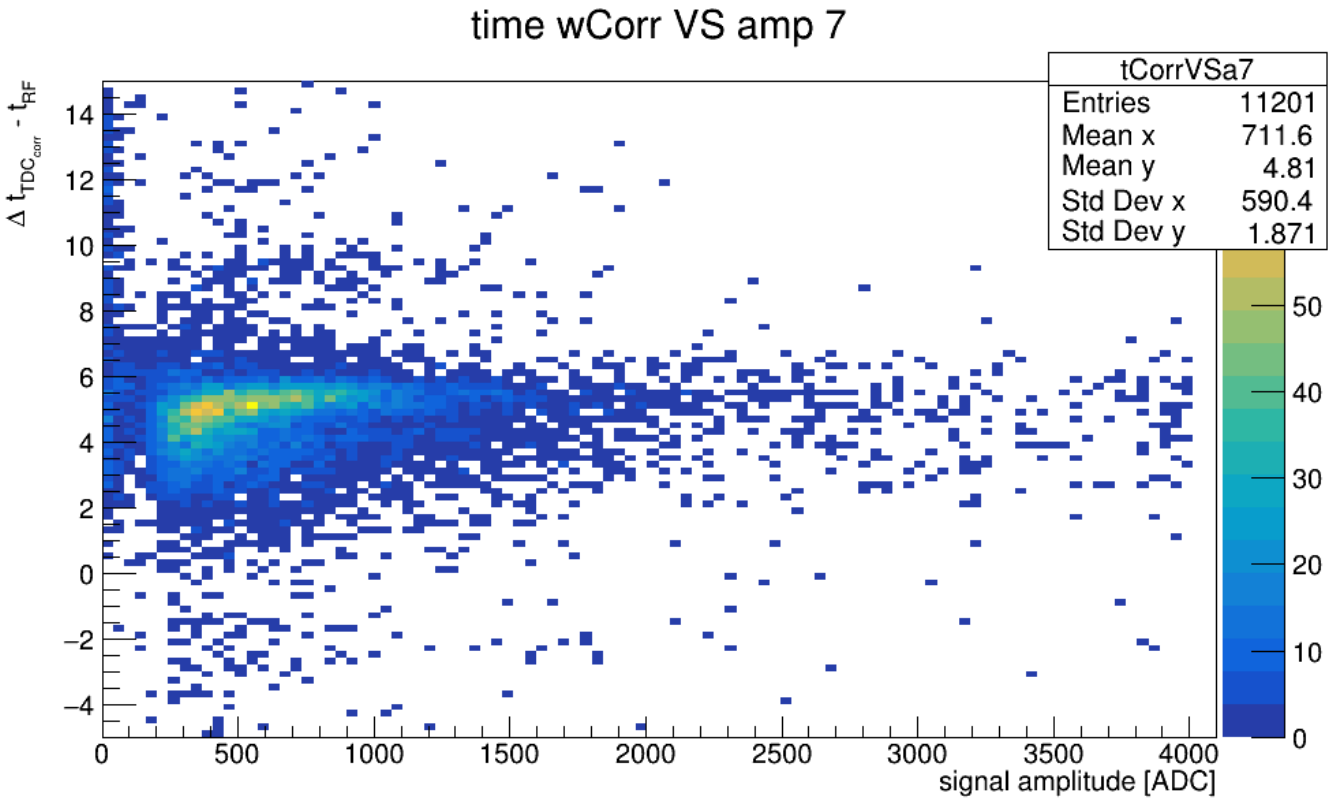


b) The second problem seen is that the walk correction is over-correcting the TDC timing:

shown first here is the TDC time minus the RF time as a function of ADC amplitude before the walk correction is applied:



while the same data after the walk correction looks like this:



the "bending" down at low amplitudes clearly indicates an over correction