

## Analysis Note

Worsening of response for ReD TPC  
in double phase  $\gamma$ -emitting source runs  
for scintillation signal.

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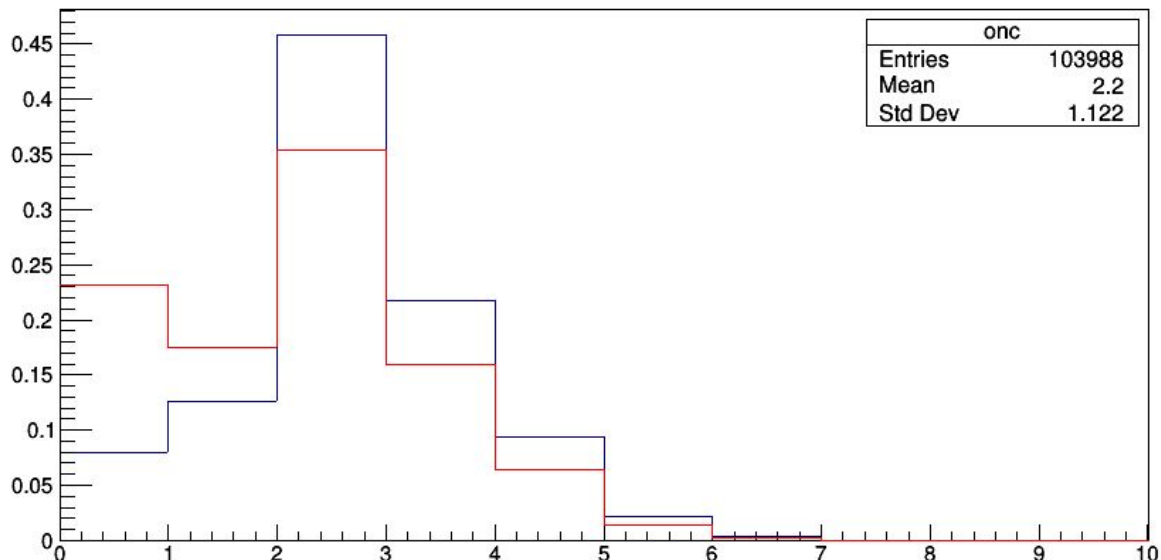
During first week of october this year a series of runs was taken with the portable DD-Gun to characterize ReD TPC response to nuclear recoils induced by neutrons, which are produced by such portable DD-Gun. During this week a  $^{241}\text{Am}$  in standard condition was taken as a control run. This run is run\_1225, with *standard conditions* meaning DP 200 V/cm drift field, 5.79kV/cm electroluminescence field, +86 V first ring, and any other parameter (HVbias, Vamp, channelmapping, thresholds, etc.) exactly the same as run 1104 (excluding the absence of Kr in 1225 - but its activity is much lower than  $^{241}\text{Am}$  activity)

run	ser	#evts	Am @ center +	top = 34 bottom = 68	t_start: 17:59 t_stop: 20:06	Fields A= +5211 V R= + 86 V K= - 744 V	Gas Pocket 20 V 71 mA 1.4 W	channelma pping_Na	DF_TPC_standalone_N a_20190607
1104	1101	103k	Kr-83						

A quick analysis over run 1225 resulted in a consistent S1 distribution but much worse S2 distribution:

(From this moment on, every 1D plot referring to run 1125 will be in red color, and any 1D plot obtained by run 1104 will be in blue color)

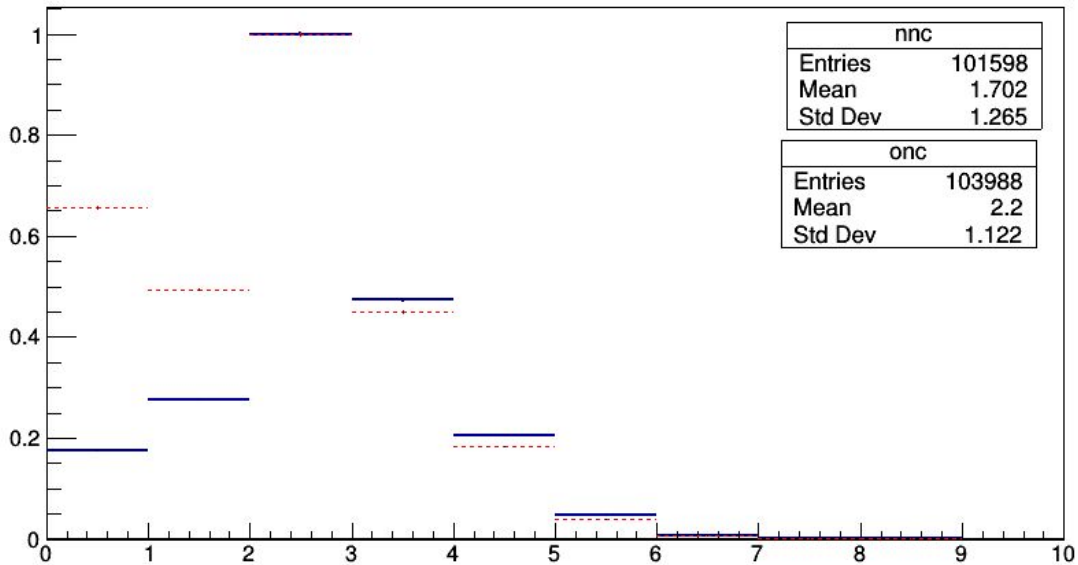
Number of clusters



Distribution in number of clusters shows a worsening of number of "good" 2-clusters events, dropping from 45% to 35% with an increase in 0 and 1 clusters events. The ratio of number of events of the two runs between 2,3,4 and 5 clustered events remains roughly constant. This

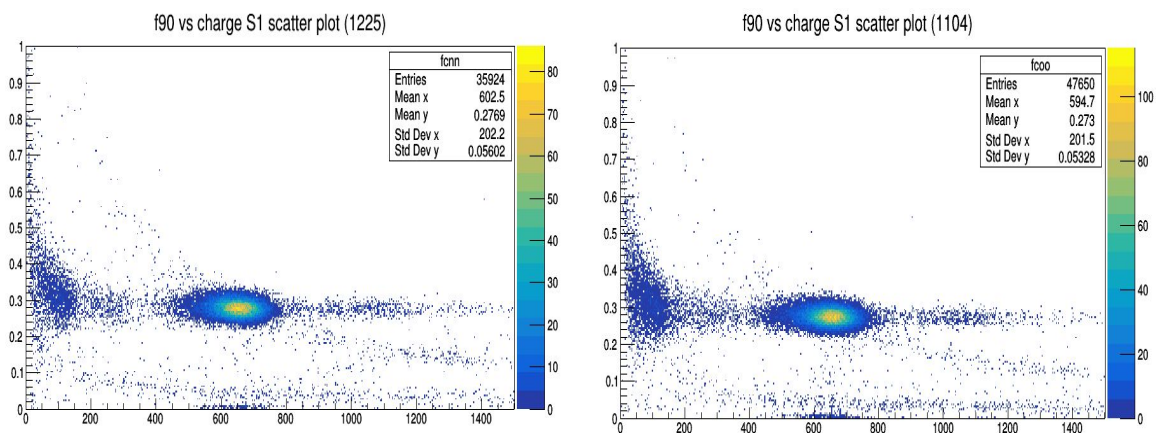
is visible in the following histogram, which still shows distribution of events in respect to number of clusters, but normalized to the third bin (2-clusters events). This can be interpreted as a no-change in “S3-echo” effect and probability of more events occurring in quick succession in the acquisition window. The increase in number of 0 and 1 clusters event is an indication to fake triggers and/or low-amplitude pulses which fail to be reconstructed properly.

Number of clusters



Distribution in number of clusters normalized to 2-clusters bin.

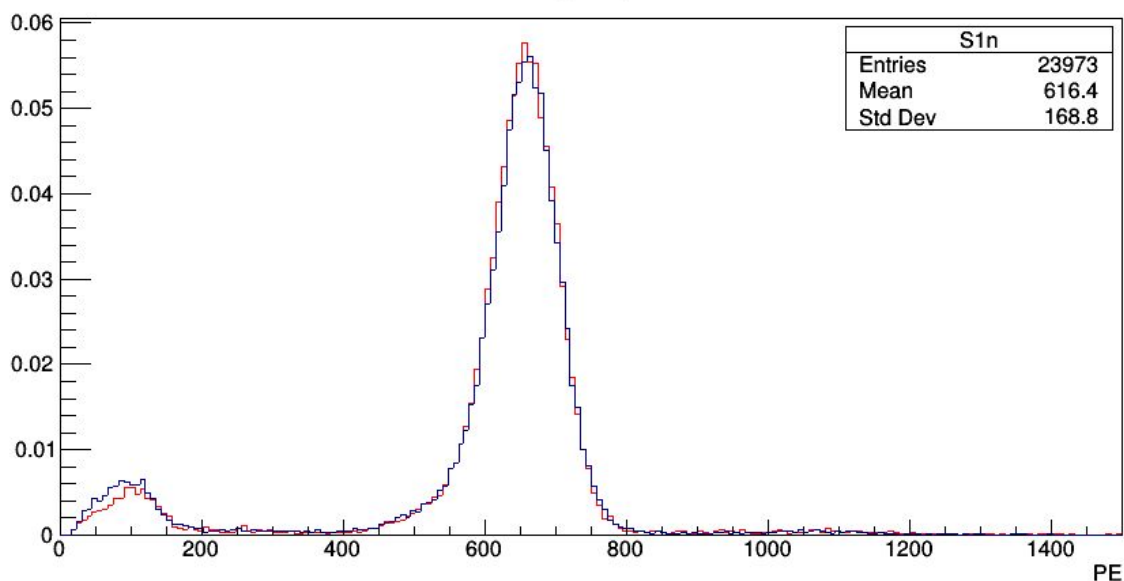
### S1 f90 vs S1 charge



The scatter plot of f90:charge for S1 (clusters[0]), cutting only on *number\_of\_clusters*==2 shows very similar distribution with no visible difference.

## S1 and S2 charge spectrum

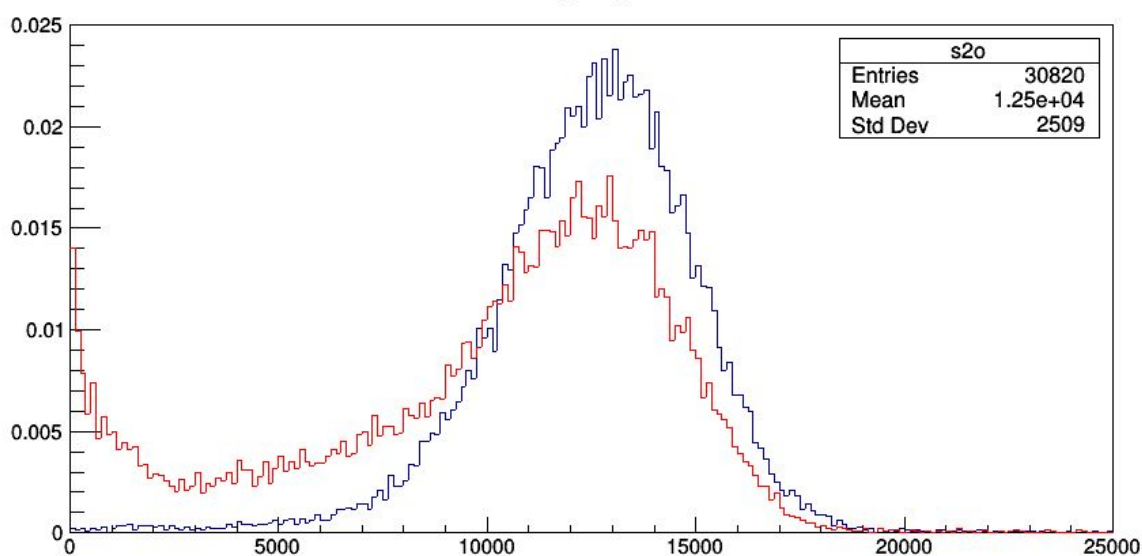
S1 charge spectrum



with cuts for S1 spectrum: `"number_of_clusters==2 && clusters[1].rep == 1 && clusters[0].rep == 1 && clusters[0].f90 < 0.4 && clusters[0].f90 > 0.2 && clusters[1].f90 < 0.15 && clusters[1].f90 > 0"` and no other correction. This cuts are to select non-trimmed, two clusters events with expected f90 for a S1 1-cluster and S2 2-cluster.

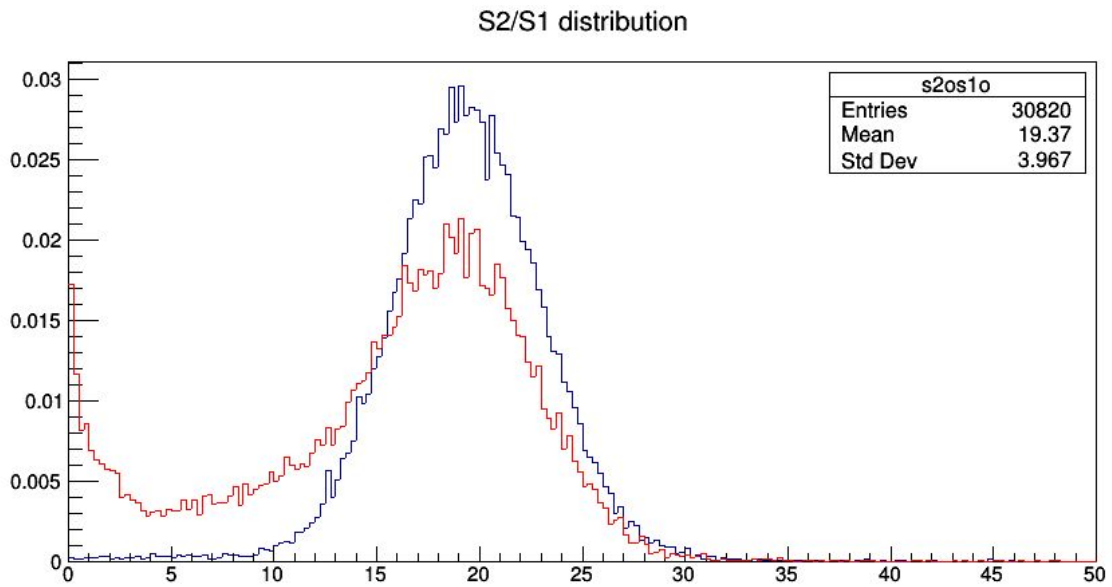
S2 distribution, on the other hand, looks way worse, with a tail of low S2 events which was not present in run 1104.

S2 charge spectrum

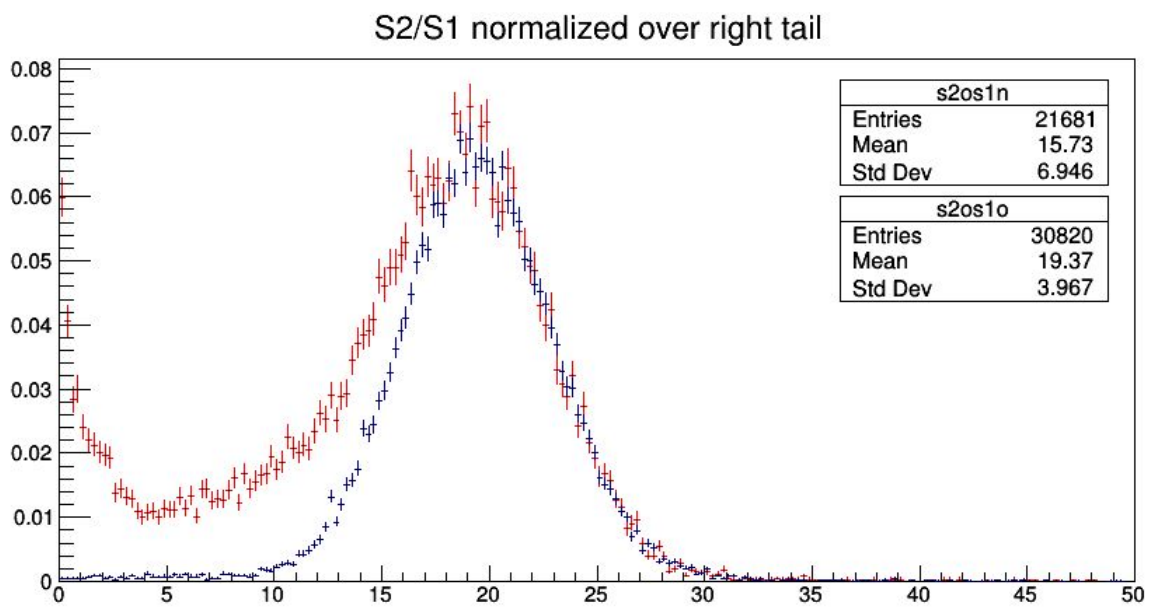


with cuts for S2 spectrum: `"number_of_clusters==2 && clusters[1].rep == 1 && clusters[0].rep == 1 && clusters[0].f90 < 0.4 && clusters[0].f90 > 0.2 && clusters[1].f90 < 0.2 && clusters[1].f90 > 0 && clusters[0].charge > 300 && clusters[0].charge < 900"` and no other correction. There is an additional cut for S2 cutting on S1 energy to select  $\gamma$  photopeak.

The same cuts for S2 spectrum are applied to produce S2/S1 distribution:



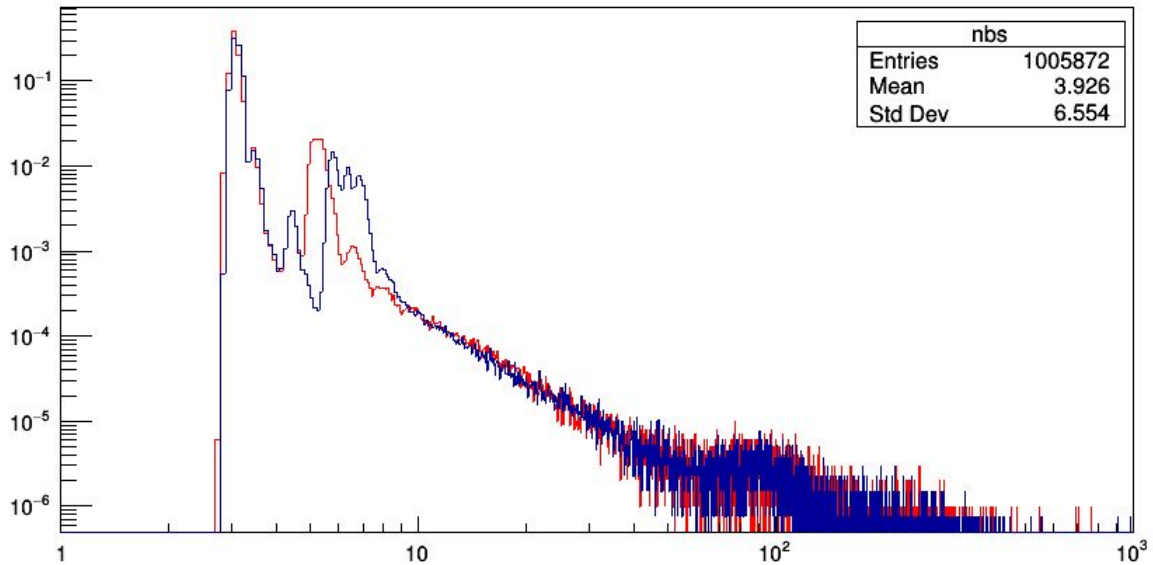
Normalized over right tail:



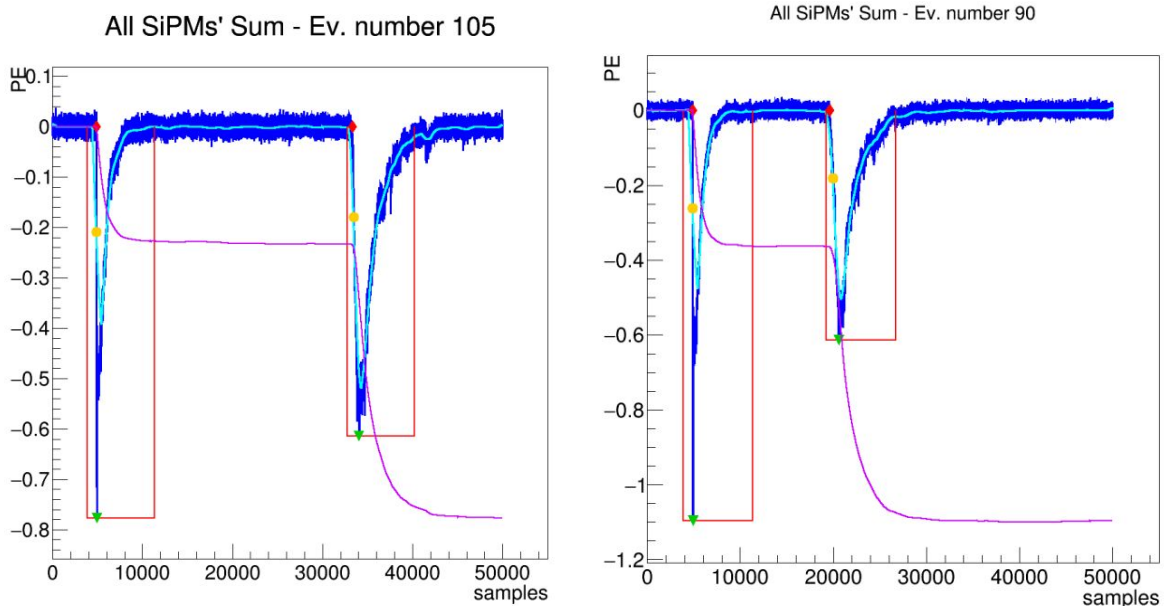
## Baseline and waveform analysis

First thing we did was to check for baselines to have changed, but no significant change was measured to explain for such inefficiency. The plot is obtained with only cut being on number of clusters.

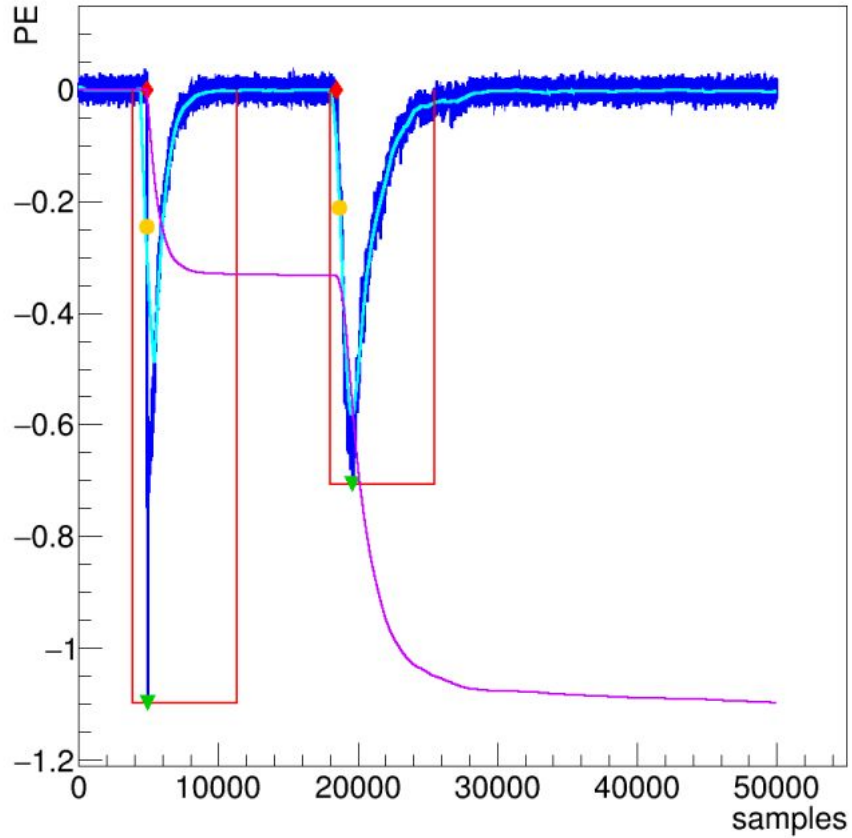
Baseline (root mean square) - all channels



Single waveforms were then looked over with offline viewer from the region in the S2 spectrum with  $S2/S1 < 5$ . Here are some of them (All SiPMs' Sum):



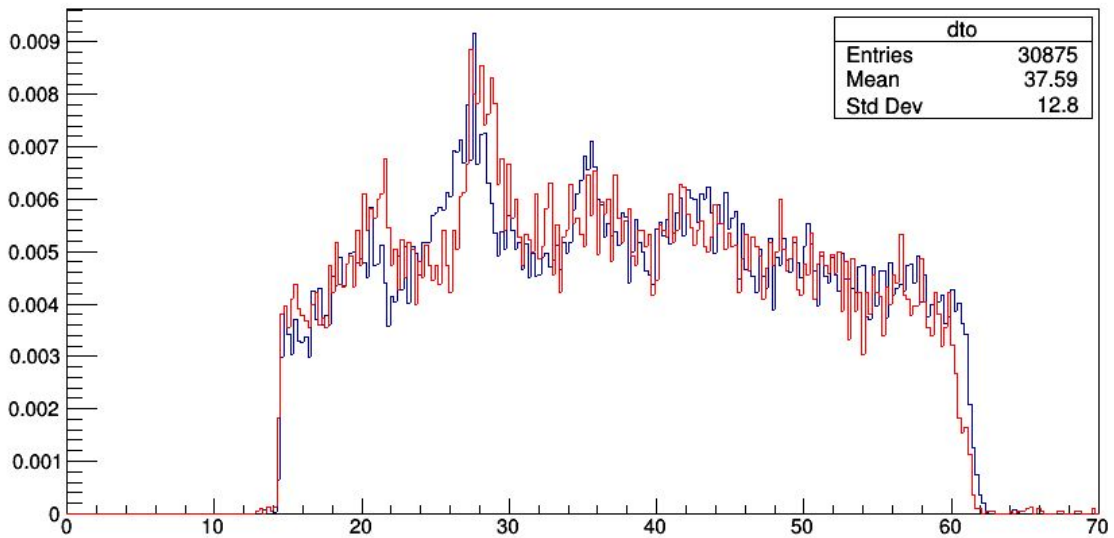
### All SiPMs' Sum - Ev. number 162



It seems clear that such second clusters are not artifacts from noise-triggering or errors in the reconstruction process, but rather physical events with very low final gain (possibly indication to loss of electrons in drift medium or low electroluminescence gain)

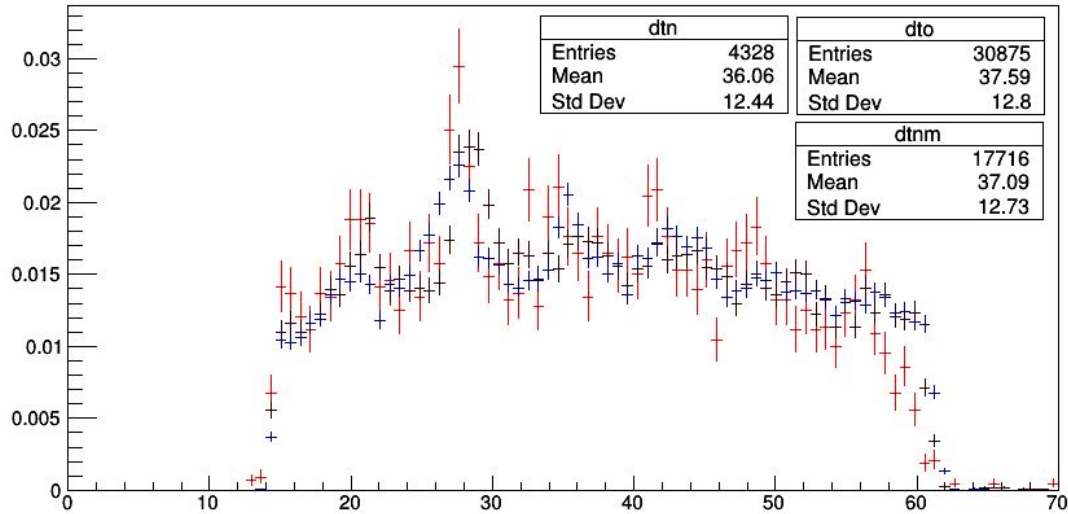
Drift time distribution also looks very similar:

### Drift Time distribution



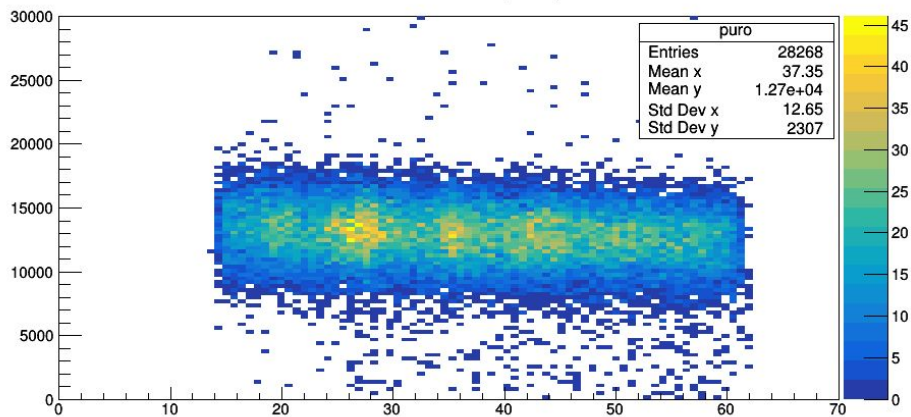
It is obtained with cuts: "number\_of\_clusters==2 && clusters[0].rep == 1 && clusters[0].f90 <0.4 && clusters[0].f90 > 0.2 && clusters[1].f90 < 0.2 && clusters[1].f90 > 0 && clusters[0].charge > 300 && clusters[0].charge < 900"

Drift time distribution (S2/S1 < 10)

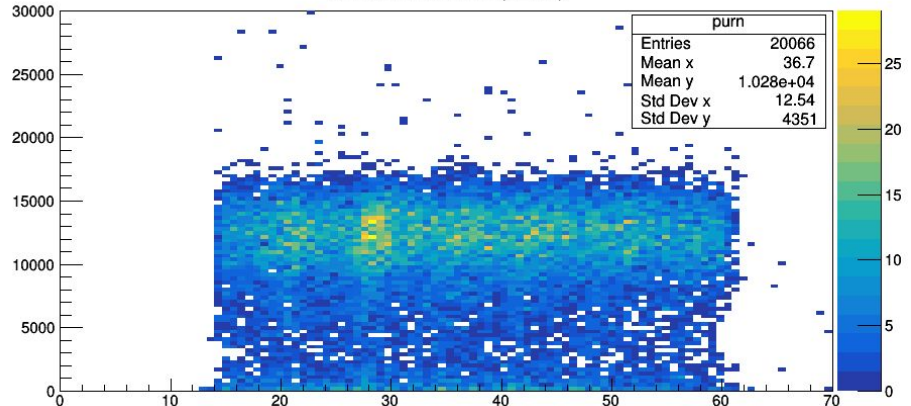


Drift time distribution for runs **1104**, **1225 (events with S2/S1 < 10)** and **1225 (events with S2/S1 > 10)**. The plot shows that events in low-S2-tail are less uniform in drift time (probably due to low statistics), but also seem to have a smoother cut-off at 60 us.

S2 vs Drift Time (1104)



S2 vs Drift Time (1225)



Purity, by eye, seems better on the other hand. Excluding the low-s2 tail visible in the 1225 scatter plot, it is noticeable that the downwards trend is not appreciable by just looking at the plot, while it's neatly visible in 1104 run. The two plots were obtained with cuts  
*number\_of\_clusters==2 && clusters[1].rep == 1 && clusters[0].rep == 1 && clusters[0].f90 < 0.4 && clusters[0].f90 > 0.2 && clusters[1].f90 < 0.2 && clusters[1].f90 > 0 && clusters[0].charge > 550 && clusters[0].charge < 750*

This seems to exclude the possibility of electron trapping impurities building up in the chamber during summer.

### **Conclusions:**

More analysis (and cross-checks) are required to understand what changed between the two runs.

Help is greatly appreciated in the form of analyzing all available data to understand if this effect was slowly appeared during summer runs or just showed from a certain moment on;

Proposed ideas:

- A change in field uniformity (actual V\_FirstRing varied, worsening field uniformity?)
- A build-up of positive ions in localized regions of the chamber, modifying the shape of the fields?