Common baseline noise
and Electronics crosstalk

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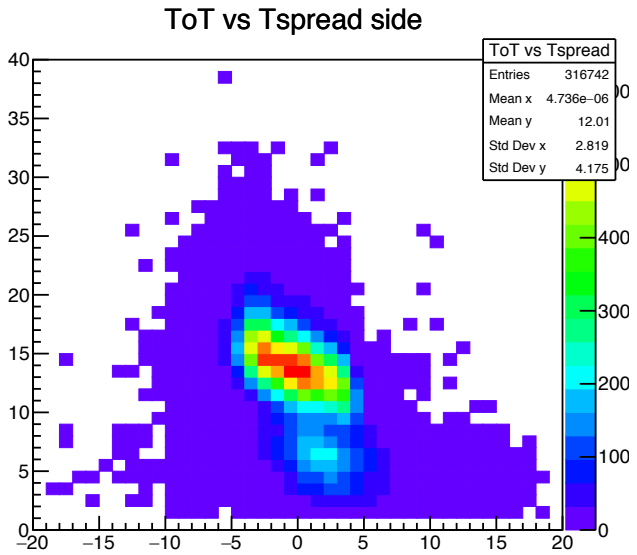
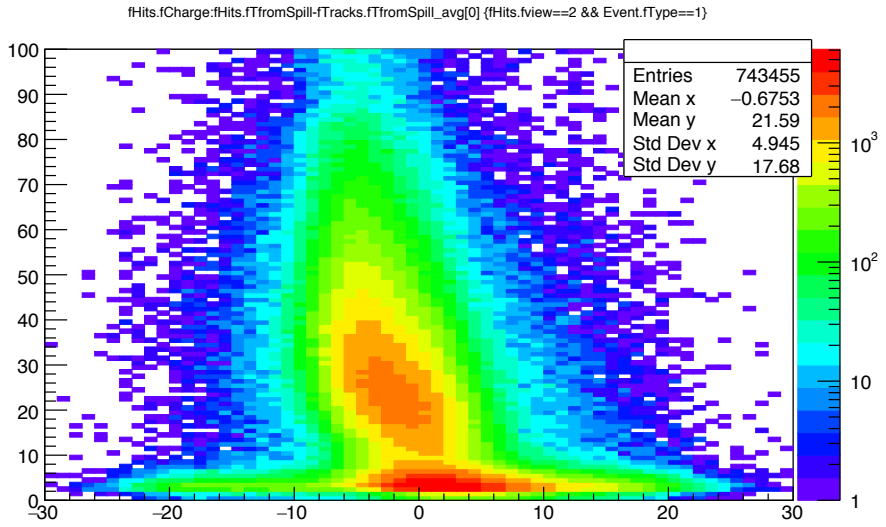
What are the fake hits in clusters and tracks?

- Using dark count flag cut (coincidence condition) does not eliminate all of them.
- They can be noise due to high energy hits.

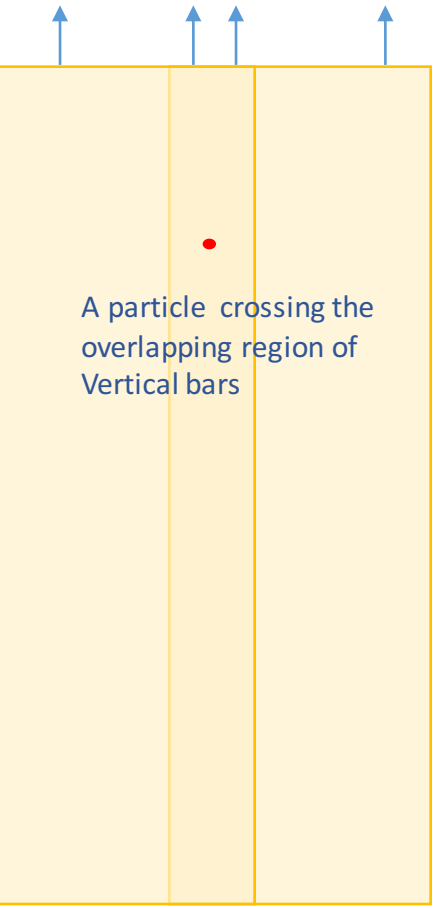


ToT vs hit time for hits in a cluster



Charge vs hit time for hits in a track

Number of hits in a clusters

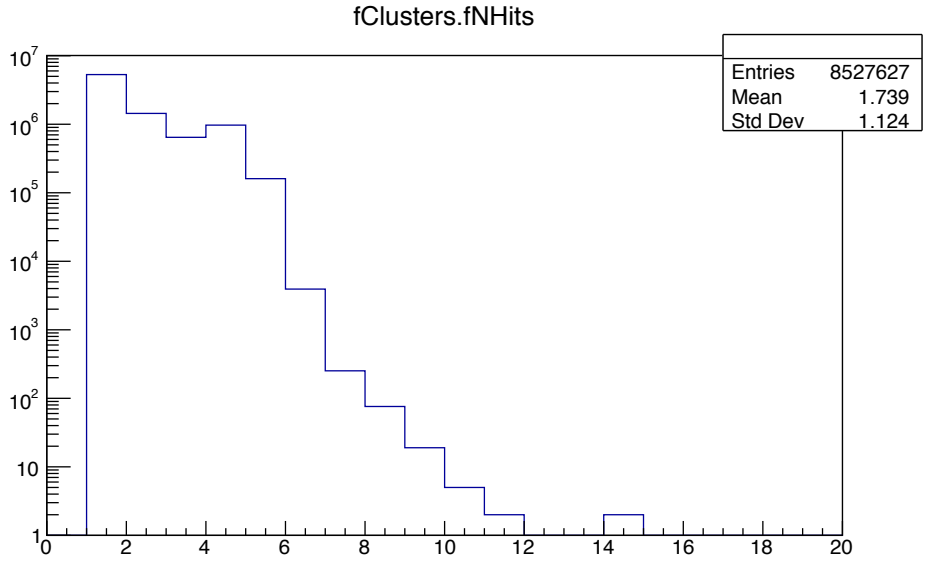


A particle crossing the overlapping region of Vertical bars

Cluster definition:
Group hits belonging to neighbor bars if they are within a 20 ticks time window.

-> Some of the noise around the main track is absorbed in the clusters.

A particle crossing the overlapping region of Horizontal bars



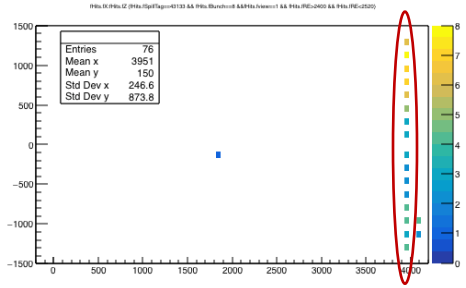
In ideal case we expect:

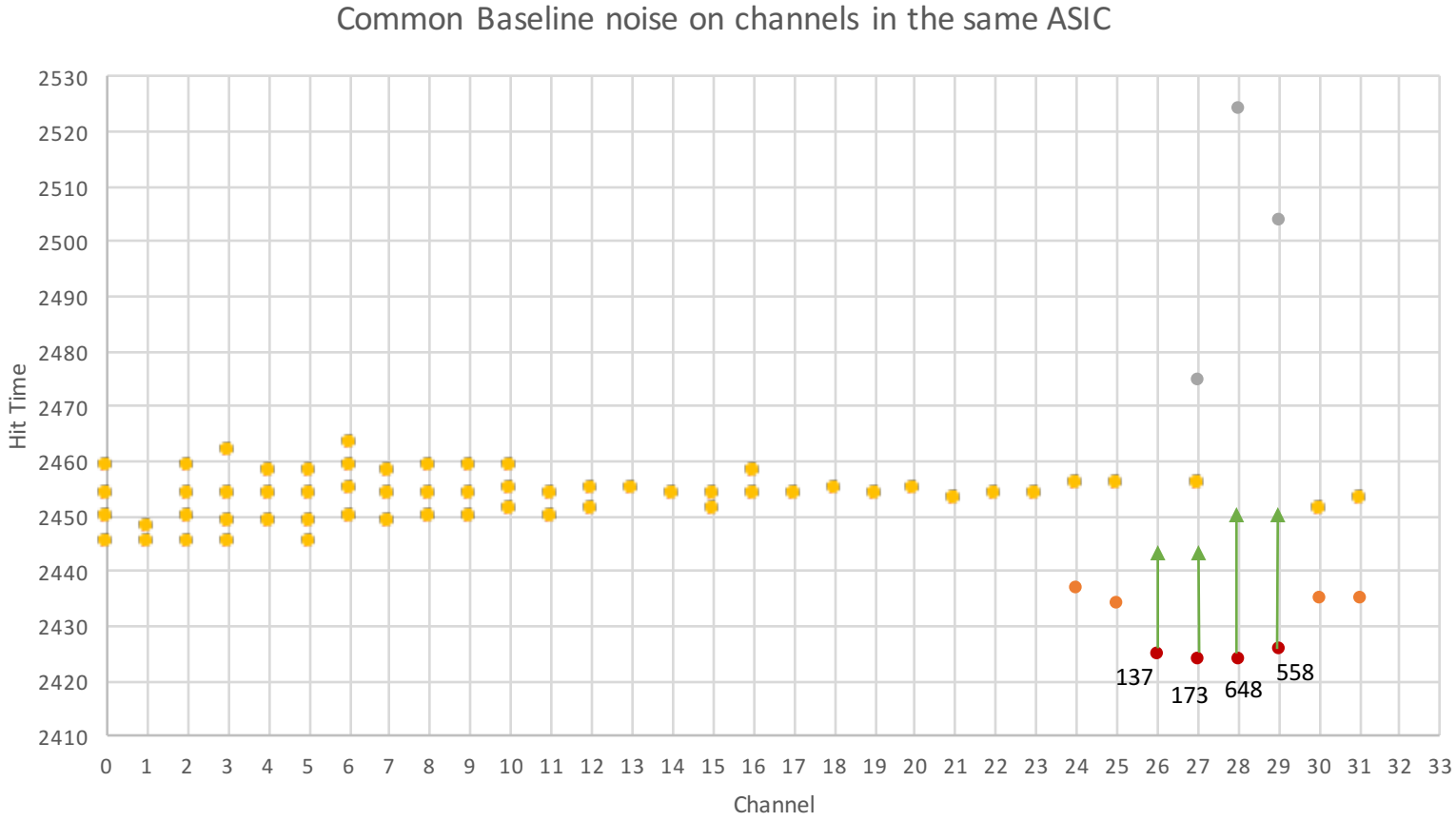
Cluster with one hit	Dark noise
Cluster with two hits	Particle passage through one bar
Cluster with 4 hits	particle passage through overlap of two bars
Clusters with other number of hits	Hit inefficiency, or noise hit, or shower hits combined with particle hits.

A Noisy Event example 1

16 Dec, Spill 43133, Bunch 8
Module 17, Top view

- Main hits charge -> (137-648) p.e
- All other hits has charge < 6 p.e
- The yellow hits are a result of the common baseline shift with some channels experience ringing effect
- The Orange hits occur earlier than the base line group, and they are closer to the main hits. They might be crosstalk





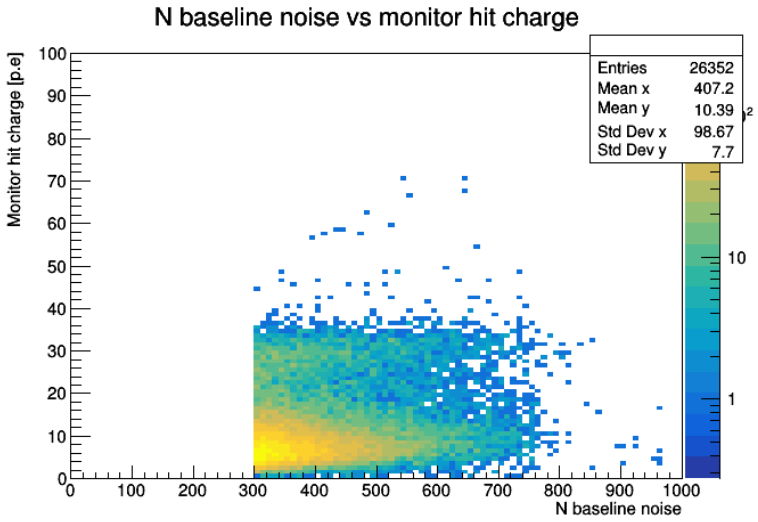
Time over threshold value of the hits

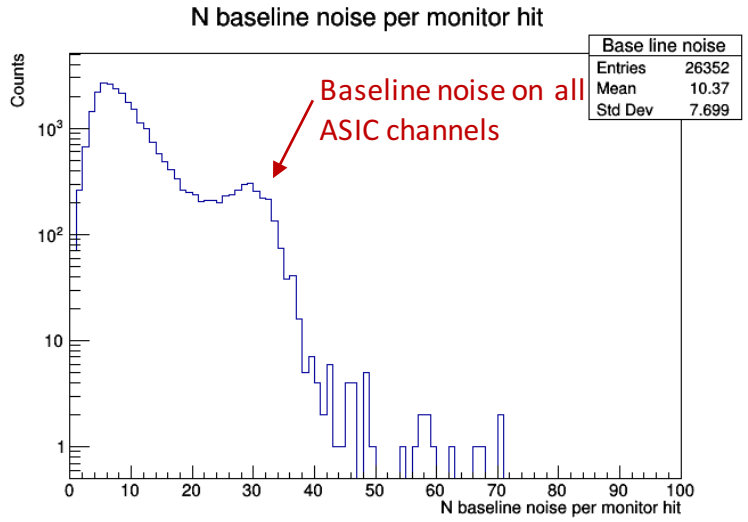
Channel	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
ToT Pulse 1	2	2	3	2	3	2	2	2	4	3	3	3	3	3	4	4	3	4	3	3	3	4	4	4	3	8	28	29	37	35	9	6
ToT After pulse 1	2	9	2	2	2	2	2	2	3	2	2	1	2			1	2								1	1		1	6	7	6	4
ToT After pulse 2	1		1	2	1	2	2	2	2	1	1																	7				
ToT After pulse 3	1		1	1		1	1																									

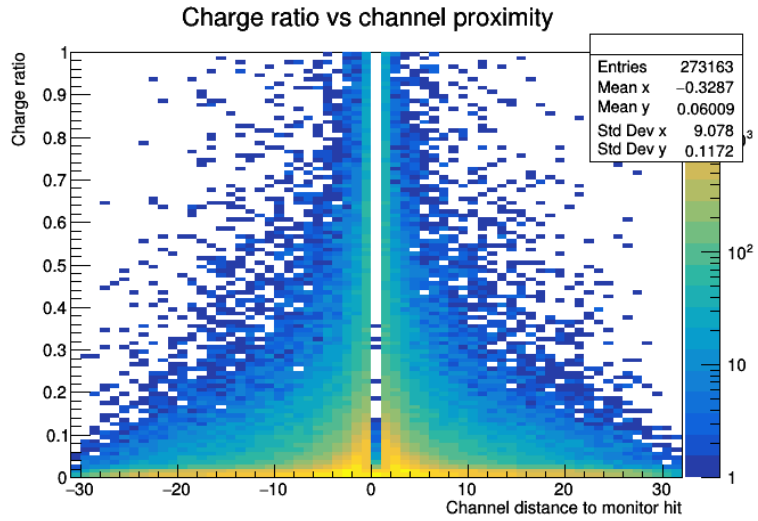
Looking for baseline noise in a large data set

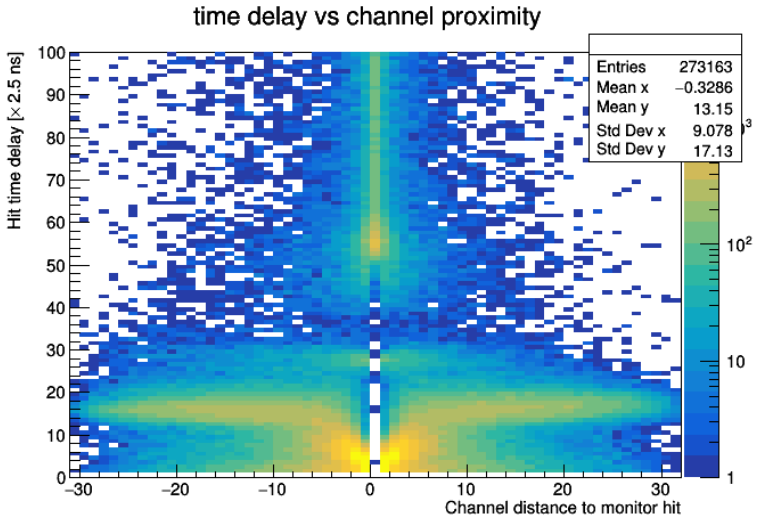
1. Monitor hits with charge >300 p.e, which are the maximum charge in an ASIC has been selected.
2. All other hits occurring on the same ASIC within 100 ticks have been studied.
3. These hits can be
   - **overlapping bar hit**
   - **crosstalk**
   - **baseline shift**
   - **after pulse**
   - **uncorrelated dark count**
   - **another particle hit which is in time with the monitor hit (shower/ pile up)**

Hits >30 p.e	30<Q<100 p.e	100<Q<300 p.e	Q>300 p.e
2742310	2453914	261002	27394
100%	89.5%	9.5%	1 %

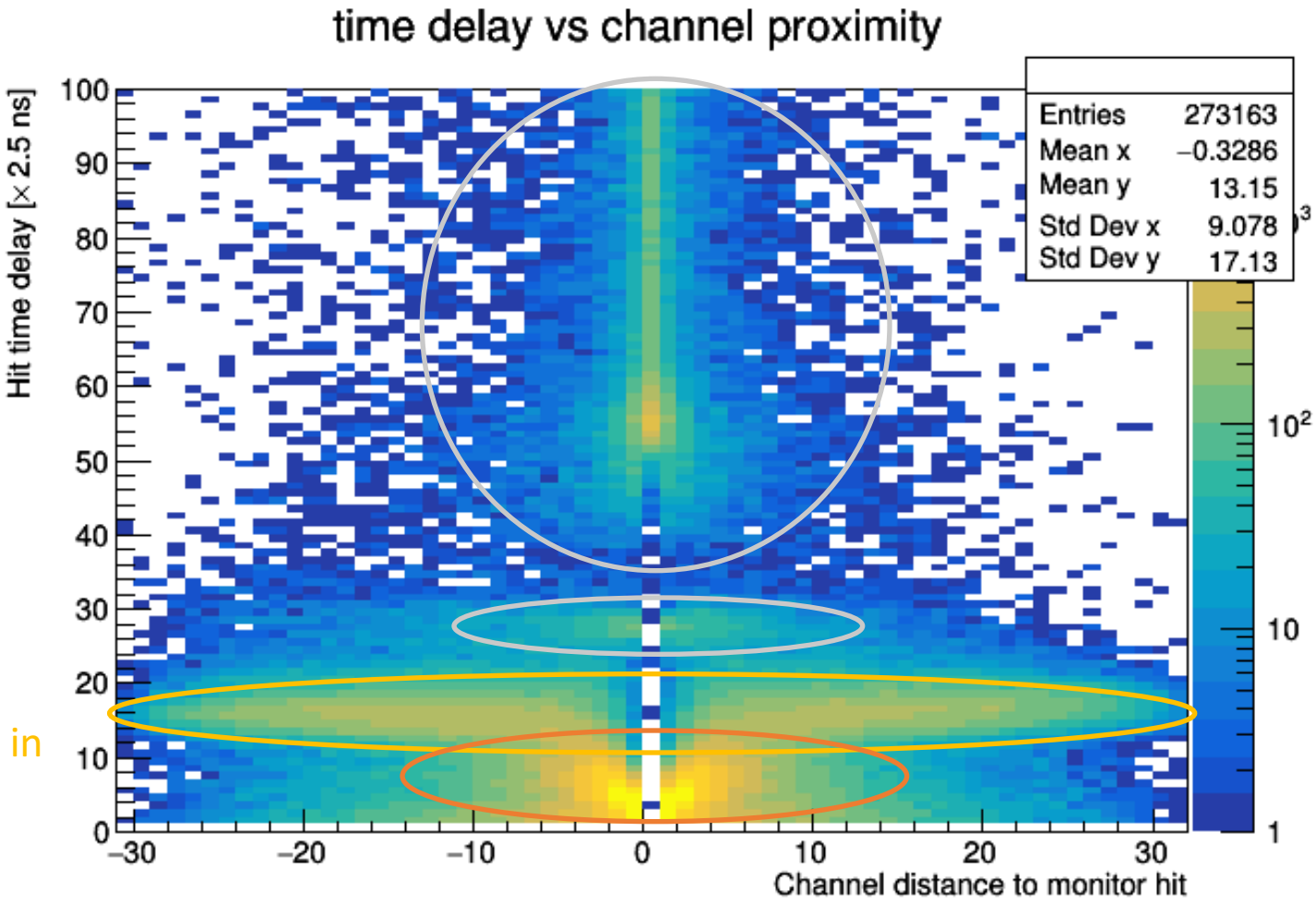








Looking for baseline noise in a large data set



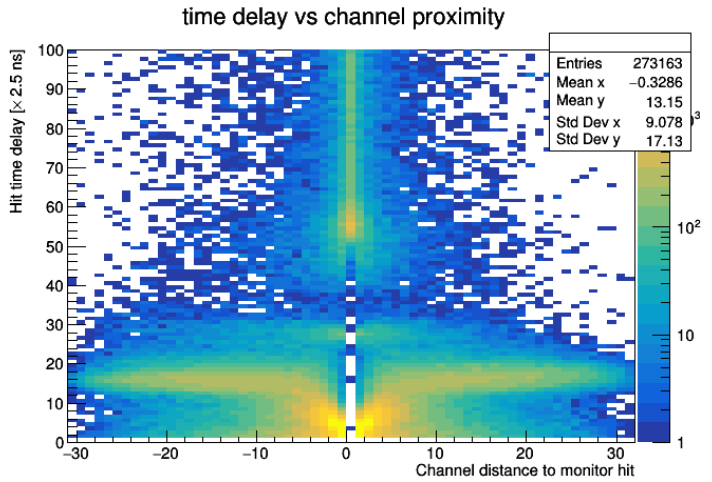
Base line shift induced hits can happen on all channels in the ASIC

Cross talks channels are closer to the main hit

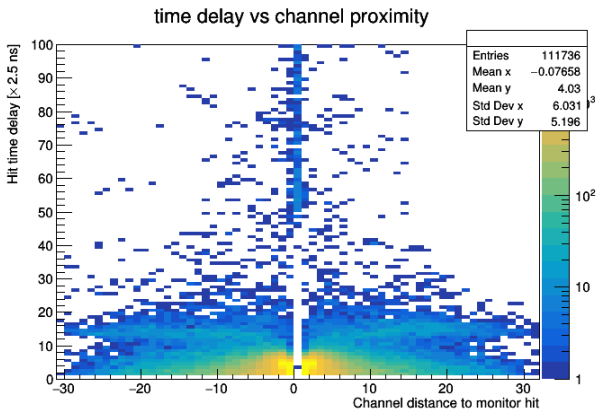
After pulses can happen for the main hit, cross talk hits and baseline noise hits, with different delays depending on the primary hit amplitude.

Can we cut away the noise by charge cut?

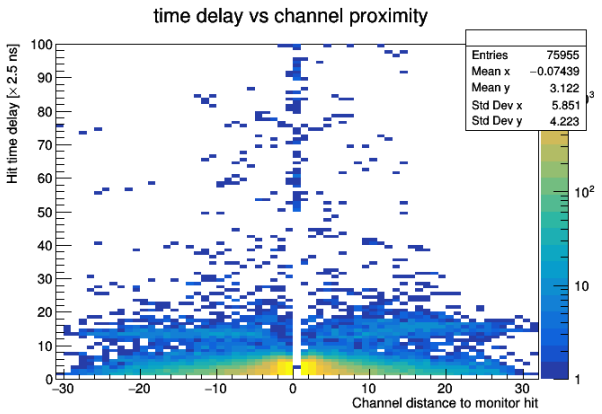
- The majority of after pulses have <10 p.e charge and delay >20 ticks



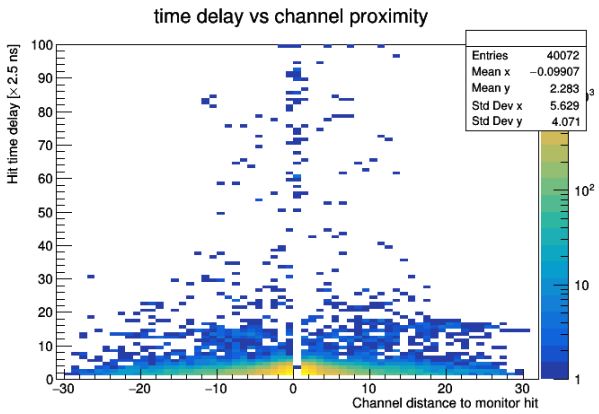
Charge cut > 10 p.e



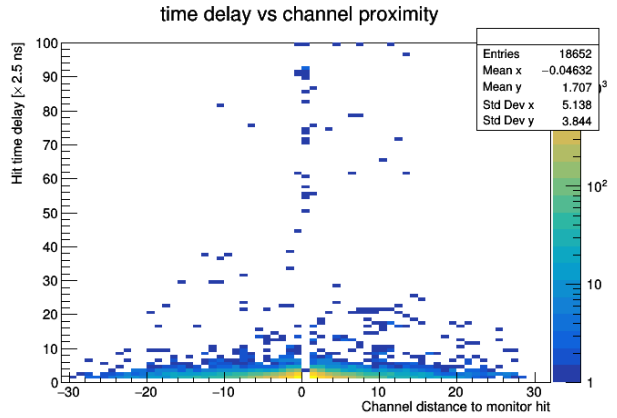
Charge cut > 20 p.e



Charge ratio cut > 0.1



Charge ratio cut > 0.2

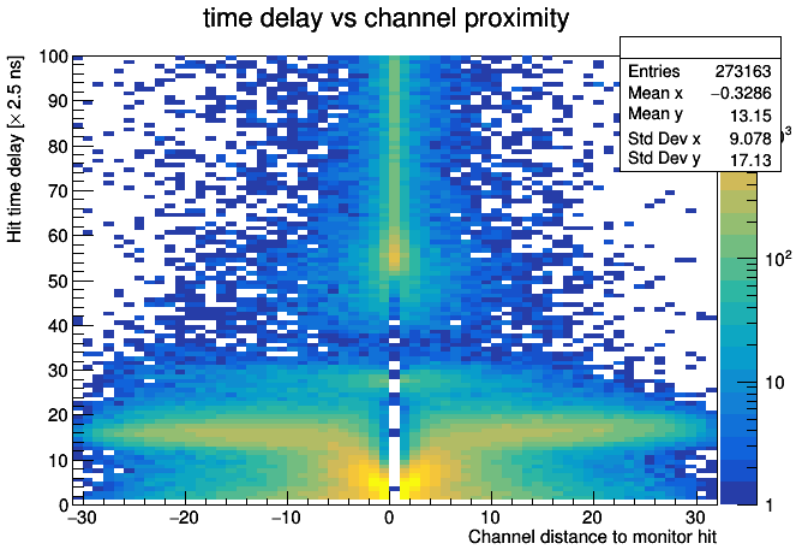


- The crosstalk talks hit amplitude is correlated to the main hit amplitude, and with Q>300 the crosstalk hit can be mistaken with a MIP hit.

Lower amplitude monitor hits

$Q_{monitor\ hit}$ >300 p.e

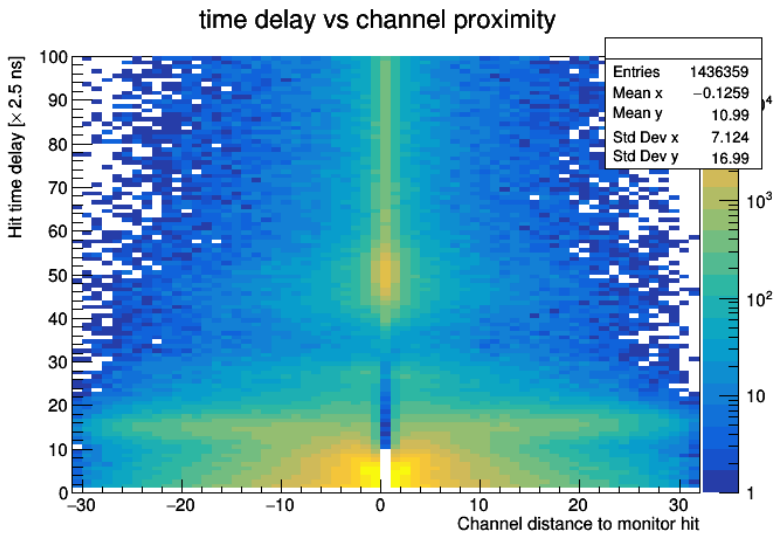
N monitor hits: 26352



45.5 % of monitor hits induce more than 10 hits in the ASIC

100 < $Q_{monitor\ hit}$ <300 pe

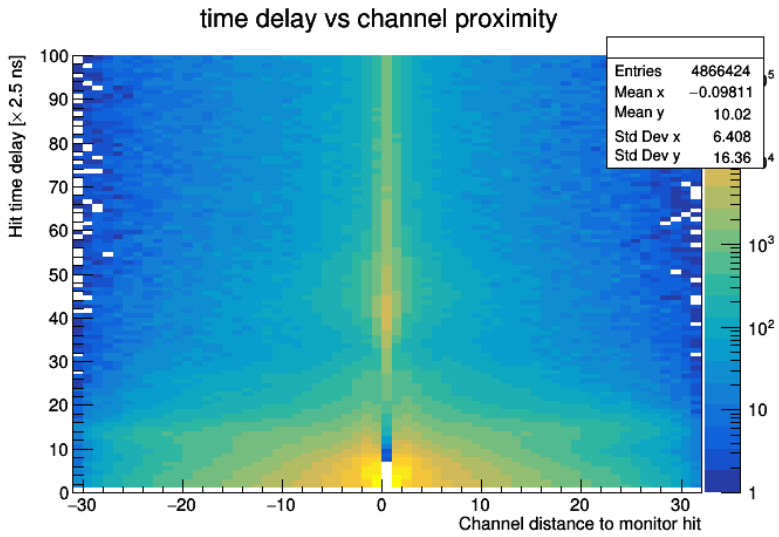
N monitor hits: 2402495



20.5 % of monitor hits induce more than 10 hits in the ASIC

30 < $Q_{monitor\ hit}$ <100 pe

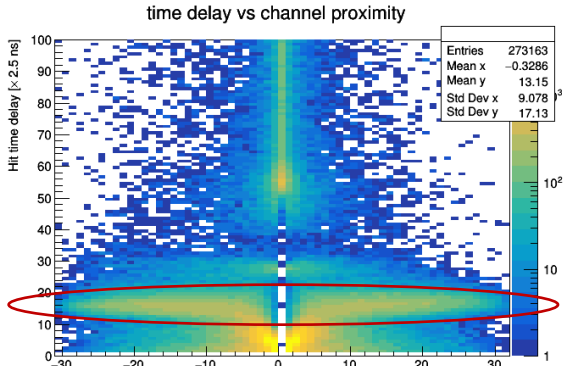
N monitor hits: 2238382

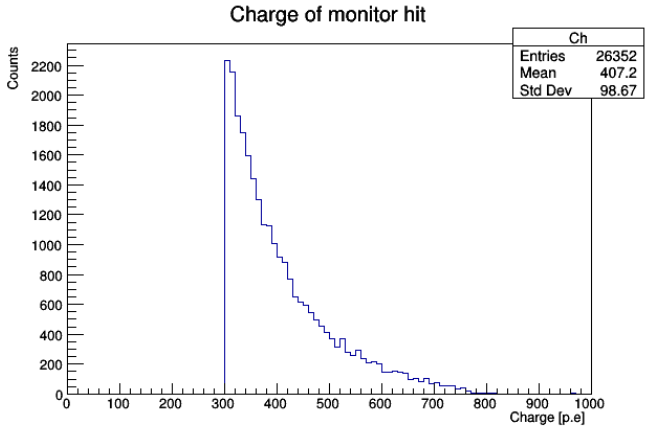


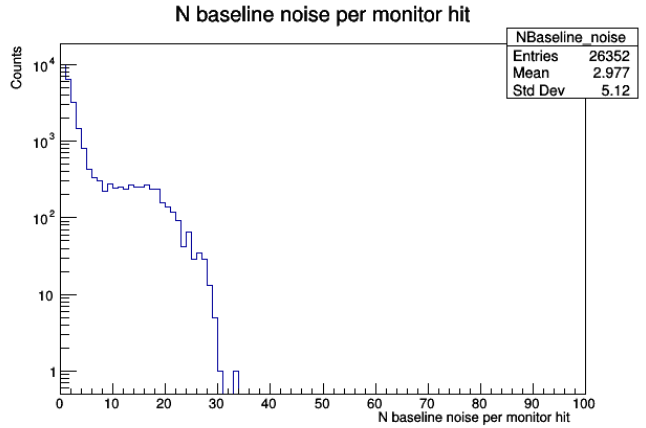
2.6 % of monitor hits induce more than 10 hits in the ASIC

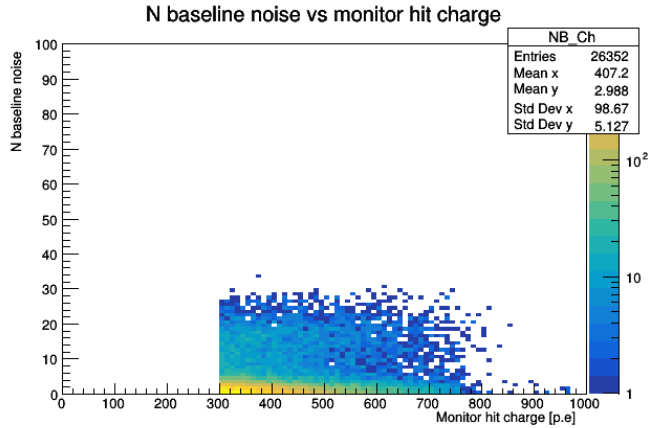
Base line shift region (delay 10-24 ticks)

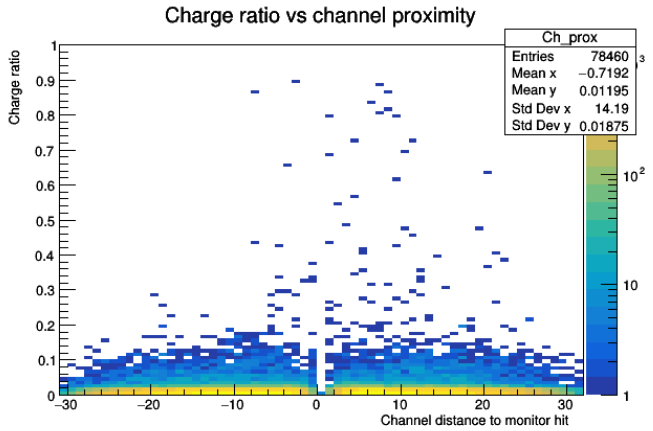
$Q_{monitor\ hit}$ >300 p.e

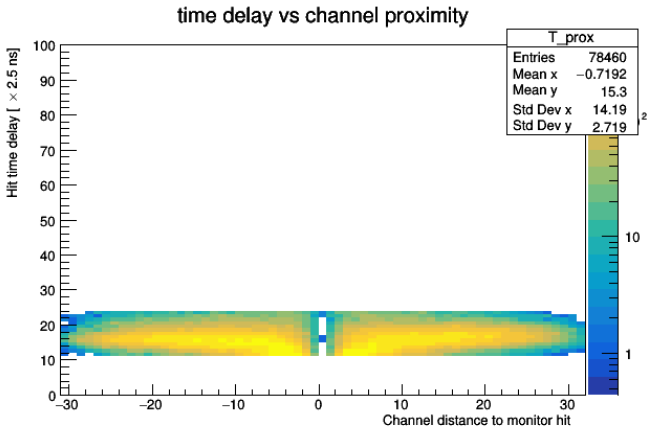


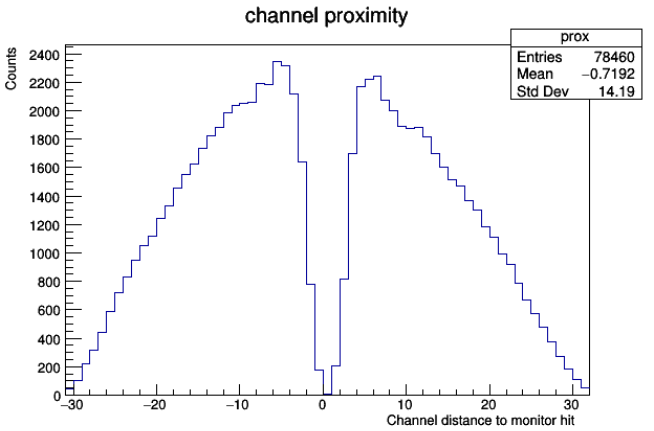






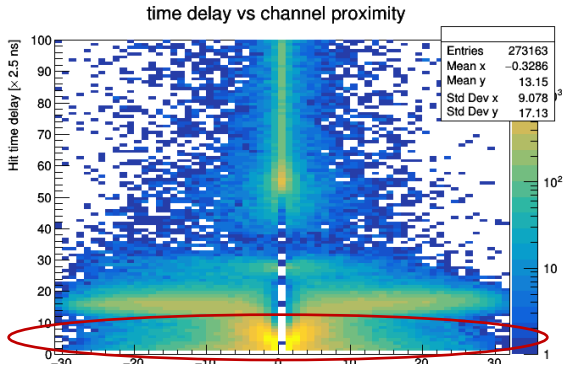


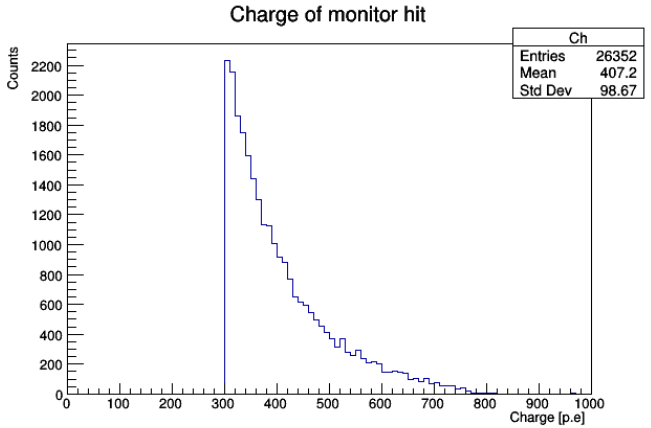


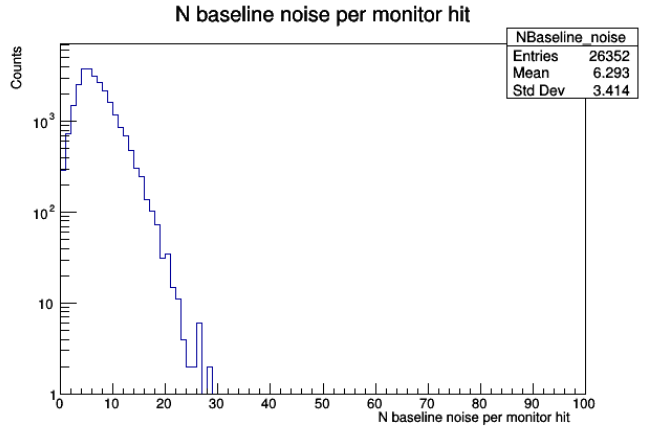


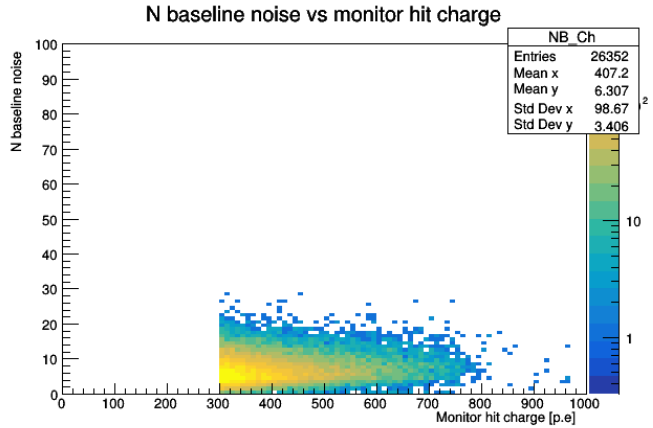
Cross talk region (delay <= 10 ticks)

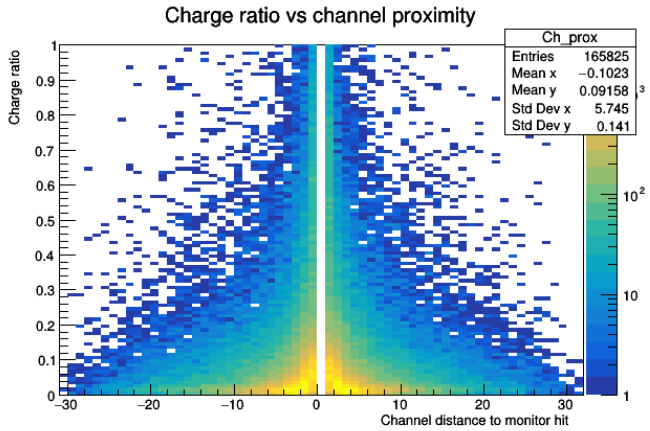
$Q_{monitor\ hit}$ >300 p.e

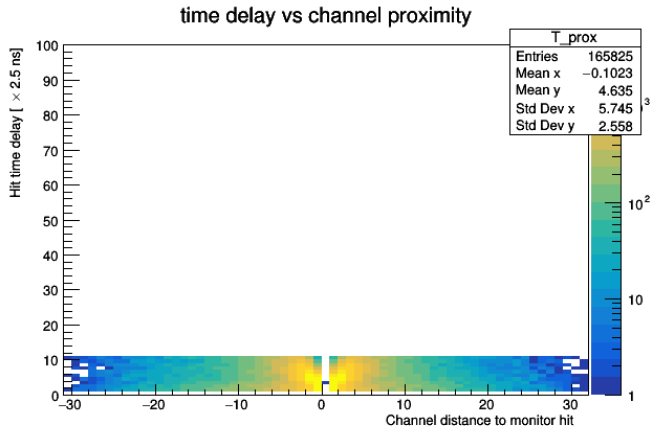


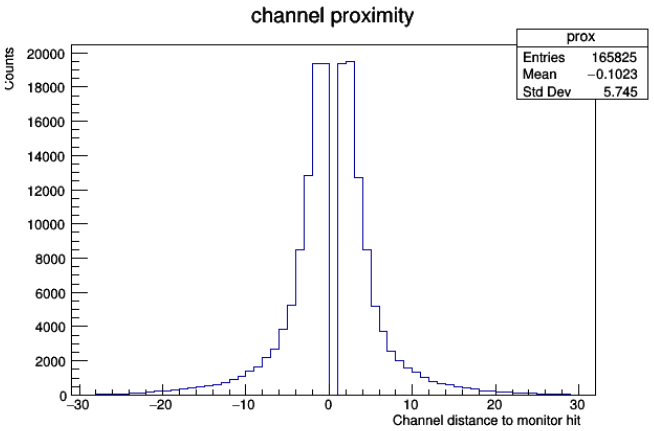






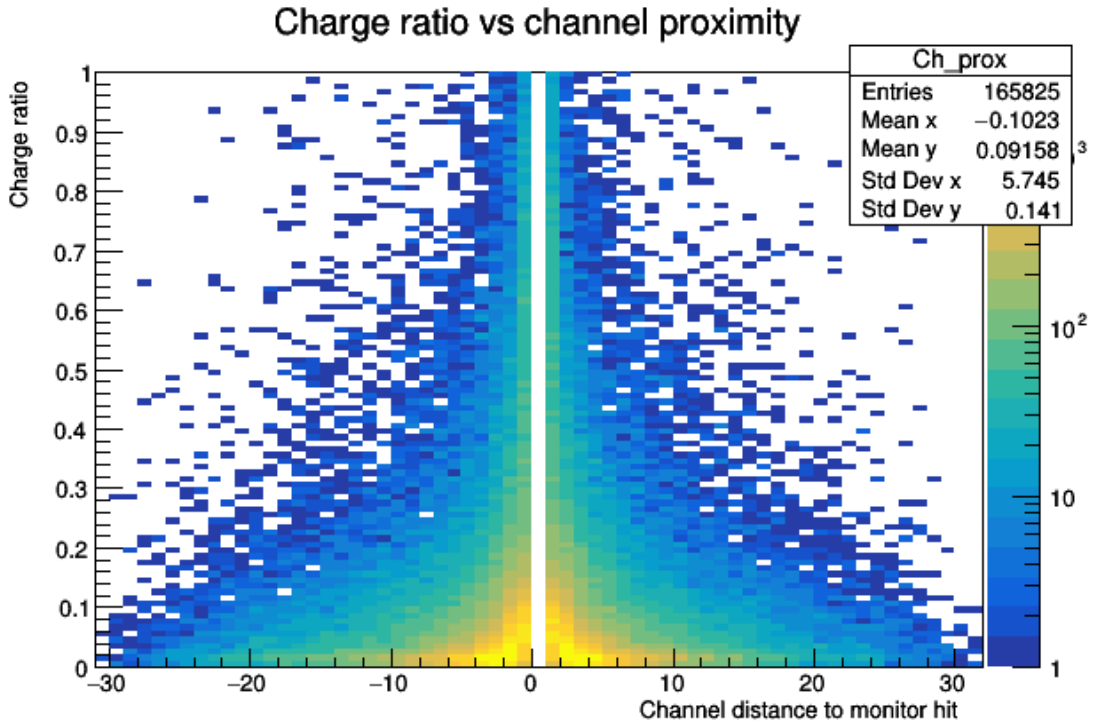


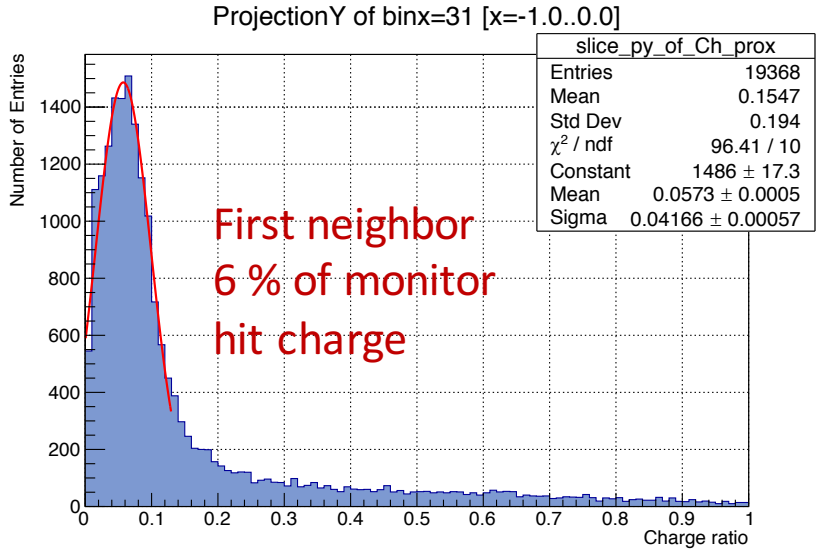


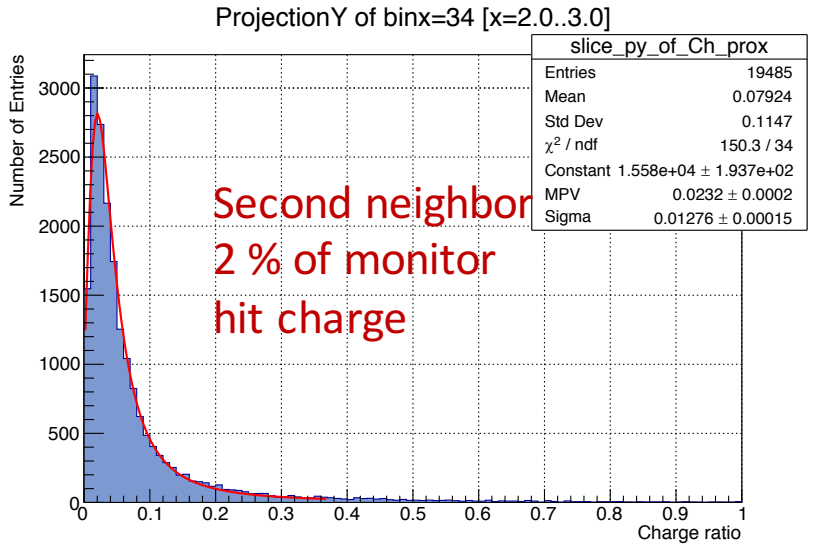


Cross talk region, Profile of first and second neighbors

$Q_{monitor\ hit}$ >300 p.e

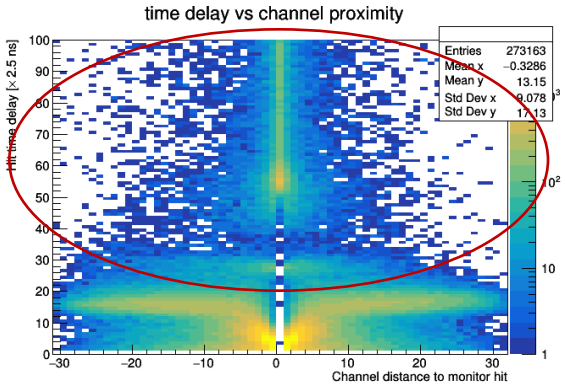


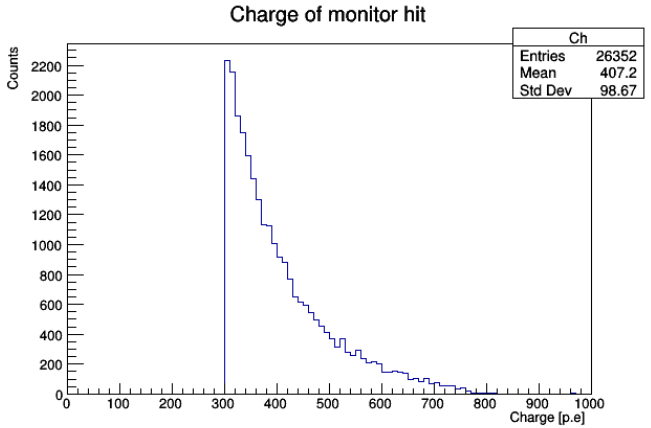


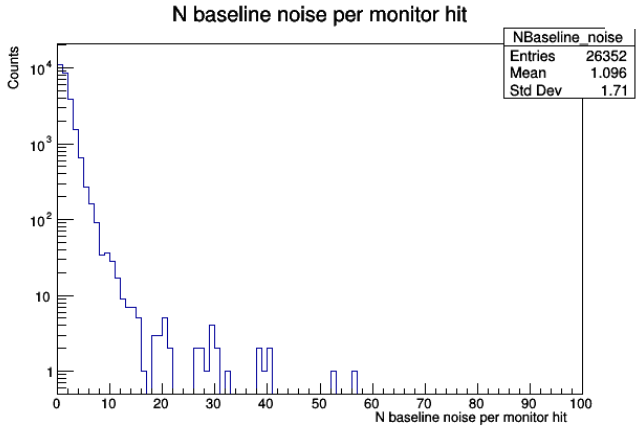


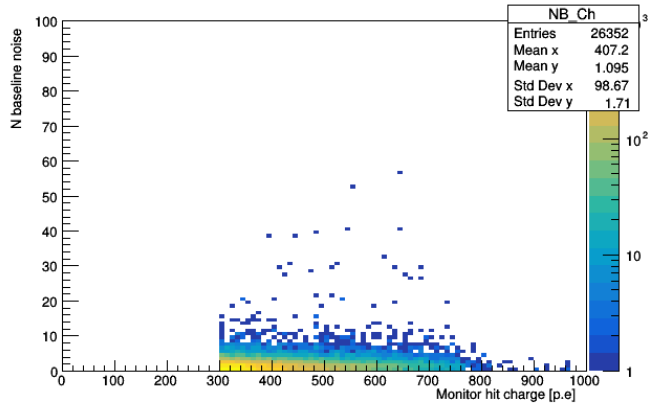
After pulse region

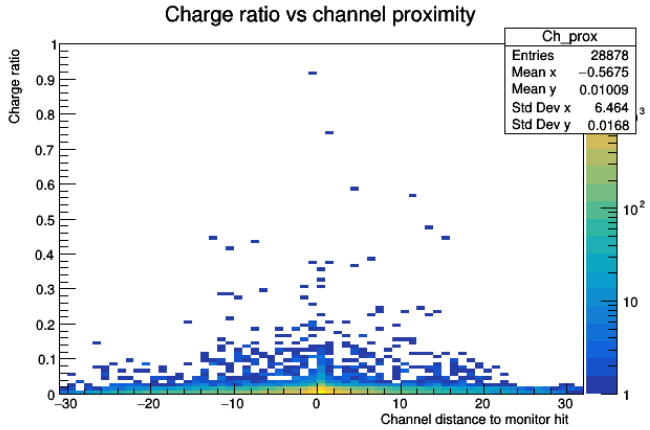
$Q_{monitor\ hit}$ >300 p.e

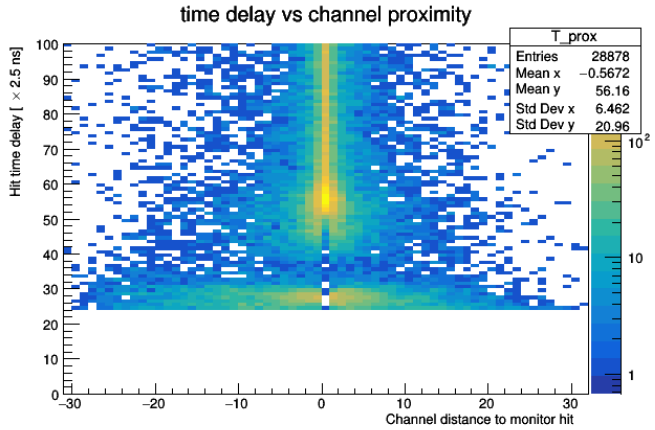


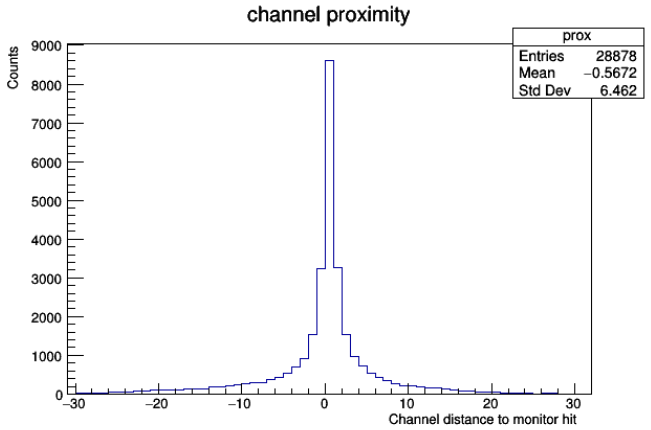












Components of the noise

$Q_{monitor\ hit}$ >300 p.e

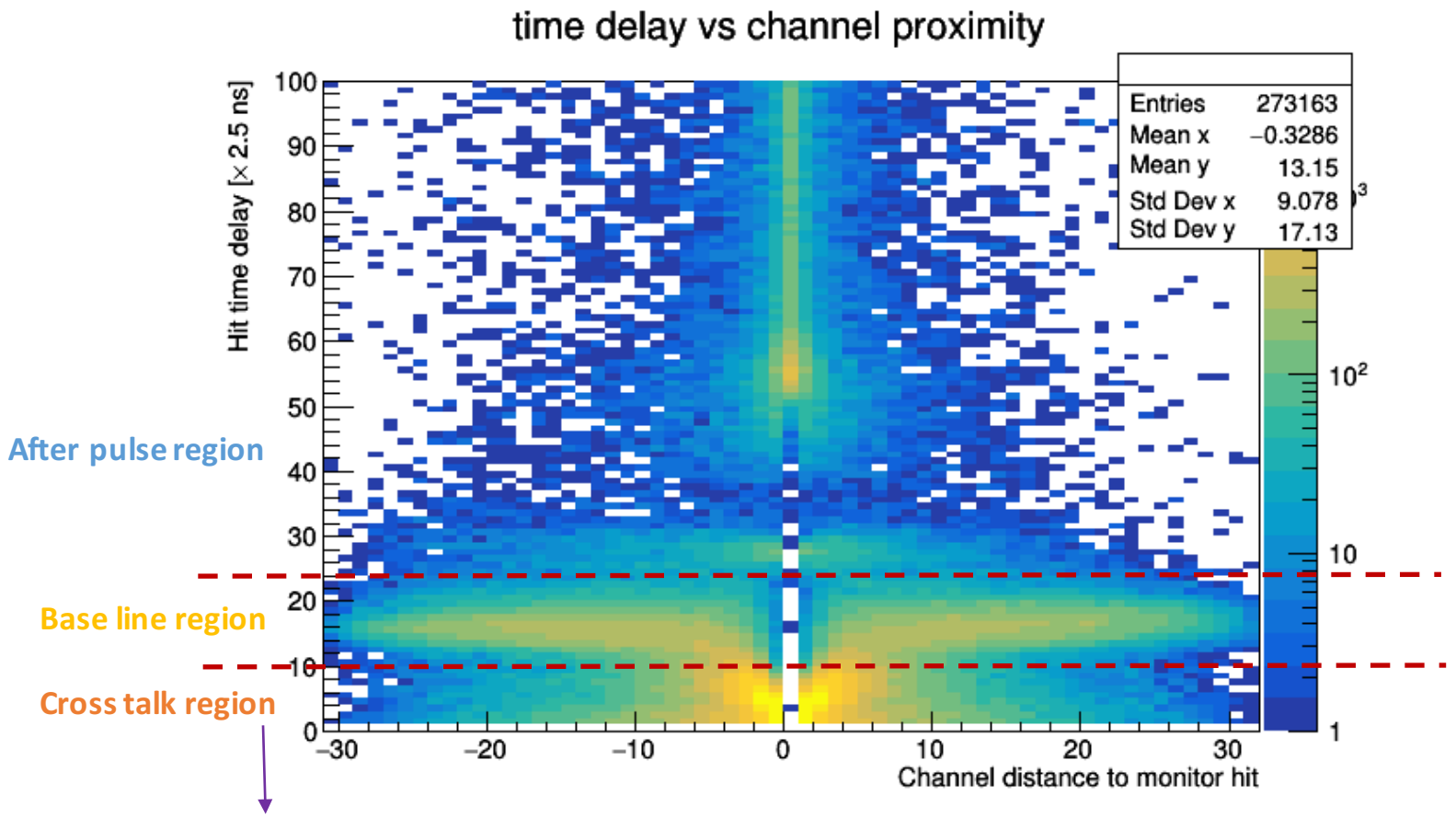
All	Cross talk	Base line	After pulse
273163	165825	78460	28876
100 %	60.1%	28.7%	10.6%

100<$Q_{monitor\ hit}$ <300 p.e

All	Cross talk	Base line	After pulse
1436359	1097614	177876	150769
100 %	76%	12%	10.5%

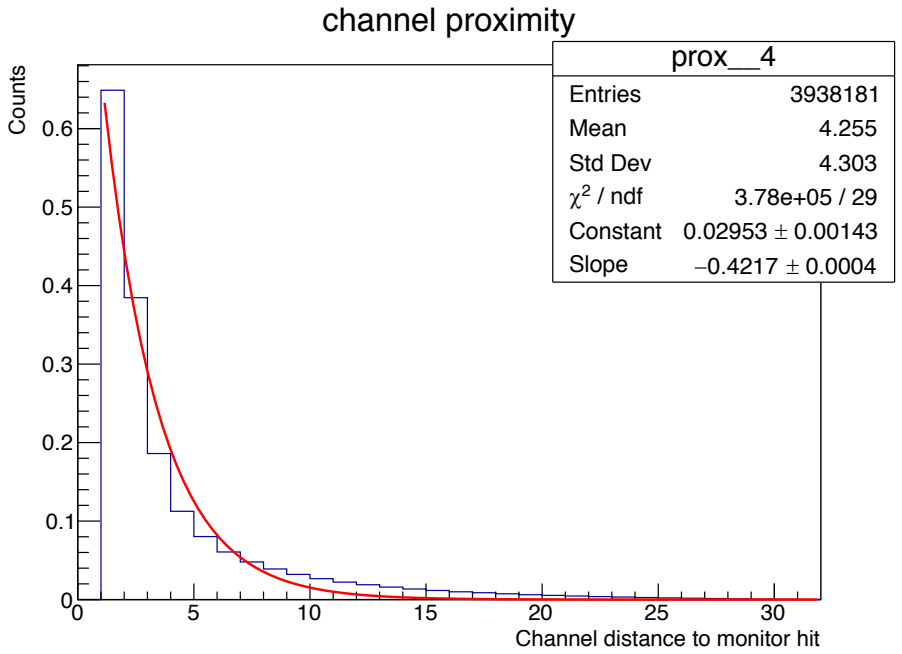
30<$Q_{monitor\ hit}$ <100 p.e

All	Cross talk	Base line	After pulse
4866424	3938181	534928	393315
100 %	81%	11%	8%



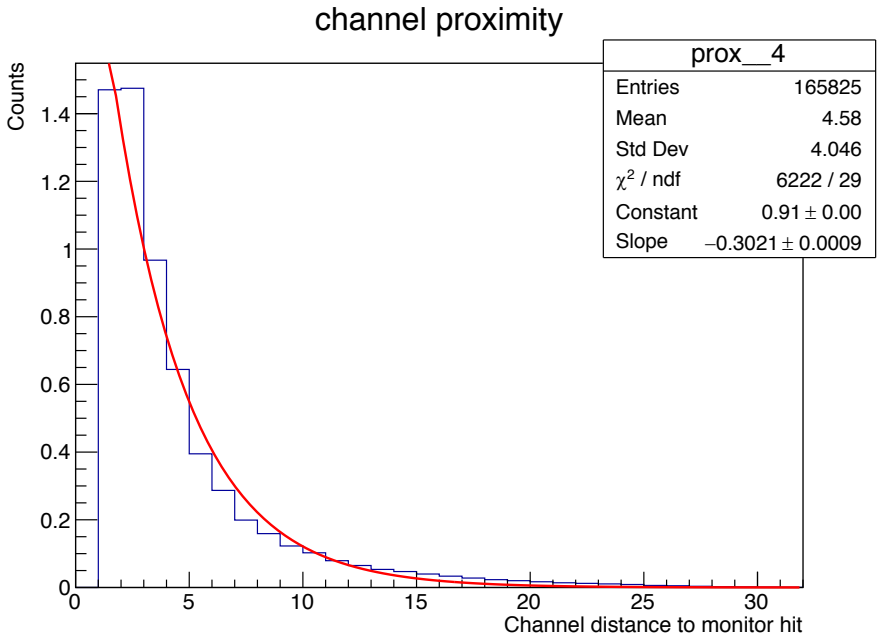
Overlapping bar hits and **shower / pile up** hits can be in cross talk region category.

Cross talk normalized to N monitor hits



$30<Q_{monitor\ hit}<100$ p.e

In 32 % of cases there is a crosstalk on each of the first neighbors

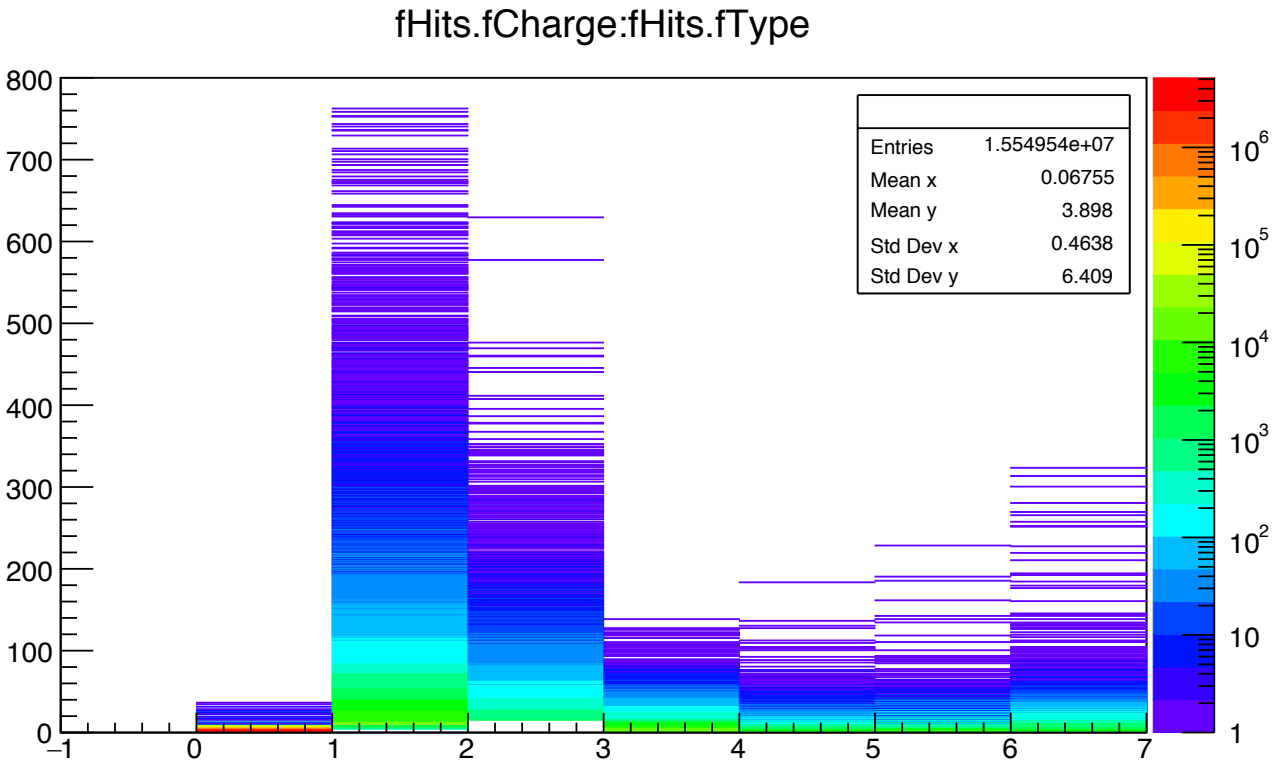


$Q_{monitor\ hit}>300$ p.e

In 72 % of cases there is a crosstalk on each of the first neighbors

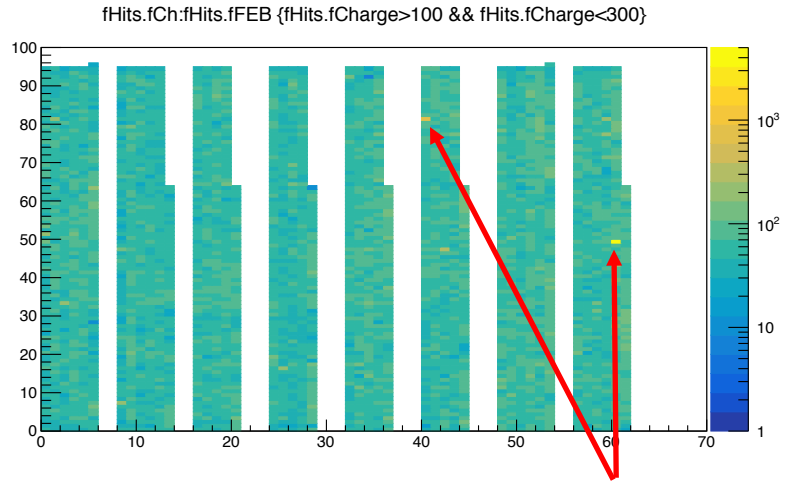
New branch: Hit type

0- Isolated hits (low charge, no larger hit in +-100 ticks)
1- Main hits (high charge, no larger hit in the preceding +-100 ticks)
2- Crosstalk High charge
3- Crosstalk low charge
4- base line noise
5- after pulse
6- hits before main hit (negative time)

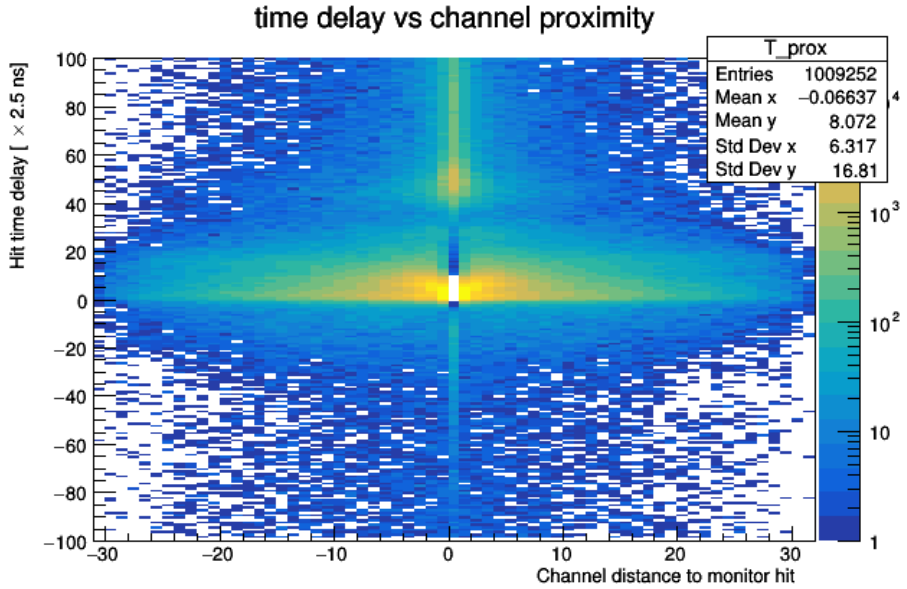


What happens before Monitor hit occur?

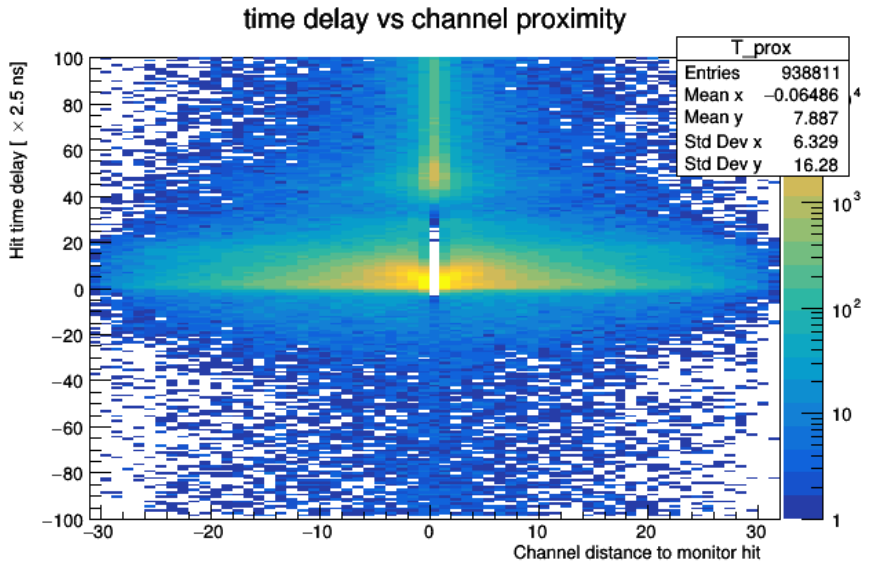
There is a hollow of hits on all channels from 20 ticks before the main hit occurs?



Noisy channels (10 times more hits)

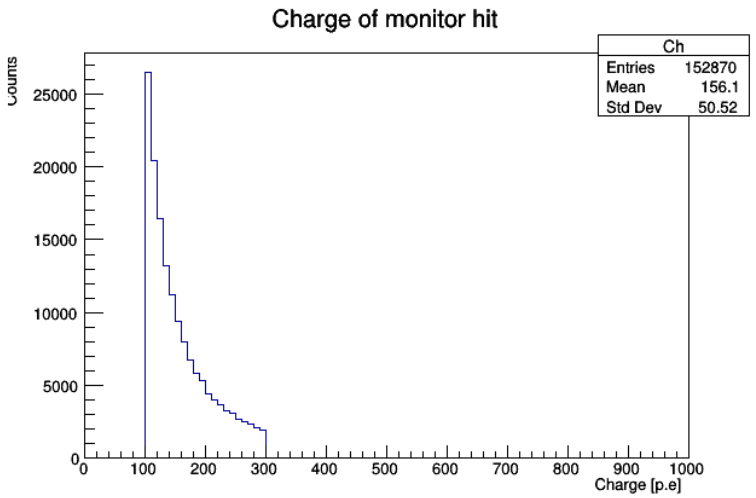


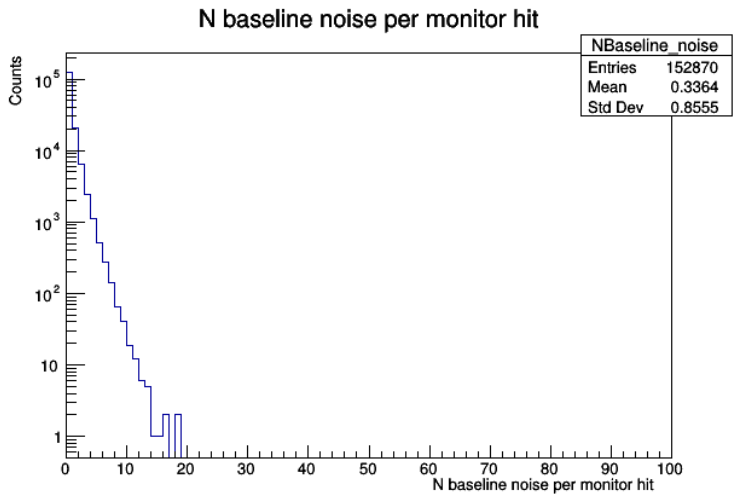
Strange behavior on monitor channel in negative delay times (more hit density) !!

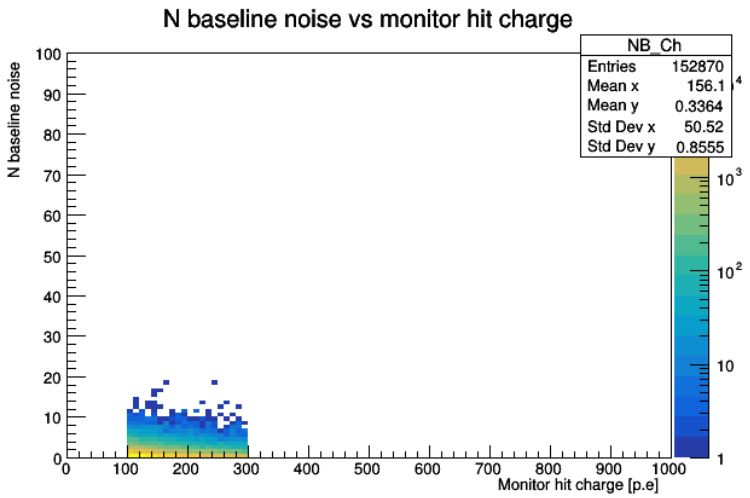


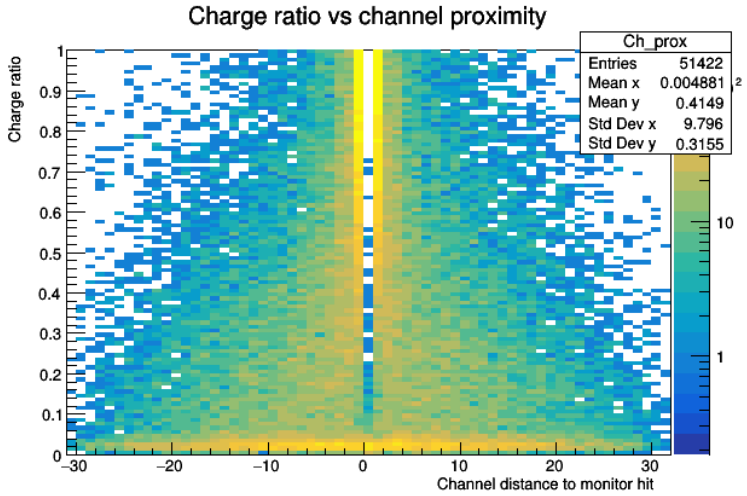
It recovered by identifying two very noisy channels and removing them.

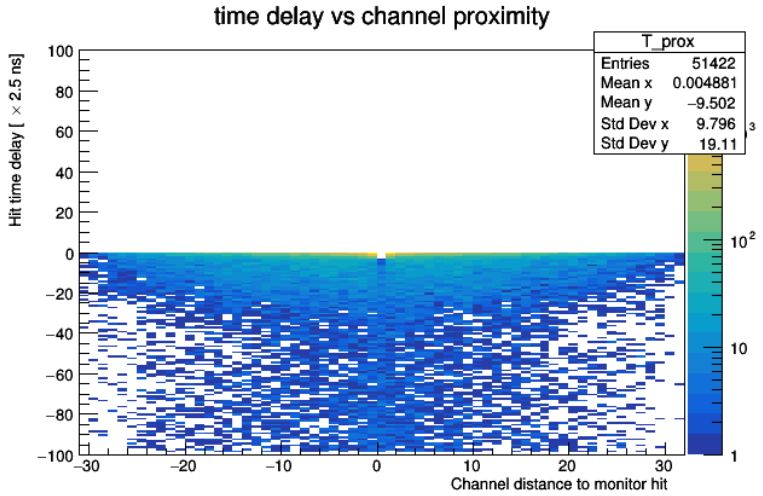
What happens before Monitor hit occur?

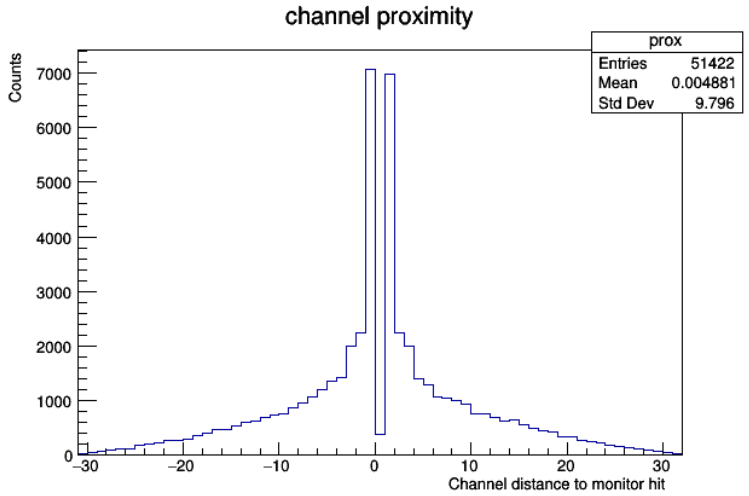






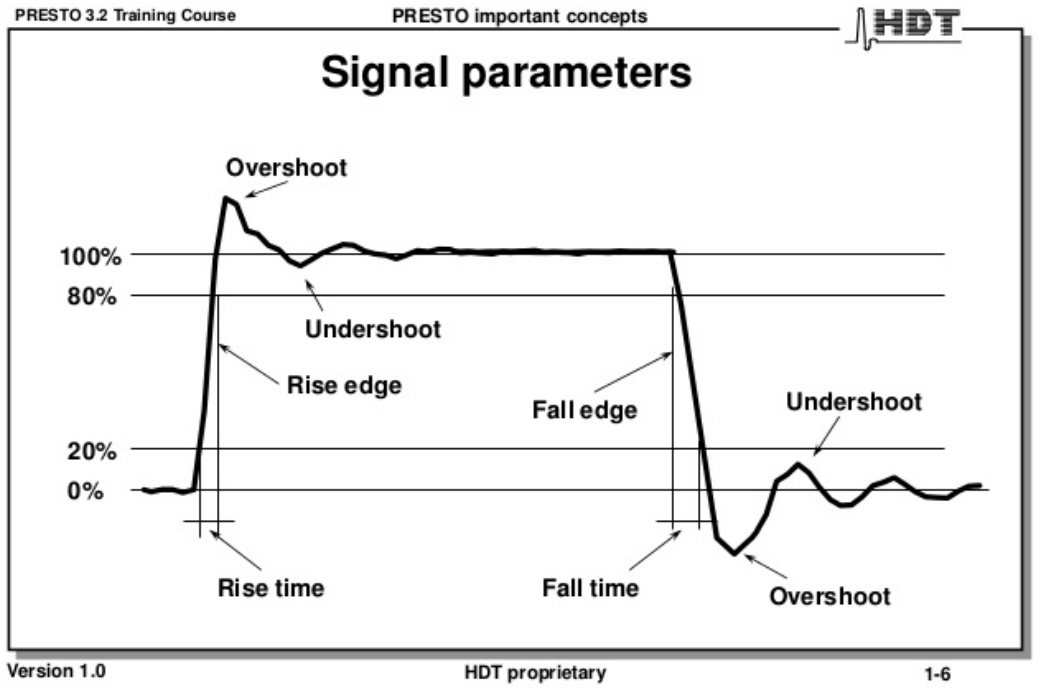


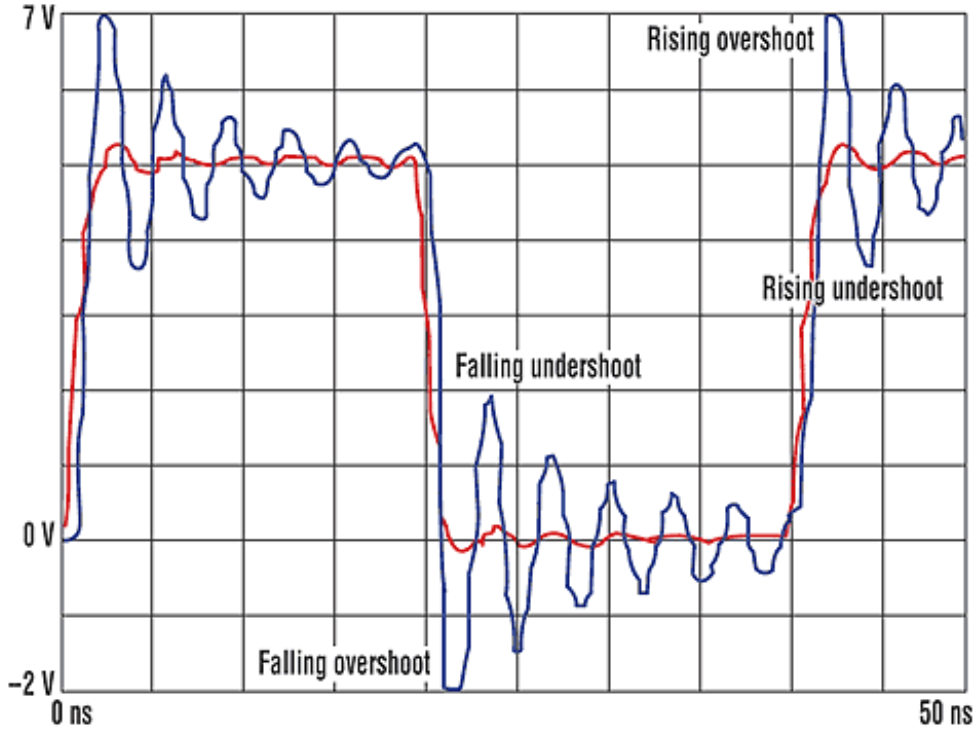




Back up

Can it be signal undershoot and ringing





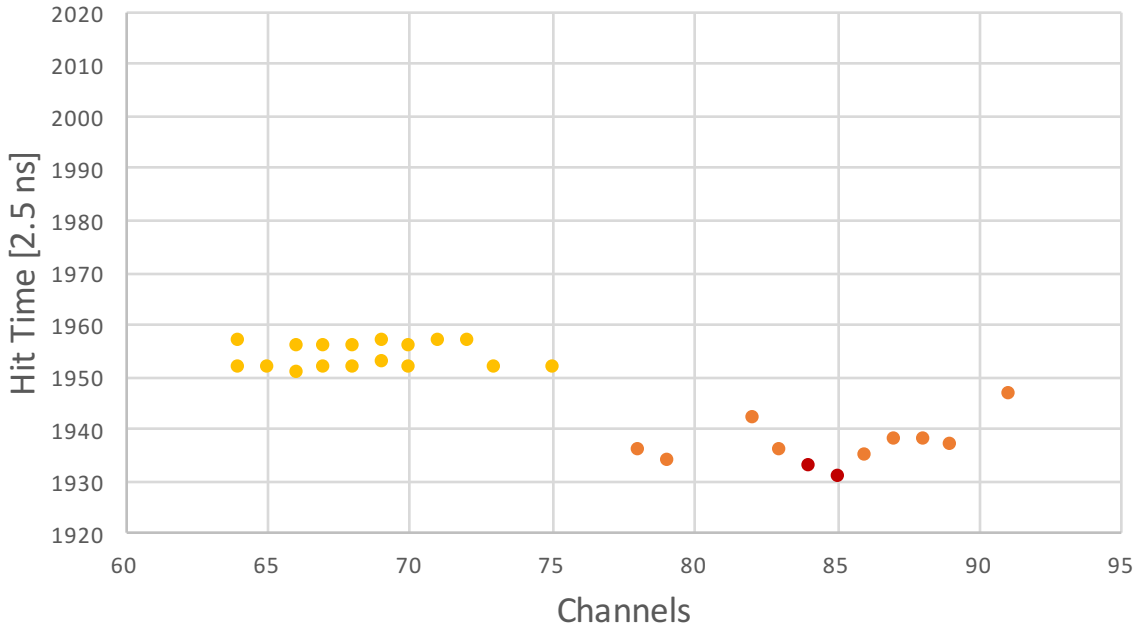
1. On nets with fast drivers, signal-integrity effects are often categorized as overshoot, undershoot, and ringing. Crosstalk also can produce the same effects, or affect timing to the point where the logic no longer operates.

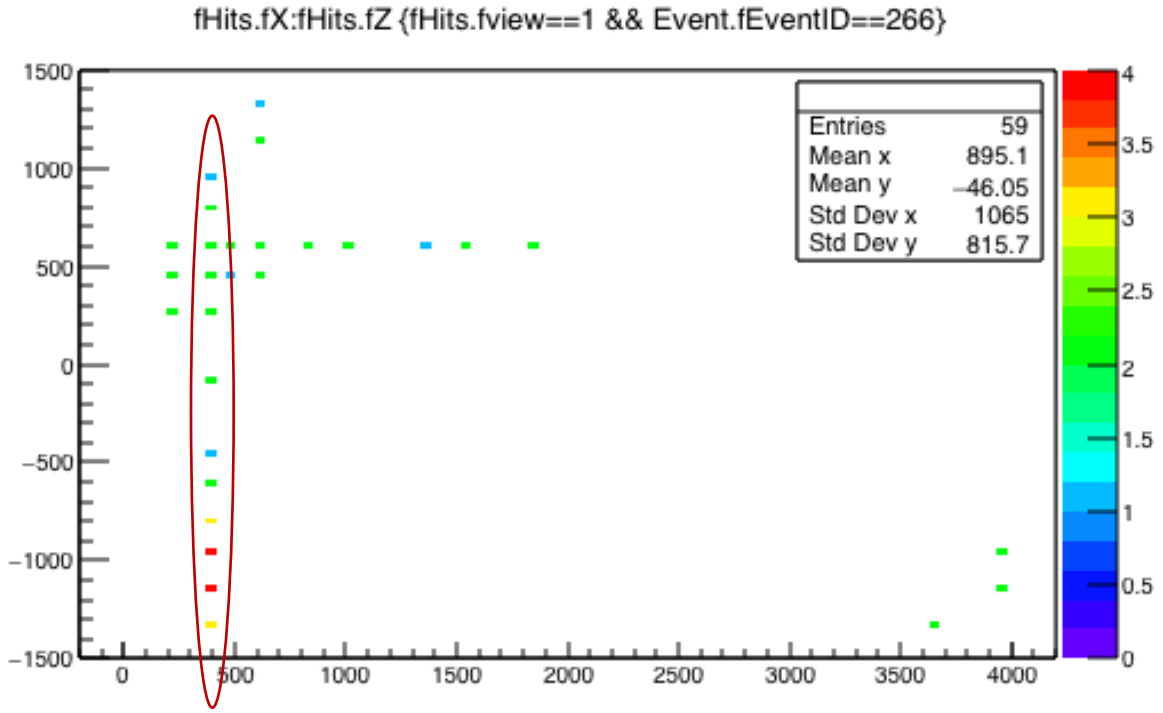
A Noisy Event example 2

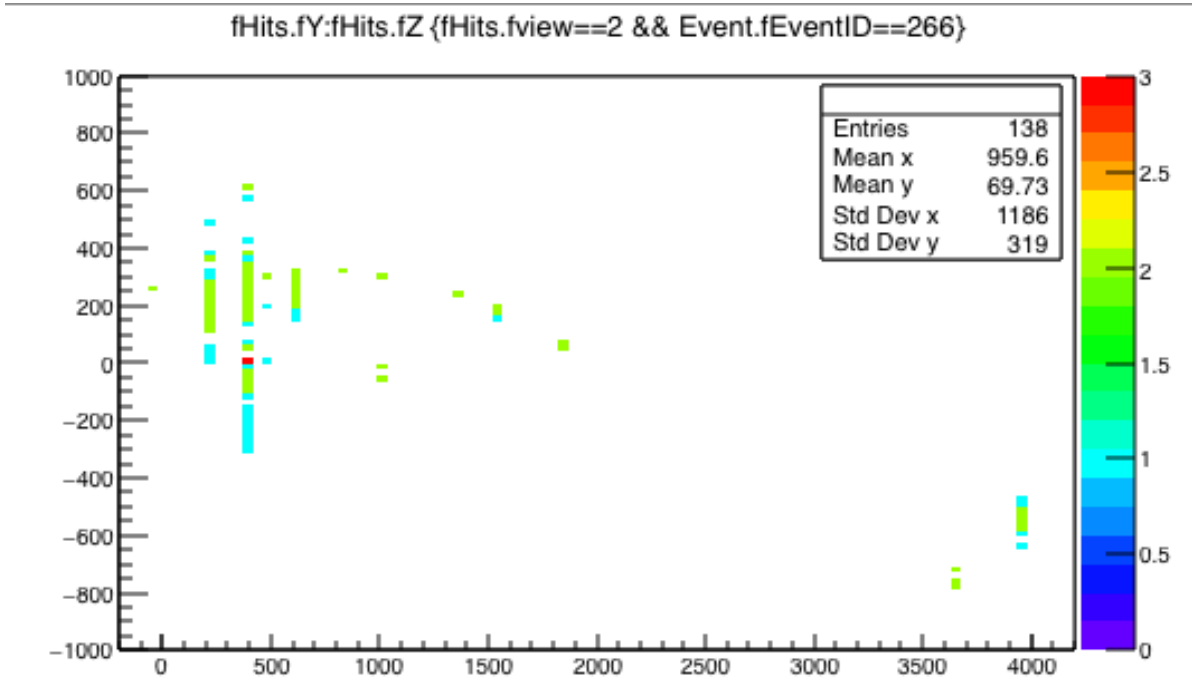
16 Dec, Spill 64260, Bunch 6
Module 3, Top view

channel	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
pulse1	4	8	4	3	3	3	2			2		2			14	13			11	13	34	37	12	14	12	12		8				
After pulse	3		3	3	3	3	3	2	1																							

Base line noise induced by saturated hits

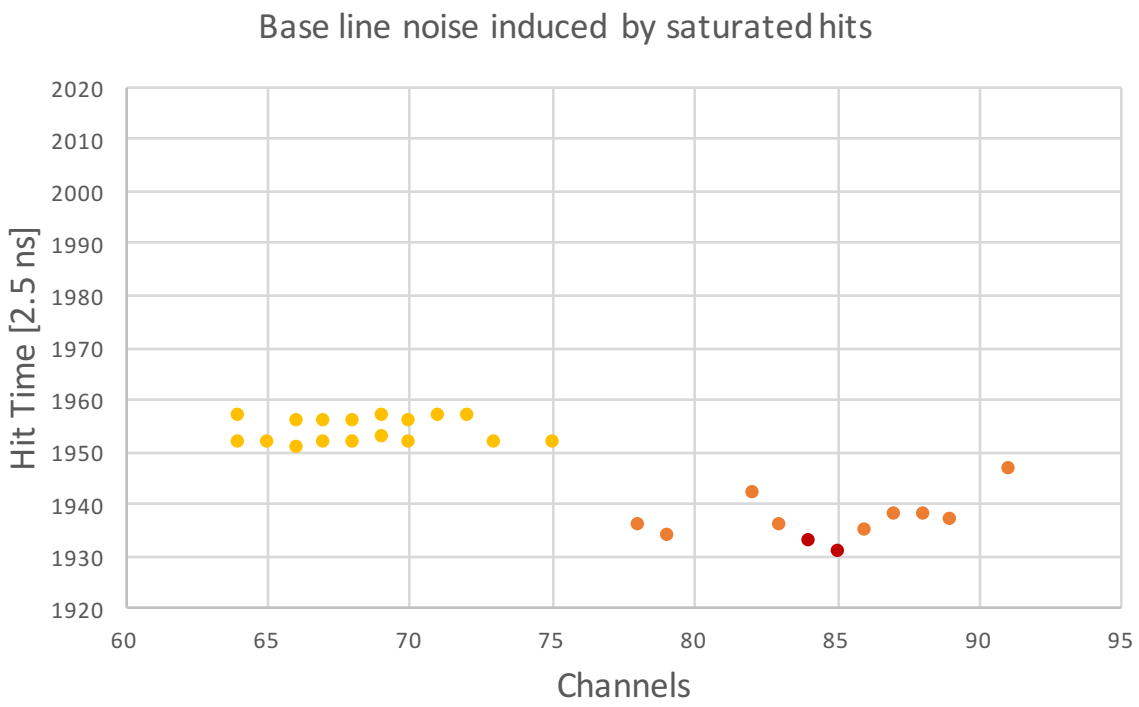





fHits.fY:fHits.fZ {fHits.fview==2 && Event.fEventID==266}
Entries 138
Mean x 959.6
Mean y 69.73
Std Dev x 1186
Std Dev y 319
1000
800
600
400
200
0
−200
−400
−600
−800
−1000
0
500
1000
1500
2000
2500
3000
3500
4000
3
2.5
2
1.5
1
0.5
0

A Noisy Event example 2

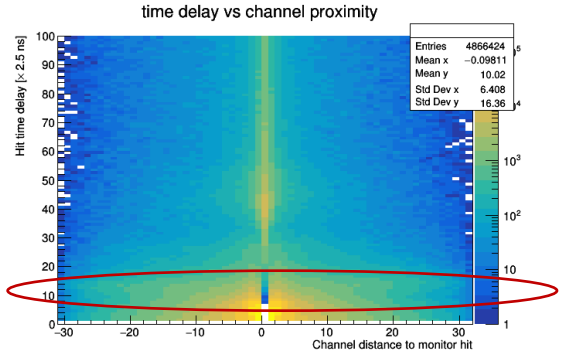
In this example separation between orange hits and yellow hits is more clear.

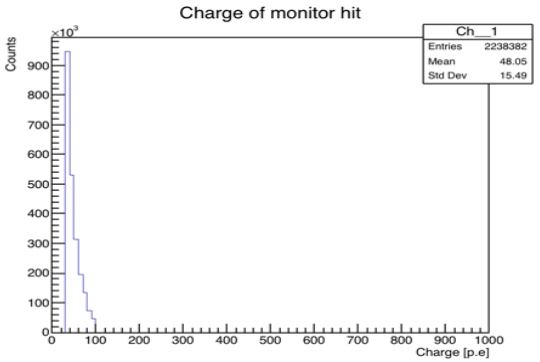


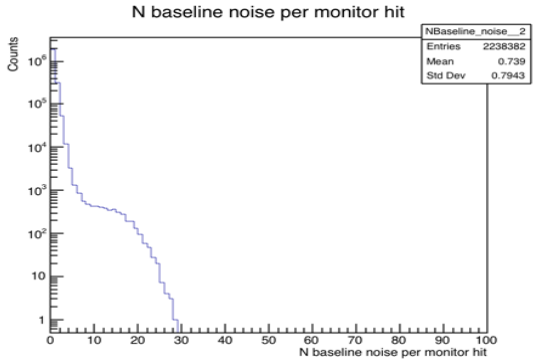
Hit type	Ch	Rising Edge	ToT	Charge
Main	85	1931	37	532.4
Main	84	1933	34	333.7
Cross talk	79	1934	13	22.0
Cross talk	86	1935	12	19.0
Cross talk	78	1936	14	17.7
Cross talk	83	1936	13	2.1
Cross talk	89	1937	12	15.1
Cross talk	87	1938	14	12.6
Cross talk	88	1938	12	12.2
Cross talk	82	1942	11	11.6
Cross talk	91	1947	8	4.0
Baseline	66	1951	4	2.0
Baseline	64	1952	4	2.1
Baseline	65	1952	8	2.1
Baseline	67	1952	3	1.9
Baseline	68	1952	3	1.8
Baseline	70	1952	2	1.8
Baseline	73	1952	2	1.8
Baseline	75	1952	2	1.6
Baseline	69	1953	3	2.3
After pulse	66	1956	3	1.9
After pulse	67	1956	3	1.9
After pulse	68	1956	3	1.9
After pulse	70	1956	3	1.8
After pulse	64	1957	3	2.3
After pulse	69	1957	3	1.9
After pulse	71	1957	2	1.7
After pulse	72	1957	1	1.7

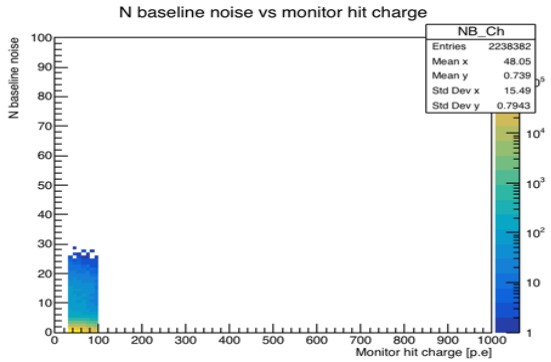
Base line shift only (delay 10-20 ticks)

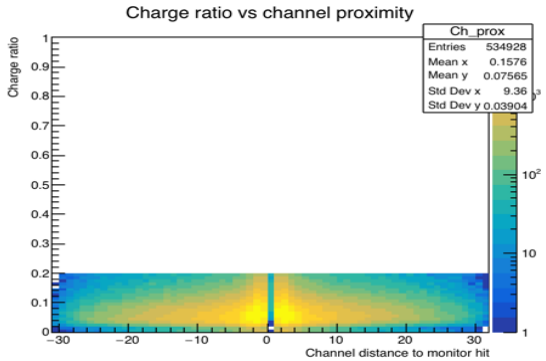
30<$Q_{monitor\ hit}$ <100 p.e

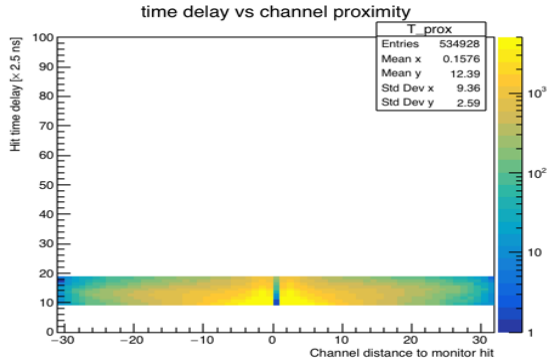


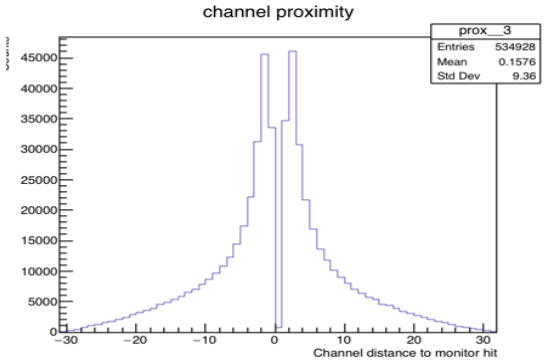


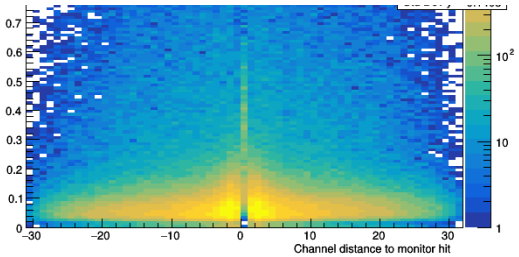


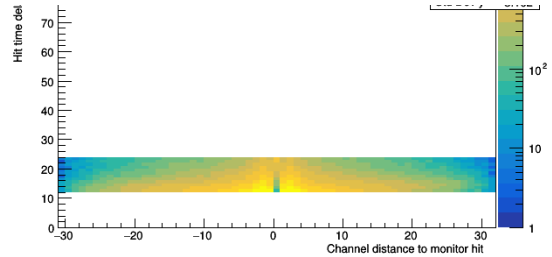


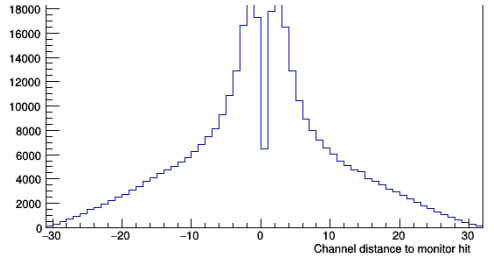






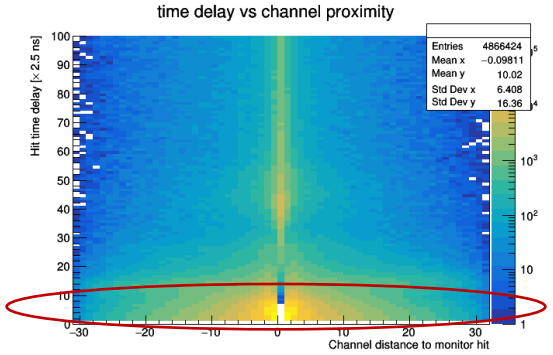


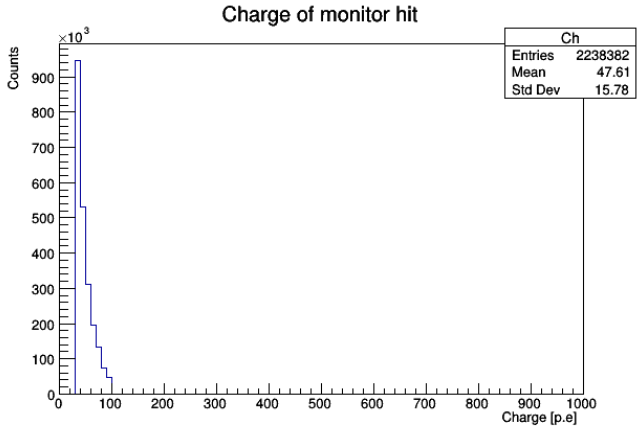


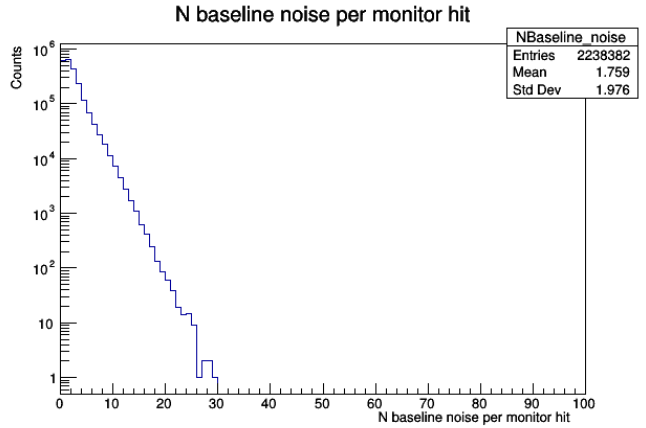


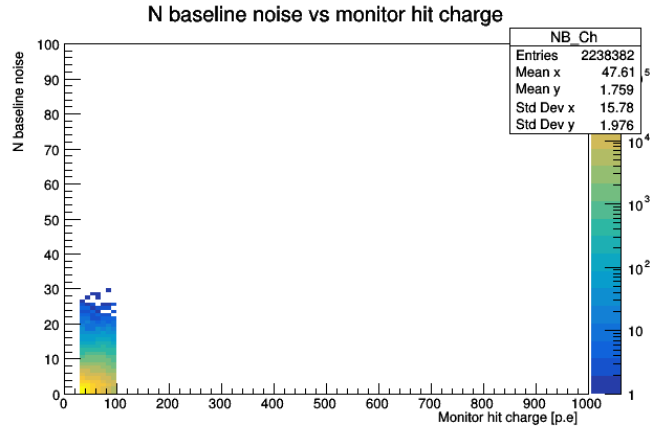
Cross talk region (delay <= 10 ticks)

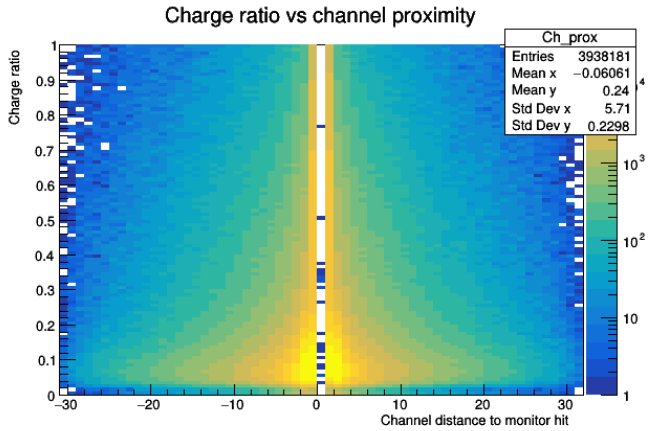
$30<Q_{monitor\ hit}<100$ p.e

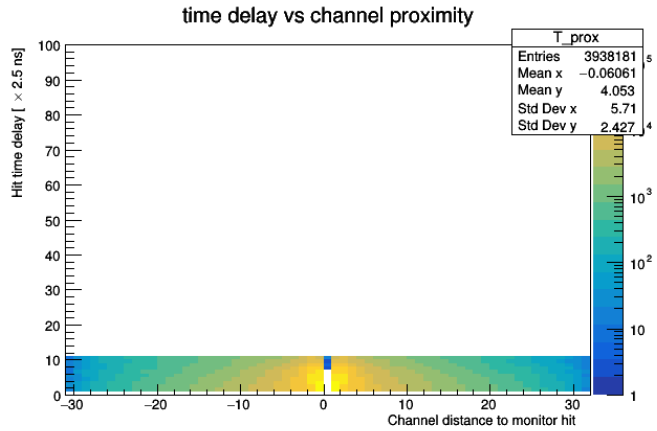


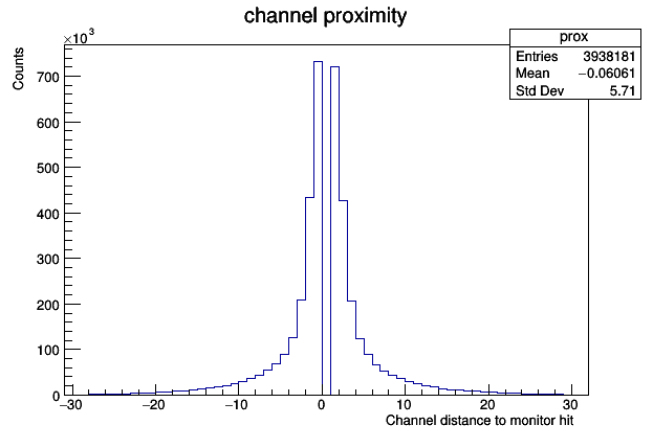






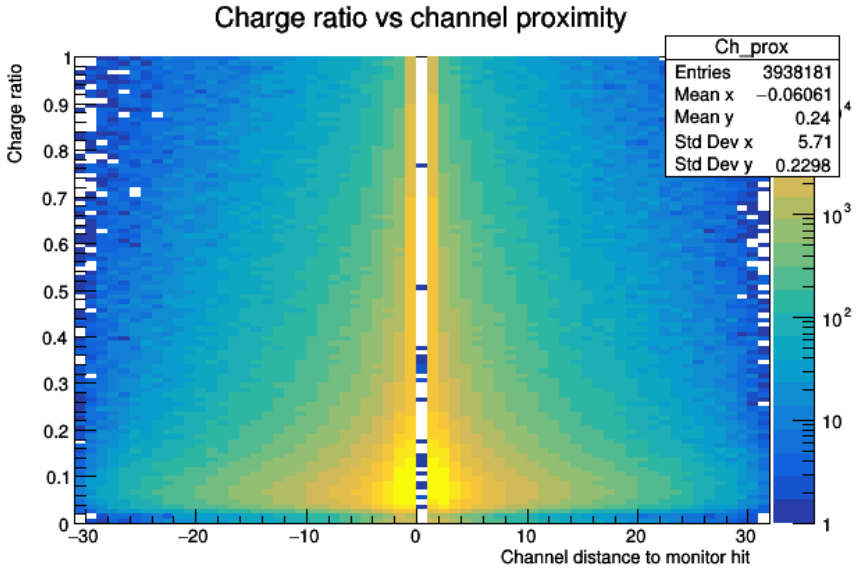


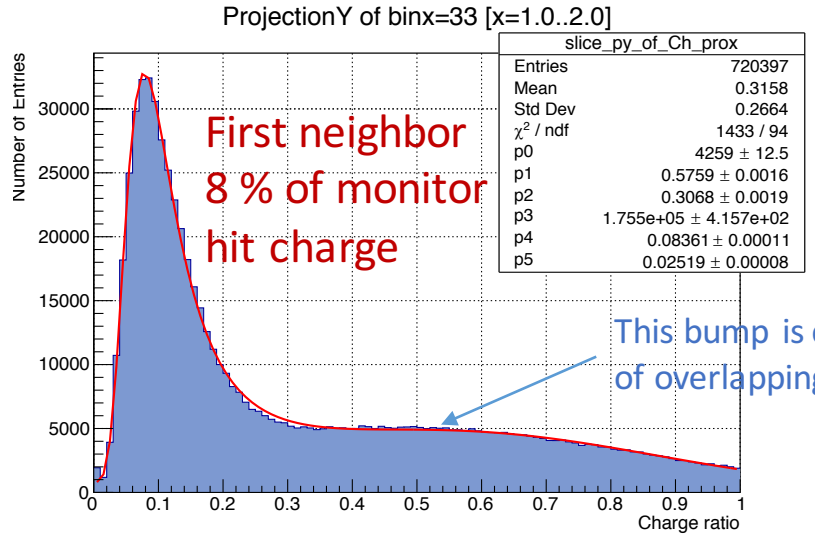


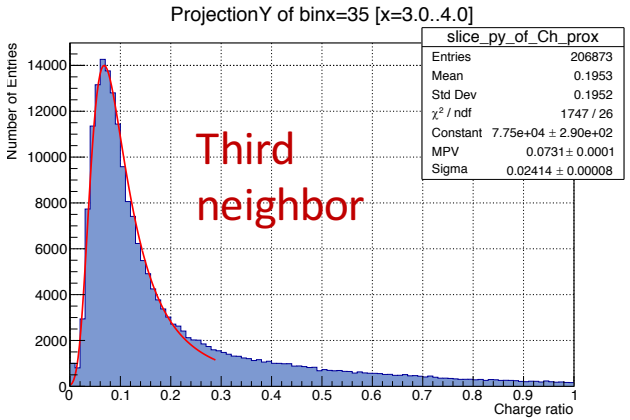


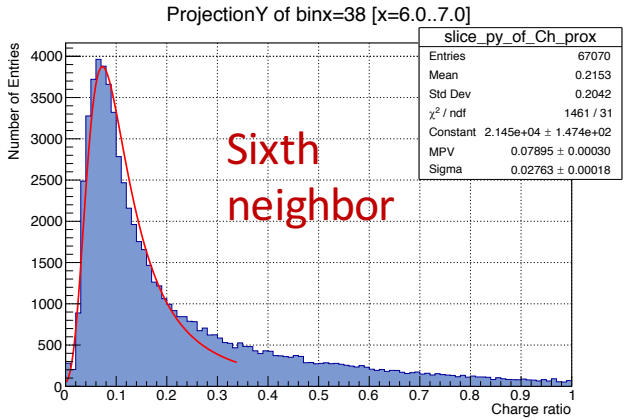
Crosstalk region, Profile of first and second neighbors

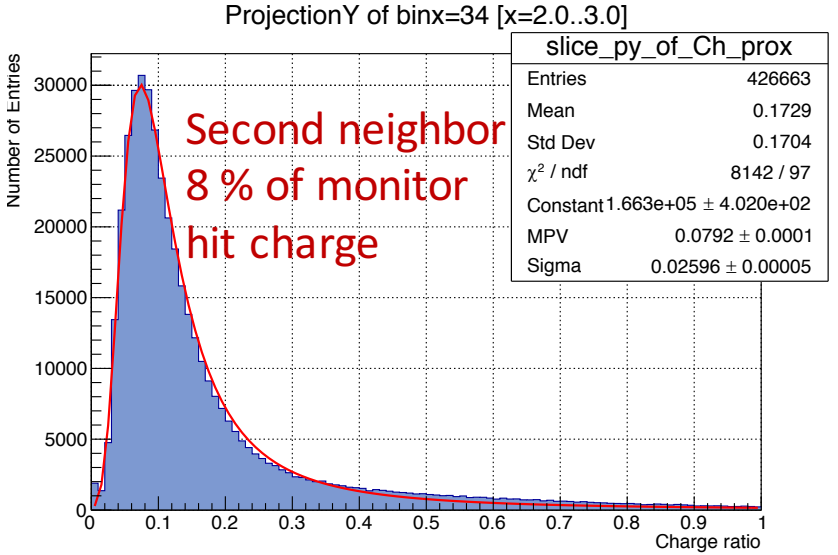
$30<Q_{monitor\ hit}<100$ p.e





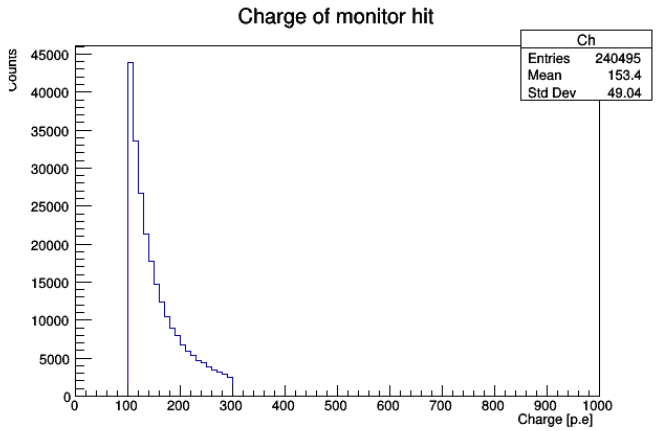


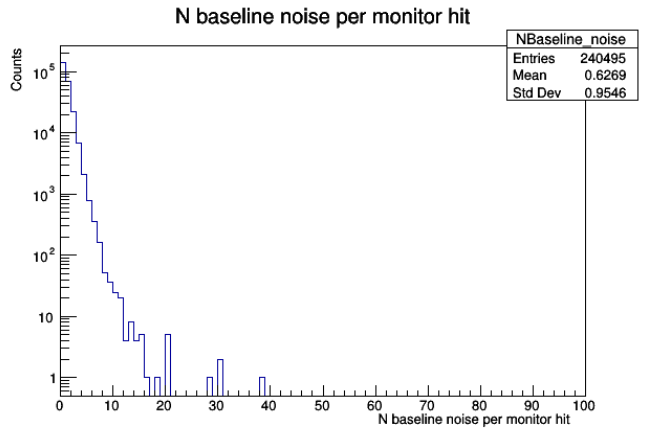


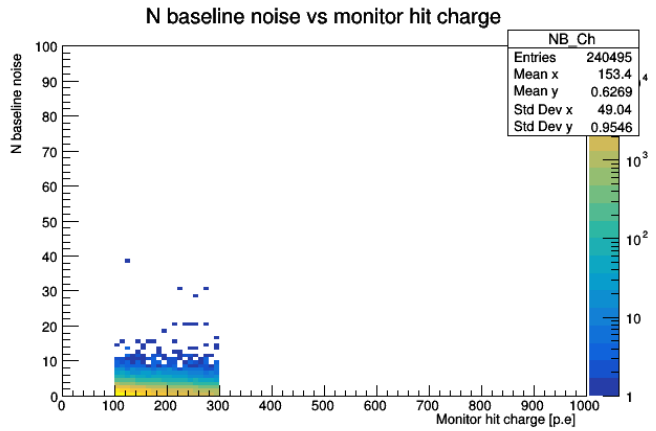


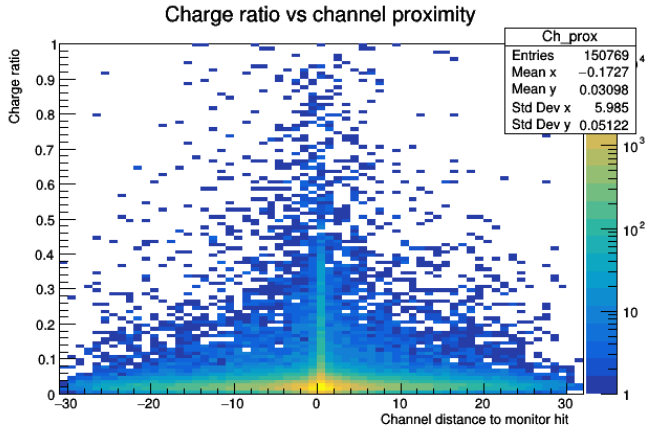
After pulse only (delay > 24 ticks)

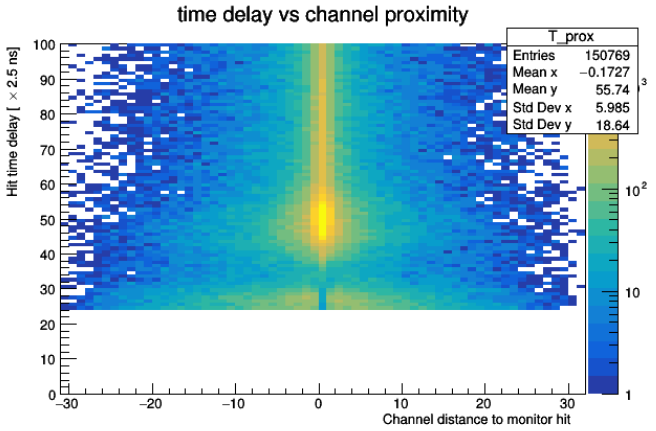
100<$Q_{monitor\ hit}$ <300 p.e

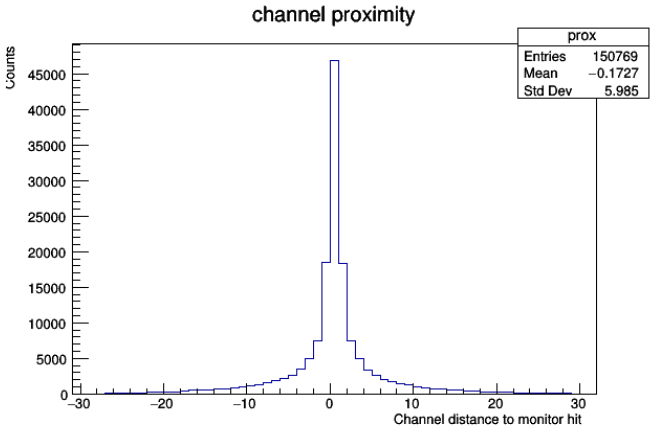






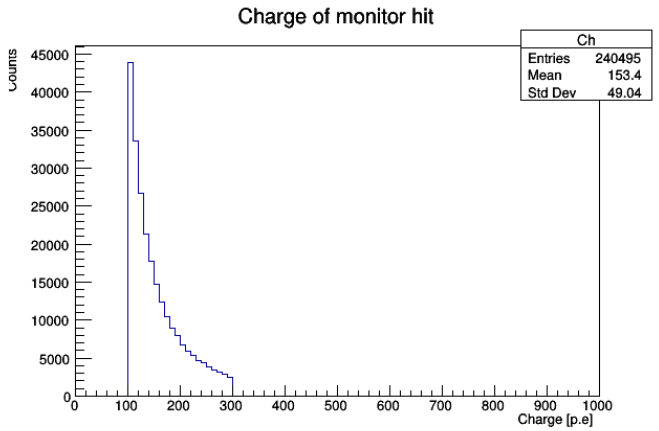


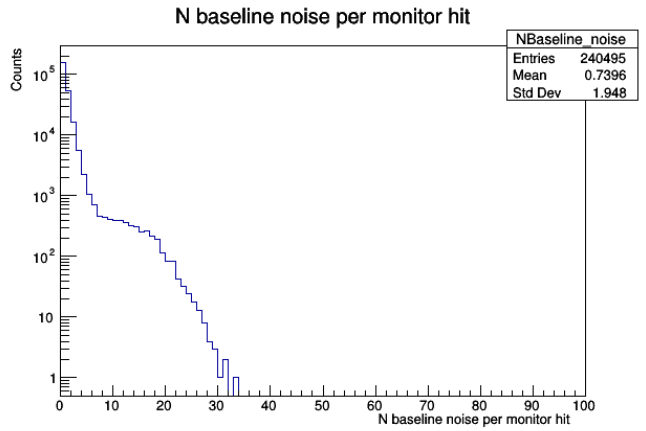


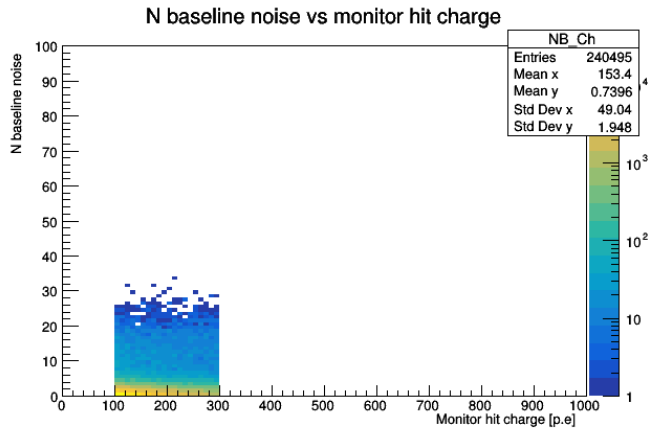


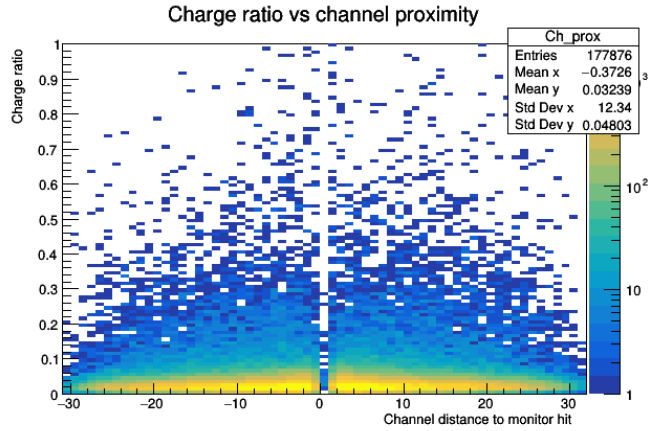
Base line shift only (delay 11_24 ticks)

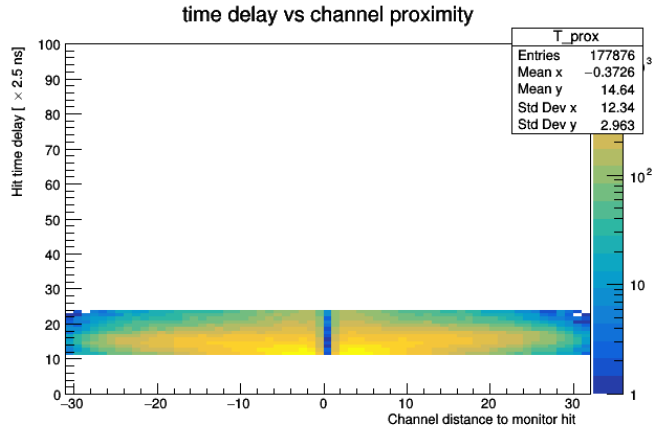
100<$Q_{monitor\ hit}$ <300 p.e

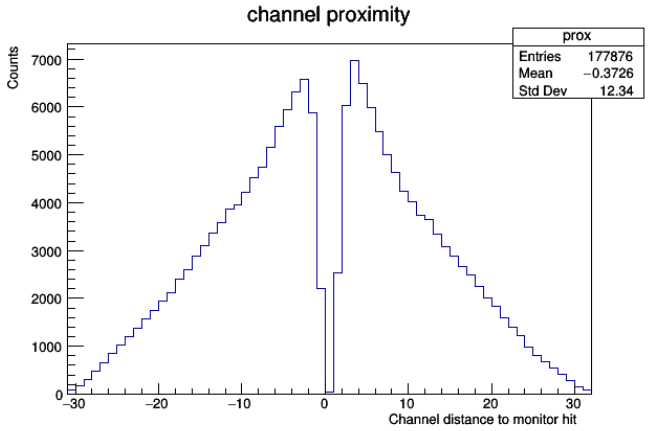






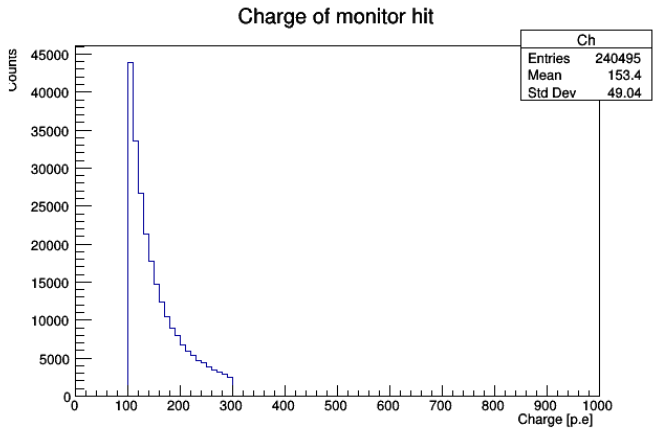


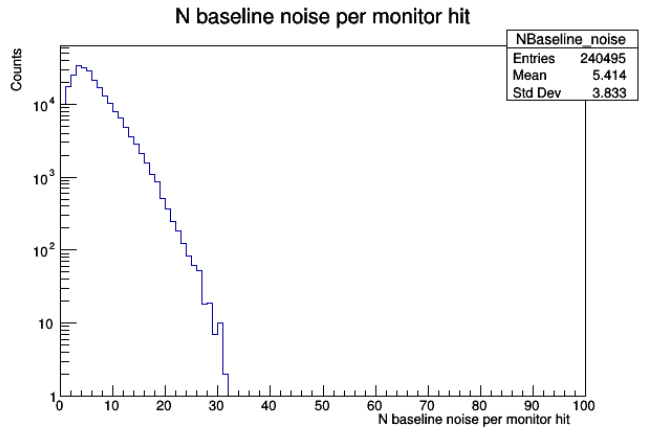


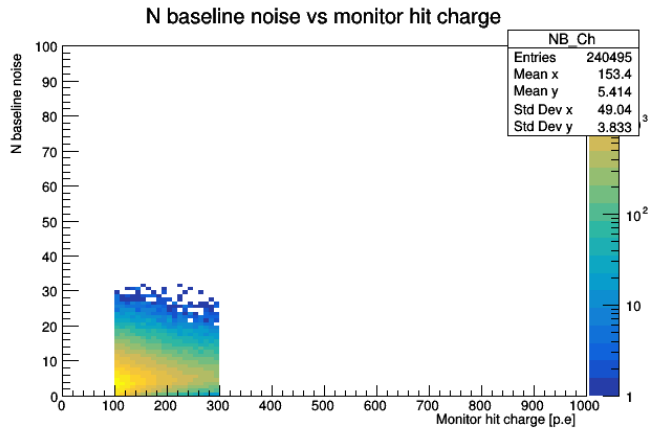


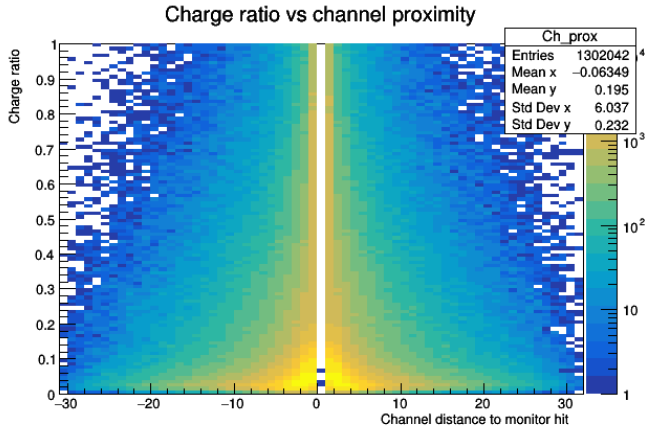
Cross talk region (delay <= 11 ticks)

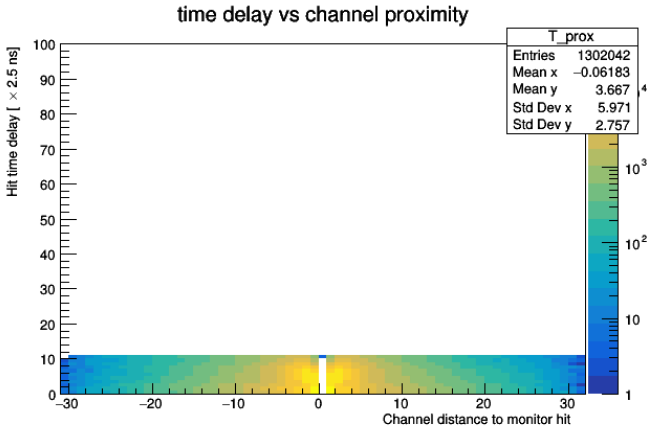
100<$Q_{monitor\ hit}$ <300 p.e

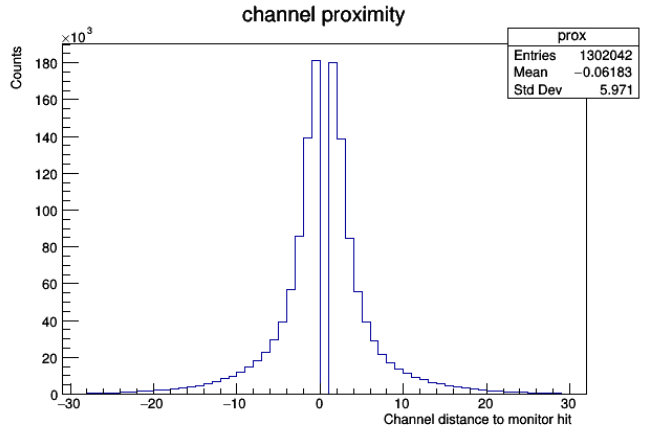




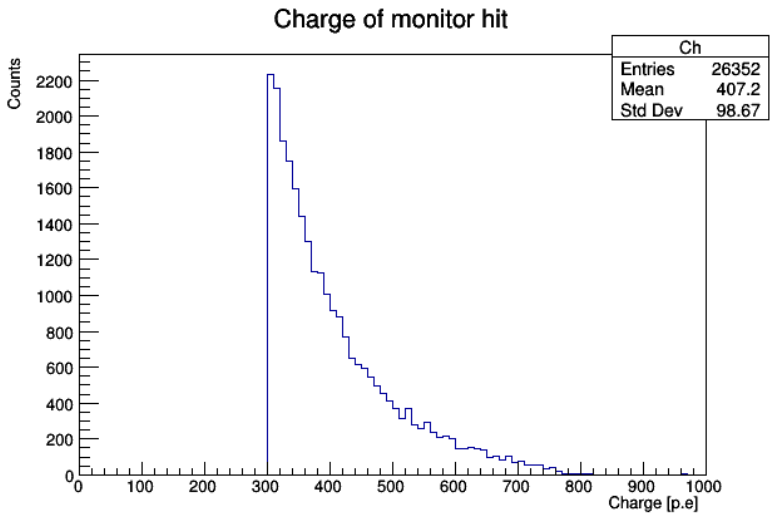


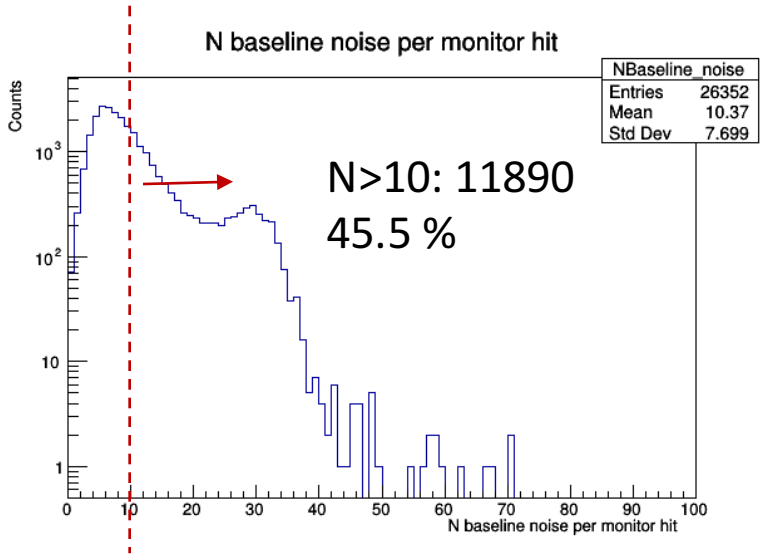


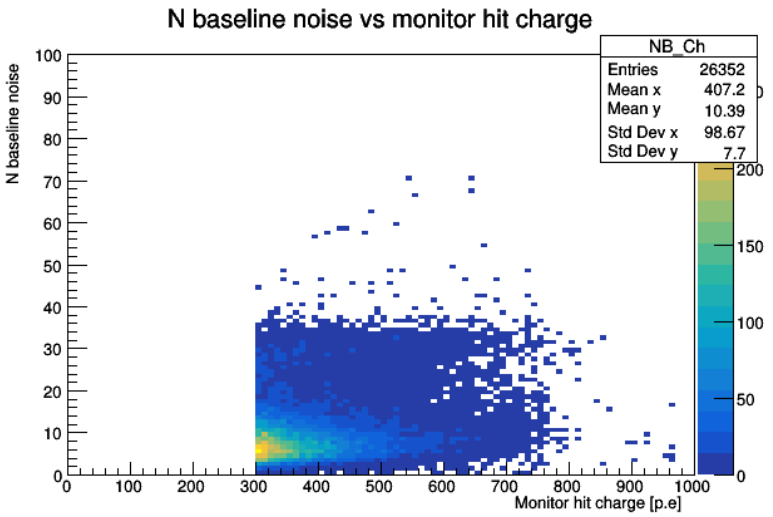


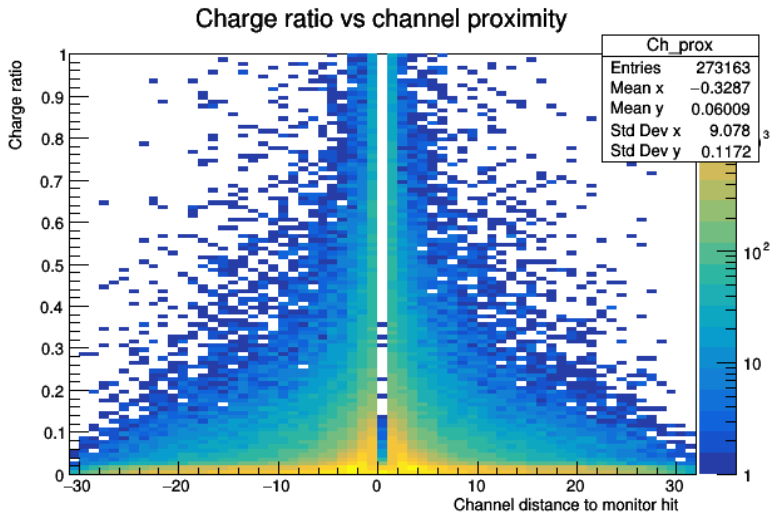


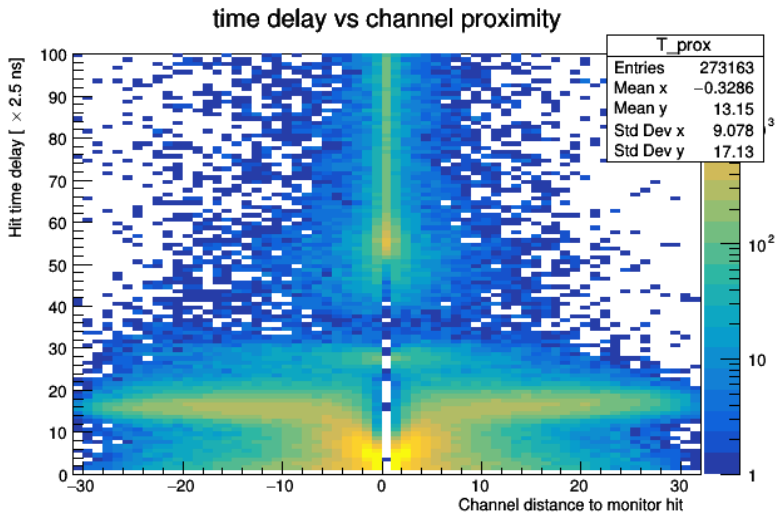
300 > $Q_{monitor\ hit}$

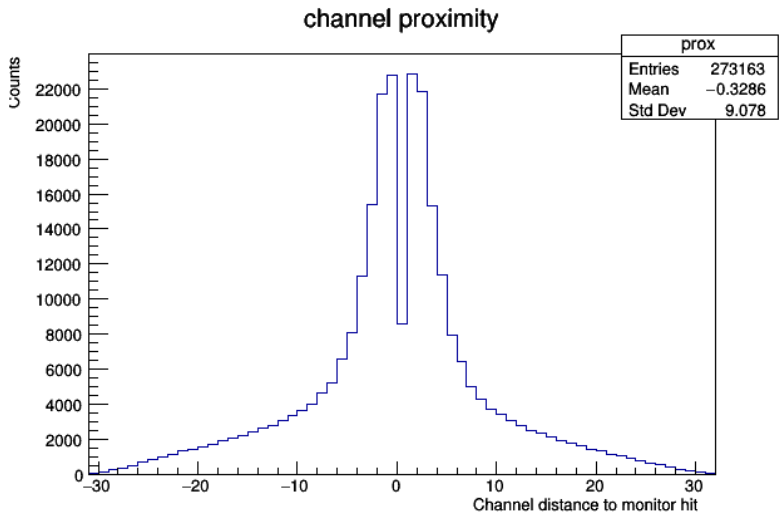




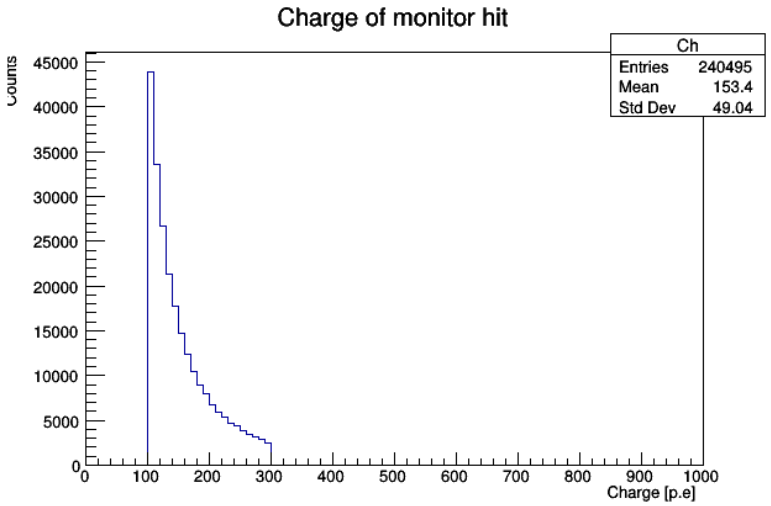


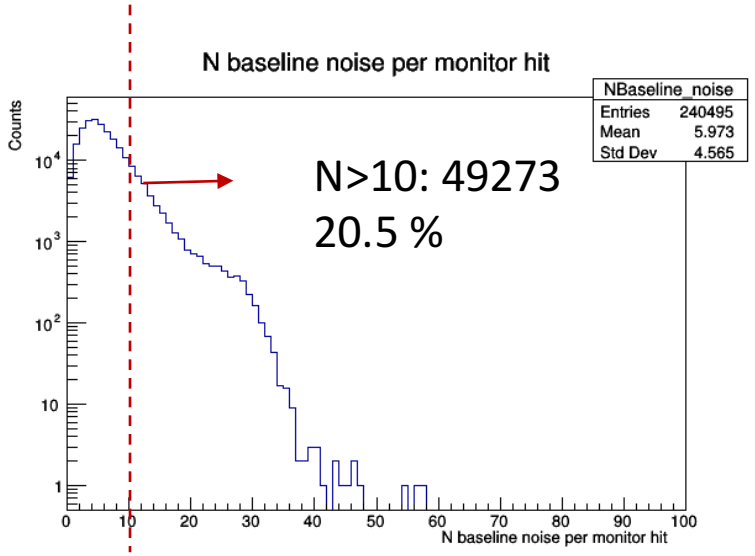


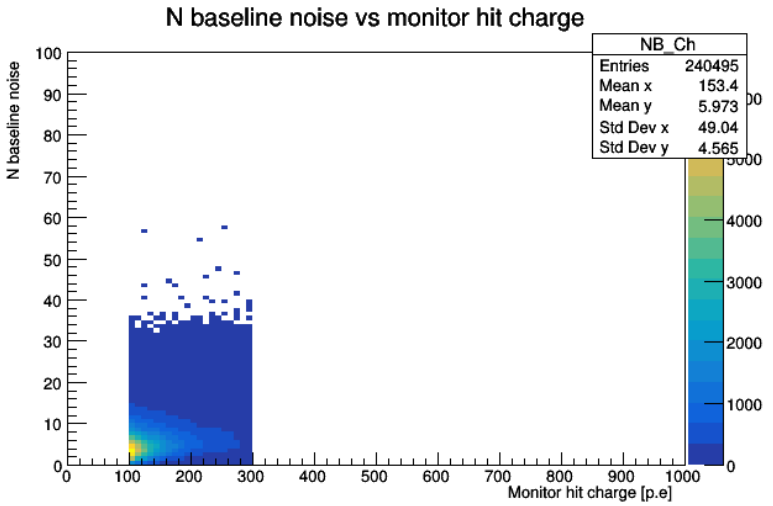


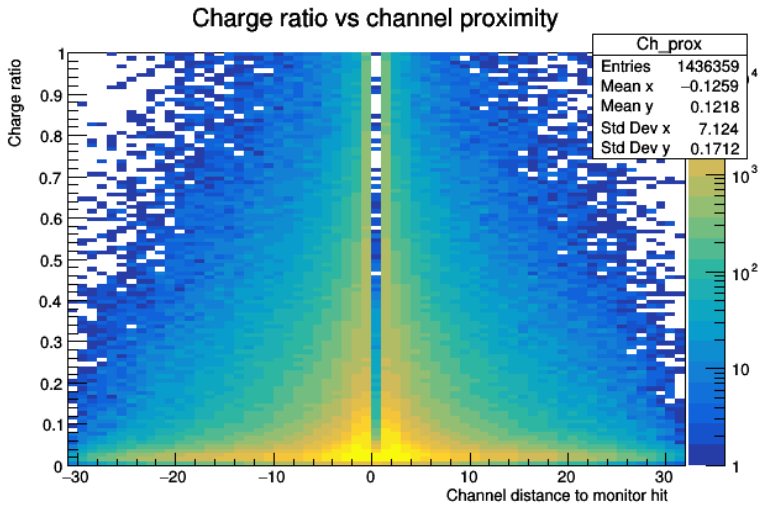


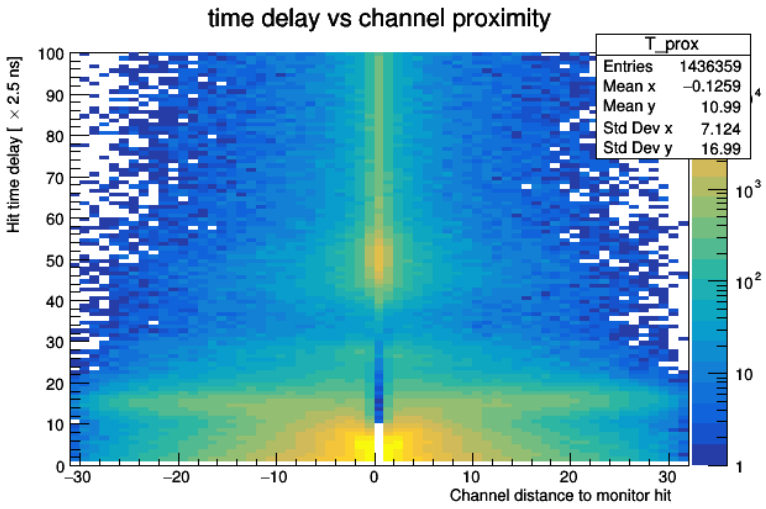
$100 < Q_{monitor\ hit} < 300$ pe

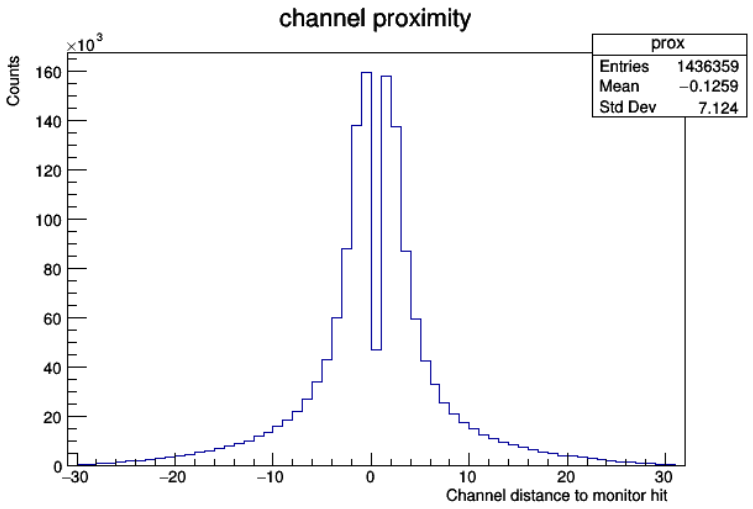




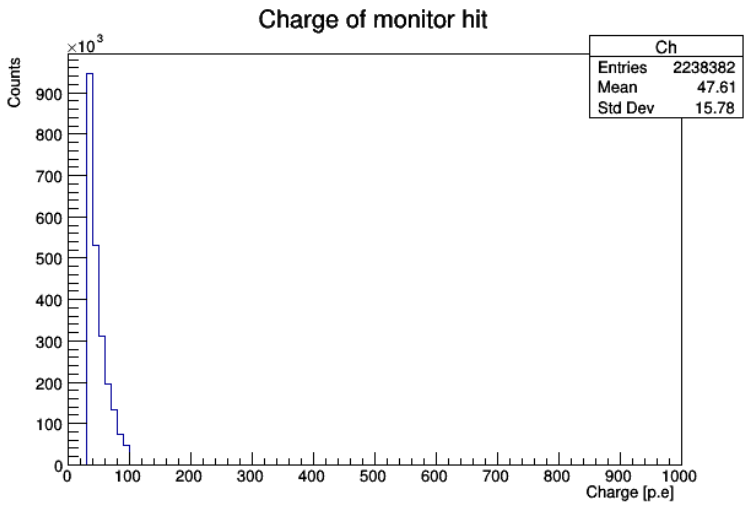


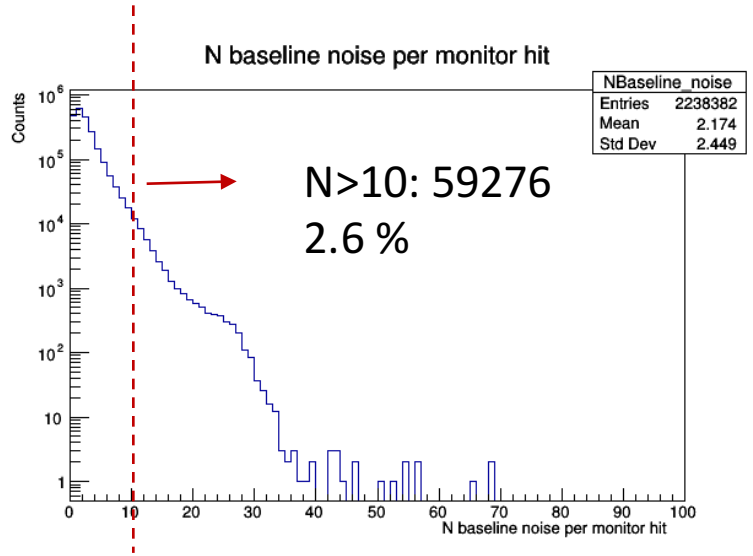


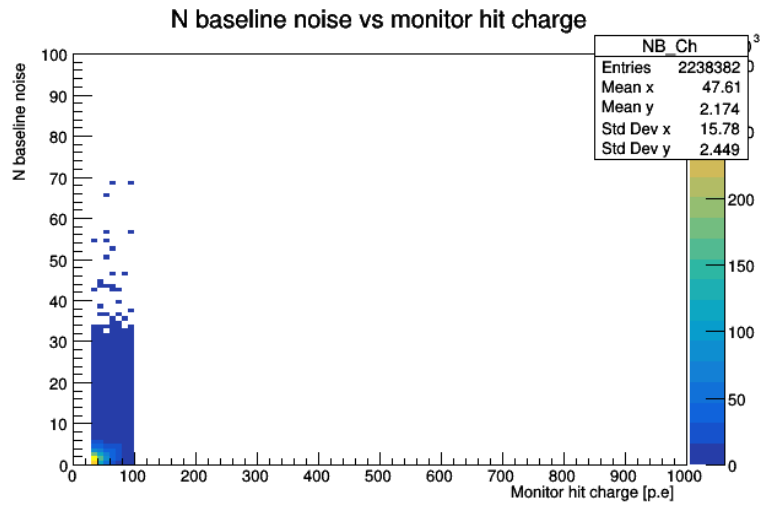


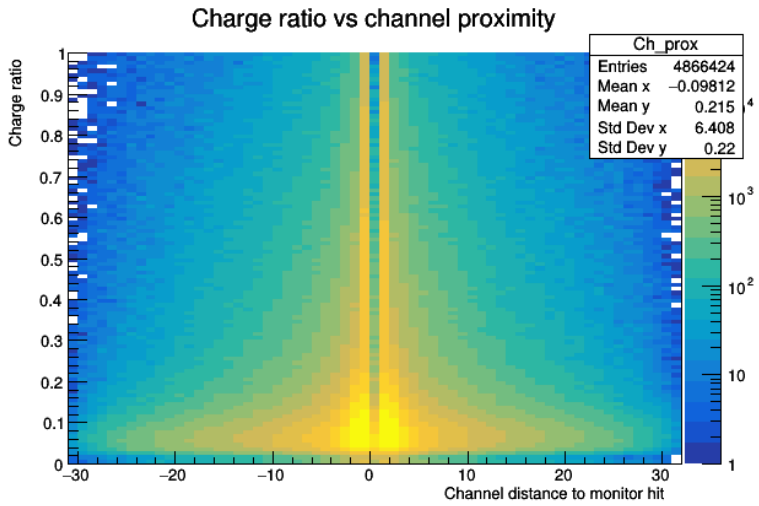


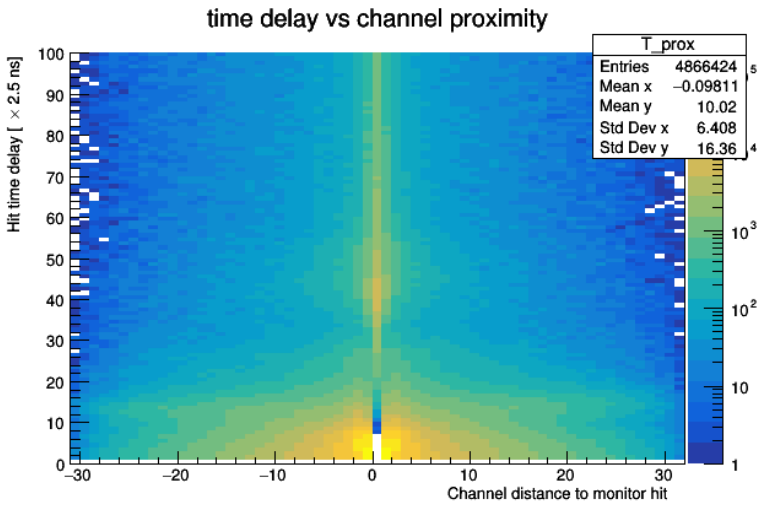
$30 < Q_{monitor\ hit} < 100$ pe

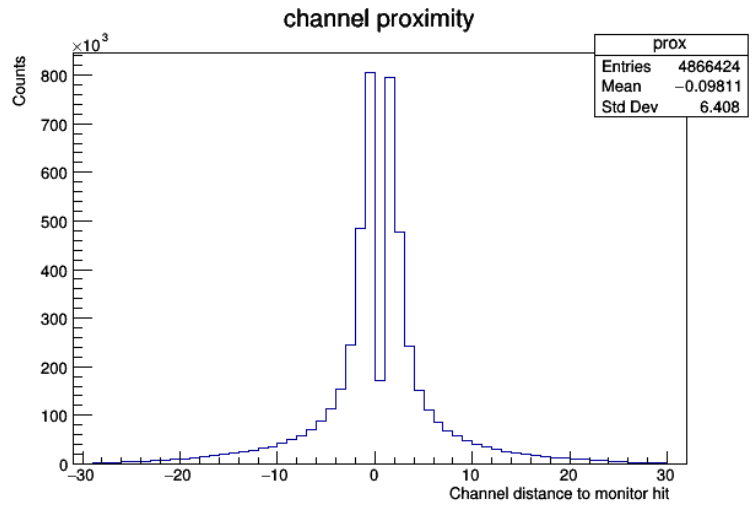






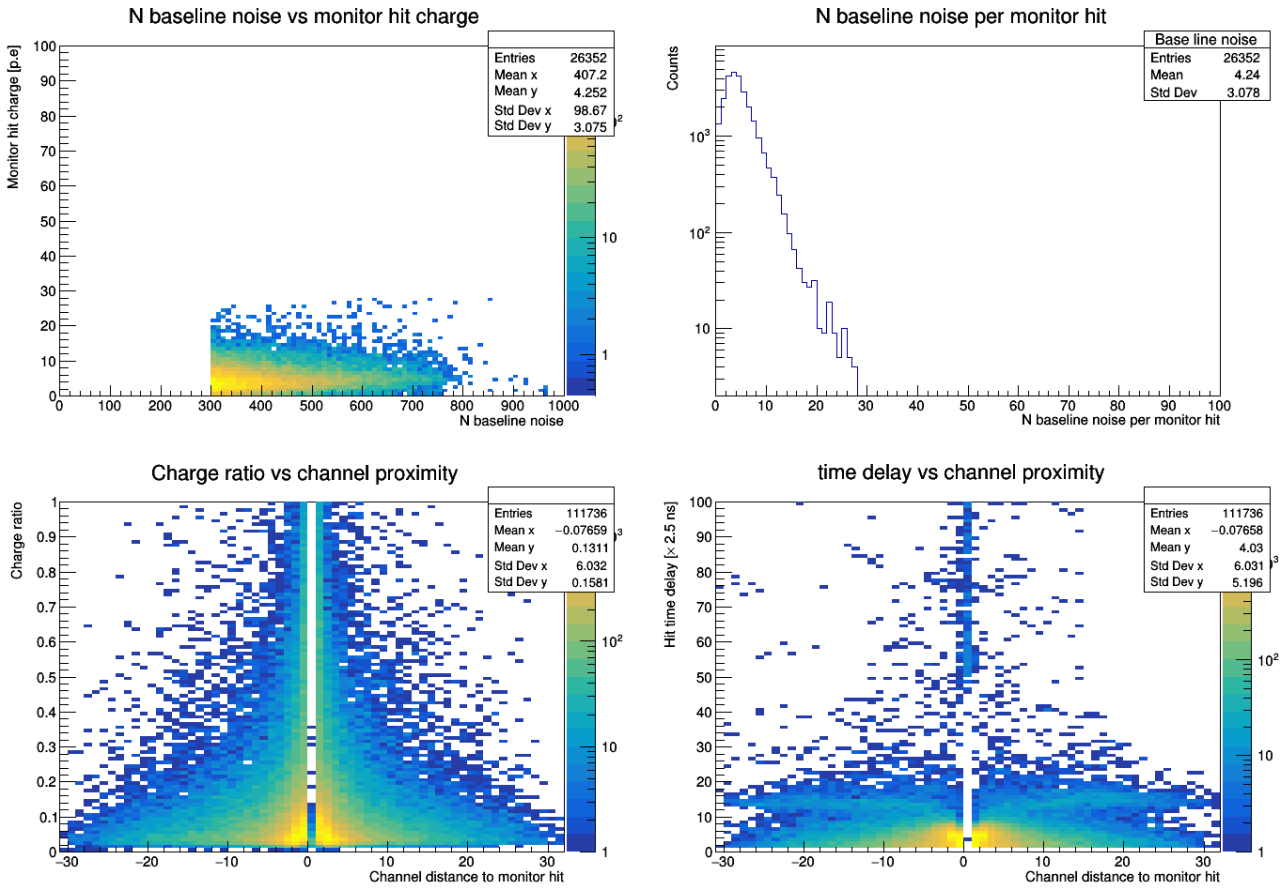






Can we cut away the noise by charge cut?

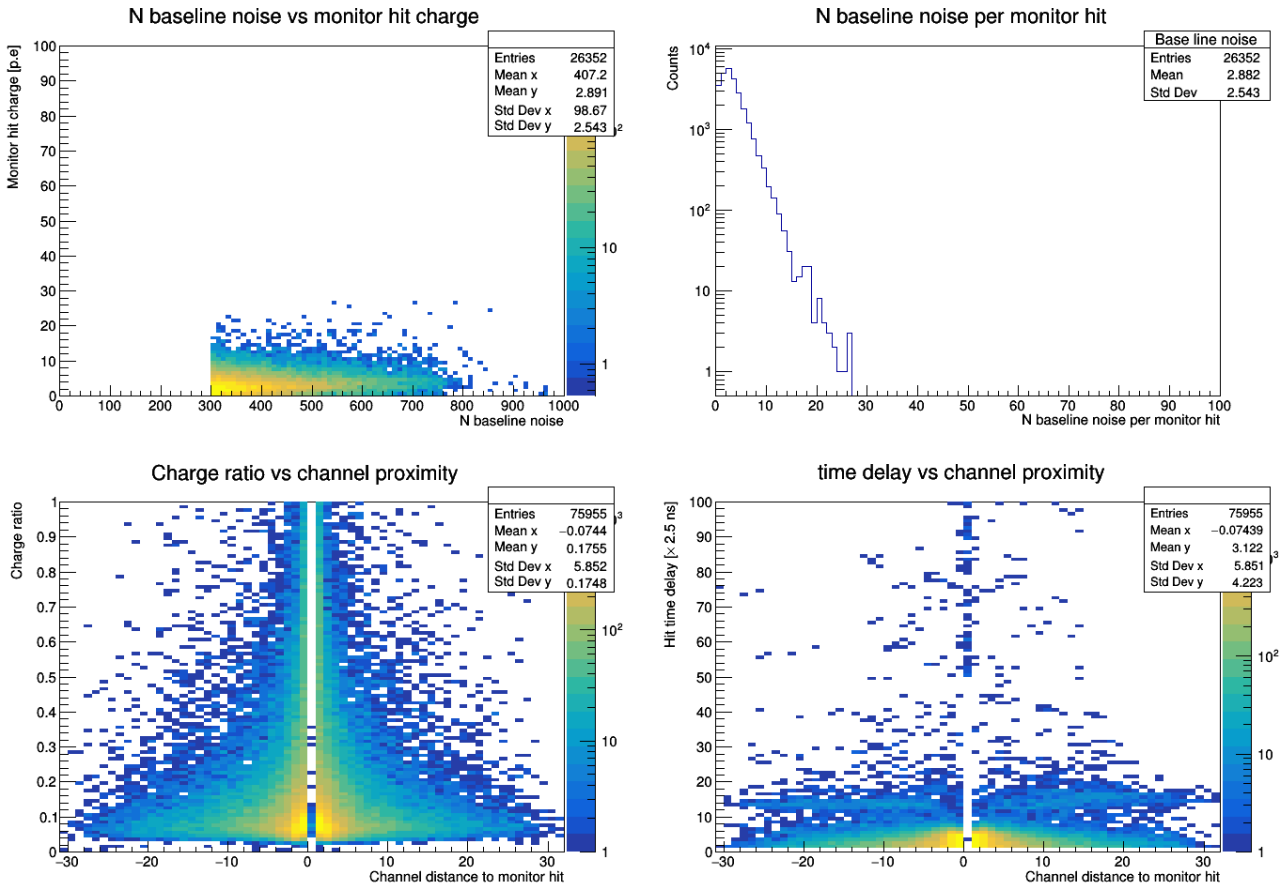
Charge cut > 10 p.e



Much of the after pulses and some of baseline noise are gone

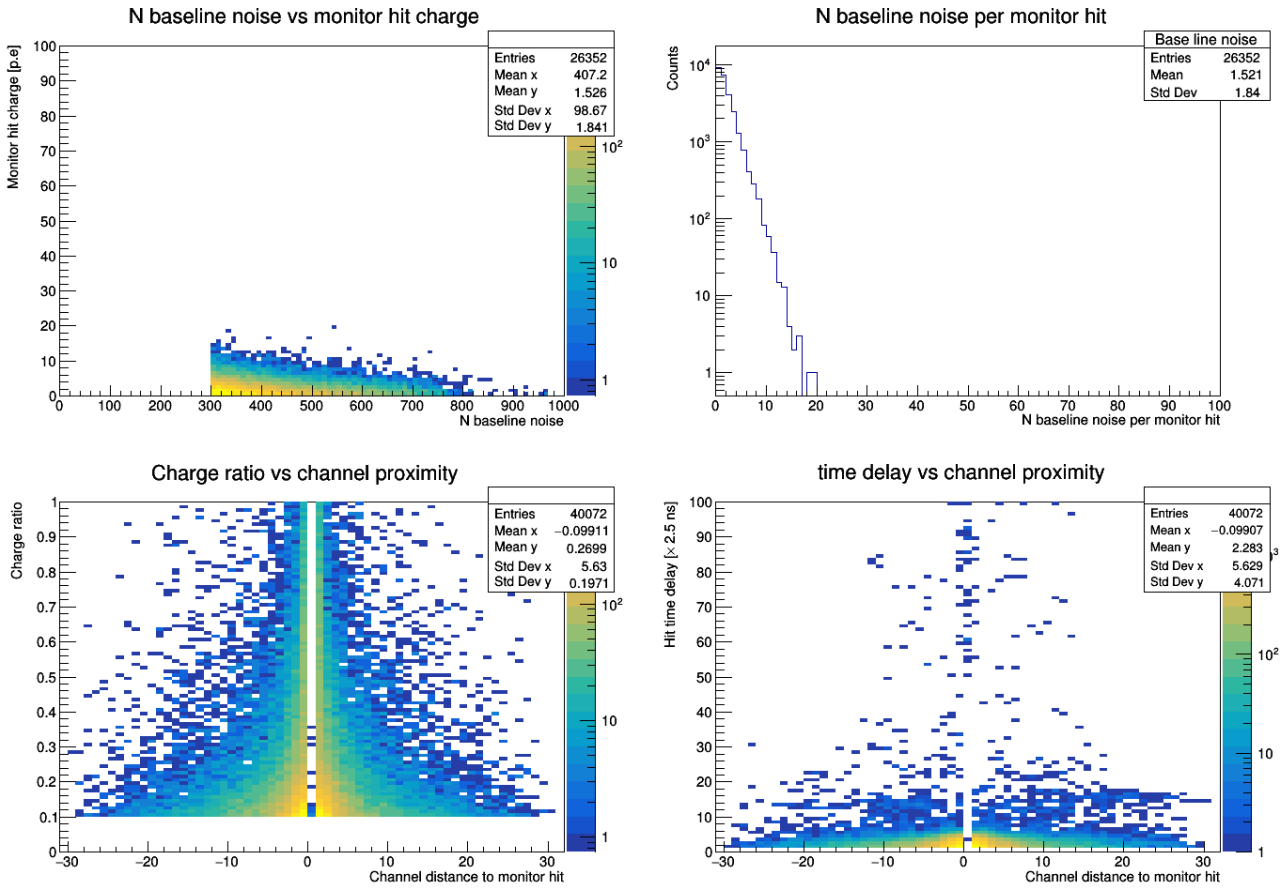
Can we cut away the noise by charge cut?

Charge cut > 20 p.e



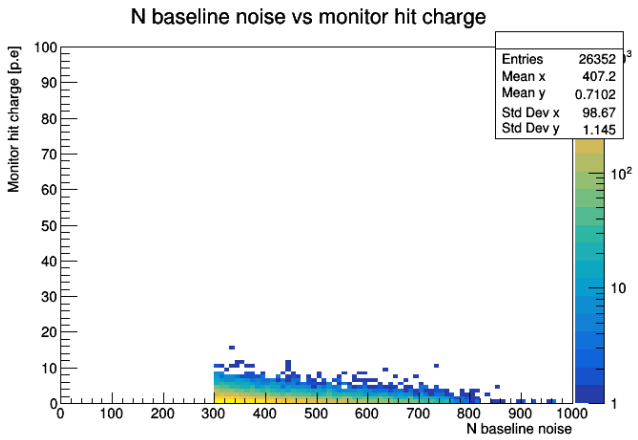
Can we cut away the noise by charge cut?

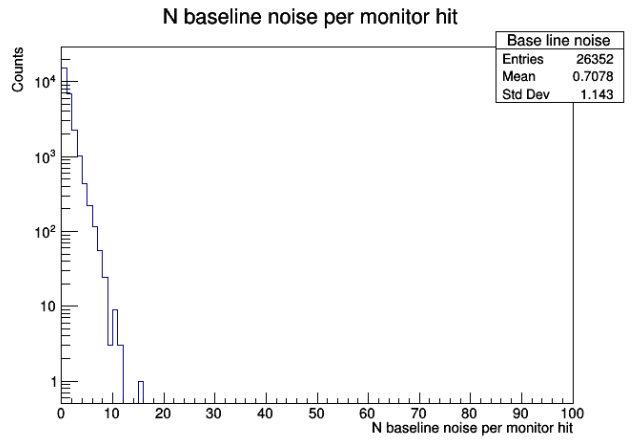
Charge ratio cut > 0.1

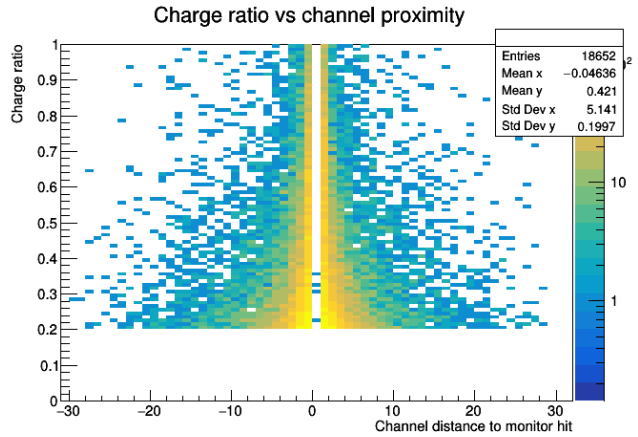


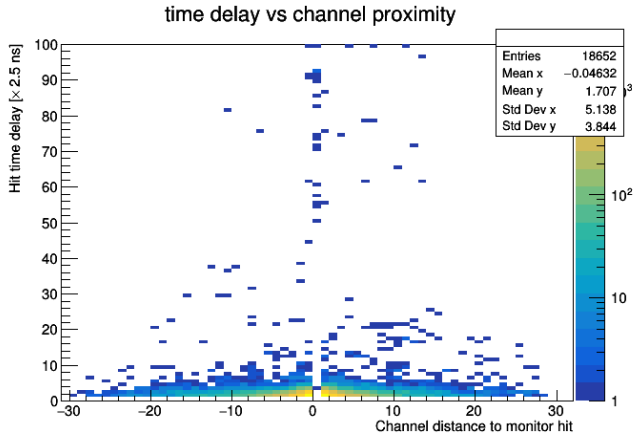
Can we cut away the noise by charge cut?

Charge ratio cut > 0.2





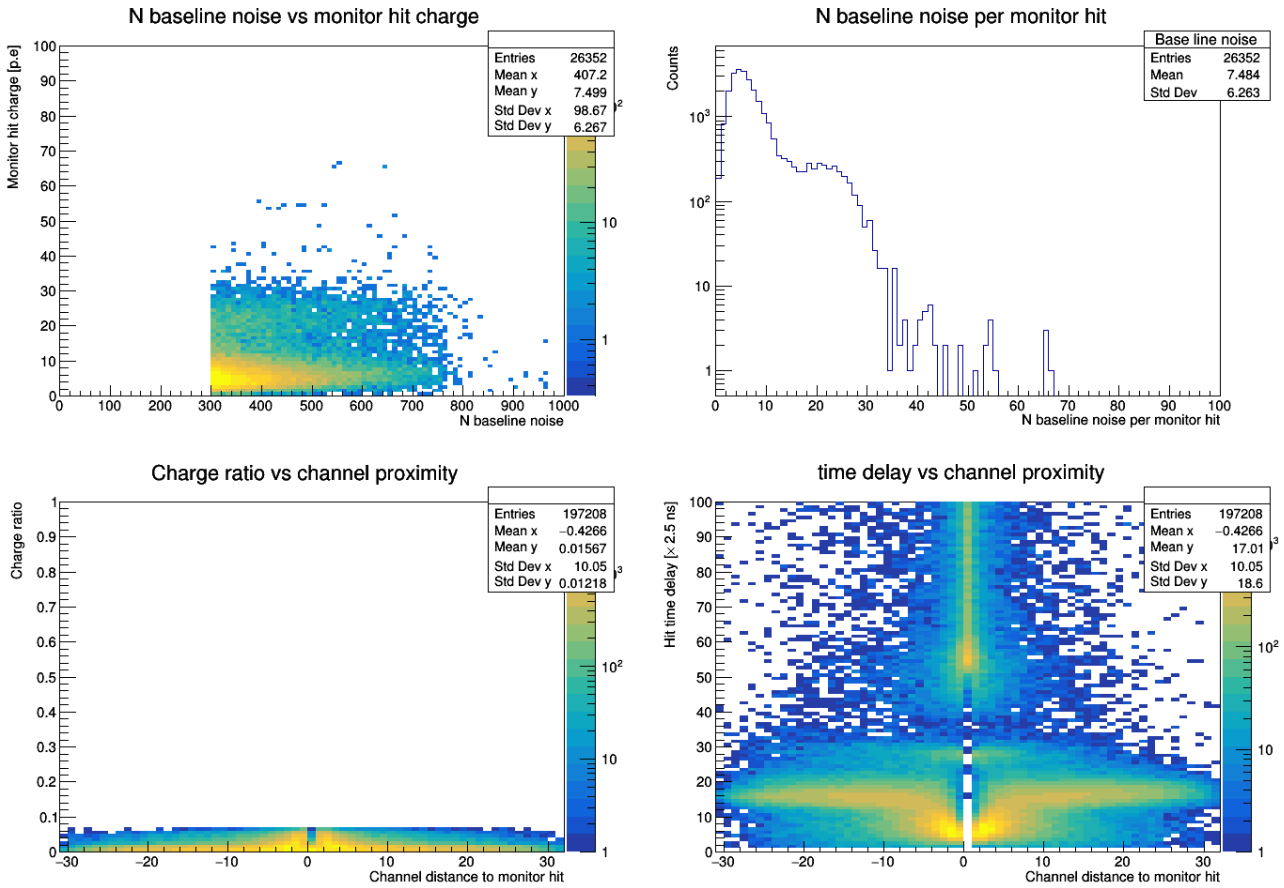


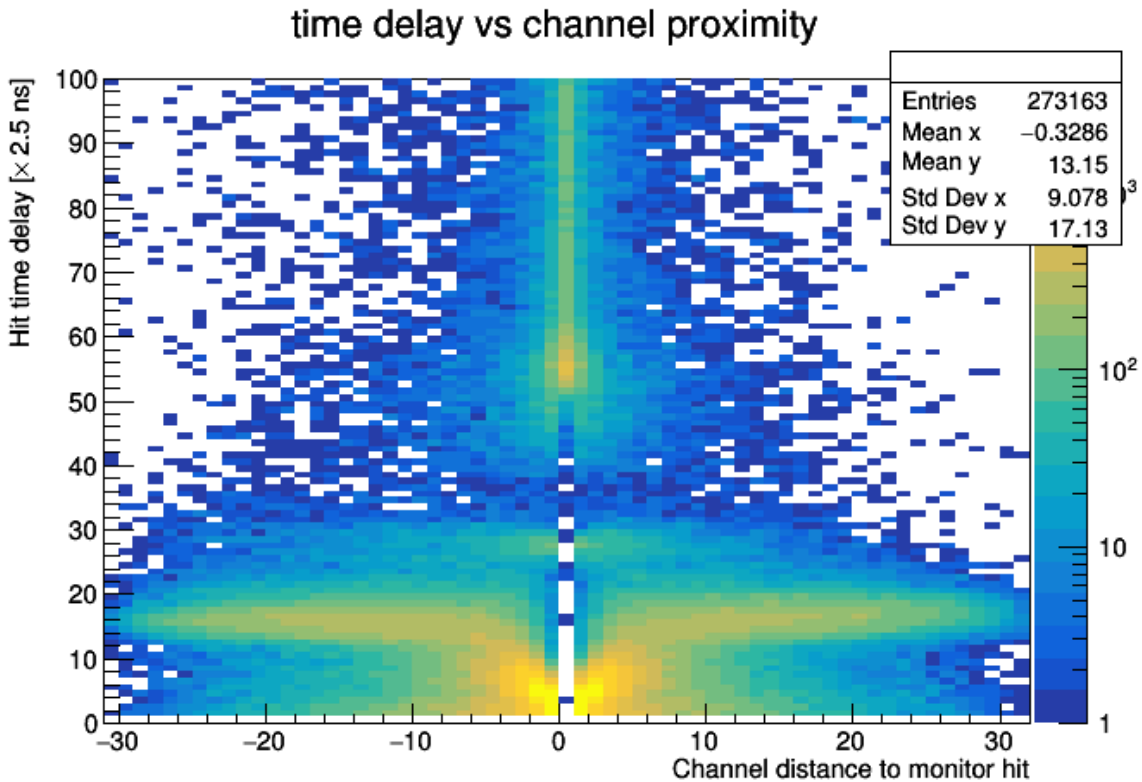


Severe cut, The remains can be particle hits or high amplitude cross talk hits.

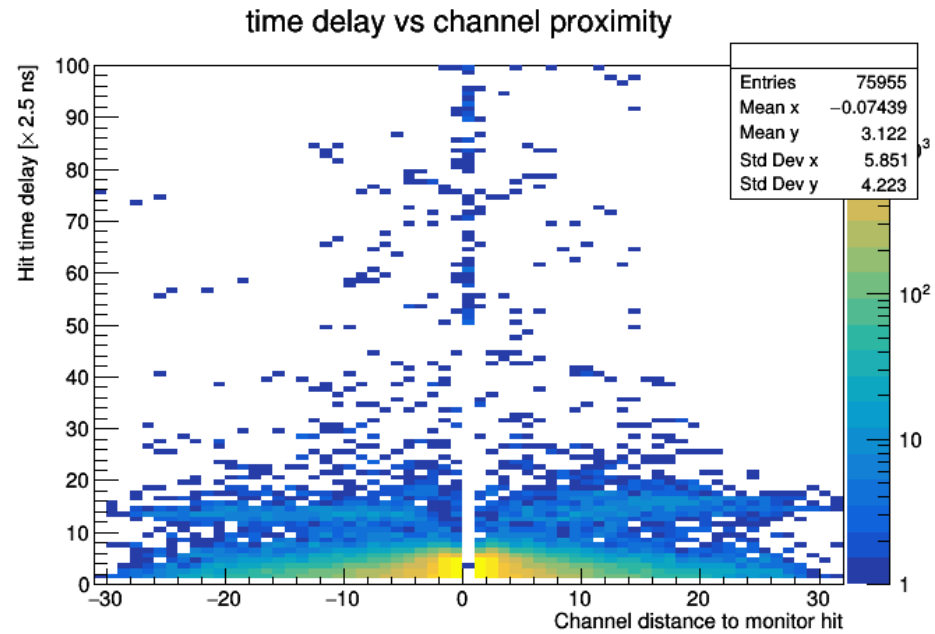
Looking at noise only

Charge cut < 20 p.e

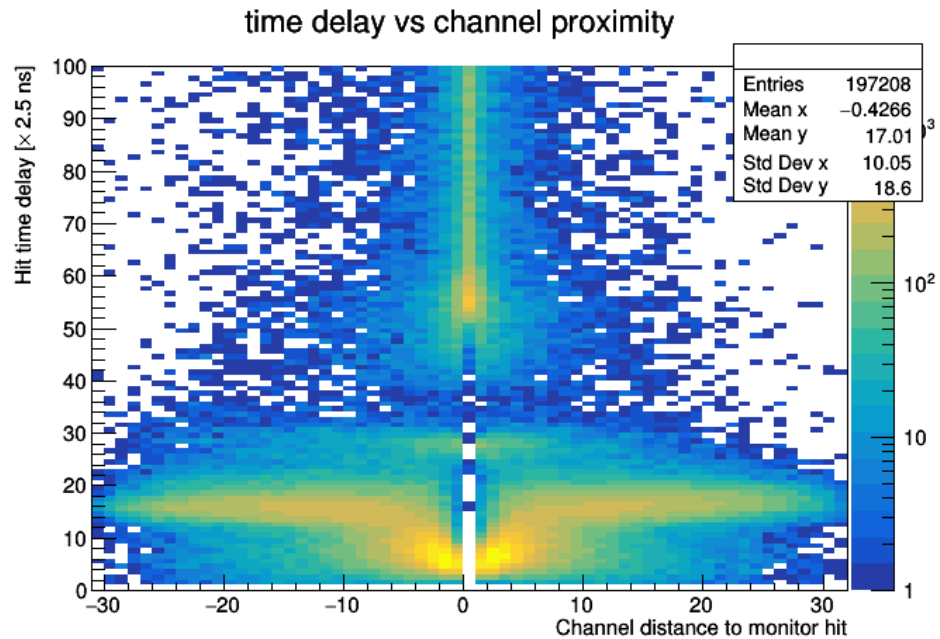




All hits in the ASIC



27.8%
hits above 20
p.e in the ASIC



72.2 %
hits below 20
p.e in the ASIC