

# 2023&2024 test-beam data analysis

*status and updates*

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# Data collected in 2023 & 2024

## 2023 mu beams

2 gas.mix. (90/10, 85/15) X  
2 angles (0, 45) X  
5 momenta (2,4,6,8,10)

configuration	runs	gas	angle	momentum	events	MB
1	tbdata_1,_2,_3 run1,2	90/10	3°	10	18800 6987	460,4 3382
2	tbdata_4 run4	90/10	45°	10	4800 2585	119,3 1240
3	tbdata_10 run10	90/10	5°	8	4709 3413	118,2 ?
4	tbdata_5,_6,_7,_8,_9 run5,7,8	90/10	45°	8	8100 + 4548 +	67,1 + 2190 +
5	tbdata_11 run11	90/10	0°	6	4618 4973	115,3 2390
6	tbdata_12 run12	90/10	45°	6	3041 ?	83,9 ?
7	tbdata_14 run14	90/10	0°	4	1001 4365	25,2 ?
8	tbdata_13 run13	90/10	45°	4	1700 5355	42,7 ?
9	tbdata_15 run15	90/10	0°	2	6947 3516	184,6 ?
10	tbdata_16 run16	90/10	45°	2	? 4023	43,9 ?
11	tbdata_17 run17	85/15	0°	10	10400 4000	268,4 ?
12	tbdata_18 run18	85/15	45°	10	2000 2500	117 ?
13	tbdata_26 run26	85/15	0°	8	19814 5039	
14	tbdata_25 run25	85/15	45°	8	10000 ?	
15	tbdata_20 run20	85/15	0°	6	9800 5019	247,5 ?
16	tbdata_19 run19	85/15	45°	6	4112 3767	104 ?
17	tbdata_21 run21	85/15	0°	4	2827 3760	70,3 ?
18	tbdata_24 run24	85/15	45°	4	2900 4215	104,9 ?
19	tbdata_22 run22	85/15	0°	2	923 2691	23,2 ?
20	tbdata_23 run23	85/15	45°	2	2000 4000	83,9 ?

## 2024 mu beams

mix(90/10) X 2 angles(0,45)X5 momenta(2,4,6,8,10)  
mix(80/20) X 1 angles(45)X5 momenta(2,4,6,8,10)  
+ 10 GeV X angle(0)

Run	Gas mix	P GeV	angel	N. events(DRS)	N. events(OSC)
21	90/10	10	0	31798	6813
22	90/10	10	45	20589	4791
23	90/10	8	45	20013	4829
24	90/10	6	45	20592	5196
25	90/10	4	45	10116	3440
26	90/10	2	45	10735	6222
27	90/10	2	0	2465	3180
28	90/10	2	0	6210	4629
29	90/10	4	0	10716	3607
30	90/10	6	0	20089	5183
31	90/10	8	0	21345	5460
32	80/20	10	0	1261	735
33	80/20	10	0	1330	
34	80/20	10	0	1100	
35	80/20	10	0	24794	5232
36	80/20	10	45	15646	4032
37	80/20	10	45	3200	1182
38	80/20	8	45	15000	4014
39	80/20	6	45	15000	4371
40	80/20	4	45	6472	
41	80/20	4	45	8875	
42	80/20	2	45	17073	

## Preliminary scan on 2023 & 2024 data

First basic checks on the data collected in 2023/2024 independent on peak-finding and cluster counting advanced analysis.

- Including: noise RMS, charge integral, voltage pulse height, maximum voltage  
(results are displayed for the combined statistics from 1 cm tubes & the combined from 1.5 cm tubes)
- **2023:**  
detailed results for each run & summary table can be found [here](#)  
All runs collected by DRS & OSC are included  
(if you don't have access to CERN web, the summary tables are [here](#))
- **2024:**  
detailed results for each run can be found [here](#)  
All runs collected by DRS

# The RTA for peak finding

## 1- Template shape

- **Krise**: Number of samples describing the rising edge
- **Kfall**: Number of samples describing the falling edge
- **NormValues**: Normalized reference pulse shape

The template is generated using  $T_{\text{rise}} = 0.5 \text{ ns}$ ,  $T_{\text{fall}} = 1.3 \text{ ns}$

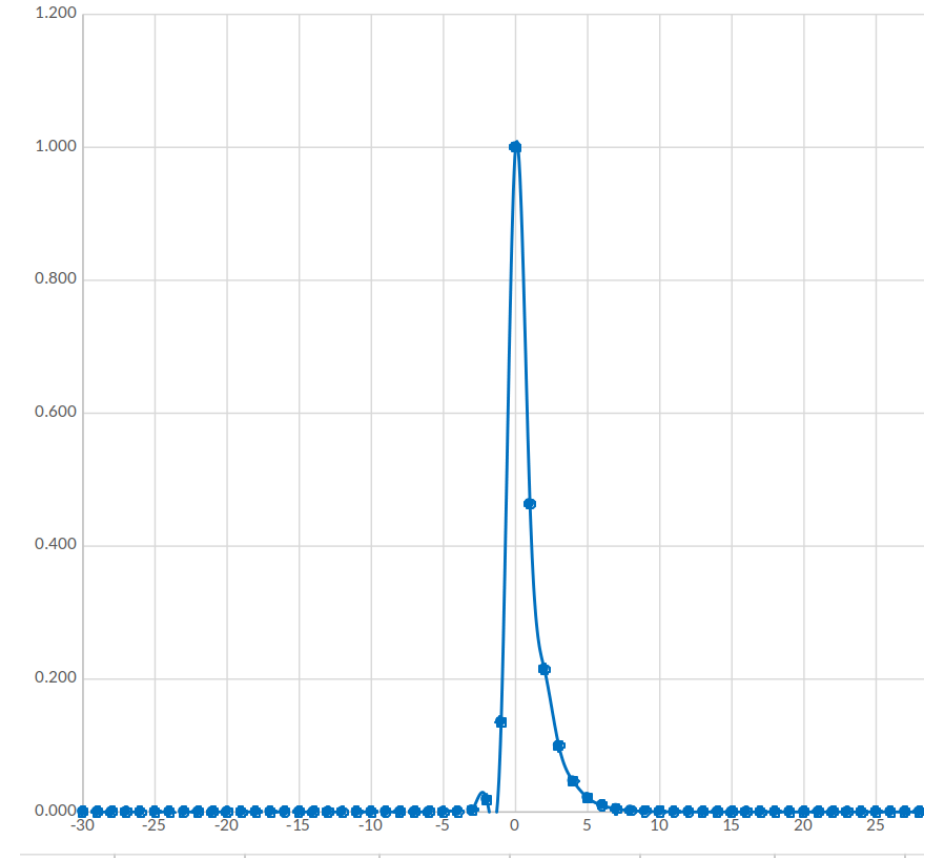
Krise = 4

Kfall = 10

Valuse = 0.0, 0.002, 0.018, 0.135,

1.0,

0.463, 0.215, 0.099, 0.46, 0.021, 0.01, 0.005, 0.002, 0.001, 0.0



# The RTA for peak finding

## 2- Amplitude, Topology and goodness of the fit

### Case 1: Clean Pulse

Amp. threshold > 0.003

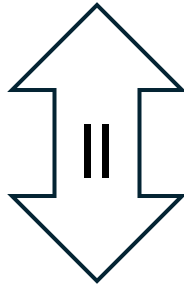
&&

(Amp[j] - Amp[j-krise] > 0.0005 && Amp[j] - Amp[j+kfall] > 0.0005)

|| Amp[j] - Amp[j-krise] > 0.005 || Amp[j] - Amp[j+kfall] > 0.005

&&

$\chi^2/\text{dof} > 15$  || Apm[j] > 0.015 && Isolated



### Case 2: Crowded Pulses

Crowded

&& Amp. threshold > 0.005

&& Amp[j] - Amp[j-krise] > 0.005

&& Amp[j] - Amp[j+kfall] > 0.005

**Isolated:**

amplitude[j-1] < 0.01 &&

amplitude[j+1] < 0.01

**Crowded:**

amplitude[j-Krise] > 0.005 &&

amplitude[j+Kfall] > 0.005

# Clusterization

Group individual reconstructed peaks into **electron clusters** based on their **time separation**.

## Inputs:

Reconstructed peaks

Time resolution

scale cut (tunable)

## Compute Time Distance $\Delta t$

$\Delta t = (\text{pkPos}[i] - \text{pkPos\_cluster\_last}) \times \text{timeRes}$

## Define the threshold cut

If  $\Delta t > \text{cut}$ :  $\rightarrow$  start new cluster

else  $\rightarrow$  Add peak to current cluster

Scale cut used: **0.28**

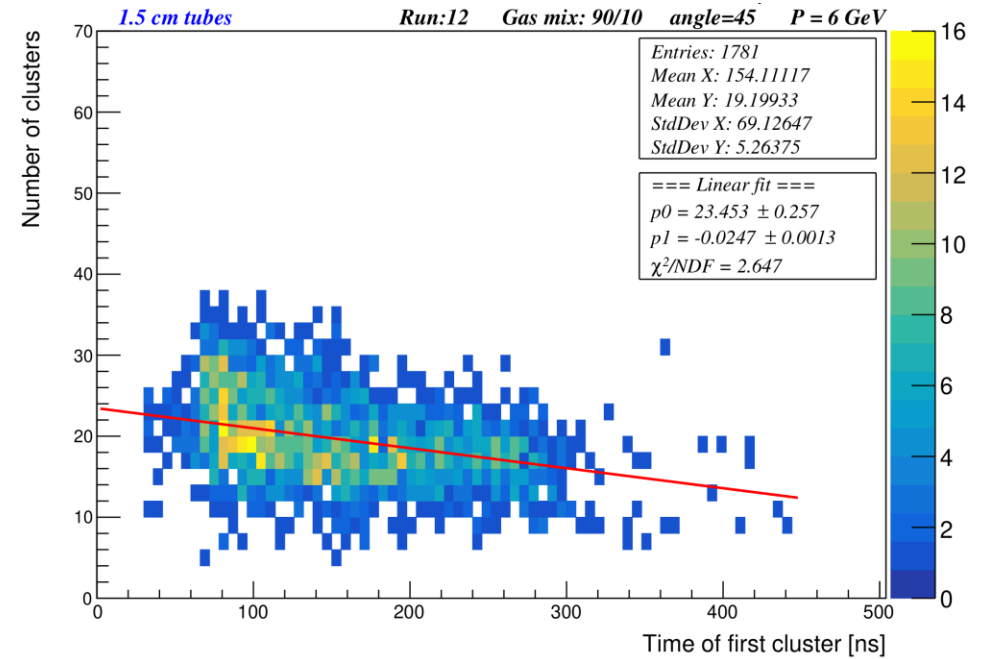
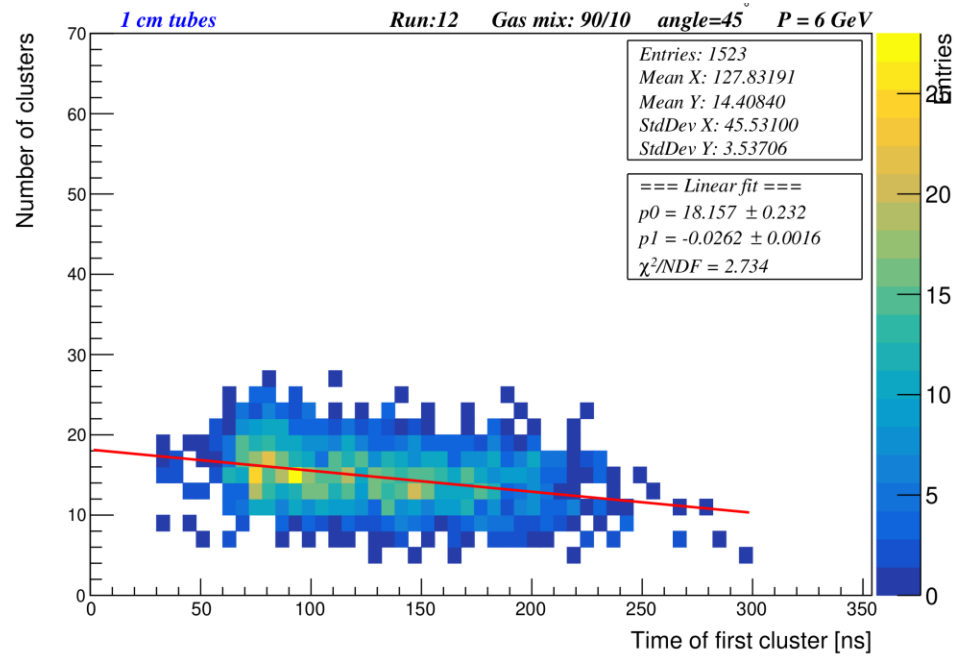
## • Outputs:

- $\text{pkPos\_clust}$ : time position of max peak
- $\text{pkHgt\_clust}$ : amplitude of max peak
- $\text{nElectrons\_per\_cluster}$ : multiplicity in cluster

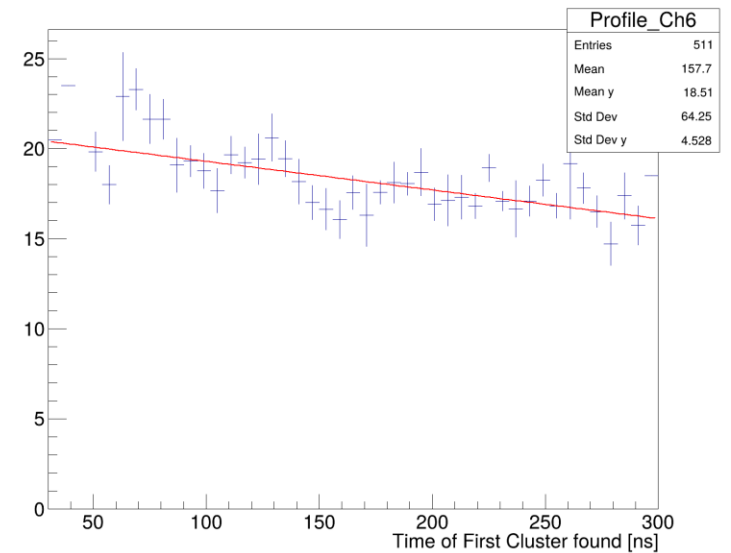
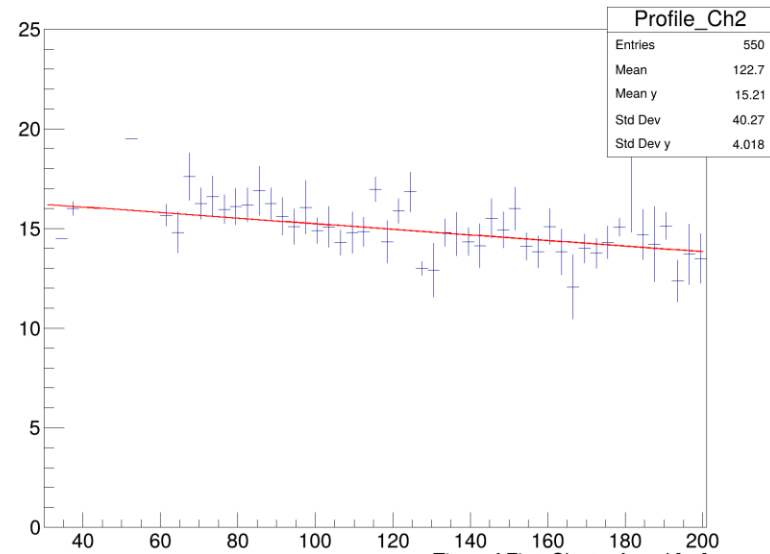
# Time windows Applied to the clusters

- **Minimum Peaks:** > 2 peaks.
- **Global time window:** 30 - 800 ns
- **Time of the first cluster:**
  - For **1 cm channel** < 300 ns
  - For **1.5 cm channel** < 450 ns
- **Cluster time span:**
  - For **1 cm channel:** cluster duration < 270 ns
  - For **1.5 cm channel:** cluster duration < 400 ns

# Correction for recombination and attachment effects

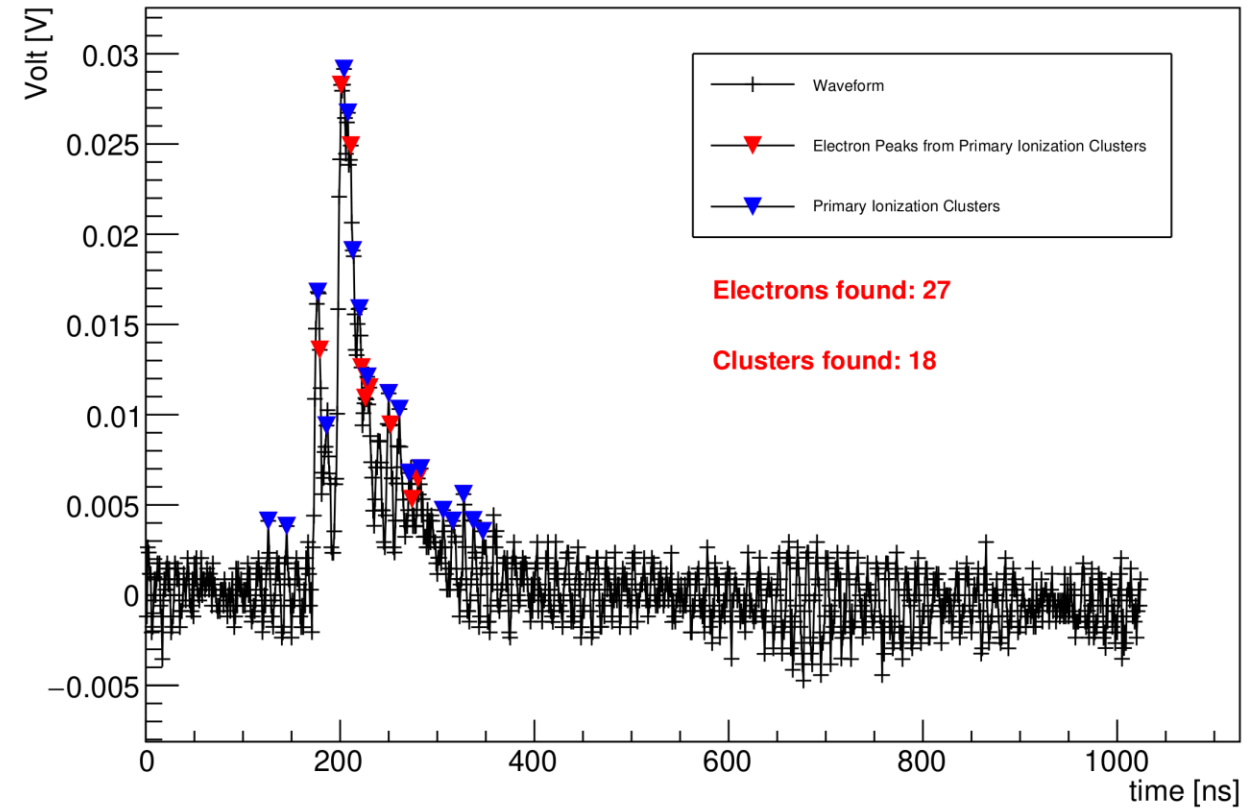
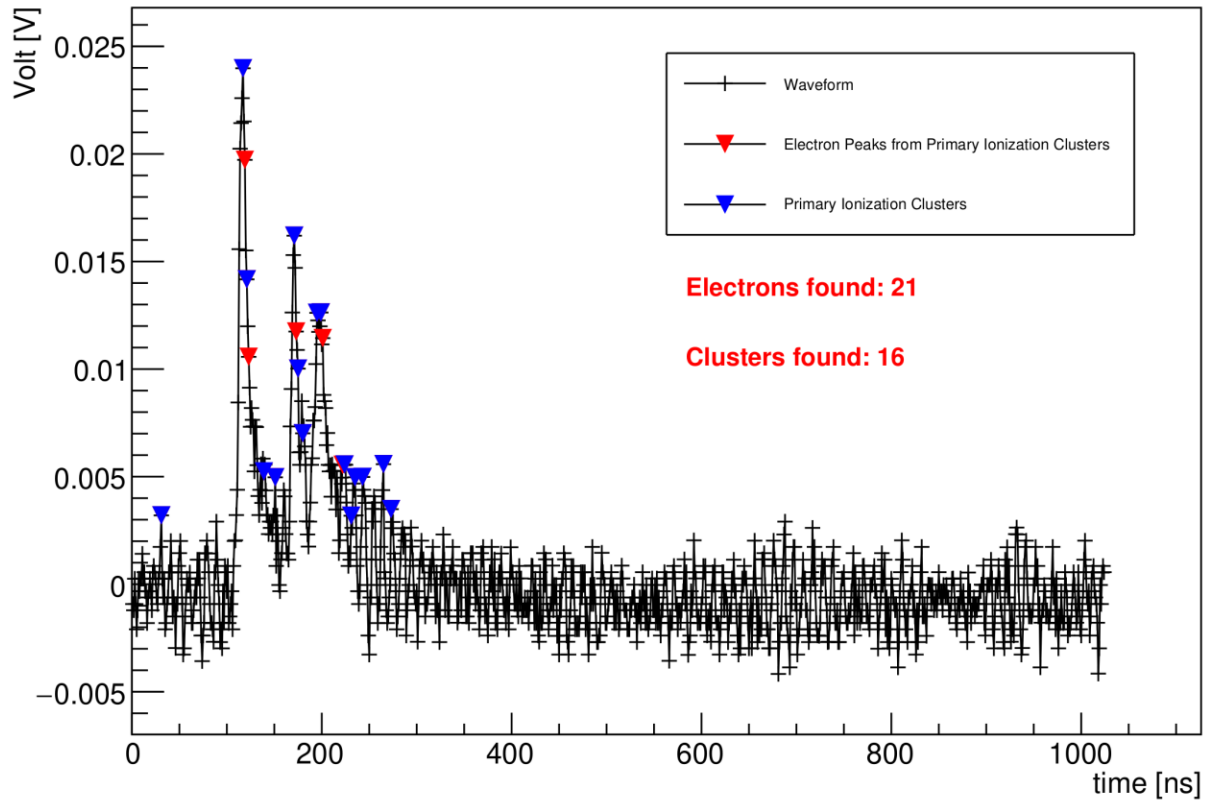


The overall combined  
1 & 1.5 cm tubes

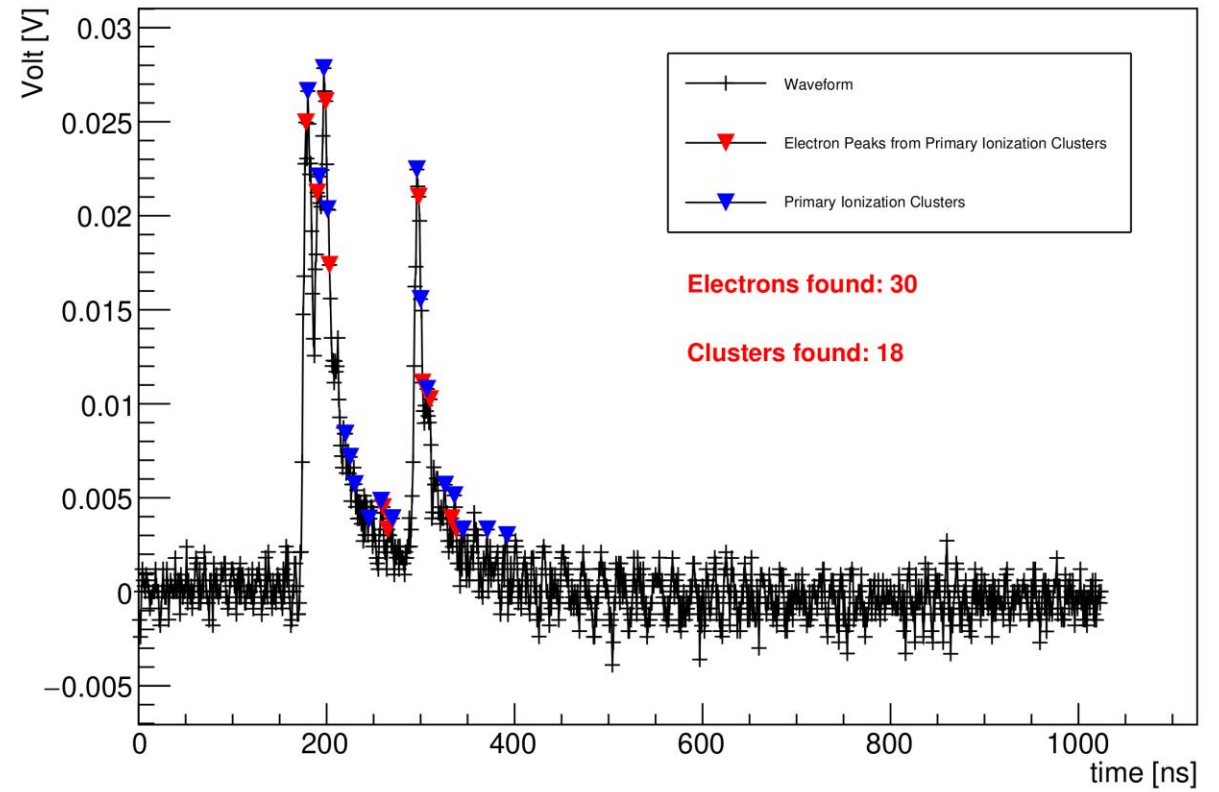
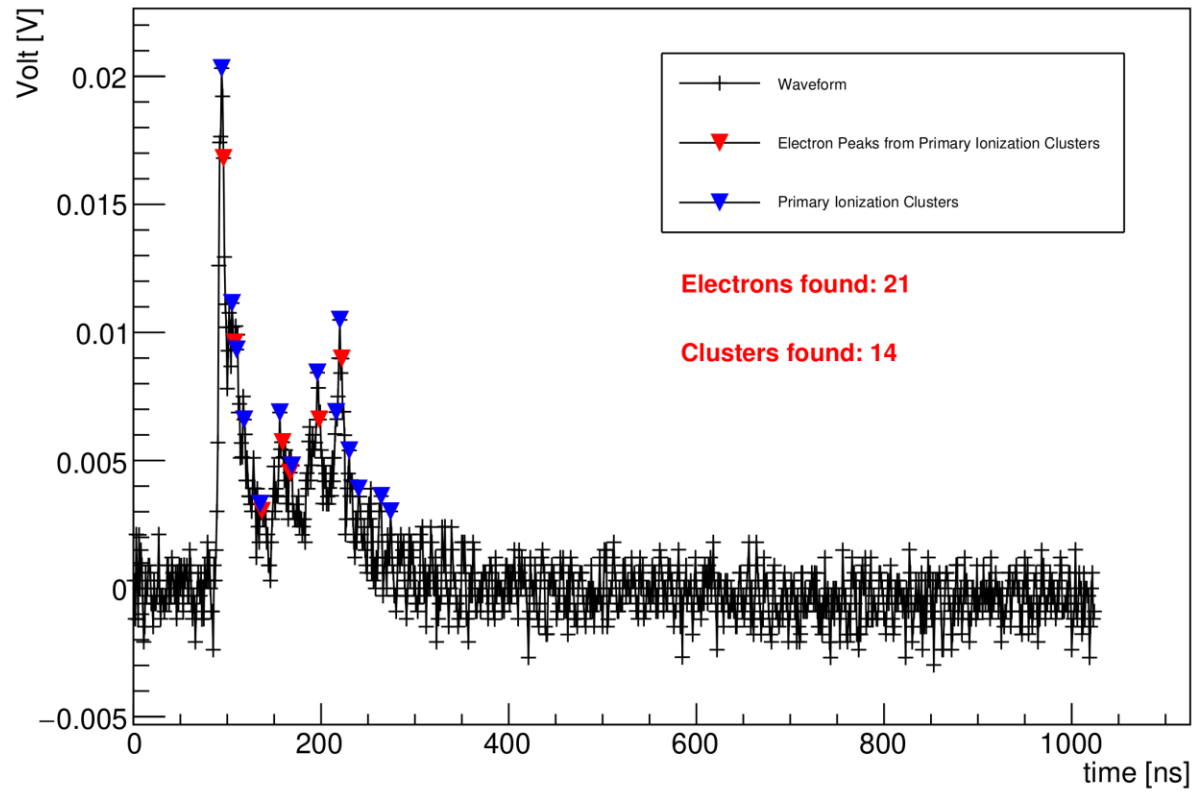


The profiles of two  
examples tubes for  
1 & 1.5 cm

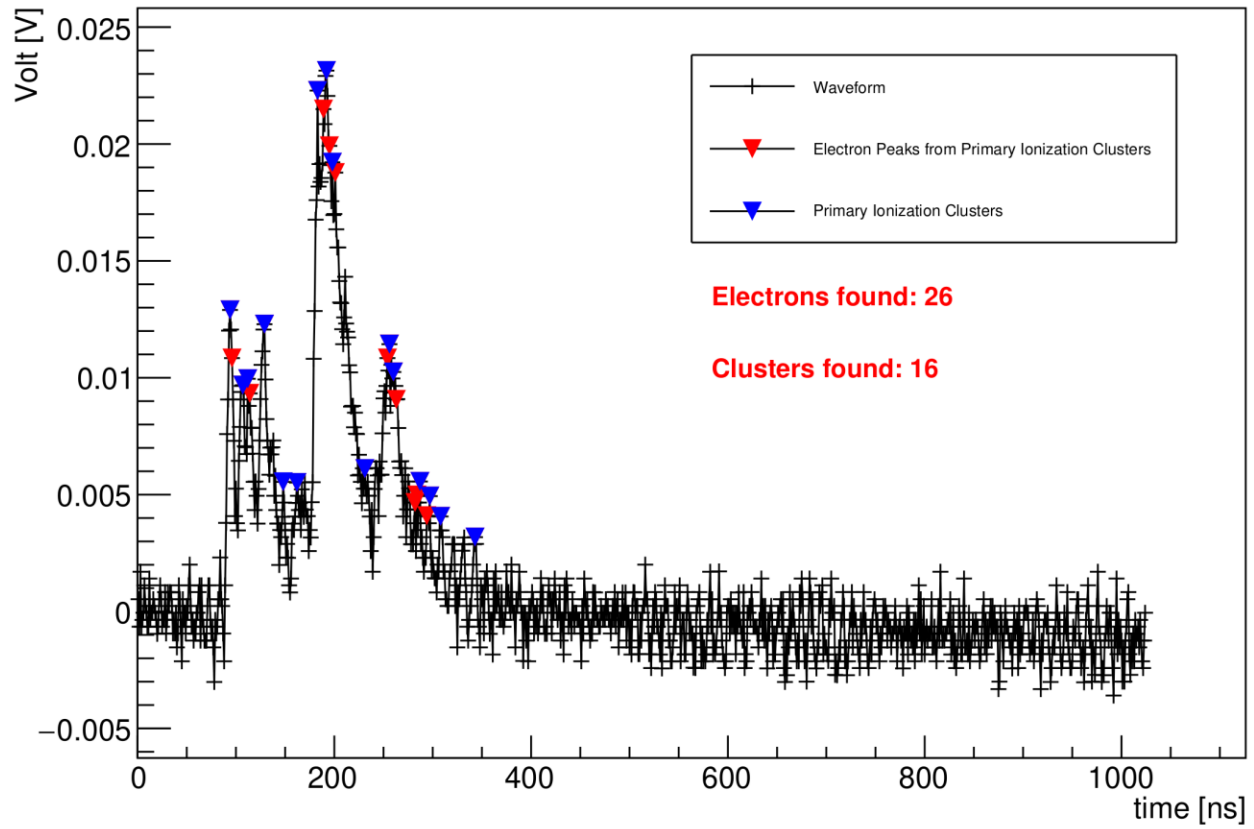
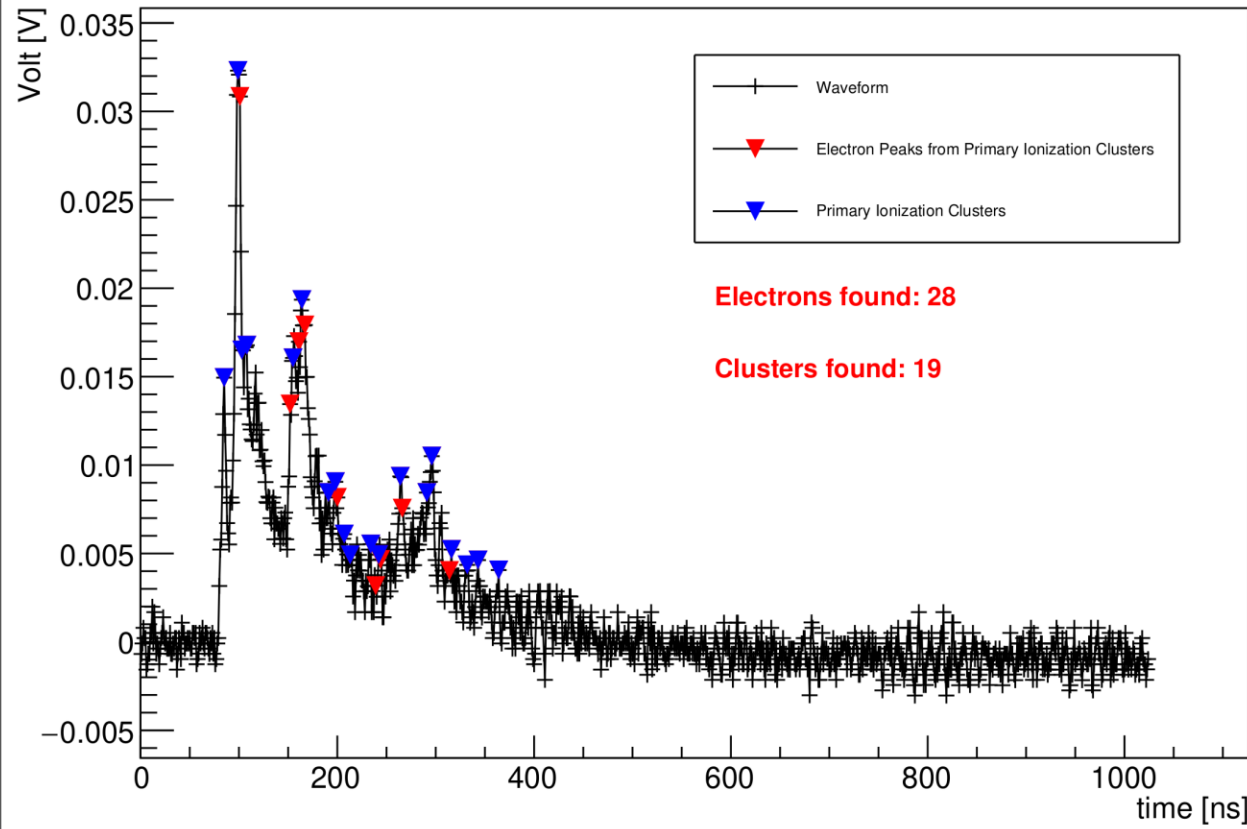
# Results



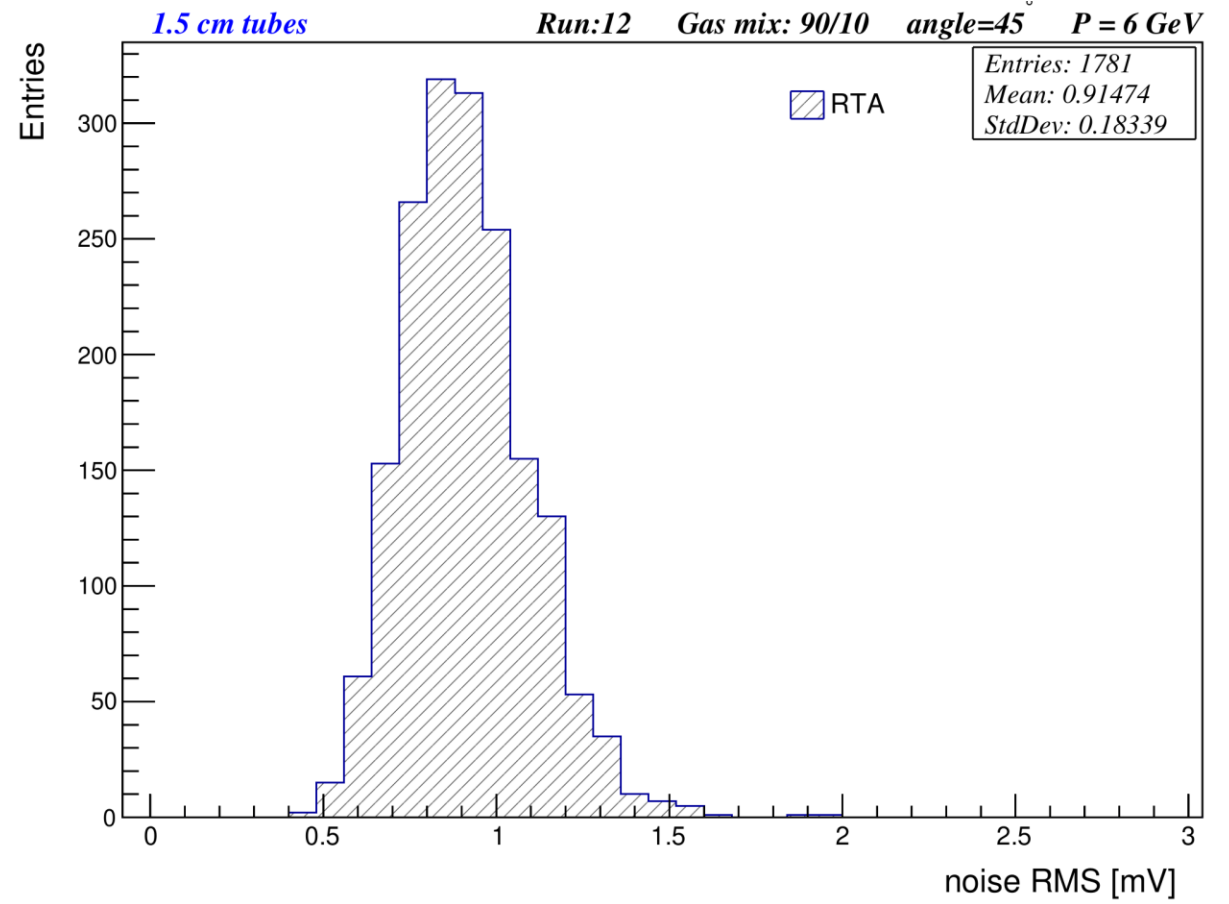
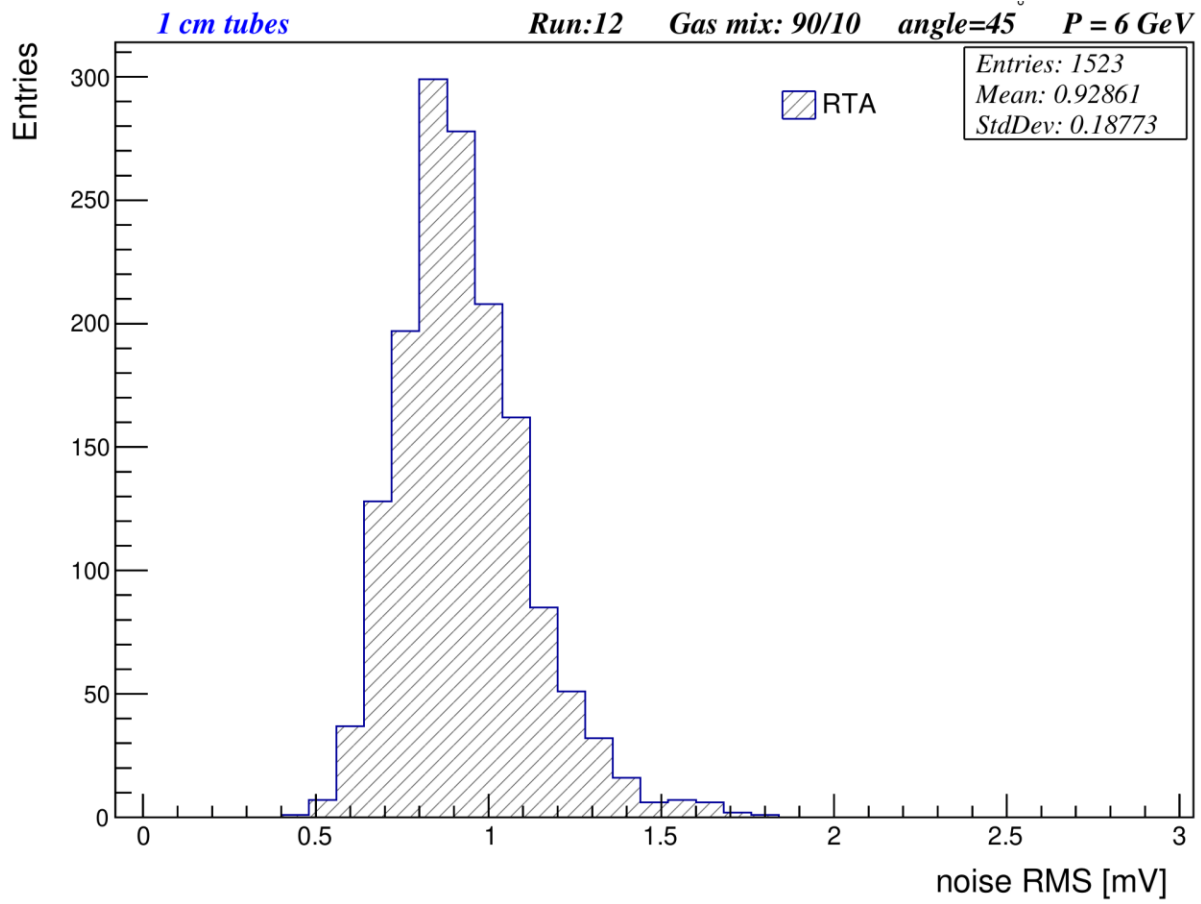
# Results



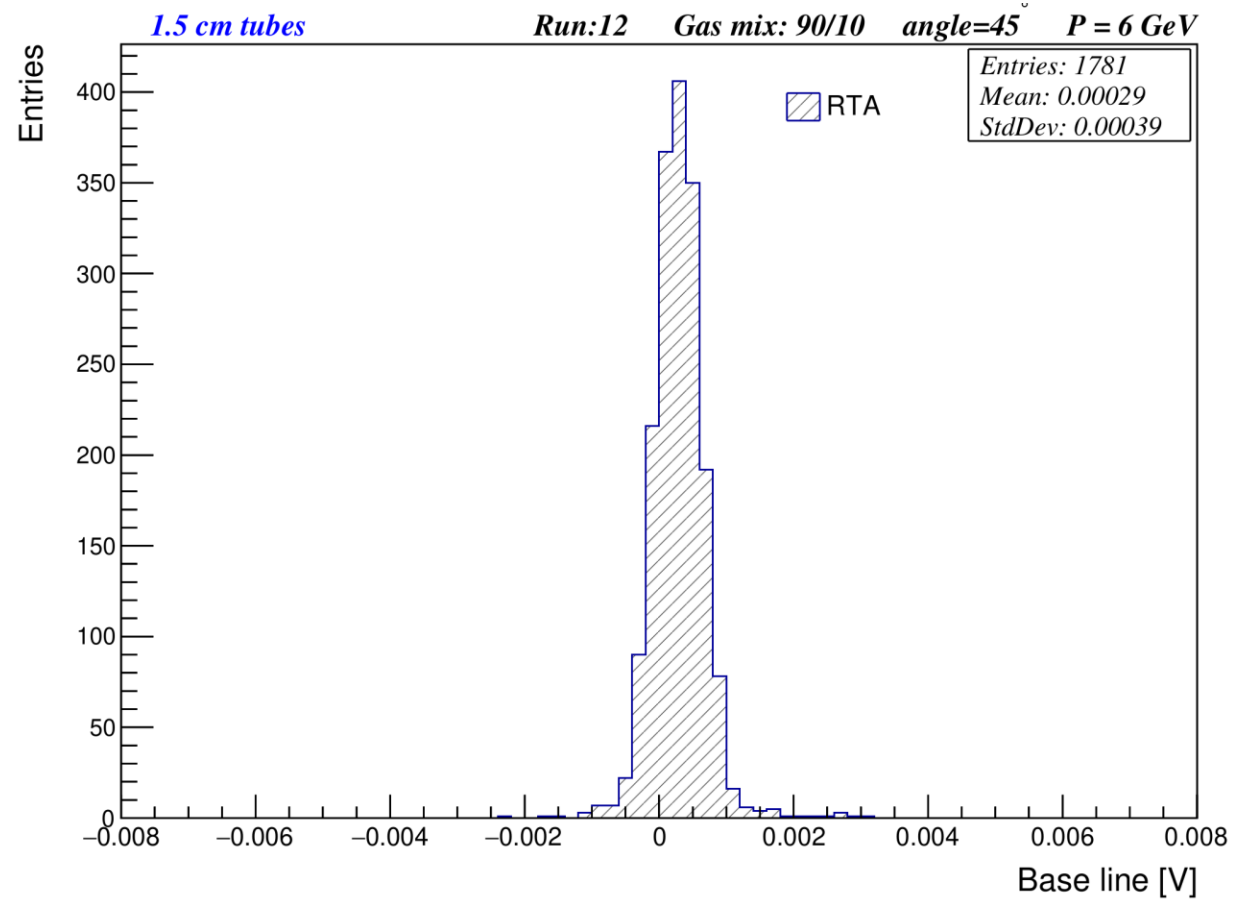
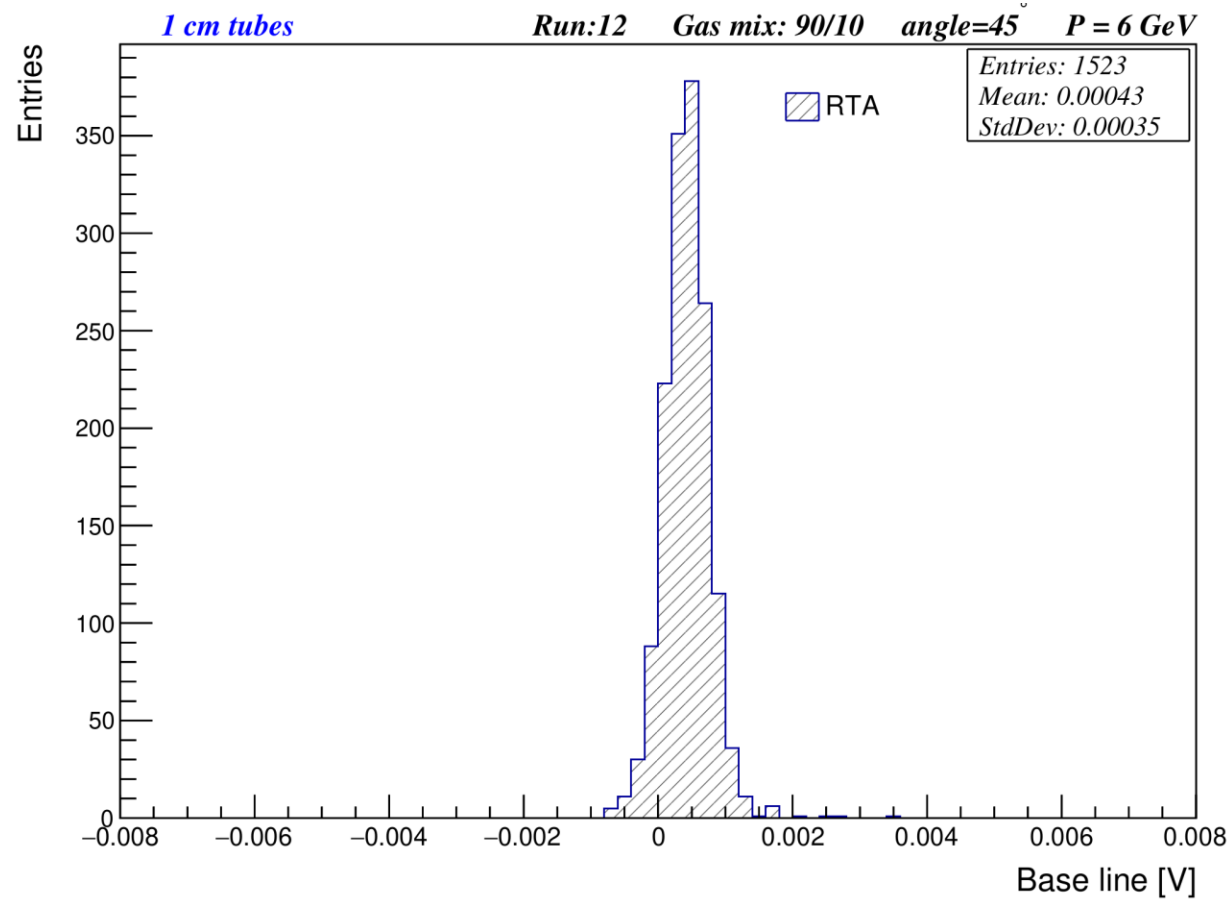
# Results



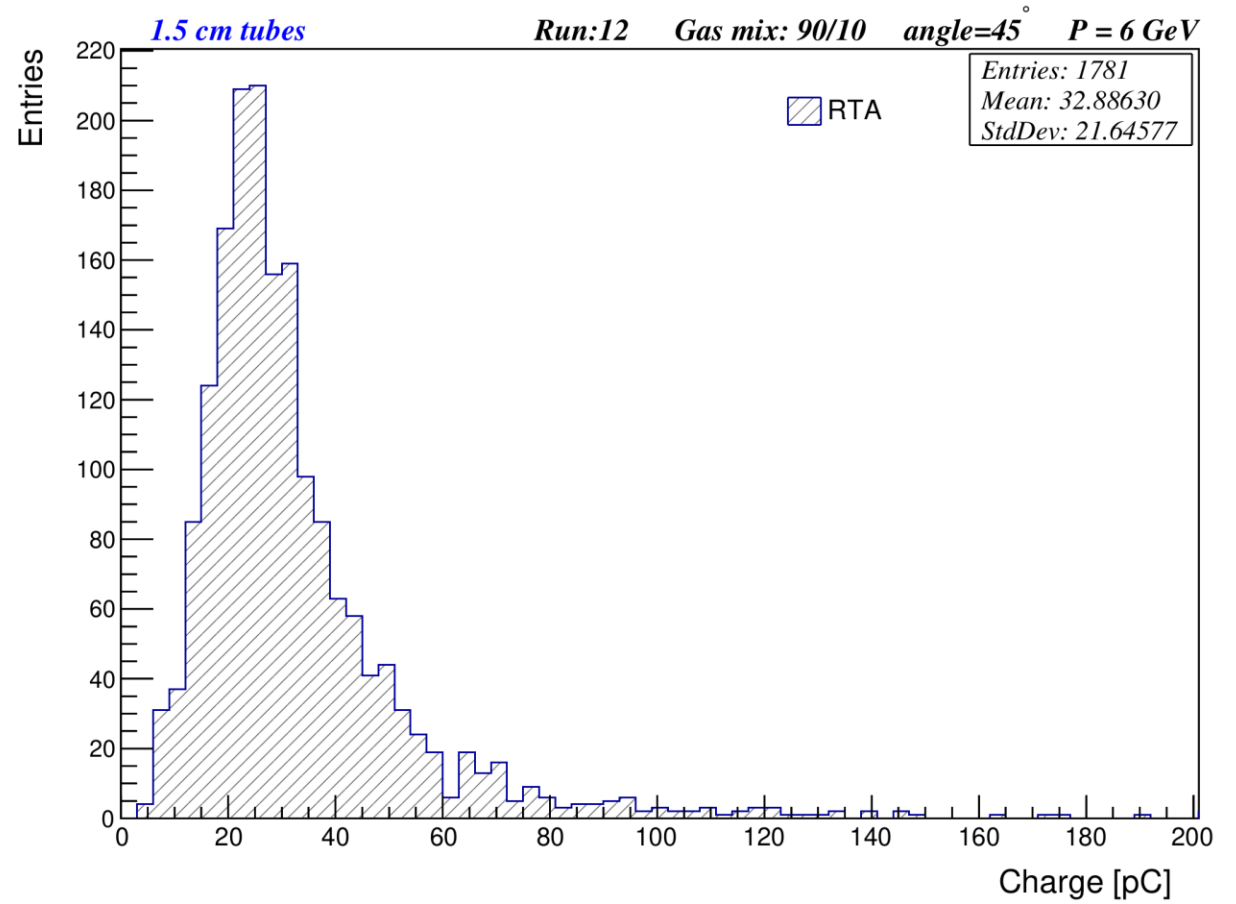
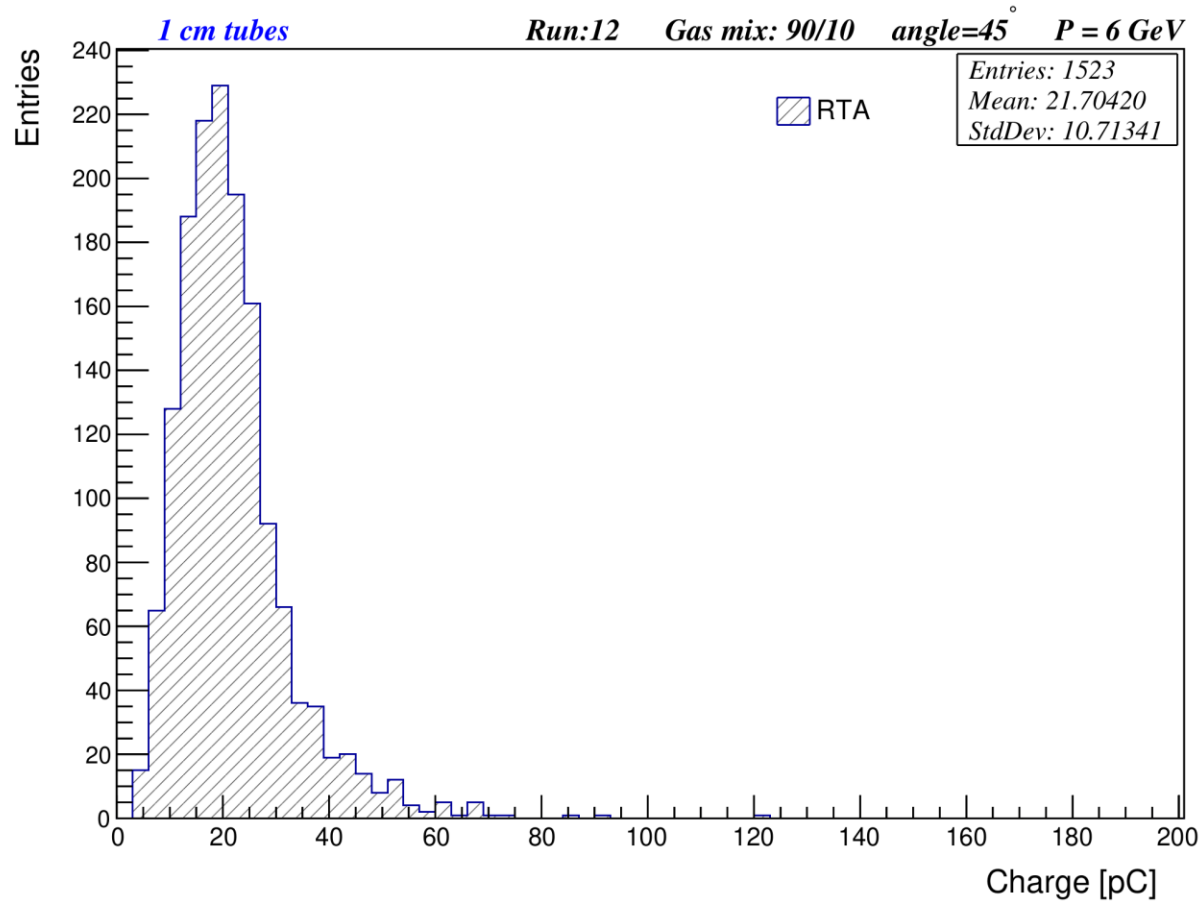
# Results



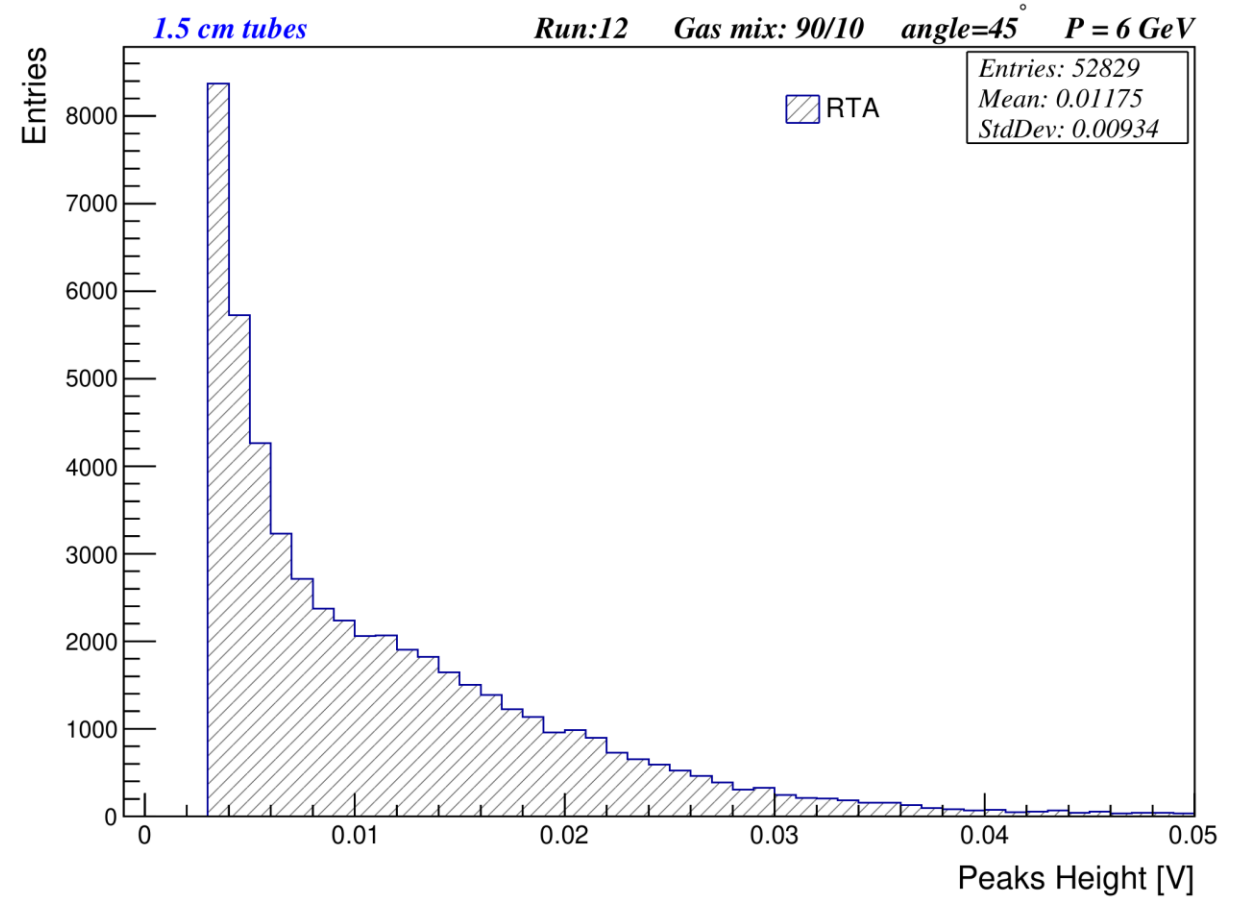
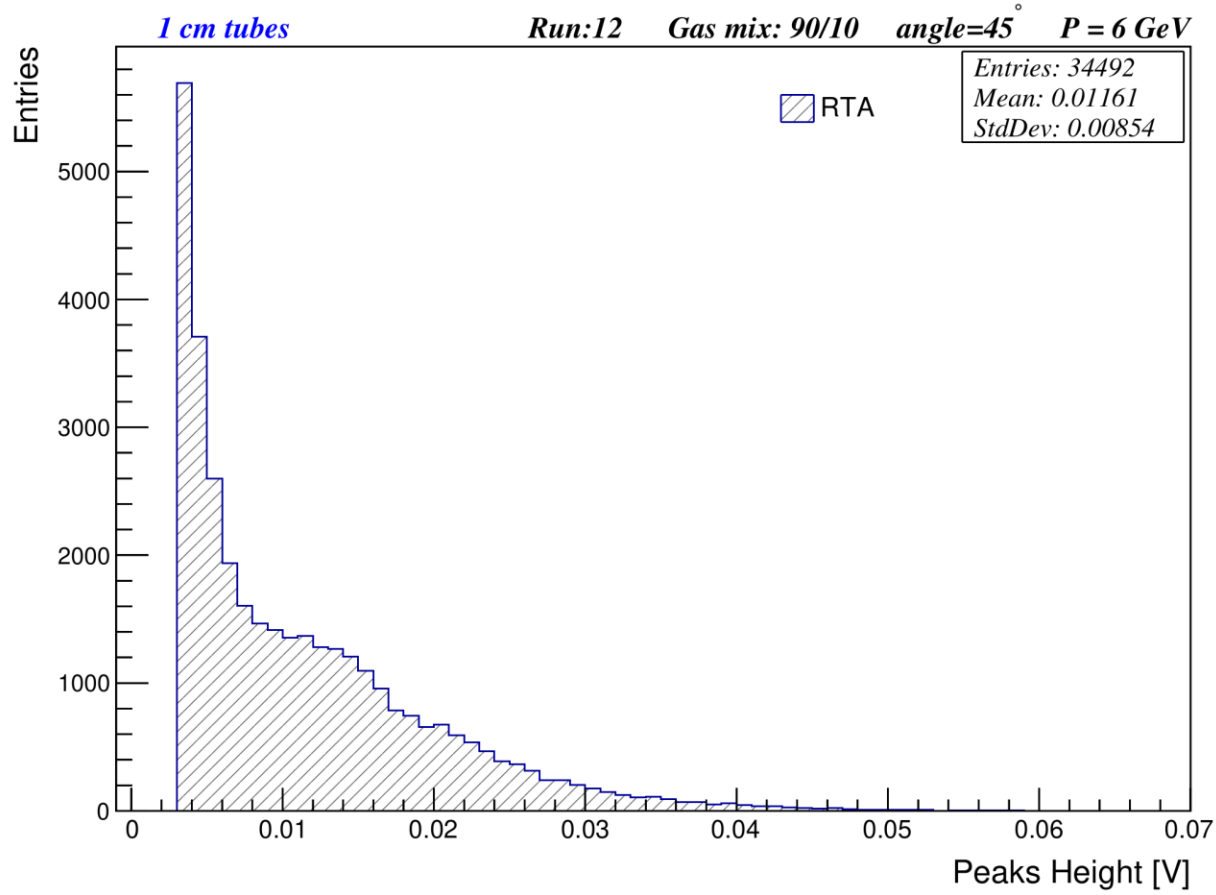
# Results



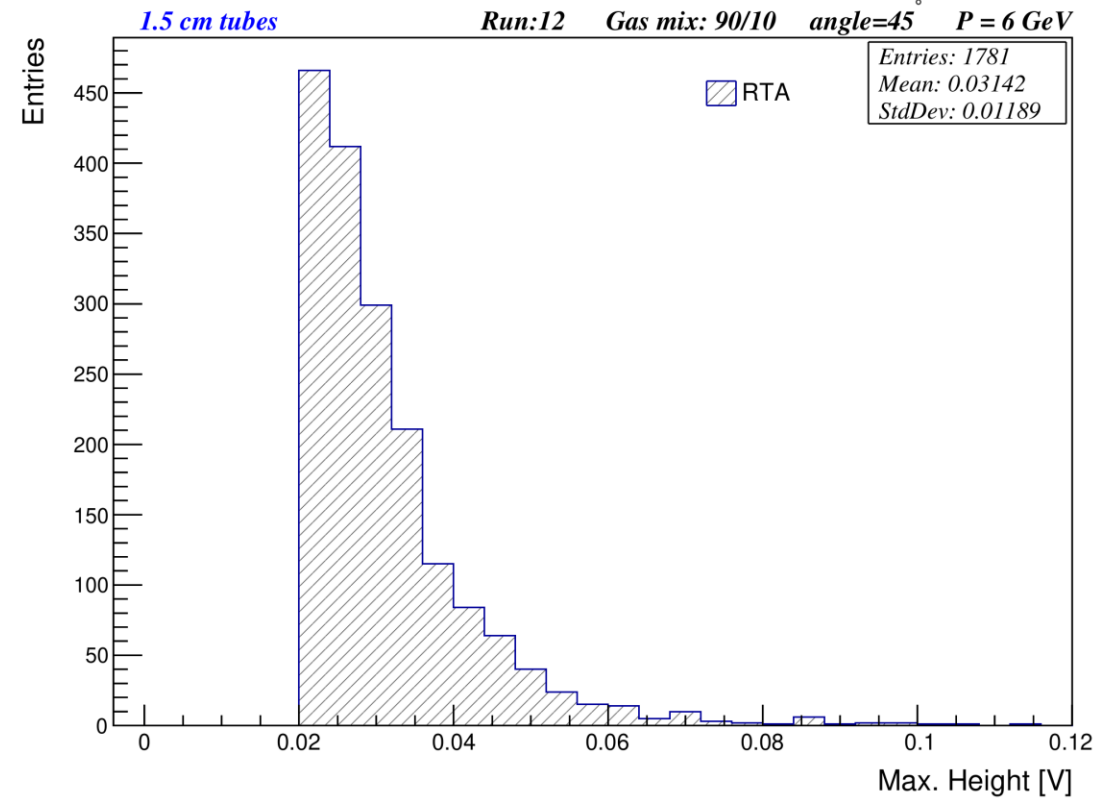
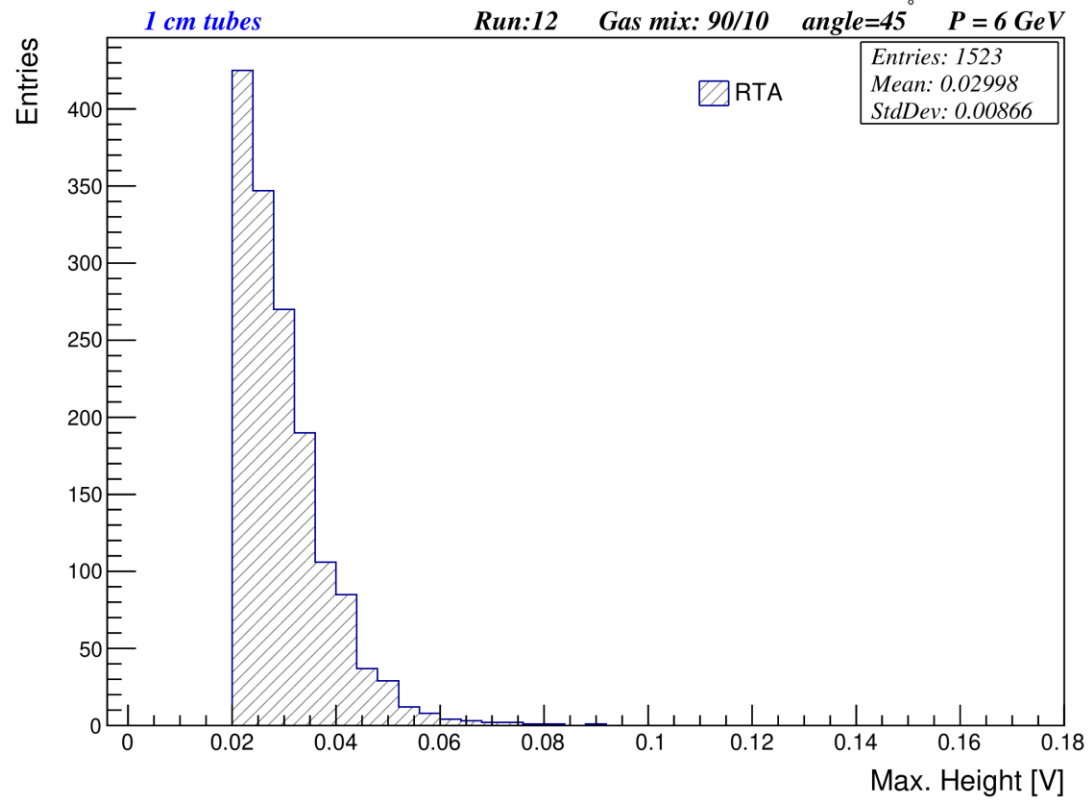
# Results



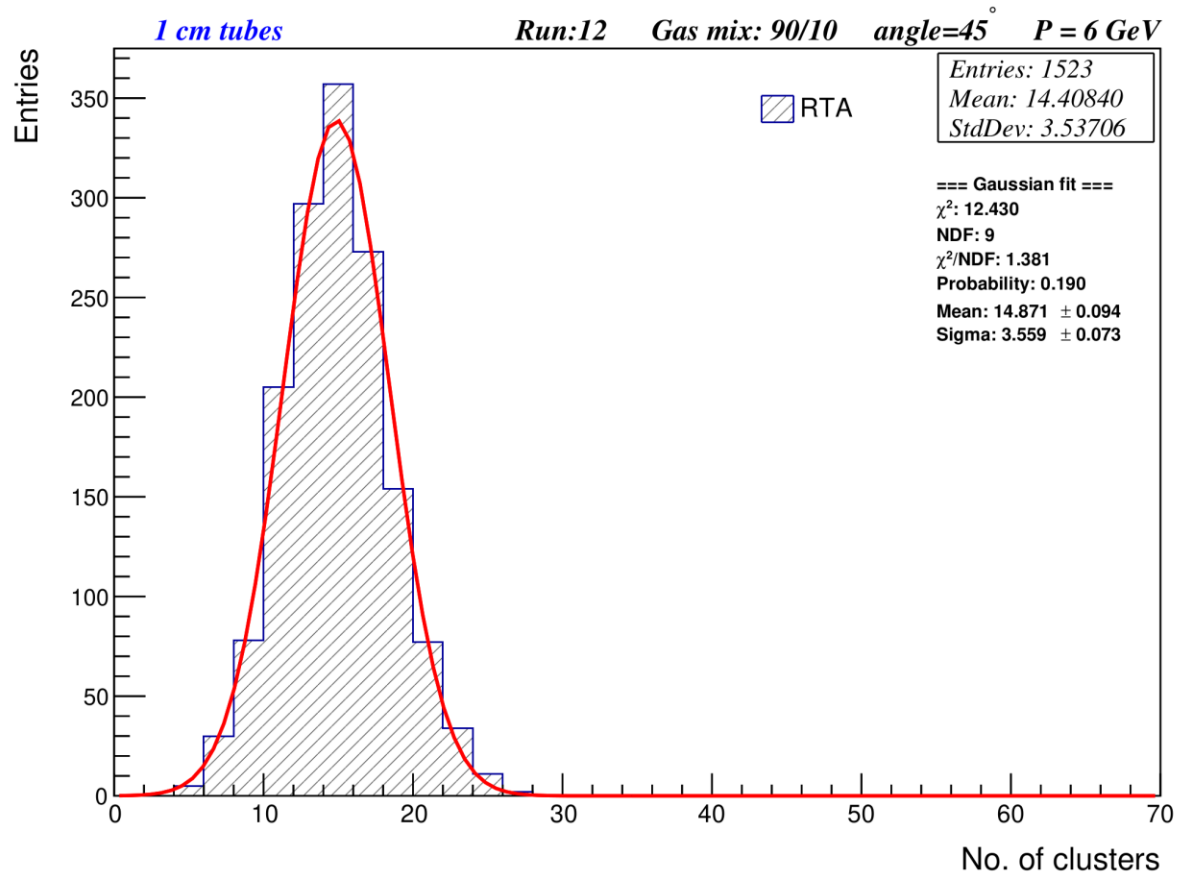
# Results



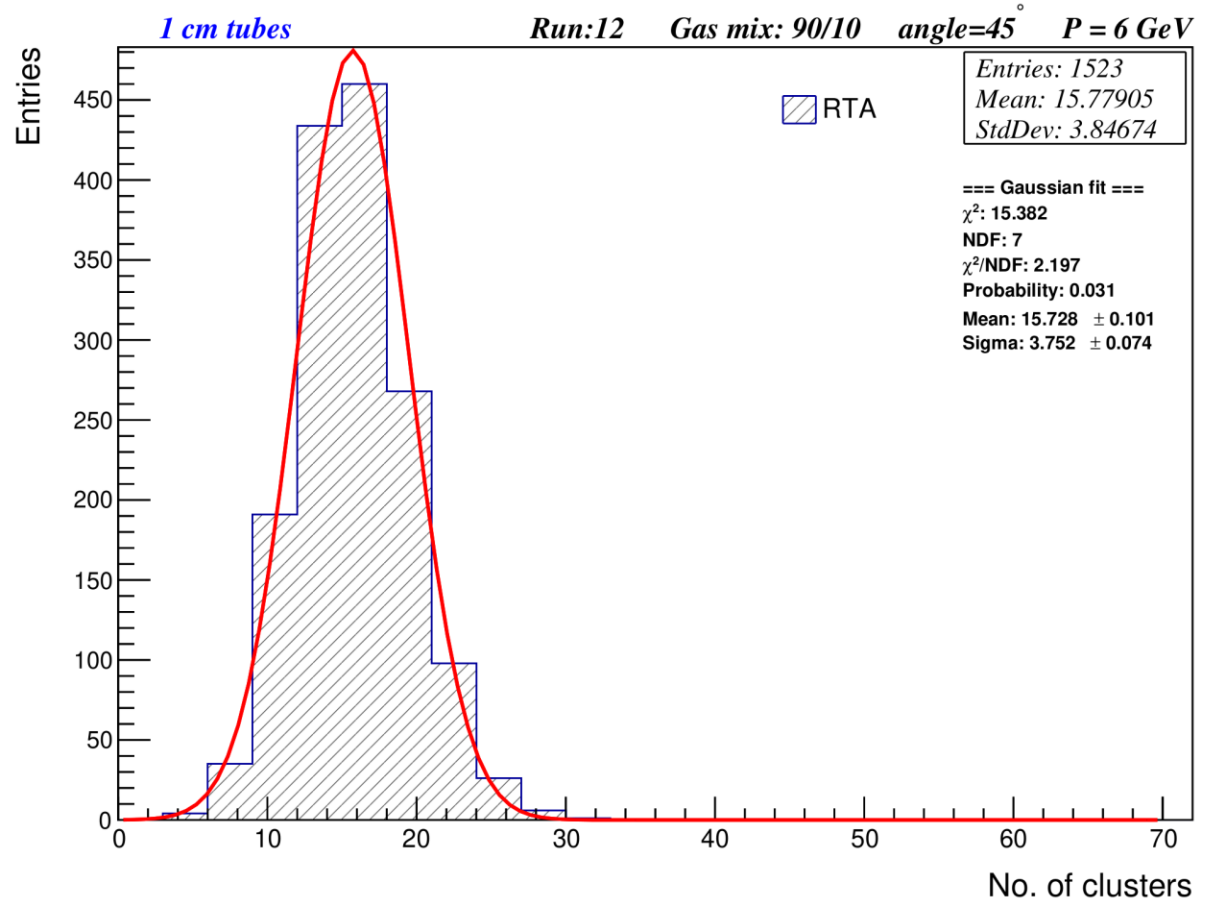
# Results



# Results

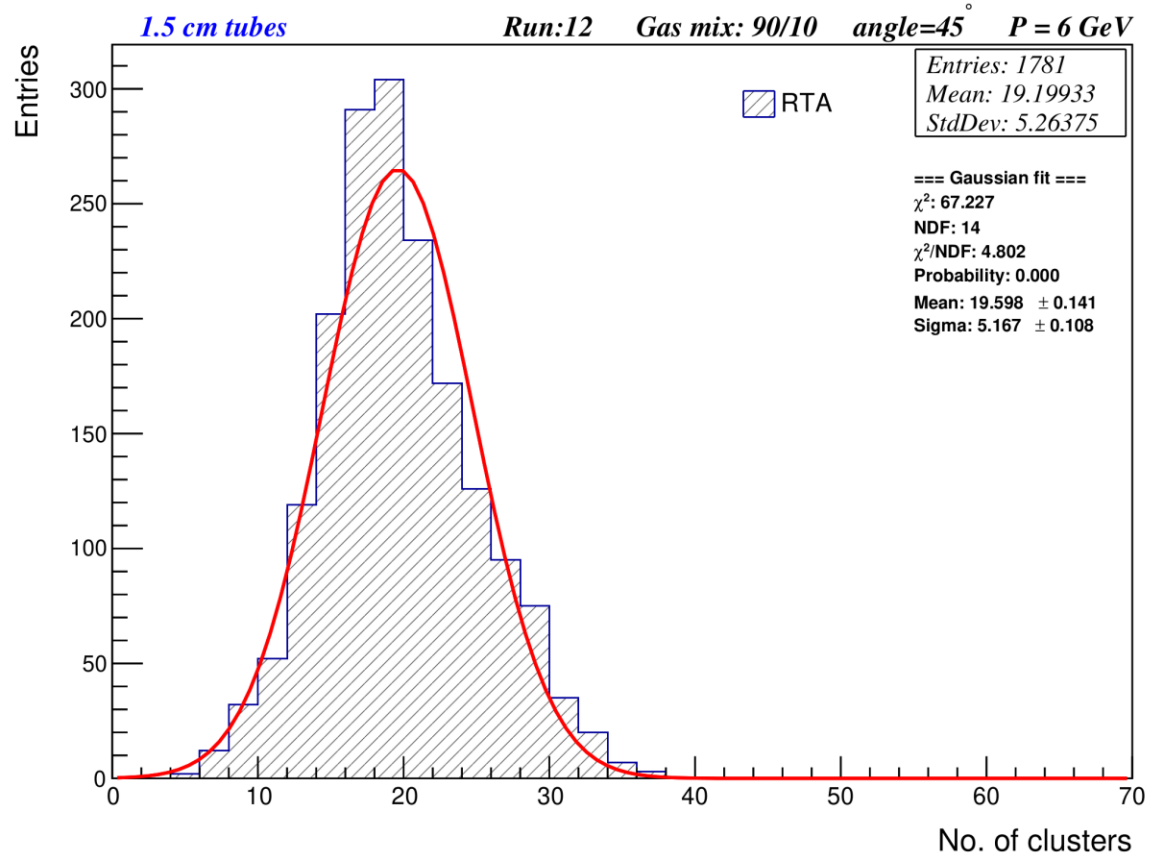


Before correction for  
attachment and Reco.

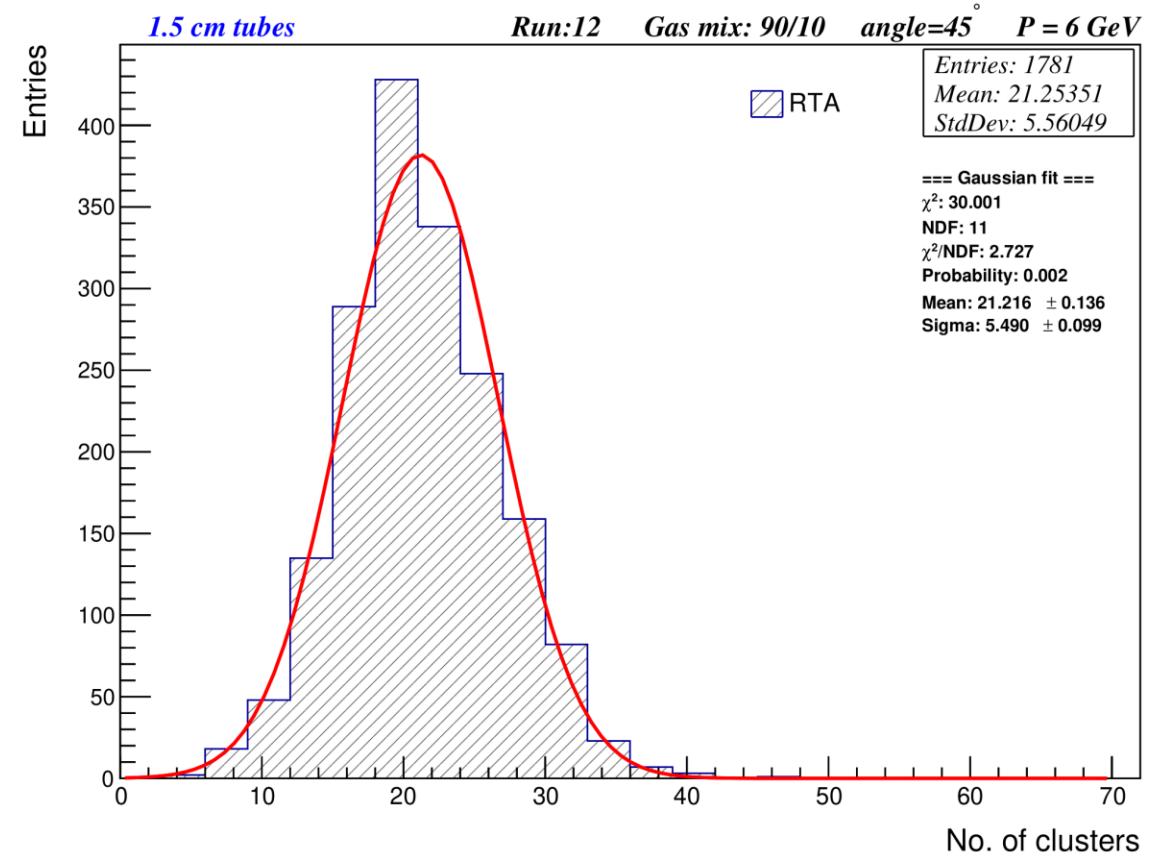


After correction for  
attachment and Reco.

# Results

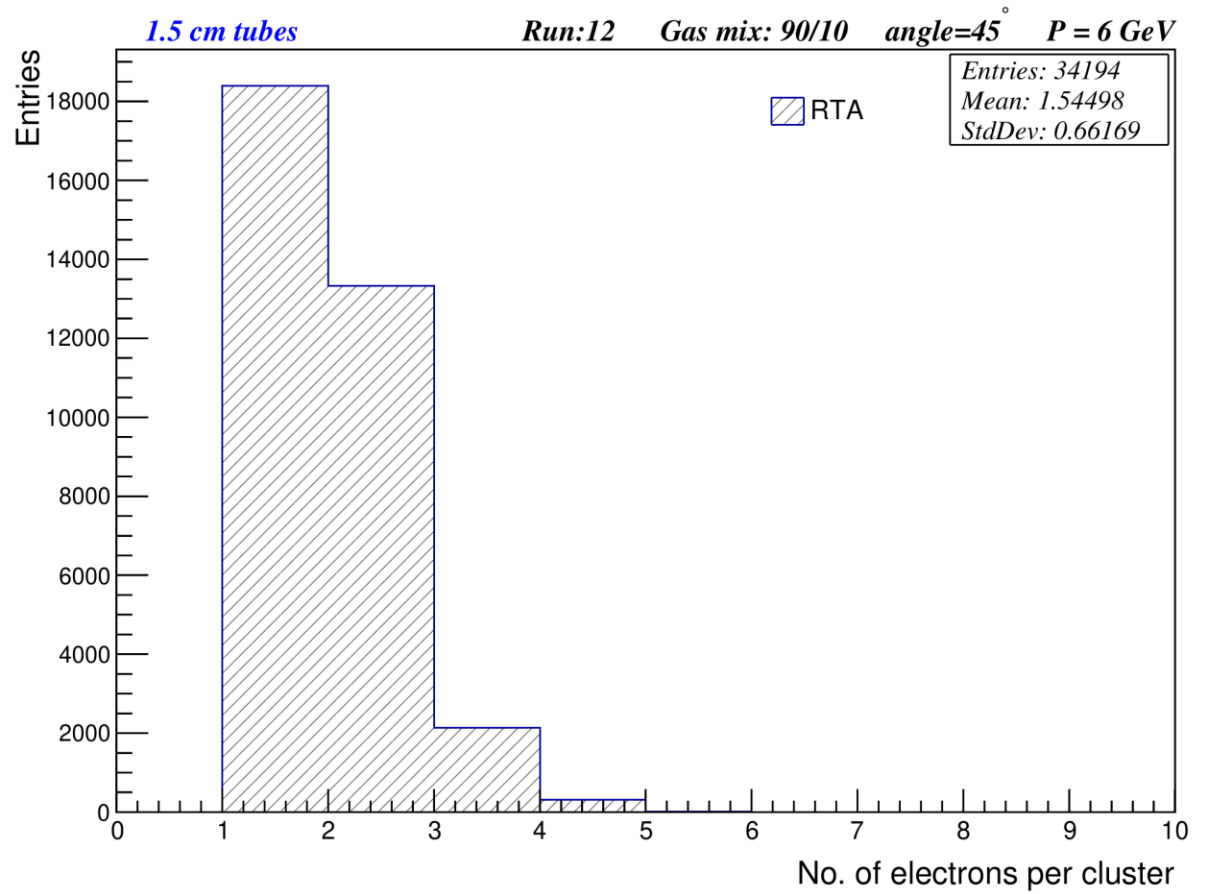
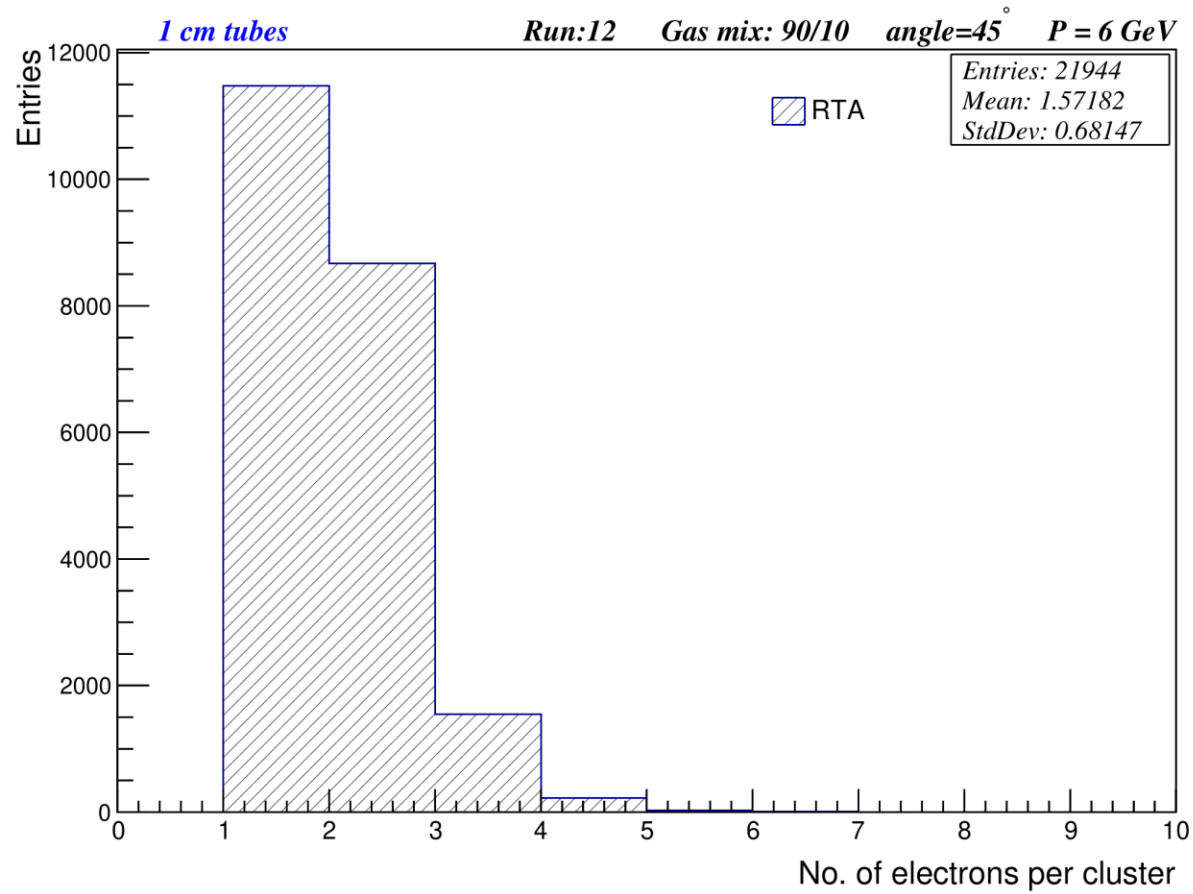


Before correction for  
attachment and Reco.



After correction for  
attachment and Reco.

# Results



# Results

90/10 & 45° runs summary

Clusterization cut scale: 0.28

<b>P GeV</b>	<b>No. <u>cls</u> 1 cm</b>	<b>No. <u>cls</u> 1.5 cm</b>	<b><u>Cls</u> size 1cm</b>	<b><u>Cls</u> size 1.5 cm</b>
<b>2</b>	16.95 (3.57)	23.35 (4.62)	1.59	1.54
<b>4</b>	16.22 (3.81)	21.17 (4.79)	1.56	1.54
<b>6</b>	15.77(3.84)	21.25(5.56)	1.54	1.57
<b>8</b>	15.95 (4.3)	21.75 (6.29)	1.56	1.54
<b>10</b>	15.6 (4.0)	22.24(6.6)	1.56	1.54

# The RTA for peak finding

## 2- Amplitude, Topology and goodness of the fit

### Case 1: Clean Pulse

Amp. threshold > 0.003

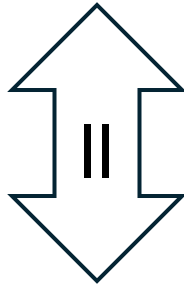
&&

(Amp[j] - Amp[j-krise] > 0.0007 && Amp[j] - Amp[j+kfall] > 0.0007)

|| Amp[j] - Amp[j-krise] > 0.007 || Amp[j] - Amp[j+kfall] > 0.007

&&

$\chi^2/\text{dof} > 15$  || Apm[j] > 0.015 && Isolated



### Case 2: Crowded Pulses

Crowded

&& Amp. threshold > 0.008

&& Amp[j] - Amp[j-krise] > 0.008

&& Amp[j] - Amp[j+kfall] > 0.008

**Isolated:**

amplitude[j-1] < 0.01 &&

amplitude[j+1] < 0.01

**Crowded:**

amplitude[j-Krise] > 0.005 &&

amplitude[j+Kfall] > 0.005

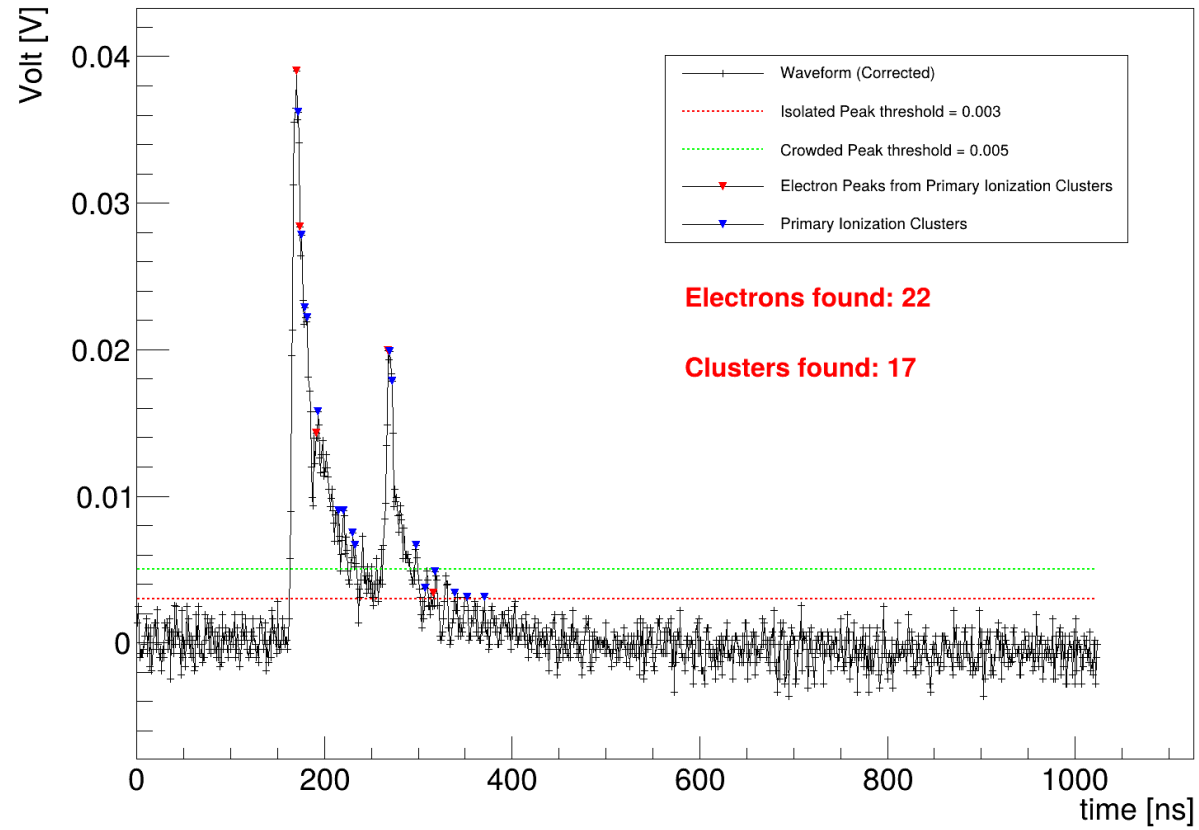
# Time windows Applied to the clusters

- **Minimum Peaks:** > 2 peaks.
- **Global time window:** 30 - 700 ns
- **Time of the first cluster:**
  - For **1 cm channel** < 300 ns
  - For **1.5 cm channel** < 400 ns
- **Cluster time span:**
  - For **1 cm channel:** cluster duration < 200 ns
  - For **1.5 cm channel:** cluster duration < 300 ns

# Results

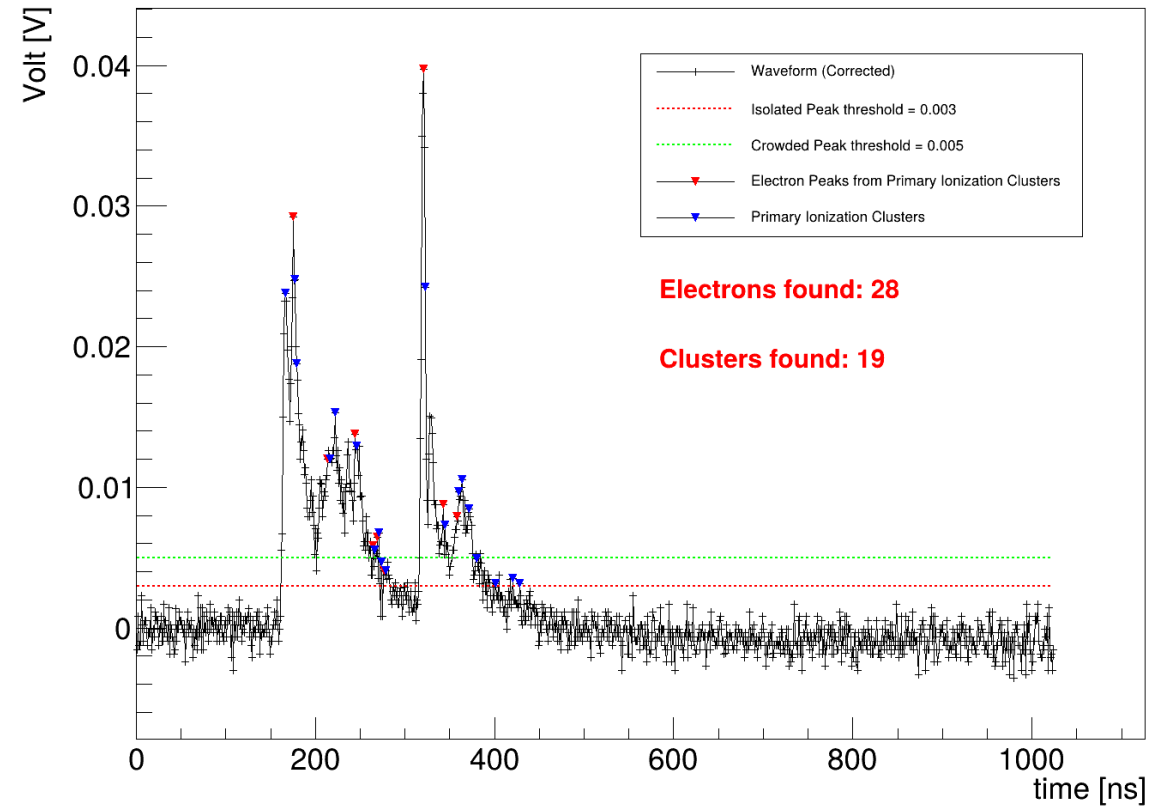
1 cm

Waveform signal (CORRECTED) Ch1 - Event 594 - Sense Wire Diameter 20  $\mu\text{m}$  - Cell Size 1.0 cm - Track Angle 0.0 - run\_16 - 1.0 GSa/s - Gas Mixture 80/20 0 - 90/10 0 - 85/15 0



1.5 cm

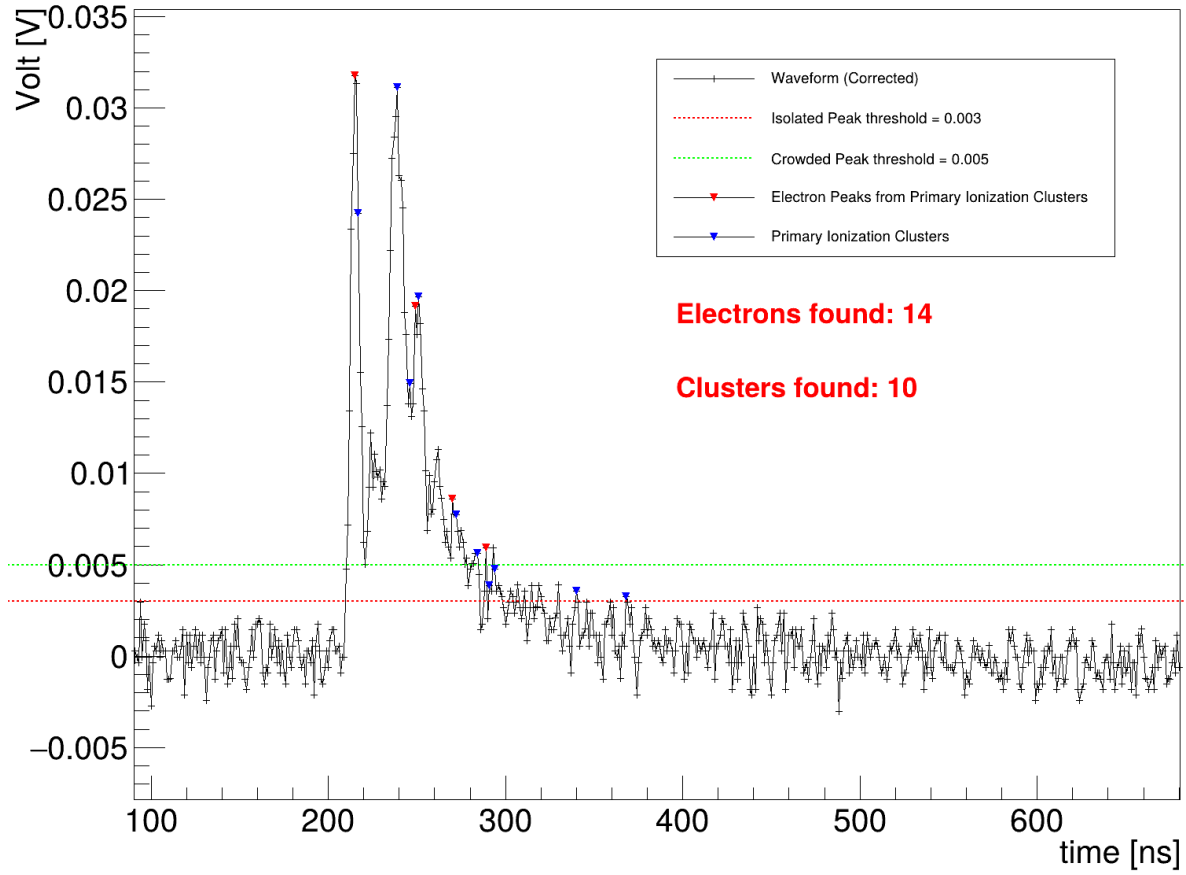
Waveform signal (CORRECTED) Ch6 - Event 2 - Sense Wire Diameter 20  $\mu\text{m}$  - Cell Size 1.0 cm - Track Angle 0.0 - run\_16 - 1.0 GSa/s - Gas Mixture 80/20 0 - 90/10 0 - 85/15 0



# Results

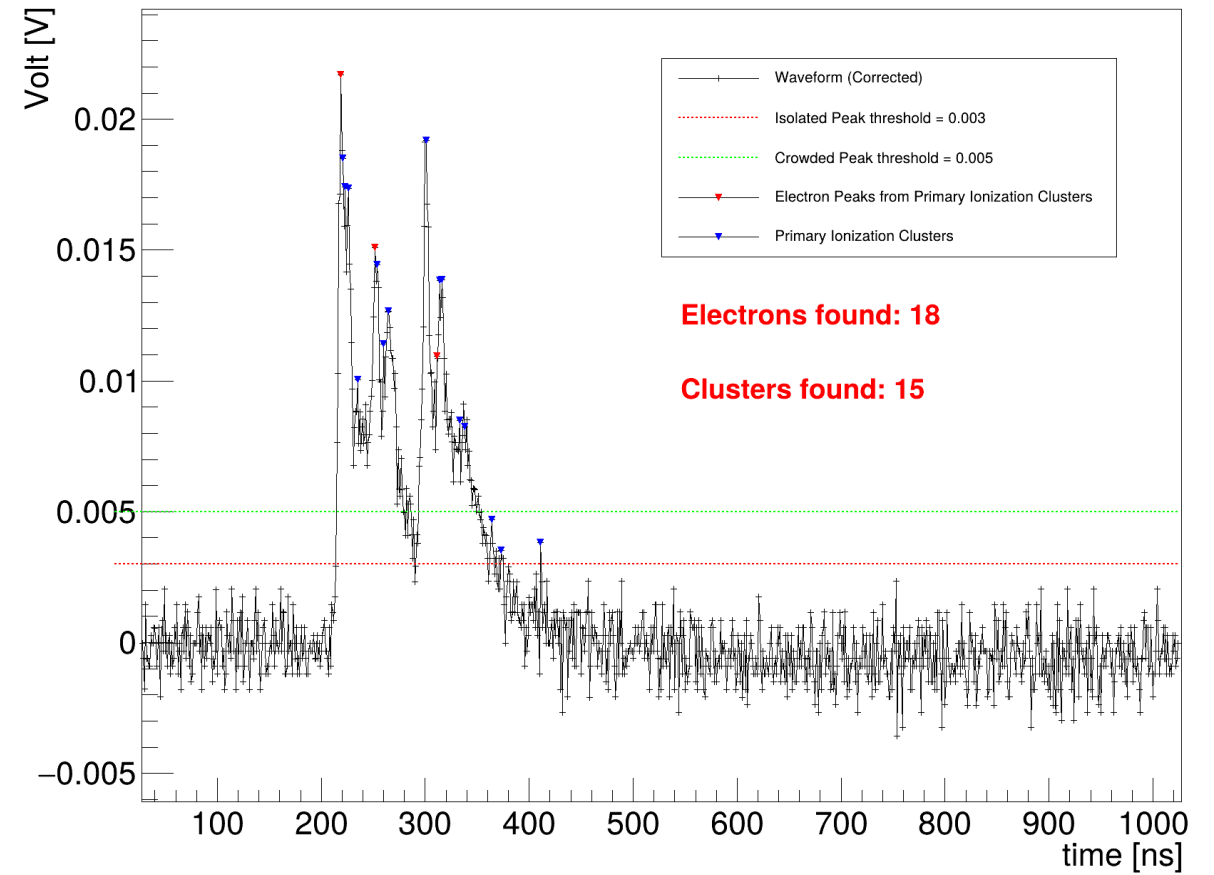
1 cm

Waveform signal (CORRECTED) Ch5 - Event 716 - Sense Wire Diameter 20  $\mu\text{m}$  - Cell Size 1.0 cm - Track Angle 0.0 - run\_16 - 1.0 GSa/s - Gas Mixture 80/20 0 - 90/10 0 - 85/15 0

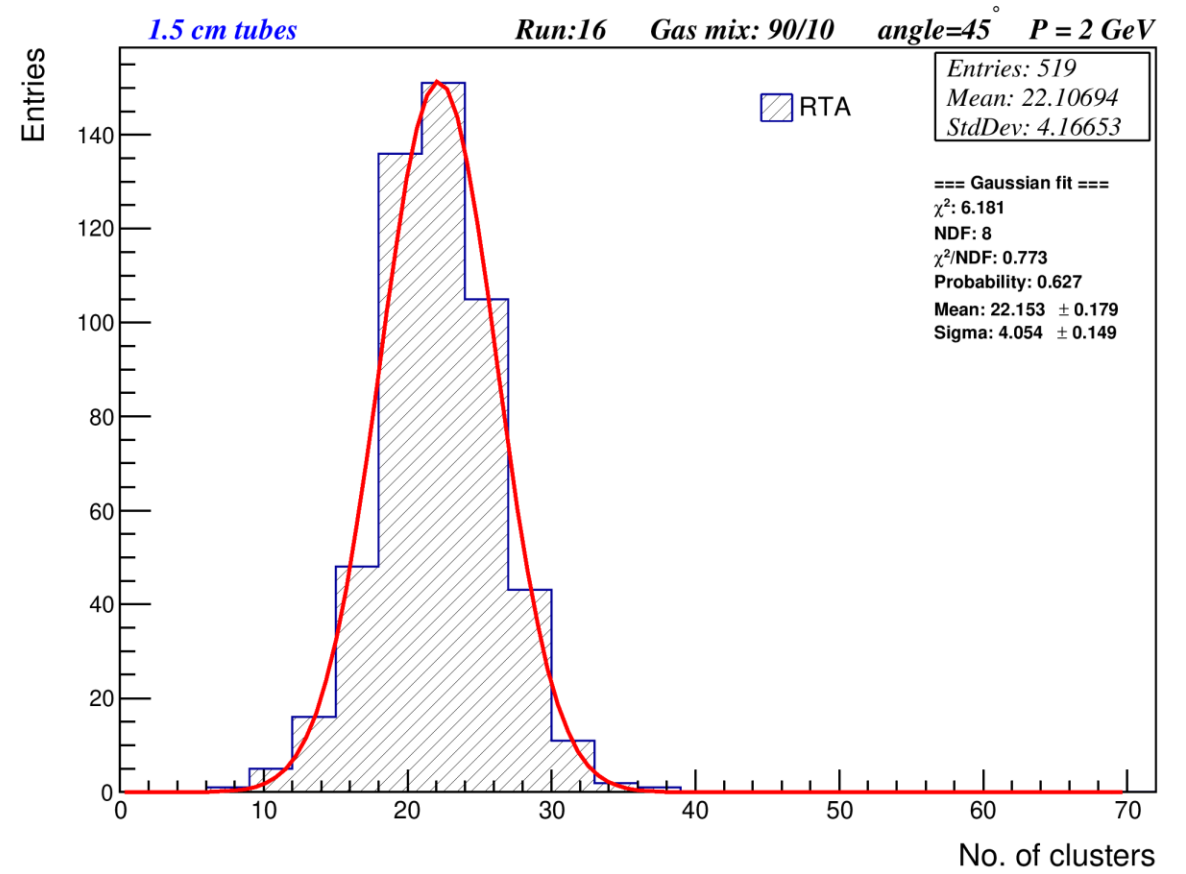
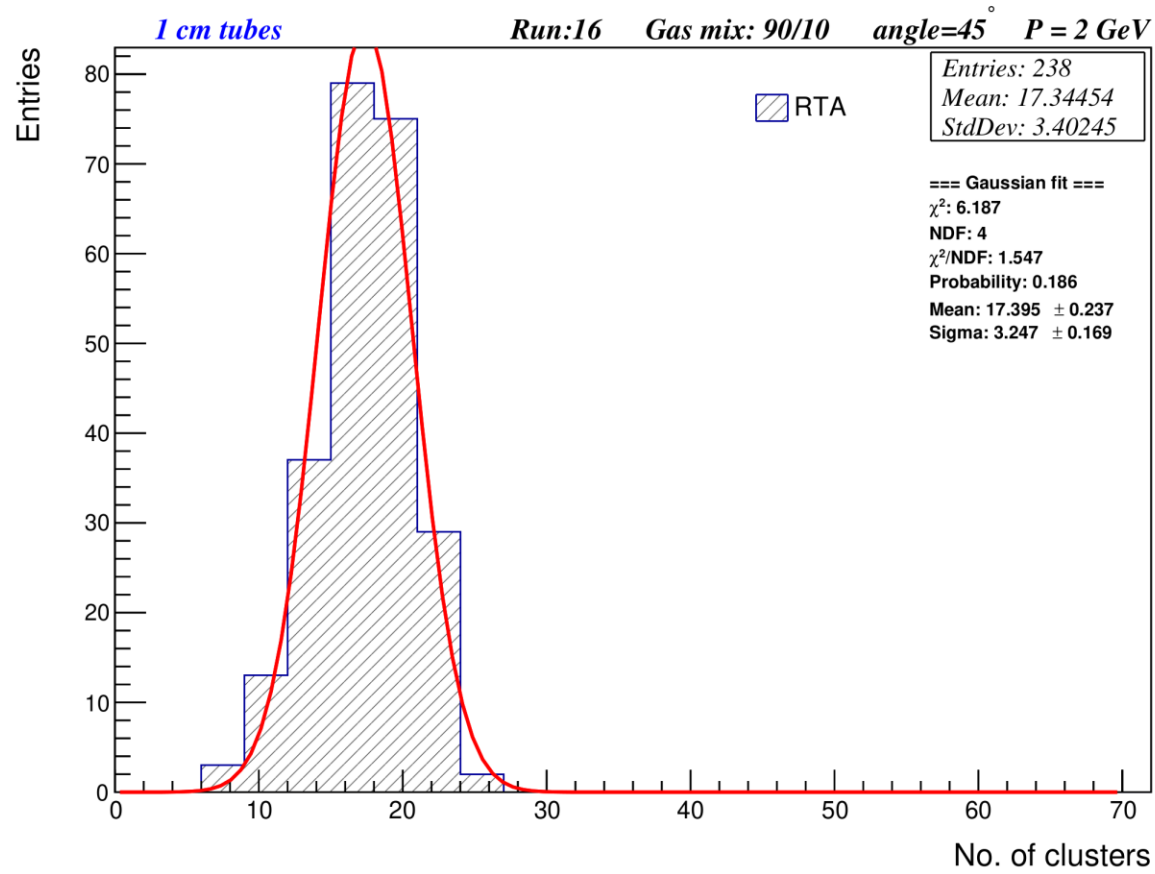


1.5 cm

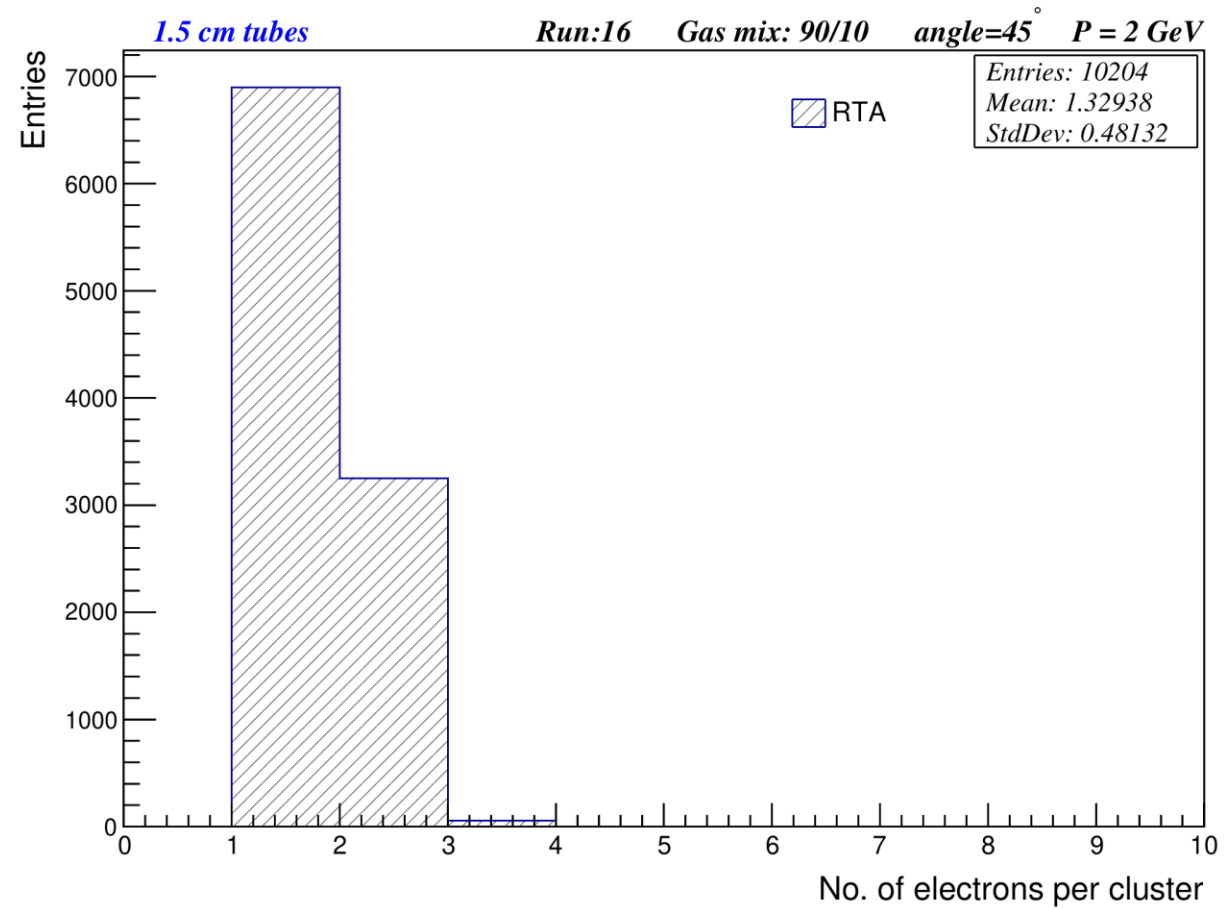
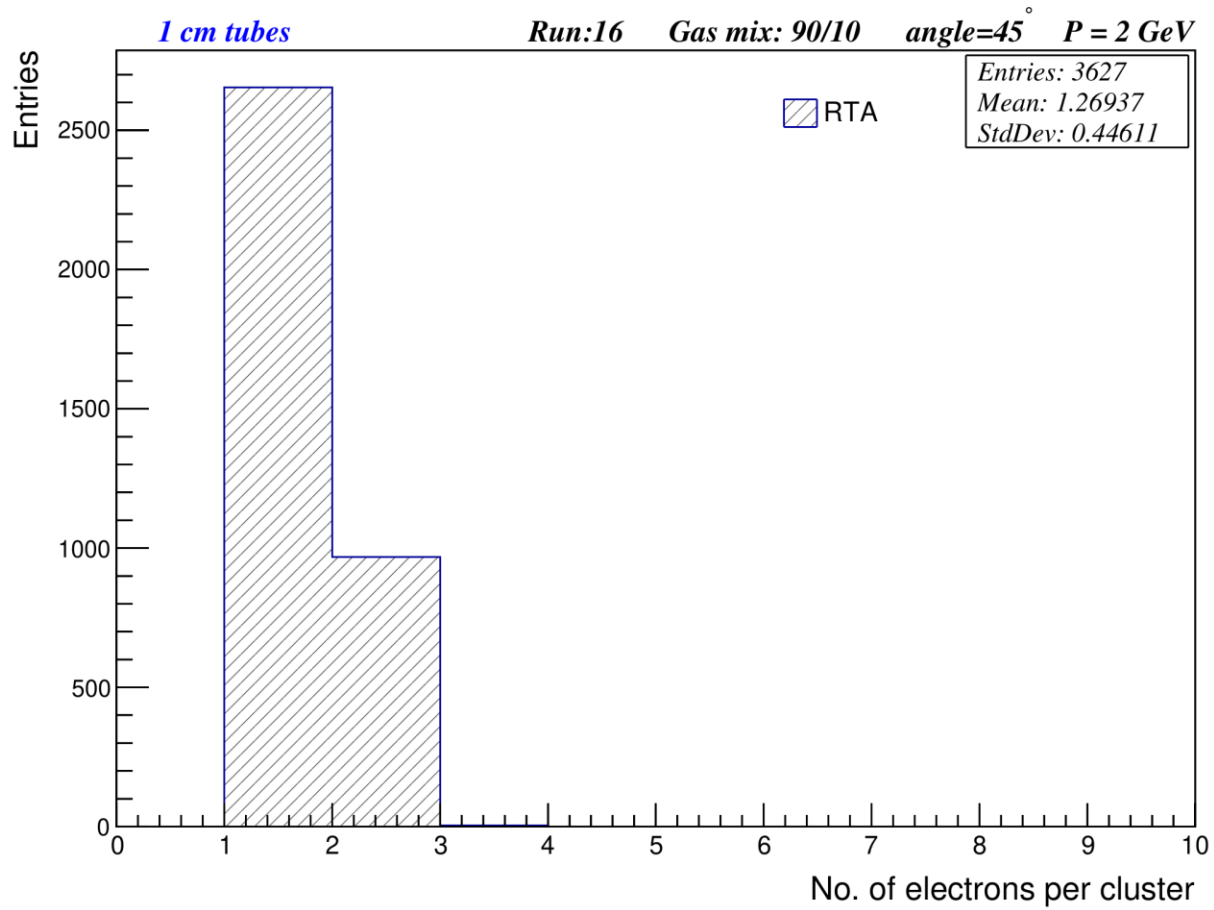
Waveform signal (CORRECTED) Ch6 - Event 207 - Sense Wire Diameter 20  $\mu\text{m}$  - Cell Size 1.0 cm - Track Angle 0.0 - run\_16 - 1.0 GSa/s - Gas Mixture 80/20 0 - 90/10 0 - 85/15 0



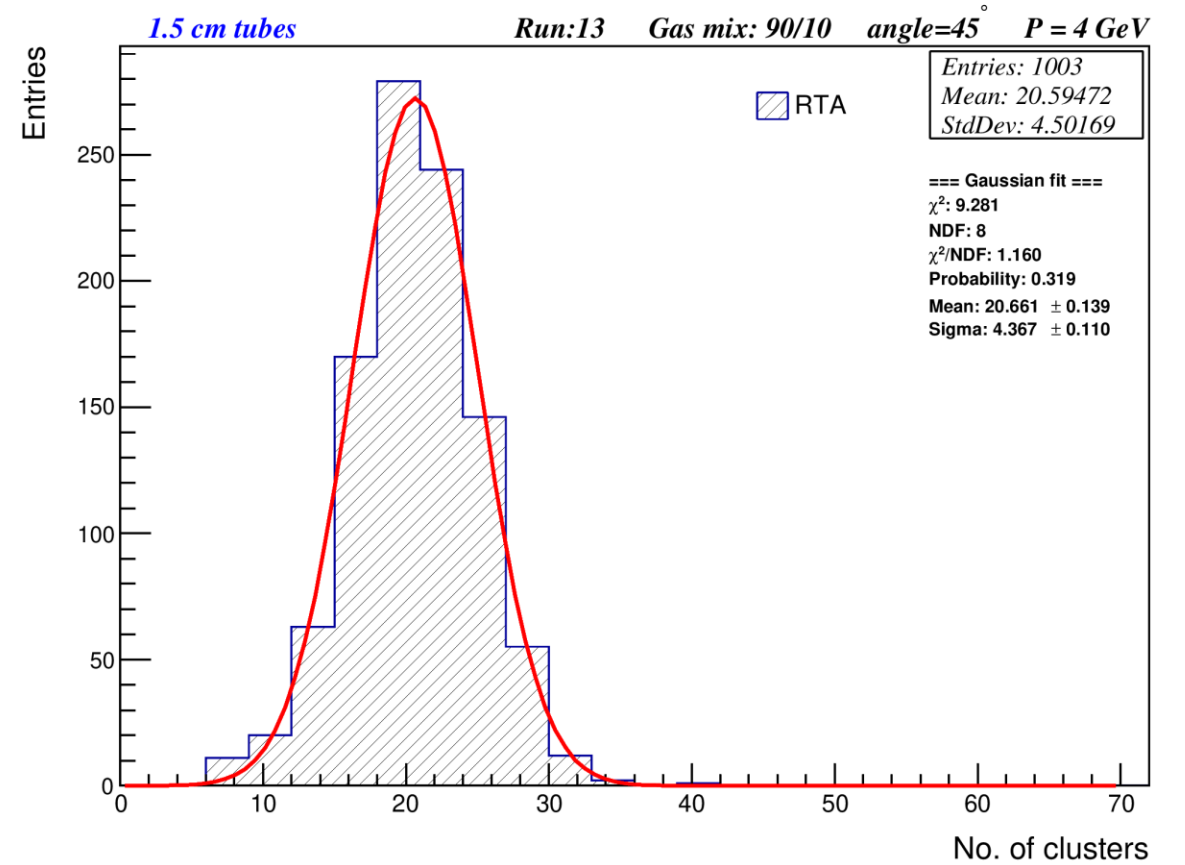
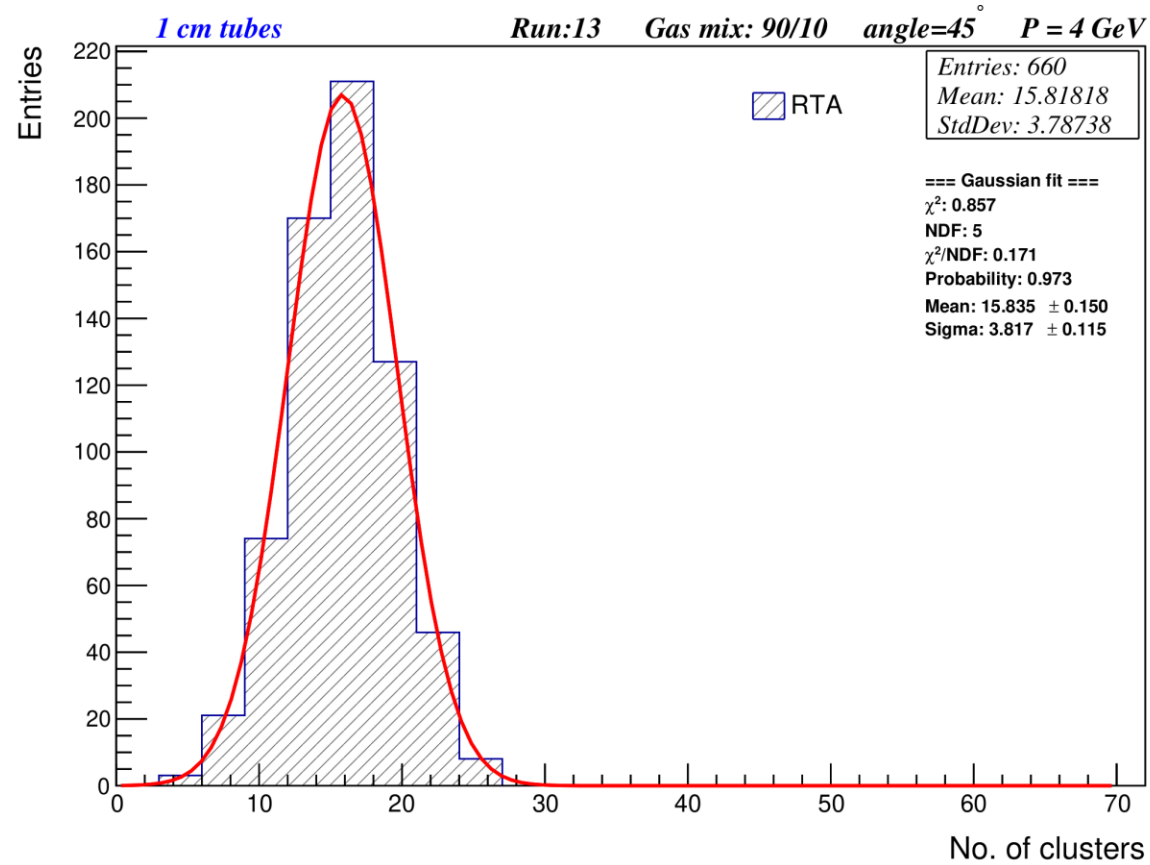
# Results



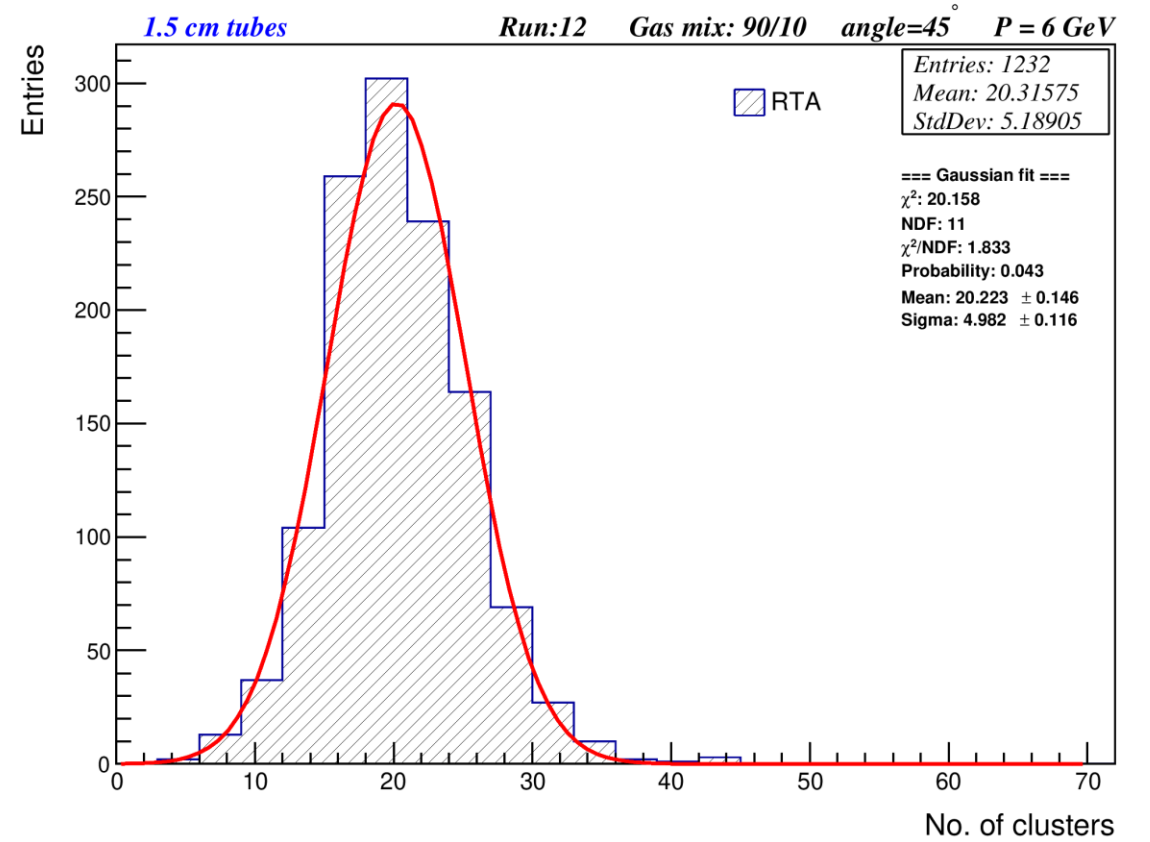
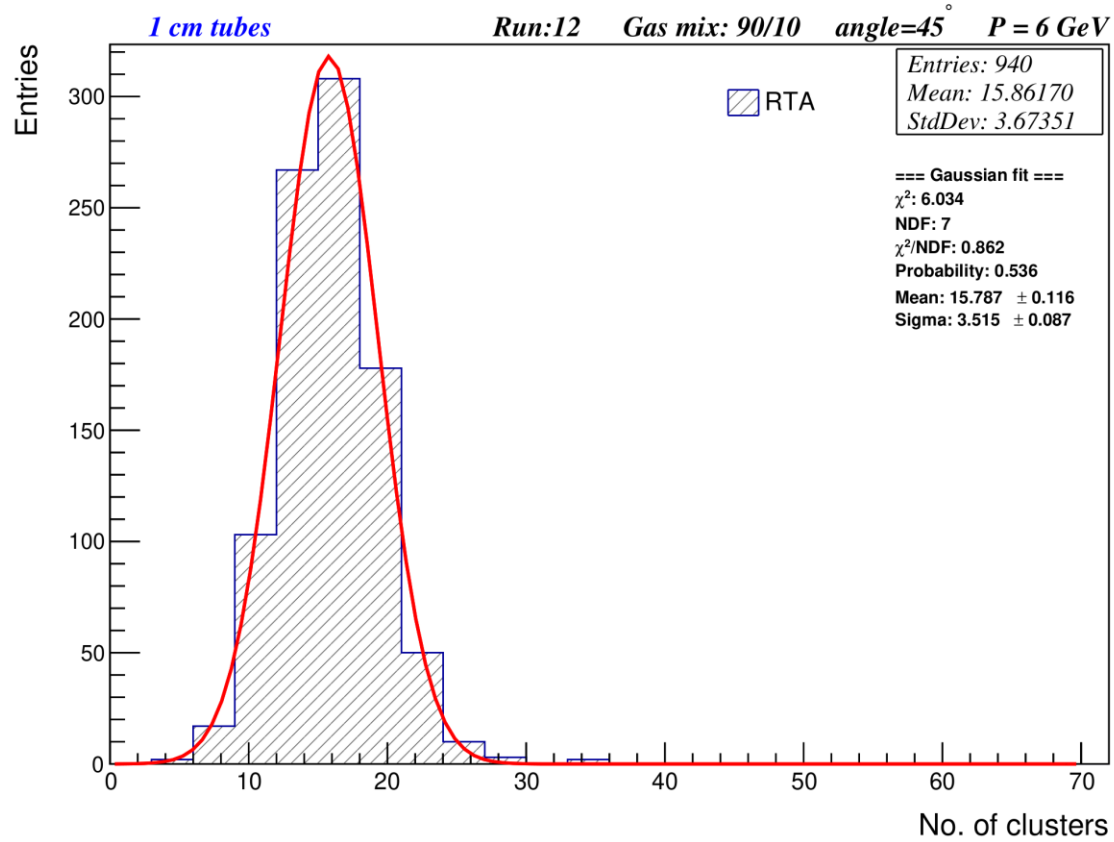
# Results



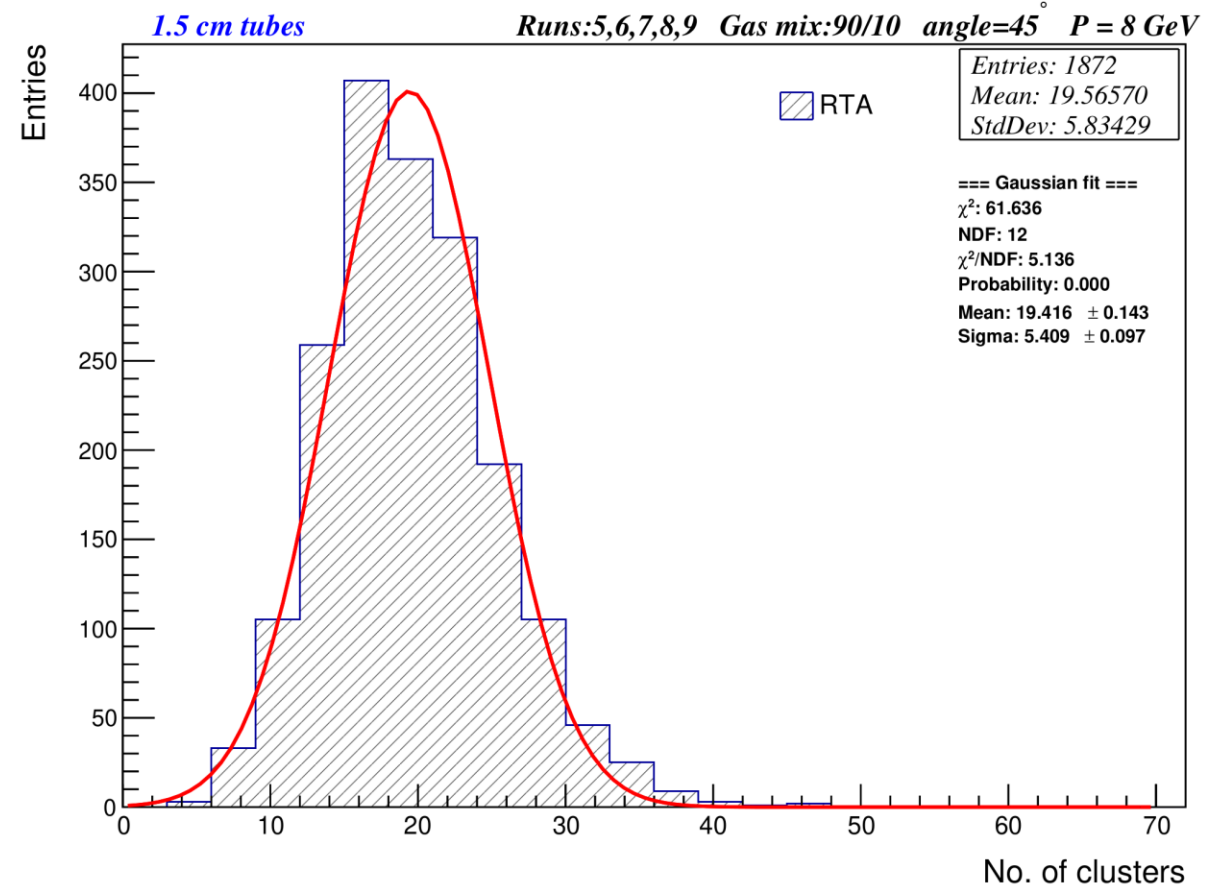
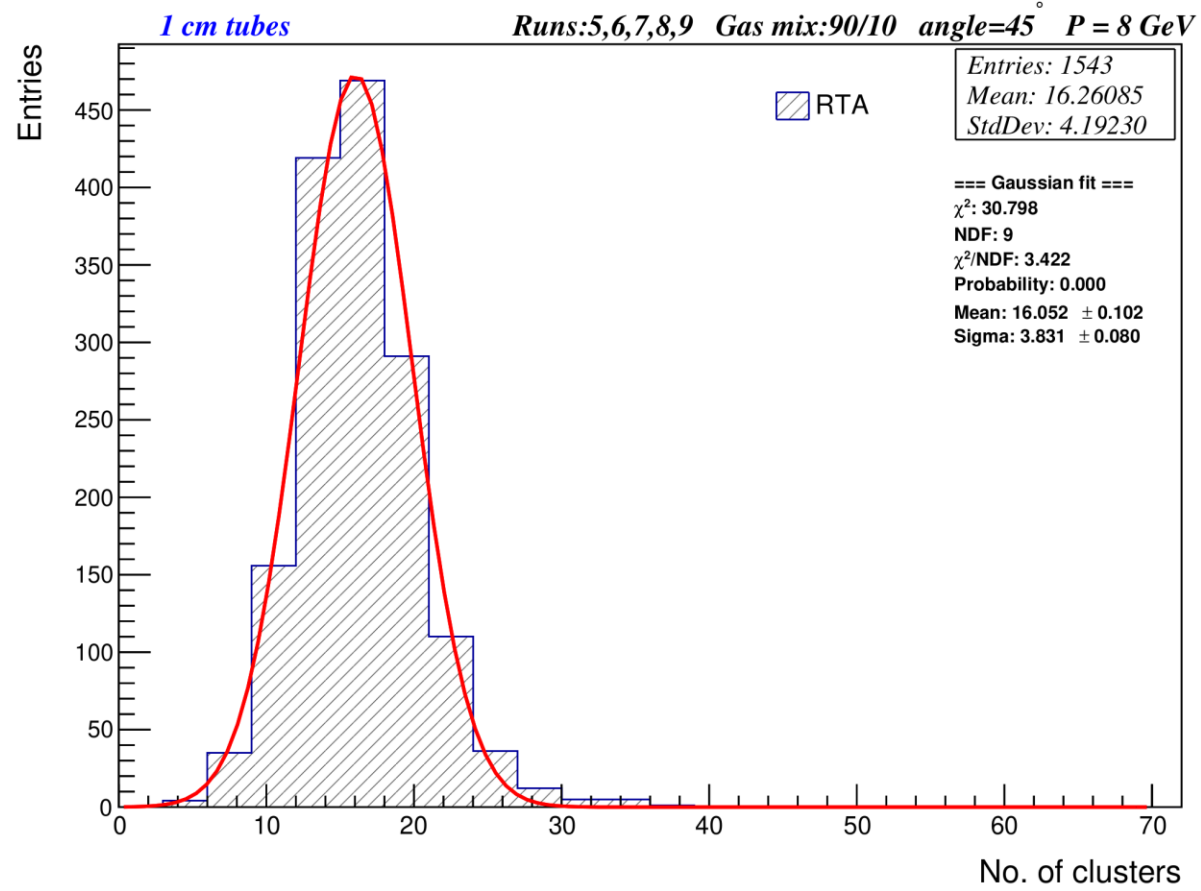
# Results



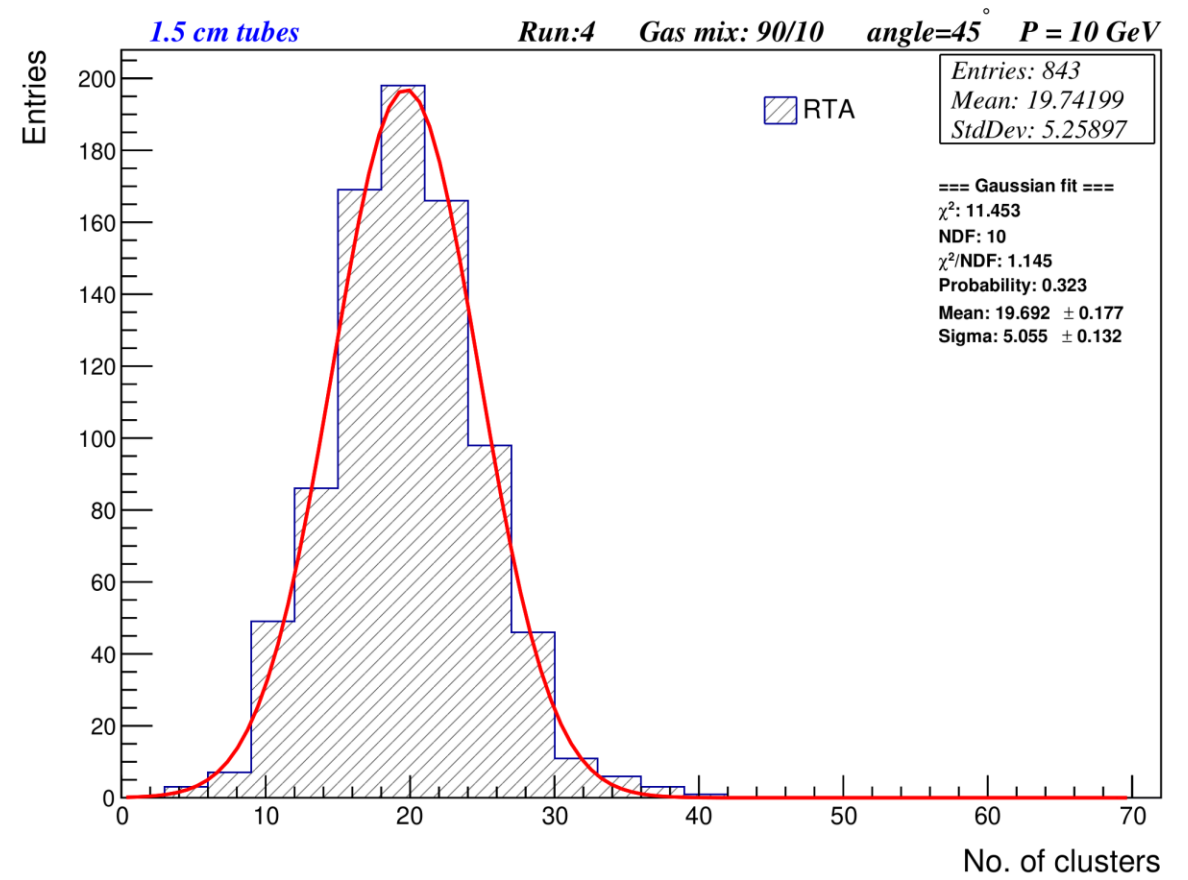
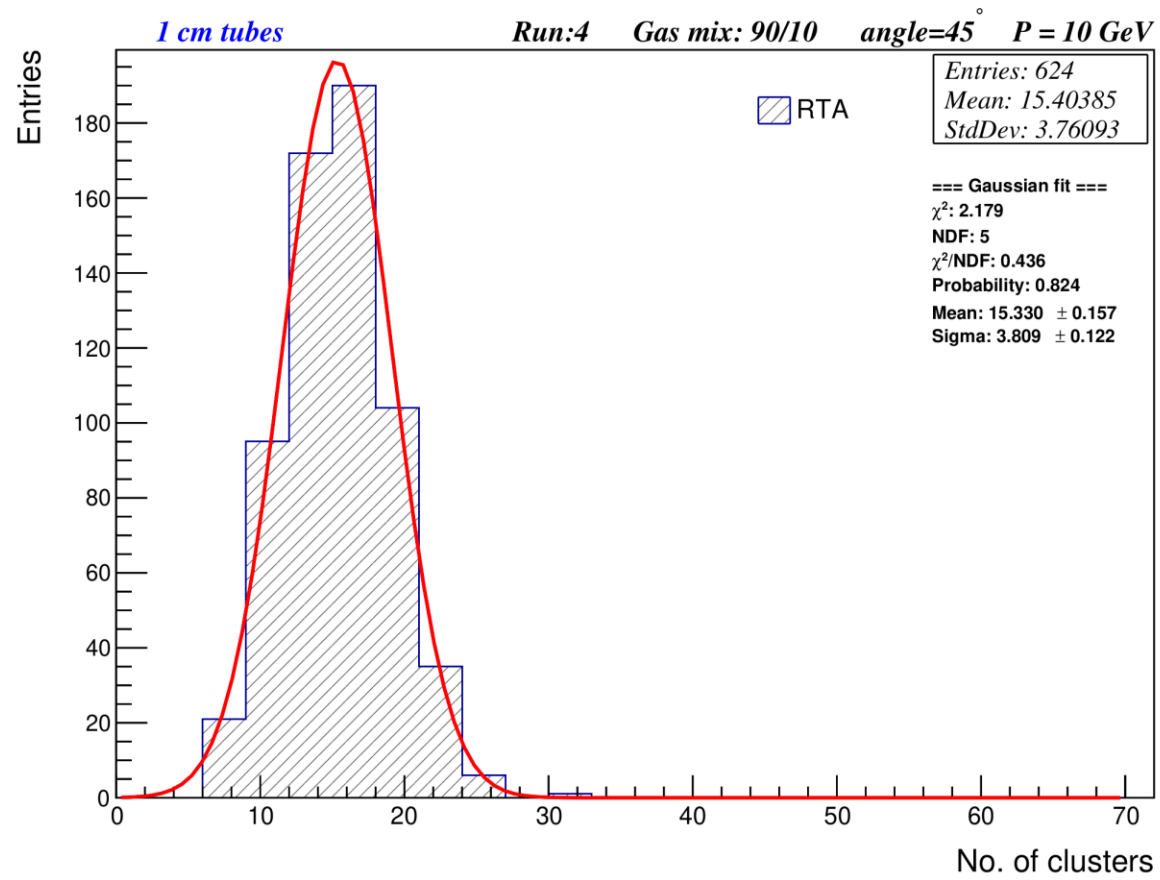
# Results



# Results



# Results



# Results

90/10 & 45° runs summary

Clusterization cut scale: 0.28

<b>P GeV</b>	<b>No. <u>cls</u> 1 cm</b>	<b>No. <u>cls</u> 1.5 cm</b>	<b><u>Cls</u> size 1cm</b>	<b><u>Cls</u> size 1.5 cm</b>
<b>2</b>	17.3 (3.40)	22.1 (4.1)	1.27	1.33
<b>4</b>	15.8 (3.78)	20.59 (4.5)	1.258	1.308
<b>6</b>	15.86 (3.67)	20.31 (5.19)	1.24	1.288
<b>8</b>	16.26 (4.19)	19.56 (5.8)	1.239	1.283
<b>10</b>	15.4 (3.76)	19.74 (5.25)	1.238	1.276



**±0.27**

**± 0.155**

**± 0.130**

**± 0.103**

**± 0.157**

**Recent iteration using the Der. Algo.**

**Tunning of the peak finding (Der. Algo.) is done based on the expected number of clusters obtained from Garfield++**

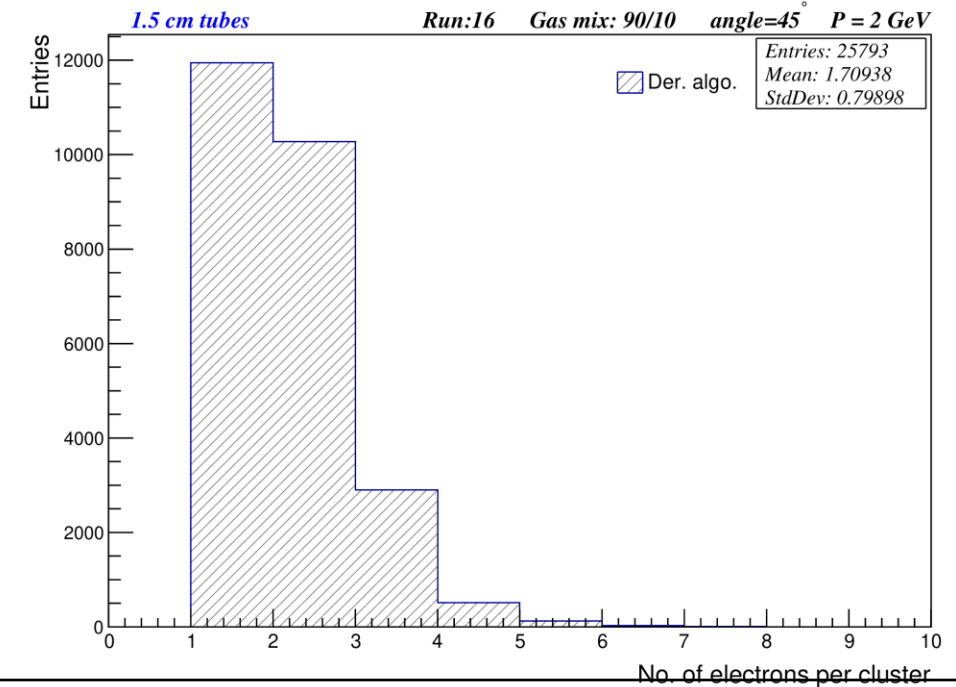
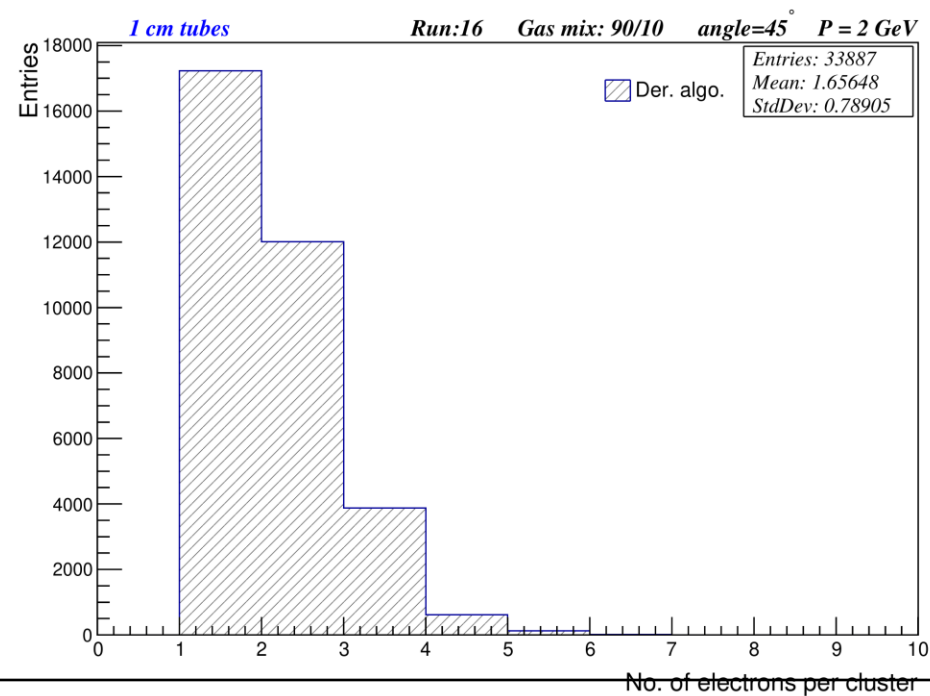
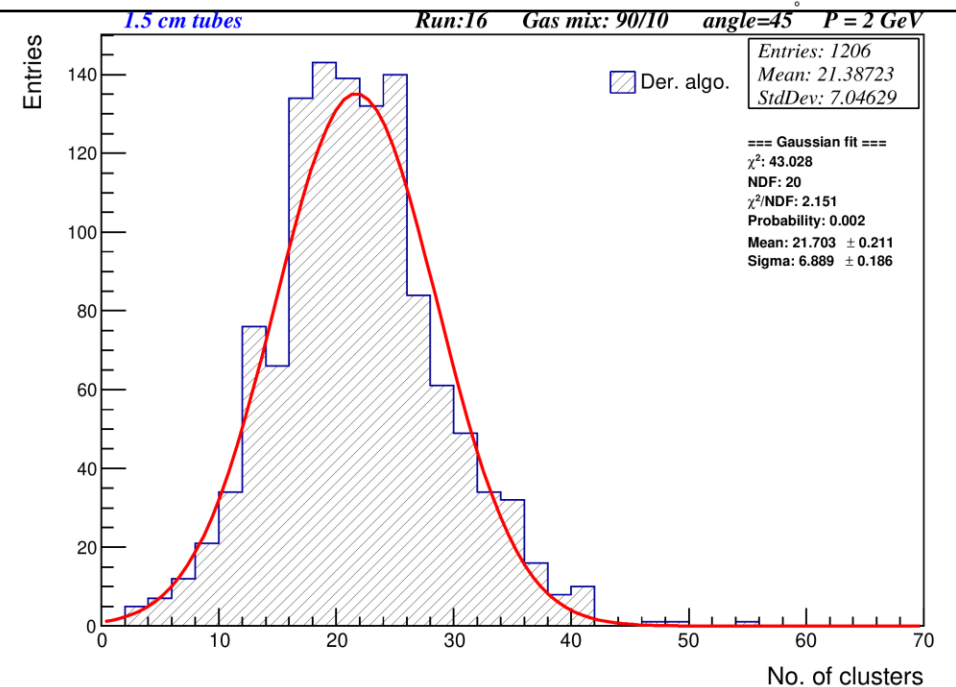
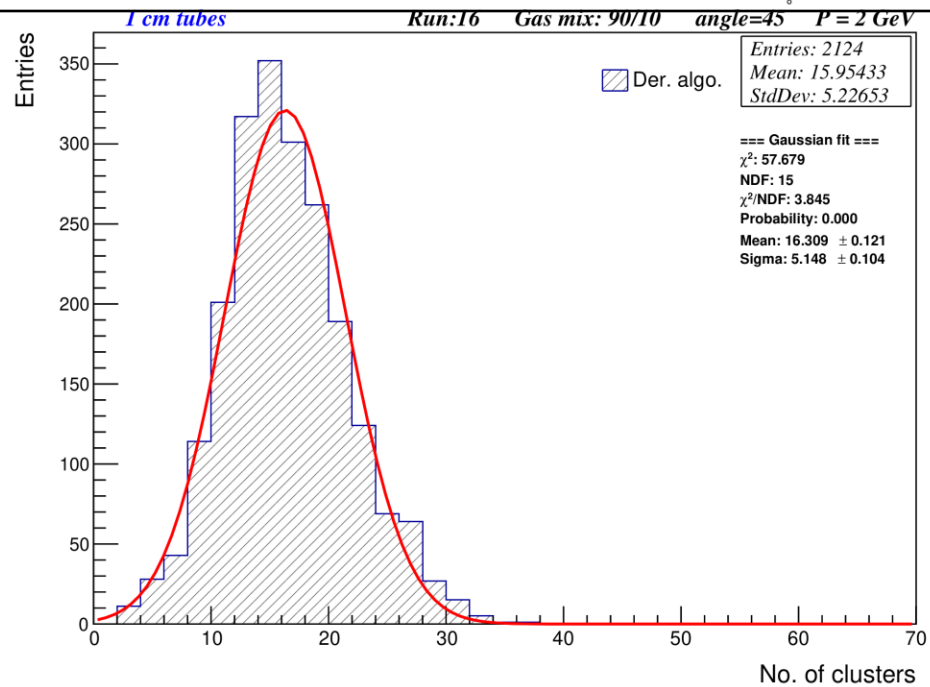
Configuration	No. Clusters Garfield++ (1 cm tube)	No. Clusters (Der. Algo.) (1 cm tube)	Cluster size (Der. Algo.) (1 cm tube)	No. Clusters (Der. Algo.) (1.5 cm tube)	Cluster size (Der. Algo.) (1.5 cm tube)
90/10 mix, 45°, 2 GeV	15.89	15.95	1.65	21.38	1.7
90/10 mix, 45°, 4 GeV	16.99	16.9	1.5	21.89	1.56
90/10 mix, 45°, 6 GeV	17.81	17.82	1.62	24.49	1.71

2 GeV parameters set used: N1=5.0; N2=0.5; N3=0.8; N4=0.08; Scale=0.28

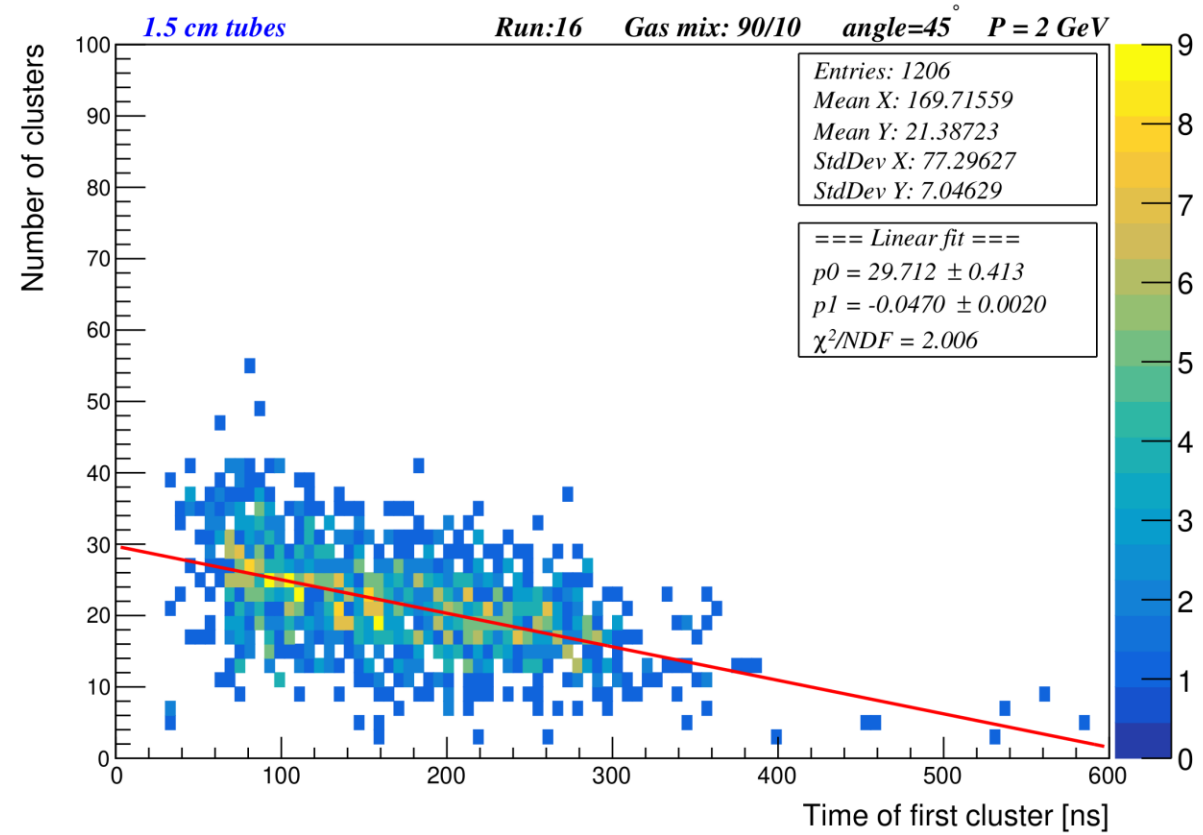
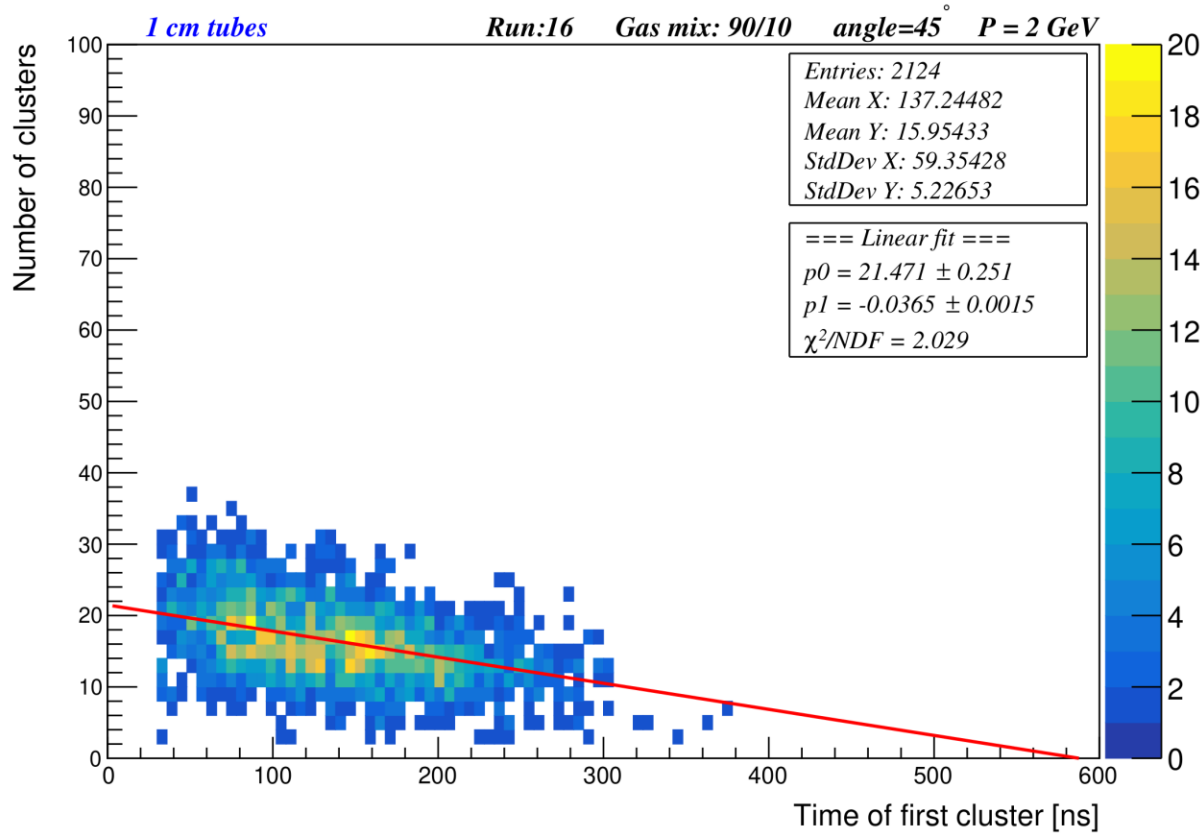
4 GeV parameters set used: N1=5.0; N2=0.5; N3=0.4; N4=0.06; Scale=0.24

6 GeV parameters set used: N1=3.0; N2=0.55; N3=0.25; N4=0.055; Scale=0.3

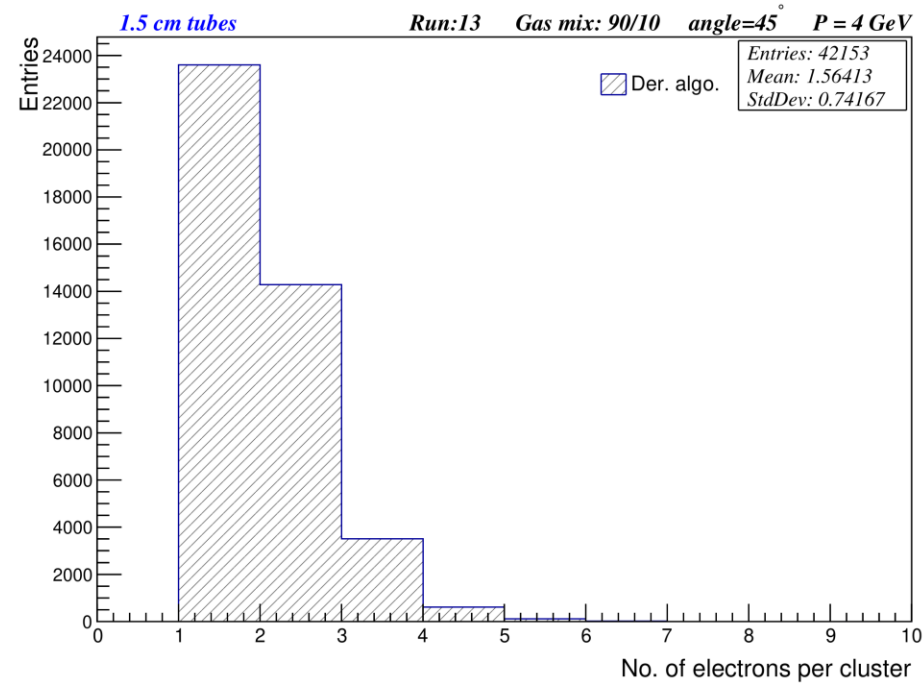
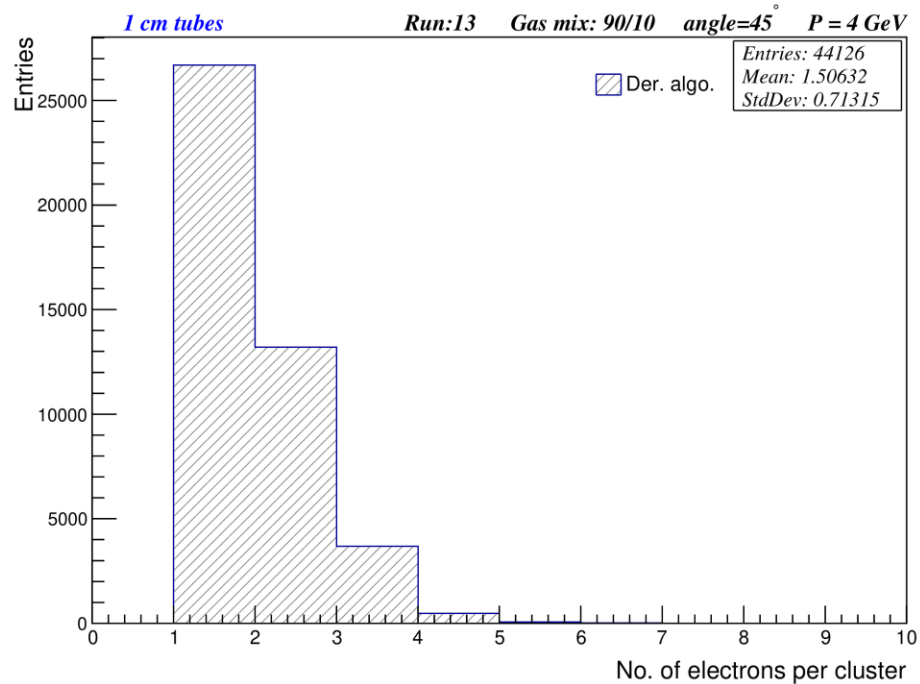
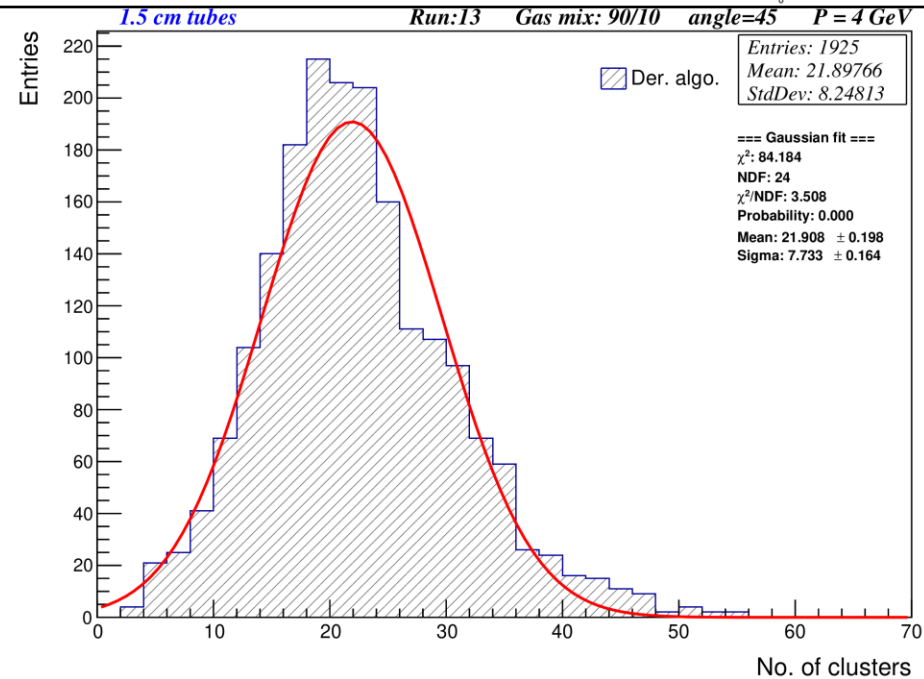
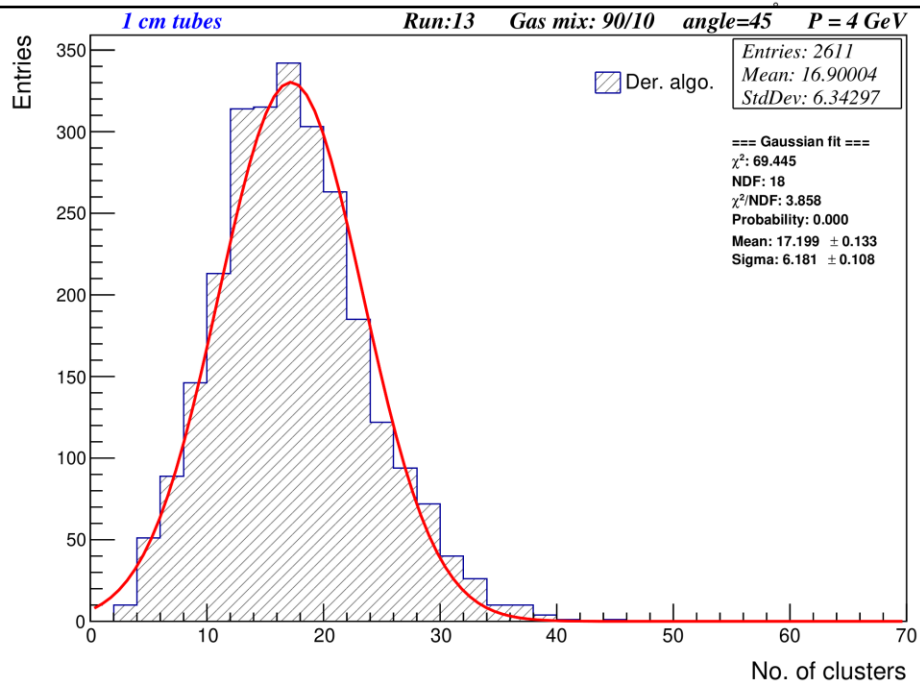
# Run16 DRS



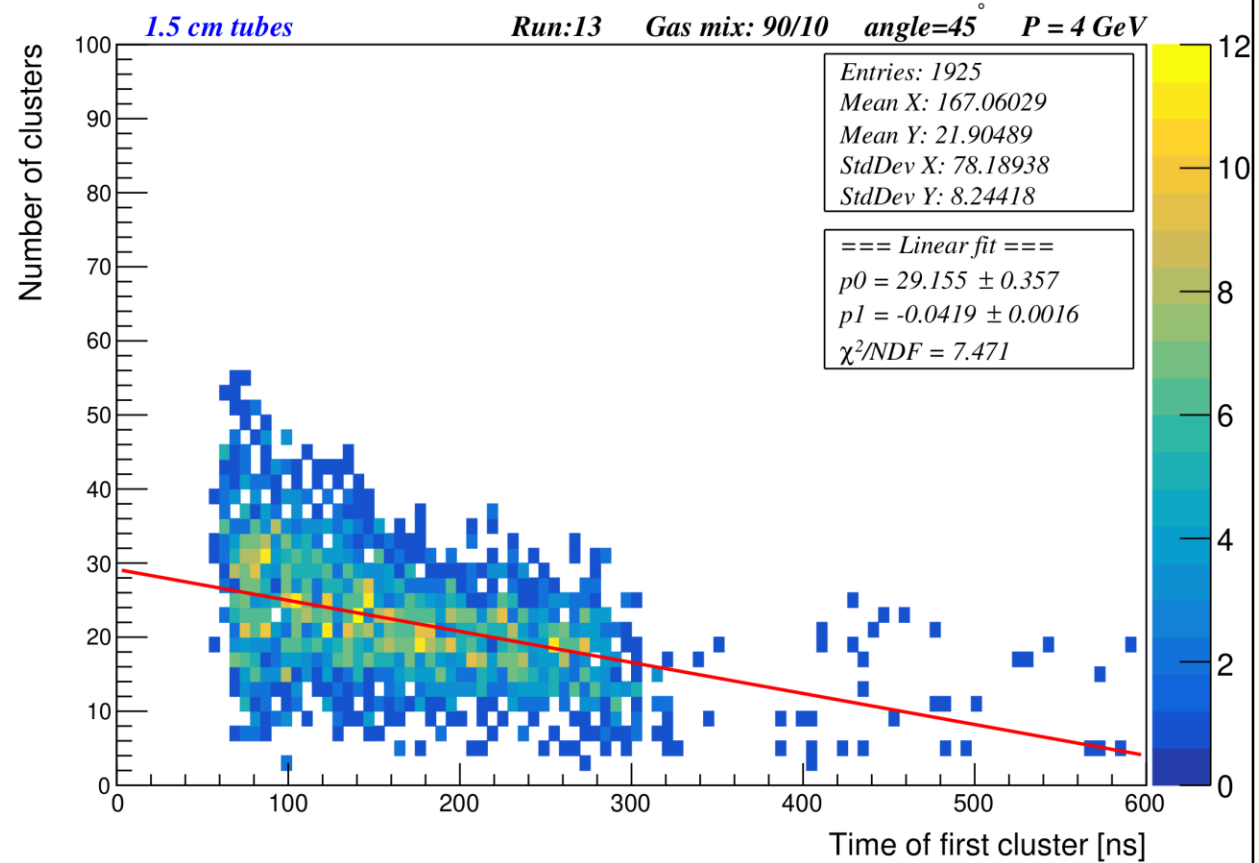
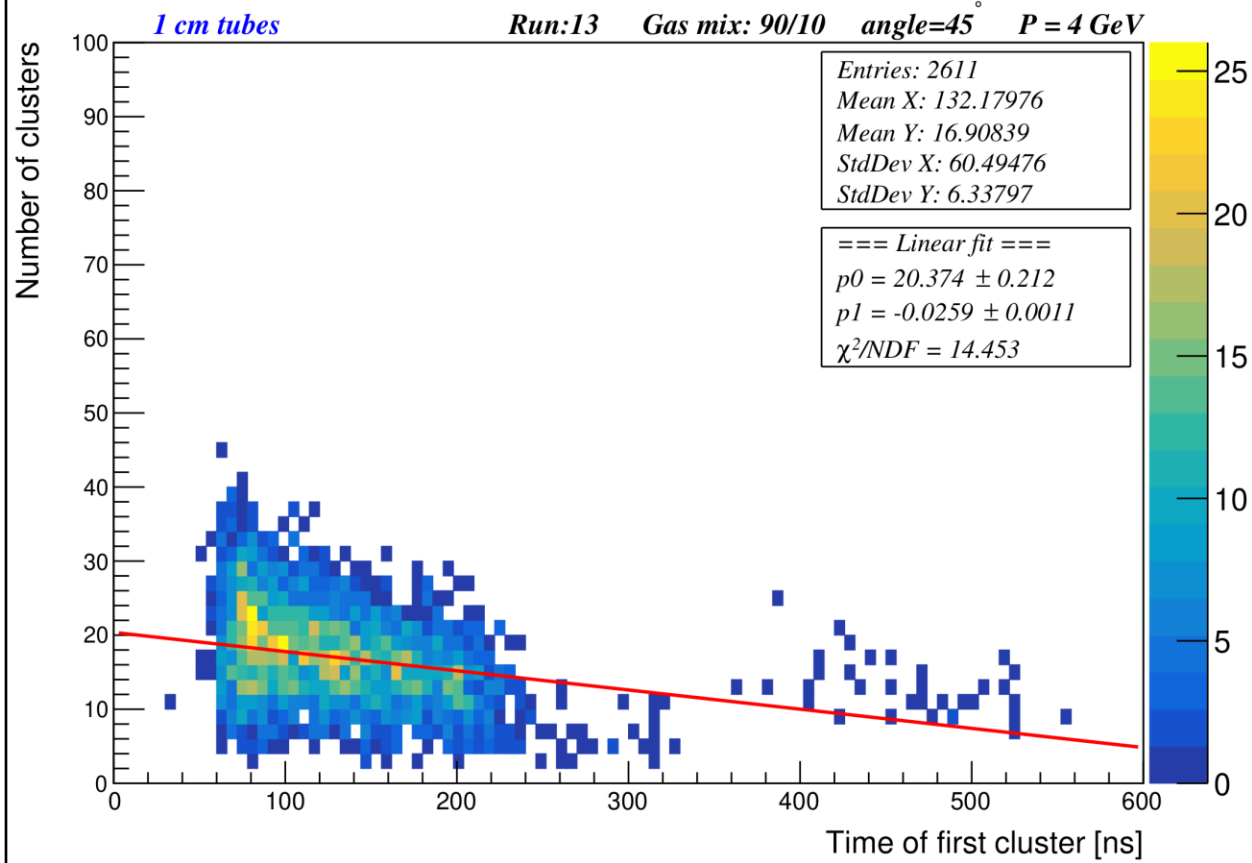
# Run16 DRS



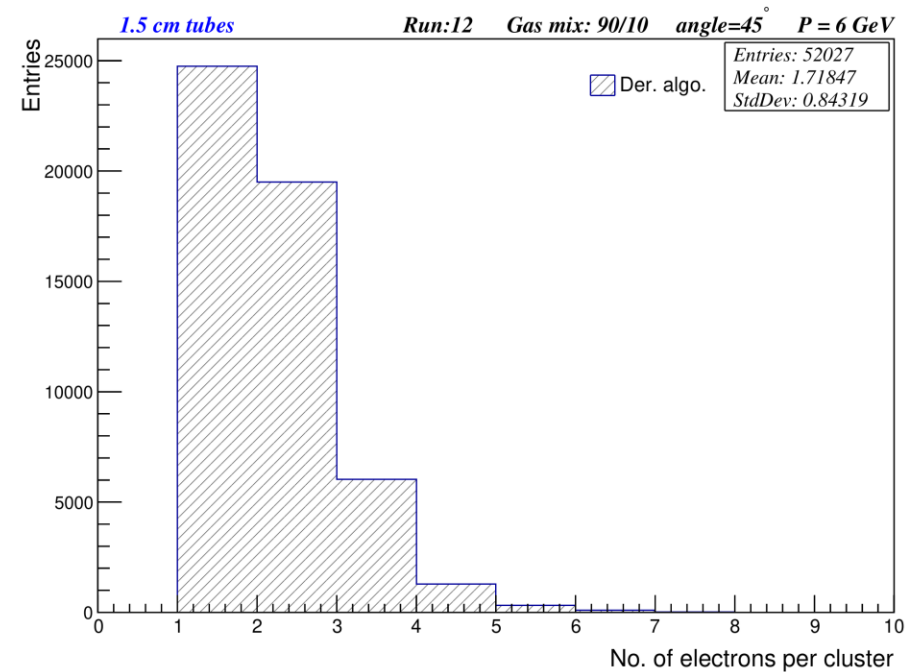
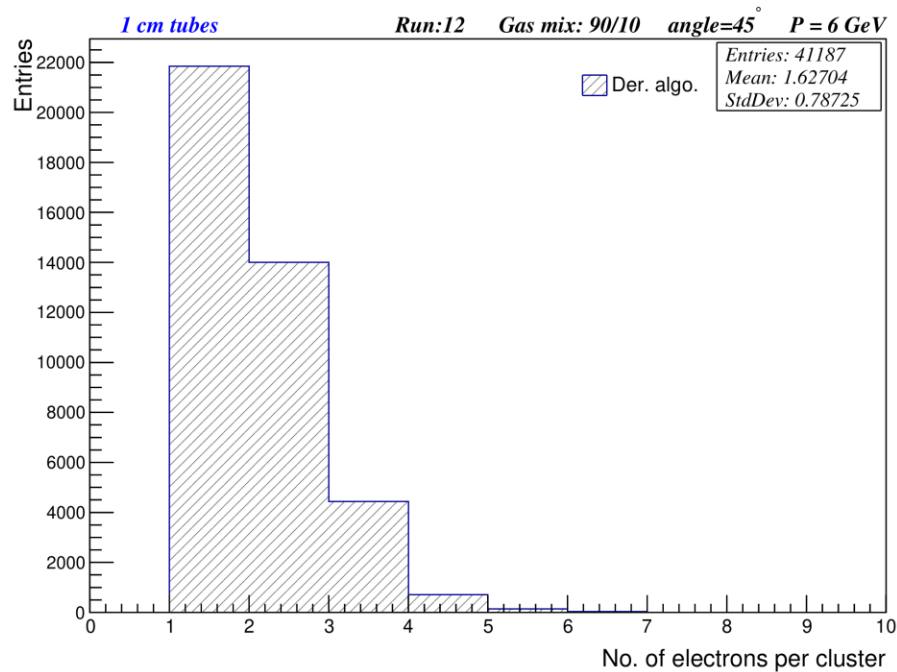
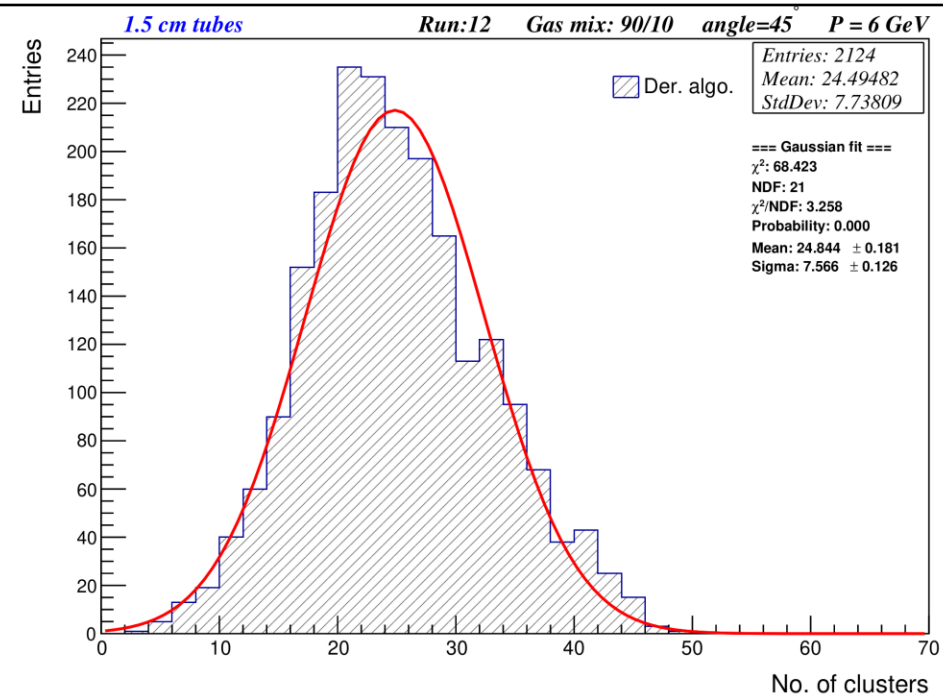
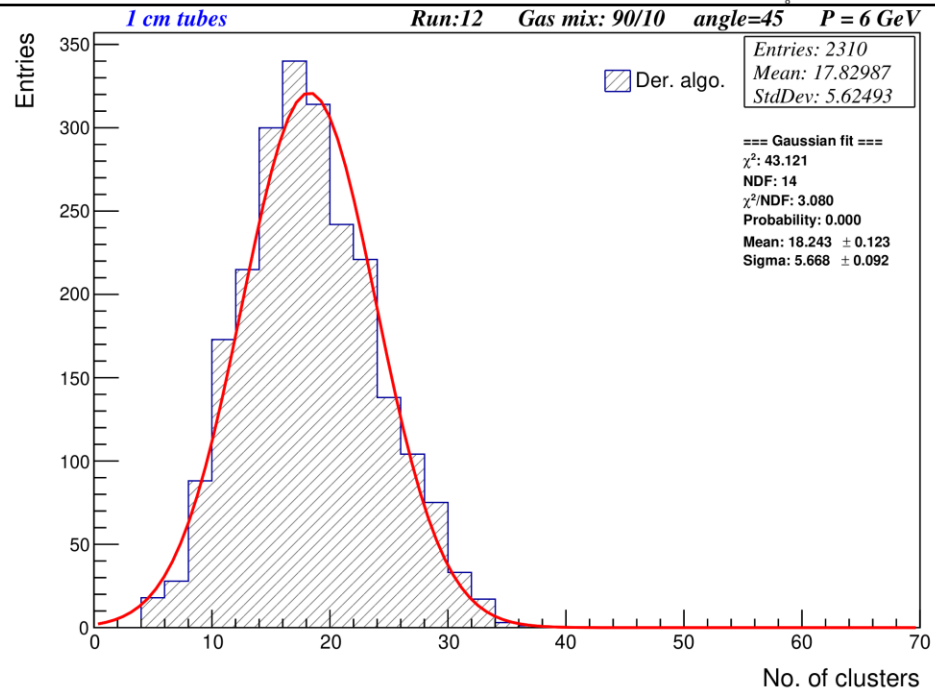
# Run13 DRS



# Run13 DRS



# Run12 DRS



# Run12 DRS

