Find Electron and Cluster Peaks algorithm

Offline Analysis for the November 2021 CERN Test Beam

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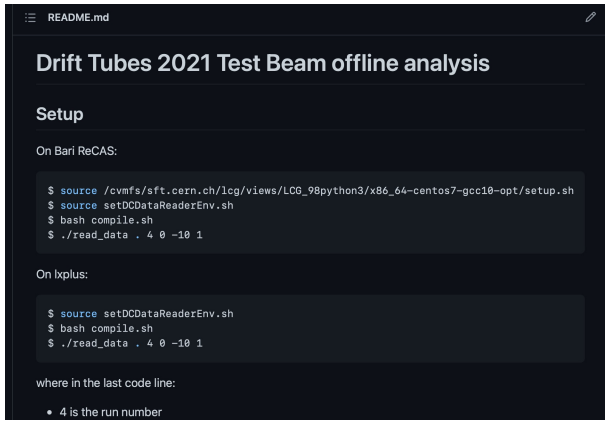
Data analysis storage

- Binary Raw Data files are converted into ROOT files **run_*.root** containing the waveform spectrum and stored in CERNBox (send an email to matteo.greco@le.infn.it for the rights of access).

- Each **run_*.root file** correspond to a different configuration (gas mixture, HV, data-taking day,trigger, track incident angle w.r.t. drift tube, sampling frequency) under which data are taken.

- In the CERNBox, **data_testbeam.xlsx** reports the association of the run number to the particular configuration.

- Github repository for the binary conversion + offline analysis by using the **Derivative Finding Peaks algorithm**: https://github.com/bdanzi/drifttubes_offline_analysis


README.md

Drift Tubes 2021 Test Beam offline analysis

Setup

On Bari ReCAS:

```
$ source /cvmfs/sft.cern.ch/lcg/views/LCG_98python3/x86_64-centos7-gcc10-opt/setup.sh
$ source setDCDataReaderEnv.sh
$ bash compile.sh
$ ./read_data . 4 0 -10 1
```

On lxplus:

```
$ source setDCDataReaderEnv.sh
$ bash compile.sh
$ ./read_data . 4 0 -10 1
```

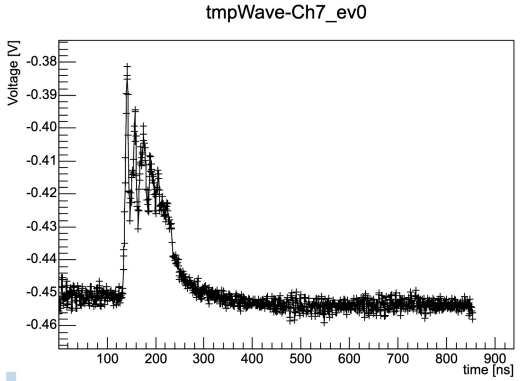
where in the last code line:

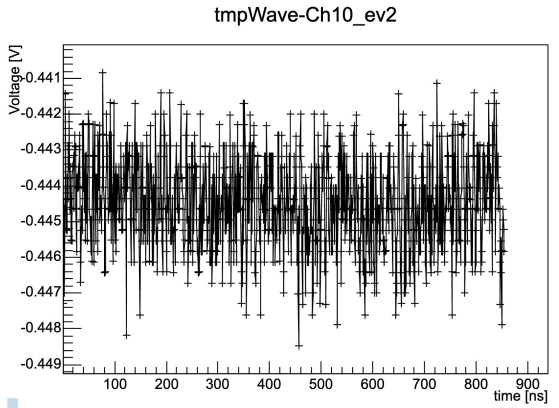
- 4 is the run number

Preliminary Signal Processing

The electron peaks search is performed:

- by working on the **waveform spectrum in time**, which is a 1024-bins sampled signal (for example for 1.2 GSPS it corresponds to almost 853.33 ns) with the assumption that the baseline is set to zero.





Preliminary step: Normalization of the Waveform spectrum in time to a **zero baseline**

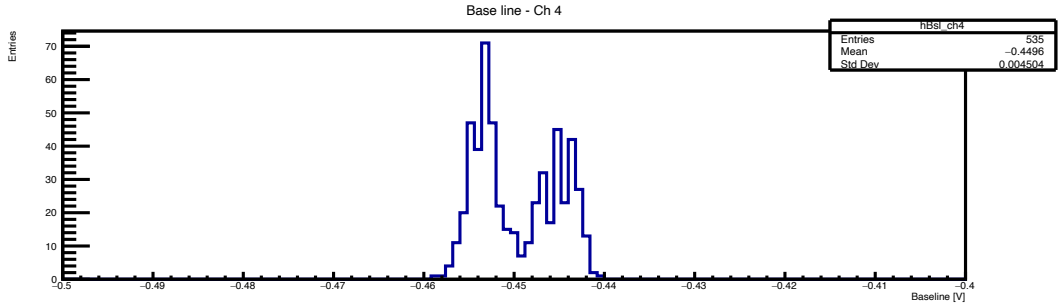
NOTE:

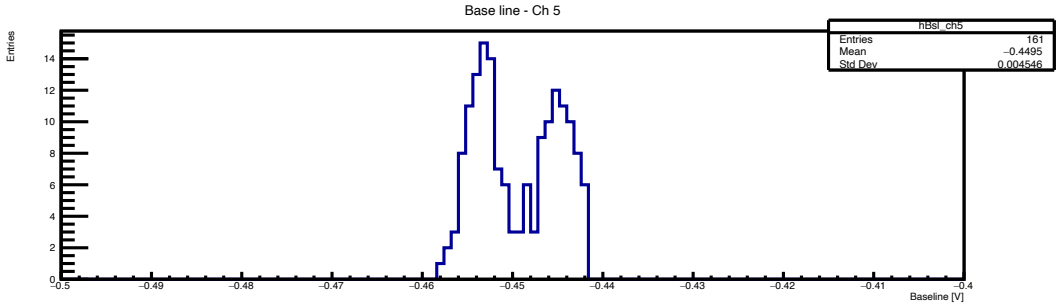
Baseline for each waveform (event,channel) = Average wave amplitude on the first signal-less bins (30 bins corresponding to 25 ns for 1.2 GSPS runs)

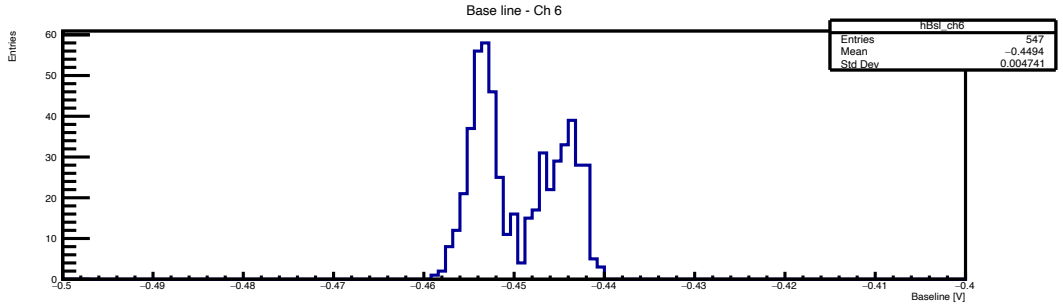
Baseline distribution before normalization

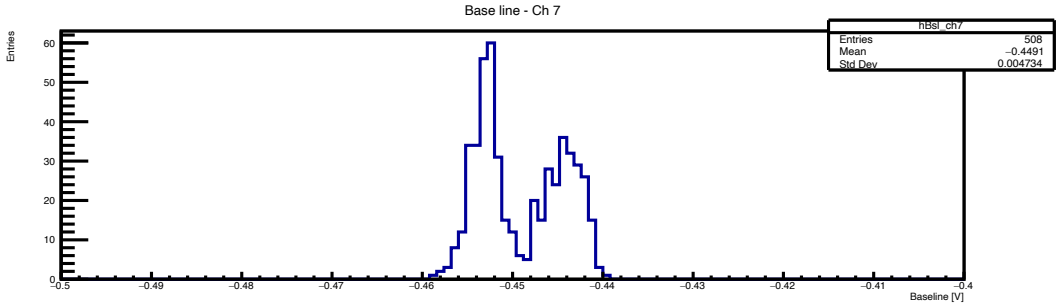
Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

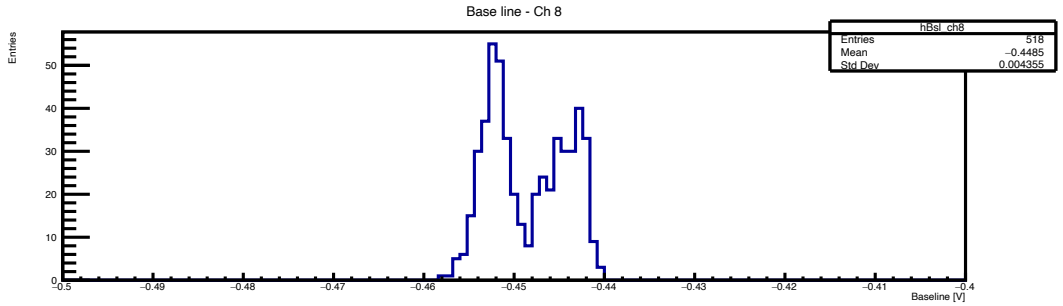
1 cm drift tubes

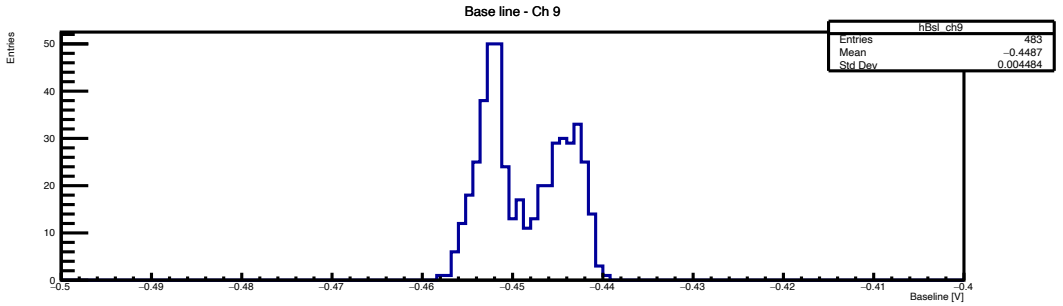








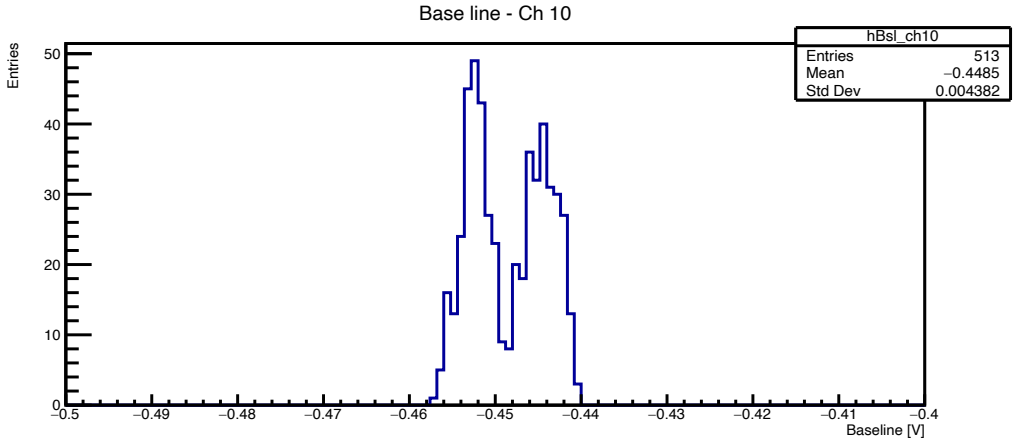


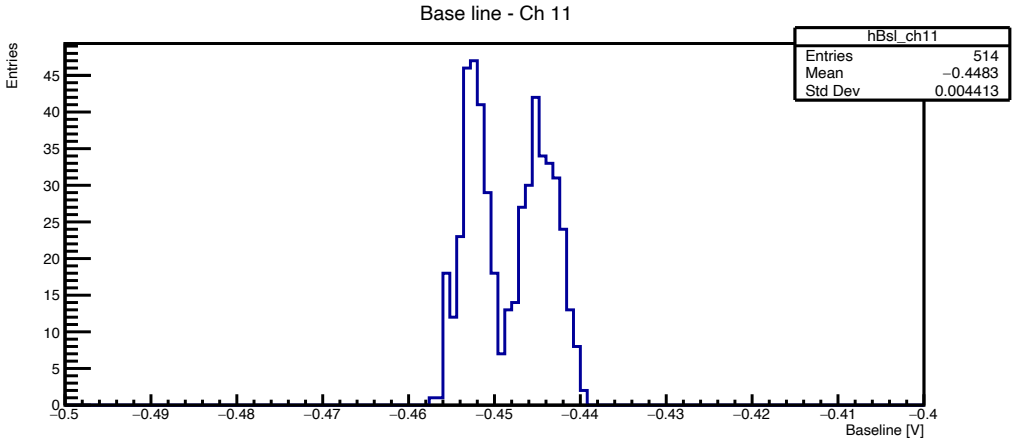


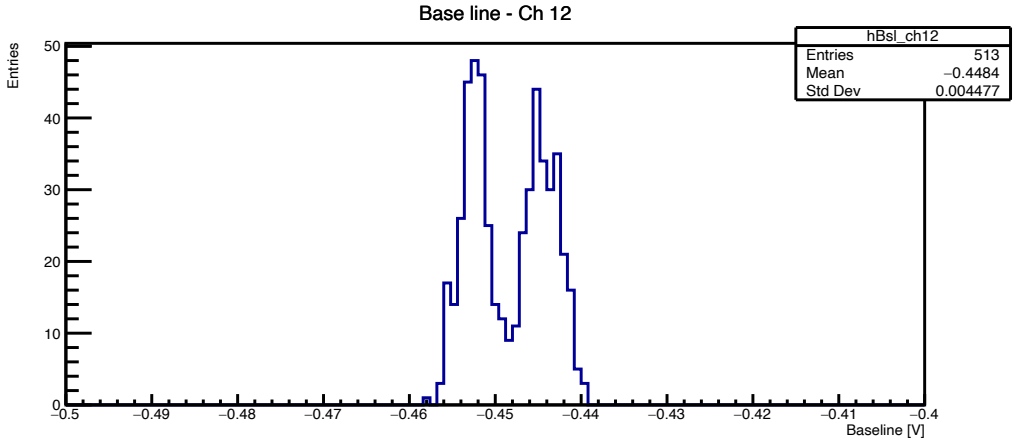
Baseline distribution before normalization

Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes







Channels correspondance

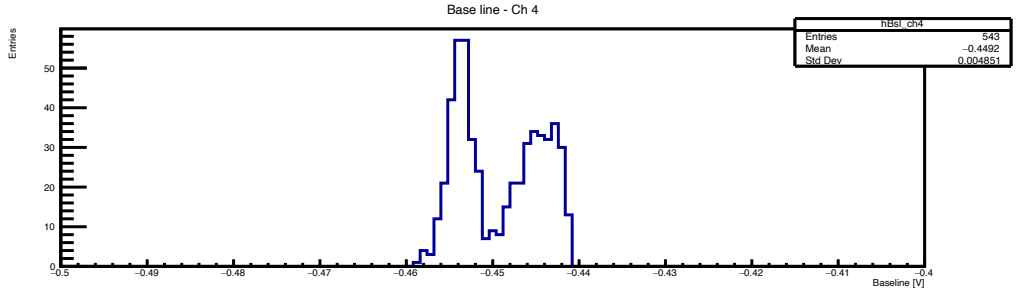
REMINDER

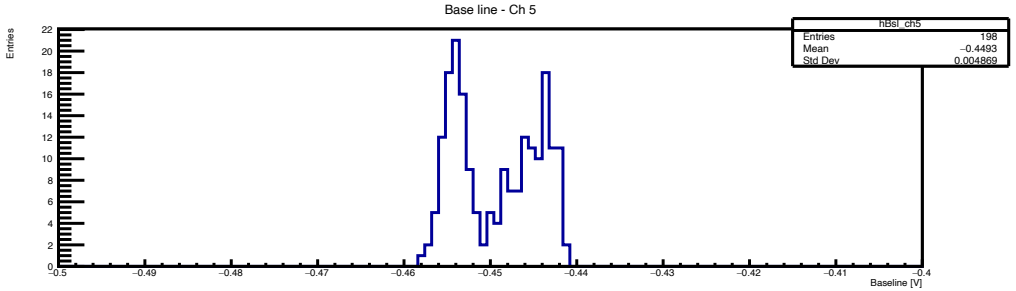
- 0,1,2,3 : Trigger Counters
- 4,5,6,7,8,9 : 6 Drift Tubes of 1 cm cell size respectively:
  - Channel 4 Wire diameter of 10 micrometer
  - Channel 5 Wire diameter of 15 micrometer
  - Channel 6 and 7 Wire diameter of 20 micrometer
  - Channel 8 and 9 Wire diameter of 25 micrometer
- 10,11,12 : 3 Drift Tubes of 2 cm cell size respectively:
  - Channel 10 Wire diameter of 20 micrometer
  - Channel 11 Wire diameter of 25 micrometer
  - Channel 12 Wire diameter of 40 micrometer
- 13,14 : 2 Drift Tubes of 3 cm cell size respectively:
  - Channel 13 Wire diameter of 25 micrometer
  - Channel 14 Wire diameter of 40 micrometer

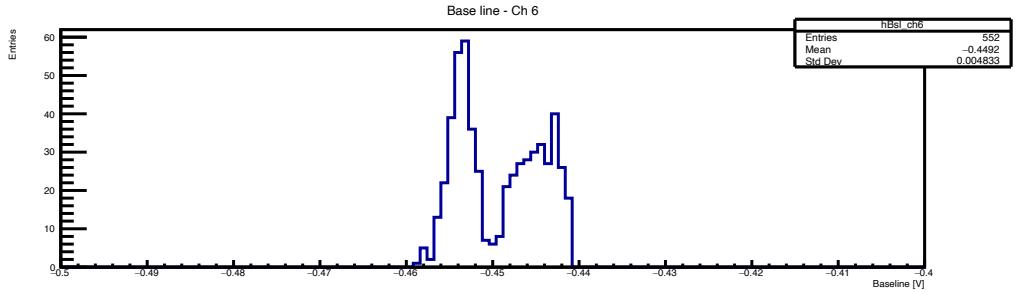
Baseline distribution before normalization

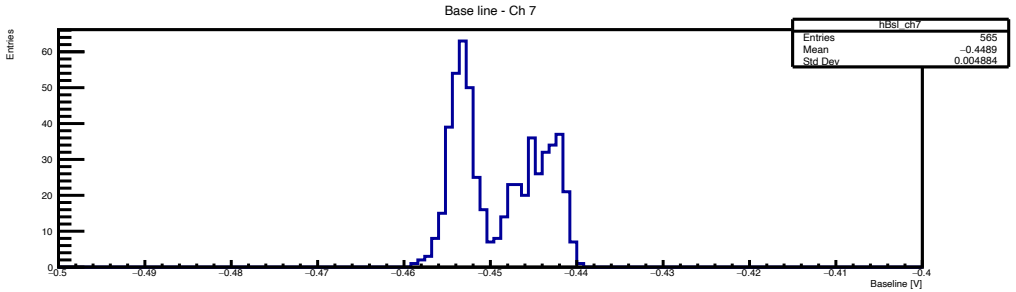
Run: run_98.root; Track angle: 15° ; Gas mixture: 90%He ; HV = +20V

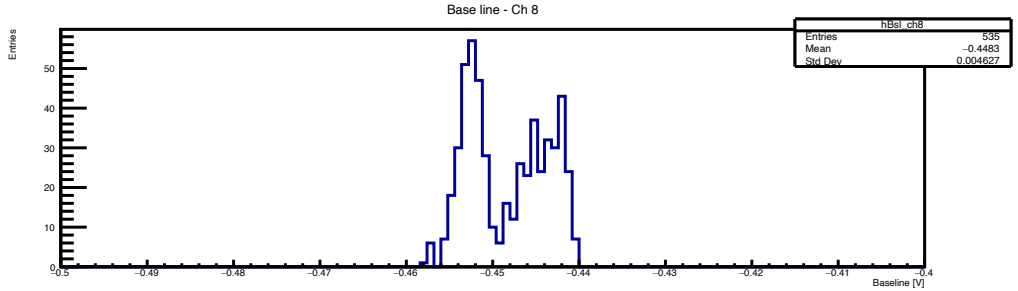
1 cm drift tubes

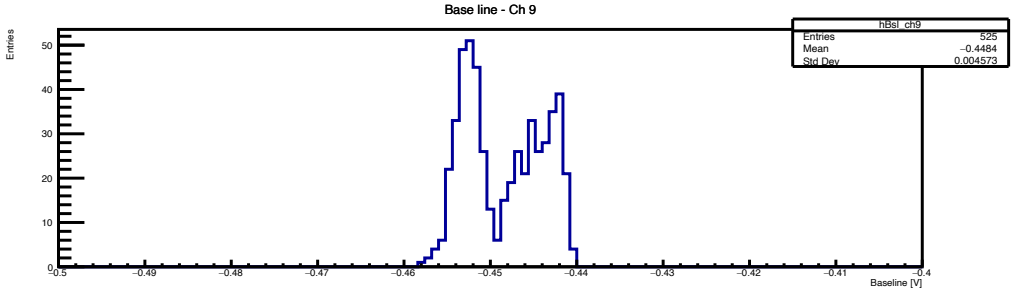








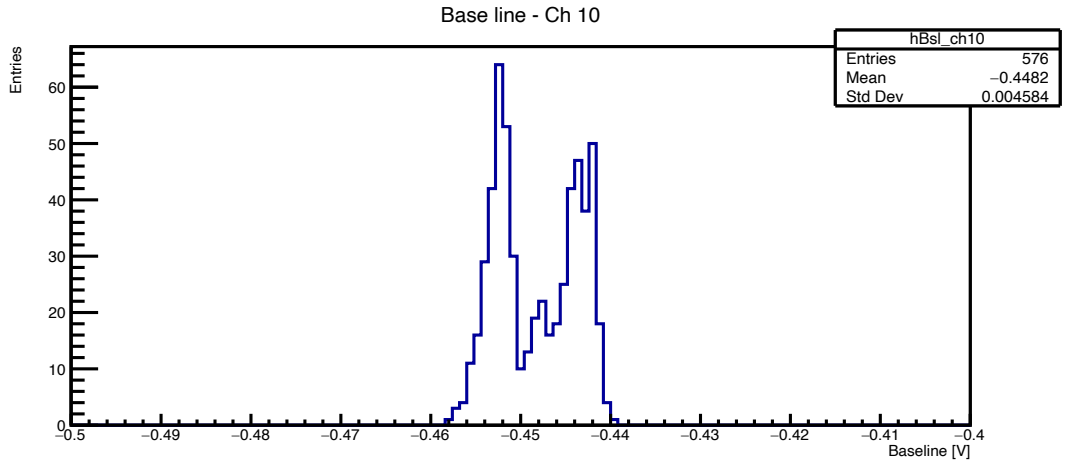


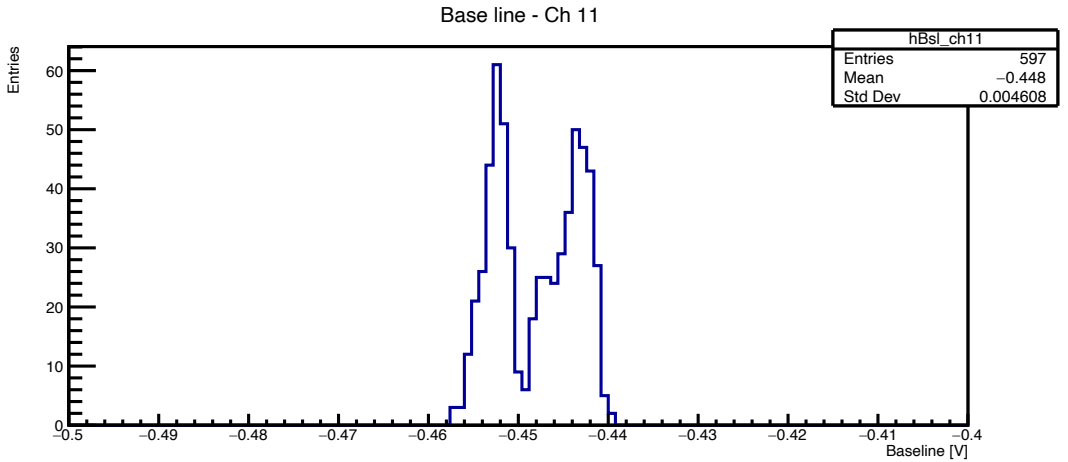


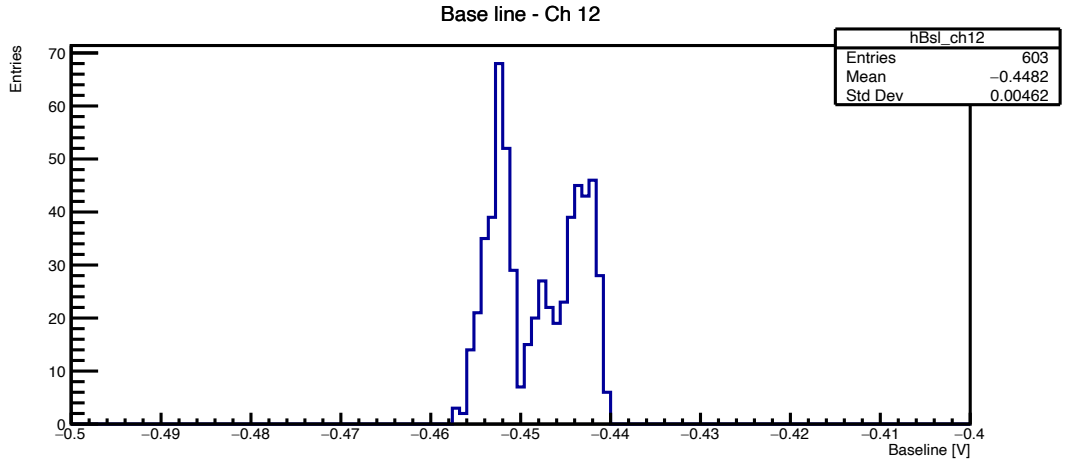
Baseline distribution before normalization

Run: run_98.root; Track angle: 15° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes





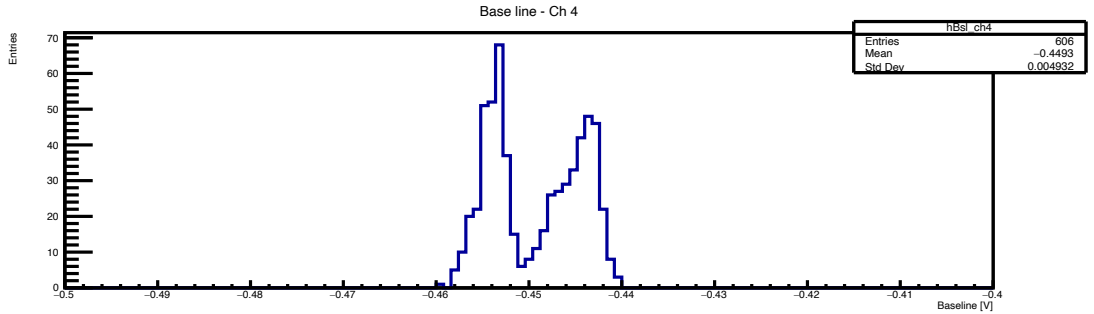


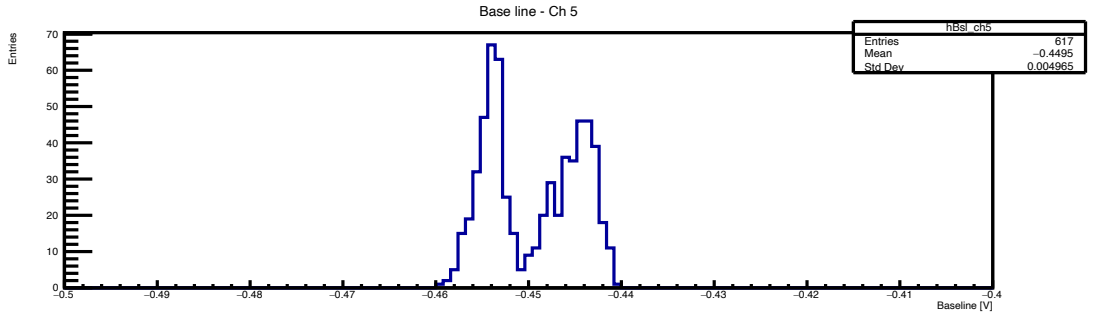
We are also thinking about to change the definition of the baseline, by computing it for each run and the specific channel once by looking at the whole spectrum (without last bins) of a only-noise event.

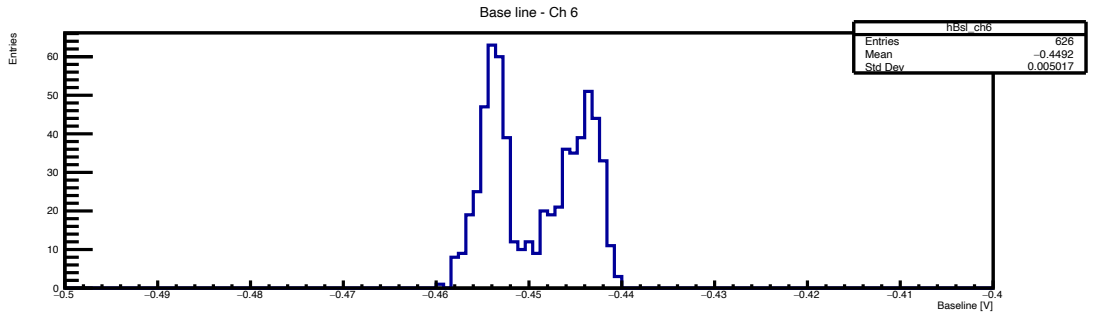
Baseline distribution before normalization

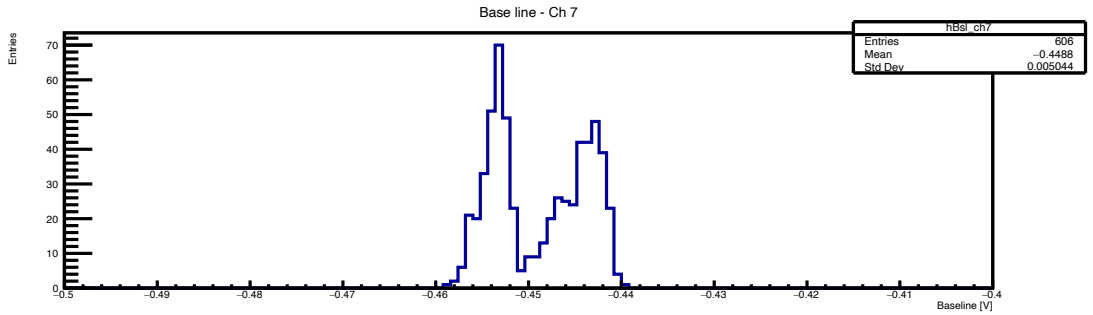
Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

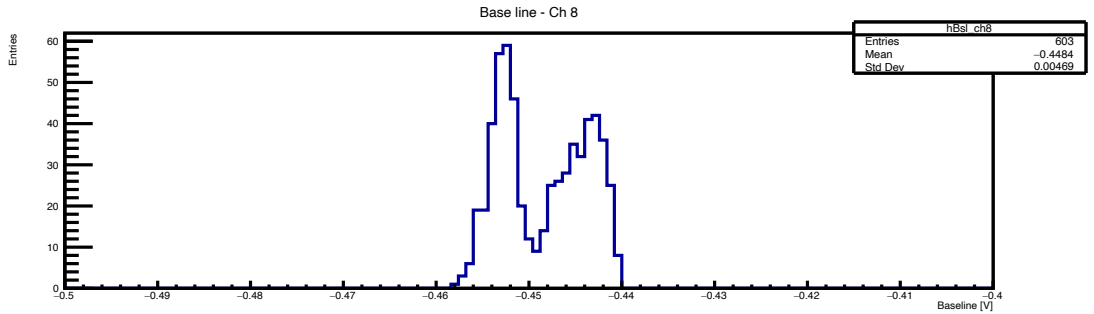
1 cm drift tubes

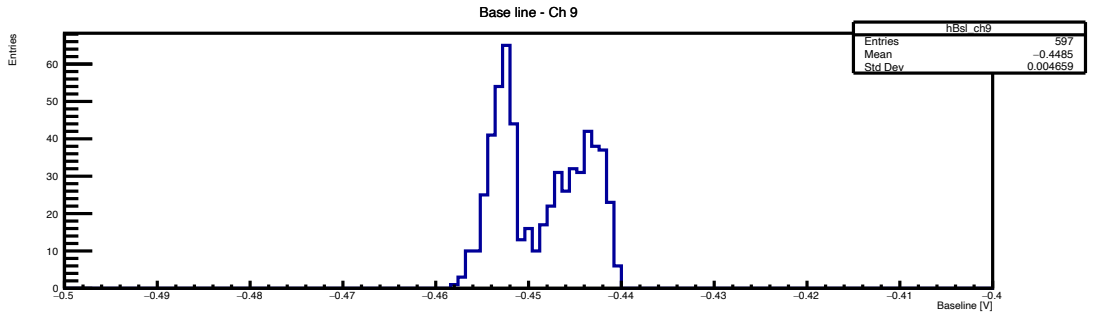








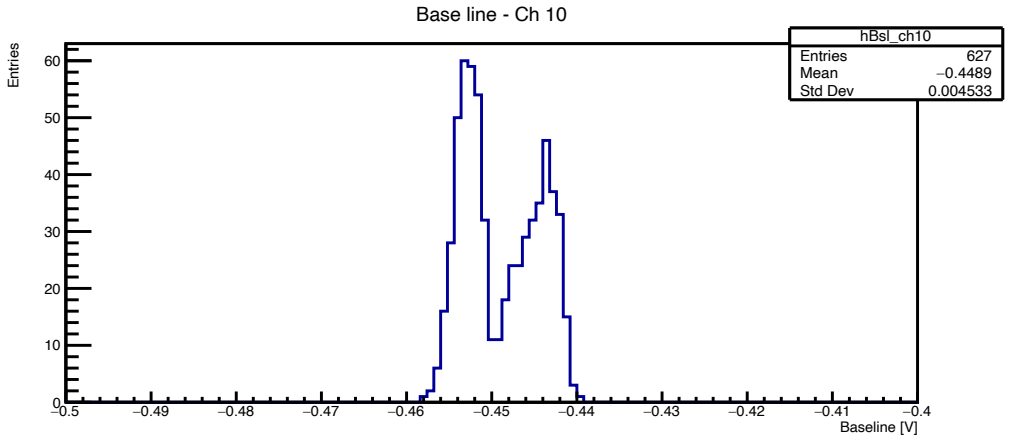


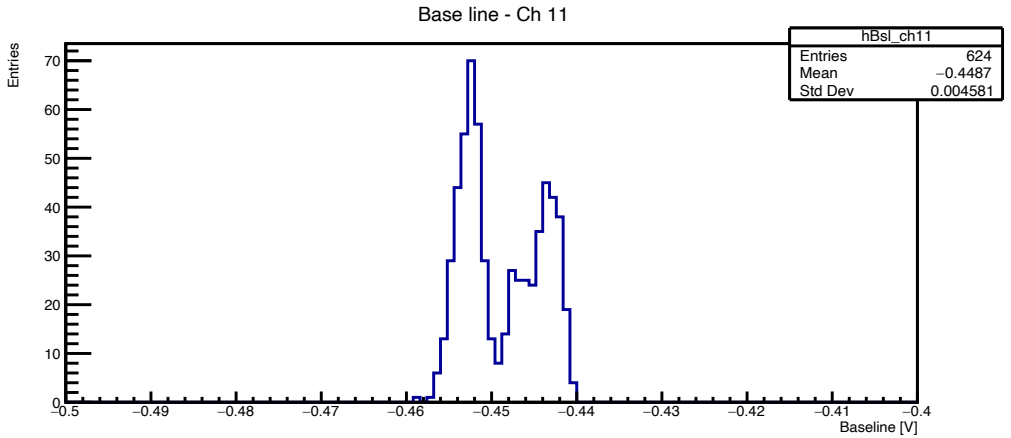


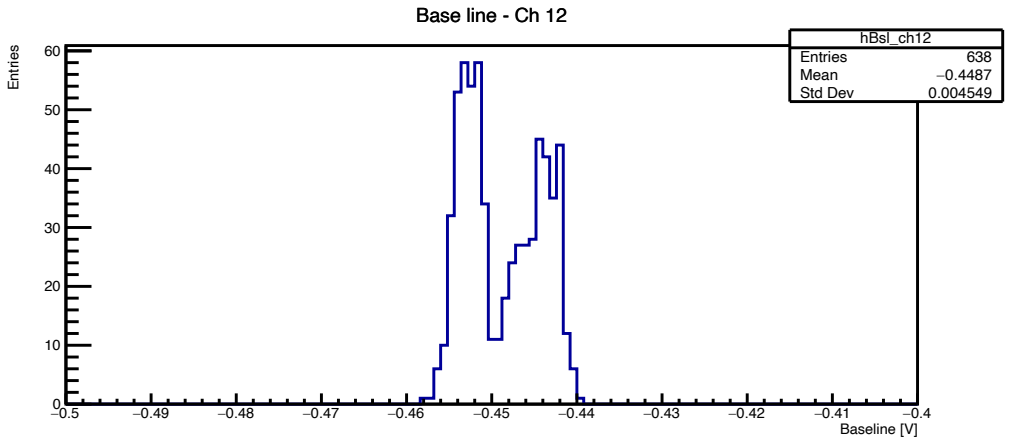
Baseline distribution before normalization

Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes





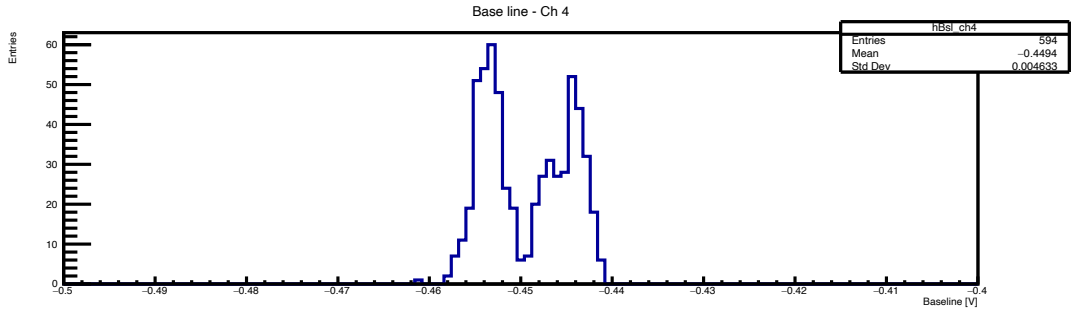


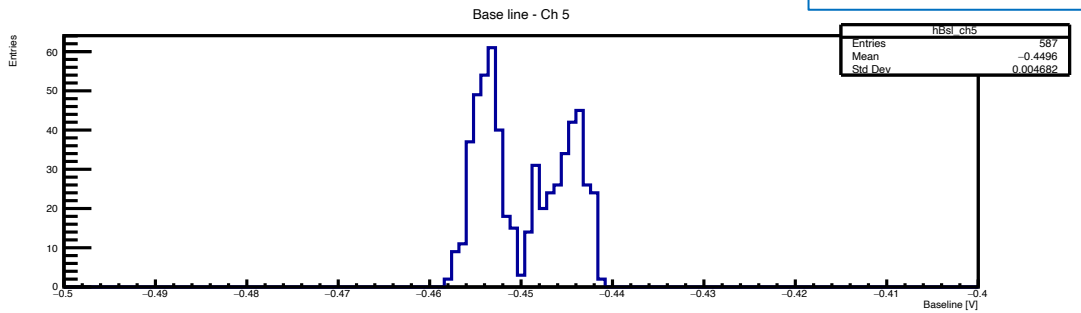
Independent channels, same conditions! The entries in the histograms are the signal-events (definition in next slides). We start usually from data samples of 5k events.

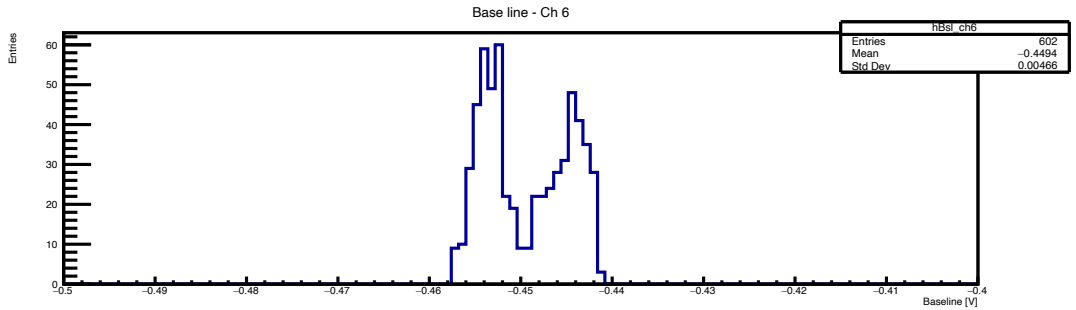
Baseline distribution before normalization

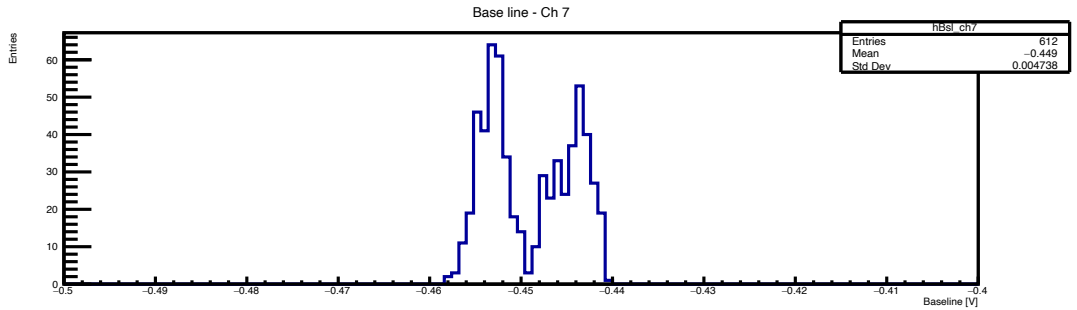
Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

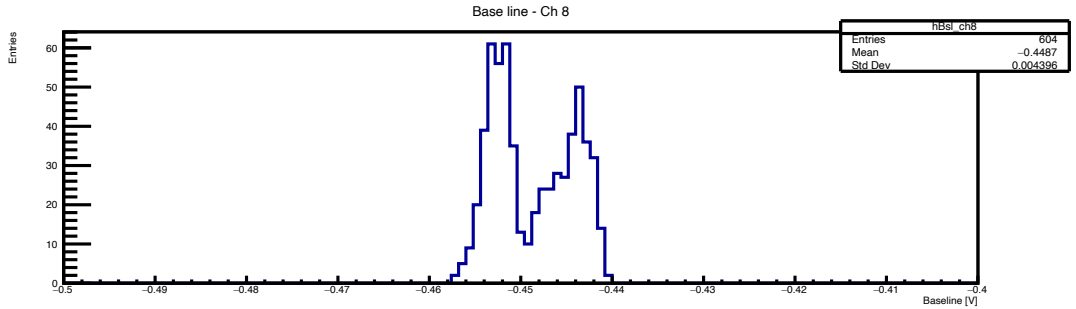
1 cm drift tubes

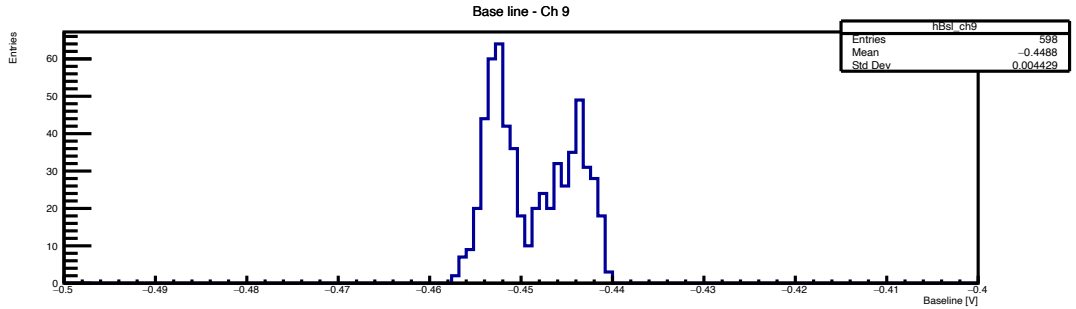








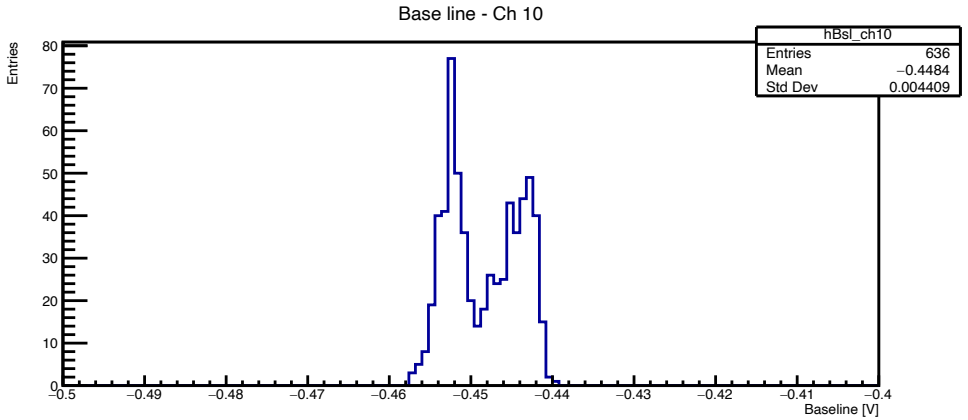


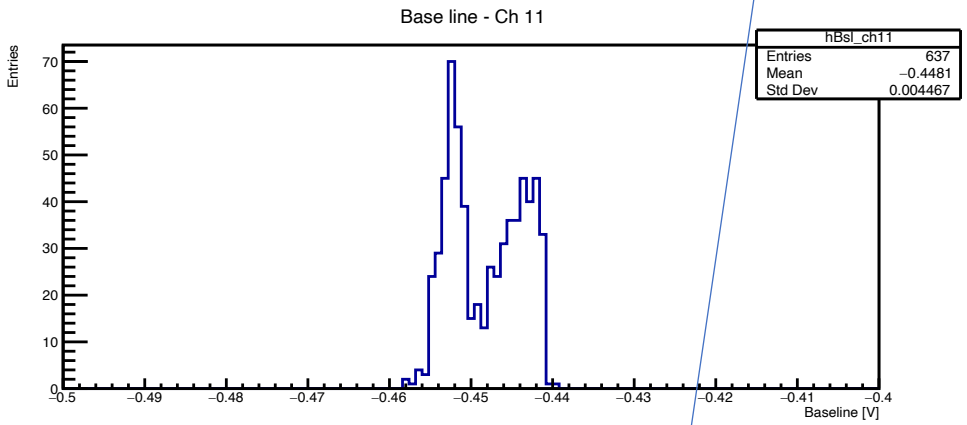


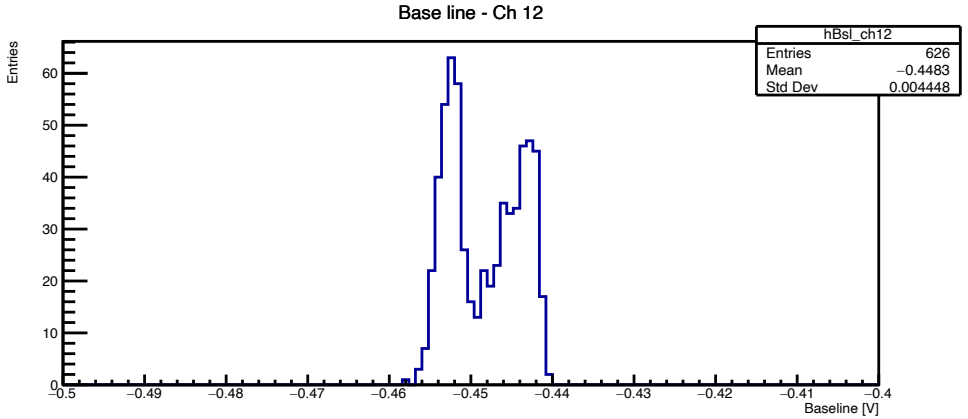
Baseline distribution before normalization

Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes





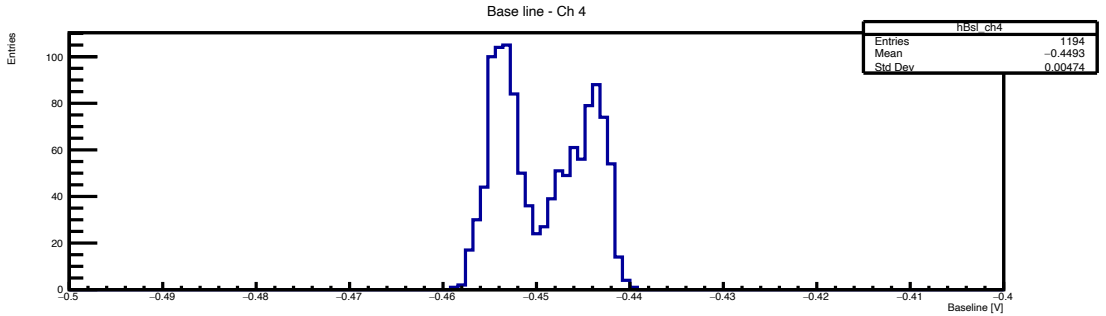


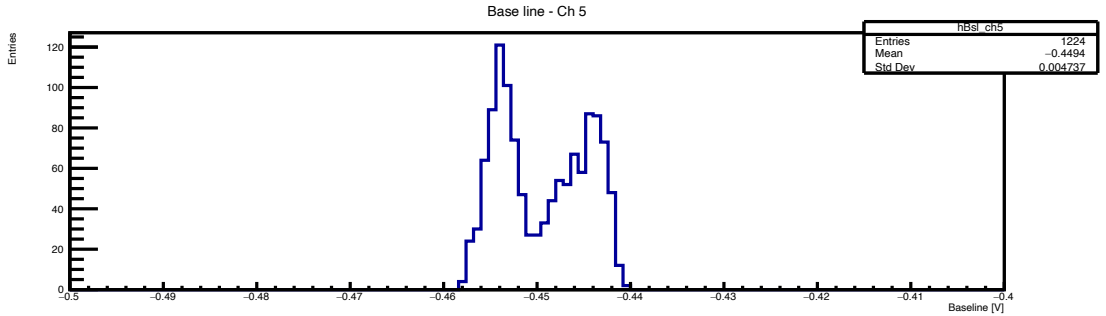
This means HV_nominal + 20V.
Motivation: overcoming a bit the Garfield predictions for obtaining a drift chamber gain of 10^5.

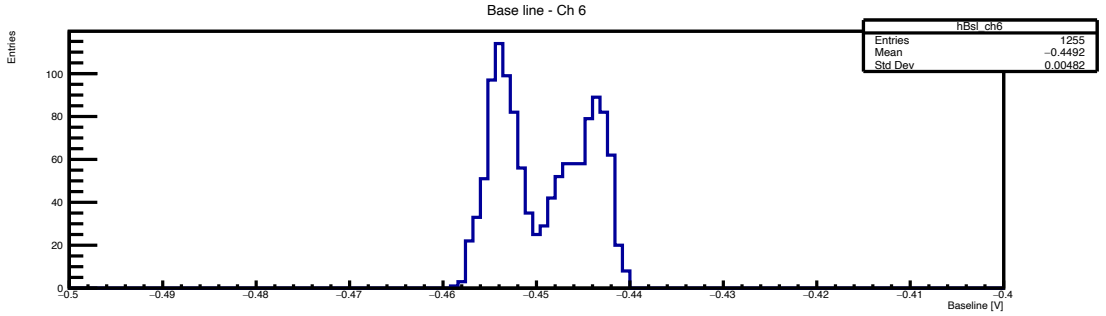
Baseline distribution before normalization

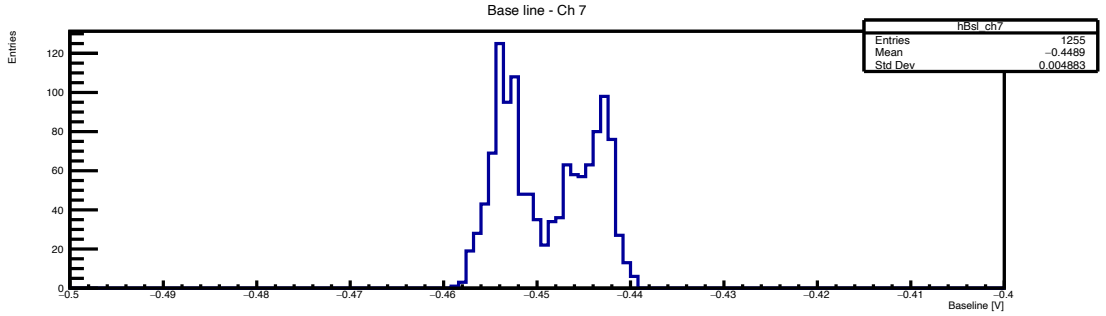
Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V

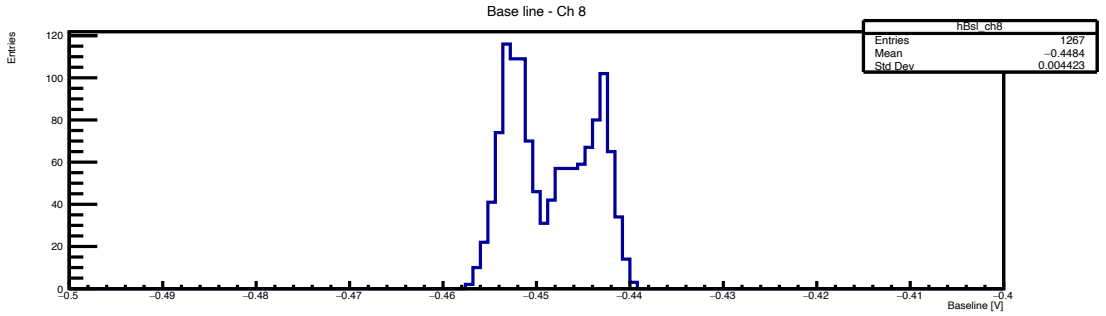
1 cm drift tubes

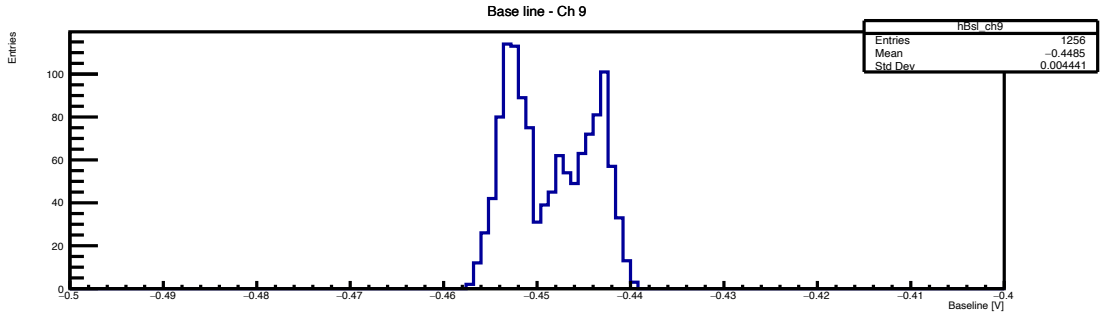






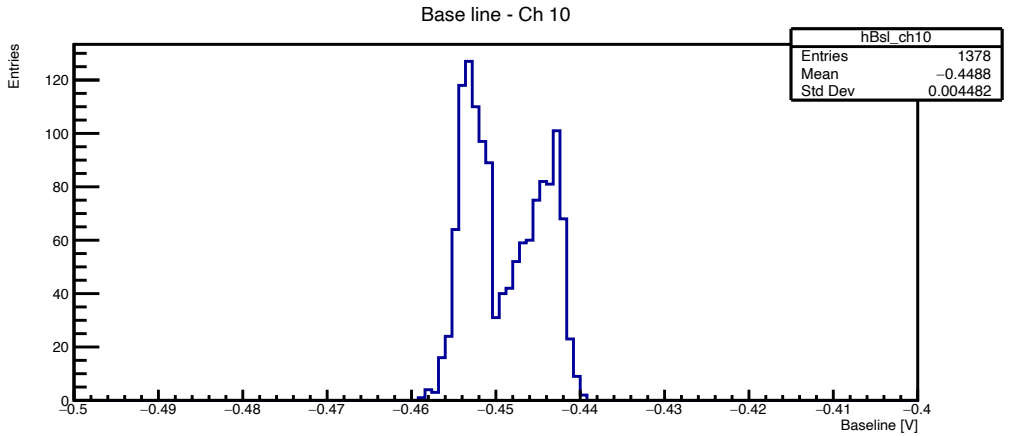


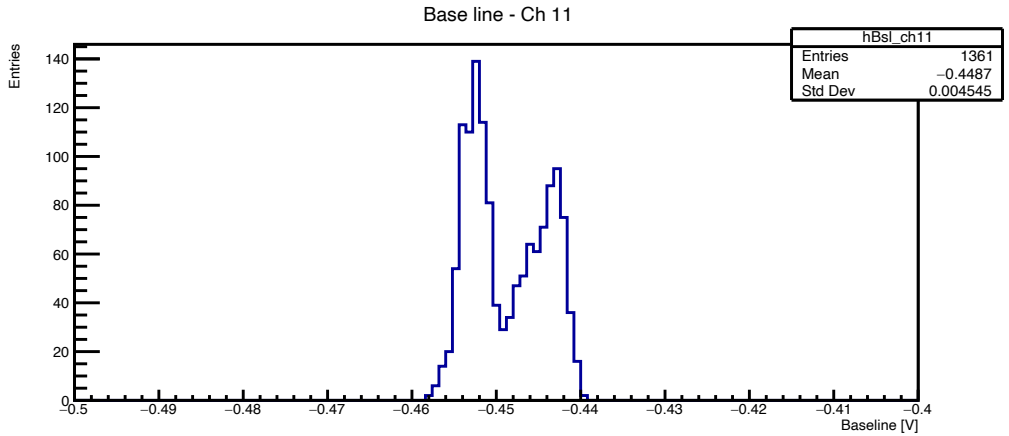


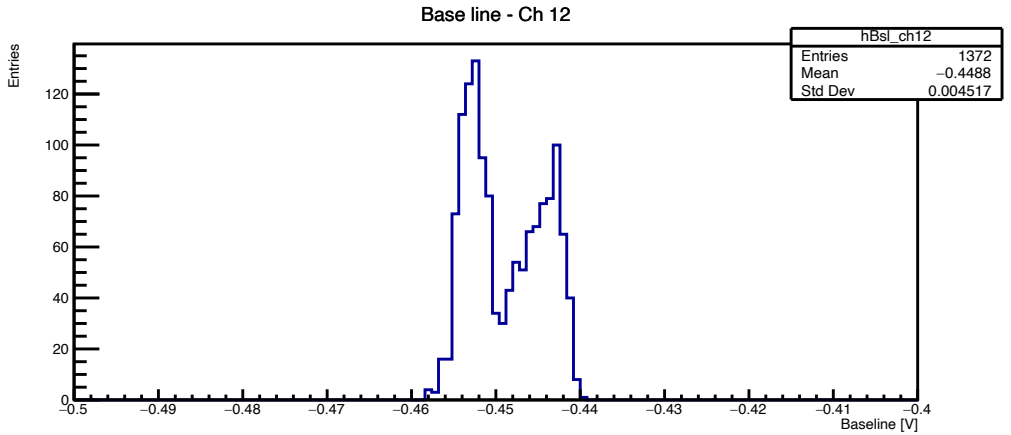


Baseline distribution before normalization

Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V 2 cm drift tubes





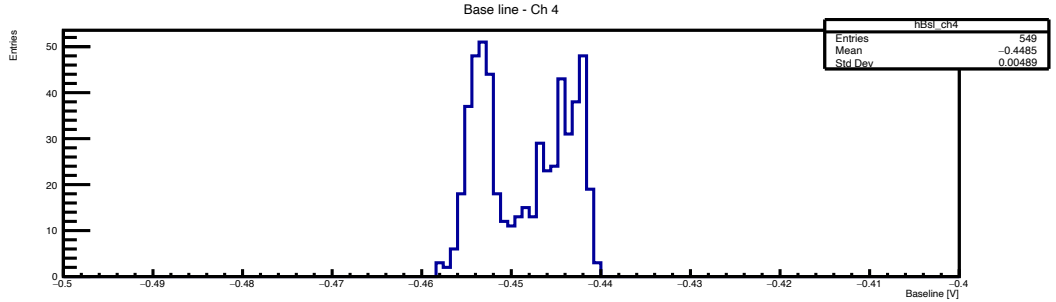


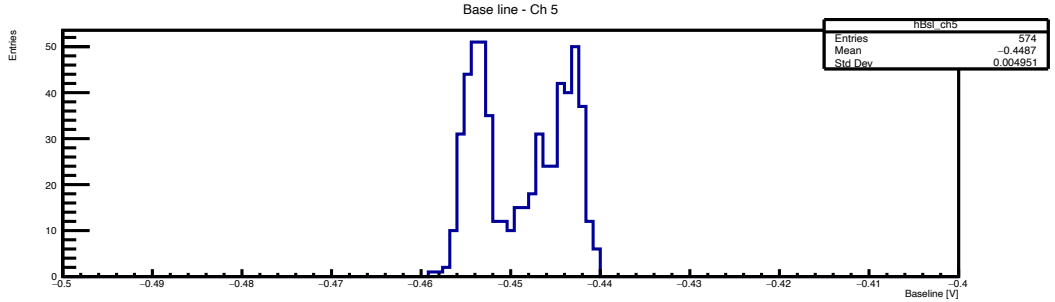
For this run we had 10k events.

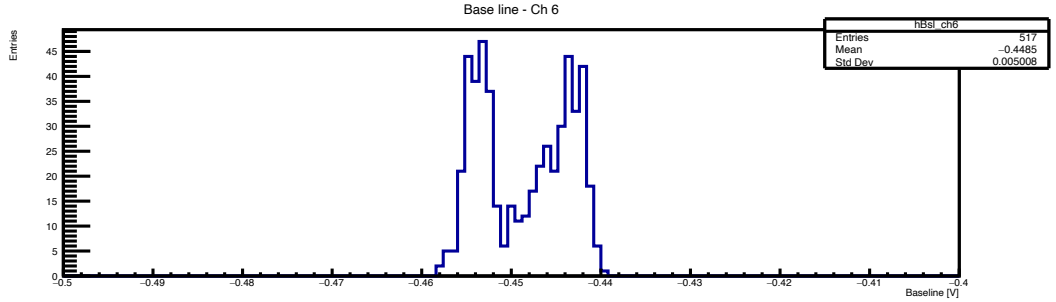
Baseline distribution before normalization

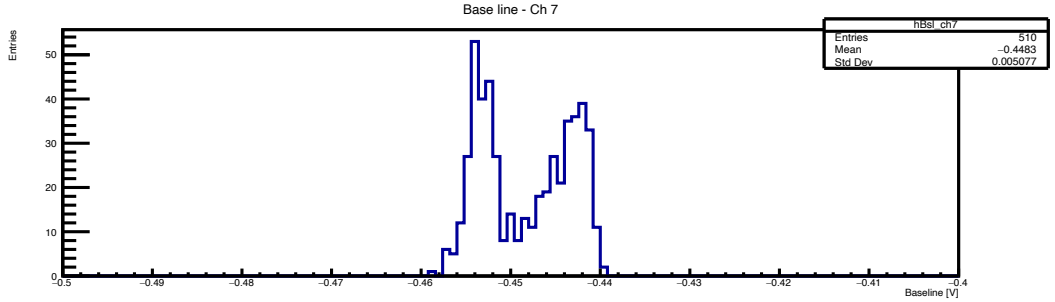
Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V

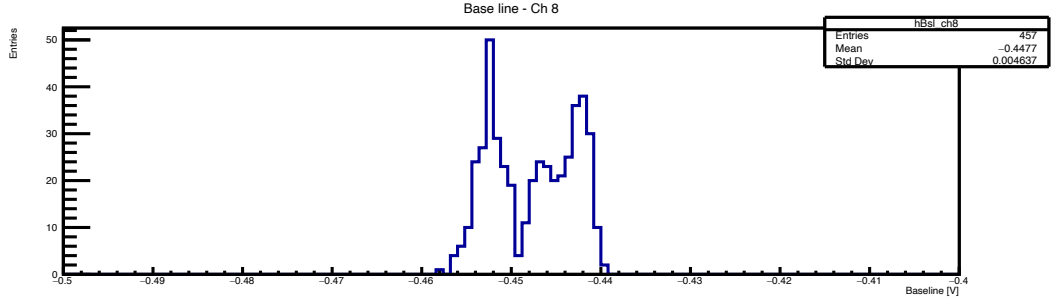
1 cm drift tubes

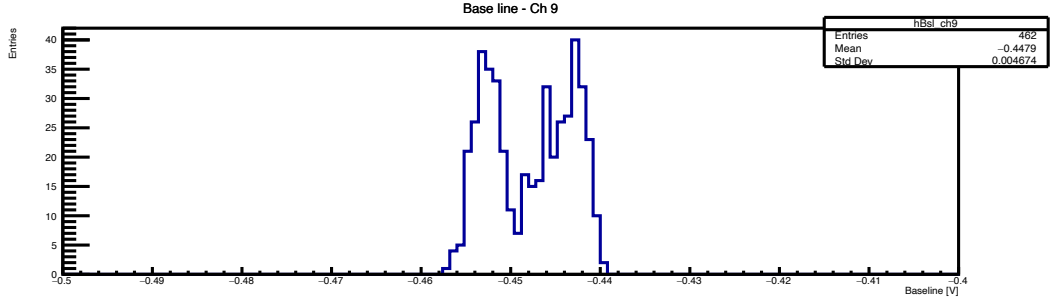






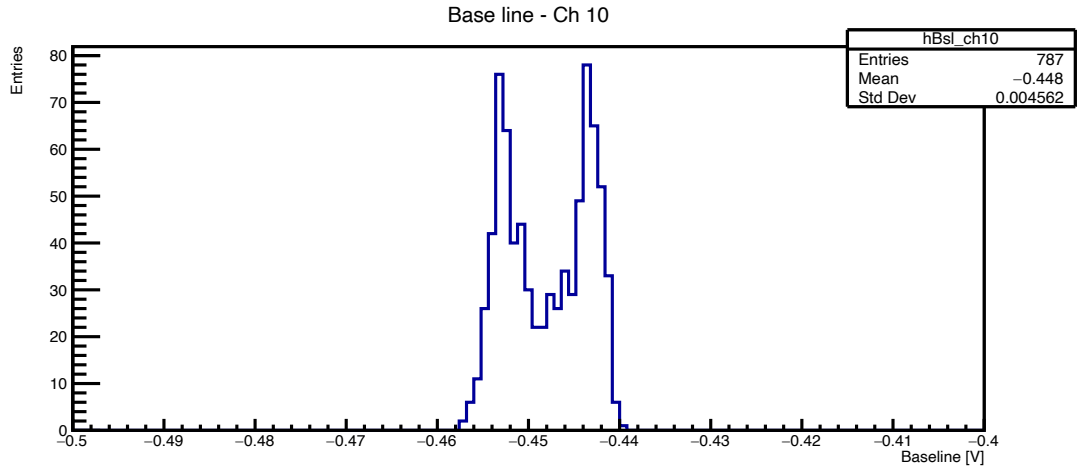


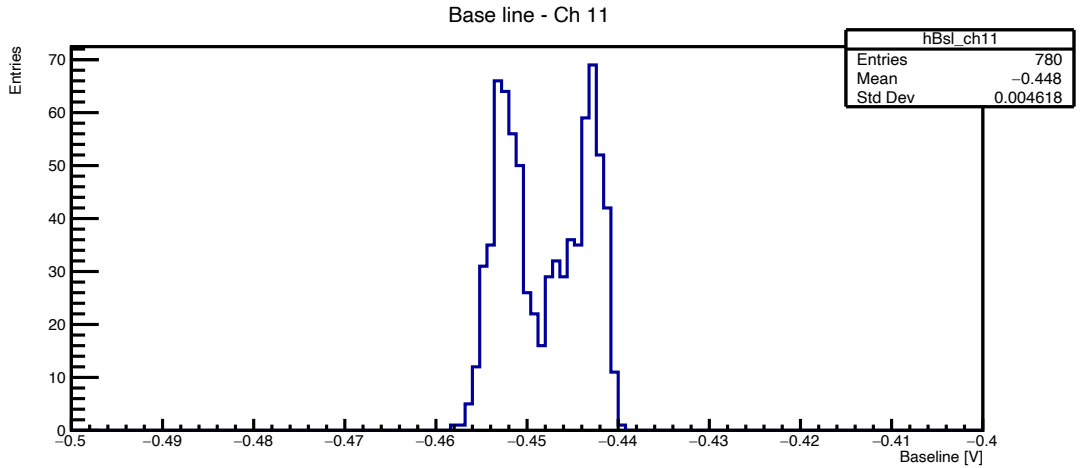


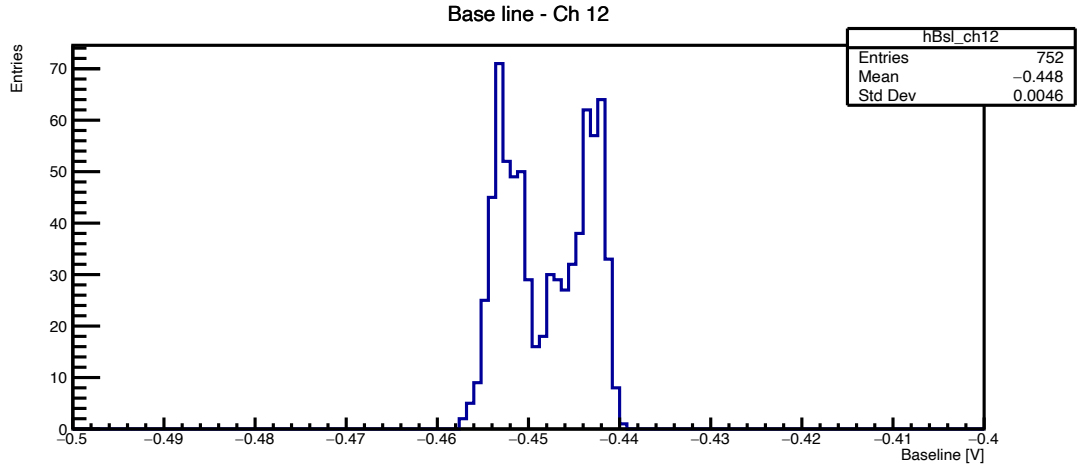


Baseline distribution before normalization

Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V 2 cm drift tubes







Find Electron Peaks strategy

Preliminary requirements on the i-th waveform event, j-th channel to be a SIGNAL event on which starting/considering a posteriori good quality Electron Peak research

- **BEFORE** starting the Electron Peaks search on the Waveform spectrum:
- Condition: Waves_normalized[channel].max > 10 r.m.s.
- Motivation: looking by eye to our noise-only spectra in time, this is a reasonable cut

- **AFTER** performing the Electron Peaks search for including an event and its observablers into distributions associated to a specific run:
- First Condition: Integral of the Waveform (sum of the Y wave values) must be >=100 mV from 20-th bin to the 700-th bin (excluding the first and last bins where the only-noise signal is present)
- Motivation: integral expected for each electron peak is around 40 mV
- Second Condition: if ((NPeak>10 && channel<=9 && NPeak<100)|| (NPeak>20 && channel>=10 && channel<=12)) {
- Motivation: Theoretical expectation on the number of Electron Peaks found (see next slides).

NOTE: r.m.s. has been defined over the first 30 bins as the $r.m.s. = \sqrt{\frac{\sum_{i=0}^{30}(Wave\_normalized[channel].Y - bsln)^2}{30}}$

Find Electron Peaks strategy (cont.)

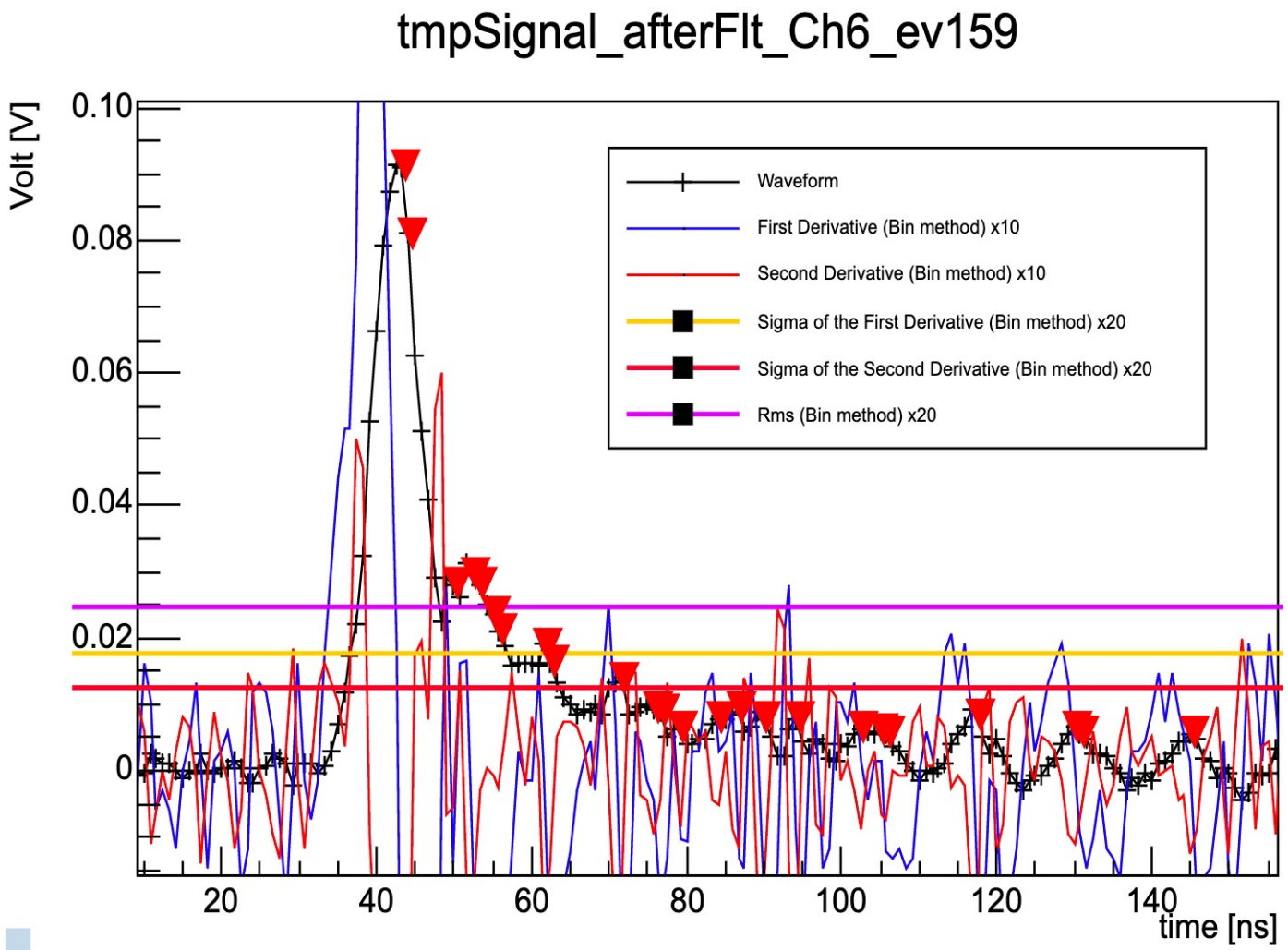
- **DURING** the Electron Peaks search:
- Search range: exclusion of the last bins for the research (424 for 1 cm drift tubes, 64 for 2 cm drift tubes)
- Motivation: DRS calibration peak at the end of the spectrum + physical constraint related to the upper limit on the drift time of the electrons
- Requirements for a good peak candidate in the bin position [ip]:
- Amplitude constraints:
- amplitude[ip]> 4*rms
- (amplitude[ip]-amplitude[ip-1])>(rms) || (amplitude[ip+1]-amplitude[ip])<(rms)
- First derivative constraint:
- fderiv[ip]< sigd1/2
- fderiv[ip-1]> sigd1 || fderiv[ip+1]< -sigd1
- Second derivative constraint:
- sderiv[ip]< 0

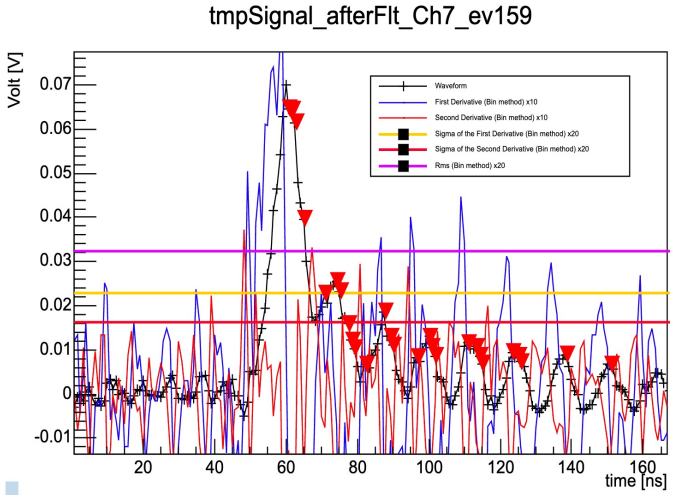
NOTE:
fderiv[ip] = (Waves_normalized.Y[ip+1]-Waves_normalized[ip-1])/2
sderiv[ip] = (fderiv[ip+1]-fderiv[ip-1])/2
sigd1 = rms/sqrt(2)
sigd2 = rms/2

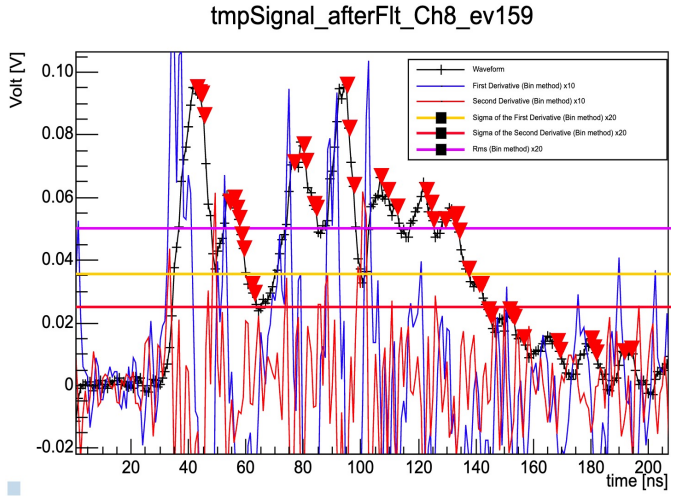
Normalized waveform spectrum with peaks found

Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

1 cm drift tubes



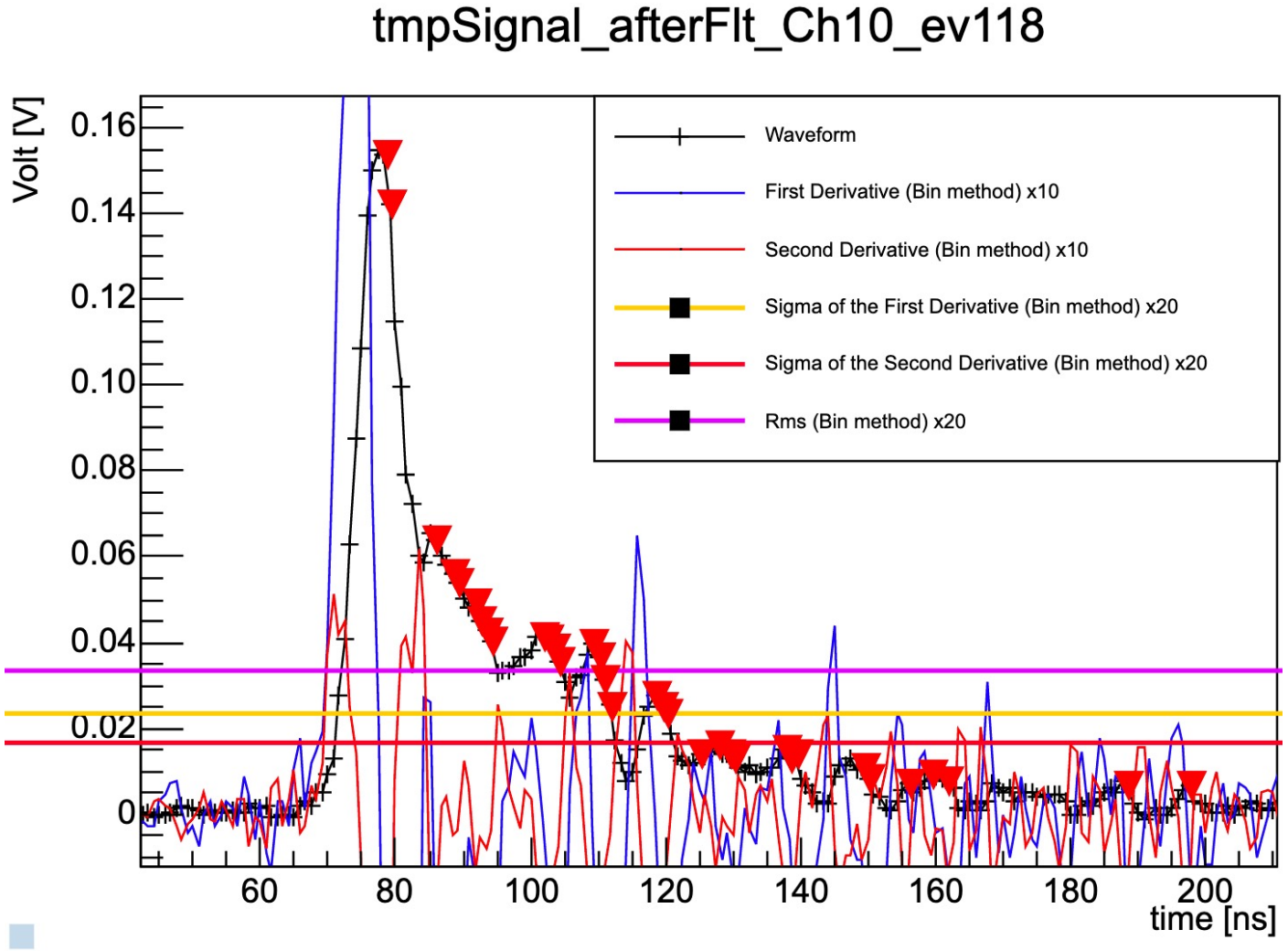


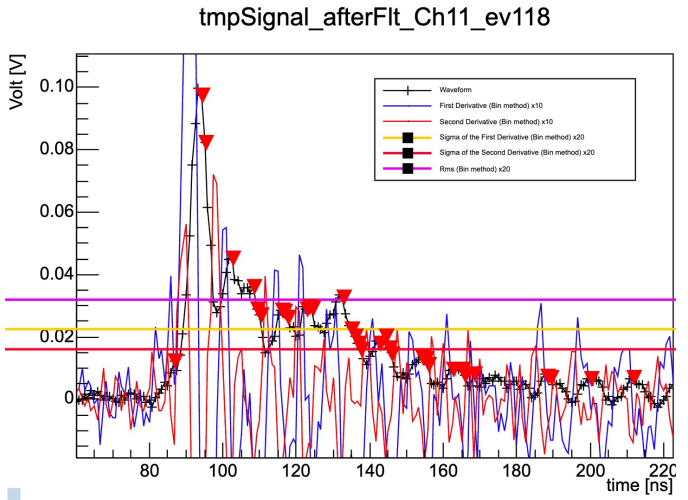


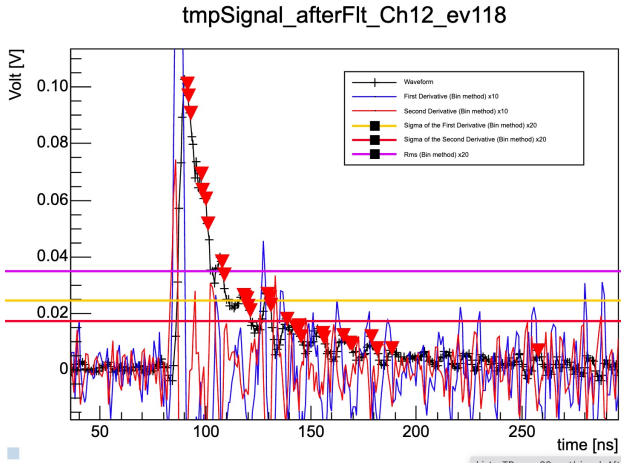
Normalized waveform spectrum with peaks found

Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes





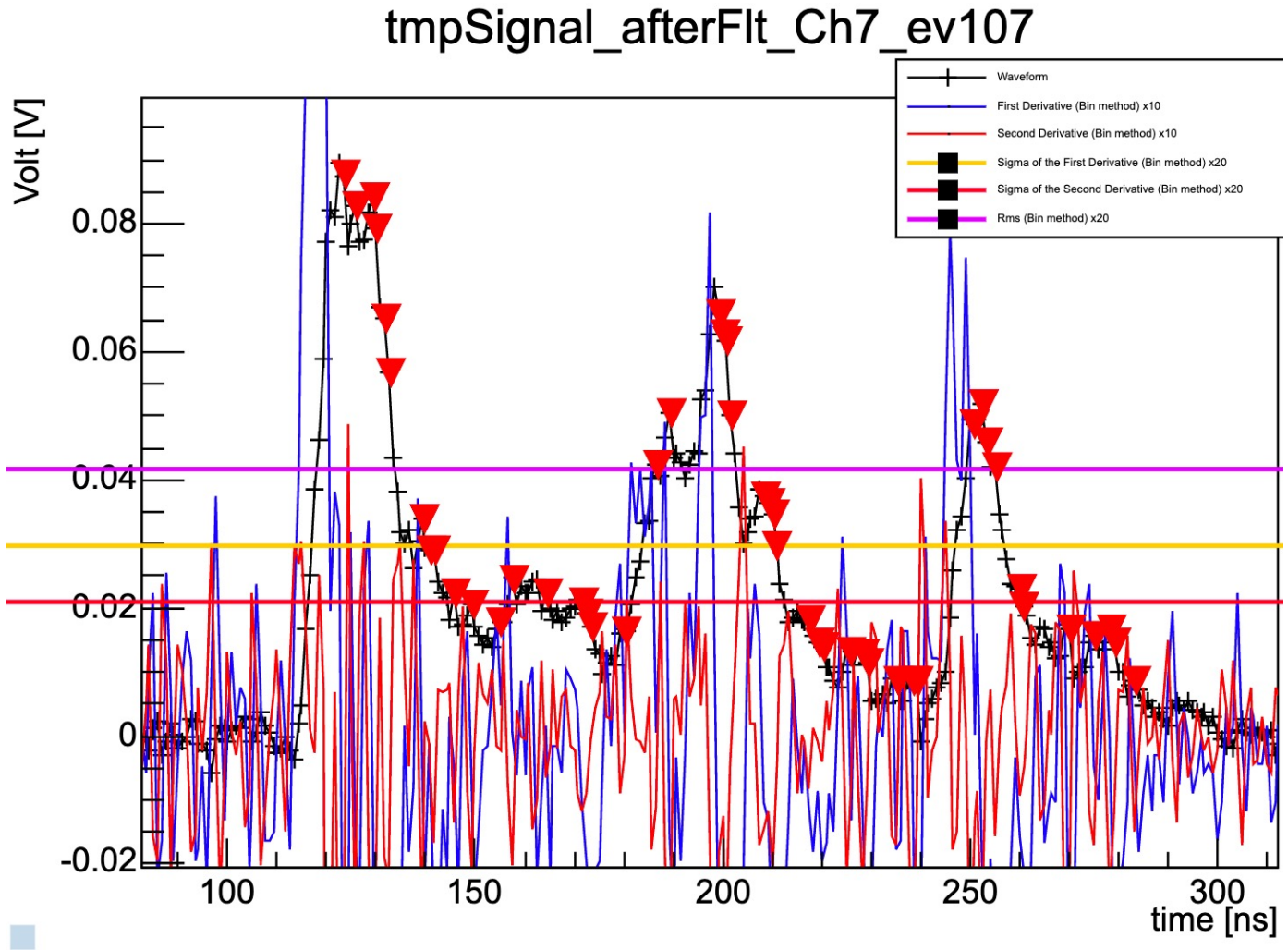


Normalized waveform spectrum with peaks found

Run: run_98.root; Track angle: 15° ; Gas mixture: 90%He ; HV = +20V

1 cm drift tubes

Representative channel of the 1 cm drift tubes (Ch4 to Ch9)

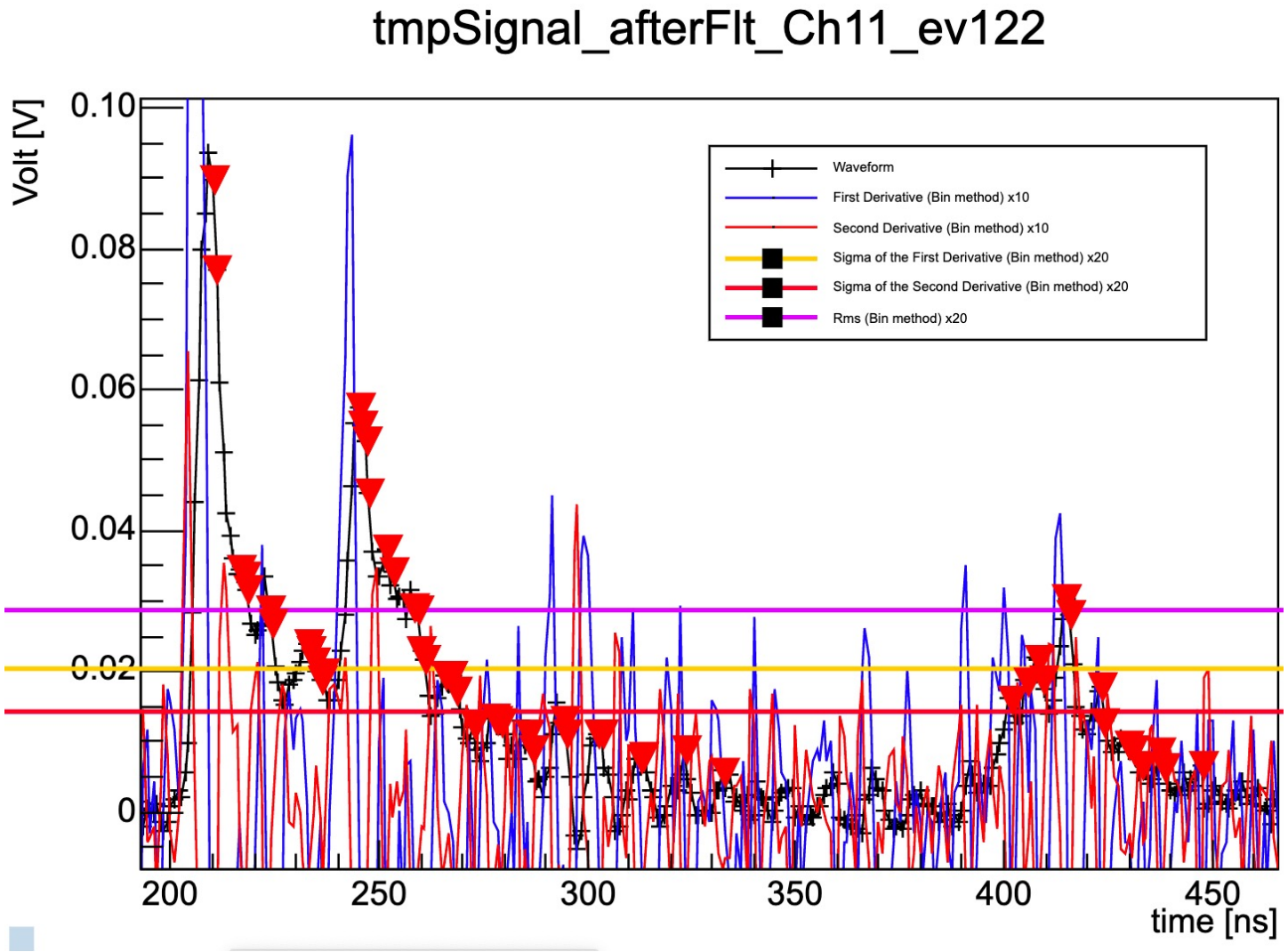


NOTE: 1st peak includes a lot of electrons -> low level of diffusion, charges related to several electrons are summed up

Normalized waveform spectrum with peaks found

Run: run_98.root; Track angle: **15°** ; Gas mixture: **90%He** ; **HV = +20V**

2 cm drift tubes

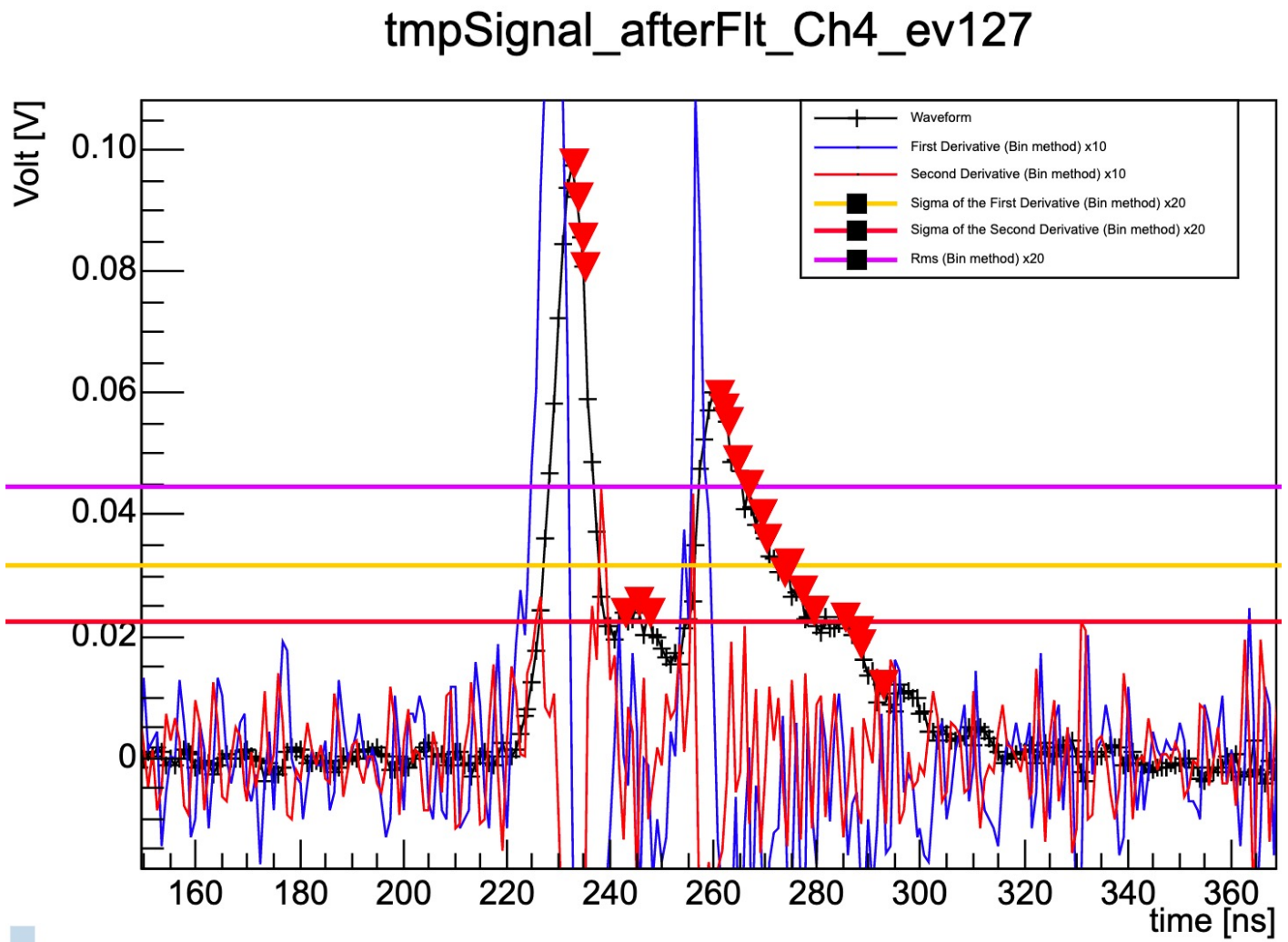


Representative channel of the 2 cm drift tubes (Ch10 to Ch12)

Normalized waveform spectrum with peaks found

Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

1 cm drift tubes

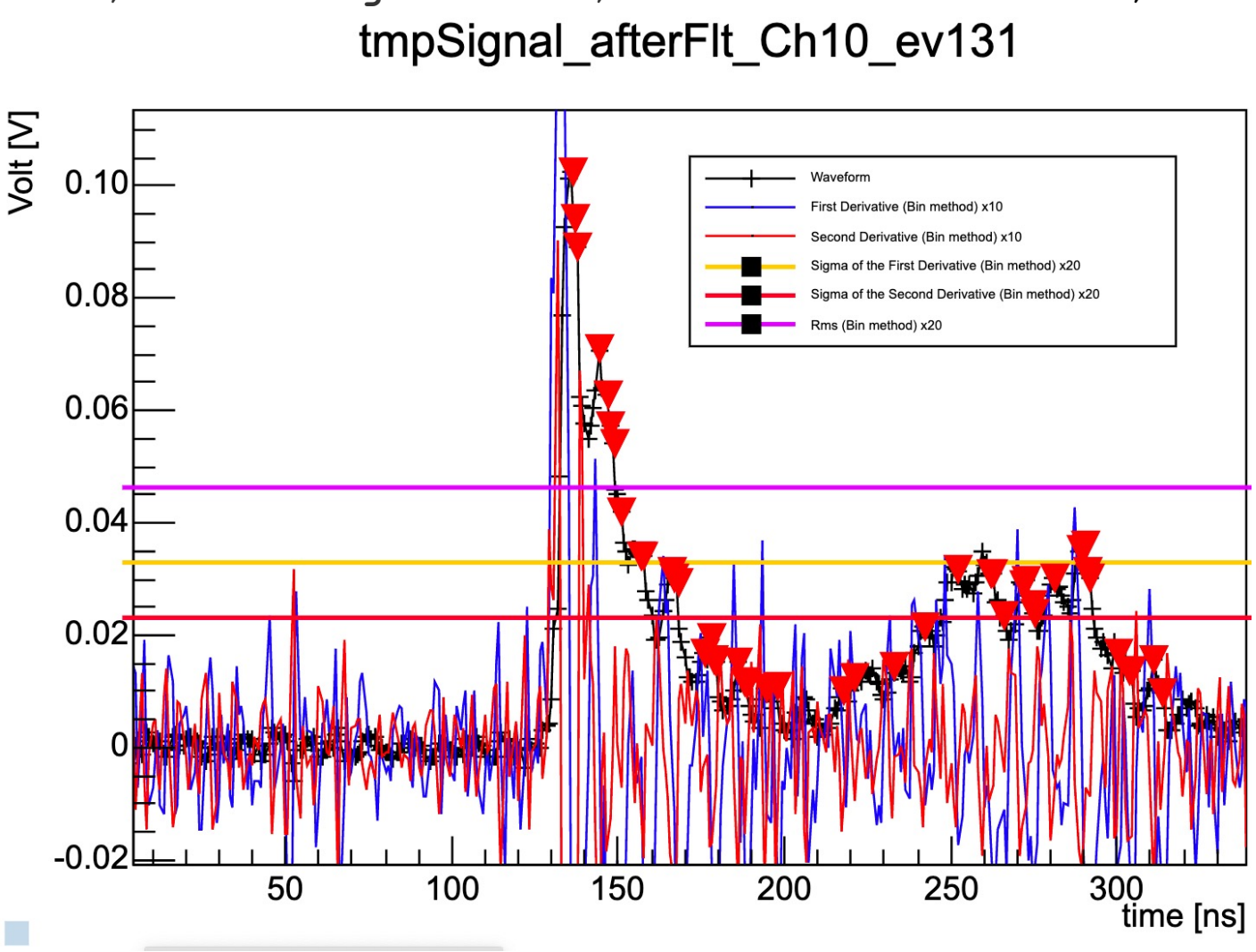


Representative channel of the 1 cm drift tubes (Ch4 to Ch9)

Normalized waveform spectrum with peaks found

Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes

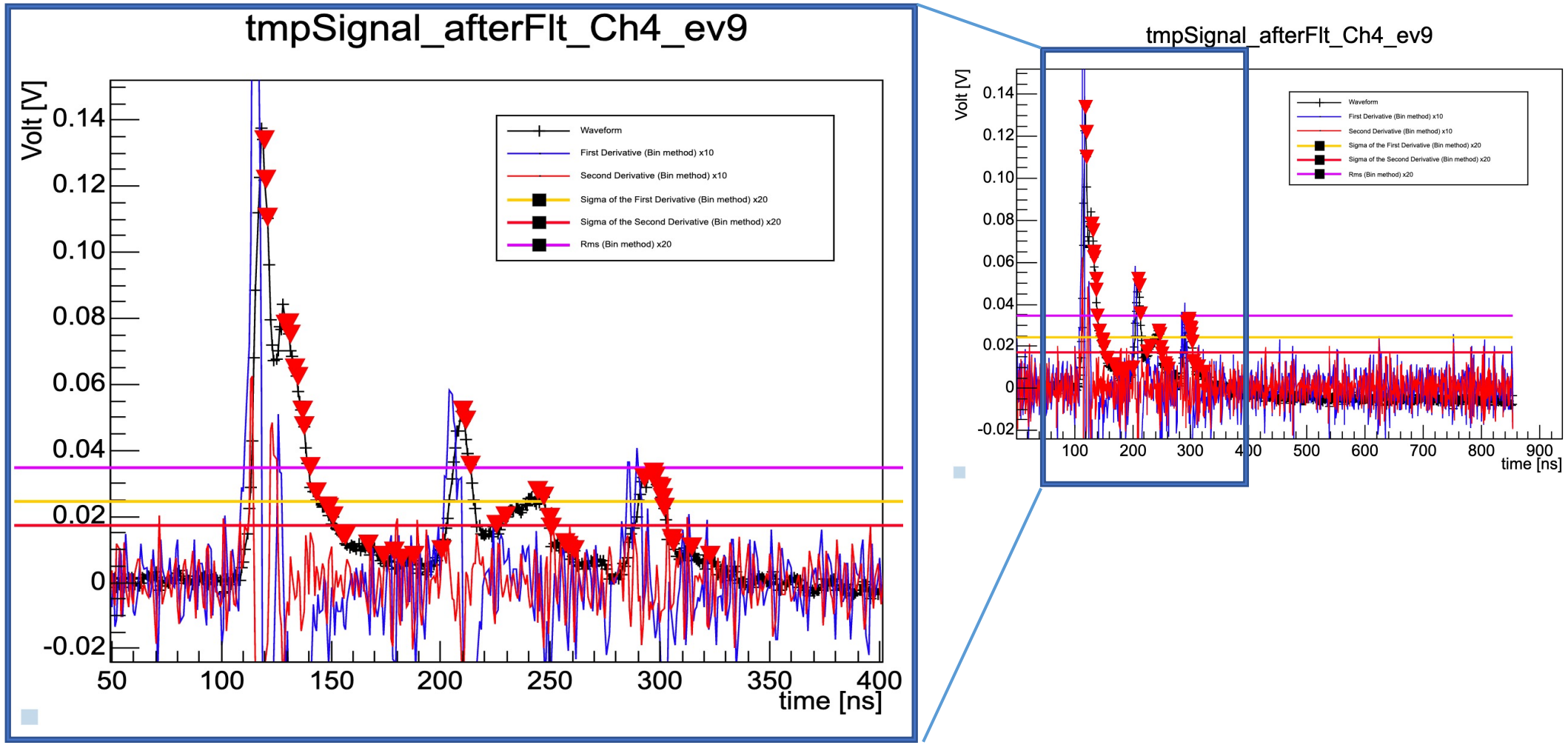


Representative channel of the 2 cm drift tubes (Ch10 to Ch12)

Normalized waveform spectrum with peaks found

Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

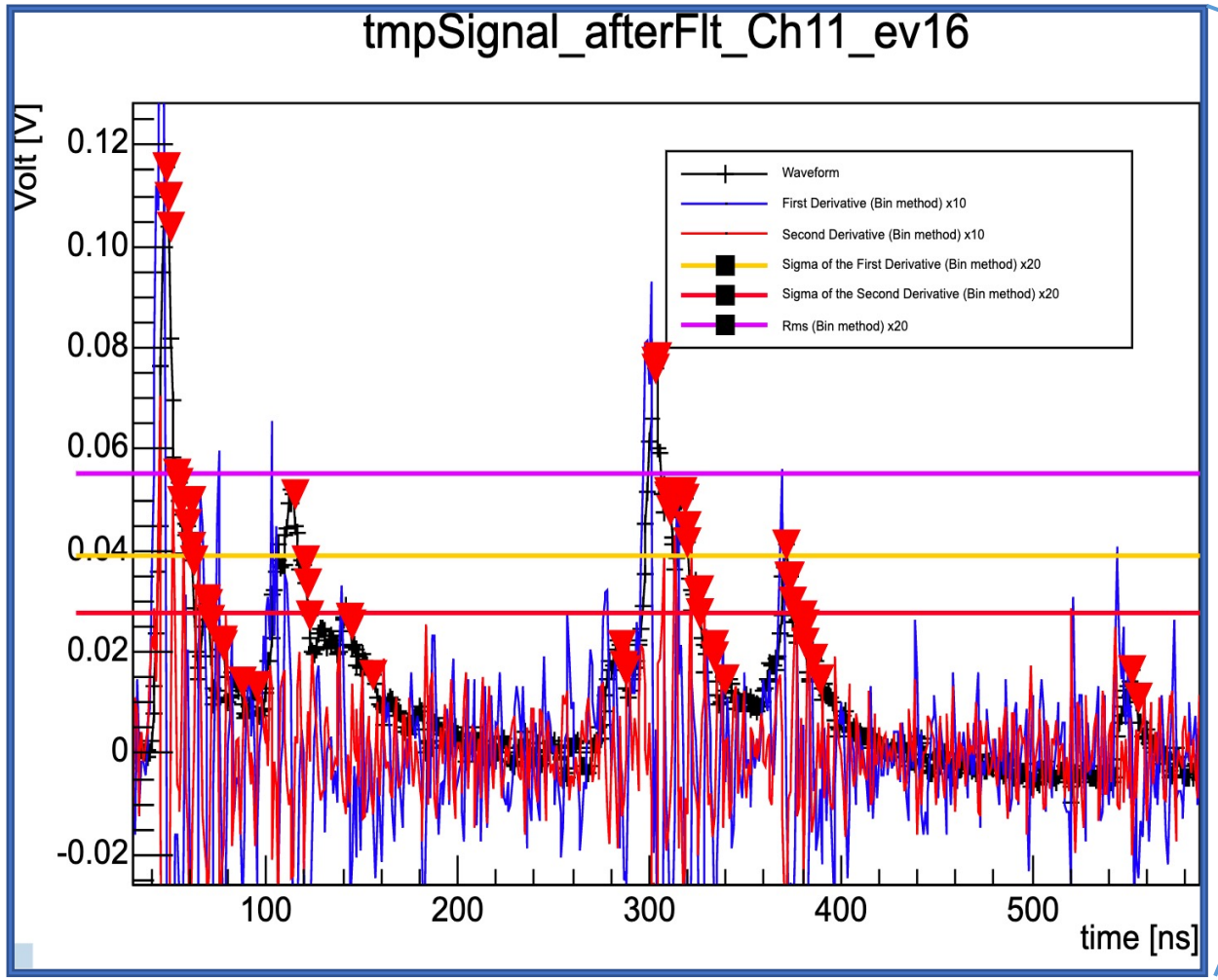
1 cm drift tubes

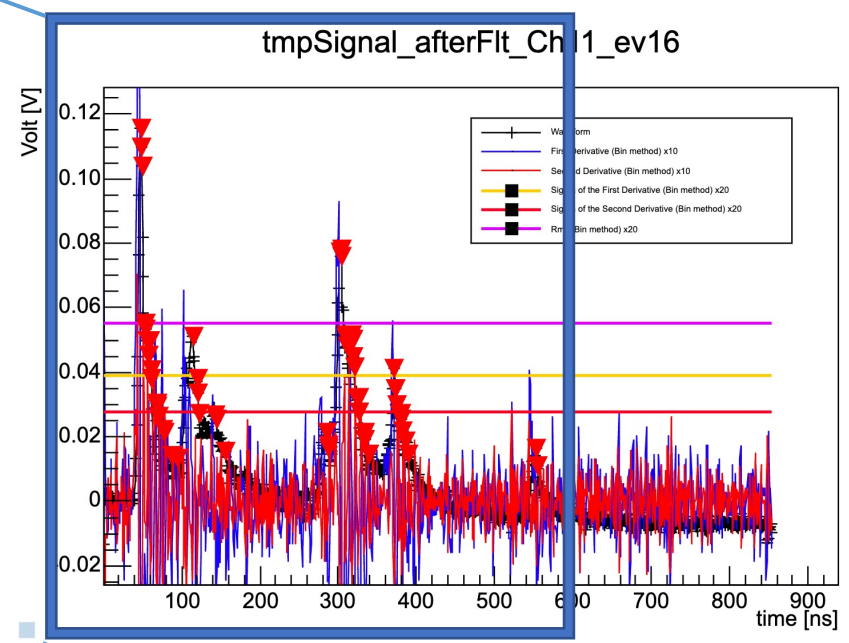


Normalized waveform spectrum with peaks found

Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes

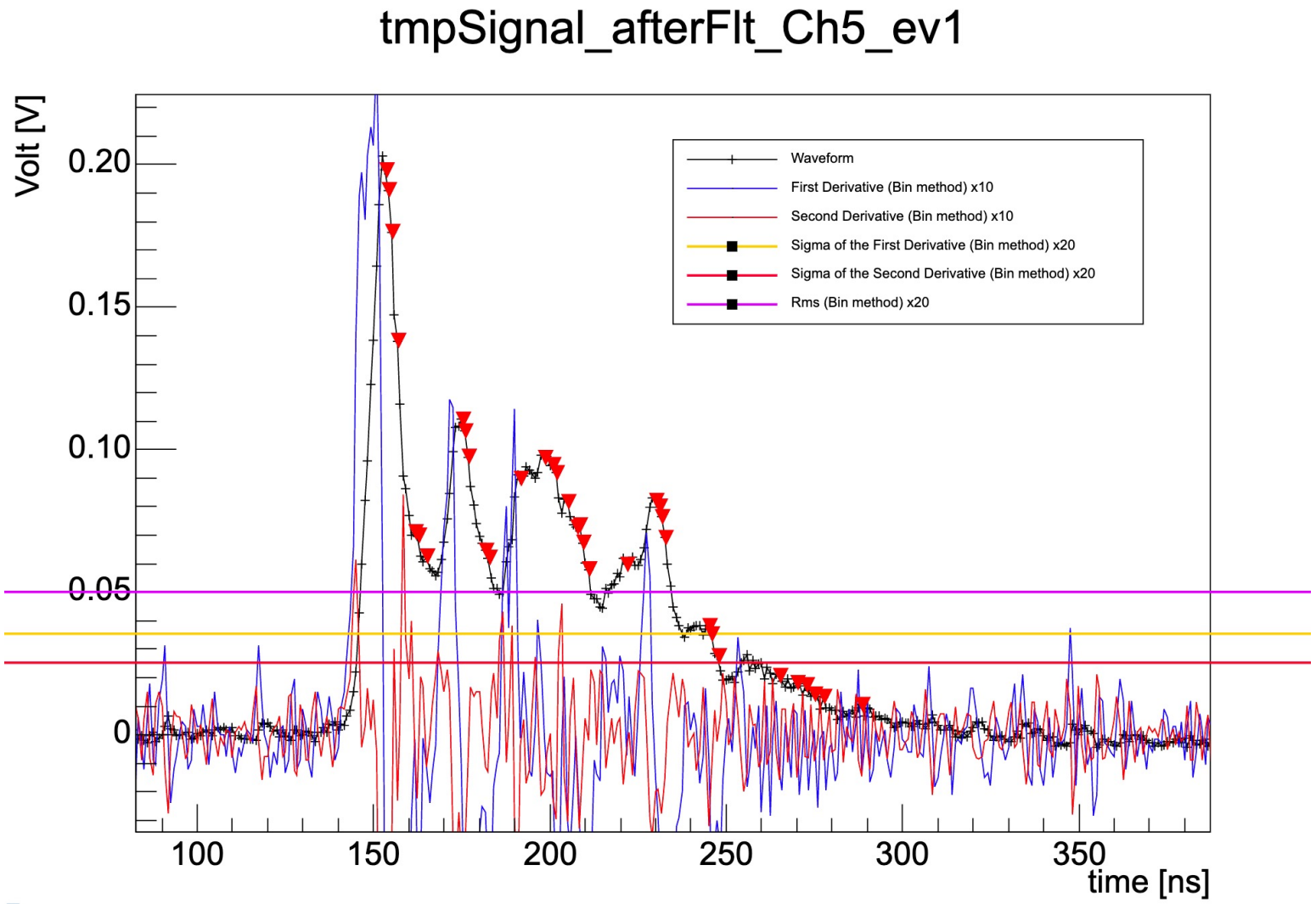




Normalized waveform spectrum with peaks found

Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V

1 cm drift tubes



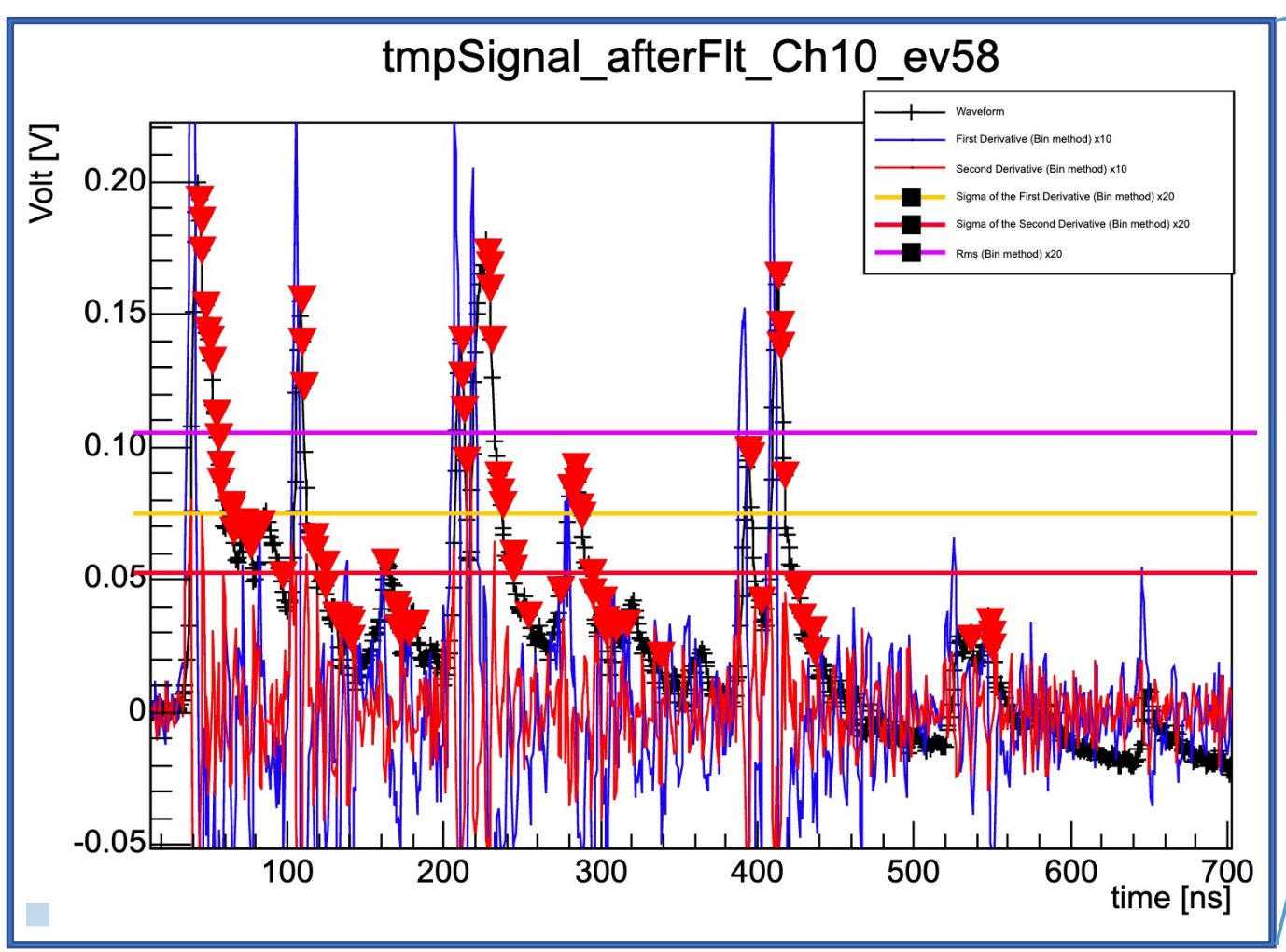
As it is expected:

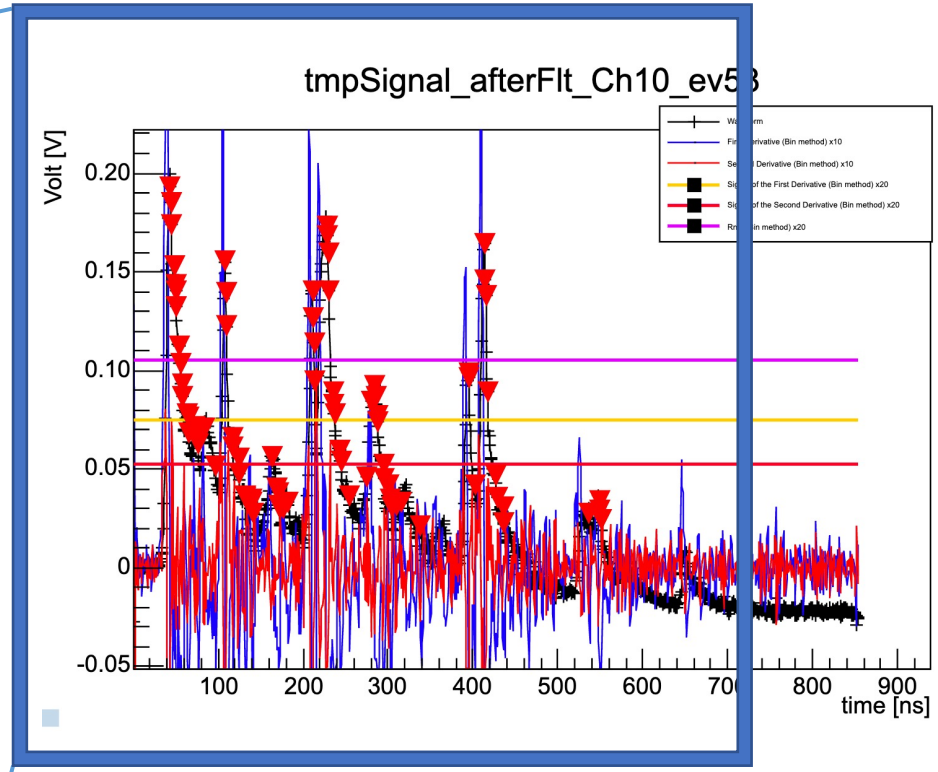
- Cluster near the wire correponds to larger amplitude and narrow time of arrival
- Cluster far from the wire corresponds to a smaller amplitude and larger time of arrival for the electrons

Normalized waveform spectrum with peaks found

Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes

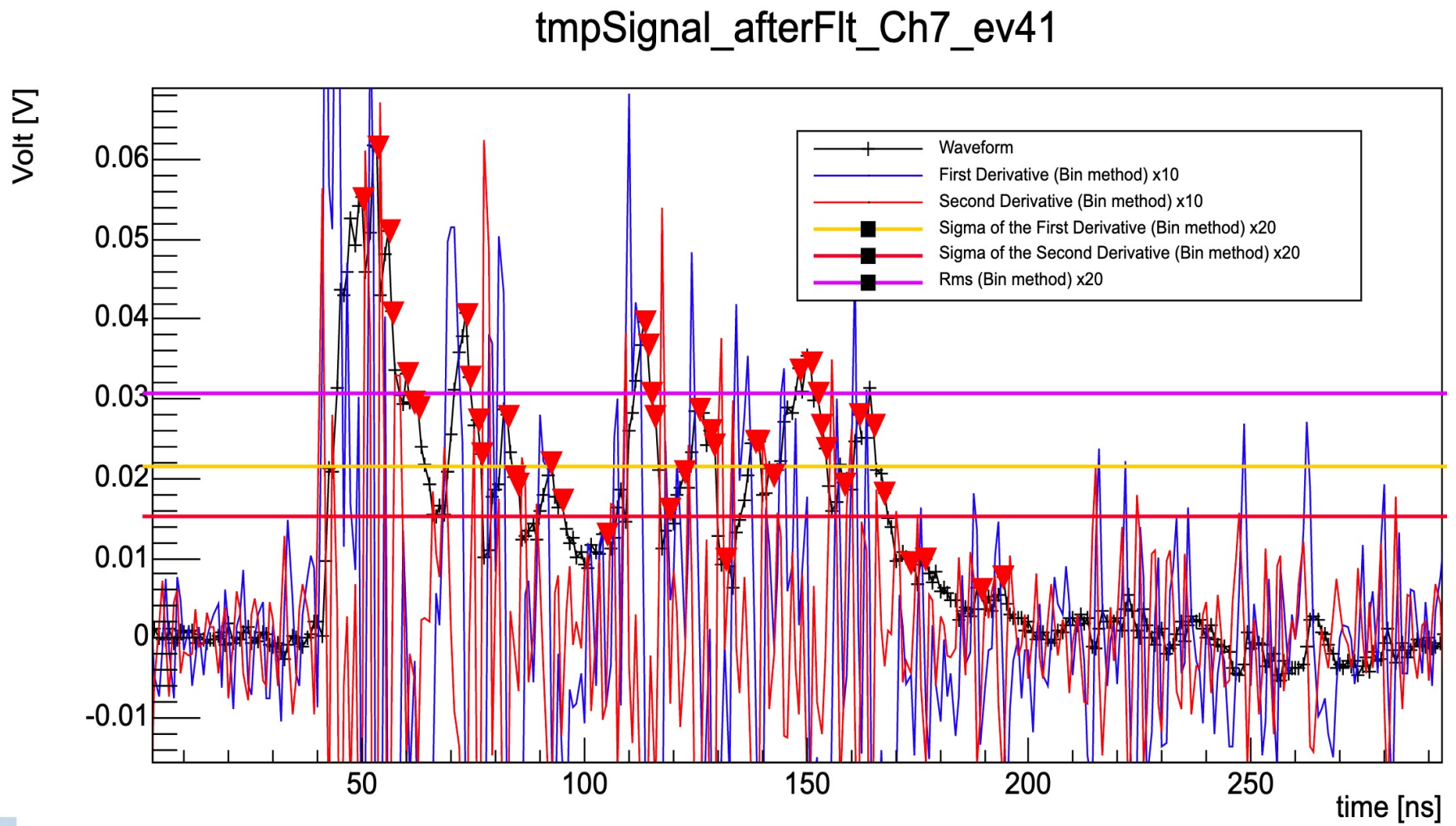




Normalized waveform spectrum with peaks found

Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V

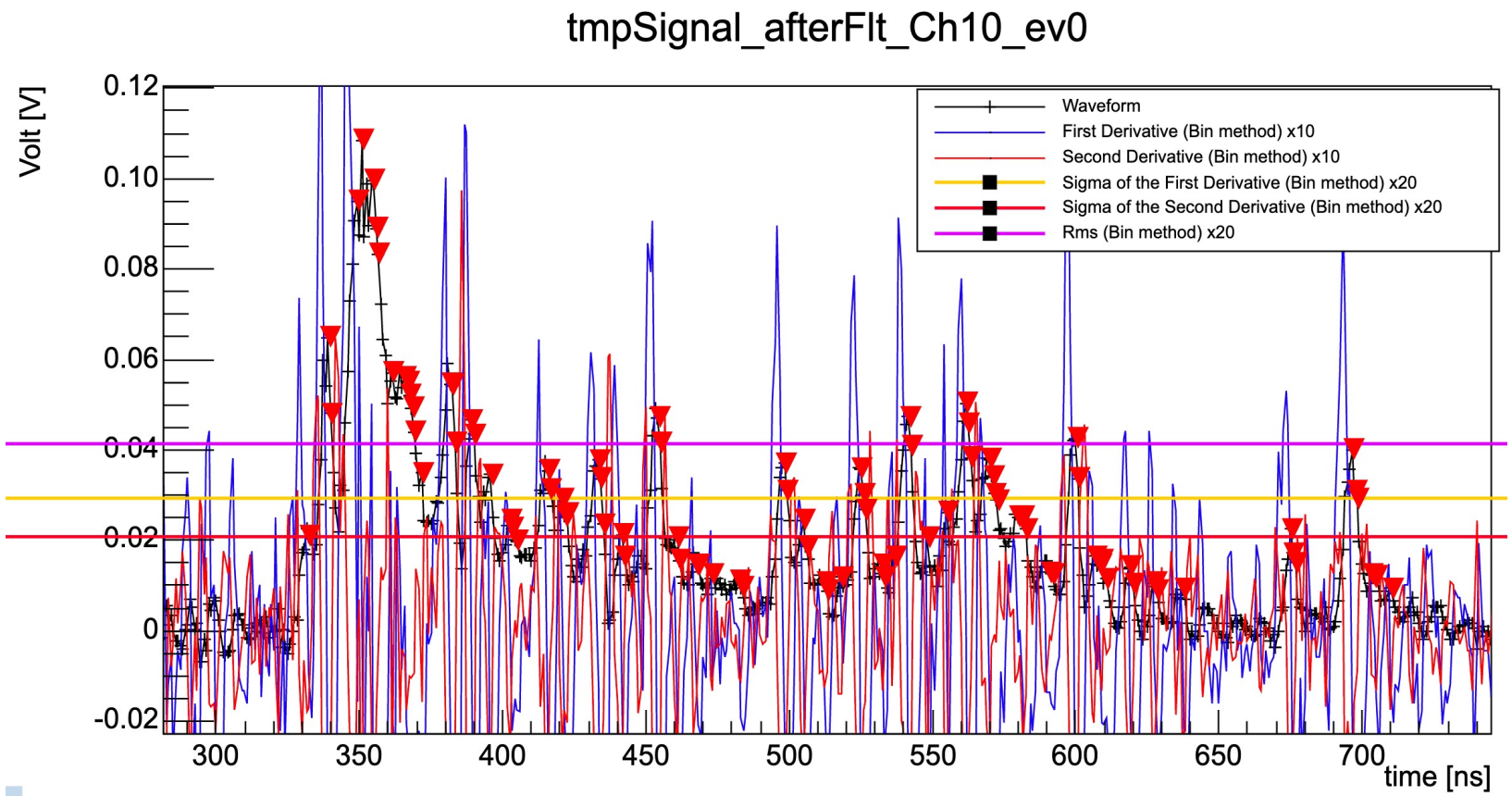
1 cm drift tubes



Normalized waveform spectrum with peaks found

Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V

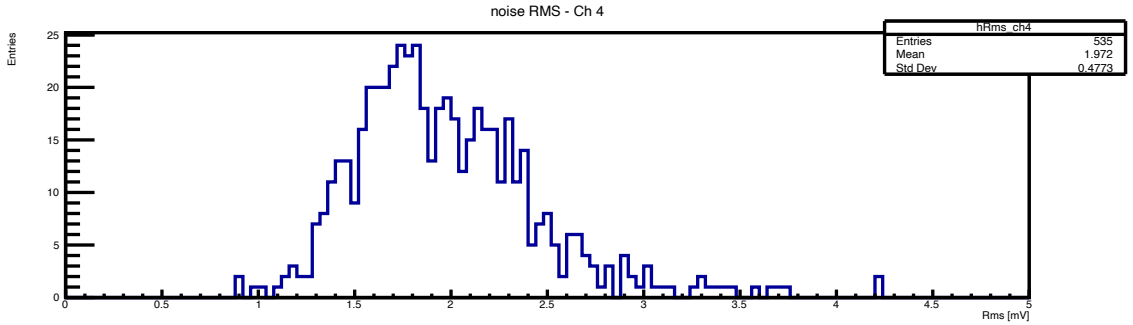
2 cm drift tubes

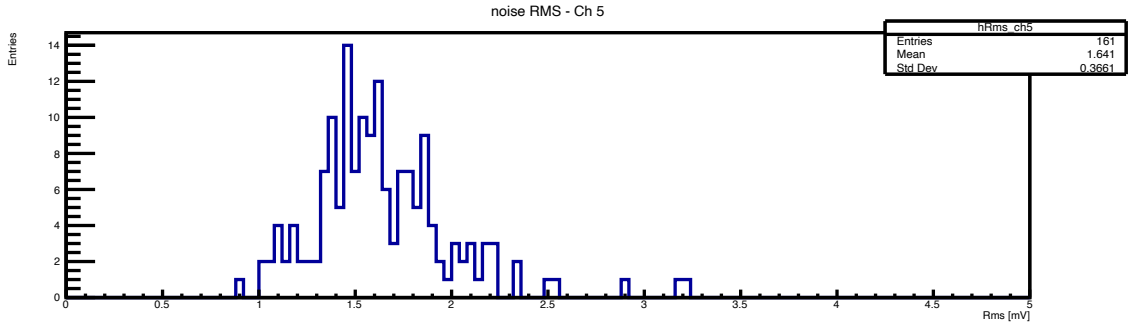


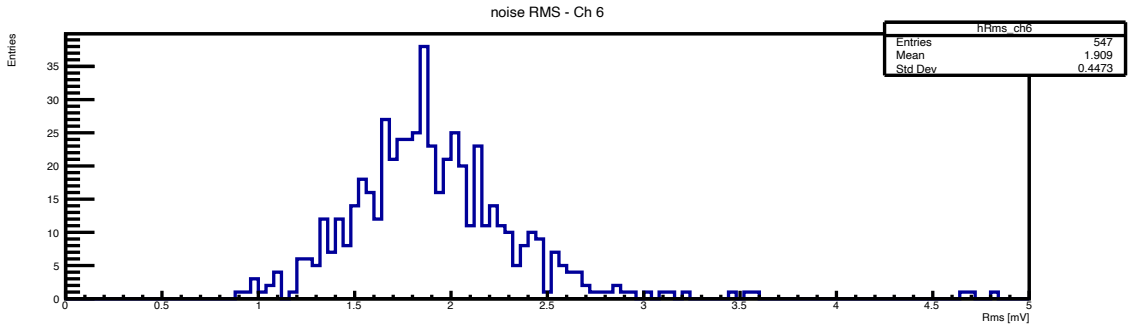
Rms for signal events

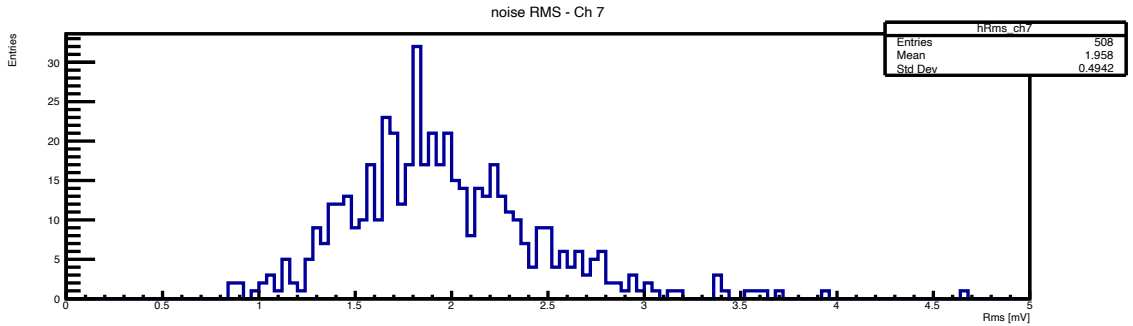
Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

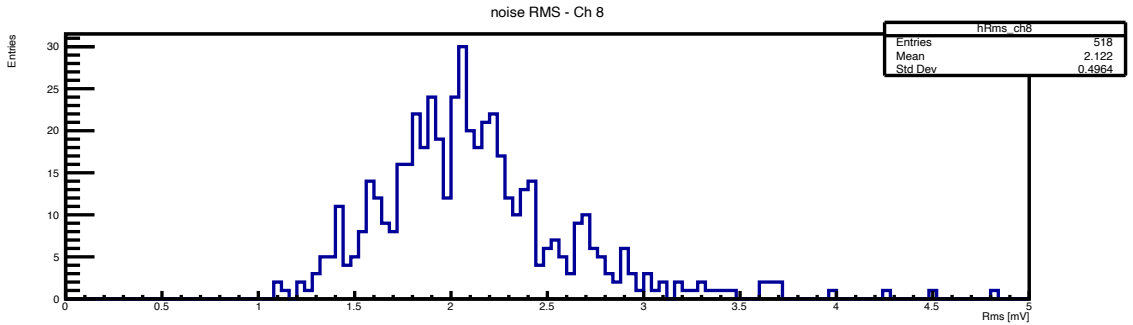
1 cm drift tubes

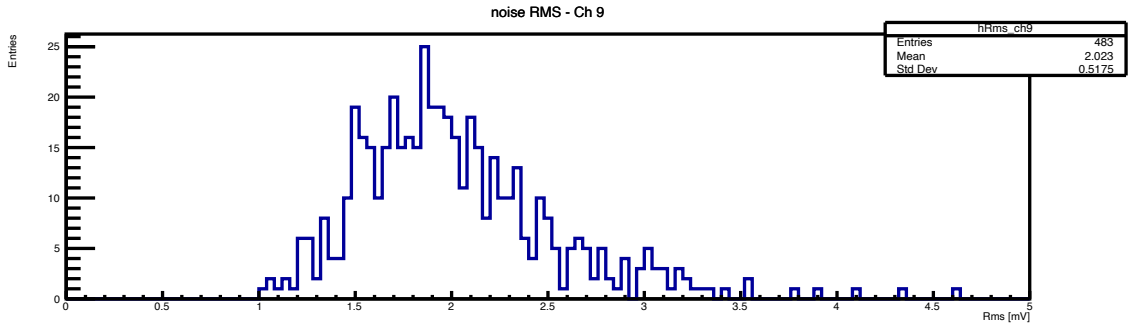








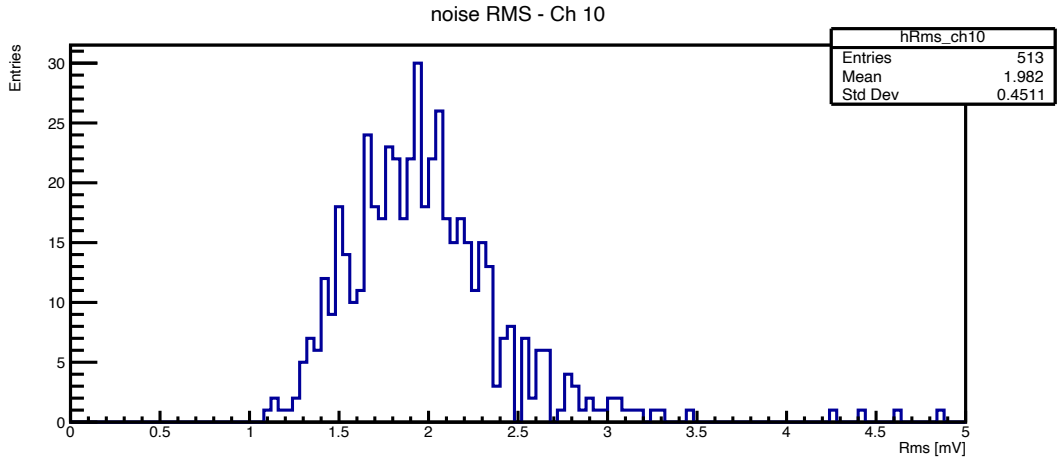


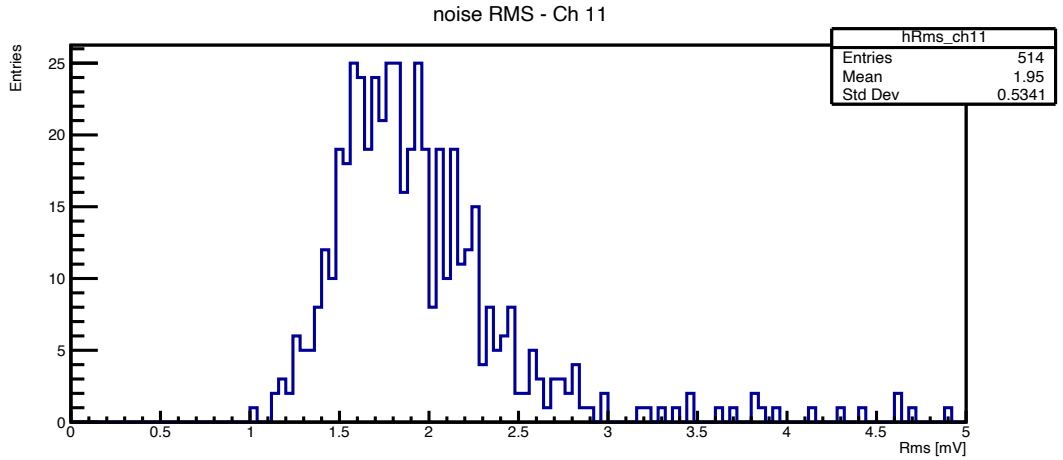


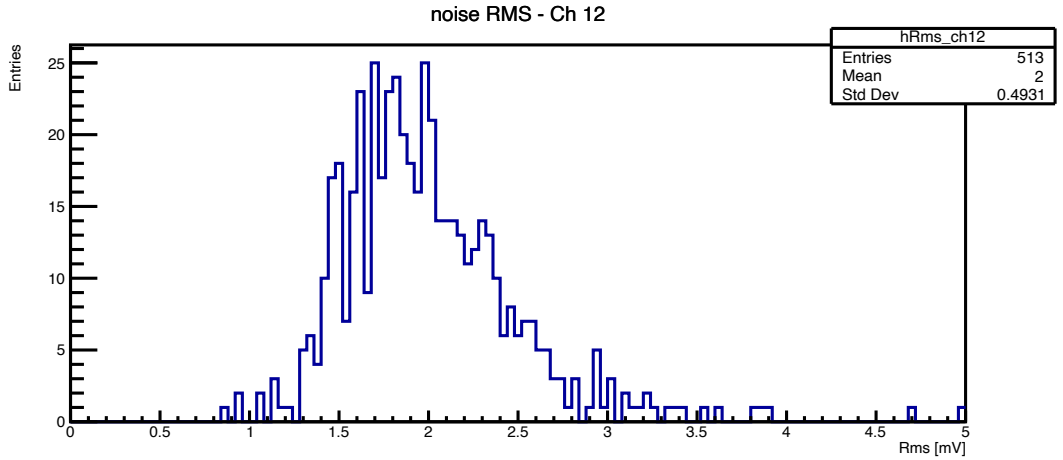
Rms for signal events

Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



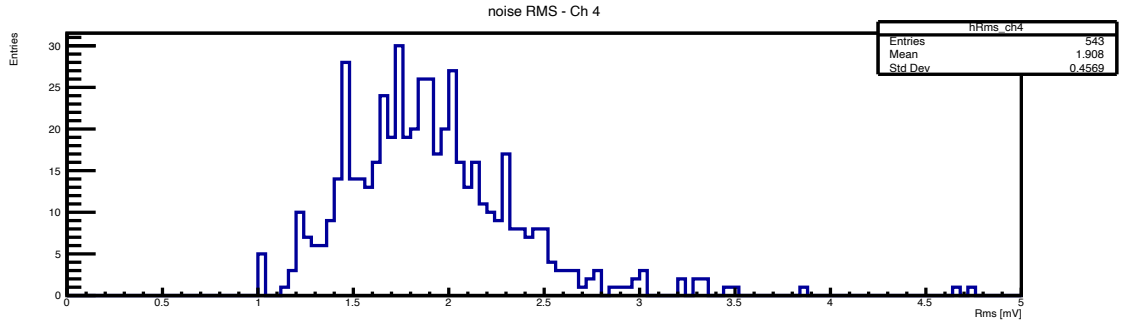


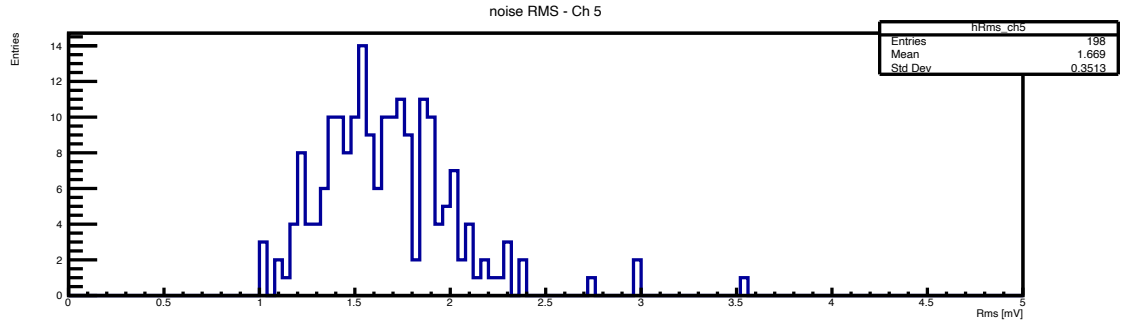


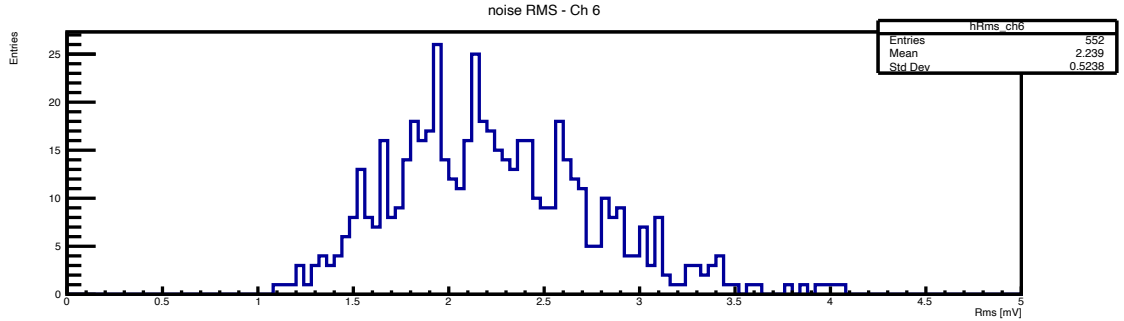
Rms for signal events

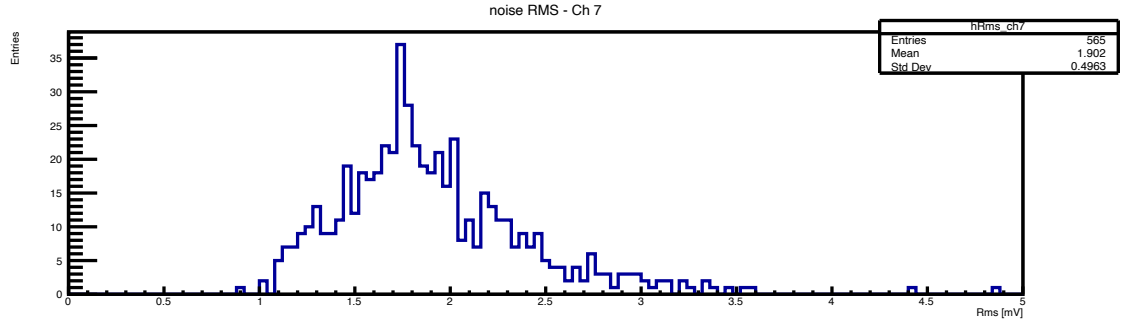
Run: run_98.root; Track angle: 15° ; Gas mixture: 90%He ; HV = +20V

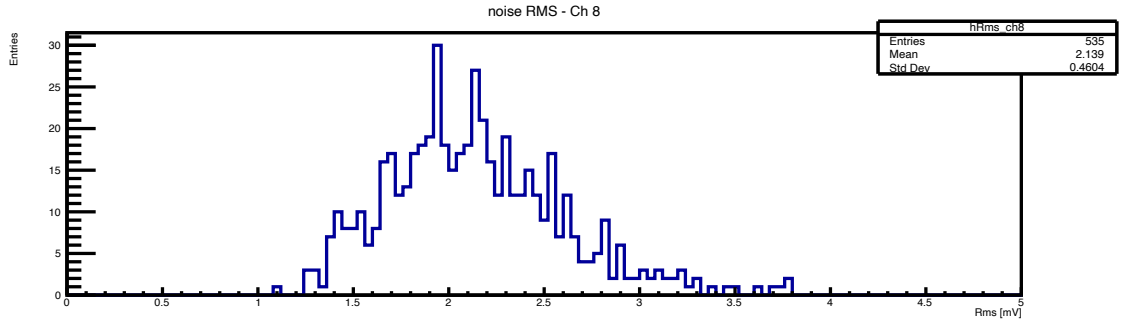
1 cm drift tubes

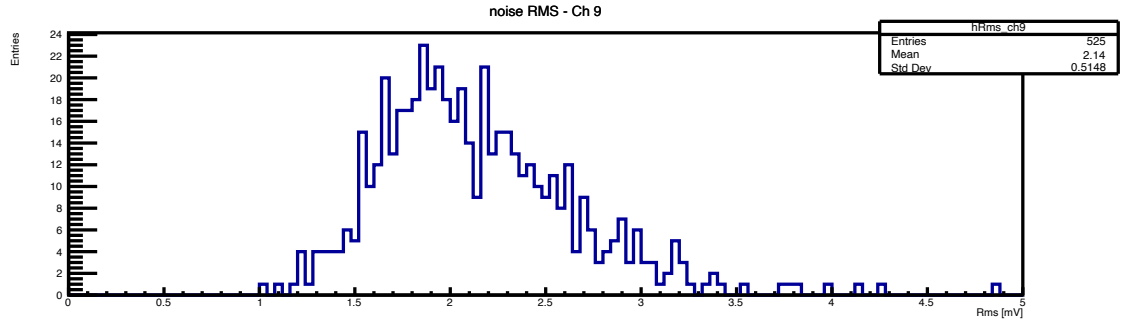








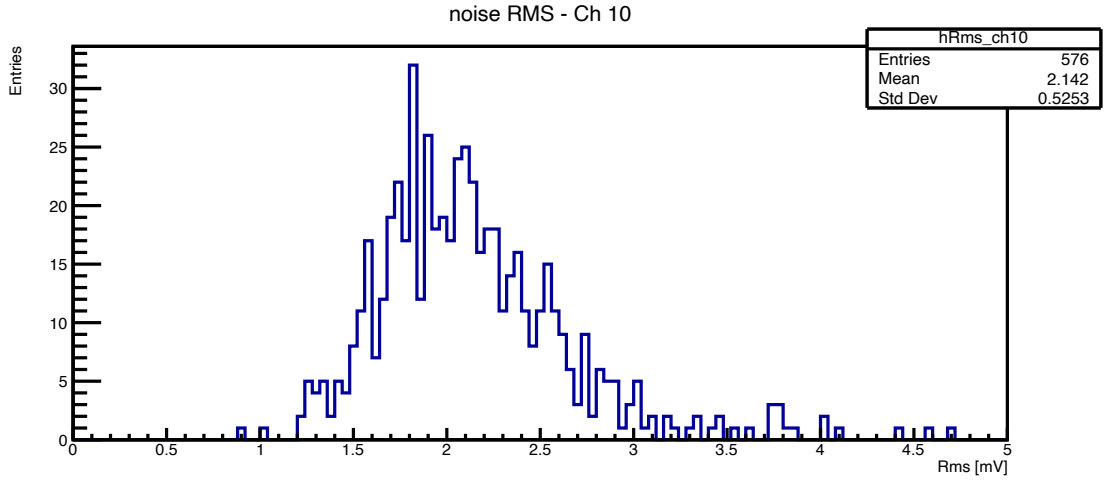


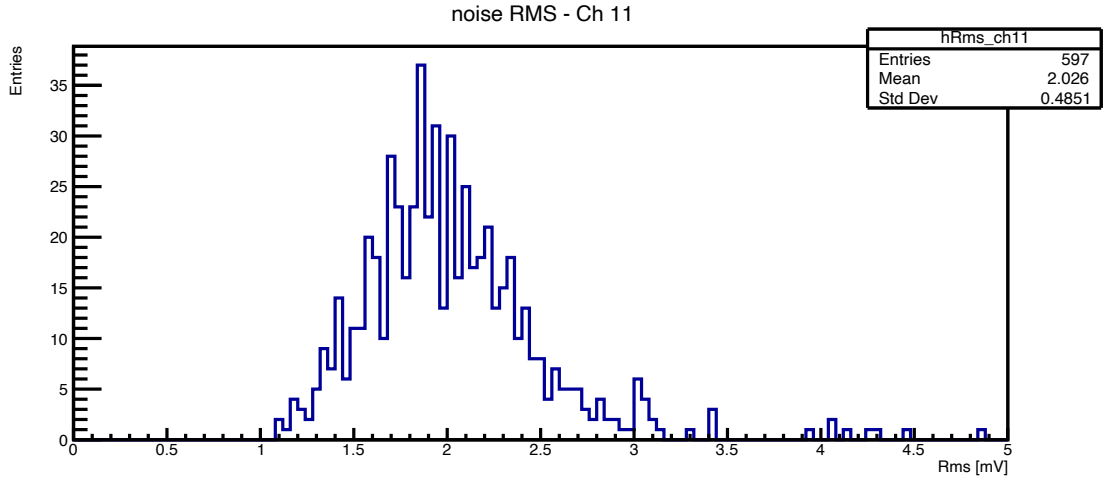


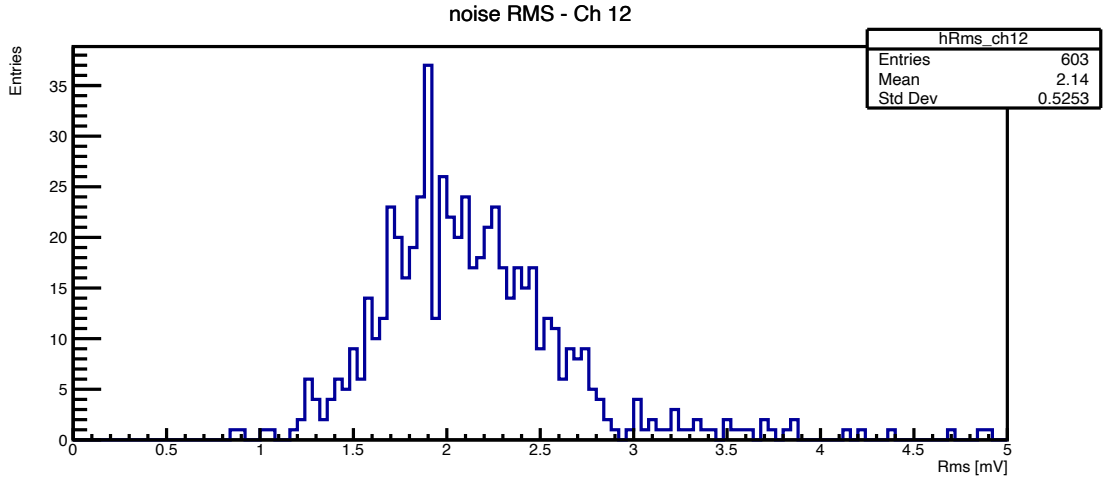
Rms for signal events

Run: run_98.root; Track angle: 15° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



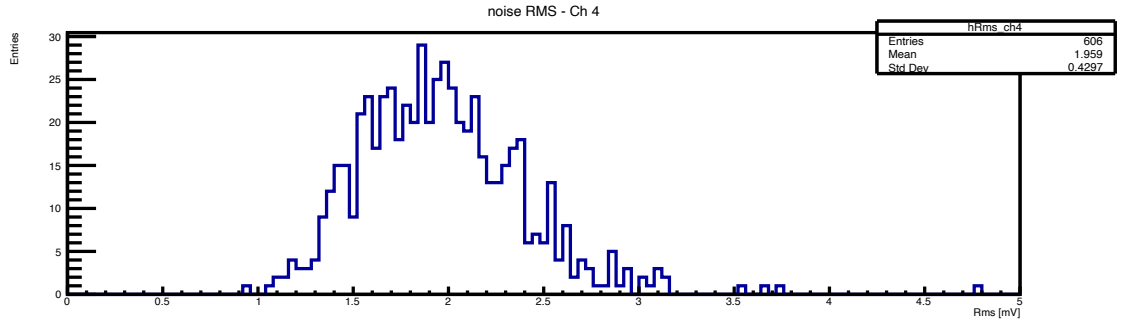


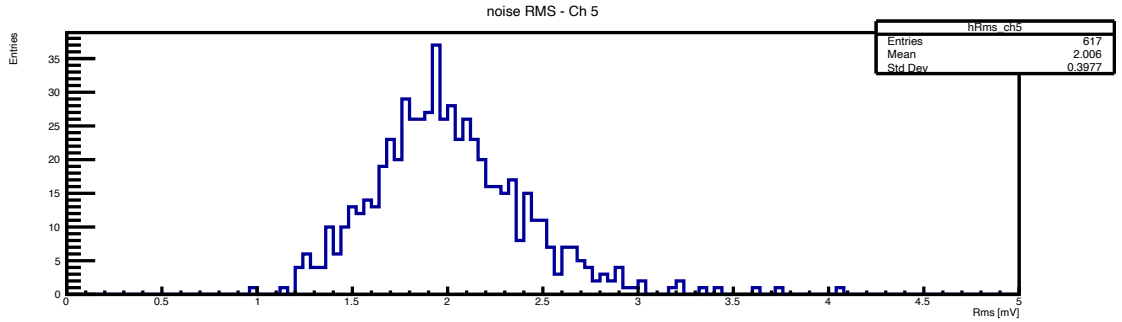


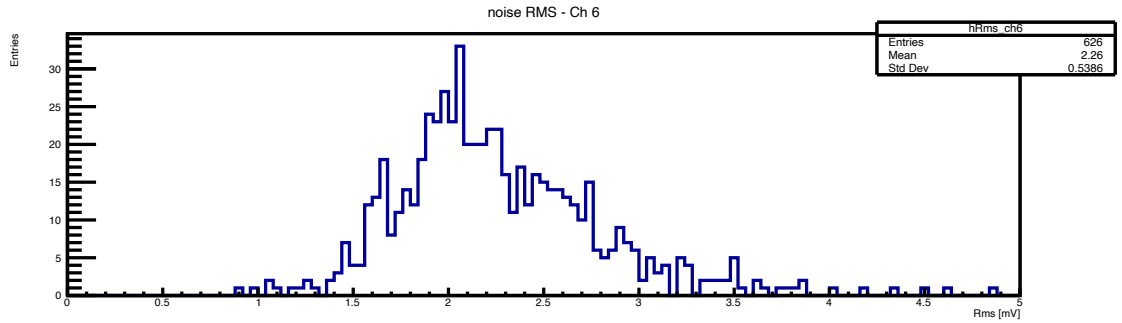
Rms for signal events

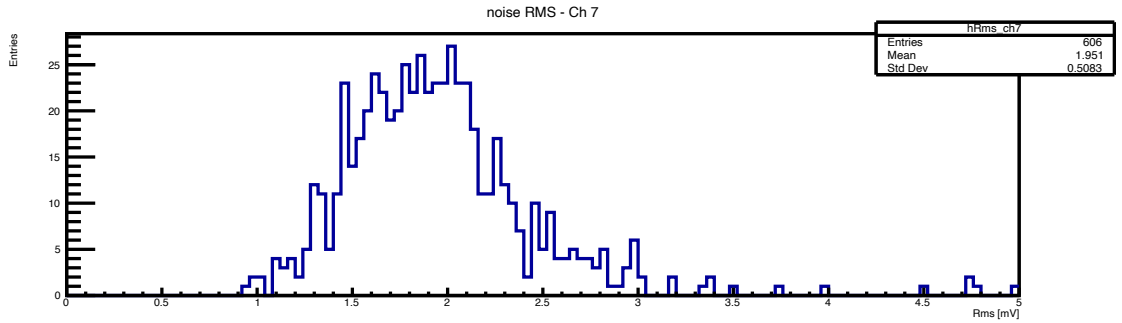
Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

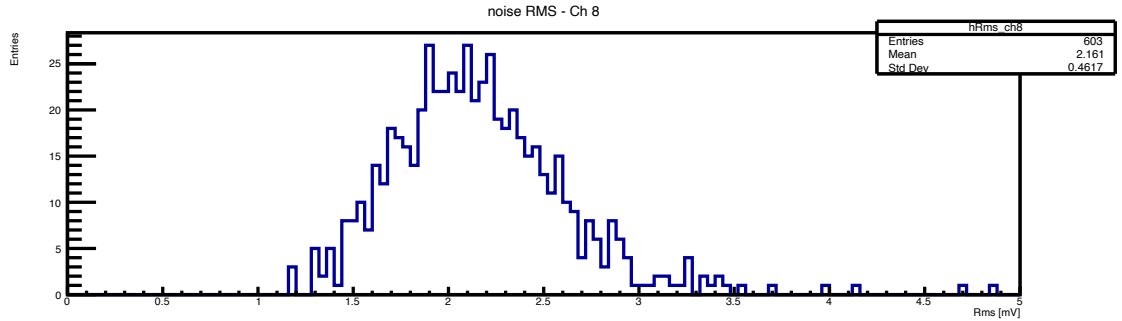
1 cm drift tubes

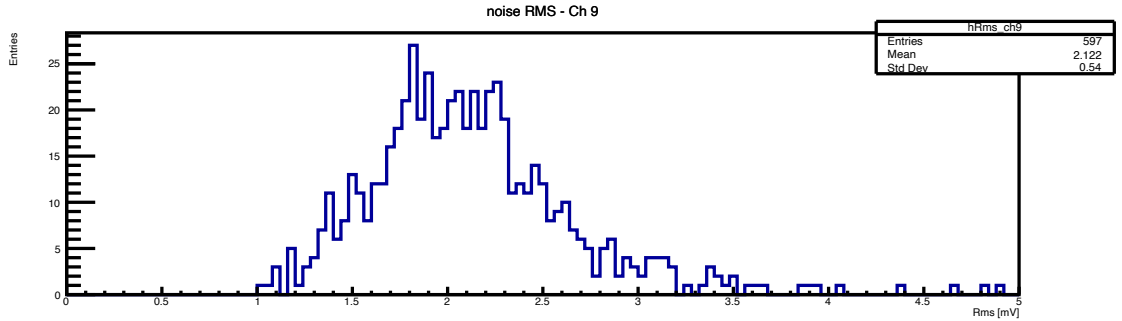








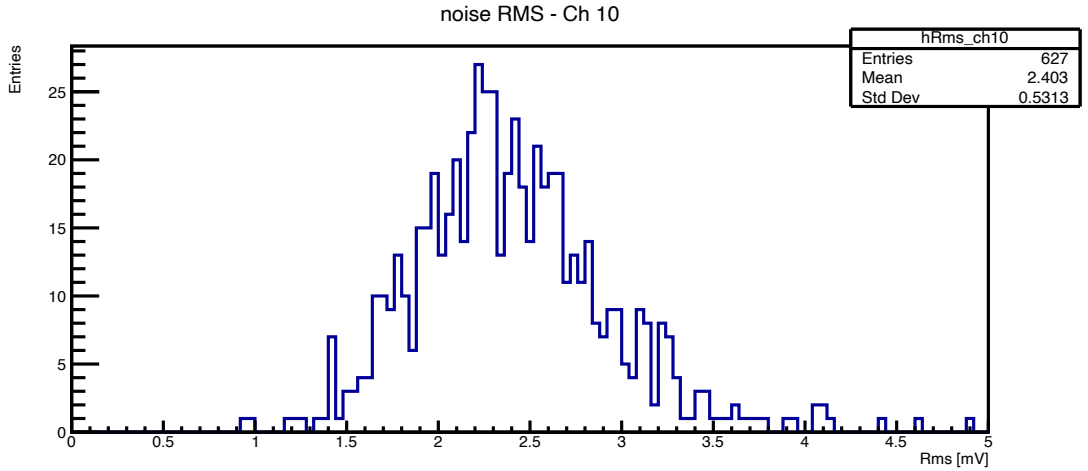


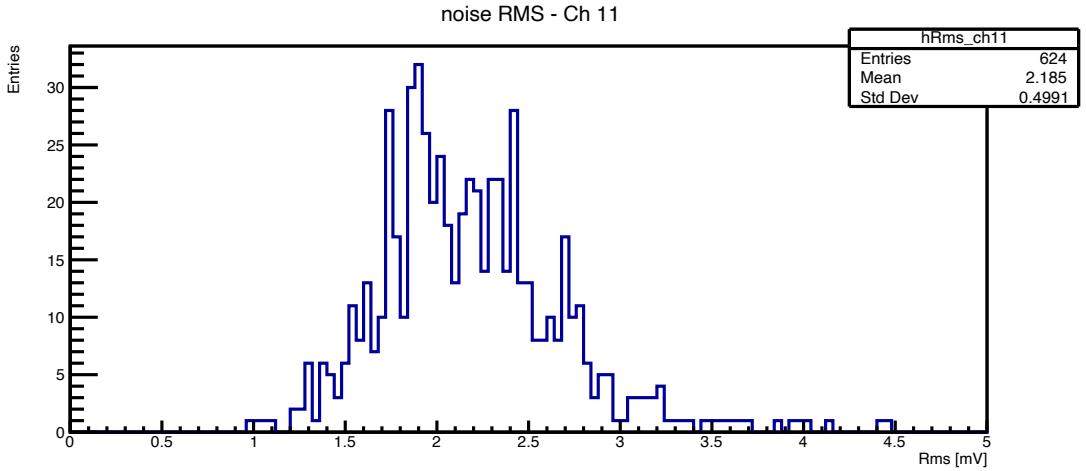


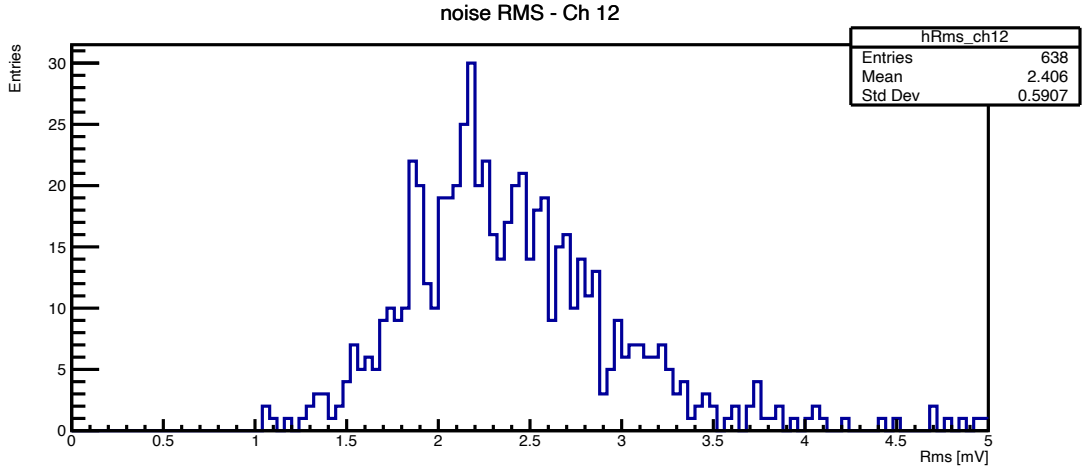
Rms for signal events

Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



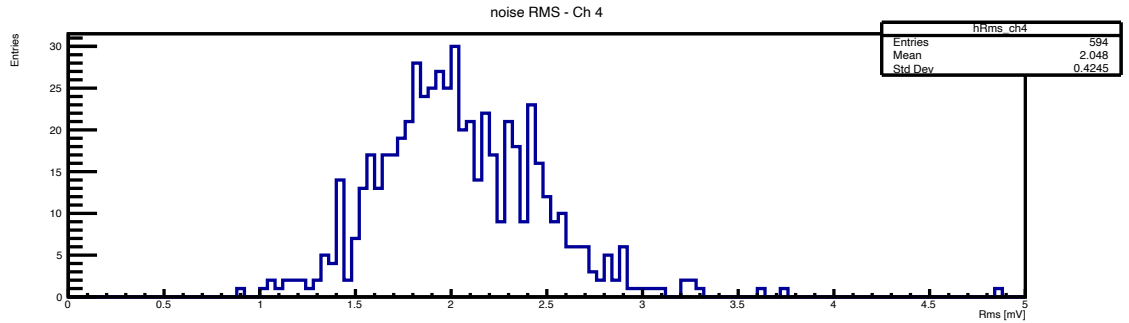


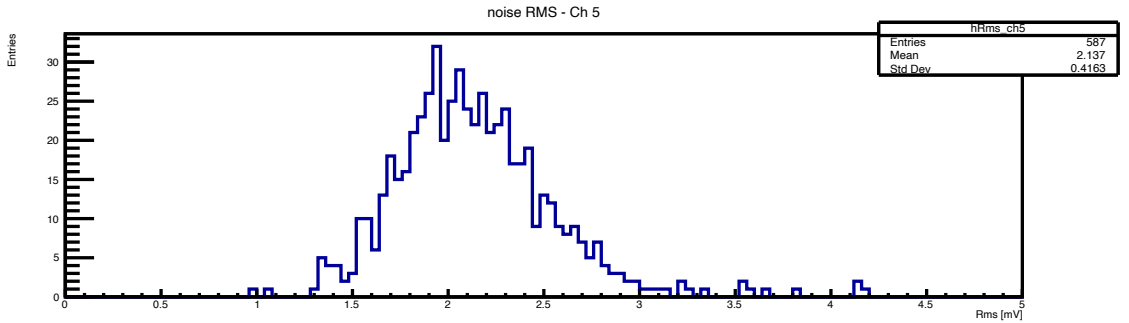


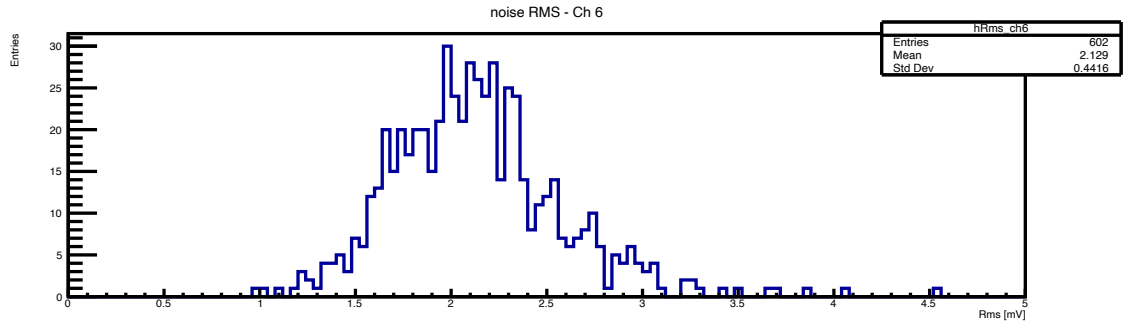
Rms for signal events

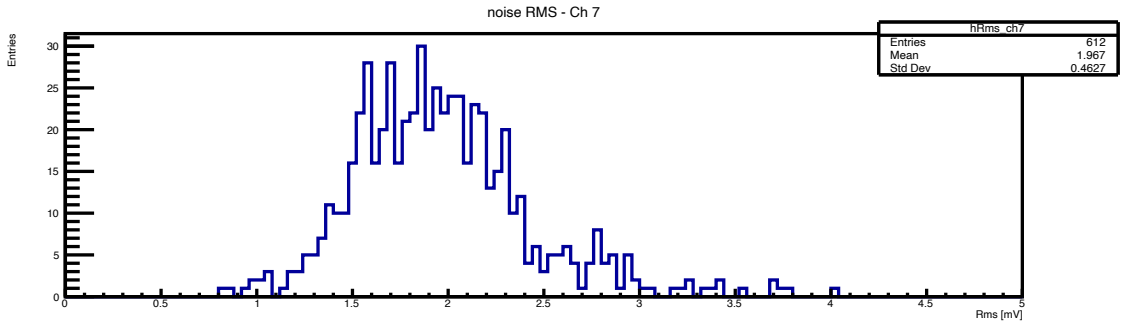
Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

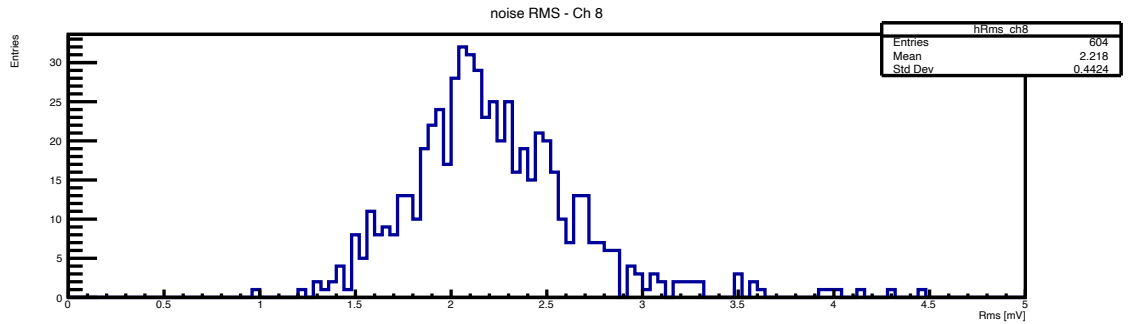
1 cm drift tubes

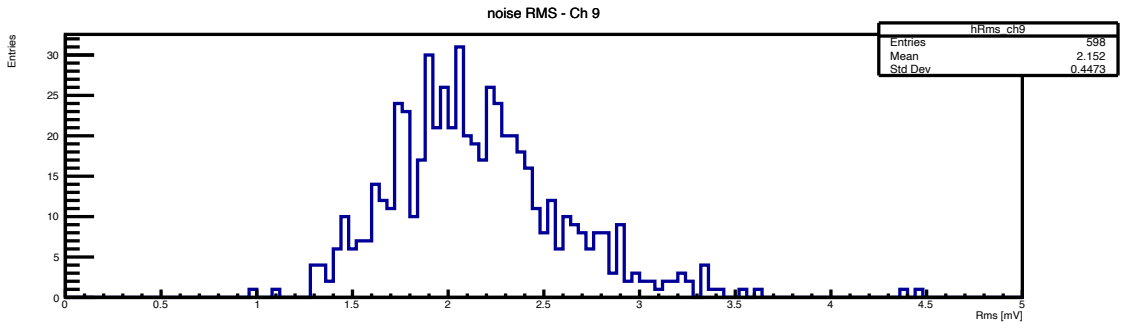








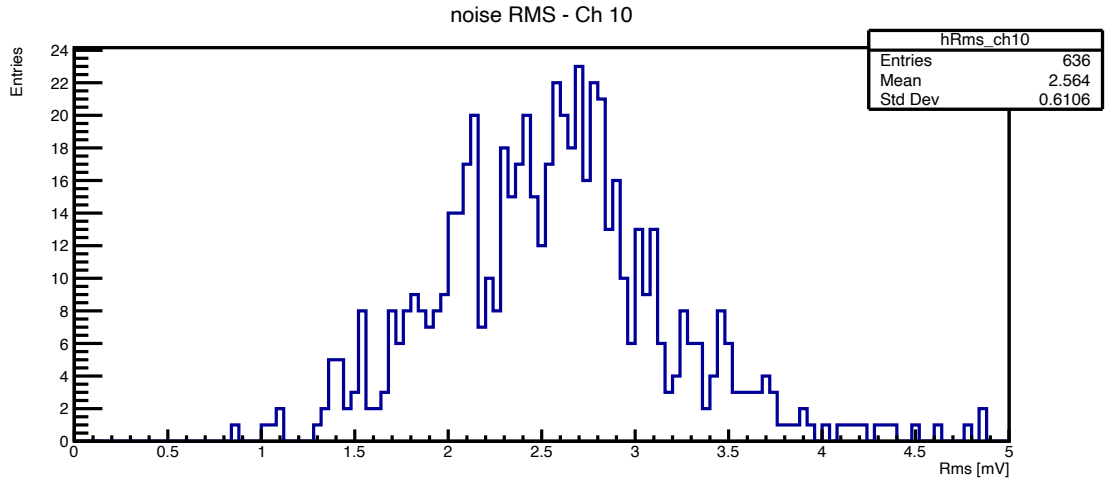


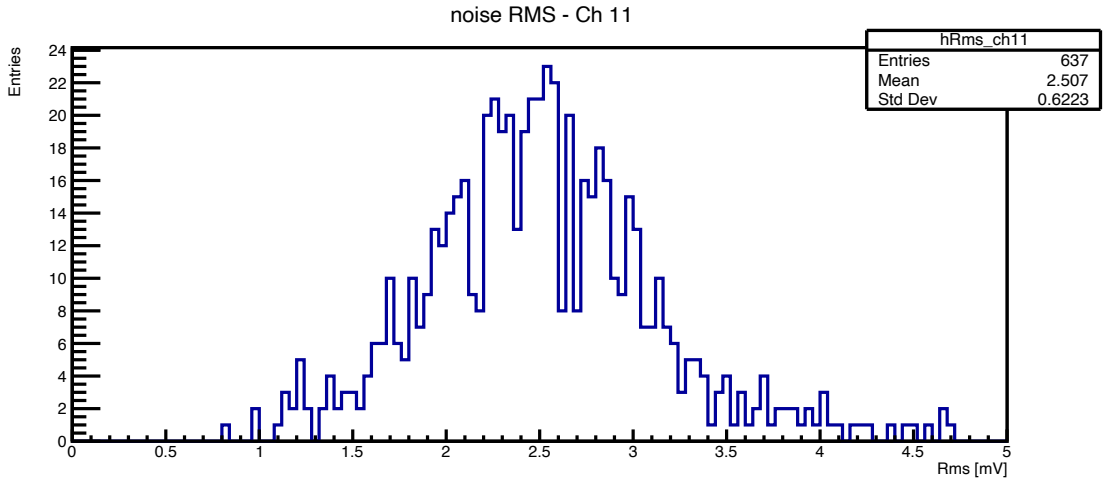


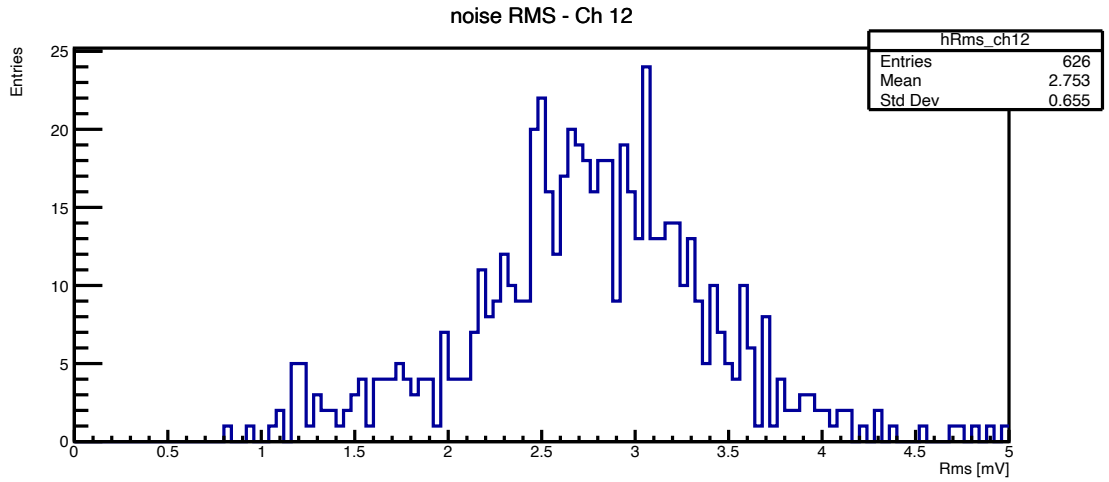
Rms for signal events

Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



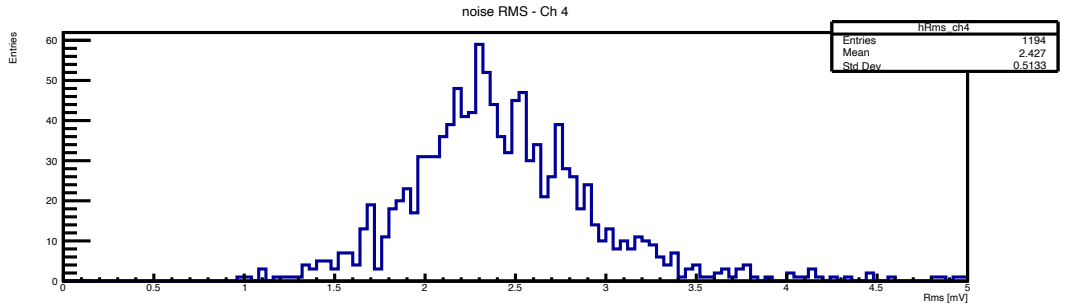


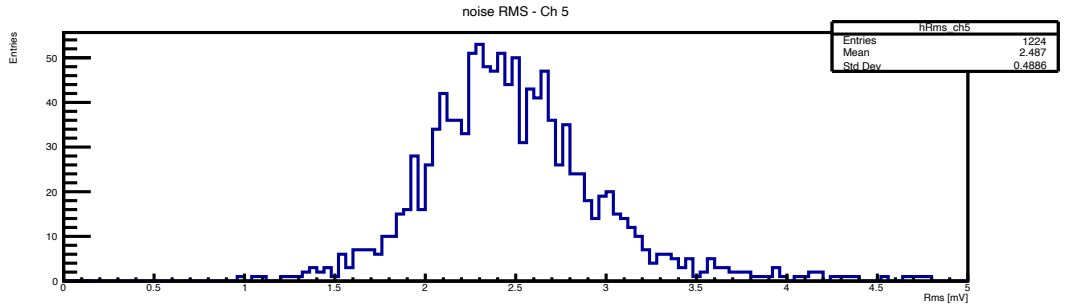


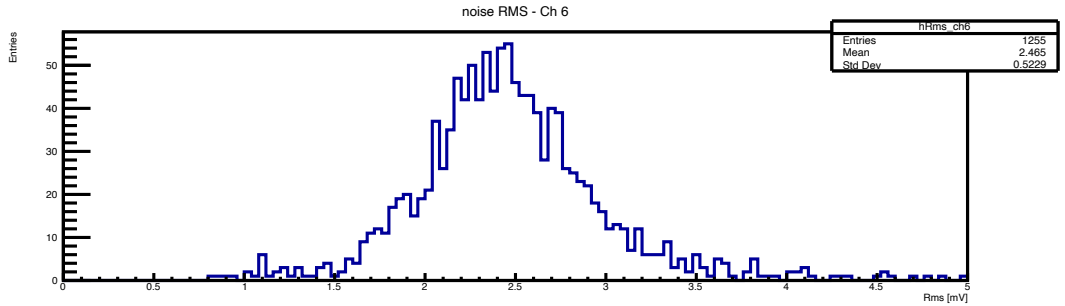
Rms for signal events

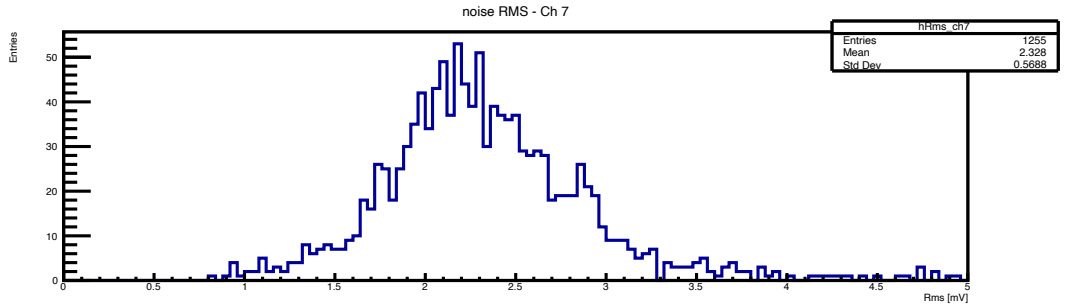
Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V

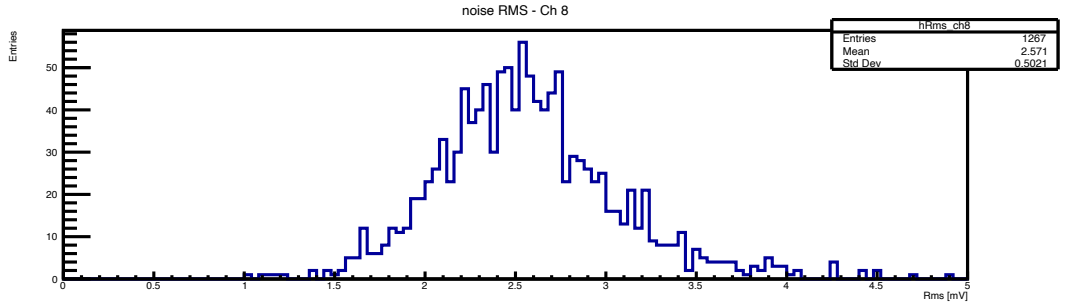
1 cm drift tubes

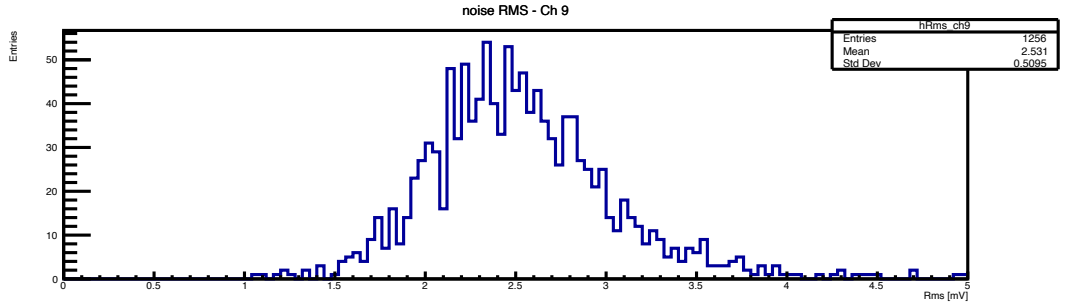








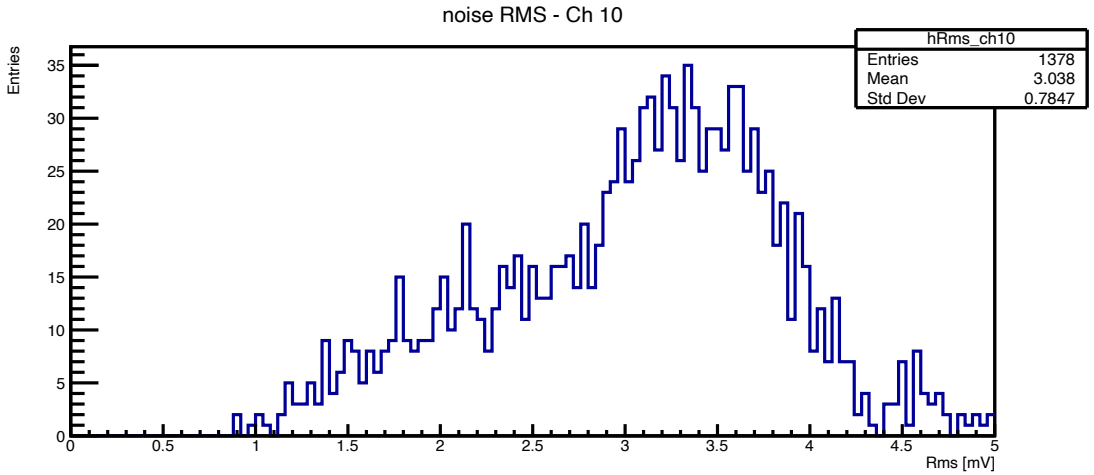


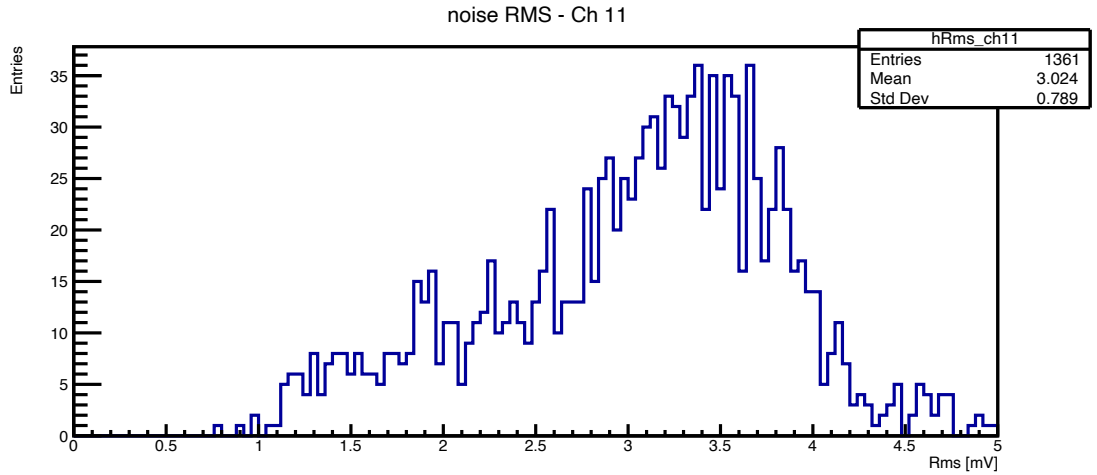


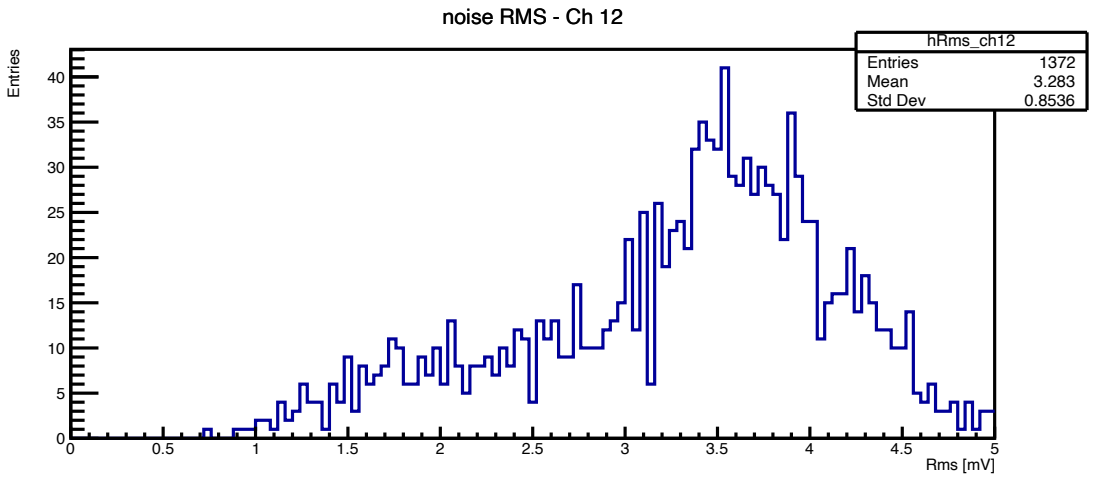
Rms for signal events

Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



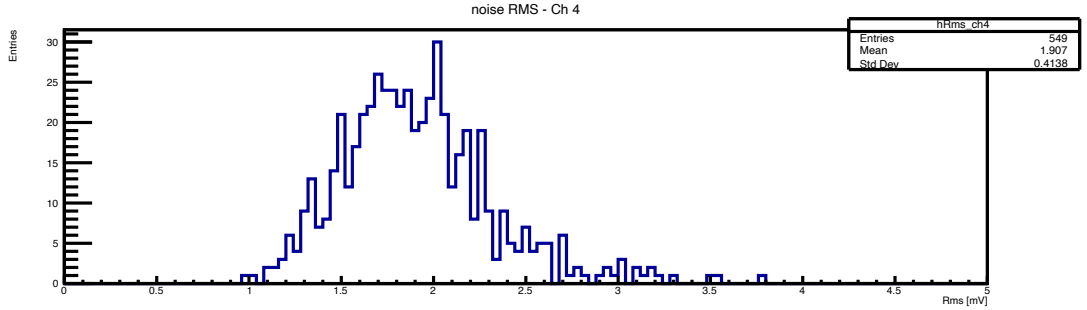


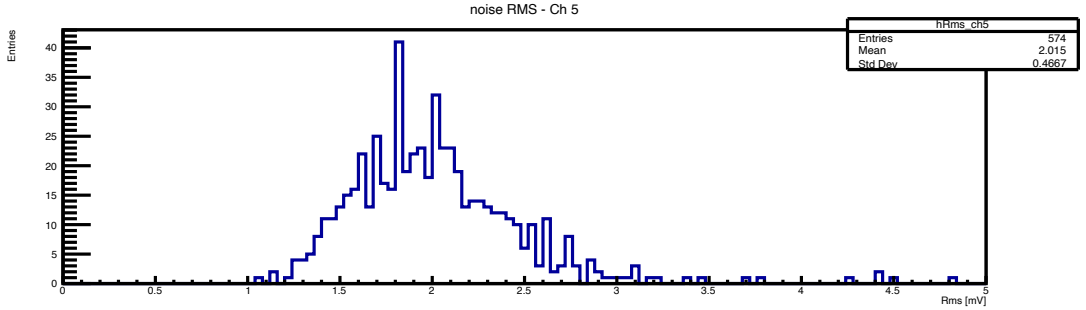


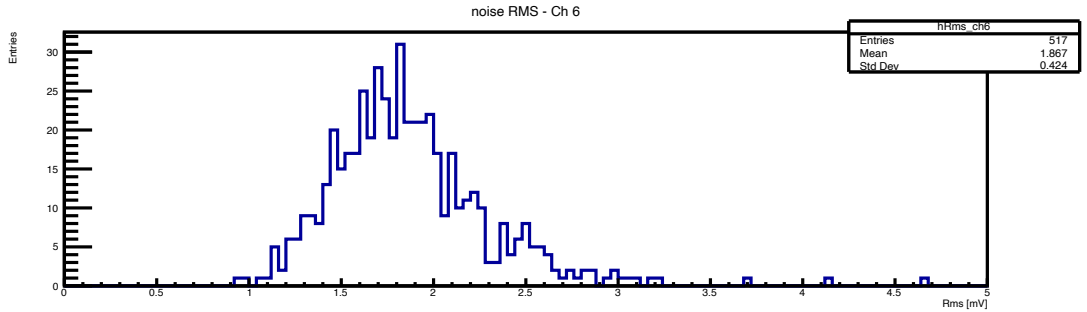
Rms for signal events

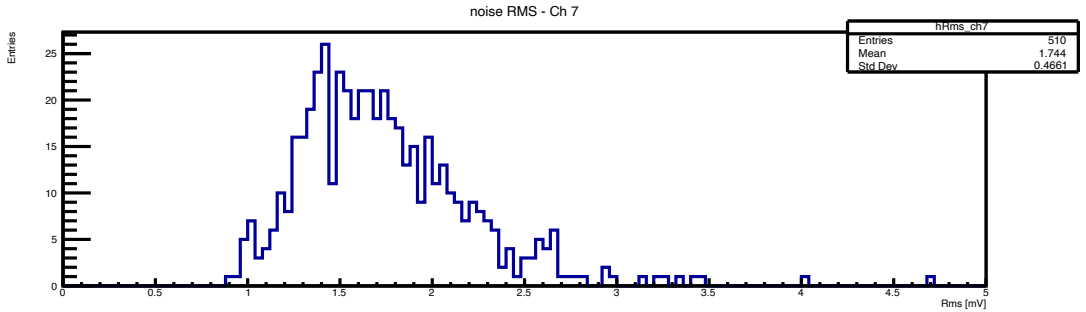
Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V

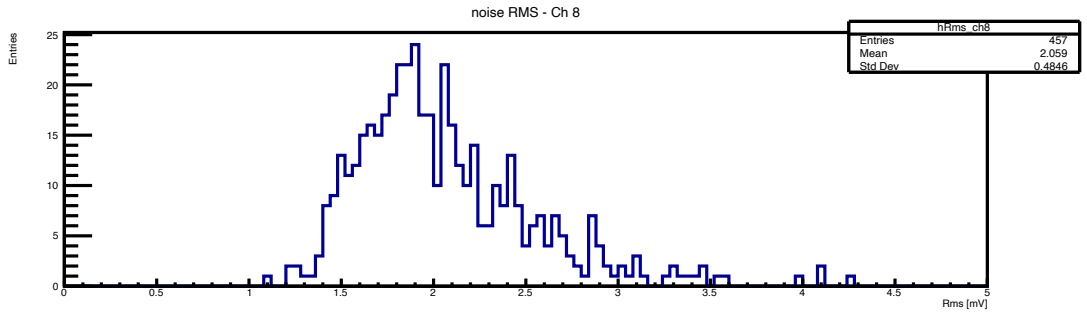
1 cm drift tubes

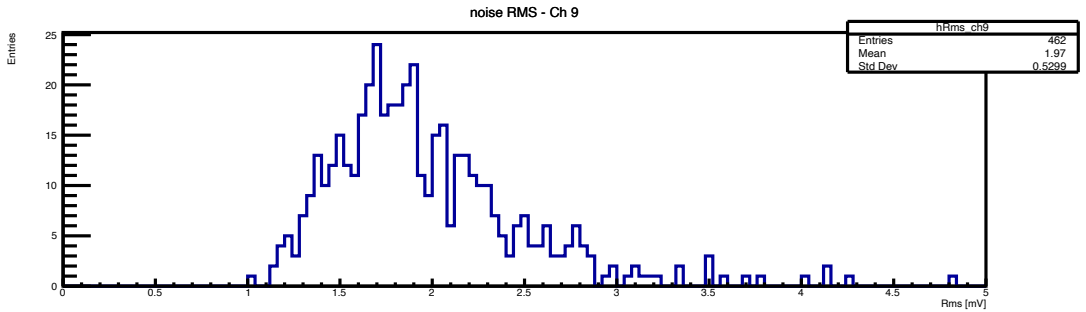








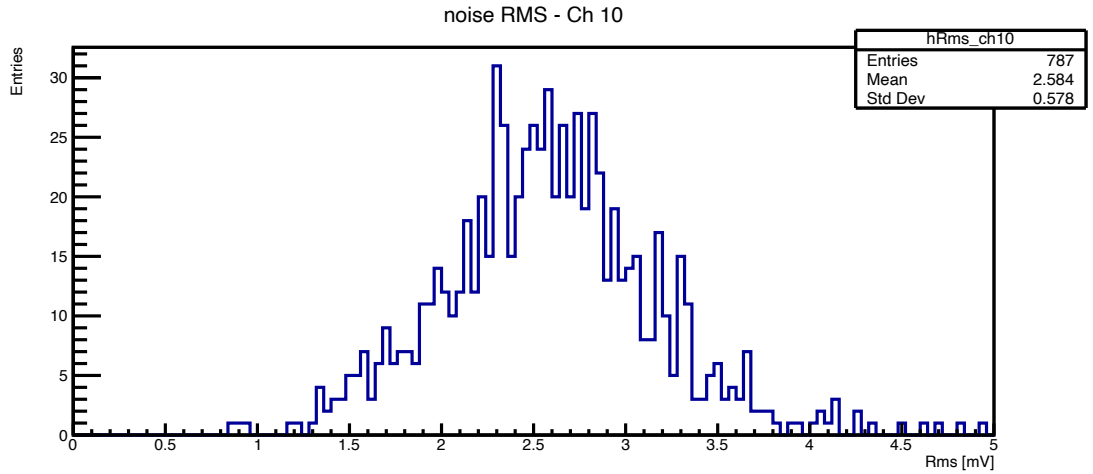


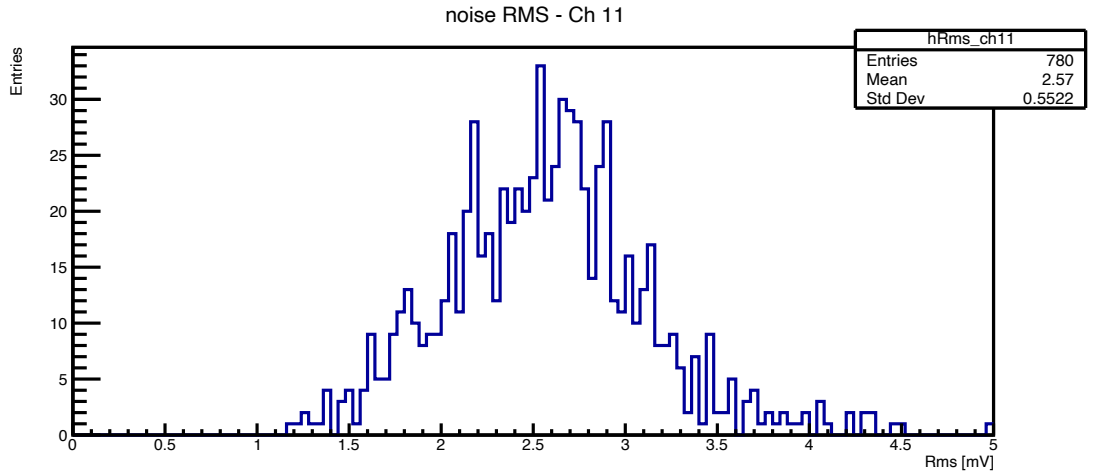


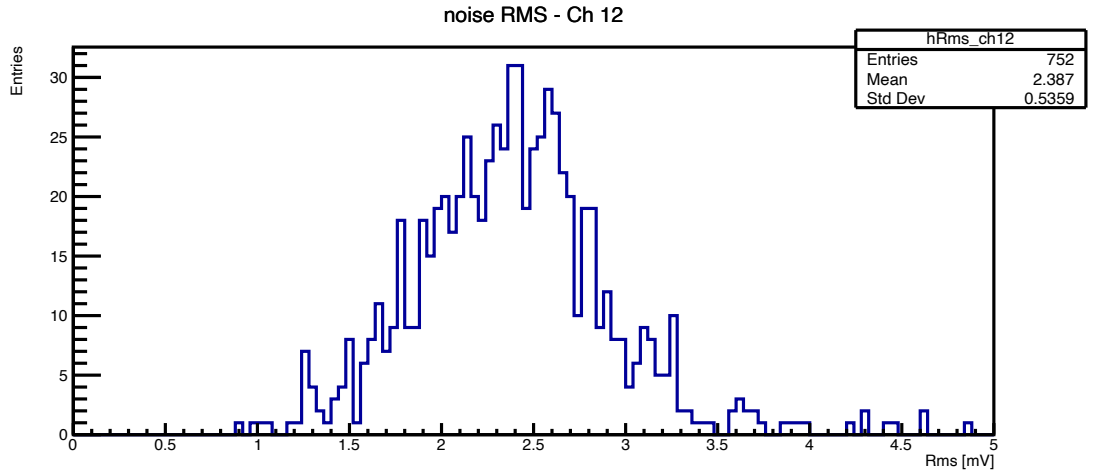
Rms for signal events

Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V

2 cm drift tubes







Expected number of Electron Peaks

Observable to be checked for understanding if we are going in the right direction with our FindPeak algorithm:

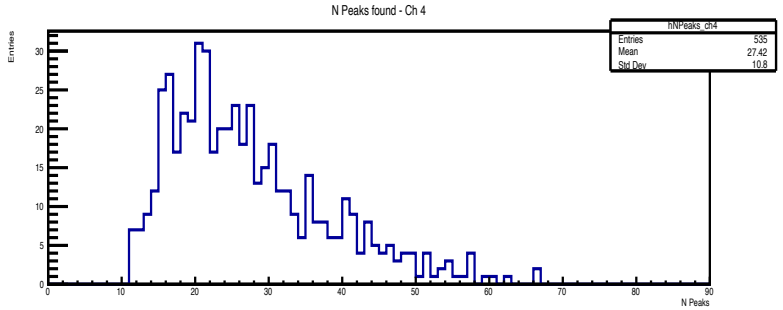
NPeak (Expected number of electron peaks) = δ cluster/cm (M.I.P.) *drift tube size [cm] *1.3 (relativistic rise)*1.6 electrons/cluster*1/cos(α)

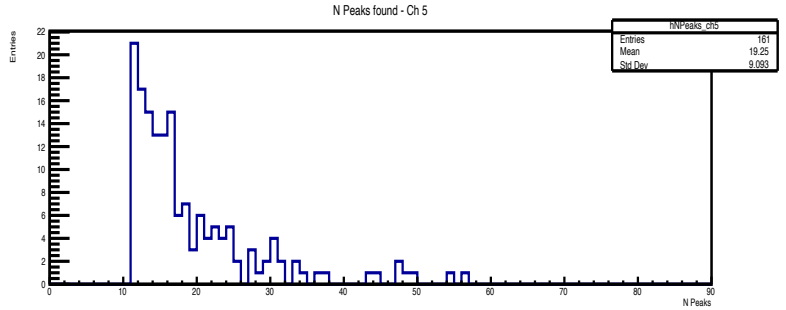
Where α corresponds to the angle of our muon track w.r.t. drift tube direction

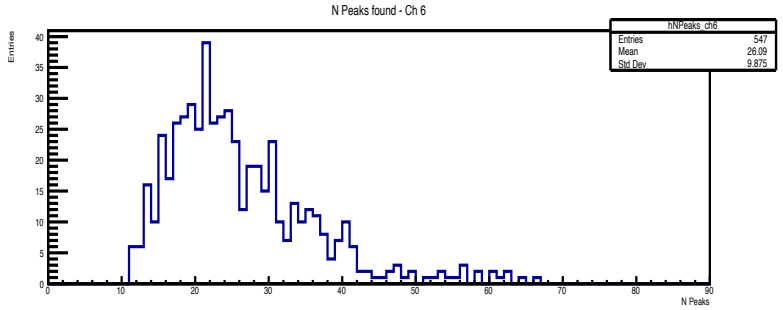
Npeak distribution for signal events

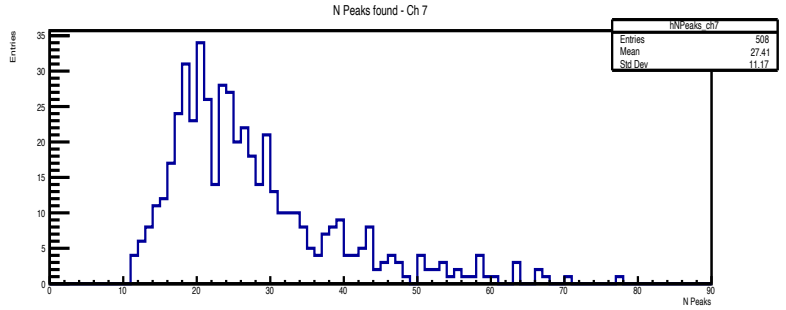
Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

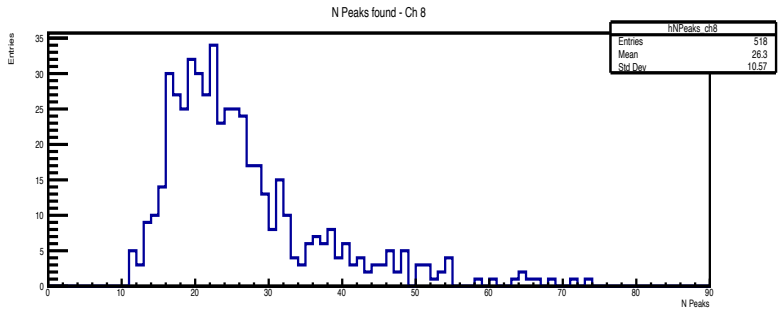
1 cm drift tubes

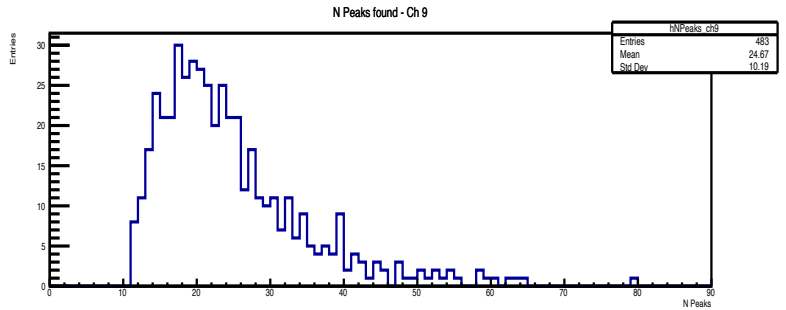


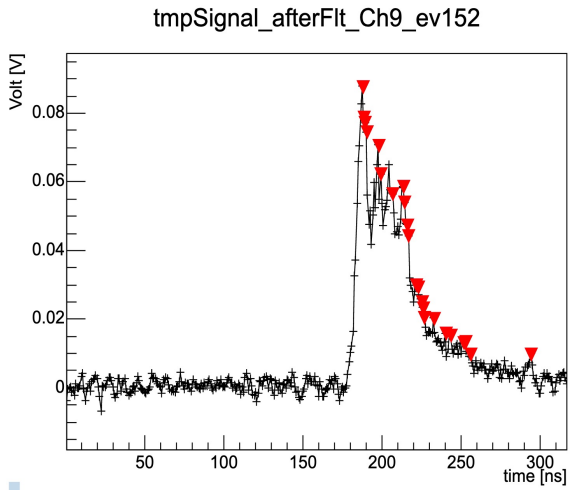












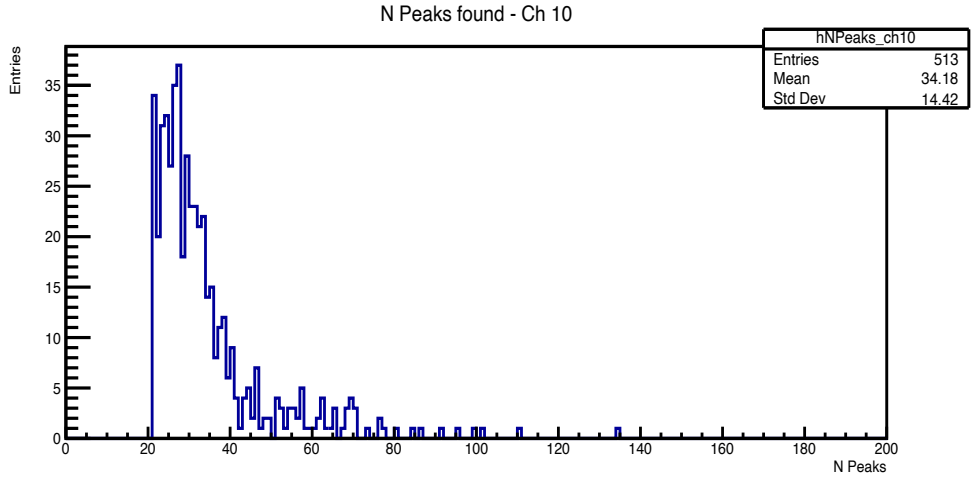
21 peaks found

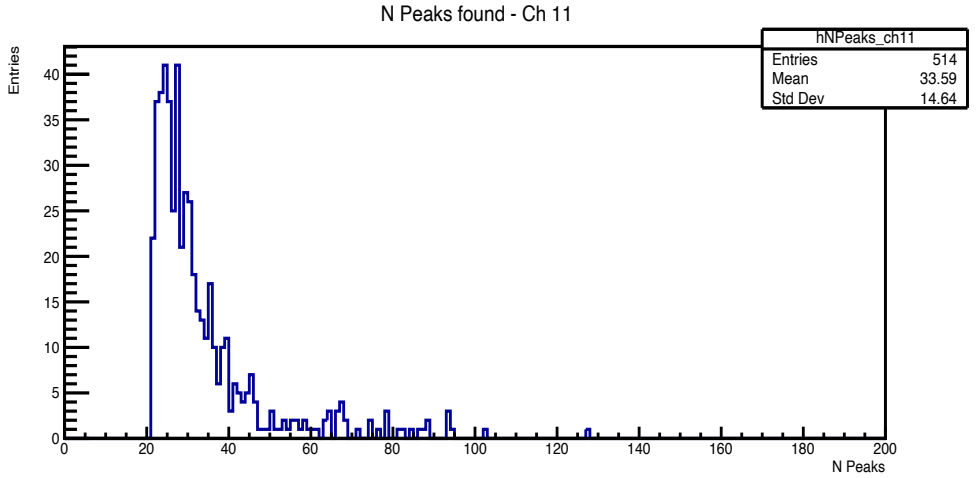
Gas(90He/10),drift tube 1 cm,angle 0° = 12/cm * 0,8 cm * 1,3 * 1,6 = 20 electron peaks

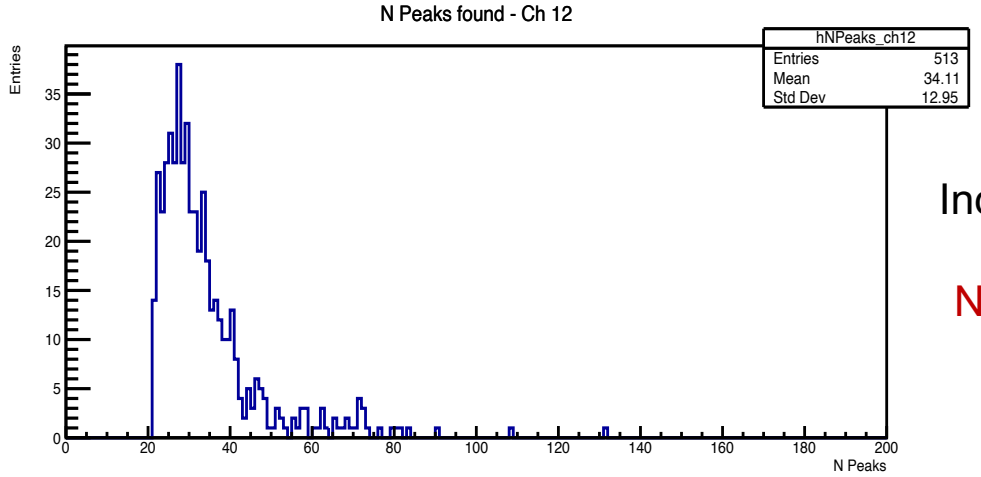
Npeak distribution for signal events

Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes

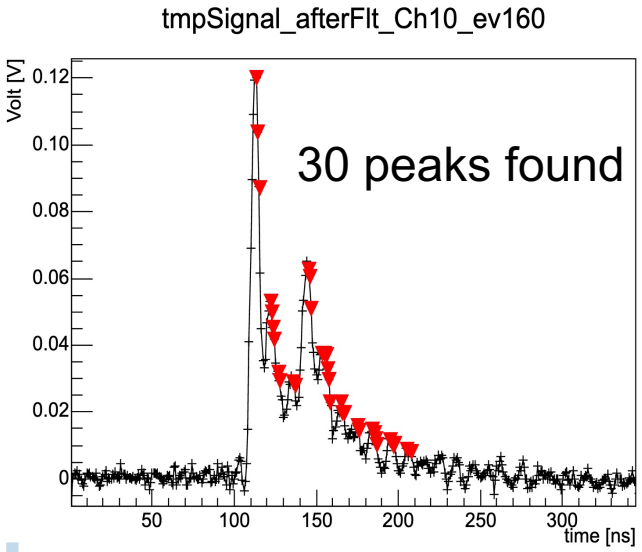






Independent channels show almost the same results!

NOTE: charge space problems at low alpha angles

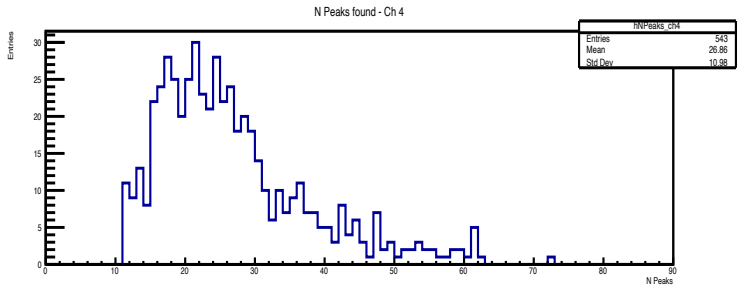


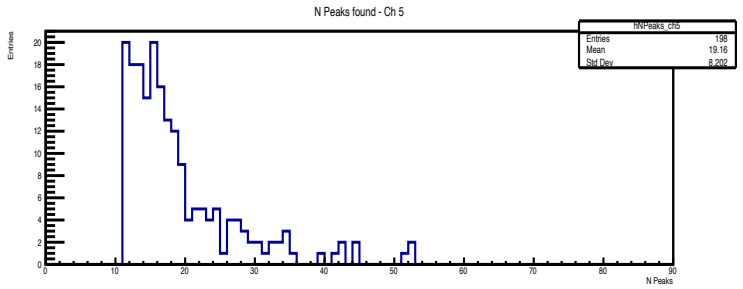
Gas(90He/10),drift tube 2 cm,angle 0° = 12/cm * 1,8 cm * 1,3 * 1,6 = 45 electron peaks

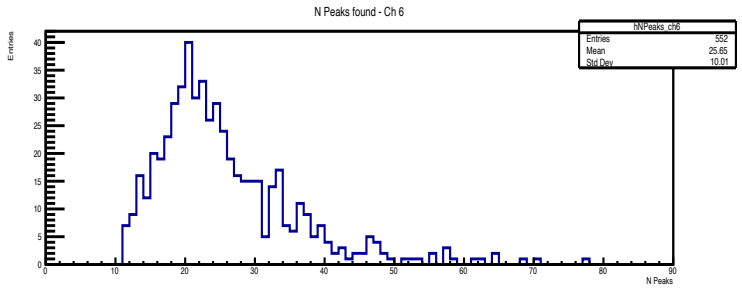
Npeak distribution for signal events

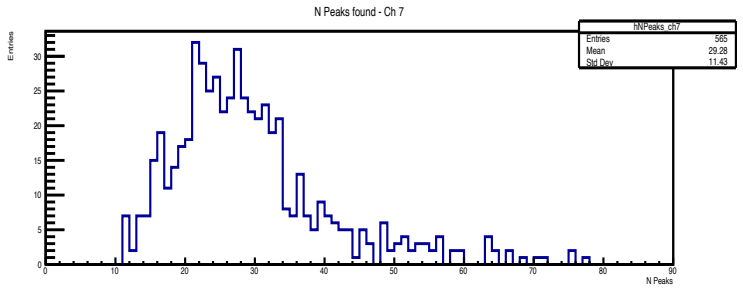
Run: run_98.root; Track angle: 15° ; Gas mixture: 90%He ; HV = +20V

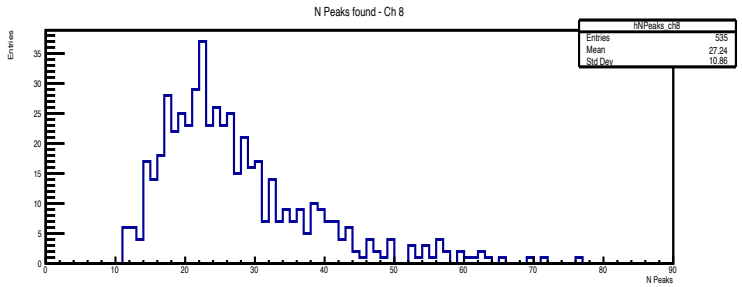
1 cm drift tubes

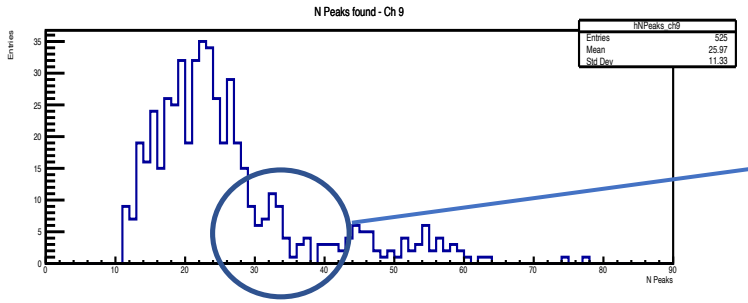


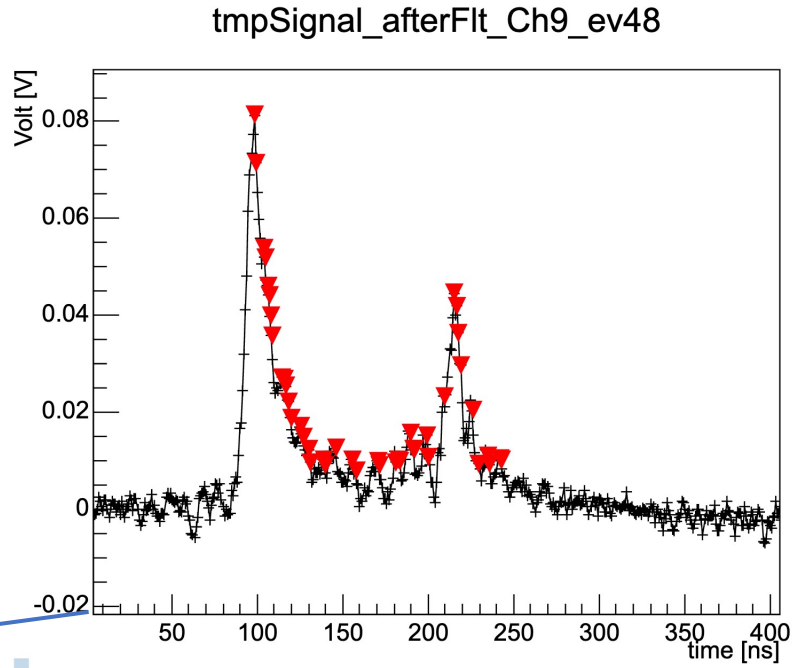










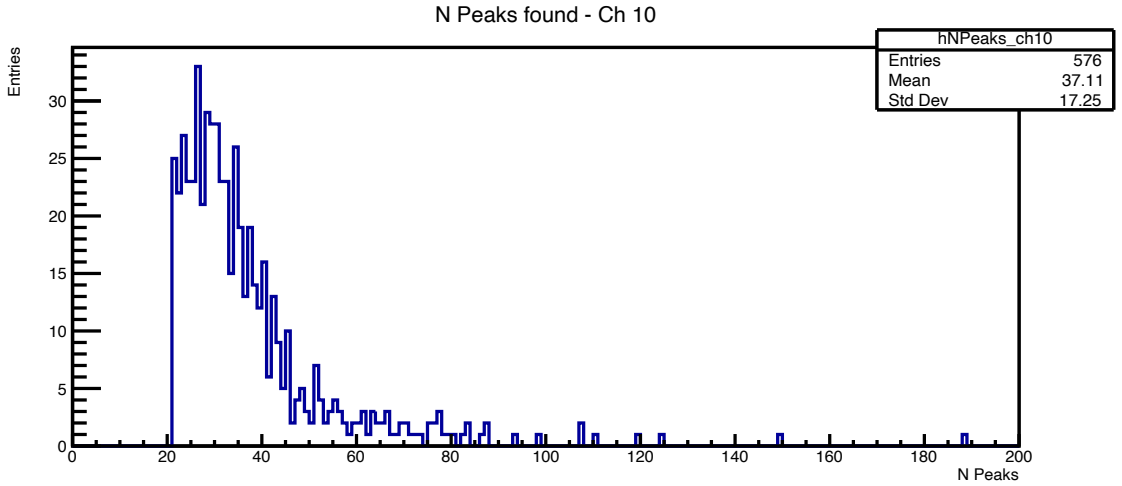


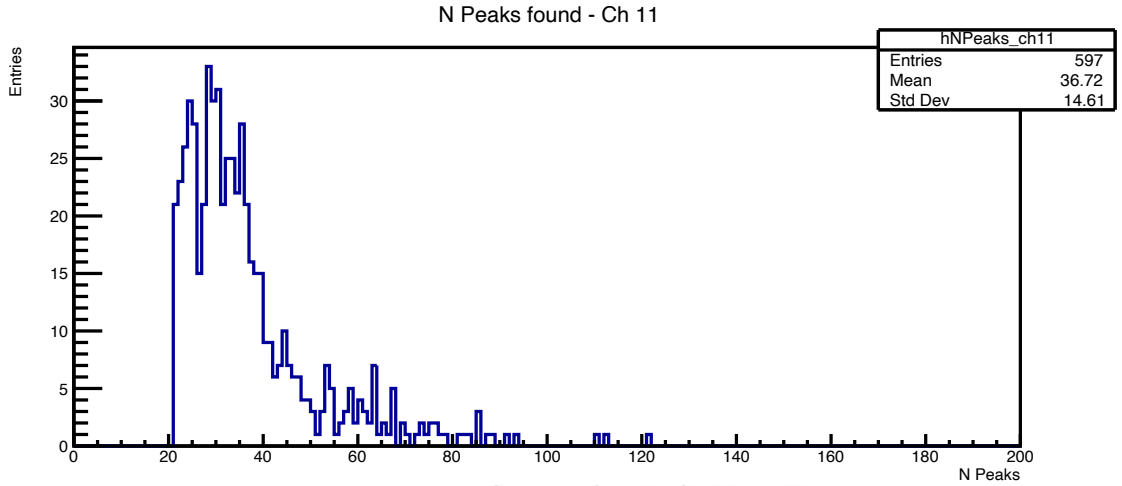
Gas(90He/10),drift tube 1 cm,angle 15° = 12/cm * 0,8 cm * 1,3 * 1,6 *1,035= 21 electron peaks

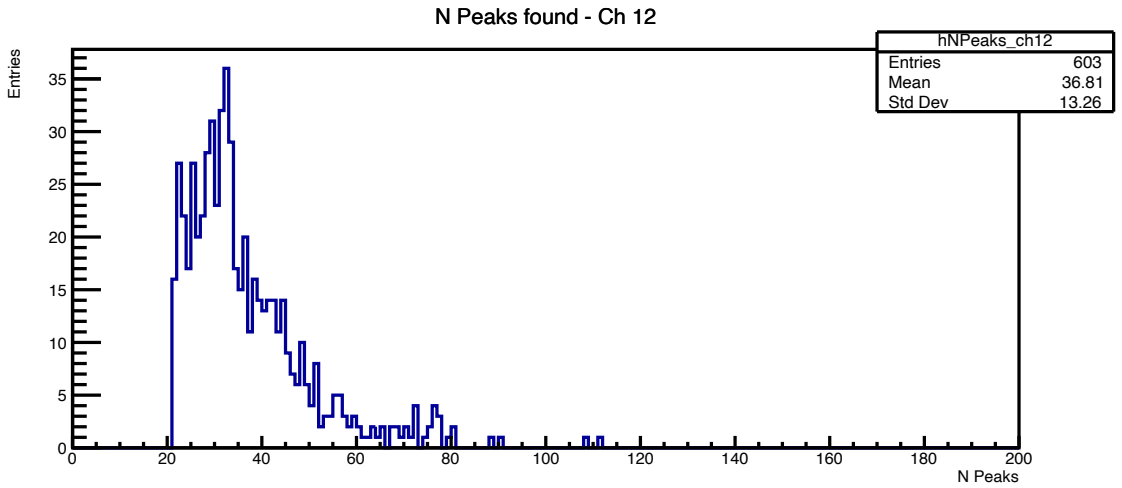
Npeak distribution for signal events

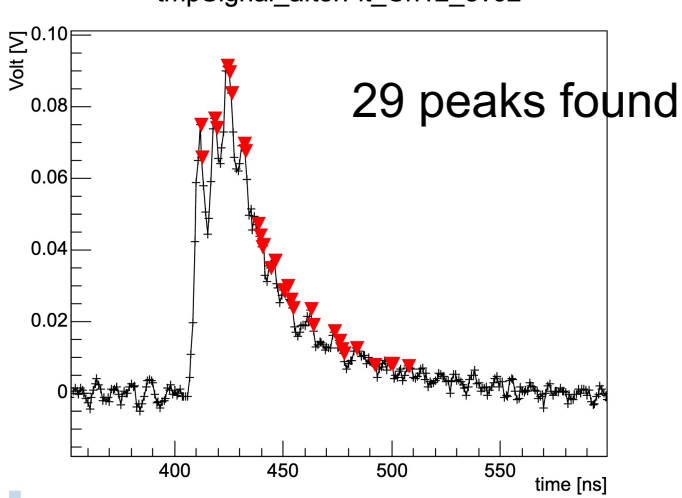
Run: run_98.root; Track angle: 15° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes







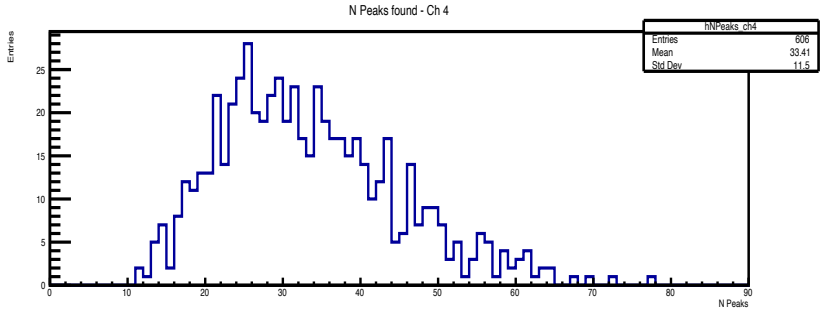


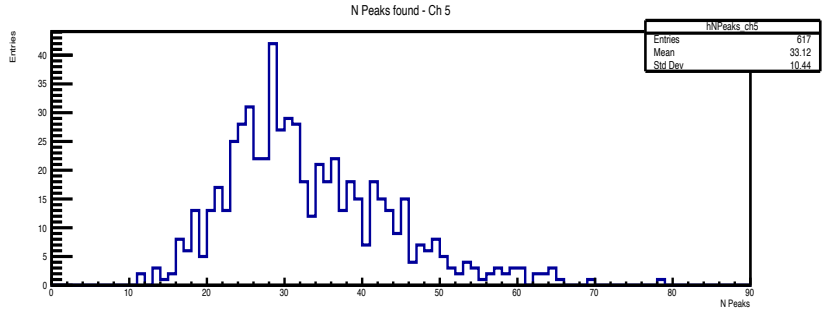
Gas(90He/10),drift tube 2 cm,angle 15° = 12/cm * 1,8 cm * 1,3 * 1,6 *1,035 = 47 electron peaks

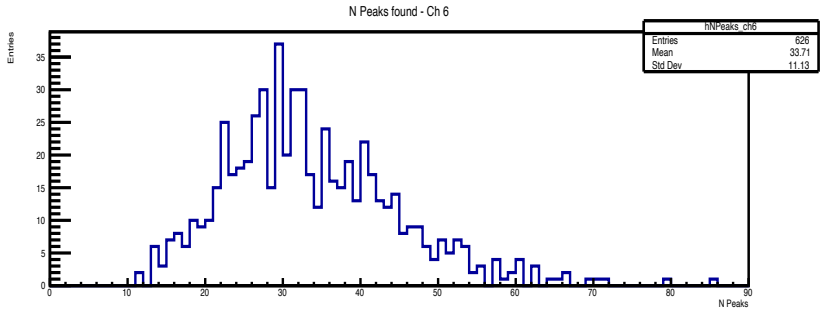
Npeak distribution for signal events

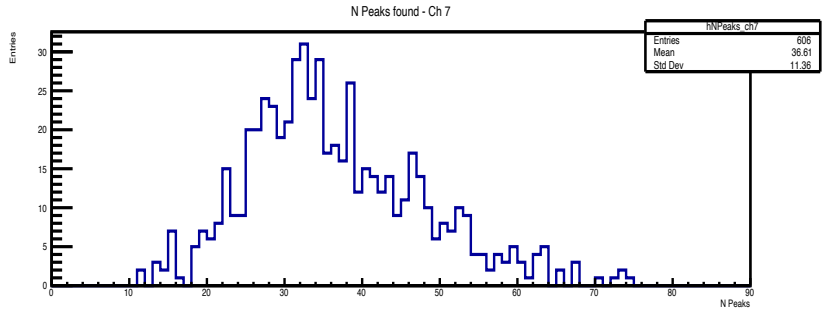
Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

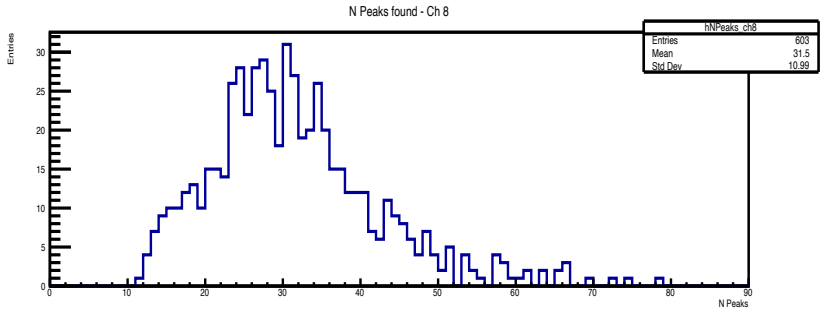
1 cm drift tubes

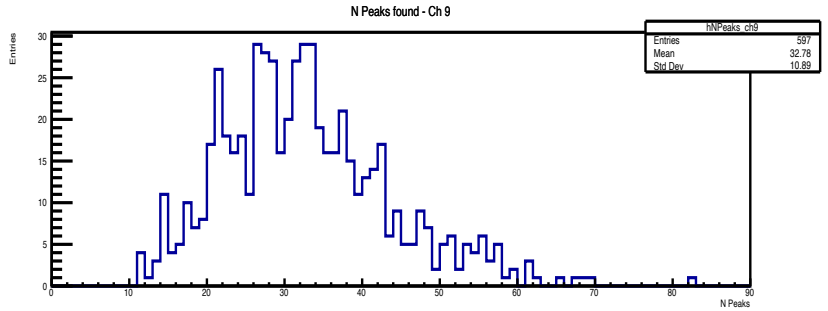


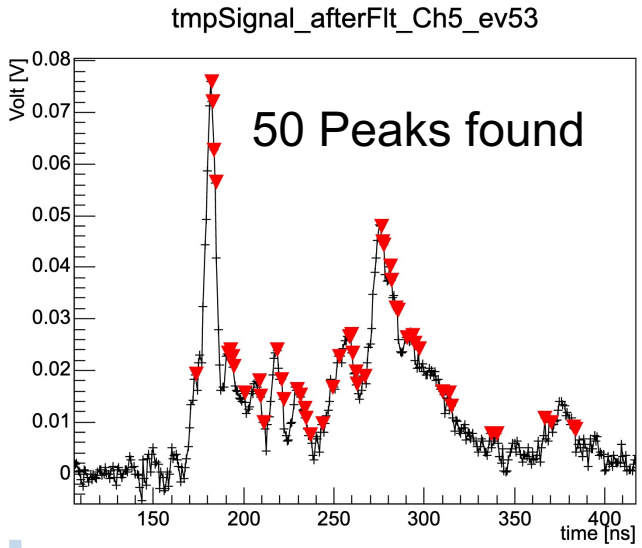










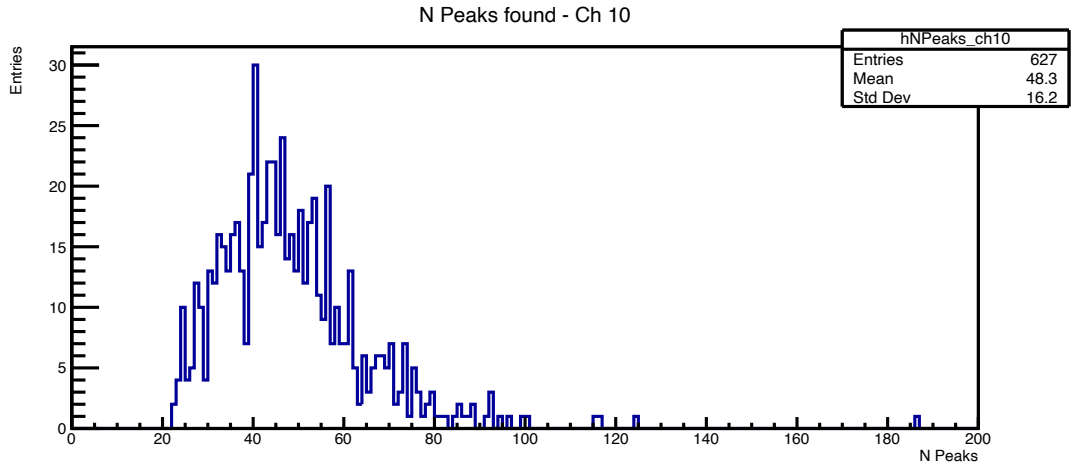


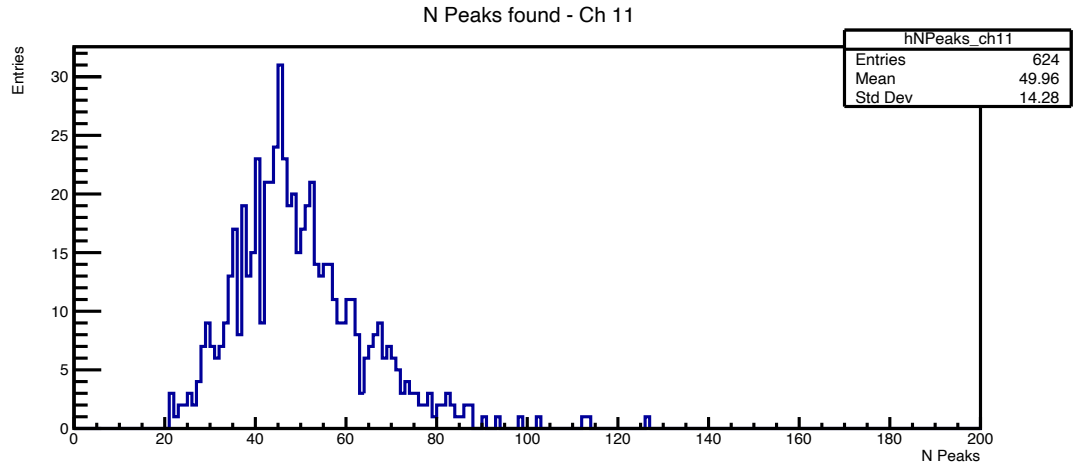
Gas(90He/10),drift tube 1 cm,angle 45° = 12/cm * 0,8 cm * 1,3 * 1,6 *1,15= 23 electron peaks

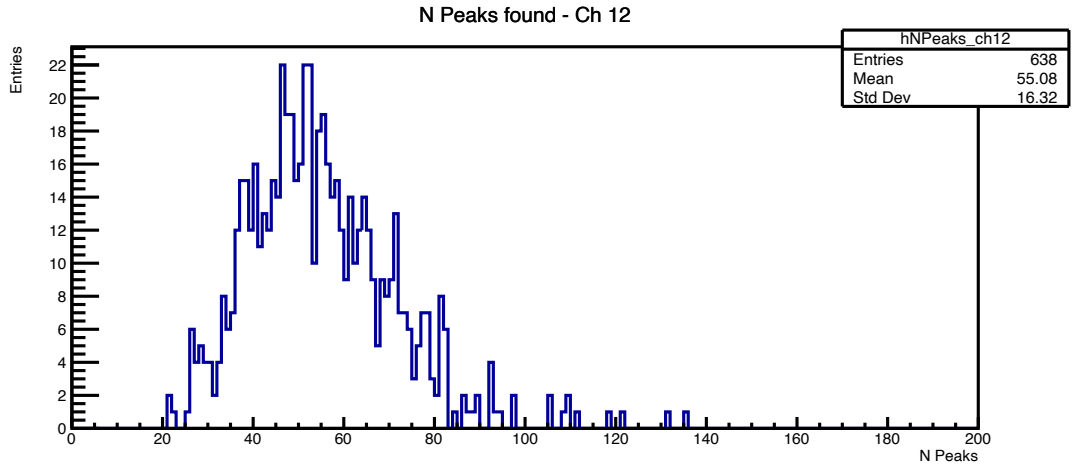
Npeak distribution for signal events

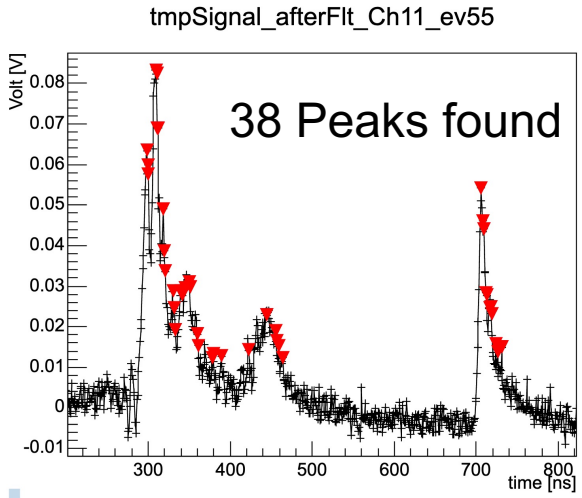
Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes







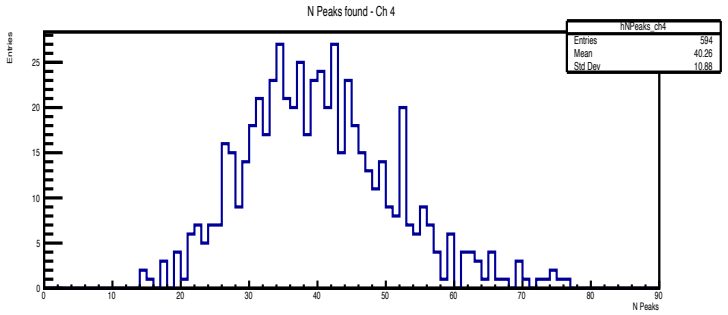


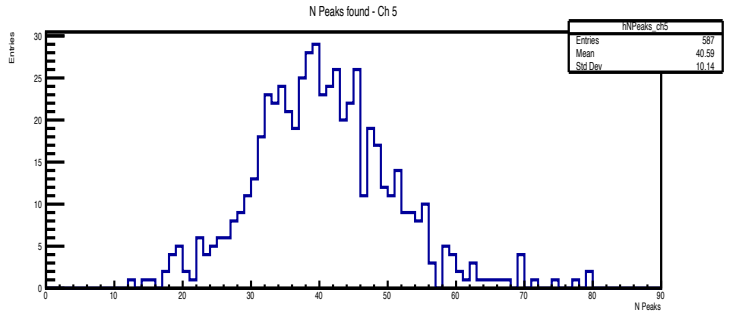
Gas(90He/10),drift tube 2 cm,angle 15° = 12/cm * 1,8 cm * 1,3 * 1,6 *1,15 = 52 electron peaks

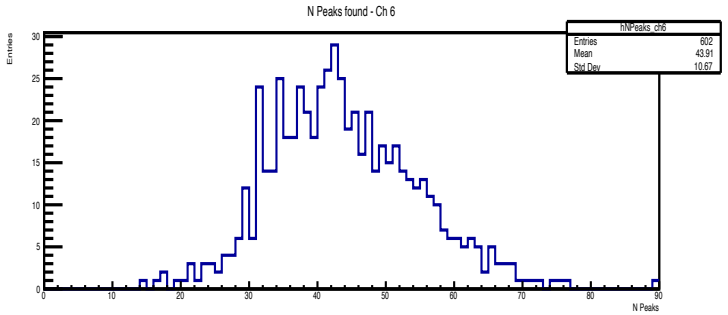
Npeak distribution for signal events

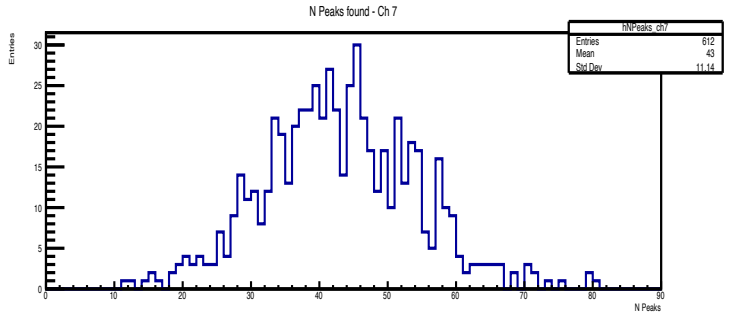
Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

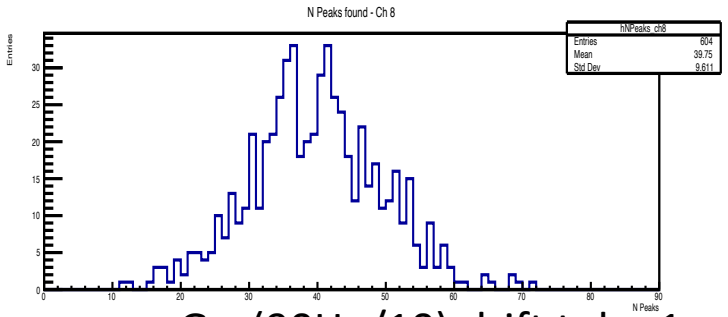
1 cm drift tubes

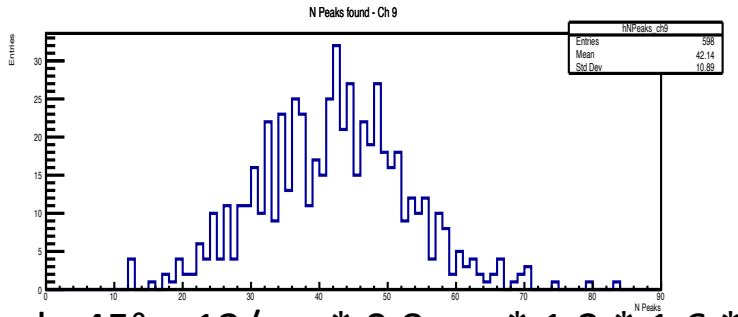


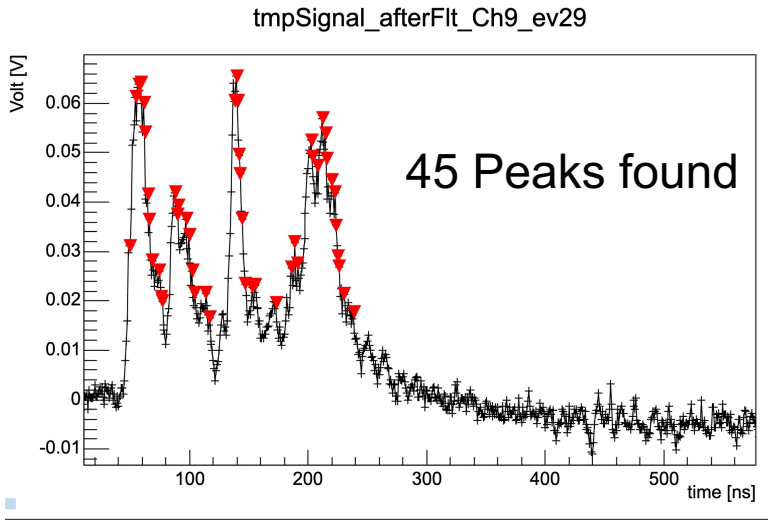










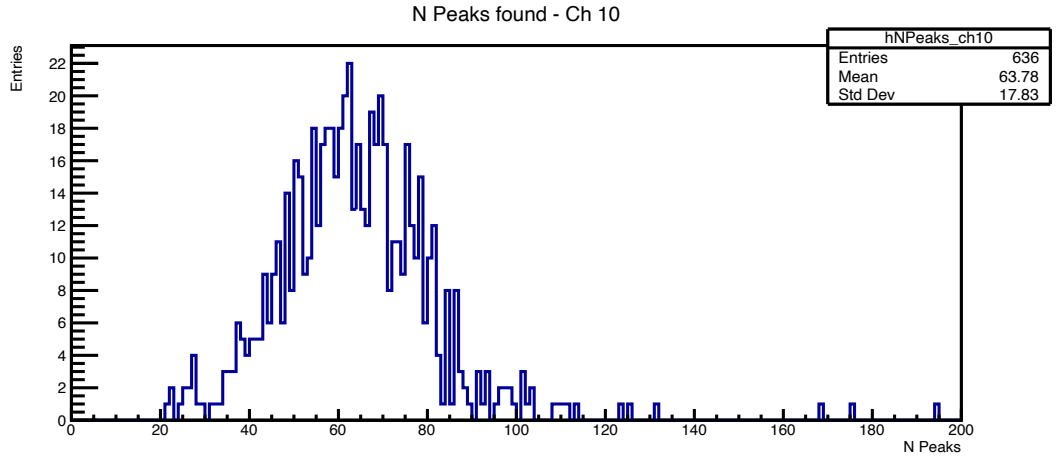


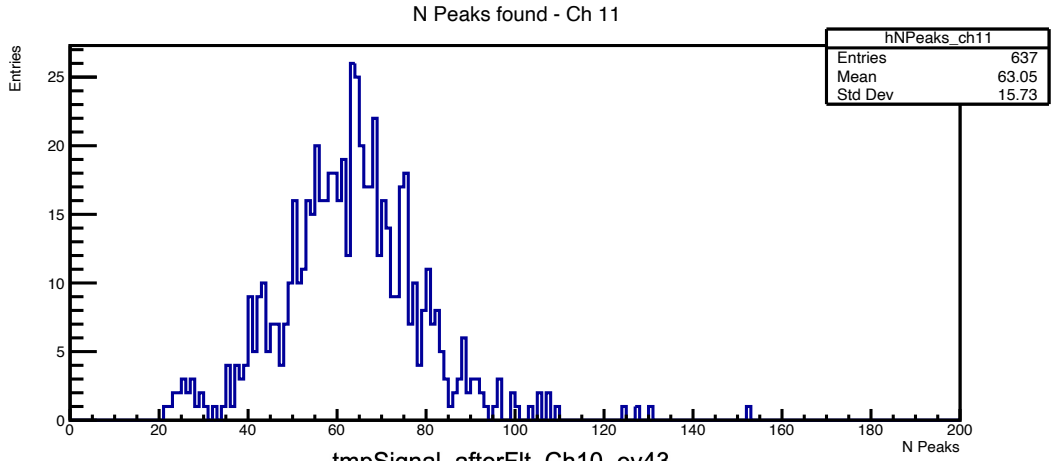
Gas(90He/10),drift tube 1 cm,angle 45° = 12/cm * 0,8 cm * 1,3 * 1,6 *1,414= 28 electron peaks

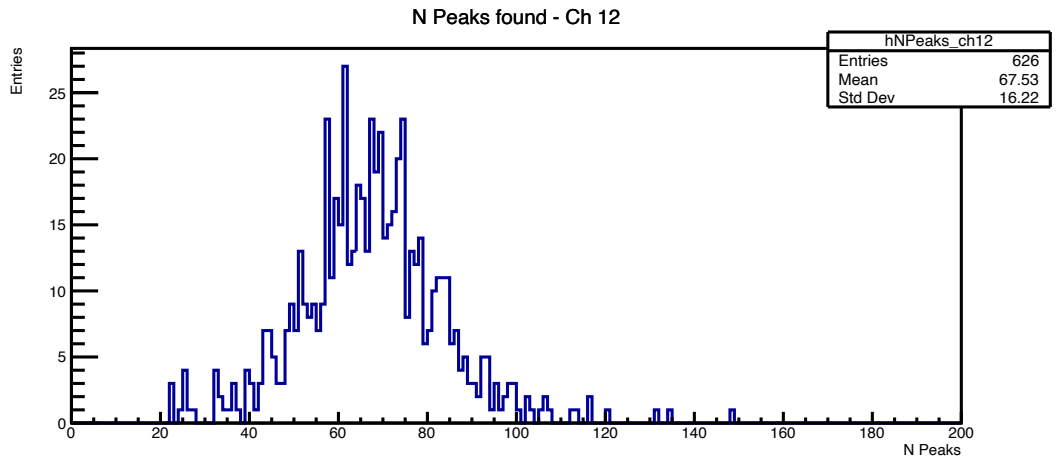
Npeak distribution for signal events

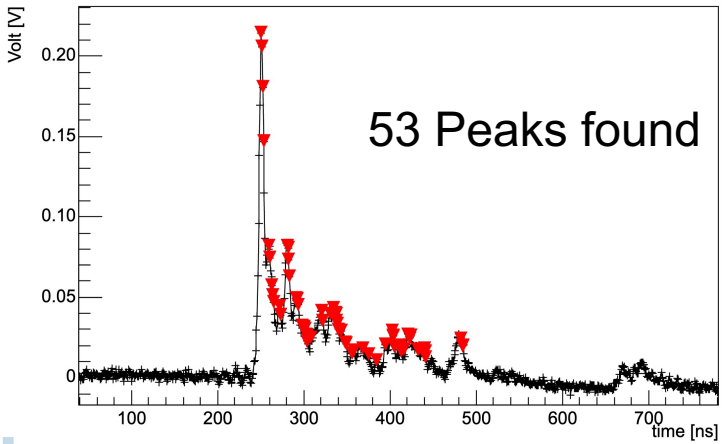
Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes







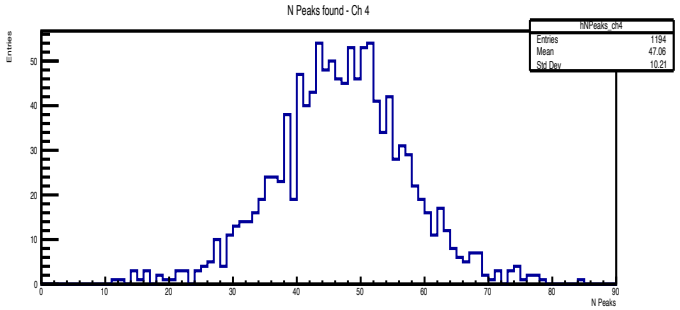


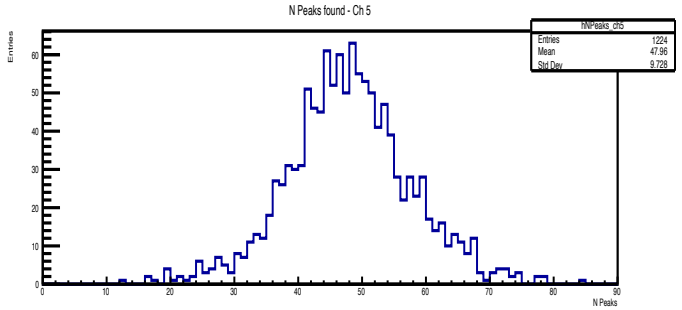
Gas(90He/10),drift tube 2 cm,angle 45° = 12/cm * 1,8 cm * 1,3 * 1,6 *1,414 = 63 electron peaks

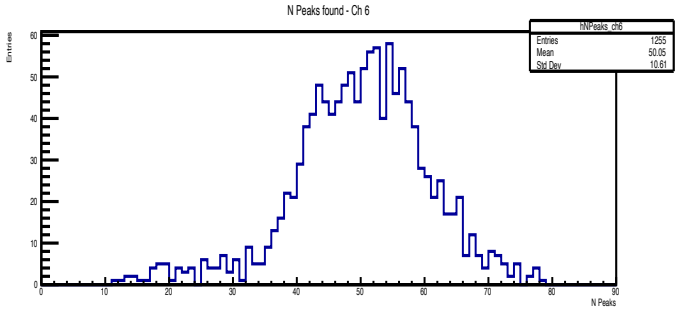
Npeak distribution for signal events

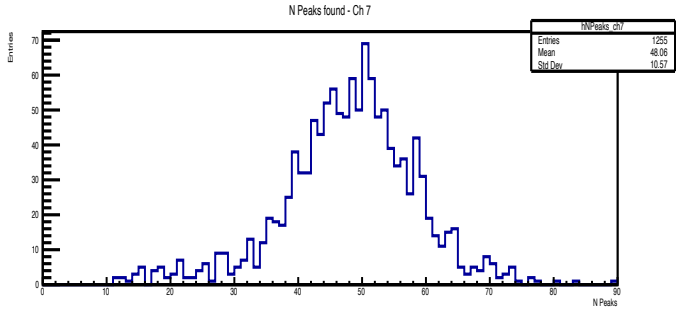
Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V

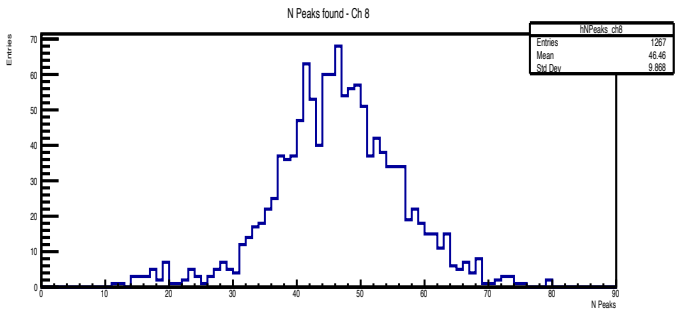
1 cm drift tubes

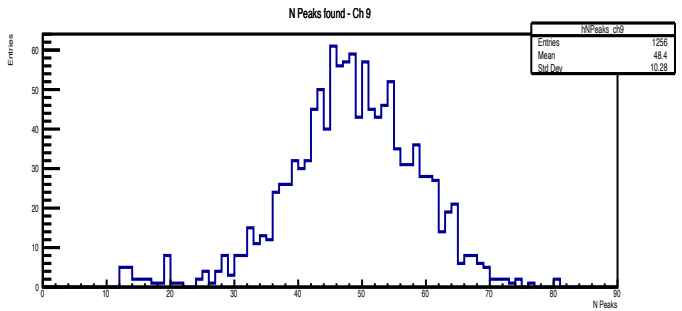


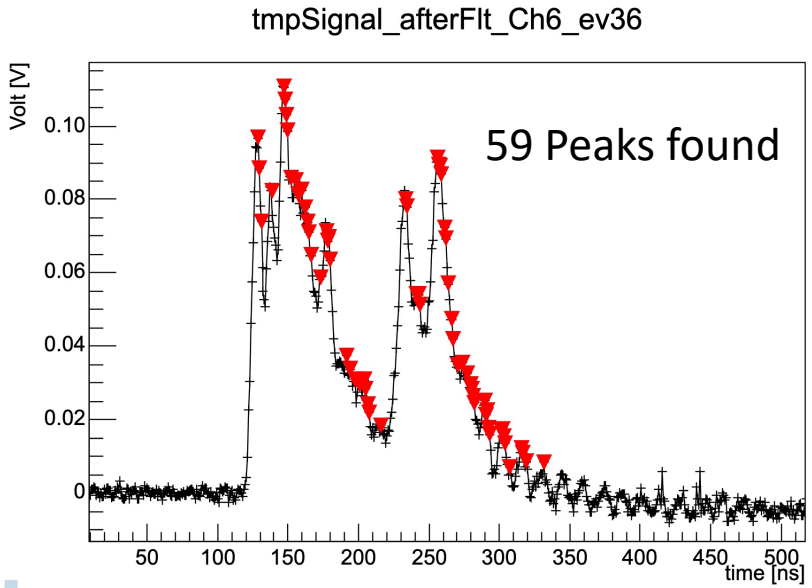










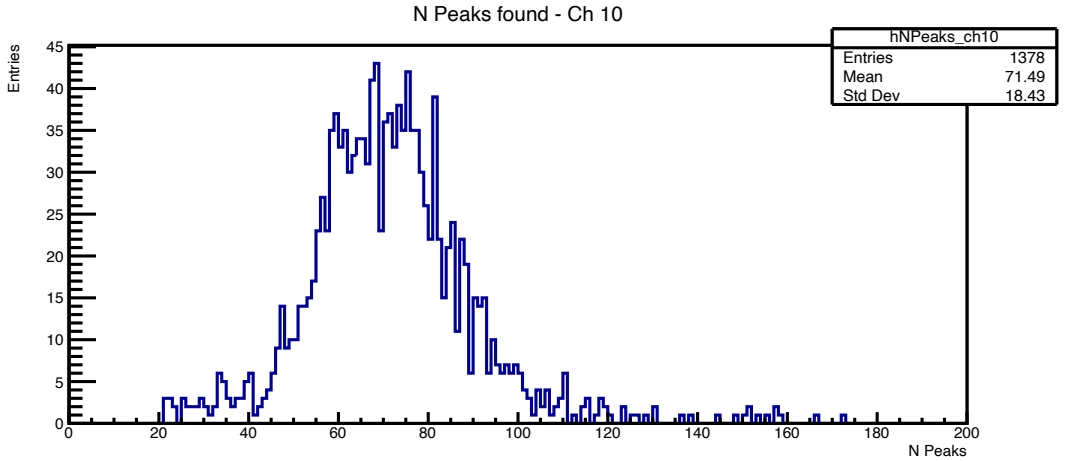


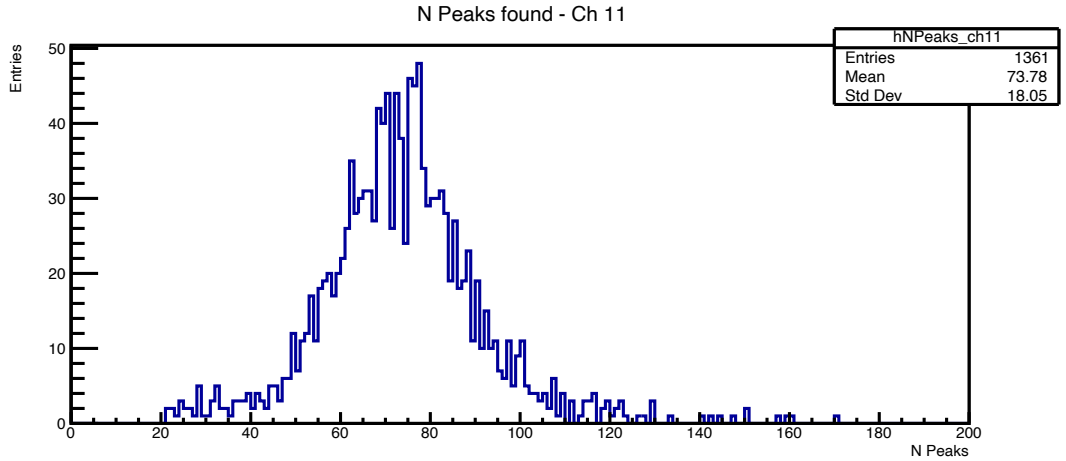
Gas(90He/10),drift tube 1 cm,angle 60° = 12/cm * 0,8 cm * 1,3 * 1,6 *2= 40 electron peaks

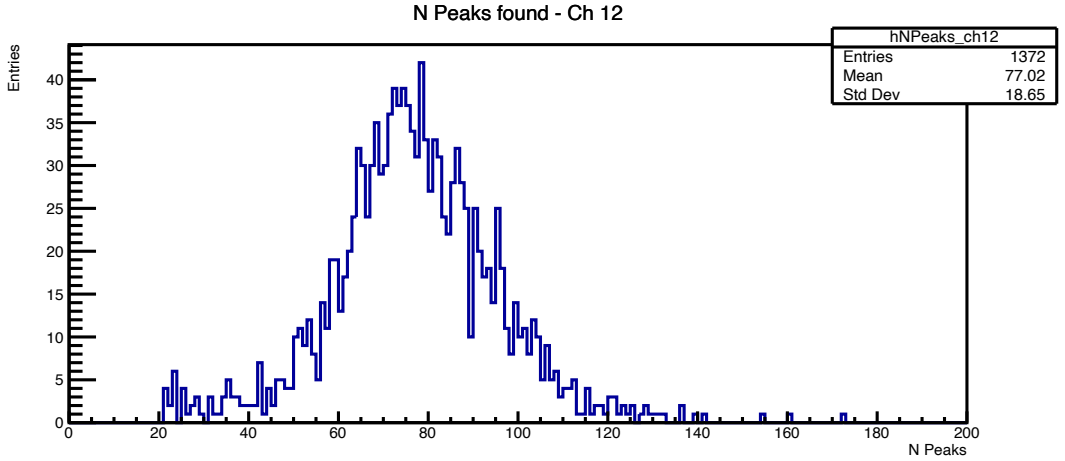
Npeak distribution for signal events

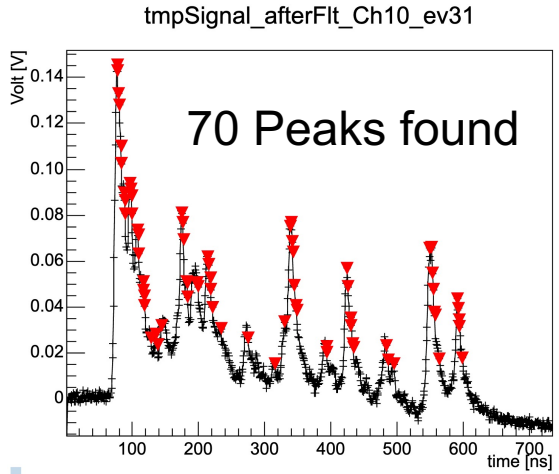
Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes





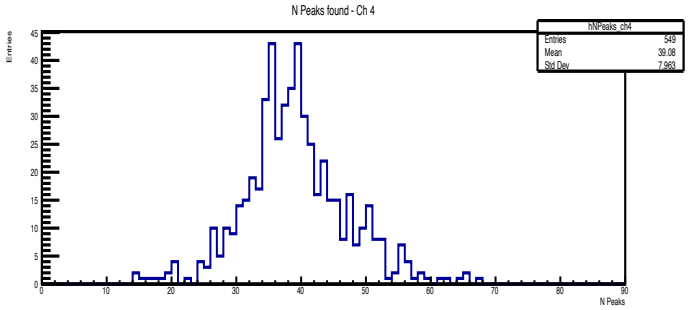


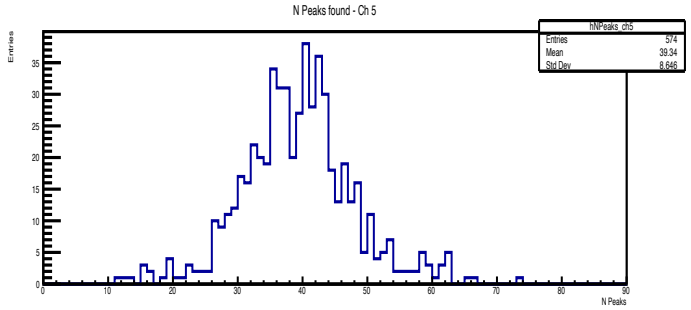


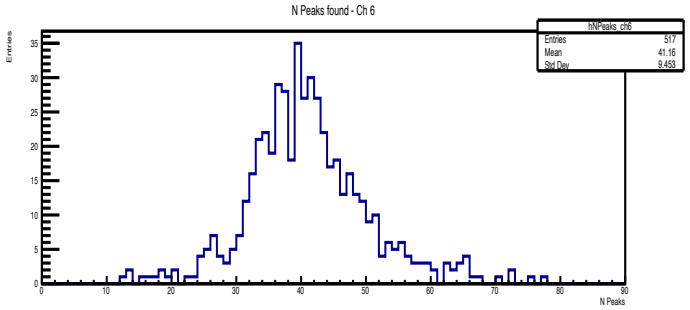
Gas(90He/10),drift tube 2 cm,angle 60° = 12/cm * 1,8 cm * 1,3 * 1,6 *2= 90 electron peaks

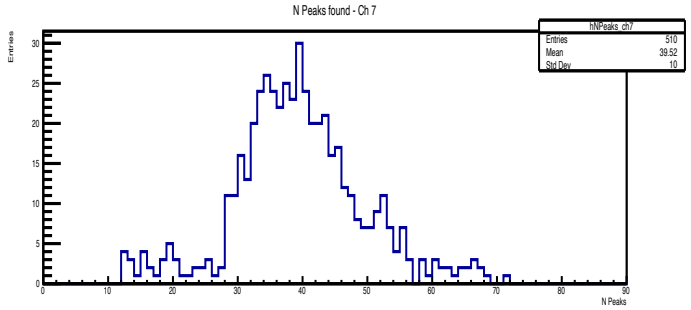
Npeak distribution for signal events

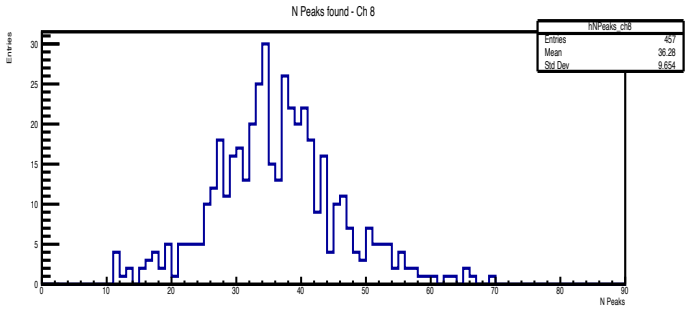
Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V 1 cm drift tubes

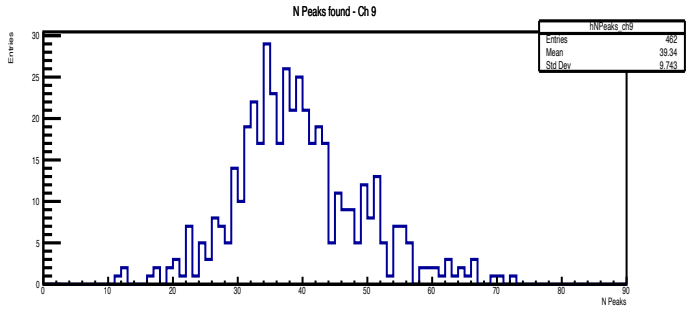


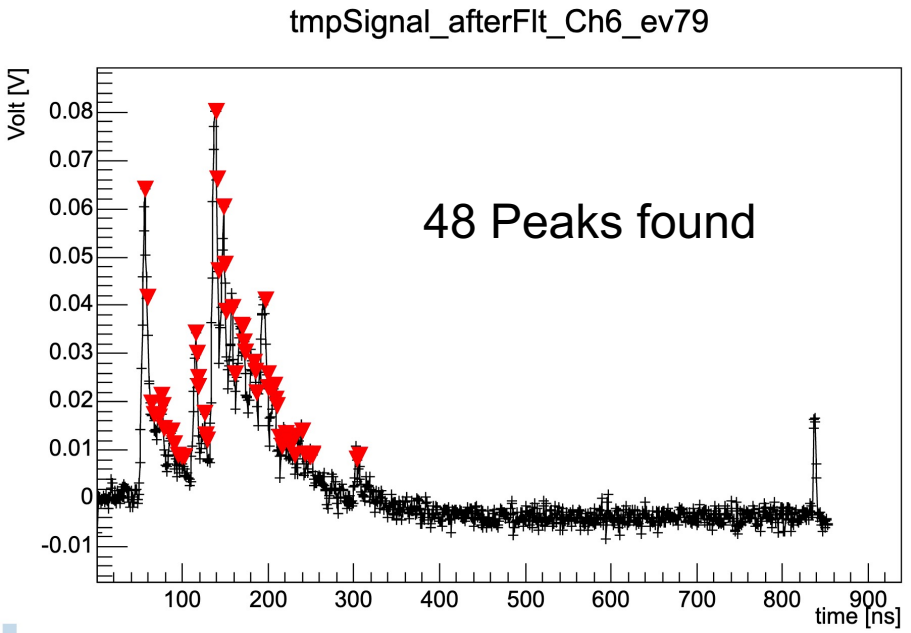








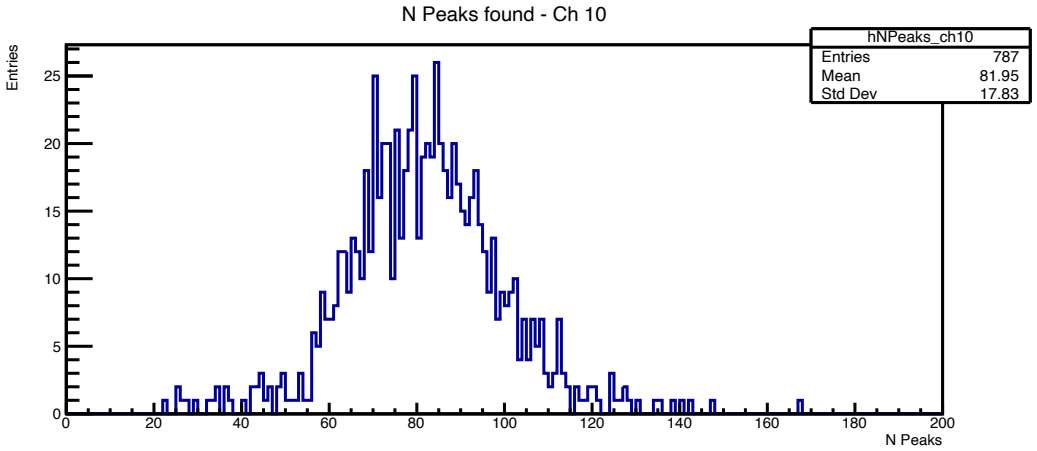


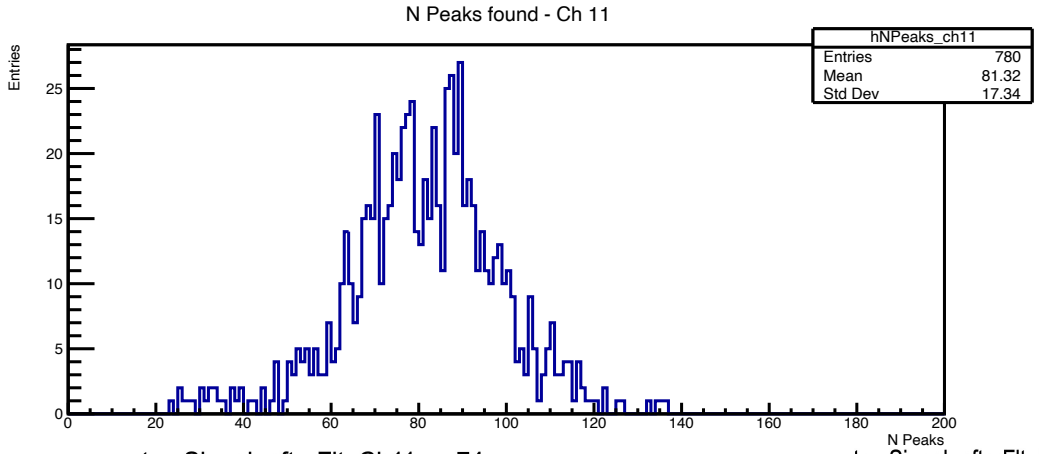


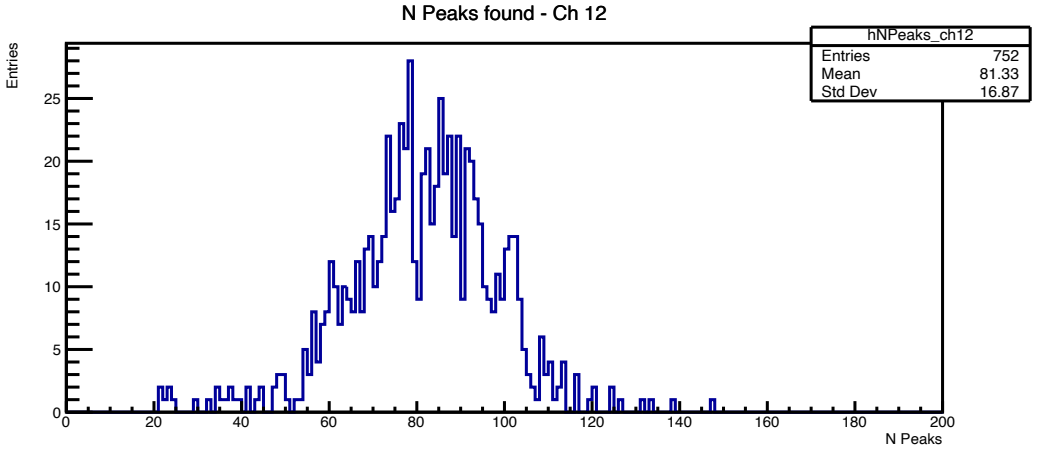
Gas(80He/20) ,drift tube 1 cm,angle 60° = 18/cm * 0,8 cm * 1,3 * 1,6 *2= 60 electron peaks

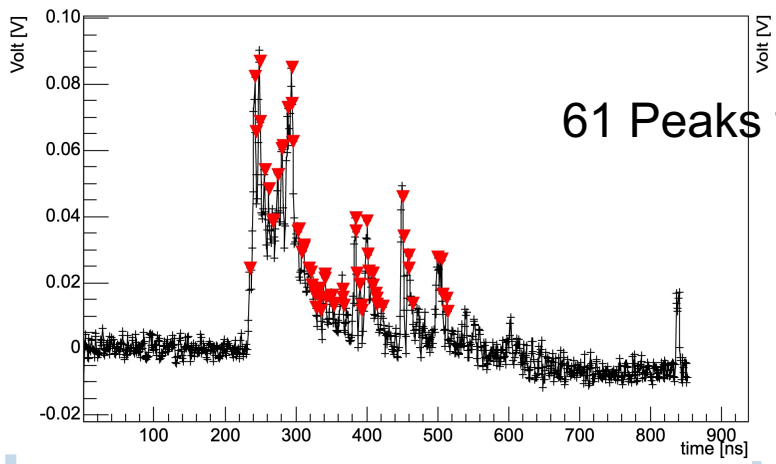
Npeak distribution for signal events

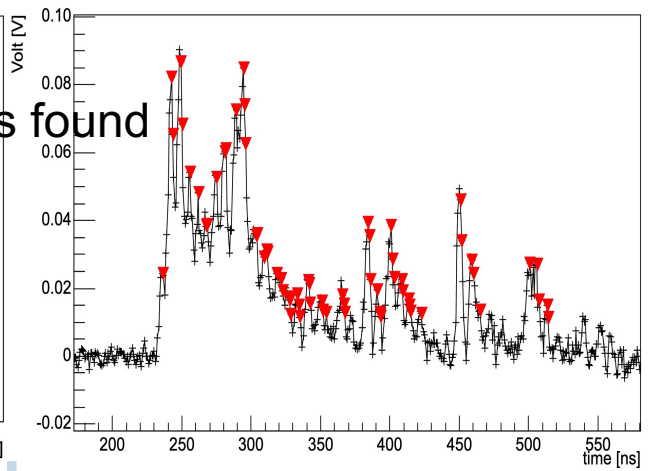
Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V 2 cm drift tubes









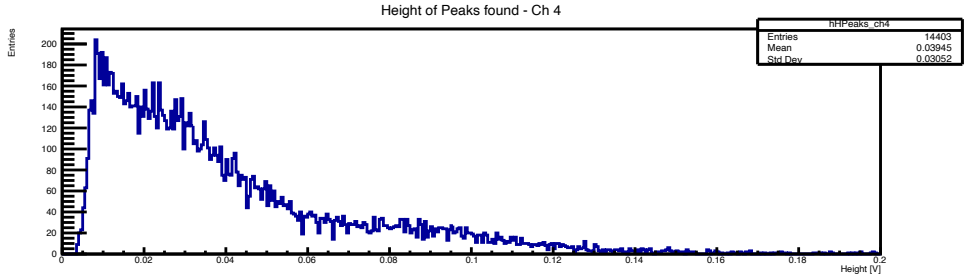


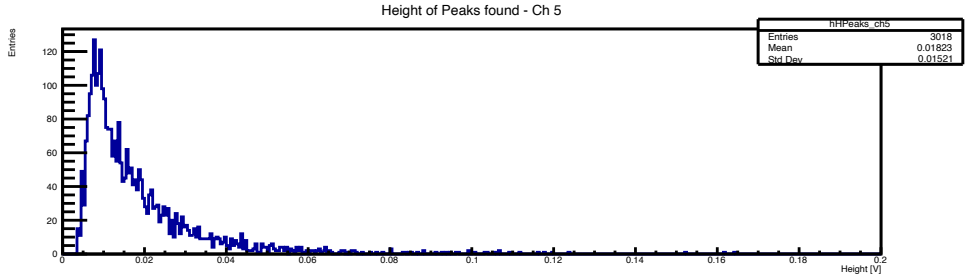
Gas(80He/20) ,drift tube 2 cm,angle 60° = 18/cm * 1,8 cm * 1,3 * 1,6 *2= 134 electron peaks

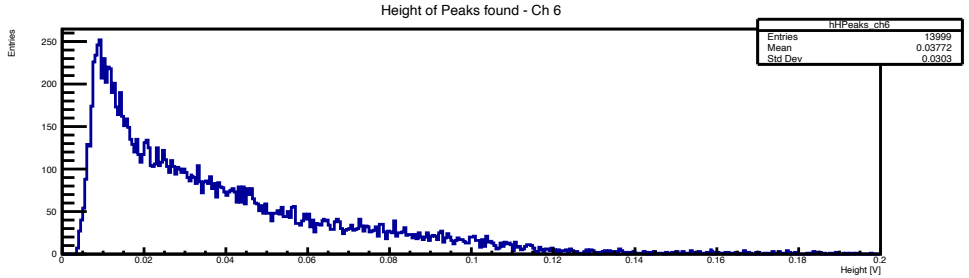
Height of Peaks found distribution for signal events

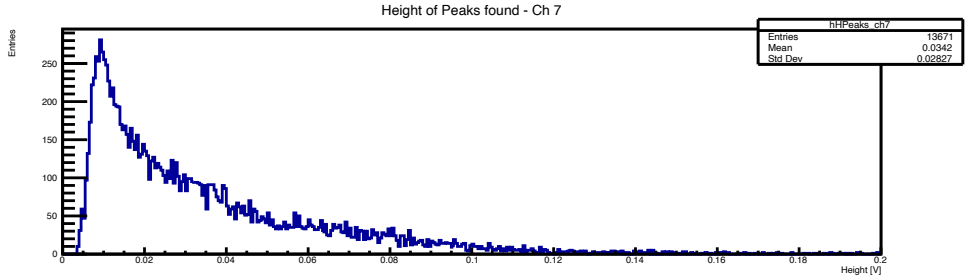
Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

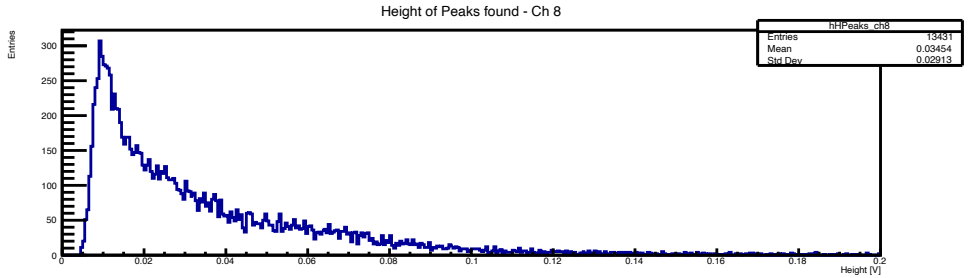
1 cm drift tubes

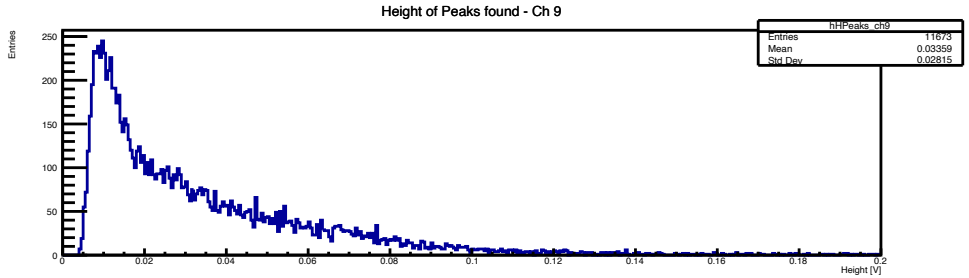








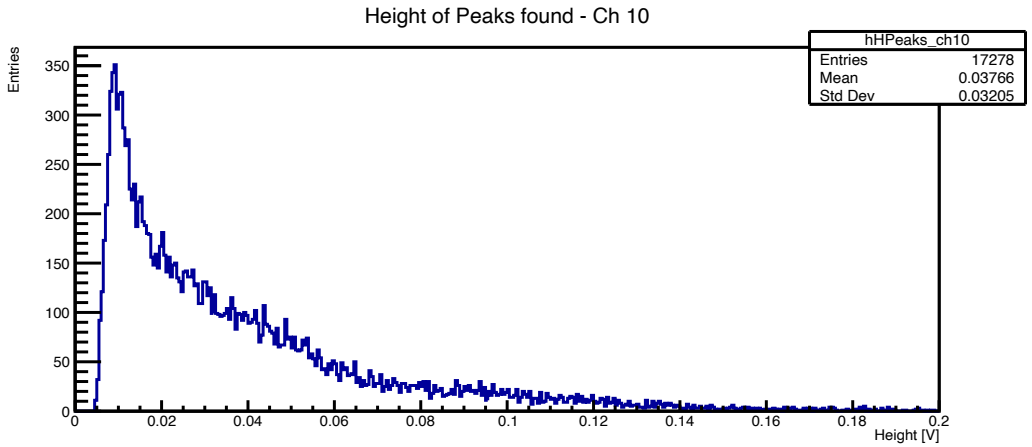


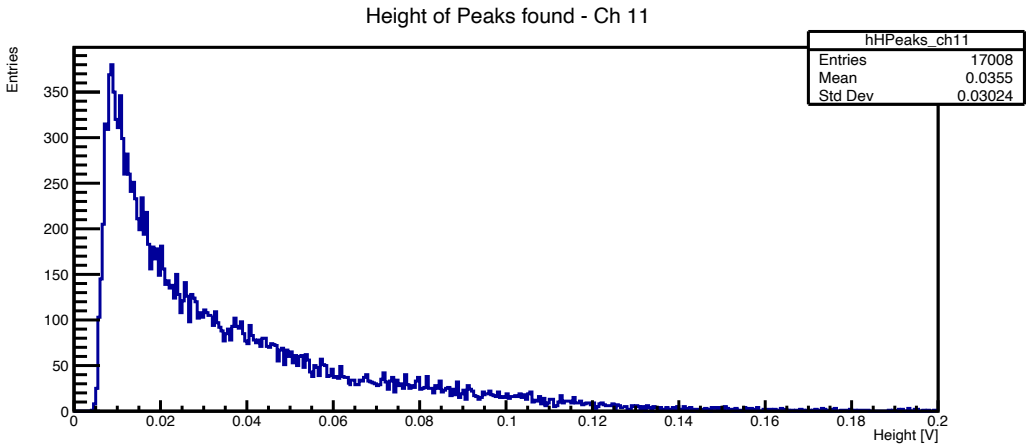


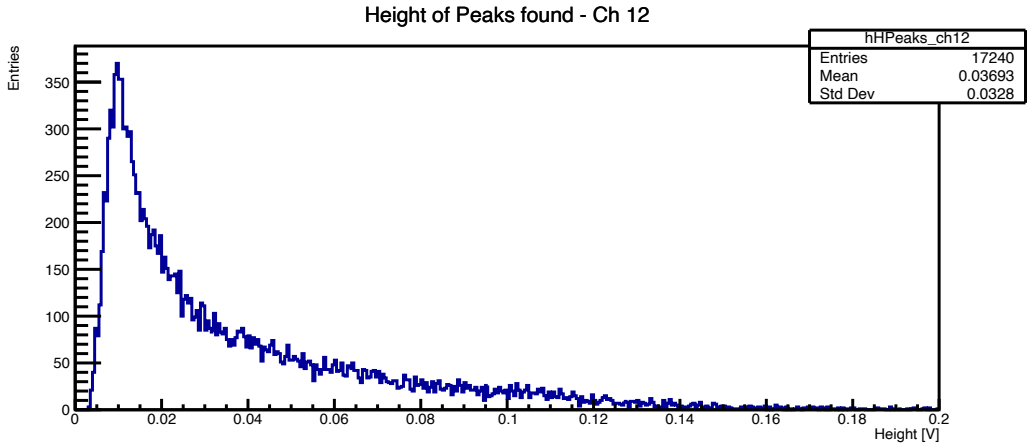
Height of Peaks found distribution for signal events

Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



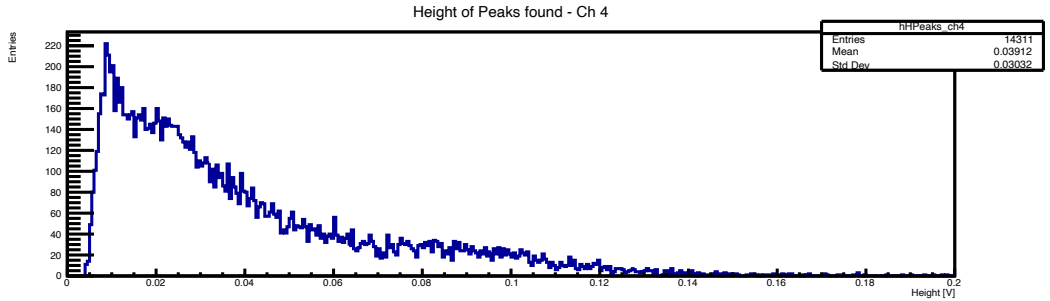


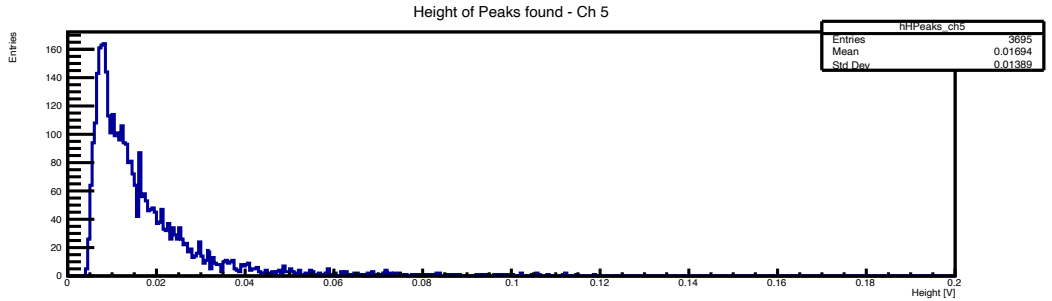


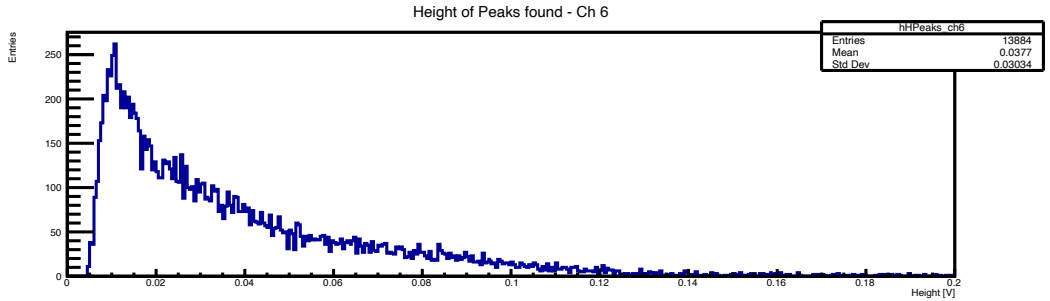
Height of Peaks found distribution for signal events

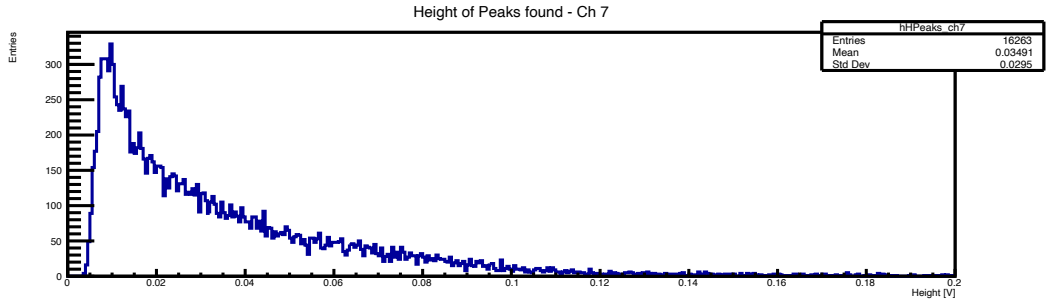
Run: run_98.root; Track angle: 15° ; Gas mixture: 90%He ; HV = +20V

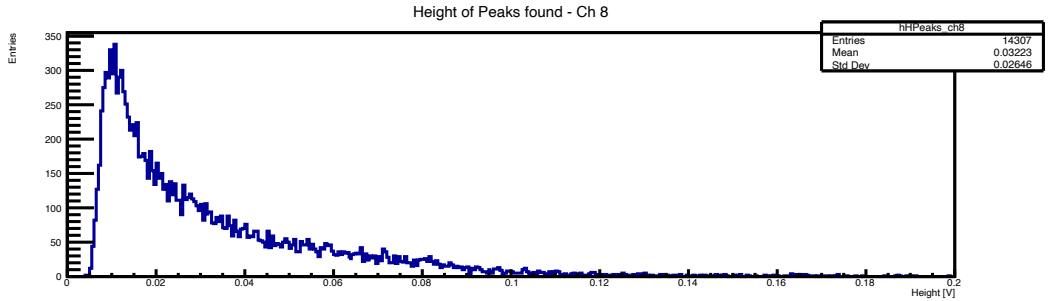
1 cm drift tubes

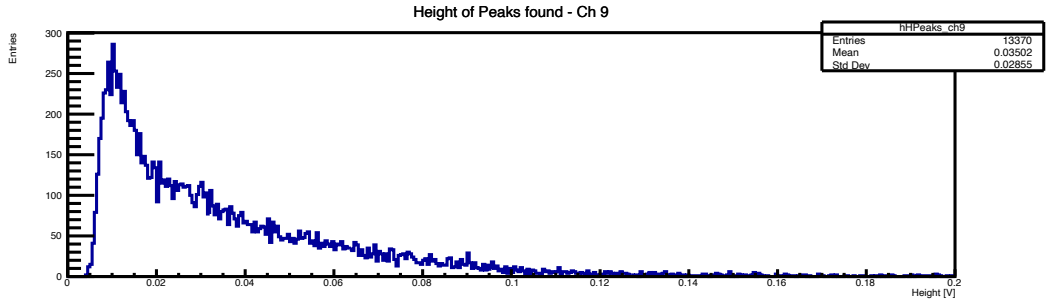








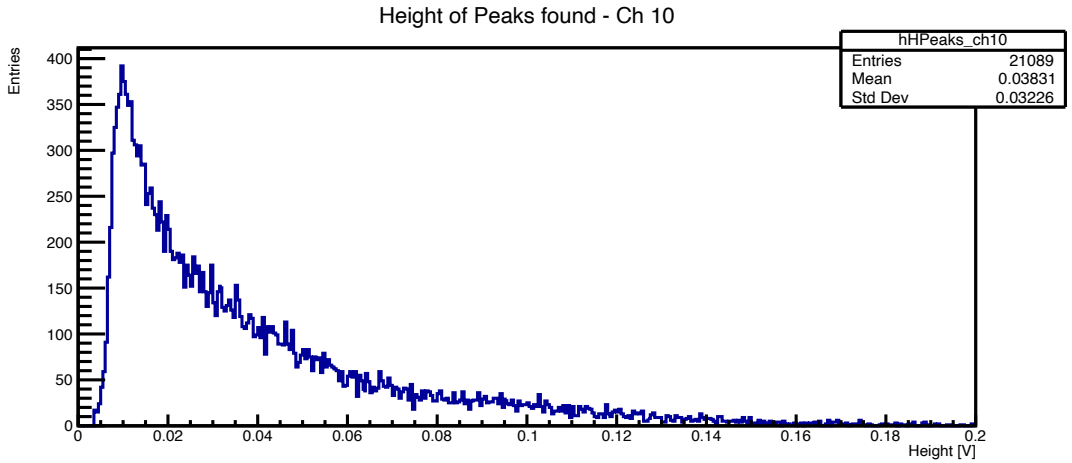


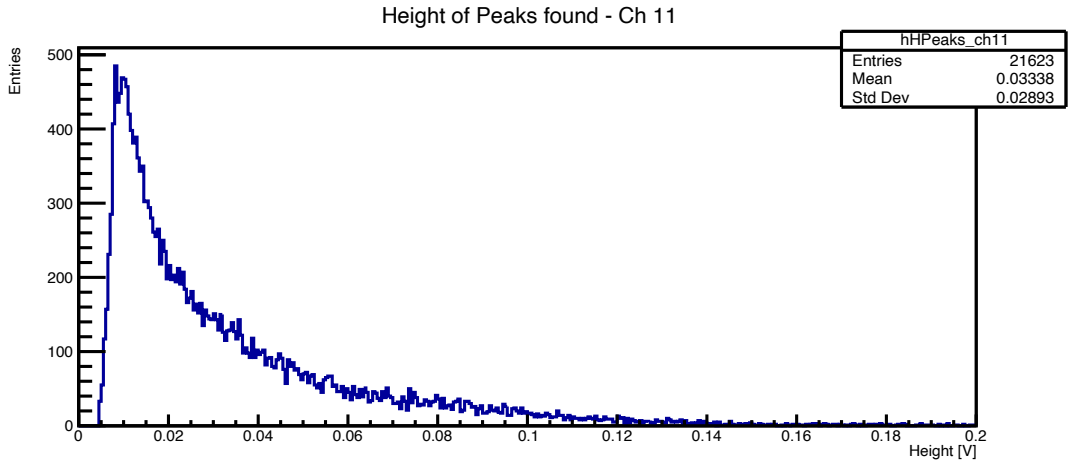


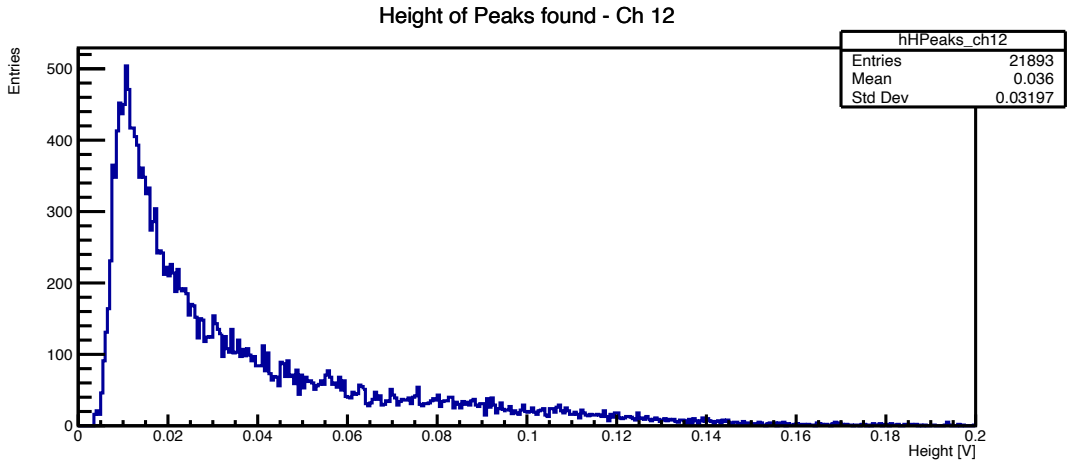
Height of Peaks found distribution for signal events

Run: run_98.root; Track angle: 15° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



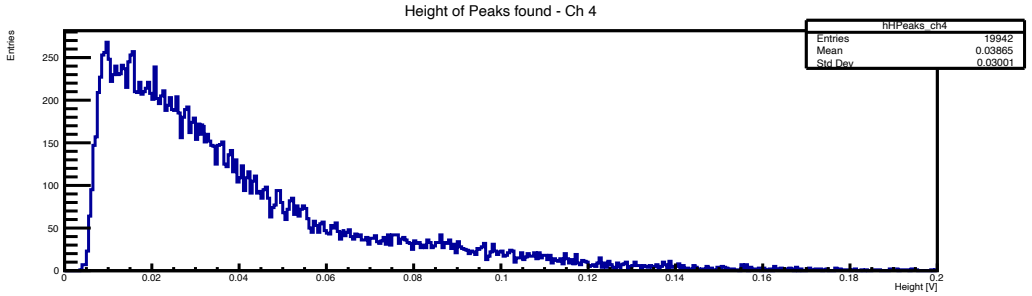


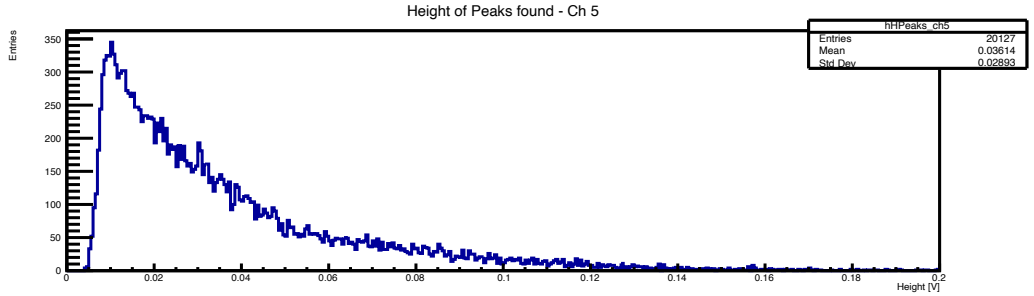


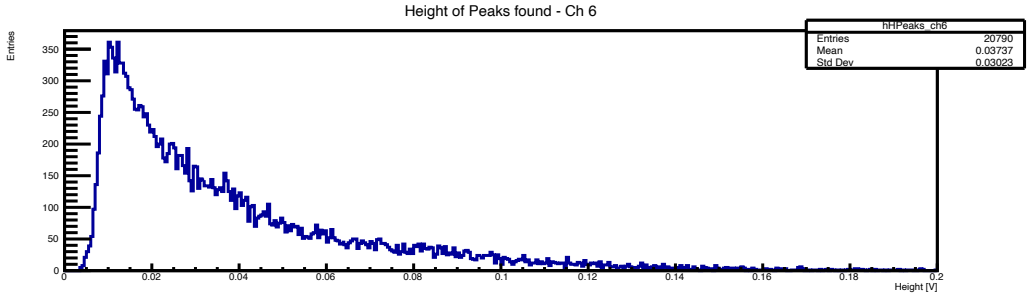
Height of Peaks found distribution for signal events

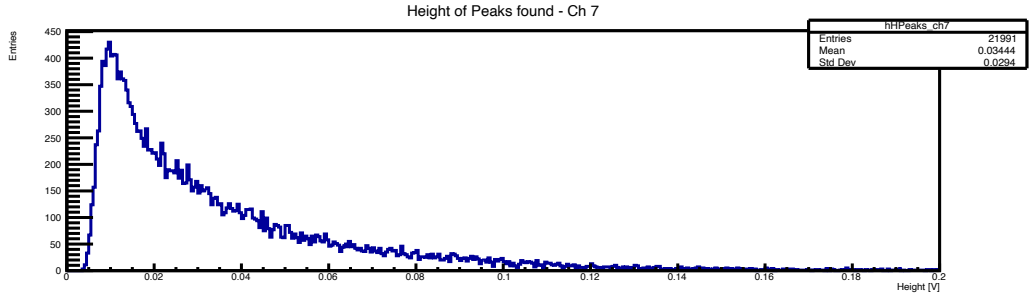
Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

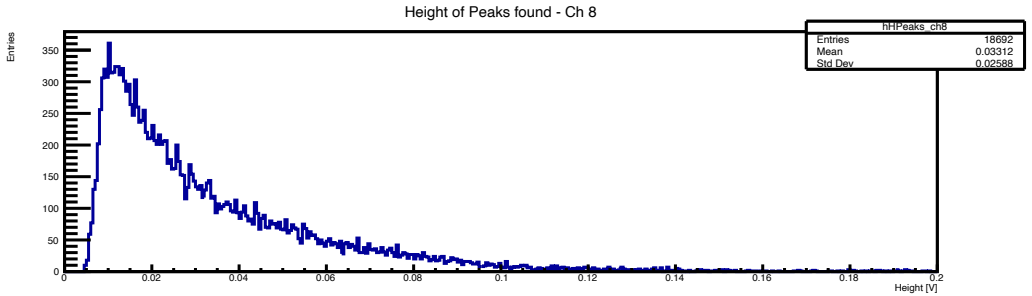
1 cm drift tubes

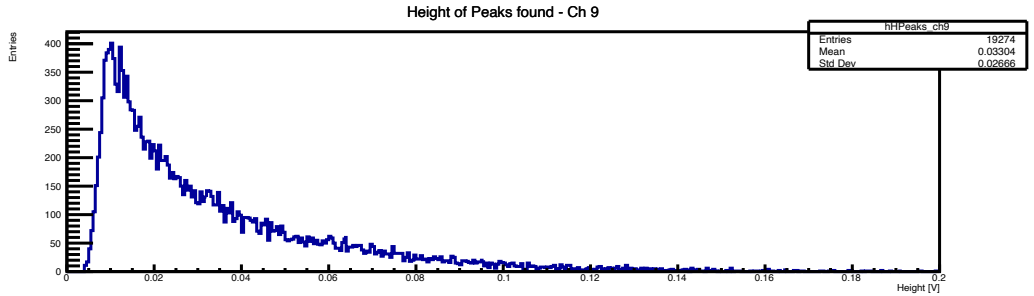








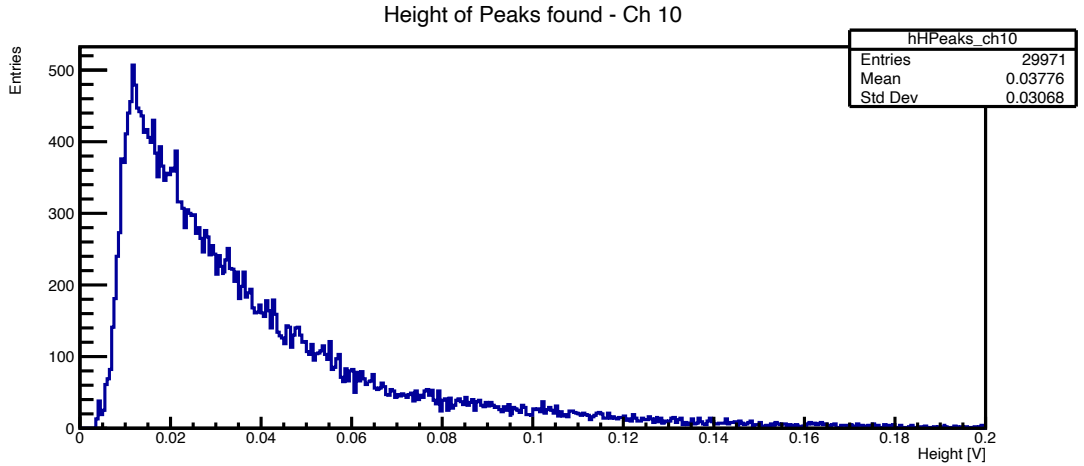


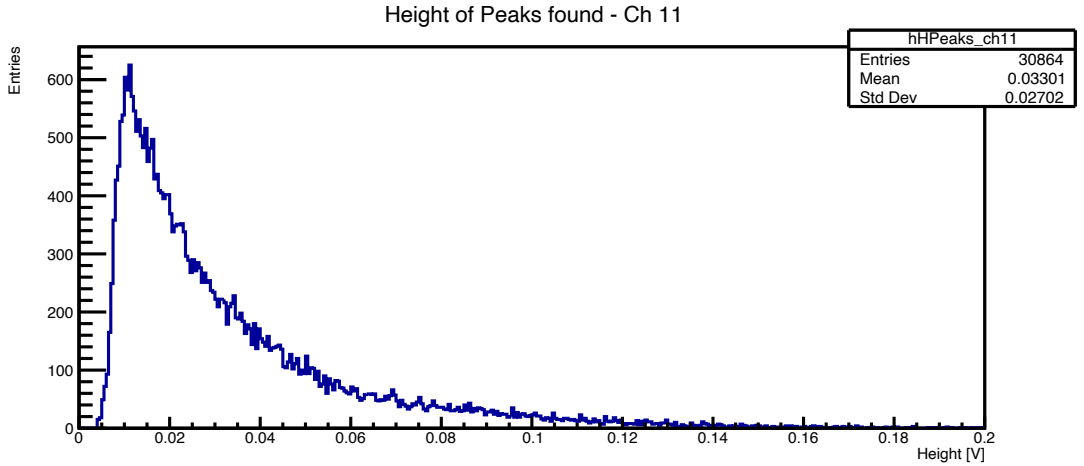


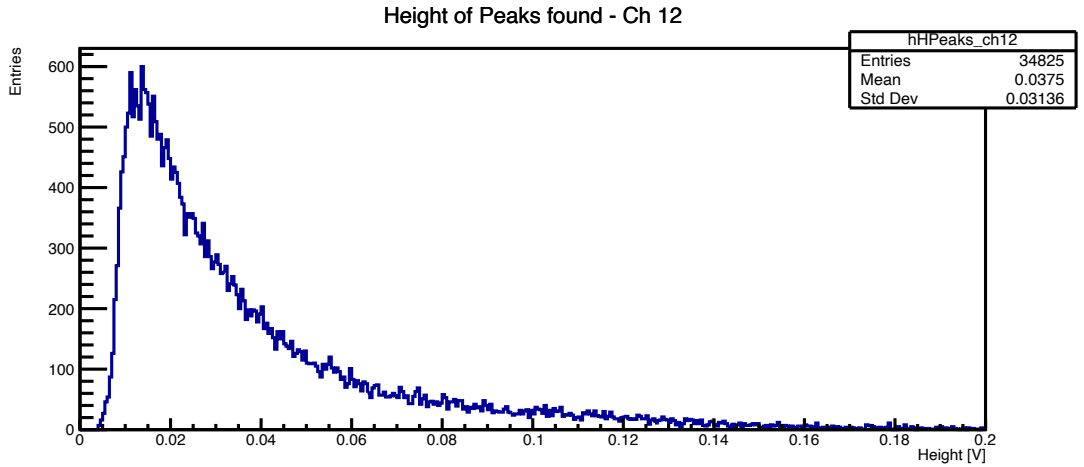
Height of Peaks found distribution for signal events

Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



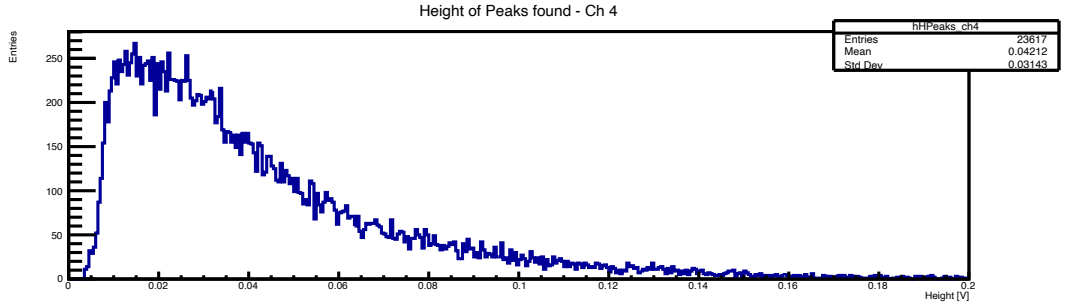


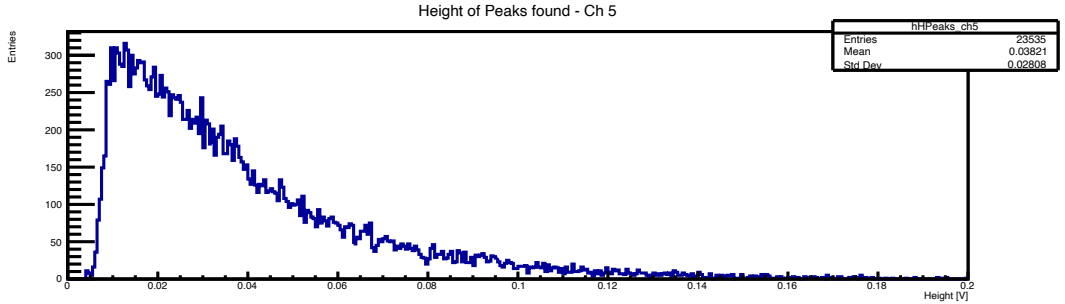


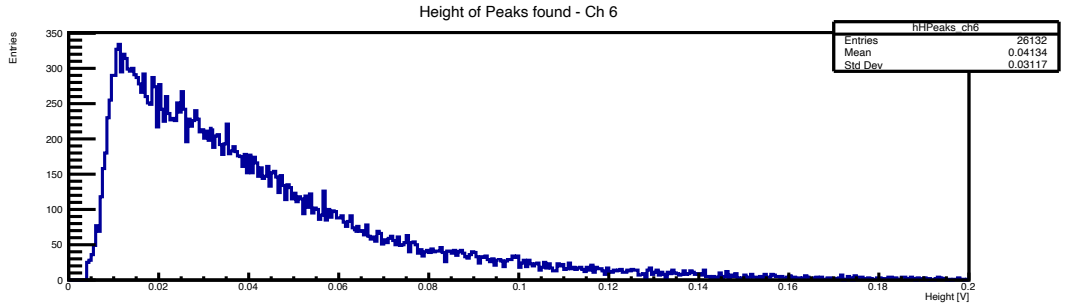
Height of Peaks found distribution for signal events

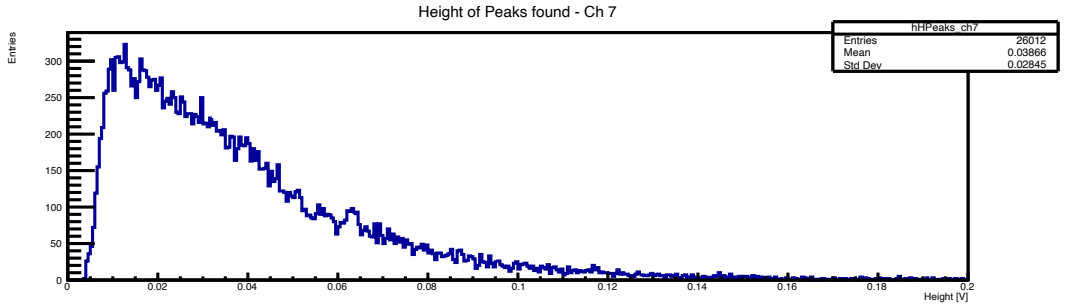
Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

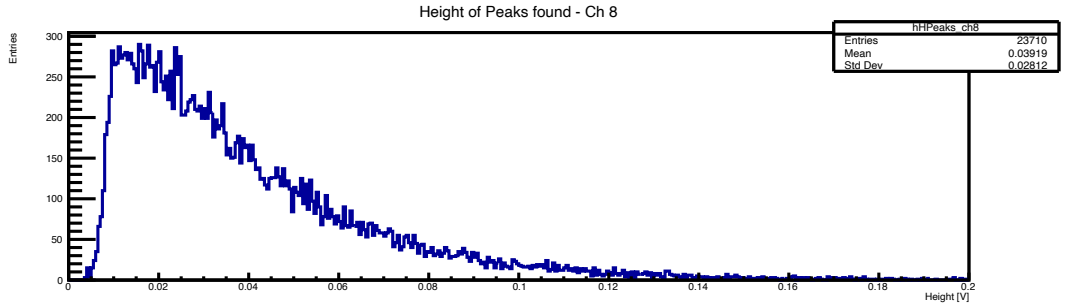
1 cm drift tubes

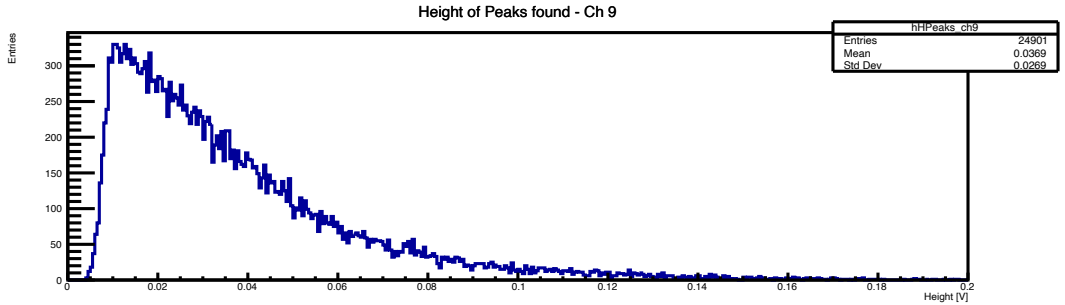








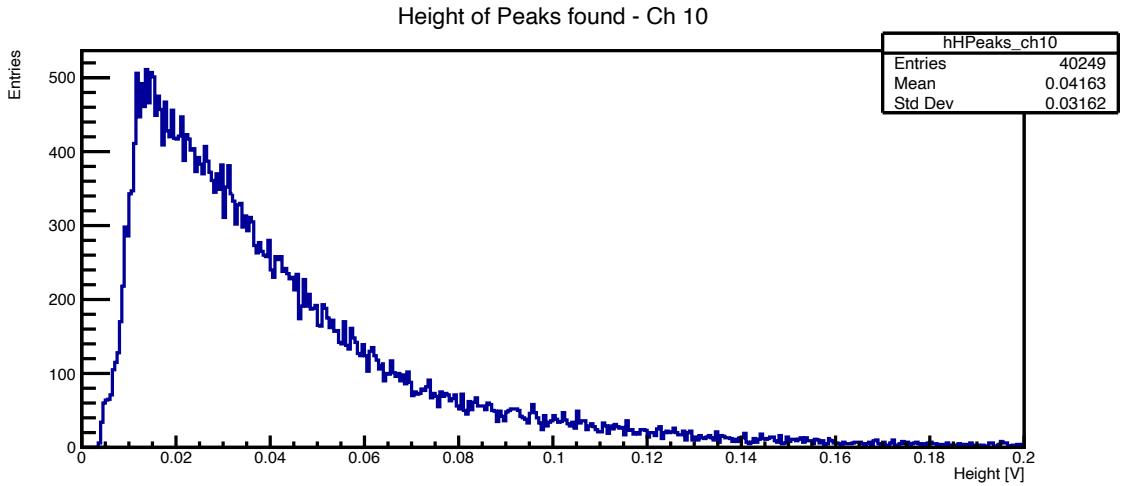


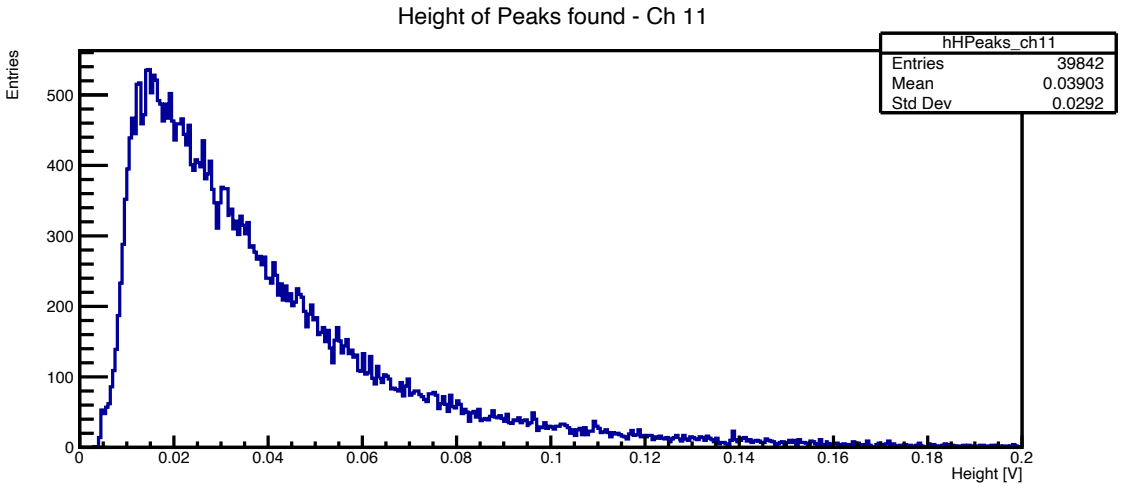


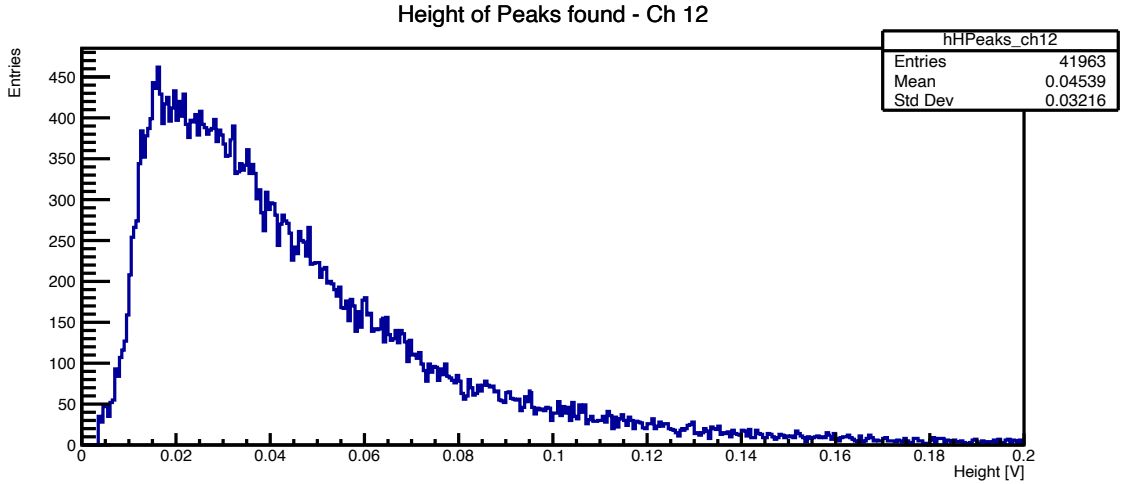
Height of Peaks found distribution for signal events

Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



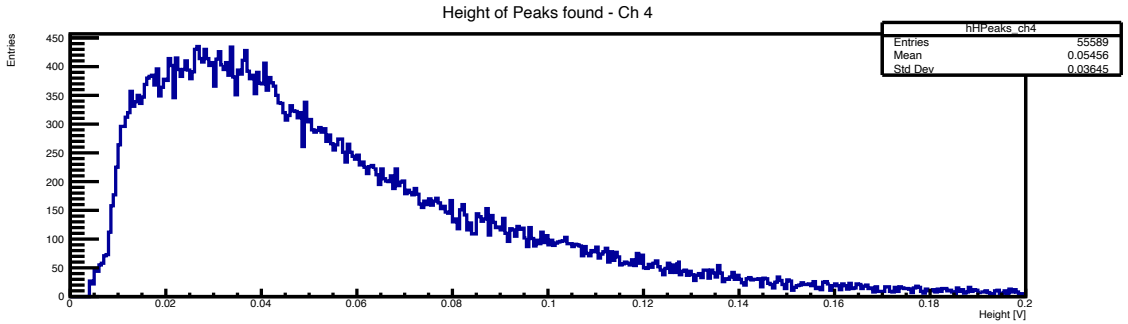


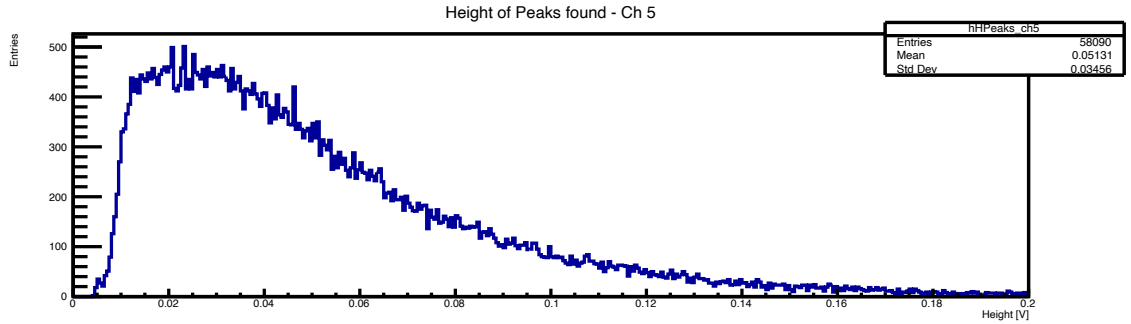


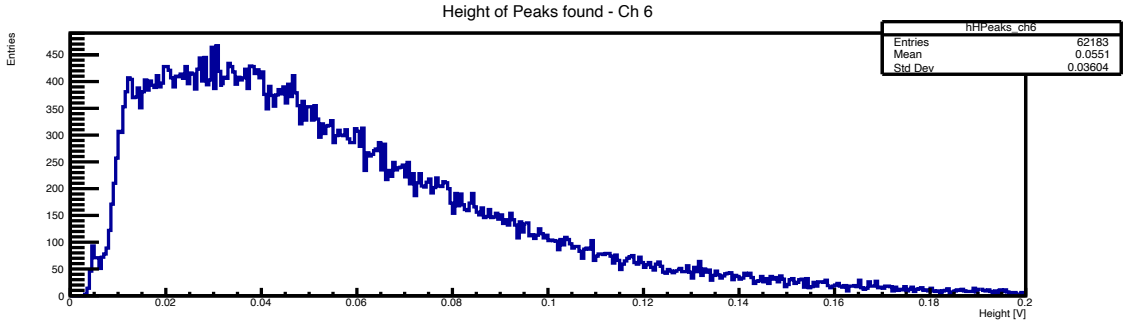
Height of Peaks found distribution for signal events

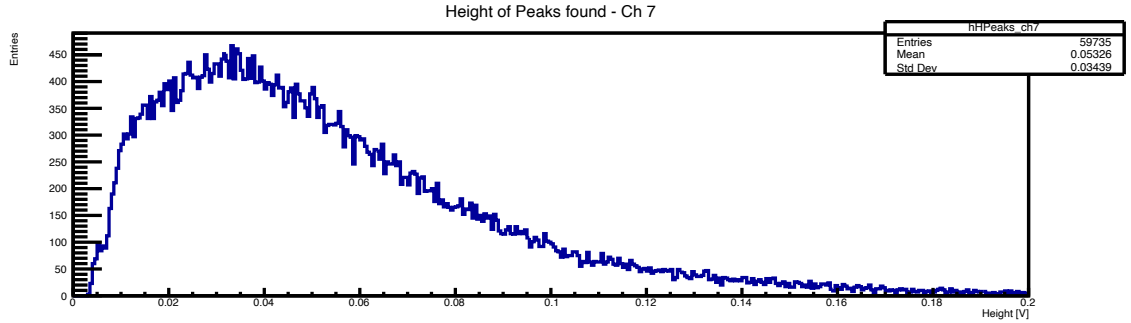
Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V

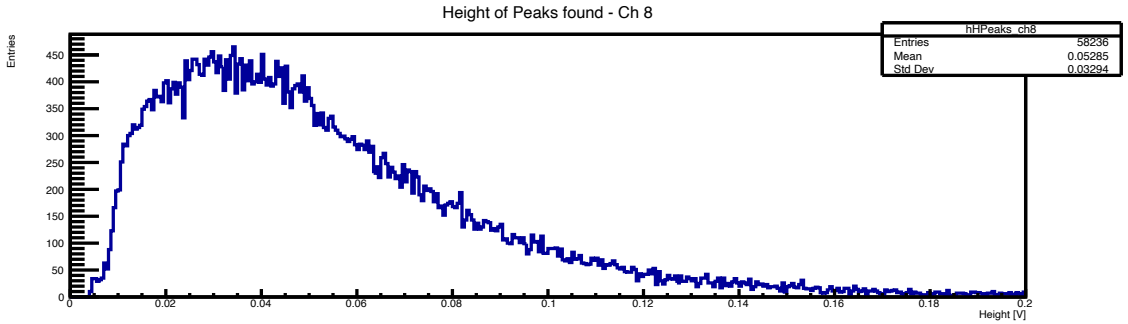
1 cm drift tubes

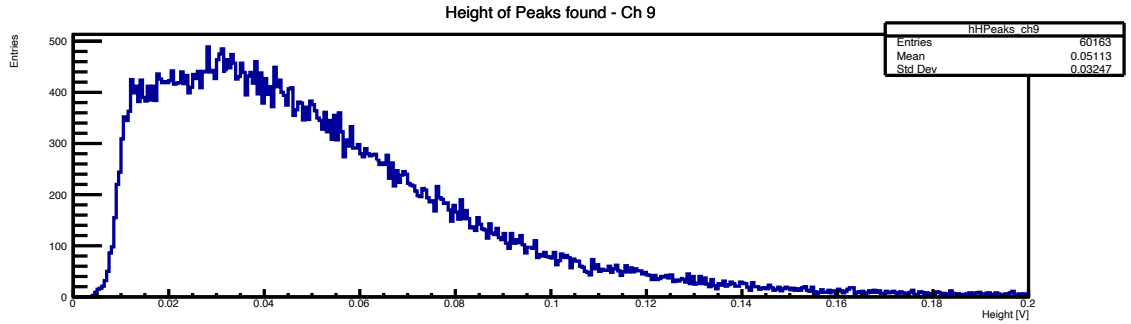








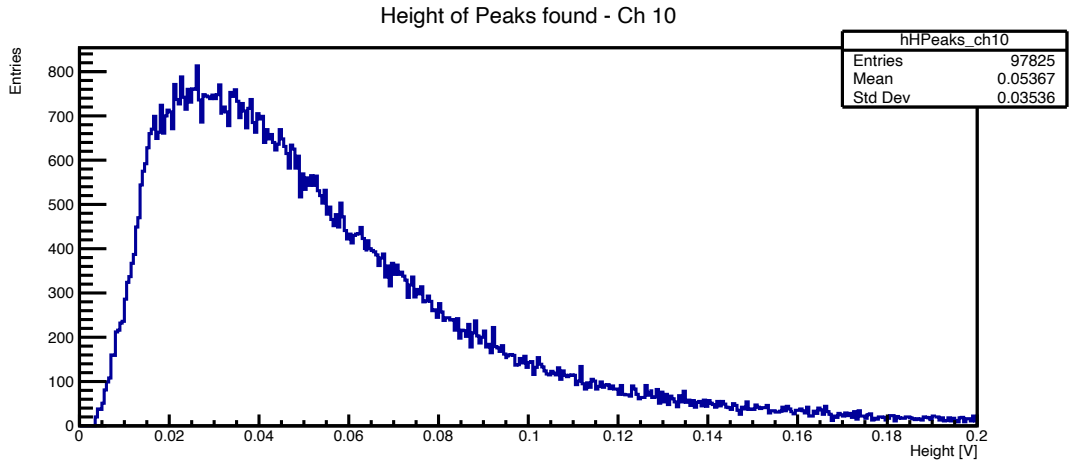


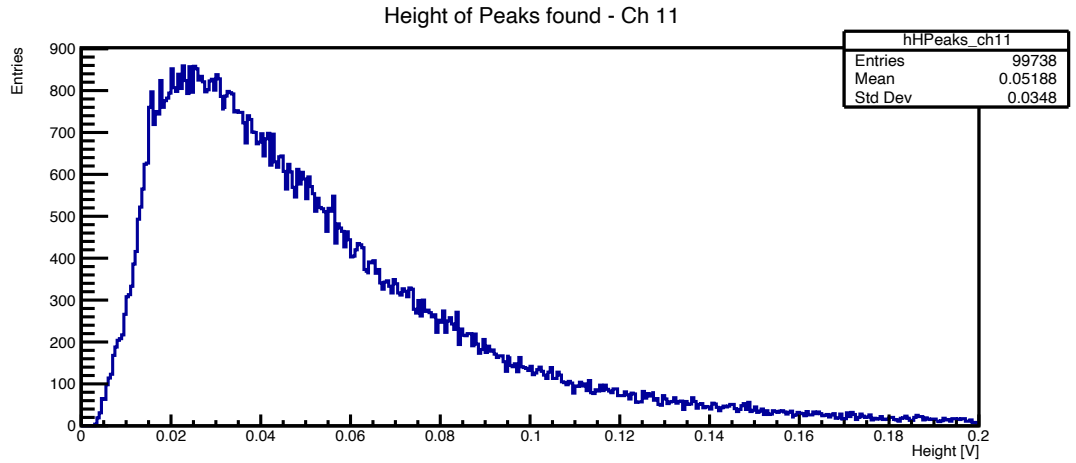


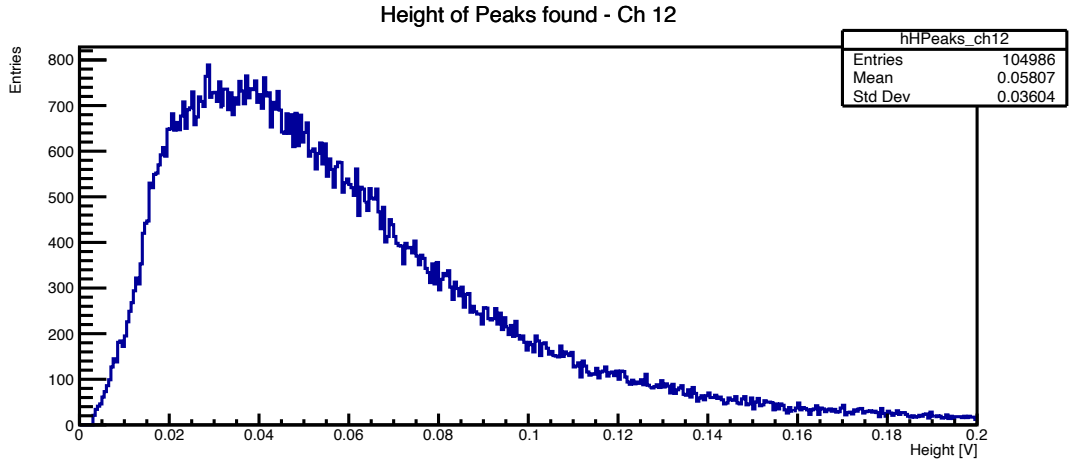
Height of Peaks found distribution for signal events

Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



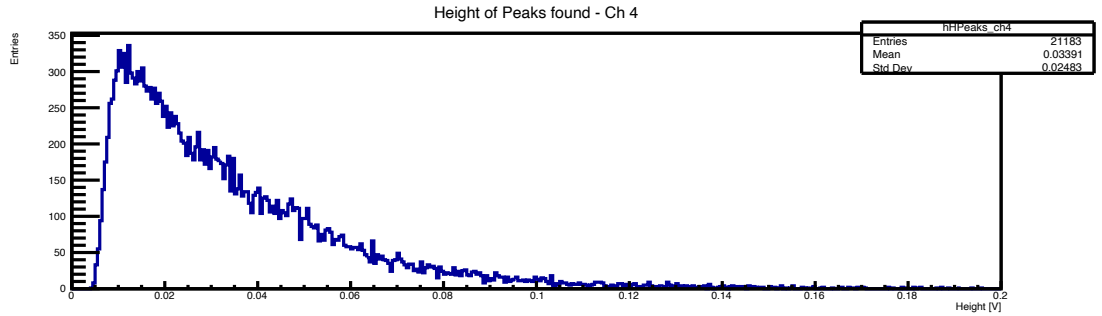


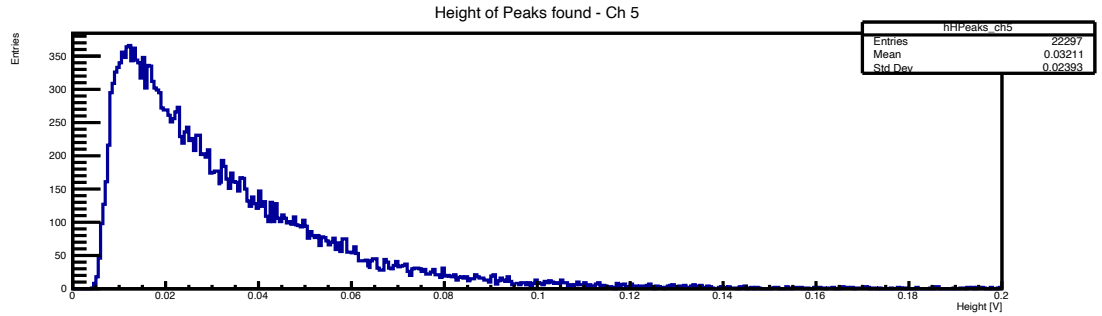


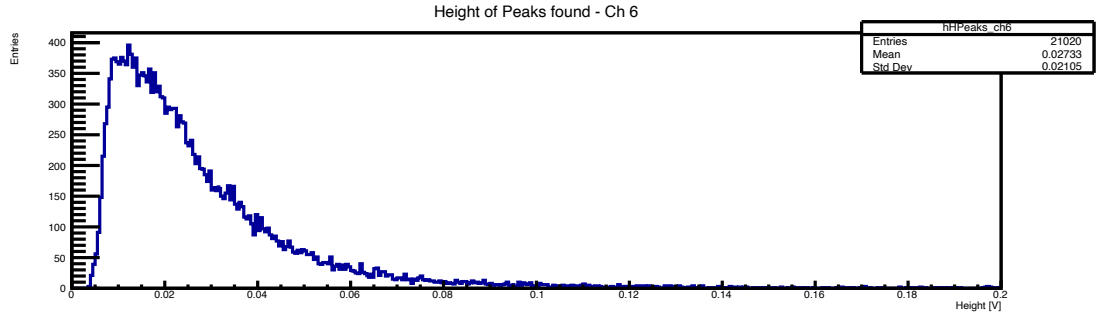
Height of Peaks found distribution for signal events

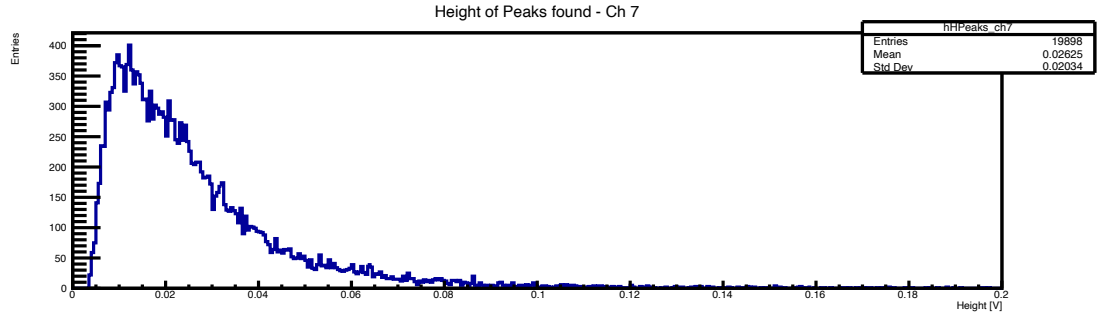
Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V

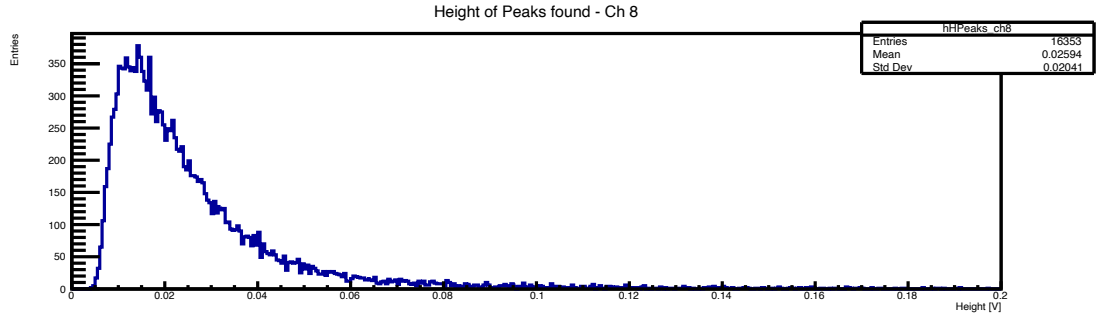
1 cm drift tubes

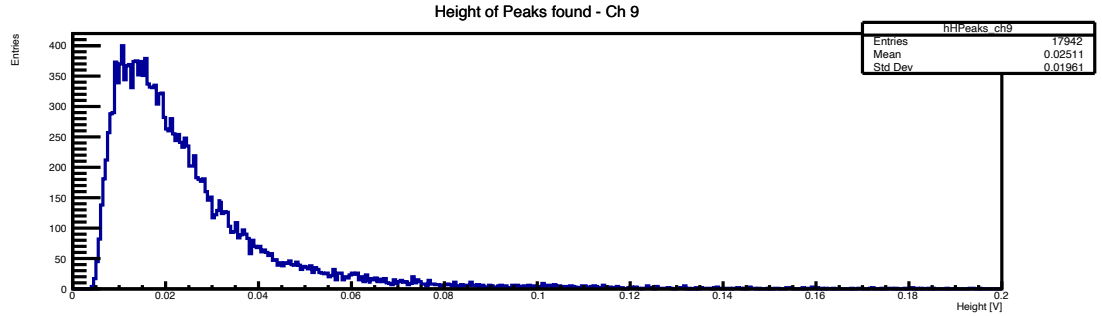






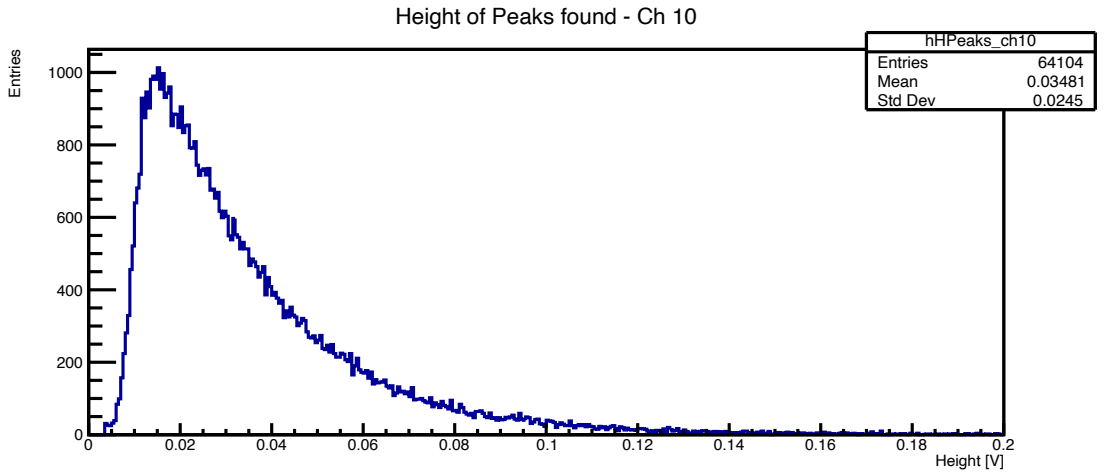


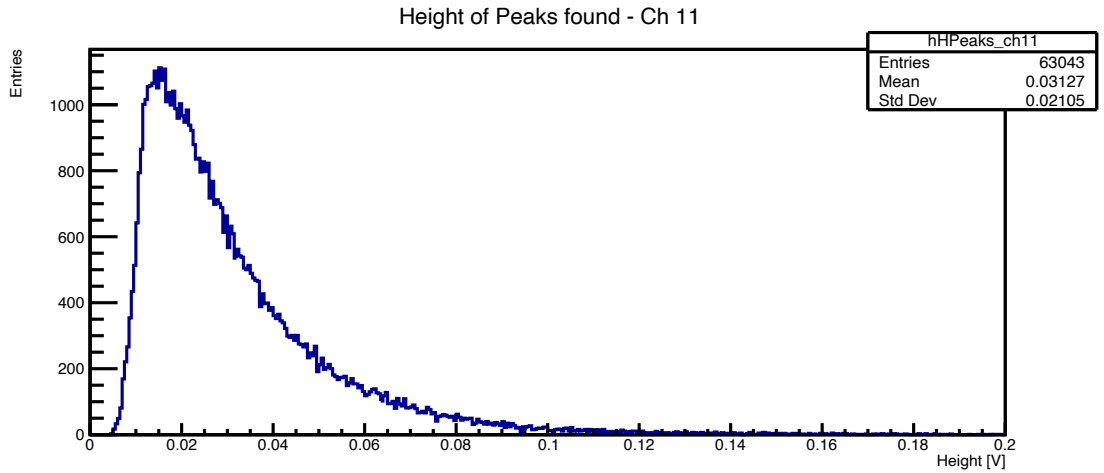


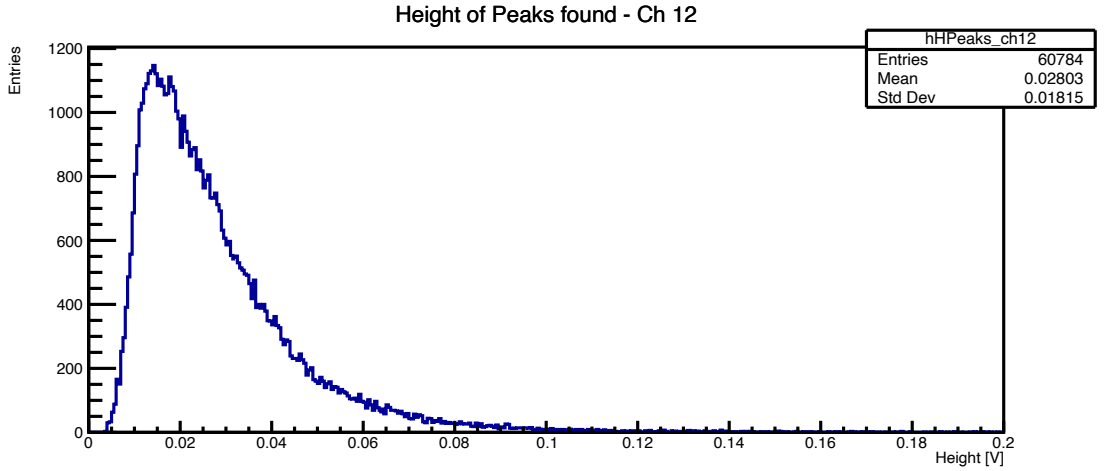


Height of Peaks found distribution for signal events

Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V 2 cm drift tubes



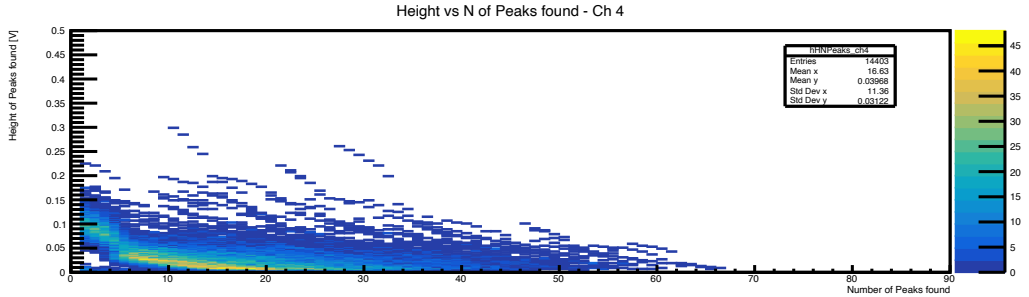


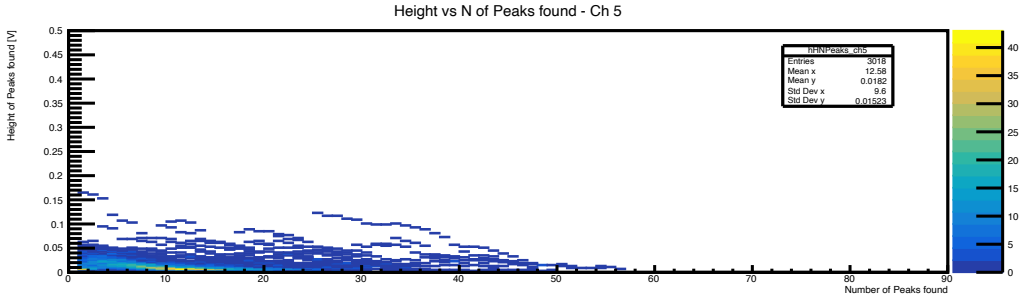


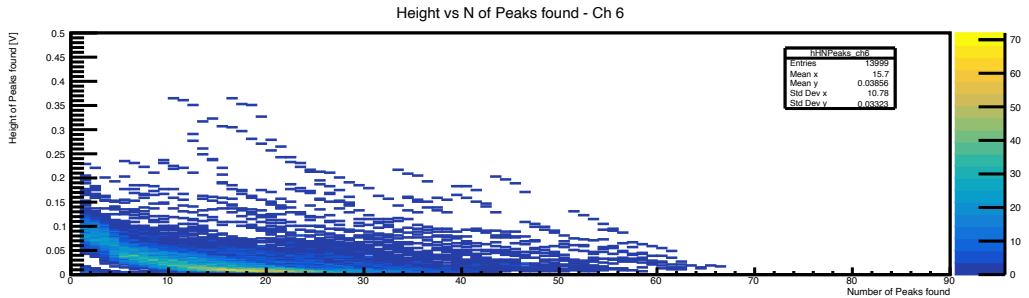
Height of Peaks vs Npeak for signal events

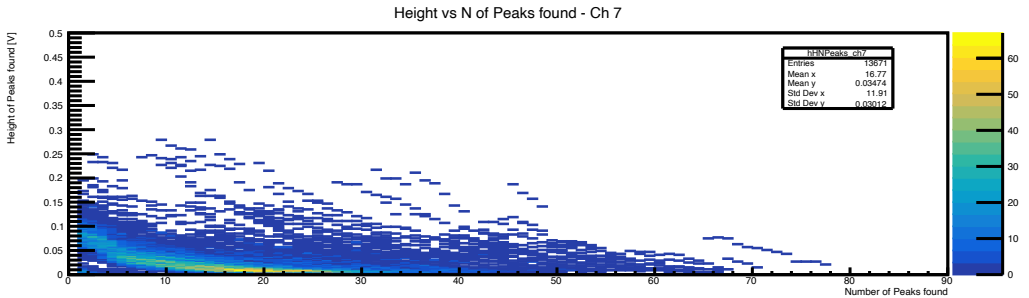
Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

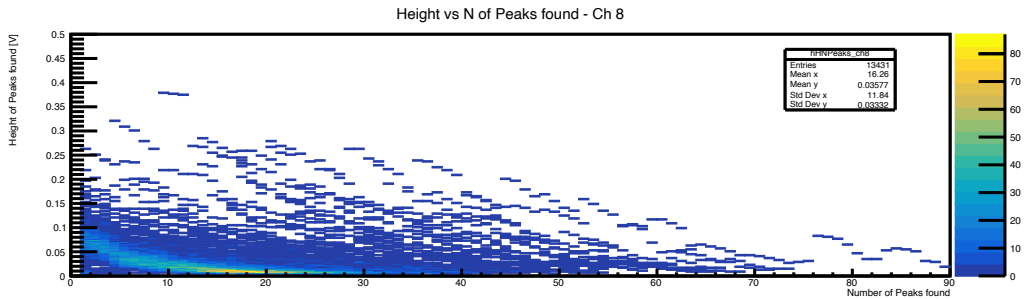
1 cm drift tubes

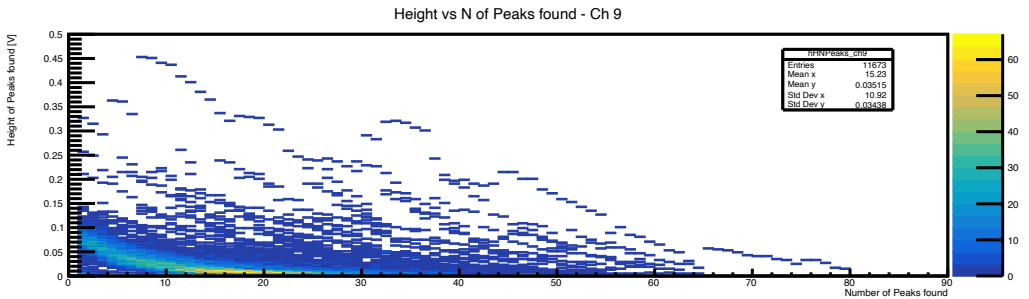








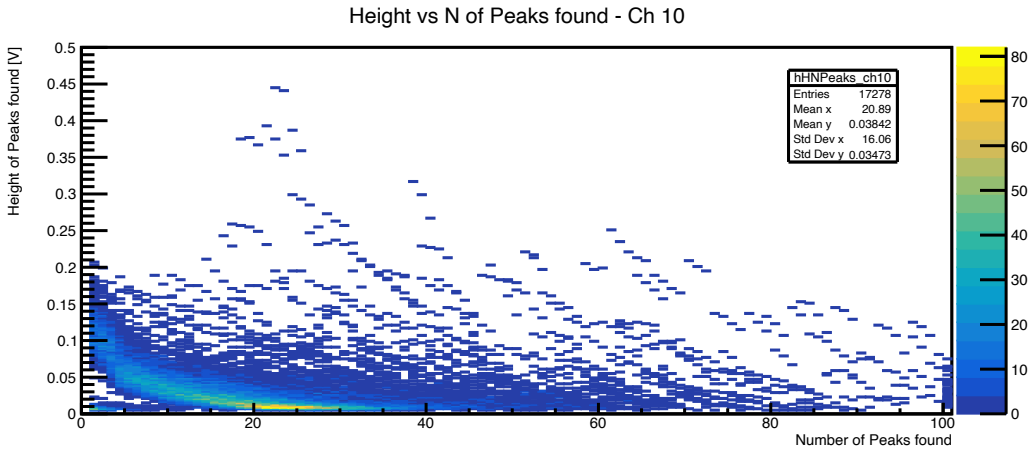


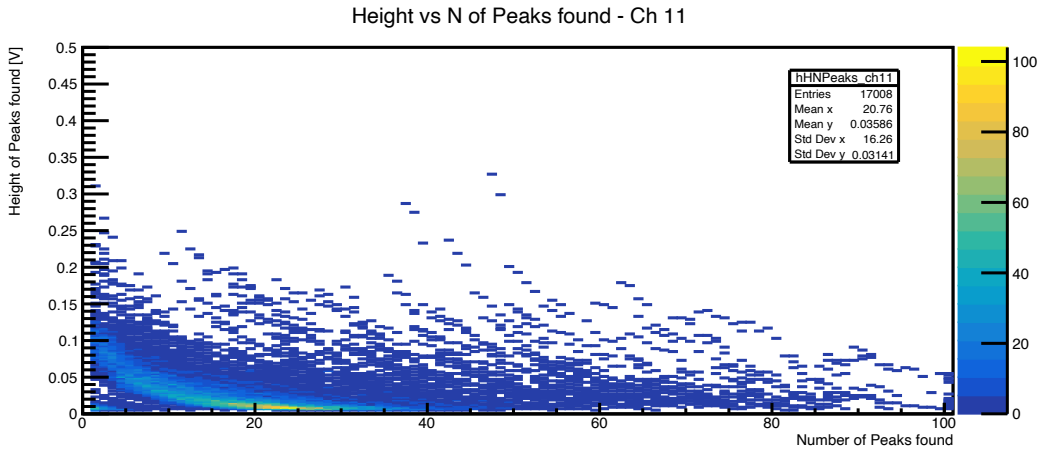


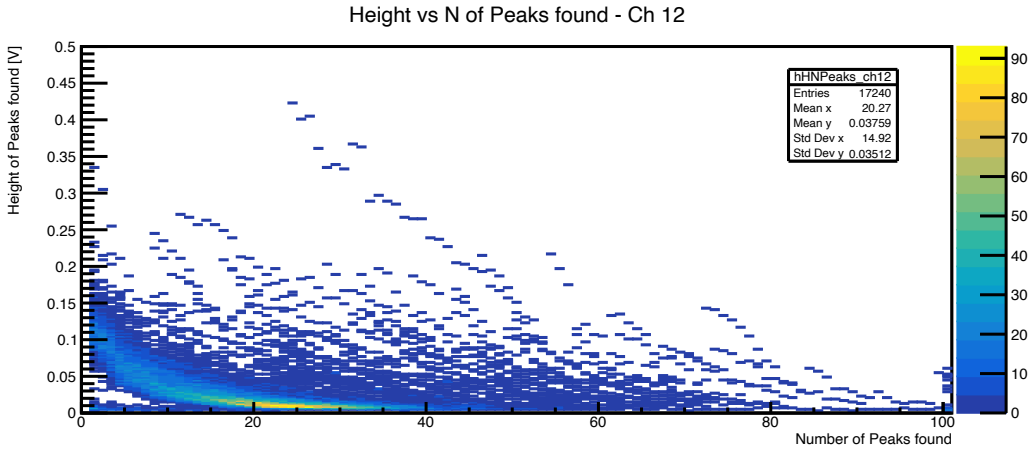
Height of Peaks vs Npeak for signal events

Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



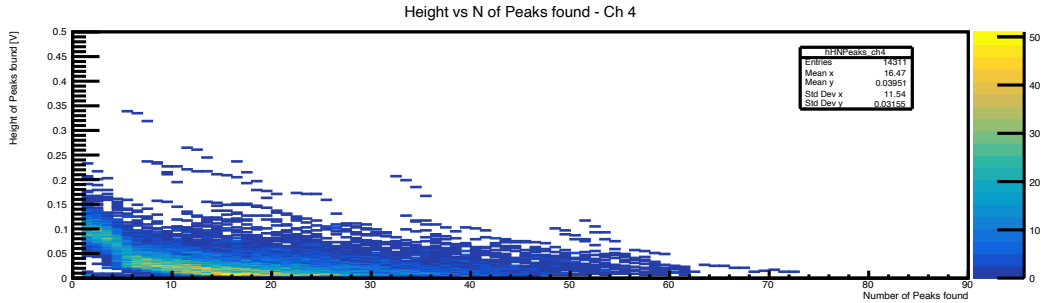


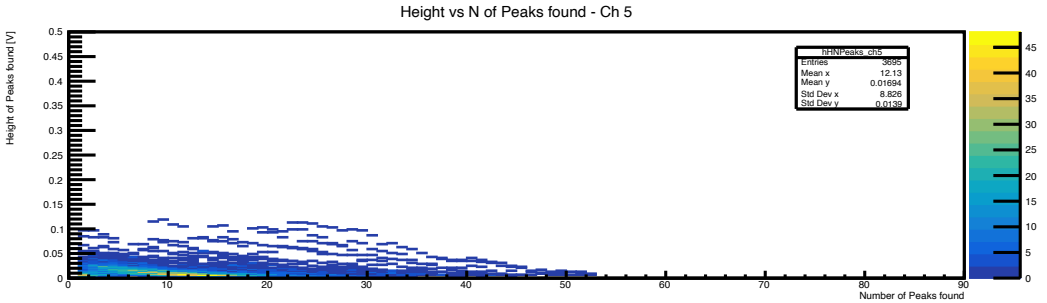


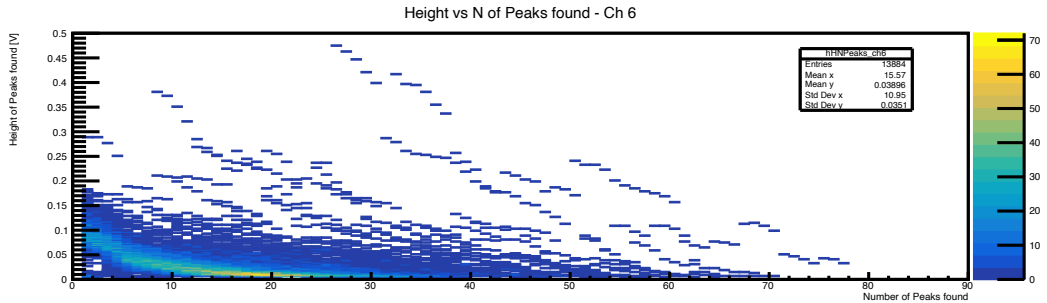
Height of Peaks vs Npeak for signal events

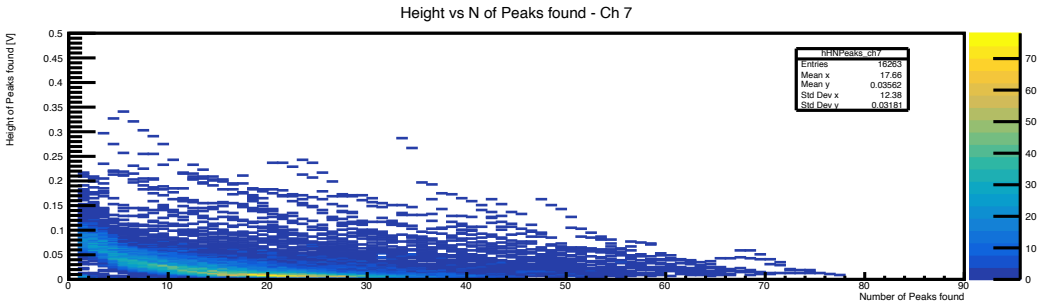
Run: run_98.root; Track angle: 15° ; Gas mixture: 90%He ; HV = +20V

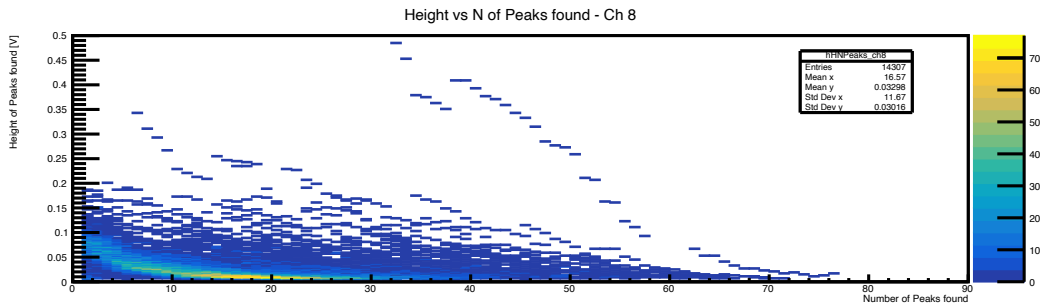
1 cm drift tubes

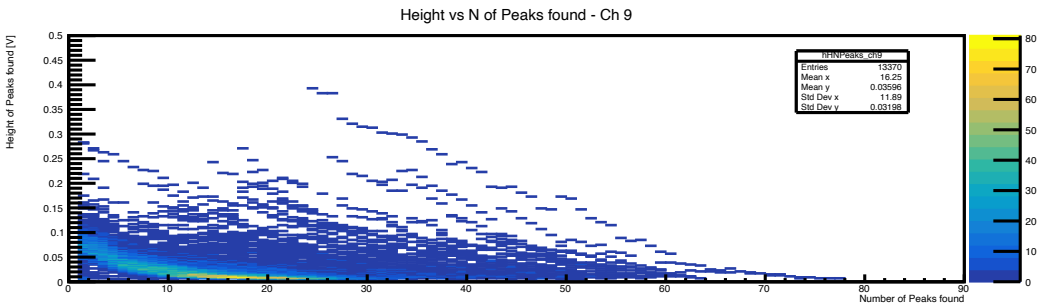








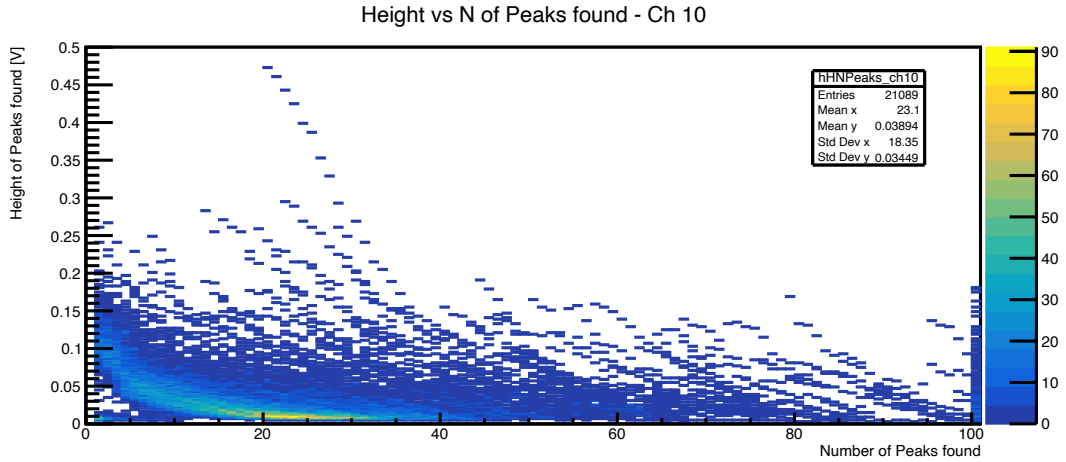


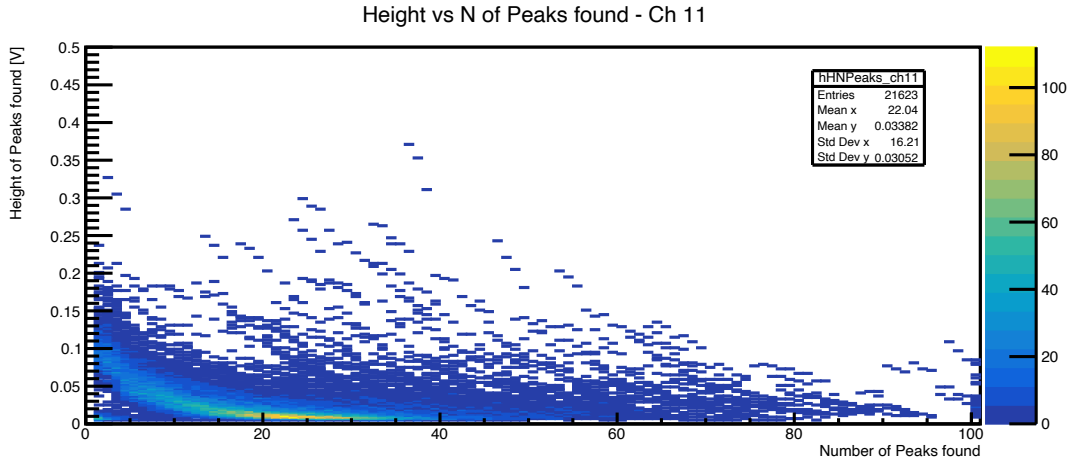


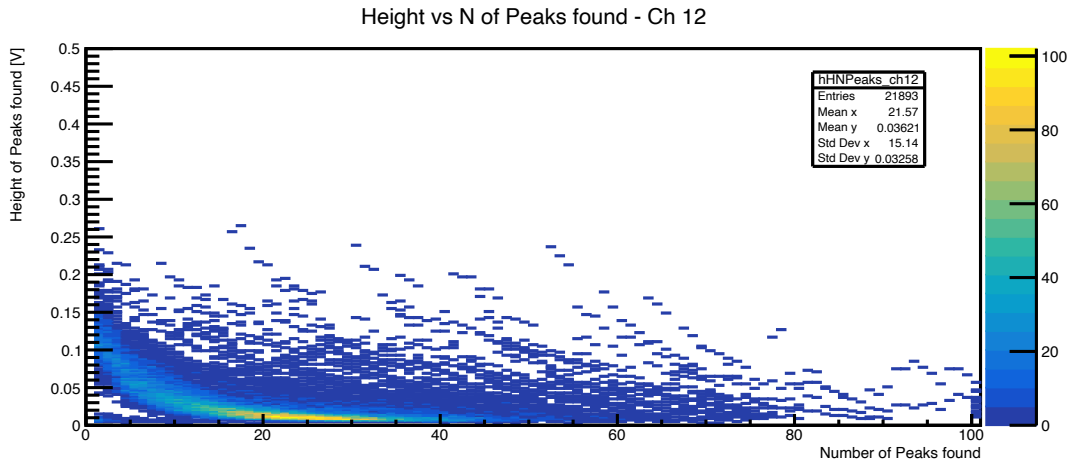
Height of Peaks vs Npeak for signal events

Run: run_98.root; Track angle: 15° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



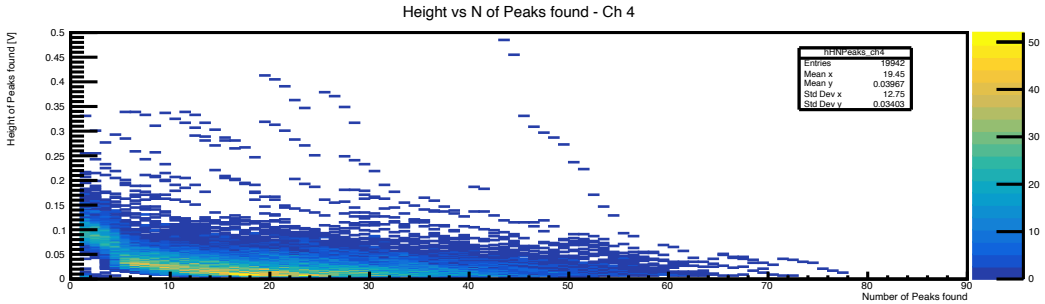


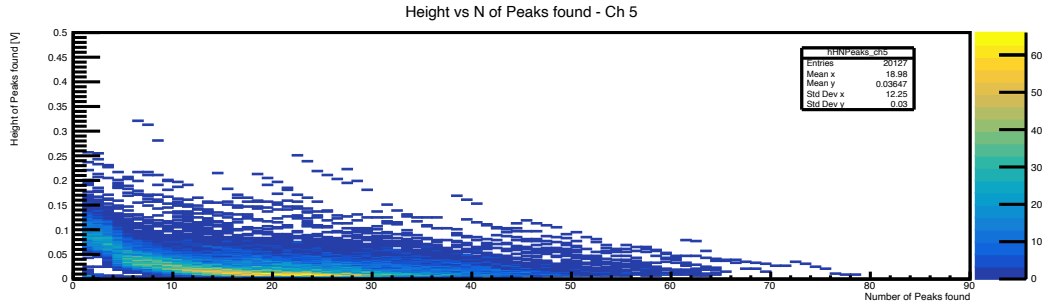


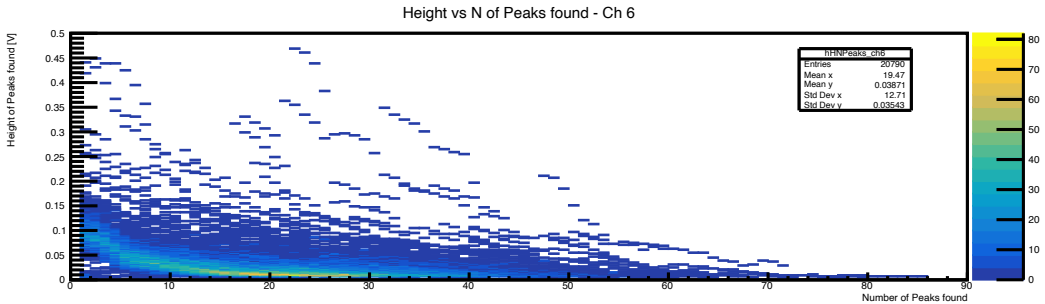
Height of Peaks vs Npeak for signal events

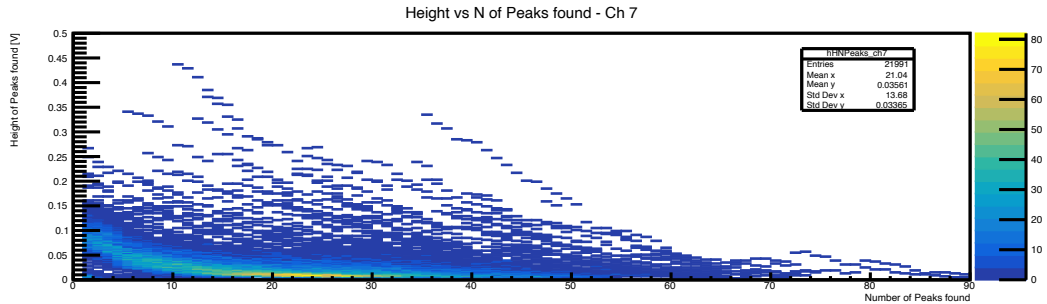
Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

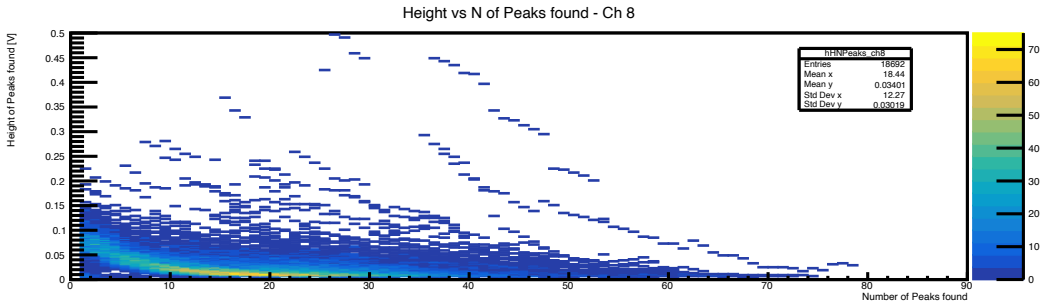
1 cm drift tubes

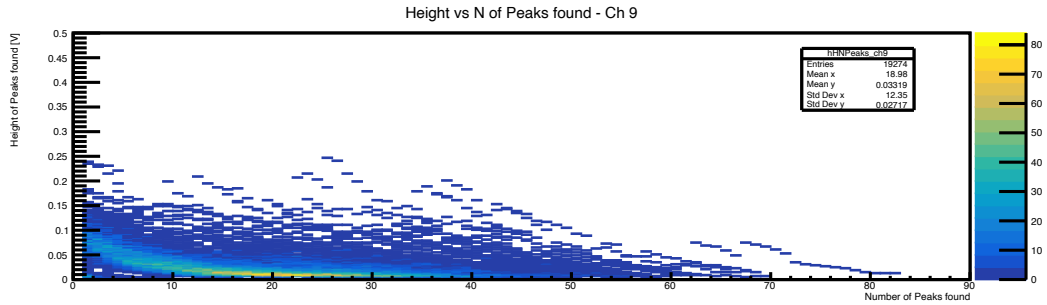








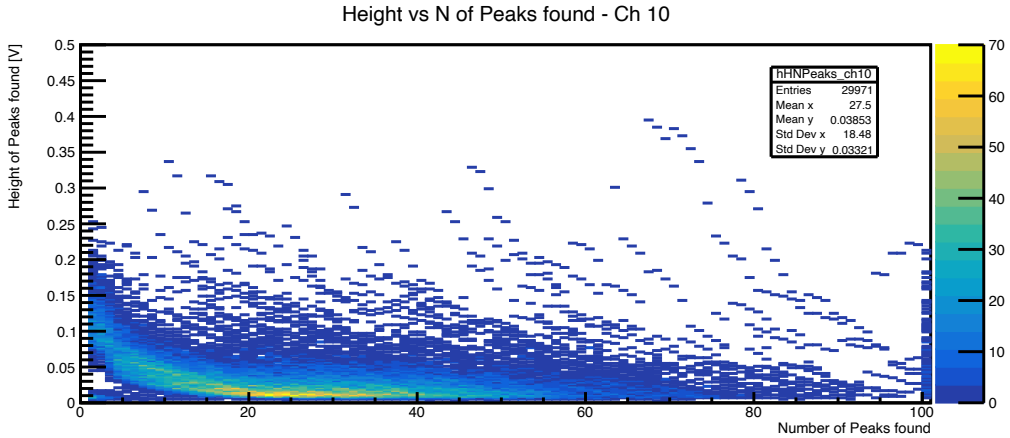


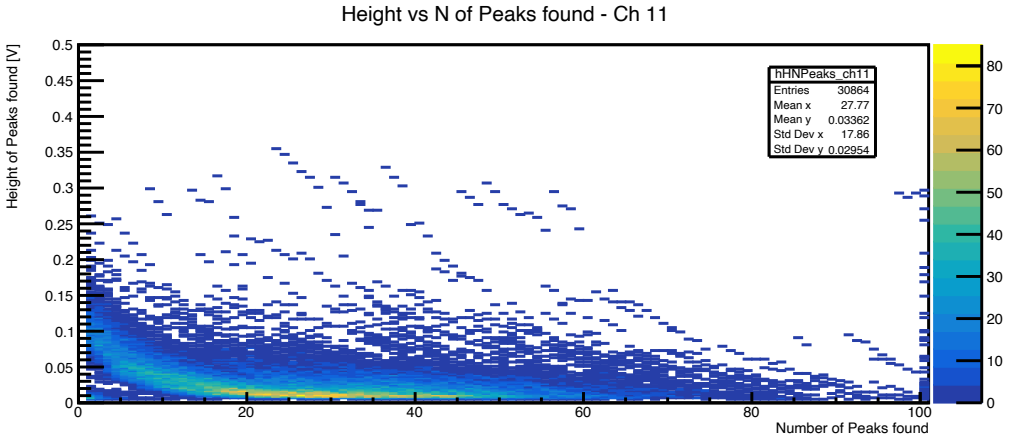


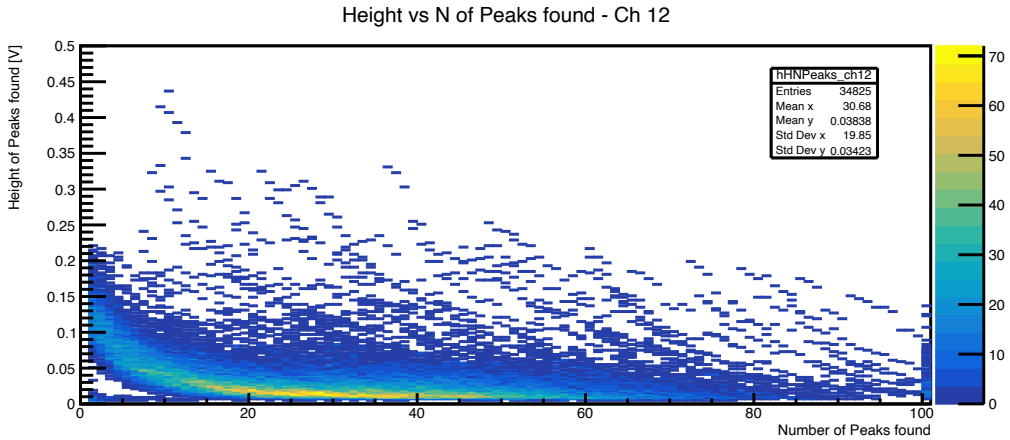
Height of Peaks vs Npeak for signal events

Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



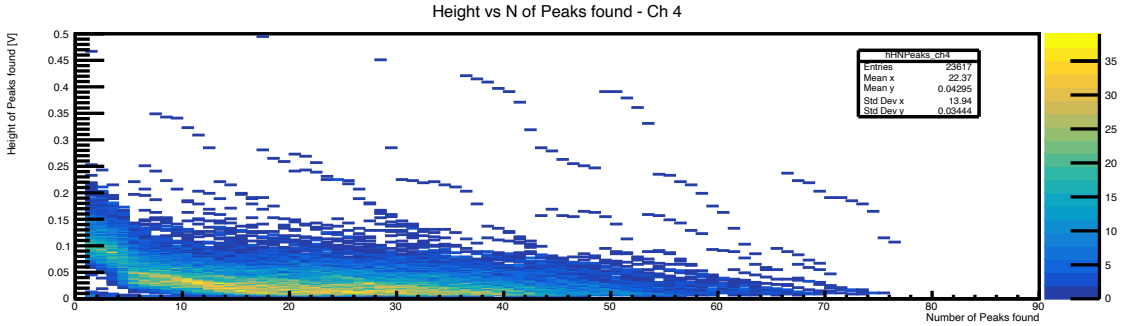


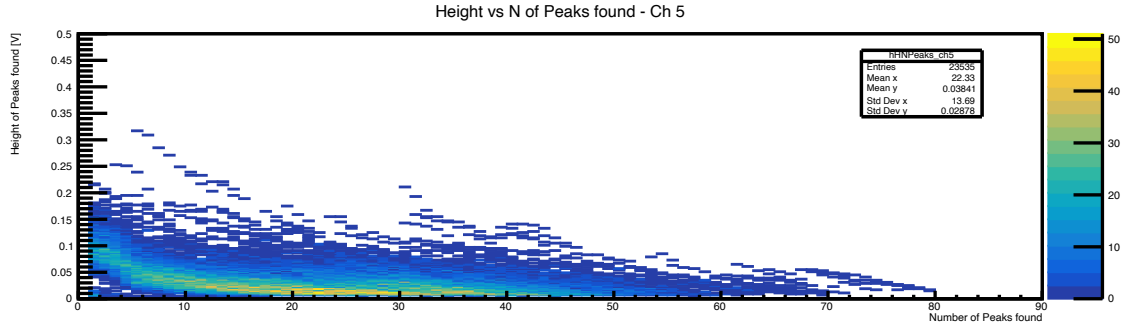


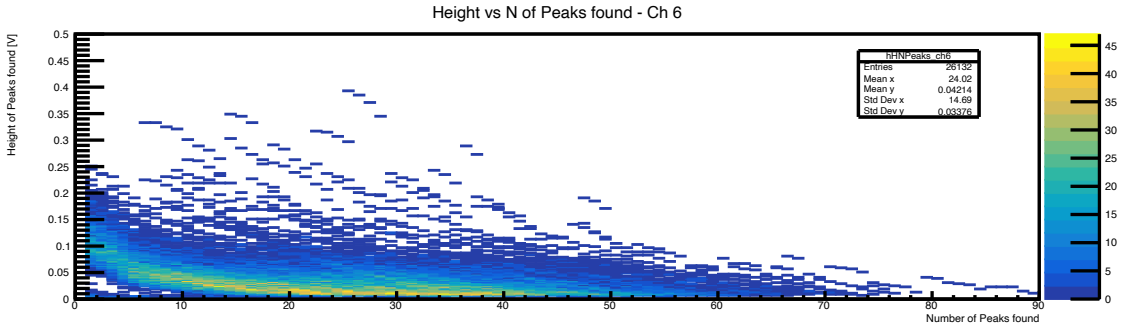
Height of Peaks vs Npeak for signal events

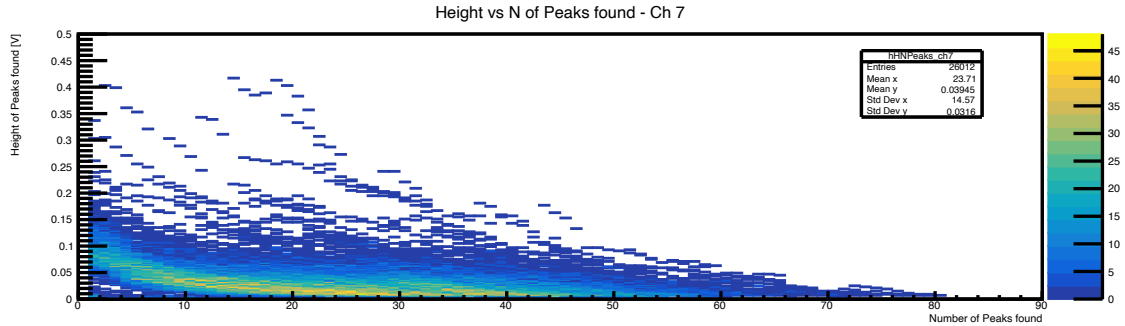
Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

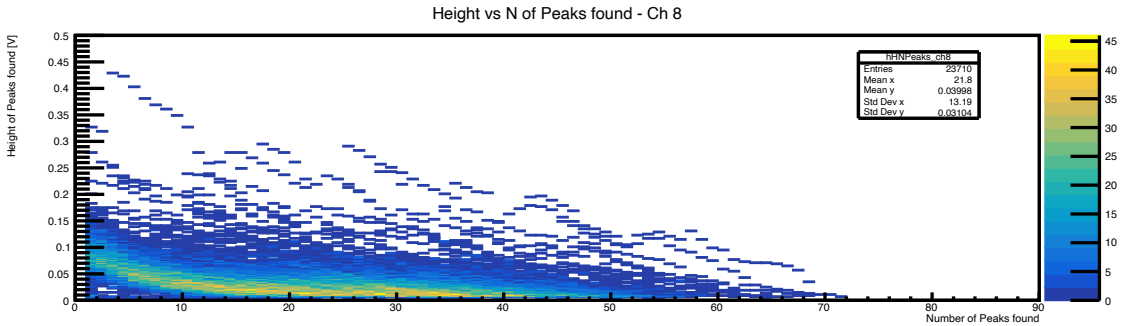
1 cm drift tubes

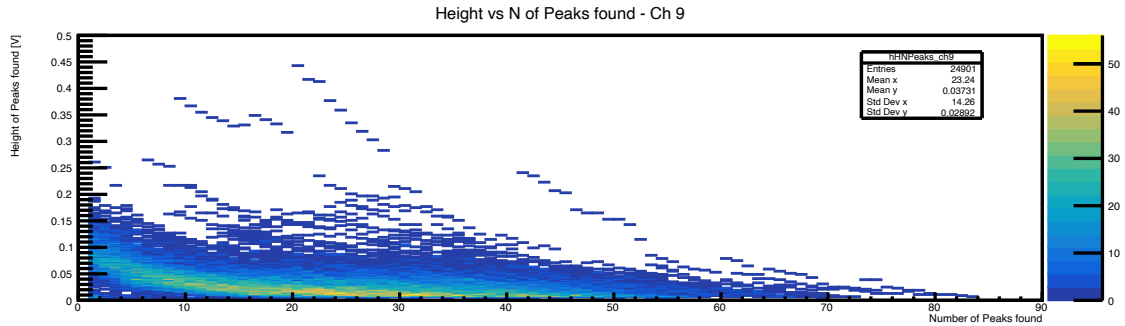










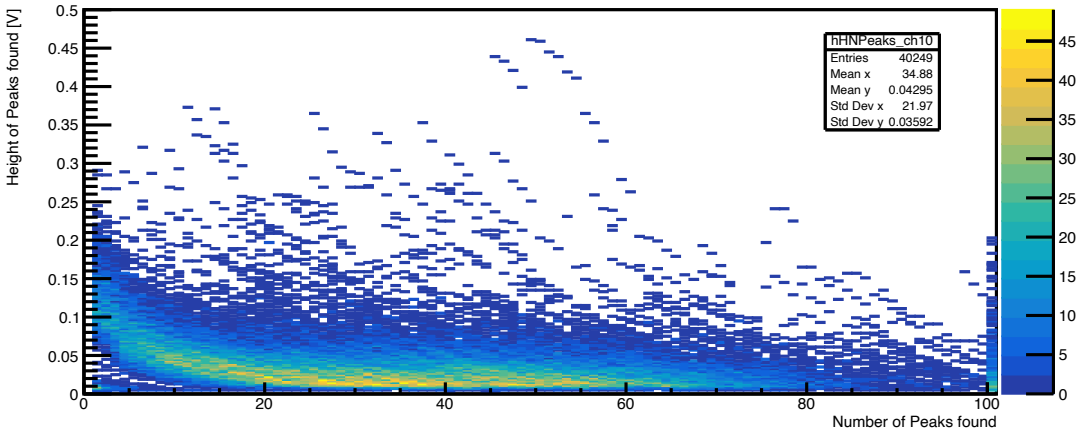


Height of Peaks vs Npeak for signal events

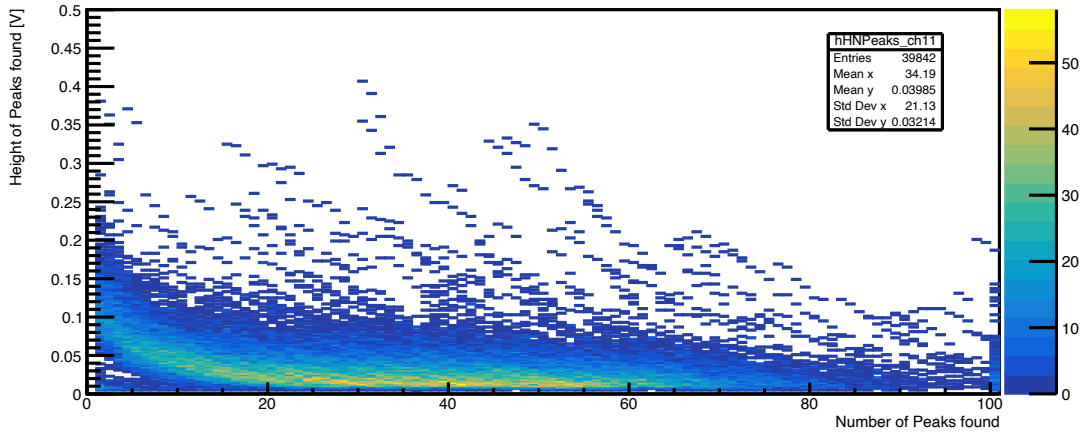
Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes

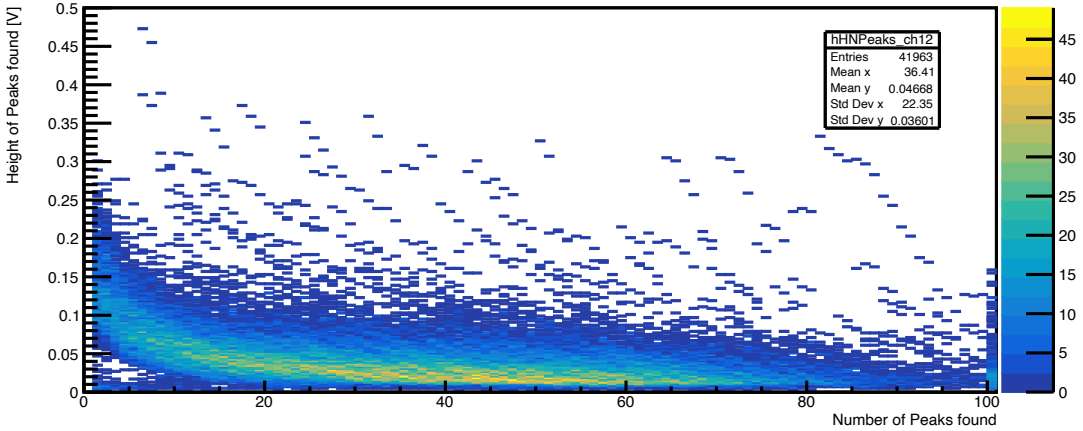
Height vs N of Peaks found - Ch 10



Height vs N of Peaks found - Ch 11



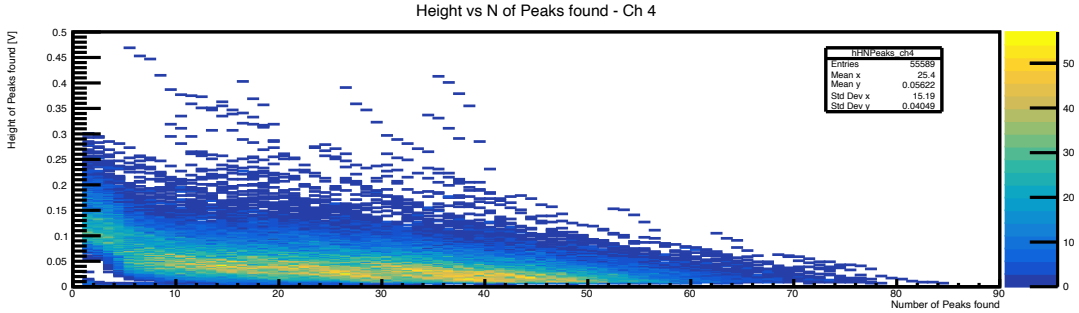
Height vs N of Peaks found - Ch 12

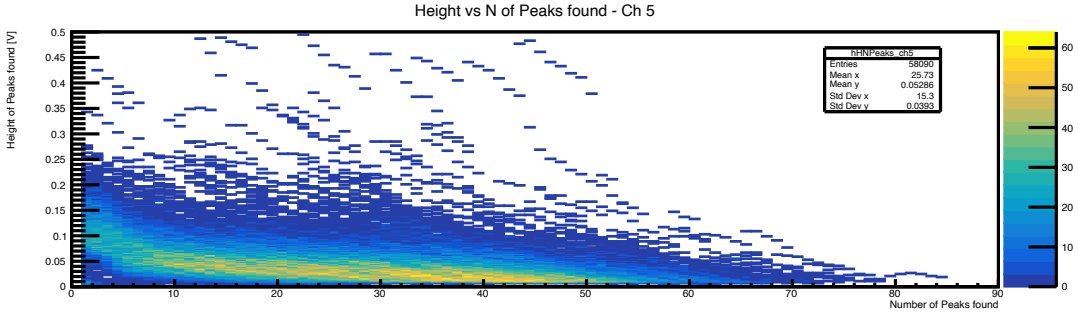


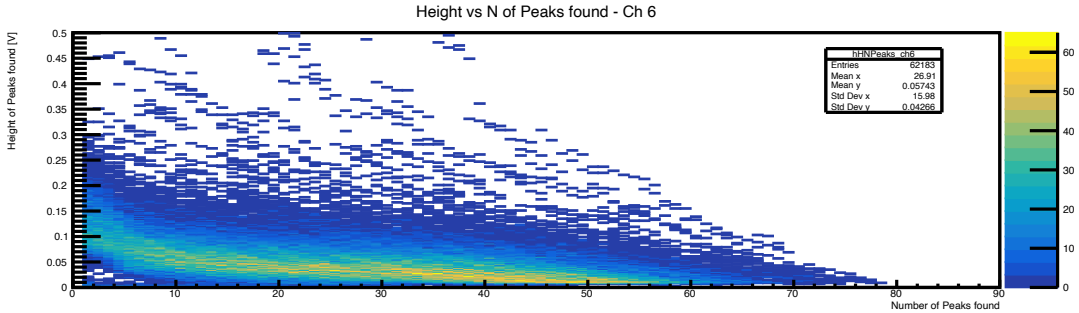
Height of Peaks vs Npeak for signal events

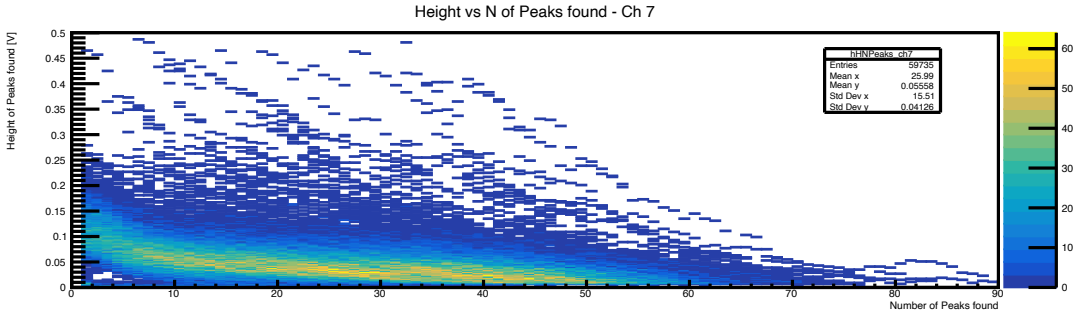
Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V

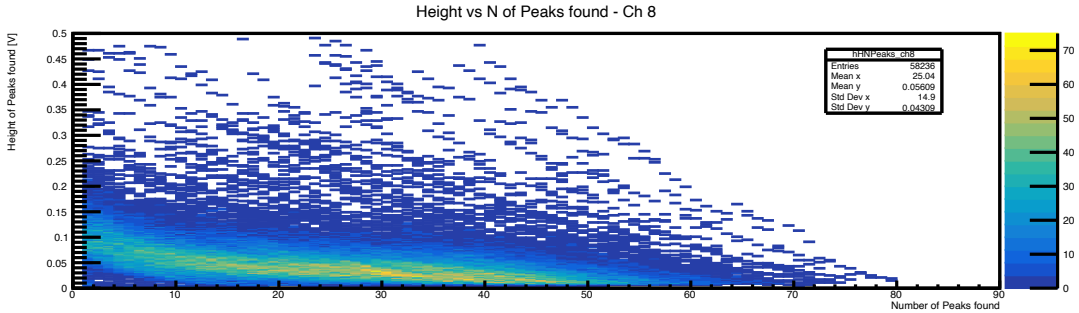
1 cm drift tubes

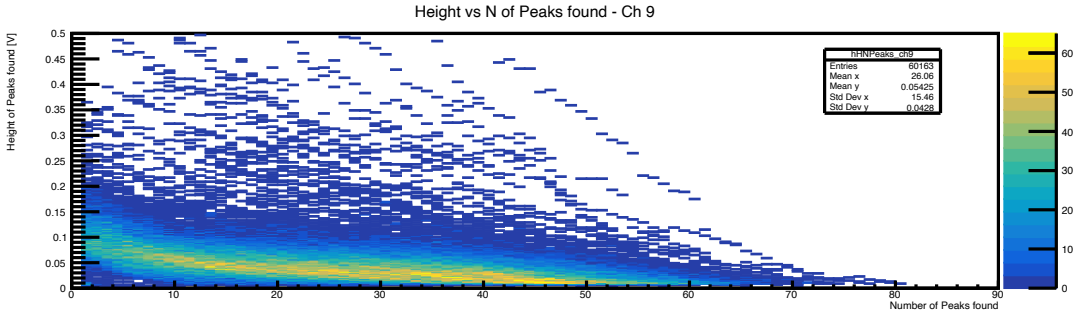










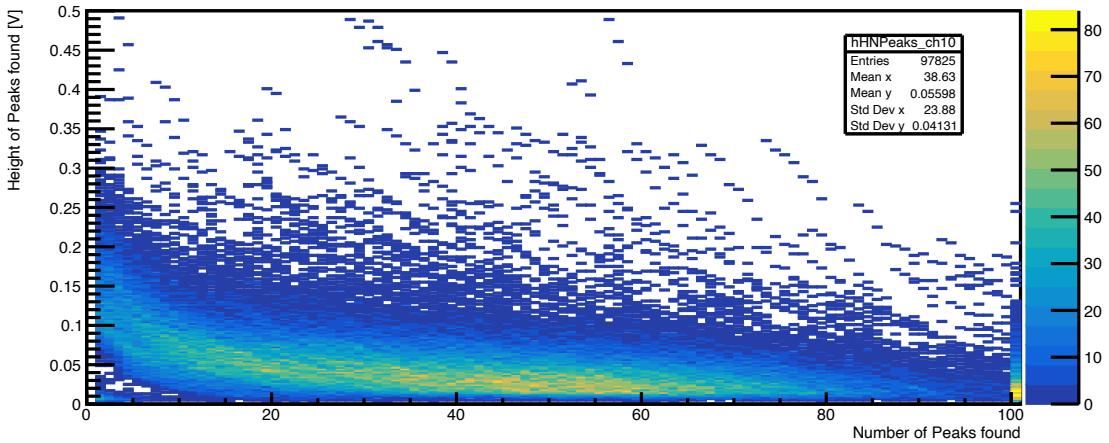


Height of Peaks vs Npeak for signal events

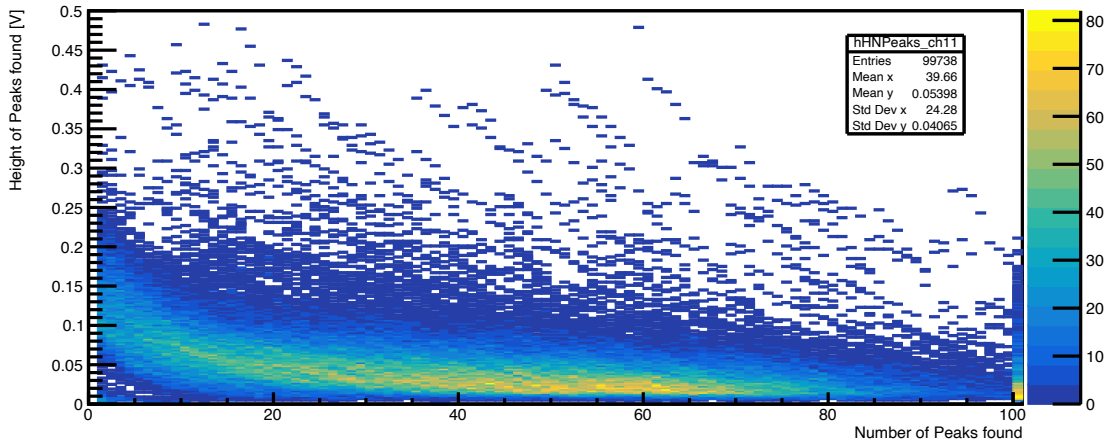
Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes

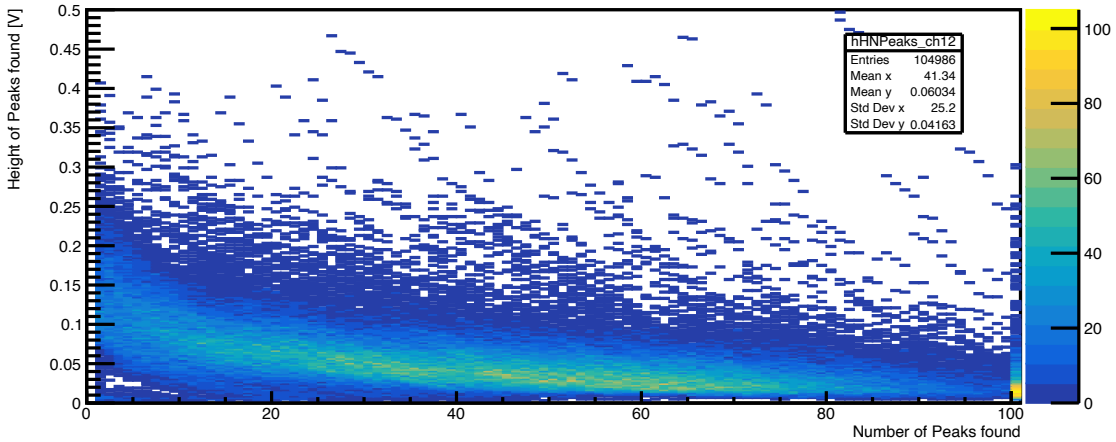
Height vs N of Peaks found - Ch 10



Height vs N of Peaks found - Ch 11



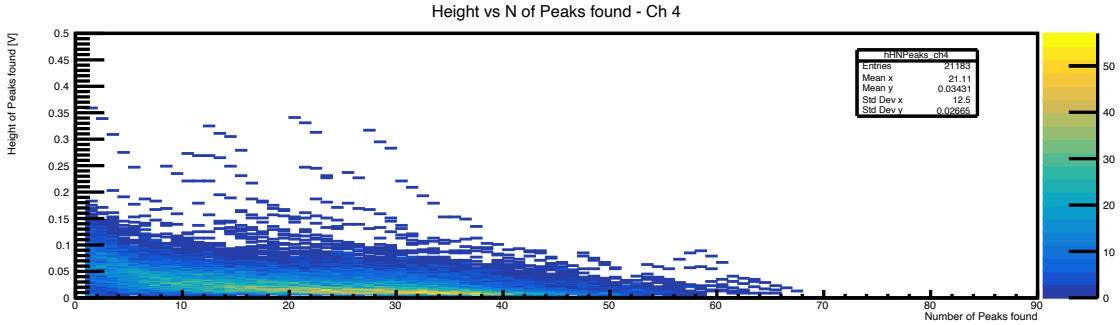
Height vs N of Peaks found - Ch 12

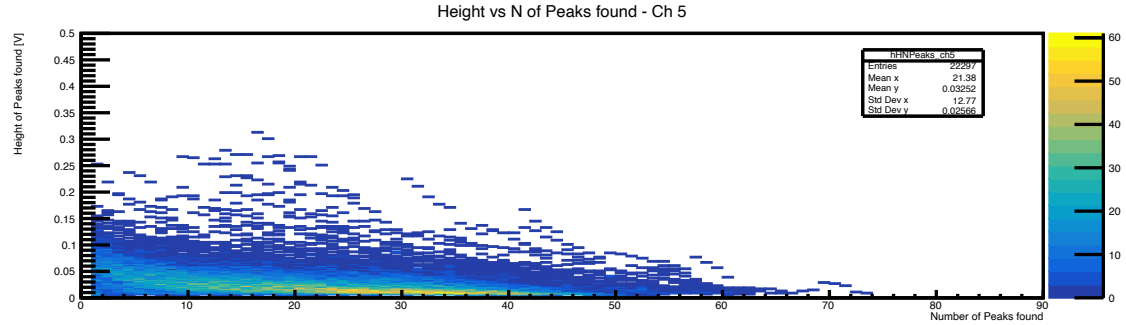


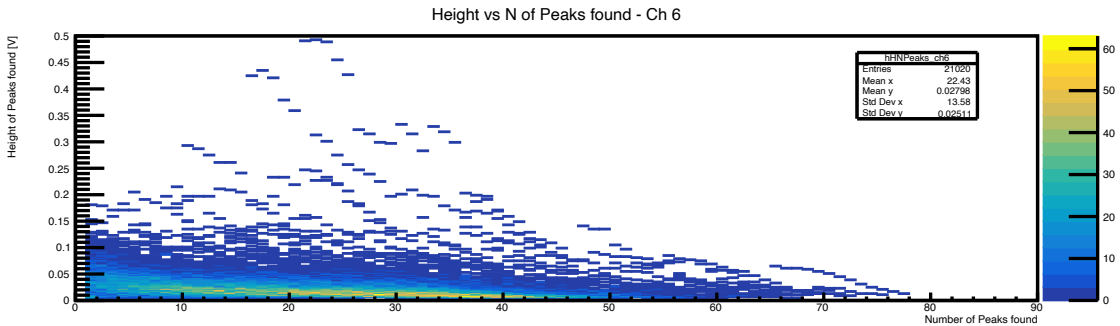
Height of Peaks vs Npeak for signal events

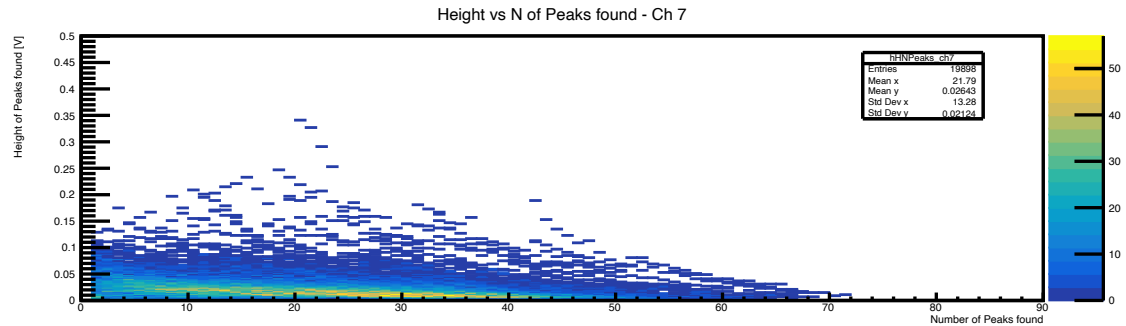
Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V

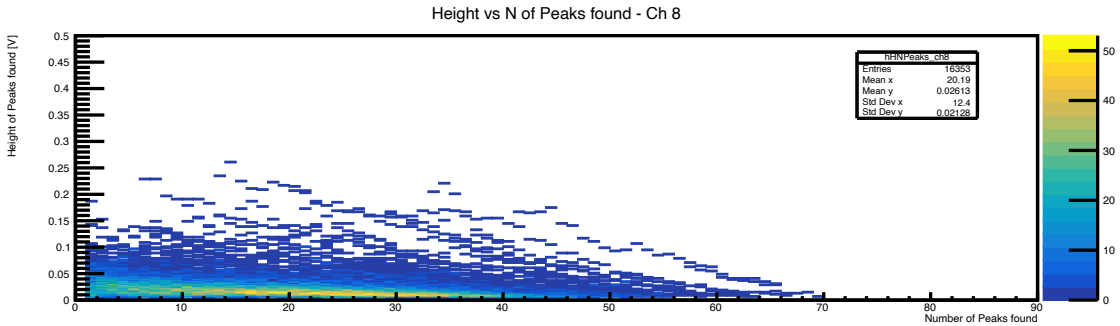
1 cm drift tubes

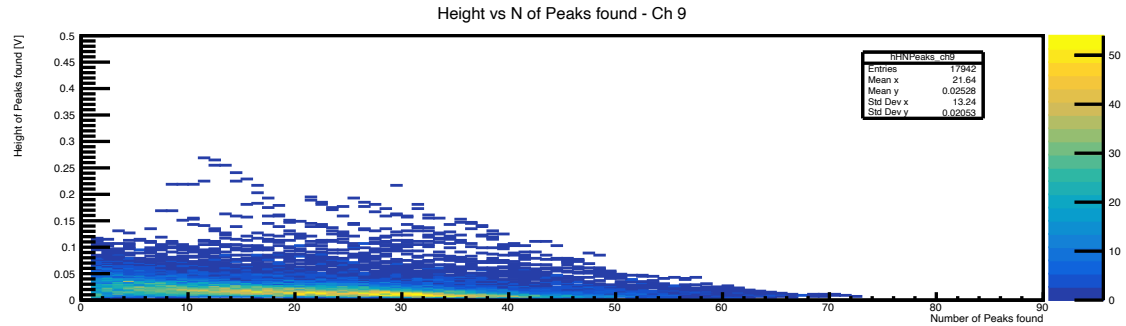






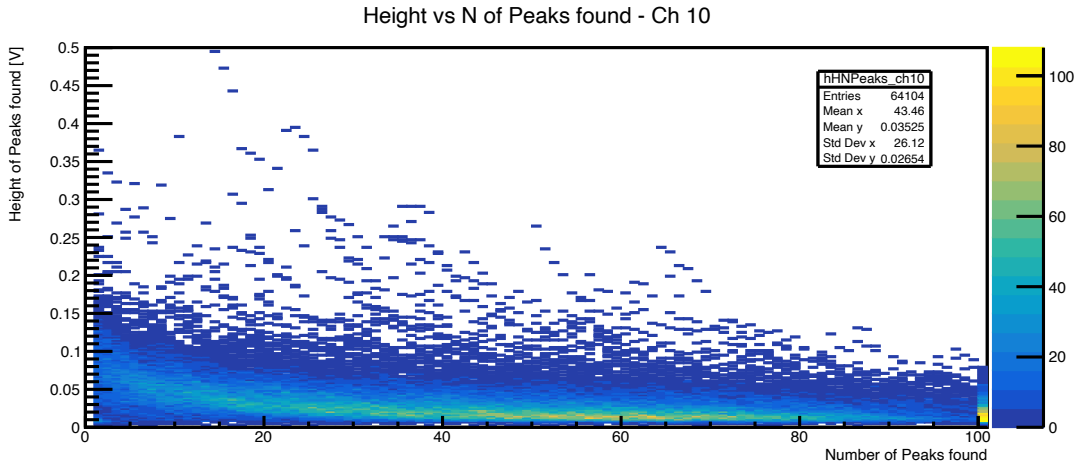


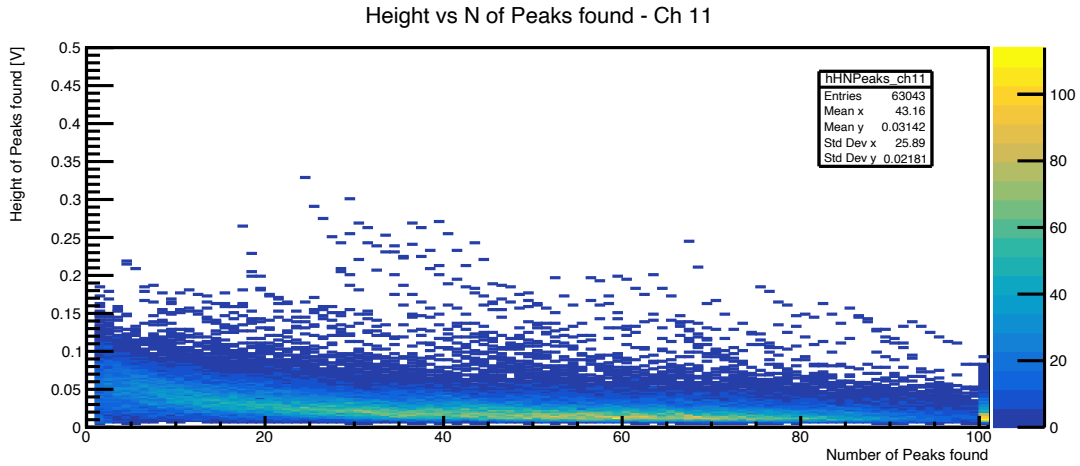


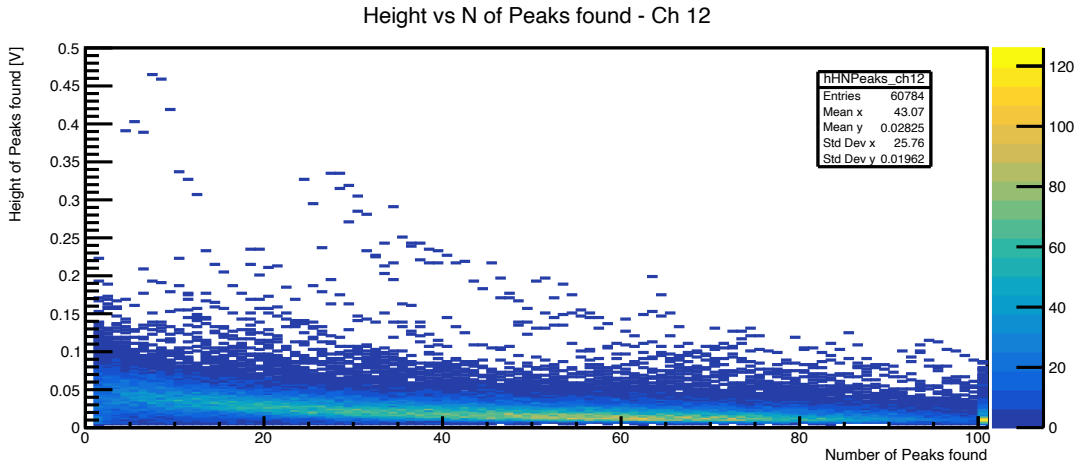


Height of Peaks vs Npeak for signal events

Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V 2 cm drift tubes



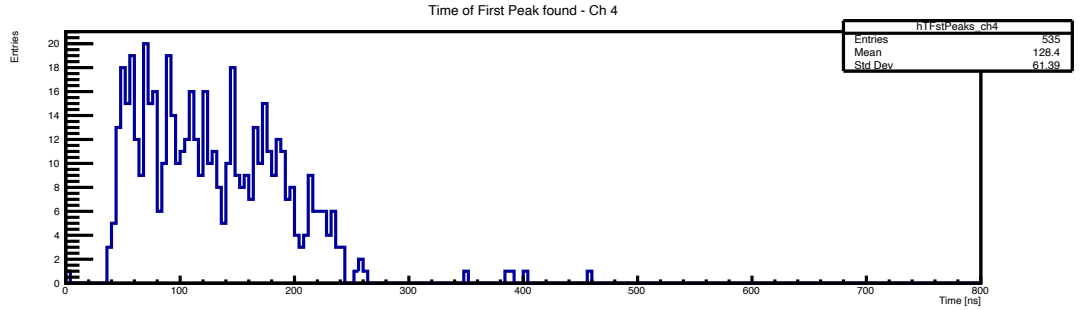


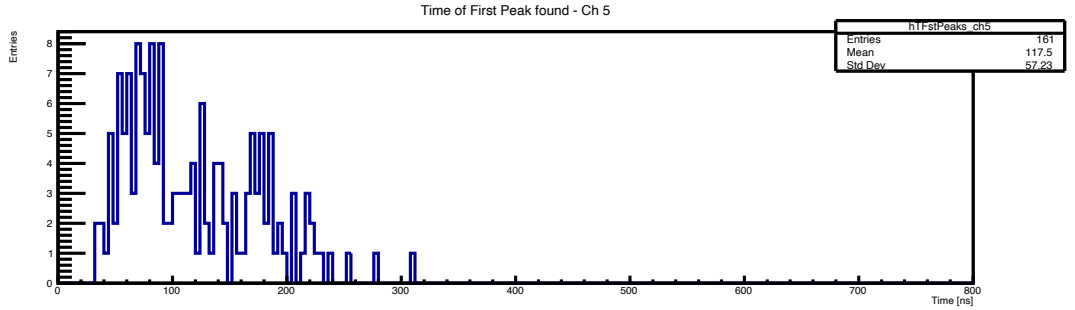


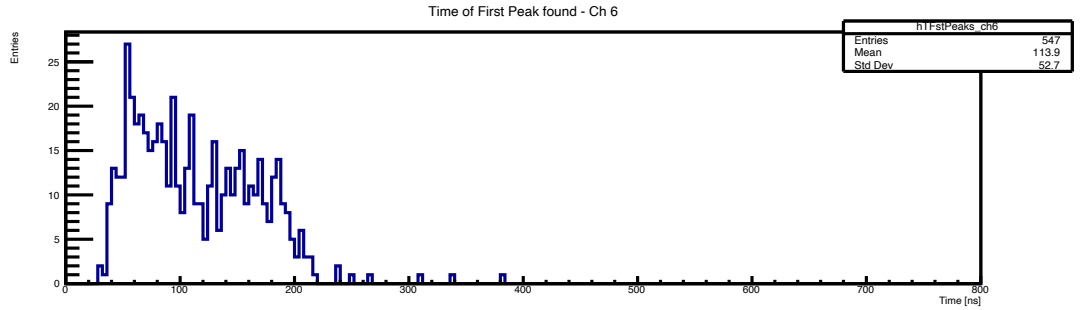
Time of First Peaks found for signal events

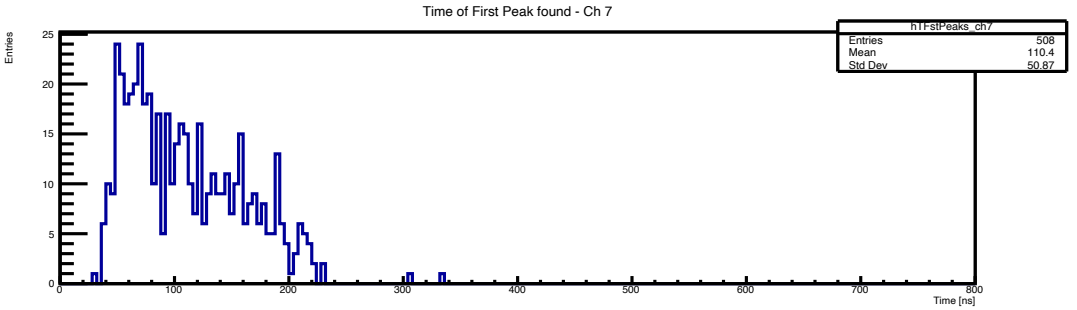
Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

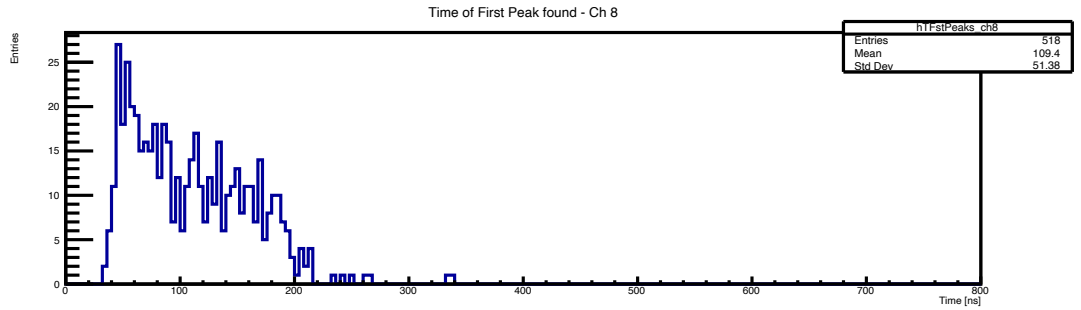
1 cm drift tubes

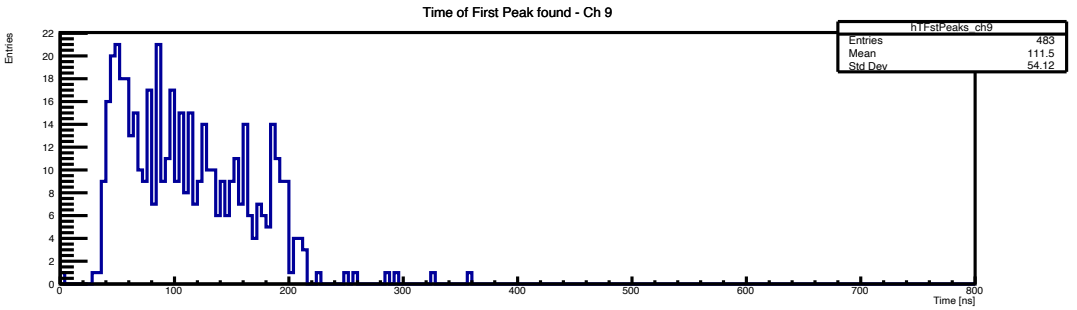








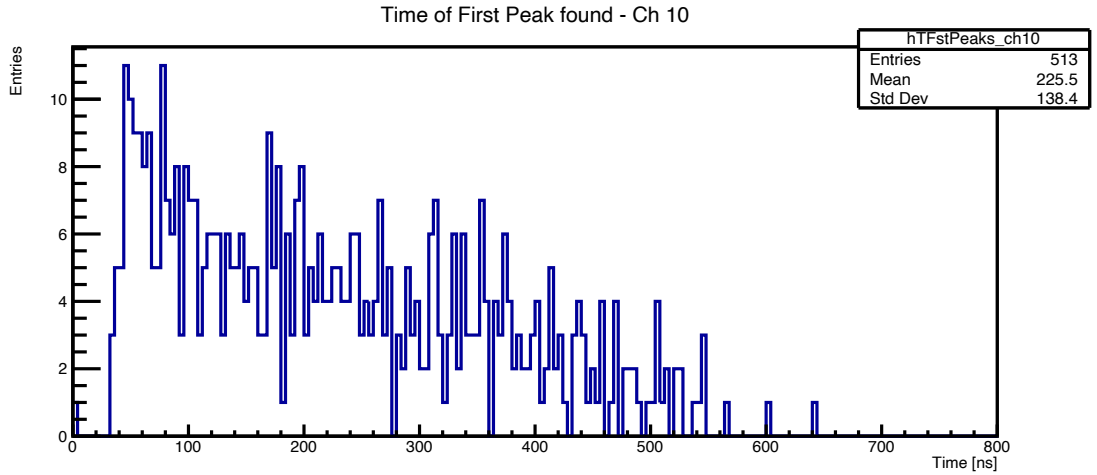


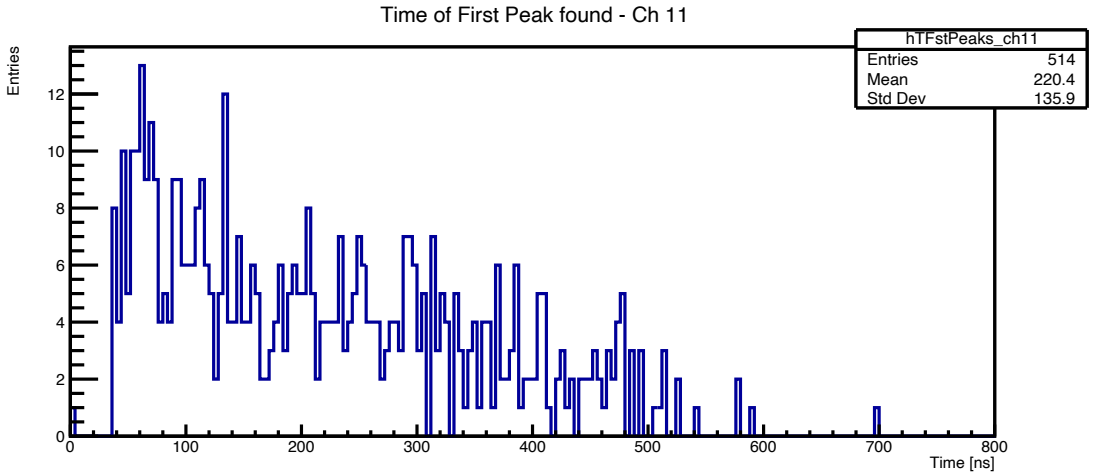


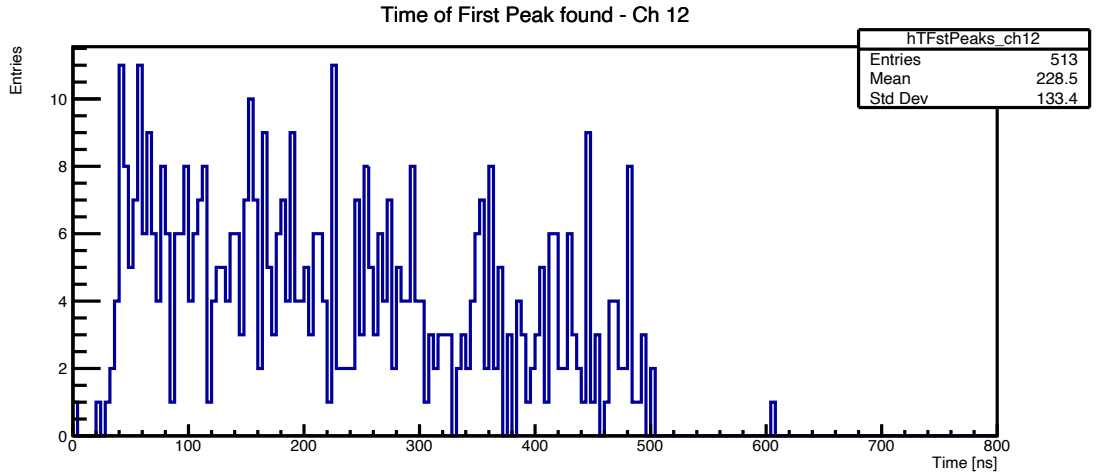
Time of First Peaks found for signal events

Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



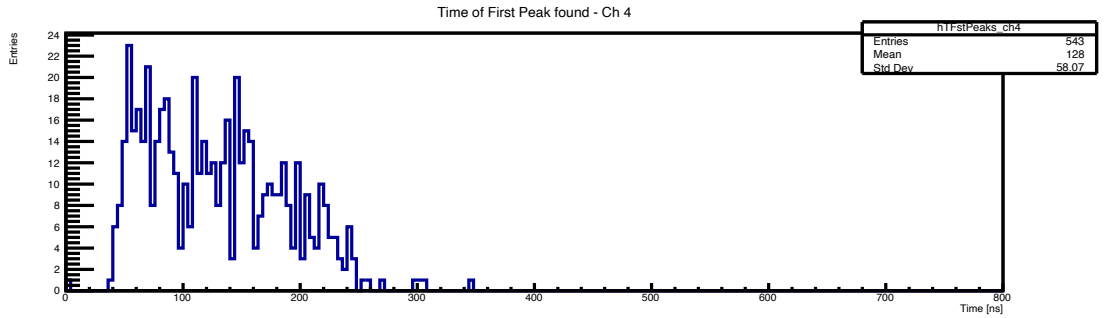


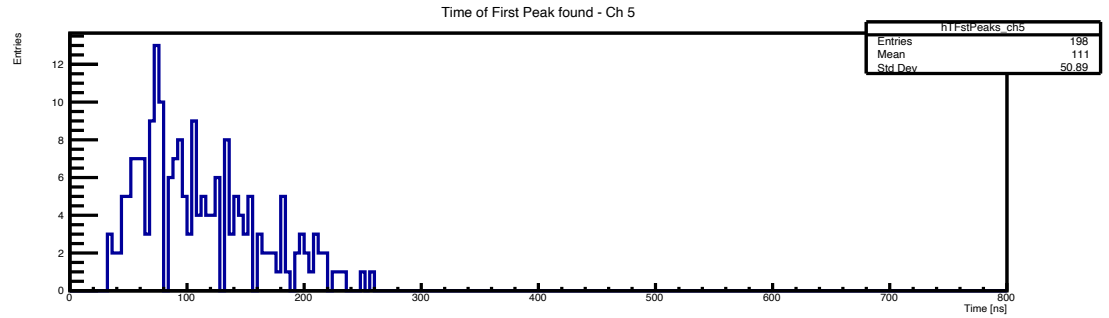


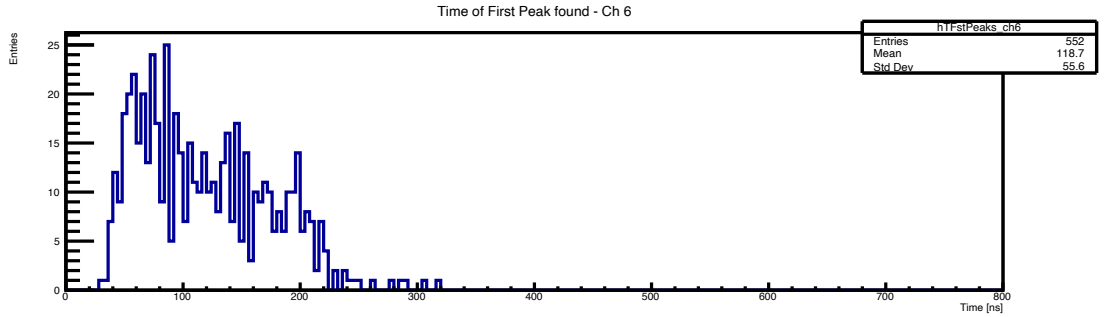
Time of First Peaks found for signal events

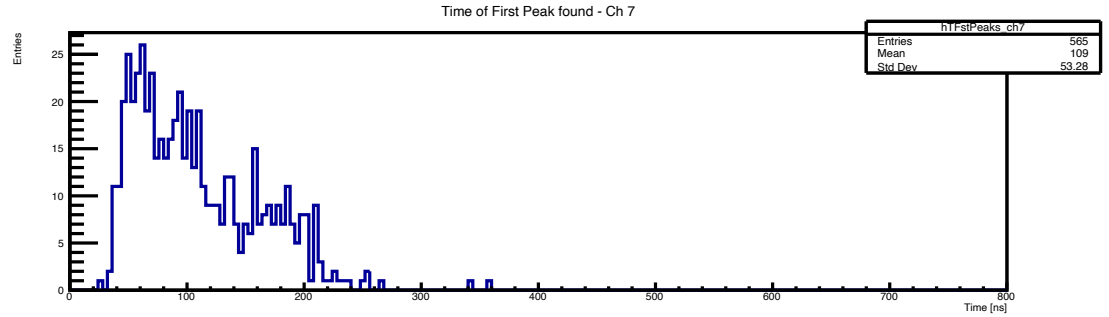
Run: run_98.root; Track angle: 15° ; Gas mixture: 90%He ; HV = +20V

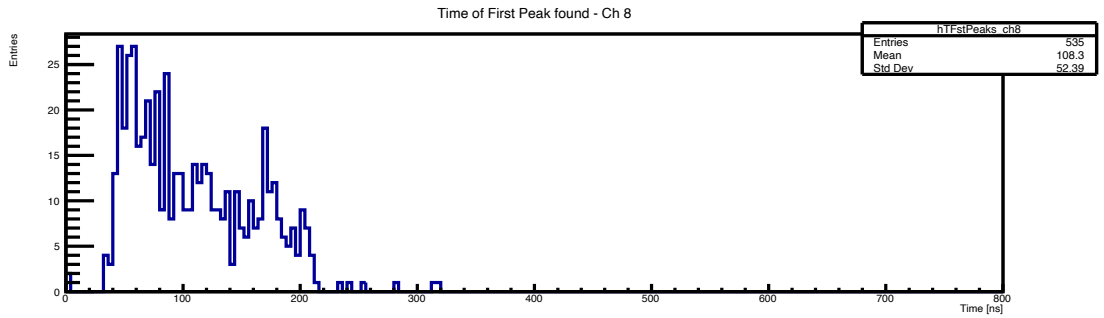
1 cm drift tubes

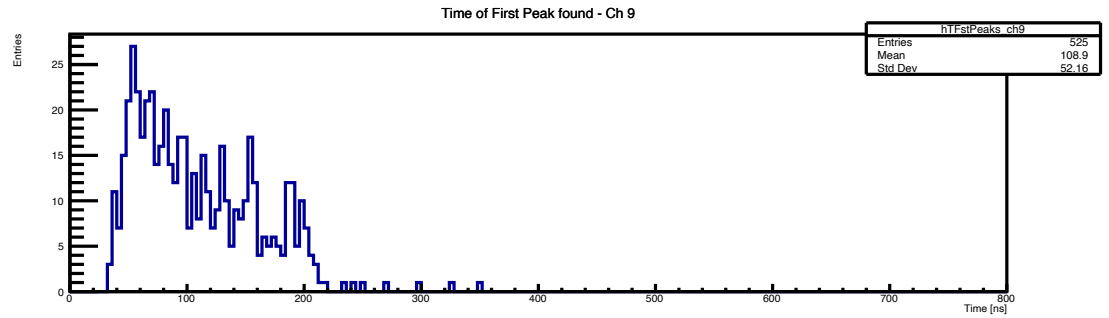








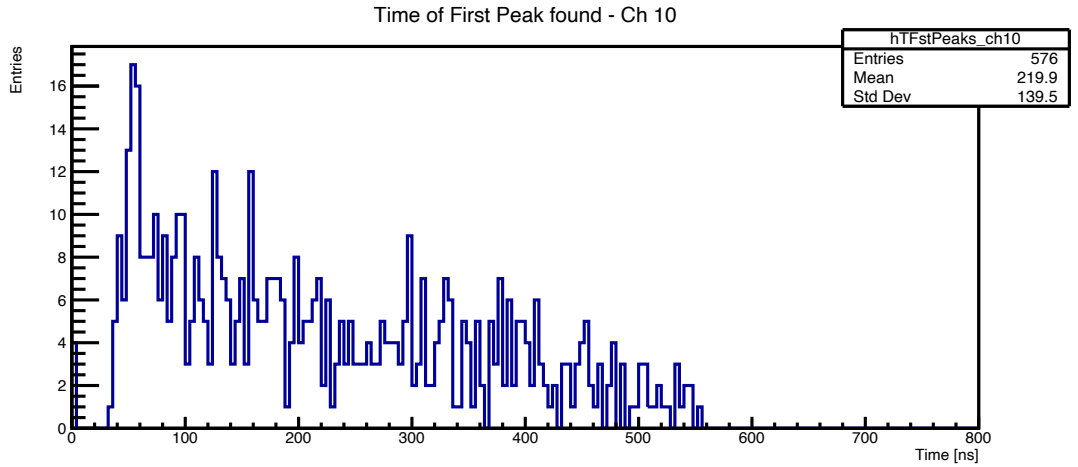


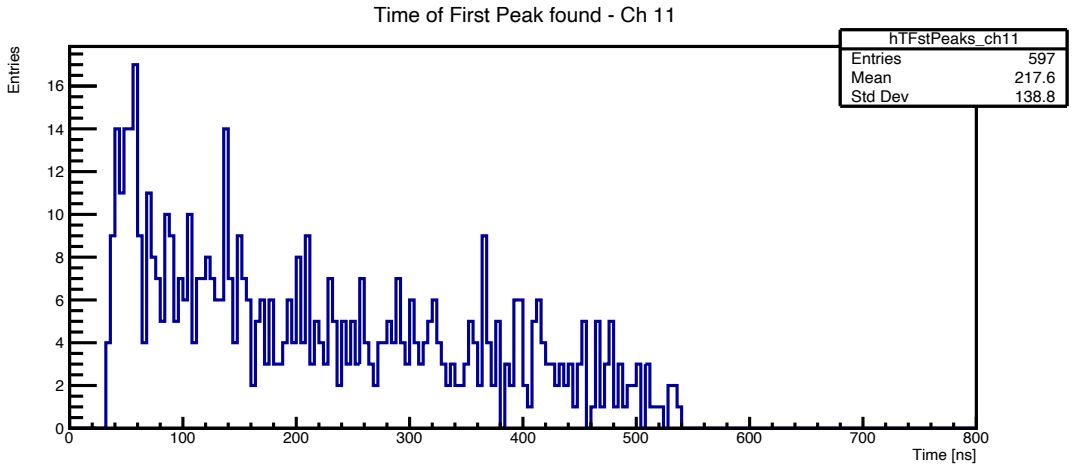


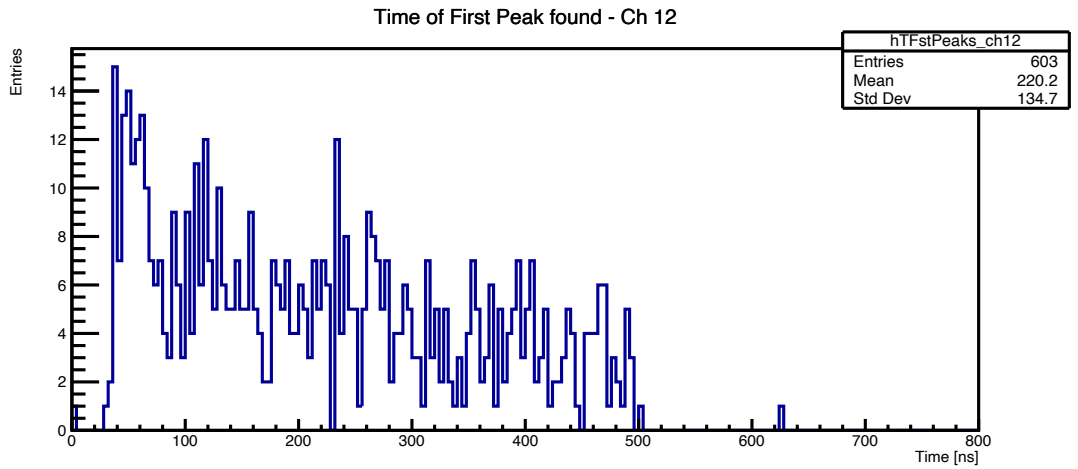
Time of First Peaks found for signal events

Run: run_98.root; Track angle: 15° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



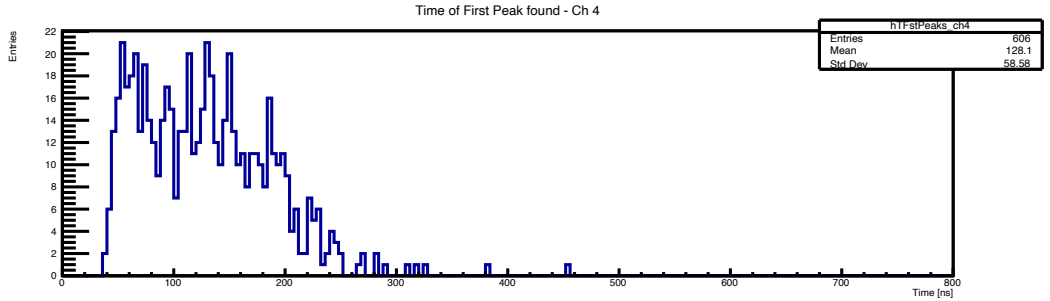


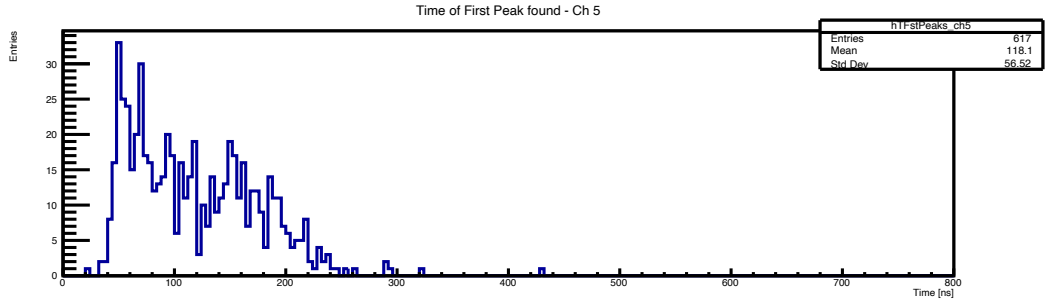


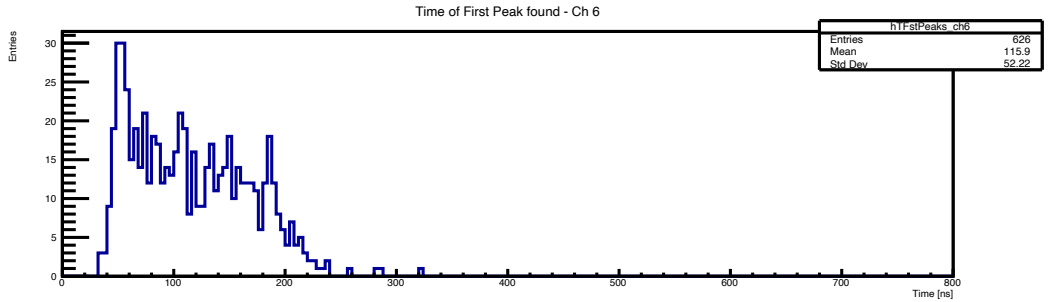
Time of First Peaks found for signal events

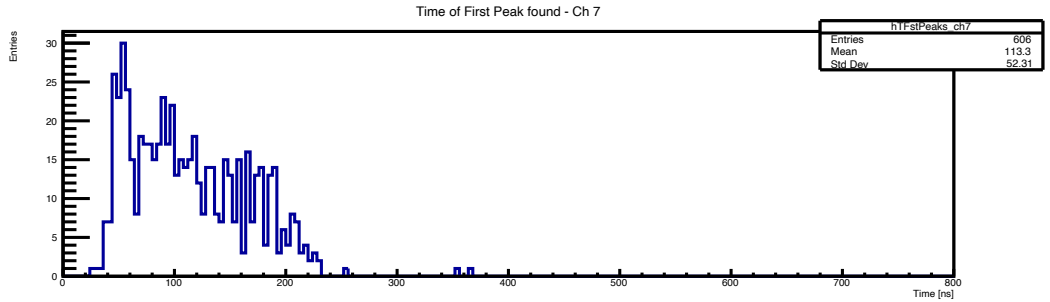
Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

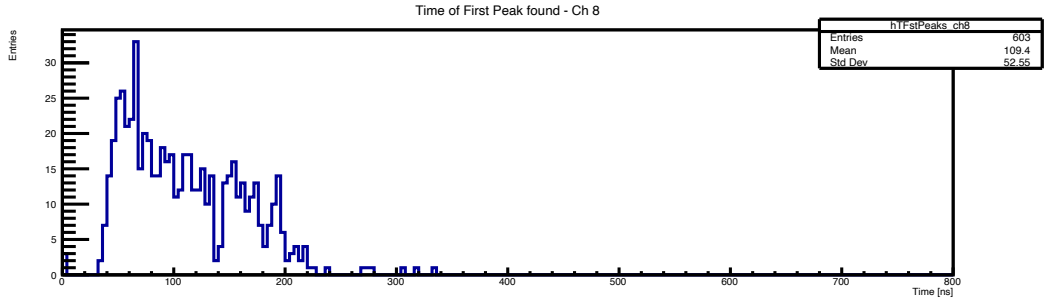
1 cm drift tubes

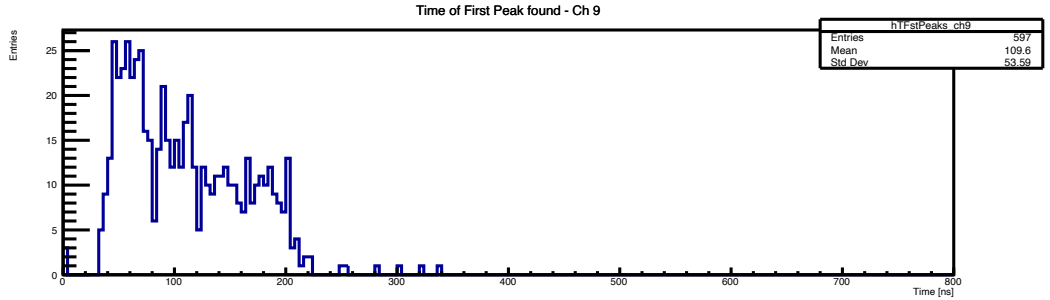








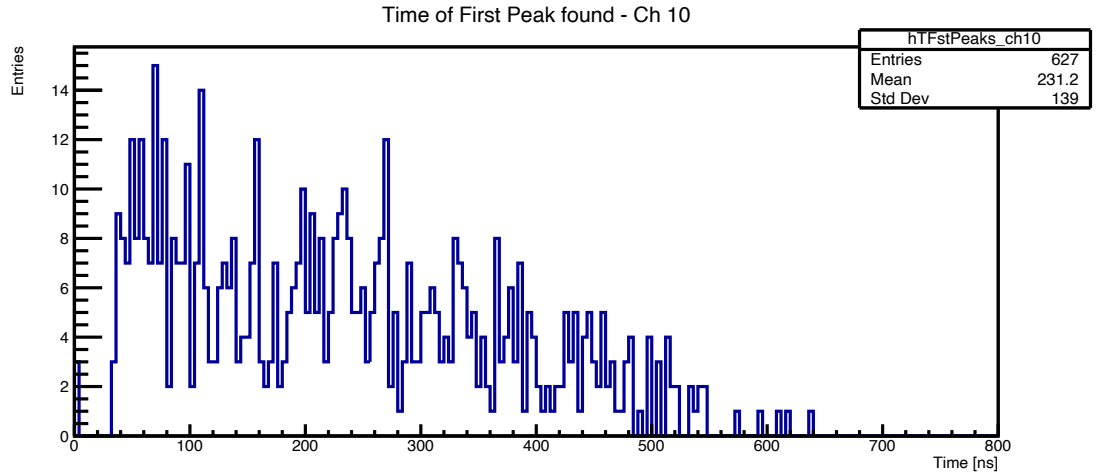


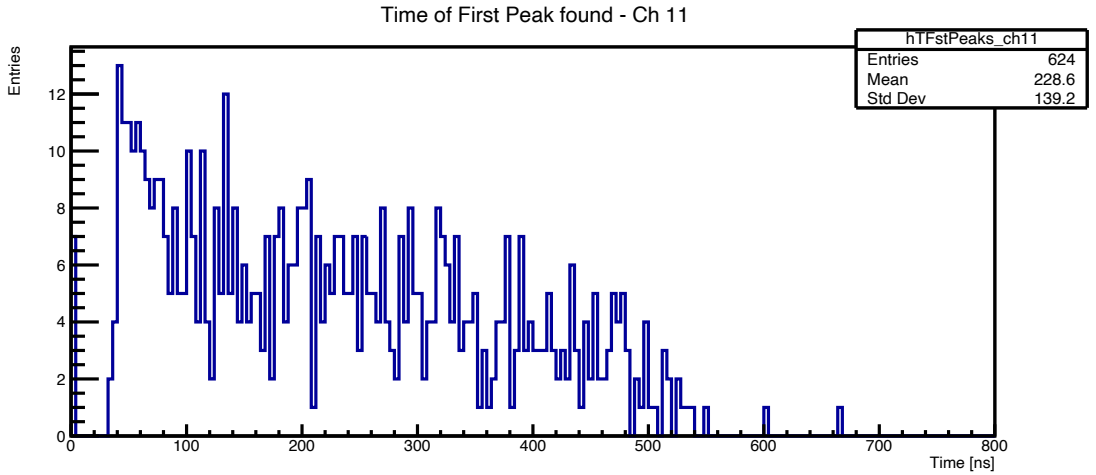


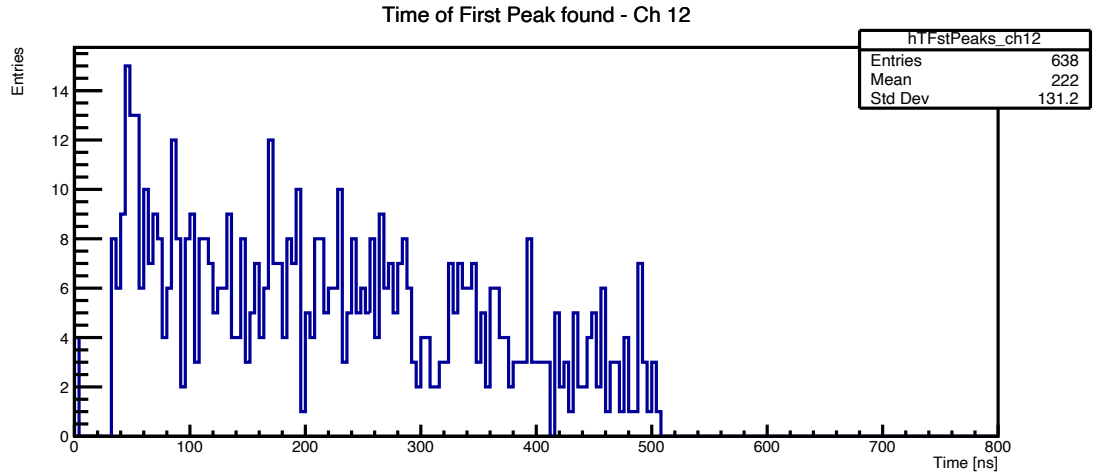
Time of First Peaks found for signal events

Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



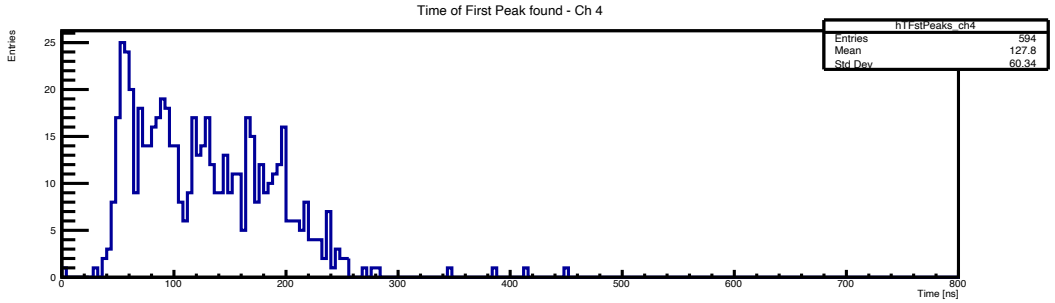


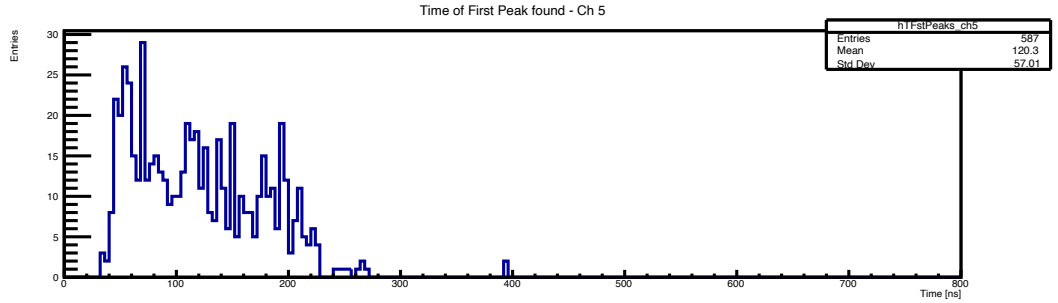


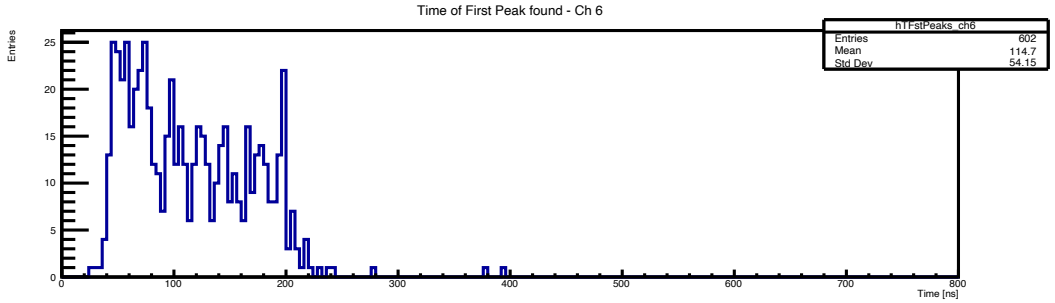
Time of First Peaks found for signal events

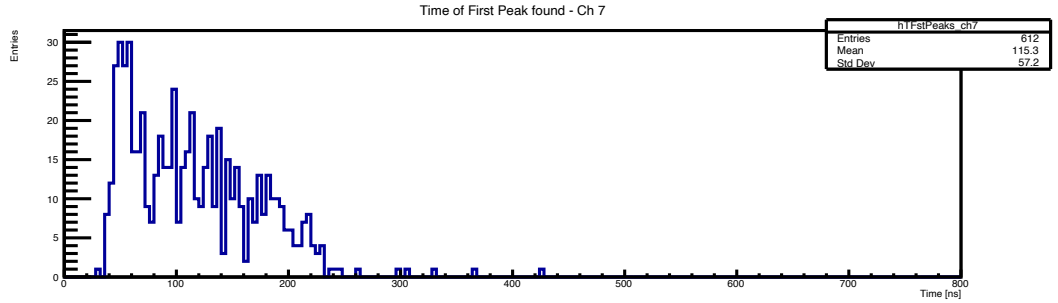
Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

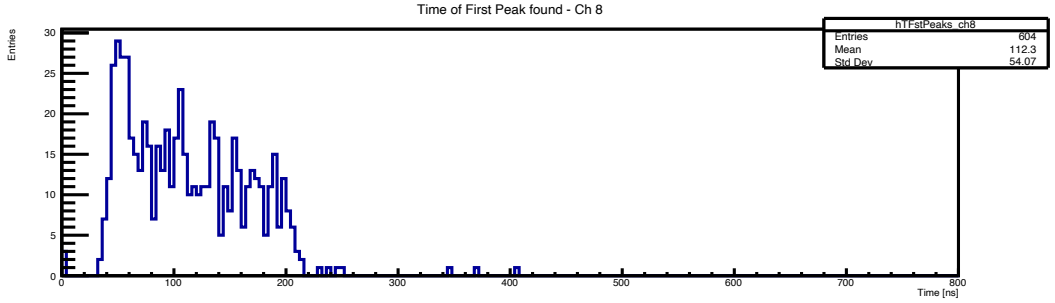
1 cm drift tubes

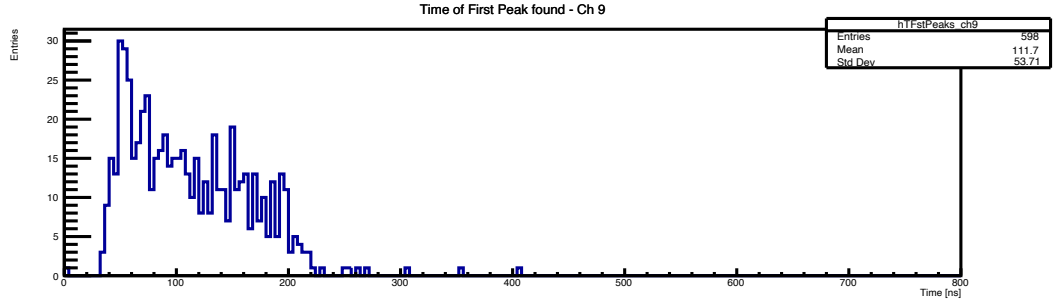








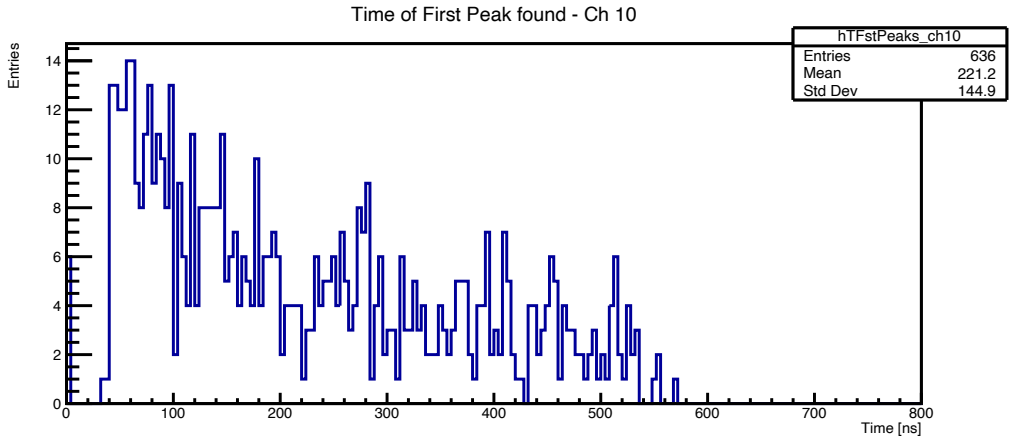


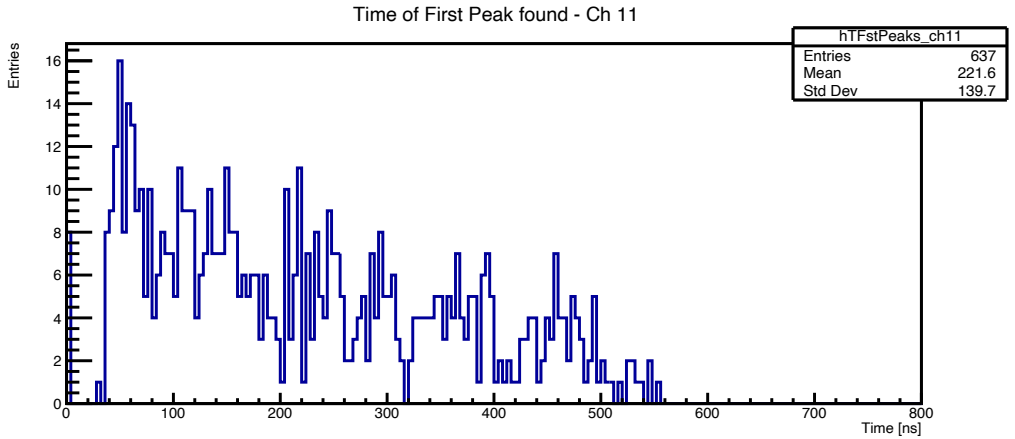


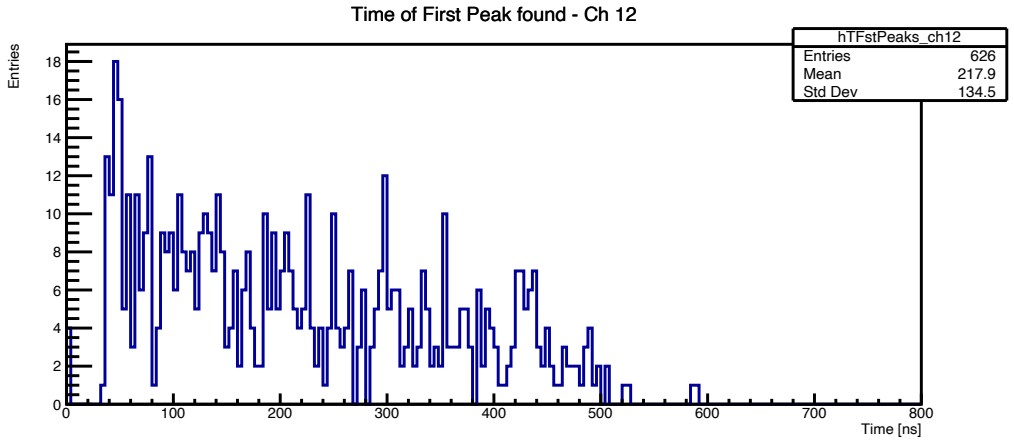
Time of First Peaks found for signal events

Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



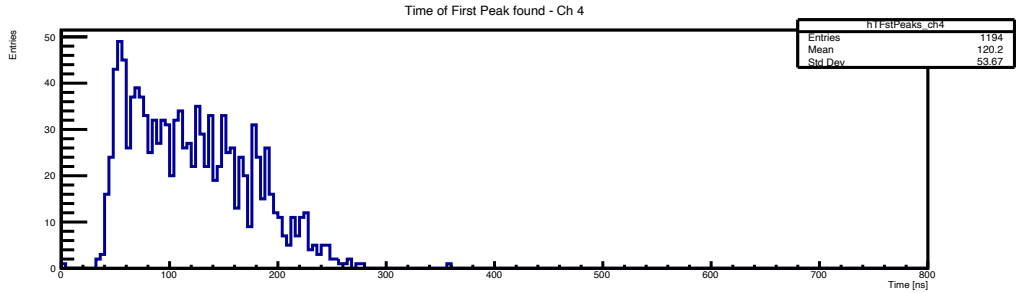


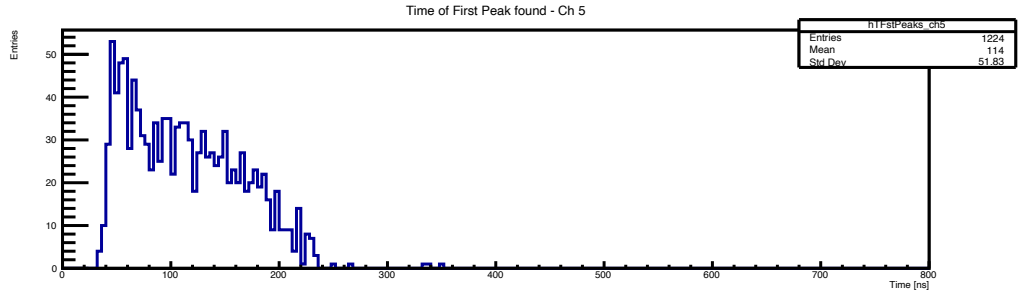


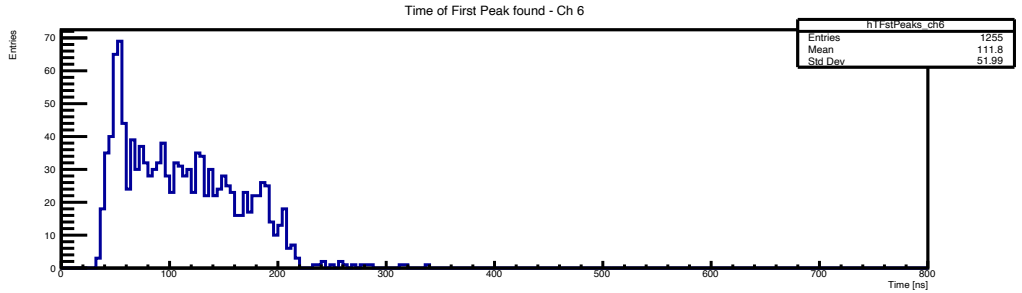
Time of First Peaks found for signal events

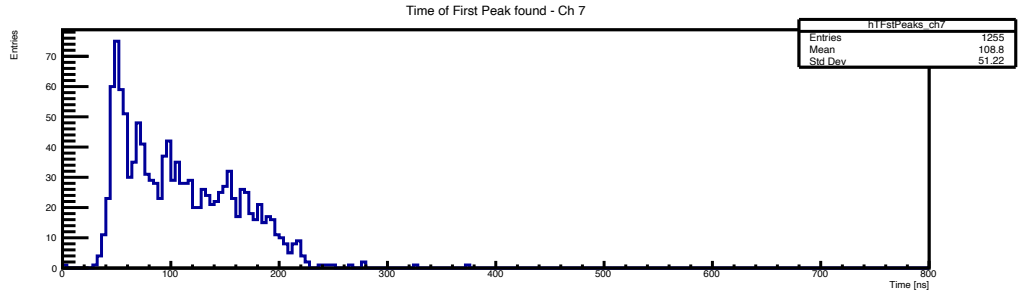
Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V

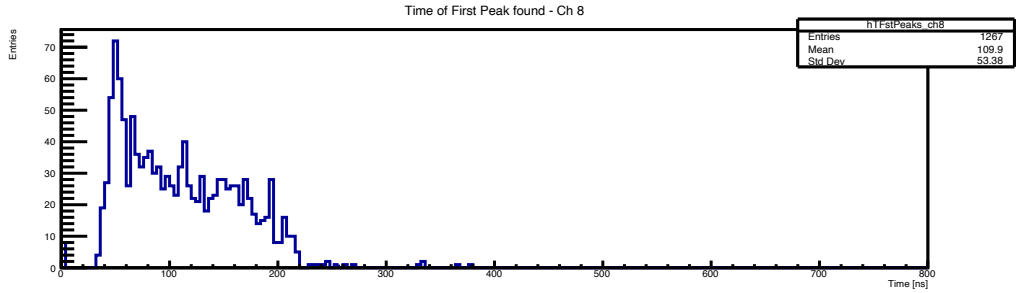
1 cm drift tubes

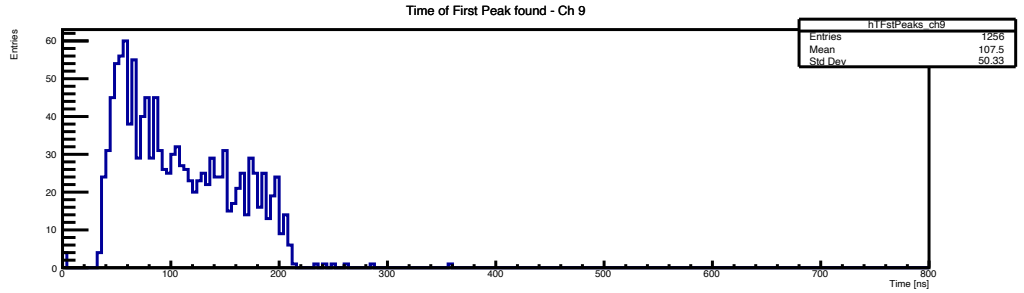








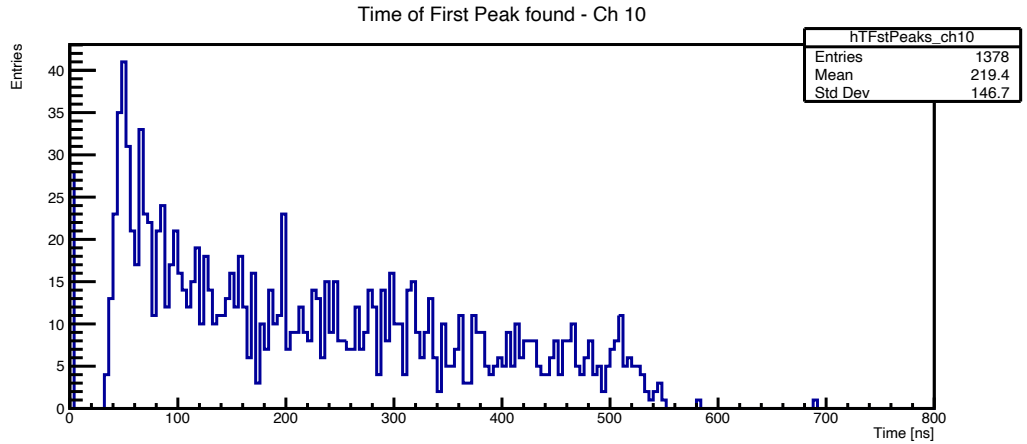


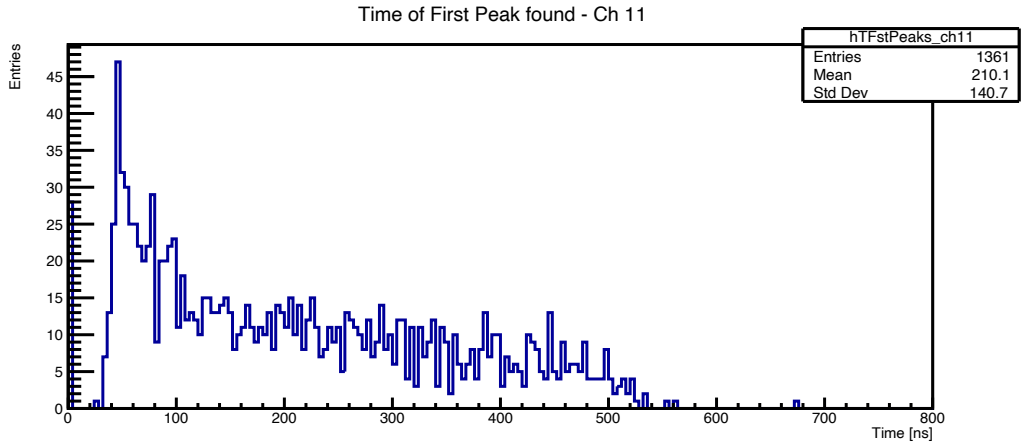


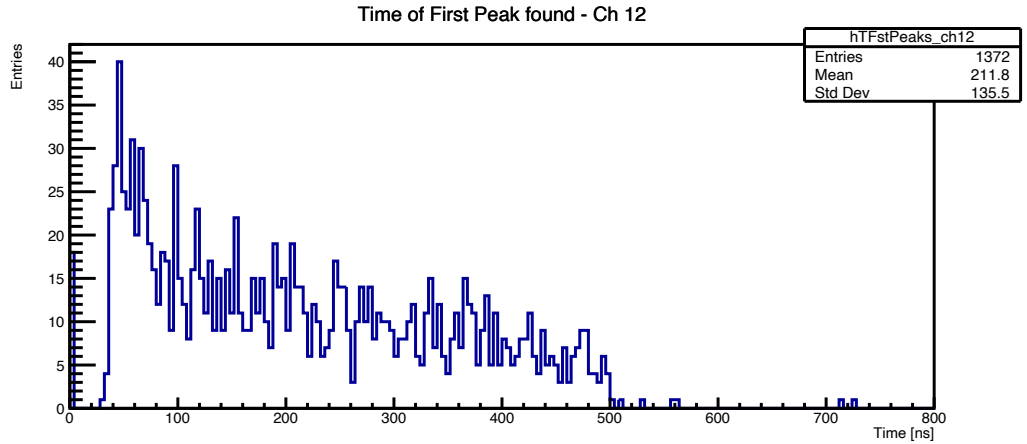
Time of First Peaks found for signal events

Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



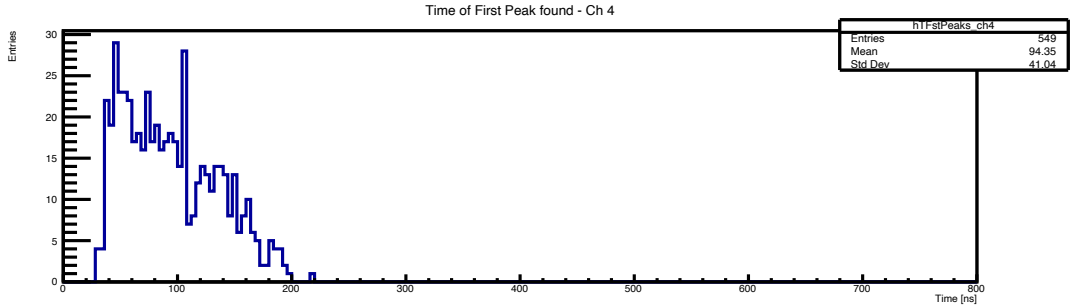


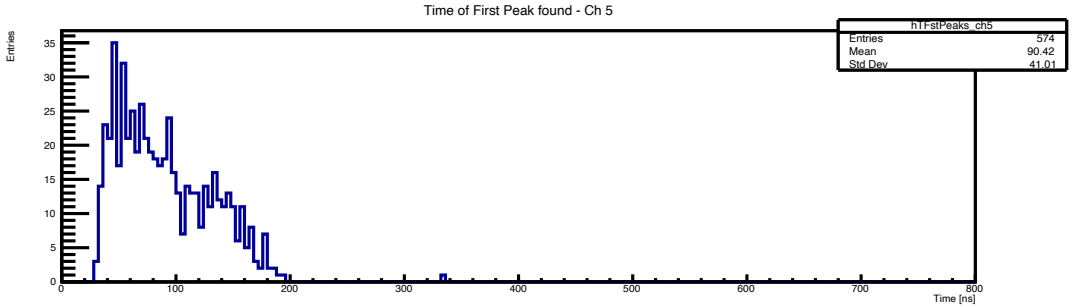


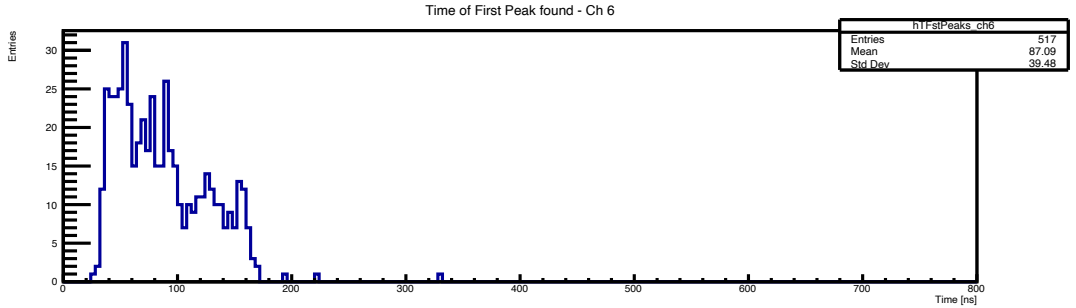
Time of First Peaks found for signal events

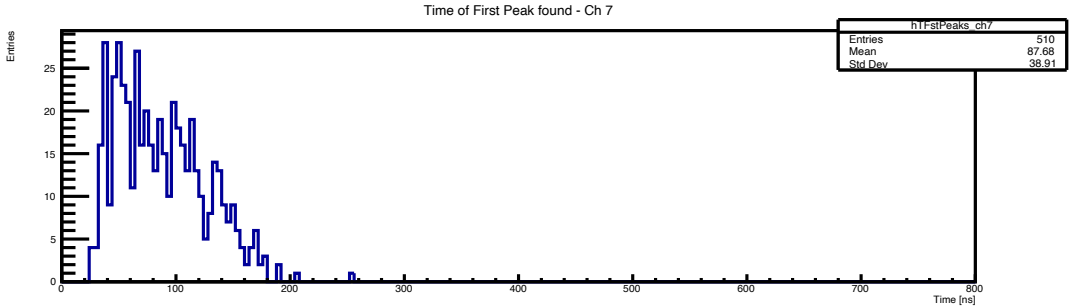
Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V

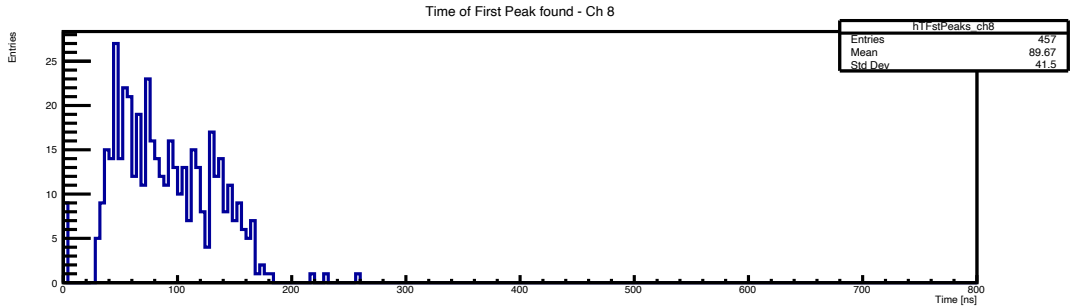
1 cm drift tubes

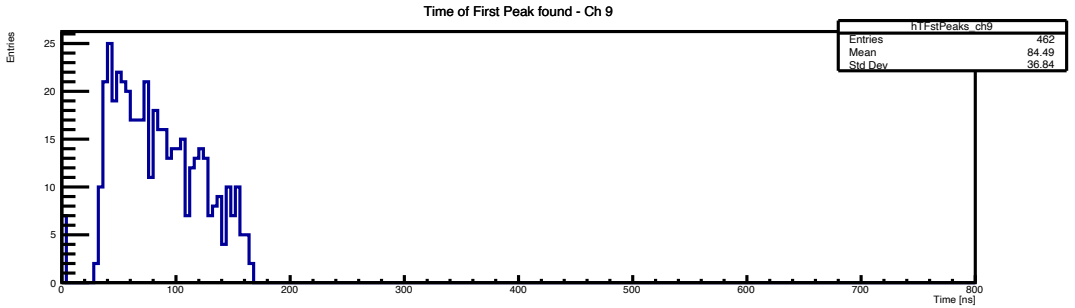








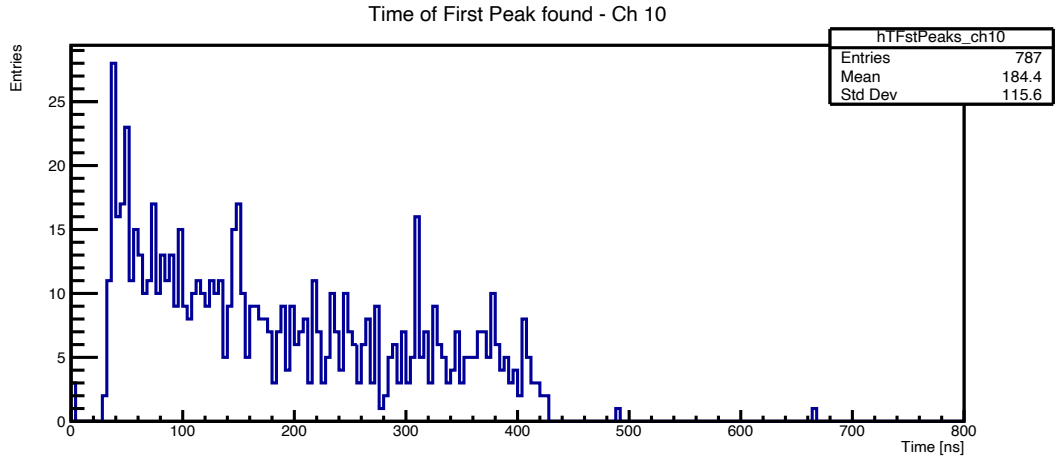


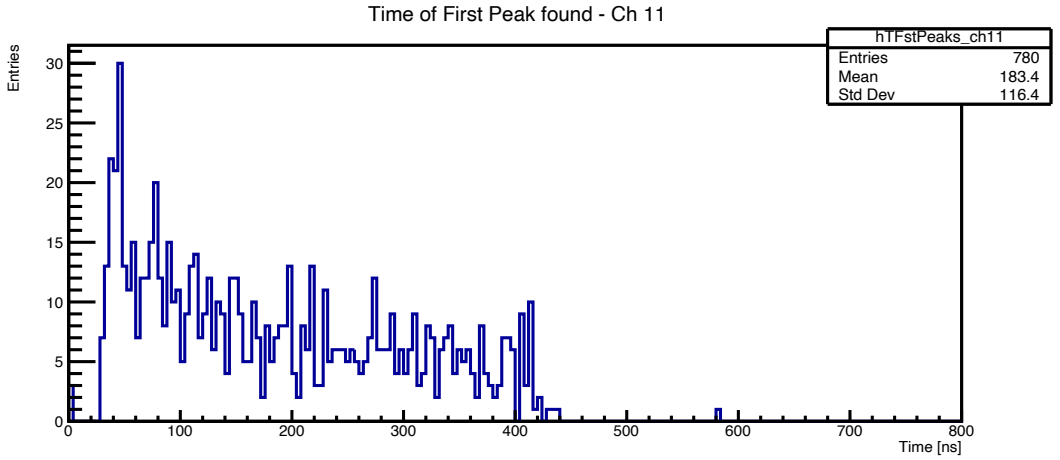


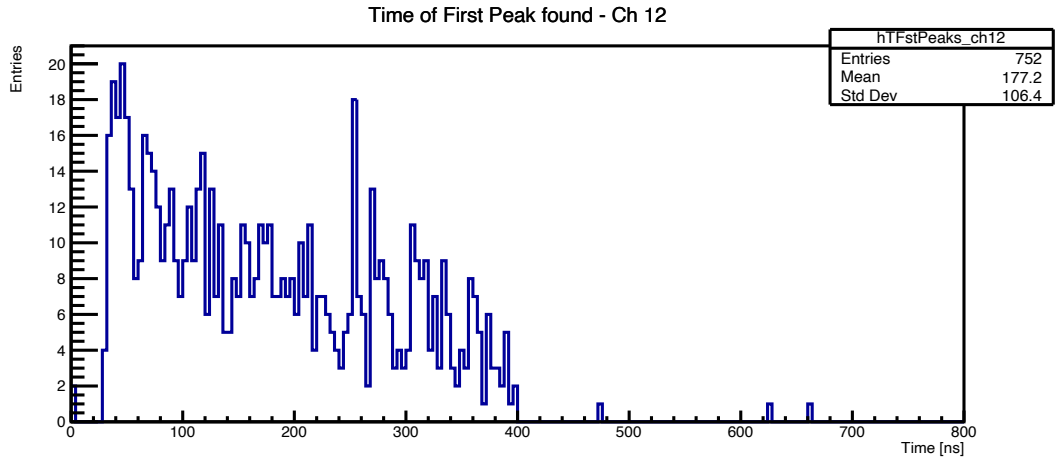
Time of First Peaks found for signal events

Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V

2 cm drift tubes



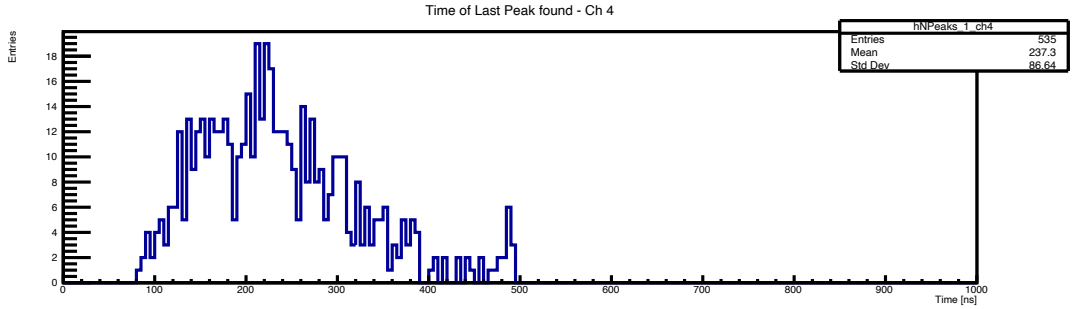


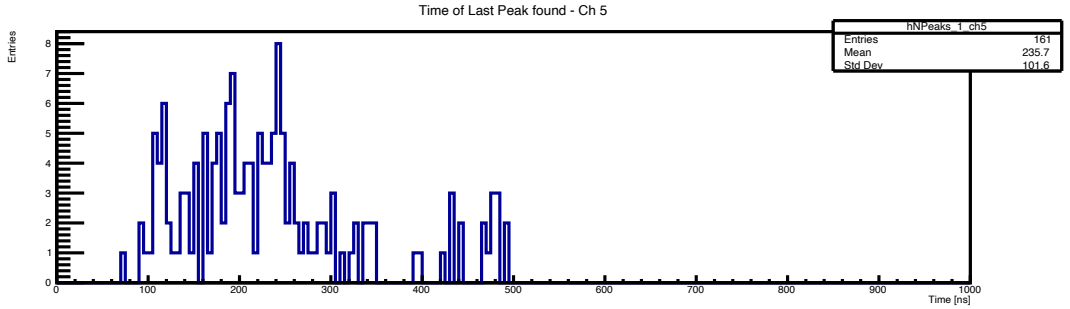


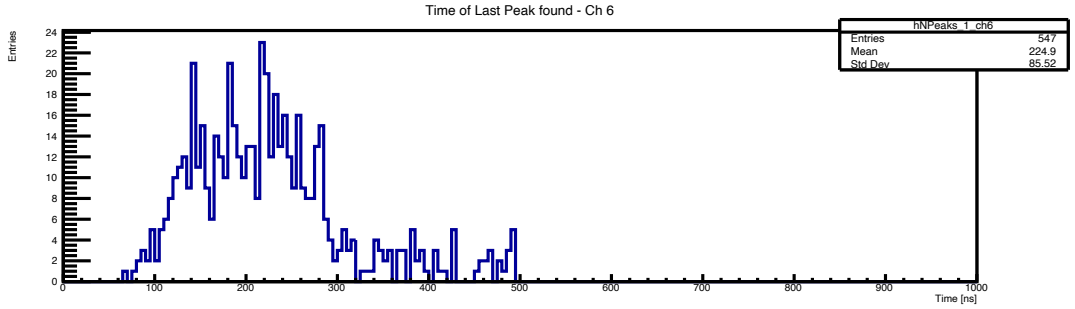
Time of Last Peaks found for signal events

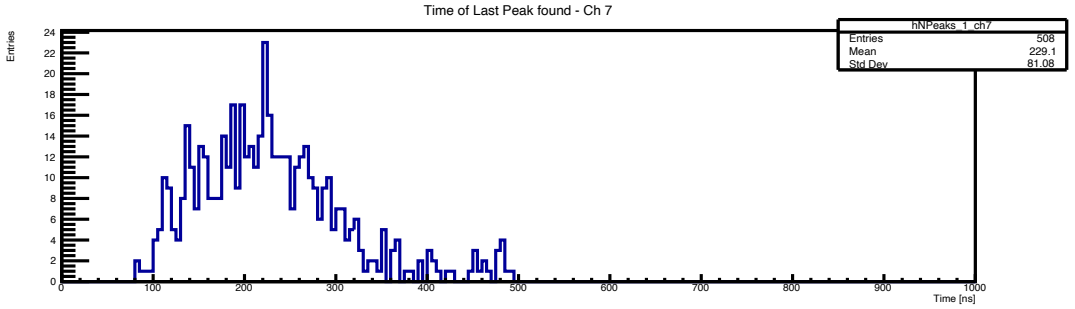
Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

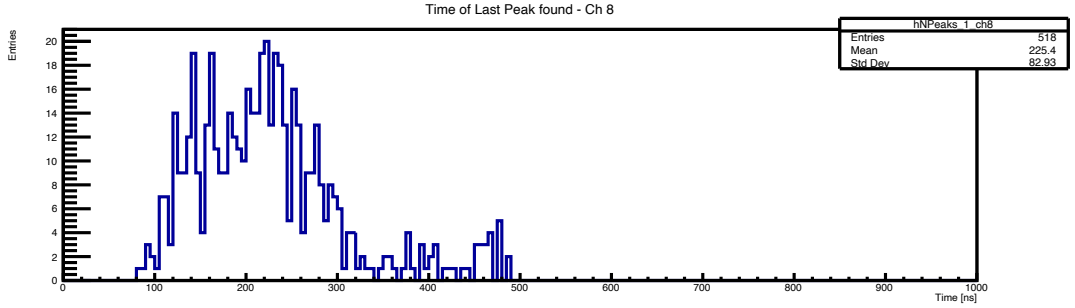
1 cm drift tubes

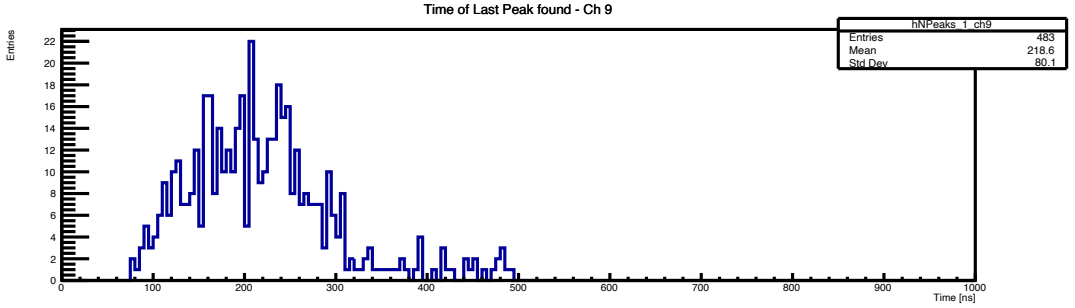








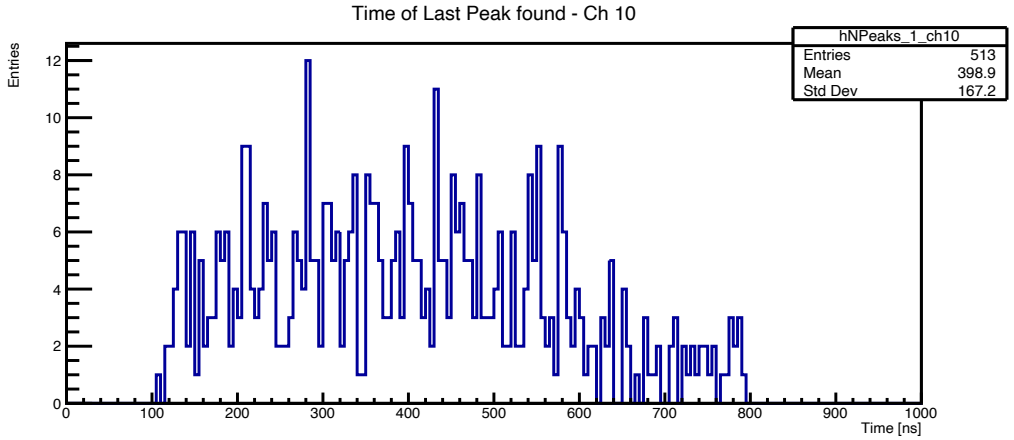


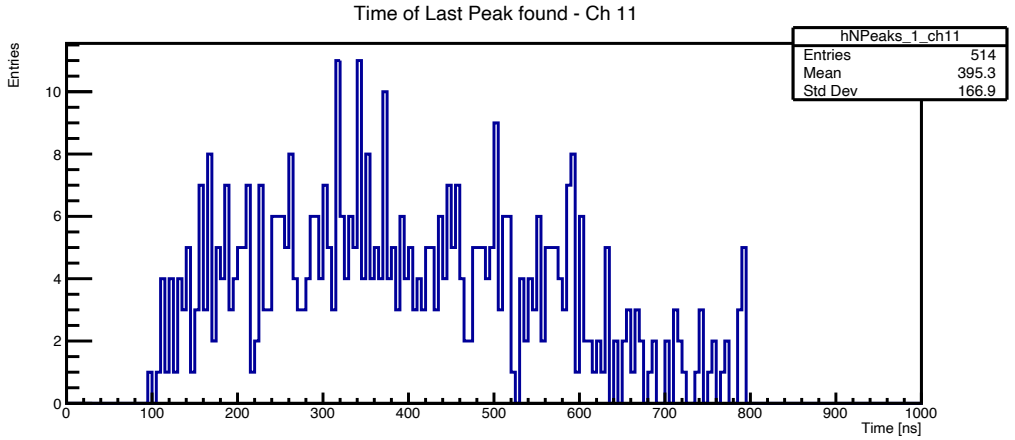


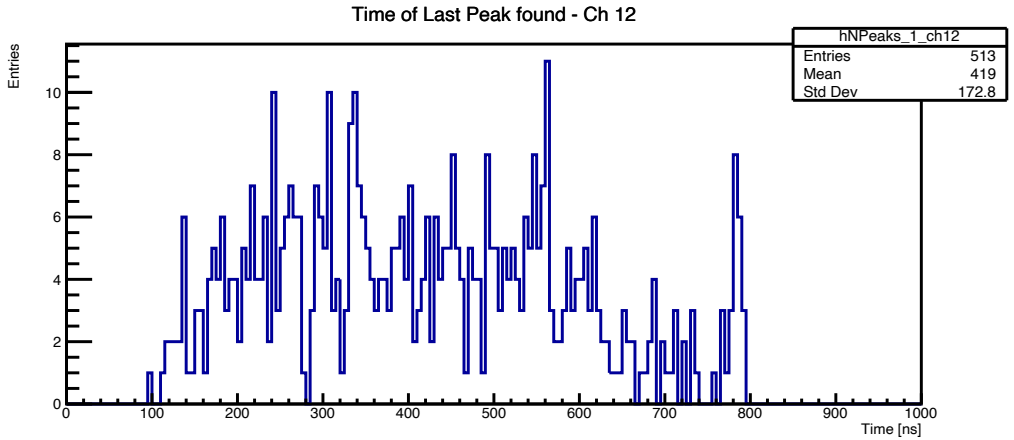
Time of Last Peaks found for signal events

Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



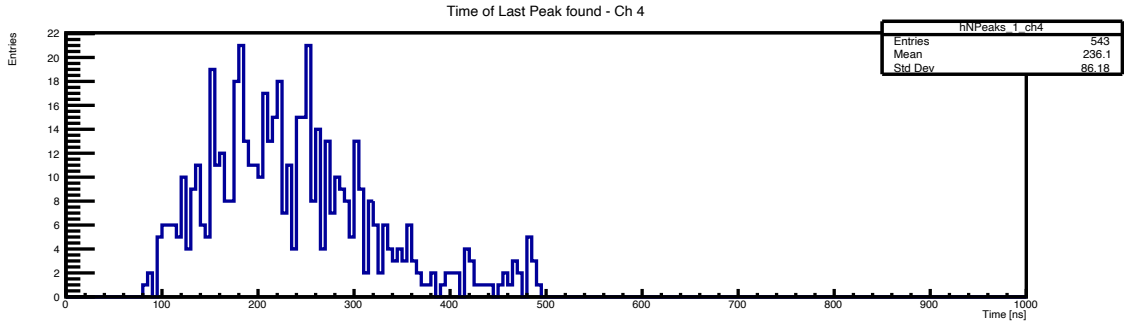


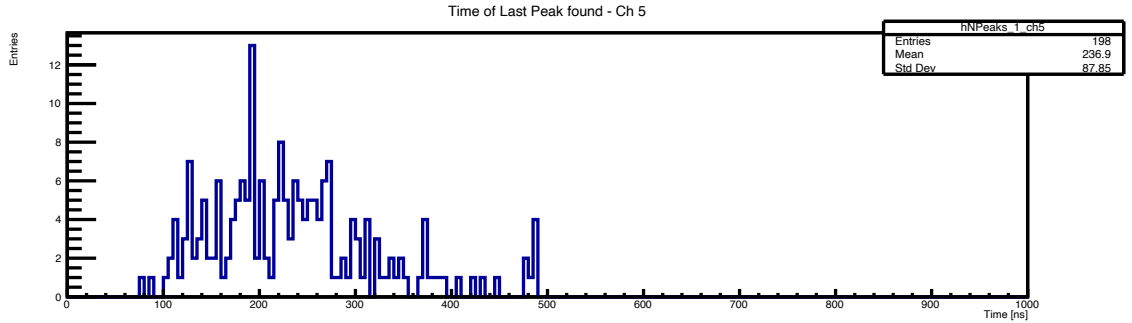


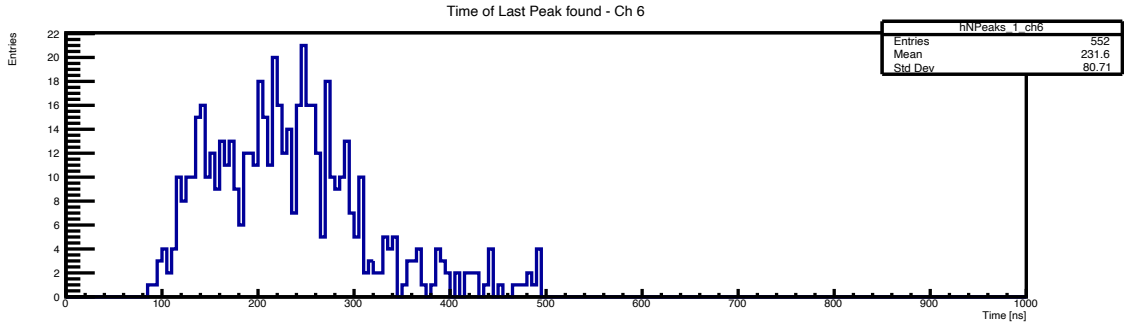
Time of Last Peaks found for signal events

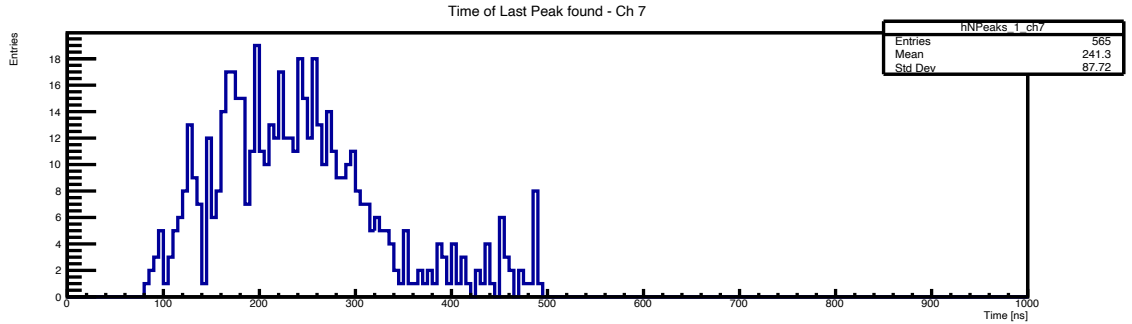
Run: run_98.root; Track angle: 15° ; Gas mixture: 90%He ; HV = +20V

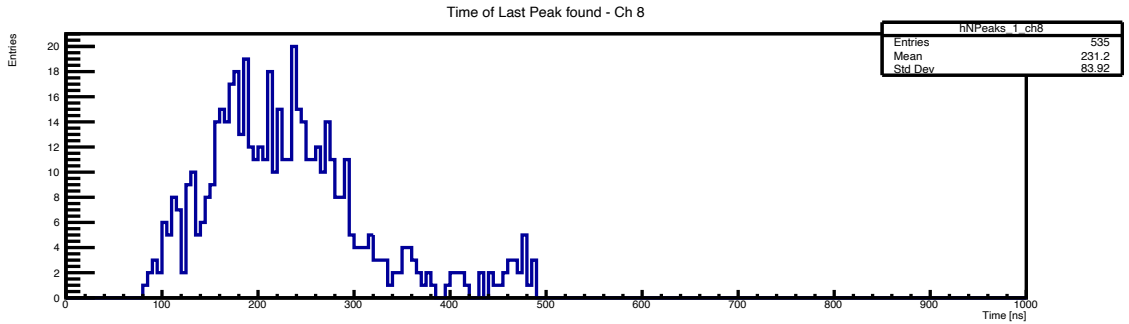
1 cm drift tubes

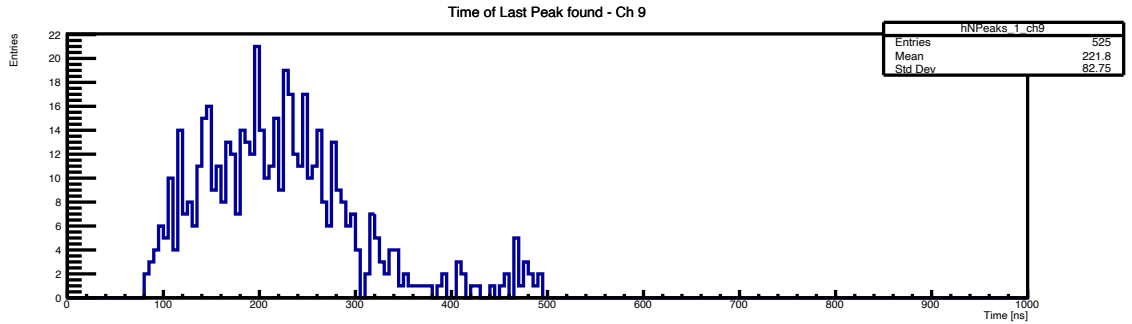








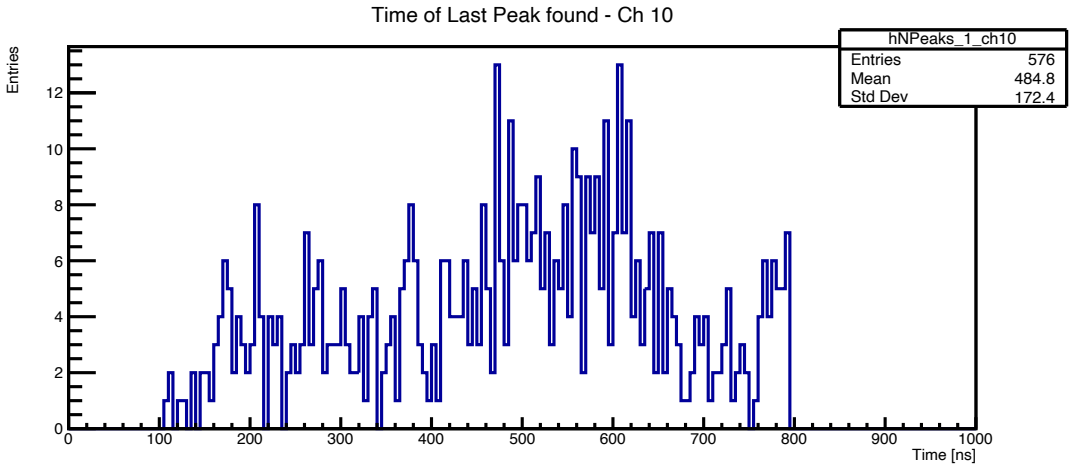


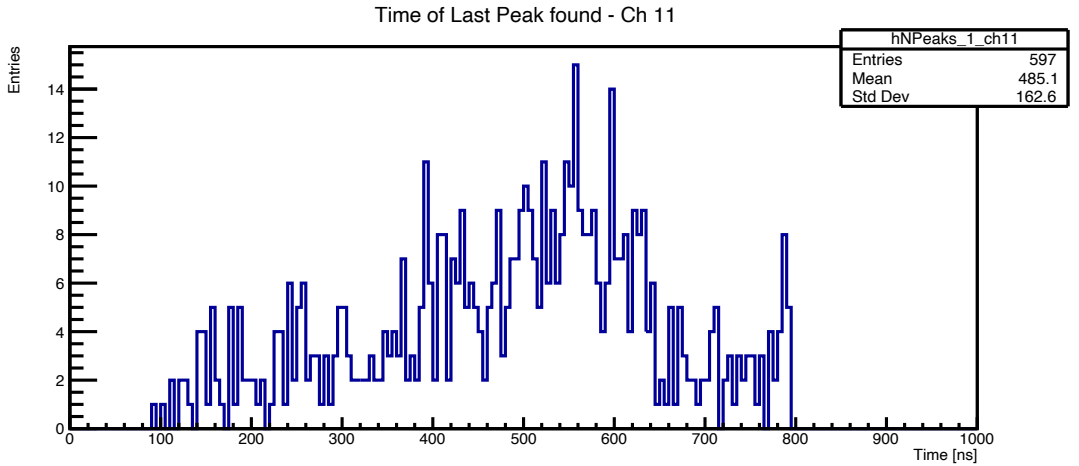


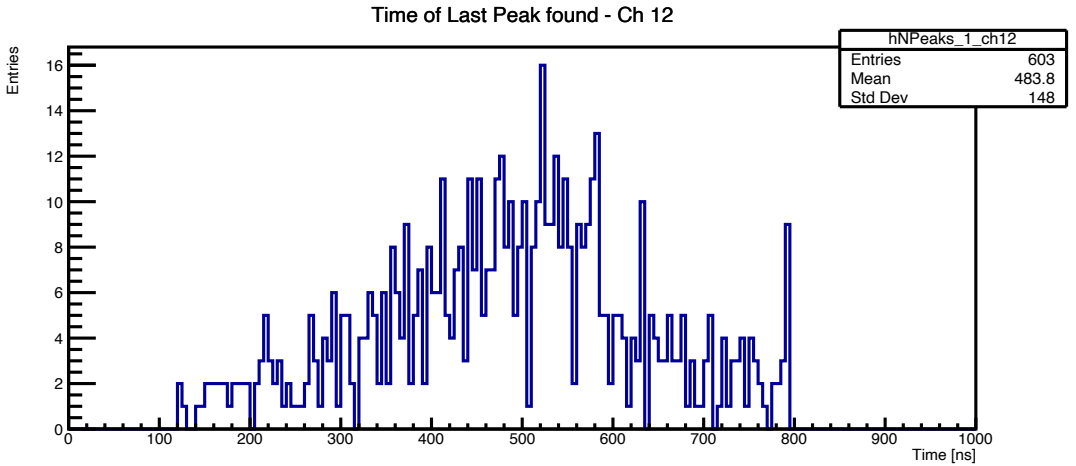
Time of Last Peaks found for signal events

Run: run_98.root; Track angle: **15°** ; Gas mixture: **90%He** ; **HV = +20V**

2 cm drift tubes



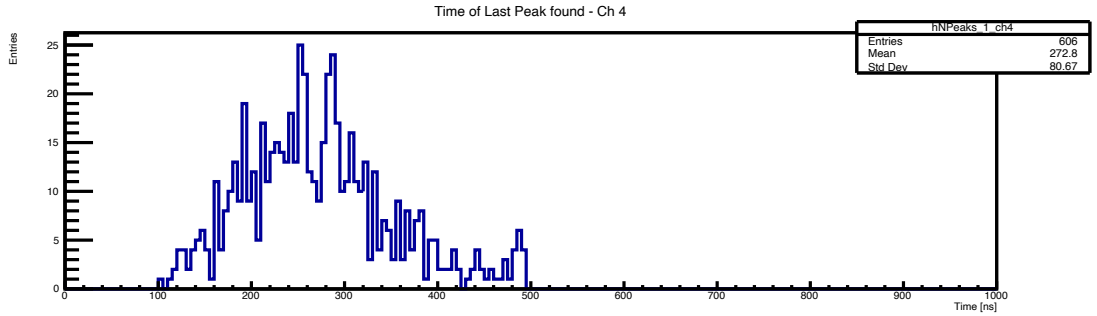


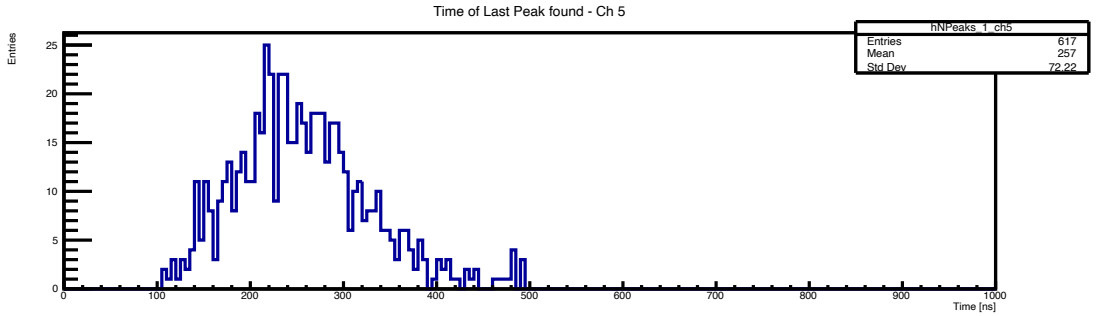


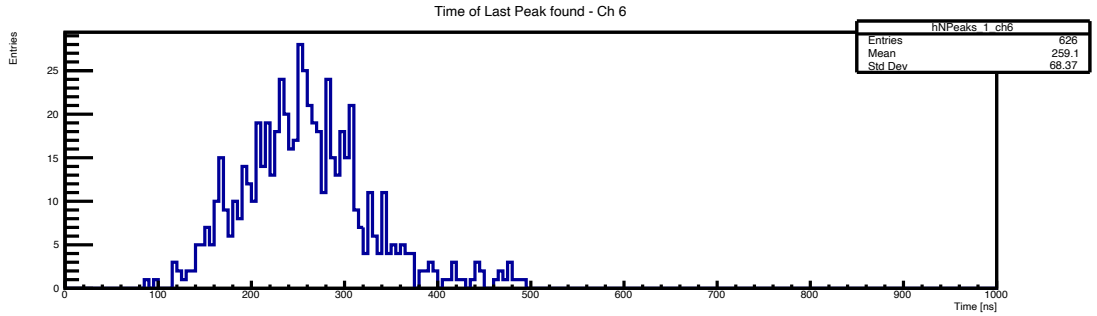
Time of Last Peaks found for signal events

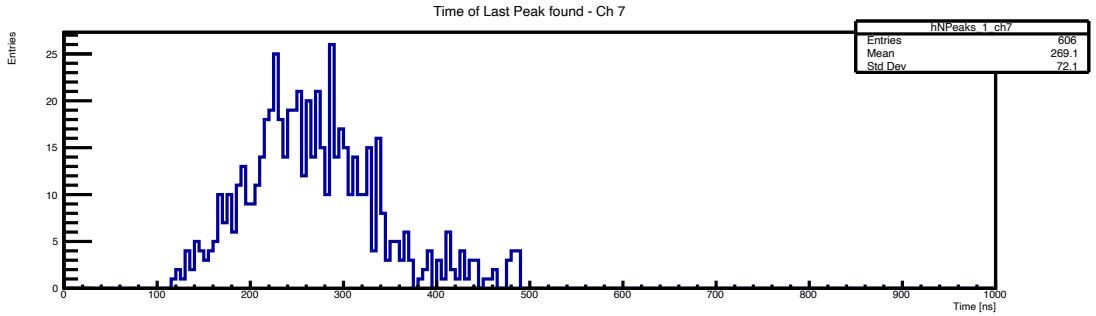
Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

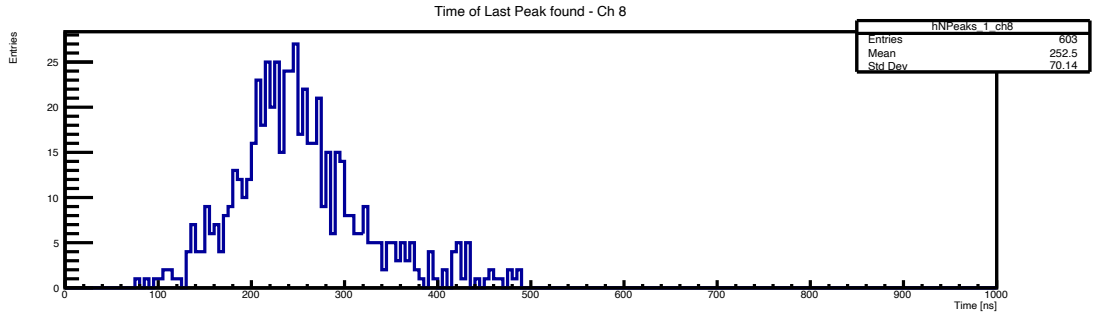
1 cm drift tubes

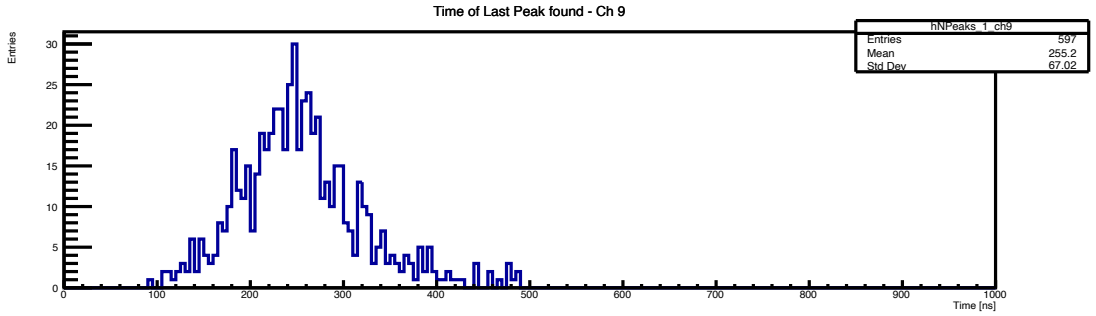








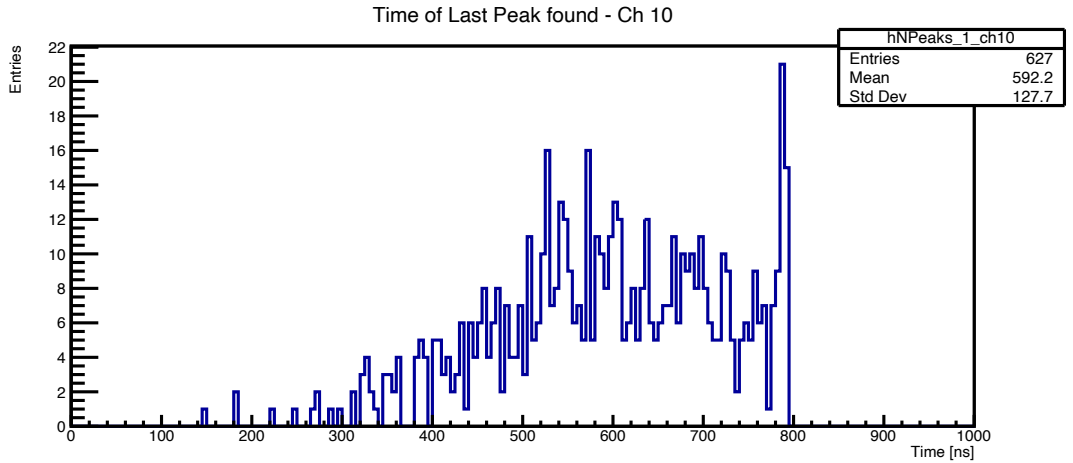


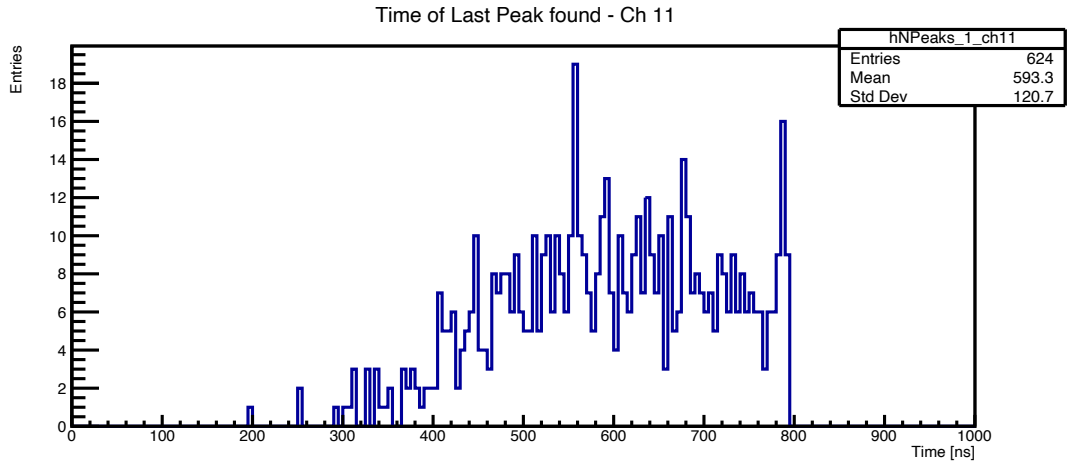


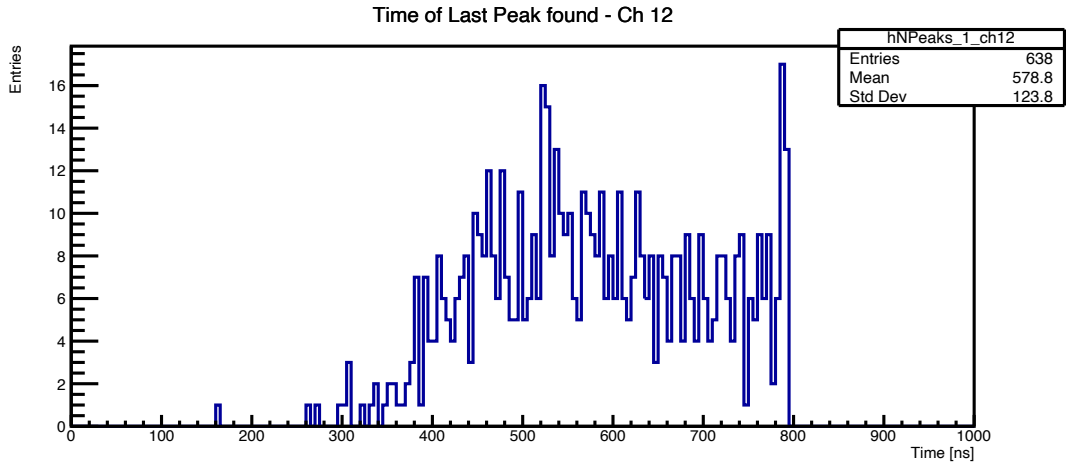
Time of Last Peaks found for signal events

Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



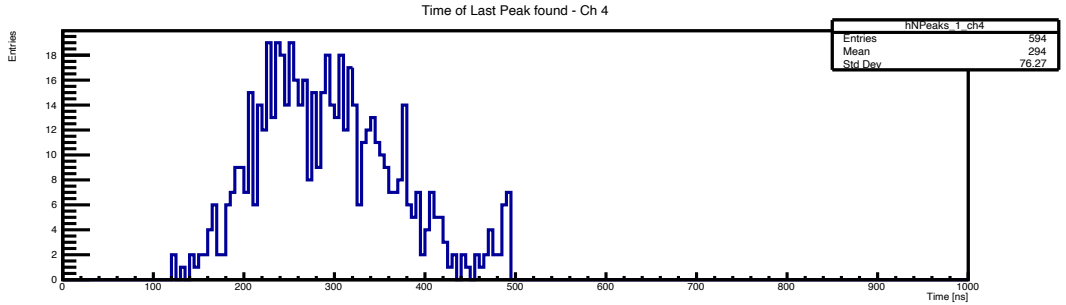


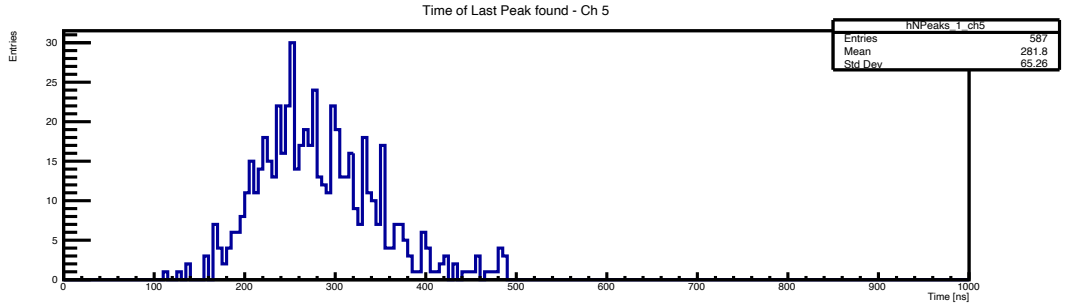


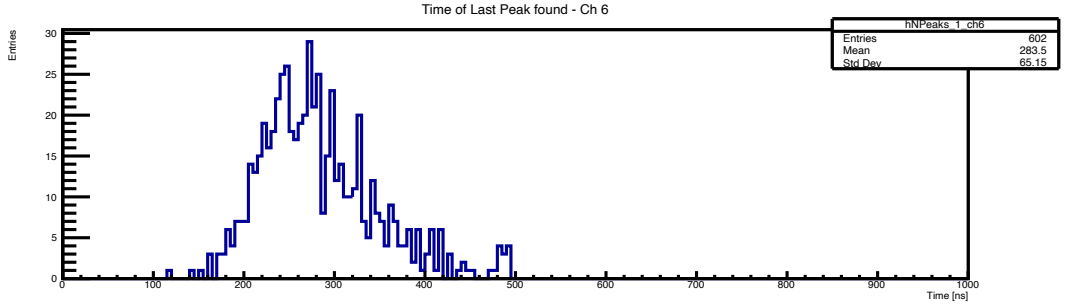
Time of Last Peaks found for signal events

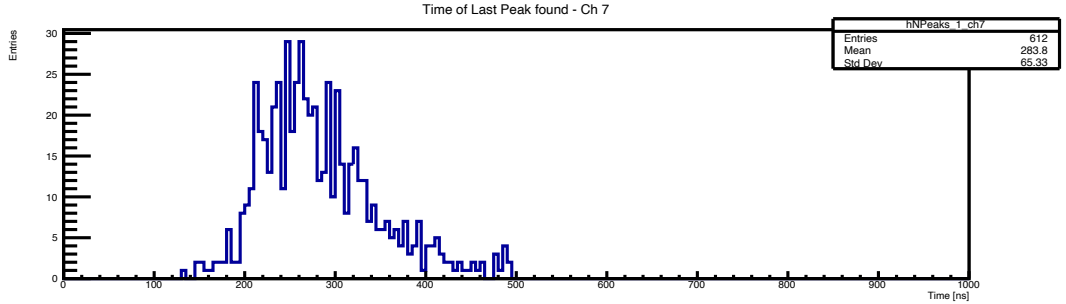
Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

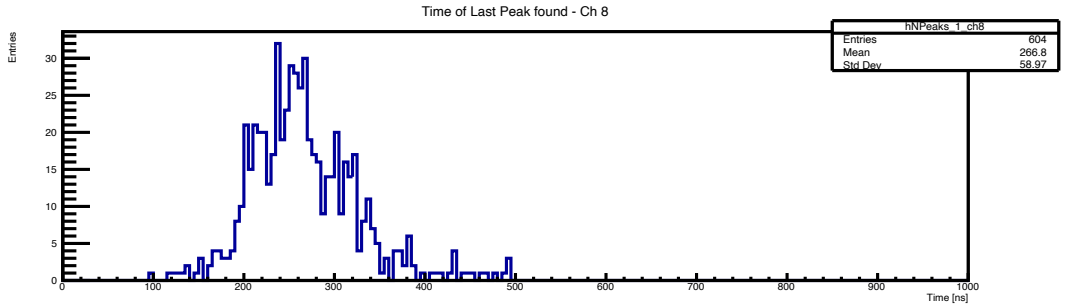
1 cm drift tubes

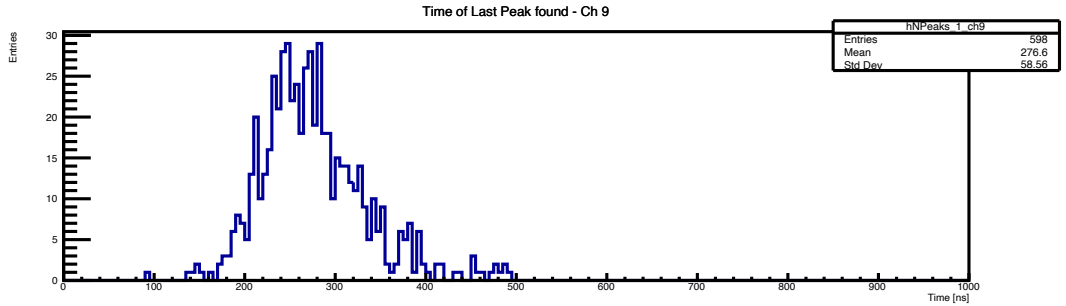








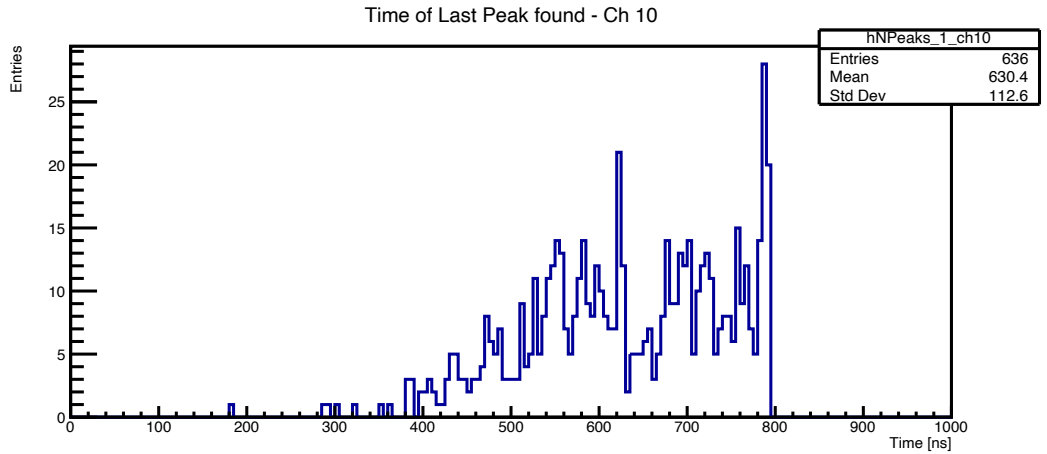


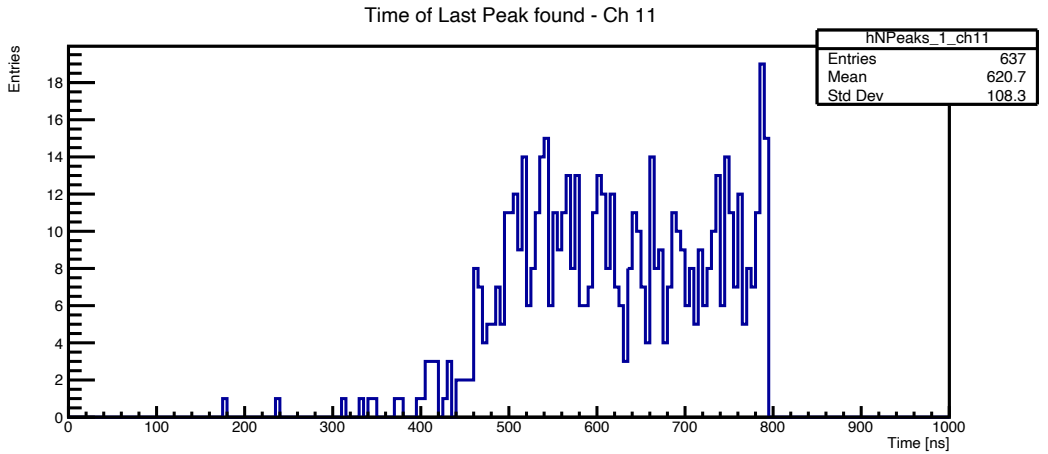


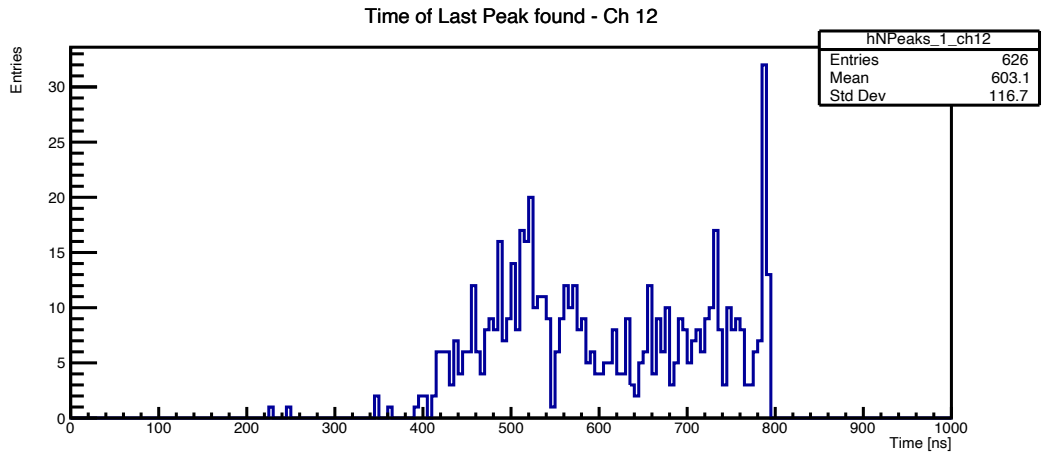
Time of Last Peaks found for signal events

Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



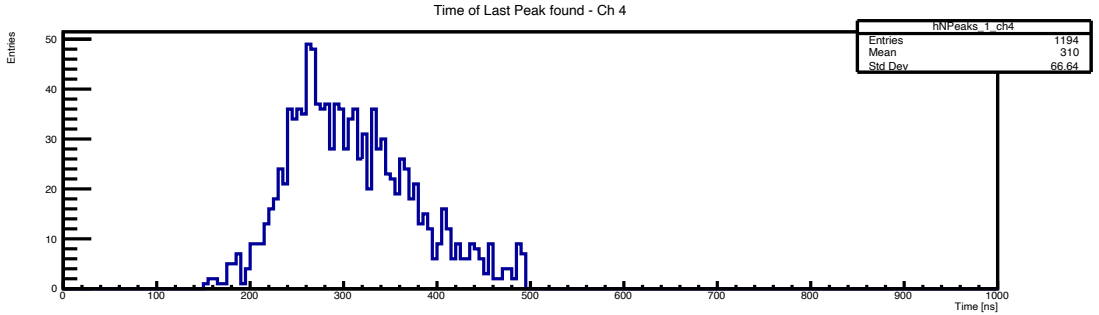


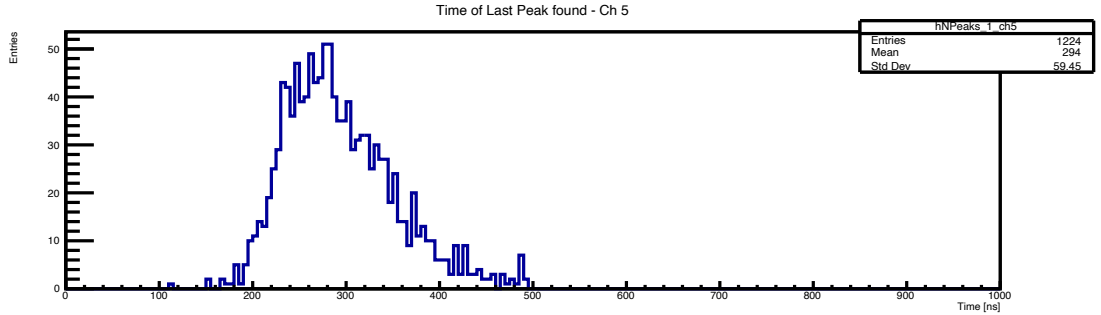


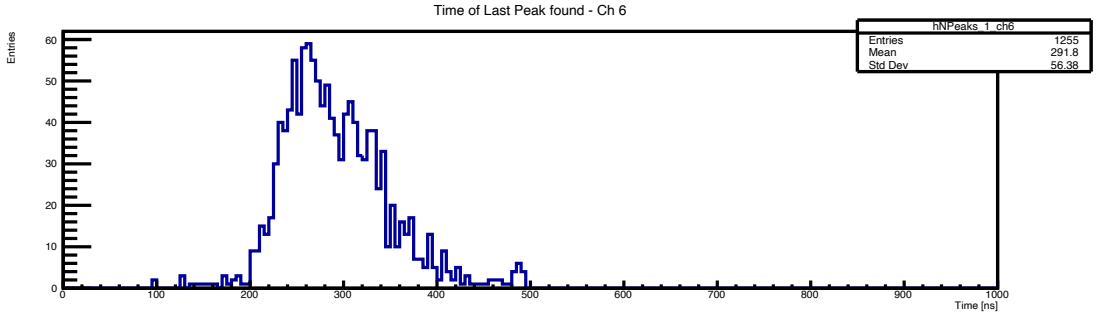
Time of Last Peaks found for signal events

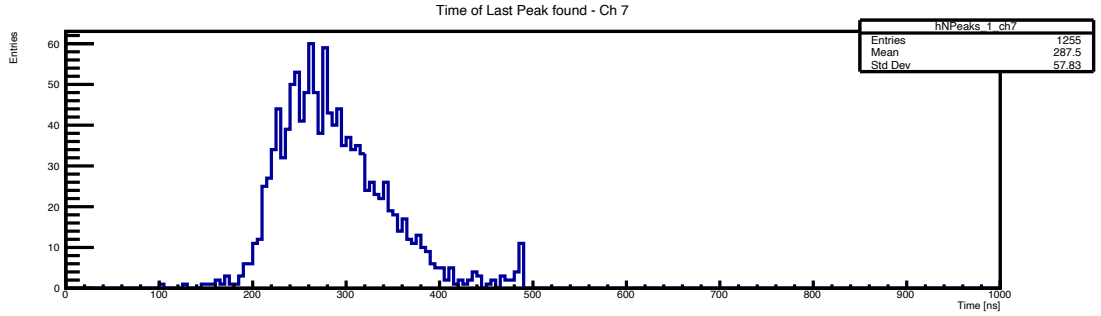
Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V

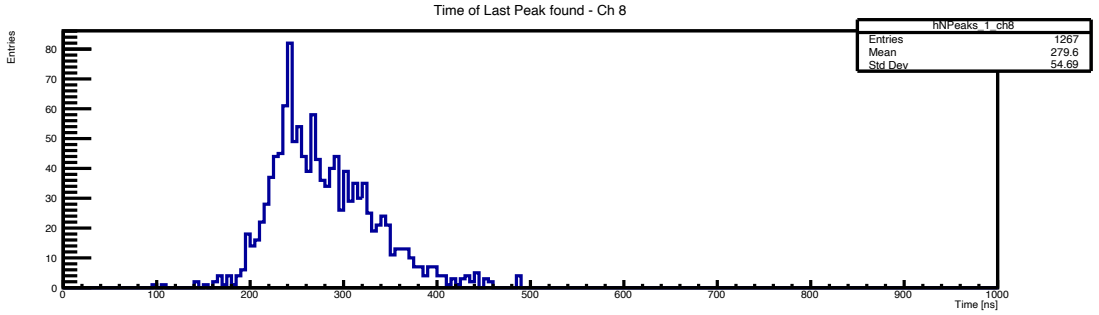
1 cm drift tubes

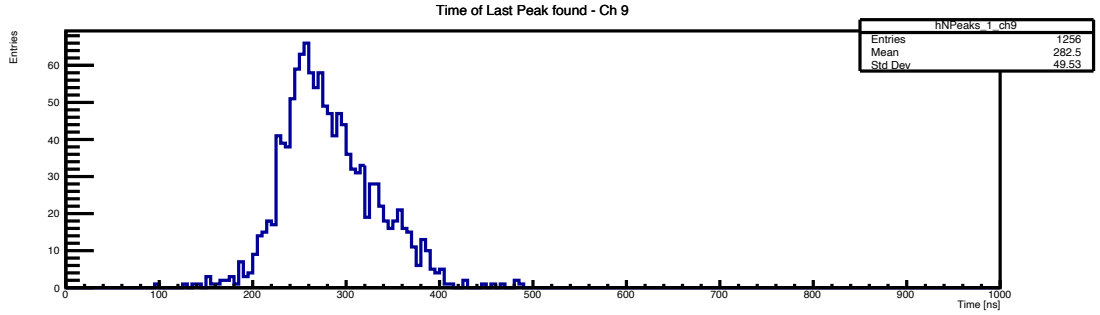








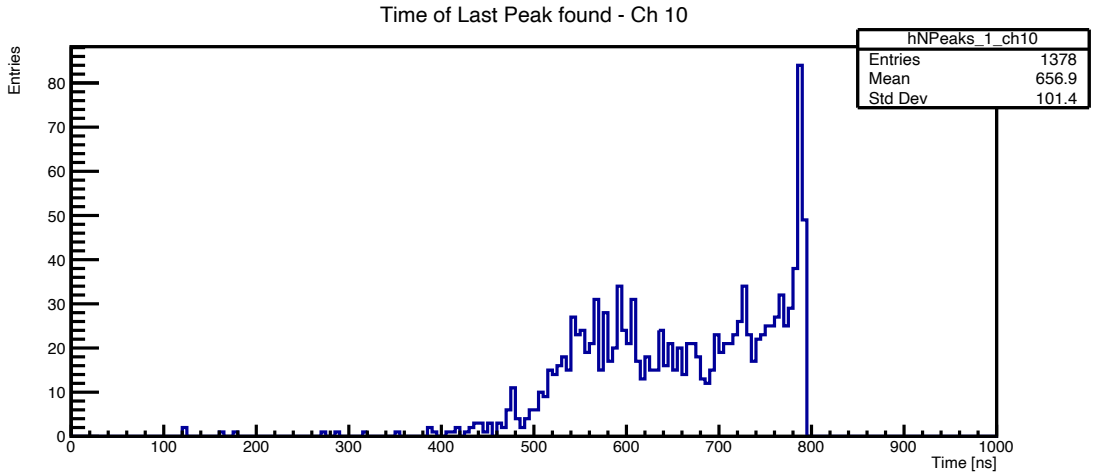


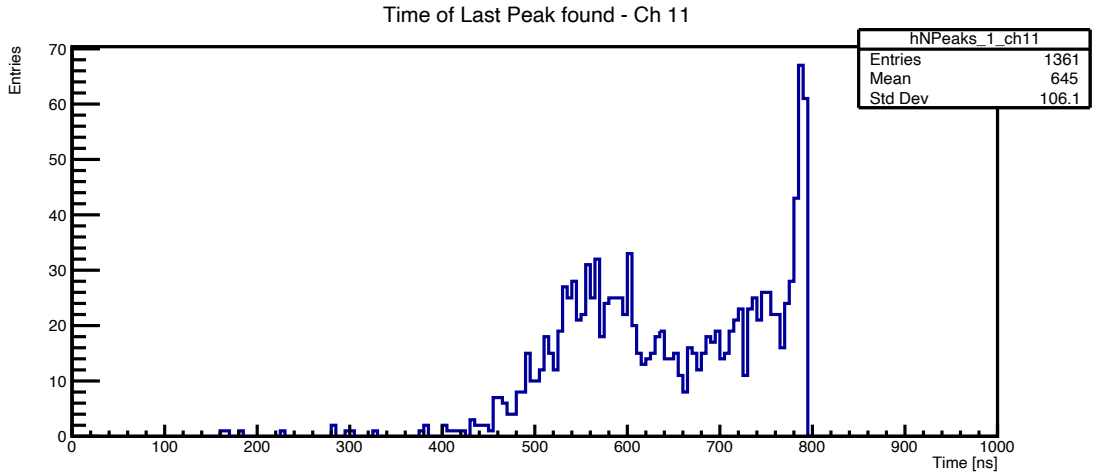


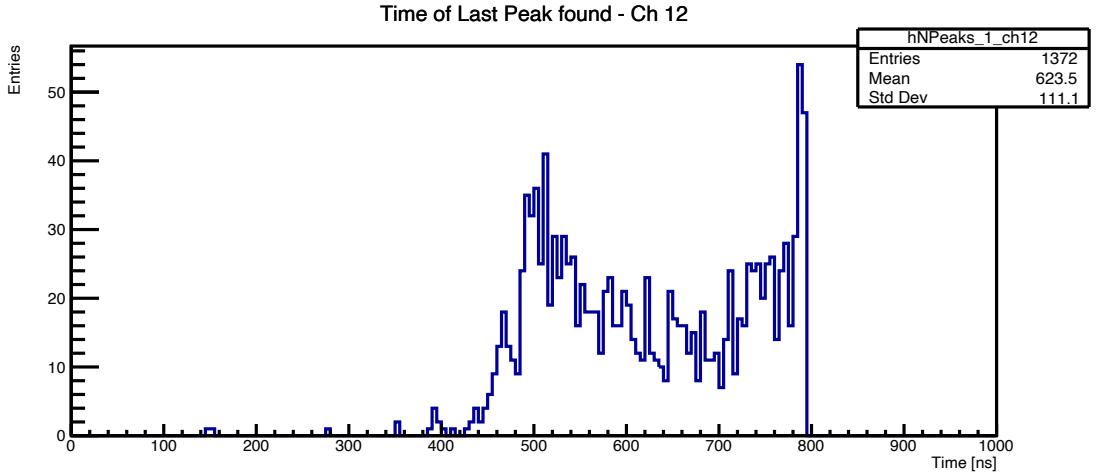
Time of Last Peaks found for signal events

Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes



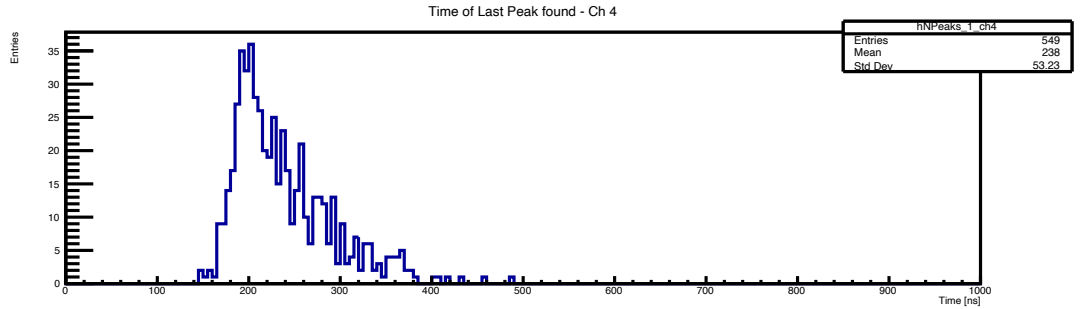


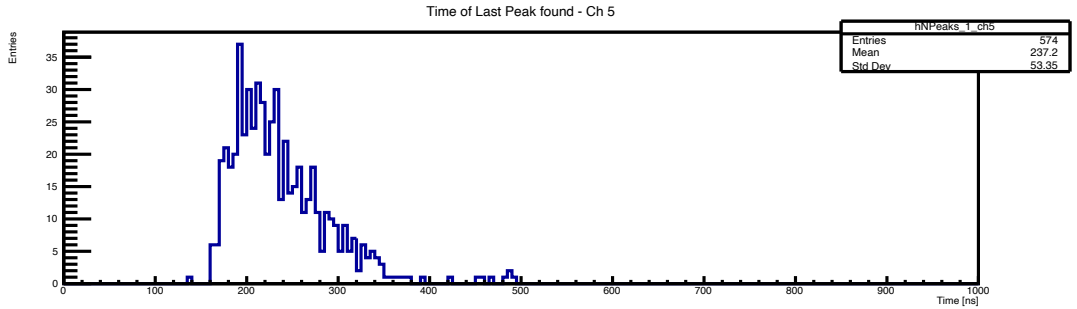


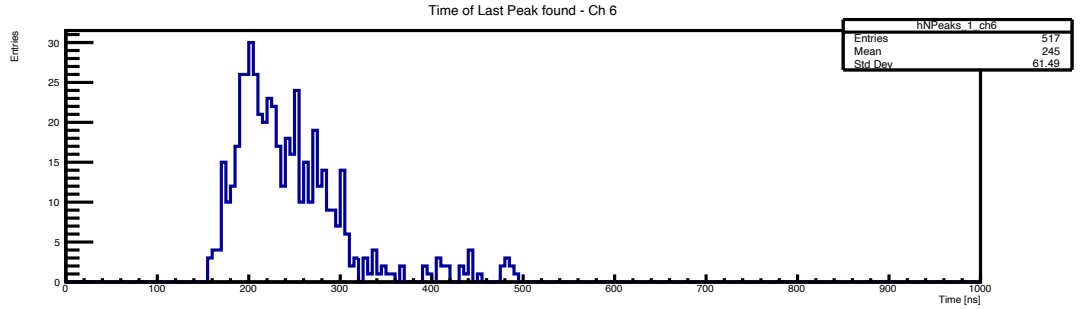
Time of Last Peaks found for signal events

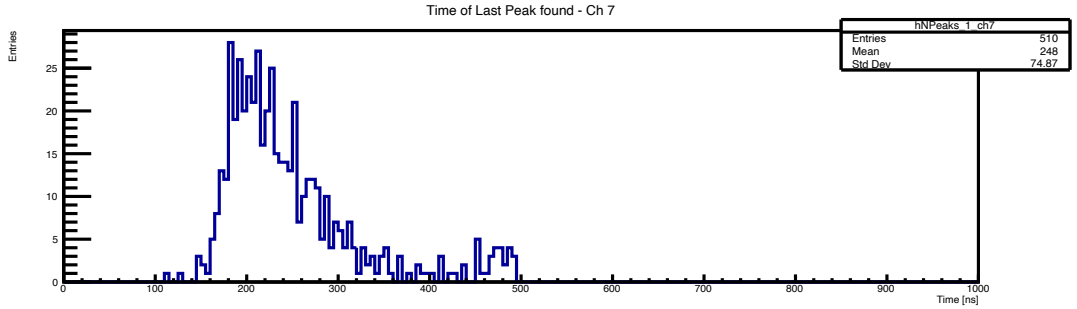
Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V

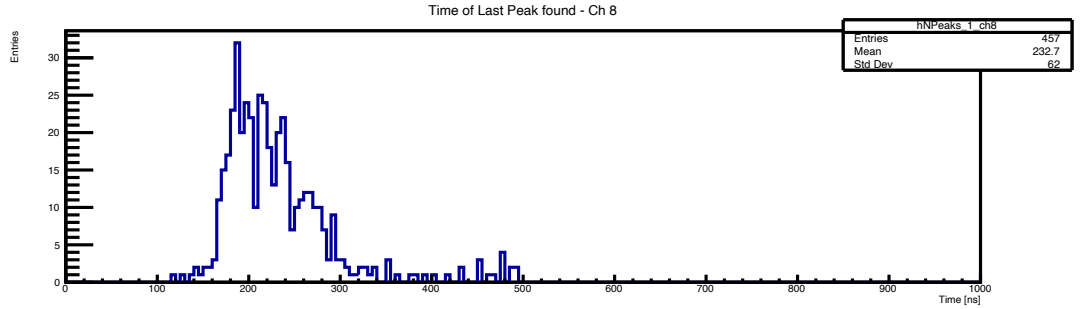
1 cm drift tubes

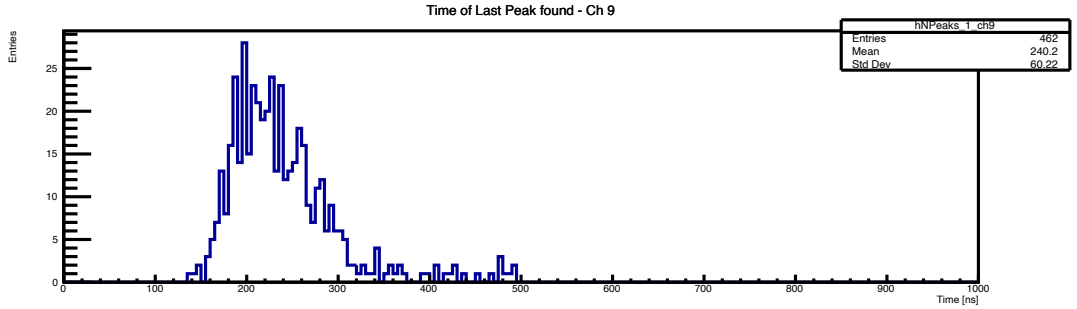








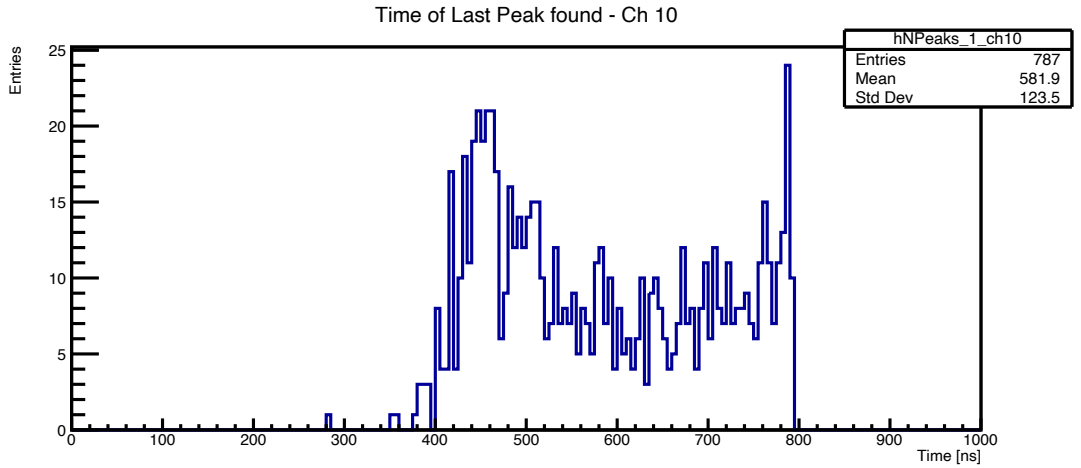


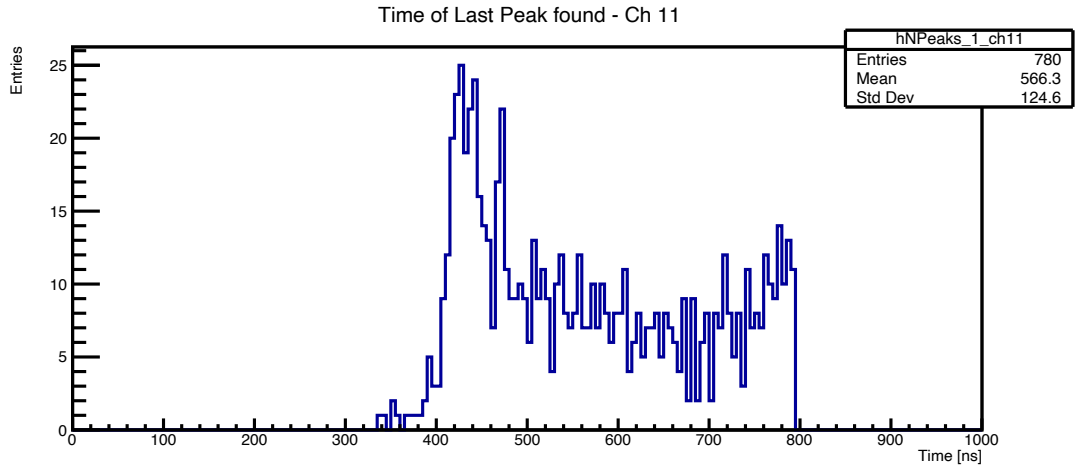


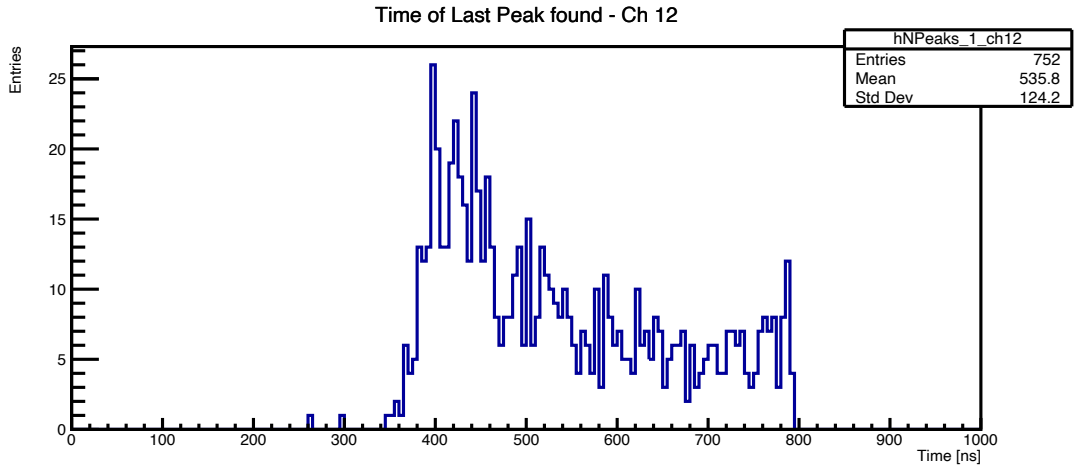
Time of Last Peaks found for signal events

Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V

2 cm drift tubes



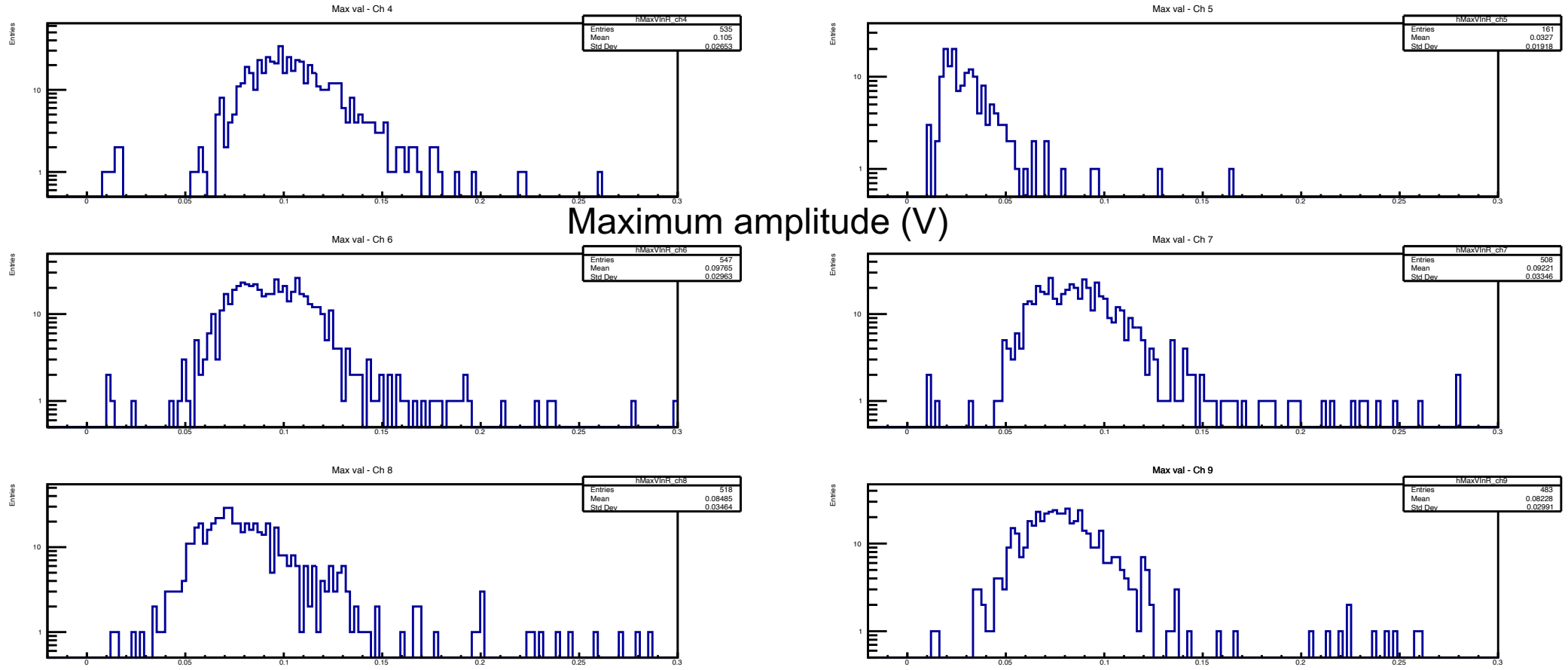




Maximum amplitude for signal events

Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

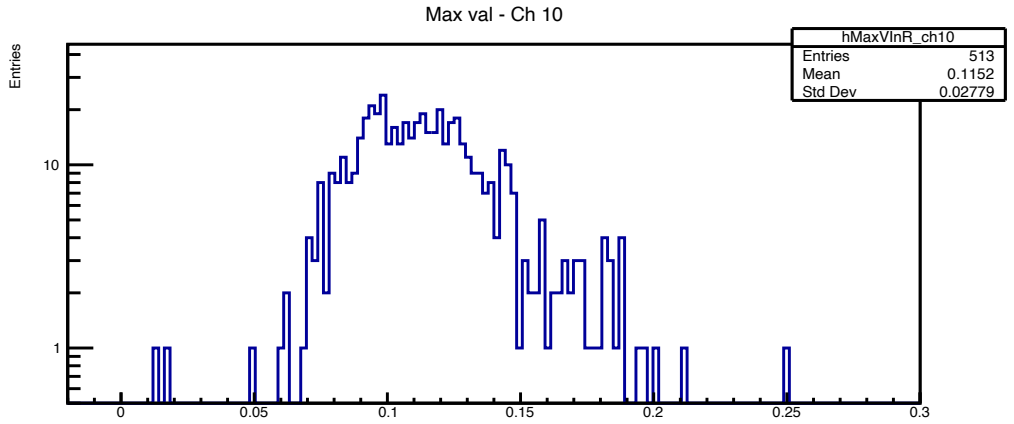
1 cm drift tubes

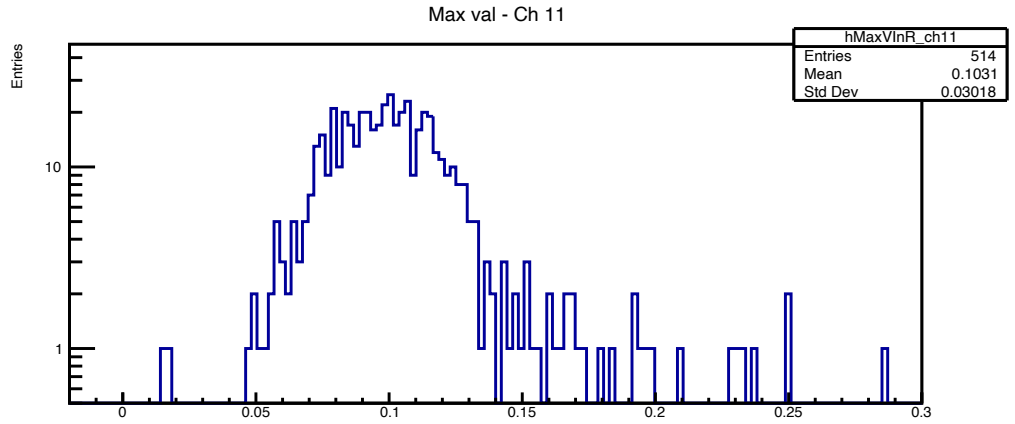


Maximum amplitude for signal events

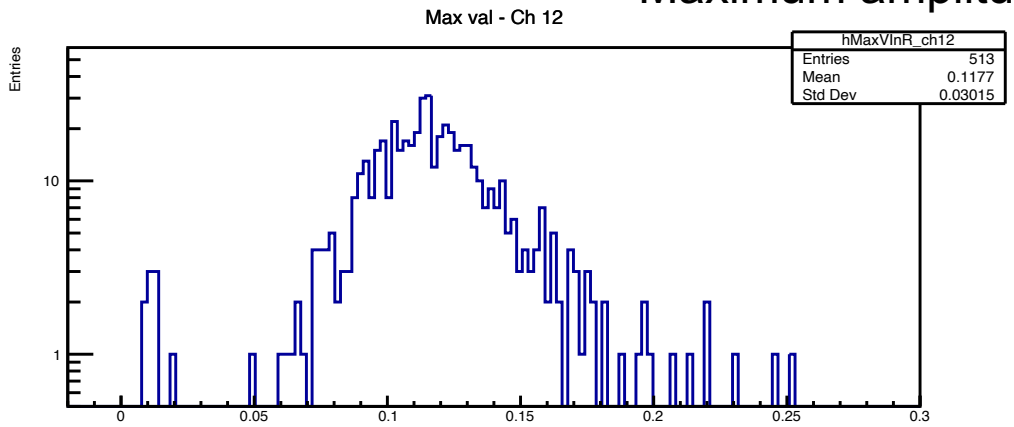
Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes





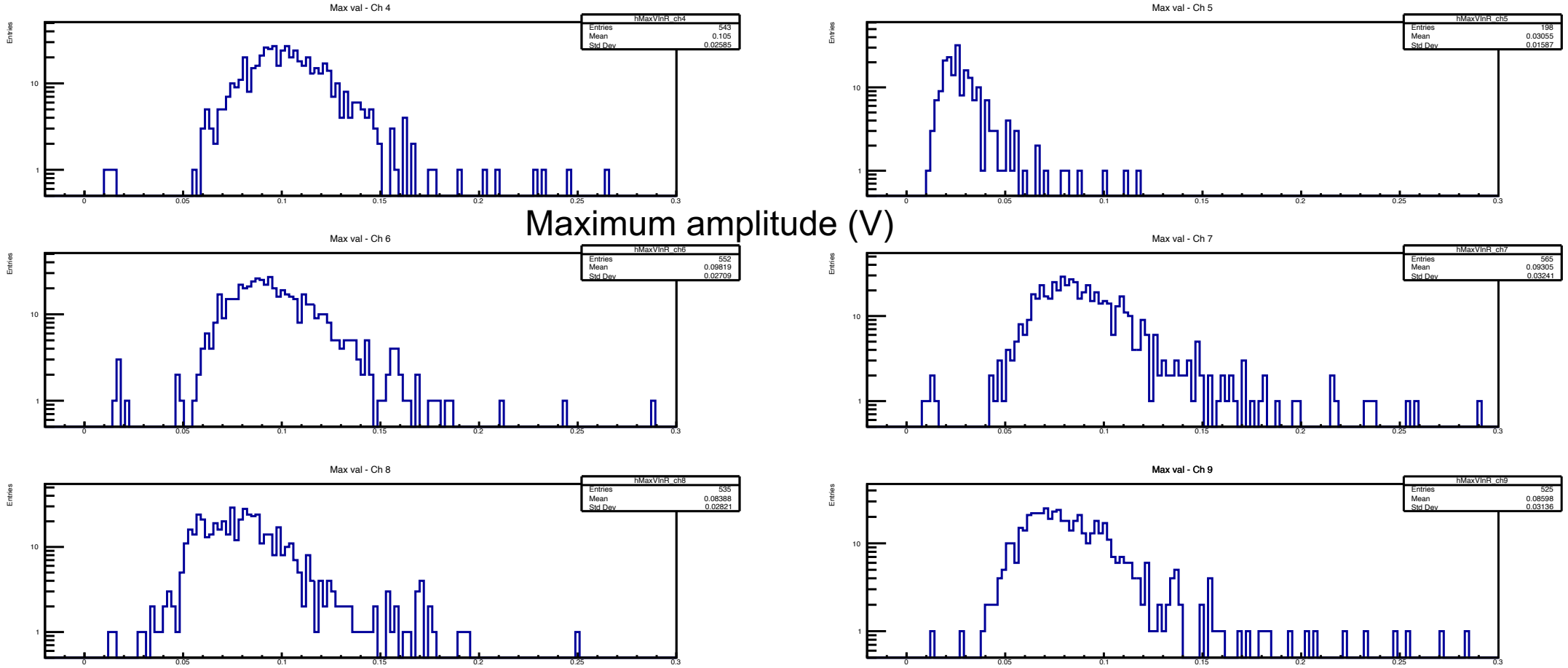
Maximum amplitude (V)



Maximum amplitude for signal events

Run: run_98.root; Track angle: 15° ; Gas mixture: 90%He ; HV = +20V

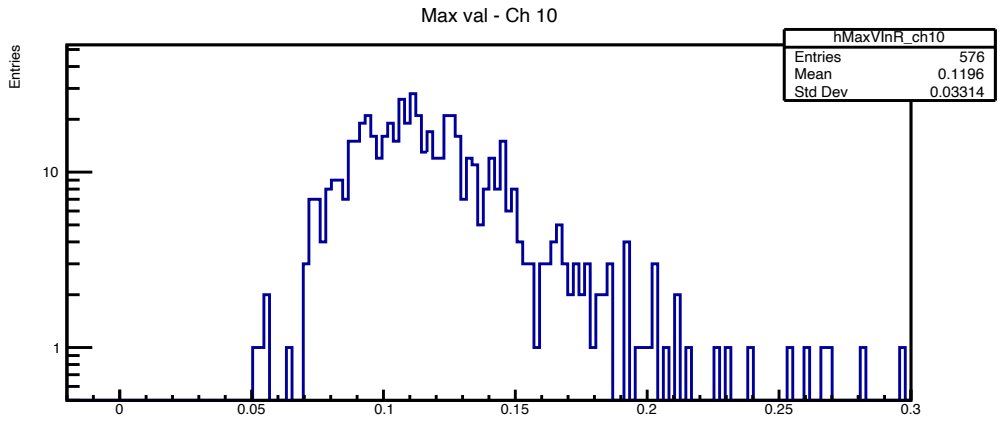
1 cm drift tubes

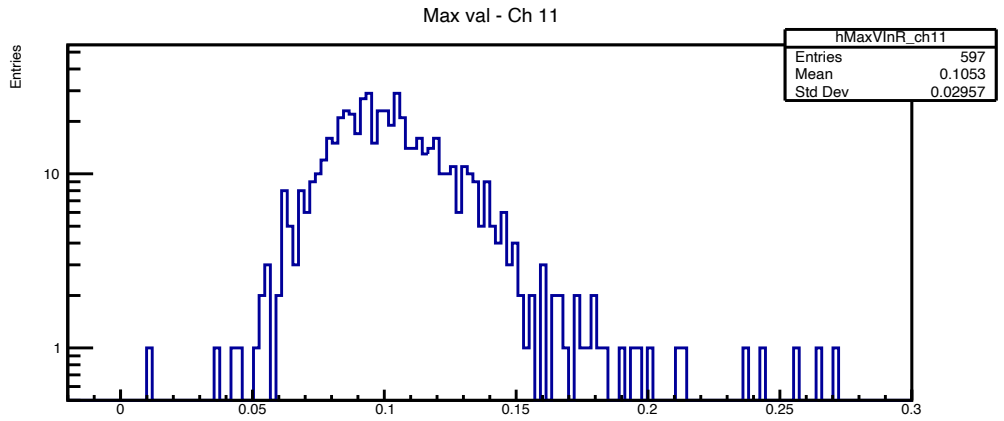


Maximum amplitude for signal events

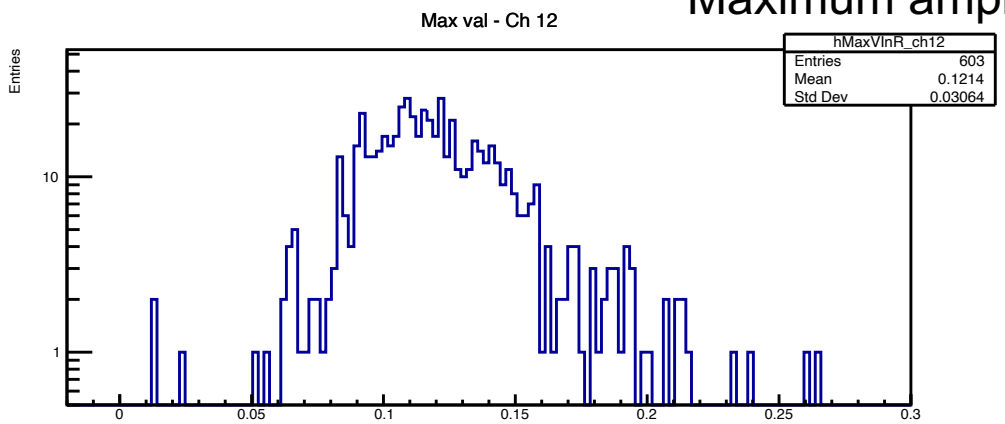
Run: run_98.root; Track angle: 15° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes





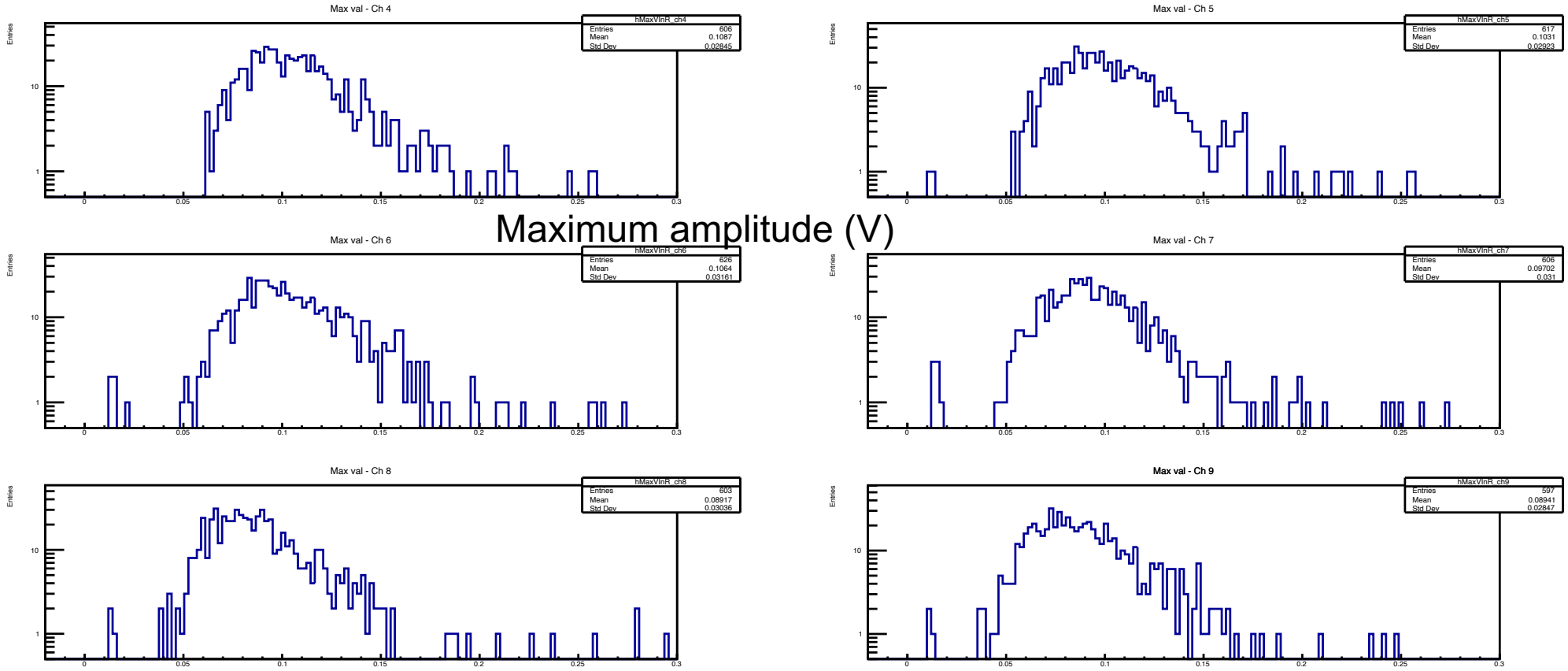
Maximum amplitude (V)



Maximum amplitude for signal events

Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

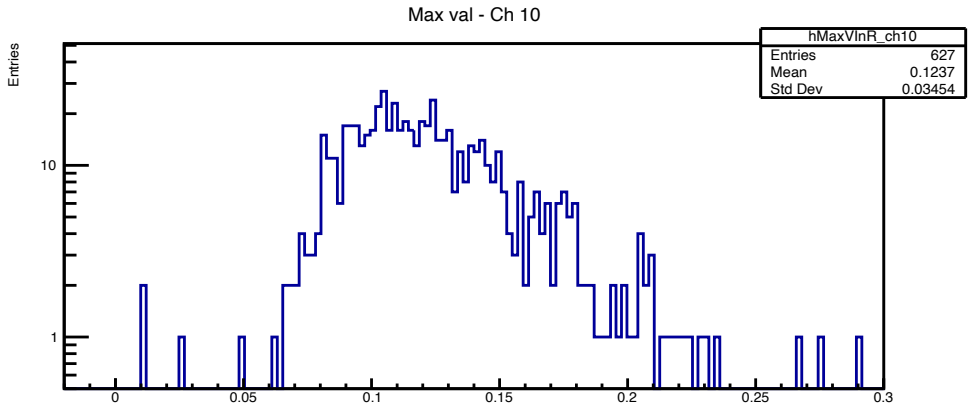
1 cm drift tubes

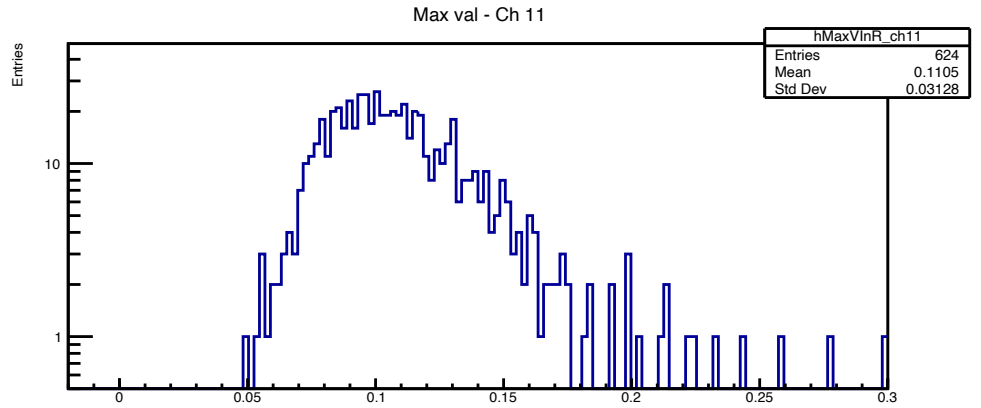


Maximum amplitude for signal events

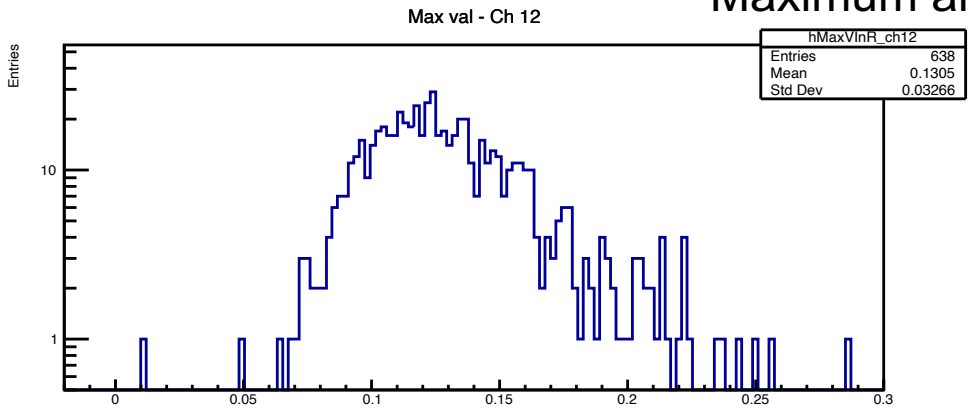
Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes





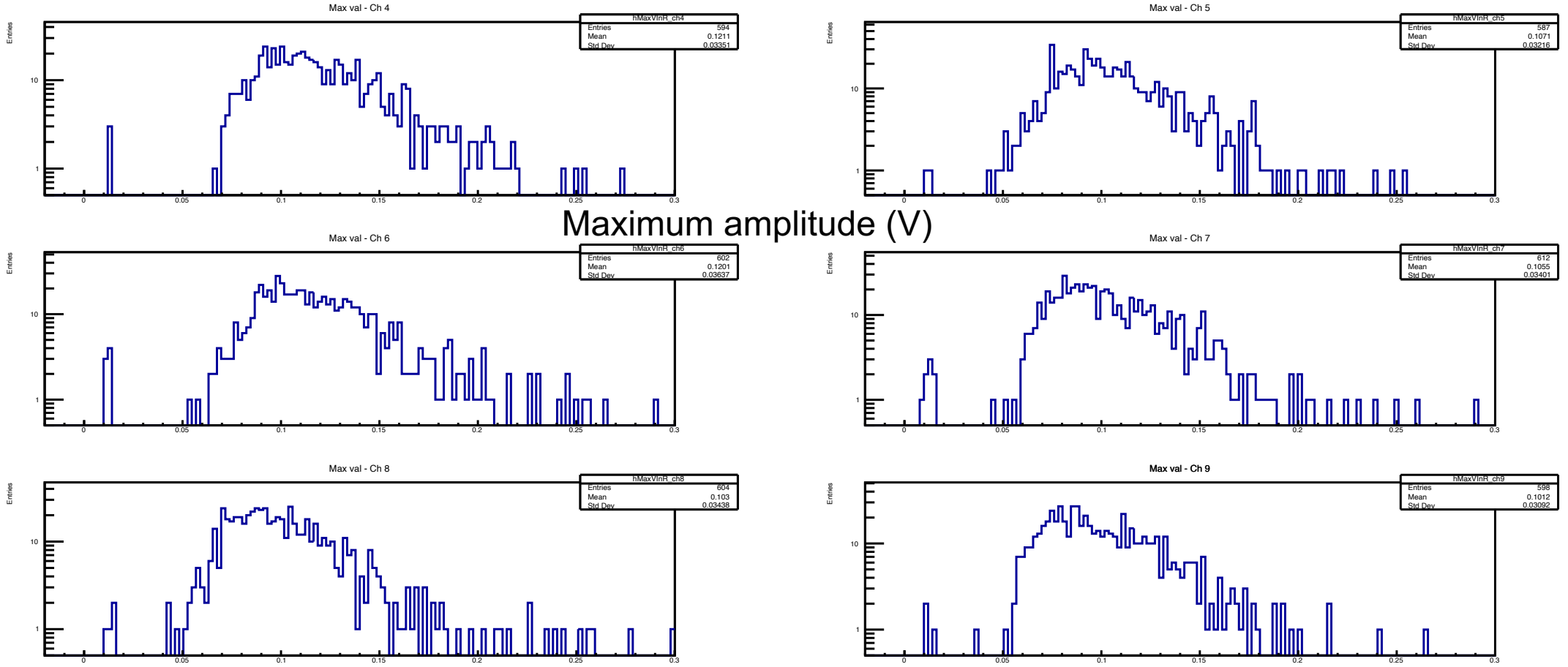
Maximum amplitude (V)



Maximum amplitude for signal events

Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

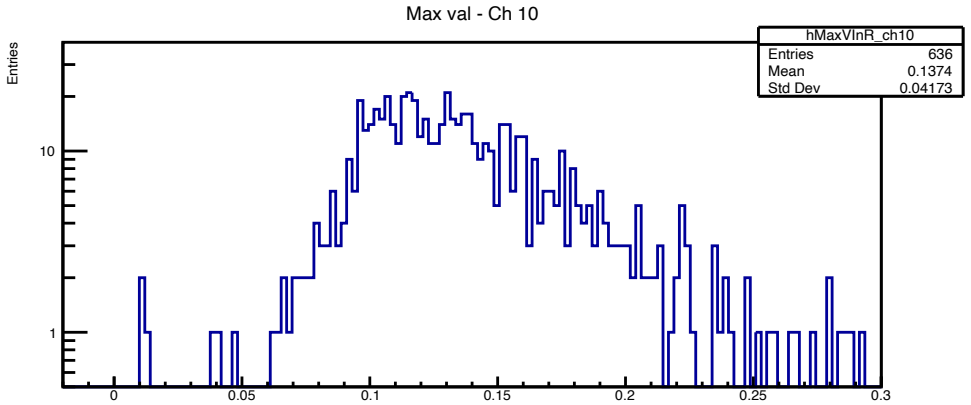
1 cm drift tubes

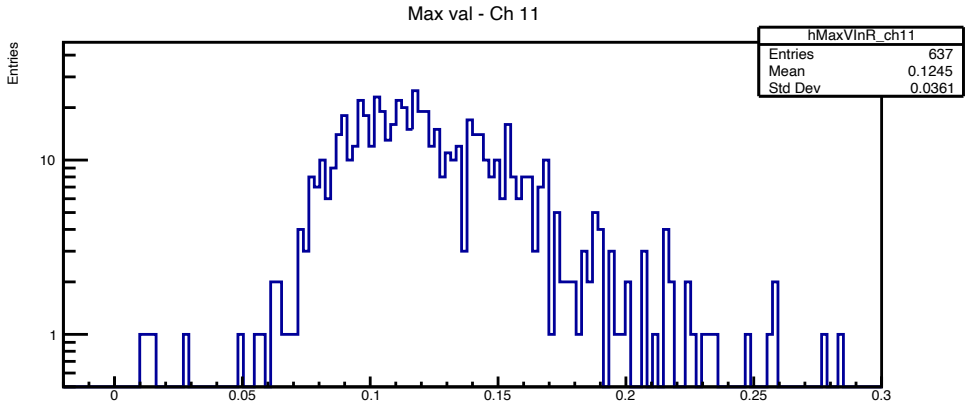


Maximum amplitude for signal events

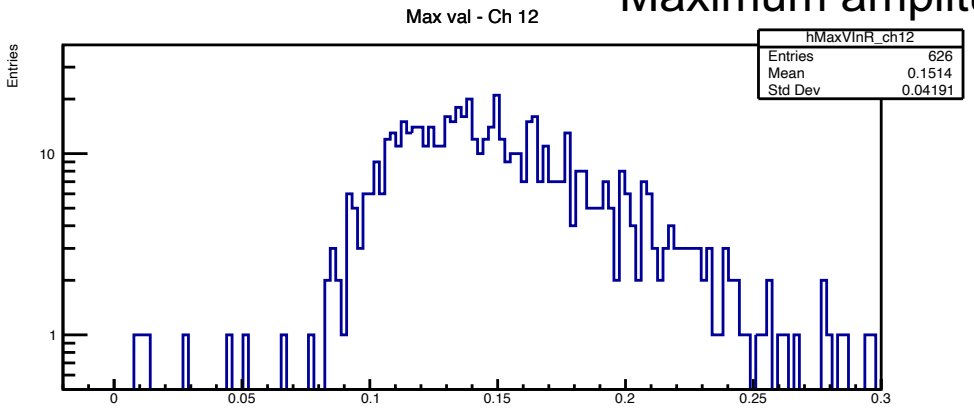
Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes





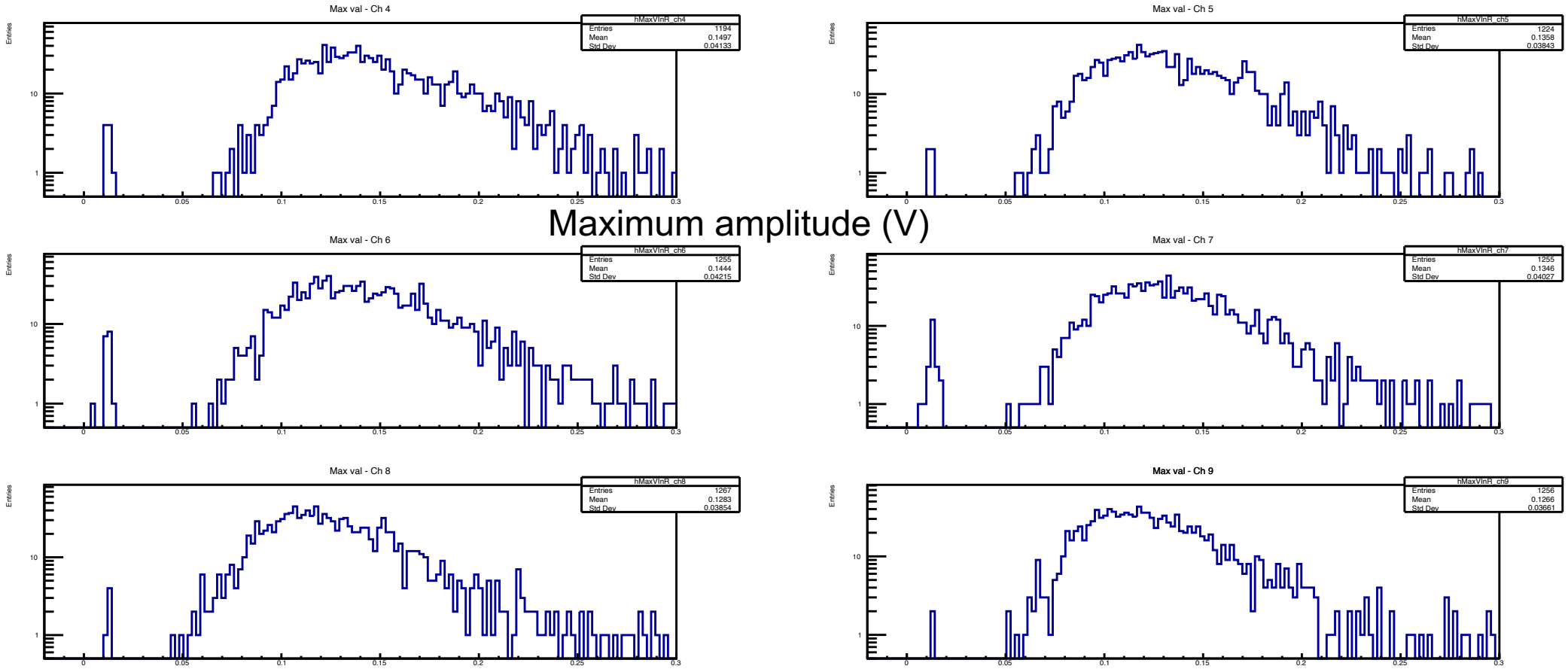
Maximum amplitude (V)



Maximum amplitude for signal events

Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V

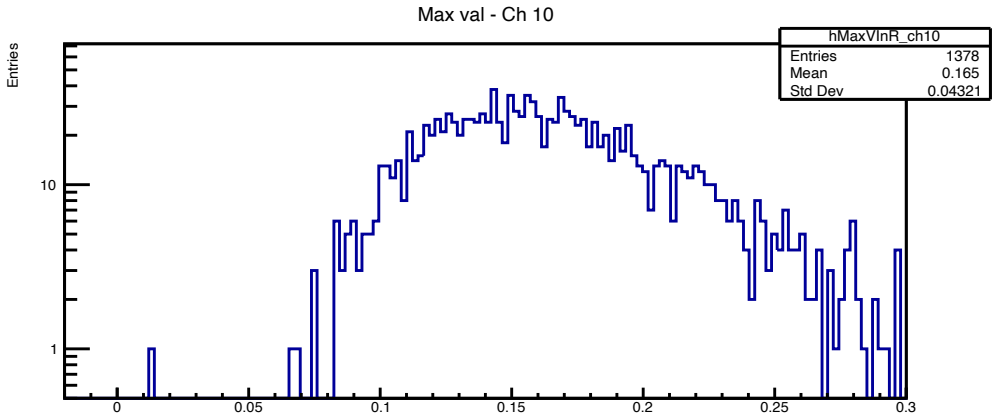
1 cm drift tubes

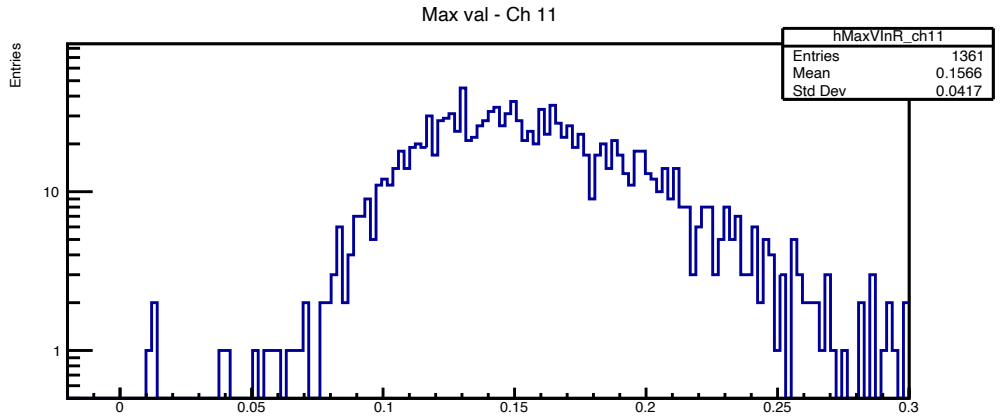


Maximum amplitude for signal events

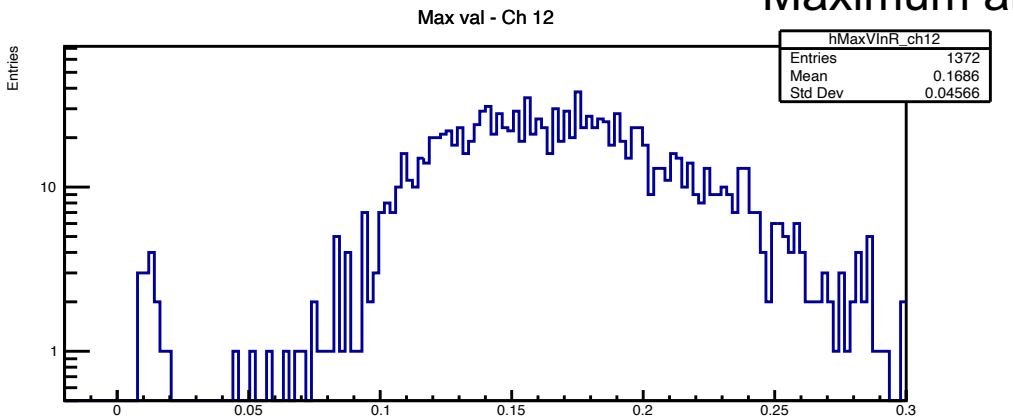
Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V

2 cm drift tubes





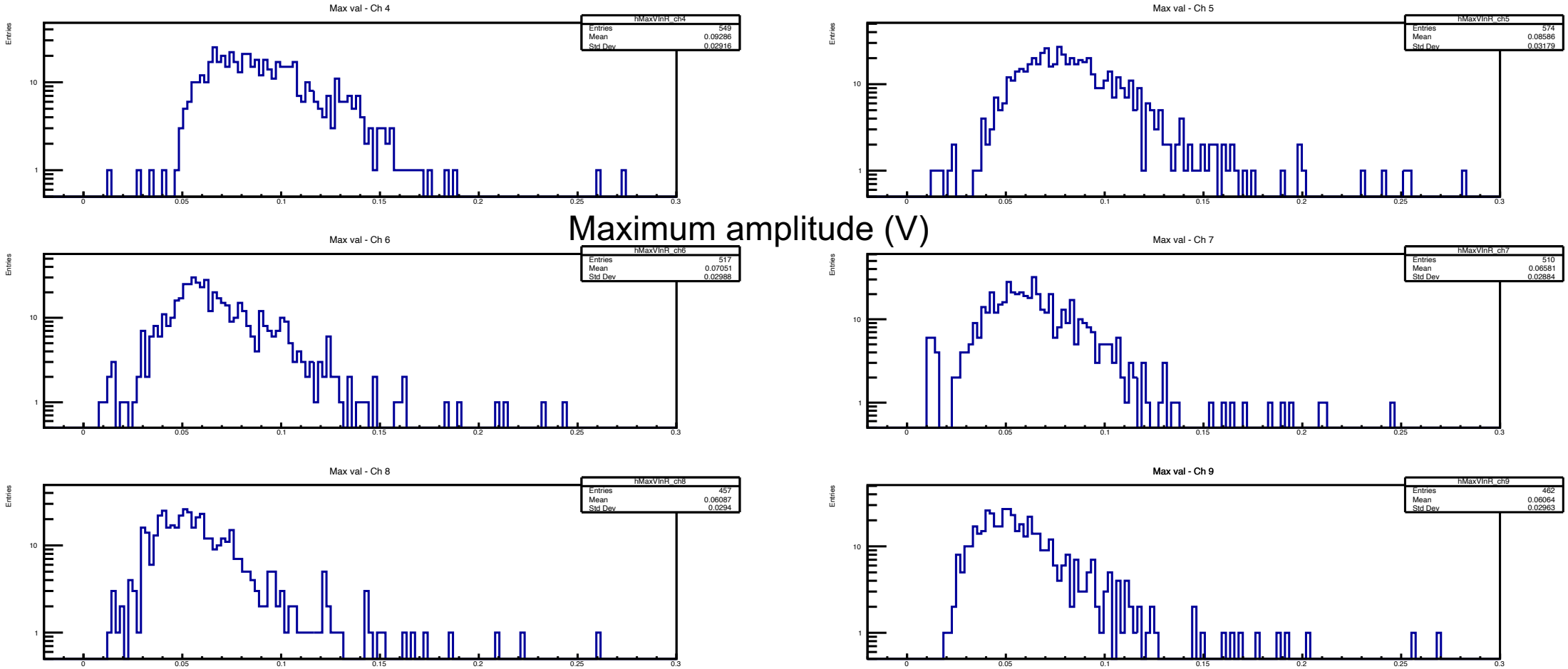
Maximum amplitude (V)



Maximum amplitude for signal events

Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V

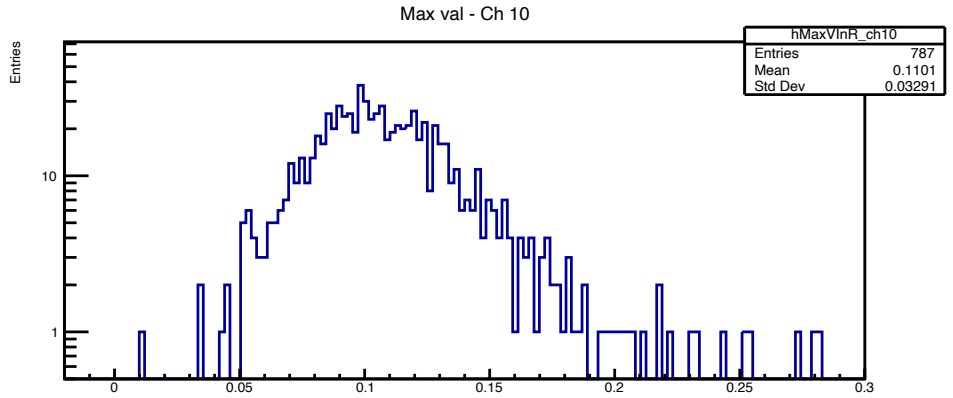
1 cm drift tubes

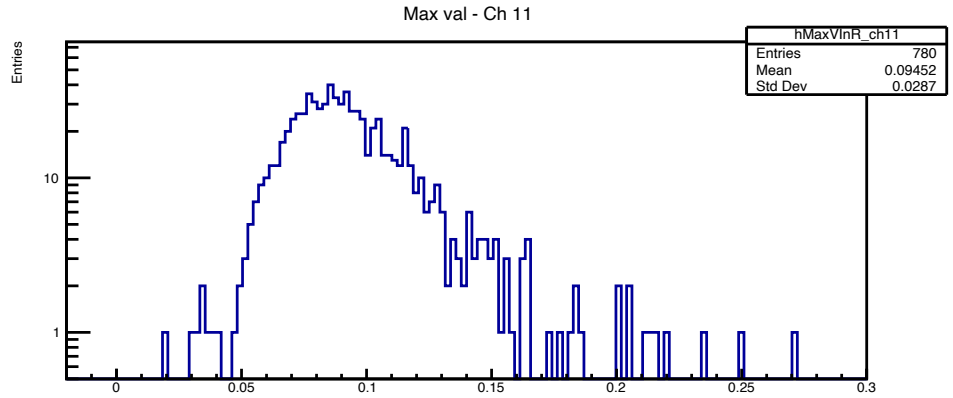


Maximum amplitude for signal events

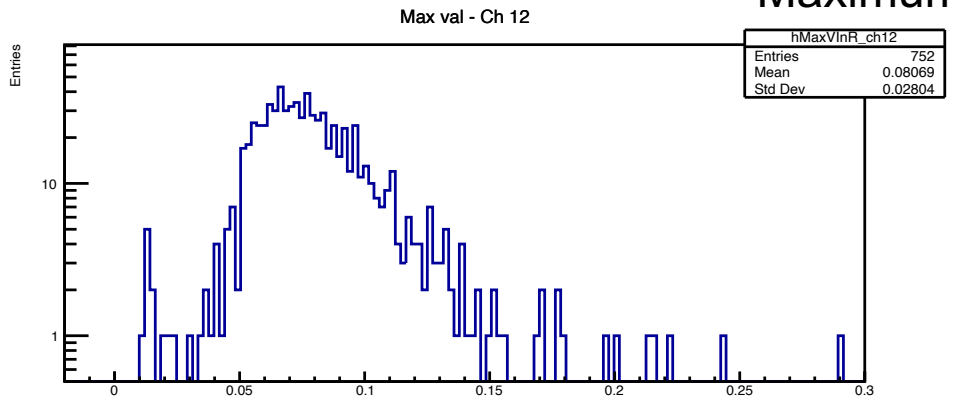
Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V

2 cm drift tubes





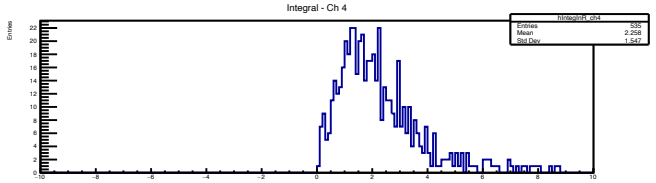
Maximum amplitude (V)

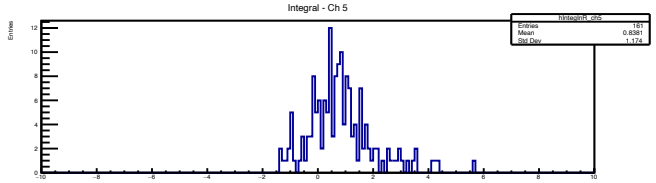


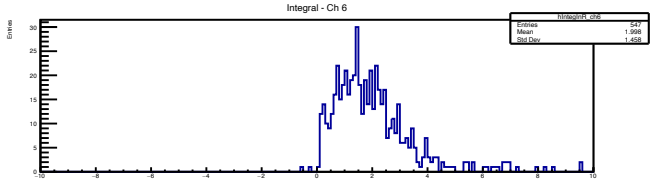
Integral for signal events

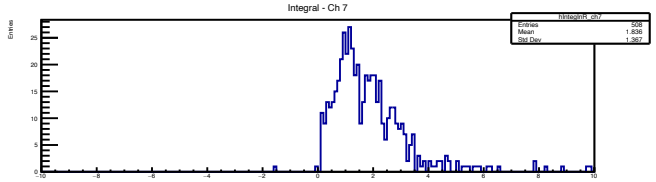
Run: run_99.root; Track angle: 0° ; Gas mixture: 90%He ; HV = +20V

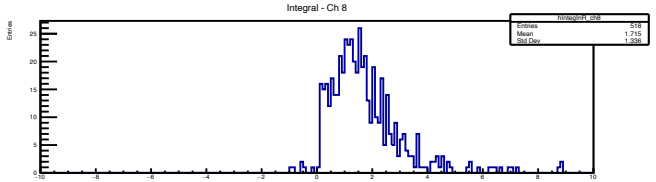
1,2 cm drift tubes

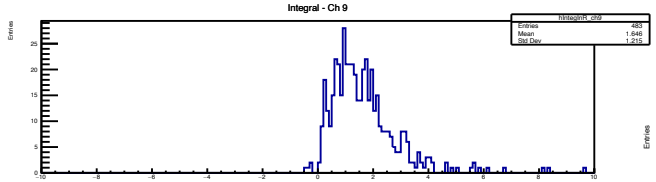


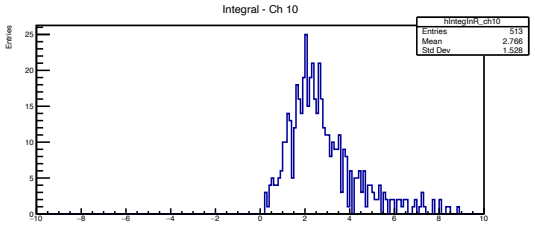


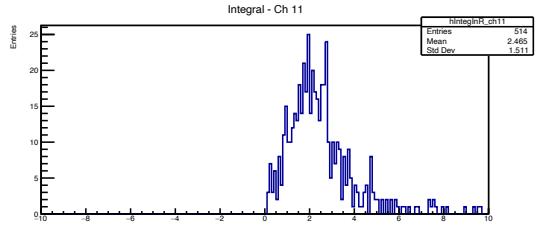


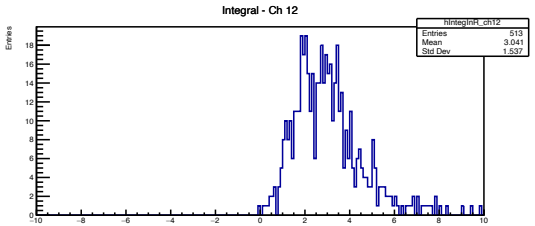










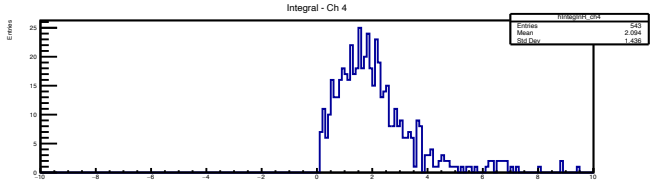


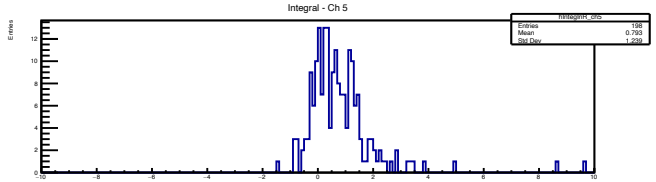
Integral (V/ns)

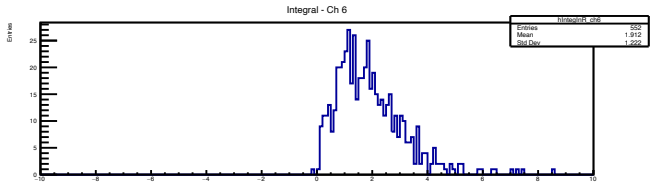
Integral for signal events

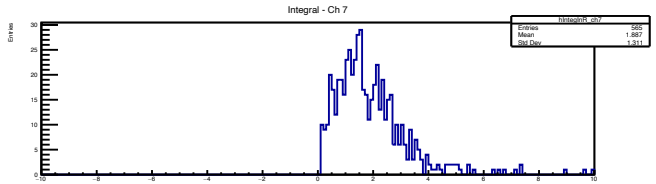
Run: run_98.root; Track angle: 15° ; Gas mixture: 90%He ; HV = +20V

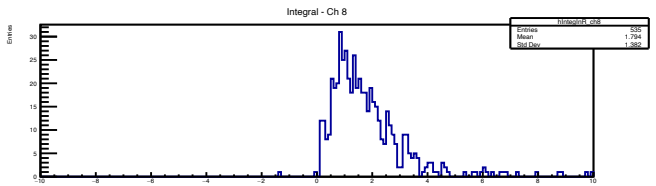
1,2 cm drift tubes

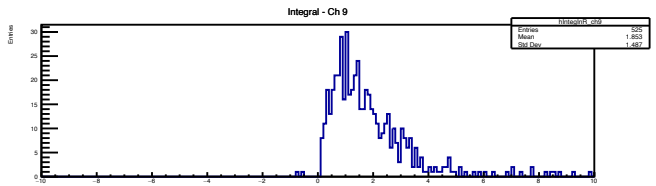




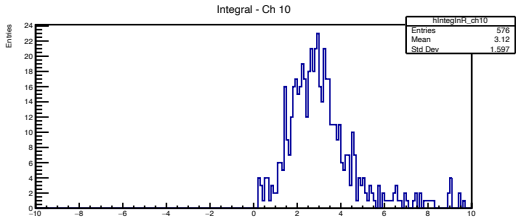


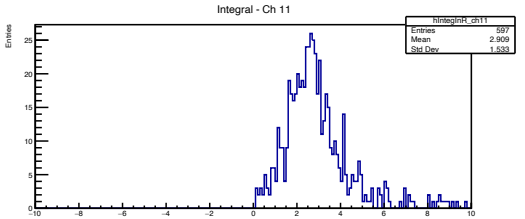


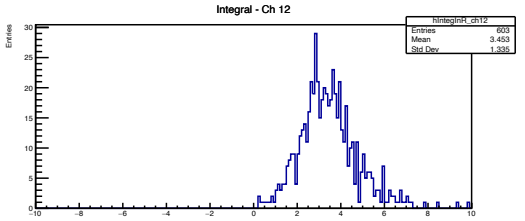




Integral (V/ns)



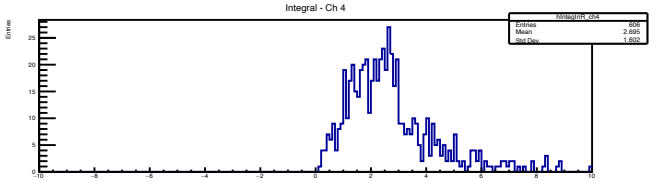


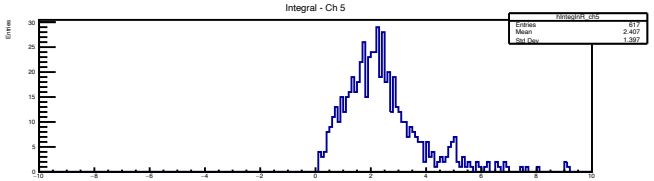


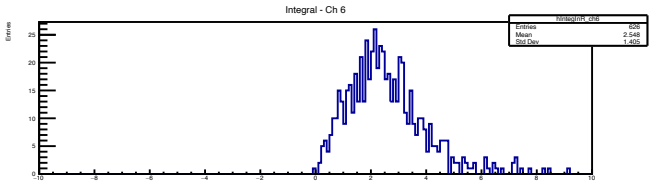
Integral for signal events

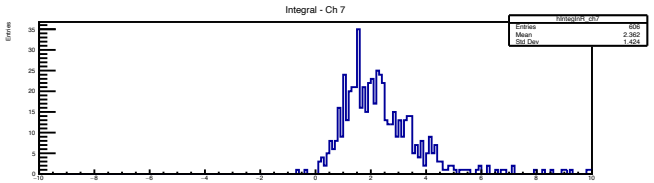
Run: run_96.root; Track angle: 30° ; Gas mixture: 90%He ; HV = +20V

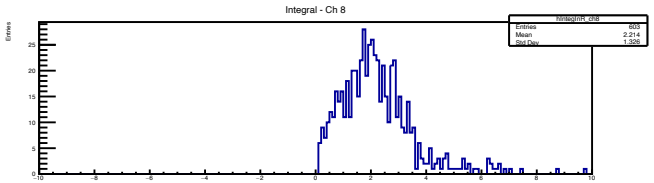
1,2 cm drift tubes

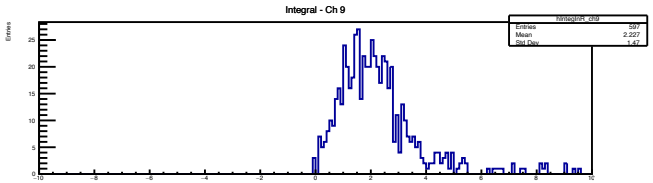




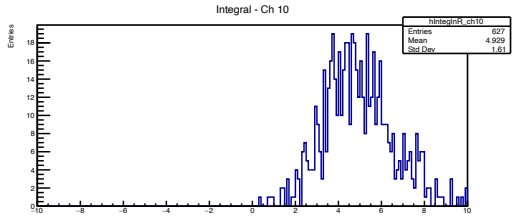


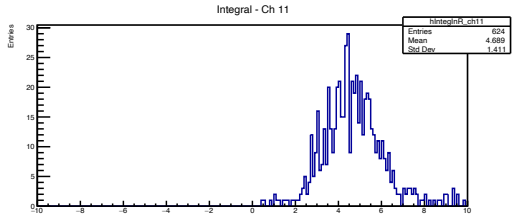


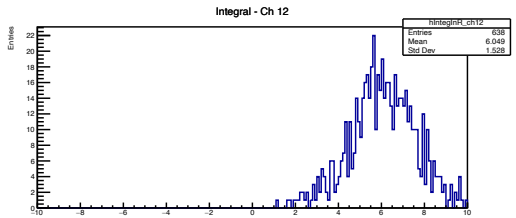




Integral (V/ns)



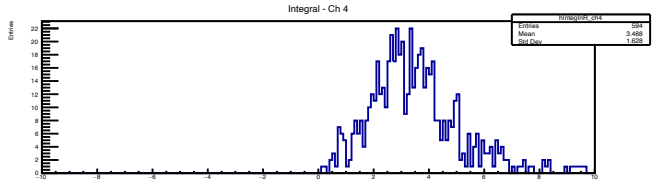


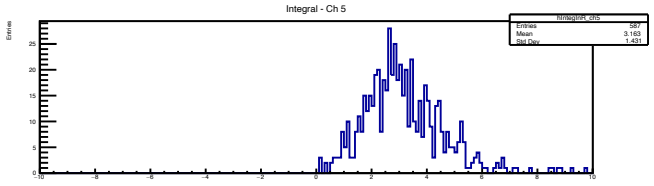


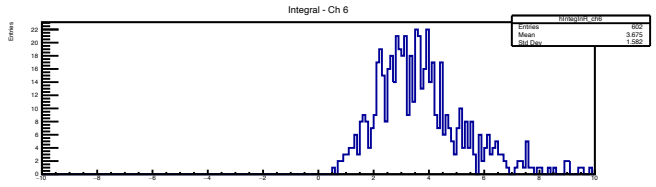
Integral for signal events

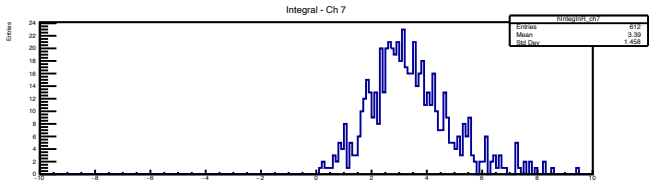
Run: run_94.root; Track angle: 45° ; Gas mixture: 90%He ; HV = +20V

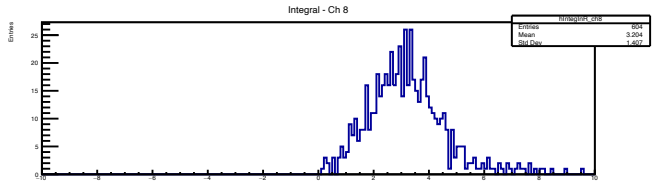
1,2 cm drift tubes

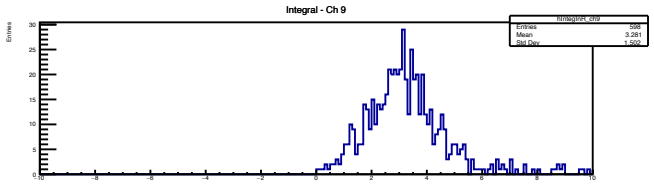




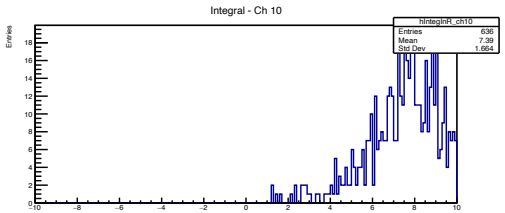


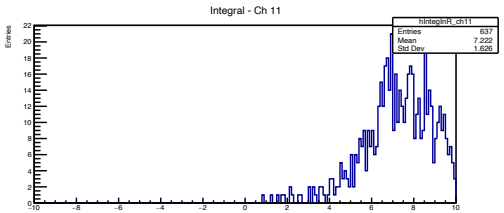


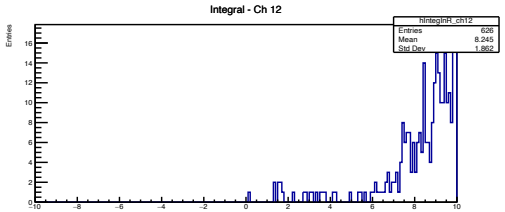




Integral (V/ns)



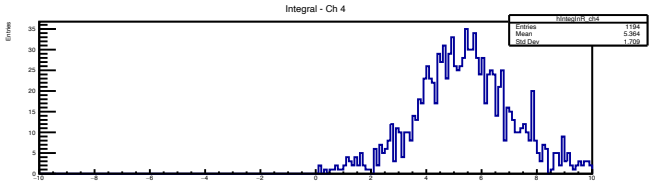


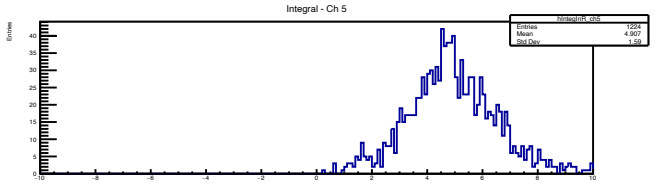


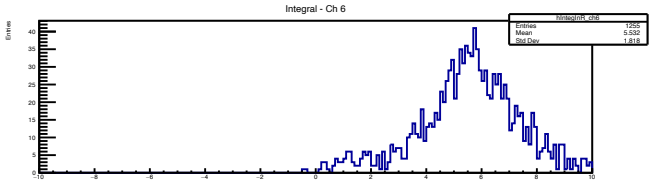
Integral for signal events

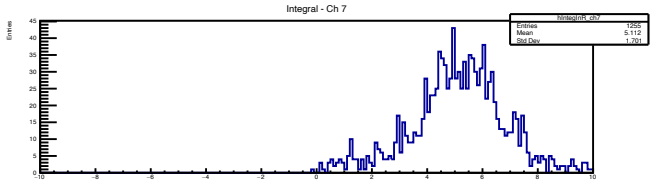
Run: run_91.root; Track angle: 60° ; Gas mixture: 90%He ; HV = +20V

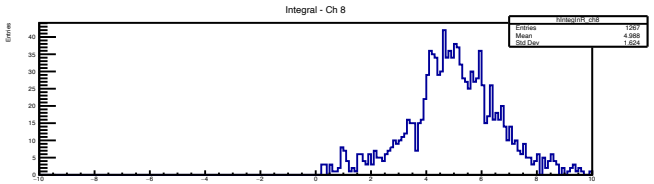
1,2 cm drift tubes

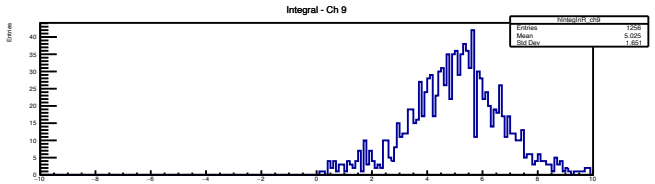




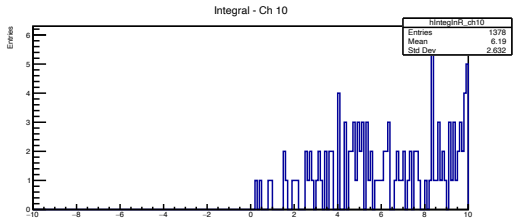


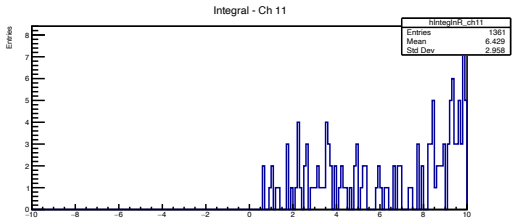


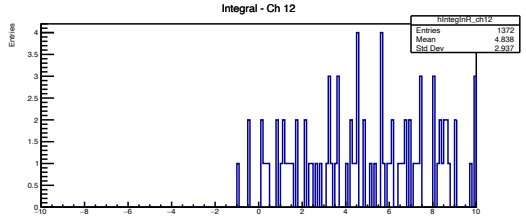




Integral (V/ns)



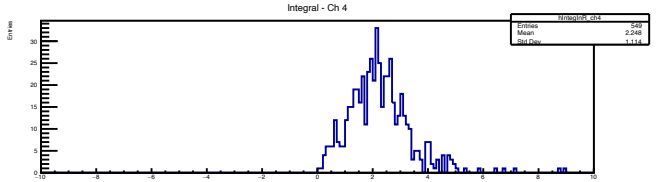


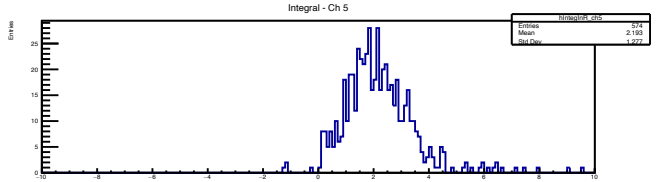


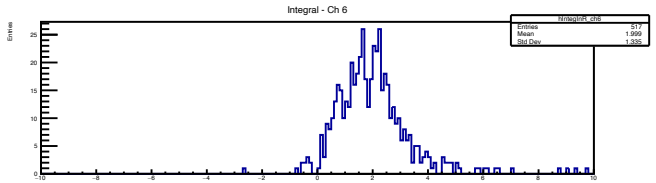
Integral for signal events

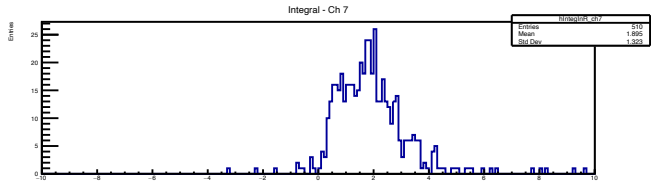
Run: run_127.root; Track angle: 60° ; Gas mixture: 80%He ; HV = +20V

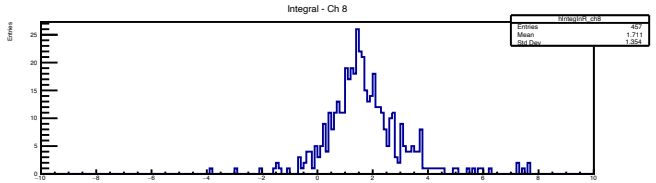
1,2 cm drift tubes

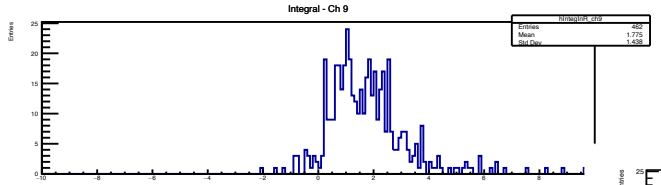




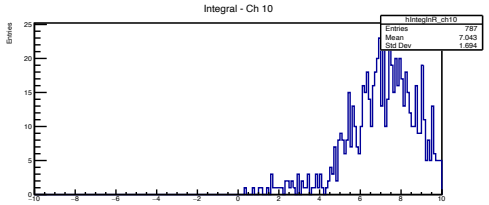


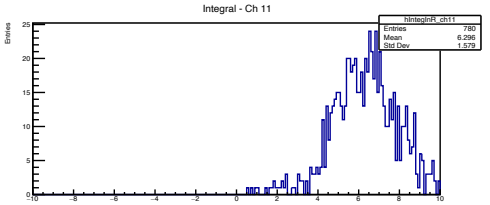


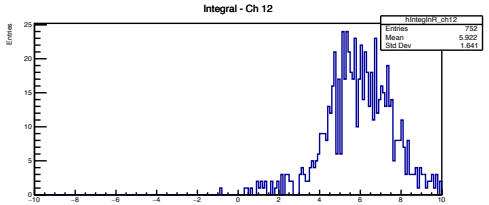




Integral (V/ns)







Clusterization counting strategy

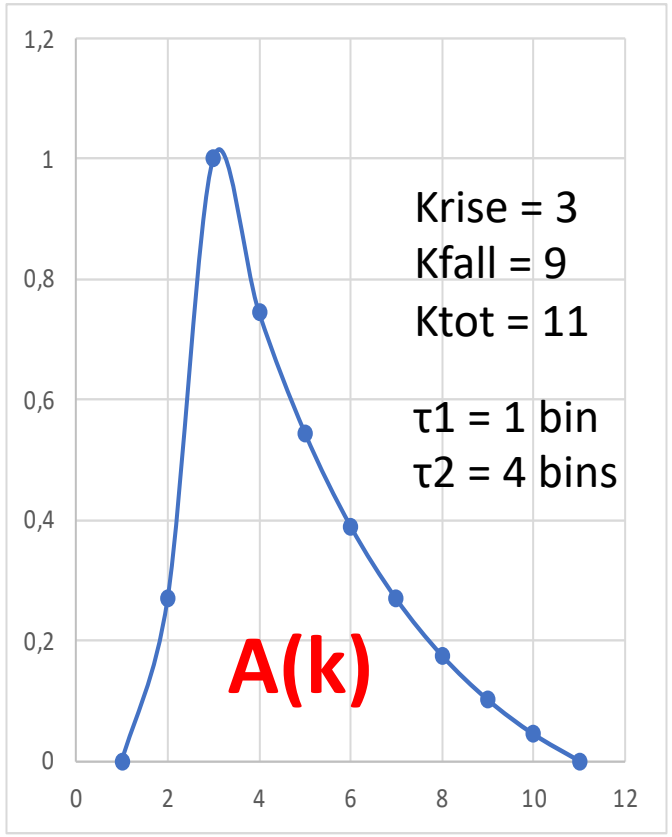
Next step to be implemented will be the clusterization of the electron peaks into ionization clusters.

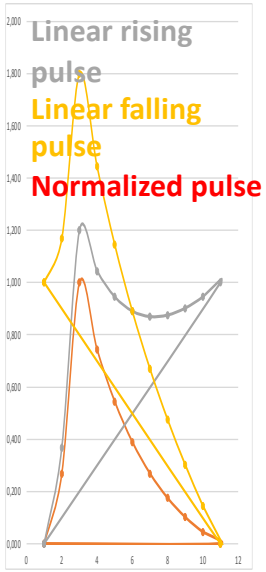
1) Association of electron peaks which are finded in consecutive bins in order to correct the current over-counting
2) Contiguous electrons peaks compatible with the diffusion time must be considered belonging to the same ionization cluster
3) Contiguous clusters must be compatible with the cluster delay depending on the impact parameter (drift time of the first cluster)

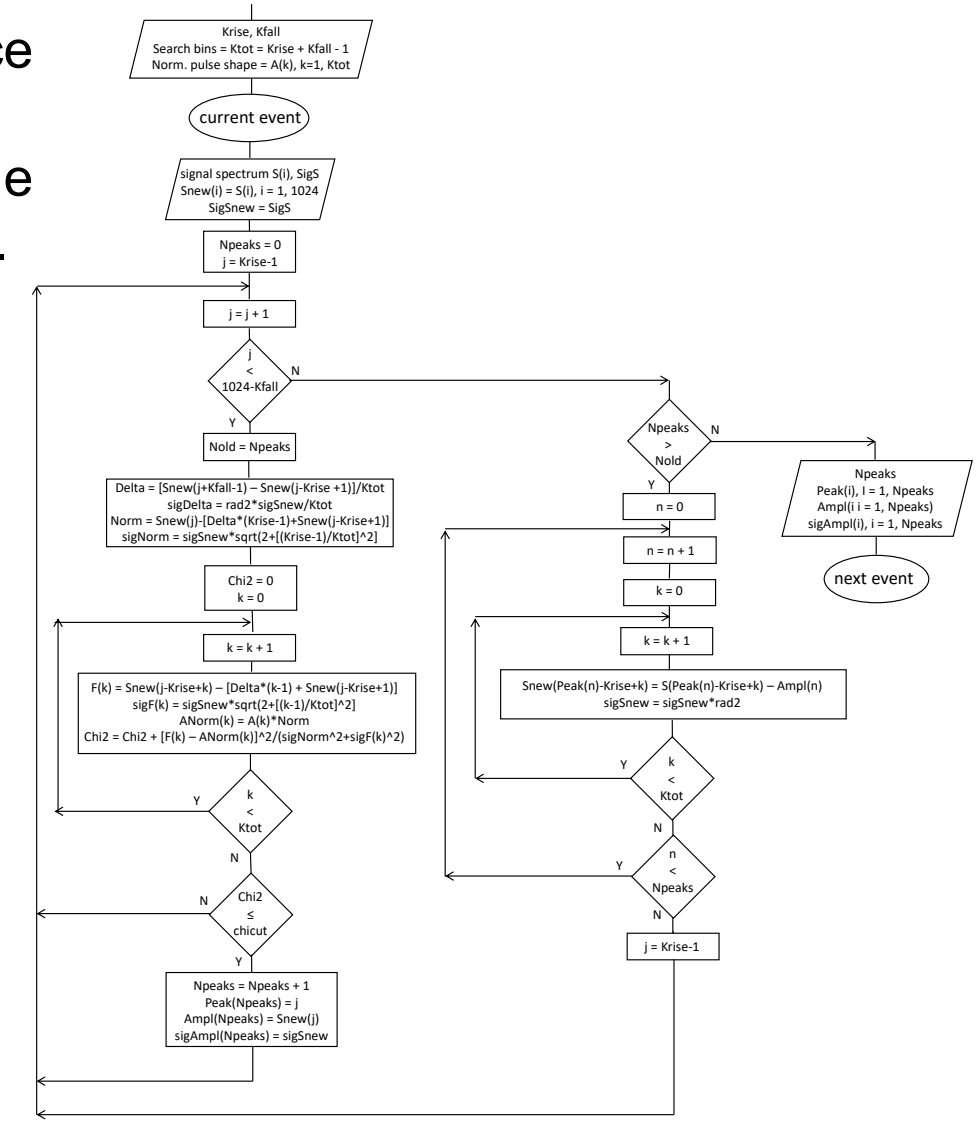
Recursive Template Algorithm

- We are working on it in order to make a performance comparison with the current algorithm!
- Both of the algorithms are quite simple from the computation point of view to be implemented in FPGAs.

k	A(k)
1	0.0
2	0.269
3	1.0
4	0.744
5	0.545
6	0.390
7	0.269
8	0.175
9	0.102
10	0.044
11	0.0







Conclusion

- We tested the Derivative Find Electron Peak algorithm on runs having 1.2 GSPS and HV_nominal + 20V in order to set the constraints of our algorithm in the most favorable conditions with different gas mixture (80%He 90%He).

- Distributions of the most important physical observables are compatible with the expected behaviours in most of the cases. Some differences are still visible due to the presence of several only-noise events. For some runs the issue is linked to the small amplification of the signal (0° for example, and especially the 1cm drift tube Ch5) .

- The Clusterization algorithm is still missing but we are quite close to implement and test it!

- Hopefully we will have a new Find Electron Peak algorithm soon!