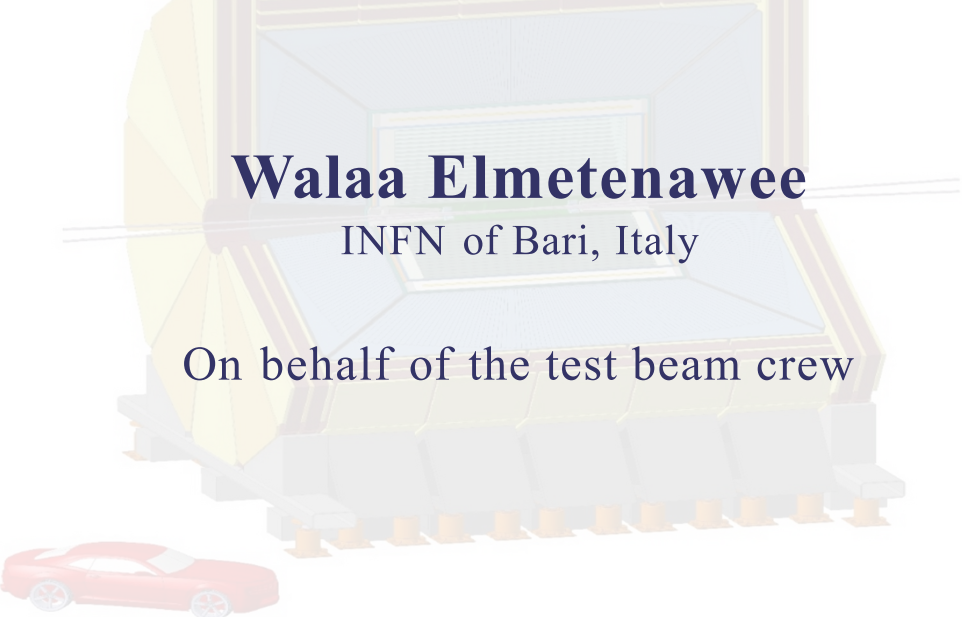
A new electron peaks counting algorithm based on a running pulse template



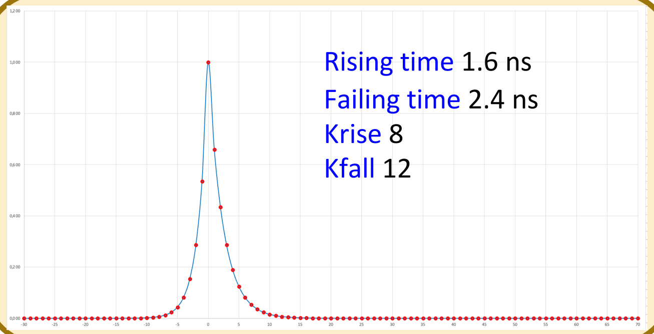
Walaa Elmetenawee
INFN of Bari, Italy

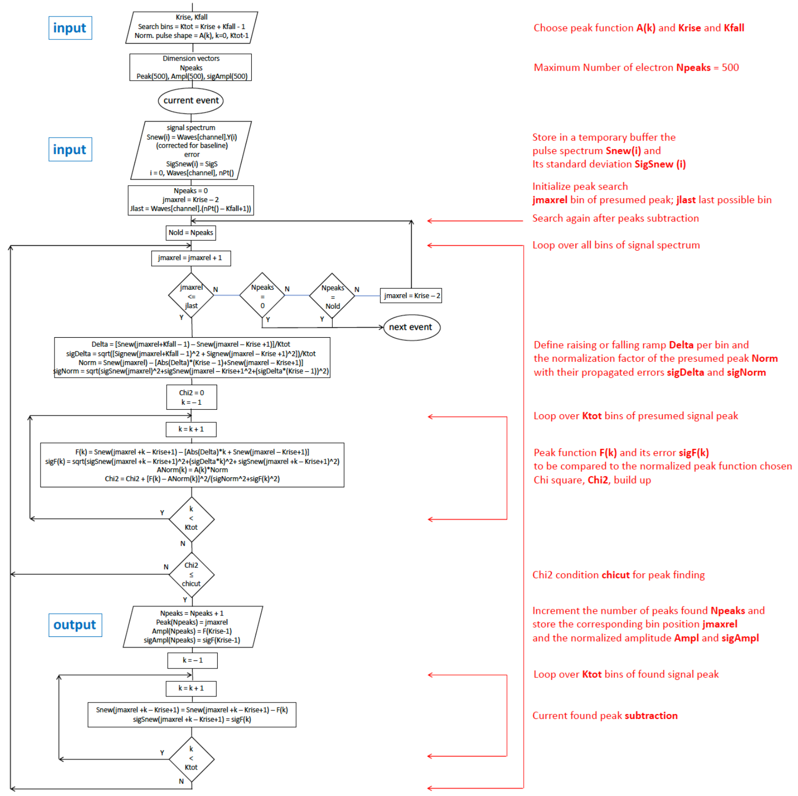
On behalf of the test beam crew

Meeting on cluster counting in drift chambers
26 May 2023

Running Template Algorithm (RTA)

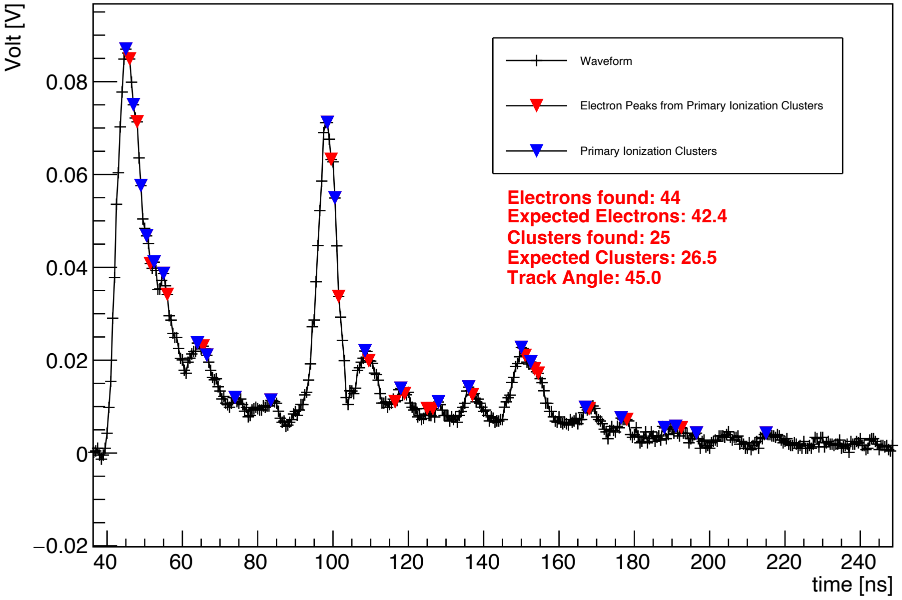
- Define an electron pulse template based on experimental data.
- Raising and falling exponential over a fixed number of bins (Ktot).
- Digitize it (A(k)) according to the data sampling rate.
- The algorithm scan the wave form and run over Ktot bins by comparing it to the subtracted and normalized data (build a sort of χ^2).
- Define a cut on χ^2.
- Subtract the found peak to the signal spectrum.
- Iterate the search.
- Stop when no new peak is found.



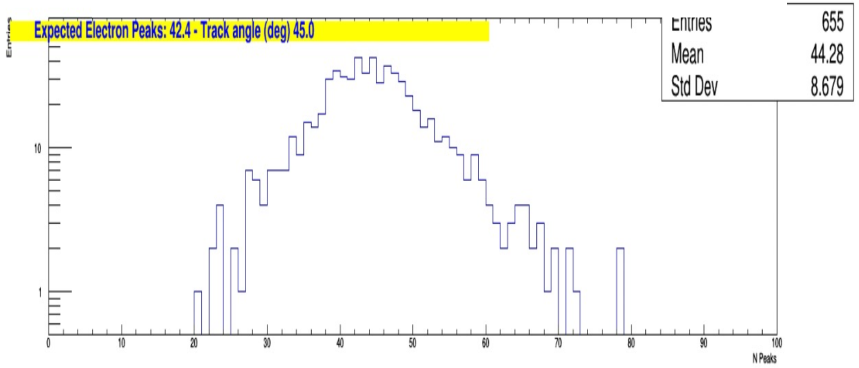


Reconstruction of Electron Peaks (RTA Algorithm)

Sense Wire Diameter 15 μm; Cell Size 1.0 cm; Track Angle 45; Sampling rate 2 GSa/s; Gas Mixture He:IsoB 80/20



Electron Peaks distribution



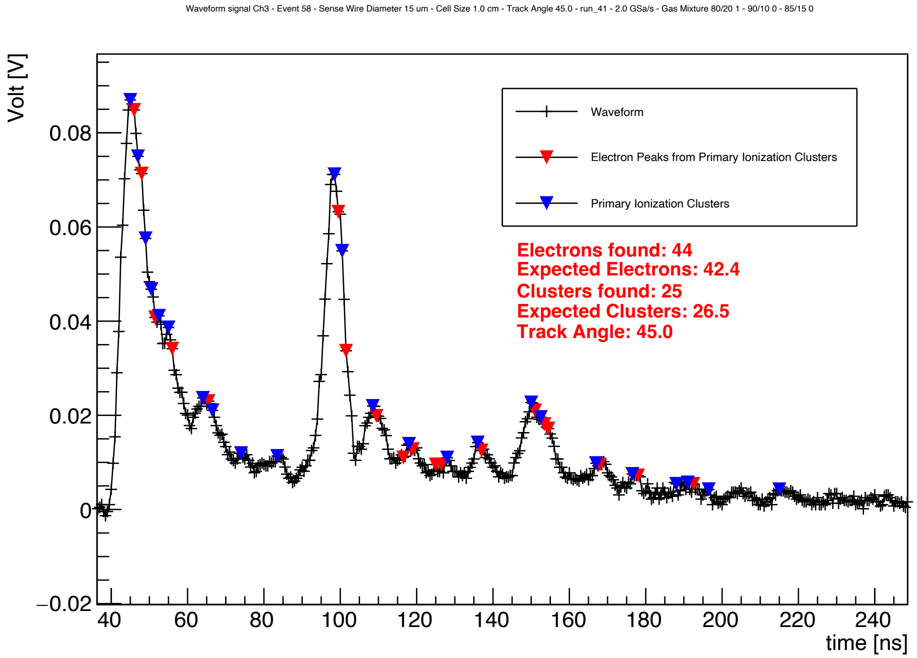
Expected number of electron =
δ cluster/cm (M.I.P.) * drift tube size [cm] * 1.3 (relativistic rise)* 1.6 electrons/cluster * 1/cos(α)

α = angle of the muon track w.r.t. normal direction to the sense wire.
δ cluster/cm (mip) changes from 12, 15, 18 respectively for He:IsoB 90/10, 85/15 and 80/20 gas mixtures.
drift tube size are 0.8, 1.2, and 1.8 respectively for 1 cm, 1.5 cm, and 2 cm cell size tubes.

Reconstruction of Primary Ionization Clusters

Sense Wire Diameter 15 μm; Cell Size 1.0 cm; Track Angle 45; Sampling rate 2 GSa/s; Gas Mixture He:IsoB 80/20

- ***Merging of electron peaks*** *in consecutive bins in a single electron to reduce fake electrons counting.*
- ***Contiguous electrons peaks*** *which are compatible with the electrons' diffusion time (it has a* $\sim\sqrt{t_{ElectronPeak}}$ *dependence, different for each gas mixture) must be considered belonging to the* ***same ionization cluster****. For them, a counter for electrons per each cluster is incremented.*
- ***Position and amplitude*** *of the clusters corresponds to the position and height of the electron having the maximum amplitude in the cluster.*
- ***Poissonian distribution for the number of clusters!***



Reconstruction of Primary Ionization Clusters

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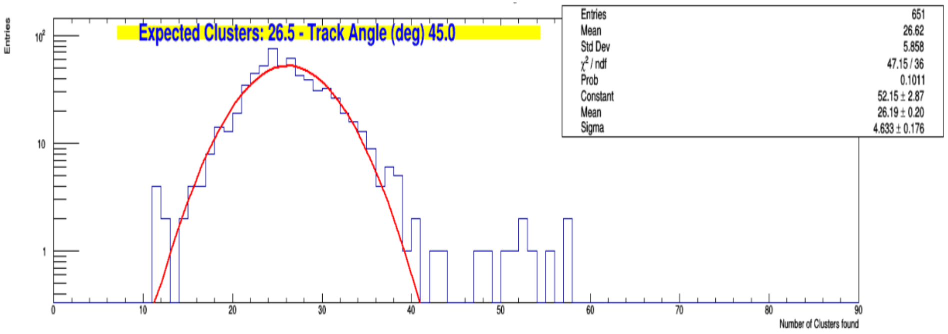
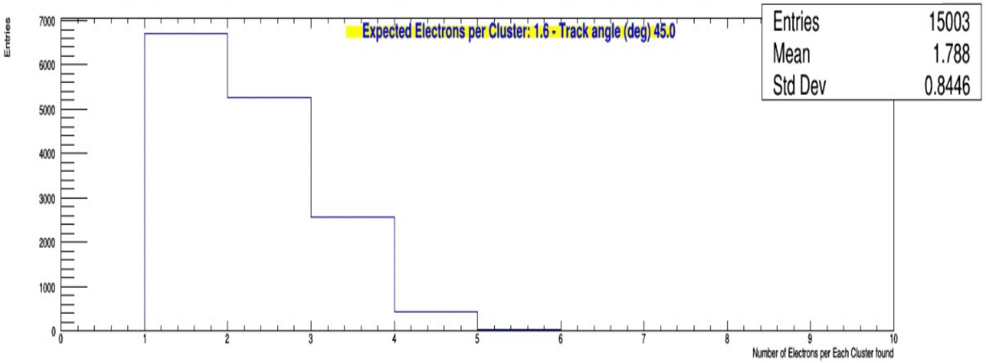
Poissonian distribution for the number of clusters



Electrons per cluster distribution



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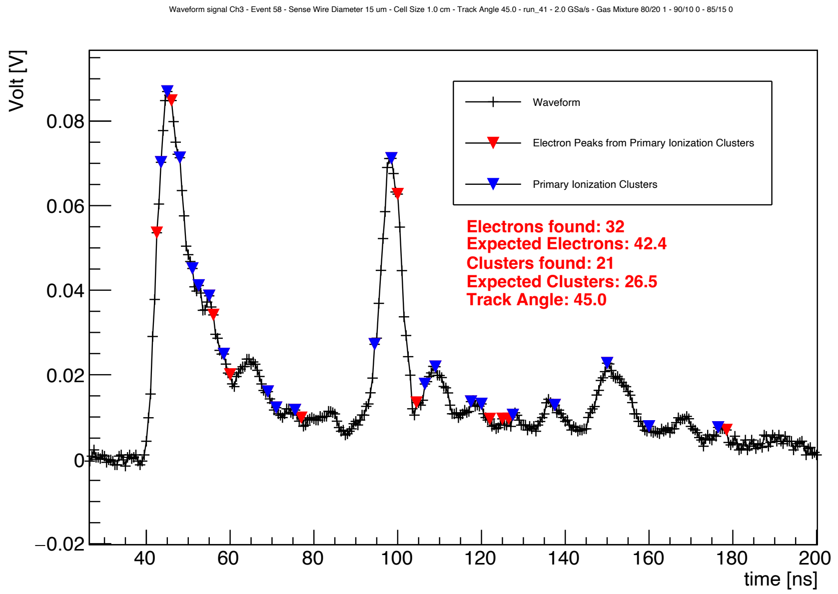
Comparison between DERV and RTA algorithm

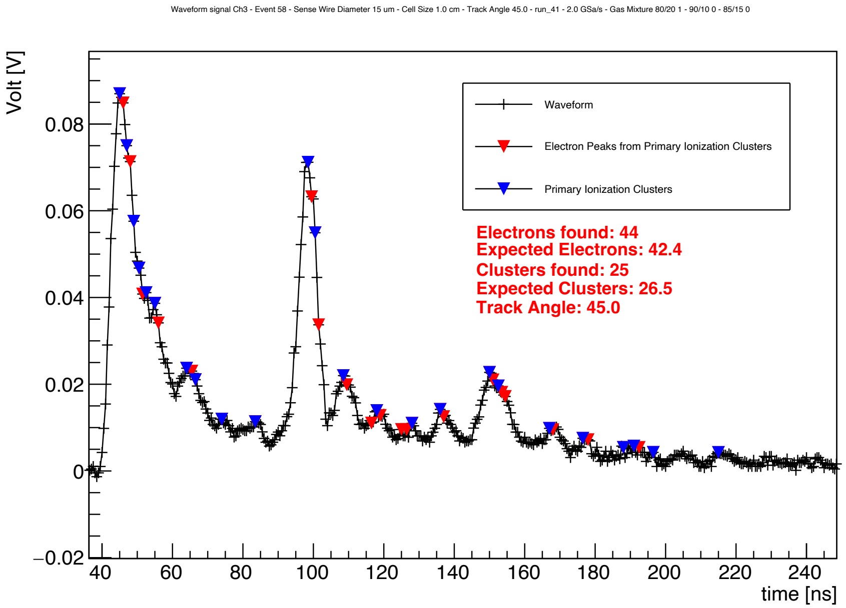
1 cm drift tubes

Run: 41; Track angle: 45^0; Gas mixture: 80% He 20% iC_4H_{10} ; HV = Nominal Sampling rate= 2 Gsa/s

DERIV Algorithm



RTA Algorithm



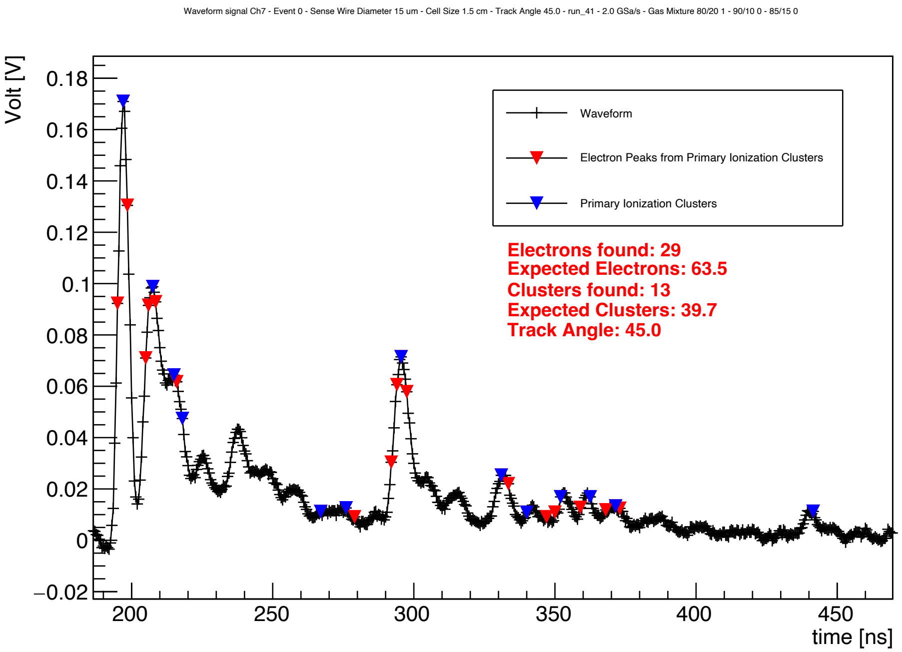
Comparison between DERV and RTA algorithm

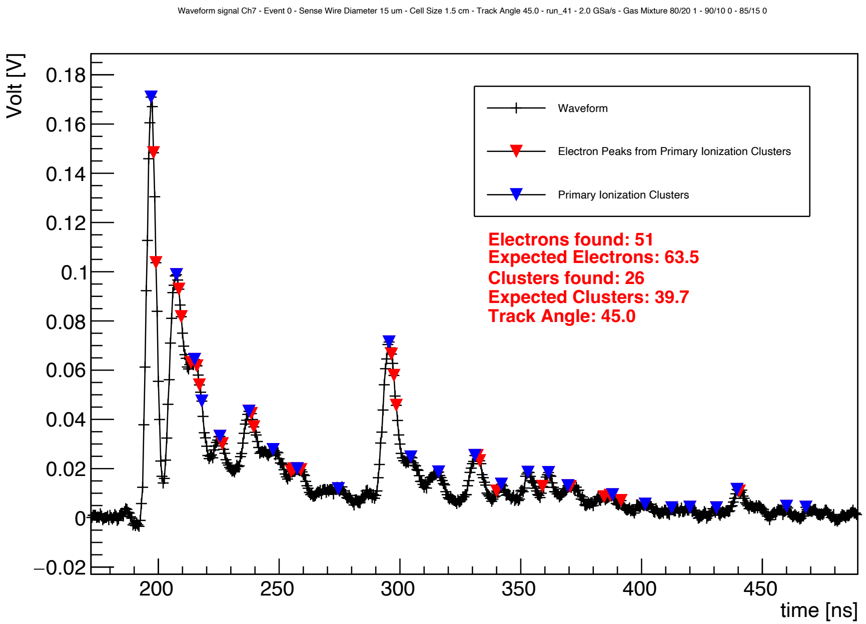
1.5 cm drift tubes

Run: 41; Track angle: 45^0; Gas mixture: 80% He 20% iC_4H_{10} ; HV = Nominal Sampling rate= 2 Gsa/s

DERIV Algorithm

RTA Algorithm



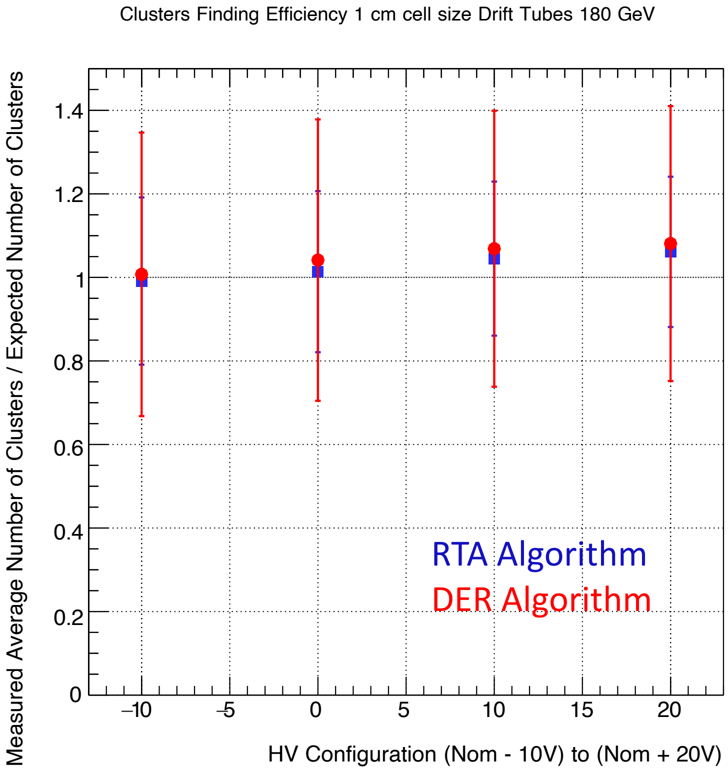


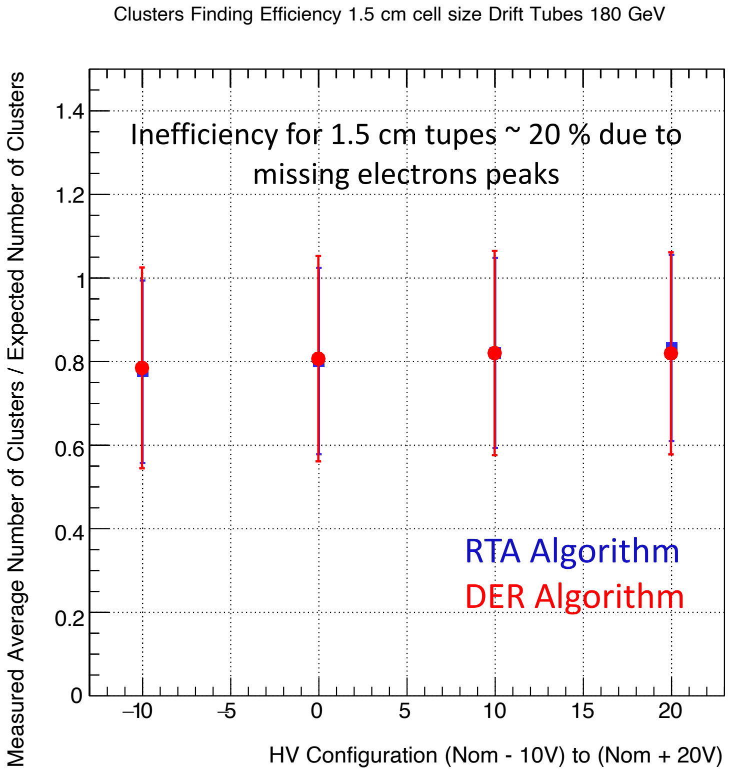
Comparison between DERV and RTA algorithm

1 cm drift tubes

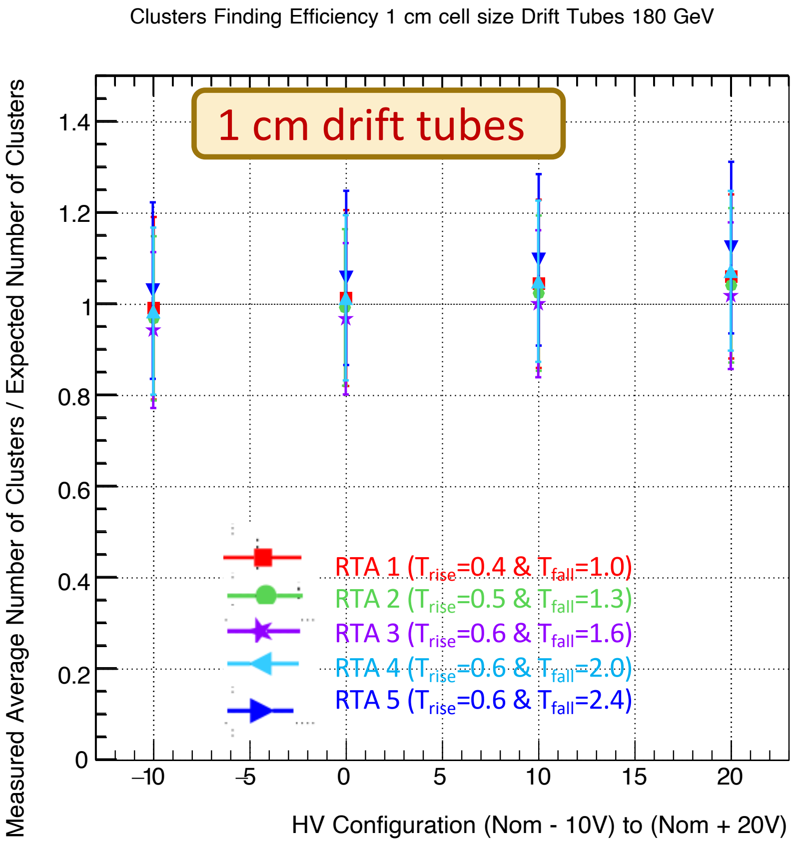
HV scan

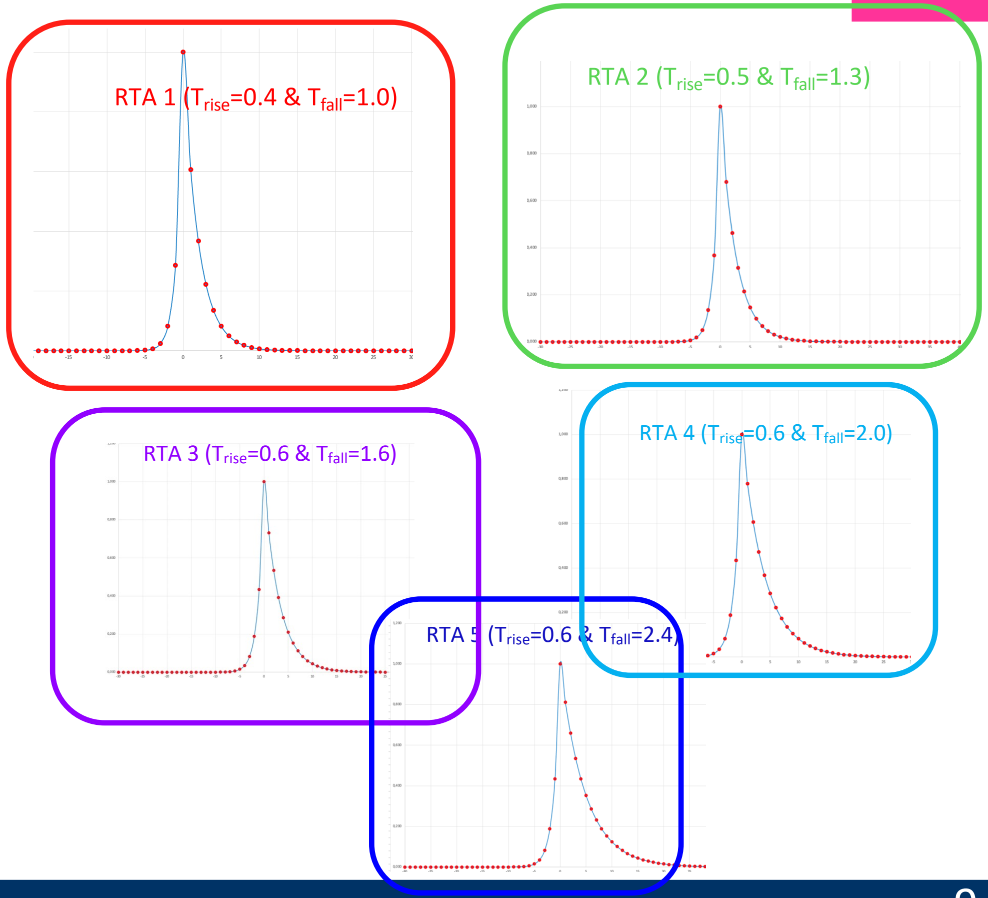
1.5 cm drift tubes



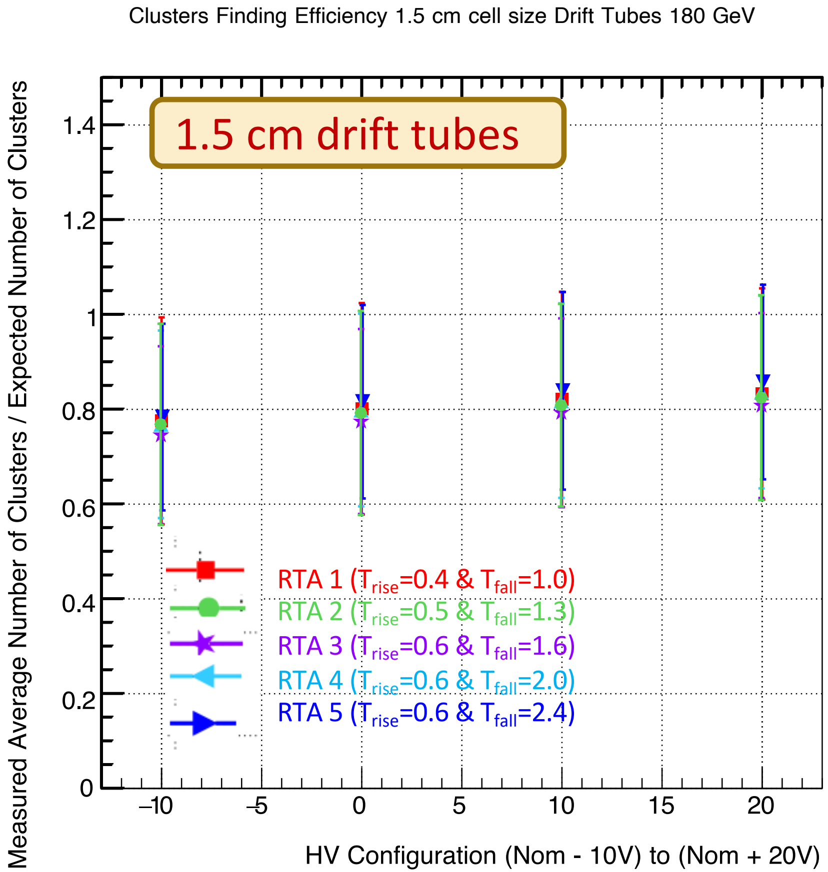


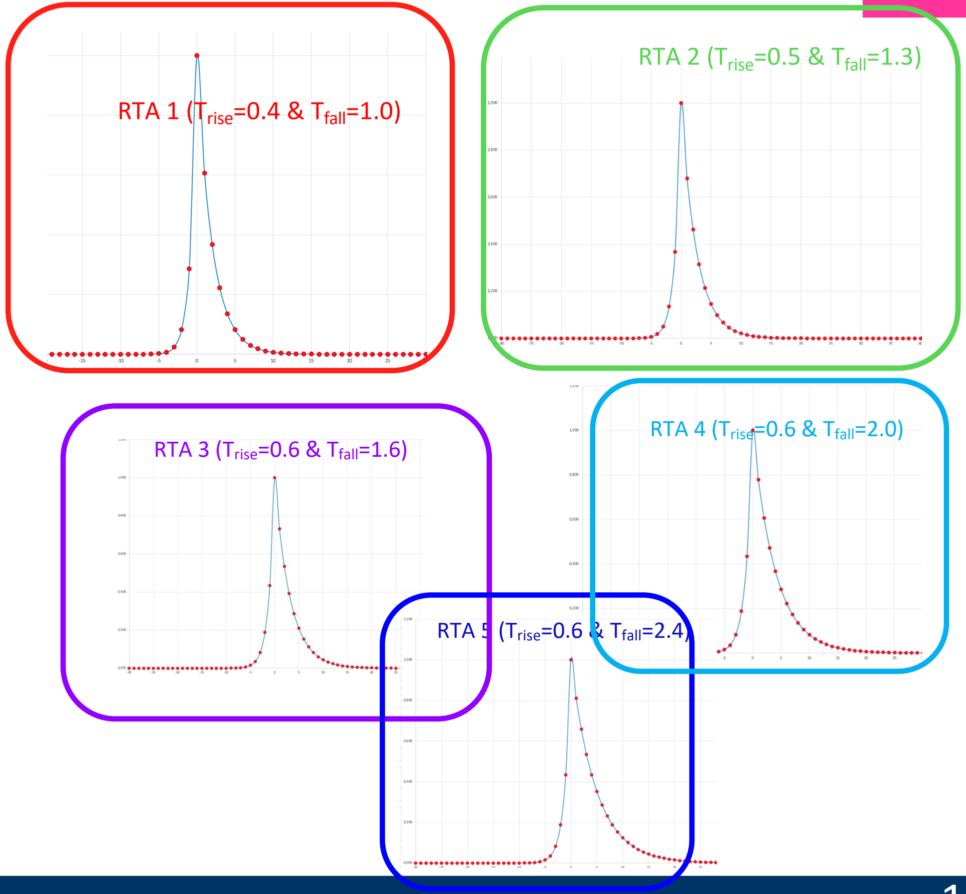
RTA Templates scan





RTA Templates scan

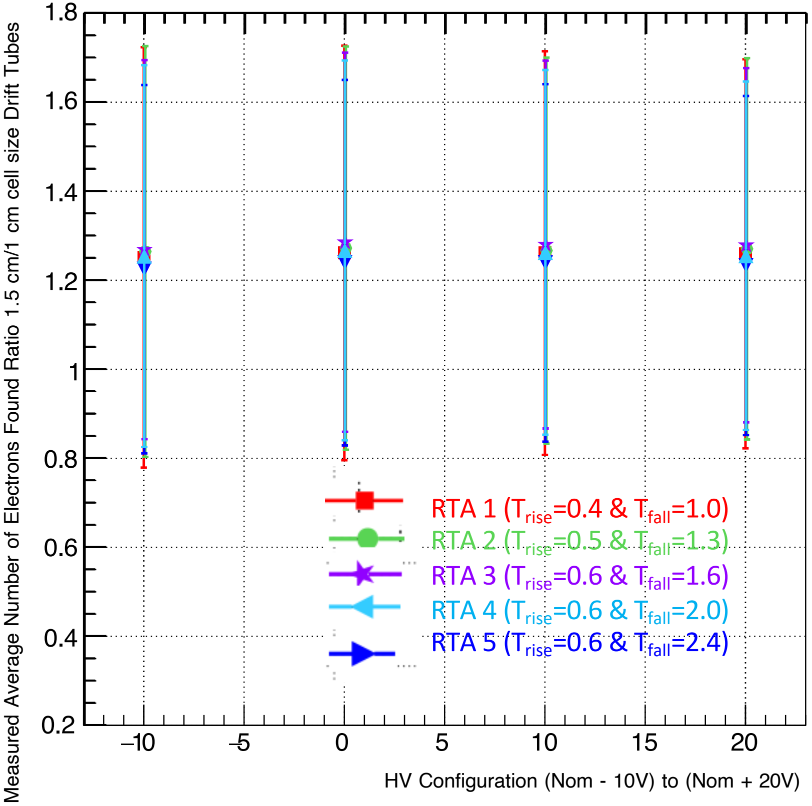


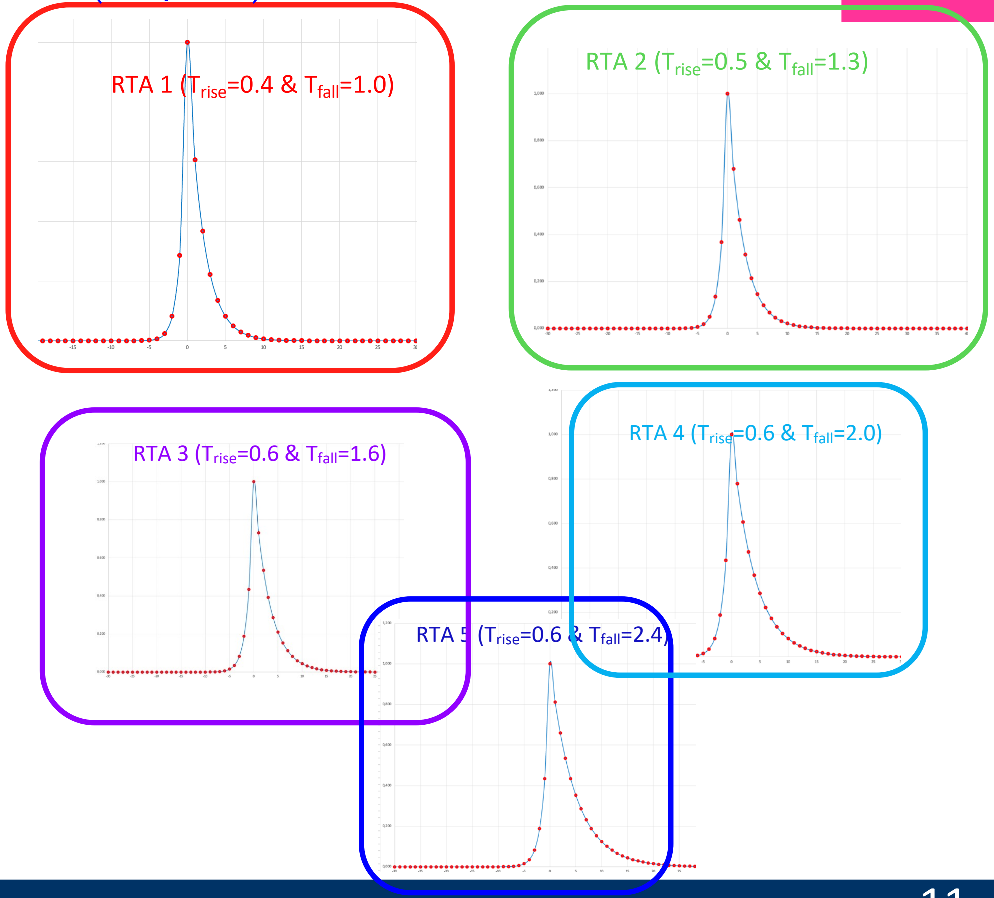


RTA scan ratio (1.5/1 cm tupes)

Ratio of drift tube size (1.2/0.8)

Electrons ratio

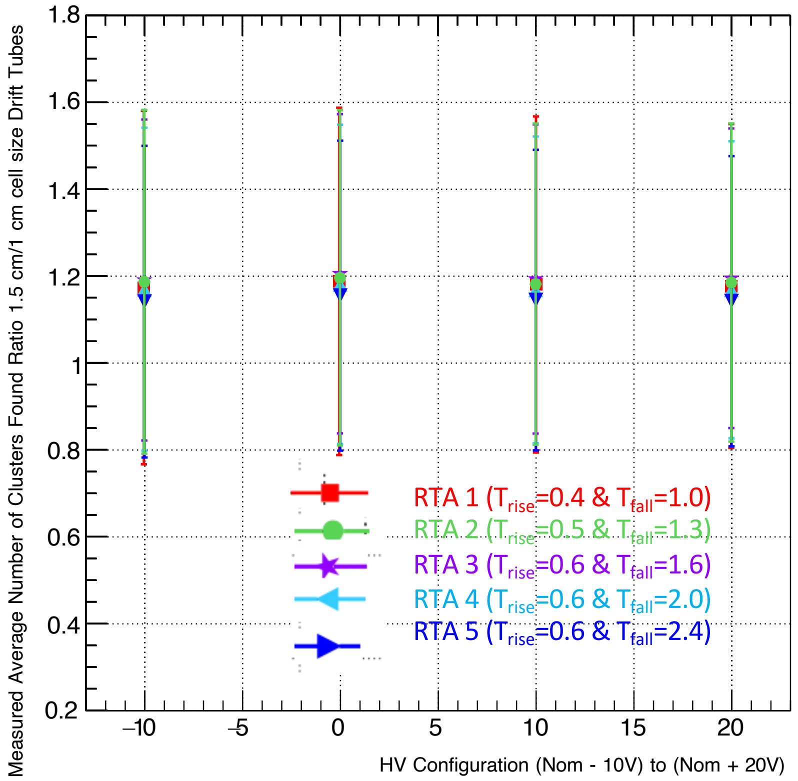


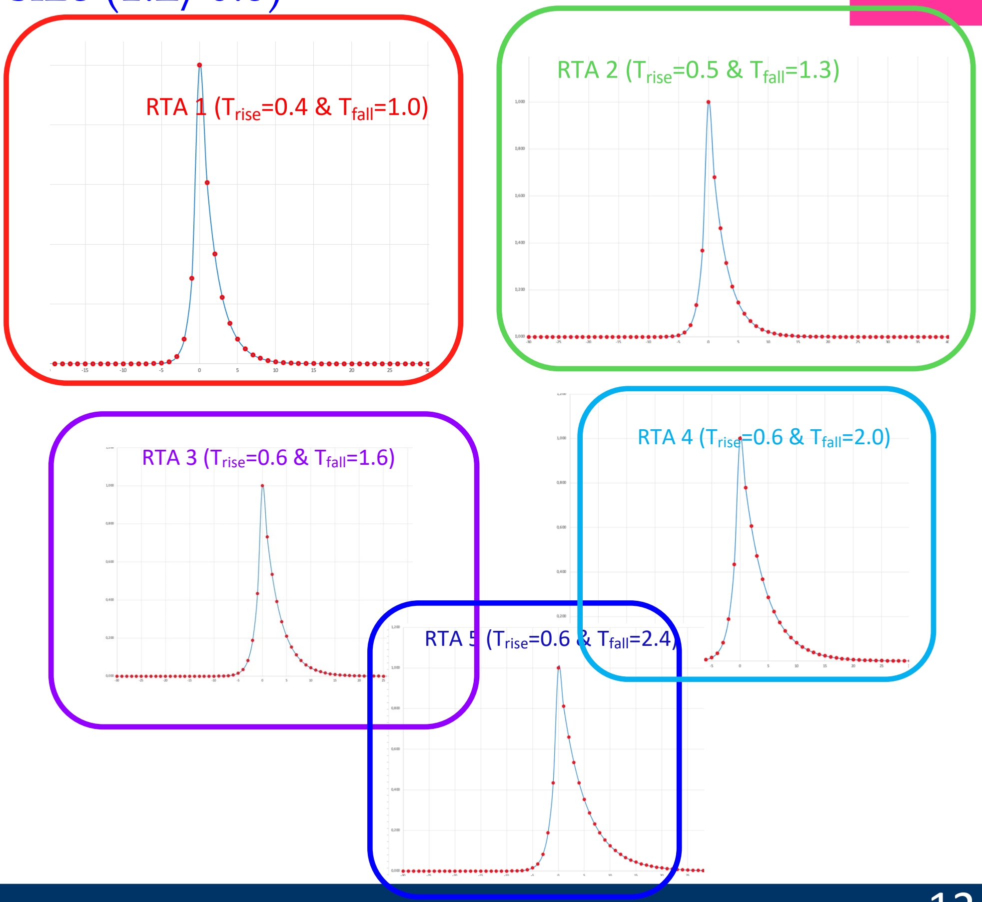


RTA scan ratio (1.5/1 cm tupes)

Ratio of drift tube size (1.2/0.8)

Clusters ratio

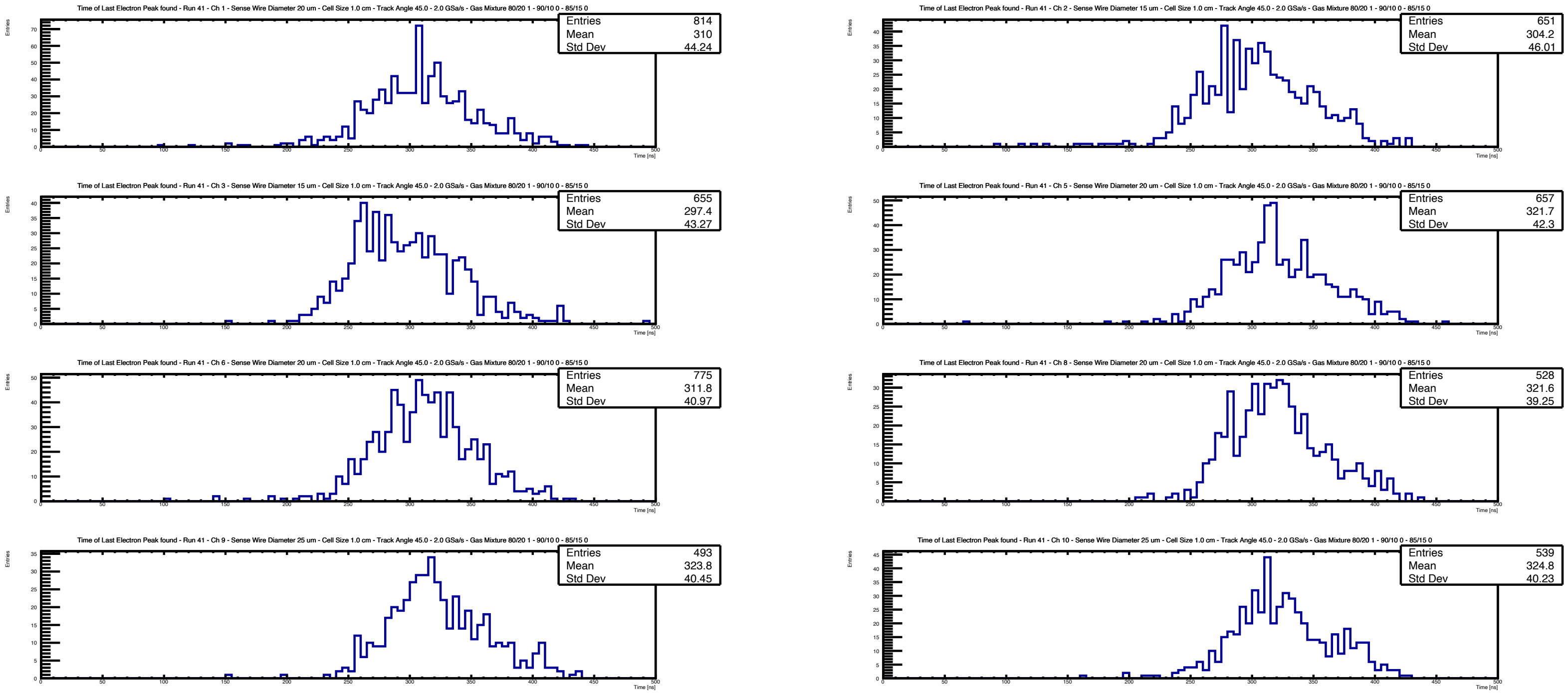




Time of the last electron peak

Time of the last electron peak 1 cm tupes

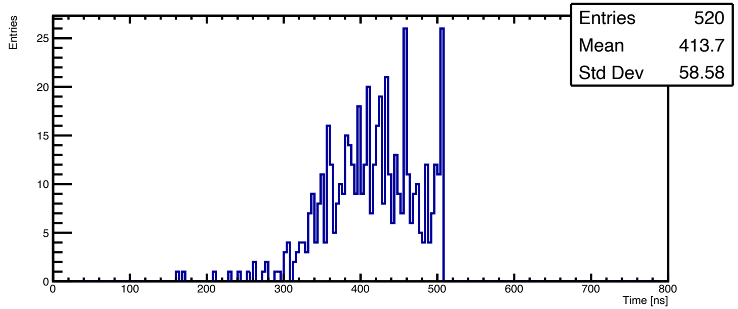
Track Angle 45; Sampling rate 2 GSa/s; Gas Mixture He:IsoB 80/20

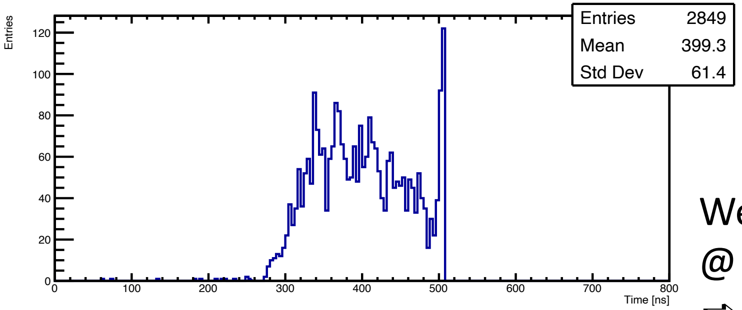


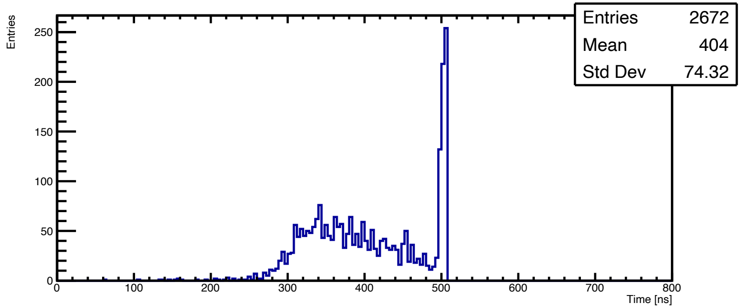
Time of the last electron peak

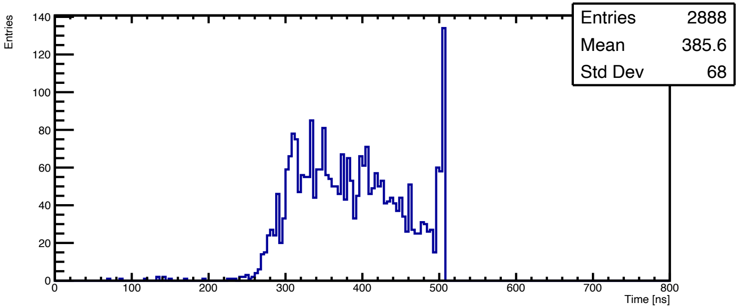
Time of the last electron peak 1.5 cm tupes
Track Angle 45; Sampling rate 2 GSa/s; Gas Mixture He:IsoB 80/20

Issue in 1.5 cm tubes due to 512 ns don’t cover the full range.







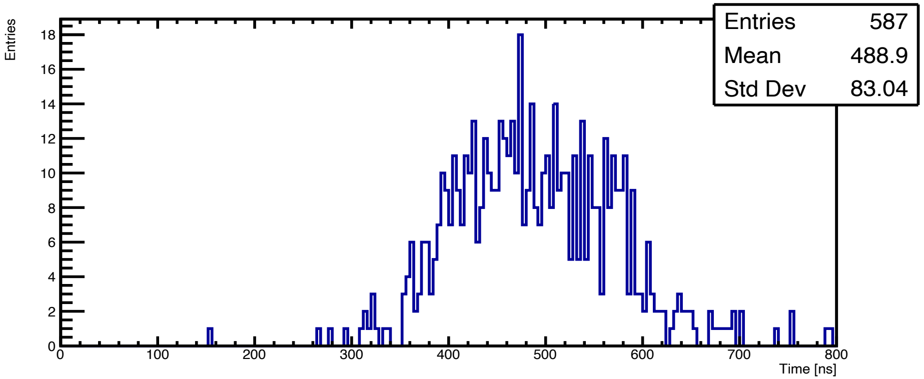


We have 1024 bins,
@ 2GSa ➪ 1/2 ns/bin
➪ 512 ns.

Time of the last electron peak

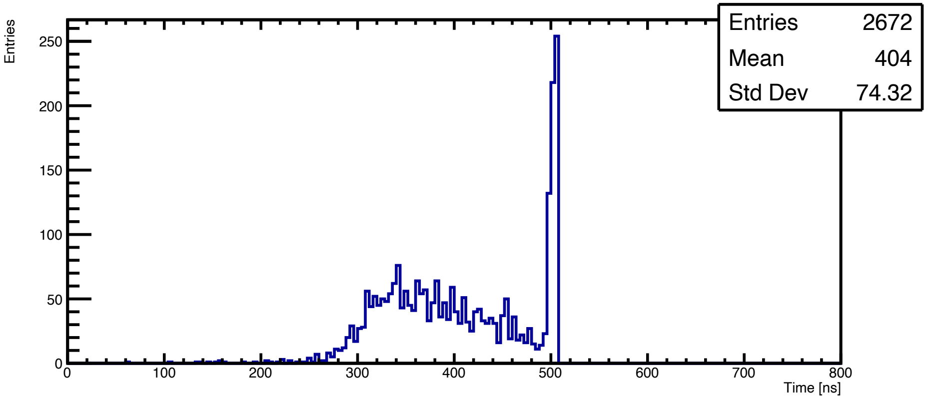
Time of the last electron peak 1.5 cm tupes, Track Angle 45; Gas Mixture He:IsoB 80/20

Sampling rate 1 GSa/s;



We have 1024 bins,
@ 1GSa ➪ 1 ns/bin ➪ 1024 ns.

Sampling rate 2 GSa/s;



We have 1024 bins,
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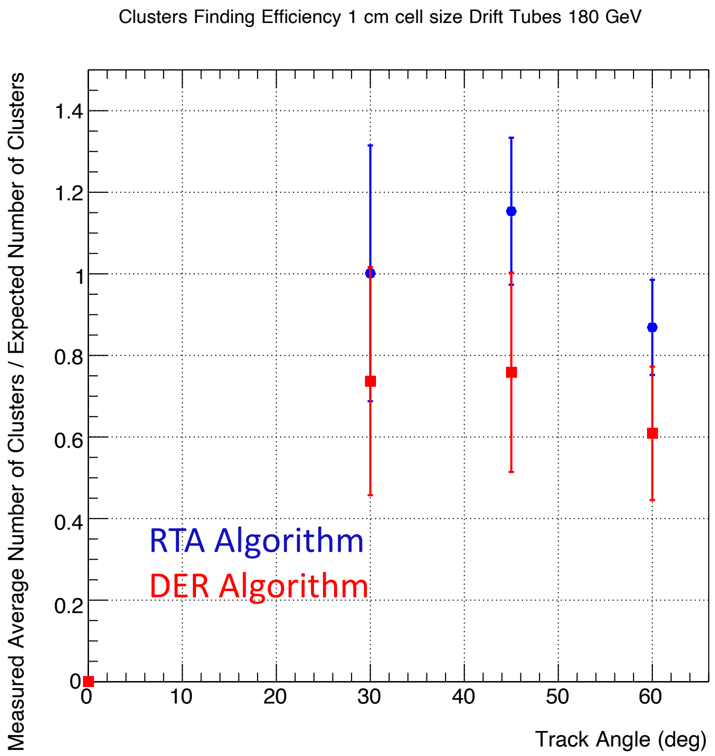
Issue in 1.5 cm tubes when using sampling rate 2GSa/s due to 512 ns don't cover the full range.

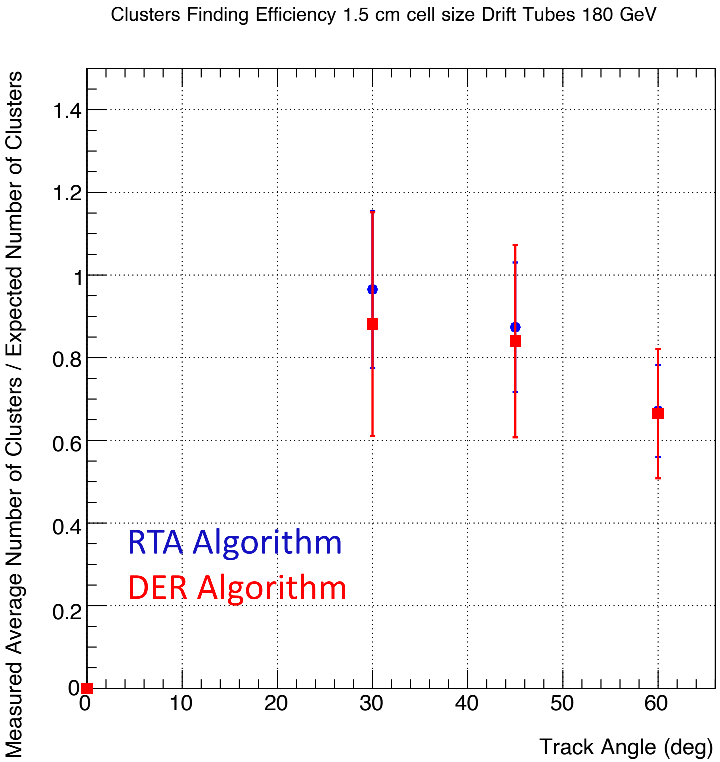
Comparison between DERV and RTA algorithm

1 cm drift tubes

Sampling rate 1 GSa/s;

1.5 cm drift tubes





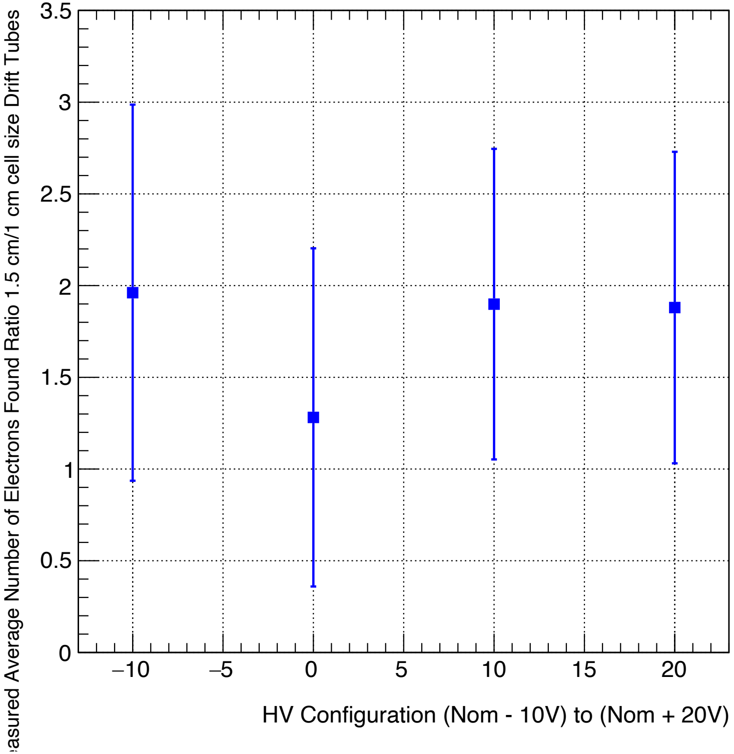
- Undercounting at $\alpha > 45^0$ due to high electron peaks density.

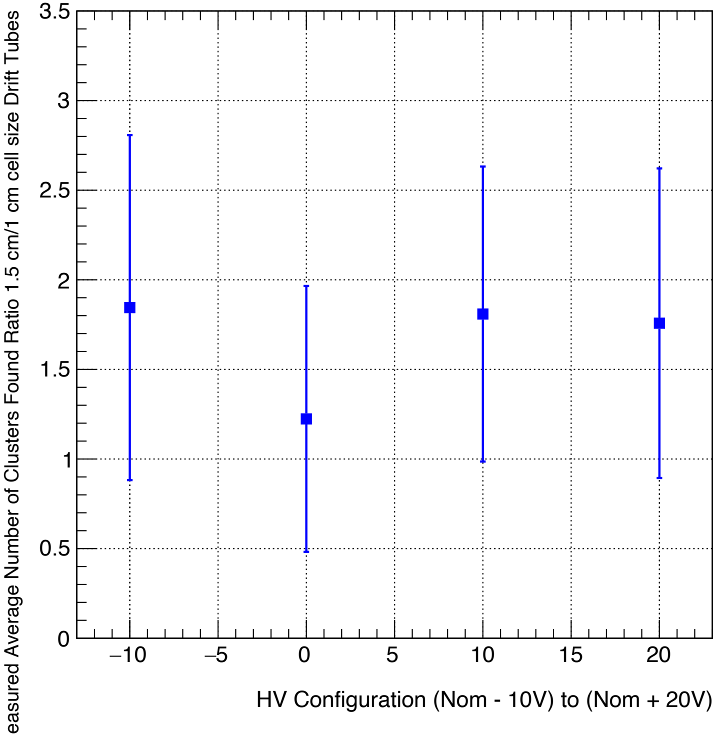
Comparison between DERV and RTA algorithm

1 cm drift tubes

Sampling rate 1 GSa/s;

1.5 cm drift tubes





Conclusions

- The inefficiency observed form the two algorithm for 1.5 cm tubes when using sampling rate 2GSa/s due to 512 ns don't cover the full range.

- Further optimization need to be done to the DERIV Algorithm in order to recover the inefficiency observed in the studies done with sampling rate 1 GSa/s.

- The application of the two different algorithms will be very useful for understanding the pathologies of both algorithms, therefore, it will be extremely useful to have a third algorithm like the one being developed at IHEP with NN.