Magnetic field influence for straw tube

Simulation in Garfield + LTSpice

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- Garfield vs Garfield++ comparison
- LTSpice signal
- Last week update (Gas gain comparison)
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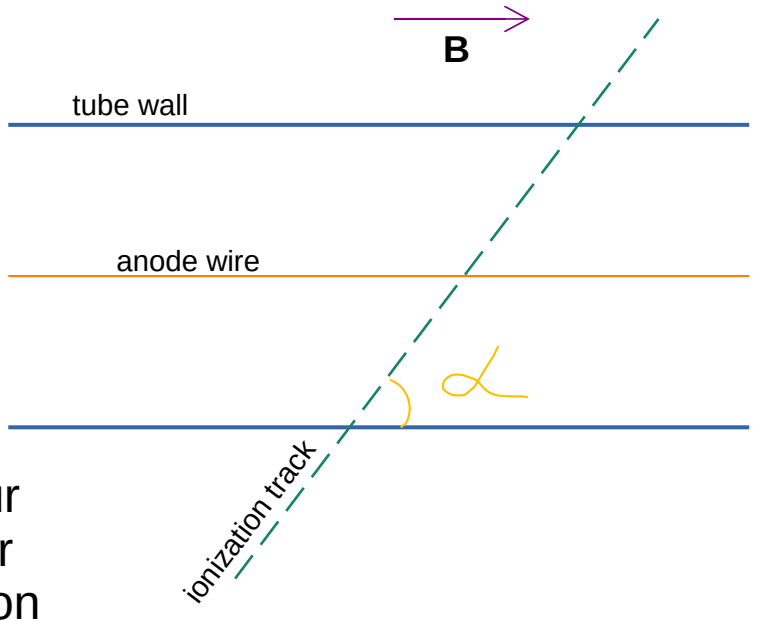
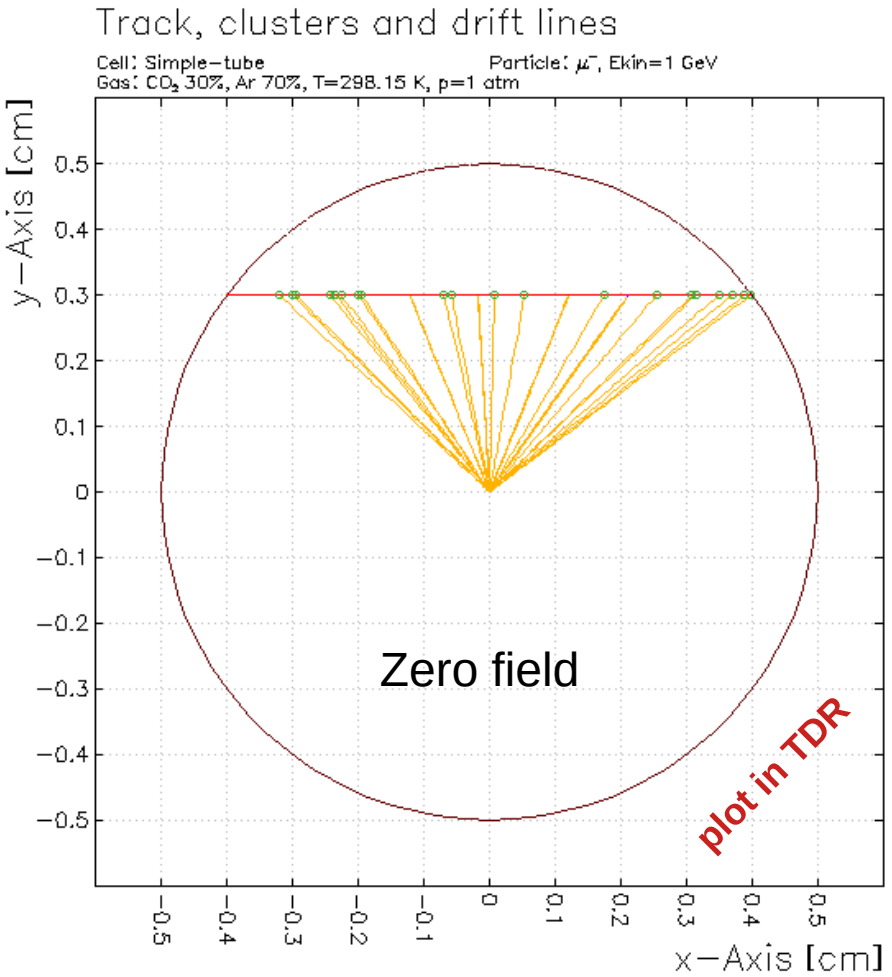
Simulation parameters

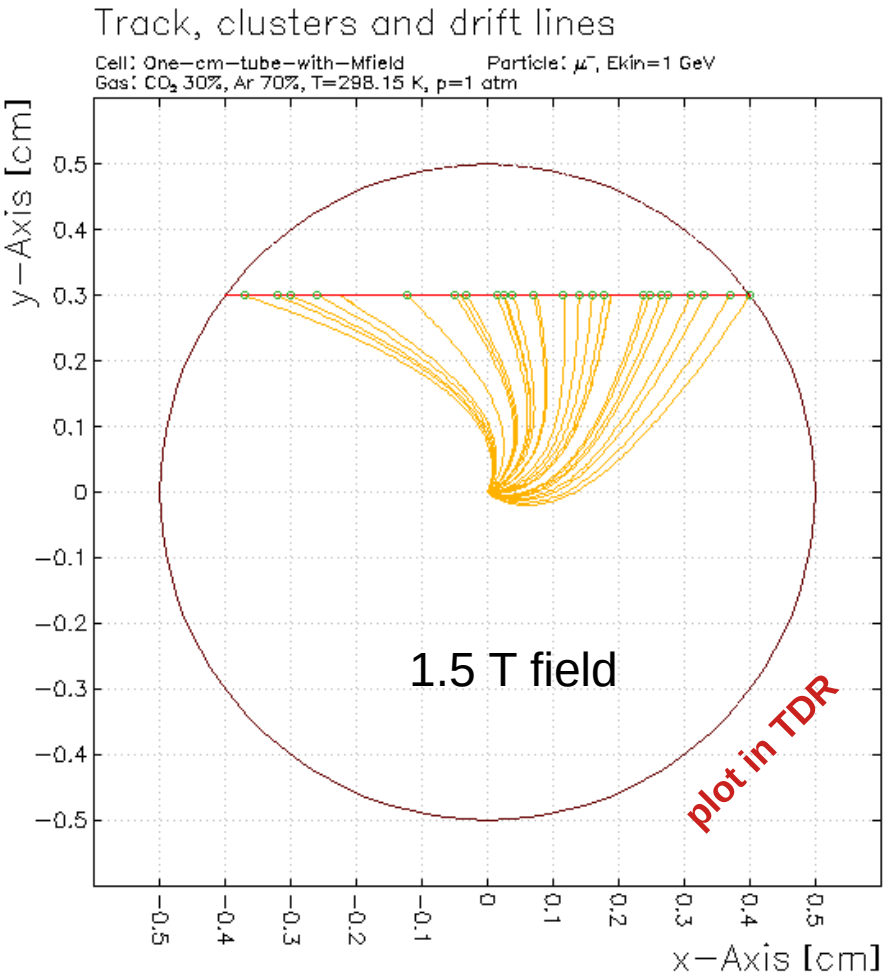
1. Straw diameter: 10 mm
2. Anode diameter: 30 mkm
3. HV: 1750 V
4. Gas mixture: Ar+CO_2 / 70:30 [%]
5. Gas mix temperature: **25** celsius
6. Gas mix pressure: 1 atmosphere
7. Ionization particle: muon 1 GeV
8. Track angle α: 90, 14 degree
9. Magnetic field: 0, 1.5 T

} gives four cases for comparison

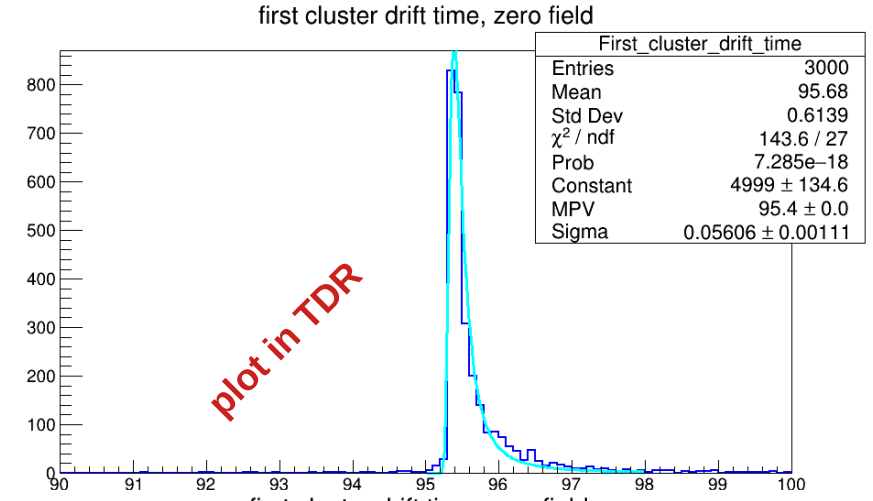


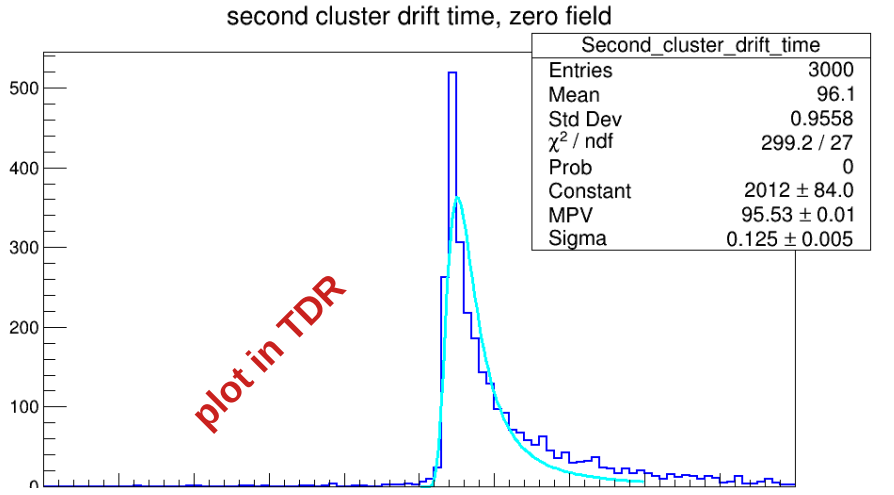
Drift line examples

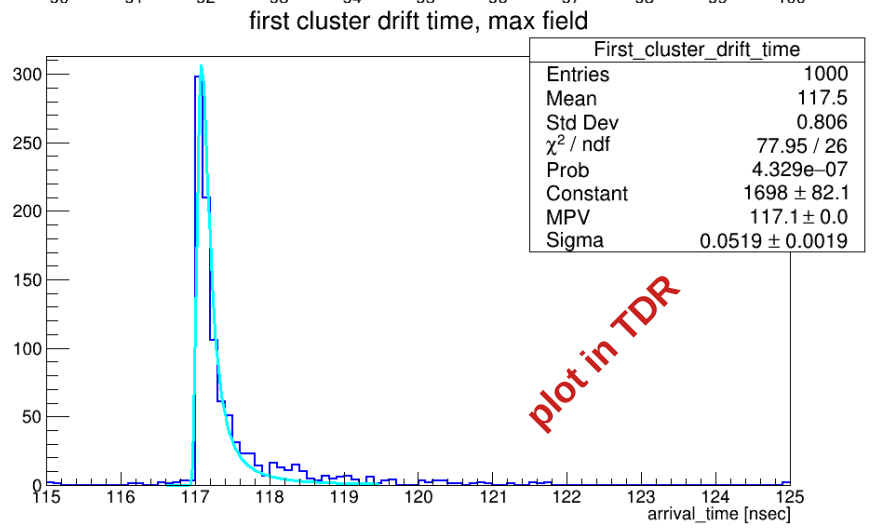


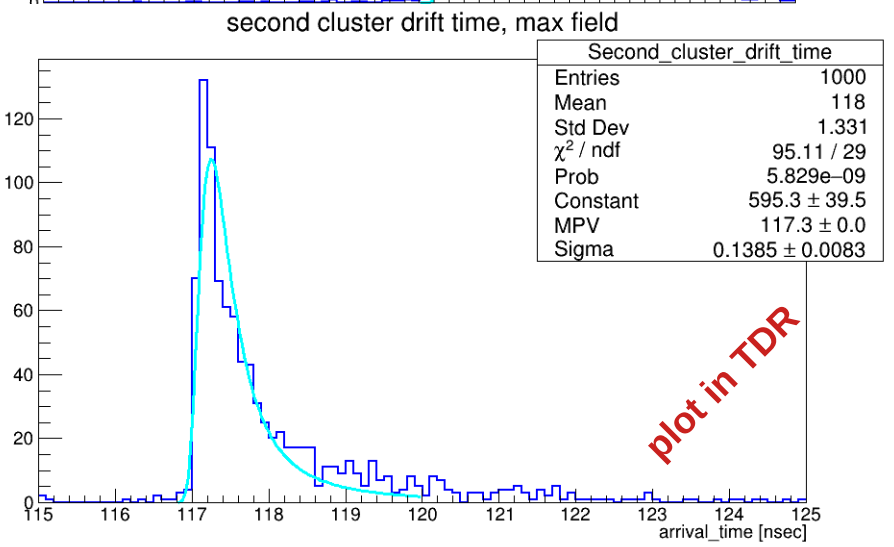


Drift time distributions (4mm distance)

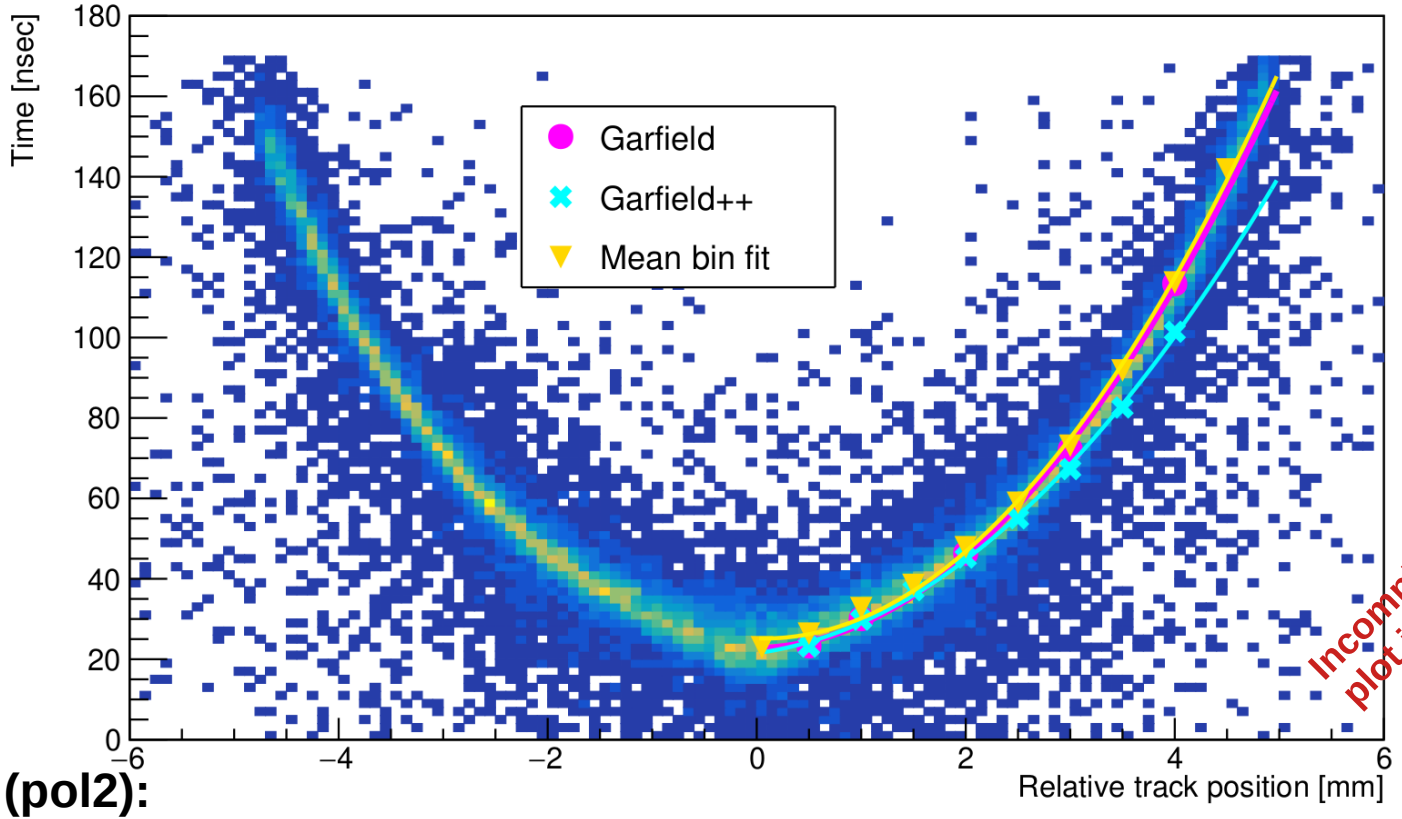








Comparison simulation and NA62 measurements



Fit curves (pol2):

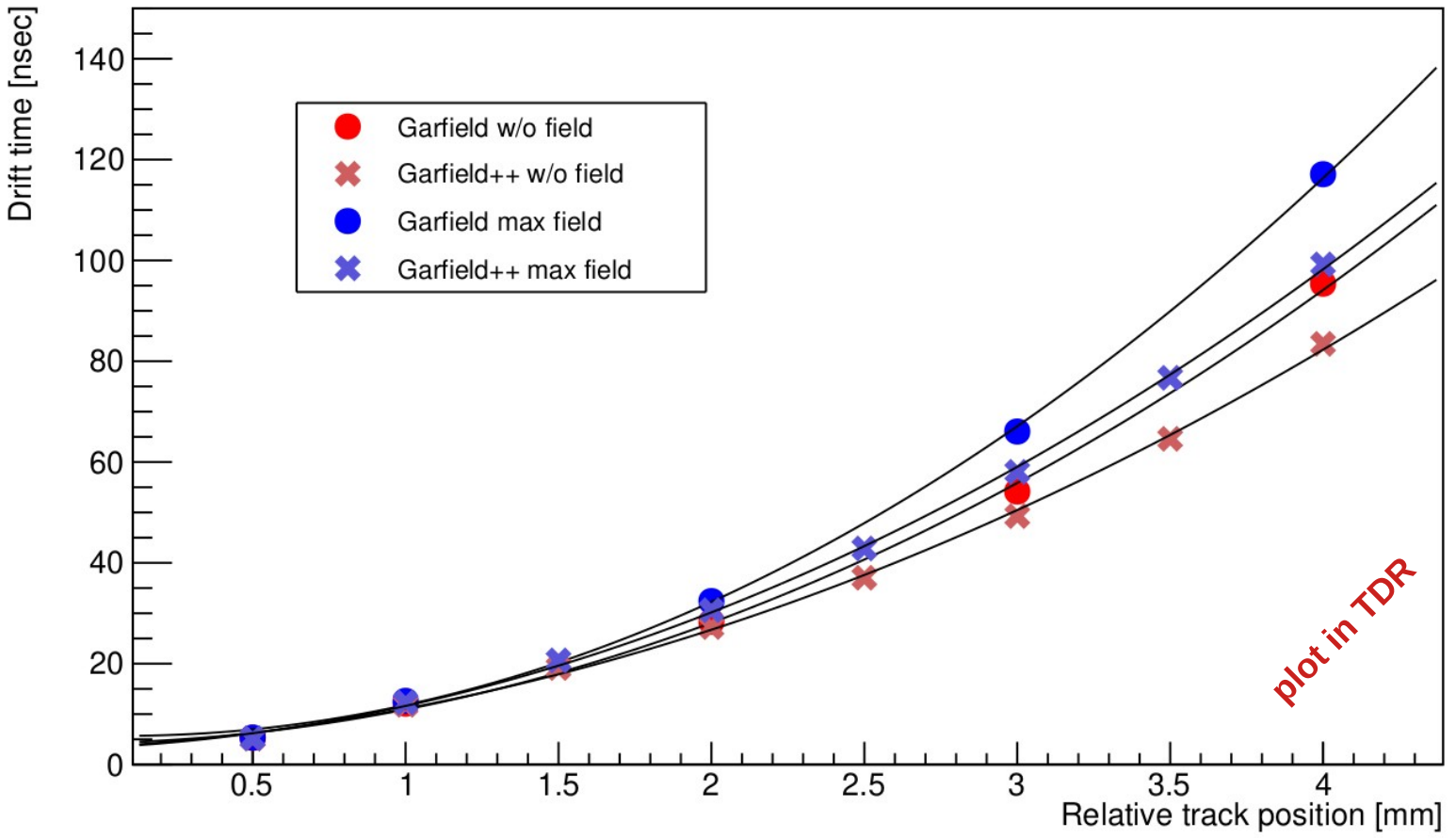
Garfield 22.74 + 0.46 * x + 5.51 * x * x

Garfield++ 21.52 + 3.53 * x + 4.04 * x * x

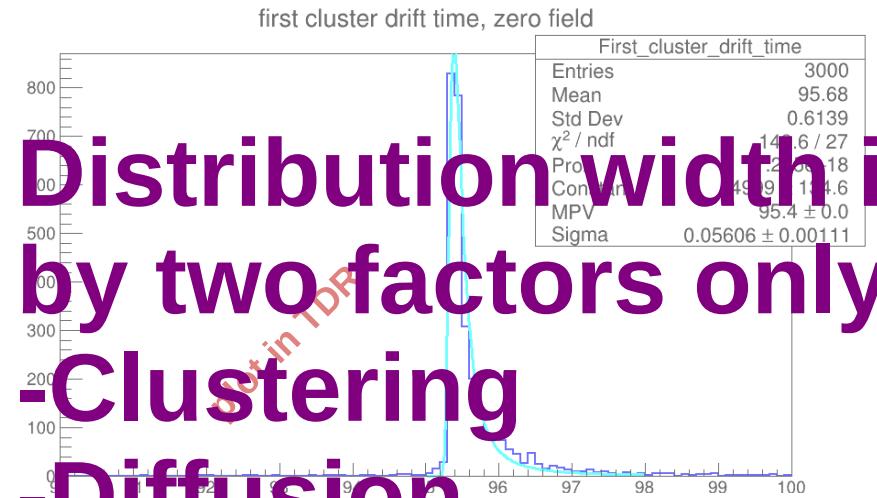
MeanGauss (data) 25.18 - 0.82 * x + 5.81 * x * x

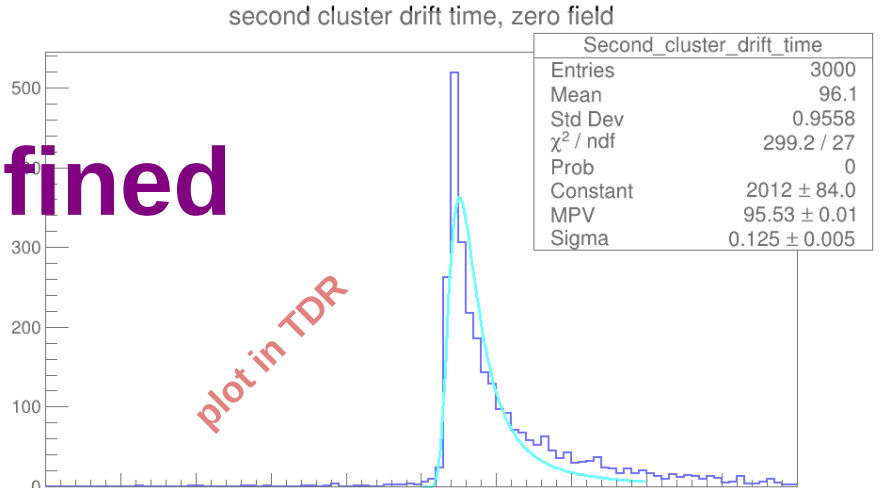
*We are grateful to **Dosbol Baigarashev** (JINR) for sharing the experimental data*

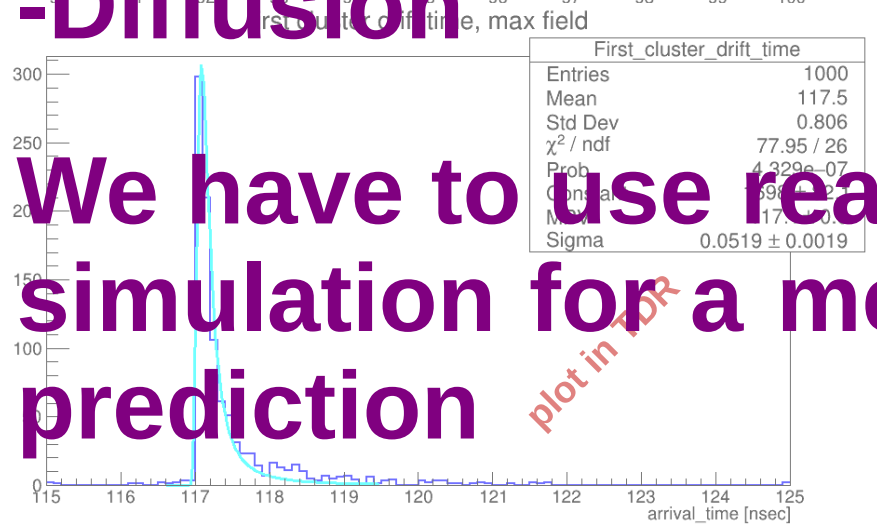
Drift time fit landau MPV for 1st cluster

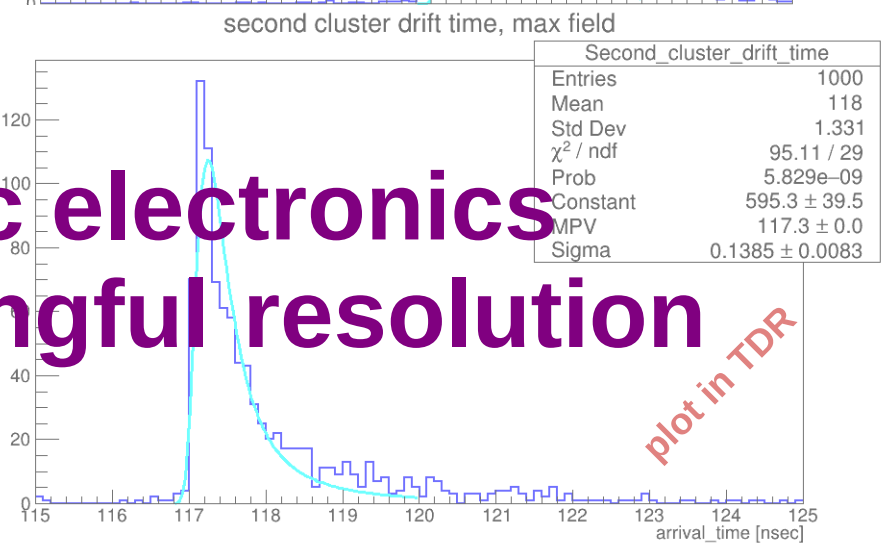


Drift time distributions (4mm distance)





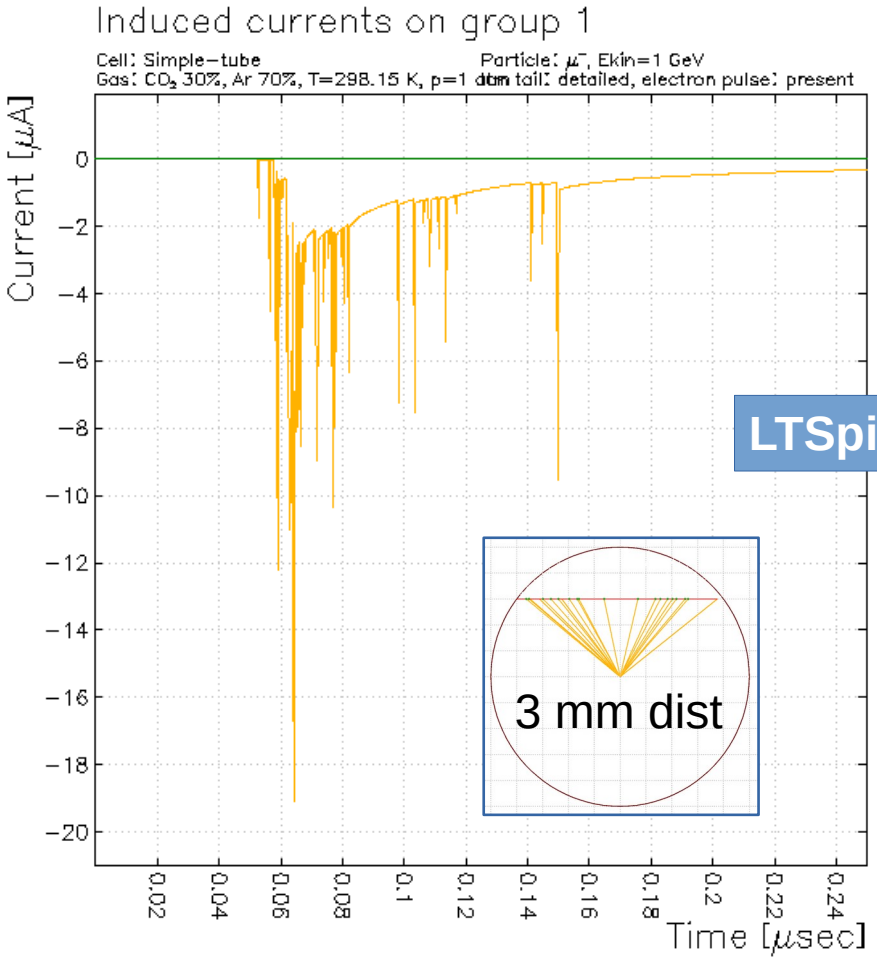




Distribution width is defined by two factors only:
-Clustering
-Diffusion

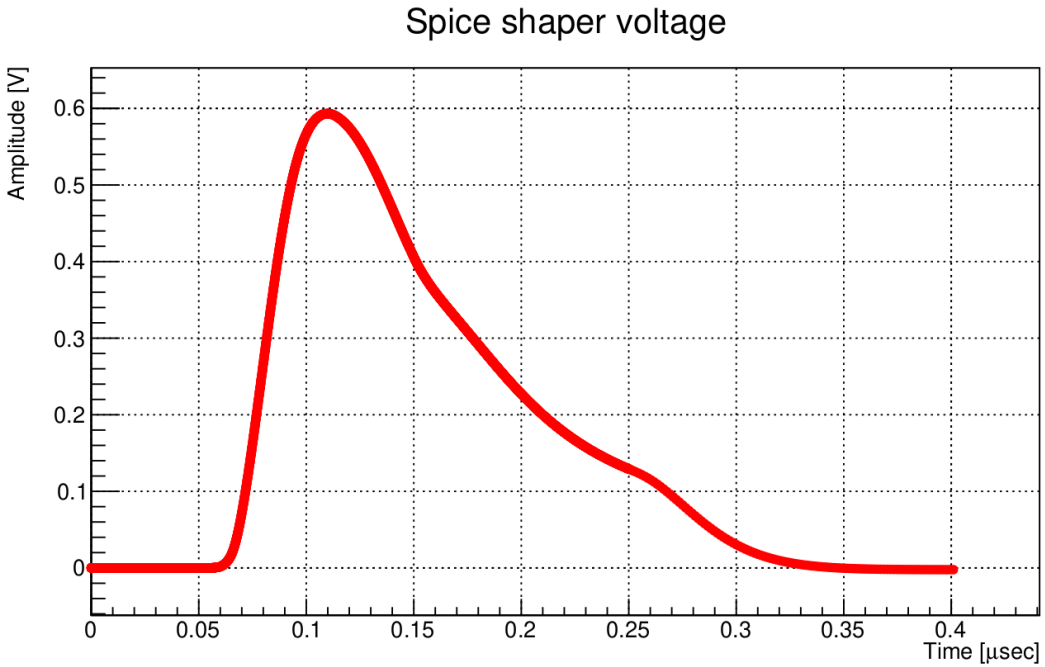
We have to use realistic electronics simulation for a meaningful resolution prediction

Simulation of real electronics



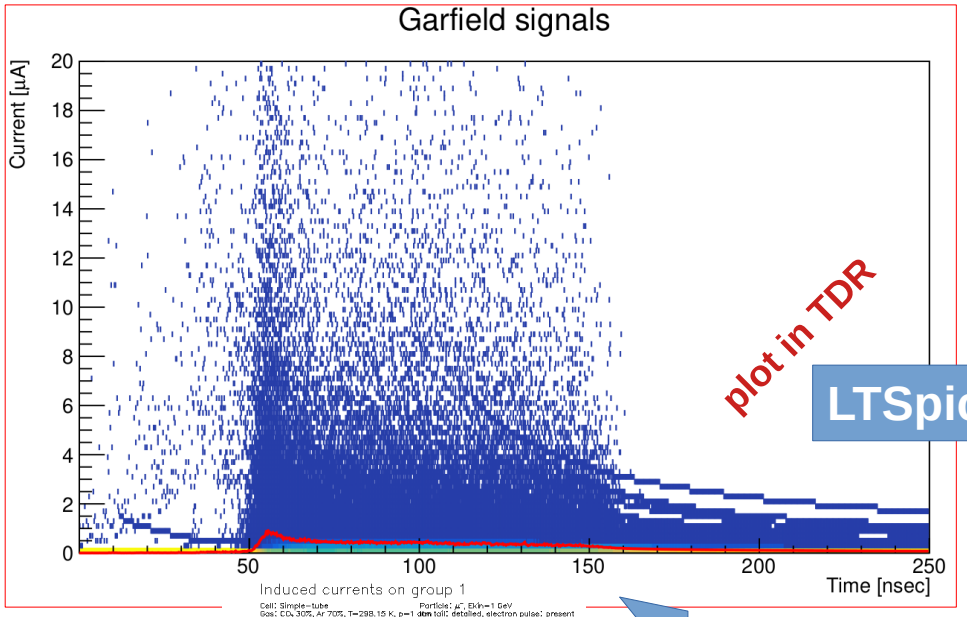
LTSpice

We assume VMM3a-based readout (see Vitaliy's slides)

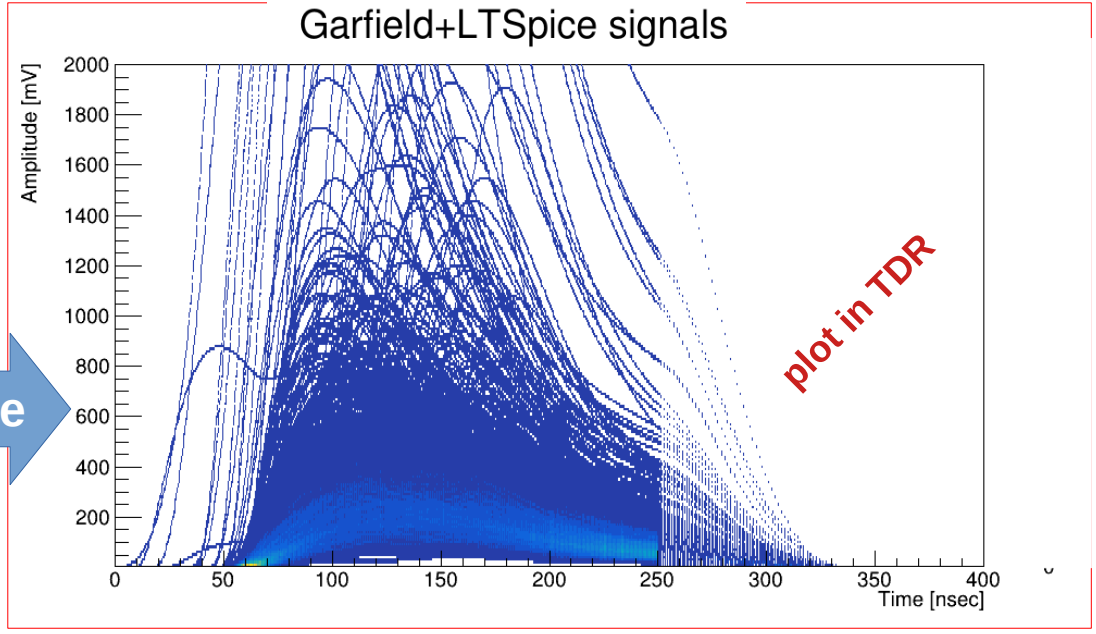


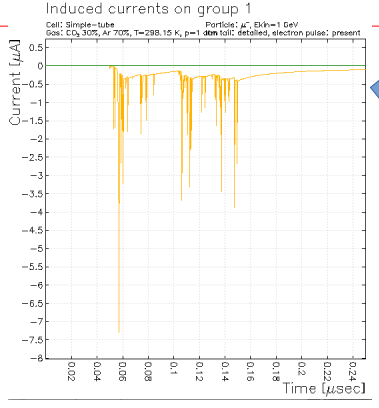
*We are grateful to **RD51 collaboration** for sharing the electronic circuit*

Signal examples (no field; 3 mm distance)



LTSpice

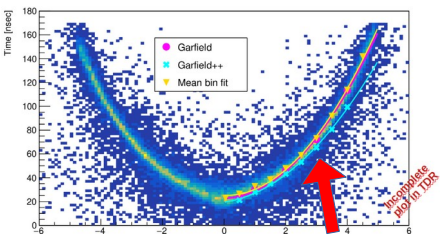




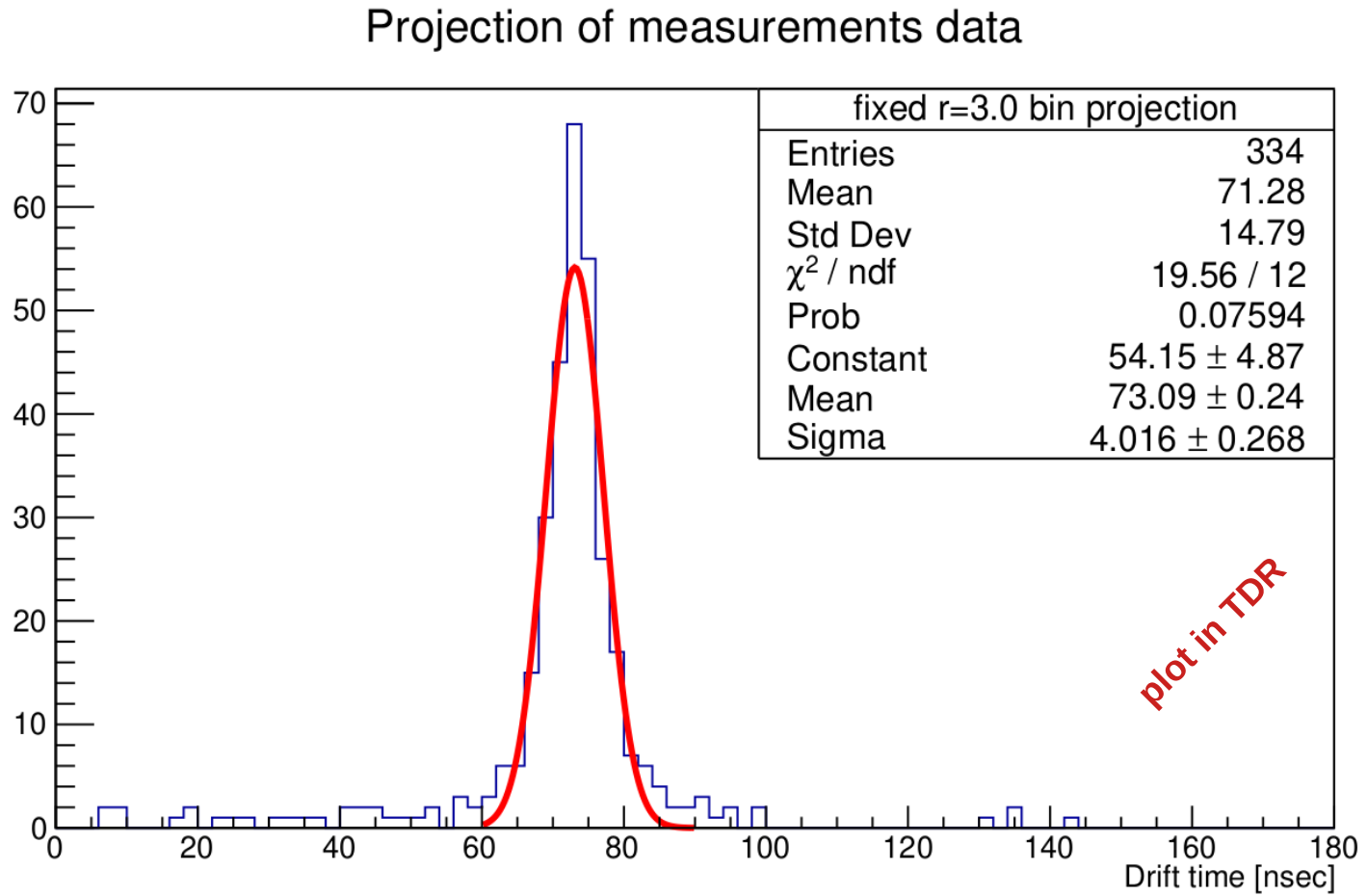
*(-1)

To be updated
(see slides >12)

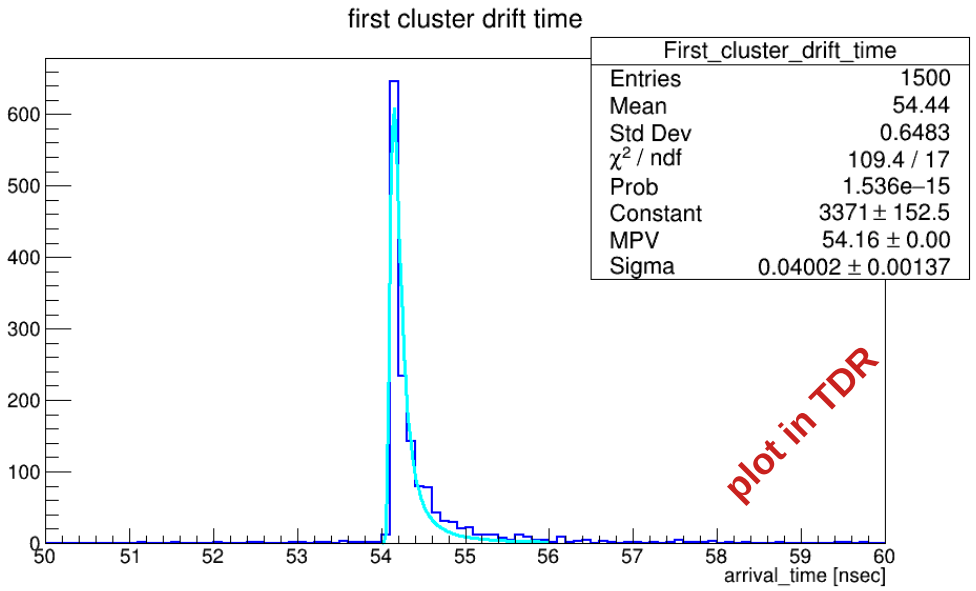
Time distribution (NA62 measurements) for 3-3.1 mm bin

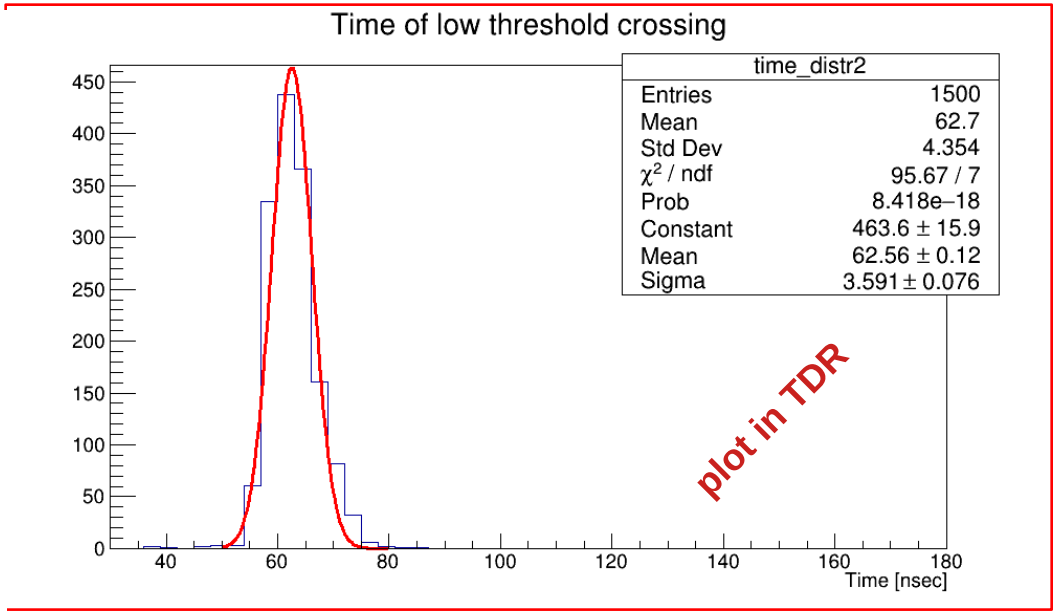


This point



Time distribution for 3-3.1 mm bin





To be updated

But:

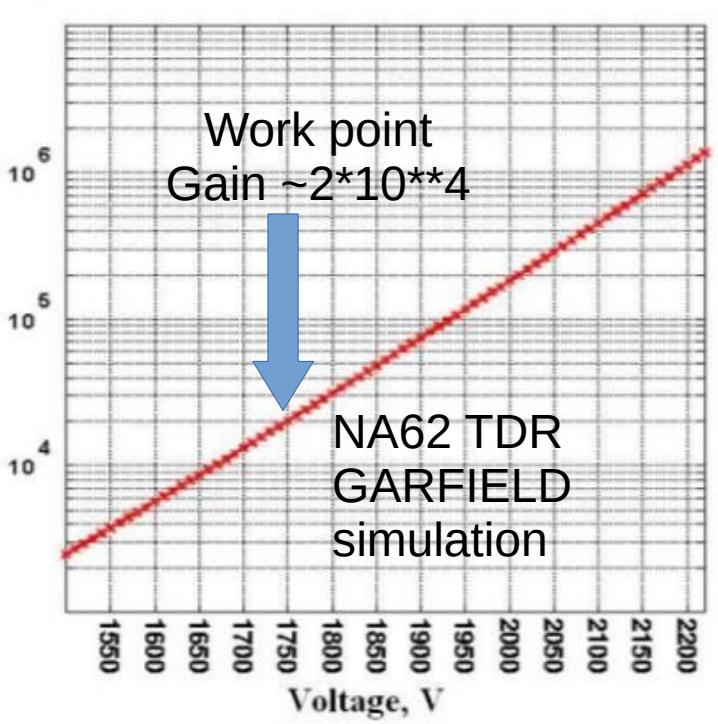
no noise

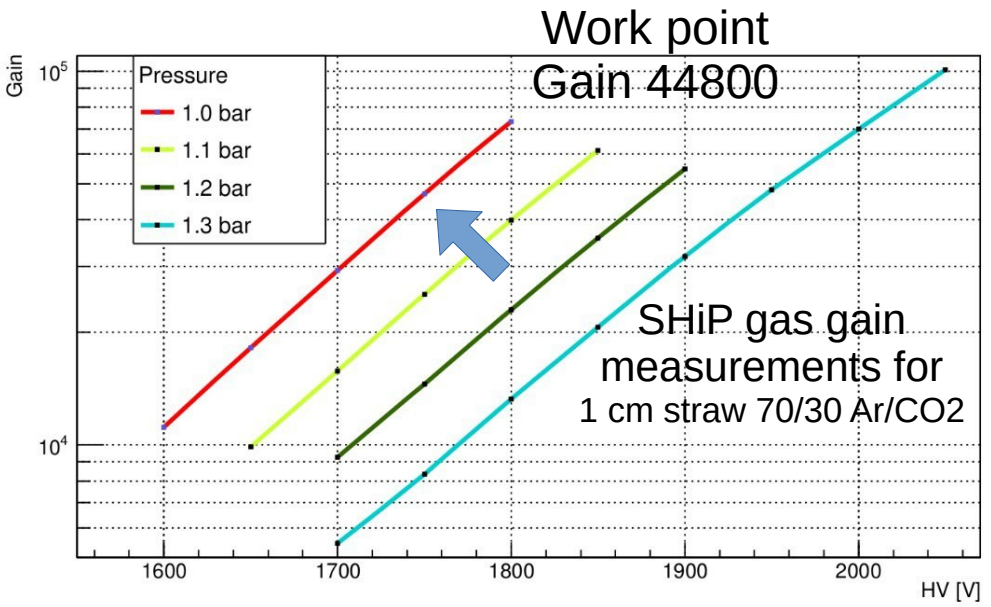
gas gain MAGBOLTZ

amplification 3 mV/fC

Last week update

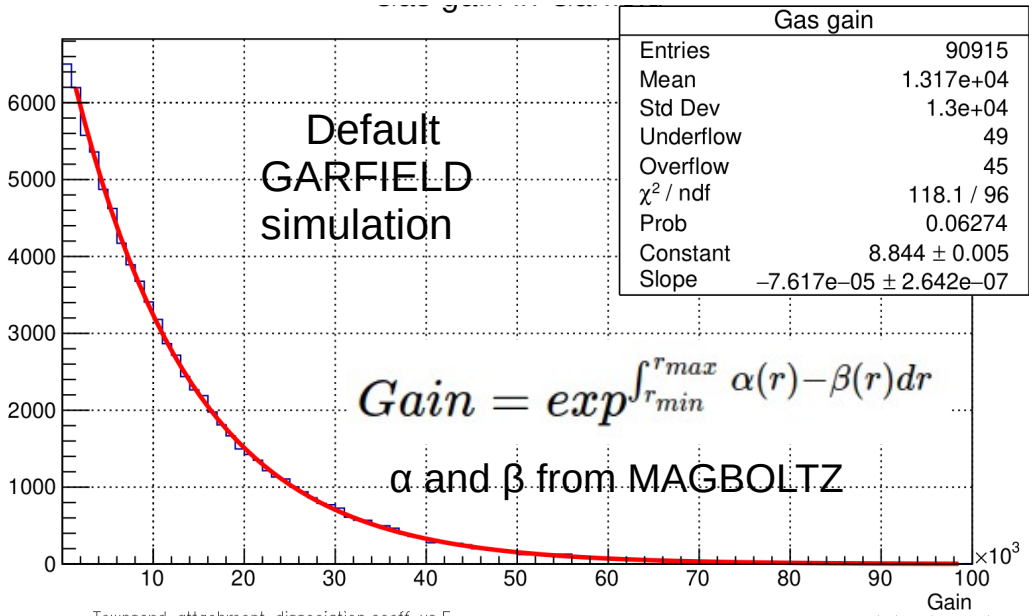
Gas gain problem

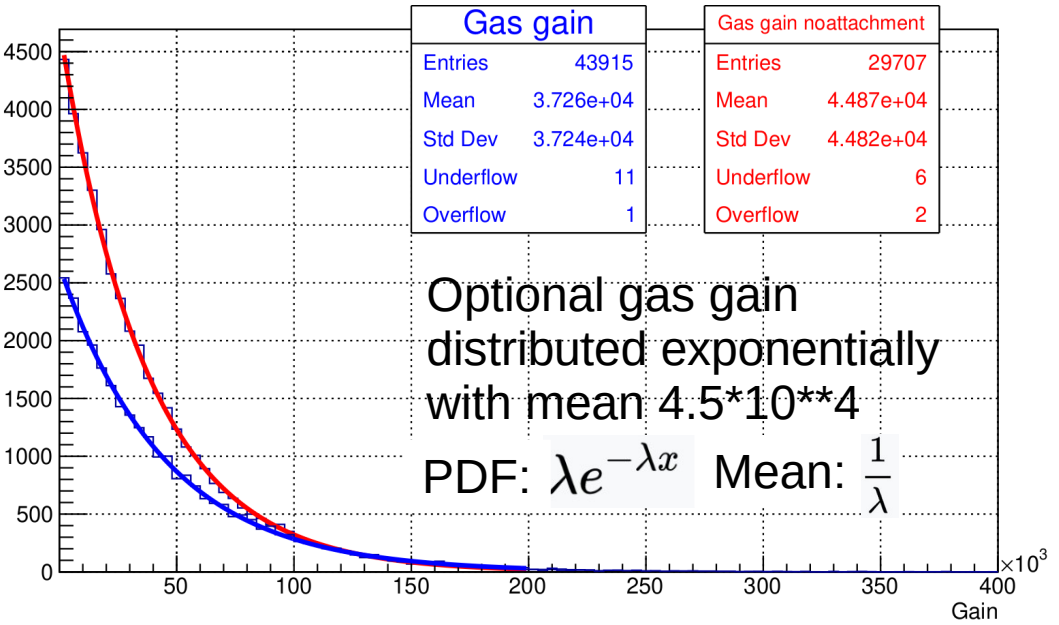


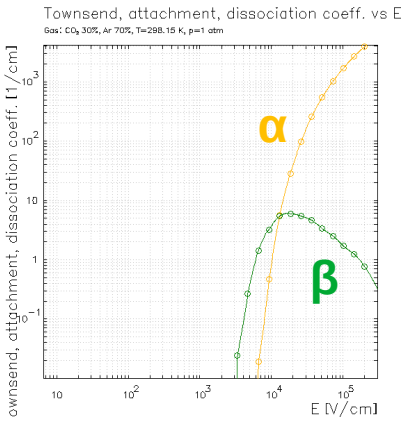


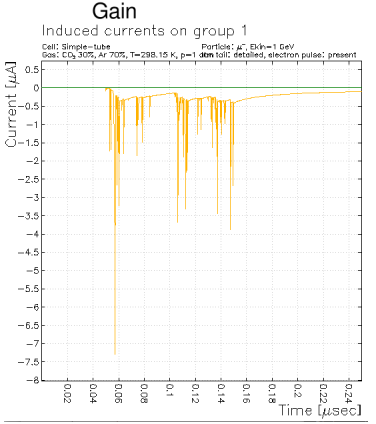
SHiP internal note

Gas gain distributions





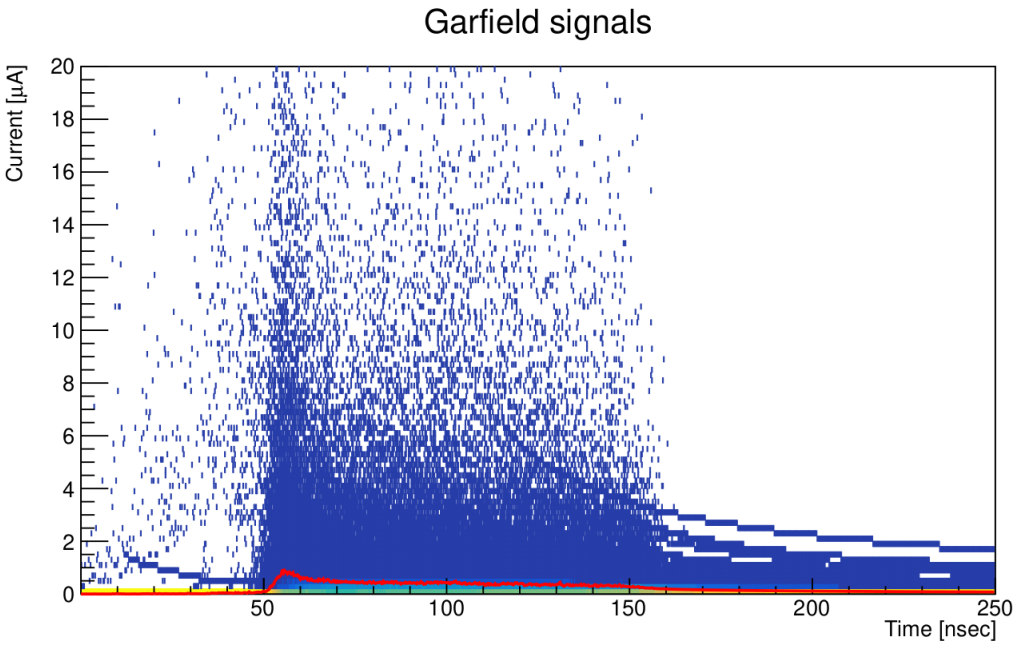




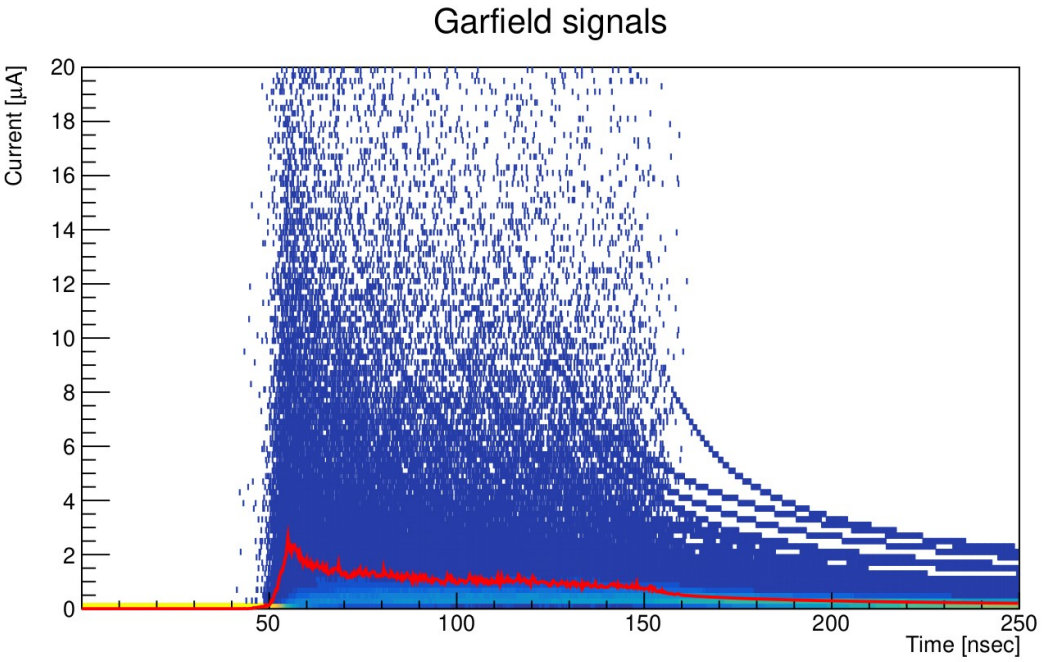
TO BE DONE: attachment should be switched off

Gas gain affects only the amplitude of the peaks;
All TDR plots related to drift time are unaffected

TDR plots changed due to the new gas gain value (3.7*10**4)



WAS



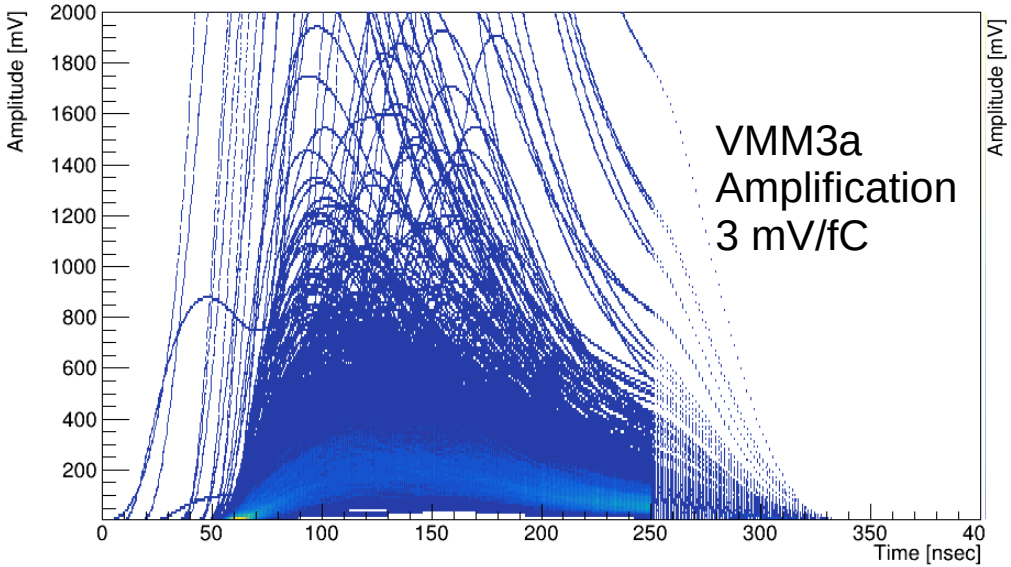
NOW

(to be updated for gain = 4.5*10**4)

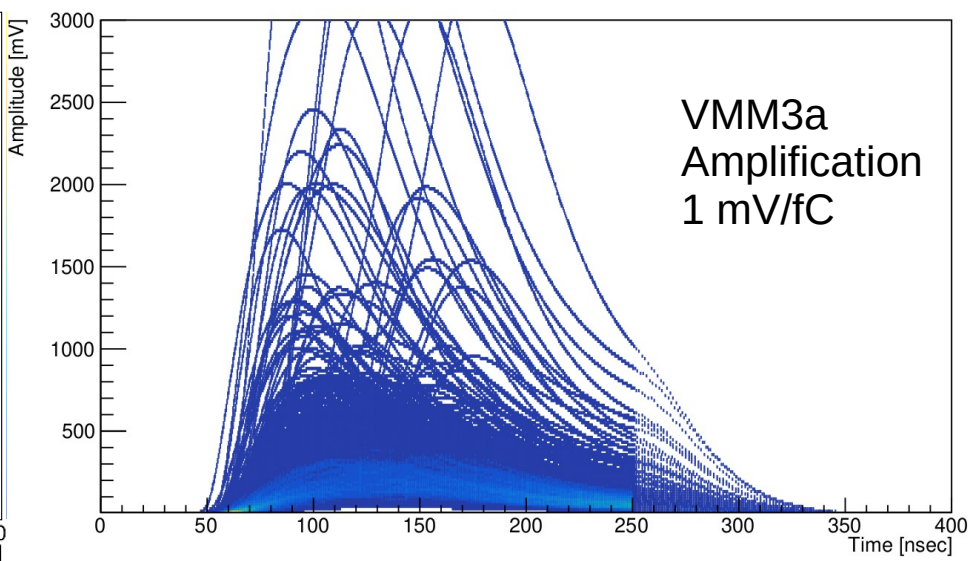
TDR plots changed due to the new gas gain value (3.7*10**4)

note: the scale change

Collected signals



Garfield+LTSpice signals

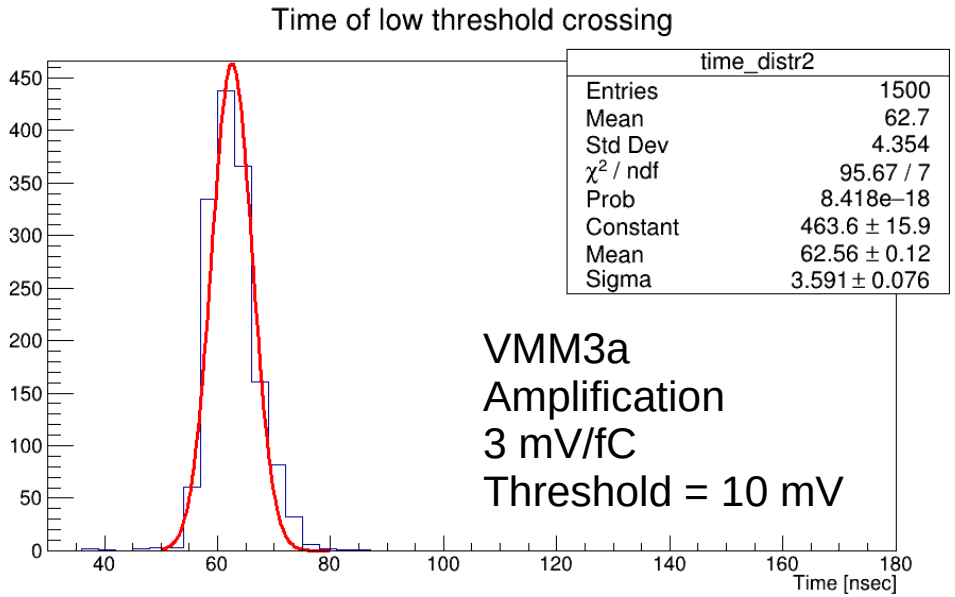


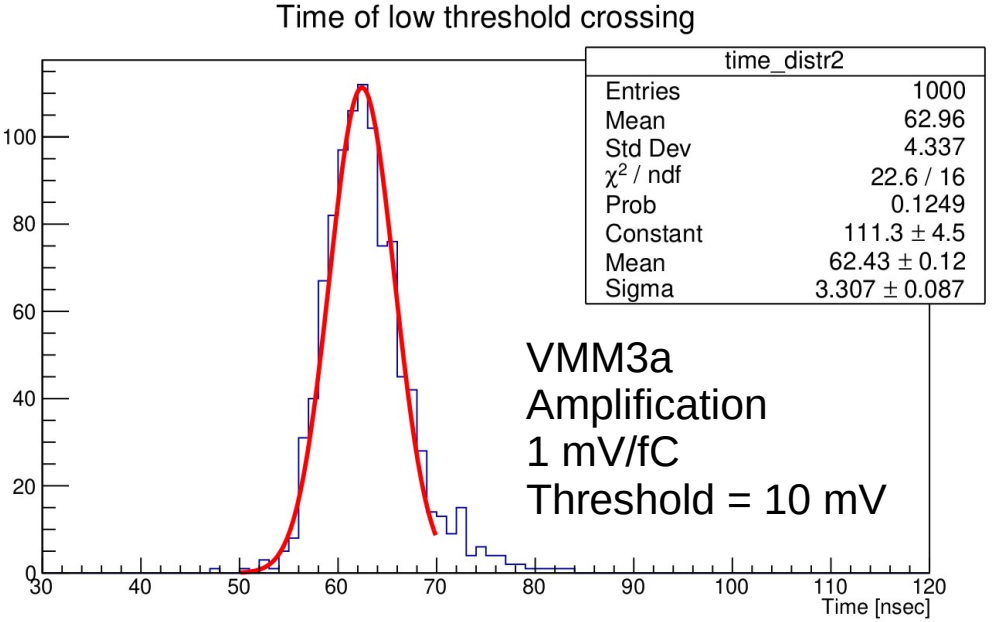
WAS

NOW

(to be updated for gain = 4.5*10**4)

TDR plots changed due to the new gas gain value (3.7*10**4)



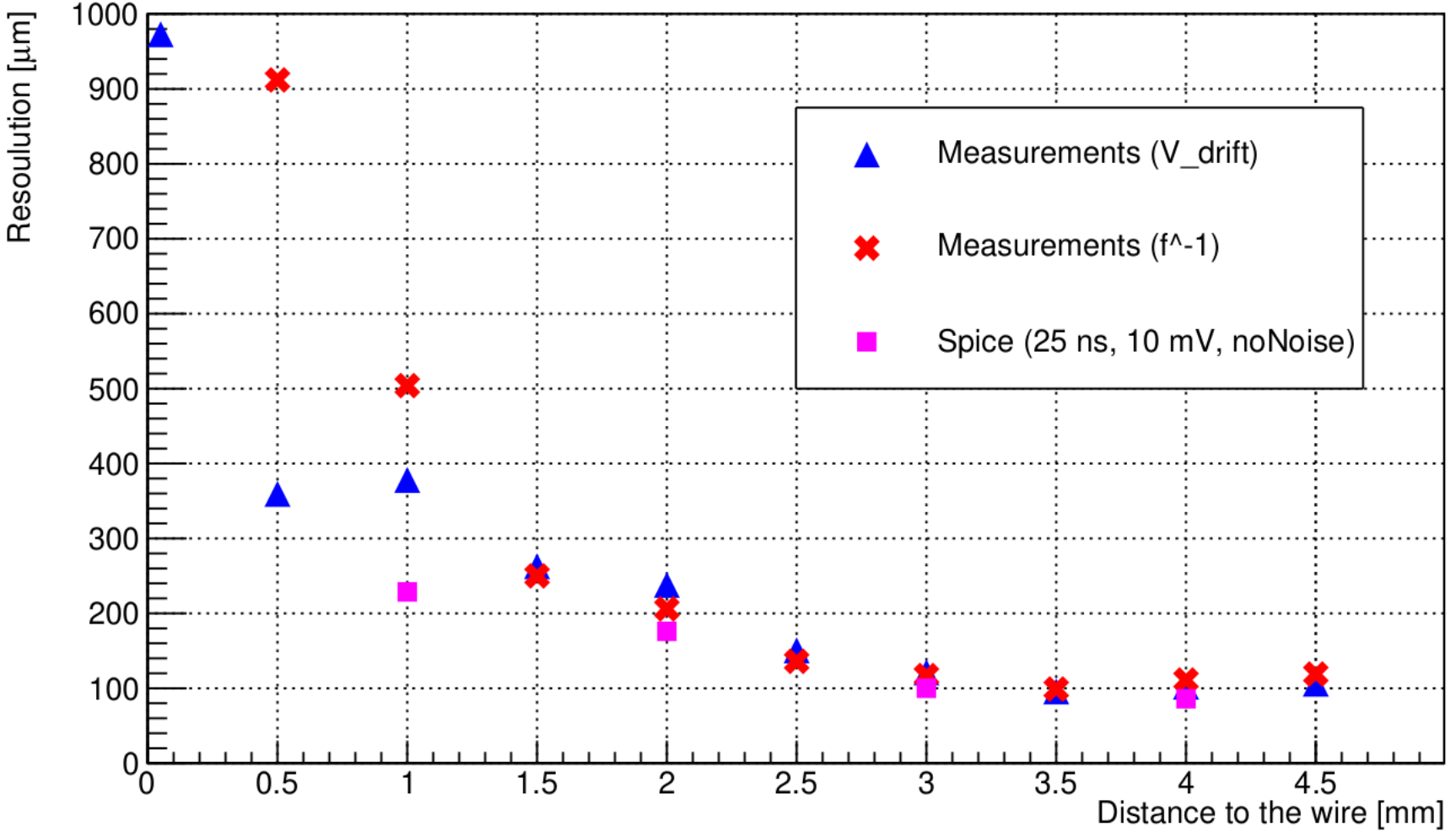


The signal disrimination threshold is kept at the same level from practical consideration

WAS **NOW**

(to be updated for gain = 4.5*10**4)

Spatial resolution



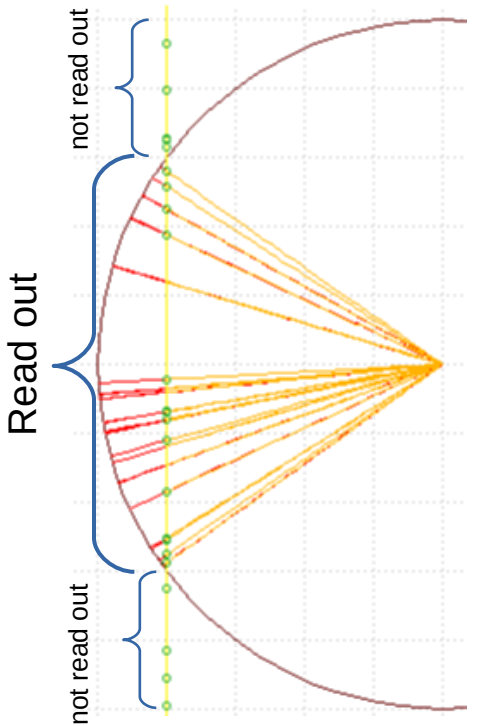
Conclusions

- Garfield MPV prediction (r-t dependence) looks reasonable and describes well NA62 measurements for the same type of straw
- We know about some issues in precision of our simulation: Garfield and Garfield++ drift times have a slight difference; Gas gain in (any) Garfield is less than measured (investigation ongoing)
- Future steps: update affected plots for G=4.5*10**4; complete the set of plots for magnetic field and inclined (along z-axis) tracks cases; add noise to the signals

Drafts >_<

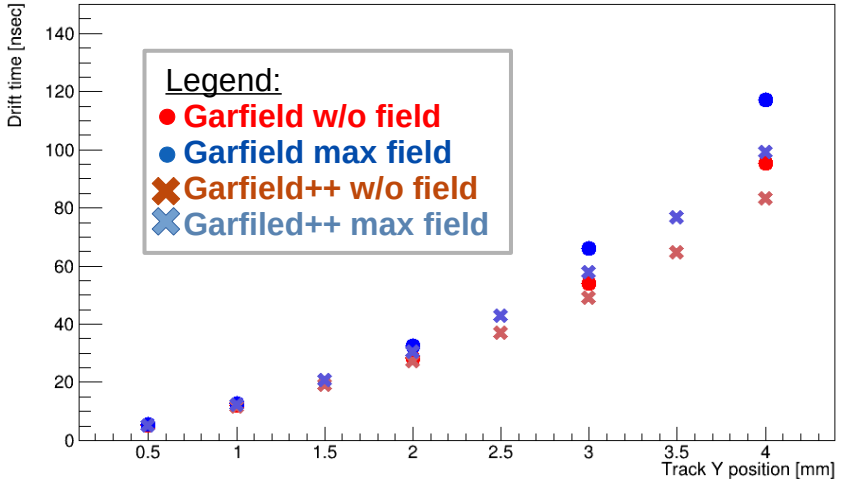
Garfield text output for signal command execution

```
Signal simulation:
 ==================
 The track begins at (-0.60000002E+00, 0.40000001E+00, 0.00000000E+00)
 and ends at         ( 0.60000002E+00, 0.40000001E+00, 0.00000000E+00)

 A single group of electrodes is currently selected for read-out:
 Group 1 consists of:
   Wire 1 with label S at (x,y)=(0,0) and at 1750 V

 No solid is currently selected outside read-out.
 Table of the clusters
 ====================
    No     x-start     y-start     z-start   Drift time   Diffusion Pairs  Pair Arrival time Total charge
             [cm]        [cm]        [cm]    [microsec]    [microsec]          [microsec]  [electrons]

     1 -0.58225E+00  0.40001E+00 -0.10001E-04  0.00000E+00  0.00000E+00     1  Hit the tube, not read out
     2 -0.57035E+00  0.39996E+00 -0.31205E-05  0.00000E+00  0.00000E+00     1  Hit the tube, not read out
     3 -0.57036E+00  0.39991E+00 -0.62397E-05  0.00000E+00  0.00000E+00     1  Hit the tube, not read out
*************************************************************************************************************************
    22 -0.40832E+00  0.40000E+00  0.13213E-05  0.00000E+00  0.00000E+00     1  Hit the tube, not read out
    23 -0.29005E+00  0.40000E+00  0.22099E-05  0.18109E+00  0.25681E-02     1  Hit S wire 1, read out
                                                    1  0.18060E+00  0.17980E+05
    24 -0.26758E+00  0.40002E+00 -0.25891E-04  0.17146E+00  0.24561E-02     1  Hit S wire 1, read out
                                                    1  0.17313E+00  0.45919E+05
    25 -0.26758E+00  0.40005E+00 -0.51769E-04  0.17147E+00  0.24634E-02     1  Hit S wire 1, read out
                                                    1  0.17252E+00  0.18328E+05
*************************************************************************************************************************
    75  0.22119E+00  0.39992E+00 -0.27980E-03  0.15403E+00  0.22965E-02     1  Hit S wire 1, read out
                                                    1  0.15032E+00  0.28830E+05
    76  0.22116E+00  0.39990E+00 -0.33574E-03  0.15400E+00  0.22968E-02     1  Hit S wire 1, read out
                                                    1  0.15414E+00  0.40571E+05
    77  0.22112E+00  0.39988E+00 -0.39167E-03  0.15398E+00  0.22967E-02     1  Hit S wire 1, read out
                                                    1  0.15176E+00  0.44243E+04
    78  0.30096E+00  0.40000E+00 -0.19983E-06  0.00000E+00  0.00000E+00     1  Hit the tube, not read out
    79  0.32922E+00  0.40000E+00  0.95340E-06  0.00000E+00  0.00000E+00     1  Hit the tube, not read out
    80  0.36628E+00  0.40000E+00 -0.11243E-05  0.00000E+00  0.00000E+00     1  Hit the tube, not read out
    81  0.47246E+00  0.39998E+00  0.87778E-05  0.00000E+00  0.00000E+00     1  Hit the tube, not read out
 Plot completed, hit RETURN to proceed.
```

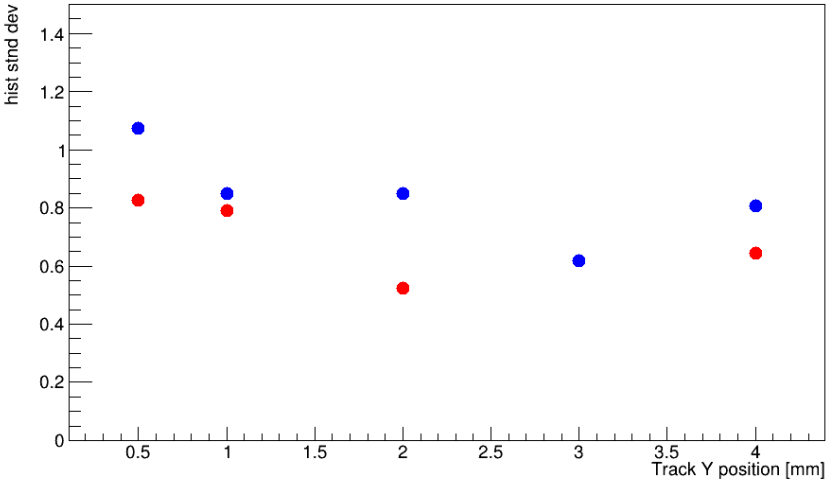


First cluster arrival properties

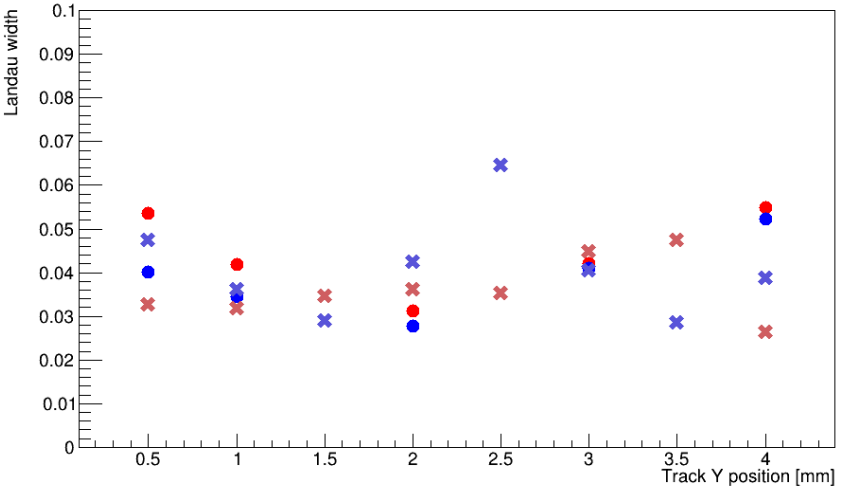
Landau MPV



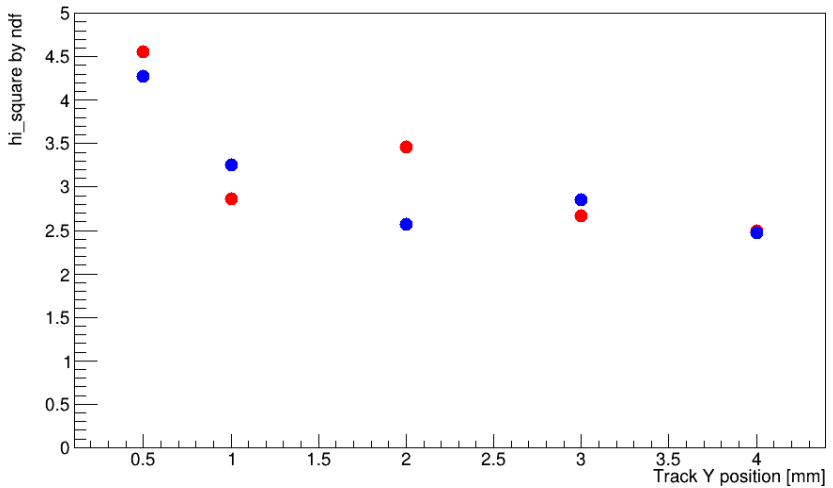
Histogram standart deviation



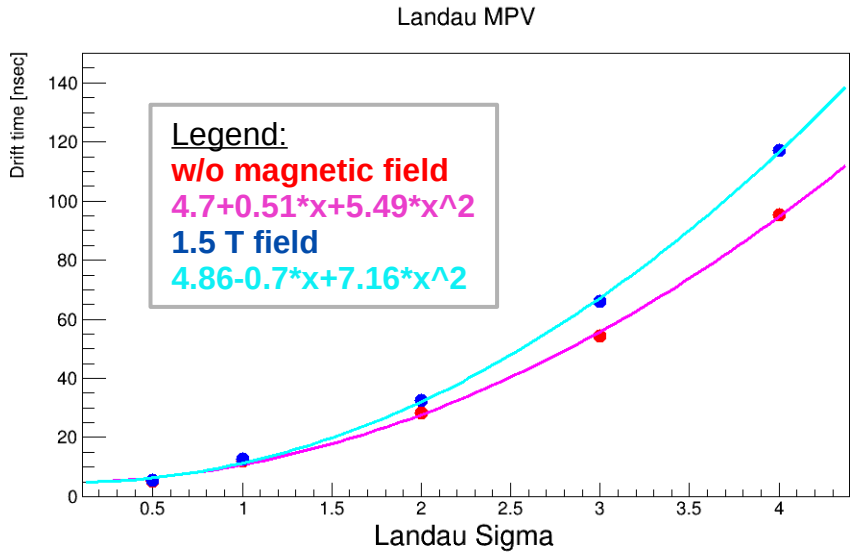
Landau Sigma

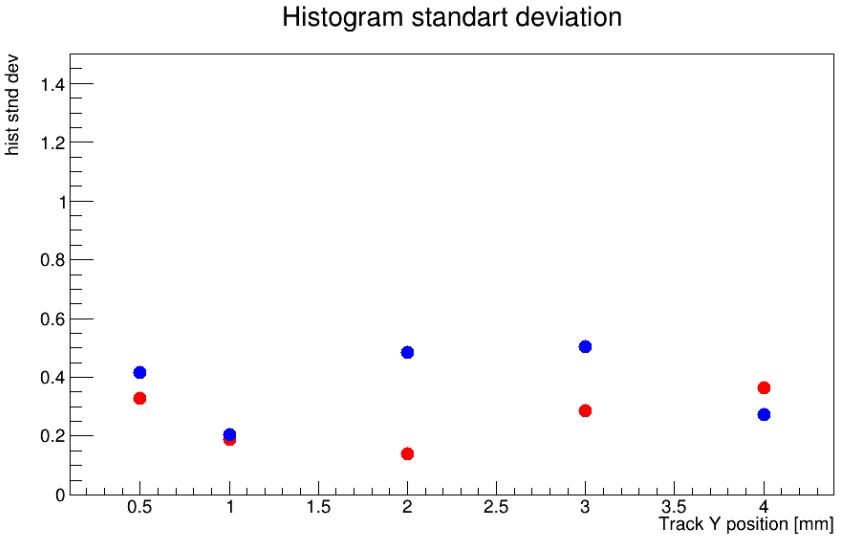


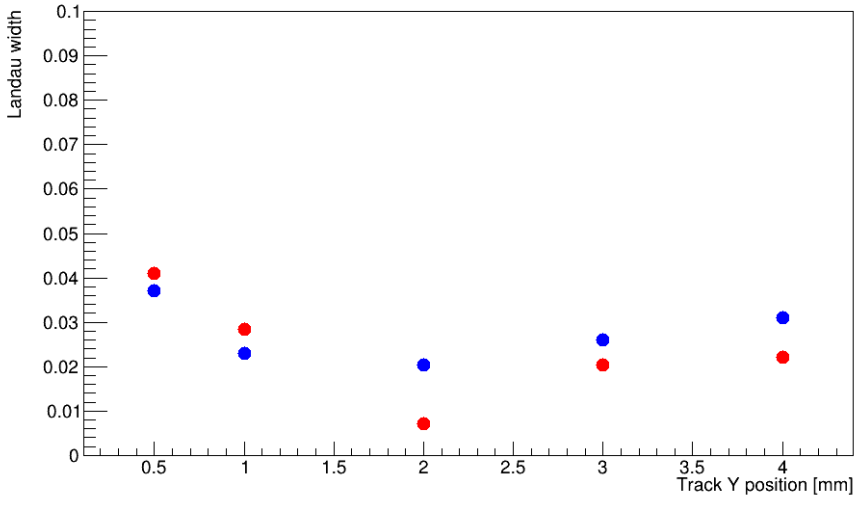
Fit quality

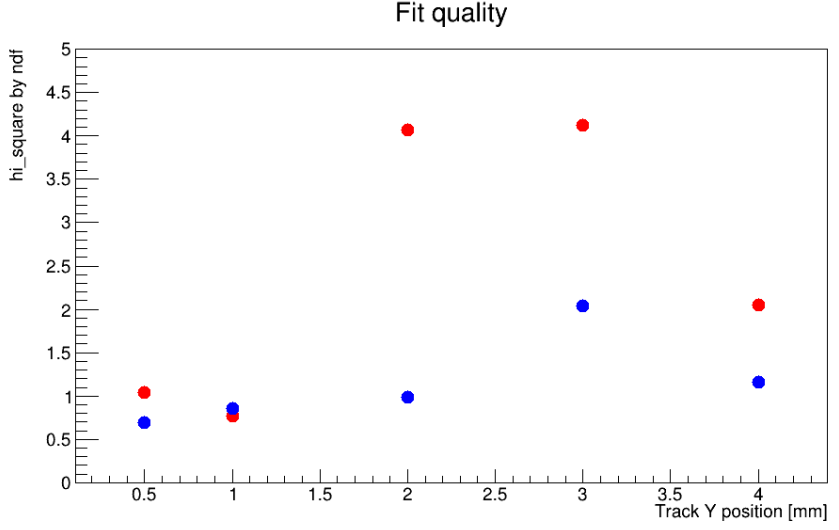


Second cluster arrival properties for long tracks

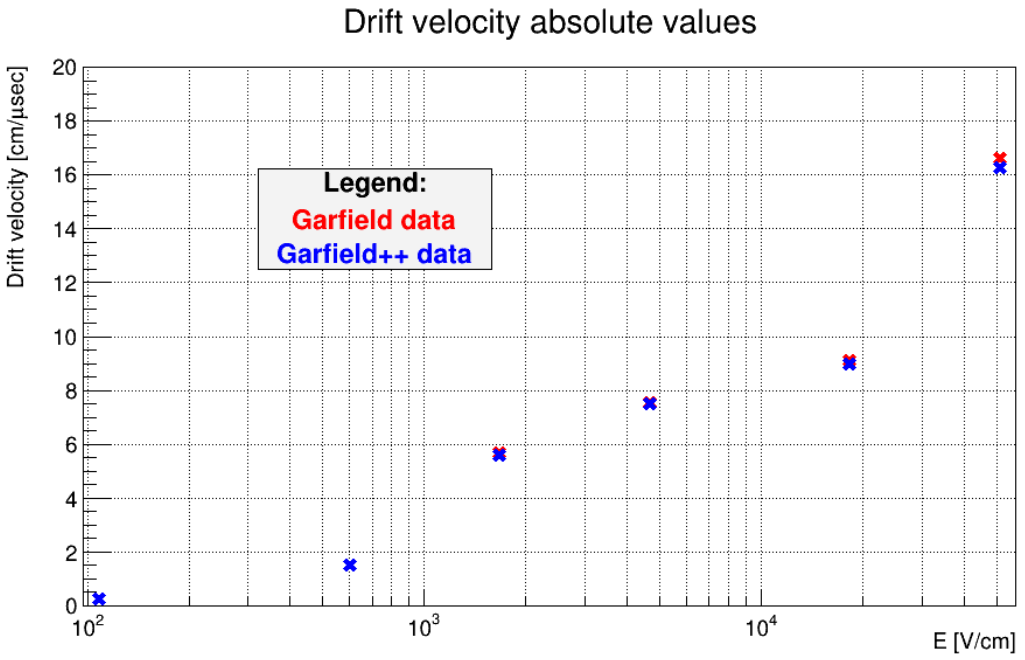


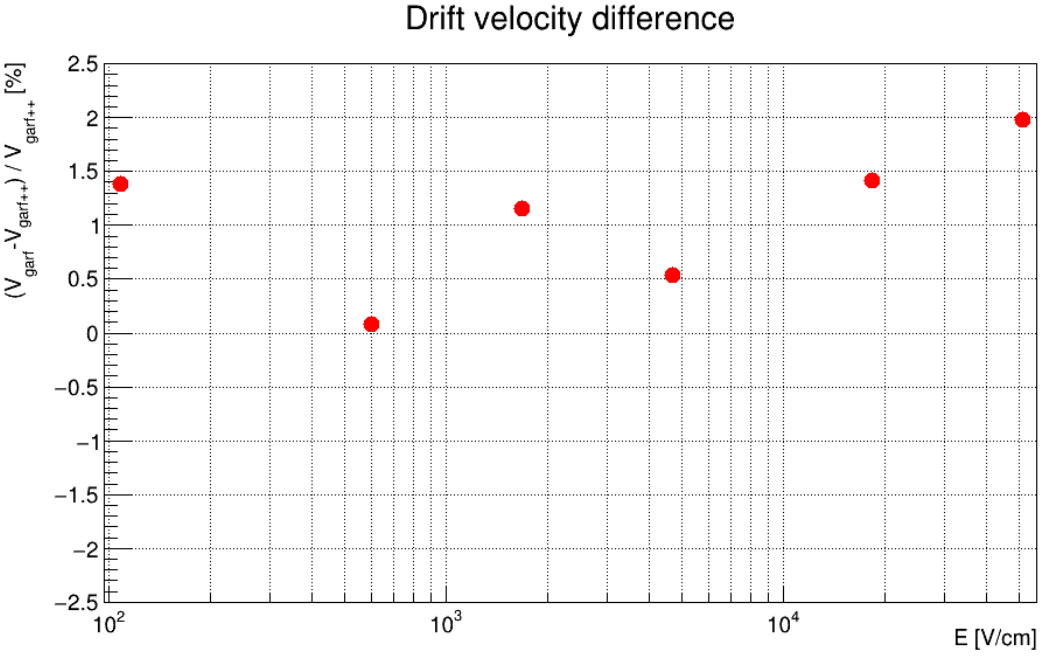






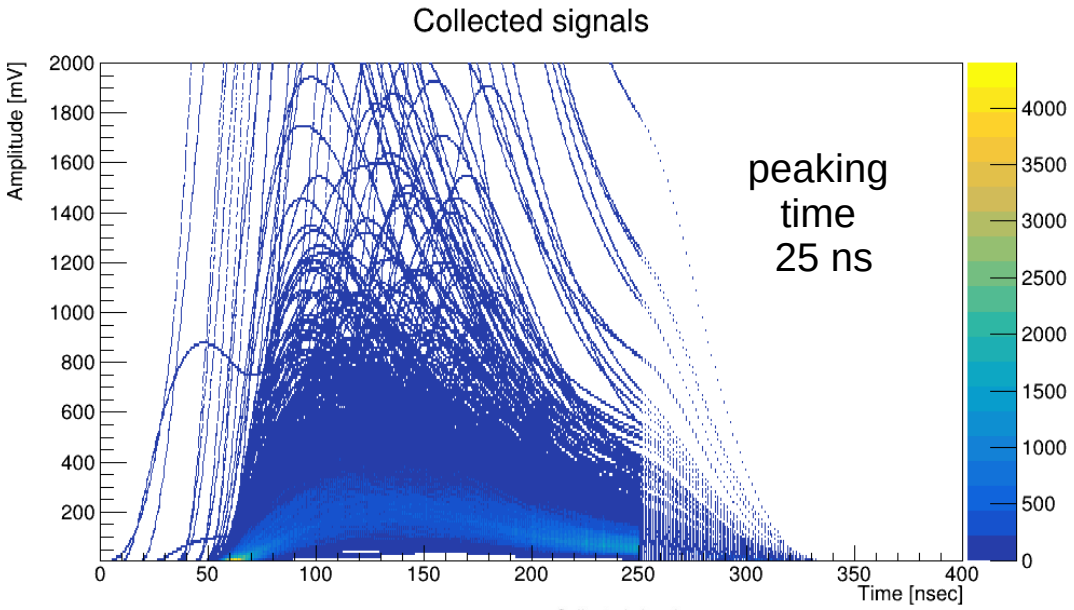
Investigation of the difference between Garfield and Garfield++ (work ongoing)

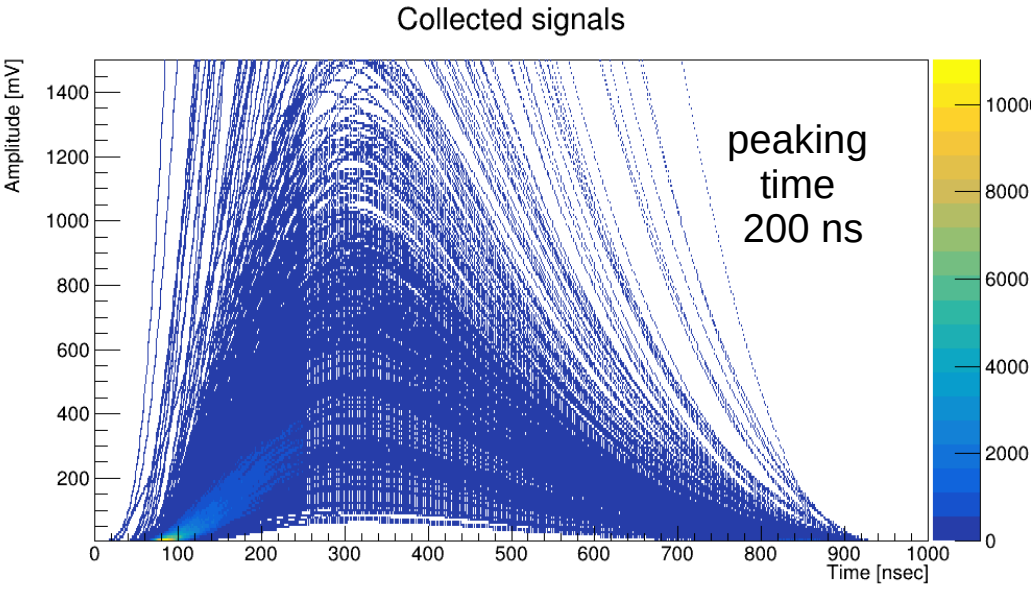




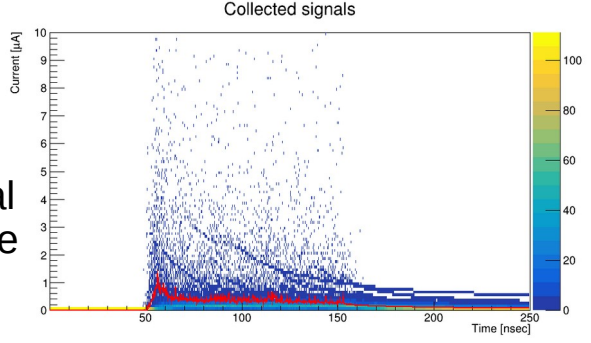
The difference in drift velocities does not exceed 2% on the full E range (gas properties in good accordance)
Configuration of the electric field inside tube is the same (very simple cylindrical geometry)

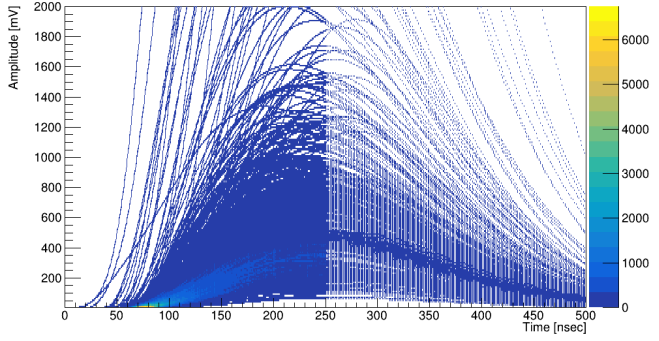
Signal shapes





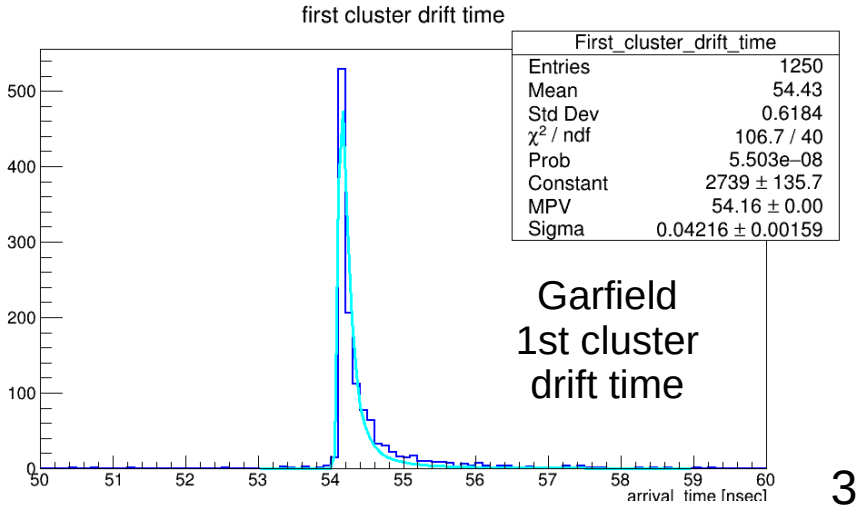
Garfield
pure signal
from anode





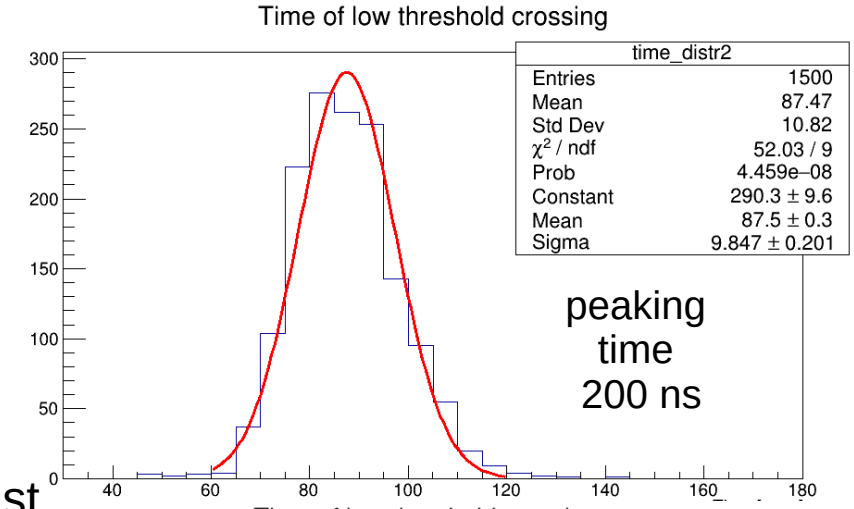
peaking
time
100 ns

Compare Garfield and LTSpice (10 mV thr)

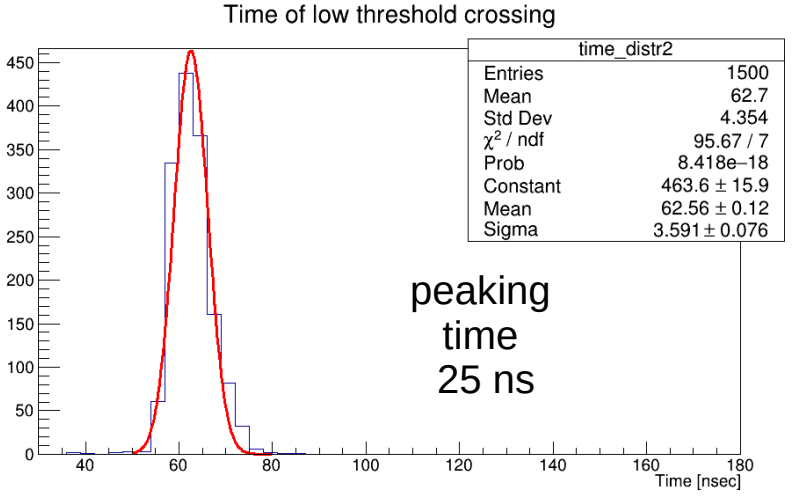


Garfield
1st cluster
drift time

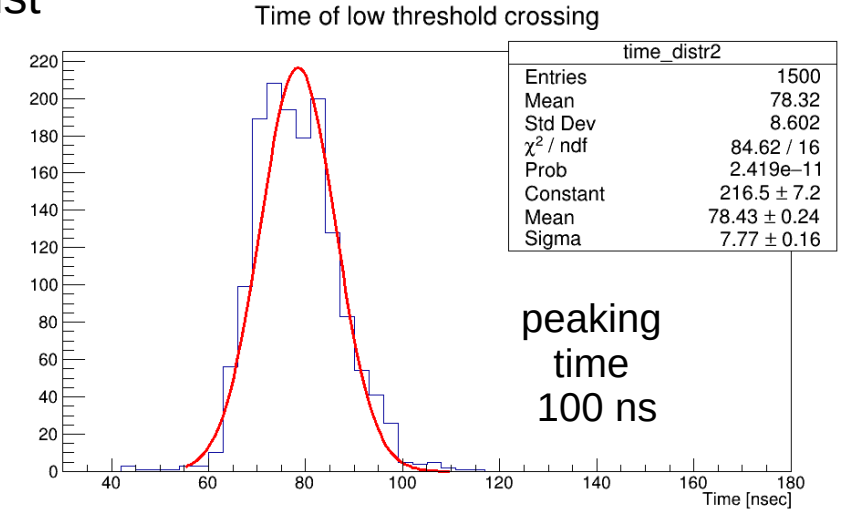
3 mm dist



peaking
time
200 ns



peaking
time
25 ns



peaking
time
100 ns

Landau function

```
//////////////////////////////////////////////////////////////////////////
/// The LANDAU function.
///
/// mu is a location parameter and correspond approximately to the most probable value
/// and sigma is a scale parameter (not the sigma of the full distribution which is not defined)
/// Note that for mu=0 and sigma=1 (default values) the exact location of the maximum of the distribution
/// (most proper value) is at x = -0.22278
/// This function has been adapted from the CERNLIB routine G110 denlan.
/// If norm=kTRUE (default is kFALSE) the result is divided by sigma

Double_t TMath::Landau(Double_t x, Double_t mu, Double_t sigma, Bool_t norm)
{
   if (sigma <= 0) return 0;
   Double_t den = ::ROOT::Math::landau_pdf( (x-mu)/sigma );
   if (!norm) return den;
   return den/sigma;
}
```

Probability density function of the Landau distribution:

$$p(x) = \frac{1}{\xi}\phi(\lambda)$$

with

$$\phi(\lambda) = \frac{1}{2\pi i}\int_{c-i\infty}^{c+i\infty} e^{\lambda s + s\log s} ds$$

where $\lambda = (x - x_0)/\xi$. For a detailed description see K.S. Kölbig and B. Schorr, A program package for the Landau distribution, Computer Phys. Comm. 31 (1984) 97-111 [Erratum-ibid. 178 (2008) 972]. The same algorithms as in CERNLIB (DENLAN) is used

Parameters

- **x** The argument x
- **xi** The width parameter ξ
- **x0** The location parameter x_0

SPICE DISCUSSION

1 mm distance; left — GasGain 45k (but with attachment so ~37)
Right — the same signals, but with amplification 1 mV / fC

SPICE DISCUSSION

2 mm distance; left — GasGain 45k (but with attachment so ~37)
Right — the same signals, but with amplification 1 mV / fC

SPICE DISCUSSION

3 mm distance; left — GasGain 45k (but with attachment so ~37)
Right — the same signals, but with amplification 1 mV / fC

SPICE DISCUSSION

4 mm distance; left — GasGain 45k (but with attachment so ~37)
Right — the same signals, but with amplification 1 mV / fC

SPICE DISCUSSION

Signals from 1 mm distance

SPICE DISCUSSION

SPICE DISCUSSION

SPICE DISCUSSION

2nd cluster arrival time diffusion infl.

Distanse 3 mm

with diff

w/o diff