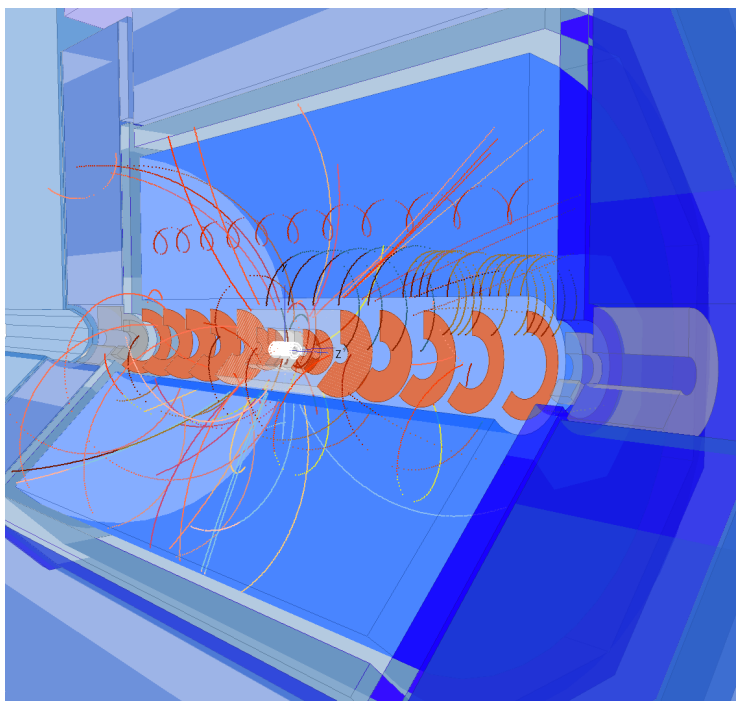
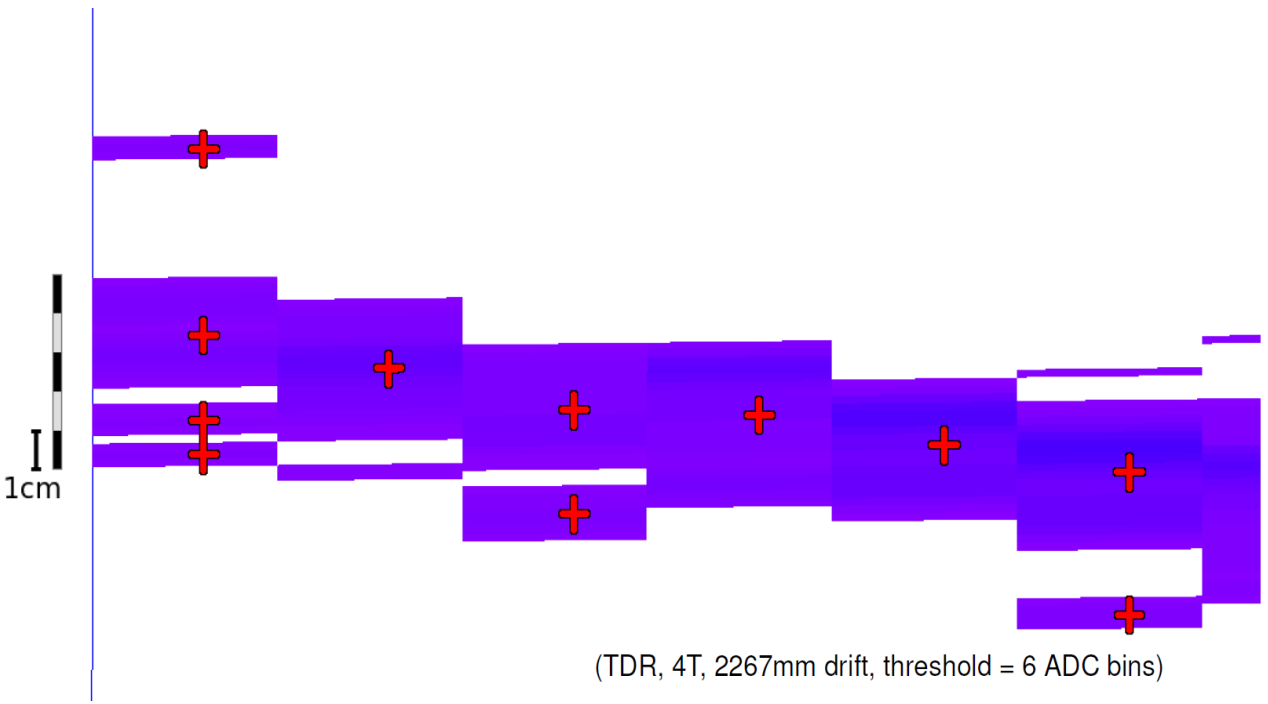
Simulation





(TDR, 4T, 2267mm drift, threshold = 6 ADC bins)

MarlinTPC Simulation

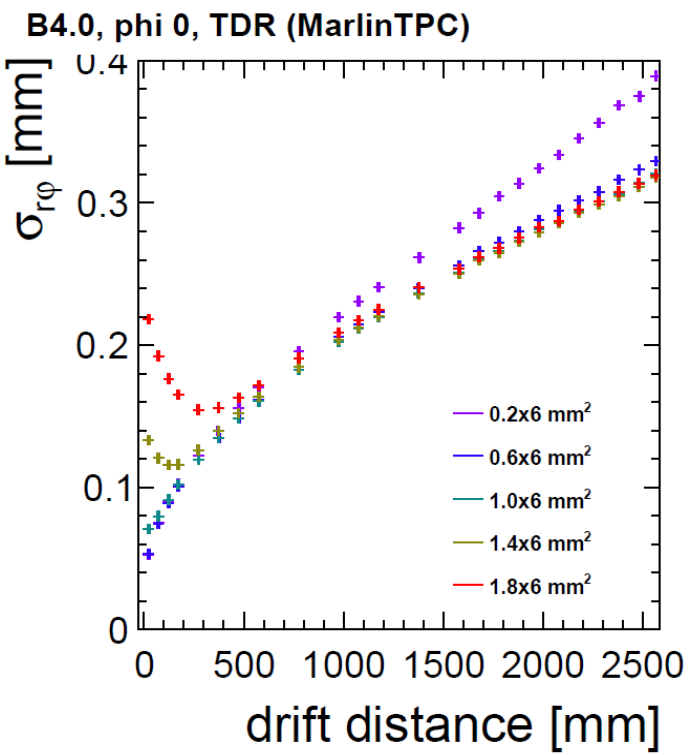
- Most results from Annika Vauth's summary of her work done before leaving DESY (work in progress)
- Starting point: study of different pad sizes
  → simulation does not accurately describe GridGEM module data

- Reminder: MarlinTPC detailed TPC simulation
  - 0. generate electrons
  - 1. primary ionization
  - 2. drift
  - 3. GEM amplification
  - 4. distribute charge on pads
  - 5. reconstruction (simulate electronics, find pulses / hits / tracks)
  - 6. analysis

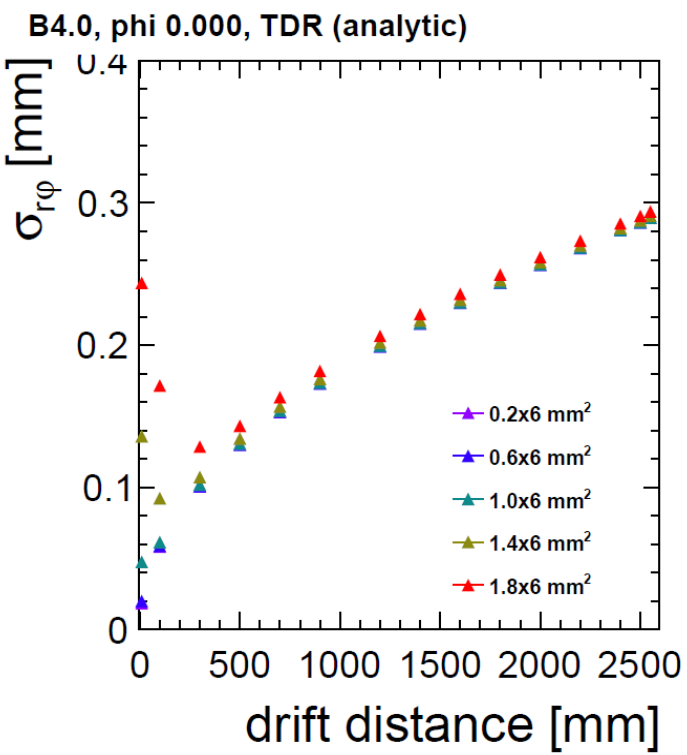
Comparison MarlinTPC – Japanese Resolution Simulation

- Comparison MarlinTPC simulation with Ryo Yonamine's resolution simulation
- TDR gas, B=4T

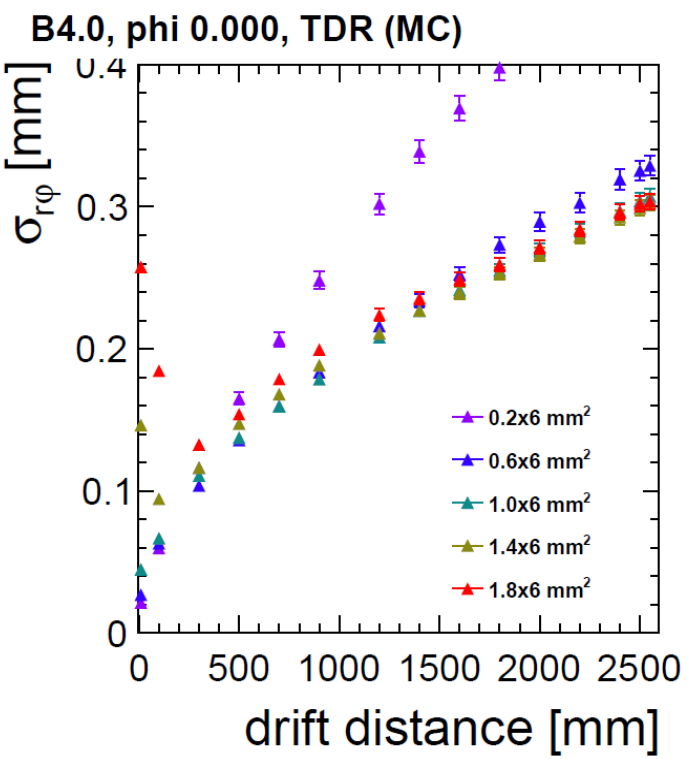
MarlinTPC + Standard Reco



Ryo's Simulation Analytic



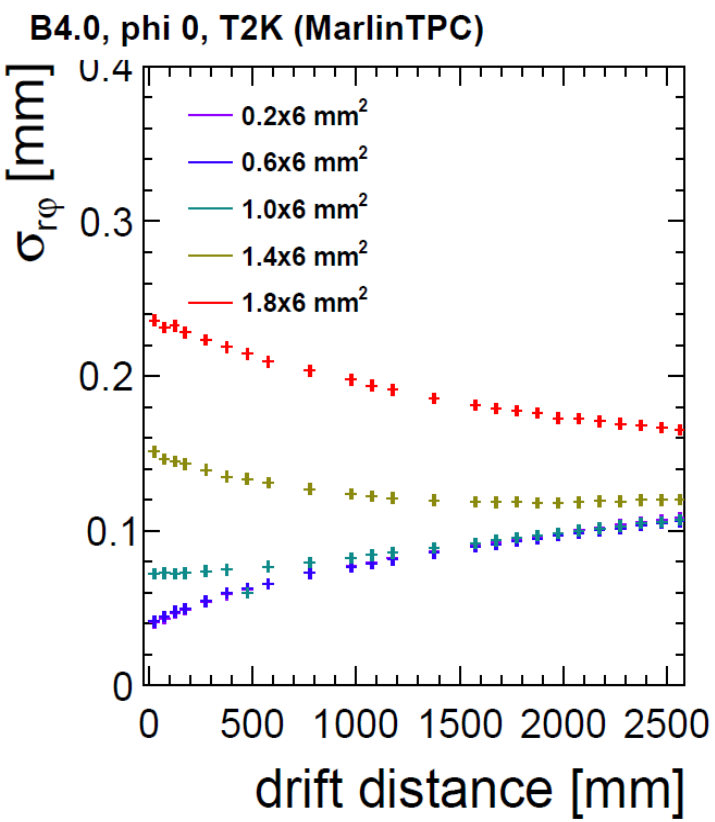
Ryo's Simulation MonteCarlo



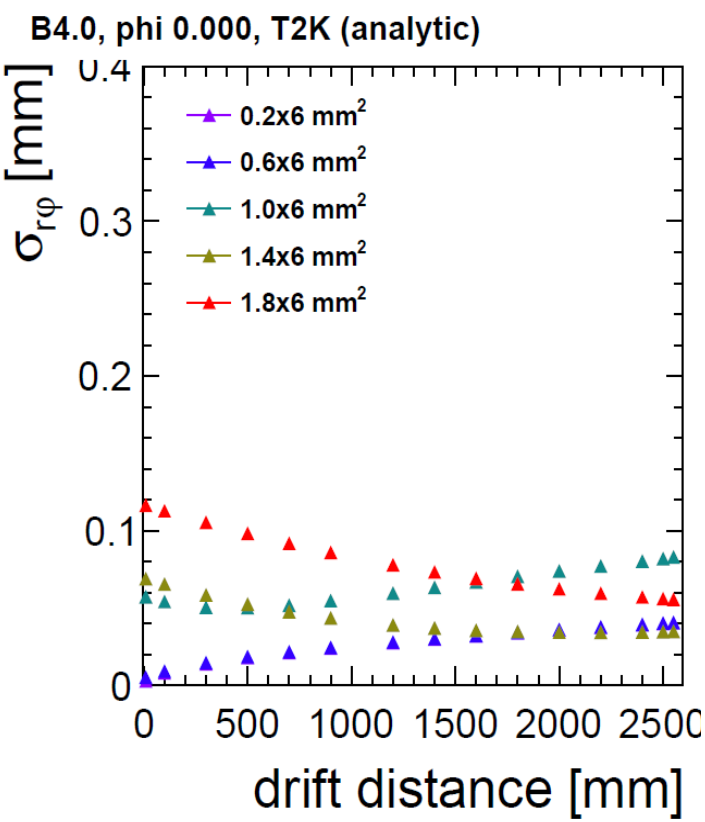
Comparison MarlinTPC – Japanese Resolution Simulation

- Comparison MarlinTPC simulation with Ryo's resolution simulation
- T2K gas, B=4T

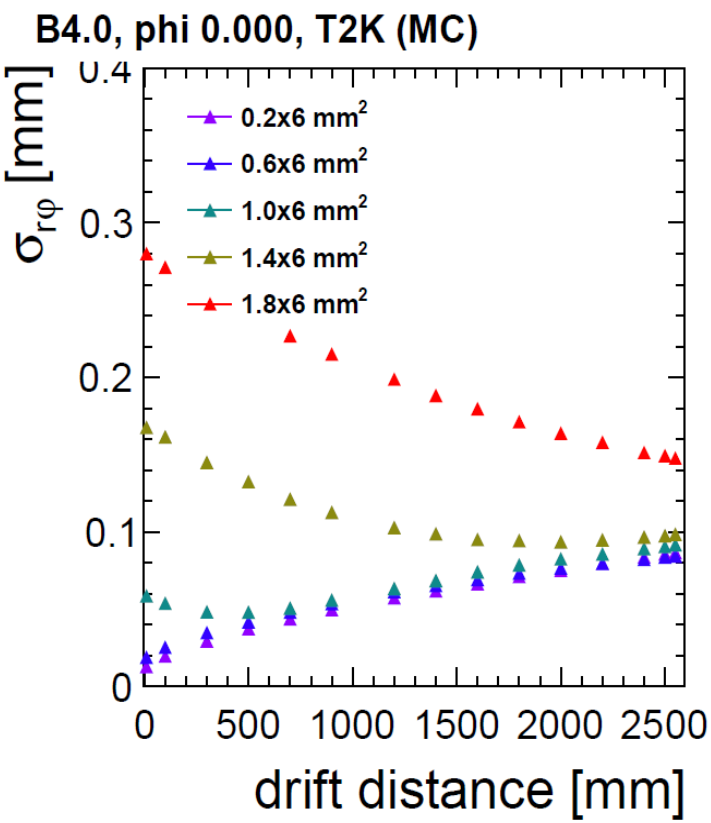
MarlinTPC + Standard Reco



Ryo's Simulation Analytic

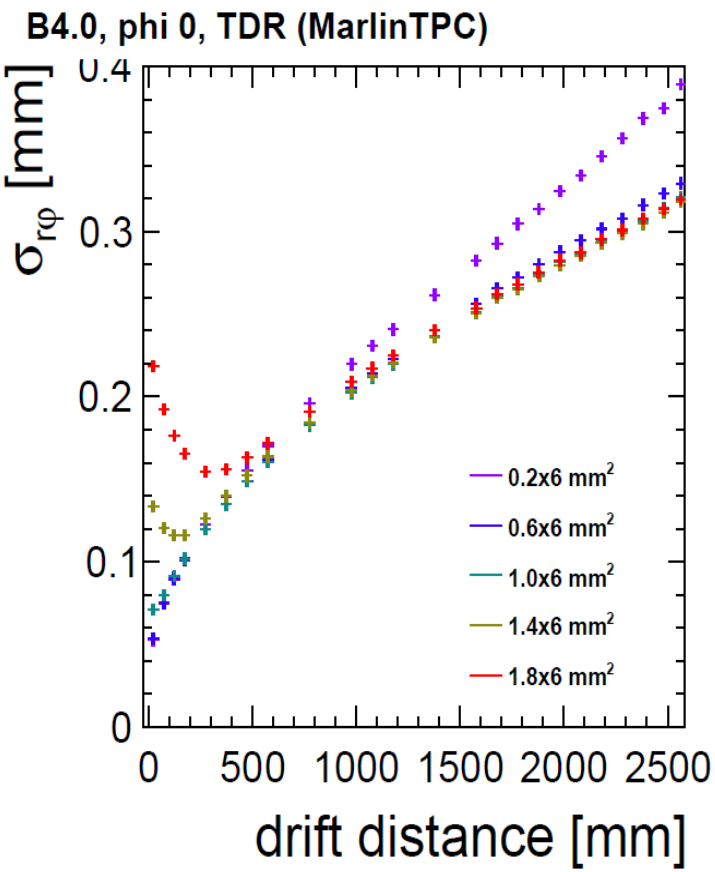


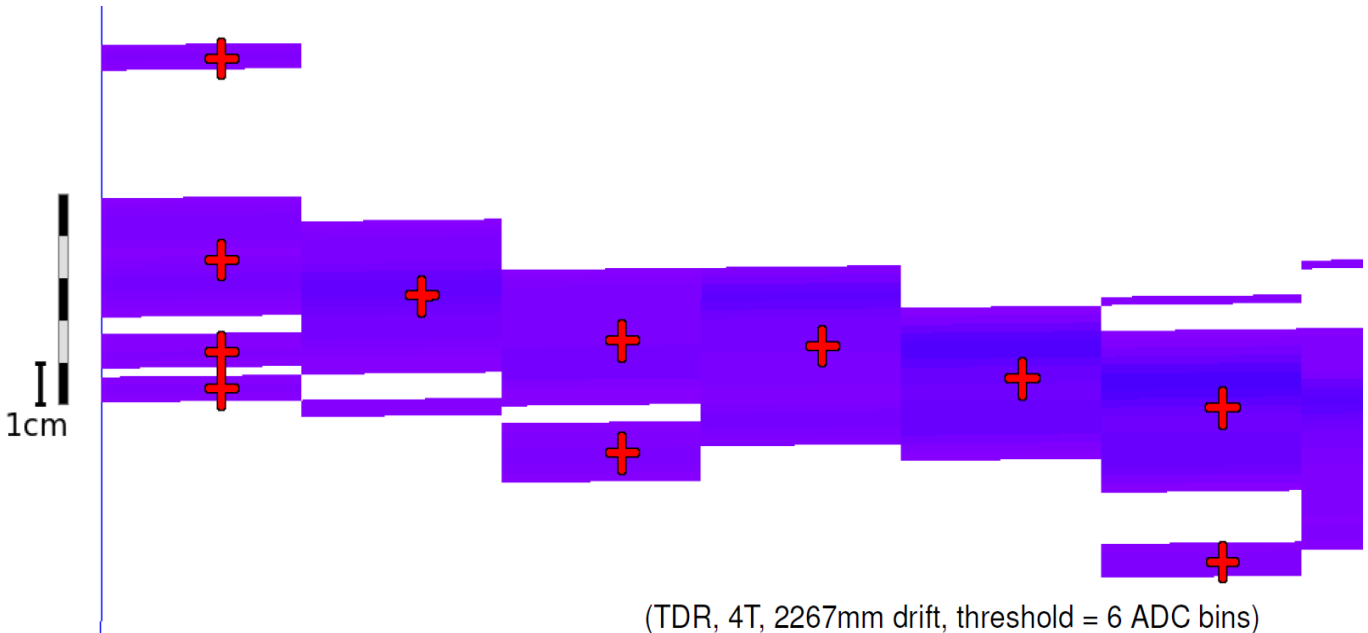
Ryo's Simulation MonteCarlo



Pad Size Studies

- Worse resolution at smaller pad sizes?





(TDR, 4T, 2267mm drift, threshold = 6 ADC bins)

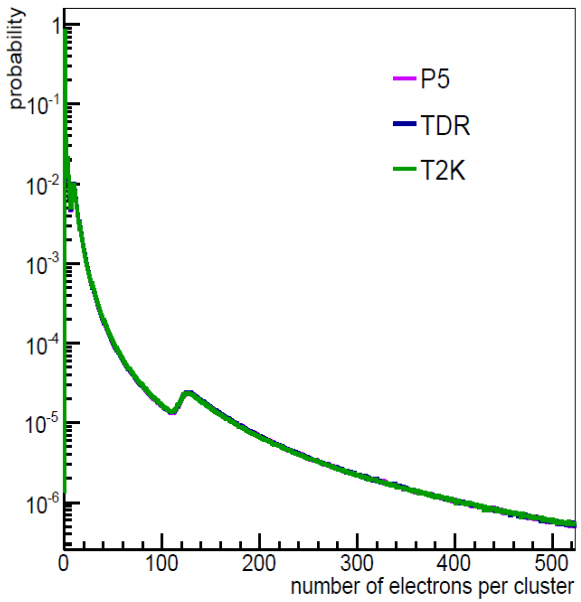
To do: our standard reco only uses one hit per row, needs to be changed for studies with very small pads

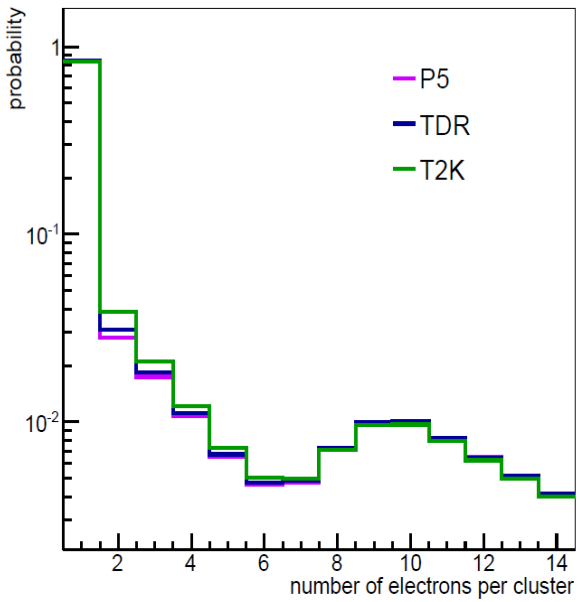
Simulation – Data Comparison

- Tested impact of:
  - Primary ionization: cluster density
  - Primary ionization: electrons per cluster
  - Drift: attachment
  - GEM gain - polya
  - GEMs: diffusion
  - Electronics: noise
  - Electronics: jitter
  - Electronics: time calculation

Primary Ionization: Electrons per Cluster

- Parametrization for TDR/P5/P10 does not match T2K gas as well

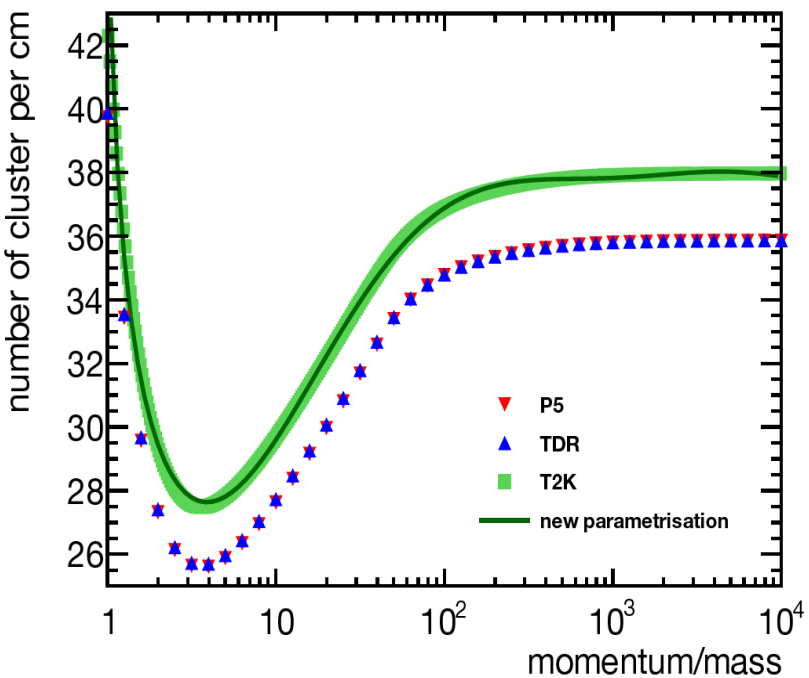




commit r4960 adding option to use user-given parametrisation for the cluster density, adding the T2K parametrisation to simulation inputs; also including the code used to obtain it in tools/SimulationClusterDensity for potential future use with other gas mixtures.

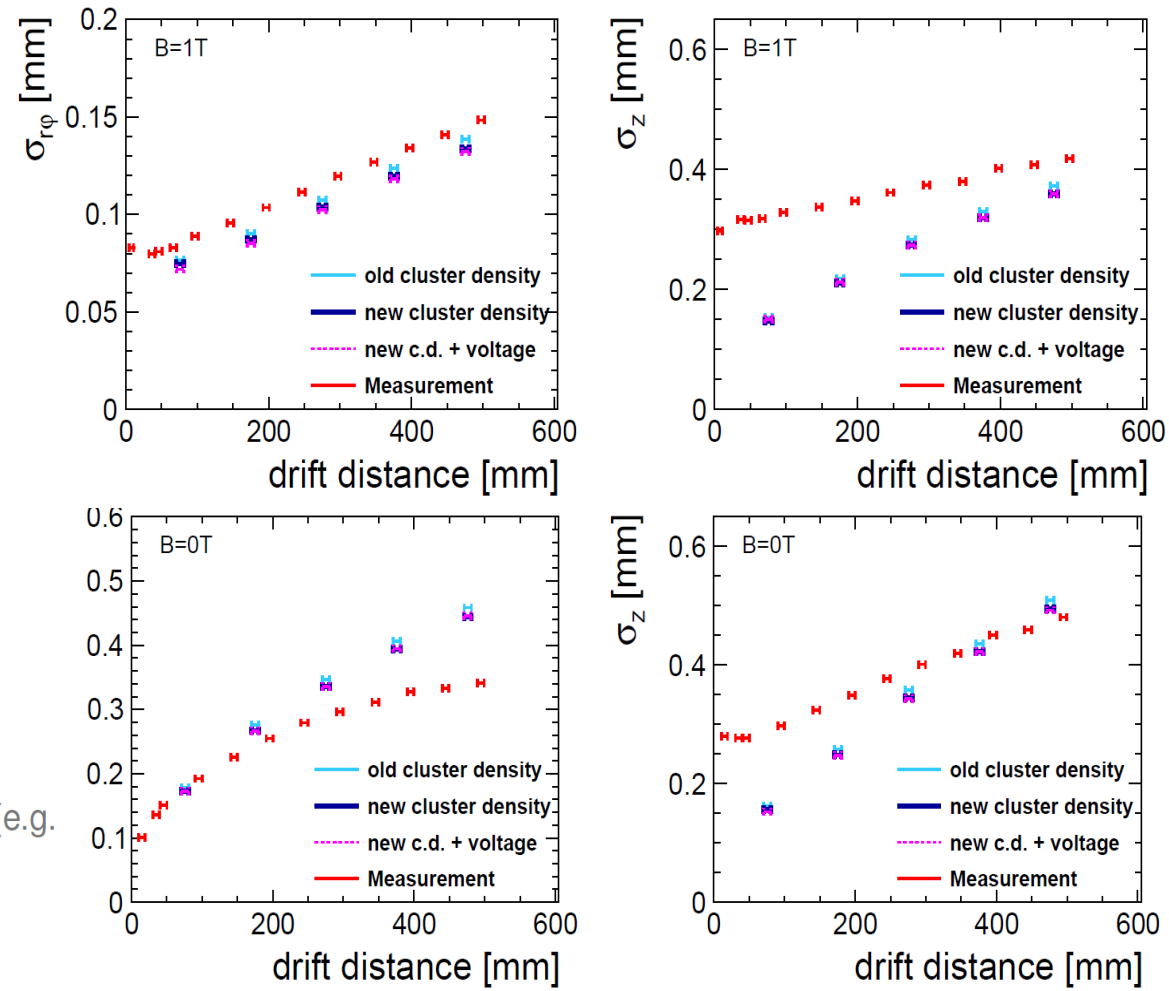
Primary Ionization - Heed

Re-ran HEED for different gases (P5 / TDR / T2K)
fitted same logx-polynomial to T2K as used for TDR



commit r4979 more flexibility in reading in electrons-per-cluster file (e.g. no more hard-coded line numbers)

Compare old and new parametrisation

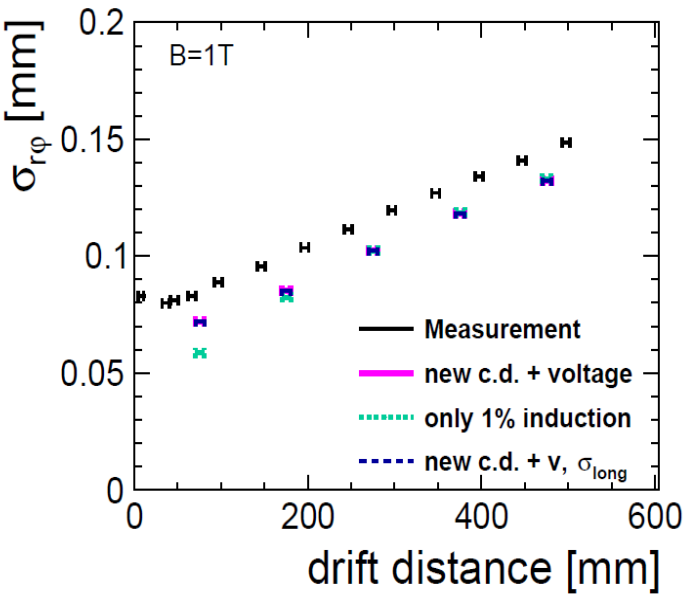


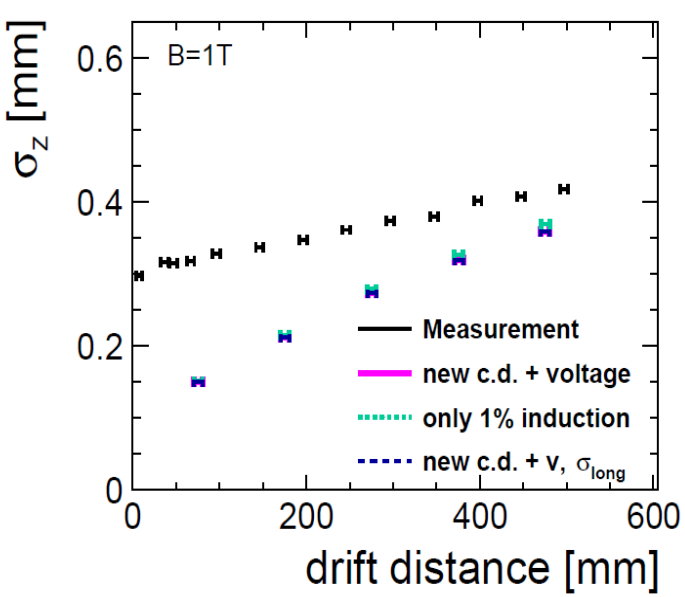
Primary Electron Range

- The range of primary electrons is related to their energy, which is related to the number of secondary electrons.
- For a range greater than 100 µm, electrons are considered δ-electrons

  → 60 sec. el. for B=0T, 1200 sec. el. for B=1T
- Else, they are simulated without spatial spread exactly on the track
- → Set threshold to 0, all electrons are treated as δ-electrons
- → Simulation takes much longer, virtually no difference in resolution

Switched on longitudinal diffusion σ_{long}
tested impact of induction (test: 1%, default: 10%)





commit r4954 bugfix: factor 0.5 missing in the gaus integral for the z-distribution when longitudinal distribution in the GEM stack is switched on

GEM Gain

For non-uniform fields: polya distribution to describe gain

$$P(G) = \frac{1}{\overline{G}} \frac{(\theta+1)^{\theta+1}}{\Gamma(\theta+1)} \left(\frac{G}{\overline{G}}\right)^{\theta} \exp\left(-(\theta+1)\frac{G}{\overline{G}}\right)$$

For $\theta = 0$: exponential distribution

Blum-Rolandi:

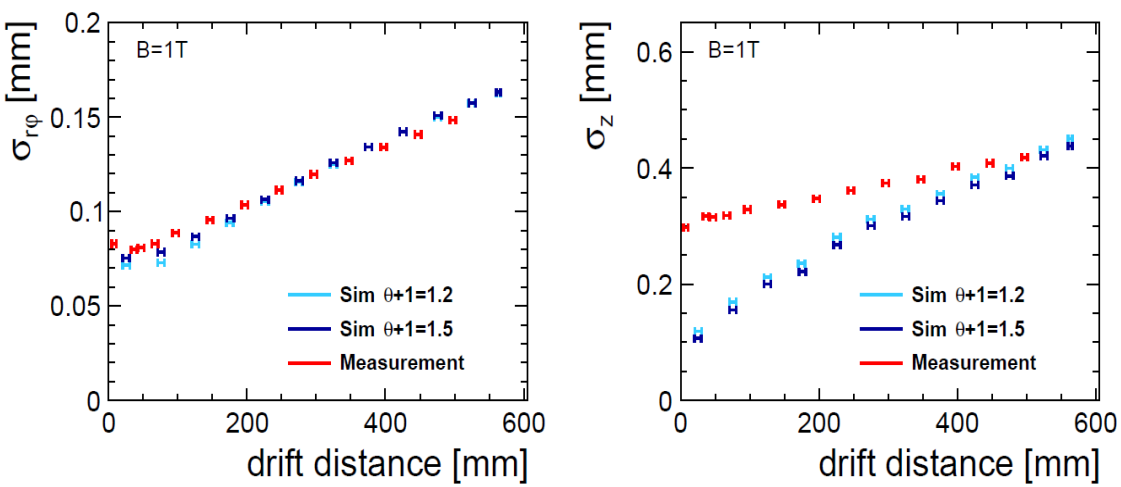
> *F*or argon and methane [...] for gas gains in the range $10^2 - 10^5$ [...] we thus have values of θ in the range of 0.25-0.67.

Polya distribution in MarlinTPC: was implemented with a hard-coded value $\theta + 1 = 1.2$, but never used

commit r4849 bugfix polya: function only returned number of electrons between 0 and 1, never amplified, due to missing function range)

commit r4942 allow setting of the theta-parameter for polya gain as an optional parameter

Value for $\theta + 1$ now an optional parameter in MarlinTPC

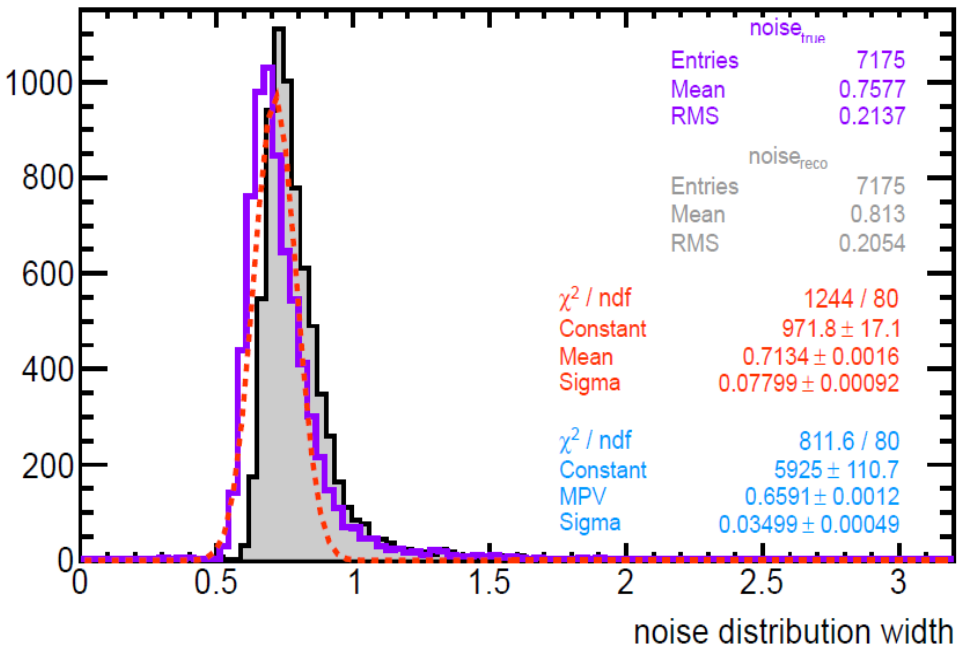


I. Bronic, "A Study of Argon-Isobutane Mixtures in a Proportional Counter, Radiat Prot Dosimetry (1995) 61 (1-3): 263-266."

$\rightarrow$ for our gas values of θ in the range of -0.25-0.5 (?).

Pedestals

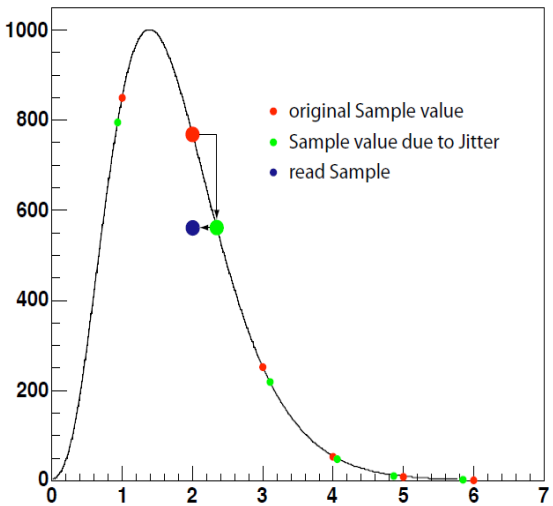
- Pedestal width distribution looks kind of Landau-like
- Implemented both Gauss and Landau in simulation
  for random distribution of σ_{noise}
  then add noise
  randomly from $G(0, \sigma_{noise,i})$ to signal of pad_i



commit r4977 Added the possibility to include noise to simulated ADC spectra, switch between different models (no noise, Gaussian, Landau).

To account for the fact that horribly noisy channels would probably be excluded from the analysis of real data, a cutoff for the allowed noise level can be set.

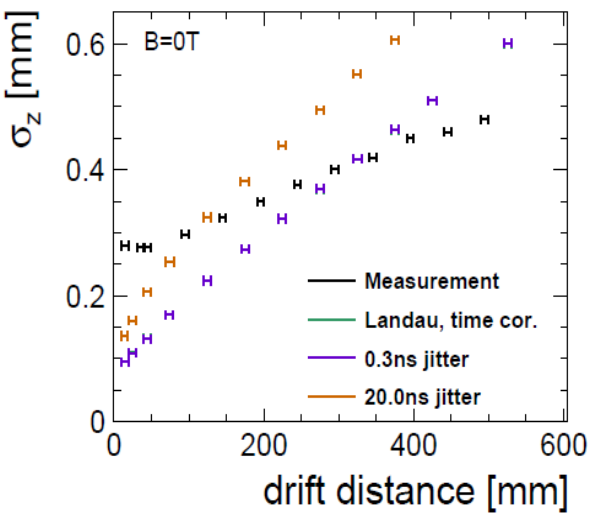
ADC Clock Jitter

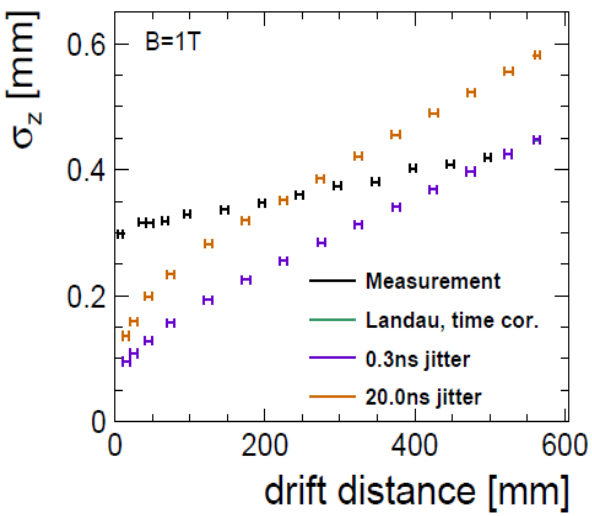


- apply random jitter
  - use gaussian random function
  - take sample at jittered Position
- scan: $0 < \sigma < 2$ns

thesis R. Bramm (Frankfurt): “foreseen clock inaccuracy of 0.3 ns“

first quick test: adding Gaus($\mu = 0$, $\sigma = 0.3ns$) to bin time
(and with 20ns to test if anything happens at all)



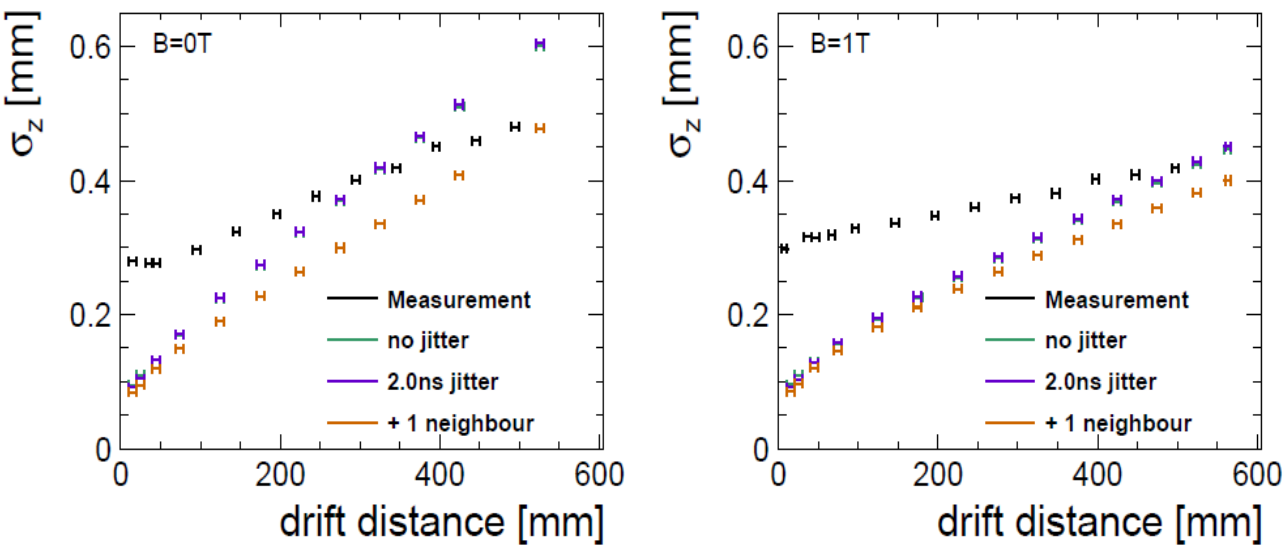


commit r4994 adding the possibility to include time jitter for Gaussian ADC and ALTRO ADC

Time Calculation

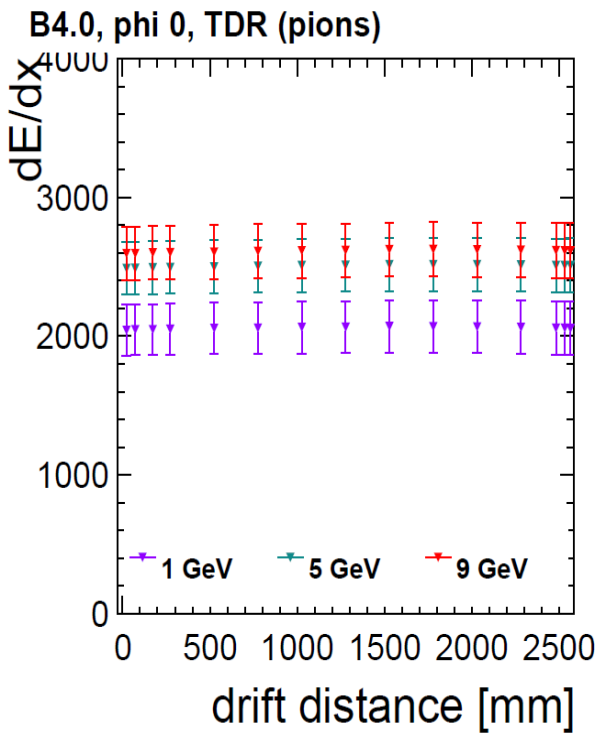
r4971 bugfix so that ReadoutFrequencyOverride is actually used, **commit r4989,r4990** calculation of hit time: added option to take neighbour pulses into account in addition to the maximum

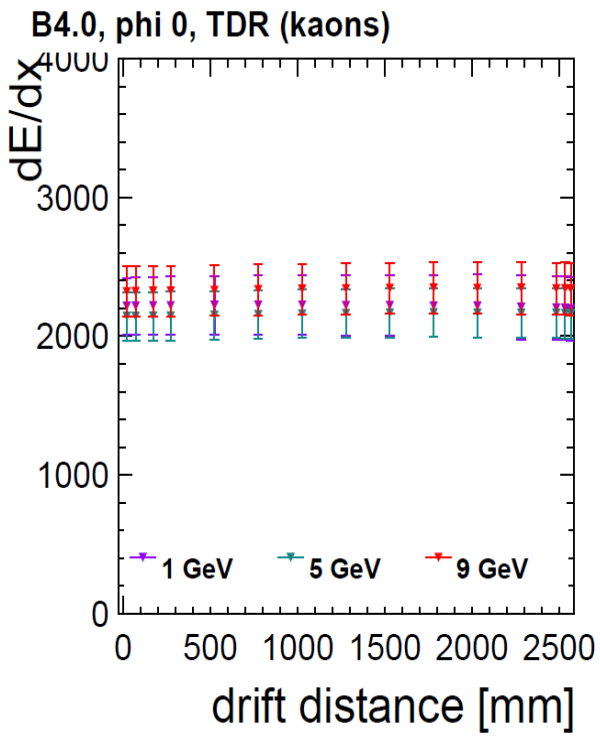
Below: one neighbour pulse on each side added in MMHitTimeCorrectionProcessor



Specific Energy Loss dE/dx

- Only started

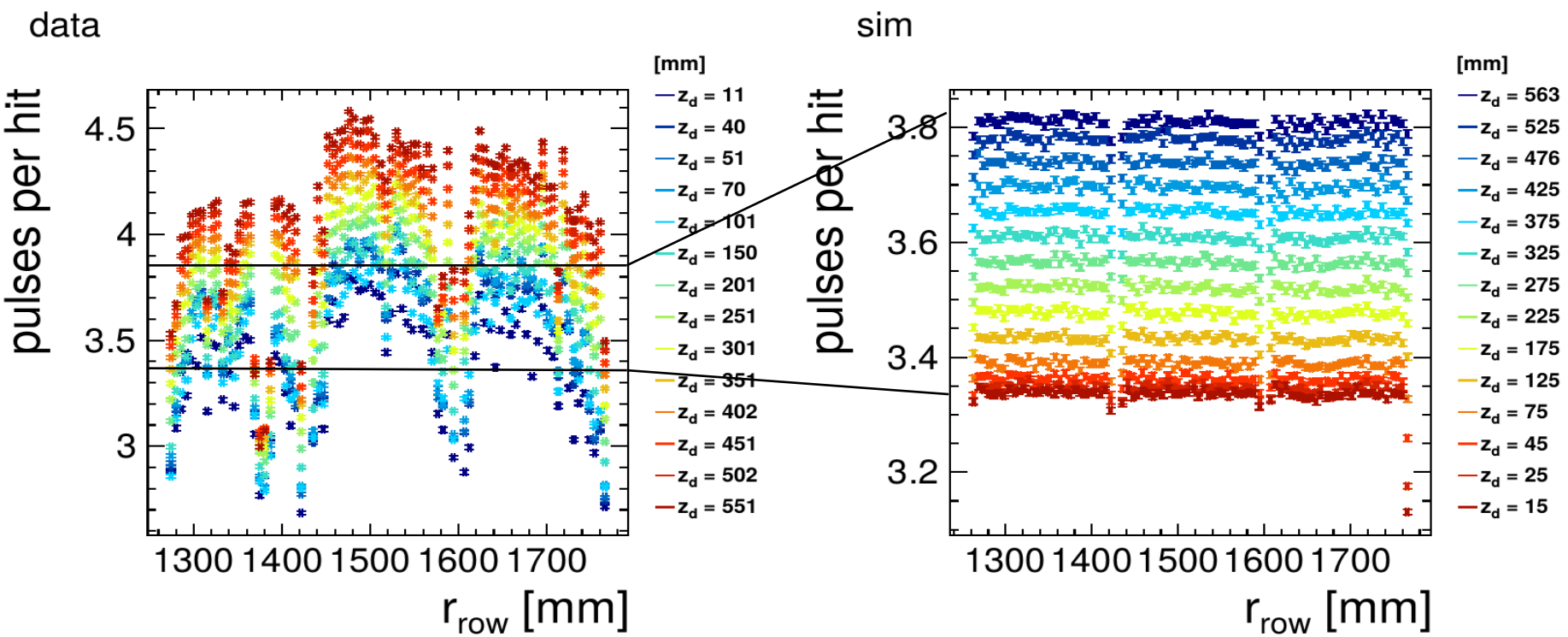




r4912 GeneralBrokenLineInterfaceHelpers: using absolute value in calculation (to have positive pathlength regardless of orientation, otherwise modules rotated by 90 degrees caused problems)

Pulses per Hit

- To be further studied

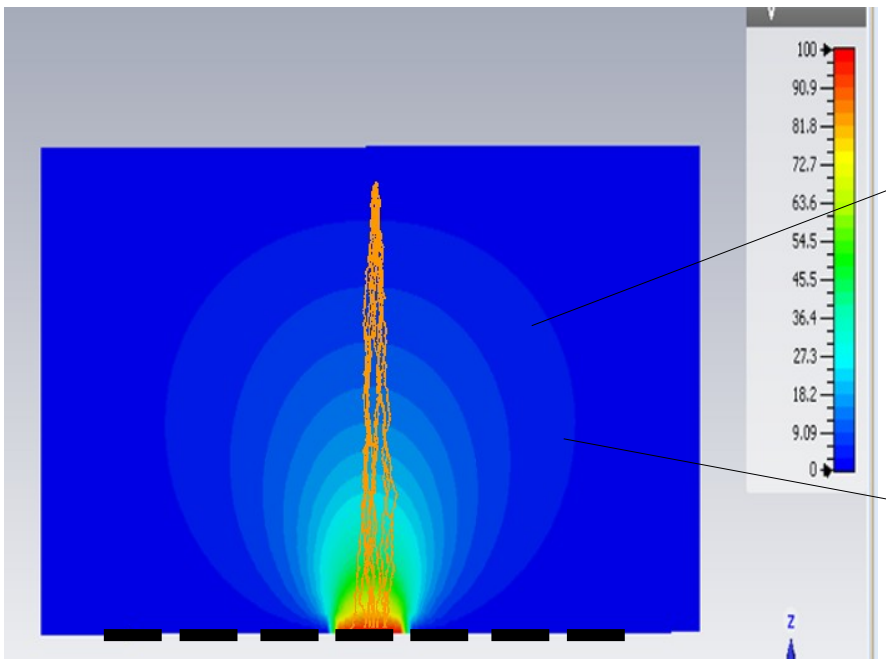


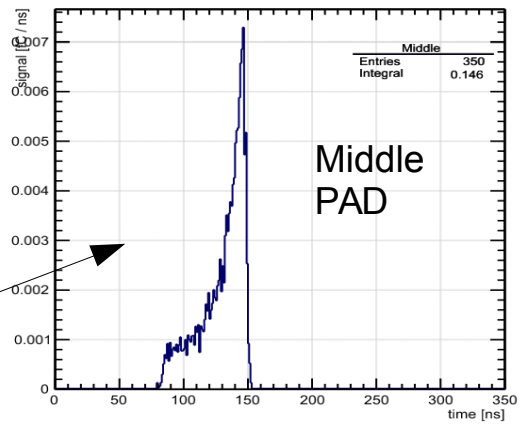
Current and planned work

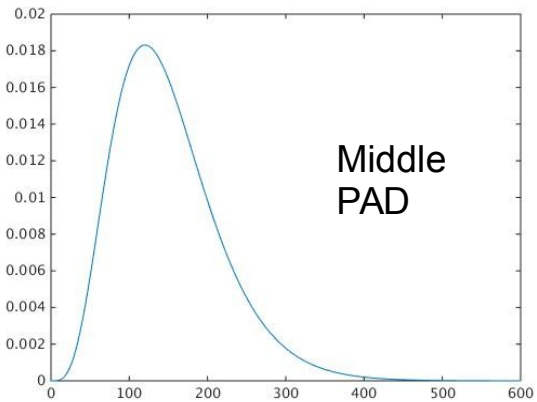
- In progress (Uli Einhaus)
  - Further study the comparison of testbeam results and simulation → improving simulation
  - Projection of electron cluster on a pad plane of the Timepix+pads setup
  - Check the implementation of the digitization of the Timepix chip
  - Analysis: study of clustering algorithms and methods

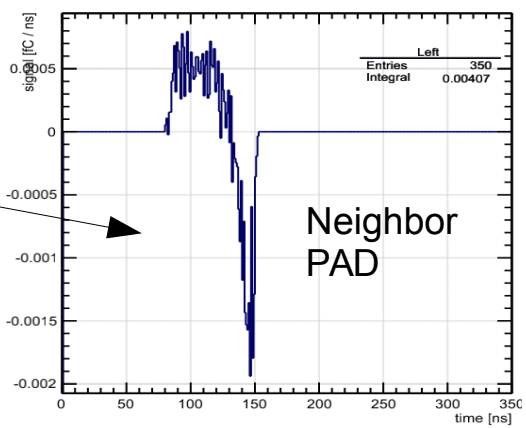
Detailed Pad Response Simulation

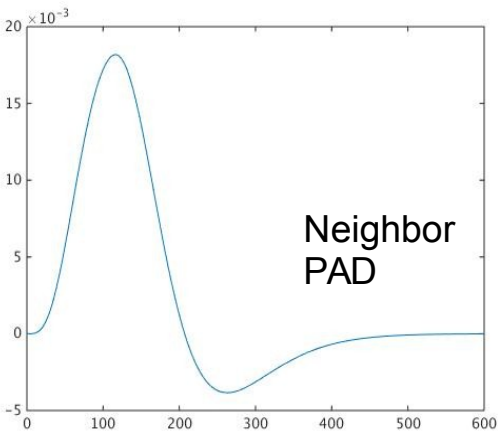
Using "A Garfield++ interface for CST TM“, K. Zenker, LC Notes. LC-TOOL-2013-022





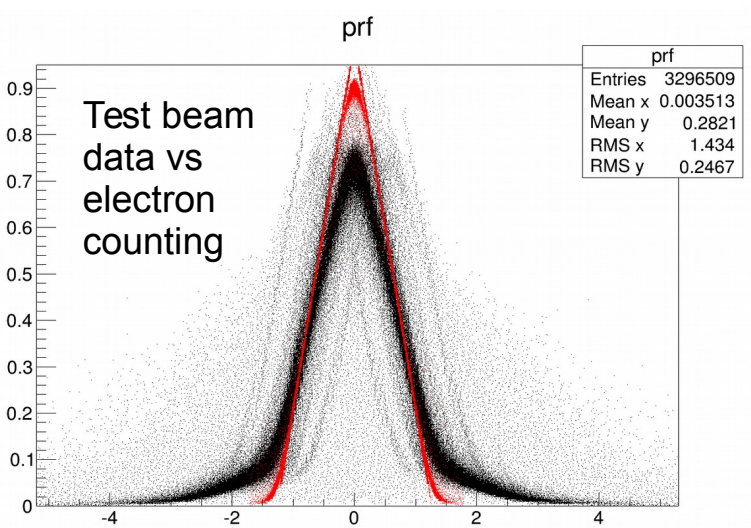


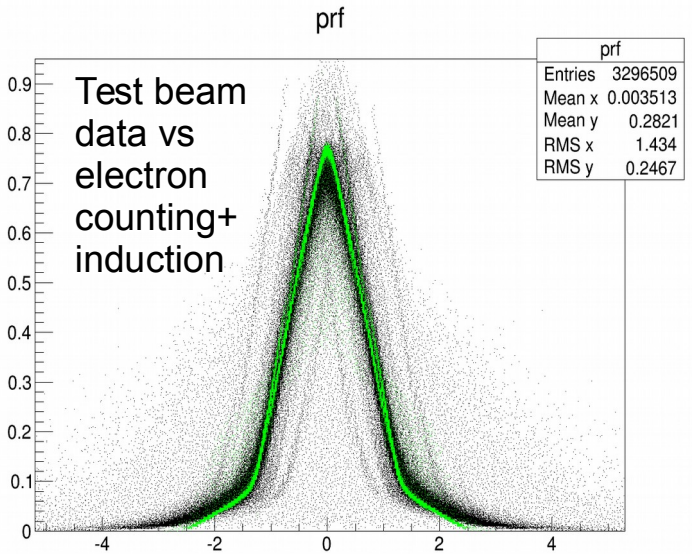


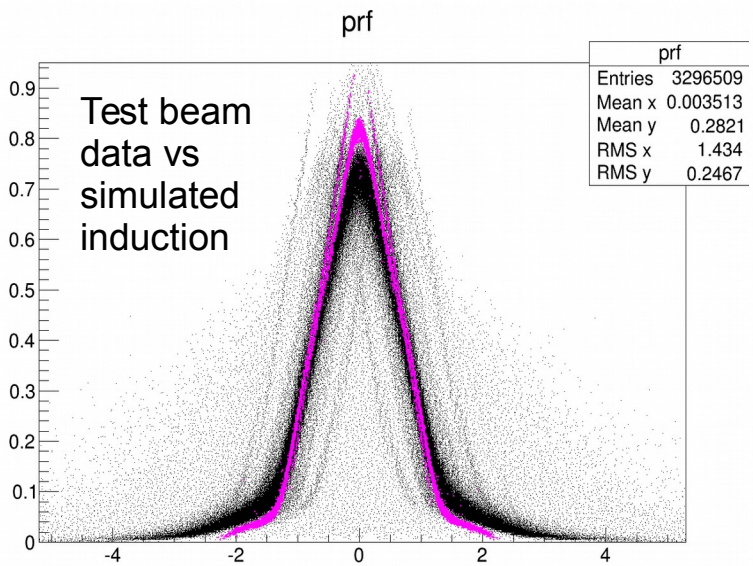


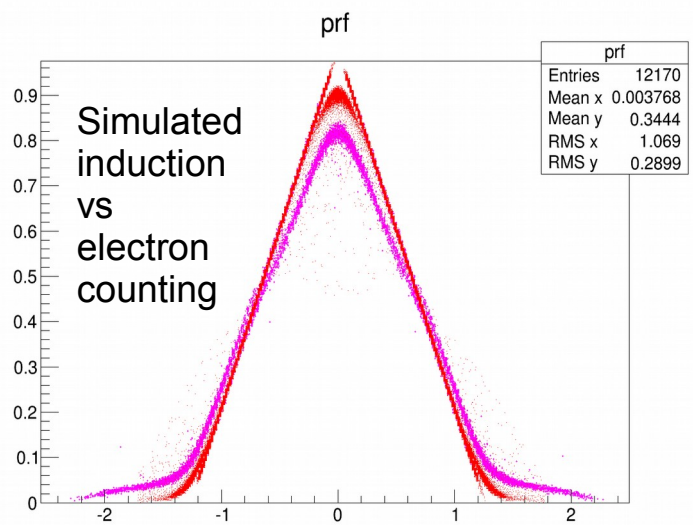
Detailed Pad Response Simulation

- Comparison of PRF from different methods to data



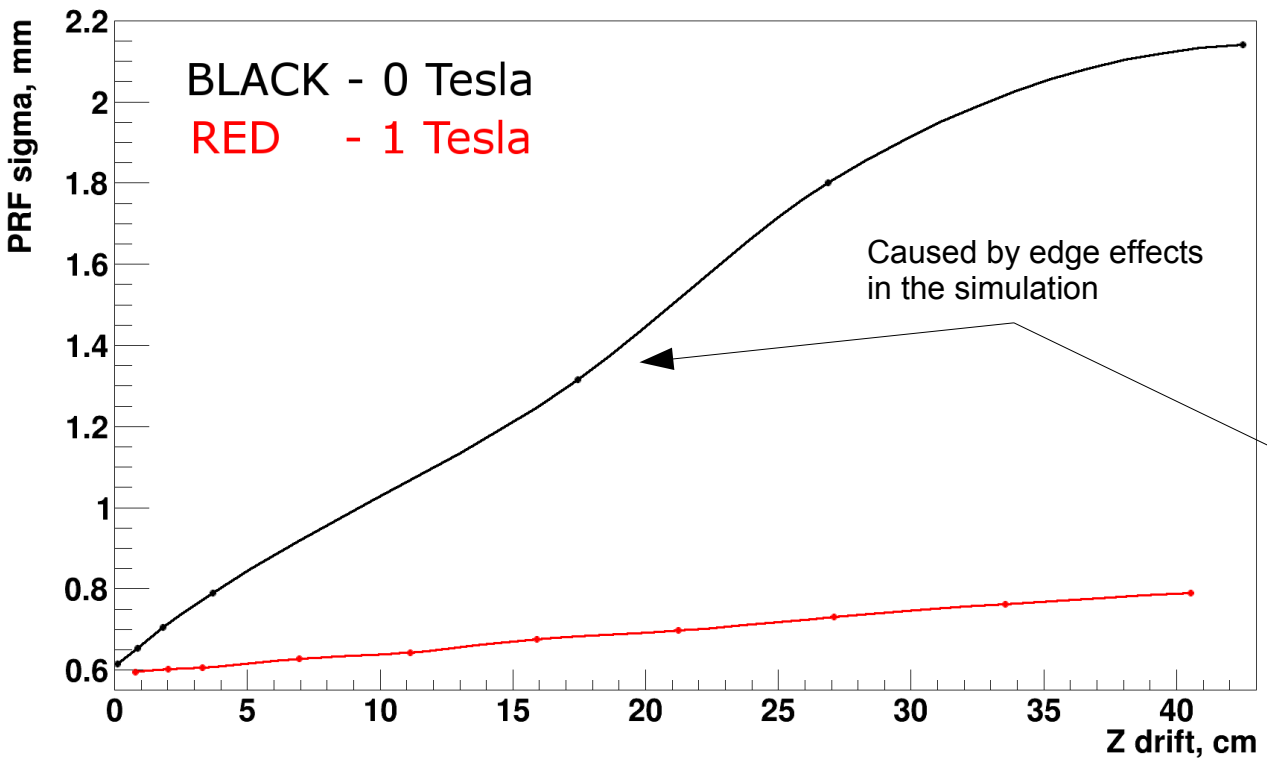


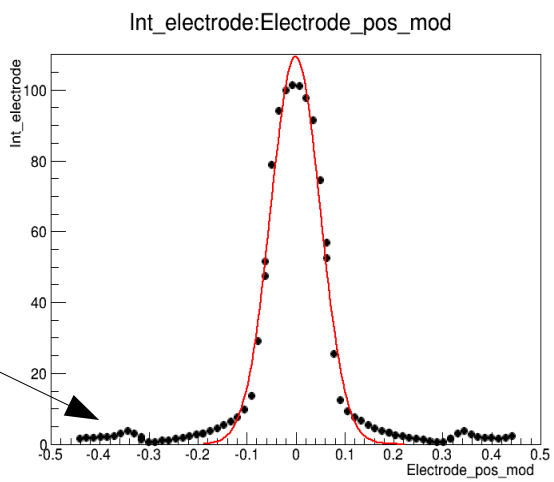




Detailed Pad Response Simulation: PRF vs Drift

- Still preliminary results → Size of the simulated system need to be increased

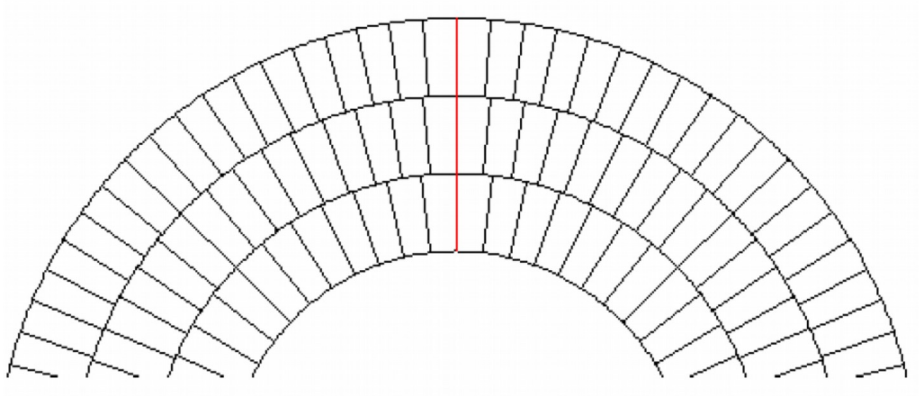




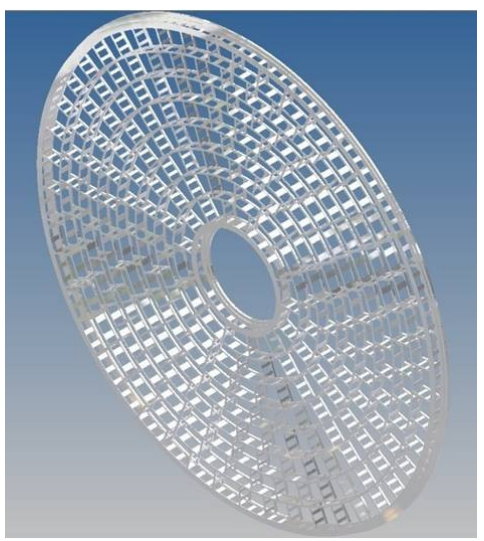
- To be continued

ILD Simulation

- TPC Driver quite old, only basic support by central software team
- Using FixedPadSizeDiskLayout
  - Polar Geometry, complete circles
  - All pads have the same size



- ILD simulation drivers should be supported and developed by the subsystem collaborations
  - So far we lived of work by central software group
  - Also DD4HEP port by F. Gaede still contains rather old code
- Should be revised and supported by us
  - More realism
  - Example:
    Possibility to simulate module gaps (simple way: throw away hits in the digitization) to study pad size and gap effects on tracking efficiency etc.



Conclusion

- We reached a level of analysis and understanding of our data,
  that the current status of simulation is not sufficiently describing the results
  - Detailed MarlinTPC simulation needs to be improved
- We need to take responsibility the TPC driver in the ILD simulation
  - Central software team will not carry this
  - More realism to study design choices for our modules / endplates

- We should as soon as possible find a software convener
  - Coordination of and support for our software tools
  - Push again data comparison on common grounds
  - Mandatory in new ILD organizational structure?
  - Restart analysis/software meetings to keep everybody informed
  - Constant, mandatory use of central tools: wiki and repository
    Things have been lost in the past → results cannot be reproduced (bad scientific standards)