Simulation Studies for a GEM-based TPC

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Worldwide Study of the Physics and Detectors for Future Linear e^+e^- Colliders

bmb+f Großgeräte der physikalischen Grundlagenforschung

Simulation Studies

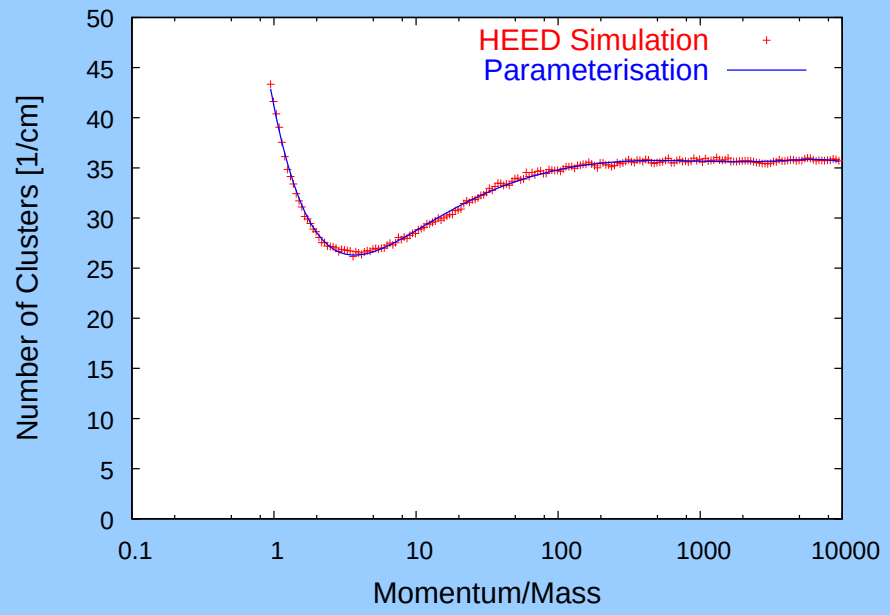
4 Modules:

1. Primary ionisation
2. Drift of electrons
3. Gas amplification with GEMs
4. Electronics (shaper, ADC)

Goals: Study influence on the spatial resolution of a TPC of

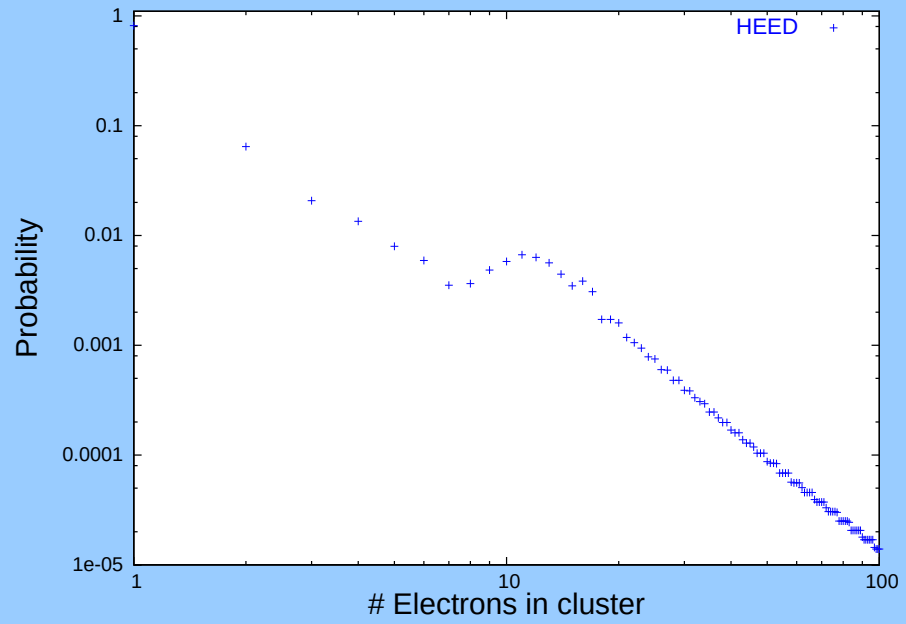
- Electric and magnetic fields
- GEM settings
- Pad response, pad geometry
- Ion backdrift

Creating Primary Ionisation



Mean number of clusters

→ Distance between clusters from exponential distribution with this mean value

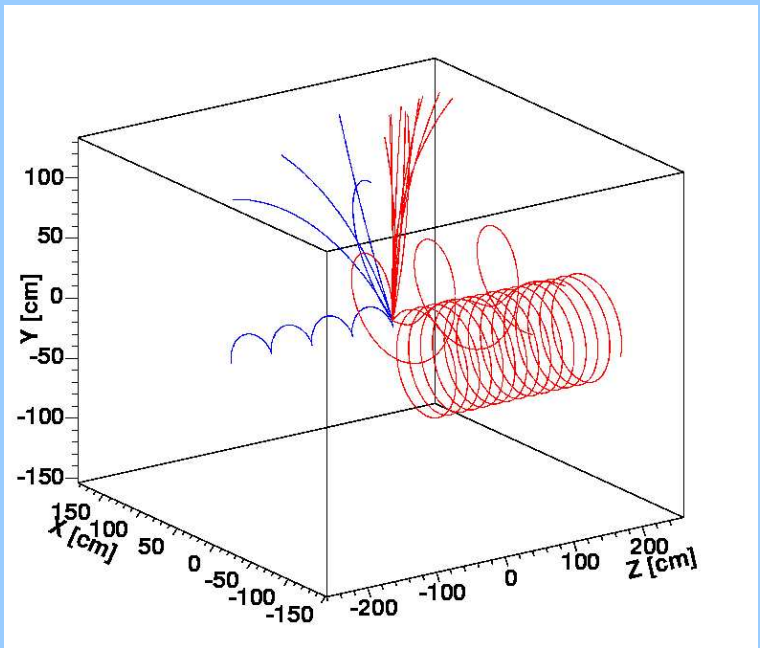


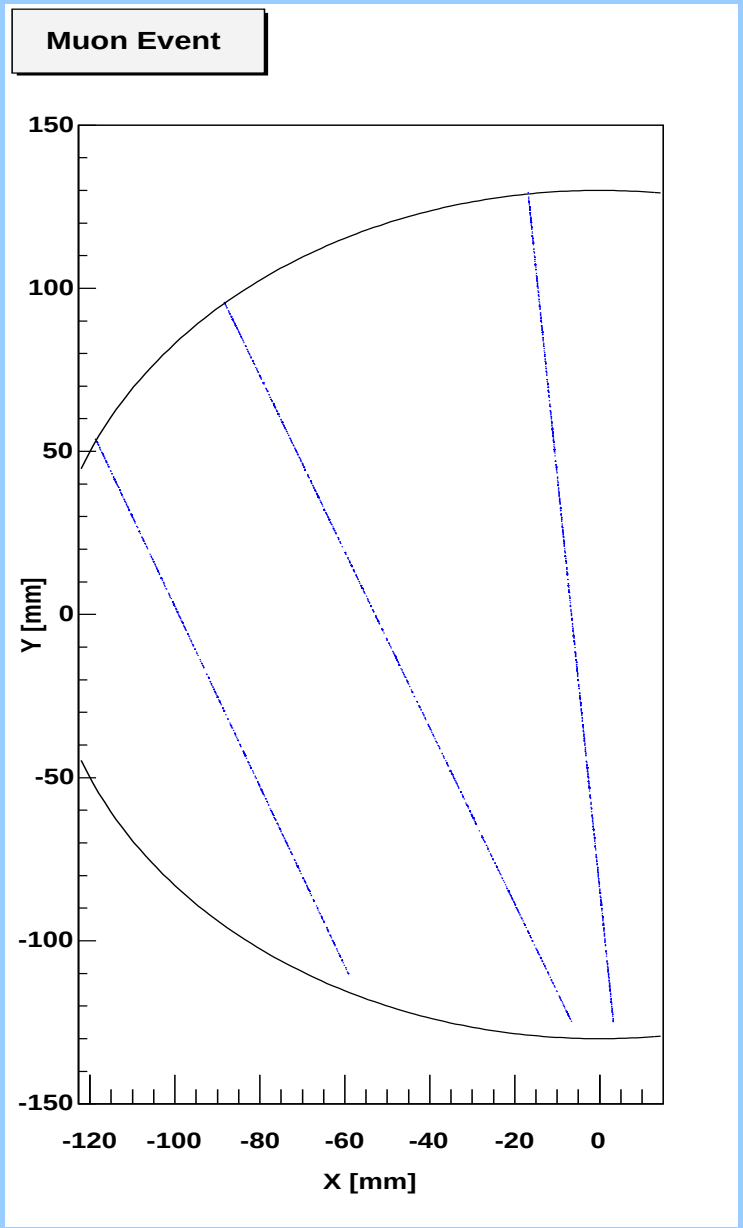
Probability for number of electrons per cluster

→ Choose randomly according to distribution

Creating a Track

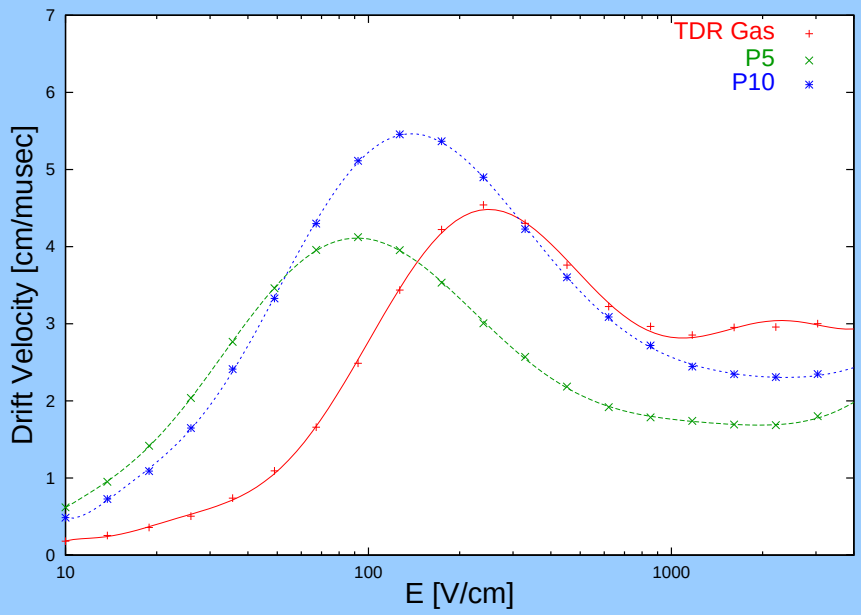
- Randomly choose distance to next cluster
- Choose # of e^- in this cluster
- 3D information possible
- B fields possible



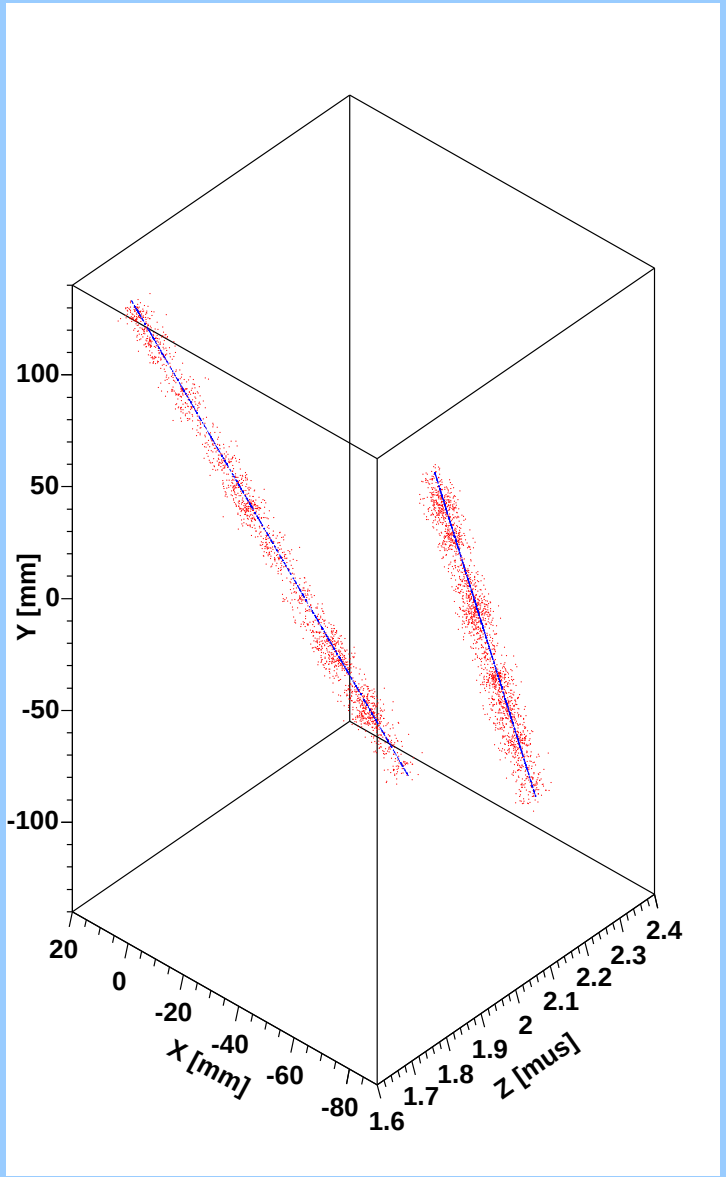


Drifting Electrons

Parametrise gas properties simulated with MAGBOLTZ



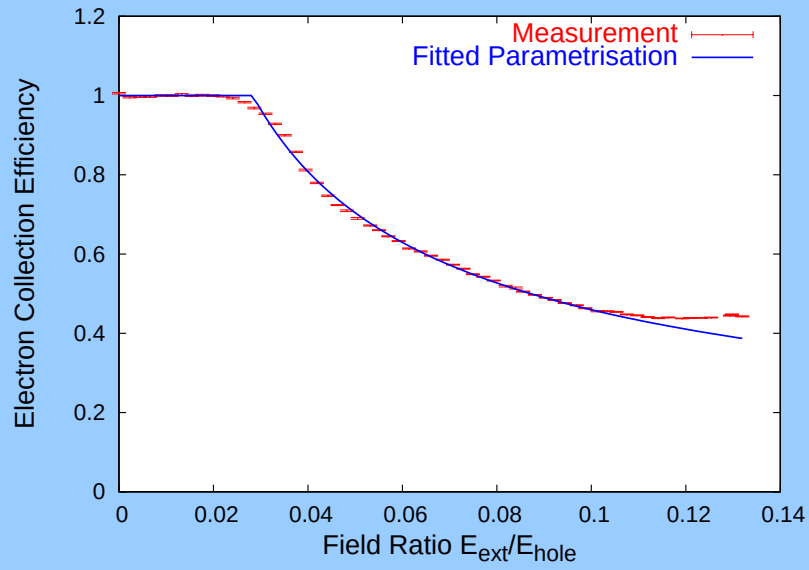
Dice coordinates after drifting according to longitudinal and transverse diffusion

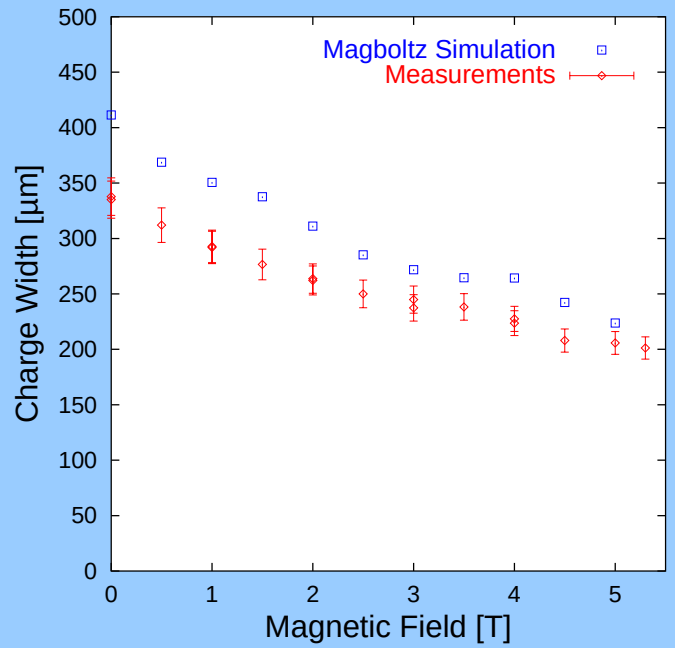


Amplification with GEMs (1)

From measurements:

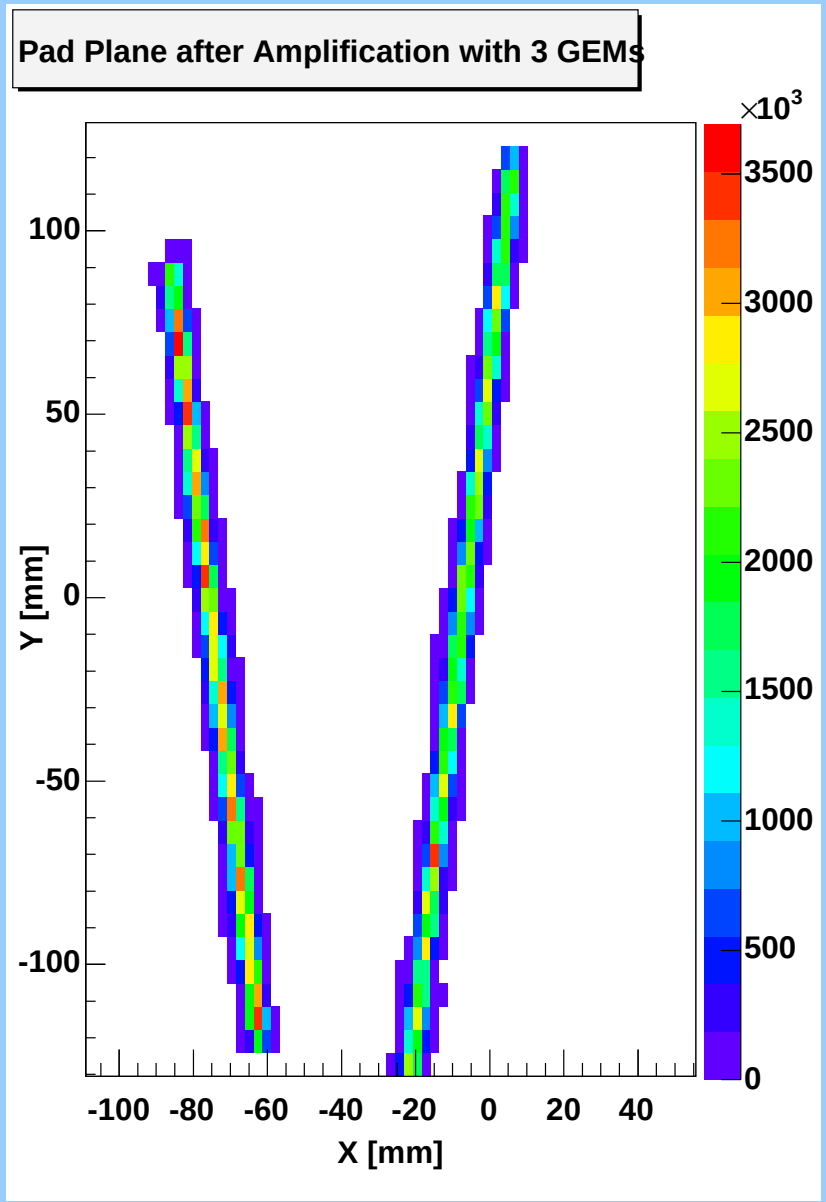
1. Parametrisation of charge transfer in triple GEM structure: collection, gain, extraction
2. Charge broadening only due to diffusion between GEMs
   $\rightarrow$ Simulate diffusion with Magboltz





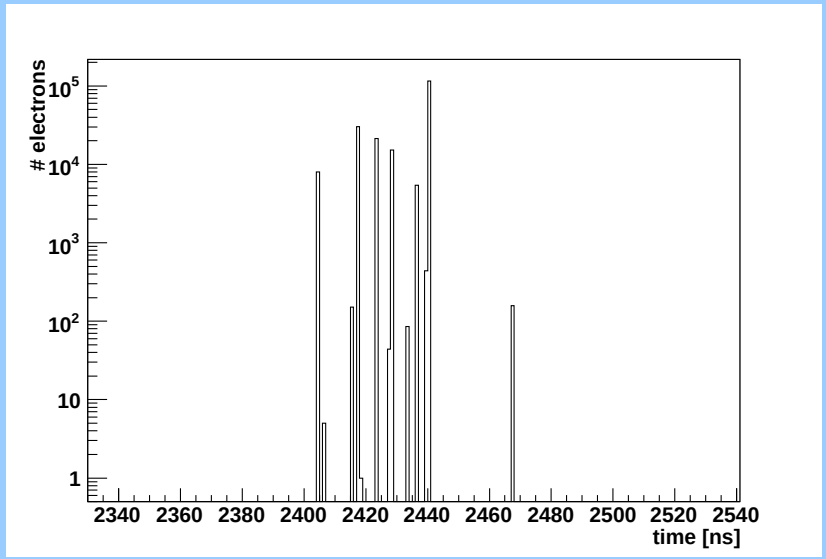
Amplification with GEMs (2)

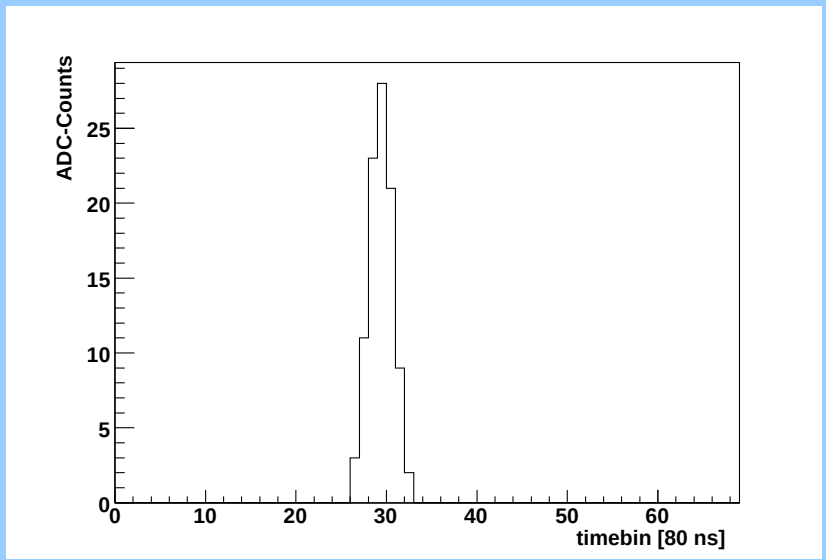
- Calculate number of secondary e^- from charge transfer combined with binomial statistics
- Integrate over 2D gaussian with sigma of charge cloud to get charge on pads
  $\rightarrow$ Voxel information:
  charge on channel c
  at time t



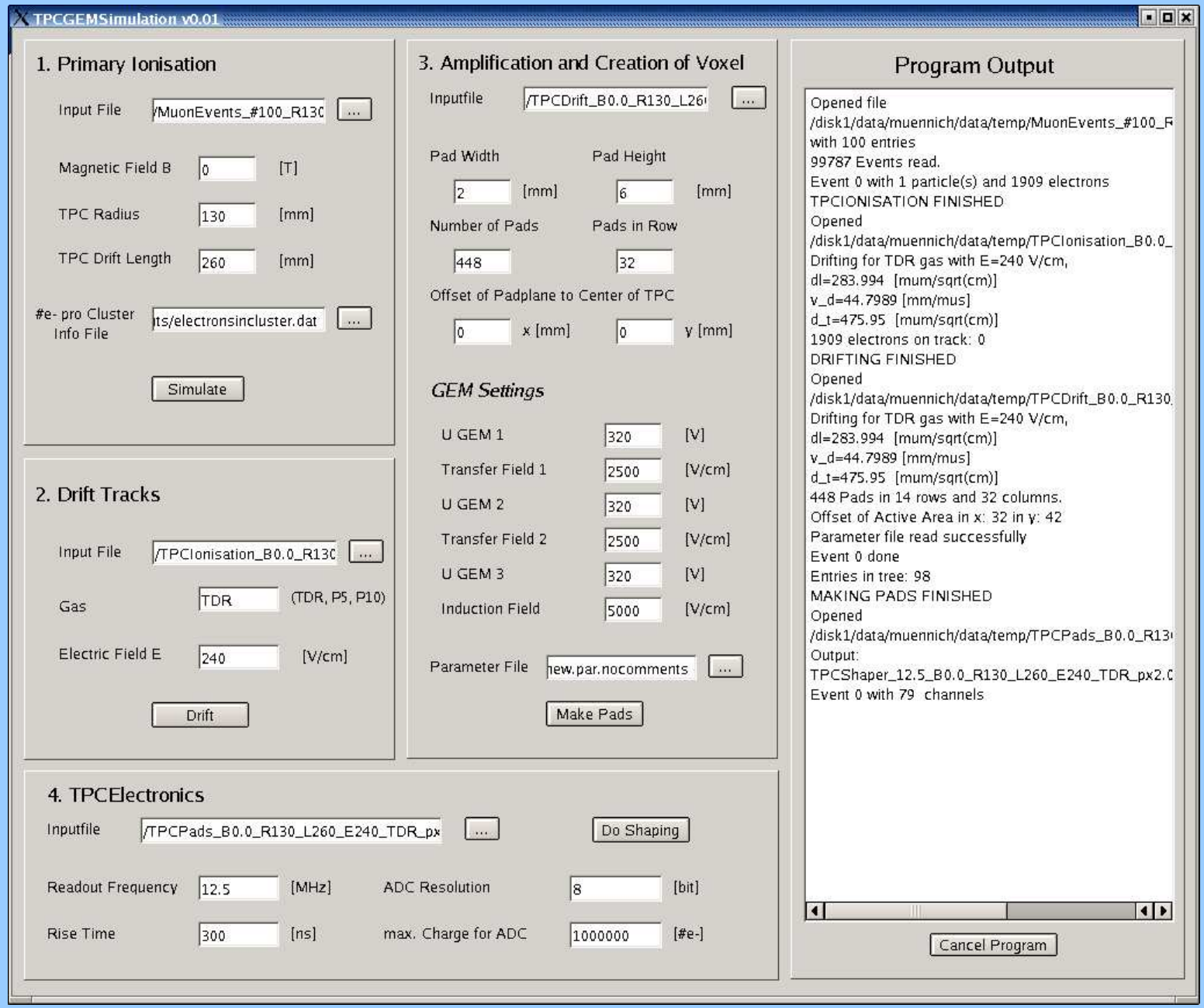
Electronics: Shaping and ADC

- Determine center of gravity of charge in time
- Apply shaping function (Gaussian at the moment)
- Fill electrons into time bins
- Normalise charge with ADC range
- Integrate charge for every ADC bin





Inputs for Simulation

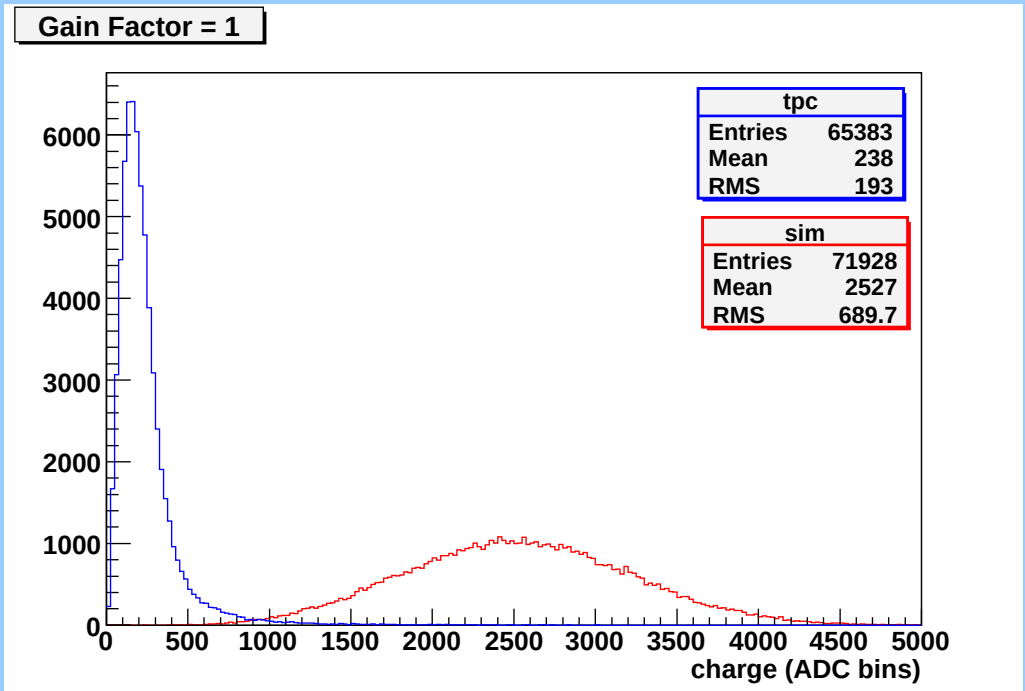


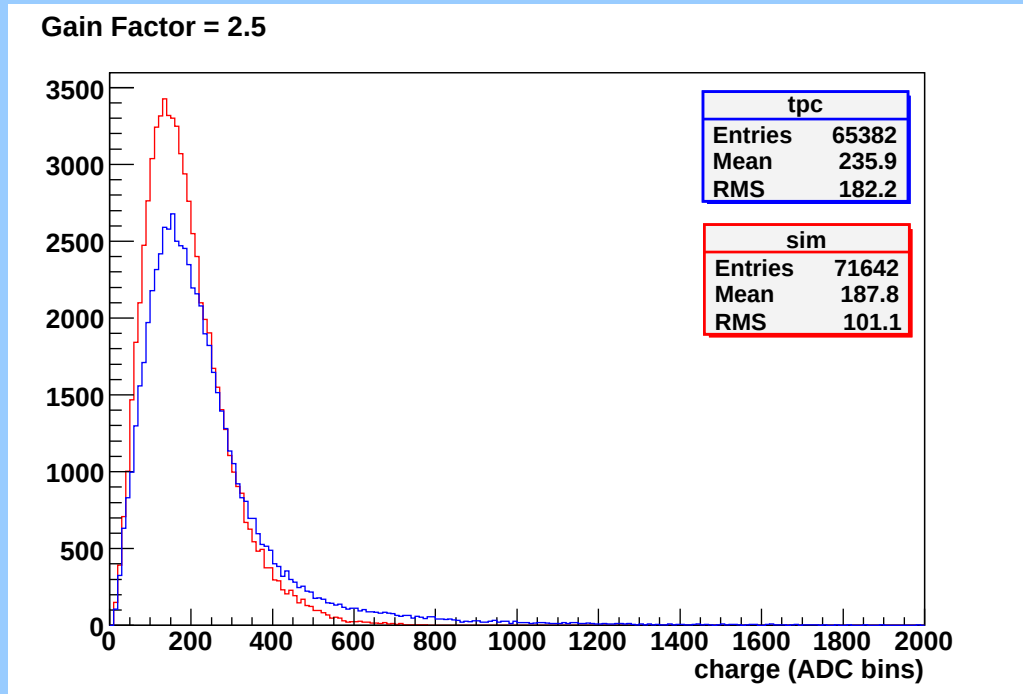
Gain Factor

Mean gain for one GEM from charge transfer parametrisation to high.

To match charge spectrum from measurement:

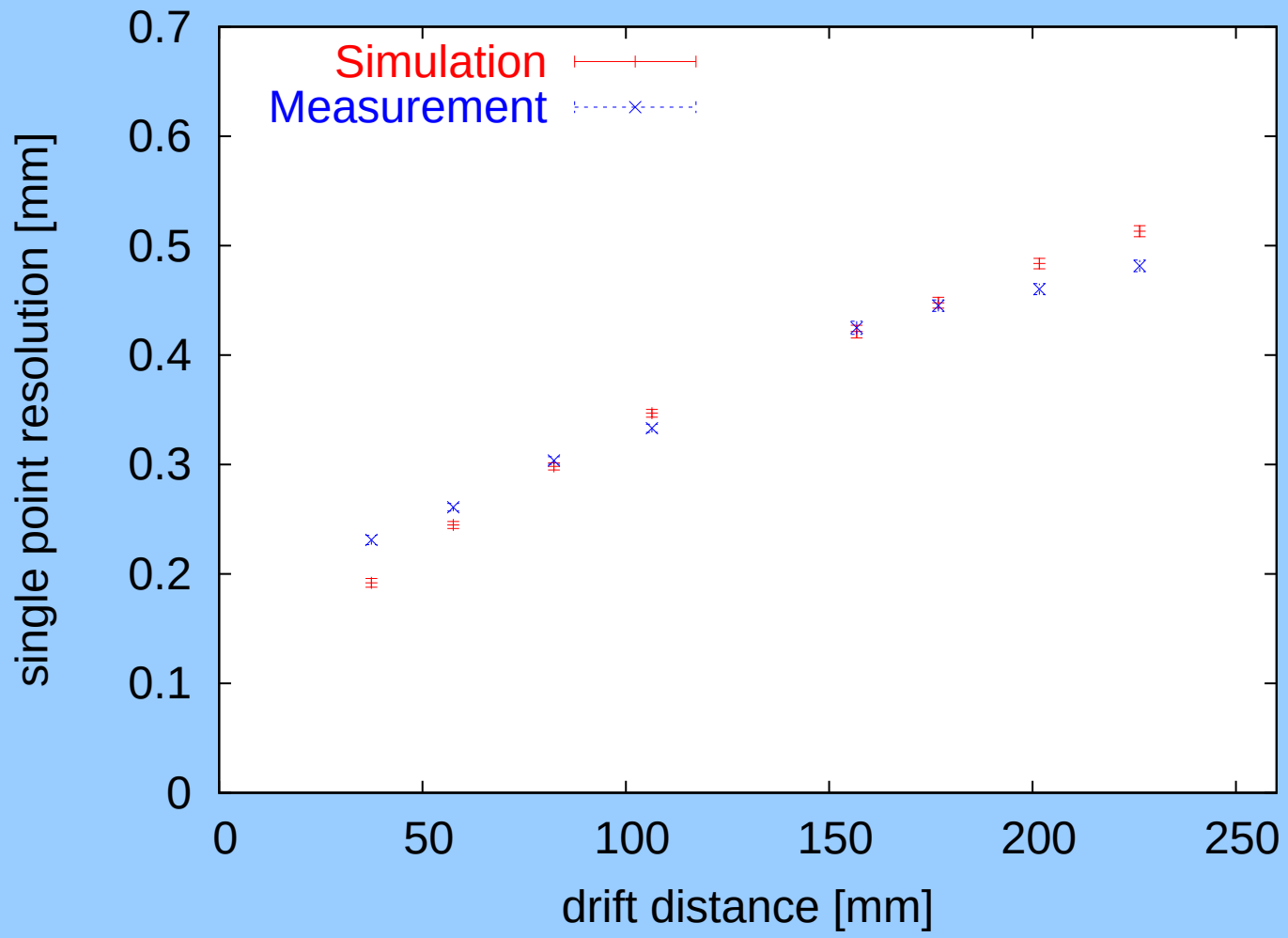
Decrease it by factor to account for temperature difference.





First Comparision to Measurement

1.27×6.985 mm^2 Pads, TDR Gas, 0T, DESY Testbeam



Conclusion

Advantages:

- Simulation independent from big simulation packages
- Amplification with GEMs (accounts for different settings)
- Magnetic fields and 3D tracks possible
- Many input parameters for systematic studies

Limitation:

- No spatial propagation of δ-electrons during primary ionisation

Outlook:

- Verification of simulation with testbeam data
- Systematic studies for ILC TPC