Simulation Studies of a GEM-based TPC at the ILC

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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

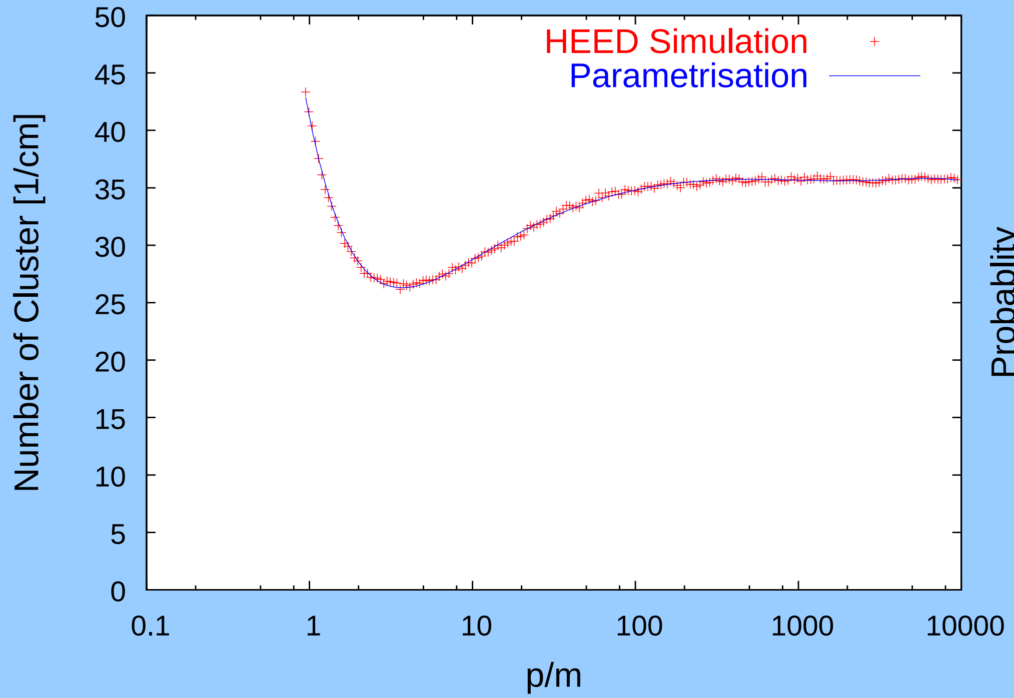
- Electric and magnetic fields
- GEM settings
- Pad response, pad geometry
- Ion backdrift

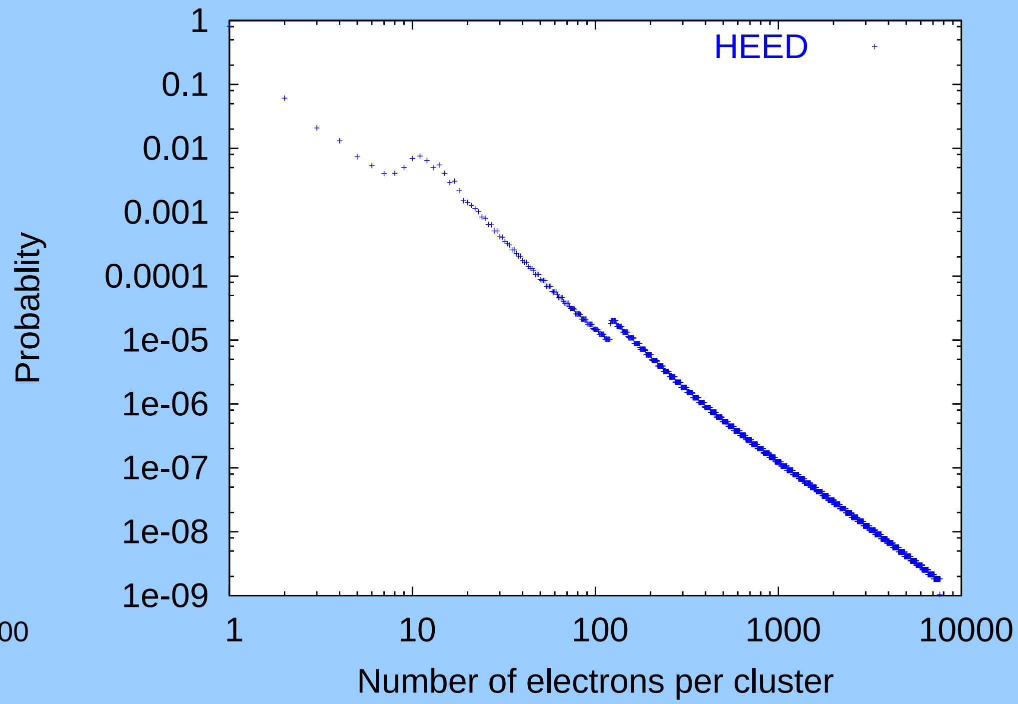
Creating Primary Ionisation

HEED: Simulation tool for primary ionisation:

$\rightarrow$ Parametrisation of:

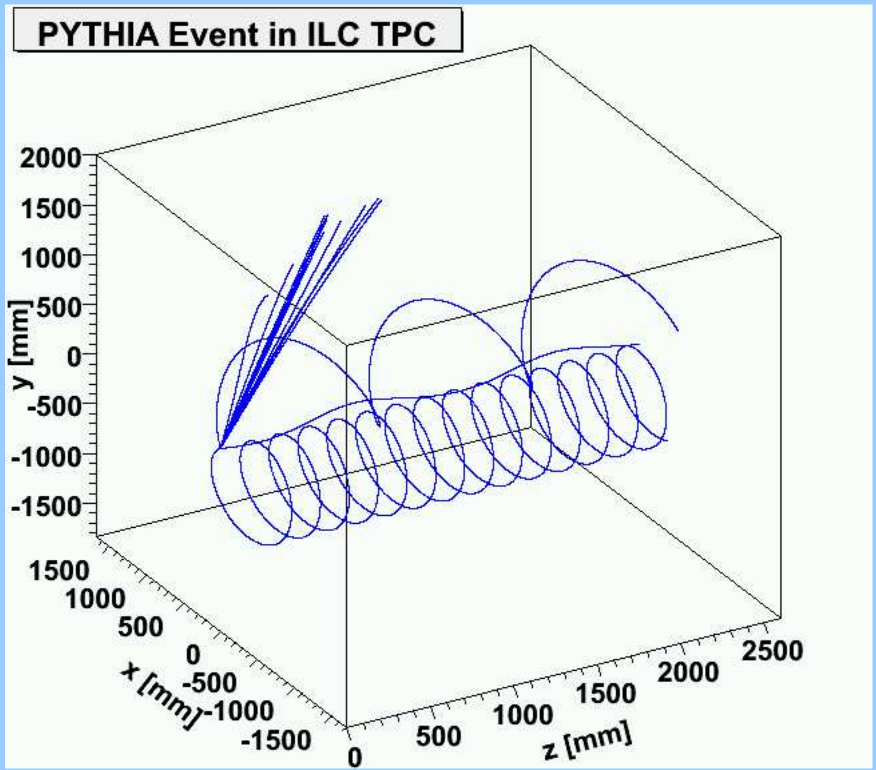
- Number of cluster per cm
- Number of electrons per cluster
- Range and energie of δ-electrons

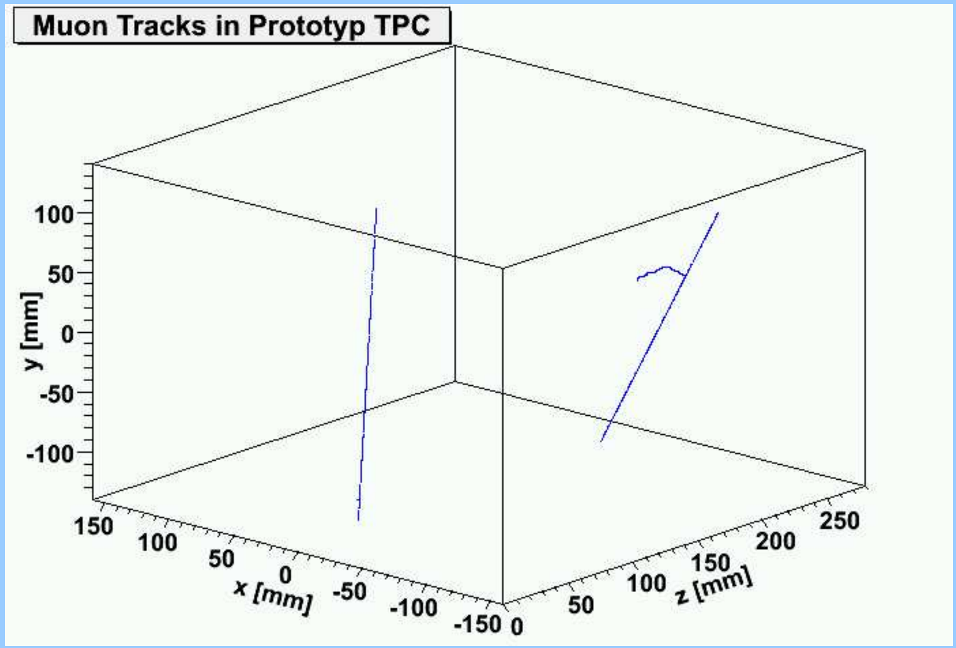




Creating a Track

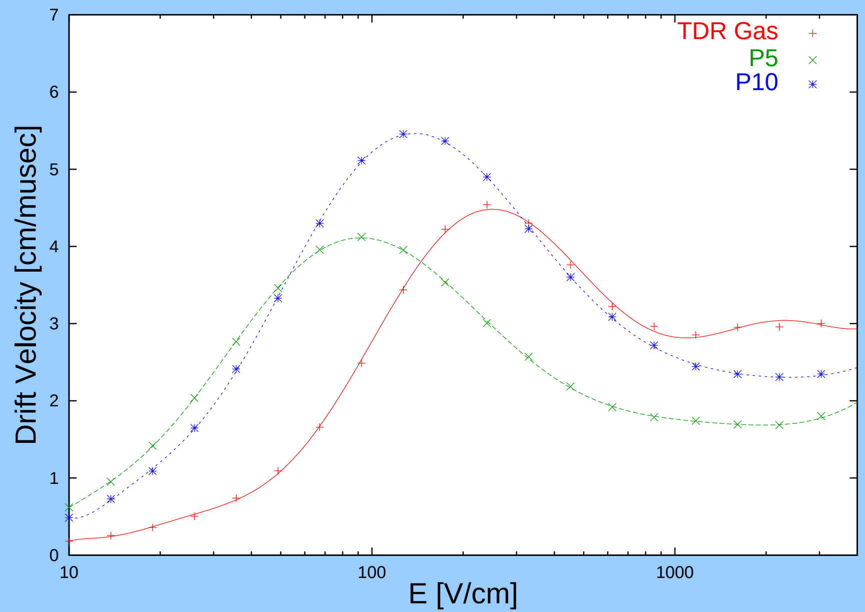
- Randomly choose distance to next cluster (exponential)
- Choose # of e^- in this cluster
- Position e^- on track (B=0: straight line, B$\neq$0: helix)
- δ-electrons with angle to track + multiple scattering



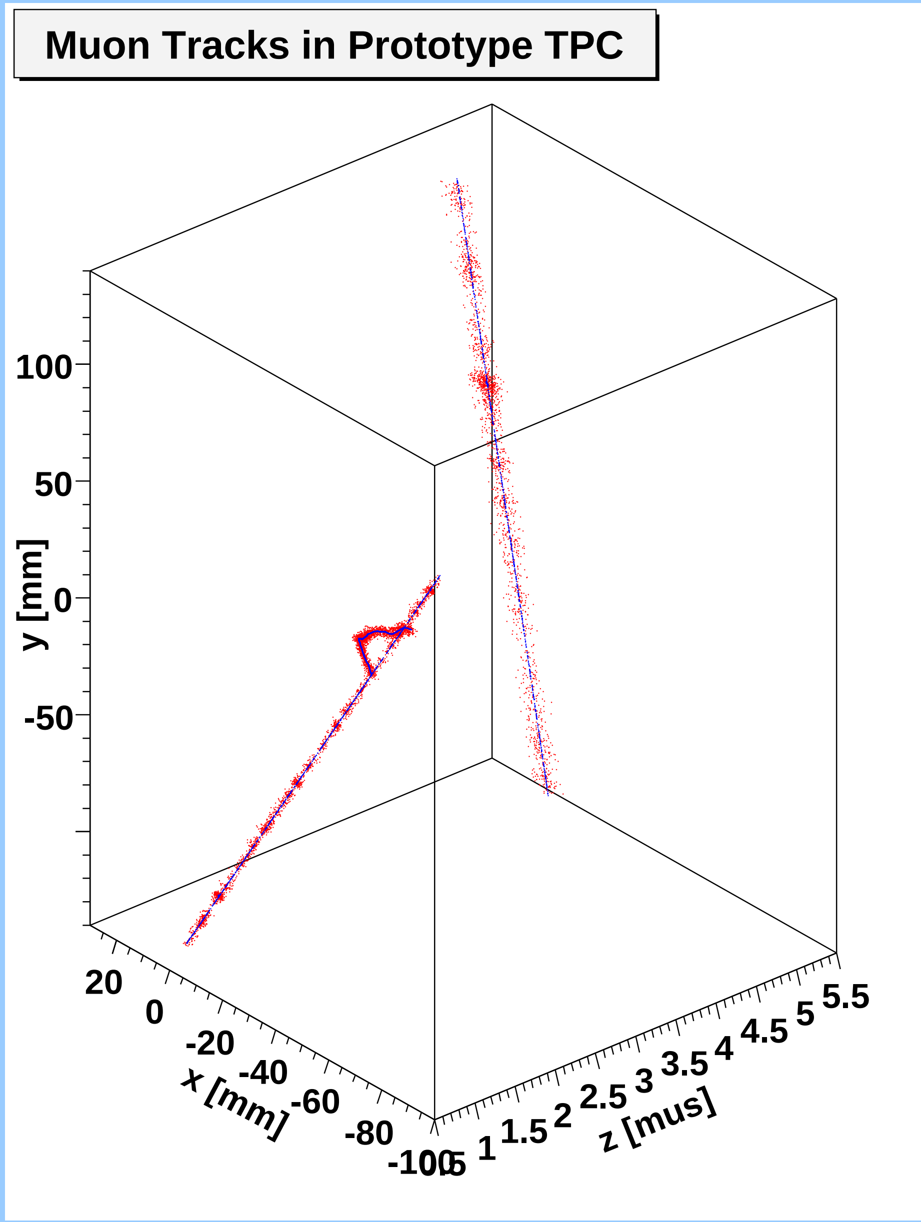


Drifting of Electrons

Parametrise gas properties simulated with MAGBOLTZ



Dice coordinates after drifting according to longitudinal and transverse diffusion

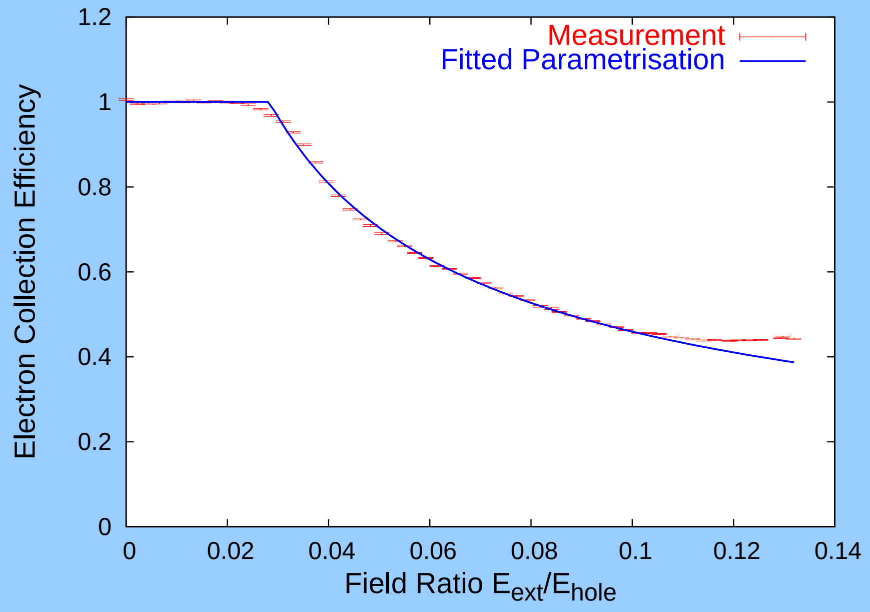


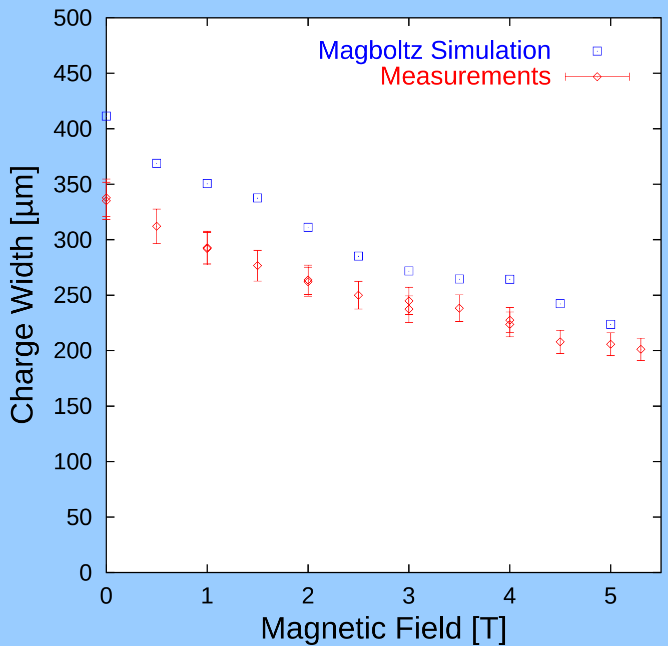
Amplification with GEMs (1)

From measurements:

1. Parametrisation of charge transfer in triple GEM structure: collection, gain, extraction

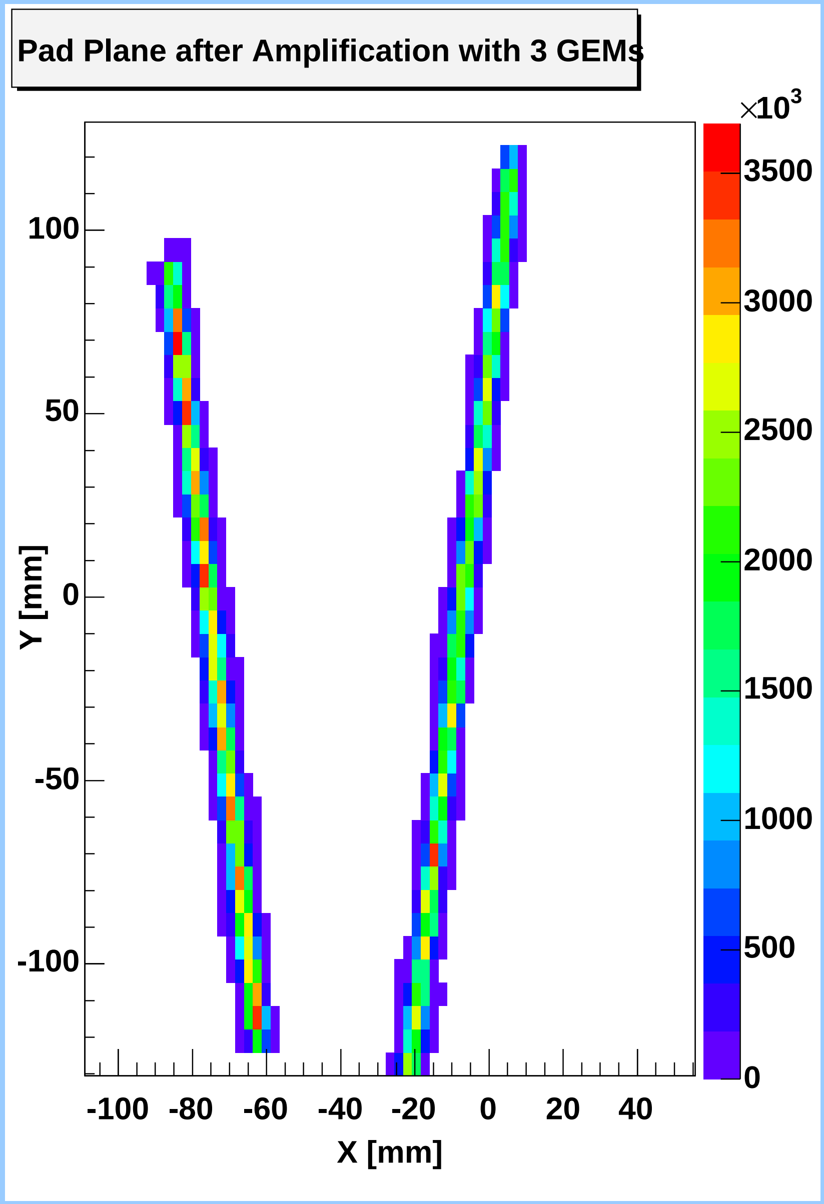
2. Charge broadening only due to diffusion between GEMs
   $\rightarrow$ Simulate diffusion with Magboltz





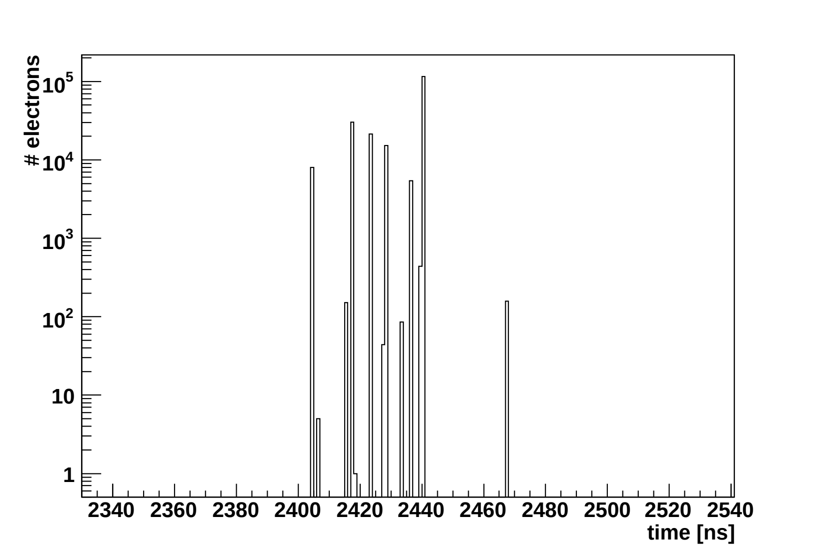
Amplification with GEMs (2)

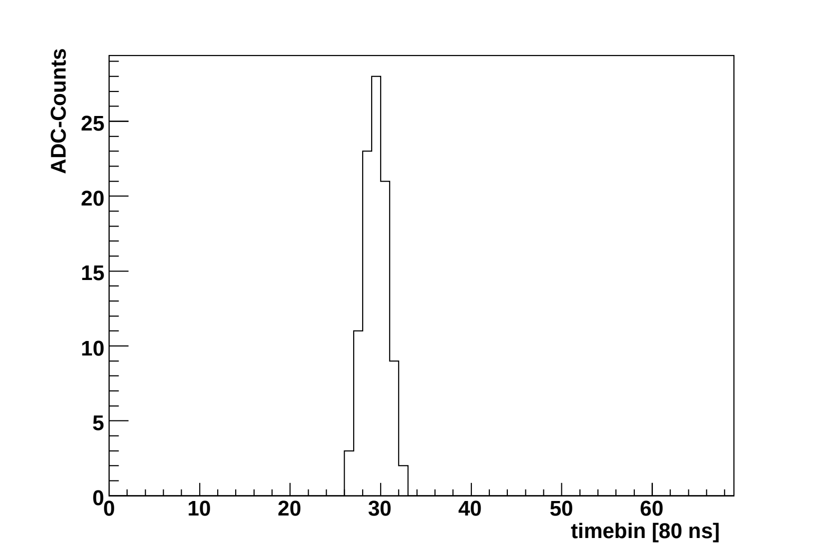
- Calculate number of secondary e^- from charge transfer combined with binomial statistics
- Integrate over 2D gaussian with sigma of charge cloud to get charge on pads
  $\rightarrow$ Voxel information:
  charge on channel c
  at time t



Elektronik: Shaping und ADC

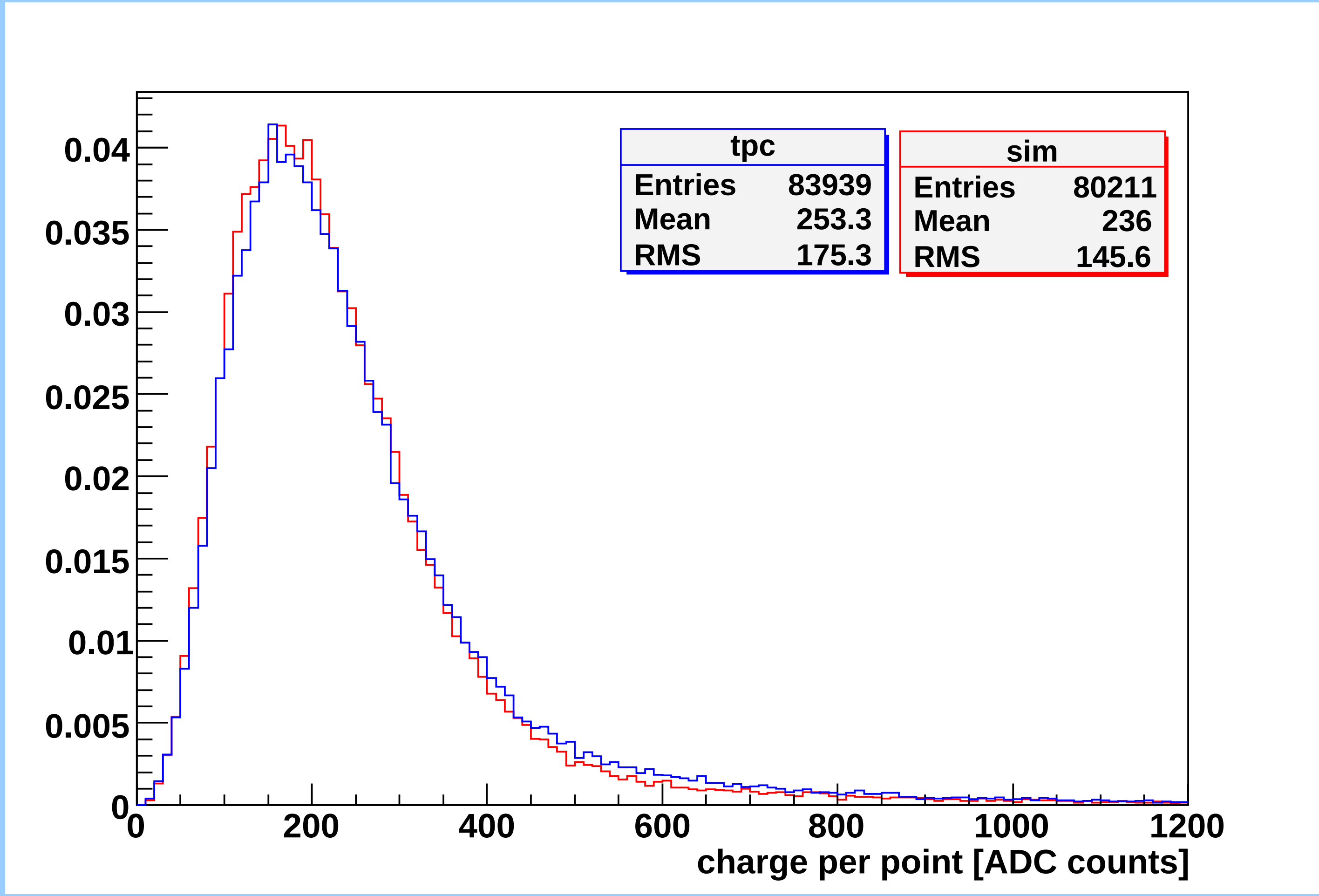
- Determine center of gravity of charge in time
- Apply shaping function (Gaussian at the moment)
- Fill electrons into time bins by integrating over every ADC bin
- Normalise charge with ADC range





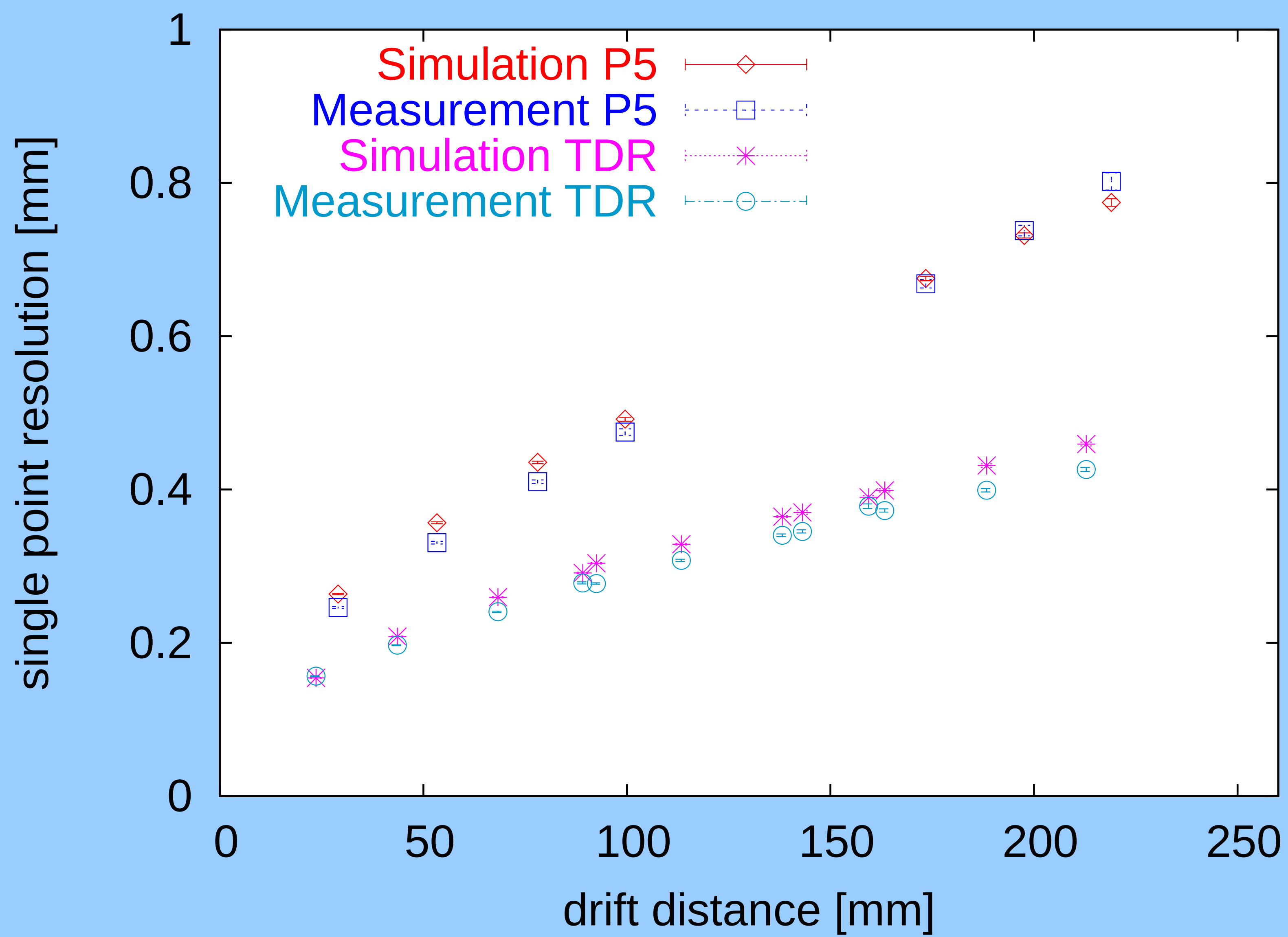
Charge Spectrum

$1.27 \times 6.985\ mm^2$ Pads, TDR Gas, 0T, DESY Testbeam



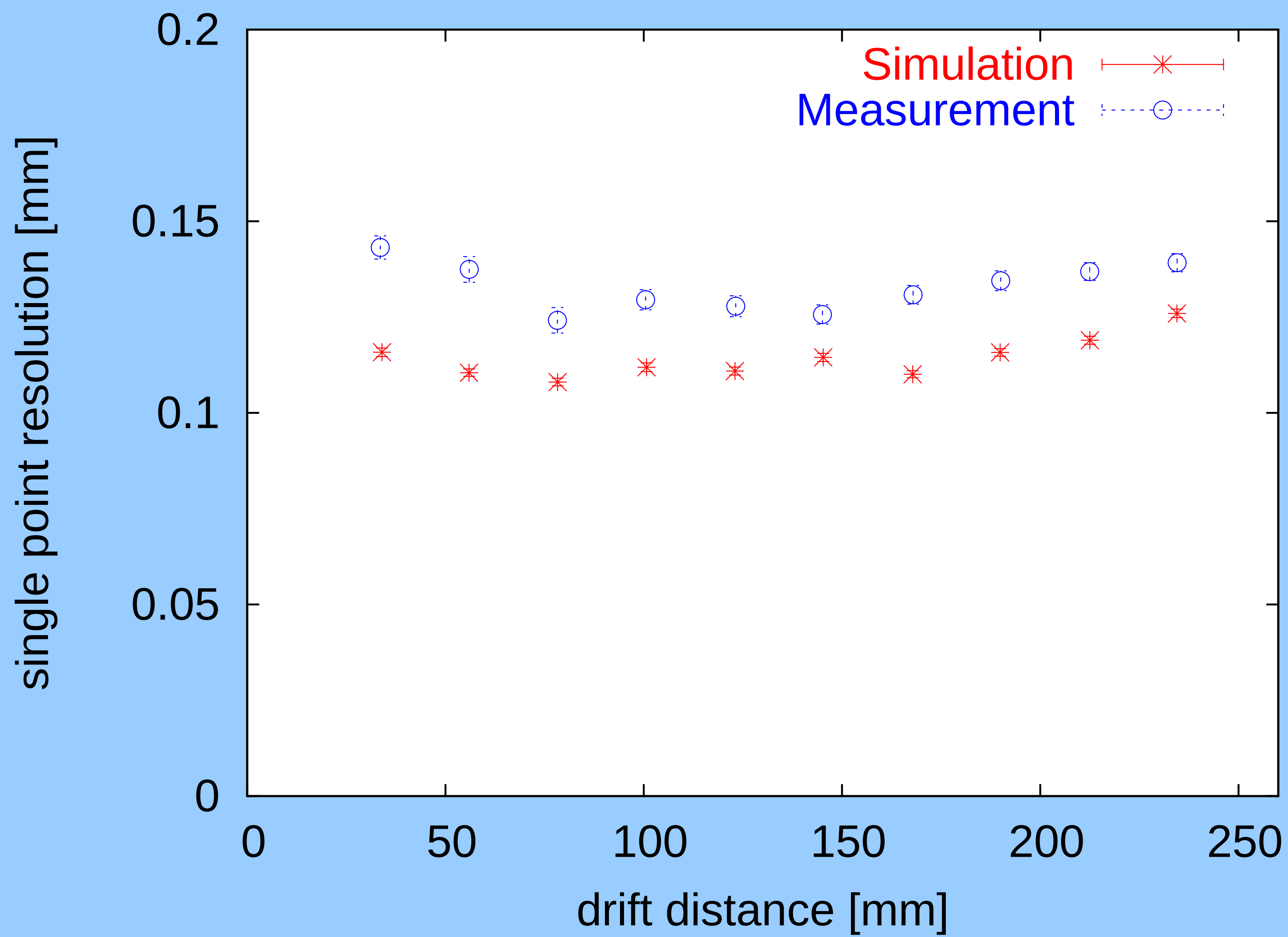
Resolution in x at 0T

1.27 $\times$ 6.985 mm^2 Pads, TDR + P5 Gas, 0T, DESY Testbeam



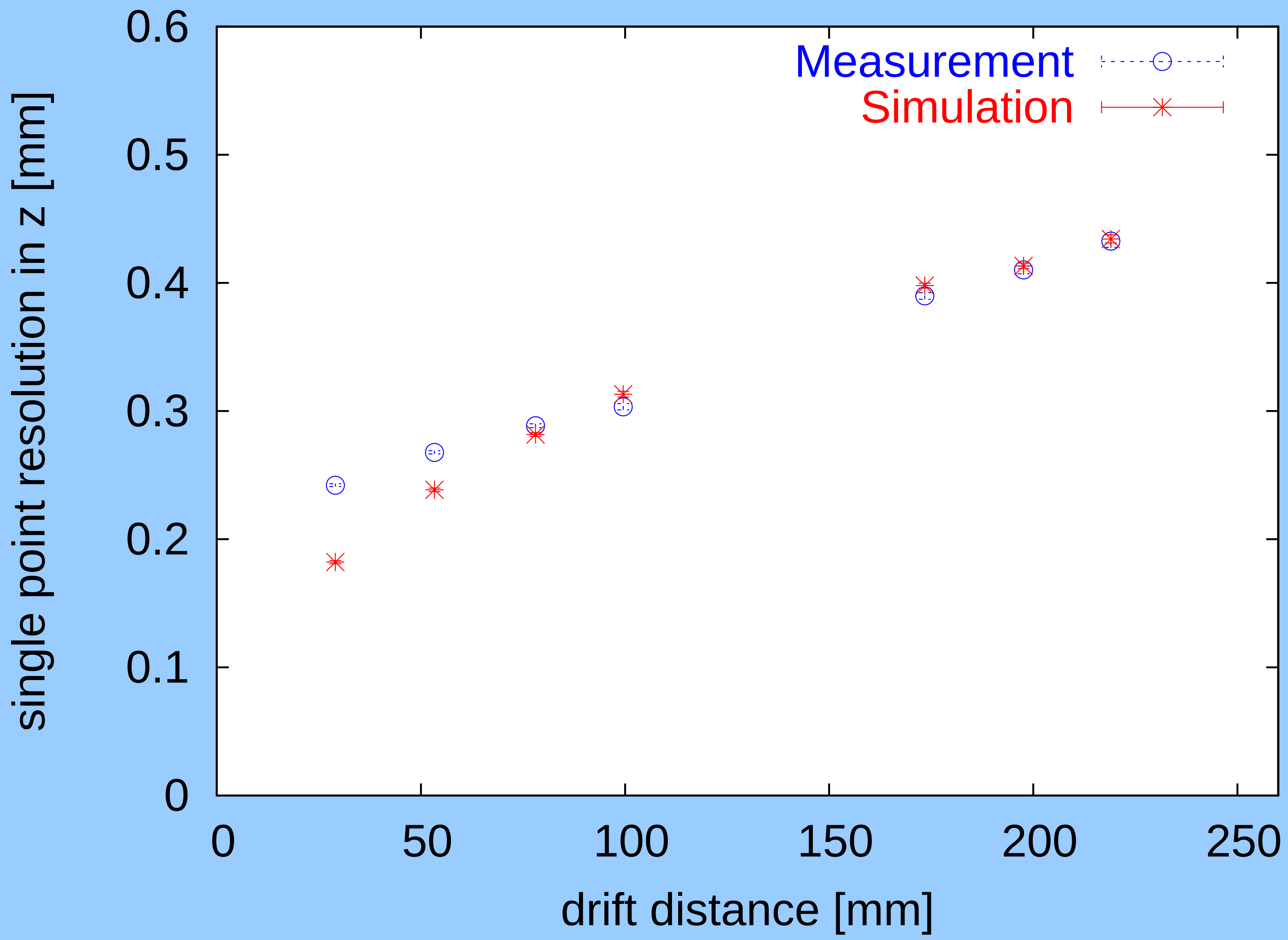
Resolution in x at 4T

1.27 × 6.985 mm^2 Pads, TDR Gas, 4T, DESY Magnet



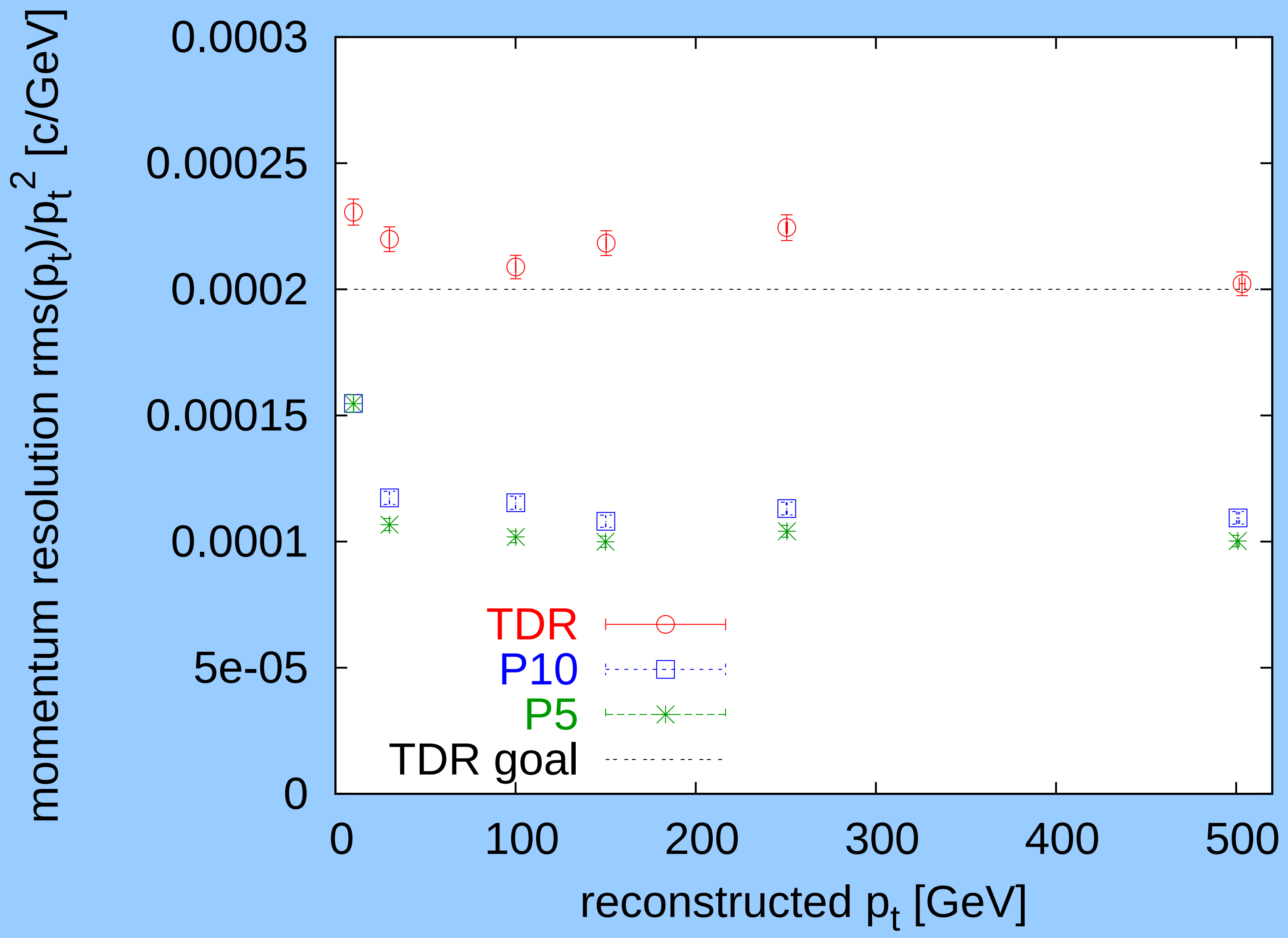
Resolution in z

8 bit ADC, 12.5 MHz, P5 Gas, 0T, DESY Testbeam



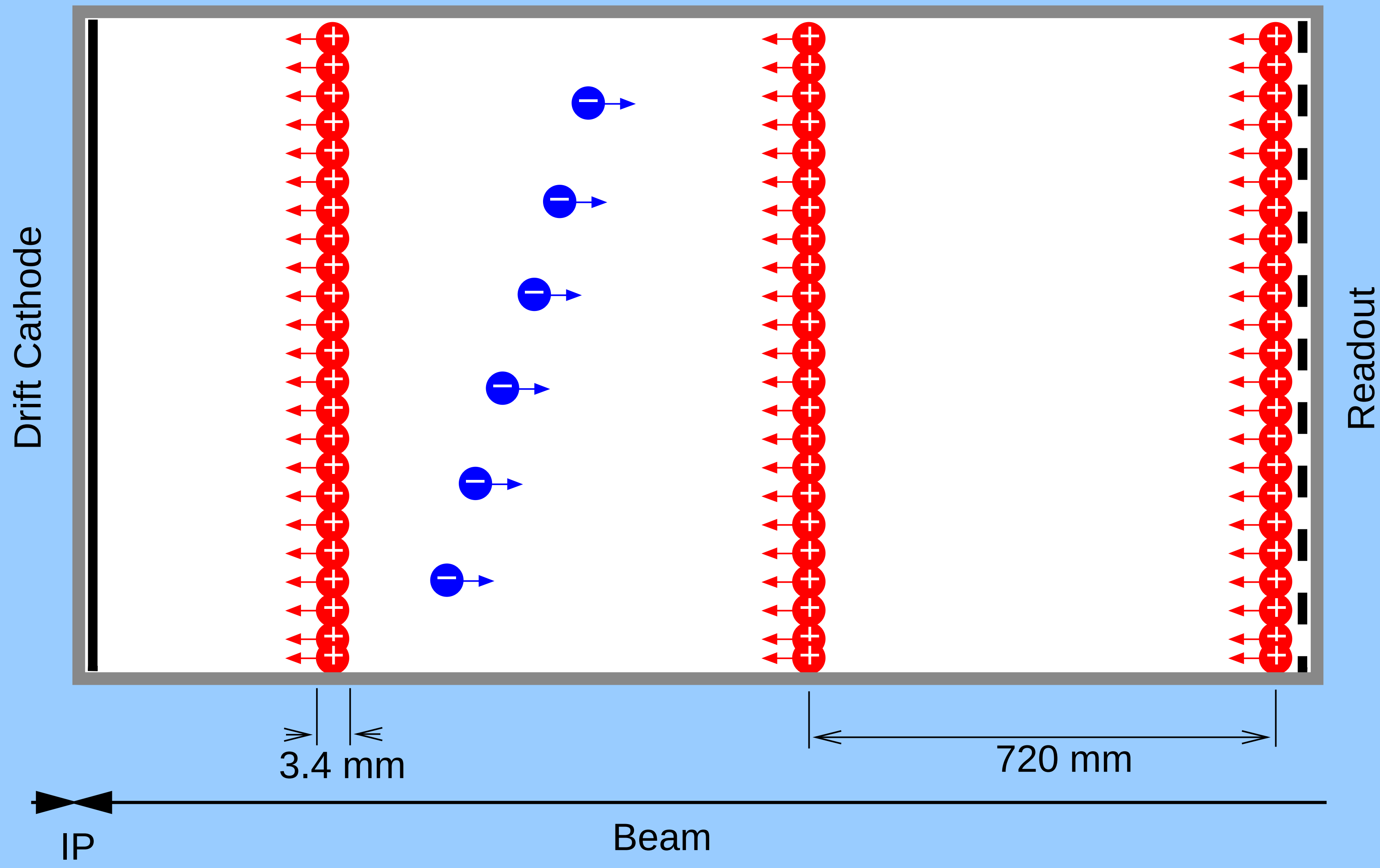
Momentum Resolution ILC TPC

1.0×7.0 mm^2 Pads, 4T, R_{TPC} = 1680 mm, L_{TPC} = 2500 mm



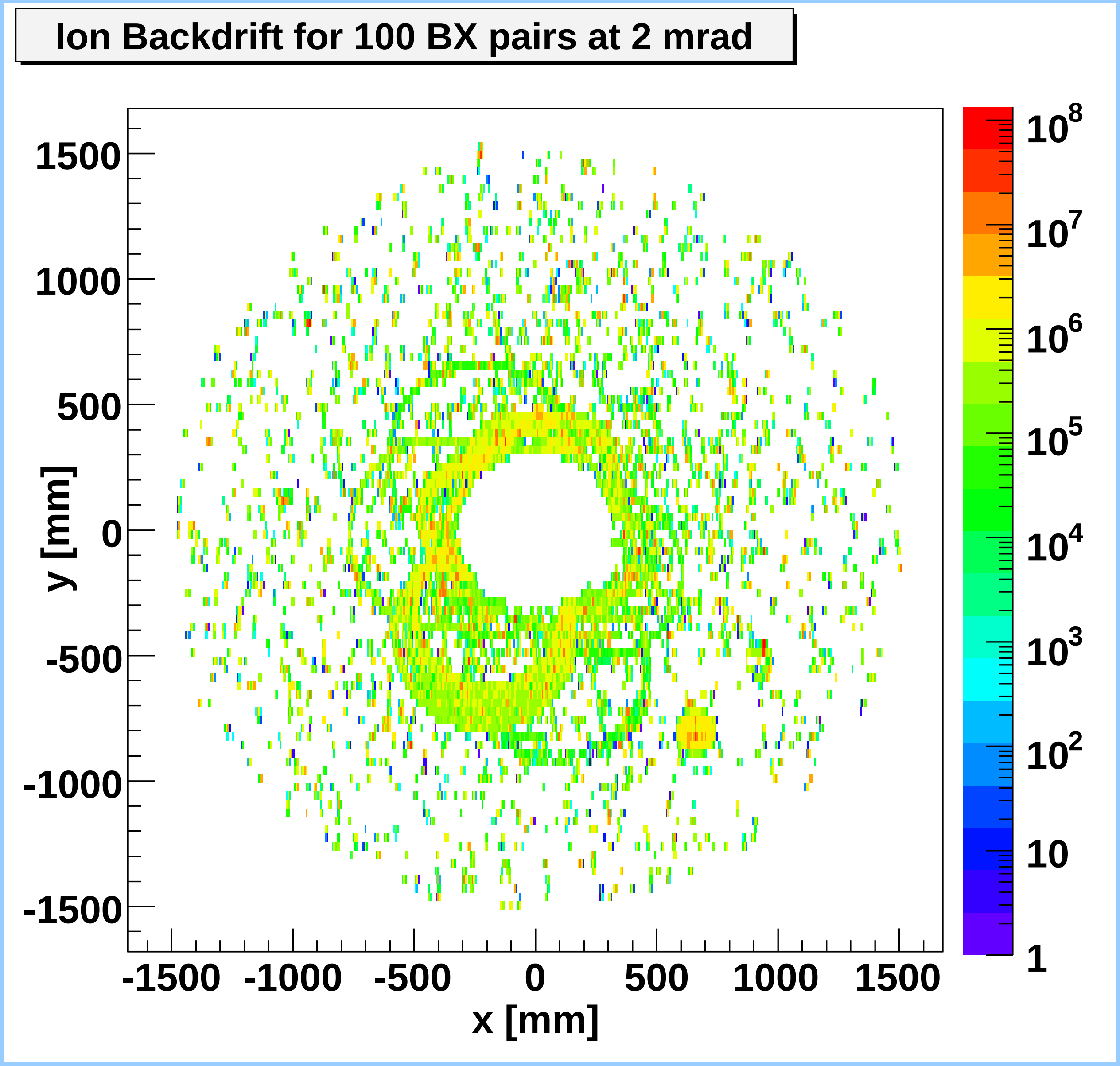
Ion backdrift in ILC TPC (1)

One ion slice per bunch train mainly due to background



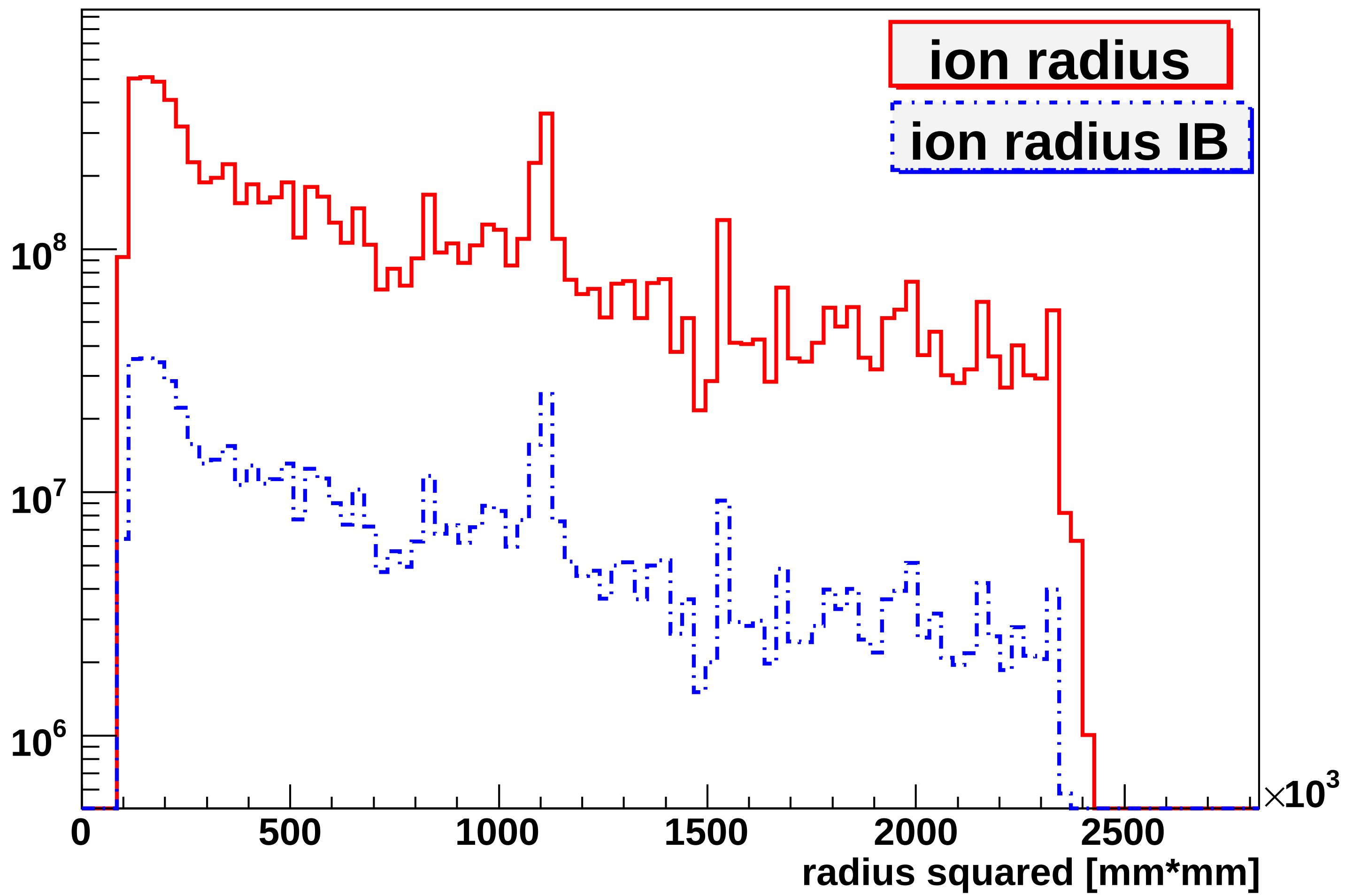
Ion backdrift in ILC TPC (2)

Back drifting ions from pad plane



Ion backdrift in ILC TPC (3)

Radial distribution of charge from 100 BX pair background



Conclusion

Advantages:

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

Outlook:

- Systematic studies for ILC TPC
- Find parametrisation of detailed studies to use in full detector simulation in MOKKA