TPC Simulation

Astrid Münnich

Manuel Giffels Gordon Kaußen Martin Killenberg Sven Lotze

Joachim Mnich Stefan Roth Michael Weber

III. Physikalisches Institut B

RWTH AACHEN

International Linear Collider Workshop

Stanford, California, USA

March 18 - 22, 2005

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

bmb+f Großgeräte der physikalischen Grundlagenforschung

Methods and Goals

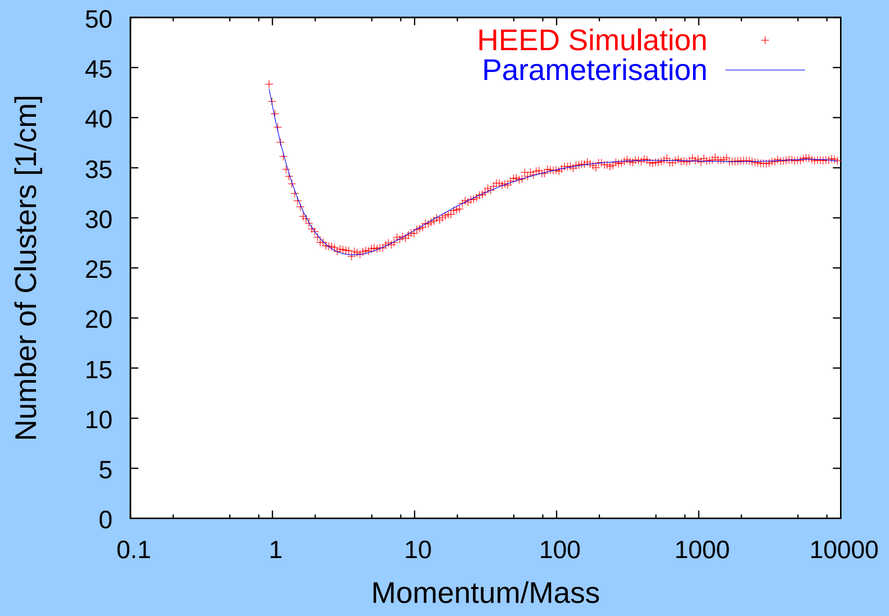
Studies of:

- Influence of electric and magnetic fields
- Ion backdrift
- Pad response, pad geometry

Simulation in three steps:

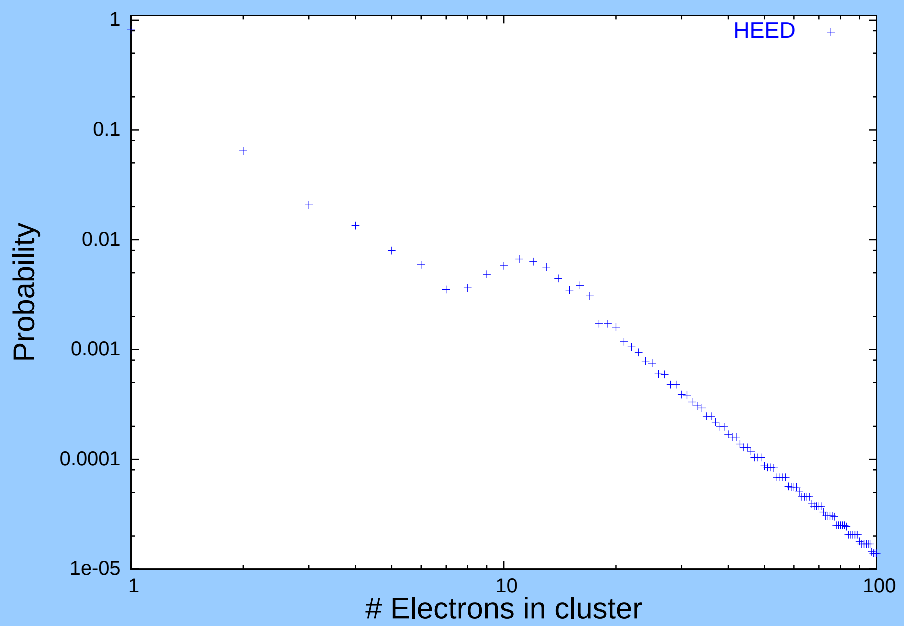
1. Primary ionisation
2. Drifting of electrons
3. Amplification with GEMs

Creating Primary Ionisation



Mean number of clusters

→ Distance between clusters from exponential distribution with this mean value

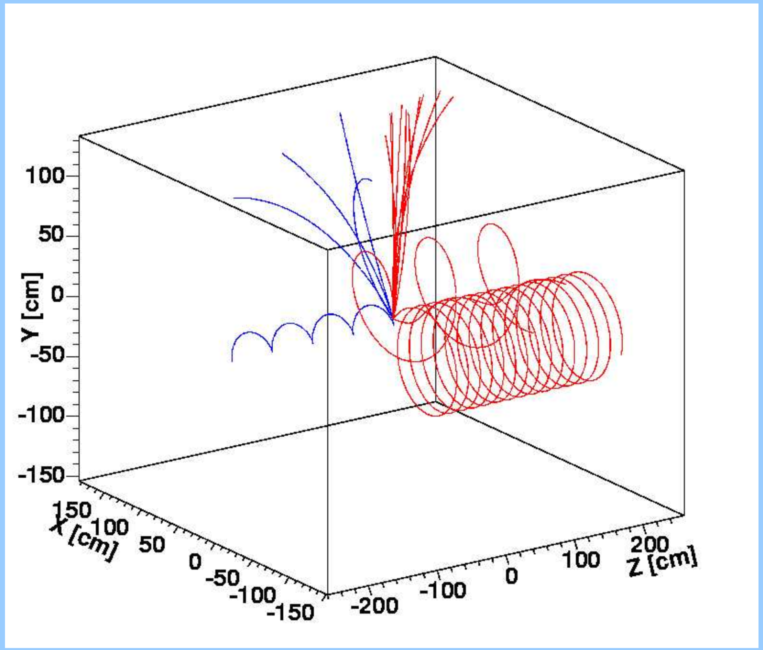


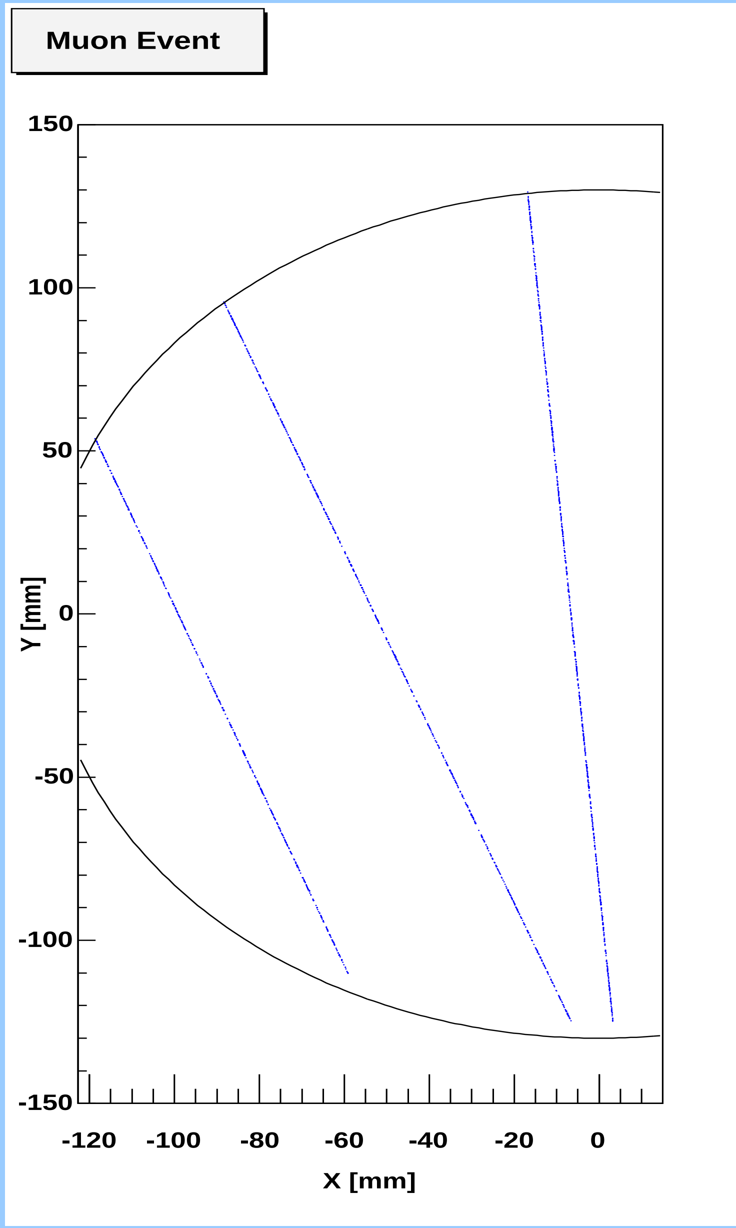
Probability for number of electrons per cluster

→ Choose randomly according to distribution

Creating a Track

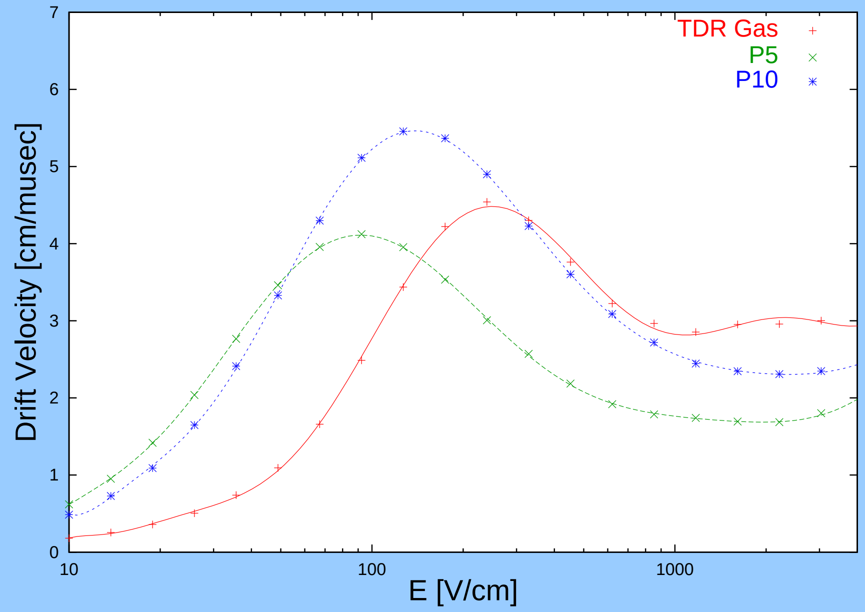
- Randomly choose distance to next cluster
- Choose # of e^- in this cluster
- 3D information possible
- B fields possible



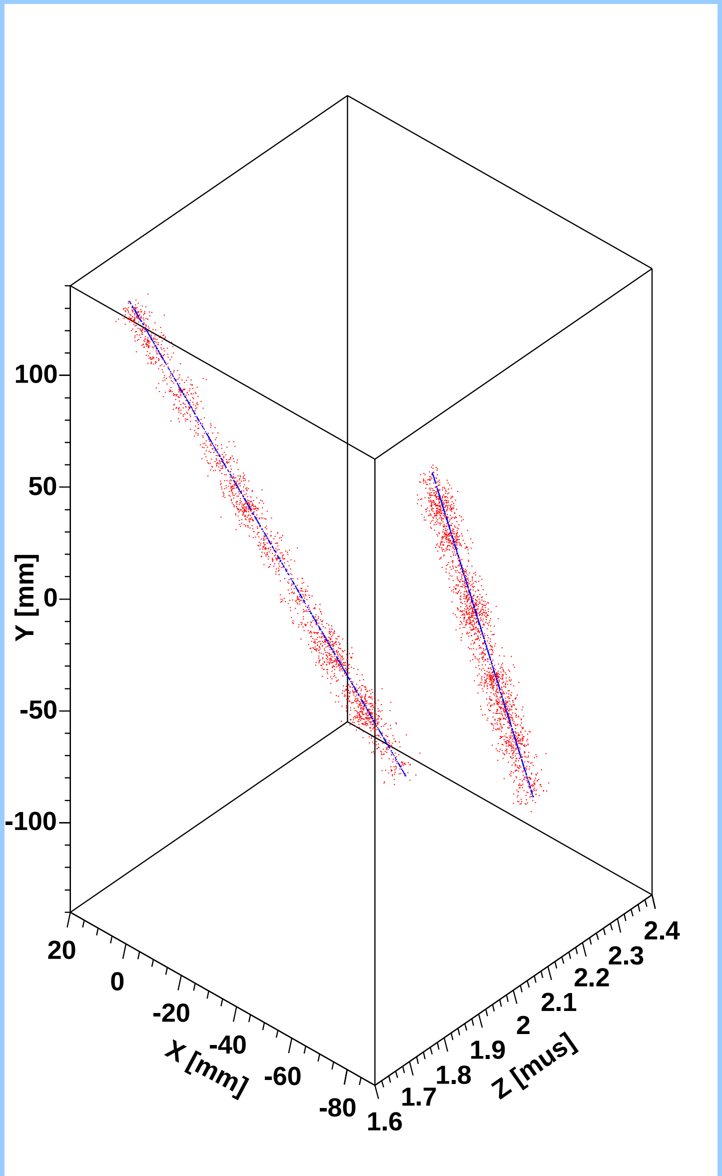


Drifting Electrons

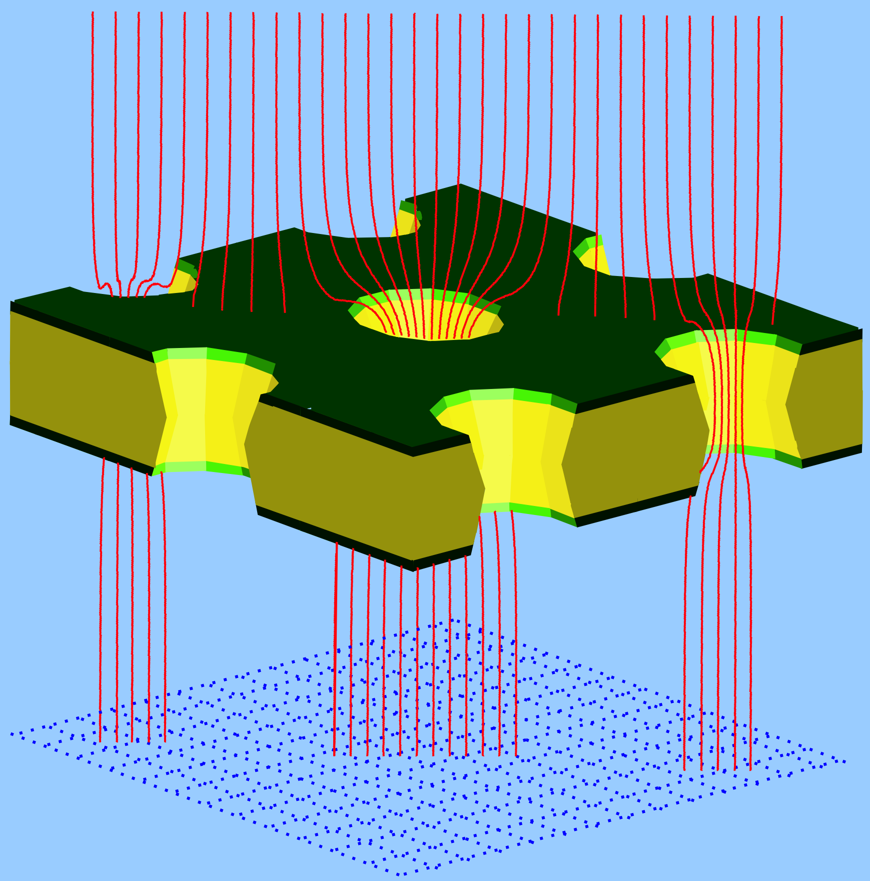
Parametrise gas properties simulated with MAGBOLTZ



Dice coordinates after drifting according to longitudinal and transverse diffusion



GEM: Gas Electron Multiplier

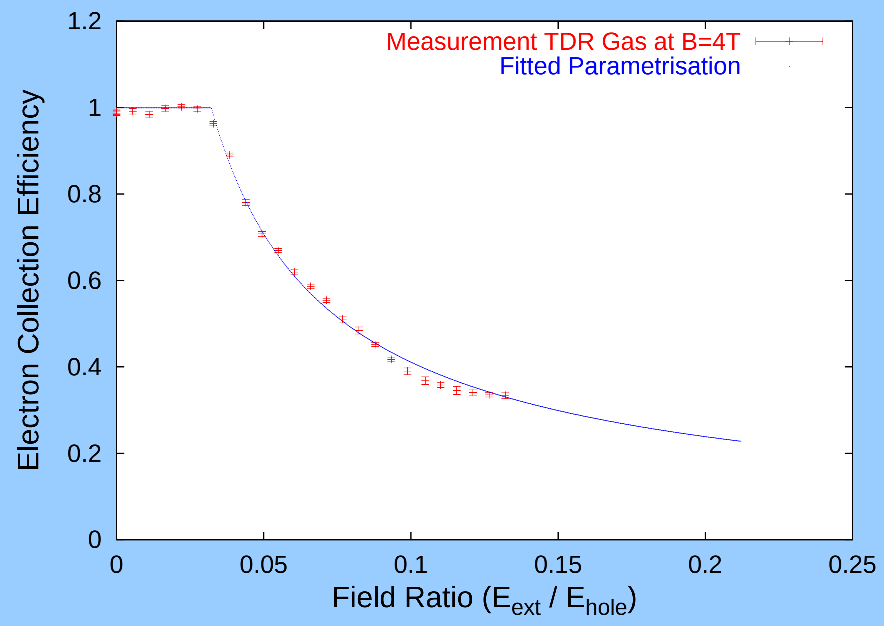


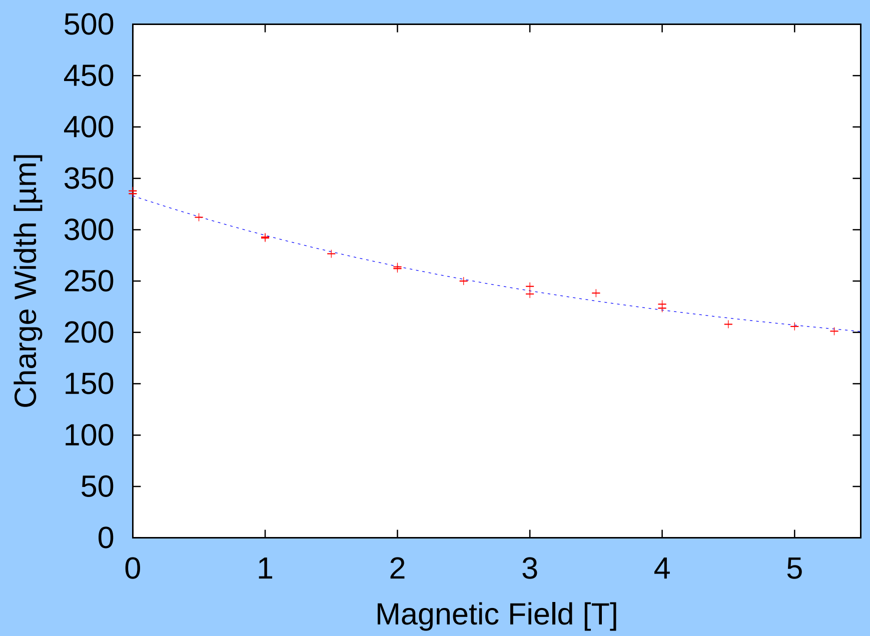
- Thickness: 5 μm copper on 50 μm Kapton foil
- Hole distance (pitch): 140 μm
- Hole diameter: 70 μm in Cu, 50 μm in Kapton
- Voltage for amplification: 250 – 450 V
- Field in hole: $\approx$ 60 kV/cm at 400 V

Amplification with GEMs (1)

From measurements:

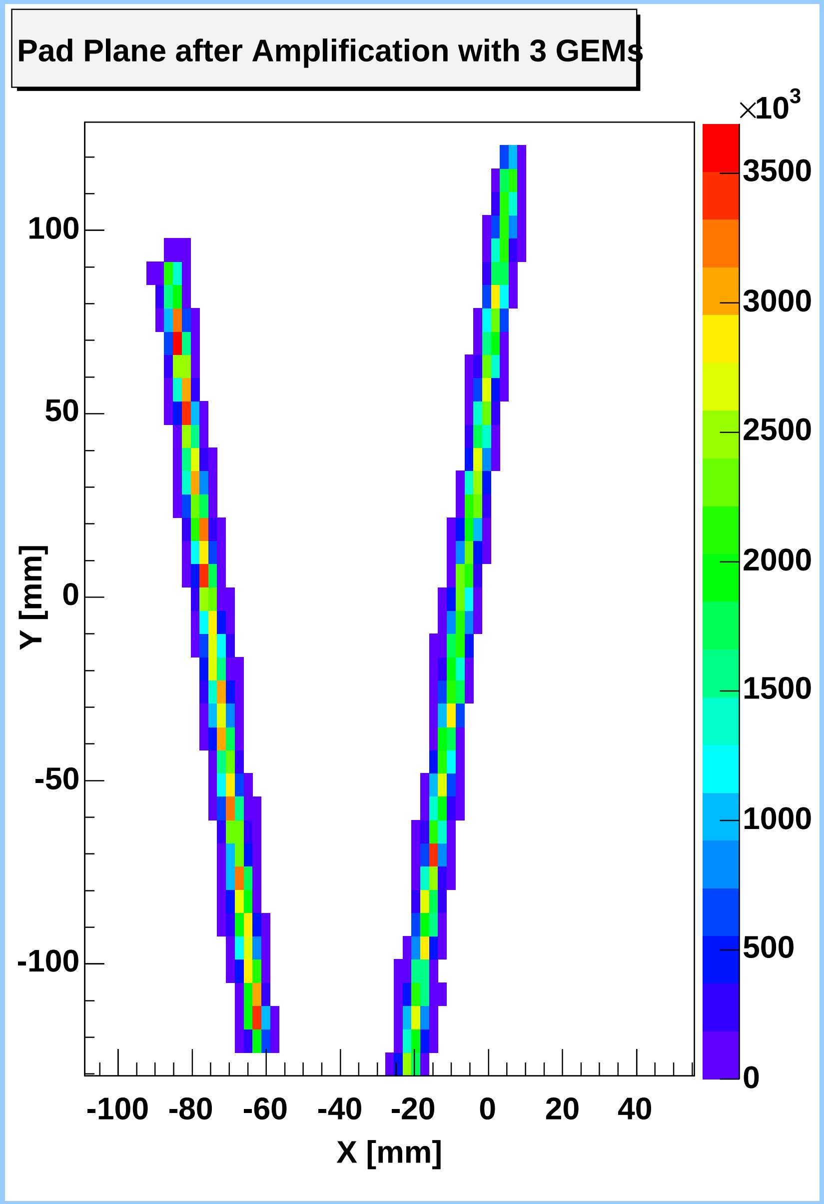
1. Parametrisation of charge transfer in triple GEM structure: collection, extraction, gain
2. Charge broadening only due to diffusion between GEMs
   $\rightarrow$ Simulate diffusion with Magboltz



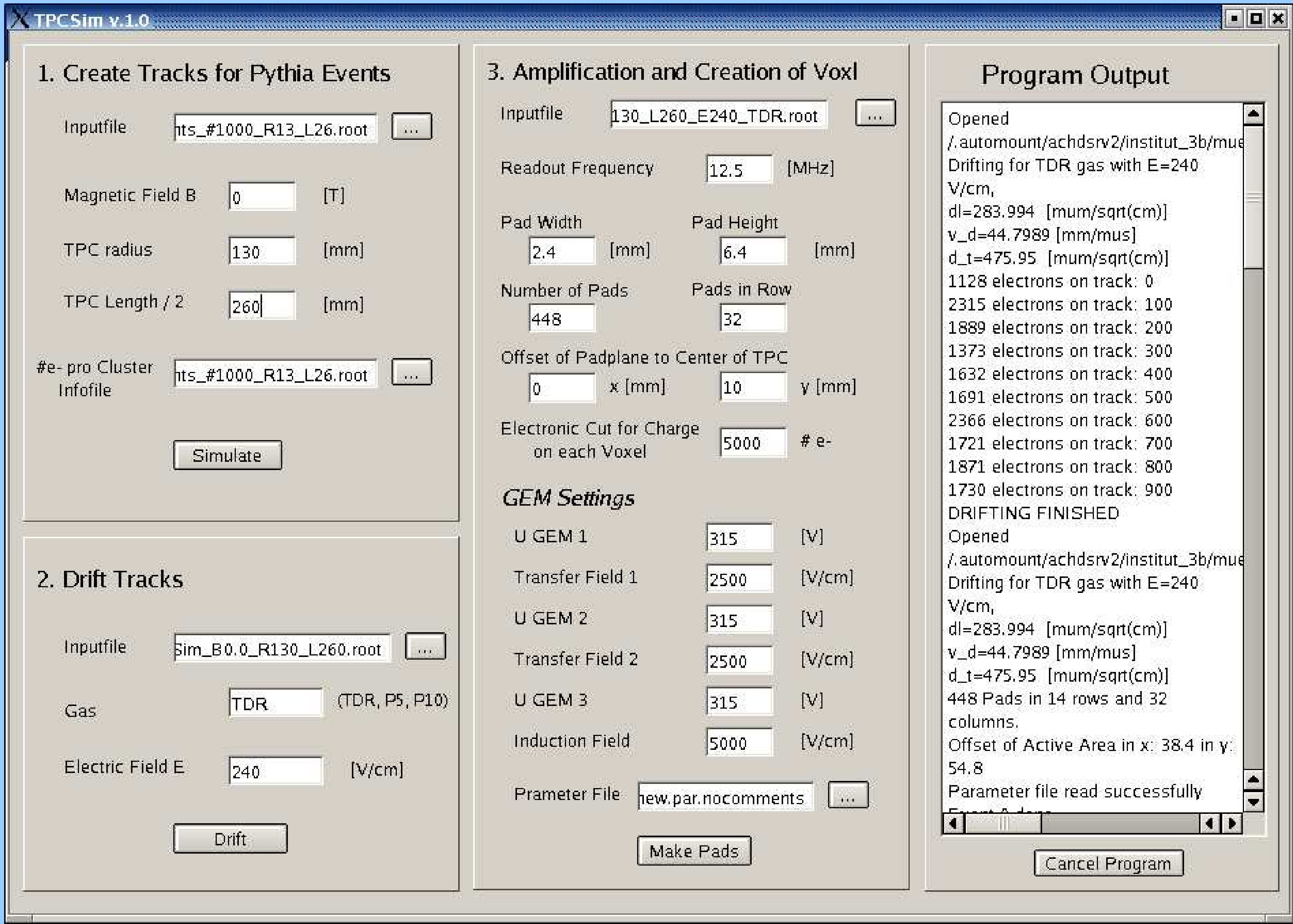


Amplification with GEMs (2)

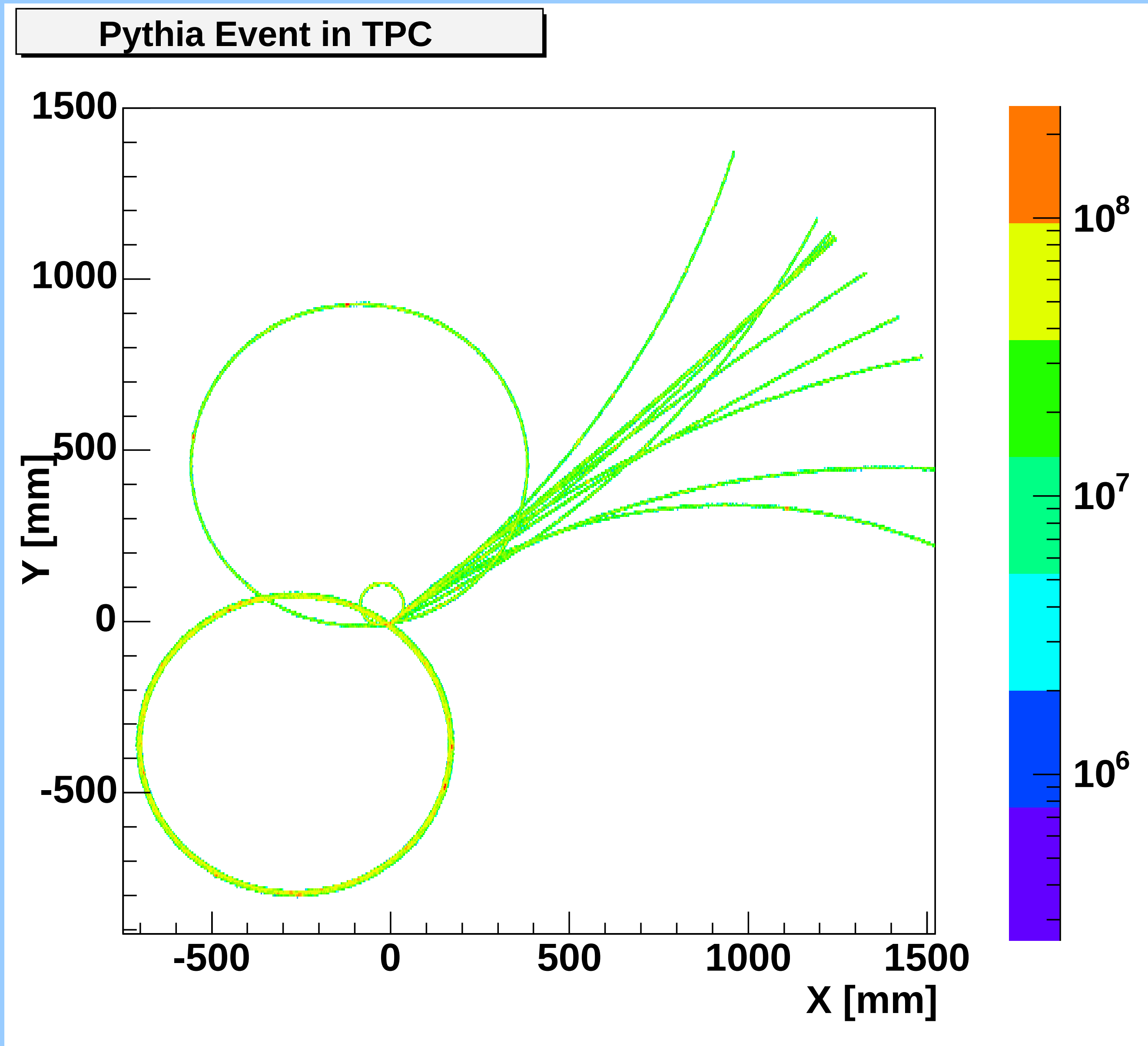
- Calculate number of secondary e^- from charge transfer combined with binomial statistic
- Integrate over 2D gaussian with sigma of charge cloud to get charge on pads
  $\rightarrow$ Voxel information: charge on channel c in timeslice t



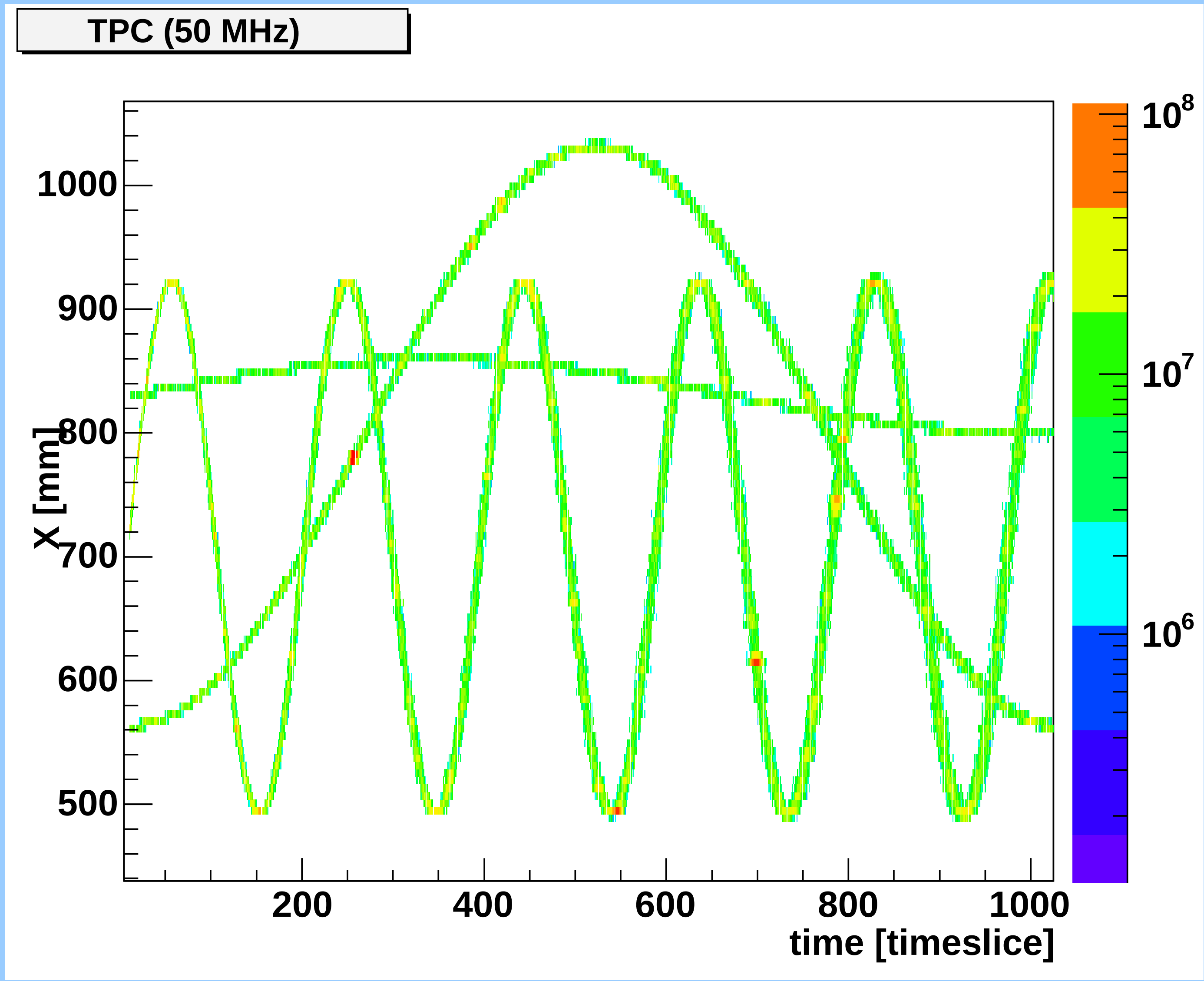
Inputs for the Simulation



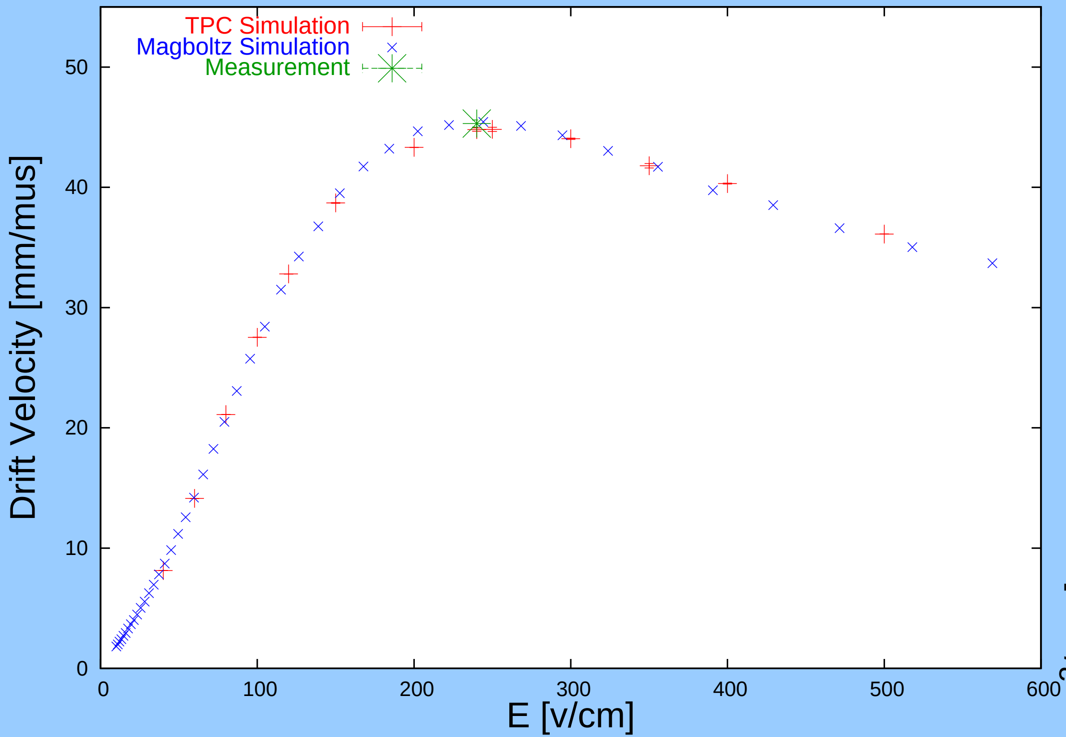
Results for a TPC (1)



Results for a TPC (2)



Results for Reproducibility

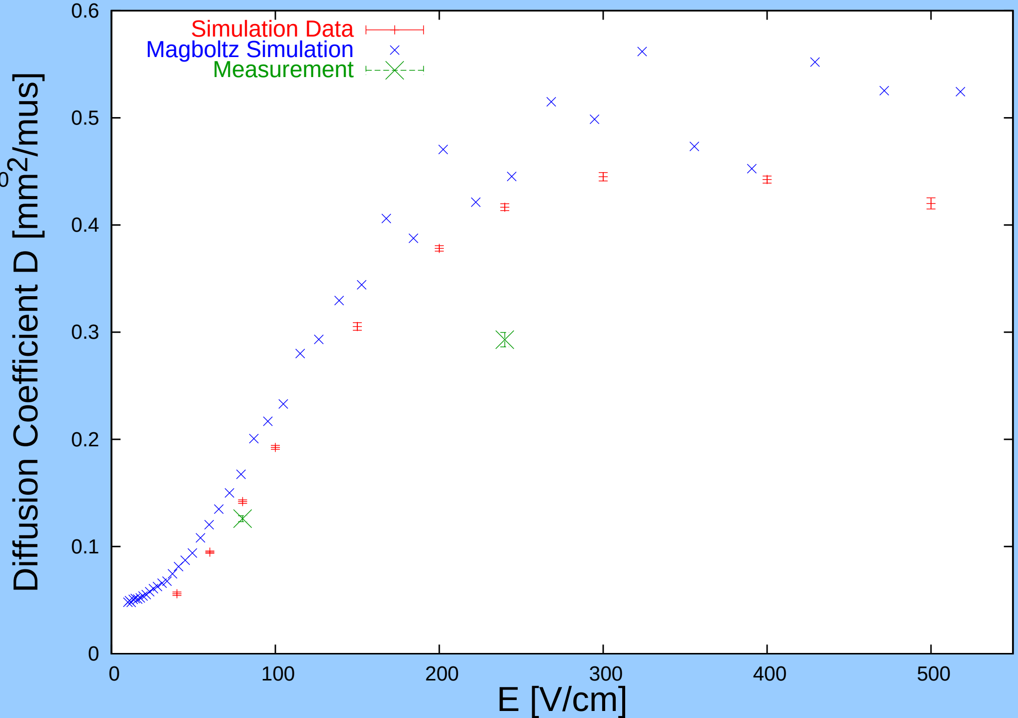


Drift velocity for

TDR Gas ($Ar/CH_4/CO_2$ 93/5/2)

Transverse diffusion

→ Problem with Magboltz or measurement ?



Summary

Advantages:

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

Disadvantages:

- No spatial propagation of δ-electrons

Outlook:

- Understand discrepancy in diffusion results
- Transfer to new data format LCIO / MARLIN
- More systematic studies