R&D for a TPC with GEM Readout

Astrid Münnich

Manuel Giffels Gordon Kaußen Martin Killenberg Sven Lotze

Joachim Mnich Stefan Roth Michael Weber

III. Physikalisches Institut B

RWTH AACHEN

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bmb+f Großgeräte der physikalischen Grundlagenforschung

Overview

- TPC Prototype
  Construction & Measurements
- Hodoscope
  Construction & Measurements
- Electronics
  Test for new readout
- TPC Simulations
  Development of framework

TPC Prototype: Requirements

- 5T magnet at DESY Hamburg: 280 mm bore
- Materials with low density (radiation length)
- GEM readout from test TPC should be used
- 26 kV for drift field available

TPC Prototype: Construction

Ø = 260 mm

pitch = 2.8 mm

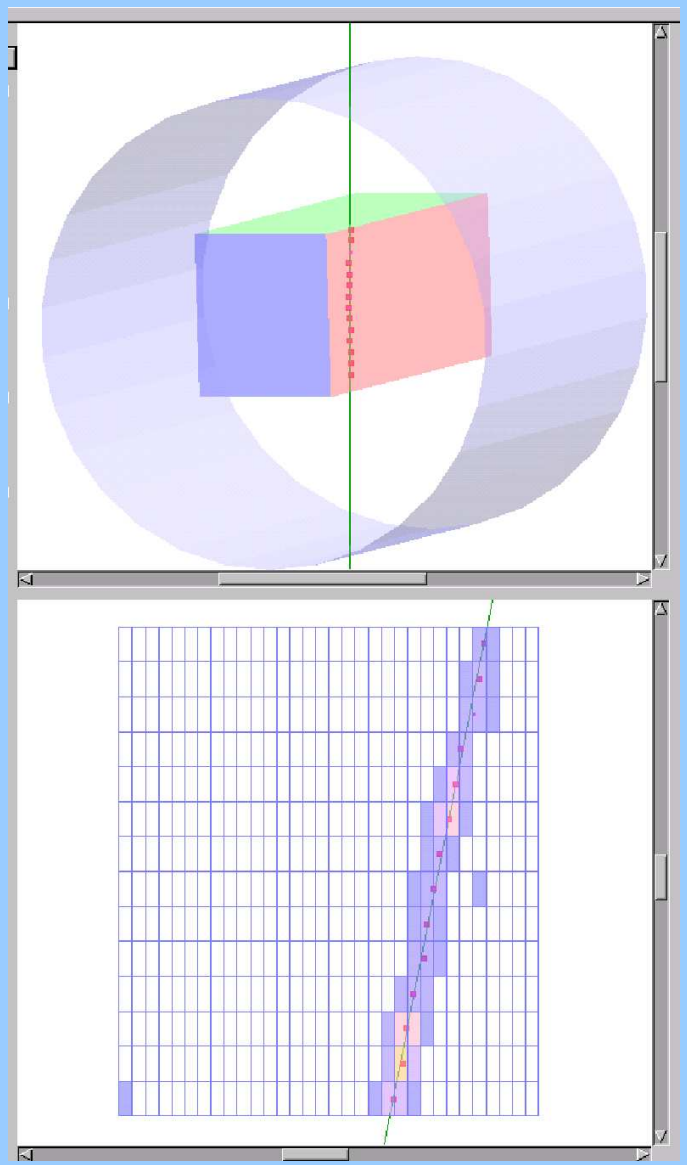
U_{max} = 26 kV

ℓ_{drift} = 26 cm

E_{max} = 1000 V/cm

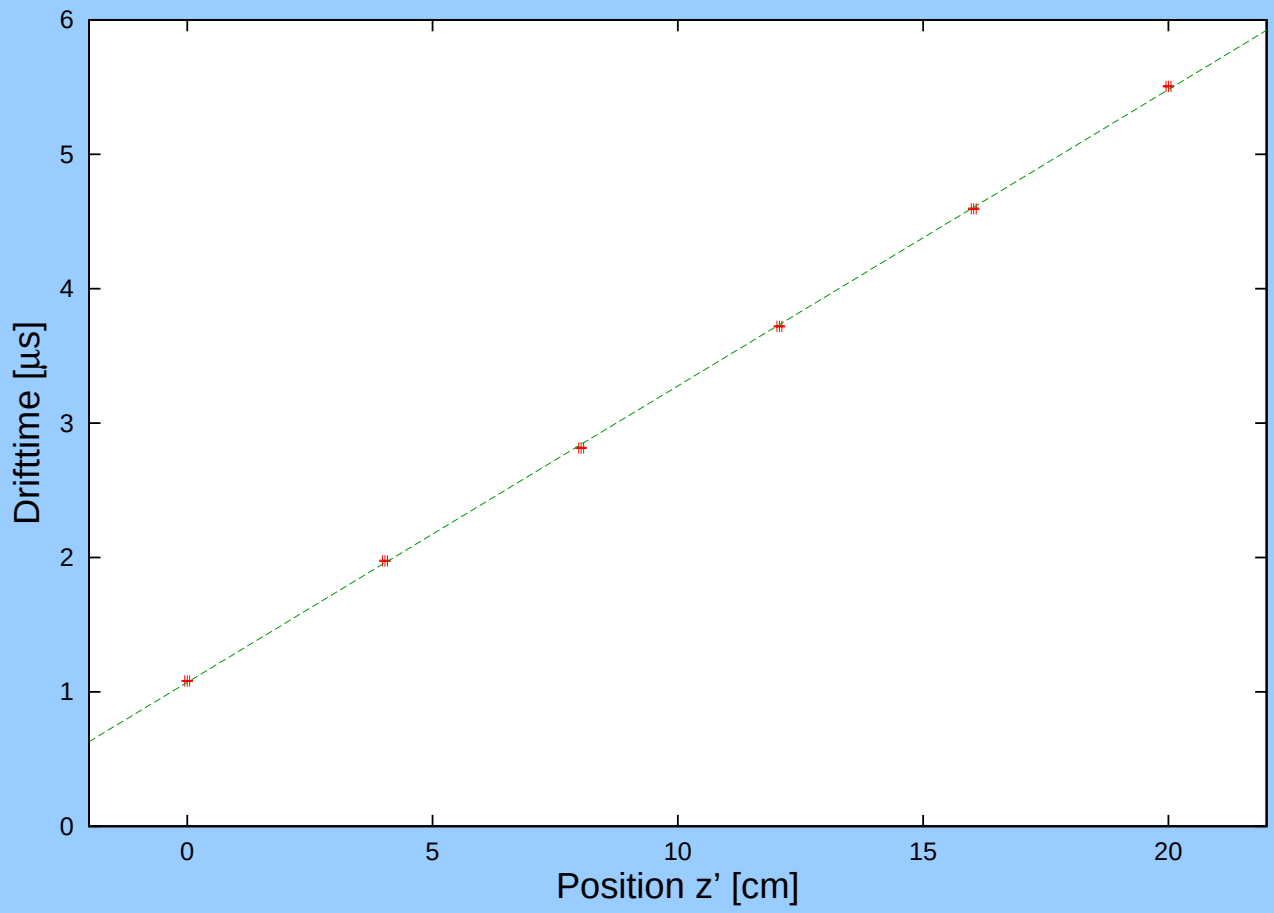
TPC Prototype: First Results

First event

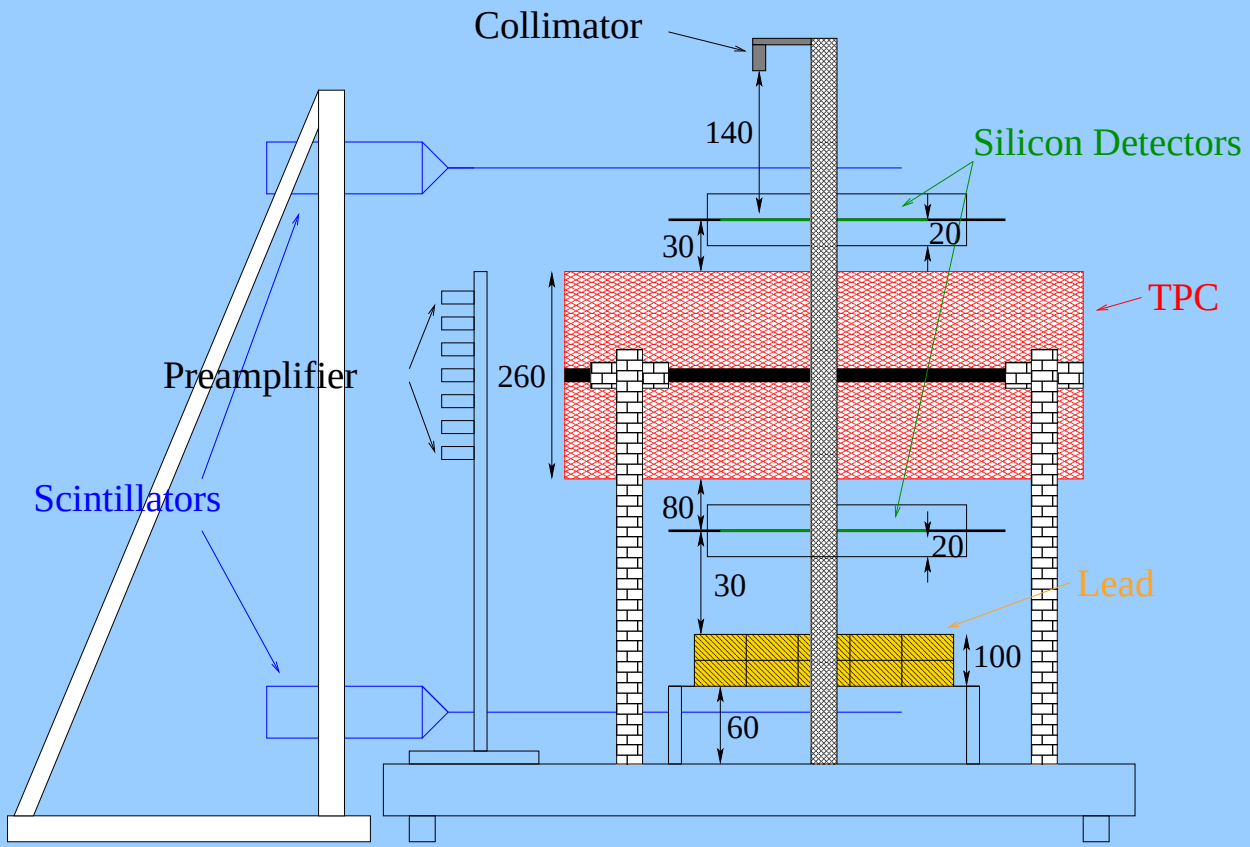


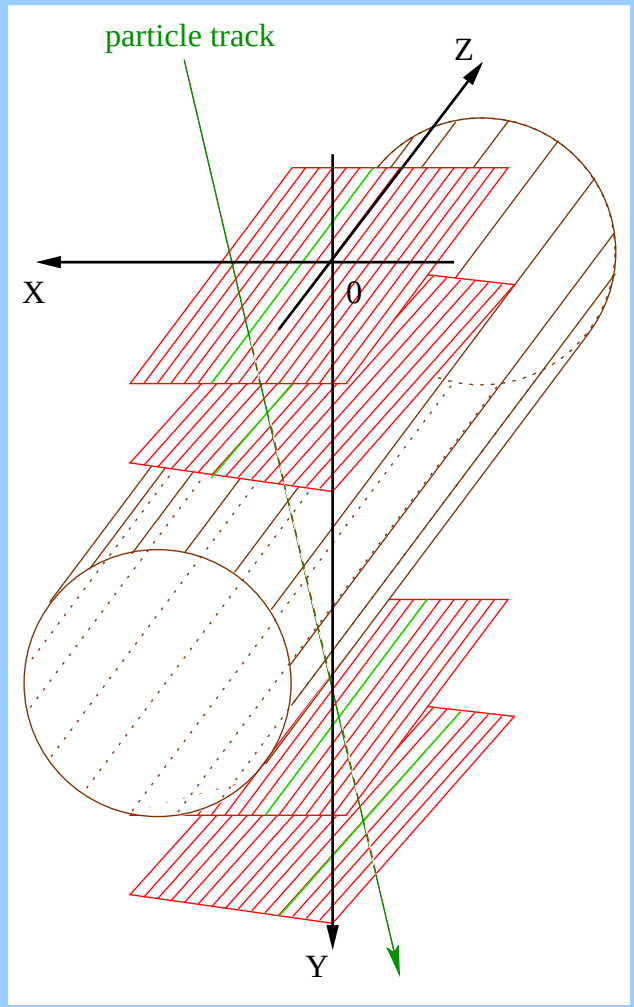
Measurement of drift velocity

$$v_d = 4.53 \pm 0.03 \frac{\mathrm{cm}}{\mu\mathrm{s}}$$

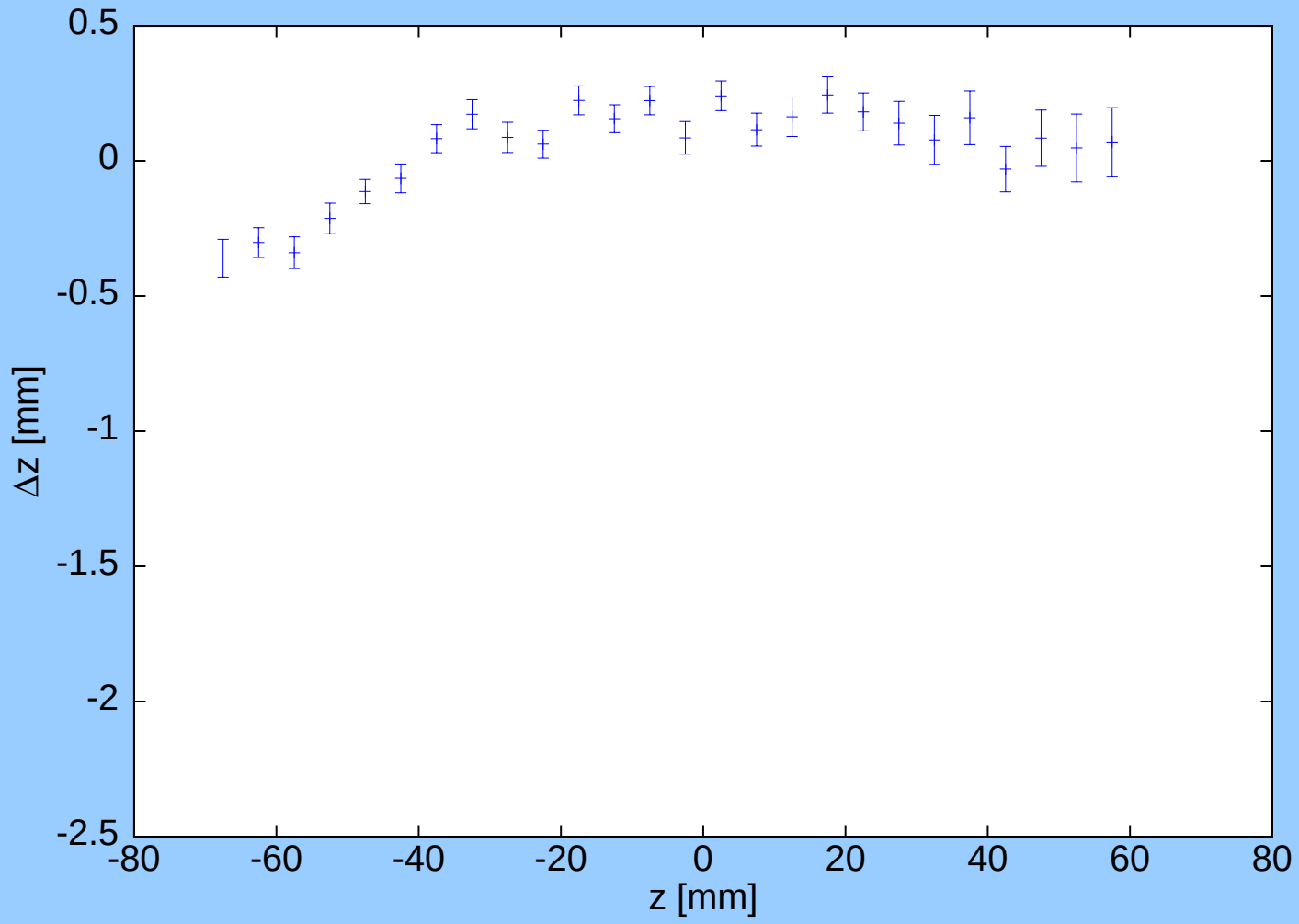


Hodoscope: Design



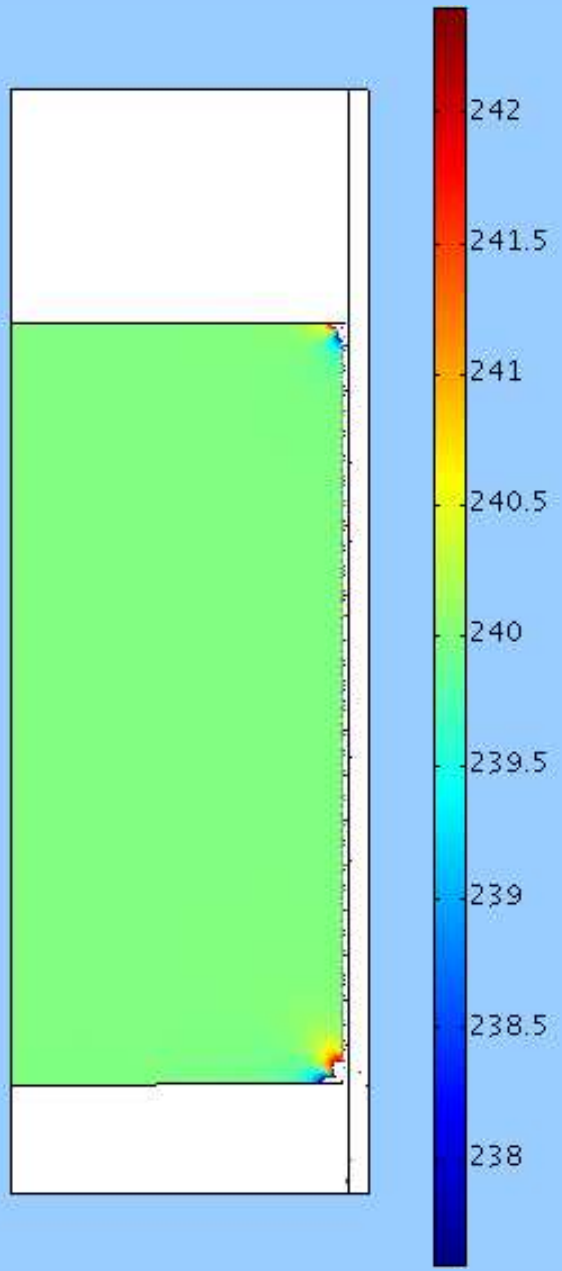


Difference between Hodoscope and TPC



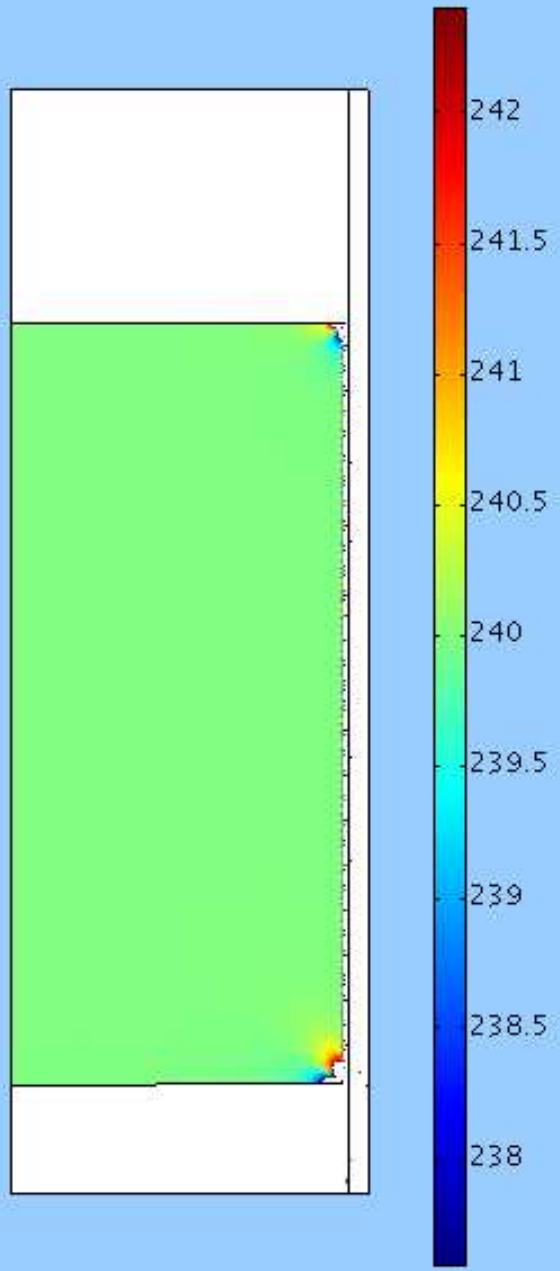
- Clear discrepancy near the anode
- Flat area in the middle of fieldcage

Simulation of Electric field

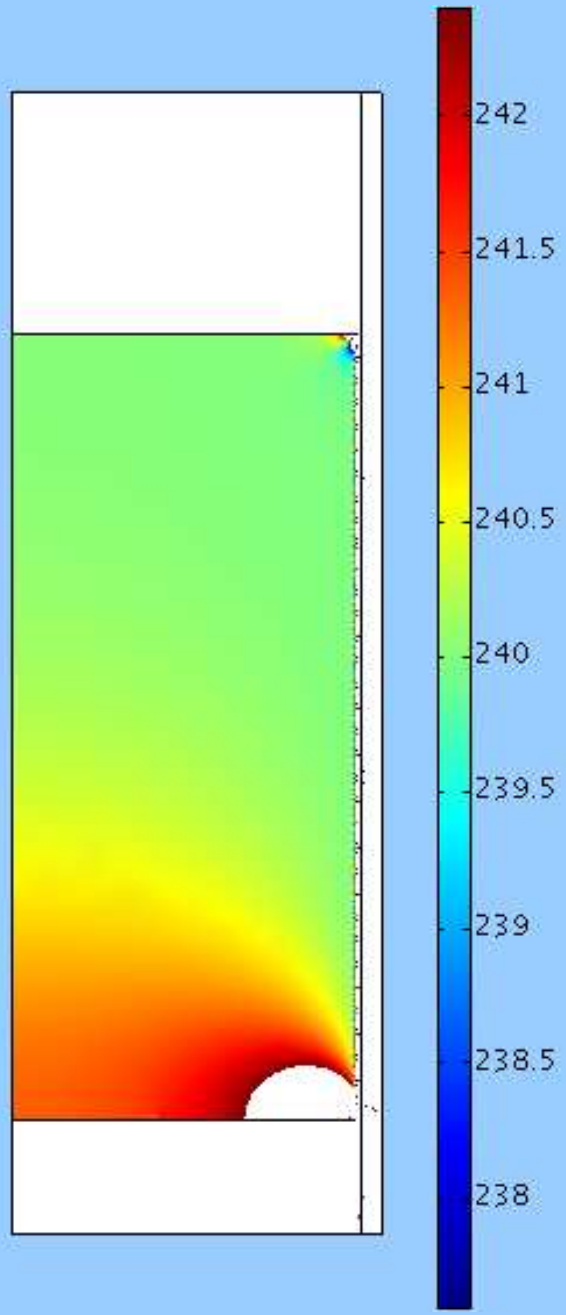


- Simulation of field with Femlab

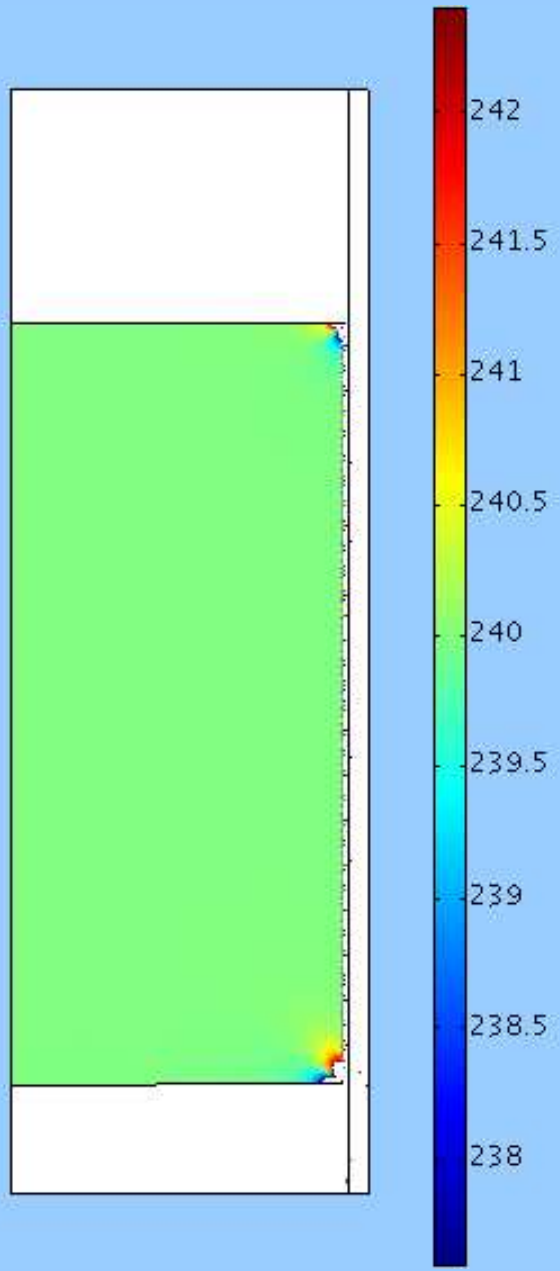
Simulation of Electric field



- Simulation of field with Femlab
- 0.5 mm displacement of readout relativ to assumed position (right)

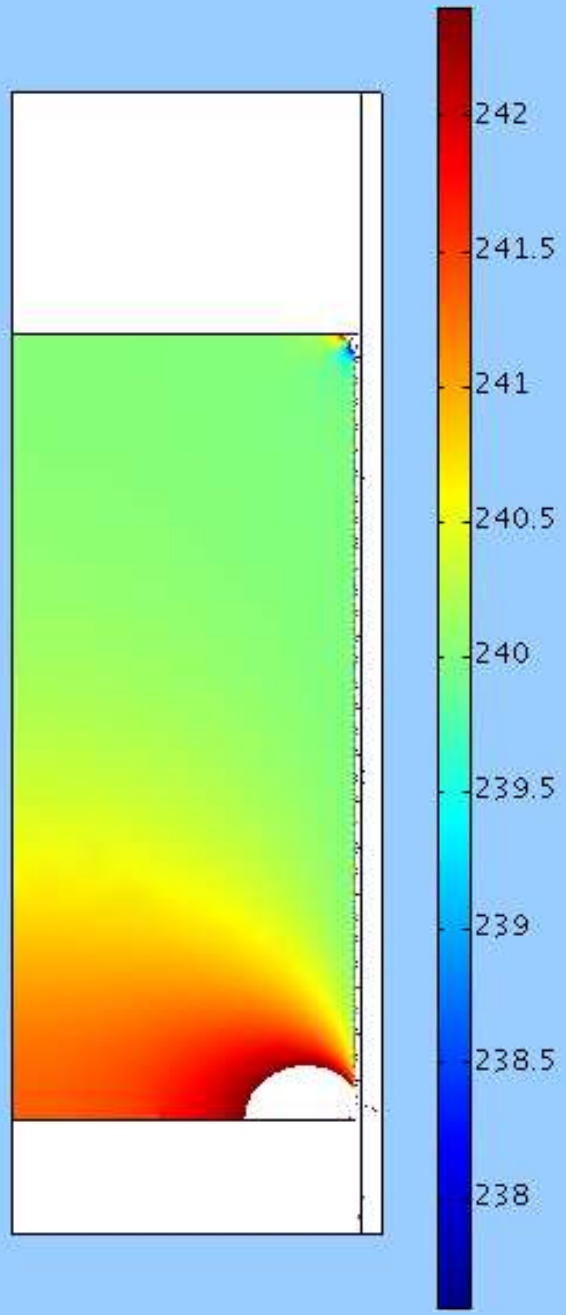


Simulation of Electric field

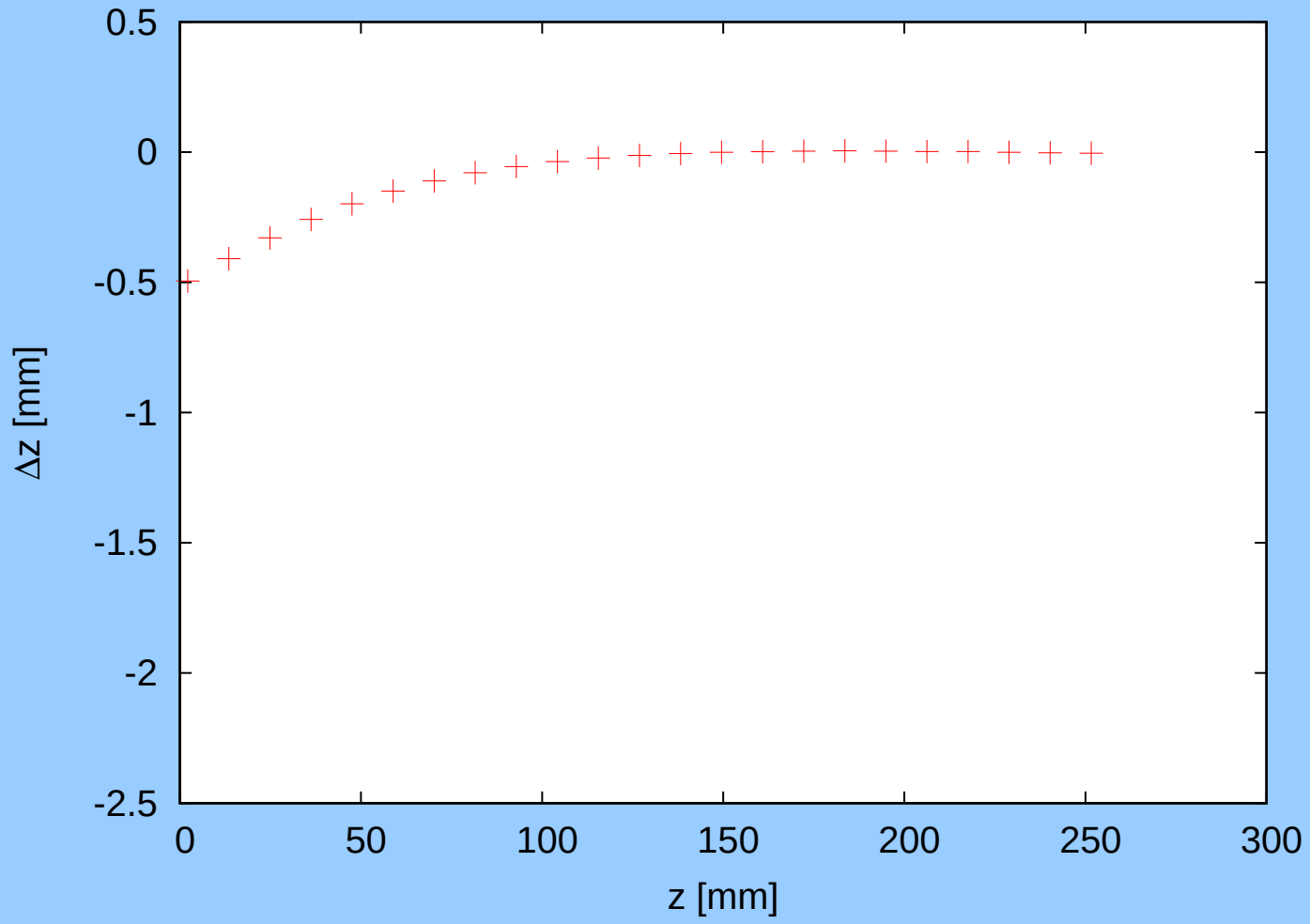


- Simulation of field with Femlab
- 0.5 mm displacement of readout relativ to assumed position (right)
- Numeric integration of $1/v(E)$ along z coordinate

$\Rightarrow$ Drift time dependency on z



Deviation from z in Simulation



- Rise of curve in region of inhomogeneities
- Qualitative same trend as in measurement

Hodoscope: Tasks and Results

Tasks:

- Measurement of the drift velocity
- Measurement of the field homogeneity to the order of $\leq 10^{-3}$
- Measurement of the spatial resolution

Results:

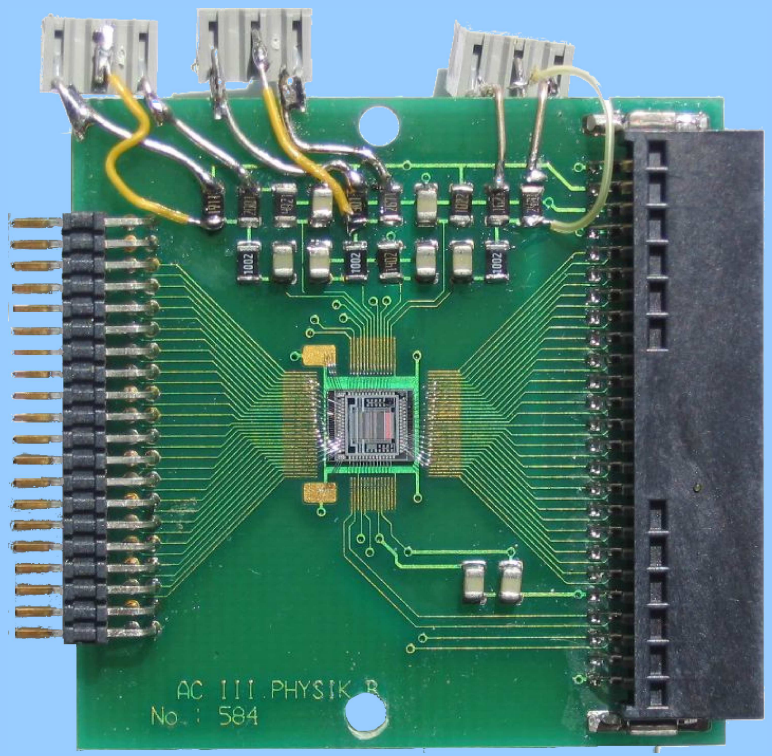
- Resolution hodoscope: 58 μm in x, 624 μm in z
- Single point resolution of TPC: 266 μm
- Measurable field inhomogeneities in TPC

Readout Electronics: Preamplifier

Goal: Fast and small preamplifiers

Preshape 32

- 32 channel preamplifier/shaper with parallel In/Out
- Nominal peaking time: 45ns
- Single ended output
- Needs cable driver to get signal to reasonable distance



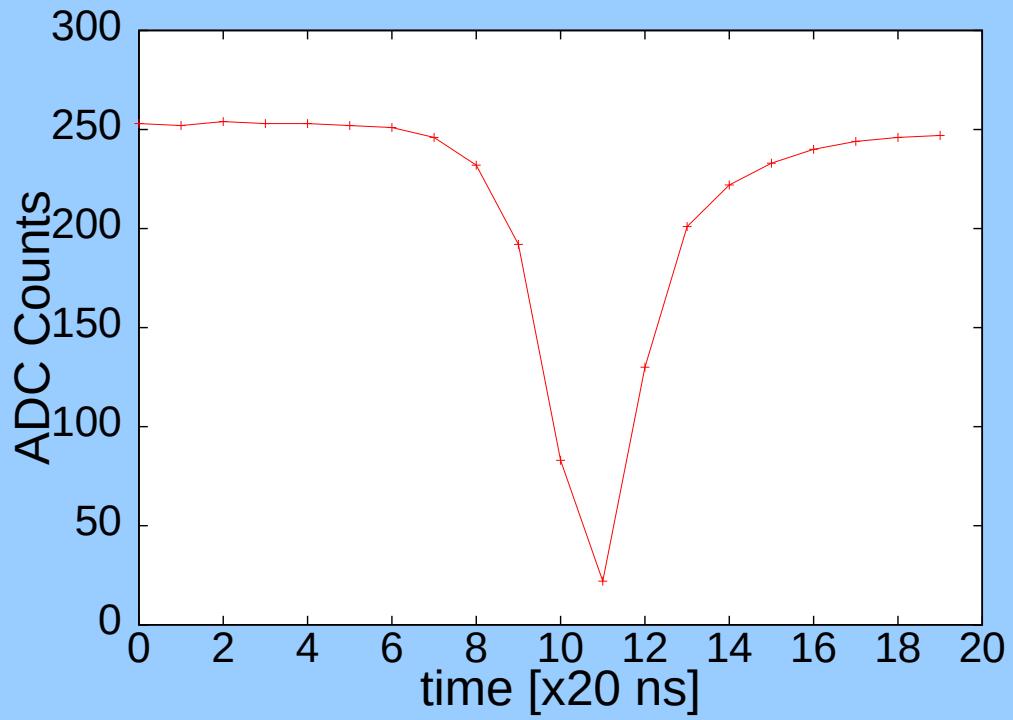
The preshape is bonded on a small board to perform tests.

⇒Possibility to reduce size for a readout with small pads.

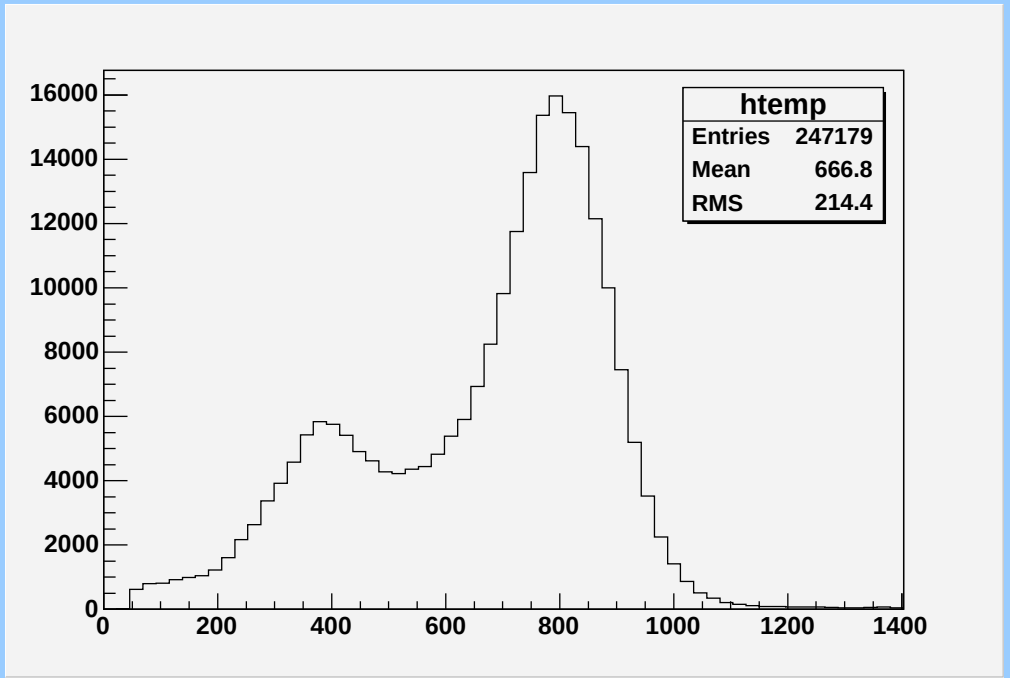
Electronics: Preamplifier Results

- Measurements with test pad plane
- 50 MHz 8 bit VME ADCs (20 channels)

^{55}Fe pulse



^{55}Fe spectrum



Electronics: ADCs

Three ADC candidates:

Origin	Munich	Canada	Hamburg
System	VME	VME	VME
Resolution [bit]	10	10	8
Frequency [MHz]	40	40	100
Memory [sample]	1000	1000	4000
channels/module	32	48	16

Goal:

Replace slow readout with best candidate for test beam

Simulation: Methods and Goals

Simulation in three steps:

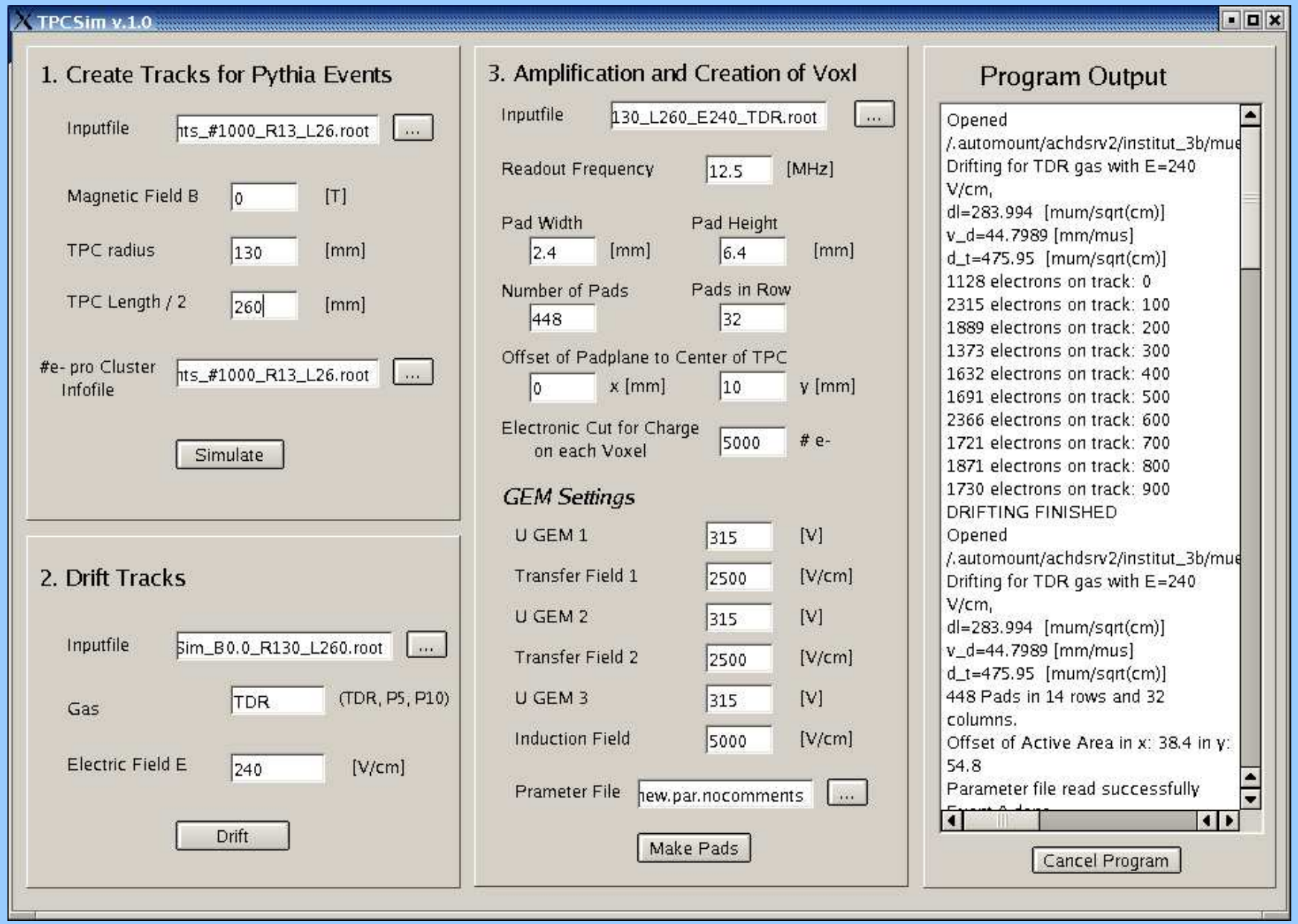
1. Primary ionisation
2. Drifting of electrons
3. Amplification with GEMs

→ Details of simulation: Session J Track 3

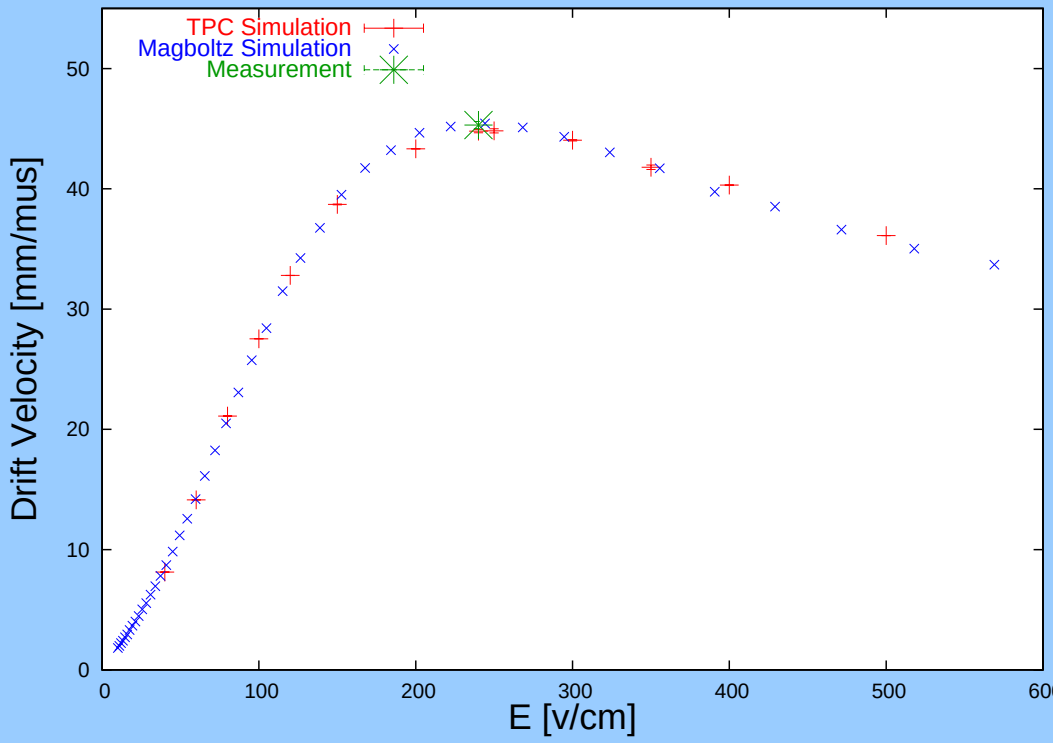
Studies of:

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

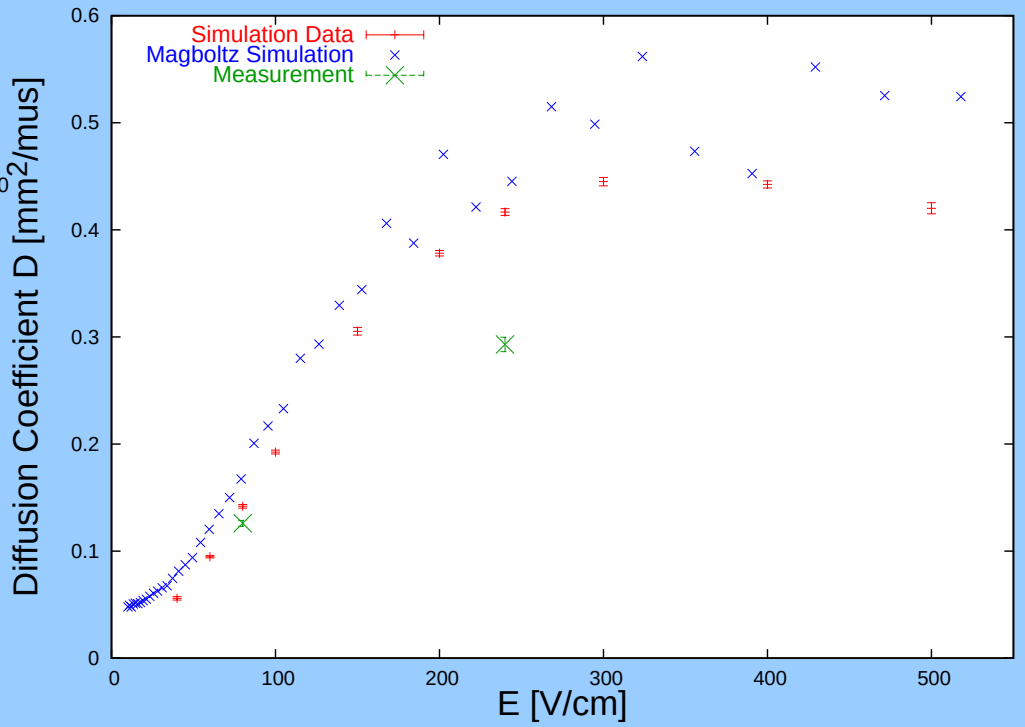
Inputs for the Simulation



Results for Reproducibility



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



Transverse diffusion
→ Problem with Magboltz or measurement ?

Summary

- Prototype & Hodoscope
  - Both working synchronously and stable
  - Systematic studies of TPC properties
  - Test beam planned for this year
- New electronics
  - Preamplifiers and cable driver chosen
  - Production in progress
  - Test with new readout plane coming soon
- Simulation
  - Understand discrepancy in diffusion results
  - Systematic studies next
  - Transfer to LCIO & Marlin started