TPC R&D Activities ongoing at DESY

UPDATE

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Activities

- DESY TPC group is
  - participating in the Large Detector Concept for the ILC
  - studying TPC-prototypes with GEM based amplification device

- Hardware
  - Design and stability test of a field cage
  - Implementation of slow control system
  - Setup of an UV Laser system
    - for 2 track separation study
    - calibration tool for drift velocity
  - Test of TDC readout electronic
  - Designing & building a large prototype

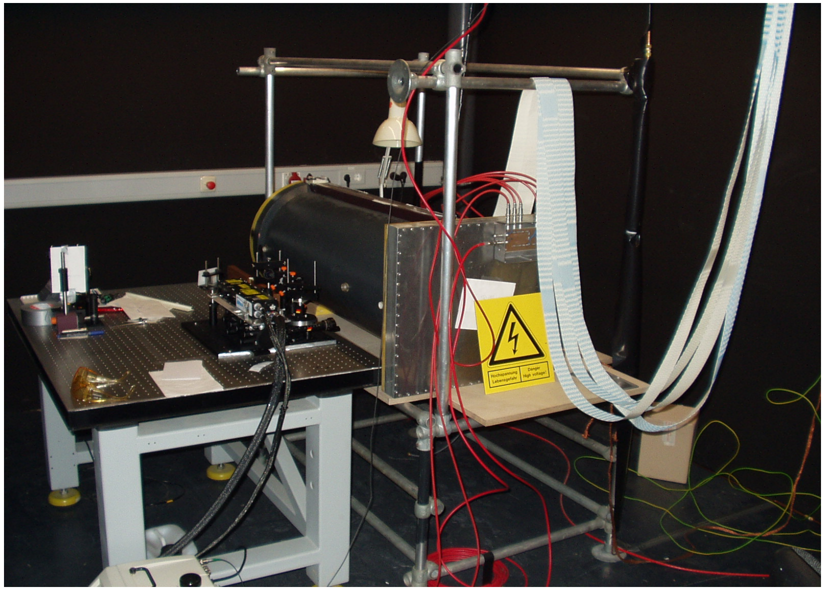
Activities

- Analysis:
  - Studies of single point and
  - Two track separation capability in high magnetic fields
  - deeper understanding of fit systematics, comparison of different fitting algorithms and techniques

- Simulation
  - Studies of neutron BG in the TPC using full MC simulator (Mokka)
  - MC studies for TPC prototype
    - pad geometries studies
  - Understanding of GEM signal generation

Studies with Laser beams

- Goals
  - Testing of track separation capability
  - Measurements of gas properties: drift velocity, diffusion
- UV-Laser
  - Wave length: λ = 266nm (NdYAG)
  - Pulse length: < 6ns
- Advantage
  - Controllable and reproducible tracks
- Disadvantages
  - Different ionization mechanism: laser v. MIP (cosmic muon)
- Prototype TPC
  - Length 1050 mm, Ø 380 mm
  - Quartz windows: 55, 305, 955 mm



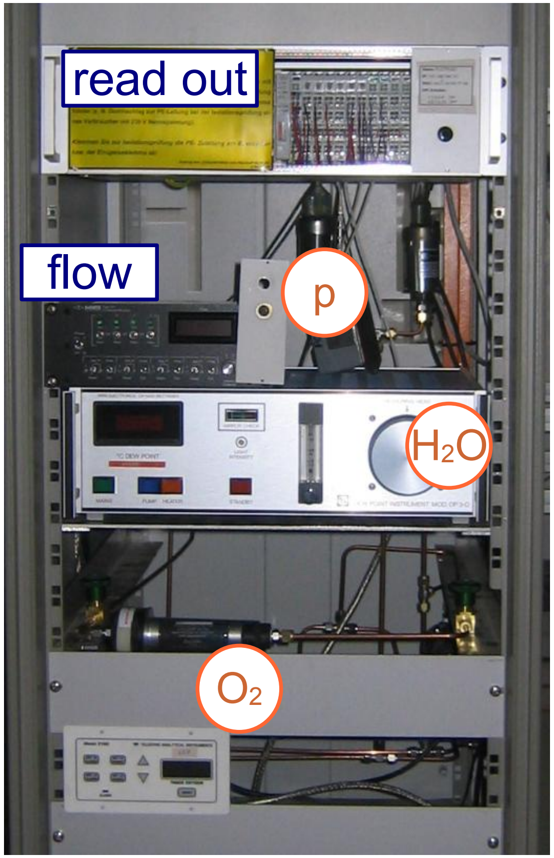
Slow Control System

- Slow control parameter for TPC
  1. Gas parameter
     (p, gas flow, O_2, H_2O)
  2. Environment condition
     (p, T, humidity)
  3. Electrical conditions
     (HV drift field & GEMs)
  4. (Magnetic field)

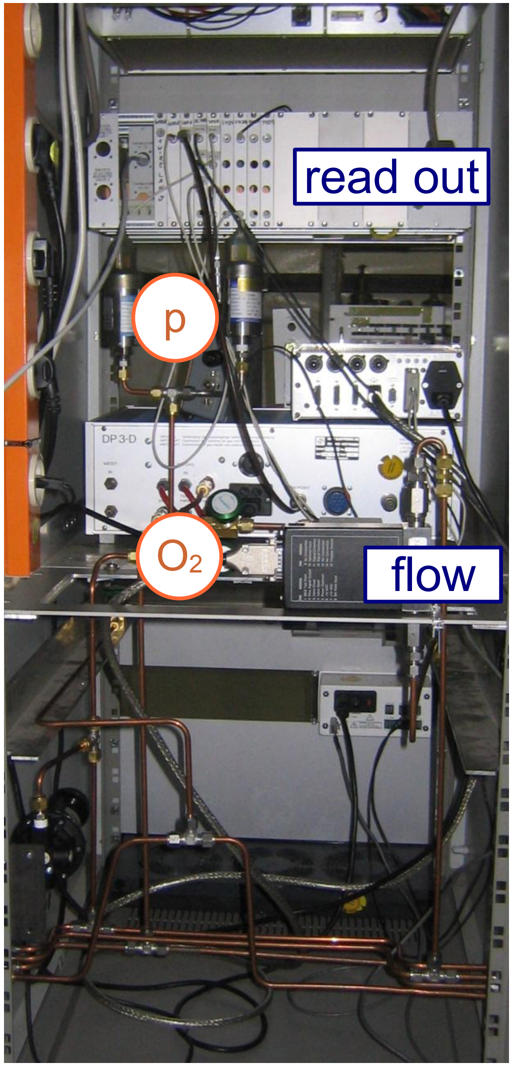
- 1.&2. installed in a rack
  – Use industrial standard
    for read out

- 3.&4. controlled separately

front view

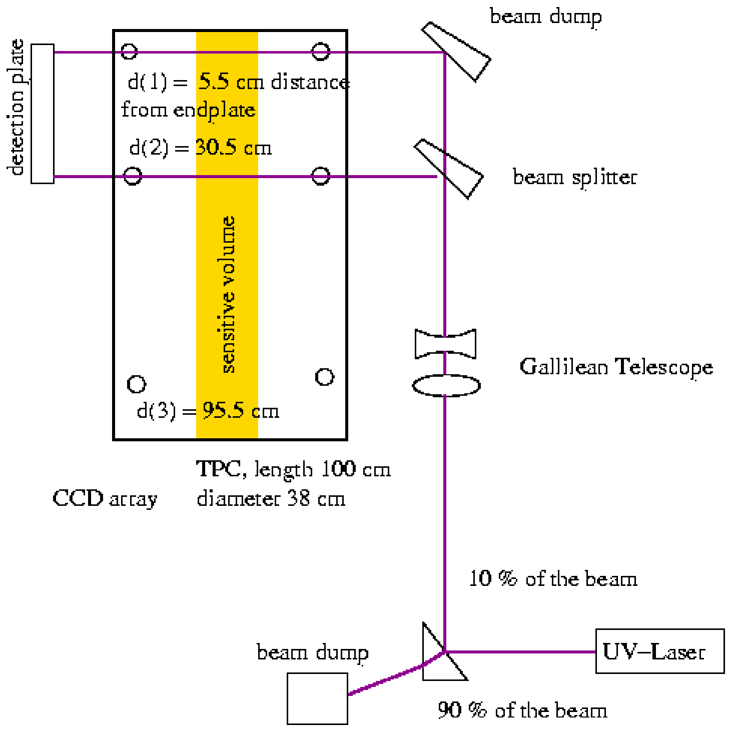


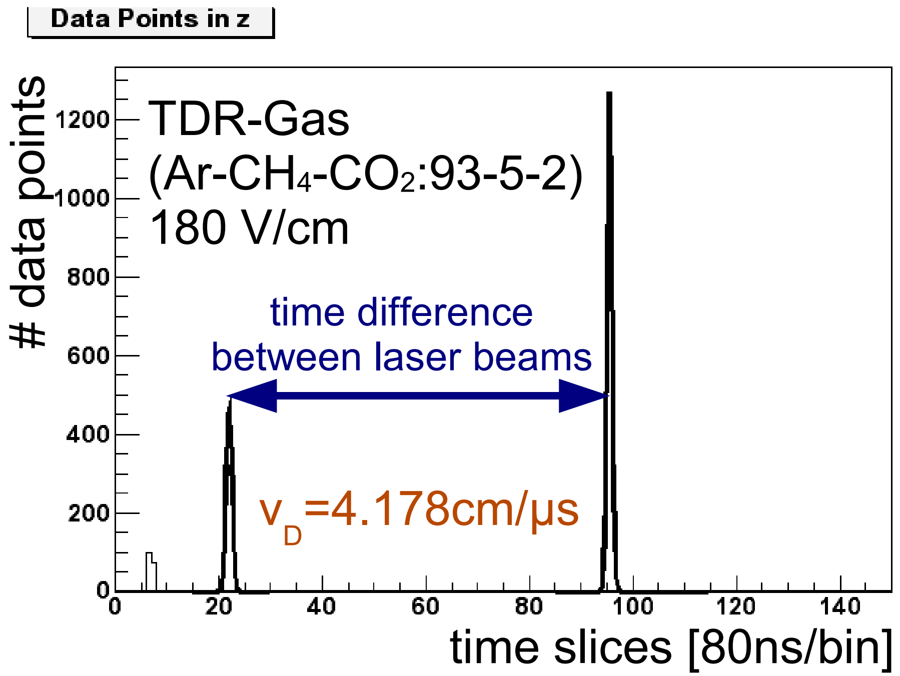
back view



Measurement of Drift Velocity

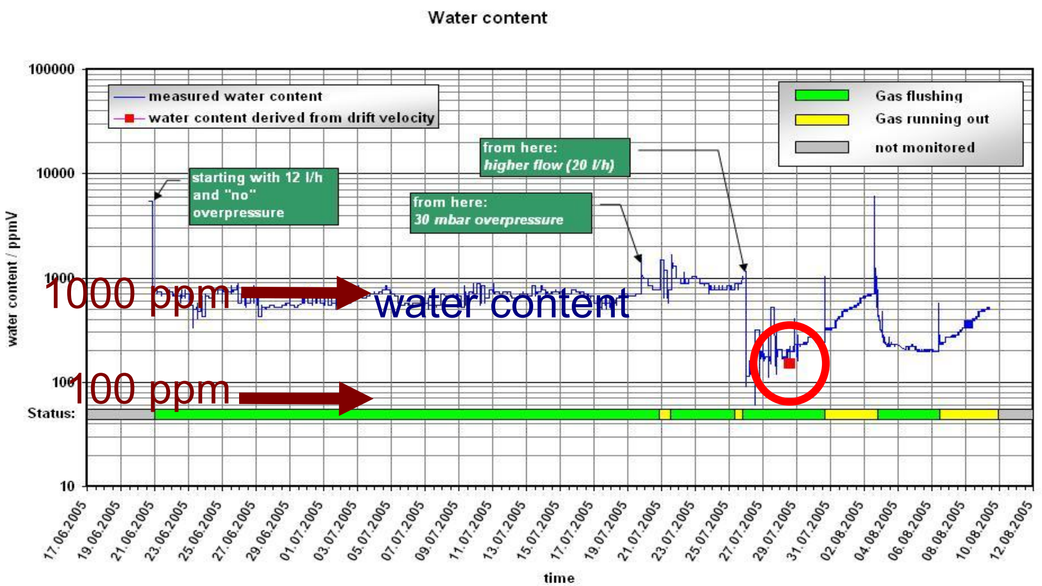
- Setup for drift velocity scan between 120 – 200 V/cm
  - 2 laser beams shoot at the same time
    but at different well known positions through the TPC
  - Count the reconstructed time for every hit
  - Gaussian fit to the time distribution and calculate drift velocity

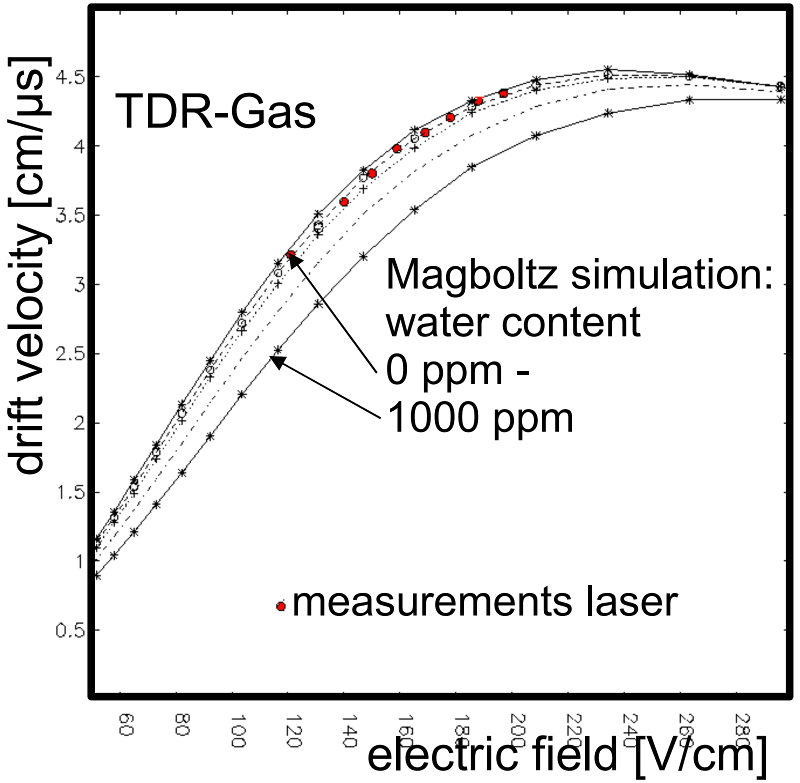




Drift Velocity & Water Content

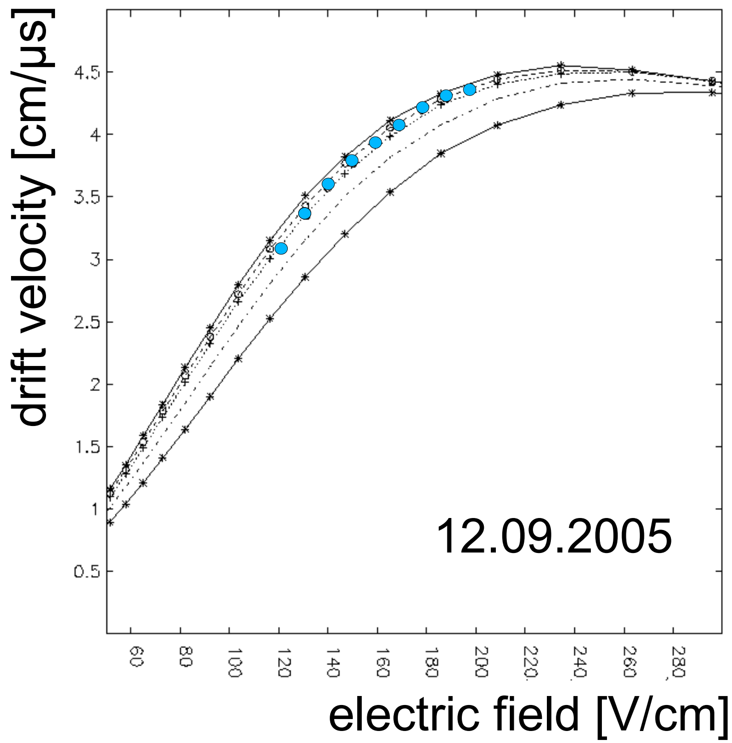
- Compare two complementary methods for measuring the water content
  - Direct measurement: slow control
  - Indirect measurement: compare drift velocity scan with Magboltz prediction for different water content

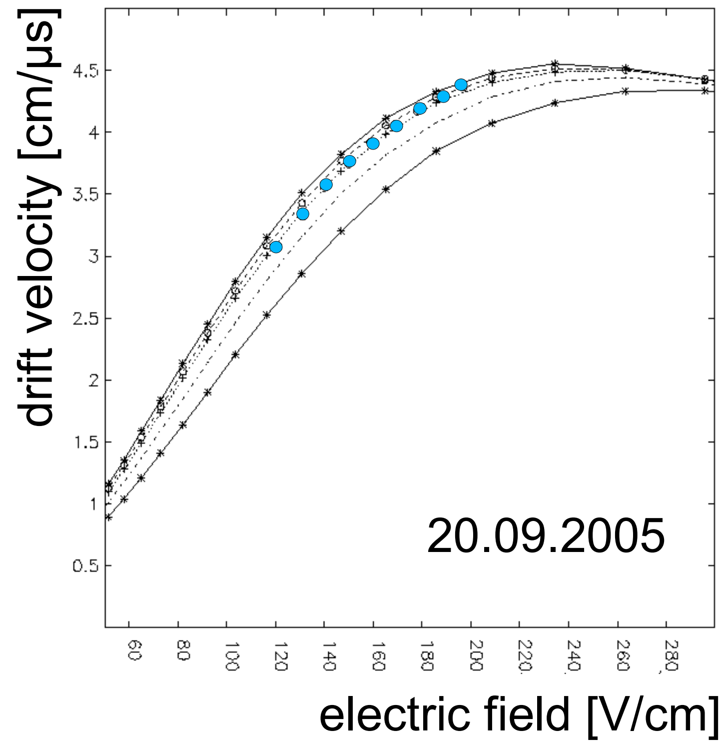




- First measurement seems to agree at 150 ppm water content, but ...

Drift Velocity & Water Content

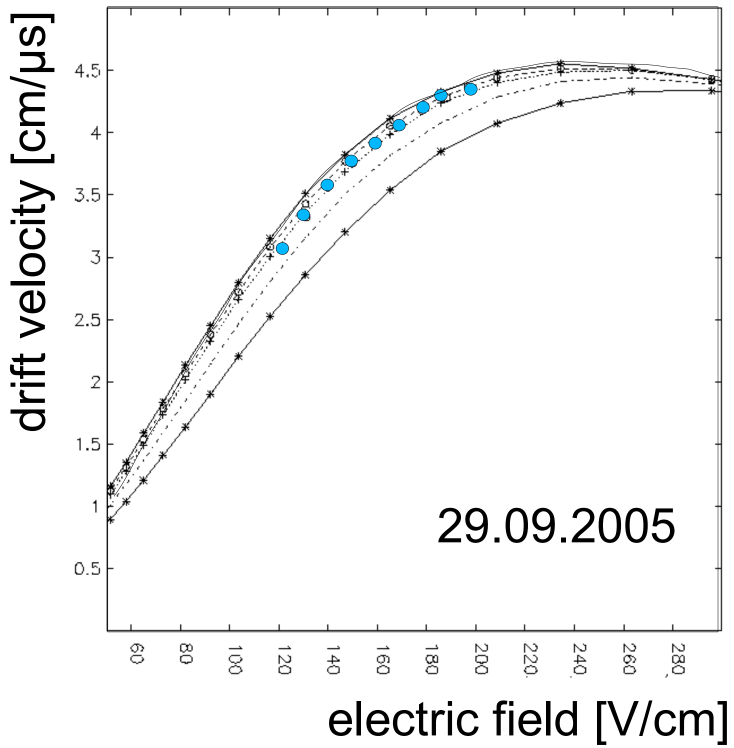




- Direct measurement with the slow control at the outlet of the chamber: 580 ppm 1120 ppm
- Discover leak at the end plate:
  - Assumption:
    water measured by slow control is not in the drift volume

Drift Velocity & Water Content

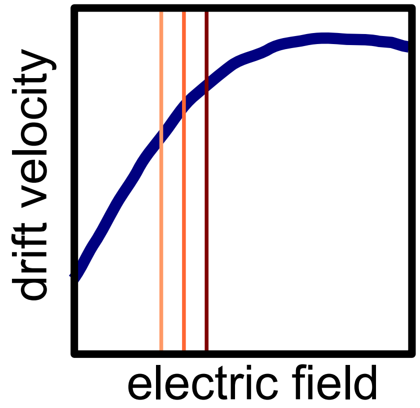
- Direct measurement at the inlet of the chamber
  - Better agreement
  - Gas seems to be polluted after passing the drift volume
- Test for consistency
  - Introduction of water 'by hand' at the inlet (before direct measurement)

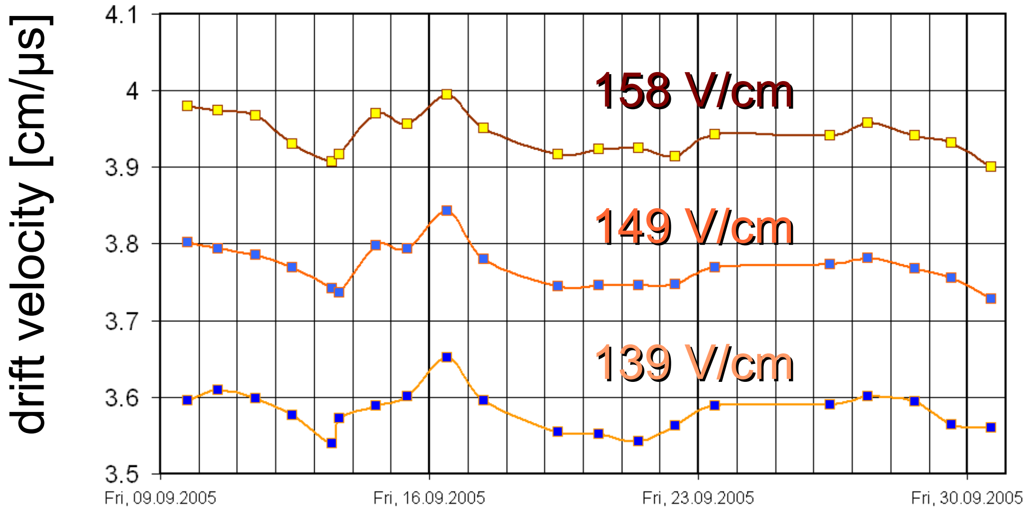


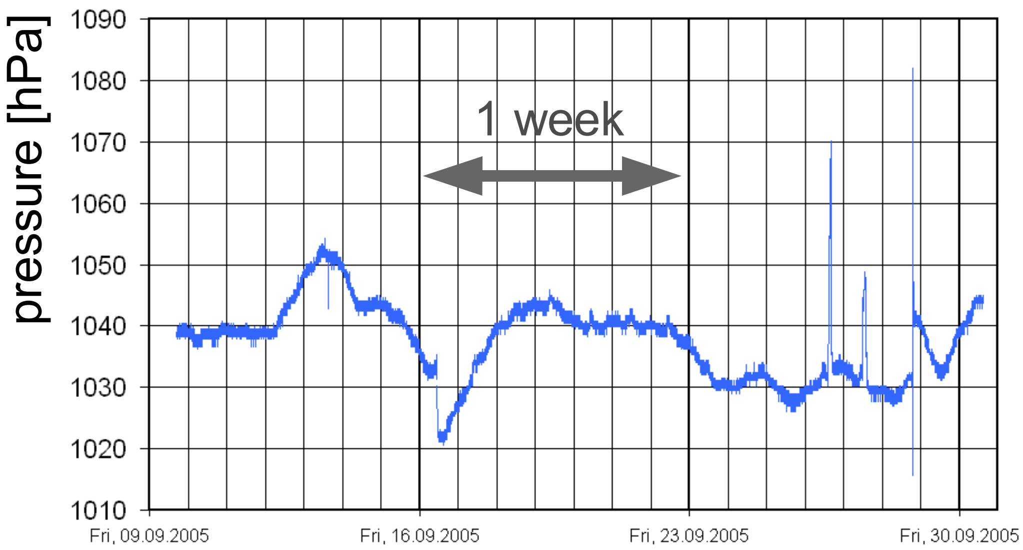
slow control: 91 ppm

Drift Velocity & Pressure

- Replace electric field E with reduced field E/p to take pressure into account
- Drift velocity measured at electric fields at the slope are most sensitive to pressure variation

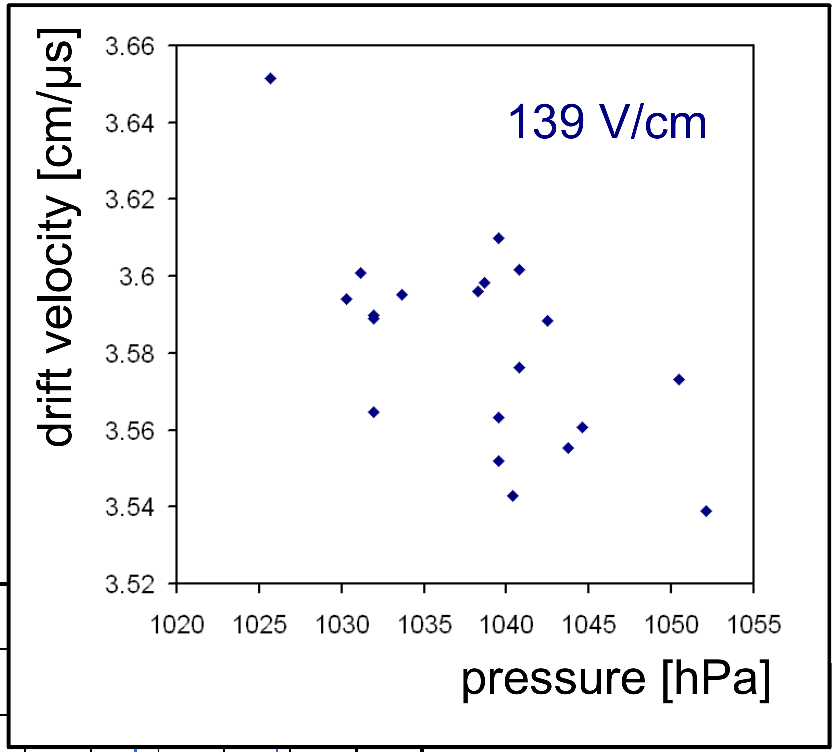


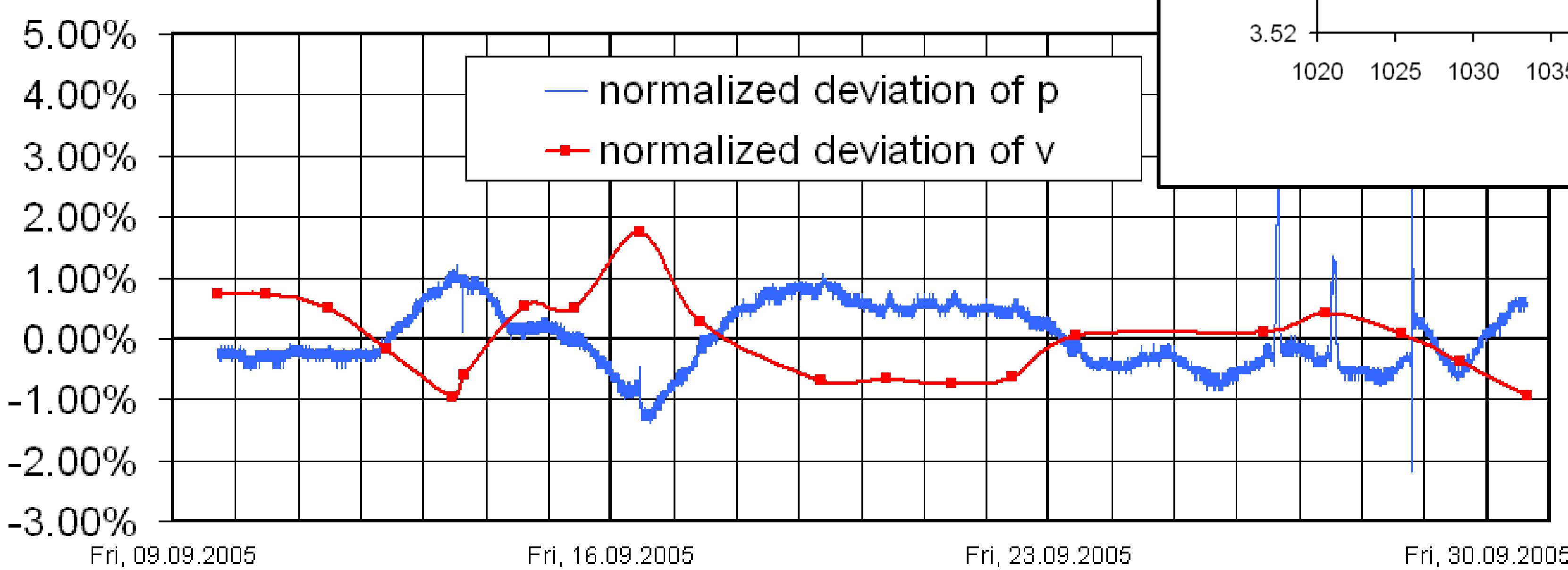




Drift Velocity & Pressure

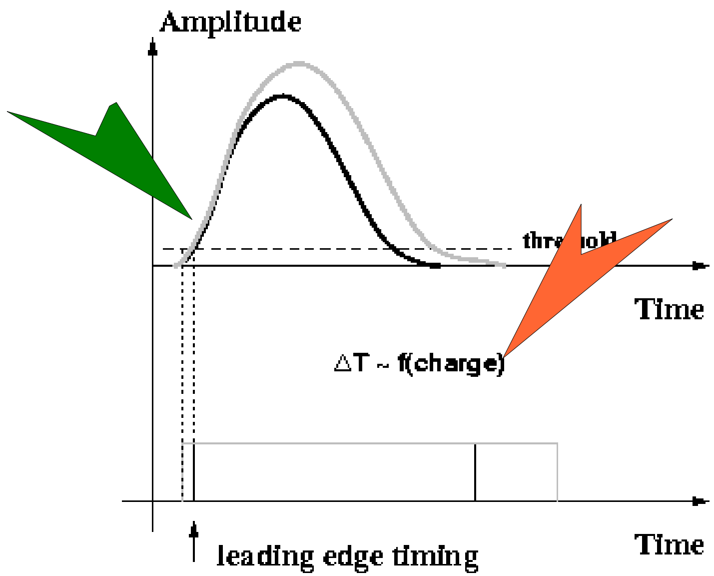
- Anti correlation expected
- Correlation coefficient for 139 V/cm is -0.66

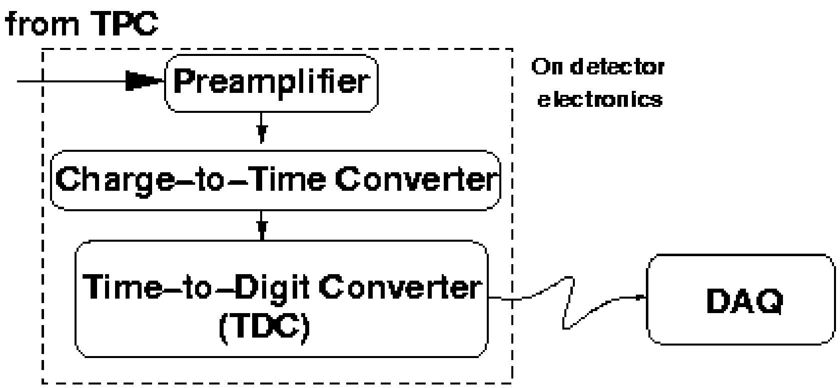




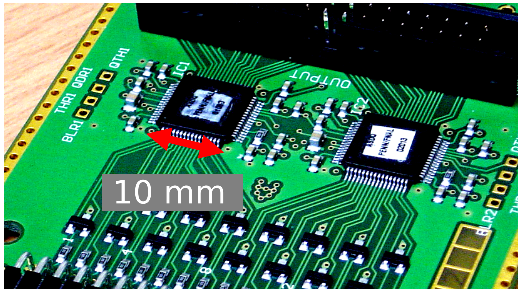
TDC based Read Out

- Principle of measurement



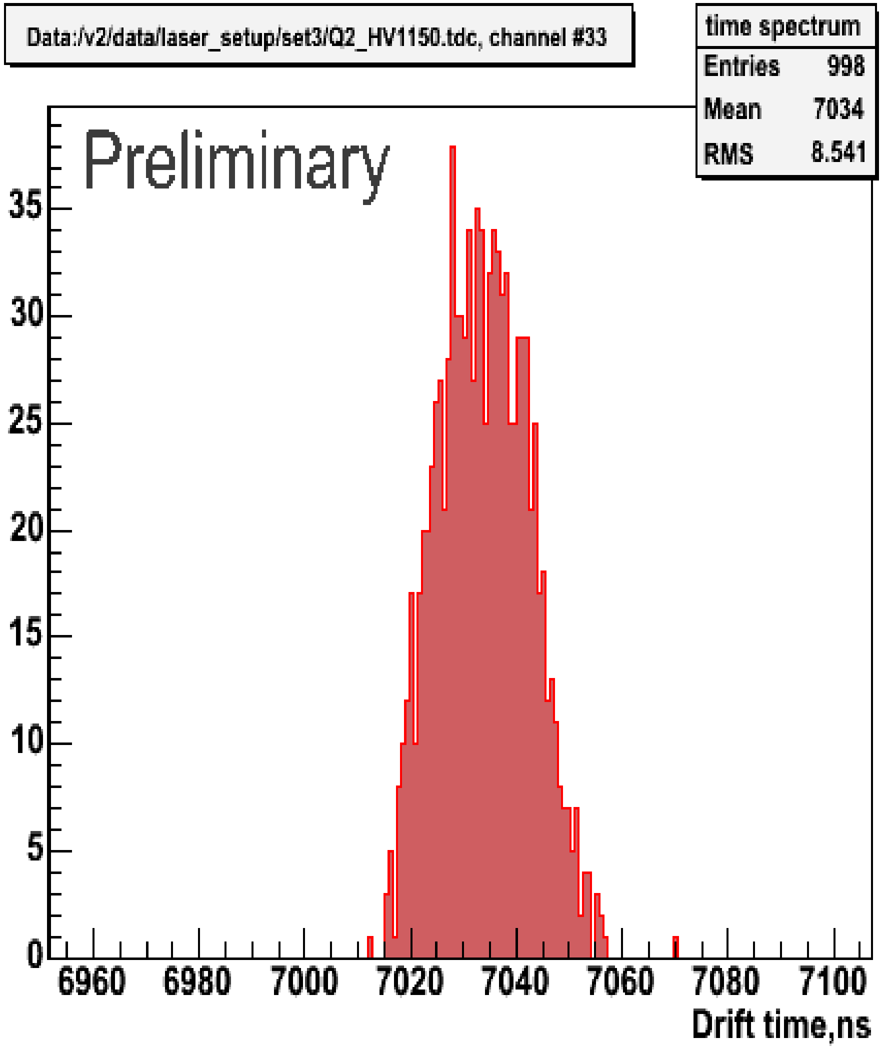


  - leading edge timing
    - Method to obtain z coordinate
    - Depends on signal height: 'Time Walk'
  - charge to time conversion
    - Coordinate in rφ plane
    - Measurement dE/dx



TDC based Read Out

- Data taken with laser setup
  - use of one beam at 305 mm
- Some effects on precision of the drift time measurement:
  1. Trigger jitter (~1…2 ns)
  2. GEM timing (5…12 ns)
  3. 'Time walk' due to signal variations in amplitude
  4. Time measurement error (~1 ns)
- At 305 mm drift length: RMS 8.5 ns ► 0.4 mm

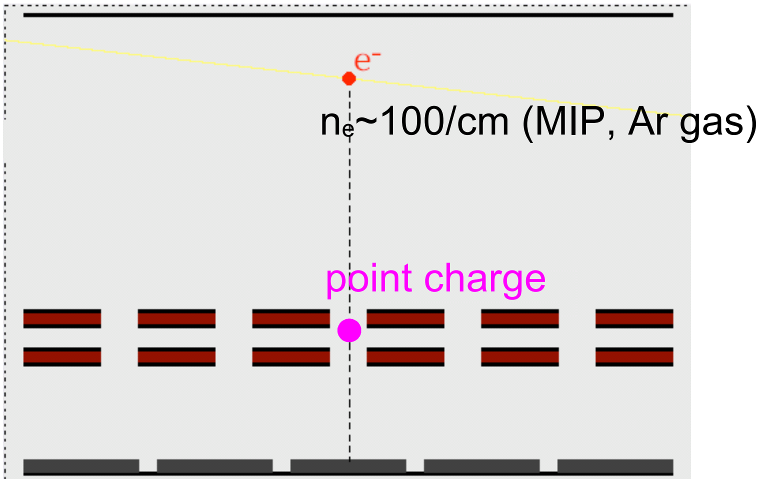


Simulation of GEM-Signal

- Goal: space-time evolution of the GEM signal for a segmented pad plane
  - Point resolution and
  - Double hit separability in drift direction
  - Readout electronic (rise-time, shaping time, etc.)
  - Signal of neighbour pads (resolution in r-φ)

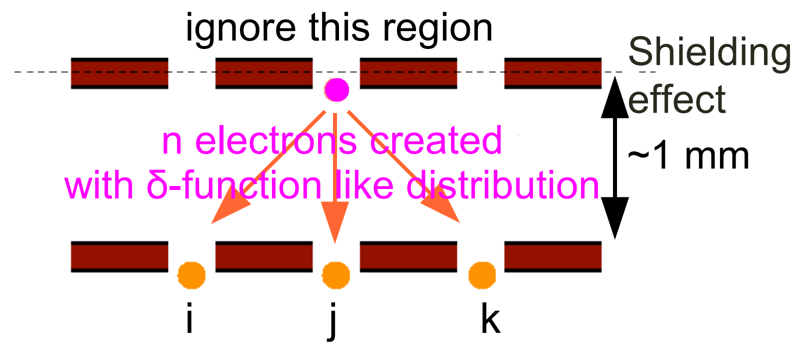
- Obtain a realistic wave form of the GEM signal as a function of
  - Pad geometry
  - GEM structure
  - Gas and
  - Electronic properties

Concept of Toy Simulation

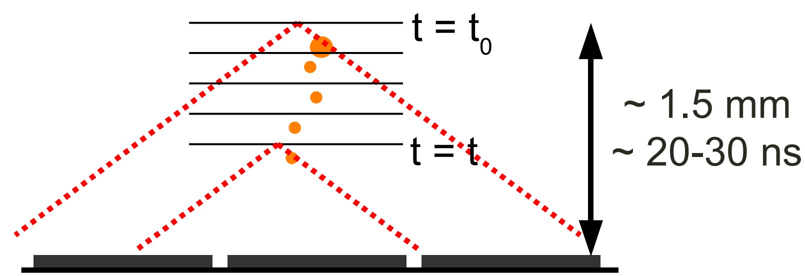


- Assumptions
  - Ignore ion velocity (1000 time slower than electrons)
  - Ignore size of electron cloud (for 1 primary electron) because it is small enough
  - Electron cloud moves to the anode plane along centre axis of GEM hole

- For simplicity: divide in two steps
  1. Amplification stage



  2. Induction state



Induced signal is derived by mirror charge method

Summary & Outlook

- Laser is working as a multi-purpose tool
  - Measurement of gas properties: e.g. drift velocity
    - Consistency check for slow control
      - Water content measurement: needs further testing
      - Pressure: showed expected correlation
  - Test of track separation capability: ongoing
  - Resolution studies: use of reproducible track generation
- Electronic development:
  - TDC based read out is working
  - First results for resolution are promising
- Simulation to answer time dependence of the GEM signal is on the way