Status of the Aachen R&D for the TESLA TPC

Martin Killenberg

Sven Lotze   Joachim Mnich   Astrid Münnich

Stefan Roth   Manfred Tonutti   Michael Weber

III. Physikalisches Institut B

RWTH AACHEN

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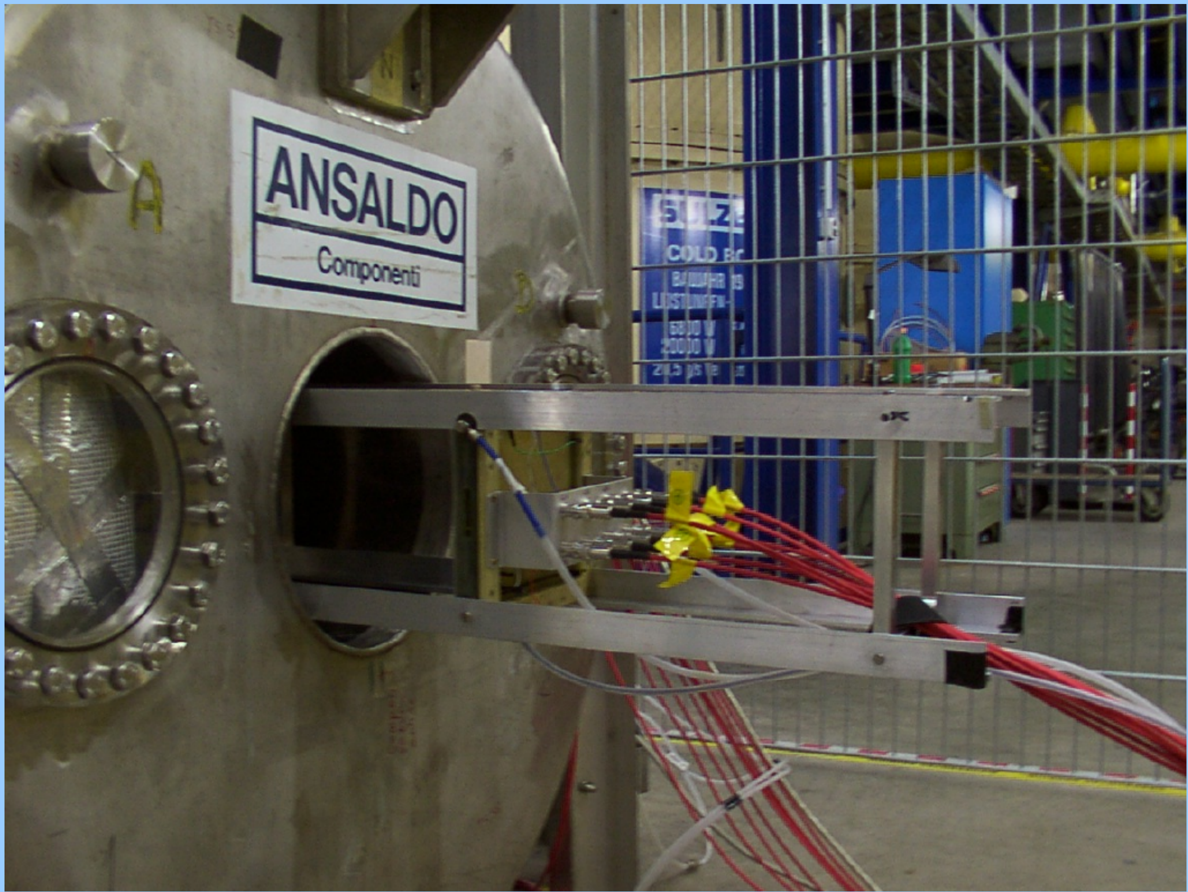
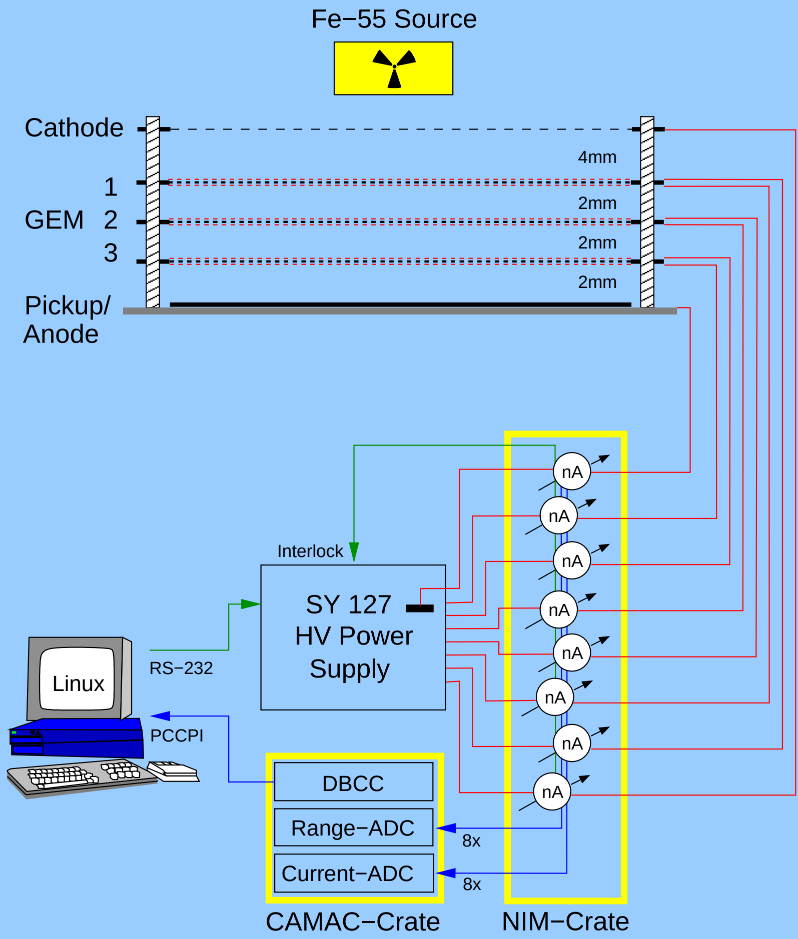
Overview

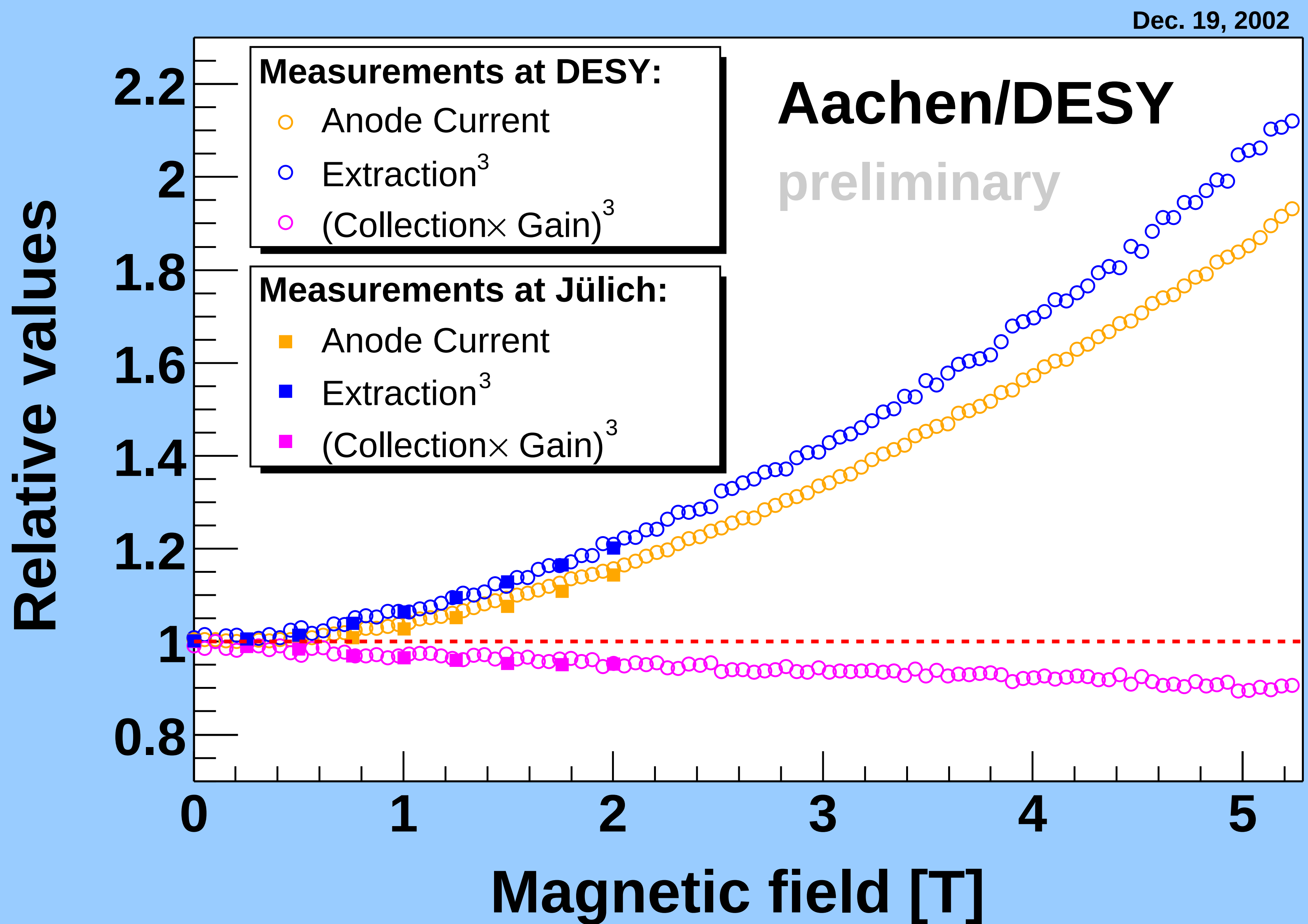
- Charge Transfer Measurement in a 5 T Magnetic Field
  - Effect on electron extraction and ion feedback
- Test Chamber for Pulse Tests
  - Pulse Shapes
  - Pulse Height Analysis
- Monte Carlo Simulations
  - Garfield simulations with different gases
- Large TPC with GEM Readout

Charge Transfer Test in 5 T Magnetic Field

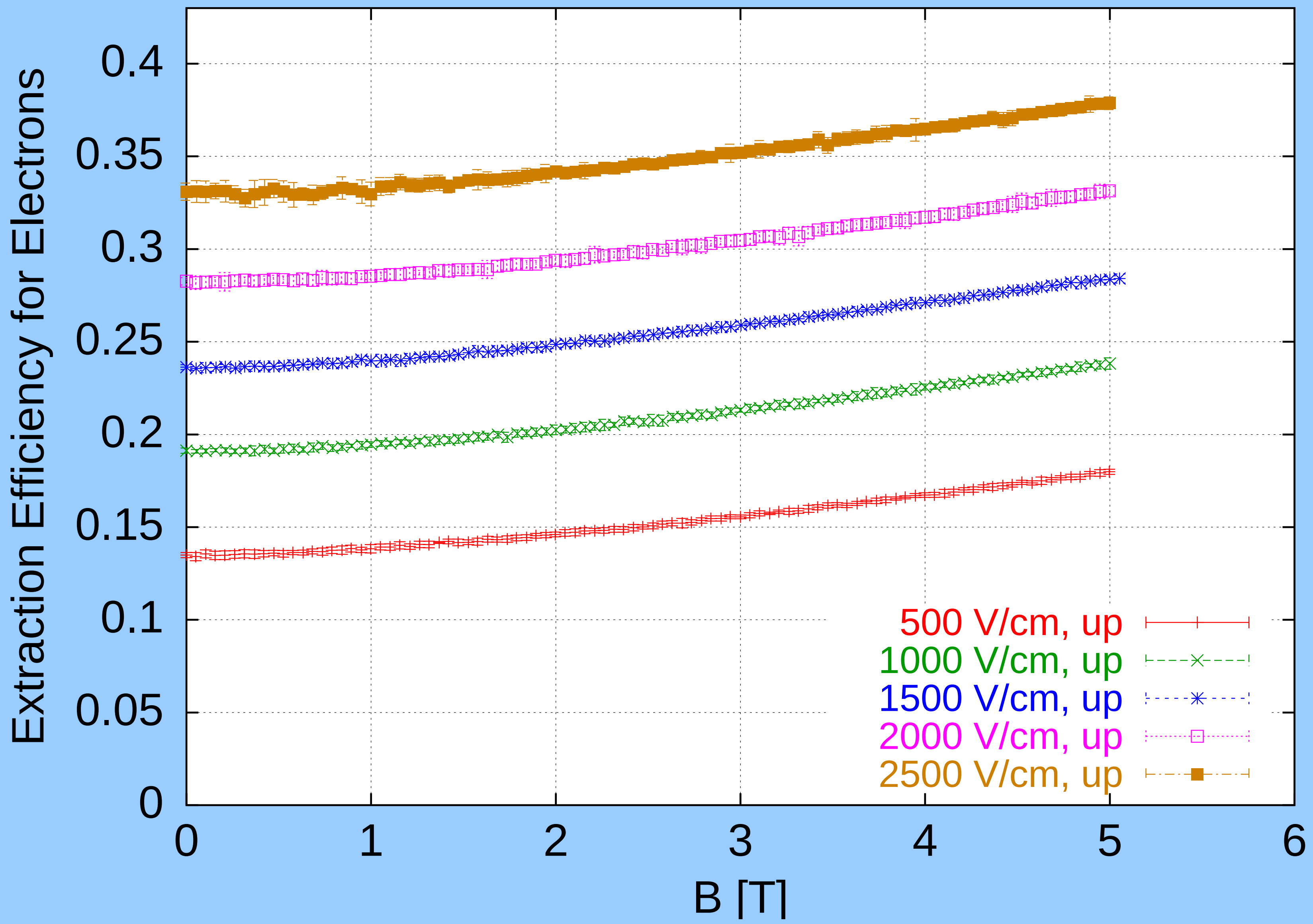




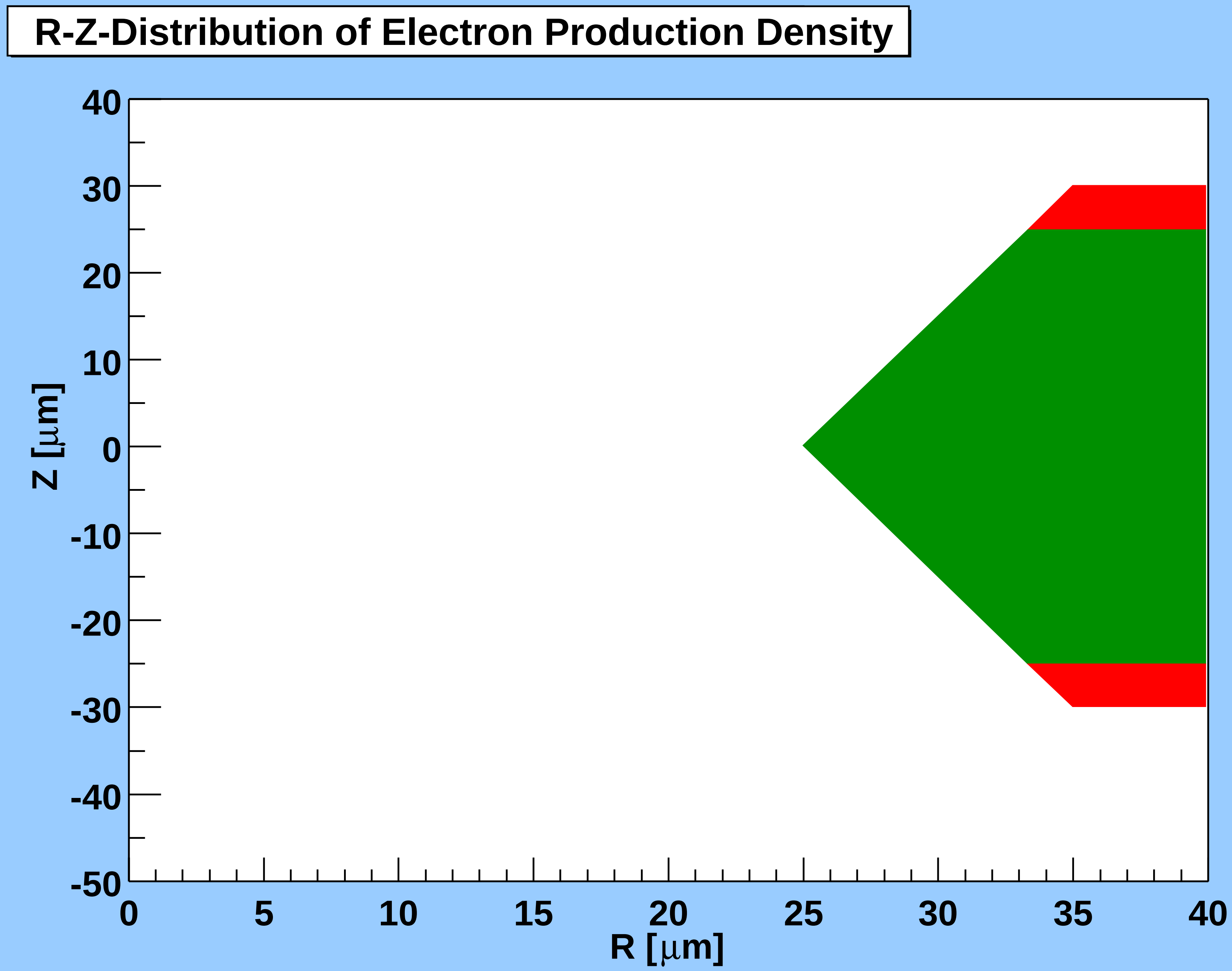
First Measurements at DESY



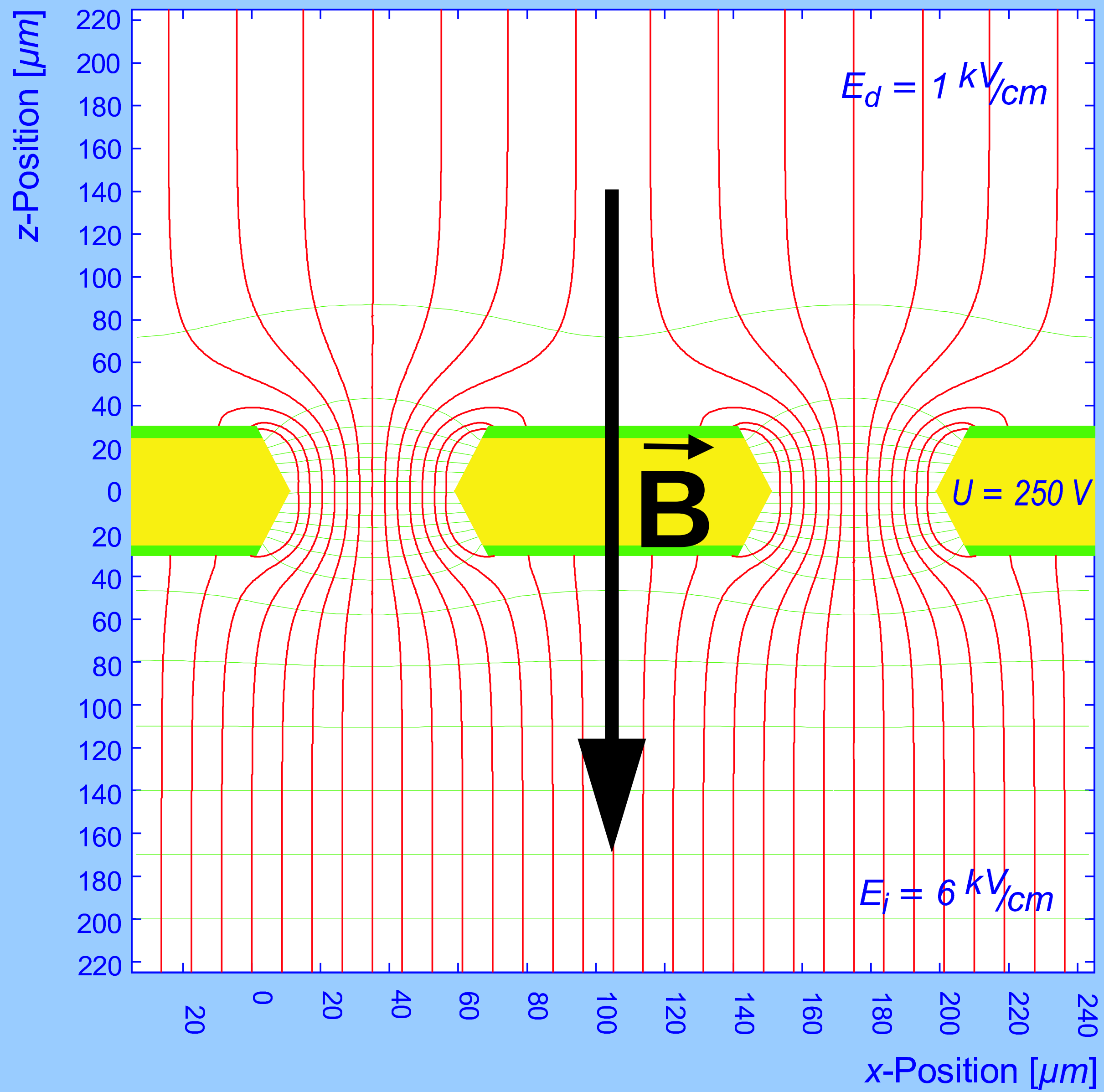
Electron Extraction in Magnetic Field



Electron Production in GEM Hole



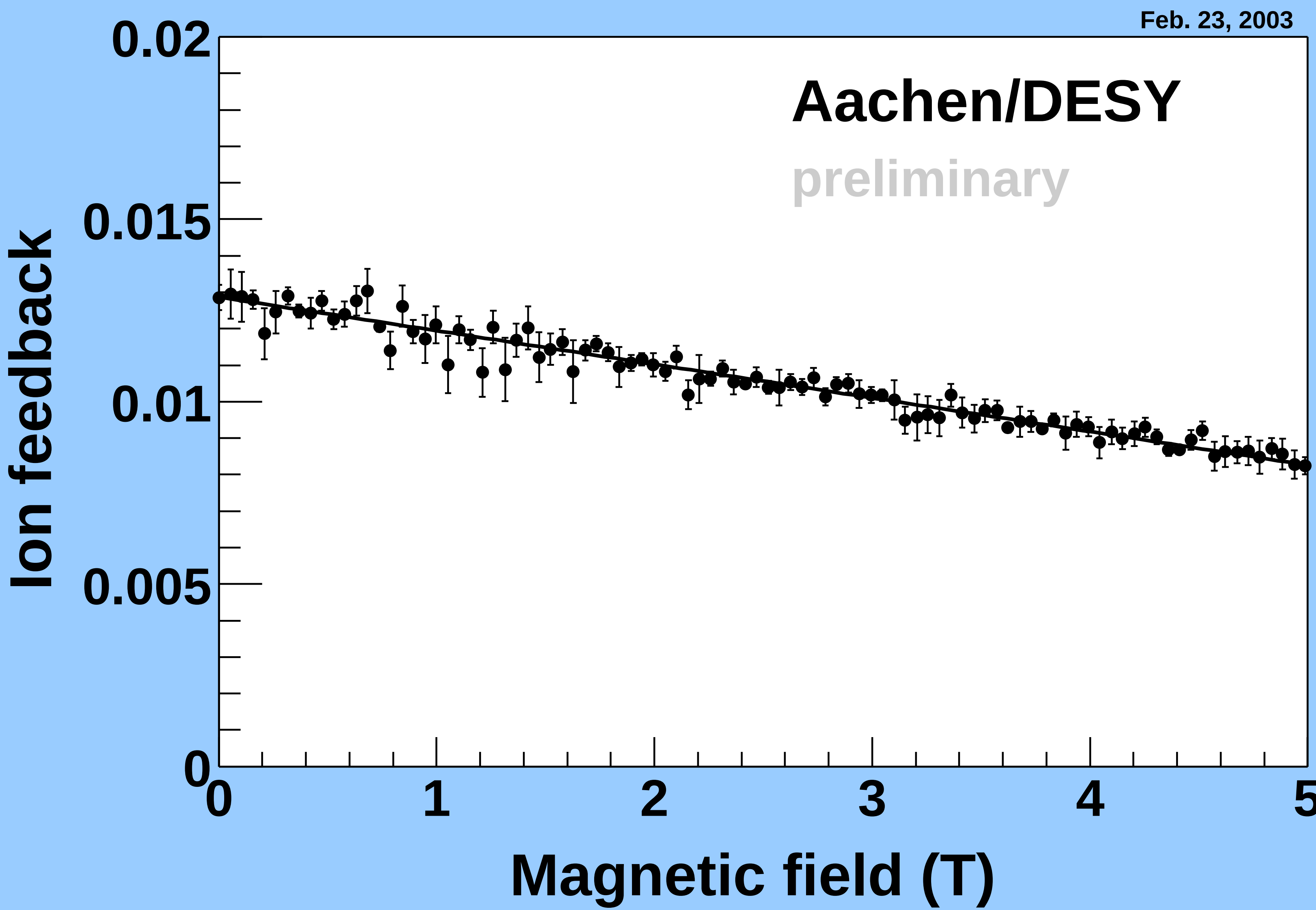
GEM in an Electric and Magnetic Field



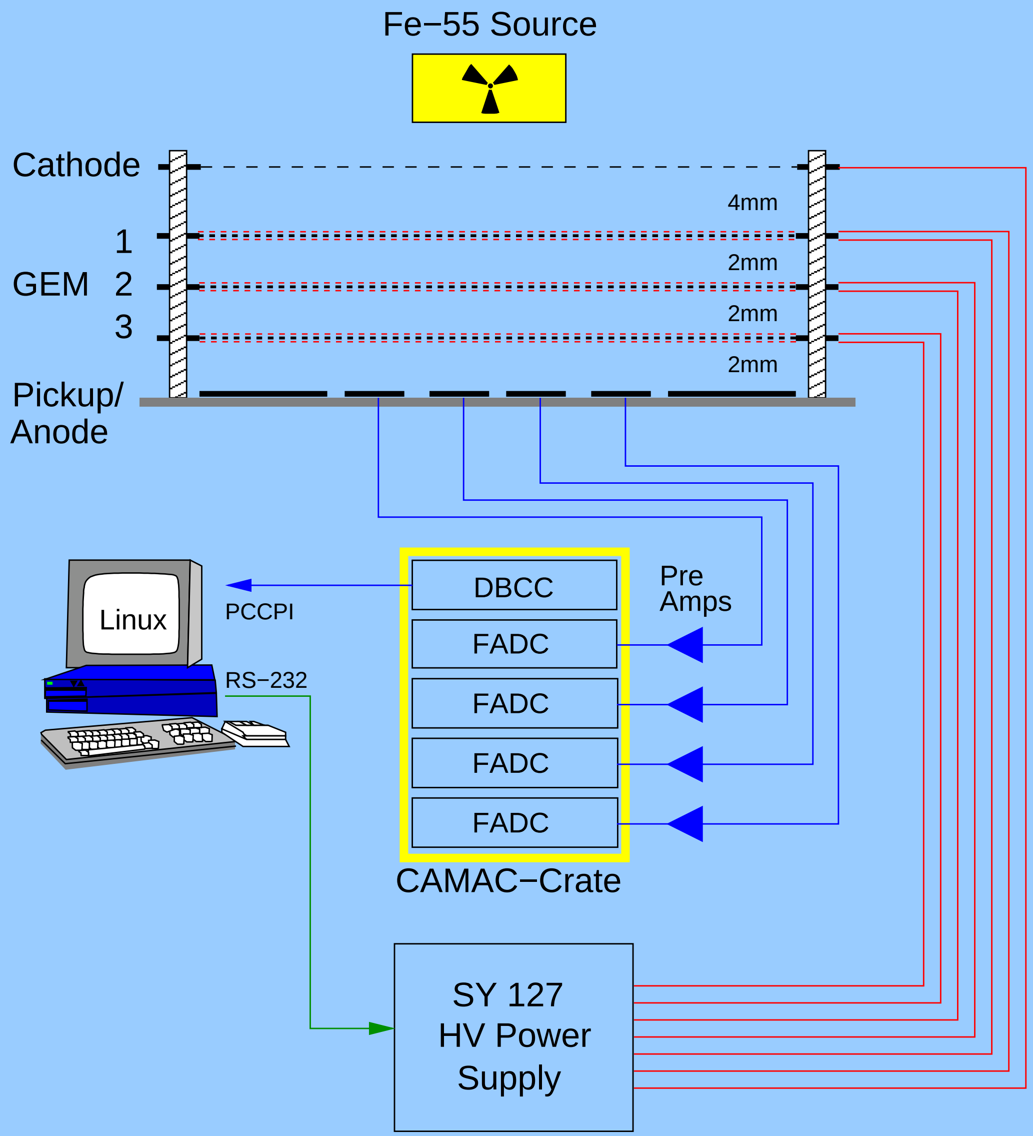
Langevin Formula:

$$\vec{v}_{Drift} \propto \frac{\vec{E}}{|\vec{E}|} + \omega\tau \left(\frac{\vec{E}}{|\vec{E}|} \times \frac{\vec{B}}{|\vec{B}|}\right) + \omega^2\tau^2 \left(\frac{\vec{E}}{|\vec{E}|} \cdot \frac{\vec{B}}{|\vec{B}|}\right) \frac{\vec{B}}{|\vec{B}|}$$

Ion Feedback in Magnetic Field



New Test Chamber Setup

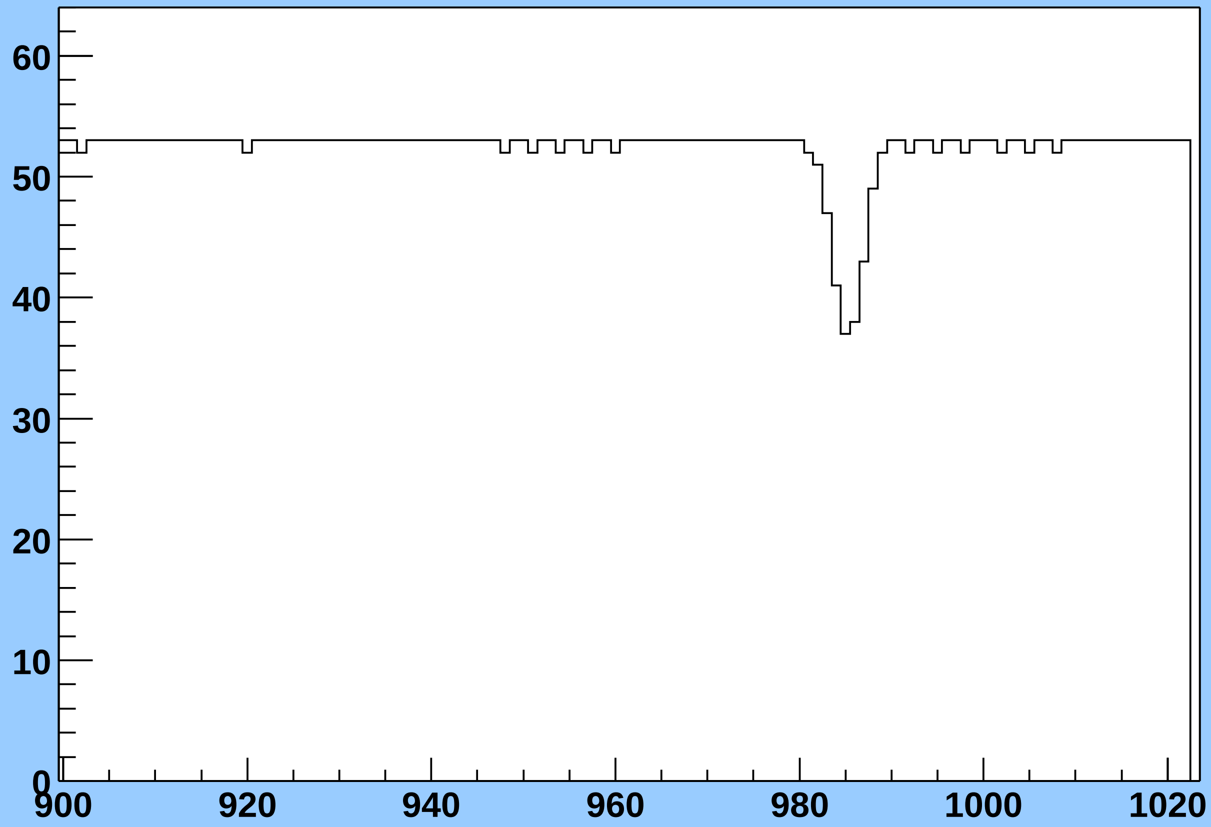


- 4 Pads
- Pad size $1 \times 1\ \mathrm{cm}^2$
- 100 MHz FADC, 6 Bit

First Pulses from the Chamber

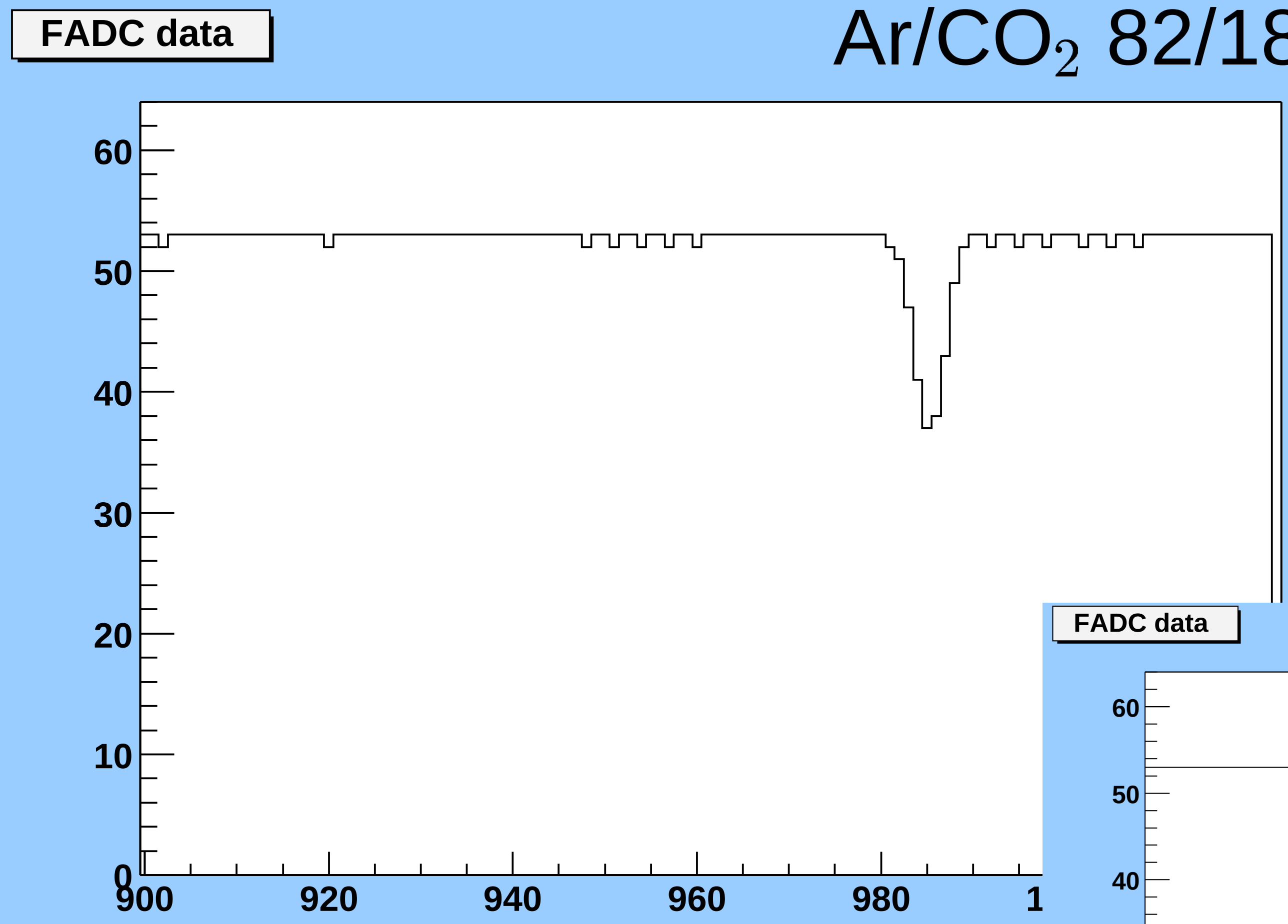
FADC data

Ar/CO_2 82/18

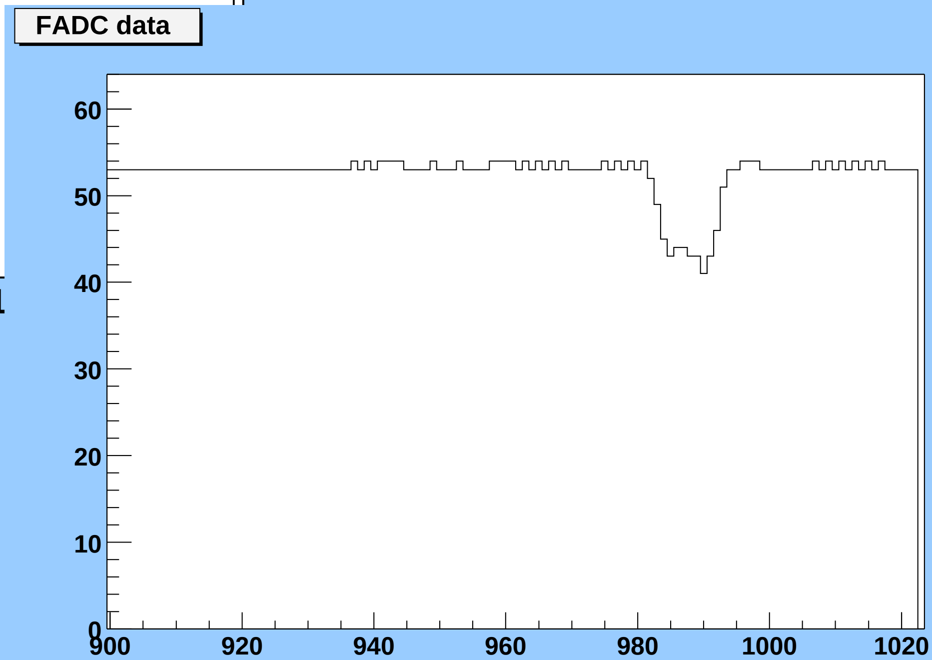


First Pulses from the Chamber

Ar/CO_2 82/18

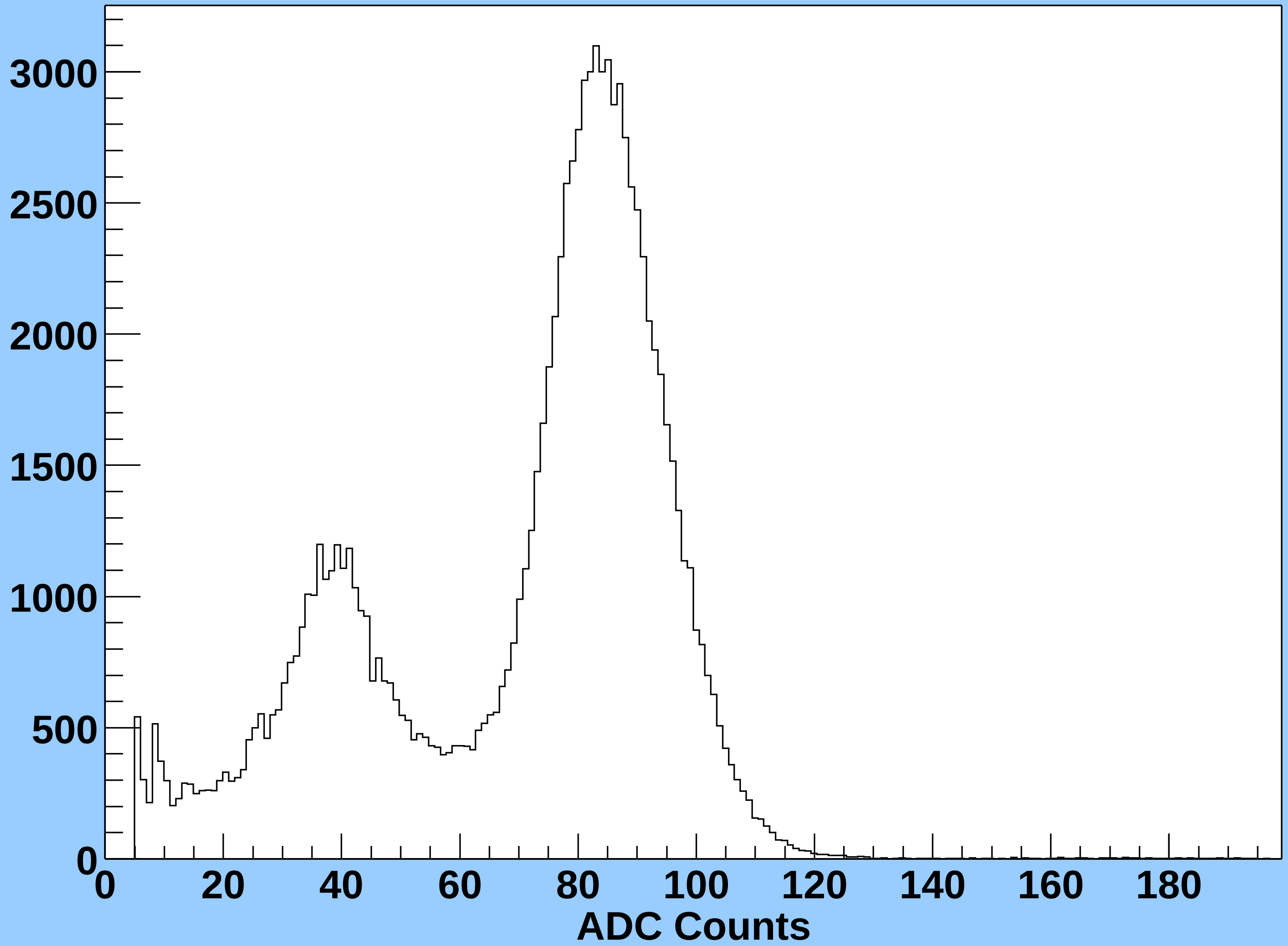


Ar/CH_4 95/5



Pulse Spectrum

Ar/CO_2 82/18



Electrostatic Simulations

- Electrons and ions follow electric field lines
- Calculation of transfer coefficients from electric flux

+ Helps to understand the effects
+ Qualitatively correct results
+ Parametrisation allows optimizations
  (e. g. ion feedback)

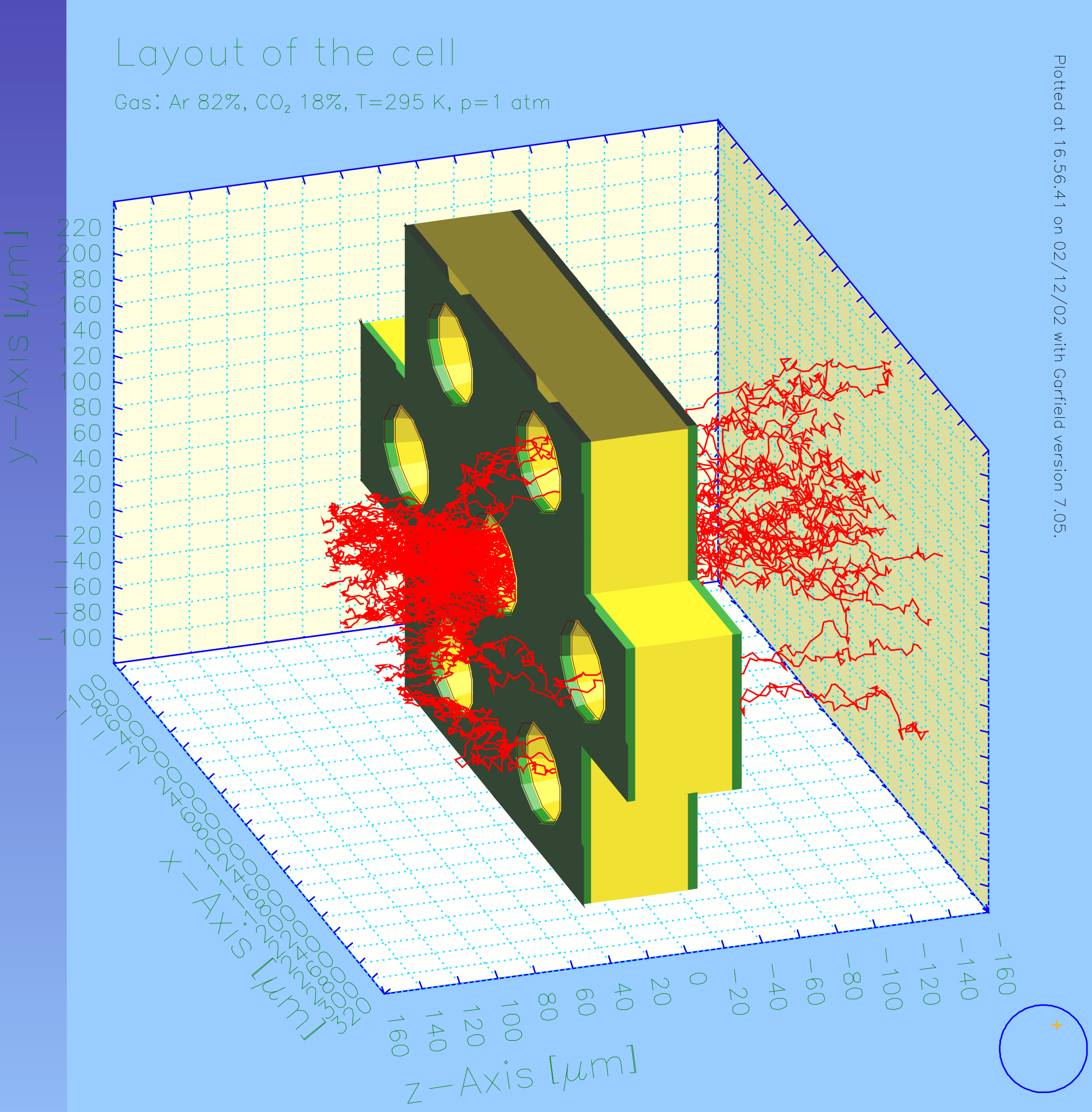
– No dependency on the gas
– No difference for electrons and ions
– No magnetic field

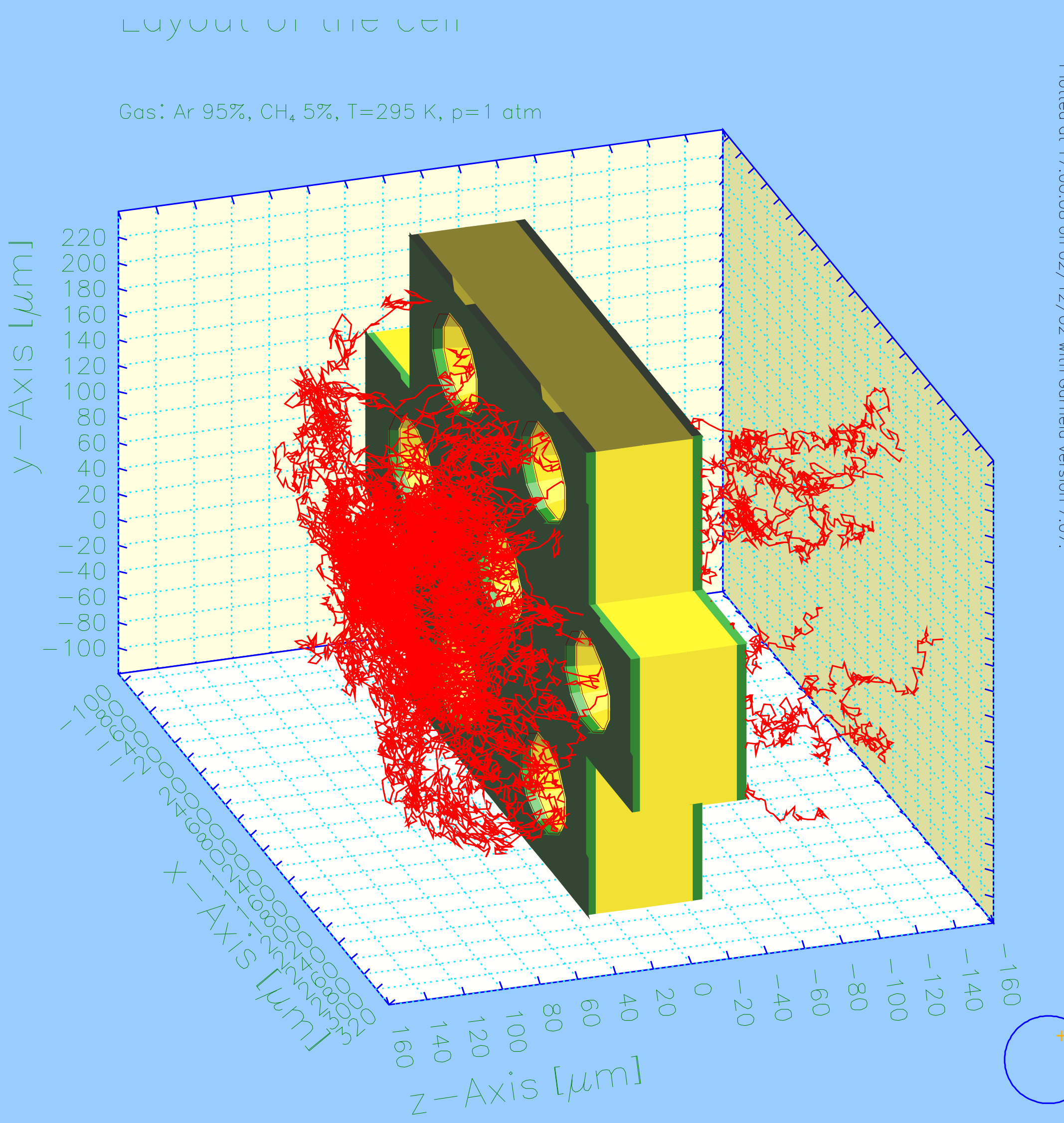
Monte Carlo Simulations with Garfield

Garfield by Rob Veenhof is a program to numerically simulate drift chambers.

- Can read field maps generated by Maxwell
- Drift and diffusion in gases are included in calculations
- Simulation of electrons and ions
- Drift in magnetic field
- Gas amplification can be simulated

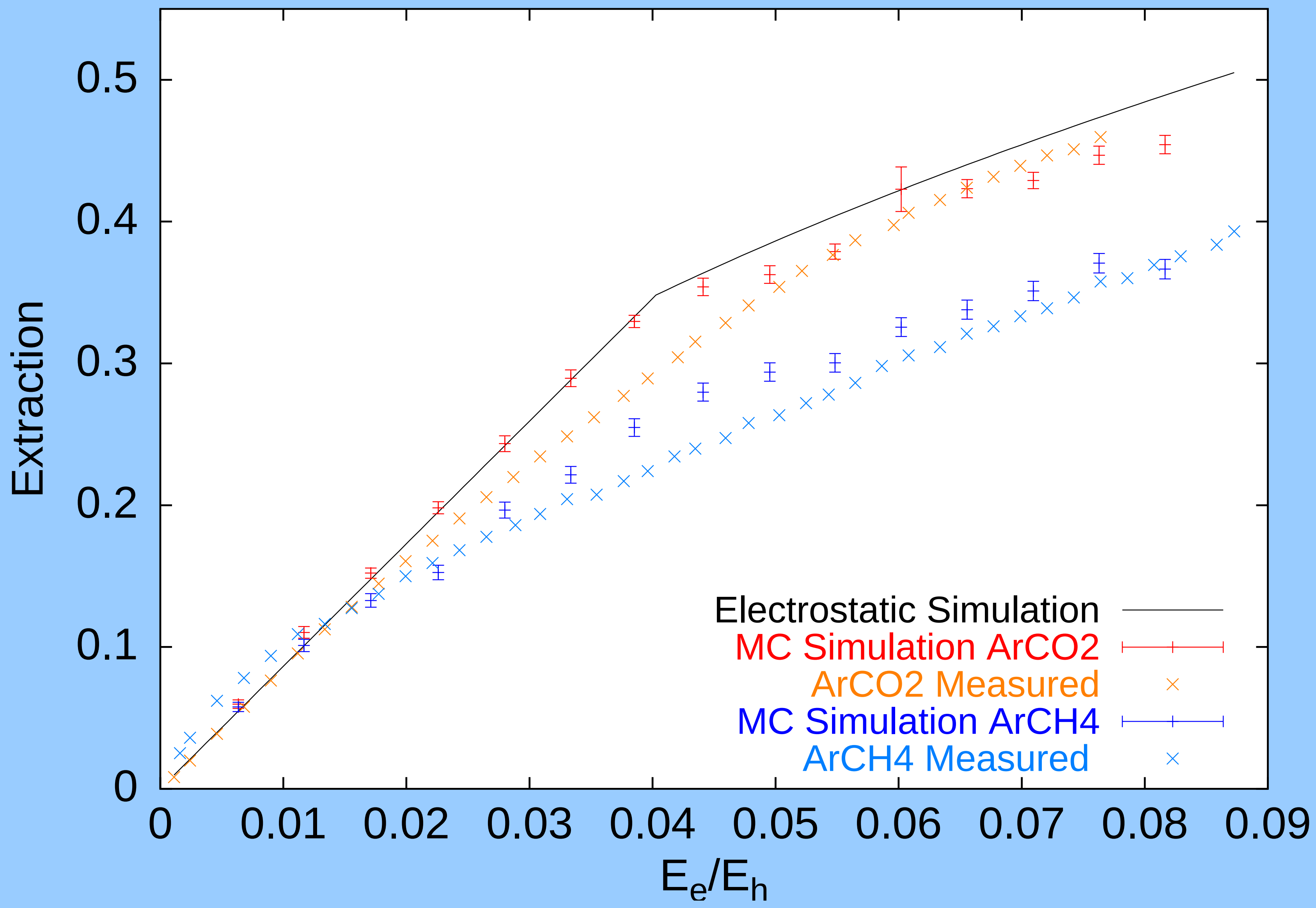
Monte Carlo Simulations with Garfield



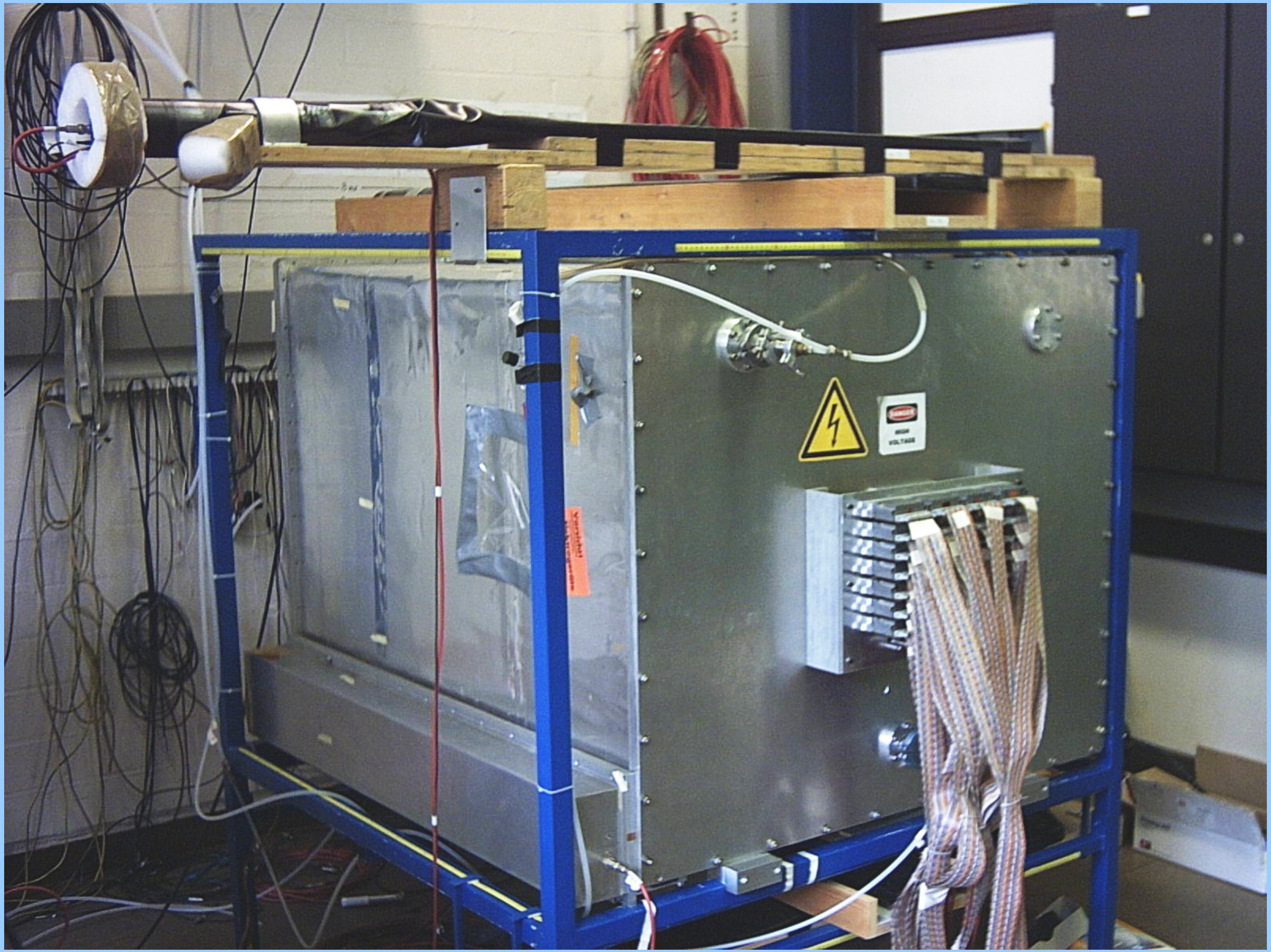


Extraction Efficiency for Electrons

Simulations and Measurement



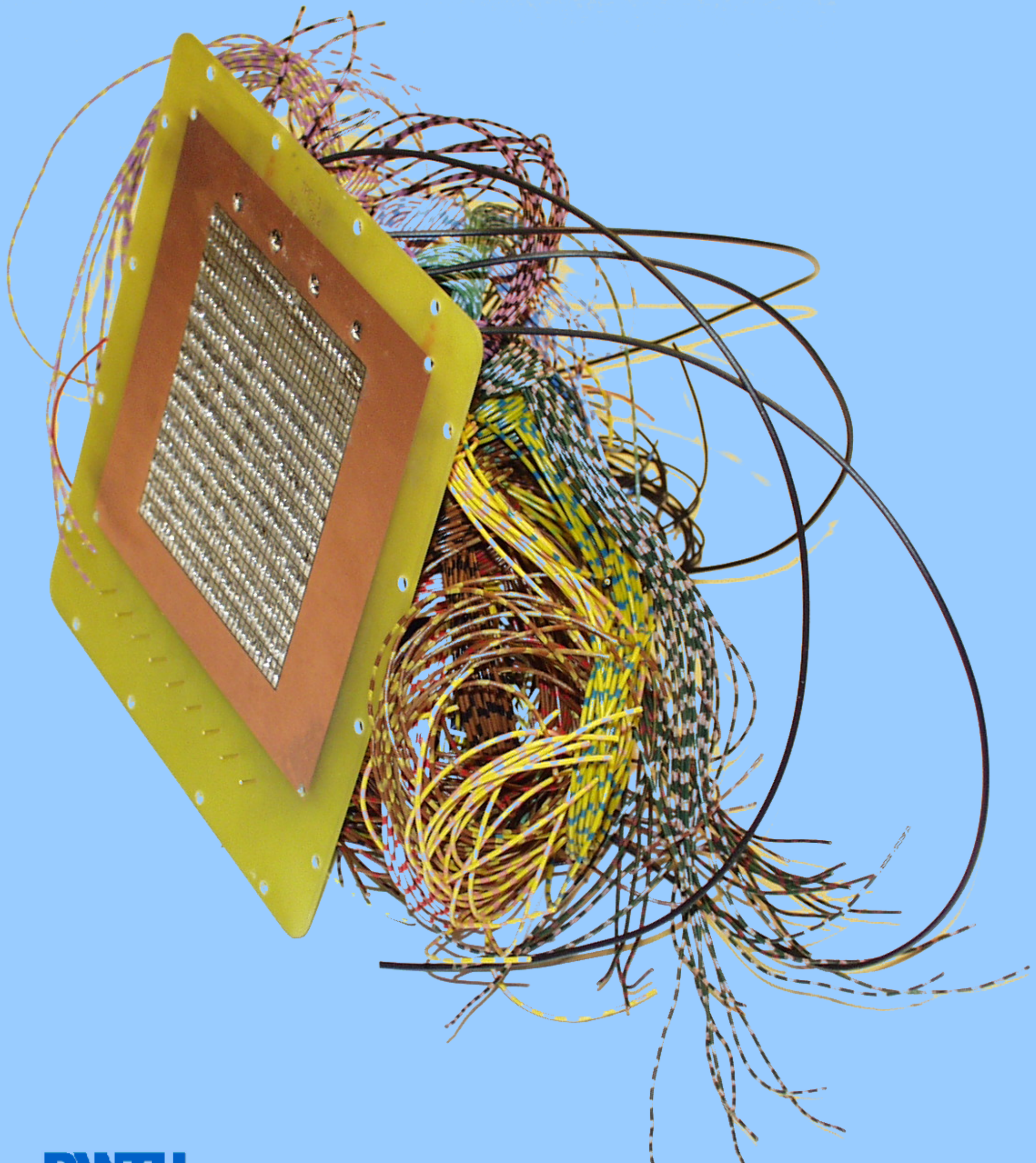
Large TPC with GEM Readout



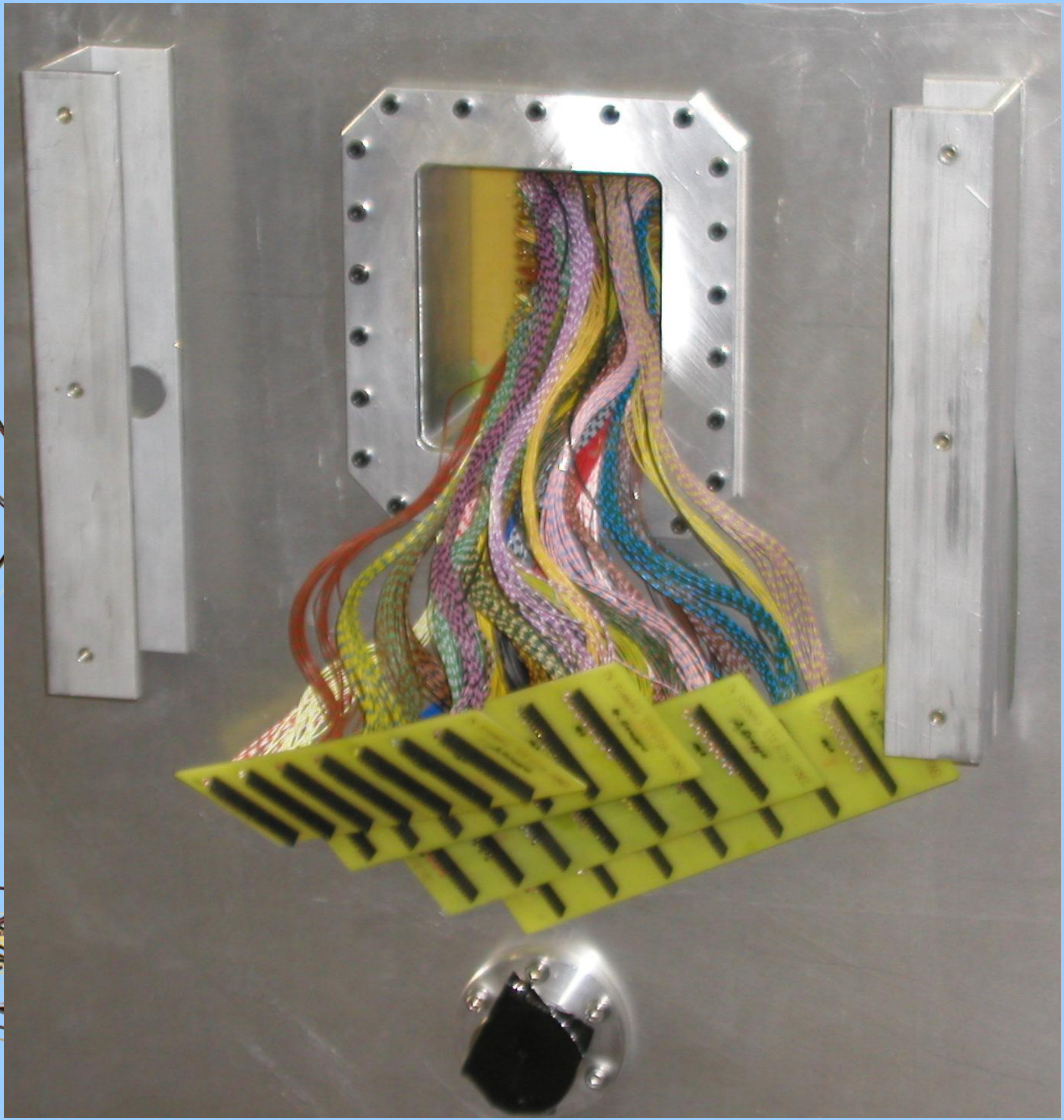
TPC Test Stand

- 3 GEMs
- Rectangular Pads: $2 \times 6\ \mathrm{mm}^2$
- Active Area: $76.8 \times 89.6\ \mathrm{mm}^2$
- 448 Channels
- 12.5 MHz 8 Bit
- Gas System
- Used Gas: Ar/CH_4 95/5

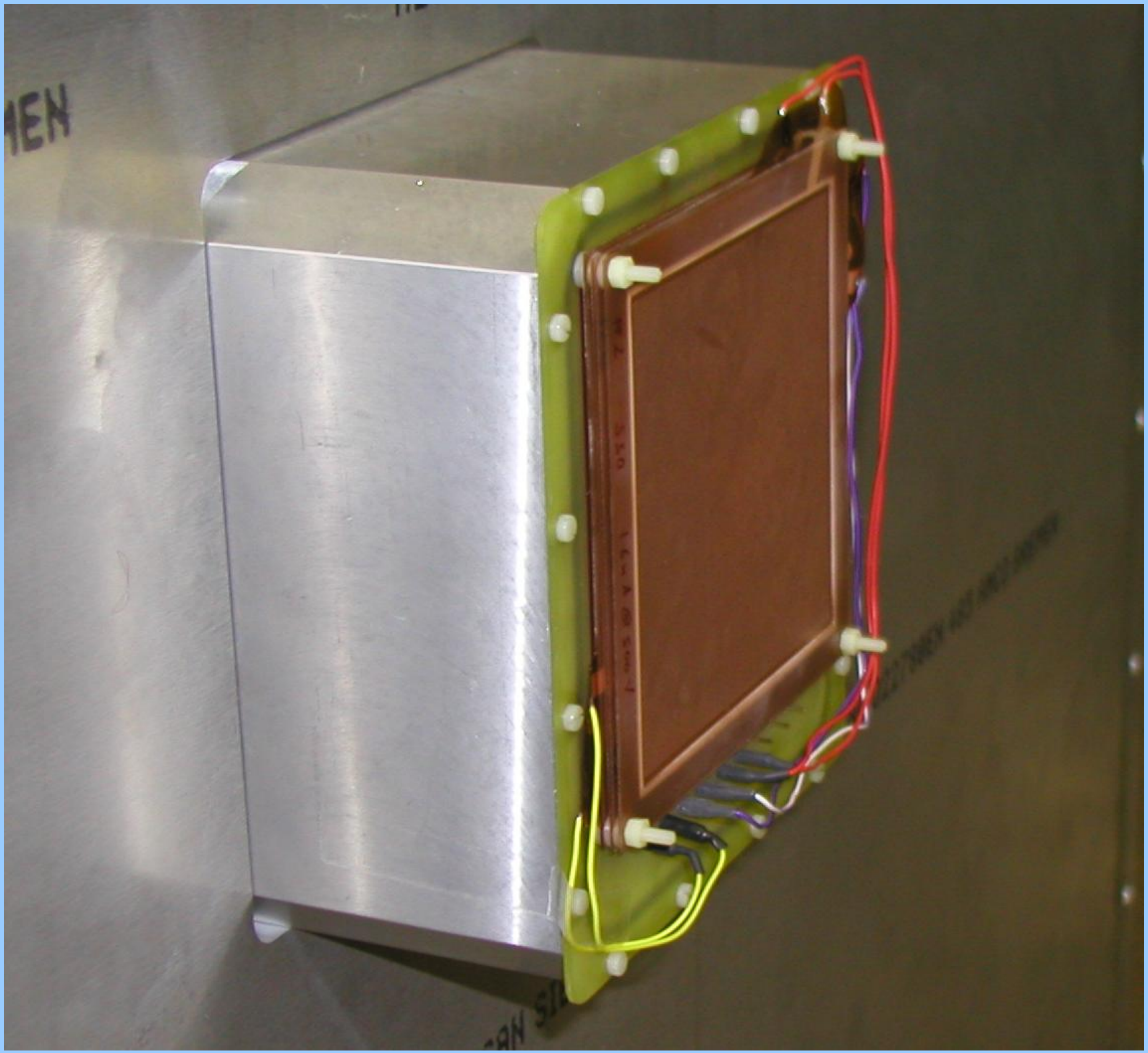
New Readout Pad Structure



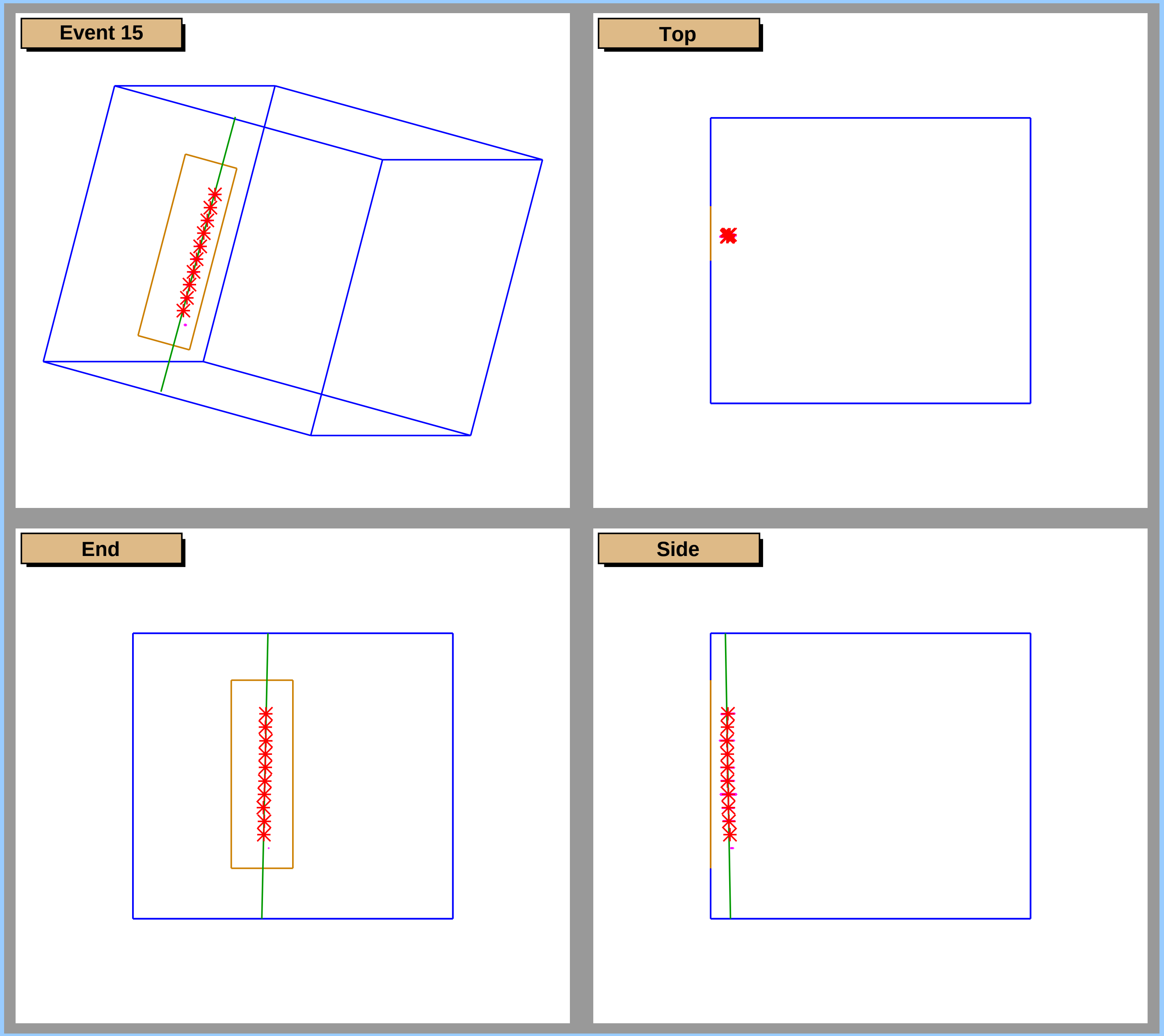
New Readout Pad Structure



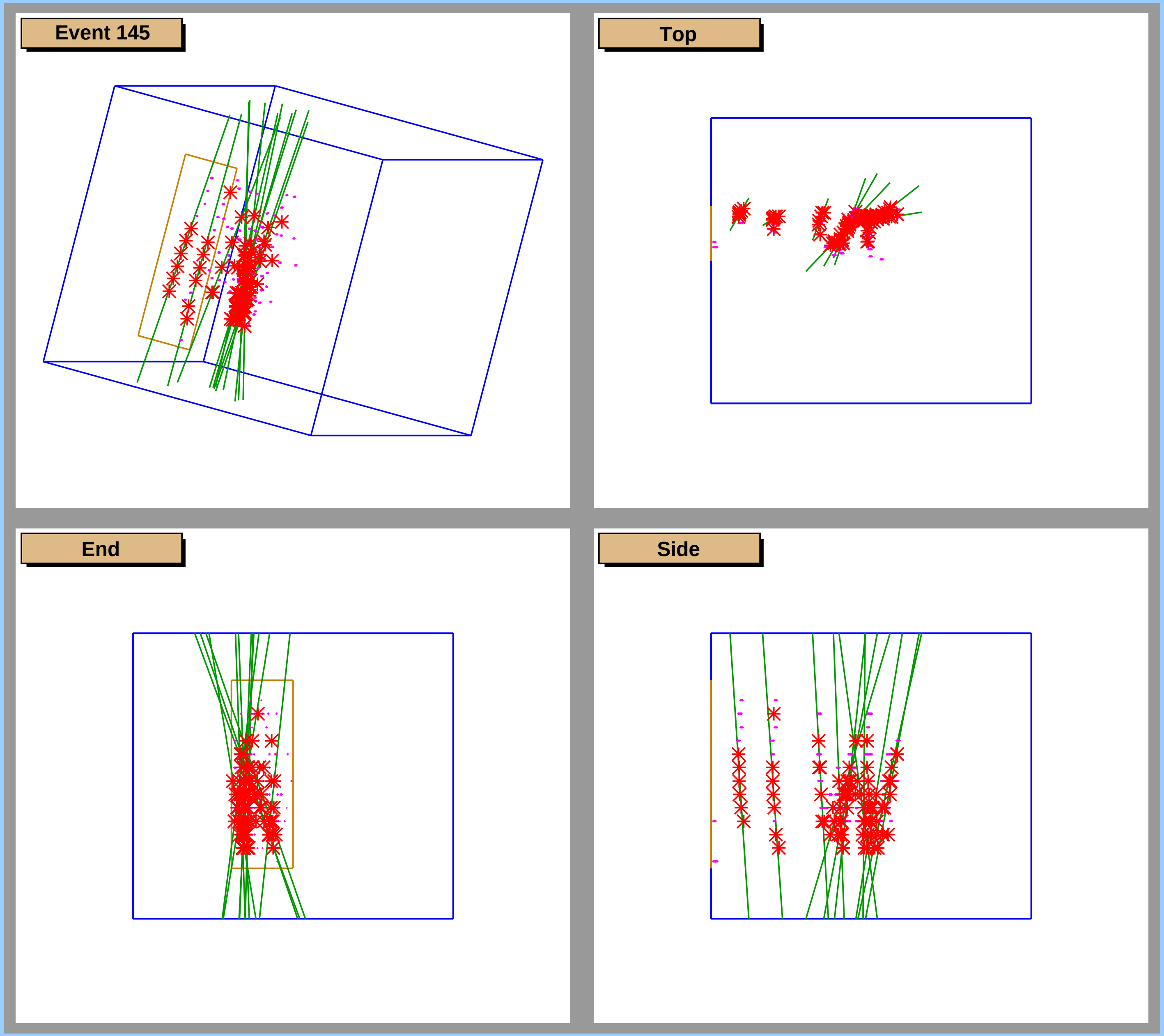
The new Readout Module



Event Display



Event Display



Outlook

- Measurements in Magnetic Field at DESY
  - New measurements in May (e. g. different gases)
- Test Chamber for Readout Tests
  - Charge spreading in GEM structures
- Garfield Simulations
  - Gas amplification
  - Magnetic fields
- TPC
  - Spatial resolution
  - dE/dX
  - Long term stability

Transfer Coefficients

- Collection Efficiency:

$$C^{\pm} = \frac{\mathrm{N}_{e^-,\,I^+}\ \text{collected into holes}}{\mathrm{N}_{e^-,\,I^+}\ \text{in drift volume in front of GEM}}$$

- Extraction Efficiency:

$$X^{\pm} = \frac{\mathrm{N}_{e^-,\,I^+}\ \text{extracted from GEM}}{\mathrm{N}_{e^-,\,I^+}\ \text{in GEM holes}}$$

- Ion Feedback:

$$\Gamma^{+} = \frac{\mathrm{N}_{I^+}\ \text{collected on cathode}}{\mathrm{N}_{e^-}\ \text{collected on anode}}$$

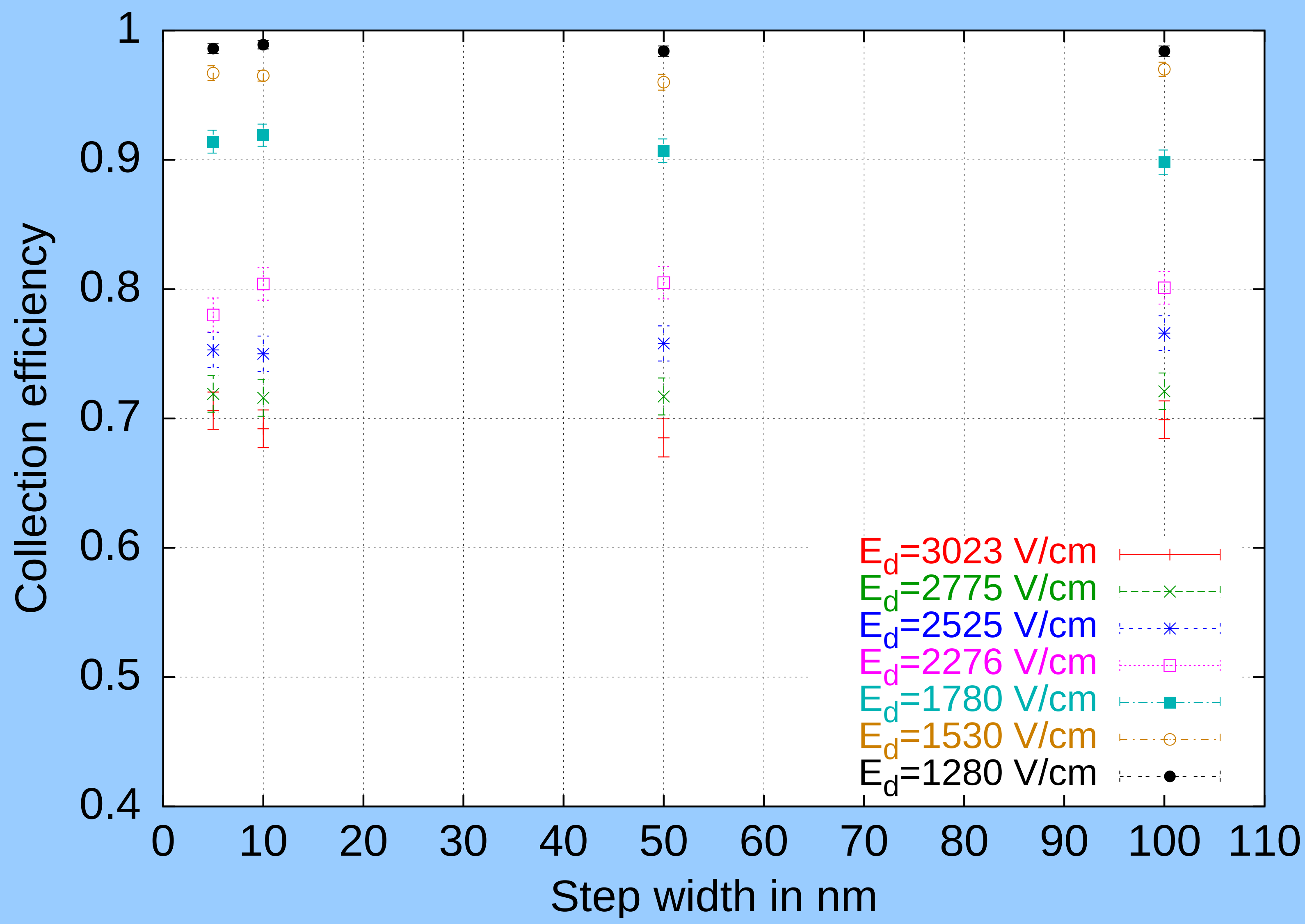
Anode Current and Transfer Coefficients

- To allow the individual analysis of coefficients a periodical setup of fields and GEM voltages was chosen:
  e. g. $U_{GEM} = 330V$, $E = 1000V/cm$
  (fields, voltages identical $\rightarrow$ coefficients identical)
- Then the anode current can be expressed by the primary ionisation and the coefficients:

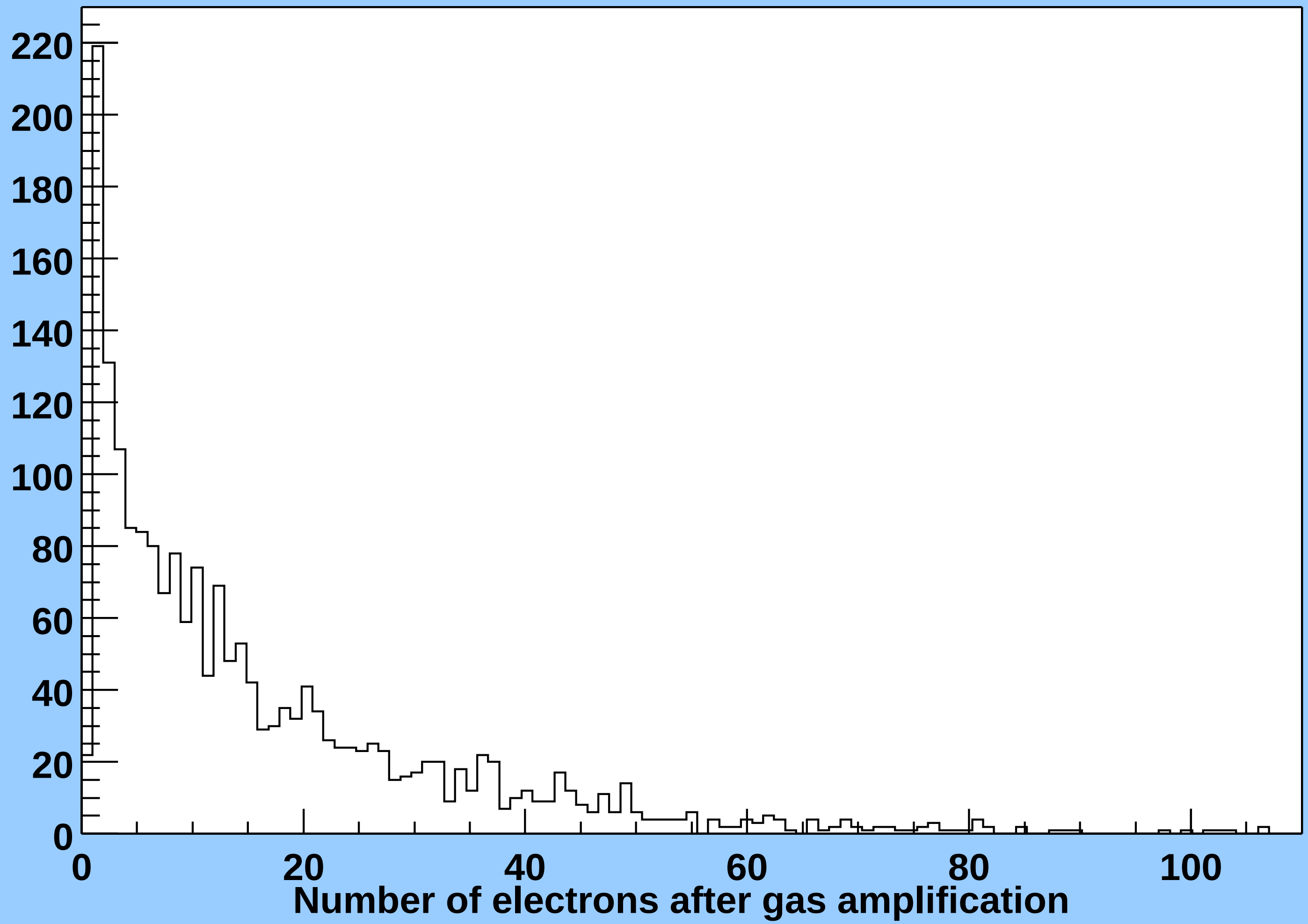
$$\begin{aligned} I_A &= I_P \quad \cdot C_{GEM1} \cdot G_{GEM1} \cdot X_{GEM1} \\ &\qquad\quad \cdot C_{GEM2} \cdot G_{GEM2} \cdot X_{GEM2} \\ &\qquad\quad \cdot C_{GEM3} \cdot G_{GEM3} \cdot X_{GEM3} \\ &= \quad I_P \cdot C^3_{GEM} \cdot G^3_{GEM} \cdot X^3_{GEM} \end{aligned}$$

Garfield: Dependency on the step width

Electron collection in Ar/CO2 82/18



Ar/C02 82/18


220
200
180
160
140
120
100
80
60
40
20
0
0
20
40
60
80
100
Number of electrons after gas amplification