Status of the Aachen R&D for the ILC TPC

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http://www.physik.rwth-aachen.de/group/IIIphys/TPC/

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

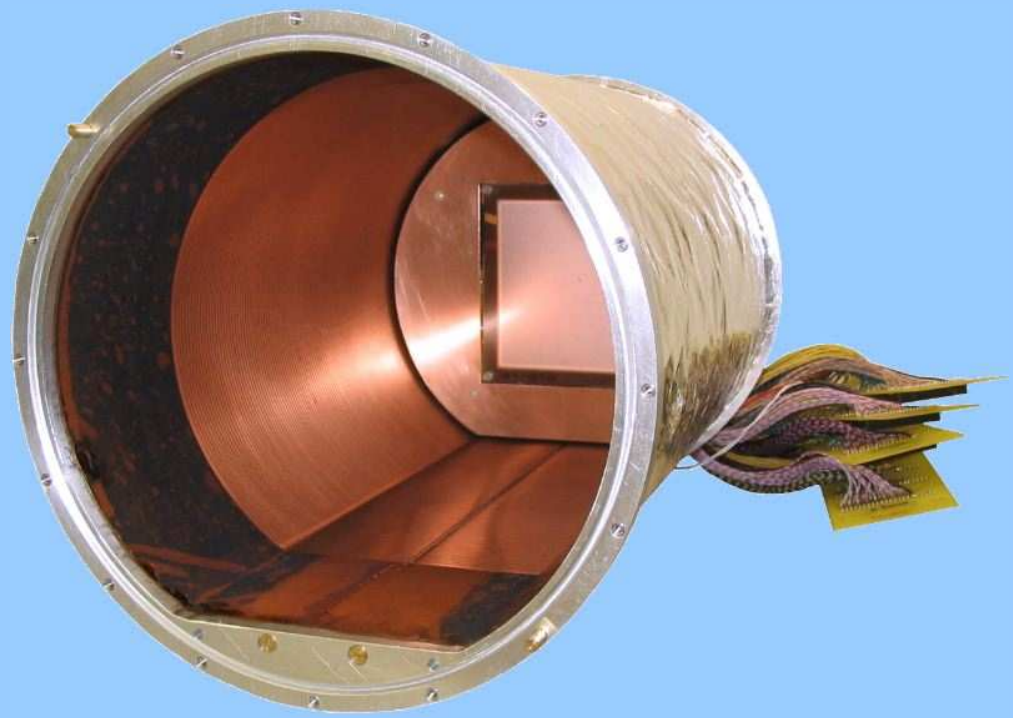
bmb+f Großgeräte der physikalischen Grundlagenforschung

Overview

- Test Beam Setup
  - TPC Prototype
  - Hodoscope
- Preliminary Results
  - Beamprofile
- Simulation Studies

TPC Prototype

- 5T Magnet at DESY Hamburg
  $\Rightarrow$ 260 mm diameter
- Triple GEM readout is used
- Drift distance = 260 mm
- Maximum drift field = 1000 $\frac{V}{cm}$
- Materials with low density

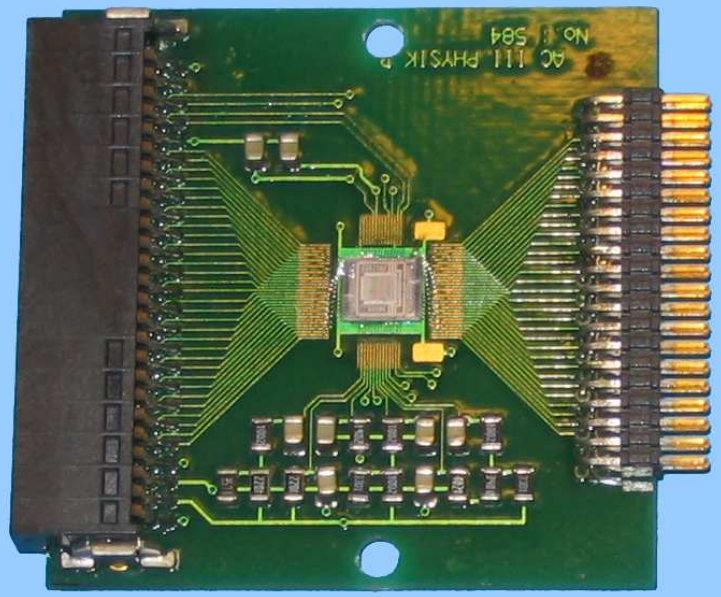


Electronics: Preamplifiers

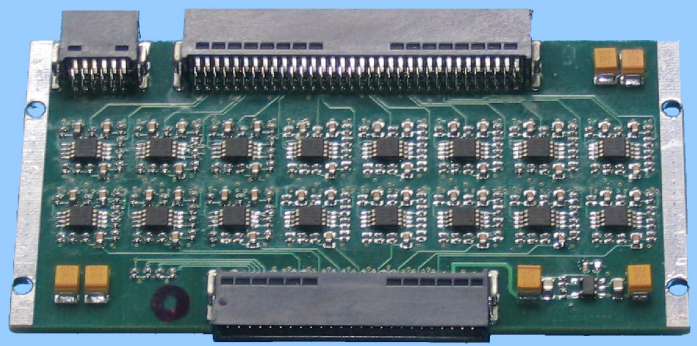
Preamplifiers: Preshape 32

- Predecessor of Premux & APV (CMS silicon tracker)
- 32 channel preamplifier/shaper
- Nominal peaking time: 45ns
- Needs cable driver to transfer signal over reasonable distance

Preamplifier



Cable Driver



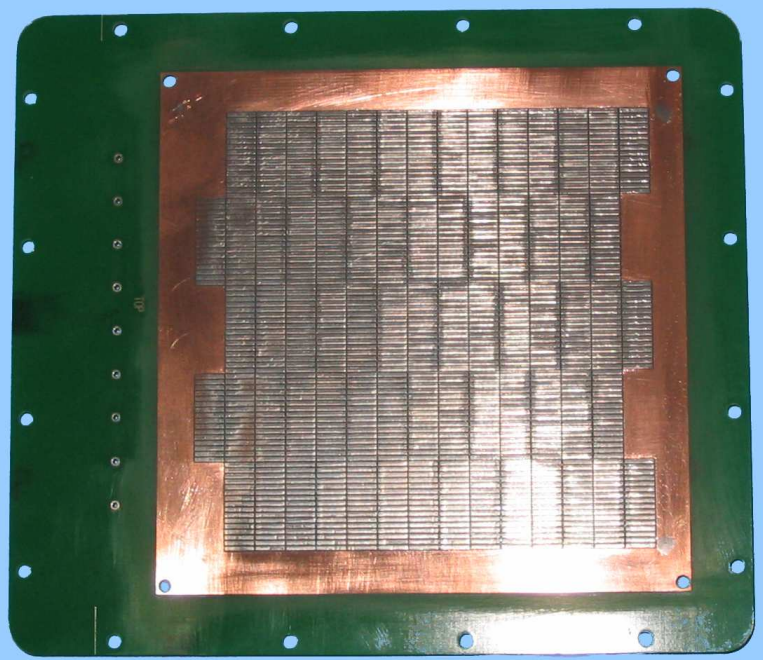
Electronics: ADCs

Fastbus ADCs (ALEPH)

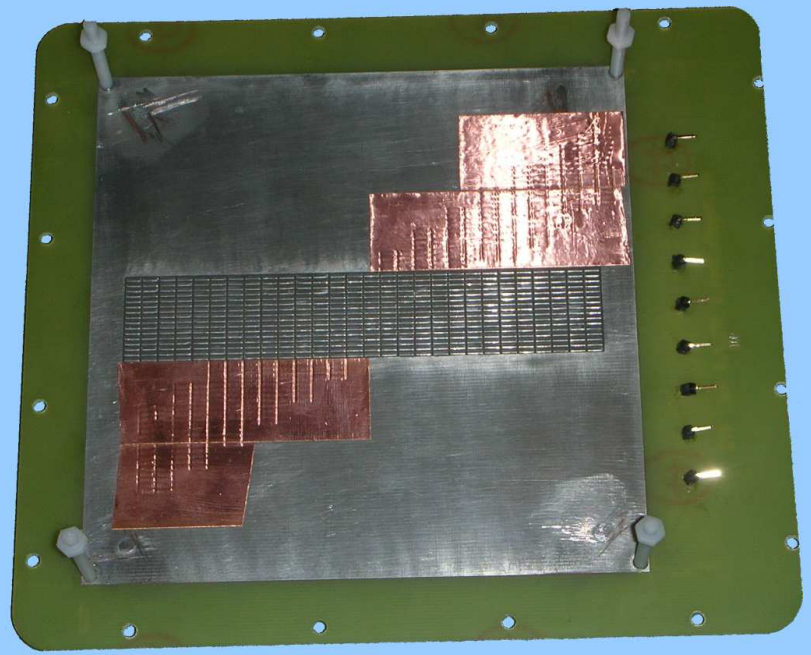
- 448 Channels
- 12.5 MHz
- 8 Bits
- 20 Hz DAQ rate

Pad Planes

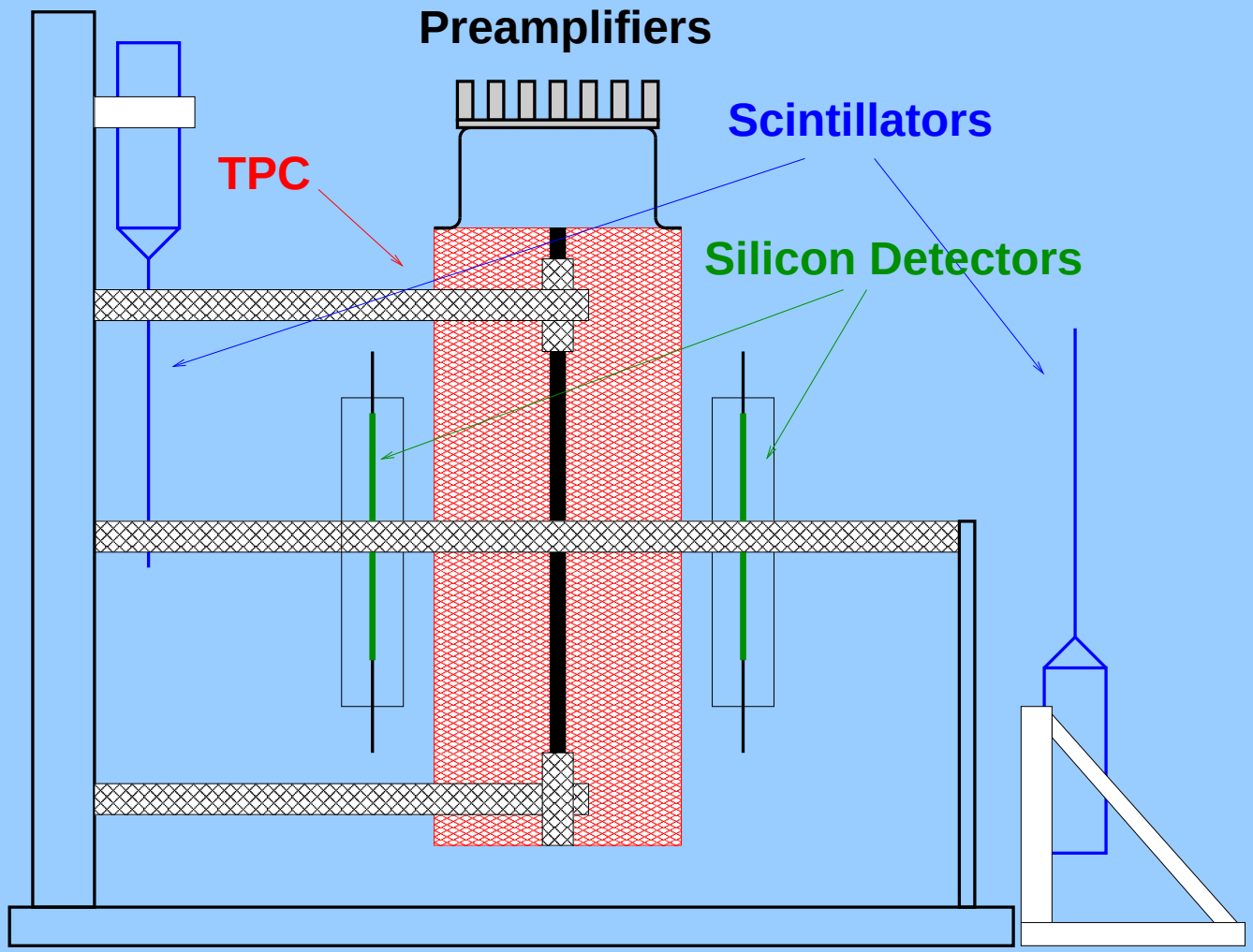
- 1.27 x 7 mm^2 Pads
- 1120 Pads
  $\Rightarrow$ flexible configuration of 448 active channels

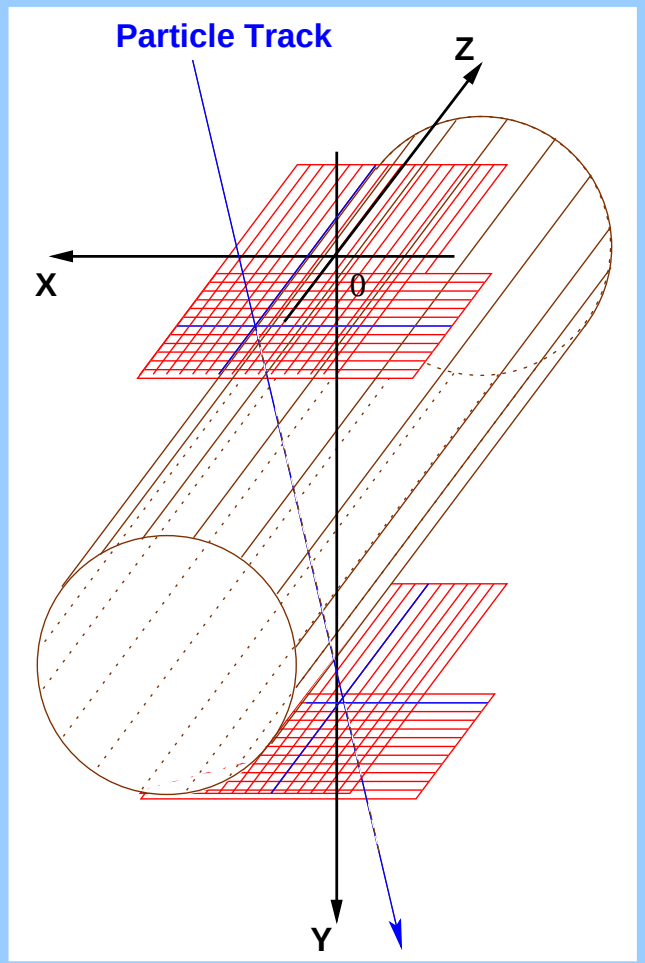


- 1.27 x 3.5 mm^2 Pads
- 448 Pads in small angle mode (0 .. 8 degrees)
- 448 Pads in large angle mode (25 .. 38 degrees)



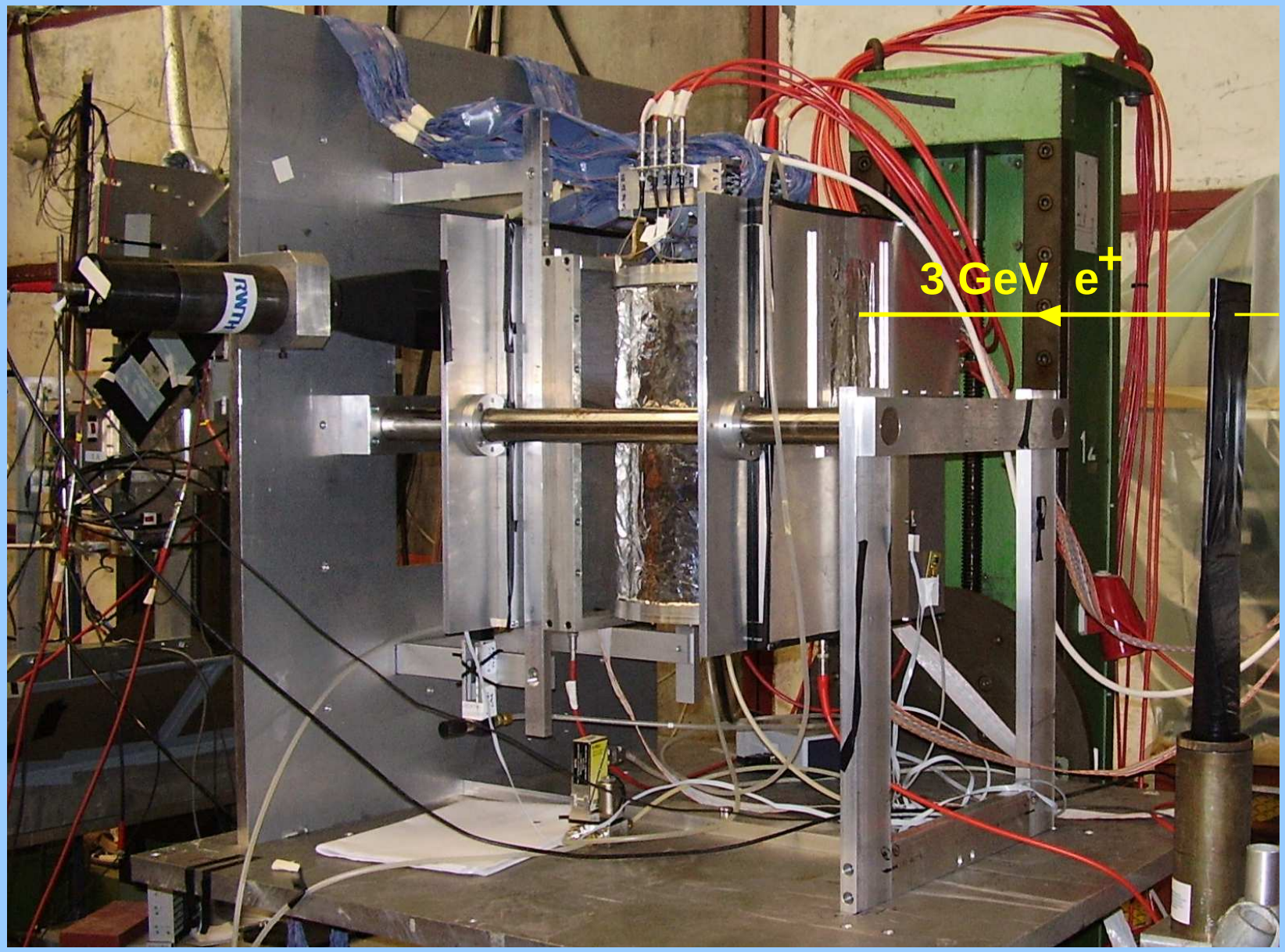
TPC Prototype: Hodoscope Test Stand





Hodoscope resolution: 60 μm

Testbeam Setup



Testbeam at DESY

Precision Measurements:

Calibration of TPC in Hodoscope :

Position in x : $\pm$ 4 μm
Position in y : $\pm$ 14 μm
Position in z : $\pm$ 3 μm

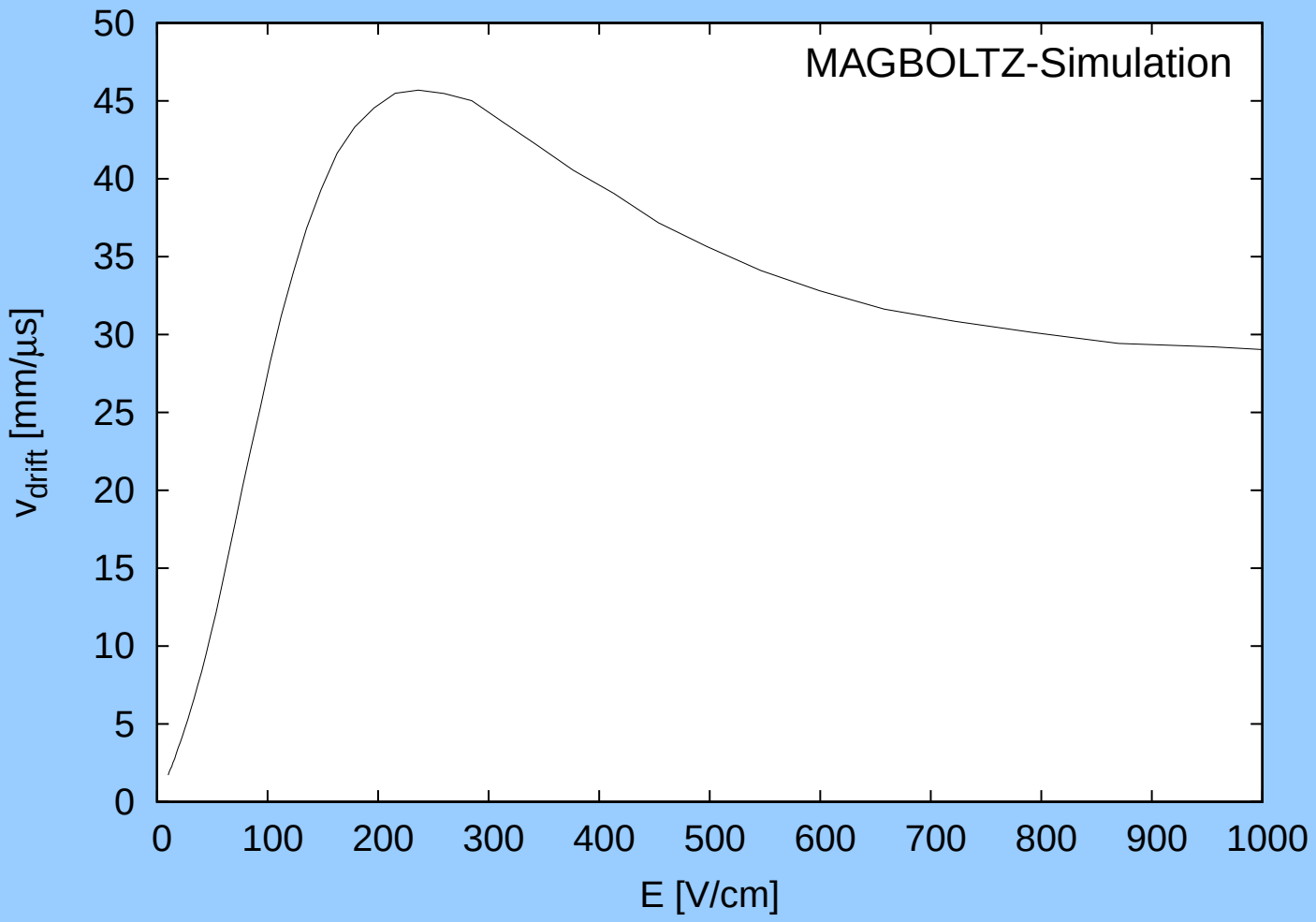
Measurement of drift velocity : $\pm$ 10^{-3} mm/μs

All values statistical errors of the fit.

Systematic errors have to be studied!

Measurement of Field Homogeneity

Drift Velocity in the Gas (TDR : Ar-CO_2-CH_4 93-2-5)



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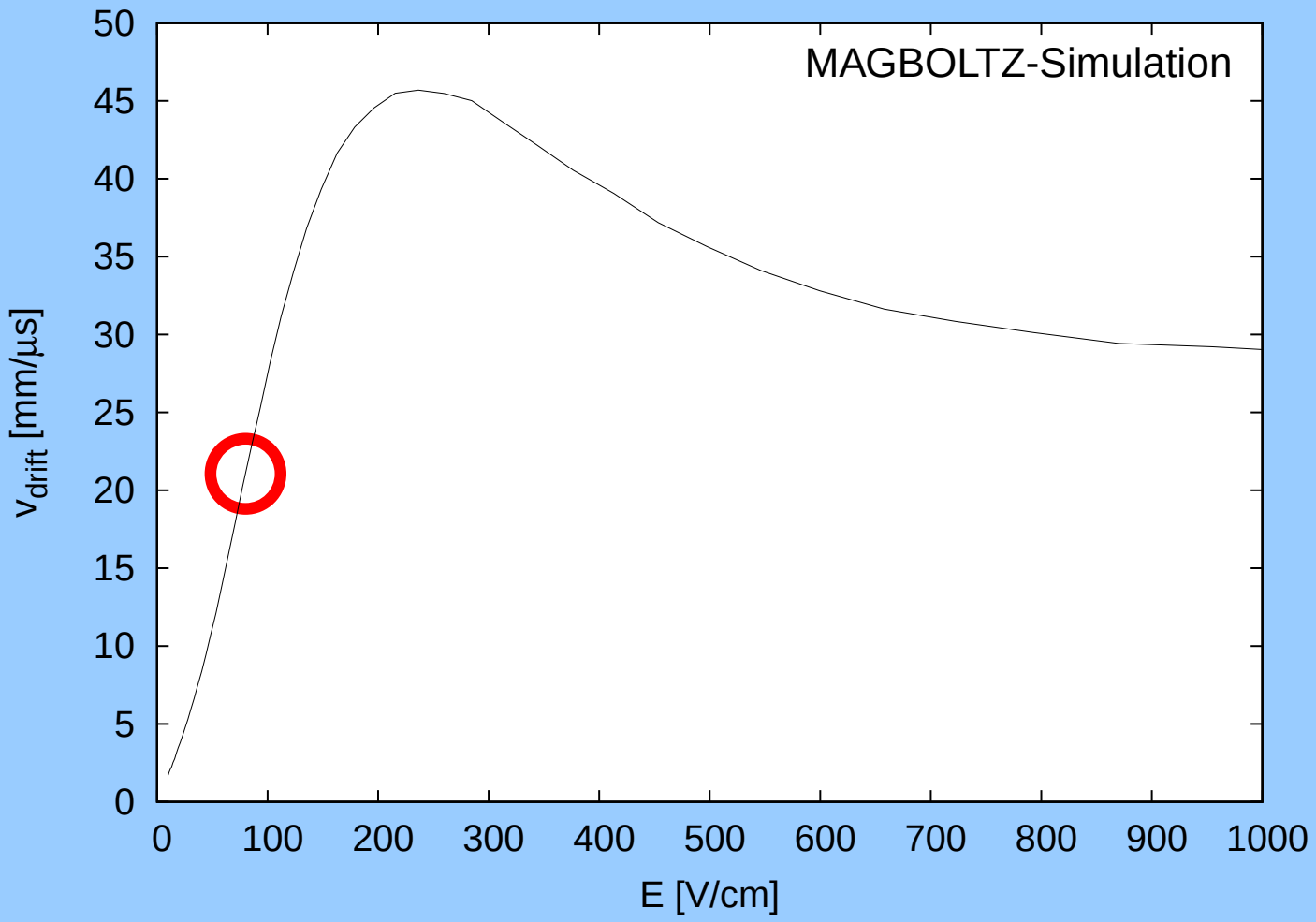
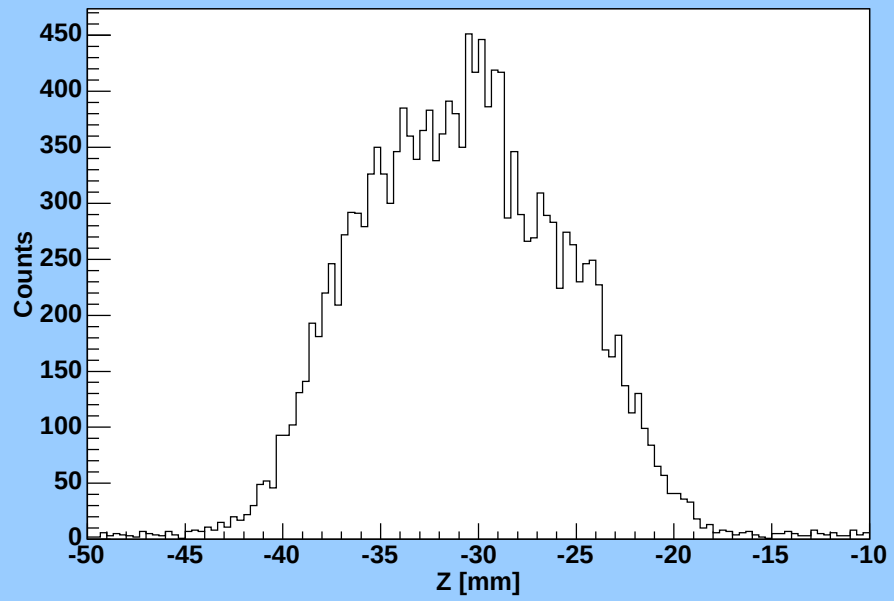


Maximum sensitivity at steepest slope (80 V/cm).

No results yet, analysis going on.

Beamprofile in z (Time Direction)

Hodoscope



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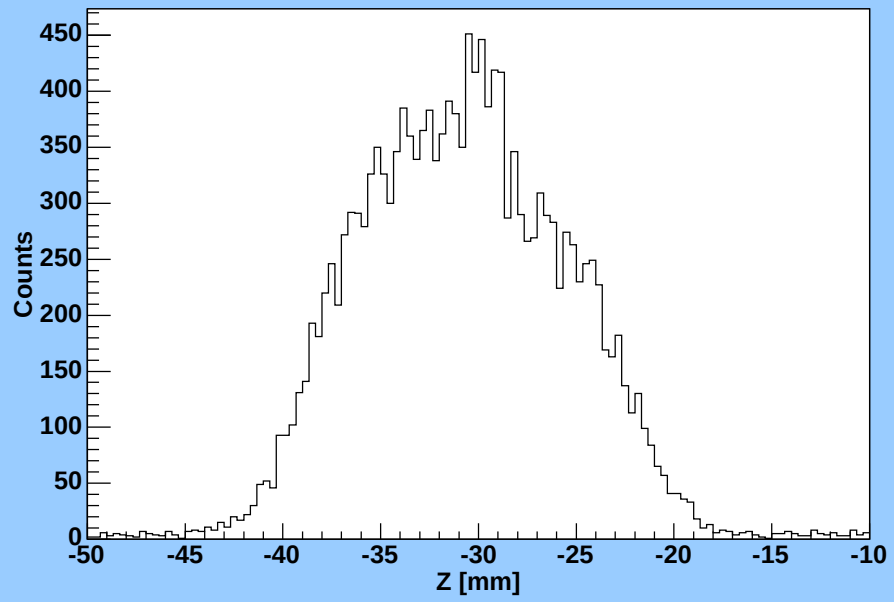
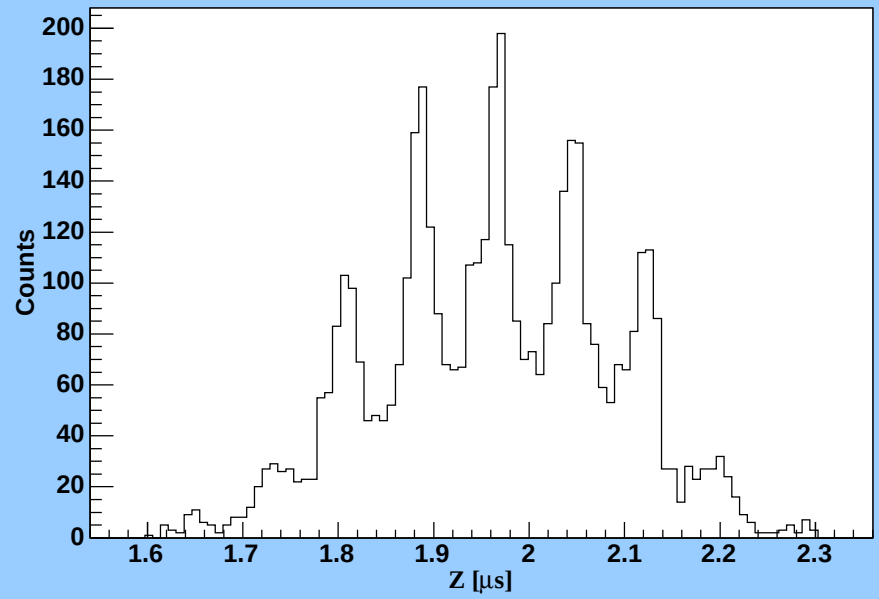
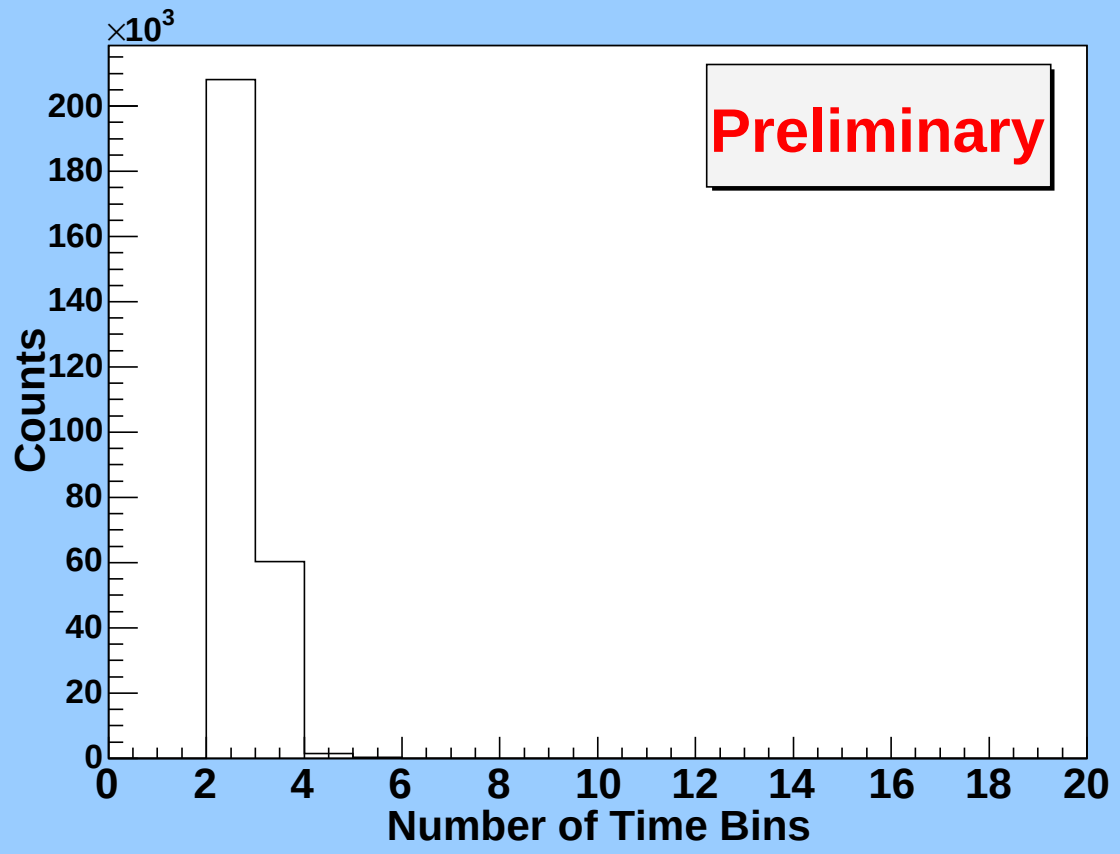


TPC



- Peaks in TPC measurement
- Distance 80 ns $\widehat{=}$ 1 timebin

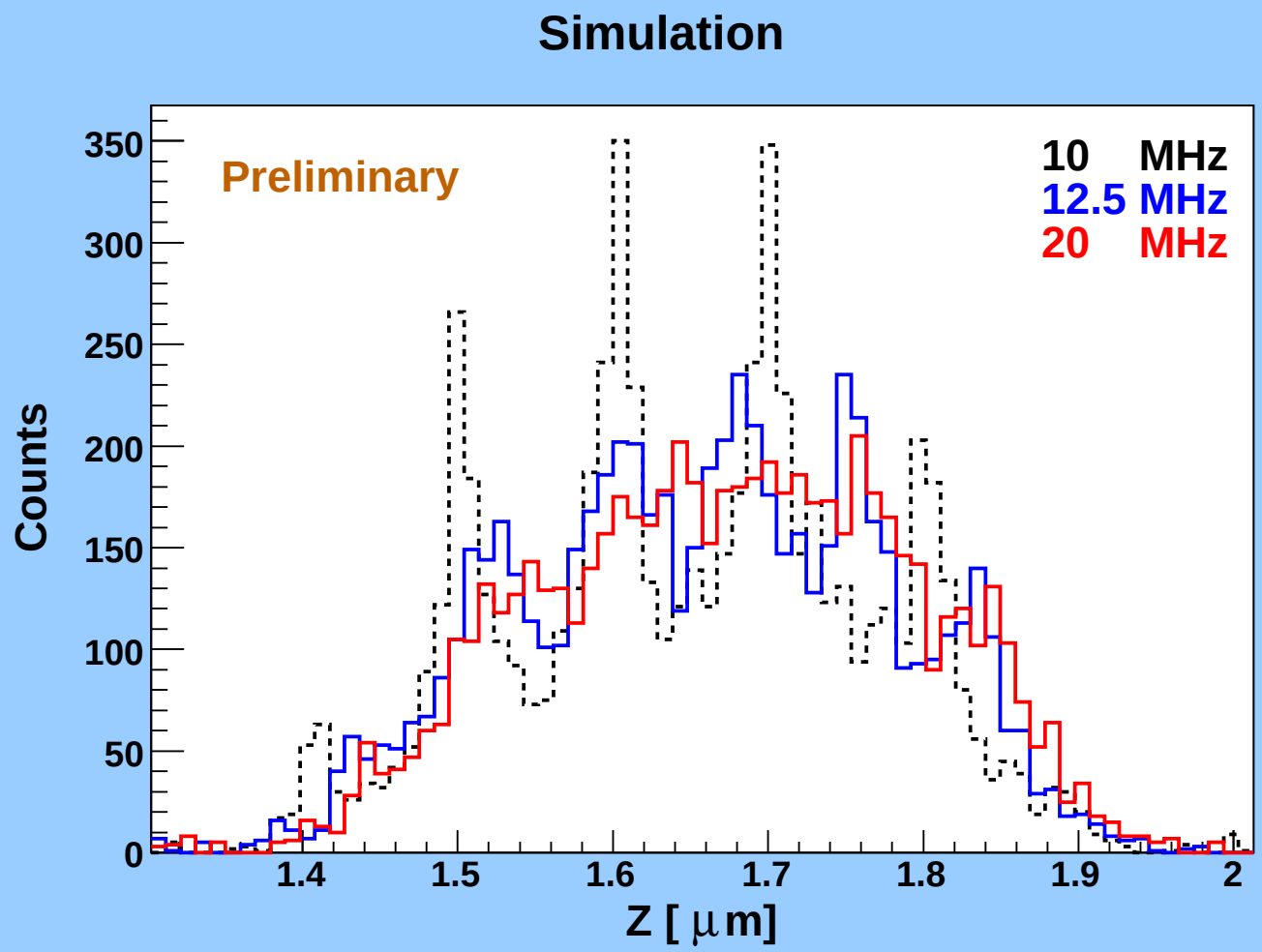
Number of Timesamples per Pulse



Only two time bins per pulse ⇒ jitter

Faster ADCs required

Beamprofile Measured with TPC



Readout frequency > 20 MHz required

Simulation Studies

Goals: Study influence on the spatial resolution of a TPC of

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

4 Modules:

1. Primary ionization
2. Drift of electrons
3. Gas amplification with GEMs
4. Electronics (shaper, ADC)

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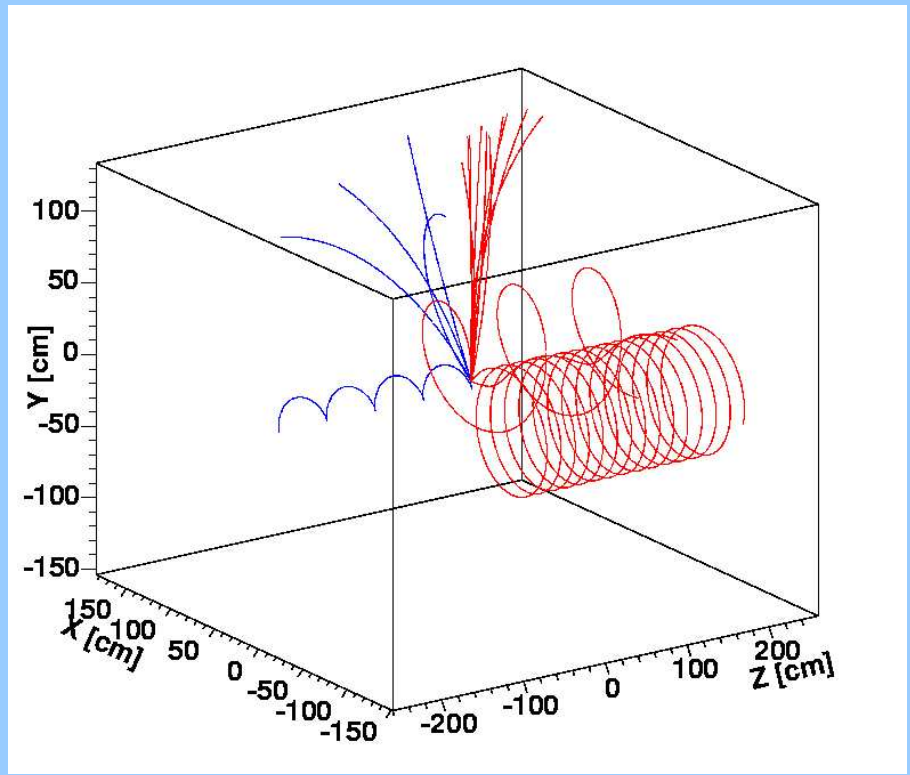

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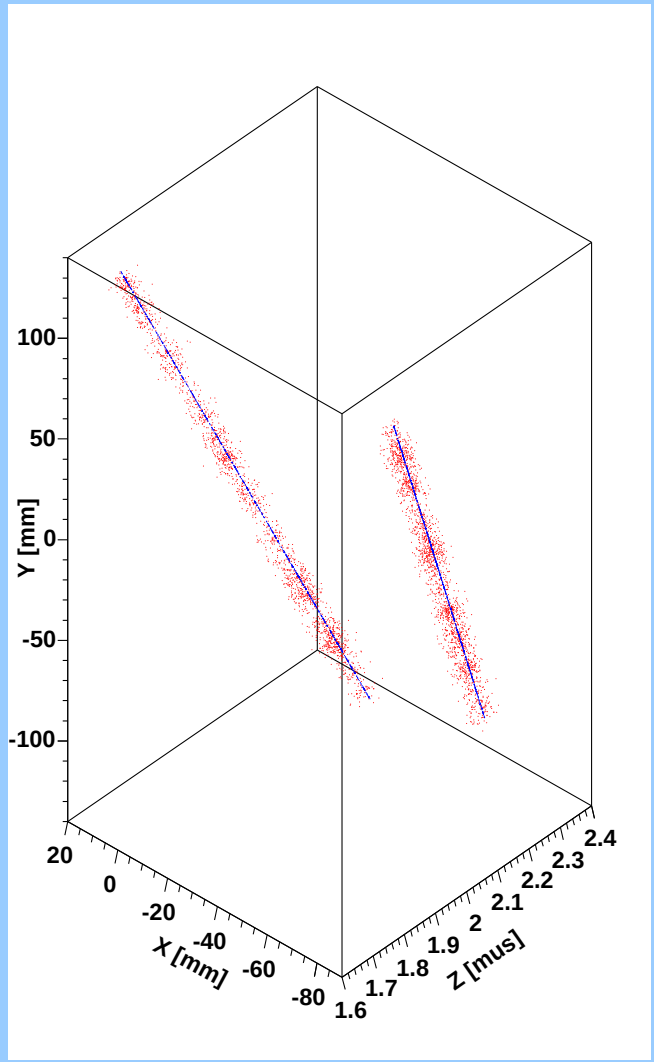

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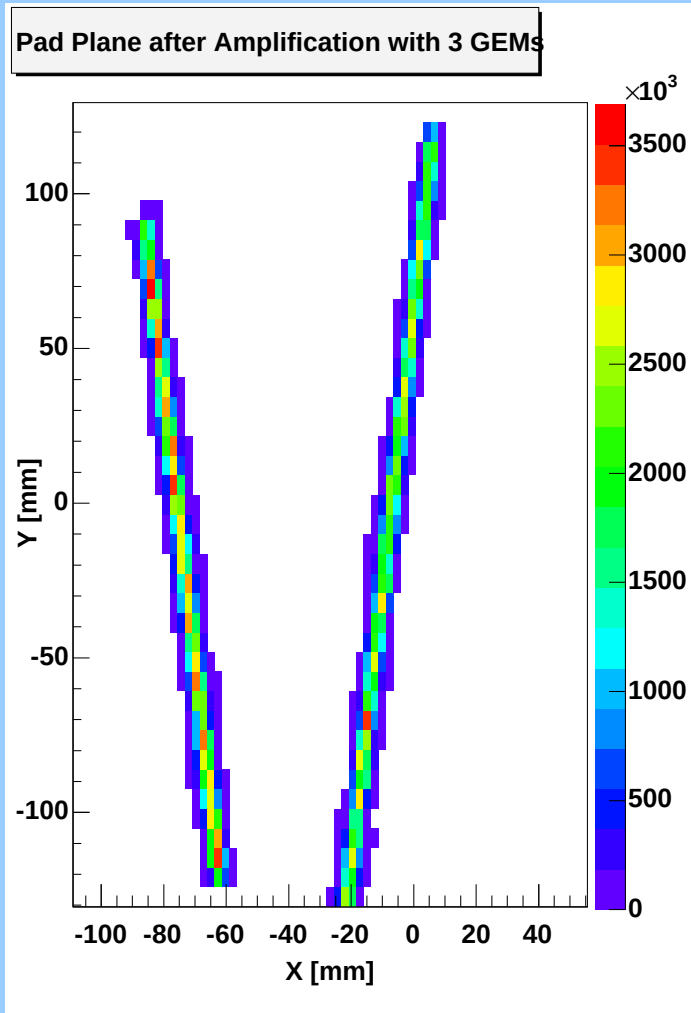


Simulation Steps 1 and 2:

Primary Ionization:

- Randomly generate distance between clusters and number of electrons per cluster according to parametrization of distributions calculated by HEED.
- Place electrons on track (helix with magnetic field, straight line without)

Drift of Electrons:

- Gaussian broadening in x, y and z according to parametrization of longitudinal and transverse diffusion calculated by MAGBOLTZ for the particular gas mixture.

Simulation Step 3: Amplification with GEMs

Input from measurement:

- Detailed parameterization of charge transfer coefficients (collection, extraction, gain) as a function of GEM settings.
- Charge broadening between GEMs mainly determined by diffusion.

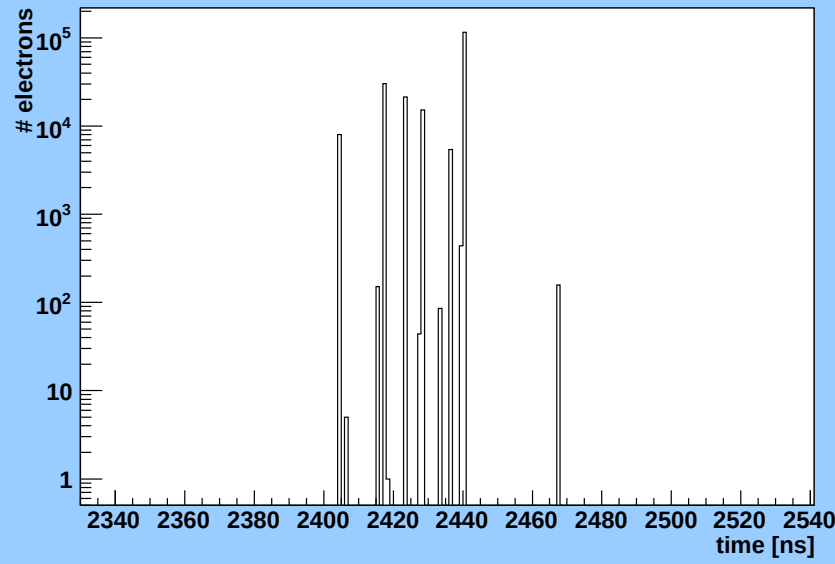
  $\Longrightarrow$ Use diffusion from parametrized MAGBOLTZ calculations.

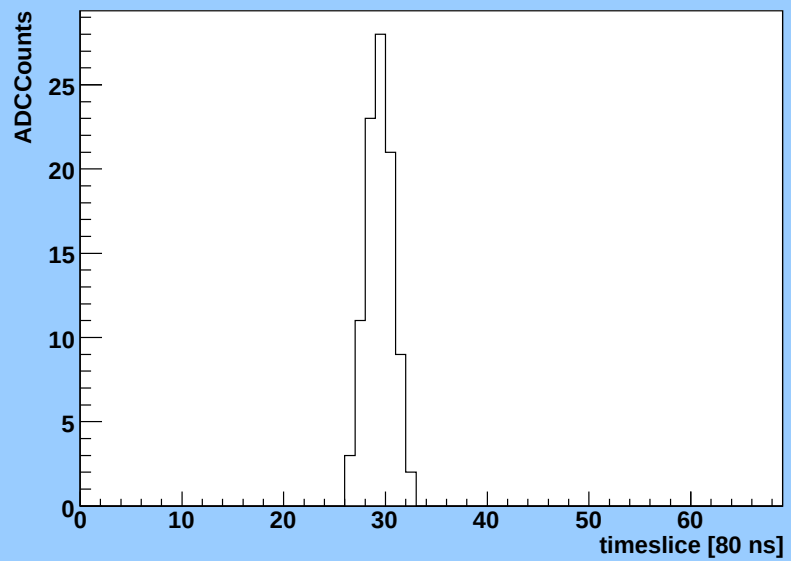
Simulation steps:

- Calculate number of electrons according to GEM settings.
- Apply broadening according to diffusion.
- Map electrons onto pads.

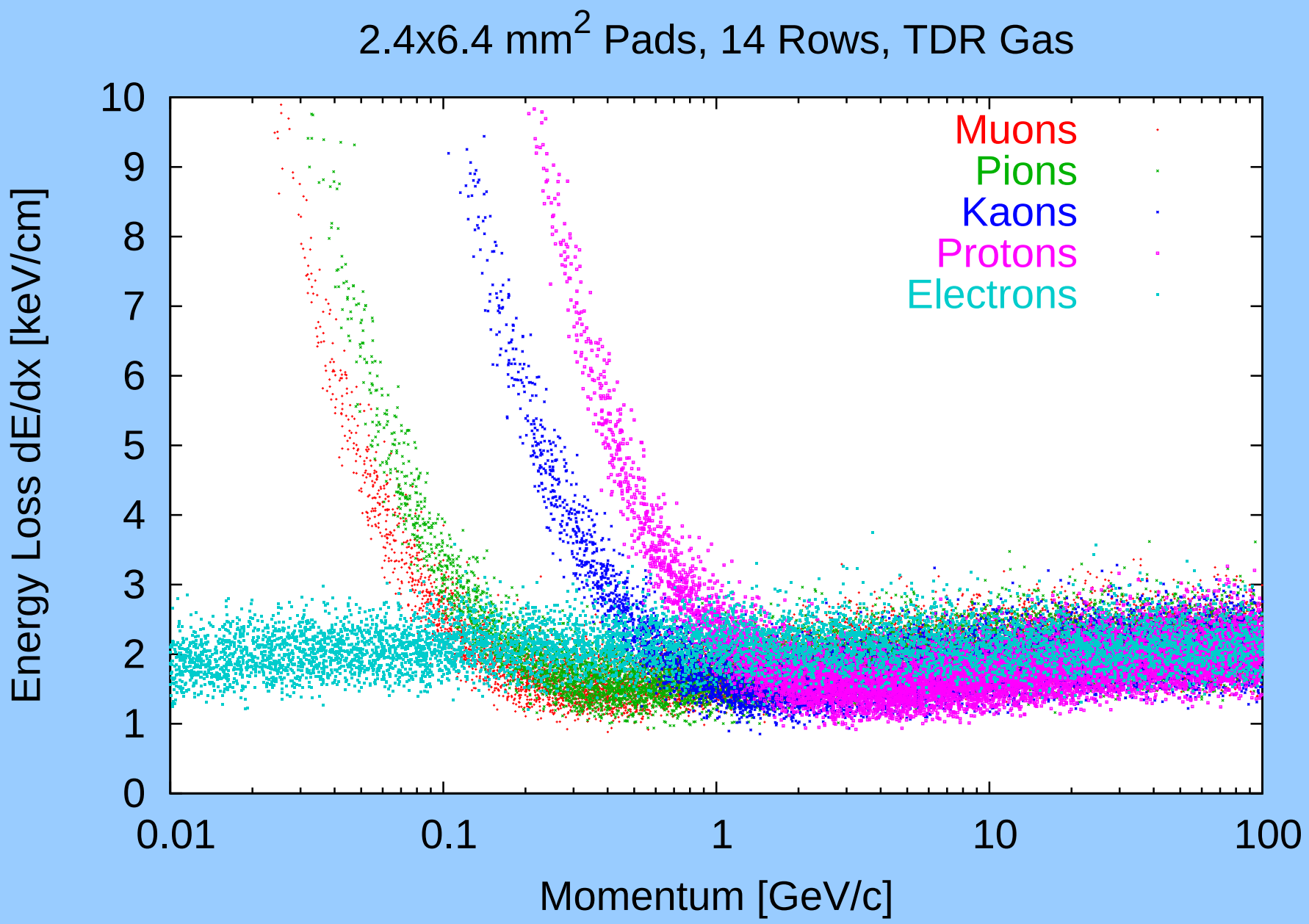
Simulation Step 4: Shaping and ADC

- Calculate center of gravity of electrons in pulse.
- Apply shape smearing of electronics (currently gauss).
- Fill the electrons into time bins.
- Map charge per time bin to the ADC range.





Simulation: Particle Identification



Conclusions and Outlook

Test Beam:

- New preamplifiers working
- Precision measurements
- More than 2.2 million events recorded
- Analysis has startet

First Preliminary Results:

- Readout frequency > 20 MHz required

Detailed Simulation of GEM TPC:

- Validate simulation with measurements
- Latest version (ROOT and LCIO based) available at *http://www.physik.rwth-aachen.de/group/IIIphys/TPC/en/software/*