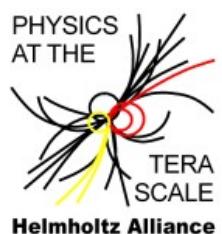


Report WP1: TPC at ILC

Jochen Kaminski
Universität Bonn



for the German TPC groups:
Aachen, Bonn, DESY, Freiburg, Hamburg,
Karlsruhe, Mainz, Rostock, Siegen

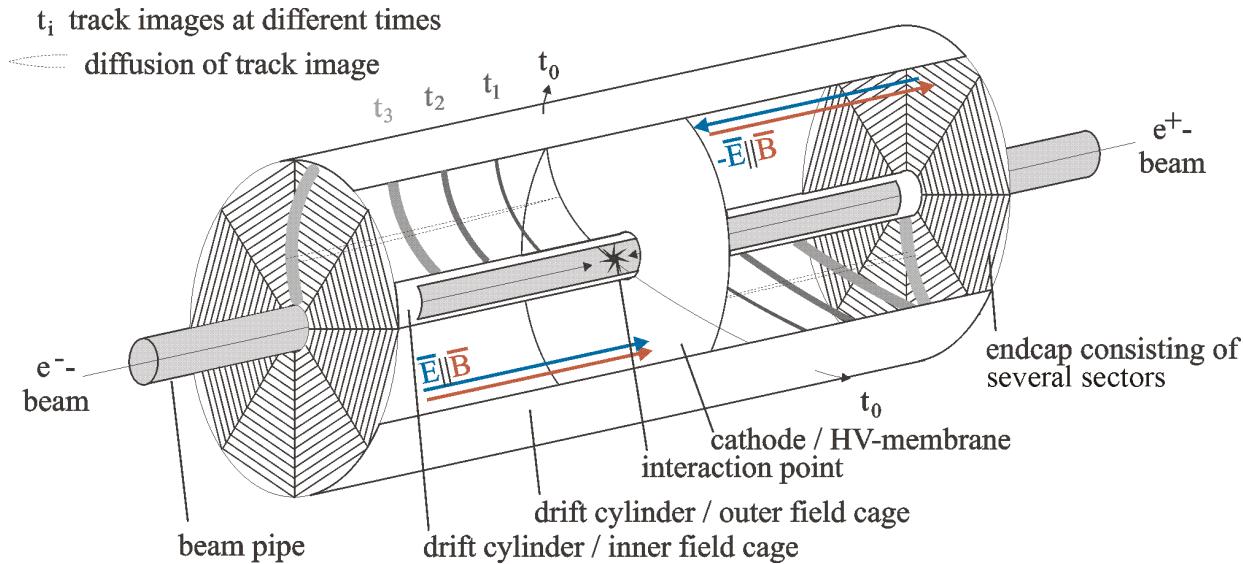


2nd Annual Workshop of the Helmholtz Allianz
'Physics at the Terascale'
Aachen, November 26th -28th, 2008



Linear Collider TPC

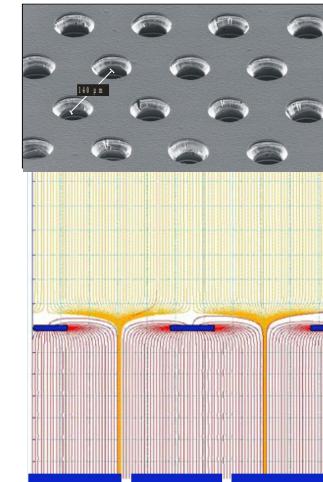
- Good spatial resolution
- Large number of track points
- Good energy resolution with dE/dx
- True 3-dimensional detector
 - no ambiguities
- High granularity
- Low material budget
- Very homogeneous - only gas



Conventional TPCs with MWPC:

- Limited space resolution
- $E \times B$ effects
- Has to be gated to remove ions
- No true 2D symmetry

⇒ use **Micropattern Gas Detectors**



GEM

Micro-
megas



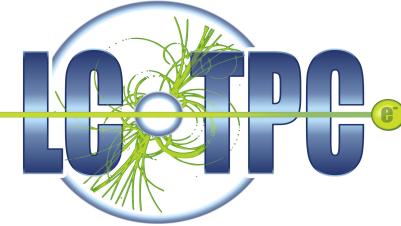
universität bonn

Requirements



Size	inner radius 30cm, outer radius 158cm, length 432cm
Momentum Resolution	$\delta(1/p_t) < 10^{-4} / \text{GeV}$
Solid angle coverage	up to at least $ \cos\theta \leq 0.98$
Material budget	< $0.03 X_0$ to outer field cage < $0.3 X_0$ for readout endcap
Number of readout pads	$> 10^6$ per endcap
Number of pad rows	~ 200
Single point readout in $r-\phi$	< 100 μm
Single point readout in z	2mm
Double track resolution in $r-\phi$	< 2mm
Double track resolution in z	< 5mm
dE/dx resolution	5,00%
Performance robustness	full precision/efficiency in backgrounds with 10%

Road Map to the Final Detector

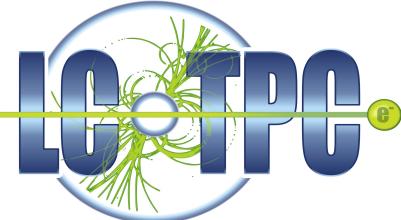


R&D in 3 steps

1. **Demonstration Phase:** Provide a basic evaluation of the properties of an MPGD TPC and demonstrate that the requirements (at ILC) can be met using small prototypes.
2. **Consolidation Phase:** Design, build and operate a “Large Prototype” (of large number of measured points) at the EUDET facility in DESY.
3. **Design Phase:** Start working on an engineering design for aspects of the TPC at ILC.

For some technologies (**GEM** and **MicroMegas**) the demonstration phase is completed and the consolidation phase has started.

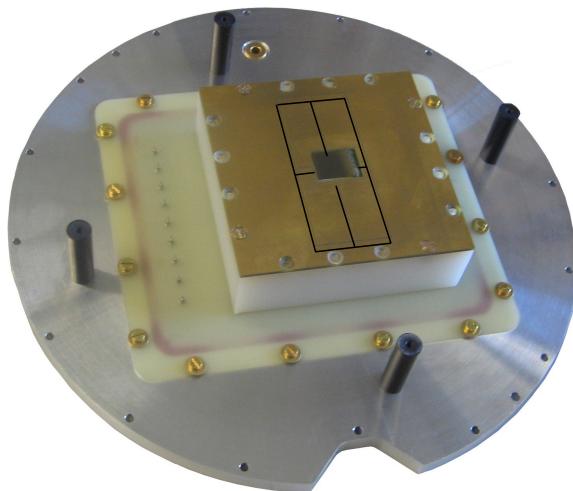
Pixel TPC: Bonn-Freiburg-Mainz



The Pixel readout is still in the demonstration phase with small prototypes.

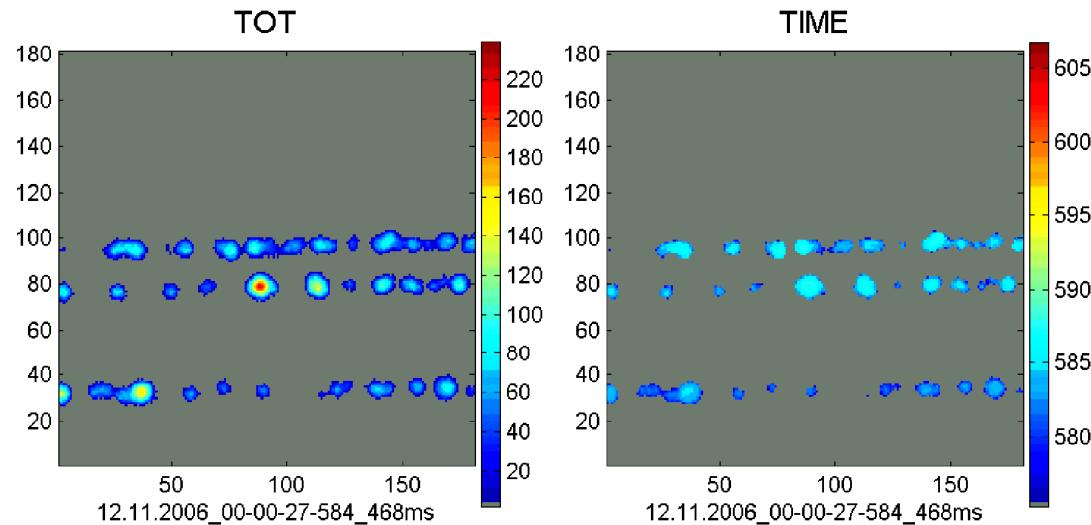
Bonn: Field cage (from RWTH)

- Max. drift length 26 cm
- Stack of 3 'standard' GEMs



Freiburg: 6 mm drift volume

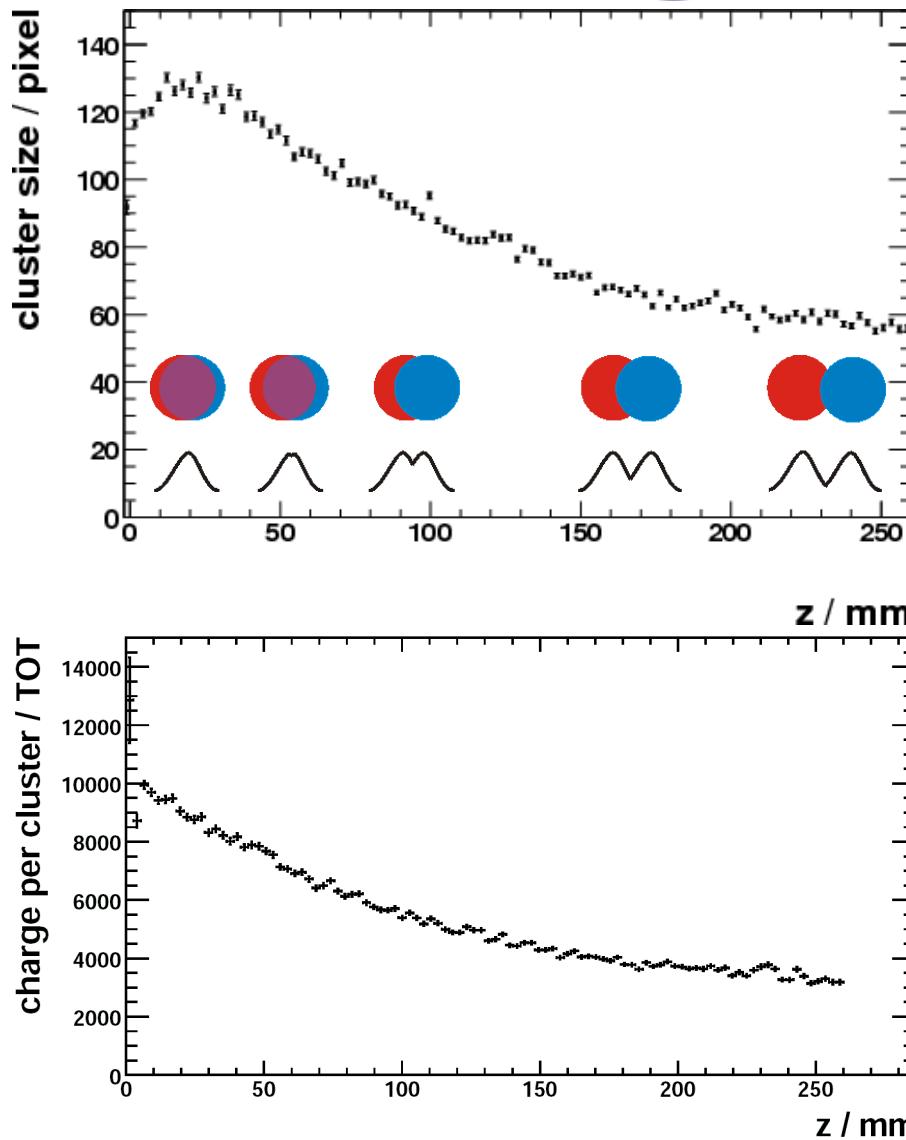
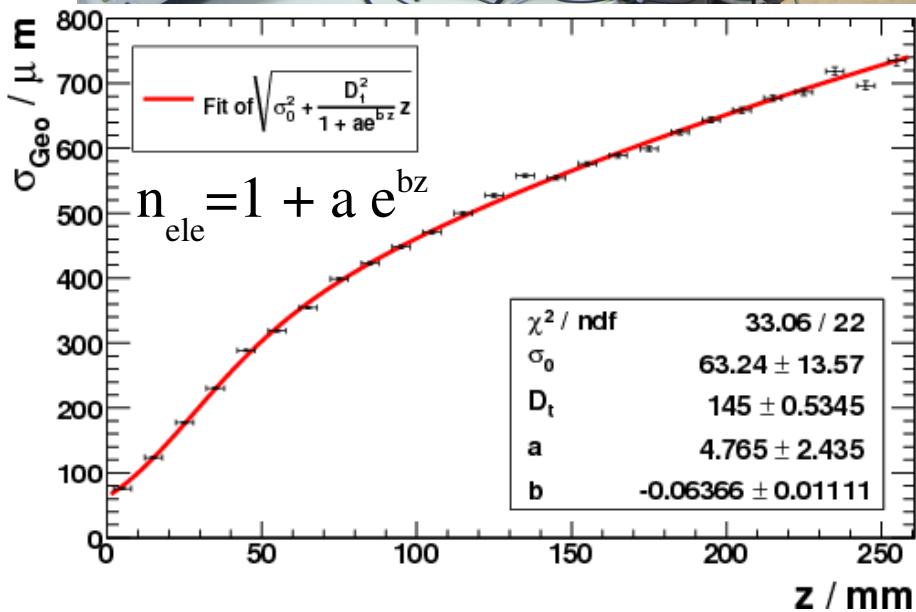
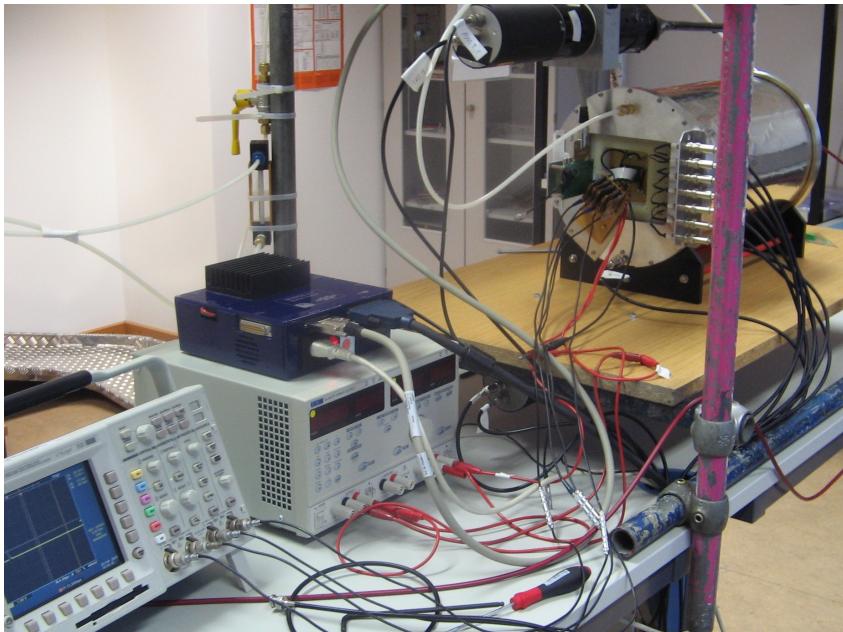
- Various GEM geometries
- Different gas mixtures



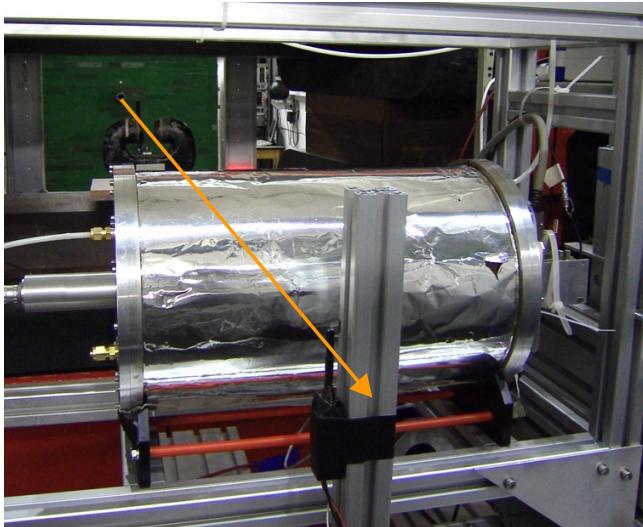
Cosmic ray setup (spring 2008)
0.5 GeV e⁻ test beam at ELSA
(June 2008)

Using DESY electron test beam
and Silicon Pixel hodoscope (2007)

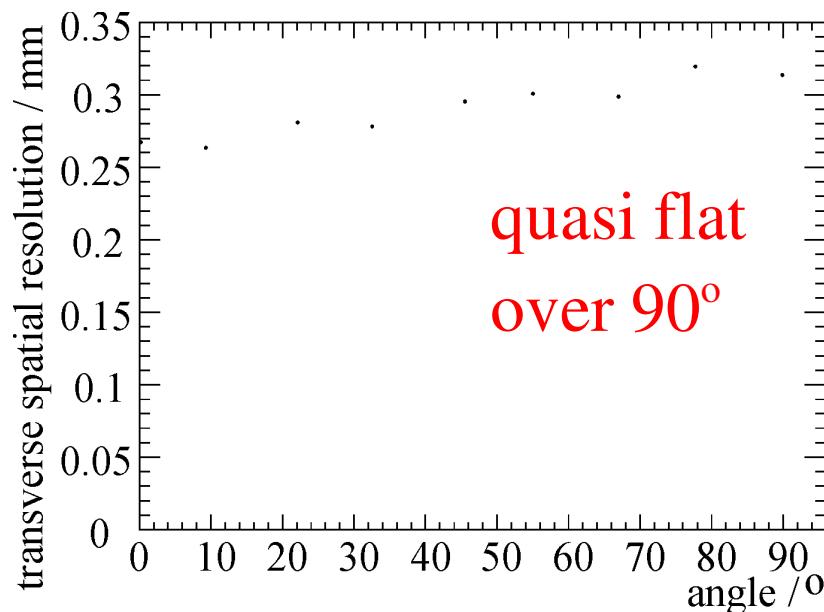
Pixel TPC: Observation of Declustering



Pixel TPC: Bonn-Freiburg-Mainz



Test beam at ELSA, Bonn

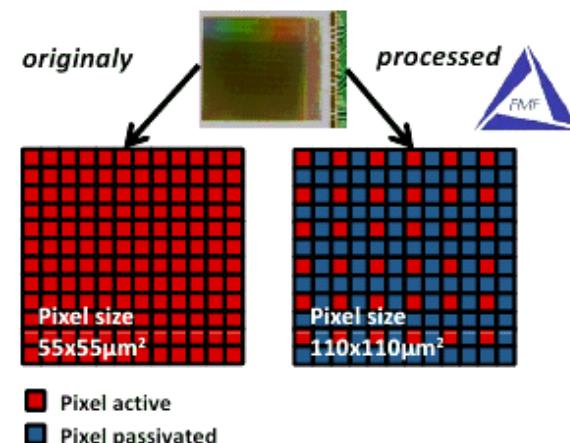


Mainz is designing and building a new FPGA-based readout for Timepix.

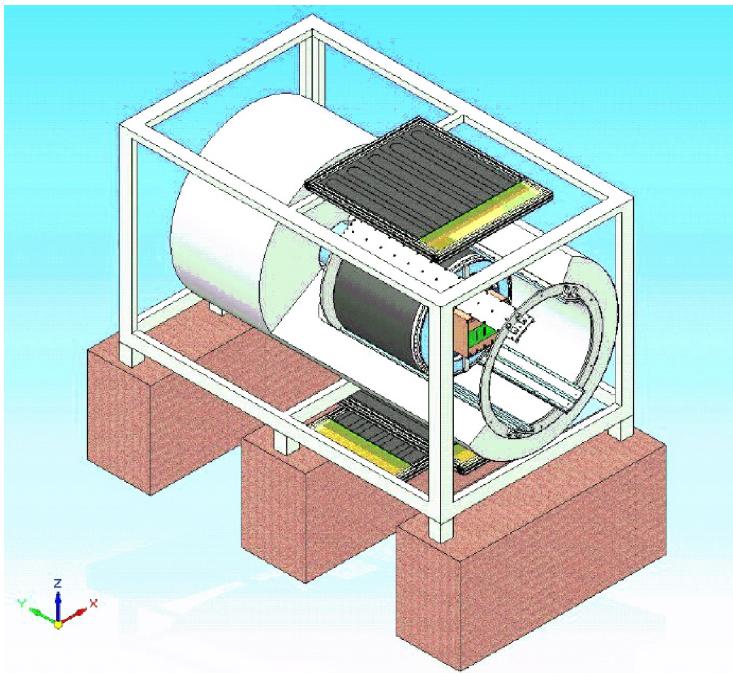
HEP-compatible

→ fast multi-chip readout

Freiburg is studying larger pixel sizes by post-processing Timepix chips



DESY Large Prototype



- Drift length: 60 cm
- Diameter: 80 cm
- 7 exchangeable modules
- Inside 1.25 T magnet
- Cosmic trigger
- Beam trigger
- Silicon hodoscope

- Build an **infrastructure & prototype** to do extensive tests of different gas amplification and charge collection systems in a TPC for precision experiments
- Demonstrate the feasibility of a MPGD TPC in a linear collider experiment
- Initial installation and operation at DESY
- Possibly move to hadron beam later

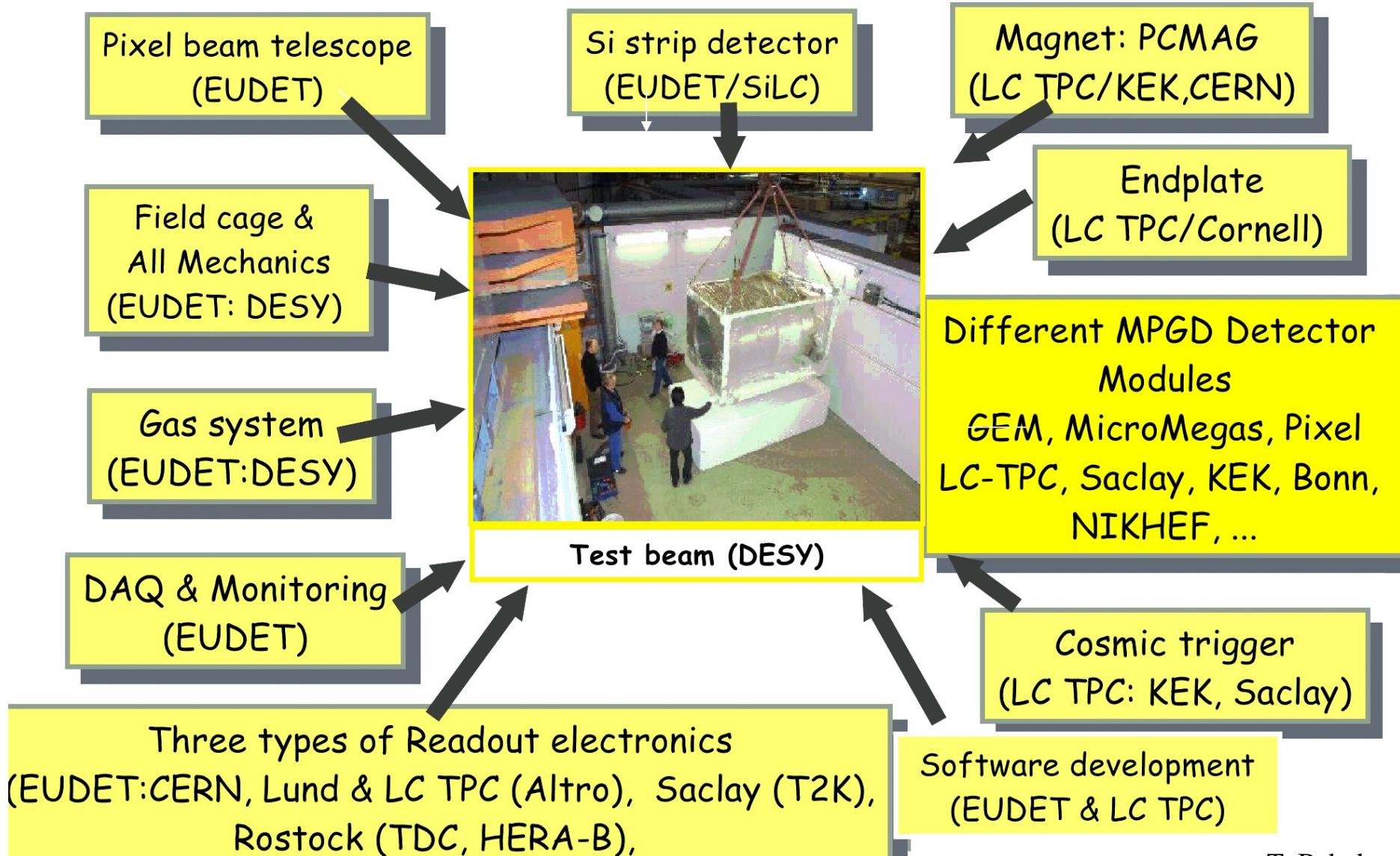
International effort:

24 groups have signed the MOA

German contributors are:

Aachen, Bonn, DESY, U. Hamburg,
Freiburg, Karlsruhe,
MPI-Munich, Rostock, Siegen

LC-TPC Facility

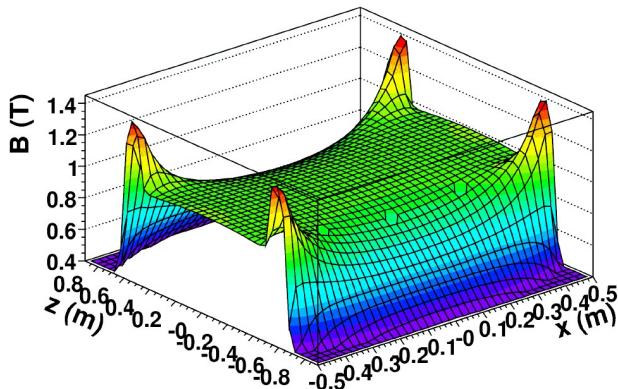


DESY: Infrastructure and Field Cage



DESY is providing the infrastructure for the setup:

- Test beam (e^- up to 6 GeV)
- Gas supply, including gas rack
- Magnet installation (PCMAG delivered from KEK)
- Slow control (together with U. Rostock and U. Siegen)



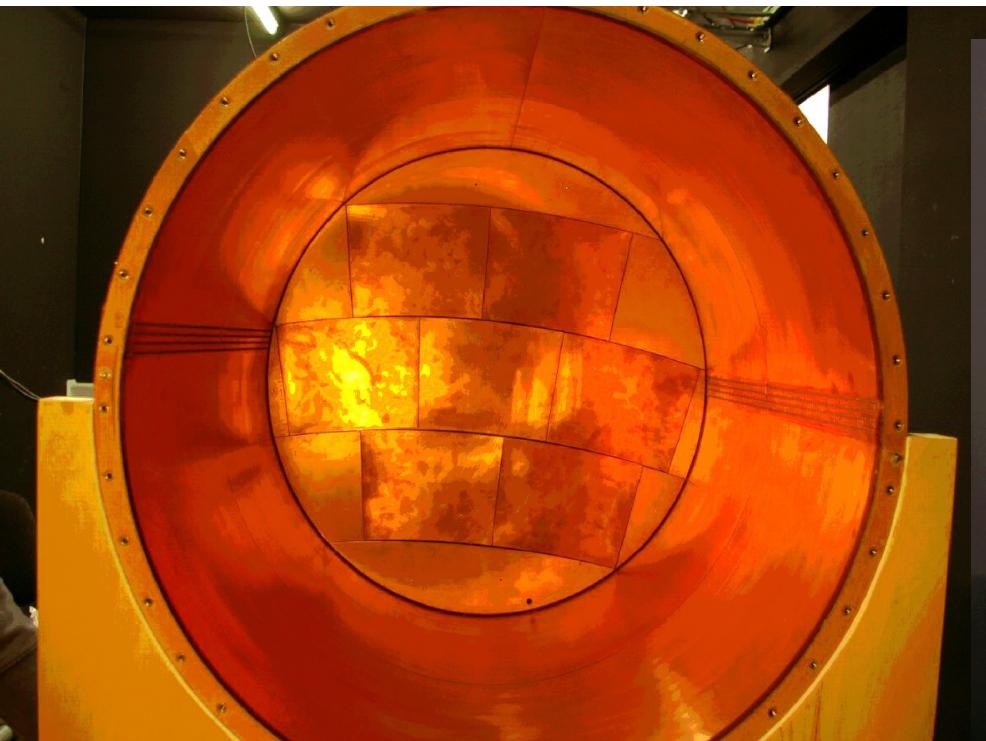
Magnet is successfully tested and approved by DESY safety group.

The field measured in detail by CERN group:
Field map with precision of 10 G

Field cage designed by DESY, constructed in industry

- Low mass field cage ($1.31\% X_0$)
- First level engineering model for a realistic TPC
- Precision survey of cathode/anode alignment

Some Impressions



Measurement with 20 μm precision:

Parallelism of cath./anode: $< 10\mu\text{m}$

Skew angle of field cage $(1\pm 0.2) \text{ mrad}$

Offset anode – cathode: $(540\pm 40)\mu\text{m}$

Flatness of cath./anode surface: approx. 35 μm



MarlinTPC



A simulation, digitization, reconstruction and analysis package
for TPC development

Requirements for TPC R&D studies

Geometry

- Prototypes
- Large collider detectors

Simulation / Digitization

- Study detector effects
- Realistic raw data

Reconstruction

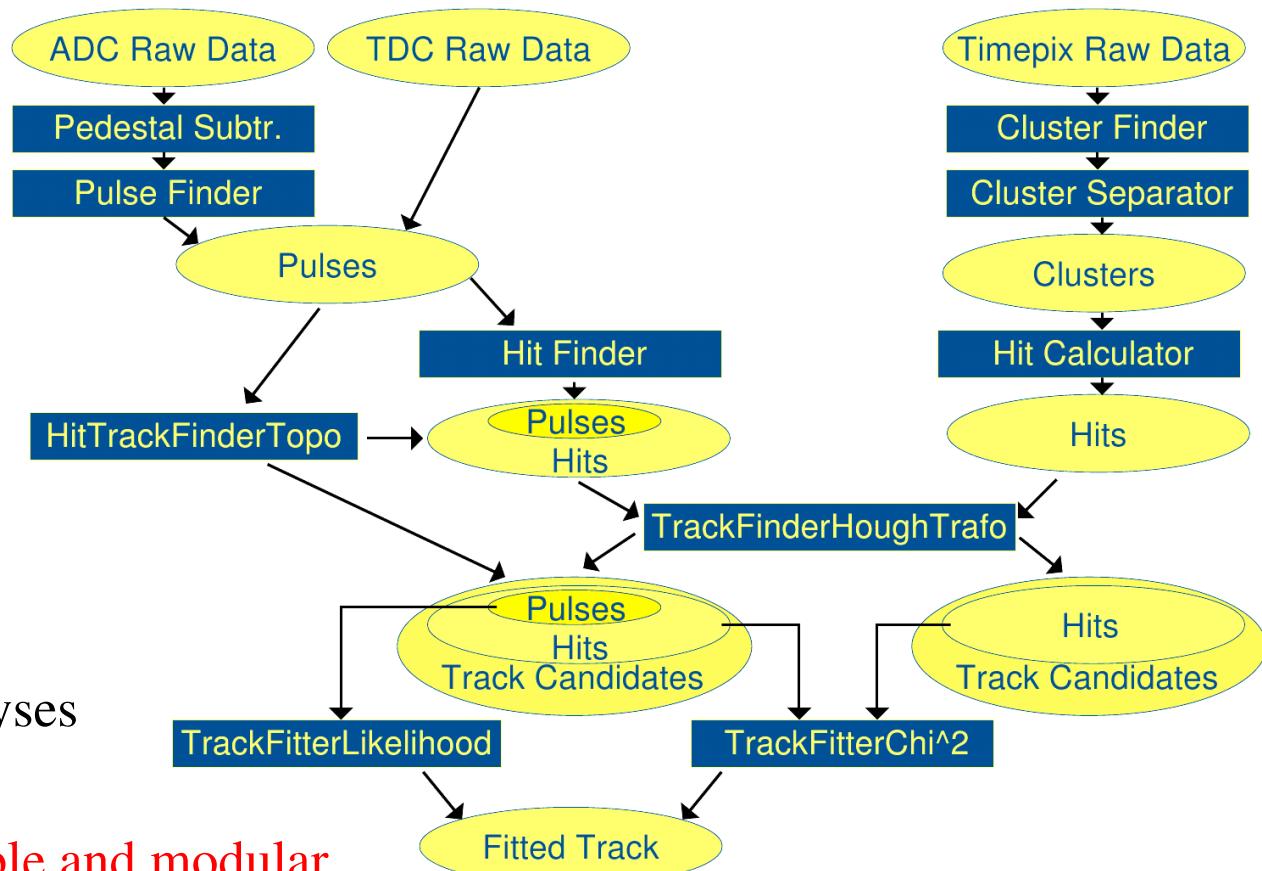
- Stand alone
- Various readout techniques

Analysis

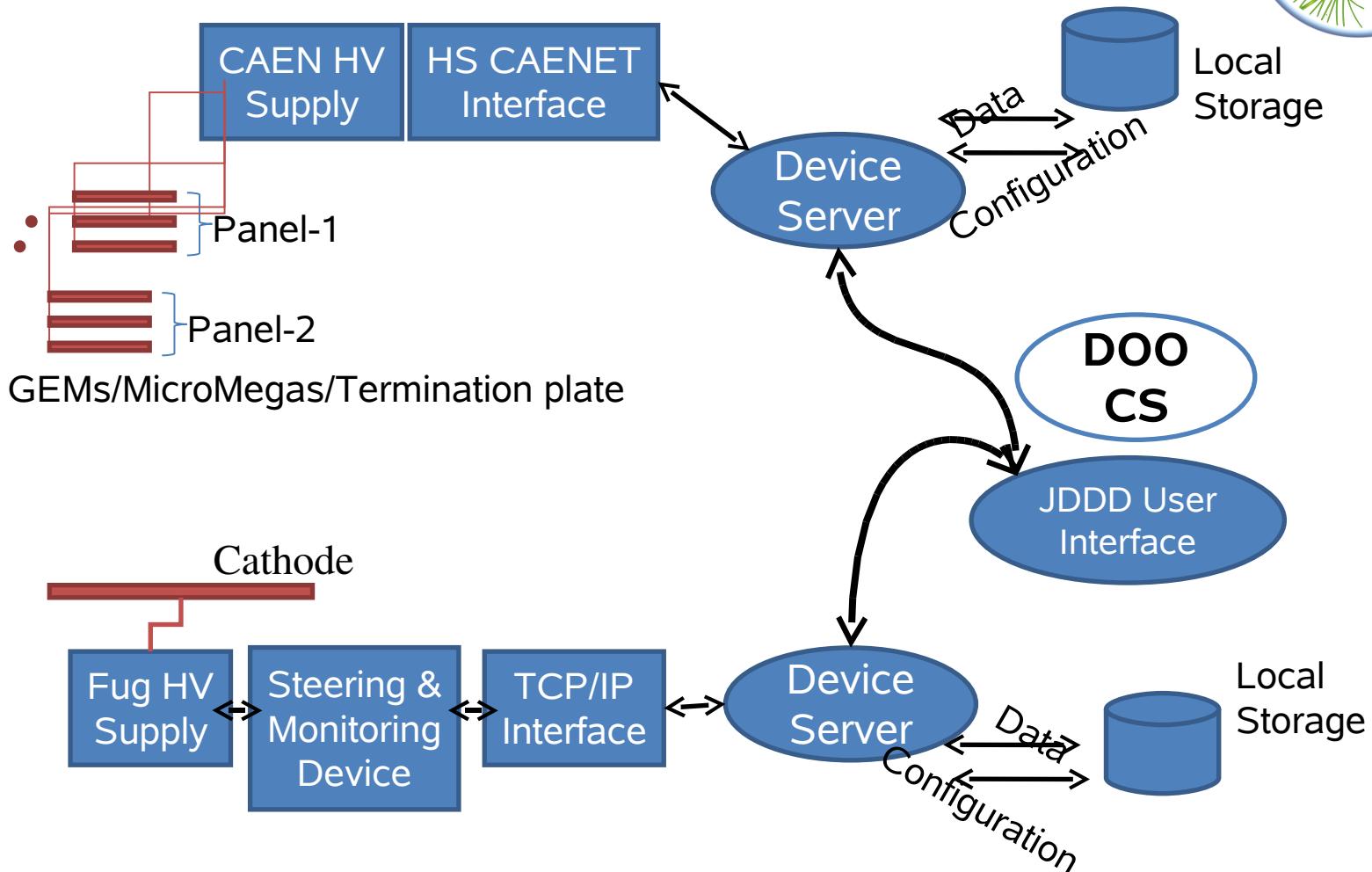
- Ready-to-use standard analyses
- Plots for commissioning

⇒ MarlinTPC is highly flexible and modular

Contributions from many groups:
Aachen, Bonn, DESY, Rostock

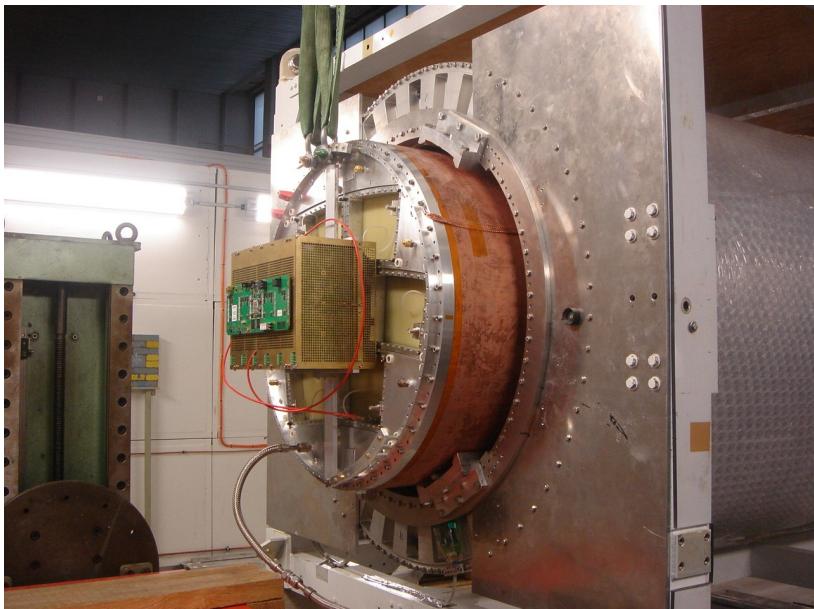


Siegen: HV Power supply

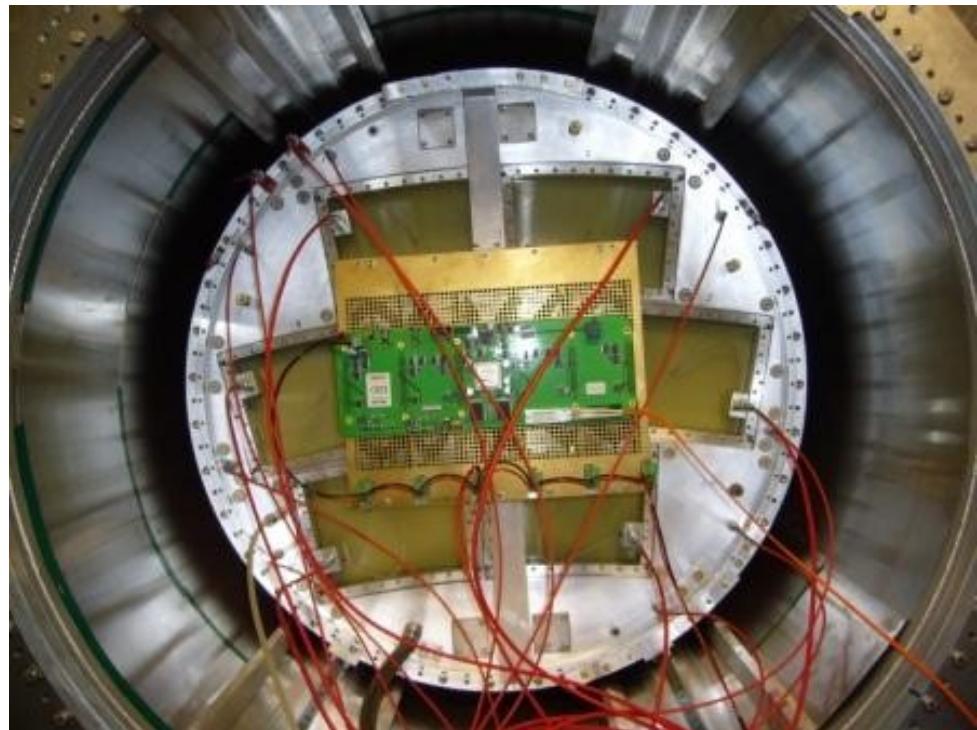


Different power supply schemes of GEM stack have been developed.

Final Steps towards Data Taking

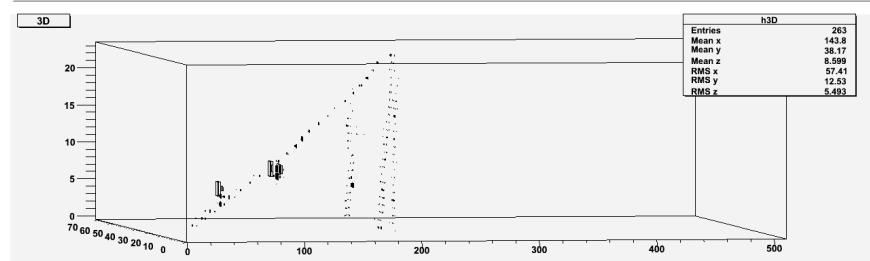
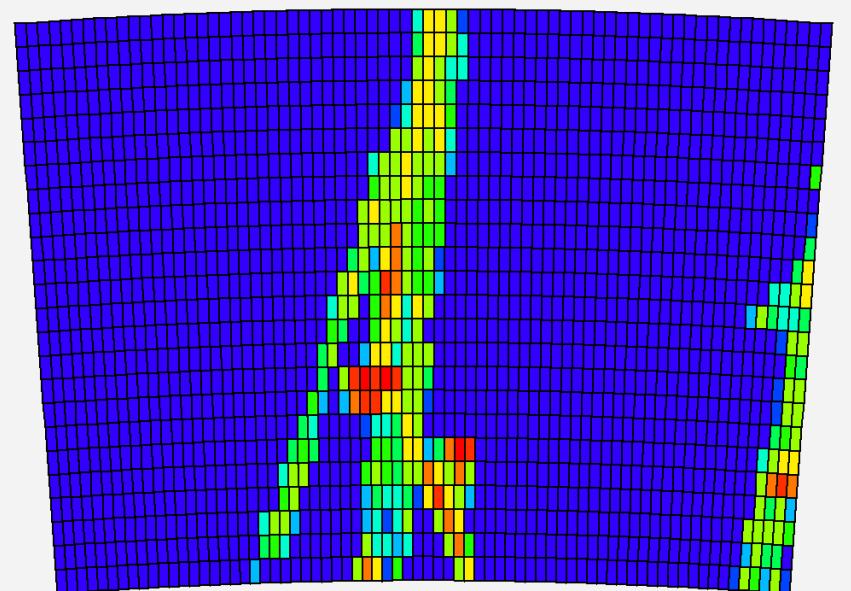
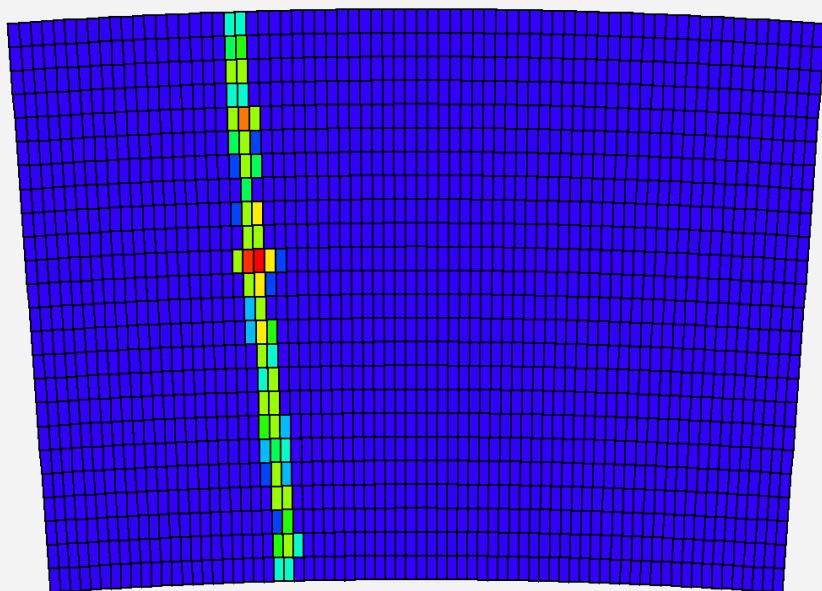
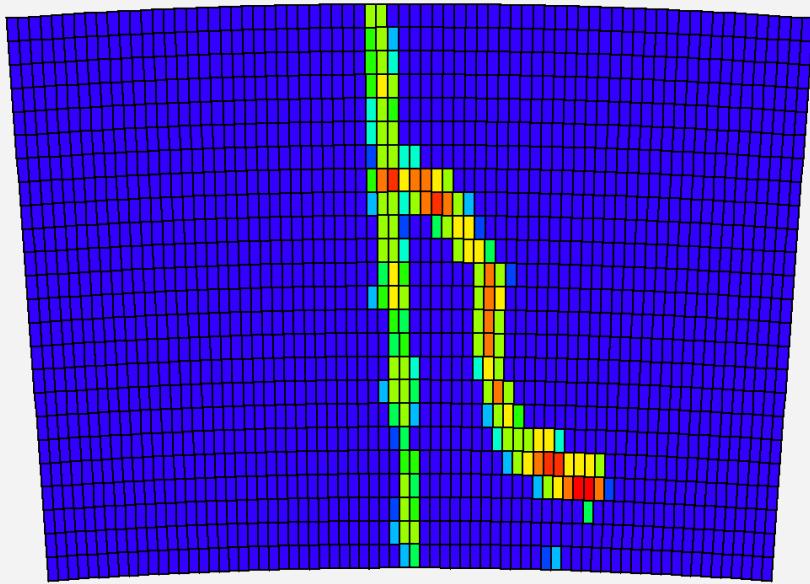


Assembly of detector parts
(field cage, end caps, 1st readout module)
end of October



Gas tightness check with overpressure
⇒ Gas leakage < 20 ccm/min
HV tests up to 15 kV:
⇒ no leakage currents observed

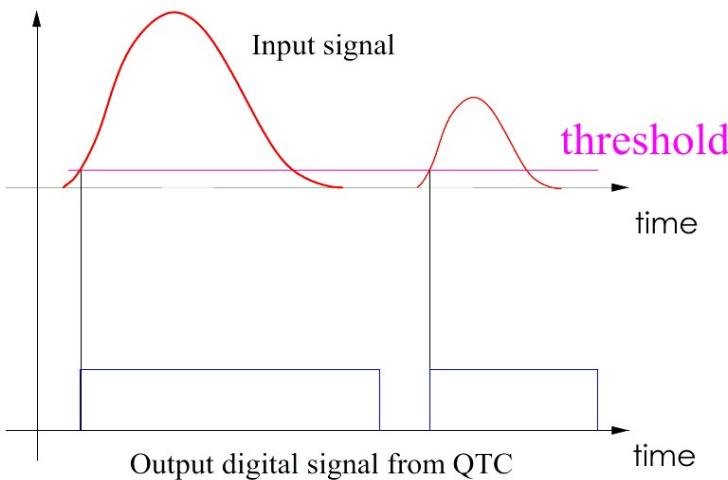
First Tracks with Micromegas Module



First tracks seen on
November 21st.

Rostock: TDC-based readout electronics

Development of alternative TPC readout electronics
based on precise time sampling + charge-to-time conversion



The following activities are pursued:

- Simulation of the signals from GEMs
- Test TDC based electronics with TPC
- Integrate with EUDAQ
- Study of GEM signals with “Barcelona” boards and new PCA16 preamplifier



28 boards with
32 channels each
Size: 30×106 mm²
Thickness: 4.4 mm

Summary



R&D for a TPC at a Linear Collider makes good progress

- Pixelized readout tested with small prototypes - very promising
- Large prototype has been constructed and commissioned at DESY
- Large prototype placed in 1.25 T magnet
- First tracks have been recorded!

Helmholtz-Alliance very helpful to increase collaboration

Helmholtz-Alliance projects:

- FPGA-readout (Mainz)
- HV (Siegen)
- HHA infrastructure (DESY, Bonn)
- Test beams (DESY-2, ELSA)
- Engineering support (DESY)
- Gas detector lab (Bonn)