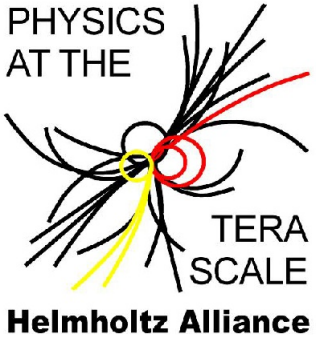
Overview of German R&D for a TPC at the ILC

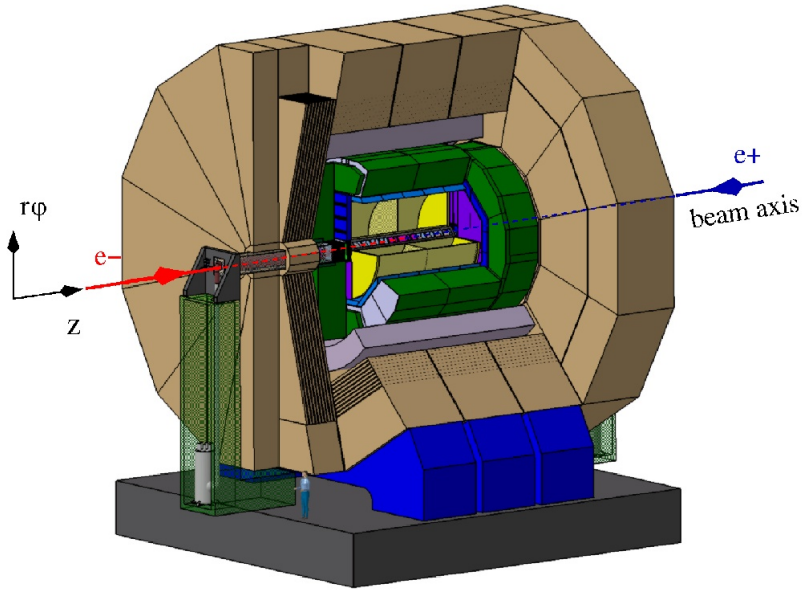
5th Annual Helmholtz Alliance Workshop
Dec. 7-9, 2011

R. Diener, DESY

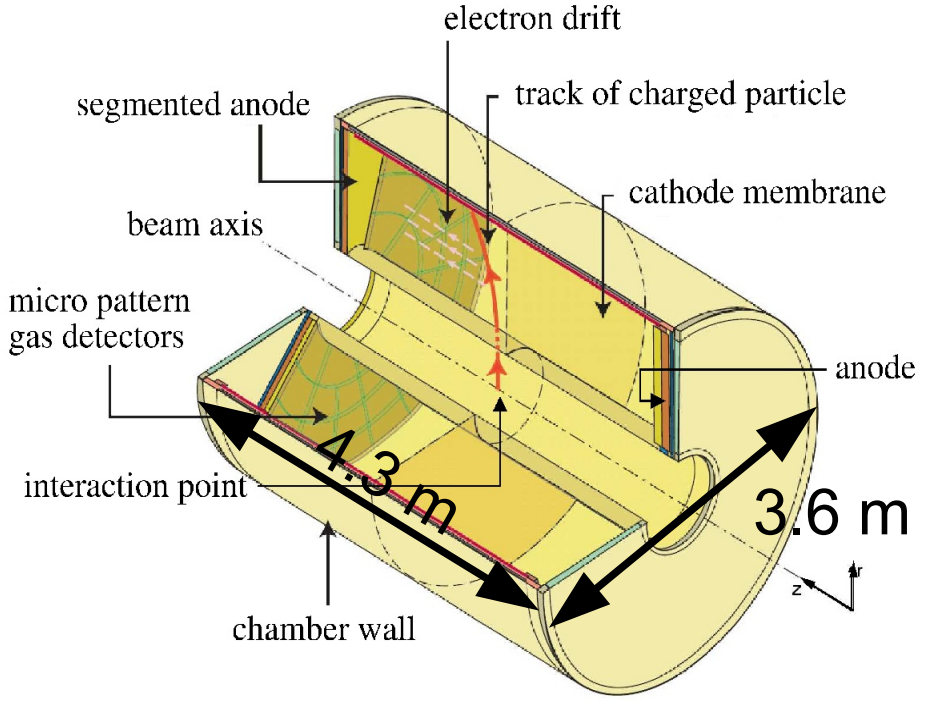


A TPC at the ILD

- ILD: a multi purpose detector for the ILC
- TPC as main tracker
  - Robust tracking, ~ 200 space points per track:
    - Easy pattern recognition
    - Robust towards machine backgrounds
  - dE/dx-measurement input to particle ID
  - σ ~ 100μm (rφ) and ~ 500μm (rz) @ 3.5 T

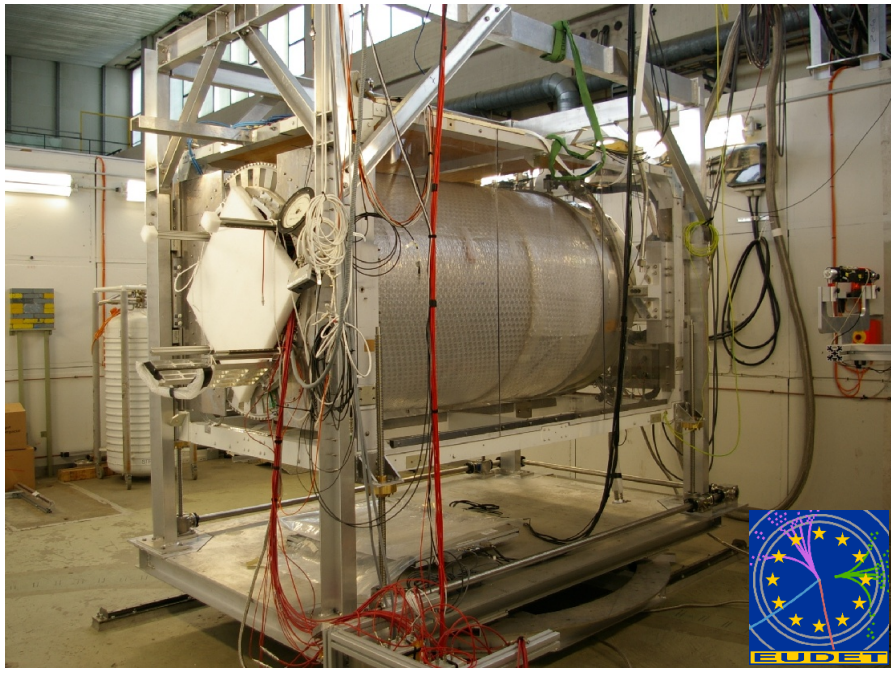


- Well suited for Particle Flow concept:
  - Good track separation
  - Good pattern recognition
  - Very light weight
    (material budget < 0.04 X_0)

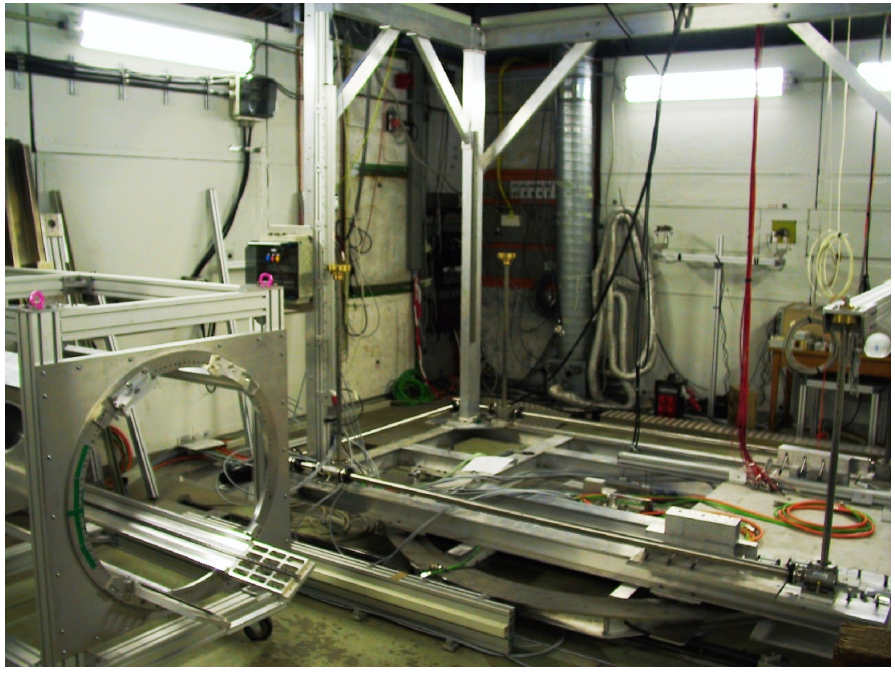


T24/1 Test Beam Setup

- Set up in DESY II test beam, area T24/1 (e^+/e^- from 1 to 6 GeV/c)
- Comprises: PCMAG magnet mounted on movable lifting stage (3 axis), HV system, cosmic and beam trigger, HV, gas and slow control systems, laser system, etc. ...

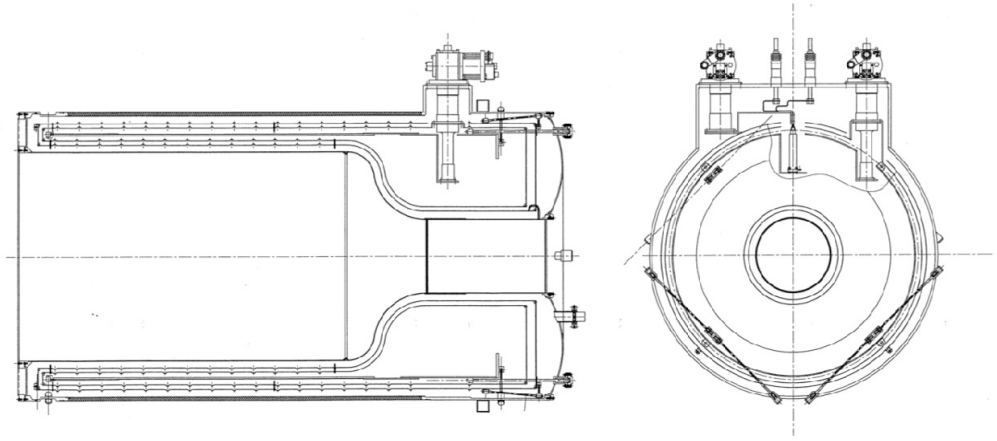


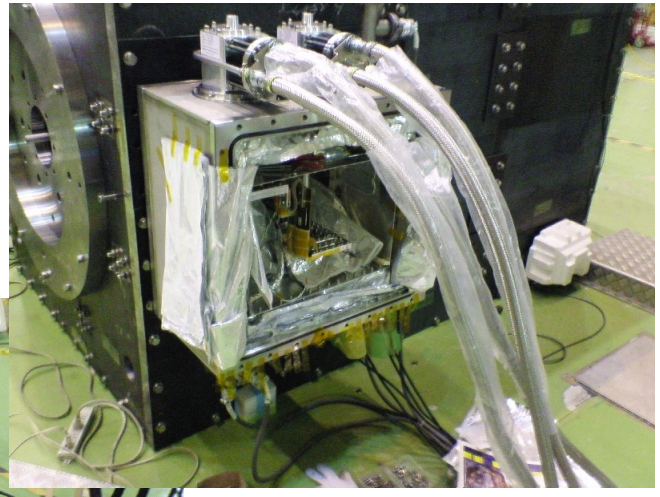
- Currently extensive work at the movable stage
  - Integration of end switches, safety systems, new position measurement devices and proper cabling
  - Mechanical and electric work at stage itself finished before Christmas
  - Steering, measuring and safety system till March '12

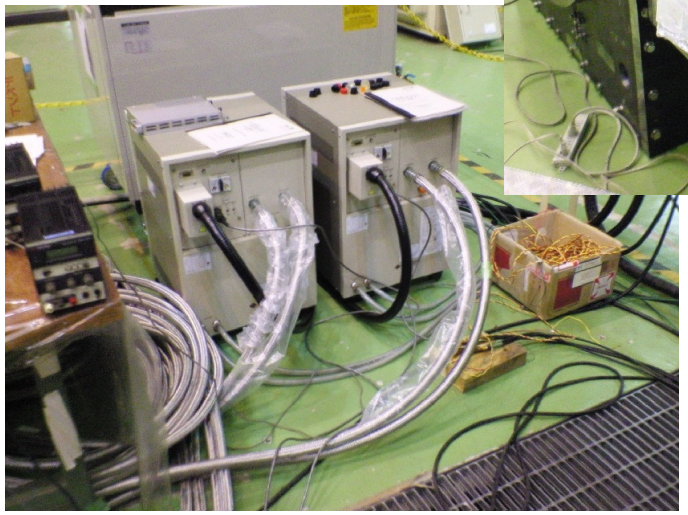


PCMAG Upgrade

- Contribution from AIDA & KEK
- Till now: manual filling with LHe
- Upgrade:
  Closed circuit system with two cryo modules added to vacuum vessel
- Helium gas compressors and a water chiller will be placed next to the setup



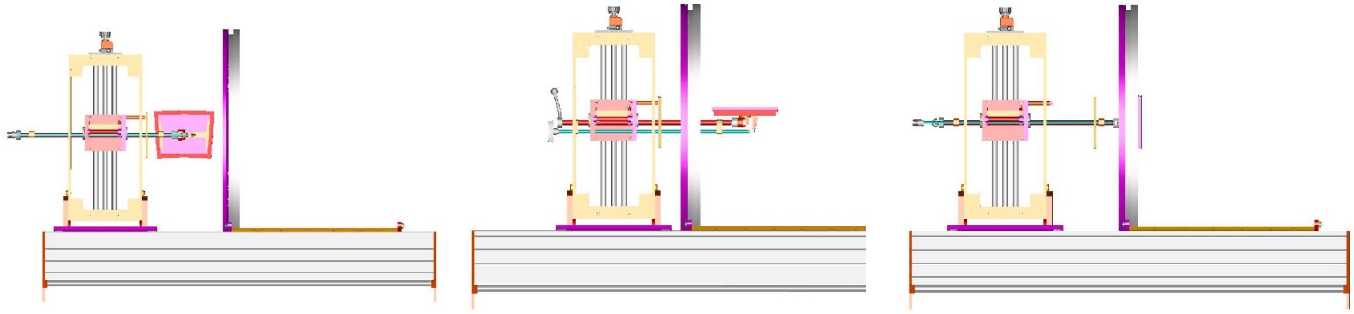


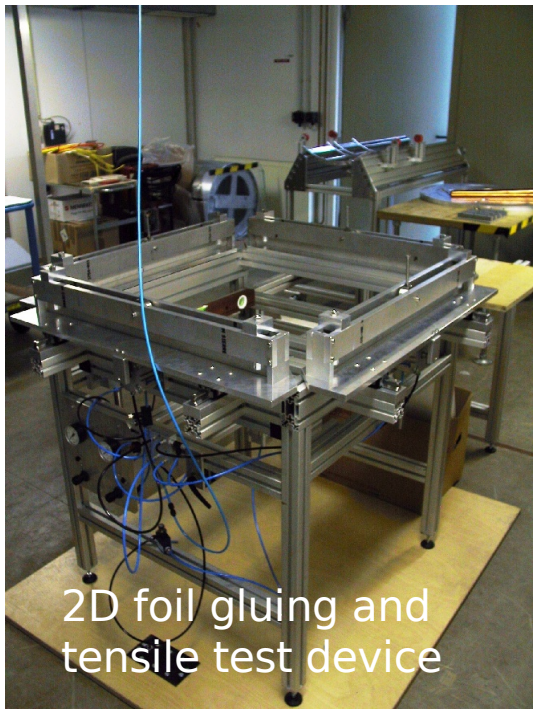


- Magnet currently in Japan for modification
- Current schedule
  - Sent to DESY in March '12
  - Mounting in April
  - Commisioning by Japanese experts in May

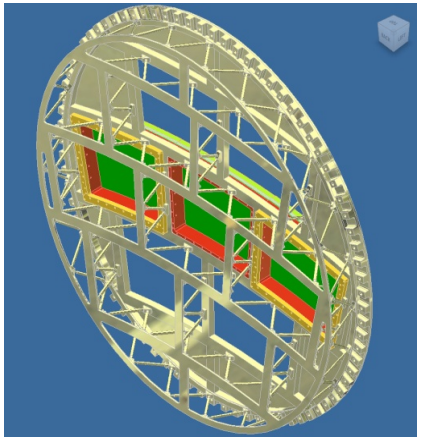
Large Prototype

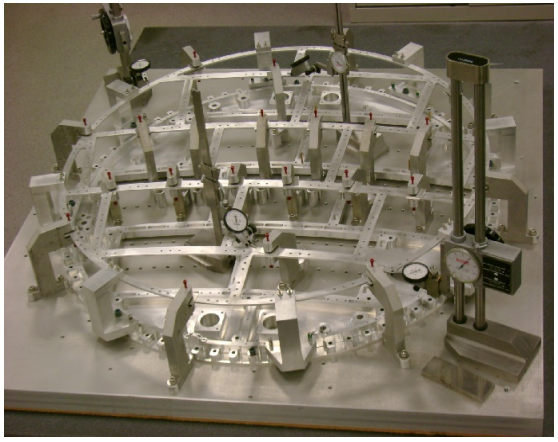
- Cathode:
  - Several designs under discussion (foil, honeycomb…)
  - Foil tests with different kind of foils being done
  - Gluing & tensile test device for two axes ready
- Module mounting tool being designed





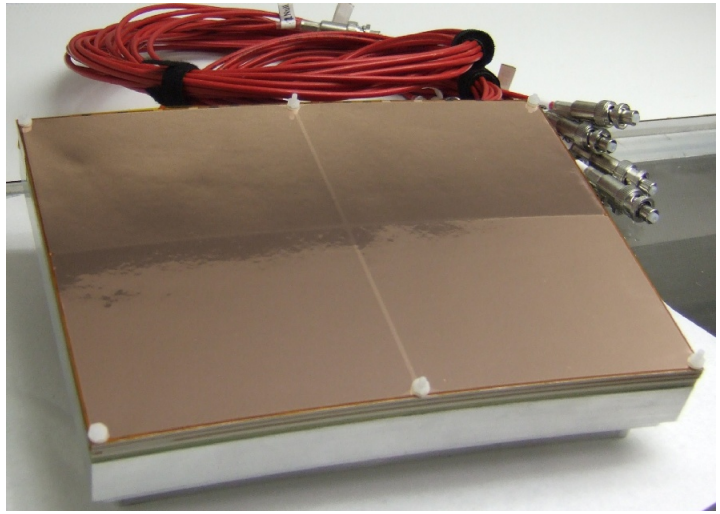
- Second field cage
  - Unclear if build in-house or external
  - Planning for second half of 2012
- New end plate currently under construction at University of Cornell

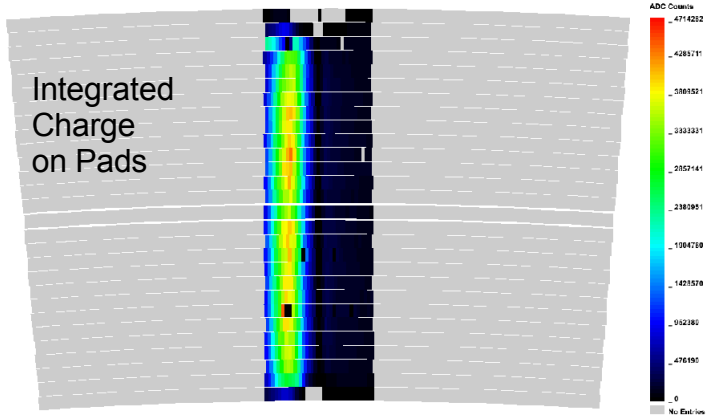


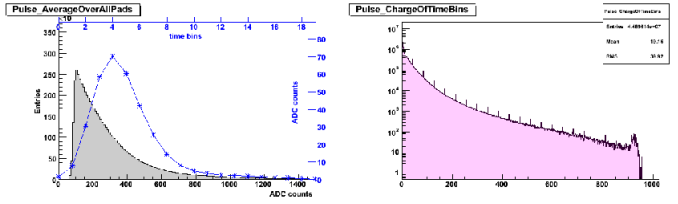


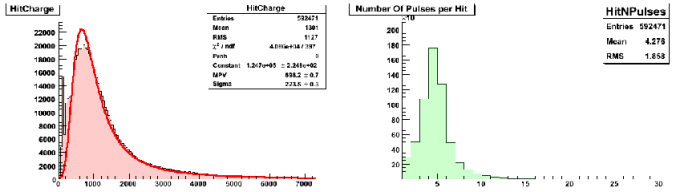
GridGEM Module @ DESY

- Triple GEM amplification, grid divides area in four sectors, Dimensions: ~ 23x17cm^2
- Pad plane (Alliance cooperation with Bonn U)
  - Only area in the middle covered by small pads (pitch: ~ 1.26x5.85mm2) and instrumented
- Read out using modified ALTRO electronics with PCA16 preamplifier @ 40MHz
- Measurements in DESY test beam summer '11:
  - First look at data: reasonable results
  - Detailed analysis in progress
- Some problems with HV during test beam
  - Second iteration planned for '12:
    - improved HV design
    - advanced pad plane
    - well defined assembly procedures



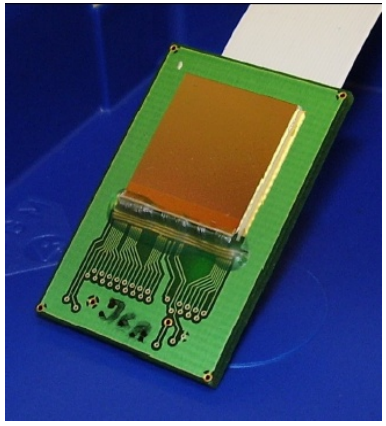


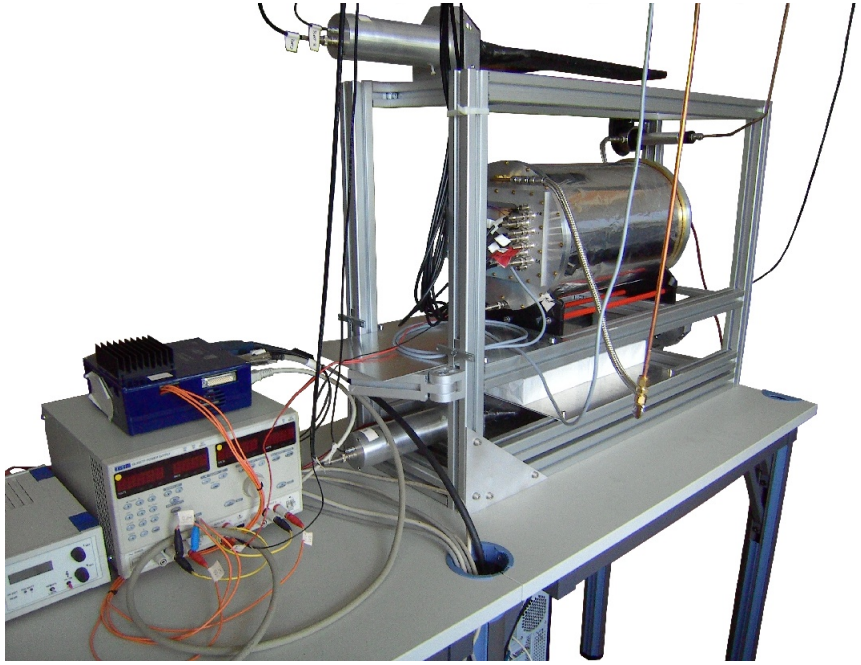


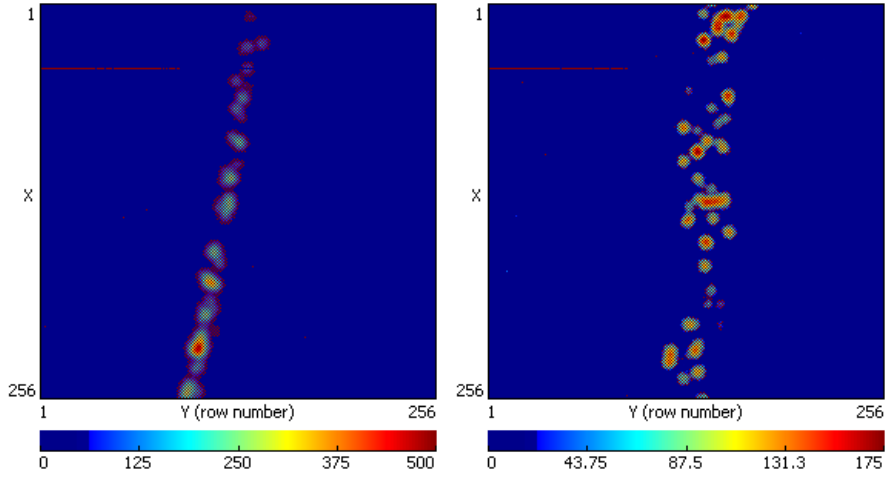


TPC Prototype @ Bonn

- Field cage:
  - Drift length: 26 cm, inner diameter: 23 cm
  - Material budget: 1% X_0
- Test setup with cosmic rays at Bonn
  - Two scintillators: 10 × 40 cm²
  - Lead layer: 5 cm
- Gas mixture: Ar:CO_2 70:30, He:CO_2 70:30
- Triple GEM amplification
- Read out with TimePix chip:
  - 256x256 pixels
  - Pixel size: 55x55µm²



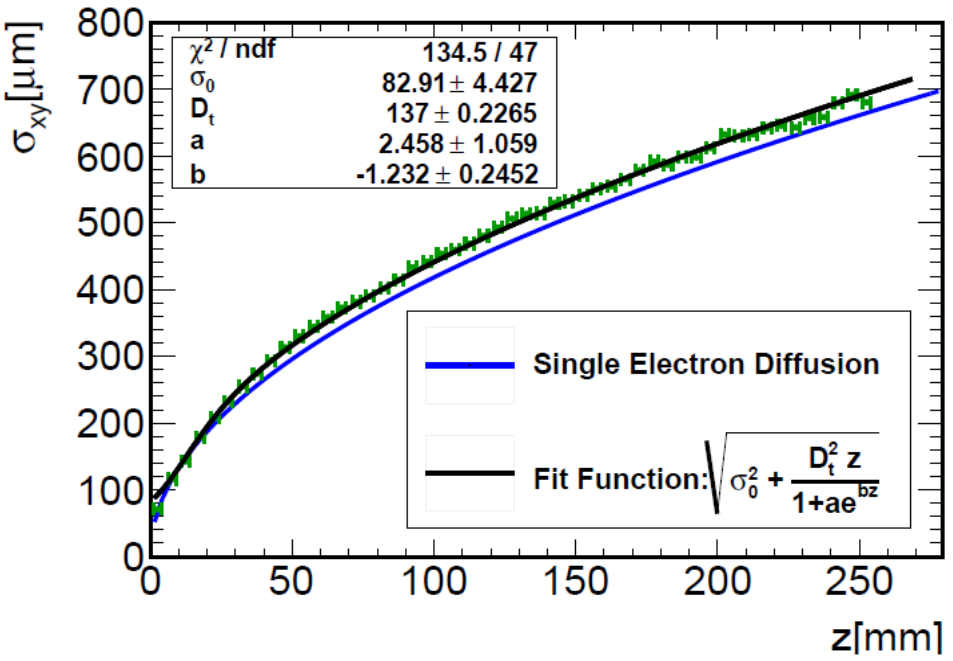




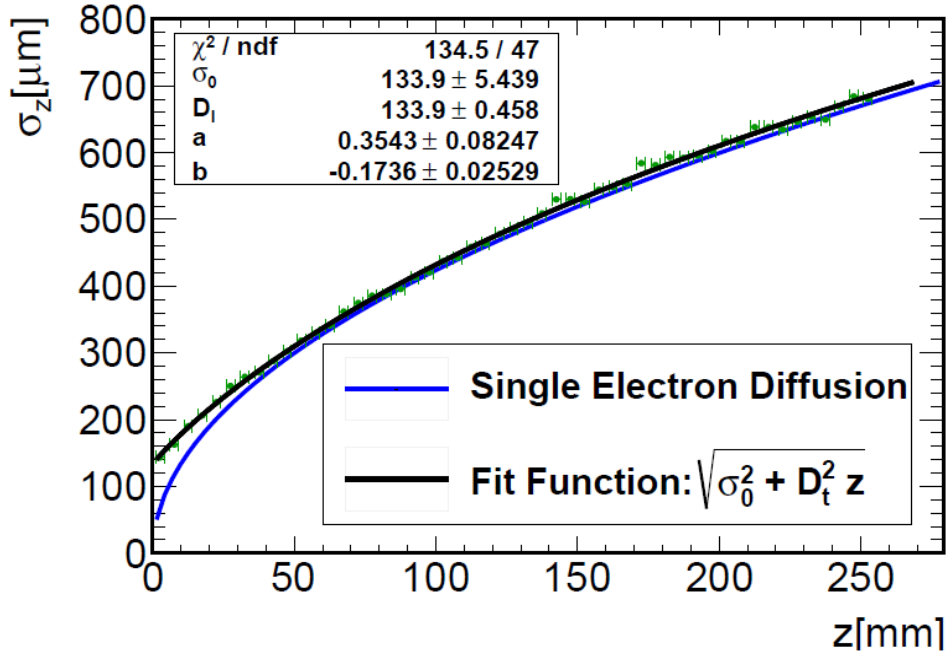
Examples for short and long drift distance

TimePix with GEM: Resolution

- XY resolution
  - Limited by transverse diffusion
  - Short drift distance:
    - Charge deposition can result from more than one primary electron
    - Taken into account by fit function



- Z resolution:
  - Limited by longitudinal diffusion
  - For drift distances larger than 50µm close to theoretical limit



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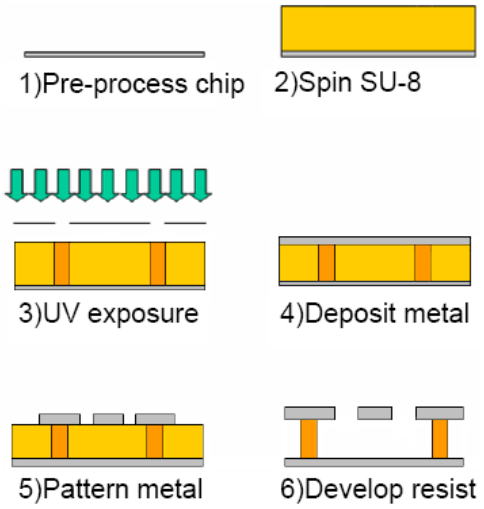
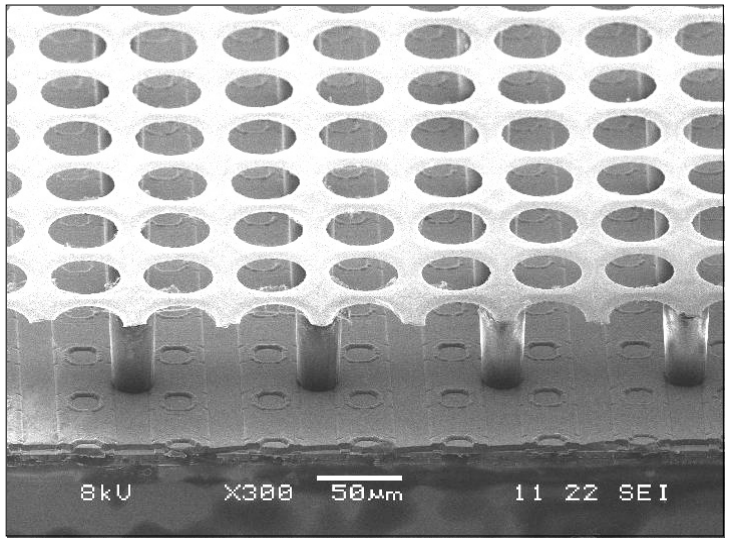
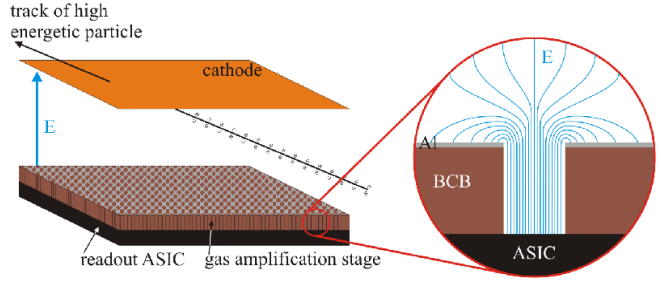
Ingrid studies @ Bonn

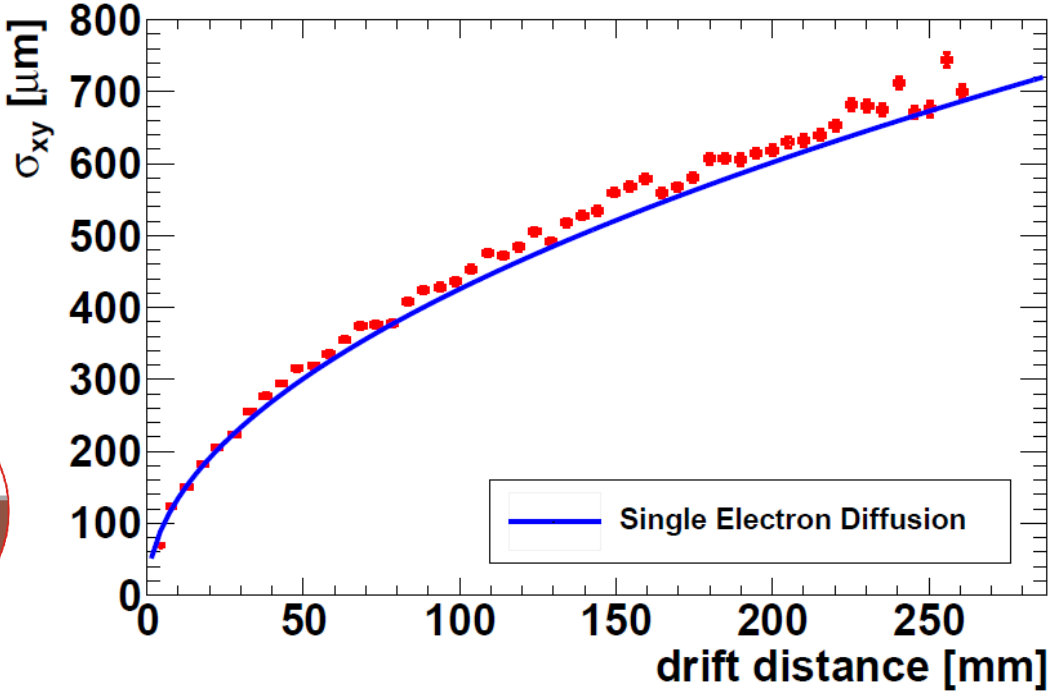
- Ingrid:
  - Micromegas on a TimePix chip
  - Produced with wafer post-processing
  - Mesh holes aligned with pixels of the chip: single e^- measurement





- First wafer processed at IZM, Berlin Signals could be seen, not optimal yet
- Processing of second wafer in progress
- GEMGrid later





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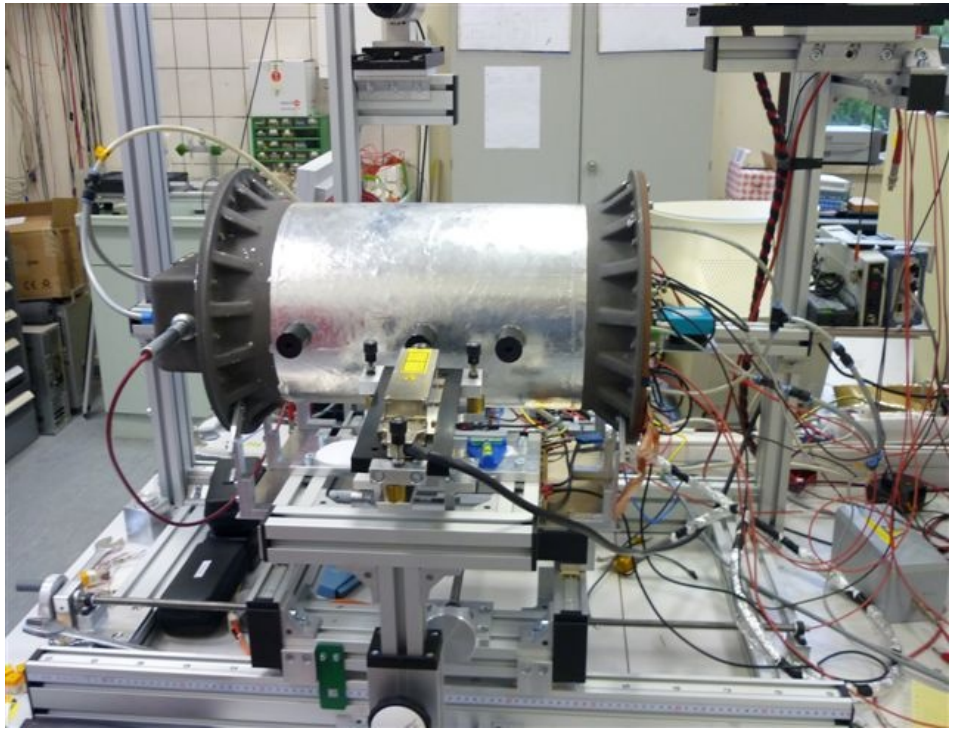
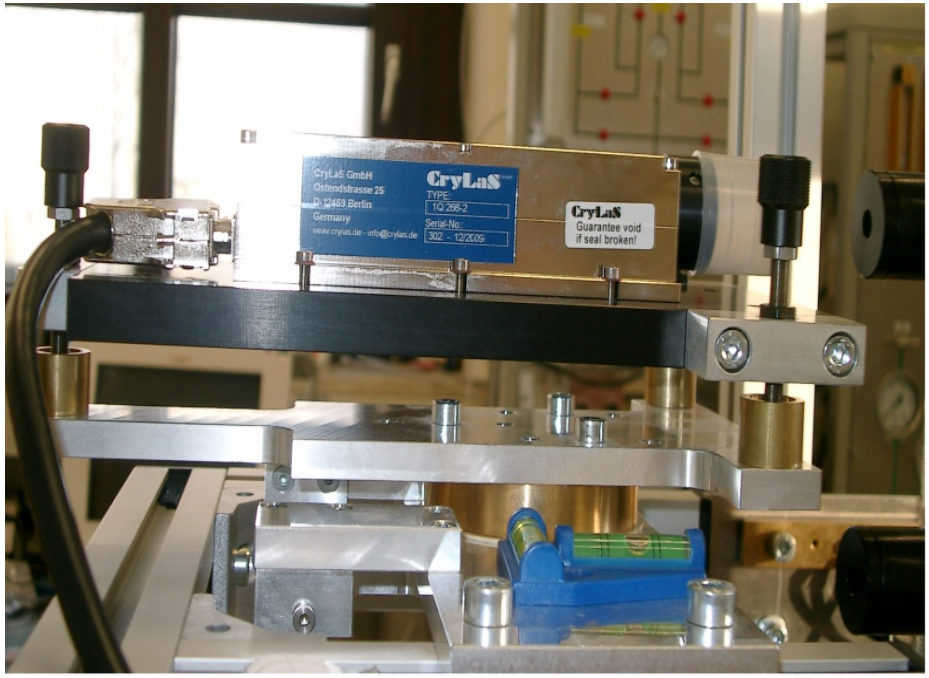
TPC Prototype @ Siegen



- Chamber is made of composite materials
- Drift length: 400mm
- Readout:
  pads (7.4 x 2.3mm²) or TimePix
- GEMs are used for gas amplification
- Whole setup developed at University of Siegen

- UV-Laser (266 nm)
- Beam Diameter at Output Plane:
  (850 ± 150) µm
- Pulse width(FWHM): ≤ 1.0 ns
- Gas: P10 (Argon-Methane 90:10)



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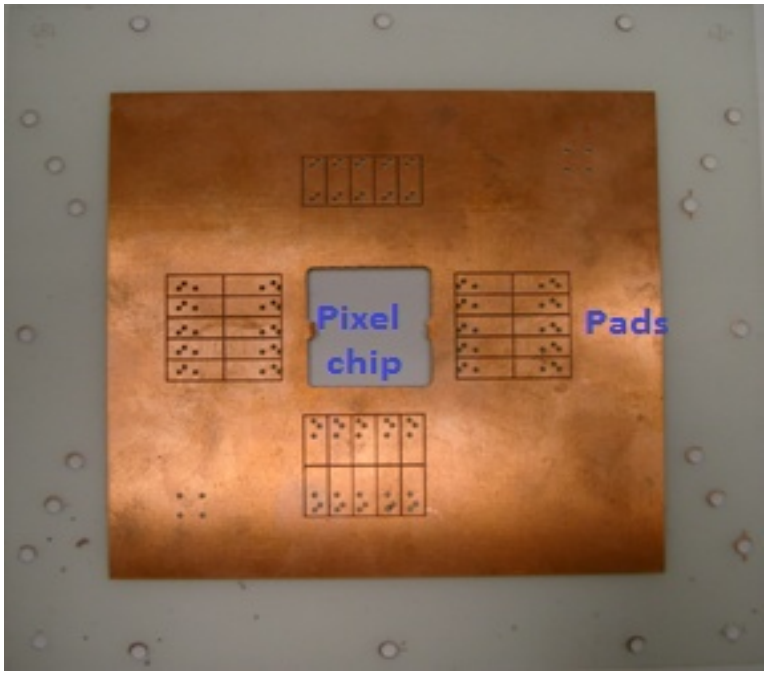
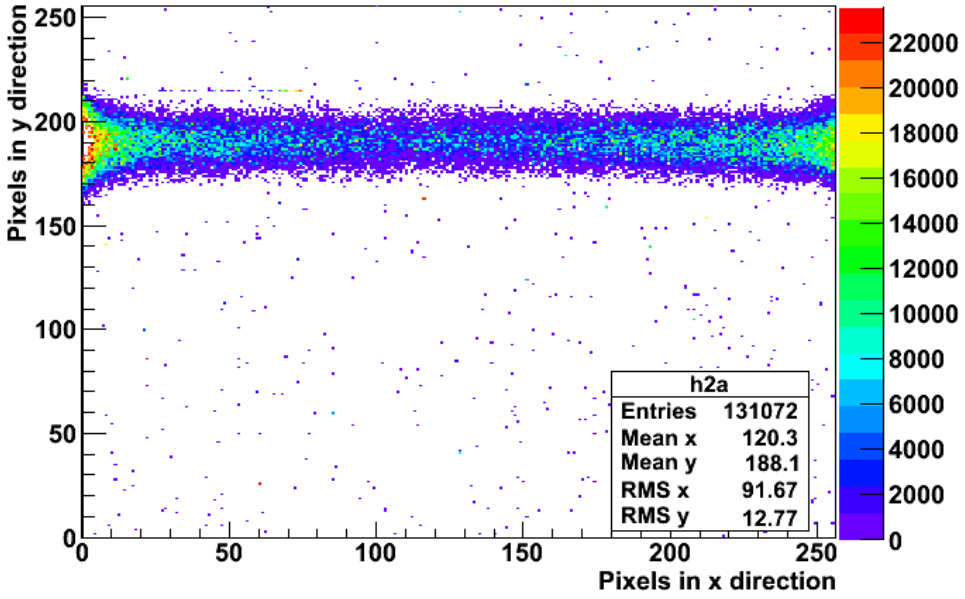
TPC with TimePix readout @ Siegen



- New end plate design contains pads (10x4 mm²) and pixel chip on the same plate
- TimePix chip provided by University of Bonn
- TimePix chip successfully tested at University of Siegen with 3 GEMs and laser signal
- Laser signal is recorded in TOT mode

- Analysis in progress
- Detailed analysis will be done with MarlinTPC framework



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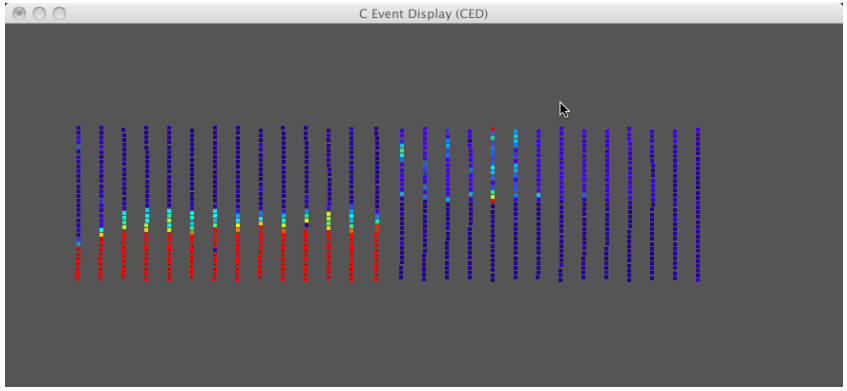
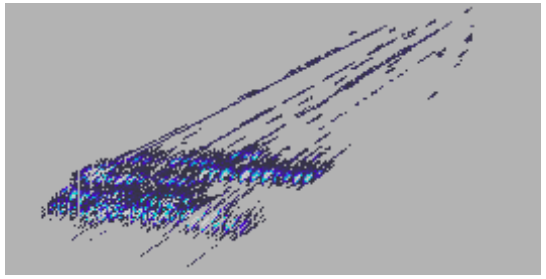
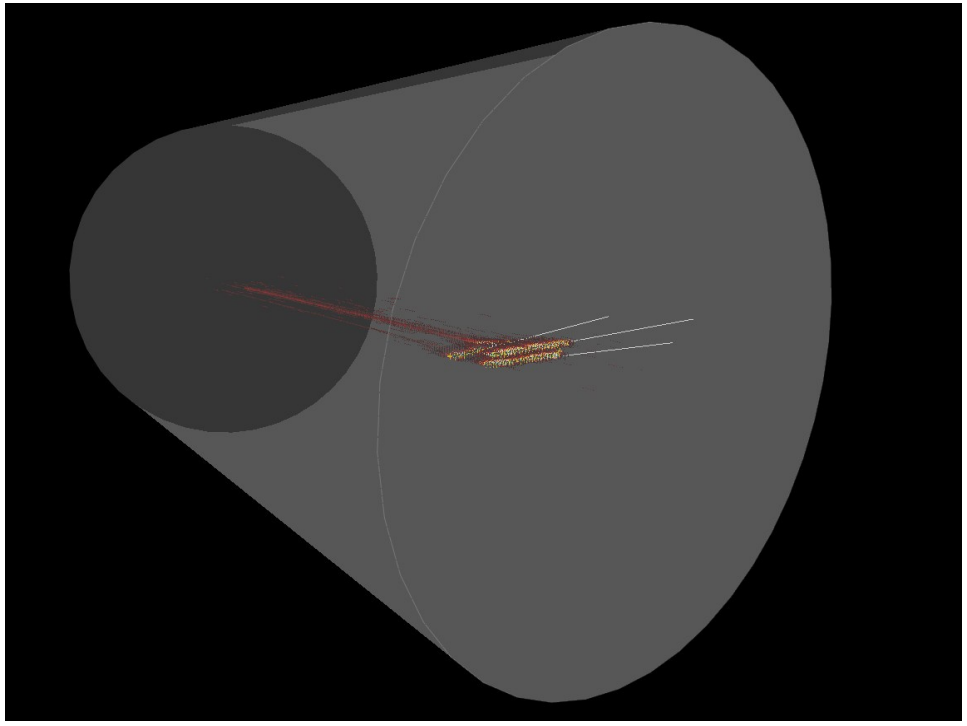
- MarlinTPC (LCTPC software package):
  - Enables R&D groups to do detailed studies, based on common ILC software
  - Used for small and large prototype, pad & pixel reconstruction and analysis
  - Many improvements on the “pixel parts”: speed-up, improved reconstruction, calibration, analysis
  - Also: pad reconstruction and infrastructure (code structure, CED event display, conditions data, tracking & track finding...)

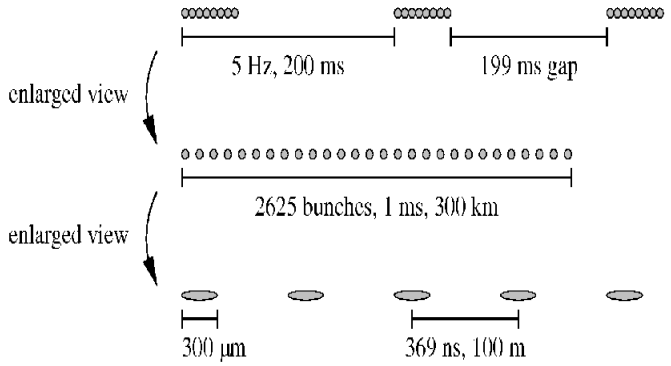






Ion Back Drift

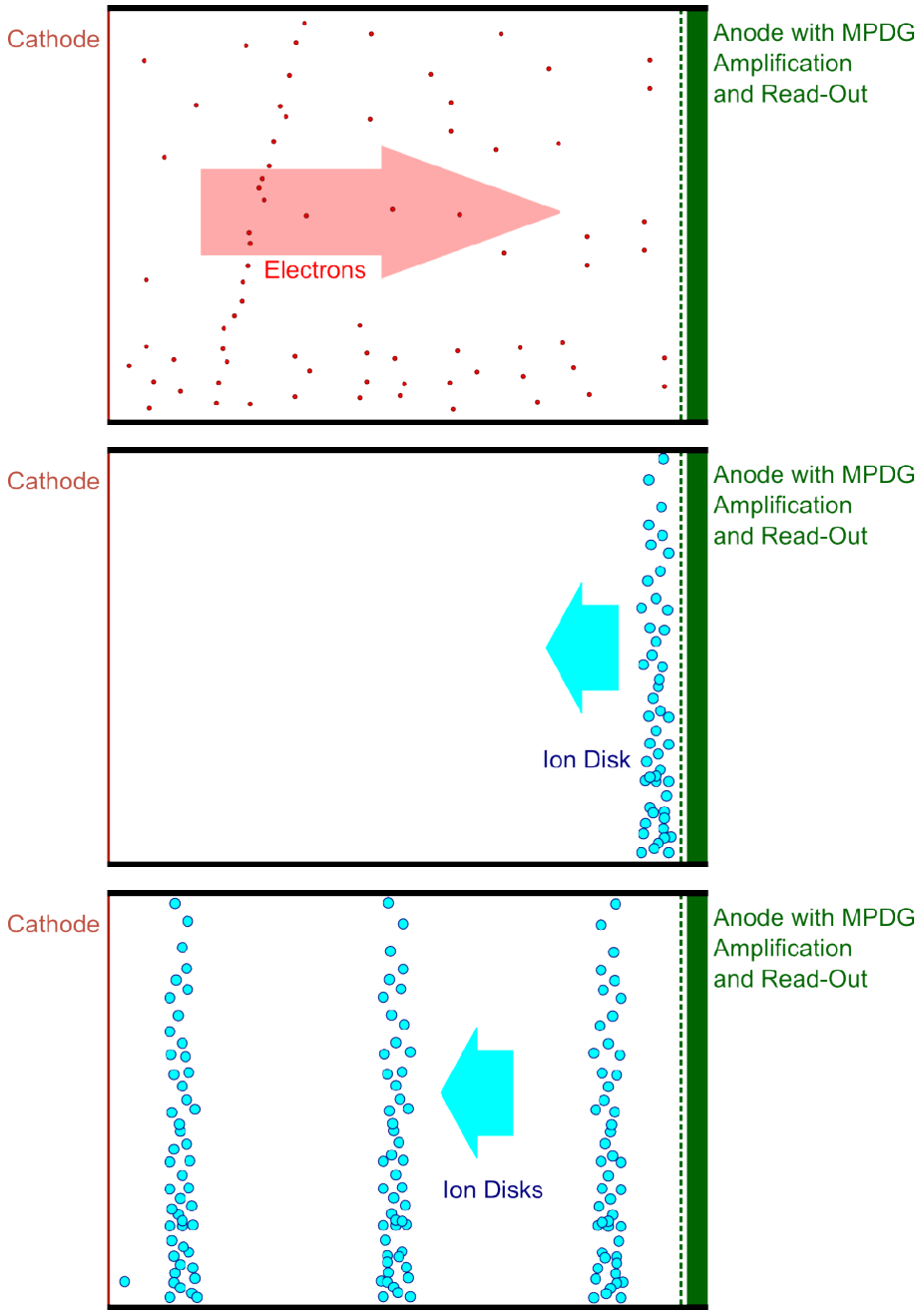
- After each bunch train, a disk of positively charged ions from the amplification stage drifts back into the TPC volume



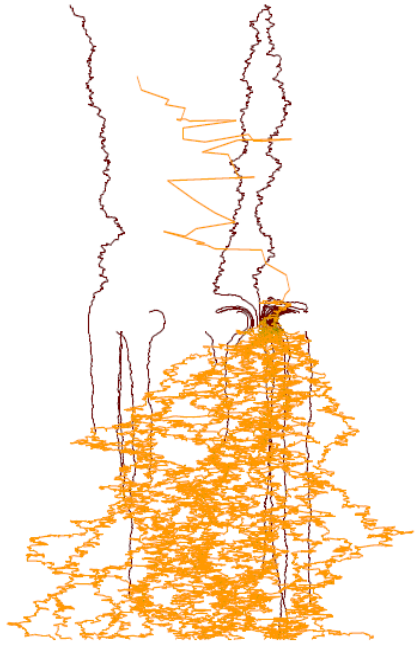
- Due to the very slow drift of ions up to three disks simultaneously in the gas volume

  → Field distortions

- With adjusted GEM settings, the ion back drift can be minimized, but not to zero
- Gating with wires, mesh, GEMs?



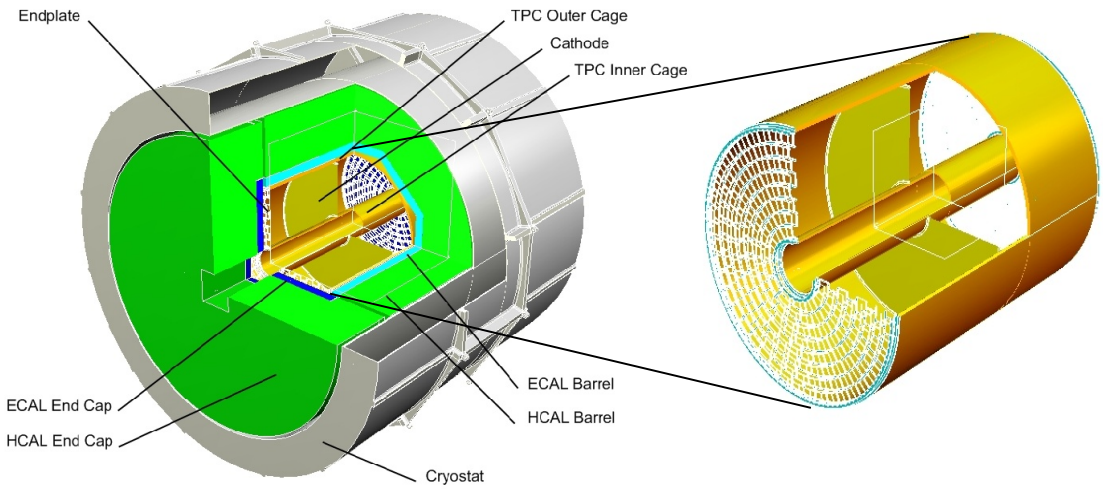
Ion Back Drift Studies

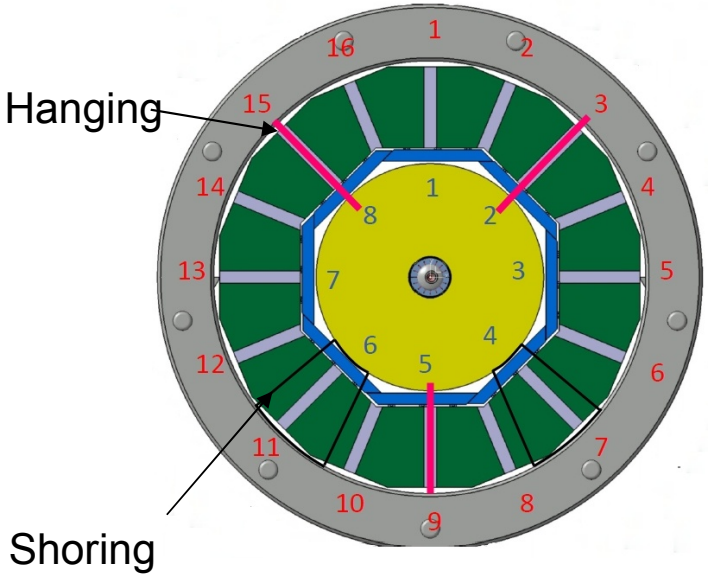


- Simulation:
  - Garfield++ with interfaces from 2 FEM field calculations (Ansys, CST) available
  - First studies done, mini-framework for automation in progress
  - Detailed studies of different GEM layouts and settings planned
- Experimental Setup
  - Small prototype including a radioactive source for gain measurements being re-commissioned
  - Double GEM setup for amplification
  - Plan: use a third GEM to optimize layout/settings for ion feedback suppression
  - Study gating? / Measuring ion back drift?
- ILD Simulation
  - Simulation of influence of ion back drift in the ILD TPC being redone using a more accurate calculation for electric field

Towards the ILD TPC

- Design of ILD TPC in consideration of the surrounding detectors
- Construction and properties of field cage, cathode and end plates
- Where should the TPC be fixed ?
  - Ecal barrel
  - HCAL barrel
  - Cryostat
- Support of SET?
  - Supported from TPC
  - How to mount the SET?
  - Estimated weight of SET





Conclusion

- Many developments last year:
  test beam area, TimePix readout, software and simulation, GEM & pad readout ...
- End of 2012: DBD (Detector Baseline Report):
  - Integrated design and mechanical concept
  - Show “readiness” of technologies for an ILD TPC

- 2012:
  - More realistic ILD TPC design
  - Complete upgrade of test beam stand at DESY (movable stage, PCMAG)
    many visiting groups expected
  - Next iteration of the GridGEM module: measurements and analysis
  - TimePix: IZM Ingrid production, scalable read-out system, next generation TimePix3, large area coverage
  - Improve and extend software and simulation
  - Ion back drift studies