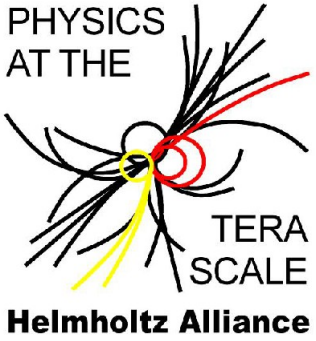
Large Prototypes and Small Pixels

German R&D for a TPC at a Linear Collider

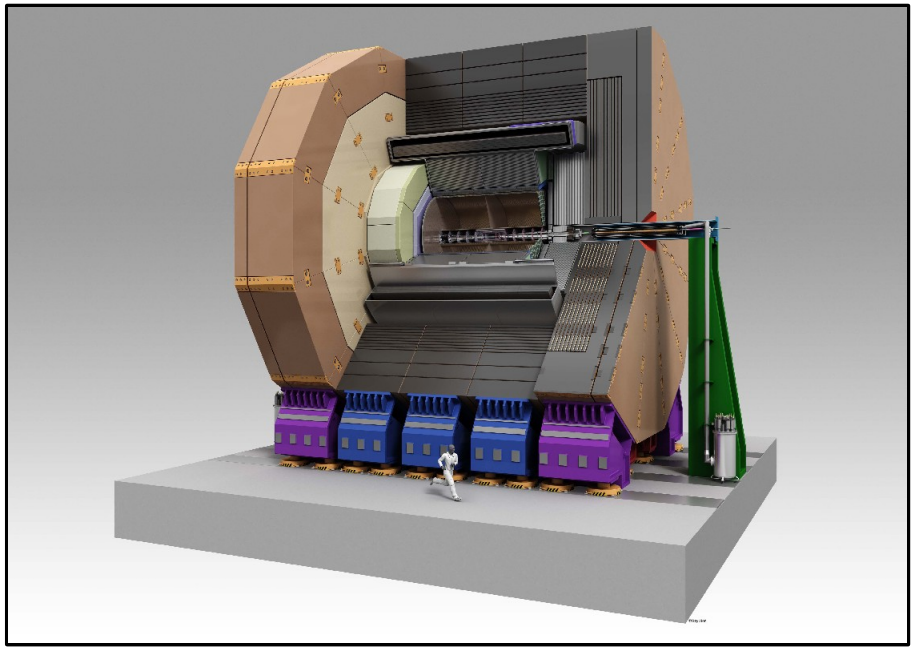
6th Annual Helmholtz Alliance Workshop
Dec. 3-5, 2012

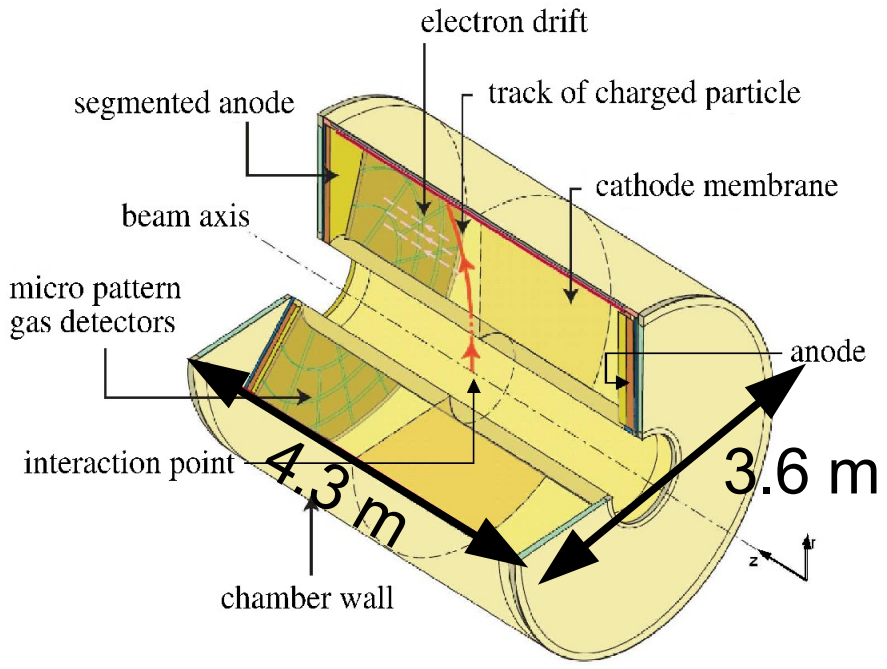
R. Diener, DESY



A TPC at the ILD

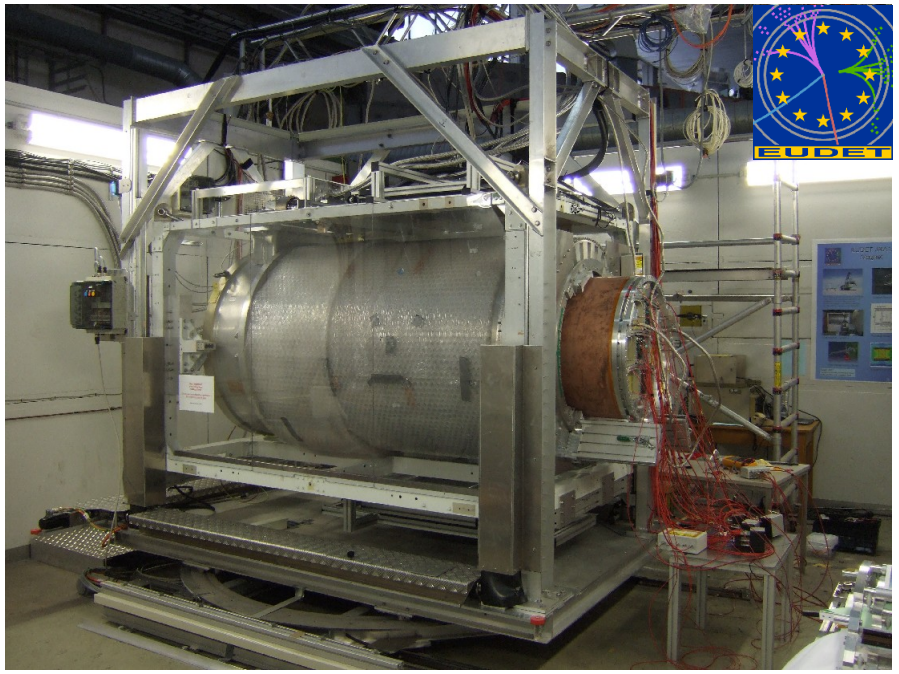
- ILD: a multi purpose detector for the ILC
- TPC as main tracker
  - Robust tracking, ~ 200 space points per track:
    - Easy pattern recognition
    - Robust towards machine backgrounds
  - dE/dx-measurement input to particle ID
  - σ ~ 100μm (rφ) and ~ 500μm (rz) @ 3.5 T
- Well suited for Particle Flow concept:
  - Good track separation
  - Good pattern recognition
  - Very light weight (material budget < 0.05 X_0)
- Research performed by international LCTPC collaboration

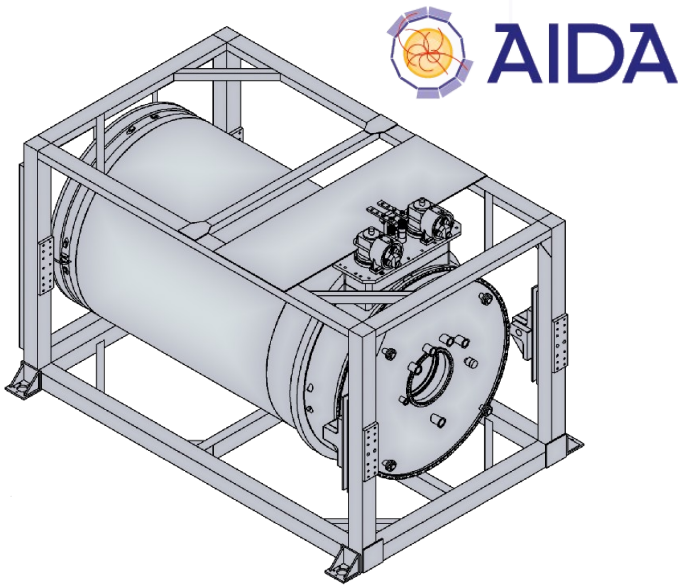


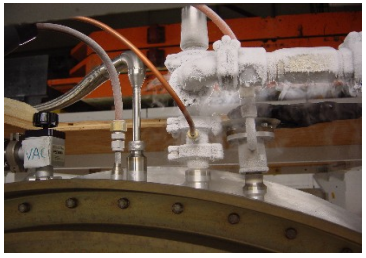


T24/1 Test Beam Setup

- Set up in DESY II test beam, area T24/1 (e^+/e^- from 1 to 6 GeV/c):
  PCMAG magnet mounted on movable lifting stage (3 axis), cosmic and beam trigger, HV, gas and slow control systems, laser calibration system, etc. …
  - Many improvements this year
- PCMAG Upgrade in AIDA (KEK & DESY)
  - Before: filling manually with liquid Helium
    - Expert work and longer running times (many fillings): increasing probability of pipe blocking due to small amounts of air in the system
  - PCMAG cooling using cryo coolers (closed circuit system)
    - No handling with cold gases,
    - Simple switch-on procedure
    - Increased safety
    - Long-period operation possible

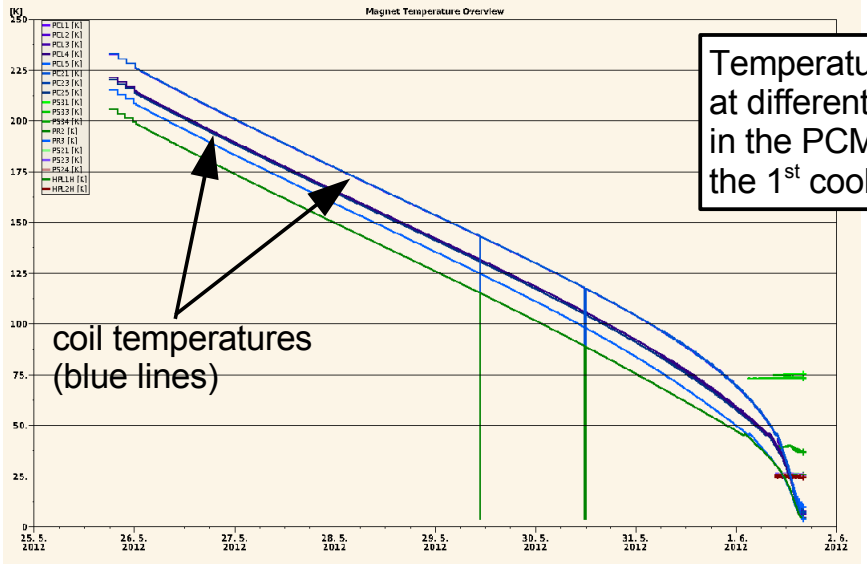






PCMAG Upgrade

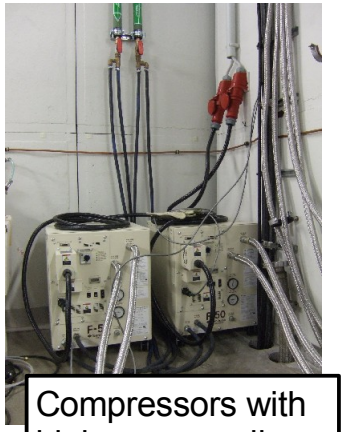
- July 2011 - March 2012
  Modification of PCMAG at Toshiba
- March/May 2012
  Installation with support from Japanese experts
- May, 2012: 1st Cooldown of magnet at DESY
- June, 2012: First excitation test
- Continuously cooled from 1.6.-29.9.
  without problems
- Cooldown on 15.-24.Nov. without problems



Temperature values at different locations in the PCMAG during the 1st cooldown in May

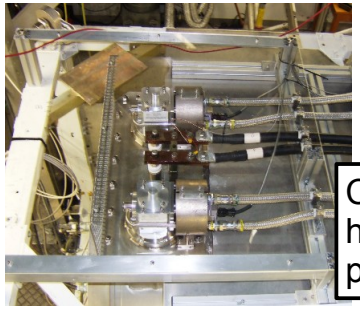
Installation of the cold heads

Mounting of PCMAG at DESY



Compressors with high pressure lines to cold heads

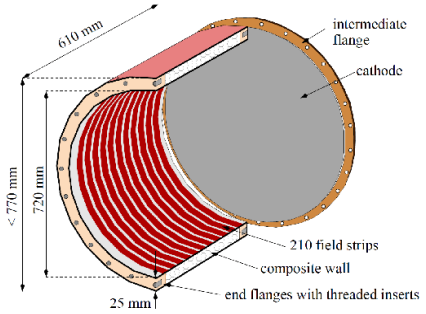
Test Beam Hut: power and monitoring racks

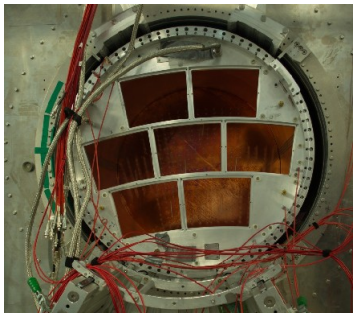


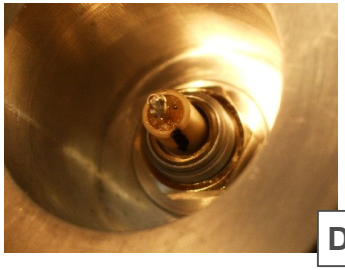
Cold heads with high pressure and power lines

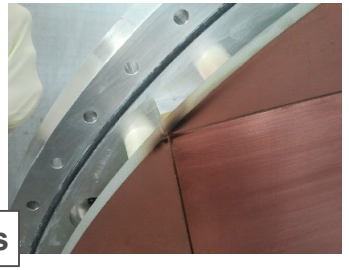
Large TPC Prototype

- High Voltage Improvements
  - Up to ~ 16kV before, unstable during test beam period
  - Touched and improved nearly every HV relevant corner of the field cage
  - Successfully tested at 17kV, further tests at higher voltages planned
- Second field cage: postponed to 2013 due to other tasks
- Module mounting tool nearly ready

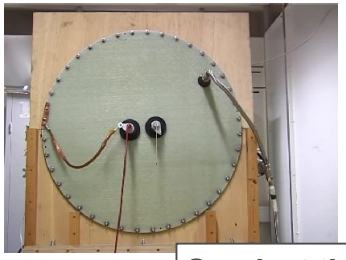


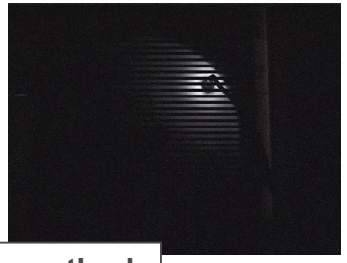




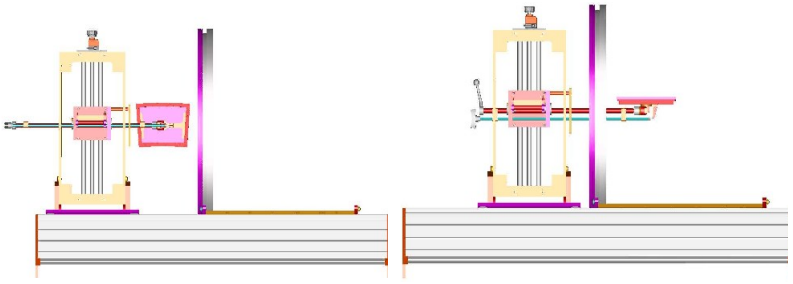


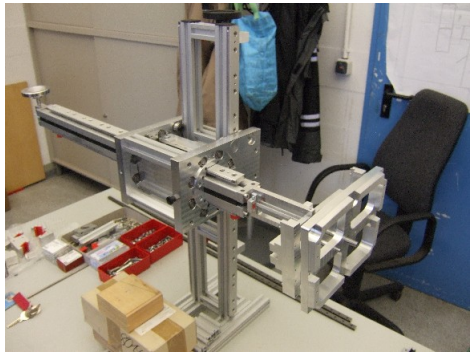
Discharge carbon traces





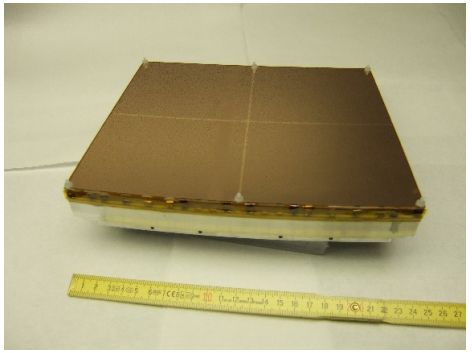
Spark at the cathode

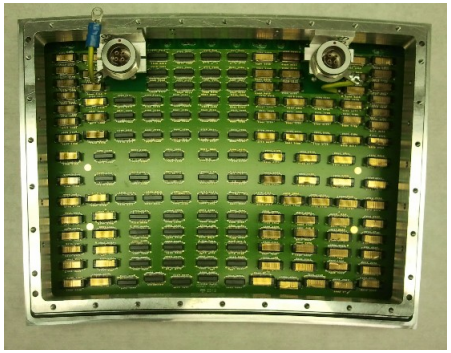


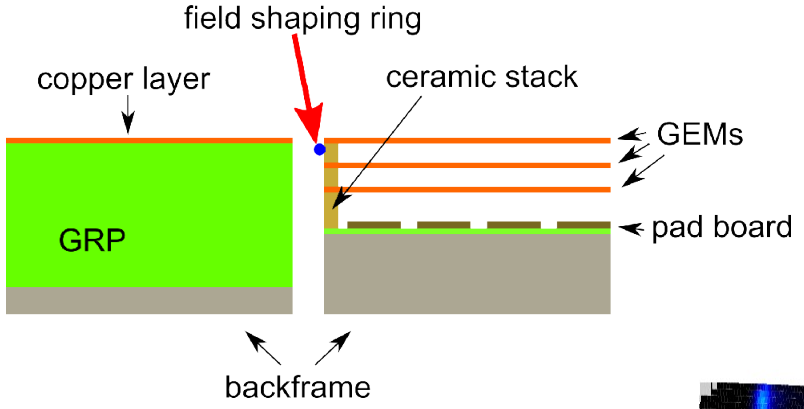


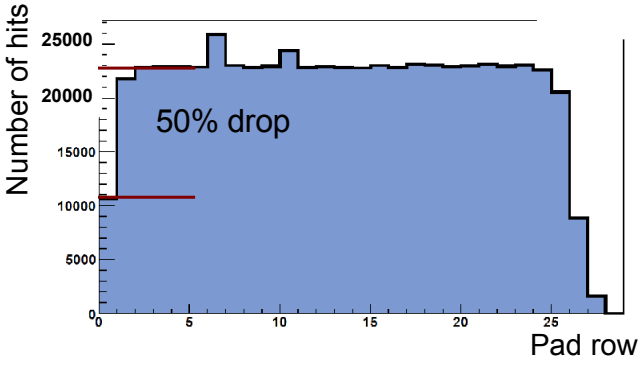
GridGEM Module @ DESY

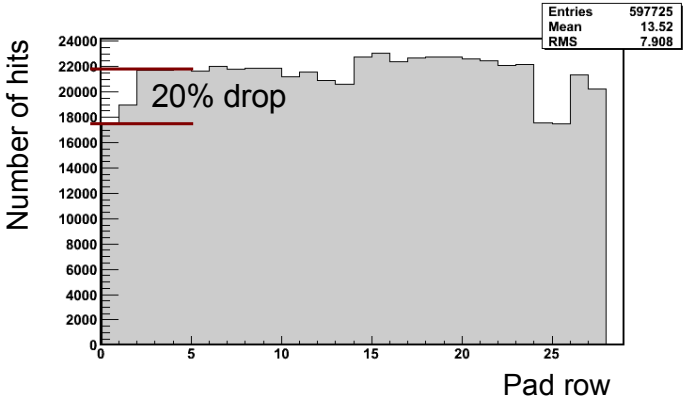
- Triple GEM amplification with ceramic grid mounting, dimensions: ~ 23x17cm^2
- Pad plane (Alliance cooperation with U Bonn): now full area covered by 1.26x5.85mm^2 pads
- Improved HV distribution and guard ring to minimize field distortions
- Sept. 2012: new measurements with three modules in DESY test beam
  - Problem with gas tightness due to new cable holding structure
  - Next test beam planned early 2013



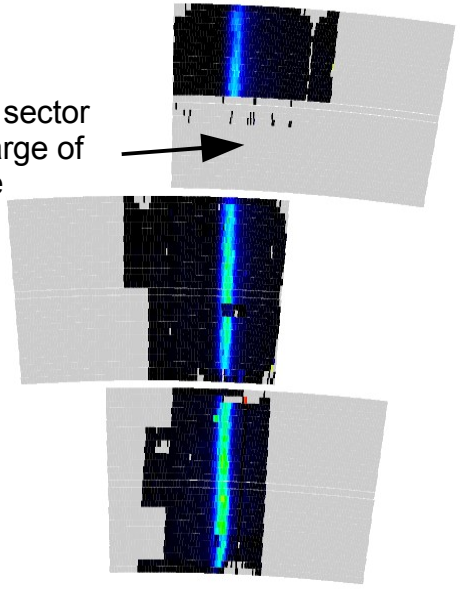






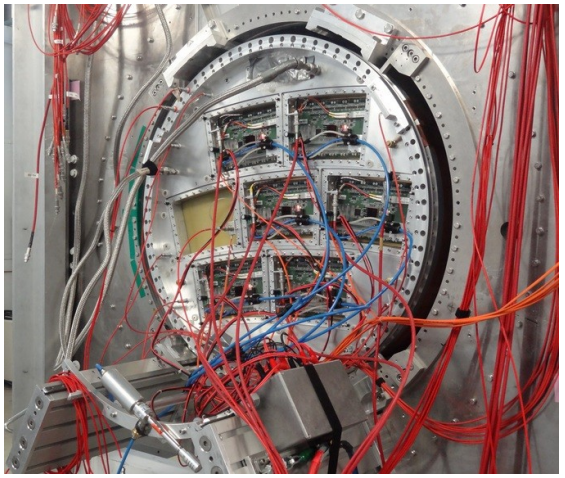


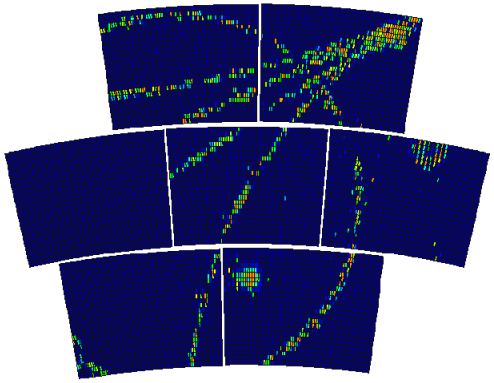
Broken GEM sector due to discharge of the field cage

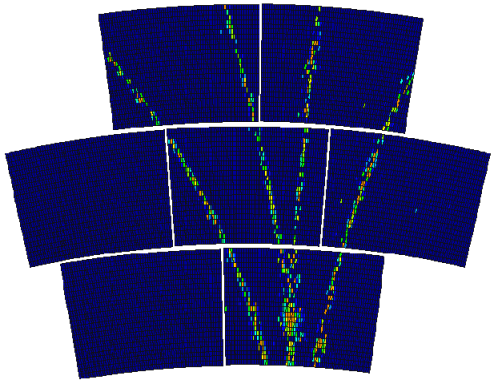


More Testbeam Activities

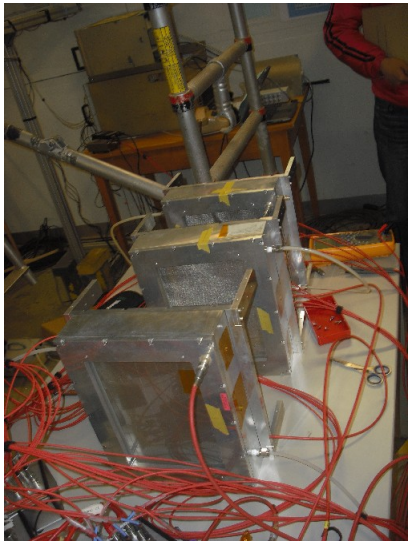
- French/Canadian testbeam campaign with 7/6 Micromegas modules with integrated electronics
  - Very fast commissioning and installation
  - Successful testbeam effort which will be continued next year

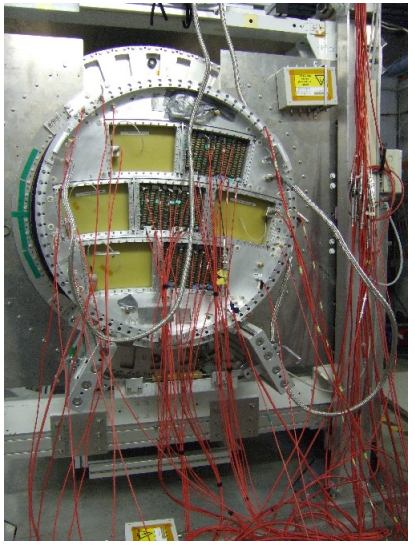






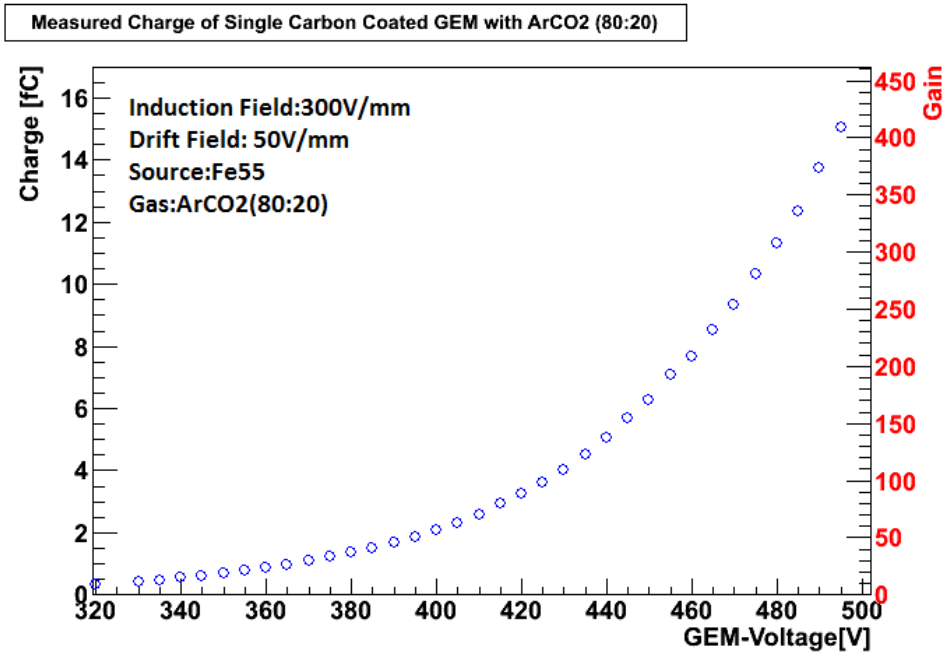
- Japanese campaign currently ongoing
  - Three double GEM modules with pad readout
  - Module commissioning in test boxes finished
  - HV stability tests currently running
  - Possibly test of wire gating layer

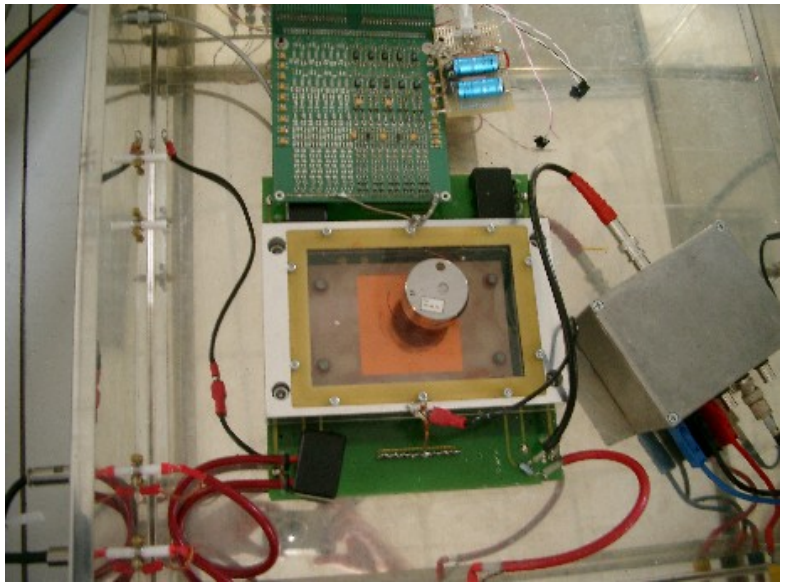




Carbon Coated GEM for TPC

- University of Siegen is testing carbon coated GEMs in a small chamber
- Using Standard GEM 50x50mm^2
- GEM coated with 0.1µm thick carbon layer over the whole surface
- Prepared at Fraunhofer Gesellschaft für Schicht und Oberflächentechnik, Braunschweig
- Drift Length: 5.4mm

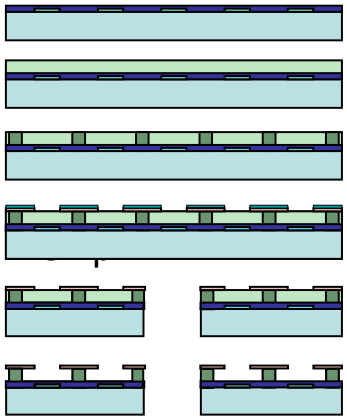




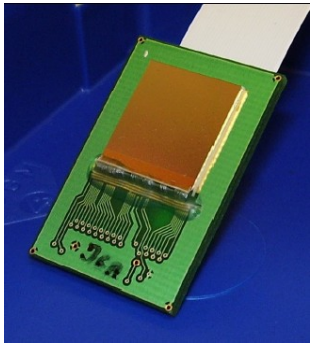
- Expected Advantages of Coated GEM:
  - Higher voltages possible → much higher gains can be achieved
  - Higher energy resolution
  - Less change in gain during time (stable in time)
  - Less change in resistance of GEMs over time
- Result:
  - GEM has been operated up to 500V
  - Gain measurement has been taken successfully
  - Current/gain stability measurements in progress

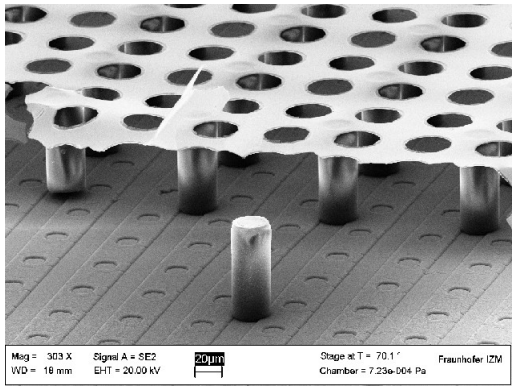
InGrid studies @ Bonn

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

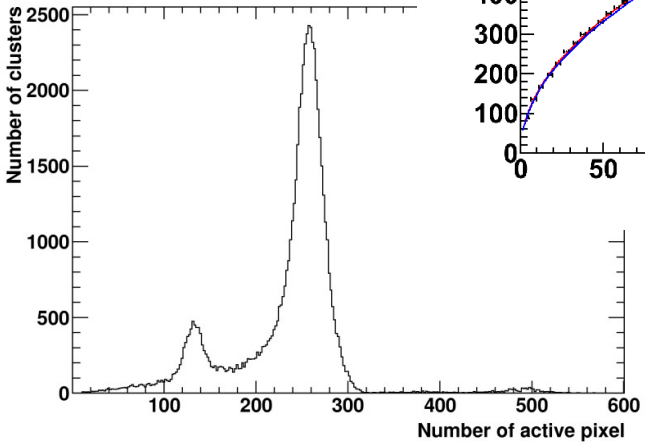


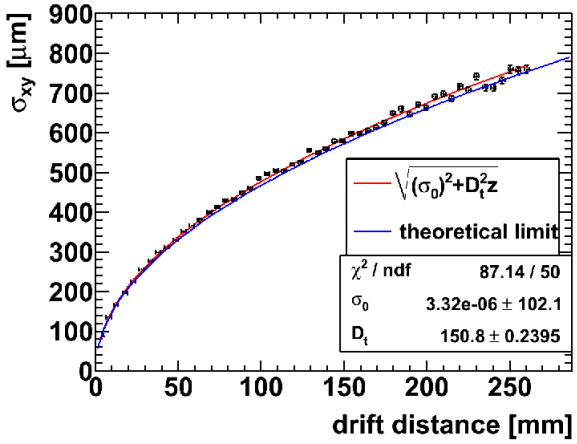
1. Formation of Si_xN_y protection layer
2. Deposition of SU-8
3. Pillar structure formation
4. Formation of Al grid
5. Dicing of Wafer
6. Development of SU-8





Energy resolution (σ/μ):
(6.82±0.17)% at 2.7keV
(4.95±0.04)% at 5.9keV

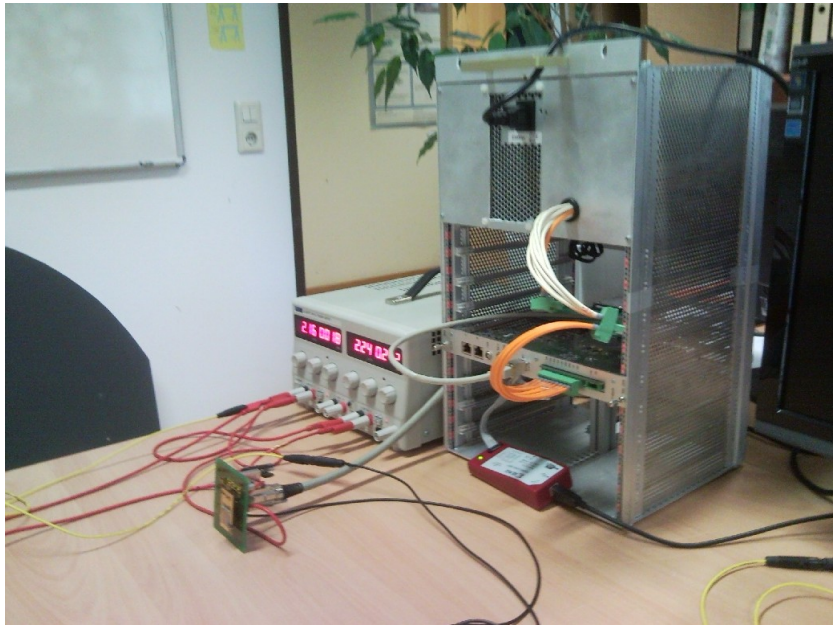




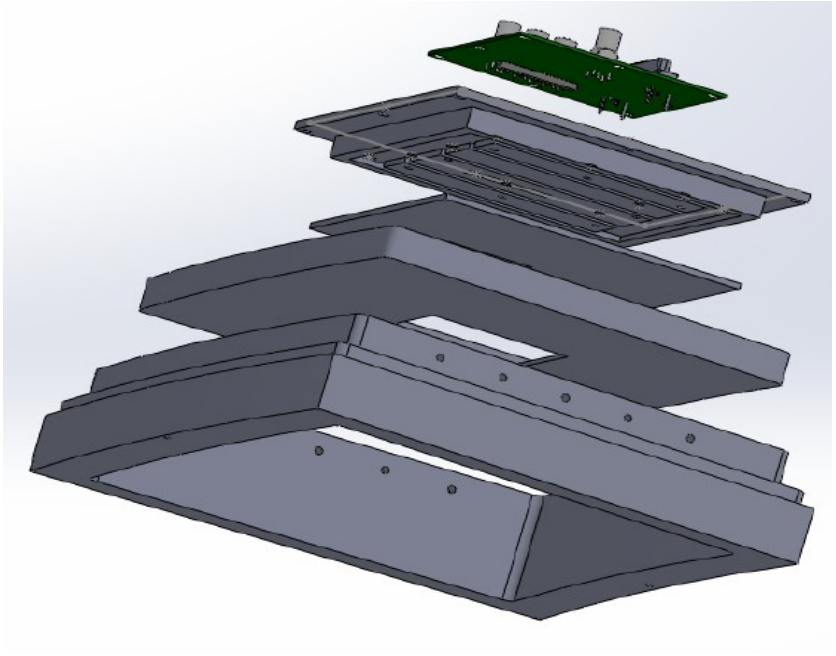
- InGrid post-processing:
  - U Twente: max 9 chips → Fraunhofer IZM: 1 wafer (107 chips)
  - First wafer processed at IZM not optimal: problems with resistive layer and Al-grid
  - Second wafer: resistive layer needs optimization (chips die after > 2 weeks)
  - Third batch (09/2012): very good behavior, 5 chips tested for > 4 weeks

Status Timepix + SRS Readout

- SRS: Scalable Readout System (RD51)
  - Adapted to Timepix chip, readout of one chip in operation
  - Octoboard in preparation:
    Test in Large TPC Prototype at DESY in March/April 2013 with GEM gas amplification
  - Long scale: 96 chip module
    (50% active surface, 6 mio. channels)

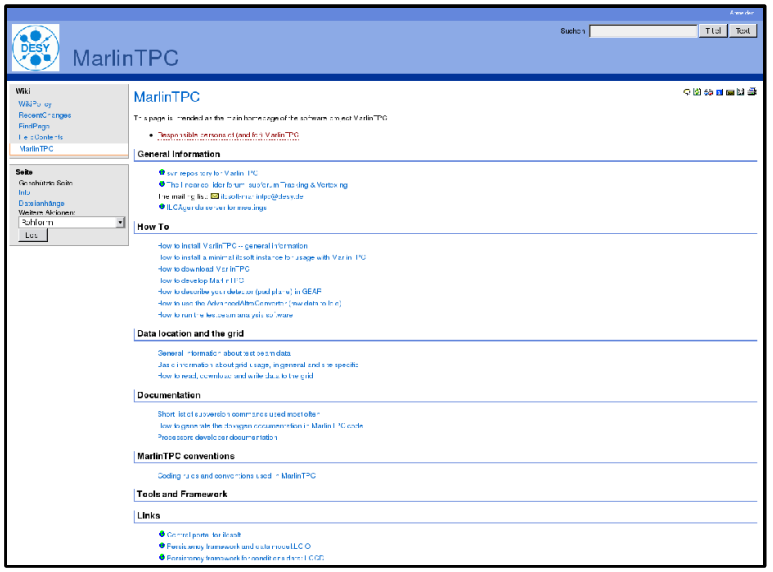


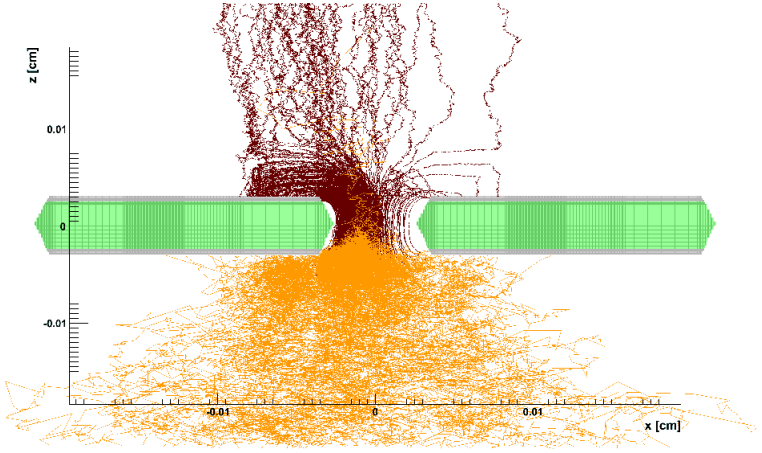
- DAQ software / SRS FPGA firmware
  - Ready to handle octoboard
  - Calibration algorithm test ongoing, current results promising



AIDA

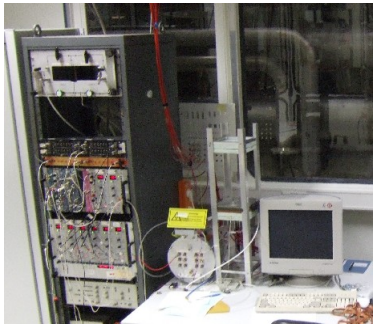
- MarlinTPC (LCTPC software package):
  - Enables R&D groups to do detailed studies, based on common ILC software
  - Used for small and large prototype, pad & pixel reconstruction and analysis
- A new track fitting package based on a General Broken Lines fit has been developed and integrated in MarlinTPC
- A fast analysis package for use at the test beam has been developed
- Documentation is being extended (wiki, notes, running examples)
- Detailed GEM Simulation
  - Garfield++ (RD51) with interfaces from 2 FEM field calculations (Ansys, CST)
  - Mini-framework for automation implemented
  - Detailed studies of different GEM layouts and settings have started

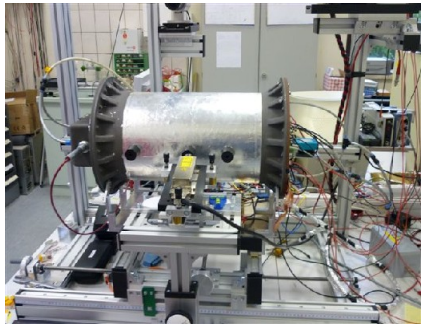


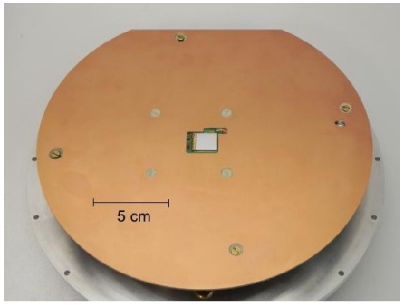


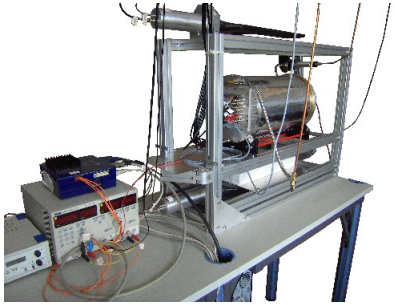
Conclusion

- Active work with smaller prototypes
  - DESY ion back flow measurement setup extended with a test chamber and fast nano-Ampere measuring devices from University of Bonn
  - Siegen test chambers reliable working in measurements with radioactive sources, cosmic muons and laser induced tracks
  - Studies with former Aachen prototype using triple GEM amplification and Timepix readout ongoing at University of Bonn









- Strong effort to study ion back flow minimization and its impact using small prototypes and simulations

- Continuous improvement of TPC test beam setup
- Testbeam campaigns planned in 2013 by DESY with GridGEM module and by Bonn with Timepix module

- Active development of software components (reconstruction and analysis), documentation and common infrastructure: data storage, conditions database servers