AIDA

Advanced European Infrastructures for Detectors at Accelerators

Presentation

LCTPC Setup at the DESY Testbeam

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14 May 2014

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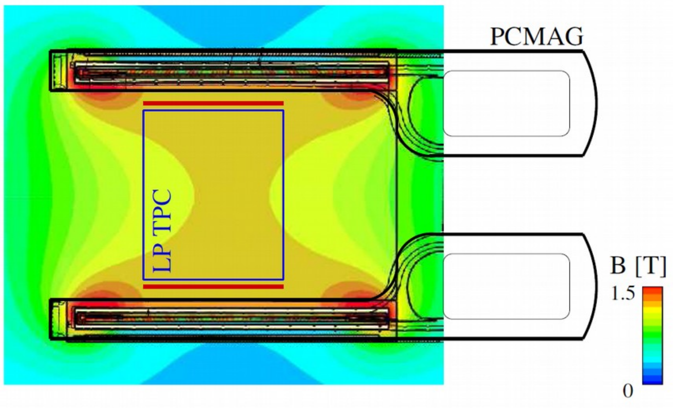
LCTPC Setup at the DESY Testbeam

AWLC 14, Fermilab

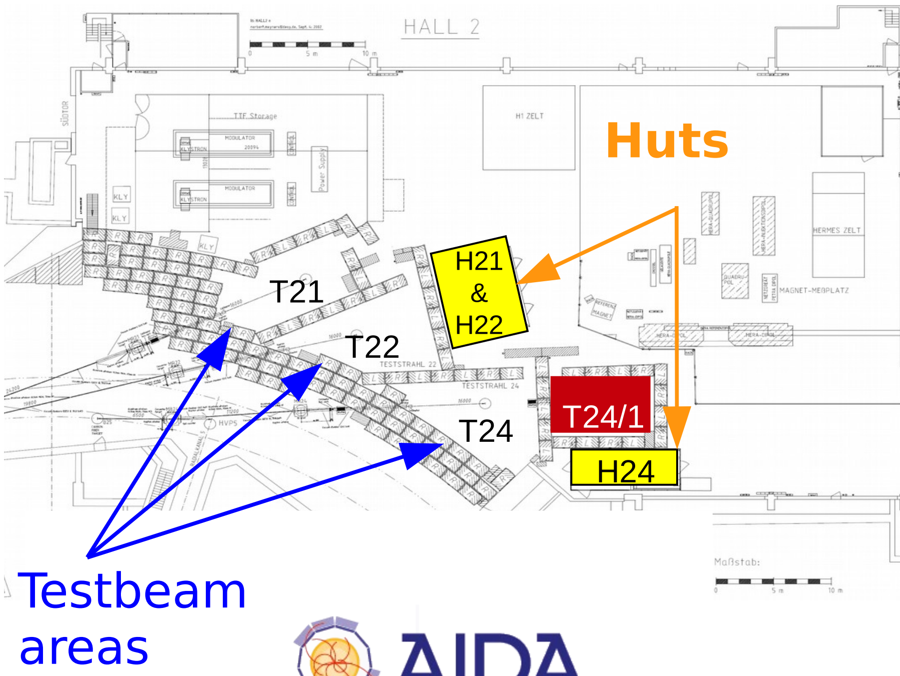
14.05.2014, R. Diener, DESY

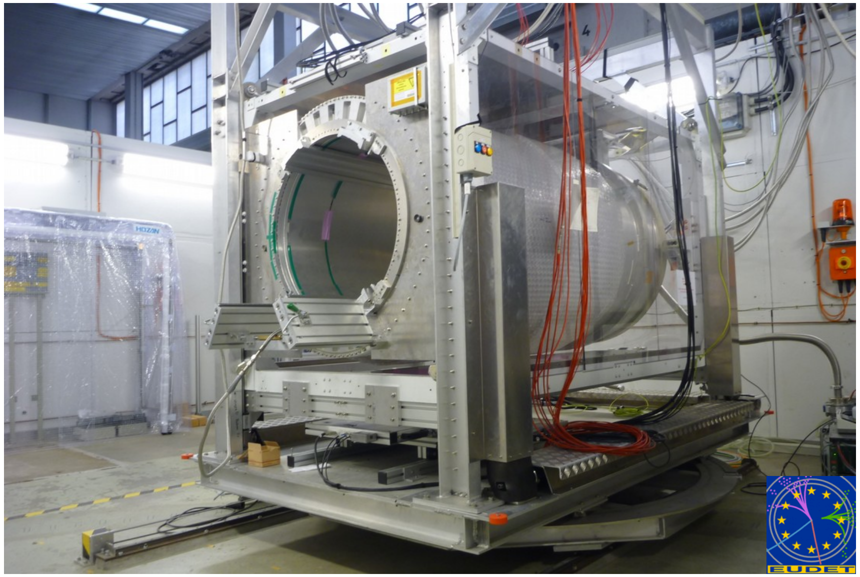
DESY II Testbeam / Area 24/1

- DESY II Testbeam facility offers
  - 3 beam lines with 1-6 GeV electrons
  - Infrastructure
    - Testbeam telescopes
    - Solenoid and Dipole magnet
  - Open to the entire community
  - High uptime, very reliable running
- PCMAG installed at area T24/1
  - Thin coil and wall ($0.2X_0$), no return yoke
  - (Operational) field up to 1T



  - Usable space inside: ∅ ~85 cm

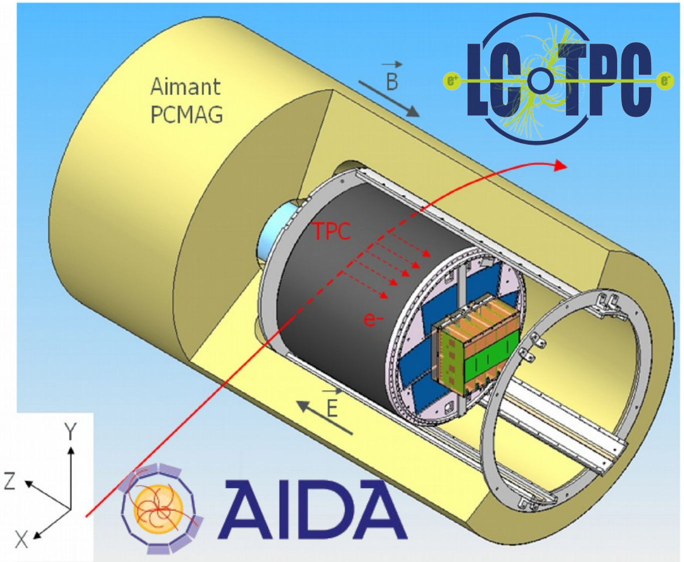


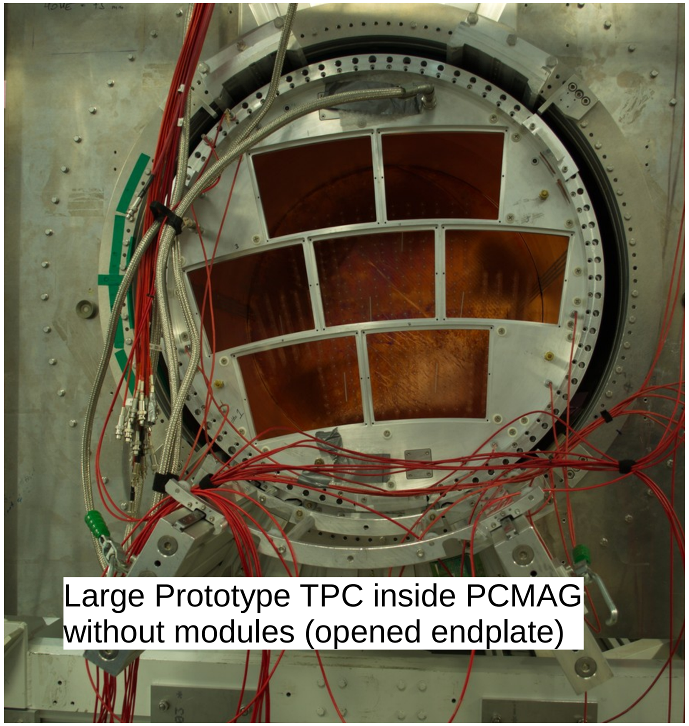


LCTPC Setup at T24/1

- LCTPC Setup in T24
  - Large TPC Prototype:
    - Light weight; made of composite materials
    - Sensitive Volume: ∅ 72cm, L= ~58cm
  - Modular end plate by U Cornell
    - Up to 7 read-out modules
    - Size/shape similar as foreseen for the final detector
- HV, gas and slow control systems
- Cosmic and beam trigger
- Laser calibration system

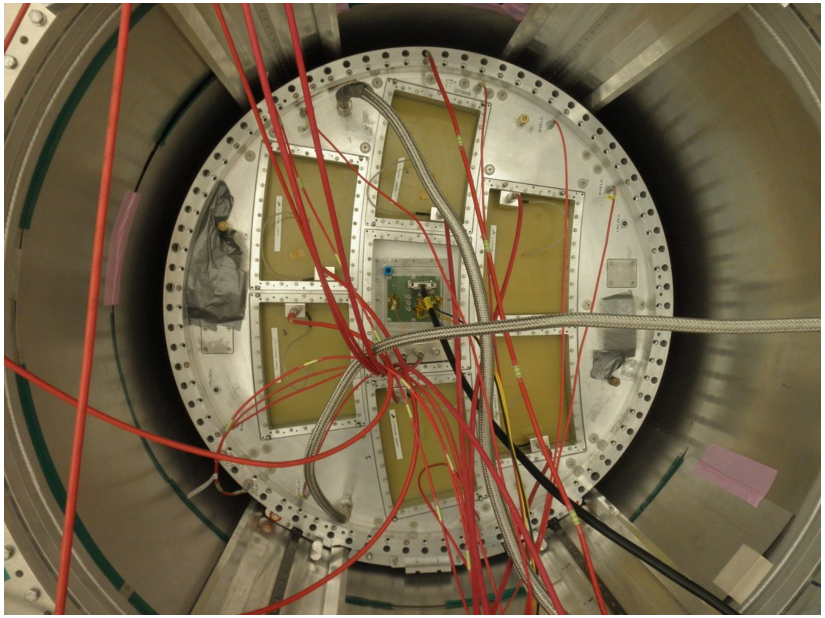
- Next slides: use in 2013/14

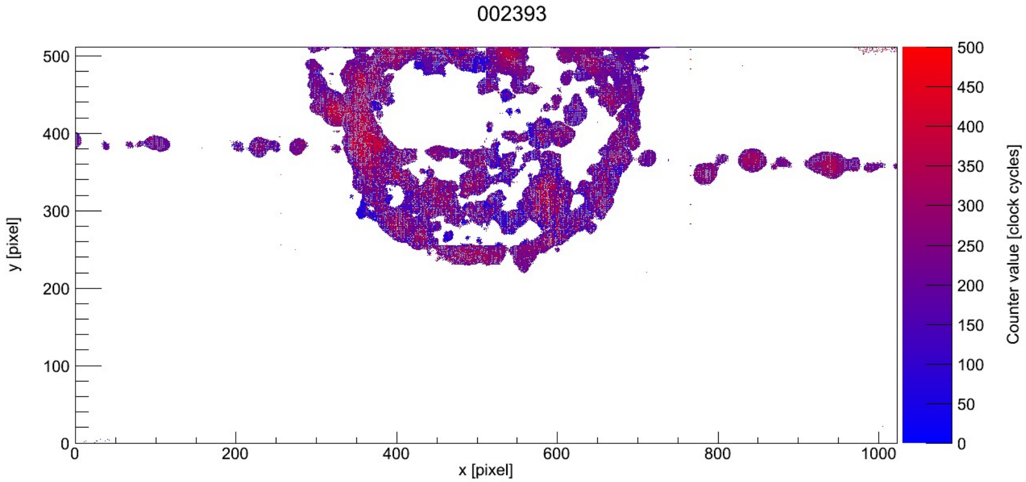


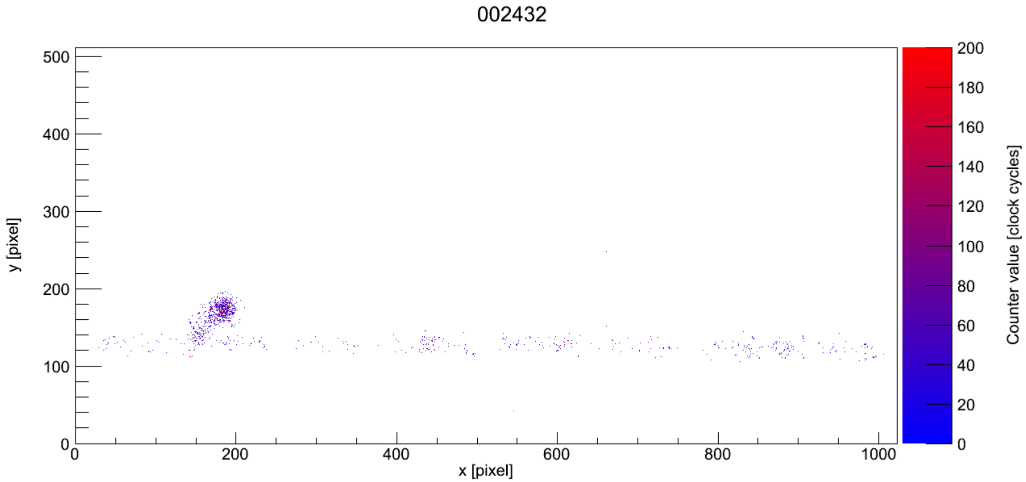

Large Prototype TPC inside PCMAG
without modules (opened endplate)

U Bonn TimePix Modules

- TimePix Octoboards, 2 modules:
  - Ingrid Octoboard (Micromegas post-processed, pixel aligned on TimePix chip)
  - Triple GEM amplification above TimePix Octoboard
  - New (scalable) readout system
  - 2 weeks beam time

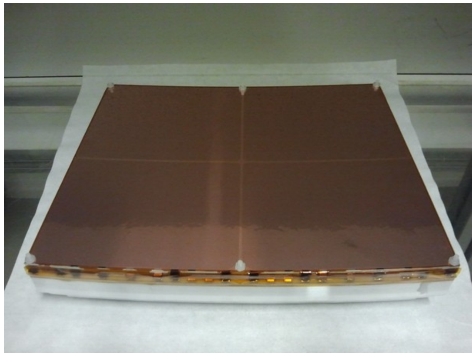


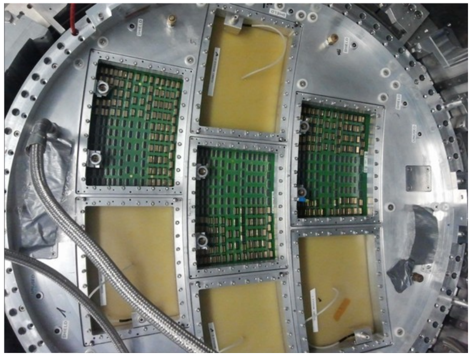




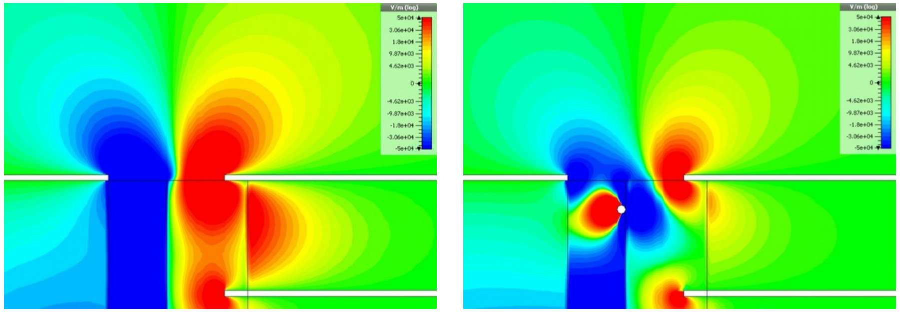
DESY GEM Modules

- 3 readout modules with triple GEM amplification with pad readout (ALTRO)

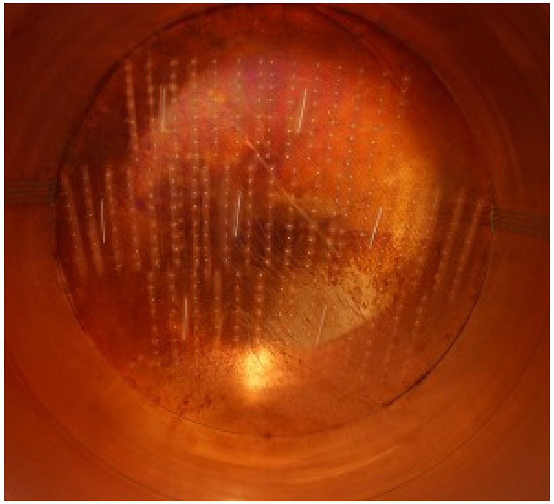




- Guard ring to minimize field distortions at module boarders



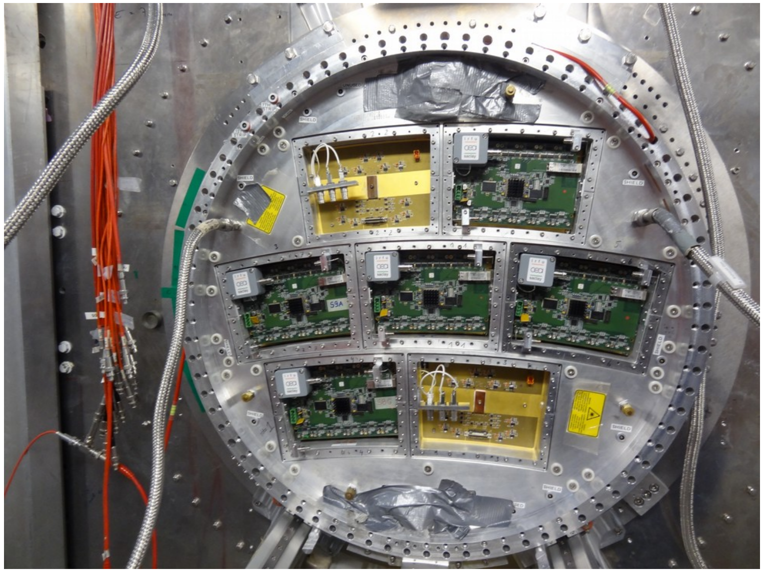
- Measurements of laser photo dots for field distortion studies

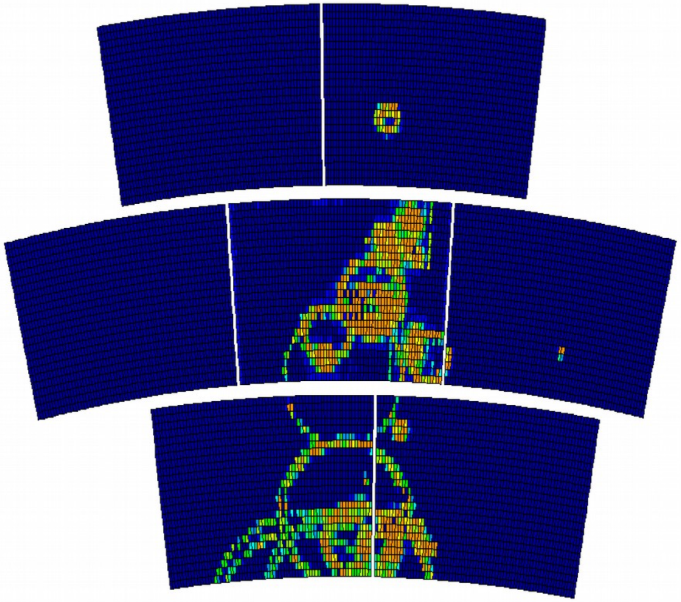


- 4 weeks beam time
  + 1 week laser measurements
- See also next presentation

Micromegas Modules

- 7 modules with Micromegas amplification
  + resistive layer to spread charge on pad layer
- Integrated AFTER readout





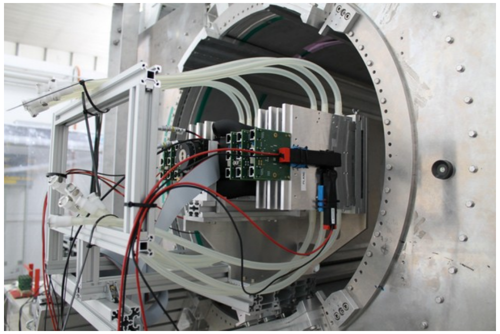
- 5 weeks of beam time
  - 4 weeks with integrated readout
    - 2 weeks with new 2PCO_2 cooling
      (incl. combined tests with 2 Octopuce modules & laser data taking)
  - 1 week with ALTRO readout
- More in A. Bellerives and S. Ganjours presentations

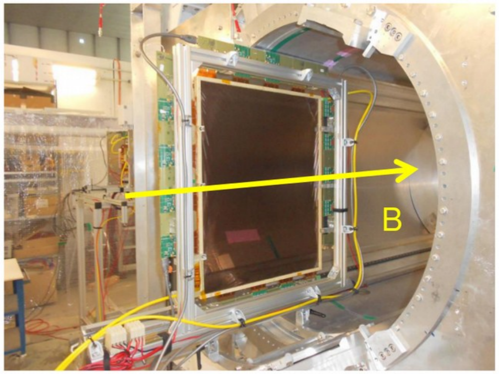
TRACI 2PCO2 Cooling

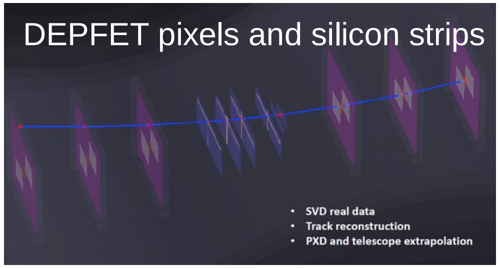
- TRACI: **T**ransportable **R**efrigeration **A**pparatus for **C**O2 **I**nvestigation
  - Very large latent heat and heat capacity makes CO_2 an excellent cooling medium
  - Room temperature operation avoids water condensation
  - High pressures (~60 bar at 20ºC)
  - Low viscosity allows very small pipe diameter
  - Easy & safe to operate
- TRACI 2a build by Nikhef/CERN and acquired by our KEK colleagues for LCTPC
- This system works with a Lewa pump (instead of Gather gear pump):
  - More reliable operation
  - Performance degradation at colder temperatures: less cooling power (not relevant for LCTPC setups)
- First operation at testbeam in February successful

Testbeam T24/1 Usage

- Also besides LCTPC high demand on beam time at DESY II in 2013/14
- ATLAS upgrade:
  - Measurement of Lorentz angle and charge collection efficiency of 12 silicon microstrip test sensors for the phase2 upgrade
    - First use of EUDET/AIDA 6 layer pixel telescope in PCMAG
    - 18 weeks of beam time in 2013/14
  - Micromegas chambers for Small Wheel upgrade
    - 10 days beam time
- GEM tracker chambers for SBS @ JLAB
    - 40x50 cm^2 triple GEM modules, magnetic field up to 500 Gauss
    - 2 weeks beam time
- Belle II Vertex detector
    - Integration test including DAQ, slow control, interlock systems and 2PCO_2 cooling
    - 6 weeks setup, 4 weeks beam time





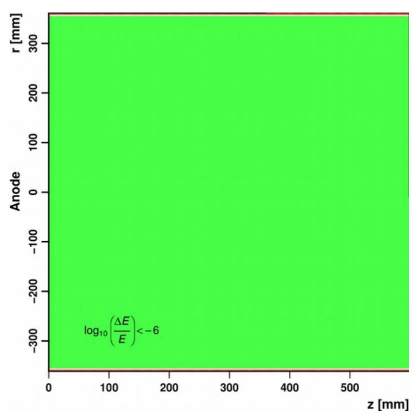


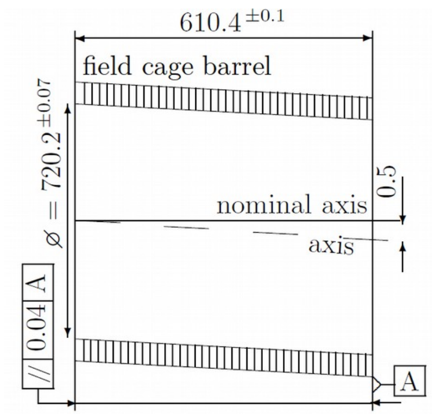
TB24/1		TB24
EUDET in PCMAG	PCMAG	none
—	—	—
—	—	—
—	TPC MMG	ECAL
—	TPC MMG	—
LorAngle	—	—
LorAngle	—	—
—	DESY TPC	—
—	DESY TPC	—
—	DESY TPC	—
—	LCTPC Time	—
—	LCTPC Time	—
LorAngle	—	—
SBS GEM	—	—
SBS GEM	—	—
LorAngle	—	—
—	GridPix	—
—	—	Belle 2 PID
—	LCTPC Time	—
—	ATLAS MMG	—
—	—	AIDA
—	—	AIDA
—		—
—	—	XFEL
—	—	Gossipo
—	—	Gossipo
Surveying		
LorAngle	—	—
LorAngle	—	—
—	—	PICSEL
—	—	PICSEL
PCMAG stage work		
		—
		Belle 2 PID
		—
LorAngle	—	—
LorAngle	—	—
LorAngle	—	—
LorAngle	—	—
LorAngle	—	—
DESY-TPC		
Belle-II Installation		
Belle II VXD		
Belle II VXD	—	—
Belle II VXD	—	—
Belle II VXD	—	—
LorAngle	—	—
—	—	PLUME
—	LCTPC Time	—
—	LCTPC Time	—

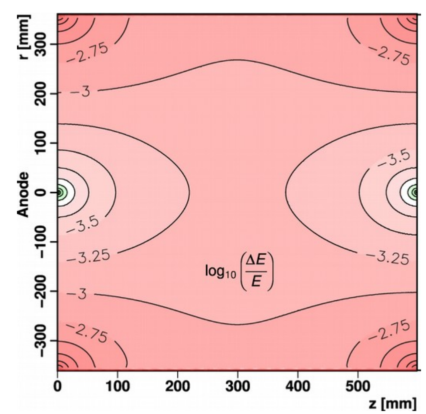
Status and Outlook

- DESY II test beam unavailable at least till autumn 2014
  - Currently maintenance and improvements ongoing
    - Cleaning up, updating equipment, more Ethernet/power plugs
    - Flat floor coating, IP cameras in all areas, lasers for alignment
    - Several “machine” improvements: new targets, shielding, counters, vacuum pumps, …
  - At re-start first slots for high priority users: ATLAS phase 1, Belle II, ...

- LCTPC: building tests for second LP field cage construction started
  - Improve mechanical accuracy
  - Only small changes to principal layout
    - HV connection
    - Test to replace glass fiber by Aramid paper (smaller X_0)







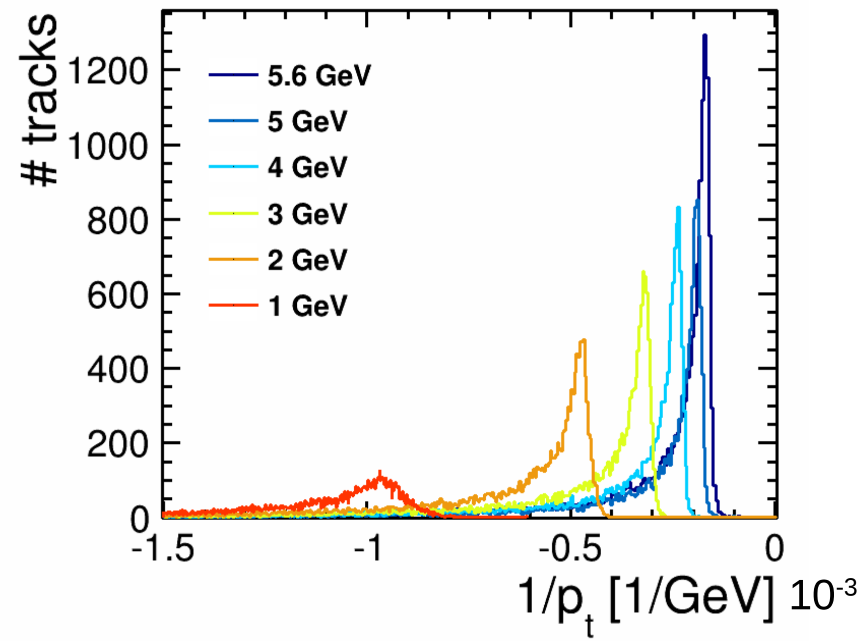
- Efforts ongoing for an external reference tracking detector

Motivation Si-Tracker Reference

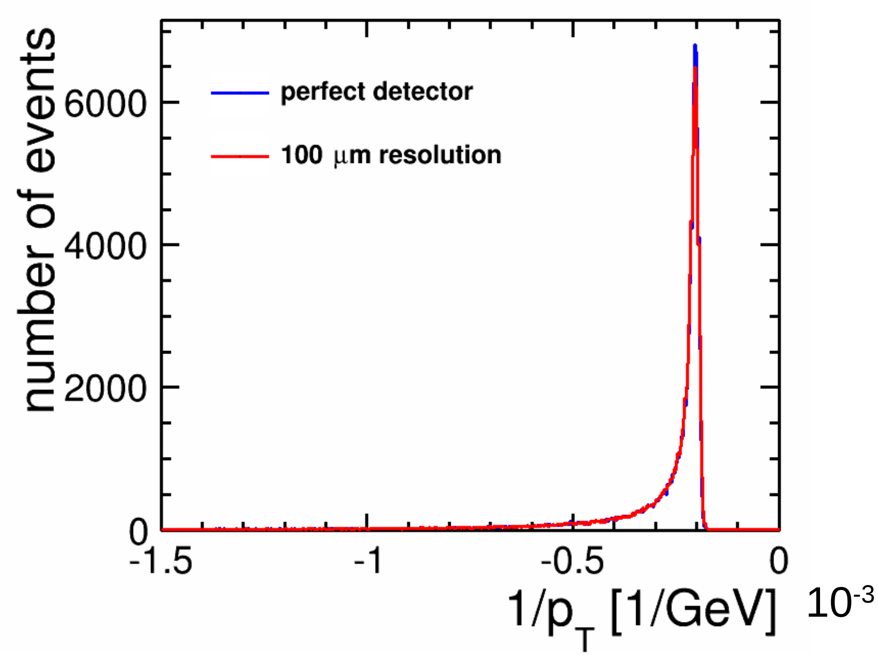
- Determine momentum resolution of the detector
  - Gluckstern formula:

$$\sigma_{p_T} = \sqrt{\frac{720}{n+4}} \frac{\sigma \cdot p_T^2}{0.3 B L^2} \quad \text{(m, GeV/c, T))}$$

  - Field inhomogeneities and distortions impact the momentum determination



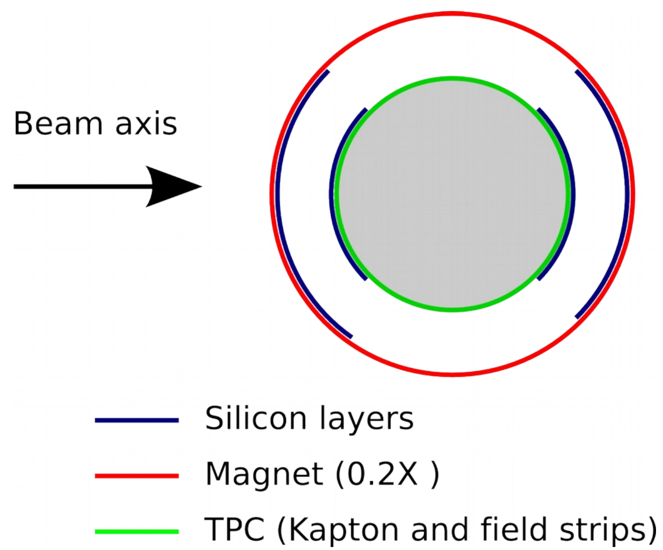
- Broad energy spectra created by:
  - Energy spread of the beam
  - Energy loss in the magnet



- External silicon tracker needed to do momentum studies

External Si-Tracker Reference

- Simple Geant 4 Simulation
  - Magnet: rad. length equivalent
  - TPC made from Kapton and field strips to match rad. length
  - 4 silicon layers (250µm)



  - Reality not so perfect:
    more material, distance of Si layers smaller, alignment...

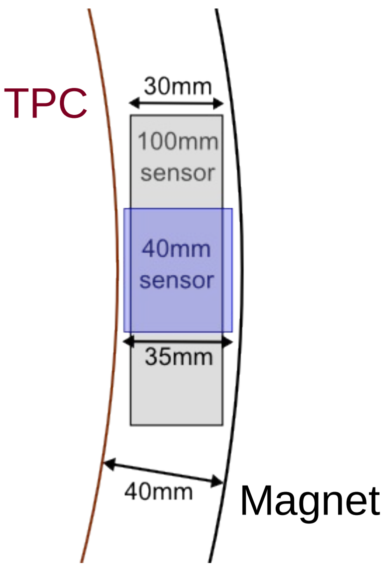
- Included effects:
  - Multiple scattering
  - Beam spread
  - Detector resolution
  - TPC hits: 100µm, every 6mm

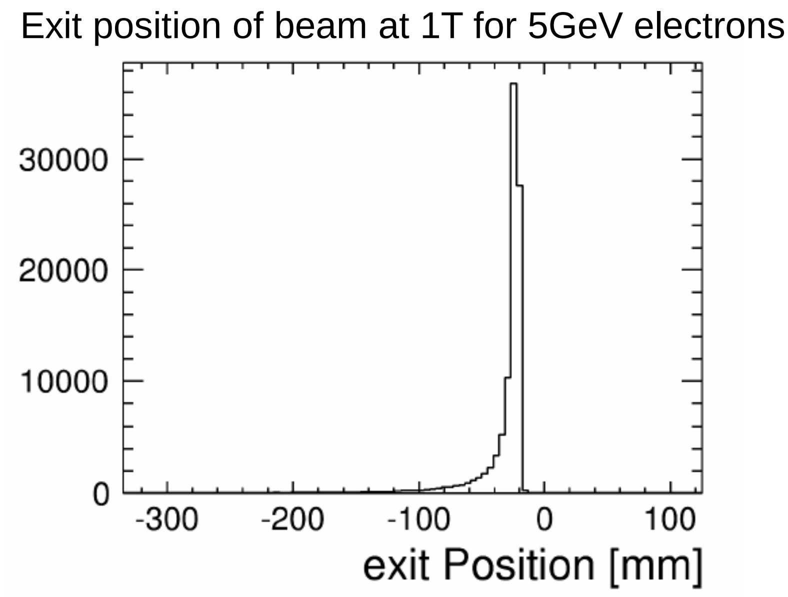
- Simulation Results:

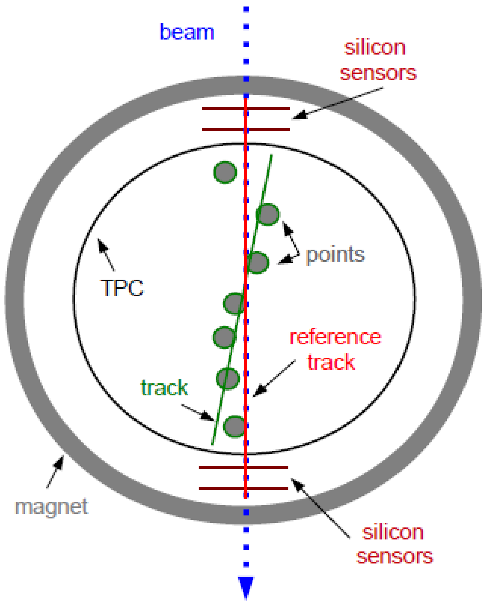
Detector	$\sigma(\Delta pt/pt2)$ [10^{-6} MeV^{-1}]
perfect TPC	4.77
perfect Si tracker	2.95
Si σ_{point}= 5µm	3.23
Si σ_{point}= 10µm	3.88
Si σ_{point}= 15µm	4.76
Si σ_{point}= 25µm	6.76

External Si-Tracker Reference

- 2 layers in space between TPC and magnet
- Need to cover about 10cm at exit point



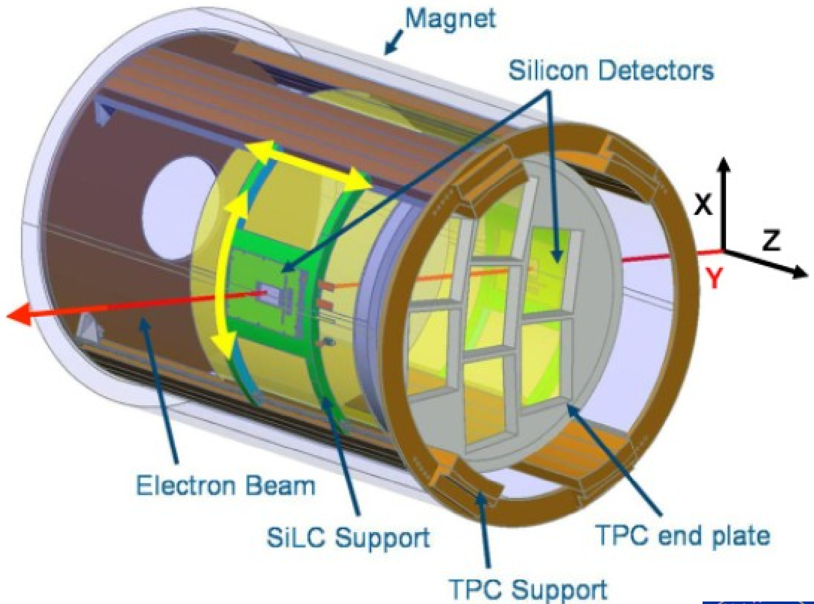


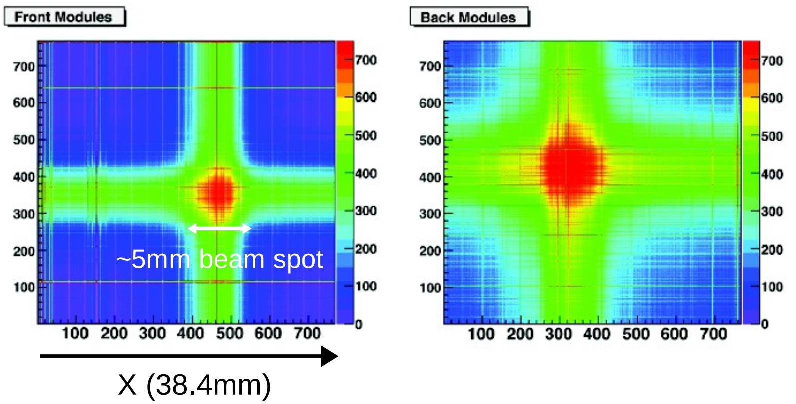


- Si-Tracker high priority for LCTPC (essential for momentum studies)
- Current efforts: AIDA 2 (Horizon2020) proposal
  - 4 layers of Silicon sensors (single sided strip detectors)
    e.g. 10x10cm^2, strip pitch 50μm
  - Small stereo angle between two adjacent layers:
    high precision measurement in phi, with additional low precision z measurement

Previous Si-Tracker Reference

- In 2009, a setup from HEPHY with two double layers was tested with one Micromegas module
  - Single sided strip sensors
  - Readout pitch 50µm
    → spatial resolution better than 10µm
  - Sensor area ~100x200mm, but only 768 strips connected → width 38.4mm
  - DAQ from CMS test setup
  - Mounted on an adjustable support





- System unfortunately not available anymore

Conclusion

- Test setup at T24/1 area at DESY test beam well demanded
  - Used 42 *(of 44 possible)* weeks in 2013/14,
    of which 11 by LCTPC groups
- Currently maintenance and enhancement of testbeam setup ongoing
- Applicability of 2PCO_2 cooling for LCTPC setup demonstrated
- Next important step: external Si reference detector
  - Essential to do momentum studies
    (at the moment limited by multiple scattering in magnet and beam spread)

The presented infrastructure has received funding from the European Commission under the FP7 Research Infrastructures project AIDA, grant agreement no. 262025.