ALICE TPC design and performance

Adam Matyja

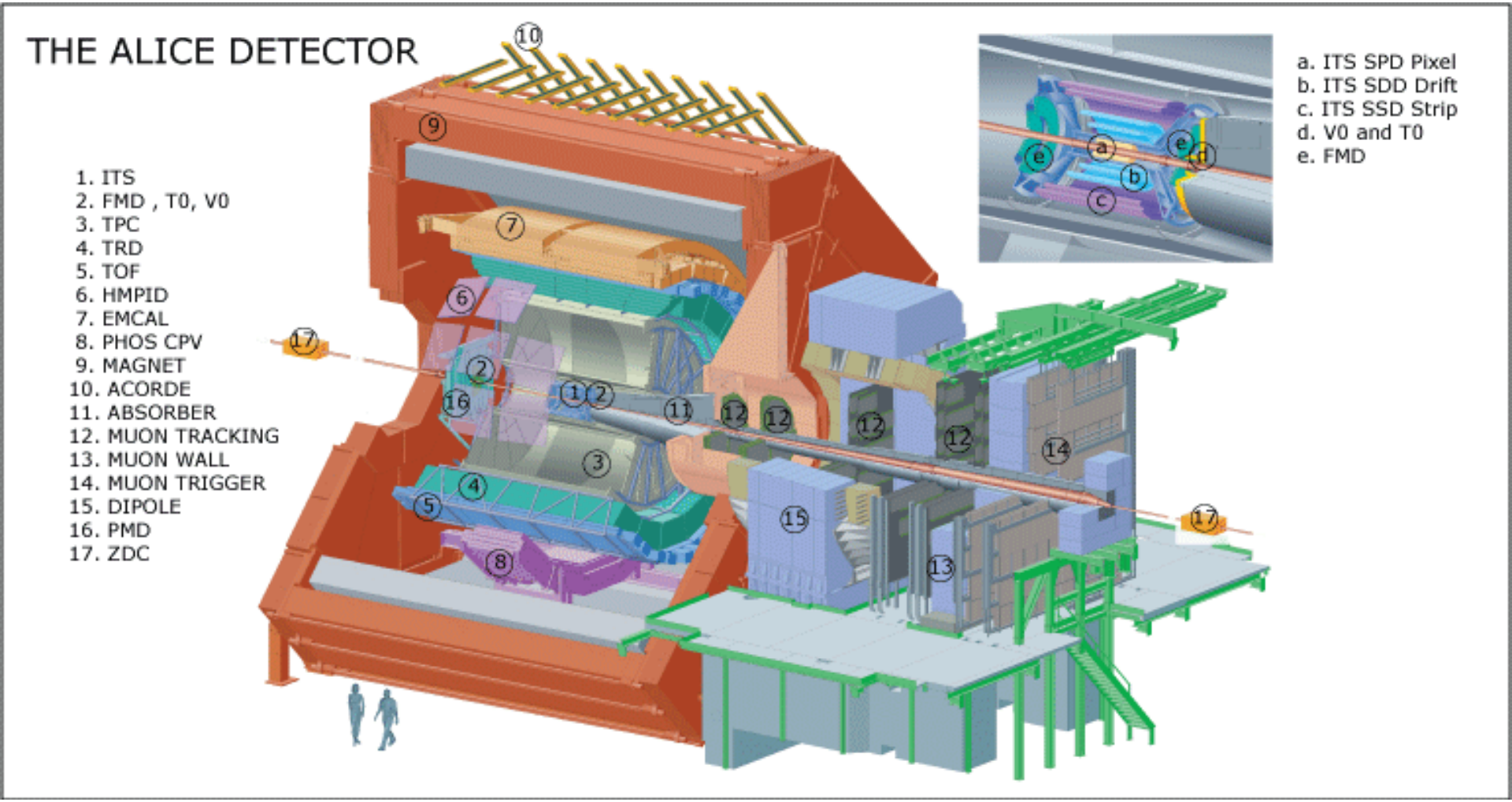
for the ALICE TPC collaboration

INP PAN Kraków

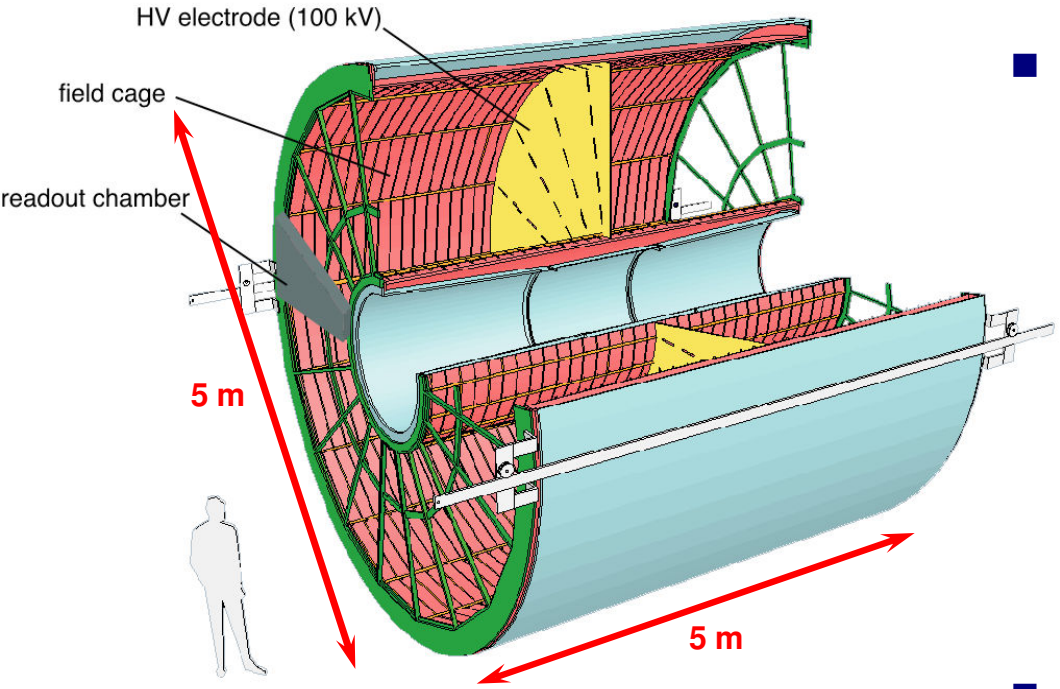
Outline

- Components
  - ReadOut chambers
  - Drift voltage system
  - Gas system
  - Cooling system
  - DCS
- Calibration
- Performance
- Summary

The ALICE detector



ALICE Time Projection Chamber



- General features:
  - Diameter × Length : 5 m × 5 m
  - Azimuthal angle coverage: 2π
  - Pseudo-rapidity interval: $|\eta|<0.9$
  - Readout chambers: 72
  - Drift field: 400 V/cm
  - Maximum drift time: 92 μs
  - Central electrode HV: 100kV

- Data readout:
  - Pads (3 types): 557 568
  - Samples in time direction: 1000
  - Data taking rate:
    - ~ 1kHz for p-p
    - ~ 200 Hz for Pb-Pb

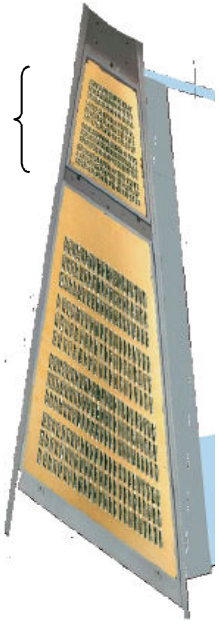
- Gas:
  - Active volume: 90 m^3
  - Ne-CO_2-N_2: 85.7% - 9.5% - 4.8%
  - Cold gas - low diffusion
  - Non-saturated drift velocity

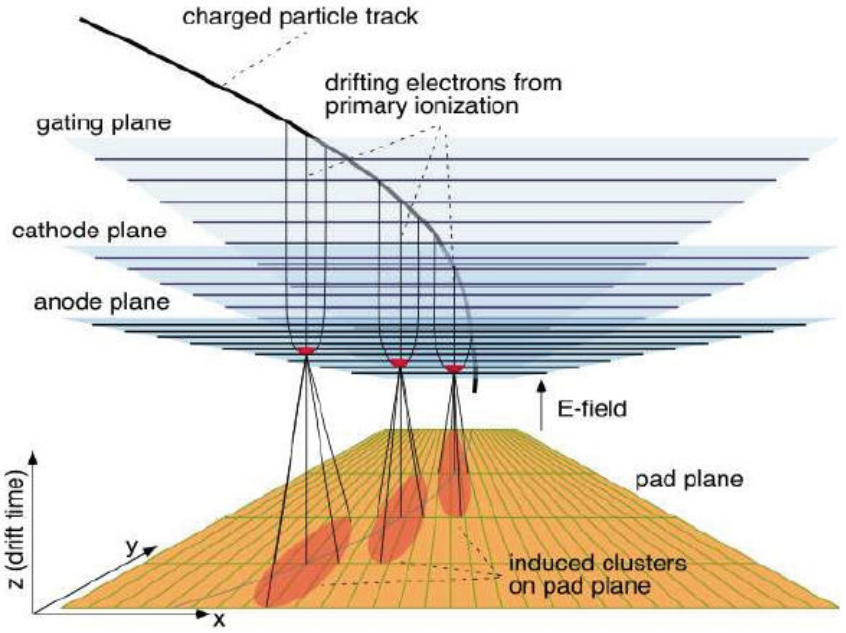
    $\Rightarrow$ temperature stability and homogeneity $\leq$ 0.1 K

ReadOut Chambers

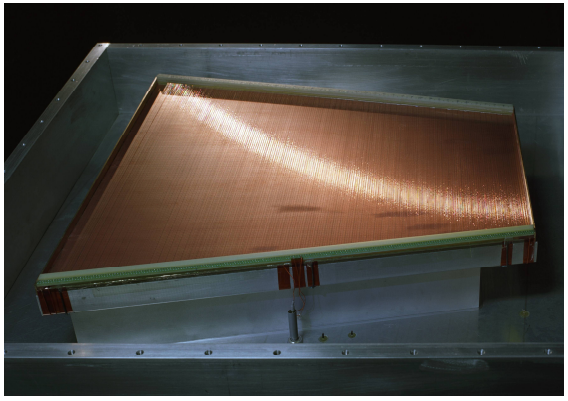
- 2 sides with 18 sectors
- Sector consists of:
  - Inner chamber (IROC)
  - Outer chamber (OROC)

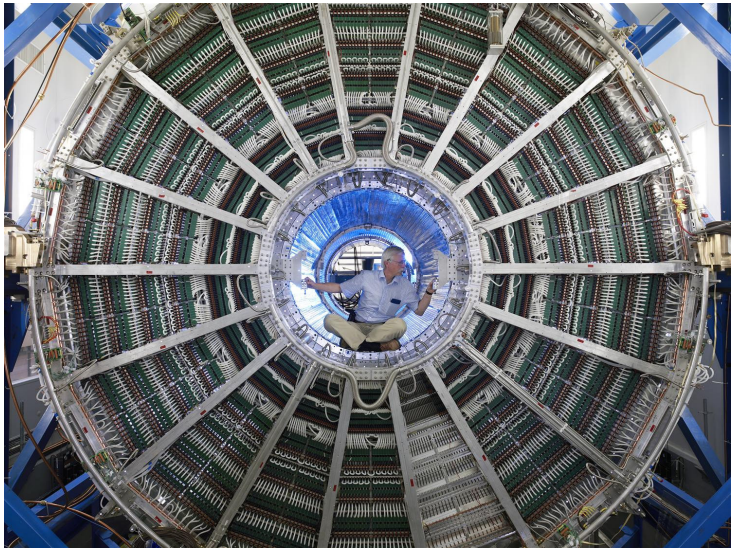
  ⇒ 72 readout chambers
- Pad readout
  - 3 sizes





No trips → stable operation

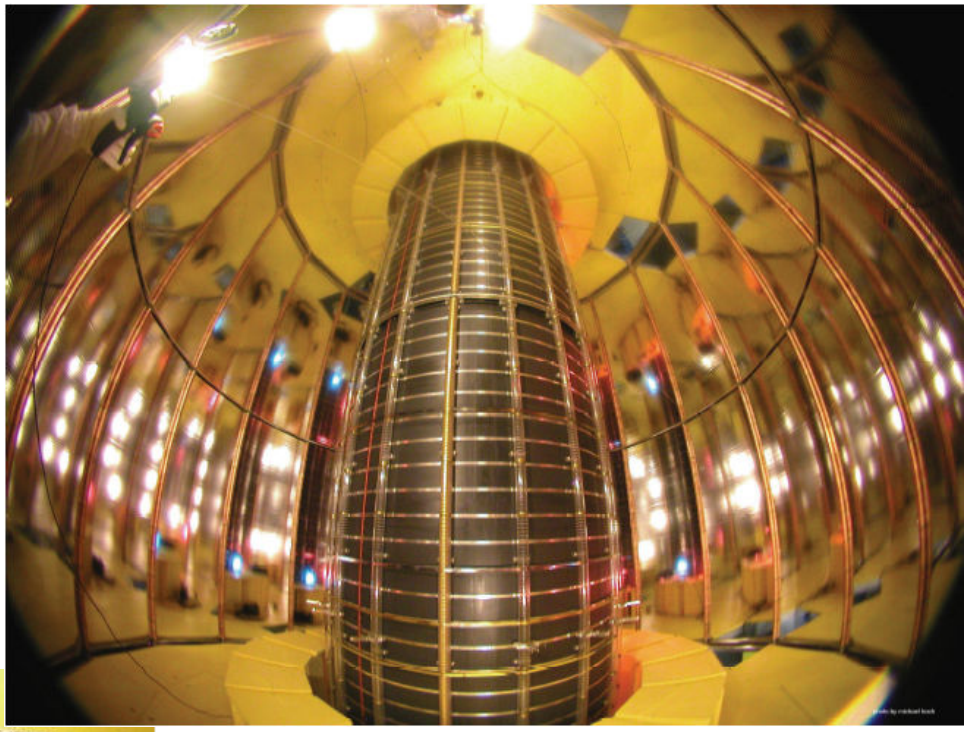




Drift voltage system

Provide constant electric field

- Water cooled voltage dividers
  → remove dissipated power
- Leakless underpressure system
- Control of water conductivity



Voltage dividers network

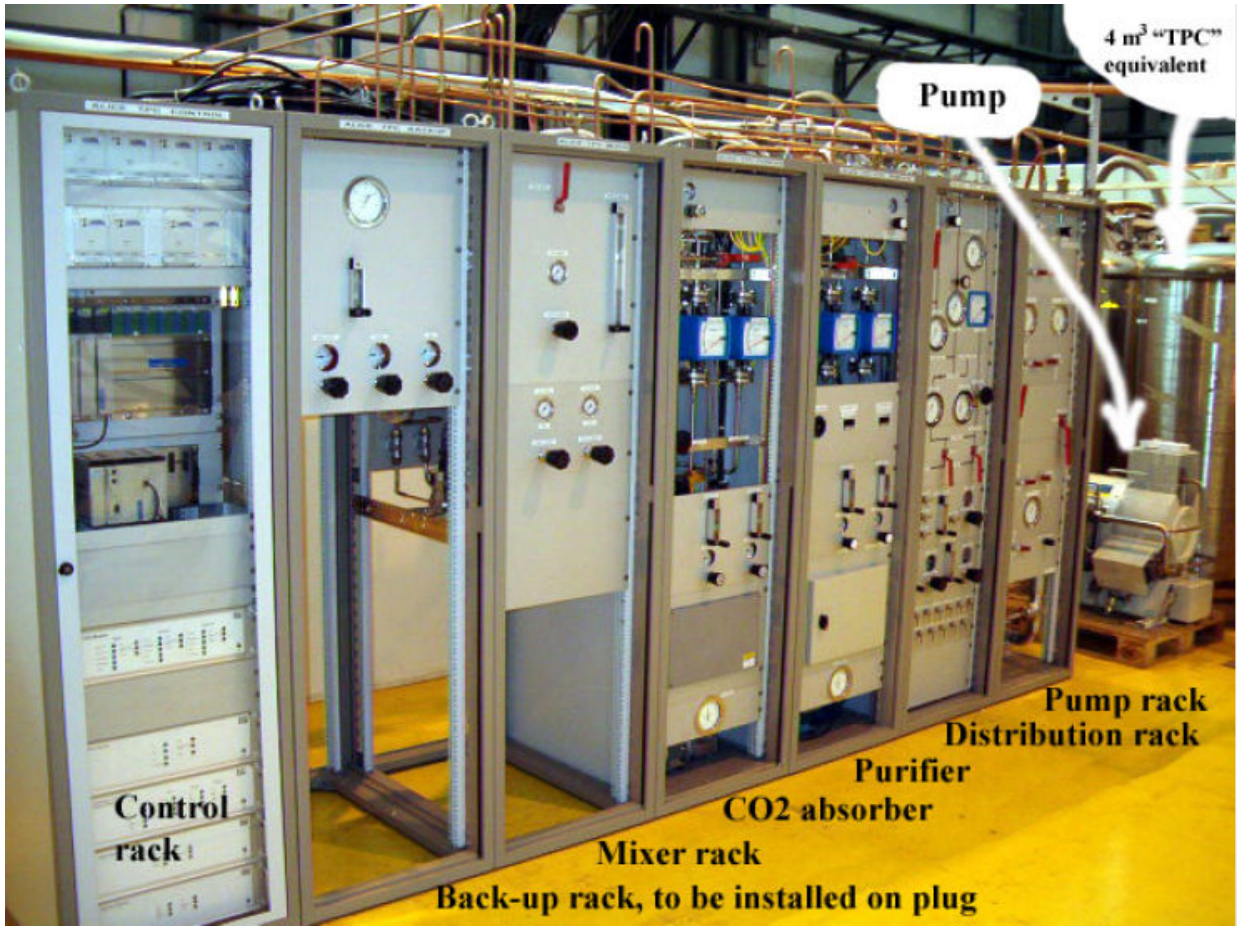
Resistor rods

Recirculating gas system

- O_2 and H_2O contamination removed by Cu catalyser
- Minimise signal loss (e^- attachment)

- Design goal: < 5 ppm O_2
- Achieved: ~ 1 ppm O_2

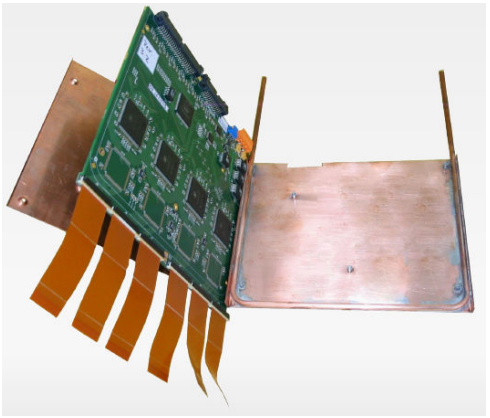
- In operation since 2006



Cooling system

Provide temperature stability

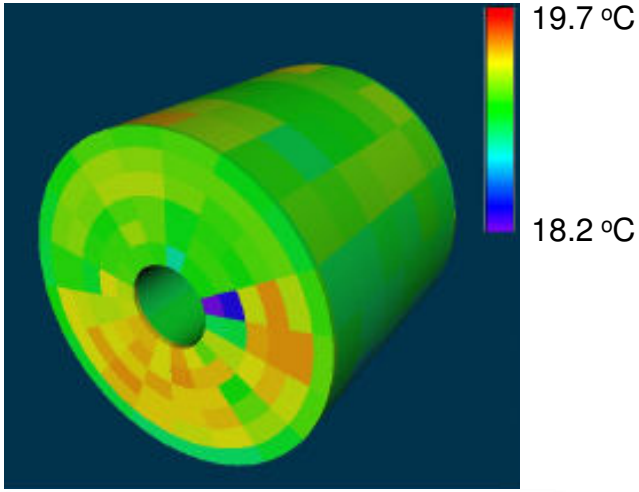
- ~ 60 adjustable cooling circuits
- ~ 500 temperature sensors
- Leakless underpressure system
- Thermal screening towards ITS and TRD
- Copper shields of service support wheel
- Cooling of ROC bodies
- Water cooling of FEE in copper envelope (~27 kW)

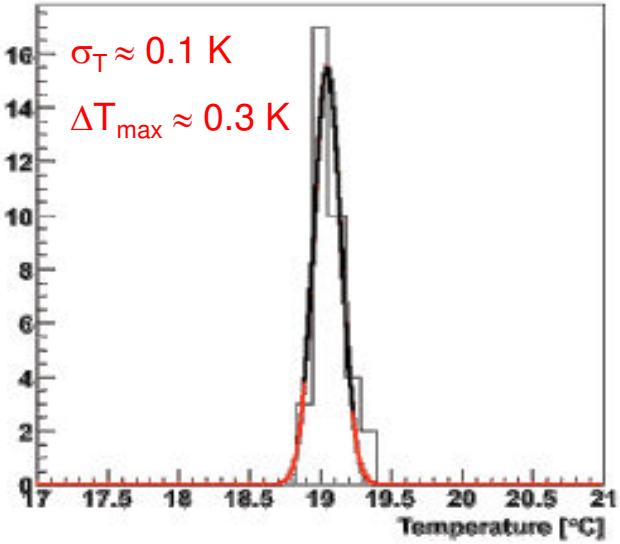


FEC with its cooling envelope

Good agreement with design specifications

Temperature outside TPC



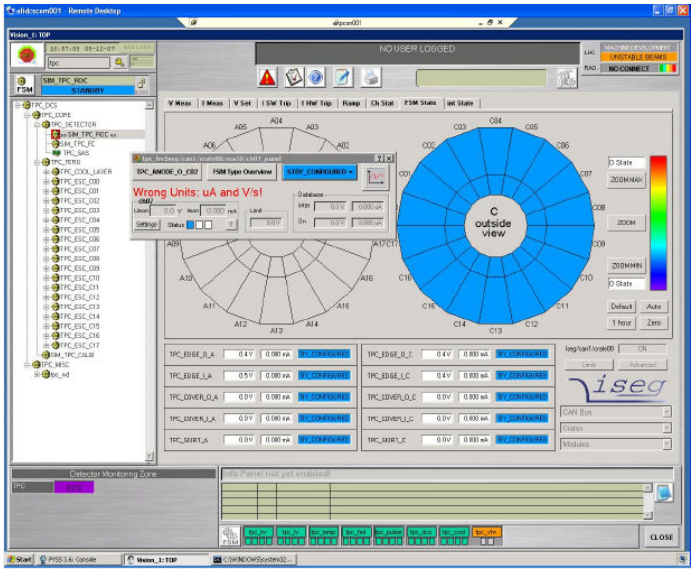


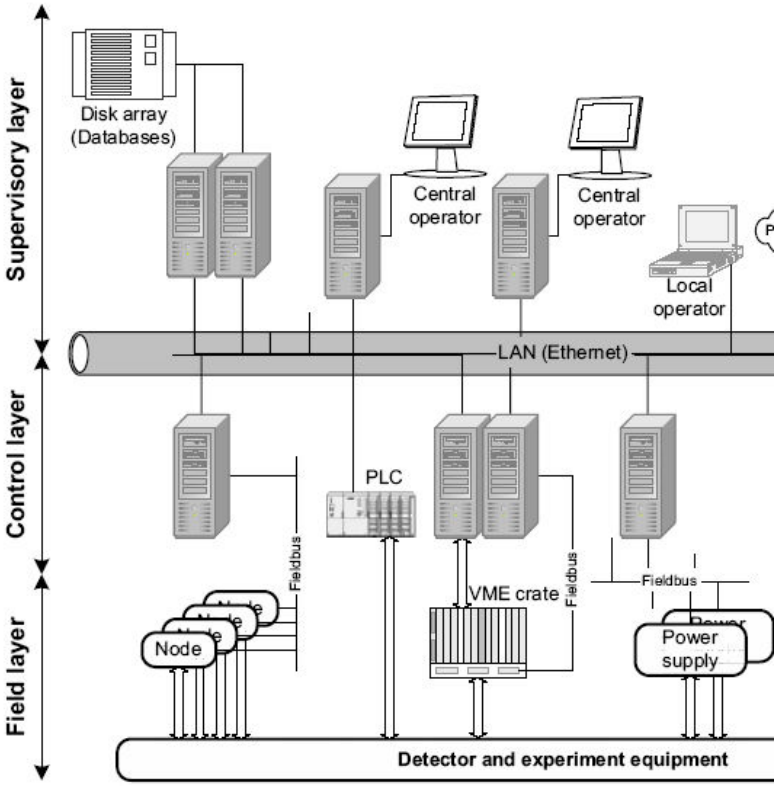
Temperature inside TPC

Detector Control System

Ensure a safe and correct operation of TPC

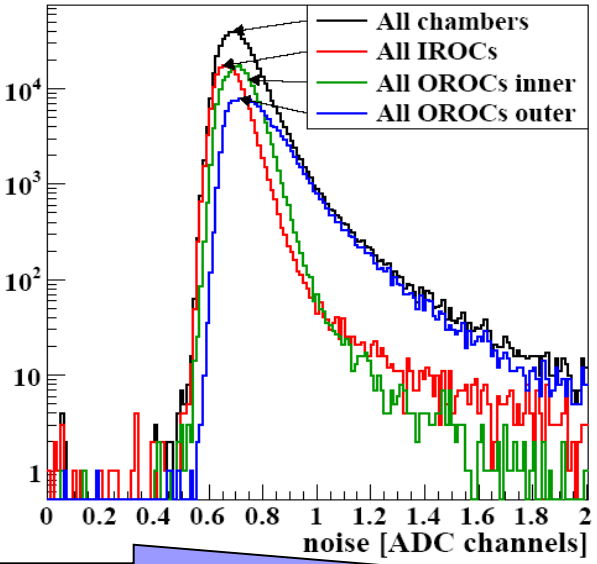
- Integrated into Experiment Control System
- Hardware architecture
  - Supervisory layer: user interface
  - Control layer: hub - collect & process information
  - Field layer: electronics to control equipment
- TPC is fully controlled from DCS





Noise measurements

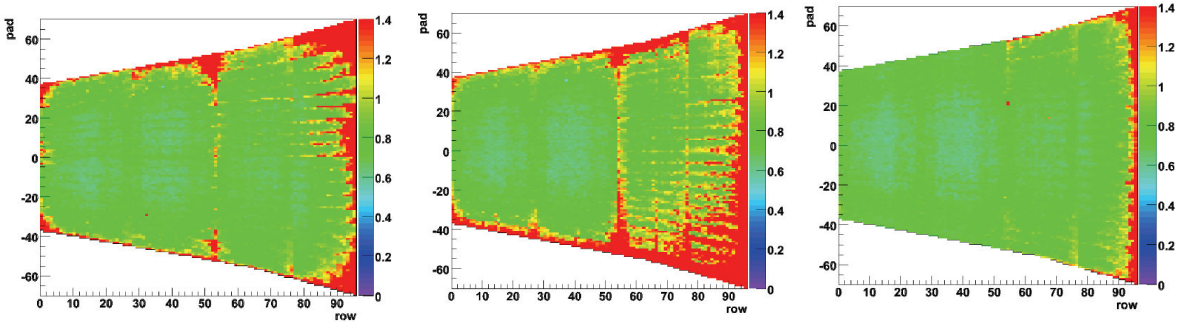
- Noise level improved during commissioning
- Mean noise level:
  - Design goal: 1 ADC count (1000 e)
  - Achieved: 0.7 ADC count (700 e)
- Data volume:
  - zero suppresed (ZS) events: < 70kB
  - non-ZS: ~ 700MB



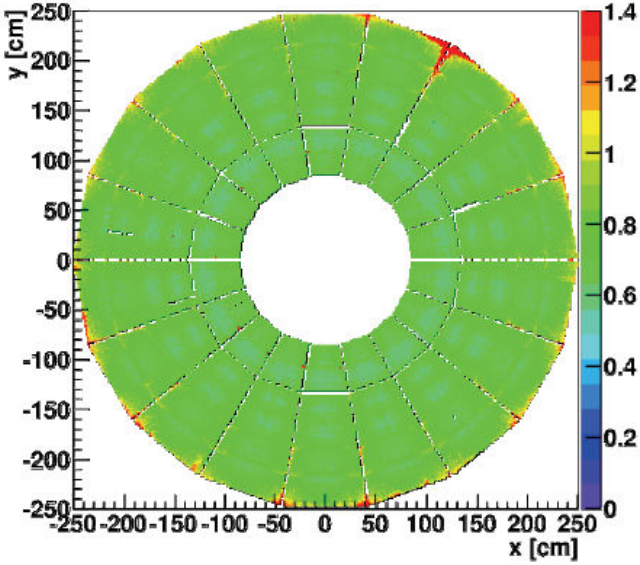
time

2006 2007 2008

Clean room Underground Underground

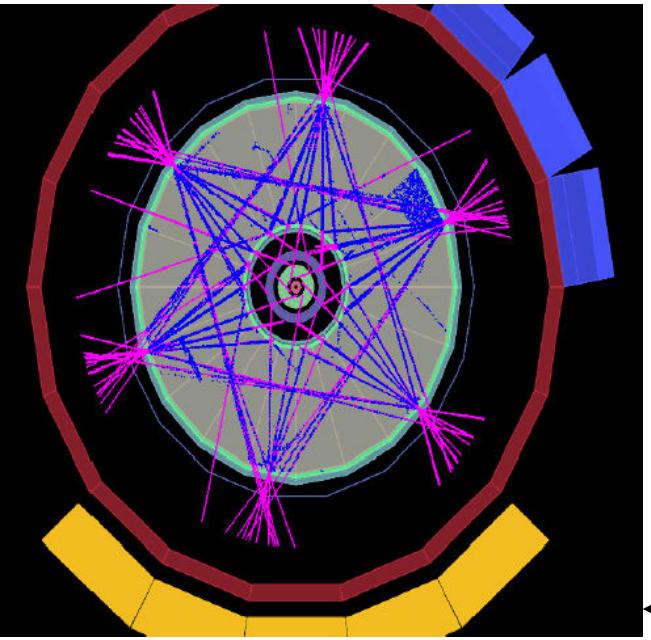


Current noise

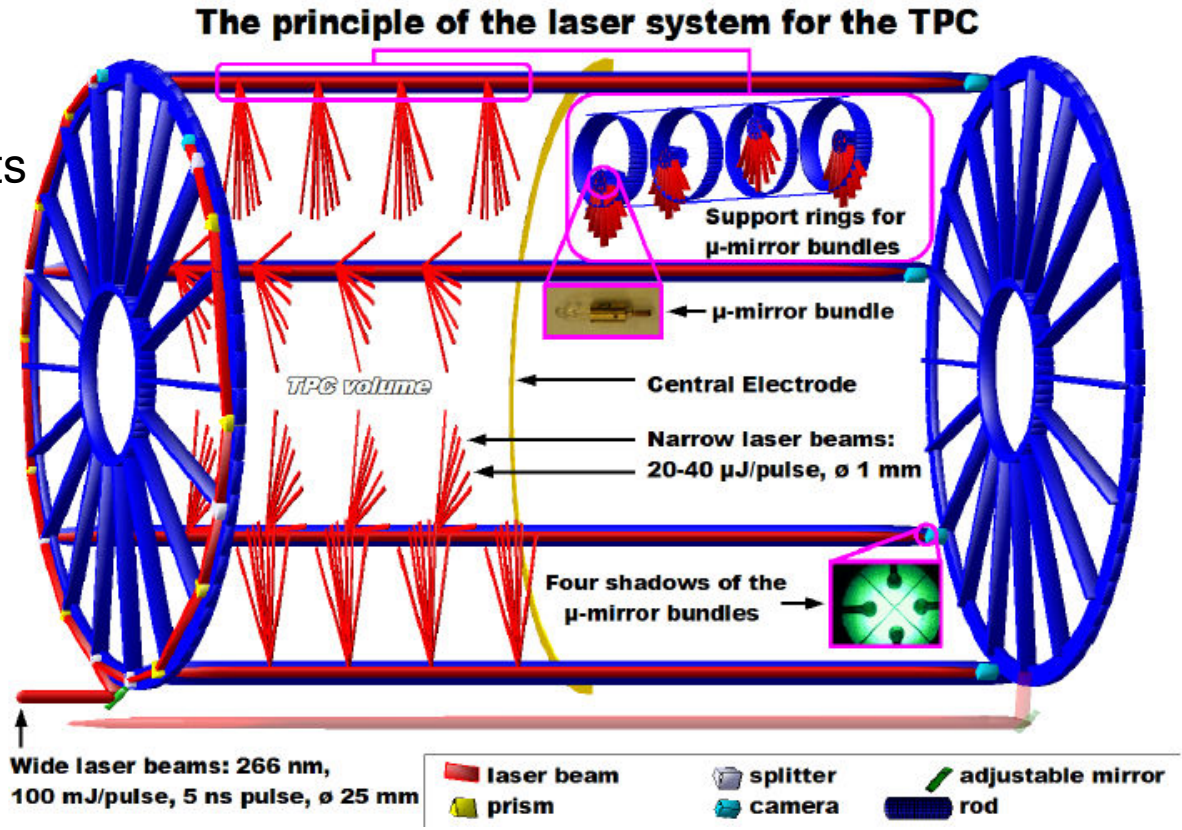


Laser system

- 336 laser beams
- Used for:
  - E × B effect
  - Drift velocity measurements
  - Alignment



Reconstructed laser tracks



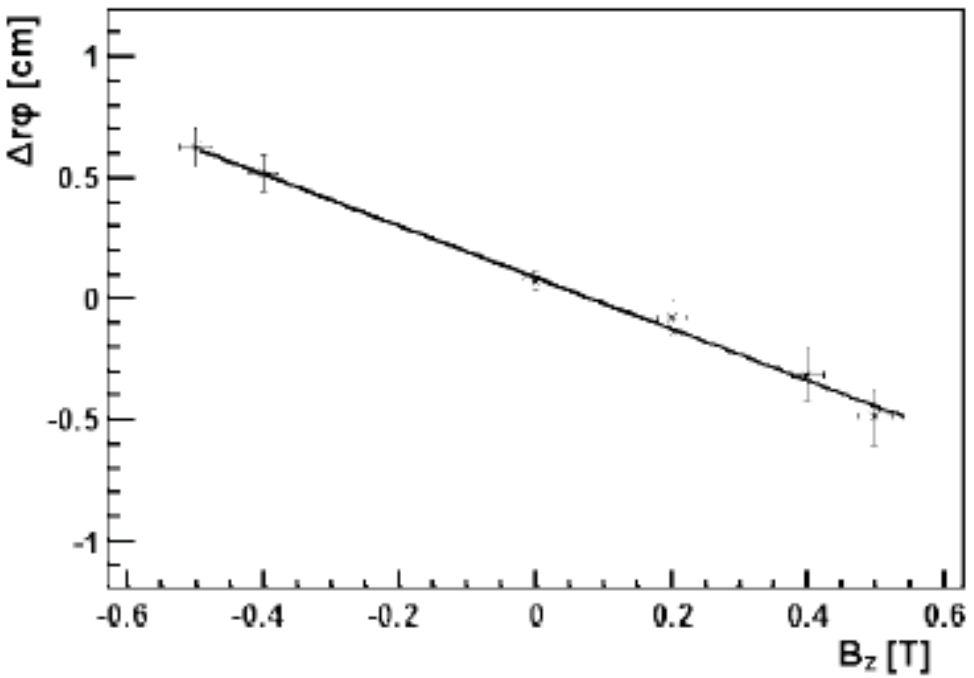
E×B effect

Correction map from laser tracks

- Measure $\Delta r\varphi$
- For each laser track
- For several magnetic field settings

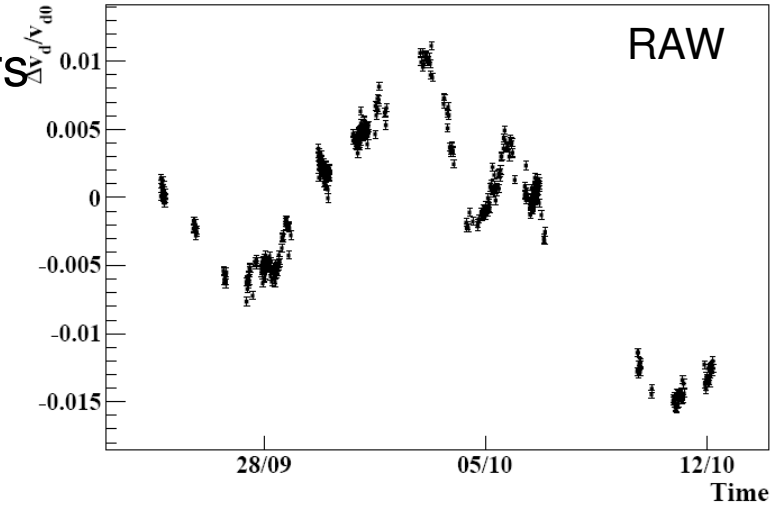
$\Delta r\varphi$ = 7 mm

for longest drift and nominal field



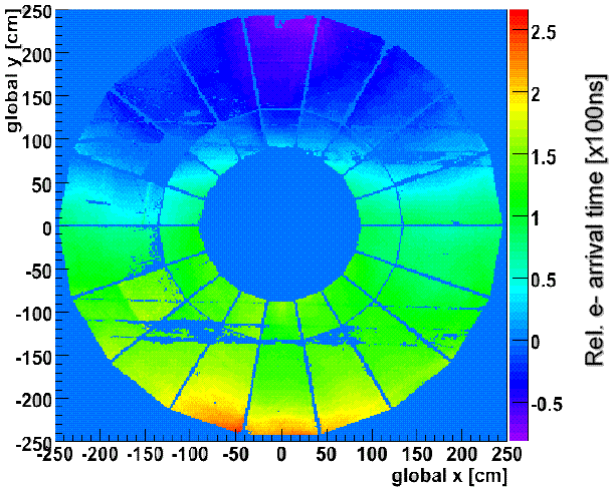
Drift velocity measurements

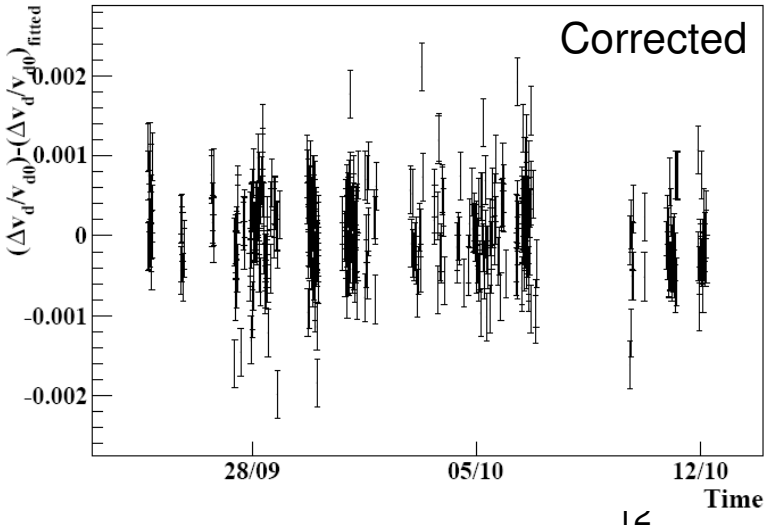
- $\upsilon_d = \upsilon_d(E, B, T, P, C_{CO2}, C_{N2})$
- Crucial for track matching with other detectors
- How to obtain drift velocity correction factor:
  - Match laser tracks and mirror positions
  - Match TPC and ITS tracks
  - Match tracks from two halves of TPC
  - Drift velocity monitor
- Required accuracy: $10^{-4} \Rightarrow$ update every 1h



- Central electrode

monitor top-bottom arrival time offset caused by T and P gradients

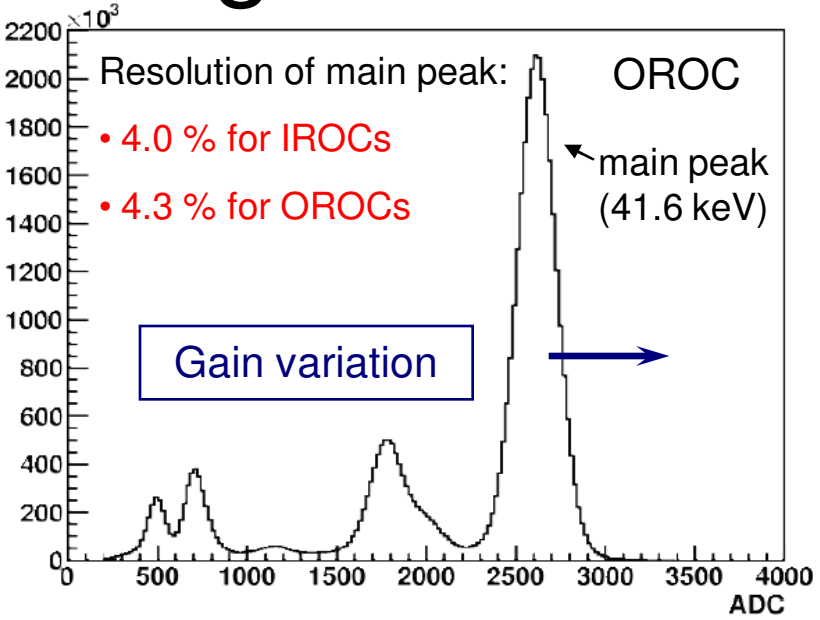




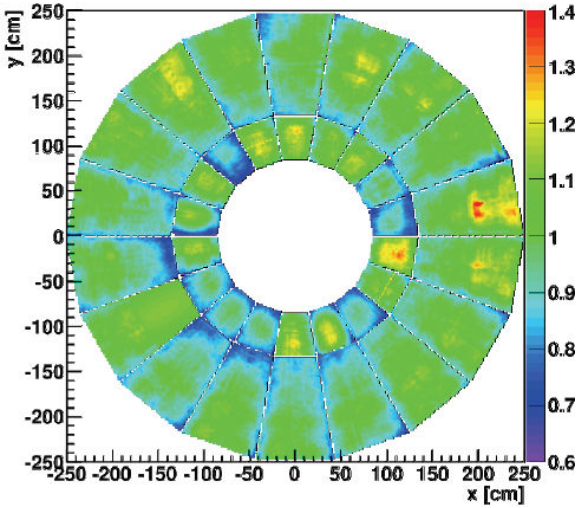
Gain calibration using ^{83}Kr

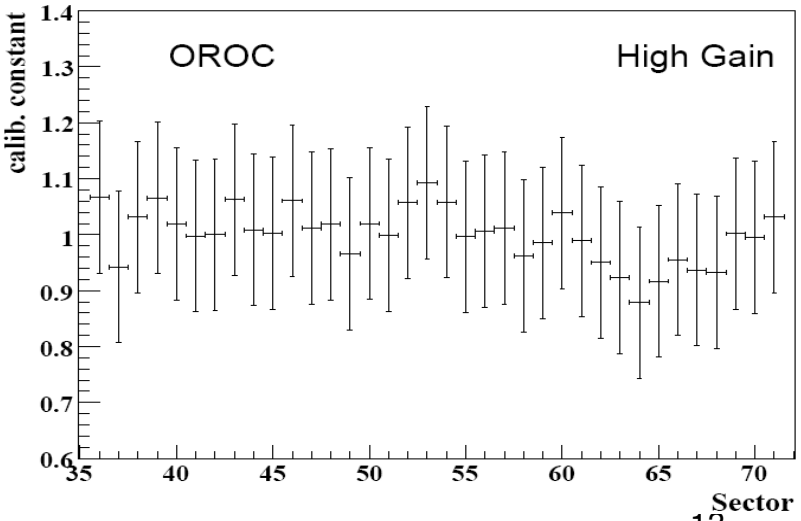
Determine gain for each pad

- Inject radioactive ^{83}Kr
- Fit the main peak (41.6 keV)
- 3 different HV settings (gains)
- High statistics: several 10^8 Kr events
- Accuracy of peak position: < 1% (design: 1.5%)
- Repeated after electronic maintenance or every year



Relative gain variation C-side

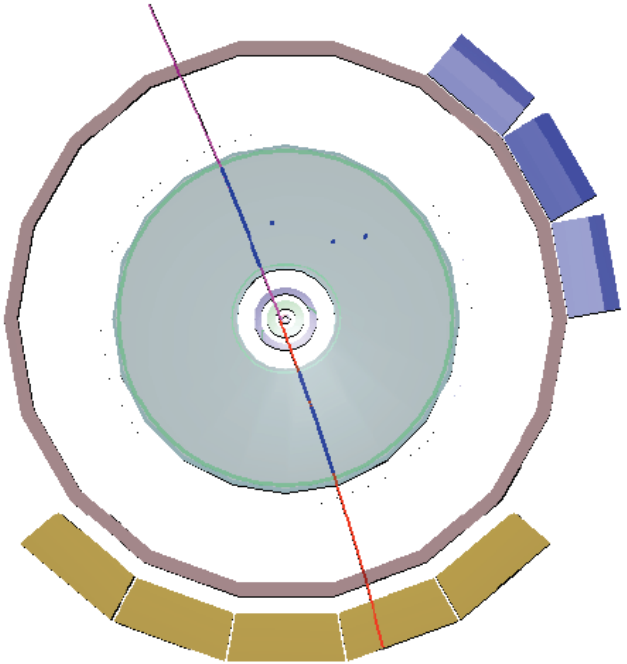


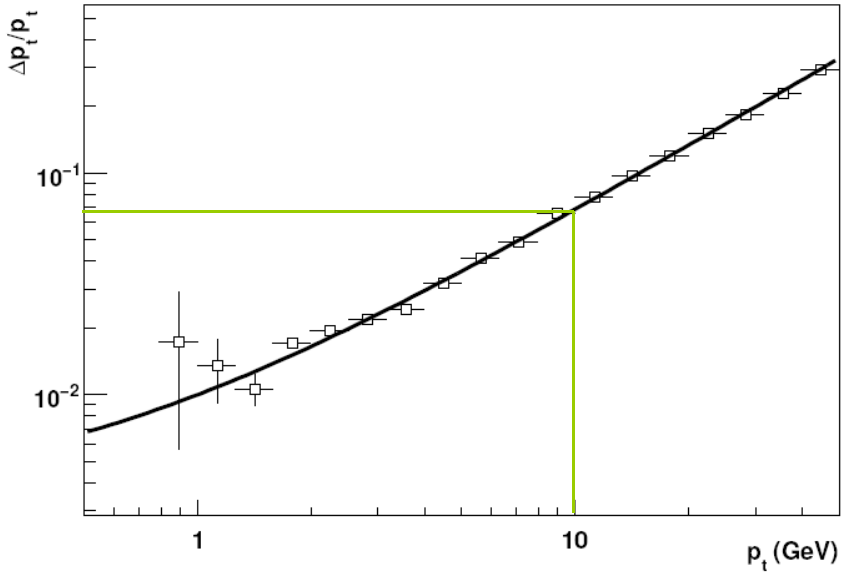


Momentum resolution

- Cosmic muon tracks treated independently in two halves of TPC
- Comparison of p_T at vertex gives resolution
- Statistics: ~ 5×10^6 events

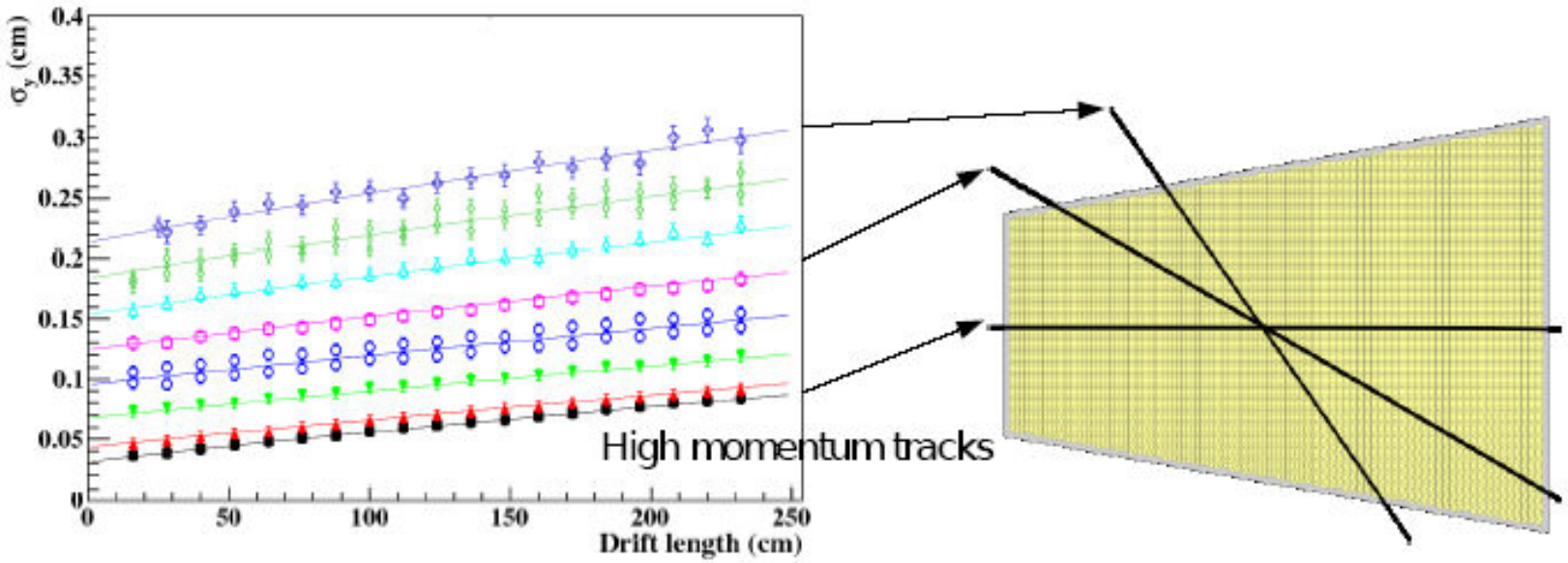
- Design goal: 4.5 % @ 10 GeV
- Achieved: 6.5 % @ 10 GeV
  ~ 1 % below 1 GeV



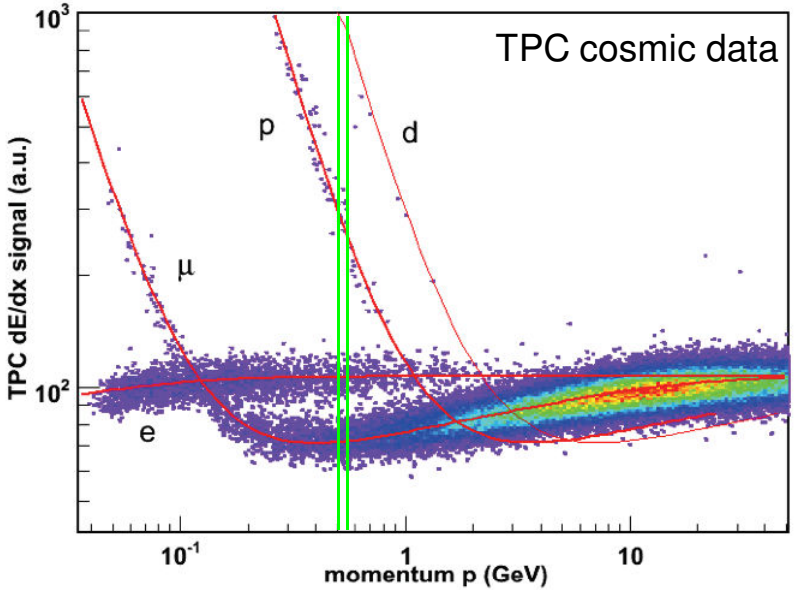


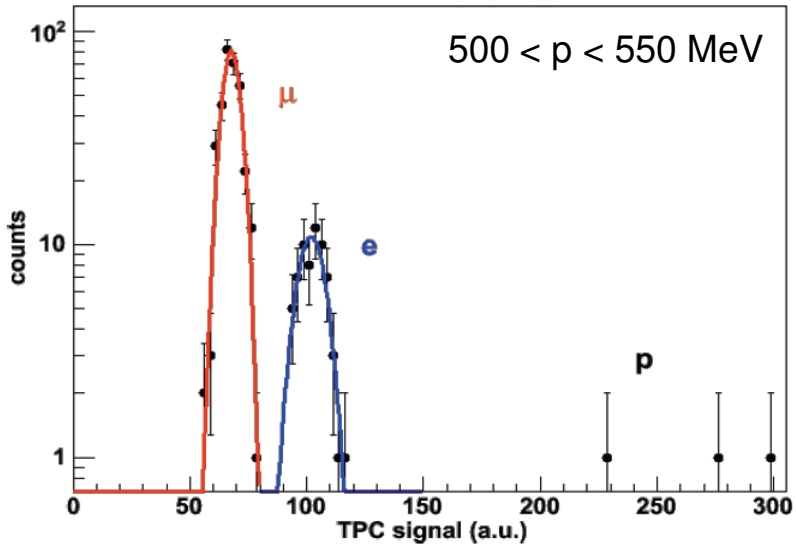
Space point resolution

- 300 - 800 μm in rφ
  - for small inclination angles (high momentum tracks)
- Good agreement with simulations



dE/dx resolution

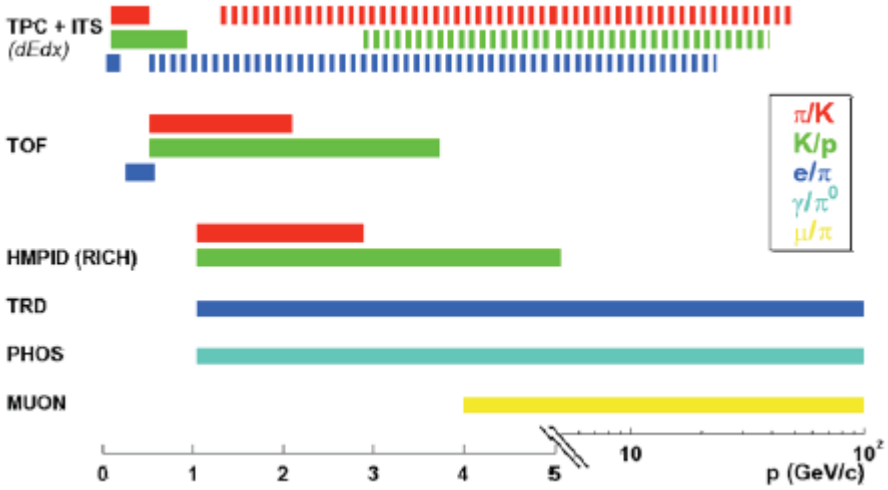




Allows particle identification up to 50 GeV/c

- Statistics: 7×10^6 cosmic tracks in 2008
- Design goal: 5.5 %
- Measured: < 5.7 %

  → close to design value



Summary

- ALICE TPC works stably
- Calibration done → working on improvements
- Very good performance, close to specifications
- Ready for physics since summer 2008
- We are looking forward to the beam

ALICE TPC collaboration

Dieter Roehrich[1], Haavard Helstrup[1], Dag Toppe Larsen[1], Dominik Fehlker[1], Brano Sitar[2], Miro Pikna[2], Martin Siska[2], Rudolf Janik[2], Peter Strmen[2], Imrich Szarka[2], Luciano Musa[3], Christian Lippmann[3], Magnus Mager[3], Attiq Ur Rehman[3], Stefan Rossegger[3], Borge S. Nielsen[4], Carsten Soegaard[4], Helmut Oeschler[5], Alexander Kalweit[5], Harald Appelshaeuser[6], Rainer Renfordt[6], Peter Braun-Munzinger[7], Hans-Rudolf Schmidt[7], Danilo Vranic[7], Chilo Garabatos[7], Ulrich Frankenfeld[7], Marian Ivanov[7], Yiota Foka[7], Johanna Stachel[8], Peter Glassel[8], Jens Wiechula[8], Hans-Ake Gustafsson[9], Peter Christiansen[9], Anders Oskarsson[9], Philippe Gros[9], Alexandru Florin Dobrin[9], Marek Kowalski[10], Adam Matyja[10]

1. Department of Physics and Technology, University of Bergen, Bergen, Norway
2. Faculty of Mathematics, Physics and Informatics, Comenius University, Bratislava, Slovakia
3. European Organization for Nuclear Research (CERN), Geneva
4. Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark
5. Institut für Kernphysik, Technische Universität Darmstadt, Darmstadt, Germany
6. Institut für Kernphysik, Johann-Wolfgang-Goethe Universität Frankfurt, Frankfurt, Germany
7. Gesellschaft für Schwerionenforschung mbH (GSI), Darmstadt, Germany
8. Physikalisches Institut, Ruprecht-Katls-Universität Heidelberg, Heidelberg, Germany
9. Division of Experimental High Energy Physics, University of Lund, Lund, Sweden
10. The Henryk Niewodniczański Institute of Nuclear Physics, Polish Academy of Sciences, Cracow, Poland

BACKUP

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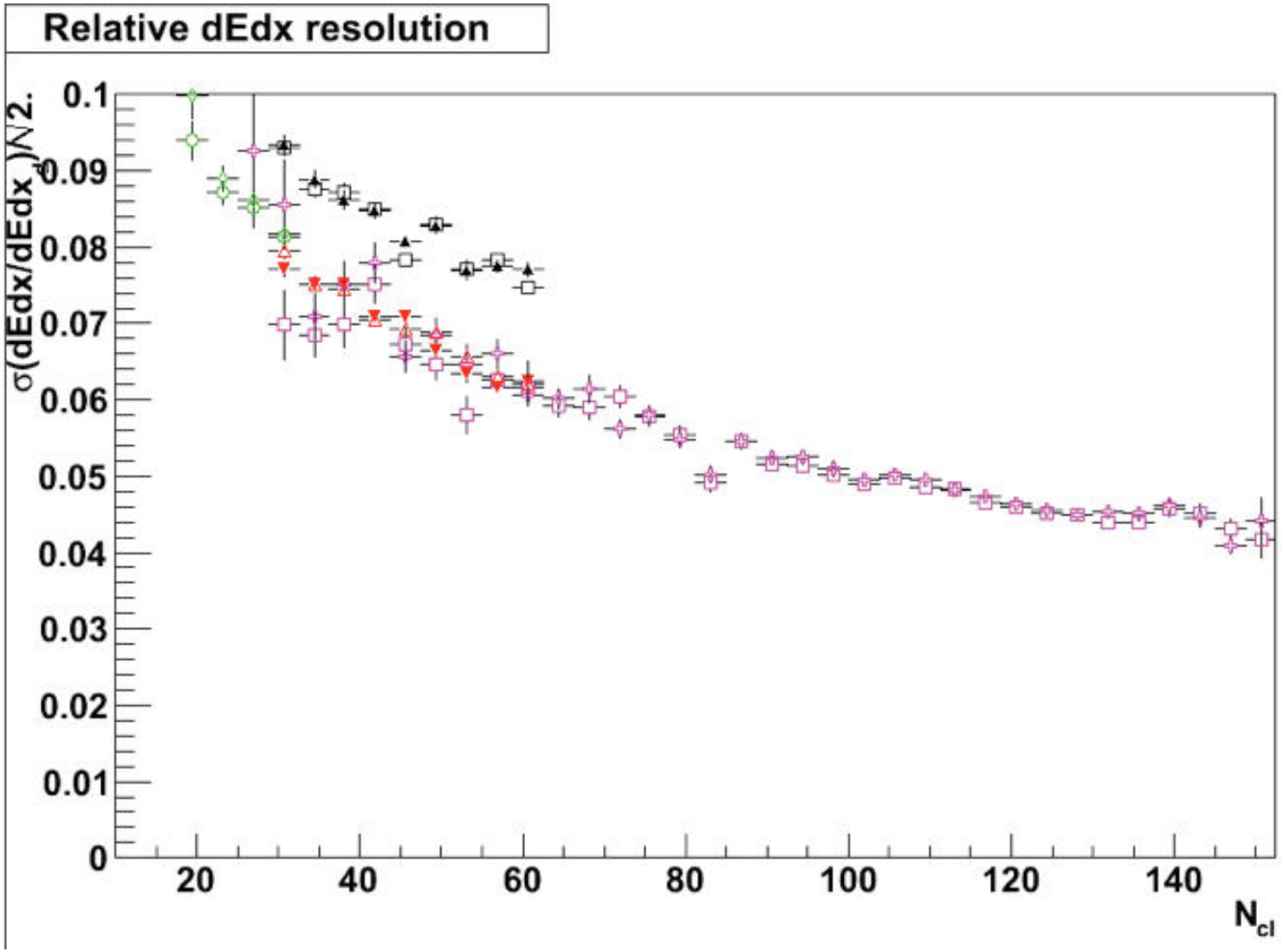
Relative dEdx resolution
σ(dEdx/dEdx_d)/√2.
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
20
40
60
80
100
120
140
N_cl