ALICE TPC
design and performance

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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: $2\pi$
- Pseudo-rapidity interval: $|\eta| < 0.9$
- Readout chambers: 72
- Drift field: 400 V/cm
- Maximum drift time: 92 μs
- Central electrode HV: 100kV

**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
  \[ \Rightarrow \text{temperature stability and homogeneity} \leq 0.1 \text{ K} \]

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

Components

- Resistor rods
- Voltage dividers network
- Resistors rods
Recirculating gas system

- $\text{O}_2$ and $\text{H}_2\text{O}$ contamination removed by Cu catalyser
- Minimise signal loss ($\text{e}^-$ attachment)
- Design goal: < 5 ppm $\text{O}_2$
- Achieved: ~ 1 ppm $\text{O}_2$
- 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

Temperature outside TPC

Temperature inside TPC

\[ \sigma_T \approx 0.1 \text{ K} \]
\[ \Delta T_{\text{max}} \approx 0.3 \text{ K} \]

Good agreement with design specifications
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 suppressed (ZS) events: < 70kB
  - non-ZS: ~ 700MB

Calibration

<table>
<thead>
<tr>
<th>Time</th>
<th>Clean room</th>
<th>Underground</th>
<th>Underground</th>
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</thead>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td>2008</td>
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Current noise
Laser system

- 336 laser beams
- Used for:
  - $E \times B$ effect
  - Drift velocity measurements
  - Alignment
Correction map from laser tracks

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

$\Delta r \phi = 7 \text{ mm}$

for longest drift and nominal field
Drift velocity measurements

- \( \nu_d = \nu_d(E, B, T, P, C_{CO2}, C_{N2}) \)
- 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: \( 10^{-4} \Rightarrow \text{update every 1h} \)

- Central electrode monitor top-bottom arrival time offset caused by T and P gradients
Gain calibration using $^{83}\text{Kr}$

Determine gain for each pad

- Inject radioactive $^{83}\text{Kr}$
- 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

Resolution of main peak:
- 4.0 % for IROCs
- 4.3 % for OROCs

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: $\sim 5 \times 10^6$ events

- Design goal: 4.5 % @ 10 GeV
- Achieved: 6.5 % @ 10 GeV
  $\sim 1$ % below 1 GeV
Space point resolution

- 300 - 800 µm in $r\phi$
  - for small inclination angles (high momentum tracks)
- Good agreement with simulations
Performance

dE/dx resolution

Allows particle identification up to 50 GeV/c
- Statistics: $7 \times 10^6$ 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

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BACKUP
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Relative dEdx resolution

\[ \frac{\sigma(dE/dx)}{2} \]

\[ N_{cl} \]

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

0 20 40 60 80 100 120 140