Space-Charge Distortions in the ALICE TPC

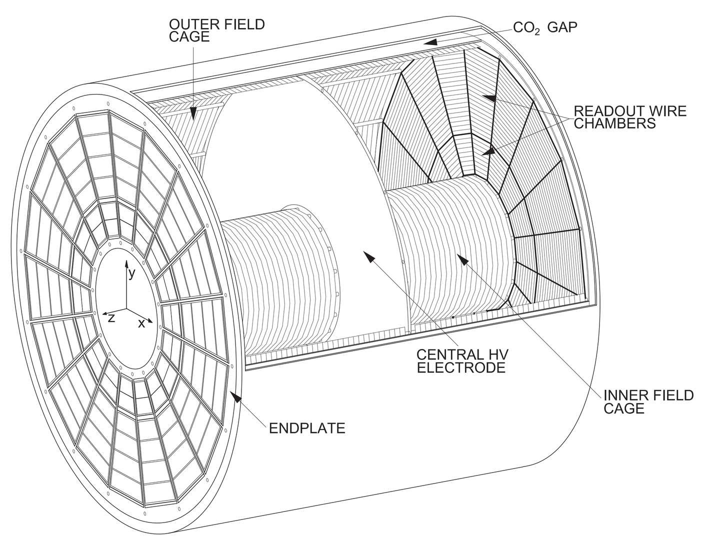
E. Hellbär[1] for the ALICE Collaboration

[1]hellbaer@ikf.uni-frankfurt.de, Institut für Kernphysik, Goethe-Universität Frankfurt

ALICE

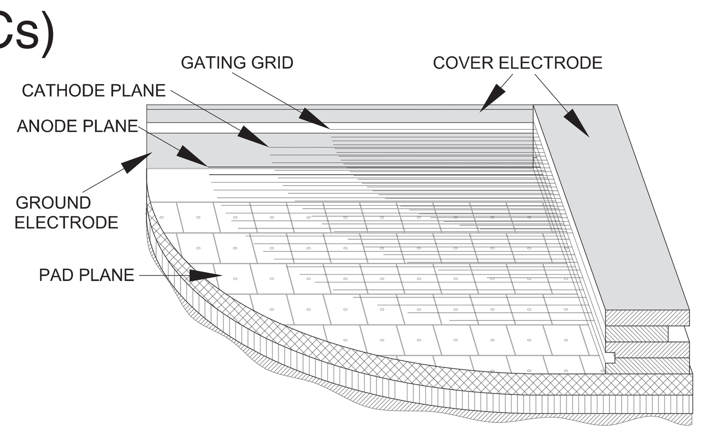
ALICE TPC

Drift volume
- Ne-CO_2(-N_2) in LHC Run 1 (2010–2013)
- Ar-CO_2 in LHC Run 2 (2015–2016)



18 trapezoidal sectors on each side
- Numbering: 0–17 (A side), 18–35 (C side)

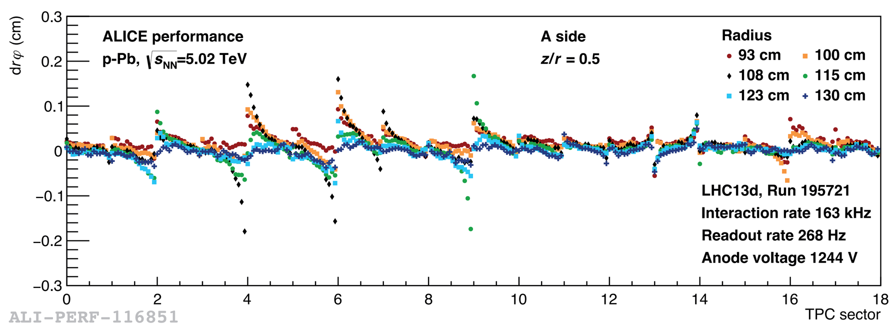
Readout chambers
- Inner (IROC) and outer (OROC) readout chamber in each sector
- Multi-Wire Proportional Chambers (MWPCs)
- Gating grid (GG)
  - — Keep ionization from reaching the amplification region in the absence of a trigger
  - — Prevent ions created in the avalanche process from entering the drift volume



Comparison to Run 1

Similar distortion pattern in p-Pb data taken in 2013

Distortions normalized to the multiplicity are smaller by a factor of 10–20
- Space-charge density depends on gas properties
  - — Primary ionization N_p
    - — $N_{p,\,Ar} \approx 2 \times N_{p,\,Ne}$
  - — Ion mobility K_0
    - — $K_{0,\,Ar} \approx K_{0,\,Ne}$ / 1.8 (arXiv:1603.07638)

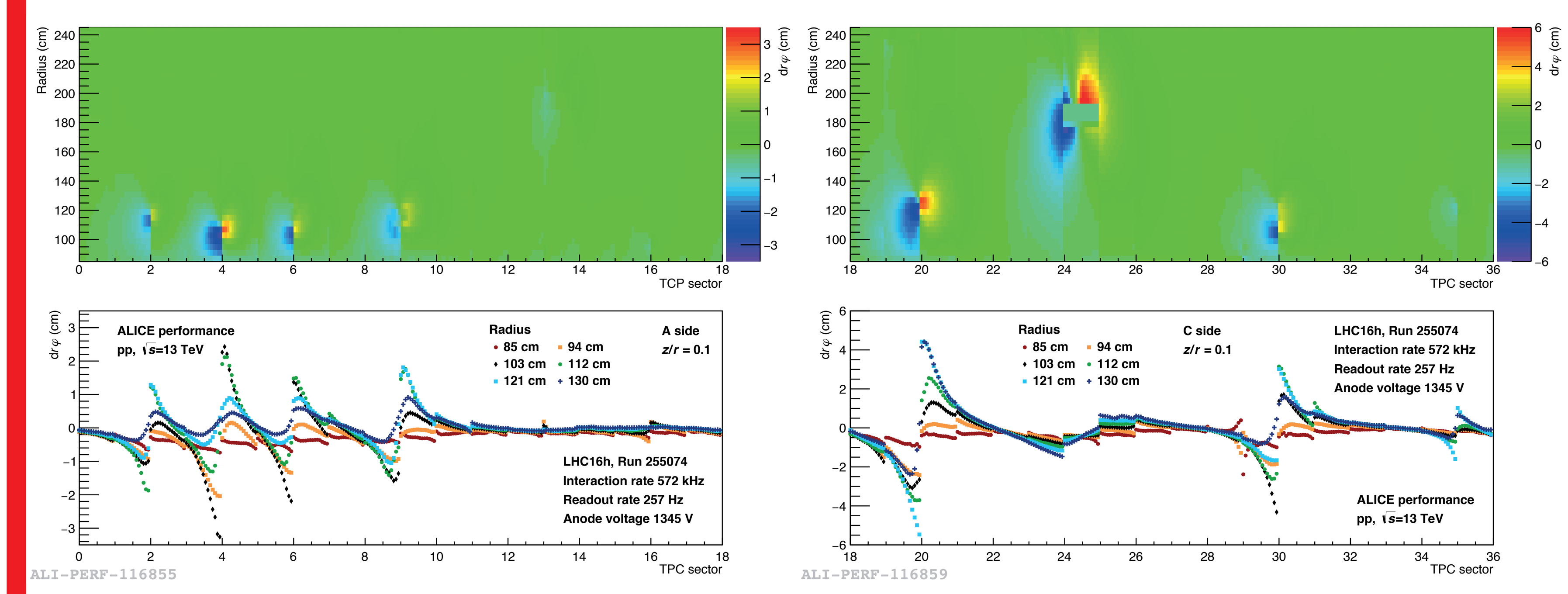


⇒ Big difference between measurements with neon and argon taking the characteristic gas properties into account

Distortions in Run 2

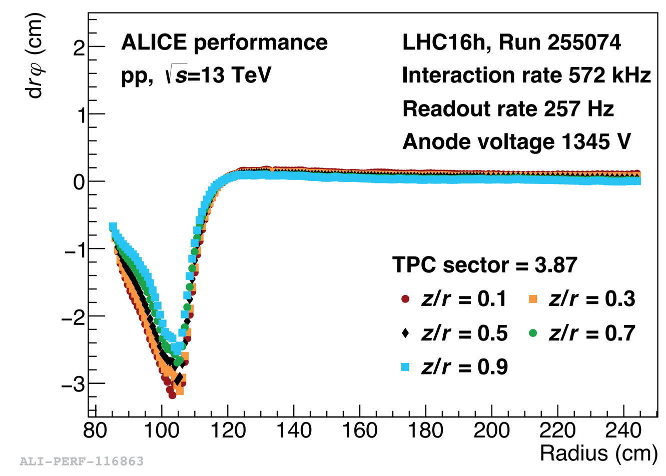
Large distortions of the uniform drift field (400 V/cm) observed in first high-luminosity data in 2015
- Ionization electrons are deflected in radial (d*r*), azimuthal (d*r*φ) and drift (d*z*) direction

Position of distortion regions well localized in radius (*r*) and azimuth (*r*φ)
- Edges of neighboring IROCs
  - — Sectors 2, 4, 6, 9, 20, 30
  - — Smaller distortions at sectors 7, 16, 31, 35
- OROC of sector 24
  - — Local inefficieny of the gating grid due to floating wires



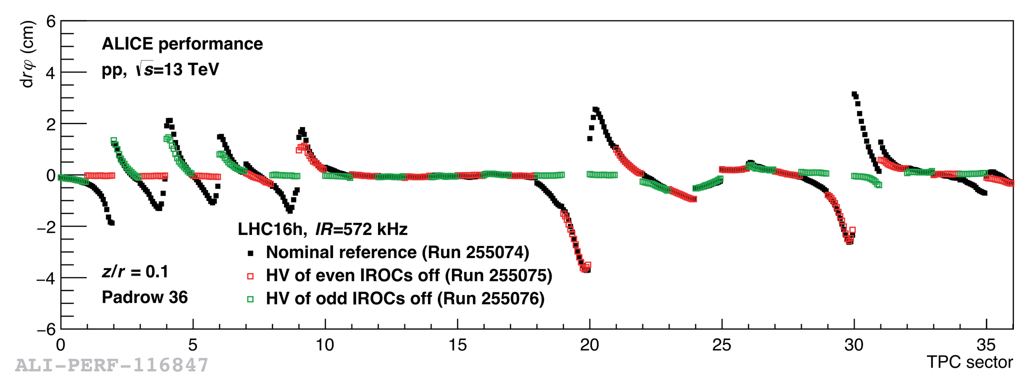
Linear dependence on the drift length (*z*)

⇒ Space-charge inside the drift volume
- Column of positive ions created at the readout chambers and drifting back towards the Central Electrode



Space-Charge Distortion Studies in Run 2

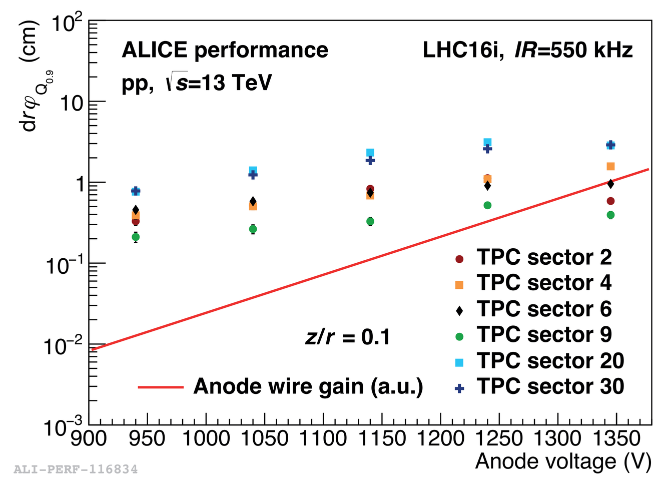
Different interaction rate (*IR*) and *B*-field dependence of distortions in each sector
- Approximately linear increase of distortions with *IR*
- Size of distortions changes with the *B*-field polarity



Single readout chambers identified as sources of space-charge
- High voltage at the anode wires of all even and odd IROCs, respectively, switched off in two consecutive runs
  - — Measurement of distortions by neighboring IROCs
- Correlation between the space-charge distortions and the high voltage of specific readout chambers

⇒ IROCs of TPC sectors 2, 4, 6, 9, 19, 29

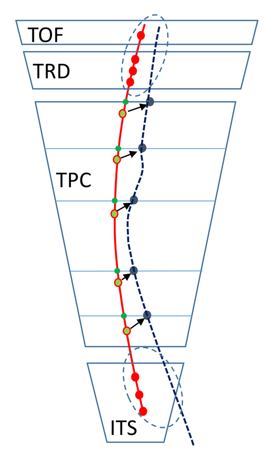
Exponential dependence of the distortions on the high voltage of IROCs responsible for the space-charge
- Different from the dependence of the usual gas amplification process
  - — Slope smaller by more than a factor of two



Increase of distortions by a factor of ~2 when increasing the water content in the TPC gas from 100 ppm to 620 ppm

Calibration

TPC track finding and matching to external detectors ITS, TRD and TOF



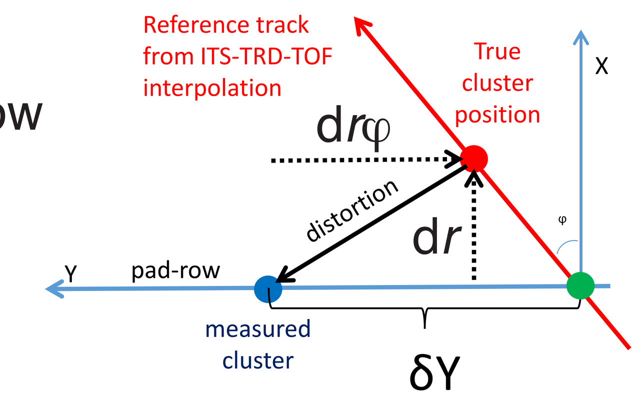
Refitted ITS, TRD and TOF **track segments** are interpolated to the TPC as **reference points** for the **true track position** at every TPC padrow

Measurement of δ*Y*, δ*Z* residuals between **distorted TPC clusters** and **reference points**

Relation between 2D residuals and real 3D distortion vector {d*r*, d*r*φ, d*z*}

$\delta Y = dr\varphi - dr \times \tan(\varphi)$ φ: angle between track direction and padrow

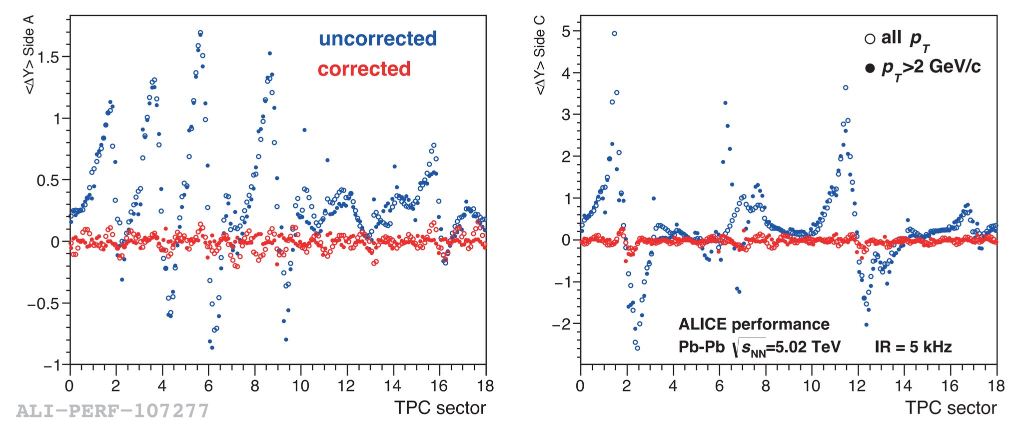
$\delta Z = dz - dr \times \tan(\lambda)$ λ: dip angle of the track



Correction of each TPC cluster by smooth parameterization of extracted distortion vectors

Mean signed distance of closest approach (DCA) of TPC tracks to the primary vertex in the bending plane as a quality measure

DCA residuals <Δ*Y*> corrected to *O*(1mm) in regions of large space-charge distortions



GOETHE UNIVERSITÄT FRANKFURT AM MAIN · IKF Institut für Kernphysik Frankfurt · HGS-HIRe for FAIR Helmholtz Graduate School for Hadron and Ion Research · EMMI · Quark Matter 2017

06-Feb-2017