The performance of the ALICE TPC

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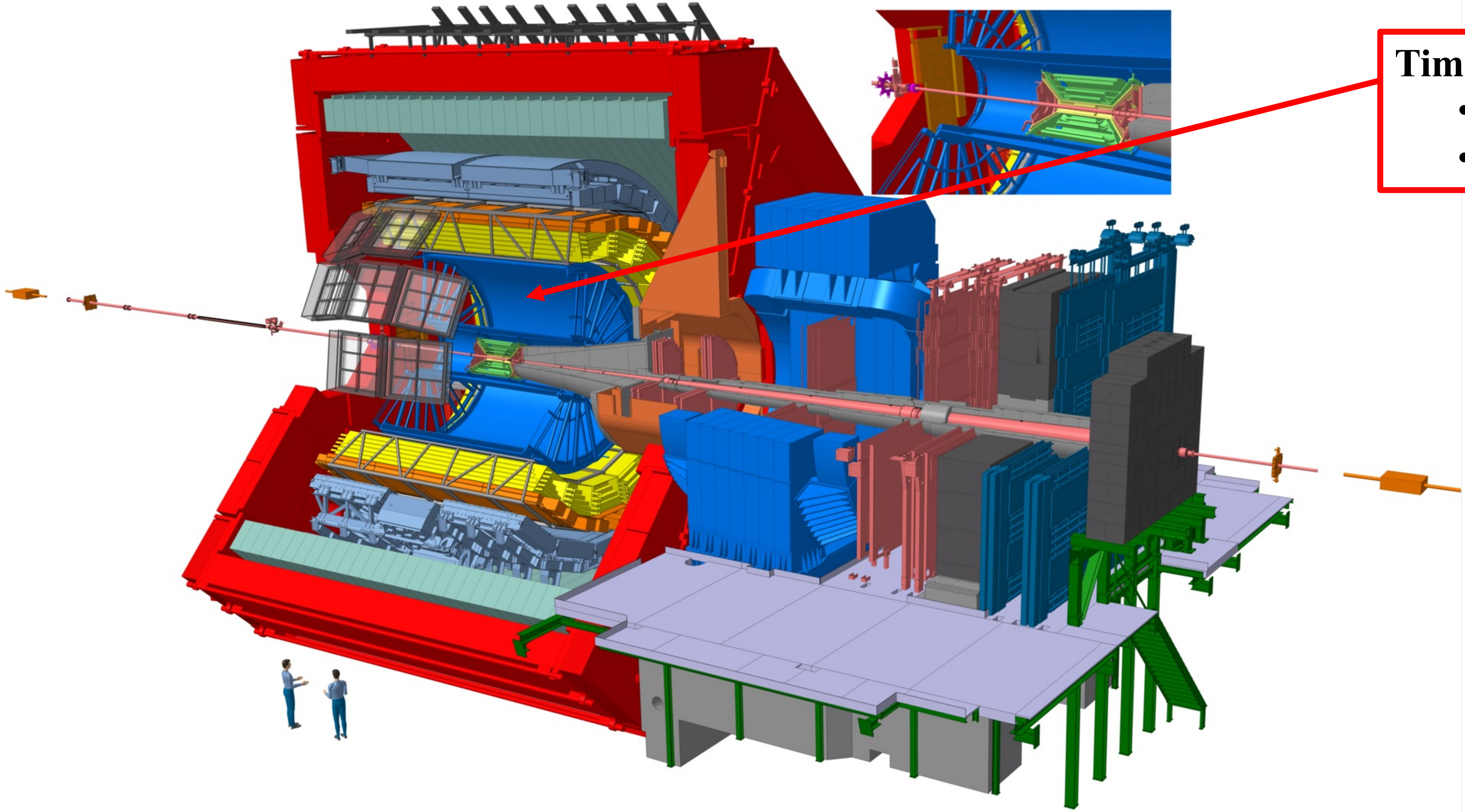
ALICE@LHC

ALICE is optimized to study the collisions of nuclei at the ultra-relativistic energies provided by the LHC. The aim is to study the physics of strongly interacting matter, called the quark-gluon plasma.

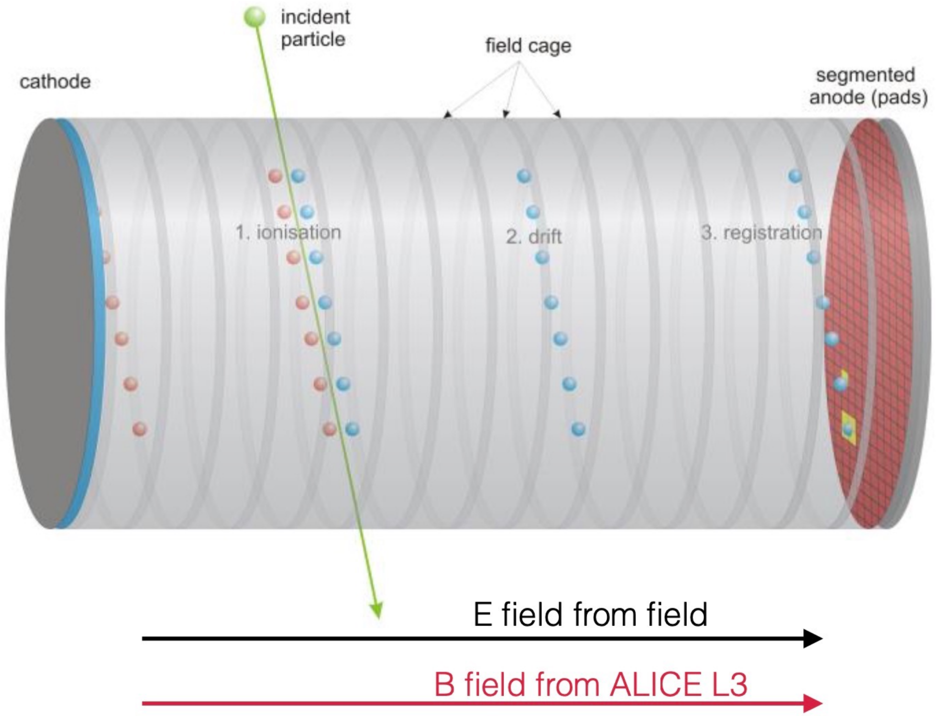
ALICE Detector Schematic



Time Projection Chamber

- Tracking,
- Particle identification

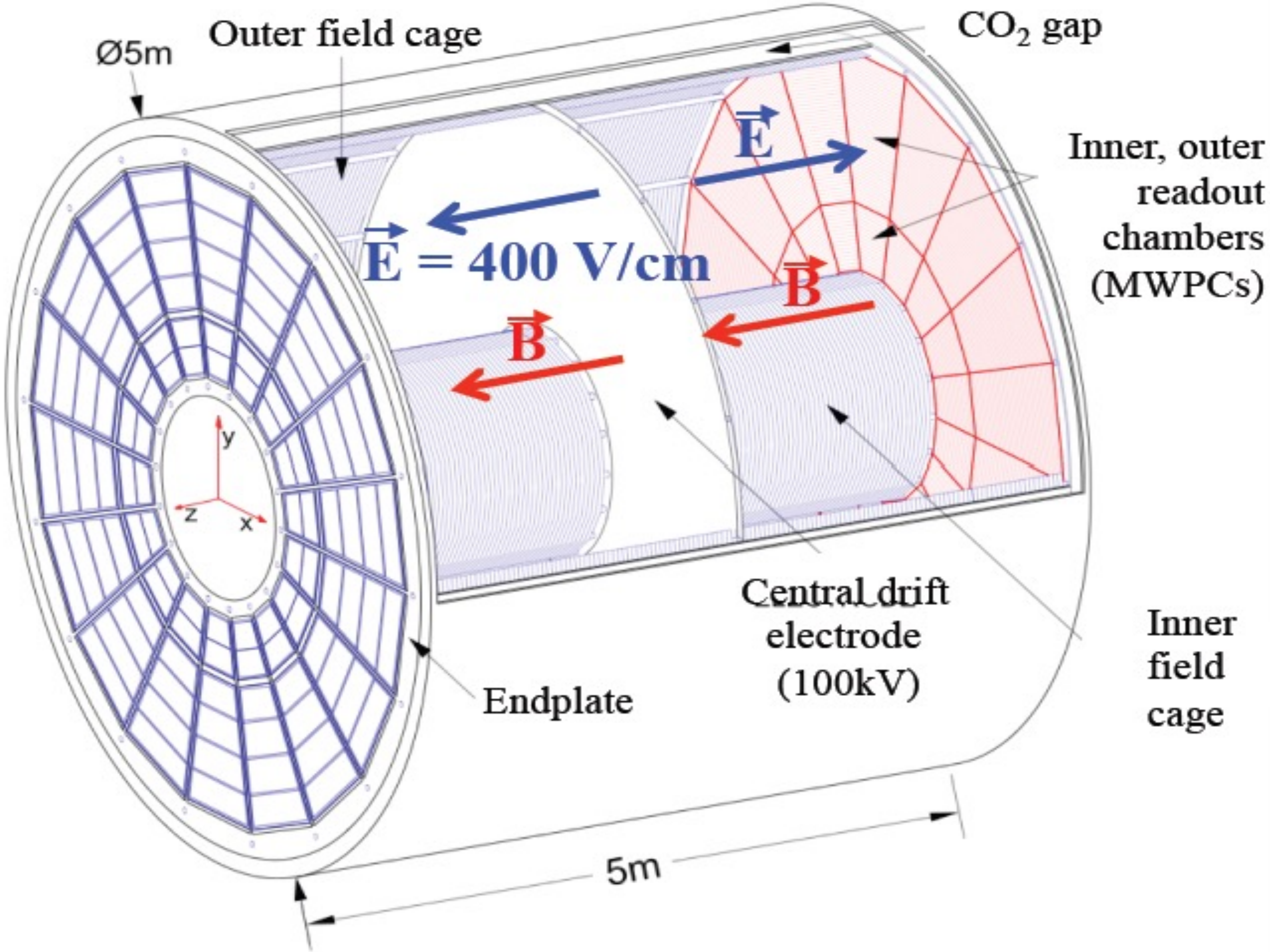
Basic principle of the TPC



- Incident particles traversing the gas volume can ionize the gas along their trajectory
- Electrons created in the ionization drift in the E-Field towards the end-plates
- The pad-planes collect the signals created in the end-plates.
- Pad signals are further amplified and shaped by the Front-End- Electronics
- X/Y position given by pad location, Z position given by drift time

Various factors impact the operation of a TPC, like changing properties of the **gas volume (T,p),** distortions created by **the charge inside the volume**, **gain variations** in the amplification region.

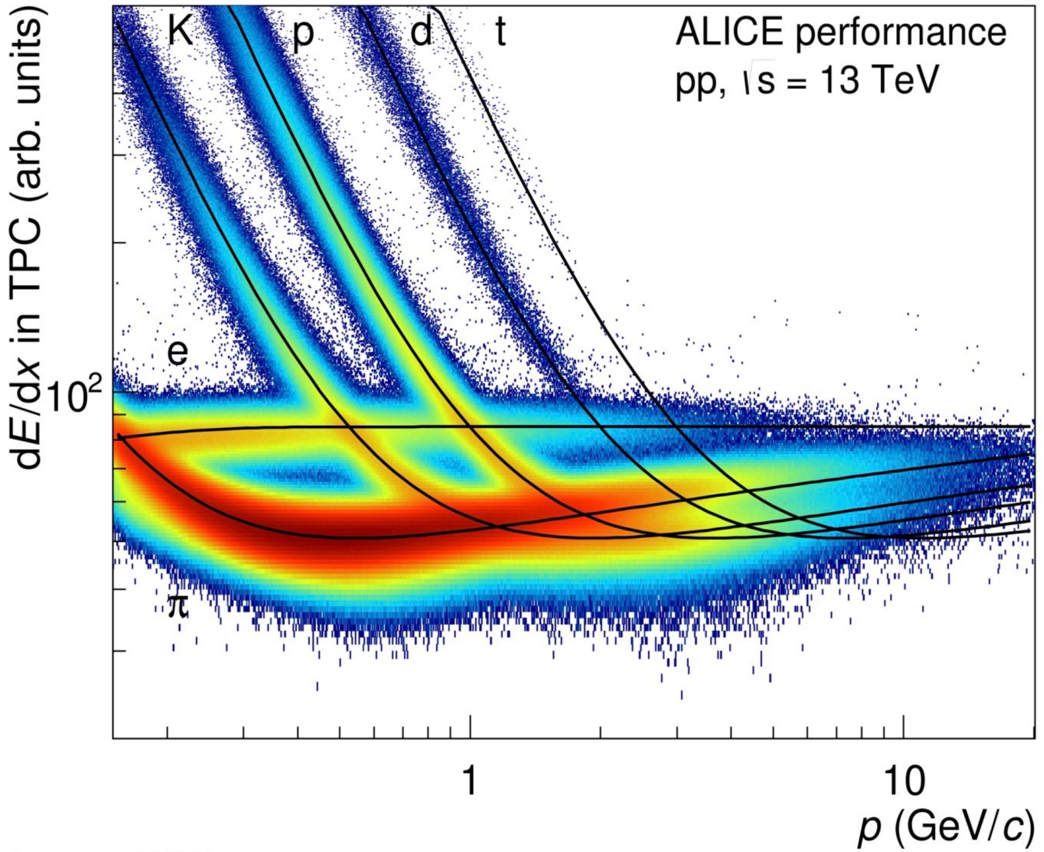
The ALICE TPC

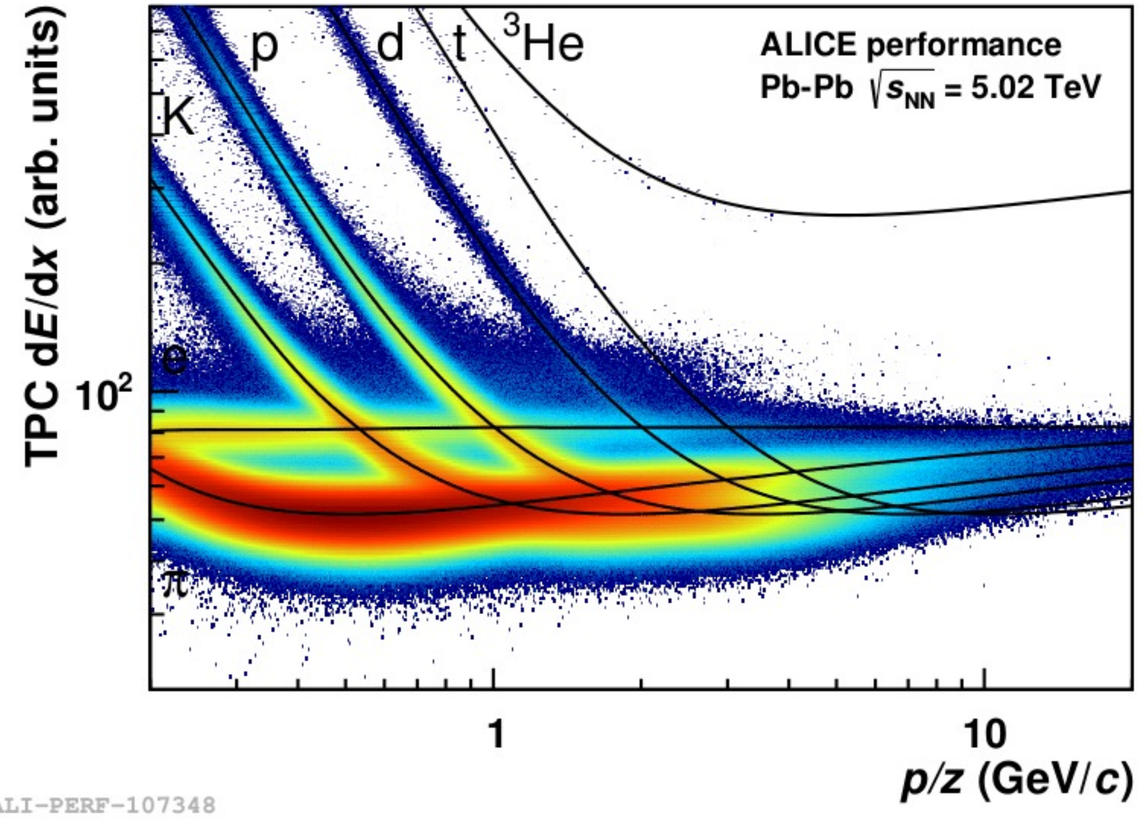


TPC main features:

- ~92 m^3 active volume with gas mixture: Ne-CO_2 (90-10)
- Low drift diffusion
- 72 (=18x2x2) MWPCs with pad readout
- Excellent performance on momentum reconstruction and dE/dx

TPC PID via dE/dx with Run 2

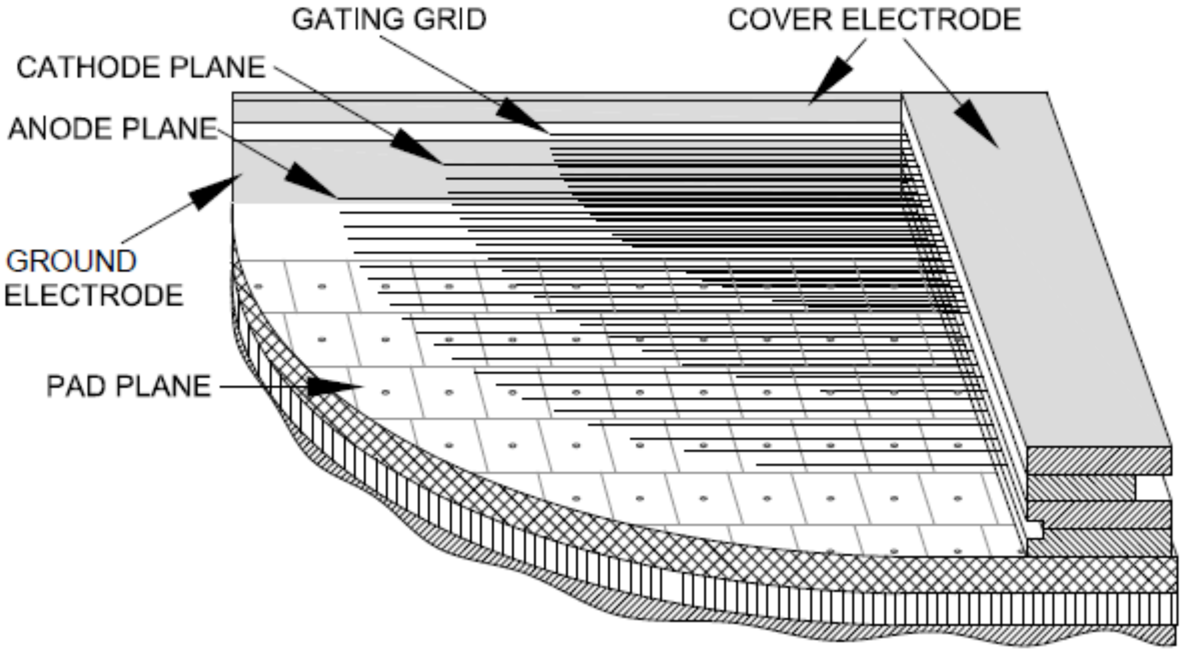




Energy loss per unit path length is described by the Bethe-Bloch formula

$$\langle\frac{dE}{dx}\rangle = \frac{4\pi Ne^4}{mc^2}\frac{z^2}{\beta^2}\left(\frac{1}{2}\ln\frac{2mc^2E_{max}\beta^2\gamma^2}{I^2} - \frac{\beta^2}{2} - \frac{\delta(\beta)}{2}\right)$$

TPC Readout Chamber (Run 2)



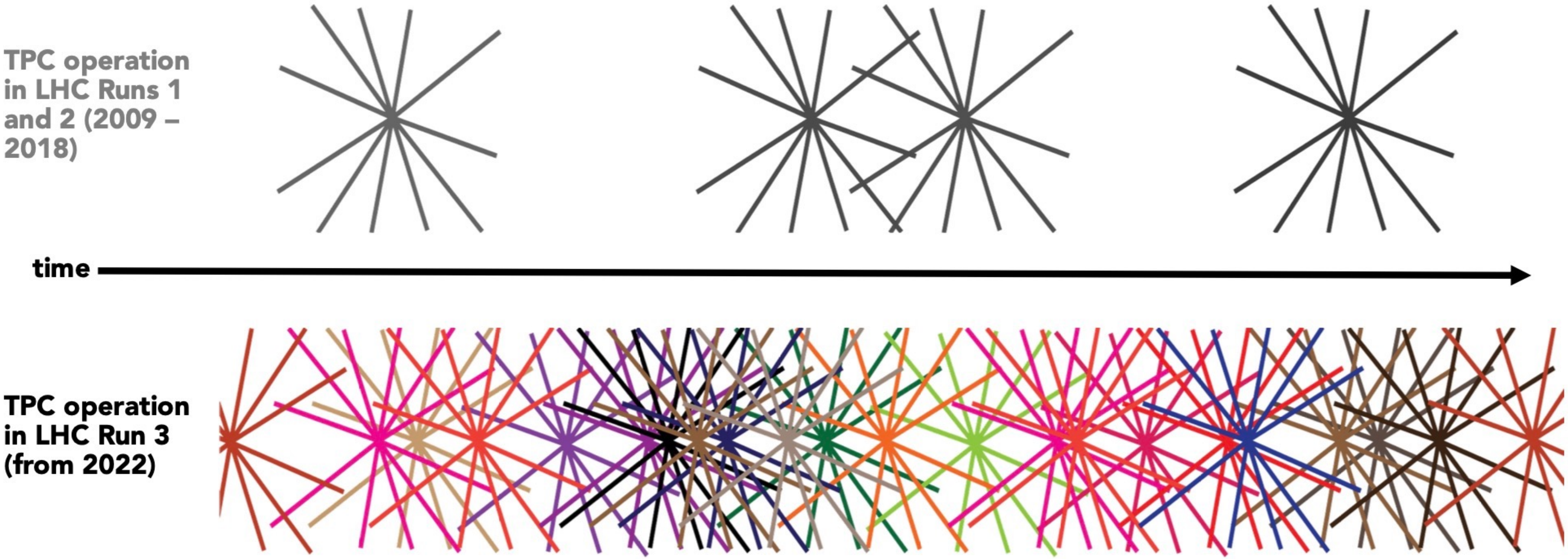
3 different pad segments:

- 63 rows with 4 x 7.5 mm^2 (IROCs)
- 64 rows with 6 x 10 mm^2 (inner OROCs)
- 32 rows with 6 x 15 mm^2 (outer OROCs)

Multi-wire proportional chambers (MWPC) + gating grid

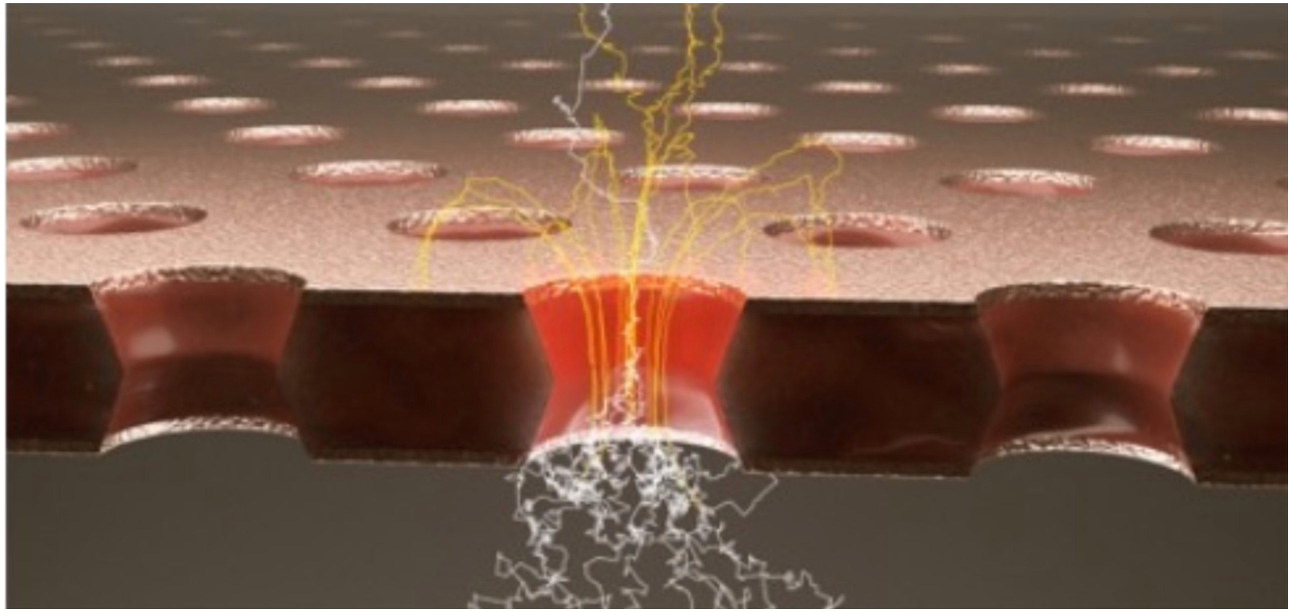
- Dead time: ~92μs (drift) + ~280μs (gating)
- Readout: 3 kHz max

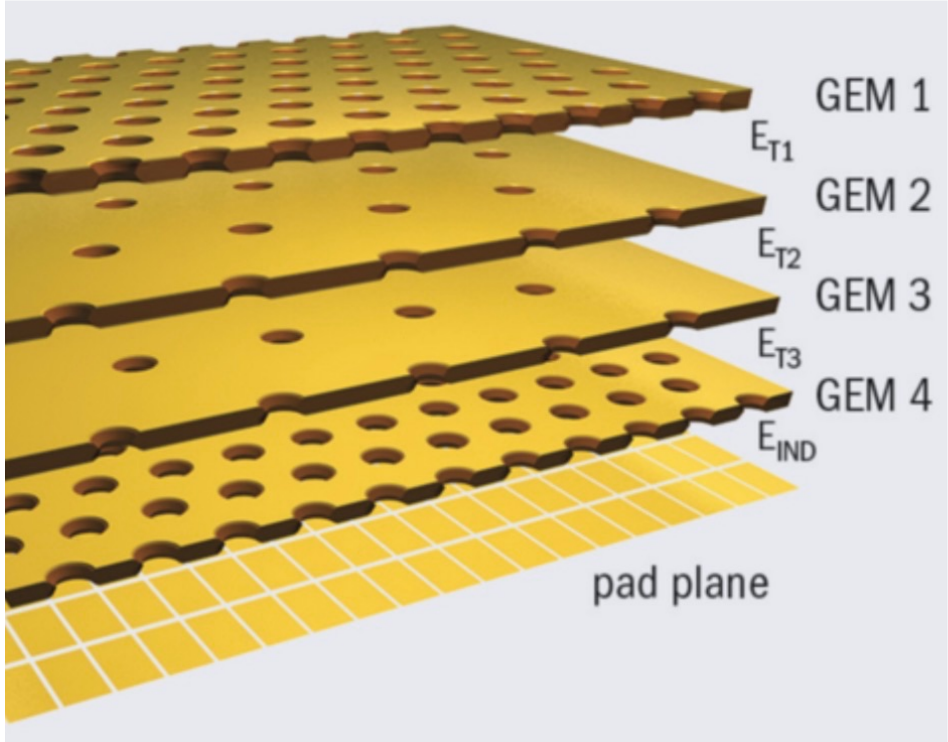
The ALICE TPC upgrades from Run 2 to Run 3



From triggered readout (Run 1&2) to continuous readout with GEMs (Run3)

The upgrade of the ALICE TPC for Run 3

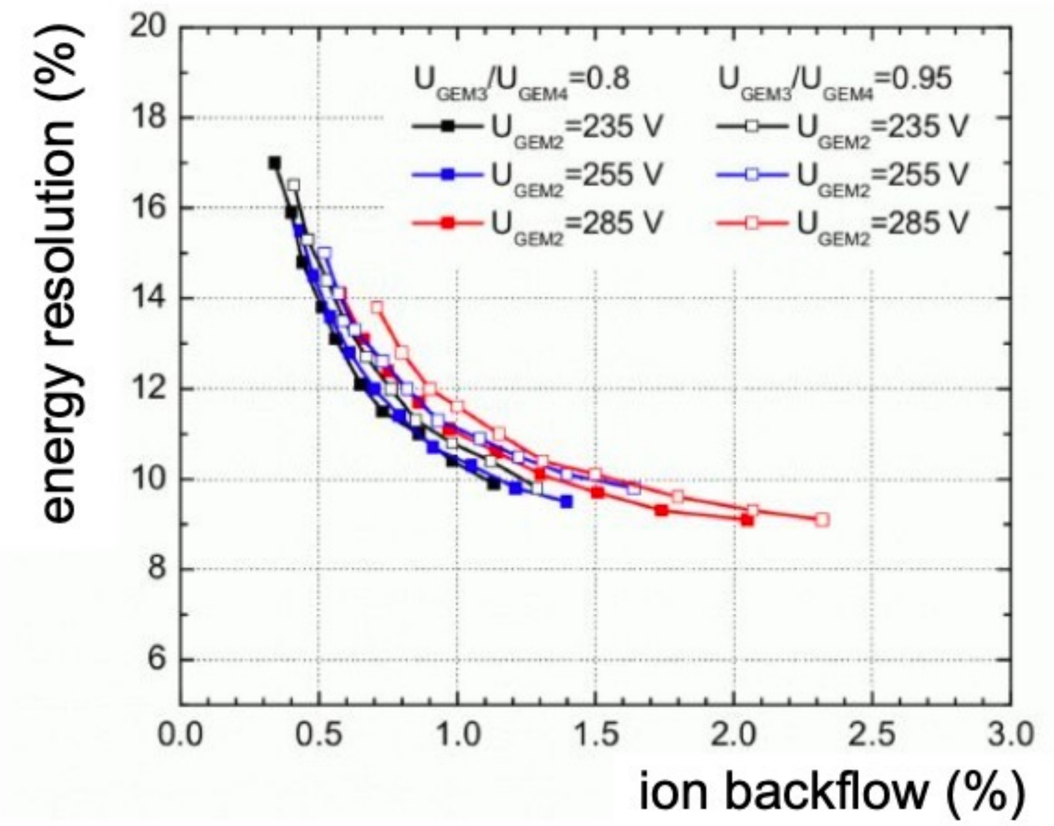




Upgrade front end electronics by Gaseous Electron Multiplier (GEM) foils

- Maintains current TPC performance
- Reduced ion backflow + high rate capability
- 4 Layers, varying GEM pitch

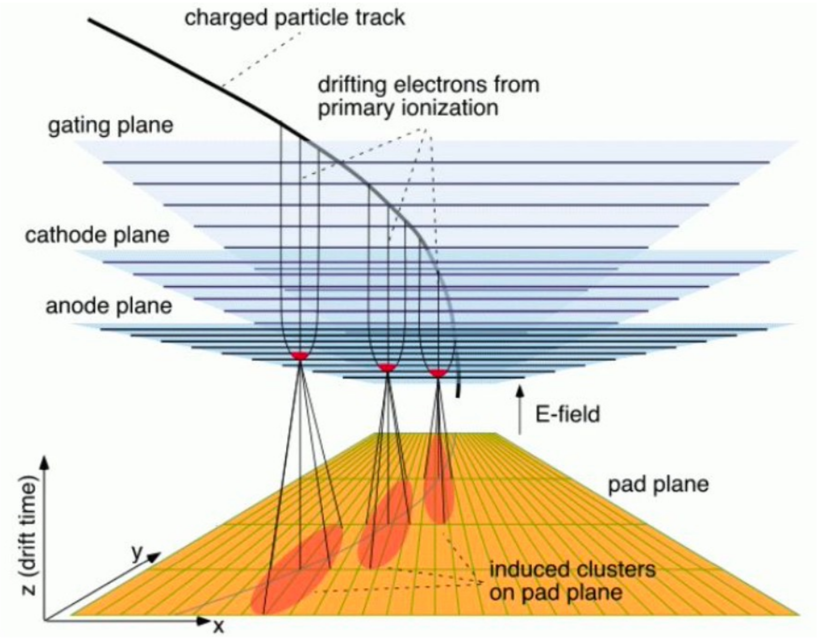
The simulation and testing of the GEM readout

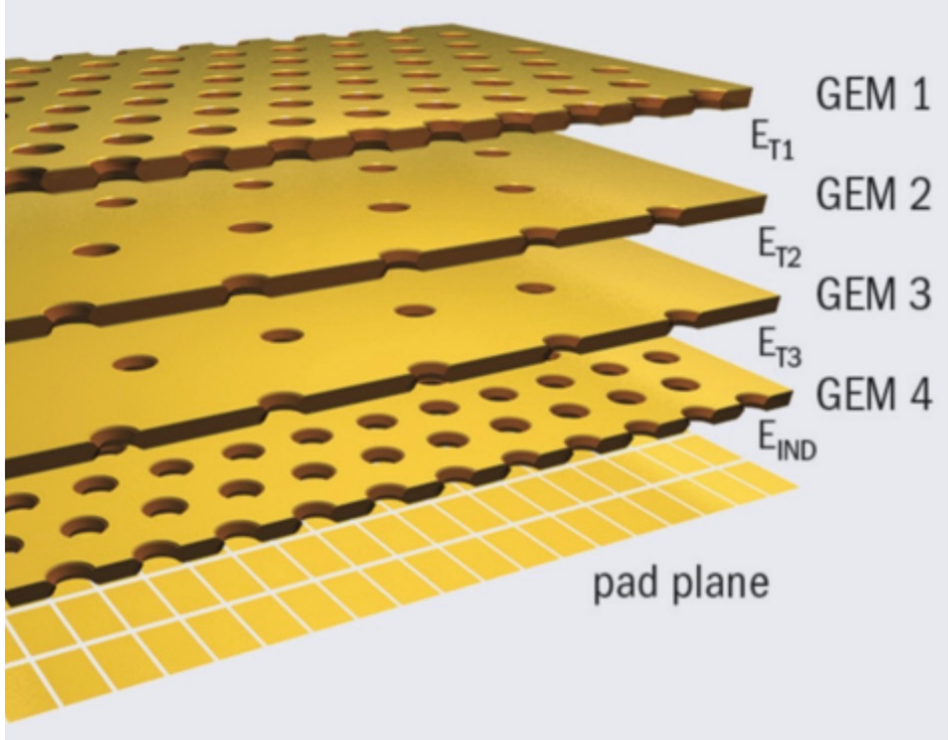


xbai@GSI clean room

- Highly optimized high voltage configuration
- Gain 2000 in Ne-CO_2-N_2 (90-10-5)
- Energy resolution < 12% for ^{55}Fe
- Ion backflow < 1 %

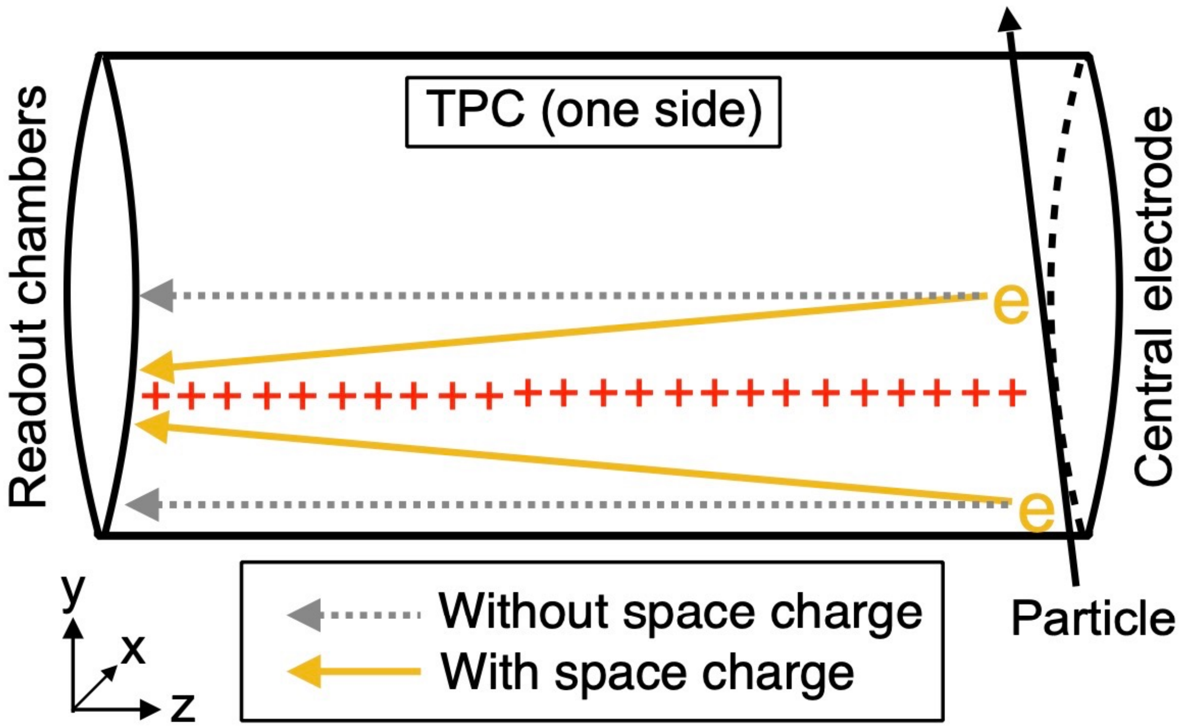
Comparison between wire and GEM chambers





	wire chamber		GEM chamber
	grid open	grid closed	
gain	8000	0	2000
ion backflow	0.13	<0.0001	<0.01

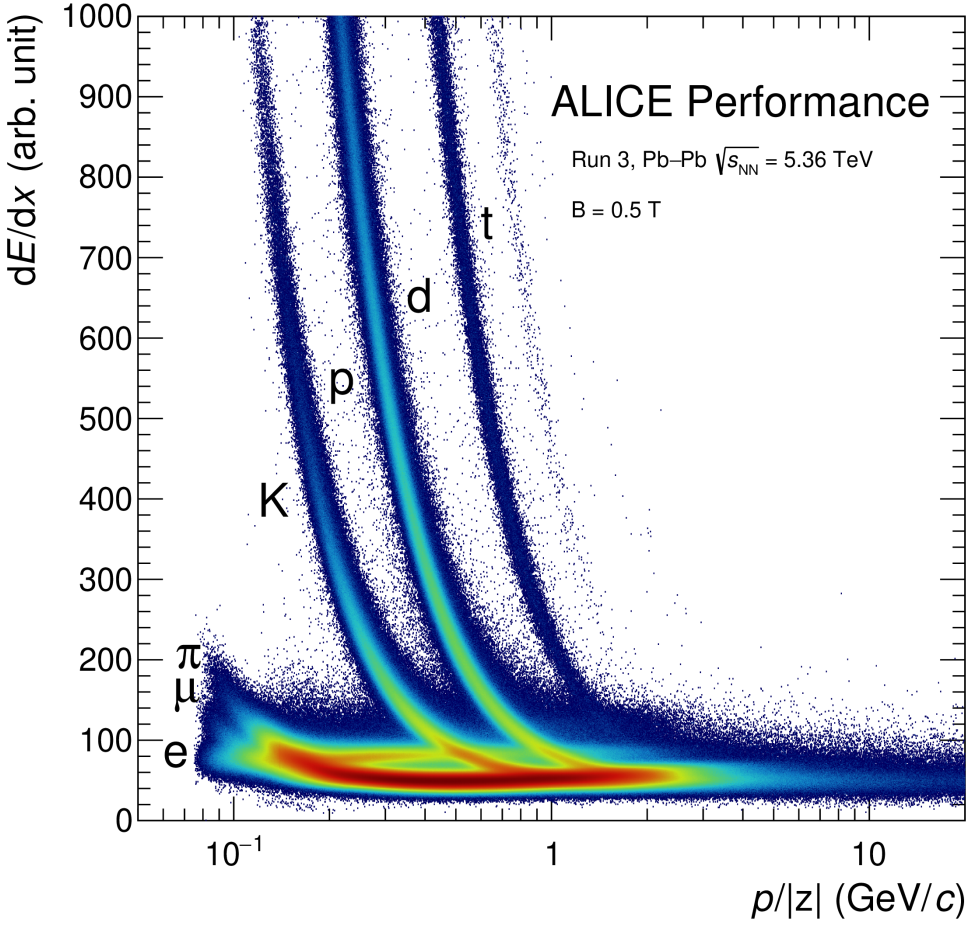
Space-charge distortion with Run3



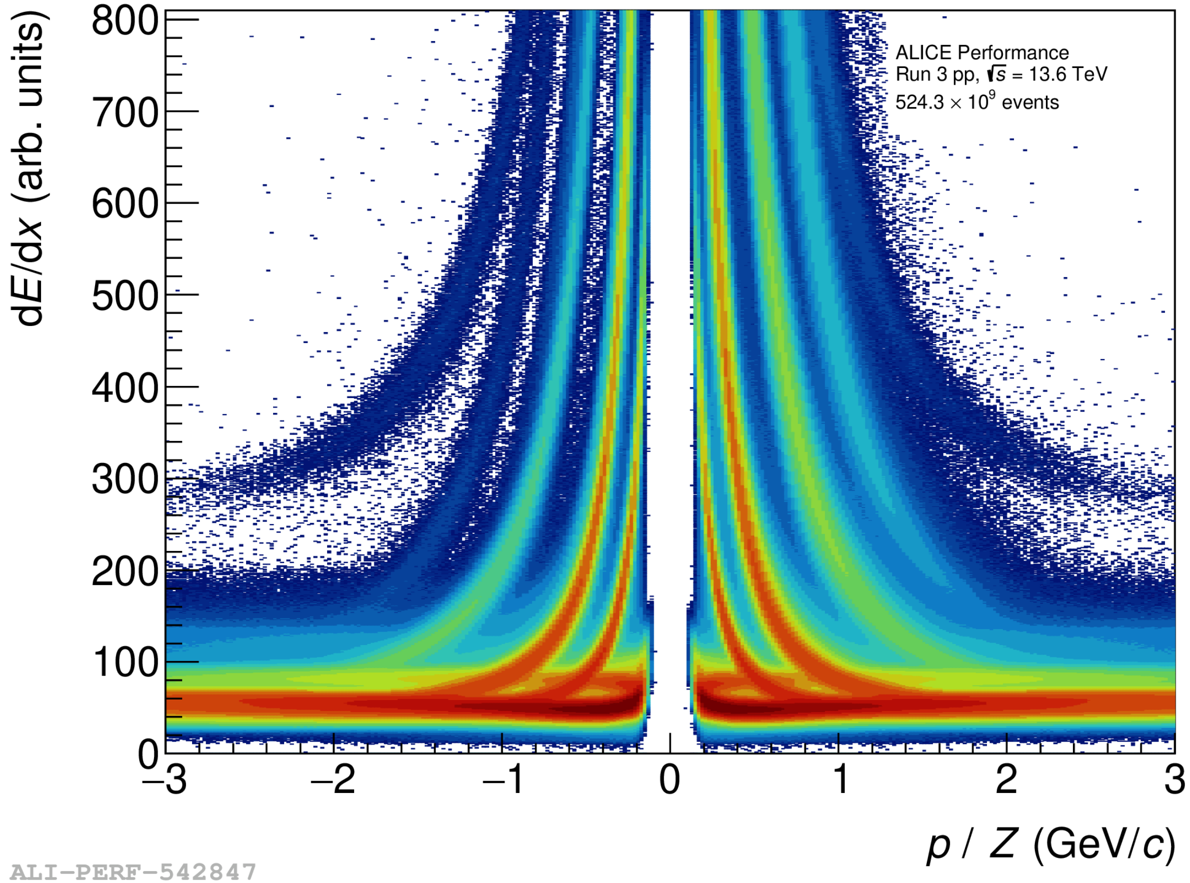
- **Large distortions** of the drift field in specific regions of the TPC observed in Run 3 data
- **Positive ions** created inside the TPC drift volume
- Deflection of ionization electrons in radial (dr), azimuthal ($dr\varphi$) and drift (dz) direction
- Dependence on the **drift length and interaction rate (IR)**

The momentum resolution is worse than that of the Run 1 and Run 2, offline calibrations are critical

The performace of the dE/dx for PID with the Run 3



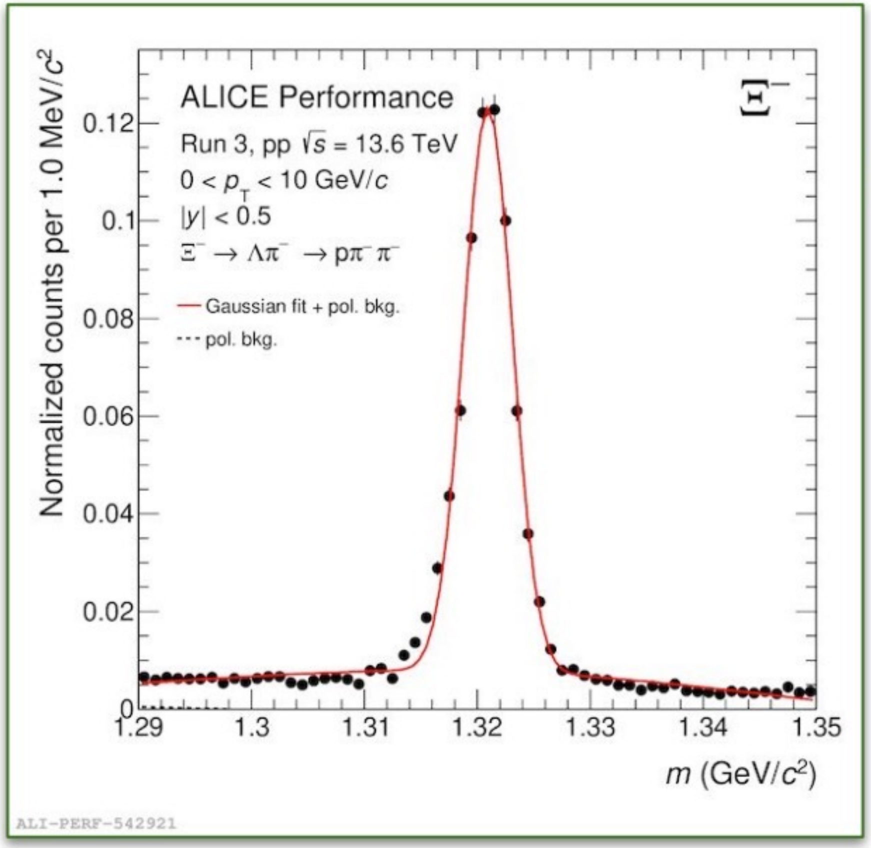
ALI-PERF-529714



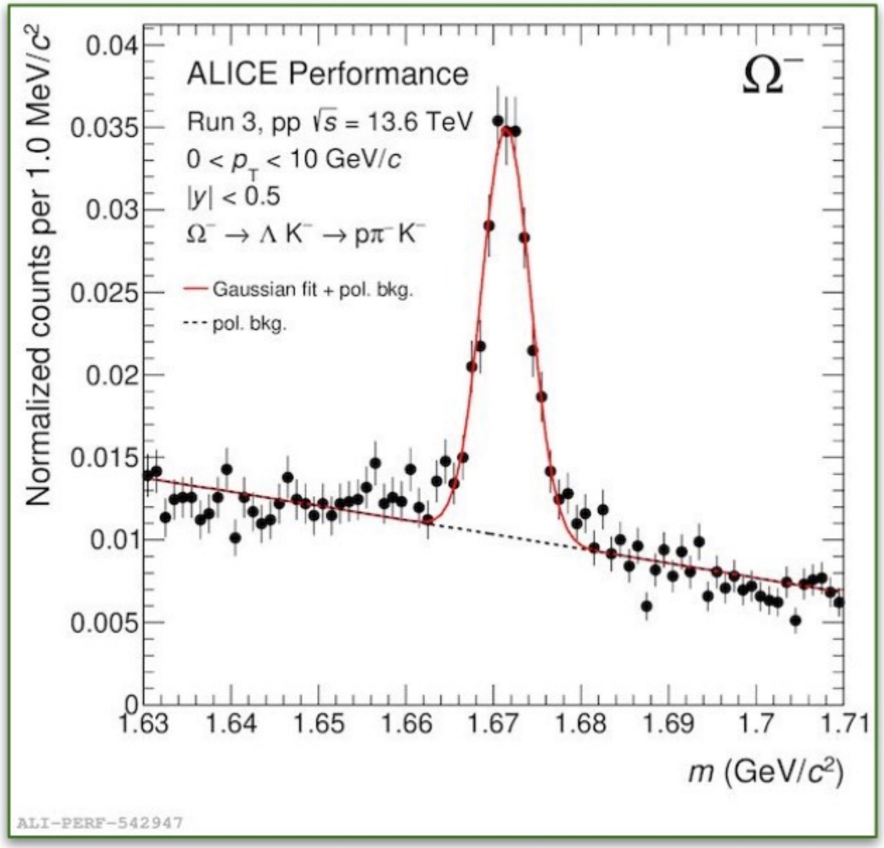
ALI-PERF-542847

Different particle species can be well discriminated by the TPC dE/dx. The resolution is slightly worse than Run 2, but it should be recovered via the new calibrations.

The permance of the Run 3 pp@13.6 TeV data



2022 pp data - Ξ⁻



2022 pp data - Ω⁻

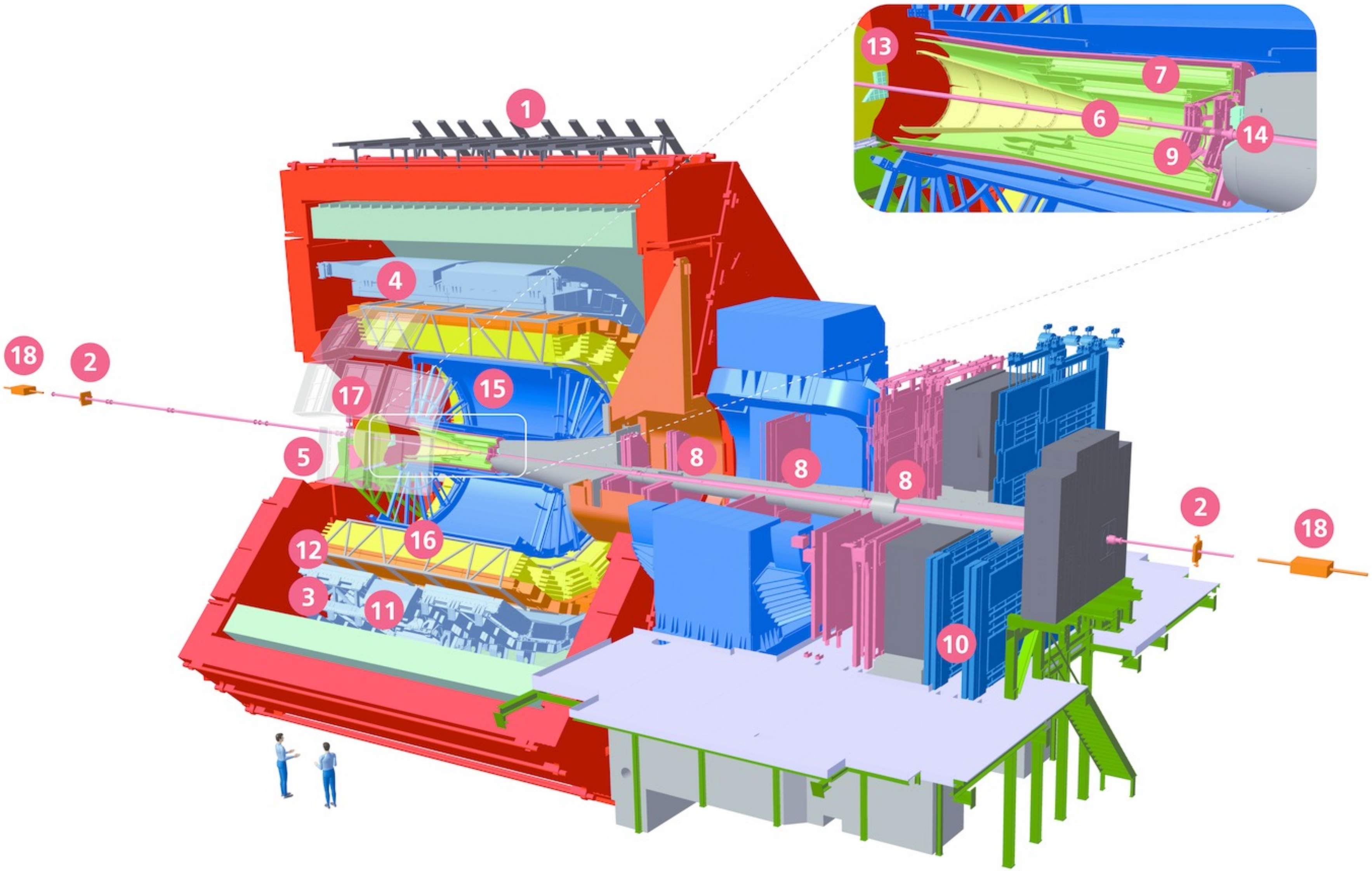
The width of the signal peak should be improved by the new SC distotion poretions as well

Summary

- **ALICE TPC upgraded for Run 3 to operate at 50 kHz rate in Pb-Pb collisions**
- **No gating, continuous readout with GEMs**
- **Improve statistics of minimum-bias for pp and Pb-Pb collisions by a factor of 10^4 and 10^2, respectively.**
- **The space charge distortion effects can be corrected by the offline calibration**

Thanks

ALICE Detector Schematic (Run 3)



1 **ACORDE** | ALICE Cosmic Rays Detector
2 **AD** | ALICE Diffractive Detector
3 **DCal** | Di-jet Calorimeter
4 **EMCal** | Electromagnetic Calorimeter
5 **HMPID** | High Momentum Particle Identification Detector
6 **ITS-IB** | Inner Tracking System - Inner Barrel
7 **ITS-OB** | Inner Tracking System - Outer Barrel
8 **MCH** | Muon Tracking Chambers
9 **MFT** | Muon Forward Tracker
10 **MID** | Muon Identifier
11 **PHOS / CPV** | Photon Spectrometer
12 **TOF** | Time Of Flight
13 **T0+A** | Tzero + A
14 **T0+C** | Tzero + C
15 **TPC** | Time Projection Chamber
16 **TRD** | Transition Radiation Detector
17 **V0+** | Vzero + Detector
18 **ZDC** | Zero Degree Calorimeter