Physics performance of the ALICE experiment in LHC Run 3

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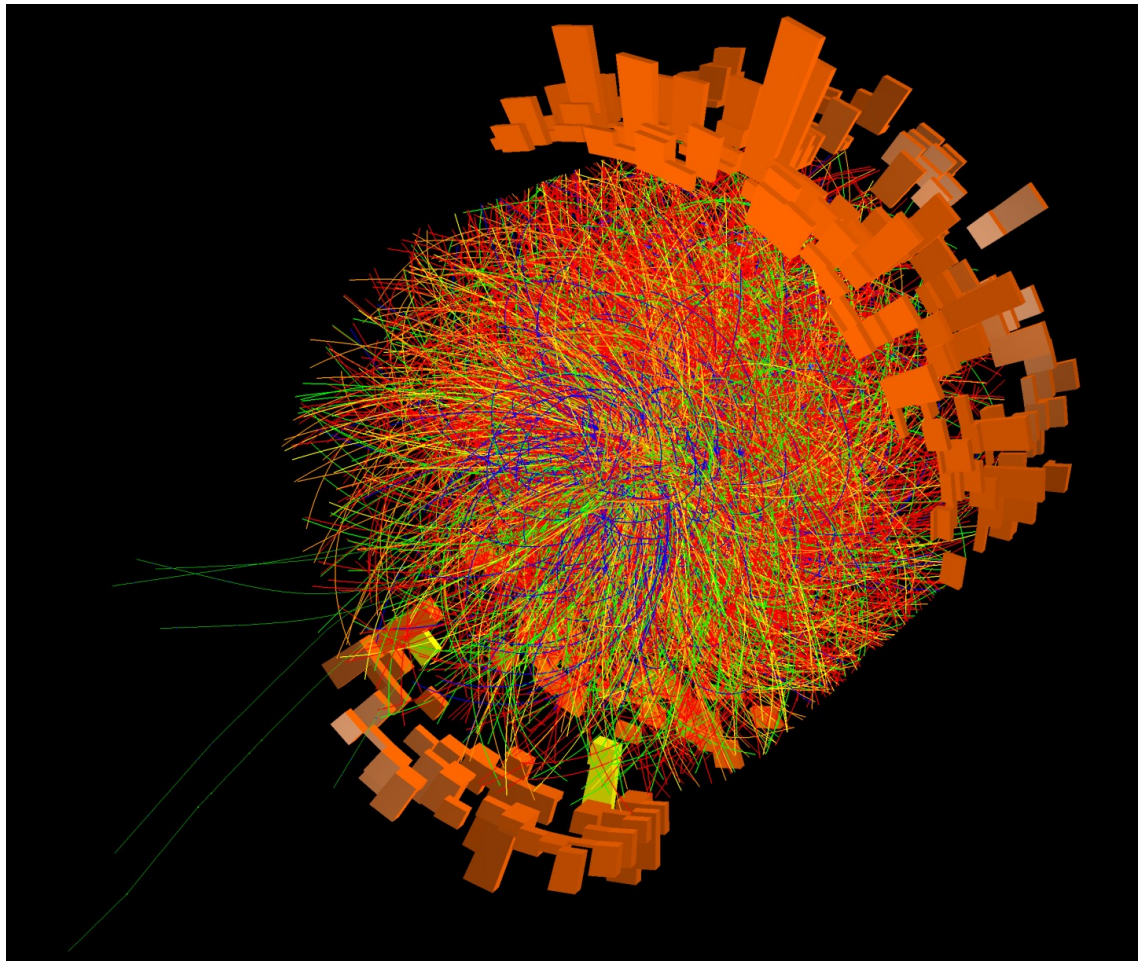
on behalf of the ALICE collaboration

Outline

I. The ALICE experiment at the LHC
II. Upgrade of ALICE for Run 3
III. Pilot Beam and results
    A. PID with TPC and TOF
    B. MFT performance
    C. FIT performance
    D. V^0 Analysis
    E. More analyses
IV. Summary

The ALICE physics motivations

- Main mission: probing the quark-gluon plasma (QGP), medium of deconfined quarks and gluons
- Focus on heavy-ion (Pb-Pb) collisions at total energies of hundreds of TeV inside the LHC
- Various probes: heavy-flavour production, low-mass dileptons, jets, strangeness enhancement, …



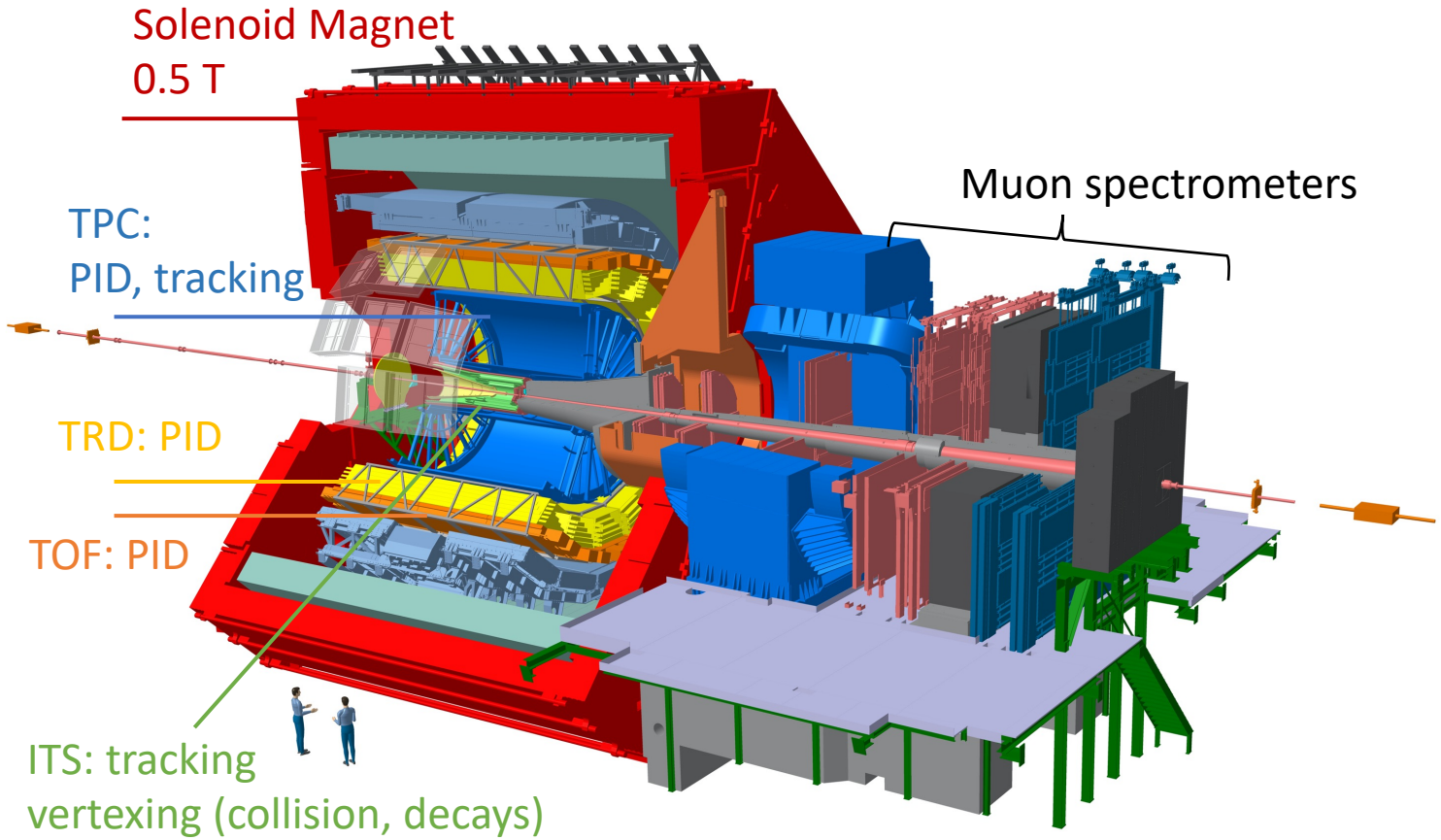
Heavy-ion collision
in ALICE – $\sqrt{s_{NN}} = 5.02$ TeV

The ALICE detector

- Combination of different detector technologies
- Tracking and identification of particles (PID) within 0.01-100 GeV/c p_{T} range

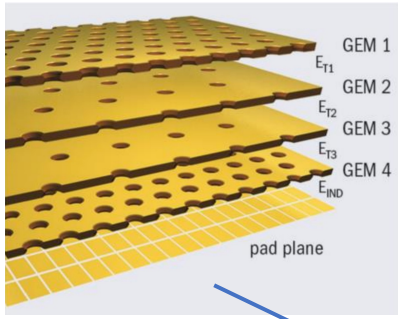
- Run 2: Pb-Pb at 1 kHz trigger rate, $\sim 1\ \mathrm{nb}^{-1}$ collected luminosity
- Run 3: Pb-Pb at 50 kHz interaction rate, $\sim 10\ \mathrm{nb}^{-1}$ luminosity projected

- **Pilot Beam** 2021: pp $\sqrt{s} = 0.9$ TeV, 0.2 T Field, 8M collisions



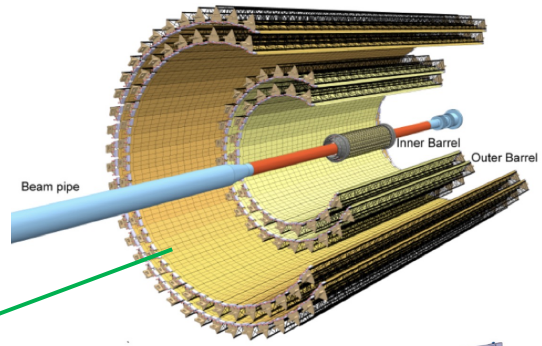
Upgrade of the ALICE detector

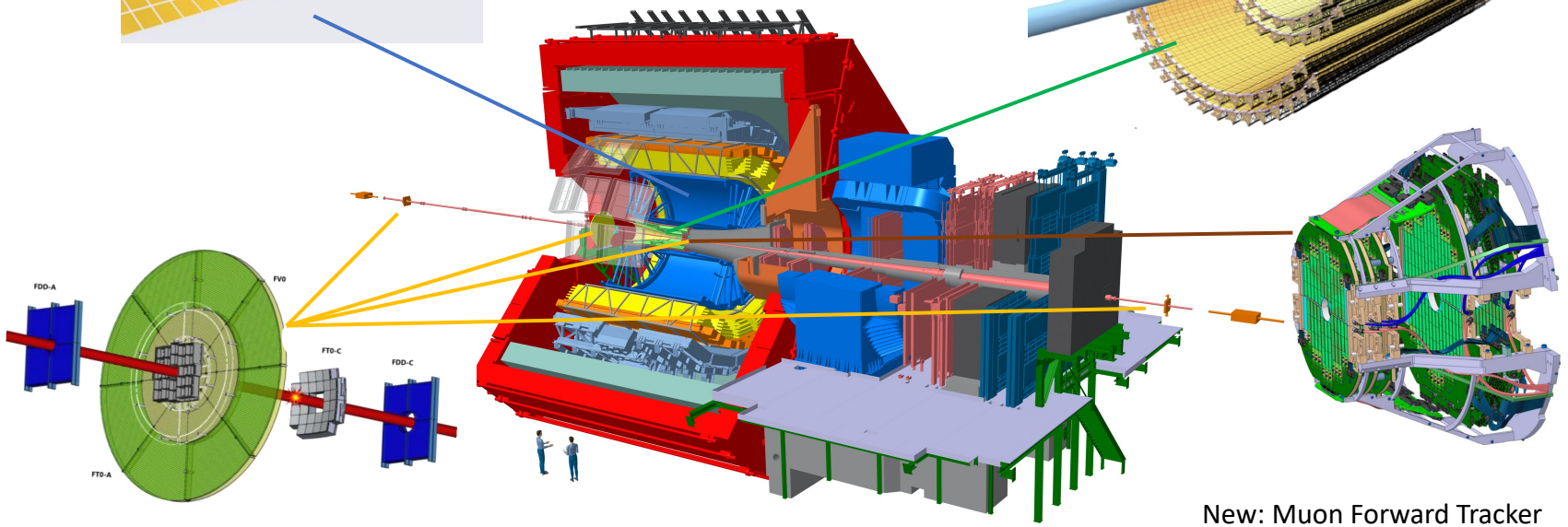
- Continuous readout to fully exploit the increased Pb-Pb interaction rate of 50 kHz
- Improve tracking efficiency and low-p_{T} resolution
- Preserve PID capabilities
- Online analysis to significantly reduce the data volume (expected raw data flow rate up to 3.5 TB/s)



Upgrade: Time Projection Chamber (TPC)
GEM on readout planes

Upgrade: Inner Tracking System (ITS)



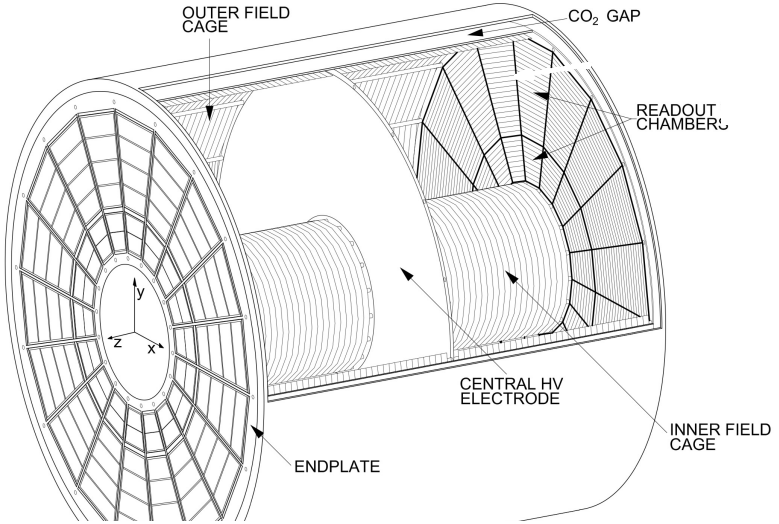


New: Fast Interaction Trigger (FIT) to provide precise event time measurement and min. bias trigger for detectors with triggered readout

New: Muon Forward Tracker to match muons before/after absorber

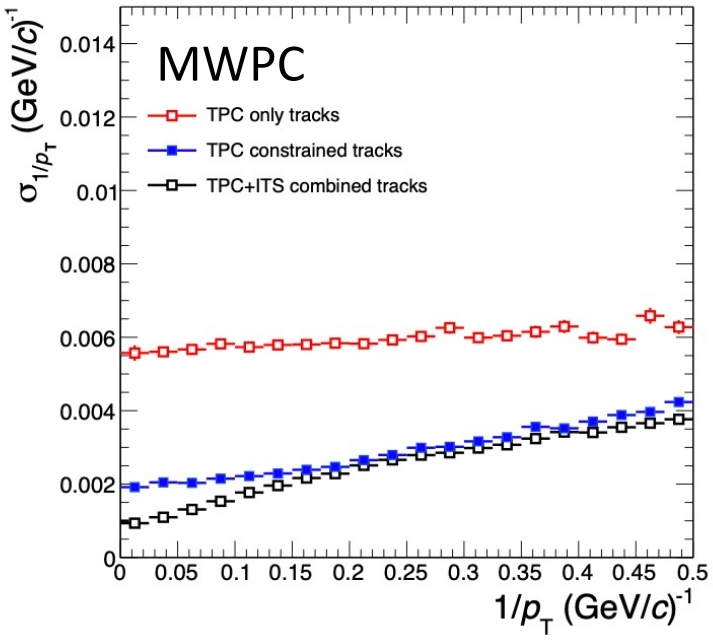
For more: see Robert Münzer's presentation

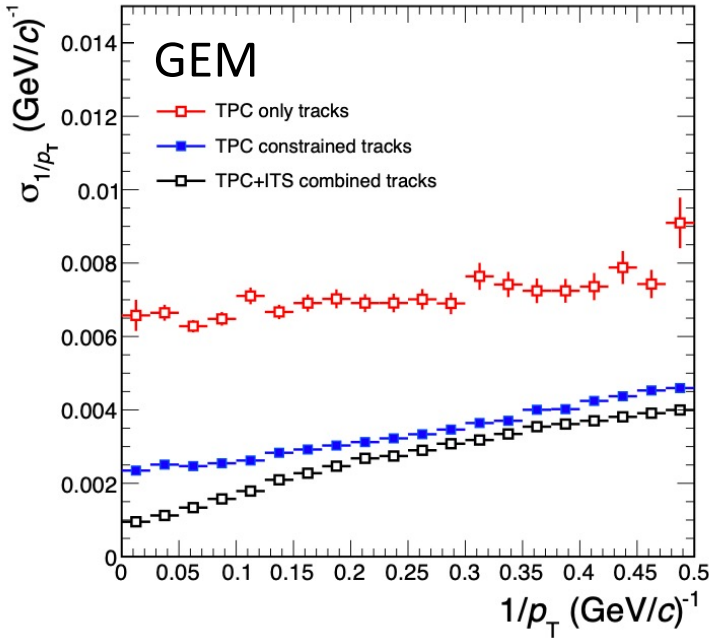
TPC upgrade

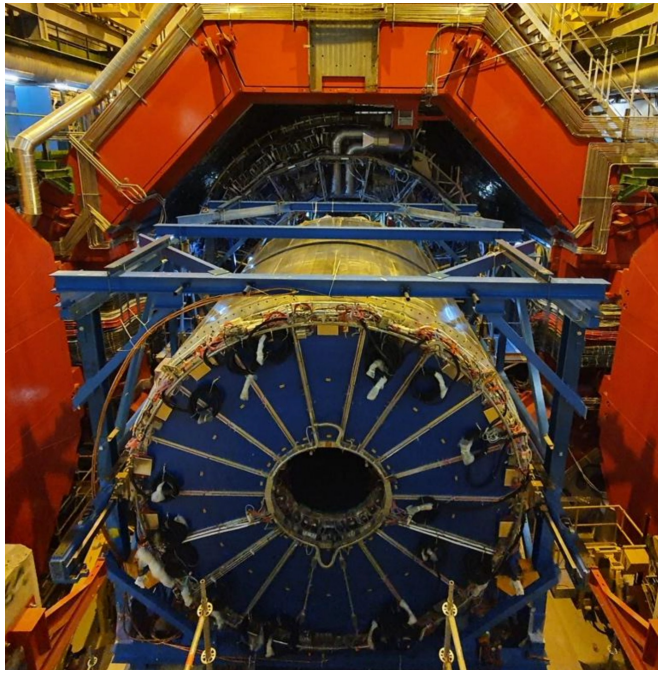


- Similar p_{T} resolution and d*E*/dx performance
- Cope with continuous readout:

Old **Wire Chambers** (MWPC, readout of 3 kHz max) ⟶ New **Gas Electron Multiplier** (GEM, 5 MHz readout rate)



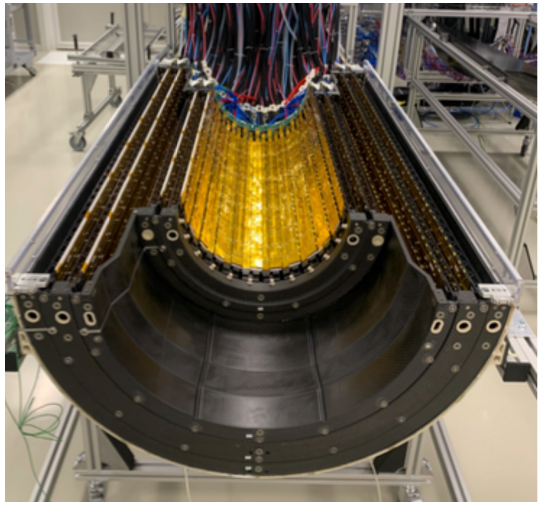




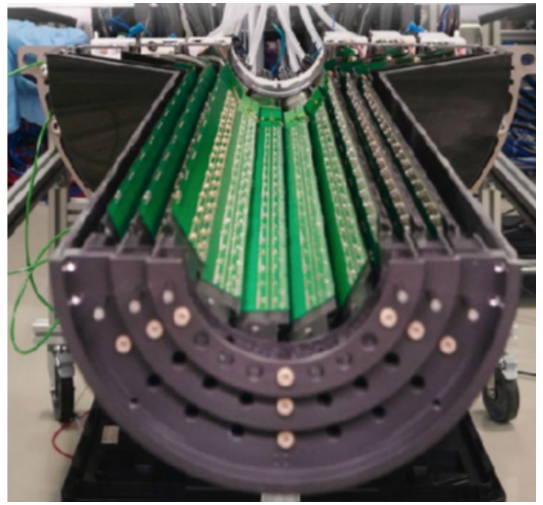
TPC p_{T} resolution – Wire chamber (left), GEM (right)

ITS upgrade

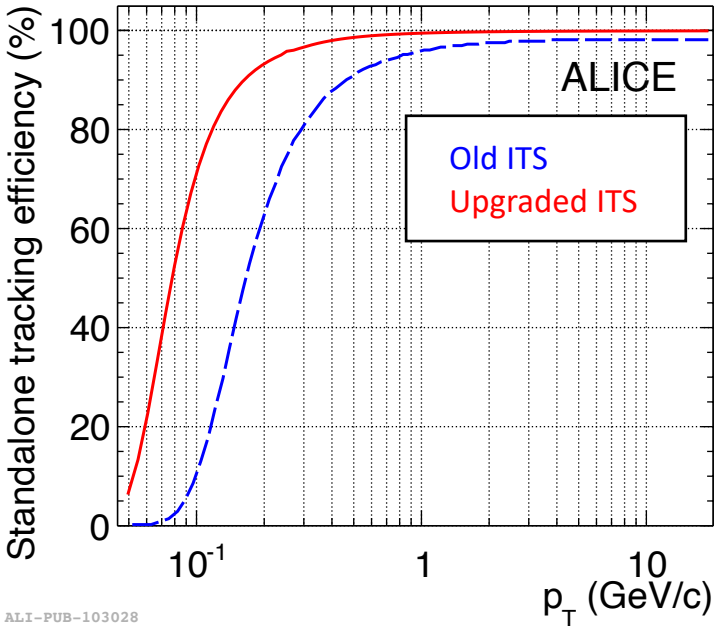
- Readout rate increased to 100 kHz (for Pb-Pb)
- Improve tracking efficiency and spatial resolution:
  - 7 layers of silicon (monolithic active) pixel detectors
  - Inner layer closer to beam pipe (38 mm to 22 mm)
  - Reduced material budget (0.35% X_0 for inner barrel)

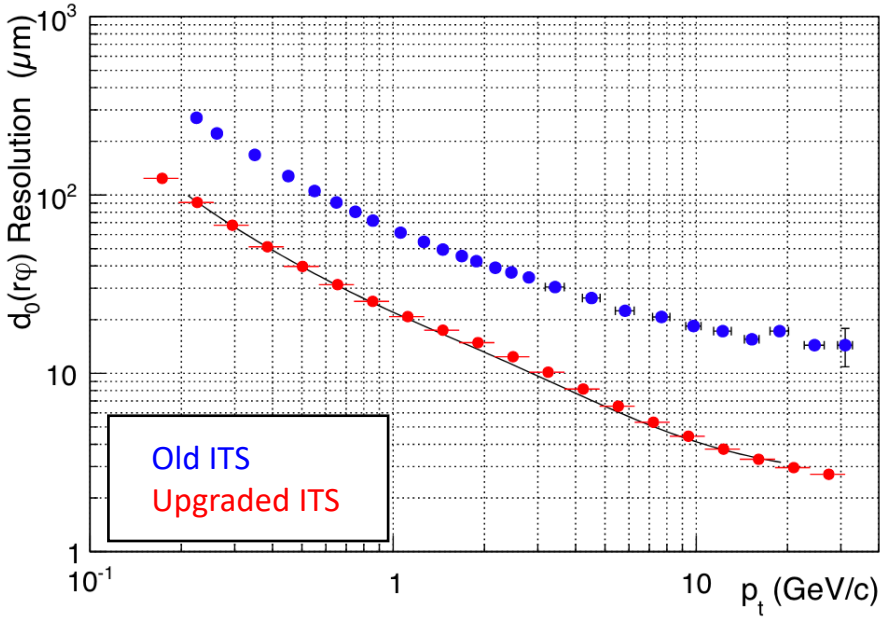


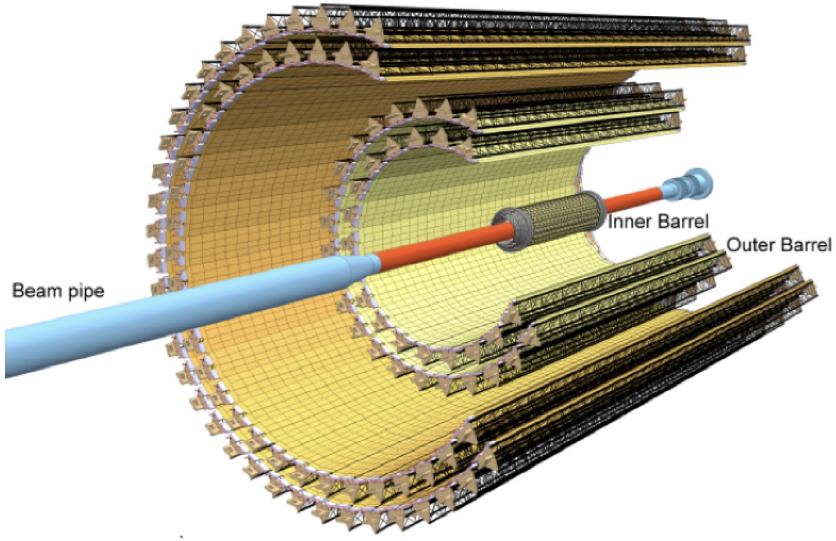
Outer barrel



Inner barrel







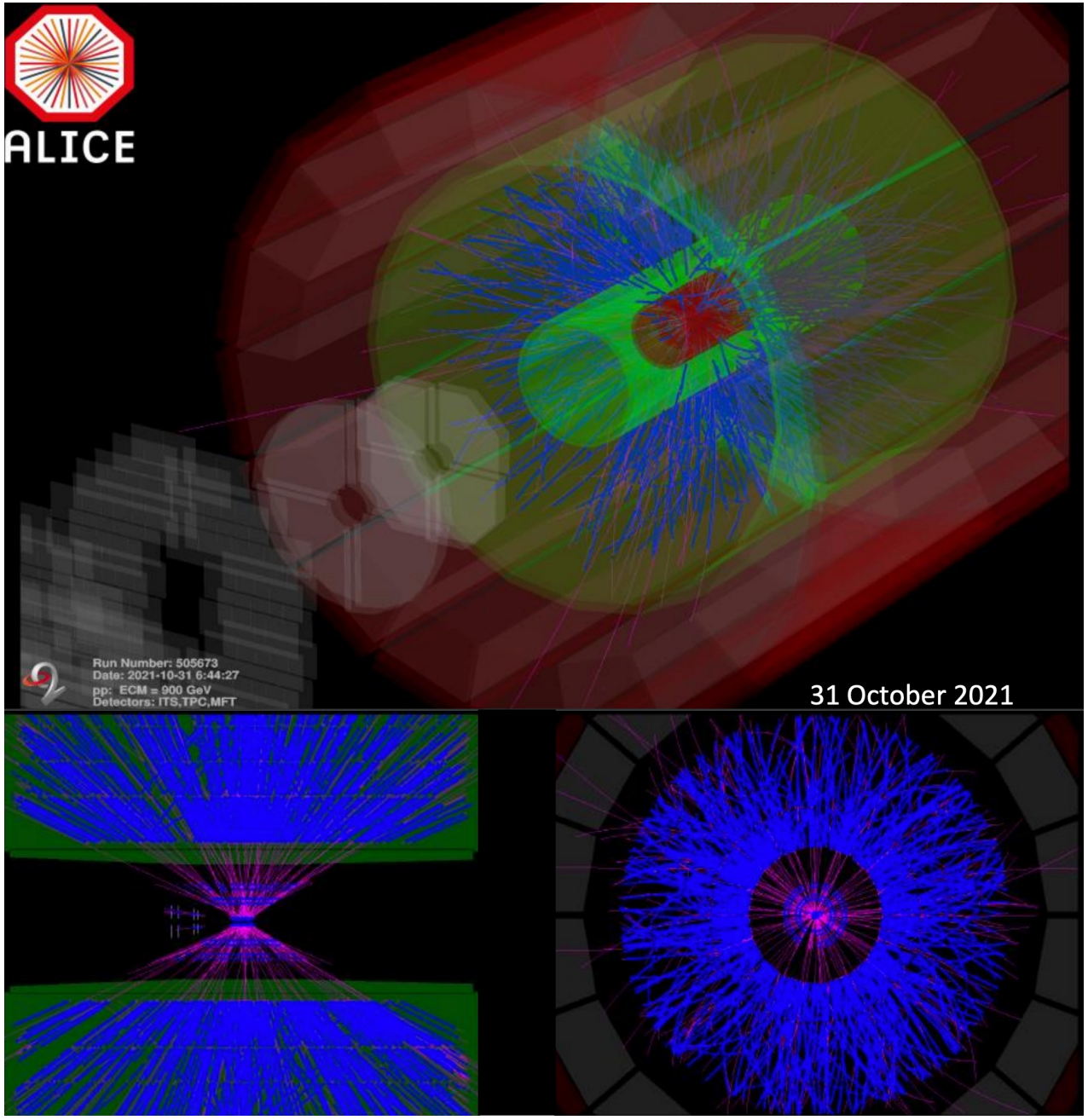
3D view of the ITS

ALI-PUB-103028

Standalone tracking efficiency (left) and Impact-parameter resolution in the transverse plane (right) for primary charged pions as a function of p_T for the current ITS (blue) and the upgraded ITS (red)

Pilot Beam

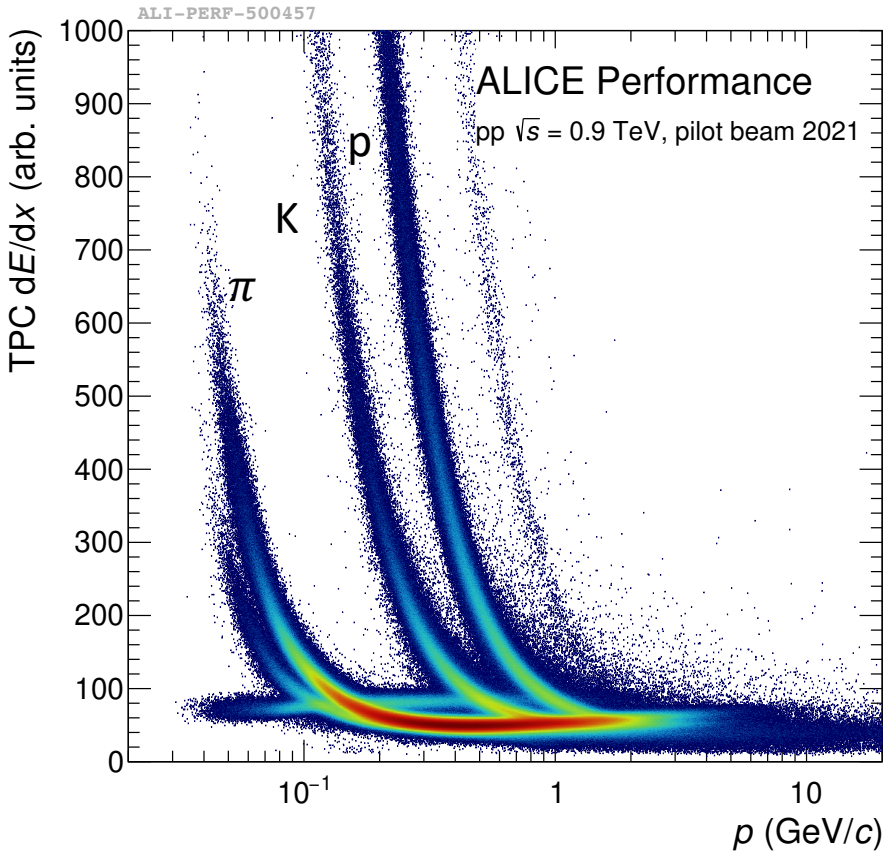
- Run in October 2021
- 8M pp collisions at $\sqrt{s} = 0.9$ TeV
- 0.2 T Field instead of usual 0.5 T
- Completion of many years of work on the ALICE upgrade, that started before LS2 even began
- Test of the detectors, reconstruction and analysis software



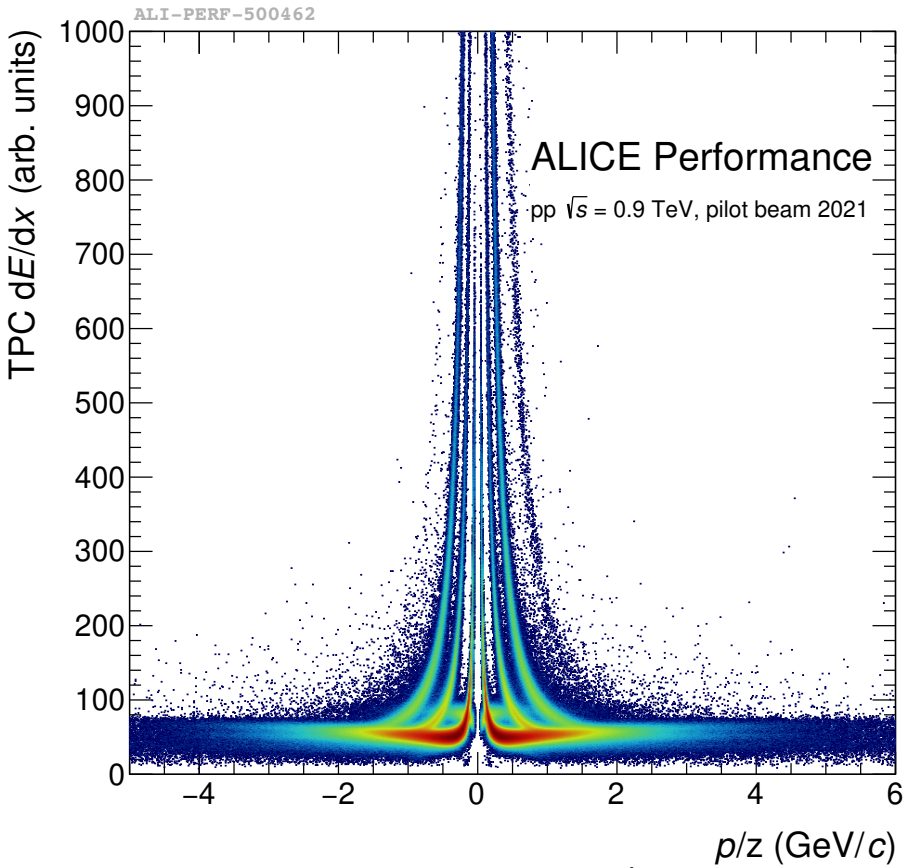
Event display of an event of the pilot beam – 3D view (top), radial view (bottom right) side view (bottom left)

Pilot Beam – π/K/p PID with TPC

- PID performance comparable with Run 1 and 2



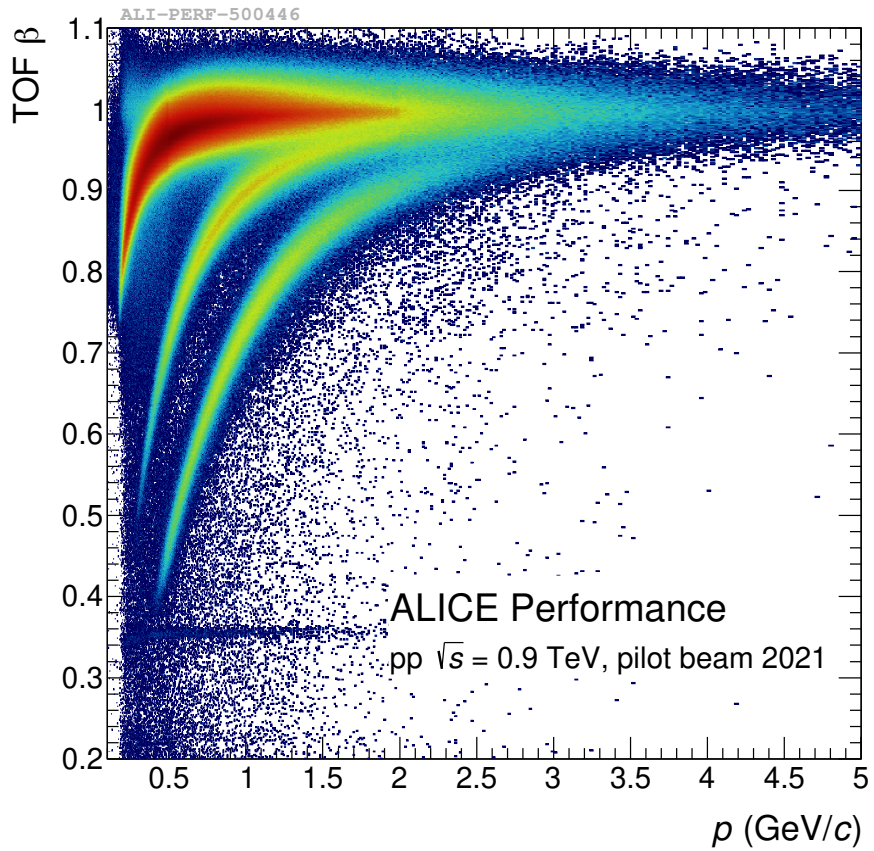
Ionisation energy loss in the TPC (dE/dx) as a function of momentum for reconstructed tracks



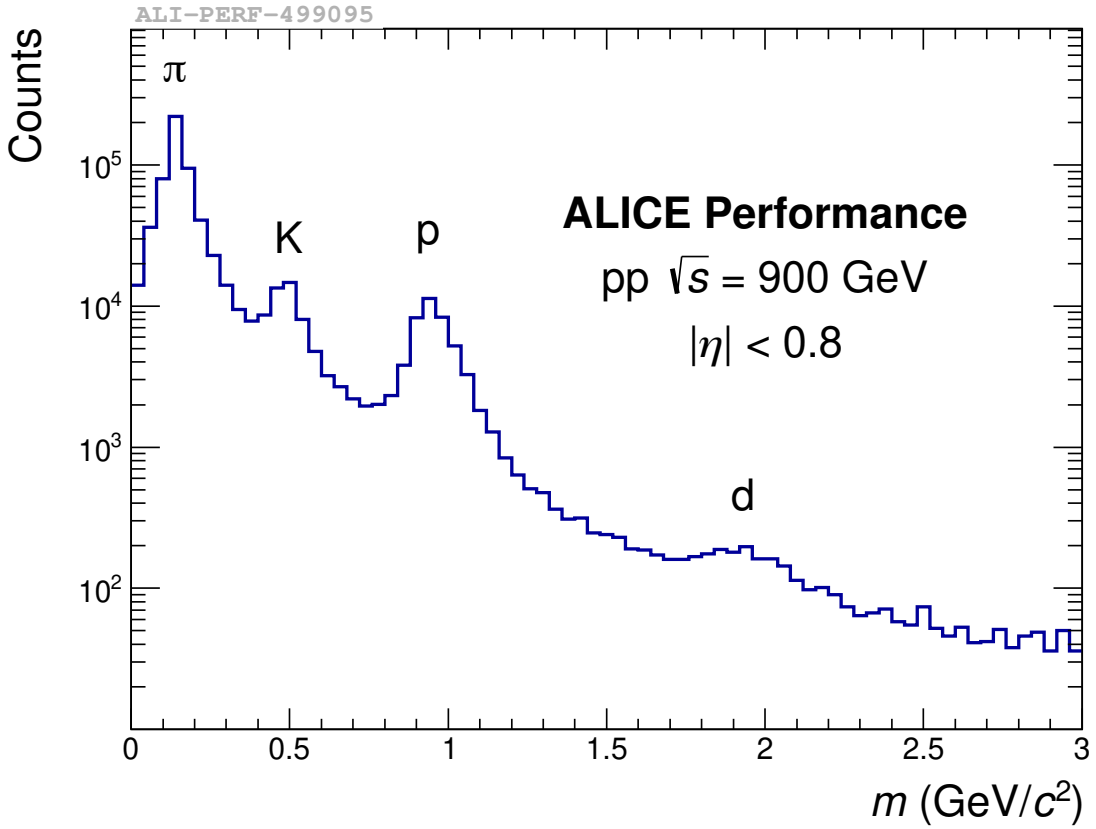
Ionisation energy loss in the TPC (dE/dx) as a function of the particle rigidity for reconstructed tracks

Pilot Beam – π/K/p PID with TOF

- PID performance comparable with Run 1 and 2



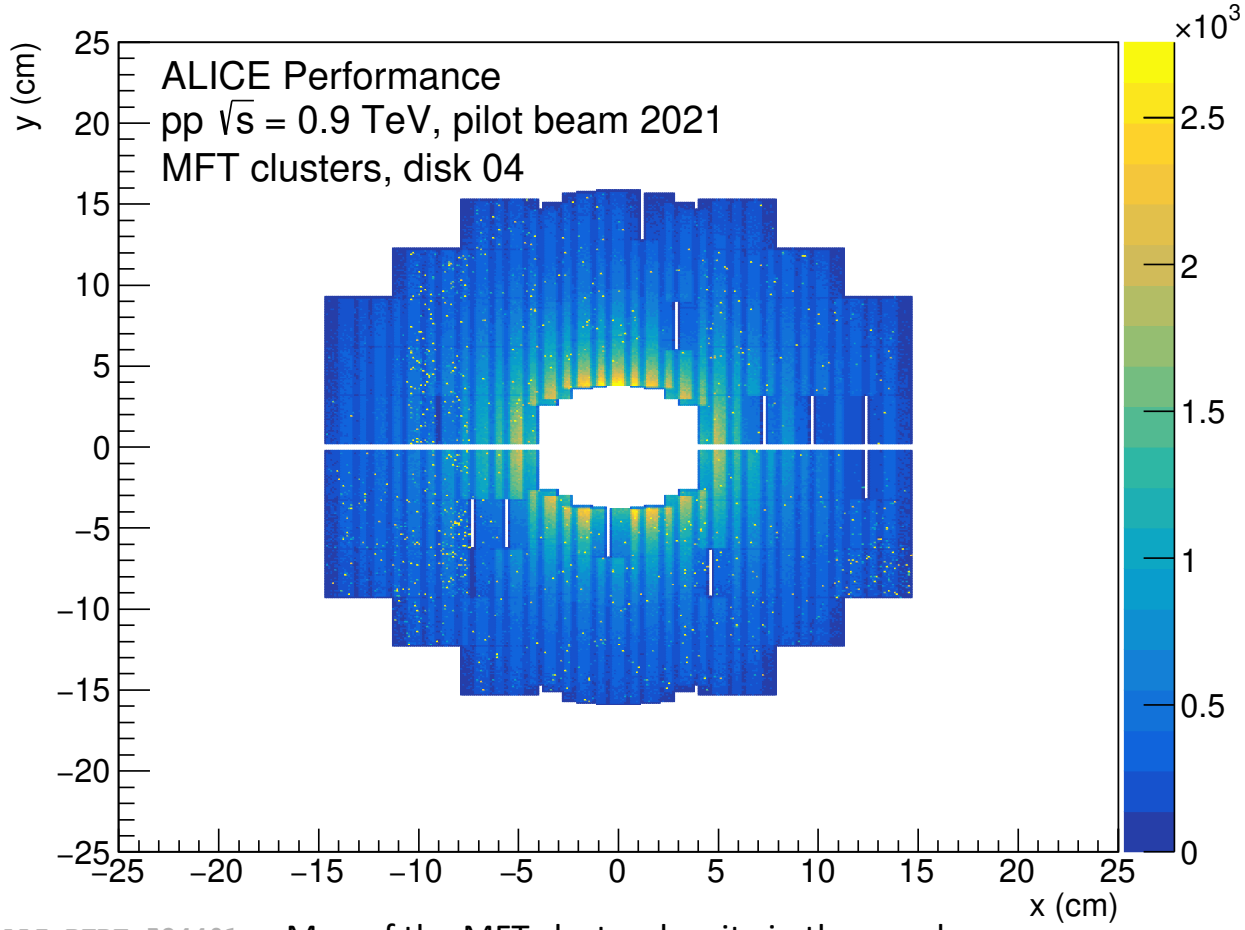
Particle velocity (β) as a function of momentum for reconstructed tracks in the TOF detector



Particle mass distribution for reconstructed tracks – calculated using the TOF detector particle velocity (β)

Pilot Beam – MFT

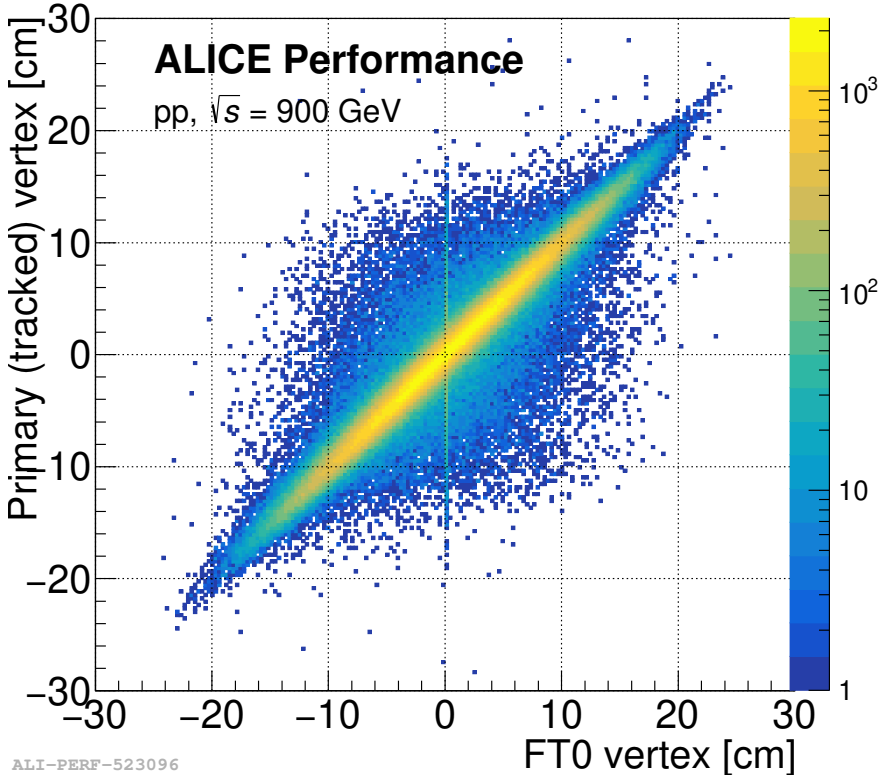
- Good performance of the new Muon Forward Tracker in the pilot beam



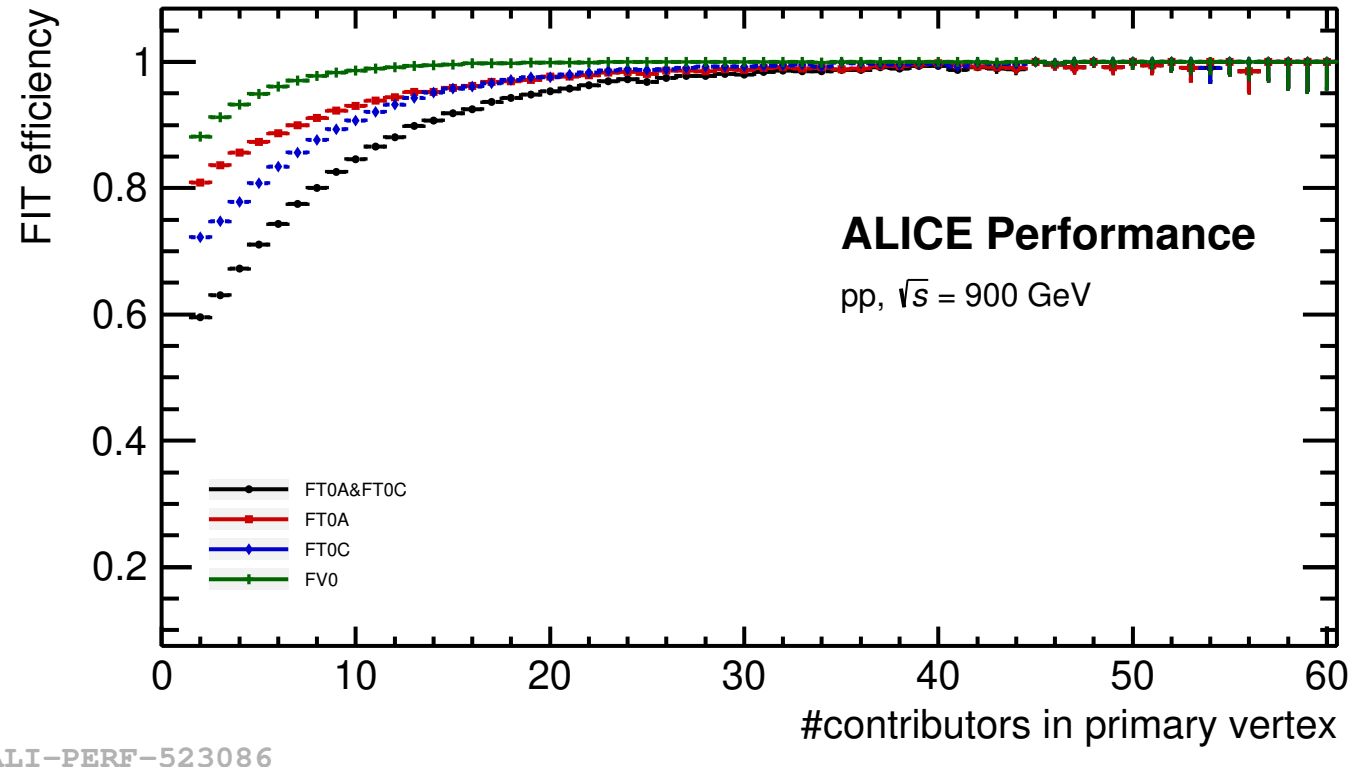
ALI-PERF-524401 Map of the MFT cluster density in the xy-plane

Pilot Beam – FIT

- FT0 is sensitive to z-position of primary vertex thanks to high timing resolution (13 ps)
- Good efficiency of FIT subdetectors



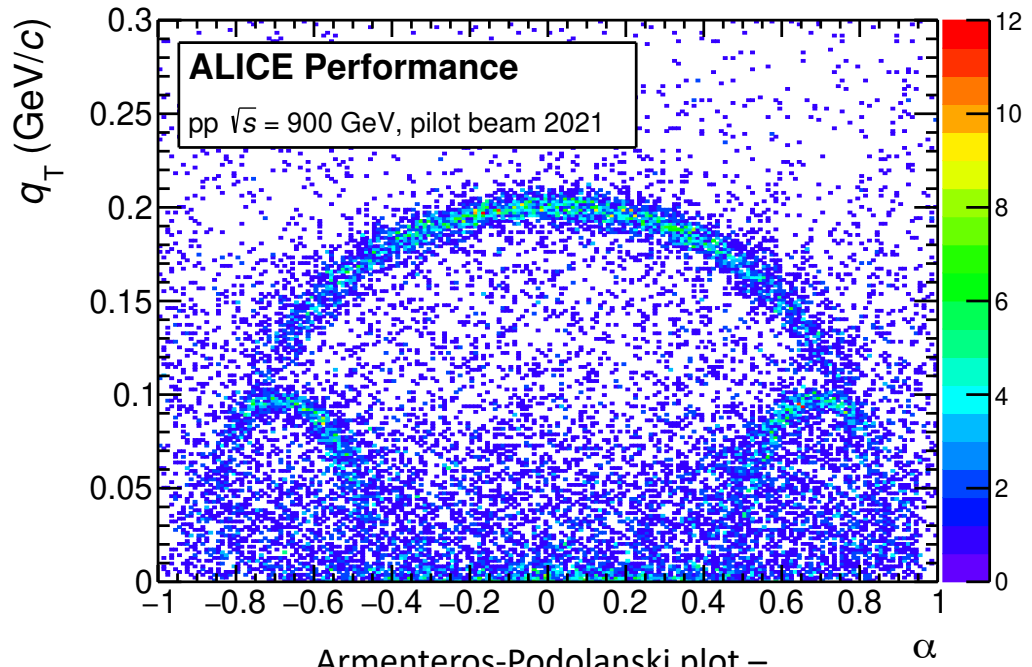
Position of the reconstructed primary vertex as a function of the FT0 vertex position



Efficiency of the FIT detector as a function of the number of primary vertex contributors

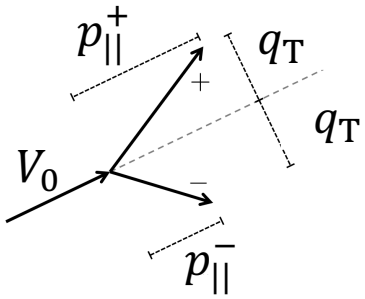
Pilot Beam – V^0: K^0_S and Λ

- Preliminary: fraction of full pilot beam data
- Invariant mass peaks clearly defined
- Armenteros plot shows K^0_S, Λ and $\bar{\Lambda}$ ellipses

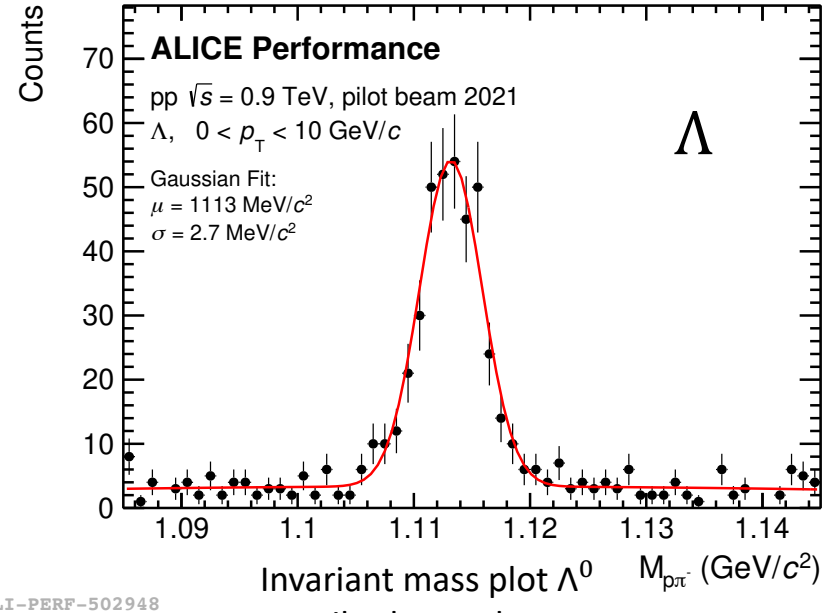


ALI-PERF-502959

Armenteros-Podolanski plot –
measure of momentum asymmetry of V^0 daughters



$$\alpha = \frac{p_{||}^+ - p_{||}^-}{p_{||}^+ + p_{||}^-}$$



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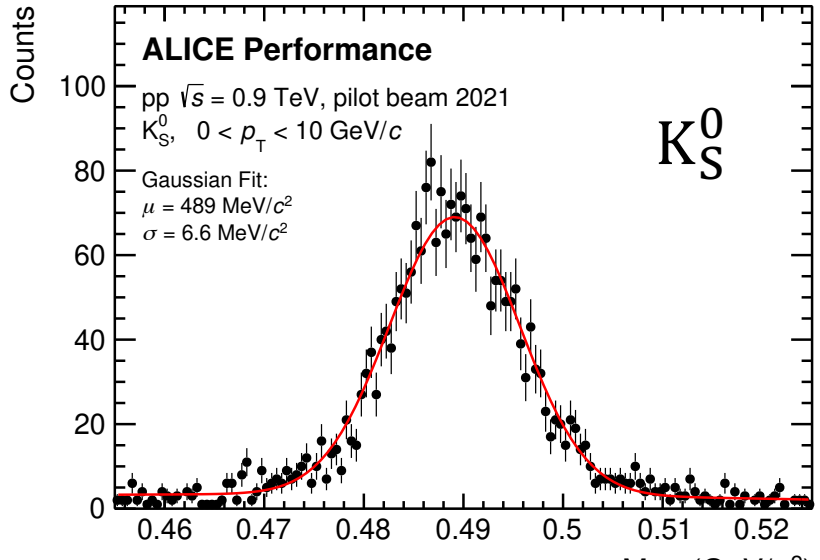
Invariant mass plot Λ^0
pilot beam data



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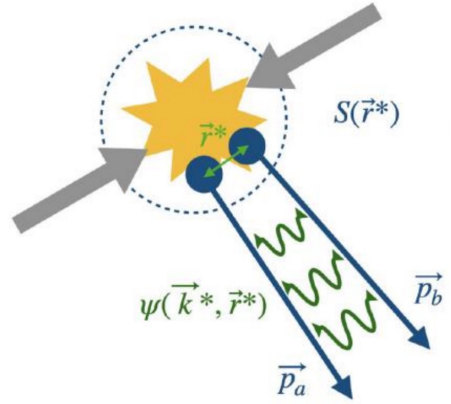
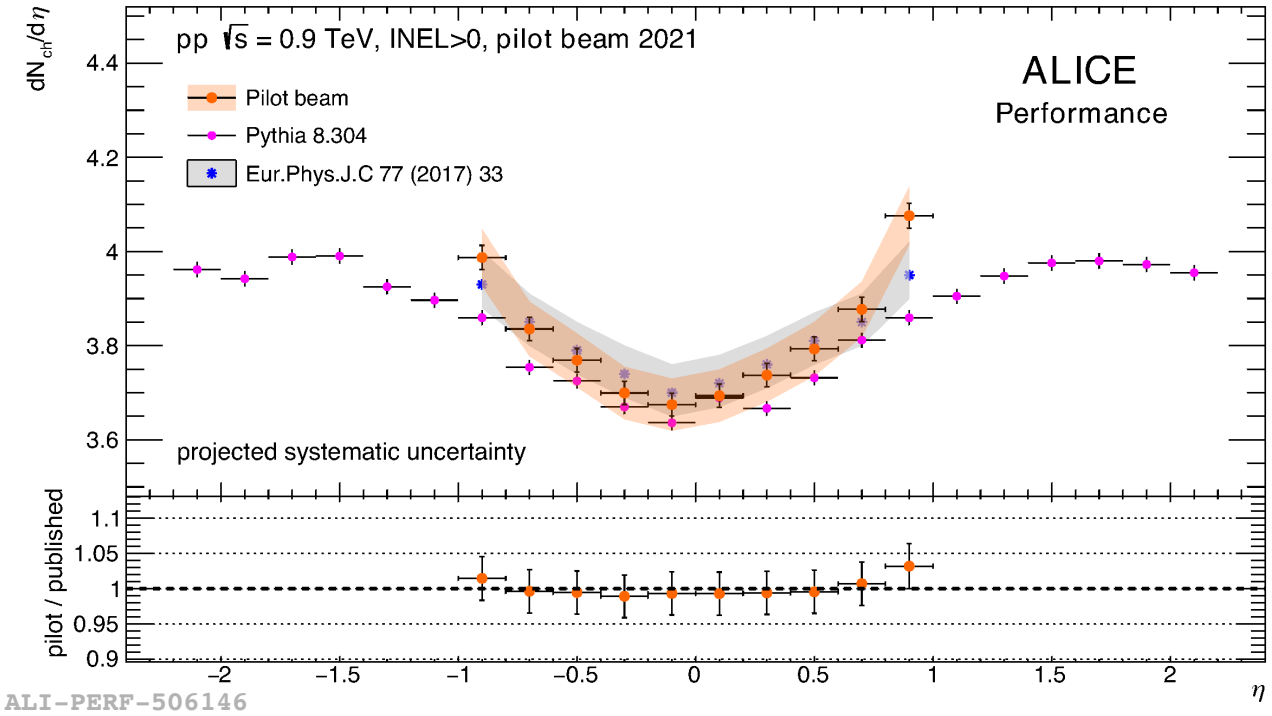
Invariant mass plot K^0_S
pilot beam data

Pilot Beam – more analyses



- Several benchmark analyses carried out with pilot beam data
- Good agreement with past 900 GeV data

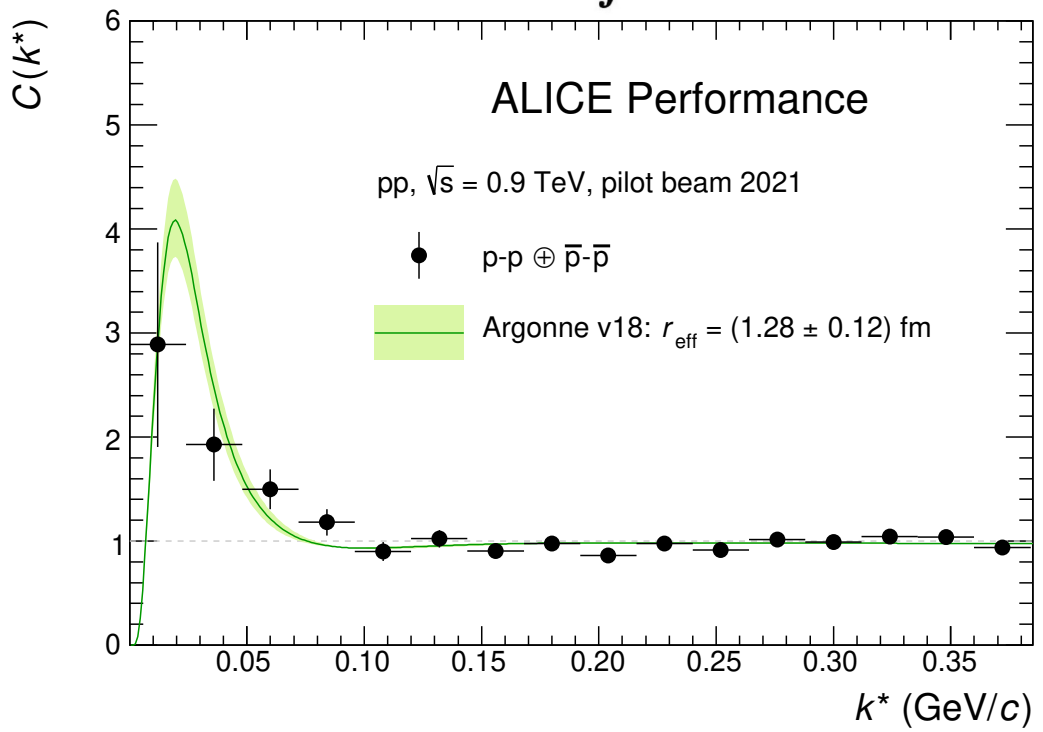
$$C(k^*) = \int S(\vec{r}^*)\,|\psi(\vec{k}^*, \vec{r}^*)|^2 \mathrm{d}^3 r^*$$



ALI-PERF-506146

Corrected pseudo-rapidity distribution for charged tracks measured in the pilot beam compared to published ALICE data and Pythia 8 simulation

For more: see [Abhi Modak's presentation]

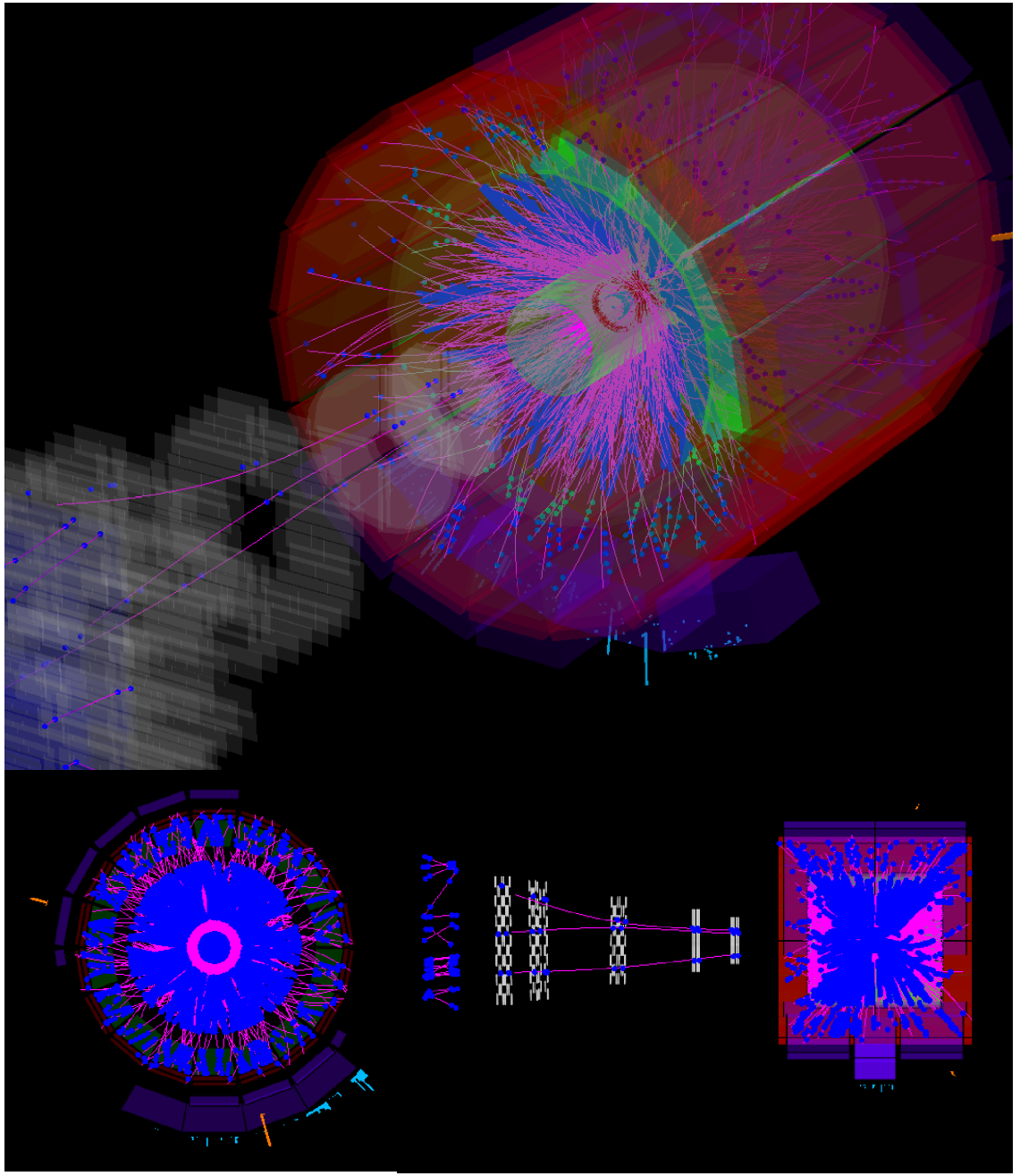


ALI-PERF-503088

(Anti)proton-(anti)proton correlation function (black), compared to theoretical prediction (green)

Summary

- Major upgrade of the ALICE detectors implemented during LS2
- First look at data from Pilot Beam run in October 2021:
  - Good π/K/p PID capabilities with the TPC and TOF
  - Promising first look at V^0s, albeit fewer events analysed
- Pilot beam shows everything working well
- On 5th of July: Run 3 started with pp run at 13.6 TeV! Looking forward to Pb-Pb in November



Event display of a time frame of the pilot beam, about 100 collisions – 3D view (top), radial view (bottom left) side view (bottom right)

Thank you for your attention