Performance of the Dielectron Analysis in Pb–Pb collisions in Run 3 with ALICE

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MOTIVATION

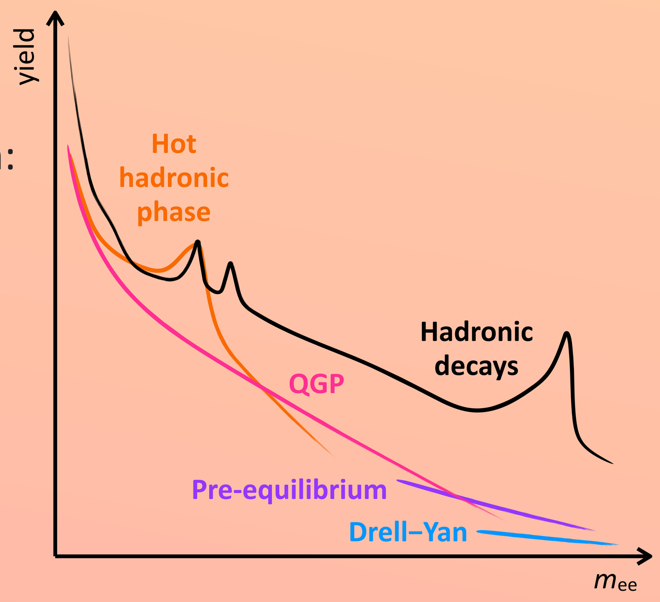
Dielectrons (e^+e^- pairs) are the ideal probe to study the properties of strongly interacting matter, produced in heavy-ion collisions

They do not interact strongly & are created in all stages of the collision

- Initial stage of the collisions:
  Drell–Yan and hard scatterings
  Pre-equilibrium contributions
- Thermal radiation from medium:
  Quark-Gluon plasma (QGP)
  Hot hadronic phase

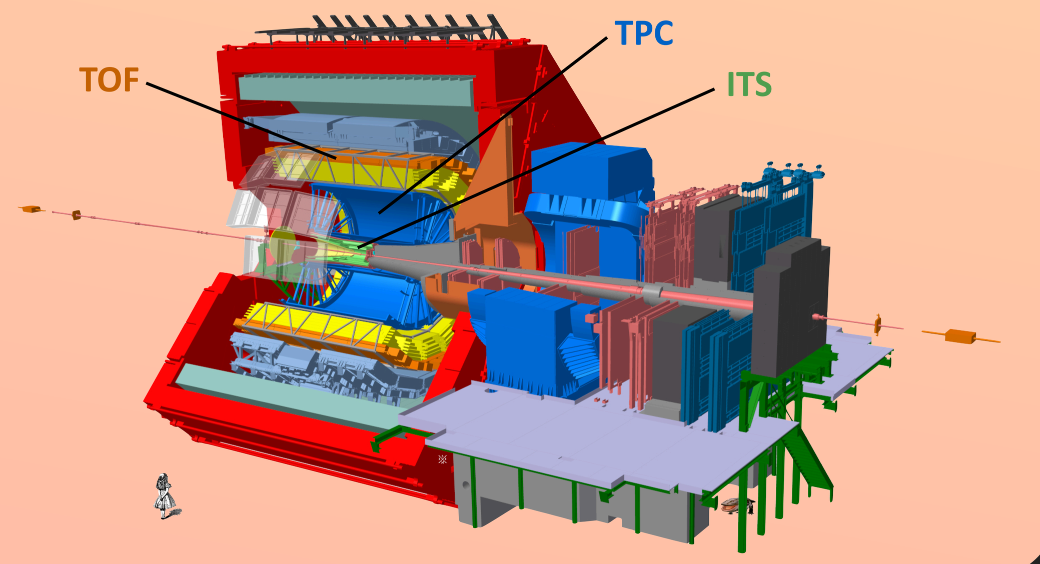
→ Separation via invariant mass (m_{ee})

- However, large combinatorial and physical backgrounds:
  Hadronic decays



ALICE UPGRADES

- New Inner Tracking System (ITS) [1]
  → Improved pointing resolution (factor ≥ 3)
- New Time Projection Chamber (TPC) [2]
  → Higher data acquisition rate via continuous readout (up to 50 kHz in Pb–Pb)



DATA SET

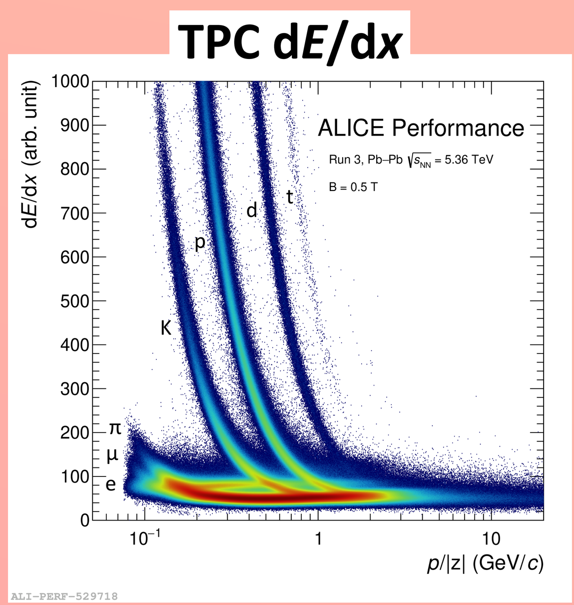
- Run 3 minimum bias Pb–Pb data from 2023
- Center-of-mass energy: $\sqrt{s_{NN}}$ = 5.36 TeV
- Interaction rates between 6 and 46 kHz

- Event selection:
  - Centrality 10–90%
  - No other collision in time range ± 10 µs
  → About 900·10⁶ events

- Kinematic track selection:
  - Transverse momentum: $p_{T,e}$ > 0.4 GeV/c
  - Pseudorapidity: $|\eta_e|$ < 0.8

ELECTRON SELECTION

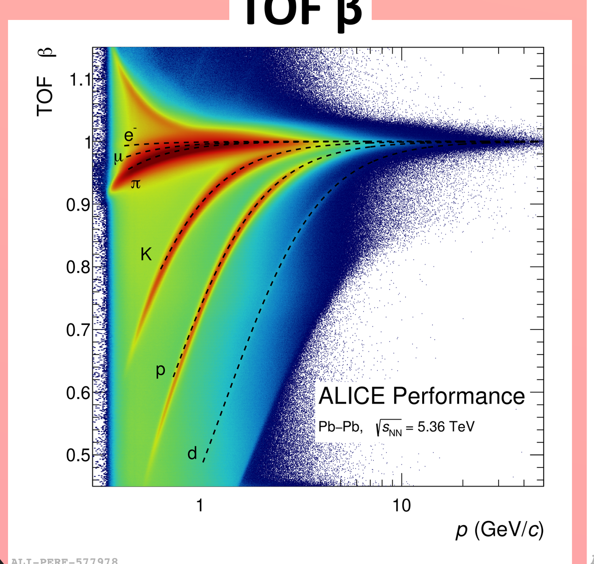
TPC dE/dx



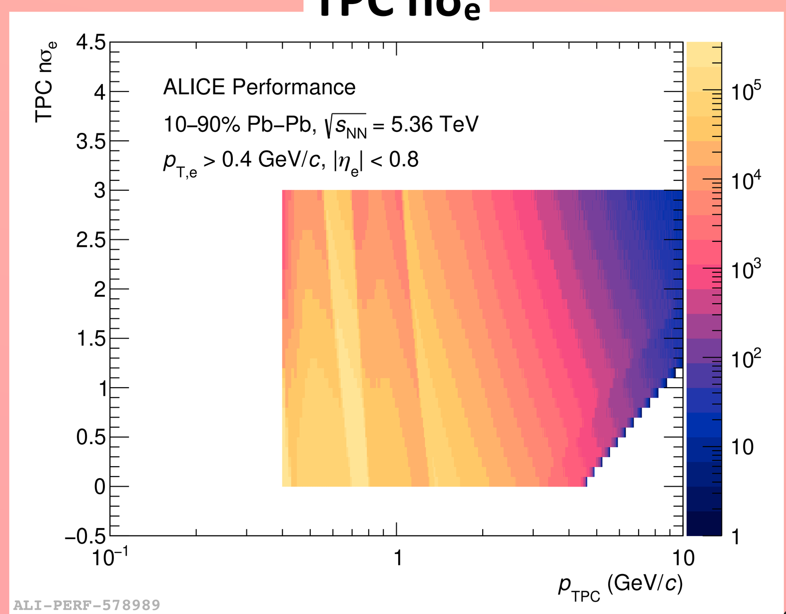
Particle identification:

- Identify electron and positron candidates with TPC dE/dx
- Reject other charged particles (hadrons) with TPC dE/dx
- Recover well separated electrons and positrons with Time of Flight (TOF)

TOF β



TPC $n\sigma_e$

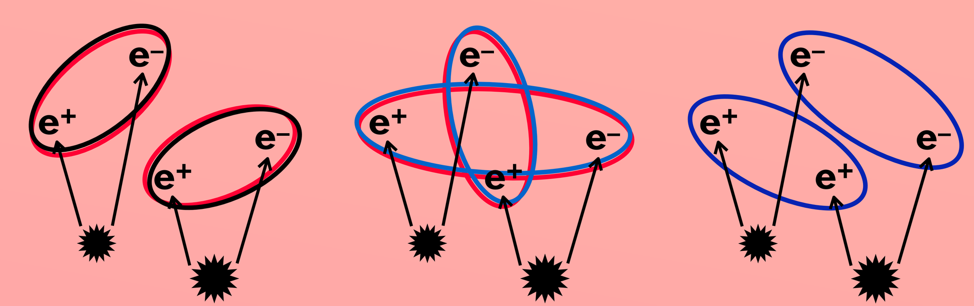


SIGNAL EXTRACTION

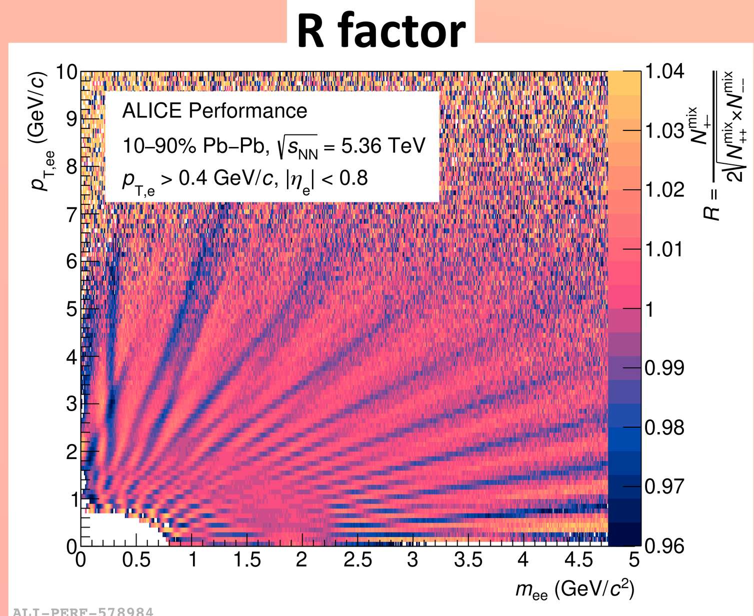
Pairing of electron and positron candidates to estimate the **combinatorial background (B)** and extract the **raw dielectron signal (S)**:

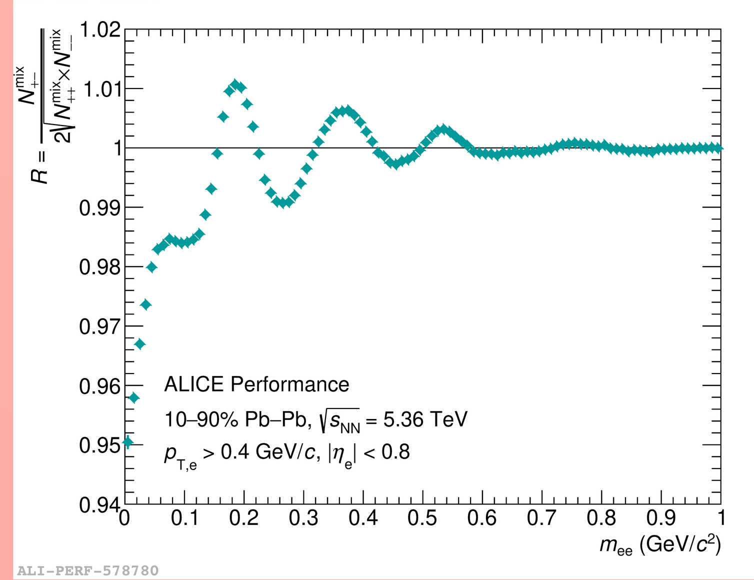
- **ULS**: unlike-sign pairs from same event N_{+-}^{same}
- **LS**: like-sign pairs from same event $N_{++,--}^{\text{same}} = 2 \cdot \sqrt{(N_{++}^{\text{same}} \cdot N_{--}^{\text{same}})}$
- **R factor**: $R = N_{+-}^{\text{mix}} / 2 \cdot \sqrt{(N_{++}^{\text{mix}} \cdot N_{--}^{\text{mix}})}$
  - Correction for different acceptance of ULS and LS pairs using mixed event
  - $R \approx 1$ due to high and uniform performance of the ALICE central barrel, remaining structures originate from TPC sectors and the different geometry of ULS and LS pairs

→ **ULS = S + B**
→ **B = LS · R**
→ **S = ULS − B**



R factor



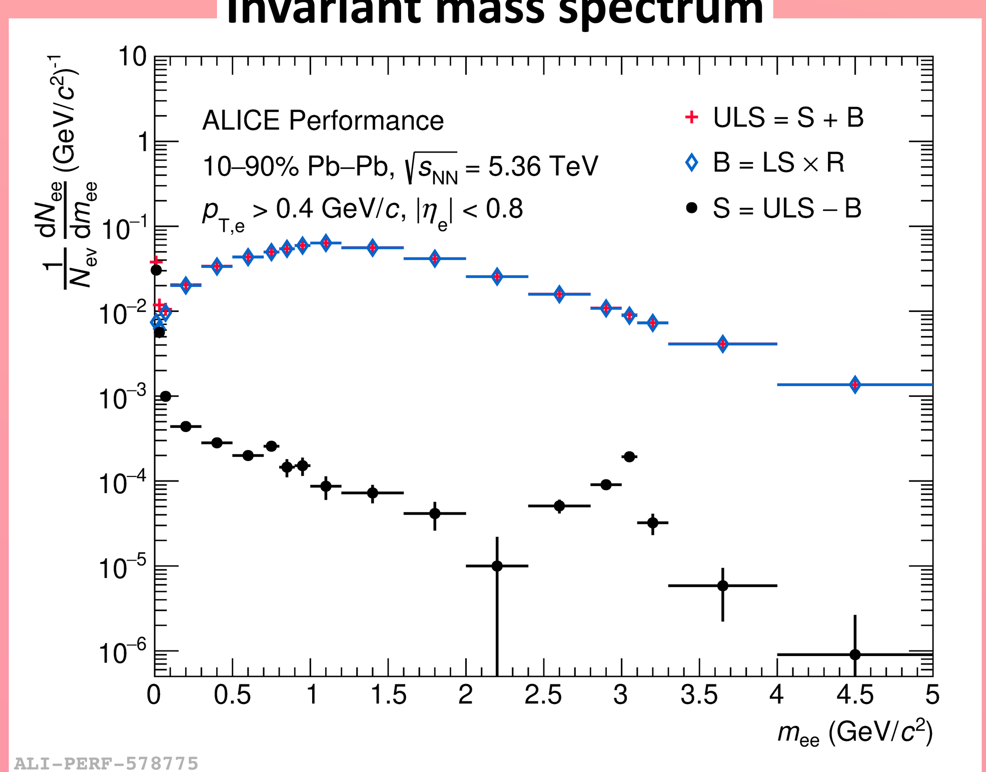


RAW DIELECTRON SPECTRA

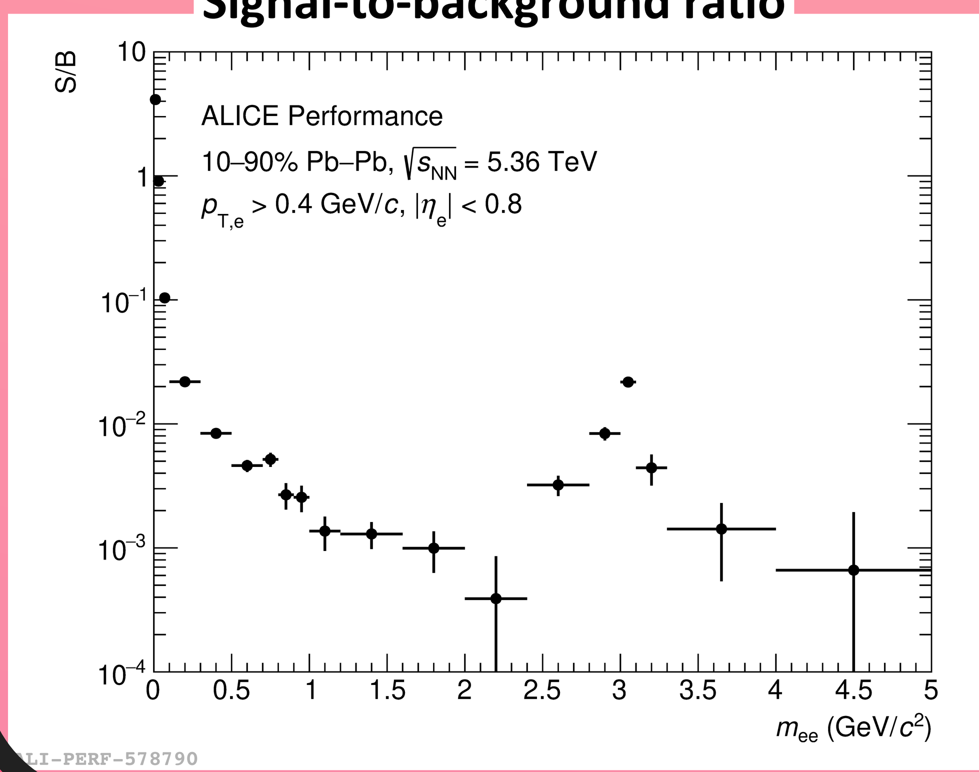
First look at the dielectron signal in Pb–Pb collisions in Run 3:

- Characteristic signatures (π^0 and J/Ψ peaks) clearly visible
- Signal over background in the intermediate mass range ($1.2 < m_{ee} < 2.6$ GeV/c^2) where thermal radiation from QGP is expected: S/B ≈ 10^{-3}
  → Compatible with S/B seen in Run 2 in central Pb–Pb collisions [4]

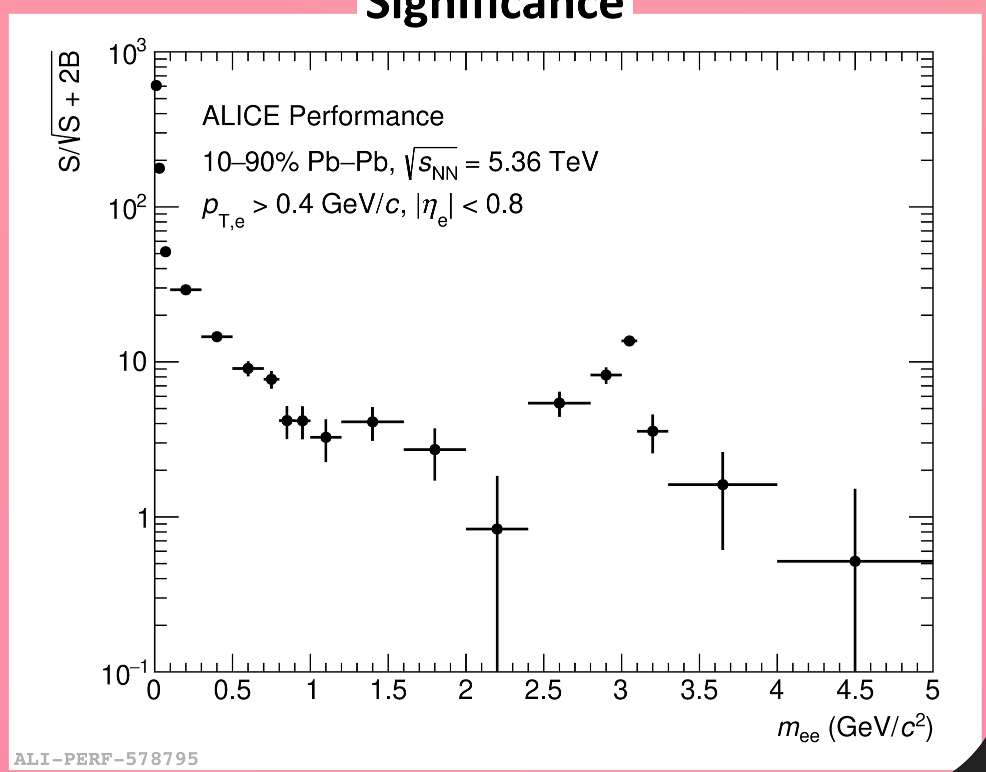
Invariant mass spectrum



Signal-to-background ratio



Significance



OUTLOOK

- Extend analysis to include most central events
- Topological separation of prompt and non-prompt dielectron sources based on distance-of-closest approach (DCA) as performed in Run 2 [3][4]
  - Search for thermal radiation in Run 2 analysis in the intermediate mass range limited by statistics and large physical background [4]
  - Improved pointing resolution of the ITS in Run 3 allows for a better separation of prompt thermal radiation and e^+e^- pairs from heavy-flavor hadron decays
  → Improve S/B with topological selection
- More data to be recorded in Run 3 & 4:
  → 13 nb⁻¹ in Pb–Pb at $\sqrt{s_{NN}}$ = 5.36 TeV [5]
  → Significant increase in the precision of the thermal radiation measurement

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References:
[1] "Upgrade of the Inner Tracking System Conceptual Design Report", CERN-LHCC-2012-013
[2] "Upgrade of the ALICE Time Projection Chamber", CERN-LHCC-2013-020, CERN-LHCC-2015-002
[3] "Dielectron production in proton-proton collisions at √s = 7 TeV", ALICE Collaboration, JHEP 1809 (2018) 064
[4] "Dielectron production in central Pb–Pb collisions at √sNN = 5.02 TeV", ALICE Collaboration, arXiv:2308.16704
[5] "ALICE upgrades during the LHC Long Shutdown 2", ALICE Collaboration, Journal of Instrumentation 19, P05062 (2024)

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