Measurements of electroweak-boson production via electrons in pp collisions at $\sqrt{s}$ =13.6 TeV with ALICE

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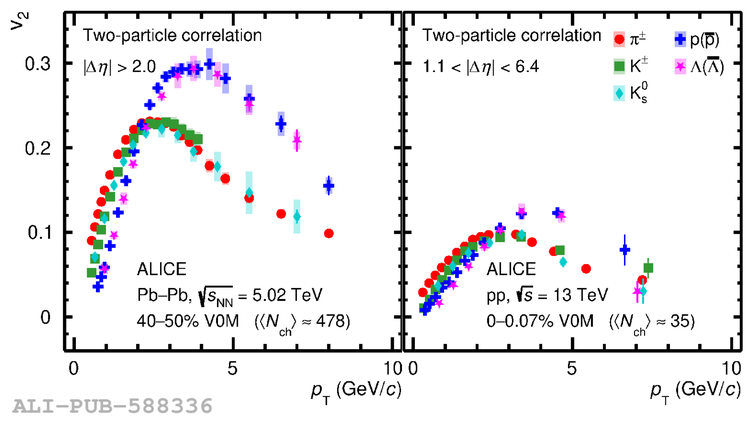
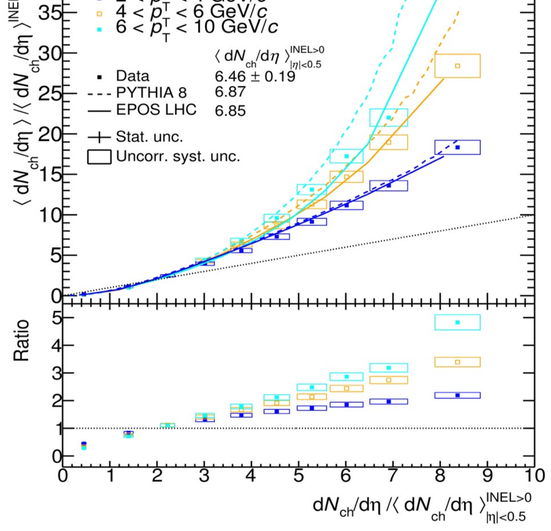
- Motivation

■ **Weak-bosons (W, Z) as clean probes of quark-gluon plasma (QGP)**:
- No strong interaction with QGP medium
- Unaffected by final-state effects and color reconnection
- Carry initial state information to final state
- Large mass (~91 GeV/c^2) ensures hard scattering origin

☐ Collective-like behavior observed in small collision systems (pp, p–Pb)
- Non-zero elliptic flow (v_2) in high-multiplicity events (left figure)

☐ High-p_T particle enhancement in high-multiplicity events (right figure)





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■ **Physics goal:**
Study multiplicity dependence of Z - hadron azimuthal correlations to understand particle production mechanisms in small systems

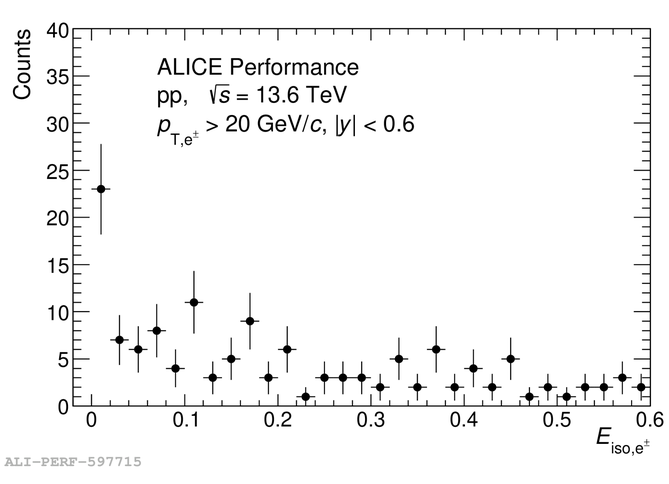
- Observable: Δφ = φ (hadron) – φ (Z)
- Focus: Away-side recoil-jet structure vs. event multiplicity
  - Away-side peak (Δφ ≈ π): back-to-back hard scattering signature
  - Peak modification/suppression in high-multiplicity events may indicate novel phenomena
- Physics interpretation:
  - Persistent correlation: conventional hard scattering
  - Modified patterns: potential collective-like effects in small systems

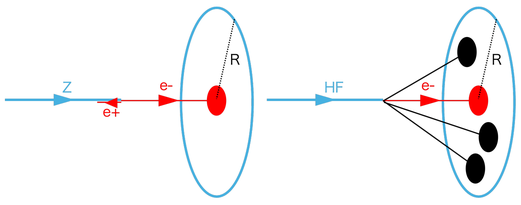
- Electron identification technique

☐ Detectors used for this analysis:
- TPC: tracking, d*E*/d*x* PID
- EMCal (pseudorapidity coverage |*η*| < 0.7): electron identification, energy measurement

☐ Electron identification criteria:
- Track-cluster matching: $R(\Delta\varphi, \Delta\eta) < 0.05$
- Energy-momentum ratio: $E/p \approx 1$
- TPC d*E*/d*x*: $-1.5 < n\sigma_e < 3.0$

☐ Isolation requirements:
- $E_{\mathrm{iso}} < 0.1$ to select electrons from weak bosons
- Cone radius $R < 0.3$ around electron candidate
- Maximum 6 tracks allowed in isolation cone

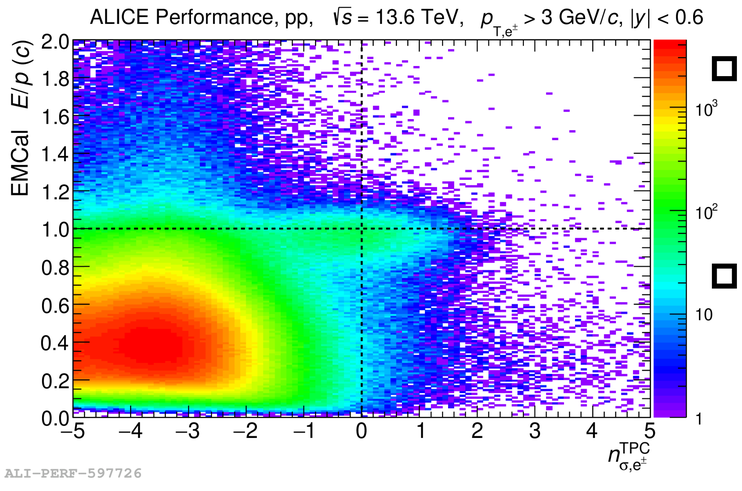




$$E_{\mathrm{iso}} = \frac{\sum_{R_i<0.3} E_{i,\mathrm{clus}} - E_e}{E_e}$$

$$R_i = \sqrt{(\Delta\phi)^2 + (\Delta\eta)^2}$$

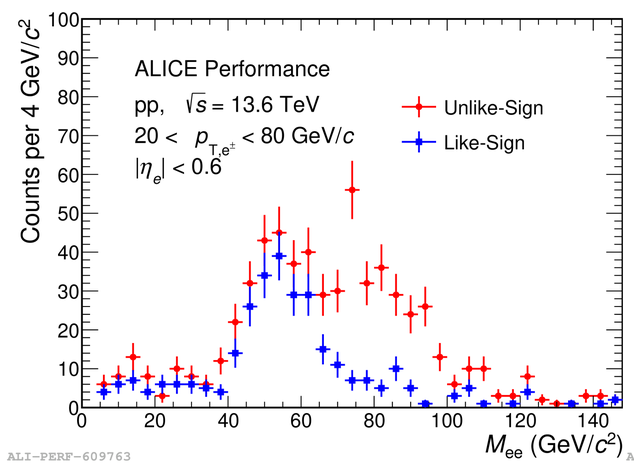
E_e: electron energy
$E_{i,\mathrm{clus}}$: cluster energy

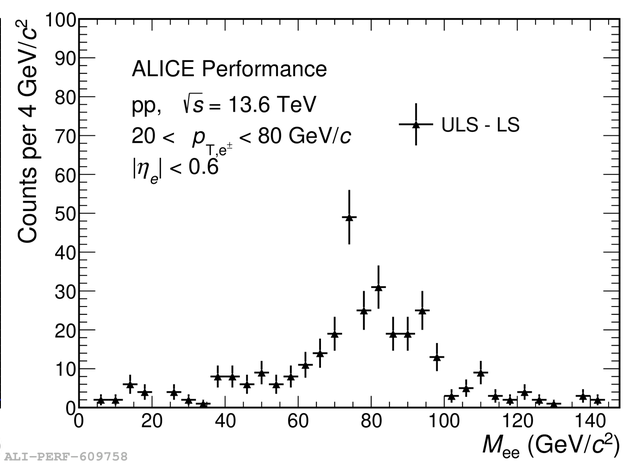


☐ Status of analysis in Run 3
- Minimum bias pp collisions at $\sqrt{s}$ = 13.6 TeV collected in 2022

☐ Successful identification through
- *E*/*p* =1 & *nσ* =0 signature for electrons

- Results: invariant mass distribution of Z bosons





☐ Z-boson reconstruction via e^+e^- pair invariant mass

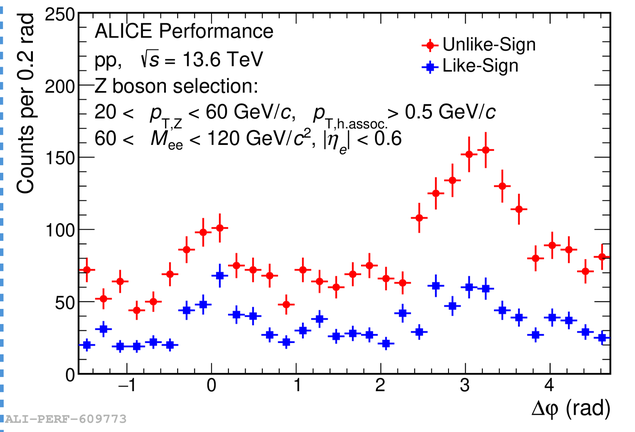
☐ Dataset: skimmed dataset collected in 2023 and 2024
- Applied offline trigger selection (cluster energy > 10 GeV/*c*)

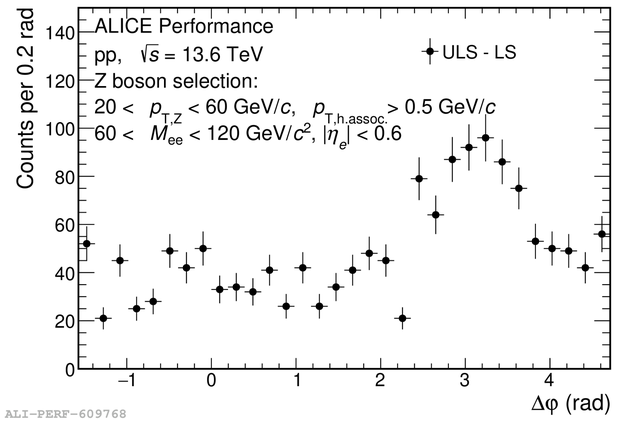
☐ Analysis strategy:
- Two electrons with strict identification criteria and pt > 20 GeV/*c*
- Mass window for Z boson selection: $60 < M_{ee} < 120$ GeV/c^2

☐ Background estimation:
- Like-sign pair method for combinatorial background
- Background subtracted

☐ Signal extraction results:
- Clear Z-boson peak observed above background
- Signal-to-background ratio suitable for further analysis

- Results: Z - hadron azimuthal correlation





☐ Correlation analysis criteria:
- Z-boson candidates as trigger particles
- Z-boson transverse momentum: $20 < p_T < 60$ GeV/*c*
- Associated hadrons: $p_T > 0.5$ GeV/*c*, |*η*| < 0.9
- Invariant mass selection: $60 < M_{ee} < 120$ GeV/c^2
- Azimuthal correlation: Δφ = φ(hadron) – φ(Z)

☐ Correlation structure:
- Near-side (Δφ ≈ 0): no peak, Z bosons mostly isolated
- Away-side (Δφ ≈ π): recoil jet structure observed
- Back-to-back correlation indicates jet production processes

☐ Background subtraction:
- Like-sign pair method for combinatorial background
- Background subtracted

- Summary and outlook

☐ Results:
- First Z-boson reconstruction in ALICE in Run 3
- First observation of Z - hadron azimuthal correlations
  - found away-side peak (recoil jet signal)

☐ Next steps:
- ➢ Analyze the full sample of pp collisions from LHC Run 3
  - Study multiplicity dependence of Z - hadron correlations
  - Framework ready for energy loss/enhancement studies
- ➢ Search for signs of jet modification/suppression which may indicate collective-like effects in pp collisions
- ➢ Extend to Pb–Pb collisions to study medium response using pp as "vacuum" reference