

# Studying magnetic fields with net-proton fluctuations with ALICE



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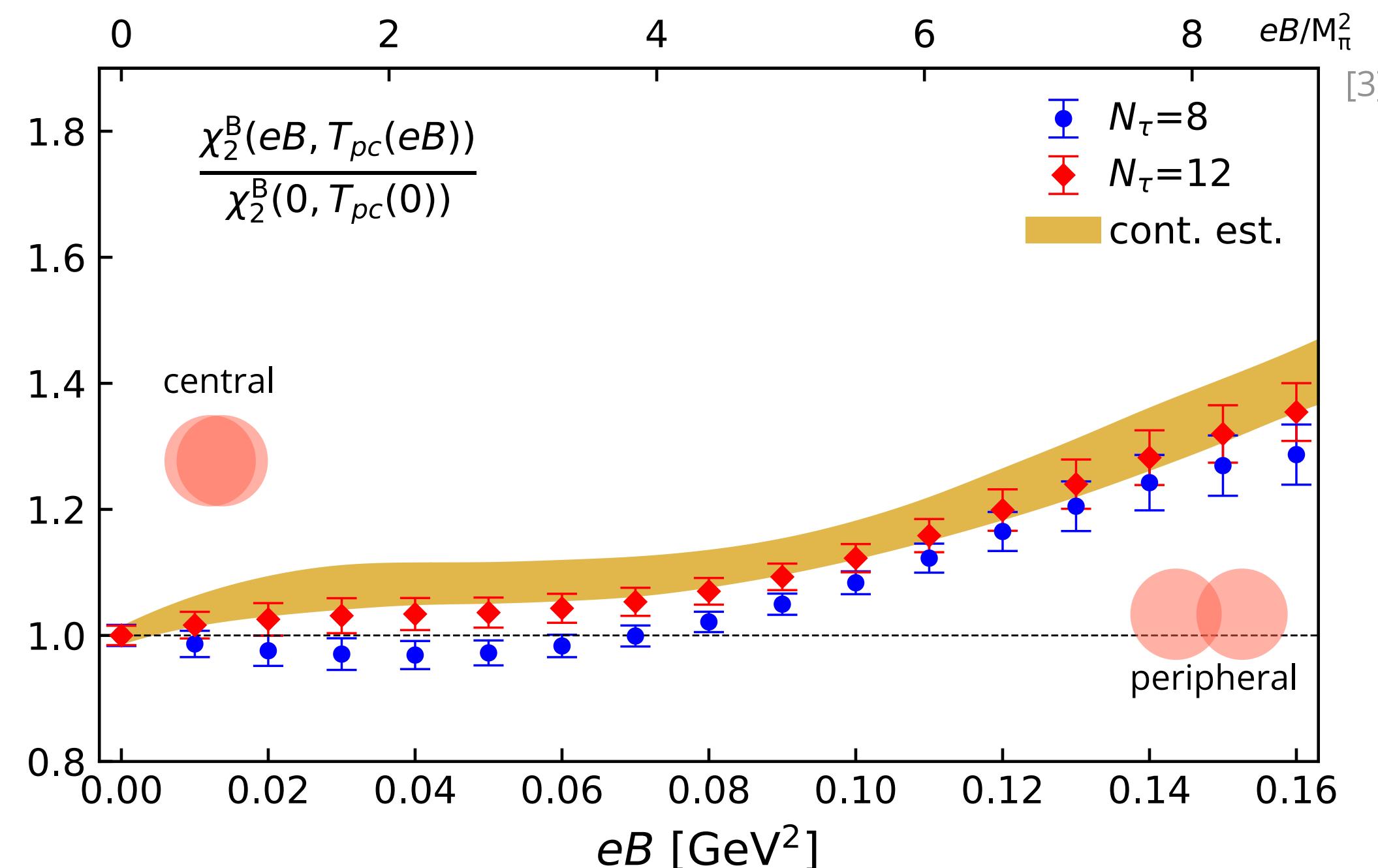
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## Fluctuations and lattice QCD

- Fluctuations are a powerful tool to study the QCD phase diagram
- Cumulants  $\kappa_n$  are related to thermodynamic susceptibilities, which can be calculated from first principles in lattice QCD (LQCD) [1]

$$\frac{\partial^n (P(\mu_B)/T^4)}{\partial (\mu_B/T)^n} \Big|_{\mu_B=0} = \chi_n^B = \frac{\kappa_n(\Delta N_B)}{VT^3}$$

- Proton number is used as a proxy for baryon number [2]
- LQCD: larger susceptibilities in the presence of large magnetic fields [3]



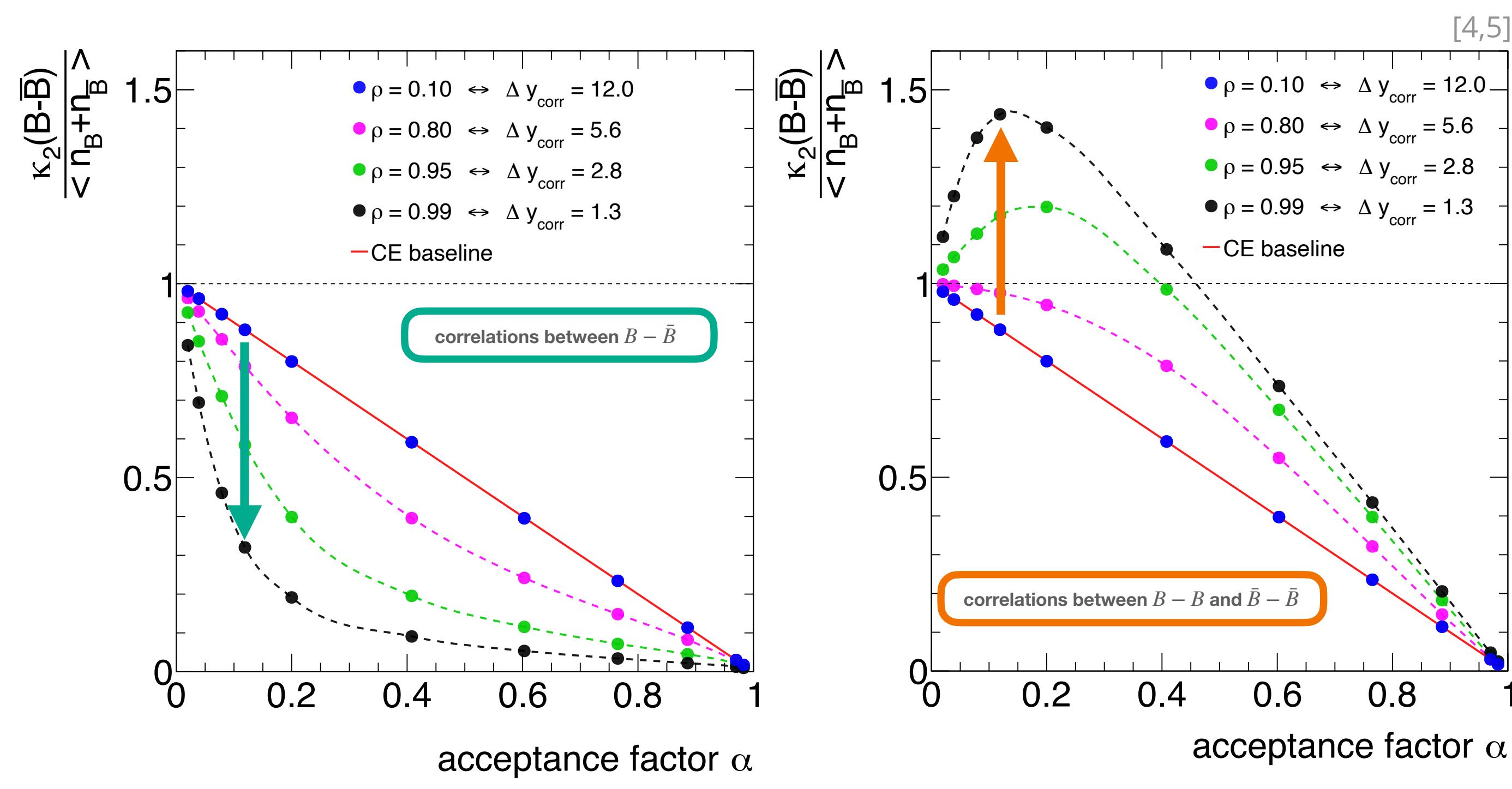
Can we measure the magnetic field produced in peripheral collisions?

## Baseline

- Considering a Hadron Resonance Gas Model within a Grand Canonical Ensemble, the second order cumulant of the distribution of the net-proton number is given by

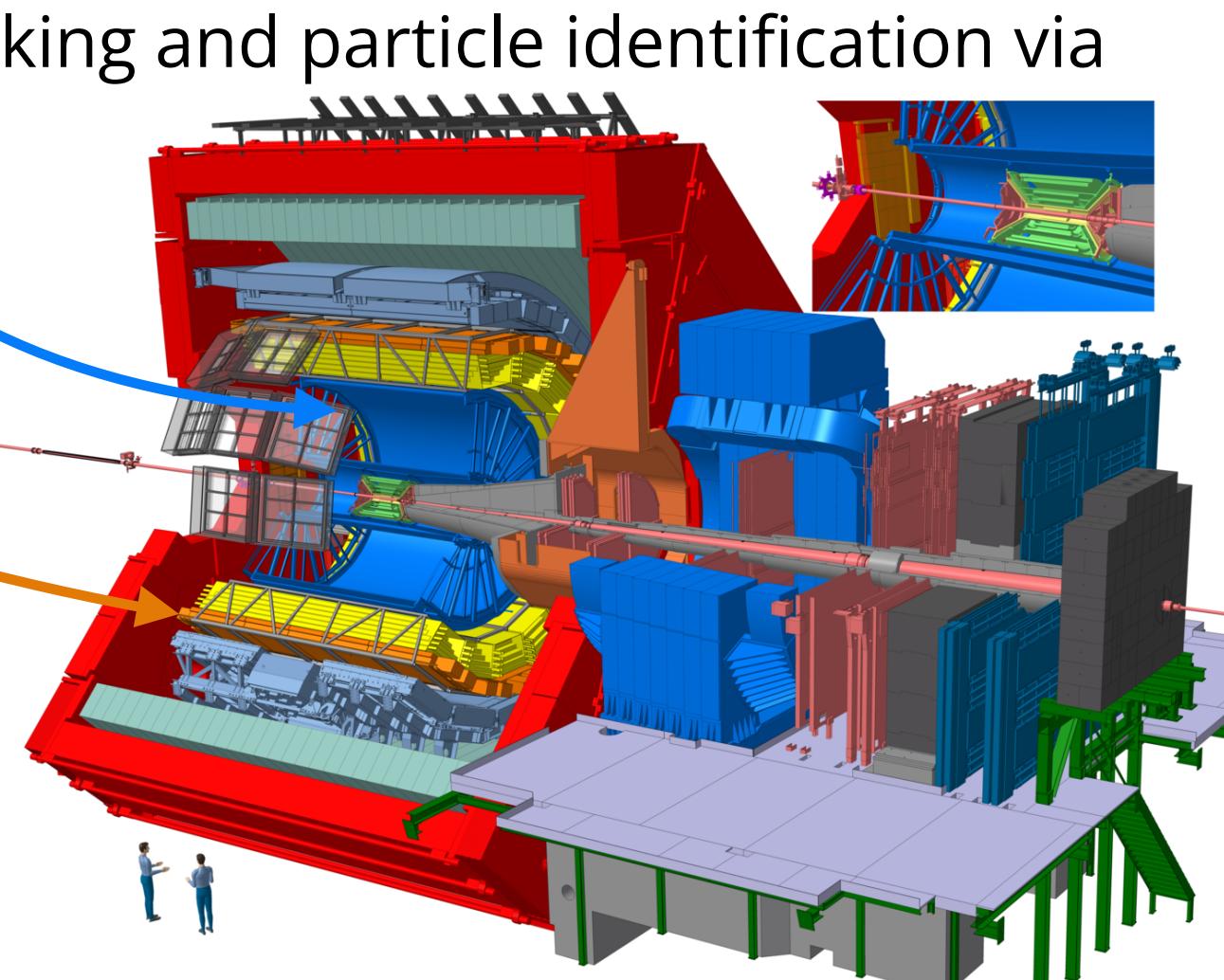
$$\kappa_2(p - \bar{p}) = \langle p + \bar{p} \rangle$$

- Deviations from this baseline may arise from
  - local baryon number conservation: **unlike-sign correlations**
  - (anti-)proton clusters: **like-sign correlations** [4,5]
- Measured values depend on the fraction of (anti-)protons in the acceptance



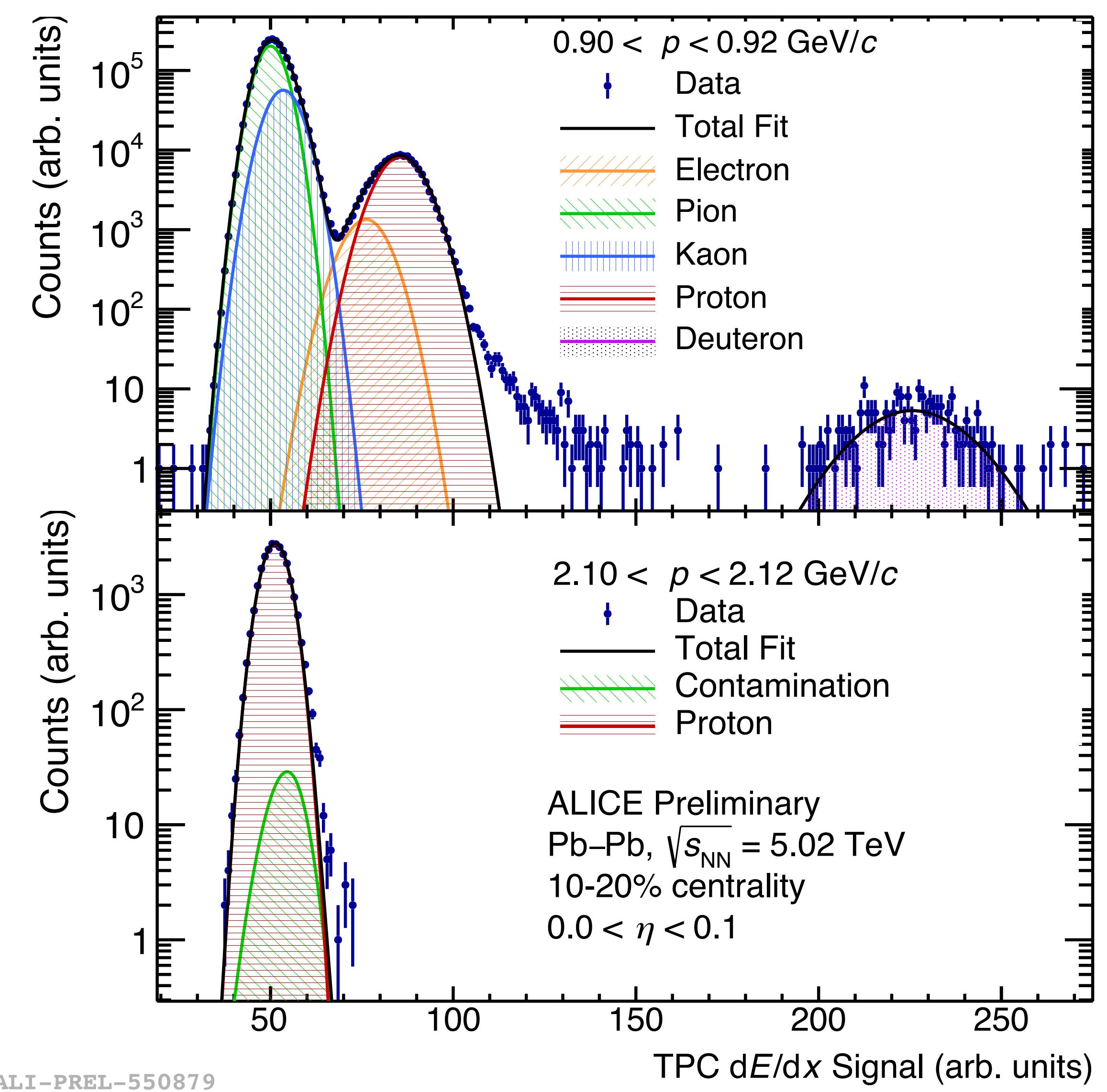
## Detector and dataset

- **Time Projection Chamber (TPC)**: tracking and particle identification via specific energy loss  $dE/dx$
- **Time-Of-Flight (TOF)**: proton selection for  $p \geq 1.5 \text{ GeV}/c$
- **V0 scintillators**: centrality determination from 0% (central) to 90% (peripheral)
- **110M Pb-Pb collisions** at  $\sqrt{s_{NN}} = 5.02 \text{ TeV}$  recorded in 2018



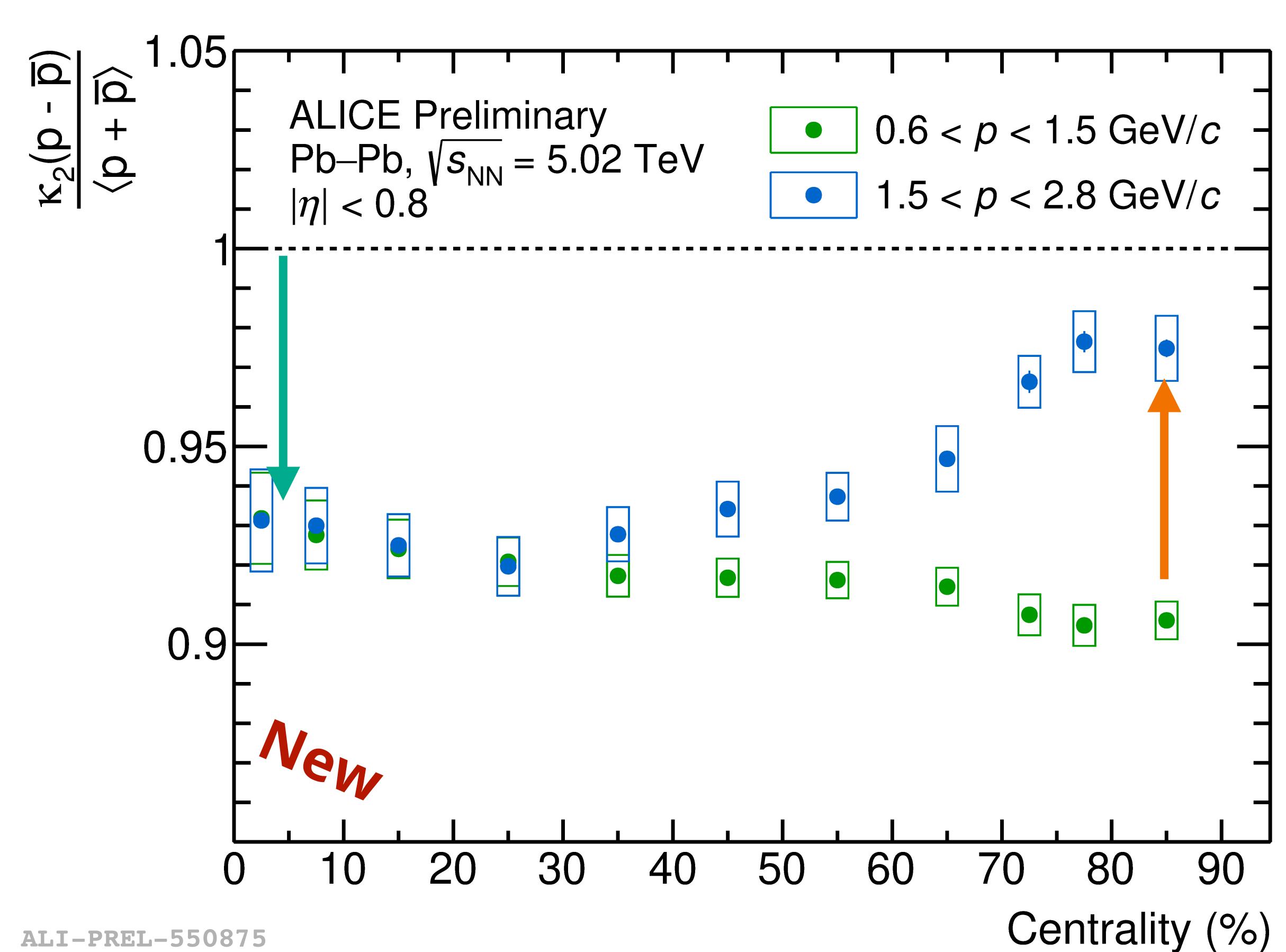
## Identity method

- Probabilistic way of calculating moments of multiplicity distributions [6]
  - Avoids the problem of misidentification
- Probability distribution functions obtained from fits of the  $dE/dx$  distributions
- PID contamination at large momenta estimated using templates from MC



## Second order cumulants

- First measurement of net-proton cumulants above  $p = 2 \text{ GeV}/c$
- Similar proton number in both acceptances in central collisions
  - same baseline
- **Low momenta**: weak centrality dependence (due to radial flow?)
- **High momenta**: significant increase towards peripheral collisions!



## Conclusions

- Striking centrality dependence for high momenta in line with LQCD expectation
- Rise is attributed to increased  $p-p$  and  $\bar{p}-\bar{p}$  correlations
- These correlations could arise from a strong magnetic field

Net-proton fluctuations as a magnetometer for heavy-ion collisions?