Measurement of azimuthal angular correlations of heavy-flavour hadron decay electrons with charged particles in p–Pb and Pb–Pb collisions at $\sqrt{s_{NN}}$= 5.02 TeV with ALICE at the LHC

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On behalf of the ALICE collaboration

Outline

- Introduction
  - ✓ Physics motivation
  - ✓ ALICE detector
- Analysis Method
  - ✓ Electron identification
  - ✓ Heavy flavour electron (HFe)–charged particle angular correlations
- Results
- Summary and outlook

Physics Motivation

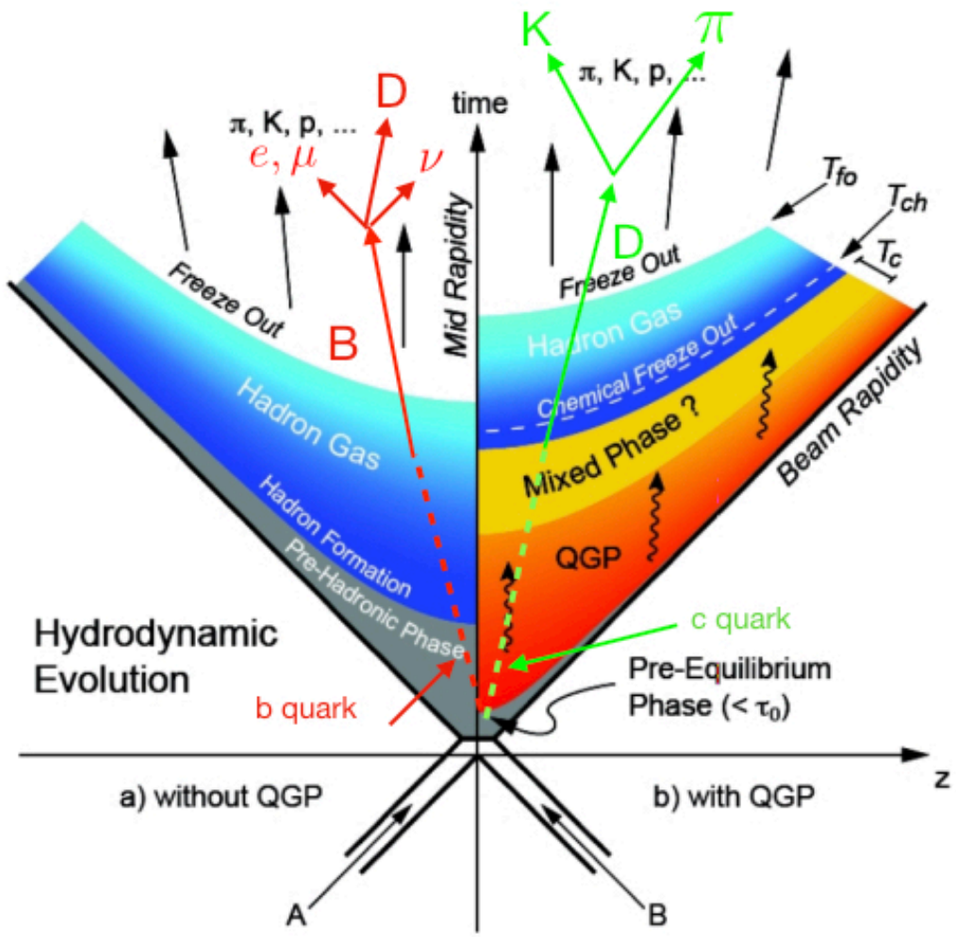
- Heavy quarks (charm and beauty), having a large mass, are produced in hard-parton scatterings in the early stages of the collision.

- They experience the whole evolution of the Quark-Gluon Plasma, representing an important tool for its characterization.

- Heavy quarks can interact with the medium via inelastic and elastic collisions with the constituents and medium-induced gluon radiation.

- Expected hierarchy on parton energy loss:

$$\Delta E_g > \Delta E_{u,d,s} > \Delta E_c > \Delta E_b$$



Dokshitzer and Kharzeev, PLB 519 (2001) 199

Physics Motivation

The study of angular correlations between electrons from heavy flavour hadron decays with charged particles in different collision systems allows investigating:

p–Pb Collisions:

- The cold nuclear matter effects on the charm jets
- Long-range ridge-like structures in near- ($\Delta\varphi \approx 0$) and away-side ($\Delta\varphi \approx \pi$) regions ("double ridges") as observed in h–h correlations.

Pb–Pb Collisions:

- Path-length dependence of heavy-quark energy loss
- Contributions from collisional and radiative energy loss mechanisms
- Medium-induced modification of heavy quark fragmentation and hadronization

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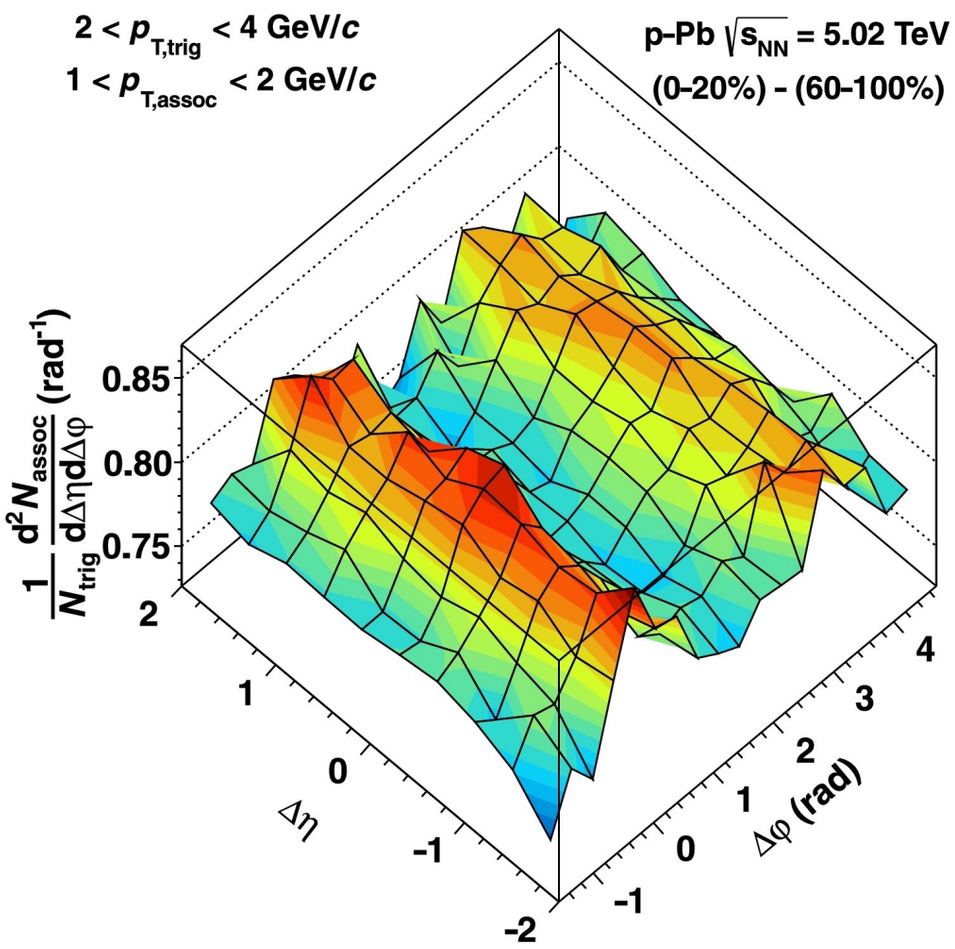
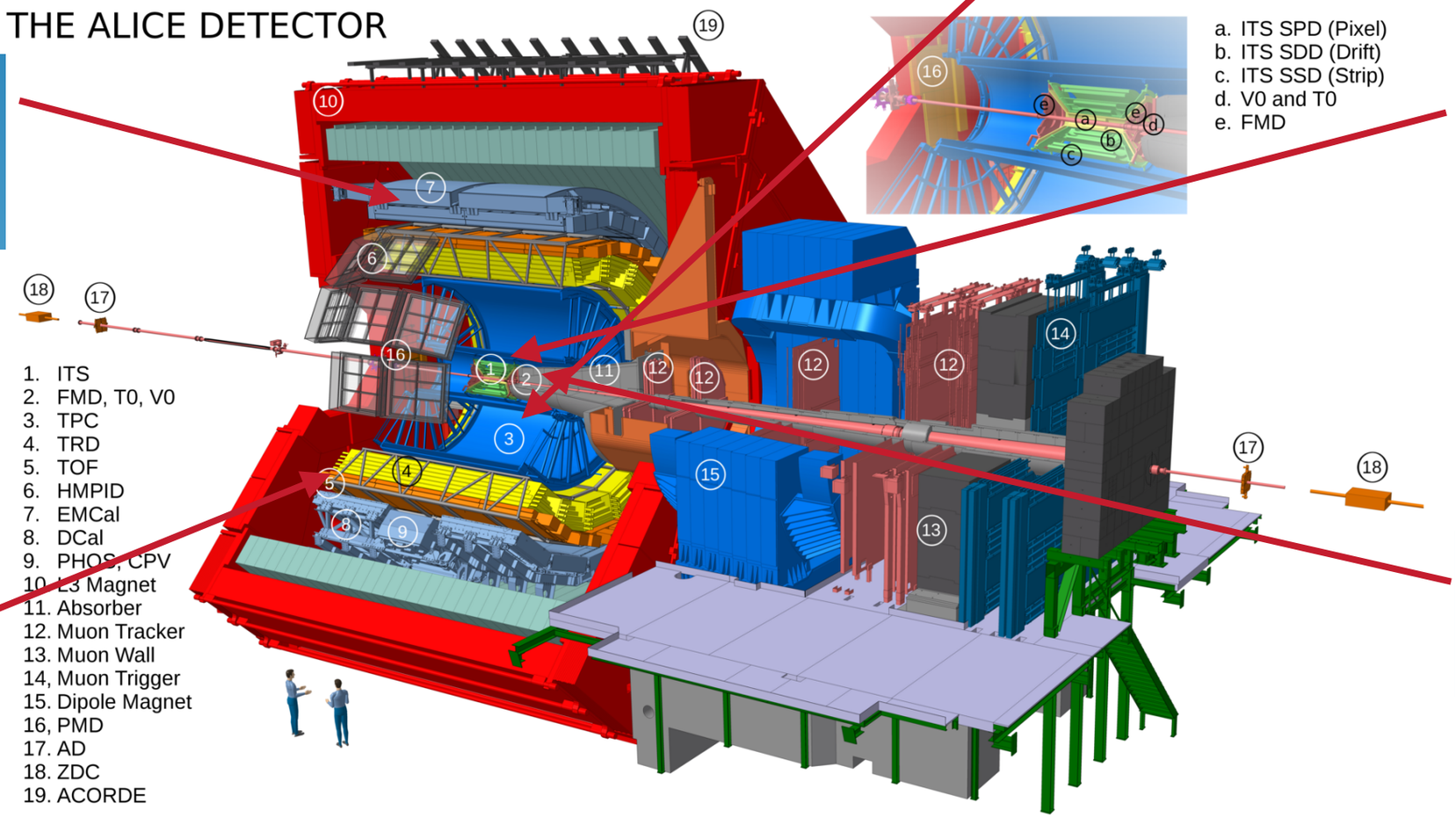


ALICE Detector

The main detectors used for the analysis, located in the central barrel with acceptance ("$|\eta| < 0.9$"), are:

TPC : (Time Projection Chamber), for PID

EMCal : (Electro Magnetic Calorimeter), for e PID and triggering



ITS : (Inner Tracking System), for tracking and vertexing

V0 detector, for triggering and multiplicity

TOF : (Time Of Flight), for particle identification

Data set : p-Pb (2016)

$L_{int} = 295\ \mu b^{-1}$

No. of events = 600 M

Data set : Pb-Pb (2016)

$L_{int} = 225\ \mu b^{-1}$

No. of events = 9.6 M (0-20%), 15 M (20-50%)

Analysis Method

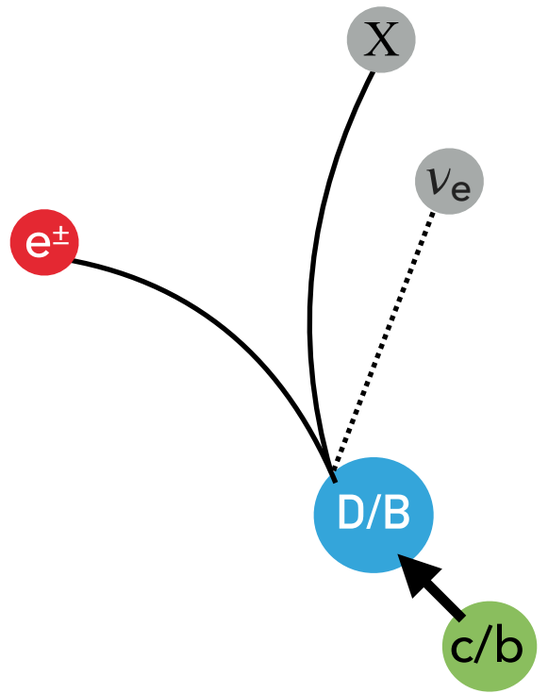
- The semi-leptonic decays of heavy-flavour hadrons :

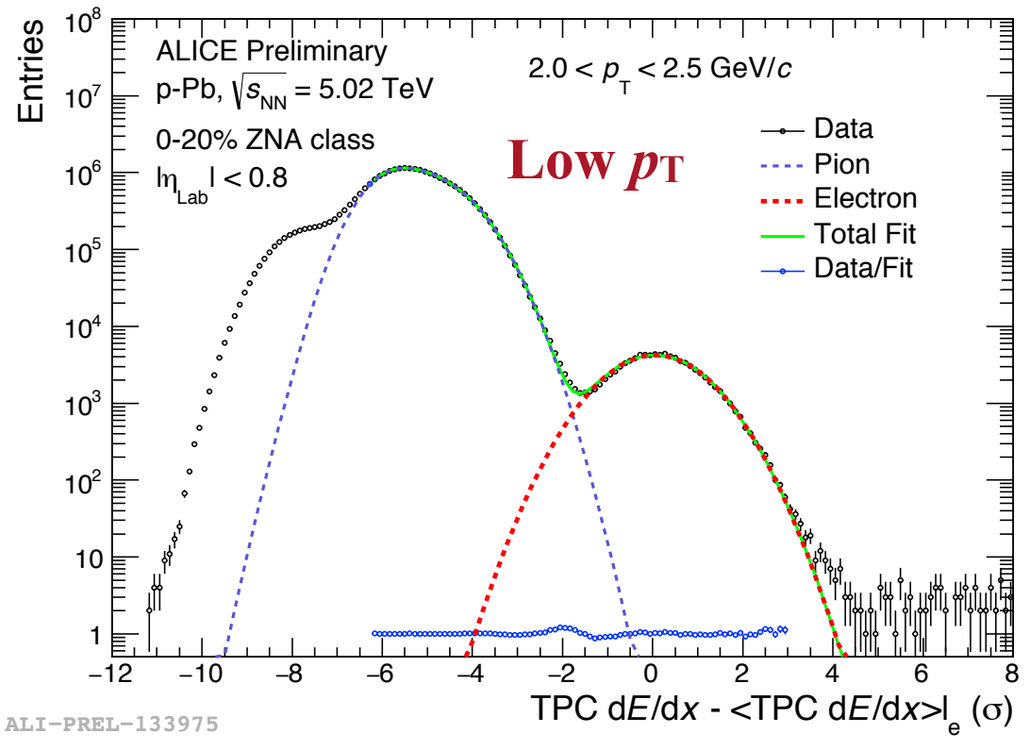
$$B \rightarrow e + X(BR \sim 10\%)$$
$$D \rightarrow e + X(BR \sim 10\%)$$

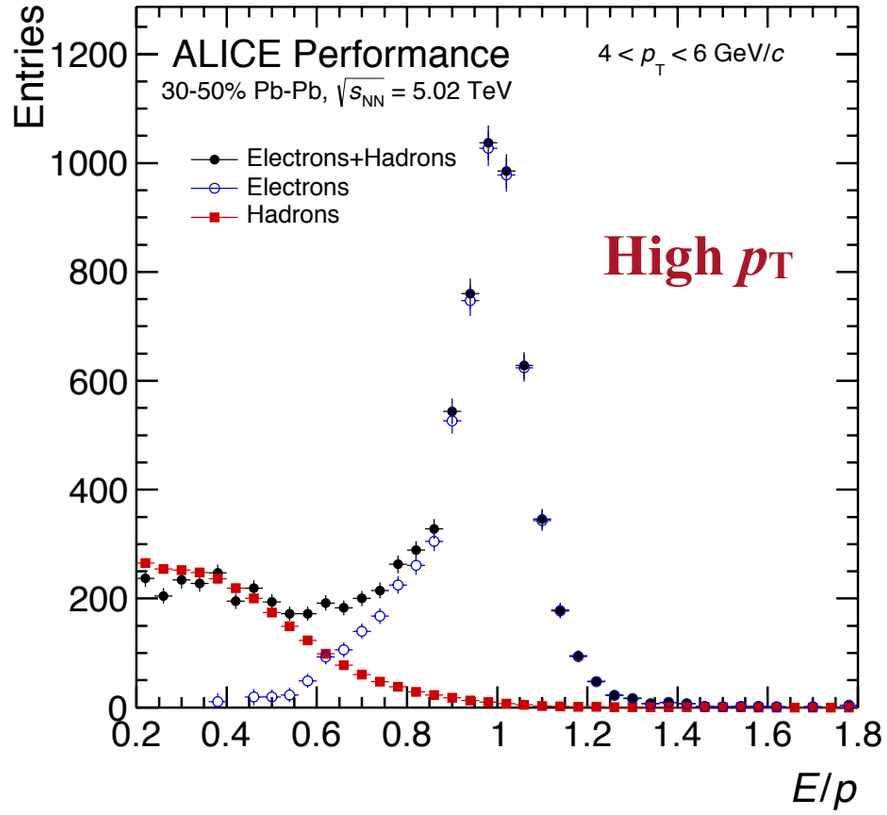
- The electron identification is done using the information form

  ➡TPC + TOF for low p_T

  ➡TPC +EMCAL for intermediate and high p_T

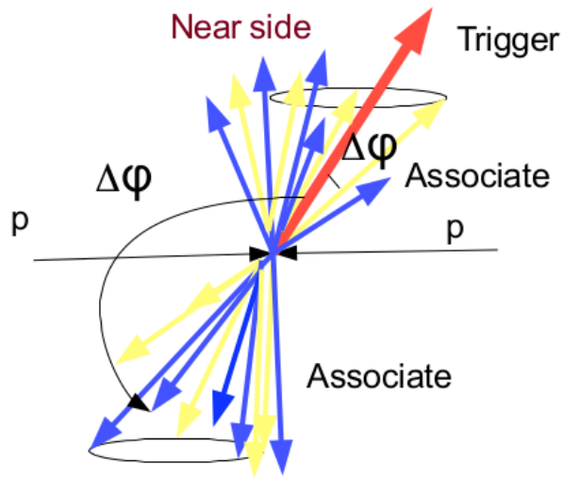






Analysis Method

- Each selected electron (e) is correlated with charged tracks produced in the collision to build the h($\Delta\eta$, $\Delta\varphi$) correlation distributions.

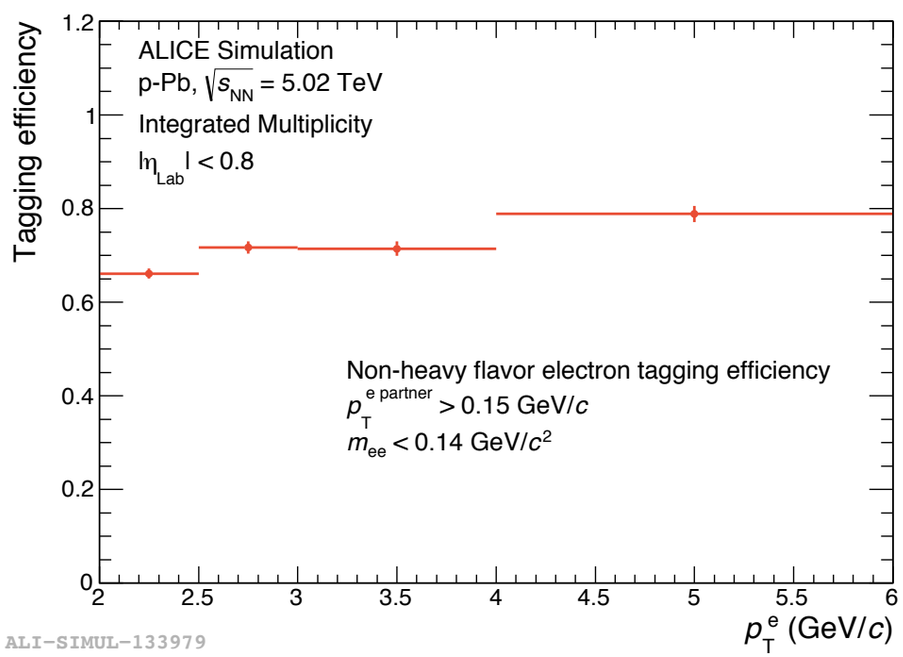


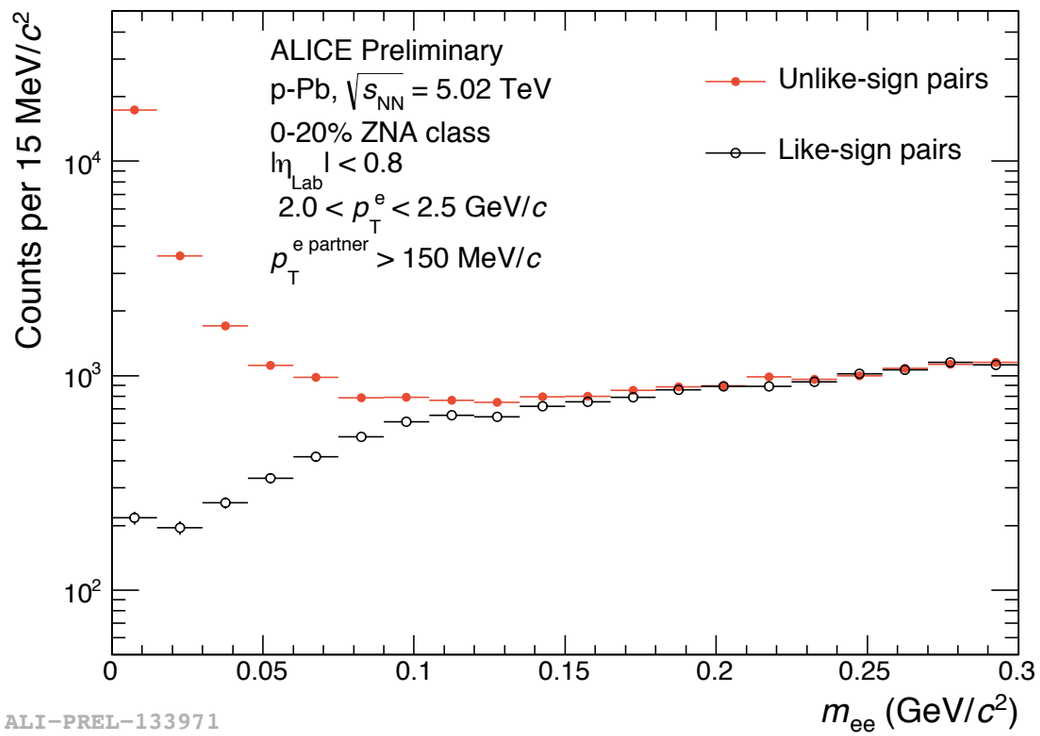
$$\Delta\varphi = \varphi_{trig} - \varphi_{assoc}$$

- Effects due to limited detector acceptance and inhomogeneities are corrected via event-mixing technique.

- Non-HF (background) electron sample is subtracted from inclusive electron sample by invariant mass technique.

- Photonic-electron tagging method: Unlikesign – Like sign pairs with $m\,(e^+,e^-) < 140\ \mathrm{MeV}/c^2$ are identified as background.





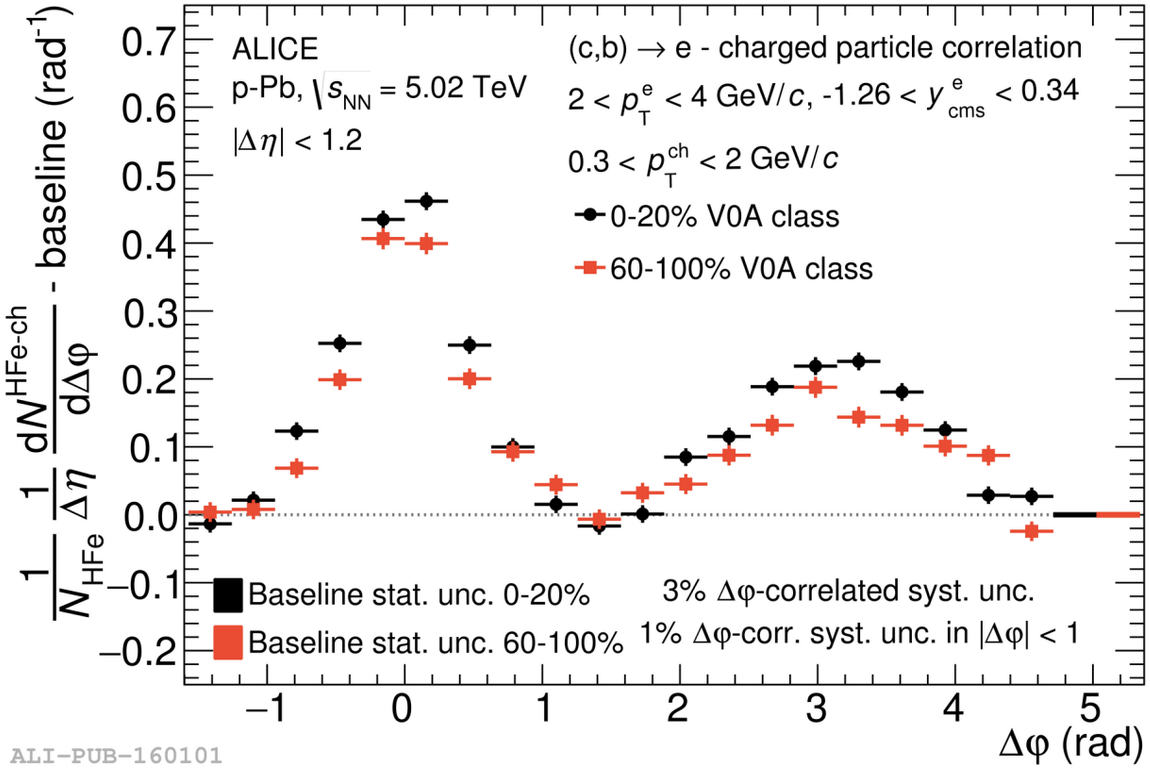
Results (I)

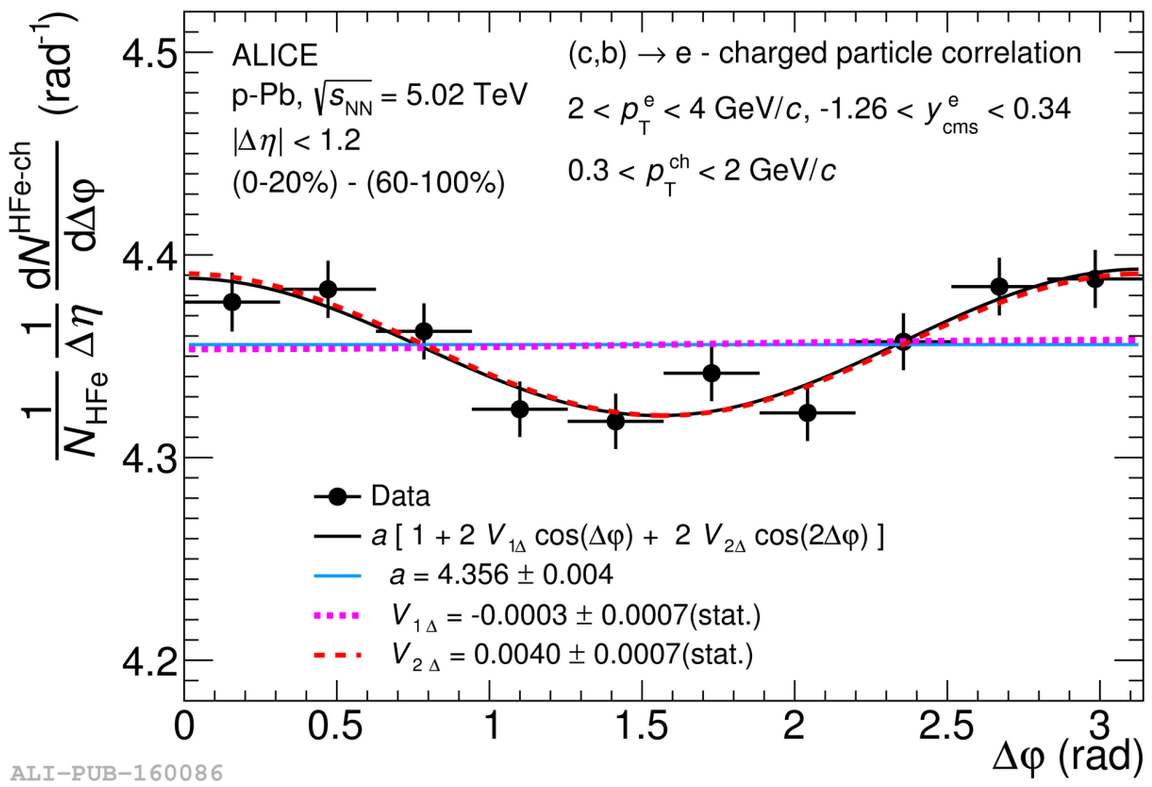
Results from p–Pb collisions @ 5.02 TeV

Trigger particle (e) p_T range : 1.5 < p_T < 2 GeV/c, 2 < p_T < 4 GeV/c, 4 < p_T < 6 GeV/c

Associated particle p_T : 0.3 < p_T < 2 GeV/c

HFe – hadron correlations in p–Pb collisions

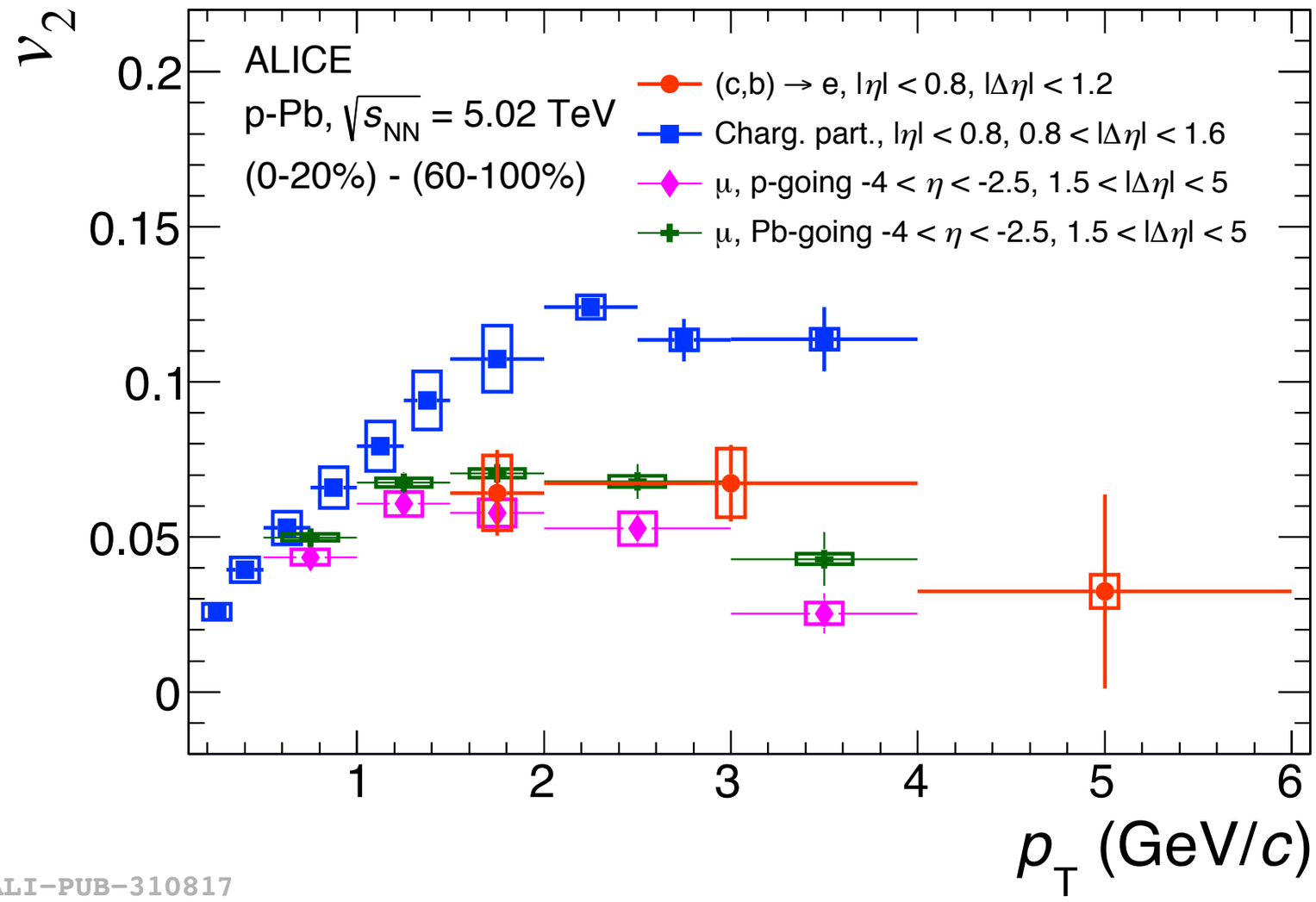




- Enhancement of the near- and away-side peaks is present in high-multiplicity collisions
- Low multiplicity event correlations is subtracted from the high multiplicity event to remove jet component. Assumption: jet correlation function is not modified in low and high multiplicity events
- The distribution is fitted by the function:

$$\frac{1}{\Delta\eta}\frac{1}{N_{\mathrm{HFe}}}\frac{\mathrm{d}N_{\mathrm{HFe-ch}}(\Delta\varphi)}{\mathrm{d}\Delta\varphi} = a[1 + 2V_{1\Delta}^{\mathrm{HFe-ch}}\cos(\Delta\varphi) + 2V_{2\Delta}^{\mathrm{HFe-ch}}\cos(2\Delta\varphi)]$$

HFe v_2 at high multiplicity



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arXiv:1805.04367

Significance :

5.1σ for $1.5 < p_T^e < 4$ GeV/c

- Effect is qualitatively similar to the one observed in the light flavour sector
- Presence of long-range anisotropies with a significance 5.1σ for heavy-flavour particles also in high-multiplicity p–Pb collisions.

Results (II)

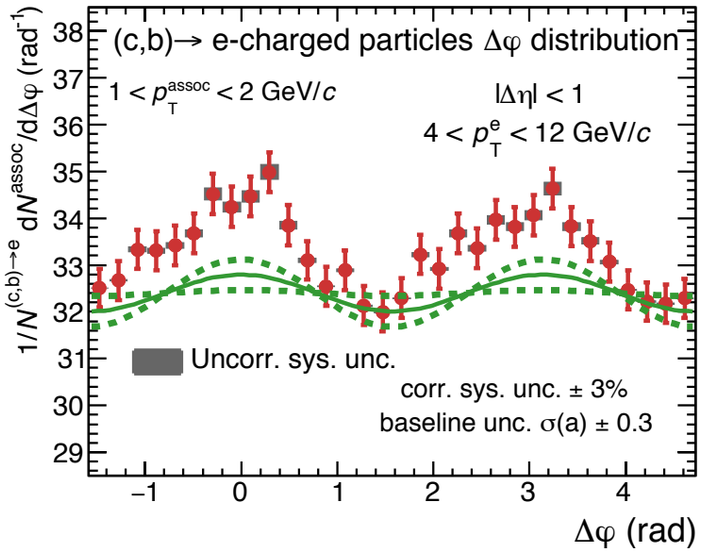
Results from Pb–Pb collisions @ 5.02 TeV

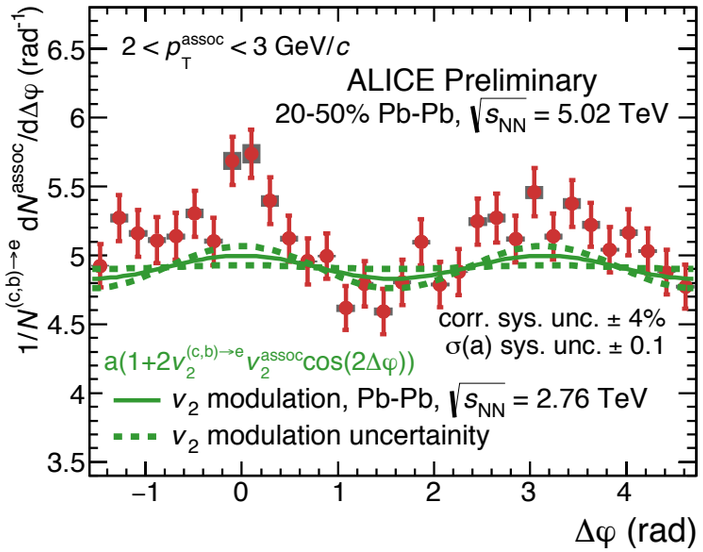
Trigger particle (e) p_T range : $4 < p_T < 12$ GeV/c

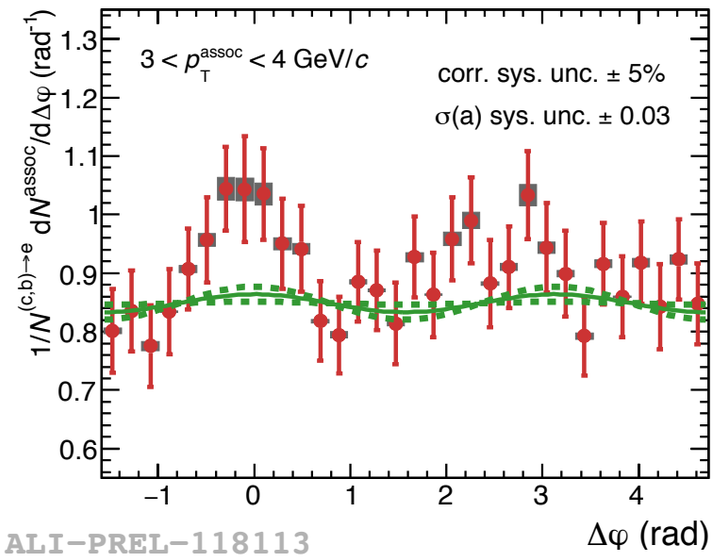
Associated particle p_T : $1 < p_T < 2$ GeV/c , $2 < p_T < 3$ GeV/c, $3 < p_T < 4$ GeV/c, $4 < p_T < 5$ GeV/c

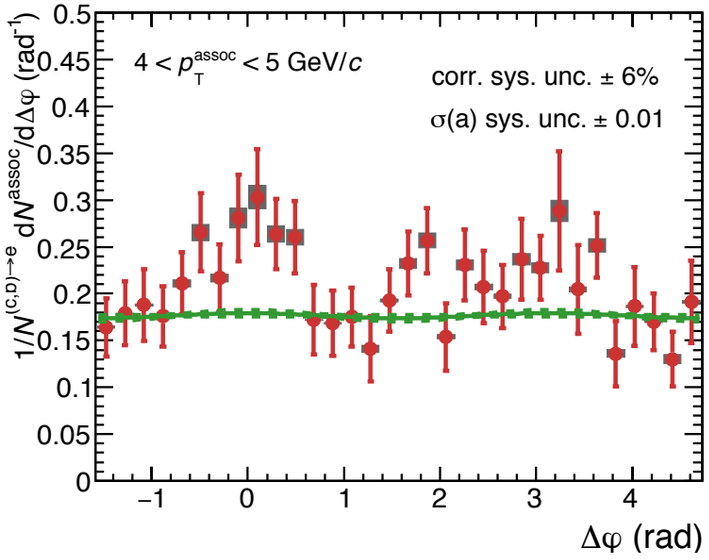
HFe – hadron correlations in Pb–Pb collisions

Azimuthal angular correlations of HF-decay electrons with charged hadrons for centrality 20–50% in Pb–Pb collisions with flow contributions









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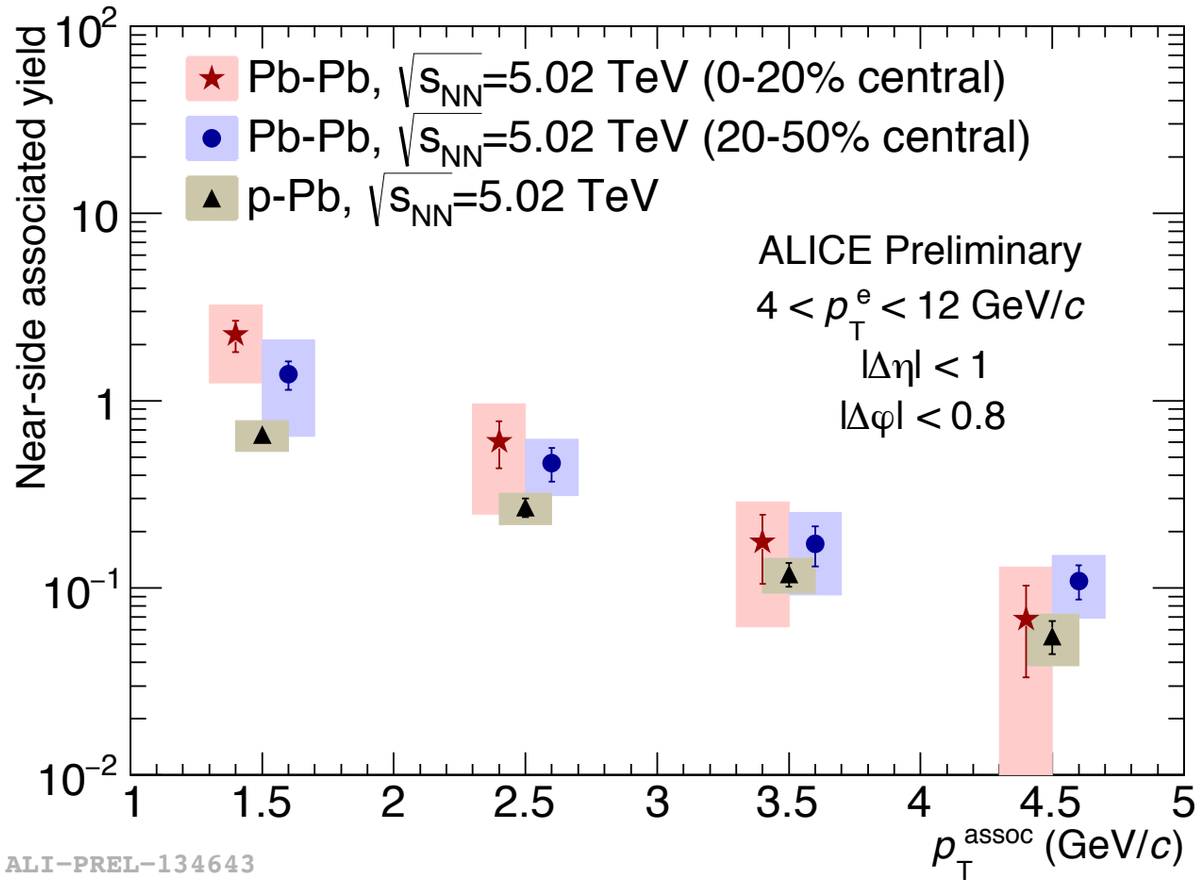
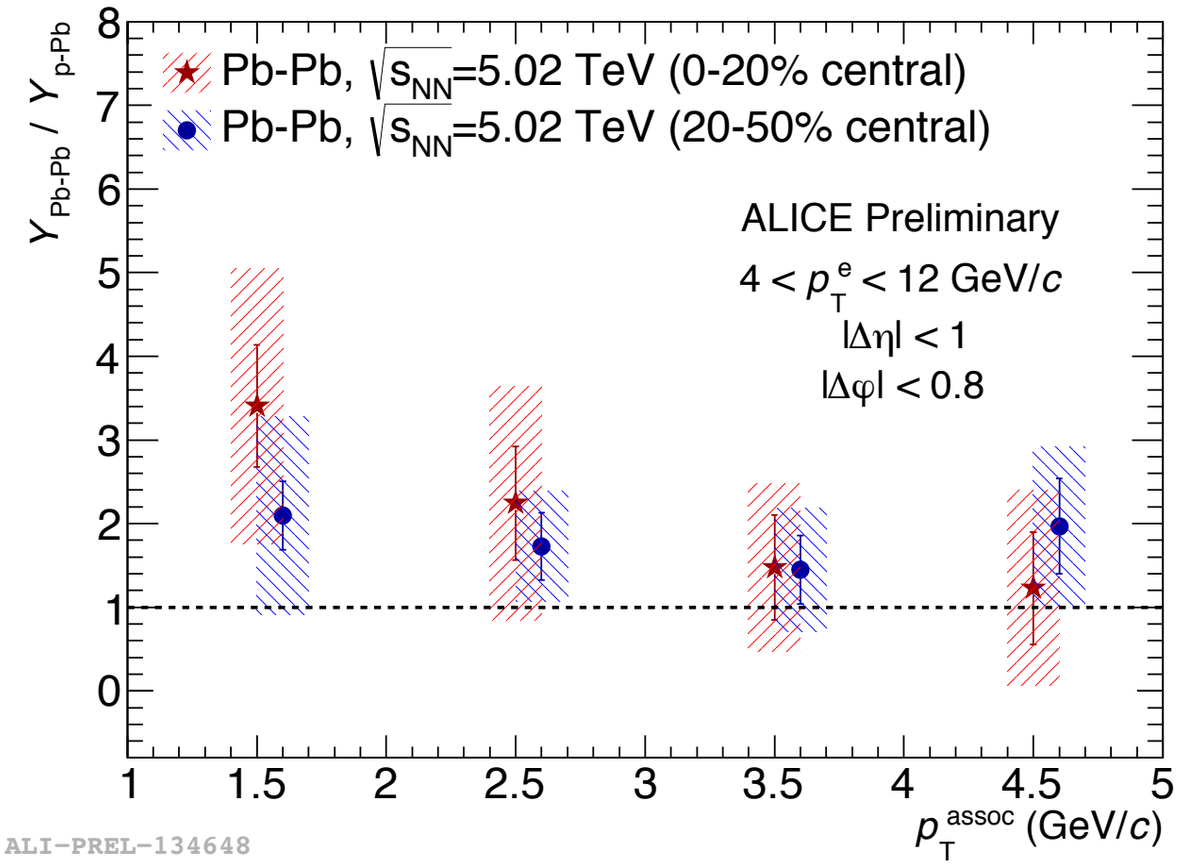
- Near side – Modification of Parton fragmentation function in QCD medium.
- Away side – Path-length dependence of in-medium energy loss
- Flow contribution estimated using v_2^{HFE} and v_2^{assoc} from Pb-Pb, $\sqrt{s_{NN}}$= 2.76 TeV

Near side peak yields in p–Pb and Pb–Pb collisions





- Near-side associated yield in Pb–Pb and p–Pb is calculated.
- The ratio of near-side yield in Pb–Pb shows an increasing order in low associated p_T, indication of possible modification of heavy quarks fragmentation.
- Ratios shows a centrality dependence with higher increase in yield

Summary and Outlook

- The results of azimuthal correlations between electron and charged particles in p–Pb and Pb–Pb collisions, extracted in different p_T intervals of trigger and associated charged particles, are presented.

- Positive v_2 for both light-flavour and heavy flavour particles seen in p–Pb collisions.

- Near-side associated yield in both p–Pb and Pb–Pb collisions are presented. The ratio of near-side associated yield of Pb–Pb w.r.t p–Pb also presented.

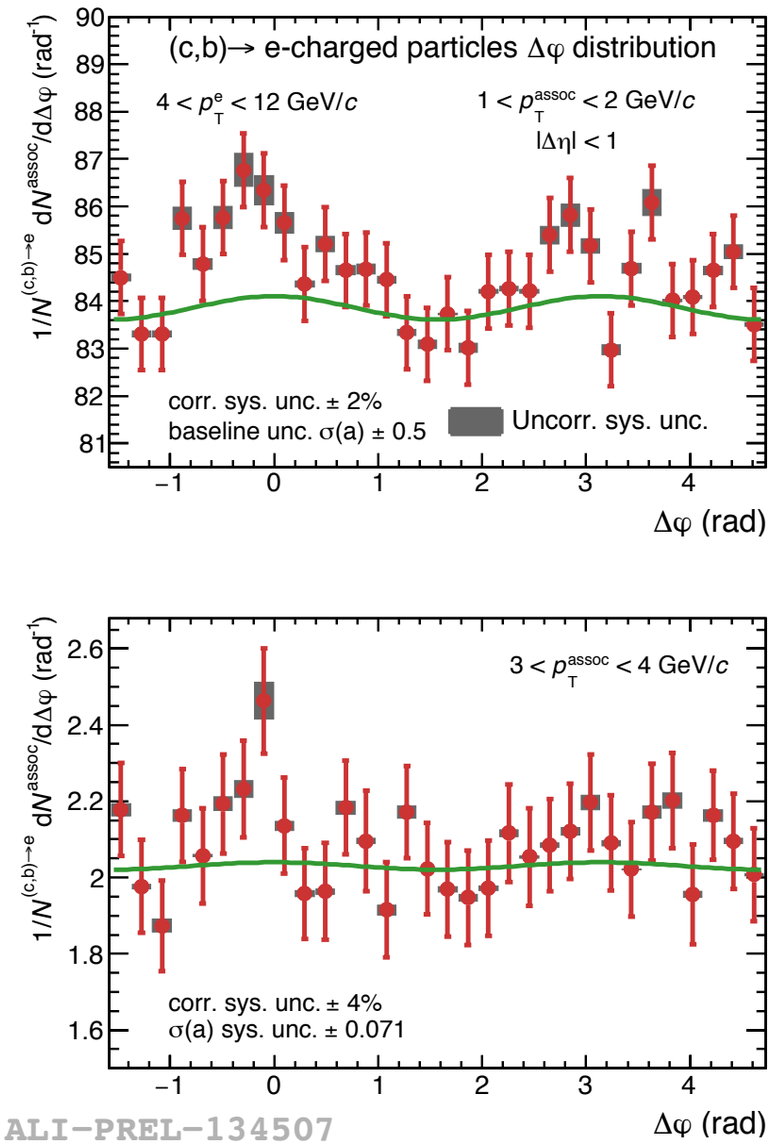
- The increase in near-side associated yield in Pb–Pb compared to p–Pb indicates a possible modification of fragmentation of heavy quarks in heavy-ion.

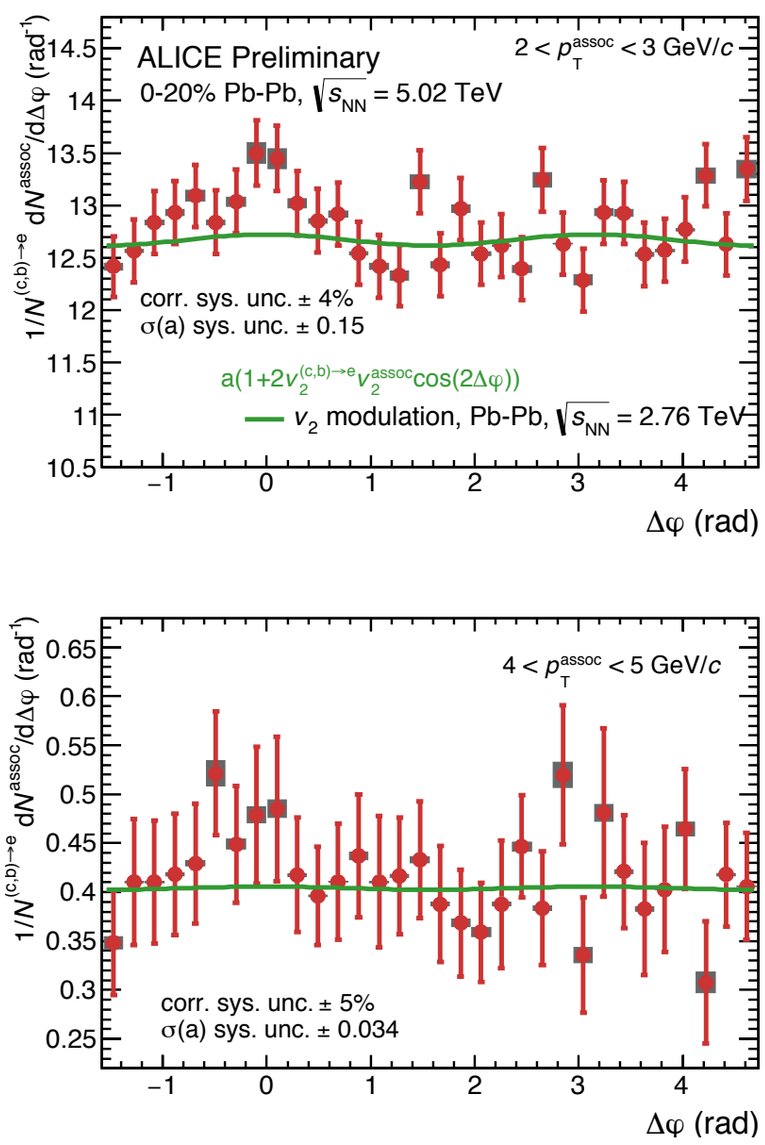
THANK YOU

Back-up

HFe – hadron correlations in Pb–Pb collisions with flow contribution

Azimuthal angular correlations of HF-decay electrons with charged hadrons for centrality 0–20% in Pb–Pb collisions with flow contributions





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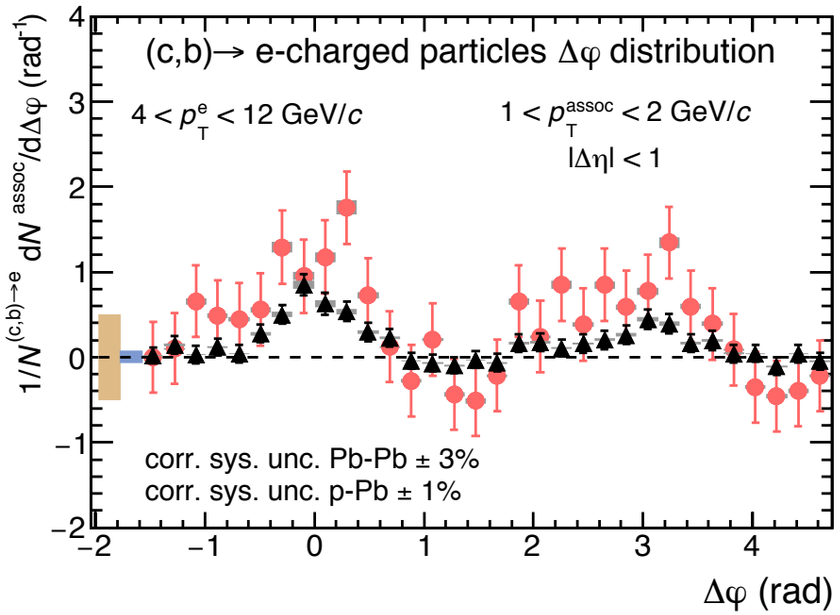
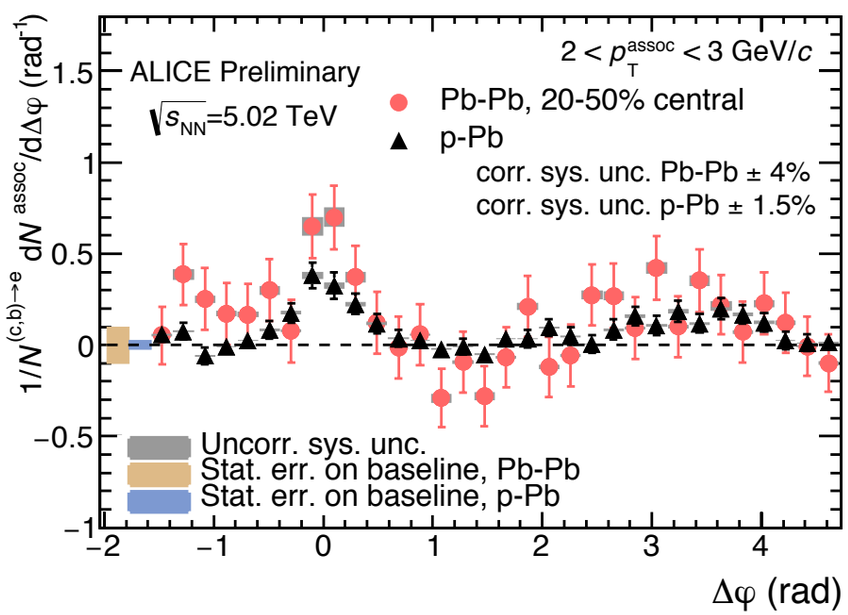
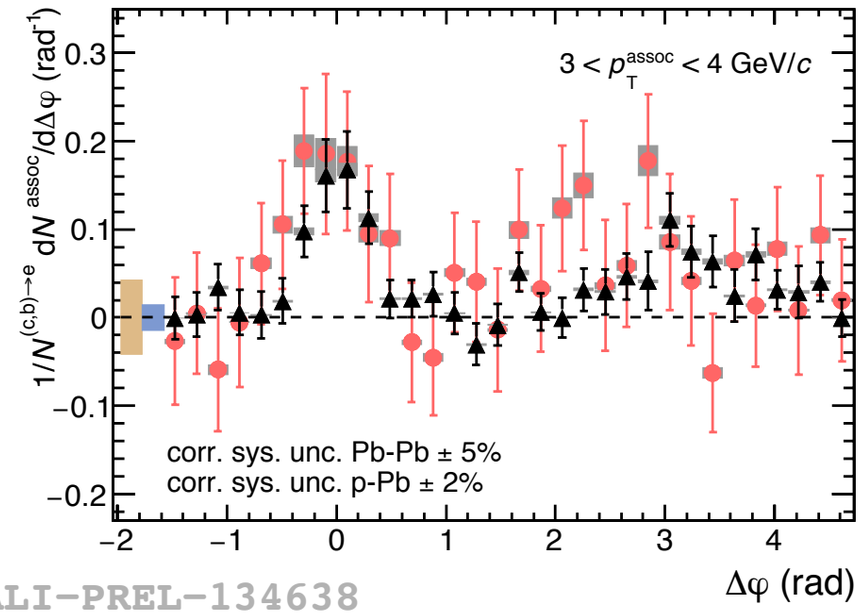
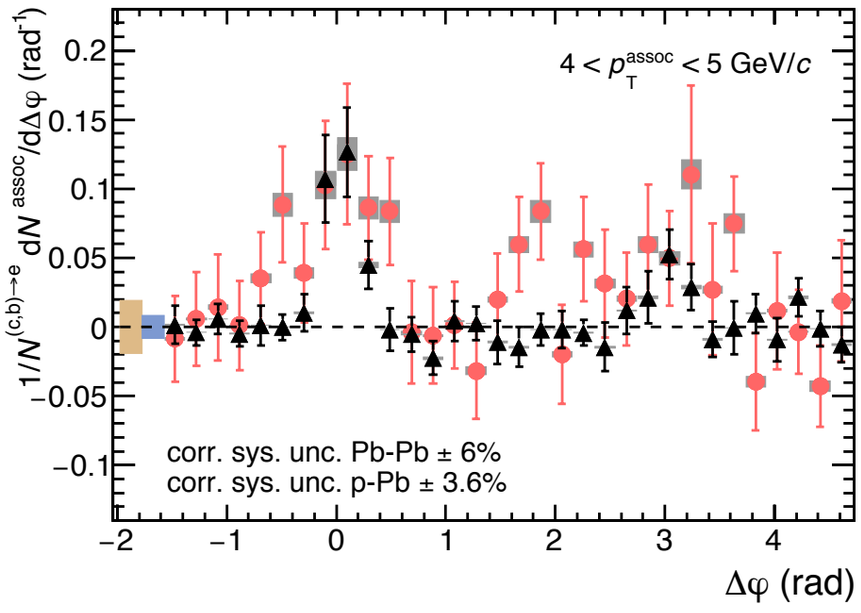
Comparison of HFe – hadron correlations in p–Pb and Pb–Pb collisions









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