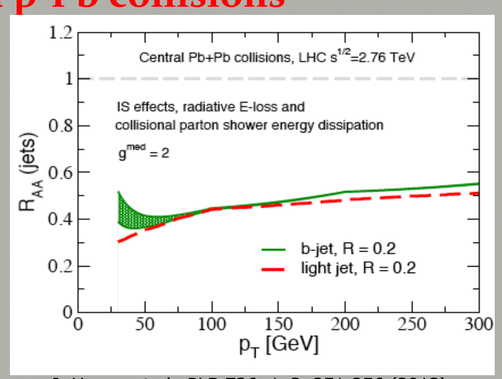
Prospects for measuring angular correlations between heavy-flavour hadron decay electrons and jets with the ALICE detector

A. Rossi, CERN
for the ALICE Collaboration

Physics Goals

Address charm and beauty interaction with the medium studying **modification to heavy-flavour jet production and properties in Pb-Pb collisions with respect to pp and p-Pb collisions**

- **In-medium energy loss**, both radiative and collisional, predicted to be smaller for heavy quarks with respect to light quarks and gluons.
  - Mass dependence stronger at low p_T.
- **With jets:** probe energy loss and angular distribution of the radiated energy.
  - Possible medium modification to heavy-flavour parton shower properties.

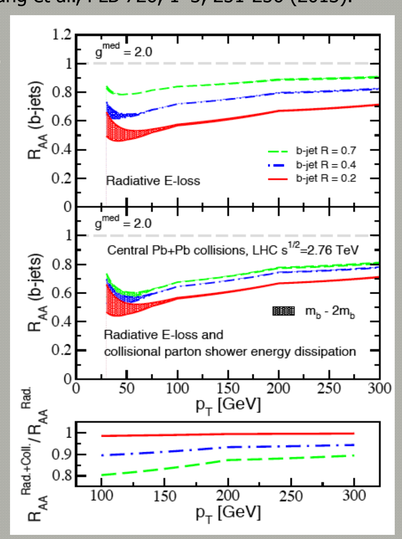


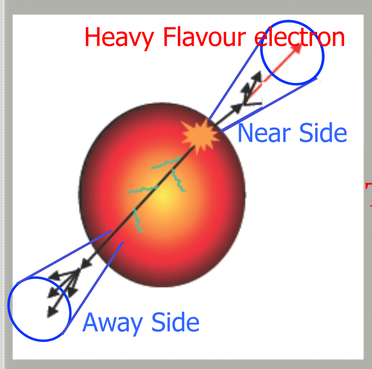
J. Huang et al., PLB 726, 1–3, 251-256 (2013).

With heavy-flavour hadron decay electron - jet azimuthal correlations:

- Probe energy loss, quantifying the away-side jet p_T-spectrum modification with respect to pp and p-Pb.
- "Surface bias": trigger-particle parent quark produced closer to the surface, going outward.

➜ Sensitivity to energy loss dependence on path length, expected $\propto L$ (L^2) for collisional (radiative) energy loss.





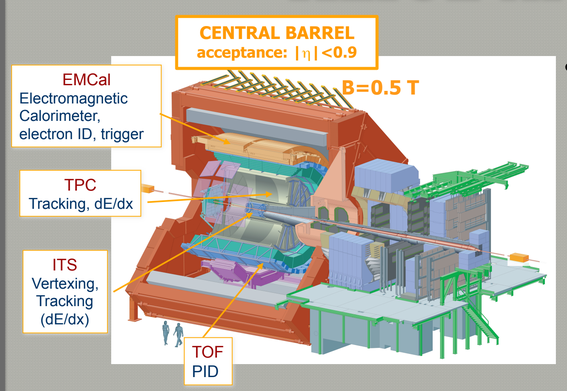
➜ Study away-side jet

- No fragmentation bias.
- Reduced importance of combinatorial background jets.

Targets for pp, p-Pb collisions:

- Reference for Pb-Pb.
- Address heavy-flavour production processes (e.g. contribution of gluon-splitting to heavy-quark production).

Alice apparatus



- Jets are reconstructed in ALICE using charged tracks with $|\eta|<0.9$ detected in the TPC and ITS ("charged jets")
  - EMCAL information not exploited in this analysis
- Electron identification for p_T>3 GeV/c with TPC (dE/dx), EMCAL (E/p, shower shape), and TOF.

Exploiting EMCal trigger

EMCAL ($\Delta\eta\times\Delta\varphi$=1.4×1.87, 4.35<$r$<4.7 m, tower size: $\Delta\eta\times\Delta\varphi$=0.014×0.014) can provide L0 and L1 trigger with centrality dependent thresholds for L1.

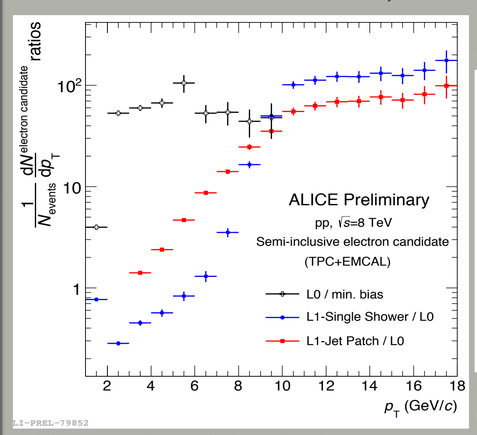
➜ **Select at trigger level events with high-p_T electrons**

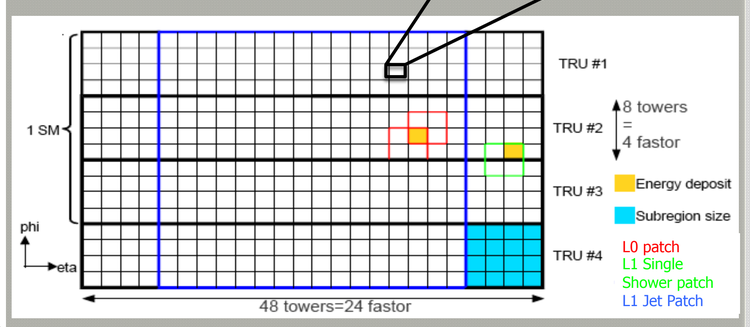
Trigger topology and energy thresholds (typical values used during pp run in 2012):

L0: 4x4 towers, E>2 GeV/c.

L1-Single Shower patch: 4x4 towers, E>10.2 GeV/c.

L2-Jet Patch: 32x32 towers, E>15.7 GeV/c.

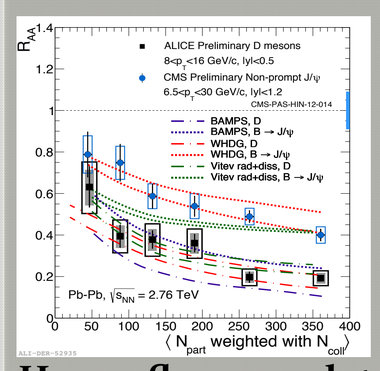


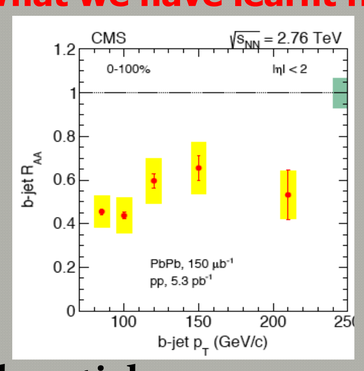


N.B. Semi-inclusive electrons: charged particles selected as electrons from heavy-flavour hadron decay

Current Related Measurements

What we have learnt from:





Heavy-flavour jets

For p_T>80 GeV/c: similar suppression for b-jets and inclusive jets, quantified by

$$R_{AA} = \frac{(dN/dp_T)^{\text{Pb-Pb}}}{\langle T_{AA}\rangle \times (d\sigma/dp_T)^{\text{pp}}}.$$

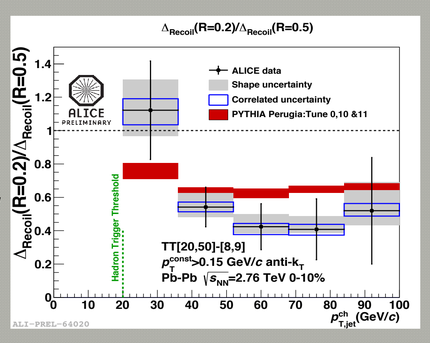
CMS-HIN-12-003, CERN-PH-EP-2013-228, arXiv:1312.4198

Heavy-flavour related particles

- Charm and beauty lose energy.
- Indication of a smaller suppression for beauty than charm in central Pb-Pb collisions.

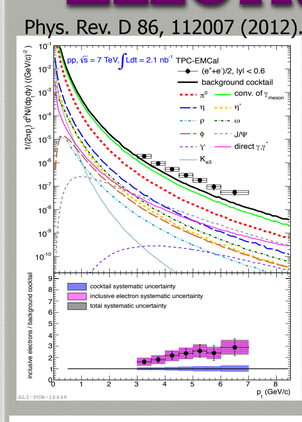
Inclusive jets & hadron-jet correlations

- Inclusive jet R_{AA} similar to single particle R_{AA}.
- Most of energy radiated to large angles.
- Recoil jet from high p_T trigger particle: ratio of R=0.5 and R=0.2 jet p_T spectra compatible with Pythia, within uncertainties.



Electron as Heavy-Flavour probe

Phys. Rev. D 86, 112007 (2012).

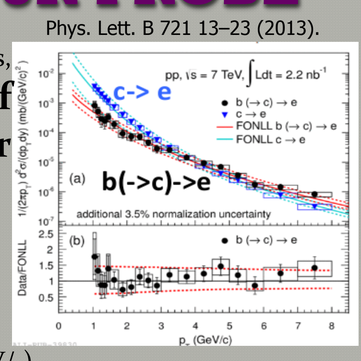


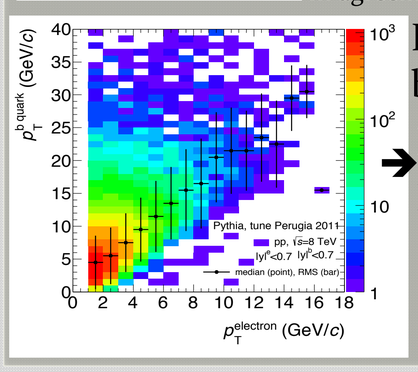
For tracks with points in the innermost detector layers, **heavy-flavour is the main source of reconstructed electrons for p_T>4 GeV/c.**

$$\frac{d\sigma^{e(\leftarrow c)\leftarrow b}}{dp_T} > \frac{d\sigma^{e\leftarrow c}}{dp_T}$$ for p_T>4-5 GeV/c, (pp, $\sqrt{s}$ = 7 TeV)

according to FONLL (cross-section ratio ~ 1.5 at p_T=8 GeV/c)
In agreement with experimental measurement.

Phys. Lett. B 721 13–23 (2013).

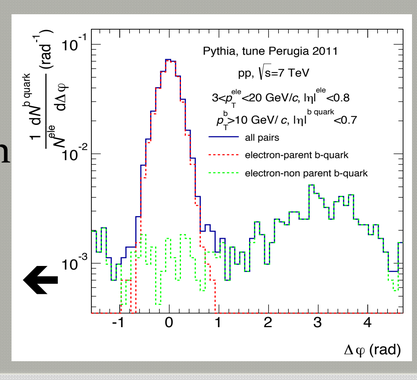




Electrons from decay of beauty hadrons, b(->c)->e:

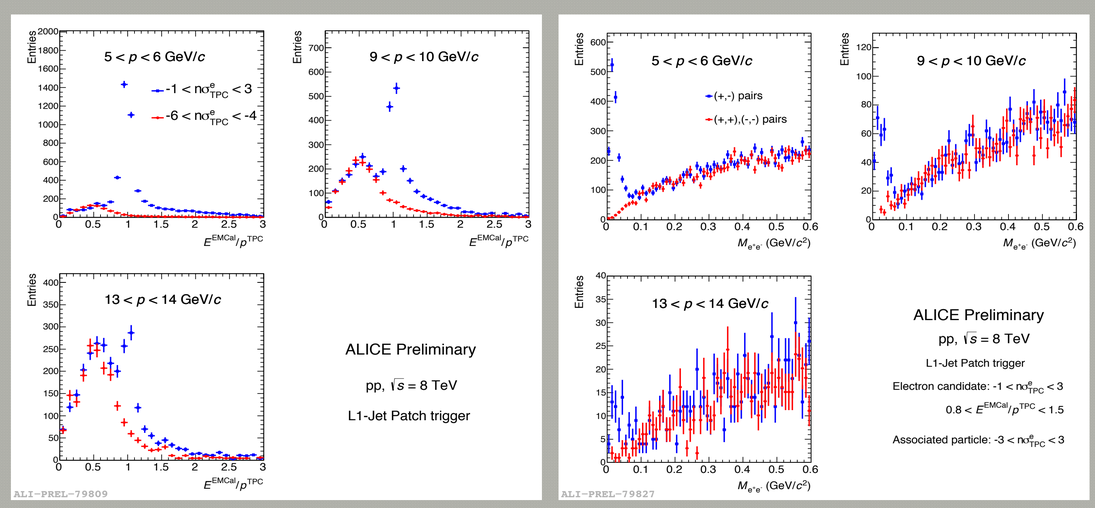
➜ Moderate correlation with parent quark momentum.

Preserve parent quark direction (already for p_T>3 GeV/c).



Analysis strategy

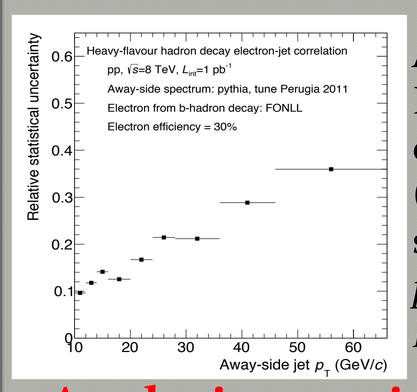
- Electron identification.
- Reject photonic electrons by requiring a point in the innermost ITS layer and by rejecting electrons that, when paired with an opposite-sign track of the event, give rise to a (e^+,e^-) pair with an invariant mass M<0.080 GeV/c^2.



- Correlate selected electrons with reconstructed charged jets.
  - In Pb-Pb case: jet energy correction to remove the contribution of background (with density ρ^{ch}), event-by-event, $p_T^{ch\,jet} = p_T^{ch\,jet,\,raw} - \rho^{ch} \times A^{jet}$.
- Subtract contamination of residual hadron-jet azimuthal correlations.
- Correction for electron selection efficiency and residual contamination of background electrons.
- Unfolding of the away-side jet p_T spectrum to account for detector effects and, in Pb-Pb, background fluctuations.
- In Pb-Pb collisions (before unfolding): subtract the spectrum obtained with low p_T trigger electrons to that obtained from electrons in a higher p_T range to decrease the relevance of background fluctuations.

➜ obtain the corrected "per-trigger" jet p_T-spectrum in the away-side.

Outlook



Away-side b-jet p_T spectrum (Pythia) + FONLL prediction of beauty decay electron cross-section + 30% electron efficiency (independent in p_T) used to estimate the statistical uncertainty on the recoil jet p_T spectrum for an integrated luminosity of L_{int}=1 pb⁻¹ for pp collisions at $\sqrt{s}$ = 8 TeV.

Analysis ongoing with pp, p-Pb and Pb-Pb data from Run 1 at LHC