Production of electrons from heavy-flavour hadron decays in pp collisions at $\sqrt{s}$ = 13 TeV as a function of charged-particle multiplicity with ALICE

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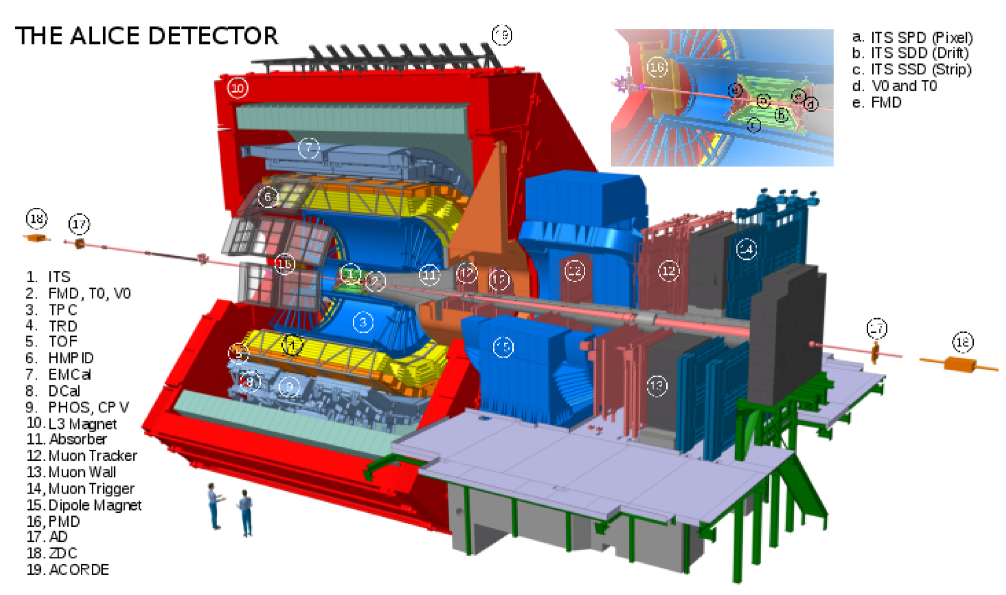
Motivation

- High-multiplicity pp collisions at the LHC exhibit features resembling those seen in relativistic heavy-ion collisions[1],[2] and point to the need for revisiting the prevailing models of the particle production mechanism in pp collisions.
- The study of the multiplicity dependence of heavy-flavour production in pp collisions provides insight into their production mechanism and into the interplay between hard and soft processes in particle production[3].
- In addition, at the LHC energies, multiple parton interactions also plays a significative role in the heavy-flavour production[4].

ALICE detectors

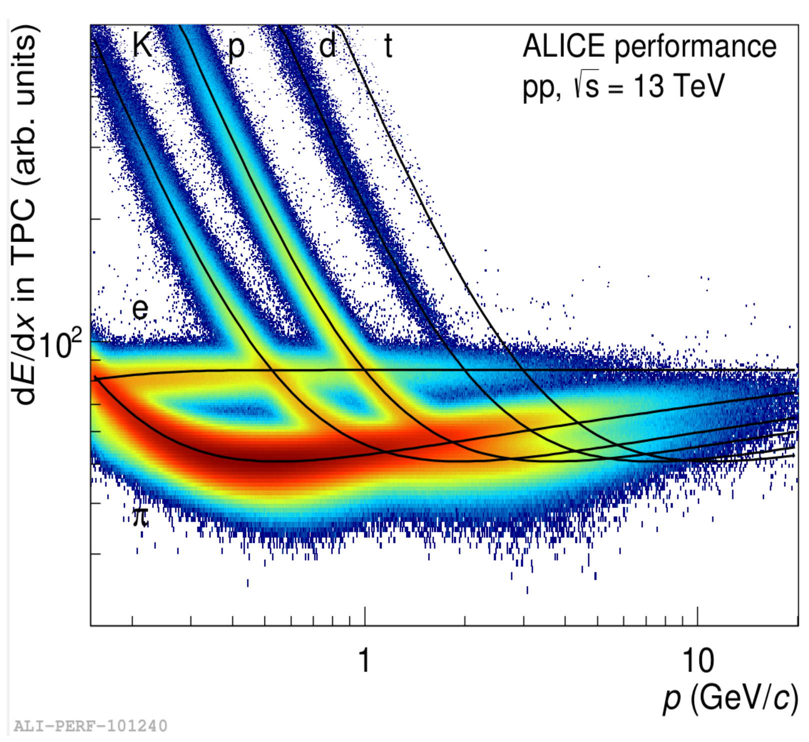
- Detectors used for electron identification in low and intermediate transverse momentum range ($0.5 < p_{\rm T} < 4.5$ GeV/c) :
  - Time Projection Chamber (TPC)
  - Time of Flight (TOF)
- Inner Tracking System (ITS) : Tracking and particle identification (PID), vertexing
  - Silicon Pixel Detector (SPD) - Multiplicity measurement
- V0 detector : Triggering and multiplicity measurement

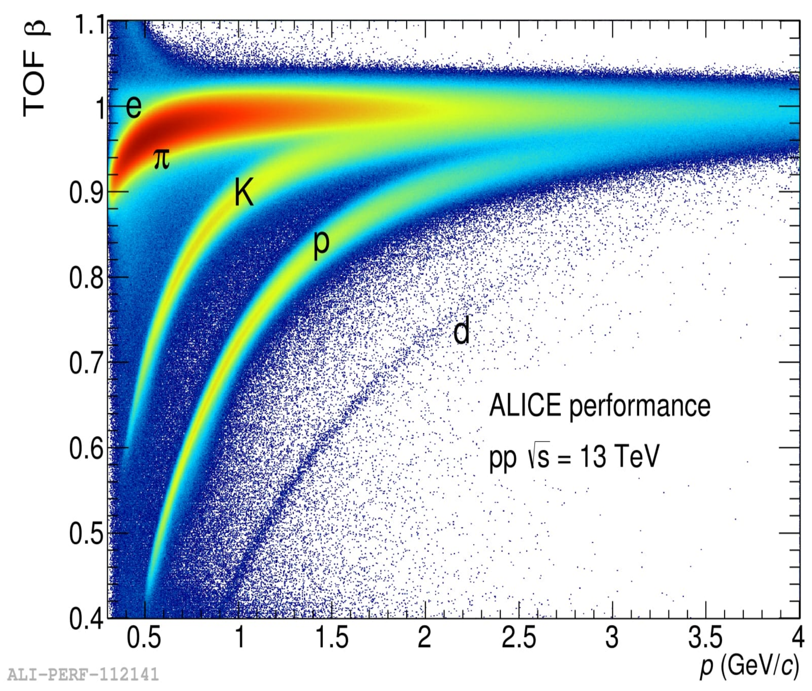


Total number of events analyzed : ~ 155 M minimum-bias pp collisions at $\sqrt{s}$ = 13 TeV

Inclusive electron identification

The charged-particle identification (PID) in the TPC is based on the specific energy loss measurement, dE/dx, of a particle in the gas detector while the TOF detector uses its time of flight. The electron sample is selected within the optimized TOF PID cut $|n\sigma^{TOF}| < 3$ and TPC PID cut $-1 < n\sigma^{TPC} < 3$ to remove the hadron contamination from the sample, where $n\sigma$ is the difference of the measured signal in the detector from the expected value for electrons.



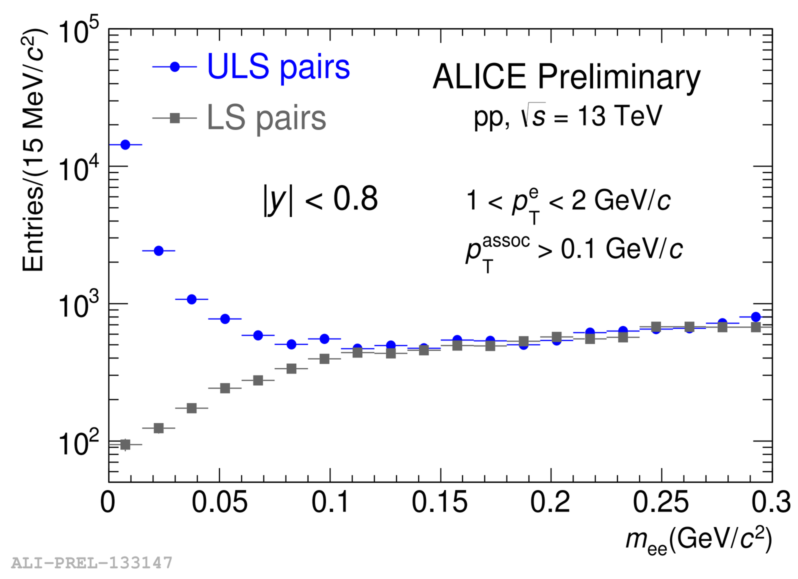


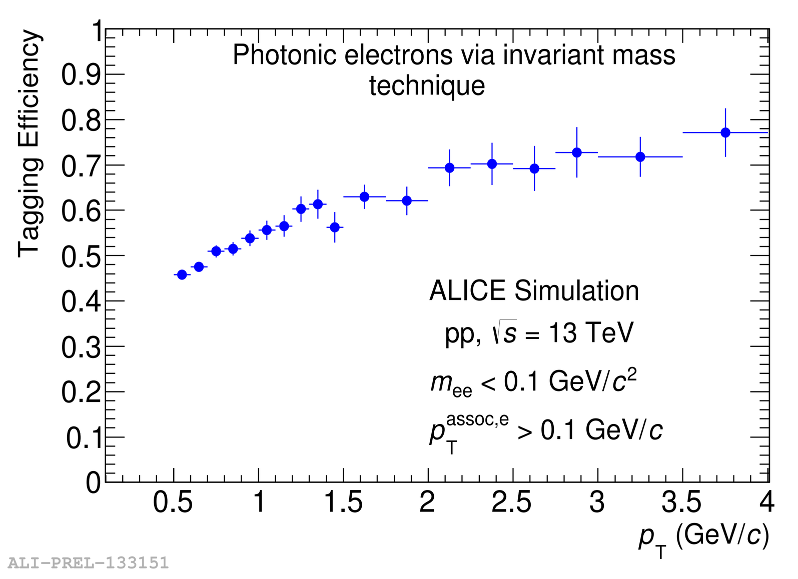
Photonic background subtraction

- The photonic background electrons which mainly come from the Dalitz decay of light neutral mesons (π^0 and η) and γ conversions in the detector material, are subtracted from the inclusive electron sample using the photonic electronic tagging method.
- To identify electrons from photonic sources ($N_{\rm photonic}$), opposite signed partners (e$^-$ e$^+$) are paired in an invariant mass spectrum. The like sign (LS) pairs are used to estimate and subtract the random combinatorial background from the unlike sign pairs (ULS).

$$N_{\rm photonic} = \frac{N_{\rm ULS} - N_{\rm LS}}{\epsilon_{\rm tagging}}$$

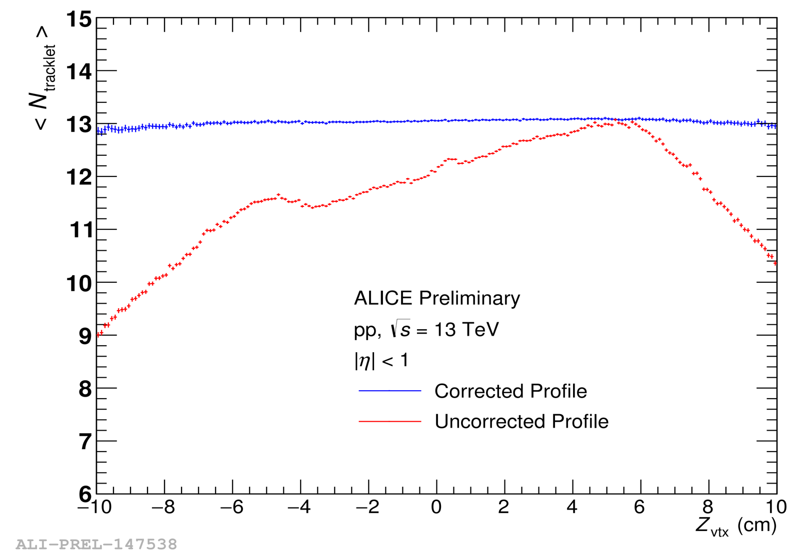
where $\epsilon_{\rm tagging}$ is the photonic electron tagging efficiency obtained from MC simulations.

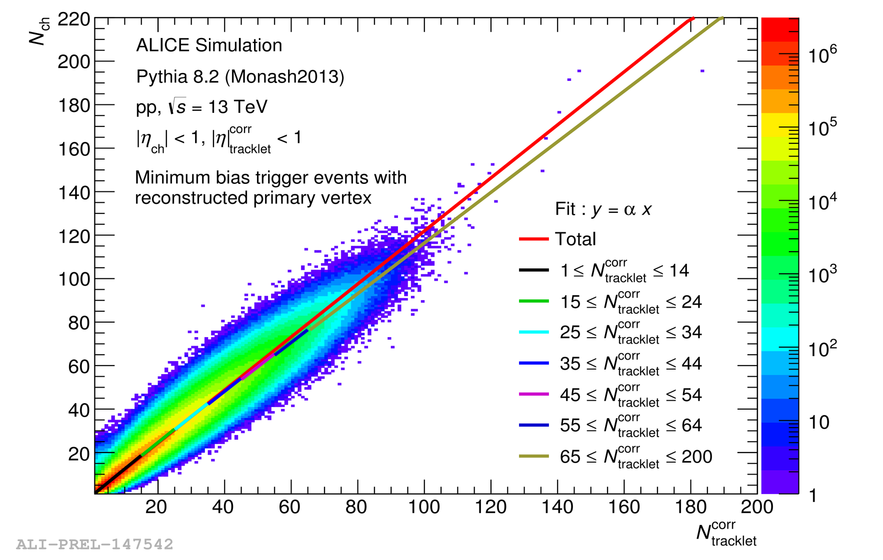




Multiplicity estimation

- Multiplicity estimator - Silicon Pixel Detector (SPD) tracklets within $|\eta| < 1$ ($N_{\rm tr}$)
- The number of SPD tracklets ($|\eta| < 1$) depends on the Z vertex due to :
  - Inhomogeneous acceptance and dead modules of SPD
  - Changes in the number of active modules in the SPD versus each data taking period
- To obtain the true SPD tracklet number ($N^{\rm corr}_{\rm tracklet}$), the SPD efficiency was equalized along the Z vertex for each event by scaling the distribution of $N_{\rm tr}$ vs. Z vertex with respect to a particular reference value of $N_{\rm tr}$ at a particular Z vertex.





- $N^{\rm corr}_{\rm tracklet}$ does not account for the global efficiency loss of the SPD. To obtain a dependence of $N^{\rm corr}_{\rm tracklet}$ on the true charged particle multiplicity of the event, $N_{\rm ch}$, a linear fit is done on the total distribution and in several multiplicity bins.

  The fit parameter (α) gives the SPD tracklet to primary charged particle effect.
- The value $({\rm d}N_{\rm ch}/{\rm d}\eta)/ < {\rm d}N_{\rm ch}/{\rm d}\eta >$ (X-axis) is calculated as :

$$\frac{({\rm d}N_{\rm ch}/{\rm d}\eta)}{< {\rm d}N_{\rm ch}/{\rm d}\eta >} = \frac{< N^{\rm corr}_{\rm tracklet} >_{\rm i} .\alpha_{\rm i}}{< N^{\rm corr}_{\rm tracklet} > . < \alpha >}$$

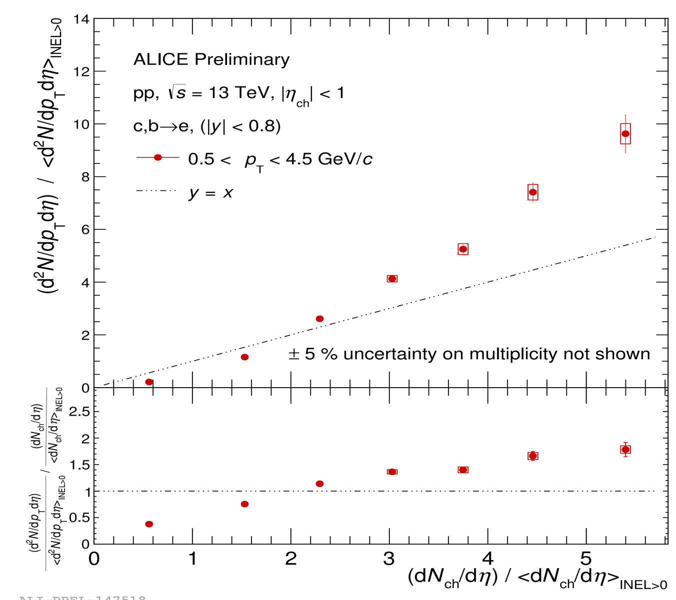
where "i" denotes multiplicity class

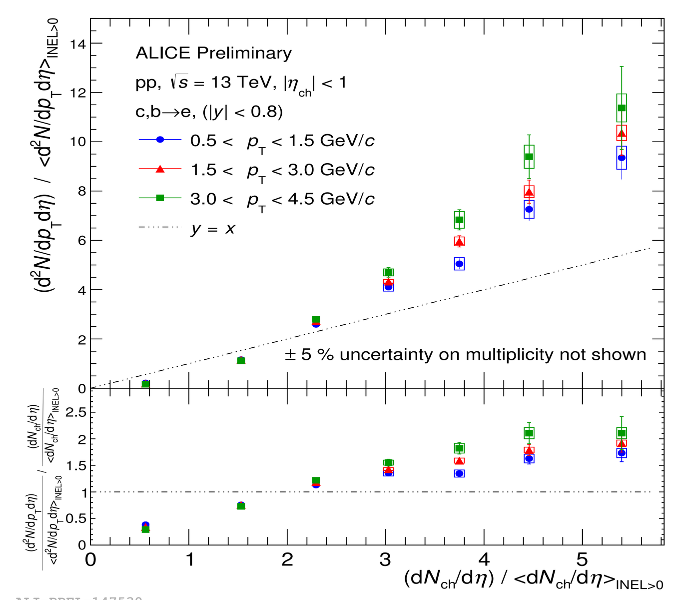
Results

The self-normalized yield of electrons from heavy-flavour hadron decays is calculated using the following formula:

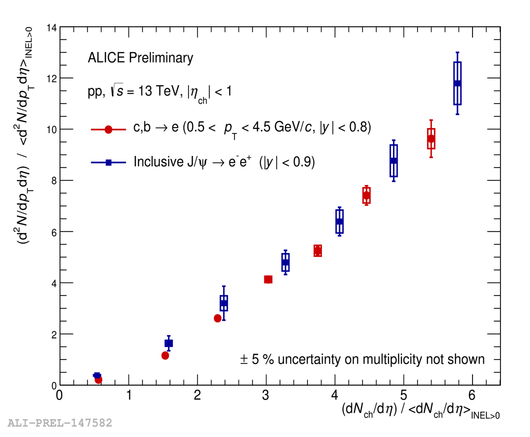
$$y = \frac{N^{\rm i}_{\rm counts}/(\epsilon^{\rm i} \times n^{\rm i}_{\rm events})}{(N^{\rm total}_{\rm counts})/(\epsilon^{\rm total} \times n^{\rm total}_{\rm events}/\epsilon_{\rm trigger})}$$

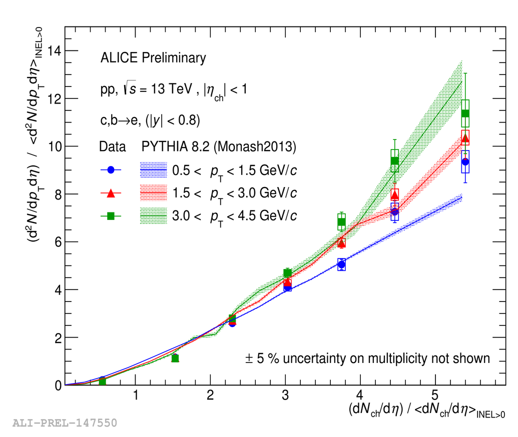
where, "i" denotes the multiplicity class, $\epsilon_{\rm trigger}$ is the minimum bias trigger efficiency estimated for INEL > 0 events which is defined as inelastic events with atleast 1 charged particle within $|\eta| < 1$, $N_{\rm counts}$ is the number of electrons from heavy-flavour hadron decays, $n_{\rm events}$ is the number of events and ϵ is the recostruction efficiency.

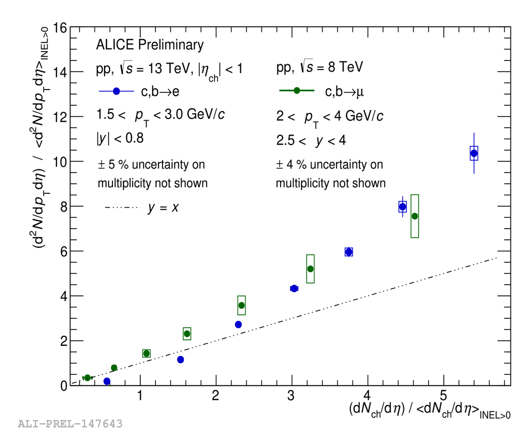




- The self-normalized yield shows a faster than linearly increasing trend.
- Higher $p_{\rm T}$ intervals show tendency for steeper increase.







- The results are compared to J/ψ measurements and PYTHIA8.2 predictions at $\sqrt{s}$ =13 TeV and with the self-normalized yield of μ from open heavy-flavour hadron decays at $\sqrt{s}$ = 8 TeV at forward rapidity.

Summary

- The self-normalized yield of electrons from heavy-flavour hadron decays is measured in the transverse momentum interval $0.5 < p_{\rm T}({\rm GeV}/c) < 4.5$ GeV/c .
- The self-normalized yield shows a faster than linearly increasing trend and higher $p_{\rm T}$ intervals tend to have a faster increase in yield.
- The results are comparable with J/ψ measurements and PYTHIA8.2 predictions at $\sqrt{s}$ =13 TeV.
- Muons from open heavy-flavour hadron decays at $\sqrt{s}$ = 8 TeV at forward rapidity seem to be much less affected due jet bias and autocorrelation effects at low multiplicity.

References : 1. JHEP 09 (2010) 091 2. Nature Physics 13 (2017) 535-539 3. JHEP 09 (2015) 148 4. Physics Letters B 712 (2012)