Dielectron production and topological separation of dielectron sources at $\sqrt{s}$ = 13.6 TeV with ALICE

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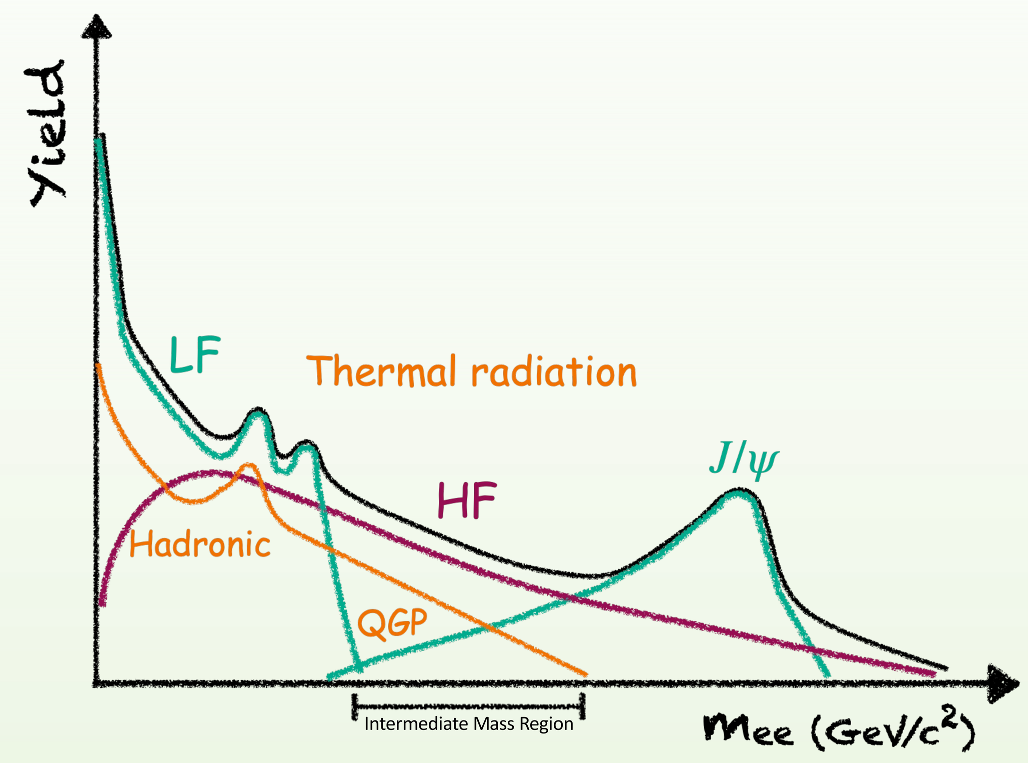
Motivation

Dileptons are a unique probe to study the hot medium properties in Pb–Pb collisions and to perform measurements of processes such as the Drell-Yan process in pp collisions.

Those signals are covered by a large heavy-flavour background.

With a very good detector pointing resolution, the decay length of D (150 μm) and B (450 μm) hadrons can be used to separate this background contribution from prompt signals.



ALICE Run 3 upgrades

New ***Inner Tracking System*** (ITS2)
7 layers of monolithic active silicon pixel sensors.
radii: 22 – 400 mm (Run 2: 39 – 430 mm)
→ Improved pointing resolution by factor 5 in z. [1]

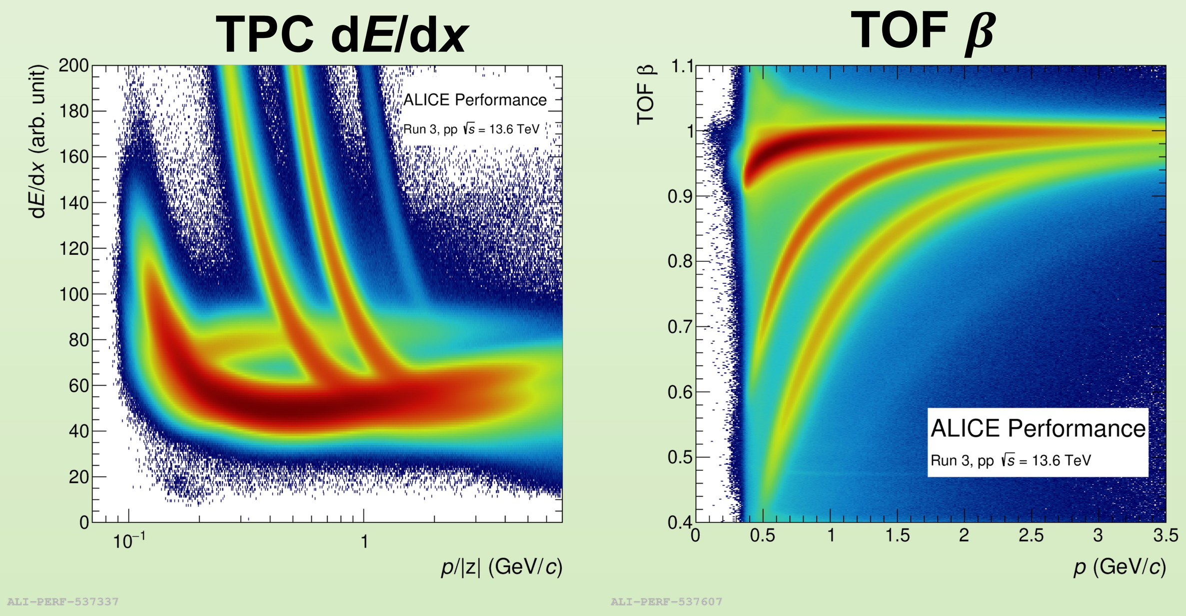
New ***Time Projection Chamber*** (TPC)
Gas Electron Multipliers (GEMs) for readout
Allows continuous readout:
1 MHz (50 kHz) in pp (Pb–Pb)
→ Increase data acquisition rate by a factor ~1000 (100). [2]

Electron identification

Use signal in the TPC and the Time-Of-Flight (TOF) detector to identify electrons.

Reject charged π, K and p within the crossing regions of the electron band.

TPC d*E*/d*x* **TOF β**



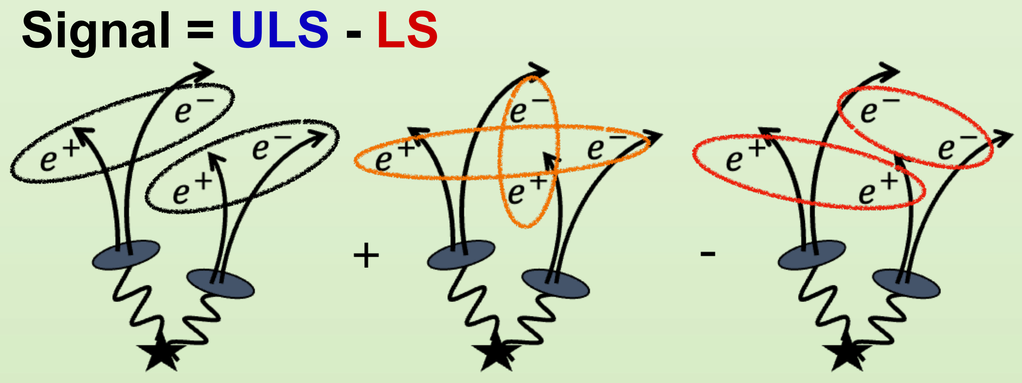
Signal extraction

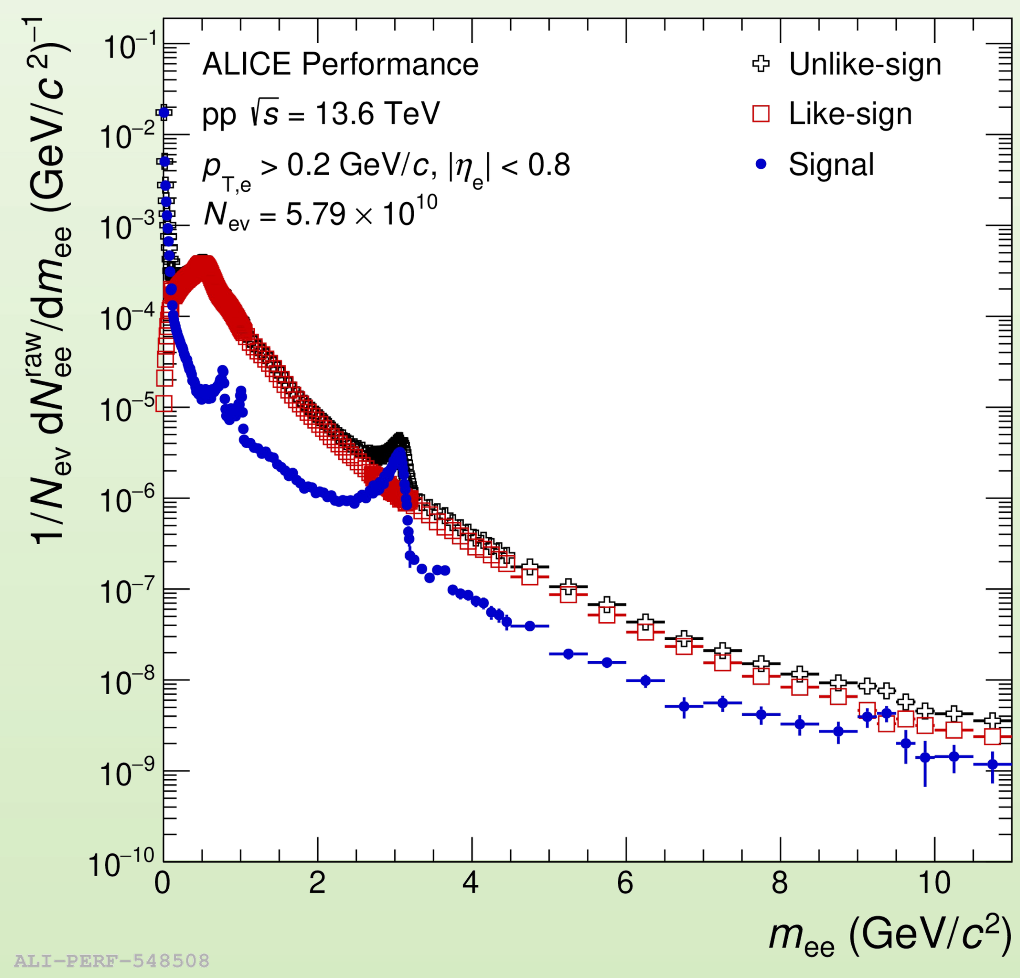
Pairing of electron candidates to estimate the combinatorial background and extract the raw dielectron signal.

ULS: Unlike-sign pairs
Signal + Combinatorial Background

LS: Like-sign pairs

Signal = ULS - LS



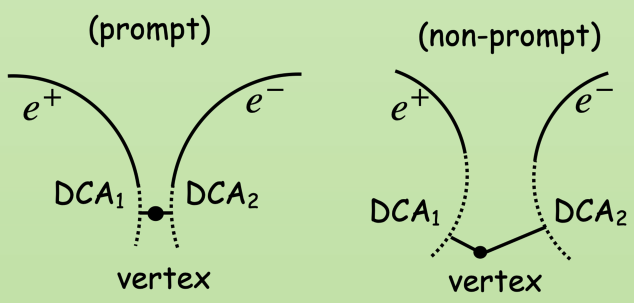


Topological separation of e^+e^- sources

Calculate for each track the Distance of Closest Approach (*DCA*) to the primary vertex → Large *DCA* reflect late decay time and small *DCA* come from tracks decaying prompt.

Combining the *DCA* of two tracks allow to define the *DCA* of the pair which then can be used to differentiate between decays with short or long decay topologies.

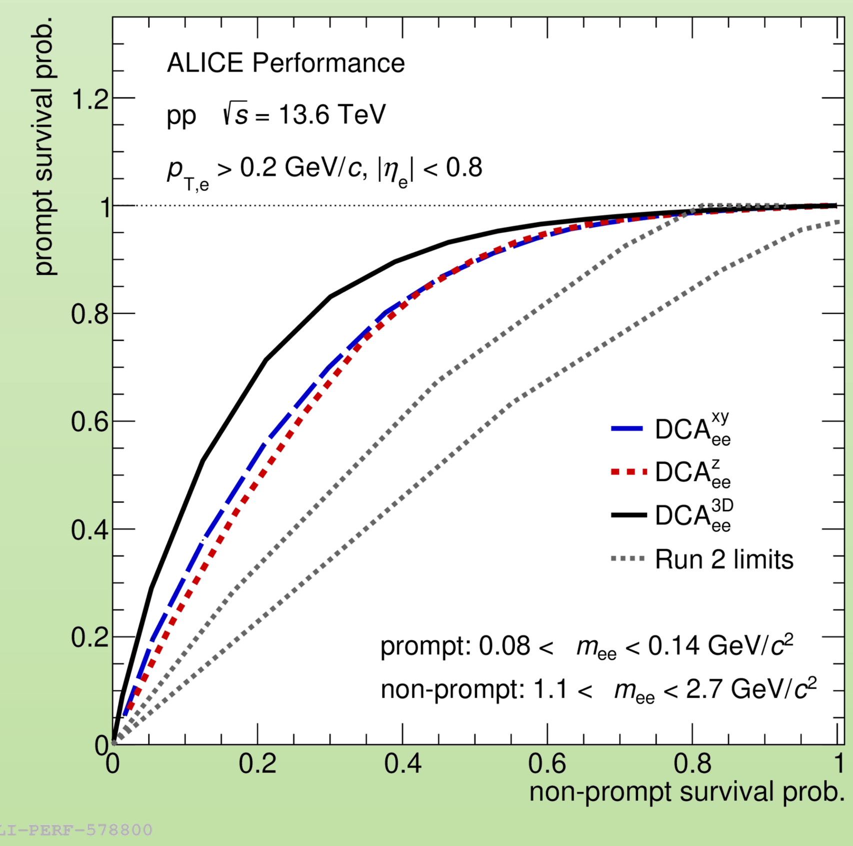
$$DCA_{ee} = \sqrt{\frac{1}{2}\left[\left(\frac{DCA_1}{\sigma_1}\right)^2 + \left(\frac{DCA_2}{\sigma_2}\right)^2\right]}$$

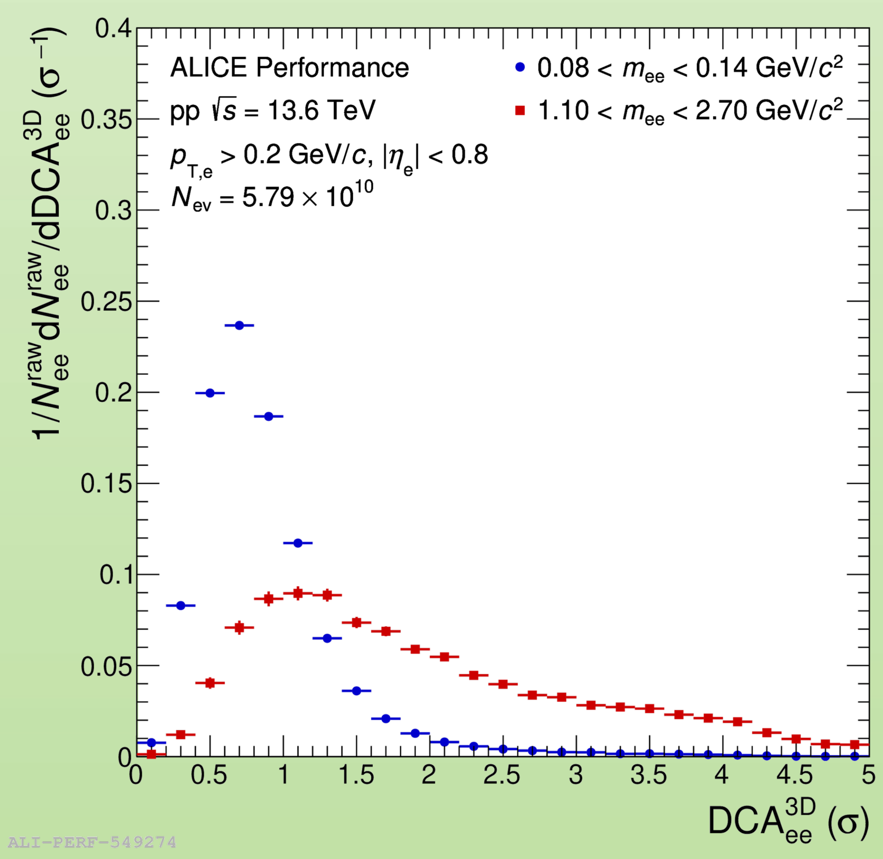


Better pointing resolution of ITS improves separation power between prompt and non-prompt sources.

Depending on the selected invariant mass, different *DCA* shapes can be observed.

Selecting small and large DCA_{ee} allows to show the contribution of light-flavour resonances and heavy-flavour decays.





Measurement of prompt and non-prompt contribution

To measure the contribution of prompt and non-prompt decays a template fit is performed in different mass intervals.

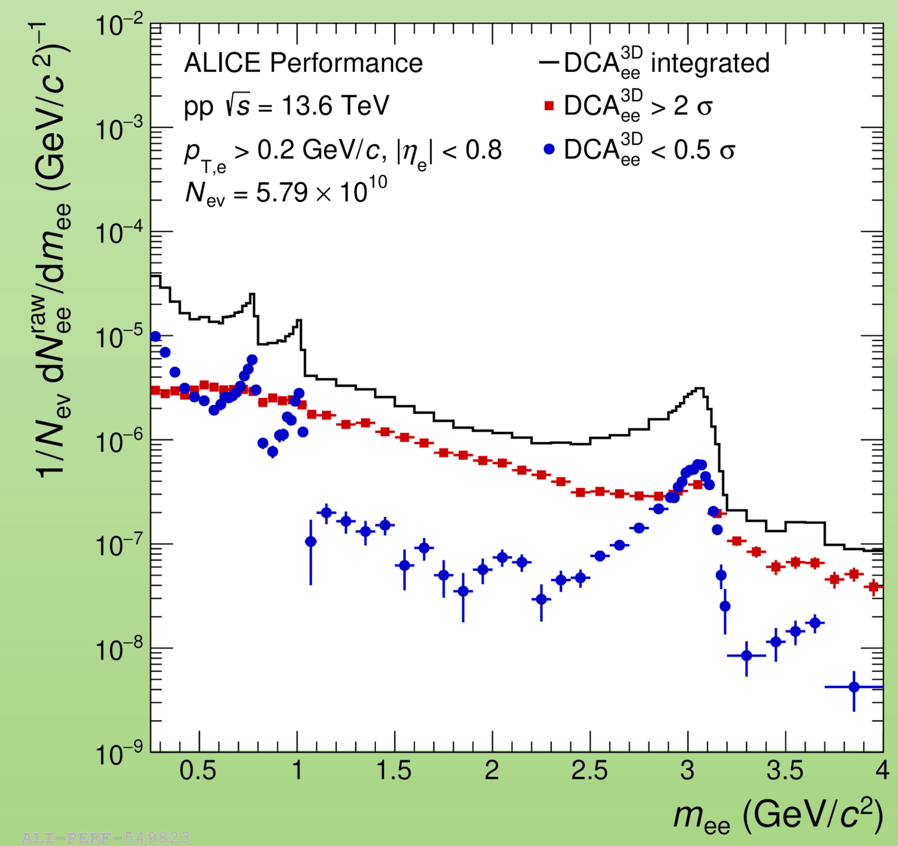
π^0 decays are used as prompt DCA_{ee} template,
D^0, $D^\pm$, D_s and Λ_c decays are used for charm template,
different decay channels of beauty hadrons used for beauty template.

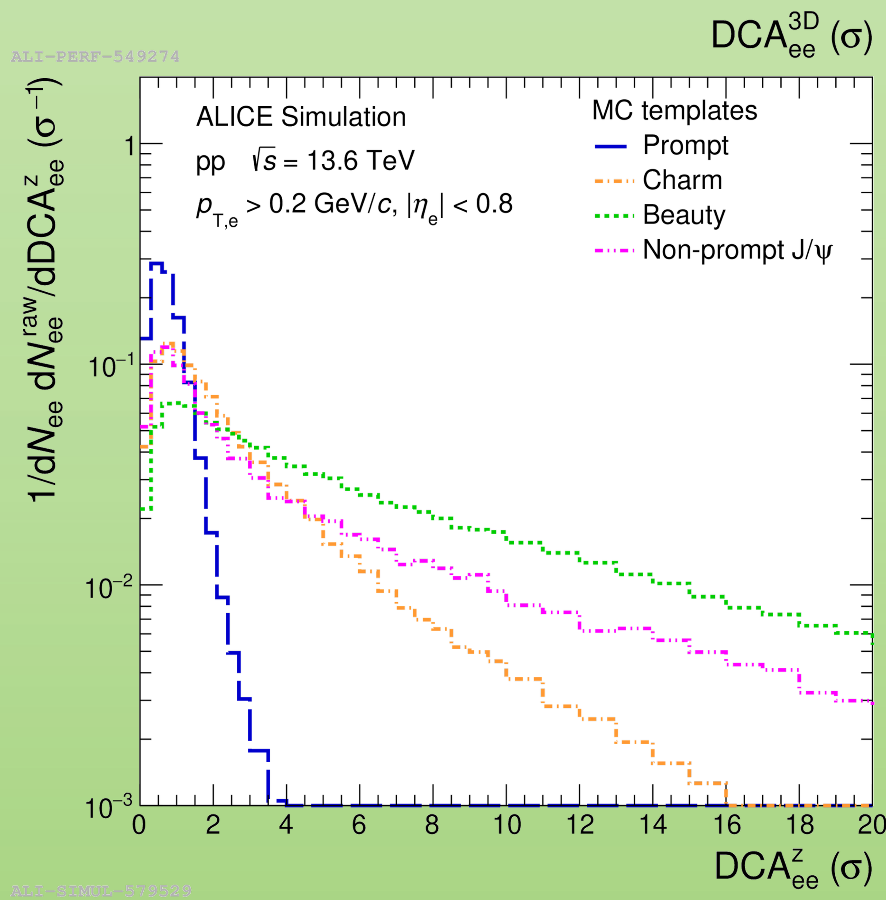
The contribution of charm and beauty hadron decays are combined into one heavy-flavour template using a mass dependent charm-to-beauty ratio from the dielectron measurement in pp collisions at $\sqrt{s}$ = 13 TeV from Run2 [3].

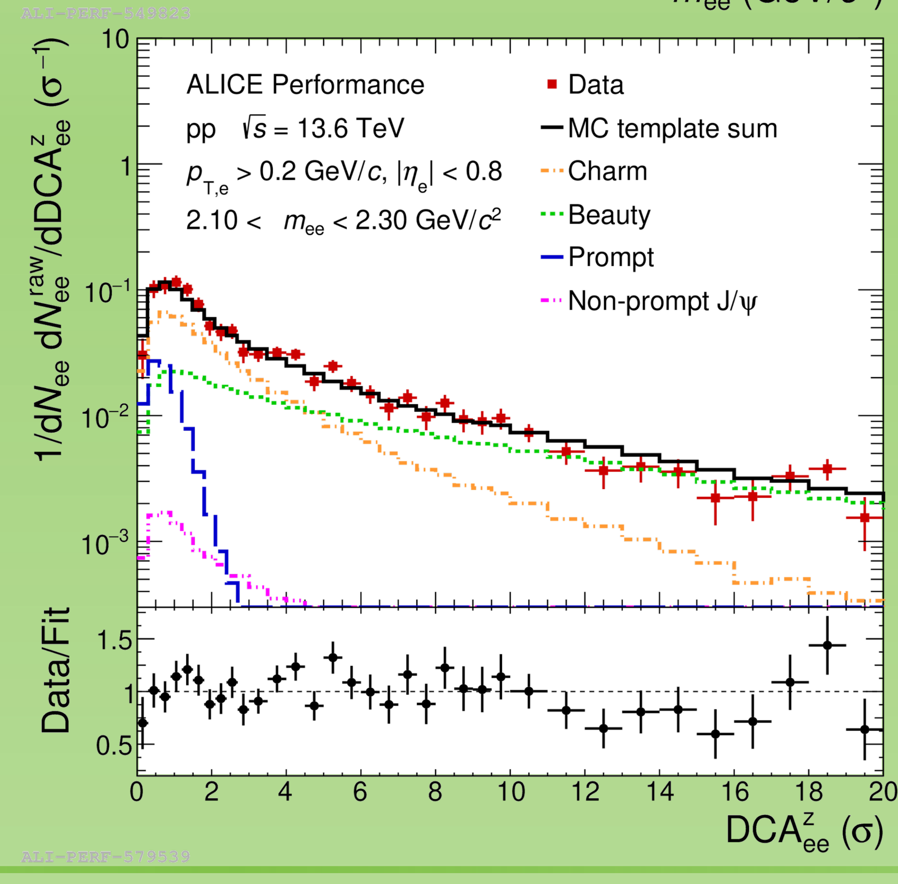
The prompt and heavy-flavour templates are scaled in each mass interval independently to data.

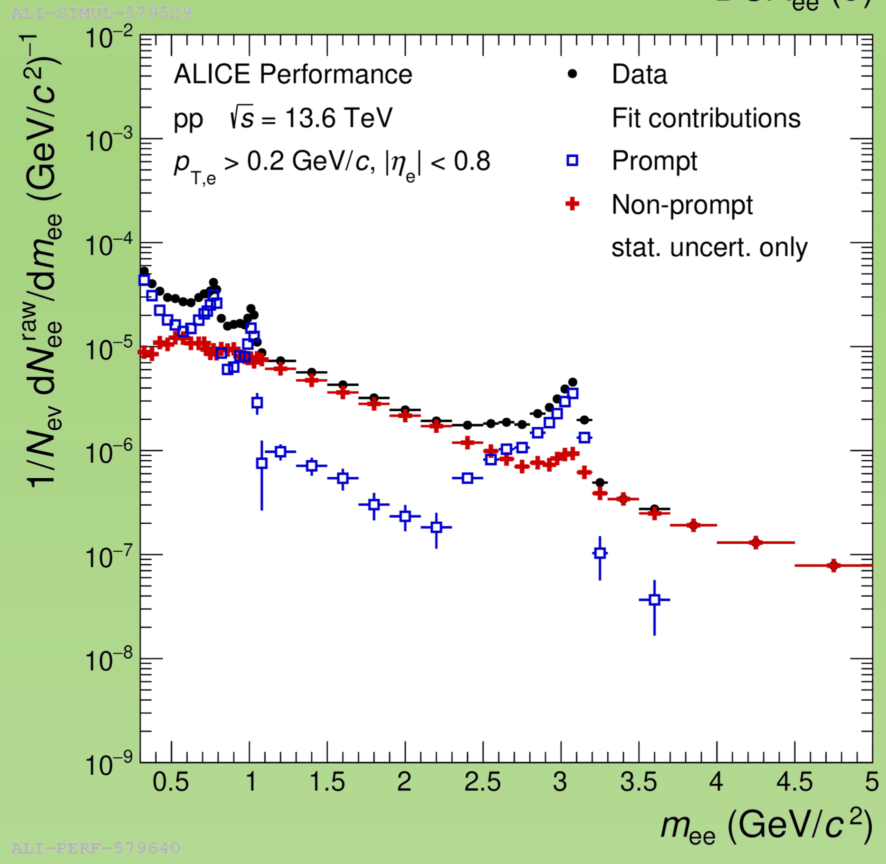
Each fit gives an estimate of the prompt and non-prompt contribution.

The precision and statistics of Run 3 allows to unfold the DCA_{ee} spectra.









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Stay tuned!

References:
[1] "Upgrade of the Inner Tracking System Conceptual Design Report", CERN-LHCC-2012-013
[2] „Upgrade of the ALICE Time Projection Chamber", CERN-LHCC-2013-020, CERN-LHCC-2015-002
[3] „Direct photon production at low transverse momentum in proton-proton collisions at s√ = 13 TeV", CERN-THESIS-2024-023