Dielectron production in pp collisions at $\sqrt{s}$ = 13 TeV measured in a dedicated low magnetic-field setting with ALICE

Jerome Jung[1] for the ALICE Collaboration

ALICE

Motivation

Electron-positron pairs are produced at all stages of the collision and are unaffected by strong interactions

→ Ideal penetrating probe to study the space-time evolution of the Quark-Gluon Plasma created in ultra-relativistic heavy-ion collisions

→ Understanding the primordial dielectron production in pp collisions crucial as vacuum baseline

Bulk of the dielectron yield is located at low momenta

→ Dedicated low-mass dielectron runs with a reduced current in the ALICE L3 solenoid magnet:

Magnetic field reduced from B = 0.5 T to 0.2 T

→ Overall charged-particle acceptance increased

→ Improve background rejection capabilities

→ Access to low-p_T particle production

Similar configuration planned for dielectron studies with ALICE in LHC Run 3 and 4

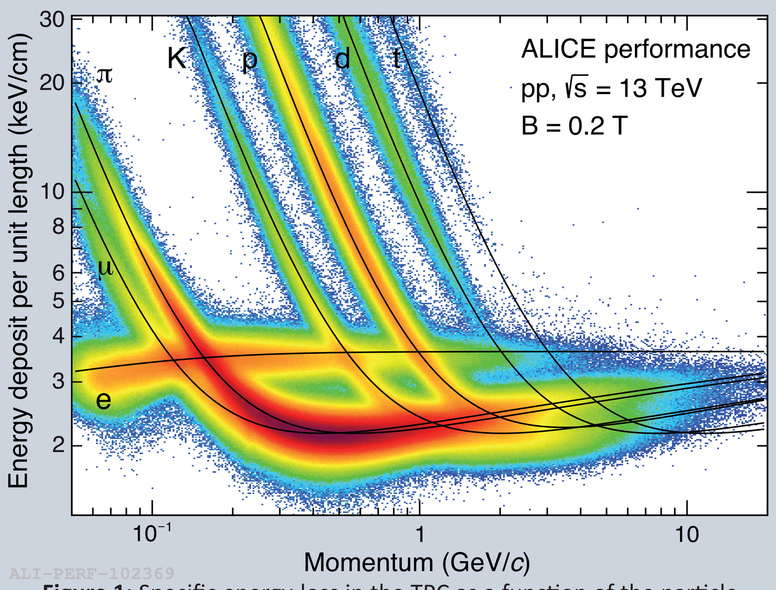


Figure 1: Specific energy-loss in the TPC as a function of the particle momentum for the low-field configuration.

LMR excess at AFS

AFS: low-mass region (LMR)

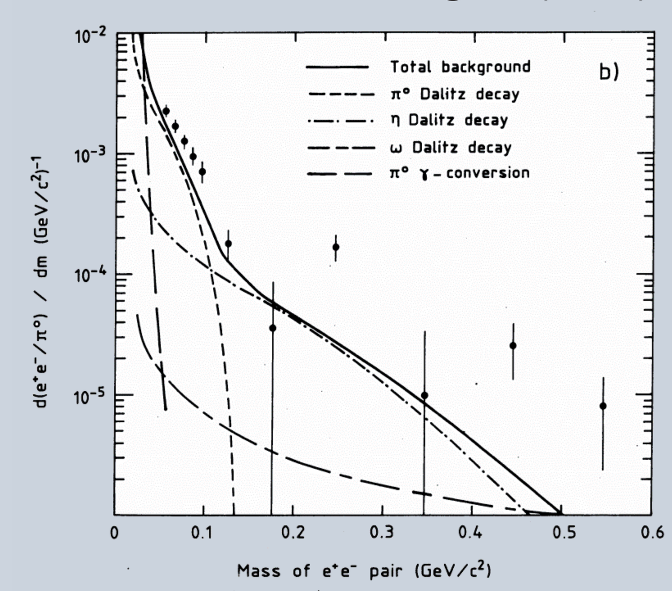


Figure 2: Mass distribution of dielectrons after the subtraction of the combinatorial background as a function of the pair mass measured by the AFS experiment [1].

Intersecting Storage Rings (CERN, 1987):
Excess of dielectrons over expectation from known hadronic sources measured by the AFS experiment in pp collisions at $\sqrt{s}$ = 63 GeV:

- $0.05 < m_{ee} < 0.6$ GeV/c^2
- $p_{T,ee} < 1$ GeV/c

with a single-electron trigger $p_{T,e1} > 0.2$ GeV/c and the requirement on the second electron $p_{T,e2} > 0.04$ GeV/c

The low-field configuration provides the possibility to probe a similar regime and allows a complementary measurement for the first time at LHC energies

Analysis

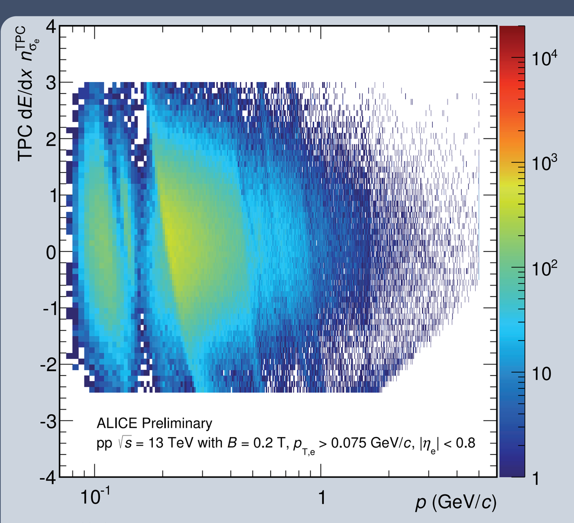


Figure 3: Specific energy-loss of electron candidates in the TPC as a function of their momentum after all cuts.

Electron identification:

Electron 3σ selection using Time Projection Chamber (TPC) & Time Of Flight (TOF) if available
+ 3σ hadron rejection in the dE/dx of TPC
+ TOF information to recover electron candidates

→ Similar electron purity but higher electron selection efficiency compared to requiring TOF, down to a momentum of 0.075 GeV/c

Signal Extraction:

Combinatorial pairing of all candidates:

- Unlike-sign (*ULS*) pairs: real signal, correlated & combinatorial background
- Like-sign (*LS*) pairs: correlated & combinatorial background

→ Signal S = $ULS - LS \cdot R$

R: Acceptance correction factor $R = ULS_{mix} / LS_{mix}$

→ Small S/B ratio: crucial to improve it

→ Main background source: electrons from γ conversions in the detector material

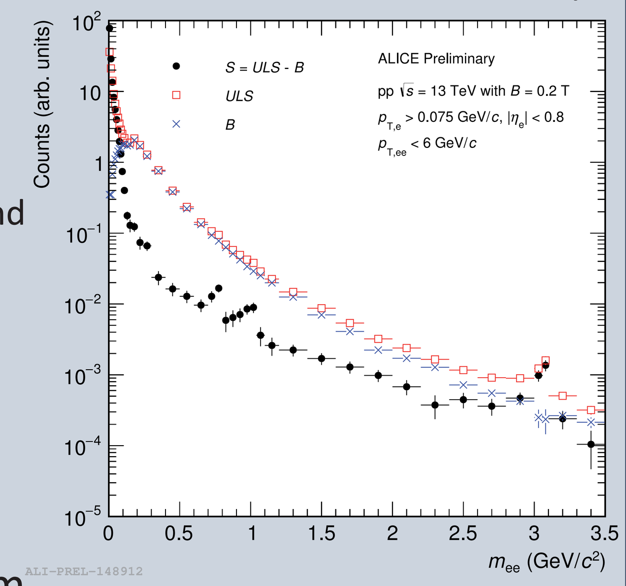
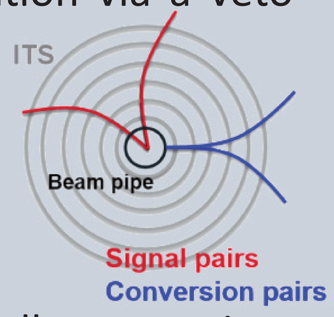


Figure 4: Illustration of the like-sign subtraction method. The unlike-sign pairs are shown in red, the like-sign in blue and the resulting signal in black.

Comparison to nominal field

Advantages of the low-field configuration:

Improved performance of conversion rejection in low magnetic-field configuration via a veto on shared clusters in the ITS in combination with an increased TOF acceptance at low momenta lead to:



- Clear improvement in S/B in all mass regions
- Boost in significance per event

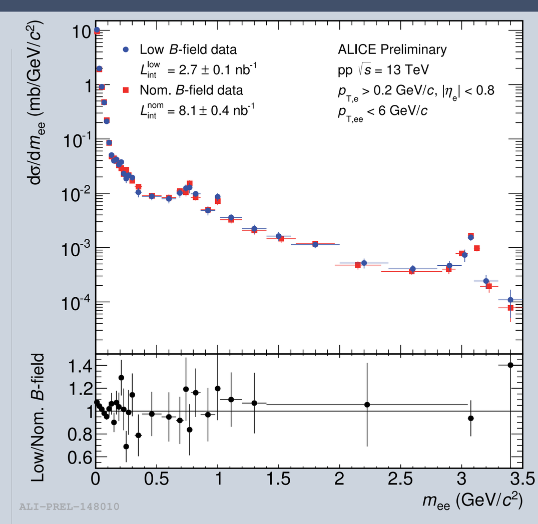


Figure 7: Comparison of the dielectron cross-section as a function of m_{ee} with a single-leg p_T-cut of 0.2 GeV/c from this analysis to results from [2].

Corrected Spectra:

- Nominal [2] and low-field analyses agree within statistical uncertainties
- Effect of low-field configuration on the resolution small

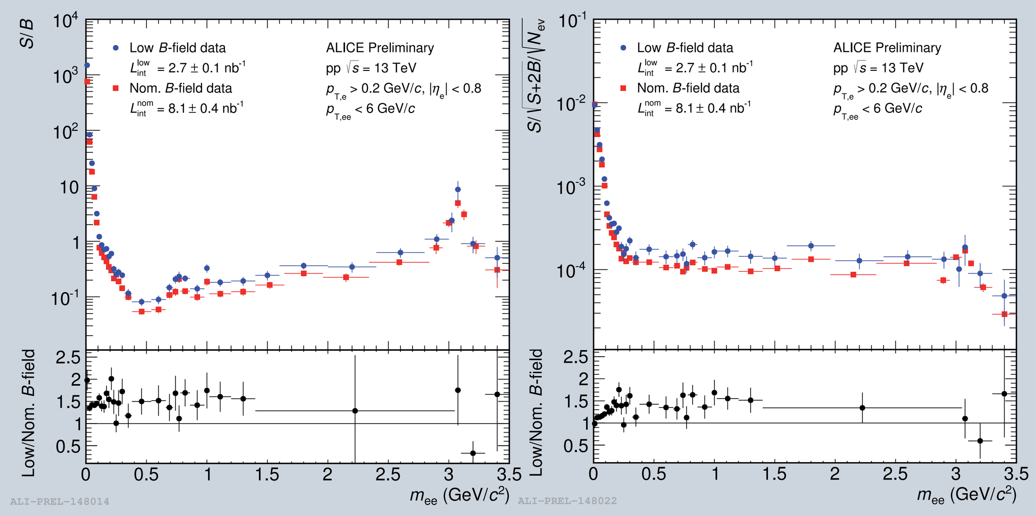


Figure 5 & 6: Comparison of two cut settings with ITS shared cluster cut, one in the low-field environment from this analysis (red) and one in nominal field [2] (blue), to illustrate the effect of the magnetic field on the ITS shared cluster cut in signal over background and significance.

For the first time in ALICE the low-field configuration enables a lower single-leg p_T cut of 0.075 GeV/c

→ Extend acceptance for small m_{ee} and $p_{T,ee}$

→ Increase sensitivity for soft virtual-photon production

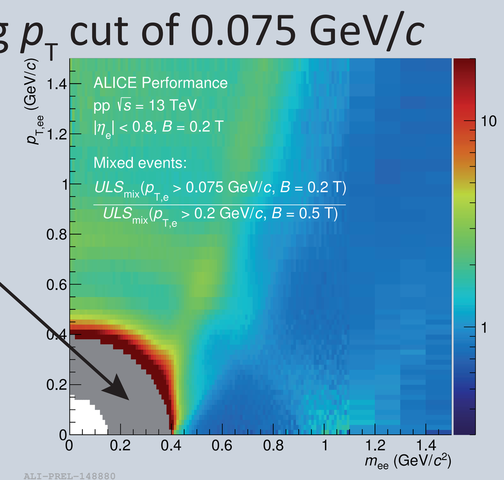


Figure 8: Acceptance gain as a function of m_{ee} and $p_{T,ee}$ due to the lower single-leg p_T-cut and increased TOF acceptance at low momenta.

Comparison to AFS

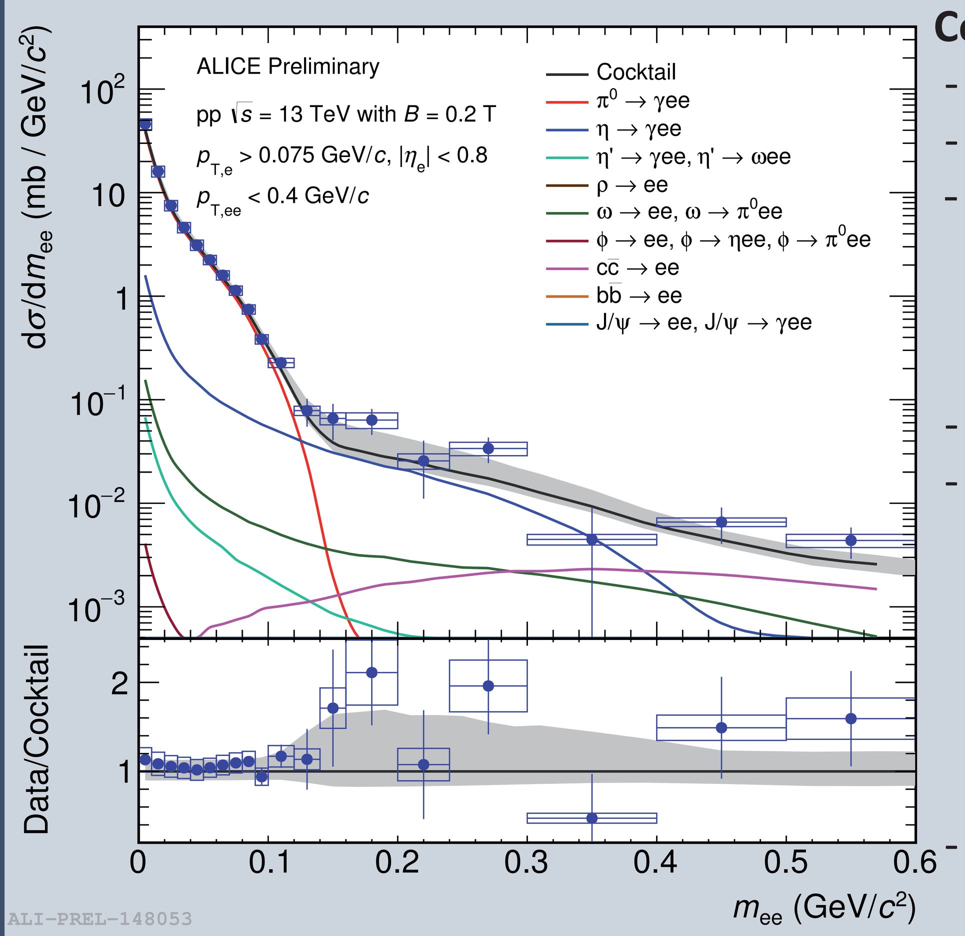


Figure 9: The dielectron cross-sectrion in pp collisions at $\sqrt{s}$ = 13 TeV as a function of m_{ee} for $p_{T,ee} < 0.4$ GeV/c with a single-leg cut $p_T < 0.075$ GeV/c (blue points) compared to the hadronic cocktail (black line) and its different contributions (colored lines). The bottom panel shows the ratio of data over cocktail.

Cocktail of know hadronic sources:

- π^0 based on 13 TeV $\pi^{\pm}$ measurement [3]
- η from measured ratio of η/π^0 [4,5]
- ρ and ω based on ρ/π^0 and ω/π^0 parametrisations from PYTHIA8 Monash-13 and compatible with measurements [6,7]
- η' and ϕ are derived from m_T scaling
- Open charm and beauty generated with PYTHIA6 Perugia2011 scaled to the cross section at 13 TeV via FONLL extrapolation based on the 7 TeV measurement [8,9]
  $((d\sigma_{cc}/dy)|_{y=0}$ = 1.296±0.17 mb at 13 TeV)
  $((d\sigma_{bb}/dy)|_{y=0} = 68.1^{+15}_{-16}$ μb at 13 TeV)
- ***J/ψ*** measured at 7 TeV [10] and extrapolated to 13 TeV like open heavy flavours
  $((d\sigma_{J/\psi}/dy)|_{y=0} = 9.55^{+1.54}_{-1.57}$ μb at 13 TeV)

Hint for enhancement at LHC energies in the mass region $0.14 < m_{ee} < 0.6$ GeV/c^2

→ 2.2σ statistical significance, ignoring systematic uncertainties on data and cocktail

Conservative approach: cocktail uncertainty of η derived from m_T scaling conjecture

→ Overpredicts η yield especially at low p_T (low-p_T η from CERES-TAPS at lower $\sqrt{s}$)

Pair momentum dependence

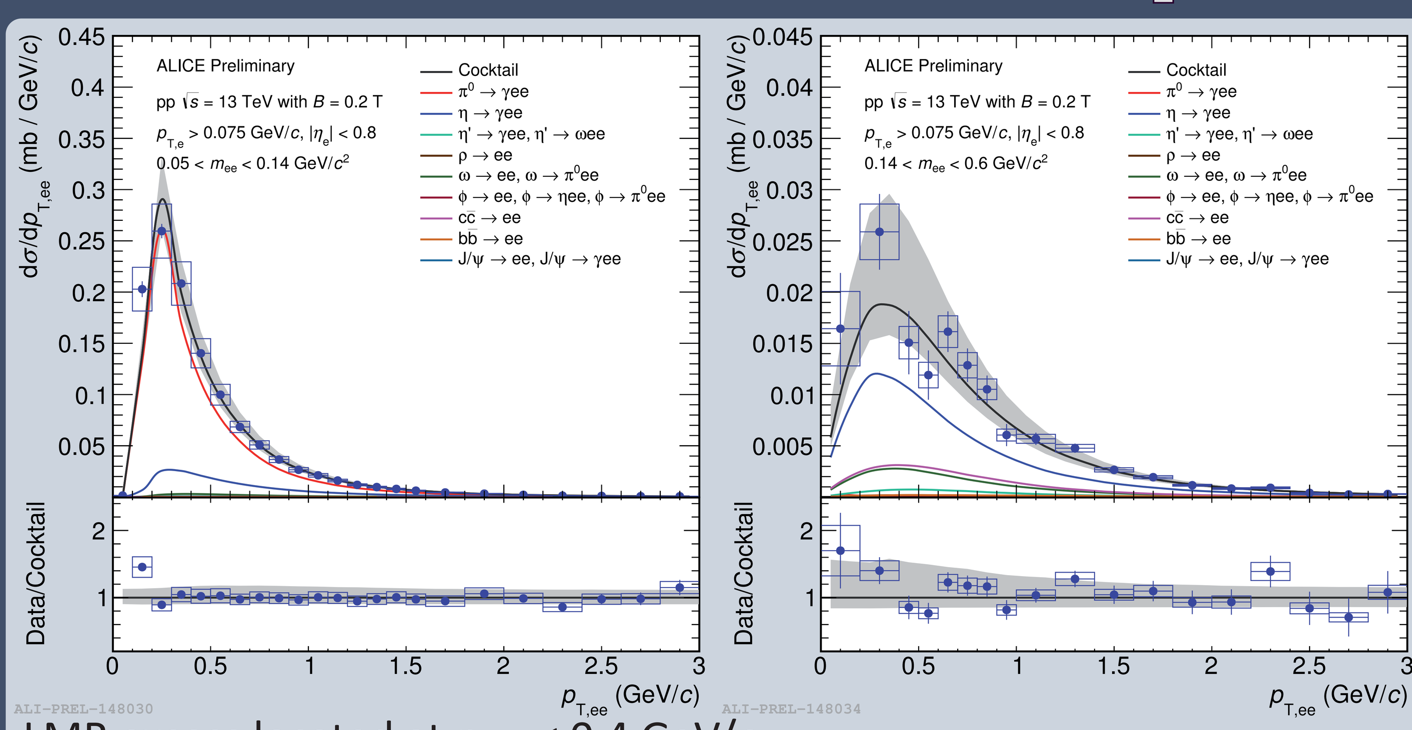


Figure 10 & 11: The dielectron cross section in pp collisions at $\sqrt{s}$ = 13 TeV as a functionas $p_{T,ee}$ in the π and LMR excess region (blue points) compared to the hadronic cocktail (black line) and its different contributions (colored lines). The bottom panel shows the ratio of data over cocktail.

LMR excess located at $p_{T,ee} < 0.4$ GeV/c

→ Low-field configuration crucial to probe this region

→ More low B-field data underway

→ A low-p_T η measurement at LHC energies essential to quantify a possible enhancement

Outlook

- Data significance will be increased with 2018 low-field data sample
- Study multiplicity dependence of LMR excess
- Improve η measurement to reduce systematic uncertainties of the hadronic cocktail

[1] V. Hedberg, *Production of Positrons with low transverse momentum and low-mass electron-positron pairs in proton-proton collisions at a center-of-mass energy of 63 GeV*, PhD thesis, Lund (1987)
[2] I. Vorobyev for the ALICE collaboration, poster at this conference (ID 239), paper on arXiv: 1805.
[3] ALICE, *Production of light flavor hadrons in pp collisions at √s = 13 TeV*, in preparation
[4] ALICE, *Neutral pion and eta meson production in proton-proton collisions at √s = 0.9 TeV and √s = 7 TeV*, Phys. Lett. **B717** (2012) 162
[5] ALICE, *Neutral pion and η meson production in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV*
[6] ALICE, *Production of the ρ(770)⁰ meson in pp and Pb–Pb collisions at √sNN = 2.76 TeV, in preparation*
[7] ALICE, *ω production measurement in th $\pi^0\pi^+\pi^-$ decay channel in pp collisions at √s = 7 TeV with ALICE*, public note in preparation
[8] ALICE, Measurement of D-meson production at mid-rapidity in pp collisions at √s = 7 TeV, Eur. Phys. J. C77 (2017) 550
[9] LHCb, *Measuremnt of J/ψ production in pp collisions at √s = 7 TeV*, Eur. Phys. J. **C71** (2011) 1645
[10] ALICE, *Rapidity and transverse momentum dependence of inclusive J/ψ production in pp collisions at √s = 7 TeV*, Phys. Lett. **B704** (2011) 442 [Erratum: Phys. Lett. **B718** (2012) 692]

GOETHE UNIVERSITÄT FRANKFURT AM MAIN · IKF Institut für Kernphysik Frankfurt · EMMI · 2018 Quark Matter Venezia

May 15th 2018

[1]jung@ikf.uni-frankfurt.de
IKF, Goethe-Universität Frankfurt