Dielectron production in proton–proton collisions at $\sqrt{s}$ = 7 TeV with ALICE

Sebastian Scheid[1] for the ALICE Collaboration

Motivation

Dielectrons are produced in all stages of the collision and have negligible final-state interaction

→ Excellent probe to study QGP properties in AA collisions

In pp collisions:

→ Baseline for Pb–Pb collisions

→ Direct photon production via γ* → e^+e^-

→ Study heavy-flavour production

Approach:

→ Measure dielectron cross section as a function of m_{ee}, $p_{T,ee}$ and DCA_{ee}

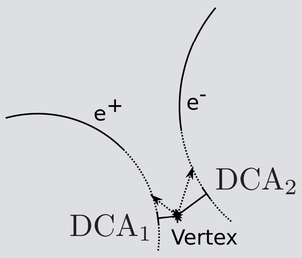
→ Compare to expectation from known hadronic sources (hadronic cocktail)

Idea:

Decay length of D and B mesons much larger than prompt sources

→ Use DCA_{ee} to separate prompt and non-prompt dielectrons

$$\mathrm{DCA_{ee}} = \sqrt{[(\mathrm{DCA_1}/\sigma_1)^2 + (\mathrm{DCA_2}/\sigma_2)^2]/2}$$



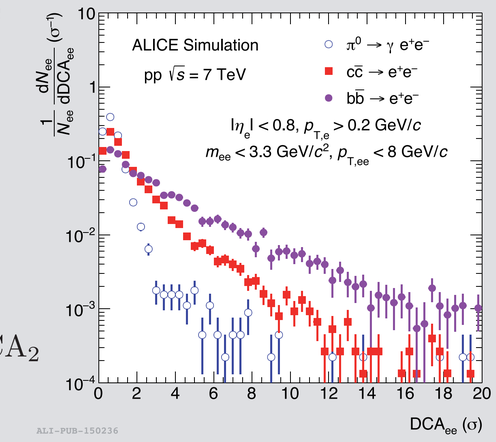


Figure 1: DCA_{ee} distribution of e^+e^- pairs from π^0 Dalitz decays and from semileptonic decays of charm and beauty hadrons simulated with PYTHIA 6.4.25 and passed through a GEANT3 simulation of the ALICE detector. The spectra are integrated over m_{ee} and $p_{T,ee}$ and normalised to unity for comparison.

Hadronic Cocktail

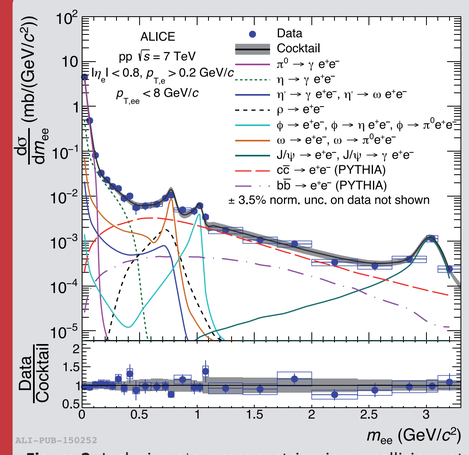


Figure 2: Inclusive e^+e^- cross sectrion in pp collisions at $\sqrt{s}$ = 7 TeV in the ALICE acceptance as function of m_{ee} compared with the hadronic cocktail.

Estimate of dielectron yield from known hadronic sources

Ingredients:

→ p_T spectra ($\pi^{\pm}$, η, ϕ, J/ψ)[1-5]

→ PYTHIA 8 Monash-2013 (ω ,ρ)

→ Assume m_T-scaling for η´

→ PYTHIA 6 Perugia-2011 (+POWHEG) scaled to measured cross section for charm and beauty [6,7]

→ Branching ratios [8]

→ Parameterised detector resolution and energy loss from Bremsstrahlung

→ Fiducial acceptance ($|\eta| < 0.8$ and $p_T > 0.2$ (0.4) GeV/c)

Cocktail estimation consistent with data within uncertainties

Comparison of Data and Hadronic Cocktail

Pion-mass region

$m_{ee} < 0.14$ GeV/c^2

$p_{T,ee}$

→ Dielectron measurement in agreement with charged-pion measurement

DCA_{ee}

→ Only prompt sources expected

→ DCA_{ee} defined by the detector resolution

→ Good description over three orders of magnitude

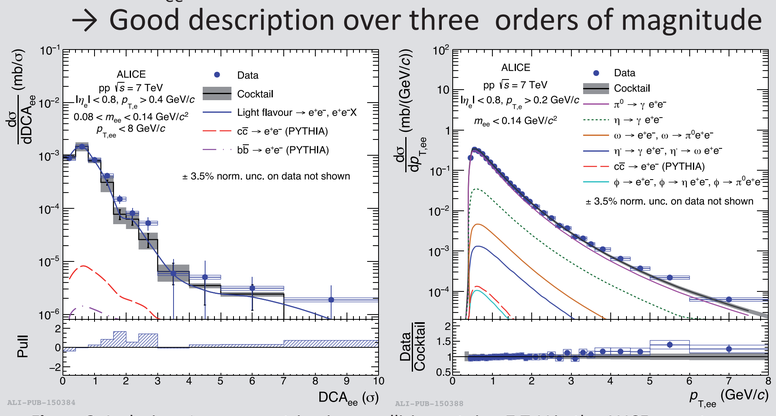


Figure 3: Inclusive e^+e^- cross sectrion in pp collisions at $\sqrt{s}$ = 7 TeV in the ALICE acceptance as function of DCA_{ee}(left) and $p_{T,ee}$(right) for $0.08 < m_{ee} < 0.14$ GeV/c^2 and $m_{ee} < 0.14$ GeV/c^2 respectively. Both are compared with the hadronic cocktail.

Resonance mass region

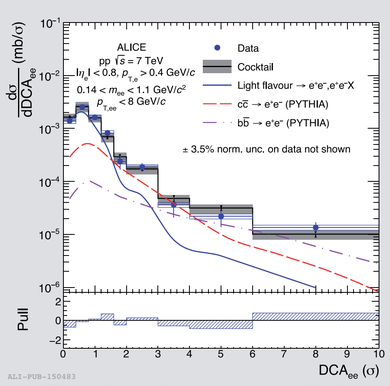
$0.14 < m_{ee} < 1.1$ GeV/c^2

Heavy flavour (HF) contribution already dominates for $m_{ee} > 0.7$ GeV/c^2

→ **Prompt and non-prompt sources can be separated via DCA_{ee}**

→ Useful in Pb–Pb collisions to measure thermal QGP radiation in the intermediate mass region (IMR)

→ DCA_{ee} resolution improvement in RUN3 after the ITS upgrade



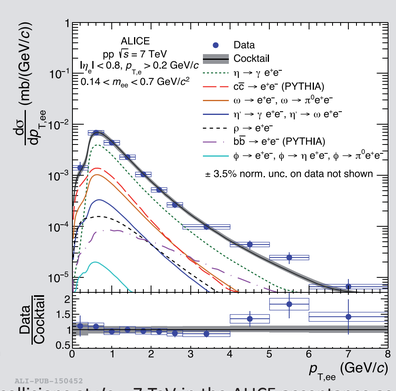


Figure 4: Inclusive e^+e^- cross sectrion in pp collisions at $\sqrt{s}$ = 7 TeV in the ALICE acceptance as function of DCA_{ee}(left) and $p_{T,ee}$(right) for $0.14 < m_{ee} < 1.1$ GeV/c^2 and 0.14 $m_{ee} < 0.7$ GeV/c^2 respectiveley. Both are compared with the hadronic cocktail.

Intermediate mass region

$1.1 < m_{ee} < 2.7$ GeV/c^2

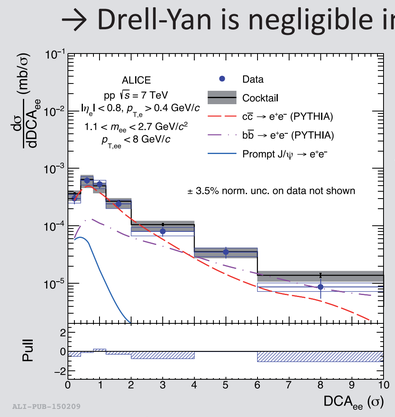
Charm dominates at low $p_{T,ee}$ (< 3 GeV/c) and small DCA_{ee}

Beauty dominates for high $p_{T,ee}$ (> 3.5 GeV/c) and large DCA_{ee}

→ Disentangle their contributions by fitting templates to data points

→ No indication for prompt dielectron source

→ Drell-Yan is negligible in the IMR at LHC energies



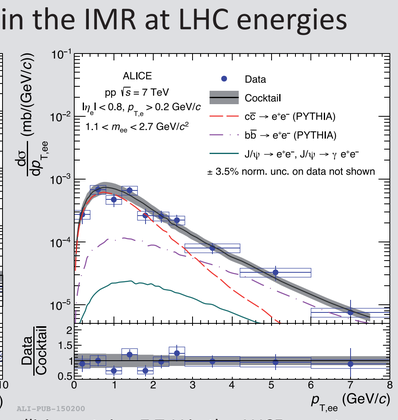


Figure 5: Inclusive e^+e^- cross sectrion in pp collisions at $\sqrt{s}$ = 7 TeV in the ALICE acceptance as function of DCA_{ee}(left) and $p_{T,ee}$(right) for $1.1 < m_{ee} < 2.7$ GeV/c^2. Both are compared with the hadronic cocktail.

Direct Photon Extraction

Direct photon measurement via γ*→ e^+e^- can reduce background from π^0 →γγ drastically

→ Fit mass spectrum in $0.09 < m_{ee} < 0.39$ GeV/c^2 in $p_{T,ee}$ intervals with one free parameter r:

$$f(m_{ee}) = r \times f_{dir}(m_{ee}) + (1 - r) \times f_{LF}(m_{ee}) + f_{HF}(m_{ee})$$

r ratio of direct to inclusive photons

f_{dir} e^+e^- from direct photons, mass shape obtained from Kroll-Wada equation (QED)

$f_{LF/HF}$ e^+e^- from light- or heavy-flavour sources

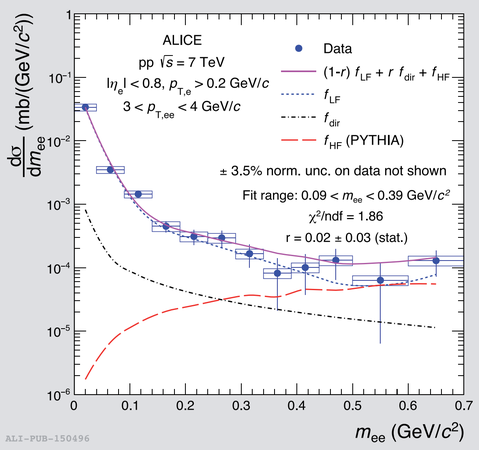


Figure 6: Fit of e^+e^- cross section in $\sqrt{s}$ = 7 TeV in the ALICE acceptance as a function of mee in the range $3 < p_{T,ee} < 4$ GeV/c with a three-component function.

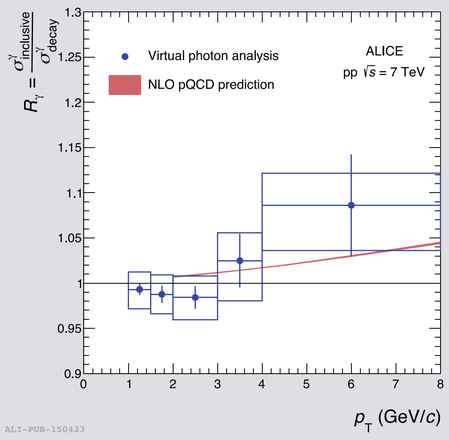


Figure 7: Ratio of inclusive to decay photon cross sections extracted from the dielectron spectra measured in pp collisions at $\sqrt{s}$ = 7 TeV compared with NLO pQCD calculations[8].

Calculate R_γ from r:

$$R_\gamma = 1/(1 - r) = 1 + N_{\gamma,dir}/N_{\gamma,decay} = N_{\gamma,inclusive}/N_{\gamma,decay}$$

→ Results in agreement with unity, no significant direct photon contributions

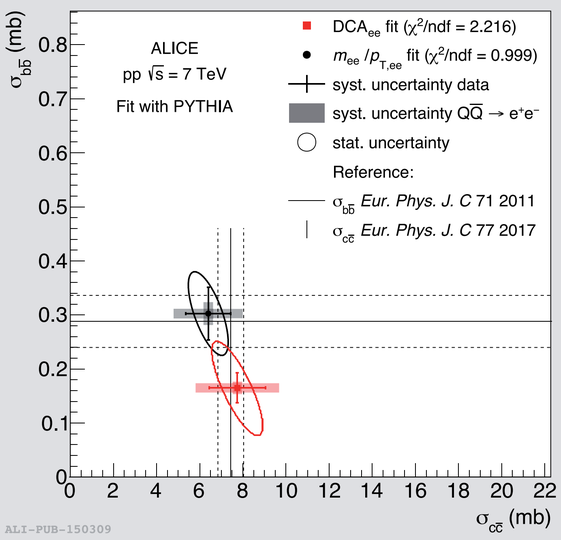
→ Consistent with a small direct photon fraction as predicted by pQCD[9] within large uncertainties

Heavy Flavour Cross Sections

Extract $\sigma_{c\bar{c}}$ and $\sigma_{b\bar{b}}$ by fitting $d\sigma/(dm_{ee}\, dp_{T,ee})$ and $d\sigma/dDCA_{ee}$ in the IMR with $c\bar{c}$ and $b\bar{b}$ templates from PYTHIA (LO) and POWHEG (NLO) with PYTHIA parton shower

→ Large model dependence observed

→ Sensitivity to different implementations of heavy-quark production [Poster, ID 879]



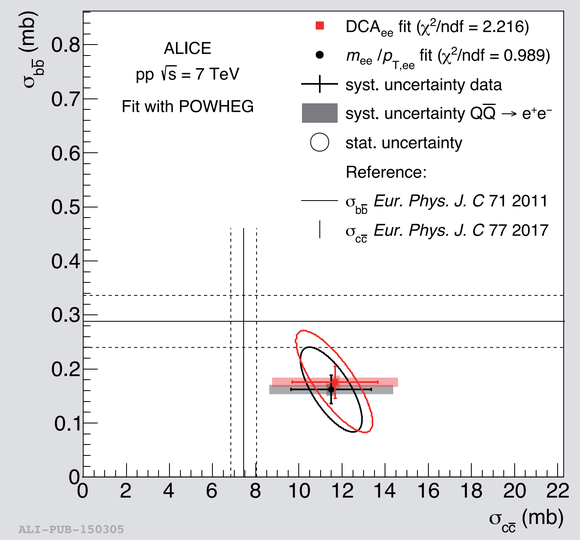


Figure 8: Total $c\bar{c}$ and $b\bar{b}$ cross sections extracted from a fit of the measured dielectron yield from heavy-flavour hadron decays in (m_{ee}, $p_{T,ee}$) and in DCA_{ee} with PYTHIA (left) and POWHEG (right). The results and their uncertainties are compared to published cross sections (solid lines), for which the total uncertainty is represented in dashed lines.

Paper on arXiv:

[1] ALICE, *Multiplicity dependence of charged pion, kaon and (anti)proton productionat large transverse momentum in pPb at $\sqrt{s_{NN}}$ = 5.02 TeV*, Phys. Lett **B760** (2016) 720

[2] ALICE, *Neutral pion and eta meson production in proton-proton collisions at $\sqrt{s}$ = 0.9 TeV and $\sqrt{s}$ = 7 TeV*, Phys. Lett. **B717** (2012) 162

[3] ALICE, *Production of $K^*(892)^0$ and ϕ(1020) in pp collisions at $\sqrt{s}$ = 7TeV*, Eur. Phys. J. **C72** (2012) 2183

[4] ALICE, *ω production measurement in th $\pi^0\pi^+\pi^-$ decay channel in pp collisions at $\sqrt{s}$ = 7 TeV with ALICE*,

[5] ALICE, *Rapidity and transverse momentum dependence of inclusive J/ψ production in pp collisions at $\sqrt{s}$ = 7 TeV*, Phys. Lett. **B704** (2011) 442 [Erratum: Phys. Lett. **B718** (2012) 692]

[6] ALICE, *Measurement of D-meson production at mid-rapidity in pp collisions at $\sqrt{s}$ = 7 TeV*, Eur. Phys. J. **C77** (2017) 550

[7] LHCb, *Measuremnt of J/ψ production in pp collisions at $\sqrt{s}$ = 7 TeV*, Eur. Phys. J. **C71** (2011) 1645

[8] Particle Data Group, *Review of Particle Physics*, Chin. Phys. **C40** (2016)

[9] L. Gordon and W. Vogelsang, *Polarized and unpolarized prompt photon production beyond the leading order*, Phys. Rev. **D48** (1993) 3136

May 15th 2018

[1]scheid@ikf.uni-frankfurt.de

IKF, Goethe-Universität Frankfurt