Dielectron Production in Pb-Pb Collisions at $\sqrt{s_{NN}} = 5.02$ TeV with ALICE

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Motivation

The ALICE experiment at the CERN-LHC was designed to understand the properties of the quark-gluon plasma (QGP) produced in ultrarelativistic heavy-ion collisions. The production of electron-positron pairs (dielectrons) is suitable to probe the QGP. Dielectrons only interact electromagnetically and are therefore not affected by the strong force in the hot and dense QGP matter. They are produced in all stages of the collision and consequently give access to the complete space-time evolution of the system. Dielectron measurements in Pb-Pb collisions can be used to extract the temperature of the QGP and allows studying in-medium modifications of the ρ-meson which are associated to a predicted chiral-symmetry restoration.

The analysed data set consists of Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV recorded in 2015 with 100M events integrated over centrality.

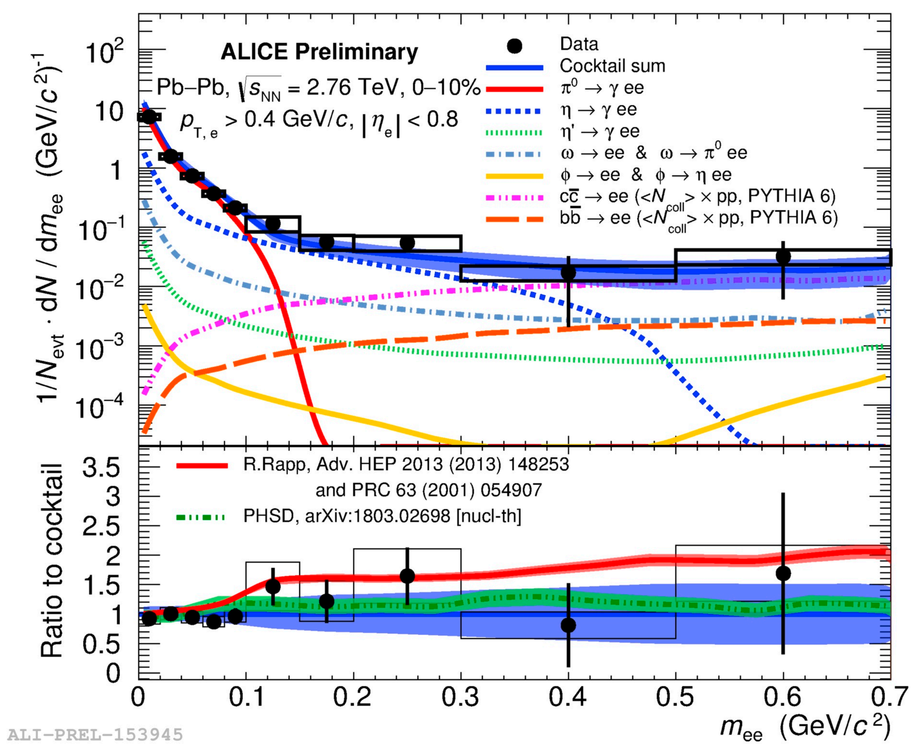


Fig. 1: Dielectron invariant mass spectrum compared to hadronic cocktail and predictions from many-body theory [1] for 10% most central collisions. Data was taken in 2011 and consists of ~19 M events with a fiducial selection of $p_{T,e} > 0.4$ GeV/c for electrons.

Electron Identification

Electrons are selected via their specific energy loss in the Inner Tracking System (ITS), in the Time Projection Chamber (TPC) and using time-of-flight (TOF) information. Pions are rejected with the TPC dE/dx. A mean purity of 90% dependent on the momentum can be achieved. For systematic studies another electron identification scheme with higher purity but smaller efficiency is investigated.

$$-3.5 < n^{ITS}_{\sigma_{ele}} < 0.5$$
$$-3 < n^{TPC}_{\sigma_{ele}} < 2$$
$$-4.5 < n^{TPC}_{\sigma_{\pi}}$$
$$|n^{TOF}_{\sigma_{ele}}| < 3.0$$

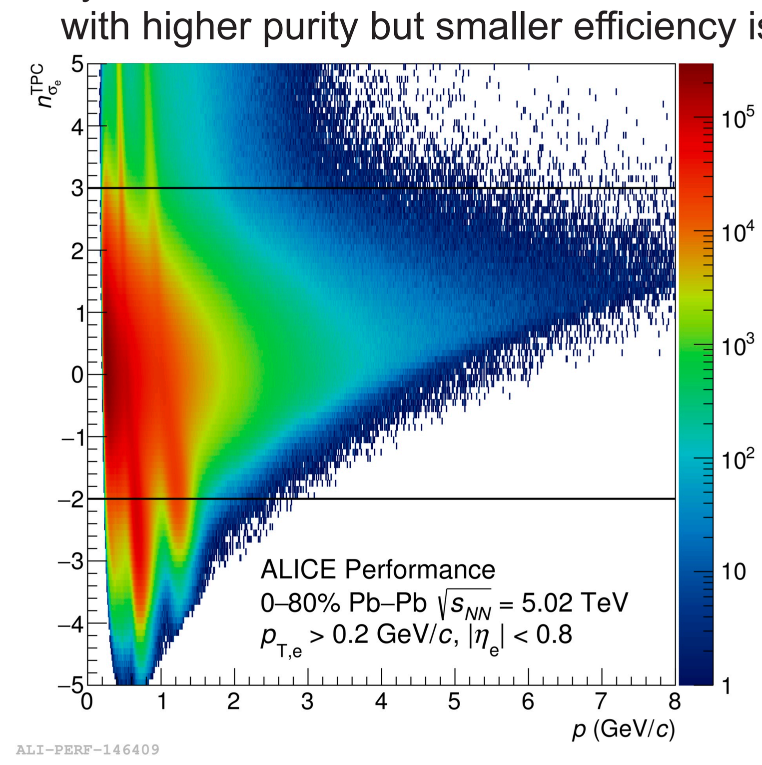


Fig. 2: Electron candidates as function of momentum after ITS and TOF selection.

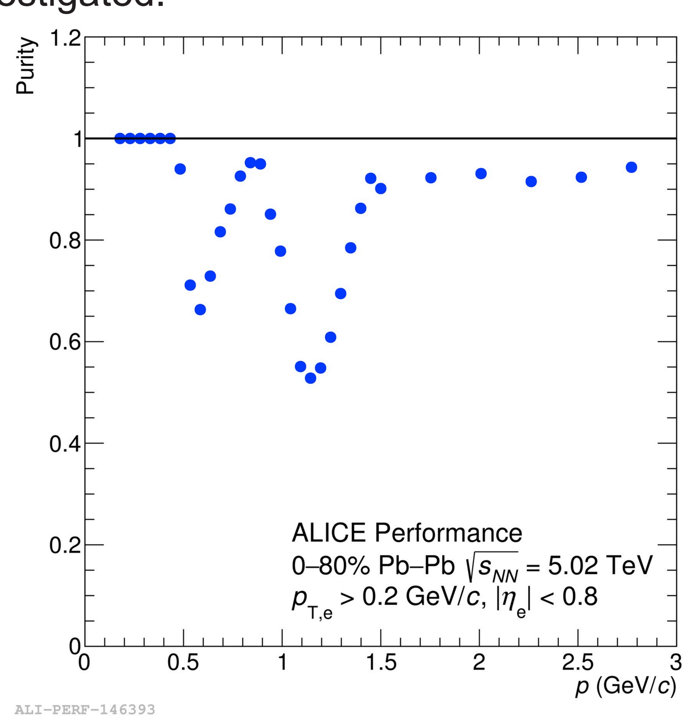
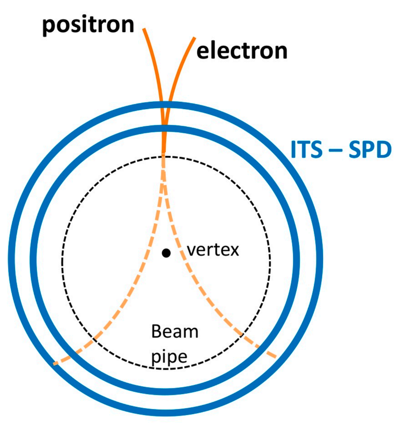
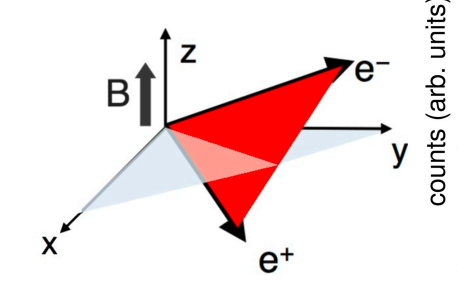


Fig. 3: Electron purity as function of momentum obtained from data.

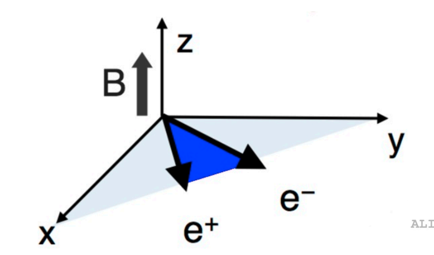
Conversion Rejection

Dielectrons from photon conversions have negligible mass and originate mainly from the beam pipe. Because of their small opening angle they often share a cluster in the first silicon layer of the ITS. A strict rejection of tracks which have at least one shared cluster leads to a suppression of conversion pairs by 98%. Residual dielectrons from photon conversions can be identified via their orientation relative to the magnetic field φ_V.

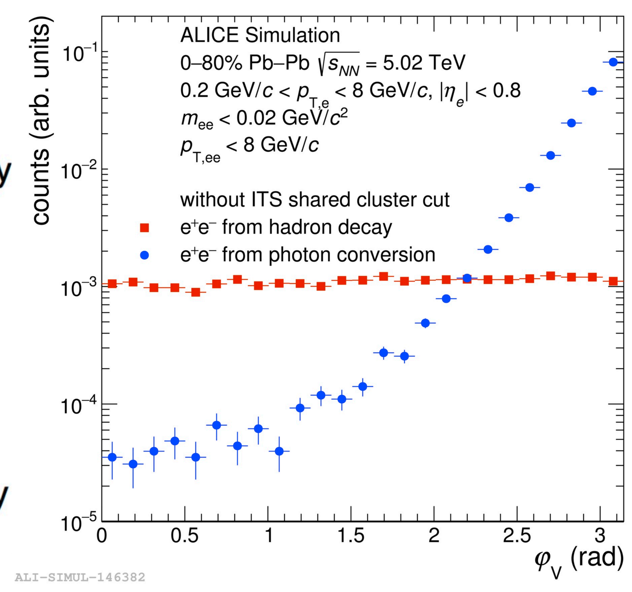




e⁺e⁻ from light-flavour decay



e⁺e⁻ from photon conversion



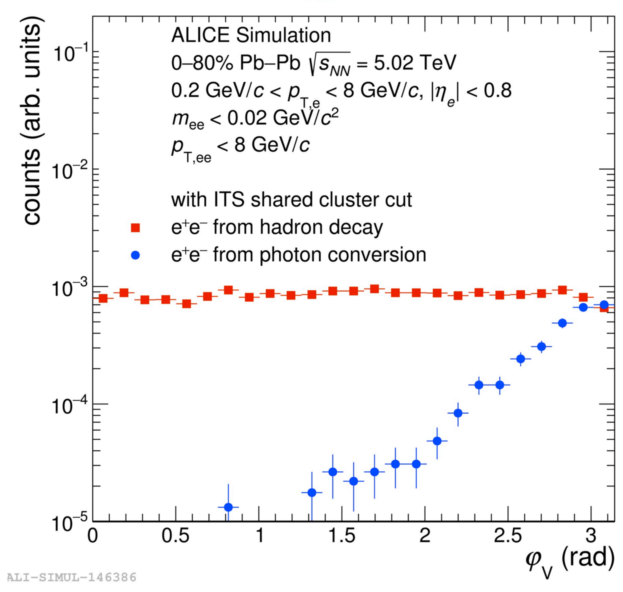
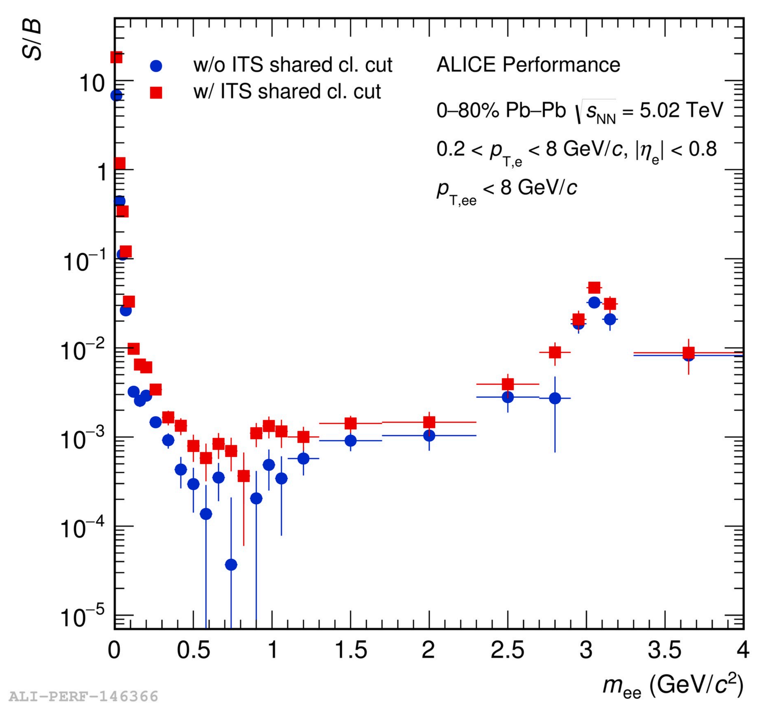


Fig. 5 & 6: φ_V distribution for dielectrons from prompt signal (red) and from photon conversions (blue). Dielectrons from photon conversion can be suppressed by 98%.



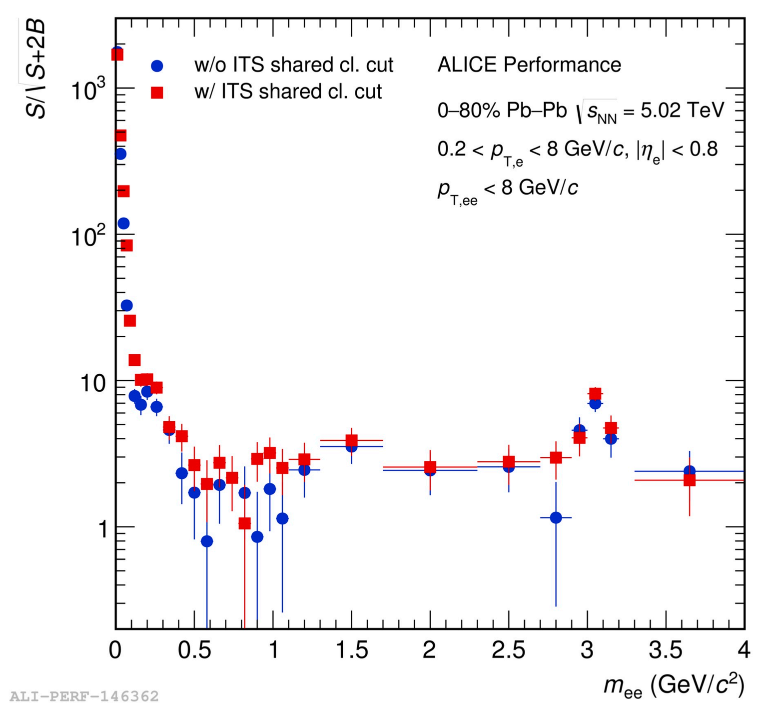


Fig. 7 & 8: Shared cluster cut (red) leads to an improved S/B by a factor of ~2 and an improved significance by a factor of ~1.4.

Signal Extraction

Signal is calculated via subtracting background B from the unlike-sign spectrum ULS:

$$S = ULS - B$$

Combinatorial background B is estimated with geometric mean of same-event like-sign distribution:

$$B = R \cdot 2 \cdot \sqrt{N_{++}N_{--}}$$

Acceptance correction factor from mixed events:

$$R = \frac{M_{+-}}{2 \cdot \sqrt{M_{++}M_{--}}}$$

S/B of ~1/1000 makes it crucial to reduce combinatorial pairs.

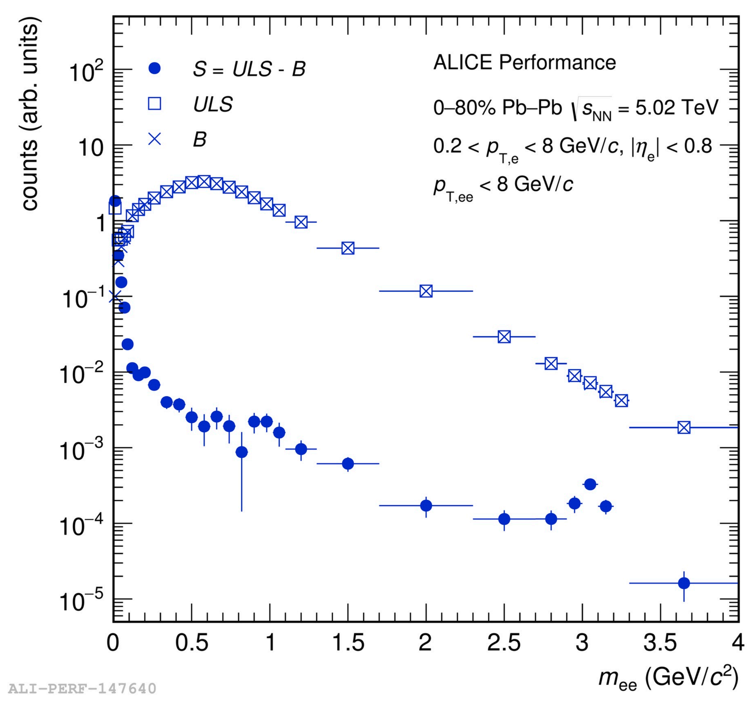


Fig. 4: Unlike-sign, background and signal as function of invariant mass

Improved Acceptance

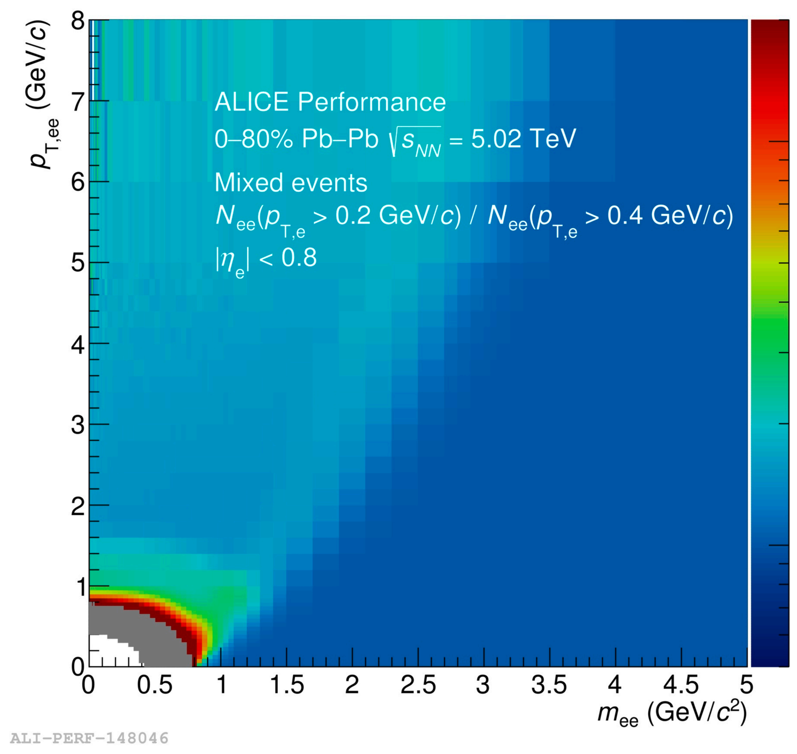
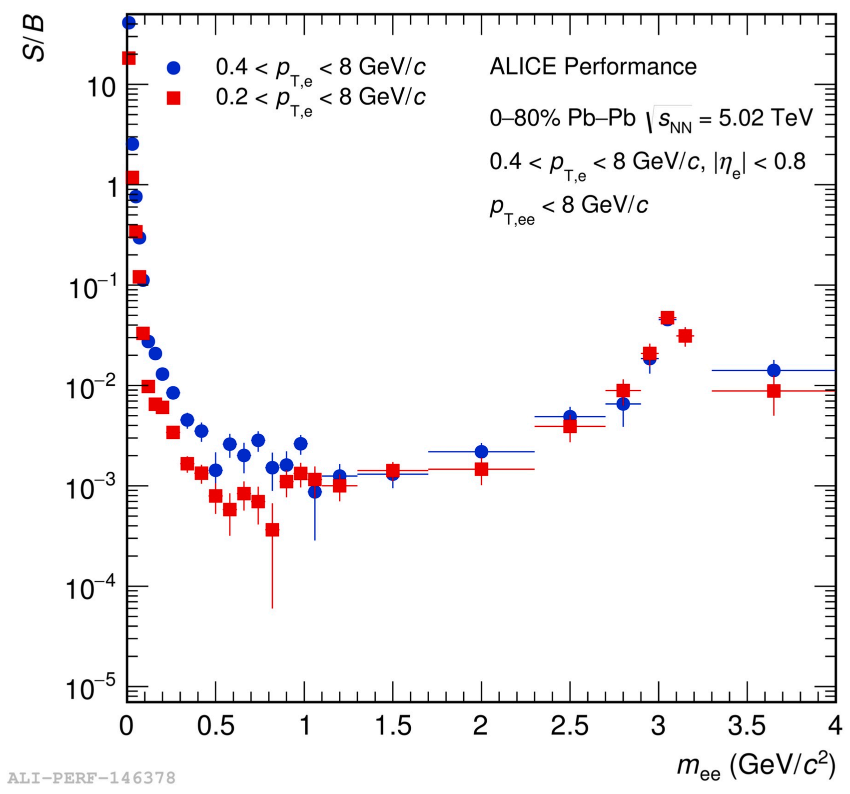


Fig. 9: New acceptance at low masses and low pair momenta (gray) and increased yield over whole phase space calculated with dielectron pairs from mixed events.

The gain in S/B and significance with strict ITS shared cluster cut together with a different electron identification scheme not relying on TOF information enables to lower the minimum p_T threshold from $p_{T,e} > 0.4$ GeV/c to $p_{T,e} > 0.2$ GeV/c and allows to probe low masses at low momenta.
This gives the opportunity to measure medium-modifications of low-p_T ρ mesons.



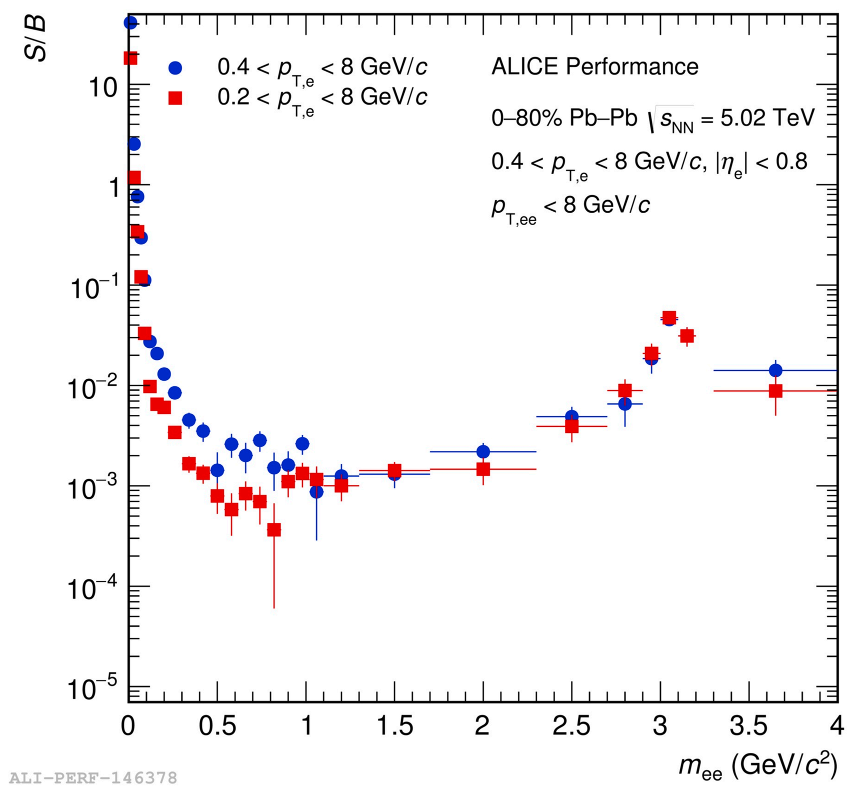


Fig. 10 & 11: A transverse momentum selection $p_T > 0.2$ GeV/c results in a comparable significance range (left). The yield is increased mostly at lower masses where the acceptance gain is largest (right).

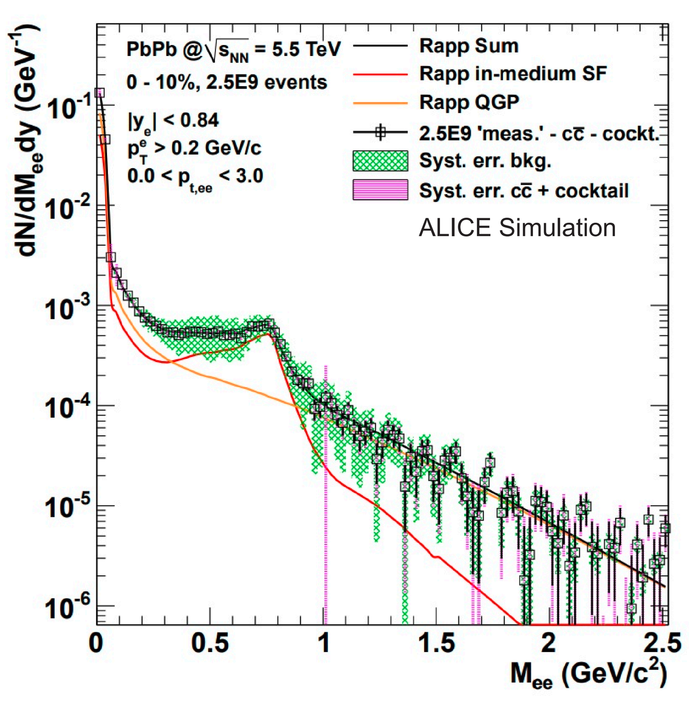
Outlook

Analysis of dielectron production in Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV ongoing:

- Large mininum bias data set (100M) allows studying centrality dependence
- Minimum bias trigger allows centrality dependent study
- Virtual direct photon extraction
- Measurement of charm modification

Run 3 (2020) with upgraded ITS [2] and TPC[3]:

- Thermal photons from the QGP



References:
[1] R. Rapp, J. Wambach, and H. van Hees: arXiv:0901.3289 [hep-ph]
[2] ALICE: CERN-LHCC-2013-024
[3] ALICE: CERN-LHCC-2013-020

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