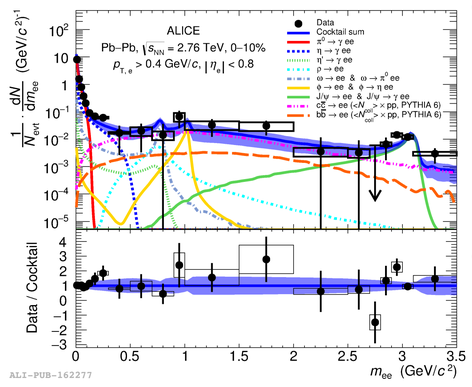
Study of dielectron production in Pb−Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV with ALICE

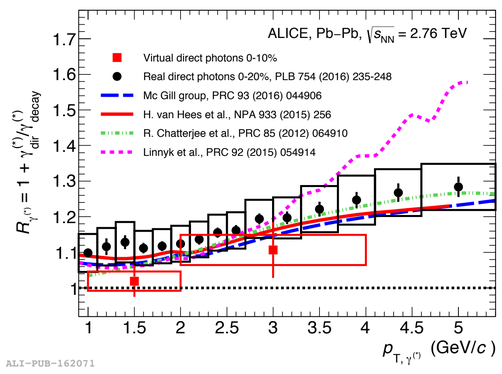
Daiki Sekihata (Center for Nuclear Study, the University of Tokyo) for the ALICE Collaboration

Introduction : motivation and latest results



Phys. Rev. C 99, 024002 (ALICE)

- Low mass region ($m_{ee} < m_\phi$) :
  -virtual direct photons to understand thermodynamic properties of the quark-gluon plasma
  -chiral symmetry restoration via mass shape of vector mesons ($\rho/\omega/\phi$)
- Intermediate mass region ($m_\phi < m_{ee} < m_{J/\psi}$) :
  -heavy quarks (c/b) production
  -thermal radiation without blue-shift
  -coherent photo-production ($\gamma\gamma \to e^+e^-$)
- High mass region ($m_{J/\psi} < m_{ee}$) :
  -Drell-Yan process to study initial state effects

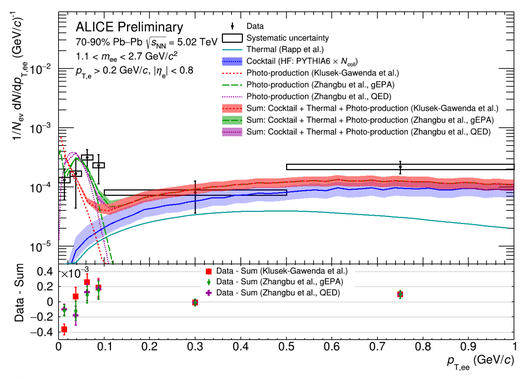


The real and virtual photon signals
Phys. Rev. C 99, 024002 (ALICE)

$$\gamma^{\mathrm{direct}} = \gamma^{\mathrm{all}} - \gamma^{\mathrm{decay}}$$

- Huge backgrounds from $\pi^0 \to \gamma\gamma$ and $\eta \to \gamma\gamma$ for direct photons.
- One of the advantages of the virtual direct photon analysis is to exclude $\pi^0 \to e^+e^-\gamma$ by selecting m_{ee} > 140 MeV/c^2.

→independent and complementary measurement to real direct photons

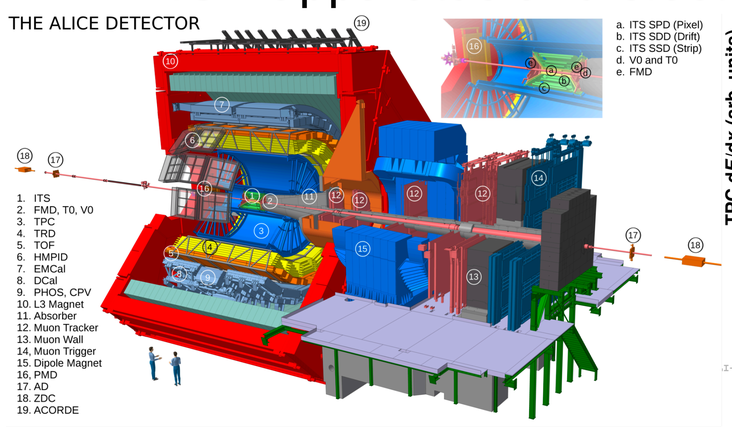


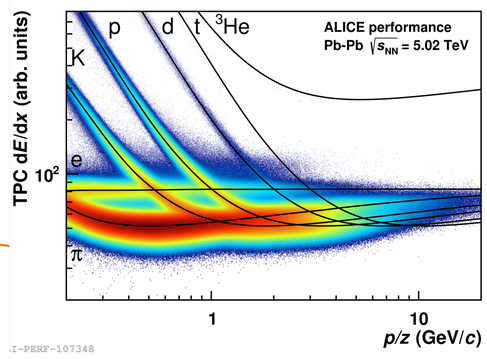
Dielectrons via coherent photo-production

- Dielectron production through coherent photo-production in peripheral collisions reported by ALICE[1] and STAR[2].
- Excess at very low pair p_T in the mass region of 1.1 < m_{ee} < 2.7 GeV/c^2
- The excess yield with respect to hadronic cocktail is well described by photo-production models, but difference is found in the pair p_T spectrum.

[1] arXiv:1909.02508, Sebastian Lehner for the ALICE Collaboration
[2] PRL 121, 132301 (2018), STAR Collaboration

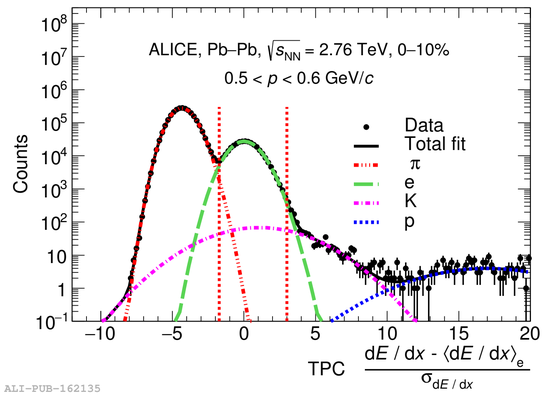
ALICE apparatus and electron identification





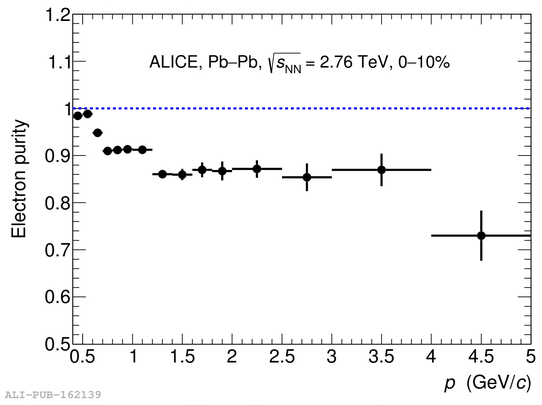
dE/dx vs. p measured by the TPC

Phys. Rev. C 99, 024002 (ALICE)



The $n\sigma$ distribution for electron candidates after eID by ITS and TOF

$$-5 < n\sigma_e^{\mathrm{ITS}} < 1$$
$$-3 < n\sigma_e^{\mathrm{TOF}} < 3$$



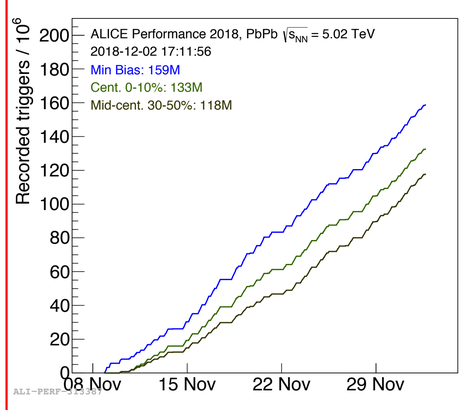
The electron purity

- Trigger detector : V0 at forward and backward rapidity
- Tracking detectors at the central barrel :
  Inner Tracking System (ITS) and Time Projection Chamber (TPC)
- Electron identification : ionizing energy loss in unit length dE/dx in ITS, TPC and the time of flight measured by the TOF detector.
  -The different subsystems have PID capabilities in different momentum regions.

$$n\sigma = \frac{\mathrm{d}E/\mathrm{d}x|_{\mathrm{meas}} - \langle \mathrm{d}E/\mathrm{d}x \rangle}{\sigma}$$

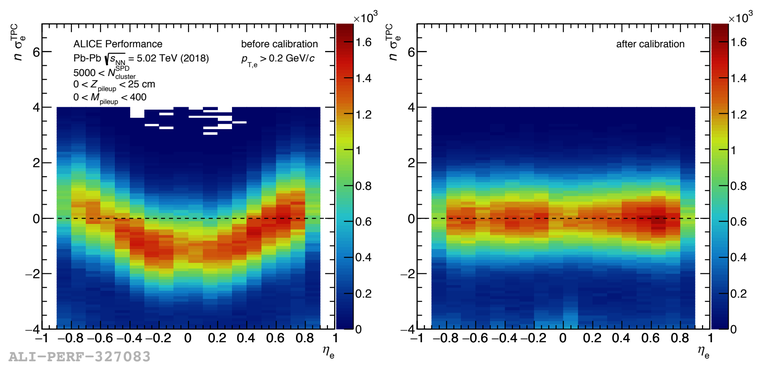
difference between measured and expected value of dE/dx in units of standard deviation for each charged particle (e, π, K, p, μ, etc.)

Data taking at high collision rate in 2018



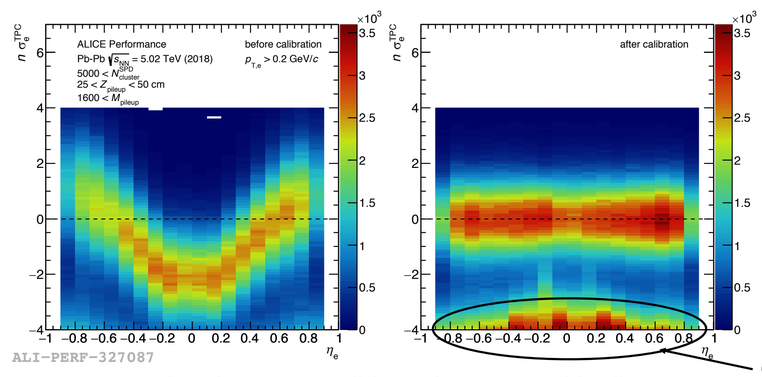
Compared to 2015 data,
- 9 times more data in the 0-10%.
- 4 times more data in the 30-50%.

- The high collision rate (~10 kHz) in 2018 to collect efficiently 0-10% and 30-50% centrality classes in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. (On the contrary, the strategy in 2015 was to record minimum-bias events at a few kHz.)
- This led to out-of-bunch pileup events. (out-of-bunch pileup : collisions before/after the triggered bunch crossing in the readout time of detectors)
- The data taking was affected by the high charged-particle multiplicity in the TPC due to pileup events at the high collision rate.
  →dE/dx in the TPC is mainly affected.



$n\sigma$ vs. η for electron candidates in events without pileup before (left) and after (right) PID calibration

Events without pileup
- The maximum deviation is -1 σ at the mid-rapidity.

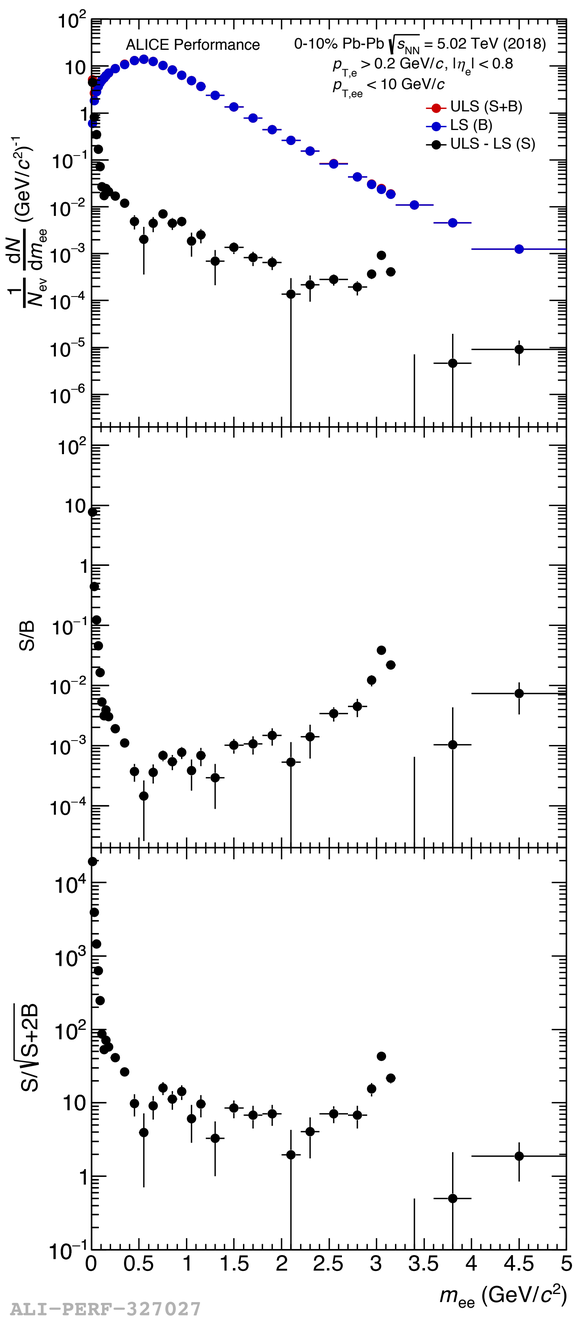


$n\sigma$ vs. η for electron candidates in events with pileup before (left) and after (right) PID calibration

Charged pions

Events with pileup
- The maximum deviation is -2 σ at the mid-rapidity.
- Stronger rapidity dependence than clean events shown above.

Dielectron invariant mass and future prospects



- UnLike Sign (e^+e^- pairs) : signal + background
  $\mathrm{ULS} = N_{+-}^{\mathrm{same}}$
- Like Sign (e^+e^+ and e^-e^- pairs) : background
  $\mathrm{LS} = 2\mathrm{R} \cdot \sqrt{N_{++}^{\mathrm{same}} \cdot N_{--}^{\mathrm{same}}}$
- ULS - LS : signal

$$\mathrm{R} = \frac{N_{+-}^{\mathrm{mix}}}{2 \cdot \sqrt{N_{++}^{\mathrm{mix}} \cdot N_{--}^{\mathrm{mix}}}}$$

(R : correction factor for acceptance)

The high statistics allows us to :
- reduce statistical fluctuations in the low mass region where virtual direct photon signals are expected.
- study p_T and azimuthal angle φ differential yields.
- observe clear J/ψ peak at 3.1 GeV/c^2.

Future prospects :
- Extract virtual direct photons in the low mass region.
- Extract dielectrons via photo-production in the intermediate mass region.