Dielectron physics opportunities with ALICE 3

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ALICE 3

Dielectron opportunities

Dielectron studies in Run 5 (ALICE 3) are intended to address:

- Thermal radiation
- Chiral-symmetry restoration

ALICE 3 characteristics in short

- First tracking layer closer to interaction point:
  - Run 4: 18 mm
  - Run 5: 5 mm
- Pointing resolution for electrons ~5x better
- Pseudorapidity coverage of \(|\eta| \leq 4\)

Down to low \(p_T\):
- Very good electron identification
- Good tracking and reconstruction efficiency

→ Access in dielectron measurements up to \(m_{ee} > 3\) GeV/c\(^2\) and low \(p_{T,ee}\)
Contributions to the correlated dielectron yield:

- Decay of light-flavour hadrons ($\pi^0, \eta, \eta', \omega$ and $\phi$)
- Semileptonic decays of pair-produced open charm
- Thermal radiation from the hadronic phase
- Thermal radiation from the QGP

Selecting $\text{DCA}_{ee} < 1.2\sigma$ is reducing the
- thermal and light-flavour contributions by 20%
- charm contribution by 94.5%
- beauty contribution by 98%

Thermal radiation becomes the dominant contribution in dielectron spectra above $m_{ee} > 0.4\text{ GeV}/c^2$
Combinatorial background

Estimated by like-sign pairing method \((e^\pm e^\pm)\)

Reject combinatorics from \(\pi^0\) Dalitz decays

Reject \(\pi^0\) pairs with:
\[
\begin{align*}
  m_{ee} &< 50 \text{ MeV}/c^2 \\
  \omega_{ee} &< 0.1 \text{ rad}
\end{align*}
\]

Use 3 different scenarios:
1. No prefilter
2. PF1: \(p_T,e > 80 \text{ MeV}/c\)
3. PF\(_{\text{ideal}}\): \(p_T,e > 20 \text{ MeV}/c\) (use inner TOF)

Improvement of signal over background ratio by a factor \(\sim 2.5\) and significance by a factor of \(\sim 1.5\)
Early-time temperature of the system

- Fit exponential function to the region of $m_{ee}$: $1.1 - 1.8$ GeV/$c^2$

$$dN_{ee}/dm_{ee} \propto (m_{ee}T)^{3/2}\exp\left(-\frac{m_{ee}}{T}\right)$$

- Fit parameter $T_{fit}$ gives estimation for early temperature of the medium

- Real temperature $T_{\text{real}}$ estimated by fit to theory input

In Run 3/4 differential measurement not possible due to large systematic uncertainties of charm contribution

Precise measurement of early temperature possible with ALICE 3

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Elliptic flow

Measure thermal dielectrons in semi-central (30-50%) collisions

- Elliptic flow measured with event-plane method
- Thermal dielectrons dominate in $m_{ee}$: 0.65 – 0.75 GeV/$c^2$
  1.1 – 1.5 GeV/$c^2$
- Extract excess $v_2$:
  $$v_2^{\text{excess}} = (1 + N_{\text{excess}} / N_{\text{LF}}) v_2^{\text{prompt}} - v_2^{\text{LF}}$$

Small statistical uncertainties for $v_2$ measurements

ALICE 3 Study
30-50% Pb-Pb, $\sqrt{s_{NN}} = 5.02$ TeV
TOF+RICH (4$\pi$, rej), $B = 0.5$ T
0.2 < $p_T$ < 4 GeV/$c$, $|\eta| < 1.75$
No bremsstrahlung included
DCA$_{\text{ee}} < 1.2\sigma$

$\sum / \text{Rapp in-medium SF}$
Rapp QGP
cocktail w/o $p$
c$\pi$

$\Delta L_{\text{int}} = 33.6 \text{ nb}^{-1}$ 'measured'
Syst. err. sig. + bkg.

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DCA$_{\text{ee}} \leq 1.2\sigma$

$\Delta v_2$ from PRC 101 044904 (2020)
$
\downarrow$ prompt dielectrons
$
\uparrow$ excess dielectrons

Only statistical uncertainties