Reconstruction of γγ mass spectra in AgAg collisions at 1.23 and 1.58 AGeV beam energy with ECal detector of the HADES experiment

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Plan

- HADES experiment
- ECAL detector
  - construction
  - calibration
- Reconstruction of $\gamma\gamma$ invariant mass spectra
  - selection of $\gamma$-quants
  - reconstruction of $\gamma$-pair spectra
  - subtraction of combinatorial background
HADES

[Graph showing the relationship between temperature (T) and momentum (μ_b)]

[Image of the HADES detector with labels for different components such as LHC/RHIC, RHIC BES, SIS100/SIS300, SIS 18, HADES, TOF, RICH, MDC I, MDC II, MDC III, MDC IV, Magnet, Target, and RPC]
Electromagnetic calorimeter

construction
ECal detector

- 6 sectors * 163 modules each
- Goals:
  - strangeness study
  - $\pi^0$ yield
  - improve e/\pi separation
Module of the ECal

Homogeneous Cherenkov radiator is made of CEREN25 lead glass (16.7 radiation length long)

3” PMT Hamamatsu register Cherenkov light

Time Over Threshold method (TOT) is used to digitize the amplitude of signal

Measurement of the amplitude with TOT method

<table>
<thead>
<tr>
<th>signal</th>
<th>threshold</th>
<th>Time over threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amp[V]</td>
<td>t[ns]</td>
<td></td>
</tr>
</tbody>
</table>

TOT
Electromagnetic calorimeter calibration
Analyzed data

March 2019 runs

Ag target+Ag beam

1.58 AGeV,

3200 A current in solenoid (28 days)

1.23 AGeV,

2500 A (3 days) - “High field”

200 A (2 days) - “Low field”
Calibration of the ECal detector

$e^+$, $e^-$ are selected for calibration

their momentum is calculated by curvature of trajectory in magnetic field
High field data

low energy e are unavailable because of their reverse in magnetic field
Low field data

momentum of high energy $e$ is defined with poor resolution
Joint distribution

Low- and High-field data are concatenated. The dependence is fitted with exponent parameters $p_0$, $p_1$, $p_2$ for each module are written to the database.

$$E = p_0 + \exp(p_1 + p_2 \cdot TOT)$$
Resolution

Energy resolution $\sim 6\%/\sqrt{E}\text{[GeV]}$
Reconstruction of $\gamma\gamma$ invariant mass spectrum
Selection criteria

**Photon selection**
- no match with any track
- $\beta > 0.95$
- $E_\gamma > 300$ MeV

**Pair selection**
- opening angle $> 5^\circ$
- both photons hit the same sector
Kinematics

\[ m_{\pi^0} = \sqrt{\left( E_1 + E_2 \right)^2 / c^4} - \left( \vec{p}_1 + \vec{p}_2 \right)^2 / c^2 \]

\[ p_t = (\vec{p}_1 + \vec{p}_2) \perp \]

sector of ECAL detector

\[ \gamma(E1) \]

\[ \gamma(E2) \]

\[ \pi0 (y, pt) \]

\[ \theta_1 \quad \theta_2 \]
Invariant mass spectra

For each possible combination of γ pairs the invariant mass is calculated.

**Ag+Ag \( \sqrt{s_{NN}} = 1.23 \text{ AGeV} \)**

<table>
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<tr>
<th>Condition</th>
<th>( \text{Sig/CB} )</th>
<th>( \langle M_\pi \rangle )</th>
<th>( \sigma_\pi )</th>
</tr>
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<tr>
<td>( \gamma\gamma )</td>
<td>0.175</td>
<td>141.083</td>
<td>14.415</td>
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</table>

**Ag+Ag \( \sqrt{s_{NN}} = 1.58 \text{ AGeV} \)**

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</thead>
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<tr>
<td>( \gamma\gamma )</td>
<td>0.145</td>
<td>135.4</td>
<td>13.0</td>
</tr>
</tbody>
</table>
Combinatorial background

Mixed event technique is used to calculate the combinatorial background.

Photons are taken from different events to combine pairs.
**π⁰ peak**

Combinatorial background is subtracted from the spectra.

π⁰ peak is fitted by Gaussian curve

(PDG:
\[ M_{\pi^0} = 134.97 \text{ MeV} \]
\[ \sigma_{\pi^0} = 0.0005 \text{ MeV} \])
Simulation

UrQMD generator + HGeant

Spectrum, obtained with used technique, represents the same results as direct selection of pi0 by its PID.
η-meson peak

η-meson peak is visible at 1.58 AGeV (high statistics, enough energy)

η-meson peak is not seen at 1.23 AGeV (low statistics, energy sub threshold)
Conclusions

- Resolution of ECAL is 6%/√E
- π0 peak is clearly visible at 1.23 and 1.58 AGV
- η-meson is visible at 1.58 AGeV
- Efficiency correction will be done in future
Thank you for attention!