Background rejection in the dilepton analysis with the CBM-MVD

Erik Krebs for the CBM Collaboration
Motivation

- Dileptons as direct probe of the high density phase.
- CERES at 40 and 158 AGeV beam energy: excess higher at lower energy.
- HADES at SIS18.
CBM Detector

[Diagram of CBM Detector components, including MVD, STRIPS, MAPS, transition radiation detectors, silicon tracking system, micro vertex detector, dipol magnet, ring imaging Cherenkov detector, and electromagnetic calorimeter with projectile spectator detector and resistive plate chambers (TOF).]
CBM Detector

- Without hadron-blind detector before the tracking.
- Background due to material budget of the STS and MVD.
- Sufficient $\pi$ discrimination (misidentification <10^{-4}).

UrQMD: Au+Au collision at beam energy 25AGeV, zero impact parameter

- $e^+ e^- \gamma$
- $1.2\%$
- $\uparrow$
- $\sim 350 \quad \pi^0 \rightarrow 98.8\% \ \gamma \gamma$
- $\sim 3 \quad \gamma_{\text{target}} \rightarrow e^+ e^-$
- $\sim 700 \quad \pi^+/\pi^-$ could be identified as an electron

DPG Darmstadt 2016
• Challenges:
  • Low branching ratios:

<table>
<thead>
<tr>
<th>Particle</th>
<th>Decay Channel</th>
<th>Branching Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho^0$</td>
<td>$e^+e^-$</td>
<td>$4.7 \cdot 10^{-5}$</td>
</tr>
<tr>
<td>$\omega$</td>
<td>$e^+e^-$</td>
<td>$7.3 \cdot 10^{-5}$</td>
</tr>
<tr>
<td>$\omega$</td>
<td>$\pi^0e^+e^-$</td>
<td>$7.7 \cdot 10^{-4}$</td>
</tr>
<tr>
<td>$\Phi$</td>
<td>$e^+e^-$</td>
<td>$3.0 \cdot 10^{-4}$</td>
</tr>
</tbody>
</table>

• Large background from $\gamma$-conversions and $\pi^0$-Dalitz decays.
Simulation

- UrQMD Central AuAu at 8 GeV.
- 25 μm gold target.
- Analysis with and without MVD.
- PID from acceptance in RICH and TRD.
- Low mass vector mesons from Pluto.
- From thermalized medium: QGP and hot hadron gas
  - → Florian Seck HK2.5
Main Cuts

- Primary track cut
  - Extrapolate tracks to primary vertex and cut on deviation to the vertex.
- Track topology cut
  - Cut on opening angle and product of momenta
• Can the Micro Vertex Detector contribute to reduce the background?
• Additional tracking stations near the target region.
• Reconstruct more low momentum tracks.
**γ-Conversions**

- Able to reconstruct additional low momentum tracks.
- But MVD is also a source of background.
- Conversions in MVD misidentified as primary tracks.
- Simple χ²-cut alone not sufficient when including MVDs.
- Many γ-conversions produced outside the target region have no hit in the first MVD station.
- Keep all tracks with a hit in the first MVD.
- Extrapolate tracks to the first station and cut if they are outside its acceptance.

Reconstruction efficiency with and without the MVD.
Invariant Mass Cocktail with MVD

After PID

All cuts applied
• Improved signal-to-background but also signal loss with the MVD.
• Overall significance is higher with MVD.
Summary

• More low momenta tracks can be reconstructed by using the MVD as additional tracking stations.
• A source of background is $e^+/e^-$ from $\gamma$-conversions produced in the MVD stations.
• This additional background can be reduced.
• Improved signal-to-background and significance at the cost of signal efficiency when including the MVD in the analysis in case of Monte-Carlo PID.
Invariant Mass with and without MVD

<table>
<thead>
<tr>
<th>Mass Range [GeV]</th>
<th>Number MVD</th>
<th>Cut Efficiency</th>
<th>$S/B$</th>
<th>$S/\sqrt{S+B}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-0.15</td>
<td>0</td>
<td>$(25\pm1)10^{-2}$</td>
<td>$4.7 \pm 0.1$</td>
<td>$238 \pm 1$</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>$(21\pm1)10^{-2}$</td>
<td>$5.8 \pm 0.1$</td>
<td>$234 \pm 1$</td>
</tr>
<tr>
<td>0.15-0.6</td>
<td>0</td>
<td>$0.75\pm0.01$</td>
<td>$0.19 \pm 0.01$</td>
<td>$57.2 \pm 0.4$</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>$0.67\pm0.01$</td>
<td>$0.28 \pm 0.01$</td>
<td>$64.4 \pm 0.4$</td>
</tr>
<tr>
<td>0.6-1.2</td>
<td>0</td>
<td>$0.81\pm0.01$</td>
<td>$0.26 \pm 0.01$</td>
<td>$46.6 \pm 0.4$</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>$0.69\pm0.01$</td>
<td>$0.46 \pm 0.01$</td>
<td>$53.4 \pm 0.5$</td>
</tr>
<tr>
<td>$\omega$</td>
<td>0</td>
<td>$0.81\pm0.02$</td>
<td>$0.73 \pm 0.01$</td>
<td>$42.8 \pm 0.5$</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>$0.68\pm0.01$</td>
<td>$1.3 \pm 0.1$</td>
<td>$45.4 \pm 0.6$</td>
</tr>
<tr>
<td>$\phi$</td>
<td>0</td>
<td>$0.83\pm0.07$</td>
<td>$0.20 \pm 0.01$</td>
<td>$6.3 \pm 0.4$</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>$0.71\pm0.06$</td>
<td>$0.38 \pm 0.03$</td>
<td>$7.5 \pm 0.5$</td>
</tr>
</tbody>
</table>

All cuts applied.
Real PID

![Graphs showing S/B, Cut Efficiency, and Significance with and without MVD]