Measurement of e^+e^- Pairs in Ar+KCl at E=1.76 A·GeV with HADES ◇

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The physics program of the HADES experiment at GSI, Darmstadt, aims to investigate the e^+e^--pair production in elementary as well as heavy ion collisions at SIS energies. We focus on production and decays of light mesons and baryons, which may give spectroscopic access to possible modifications of hadron properties in nuclear matter.

From systematic investigations of the C+C collision system [1,2] we have observed an enhanced e^+e^--pair production over a cocktail of so far established hadronic sources. In the η meson mass range, the data clearly call for extra e^+e^--sources such as Δ-Dalitz decay and pn-Bremsstrahlung. Recent theoretical work [3,4] together with our new experimental data from pp collisions [5] try to disentangle the individual contributions of these sources and fix their absolute yields.

In this report we present preliminary results on e^+e^--pair production for a heavy collision system of moderate size, i.e. in the mass region $A_{tot} \approx 80$. The analyzed experimental data set of Ar+KCl collisions at E=1.756 A·GeV is equivalent to a total of 2.2×10^9 inspected reactions. We have selected only semicentral collisions including the innermost 50% of impact parameters by applying a ch. p. multiplicity trigger in the TOF wall. After momentum reconstruction and particle identification using a probabilistic approach [6] following the theorem of Bayes, the reconstructed e^+/e^- tracks were combined to like-sign and unlike-sign pairs from which invariant mass distributions were then calculated. The yield of non physical like-sign pairs was used to estimate the combinatorial background (CB). It was an order of magnitude larger than in the C+C system, where we had achieved a signal to background ratio $S/B > 1$ in the mass region of interest.

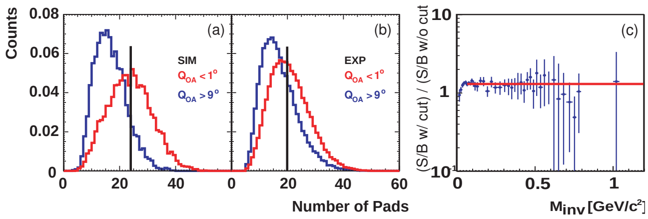

Fig. 1: Number of pads for identified Cherenkov rings induced by single electron tracks (blue) and by very close tracks of electron pairs (red), in simulation and experiment. Cutting away all rings with N>20 leads to a ≃ 30% improvement of the S/B ratio (right panel).

Table 1: Yields of double- and single-track rings in sim. and exp.

Ring	Y^{sim}_{tot}	$Y^{sim}_{npads\leq 24}$	Y^{exp}_{tot}	$Y^{exp}_{npads\leq 20}$
Double	47 k	52%	113 k	50%
Single	27 k	89%	26 k	71%

The main contribution to the CB stems from unidentified close pairs (CP) (pair opening angle $\Theta_{OA} < 1^o$) originating mainly from external γ-conversion. We have made an attempt to reduce the CB and improve the S/B ratio by making additional use of RICH detector observables for CP identification. It turned out that a good RICH observable to cut on is the number of pads per ring. Arbitrarily normalized distributions are shown for simulation and experimental data in Fig. 1 and Tab. 1.

Suppression of all so-called double rings (N > 20) gives a reasonable reduction of the CB. For experimental data, an overall S/B improvement of ≃ 30% can be achieved, as compared to the standard analysis. This improvement is almost constant over the entire invariant mass range (Fig. 1c), but at the expense of a net signal loss of ≃ 40%.

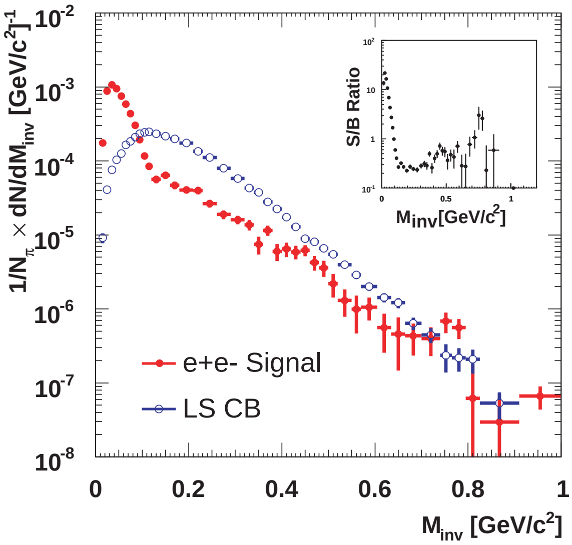

Fig. 2: Efficiency corrected invariant mass distribution of e^+e^--pairs in Ar+KCl at 1.756 A·GeV. The combinatorial background (blue) exceeds the net signal (red).

Fig. 2 depicts the measured invariant mass distributions for signal pairs together with that of the CB. The distributions are corrected for detector and reconstruction efficiencies and were normalized to the mean multiplicity (≃ 3.8) of charged pions per collision, measured simultaneously for each event. In total 76,539 ± 429 signal pairs have been reconstructed, from which 8,440 ± 261 pairs are above the π^0 mass and 232 ± 31 in the ρ/ω mass region. The S/B ratio (see inlet of Fig. 2) is about $0.2 - 0.5$ for invariant masses above the π^0 mass and reaches values close to ≈ 1 in the region of the ρ/ω pole mass. Hence, the observed peak structure at $M_{inv} \simeq 780\,\mathrm{MeV/c^2}$ is a clear experimental fingerprint of the ω meson. At these low energies close to the free NN production threshold, the ω meson has not been seen before in HI collisions.

The preliminary normalization of the experimental data will be finalized soon and will then allow a comparison to recent predictions of transport calculations [4].

References

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