ETA PRODUCTION IN HEAVY-ION COLLISIONS AND THE DLS DI-ELECTRON ENHANCEMENT*

ROMAIN HOLZMANN

Gesellschaft für Schwerionenforschung, D-64291 Darmstadt, Germany

for the TAPS Collaboration

GANIL Caen, GSI Darmstadt, Universität Gießen, KVI Groningen
NPI Řež, IFIC Valencia

(Received June 5, 1998)

The Dalitz-decay contribution of neutral mesons to the di-electron invariant-mass spectrum at 1 AGeV is deduced from a systematics of meson production cross sections measured with the photon spectrometer TAPS. A comparison with recently published di-electron mass spectra of the DLS collaboration shows that $\eta$ Dalitz decay does not exhaust the $e^+e^-$ yield in the mass range of 0.2–0.5 GeV/$c^2$.

PACS numbers: 25.75.Dw, 13.40.Hq

Dileptons are considered to be among the most direct probes of the hot and dense phase of heavy-ion reactions, as well as of the in-medium properties of hadrons produced in such collisions. In the few-GeV regime pioneering work has been done by the Dilepton Spectrometer (DLS) collaboration who has investigated di-electron emission in a series of experiments at the BEVALAC, both in $p$–$p$, $p$–$d$ and heavy-ion collisions [1, 2]. At GSI this line of work will be taken up soon with a much superior device, namely the High-Acceptance Di-Electron Spectrometer HADES [3].

Here we report on a determination of the Dalitz-decay contribution of neutral meson ($\pi^0$ and $\eta$) to the di-electron invariant-mass spectrum. Calculated from the systematics of meson production cross sections measured with the photon spectrometer TAPS, these results are compared with recently published DLS data obtained at 1 AGeV [2].


(3051)
We have investigated $\pi^0$ and $\eta$ production in various collision systems, in particular the C+C and Ar+Ca systems have been extensively studied [4,5]. Based on this, inclusive production cross sections can now be interpolated over $0.8–2.0$ AGeV with errors $<30\%$, including uncertainties due to imperfectly known angular distributions (see Ref. [6] for details). From these cross sections the $\pi^0$ and $\eta$ Dalitz contributions have been obtained in a Monte Carlo calculation using:

1. thermal meson sources at midrapidity with temperatures taken from fits to the measured transverse-mass distributions;
2. Dalitz decay branching ratios of 1.198% for the $\pi^0$ and 0.49% for the $\eta$, respectively, and a phase-space population governed by VDM form factors; and finally
3. a filter modeling the DLS detector acceptance.

Beyond the comparison with the Ca + Ca and C + C DLS data (upper part of Fig. 1) we have done the calculation also for light asymmetric

---

\[\text{Fig. 1. Acceptance-filtered } e^+e^- \text{ mass spectra at 1 AGeV. Data points are from DLS [2], histograms are our evaluated } \pi^0 \text{ and } \eta \text{ Dalitz contributions, with overall errors (statistical + systematic) shown as shaded bands.}\]
systems, using scaled [6] meson production cross sections (lower part of Fig. 1). It is apparent that the experimental mass spectra are dominated for $M_{e^+e^-} \leq 0.15 \text{ GeV}/c^2$ by the $\pi^0$ Dalitz decay. While we obtain good agreement with DLS in the Ca + Ca and C + C systems, our calculation overshoots somewhat in the two lighter systems, which could be impounded on the scaling procedure used. However, in the mass range spanned by the $\eta$ Dalitz decay, i.e. $M_{e^+e^-} \simeq 0.15–0.5 \text{ GeV}/c^2$, the DLS data exceed the deduced $\eta$ component by large factors, ranging, e.g. at 0.25 GeV/c², from 10 in Ca + Ca and C + C, to 6 in α+Ca and still 4 in d+Ca. Furthermore, a comparison of DLS $e^+e^-$ data on $p+p$ reactions at 1–2 GeV [1] with the Dalitz contributions calculated in a similar manner from published $p+p$ $\pi^0$ [7] and $\eta$ [8] production cross sections also reveals excess yield, albeit much less, as shown in Fig. 2 below.

Fig. 2. Acceptance-filtered $e^+e^-$ mass spectra for the $p+p$ reaction. Data points are from DLS [1], histograms are the $\pi^0$ and $\eta$ Dalitz contributions evaluated from published meson production cross sections [7, 8].

Consequently, in the mass range spanned by the $\eta$ decay, additional physical processes, like pn bremsstrahlung, radiative $\Delta$ decays or yet other processes, are needed to account for the measured dilepton yields. This is also supported by transport models, e.g. HSM [9] and UrQMD [10] calculations. Finally, in the near future, data on $\omega$ production obtained by the TAPS collaboration [11] will put constraints too on the decay contributions of this heavy meson to the di-electron yields.

I would like to thank all my colleagues from the TAPS collaboration, in particular R. Averbeck, A. Marin and V. Metag. In addition, discussions with R.J. Porter and W.K. Wilson from DLS are gratefully acknowledged.
REFERENCES

[10] C. Ernst et al., to be published.