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INCLUSIVE DI-ELECTRON PRODUCTION IN C+C COLLISIONS WITH HADES

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Abstract

Inclusive di-electron production in C+C collisions at 1 and 2 AGeV has recently been measured by the HADES collaboration at GSI. Results are compared to a di-electron cocktail calculated from free hadron (π^0, η, ω) decays after freeze-out. For the low invariant masses, $M_{e+e-} < 0.15$ GeV/c^2, the measured distributions are largely explained by the $\pi^0 \to e^+e^-\gamma$ Dalitz decay but for higher masses experimental yields significantly exceed expectations.

1 HADES

The High-Acceptance DiElectron Spectrometer HADES at GSI, Darmstadt, uses direct probes, i.e. di-electronic decays of light vector mesons, ρ and ω, to investigate hadron properties inside a dense and nuclear medium. These properties are governed by non-perturbative QCD. Models predict,

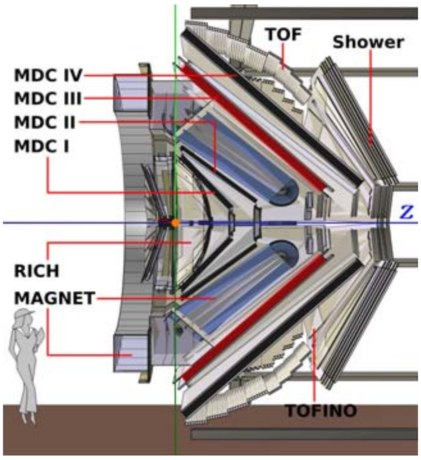

Figure 1: Cross section of HADES, beam from the left. Detectors: Ring-Imaging Cherenkov (RICH, $\mathcal{O} \sim 1.6$ m) detector, tracking system (2 Mini-Drift Chambers (MDC-I, MDC-II) before, 2 (MDC-III, MDC-IV) behind the magnet), Time-Of-Flight wall (TOF/TOFino) and Pre-SHOWER detectors. A fast diamond start detector located upstream provides a time reference. Solid state targets as well as a liquid hydrogen target may be used [figure from [2]].

that hadron masses and/or lifetimes, depend on the temperature and density of the surrounding nuclear medium, such that a sizeable broadening or shifting of these resonances may be observed. The latter may be related to chiral symmetry restoration (cf. [1]).

HADES consists of a 6-coil toroidal magnet centered on the beam axis and six identical detection sectors located between the coils, covering polar angles between 18° and 85°, see Fig. 1. Details of the data acquisition, trigger, readout etc. as well as details, of the analysis, combinatorial background and systematical uncertainties are in [3].

2 Results on C+C collisions

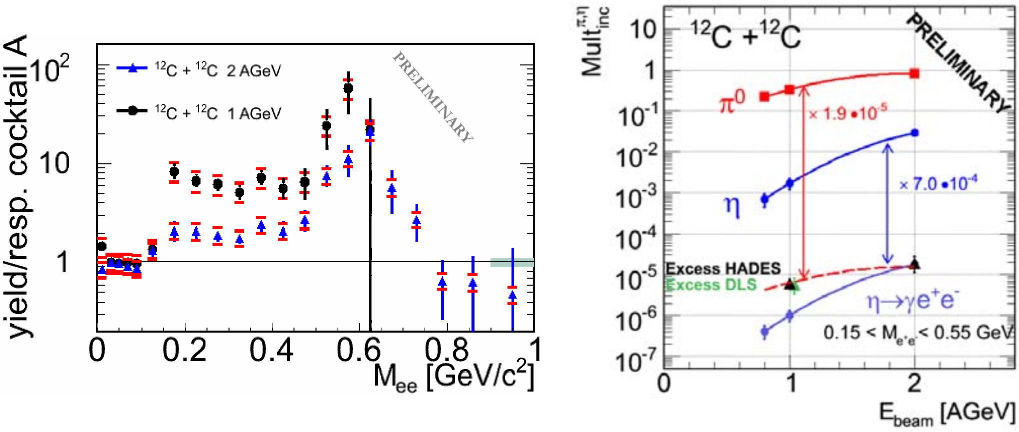

Figure 2: (left) Invariant mass distributions normalized to cocktail A for C+C data at 1 and 2 AGeV. (right) Excitation function of excess in the η region (see text).

The final result on the di-electron invariant mass distributions M_{ee} for 2 AGeV C+C (cf. [3]) included efficiency correction and normalization to the average number of charged pions. The pions were measured within the HADES acceptance and extrapolated to 4π, using measured angular distributions that are also in agreement with UrQMD calculations [4]. The pion multiplicity per number of participating nucleons $M_\pi/A_{part} = 0.137 \pm 0.015$ ($A_{part} = 9.0$) agrees with results from [5] within 11%. The combined systematic uncertainties yield roughly 18%. A pair cocktail (A) was calculated (cf. [3]) from free π^0, η and ω meson decays, representing all contributions emitted after the chemical freeze-out of the fireball. The π^0 and η sources are constrained by data [5], the ω meson is taken from a $m_\perp$-scaling ansatz [6].

The HADES event generator PLUTO [7] modeled meson emission from a thermal source with a temperature $T = 80$ MeV, respecting the aforementioned anisotropic angular distributions for pions. While experimental data and the simulated cocktail A are in good agreement in the π^0 region, the cocktail underestimates the data for $M > 0.15$ GeV/c^2. Adding decays of short-lived resonances (as ρ, $\Delta(1232)$), excited in the early phase of the collision, will additionally contribute here and slightly improve the situation by populating also the higher-mass regions, but will eventually fail to reproduce the data as well. In Fig. 2 the ratio of the data and cocktail A is shown. In the intermediate mass range of $0.15 - 0.50$ GeV/c^2 (η region), the enhancement factor above the dominant η contribution is $F(2.0) = 2.1 \pm 0.2(stat) \pm 0.3(sys) \pm 0.4(\eta)$. The third uncertainty (η) reflects the quoted uncertainty of the η multiplicity measured with TAPS [5].

The analysis of the 1 AGeV C+C run was performed on the same footing as for 2 AGeV, and is nearly completed. Compared to the 2 AGeV invariant mass spectrum the excess yield is more pronounced, cf. Fig. 2, the preliminary enhancement factor in the η region is $F(1.0) = 7.0 \pm 0.6(stat) \pm 1.1(sys) \pm 2.0(\eta)$. Here, the corresponding cocktail A (1 AGeV) was generated assuming T=55 MeV for freeze-out. Employing the η-yield by TAPS [5] at 1.04 and 2 AGeV the preliminary ratio of the absolute excess yields Y_{exc} in C+C reactions at both energies is: $Y_{exc}^{2AGeV}/Y_{exc}^{1AGeV} = 2.8 \pm 0.2(stat) \pm 1.0(sys) \pm 1.0(\eta)$. Note that the energy scaling of the excess yield follows that of pion production rather than that of η production (cf. [5]).

3 Summary

We discussed a comparison of di-electron invariant mass distributions for C+C 2 AGeV and 1 AGeV, the latter data being preliminary. Both data reveal a significant di-electron excess yield above a thermal pair cocktail from long-lived mesons. We note that the excess for HADES (1 AGeV) is very similar to the excess reported by DLS for C+C at 1.04 AGeV [10]. The excess energy dependence is similar to that of pions. This hints at the importance of baryonic resonances for the origin of the excess yield, and also demonstrates the need of a systematic investigation of elementary reactions by HADES as input for (cf. [11]). Data on the heavier systems AA system (Ar+KCl) are currently being analyzed.

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