Study of pp and pd Reactions with HADES — Simulations and First Measurements ◇

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Elementary reactions like $p+p$, $p+n$ with $E_p = 1-4$ GeV provide an effective tool to determine detector efficiencies and momentum resolution in the HADES electron pair spectrometer at GSI Darmstadt. Moreover, the features of HADES like its large acceptance etc. open up the possibility to study weak and partly unknown reaction channels in the accessible energy regime. For instance, the properties of Δ-dalitz decays ($\Delta \to N\, e^+e^-$) and pn bremsstrahlung ($pn \to pn\,\gamma^* \to pn\, e^+e^-$) and their contribution to the e^+e^- invariant mass spectra are of particular interest for the anticipated $A+A$ collision studies within the HADES physics programme. We report here simulation studies and preliminary results from first measurements.

Full scale Monte Carlo simulations have been performed, using different codes like PLUTO [1] and HSD [2] for event generation and GEANT to model the detector properties in detail. The calculations were done for several beam-target combinations, projectile energies, and trigger settings. As an example, Fig. 1 depicts for $p+p$ at ($E_p = 3.5$ GeV) the invariant mass spectrum of e^+e^- pairs obtained after full data analysis. The achievable event statistics correspond to one week of beamtime. For illustration, the spectrum is split up into the contributions from the various reaction channels.

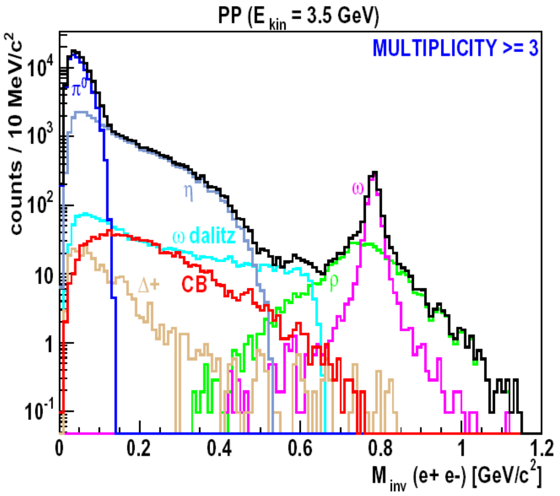

Fig. 1: Expected invariant mass distribution of e^+e^- pairs for $p+p$ at $E_{kin} = 3.5$ GeV. The trigger condition requires a charged particle multiplicity M≥ 4.

From the width and the total yield of the ω peak, mass resolution and efficiency can be determined as the production cross sections, branching ratios and the width of the ω in free decay are well known. We expect a low combinatorial background from real e^+ and e^- not belonging to the same physical process. A comparison to the much larger background in heavy ion collisions will show whether scaling with the participant number is applicable and thus helps in quantitative signal extraction in these cases.

Furthermore, $p+p$ and $p+d$ collisions at $E_{kin} = 1.25$ GeV have been simulated to get more insight into the isospin dependence of η production [3] close to production threshold ($m = 546\,\mathrm{MeV}/c^2$, $E_{thr} = 1.27$ GeV). It could be demonstrated that pn reactions can be successfully tagged by using inverse kinematics and detecting the spectator proton. This will allow to make semi-exclusive measurements of the respective e^+e^- pair production channel.

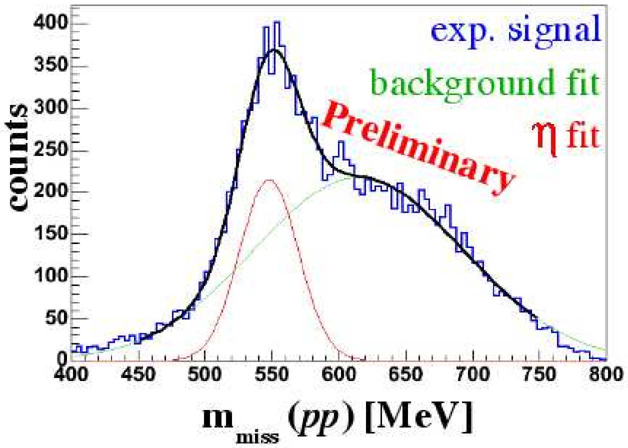

Fig. 2: pp missing mass distribution for $p+p$ at $E_{kin} = 2.2$ GeV. See the text for the applied analysis conditions.

First measurements of $p+p$ reactions at $E_{kin} = 2.2$ GeV have been performed in 2004. This energy is well above the pp threshold for η production, but not sufficient to produce the heavier vector mesons ρ^0 and ω. In the data analysis we have reconstructed the η in the two main charged decay channels, the hadronic ($\eta \to \pi^+\pi^-\pi^0$, BR $\approx$ 23%) and the leptonic (η-dalitz: $\eta \to \gamma\, e^+e^-$, BR $\approx 0.6\%$) one. Selecting only events with four charged particles ($pp\pi^+\pi^-$) and requiring a four particle missing mass $m_{miss,pp\pi^+\pi^-} > 90\,\mathrm{MeV}/c^2$ results in the pp missing mass distribution shown in Fig. 2. The two pion production channels are removed from the data sample and the η signal ($m_\eta = m_{miss,pp}$) is clearly visible above contributions from the non-resonant three pion production.

The analysis for the leptonic decay channel — both inclusive e^+e^- production and exclusive identification of mesonic sources to this signal — is ongoing.

References

[1] Pluto homepage: `http://www-hades.gsi.de/computing/pluto/html/PlutoIndex.html`
[2] W. Ehehalt and W. Cassing, Nucl.Phys. **A602** (1996) 449-486
[3] H. Calen *et al.*, Phys.Rev. **C58** (1998) 2667,
Phys.lett. **1996** (366) 39,
J. Smyrski *et al.*, Phys.Lett. **474** (2000) 182

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