Simulation of the reaction $pp \to d\pi^+\eta$ for WASA*

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The reaction $pp \to da_0^+ \to d\pi^+\eta$ followed by $\eta \to \gamma\gamma$ can be measured at COSY with the WASA facility by detecting deuterons in the forward detector (FD) and pions and photons in the central detector (CD). The reaction can be identified by reconstruction of the masses $m(\eta)$=inv($\gamma\gamma$) and $m(d)$=m.m.($\pi^+\gamma\gamma$). The study of the reaction $pp \to da_0^+$ is preferable to $pp \to pna_0^+$, since the ratio of cross sections for the resonant/nonresonant reactions is about one order larger for the deuteron in final state [1].

Two main background reactions are expected: non-resonant production $pp \to d\pi^+\eta$ and $pp \to pn\pi^+\eta$ with misidentification of a proton as a deuteron.

In order to investigate the background suppression, simulations were performed for the $a_0^+(980)$ production and both background reactions. In the simulations the following initial distributions have been used: for $a_0^+(980)$ production according to the Quark-Gluon Strings Model (QGSM) [2], for direct $d\pi^+\eta$ production via N^*- and Δ-resonance excitation [3, 4, 5] and for $pn\pi^+\eta$ a phase space distribution. Figure 1 shows the invariant masses ($\pi^+\eta$) for these reactions. The cross sections have been estimated according to Refs. [3, 6, 7] as $\sigma(a_0^+)$:$\sigma(d\pi^+\eta)$:$\sigma(pn\pi^+\eta) = 1.1$:3.5:96. Thus, the expected background from the reaction $pp \to pn\pi^+\eta$ is about two orders higher than the a_0^+ signal.

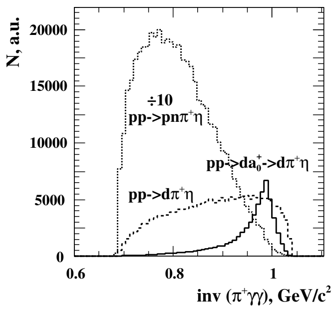

Fig. 1: Invariant mass ($\pi^+\eta$) for $a_0^+(980)$ production in $pp \to da_0^+ \to d\pi^+\eta$ and two background processes: direct production $pp \to d\pi^+\eta$ and $pp \to pn\pi^+\eta$ (divided by a factor 10).

Due to the high kinetic energies of protons and deuterons for a COSY beam energy $T = 2.65$ GeV they cannot be stopped in the FD and their initial kinetic energy cannot be reconstructed. Moreover, their energy losses become close to minimal ionizing and the standard WASA@CELSIUS $\Delta E/E$ method cannot be used for *p/d* separation.

In order to suppress the proton background a set of cuts has been used. The first cut was applied to the reconstructed m.m.($\pi^+\gamma\gamma$) (Fig. 2(a)). The cut at 1.95 GeV suppresses protons by a factor $\sim$1.6. A 2-dimensional distribution energy losses *vs.* kinetic energy of the deuteron calculated from pion and two photons is correlated for a_0^+ events (Fig. 2(b)). Applying a gate $\pm$20 MeV protons can be suppressed by a factor $\sim$3.9.

The next cuts have been applied to the difference between measured azimuthal and polar angles of forward particles and expected deuteron angles calculated from the measured pion and two photons. If one assumes that all forward particles are deuterons, then the real deuterons are seen as lines and the

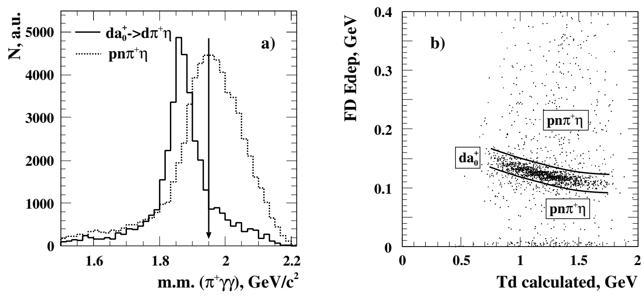

Fig. 2: (a) Reconstructed missing mass ($\pi^+\gamma\gamma$) for $pp \to da_0^+ \to d\pi^+\eta$ and $pp \to pn\pi^+\eta$. The cut is indicated by the arrow. (b) Energy losses in FD *vs.* kinetic energy of deuterons calculated from the measured pion and two photons. The cuts are indicated by curves.

protons are smeared (Fig. 3(a,b)). With an azimuthal angle cut of $\pm 20^\circ$ and a polar angle $\pm 2^\circ$, protons can be suppressed by a factor $\sim$21.

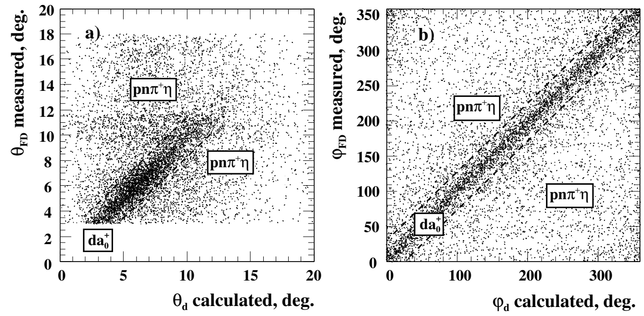

Fig. 3: (a,b) Measured forward angles *vs.* angles calculated for deuterons. The cuts are shown by lines.

Additional proton suppression comes from the different acceptances for a_0^+ and $pn\pi^+\eta$ events by a factor $\sim$1.3

Taking into account all mentioned cuts and the difference in acceptance the total proton suppression factor is: $1.3 \times 1.6 \times 3.9 \times 21 \approx 170$. Thus, it is expected that the a_0^+ resonance production in the reaction $pp \to da_0^+ \to d\pi^+\eta$ can be measured with WASA.

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