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MEASUREMENT OF THE η PRODUCTION IN PROTON PROTON COLLISIONS WITH THE COSY TIME OF FLIGHT SPECTROMETER*

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The reaction $pp \to pp\eta$ was measured at excess energies of 15 and 50 MeV at an external beam-line of COSY with the Time of Flight Spectrometer. During one week of beam-time about 5000 events were measured for each excess energy. Both reaction protons of the process $pp\eta$ are detected with an acceptance of nearly 100% and the η is reconstructed by the missing mass technique. In a first step one third of the 15 MeV excess energy events are evaluated and examined with respect to differential values of which preliminary distributions are presented.

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1. Introduction

The η production in pp collisions has been intensively studied in the last years [1–6]. The production mechanism seems to be dominated by the excitation and decay of the S11(1535) resonance which covers the η N threshold with its decay width. The existence of direct η production near threshold or the influence of other nucleon resonances (*e.g.* $N(1440)$, $N(1700)$) is still not proven, but a measurement from PROMICE/WASA [5] shows that even at 16 MeV excess energy there are higher momenta than s waves involved. As the η is the lightest meson containing $s\overline{s}$ quarks the question of direct production channels is interesting because it may be connected to the possible $s\overline{s}$ contents of the proton.

2. Experiment

The external proton beam with a diameter of 1–2mm impinges on a 4mm thick liquid hydrogen target enclosed with plastic foils of only 0.9μm thickness. The start and stop counters are built symmetrically in respect to the azimuthal angle with holes for the beam, so only reaction particles are hitting the counters; the beam halo is vetoed by a scintillator with a hole of 2mm diameter. All particle tracks and the beam are fed through vacuum in order to minimize multiple scattering and secondary reactions (Fig. 1). The high granularity of the stop scintillators results in a resolution for the

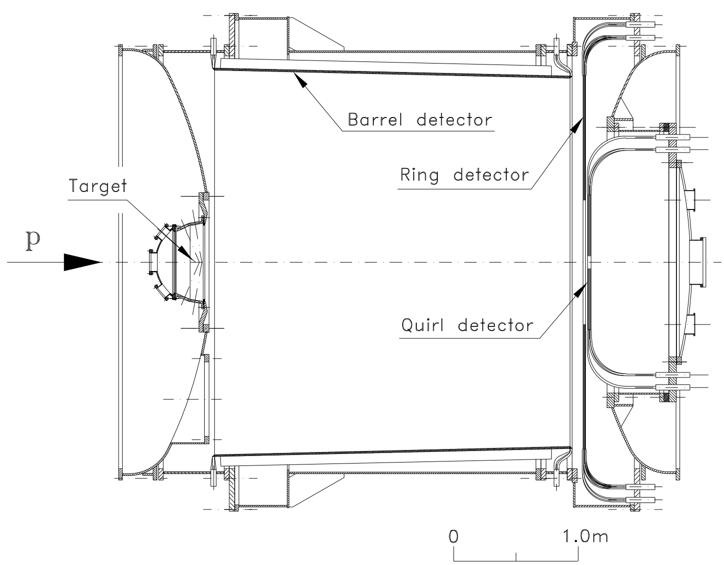

Fig. 1. The experimental set up of the COSY-TOF detector.

azimuthal angle of 2°–4° and for the scattering angle of typically 0.5°. The acceptance for charged particles in φ is 100%, for θ it ranges from 0.8°–75°. The time of flight is measured with a resolution of σ =250ps which is 1% of the typical time of flight for protons of this reaction.

3. Data analysis

In the first step the η is reconstructed only from the tracks of both protons and the charged decays are discarded. For each track the momentum is calculated from the time of flight and the measured directions, the mass of the proton is assumed. The missing mass is calculated by applying momentum and energy conservation. Pion tracks lead to negative squared missing masses when the mass of the proton is assumed. Near the maximum of excess energy which corresponds to a missing mass of 562 MeV/c^2 only $pp\eta$ and multi-pion production ($ppn\pi$) events are contributing to the missing mass distribution (Fig. 2). The width of the η signal in the data is 1.2% (FWHM).

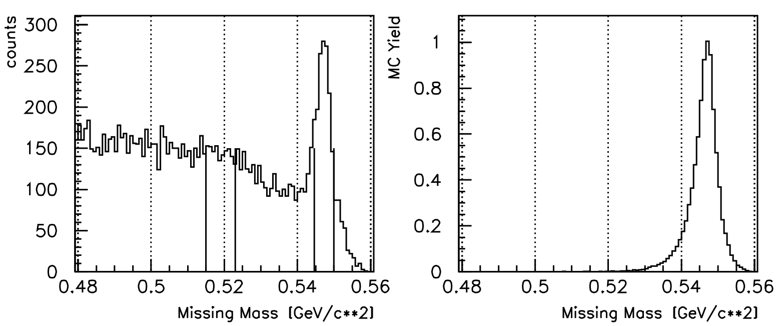

Fig. 2. The missing mass distribution for the excess energy of 15 MeV. Left figure: raw data. The lines are indicating the cuts for η events and for background events. Right figure: missing mass resolution from Monte Carlo calculations.

The c.m. momenta of the three ejectile particles are defining a plane ("ejectile-plane"); the normal vector to this plane can be calculated from $\vec{p}_3^{\,\mathrm{c.m.}} \times \vec{p}_4^{\,\mathrm{c.m.}}$ ($\vec{p}_i^{\,\mathrm{c.m.}}$ are the c.m. momenta of the reaction protons). The angle between this vector and the beam axis gives in one limit the ejectile plane perpendicular to the beam axis ($\cos(\kappa) = \pm 1$), in the other limit the beam axis lies within this plane ($\cos(\kappa) = 0$). Due to the complete measurement of both proton tracks the distribution of $\cos(\kappa)$ can be deduced from the data.

4. Results

The distribution of the orientation of the ejectile plane for the η events is given in Fig. 3. For the $pp\eta$ reaction the ejectile plane has a high probability to be perpendicular to the beam axis whereas the background reactions are tending to lay together with the beam direction in one plane.

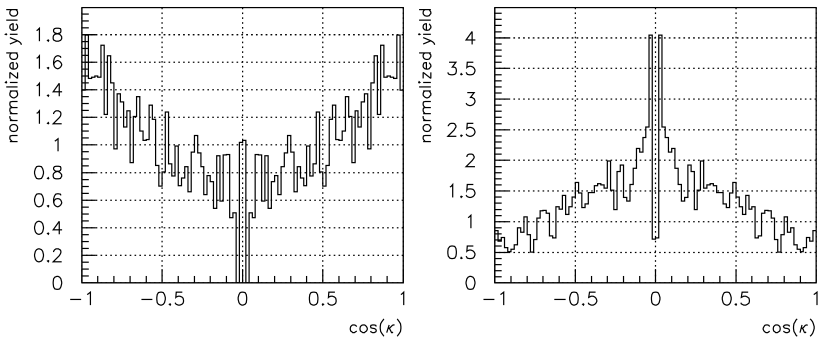

Fig. 3. Left figure: the distribution of the direction of the ejectile plane for $pp\eta$ events (the cuts are defined in Fig. 2). The raw data are normalized with Monte Carlo events. Right figure: the same distribution for background events. The figures are symmetrized by exchanging the sequence of the scattered protons in the calculations and filling both solutions. For collinear proton tracks the orientation of the plane cannot be determined, these events are sorted to $\cos(\kappa) = 0$.

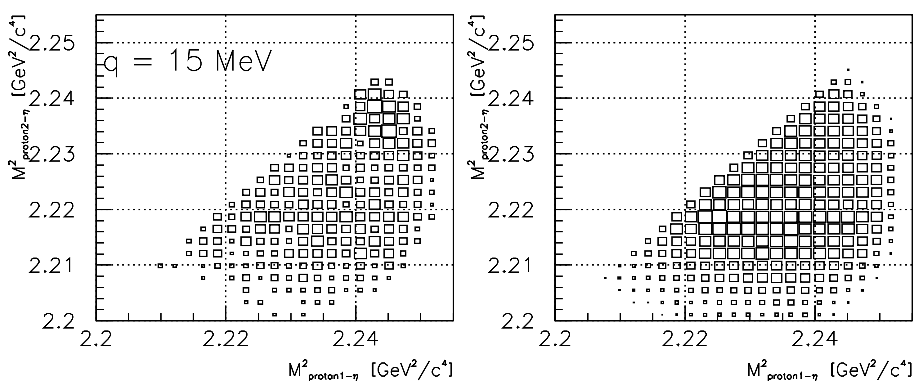

Fig. 4. Left figure: the Dalitz plot for the proton η system. The protons are sorted due to their magnitude of c.m. momentum. Only raw data are plotted with cuts to the η mass as indicated in Fig. 2. Right figure: Monte Carlo Data with the same cut on the η mass.

The Dalitz plot is shown in Fig. 4. The raw data (with the cut on the η mass) are compared with the Monte Carlo data. Due to the high acceptance the Monte Carlo Data show a nearly flat distribution. The raw data exhibit a strong peak in the range of low proton–proton relative momenta due to the *pp* final state interaction.

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