Time resolution of the COSY–11 neutron detector tested via the $pp \to pn\pi^+$ reaction

P. Moskal[1] for the COSY–11 collaboration

In order to study charged hyperon production, for example Σ^+ via the reaction $pp \to n\mathrm{K}^+\Sigma^+$ or quasi free meson production in proton-neutron interactions, the COSY–11 facility was extended by a neutron detector. At the present stage it consists of twelve modules each built out of eleven plates of plastic scintillator with dimensions of 270 x 90 x 4 mm^3 interlayed by lead plates [1]. The scintillators are read out on one side by a light guide manufactured from one solid block of plexiglass, which changes smoothly its shape from rectangular to cylindrical. This enables to collect the scintillation light on a circular (4 cm diameter) photocathode of a photomultiplier.

During the measurement of the $pp \to pp\mathrm{K}^+\mathrm{K}^-$ reaction [2] in April 2001, one day of beam time was devoted for the test of the performance of the neutron detector. For this purpose we measured the $pp \to pn\pi^+$ reaction registering outgoing protons and neutrons in coincidence. The neutron detector was positioned behind the COSY–11 dipole magnet downstream the beam at a distance of 4 m from the target location as shown in the accompanying report [3]. In order to identify the $\mathrm{p}\mathrm{n}\pi^+$ final state the momentum vectors of the registered protons and neutrons have been determined for each event. Proton momenta have been reconstructed by tracking back trajectories, registered by drift chambers, to the interaction point [4].

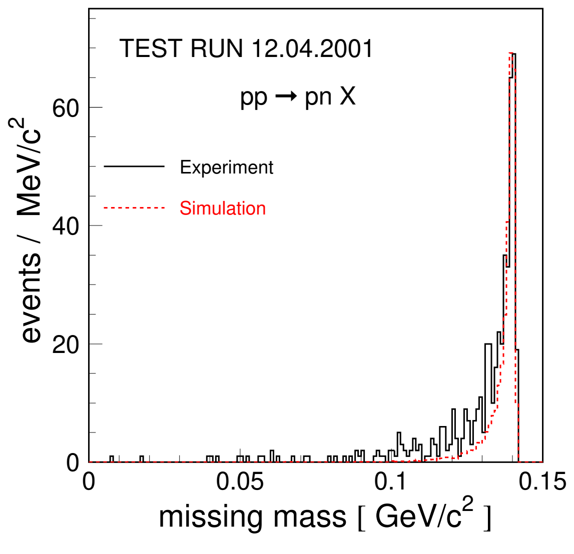

Fig. 1: Missing mass spectrum of the $pp \to pn\pi^+$ reaction. The data shown by the solid line are compared to the result of Monte-Carlo simulations indicated by the dashed line. The FWHM of the peak amounts to $\sim 4\ MeV/c^2$.

The neutron momenta have been determined from the time of flight between the target and neutron detector and the angle defined by the centre of the hit segment. The neutron detector granularity allows to determine the horizontal hit position with an accuracy of ± 4.5 cm. Figure 1 shows a missing mass spectrum with respect to the measured proton-neutron system. The obtained distribution is clearly peaked at the mass corresponding to the mass of the π^+ meson ($\sim 140\ MeV/c^4$) and because there is no physical reaction which could contribute to this spectrum one can assign the observed events to the $pp \to pn\pi^+$ reaction, especially since its shape agrees well with Monte-Carlo simulations. The simulations have been performed with the time resolution of the neutron detector as free parameter, which determines the width of the missing mass spectrum. By the fit to the data the time resolution of the detector was established to be 0.5 ns (rms).

Taking into account the number of registered events, the detection efficiency and the luminosity we determined the total cross section for the $pp \to pn\pi^+$ reaction at the kinetic beam energy of 296.7 MeV. The result – shown in Figure 2 – agrees within the error bars with the measurements performed at other laboratories [5–7].

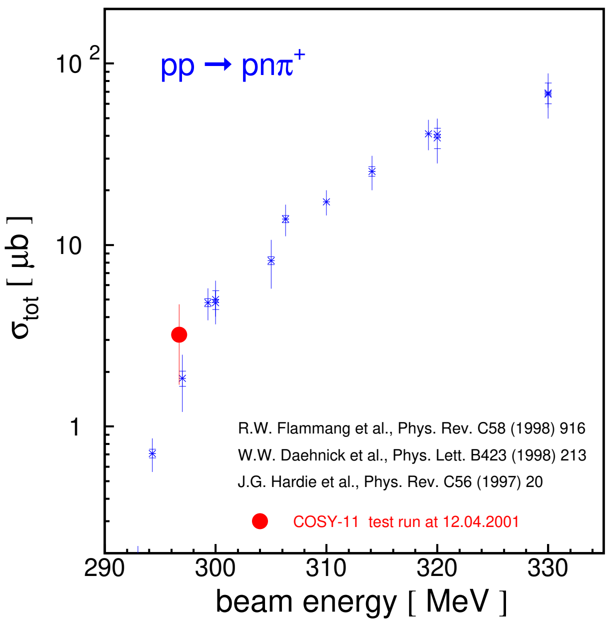

Fig. 2: Total cross section for the $pp \to pn\pi^+$ reaction. Full circle shows the result of the test run juxtaposed with the existing data.

References:

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[1] Institute of Physics, Jagellonian University, 30–059 Cracow, Poland