Status of the analysis of the $pn \to pn\eta'$ reaction

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In August 2004 –for the first time– using the COSY–11 [1] facility we have conducted a measurement of the η' meson production in the proton-neutron collision [2]. The aim of the experiment is the determination of the total cross section of the $pn \to pn\eta'$ reaction near the kinematical threshold. The comparison of the $pp \to pp\eta'$ and $pn \to pn\eta'$ total cross sections will allow to learn about the production of the η' meson in different isospin channels and to investigate aspects of the gluonium component of this meson.

The experimental precision of the missing mass determination of the $pn \to pn\eta'$ reaction rely on the accuracy of the reconstruction of the momentum of protons and neutrons. For each proton, which gave a signal in the drift chamber, the momentum vector can be determined. First the trajectories of the particles are reconstructed, and then knowing the magnetic field of the dipole, the momentum vector is derived. In this report we give an account on the time-space calibration of drift chambers and timing calibration of the neutral particle detector.

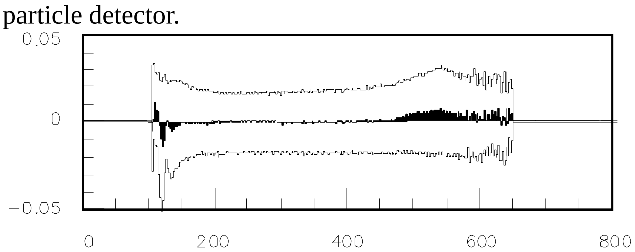

Fig. 1: Example of the spectrum used for the drift chamber calibration. Shaded area presents mean values of ΔX (in cm) as a function of the drift time (in ns). Upper and lower histograms indicate a band of one standard deviation of the ΔX distribution.

Due to changes of the pressure, temperature and humidity of the air inside the COSY tunnel, the drift chamber calibration has to be performed for time frames not longer than few hours. The calibration is derived in an iterative way. First, distances of the particle's trajectory to the wires are derived from the working calibration, and to the obtained points a straight line is fitted. Next, the deviation ΔX between the fitted and measured distances of the particle's trajectory to the wire is calculated. An example of a mean value of ΔX as a function of the drift time is shown in the Fig.1. Afterwards the relation between the drift time and distance from the wire is corrected by the determined mean value of ΔX. The procedure is repeated until corrections become negligible.

The neutral particle detector delivers information about the time at which the registered neutron or gamma quanta induced correspondingly a hadronic or electromagnetic reaction.

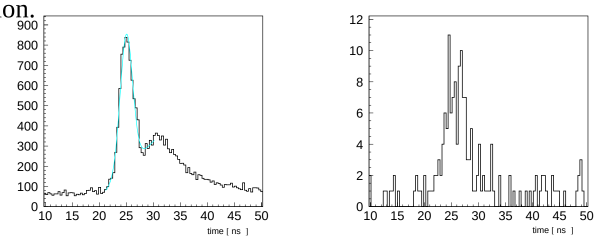

Fig. 2: Time–of–flight determined between the target and the neutron detector. Details are described in the text.

This information together with the time of the reaction allows to calculate the time-of-flight between the target and the neutron detector and to determine the absolute momentum of registered paricles, provided that it could have been identified. The time calibration of the neutron detector proceeds in two steps. First the relative timing between modules of the neutron detector are established from experimental distributions of time differences between neighbouring modules. In the next step a general time offset of the neutron counter with respect to another (S1) detector has to be established. For this purpose the $pd \to pd\pi^0\pi^0$ reaction is used. The meson π^0 decays in the target into two gamma quanta. Thus, the calibration is based on the measurement of the proton, deuteron in drift chambers and scintillators (S1 and S3), and gamma quanta in the neutral particle detector. Knowing the distance between the target and a module in the neutral particle detector which gave the signal as a first one, one can adjust the general time offset between this detector and the S1 counter. The time of the reaction in the target can be calculated from the times when proton and deuteron crossed the S1 scintillator and from their reconstructed momenta and trajectories. Figure 2(left) presents the time-of-flight distribution –for neutral particles– measured between the target and the neutral particle detector. The spectrum was obtained under the condition that in coincidence with a signal in the neutral particle detector two charged particles were registered in the drift chambers. A clear signal originating from the gamma rays is seen over a broad enhancement from neutrons. This histogram shows that discrimination between signals originating from neutrons and gamma quanta can be done by a cut on the time of flight. An analogous spectrum with an additional requirement that the registered charged particles correspond to proton and deuteron ($pd \to pdX$) is shown in the right panel of figure 2. As expected, in this spectrum only a signal from the gamma quanta is seen.

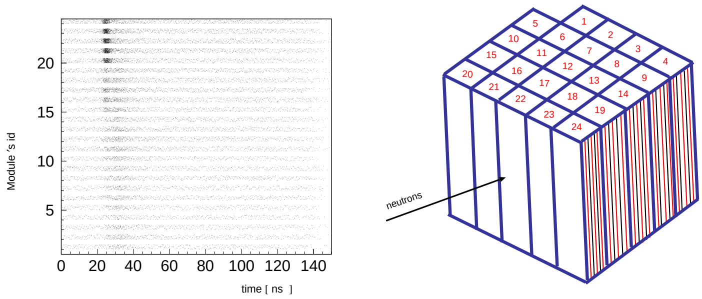

Fig. 3: (left) Time–of–flight determined between the target and the neutral particle detector as a function of module's number. (right) Confi guration of the detection units

Figure 3 shows, as expected from the known absorption coefficients [3], that the gamma quanta are predominantly registered in the first row of the detector whereas interactions points of neutrons are distributed more homogenously.

As a next step in the analysis of the $pn \to pn\eta'$ reaction a calibration of the spectator detector will be conducted.

References:

[1] S. Brauksiepe et al., Nucl. Inst. & Meth. **A 376** 396 (1996).

[2] P. Moskal et al., COSY Proposal **No. 133** (2003).

[3] K. Hagiwara et al., Phys. Rev. **D 66** 010001 (2002).