Momentum resolution of the neutron detector

J. Przerwa[1], P. Moskal for the COSY-11 collaboration

The installation of the neutral–particle–detector at the COSY–11 [1] facility enables to study a plethora of new reaction channels. It gives ability not only to measure the bremsstrahlung radiation created in the collision of nucleons but also opens wide possibilities to investigate the isospin dependence of the meson production in the hadronic interactions [2]. For example at present the COSY–11 facility permits to study η-meson production in proton–proton and proton–neutron collisions [3, 4]. The neutron detector is desined to deliver the information about the time at which the registered neutron or gamma quanta induced a hadronic or electromagnetic reaction. The time of the reaction combined with this information allows to calculate the time–of–flight (TOF^N) of the neutron (or gamma) on the 7 m distance between the target and the neutron detector, and — in case of neutrons — to determine the absolute value of the momentum (p) what can be expressed as:

$$p = m \cdot \frac{l}{TOF^N} \cdot \frac{1}{\sqrt{1-(\frac{l}{TOF^N})^2}},$$

where m denotes the mass of the particle, l stands for the the distance between the target and the neutron detector and TOF^N is the time–of–flight of the particle.

The experimental resolution of the missing mass determination eg. in the analysis of reactions like $pn \rightarrow pn\eta'$ strongly rely on the accurate measurement of the momentum of the neutrons [3]. Therefore, the momentum resolution of the neutron detector has to be established.
Monte Carlo studies of the $dp \rightarrow ppn_{sp}$ reaction have been performed in order to establish the momentum resolution of the neutron detector.

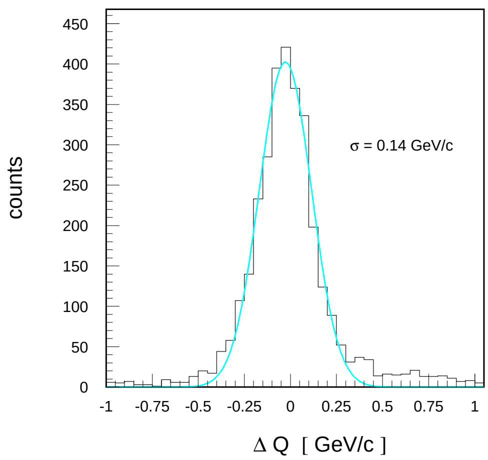

Fig. 1: Difference between generated (P_{gen}) and reconstructed (P_{rec}) neutron momenta for the $dp \rightarrow ppn_{sp}$ reaction simulated at a deuteron beam momentum of 3.204 GeV/c.

Figure 1 presents the difference between the generated neutron momentum (P_{gen}) and the reconstructed neutron momentum from signals simulated in the detectors (P_{rec}).

$$\Delta P = P_{gen} - P_{rec}$$

The value of (P_{rec}) was calculated taking into account the time resolution of the neutron detector (σ = 0.4 ns) [5] as well as the time resolution of the S1 counter (σ = 0.25 ns). The distribution of ΔP was fitted by a Gaussian function resulting in a momentum resolution of σ(P) = 0.14 GeV/c [6]. The momentum resolution of the neutron detector – as shown in figure 2 – strongly depends on the momentum of the neutron.

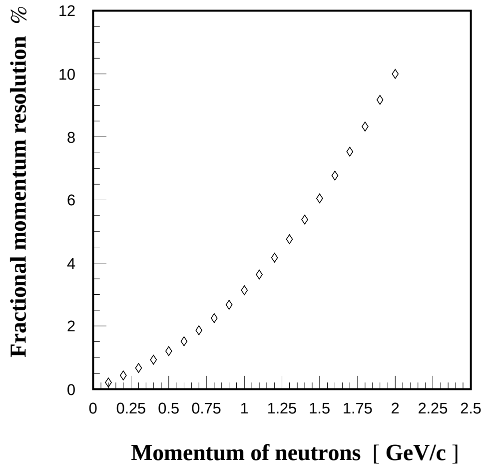

Fig. 2: Fractional momentum resolution of the neutron detector as a function of neutron momentum.

A fractional momentum resolution is given by the equation:

$$\frac{\sigma p}{p} = \frac{\frac{dp}{dt} \cdot \sigma_t}{p},$$

where σ_t accounts for both the time resolution of the neutron and S1 detectors and can be written as:

$$\sigma_t = \sqrt{\sigma_n^2 + \sigma_{S1}^2}$$

The result presented in figure 2 was obtained assuming that σ_n = 0.4 ns, σ_{S1} = 0.25 ns, and l = 7 m.

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