Study of the nucleon-nucleon bremsstrahlung radiation at COSY-11

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Installation of the neutron detector at the COSY-11 facility enables to study a plethora of new reaction channels. It opens wide possibilities not only to investigate the isospin dependence of the meson production [1] but also it enables to measure the bremsstrahlung radiation created in the collisions of nucleons. The study of the latter process is interested since it is highly sensitive to the kind of the nucleon-nucleon potential, and hence may serve as a tool to discriminate between various existing potential models [2, 3]. The bremsstrahlung radiation may also be helpful for the calibration of the absolute timing of the neutron detector, necessary for the determination of the momentum of neutrons eg. in the analysis of such reactions like $pn \to pn\eta'$. Gamma quants produced in NN collisions are an excellent tool for the calibration of the neutron detector since their velocity is constant and the time-of-fligh between the target and the hitted module depends only on the path length the gammas need to pass. Figure 1a presents the time-of-flight spectrum – for the neutral particles – measured between the target and the neutron detector using detector arrangement shown in figure 2. The data are from the experiment performed with deuteron target and proton beam with momentum of 2.075 GeV/c [1]. The distribution consists of a rather broad spectrum originating from the neutrons emitted from different reactions, eg. $pn \to pn\eta$ as shown in figure 1b, and of a sharp peak which we interpret as due to the gamma quants. In the preliminary analysis of the data [1] we have adjusted the absolute time offset of the neutron detector such as the vissible peak would correspond to the gamma quants. Under this supposition we have obtained satisfactorily coherent results [1], yet naturally, for the final evaluation of the data this assumption must be verified.

At present, in order to perform a more thorough calibration we are analysing data taken in January 2003 from the run with a deuteron beam and proton target. This experiment performed at the beam momentum of 3.204 GeV/c was primordially devoted to study of the $dp \to dp\eta$ reaction [4], however, we expect that the kinematical conditions when using a deuteron beam and a proton target enabled to register, by the used detection system (fig. 2), many reactions with the gamma quant in the final state. To study them is interesting in itself, and additionally it will also allow us to perform the timing calibration of the whole system.

As a first step we made a presort of the data selecting events with simultaneous signals in any of drift chambers and the neutron detector. In parallel we have extented the simulation programme to the free and quasi-free nucleon-nucleon reactions with bremsstrahlung radiation. Specifically, we have implemented free $dp \to dp\gamma$ and $dp \to {}^3He\gamma$ reactions and also quasi-free reactions viz., $dp \to d\gamma\, p_{sp}$, $dp \to np\gamma\, p_{sp}$, as well as the $dp \to pp\gamma\, n_{sp}$. The suffix "$_{sp}$" indicates here the spectator nucleon which does not take part in the reaction. In order to account for the Fermi motion of the nucleons inside a deuteron, we have used an analytical parametrization of its wave function resting on the PARIS potential [5]. Kinematics of events corresponding to the first three of the above listed reactions can be entirely determined by measuring the outgoing charged ejectiles. Therefore, they seem to be the best suited for the calibration purposes. However, in the next year, by degrees, we will study the response of the COSY-11 detection system to all the above mentioned reactions in order to estimate their usefulness for the calibration of the system and the ability of the determination of their cross sections. Searching for the best calibration method, complementary to the reactions with the bremsstrahlung radiation, we intend also to consider the quasi free proton-proton scattering (see figure 2) and also production of π^0 meson via the $dp \to ppn_{sp}\pi^0 \to ppn_{sp}\,\gamma\gamma$ process.

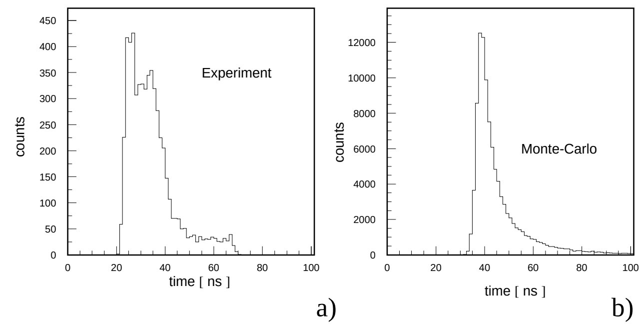

Fig. 1: Time of flight distribution determined between the target and the neutron detector. Simulation corresponds to the $pn \to pn\eta$ reaction. In the experimental spectrum in addition to neutrons the peak from gamma rays is seen at a value of about 25 ns.

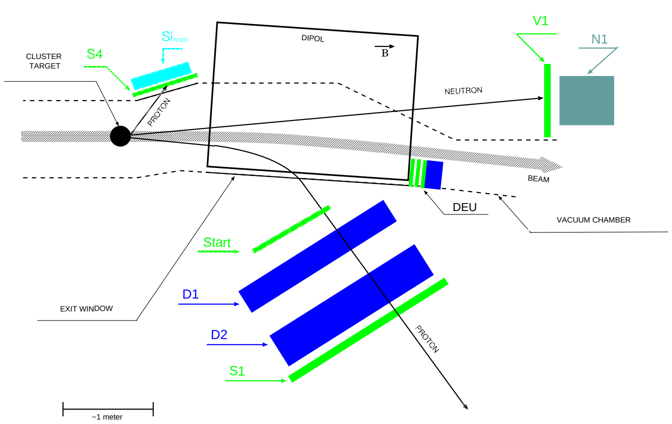

Fig. 2: Scheme of the COSY-11 detection system with superimposed tracks from the $dp \to pp\, n_{sp}$ reaction. Fast protons are registered in two drift chambers D1, D2 and in the scintillator hadoscopes. Protons scattered under large angle are measured in Si_{mon} detector. Neutrons are registered in the neutron modular detector (N1), and deuterons in the deuteron detector denoted by *DEU*.

References:

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