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STATUS OF PREPARATION OF dp-ELASTIC SCATTERING STUDY AT THE EXTRACTED BEAM OF THE NUCLOTRON

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Гурчин Ю. В. и др. E1-2010-122
Статус подготовки эксперимента
по изучению реакции dp-упругого рассеяния
на выведенном пучке нуклотрона

Показано выделение событий dp-упругого рассеяния с использованием сцинтилляционных детекторов при энергиях 1,6 и 2,0 ГэВ. Разработана процедура CH_2–C вычитания. Исследована зависимость выхода упругих событий от толщины фильтра. Этот метод может быть использован для высокоэффективной поляриметрии дейтронного пучка.

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Status of Preparation
of dp-Elastic Scattering Study
at the Extracted Beam of the Nuclotron

A selection of dp-elastic scattering events at energies of 1.6 and 2.0 GeV by using scintillation counters has been performed. The procedure of the CH_2–C subtraction has been established. The dependence of the elastic events yield on the filter thickness has been investigated. This method can be used to develop the efficient high-energy deuteron beam polarimetry.

The investigation has been performed at the Veksler and Baldin Laboratory of High Energy Physics, JINR.

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INTRODUCTION

The investigations with the use of high-energy polarized deuteron beams proposed at different facilities require the efficient polarimetry at these energies to deduce values of polarization observables reliably. However, only some reactions can be used to provide efficient polarimetry of high-energy deuteron. Since deuteron is a spin-1 particle, deuteron beam has vector and tensor polarizations. The polarimetry should have a capability to determine both components of polarization, if possible, simultaneously.

The polarimeters based on deuteron inclusive breakup with the proton emission at zero degree [1] and pp-quasi-elastic scattering [2] are currently used at LHEP-JINR Accelerator Complex to provide the polarimetry of the deuterons at high energies. But these analyzing reactions cannot be used for the simultaneous measurements of the tensor and vector polarizations of the beam, because deuteron inclusive breakup at zero degree and pp-quasi-elastic scattering have no vector and tensor analyzing powers, respectively.

The dp-elastic scattering has been successfully used for the deuteron polarimetry at RIKEN at a few hundreds of MeV [3] and polarimeter ALPHA (LHE, JINR) [4]. This reaction has several advantages as a beam-line polarimetry over the others. Firstly, both vector and tensor analyzing powers have large values. Secondly, a kinematical coincidence measurement of deuteron and proton with simple plastic scintillation counters suffices for event identification. The same polarimeter for higher energies has been proposed [5], constructed and calibrated at 880 MeV [6] at the Internal Target Station at the Nuclotron.

The goal of the present investigation is to study the possibility to use high-energy dp-elastic scattering at forward angles with the selection by means of the kinematical coincidences of deuteron and proton with simple plastic scintillation counters for extracted beam polarimetry at the Nuclotron.

1. DEUTERON–PROTON ELASTIC SCATTERING EVENTS SELECTION

The schematic view of the experiment at extracted beam of the Nuclotron is shown in Fig. 1. The setup consists of two scintillation detectors based on PMT-85 photomultiplier tubes. Measurements were performed using deuteron beam of

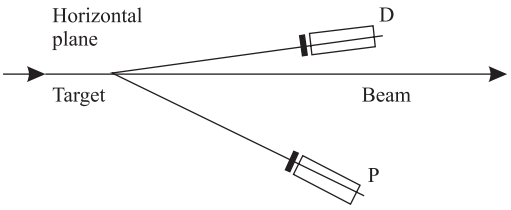

Fig. 1. Schematic view of the experiment. P — proton detector, D — deuteron detector

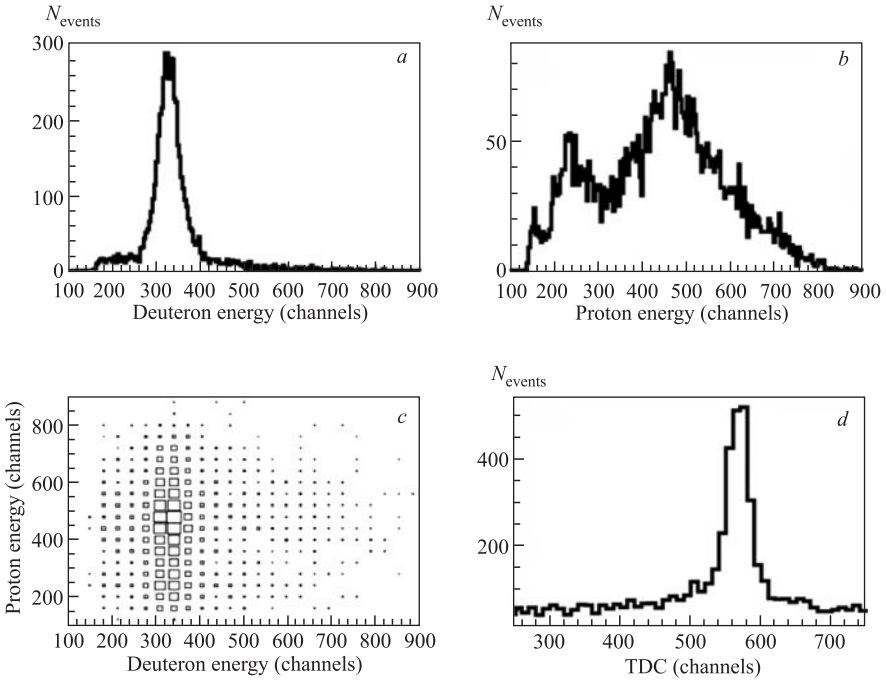

Fig. 2. The results obtained at 2.0 GeV deuteron beam on polyethylene target: *a*) deuteron energy losses, *b*) proton energy losses, *c*) correlation of proton and deuteron energy losses, *d*) time difference between the signals for deuteron and proton detectors

2.0 and 1.6 GeV and polyethylene and carbon targets. The deuteron detector was placed at 8° lab for the energy 1.6 GeV, the proton detector was placed in the kinematical coincidence.

The amplitudes of the signals and timing information from both the P and D detectors were recorded for each event. The distributions of the amplitudes for scattered deuterons and recoil protons for polyethylene target are presented in Figs. 2, *a* and 2, *b*, respectively. The correlation of the amplitudes

and time difference are shown in Figs. 2, *c* and 2, *d*, respectively. One can see a clean correlation between the amplitudes from P and D detectors and a well-pronounced peak in the time difference spectrum corresponding to the dp-elastic scattering events.

The selection of the dp-elastic scattering events was done by applying the graphical cut on the amplitudes correlation (see Fig. 3, *a*). This cut allows one to reduce significantly background in the time difference spectrum shown in Fig. 3, *b*.

The measurements on carbon target were also performed to estimate the carbon contribution from polyethylene target. The corresponding distributions of the amplitudes for scattered deuterons and recoil protons, the correlation of the amplitudes and time difference are shown in Fig. 4. One can see that the distribution for recoil proton energy losses for $d + \mathrm{C}$ interaction is much wider than for $d + \mathrm{CH_2}$ scattering.

The time differences for P and D detectors for polyethylene and carbon targets after applying the graphical cut on the amplitudes correlation are shown in Figs. 5, *a* and 5, *b*, respectively. The relative normalization of the spectra was obtained from the ratio of the background events placed on the left and right from the peak. For this purpose the time difference spectra in Fig. 5 were fitted by the sum of Gaussian and constant. The ratio of the obtained constants was considered as a normalization factor.

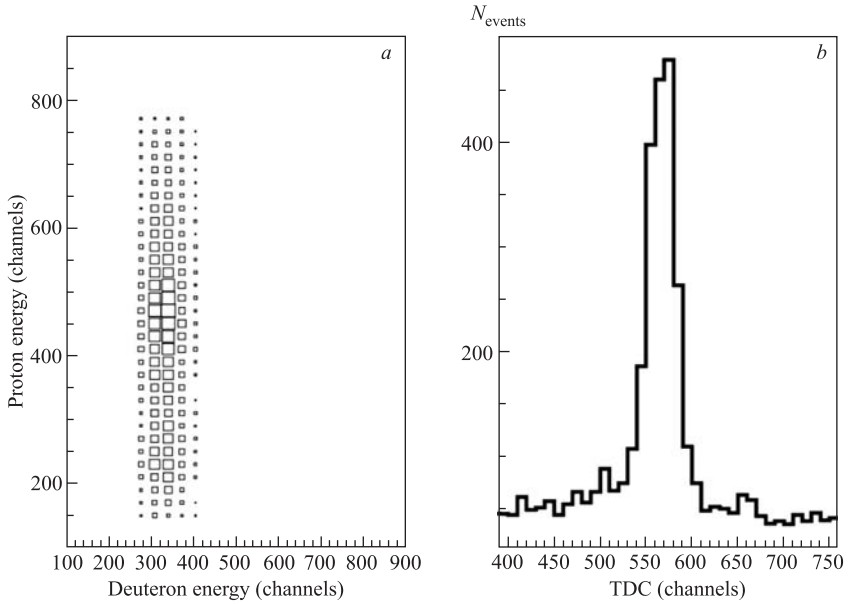

Fig. 3. The selection of the dp-elastic scattering events by the energy losses correlation (*a*) and time difference (*b*) after appying of the energy losses correlation cut

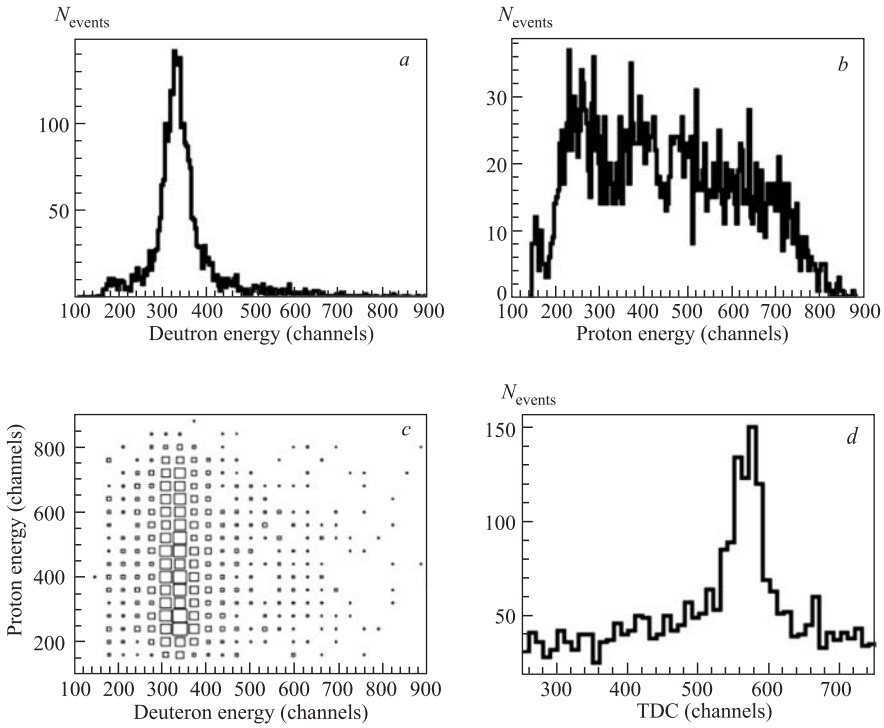

Fig. 4. The results obtained at 2.0 GeV deuteron beam on carbon target: *a*) deuteron energy losses, *b*) proton energy losses, *c*) correlation of proton and deuteron energy losses, *d*) time difference between the signals for deuteron and proton detectors

The results of the CH_2–C subtraction of the time difference spectra for 1.6 and 2.0 GeV are presented in Figs. 6 and 7, respectively. The lines correspond to the prompt time windows for dp-elastic events. The background placed outside of the window is about 3% from the peak height.

2. DEPENDENCE OF THE YIELD ON THE FILTER THICKNESS

The dependence of the dp-elastic events yield on the lead filter thickness has been investigated using 1.6 GeV deuteron beam and polyethylene target. The thickness of the Pb filter placed in front of the P detector was 0, 2, 4 and 6 mm.

The selection of the dp-elastic events has been performed in three stages. At the first stage the events were selected using by graphical cut on the proton–deuteron energy losses correlation only (criterion A). At the second stage, additionally the prompt time window (between 520 and 620 bins) was imposed on

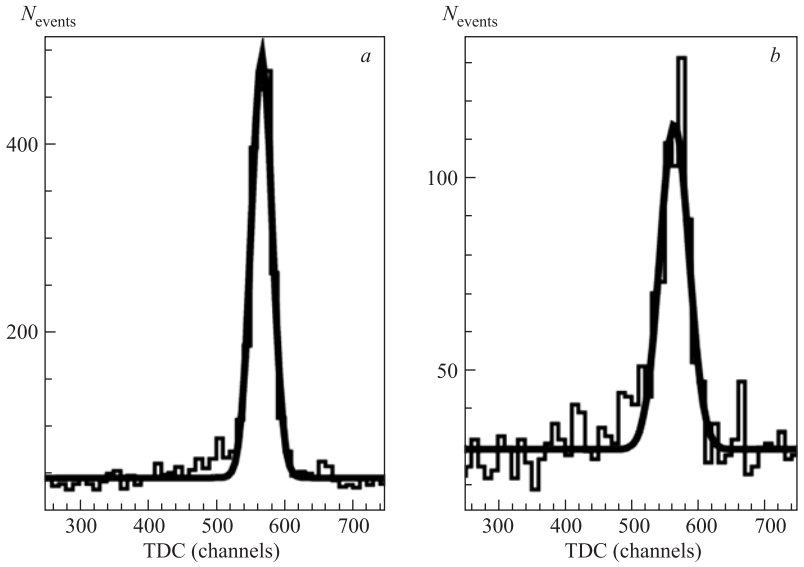

Fig. 5. Time difference spectra obtained on polyethylene (*a*) and carbon (*b*) targets

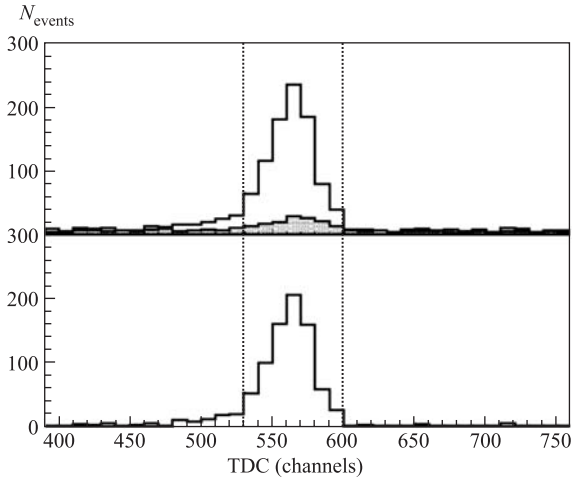

Fig. 6. Time difference distribution for *dp*-elastic events obtained from CH_2–C subtraction at a deuteron energy of 1.6 GeV

the time difference spectra (criterion B). Finally, background events under time difference peak were subtracted. The estimation of the background was done from the events placed on the left and right from the peak in time difference spectra.

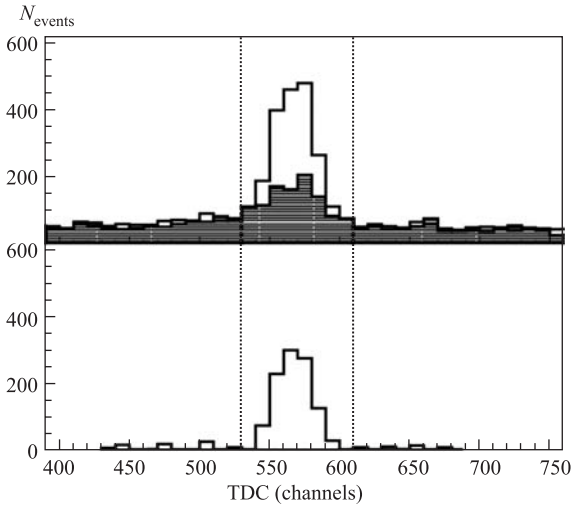

Fig. 7. Time difference distribution for *dp*-elastic events obtained from CH_2–C subtraction at a deuteron energy of 2.0 GeV

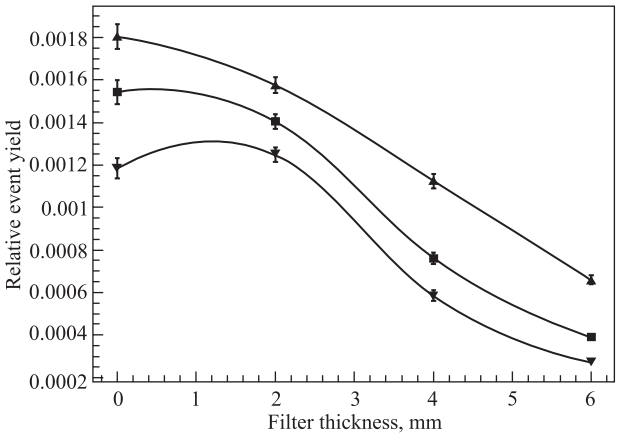

Fig. 8. Relative yield of selected *dp* events as a function of the filter thickness: ▲ — criterion A, ■ — criteria A + B, ▼ — criteria A + B with the background subtraction (curves are presented for better visualization)

The results of the filter thickness studies are presented in Fig. 8 as a function of the selected events yield normalized to the monitor value on the filter thickness. The symbols ▲, ■, ▼ are the data obtained by applying the criterion A only, A + B and A + B with the background subtraction, respectively.

The applied criteria do not remove completely the background from the carbon content of CH_2. However, one can see that the use of 2 mm Pb degrader allows one to increase the relative yield of events useful for polarimetry.

CONCLUSIONS

The following results have been obtained:

The possibility of the *dp*-elastic scattering events selection at high energies and small scattering angles by using scintillation counters techniques has been demonstrated for the first time. This method can be used for the high-energy deuteron beam polarimetry.

The dependence of the events useful for the polarimetry on the Pb filter thickness has been investigated. It is shown that the use of degrader can allow one to increase the yield of useful events.

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