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The results of the deuteron beam polarization measurement for dp-elastic scattering reaction at 270 MeV energy

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Abstract. The current deuteron beam polarimetry at Nuclotron is provided by the Internal Target polarimeter based on the use of the asymmetry in dp- elastic scattering at large angles in the cms at 270 MeV. The upgraded deuteron beam polarimeter has been used obtain the vector and tensor polarization during 2016/2017 runs for the DSS experimental program. The polarimeter has been used also for tuning of the polarized ion source parameters for 6 different spin modes.

1. Introduction

The study of the spin structure of two-nucleon and three-nucleon short-range correlations is main goal of the DSS project at Nuclotron [1, 2, 3]. This study was doing by the polarization measurement of the deuteron reactions.

We presents the vector and tensor beam polarizations study which uses upgraded polarimeter. It's based on the measurements of the *dp*-elastic scattering asymmetry at 270 MeV [4]. The polarimeter is located on the internal target of the Nuclotron. The measurement was performed during the DSS experiment on the study of the vector A_y, tensor A_{yy} and A_{xx} analyzing powers in *dp*-elastic scattering at large transverse momenta [5].

2. Deuteron polarimeter at ITS

Efficient polarimetry can be achieved even at relatively low beam intensity with using a thin solid target inside the inner ring of the accelerator. The luminosity can be increased significantly due to multiple beam passage through the interaction point and the use of a correctly configured internal target trajectory. Therefore, the internal beam polarimeter with a very thin target may have approximately the same efficiency as the extracted beam polarimeters.

The polarimeter based on the use of dp- elastic scattering at large angles ($\theta_{\rm cm} \geq 60°$) at 270 MeV [4], where precise data on analyzing powers [6]-[8] exist, has been developed at internal target station (ITS) at Nuclotron[9]. The accuracy of the determination of the deuteron beam polarization achieved with this method is better than 2% because the values of the analyzing powers were obtained for the polarized deuteron beam, which absolute polarization had been calibrated via the $^{12}{\rm C}(d,\alpha)^{10}{\rm B}^*[2^+]$ reaction[8].

Deuteron beam polarimeter [4] is placed in the ring of the Nuclotron. It consists of a spherical scattering chamber and system change targets that can be set six different targets. A detector support with 39 mounted plastic scintillation counters is placed downstream the ITS spherical chamber. All plastic scintillation detectors consist of photo-multiplier tube Hamamatsu H7416MOD. Eight counters were installed for left, also for right and up, but only four counters for down. The angular span of one proton detector was 2° in the laboratory frame, which corresponds to ∼4° in the cms. Three counters were installed at angles of the deuteron scattering, which coinciding kinematically with the protons angles. As well as, one pair of detectors register two protons from quasi-elastic $p-p$ scattering at θ_{pp}=90° in the cms. It were installed in the horizontal plane. The scattered deuterons and recoil protons at 270 MeV were detected in kinematic coincidence over the cms angular range of 65–135° at eight different angles, defined by the positions of the proton detectors.

The VME (Versa Module Eurocard) based data acquisition system (DAQ) is used for the data taking from scintillation detectors. The signals from the detectors are fed in 16-channel TQDC-16 [10] charge-time-digital converters via commutator bar. TQDC-16 module allows us to measure the amplitude and time appearance of the signal simultaneously. The hardware of the DSS DAQ system [11] consists of 4 TQDC-16 modules, trigger module TTCM [10] and VME controller. There is a possibility to tune the first-level trigger using logic of trigger and TQDC-16 modules. During 2017 the trigger modules TMWR and u40 [10] are used instead of TTCM as well as the new.

Multichannel high-voltage power supply system (Wiener MPod) [12] is used to provide the power for about 70 scintillation detectors based on Hamamatsu photomultipliers.

3. Experiment at ITS

The internal target station setup is well suited for study of the energy dependence of polarization observables for the deuteron-proton elastic scattering and deuteron breakup reaction with the detection of two protons at large scattering angles. For these purposes the CH_2-target of 10 μm thick is used. The yield from carbon content of the CH_2-target is estimated in separate measurements using C-target of several twisted 8μm carbon wires. The measurements were performed using internal target station at Nuclotron [9] with new control and data acquisition system [13].

Polarized deuteron beam was obtained from a polarized ions source (SPI) [14]. The study of the deuteron beam polarization has been used at 270 MeV energy [4].

The DSS experiment was separated on 3 sections: November 2016, December 2016 and February 2017. The deuteron beam polarization measurements were performed at 270 MeV before and after each energy studied in the range of 400-1800 MeV [5].

The data analysing library were based on the ROOT package [15] in C++. The dp-elastic scattering events at 270 MeV are selected using deuteron and proton detectors energy losses correlation and time-of-flight difference. The measurements were performed using CH_2 target only, as the carbon contamination was measured to be less than 0.5%.

The precise data on the deuteron analyzing powers at 270 MeV [6]-[8] were used to get the polarization values at several angles [4]. Assuming that the Y-axis is a symmetry axis (β=90°, φ =0°) one can calculate P_z and P_{zz} using the normalized dp-elastic scattering events and analyzing powers known [4]. The values of the beam polarization for different spin modes

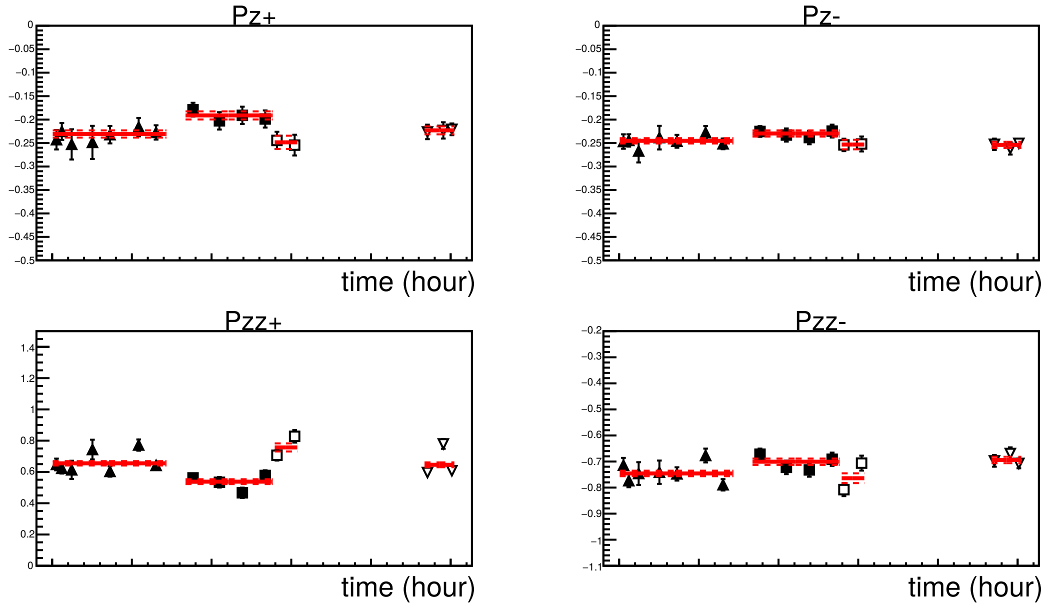

Figure 1. Polarizations values P_z and P_{zz} for runs in 2016 — 2017 yy.

have been obtained as weighted averages for 8 scattering angles for *dp*-elastic scattering in the horizontal plane only. The typical values of the beam polarization were ~65-75% from the ideal values.

4. The polarization measurement results

The experimental data contain of 3 parts. It was seven runs at November 2016, six runs at December 2016 and four runs at February 2017. Vector and tensor values have small errors. All polarization values are stable within each part of the experiment. The exception is the December-2016 part, when the physics program was separated on two parts by the tuning of the SPI. The polarization values approximatly equal to constants for all four data sets. The results of the measurements and approximation are presented in Fig. 1. The beam had quite stable polarization values within more than 200 hours of the SPI operation. Also SPI demonstrates good reproducibility of the polarization values for different sets of the data after long interruptions.

5. Conclusion

The polarimeter has been used to obtain the vector and tensor polarizations during 2016 and 2017 runs. The long-term stability of the vector and tensor components of the beam polarization has been demonstrated.

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