EXPERIMENTS TO STUDY THE DENSE BARYONIC MATTER AT NUCLOTRON

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Abstract

The results of preparation of the experiments at extracted beam and internal target station at Nuclotron-JINR are reported. First extraction of the 3.42 A·GeV carbon beam and of the 4 A·GeV deuteron beam at Nuclotron and their transportation to the beam experimental area as well as the measurements of dp-elastic scattering, dW- and dAg- quasi-elastic scattering at internal target station at Nuclotron are performed.

The study of the strange matter in heavy-ion collisions at the beam energies from 2 to 6 A·GeV is main direction of BM@N project [1]. Installation of experimental setup at the 6V beamline in the fixed-target hall at Nuclotron is proposed. The basic setup will include the set of magnets and detector system. Namely small and large-acceptance dipole magnets, tracking detector modules, trigger and time-of-flight systems. The researches at this setup are focused to understanding the strange matter.

The goal of DSS project [2] is the systematic study of the polarization observables in hadronic reactions by using polarized deuteron beam and polarized ^3He - target [3] at intermediate and high energies. The experiment to measure T_{20} and C_{yy} for the $^3He(d,p)^4He$ - reaction at 1.0-2.0 GeV deuterons energy is planned. The results of this experiment will help to understand the short-range deuteron spin structure. In addition the study of deuterons interaction with protons and nuclei is included in DSS project.

In this paper the results of first extraction of the 3.42 A·GeV carbon beam and of the 4 A·GeV deuteron beam [4] at Nuclotron and their transportation to the beam experimental area are reported. The measurements of dp-elastic scattering, dW- and dAg- quasi-elastic scattering at internal target station at Nuclotron are presented.

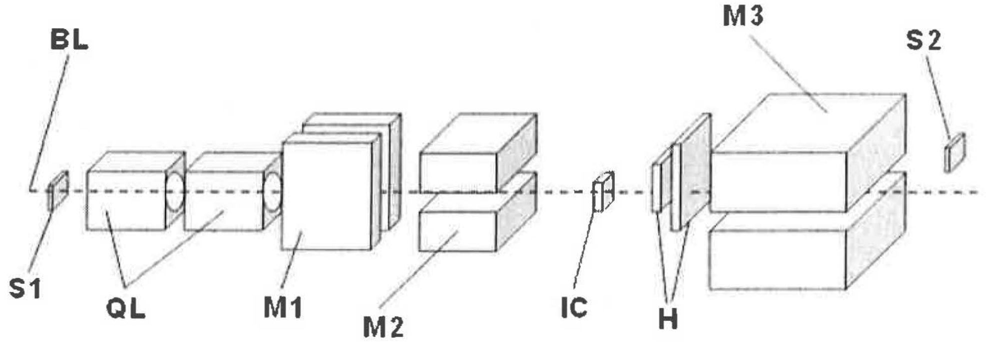

Figure 1: The layout of the experiment. **BL** is the optical axis of the 6V beam line, **QL** and **M1-M3** are the quadrupole and dipole magnets, respectively. **IC** is the coordinate ionization chamber, **S1** and **S2** are the start- and stop- scintillation counters, respectively, **H** are 2 planes of the scintillation counters hodoscopes.

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The magnetic scheme of the 6V line is shown in Fig. 1. The experimental setup of the experiment is placed at the distance of about 110 m from the ring of Nuclotron. The doublet of quadrupole magnets (QL) allows to focus the beam. Two small dipole magnets M1 and M2 can deflect the beam in the horizontal and vertical directions. The large aperture magnet SP41 (GIBS magnet, M3) can be used as an analyzing magnet.

The start scintillation counter S1 is based on the use of XP2020 PMT. The stop scintillation counter S2 is based on the use of PMT FEU-87. The additional multi-wire ionization chamber (IC) and two scintillation hodoscopes (H) are installed in the experimental area.

The first and second hodoscopes provided the coordinate measurements in the horizontal and vertical planes, respectively. Each hodoscope (see Fig. 2) consist of 8 scintillators with the size of 400x40x4 mm^3 viewed by PMTs FEU-85 from both sides each [5].

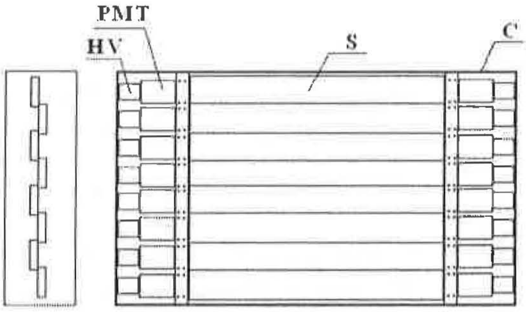

Figure 2: The scheme of the hodoscope. Left: profile of the hodoscope. Right: the layout of the hodoscope. **C**-case, **HV**-cells of high-voltage power,**PMT** - photomultipliers FEU-85, **S**-scintillation plates

The VME based data acquisition system was used for the data taking from scintillation detectors. 16 - channel time and charge digitizer (TQDC16) allows to measure the amplitude and time appearance of the signal [6].

The carbon- and deuteron- beams with energies 3.42 and 4 A·GeV respectively were successfully transported to 6V - area. The correlation of the signal amplitudes taken from the both sides of one of the scintillation detector of hodoscope for carbon nuclei beam is shown in Fig. 3.

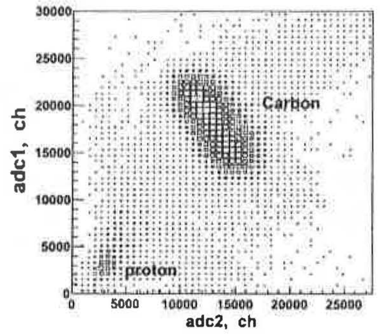

Figure 3: The signal amplitudes correlation for carbon nuclei beam for one of the scintillation detector of the hodoscope.

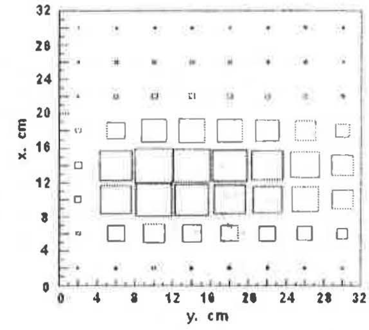

Figure 4: The X-Y coordinates correlation for carbon nuclei.

One can see the clean separation of the primary carbon nuclei and background single charged particles. The X-Y coordinates correlation for carbon nuclei was plotted (see Fig. 4). One can see that the size of the carbon beam in Y- direction is wider. The amplitude distribution for the deuteron beam (see Fig. 5) is corresponded to amplitude distribution for the single charged particles in Fig.3. The inclusion of quadrupole magnetic lenses allowed to reduce the size of the beam (see. Fig 6).

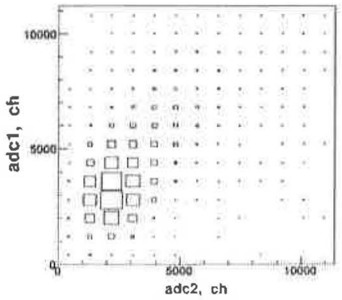

Figure 5: The signal amplitudes correlation for deuteron beam for one of the scintillation detector of the hodoscope.

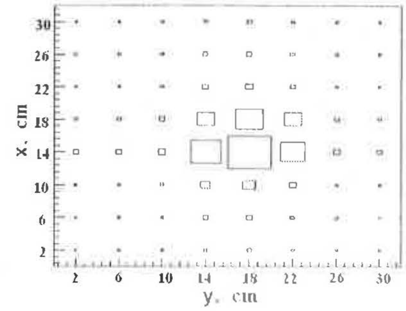

Figure 6: The X-Y coordinates correlation for deuteron beam.

In addition the methodical measurements to obtain of the differential cross section for dp-elastic scattering at the ITS was performed. The measurements have been performed by using CH_2-target and deuteron beam at 1GeV/nucleon energy. The dp- and pp-detectors were mounted at angle $\theta^* = 75^o$ and $\theta^* = 90^o$ in the c.m.s., respectively. Subtraction of the time signal taken from the D- and P- detectors for counters based on the FEU -85 and counters based on the Hamamatsu H7416MOD is shown in Fig.7 and Fig. 8 respectively. One can see, that the dp-elastic scattering events and background are not selected in the case of the measurements with the counters based on the FEU -85 unlike the counters based on the Hamamatsu H7416MOD.

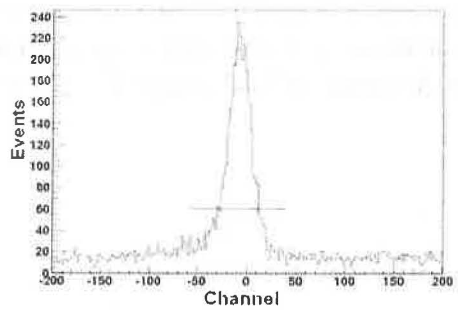

Figure 7: Subtraction of the time signal from D- and P- counters. The data were obtained by using the counters based on the FEU-85.

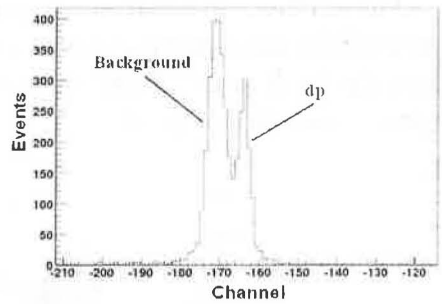

Figure 8: The subtraction of the time signal from D- and P- counters. The data were obtained by using the counters based on the Hamamatsu H7416MOD.

The anomalous pion yield is observed in the interaction of protons and deuterons with nuclei [7]. The experiment at ITS with DELTON setup [8] on the measurement of the pion yield in the interact of deuterons with W and Ag nuclei was performed in 2011 - 2012 years. During these experiments the energy dependence of the dp- and pp-yield in dW and dAg - interactions have been measured. The reaction products were registered by the scintillation counters. Each counter consist of two detectors with thin and thick scintillators [9]. First particle passes in a thin plastic scintillator and then in thick plastic scintillator. The thin scintillator is used to clean background. The set of detectors to register reaction products is placed in horizontal plane. D- and P- counters are to register dp-elastic scattering. PPL and PPR - to register pp- quasi-elastic scattering. The monitor-counters are mounted in the vertical plane. The results of these measurements are shown in Fig. 9 and Fig 10, respectively. Any anomalous effect isn't observed for studied channels.

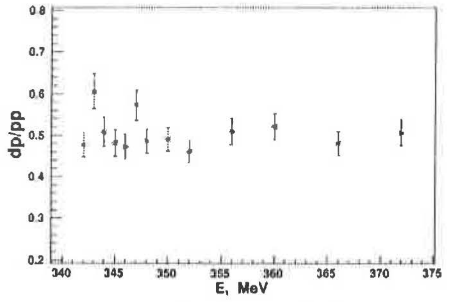

Figure 9: Energy dependences of the dp- to pp-quasi-elastic yields ratio for dW-interaction.

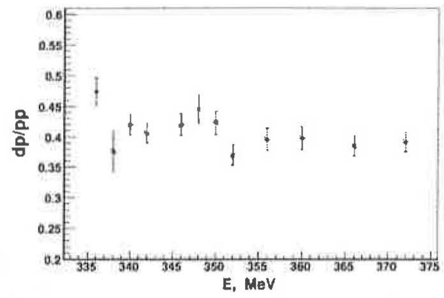

Figure 10: Energy dependences of the dp- to pp-quasi-elastic yields ratio for dAg-interaction.

Measurements with the omission of target cycles was performed in regime of the simultaneous run at ITS and at the extracted beam setup. The target was injected out from the beam every third, every second and every fourth cycle. One can see in Fig.11 the statistic of the extracted beam setup is increased when the target doesn't cross beam, unlike the statistic of ITS setup.

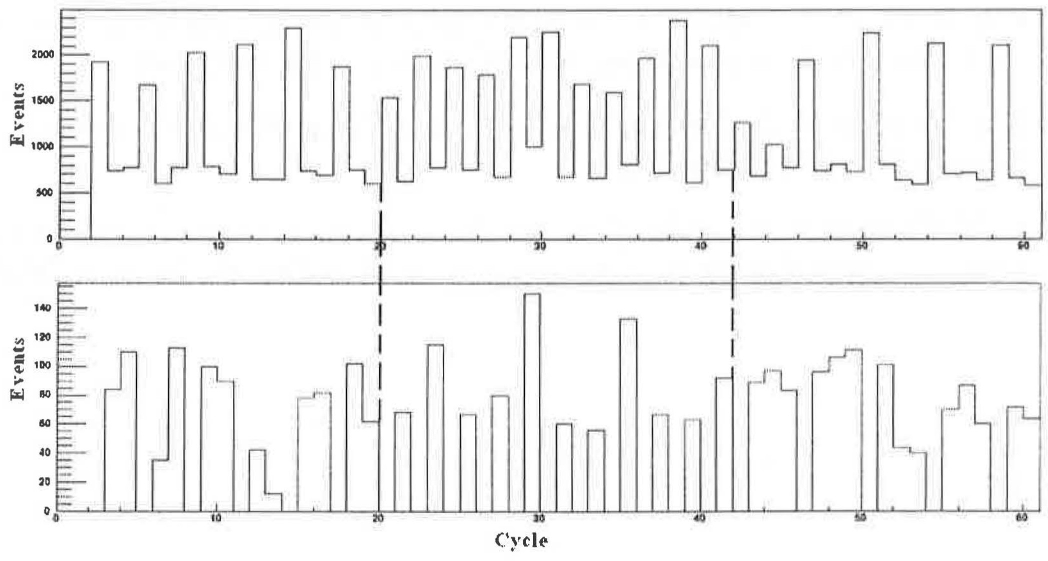

Figure 11: Distribution of events over cycles recording. Upper - for extracted beam setup, bottom - for ITS

In summary, first extraction of the 3.42 A·GeV carbon beam and 4 A·GeV deuteron beam at Nuclotron and their transportation to the BM@N experimental area are performed. The measurements of dp-elastic scattering, dW- and dAg- quasi-elastic scattering at internal target station at Nuclotron are performed. Energy dependences of dp- and pp-quasi-elastic scattering yields ratio are measured. Any anomalous effect isn't observed for these channels. The regime of the beam sharing between the experiment at ITS and extracted beam is realized. The simultaneous work of the ITS and extracted beam setup is demonstrated.

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KRATTA, a triple telescope array for
the ASY-EOS experiment


Covariant separable potential of nucleon-nucleon
interaction in the Bethe-Salpeter approach


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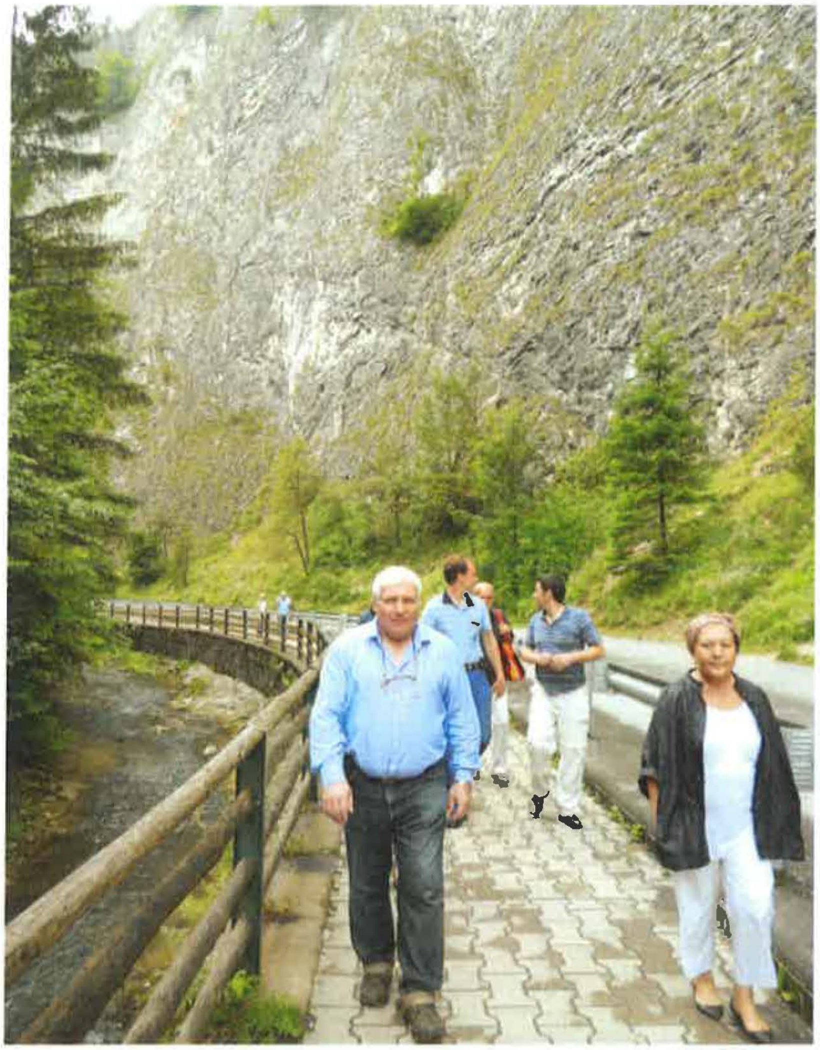


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