MEASUREMENT OF DIFFERENTIAL CROSS SECTIONS FOR BINARY $\pi^- p$ REACTIONS WITH BOTH NEUTRAL PARTICLES IN FINAL STATE IN THE REGION OF $P_{11}(1440)$ AND $S_{13}(1535)$ RESONANCES

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A general program of studying binary $\pi^- p$ reactions with both neutral particles in the final state is now in progress at PNPI. This program includes measurement of differential cross sections and the polarization parameter P for the reaction $\pi^- p \to \pi^0 n$ in the momentum range from 500 to 725 MeV/c and also for the near-threshold η production $\pi^- p \to \eta n$. The experiments are being performed by the collaboration PNPI–UCLA–ACU on a pion channel of the PNPI synchrocyclotron.

In the first stage, experiment on measuring absolute yields of the η production process $\pi^- p \to \eta n$ was undertaken. The objective of the experiment is to investigate this process in the near-threshold region where reliable experimental data are very scarce up to now. Given new accurate data on the η production cross sections one is able to extract a value of the ηN scattering length and determine more accurately a value of the η mass.

The experiment was carried out by means of detecting neutrons produced in this reaction and measuring their energies by TOF-technique. The neutron detectors were designed, constructed and calibrated by scientists of UCLA [1,2]; each detector with the size 26.7 $\times$ 25.4 $\times$ 25.4 cm^3 (the first figure is a width) consists of three contiguous, optically isolated counters each viewed by two photomultiplier tubes. Angles covered by the neutron detectors are from 1 to 12 degrees in the lab. system. To prevent irradiation of these detectors by an incident beam, a bending magnet with a big gap was placed between them and a hydrogen target. The latter was a vertical cylinder 10 cm diameter and 12 cm high, the flask was made of aluminium 0.1 mm thick. In order to provide simultaneous measurements in several momentum bins of the incident pions, a special hodoscope of narrow vertical scintillation counters was installed in a dispersive plane of the pion channel.

During 1994–1995 we have measured momentum dependences of the η production yield for nine neutron angles; measurements were made at central momenta of the pion beam 670, 680, 690, 695, 700, and 710 MeV/c for both hydrogen–filled and empty target. In order to provide proper subtraction of physical background due to reactions of two– and three–pions production, additional run was performed in the below–threshold region (for momenta of the incident pions 610, 630, and 650 MeV/c). Data obtained in this run were used for estimation of the above mentioned physical background by means of extrapolating these data to the above-threshold region. Momentum dependences of the η production yields obtained in this experiment [3] are shown in Fig.1. The yields are normalized to one incident pion. Later

on these dependences will be used for specifying the near-threshold behaviour of the total cross section for the investigated process.

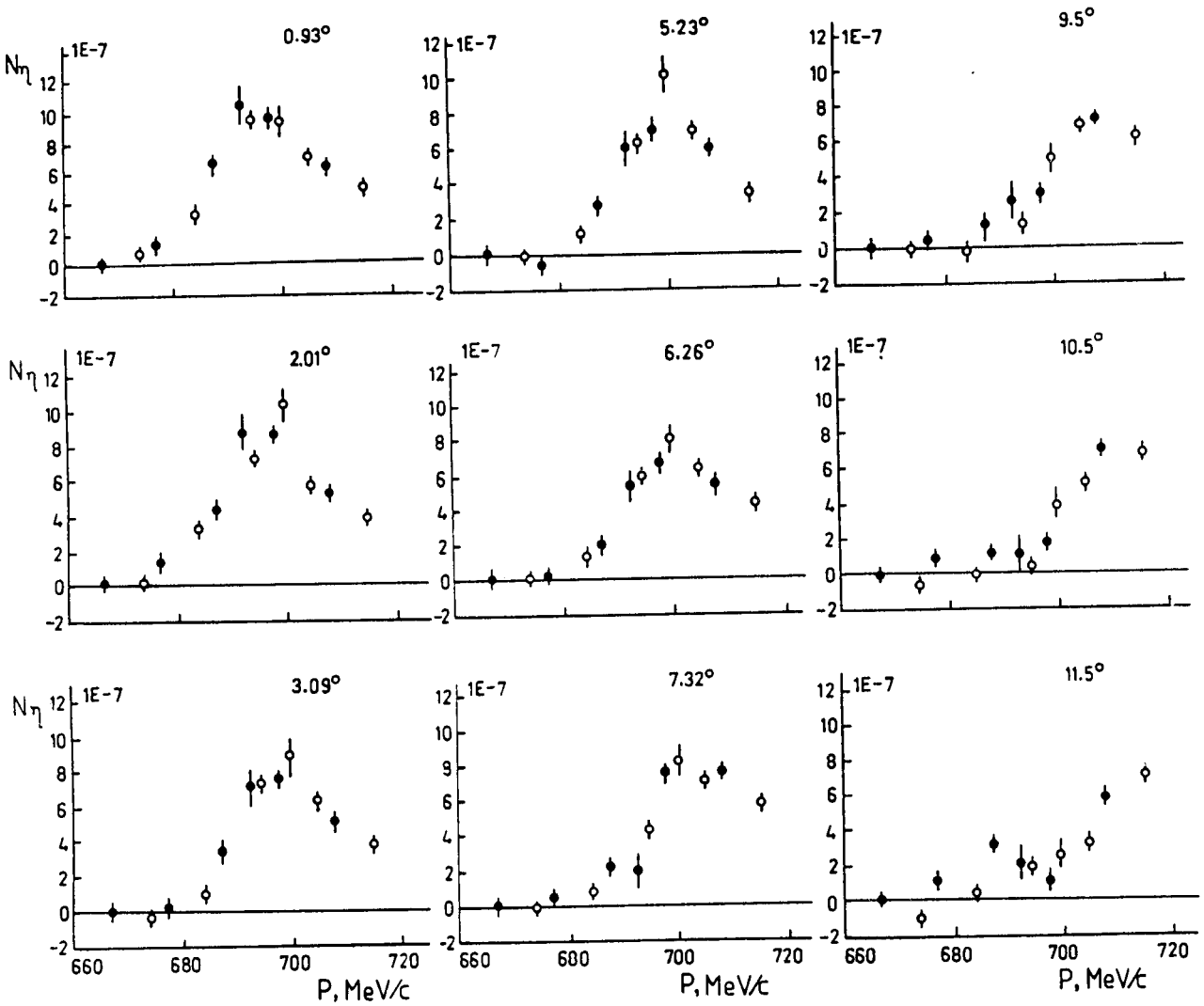

Fig.1. Yields of the η production as functions of momentum of incident pions for different neutron angles

The next step of program is measurement of differential cross sections of the reaction $\pi^- p \to \pi^0 n$ in the momentum range 500 to 725 MeV/c. New accurate values of DCS while being used in a new partial-wave analysis will allow to determine partial amplitudes for $\pi^- p$ scattering with a higher precision and, hence, to provide a quantitative estimation of a charge splitting effect which was observed recently in the partial-wave analysis PNPI-94 [4].

In 1995 we have performed measurements of DCS of $\pi^- p$ charge scattering to the backward hemisphere. The experiment was carried out by detecting emitted neutrons in coincidence with gammas from the π^0-decay. A schematic drawing of the experimental setup is shown in Fig.2. Two kinds of total absorption calorimeters were built for detecting gammas.

One was made of eight Čerenkov lead glass blocks having each a cross section of 15 × 15 cm^2 and a thickness of 35 cm (14 X_0). Another was a four-by-four array of CsI(Na) crystals with an individual size 6 × 6 × 30 cm^3 (the last figure is a thickness, it corresponds to 16 X_0).

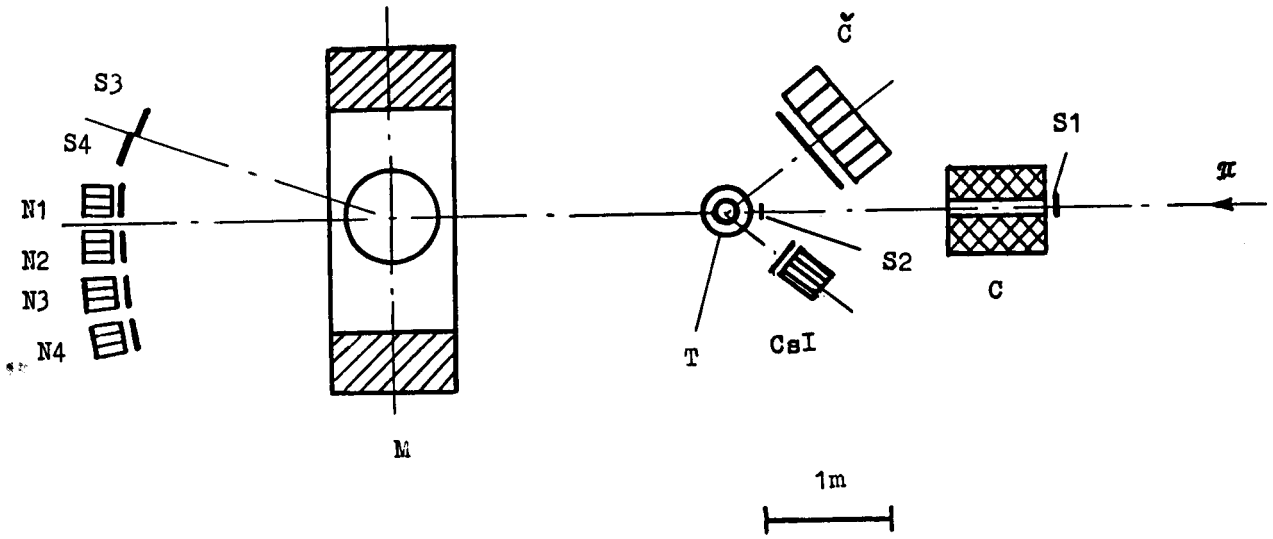

Fig.2. Experimental layout. N1 ÷ N4 – neutron detectors; T – liquid hydrogen target; S1 and S2 – monitor counters; S3 and S4 – anti-counters; C – collimator; Č – Čerenkov spectrometers; CsI – electromagnetic calorimeter consisting of 16 crystals CsI(Na); M – bending magnet for deflection of incident pion beam out of neutron detectors

An energy calibration of both types of gamma–detectors was performed using electron beams with energies from 100 to 500 MeV available on the pion channel of the PNPI synchrocyclotron. In order to monitor stability of the photomultiplier gains, pulses from PMTs caused by cosmic muons were recorded in the course of the experiment using a special trigger.

First measurements were performed in the momentum range 650 to 700 MeV/c (covering the η production threshold) for both hydrogen–filled and empty target. We used the same disposition of the neutron detectors as in the previous experiment, gamma detectors were placed at kinematically conjugated angles. This allowed to measure DCS of $\pi^- p$ charge exchange scattering for angles from 150° to 180° in the centre of mass system.

In order to extract absolute values of DCS from numbers of detected π^0-mesons we need to know an angular acceptance of each gamma detector with a high precision. A Monte Carlo simulation of the experiment was undertaken for this purpose. A real geometry of the setup, constructive features of the target, spatial characteristics of the pion beam and its momentum spread were taken into account while performing these calculations.

Total statistics which was obtained during the experiment in each momentum bin is about 10^3 π^0-mesons providing the statistical accuracy on a level of ±3%. As to a possible systematic uncertainty, we expect it to be not more than ±5%. Data processing is under way now.

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HERMES EXPERIMENT AT HERA COLLIDER

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The experiment HERMES was designed to measure spin-dependent structure functions g_1 and g_2 of the proton and the neutron in deep inelastic scattering of the polarized 27 GeV electrons (positrons) of the HERA collider on a polarized gas target.

Experimentally, g_1 and g_2 can be separated by measuring two spin asymmetries related to the longitudinal and transverse target polarizations. Precise determination of g_1 and g_2 is of particular importance for verification of the Ellis-Jaffe [1] and fundamental Bjorken [2] sum rules.

The double spin asymmetries in the semi-inclusive hadron electroproduction are also measured with the help of the HERMES detector in order to directly separate the different quark flavour contributions to the nucleon spin. In semi-inclusive measurements, HERMES is superior to the other spin experiments. Thus the SLAC experiments E-142 and E-143 have no possibilities for semi-inclusive measurements and SMC in CERN has a very limited statistics in these measurements.

The most important and direct method of studying the helicity distributions of valence quarks makes use of the spin asymmetry differences for the production of the positive and negative pions in the reactions

$$\vec{e} + \vec{p} \rightarrow e' + \pi^{\pm} + X. \qquad (1)$$

Under assumption that the fragmentation process and the hard electron-quark collision are factorized and using the approximation of the independent quark fragmentation, all the fragmentation effects are ruled out in the measured pion asymmetries [3], [4] and spin-dependent u and d valence quark distributions can be deduced from the data.

In addition to the reactions with charged pions and kaons detected in coincidence with the scattered positrons, the reactions in which decaying particles are produced with a mean lifetime less than the time needed to pass through the detector, like π^0, ρ^0, K^0_S, ϕ and J/ψ mesons and Λ-hyperon, can be investigated.

The HERMES setup is described in [5], [6], [7]. The target is a thin-walled storage cell which is fed by a high intensity source of polarized H, D, and ^{3}He atoms providing the