

The scientific program "Physics with η mesons", including a wide spectrum of experiments on the study of η production and η interaction with nucleons and nuclei, is underway at the Meson Physics Laboratory since 1992. Experiments are carried out at the pion channel of the PNPI synchrocyclotron, which is very suitable by its characteristics (pion energy up to 640 MeV, pion flux up to $(2-5) \times 10^5$ 1/c) for studying processes of η production on nucleons and nuclei in the near-threshold region.

In particular, yields of the reaction $\pi^- p \rightarrow \eta n$ were measured at 12 incident pions momenta from the threshold (685 MeV/c) to 710 MeV/c. Measurements were made by detecting neutrons (and determining their time of flight) for 9 different values of neutron emission angles at the lab. frame. Measured energy dependences of yields were compared with calculated curves obtained using a Monte Carlo simulation; while calculating, the value of η -mass $M_\eta = 547.3$ MeV/c² given in the last version of Particle Data Group Listings was used. The results of calculations agree well with the experimental data for all 9 neutron angles that confirms correctness of the above value of M_η . The above mentioned experiment was carried out in collaboration with USA physicists from the University of California at Los Angeles (the Head of group – Prof. B.M.K. Nefkens) and Abilene Christian University (the Head of group – Prof. M.E. Sadler).

In the framework of the program of studying the η -production process, measurements of the differential cross sections of the reaction $\pi^- p \rightarrow \eta n$ at the incident pions momenta close to the threshold of this reaction are being performed now at the PNPI pion channel using the neutral meson spectrometer. Since in the near-threshold region the total cross section of the reaction under study rises very sharply with the momentum of the incident pions, the momentum spread of the beam was decreased in this experiment down to 1.5% (FWHM) by placing a narrow vertical momentum slit at that part of the pion channel where the momentum dispersion is maximal. The kinematics of reaction $\pi^- p \rightarrow \eta n$ has some specific features. In the near-threshold region, η mesons produced in the centre-of-mass system (c.m.s.) in the wide angular range from 0° to 180° appeared to be in a rather narrow angular cone after transferring to the laboratory frame. In the process of subsequent decay $\eta \rightarrow 2\gamma$, photons are emitted in the angular range from 0° to 180° (relatively to the momentum of η meson), but their symmetrical emission has the maximal possibility. The above described kinematical peculiarities allow to measure with the help of the PNPI neutral meson spectrometer (which has a rather restricted angular coverage) the differential cross sections of reaction $\pi^- p \rightarrow \eta n$ in the full c.m.s. angular range from 0° to 180°. The value of total cross section was calculated after that by integrating the differential cross section over c.m.s. angle.

Till now, the measurements are made at the incident pions momenta of 700, 710 and 720 MeV/c. Angular distributions of the differential cross sections obtained at above momenta differ very essentially – being practically isotropic at 700 MeV/c, angular dependences are becoming anisotropic but symmetric at relatively to $\cos\theta^{\text{cm}}$ at 710 and 720 MeV/c (these dependences have a bowl-like shape). It means that immediately near the threshold the reaction $\pi^- p \rightarrow \eta n$ is going through the excitation of $S_{11}(1535)$ resonance with its subsequent decay to πN state, but at higher momenta the contribution of D -wave plays a significant role.