Experiments at PNPI

Realization of the experimental program "Baryon spectroscopy with pion beams up to 2000 MeV" is underway at the Meson Physics Laboratory. In the framework of this program, at the pion channel of the PNPI synchrocyclotron a series of experiments have been carried out in which precision measurements of the differential cross sections (DCS), the polarization parameters P, A, R for $\pi^- p$ and $\pi^+ p$ elastic scattering were made at many momenta of the incident pions in the range of low-lying πN resonances $P_{33}(1232)$, $P_{11}(1440)$, $D_{13}(1520)$, $S_{11}(1535)$. In total, more than 500 new experimental points were obtained during these experiments. Using these experimental data, we have performed a new partial-wave analysis PNPI-94. One of mostly fundamental results of this analysis is an observation of charge splitting of the P_{33} resonance that has given a possibility to determine separately masses and widths of the P_{33}^0 and P_{33}^{++} resonances as well as masses of the u and d quarks.

A logical continuation of the above mentioned experiments is the study of $\pi^- p$ reactions with production of neutral mesons in the final state. At the first stage, $\pi^- p$ charge exchange scattering $\pi^- p \to \pi^0 n$ was investigated. After measuring cross sections of this reaction to the backward direction (performed by detecting the recoil neutron in coincidence with one of photons from the decay $\pi^0 \to \gamma\gamma$), a next step of investigations started – measurements of the forward-angle DCS. For carrying out such experiment, a new device – the neutral meson spectrometer – was designed and created at the Meson Physics Laboratory. This spectrometer (see Fig. 1) consists of two total absorption electromagnetic

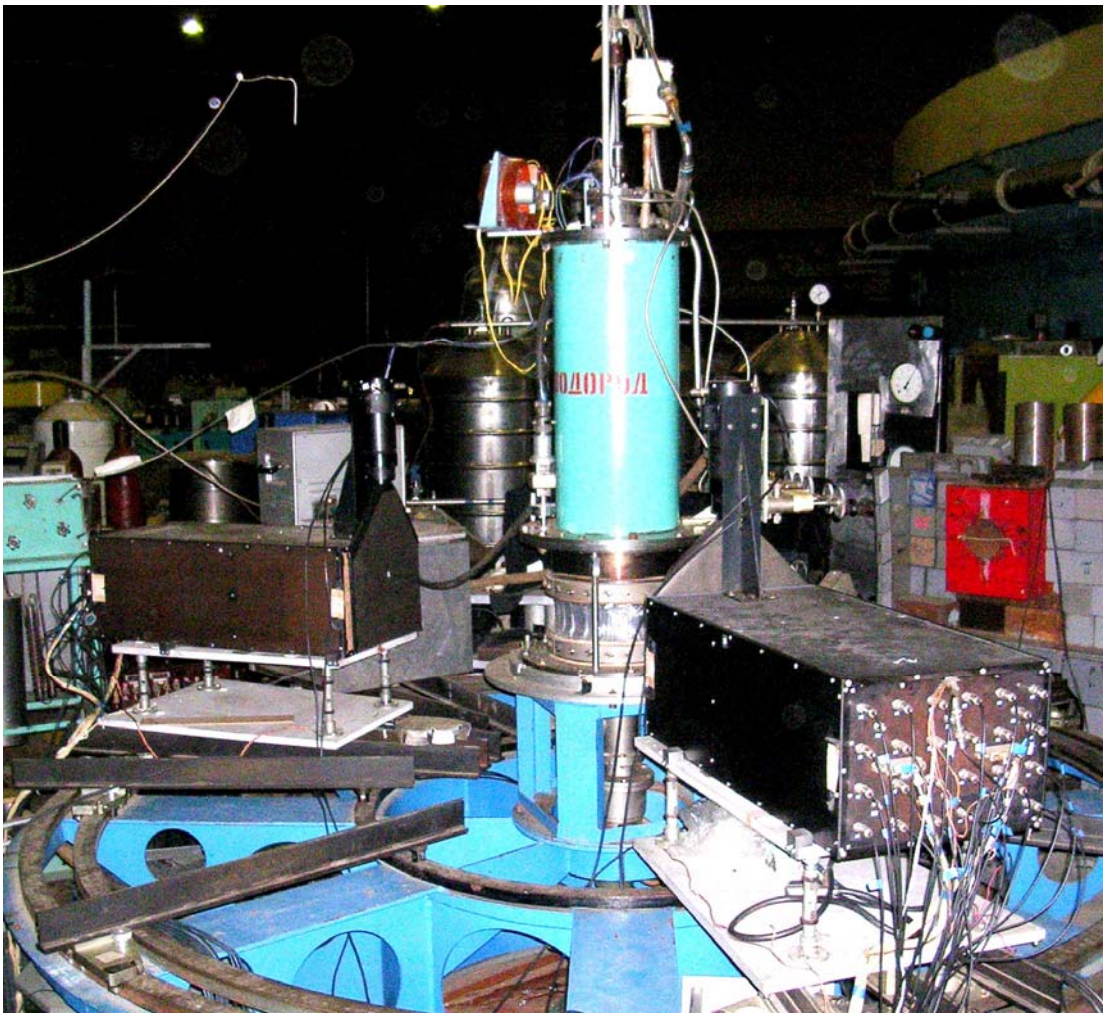

FIG. 1. Neutral meson spectrometer and liquid hydrogen target

calorimeters each made of 24 CsI(Na) crystals. Owing to good energy and spatial resolutions of the calorimeters, the energies of both photons from the decay $\pi^0 \to \gamma\gamma$ and the emission angles of these photons can be measured with a good accuracy. On the base of these measurements, one can reconstruct the energy of π^0 meson produced in the reaction $\pi^- p \to \pi^0 n$ and the angle at which this meson was produced. Using the neutral meson spectrometer we have measured the cross sections of this reaction at angles close to 0° (*i.e.* for forward scattering). The measurements were performed in that range of the incident pions momenta (from 417 to 710 MeV/c), where results of all previous experiments were scarce, contradictory and inaccurate. Our measurements were made with a high accuracy at ten values of the incident pions momemum in the range mentioned above.

At the present time, a series of measurements of the differential and total cross sections of the η-production process $\pi^- p \to \eta n$ is underway using the neutral meson spectrometer at momenta of the incident pions near the threshold of this reaction (685 MeV/c). These measurements are aimed at studying the mechanism of this process. Since in the near-threshold region the cross section of the reaction under study rises very sharply with the momentum of the incident pions, for investigating in more details the momentum dependence of angular distributions of the differential cross sections 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. At the present time, the differential and total cross sections of the reaction $\pi^- p \to \eta n$ are measured at the incident pions momenta of 700, 710 and 720 MeV/c. The shape of differential cross sections obtained at above momenta are differing very essentially – if at 700 MeV/c the DCS is practically isotropic by angle, at higher momenta the angular dependence of DCS is anisotropic but symmetric relatively to $\cos\theta^{cm} = 0$ (its profile has a bowl-like shape). This may be considered as an indication that the cross section of process under consideration just above the threshold is defined by the resonance $S_{11}(1535)$ having rather big branching ratio (at a level of 45–60%) for the decay into ηN. However, higher partial waves begin to contribute with increasing the incident pions momenta. An analysis of measured angular dependences of the differential cross sections shows that the resonance $D_{13}(1520)$ can give significant contribution to the cross section value – although this resonance has very small branching ratio for the decay into ηN. At the same time, the contribution of *P*-wave is practically negligible. To make quantitative estimation of this effects, measurements at higher momenta are needed.