Experiments at ITEP

To extend measurements of the spin rotation parameters A and R to the second resonance region of pion-nucleon scattering, similar experiments were carried out at the pion channel of the ITEP accelerator. Measurements of the spin rotation parameters A and R are the key experiments in the whole program of studying $\pi^{\pm}p$ elastic scattering since only such measurements permit to remove discrete ambiguities arising in the course of a partial-wave analysis (PWA) if experimental data on the spin rotation parameters are absent. Planning of these experiments was made taking into account results of PWAs existing to the moment of starting experiments.

The experiment requires a special type of polarized proton target with the polarization vector lying in the horizontal plane and a proton polarimeter for measuring the asymmetry of the secondary scattering of the recoil protons by nuclei of a substance –analyzer (usually carbon) with the known analyzing power. The polarized proton target (see Fig. 2) was designed and manufactured at PNPI by

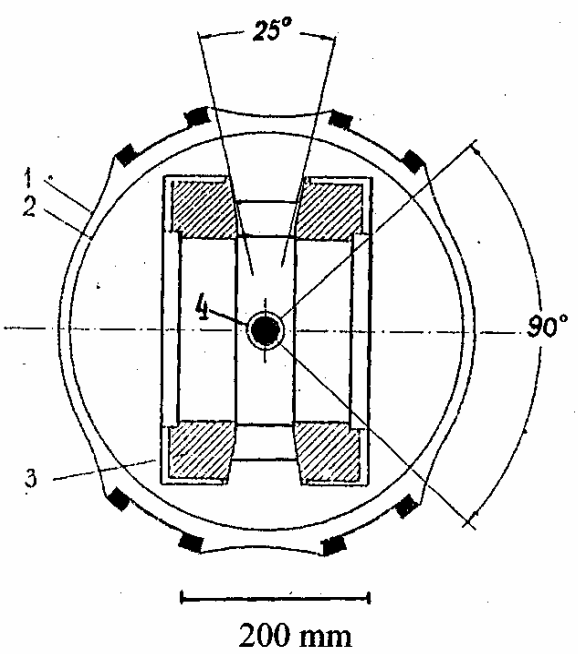

Fig. 2. Polarized target section by horizontal plane.

physicists of the Meson Physics Laboratory (MPL) and the Laboratory of Polarization Effects. The working material of the target propanediole $C_3O_2H_8$ doped with Cr^V was frozen down to 0.6 K with a refrigerator using helium-3 evaporation, a required magnetic field of 2.5 T was produced by a pair of superconducting Helmholtz coils. A typical value of the target polarization is 70%.

A scheme of the experimental setup is given in Fig. 3. As to the proton polarimeter, two types were used at different stages of the experiment. One was a multiplate polarimeter made of optical spark chambers with graphite electrodes; a special television system was developed for filmless readout in this case. Another type of polarimeter consists of one thick graphite block (36.5 g/cm^2) with two arrays of magnetostrictive spark chambers (in front and behind of this block) to detect the recoil proton before and after the secondary scattering. A special measurements of the analyzing power of proton-carbon scattering were made in the full energy diapason of recoil protons.

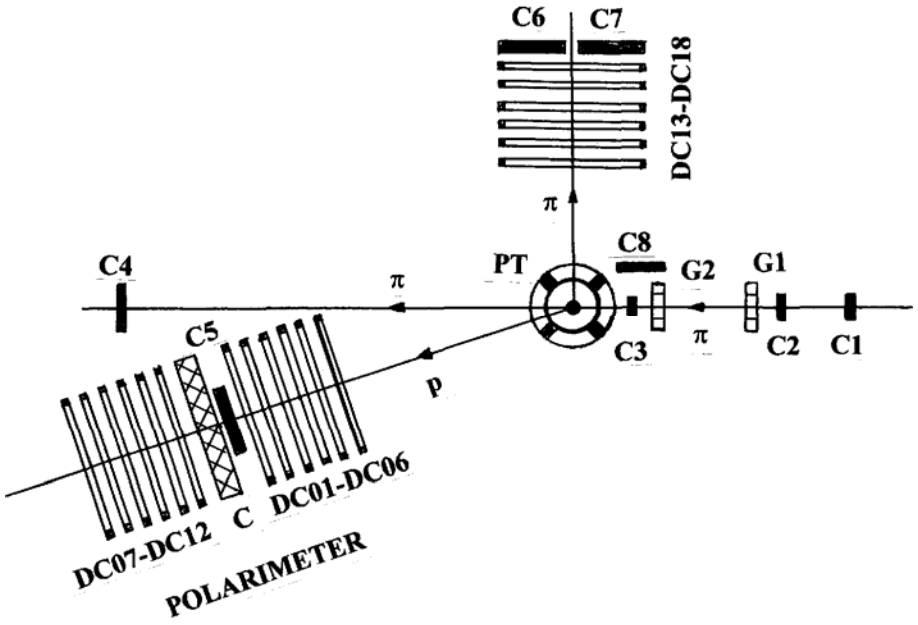

Fig. 3. The experimental layout SPIN-PMJ (not to scale).

The spin rotation parameters A, R for for $\pi^- p$ and $\pi^+ p$ elastic scattering were measured at ITEP at three momenta of the incident pions: 1000, 1430 and 1620 MeV/c. One of the most interesting results is the fact that experimentally measured values of the parameter A agree well with the predictions of the partial-wave analysis performed by the group of physicists from the George Washington University and contradict to the analyses KH and CMU-LBL. Since all the characteristics of πN resonances presented in Listings of the Review of Particle Physics are obtained just on the base of the analyses KH and CMU-LBL, which seem to be not entirely correct in the light of our last experimental data, it is necessary to revise and specify these fundamental constants by means of performing a new partial-wave analysis with inclusion our new experimental data on the spin rotation parameters.

At the present time, a next stage of the experiment – measurements of the polarization parameter P – is underway at the pion channel of the ITEP synchrotron. Already done are the measurements at the incident pions momenta of 800, 1780, 1940 and 2070 MeV/c in the angular range 150°–170° in the centre-of-mass system. No measurements were done in this angular range till now because of the extremely small values of the differential cross section. The predictions of the latest solution SP-06 of the GWU group seems to be consistent with our measurements in the low-momentum domain, while at the momenta around 2000 MeV/c the behavior of these predictions looks unstable.

At the pion channel 322 of the ITEP synchrotron, which has high momentum resolution (better than 0.1%), a new experiment "EPECUR" is underway. Its goal is to search for exotic baryonic resonance – a non-strange member of the "pentaquark" antidecuplet P_{11} with expected mass about 1700 MeV. To realize this goal, the reactions $\pi^- p \to \pi^- p$ and $\pi^- p \to K\Lambda$ are being investigated. The experiment is carried out by scanning the invariant mass of $\pi^- p$ system in the range 1620–1770 MeV (corresponding interval of the incident pions momenta is from 900 to 1200 MeV/c). The scan is being done by changing the incident pions momentum by a step of approximately 1 MeV; an accuracy of measuring this momentum 0.08% (*i. e.* better than 1 MeV in terms of the invariant mass) was achieved with the help of multi-wire proportional chambers located in the first and second focuses of the pion channel. Secondary particles produced in a liquid hydrogen target are detected by a two-arm non-magnetic spectrometer made of arrays of drift chambers with hexagonal structure equipped with modern read-out electronics. All wire chambers were designed and manufactured at PNPI. The photo of the experimental setup is presented in Fig. 4. In 2008, tuning of the pion channel 322 was

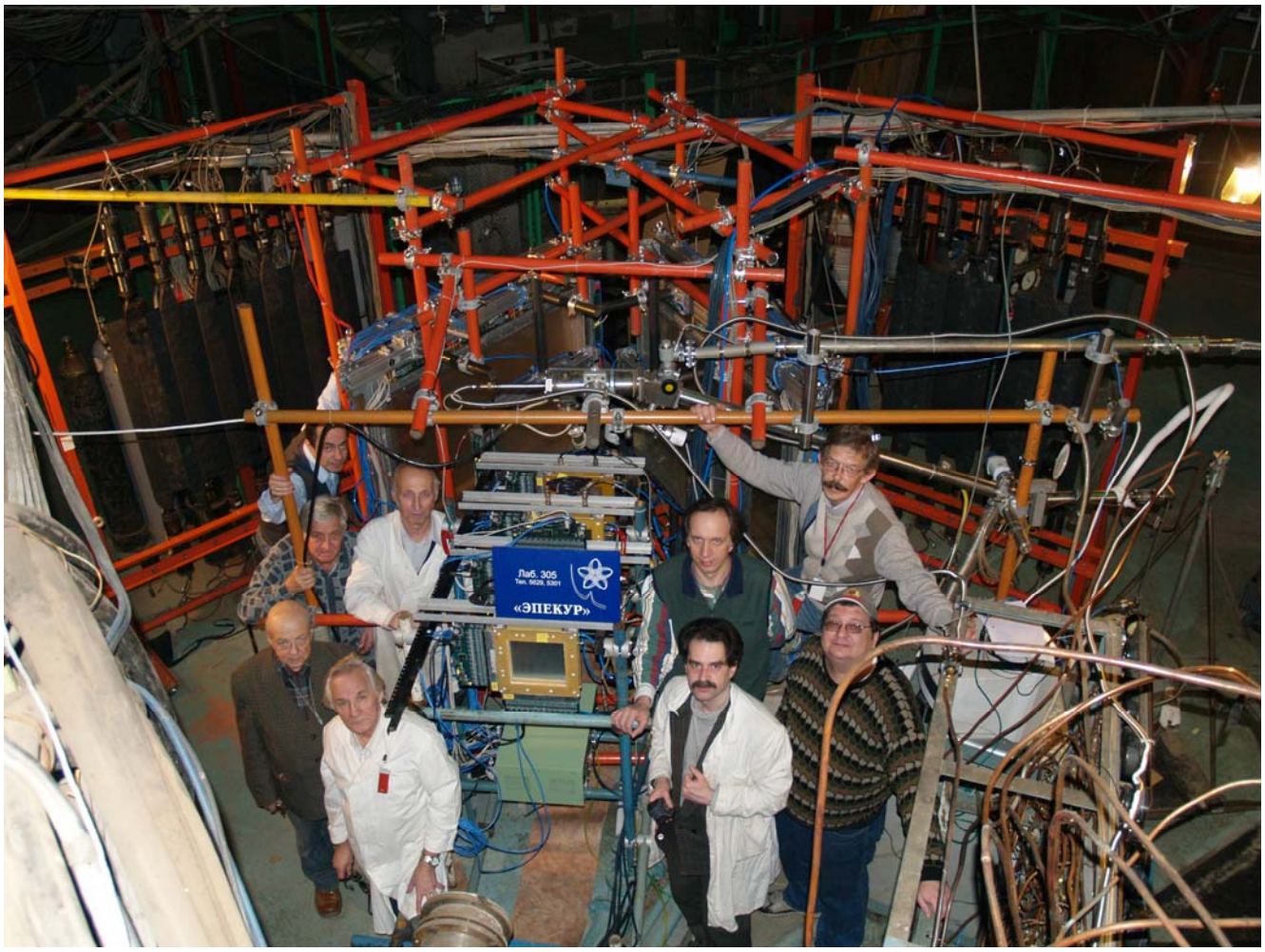

Fig. 4. Photo of the experimental setup "EPECUR".

completed, the experimental setup was fully put into operation, and we started the first stage of experiment, at which a search for the narrow exotic resonance is being performed in the reaction $\pi^- p \to \pi^- p$. In the first methodical run all systems of the experimental setup were tested, and 7×10^6 triggers were written when using the liquid hydrogen target.