MEASUREMENT OF DIFFERENTIAL CROSS SECTIONS FOR BINARY $\pi^- p$ REACTIONS WITH BOTH NEUTRAL PARTICLES IN FINAL STATE IN REGION OF P_{11} (1440) AND S_{11} (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 reactions $\pi^- p \to \pi^0 n$, $\pi^- p \to \gamma n$ in the momentum range from 500 to 750 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 the first stage, experiment on measuring absolute yields of the η production process $\pi^- p \to \eta n$ was undertaken in the momentum range 665 to 715 MeV/c. The objective of the experiment is to obtain precise cross sections of this process in the near-thresnold 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 eta mass.

The experiment is 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 consists of three optically isolated counters with size 8.9 cm×25.4 cm×25.4 cm (the first figure is width) viewed by two photomultiplier tubes. Each neutron detector has a charged particle veto-counter mounted in front of it. Angles covered by the neutron counters are from 1 to 12 degrees in the lab. frame. A liquid hydrogen target of vacuum type is used in the experiment; a hydrogen flask is a vertical cylinder 10 cm diameter and 12 cm high. The target is surrounded with scintillation veto-counters — for reducing the level of physical background arising from reactions with three particles in the final state. To prevent irradiation of the neutron counters by the incident pion beam, a special bending magnet with a big gap is placed between the hydrogen target and neutron detectors. Experimental lay-out is shown in Fig.1.

During 1992–93, testing and tuning of the experimental setup was completed and preliminary measurements of momentum dependences of the η yield were performed for twelve neutron angles; the momentum acceptance of the pion beam was characterized by $\Delta p/p = 1.5\%$ (FWHM). A Monte Carlo program for calculation the η yields in different initial assumptions was also developed [3]. An example of the obtained results is presented in Fig.2 [4]. Shown by curves are momentum dependences of the η yields calculated for two different values of the eta mass. Some preference can be given to the value $M = 548.8$ MeV.

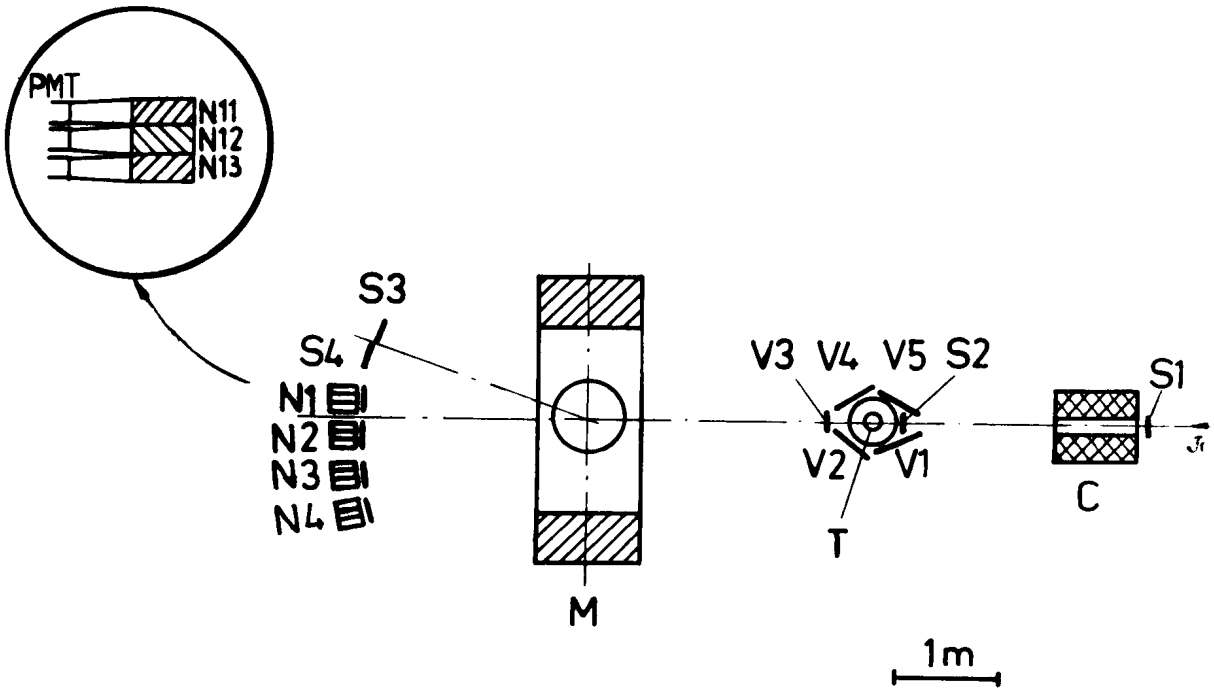

Fig.1. Experimental lay-out.
C — collimator; T — liquid hydrogen target; N1–N4 — neutron detectors; S1 and S2 — monitor counters; S3 and S4 — anticounters; V1–V5 — veto-counters; M — deflecting magnet. Shown in the corner is a sketch of one of neutron detectors

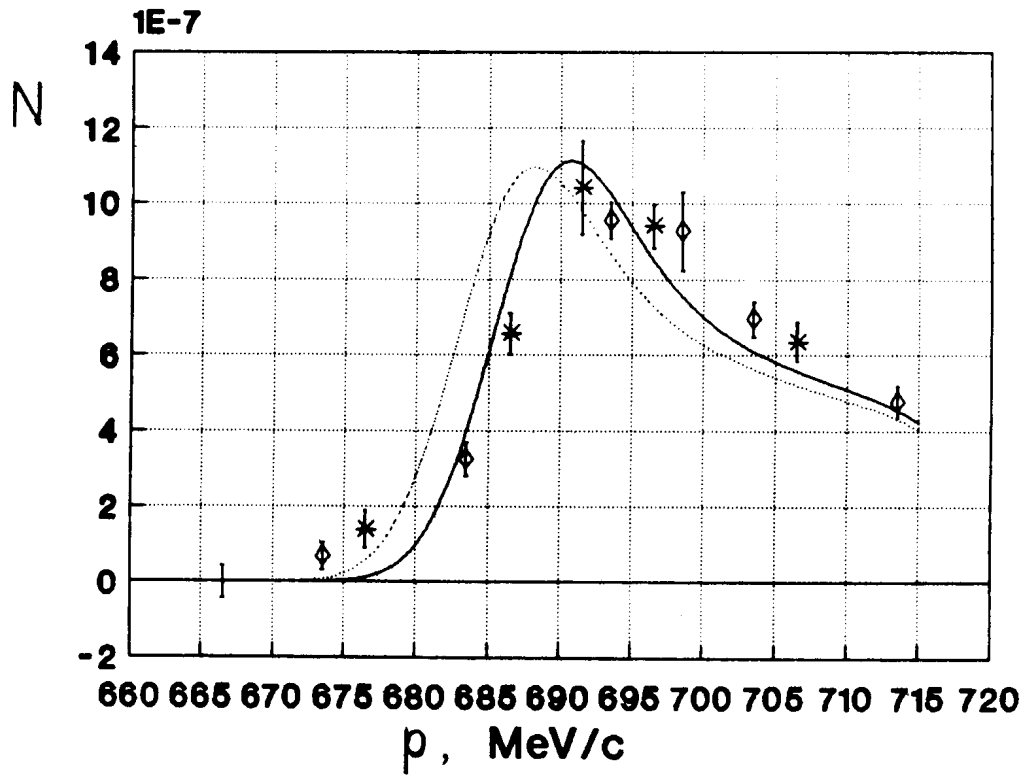

Fig.2. Yield of η production as function of momentum of incident pions for $\Theta_n = 0.93°$. Shown by curves are results of calculations using two different values of the eta mass: 548.8 MeV (solid curve) and 547.3 MeV (dashed curve)

In 1994, we plan to complete data taking in measurements of the η yield. A new Monte Carlo program using the GEANT simulation code is being developed for detailed analysis of experimental data; this analysis is aimed at extraction of cross sections of the η production process.

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