HIGH PRECISION MEASUREMENTS OF THE PION PROTON DIFFERENTIAL ELASTIC CROSS SECTION IN THE SECOND RESONANCE REGION*

I. G. ALEKSEEV^{†,‡}, I. G. BORDYUZHIN, D. V. KALINKIN, L. I. KOROLEVA,
B. V. MOROZOV, V. M. NESTEROV, V. V. RYLTSOV, M. M. SHESTAKOVA,
B. M. SHURYGIN, P. S. SMIRNOV, A. D. SULIMOV and D. N. SVIRIDA

*Institute for Theoretical and Experimental Physics,
B. Cheremushkinskaya 25, Moscow, 117218, Russia*
[‡]igor.alekseev@itep.ru

V. A. ANDREEV, YE. A. FILIMONOV, V. V. GOLUBEV, A. B. GRIDNEV,
E. A. KONOVALOVA, N. G. KOZLENKO, V. S. KOZLOV, A. G. KRIVSHICH,
V. A. KUZNETSOV, D. V. NOVINSKY, V. V. SUMACHEV[§], V. I. TARAKANOV
and V. YU. TRAUTMAN

*Petersburg Nuclear Physics Institute,
Orlova Roscha, Gatchina, Leningrad district, 188300, Russia*
[§]sumachev@pnpi.spb.ru

M. SADLER

*Engineering and Physics Department, Abilene Christian University,
Abilene, Texas, TX 79699-7963, USA*
sadlerm@acu.edu

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One of the main sources of the information about nuclear resonances are partial wave analyses (PWA) of pion-proton elastic scattering. Nearly all of the data available for PWA were obtained more than 20 years ago with old measurement techniques. The talk presents new high precision data obtained recently by the EPECUR collaboration. The experiment features high statistics and better than 1 MeV resolution in the invariant mass thus allowing searches for narrow resonances with the coupling to the πp channel as low as 5%. The experimental setup consists of a 25 cm long liquid hydrogen target in a non-magnetic spectrometer of wire drift chambers with hexagonal structure. The

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[†]Speaker at the conference.

measurements started in 2009. 3 billions of triggers are already collected with positive and negative pion beams in the beam momentum range 820-1330 MeV/c.

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In 2003 the experiments LEPS¹ and DIANA² reported evidence for a new baryonic state θ^+ with positive strangeness and very small width. The quantum numbers of θ^+ were not measured but it was interpreted as a member of the pentaquark anti-decuplet predicted in 1997 by D. Diakonov, V. Petrov and M. Polyakov.³ Later several strong results were published where the state was not seen (see ref. 4 for example). Nevertheless, recent results from LEPS⁵ and DIANA⁶ still insisted on their evidence and a new analysis⁷ of the same CLAS data⁴ demonstrated a signal of θ^+ in the kinematic region where it interferes with ϕ -meson and which was excluded in the initial analysis.

If the anti-decuplet exists, a non-strange neutral resonance P_{11} with mass near 1700 MeV should also exist. Certain hints in favour of its presence were found in the modified PWA of GWU group⁸ at masses 1680 and 1730 MeV.⁹ An indication for a narrow state was found in η -photoproduction off neutrons in GRAAL.^{10,11} The observed structure had a mass of 1685 MeV and a width of less than 30 MeV, which was determined by the detector resolution. No counterpart was found in η

Fig. 1. Preliminary results for differential cross section of the elastic π^-p -scattering as a function of the incident pion momentum for 5-degree θ_{CM} intervals in the range $45 - 65^\circ$. Statistical errors only.

production off protons. A similar peak-like structure was also observed in experiments Tohoku-LNS,¹² CB-ELSA¹³ and CB-MAMI.¹⁴ A corresponding N(1685) state appeared in the recent PDG listing¹⁵ with 1-star status.

The idea of the experiment EPECUR^{16,17} was to look for this state in the "formation" type experiment using pion-proton initial state. The experiment features high statistics and better than 1 MeV resolution in the invariant mass thus allowing searches for narrow resonances with coupling to the πp channel as low as 5%. The scan over the invariant mass is done by the variation of the incident pion momentum, measured with an accuracy of 0.1% by a set of 1 mm pitch proportional chambers, located in the first focus of the beam line. The reactions are identified by a non-magnetic spectrometer based on wire drift chambers with a hexagonal structure. The selection of the elastic events relies on the complanarity and correlation of scattering angles in the laboratory frame.

The measurements started in 2009 with a two-arm setup optimized for elastic pion-proton scattering. 3 billions of triggers are already recorded with negative and positive beams. Only about 40% of the data are analysed by now. Some irregularity was found at $p_{beam} = 1020 - 1040$ MeV/c for $\pi^- p$ elastic scattering¹⁸ (Fig. 1). The lines in the figure represent the WI08 solution of the GWU group⁸ predictions (the light line) and the same solution with a Breit-Wigner resonance artificially added to P_{11} wave with mass $M = 1687$ MeV, width $\Gamma = 6$ MeV and elasticity $\eta = 5\%$

Fig. 2. Preliminary results for differential cross section of the elastic $\pi^+ p$ -scattering as a function of the θ_{CM} for about 5 MeV/c beam momentum intervals in the range 1016 – 1036 MeV/c. Statistical errors only. Black points: preliminary results; blue symbols: existing data.

Fig. 3. Preliminary results for differential cross section of the elastic π^+p -scattering as a function of the incident pion momentum for 2-degree θ_{CM} intervals in the range $47 - 55^\circ$. Statistical errors only. Black points: preliminary results; blue symbols: existing data.

(the dark line). The later is not a fit but just a toy to see how a narrow resonance would be seen. The nature of the irregularity could be either connected to a narrow resonance with mass around 1690 MeV or to a threshold effect,¹⁹ caused by the opening of the $\pi^-p \rightarrow K\Sigma$ channel.

Preliminary results on the cross sections of the π^+p -elastic scattering are shown in Figs. 2 and 3 as function of angle and beam momentum in comparison with the existing data^a. We don't expect to see N(1685) here, but a threshold effect, caused by opening of the $\pi^+p \rightarrow K\Sigma$ channel, could still be present.

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^aThe data are taken from the CNS Data Analysis Center <http://gwdac.phys.gwu.edu/>.

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