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Light Hadron Production in Experiments with the SND Detector at the e+e- Collider VEPP-2000

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Abstract. The experiments have been carried out with the SND detector at the VEPP-2000 e^+e^- collider in the energy range from 0.3 to 2.0 GeV. The cross sections for the processes $e^+e^- \to \omega\pi^0$, K^+K^-, 3π, $\eta\pi^+\pi^-$, $\eta\gamma$, $p\bar{p}$, $n\bar{n}$ have been measured.

1 Introduction

Low energy e^+e^- colliders are an important source of new data on light mesons and baryons. In 2010 experiments at the collider VEPP-2000 [1] were started in Novosibirsk. The collider operates in the center-of-mass energy range E=0.3–2.0 GeV. The two general purpose detectors, SND [2] and CMD-3 [3] take data in parallel at VEPP-2000. At present the integrated luminosity collected at each detector is about 70 pb^{-1}.

Spherical Neutral Detector (SND) (Fig. 1) is a nonmagnetic detector, main parts of which are a three-layer spherical NaI(Tl) electromagnetic calorimeter, a tracking system, an aerogel Cherenkov identifier and a muon detector. In this talk new data from SND are reviewed.

2 Production of meson states

Process $e^+e^- \to \omega\pi^0$. This process was studied in the $\pi^0\pi^0\gamma$ final state. The result is already published [4]. Up to date, this is the most accurate measurement of this process above 1.4 GeV. The measured cross section can be expressed in term of the $\gamma^* \to \omega\pi^0$ transition form factor $F_{\omega\pi\gamma}$:

$$\sigma_{\omega\pi^0}(E) = \frac{4\pi\alpha^2}{E^3}|F_{\omega\pi\gamma}(E^2)|^2 \cdot P_f(E),$$

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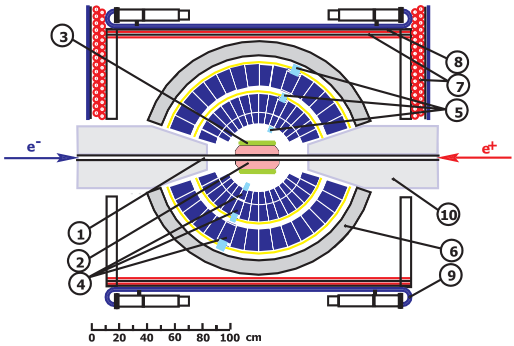

Figure 1. SND view along beam: 1 - vacuum pipe, 2 - tracking system, 3 - Cherenkov counter, 4-5 - electromagnetic calorimeter, 6 - iron absorber, 7-9 - muon detector, 10 - focusing solenoids.

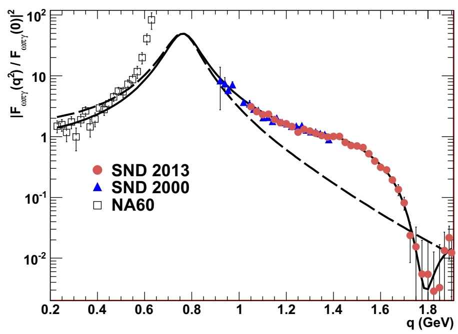

Figure 2. The $\gamma^\star \to \omega\pi^0$ transition form factor. The solid curve is the result of the fit to the SND data with the VMD model. The $\rho(770)$ contribution is shown by the dashed curve.

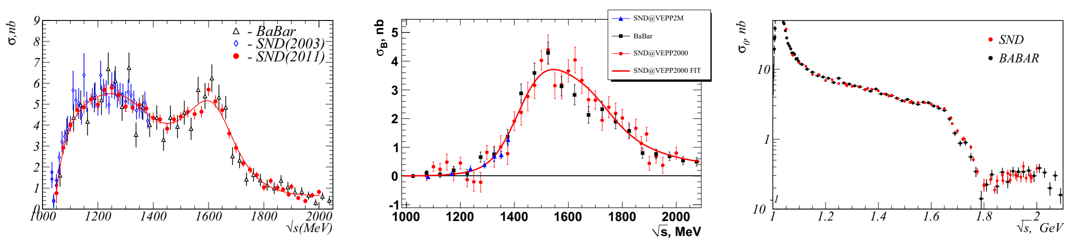

Figure 3. Left: the measured cross section for $e^+e^- \to \pi^+\pi^-\pi^0$ in comparison with previous measurements by SND at VEPP2M [6] and BABAR [7]. The curve represents the result of the VMD fit. Middle: the measured $e^+e^- \to \eta\pi^+\pi^-$ cross section in comparison with previous experiments. The curve is the result of the fit with the VMD model. Right: the measured cross section for $e^+e^- \to K^+K^-$ compared with the BABAR result.

where $P_f(E)$ is the phase space factor. From the measured cross section the energy dependence of the transition form factor was obtained (Fig. 2). It is seen that the SND data on the form factor are well described by the vector-meson dominance (VMD) model, while the low-q^2 NA60 data [5] are in sharp disagreement with this model.

Process $e^+e^- \to 3\pi$. The cross section for this process measured by SND is shown in Fig.3 left together with some preceding data. This is the most precise measurement in the energy range under study. The VMD fit describes data well and gives parameters of the $\omega(1420)$ and $\omega(1650)$ states agreeing with PDG values [8].

Process $e^+e^- \to \eta\pi^+\pi^-$. This process giving a contribution to the isovector part of the total hadronic cross section is studied in the decay mode $\eta \to 2\gamma$. Its cross section shown in Fig.3 middle is well described by the VMD fit. Found $\rho(1450)$ and $\rho(1700)$ parameters do not contradict PDG values [8].

Process $e^+e^- \to K^+K^-$. The $e^+e^- \to K^+K^-$ cross section was recently measured by BABAR [9]. Our preliminary results shown in Fig.3 right confirm the BABAR measurement. The interference

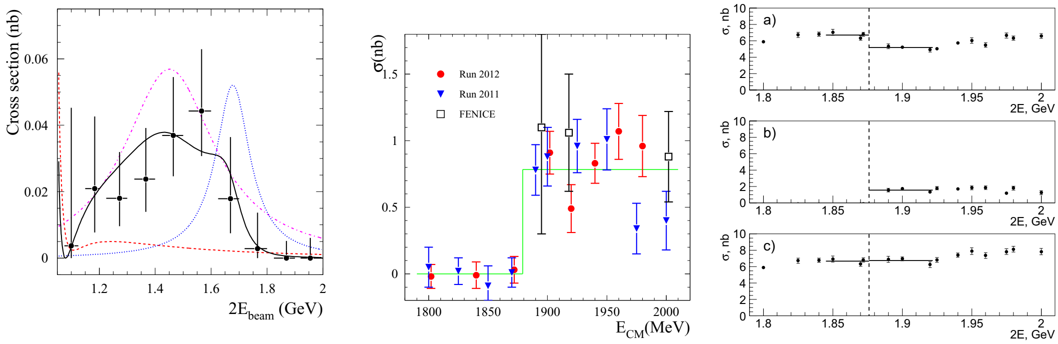

Figure 4. Left: the $e^+e^- \to \eta\gamma$ cross section measured by SND. The dash-dotted and dotted curves show the contributions of the $\rho(1450)$ and $\phi(1680)$ states, respectively. Middle: The $e^+e^- \to n\bar{n}$ cross section measured by SND and FENICE [13]. Right: a) - the sum of the $e^+e^- \to 6\pi^{+-}$ and $e^+e^- \to 4\pi^{+-}2\pi^0$ cross sections, b) - the sum of the $e^+e^- \to p\bar{p}$ and $e^+e^- \to n\bar{n}$ cross sections, c) - the sum of the 6π, $p\bar{p}$ and $n\bar{n}$ cross sections.

pattern near 1.8 GeV can be explained by a contribution of the $\phi(1680)$ state. To identify K-mesons the aerogel threshold Cherenkov detector with the refractive index $n = 1.13$ is used [10].

Process $e^+e^- \to \eta\gamma$. Up to now radiative decays of excited vector mesons were not observed. In the SND experiment the process $e^+e^- \to \eta\gamma$ was searched in the η decay mode $\eta \to 3\pi^0$ [11]. The measured cross section shown in Fig.4 left is about 40 pb. The VDM fit shows that the most contribution comes from the $\rho(1450)$ and $\phi(1680)$ states; the contribution of the low lying states $\rho(770)$, $\omega(783)$ and $\phi(1020)$ is found to be small.

3 Production of baryons

In the SND experiment the processes $e^+e^- \to p\bar{p}, n\bar{n}$ have been studied [12]. The measured cross section for $e^+e^- \to n\bar{n}$ is shown in Fig.4 middle. Our results agrees with the only previous measurement by FENICE [13]. The cross section is nearly uniform in the range from threshold up to 2 GeV. Its average value, about 0.8 nb, is close to the value of the $e^+e^- \to p\bar{p}$ cross section in the same region.

We calculate a sum of the $e^+e^- \to 6\pi$ cross sections measured in different charge modes, and a sum of the $e^+e^- \to p\bar{p}$ and $n\bar{n}$ cross sections. The results are shown in Fig.4 right a) and Fig.4 right b). Both show a step-like behavior at nucleon-antinucleon threshold. It is remarkable that the steps have opposite signs, and the sum of the 6π and nucleon-antinucleon cross sections shown in Fig.4 right c) does not exhibit any structure near threshold. This means that in the total hadronic cross section the opening of the nucleon-antinucleon channel is fully compensated by the $e^+e^- \to 6\pi$ process [14].

The polar-angle distribution of produced baryons allows to determine the important parameter $|G_E/G_M|$. Our measurement for protons gives $|G_E/G_M|_p = 1.64 \pm 0.26$ for the energy range below 2 GeV. This result confirms the BABAR measurement [15]. For neutrons, the accuracy is not sufficient still for such definite result.

4 Discussion and conclusions

In experiments with the SND detector at the VEPP-2000 e^+e^- collider in Novosibirsk we have obtained new results for many processes of e^+e^- annihilation to hadrons. Most results are preliminary, analyses are going on. The obtained results are important for $(g-2)_\mu$ calculation, determination of parameters of excited vector mesons, study of meson and baryon form factor models, test of CVC. The experiments at VEPP-2000 will be continued with higher statistics in 2015 after collider and detector upgrades.

Acknowledgements

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