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STUDY OF DIFFRACTIVE PRODUCTION PROCESSES IN PROTON-NUCLEON AND PROTON-NUCLEUS INTERACTIONS AND SEARCH FOR EXOTIC BARYONS

The SPHINX Collaboration (IHEP-ITEP)

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Abstract

Golovkin S.V. et al. Study of Diffractive Production Processes in Proton-Nucleon and Proton-Nucleus Interactions and Search for Exotic Baryons: IHEP Preprint 95-144. – Protvino, 1995. – p. 14, figs. 8, refs.: 25.

In the experiments at the SPHINX facility in 70 GeV proton beam of the IHEP accelerator the coherent diffractive production reactions on carbon nuclei $p + C \to [\Sigma(1385)^{\circ} K^{+}] + C$ and $p + C \to [\Sigma^{\circ} K^{+}] + C$ were investigated. The evidence for new baryon states were obtained in the study of hyperon-kaon effective mass spectra in these two reactions: $X(2050)$ with mass $M = 2052 \pm 7$ MeV and width $\Gamma = 35^{+22}_{-35}$ MeV in $M[\Sigma(1385)^{\circ} K^{+}]$ and $X(2000)$ with $M = 1999 \pm 7$ MeV and $\Gamma = 91 \pm 17$ MeV in $M[\Sigma^{\circ} K^{+}]$. The unusual features of these massive states (small enough decay widths, anomalously large branching ratios for decays with strange particles emission) make them very serious candidates for cryptoexotic pentaquark baryons with hidded strangeness. Preliminary data on the reactions $p + N \to [p\eta] + N$ and $p + N \to [p\eta'] + N$ as well as the first results for $M[\Sigma^{\circ} K^{+}]$, $M(p\eta)$ and $M(p\eta')$ effective mass spectra in nonperipheral region (with $P_T^2 > 0.3$ GeV^2) are presented.

Аннотация

Головкин С.В. и др. Изучение дифракционных процессов в протон-нуклонных и протон-ядерных взаимодействиях и поиски экзотических барионов: Препринт ИФВЭ 95-144. – Протвино, 1995. – 14 с., 8 рис., библиогр.: 25.

В экспериментах на установке СФИНКС, работавшей на протонном пучке ускорителя ИФВЭ с энергией 70 ГэВ, изучены реакции когерентного дифракционного образования на ядрах углерода: $p + C \to [\Sigma(1385^{\circ} K^{+}] + C$ и $p + C \to [\Sigma^{\circ} K^{+}] + C$. При изучении спектра эффективных масс системы гиперон-каон в этих реакциях получены указания на существование новых барионных состояний: $X(2050)$ с массой $M = 2052 \pm 6$ МэВ и шириной $\Gamma = 35^{+22}_{-35}$ МэВ в $M[\Sigma(1385)^{\circ} K^{+}]$ и $X(2000)$ с $M = 1999 \pm 7$ МэВ и $\Gamma = 91 \pm 17$ МэВ в $M[\Sigma^{\circ} K^{+}]$. Необычные свойства этих массивных состояний (достаточно малые распадные ширины, аномально большие вероятности распадов с испусканием странных частиц) делают их серьезными кандидатами в криптоэкзотические пятикварковые барионы со скрытой странностью. Представлены предварительные данные по реакциям $p + N \to [p\eta] + N$ и $p + N \to [p\eta'] + N$, а также первые результаты для спектров эффективных масс $M[\Sigma^{\circ} K^{+}]$, $M(p\eta)$ и $M(p\eta')$ в непериферической области (с $P_T^2 > 0.3$ GeV^2).

1. Introduction

A rapid development of the hadron spectroscopy in recent years has led to a significant advance in the systematics of "ordinary" hadrons with the simplest valence quark structure: $q\bar{q}$ for mesons and qqq for baryons. At the same time several unusual hadrons with some anomalous features have been found. They do not fit into this simplest quark model systematics and are interpreted as new forms of hadronic matter — exotic hadrons. These states can include multiquark formations ($qq\bar{q}\bar{q}$ mesons and $qqqq\bar{q}$ baryons), hybrid systems with valence quarks and gluons ($q\bar{q}g$ mesons and $qqqg$ baryons), or glueballs, i.e. mesons consisting solely of valence gluons (gg, ggg). The discovery of the exotic hadrons would have far-reaching consequences for quantum chromodynamics, for the concept of confinement and for specific models of hadron structure (lattice, string and bag models). Detailed discussions of exotic hadron physics can be found in recent reviews [1-5].

Exotic hadrons can have anomalous quantum numbers not accessible to three-quark baryons or quark-antiquark mesons (open exotic states) or even usual quantum numbers (cryptoexotic states). Cryptoexotic hadrons can be identified only by their unusual dynamical properties (anomalously narrow decay widths, anomalous decay branching ratios and so on).

As is clear from review papers [1-5], in the last decade searches for exotic mesons have led to considerable advance in this field. Several new states have been observed whose properties cannot be explained by using the naive quark model of ordinary mesons with $q\bar{q}$ valence quark structure. These states are serious candidates for exotic mesons (most of them are of cryptoexotic type).

At the same time the situation for exotic baryons is far from being clear. There are also some examples of possible unusual baryon resonances [6-9], but these data do not have enough precision and are not supported by some new experimental results [1,10-13].

The recent data of the SPHINX experiment at IHEP 70 GeV accelerator [14-17] gave new important evidence of possible existence of cryptoexotic baryons with hidden strangeness ($uuds\bar{s}$ valence quark structure) $X(2050)^+ \to \Sigma(1385)^\circ K^+$ and $X(2000)^+ \to \Sigma^\circ K^+$. We shall briefly summarize these data in Sect.3, after general description of the nature and expected properties of cryptoexotic baryons as well as some promising ways for their production and observation.

We shall also present here some preliminary results on the production of $[p\eta]$ and $[p\eta']$ states in the proton diffractive-like reactions.

2. Cryptoexotic baryons

As has been stated before, cryptoexotic baryons have no external exotic features and their complex internal valence structure can be established indirectly by examining their anomalous dynamical properties (such as small decay widths, unusual decay branching ratios and so on).

The searches for heavy baryons with anomalously narrow decay widths, would they be successful, make it possible to obtain the best evidence of cryptoexotic baryon states. In this connection let us consider the properties of multiquark baryons with hidden strangeness $B_\phi = |qqqs\bar{s}>$ $(q = u, d, s)$.

If such cryptoexotic baryon structure consists of two color parts separated in space with a centrifugal barrier, then its decays into the color singlet final states may be suppressed because of a complicated quark rearrangement in these processes. The properties of multiquark exotic baryons with internal color structure

$$|qqqq\bar{q}>_{1c} = |(qqq)_{8c} \odot (q\bar{q})_{8c}> \tag{1}$$

(color octet bonds) or

$$|qqqq\bar{q}>_{1c} = |(qq\bar{q})_{6\bar{c}} \odot (qq)_{6c}> \tag{2}$$

(color sextet-antisextet bonds) are discussed in [18-20]. Here subscripts 1c, 8c and so on specify the representation of the color $SU(3)_c$ group. If the mass of a nonstrange baryon with hidden strangeness is above the threshold for the decay modes with the strange particlees in final states, then the main decay channels should be of the type

$$B_\phi \to YK + n\pi \tag{3}$$

or

$$B_\phi \to \phi N(\eta N;\ \eta' N) + n\pi \tag{4}$$

(n=0,1,...), i.e. with strange particle pairs or with particles with significant hidden strangeness component in their valence quark structure. It must be also stressed that η and particularly η' mesons are strongly coupled with gluon fields and with states with enriched gluon component. Thus baryon decays of $B \to N\eta,\ N\eta'$ type may be the specific decay modes for the hybrid baryons (see, for example, reviews [1]).

The nonstrange decays of baryons with hidden strangeness $B_\phi \to N + n\pi$ must be suppressed by the OZI rule. Thus, the effective phase space factors for the decays of massive B_ϕ baryons would be significantly reduced because of this OZI suppression (owing to a large enough mass threshold for the allowed $B_\phi \to YK$ decays to be compared with suppressed $B_\phi \to N\pi, \Delta\pi$ ones). The mechanism of quark rearrangement of color clusters in the decay processes for the objects with complicated inner structure of (1) or (2) type can additionally reduce the decay width of cryptoexotic baryons and do it anomalously narrow (of the order of several tens of MeV). The theoretical predictions here are rather arbitrary [18-21]. So the question of the existence of such narrow baryon resonances with hidden strangeness can be resolved only with experiments. It seems quite desirable to perform the search for cryptoexotic baryons with anomalous dynamical features which are different from the properties of usual (qqq)-isobars [22]. These anomalous features are:

1. The main decay modes of $|qqqs\bar{s}>$ are with strange particles in the final states (for usual isobars such decays have branching ratios at the percent level).

2. Owing to a complicated valence quark structure, quark rearrangement suppression of the decay probability and limited phase space for the OZI allowed decays, cryptoexotic baryons $|qqqs\bar{s}>$ can have heavy enough masses ($M \geqslant 1.9 \div 2.0$ GeV) with narrow enough decay widths ($\Gamma \leqslant 50 \div 100$ MeV).

3. Study of Coherent Diffractive Production reactions of $p + C \to [Y^o K^+] + C$ Type and Observation of Narrow Structures in $\Sigma(1385)^o K+$ and $\Sigma^o K^+$ Effective Mass Spectra

As has been emphasized in a number of papers (see [1], [6], [19] and the references herein), the diffractive production processes with Pomeron exchange offer new possibilities in the search for exotic hadrons especially in the high energy region, since the cross sections of these exclusive processes do not decrease with energy. These possibilities are associated with the multigluon nature of the pomeron and with an enlarged probability to produce exotic hadrons in gluon-rich processes. In diffractive production reactions the mechanism of pomeron exchange can induce coherent processes on the target nucleus; in such processes the nucleus acts as a discrete unit. These processes are easily identified from the square of the transverse momentum distribution of the final-state particle system. They manifest themselves as diffractive peaks with large values of the slope parameters, determined by the size of nucleus [$dN/dP_T^2 \simeq const * exp(-bP_T^2)$, where $b \sim (8 \div 10)A^{2/3}$ GeV^{-2}]. Owing to different absorption of single-particle and multiparticle objects in nuclei, coherent processes could serve as an effective tool for isolating resonances against the multiparticle nonresonant background. All these questions have been discussed in more detail in review papers [1].

In the experiments of the SPHINX Collaboration a wide program of studying the hadron diffractive production by protons with $E_p = 70$ GeV and the search for exotic baryons in these processes has been carried out. The SPHINX setup [10] used for measurements in the proton beam experiments includes a wide-aperture magnetic spectrometer for charged secondaries and multichannel γ-spectrometer with total absorption Cherenkov lead glass counters for photon detection. The charge particles in final states were identified with the differential Cherenkov detector of the RICH type and two multisell threshold gas Cherenkov counters. Some experimental results, obtained in the experiment of the

SPHINX Collaboration, are discussed in the Refs. [10]-[17], where many diffractive production reactions have been studied

$$
\begin{aligned}
p + N \;&\rightarrow\; [pK^+K^-] + N, & (5)\\
&\rightarrow\; (\phi p) + N, & (6)\\
&\qquad \hookrightarrow K^+K^- & (7)\\
&\rightarrow\; [\Lambda(1520)K^+] + N, & \\
&\qquad \hookrightarrow K^-p & (8)\\
&\rightarrow\; [\Sigma(1385)^o K^+] + N, & \\
&\qquad \hookrightarrow \Lambda\pi^o & (9)\\
&\rightarrow\; [\Sigma(1385)^o K^+] + N + (\boldsymbol{neutrals}), & \\
&\qquad \hookrightarrow \Lambda\pi^o & (10)\\
&\rightarrow\; [\Sigma^o K^+] + N, & \\
&\qquad \hookrightarrow \Lambda + \gamma & (11)\\
&\rightarrow\; [pp\bar{p}] + N, & \\
&\rightarrow\; [pp\bar{p}\pi^o] + N, & (12)\\
&\rightarrow\; [p\pi^+\pi^-] + N, & (13)\\
&\rightarrow\; [\Delta^{++}\pi^-] + N. & (14)\\
&\qquad \hookrightarrow p\pi^+ &
\end{aligned}
$$

As is seen from dN/dP_T^2 plots for all the processes mentioned above, there are strong narrow forward cones in these distributions with the slope $b \sim 50$ GeV^2 which correspond to coherent diffractive production reactions on carbon nuclei. For the isolation of the coherent production events the "soft" or "stringent" cuts in P_T^2 can be used:

1. The soft transverse momentum cut $P_T^2 < 0.075 \div 0.1$ GeV^2; with this soft cut the noncoherent background among the selected events may be as much as 30÷40%.

2. The stringent transverse momentum cut $P_T^2 < 0.02$ GeV^2; with this cut the noncoherent background constitutes not more than 8÷10% of the selected events. The price for this low noncoherent background is a partial reduction of the coherent reaction statistics.

These criteria were used in a study of coherent diffractive reactions on carbon nuclei

$$
p + C \rightarrow \quad [\Sigma(1385)^o K^+] + C, \qquad \hookrightarrow \Lambda\pi^o \tag{15}
$$

$$
p + C \rightarrow \quad [\Sigma^o K^+] + C. \qquad \hookrightarrow \Lambda\gamma \tag{16}
$$

3.1. Reaction $p + C \to [\Sigma(1385)^o K^+] + C$

In the analysis of the SPHINX data the exclusive process with Λ-hyperons $P + N \to [\Lambda\pi^o K^+] + N$ was identified [11,12]. In Fig.1a the effective mass spectrum of the $\Lambda\pi^o$ system in this reaction is presented. In $M(\Lambda\pi^o)$ mass spectrum the peak of $\Sigma(1385)^o \to \Lambda\pi^o$ is dominating. The background level under the $\Sigma(1385)^o$ peak is quite small. This fact simplifies the identification of reaction (8) and corresponding coherent reaction (5).

Coherent events of (15) were singled out in the analysis of dN/dP_T^2 distribution as a strong forward peak with the slope $b \sim 50$ GeV^{-2}. In order to reduce the noncoherent background and to obtain the $\Sigma(1385)^o K^+$ mass spectrum for the "pure" coherent production reaction on carbon nuclei a stringent requirement $P_T^2 < 0.02$ GeV^2 has been imposed and the mass spectra of $\Sigma(1385)^o K^+$ for the coherent events of (15) has been obtained (see, for example, Fig.1b). These spectra were studied with different values of ΔM bin widths in histograms and with bin shifting. The thorough background evaluation under the peaks was obtained using the information on the side bands near the peak. The statistical confidence levels of the peaks were determined from these data.

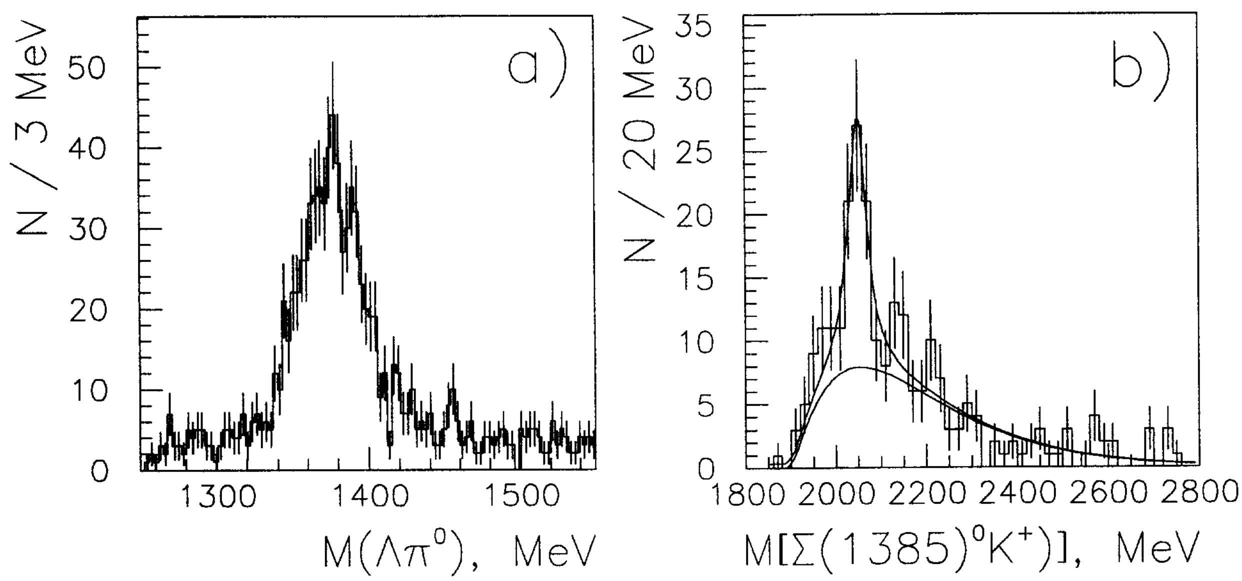

Fig. 1. a) The separation of reaction $p + N \to \Sigma(1385)^o K^+ + N$ in the study of invariant mass spectrum $M(\Lambda\pi^o)$ in the reaction $p + N \to \Lambda\pi^o K^+ + N$. b) The invariant mass spectrum $M[\Sigma^o(1385)K^+]$ in the coherent reaction (15) with stringet coherent cut $P_T^2 < 0.02$ GeV^2. The spectrum is fitted by the sum of smooth polynominal background curve and $X(2050)$ peak with parameters (17).

The fits of the spectra with Breit-Wigner peaks and polynomial smooth background were carried out, and the average values for the main parameters of $X(2050)$ structure were determined

$$\left.\begin{array}{l} M = 2052 \pm 6 \text{ MeV;} \\ \Gamma = 35^{+22}_{-35} \text{ MeV} \\ \text{(with the account of the apparatus mass resolution);} \\ \text{statistical C.L. of the peak} \geqslant 5 \text{ standard deviations} \end{array}\right\}. \quad (17)$$

This narrow structure can not be explained by diffractive nonresonant process of the Deck-type and seems to be caused by the production of a new cryptoexotic baryon with hidden strangeness.

3.2. Reaction $p + C \to [\Sigma^o K^+] + C$

During the study of the reaction with Λ-hyperons and K-mesons the events with one and only one additional γ-cluster detected in γ-spectrometer of the SPHINX apparatus were separated.

The effective mass spectrum of $\Lambda\gamma$ system for these events is shown in Fig.2a. The peak of $\Sigma^o \to \Lambda\gamma$ decay in this spectrum is clearly seen. Thus, reaction (10) is identified and coherent events of (16) type are singled out using the P_T^2 distribution.

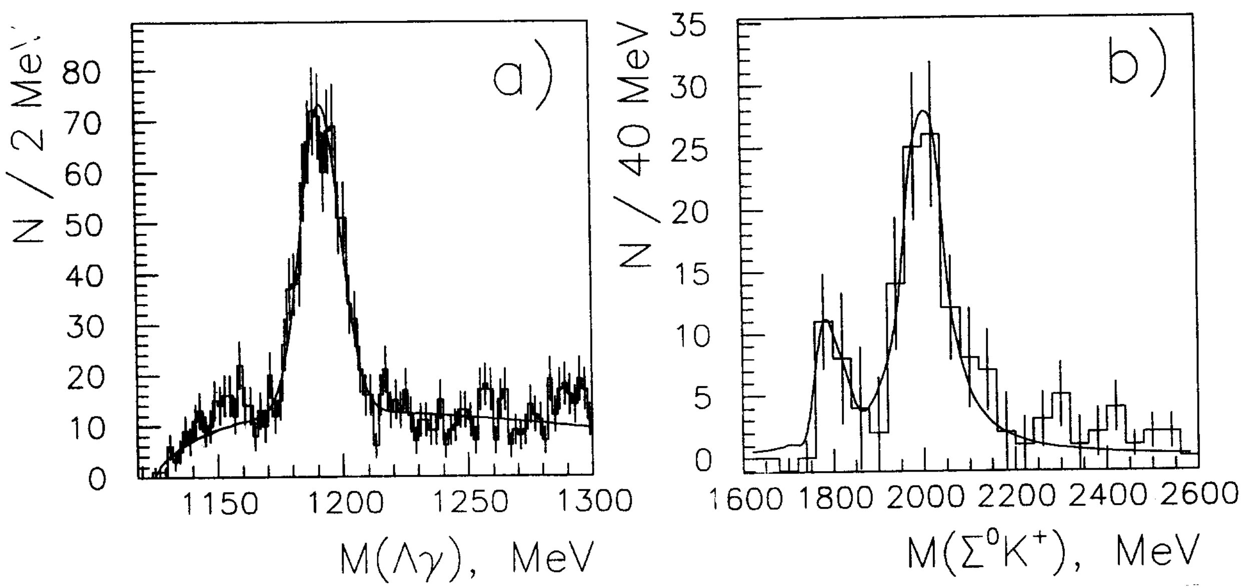

Fig. 2. a) The separation of the reaction $p + N \to \Sigma^o K^+ + N$ in the study of invariant mass spectrum $M(\Lambda\gamma)$ in the reaction $p + N \to \Lambda\gamma K^+ + N$. b) The invariant mass spectrum $M(\Sigma^o K^+)$ in cocherent reaction (16) with soft coherent cut $P_T^2 < 0.1$ GeV^2. Here the background under Σ^o peak is subtracted by the standard sideband method (see [17] for all the details. In this spectrum some structure in the threshold region with $M = 1802 \pm 3$ MeV and a clear $X(2000)$ peak with parameters of (18) are observed.

The effective mass spectrum $M(\Sigma^o K^+)$ for coherent reaction (16) with soft transverse momentum cut $P_T^2 < 0.1$ GeV^2 is presented in Fig.2b. In this spectrum besides some small structure with $M \sim 1800$ GeV in the threshold region, a strong peak $X(2000)$ is clearly observed. The main parameters of $X(2000)$ structure are:

$$\left.\begin{array}{l} X(2000) \to \Sigma^o K^+ \\ M = 1999 \pm 7 \text{ MeV} \\ \Gamma = 91 \pm 17 \text{ MeV} \\ \text{statistical C.L. of the peak} \geqslant 7 \text{ s.d.} \end{array}\right\}. \quad (18)$$

Such shape of mass spectrum $M(\Sigma^o K^+)$ (with additional structure in the threshold region) shows that $X(2000)$ peak cannot be explained by the nonresonant Deck-type diffractive singularity. It seems that this peak has a resonant nature.

3.3. Study of Other Decay Channels for $X(2050)$ and $X(2000)$ States

To search for other decay channels of $X(2050)$ and $X(2000)$ baryon states the simultaneous analysis of the SPHINX data on the coherent reactions

$$p + C \to p\pi^+\pi^- + C, \quad (19)$$

$$\to \Delta(1232)^{++}\pi^- + C \quad (20)$$

has been performed together with (15) and (16) and under the same kinematical conditions. These data were obtained in studying reactions (13) and (14) in a coherent region. Preliminary data on the reaction of $[\Delta(1232)^{++}\pi^-]$ production had been obtained in our previous work [12]. The diffractive production of some isobar-like structures with mass ≈1460 MeV and ≈1715 MeV were clearly seen in these data.

But in the mass region of $X(2050)$ and $X(2000)$ states there are no such structures in all mass spectra of $M(p\pi^+\pi^-)$ and $M[\Delta(1232)^{++}\pi^-]$ in reactions (19) and (20). The lower limits for the ratios of the corresponding decay branchings were estimated to be (with 95% C.L.):

$$R_1 = \frac{BR\{X(2050)^+ \to [\Sigma(1385)K]^+\}}{BR\{X(2050)^+ \to [\Delta(1232)\pi]^+\}} > 1.7, \quad (21)$$

$$R_2 = \frac{BR\{X(2050)^+ \to [\Sigma(1385)K]^+\}}{BR\{X(2050)^+ \to p\pi^+\pi^-\}} > 2.6, \quad (22)$$

$$R_2' = \frac{BR\{X(2050)^+ \to [\Sigma(1385)^o K]^+\}}{BR\{X(2050)^+ \to p\pi^+\pi^-\}} > 0.86, \quad (23)$$

$$R_3 = \frac{BR\{X(2000)^+ \to [\Sigma K]^+\}}{BR\{X(2000)^+ \to [\Delta(1232)\pi]^+\}} > 0.83, \quad (24)$$

$$R_4 = \frac{BR\{X(2000)^+ \to [\Sigma K]^+\}}{BR\{X(2000)^+ \to p\pi^+\pi^-\}} > 7.8, \quad (25)$$

$$R_4' = \frac{BR\{X(2000)^+ \to \Sigma K^+\}}{BR\{X(2000)^+ \to p\pi^+\pi^-\}} > 2.6. \quad (26)$$

Here the isotopic conditions for the decays of $X(2050)$ and $X(2000)$ baryons with isotopic spin $I = 1/2$ were used (these states belong to isodoublets because they are produced in the diffractive dissociation of protons).

The ratios $R_1 - R_4$ for $X(2050)$ and $X(2000)$ decays with strange and nonstrange particles are much larger than the same ratios for the decays of usual (qqq)-isobars (where they are of an order of several percent [22]).

The small enough widths of $X(2000)$ and $X(2050)$ baryon states as well as the anomalously large branching ratios for their decay channel with strange particles (large values of $R_1 - R_4$) are the reasons to consider these states as serious candidates for the cryptoexotic baryons with hidden strangeness $|uuds\bar{s}>$.

4. Reactions $p + N \to [p\eta] + N$ and $p + N \to [p\eta'] + N$

In the study of exclusive diffractive-like reactions with $\pi^+\pi^-$ pairs and two photon clusters in the final state ($p + N \to p\pi^+\pi^-\gamma\gamma + N$) clear peaks of π^o and η are seen in the effective mass spectrum of $\gamma\gamma$ pairs, and the reactions

$$p + N \to \quad [p\,\pi^+\,\pi^-\pi^o] + N, \quad \pi^o \hookrightarrow \gamma\gamma \tag{27}$$

$$\to \quad [p\,\pi^-\pi^-\eta] + N, \quad \eta \hookrightarrow \gamma\gamma \tag{28}$$

are well separated. The first reaction is used to study $[p\eta]$ and $[p\omega]$ production processes. As is seen from Fig.3a, the reaction

$$p + N \to \quad [p\,\eta] + N, \quad \eta \hookrightarrow \pi^+\pi^-\pi^o \tag{29}$$

is singled out from the events of (27). The data on $[p\omega]$ production are presented in a separate publication. It is clear from dN/dP_T^2 distribution for (20) (Fig.3b) that the coherent diffractive production process on carbon nuclei with the slope of diffractive cone $b \sim 50$ GeV^{-2} dominates in the region of small transverse momenta. The mass spectrum $M[p\eta]$ for all P_T^2 is presented in Fig.4.

The reaction

$$p + N \to \quad [p\,\eta'] + N, \quad \eta' \hookrightarrow \pi^+\pi^-\eta \tag{30}$$

is also separated from the events of (28) (see Fig.5a for the mass spectrum of $\pi^+\pi^-\eta$ system in (28)). The dN/pP_T^2 distribution for (30) is given in Fig.5b. As is seen from this figure, reaction (30) is the only diffractive-like production process studied by the SPHINX Collaboration (among more than dozen other reactions) in which one does not observe the strong coherent production on carbon nuclei (the absence of the forward peak in dN/dP_T^2 with a slope $b \sim 50$ GeV^{-2}). Thus the $[p\eta']$ production reaction (30) is obviously a process of a nonperipheral character. It is instructive to compare Fig.5b with Fig.3b (as well as with dN/dP_T^2 distributions for (5)-(14) — see [10], [12], [16]) to demonstrate this phenomenon.

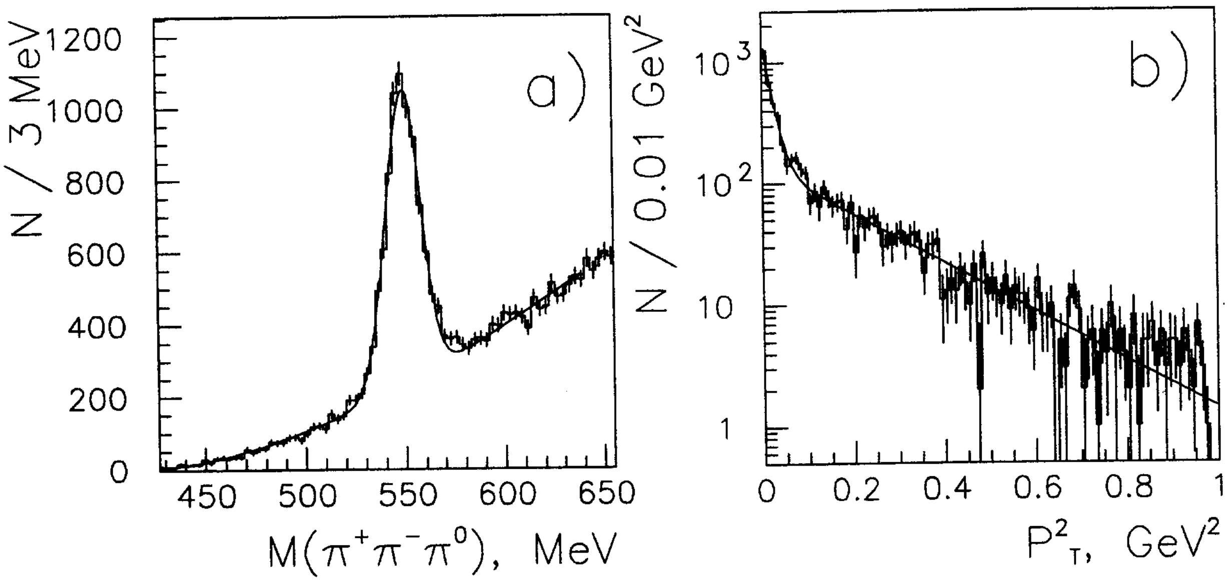

Fig. 3. a) The separation of reaction $p+N \to [\eta p]+N$ in the study of invariant mass spectrum $M(\pi^+\pi^-\pi^o)$ in (27). b) dN/dp_T^2 distribution for reaction (29). This distribution is fitted by sum of two exponents with the slopes b_1 =55 GeV^{-2} and b_2 =4.6 GeV^{-2}. All the data for (29) here and below were obtained by the subtraction the background under η-peak using the standard sideband method.

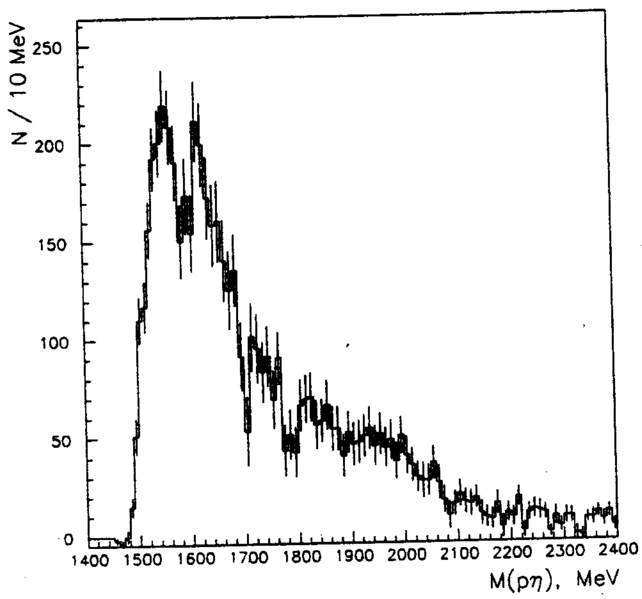

Fig. 4. The invariant mass spectrum $M(p\eta)$ for reaction $p+N \to [p\eta]+N$ for all p_T^2.

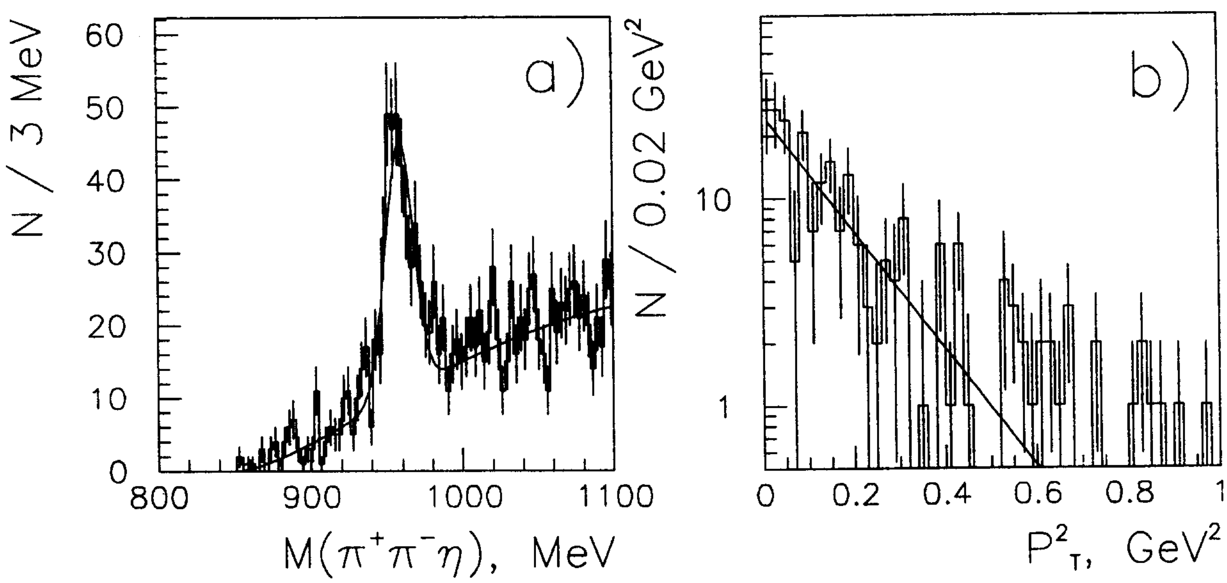

Fig. 5. a) The separation of reaction $p+N \to [p\eta'] + N$ in the study of invariant mass spectrum $M(\pi^+\pi^-\eta)$ in (28). b) dN/dp_T^2 distribution for reaction (30). In this distribution there is no evidence of coherent diffractive peak with $b \sim 50$ GeV^{-2}. The slope of the distribution in the region of $P_T^2 < 0.5$ GeV^2 is $b_1 \simeq 6.5$ GeV^{-2}. All the data for (30) here and below were obtained by the subtraction of the background under η' peak using the standard sideband method.

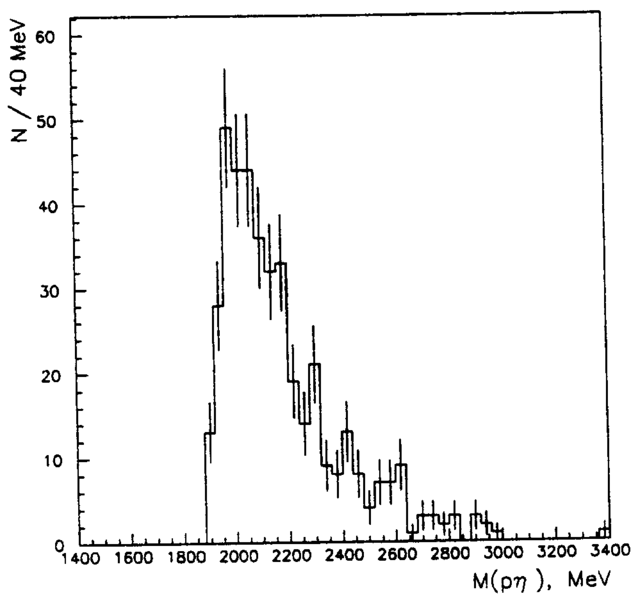

Fig. 6. The invariant mass spectrum $M(p\eta')$ in reaction (30) for all P_T^2.

The mass spectrum $M[p\eta']$ in (30) for all P_T^2 is presented in Fig.6. It is clear from Figs.4 and 6, that we did only the first step in studying processes of $[p\eta]$ and $[p\eta']$ production and this investigation demands further development.

5. First Data for the Proton Diffractive-Like Production Reactions in a Nonperipheral Domain

As has been discussed above the coherent diffractive production reactions seem to be quite promising processes for the study of exotic hadrons. But, certainly, this method is not unique for exotics searches. For some states (and especially for those that are formed at small distances) the nonperipheral processes can be the most effective for their production. In these cases the best conditions for the exotic hadron searches can be obtained in the region of large enough or intermediate transverse momenta (with $P_T^2 > 0.3 - 0.5$ GeV^2), where the background from peripheral processes is strongly reduced. For example, in the study of the charge-exchange reactions $\pi^- p \to \eta\eta + \Delta^o$ and $\pi^- p \to \eta\eta' + n$, after the selection of events with $P_T^2 \geq 0.3$ GeV^2, unusually narrow meson states $X(1740) \to \eta\eta$ [23] and $X(1910) \to \eta\eta'$ [24] were observed. These anomalous states are good candidates for cryptoexotic mesons. A mechanism of multiple rescattering with the Pomeron exchange (gluon rich process) may explain the $X(1740)$ and $X(1910)$ production [25].

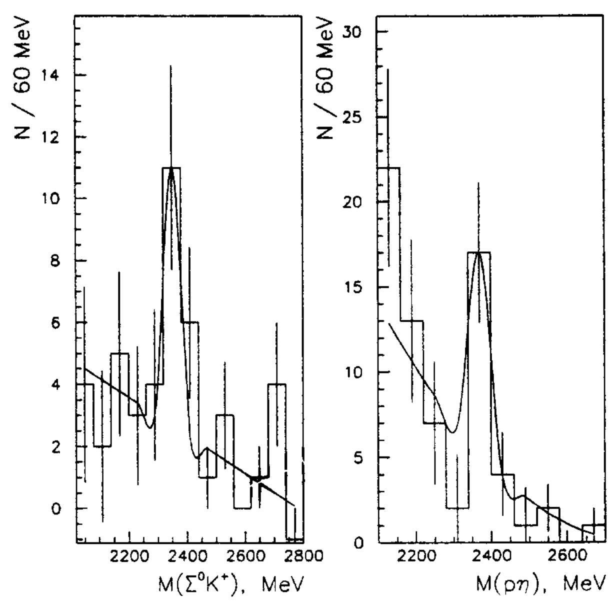

Fig. 7. a) The invariant mass spectra $M(\Sigma^o K^+)$ in the reaction $p + N \to [\Sigma^o K^+] + N$ at $P_T^2 > 0.3$ GeV^2. b) The invariant mass spectrum $M(p\eta)$ in the reaction $p+N \to [p\eta]+N$ at $P_T^2 > 0.3$ GeV^2. In these two spectra in nonperipheral regions of (8) and (29) some structure with $M \sim 2350$ MeV and $\Gamma \sim 60$ MeV is seen.

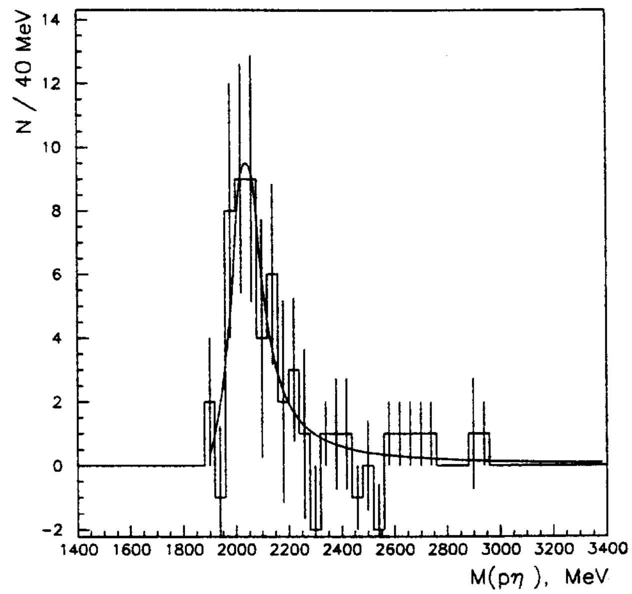

Fig. 8. The invariant mass spectrum $M(p\eta')$ in the reaction $p + N \rightarrow [p\eta'] + N$ in the region of $P_T^2 > 0.3$ GeV^2. This spectrum is dominated by peak with $M \sim 2000$ MeV and $\Gamma \sim 100$ MeV.

The search for new baryons for large P_T^2 domain in proton induced diffractive-like reactions also seems quite interesting. Here we present the first and very preliminary results obtained for the effective mass spectra $M(\Sigma^o K^+)$, $M(p\eta)$ and $M(p\eta')$ for $P_T^2 >$ 0.3 GeV^2 in reactions (10), (29) and (30) (Figs.7 and 8). In spite of quite limited statistics the two possible structures are clearly seen and need further investigation.

6. Conclusion from the SPHINX experimentss

In the study of coherent diffractive production (15) and (16) for the energy of proton beam $E_p = 70$ GeV two new baryon structures $X(2050)^+ \rightarrow \Sigma(1385)^o K^+$ and $X(2000)^+ \rightarrow \Sigma^o K^+$ have been observed with the statistically significant confidence level. These states are characterized by the unusual dynamical features: small enough decay widths and anomalously high decay rates with strange particles in final states. Thus $X(2050)$ and $X(2000)$ are serious candidates for cryptoexotic baryons with hidden strangeness.

With the existing statistics the above results are considered as preliminary [17]. They should be confirmed in further measurements with an increased statistics.

The first data for $[p\eta]$ and $[p\eta']$ production in proton induced reactions and especially the results obtained for nonperipheral domain for these reactions look exciting but they required more statistics and more sophisticated analysis to obtain some meaningful conclusions. We hope to obtain up to an order of magnitude increase in a number of events of all the above reactions in the near future experiments with the upgraded SPHINX setup.

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