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Meetings and Conferences

NINTH INTERNATIONAL CONFERENCE ON HIGH ENERGY PHYSICS

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THE ninth International conference of scientists from the socialist countries on high energy physics took place in the Polish city of Krakow from the 24 to the 26 of September, 1963.

The conference was devoted mainly to the interactions of particles, whose energies ranged from a few GeV to hundreds of GeV, with nucleons and nuclei. In accordance with the program the first three sessions were devoted to work performed with accelerators; two sessions were devoted to work carried out with cosmic rays, one session to problems of techniques, and one session to individual problems in the theory of the interactions of high energy particles. The last two sessions were held in parallel.

Altogether 111 scientists from the socialist countries participated in the conference; 9 from the Academy of Sciences, U.S.S.R., 10 from the Joint Institute for Nuclear Research, 4 from Bulgaria, 5 from Hungary, 9 from East Germany, 2 from China, 60 from Poland, 6 from Rumania and 6 from Czechoslovakia. Below we mention those papers that were, in our opinion, the most interesting ones.

The work of the conference was opened with an introductory word by Prof. **M. Miesowicz**. Afterwards **E. L. Feĭnberg** (Moscow) described in a long review report the present status of the theory of strong interactions at high energy.*

G. I. Budker (Novosibirsk) outlined to the conference participants the prospects for physics research with small scale accelerators of large current densities, which are being currently worked on.

Research in the region of synchrocyclotron energies was represented in review reports on work done at Dubna—"Muon Capture by Nuclei" (**A. I. Mukhin**) and "Research on Phase Shift Analysis of Nucleon-Nucleon Scattering" (**Yu. M. Kazarinov**).

In the capture of polarized μ^- mesons by Ca^{40} nuclei **V. S. Evseev** et al. studied the angular distribution of the neutrons, emitted by the nucleus, with respect to the spin direction of the muon. The values of the asymmetry coefficient A in the angular distribution $f(\theta) \sim 1 + A\cos\theta$, as a function of the energy threshold of neutron detection (muon polarization $P_\mu = 0.190 \pm 0.015$), are given in the table

Neutron detection threshold E_n, MeV	7.0	11.0	14.0
$-A$	0.054 ± 0.012	0.100 ± 0.016	0.134 ± 0.020
Neutron detection threshold E_n, MeV	18.0	19.5	23.0
$-A$	0.193 ± 0.025	0.234 ± 0.026	0.235 ± 0.040

These results are in contradiction with the theoretical predictions of I. S. Shapiro et al,, based on the universal theory of weak interactions and certain nuclear models ($A_{theor} \cong 0.4$, $P_\mu = -0.076$).

As one of possible attempts for the resolution of this contradiction it is proposed to introduce the induced scalar interaction and to substantially increase the induced pseudoscalar interaction coupling constant compared to its theoretical value $G_P = 8G_A$ (**M. Ya. Iovnovich** et al.).

O. A. Zaĭmidoroga et al. continued the study of nuclear capture of muons in He^3. By observing in a cloud chamber the processes

$$\begin{aligned}\mu^- + He^3 &\to H^3 + \nu,\\ &\to d + n + \nu,\\ &\to p + 2n + \nu,\end{aligned}$$

the authors determined the total absorption rate of μ^- mesons by the He^3 nucleus. The experimental value $\Lambda_{He^3} = (2.14 \pm 0.20) \times 10^3\ \text{sec}^{-1}$ is in satisfactory agreement with the universal theory of weak interactions.

The large amount of experimental data now existing on the elastic nucleon-nucleon interaction in the below 1 GeV energy region has been analyzed in the papers of **Yu. M. Kazarinov** et al. As a result of a simultaneous phase shift analysis of the pp and np scattering data practically unique solutions were obtained for the elastic NN scattering phase shifts. In the energy region below the meson production threshold the energy dependence of the phase shifts was obtained. The complicated energy dependence of the phase shifts rules out a description of the scattering by means of simple potentials. The special role played by the spin-orbit forces in nucleon-nucleon scattering is noted.

Next a few reports were delivered on the study of fragments and hyperfragments (HF).

Fragments with $Z \geq 3$ and energy $E > 8$ MeV/nucleon, produced in the p-nucleus interactions at 25 GeV, were studied with the help of photoemulsions (**I. Suchozewska**, Warsaw). In addition a particular study was made of Li^8 fragments (**Gajewski**, Warsaw), produced in the p-nucleus interaction (9 and 24 GeV), and also in K^--nucleus and π-nucleus collisions.

*See the article by E. L. Feĭnberg and D. I. Chernavskiĭ in UFN 82, 3 (1964), Soviet Phys. Uspekhi 7, 1 (1964).

An analysis of the experimental data shows that the probability of emission of Li^8 weakly increases with energy and is practically independent of the type of bombarding particle. In that and another paper it is noted that the angular distribution of the fragments is anisotropic; they are emitted preferentially into the forward hemisphere and their energy spectrum differs from the "evaporation" spectrum. To explain these peculiarities it is supposed that the evaporation of the fragments proceeds from moving clusters of nuclear matter, whose average speed is equal to 0.015c and is also independent of the type of bombarding particle (in this moving system the emission of the fragments proceeds at a temperature of T = 12 MeV). An analogous picture is observed in the study of hyperfragments (**E. Zakrzewski**, Warsaw) produced in K^--nucleus interactions (K-meson momentum 1.3 and 1.5 GeV/c). It was found in the analysis of 54,000 K^- stars that the probability of HF production on heavy nuclei amounts to 1.2–1.3%. It also appeared that HF production proceeds analogously to the process of production of ordinary fragments.

The study of the production of below-barrier π^+ mesons may also be referred to the problem of fragmentation (**T. Visky**, Bucharest). It is assumed that the presence of these π^+ mesons is related to the disturbance of the Coulomb barrier when the nucleus is disrupted (fast process). Such an assumption explains the difference in the number of below-barrier π^+ mesons in p-nucleus and π^--nucleus interactions. An alternative hypothesis for the production of below-barrier particles consists of resonant neutral states of the ρ^0-meson type, which decay after crossing the Coulomb barrier. This question may be resolved by a study of correlations between below-barrier π^+ mesons and heavier particles (protons, α particles).

A large number of papers presented at the conference was devoted to the study of the interaction of elementary particles with protons.

The interaction of 3.0 ± 0.45 GeV/c antiprotons with protons was studied with the help of a hydrogen bubble chamber (**T. Hofmokl**, Warsaw). The reaction

$$\tilde{p}+p \to N+\tilde{N}+\pi \qquad (1)$$

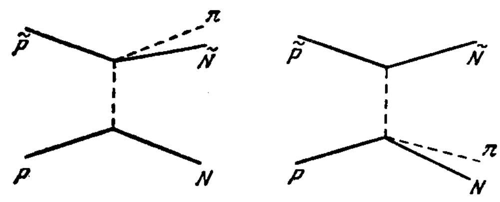
was studied. From 4400 two-prong events 187 were selected corresponding to reaction (1). Cross sections for various channels of reaction (1) were determined:

$$\sigma_1(\tilde{p}p\pi^0)=2.41 \pm 0.29 \text{ mb}$$
$$\sigma_2(\pi^+\tilde{p}n)=2.07 \pm 0.27 \text{ mb}$$
$$\sigma_3(p\pi^+\tilde{n})=1.96 \pm 0.27 \text{ mb}$$

The ratio of these reactions is

$$\sigma_1:\sigma_2:\sigma_3=1.22:1.05:1.$$

If it is assumed that the process goes through the ($^3/_2$, $^3/_2$) isobar then this ratio should be 2:1:1. Effective mass spectra for the πp and $\pi\tilde{p}$ were constructed. In both cases these distributions show peaks correspond-



a) b)

ing to the ($^3/_2$, $^3/_2$) isobar. It would seem that the process may be described by the one-meson diagrams (see figure). This is confirmed by the fact that the Treiman-Yang criterion is satisfied within the statistics limits.

Great interest was evoked by the paper of **K. Lanmus** (Berlin) devoted to the study of the π^+p interaction at a momentum of 4.0 GeV/c. In the scanning of pictures obtained in a 81 cm hydrogen bubble chamber 2- and 4-prong events were selected . Altogether 2415 2-prong and 960 4-prong stars were analyzed. Measurements of the momenta and ionization of all the charged particles were carried out. This was followed by a kinematical analysis. The cross section for the production of 2- and 4-prong events is equal to 26.6 ± 1.5 mb.

Cross sections were determined for the reaction channels:

$$\begin{aligned}\pi^+ + p &\to p\pi^+ && -6.7 \pm 0.3 \text{ mb},\\ &\to p\pi^+\pi^0 && -2.6 \pm 0.1 \text{ mb},\\ &\to n\pi^+\pi^+ && -1.6 \pm 0.1 \text{ mb},\\ &\to p\pi^+(m\pi^0) && -4.0 \pm 0.2 \text{ mb},\\ &\to n\pi^+\pi^+(m\pi^0) && -2.2 \pm 0.1 \text{ mb},\\ & && \sigma_t = 17.1 \pm 0.3 \text{ mb};\end{aligned}$$

$$\begin{aligned}\pi^+ + p &\to p\pi^+\pi^+\pi^- -3.0 \pm 0.2 \text{ mb},\\ &\to p\pi^+\pi^+\pi^-\pi^0 -3.2 \pm 0.2 \text{ mb},\\ &\to n\pi^+\pi^+\pi^+\pi^- -1.1 \pm 0.1 \text{ mb},\\ &\to p\pi^+\pi^+\pi^-(m\pi^0) -1.6 \pm 0.1 \text{ mb},\\ &\to n\pi^+\pi^+\pi^+\pi^-(m\pi^0) -0.6 \pm 0.1 \text{ mb}.\end{aligned}$$

Effective mass distributions were constructed for various combinations of particles. In the distribution $M_{\pi^+\pi^0}$ in the 2-prong events a distinct peak is observed corresponding to the mass of the ρ^+ meson, i.e., the reaction

$$\left.\begin{aligned}\pi^+ + p \to \underset{\downarrow}{\rho^+} + p,\\ \pi^0+\pi^+.\end{aligned}\right\} \qquad (2)$$

At that its cross section equals 0.26 ± 0.04 mb. It is interesting to note that for the π^-p interaction at the same energy the cross section for the reaction $\pi^- + p \to \rho^- + p$ ($\rho^- \to \pi^0 + \pi^-$) is equal to 0.45 ± 0.08 mb. In the one-meson approximation these cross sections should be equal. The authors explain the inequality of these cross sections by the presence of the channel

$$\pi^+ + p \to N^{++} + \pi^0 \to p\pi^+\pi^0 \; (0.47 \pm 0.07 \text{ mb}),$$

whose amplitude, by interfering with (2), reduces the cross section for reaction (2).

Two-particle effective mass distributions were constructed for the 4-prong interactions. In the effective mass spectra peaks are observed corresponding to the ρ meson and the $(3/2, 3/2)$ isobar, with the cross sections for the various channels being as follows:

$$\pi^+ + p \to p\pi^+\pi^-\pi^+ \text{ (without the } \rho \text{ and } N^*) - 1.0 \text{ mb},$$
$$\to N^{++}\pi^-\pi^+ \quad - \quad 1.1 \text{ mb},$$
$$\to \rho^0 p\pi^+ \quad - \quad 0.4 \text{ mb},$$
$$\to \rho^0 N^{++} \quad - \quad 0.5 \text{ mb}.$$

The effective mass spectrum for the combination $p\pi^+\pi^+$ has a maximum at 2400 ± 20 MeV, which may be related to an isobar with T = $5/2$.

For the events with the π^0 meson the effective mass distribution $M_{\pi^+\pi^-\pi^0}$ was constructed and found to have a peak at M_{ω^0}. The following values were obtained for the cross sections for the various reaction channels:

$$\pi^+ + p \to p\pi^+\pi^+\pi^-\pi^0 - 2.1 \text{ mb},$$
$$\to N^{++}\pi^+\pi^-\pi^0 - 0.4 \text{ mb},$$
$$\to p\pi^+\omega^0 \quad - 0.4 \text{ mb},$$
$$\to N^{++}\omega^0 \quad - 0.3 \text{ mb}.$$

In the missing mass spectrum a distinct peak was observed in the reaction $\pi^+ p \to \pi^+ p(m\pi^0)$, corresponding to the mass of the η^0 meson (cross section 0.29 ± 0.07 mb).

M. Bardadin (Warsaw) reported on the results of an analysis of $\pi^- p$ interactions with a number of charged particles $n \geq 6$ at a momentum of 9.9 ± 0.5 GeV/c (hydrogen bubble chamber). These interactions amounted to approximately 14%.

Particular study was devoted to the reaction

$$\pi^- + p \to 3\pi^- + 2\pi^+ + p \text{ (103 events } \sigma = 0.47 \text{ mb)}.$$

Angular and momentum distributions of the protons in the c.m.s. were constructed. The angular distribution turned out to be asymmetric: the protons are emitted into the backward hemisphere. The momentum distribution is practically indistinguishable from that given by phase space. The effective mass distribution $M_{\pi^+ p}$ has a peak corresponding to the $(3/2, 3/2)$ isobar, in which are contained 22 ± 7% of the events. The analogous peak is not seen in the $M_{\pi^- p}$ distribution.

Angular and momentum distributions in the c.m.s. were also constructed for the $\pi^\pm$ mesons. It turned out that π^- mesons were emitted preferentially forward in the c.m.s. The momentum distribution of the $\pi^\pm$ mesons differs from that given by the phase-space curve in the region of small momenta. The transverse momentum of the protons turned out to be somewhat larger than for the π^- and π^+ mesons: 420 ± 20, 365 and 314 MeV/c respectively. In the $M_{\pi\pi}$ distribution the ρ meson peak is observed, containing 30 ± 13% of all events. Further, electron pairs were studied, produced by photons converted within the chamber volume (46 pairs); from this analysis it was concluded that the average number of π^0 mesons in the interactions under study was equal to 1.3.

In this same hydrogen chamber, irradiated by 10.6-GeV/c π^- mesons, a study was made of secondary stars caused by neutrons (**A. Eskreis**, Krakow). Events known to contain protons were used to determine the background. It was shown that the distribution of the number of secondary stars as a function of the distance r from the primary star can be represented in the form

$$\frac{dn}{dr} = ar^2,$$

while the true "neutron" events obey the law (for small r)

$$\frac{dn}{dr} = \text{const}.$$

Altogether 74 neutral stars were found. After corrections for the background and the decay of neutral particles their number was estimated as 39.6, which gives for the cross section for the production of neutrons in π^--p interactions 13 ± 4 mb. It is claimed that in the c.m.s. the neutrons are emitted strictly backwards.

I. Vrana (Prague) reported on preliminary results of an analysis of the π^--N interaction at an energy of ~ 7 GeV, in which the slow proton or positive particle has a momentum < 1 GeV/c [propane bubble chamber of OIYaI (Joint Inst. Nuc. Res.)]. It is noted that the angular distribution of the pions is asymmetric in the c.m.s. (for the π^-, as well as for the π^+). Besides, the transverse momentum of the π^- mesons in the $\pi^- p$ interactions turns out to be equal to 356 ± 16 MeV/c, and in the πn interaction — 261 ± 18 MeV/c. The authors therefore assert that the size of the interaction region is larger for πn collisions.

I. Klugow (Berlin) reported on results relating to the study of the production of π^0 mesons in $\pi^- N$ interactions. From 9000 photographs, obtained with the propane chamber, $\pi^- N$ events were selected containing two or more photons. For these events the distribution $M_{\gamma\gamma}$ was constructed. In the resultant distribution a peak is seen at the mass of the π^0 meson and no other maximum, corresponding to the η^0 meson, is seen. The average transverse momentum of the π^0 mesons is equal to $\bar{p}_\perp$ = 270 ± 50 MeV/c and the average momentum in the c.m.s. is 350 ± 160 MeV/c. The angular distribution of the π^0 mesons in the c.m.s. is asymmetric: the ratio $N_{forward}/N_{backward} = 1.8$.

A study, also in a propane bubble chamber, of the reaction

$$\pi^- + p \to \pi^- + p + m\pi^0$$

at small momentum transfer Δ ($150 < \Delta < 700$ MeV/c) was reported on by **A. Mihul** (Bucharest).

The kinematics of each event were studied to determine the number of neutral pions. The following methods for the determination of this number were used:

a) missing mass,
b) method of the target mass,
c) nonconservation of the longitudinal momentum.

The following distribution in the multiplicity of neutral pions was obtained:

n_{π^0}	1	2	3	4
Fraction of events, %	14	29	52	5

Thus the fraction of events with the production of a single neutral pion is very small, which disagrees with the data obtained from the analysis of the number of photons ($n_{\pi^0} = 1.3 \pm 0.2$). The authors, therefore, suppose a possible existence of some other neutral long-lived particle.

In the analysis of the π^-p interaction at $E \cong 7$ GeV (**E. Balya**, Bucharest) the following reactions were singled out:

$$\begin{aligned}\pi^-+p &\to p+\pi^-+k\pi^0\text{—185 events,}\\ &\to n+\pi^++\pi^-+k\pi^0\text{—475 events,}\\ &\to p+\pi^++2\pi^-+k\pi^0\text{—121 events,}\\ &\to n+2\pi^++2\pi^-+k\pi^0\text{—533 events.}\end{aligned}$$

The angular distribution of protons and π^- mesons turned out to be asymmetric in the c.m.s.: the protons are emitted backward and the π^- mesons forward; the distribution of the π^+ and π^- mesons is symmetric. In the distribution $M_{\pi^+\pi^-}$ a peak is seen at $M_{\pi^+\pi^-} = 922 \pm 30$ MeV with $\Gamma \le 150$ MeV.

The production of neutral pions was also studied in a xenon bubble chamber irradiated by ~ 9 GeV/c π^- mesons (**E. Loskiewicz**, Krakow). Altogether 277 stars, and 805 photons connected with them, were investigated. The average number of photons is $n_\gamma = 3.44 \pm 0.12$.

The photon energy spectrum has a peak at 70 MeV and a small peak at 250 MeV, which is 2.5 standard deviations away from the smooth curve drawn through the neighboring intervals. It is supposed that this peak is due to a two-photon decay of the η^0 meson.

In the $M_{\gamma\gamma}$ distribution for events with two and three photons the η^0 meson was not seen. It is noted, on the other hand, that events in which the photon energy lay in the interval 220—260 MeV had an average multiplicity $\bar{n}_\gamma = 6.1 \pm 0.4$ (as compared with $\bar{n}_\gamma = 4.1 \pm 0.12$ for all events with $n_\gamma \ge 1$). Therefore the authors suppose that η^0 mesons are produced in stars with larger photon multiplicity. The results of two experiments performed with a xenon bubble chamber irradiated by ~ 9 GeV π^- mesons were reported on by **I. M. Gramenitskiĭ** (Dubna). The first of these was devoted to a study of production of π^0 mesons by π^- mesons in the Coulomb field of the xenon nucleus. It was found that the cross section for such a process is quite small and amounts to no more than 0.5 mb. In the second experiment elastic scattering of π^- mesons on quasi-free neutrons and charge exchange of π^- mesons on quasi-free protons were studied. The elastic πn scattering cross section in the range of angles 9—18° in the c.m.s. turned out to be equal to 1.75 ± 0.35 mb, and 1.1 ± 0.3 mb for charge exchange, per xenon nucleus.

Production of strange particles in π^-p interactions was reported on by **R. Sosnowski** (Warsaw). In a hydrogen chamber irradiated by π^- mesons (10 GeV/c) the following reactions were studied:

$$\begin{aligned}\pi^++p &\to K_1^0+\tilde{K}_1^0+p+\pi\text{—28,}\\ &\to K_1^0+\tilde{K}^0+n+\pi\text{—28,}\\ &\to \Lambda+K^0+\pi\quad\text{—95,}\\ &\to \Sigma^++\ldots\quad\text{—43,}\\ &\to \Sigma^-+\ldots\quad\text{—43,}\\ &\to \Xi^-+\ldots\quad\text{—12.}\end{aligned}$$

It is noted that all baryons preserve their direction in the c.m.s. after the interaction. Protons, neutrons, Λ^0 and Σ^+ are emitted strictly backwards. Only for the Σ^- did the distribution turn out to be practically isotropic. The longitudinal momentum of the baryons is also the same: $p_{\|}^* \cong 650$—700 MeV/c, except for the Σ^- hyperons for which $p_{\|}^* = 210$ MeV/c. A linear relation was found between the longitudinal momentum in the c.m.s. and the particle mass. Previously an analogous relation was observed for the transverse momentum.

In the scanning of 50,000 pictures from a 32-cm hydrogen chamber irradiated by π^- mesons (~ 16 GeV/c) (**E. Bartke**, Krakow) 157 interactions were found involving strange particle production:

$$\pi^-+p \to Y+K+m\pi, \quad \to K+\tilde{K}+N+m\pi.$$

It was found that the total number of K and π mesons is close to the number of pions in events without strange particles:

$$\bar{n}_{\text{strange}} = 5.8 \pm 0.4, \quad \bar{n}_{\text{nonstrange}} = 5.4 \pm 0.1.$$

It is also noted that the number of neutral pions decreases with increasing multiplicity. Among the associated production events it is possible to distinguish a group with small momentum transfers ($\Delta^2 < 1$ (GeV)^2), in which the hyperons are emitted sharply backwards in the c.m.s. and the K mesons—forward. The authors identify this group of interactions ($\sim 20\%$) as peripheral.

In a report delivered by members of the OIYaI High Energy Laboratory group (reported by **V. I. Moroz**, Dubna) a possible classification of isobaric states and their transition schemes were considered. In this classification the nucleon and hyperon resonances are viewed as "excited states" (isobars) of nucleons and hyperons with definite values of effective mass, isospin, spin, parity, etc. They are divided into three groups according to their strangeness (hypercharge):

$$(S=0,\ Y=+1), \quad (S=-1,\ Y=0) \quad \text{and} \quad (S=-2,\ Y=-1).$$

Possible transitions between these isobars are indicated; some of these have already been observed experimentally previously. Transitions within a group proceed by means of emission of one meson with strangeness $S = 0$ (π, ρ, η^0, ω^0); transitions between groups involve a meson with strangeness $S = \pm 1$ (K, $\tilde{K}$).

The scheme under discussion was used to interpret the momentum spectrum of Λ hyperons produced in $\pi^- p$ interactions at ~ 7 GeV/c. The experimental data give some indication that the $\pi^- p$ interaction in which strange particles are produced proceeds with an appreciable probability as a two-particle reaction, whose products could be the isobars.

In the report of **E. Skrzypczak** (Warsaw) preliminary results were given of an analysis of the interactions of 24 GeV protons and 17 GeV pions with heavy nuclei in photoemulsion. The photoemulsion was irradiated in a magnetic field of 180 and 150 kG respectively. The sign and momentum of the fast particles was determined from the deviation in the magnetic field. It was shown that the excess of positive particles in the interactions p-nucleus and π^--nucleus is equal to 2.3 ± 0.3 and 1.1 ± 0.2 respectively. It is noted that the transverse momentum of the positive particles increases with increasing N_h and is independent of N_h for negative particles in p-nucleus collisions. In π^--nucleus collisions no such dependence of $p_\perp$ on N_h for positive particles is seen.

Two sessions of the conference were devoted to cosmic rays physics. Nuclear interactions of cosmic ray particles were discussed in one session, extensive air showers (EAS) were discussed in the second.

Great interest at the conference was attracted by the work of the Krakow physics group (headed by Profs. **M. Miesowicz** and **E. Gierula**), in which nuclear interactions were studied in photoemulsions exposed with the help of sounding balloons at high altitudes. For the organization of such flights the Krakow laboratory participates in the international union of laboratories (ICEF), in Krakow itself only the exposed emulsion is analyzed. **M. Miesowicz** reported the observation at an energy of 10^{12} eV of streams with anomalously small number of secondary particles, which are interpreted as nucleon collisions with the production of just one excited meson cluster ("fire ball"), i.e., as asymmetric (in the c.m.s.) showers, first seen at lower energies ($\sim 10^{11}$ eV) in the cosmic-ray laboratory of FIAN (Phys. Inst. Acad. Sci.) (**N. A. Dobrotin** et al.). The physicists from Krakow are now enlarging the study of this phenomenon by using photoemulsions containing layers of lead (**S. Krzywdzinski**). In the report of **E. Gierula** was included a large amount of experimental material, containing 200 events corresponding to interactions of high energy nucleons, alpha particles and heavy nuclei in emulsion at energies about 10^{12} eV. In this work the authors continue the study of angular distributions of secondary particles and, in particular, find two maxima (in appropriately chosen coordinates) which testify to the formation of two "fire balls" (by the way, this "two-hump" phenomenon was discovered several years ago by precisely the Krakow physicists). It was clarified that in the interactions of both nucleons and heavier nuclei with the nuclei of the photoemulsion the "two-hump" phenomenon disappears with increasing number of secondary particles n_s. In addition maxima were found in the distribution in n_s, which can be interpreted on the assumption that n_s is proportional to the number of nucleons in the target nucleus participating in the collision, with a proportionality constant which is, apparently, the same for all types of collisions mentioned. These results are preliminary and require further study and confirmation since a reliable establishment of these facts is of great importance to the understanding of the mechanism of nuclear interactions at high energies. The report of **K. Zalewski** (Krakow) was devoted to a theoretical analysis of the role of statistical fluctuations in the study of angular distributions (in particular in the observation of the "two-hump" phenomenon).

In the work of the FIAN staff members **N. A. Dobrotin** et al. (reported by **V. M. Maksimenko**) it was possible to completely construct the momentum spectrum of secondary pions, produced in interactions with an average energy of 220 GeV. The main part of this spectrum is in good agreement with the Plank function, however in the large momentum region an excess of particles is observed experimentally. A kinematical analysis allows the possibility that these energetically selected pions are due to decays of nucleon isobars, whose production probability is in that case very large. These pions carry off approximately half of all the energy that goes into pion production. In another experiment of the same group (**S. A. Slavatinskiĭ** and **I. N. Fetisov**) an upper limit is determined for the cross section for the production of K^0 mesons and hyperons in the interaction of nucleons with an average energy of 300 GeV: $\sigma(K^0) \leq 6$ mb, $\sigma(Y) \leq 11$ mb.

V. Ya. Shestoperov reported on the main results of the work of **N. L. Grigorov** et al. [MGU (Moscow State Univ.)], in which experimental evidence was obtained in favor of the existence at energies of 10^{12}–10^{13} eV and higher of almost completely inelastic interactions of nucleons with nuclei, in which the major part of the energy of the primary nucleon (over 60%) is transferred to a small number (3–5) of secondary pions. The authors believe that interactions of this type occur in 20–30% of the events and are responsible for a whole series of phenomena in cosmic rays: production of π mesons, μ mesons and photons of high energy, generation of large ionizing bursts, etc.

In the work of **Yu. A. Smorodin** et al. (Moscow, FIAN) the production of electron-photon avalanches in the energy interval 5×10^{10}–10^{13} eV in the atmosphere was studied. The authors arrived at the following conclusions:

1. The experimental data on the spectrum of the primary nucleons and on the absorption of the nuclear-active component may be explained if it is assumed that the energy loss distribution in the interaction is independent of energy and that the spectrum of the primary nucleons has the form

$$N(>E)=500\left(\frac{E}{10^{12}}\right)^{-1.7}\left[0.15+2.75\left(\frac{E}{10^{12}}\right)^{-0.2}-1.6\left(\frac{E}{10^{12}}\right)^{-0.4}\right]\frac{\text{nucleon}}{\text{hr}\cdot\text{m}^2\cdot\text{sr}}.$$

The effective fraction of the energy retained by the nucleon amounts to approximately 0.5.

2. Along with "fire-ball" type mechanism for the production of pions there is also present a mechanism for the production of pions with energy proportional to the energy of the primary particle.

3. The pions make a noticeable contribution to the stream of nuclear-active particles.

4. An overwhelming fraction of the muons is produced in the atmosphere as a result of pion decay.

In recent times in cosmic rays physics ever greater attention is being given to the study of the composition of the primary cosmic radiation and, in particular, to the search for high energy photons. A number of papers read at the conference dealt with this question. **A. E. Chudakov** et al. (Moscow, FIAN, reported by **N. M. Nesterova**) detected the Cerenkov radiation produced in the atmosphere by the electronic component of the EAS. The apparatus (a system of parabolic mirrors with a set of photomultipliers, connected in coincidence, placed at the focal point) allowed a determination of the direction of the primary particle with an accuracy of the order of a degree, thus making it possible to search for high energy photons from local sources on the celestial sphere. The authors found no source of photons with an energy in excess of 5×10^{12} eV (the upper limit of the flux of such photons is 5×10^{11} cm^{-2} sec^{-1}) in the investigation of a number of objects (Cygnus-A, Taurus-A, Cassiopeia-A, Virgo-A). A different method is used by the Polish physicists working under the guidance of Prof. **A. Zawadzki** (Lodz). This group of scientists searched, using a hodoscope made out of Geiger counters, for EAS with an anomalously small number of muons which could be due to high energy photons. The fraction of such photon showers, as is shown by a rather complex analysis of the experimental data, amounts to 0.5–1% (for a given total number of particles in the shower). A smaller value for this quantity (0.1%) was obtained in an experiment carried out on a larger setup for complex study of EAS (**S. N. Vernov** et al., reported by **B. A. Khrenov**) and devoted to the study of the fluctuations of the number of muons in showers, which allows one to draw conclusions on the composition and spectrum of the primary cosmic radiation. The possibility was also discussed (**N. M. Nesterova, S. I. Nikol'skiĭ**) of studying the composition of the primary radiation by looking at the fluctuations of the relative magnitude of the Cerenkov burst in the atmosphere, caused by a EAS with a given number of particles.

After the conference ended the Polish physicists acquainted the guests with the equipment and work going on in the physics laboratories in Krakow, Warsaw, and Lodz.