to the total number of points in each region divided by the average value of the phase volume. The analysis carried out with a χ^2 distribution[6] has shown that within the experimental errors the points lie on a plane. The ratio c/d as obtained from the equation of the plane is equal to $-(0.76 \pm 0.65)$. It should be noted that other divisions analogous to that shown in Fig. 1 lead to the same value of c/d. From Eq. (3) one obtains a value $-(5 \pm 4) \times 10^{-14}$ cm for the difference $(a_2 - a_0)$; this corresponds to a charge-exchange cross section $\sigma_{\pi^+-\pi^- \to \pi^0+\pi^0} = 4\pi a_{12}^2 = 4^{+6}_{-4}$ mb. The given experimental errors are determined by statistics and not by inaccuracies of the theory at our energy which have not been included.

All the data available at present concerning the amplitude of S-wave π-π scattering are listed in Table II. As is seen from the table, the results of various authors differ both in absolute value and in sign. In such a situation it is of great interest to obtain more accurate data. Since in our treatment the accuracy of the theory is the main problem, it is more useful to run an experiment at lower energies, where the theoretical assumptions are more valid. At present such an experiment is being performed at an energy of 240 — 250 Mev (40 — 50 Mev in the c.m.s.).

TABLE II. S wave π-π scattering lengths ($\hbar/\mu_\pi c$ units)

a_2	a_0	$a_2 - a$	Initial reaction
~ 1			$\tau^+ \to \pi^+ + \pi^+ + \pi^-$ [7]
		$-(0,35 \pm 0,30)$	$\pi^- + p \to \pi^+ + \pi^- + n$*
	~ 1		$\pi + N \to \pi + N$ [10]
$-0,48$	$-0,8$	$0,3$	$K^\pm \to 3\pi$ [11]
$-0,3$	-1	$0,7$	$K^\pm \to 3\pi$ [12]
	~ 1		$\pi + N \to \pi + N$ [13]

*Present paper.

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THE NATURE OF THE PARTICLE BEAMS IN THE CORE OF EXTENSIVE AIR SHOWERS

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In a previous article,[1] the existence of a peculiar feature in the lateral distribution of shower particles in the core region of extensive air showers (EAS) was reported. Narrow beams consisting of a large number of particles (from four to fifteen) were detected in studying the core structure by means of a diffusion chamber. The experimental results obtained previously made it possible to regard the observed particle beams either as the cores of electron-photon showers produced by π^0 mesons, or as groups of high-energy μ mesons. It will be shown that the second hypothesis is the more likely one.

Let us assume that the beams under consideration represent the cores of electron-photon showers initiated in the decay of π^0 mesons produced in nuclear interactions. We shall estimate the energy of the primary particle which produced the shower, and the altitude of shower production above the observation level. For this purpose, it is necessary that, in a circle with 4 cm radius (which corresponds to the maximum dimension of the observed particle beams), the average number of particles be n = 7 (which corresponds to the average number of particles in the beams). From the results[2] of the electromagnetic cascade theory for the lateral structure of an electron-photon shower initiated by a particle with a finite energy E_0, we find that the required number of particles in a circle with the given radius can, at any stage of shower development, be produced only for $E_0 \geq 10^{12}$ ev. Moreover, at $E_0 = 10^{12}$ ev, the maximum number of particles in a circle with the given radius is attained at the depth of ~ 2t, and is equal to ~ 6, which is in agreement with the experiment.*

The energy spectrum of electrons and photons in a shower produced by a 10^{12} ev particle has, at the depth of 2t, the following form (where N_e and N_{ph} are the number of electrons and photons respectively with energy greater than E):

E	10^8	10^9	10^{10}	10^{11}
$N_e(>E)$	5.5	4.0	2.5	0.5
$N_{ph}(>E)$	10	8.0	4.0	0.8

In order to study the shower-producing properties of the particles belonging to the bunches, a TF-1 glass plate with a high lead content was placed on top of the diffusion chamber in the present experiment. The plate was 0.8 t thick. (The critical energy in glass is β = 14 Mev, and the radiation length is $t_0 = 9$ g/cm^2.) According to the calculations of Arley,[3] the number of particles in the beam should, after traversing 0.8 t of lead glass, multiply by a factor of four. Moreover, one should consider only those particles under the glass having an energy above 10^8 ev, since the distance between the sensitive layer of the chamber and the glass amounts to 25 cm, and particles having lower energies may, because of a large deflection angle, merge with the background. Thus, beams with four or more particles should, after traversing the lead glass, contain on the average ≥ 15 particles.†

In the experiment, the lead glass covered half of the diffusion chamber. During 850 hours of operation, 16 particle beams with ≥ 4 particles were detected in the uncovered part of the chamber. The number of particles in the beams, their distance from the shower axis r, and the total number of particles in the shower to which the beam belongs N, are shown in the table. Measurements were made under the lead glass during 440 hours. The features of the beams observed under the lead glass are also presented in the table.‡

On the average, one should observe, during the above-mentioned period, 8 beams with ≥ 15 particles under the lead glass. In reality, no beams with > 8 particles were observed under the lead glass. In order to assess the probability of such an event, it is necessary to know the character of the fluctuations in the development of showers produced by electrons and photons in the lead glass. Calculations** show that in spite of the small thickness of matter, fluctuations do not play an important role, since many particles are present in the beam.

The diffusion chamber was placed above a two-row array of ionization chambers.[4] The first row of ionization chambers was shielded by a 5 t layer of lead, and was used for determining the energy flux of the electron-photon component. The second row of ionization chambers, placed under a composite lead and graphite absorber, was used for the determination of the energy flux of the nuclear-active component. Unfortunately, it was not possible to trace fully the transformation of a particle beam in the absorber, since it is accompanied by the electron-photon and nuclear-active components of EAS. The observed large multiplication during the passage of the beam through the first row of chambers may be due to the electron-photon component of EAS, since the area of an ionization chamber is roughly 20 times greater than the dimensions of the particle beam. Ionization bursts in the second row of chambers are also observed during the passage of the beam. Although a fraction of the bursts are possibly due to the nuclear-active component, the bursts ob-

Open part of the chamber			Part of the chamber under the lead glass			Open part of the chamber			Part of the chamber under the lead glass		
r, m	$N\cdot10^{-3}$	n	r, m	$N\cdot10^{-3}$	n	r, m	$N\cdot10^{-3}$	n	r, m	$N\cdot10^{-3}$	n
1	5	5	1	22	5	5	50	7	6	880	8
1.5	30	6	1	20	5	5	20	8	7	120	7
1.5	30	10	1	10	6	6	100	5	10	60	6
2	400	6	1	31	5	8	650	5	10	600	4
2	60	13	1.5	10	4	9	40	9	12	500	4
3	150	5	2	100	4	10	100	5			
4	200	4	2	350	8	11	1100	12			
5	50	5	2.5	630	6	12	200	4			

served in the second row of chambers characterize the passage of the beam through the absorber more directly than the bursts in the first row, since the flux of nuclear-active particles in the shower core amounts to about 1% of all charged particles. The experimental size distribution of bursts in the second row of chambers is as follows (where ΔE is the energy interval, and Φ_E is the observed number of events in the given interval††):

ΔE, ev	$<2\cdot10^9$	$2\cdot10^9$–$2\cdot10^{10}$	$>2\cdot10^{10}$
Φ_E	39	7	2
Φ_B	40	5	3

Let us assume that the observed particle beams consist of high-energy μ mesons. The main process leading to the appearance of bursts of the size given above is the production of electron-positron pairs by μ mesons. Assuming a μ-meson energy $E = 10^{13}$ ev, as found in an earlier estimate,[1] we find that the probability that a single μ meson produces a pair of $> 10^9$ ev in the lead-graphite absorber (~ 10 t) is 0.3. This means that the passage of μ mesons should, in general, be accompanied by small bursts in the second row of ionization chambers. A comparison of the experimental distribution of bursts in the second row of ionization chambers with the theoretical distribution Φ_B, obtained taking pair production by μ mesons into account,[5] is given above.

If we assume that the particle beam consists of μ mesons, then the relative increase in the particle number during the passage through 0.8 t of lead glass due to electromagnetic interactions of μ mesons should be negligible. This is borne out by the experiment.

Thus, the absence of multiplication during the passage of the particle beam through a 0.8 t thickness of lead glass strengthens the hypothesis that the beam consists of high-energy μ mesons. Also, this assumption is not contradicted by the ionization chamber data.

In conclusion, the authors would like to thank L. G. Smolenskiĭ and B. A. Zelenov for help in carrying out the experiment, and S. F. Semenko for help with the calculations.

*For $t_0 = 10^{11}$ ev, the maximum number of particles in the circle with the given radius is roughly 50 times smaller than for $E_0 \approx 10^{12}$ ev.

†The observed particle beams cannot be due to low-energy ($E_0 < 10^9$ ev) electrons and photons, since, in that case, the trajectories would not be collinear.

‡Although the difference in the frequency of beams in the open part of the chamber and under the lead glass lies within the limits of statistical error, it is possible that a certain increase in the beam frequency under the lead glass is due to the multiplication of single high-energy electrons and photons in the lead glass.

**We have carried out the calculations assuming a Furry distribution for the fluctuations (which leads to a large overestimate of events with a low multiplication). Even in this limiting case, we would be able to observe a picture under the lead glass for which the table predicts a probability of only $< 10^{-2}$.

††The detection threshold is equal to ten relativistic particles, which corresponds to an energy of $\sim 10^9$ ev transferred to the electron-photon component.

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NON-MONOTONIC DEPENDENCE OF THE SURFACE IMPEDANCE OF TIN ON THE MAGNETIC FIELD AT 1.9 MEGACYCLES

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We carried out preliminary experiments on measuring the reactive part of the surface impedance of Sn at 1.9 Mc/sec and helium temperatures. Samples of a cylindrical shape were placed in the coil of an oscillating circuit. On applying the magnetic field the frequency of the generator was changed by change of reactive component of the sample impedance. The frequency shift was measured to an accuracy of 0.01 cycles by means of apparatus, the detailed description of which will be published shortly.

In the diagram are plotted the results of measurement on one of the samples placed in a mag-