PROGRESS REPORT ON WORK WITH THE 25 GeV PROTON SYNCHROTRON

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On November 24, 1959, the 25 GeV Proton Synchrotron of CERN accelerated for the first time to the nominal energy 10^{10} protons per pulse. Immediately after that date, measurements were started on the secondary particles that the protons produced when hitting an internal Al target.

Here I am reporting on the main results obtained since then as well as on some experiments already in an advanced state of realization.

However, before coming to these topics, I shall make two comments, one historical and the other one eulogistic.

As to history, I want to remind you that at the time of the " birth " of the CERN Proton Synchrotron beam, nine months ago, very little apparatus for experimenting was available; only three small deflecting magnets, no quadrupoles and no separators. Only during the last two months, deflecting magnets, quadrupoles and generators have started to arrive, thus permitting the realization of more elaborate set-ups. The time during which the machine was available to the experimenters has been, so far, necessarily limited. About 100 hours during the first trimester of 1960; 180 hours during the second trimester; and finally about 200 hours during the last two months, July and August; a total of about 20 full days.

The eulogy comes from all of us experimenters and goes to the people who have conceived and built the accelerator and its facilities. Starting from the first day of operation, the machine never failed to produce a good beam when the beam was scheduled for experiments, and during the running periods the machine worked for about 93% of the time. The beam intensity increased from 10^{10} protons circulating inside the vacuum chamber in November 1959, to 10^{11} in March 1960, and during the last two months has been around 2×10^{11}. About 50% of these protons interact in the target, giving secondary particles in bursts (1 every 3 seconds) that can be made to last 60 milliseconds for counter work or can be shrunk to 0.1 ms for bubble chamber irradiation. During the last month, it has also been possible to operate simultaneously two targets in such a manner as to allow the simultaneous operation of a bubble chamber and of counter experiments.

Coming now to the measurements performed thus far, I will first review the information gathered about the energy spectra and the angular distribution of the secondary particles, produced in an Al target by the 25 GeV proton beam. These data do not come from a systematic research. Various groups have performed measurements using different techniques and different beams, and there is no good monitor to normalize the various measurements. For these reasons the quantities quoted must be considered only as indicative. However, they are of interest to experimenters, for making estimates of the intensity of the various secondary beams. All intensities are evaluated assuming that 10^{11} protons interact in the target.

The experimental results are compared with the results of calculations performed by Hagedorn [1] utilizing a statistical model for multiple production in nucleon-nucleon interaction (the Fermi model), in which isotropic distribution in the center of mass system was always assumed. It must be emphasized that while the model considers nucleon-nucleon interactions, most of the experimental results refer to proton-aluminum interactions, and the difference between the two cases can be expected to be often substantial.

The total multiplicity of charged particles in proton-proton interactions at 25 GeV has been measured last week in the hydrogen bubble chamber of CERN. If the two prong events are included, i.e. some elastic scatterings, the multiplicity is 4.0. Excluding them, it becomes 5.2. These values compare well with the 4.7 predicted by Hagedorn.

In Fig. 1 are given some energy spectra of the π^- mesons produced by 25 GeV protons on Al. The measurements were made with an analyzing magnet and scintillators. The results at 0° to the proton beam agree rather well with Hagedorn's predictions, while at larger angles the experimental spectra are decidedly lower than the calculated ones. The π^+ meson spectra, whenever measured, were found to be equal to that of the π^-.

The same trend can be observed in the photon spectra of Fig. 2. These photons come mostly from the disintegration of π° mesons and were measured with total absorption Čerenkov counters. The 16° spectrum runs about one decade below the calculated one, while, in the backward direction at 180°, the experimental spectrum is several decades higher than that calculated by Hagedorn. The most likely explanation of these results is the following: while Hagedorn assumed an isotropic distribution of particles in the c.m. system of the *N-N* interaction, the π-meson distribution is peaked forward and backward. The angle of 16° in the laboratory system corresponds to ~90° in the center of mass system and the difference between 0° and 16° is thus greater than expected. The abundance of backward photons can instead be justified by taking into account the secondary interactions inside the Al nucleus. The center of mass of these secondary interactions moves more slowly than in the case of *p-p* interaction and the π° mesons created in Al can produce, in the laboratory, backward photons of greater energy.

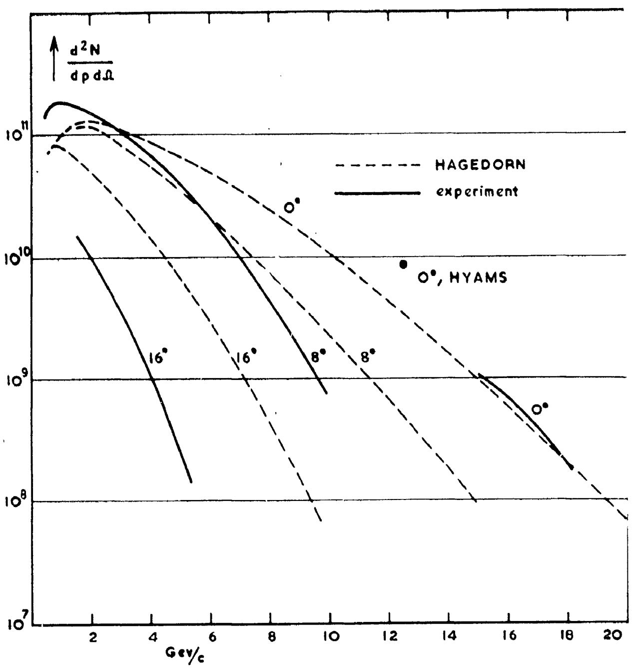

Fig. 1 Number of π^- $(\mathrm{GeV/c})^{-1}$ ster^{-1} produced by 10^{11} protons of 25 GeV interacting in aluminium.

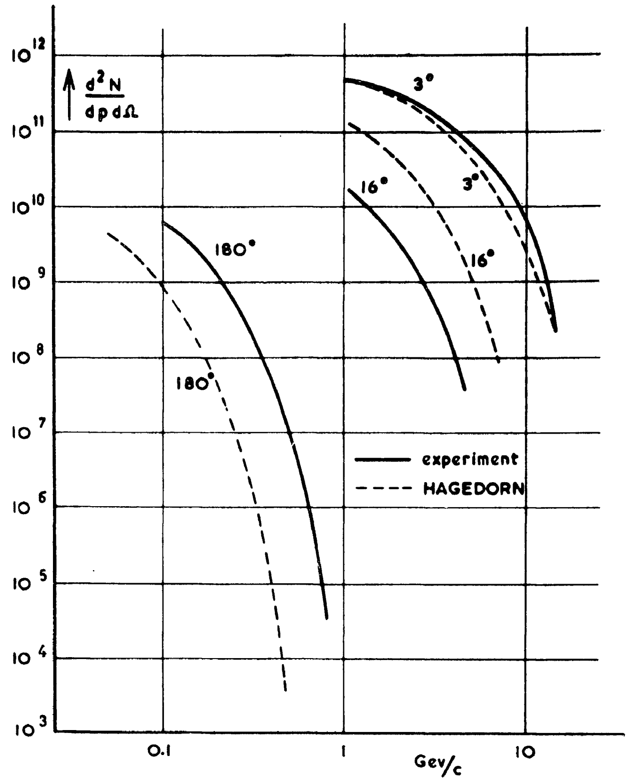

Fig. 2 Number of quanta $(\mathrm{GeV/c})^{-1}$ ster^{-1} produced by 10^{11} protons interacting in aluminium.

The mass spectra of some secondaries are given in Table I. Von Dardel's group separated the masses by means of a high pressure gas Cerenkov counter, 1.5 m long, with a resolution $\Delta\beta/\beta = 0.001$. Fidecaro and Merrison's group used the time of flight technique, utilizing a transistorized time sorter that allows a resolution of less than 1 nanosecond. The agreement with Hagedorn's estimates is generally rather good, except for the antiprotons, which are systematically quenched down by a factor of $10^{1.5}-10^2$.

The Fidecaro Merrison group was able to establish, as a by-product of these investigations, that the anti-

Table I. Mass spectrum of particles produced by protons of 25 GeV on aluminium

2°, 3° and 6° data from ref[4] 16° data from [2]

	Angle (degr.)	Momentum (GeV/c)	Exper. ratio	Hagedorn
Protons / π^+	3°	18	3.0	3.0
	6°	6	1.3	4.5
		8	2.0	5.0
	16°	2	0.6	0.4
		3	1.0	0.7
		5	3.0	1.5
K^+ / π^+	3°	18	0.40	0.35
	6°	5	0.26	0.3
		6	0.19	0.3
		8	0.19	0.3
	16°	2	0.25	0.14
Antiprotons / π^-	2°	11	0.003	0.7
		16	0.003	0.5
	6°	5	0.015	0.4
		6	0.014	0.6
		8	0.008	0.6
	16°	2	0.003	0.06
		3	0.007	0.13
		4	0.012	0.2
		4.6	0.012	0.2
K^- / π^-	6°	5	0.07	0.07
		6	0.06	0.07
		8	0.04	0.07
	16°	2	(0.12)	0.03

proton mass is 1.008±0.005 times the proton mass. This is probably, thus far, the best antiproton mass determination.

The most unexpected result of these analyses of the mass spectra was the discovery made, four months ago, by the Fidecaro Merrison group[2] that deuterons of total momenta up to 11 GeV/c and transverse momenta of several GeV/c are produced in the collision of the GeV protons with the target material. The justification for calling the observed particles deuterons rests on the fact that they have the following characteristics: Mass = deuteron mass ± 1%, Charge = 1, Lifetime> 10^{-7} sec.

Some of the relevant data on the deuteron production by 25 GeV protons are collected in Table II. The main points of interest are the relatively high abundances of deuterons, the momentum independence of the d/p ratio and its weak dependence on the atomic number of the target.

Table II. Deuteron production by 25 GeV protons[3]

Target	Lab. Angle	Momentum (GeV/c)	D/P
Pt	16°	3.3	0.034
		4	0.026
		5.3	0.026
Al	16°	2.5	0.016
		4	0.016
		5.3	0.020
Al	12°	5.2	0.02
		8.0	0.02
	3°	18.0	0.001
Be	12°	5.2	~0.015

To the deuterons must now be added He^3 and H^3, discovered a few weeks ago, by the Lundby group[3].

The mass analysis was made, in this case, with a bending magnet and liquid Čerenkov counters whose optics is such as to allow the detection only of particles moving parallel to the counters axis within a degree and with $\beta = 0.950 \pm 0.0015$ ($\gamma = 3.2$).

He^3 and H^3 were found in a focused beam at 8° to the proton beam and at 45 m from the Al target. The results are the following:

He^3 Mass = He^3 mass ±1% Charge = 2

Lifetime > 10^{-8} sec.

Abundance, at 3.2 GeV/nucleon

$$\frac{He^3}{p} = 10^{-3.5} \quad \frac{He^3}{d} = 10^{-1.5}$$

H^3 Mass = H^3 mass ±1% Charge = 1

Lifetime > 10^{-8} sec.

Abundance, at 3.2 GeV/nucleon

$$\frac{H^3}{p} = 10^{-3.5} \quad \frac{H^3}{d} = 10^{-1.5}$$

For the time being only one velocity has been analyzed, but the evidence is unmistakable.

The discovery of the light nuclei has prompted discussions to explain their production. There are essentially two points of view, According to the first, the nuclei are fragments of nuclear matter, violently shaken by the penetration in the nucleus of the 25 GeV proton. No specific calculation has been made on these lines, as far as I know, but if this point of view is true, light nuclei are not expected from collisions of protons on hydrogen. In the second case, deuterons are produced in the nucleon-nucleon interaction and are formed whenever two nucleons with the appropriate relative momentum are present in the hot spot of the interaction. Their production is then expected also in hydrogen. The consequences of this model can be roughly evaluated by assuming, as has been done by Hagedorn, that the Hulthen deuteron wave function is valid down to distances smaller than one fermi, and then evaluating with the statistical model the probability that a particle of mass equal to that of the deuteron is actually formed. The predicted d/p ratios turn out to be momentum dependent, which is contrary to the evidence thus far obtained, but of the right order of magnitude. At 16°, e.g., Hagedorn finds for the d/p ratios at 2, 4, 6 and 8 GeV/c the following values: 10^{-5}, 0.003, 0.01 and 0.04, respectively. In the same model He^3 and H^3 production can take place when nucleon-antinucleon pairs are created. However, in my opinion, what has been observed thus far is a result of a more complex situation. I believe that, especially the production of the mass 3 nuclei is favored by the occurrence, in the Al nucleus, of composite collisions, i.e., of collisions between the 25 GeV proton and *more than one* nucleon at the same time, classically speaking. We hope that further experiments on hydrogen and with other bombarding particles, e.g. π mesons, will soon help us to clarify the situation.

The measurements discussed thus far show that the CERN Proton Synchrotron is now able to offer intense beams of various kinds.

π^- meson beams can be obtained at all energies and at all angles, 0° included. π^+ meson beams instead can be had, for the time being, at all energies only at angles greater than 3°. The availability of $\pi^\pm$ beams implies, of course, that also the decay beams of $\mu^\pm$ mesons, up to energies around 15 GeV, of neutrinos and of antineutrinos up to energies around 7 GeV are available.

The photon beam from π° decays is available at all angles.

The same situation holds for $K^{+,-,\circ}$ beams which, at the target, are 10 to 30% of the pions. Because of the short lifetime, however, the intensity of the low energy K beams at practical distances from the target (>15 m) is strongly reduced.

The antiprotons, about 1% of all particles emitted up to about 10 GeV, are available at all angles and at all energies, the deuterons instead only at angles larger than 3°. As an example, at 5° to the proton beam and with 10^{11} interactions in the target, an antiproton channel with 10^{-4} sterad acceptance will give in each pulse $\sim 10^4$ antiprotons of 5 GeV with a momentum resolution of 1%.

The extraction of the internal beam will not be feasible for another year or so. However, the strong focusing system has allowed the realization of an external 25 GeV proton beam which, though weak, is proving very useful for plate exposure, bubble chambers and also for counter work. This beam has initially been studied by B. Dayton and H. Winzeler of Bern, and consists of the protons elastically scattered (shadow scattering) by the individual nucleons of the target. Though the characteristic scattering angle is only 20 milliradians, the synchrotron doughnut is so small that the protons can escape the magnetic field some 10 m downstream. A typical intensity of this beam at 100 m from the target is 10^3 protons of 24 GeV ± 1 GeV per pulse per cm^2, when 2×10^{11} protons are accelerated (emission angle 25 mrad).

The first experiment with the secondary particles completed thus far has been conducted by von Dardel's group[4]. Sorting out the masses with the 1.5 m long high pressure gas Cerenkov counter, they measured the total cross sections, diffraction scattering included, of $\pi^\pm$, $K^\pm$ and $p^\pm$ in a 3 m long liquid hydrogen target, for momenta going from about 3 to 10 GeV/c. I am glad to report that nothing " extraordinary " has been observed.

In Fig. 3 are plotted the values obtained for π^- and π^+ mesons. The μ meson contamination, estimated to be around 10%, could shift the absolute values somewhat. However, the π^- points are consistent with a smooth dependence of the cross section on momentum. It is not yet clear whether the difference observed between the cross sections of π^- and π^+ is real or due to different $\mu^\pm$ contamination.

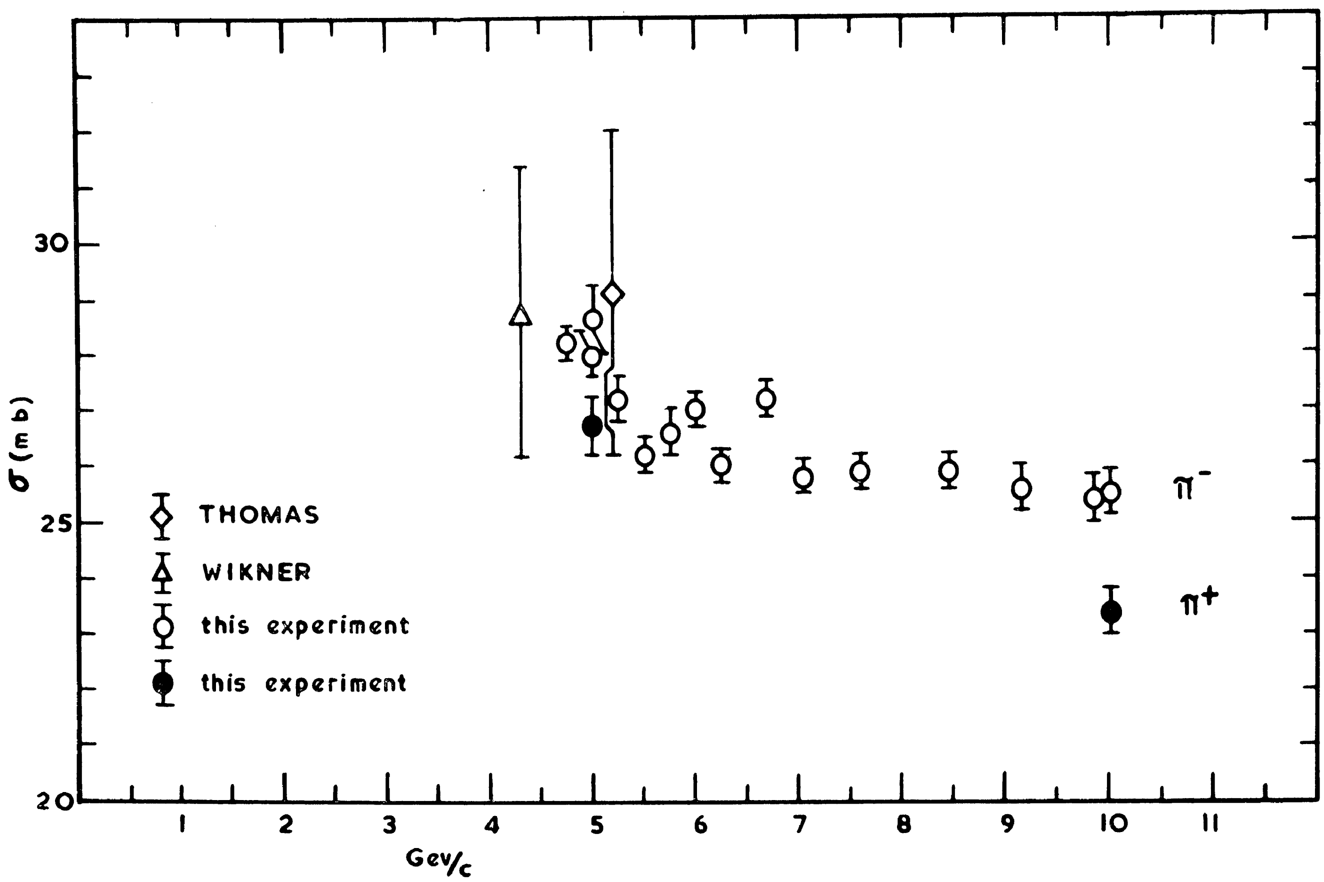

Fig. 3 Total cross sections (diffraction scattering included) of π^+ and π^- on protons.

The results for K mesons are given in Fig. 4. In the case of K^+, the cross section seems to be nearly constant, from a few GeV to 8 GeV. There is a certain disagreement between CERN results and those found by Borrowes et al[5]. However, Borrowes' data are not corrected for diffraction scattering and such a correction should make the difference smaller. The K^- cross section, after a steep decrease at small energies, levels off too, as the energy increases, at around the value of 25 mb, some 5 mb higher than the K^+ plateau.

Finally, Fig. 5 gives the cross sections found for protons and antiprotons. It is encouraging to see the antiproton cross section decrease regularly and converge toward that of the proton. The joining, if it exists, takes place at still higher energies. A plateau at 40 mb is present above 5 GeV. This is confirmed by the results obtained by my group, (Astbury, Cocconi, Diddens and Wetherell) which give a constant $\sigma_{p-p} = 40 \pm 3$ mb for a series of proton energies ranging from 10 to 25 GeV/c. For these measurements we have used the external proton beam

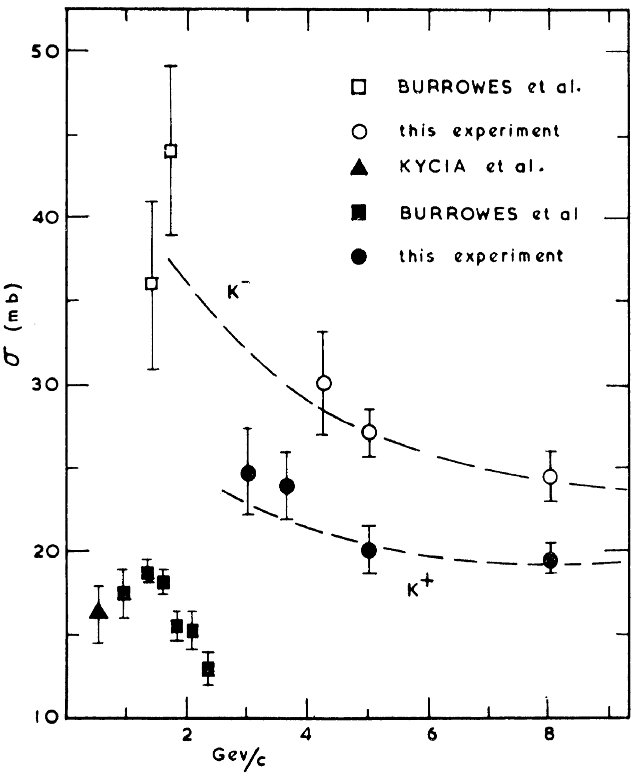

Fig. 4 Total cross sections (diffraction scattering included) of K^+ and K^- on protons.

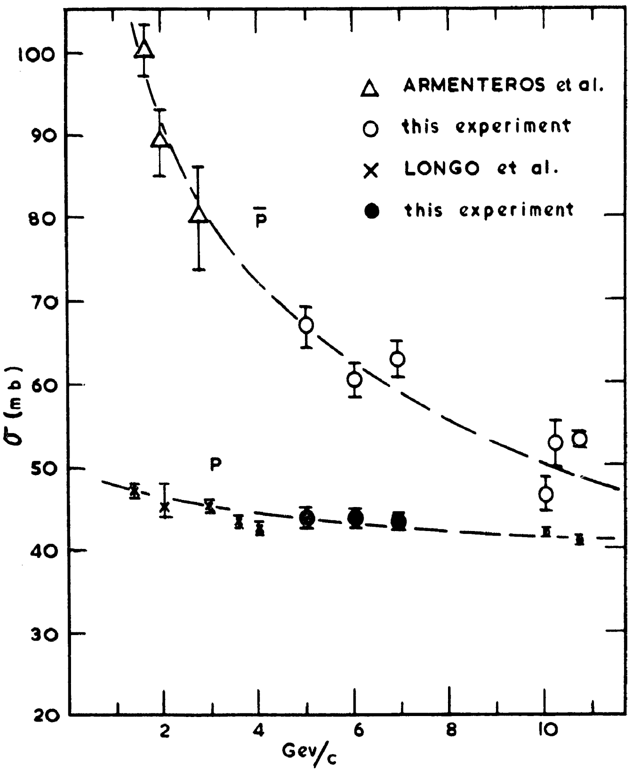

Fig. 5 Total cross sections (diffraction scattering included) of protons and antiprotons on protons.

generated by the protons elastically scattered 25 mrad off the target. We have also measured the absorption cross sections of various elements at 25 GeV/c. The results are given in Fig. 6.

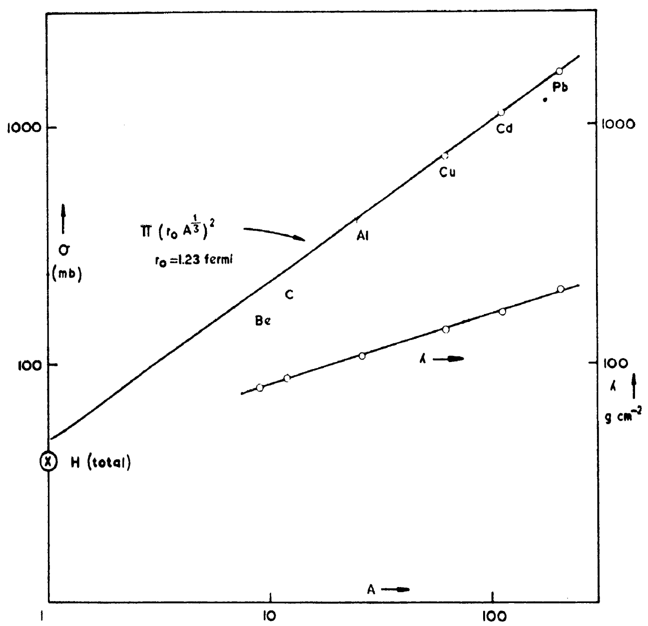

Fig. 6 Absorption cross sections of 25 GeV protons on various elements.

Last March, the 30 cm liquid hydrogen bubble chamber of Peyrou's group was exposed for 60 hours to a beam of 16 GeV π^- mesons. About 50,000 pictures were taken. Three groups are now analyzing these pictures, each group concentrating on a particular class of phenomena. The CERN group (bubble chamber and IEP) and the Italian groups of Pisa and Trieste study the heavy meson and hyperon production. The British groups (Imperial College, Birmingham and Oxford) study the kinematics of multiple particle production. Here I can quote only some preliminary results. For example, the CERN group finds that all the hyperons ($34\Lambda^0$ and $\sim 20\Sigma$) produced in π^--p collisions are emitted, in the c.m. system, in the backward direction with respect to the π^- motion, as if in the interaction its proton was picking up a partner to form the hyperon. No events were found forward and for the Λ^0's the average value of $\cos\theta$ was $\langle\cos\theta\rangle = -0.9$. The K^0 mesons instead are practically isotropic.

The Birmingham and Imperial College groups found the c.m. momenta and angular distributions of Fig. 7. A way of looking at these data is to say that the determining parameter is the average trans-

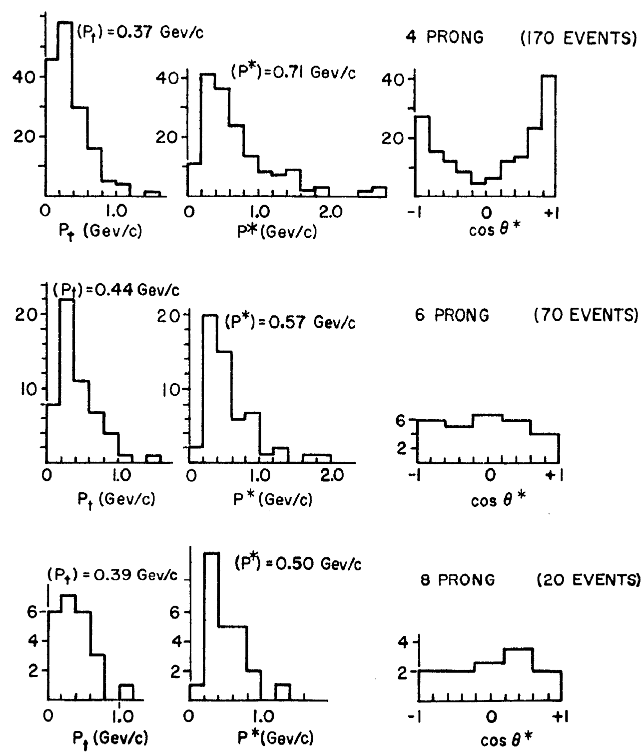

Fig. 7 Momentum and angular distributions, in the center of mass system, of particles produced by 16 GeV π^- mesons on protons.

verse momentum, which is a constant around 0.4 MeV/c. When the multiplicity is small, the average momentum of the secondaries is large and consequently anisotropy develops. Anyway it is remarkable how the angular distribution changes radically when going from 4 to 6 prong events. Especially illuminating are some events where no neutral secondaries were produced as evidenced by the total energy of the charged secondaries and by the momentum balance. Some typical cases are given in Fig. 8 and Table III. These interactions seem to show the qualitative aspects which might be expected from peripheral collisions of the primary π^--meson with the pion cloud of the proton.

Table III. Some data concerning the four events illustrated in Fig. 8

Event	$\Sigma p \cos\theta$ (GeV/c)	$\Sigma(E\text{-}p\cos\theta)$ (GeV)	$\Sigma p^* \cos\theta^*$ (GeV/c)
a	17.5	0.94	0.24
b	16.3	0.96	0.02
c	17.1	0.92	0.25
d	15.6	0.1	0.95

Finally, the neutrino experiment. A straightforward extension of the currently accepted beta decay theory to energies in the GeV range (Lee and Yang, Yamaguchi, Cabibbo and Gatto) predicts that 1 GeV neutrinos have a total cross section against nucleons of a few 10^{-38} cm^2. This corresponds to a mean free path of about one astronomical unit (the distance earth-sun) of lead. Several people in CERN are trying to find the best conditions for conducting an experiment to check this prediction. There is also hope, created by Lee and Yang [6], that an intermediate charged boson will increase the above-mentioned cross section by a factor larger than 10, just as there is also the possibility that, for some unforeseen reason, the cross section is substantially smaller than the already very small 10^{-38} cm^2. In this last case the experimenting with high energy neutrinos would become extremely painful. The flux of neutrinos with energies ≥ 0.5 GeV, created in the forward direction ($\pm 5°$) by 10^{11} protons of 25 GeV interacting in the target, when the π mesons travel some 30 m, must be around 10^{12} sterad^{-1}. After another 30 m of heavy concrete all other particles should be eliminated and in one ton of material the neutrinos are expected to give rise to some few interactions per day. The background associated with a " neutrino beam " after different kinds of shielding has been examined both with counters and with a small freon bubble chamber, and recently the conclusion was reached that it can be reduced to a level which should make the neutrino interactions detectable. The reactions expected are rather conspicuous, since, e.g., electrons of several hundred MeV are created in the inverse beta decay. As things stand now, it seems probable that at the beginning of the next year an attempt will be made to see the neutrino interactions by means of counters associated with a ½ m^3 bubble chamber filled with freon. The expected rate of events in the bubble chamber is of the order of one interaction per day.

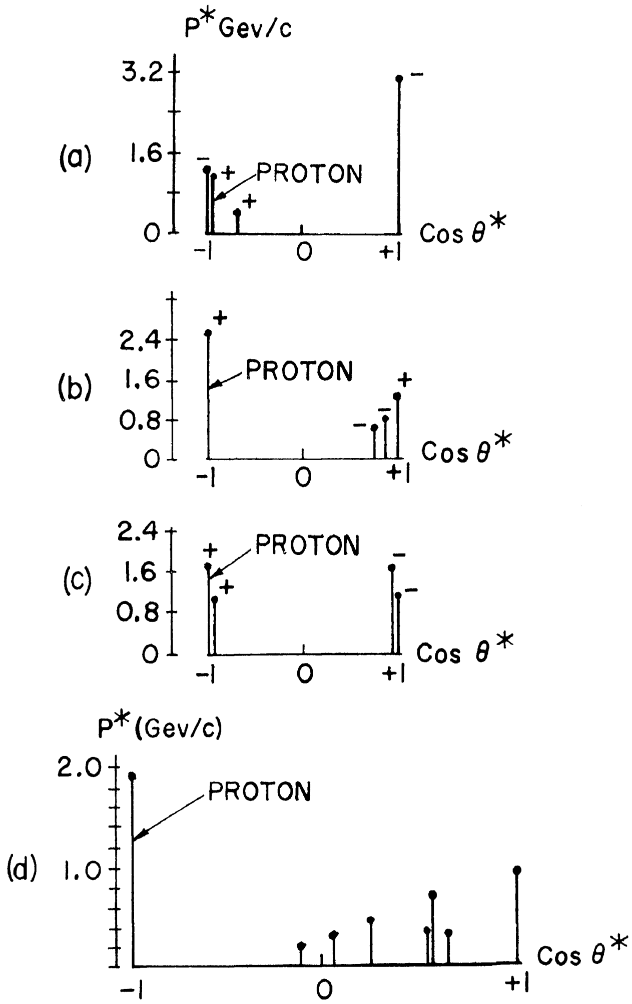

Fig. 8 Angular distributions, in the center of mass system, of secondaries produced by 16 GeV π^- mesons on protons, in interactions in which no neutral particles were produced. See Table III for details on kinematics.

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DISCUSSION

BERNARDINI: Many persons at CERN have been discussing the appearance of these deuterons and tritons and He^3 and at CERN the situation is more or less the following: the theoreticians consider that this is more or less a banal fact. Instead, the experimentalists since the very beginning have been quite excited about it. Now here we are in a very eclectic audience and I would like to know if also in this audience we can share the opinions in the same manner. In other words, whether the theoreticians consider also that this is a banal fact, and the experimentalists as a group instead consider it quite exciting.

GOTTSTEIN: The occurrence of deuterons, tritons, and He^3 fragments which were mentioned by Cocconi is something which has been known by cosmic ray emulsion workers for many years, and I think has also been theoretically explained by statistical calculations carried out in Russia a few years ago by, I think it was, Blokhintsev. In cosmic rays it has been seen that heavy fragments are emitted from heavy nuclei at rest in nuclear emulsion hit by high energy protons. These investigations have been started systematically many years ago by Sørensen.

COCCONI: It is true the existence of deuterons among the secondaries of cosmic ray interactions has been observed already many years ago, but the evidence was limited to momenta below 600 or 700 MeV/c, and the explanation given was in terms of an evaporation of fragments from the nuclei excited by the interaction.

GOTTSTEIN: I do not think it is right that this could be accounted for by evaporation theory. The energies were much higher than the energy that could be expected on the basis of evaporation theory. It is true that the energies were not so high as observed here, but the binding energies are so small that I think, once you have a few hundred MeV, it does not make much difference whether you have a few thousand or a few hundred. Also at these high energies, the difference between the binding energy of the deuteron and the alpha particle is probably negligible.

BLOKHINTSEV: In his report, Cocconi told us of a very interesting phenomenon; namely ejection of deuterons from nuclei with energies several orders of magnitude larger than the binding energy of the deuteron.

I should like to recall that three years ago Meshcheriakov and Leksin observed a similar phenomenon in the region of 700 MeV. At that time I gave an explanation of this phenomenon on the basis of fluctuations in the density of nuclear matter.

According to this explanation, these high energy recoil deuterons arise from a collision of the incident proton with a pair of nucleons in a nucleus at an instant when the separation of the pair is $\sim\hbar/Mc$ where M is the nucleon mass. This theory predicts the deuteron yield to be $\sim 2\%$, independent of the incident proton energy (provided it is high enough) and almost independent of mass number. The work is described in ref. [1].

BERNARDINI: To avoid confusion and to answer Gottstein, I feel obliged to explain what banal means for me: The question is the following: I think the reason why the theoreticians are so quiet is essentially because as an order of magnitude, this number of deuterons etc. is just what is expected from the statistical theory as has been elaborated by Hagedorn. However, this theory is more or less a crude approximation of S-matrix formalism and implies extremely crude assumptions particularly for what are the high momenta in the deuteron wave function. According to this statistical theory, what you see depends only on the phase space relations among the particles which are produced in the elementary *p-p* collisions. Now how much these implications and these crude assumptions can be considered something about which you do not have to worry was never clear to me.

OPPENHEIMER : This is not a delegate's report. More specifically, I would say that neither is it trivial not is it very radical. It seems to me in the first case these experiments explore the high Fourier transforms of the pair and triplet correlations and they show that these are very big, much bigger than the softness of nuclear matter would lead one to believe and they are therefore very closely related to the regions that were discussed this morning about which one introduces a phenomenological constant, since one does not understand it. I think we learn a great deal from this but not something that one can prove could not happen.

BERNARDINI : I wish to thank Oppenheimer for what he said but I must ask him this question : if it is understood that this phenomenon is at least in part connected with the high momenta and the high frequencies, then we just reach more or less the major point on which this discussion has been focused. But the answer which has been given particularly by Yamaguchi and by Pais is that to have these high momenta essentially you have to use the asymptotic behavior of the deuteron wave function. You take a Hulthén wave function, which everybody knows to be very good up to the core and where you expect something very exciting (that is the core, the high frequencies, etc.) then the answer is that practically there is no effect of them on the production of those deuterons.

OPPENHEIMER : I could not disagree more.

COLLINS : There is a process which has been discovered by the radiochemists at Brookhaven which involves the development, in a nucleus, of a cone of charged particles which drives out nucleons and π mesons from the back side of a large nucleus. I wonder if this process could be responsible for creating a general movement in the forward direction of enough nucleons so that subsequently they would form into deuterons and tritons of rather high momentum.

COCCONI : I meant just this when I said that one of the models was considering these deuterons as fragments of the nucleus excited by some waves developed by the incoming particle. However, in this case it is very difficult to see how two nucleons can be excited coherently in the nucleus in such a manner as to stay together. It is much more natural to think of the two nucleons as being present in the elementary region in which the interaction is taking place and from there to come out together.

BERNARDINI : To continue the discussion, I want to confess to him that these days I try to sell the study of a reaction which after all does not imply the use of proton targets, etc. The reaction is the following and was considered mainly together with Yamaguchi : if you shoot a negative pion against a proton you must have now and then a pair (that is a two body process), of a deuteron and an antiproton and I thought that this process in one manner or another should be connected with the form factor of the pion. After all it is equivalent to say that now and then the pion is a nucleon-antinucleon pair and then when the collision favors the association in the phase space you should have an antiproton and a deuteron. It is an extremely simple experiment and the calculation can be done to show that you can find one out of 10^7 of these processes.

WATTENBERG : To some extent I am addressing a question to Blokhintsev. It seems to me that even though he did his density fluctuation calculation at 700 MeV that essentially the answer he would get at higher energies would be the same thing. One is comparing in these data that have been shown the ratio of deuterons ejected to protons. The protons that one sees are recoils from quasi-elastic scatterings. The relative frequency with which one will knock out a proton or a deuteron due to density fluctuations might therefore be essentially independent of energy. I am wondering whether Blokhintsev has considered the energy dependence.

BLOKHINTSEV : That is right. I expected that this ratio will be constant. I can give you my reprint to see the details of this calculation.

CHAMBERLAIN : I think there is one mechanism for producing these deuterons which could be fairly important and which I believe would be independent of the deuteron wave function; namely, close collisions between two nucleons which could even be *p-p* collisions. In the close collisions sometimes the relative energy of the two final nucleons is small, I mean small compared to 25 GeV. I believe if you consider all of the highly inelastic collisions, including some where the relative energy is really very small you can compute the deuteron formation independently of the deuteron wave function.

TAFT : I would like to report on a measurement of one thousand inelastic collisions (two pronged events) of protons on protons at 3 BeV. Only two such events out of a thousand could be of the fundamental process $p+p \rightarrow \pi^+ + d$.

HAGEDORN : As to the proposal of Chamberlain I would like to say : it can be proven more or less rigorously that the condition that the final relative momentum of the two nucleons is small turns out to be the same as if you consider an interaction volume which is different from the interaction volume for production of pions by a factor which is roughly the deuteron wave function, squared, at the origin. So the two pictures are more or less the Fourier transform of each other.

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PARTICLES PRODUCED BY 24 BeV PROTONS

L. Gilly, B. Leontic, A. Lundby, R. Meunier, J. P. Stroot and M. Szeptycka

CERN, Geneva, Switzerland

(presented by A. Lundby)

We have partly completed an experimental program to search for unusual particles produced by the CERN Proton Synchrotron (CPS). The first stage consisted in measuring the mass spectrum of long-lived ($\gtrsim 10^{-8}$ sec) charged particles produced in the forward direction by 24 BeV protons striking an internal target (usually 10-50 microns Al). In order to avoid an appreciable displacement of the apparent target position at different momenta due to the fringing magnetic field of the machine, we chose a direction 8.5° with respect to the protons striking the target located at the beginning of a 3 m long straight section. The beam layout is shown in Fig. 1.

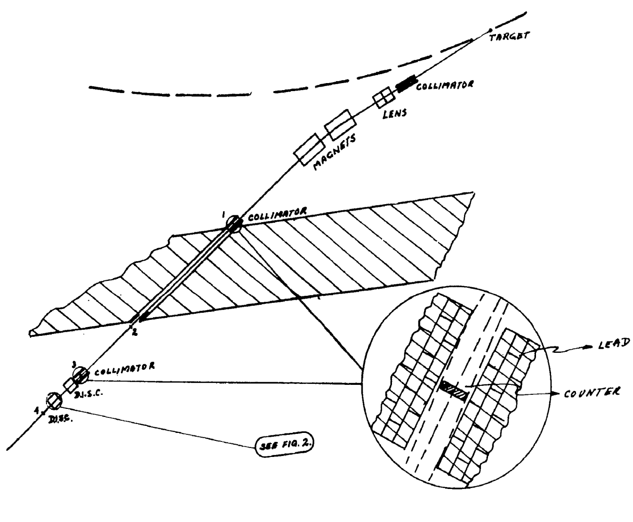

Fig. 1 Experimental layout.