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Letter of intention

TO MEASURE CORRELATIONS IN PARTICLE PRODUCTION AT THE ISR

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ABSTRACT

We intend to measure the two body final state correlation in the reaction

$$p+p \to A+B+X$$

where A=B or $\bar{B}$. The measurement will be done systematically as function of energy, $p_{\perp}$ and $p_{\parallel}$.

The purpose of this program is to perform a critical test of current theories of strong interactions.

We present two preliminary designs as an introduction of various possibilities to perform a program of this kind.

The first measurement intended is included. The final designs will depend on detail discussions with SFM group and ISR group.

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FIRST MEASUREMENT : TEST OF THE APPLICABILITY OF CONVENTIONAL FIELD THEORY TO STRONG INTERACTIONS.

INTRODUCTION:

Recently, a striking phenomenon of high-energy collisions has received wide and increasing theoretical attention. This phenomenon is the existence of pionization products. For example, in proton-proton collisions, the production of a low-energy pion in the CM system when summed over all possible processes has been theoretically shown to follow the distribution law

$$\frac{d^3 p_\pi}{E_\pi} f(p_{\pi\perp}) \tag{1}$$

where $p_{\pi\perp}$ is the transverse momentum of the pion. Equation (1) has been predicted by the multipheripheral model, the parton model, and the field theoretical model. If (1) is experimentally established to be false, most of the models would collapse with it.

Of the models mentioned above, the field theoretical model offers even more stringent tests. The recent theory of Cheng and Wu [1,2] shows that, if field theory can be applied to strong interactions, then it follows from

(1) Lorentz invariance

(2) Particle production at high energies

(3) Unitarity

that (1) is true not only for the sum of processes but also for an individual process. In addition, the number of π^+ produced must be equal to that of π^- produced. Furthermore, for the process

$$p + p \rightarrow \pi_1^{\pm} + \pi_2^{\pm} + X \tag{2}$$

the coincidence yields, for any charge combination of 1 and 2, follow a similar scaling law, both for the sum of processes and for an individual process. In particular, if

$$p_{\pi_1\perp} = p_{\pi_2\perp} = p_\perp \; ; \quad p_{\pi_1 /\!/} = p_{\pi_2 /\!/}$$

then the two-particle distribution function is

$$\frac{1}{E_\pi^2}\, g\left(P_\perp,\ \vec{P}_{\pi_1\perp}\cdot\vec{P}_{\pi_2\perp}\right) \tag{3}$$

provided that

$$E_\pi \ll E\,\frac{m_\pi}{m_p}$$

where

$$2E = \sqrt{s}$$

Also, if one detects X in a $P_{//}$ invariant way (for example counting all the X emitted from a 180° counter along the beam covering the intersecting region), then (3) is still valid.

It has been emphasized by Cheng and Wu that if the above predictions are not true, then the conventional field theory cannot be applied to strong interactions.

Because of the fundamental implications it carries, we propose this as an important experiment to be done accurately at the ISR. Because of the precision and large solid angle required, we propose to do this experiment using either the split field magnet spectrometer that is currently being built at the ISR or build a new spectrometer with a magnetic field that is approximately parallel to the proton beams. To help in the detailed design of the experiment, we request a few days of testing this summer at the ISR.

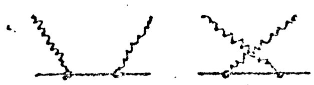
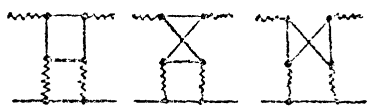
THEORY:

As a model for high-energy scattering, conventional relativistic field theory has all the desirable properties. In particular, unitarity and Lorentz transformation are incorporated from the beginning and particle production is automatically present. It is therefore interesting to find out whether predictions obtained on the basis of field theory are indeed correct for high-energy hadronic interactions.

In obtaining predictions from field theory, we must remember the following points:

(A) Since the coupling constants are not small for hadronic interactions, we cannot take the results from low-order perturbation theory seriously. Moreover, to any finite order of perturbation theory the unitarity condition is not satisfied.

(B) Even when the coupling constant is small as in quantum electrodynamics at high energies, the importance of a contribution to a matrix element is not predominantly determined by the number of times this small coupling constant appears. As a concrete example, consider the Compton scattering of an electron at high energies but a fixed small momentum transfer.

	Second-order diagrams	Sixth-order diagrams
		
Dependence on e	e^2	e^6
Dependence on energy	$(s/m^2)^0$	$(s/m^2)^1$

Therefore, in spite of the smallness of the coupling constant, the contribution from the sixth-order diagrams dominates over that from the second-order diagrams provided that the energy is sufficiently high.

For these reasons, in order to apply field theory to hadron physics, we must study the high energy behavior to all orders of perturbation theory. Furthermore, we must avoid the pitfall of studying only an arbitrarily selected subset of diagrams for mathematical convenience. With these restrictions, we must look for general features of field theory valid to all orders.

As an example let us contrast what we must do here with, say, the problem of the sixth-order magnetic moment of an electron. For the theoretical calculation of this magnetic moment, a large set of diagrams for quantum electrodynamics must be evaluated exactly. After the completion of this interesting but difficult job, we would have a precise number, which could be compared directly with experimental measurements. On the other hand, to get general features from field theory for possible application to hadron physics, we need to consider a large set of diagrams from several possible field theories. These diagrams are not to be evaluated exactly but only asymptotically for high energies, i.e. $s \rightarrow \infty$ with all transverse momenta fixed. Even the precise form of the asymptotic expansion is not of central interest. Rather, we ask the question: Do the results from different diagrams of this set show any common feature?

It is by no means clear that, for different diagrams on the basis of various interactions, there is any common feature at all. For example in the case of $s \rightarrow \infty$ with all angles fixed but not the momentum transfers, no common feature is known. If there is no common feature, then we conclude that, in this way, the present field theories cannot be applied to strong interactions. If some common feature is found, then we ask ourselves whether there is any simple intuitive interpretation of this common feature. With the help of such an interpretation, we can venture to extrapolate to strong interactions.

What interactions must be taken for the field theory? The only field theory with theoretical and experimental triumphs of the past is quantum electrodynamics, i.e., the field theory with a spin - $\frac{1}{2}$ fermion interacting with an electromagnetic field. Therefore, this is the first field theory to study. Since no massless hadron exists, we must ignore features due to the long-range nature of the Coulomb interaction. The generalization to scalar electrodynamics, where a charged scalar particle interacts minimally with the electromagnetic field, is straightforward. Because of the presence of the photon (or a massive vector meson) in both of these theories, it is instructive to check whether general features from these theories are still present in field theories where there is no spin-1 particle. Since we need to study the perturbation series to arbitrarily high orders, we are restricted to renormalizable field theories. So far only the ϕ^3-theory has been studied with this purpose in mind. Indeed there is no other field theory where the high energy behavior has been studied systematically.

On the basis of these three field theories - namely quantum electrodynamics, scalar electrodynamics, and ϕ^3-theory - a number of general features have been found. All the general features are rather closely related to each other. The most striking feature is that all total cross sections increase logarithmically at high energies. However, this feature is hard to check at ISR even in the case of pp scattering. We thus concentrate on a closely related feature - pionization or the production of pions of relatively low energies in the center-of-mass system.

In connection with the three field theories, we are really dealing with the production of fermions in quantum electrodynamics and the spin-0 particle in scalar electrodynamics and ϕ^3-theory. To avoid confusion, however, we shall use the word pion, which is the experimentally relevant particle in hadron scattering.

Let

$$\rho(\vec{p}_\perp, p_{//})\, d^2p_\perp\, dp_{//}$$

be the distribution of low-energy pions in the center-of-mass system for very high incident energies where both of the incoming particles move in the z or $//$ direction, then

$$\rho(\vec{p}_\perp, p_{//}) = \frac{1}{E_\pi} f(p_\perp)$$

where

$$E_\pi^2 = p_\perp^2 + p_{//}^2 + m_\pi^2$$

and $f(p_\perp)$ is independent of $p_{//}$ and the incident energy but depends on $p_\perp$. In other words, we know the dependence of the distribution on $p_{//}$ completely, but not that on $p_\perp$. If we further assume that diffraction proceeds only through C = + 1 exchange (C is the charge conjugation operator), then the same function f holds for both π^+ and π^-.

The corresponding result for two pion distribution is

$$\rho(\vec{p}_{1\perp}, p_{1//}; \vec{p}_{2\perp}, p_{2//}) = \frac{1}{E_{\pi_1} E_{\pi_2}} g(E_{\pi_1} E_{\pi_2} - p_{1//} p_{2//}, \vec{p}_{1\perp}, \vec{p}_{2\perp})$$

there g is independent of the incident energy, and the variable $E_{\pi_1} E_{\pi_2} - p_{1//} p_{2//}$ shows the presence of correction between pions. Note that different g's are needed for the two cases of like charges and opposite charges. In particular, if we consider the special case

$$p_{1\perp} = p_{2\perp} = p_\perp \quad ; \quad p_{1//} = p_{2//} = p_{//}$$

then

$$E_{\pi_1} = E_{\pi_2} = E_\pi \quad \text{and} \quad E_{\pi_1} E_{\pi_2} - p_{1//} p_{2//} = p_\perp^2 + m_\pi^2$$

and therefore

$$\rho(\vec{p}_{1\perp}, p_{1//}; \vec{p}_{2\perp}, p_{2//}) = \frac{1}{E_\pi^2} g(p_\perp^2, \vec{p}_{1\perp} \cdot \vec{p}_{2\perp})$$

which is eq. (3).

All these results depend on the use of Lorentz transformation along the // direction. Therefore they hold for (1) provided the selection of X is Lorentz invariant in the // direction.

We discuss briefly the intuitive interpretation of these results. For low-energy reactions, the center-of-mass system is of special importance because of the relation to the total available energy. For scattering at very high energies, the center-of-mass system is no longer a particularly important one. Let us define a central coordinate system to be a coordinate system such that one incoming particle has a large momentum in the positive // direction of magnitude ω, while the other has a large momentum in the negative // direction of magnitude ω'. Both ω and ω' are large, but they are not necessarily equal. Thus the center-of-mass system is the particular central coordinate system where $\omega = \omega'$. The results from field theory thus means that the center-of-mass system has no special significance, or more precisely that the distribution is the same for all central coordinate systems. With this interpretation, it is reasonable to believe that these results are also valid for high-energy hadron interactions.

For a discussion of the implication of these distributions for low-energy pions, see reference (4).

EXPERIMENTAL CONSEQUENCES:

The following is a summary of the constraints the impact picture imposes on the reactions

$$p + p \rightarrow \pi^{\pm} + X \qquad \text{A}$$

$$p + p \rightarrow \pi_1^{\pm} + \pi_2^{\pm} + X \qquad \text{B}$$

for

$$E_{\pi_{1,2}} \ll \frac{m_\pi}{m_p} E \qquad (4)$$

If any of the statements are not true, the above theory is incorrect; the longitudinal distribution Λ of any soft pion from A has the form

$$\Lambda = \frac{d^3\sigma}{d^2p_\perp \, dp_{//}} = f(p_\perp) \cdot \frac{1}{E_\pi} \qquad (5)$$

Thus, independent of absolute normalization, the relative soft pion yields as a function of $P_{//}$, for fixed $P_\perp$ scales down as $(p_\perp^2 + p_{//}^2 + m_\pi^2)^{-1/2}$ and:

(a) for fixed $P_\perp$, $P_{//}$. The number $\Lambda_{\pi^+} = \Lambda_{\pi^-}$

(b) Λ is independent of incident colliding beam energy.

(c) $f(P_\perp)$ is independent of $P_{//}$.

(d) If the criterion of selecting X is Lorentz invariant in $P_{//}$, then (a), (b), and (c) still hold.

When detecting both π_1 and π_2 in reaction B with

$p_{1\perp} = p_{2\perp}$; $p_{1//} = p_{2//}$ i.e. detecting two pions in coincidence (with or without detecting X along $P_{//}$). Then

$$\Sigma = \frac{1}{E_\pi^2} \, g(p_\perp^2, \vec{p}_{1\perp} \cdot \vec{p}_{2\perp}) \qquad (6)$$

(a) Σ is independent of incident energy

(b) g is independent of $P_{//}$.

ACCURACY NEEDED TO CHECK THE ABOVE THEORY:

It is difficult to have a reliable estimate of the background theoretically. For one-pion distribution, on the basis of fireballs and Bremsstrahlung, the background is not expected to have a rapid dependence of the form E_{π}^{-1}. Thus the distribution, with background taken into account, is

$$\frac{1}{E_{\pi}} f(p_{\perp}) + F(p_{\perp}) \tag{7}$$

where F is approximately independent of $p_{//}$ but depends on $p_{\perp}$ and is inversely proportional to the incident energy. If, for a given $p_{\perp}$, the entire distribution in $p_{//}$ is measured, then we can fit the result with this form and, if a reasonable fit is obtained, obtain both f and F.

In the absence of such a measurement, we can only give a rough estimate as follows:

$$\frac{1}{E_{\pi}} f(p_{\perp}) \gg F(p_{\perp})$$

if $$E_{\pi} \ll \frac{m_{\pi}}{m_p} E$$

Thus roughly $$\frac{1}{E_{\pi}} f(p_{\perp}) \simeq F(p_{\perp})$$

when $$E_{\pi} \simeq \frac{m_{\pi}}{m_p} E$$

With this estimate, the background for $p_{//} = 0$ is

$$\frac{\sqrt{p_{\perp}^2 + m_{\pi}^2}}{E\, m_{\pi}/m_p}$$

For $p_{\perp}$ = 300 MeV/c and E = 20 GeV, we get 10% background.

From the above considerations, we can give the following criteria for a critical test of the theory.

A. Shape of the curve: One fits the measured distribution with (7), and determine $f(p_\perp)$ and $F(p_\perp)$. If an anomalously large backgrośund is needed to fit the data, i.e., if

$$\frac{F(p_\perp)\, E_\pi}{f(p_\perp)} \gg 10\%.$$

at $p_{/\!/} = 0$, $p_\perp \leqslant 300$ MeV/c and E = 20 GeV, then the theory is in trouble.

B. Equality of π^+ and π^- distributions: According to theory, the function $f(p_\perp)$ is the same, while the function $F(p_\perp)$ may be different, for the one-particle distributions of π^+ and π^- . The equality of f_{π^+} and f_{π^-} is further subject to the experimental limitation for isolating π's from K's, which may be 5% - 10%. Accordinly, we expect

$$\left| \frac{f_{\pi^+} - f_{\pi^-}}{f_{\pi^+}} \right| \leqslant 10\%,$$

at $p_{/\!/} = 0$, $p_\perp \leqslant 300$ MeV/c and E = 20 GeV. If the left side of the above equation is considerably greater than 10%, the theory is incorrect.

The term pionization products refer not only to $\pi^\pm$, but also to $K^\pm$, p and $\bar{p}$ as well. However, to produce a particle with higher mass, higher incident energy is necessary. Therefore, the pion should approach its asymptotic distribution at a lower incident energy than the kaons and the baryons. Thus the crucial test of the theory should first be applied to pions. If the pions have already reached their asympotic distribution at 20 GeV, it would then be interesting to see if the kaon distribution also has approached its asymptotic limit at 20 GeV.

COMMENTS ON CURRENT EXPERIMENTS AND MODELS:

Fig. 1 shows the results of experiments by J.W. Allaby et al.[5] and E.W. Anderson et al.[6]. Also shown in Fig. 1 is the analysis of these experiments, based on the work of R.P. Feynman[3], by N.F. Bali and collaborators[7].

The solid curves are their fits to the Feynman scaling law

$$\frac{d^3\sigma}{d^2p_\perp \, dp_\parallel} = \frac{1}{E_\pi} f(x, p_\perp)$$

$$X = \frac{2p_\parallel}{\sqrt{s}}$$

with

$$\begin{aligned} f(X, p_\perp) &= F(p_\perp)\, G(X) \\ F(p_\perp) &= \exp\{-b(p_\perp + p_\perp^2/m_p)\} \\ b &= 2.44 \ \text{GeV}^{-1} \end{aligned} \qquad (8)$$

From these fits they conclude the following

(a) when $X \to 0$;

$G(X) = G_0(S)$ and $G_0^\pm$ for π^+ and π^- are different. Thus

$$\frac{d^3\sigma^\pm}{d^2p_\perp \, dp_\parallel} = \frac{1}{E_\pi} G_0^\pm(s) \, F(p_\perp)$$

Therefore the Feynman prediction of current experimental data is drastically different from the theory of Cheng and Wu in that:

TABLE OF COMPARISON

Bali's fitting of Feynman scaling	Cheng and Wu
G_o is function of s; at 30 BeV/c G_o (π^+) = 37 mb/GeV/c^2 at 19.2 BeV/c G_o (π^+) = 44 mb/GeV/c^2	G_o is independent of s
G_o (π^+) is different from G_o (π^-); at 19.2 BeV/c G_o (π^+) = 44 mb/GeV^2, G_o (π^-) = 25 mb/GeV^2	G_o (π^+) = G_o (π^-)

EXPERIMENTAL ARRANGEMENT:

In the experiment we would like to test all the predictions of the theory summarized on p. 8 of this proposal.

At ISR energies the criterion $E_\pi \ll \frac{m_\pi}{m_p} E$ corresponds to $E_\pi \lesssim 1$ GeV. The experiment thus consists of studying the production of pions of momentum less than 1 GeV and of their correlations as a function of $p_\perp$, $p_\parallel$ and E.

Initially we plan to make measurements for $p_\perp^{c.m.}$ near 200 MeV/c and $p_\parallel$ in the range 0 to 700 MeV/c.

The requirements on the detector are that

a) it has a large acceptance in solid angle and momentum.

b) good discrimination of π's from other particles.

c) known dependency of efficiency with charge, and momentum.

d) momentum resolution up to 700 MeV/c of $\lesssim$ 5%.

Presently we are studying two possible designs for the detector. The first consists of a spectrometer which uses the split field magnet that is being built for the ISR; in the second we are investigating the possibility of using a magnetic field which is approximately parallel to the proton beams.

Below we describe briefly the two possible systems.

I. SPECTROMETER USING THE SPLIT FIELD MAGNET

For $p_{\perp}$ = 200 MeV/c the range in $p_{\parallel}$ of 0 to 700 MeV/c corresponds to pions in the laboratory having angles between 20^{o} and 90^{o} as shown in Fig. 2. A spectrometer covering this range of angles and momenta and using the split field magnet is shown in Fig. 3.

Detectors in only one quadrant are shown. The experimental set up in the other three quadrants is similar.

A, B and C are scintillation counter hodoscopes used for triggering the logic circuits and measuring the time of flight of the particles. Their sizes are given in the Table below.

H1, H2, H3 and H4 are proportional wire chambers which measure the horizontal position and hence both the horizontal angles and the radius of curvature of the particles in the magnetic field of about 8.9 kilogauss.

V1, V2 and V4 are proportional wire chambers which measure the vertical angles. The sizes of these chambers are given in the table below. They all use a wire spacing of 2 mm.

COUNTER HODOSCOPES (Preliminary)

	A	B	C
No. of counters	3	10	12
Width of each	20 cm	20 cm	20 cm
Thickness	0.3 cm	0.5 cm	0.5 cm
Height	3 cm	100 cm	160 cm

	V1, H1	V2, H2	H3	V4, H4
Width	0.6 m	1.2 m	1.6 m	1.9 m
Height	3 cm	0.4 m	0.7 m	1.0 m

The principle of detection is as follows:

A. Hodoscopes A, B and C are used to select the two kinds of events of interest.

(1) The combinations from A, B and C which correspond to particles with $p_\perp^{c.m.}$ in the vicinity of 200 MeV/c. For example, the combination of counter # 3 in A, # 9 in B and # 11 in C gives particles of $p_\perp^{c.m.}$ = 200 MeV/c and $p_{//}$ = 700 MeV/c.

(2) Combinations from A, B and C in the same or two different quadrants to measure two pions π_1 and π_2 such that each pair of combinations corresponds to $p_\perp(\pi_1) = p_\perp(\pi_2)$ and $p_{\parallel}(\pi_1) = p_{\parallel}(\pi_2)$ or other combinations such that $E_1E_2 - p_{\parallel 1}p_{\parallel 2}$ remains constant.

The first type of events measure the single pion distributions given in eq. 5 and the second type measures the two pion distributions given in eq. 6. For particles that do not decay the momentum is determined by the curvature in the magnetic field.

C. Time of flight between counters A and C together with knowledge of momentum isolate π's, from K's and protons. For example, the time difference for π and K of 250 MeV/c is 10 nsec and of 750 MeV/c is 2 nsec.

B. $\gtrsim$ 98% of the K's that decay are rejected by reconstructing the tracks using the proportional chambers' information.

Momentum and angular resolution

At a field strength of about 8.9 kilogauss with 2 mm spacings in the chambers the momentum resolution for a 300 MeV/c particle is about $\pm$ 1 %. Because of the fact that the magnetic field length increases as $P_{//}$ increases the momentum resolution does not get any worse for larger $P_{//}$. The angular resolution is about $\pm$ 0.5°.

Event Rate :

A Monte Carlo calculation using the Hagedorn model and the particle distribution given in eq. (8) shows that at 20A in each ring we can expect a single particle event rate (with p_{π}<1200 MeV) of 10^4 events/sec. The corresponding two particle rate is 10^3 events/sec.

II. SPECTROMETER USING A MAGNETIC FIELD APPROXIMATELY PARALLEL TO THE PROTON BEAMS

As an alternative experimental arrangement we propose the spectrometer shown in Fig. 4. It consists of a set of five cylindrical hodoscopes surrounded by an 8 m long cylindrical coil. This coil, with a 1 meter radius has 40 turns per meter and a current of 4 kA. It provides a homogeneous field of 2.0 kGauss. This coil could be made out of aluminum with a 2.3 x 2.3 cm cross section and a cylindrical inner channel of 0.7 cm Ø for water cooling.

Particles escaping the beam pipe at the intersection region with a transverse momentum of 200 MeV/c will be bent through a polar angle Ø = 150 mrad. To measure the transverse momentum three sets of proportional wire chambers are used. They are arranged in three cylinders around the intersection axis with diameters of 80, 140 and 200 cms. These chambers give a 5% resolution in $P_{\perp}$ at a value of $P_{\perp} \approx$ 200 MeV/c. To determine the longitudinal momentum $P_{\parallel}$, two sets of circular chambers or scintillators are used at diameters of 80 and 200 cms respectively. Since the angular resolution is very good, the resolution of $p_{\parallel}$ is the same as its corresponding $p_{\perp}$.

A total range of azimuthal angles from 15° to 165° would be covered. For $P_{\perp}$ = 200 MeV/c and $\alpha = 15^\circ$ the corresponding $P_{\parallel} = P_{\perp} * \text{ctg}\,\alpha$ = 745 MeV/c. The solid angle thus subtended is $4\pi \sin 75^\circ = 4\pi * 0.966$.

As in design I discrimination against other particles will have to be done using information from the time of flight and the decay of the K meson.

To correct for the distortion of the two beams passing through the field of the coil at an angle of 7.5°, four magnets with iron yokes are used. These should provide a field of 20 kGauss over a length of 0.40 m in the opposite direction of the coil's field.

SUMMARY:

To summarize, Cheng and Wu claim that if present field theory is applicable to strong interactions then in high energy pp collisions the $P_{\perp}$ and $P_{//}$ momentum distribution of particles must have a very definite distribution. We consider it of great interest to study this distribution and check the predictions. We are presently looking in detail into the best way of measuring the distribution and correlation of low energy pions at the ISR. In this proposal we have outlined two spectrometers which are under consideration.

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FIGURE CAPTIONS:

Fig. 1 Some results of $\pi^{\pm}$ distribution. (From references 4,5 and 6).

Fig. 2 Kinematics for $\pi^{\pm}$ with $P_{\perp}^{c.m.}$ = 200 MeV/c.

Fig. 3 Spectrometer detecting $\pi^{\pm}$ in the split field magnet.

Fig. 4 Spectrometer using a magnetic field approximately parallel to the proton beams.

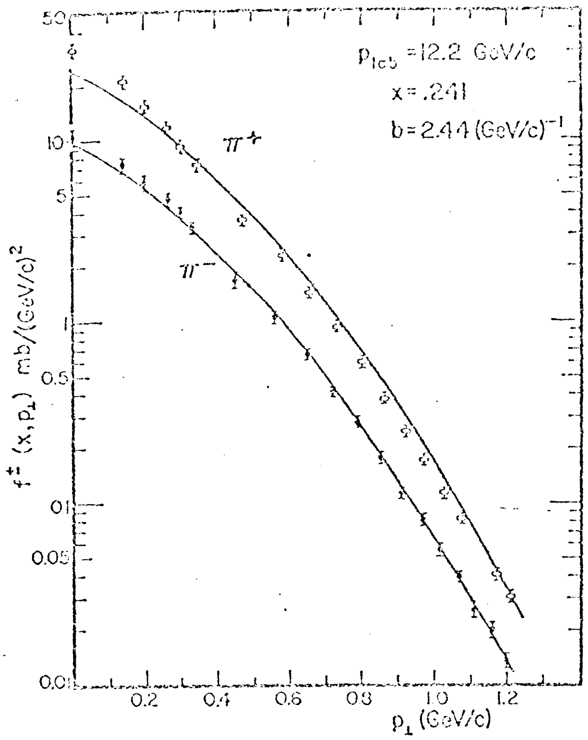


FIG. A Fit to the $p_\perp$ dependence at fixed x

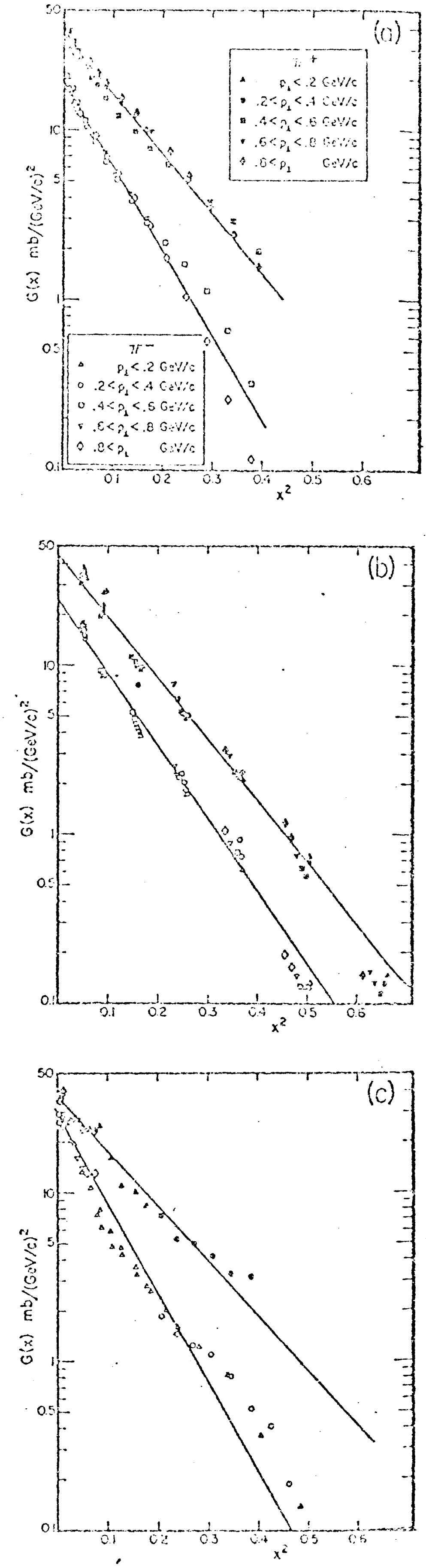


FIG. B The x dependence of the reduced data. (a) p_{lab} = 12.2 GeV/c, G_0^+ = 36 mb/GeV^2, G_0^- = 19 mb/GeV^2, a^+ = 8.2, a^- = 11.5 (b) p_{lab} = 19.2 GeV/c, G_0^+ = 44 mb/GeV^2, G_0^- = 25 mb/GeV^2, a^+ = 8.5, a^- = 10 (c) p_{lab} = 30.0 GeV/c, G_0^+ = 37 mb/GeV^2, G_0^- = 29 mb/GeV^2, a^+ = 7.4, a^- = 12.1

Fig. 1

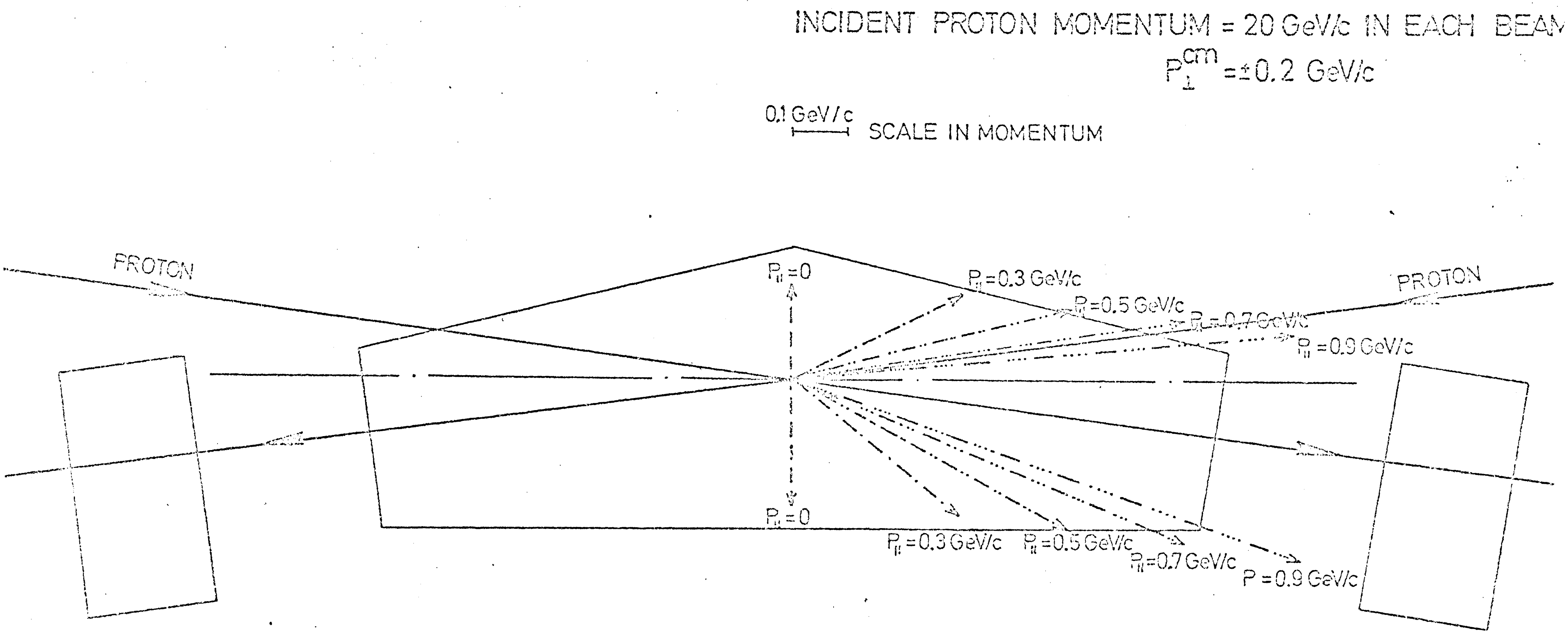
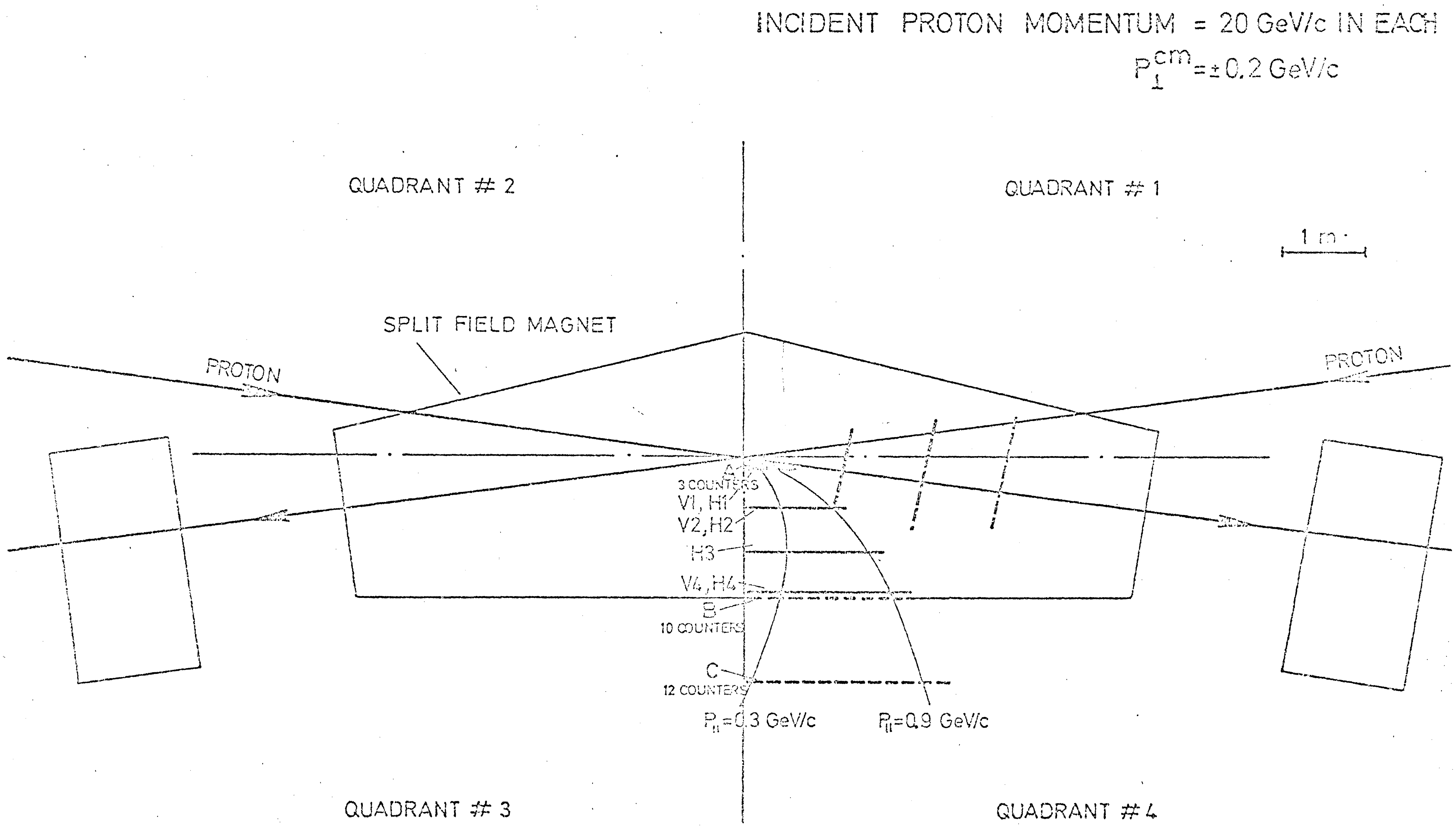

INCIDENT PROTON MOMENTUM = 20 GeV/c IN EACH BEAM
P⊥cm = ±0.2 GeV/c
0.1 GeV/c SCALE IN MOMENTUM
PROTON
PROTON
P∥=0
P∥=0
P∥=0.3 GeV/c
P∥=0.5 GeV/c
P∥=0.7 GeV/c
P∥=0.9 GeV/c
P∥=0.3 GeV/c
P∥=0.5 GeV/c
P∥=0.7 GeV/c
P =0.9 GeV/c

Fig. 2



INCIDENT PROTON MOMENTUM = 20 GeV/c IN EACH
$P_{\perp}^{cm} = \pm 0.2$ GeV/c
QUADRANT # 2
QUADRANT # 1
1 m
SPLIT FIELD MAGNET
PROTON
PROTON
A
3 COUNTERS
V1, H1
V2, H2
H3
V4, H4
B
10 COUNTERS
C
12 COUNTERS
$P_{\parallel}=0.3$ GeV/c
$P_{\parallel}=0.9$ GeV/c
QUADRANT # 3
QUADRANT # 4

Fig. 3

PION DETECTOR

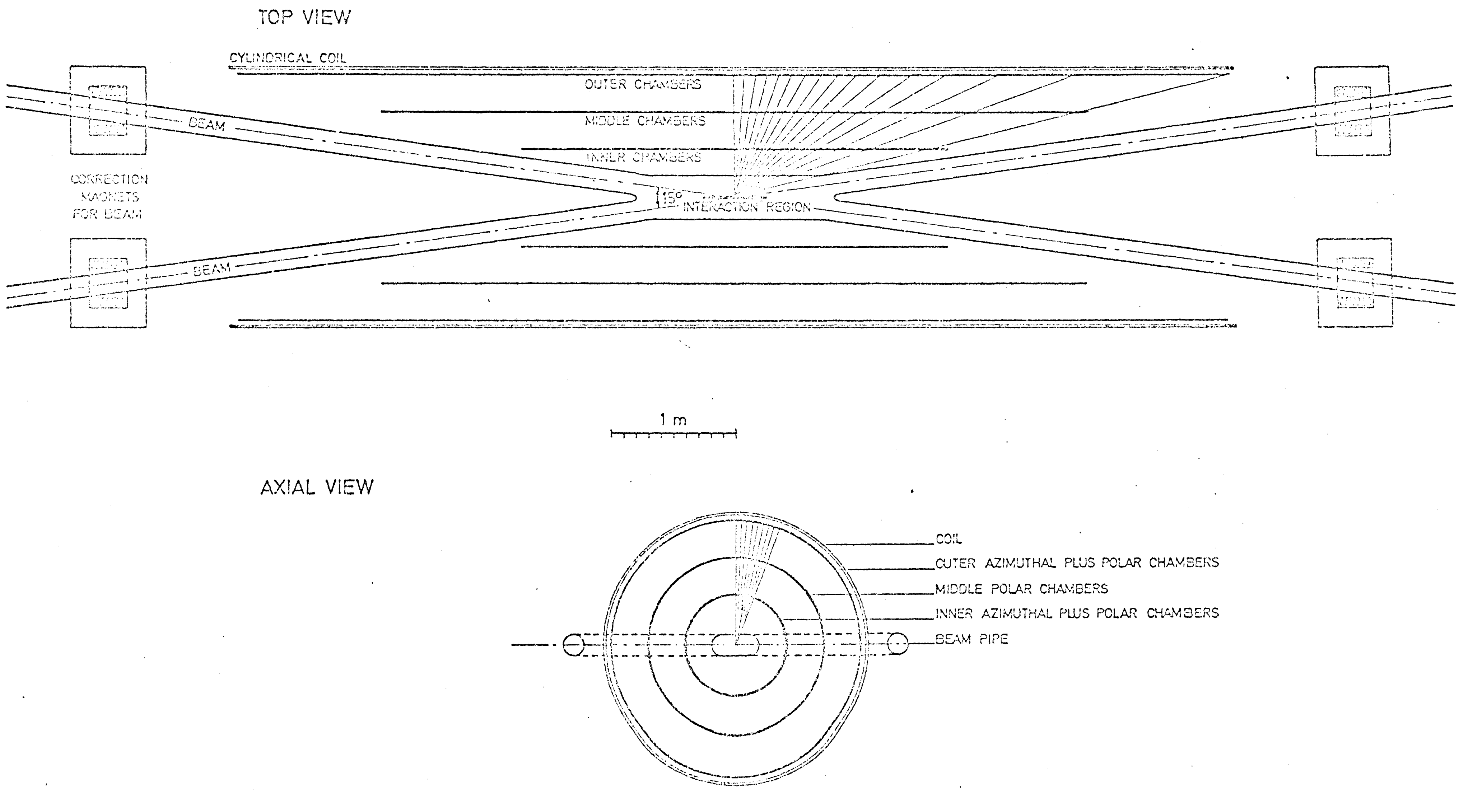


Fig. 4