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PROPOSAL TO STUDY PARTICLES CORRELATIONS IN THE PIONISATION REGION AT THE ISR

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ABSTRACT

We intend to measure reactions of the type

$$p + p \rightarrow \pi^{\pm} + X$$

and

$$p + p \rightarrow \pi + \pi + X'$$

where we measure π^+, π^- accurately, but X, X' only roughly.

The purpose of this program is to perform tests on current theories of strong interactions.

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PHYSICAL MOTIVATIONS

We intend to use the split field magnet system to study reactions :

$$p + p \rightarrow \pi + X$$

$$p + p \rightarrow \pi_1 + \pi_2 + X'$$

Here we measure the π's accurately, but the rest of the particles X only roughly.

On the basis of the fireball model (FB), the multiperipheral model (MP), the multi-Regge model (MR), the droplet model of Chou and Yang (CY), the parton model of Feynman (FP), and the field-theoretic model of Cheng and Wu (CW), we have now a good theoretical understanding of semi-inclusive reactions. It is extremely important to find out whether this theoretical understanding is correct or not, particularly for the case of extreme high energy processes, where theories are best put to test, yet where virtually no experimental data exist at all at present.

With a split field magnet at ISR, any experimentally feasible detecting apparatus must give substantial information about X. Since this information, obtained as no cost, contains a great deal of physics, it is completely senseless to restrict ourselves to the extreme case of inclusive measurements only.

We discuss in some detail here the present theoretical understanding together with some of the possible experimental tests.

i) General considerations :

We choose the y-axis to be in the direction of the incident protons in the center of mass system. Let $\vec{P}$ be the momentum in the laboratory frame of the π^+ or π^- to be measured accurately, and $P_\parallel$ and $\vec{P}_\perp$ be the components of $\vec{P}$ in the y and the perpendicular directions. Also P and $P_\perp$ denote the magnitudes of $\vec{P}$ and $\vec{P}_\perp$. For definiteness, we consider here the case of 25 BeV ISR beam.

ii) Pionization :

We first consider the region of pionization where $P_\parallel$ (CM) is small, i.e. :

$$|P_\parallel(\mathrm{CM})| \ll \frac{m_\pi E^{inc}(\mathrm{CM})}{m_p C}$$

or roughly :

$$|P_\parallel(\mathrm{CM})| \lesssim 1.0 \text{ BeV/c} \qquad (1)$$

We choose X in a way that it is invariant under Lorentz transformations along the y-axis (CW). More precisely, we choose X such that, if any combination of particles is acceptable as X, then the same combination Lorentz transformed along the y-axis must also be acceptable as X. The special case of inclusive measurements satisfies this condition automatically. For reasons to be discussed below in (iii), the choice of X should not be so stringent that the rate is much lower than, say, 5% of the inclusive case. With such a choice of X, the one-pion distribution function in the CM system is given, for extremely high energies, by (CW)

$$E^{-1} \; P^2\vec{P}_\perp dP_\parallel(\mathrm{CM}) \;\; f\,(P_\perp) \qquad (2)$$

when (1) is satisfied, where $E = |P_{\parallel}^2(CM) + P_{\perp}^2 + m^2|^{\frac{1}{2}}$ is the energy of the pion in the CM system. This $f(P_{\perp}) \neq 0$ is independent of $P_{\parallel}$ and the incident proton energy.

<u>TEST 1</u> : Is (2) correct for various choices of X ?

The correctness of (2) is crucial to CW. If (2) is not correct, even the general features of quantum field theories fail to hold for the real world at high energies, and hence further study of field-theoretic models has very little relevance to high-energy physics. In the inclusive case, where no measurement whatsoever is performed on X, FP also gives (2) but since in FP $f(P_{\perp})$ can be zero, test 1 will not be conclusive for FP. Also in this inclusive case, MP and MR give a weaker form of (2), where $f(P_{\perp})$ is independent of $P_{\parallel}$ but may depend on the incident proton energy. Thus test 1 in this special case is also important for MO and MR, but not for FB and CY. If the charge conjugation quantum number C = +1 can be assigned to the Pomeron (or vacuum trajectory in Regge language), then the functions $f^+(P_{\perp})$ for π^+ and $f^-(P_{\perp})$ for π^- are equal.

<u>TEST 2</u> : If yes to test 1, are $f^+(P_{\perp})$ and $f^-(P_{\perp})$ approximately equal for various choices of X ?

iii) <u>Further consideration on pionization</u> :

Suppose we choose X differently from the criteria in (ii). There are numerous possibilities and we shall mention only one.

$$X = \pi^+ + \text{neutrals}$$

This is possible only for $\pi^+ + \pi^+ + X'$, and X' contains nn and in addition $n\bar{n}$ pairs, π^o, η, and possibly ω in the decay mode $\pi^o + \gamma$. This choice is interesting in that the condition of Lorentz invariance in the y direction is satisfied and yet theoretically (2) does not hold (MP, MR, CW).

TEST 3 : Is (2) correct for the above choice of X ?

One purpose of this test is to demonstrate that (2) is by no means trivial.

iv) Pion correlations :
Consider

$$p + p \rightarrow \pi_1 + \pi_2 + X'.$$

The two particle distribution is (CW)

$$E_1^{-1}\ E_2^{-1}\ d^2\overrightarrow{P_{\perp 1}}\ d^2\overrightarrow{P_{\perp 2}}\ dP_{\parallel 1}\ dP_{\parallel 2}\ g \qquad (3)$$

where g is a function of $\overrightarrow{P_{\perp 1}}$, $\overrightarrow{P_{\perp 2}}$ and $E_1E_2 - P_{\parallel 1}P_{\parallel 2}$, but not of the incident energy or the values of $P_{\parallel 1}$ and $P_{\parallel 2}$ separately. (3) like (2) must be true if X' is choosed in a Lorentz invariant way (see p. 2).

TEST 4 : Is (3) correct for such choices of X' ?

This is a generalization of test 1. It is specially interesting to study the two pions invariant mass in the $\pi^+\pi^-$ case.

If the answer to test 2 is yes, so that we assign C = +1 to the Pomeron, then at extremely high energy, the production is dominant according to (FP), but suppressed according to (CW).

This is one of the few points where different theories give opposite predictions.

TEST 5 : How strongly does ρ^{o} show up in the $\pi^{+}\pi^{-}$ invariant mass ?

It may be necessary for this test to select X' so as to avoid other pions in the same phase space region.

THEORETICAL CONSIDERATIONS ON PIONIZATION AND TWO PARTICLE CORRELATION

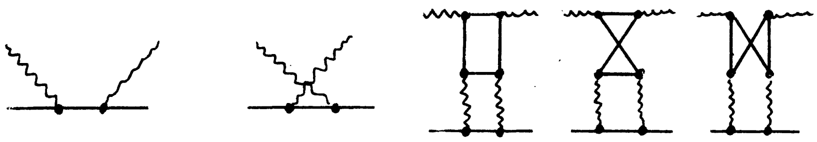
As a model for high-energy scattering, conventional relativistic field theory has all the desirable properties. In particular, unitarity and Lorentz transformation are incorporated from the beginning and particle production is automatically present. It is therefore interesting to find out whether predictions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



	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 behaviour 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 <u>general features</u> 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. $s \to \infty$ 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 $s \to \infty$ 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 longrange 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 behaviour 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. We concentrate here 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 work pion, which is the experimentally relevant particle in hadron scattering.

Let

$$\rho\ (P_\perp, P_\parallel)\, d^2P_\perp dP_\parallel$$

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 // direction, then

$$\rho\ (\vec{P}_\perp, P_\parallel) = \frac{1}{E_\pi}\ f(P_\perp)$$

where

$$E_\pi^2 = P_\perp^2 + P_\parallel^2 + m_\pi^2$$

and $f(P_\perp)$ is independent of $P_\parallel$ and the incident energy but depends on $P_\perp$. In other words, we know the dependence of the distribution on $P_{\parallel}$ 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

$$\rho(\vec{P}_{1\perp},P_{1\parallel};\vec{P}_{2\perp},P_{2\parallel}) = \frac{1}{E_{\pi_1}E_{\pi_2}}\, g(E_1E_2 - P_{\parallel 1}P_{\parallel 2},\vec{P}_{\perp 1},\vec{P}_{\perp 2})$$

there g is independent of the incident energy, and the variable $E_{\pi_1}E_{\pi_2} - P_{1\parallel}P_{2\parallel}$ shows the presence of correlation 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 :

$$P_{\perp 1} = P_{2\perp} = P_{\perp} \;;\; P_{1\parallel} = P_{2\parallel} = P_{\parallel}$$

then :

$$E_{\pi_1} = E_{\pi_2} = E_{\pi} \text{ and } E_{\pi_1}E_{\pi_2} - P_{1\parallel}P_{2\parallel} = P^2 + m_{\pi}^2$$

and therefore :

$$\rho(\vec{P}_{1\perp},P_{1\parallel};\vec{P}_{2\perp},P_{2\parallel}) = \frac{1}{E_{\pi}^2}\, g(P_{\perp}^2,\vec{P}_{1\perp},\vec{P}_{2\perp})$$

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

ACCURACY NEEDED

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 :

$$\frac{1}{E_\pi} f(P_\perp) + F(P_\perp) \qquad (4)$$

where F is approximately independent of $P_\parallel$ but depends on $P_\perp$ and is inversely proportional to the incident energy. If, for a given $P_\perp$, the entire distribution in $P_\parallel$ 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 :

$$\frac{1}{E_\pi} f(P_\perp) >> F(P_\perp)$$

if

$$E_\pi << \frac{m_\pi}{m_P} E.$$

Thus roughly :

$$\frac{1}{E_\pi} f(P_\perp) \simeq F(P_\perp)$$

when

$$E_\pi = \frac{m_\pi}{m_P} E.$$

With this estimate, the background for $P_{\parallel} = 0$ is :

$$\frac{\sqrt{P_\perp^2 + m^2}}{Em\pi/mP} .$$

For P_1 = 100 MeV/c and E = 25 GeV, we get 5% 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 (4), and determine $f(P_\perp)$ and $F(P_\perp)$. If an anomalously large background is needed to fit the data, i.e. if :

$$\frac{F(P_\perp) E_\pi}{f(P_\perp)} >> 5\%$$

at $P_{\parallel} = 0$, $P_{\perp} \sim 100$ MeV/c and E = 25 GeV, then the theory is in trouble.

b) Equality of π^+ and π^- distributions : according to theory, the function $f(P_{\shortmid})$ is the same, while the function $F(P_{\shortmid})$ 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%. Accordingly, we expect :

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

at $P_{\parallel} = 0$, $P_{\perp} \sim 100$ MeV/c and E = 25 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 asymptotic distribution at 25 GeV, it would then be interesting to see if the kaon distribution also has approached its asymptotic limit.

COMMENTS ON CURRENT EXPERIMENTS

Fig. 1 shows the results of experiments by J.V. 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

$$\frac{d^3\sigma}{d^2P_\perp dP_\parallel} = \frac{1}{E_\pi} f(X,P_\perp) \quad , \quad X = \frac{P_\parallel}{E_{in}}$$

with

$$f(X,P_\perp) = F(P_\perp)\ G(X)$$

$$F(P_\perp) = \exp\{-\ b(P_\perp + P_\perp^2/m_p)\} \quad , \quad b = 2.44\ \mathrm{GeV}^{-1} \qquad (8)$$

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 :

Bali's fitting of Feynman scaling	Cheng and Wu
G_0 is function of s; at 30 BeV/c $G_0(\pi^+) = 37\ \mathrm{mb/GeV/c^2}$ at 19.2 BeV/c $G_0(\pi^+) = 44\ \mathrm{mb/GeV/c^2}$	G_0 is independent of s
$G_0\ (\pi^+)$ is different from $G_0\ (\pi^-)$ at 19.2 BeV/c $G_0(\pi^+) = 44\ \mathrm{mb/GeV^2}$ $G_0(\pi^-) = 25\ \mathrm{mb/GeV^2}$	$G_0\ (\pi^+) = G_0\ (\pi^-)$

EXPERIMENTAL ARRANGEMENT

We propose to measure low energy two particles correlations to test the predictions of current theories and in particular the theory summarized above.

At ISR energies, the criterion :

$$E_\pi << \frac{m_\pi}{m_p} E$$

corresponds to $E_\pi \lesssim 1$ GeV.

We plan to first make this measurement with charged pions in the momentum range :

$$100 < p_\perp^{cm} < 300 \text{ MeV/c}$$
$$0 < p_\parallel^{cm} < 1 \text{ GeV/c}.$$

The requirements on the detector are :

- large acceptance in solid angle and momentum,
- good identification of pions,
- knowledge of the acceptance as a function of charge and momentum,
- momentum resolution $\lesssim \pm 2\%$.

A detector in the Split Field Magnet seems to satisfy such conditions.

a) Particle identification.

The identification of pions will be done by measuring the time of flight in addition to the momentum. With a time resolution of ± 0.5 ns which is commonly achieved with 1 m. long scintillators [8] and a 6 m. time basis, one can discriminate π's from K's up to 1 GeV/c with 3 standard deviations. The time of flight will be measured between two hodoscopes (fig. 2) H_1 or H'_1 and H_2 or H'_2 described in table 1. The K's decaying between them are eliminated during track reconstruction; less then 10% of K's can decay before the first or after the last chamber (see later) and simulate π's. We can correct for that amount or reduce it by small set-up modifications if K's production is unexpectedly large.

Table 1

	No. of counters	Total width	Total height
H_1, H'_1	20, 10	2 m., 1 m.	10 cm.
H_2, H'_2	60	6 m.	2 m.

b) Momentum measurement :

The trajectories of the particles will be measured in the magnetic field with the set of proportional chambers shown in fig. 2. They are arranged so as to measure 4 points on each trajectory (3 geometrical constraints).

Each chamber will contain 2 wire planes at right angle and a reading of the high voltage planes so as to associate directly coordinates into a point in space. They will be built so as to use the standard electronical hardware and software foreseen for SFM. But they should be frame chambers to minimize the multiple scattering for low momentum particles.

To measure the momentum with a standard deviation less than ± 2%, the sagitta in the magnetic field must be larger than about 10 cm. This condition is met everywhere for particles accepted in the hodoscopes, except in a small region around the X axis of the ISR.

The multiple scattering in the vacuum chamber, the hodoscope H_1 and the chambers (assuming frame chambers) induces an error of about ± 1% on the total momentum and ± 3 to 5% on $P_\perp$ for $P_\perp$ = 100 MeV/c; these values become smaller when $P_\perp$ increases.

The set-up drawn in fig. 2 contains a total number of 30.000 wires assuming a 2 mm wire spacing. It has not been still optimized for minimum number of wires or for compatibility with other experiments.

c) Trigger :
In order to perform an inclusive experiment, and more specifically to test the above theory, we are not allowed to include in the trigger particles other than the two we want to measure (for example : selection of beam-beam events with forward counters).

The fast trigger will be to select a minimum of two counts in $H_1 + H'_1$ and $H_2 + H'_2$ within the correct range of time of flight, in coincidence with the respective chamber fast "OR". In these conditions we have evaluated the random coincidences rate to be less than 5% of the good events for 20 x 20 Amp^2 (extrapolation of single counting rates from ref. 9) and 10)). The main difficulty comes from real coincidences induced by the upstream jets of the ISR background. In order to prevent them, we shall use counters A_1 and A_2 in anticoincidence for particles being in the wrong time conditions. The time of flight window between H_1, H'_1 and H_2, H'_2 will kill also a part of these parasitic events.

We are studying the feasibility of using in second level of decision the DC logic of the SFM chambers in order to require relevant combinations of the 32 wires clusters associated with the hodoscope pattern.

d) Acceptance :

Considering only for simplicity the case where $P_{\perp 1} = P_{\perp 2}$, the unknown part of the correlation function must depend on the following 3 variables (according to the above theory) :

- $E_1E_2 - P_{\parallel 1}P_{\parallel 2}$ which is related to the invariant mass m_{12} of the two pions through :

$$m_{12}^2 = 2(E_1E_2 - P_{\parallel 1}P_{\parallel 2}) + 2m_\pi^2 - 2\overrightarrow{P_{\perp 1}}\cdot\overrightarrow{P_{\perp 2}}$$

- $P_\perp = P_{\perp 1} = P_{\perp 2}$

- $$\frac{\overrightarrow{P_{\perp 1}} \cdot \overrightarrow{P_{\perp 2}}}{P_\perp^2} = \cos\phi$$

Figures 3, 4 and 5 give the variation of the acceptance with m_{12}, $P_\perp$ and ϕ.

The total acceptance, assuming uncorrelated pions following the Bali et al. distribution [7)] is given in table 2.

Table 2

Combination	Acceptance
+ +	0,05
+ -	0,07
- -	0,10

e) Rate :

We have extrapolated accelerator data to determine a cross-section for π^- production in the range of secondary momenta which characterizes our acceptance :

$$0.1 \text{ GeV/c} < P_\perp < 0.3 \text{ GeV/c}$$

$$P_\perp^2 + P_\parallel^2 < 1.(\text{GeV/c})^2$$

Under the assumption that $E \frac{d^2\sigma}{dP_\perp dP_\parallel}$ for $X = P_\parallel^{cm}/\sqrt{s} = 0$ obeys Feynman scaling [3], this quantity describes π^- production at all total c.m.energies. But, as mentioned above, for small values of secondary c.m.momenta, we expect $\frac{d^2\sigma}{dP_\perp dP_\parallel}$ to have the form $\frac{f(P_\perp)}{E}$ so that $E \frac{d^2\sigma}{dP_\perp dP_\parallel}$ determines $f(P_\perp)$.

With the $f(P_\perp)$ found by scaling the data at 28 GeV/c, we find from data obtained in the experiment described in ref. 11) $\sigma = 24$ mb $\pm$ 2 mb.

With the simple assumption of no correlations between final π^-'s, one can crudely estimate the rate of production of two π^-'s in the momentum region above. In an inelastic event, the probability of producing a π^- in the momentum range is σ/σinel.

Then the cross section for uncorrelated dipion production in this range of secondary momenta is (assuming a multiplicity >> 1) roughly $\sigma(\sigma/\sigma inel)$ = 19 mb.

Folding in the design luminosity of $4.10^{30}/cm^2$ sec. for 20 A x 20 A and the total acceptance given above we obtain a rate of about 10^4 events/sec.

f) Background :

The reconstruction of the vertex will allow us to reject all the background interactions of the ISR beams except the beam-gas interactions in the intersection region. The standard deviation on the vertex position (mainly due to multiple scattering) is ± 1.5 to 3.5 mm in the vertical direction, depending on the momenta and the configuration, and ± 2 to 5 mm in the horizontal direction.

From accelerator data [11)] the cross section for π^- production integrated over our momentum-range of acceptance is 8 mb. This is already below the value found for beam-beam production of two pions. Furthermore the luminosity for beam-gas interaction is expected to be at least 100 times less than for beam-beam interaction at 20 A x 20 A. So this source of background will probably be negligible.

There are two ways for measuring it if necessary, among which we cannot choose for the moment :

- take data with only one circulating beam,
- accept events whose origins are on each side of the intersection region. Our set-up is designed to be able to do it.

g) <u>Experimental program :</u>

We will be able to measure single pions distributions with or without conditions on X (eq.1) (Tests 1 and 2) if this has not been done by the time this experiment will be running.

Our main aim is anyway to measure $\pi\pi$ correlations (Tests 3, 4 and 5). We wish to do this for 3 energies of the incoming proton beams, namely 15 GeV (corresponding to an accelerator energy of 500 GeV), 20 and 25 GeV. For tests involving conditions on X' (eq. 1), we plan to use the complete set of chambers which will be built in the SFM to look for other trajectories and then make the desired selections.

Possible extensions will be :

- measurement of correlation for more than 2 pions,
- measurement of $K\pi$ correlation by selecting one K in the trigger either by time of flight (for slow kaons) or with a Cerenkov counter selecting a given (small) solid angle. The KK correlation can be measured in the same manner but at a much lower rate since with Cerenkov counters one cannot use the large solid angle property of the SFM,
- measurement of $\pi\pi$ correlations in a solid angle of nearly 4π but without identification if the rate of K production is low enough.

h) <u>Time requirements :</u>

We need 15 days of production time to perform the first part of the program ($\pi\pi$ correlations).

To test the set-up we need two periods of 15 days. The first will be used to study the background problems in the SFM, the second one to test the trigger logic and the software.

Apart from the signatories of this proposal, several physicists are interested in participating in this experiment, but no definite list can be given before a more precise knowledge of the time schedule.

XDB/ea

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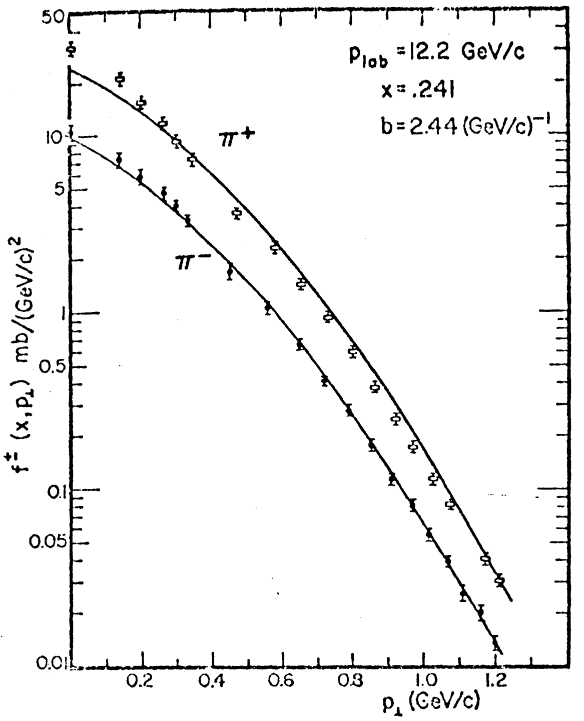

FIG. A Fit to the $p_\perp$ dependence at fixed x

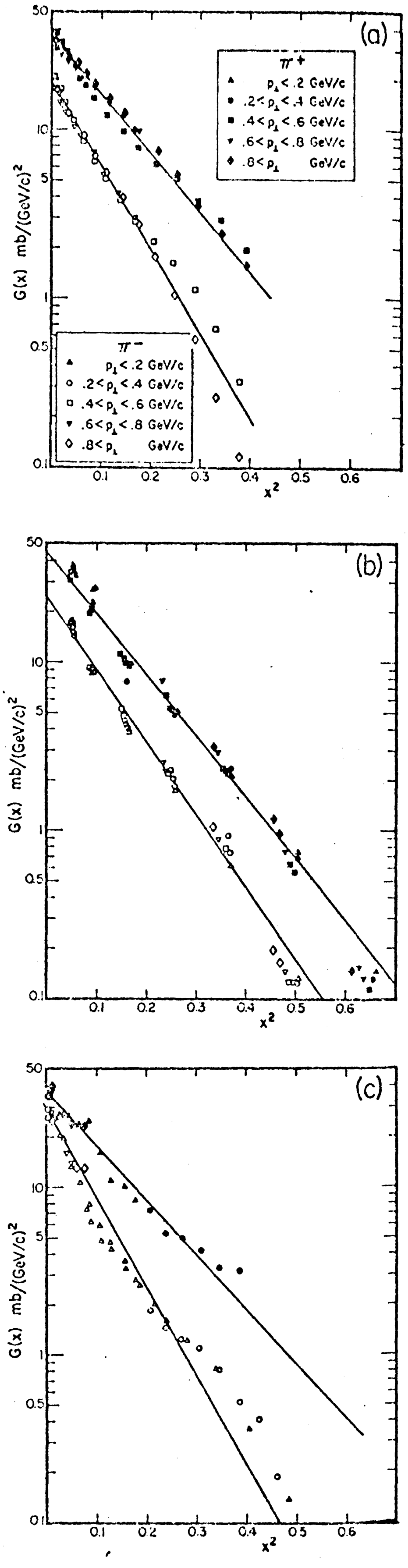

FIG. B The x dependence of the reduced data. (a) p_{lab} = 12.2 GeV/c, G_0^+ = 36 mb/GeV^2, G_0^- = 19 mb/GeV^2, a^+ = 8.2, a^- = 11.5 (b) p_{lab} = 19.2 GeV/c, G_0^+ = 44 mb/GeV^2, G_0^- = 25 mb/GeV^2, a^+ = 8.5, a^- = 10 (c) p_{lab} = 30.0 GeV/c, G_0^+ = 37 mb/GeV^2, G_0^- = 29 mb/GeV^2, a^+ = 7.4,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

Fig. 1

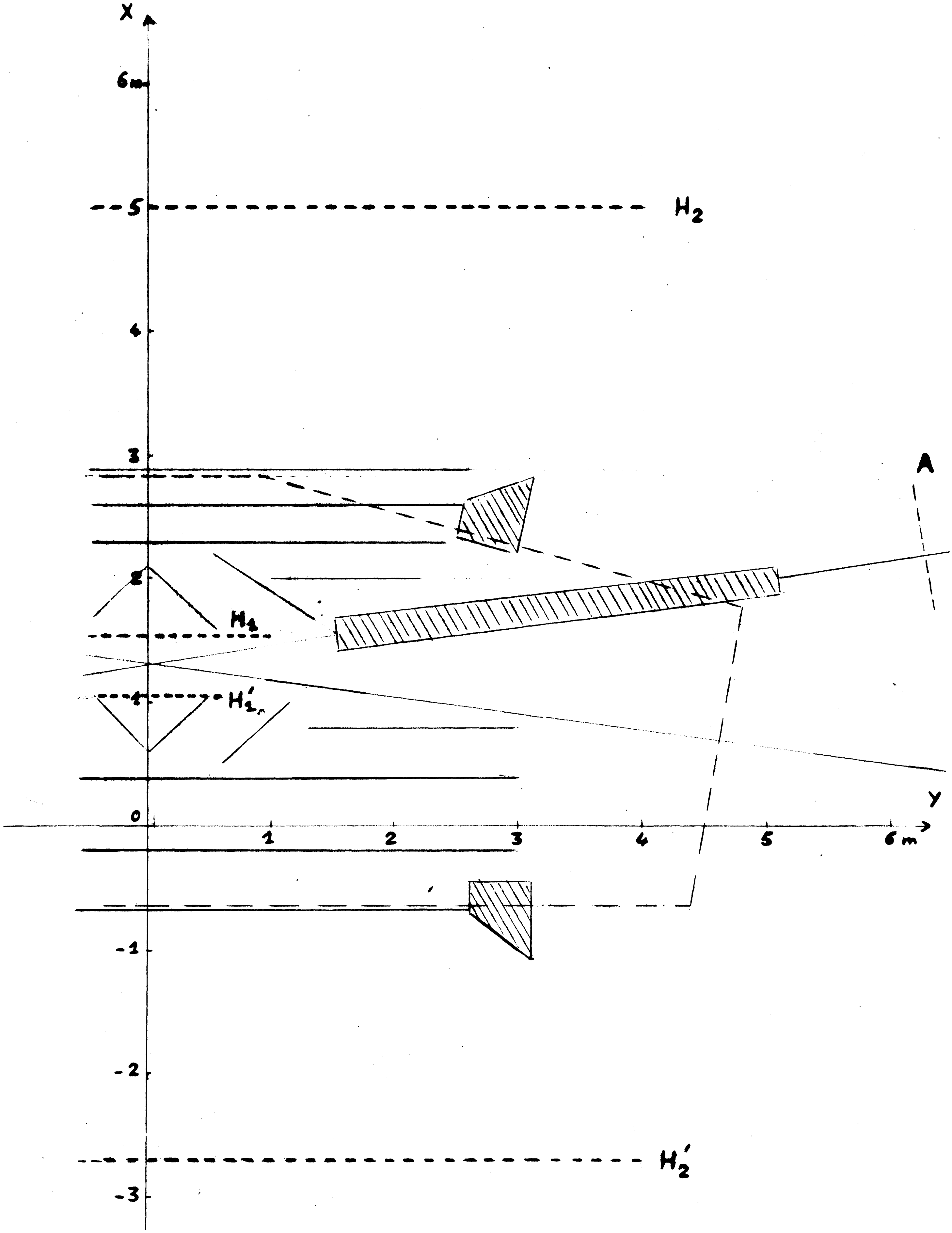

Fig. 2: provisional detector layout

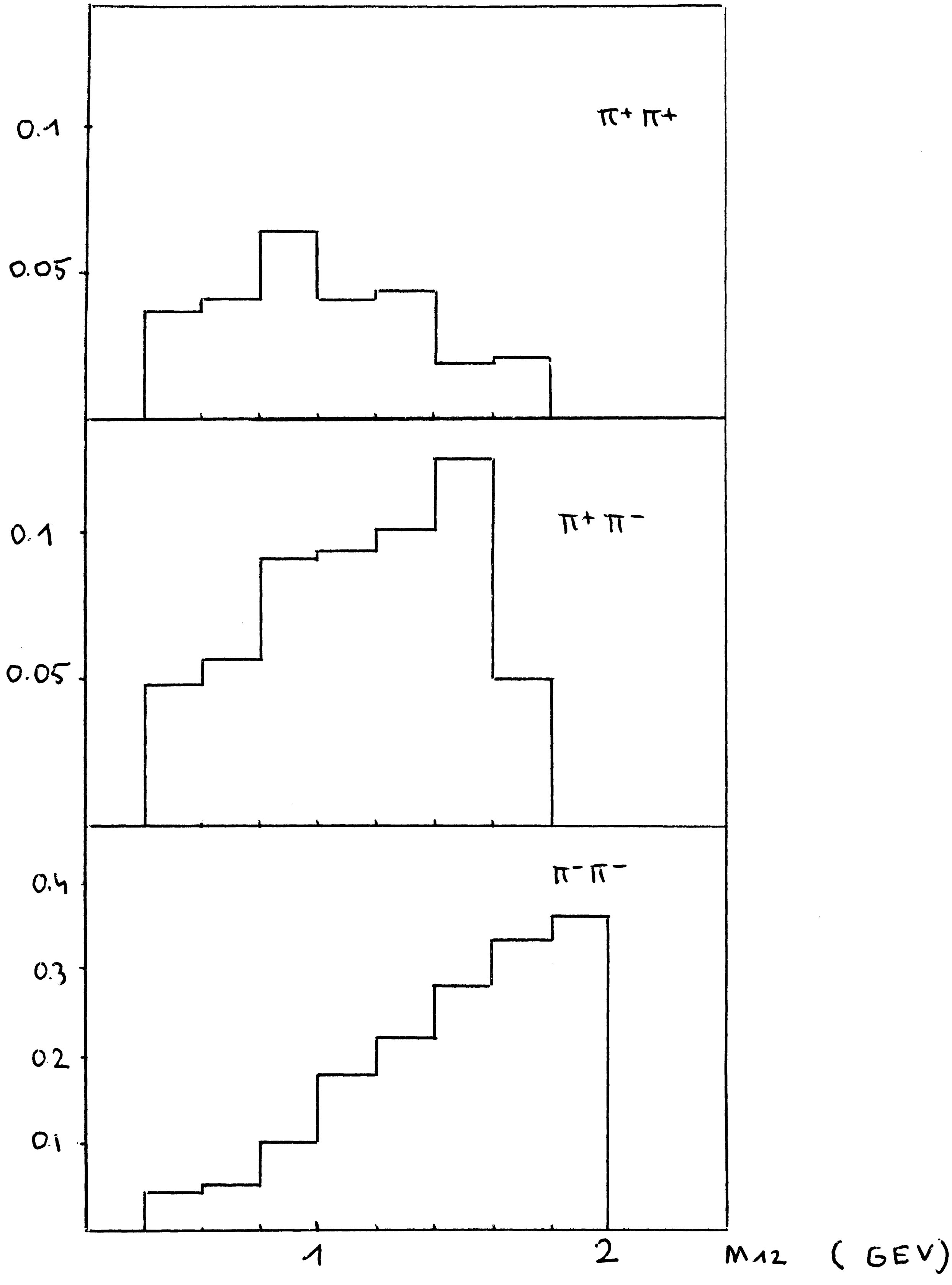

FIGURE 3. ACCEPTANCE IN INVARIANT MASS

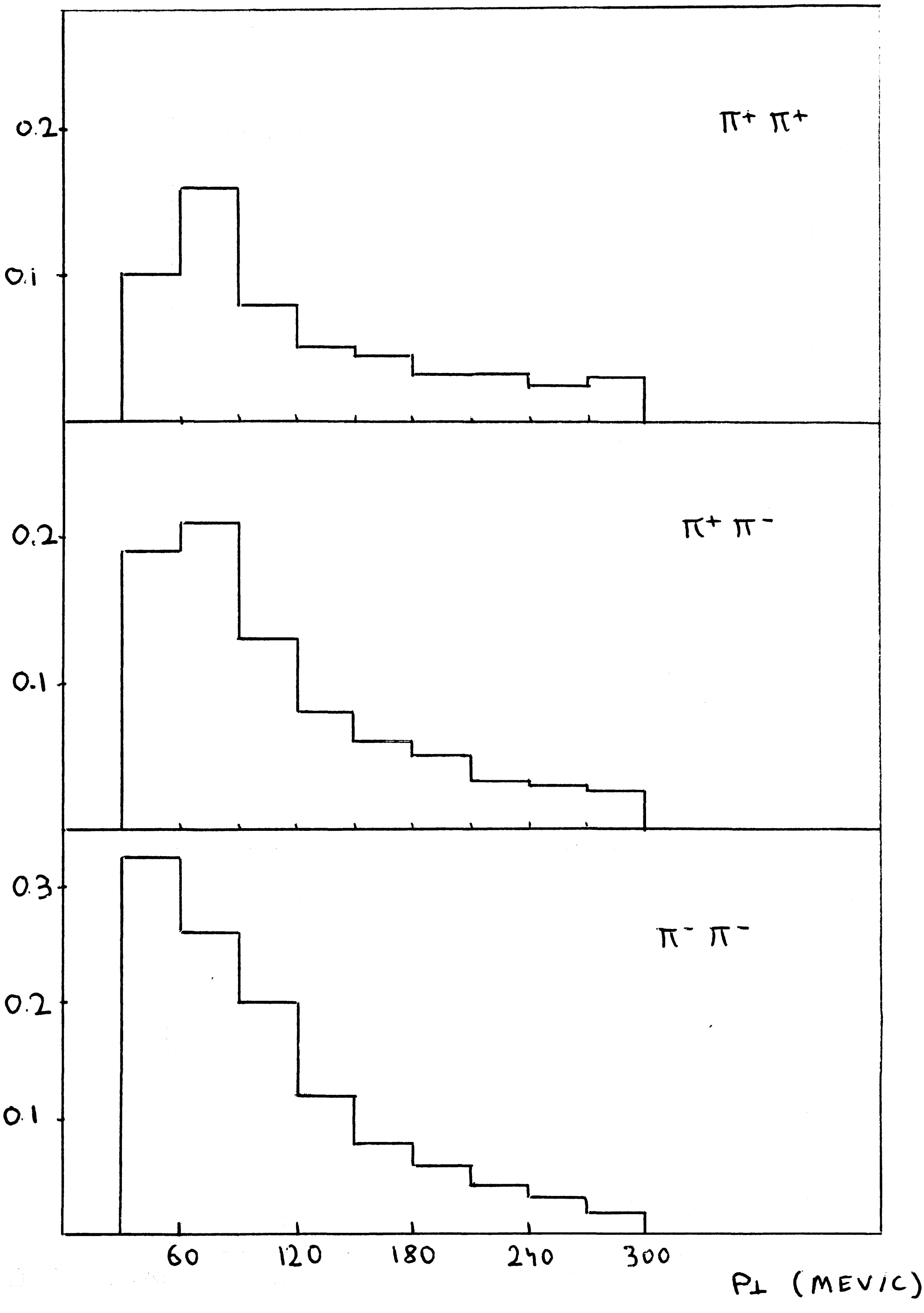

FIGURE 4. ACCEPTANCE IN $P_\perp$

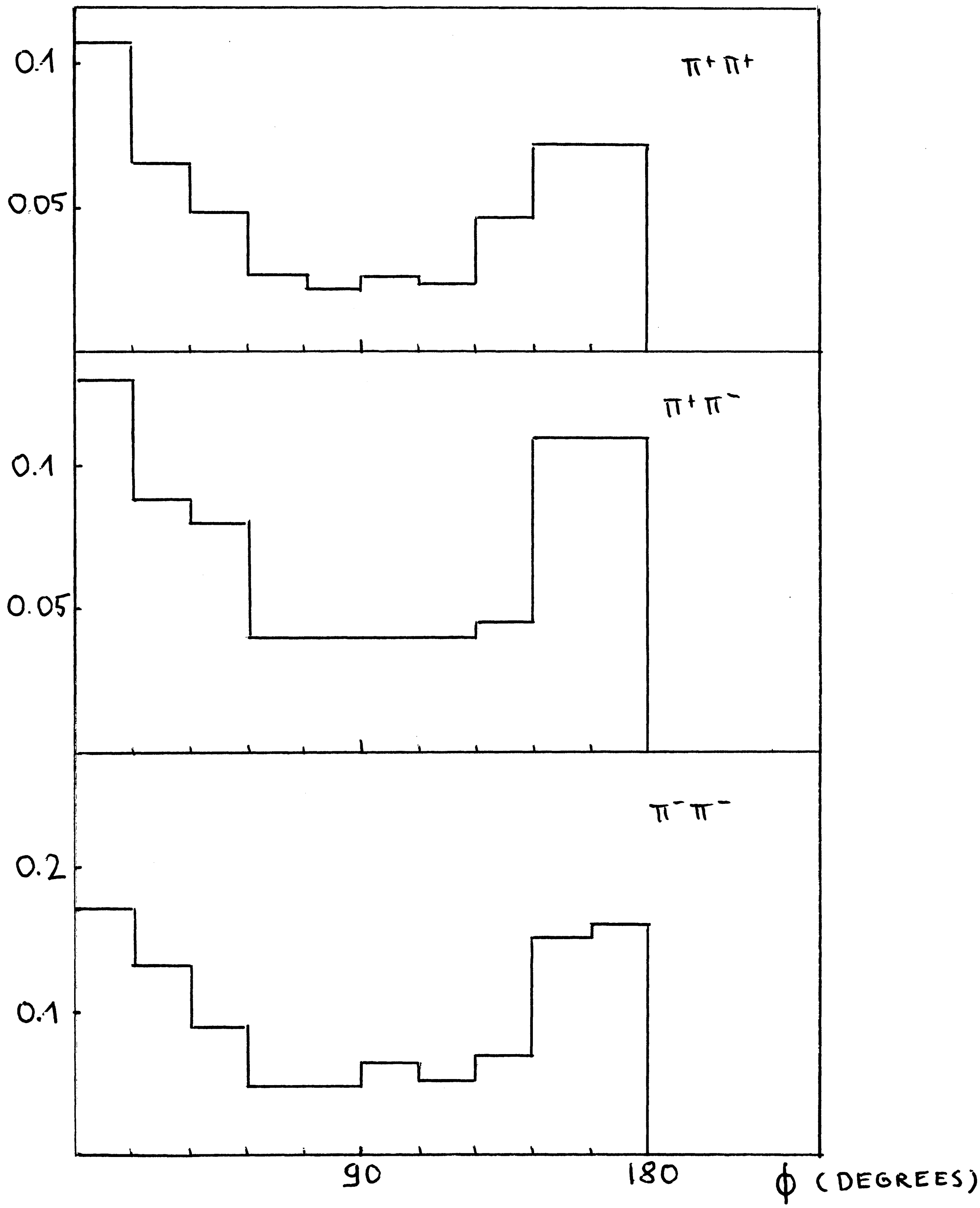

FIGURE 5. ACCEPTANCE IN ϕ