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MEASUREMENT OF TWO PARTICLE CORRELATIONS IN MULTIPARTICLE EVENTS IN THE FRAGMENTATION REGION WITH THE SFM SPECTROMETER

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I. Introduction

At ISR energies the investigation of many particle processes will be of major interest in particular with respect to genuine multibody effects. Events with twelve particles in the final state have so many free kinematical variables that exclusive experiments seem unfeasible. For inclusive experiments single particle spectra have found a considerable interest, and existing data support for some reactions theoretical hypothesis, e.g. Feynman scaling or limiting fragmentation. Approved ISR experiments will test such theoretical concepts at ISR energies.

The next obvious step is to investigate multiparticle correlations in production processes and two-particle correlations are of course the simplest ones to measure and to interpret. By observing correlations one might hope to get more detailed information on the dynamics of strong interaction at high energies and to be able to distinguish better between different models than by studying single particle spectra which seem to be connected mainly with general properties of the interaction and are not very sensitive to the specific properties of the interaction[1)4)16]. Very little is known so far on correlations. Indeed it is not even completely clear which kinematical variables are relevant, and hence experimental results will have to be approached from a phenomenological point of view. In section II some specific arguments will be given to support the proposed experiment. However, these should be taken rather as examples of what could be done with the data.

We propose to measure the following two-particle correlations in the fragmentation region :

1) p - n correlations for the two leading nucleons in the reaction $p + p \rightarrow p + n + \text{anything}$.

We are mainly interested in the fragmentation region and hence the observed longitudinal momenta will lie in the range $0.2 < x < 1$ where $x = p_{\parallel}/p_0$ and $p_{\parallel}$ and p_0 are the longitudinal and primary momentum of the nucleon in the c.m. system, respectively. As large a range of transverse momenta as possible would be of interest. Besides investigating various correlations between x and $p_{\perp}$ of the two particles a major aim of the experiment is to test the existence of possible azimuthal asymmetries.

Of course pp correlations in the process $p + p \to p + p + X$ should also be measured. Since another group [19] has proposed such an experiment this information will become available. We certainly would also be prepared to collaborate with this or other groups.

2) In the processes $p + p \to p + \pi +$ anything and $p + p \to \pi + \pi +$ anything the correlation between a proton and π and two fast π going roughly in the same direction can be measured with the same equipment that is necessary to measure the correlation 1). In both correlations a Čerenkov counter able to identify more than one particle is necessary to distinguish π from p. The kinematical parameters will be similar to those in 1). As will be discussed in section II a search for azimuthal asymmetries is of particular interest in this case.

Since by measuring the correlations proposed here at the ISR one is entering a new field of hadron physics as large a range of phase space as possible should be investigated. In addition some of the expected correlations will be small and hence a high statistical accuracy will be required. For these reasons the SFM spectrometer is necessary for the proposed measurements.

As a by-product of correlation 1) the single particle neutron spectrum will be obtained which is interesting in itself (see section II) and is not measured in any other proposed experiment.

The trigger will be made as loose as background will permit. Hence some information on multiplicities will also be obtained.

II. Current theoretical ideas

Multiparticle production processes can be described by various models, the two most popular being the multiperipheral models [2] and the thermodynamic model [3]. The latter does not make any predictions on particle correlations except those originating from resonance production and hence it is of no use for our purposes. In order to extract predictions from the multiperipheral model one can use the Feynman gas analogy [4] or different approaches based on Regge pole exchanges. A generalised optical model introduced by Mueller [5] provides a tool to discuss inclusive reactions in the familiar Regge language at least for certain kinematical regions. Since most of the recent theoretical papers are based on this approach we shall mainly use it in the following. We are interested in the fragmentation region implying that the resonance as well as the pionization region are not considered.

1) Single particle inclusive spectra

Although the main aim of this experiment is to measure correlations, we shall also automatically get data on single particle spectra, in particular of neutrons from the reaction $p + p \to n + X$. In order to explain the interest in such distributions one has to consider the different kinematical limits.

The one-particle-inclusive spectrum of $a + b \to c + X$ (fig. 1a) can be related to a missing mass total discontinuity of the forward elastic scattering amplitude $a + b + \bar{c} \to a + b + \bar{c}$ (fig. 1b). This amplitude depends on three independent variables, i.e. the c.m. energy squared s, the missing mass squared M^2 and the low momentum transfer from particle b to c t_b (or instead the longitudinal momentum of particle c in any frame).

1.1) In the fragmentation region (single Regge limit) it is assumed that s and t_b become large, whereas s/M^2 remains finite (fig. 1c). For large s one has $M^2/s \approx 1 - x$ where x is the normalised c.m. momentum of particle c and hence $s/M^2 \approx$ finite implies that x can take any value between 0 and 1 in this kinematical limit. Measurements at accelerator energies for the reaction $p + p \to p + X$ show [6] that scaling holds approximately for $0.2 < x < 0.9$. In the higher x range deviations might exist. It seems interesting to investigate if the leading neutron spectrum also exhibits scaling or if there are larger deviations.

The form of the neutron spectrum at one energy alone would be interesting by itself. Chou and Yang [7] distinguish between "favoured" and "disfavoured" fragmentation distributions. A favoured fragment c has the same internal quantum numbers (except J^P) as particle a. Other fragments are disfavoured. Favoured distributions are expected to be non-zero on the kinematic boundary ($x \to 1$), whereas disfavoured distributions fall off rapidly. Indeed protons from pp collisions have a δ-function peak at $x = 1$ (elastic scattering), but all other spectra vanish rapidly. All disfavoured distributions which have been measured so far involve one particle fragmenting into another with quite different quantum numbers ($|\Delta Q| = 2$, $|\Delta B| = 1$, etc.). The fragmentation of a proton into a neutron is associated with a less drastic change of quantum numbers and it would be interesting to see the qualitative behaviour of this spectrum. No experimental data of $p + p \rightarrow n + X$ exist except for some very preliminary results obtained in an ISR test run[8].

1.2) In the triple Regge limit it is assumed that both s and s/M^2 become very large. The reaction can then be described approximately by a graph as shown in fig. 1d. The condition $s/M^2 \rightarrow \infty$ implies $x \rightarrow 1$. A comparison of the reactions $p + p \rightarrow p + X$ and $p + p \rightarrow n + X$ is very interesting for the following arguments [8a]. If one looks at resonance production the two processes $p + p \rightarrow p + N^*$ and $p + p \rightarrow n + N^*$ differ essentially since one expects from duality that the first cross section should be much larger than the latter. This is because Pomeron - Pomeron - Reggeon coupling can contribute to the first process but not to the second, and this coupling should be important a priori. The inclusive reaction $p + p \rightarrow p + X$ however involves a triple Pomeron coupling (fig. 1d) which seems to be small and hence we expect that its cross section is not larger than that of $p + p \rightarrow n + X$. Indeed for $x \simeq 1$ one expects $\sigma(pp \rightarrow nX) \approx 2\,\sigma(pp \rightarrow pX)$ if pion exchange dominates. In contrast to resonance production one would observe a genuine multi-particle effect. The cross section should be of the type

$$\omega \frac{d\sigma}{d^3q} \approx \frac{1}{s} \left(\frac{s}{M^2}\right)^{2\alpha(t)} M^{2\bar{\alpha}(0)}$$

for $x \approx 1$, s/M^2 large. α and $\bar{\alpha}$ are defined in fig. 1d.

No results are available for $p + p \rightarrow n + X$.

The data on $p + p \rightarrow p + X$ at accelerator energies have been interpreted by various authors [9] [10] [11] but the conclusions do not agree yet. In the resonance region Pomeron exchange predominates, while it seems that in the region $x < 0.8$ α_{eff} is not very different from zero. This might indeed be an indication for π exchange. In this case one would expect, as was mentioned above, that for $x \approx 0.8$ the number of neutrons should be twice the number of protons. This is because the upper vertices in fig. 1d) are $pp\pi^0$ and $pn\pi^+$, respectively, and hence the vertex functions differ by a factor $\sqrt{2}$. However, the number of neutrons cannot be larger than the number of protons for all x values. This is because it was shown [7] [10] that in pp collisions the overall fragmentation fractions are 40% for protons, 12% for neutrons and 40% for pions. Even if about half of the protons are due to elastic scattering the total number of protons is still higher than the total neutron number. Hence one might expect that the neutron spectrum is higher than the proton spectrum around $x \approx 0.8$ (outside the resonance region), but at smaller x where the arguments of the triple Regge limit do not hold anyway, the neutron spectrum might be lower than the proton spectrum. It certainly would be very interesting to see if such a cross over exists.

A further argument to measure $pp \rightarrow n + X$ in addition to $pp \rightarrow p + X$ follows from the work of Chliapnikov et al.[12]. They showed that the most significant features of the charge exchange reaction $K^+p \rightarrow K^0 + X^{++}$ can be reproduced by the triple Regge behaviour, and they think this should be true for other charge exchange reactions including $p + p \rightarrow n + X^{++}$, whereas missing mass analysis with leading Pomeron and baryon exchange seems to be less successful.

2) Two particle inclusive correlations

We propose to investigate the correlation between

a) two leading nucleons, in particular between a proton and a neutron going in opposite directions,

b) a proton and a pion both going in the same direction, and

c) two fast pions going in the same or opposite directions.

Again we shall investigate the fragmentation region which implies $0.2 < x \lesssim 1$, whereas the pionization region ($x \sim 0$) is excluded by our experimental set-up.

The inclusive two-particle reaction as shown in fig. 2a is determined by six independent variables, i.e. the two momentum transfers t_α and t_β, the missing mass M^2 and the two energies squared s_α and s_β as defined in fig. 2a. The sixth variable is the difference $\varphi_{\alpha\beta}$ between the azimuthal angles of particles α and β. If M^2 is large the c.m. energy squared is related to these variables by

$$s \approx \left(\frac{s_\alpha}{M^2}\right) \cdot \left(\frac{s_\beta}{M^2}\right) \cdot M^2$$

and in terms of Feynman variables one has

$$\frac{M^2}{s_\alpha} \approx 1 - x_\alpha \quad , \quad \frac{M^2}{s_\beta} \approx 1 - x_\beta$$

$$\frac{M^2}{s} \approx (1 - x_\alpha)(1 - x_\beta).$$

If the probability of finding the single particles α and β with a given momentum transfer (or transverse momentum) and a given longitudinal momentum is designated by $\rho_\alpha(t_\alpha, x_\alpha)$ and $\rho_\beta(t_\beta, x_\beta)$ and $P(t_\alpha, x_\alpha, t_\beta, x_\beta)$ is the probability of finding both particles simultaneously then one can define a correlation function for a given s

$$F(t_\alpha, x_\alpha, t_\beta, x_\beta) = P(t_\alpha, x_\alpha, t_\beta, x_\beta) - \rho_\alpha(t_\alpha, x_\alpha) \cdot \rho_\beta(t_\beta, x_\beta). \qquad (1)$$

If the two particles are produced independently F goes to zero.

The information one would like to get on F is twofold :

2.1) <u>General predictions of the multiperipheral model</u> should be established, e.g.

a) There should be no correlation if the difference between x_α and x_β (or between the respective rapidities) is large. Hence for nucleons going in opposite directions $F \approx 0$ should be expected. However theory cannot predict so far how rapidly the correlation should disappear. Wilson [4] suggests that it should die out exponentially as the difference in rapidities increases.

b) It should be checked if there are scaling laws for F of a similar type as those found for ρ , e.g. scaling in x_α if t_α, t_β and x_β are fixed.

c) The question as to whether factorization holds in correlations should be tested.

Although no definite quantitative prediction is possible at present it seems that for particles with not too different rapidities the correlations could be quite sizeable. This follows from arguments given by Bassetto, Toller and Sertorio [14], who relate the variance of the average multiplicity n to the average correlation

$$\langle n^2 \rangle - \langle n \rangle^2 = \langle n \rangle + \sum R_{\alpha\beta} \qquad (2)$$

where $R_{\alpha\beta}$ is essentially the integral of the normalized correlation function F of Equ. (1) over the kinematical variables. The authors showed that from experimental data one can conclude that the two terms on the right hand side of the above equation have about the same size. A sizeable part of the summed correlation probably occurs in the pionization region [15], but large correlations may appear in the fragmentation region.

2.2) A study of more detailed dynamical questions can give a deeper insight into strong interactions. In particular a measurement of the <u>azimuthal correlation</u> of the two particles could help to reveal the nature of the

Pomeranchuk singularity. Two suggestions have recently been made in this respect.

a) Freedman et al. [16] proposed to investigate whether Regge cuts contribute to the Pomeranchon singularity. For this purpose the two-particle distribution is related to the diagram shown in fig. 2c using Mueller's technique. If one takes the high energy limit $\mathcal{M}^2 \approx$ large, but t_1, t_2, $s_1/\mathcal{M}^2$ and $s_2/\mathcal{M}^2$ finite, it is found that the cross section for the emission of particles α and β is

$$\frac{d\sigma}{\frac{d^3q_\alpha}{\omega_\alpha}\cdot\frac{d^3q_\beta}{\omega_\beta}} = \frac{1}{s}\sum_{M=-\infty}^{\infty} e^{-iM\varphi_{\alpha\beta}}\left(\mathcal{M}^2\right)^{\alpha_v(0)} F_M\left(t_\alpha, t_\beta, x_\alpha, x_\beta\right) \qquad (3)$$

where $\alpha_v(0)$ is related to the leading singularity with the Lorentz quantum number M and coincides with the leading vacuum angular momentum singularity. $\varphi_{\alpha\beta}$ is the azimuthal angle between the particles α and b.

In the case of a simple pole the sum over M reduces to the single term with M = 0 and there is no azimuthal correlation. If the leading singularity is a cut the entire sum over M will contribute. Hence an observed dependence on $\cos\varphi_{\alpha\beta}$ implies a cut component to the Pomeron or some other more complicated singularity than a simple pole.

For the Pomeron one has $\alpha_v(0) = 1$ and hence the dependence on s drops out since $\mathcal{M}^2/s \approx$ const. If on the other hand cuts contribute one gets additional $\log \mathcal{M}^2 \sim \log s$ terms. Therefore it seems interesting to investigate the s-dependence of the azimuthal correlation.

In the triple Regge limit with $\mathcal{M}^2$, $s_\alpha/\mathcal{M}^2$, $s_\beta/\mathcal{M}^2$ all large, but t_α, t_β finite (fig. 2d) (which implies $x_\alpha \to 1$, $x_\beta \to 1$, $(1 - x_\alpha)(1 - x_\beta)\cdot s$ large) one obtains [16] instead of Equ. (3)

$$\frac{d\sigma}{\frac{d^3q_\alpha}{\omega_\alpha}\,\frac{d^3q_\beta}{\omega_\beta}} = \frac{1}{s}\sum_{M} e^{-iM\varphi_{\alpha\beta}}\left(\mathcal{M}^2\right)^{\alpha_v(0)}\left(\frac{s_1}{\mathcal{M}^2}\right)^{2\alpha(t_\alpha)}\left(\frac{s_2}{\mathcal{M}^2}\right)^{2\alpha(t_\beta)}\bar{F}_M(t_\alpha, t_\beta) \qquad (4)$$

The general arguments on the relation between the $\varphi_{\alpha\beta}$-dependence and the nature of the leading singularity are not changed.

If $\alpha_v(0)$ is a simple pole both Equ. (3) and (4) should scale when divided by $\sigma_{tot}(s)$. Furthermore if factorization occurs then F_0 should be the product of the single particle distributions.

To test the nature of the leading singularity it seems advantageous to observe particles going in opposite directions ($x_\alpha > 0$, $x_\beta < 0$) since in this case the contribution from non-leading singularities should be small [17]. However a high precision is needed since the correlations will be small. In the pionization region the influence of cuts seems to be small.

b) Bassetto and Toller [17] considered the possible contributions of non-leading asymptotic terms to a Lorentz pole with M = 0. An expansion in the relative rapidity $\xi_{\alpha\beta}$ between the two observed particles α and β leads to the following expression for the correlation function

$$\frac{P(\alpha,\beta)}{\sigma_{TOT}} \simeq \rho_\alpha(p_\alpha,\theta_\alpha)\cdot\rho_\beta(p_\beta,\theta_\beta) - \tag{5}$$
$$- \frac{2M^2}{s\,a(0)} \cos\varphi_{\alpha\beta} \frac{\partial}{\partial\theta_\alpha}\rho_\alpha(p_\alpha,\theta_\alpha)\cdot\frac{\partial}{\partial\theta_\beta}\rho_\beta(p_\beta,\theta_\beta)$$

where particle α is emitted with momentum p_α under the direction θ_α, φ_α and similarly particle β and $\varphi_{\alpha\beta} = \varphi_\alpha - \varphi_\beta$. $a(0)$ is the intercept of the leading pole.

If the proton (α) and the pion (β) go in the same direction Equ. (5) can be written in the form [18]

$$\frac{P(\alpha,\beta)}{\sigma_{TOT}} \simeq \rho_\alpha\cdot\rho_\beta - \frac{\partial}{\partial\theta_\alpha}\rho_\alpha(p_\alpha,\theta_\alpha)\,\frac{\partial}{\partial p_{\perp\beta}}\rho(p_{\perp\beta})\sqrt{p_{\perp\beta}^2+M_\beta^2}\;e^{-\xi_{\beta A}}\cos\varphi_{\alpha\beta} \tag{6}$$

where $\xi_{\beta A}$ is the relative rapidity between particle β and the incident particle A, both going in the same direction.

It should be noted that the correlation term in Equ. (6) does not contain s any more and therefore no energy dependence is expected. This differes from cut contributions which lead to (log s) terms as has been discussed above.

The exponential dependence on the rapidity $\xi_{\beta A}$ is also quite characteristic and should be checked experimentally. In the case of cut contributions one would rather expect a dependence as some power of $\xi_{\beta A}$. Since the effect of non-leading singularities dies out exponentially with $\xi_{\beta A}$ it seems that our proposed measurement of the correlation between a proton and a pion both going in approximately the same direction is quite advantageous. A correlation with a $\cos\varphi_{\beta\alpha}$ term would indicate contributions of non-leading singularities if it goes with $e^{\xi_{\beta A}}$. Discrepancies with Equ. (6) on the other hand would suggest the existence of singularities with $M \geq 1$ as discussed under a).

c) If both the azimuthal correlations $p + p \rightarrow p + \pi^+ + X$ and $p + p \rightarrow p + \pi^- + X$ are measured one can calculate their difference which is associated only to I = 1 exchange. In this way it might be possible to establish contributions from the ρ' which has M = 1 [18].

III. Experimental set-up

For the proposed experiment the basic set-up of the proportional wire chambers can be used. The essential additions to these chambers are (see fig. 1) :

Čerenkov hodoscopes to identify charged particles,
a total absorption neutron spectrometer,
trigger counters

a) Two gas Čerenkov counters will be used to separate π from K and protons. Since we will investigate multiparticle events the Č counter must be able to identify more than one charged particle per event. With an average charged multiplicity of about 7 we expect 2 to 5 charged particles traversing the Č counter. Instead of using a Č counter hodoscope to identify those particles we propose to use a single Č counter of special design together with the information from the MWPC.

The only place to install a Č counter is between chambers 21(15) and 22(16) (see fig. 3). The available length is just sufficient for a gas Č counter. Its dimensions will be approximately: 230 cm wide, 100 cm high and 100 cm deep. The counter on the right side of the intersection (C_R) will be composed of two identical parts each 50 cm high. The counter on the left (C_L) consists only of one half, since the remaining space is required for the neutron counter.

The design of the Č counters is shown in fig. 4. A cylindrical mirror reflects the light onto a second adjustable cylindrical mirror from where it is guided by a reflecting cone onto the photo-multipliers. About 23 multipliers are foreseen for each half of the counter. The light emitted by a particle flying in a given direction will in a typical case hit two of the 23 phototubes. A computer programme using the information on the trajectories and momenta of the particles supplied by the MWP chambers will single out those particles which produced light and those which did not.

Preliminary calculations indicate that with the available length of about 1m separation of π from K and p should be possible up to 10 GeV/c and separation of π and K from p up to 20 GeV/c. A horizontal spatial resolution of about 10cm seems feasible. The detailed design of this counter is still in progress.

b) A neutron total absorption counter N_L will be placed beneath the beam tube on the left side. It will thus be installed just below C_L. There is not enough space available to set up the Cerenkov hodoscope and the neutron counter one behind the other. The reason for installing the neutron counter below (or if necessary above) the beam tube instead of sideways is due to the fact that the azimuthal asymmetries are proportional to $\cos\varphi_{\alpha\beta}$ and hence the most precise information is obtained from $\varphi_{\alpha\beta} \approx 0$ and $\approx 180^{\circ}$. Now in the SFM the range of accepted $p_{\perp}$ is larger for particles emitted up or down than for particles produced in the horizontal plane.

The neutron spectrometer is shown in fig. 2. It consists of an anticounter A, a converter C (about 6cm Al), a trigger hodoscope T and a Fe-scintillator sandwich. In order to get as good an energy resolution the following measures are taken. Only neutrons converted in C are counted by requiring a trigger of T. This assures that practically the full length of the shower is contained in the iron. The converter C is smaller than the cross section of the total absorption sandwich in order to minimize lateral losses in the shower. In total about 80cm of Fe (about 6 interaction lengths) are used. In a previous experiment [20] 4cm thick iron plates were used and a resolution of about $\pm$ 12% could be achieved for neutron energies of 10 GeV and higher. We are testing at present whether thinner plates would give a better resolution.

In order to determine the point of interaction of the neutron the trigger counter T will in reality be a hodoscope. The most favourable subdivision of T is still being studied.

Events with A in coincidence instead of anticoincidence with T and S can be recorded simultaneously. This will permit to compare neutrons and charged particles under the same conditions (resolution, solid angle).

A neutron counter as described here has been used during some test runs at the ISR [8] and it was found that it is performing as expected also under ISR conditions.

c) Trigger

The trigger will be made as loose as possible in order to be able to collect as much information as possible. A scintillation counter ($260 \times 50 \times 2$ cm^3) will be placed in front of each of the C counters (T_R, T_L in fig. 3). The following trigger combinations will be recorded simultaneously and identified by a pattern unit :

coincidences T_R T_L : correlation of 2 charged particles going in opposite directions : pp, $p\pi^{\pm}$, $\pi^{\pm}\pi^{\pm}$.

There should be no background problem since beam - gas and beam - wall events are strongly suppressed by this trigger, especially if the time difference between T_R and T_L is measured.

coincidences T_R N_L, where N_L stands for ($\bar{A}$TS) of the neutron counter : correlations pn and $\pi^{\pm}n$ for particles going in opposite directions.

Test measurements have shown that also in this case background can be eliminated if the beam tube is not too thick.

coincidences T_R C_R or T_L C_L (perhaps with the additional requirement for the pulse height of T to correspond to two or more particles) : correlation $p\pi^{\pm}$ with both particles going in the same direction.

The suppression of background will be much more difficult in this case since beam - gas events can lead to such a trigger. However extrapolating from present one arm spectrometer experiments it may be hoped that the background is smaller than 20%. Of course it could be measured by displacing the two beams with respect to one another or by dumping one beam. Including some of the fast signals of wire planes in the trigger might also help. A further possibility investigated is the use of a 2π scintillation counter set up in the opposite direction of the $p\pi^{\pm}$ particles in coincidence with T_R C_R or with T_L C_L.

coincidences N_L C_L : correlation $n\pi^{\pm}$ for particles going in the same direction.

The background problem will be the same as in the previous case.

IV. Expected event rates

The estimates of counting rates are based on a current of 10 A in each ring and a beam height of 0.5cm which corresponds to a luminosity of $L = 2 \times 10^{30} cm^{-2} sec^{-1}$ and an interaction rate of $N_{inter} = 8 \cdot 10^4/sec$. We used the formulae given by Cocconi [21] to calculate the single particle rates. The coincidence rates were estimated simply by $N_{coin} = N_{inter} \cdot \mathcal{E}_1 \cdot \mathcal{E}_2$ where $\mathcal{E}_1$ and $\mathcal{E}_2$ are the production probabilities per momentum interval for particles 1 and 2 respectively. That means correlation effects are neglected.

All rates are given for the momentum rates :

- charged particles $\Delta p_\perp = 0.05$ GeV/c
  $\Delta p_\parallel = 0.5$ GeV/c

- neutrons $\Delta p_\perp = 0.1$ GeV/c
  $\Delta p_\parallel = 2.0$ GeV/c

The acceptance of the SFM magnet was determined with the help of tables prepared by Kaufhold [22]. Some examples are shown in Table I. As far as acceptance of the detection system and the identification of the particles are concerned the longitudinal momentum range accessible to measurement is approximately from 3 to 20 GeV/c. The acceptance is still sufficient for transverse momenta up to about 1 GeV/c.

Examples of expected counting rates are shown in Tables II, III and IV . Except for those cases where $p_\perp$ of both particles is approximately 1 GeV/c or higher the statistical errors which could be obtained during 100 h of running time would be less than 5%. For π momenta above 12 GeV/c the accessible range of $p_\perp$ becomes much smaller, however.

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TABLE I

DETECTION PROBABILITY FOR CHARGED PARTICLES

Positive charged particles

$p_\perp$ (GeV/c) \ p (GeV/c)	5	10	15
0.1	1	1	1
0.5	0.4	0.7	0.6
1.0	0.1	0.6	0.5

Negative charged particles

$p_\perp$ (GeV/c) \ p (GeV/c)	5	10	15
0.1	1	1	1
0.5	1	1	1
1.0	0.2	0.7	0.7

TABLE II

Estimation of counting rates (h^{-1}) for $L = 2 \times 10^{30} cm^{-2} sec^{-1}$

π^- - p coincidences

E_{CM} = 40 GeV

1) proton momentum 5(GeV/c); pion momentum 5(GeV/c)

pion $p_\perp$(GeV/c) \ proton $p_\perp$(GeV/c)	0.1	0.3	0.7	1.0
0.1	900	770	80	15
0.3	1100	900	100	18
0.7	400	500	40	7
1.0	30	30	3	0.3

2) proton momentum 5(GeV/c); pion momentum 9(GeV/c)

pion $p_\perp$(GeV/c) \ proton $p_\perp$(GeV/c)	0.1	0.3	0.7	1.0
0.1	60	50	6	1
0.3	70	60	8	2
0.7	30	25	3	0.4
1.0	7	8	0.7	0.1

For higher proton momenta the counting rate will increase.

TABLE III

Estimation of counting rates (h^{-1}) for $L = 2 \times 10^{30} cm^{-2} sec^{-1}$

$\pi^+ - p$ coincidences

$E_{CM} = 40$ GeV

1) proton momentum 5(GeV/c); pion momentum 5(GeV/c)

pion $p_\perp$ (GeV/c) \ proton $p_\perp$ (GeV/c)	0.1	0.3	0.7	1.0
0.1	900	600	80	15
0.3	600	650	60	10
0.7	80	80	8	1.5
1.0	15	10	1.5	0.2

2) proton momentum 5(GeV/c); pion momentum 9(GeV/c)

pion $p_\perp$ (GeV/c) \ proton $p_\perp$ (GeV/c)	0.1	0.3	0.7	1.0
0.1	60	50	6	1
0.3	60	60	8	2
0.7	20	20	2	-
1.0	6	5	0.6	-

For higher proton momenta the counting rate will increase.

TABLE IV

Estimation of counting rates (h^{-1}) for $L = 2 \times 10^{30} cm^{-2} sec^{-1}$

proton - neutron coincidences

E_{CM} = 40 GeV

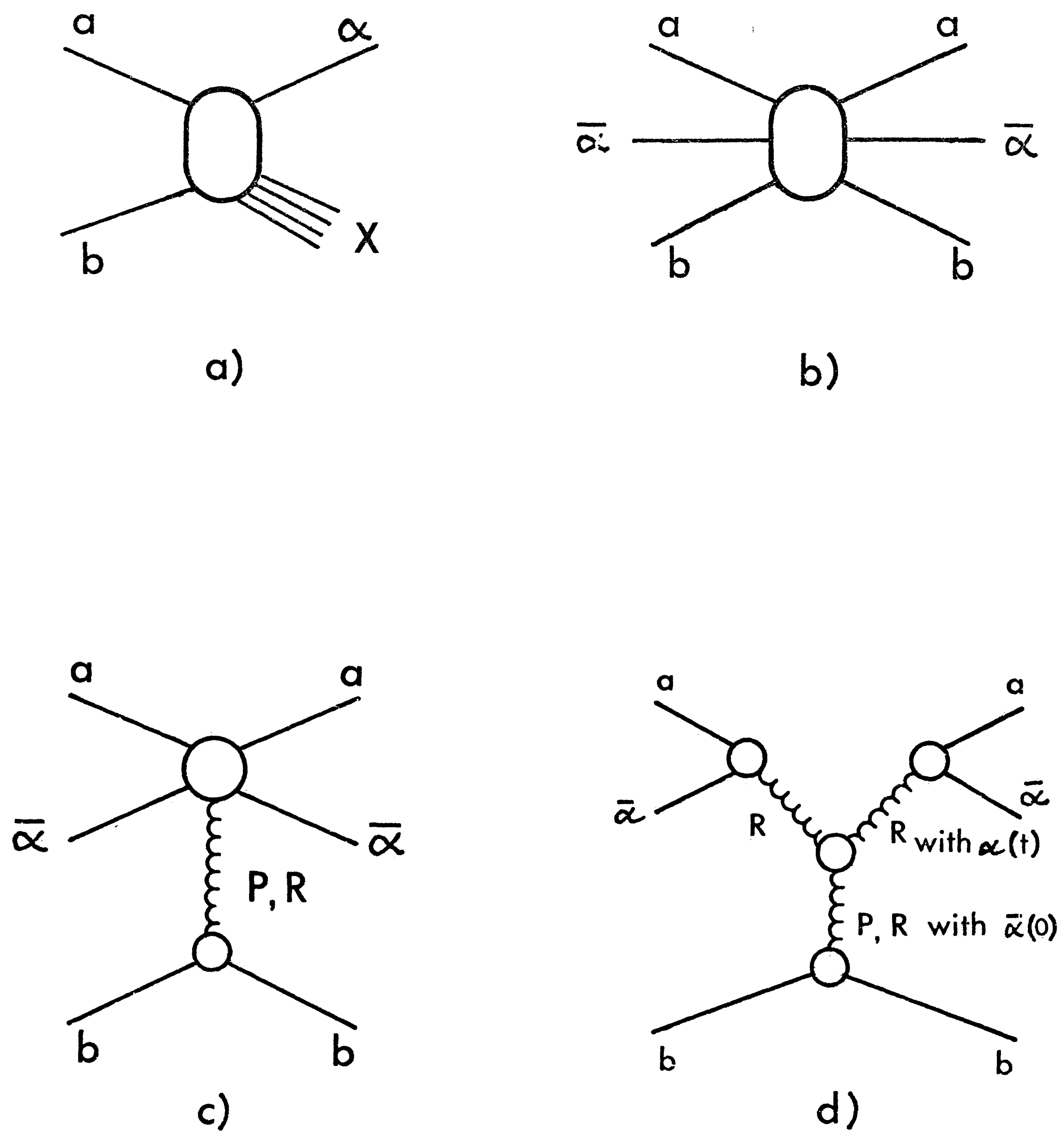
proton momentum 9 GeV/c

neutron momentum 9 GeV/c

efficiency of neutron counter $\mathcal{E}n$ = 0.1

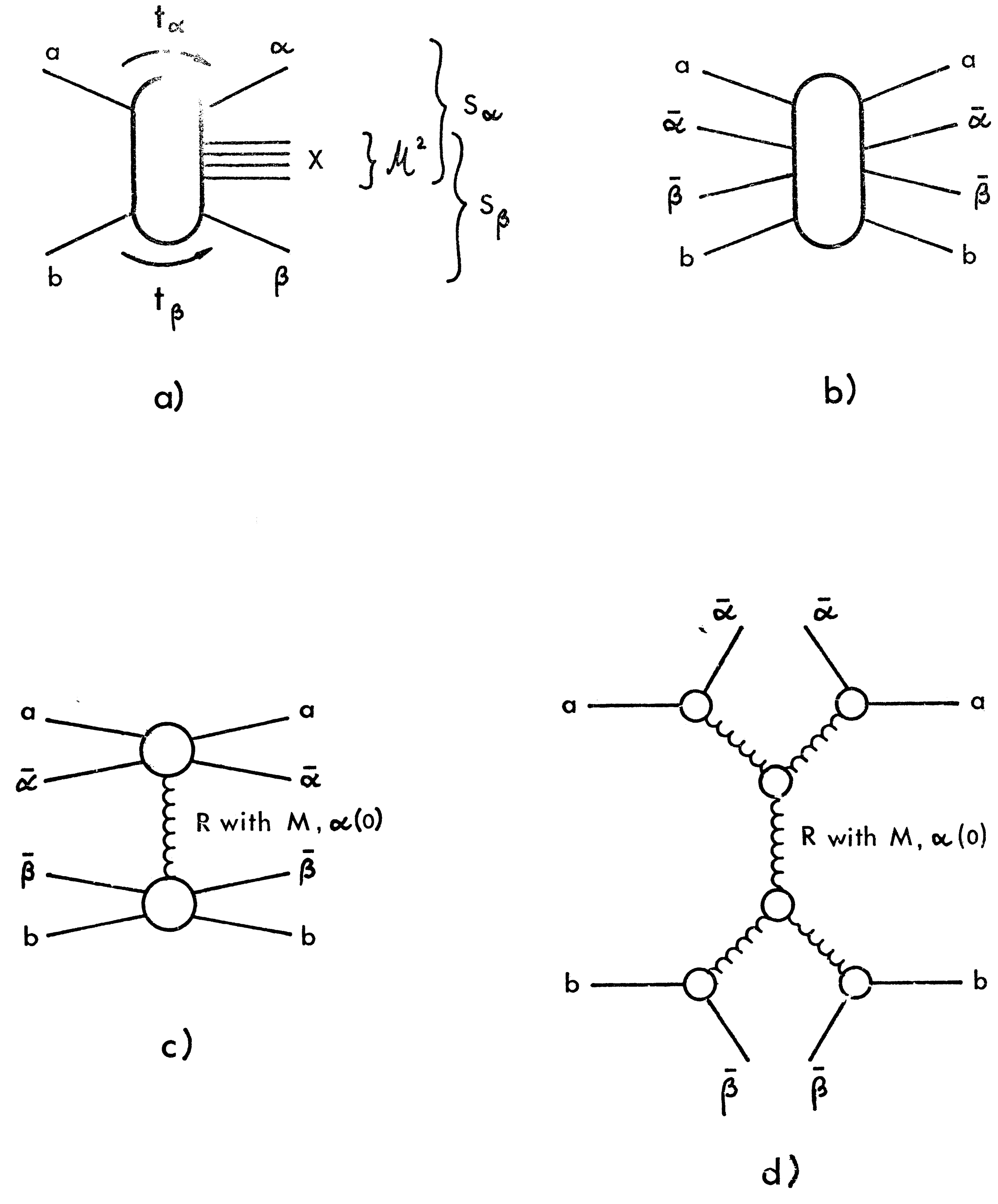
$\Delta p_{\parallel}$ = 2 GeV/c
$\Delta p_{\perp}$ = 0.1 GeV/c
for neutrons

neutron $p_{\perp}$ (GeV/c) \ proton $p_{\perp}$ (GeV/c)	0.1	0.3	0.7	1.0
0.1	480	580	130	50
0.3	580	700	160	60
0.7	220	270	60	20
1.0	79	100	20	7



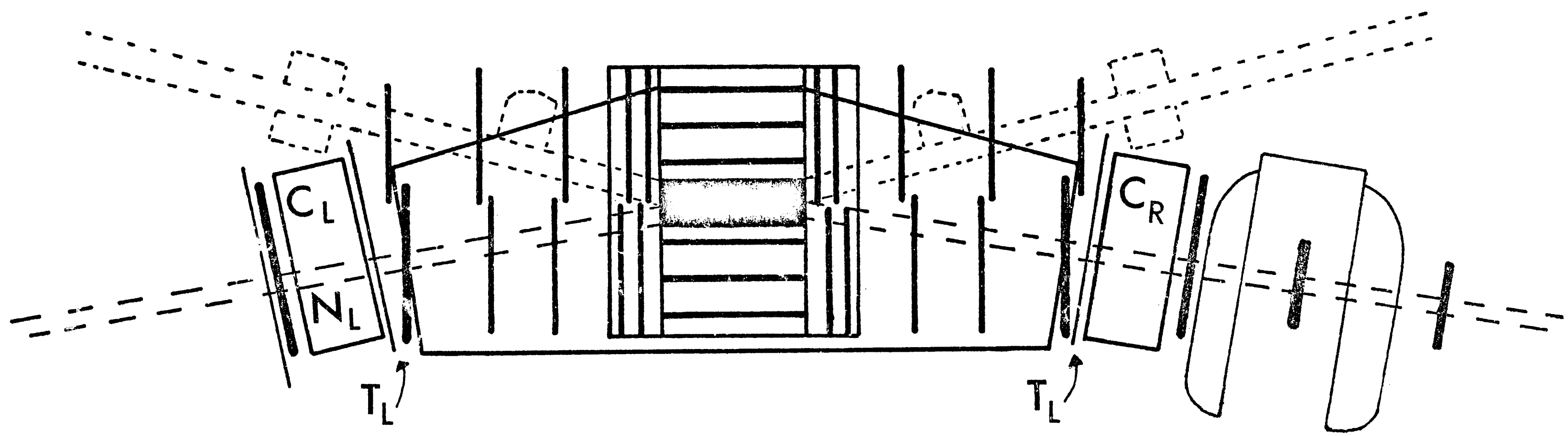
Single particle inclusive reactions

Fig. 1



Two particle inclusive reactions

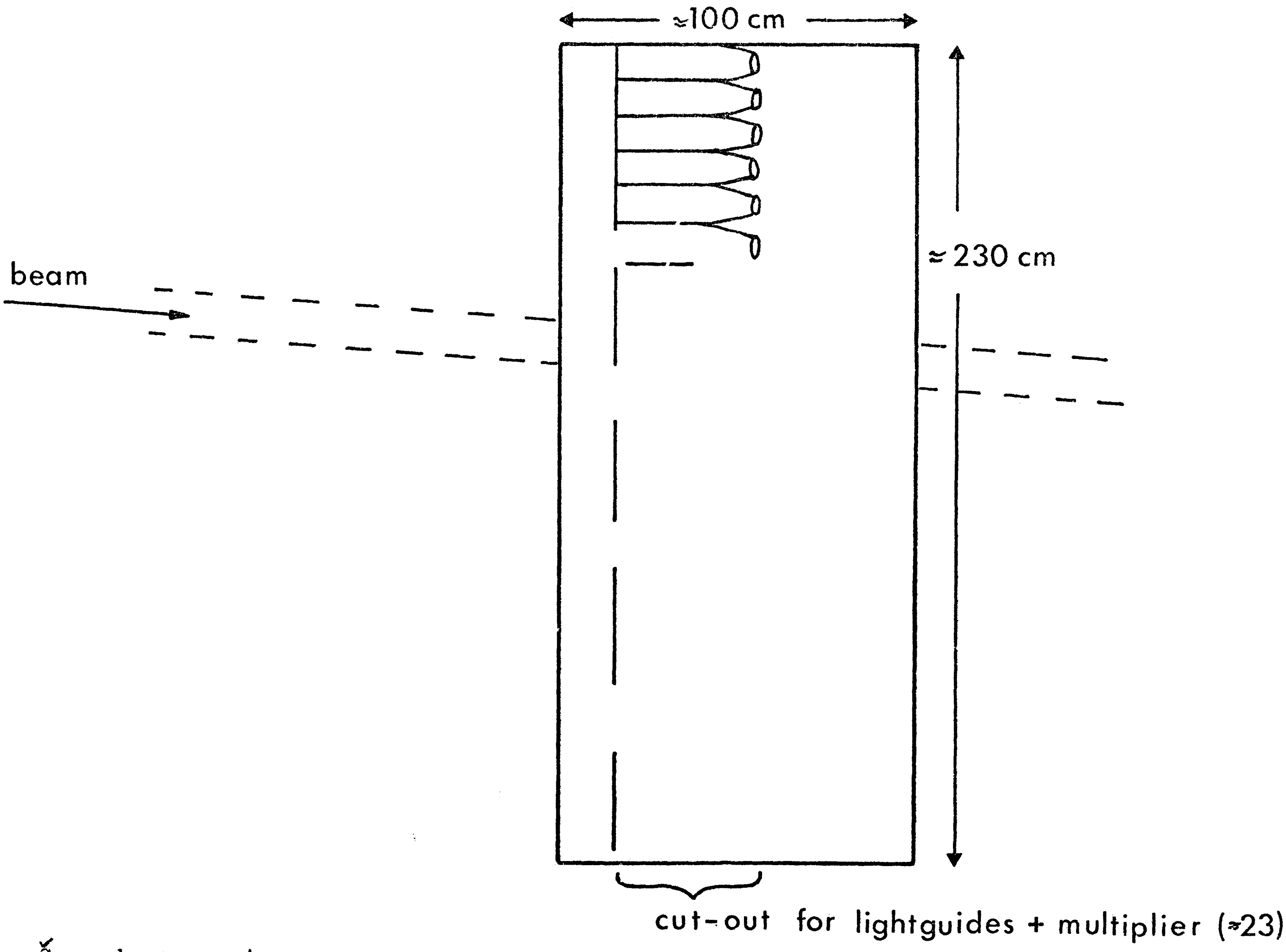
Fig. 2



Experimental set-up

Fig. 3

TOP VIEW



Čerenkov counter

SIDE VIEW

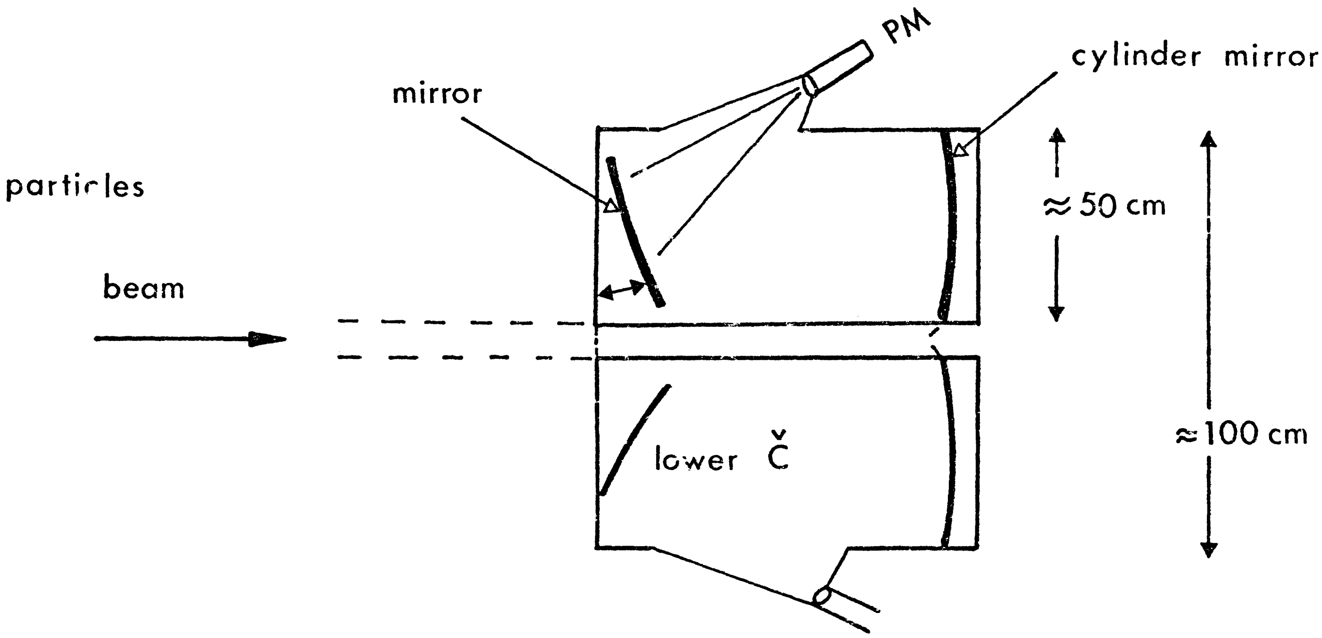
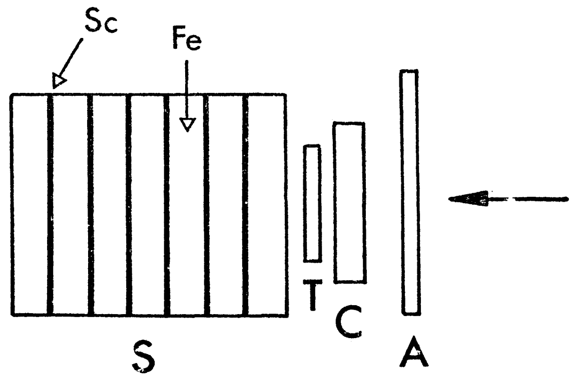


Fig. 4



Neutron total absorption spectrometer

Fig. 5