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Proposal of an experiment to study in BEBC pp interactions in the momentum region around 50 GeV/c, where the cross section is minimum and correlations are nearly absent.

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The momentum region around 50 GeV/c in pp interactions displays some peculiar features, namely

1) the total cross section reaches a minimum value (fig.1),
2) two-particle correlations are nearly zero(see in fig.2 the dependence on the incident momentum of the g^2 parameter [1], $g^2 = f_2/\langle n\rangle = (\langle n(n-1)\rangle - \langle n\rangle^2)/\langle n\rangle^2$, which is essentially the integral of the two-particle correlation function),
3) the correlation between the average number of π^0's and the charged multiplicity changes from negative to positive (see fig.3 and ref.2).

The second of these features is also present in other reactions ($\pi^{\pm}p, K^{\pm}p$) at about the same energy. These facts may support the idea of the occurrence of a 'phase transition' [1] in the 'intermediate' energy region and urge a more detailed experimental investigation.

We propose to start with the study of pp interactions which, being forward-backward symmetric, allow independent checks of the goodness of the event reconstruction and recovery of the extremely difficult forward cone. A series of experiments should eventually be performed with other incident particles, in order to obtain a systematic examination of this energy region.

For pp interactions the study could be made at five (or less) momenta between 35 and 65 GeV/c with the aim of analyzing how the possible phase transition might be reached.

In particular one should systematically study tne behavior of the charged particles correlations across the region where they become zero in order to see how this zero is approached. Also all accessible features of neutral production should be examined. Specifically some of the quantities to be measured are:

1) charged and neutral multiplicity distributions,

2) single particle distributions,

3) two-particle and higher order correlations,

4) charge and multiplicity characteristics of clusters.

Points 2 and 3 should be studied both inclusively and semi-inclusively (selecting on topologies).

The experiment consists of two parts; the first part is the study of charged particles to be made in bare BEBC, the second is the study of neutral pions to be made when the track sensitive target (TST) for hadronic interactions will be available. In the following both parts will be discussed for completeness, though the approval is at present requested only for the first part. To test the feasibility of the experiment we made a Montecarlo calculation [3] using published inclusive distributions of pp interactions at 24 GeV/c [4] and scaling them up to the energies of interest. The results reported below refer to the central energy value of 50 GeV; their variation over the entire energy range is in general small.

For the charged particles the reconstruction of transverse and longitudinal momenta can be done with a precision more than sufficient for an inclusive analysis in both the backward and the forward hemisphere. Regarding particle identification, in the backward hemisphere the proton momentum in the laboratory results smaller than 1.0 GeV/c in about 70% of the cases and should be identifiable by ionization; the identification of pions will be almost always possible only for pions produced in the very backward direction. However the identification of particles is not crucial for any of the problems mentioned above; the more so since the principal aim of the experiment is the energy dependence of the inclusive distributions and correlations rather than the distributions themselves. Due to the considerable size of BEBC a non negligible amount of gammas from π^0 decay will convert in the chamber even without a TST. The probability of converting in the chamber at least one gamma from each π^0 decay is about 20% if the primary interaction is in the first 200 cm of the chamber (see the first line in table 1). This will provide a sufficient number of gammas, as discussed in more detail below, to allow a first rough examination of the principal features of neutral production.

For a more complete analysis of neutral pions a TST should be used, possibly in conjunction with a forward gamma detector. To simulate the π^0 detection in the Montecarlo calculation, we assumed that a TST can be operated in BEBC with a 75% by volume Ne-H mixture. For the sake of simplicity we assumed a rectangular TST 100 cm wide, 20 cm thick and 280 cm long in the beam direction. This leaves about two radiation lengths in the very forward cone for the detection of forward gammas inside the chamber. If it results from operational requirements that the TST must extend over the entire chamber, the detection of forward gammas will have to depend on an external forward gammas detector. The other dimensions of the TST and its shape do not affect crucially the experiment. The fiducial volume for primary interactions was assumed to be the first 200 cm of target in the beam direction. The average conversion probability of the two gammas from the π^0 decay are collected in the second part of table 1.

Table 1

	forward π^0 (%)	backward π^0 (%)
bare BEBC: 1 γ from each π^0	20	16
with TST: 1 γ from each π^0	15	15
with TST: 2 γ " " "	70	85

The features of the gammas from forward π^0 are quite different from those of backward π^0. They are mainly emitted in a narrow cone ($\simeq 6^0$) around the beam direction, with a very narrow ($\simeq 1^0$) opening angle between the two gammas from the decay of the same π^0. Forward π^0's with both gammas converted should in principle have a good probability of a complete non-ambiguous reconstruction. However they will be affected by background from bremstrahlung gammas. Reduction of this background and of possible ambiguities should be favoured by the chosen target length and fiducial interaction volume which allow a convenient distance between production and conversion point of the forward gammas and thus a better separation. Backward π^0's produce gammas at a larger angle with the beam direction ($\geq 10^0$) with a rather large opening angle. For both backward and forward gammas it will be possible to obtain inclusive gamma distributions and average π^0 multiplicities with the help of a Montecarlo simulation. A small number of beam tracks per picture with a transverse distribution of the beam as wide as possible will be required to reduce correlation ambiguities.

Number of pictures requested.

For the first part of the experiment, concerning the charged particles, assuming 10 beam tracks per picture and 2m fiducial volume, 10000 pictures at each energy will provide the yield of various topologies given in the second column of table 2. The corresponding total number of gammas is given in the third column.

Table 2

topology	first part		second part	
	events	gammas	events	gammas
2 prong inelastic	3800			
4 prong	6000	2500	2400	9600
6 prong	5000	2000	2000	8600
8 prong	3000	1500	1200	5800
10 prong	900	500	350	2000
12 prong	350	200	120	800

A total of 50 Kpx for the five energies is therefore requested for the first part.

For the second part of the experiment, i.e. detection of π^0's, we assume 6 beam tracks per picture and 2m fiducial volume in the TST. With 6Kpx at each energy one would obtain for each topology the numbers of events and of gammas listed in the two last columns of table 2. For the calculation we used the average number of π^0 found at 40 GeV/c [2] and the conversion probabilities of table 1. A total of 30Kpx for the five energies should therefore provide a sufficient number of gammas for the analysis of the main inclusive features.

We note that the only data in this energy region is at present the 50 and 69 GeV/c experiment [5] of the France-Soviet union Collaboration, which has a rather low statistics for charged tracks only.

The groups of Torino and Pavia will have available by 1976 two BEBC scanning tables, 8 image plane digitizers for premeasurements, on line to an IBM 1130 (Torino) and to a PDP11/45 (Pavia), and access to two HPD's of the national centre in Bologna (CNAF). It should be possible to complete the first part of the experiment in one year, the second part in two years provided that the TST film be measurable on HPD machines. The Torino group is at present analyzing TST film obtained in the 1.5m chamber exposed to a 4 GeV π^+ beam, in collaboration with RHEL, CERN and LBL. The principal problems of scan, geometrical reconstruction and kinematical analysis have been solved [6] and some events successfully measured on HPD machines.

References.

(1)'Multiplicity distributions and normalized cumulants at low and high energy hadron-hadron scattering' - A.Giovannini et al. IFTT 205 (1974) - Universities of Torino and of Pavia preprint - to be published in Il Nuovo Cimento.

(2) L.Foa', Proceedings of the International Conference on Elementary particles, Aix-en-Provence-(1973)

(3) G.Gorlato - Tesi di Laurea - Universita' di Torino (1974)

(4)'Multiplicities, topological cross sections and single particle inclusive distributions from pp interactions at 12 and 24 GeV/c' - V.Blobel et al. (Bonn,Hamburg,Munchen Coll.) - Desy preprint 73/36 (1973).

(5) V.V.Ammosov et al. - France-Soviet Union Collaboration - Phys.Letters 42B[519 (1972)

(6) C.M.Fisher, J.G.V.Guy, J.W.G.Wignall, RL-73-142.

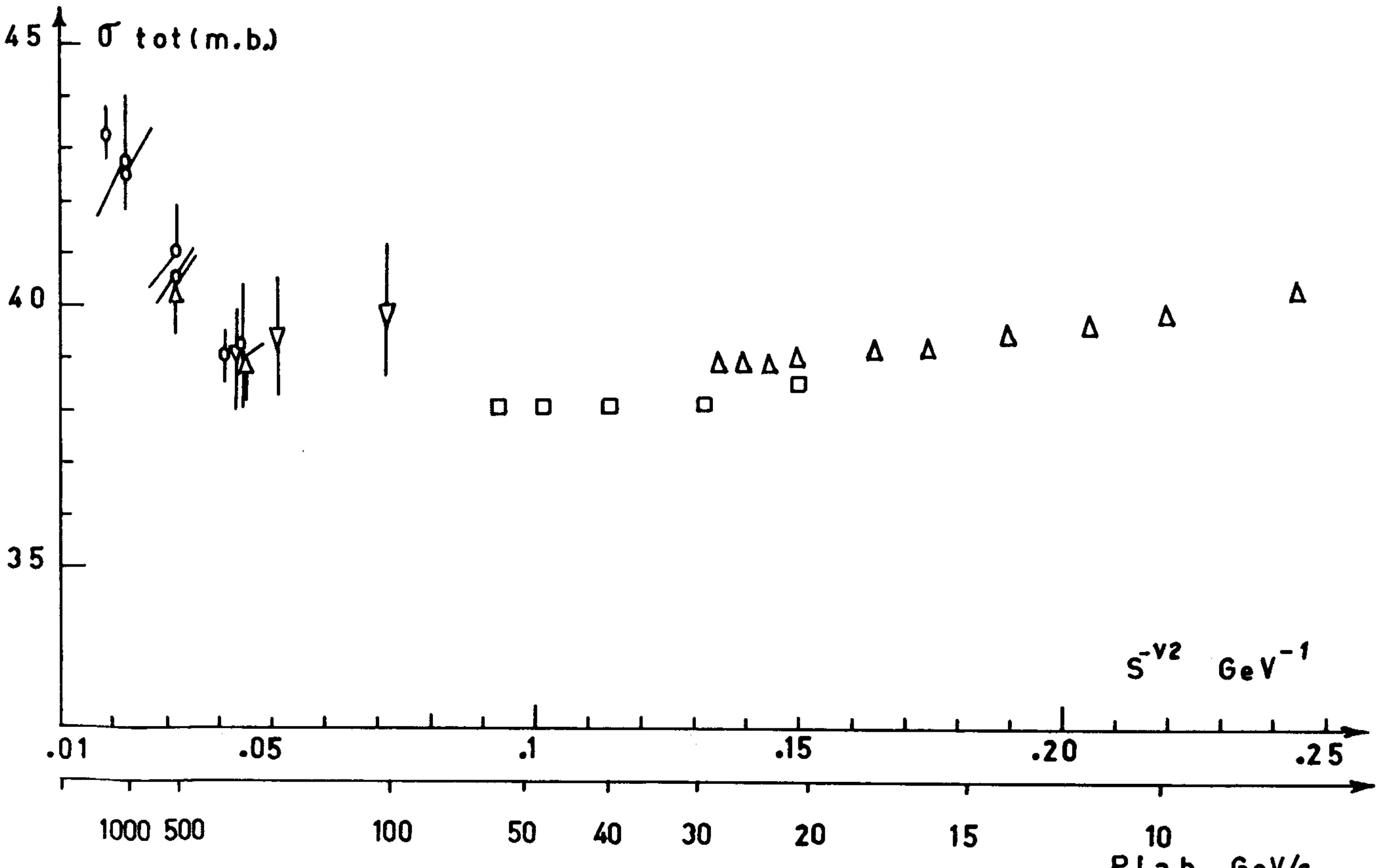
45
40
35
σ tot(m.b.)
S^-1/2 GeV^-1
.01
.05
.1
.15
.20
.25
1000 500
100
50
40
30
20
15
10
Plab GeV/c

Fig. 1

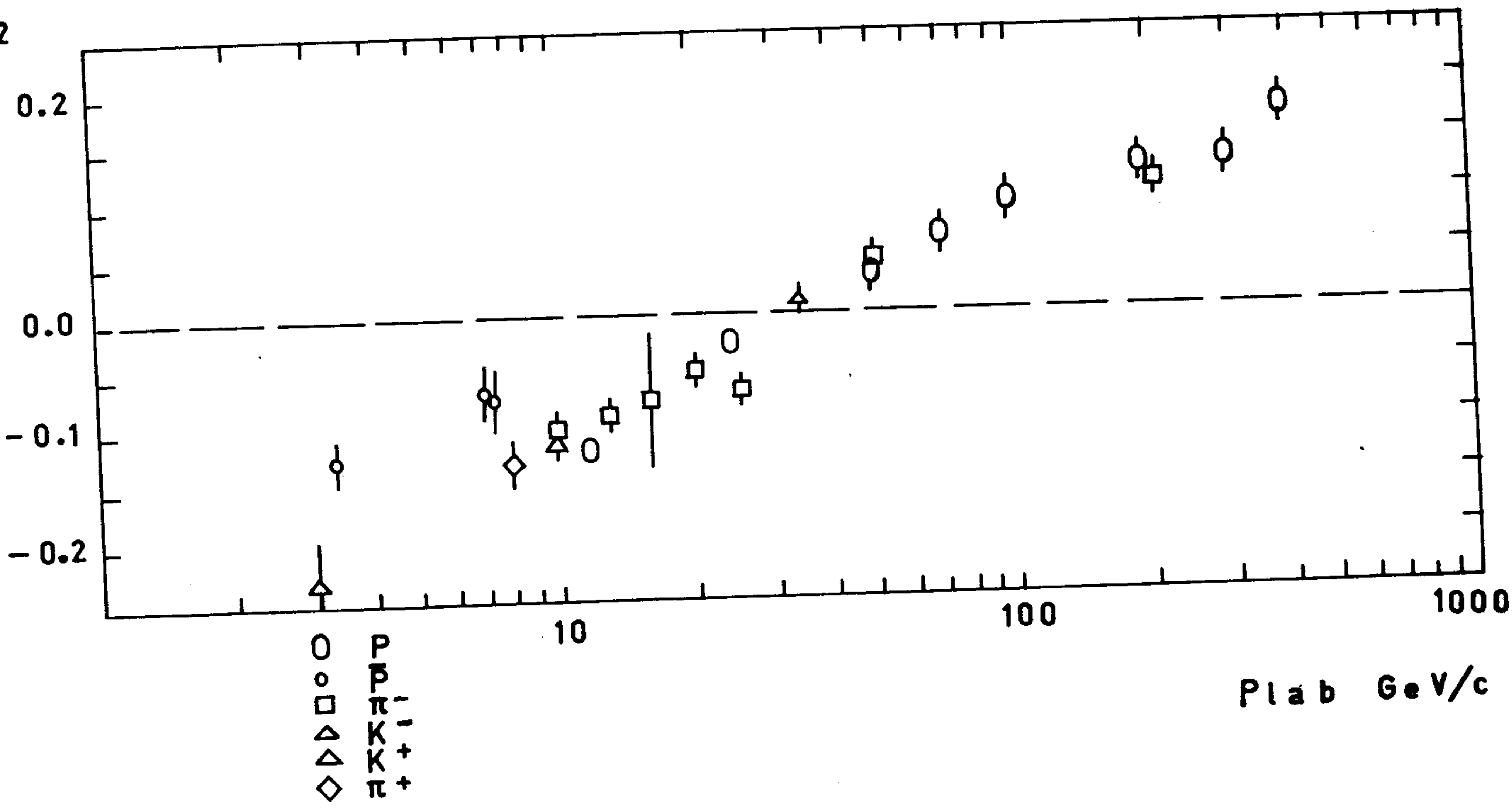

Fig. 2

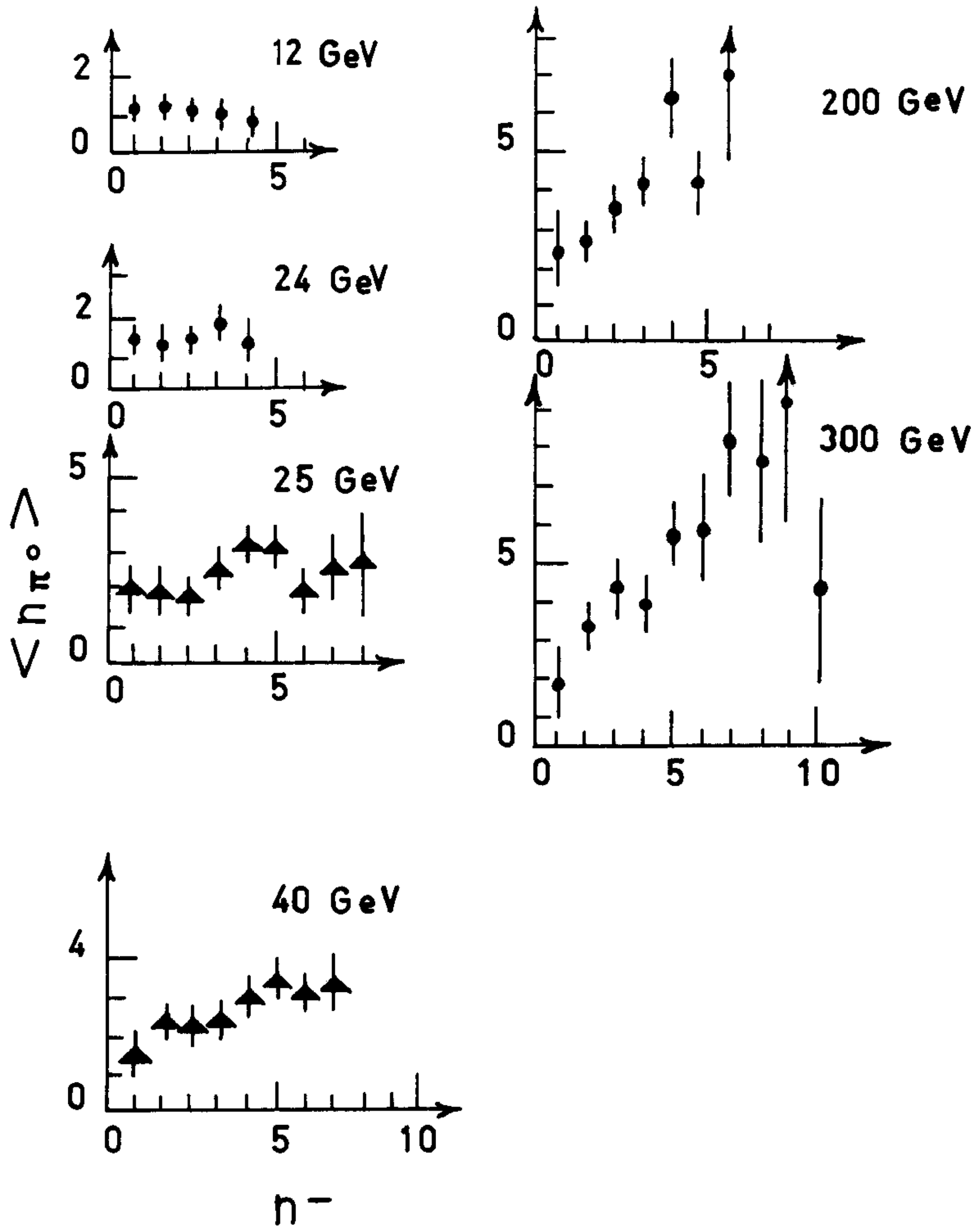

Fig. 3