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CHARGE DISTRIBUTIONS IN K^-p INTERACTIONS AND SEPARATION OF BEAM AND
TARGET FRAGMENTS WITH ENERGY

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ABSTRACT

The distribution with c.m. rapidity, y , of the net charge of hadrons produced in K^-p interactions at 110 GeV/c is presented and compared with K^-p and π^-p data at several energies from 10 to 360 GeV/c. In both reactions and at all energies the net charge changes sign from positive to negative at $y \sim 0$. The total net charge in the forward direction is -0.70 ± 0.02 at 110 GeV/c. It decreases with increasing energy and the results are consistent with a total net forward charge of -1.0 at infinite energies. These results imply that the fragments of the beam and target particles are far from being completely separated even at the highest energies available at present accelerators.

Results on the distribution of positive and negative charged secondaries are important in investigating the mechanism of hadron-hadron interactions. In particular, they permit a measure of the separation of the fragments from the differently charged beam and target particles as a function of energy.

In this letter the net charge, Q , i.e. the difference between the number of positive and negative particles, is studied as a function of the c.m. rapidity y :

$$\frac{dQ}{dy} = \frac{1}{\sigma_{inel}} \left[\frac{d\sigma^+}{dy} - \frac{d\sigma^-}{dy} \right] \quad (1)$$

where the numbers are normalized to the respective average multiplicities $\langle n_{\pm} \rangle$:

$$\frac{1}{\sigma_{inel}} \int \frac{d\sigma^{\pm}}{dy} dy = \langle n_{\pm} \rangle \quad (2)$$

The distributions are analysed for inelastic interactions at several incident momenta from 10 to 110 GeV/c for K^-p and from 16 to 360 GeV/c for π^-p experiments. The results for 110 GeV/c K^-p interactions are obtained in an experiment performed by this Collaboration in the Big European Bubble Chamber (BEBC) filled with hydrogen and exposed to an r.f. separated tagged K^- beam from the CERN SPS. This is the highest energy at which data on inclusive particle production in K^-p interactions are available over the whole phase space.

Fig. 1 shows the net charge distributions in K^-p interactions at 10 GeV/c [1], 16 GeV/c [1], 32 GeV/c [2], 70 GeV/c [3] and 110 GeV/c. At 10, 16 and 110 GeV/c all charged particles are included so that the overall net charge is zero. Those particles which were not identified were assumed to be pions. At 32 and 70 GeV/c, identified protons have been removed from the distributions. Such identified protons have laboratory momenta < 1 GeV/c and are emitted substantially backwards in the centre of mass system. This distorts the net charge distribution for large negative rapidities. At 110 GeV/c they give a peak in fig. 1 at y_{max} for protons of -2.73 whereas some backward pions extend to y_{max} for pions of -4.63.

However, in the central region, $y \approx 0$, and in the forward direction the effect of misidentification of protons and kaons is estimated to be small compared to the statistical errors and has therefore been neglected.

In fig. 2 the net charge distribution is given for $\pi^- p$ interactions at 16 GeV/c [4], 100 GeV/c [5] and 360 GeV/c [6]. For the 16 and 100 GeV/c distributions, identified protons are included. At 360 GeV/c they have been excluded, but again this does not affect the results near $y = 0$ and for positive values of rapidity.

The results shown in figs 1 and 2 for $K^- p$ and $\pi^- p$ interactions at the different energies are basically similar. In all cases the net charge is positive in the backward direction and negative in the forward direction. The crossover point, y_c , from positive to negative (determined by a linear fit to the data in the region $y \approx 0$) is close to $y = 0^{(*)}$, and, as shown in fig. 3 there is no significant variation of y_c with energy.

The integrated charge forward of y_c ,

$$Q_{\text{FORW}} = \int_{y_c}^{y_{\text{max}}} \frac{dQ}{dy} dy,$$

is presented in table 1 for K^- reactions and shown in fig. 4 for all reactions plotted as a function of $1/\sqrt{s}$. Because of lack of sufficient data on identified protons the corresponding $Q_{\text{BACK}} = \int_{y_{\text{min}}}^{y_c} \frac{dQ}{dy} dy$, has not been calculated, but by charge conservation for the reactions studied here $Q_{\text{BACK}} = -Q_{\text{FORW}}$. From fig. 4 we see that there is general agreement for Q_{FORW} between $K^- p$ and $\pi^- p$ interactions. The values of $|Q_{\text{FORW}}|$ increase as $\sqrt{s}$ increases, with values of $Q_{\text{FORW}} = -0.70 \pm .02$ and -0.78 ± 0.04 at the highest available K^- and π^- momenta of 110 and 360 GeV/c, respectively. An extrapolation to infinite energies ($1/\sqrt{s} = 0$) suggests a value of Q_{FORW} consistent with -1.

(*) It may be noted that Elbert et al., [9] considered that the centre of symmetry is not at $y = 0$ in a collision between an incoming system of two quarks (meson) and a target system of three quarks (nucleon). In this system the quark-quark centre of symmetry is at $y = 1/2 \log 3/2 \approx 0.2$. In this paper the values of the cross-over point y_c , are found to be much closer to $y = 0$ than to $y = 0.2$.

These results can be interpreted in terms of the separation of the beam and target fragments. Each of the incident particles is assumed to fragment into a number of particles (or resonances) of various charges, but such that the sum of the charges is equal to the initial charges Q_{TARG} and Q_{BEAM} of the target and beam particles,

$$\int_{y_{\min}}^{y_{\max}} \frac{dQ_{\text{TARG}}}{dy} dy = Q_{\text{TARG}} \quad \text{and} \quad \int_{y_{\min}}^{y_{\max}} \frac{dQ_{\text{BEAM}}}{dy} dy = Q_{\text{BEAM}}$$

The parameter λ is then introduced as a measure of the separation, such that

$$Q_{\text{FORW}} = \lambda Q_{\text{BEAM}} \quad \text{and} \quad Q_{\text{BACK}} = \lambda Q_{\text{TARG}}$$

In the reactions considered here $Q_{\text{BEAM}} = -1$ and $Q_{\text{TARG}} = +1$ hence λ is numerically equal to $-Q_{\text{FORW}}$. Thus the results presented in fig. 4 in terms of λ , imply that the fragments of the incident particles are far from being completely separated even at the highest available accelerator energies. An extrapolation to $1/\sqrt{s} = 0$, however, is consistent with complete separation ($\lambda = 1$) at infinite energies.

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TABLE 1

The total charge forwards i.e. for $y > y_c$, in K^-p interactions
at various lab momenta, p_{lab} [1-3]

p_{lab} , GeV/c	$-Q_{FORW}$
10	0.36 ± 0.002
16	0.45 ± 0.004
32	0.52 ± 0.02
70	0.60 ± 0.04
110	0.70 ± 0.02

FIGURE CAPTIONS

- Fig. 1 Charge distributions as a function of the c.m. rapidity for K^-p interactions at various energies [1-3].
- Fig. 2 Charge distributions as a function of the c.m. rapidity for π^-p interactions at various energies [4-6].
- Fig. 3 Results of linear fits to the charge distributions dQ/dy in the region $y \sim 0$, giving the values y_c , of the cross-over from positive to negative charge (data from refs [1-8]).
- Fig. 4 Values of the total forward charge $\int_{y_c}^{y_{\max}} \frac{dQ}{dy} \cdot dy$ for K^-p and π^-p interactions as a function of the inverse of the total c.m. energy (data from refs [1-8]).

Fig.1

Fig. 2

Fig. 3

Fig. 4