ligible by the following steps:

(i) During the 95 hours of counting, the electronic channels for left and right scattering were switched every hour.

(ii) The arrangement is such that each of the No. 4 counters is a "left" counter for one set and a "right" counter for the adjacent set.

(iii) The counters were aligned on the wheel to within ±0.016 in. around the 3-ft diameter. The repetitive pattern also serves to average out any residual asymmetry.

(iv) The wheel assembly was rotated about the π beam by one-fifth turn (incoherently) every two hours to smooth the small deviations from axial symmetry (beam shape and aim).

(v) Finally, a π^+ beam was scattered into the counters by 6 g/cm^2 of lead placed at No. 2 collimator. The π^+ mesons simulated true events by scattering back from the lead, stopping in No. 4 and giving a delayed electron via the $\pi^+ \rightarrow \mu^+ \rightarrow e^+$ chain. This yielded an inherent asymmetry (for almost isotropic scattering from Pb) of $+0.008 \pm 0.019$.

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RELATIVE INELASTICITY AND ANISOTROPY OF PROTON INTERACTIONS AT 9 AND 23.5 Gev

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Recent observations of cosmic-ray jets[1] have brought evidence for a decrease of the inelasticity K of nucleon-nucleon collisions with increasing energy of the primary, together with an increase of the forward-backward peaking of the c.m. angular distribution of the secondaries.

In view of the obvious uncertainties connected with the estimation of primary energy and/or energy and identity of the created particles, we thought it desirable to check these trends under as far as possible controlled conditions at the highest available accelerator energies. We have measured K by two independent methods and found it to decrease significantly in the energy interval 9-25 Gev.

Electron pairs from π^0-2γ decay were detected by upstream scanning[2] along relativistic tracks: (1) in a stack of NIKFI-R pellicles, used in an earlier investigation,[3] irradiated in the internal beam of the Dubna proton-synchrotron circulating at 9-Gev total energy, and (2) in two Ilford G-5 pellicles irradiated in the external (scattered) momentum-analyzed beam of the CERN proton synchrotron (average momentum ~23.5 Gev/c). Only tracks with a projected length per plate ≥ 2 mm and a projected angle $\leq 30°$ with the beam direction were accepted. For each detected pair the projected opening angle α and the angle θ of the pair bisector with the beam direction were recorded. Since at least one electron track in each pair was essentially flat, the quantity $\langle \alpha^{-1} \rangle$ is proportional to the average π^0 energy within the accepted solid angle interval. In order to obviate the well-known difficulties connected with the estimation of the proportionality factor,[4] we preferred to compare directly $\langle \alpha^{-1} \rangle$ from the two stacks, since

$$\frac{K_{23.5}}{K_9} \leq \frac{9}{23.5}\frac{\langle\alpha^{-1}\rangle_{23.5}}{\langle\alpha^{-1}\rangle_9}\frac{\langle n_\pi\rangle_{23.5}}{\langle n_\pi\rangle_9}, \quad (1)$$

the inequality sign in (1) being due to the stronger collimation of the secondaries at the higher energy. Using the experimental results on $\langle\alpha^{-1}\rangle$ given in Table I and the charged-pion multiplicities detected in along-the-track scans,[5,6] we obtain

$$K_{23.5}/K_9 \leq 0.70 \pm 0.08. \quad (2)$$

The quantities $\langle\alpha^{-1}\sin\theta\rangle$, which are a measure of the average transverse momentum of the neutral pions, are also given in Table I. The absence of any significant difference in the transverse momenta, as well as the practical independence of the transverse momentum on emission angle, allows an independent check of the above result by means of the charged secondaries.

Meson showers of at least three relativistic prongs and $N_h \leq 4$ were collected by an area scan, and the angular distribution of the shower tracks was measured. The condition $N_h \leq 4$ selected light target nuclei[3] and provided us with a sample enriched in proton-nucleon collisions. No effort was made to detect $N_h = 0$ stars in this run.

Provided p_T is independent of emission angle, we have

$$\frac{K_{23.5}}{K_9} = \frac{9}{23.5}\frac{\langle\csc\theta_s\rangle_{23.5}}{\langle\csc\theta_s\rangle_9}\frac{\langle n_\pi'\rangle_{23.5}}{\langle n_\pi'\rangle_9}, \quad (3)$$

where θ_s are the emission angles of the relativistic secondaries with respect to the incoming proton, and $\langle n_\pi'\rangle$ is the average multiplicity of shower tracks in the analyzed showers ($n_s \geq 3$).

Table I. Comparative data from measurements at 9 and 23.5 Gev.

Stack	9 Gev	23.5 Gev
No. of electron pairs	504	102
$\langle\alpha^{-1}\rangle$	251 ±11	273 ±27
$\langle\alpha^{-1}\sin\theta\rangle$	37 ±4	35 ±4
No. of stars with $n_s \geq 3$, $N_h \leq 4$	616	67
No. of tracks	2281	441
$\langle n_\pi'\rangle$	4.33 ±0.05	4.92 ±0.23

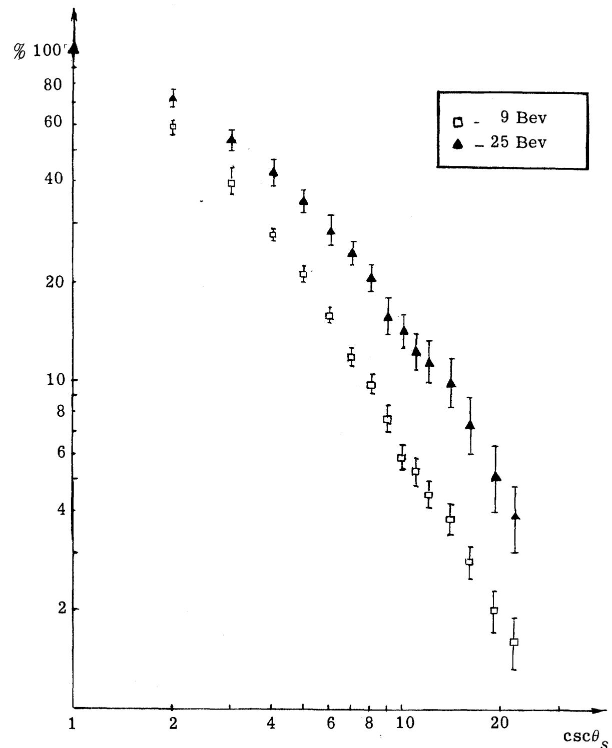

FIG. 1. Integral normalized distributions of $\csc\theta_s$ for 9-Gev meson showers (squared points) and 23.5-Gev meson showers (circles) with $n_s \geq 3$, $N_h \leq 4$.

The (normalized) integral distributions of $\csc\theta_s$ are shown in Fig. 1. The pertinent numerical data are also given in Table I and yield

$$K_{23.5}/K_9 = 0.67 \pm 0.06, \quad (4)$$

a result quite consistent with that from the π^0 measurement. Using the upper limit for the inelasticity at 9 Gev, deduced in reference 4, we obtain

$$K_{23.5} \leq 0.23 \pm 0.06. \quad (5)$$

In order to check the peaking of the c.m. angular distribution, an anisotropy parameter,

$$\eta \equiv (\tfrac{1}{2}\pi)^{1/2}(\sum|\ln\cot\theta_s - \langle\ln\cot\theta_s\rangle|)[n_s(n_s-1)]^{-1/2}, \quad (6)$$

was computed for every shower with no relativistic prong in the backward hemisphere. It can be shown that if the quantities $\ln\cot\theta_s$ belong to a normal population of variance σ^2, then

$$\langle\eta\rangle = \sigma, \quad (7)$$

and

$$\sigma_\eta = 0.75\,\eta\, n_s^{-1/2}. \qquad (8)$$

The distributions of the η values for 9-Gev and 23.5-Gev showers are shown in Fig. 2 normalized to the same area. The marked shift towards higher η values at the higher energy is proved to be significant by a Pearson test ($\chi^2 = 20.5$ with 6 degrees of freedom). The average values are

$$\langle\eta\rangle_{23.5} = 0.54 \pm 0.02,$$

$$\langle\eta\rangle_9 = 0.42 \pm 0.01, \qquad (9)$$

and prove that both distributions are significantly peaked (0.39 would be expected for isotropy).

The above results, which are consistent with recent indirect evidence from counter experiments,[7,8] are suggestive of an increasing part

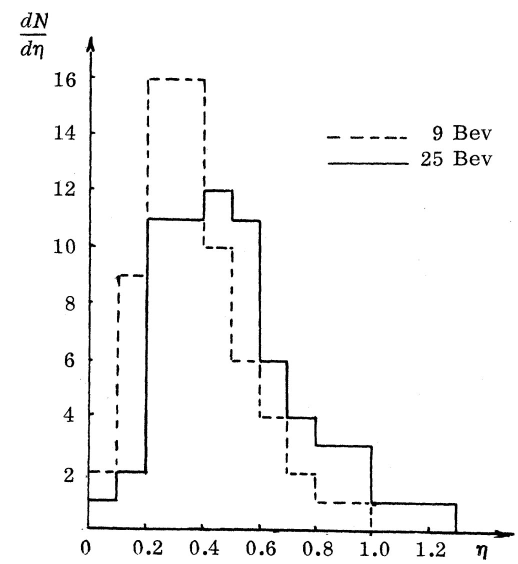

FIG. 2. Differential distributions of the anisotropy parameter η in the same showers. Dashed line at 9 Gev, full line at 23.5 Gev. The two histograms are normalized to the same area.

played by peripheral collisions, involving "almost real" pions in the meson clouds of the collision partners.[9-12] The implications of these results will be discussed quantitatively in a forthcoming paper, based upon the model discussed in references 10 and 11.

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