Current speculations\textsuperscript{4} on weak interactions raise the possibility that the neutrino associated with the \( \mu \) meson may be different from the neutrino of beta decay. Thus the helicity of \( \nu_\mu \) may be different from that of \( \nu_e \). This experiment was designed to observe the helicity of the \( \mu^- \) meson (and hence that of the associated \( \bar{\nu}_\mu \)) from the reaction:

\[
\pi^- \rightarrow \mu^- + \bar{\nu}_\mu.
\]  

The method used was to analyze the polarization of the muons by Coulomb scattering of a transversely polarized \( \mu^- \) beam (Mott scattering) which predicts a left-right asymmetry due to spin-orbit coupling:

\[
o(\theta, \phi) = f(\theta)[1 + g(\theta) P_y \cos \phi].
\]  

Here \( P_y \) is the transverse muon polarization, along the \( y \) axis, and the \( z \) axis is in the direction of the incoming muon momentum. Explicit calculations of the energy-dependent terms, \( f(\theta) \) and \( g(\theta) \), were performed by Rawitscher,\textsuperscript{2} and by Franklin and Margolis.\textsuperscript{3} Integration of the equation for the experimental arrangement used leads to a predicted asymmetry,

\[
(L - R)/(L + R) = \pm 0.09 \text{ for } P_y = \pm 1,
\]  

where \( L \) and \( R \) represent the number of scattering events into the left and right counters with respect to the plane defined by the \( \mu \) momentum and spin.

Our results, corrected for accidentals and based on \( \sim 100 \) hours of counting (\( \sim 3 \times 10^8 \) muons), were \( L = 515 \) and \( R = 618 \). This leads to an asymmetry of \( -0.09 \pm 0.031 \) for our \( P_y = 0.9 \), from which it is concluded that the helicity of the \( \mu^- \) meson in reaction (1) is positive (right-handed) in agreement with the \( V-A \) theory. Thus the anti-neutrino in (1) is also right-handed, and hence no evidence is deduced from this result for \( \nu_e \neq \nu_\mu \). This conclusion is in agreement with those obtained by measuring the knock-on electrons produced by high-energy longitudinally polarized \( \mu \) mesons in magnetized iron.\textsuperscript{4,5}

The agreement of predicted and observed asymmetry is interesting in that, to our knowledge, there are no pre-existing data on polarized electron or muon scattering in this momentum transfer region \((\langle \Delta q \rangle_{AV} \sim 100 \text{ Mev/c})\). More explicit discussion of this and of \( o(\theta) \) will be published later. We only note here that the inelastic scattering contribution is strongly limited by the low energy of the outgoing muon.

The Mott scattering experiment involved the extraction of a low-energy \( \pi^- \) beam, and the production from this beam of transversely polarized \( \mu \) mesons by decay in flight. A magnetic channel was designed to this end, and its front inserted into a recessed window in the cyclotron vacuum chamber. The resulting beam of 43-Mev \( \pi \) mesons was further moderated by 3 in. of lithium, placed at the focus of a collimating magnetic system so as to produce a parallel \((\pm 2^\circ)\) beam of \( (28 \pm 2.5)\)-Mev \( \pi \) mesons in the decay region. The resulting muons selected by decay angle had an average transverse polarization of \( 90\% \) \((P_y = 0.9)\) in the plane of decay, and were uniformly dis-
distributed in energy from 9 to 33 Mev. This energy band was chosen as a compromise between intensity of backward scatterings and magnitude of asymmetry. The experimental arrangement (Fig. 1) makes use of the azimuthal symmetry of the pion decays in order to maximize the counting rate and minimize instrumental asymmetries. Lead was used as the scatterer and the scattering angles accepted were from $105^\circ$ to $165^\circ$. The thickness of the lead was chosen for the greatest yield of events consistent with a not too substantial reduction of the asymmetry by plural scatterings.

The incoming muon is counted by a thin plastic counter (No. 3) and strikes a 2-g/cm$^2$ thick lead sheet. An event occurs when the muon is scattered back through No. 3 into either the left or the right No. 4 counters which are placed radially on either side of No. 3. This setup of counters and lead is repeated 10 times so as to form an annular arrangement about the pion beam as axis. The small scattering probability ($\sim 0.6 \times 10^{-5}$ per muon), together with a background of $\mu$-mesonic x rays due to muons stopping in the lead, makes it necessary to further identify events by detecting the decay electrons from the scattered muons which are required to stop in the No. 4 counters ($\frac{3}{4}$ in. thick). Direct passage by a particle from the beam through No. 4 and then No. 3 is prevented by $\frac{3}{4}$-in. copper shields mounted on the edges of the No. 4 counters toward the beam.

Figure 2 shows a simplified block diagram of the fully transistorized electronics. The No. 2 counter was put in anticoincidence with No. 1, and ten such 12 signals were obtained from an emitter follower fan-out system. Each was then put in coincidence with a signal from one of the ten No. 3 counters; the $123$ then representing a $\mu^-$ meson which reached a particular set in the wheel. Each of these signals was sent to two emitter followers, and, as shown in Fig. 2, was counted in coincidence with a pulse from an adjacent No. 4 counter through a double-pole, double-throw relay. This device permitted the switching back and forth at regular intervals of the whole electronic chain following the $123$ coincidence, thus eliminating some possible instrumental asymmetries. The $1234$ coincidence output was used to open a 3-$\mu$sec gate during which a pulse in No. 4, due to an electron from the decay of a stopped $\mu$ meson, would count as an event. Single counts in No. 4 gave accidental events which were about one-tenth of the true events. This low accidental rate was made possible by the use of the Nevis vibrating target, which gave an average duty cycle of 3.

Instrumental asymmetries were rendered neg-
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/cm² 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 π⁺ → μ⁺ → e⁺ chain. This yielded an inherent asymmetry (for almost isotropic scattering from Pb) of −0.008 ± 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 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 π⁰-2γ decay were detected by upstream scanning along relativistic tracks: (1) In a stack of NIKFI-R pellicles, used in an earlier investigation, 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 ≤ 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 ⟨α⁻¹⟩ is proportional to the average π⁰ energy within the accepted solid angle interval. In order to obviate the well-known difficulties connected with the estimation of the proportionality factor, we preferred to compare directly ⟨α⁻¹⟩ from the