of particle-hole structures involving the $d_{5/2}$ or $g_{9/2}$ proton orbitals. The last two neutrons in ^{85}As occupy the $d_{5/2}$ orbital just beyond the closed shell $N=50$. A crude estimate locates the energy of the two-particle, one-hole configuration $[\pi(d_{5/2})^1(f_{5/2})^{-1};\ \nu(d_{5/2})^1]$ at 6–7 MeV in ^{85}Se, and the more complex structure resulting from decay of a $g_{9/2}$ neutron should lie within several MeV of this energy. It is possible that the selectivity in β decay is probing that part of the particle-hole structure in ^{85}Se contained in the antianalog state (AIAS) orthogonal to the analog state (IAS) of the ^{85}As ground state. Using the value of 110 MeV for the Lane potential,[14] the AIAS is calculated to lie near 6.3 MeV in ^{85}Se and should have its strength spread by strong coupling to core polarization states.[15] Since the strength of Gamow-Teller β decay to the AIAS is proportional to that of the $\Delta T=1$, $M1$ γ transition between the IAS and the AIAS, this correlation may possibly serve as the basis for interpretation of the structure in the delayed-neutron spectrum from ^{85}As.

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Pion Production in the Regime of Target Fragmentation*

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We examine the energy dependence of π^+ and π^- production in pp collisions for incident laboratory momenta between 6 and 400 GeV/c. The cross section for pion emission into the backward hemisphere in the laboratory frame falls substantially with incident momentum. This departure from the hypothesis of limiting fragmentation for momenta in excess of 20 GeV/c is consistent with an energy dependence of the form expected on the basis of Mueller-Regge ideas.

Pion production in hadronic interactions can be classified into two general categories. One is the "central" regime of particle production, typified through the production of particles whose longitudinal momenta, as calculated in the center-of-mass frame, are small ($|p_l^*| \lesssim 0.1 p_0^*$, where p_0^* is the incident momentum in the center of mass); the invariant cross section for pion production for small p_l^* is known to rise substantially as the incident energy increases.[1] The noncentral regions of pion production are referred to as fragmentation regimes, one being the projectile-fragmentation region ($p_l^* \gtrsim 0.1p_0^*$), and the other the target-fragmentation domain ($p_l^* \lesssim -0.1p_0^*$); the invariant cross section for pion production in the fragmentation regime is known to fall with increasing energy for reactions which are termed nonexotic (i.e., the quantum numbers of the $A\overline{C}B$ system in the reaction $A+B\rightarrow C+$anything are such as can be accommodated in a simple quark model); cross sections for exotic inclusive reactions, on the other hand, are known to be essentially energy independent.[2]

In this note we re-examine the validity of the generally held belief that the cross sections in the proton-fragmentation regime for

$$p+p\rightarrow \pi^+ + \text{anything} \qquad (1)$$

and for

$$p+p\rightarrow \pi^- + \text{anything} \qquad (2)$$

are independent of energy for laboratory momenta between ~10 GeV/c and intersecting storage ring (ISR) energies.[3] To study this question of the "scaling" of the pion-production cross section,[4] or, equivalently, the validity of the hypothesis of limiting fragmentation (HLF),[5] for incident momenta between 6.6 and 400 GeV/c, we have compiled previously available data[6] and the most recent results from NAL bubble-chamber measurements.[7] Specifically, we will examine the cross section for the emission of pions in the kinematic region which most typifies the fragmentation of the target proton, namely, production into the backward hemisphere in the laboratory frame [i.e., $p_l<0$, corresponding to $p_l^* \simeq -p_0^*$, or to $y=\frac{1}{2}\ln(E+p_l)/(E-p_l)<0$].

Figures 1 and 2 summarize the energy dependence characterizing the cross sections for pion

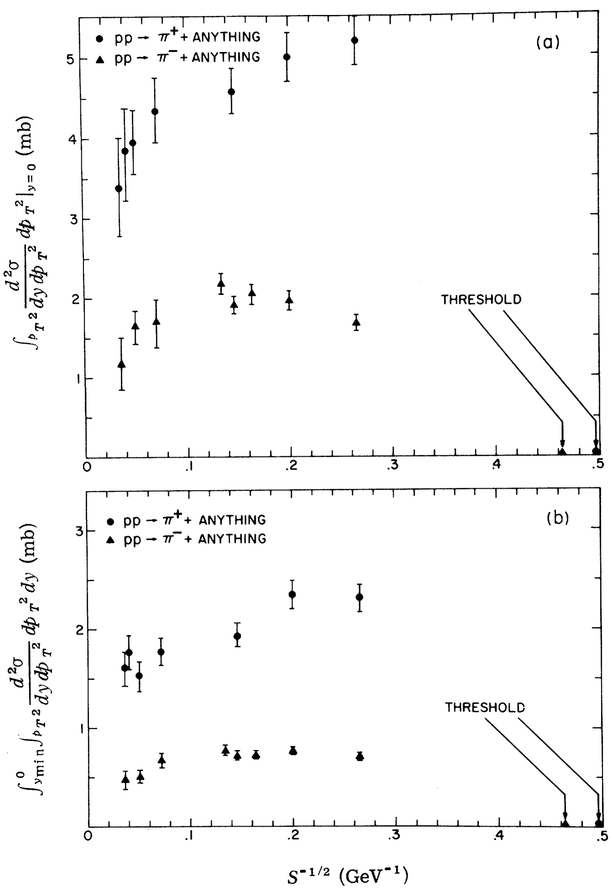

FIG. 1. Invariant cross sections for π^+ and π^- production, integrated over all transverse momenta, displayed as a function of $s^{-1/2}$. (a) The differential cross section at the value of laboratory rapidity equal to zero. (b) The integrated cross section for negative values of laboratory rapidity.

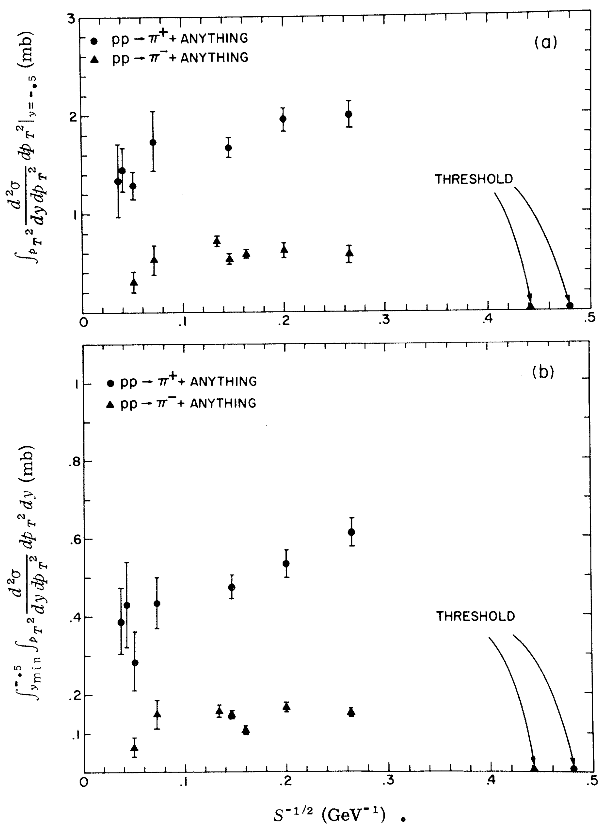

FIG. 2. Invariant cross sections for π^+ and π^- production, integrated over all transverse momenta, displayed as a function of $s^{-1/2}$. (a) The differential cross section at the value of laboratory rapidity equal to -0.5. (b) The integrated cross section for values of laboratory rapidity less than -0.5.

production in reactions (1) and (2) for negative y values. Four quantities, all integrated over p_T^2, are shown: (1) the cross sections for all $y<0$; (2) the cross sections for all $y<-0.5$; (3) the differential cross sections evaluated at $y=0$; and (4) the differential cross sections evaluated at $y=-0.5$. The data have been plotted as a function of $s^{-1/2}$, where s is the square of the energy available in the center of mass. An $s^{-1/2}$ dependence is expected for the approach to scaling for inclusive production in the fragmentation domain on the basis of Mueller-Regge analysis.[2,3] The arrows in the figures indicate the values of s corresponding to thresholds for reactions (1) and (2). The error bars on the data points have ±6% systematic uncertainties folded in quadrature with the statistical errors.

The following conclusions may be drawn from the data presented in Figs. 1 and 2: (1) All the data are inconsistent with a constancy of the cross section for variations in s. (The χ^2 probabilities for such a hypothesis are 0.02% and 1.5%, respectively, for π^+ and π^- production for $y<0$, for incident momenta in excess of 10 GeV/c.) (2) The cross section for reaction (1) falls more rapidly with energy, for $s>14$ GeV^2, than the cross section for reaction (2). (3) The drop in the cross sections with increasing energy for negative y values is comparable to that for rapidities near $y\sim 0$. (4) Cross sections for negative y values appear to have a broad maximum at incident momenta near ~20 GeV/c in reaction (2); a much less pronounced threshold effect may also be apparent in the cross sections shown for reaction (1).[8]

Consequently, we surmise that there is substantial energy dependence for pion production in the proton-fragmentation regime. Qualitatively, the percentage decrease of the cross sections for reactions (1) and (2) with increasing s near $y_{\rm lab}\simeq 0$ is comparable to the percentage increase occurring near $y_{\rm c.m.}\simeq 0$. These violations of the Feynman scaling conjecture and of the HLF at momenta in excess of 20 GeV/c are such as to be consistent, within sizable error, with the $s^{-1/2}$ energy dependence suggested through Mueller-Regge analysis. We wish to point out that although our results appear to be in conflict with the claims made for scaling in pion production at the ISR,[3] in fact, the ISR data are available, typically, at values of $y_{\rm lab}>0$.

Finally, we note that although reaction (1) has a somewhat greater energy dependence than reaction (2), it appears that the ratio of the two cross sections for negative y values is approximately independent of s and equal to ~3.[9]

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[8]In the fragmentation region the phase-space boundary for $p_l<0$ rapidly approaches an asymptotic limit (see Ref. 5). For example, the phase-space boundary above 102 GeV/c remains essentially unchanged. At lower energies, corrections for diminishing phase space in the region $p_l\lesssim 0$ can be made, but these corrections are model dependent. The effect of such corrections would be to increase the s dependence of the matrix elements. We estimate that an upward correction of <20% to the 6.6 GeV/c cross sections would be expected for $y_{\rm lab}\lesssim -0.5$. The other experimental points are relatively insensitive to changing phase-space boundaries because of the sharp fall of the data with transverse momentum.

[9]It is interesting that a ratio of 2.6 is expected on the basis that the $y<0$ region is dominated through the production of equal amounts of $I=\frac{1}{2}$ $N^*\to N\pi$ and $N^*\to\Delta\pi$.