KNO scaling in the central region

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Experimental data on KNO scaling are reported for the charged particles produced in the central region in π^-p interactions at 5 and 40 GeV/c. The results agree with data at high energies.

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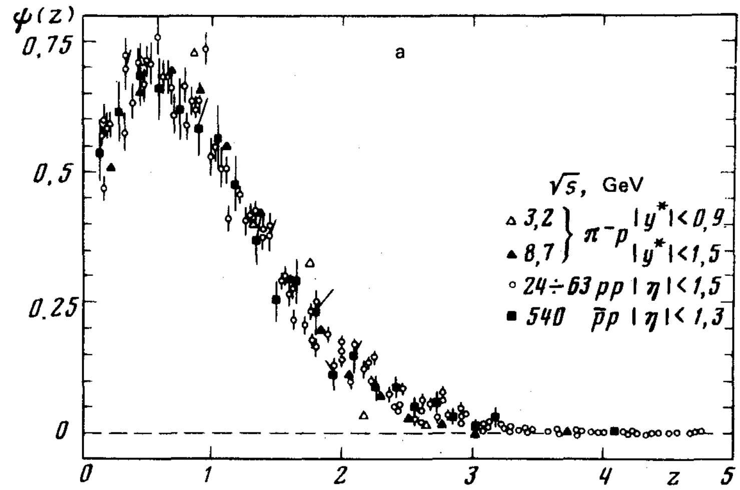
The first experimental data[1,2] from $\bar{p}p$ collisions at a c.m. energy $\sqrt{s} = 540$ GeV showed that the general characteristics of the multiple production of particles continued the trends established at low energies. In particular, the density of the particle distribution in the central region continues to increase with increasing primary energy; in other words, there is no scaling of the inclusive distributions here, even at energies of tens or hundreds of gigaelectron volts (in the c.m. frame). On the other hand, the normalized multiplicity distributions for the charged particles from the central region [the function $\psi(z) = \langle n \rangle P_n$, where $z = n/\langle n \rangle$, or KNO scaling[3]] are in agreement, both for the entire ISR range[4] ($\sqrt{s} = 23.6$–62.8 GeV) for pp interactions and for $\bar{p}p$ collisions at 540 GeV (this figure corresponds to 1.55×10^5 GeV in the laboratory frame), although the density of the particle distribution in the pseudorapidity η increases by a factor of 2.7 over this energy range.[2]

We have now studied the behavior of the function $\psi(z)$ for the particles produced in the central region for much lower primary energies. We used data on the π^-p interactions at $\sqrt{s} = 3.2$ and 8.7 GeV (5 and 40 GeV in the laboratory frame). For the 8.7-GeV data we used selection criteria corresponding to those used to analyze pp interactions on the ISR,[4] but the selection of tracks was based on the c.m. rapidity y^* instead of the pseudorapidity η: $|y^*| < 1.5$. It was required that at least one particle fall in the central region, as in Ref. 4. Figure 1a shows the distribution $\psi(z)$ for such events, along with data from Refs. 2 and 4. This distribution for π^-p interactions at 8.7 GeV agrees with data for much higher energies; i.e., KNO scaling does hold, at least qualitatively, over a broad range of primary energies and in various types of interactions, for events with particles from the central region. Shown in the same figure are data for an extremely low primary energy, 3.2 GeV, at which the selection criterion was slightly different: $|y^*| < 0.9$ (these cutoff values of y^*, we might note, correspond to the half width at half maximum in the inclusive rapidity distribution of all charged particles). Although there is evidently no mechanism for central production at such low energies, we again observe an approximate agreement between the $\psi(z)$ distribution and the data at high energies, confirming that this behavior is universal. An attempt to approximate the 8.7-GeV data by the function $\psi(z) \sim (a_1 z + a_2 z^3 + a_3 z^5) \exp(-bz)$, which has been used successfully to describe data on "complete" KNO scaling (see Ref. 5, for example), did not result in a satisfactory description. The implication is that the distribution $\psi(z)$ is of a different form for the central region; in particular, it is broader than that for the charged particles from throughout



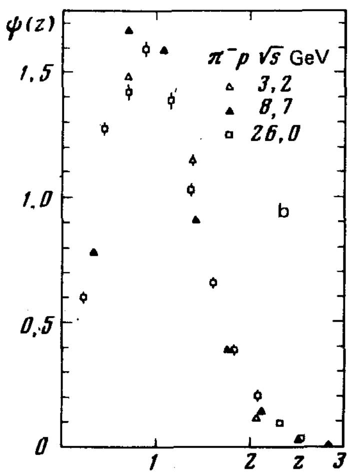


FIG. 1. a–The distribution $\psi(z) = \langle n_\pm \rangle P_n$, with the independent variable $z = n_\pm / \langle n_\pm \rangle$, for the particles produced in the central region in $\pi^- p$ interactions (the present study) and also in $\bar{p}p$ (Ref. 2) and pp (Ref. 4) interactions. (It was required that the event contain at least one particle satisfying the selection criteria.); b–the distribution $\psi(z)$ for charged particles from the entire phase space in $\pi^- p$ interactions at 5, 40 (the present study), and 360 (Ref. 6) GeV/c.

the phase space, and the dispersion of this distribution is 0.58 ± 0.02 (for the central region) and 0.471 ± 0.003 (for all particles) at 8.7 GeV.

Figure 1b shows for comparison the $\psi(z)$ distribution for charged particles from the entire phase space in $\pi^- p$ interactions at 5, 40, and 360 GeV/c (the data for 360 GeV/c are from Ref. 6). In contrast with the case of the particles from the central region, KNO scaling does not hold here, even in a single type of interaction and in a much narrower energy range. We might note in this connection that an analysis of the data on KNO scaling[5] has shown that it holds quantitatively only in pp interactions in the energy interval $\sqrt{s} = 9.8$–27.4 GeV, while at the higher ISR energies there is a deviation from scaling.[4] It was also shown in Ref. 5 that the agreement among the data obtained from different types of interactions can be improved by eliminating from the multiplicity the events associated with diffraction processes.

For the particles produced in the central region we thus find an agreement of the $\psi(z)$ distributions over a very broad range of primary energies in different types of interactions (even with slightly different selection criteria), although it is in the central region that we observe the greatest deviation from scaling in the inclusive distributions. It would be extremely interesting to analyze new data for other types of interactions at various energies.

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1. K. Alpgard *et al.*, Phys. Lett. **107B**, 310, 315 (1981).
2. G. Arnison *et al.*, Phys. Lett. **107B**, 320 (1981).
3. Z. Koba *et al.*, Nucl. Phys. **B40**, 317 (1972).
4. W. Thome *et al.*, Nucl. Phys. **B129**, 365 (1977).
5. J. Dumarchez *et al.*, Nuovo Cimento **66A**, 114 (1981).
6. A. Firestone *et al.*, Phys. Rev. D **14**, 2902 (1976).

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