GENERAL CHARACTERISTICS OF PROTON-NUCLEON INTERACTIONS IN NUCLEAR EMULSION AT 67 GeV/c

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Interactions of 67 GeV/c protons with nucleons were studied in nuclear emulsion. Average proton-proton multiplicity is 6.63 ± 0.16. Strong anisotropy of the angular distribution is seen.

In this letter some general characteristics of proton-nucleon interactions at 67 GeV/c are reported. They were studied by the collaboration under the auspices of the Emulsion Committee of the Joint Institute for Nuclear Research. Preliminary results were presented at the Amsterdam International Conference on Elementary particles [1]. Coherent interactions of protons are described in another paper [2].

Experimental. An emulsion stack 20 cm × 10 cm × 0.065 cm in size was irradiated by (67±2) GeV/c protons at the Serpukhov accelerator. The admixture of pions and kaons in the beam was less

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than 1%.

Along-the-track scanning for nuclear inelastic interactions was performed on the total length of 3057 m. The following type of events were not used for the calculation of the inelastic-interaction length λ_{int}:

i) stars with single relativistic tracks deflected by less than 7 mrad (mostly elastic scatters),

ii) electron-positron pairs on the beam track,

iii) knock-on electrons.

Altogether 8239 inelastic nuclear interactions were found, which corresponds to $\lambda_{int} = (37.1 \pm 0.4)$ cm, the error being purely statistical. A comparison of our result with $\lambda_{int} = (37.7 \pm 0.3)$ cm obtained previously [3] at (6 - 28) GeV/c shows that there is no great change of the inelastic proton-nucleon cross section up to 67 GeV/c.

Interactions with free and quasi-free nucleons were selected as those with at most one grey track (for a proton this corresponds to kinetic energy between 25 MeV and 400 MeV) in the forward hemisphere in the laboratory system and without a visible recoil nucleus. For even-prong-number (p-p) events there was the additional criterion of the absence of an accompanying electron which could come from the excitation of the target nucleus. Altogether 1473 proton-nucleon interactions were found, which represent 18% of all inelastic nuclear interactions in emulsion. From its composition one can estimate that nearly half (~45%) of our 685 p-p stars correspond to collisions with free protons (i.e. emulsion hydrogen), the remaining ones being collisions with quasi-free protons of the emulsion nuclei. Odd-prong-number stars (p-n) correspond to collisions with quasi-free neutrons. As is estimated in the following paper [2], there is a 25% admixture of coherent interactions in our 788 odd-prong stars. Therefore in this letter we shall deal mainly with p-p events which represent a purer sample of elementary interactions than p-n events.

Prong number distribution. The prong-number n_{ch} distribution of proton-nucleon events is shown in fig.1. An overabundance of $n_{ch} = 3$ and $n_{ch} = 1$ stars is interpreted in terms of coherent interactions in another paper [2]. The average multiplicities for p-p and p-n interactions are 6.63 ± 0.16 and 6.17 ± 0.22, respectively. (Without correction for the coherent events the latter multiplicity is 5.42 ± 0.16.)

The average multiplicities for p-p collisions at various total centre-of-mass energies E_{CM} are shown in fig.2. Our point at 67 GeV/c is slightly (by ~ 0.3) above the power dependence $\langle n_{ch}\rangle \propto E_{CM}^{0.7}$ plot describing the hydrogen-bubble-

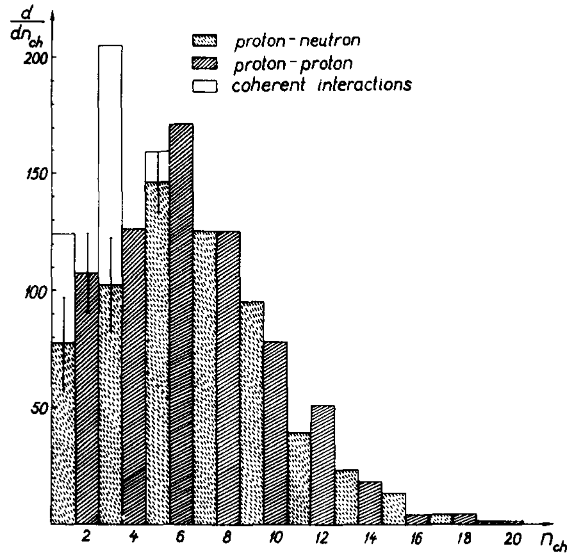

Fig.1. Prong number distribution in proton-nucleon interactions at 67 GeV/c. The errors for n_{ch} = 1, 2, 3 and 5 include uncertainties connected with elastic and coherent events. The errors for the remaining multiplicities are purely statistical.

chamber data at lower energy [4]. The $\langle n_{ch}\rangle$ values obtained by the Echo Lake group [5] at cosmic-ray energies up to ~ 300 GeV are lower than our average multiplicity. We are aware tht our result can be affected by the influence of bound protons. E.g. the realtively thick tail of high multiplicities $n_{ch} \gtrsim 10$ in our work indicates that our estimate of $\langle n_{ch}\rangle$ may be too large. Low energy emulsion data [6] on $\langle n_{ch}\rangle$ are 0.2 - 0.3 higher than the hydrogen-bubble-chamber ones at the same energy, as can be seen in fig.2. On the other hand, any increase of the average multiplicity in interactions with bound nucleons should be stronger in p-n events (only bound neutrons)

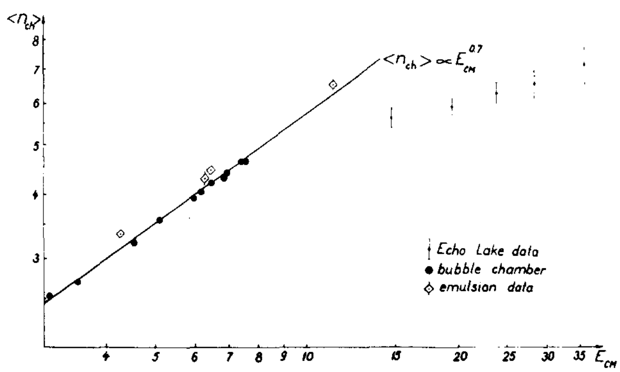

Fig.2. Average multiplicity $\langle n_{ch}\rangle$ versus total centre-of-mass energy E_{CM}^{tot}.

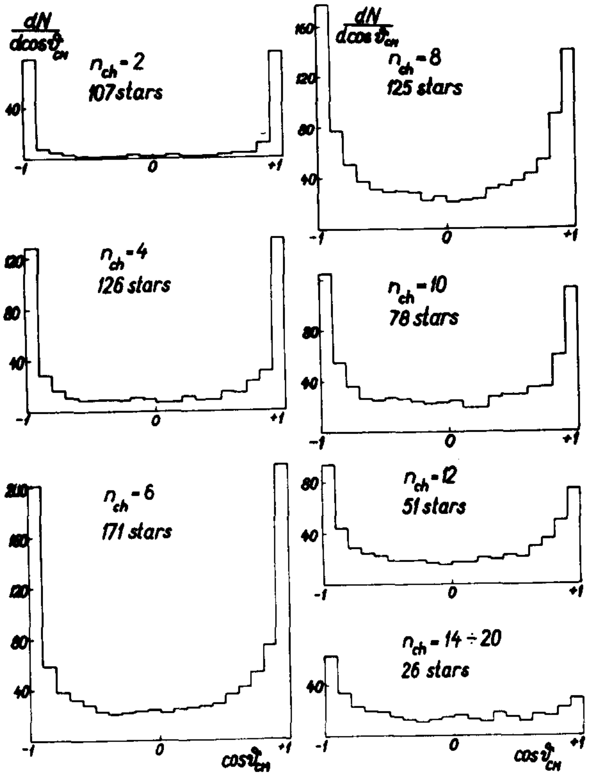

Fig.3. Angular distribution of secondary particles in $\cos\theta_{CM}$ coordinate for various p-p multiplicities at 67 GeV/c.

than in p-p events (45% of hydrogen), while the $\langle n_{ch}\rangle$-value in the former is still smaller than in the latter.

Angular distribution of secondary particles. Angular distributions of secondary particles for various p-p multiplicities are shown in fig.3, in $\cos\theta_{CM}$-coordinate. The transformation to the CMS was done using the transverse-momentum distribution and other p-p data from lower energy results [7] similar to what was done for pions in ref.[8]. An anisotropy of the angular distributions is seen. This anisotropy decreases with the increasing multiplicity as was observed at lower energies. However, at our energy there is still a significant anisotropy up to n_{ch} = 12.

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