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Nuclear Physics B44 (1972) 333–343. North-Holland Publishing Company

PARTICLE PRODUCTION IN PROTON INTERACTIONS IN NUCLEI AT 24 GeV/c

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Received 15 March 1972

Abstract: Particle production by 24 GeV/c protons from Be, B_4C, Al, Cu and Pb has been measured. Pion, kaon, proton and antiproton production spectra measured over a range of angles from 17 to 127 mrad and momenta from 4 to 18 GeV/c are given in a table.

1. INTRODUCTION

The aim of the present experiment was to measure pion and kaon production in proton-nucleus collisions at 24 GeV/c primary proton momentum. The measurements cover the secondary momentum range 4–18 GeV/c and the angular range 17–127 mrad. These data are essential for the estimation of the neutrino spectrum for the present CERN neutrino experiment.

The experiment was performed with the single-arm magnetic spectrometer of the CERN-Rome group [1] (fig. 1) with their hydrogen target replaced by a set of thin nuclear targets (Be, B_4C, Al, Cu, Pb). Pion, kaon and proton data were taken simultaneously and the various targets compared directly without changing the spectrometer setting.

This experiment extends the studies done at 19.2 GeV/c by Allaby et al. [2].

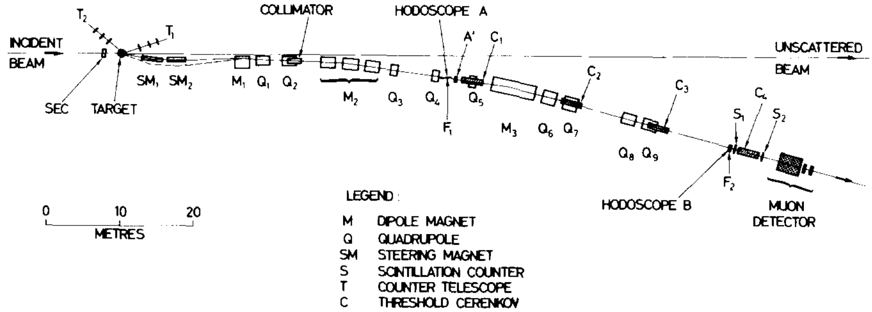


Fig. 1. Layout of the magnetic spectrometer.

2. EXPERIMENTAL RESULTS

Table 1 shows the measured Lorentz invariant one particle distribution functions $\omega(p, \theta)$ defined by

$$d^2N = \frac{1}{\sigma_a} \frac{\delta^2\sigma}{\delta p \delta \Omega} \, dp d\Omega = \omega(p, \theta) \frac{p^2 dp d\Omega}{2E}$$

where $\delta^2\sigma/\delta p \delta\Omega$ is the differential production cross section, σ_a is the absorption cross section for pBe, pAl, etc. [3], p, E are the laboratory momentum and energy of the produced particle (GeV), Ω is the solid angle (sterad), and θ is the production angle (mrad).

Essentially three corrections have been applied to the measurements:

(i) for absorption of the produced particles along the spectrometer (10–30% depending on momentum);

(ii) for decay of pions and kaons along the spectrometer (substantial for low momenta);

(iii) subtraction of the empty target background ($\approx$ 10%).

The statistical errors were nearly always negligible compared to the systematic errors. The overall scale error arising from the uncertainties in the spectrometer acceptance and in the absolute calibration of the primary proton beam intensity (by Al activation) is estimated to be 15% [4]. The systematic errors of individual data points are determined by the irreproducibility of a given spectrometer (setting (about 5%) and by the uncertainties in the corrections applied (2–5% depending on momentum). Ratios obtained from one and the same spectrometer setting (K/π ratios and ratios between different targets) are much more accurate (total error generally less than 4%), as most systematic errors drop out. Details of the data evaluation have been given in refs. [5, 6].

Table 1

SINGLE PARTICLE PRODUCTION DENSITY PER INTERACTING PROTON IN PROTON - NUCLEUS COLLISIONS AT 24 GEV/C : W(P,THETA)=2*E/(P*P)*D2N/(DP*DOMEGA)
E IS THE TOTAL ENERGY OF THE PRODUCED PARTICLE WITH MOMENTUM P (UNIT GEV/C), OMEGA THE SOLID ANGLE (UNIT STERAD) IN THE LABORATORY SYSTEM
THE LORENTZ INVARIANT DENSITY W(P,THETA) IS TABULATED AS FUNCTION OF PRODUCTION ANGLE THETA (MRAD) AND MOMENTUM (GEV/C)
NOTE : THE INTEGRATION OVER D2N GIVES THE MEAN MULTIPLICITY OF THE PRODUCED PARTICLE
NOTE : BC STANDS FOR B4C (BORON CARBIDE)

T	ANG	MOM	PI PLUS	KA PLUS	PROTON	PI MINUS	KA MINUS	ANTI P
BE	17	4	1.10E+00	8.26E-02	2.73E-01	8.20E-01	3.16E-02	4.81E-03
BE	37	4	1.05E+00	7.23E-02	2.50E-01	7.20E-01	2.74E-02	4.38E-03
BE	57	4	8.86E-01	6.57E-02	2.26E-01	5.76E-01	2.36E-02	3.86E-03
BE	67	4	7.70E-01	6.08E-02	2.16E-01	5.16E-01	2.24E-02	3.65E-03
BE	87	4	5.41E-01	5.15E-02	1.87E-01	3.83E-01	1.74E-02	3.06E-03
BE	107	4	3.87E-01	4.08E-02	1.56E-01	2.93E-01	1.44E-02	2.49E-03
BE	127	4	2.68E-01	3.09E-02	1.28E-01	2.12E-01	1.07E-02	1.94E-03
BE	17	5	1.06E+00	6.82E-02	3.59E-01	6.32E-01	2.41E-02	4.29E-03
BE	37	5	9.10E-01	6.13E-02	3.16E-01	5.14E-01	2.14E-02	3.72E-03
BE	57	5	6.29E-01	5.39E-02	2.68E-01	3.75E-01	1.63E-02	3.16E-03
BE	67	5	5.09E-01	4.78E-02	2.45E-01	3.16E-01	1.46E-02	2.87E-03
BE	87	5	3.36E-01	3.76E-02	1.92E-01	2.23E-01	1.09E-02	2.20E-03
BE	107	5	2.23E-01	2.69E-02	1.44E-01	1.51E-01	7.56E-03	1.60E-03
BE	127	5	1.34E-01	1.83E-02	1.03E-01	9.65E-02	5.09E-03	1.08E-03
BE	17	6	9.56E-01	5.58E-02	4.24E-01	4.58E-01	1.70E-02	3.14E-03
BE	37	6	6.63E-01	4.80E-02	3.59E-01	3.45E-01	1.43E-02	2.69E-03
BE	57	6	3.99E-01	3.87E-02	2.83E-01	2.29E-01	1.07E-02	2.13E-03
BE	67	6	3.09E-01	3.44E-02	2.46E-01	1.89E-01	8.95E-03	1.84E-03
BE	87	6	1.97E-01	2.39E-02	1.74E-01	1.23E-01	5.90E-03	1.25E-03
BE	107	6	1.14E-01	1.50E-02	1.13E-01	7.45E-02	3.73E-03	8.29E-04
BE	127	6	6.21E-02	9.47E-03	7.19E-02	4.19E-02	2.19E-03	4.78E-04
BE	17	8	6.10E-01	3.58E-02	5.35E-01	2.41E-01	8.72E-03	1.40E-03
BE	37	8	3.02E-01	2.91E-02	4.09E-01	1.46E-01	6.06E-03	1.05E-03
BE	57	8	1.60E-01	2.05E-02	2.72E-01	8.69E-02	3.74E-03	6.98E-04
BE	67	8	1.19E-01	1.59E-02	2.12E-01	6.69E-02	2.79E-03	5.46E-04
BE	87	8	6.29E-02	8.62E-03	1.16E-01	3.55E-02	1.44E-03	3.01E-04
BE	107	8	2.82E-02	4.52E-03	5.76E-02	1.69E-02	7.32E-04	1.53E-04
BE	127	8	1.20E-02	2.18E-03	2.77E-02	7.67E-03	3.40E-04	6.62E-05
BE	17	10	2.86E-01	2.42E-02	6.46E-01	1.19E-01	4.11E-03	4.81E-04
BE	37	10	1.39E-01	1.67E-02	3.99E-01	6.38E-02	2.16E-03	3.16E-04
BE	57	10	6.34E-02	9.22E-03	2.17E-01	3.17E-02	1.12E-03	1.71E-04
BE	67	10	4.29E-02	6.26E-03	1.48E-01	2.21E-02	7.56E-04	1.19E-04
BE	87	10	1.75E-02	2.74E-03	6.19E-02	9.03E-03	3.00E-04	5.04E-05
BE	107	10	5.81E-03	1.08E-03	2.26E-02	3.30E-03	1.16E-04	1.85E-05
BE	127	10	1.98E-03	4.21E-04	8.34E-03			
BE	17	12	1.62E-01	1.48E-02	7.14E-01	6.18E-02	1.41E-03	1.39E-04
BE	27	12	1.03E-01	1.17E-02	5.04E-01	4.25E-02	1.10E-03	1.03E-04
BE	37	12	6.04E-02	8.80E-03	3.51E-01	2.78E-02	7.52E-04	7.29E-05
BE	47	12	3.71E-02	5.75E-03	2.34E-01	1.66E-02	4.67E-04	4.76E-05
BE	57	12	2.38E-02	3.67E-03	1.50E-01	1.03E-02	2.84E-04	3.08E-05

Table 1 (continued)

T ANG MOM	PI PLUS	KA PLUS	PROTON	PI MINUS	KA MINUS	ANTI P
BE 67 12	1.41E-02	2.23E-03	9.05E-02	6.16E-03	1.63E-04	1.81E-05
BE 87 12	3.93E-03	7.29E-04	2.72E-02	1.88E-03	4.91E-05	5.68E-06
BE 107 12	9.93E-04	2.17E-04	7.40E-03			
BE 17 14	7.47E-02	8.71E-03	7.95E-01	2.62E-02	5.66E-04	2.79E-05
BE 27 14	4.41E-02	6.28E-03	4.86E-01	1.83E-02	3.56E-04	1.96E-05
BE 37 14	2.35E-02	4.17E-03	2.84E-01	9.35E-03	1.81E-04	1.15E-05
BE 47 14	1.41E-02	2.47E-03	1.68E-01	4.95E-03	9.17E-05	6.69E-06
BE 57 14	7.36E-03	1.30E-03	9.26E-02	2.72E-03	4.86E-05	3.60E-06
BE 67 14	3.81E-03	7.14E-04	4.89E-02			
BE 87 14	7.35E-04	1.55E-04	1.04E-02			
BE 107 14	1.41E-04	3.51E-05	2.06E-03			
BE 17 16	3.23E-02	4.84E-03	8.63E-01	8.51E-03	9.50E-05	2.77E-06
BE 27 16	1.52E-02	3.[illegible]5E-03	4.37E-01	4.51E-03	5.17E-05	1.36E-06
BE 37 16	7.58E-03	1.73E-03	2.17E-01	2.17E-03	2.37E-05	1.06E-06
BE 47 16	3.86E-03	8.66E-04	1.09E-01	1.07E-03	1.10E-05	4.31E-07
BE 57 16	1.80E-03	3.74E-04	5.10E-02	5.09E-04	5.01E-06	1.45E-07
BE 67 16	7.47E-04	1.61E-04	2.23E-02			
BE 87 16	9.92E-05	2.63E-05	3.24E-03			
BE 17 18	7.80E-03	2.28E-03	6.19E-01	1.80E-03	6.54E-06	6.54E-08
BE 22 18	5.59E-03	1.61E-03	5.53E-01			
BE 27 18	3.70E-03	1.24E-03	3.51E-01	8.66E-04	3.73E-06	7.47E-08
BE 32 18	2.71E-03	8.61E-04	2.37E-01			
BE 37 18	1.76E-03	5.44E-04	1.44E-01	2.67E-04	1.22E-06	8.62E-09
BE 42 18	1.26E-03	3.57E-04	9.69E-02			
BE 47 18	7.95E-04	2.39E-04	6.11E-02	1.76E-04	6.71E-07	1.25E-08
BE 57 18	3.25E-04	8.11E-05	2.42E-02			
BE 67 18	1.01E-04	2.66E-05	6.28E-03			
BE 87 18	9.69E-06	2.87E-06	8.58E-04			
BC 17 4	1.15E+00	8.86E-02	2.96E-01	8.52E-01	3.27E-02	4.73E-03
BC 57 4	9.17E-01	7.04E-02	2.49E-01	5.99E-01	2.51E-02	3.99E-03
BC 87 4	5.62E-01	5.54E-02	2.06E-01	4.20E-01	1.96E-02	3.26E-03
BC 127 4	2.83E-01	3.48E-02	1.42E-01	2.22E-01	1.15E-02	2.05E-03
BC 17 6	9.61E-01	5.81E-02	4.45E-01	4.67E-01	1.78E-02	3.23E-03
BC 57 6	4.07E-01	4.15E-02	3.00E-01	2.37E-01	1.08E-02	2.18E-03
BC 87 6	2.05E-01	2.62E-02	1.88E-01	1.28E-01	6.36E-03	1.34E-03
BC 127 6	6.52E-02	1.04E-02	7.95E-02	4.41E-02	2.28E-03	5.12E-04
BC 17 10	2.84E-01	2.48E-02	6.58E-01	1.18E-01	3.99E-03	4.67E-04
BC 57 10	6.47E-02	9.56E-03	2.22E-01	3.23E-02	1.12E-03	1.71E-04
BC 87 10	1.77E-02	2.92E-03	6.43E-02	9.24E-03	3.14E-04	5.50E-05
BC 17 14	7.28E-02	8.57E-03	7.77E-01	2.58E-02	5.57E-04	2.88E-05
BC 57 14	7.29E-03	1.35E-03	9.29E-02	2.68E-03	4.86E-05	3.80E-06
BC 17 18	7.56E-03	2.21E-03	7.84E-01	1.70E-03	6.77E-06	6.17E-08

Table 1 (continued)

T ANG MOM	PI PLUS	KA PLUS	PROTON	PI MINUS	KA MINUS	ANTI P
AL 17 4	1.12E+00	9.33E-02	3.27E-01	8.37E-01	3.43E-02	4.80E-03
AL 37 4	1.03E+00	8.33E-02	3.02E-01	7.31E-01	2.88E-02	4.63E-03
AL 57 4	8.74E-01	7.38E-02	2.75E-01	5.87E-01	2.58E-02	4.01E-03
AL 67 4	7.66E-01	7.02E-02	2.64E-01	5.29E-01	2.41E-02	3.81E-03
AL 87 4	5.52E-01	5.99E-02	2.31E-01	3.98E-01	1.88E-02	3.20E-03
AL 107 4	4.01E-01	4.78E-02	1.94E-01	3.06E-01	1.62E-02	2.60E-03
AL 127 4	2.84E-01	3.77E-02	1.62E-01	2.23E-01	1.20E-02	2.07E-03
AL 17 5	1.01E+00	7.77E-02	4.06E-01	6.30E-01	2.42E-02	4.21E-03
AL 37 5	8.64E-01	6.83E-02	3.60E-01	5.11E-01	2.12E-02	3.74E-03
AL 57 5	6.12E-01	5.69E-02	3.09E-01	3.78E-01	1.74E-02	3.19E-03
AL 67 5	5.04E-01	5.35E-02	2.85E-01	3.20E-01	1.55E-02	2.84E-03
AL 87 5	3.39E-01	4.23E-02	2.26E-01	2.27E-01	1.17E-02	2.21E-03
AL 107 5	2.29E-01	3.13E-02	1.74E-01	1.57E-01	8.17E-03	1.63E-03
AL 127 5				1.02E-01	5.74E-03	1.14E-03
AL 17 6	8.73E-01	5.97E-02	4.56E-01	4.41E-01	1.68E-02	3.05E-03
AL 37 6	6.22E-01	5.31E-02	3.88E-01	3.35E-01	1.41E-02	2.59E-03
AL 57 6	3.89E-01	4.27E-02	3.10E-01	2.28E-01	1.09E-02	2.07E-03
AL 67 6	3.06E-01	3.78E-02	2.72E-01	1.88E-01	9.28E-03	1.76E-03
AL 87 6	1.97E-01	2.74E-02	1.97E-01	1.24E-01	6.40E-03	1.28E-03
AL 107 6	1.18E-01	1.78E-02	1.34E-01	7.66E-02	4.02E-03	8.28E-04
AL 127 6	6.60E-02	1.13E-02	8.73E-02	4.43E-02	2.41E-03	5.02E-04
AL 17 8	5.54E-01	3.83E-02	5.48E-01	2.21E-01	7.72E-03	1.30E-03
AL 37 8	2.82E-01	2.97E-02	4.09E-01	1.39E-01	5.61E-03	9.51E-04
AL 57 8	1.54E-01	2.12E-02	2.77E-01	8.38E-02	3.70E-03	6.57E-04
AL 67 8	1.16E-01	1.69E-02	2.19E-01	6.47E-02	2.83E-03	5.21E-04
AL 87 8	5.95E-02	9.30E-03	1.20E-01	3.52E-02	1.50E-03	2.99E-04
AL 107 8	2.88E-02	5.13E-03	6.46E-02	1.75E-02	7.84E-04	1.51E-04
AL 127 8	1.32E-02	2.75E-03	3.31E-02			
AL 17 10	2.54E-01	2.35E-02	6.27E-01	1.98E-01	3.72E-03	4.24E-04
AL 37 10	1.28E-01	1.61E-02	3.77E-01	5.87E-02	2.01E-03	2.82E-04
AL 57 10	5.82E-02	9.40E-03	2.09E-01	2.96E-02	1.06E-03	1.54E-04
AL 67 10	3.95E-02	6.41E-03	1.42E-01	2.07E-02	7.34E-04	1.09E-04
AL 87 10	1.63E-02	2.93E-03	6.19E-02	8.86E-03	3.32E-04	5.03E-05
AL 107 10	6.37E-03	1.30E-03	2.58E-02			
AL 127 10	2.27E-03	5.61E-04	1.03E-02			
AL 17 12	1.42E-01	1.36E-02	6.21E-01	5.17E-02	1.17E-03	1.06E-04
AL 27 12	9.13E-02	1.11E-02	4.47E-01	3.72E-02	9.46E-04	9.18E-05
AL 37 12	5.36E-02	8.33E-03	3.14E-01	2.43E-02	6.74E-04	6.22E-05
AL 47 12	3.38E-02	5.67E-03	2.13E-01	1.48E-02	4.07E-04	4.08E-05
AL 57 12	2.17E-02	3.74E-03	1.39E-01	9.27E-03	2.58E-04	2.86E-05
AL 67 12	1.27E-02	2.27E-03	8.37E-02	5.71E-03	1.54E-04	1.57E-05
AL 87 12	4.09E-03	8.55E-04	2.85E-02			
AL 107 12	1.15E-03	2.81E-04	8.71E-03			
AL 17 14	6.26E-02	7.68E-03	6.67E-01	2.20E-02	4.59E-04	2.14E-05
AL 27 14	3.78E-02	5.79E-03	4.13E-01	1.49E-02	2.82E-04	1.55E-05
AL 37 14	2.06E-02	3.83E-03	2.45E-01	7.93E-03	1.60E-04	9.10E-06
AL 47 14	1.24E-02	2.40E-03	1.49E-01	4.34E-03	8.07E-05	6.17E-06
AL 57 14	6.62E-03	1.35E-03	8.47E-02	2.43E-03	4.52E-05	3.16E-06
AL 67 14	3.64E-03	7.56E-04	4.66E-02			

Table 1 (continued)

T	ANG	MOM	PI PLUS	KA PLUS	PROTON	PI MINUS	KA MINUS	ANTI P
AL	87	14	7.98E-04	1.93E-04	1.12E-02			
AL	17	16	2.65E-02	4.10E-03	7.02E-01	6.59E-03	7.15E-05	1.87E-06
AL	27	16	1.29E-02	2.71E-03	3.61E-01	3.64E-03	4.29E-05	1.06E-06
AL	37	16	6.56E-03	1.58E-03	1.86E-01	1.83E-03	2.01E-05	8.51E-07
AL	47	16	3.41E-03	8.47E-04	9.63E-02	9.21E-04	9.65E-06	2.69E-07
AL	57	16	1.65E-03	3.91E-04	4.67E-02			
AL	17	18	6.30E-03	1.90E-03	6.54E-01	1.40E-03	5.74E-06	1.50E-08
AL	22	18	4.64E-03	1.45E-03	4.64E-01			
AL	27	18	3.12E-03	1.08E-03	2.91E-01	7.03E-04	2.87E-06	5.47E-08
AL	32	18	2.32E-03	7.78E-04	1.98E-01			
AL	37	18	1.51E-03	5.06E-04	1.23E-01	3.34E-04	1.74E-06	1.41E-08
AL	42	18	1.07E-03	3.48E-04	8.46E-02			
AL	47	18	7.00E-04	2.15E-04	5.41E-02	1.55E-04	5.42E-07	7.62E-09
AL	57	18	2.88E-04	8.49E-05	2.27E-02			
AL	67	18	1.02E-04	3.17E-05	8.32E-03			
AL	87	18	1.13E-05	3.99E-06	1.03E-03			
CU	17	4	1.08E+00	9.77E-02	3.45E-01	8.30E-01	3.39E-02	4.41E-03
CU	37	4				7.14E-01	2.95E-02	4.03E-03
CU	57	4	8.26E-01	7.69E-02	2.93E-01	5.71E-01	2.60E-02	3.67E-03
CU	67	4				5.02E-01	2.24E-02	3.41E-03
CU	87	4	5.29E-01	6.25E-02	2.48E-01	4.06E-01	2.06E-02	3.04E-03
CU	127	4	2.78E-01	4.02E-02	1.79E-01	2.23E-01	1.25E-02	2.03E-03
CU	37	5				5.58E-01	2.44E-02	3.62E-03
CU	17	6	7.81E-01	5.88E-02	4.45E-01	4.13E-01	1.58E-02	2.68E-03
CU	57	6	3.56E-01	4.21E-02	3.06E-01	2.16E-01	1.04E-02	1.90E-03
CU	87	6	1.86E-01	2.82E-02	2.02E-01	1.19E-01	6.22E-03	1.17E-03
CU	127	6	6.38E-02	1.20E-02	9.30E-02	4.38E-02	2.43E-03	4.81E-04
CU	37	8				1.27E-01	5.20E-03	8.18E-04
CU	57	8				7.72E-02	3.42E-03	5.86E-04
CU	17	10	2.21E-01	2.09E-02	5.53E-01	9.50E-02	3.21E-03	3.50E-04
CU	37	10				5.28E-02	1.84E-03	2.26E-04
CU	57	10	5.31E-02	8.94E-03	1.88E-01	2.70E-02	9.73E-04	1.33E-04
CU	67	10				1.88E-02	6.84E-04	9.93E-05
CU	87	10	1.48E-02	2.86E-03	5.81E-02	8.38E-03	3.05E-04	4.42E-05
CU	37	12				2.12E-02	5.72E-04	5.05E-05
CU	17	14	5.26E-02	6.65E-03	5.60E-01	1.85E-02	3.87E-04	1.88E-05
CU	57	14	5.75E-03	1.28E-03	7.43E-02	2.14E-03	3.88E-05	2.67E-06
CU	17	18	5.15E-03	1.59E-03	5.35E-01	1.18E-03	4.65E-06	1.29E-08
CU	57	18	2.55E-04	8.03E-05	1.99E-02			

Table 1 (continued)

T	ANG	MOM	PI PLUS	KA PLUS	PROTON	PI MINUS	KA MINUS	ANTI P
PB	17	4	1.05E+00	9.77E-02	3.61E-01	8.29E-01	3.12E-02	3.72E-03
PB	57	4	7.60E-01	7.93E-02	3.13E-01	5.49E-01	2.36E-02	3.21E-03
PB	67	4				4.81E-01	2.32E-02	3.02E-03
PB	87	4	4.93E-01	6.54E-02	2.70E-01	3.96E-01	1.93E-02	2.66E-03
PB	127	4	2.67E-01	4.31E-02	2.01E-01			
PB	17	6	6.85E-01	5.74E-02	4.11E-01	3.74E-01	1.38E-02	2.23E-03
PB	57	6	3.16E-01	4.13E-02	2.93E-01	1.96E-01	9.66E-03	1.58E-03
PB	87	6	1.66E-01	2.75E-02	1.97E-01	1.10E-01	5.75E-03	1.02E-03
PB	127	6	6.02E-02	1.27E-02	9.69E-02			
PB	17	10	1.82E-01	1.90E-02	4.63E-01	7.86E-02	2.63E-03	2.72E-04
PB	57	10	4.50E-02	8.14E-03	1.64E-01	2.34E-02	8.47E-04	1.12E-04
PB	87	10	1.25E-02	2.77E-03	5.16E-02	7.47E-03	2.86E-04	3.69E-05
PB	17	14	4.03E-02	5.50E-03	4.32E-01	1.48E-02	2.98E-04	1.38E-05
PB	57	14	4.71E-03	1.15E-03	6.20E-02	1.83E-03	3.62E-05	2.38E-06
PB	17	18	4.03E-03	1.32E-03	4.22E-01	9.61E-04	4.01E-06	5.21E-12

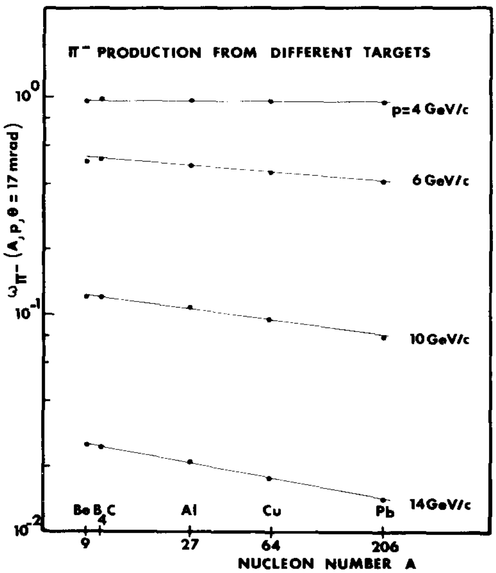


Fig. 2. Dependence of π^- production upon the nucleon number A.

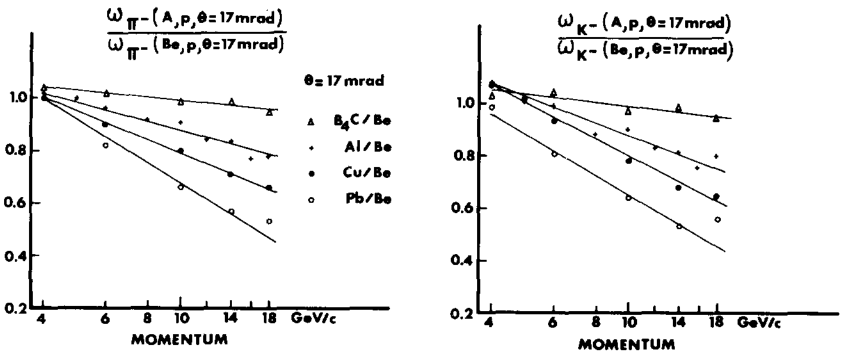


Fig. 3. Ratio of the π^- and K^- yield from various nuclei and beryllium at fixed production angle 17 mrad as a function of laboratory momentum.

3. SOME REMARKS

Fig. 2 shows the dependence of π^- production upon the nucleon number A. The data points lie on straight lines, indicating a power law. Similar behaviour is found at other angles and for the other produced particles. The reason for the various slopes comes presumably from secondary interactions inside the nucleus whose probability increases with A. For example, if a pion produced with high momentum interacts again inside the nucleus, it will in general emerge with smaller momentum (fig. 3) and higher angle (fig. 4). Fig. 5 shows that the π^-/π^+ ratio is practically independent of the nucleon number A, as had been already found in an experiment at 18.8 GeV/c [7].

The dependence on longitudinal and transverse momentum of the charge ratios of K and π and of the K/π ratios (figures 6a–d) shows complex structure which may be partly due to isobar production [8].

The predictions of the thermodynamical model [9] are in reasonable agreement with the pion production data. For example, the prediction for beryllium agrees within 15% with the π^+ data below 1 GeV/c transverse momentum and is systematically too high by up to a factor 1.5 for higher transverse momenta. The agreement with the kaon data is less satisfactory. For example, the behaviour of the K^+/π^+ ratio shown in fig. 6d is not reproduced.

The apparatus used in this experiment has been built by the CERN-Rome group. We would like to express our gratitude to the members of this group: J.V. Allaby, A.N. Diddens, R.W. Dobinson, A. Klovning, J. Litt, L.S. Rochester, K. Schlüpman and A.M. Wetherell (CERN), and U. Amaldi, R. Biancastelli, C. Bosio and G. Matthiae (Rome) for their cooperation and continuous help during the measurements. We are indebted to Miss I. Jarstorff for carrying out the radioactivity measurements of the aluminum foils.

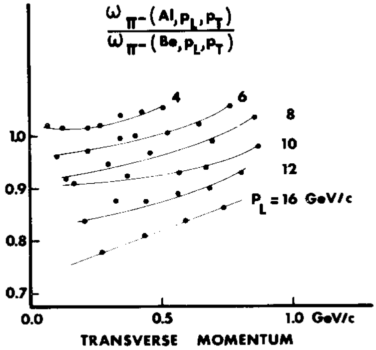


Fig. 4. Ratio of the π^- yield from aluminum and beryllium for various momenta as a function of transverse momentum.

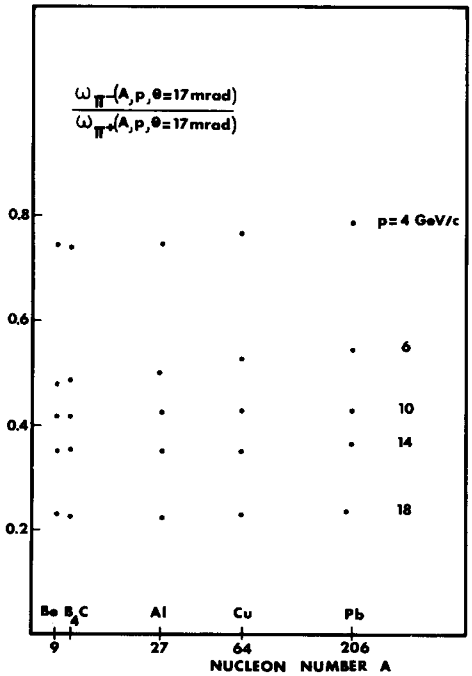
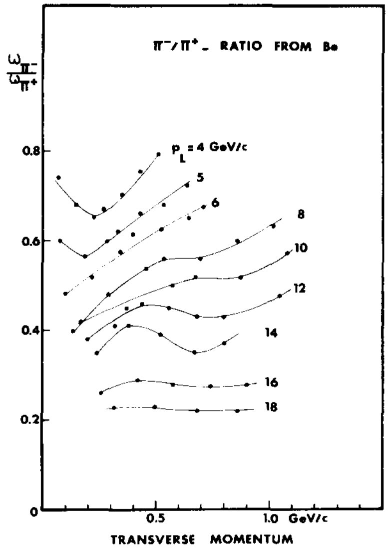
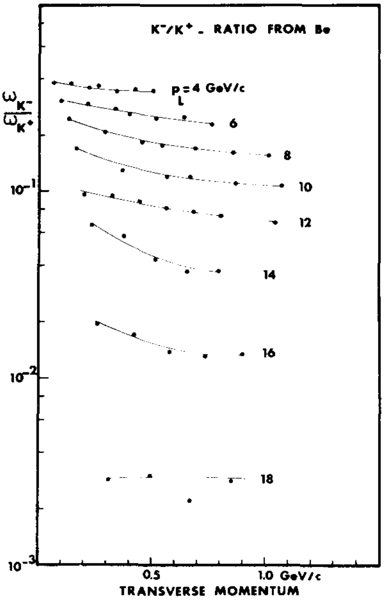


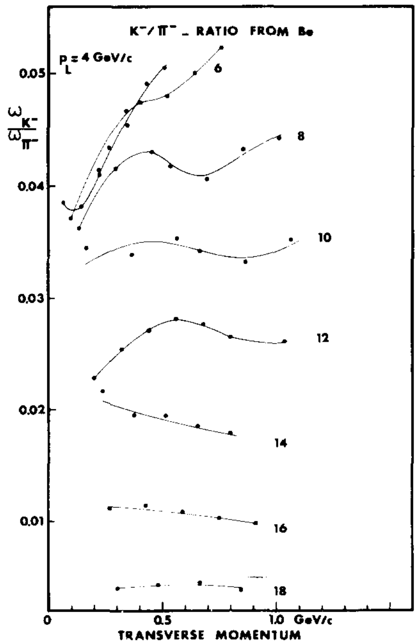
Fig. 5. Ratio of the π^- and π^+ yield for various momenta at fixed angle (θ = 17 mrad) as a function of the nucleon number A.



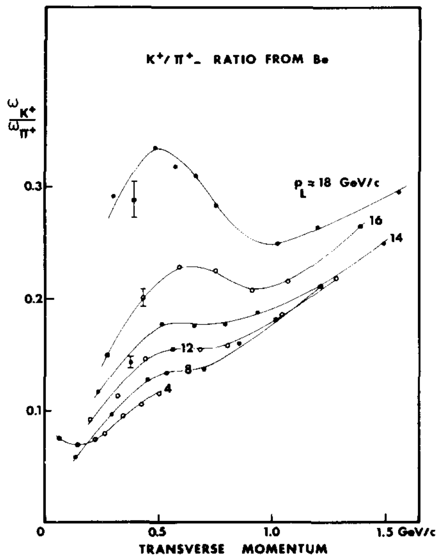
(a)



(b)



(c)



(d)

Fig. 6(a). Transverse momentum dependence of the π^-/π^+ ratio from Be for various longitudinal (laboratory) momenta. (b) Idem for K^-/K^+. (c) Idem for K^-/π^-. (d) Idem for K^+/π^+.

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