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EXPERIMENTAL RESULTS ON CUMULATIVE PARTICLE PRODUCTION BY PROTONS AND LIGHT NUCLEI

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In this paper we present the experimental results on inclusive processes

$$B + A \longrightarrow c + \ldots,$$

where B denotes primary beams of protons, α–particles and carbon nuclei with momenta of 4.5·A GeV/c. In the first round of the measurements a target nucleus atomic weight dependence (A-dependence) of the cross-sections was studied on the following targets: A: D, He, ^{6}Li, ^{6}Li, C, Al, Si, Cu, ^{58}Ni, ^{64}Ni, ^{64}Zn, ^{114}Sn, ^{124}Sn, Pb. The list of secondary particles includes π^+, π^-, K$^+$, protons (p), deuterons (d) produced at an angle $\vartheta = 120°$ with a momentum of 0.5 GeV/c.

The second round of the measurements was carried out in a 8.9 GeV/c proton beam on the production of π^+, π^-, p, d in over a range of 0.3 – 0.7 GeV/c. Besides, A-dependence of the production of π^+, π^-, K$^+$, K$^-$, p, d was studied for the fragmentation of ^{58}Ni, ^{64}Ni, ^{64}Zn, ^{114}Sn, ^{124}Sn, Pb. The production angle and momentum were fixed to be 120°, 0.5 GeV/c.

The measurements were taken on the DISK spectrometer[1, 2], in an extracted beam of the Dubna Synchrophasotron. The spectrometer consists of a bending dipole magnet and a doublet of quadrupole lenses. Secondary particles are identified by a scintillation time-of-flight system with a resolution of ± 260 ps. Ionization losses in the scintillation detectors and the intensity of Cherenkov radiation in two plastic radiators provide additional selection criteria. The absolute calibration of an intensity monitoring telescope is carried out by the activation method based on a reaction ^{12}C(p,pn)^{11}C. The systematic error of the method is 10 – 15%. A detailed description of the spectrometer and the cross-section calculation procedure can be found in papers [1, 2].

The results on the differential cross-sections are in tables 1 – 11. Tables 1 – 4 show the data on d, p, π^+, π^-. Table 5 contains the data on K$^+$–mesons. This data set corresponds to a primary beam momentum of 4.5·A GeV/c.

The data on the A-dependence of the of K$^+$ and K$^-$ production cross-sections by 8.9 GeV/c protons are presented in table 6. The energy and A-dependence can be derived from tables 7 – 11.

The invariant differential cross-sections normalized per nucleon are presented in the following form:

$$\frac{1}{A} E \frac{d\sigma}{d\vec{p}} = \frac{1}{A} \frac{E}{p^2} \frac{d^2\sigma}{dp\, d\Omega} \quad (\mathrm{mb\, GeV^{-2}\, c^3\, sr^{-1} nucleon^{-1}})$$

The errors are just statistical ones, and the systematic errors produced by the correction factors are estimated at a level of $\simeq 2\%$.

The parametrization of cumulative particle production usually has an exponential expression:

$$\frac{E}{A} \frac{d\sigma}{d\vec{p}} = B_T \exp(-\frac{T}{T_0}) \qquad (1)$$

$$\frac{E}{A} \frac{d\sigma}{d\vec{p}} = B_X \exp(-\frac{X}{X_0}) \qquad (2)$$

$$\frac{E}{A}\frac{d\sigma}{d\vec{p}} = B_\alpha \exp(-\frac{\alpha}{\alpha_0}) \quad (3)$$

In expression (1) T is the secondary particle kinetic energy, T_0 the spectrum slope parameter (effective temperature). Formula (2) describes the data vs the scale variable with mass effect corrections (cumulative number) [3]:

$$X = \frac{(P_I P_1) + M_I M_1 + (M_2^2 - M_1^2)/2}{(P_I P_{II}) - (P_1 P_{II}) - M_I M_{II} - M_2 M_{II}}$$

where P_I and P_{II} are the 4-momenta per nucleon of fragmenting and target nuclei, respectively; P_1, the 4-momentum of a measured particle; M_I, M_{II}, M_1, the corresponding masses ($M_I^2 = P_I^2$); M_2, an additonal mass of particles needed to obey the quantum number conservation laws.

In the third parametrization (3) α is a light cone variable defined by the expression:

$$\alpha = \frac{E - P\cos\vartheta}{M_n} ,$$

E, P, ϑ are the energy, momentum and production angle of a particle, M_n - the nucleon mass.

The data on the energy dependence were fitted in accordance with these parametrizations 1 – 3 (tables 12 – 29). The physical analysis and our conclusions can be found in ref. [4, 5].

In conclusion we wish to thank N.S. Moroz, O.Yu. Kulpina, G.S. Averichev, Yu.A. Panebratsev, V.G. Perevozchikov for their contribution to this experiment.

Table 1: p (4.5 GeV/c) + A , $\vartheta = 120°$, p = 0.5 GeV/c

A	d	p	π^+ ($\times 10^{-1}$)	π^- ($\times 10^{-1}$)
^{6}Li	$.212 \pm .004$	$1.47 \pm .03$	$.58 \pm .012$	$.48 \pm .01$
C	$.67 \pm .02$	$3.02 \pm .06$	$.65 \pm .013$	$.66 \pm .013$
Si	$1.25 \pm .03$	$4.63 \pm .09$	$.85 \pm .017$	$.73 \pm .014$
^{58}Ni	$2.04 \pm .04$	$6.23 \pm .13$	$.85 \pm .017$	$.70 \pm .014$
^{64}Ni	$2.10 \pm .04$	$5.68 \pm .11$	$.76 \pm .015$	$.78 \pm .016$
^{64}Zn	$2.08 \pm .04$	$6.02 \pm .12$	$.79 \pm .016$	$.70 \pm .014$
^{114}Sn	$2.39 \pm .05$	$6.37 \pm .13$	$.69 \pm .014$	$.65 \pm .013$
^{124}Sn	$2.39 \pm .05$	$5.66 \pm .11$	$.62 \pm .012$	$.70 \pm .014$
Pb	$3.18 \pm .06$	$6.43 \pm .12$	$.57 \pm .011$	$.59 \pm .012$

Table 2: d (4.5·A GeV/c) + A , $\vartheta = 120°$, $\mathbf{p} = 0.5$ GeV/c

A	d	p	π^+ ($\times 10^{-1}$)	π^- ($\times 10^{-1}$)
D		$.42 \pm .012$	$.228 \pm .006$	$.241 \pm .006$
^{4}He	$.334 \pm .009$	$2.26 \pm .07$	$.890 \pm .018$	$.93 \pm .02$
^{6}Li	$.344 \pm .007$	$2.24 \pm .05$	$.848 \pm .017$	$.76 \pm .04$
C	$1.12 \pm .02$	$4.97 \pm .1$	$1.21 \pm .02$	$1.08 \pm .12$
Si	$2.05 \pm .04$	$6.99 \pm .14$	$1.29 \pm .03$	$1.28 \pm .12$
^{58}Ni	$3.74 \pm .07$	$9.8 \pm .2$	$1.27 \pm .03$	$1.17 \pm .04$
^{64}Ni	$3.73 \pm .12$	$8.87 \pm .3$	$1.16 \pm .02$	$1.31 \pm .03$
^{64}Zn	$3.92 \pm .08$	$9.9 \pm .2$	$1.24 \pm .02$	$1.15 \pm .03$
^{114}Sn	$4.72 \pm .09$	$10.5 \pm .2$	$1.08 \pm .02$	$1.10 \pm .02$
^{124}Sn	$4.90 \pm .09$	$9.67 \pm .19$	$.98 \pm .02$	$1.13 \pm .05$
Pb	$6.32 \pm .13$	$11.0 \pm .2$	$.94 \pm .03$	$.95 \pm .02$

Table 3: α (4.5·A GeV/c) + A , $\vartheta = 120°$, $\mathbf{p} = 0.5$ GeV/c

A	d	p	π^+ ($\times 10^{-1}$)	π^- ($\times 10^{-1}$)
^{6}Li	$.302 \pm .016$	$2.16 \pm .05$	$.783 \pm .029$	$.746 \pm .041$
C	$1.17 \pm .02$	$6.08 \pm .12$	$1.63 \pm .04$	
Si	$2.13 \pm .06$	$7.24 \pm .14$	$1.30 \pm .06$	$1.13 \pm .07$
^{58}Ni	$3.65 \pm .07$	$10.2 \pm .2$	$1.41 \pm .05$	$1.05 \pm .08$
^{64}Ni	$3.95 \pm .08$	$9.6 \pm .2$	$1.41 \pm .05$	$1.33 \pm .10$
^{64}Zn	$3.98 \pm .08$	$10.6 \pm .2$	$1.54 \pm .05$	$1.26 \pm .07$
^{114}Sn	$5.62 \pm .11$	$11.6 \pm .2$	$1.32 \pm .04$	$1.22 \pm .05$
^{124}Sn	$5.51 \pm .11$	$10.6 \pm .2$	$1.23 \pm .05$	$1.28 \pm .05$
Pb	$7.6 \pm .3$	$12.9 \pm .3$	$1.17 \pm .02$	$1.11 \pm .03$

Table 4: C (4.5·A GeV/c) + A , $\vartheta = 120°$, $\mathbf{p} = 0.5$ GeV/c

A	d	p	π^+ ($\times 10^{-1}$)	K^+ ($\times 10^{-1}$)
^{6}Li	$.66 \pm .02$	$4.77 \pm .09$	$1.84 \pm .05$	$.104 \pm .061$
^{7}Li	$.81 \pm .06$	$4.97 \pm .09$	$2.20 \pm .11$	$.28 \pm .13$
C	$1.81 \pm .04$	$10.21 \pm .42$	$3.18 \pm .04$	$.15 \pm .04$
Al	$3.42 \pm .08$	$14.08 \pm .28$	$3.45 \pm .06$	$.16 \pm .034$
Cu	$7.84 \pm .14$	22.3 ± 1.0	$3.89 \pm .06$	$.35 \pm .05$
^{114}Sn	$10.6 \pm .3$	$25.22 \pm .35$	$3.4 \pm .2$	$.29 \pm .17$
^{124}Sn	$10.6 \pm .24$	$24.6 \pm .5$	$3.43 \pm .07$	$.52 \pm .08$
Pb	$11.9 \pm .5$	$25.91 \pm .35$	$3.17 \pm .12$	$.39 \pm .04$

Table 5: B (4.5·A GeV/c) + A $\longrightarrow K^+ + \ldots$, $\vartheta = 120°$, $\mathbf{p} = 0.5$ GeV/c

A	B			
	p ($\times 10^{-3}$)	d ($\times 10^{-3}$)	α ($\times 10^{-3}$)	C ($\times 10^{-2}$)
D		$.16 \pm .08$		
^{4}He		$.91 \pm .22$		
^{6}Li	$.53 \pm .19$	$1.0 \pm .3$	2.0 ± 1.3	$1.0 \pm .6$
^{7}Li				2.8 ± 1.3
C	$.70 \pm .22$	$2.2 \pm .3$	$3.0 \pm .9$	$1.5 \pm .4$
Al				$1.6 \pm .3$
Si	$3.0 \pm .5$	$4.3 \pm .7$	3.9 ± 2.0	
^{58}Ni	$2.7 \pm .7$	7.4 ± 1.0	3.2 ± 1.9	
^{64}Ni	$2.0 \pm .9$	7.2 ± 1.2	8.0 ± 3.7	
Zn	$3.0 \pm .5$	$6.5 \pm .9$	9.9 ± 3.0	
Cu				$3.5 \pm .5$
^{114}Sn	$3.0 \pm .5$	6.9 ± 1.0	11 ± 3	2.9 ± 1.7
^{119}Sn				$5.2 \pm .8$
^{124}Sn	$3.7 \pm .8$	$8.2 \pm .9$	13 ± 6	
Pb	$2.6 \pm .8$	12 ± 4	12 ± 2	$3.9 \pm .4$

Table 6: p (8.9 GeV/c) + A , $\vartheta = 120°$, $\mathbf{p} = 0.5$ GeV/c

A	K^+ ($\times 10^{-2}$)	K^- ($\times 10^{-4}$)
^{58}Ni	$1.22 \pm .05$	$2.9 \pm .7$
^{64}Ni	$1.19 \pm .05$	3.6 ± 1.0
^{64}Zn	$1.32 \pm .03$	$3.2 \pm .7$
^{114}Sn	$1.59 \pm .05$	$3.9 \pm .4$
^{124}Sn	$1.48 \pm .06$	$3.0 \pm .5$
Pb	$1.25 \pm .18$	

Table 7: p (8.9 GeV/c) + A , $\vartheta = 120°$, $\mathbf{p} = 0.3$ GeV/c

A	p	π^+	π^-
^{58}Ni	61.0 ± 1.2	$1.43 \pm .06$	$1.05 \pm .02$
^{64}Ni	57.6 ± 1.2	$1.30 \pm .04$	$1.10 \pm .02$
^{64}Zn	59.7 ± 1.2	$1.49 \pm .03$	$1.09 \pm .02$
^{114}Sn	69.3 ± 1.4	$1.38 \pm .03$	$.985 \pm .020$
^{124}Sn	57.3 ± 1.2	$1.22 \pm .02$	$.971 \pm .020$
Pb	77.3 ± 1.5	$1.20 \pm .04$	$.907 \pm .019$

Table 8: p (8.9 GeV/c) + A , $\vartheta = 120°$, $\mathbf{p} = 0.4$ GeV/c

A	p	π^+ ($\times 10^{-1}$)	π^- ($\times 10^{-1}$)
^{58}Ni	$18.8 \pm .4$	$4.30 \pm .10$	$3.03 \pm .07$
^{64}Ni	$17.1 \pm .3$	$3.81 \pm .12$	$3.27 \pm .07$
^{64}Zn	$19.3 \pm .4$	$4.30 \pm .10$	$3.24 \pm .06$
^{114}Sn	$22.2 \pm .4$	$3.75 \pm .09$	$3.06 \pm .06$
^{124}Sn	$18.9 \pm .4$	$3.44 \pm .08$	$2.91 \pm .06$
Pb	$25.0 \pm .6$	$3.35 \pm .07$	$2.90 \pm .06$

Table 9: p (8.9 GeV/c) + A , $\vartheta = 120°$, $\mathbf{p} = 0.5$ GeV/c

A	d	p	π^+ ($\times 10^{-1}$)	π^- ($\times 10^{-1}$)
^{58}Ni	$2.33 \pm .05$	$5.39 \pm .11$	$1.11 \pm .03$	$.91 \pm .03$
^{64}Ni	$2.41 \pm .05$	$5.12 \pm .10$	$1.00 \pm .02$	$.99 \pm .03$
^{64}Zn	$2.36 \pm .05$	$5.88 \pm .12$	$1.16 \pm .03$	$.91 \pm .05$
^{114}Sn	$3.46 \pm .07$	$6.82 \pm .14$	$.98 \pm .02$	$.93 \pm .02$
^{124}Sn	$3.13 \pm .06$	$6.03 \pm .12$	$.88 \pm .02$	$.97 \pm .02$
Pb	$4.50 \pm .09$	$7.22 \pm .14$	$.88 \pm .03$	$.93 \pm .02$

Table 10: p (8.9 GeV/c) + A , $\vartheta = 120°$, $\mathbf{p} = 0.6$ GeV/c

A	d	p	π^+ ($\times 10^{-2}$)	π^- ($\times 10^{-2}$)
^{58}Ni	$.82 \pm .02$	$1.73 \pm .04$	$3.00 \pm .07$	$2.41 \pm .06$
^{64}Ni	$.84 \pm .02$	$1.60 \pm .03$	$2.75 \pm .06$	
^{64}Zn	$.86 \pm .02$	$1.78 \pm .04$	$2.95 \pm .07$	$2.61 \pm .07$
^{114}Sn	$1.24 \pm .03$	$2.05 \pm .04$	$2.84 \pm .12$	$2.51 \pm .06$
^{124}Sn	$1.15 \pm .03$	$1.82 \pm .05$	$2.50 \pm .06$	$2.57 \pm .06$
Pb	$1.69 \pm .04$	$2.25 \pm .05$	$2.66 \pm .08$	$2.60 \pm .06$

Table 11: p (8.9 GeV/c) + A , $\vartheta = 120°$, $\mathbf{p} = 0.7$ GeV/c

A	d ($\times 10^{-1}$)	p ($\times 10^{-1}$)	π^+ ($\times 10^{-3}$)	π^- ($\times 10^{-3}$)
^{58}Ni	$2.85 \pm .06$	$4.97 \pm .11$	$7.30 \pm .30$	$5.95 \pm .24$
^{64}Ni	$2.87 \pm .06$	$4.68 \pm .09$	$6.34 \pm .21$	$6.58 \pm .25$
^{64}Zn				$6.36 \pm .25$
^{114}Sn	$4.53 \pm .11$	$6.22 \pm .12$	$6.92 \pm .25$	$6.20 \pm .20$
^{124}Sn	$4.07 \pm .08$	$5.44 \pm .11$	$5.94 \pm .16$	$6.40 \pm .20$
Pb	$5.90 \pm .15$	$6.60 \pm .10$	$6.30 \pm .20$	$6.56 \pm .21$

Approximation parameters of kinetic energy dependence for protons (form. 1)

Table 12: p, 0.3 – 0.5 GeV/c

A	T_0 (MeV)	B_T	χ^2/d.f.
^{58}Ni	32.3 ± 0.4	252 ± 8	13
^{64}Ni	32.5 ± 0.4	231 ± 8	30
^{64}Zn	33.8 ± 0.4	231 ± 8	14
^{114}Sn	33.8 ± 0.4	267 ± 9	18
^{124}Sn	34.9 ± 0.4	211 ± 7	17
Pb	33.0 ± 0.4	313 ± 10	6

Table 13: p, 0.5 – 0.7 GeV/c

A	T_0 (MeV)	B_T	χ^2/d.f.
^{58}Ni	45.0 ± 0.6	86 ± 4	1.0
^{64}Ni	44.9 ± 0.5	81 ± 4	2.4
^{64}Zn	42.3 ± 1.0	113 ± 10	1.0
^{114}Sn	45.0 ± 0.5	107 ± 5	10
^{124}Sn	44.7 ± 0.5	97 ± 5	5
Pb	44.9 ± 0.5	115 ± 5	2.4

Approximation parameters of cumulative number dependence for protons (form. 2)

Table 14: p, 0.3 – 0.5 GeV/c

A	X_0	B_X	χ^2/d.f.
^{58}Ni	0.093 ± 0.001	781 ± 36	1.4
^{64}Ni	0.094 ± 0.001	718 ± 33	8
^{64}Zn	0.098 ± 0.001	681 ± 31	2
^{114}Sn	0.098 ± 0.001	788 ± 36	3
^{124}Sn	0.101 ± 0.001	605 ± 28	3
Pb	0.096 ± 0.001	941 ± 43	10

Table 15: p, 0.5 – 0.7 GeV/c

A	X_0	B_X	χ^2/d.f.
^{58}Ni	0.115 ± 0.001	313 ± 21	1.0
^{64}Ni	0.114 ± 0.001	300 ± 19	1.0
^{64}Zn	0.110 ± 0.003	408 ± 50	1.0
^{114}Sn	0.114 ± 0.001	394 ± 25	4.6
^{124}Sn	0.114 ± 0.001	359 ± 23	2.0
Pb	0.114 ± 0.001	422 ± 27	1.0

Approximation parameters of light cone variable dependence for protons (form. 3)

Table 16: p, 0.3 – 0.5 GeV/c

A	α_0	B_α	χ^2/d.f.
^{58}Ni	0.078 ± 0.001	872 ± 41	1.0
^{64}Ni	0.078 ± 0.001	802 ± 38	6.0
^{64}Zn	0.082 ± 0.001	756 ± 35	1.0
^{114}Sn	0.082 ± 0.001	875 ± 41	2.0
^{124}Sn	0.084 ± 0.001	671 ± 32	2.0
Pb	0.080 ± 0.001	1047 ± 49	1.0

Table 17: p, 0.5 – 0.7 GeV/c

A	α_0	B_α	χ^2/d.f.
^{58}Ni	0.093 ± 0.001	398 ± 28	1.0
^{64}Ni	0.092 ± 0.001	381 ± 25	1.0
^{64}Zn	0.090 ± 0.002	501 ± 64	1.0
^{114}Sn	0.092 ± 0.001	502 ± 34	3.0
^{124}Sn	0.092 ± 0.001	457 ± 30	1.0
Pb	0.092 ± 0.001	537 ± 35	1.0

Approximation parameters of kinetic energy dependence for $\pi^{\pm}$-mesons (form. 1)

Table 18: π^+, 0.3 – 0.7 GeV/c

A	T_0 (MeV)	B_T	χ^2/d.f.
^{58}Ni	72.4 ± 0.6	21.0 ± 0.1	1.6
^{64}Ni	72.5 ± 0.5	18.8 ± 0.8	3.6
^{64}Zn	72.8 ± 0.5	21.0 ± 0.7	1.1
^{114}Sn	72.4 ± 0.5	19.0 ± 0.6	1.8
^{124}Sn	72.3 ± 0.4	17.3 ± 0.5	2.7
Pb	73.6 ± 0.5	16.0 ± 0.6	3.0

Table 19: π^-, 0.3 – 0.5 GeV/c

A	T_0 (MeV)	B_T	χ^2/d.f.
^{58}Ni	76.5 ± 1.0	12.7 ± 0.7	1.6
^{64}Ni	78.0 ± 1.0	12.8 ± 0.6	1.0
^{64}Zn	75.8 ± 1.0	13.7 ± 0.7	1.0
^{114}Sn	79.6 ± 1.0	11.0 ± 0.5	2.4
^{124}Sn	86.6 ± 2.0	7.8 ± 0.7	1.0
Pb	82.7 ± 1.0	9.1 ± 0.4	1.0

Table 20: π^-, 0.5 – 0.7 GeV/c

A	T_0 (MeV)	B_T	χ^2/d.f.
^{58}Ni	71.5 ± 1.0	19.0 ± 2.0	1.0
^{64}Ni	71.8 ± 1.3	19.0 ± 2.0	1.2
^{64}Zn	74.0 ± 1.3	16.0 ± 1.7	4.7
^{114}Sn	72.4 ± 1.0	18.0 ± 1.5	1.7
^{124}Sn	71.8 ± 1.0	19.0 ± 1.6	1.0
Pb	73.8 ± 1.0	16.0 ± 1.4	2.3

Approximation parameters of cumulative number dependence for $\pi^{\pm}$-mesons (form. 2)

Table 21: π^+, 0.3 – 0.7 GeV/c

A	X_0	B_X	χ^2/d.f.
^{58}Ni	0.149 ± 0.001	78 ± 4	1.0
^{64}Ni	0.150 ± 0.001	69 ± 3	1.8
^{64}Zn	0.149 ± 0.001	82 ± 4	1.0
^{114}Sn	0.149 ± 0.001	73 ± 3	4.8
^{124}Sn	0.149 ± 0.001	65 ± 2	3.2
Pb	0.152 ± 0.001	57 ± 3	3.3

Table 22: π^-, 0.3 – 0.5 GeV/c

A	X_0	B_X	χ^2/d.f.
^{58}Ni	0.155 ± 0.002	48 ± 4	2.5
^{64}Ni	0.157 ± 0.002	48 ± 3	1.7
^{64}Zn	0.153 ± 0.002	53 ± 4	1.5
^{114}Sn	0.161 ± 0.002	39 ± 2	1.0
^{124}Sn	0.176 ± 0.002	24 ± 3	1.0
Pb	0.167 ± 0.002	31 ± 2	1.1

Table 23: π^-, 0.5 – 0.7 GeV/c

A	X_0	B_X	χ^2/d.f.
^{58}Ni	0.150 ± 0.003	60 ± 9	1.0
^{64}Ni	0.151 ± 0.003	62 ± 8	1.0
^{64}Zn	0.155 ± 0.002	50 ± 6	3.0
^{114}Sn	0.152 ± 0.002	57 ± 6	1.0
^{124}Sn	0.151 ± 0.002	62 ± 6	1.0
Pb	0.155 ± 0.002	50 ± 5	1.0

Approximation parameters of light cone variable dependence for $\pi^{\pm}$-mesons (form. 3)

Table 24: π^+, 0.3 – 0.7 GeV/c

A	α_0	B_α	χ^2/d.f.
^{58}Ni	0.117 ± 0.001	121 ± 7	2.0
^{64}Ni	0.118 ± 0.001	106 ± 6	4.0
^{64}Zn	0.118 ± 0.001	115 ± 5	1.8
^{114}Sn	0.117 ± 0.001	107 ± 5	1.4
^{124}Sn	0.117 ± 0.001	97 ± 4	3.0
Pb	0.119 ± 0.001	88 ± 4	3.1

Table 25: π^-, 0.3 – 0.5 GeV/c

A	α_0	B_α	χ^2/d.f.
^{58}Ni	0.125 ± 0.002	63 ± 5	1.1
^{64}Ni	0.127 ± 0.002	62 ± 4	1.0
^{64}Zn	0.124 ± 0.002	69 ± 5	1.0
^{114}Sn	0.130 ± 0.001	51 ± 3	1.0
^{124}Sn	0.140 ± 0.003	33 ± 4	1.0
Pb	0.135 ± 0.002	40 ± 3	1.0

Table 26: π^-, 0.5 – 0.7 GeV/c

A	α_0	B_α	χ^2/d.f.
^{58}Ni	0.115 ± 0.002	112 ± 1	1.0
^{64}Ni	0.116 ± 0.002	117 ± 1	1.0
^{64}Zn	0.119 ± 0.002	90 ± 1	4.9
^{114}Sn	0.117 ± 0.002	104 ± 1	1.9
^{124}Sn	0.116 ± 0.001	115 ± 1	1.0
Pb	0.119 ± 0.002	91 ± 1	2.5

Cross-section approximation parameters for deuterons (1 – 3)

Table 27: d, 0.5 – 0.7 GeV/c

A	T_0 (MeV)	B_T	χ^2/d.f.
^{58}Ni	29.0 ± 0.4	22.0 ± 1	7.0
^{64}Ni	28.6 ± 0.4	23.0 ± 1	6.0
^{64}Zn	27.9 ± 0.9	25.0 ± 2	1.0
^{114}Sn	29.8 ± 0.5	30.0 ± 1	9.0
^{124}Sn	29.9 ± 0.4	28.0 ± 1	4.0
Pb	29.9 ± 0.5	40.0 ± 2	2.0

Table 28: d, 0.5 – 0.7 GeV/c

A	X_0	B_X	χ^2/d.f.
^{58}Ni	0.101 ± 0.001	111 ± 8	1.0
^{64}Ni	0.100 ± 0.001	121 ± 8	1.0
^{64}Zn	0.101 ± 0.003	113 ± 1	1.5
^{114}Sn	0.104 ± 0.002	146 ± 1	3.0
^{124}Sn	0.104 ± 0.001	134 ± 9	1.0
Pb	0.104 ± 0.002	191 ± 1	1.0

Table 29: d, 0.5 – 0.7 GeV/c

A	α_0	B_α	χ^2/d.f.
^{58}Ni	0.081 ± 0.001	139 ± 1	1.0
^{64}Ni	0.080 ± 0.001	151 ± 1	1.0
^{64}Zn	0.082 ± 0.003	135 ± 1	1.0
^{114}Sn	0.084 ± 0.001	181 ± 1	2.0
^{124}Sn	0.084 ± 0.001	166 ± 1	1.0
Pb	0.084 ± 0.001	236 ± 1	1.0

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