T A B L E S


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T A B L E 3.1

Target parameters

| | Atomic Number | Length (cm) | Density ($g/cm^3$) | $\chi$ |
|---|---|---|---|---|
| C | 12.00 | 99.06 ± .005 | 1.720 ± .002 | 1.62 |
| Al | 27.98 | 90.17 ± .005 | 2.714 ± .002 | 2.02 |
| Cu | 63.54 | 27.00 ± .005 | 8.93 ± .01 | 1.76 |
| $Sn$ | 118.69 | 36.06 ± .005 | 7.30 ± .01 | 1.74 |
| $Sn^*$ | 118.69 | 15.24 ± .005 | 7.30 ± .01 | 0.74 |
| Pb | 207.19 | 26.04 ± .005 | 11.33 ± .02 | 1.74 |

T A B L E 3.2

Components of spectrometer

| Object | Relative long. (cm) position | Transverse Dimensions W x H | Effective radiation length $\times 10^{-3}$ |
|---|---|---|---|
| RA | - 3214 | 8 x 18 | - |
| Upst } Decay pipe | - 3202 | 15 cm ø | - |
| Downstr } window | - 2118 | 90 cm ø | 7.96 |
| MF | - 2073 | 86 x 43 | 4.69 |
| CH1 | - 1205 | 120 x 60 | 8.01 |
| C2 | - 2235 | 100 x 70 | 11.4 |
| CH2 | - 194 | 120 x 60 | 5.03 |
| CH3 | - 121 | 120 x 60 | 5.65 |
| MAGNET | 0 | 150 x 66 | - |
| CH4 | 157 | 140 x 95 | 6.07 |
| CH5 | 1330 | 140 x 95 | 5.22 |
| C3, C4 | 1398 | 122 x 122 | 29.5 |
| SC | 1501 | 110 x 110 | - |
| μ-filter | 1638 | - | - |
| C5 | 1971 | 168 x 152 | |

TABLE 5.1

Spectrometer acceptance integrated over the decay region.

| p (GeV/c) | A(Kπ2,p) | A(Kμ3,p) | A(Ke3,p) |
|---|---|---|---|
| 25. | .0117 +/- .0004 | .0026 +/- .0002 | .000022 +/- .000009 |
| 35. | .1098 +/- .0015 | .0306 +/- .0007 | .000353 +/- .000043 |
| 45. | .2455 +/- .0030 | .0758 +/- .0013 | .000665 +/- .000070 |
| 55. | .4475 +/- .0046 | .1065 +/- .0018 | .000869 +/- .000095 |
| 65. | .5290 +/- .0063 | .1200 +/- .0023 | .000802 +/- .000109 |
| 75. | .5640 +/- .0080 | .1251 +/- .0029 | .000843 +/- .000135 |
| 85. | .5822 +/- .0101 | .1278 +/- .0036 | .000745 +/- .000155 |
| 95. | .5738 +/- .0125 | .1289 +/- .0045 | .000775 +/- .000194 |
| 105. | .5145 +/- .0147 | .1176 +/- .0052 | .001011 +/- .000280 |
| 115. | .5066 +/- .0193 | .1293 +/- .0073 | .000779 +/- .000318 |
| 125. | .5164 +/- .0275 | .1192 +/- .0092 | .000445 +/- .000315 |
| 135. | .4218 +/- .0306 | .0996 +/- .0109 | .000393 +/- .000393 |

N.B.: A(Ke3,p) is the probability for a Ke3 decay to be accepted as a Kμ3 decay.

T A B L E  6.1

Total cross-section data

| | Accelerator Pulses | Triggers K | Fully reconstructed Events K | After kinematic cuts | After unambigous cuts |
|---|---|---|---|---|---|
| C | 984 | 348 | 182 | 95 | 33 |
| Al | 11694 | 1913 | 1094 | 581 | 204 |
| Cu | 7379 | 2088 | 1211 | 589 | 200 |
| Sn | 8231 | 1828 | 960 | 495 | 175 |
| Sn | 2288 | 519 | 312 | 159 | 56 |
| Pb | 8454 | 1984 | 1013 | 509 | 174 |

T A B L E 6.2

Diffraction correction. (%)

| p (GeV/c) | C | Al | Cu | Sn | Sn* | Pb |
|---|---|---|---|---|---|---|
| 25. | .01 | .02 | .03 | .05 | .02 | .08 |
| 35. | .01 | .03 | .06 | .10 | .04 | .16 |
| 45. | .02 | .06 | .10 | .17 | .07 | .27 |
| 55. | .03 | .06 | .15 | .25 | .10 | .40 |
| 65. | .04 | .12 | .21 | .35 | .14 | .57 |
| 75. | .06 | .16 | .29 | .47 | .18 | .75 |
| 85. | .07 | .20 | .37 | .61 | .24 | .97 |
| 95. | .09 | .25 | .46 | .76 | .30 | 1.21 |
| 105. | .11 | .30 | .56 | .93 | .36 | 1.48 |
| 115. | .14 | .37 | .67 | 1.11 | .43 | 1.77 |
| 125. | .16 | .43 | .79 | 1.31 | .51 | 2.09 |
| 135. | .19 | .50 | .92 | 1.53 | .60 | 2.44 |
| 145. | .22 | .58 | 1.07 | 1.76 | .69 | 2.82 |
| 155. | .25 | .66 | 1.22 | 2.02 | .79 | 3.22 |

TABLE 6.3

$K_L$ total cross-sections on nuclei. Results in mb for the "unambigous Kμ3" sample.

| p (GeV/c) | C | Al | Cu | Sn | Sn* | Pb |
|---|---|---|---|---|---|---|
| 25. | 190.5 +/- 15.3 | 370.7 +/- 10.5 | 707.2 +/- 22.0 | 1278.4 +/- 42.1 | 1312.7 +/-135.9 | 2048.0 +/- 65.3 |
| 35. | 195.2 +/- 5.6 | 373.4 +/- 3.8 | 795.2 +/- 8.4 | 1316.8 +/- 15.3 | 1339.0 +/- 48.8 | 2128.5 +/- 24.5 |
| 45. | 186.6 +/- 3.8 | 372.2 +/- 2.8 | 774.2 +/- 6.1 | 1326.5 +/- 11.1 | 1364.9 +/- 35.6 | 2049.2 +/- 17.3 |
| 55. | 189.3 +/- 3.8 | 375.6 +/- 2.8 | 771.7 +/- 6.1 | 1292.3 +/- 10.9 | 1316.9 +/- 35.2 | 2036.2 +/- 17.4 |
| 65. | 186.1 +/- 4.2 | 371.8 +/- 3.1 | 783.6 +/- 7.0 | 1291.8 +/- 12.4 | 1246.8 +/- 40.0 | 2047.3 +/- 19.6 |
| 75. | 185.6 +/- 5.0 | 369.1 +/- 3.7 | 775.2 +/- 8.3 | 1307.1 +/- 14.9 | 1246.6 +/- 47.6 | 2055.1 +/- 23.4 |
| 85. | 196.1 +/- 6.4 | 378.5 +/- 4.7 | 770.8 +/- 10.2 | 1289.3 +/- 18.3 | 1308.3 +/- 60.0 | 2097.6 +/- 29.3 |
| 95. | 197.5 +/- 8.1 | 367.6 +/- 5.9 | 786.7 +/- 12.9 | 1289.0 +/- 23.2 | 1246.5 +/- 73.6 | 2027.3 +/- 36.0 |
| 105. | 197.0 +/- 10.3 | 374.1 +/- 7.6 | 801.1 +/- 16.5 | 1306.9 +/- 29.4 | 1478.3 +/- 98.3 | 2019.9 +/- 45.8 |
| 115. | 215.4 +/- 14.3 | 388.9 +/- 9.9 | 768.1 +/- 20.8 | 1311.0 +/- 37.4 | 1389.7 +/-122.5 | 1887.1 +/- 56.1 |
| 125. | 165.6 +/- 15.7 | 364.0 +/- 12.1 | 780.0 +/- 27.3 | 1270.3 +/- 47.6 | 1382.2 +/-163.0 | 1985.9 +/- 75.1 |
| 135. | 146.5 +/- 20.1 | 361.9 +/- 15.6 | 754.9 +/- 33.9 | 1358.9 +/- 64.5 | 1535.2 +/-205.6 | 2079.5 +/-100.8 |
| 145. | 183.6 +/- 26.3 | 360.0 +/- 20.5 | 774.6 +/- 43.4 | 1226.5 +/- 77.2 | 1168.8 +/-263.5 | 1982.1 +/-122.2 |
| 155. | 215.1 +/- 36.0 | 442.8 +/- 31.9 | 720.7 +/- 57.6 | 1209.3 +/- 98.6 | 1353.6 +/-344.6 | 2109.6 +/-163.4 |

N.B.: Statistical errors only.

TABLE 6.4

$K_L$ total cross-sections on nuclei. Results in mb for the "all Ku3" sample.

| P (GeV/c) | C | Al | Cu | Sn | Sn* | Pb |
|---|---|---|---|---|---|---|
| 25. | 197.7 +/- 13.6 | 383.4 +/- 8.8 | 749.1 +/- 18.2 | 1306.4 +/- 34.7 | 1238.9 +/-109.4 | 2027.3 +/- 52.6 |
| 35. | 187.7 +/- 3.3 | 371.5 +/- 2.3 | 777.3 +/- 4.9 | 1311.3 +/- 9.1 | 1336.4 +/- 29.1 | 2088.1 +/- 14.3 |
| 45. | 188.9 +/- 2.2 | 371.1 +/- 1.6 | 769.9 +/- 3.5 | 1319.3 +/- 6.5 | 1308.6 +/- 20.6 | 2069.1 +/- 10.1 |
| 55. | 186.6 +/- 2.2 | 371.6 +/- 1.6 | 780.7 +/- 3.5 | 1297.8 +/- 6.4 | 1298.8 +/- 20.4 | 2051.4 +/- 9.9 |
| 65. | 188.7 +/- 2.5 | 372.0 +/- 1.8 | 782.2 +/- 4.0 | 1300.5 +/- 7.2 | 1275.0 +/- 23.1 | 2041.7 +/- 11.1 |
| 75. | 186.0 +/- 2.9 | 372.2 +/- 2.2 | 777.3 +/- 4.8 | 1291.5 +/- 8.7 | 1272.9 +/- 28.1 | 2067.9 +/- 13.6 |
| 85. | 192.7 +/- 3.8 | 371.8 +/- 2.8 | 773.7 +/- 6.0 | 1296.0 +/- 11.1 | 1263.0 +/- 35.3 | 2038.9 +/- 17.0 |
| 95. | 191.5 +/- 4.8 | 372.5 +/- 3.6 | 782.3 +/- 7.8 | 1263.8 +/- 14.1 | 1299.6 +/- 45.5 | 2037.8 +/- 21.8 |
| 105. | 184.0 +/- 6.1 | 372.7 +/- 4.7 | 777.3 +/- 10.1 | 1288.3 +/- 18.4 | 1344.4 +/- 59.3 | 1992.7 +/- 28.1 |
| 115. | 187.1 +/- 8.0 | 380.7 +/- 6.3 | 793.4 +/- 13.4 | 1306.8 +/- 24.2 | 1369.8 +/- 79.7 | 2034.7 +/- 37.2 |
| 125. | 193.5 +/- 10.4 | 369.7 +/- 8.0 | 766.9 +/- 17.2 | 1317.5 +/- 32.1 | 1327.3 +/-101.7 | 2015.6 +/- 48.2 |
| 135. | 164.4 +/- 13.6 | 345.1 +/- 10.1 | 791.8 +/- 23.4 | 1293.3 +/- 41.6 | 1246.8 +/-136.8 | 1973.1 +/- 63.7 |
| 145. | 173.2 +/- 17.4 | 394.5 +/- 14.8 | 759.7 +/- 29.6 | 1270.5 +/- 54.4 | 1335.7 +/-175.4 | 2017.9 +/- 84.3 |
| 155. | 186.6 +/- 23.1 | 364.7 +/- 19.3 | 726.4 +/- 39.2 | 1230.9 +/- 71.9 | 1460.1 +/-249.5 | 2004.8 +/-110.5 |

N.B.: Satistical errors only.

T A B L E  6.5

Regeneration data

| | Al | Cu | Sn | Pb | $\eta^+ - \eta^-$ |
|---|---|---|---|---|---|
| Pulses | 8867 | 6833 | 6765 | 5904 | 3743 |
| Trigger | 1743 K | 1776 K | 1848 K | 1547 K | 1110 K |
| Recon-structed | 969 K | 929 K | 953 K | 997 K | 511 K |
| KPI2 | 60937 | 40456 | 34637 | 24131 | 18962 |
| KMU3 | 10389 | 6456 | 12800 | 9848 | - |

T A B L E 6.6

$K_S$ coherent regeneration on nuclei. Results in mb for $\left|\frac{f(0)-\bar{f}(0)}{p}\right|$ .

| p (GeV/c) | Al | Cu | Sn | Pb |
|---|---|---|---|---|
| 25. | 3.92 +/- .22 | 8.18 +/- .55 | 12.02 +/- .66 | 16.90 +/- 1.01 |
| 35. | 3.12 +/- .06 | 6.25 +/- .18 | 9.42 +/- .19 | 13.97 +/- .31 |
| 45. | 2.64 +/- .04 | 4.98 +/- .09 | 8.04 +/- .12 | 11.95 +/- .19 |
| 55. | 2.42 +/- .04 | 4.60 +/- .08 | 7.23 +/- .10 | 10.65 +/- .17 |
| 65. | 2.21 +/- .04 | 4.00 +/- .08 | 6.52 +/- .10 | 9.64 +/- .17 |
| 75. | 2.01 +/- .04 | 3.69 +/- .08 | 5.90 +/- .11 | 8.69 +/- .18 |
| 85. | 1.83 +/- .04 | 3.42 +/- .09 | 5.32 +/- .12 | 7.96 +/- .20 |
| 95. | 1.74 +/- .06 | 3.31 +/- .12 | 5.10 +/- .14 | 7.55 +/- .24 |
| 105. | 1.67 +/- .06 | 3.17 +/- .18 | 4.74 +/- .18 | 7.11 +/- .30 |
| 115. | 1.72 +/- .08 | 3.21 +/- .19 | 4.83 +/- .23 | 6.76 +/- .36 |
| 125. | 1.40 +/- .09 | 2.36 +/- .16 | 4.92 +/- .34 | 6.87 +/- .49 |
| 135. | 1.29 +/- .11 | 2.55 +/- .27 | 4.71 +/- .44 | 6.36 +/- .52 |

N.B.: Statistical errors only.

T A B L E  6.7

Physical constants.

$\tau_S = 1/\Gamma_S = (0.8930 \pm 0.0023) \times 10^{-10}$ sec

$\tau_L = 1/\Gamma_L = ( 518.1 \pm 4 ) \times 10^{-10}$ sec

$\Delta m = m_L - m_S = (0.5349 \pm .0023) \times 10^{10}$ $sec^{-1}$

$BR(K_S \to \pi^+ \pi^-) = 0.6827 \pm 0.0025$

$BR(K_L \to K\mu\nu) = 0.271 \pm 0.005$

$|\eta_{+-}| = (2.183 \pm 0.023) \times 10^{-3}$

$Arg\ \eta_{+-} = (45 \pm 1.2)^\circ$

T A B L E  8.1

Linear interpolation fits

TOTAL CROSS-SECTIONS (25 → 135 GeV)

| | Unambigous Kμ3 | | All kμ3 | |
|---|---|---|---|---|
| | A | B | A | B |
| C | 188 ± 5 | + 0.03 ± .08 | 188.4 ± 3 | 0 ± .05 |
| Al | 373 ± 4 | 0.0 ± .06 | 372 ± 2 | 0 ± .04 |
| Cu | 774 ± 9 | .05 ± .13 | 771 ± 5 | + .11 ± .08 |
| Sn | 1320 ± 15 | - .26 ± .27 | 1324 ± 10 | - .34 ± .15 |
| Sn* | 1328 ± 50 | - .23 ± .76 | 1317 ± 30 | - .32 ± 47 |
| Pb | 2105 ± 24 | - .83 ± .36 | 2100 ± 15 | - .74 ± 21 |

REGENERATION (25 → 135 GeV)

| | γ | α |
|---|---|---|
| C | 13.77 ± 1.22 | 0.397 ± .021 |
| Al | 24.33 ± 2.04 | 0.422 ± .020 |
| Cu | 59.1 ± 6.0 | 0.359 ± .025 |
| Sn | 82.0 ± 6.8 | 0.392 ± .020 |
| Pb | 126.6 ± 11.5 | 0.381 ± .022 |

Note: For C, a fit from 4.5 to 135 GeV gives $\gamma = 13.78 \pm 0.15$, $\alpha = 0.397 \pm 0.003$.

TABLE 8.2

Regge fit parameters of kaon-, pion-, and nucleon-nucleon total cross-sections.

| Fit | | $\chi^2$ | $a_p$ | $b_p$ | $c_p$ | $\gamma_\omega$ | $\alpha_\omega$ | $\gamma_\rho$ | $\alpha_\rho$ | $a_n$ | $b_n$ | $c_n$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | K | .81 | 17.1771<br>.0330 | .2104<br>.0111 | 5.9533<br>.4798 | 7.8457<br>.0949 | .4420<br>.0087 | 1.6819<br>.0755 | .5503<br>.0271 | 17.6764<br>.0479 | .2253<br>.0151 | 7.4216<br>.6502 |
| (i) | π | 1.21 | 22.2018<br>.0746 | .2804<br>.0903 | 24.4876<br>16.4607 | 11.5549<br>4.0580 | .4420<br>0.0000 | 2.7338<br>0.0000 | .5726<br>0.0000 | | | |
| | p | 1.00 | 38.3664<br>.0293 | .4340<br>.0163 | 63.2039<br>1.9335 | 24.7861<br>1.4324 | .4373<br>.0169 | 3.0914<br>3.4671 | .1219<br>.2807 | 38.4860<br>.0776 | .3935<br>.0626 | 41.1164<br>4.1914 |
| | K | .81 | 17.1756<br>.0330 | .2102<br>.0109 | 6.0775<br>.4655 | 7.8641<br>.0928 | .4400<br>.0084 | 1.6300<br>.0408 | .5726<br>0.0000 | 17.6857<br>.0462 | .2212<br>.0143 | 7.1652<br>.5775 |
| (ii) | π | 1.21 | 22.2811<br>.0625 | .2812<br>.0900 | 24.7918<br>16.4109 | 11.5190<br>4.0702 | .4400<br>0.0000 | 2.7338<br>0.0000 | .5726<br>0.0000 | | | |
| | p | 1.02 | 38.3656<br>.0293 | .4304<br>.0162 | 63.4481<br>1.9204 | 26.3519<br>1.1129 | .4201<br>.0116 | .7462<br>.1903 | .5726<br>0.0000 | 38.4986<br>.0765 | .3758<br>.0513 | 39.1518<br>4.2104 |
| | K | 1.01 | 17.1971<br>.0332 | .1941<br>.0102 | 5.0691<br>.4131 | 8.0176<br>.0811 | .3970<br>0.0000 | 1.6449<br>.0407 | .5726<br>0.0000 | 17.7396<br>.0444 | .2003<br>.0137 | 6.0287<br>.5552 |
| (iii) | π | 1.21 | 22.0231<br>.4514 | .2976<br>.0915 | 31.0013<br>17.2960 | 10.7663<br>3.7365 | .3970<br>0.0000 | 2.7338<br>0.0000 | .5726<br>0.0000 | | | |
| | p | 1.05 | 38.3776<br>.0286 | .4275<br>.0156 | 62.4541<br>1.8785 | 28.5047<br>.3546 | .3970<br>0.0000 | .7845<br>.1893 | .5726<br>0.0000 | 38.5160<br>.0756 | .3620<br>.0609 | 37.8723<br>4.3398 |
| | K | 1.01 | 17.1964<br>.0331 | .1993<br>.0106 | 5.1502<br>.4562 | 8.0676<br>.0811 | .3970<br>0.0000 | 1.6206<br>.0396 | .5829<br>.0241 | 17.7413<br>.0445 | .1988<br>.0141 | 5.9317<br>.6021 |
| (iv) | π | 1.21 | 22.0231<br>.4514 | .2976<br>.0915 | 31.0013<br>17.2960 | 10.7663<br>3.7365 | .3970<br>0.0000 | 2.7338<br>0.0000 | .5726<br>0.0000 | | | |
| | p | 1.05 | 38.3749<br>.0291 | .4296<br>.0161 | 62.7250<br>1.9512 | 28.5246<br>.3564 | .3970<br>0.0000 | .4916<br>.4994 | .6956<br>.2478 | 38.5150<br>.0756 | .3605<br>.0610 | 37.5618<br>4.4074 |

N.B.: From a separate fit to the $\pi^+ - \pi^-$ difference, we get $\gamma_\rho = 2.73 \pm 0.06$ and $\alpha_\rho = 0.57 \pm 0.01$ .

TABLE 8.3

Results and predictions from the Regge parametrization of the kaon-nucleon amplitudes.

| p | $K^+p$ | | $K^-p$ | | $K^+n$ | | $K^-n$ | | $K^-p \to \bar{K}^0 n$ | $K^+n \to K^0 p$ | $K_L p \to K_S p$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (GeV/c) | $\sigma_T$(mb) | a | $\sigma_T$(mb) | a | $\sigma_T$(mb) | a | $\sigma_T$(mb) | a | $d\sigma/dt$ | $d\sigma/dt$ | $\lvert f-\bar{f}\rvert/p$ | $\phi$ |
| 5. | 17.184 | -.317 | 24.631 | .093 | 17.712 | -.129 | 22.201 | .080 | .367 | .521 | .482 | -132.2 |
| 15. | 17.300 | -.108 | 21.602 | .050 | 17.788 | -.059 | 20.108 | .041 | .122 | .186 | .238 | -129.0 |
| 25. | 17.619 | -.107 | 20.849 | .059 | 18.009 | -.023 | 19.712 | .046 | .071 | .117 | .172 | -127.9 |
| 35. | 17.880 | -.072 | 20.551 | .064 | 18.218 | -.002 | 19.606 | .052 | .050 | .087 | .139 | -127.1 |
| 45. | 18.054 | -.048 | 20.418 | .068 | 18.408 | .014 | 19.599 | .058 | .038 | .070 | .118 | -126.6 |
| 55. | 18.237 | -.030 | 20.361 | .072 | 18.580 | .025 | 19.633 | .063 | .030 | .059 | .104 | -126.2 |
| 65. | 18.402 | -.017 | 20.346 | .075 | 18.737 | .033 | 19.688 | .067 | .025 | .051 | .093 | -125.8 |
| 75. | 18.553 | -.006 | 20.356 | .078 | 18.882 | .040 | 19.752 | .070 | .021 | .045 | .086 | -126.5 |
| 85. | 18.693 | .002 | 20.379 | .081 | 19.016 | .046 | 19.821 | .073 | .018 | .041 | .079 | -126.3 |
| 95. | 18.822 | .010 | 20.412 | .083 | 19.141 | .051 | 19.893 | .075 | .016 | .037 | .073 | -126.0 |
| 105. | 18.943 | .016 | 20.451 | .084 | 19.258 | .055 | 19.965 | .077 | .014 | .034 | .069 | -124.8 |
| 115. | 19.057 | .021 | 20.494 | .086 | 19.369 | .058 | 20.037 | .079 | .012 | .032 | .065 | -124.6 |
| 125. | 19.164 | .026 | 20.539 | .087 | 19.473 | .061 | 20.108 | .081 | .011 | .030 | .061 | -124.5 |
| 135. | 19.266 | .030 | 20.586 | .088 | 19.572 | .064 | 20.177 | .082 | .010 | .028 | .058 | -124.3 |
| 145. | 19.363 | .033 | 20.634 | .089 | 19.667 | .066 | 20.245 | .083 | .009 | .027 | .056 | -124.1 |
| 155. | 19.455 | .036 | 20.682 | .090 | 19.757 | .068 | 20.312 | .084 | .008 | .025 | .053 | -124.0 |
| 165. | 19.543 | .039 | 20.731 | .091 | 19.844 | .070 | 20.377 | .085 | .007 | .024 | .051 | -123.9 |
| 175. | 19.628 | .041 | 20.779 | .092 | 19.927 | .071 | 20.441 | .086 | .007 | .023 | .049 | -123.7 |

TABLE 8.4

Nuclear size parameters (Fermis)

| | A | Z | R | S | $\sqrt{\langle r^2 \rangle}$ |
|---|---|---|---|---|---|
| D | 2 | 1 | - | - | 2.096 |
| Be | 9 | 4 | - | - | 2.519 |
| C | 12 | 6 | - | - | 2.470 |
| Al | 27 | 13 | 3.070 | .519 | 3.060 |
| Fe | 56 | 26 | 3.980 | .569 | 3.737 |
| Cu | 64 | 29 | 4.205 | .569 | 3.882 |
| Cd | 112 | 48 | 5.382 | .533 | 4.615 |
| Sn | 119 | 50 | 5.320 | .576 | 4.643 |
| W | 184 | 74 | 6.520 | .491 | 5.370 |
| Pb | 207 | 82 | 6.670 | .503 | 5.494 |
| U | 238 | 92 | 6.962 | .605 | 5.843 |

T A B L E 8.5.1

Sensitivity of the calculated cross-sections and regenerations to changes in input parameters at 10 GeV/c.

| | | $\Delta R_p =$ | $\Delta R_p = \Delta R_n =$ | $\Delta R_n =$ | $\Delta\beta =$ | $\Delta\delta =$ | $\Delta\sigma(K^o p)$ | $\Delta\sigma(K^o n)$ | $\Delta\sigma(\bar{K}^o p)$ | $\Delta\sigma(\bar{K}^o n)$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | | +0.1fm | +0.1fm | +0.1fm | $+1GeV^2$ | $+1GeV^n$ | +1mb | +1mb | +1mb | +1mb |
| | C | .40 | .71 | .31 | .28 | -.01 | 1.11 | 1.11 | 1.03 | 1.03 |
| $\Delta\sigma_T$ | Al | .56 | 1.03 | .49 | .27 | -.01 | .99 | 1.06 | .89 | .96 |
| | Cu | .58 | 1.16 | .89 | .24 | -.00 | .83 | 1.01 | .73 | .88 |
| (%) | Sn | .55 | 1.22 | .67 | .21 | -.00 | .70 | .96 | .59 | .81 |
| | Pb | .53 | 1.26 | .74 | .19 | -.00 | .58 | .88 | .48 | .72 |
| | C | .50 | 1.25 | .76 | .29 | -.02 | -7.13 | -7.09 | 6.64 | 6.66 |
| $\Delta\lvert\frac{\bar{f}-f}{p}\rvert$ | Al | .67 | 1.87 | 1.22 | .34 | -.01 | -6.91 | -7.40 | 6.07 | 6.56 |
| | Cu | .65 | 2.15 | 1.52 | .36 | -.01 | -6.67 | -7.86 | 5.33 | 6.46 |
| (%) | Sn | .57 | 2.32 | 1.77 | .37 | -.01 | -6.14 | -8.37 | 4.61 | 6.40 |
| | Pb | .52 | 2.51 | 2.01 | .41 | -.01 | -5.91 | -8.86 | 4.07 | 6.25 |

TABLE 8.5.2

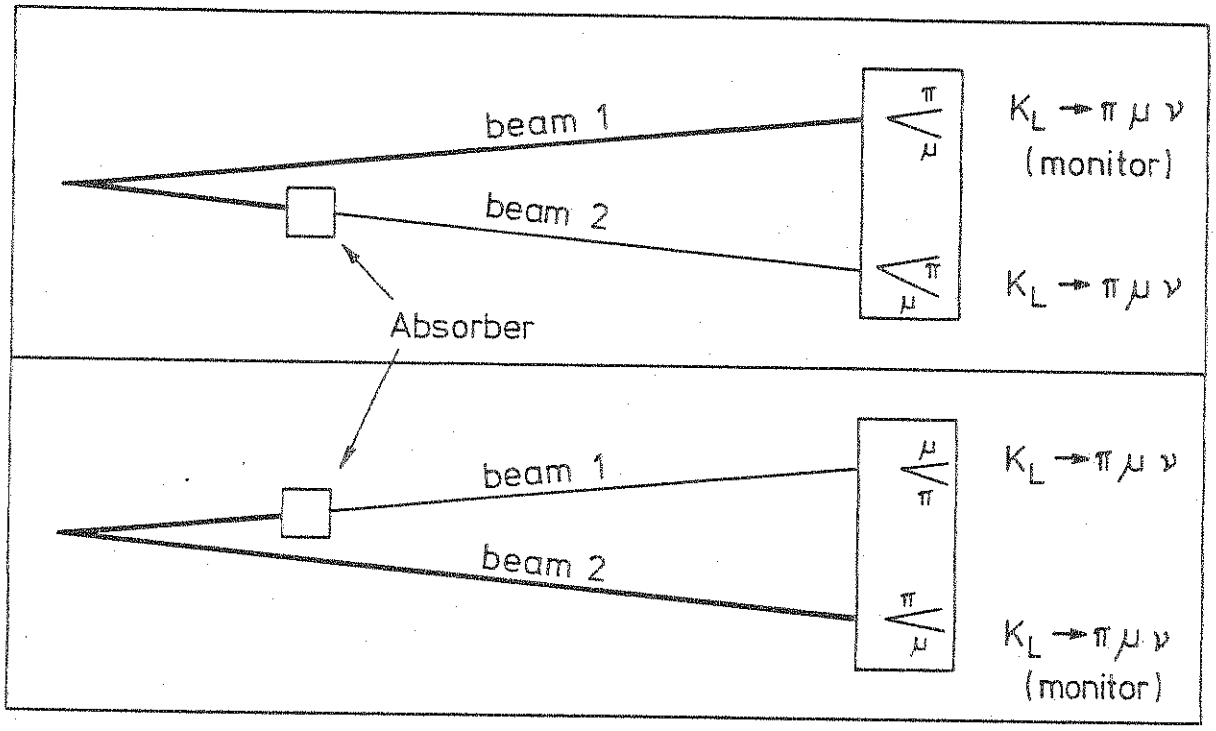
Sensitivity of the calculated cross-sections and regenerations to changes in input parameters at 100 GeV/c.

| | | $\Delta R_p =$ +0.1fm | $\Delta R_n^p = \Delta R_p^n =$ +0.1fm | $\Delta R_n =$ +0.1fm | $\Delta\beta =$ +1GeV$^2$ | $\Delta\delta =$ +1GeV$^4$ | $\Delta\sigma(K^o p)$ +1mb | $\Delta\sigma(K^o n)$ +1mb | $\Delta\sigma(\bar{K}^o p)$ +1mb | $\Delta\sigma(\bar{K}^o n)$ +1mb |
|---|---|---|---|---|---|---|---|---|---|---|
| | C | .50 | .77 | .27 | .28 | -.01 | 1.10 | 1.10 | 1.08 | 1.08 |
| $\Delta\sigma_T$ | Al | .68 | 1.09 | .42 | .26 | -.00 | .99 | 1.07 | .97 | 1.04 |
| | Cu | .69 | 1.20 | .51 | .25 | -.00 | .86 | 1.04 | .83 | 1.01 |
| (%) | Sn | .64 | 1.22 | .56 | .22 | -.00 | .75 | 1.03 | .72 | .99 |
| | Pb | .60 | 1.22 | .63 | .21 | -.00 | .68 | .99 | .62 | .94 |
| | C | .36 | 1.08 | .73 | -1.36 | -.01 | -26.36 | -26.30 | 32.40 | 32.44 |
| $\Delta\lvert\frac{\bar{f}-f}{p}\rvert$ | Al | .41 | 1.56 | 1.16 | -1.09 | -.01 | -24.40 | -25.78 | 29.62 | 32.06 |
| | Cu | .26 | 1.69 | 1.44 | -.65 | -.01 | -21.93 | -25.29 | 25.99 | 31.73 |
| (%) | Sn | .11 | 1.76 | 1.66 | -.32 | -.00 | -19.60 | -25.07 | 22.46 | 31.61 |
| | Pb | -.00 | 1.85 | 1.87 | -.08 | -.01 | -18.04 | -24.97 | 20.01 | 31.29 |

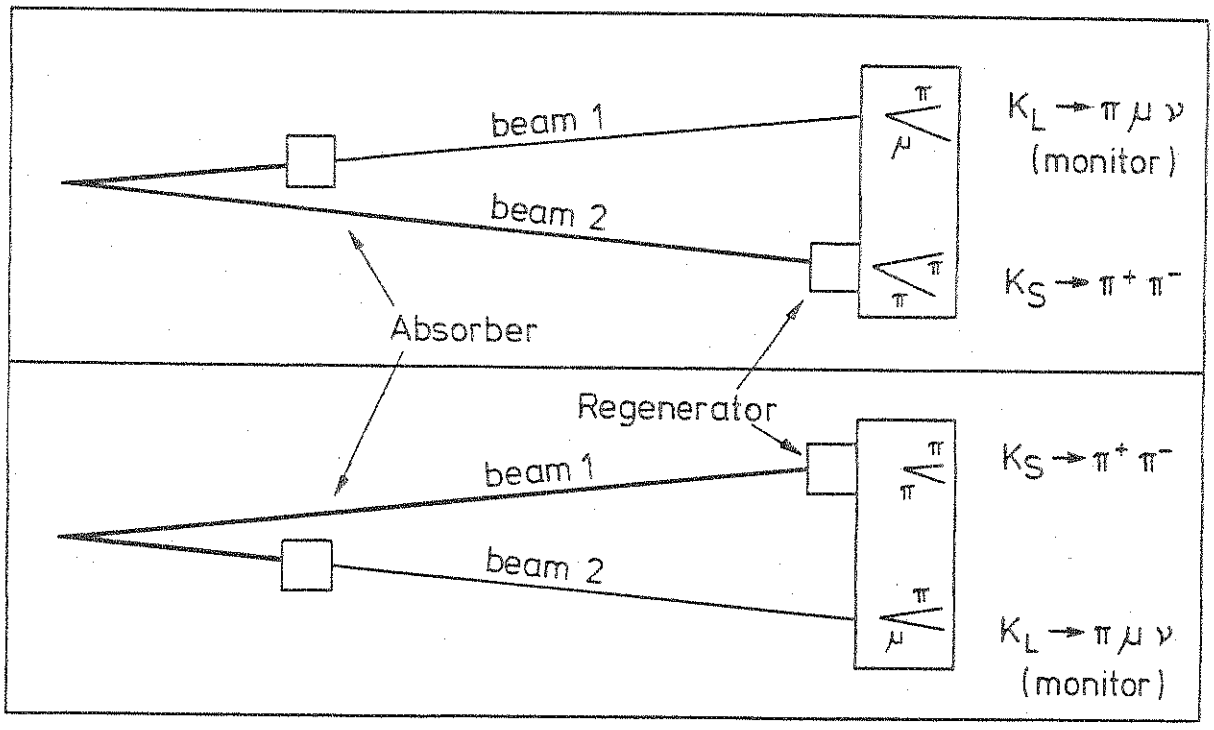
# FIGURES

Fig. 2.1 Principle of $K_L$ total cross-section measurement method.

Fig. 2.2 Principle of $K_S$ regeneration measurement method.




$K_L$ Total Cross-section Measurement.




$K_S$ Regeneration Measurement

Fig. 3.1 M4 Beam line. Shown are the main components of the neutral double-beam and their relative positions.

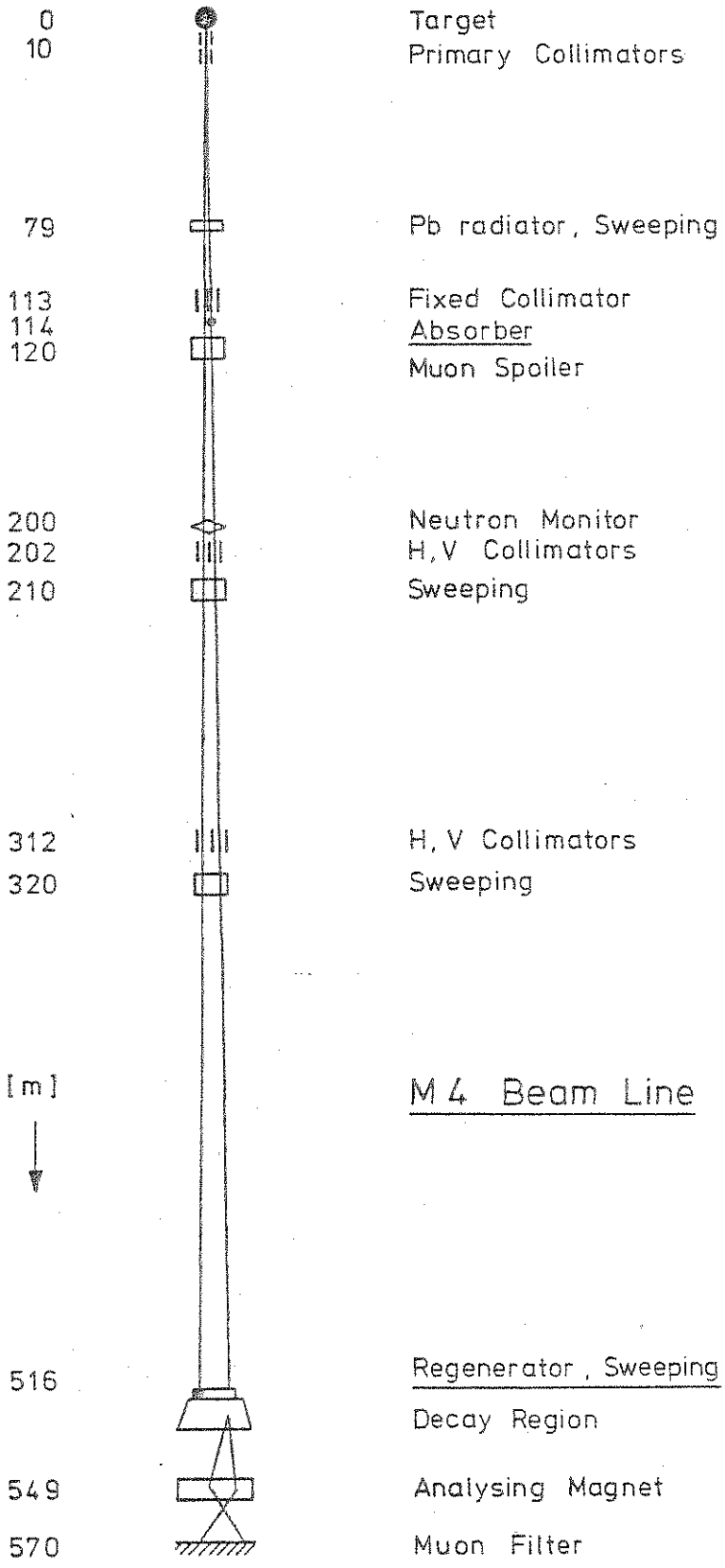
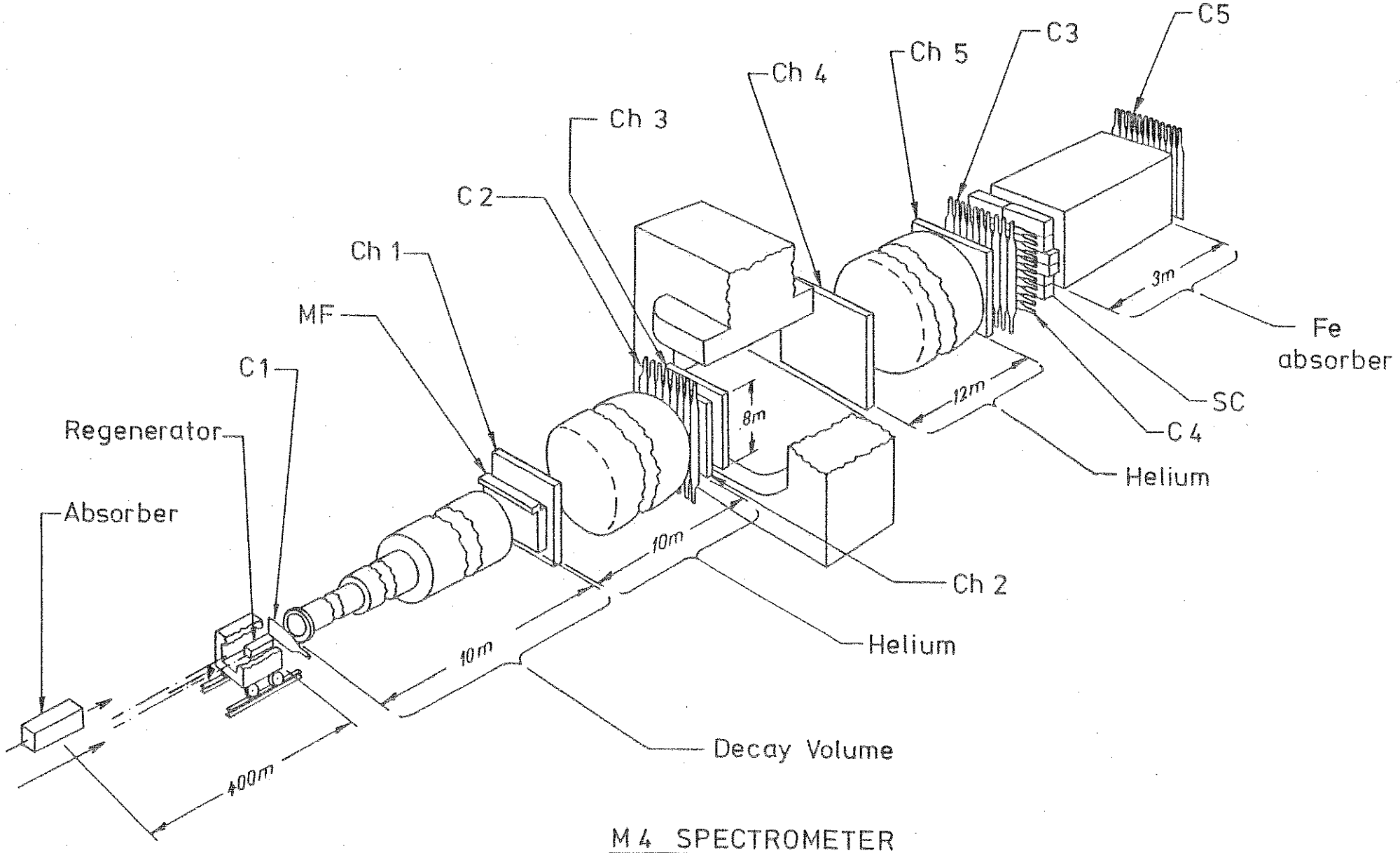

0
Target
10
Primary Collimators
79
Pb radiator, Sweeping
113
Fixed Collimator
114
Absorber
120
Muon Spoiler
200
Neutron Monitor
202
H,V Collimators
210
Sweeping
312
H, V Collimators
320
Sweeping
[m]
M4 Beam Line
516
Regenerator, Sweeping
Decay Region
549
Analysing Magnet
570
Muon Filter

Fig. 3.2 The detection apparatus. C1 and MF are defining the decay region. C2-C5 are the counter hodoscopes. Ch1 to Ch5 are the multiwire proportional chambers. The analysing magnet is between Ch3 and Ch4.




M 4 SPECTROMETER

Fig. 3.3 M4 $K_L$ spectrum.
The $K_L$ spectrum is calculated from observed Kμ3 decays in the apparatus.

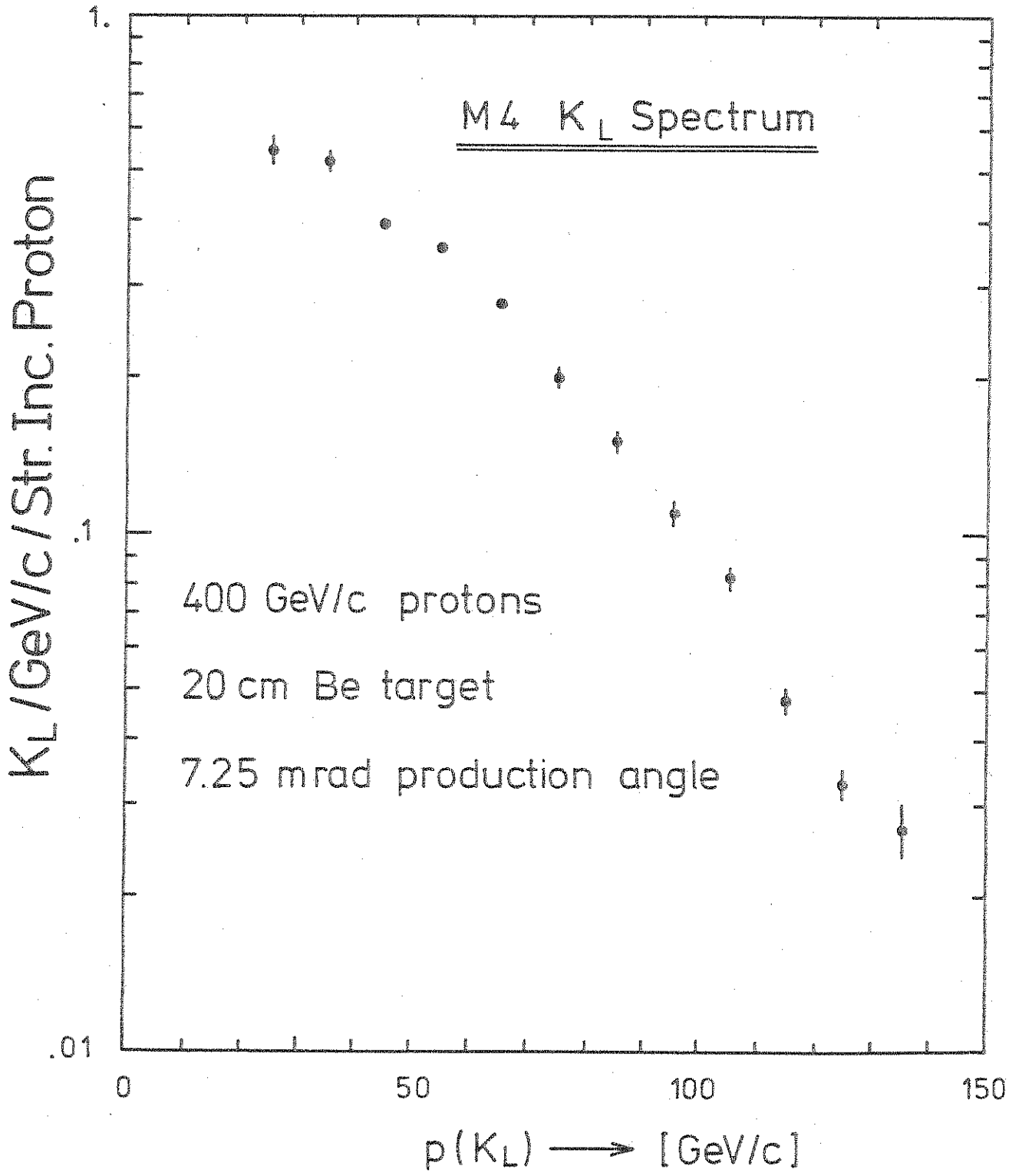
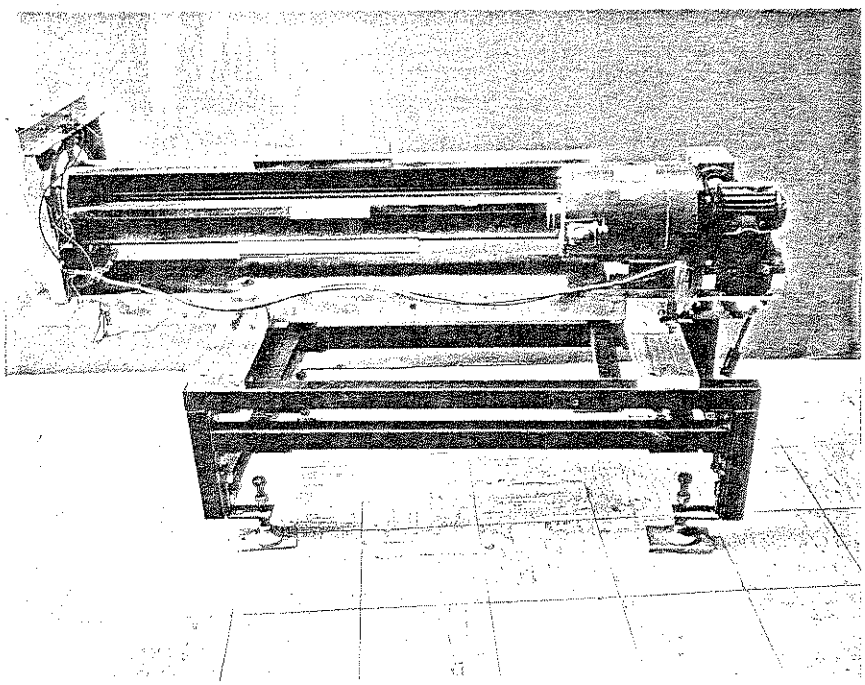

M4 $K_L$ Spectrum
400 GeV/c protons
20 cm Be target
7.25 mrad production angle
$K_L$/GeV/c/Str. Inc. Proton
1.
.1
.01
0
50
100
150
p($K_L$) ⟶ [GeV/c]

Fig. 3.4 Absorber block moving machine. The absorbers were mounted on a rotating frame.

Fig. 3.5 Regenerator block moving machine. A right angle shaft and four cams were used to translate the regenerator vertically.



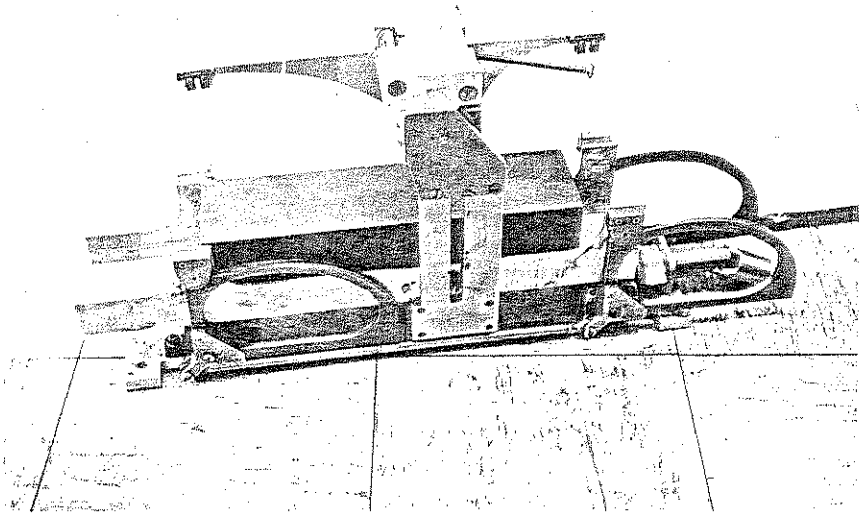


Fig. 4.1 Electronics. From left to right: the trigger counters, the first level logic, the second level logic (C2X), the camac. The EVENT, RESET and VETO signals are the main control signals interacting with the computer.

# ELECTRONICS

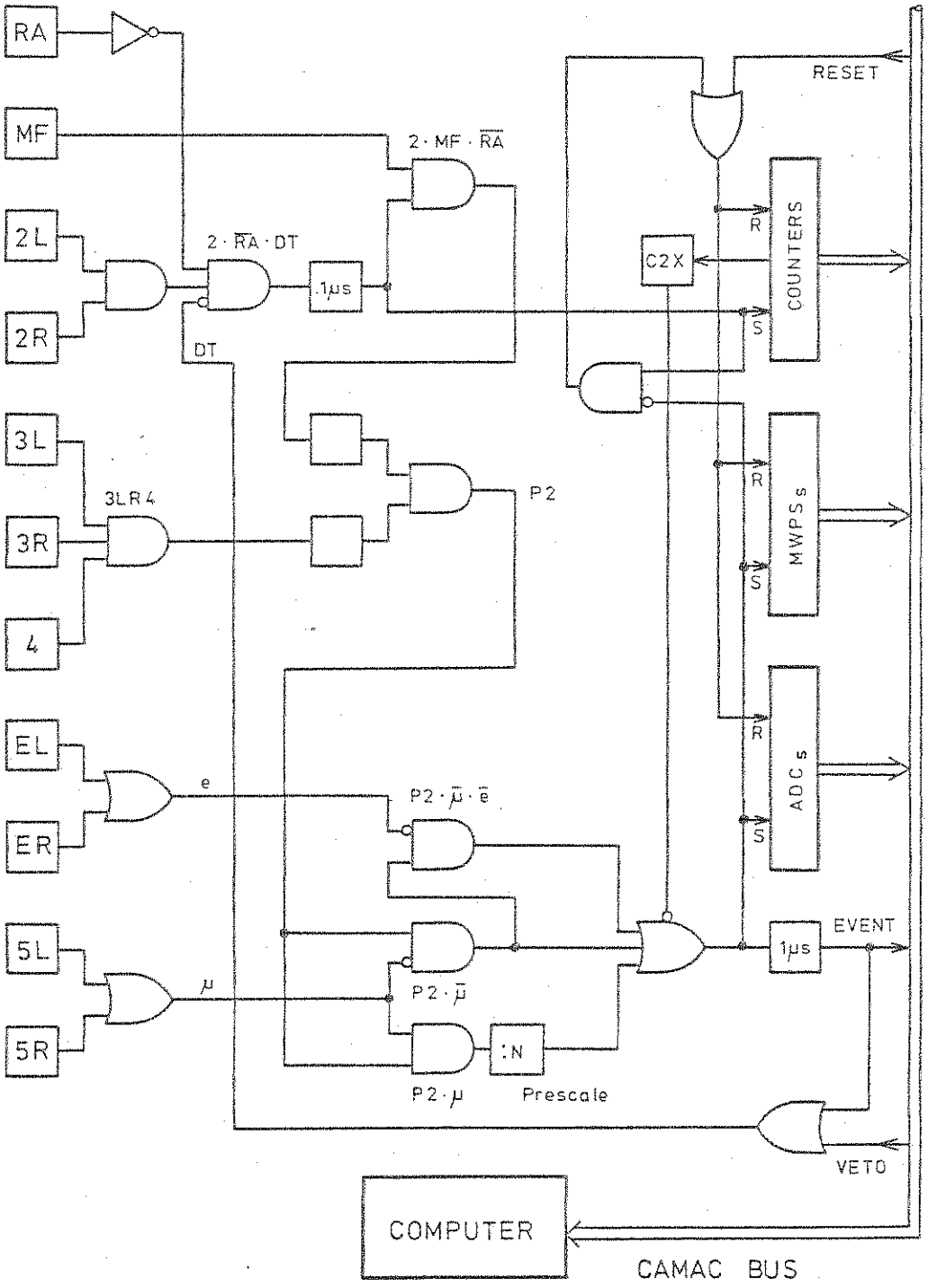


Fig. 5.1 Deviation$^2$ vs. $1/p^2$.

Data: ——

M.C.: •

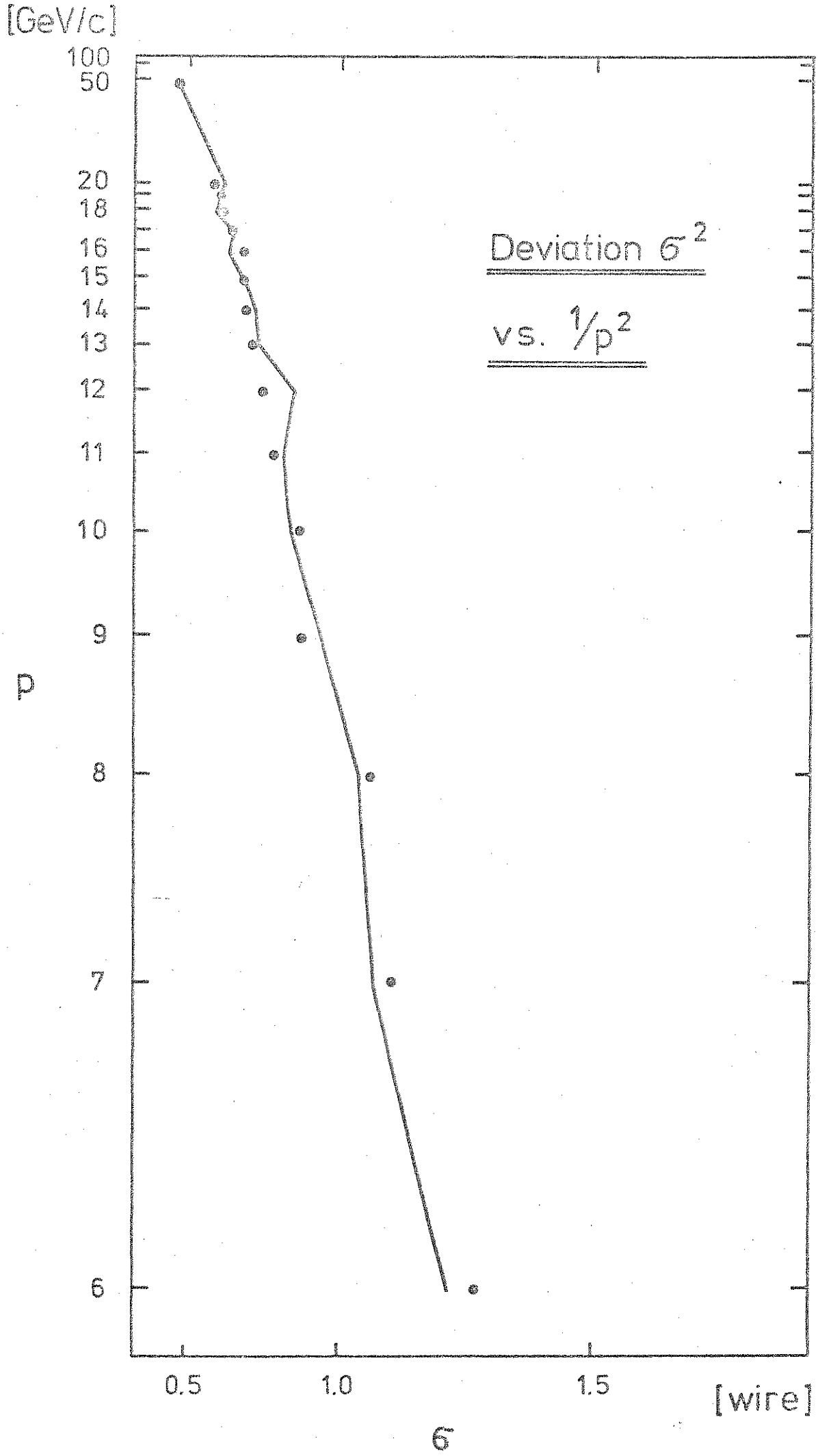
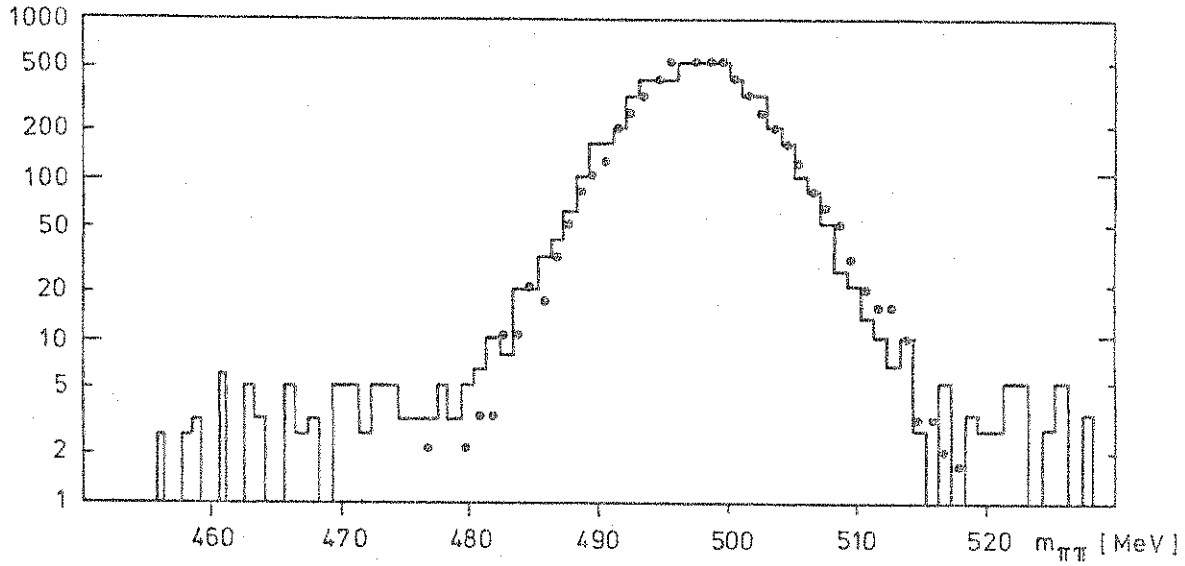
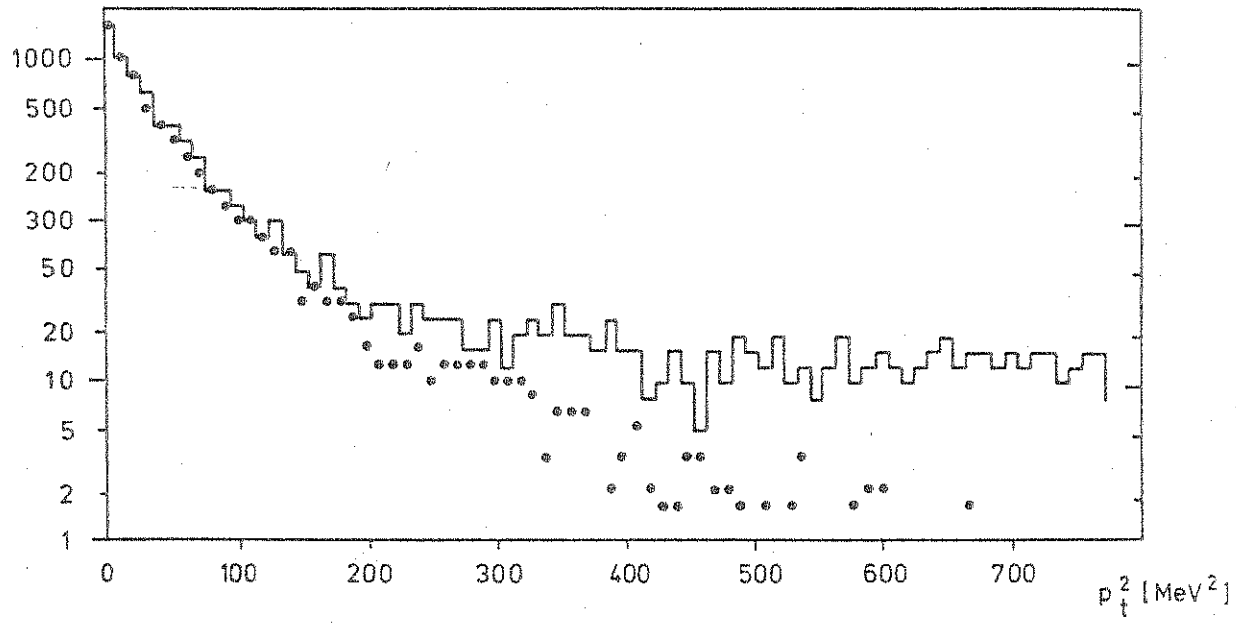

[GeV/c]
100
50
20
18
16
15
14
13
12
11
10
9
8
7
6
p
Deviation $\sigma^2$
vs. $1/p^2$
0.5
1.0
1.5
[wire]
σ

Fig. 5.2 $K_S$ invariant mass $m_{\pi\pi}$ .
50 GeV/c $<$ p $<$ 60 GeV/c ,
0 $< p_t^2 <$ 150 $(MeV/c)^2$ .
Data: ——
M.C.: •

Fig. 5.3 $K_S$ transfered momentum squared $p_t^2$ .
50 GeV/c $<$ p $<$ 60 GeV/c ,
487 MeV $< m_{\pi\pi} <$ 507 MeV .
Data: ——
M.C.: •



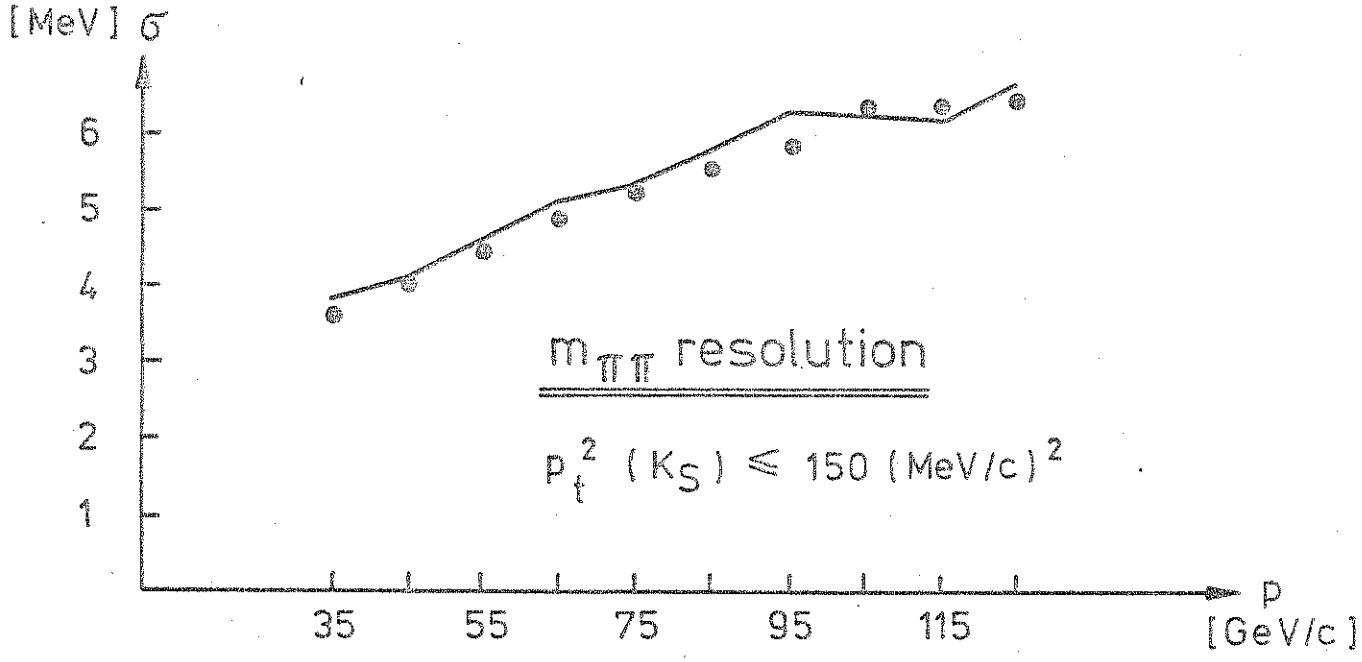

$K_S$ In variant mass

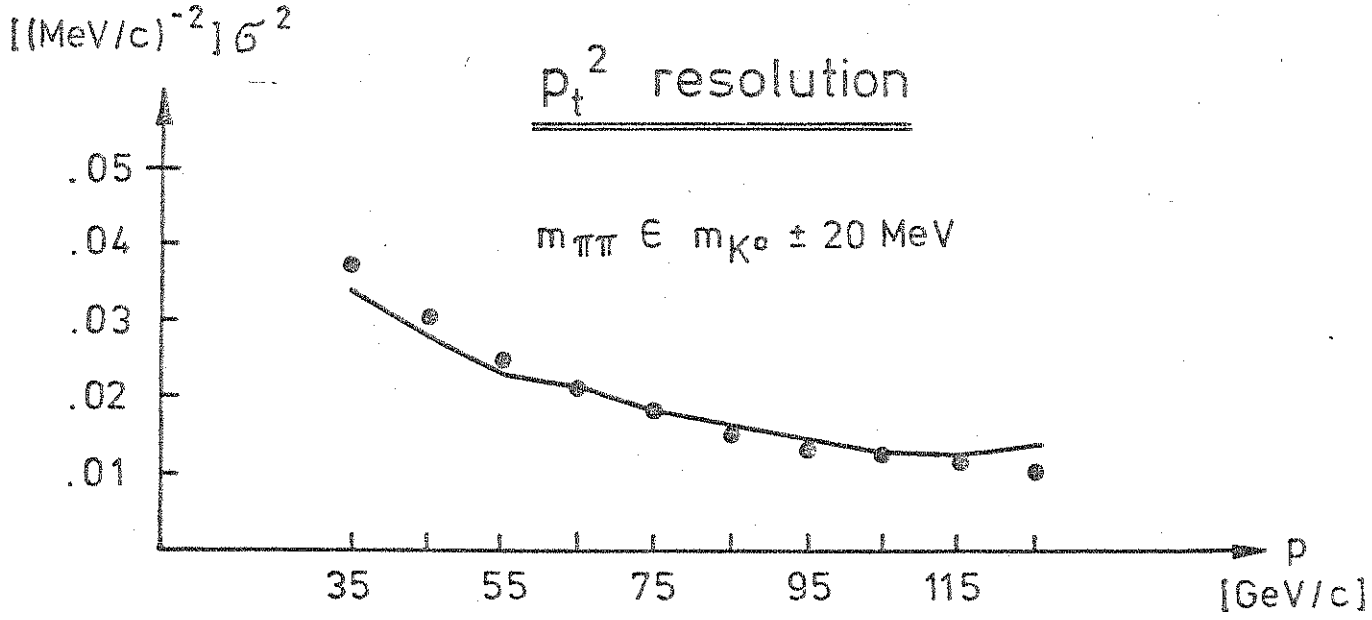



$K_S$ transverse momentum squared

Fig. 5.4 $K_S$ invariant mass resolution as a function of kaon momentum.
$0 < p_t^2 < 150$ (MeV/c)$^2$ .
Data: ———
M.C.: •

Fig. 5.5 $K_S$ transfered momentum squared resolution as a function of kaon momentum.
477 MeV $< m_{\pi\pi} <$ 517 MeV .
Data: ———
M.C.: •


[MeV] σ
6
5
4
3
2
1
$m_{\pi\pi}$ resolution
$p_t^2$ ($K_S$) ≤ 150 (MeV/c)$^2$
35
55
75
95
115
p
[GeV/c]


[(MeV/c)$^{-2}$] σ$^2$
$p_t^2$ resolution
$m_{\pi\pi}$ ∈ $m_{K^0}$ ± 20 MeV
.05
.04
.03
.02
.01
35
55
75
95
115
p
[GeV/c]

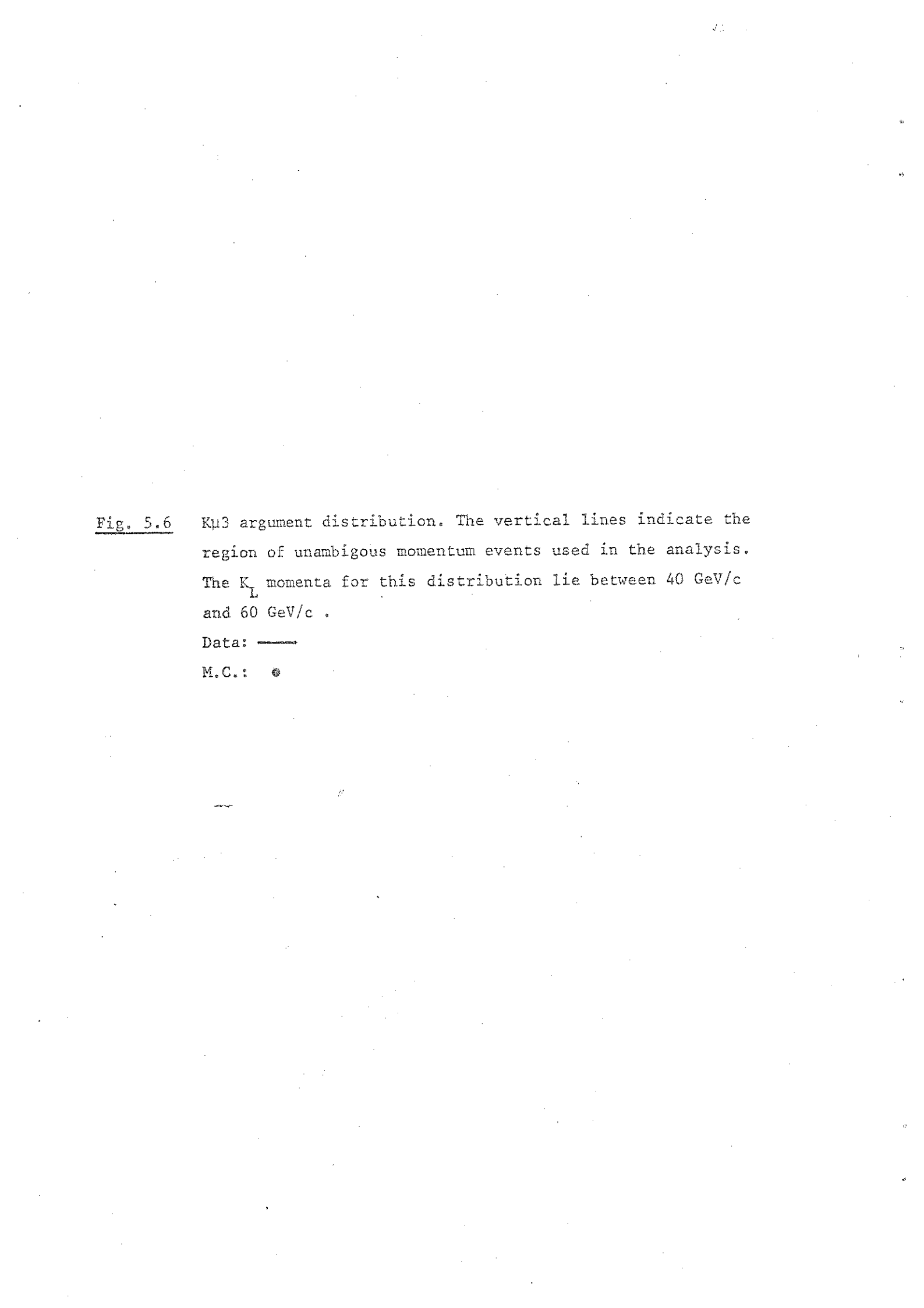
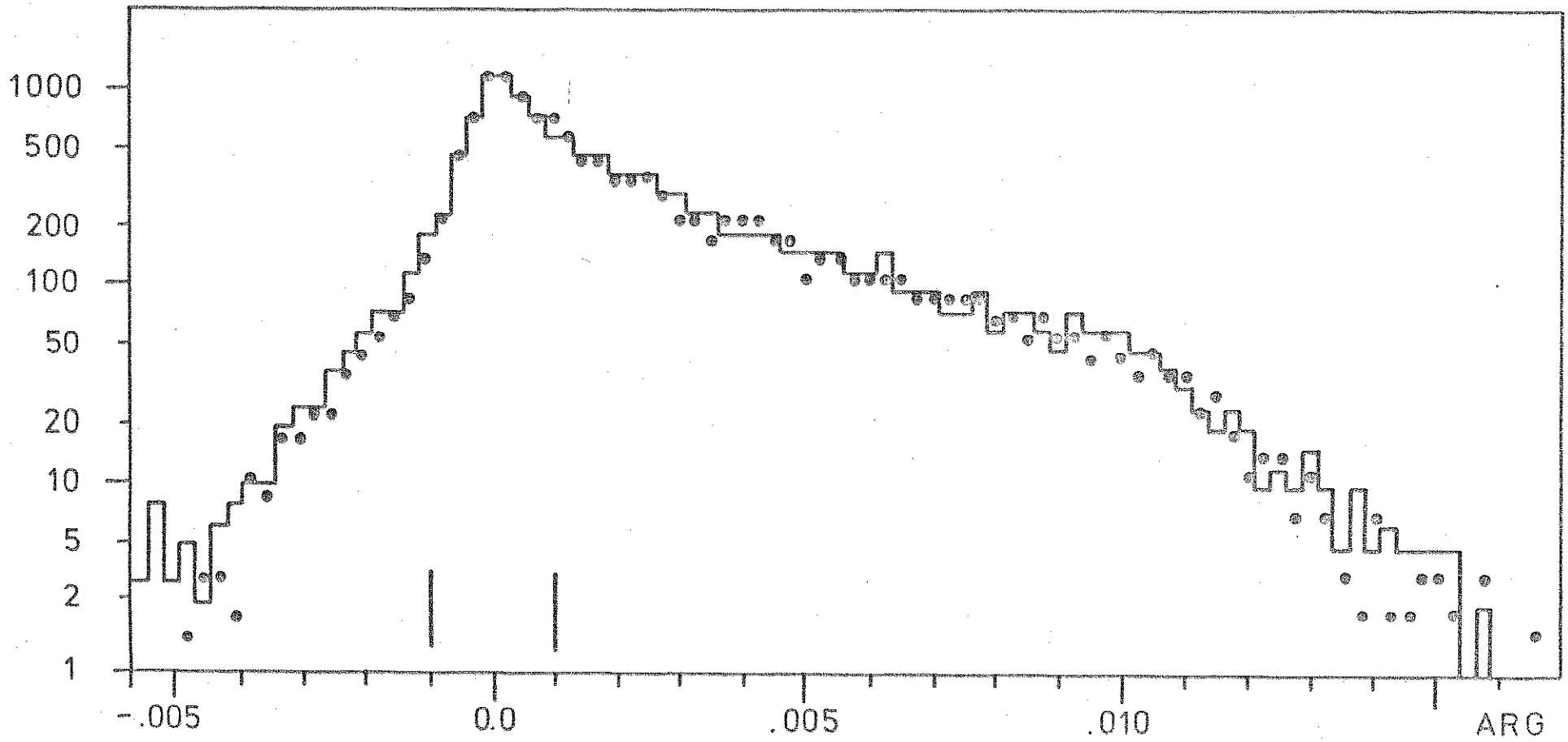


Fig. 5.6 Kμ3 argument distribution. The vertical lines indicate the region of unambigous momentum events used in the analysis. The $K_L$ momenta for this distribution lie between 40 GeV/c and 60 GeV/c .

Data: ———

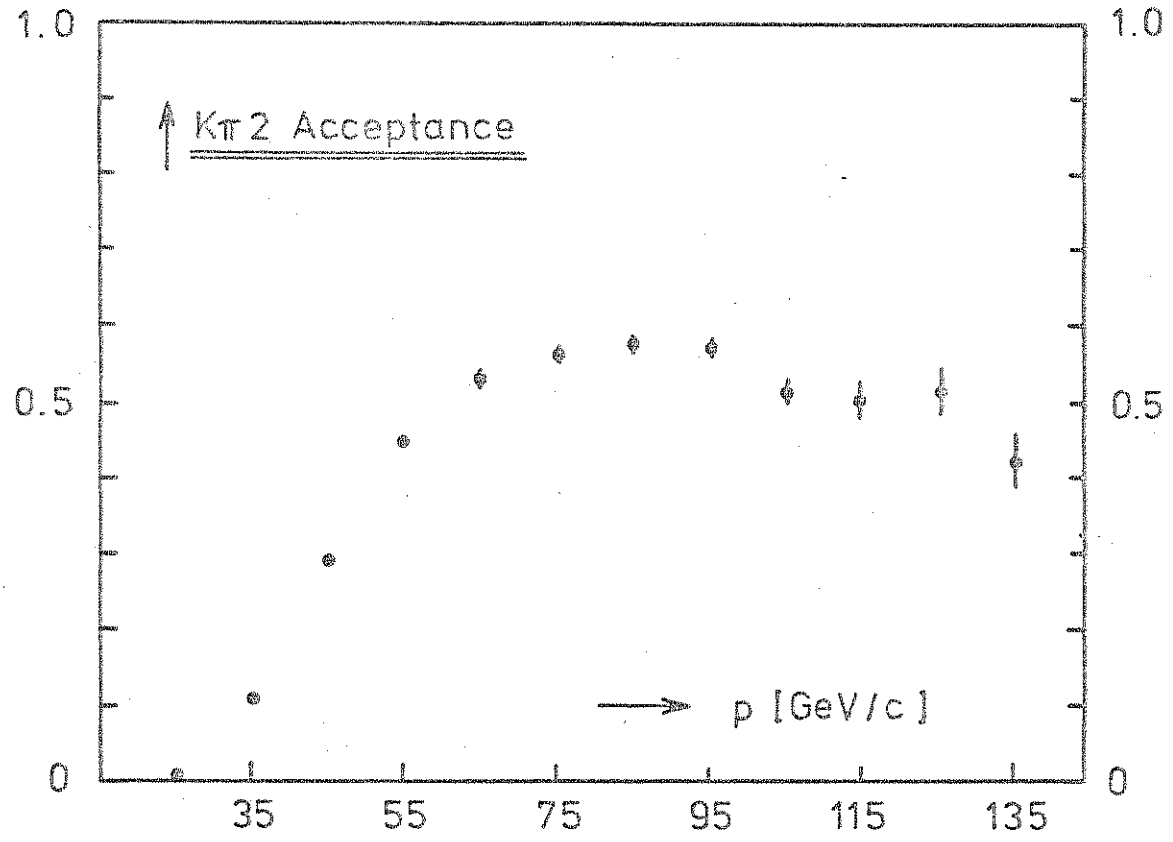
M.C.: ●




Kμ3 Argument distribution.

Fig. 5.7 $K_{\pi 2}$ acceptance (integrated over the decay region) as a function of the kaon momentum.

Fig. 5.8 $K_{\mu 3}$ acceptance (integrated over the decay region) as a function of the kaon momentum.


1.0
0.5
0
Kπ2 Acceptance
p [GeV/c]
35
55
75
95
115
135

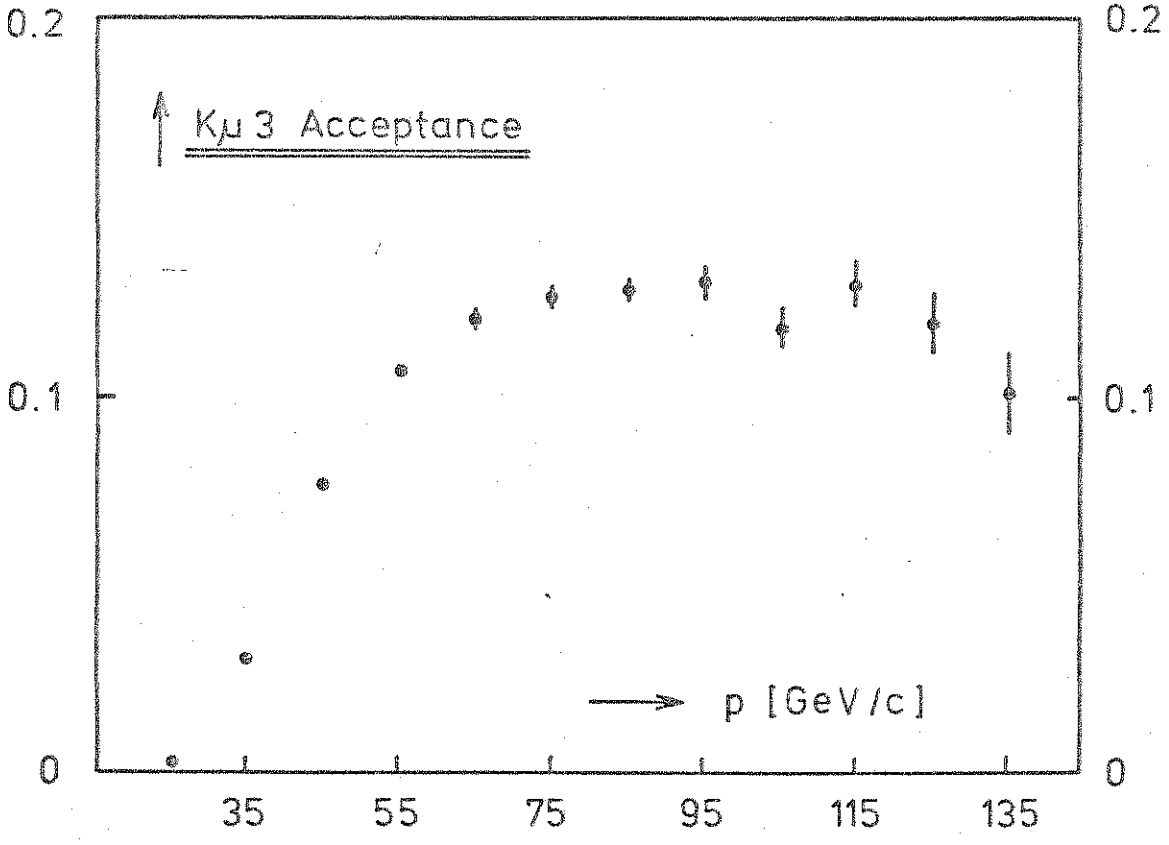

0.2
0.1
0
Kμ3 Acceptance
p [GeV/c]
35
55
75
95
115
135

Fig. 6.1 Number of MWPC hits per event.

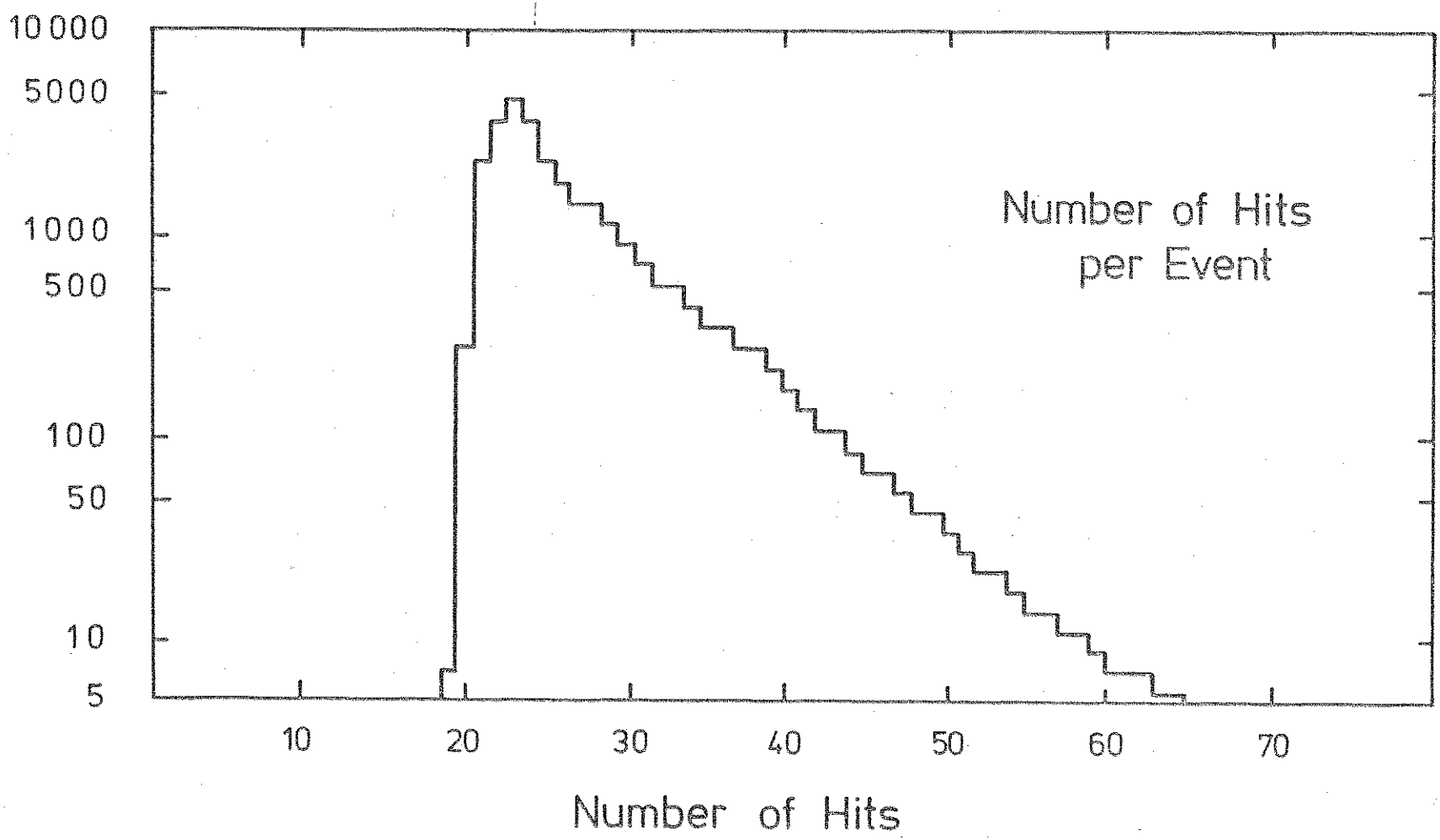
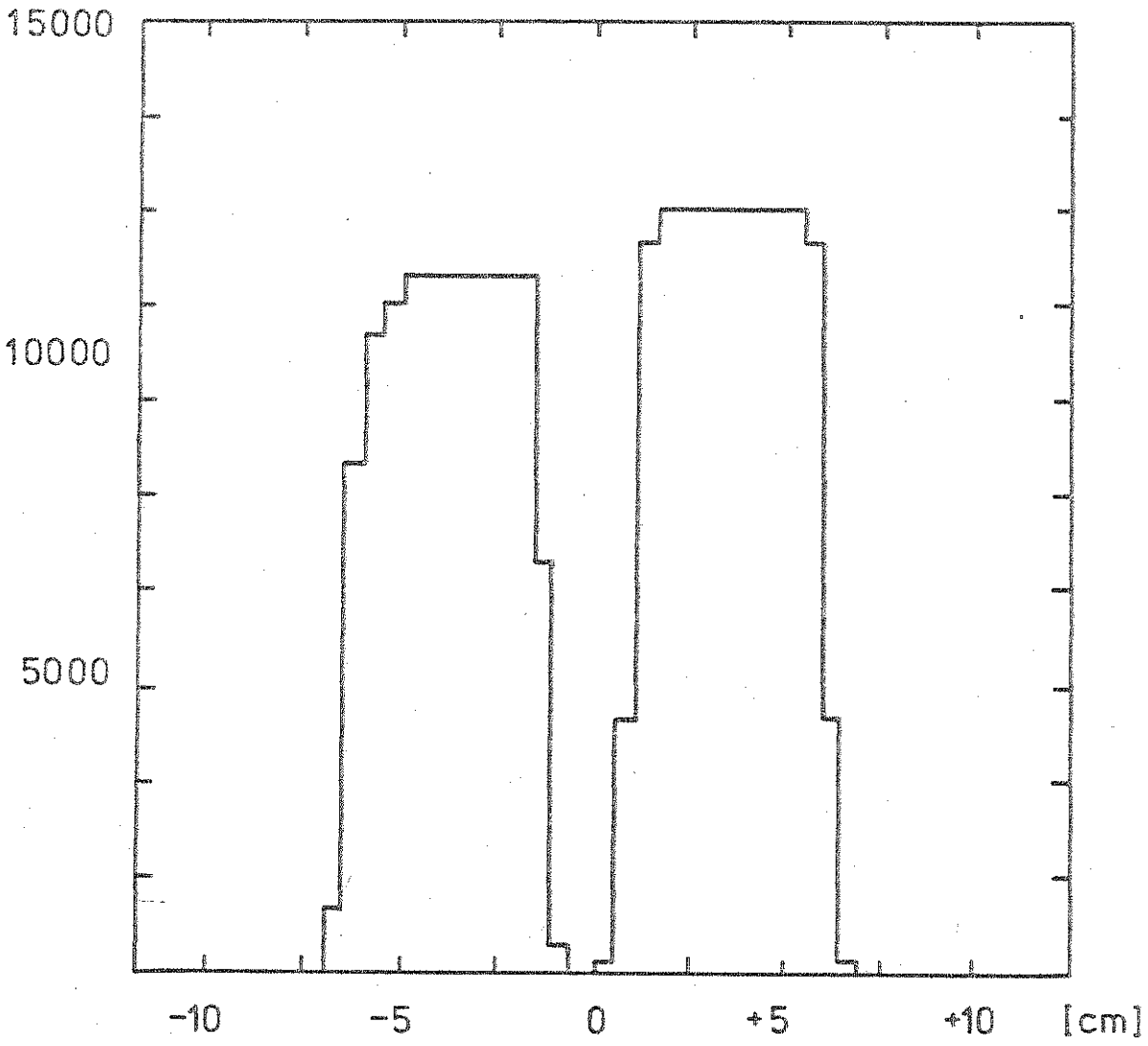

10000
5000
1000
500
100
50
10
5
10
20
30
40
50
60
70
Number of Hits
per Event
Number of Hits

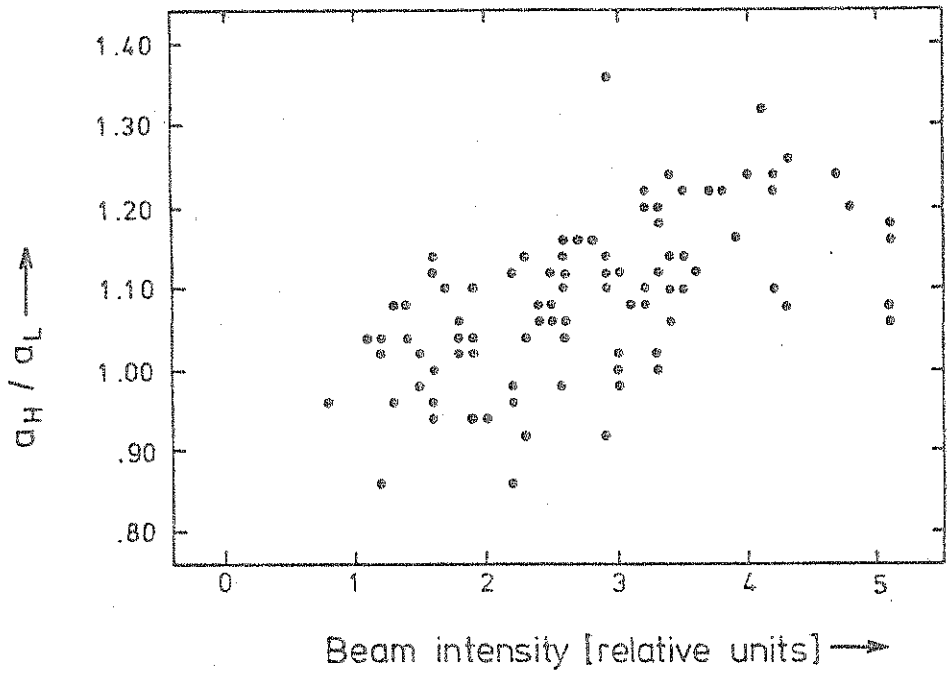
Fig. 6.2 Vertical profile of the reconstructed vertex position showing the two beams.




Reconstructed Vertex

Fig. 6.3 Ratio of the higher beam attenuation over the lower beam attenuation versus the primary beam intensity. The scatter plot shows a clear correlation with the beam intensity.

Fig. 6.4 Beam attenuation calculated by combining the information from the two beams. The scatter plot shows this attenuation normalized by exp(-X/L) versus the primary beam intensity. No rate dependence effect is visible.


1.40
1.30
1.20
1.10
1.00
.90
.80
0
1
2
3
4
5
$a_H / a_L$
Beam intensity [relative units]

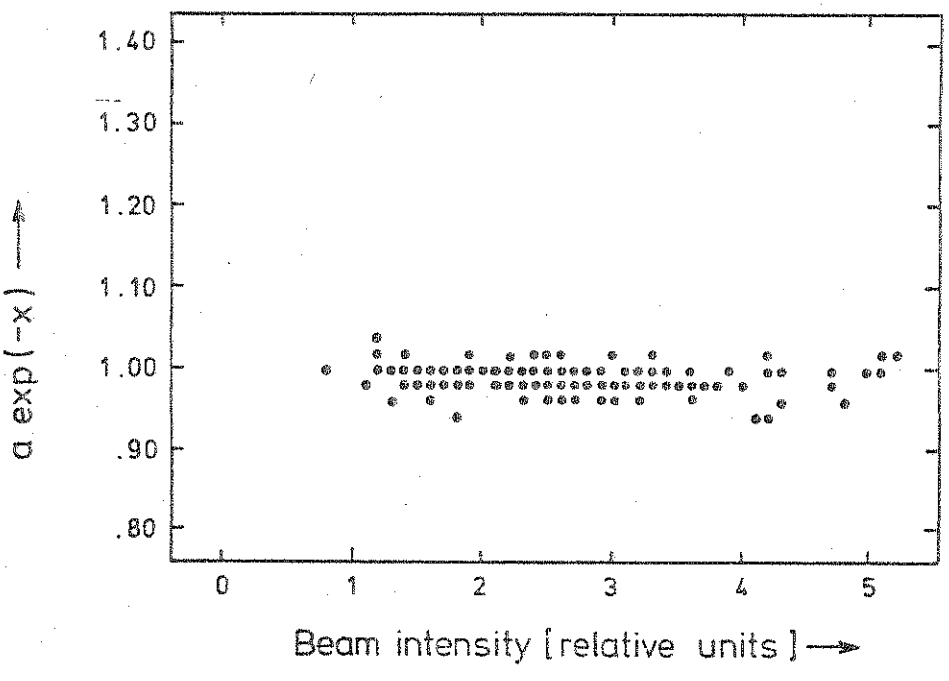
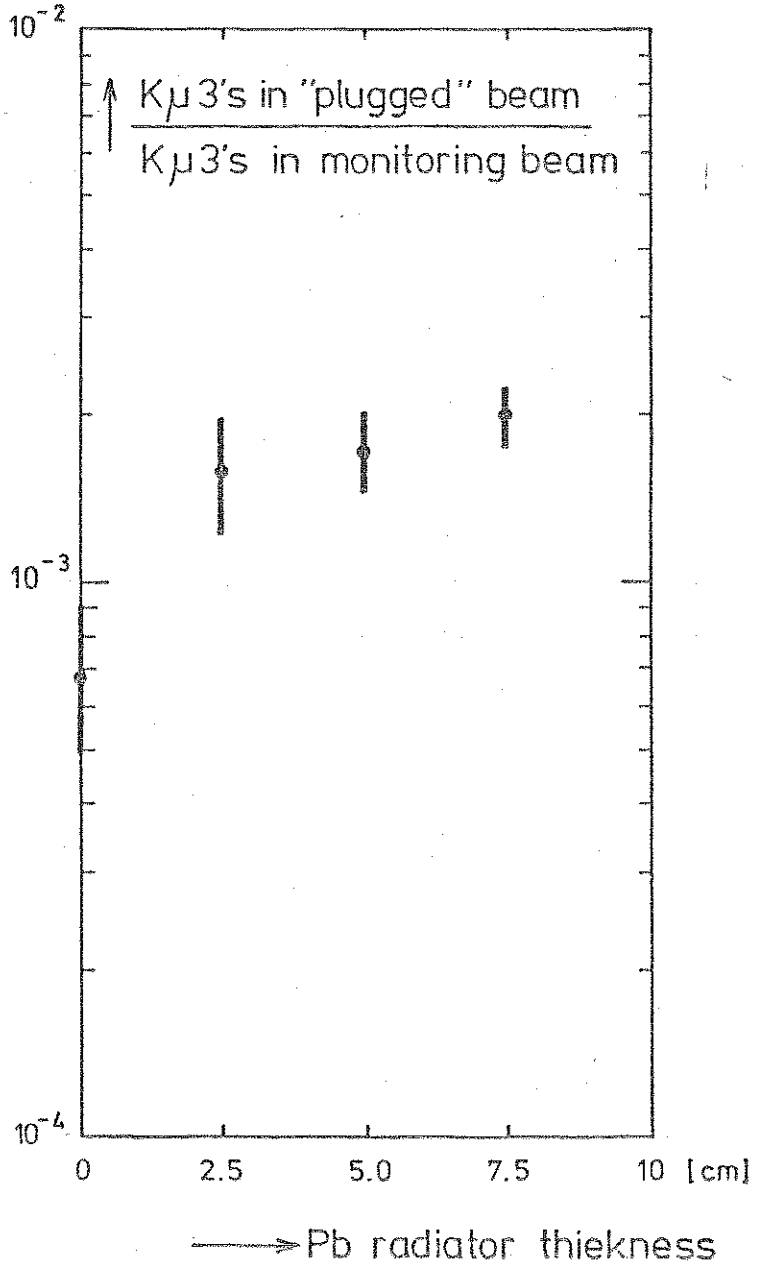

1.40
1.30
1.20
1.10
1.00
.90
.80
0
1
2
3
4
5
a exp(-x)
Beam intensity [relative units]

Fig. 6.5 Monte Carlo calculated probability of a kaon to scatter from one beam into the other (cross-talk) .

Fig. 6.6 Measured fraction of kaons detected in the plugged beam (plugged by filling one of the holes of the fixed collimator) as a function of the lead radiator thickness.


$10^{-2}$
$10^{-3}$
$10^{-4}$
Kμ3's in "plugged" beam
Kμ3's in monitoring beam
0
2.5
5.0
7.5
10 [cm]
Pb radiator thiekness

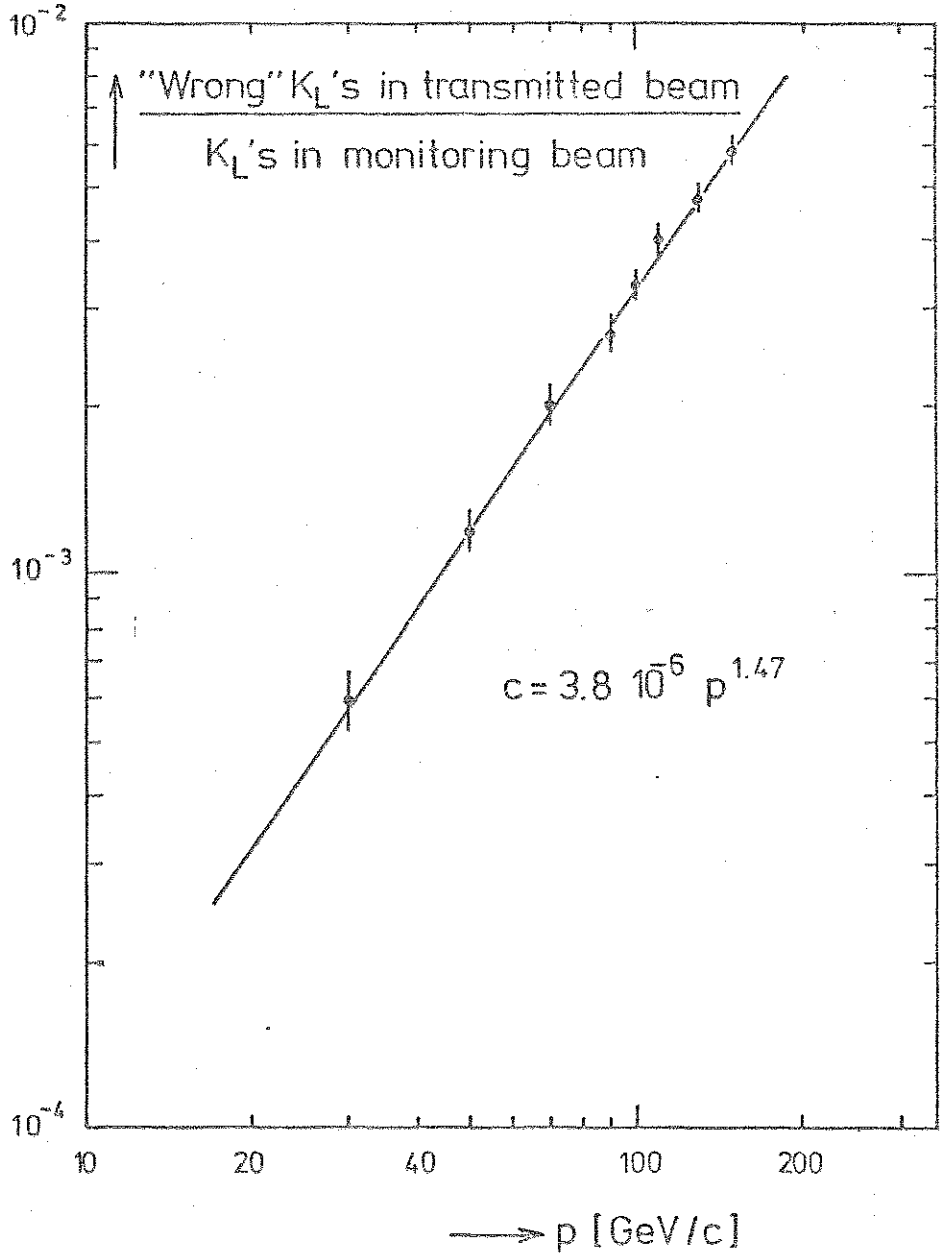
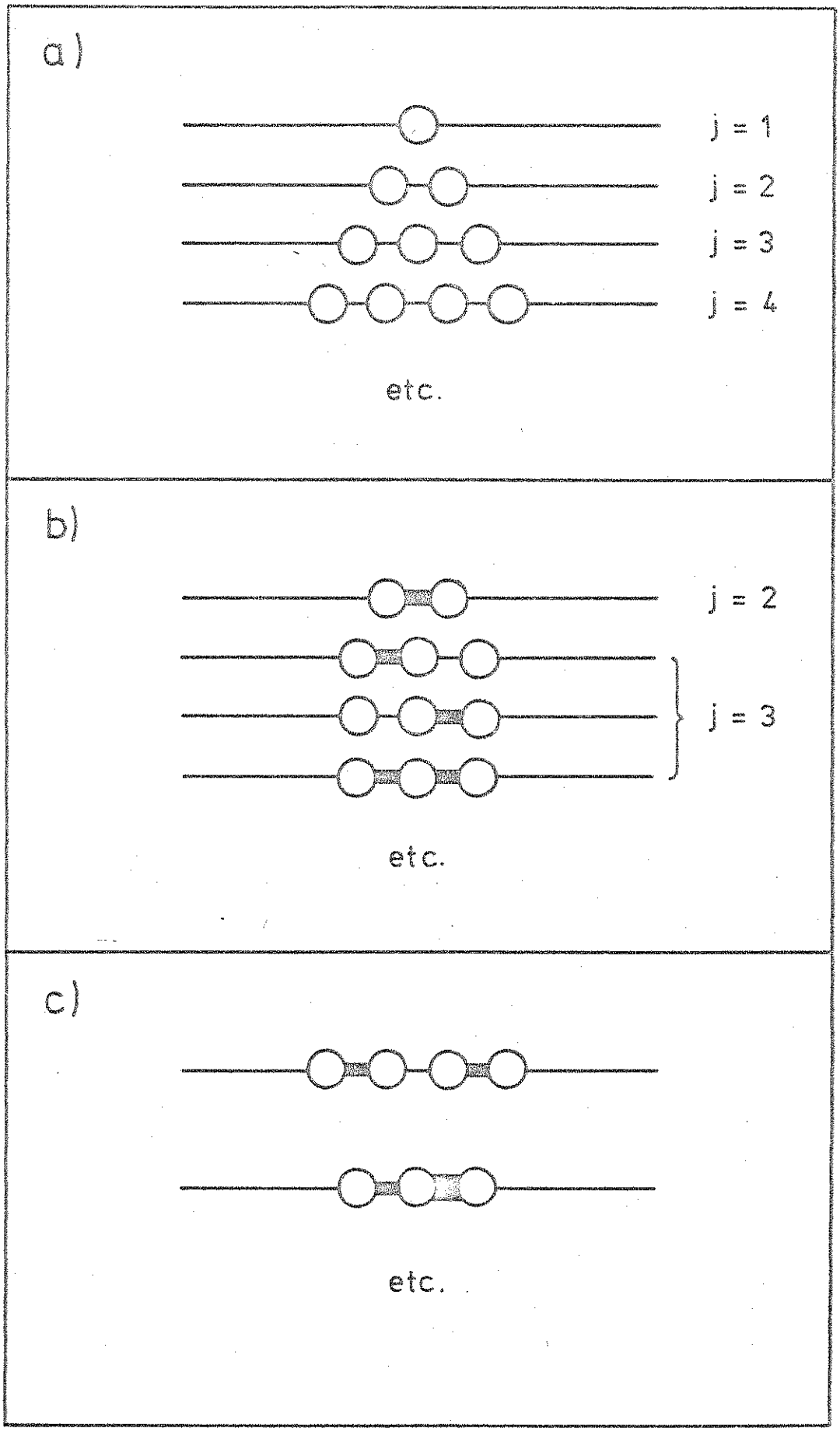

$10^{-2}$
$10^{-3}$
$10^{-4}$
"Wrong" $K_L$'s in transmitted beam
$K_L$'s in monitoring beam
$c = 3.8\ 10^{-6}\ p^{1.47}$
10
20
40
100
200
p [GeV/c]

Fig. 7.1.a Typical elastic multiple-scattering diagrams included in the standard Glauber model.

Fig. 7.1.b Typical inelastic multiple-scattering diagrams included in the Karmanov-Kondratyuk model. The fat lines correspond to the propagation of the inelastic intermediate states.

Fig. 7.1.c Typical inelastic multiple-scattering diagrams not included in the Karmanov-Kondratyuk model, i.e.

- multiple excitation/desexcitation of the projectile.
- double excitation of the projectile.


a)
j = 1
j = 2
j = 3
j = 4
etc.
b)
j = 2
j = 3
etc.
c)
etc.

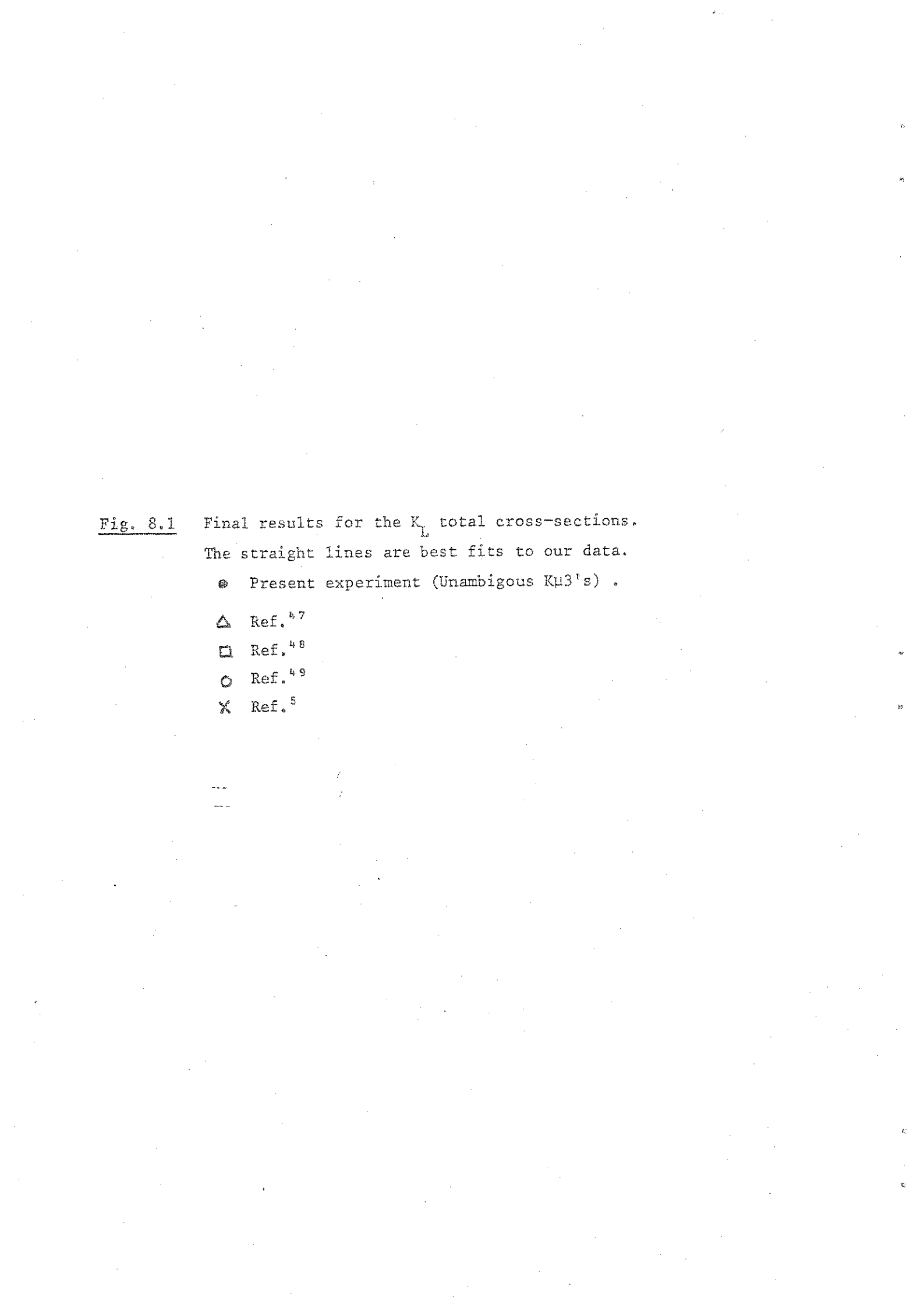


Fig. 8.1 Final results for the $K_L$ total cross-sections. The straight lines are best fits to our data.

- ● Present experiment (Unambigous Kμ3's) .
- △ Ref.[47]
- □ Ref.[48]
- ○ Ref.[49]
- ✕ Ref.[5]

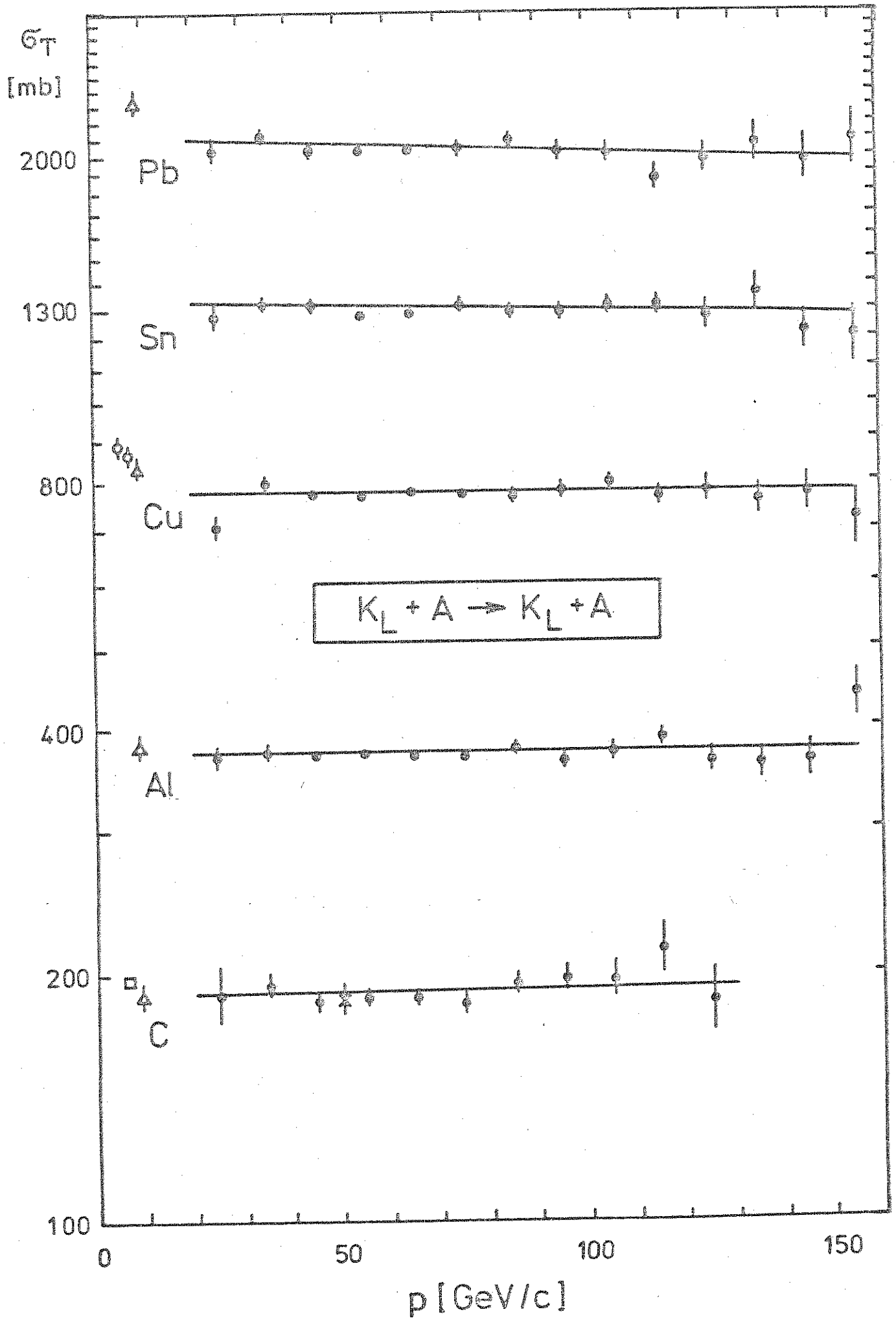

$\sigma_T$ [mb]
2000
1300
800
400
200
100
Pb
Sn
Cu
Al
C
$K_L + A \rightarrow K_L + A$
0
50
100
150
p [GeV/c]

Fig. 8.2 Final results for $K_S$ coherent regeneration. The lines are the best fits to $p^{\alpha-1}$ in the 25-135 GeV/c momentum range.

- ✕ Ref.[34] (Pb)
- ● This experiment for Al, Cu, Sn and Pb above 10 GeV/c.
- ● Ref.[46] (Pb)
- ● Ref.[49] , Ref.[50] (Cu)
- ● Ref.[51] , Ref.[5] (C)

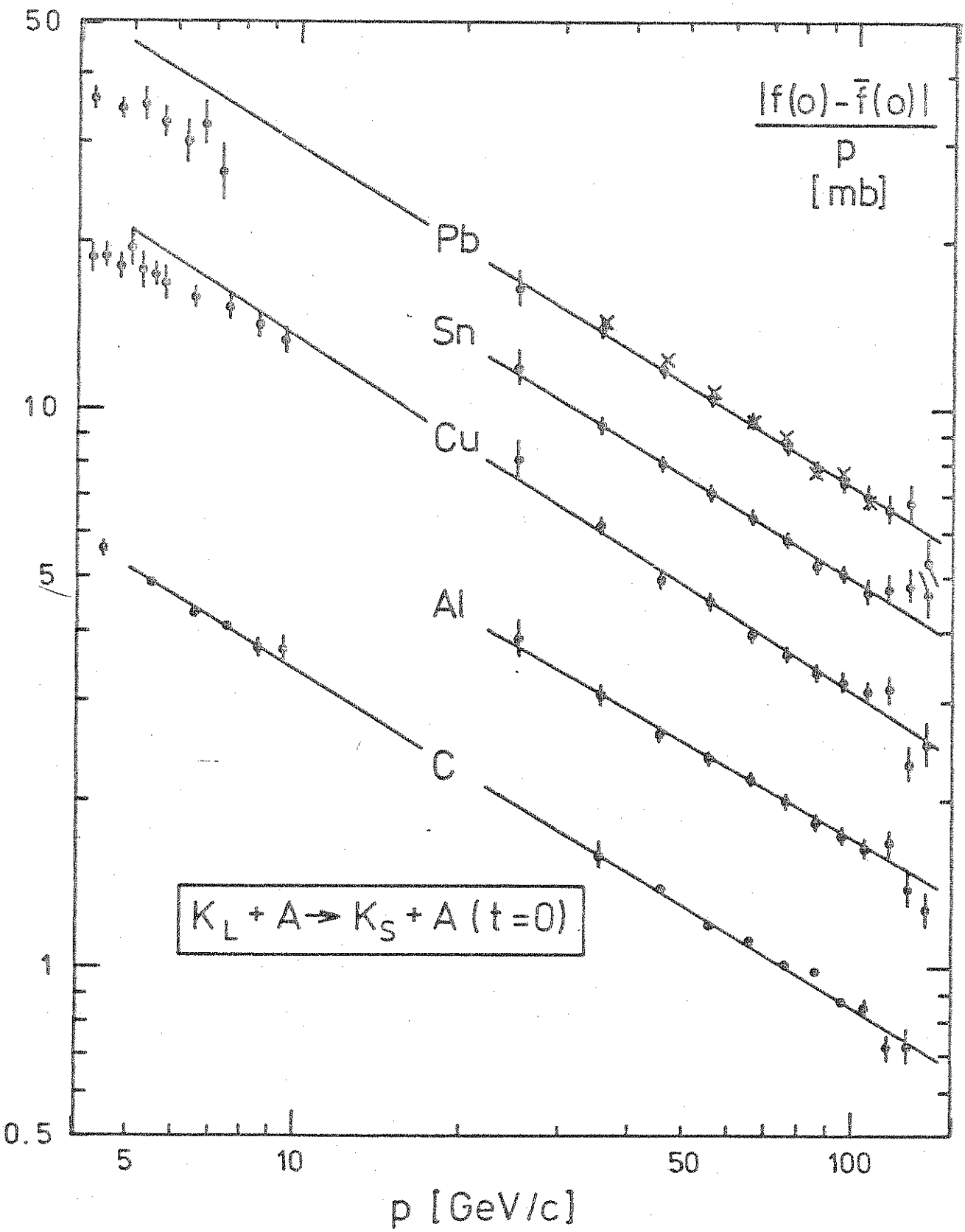
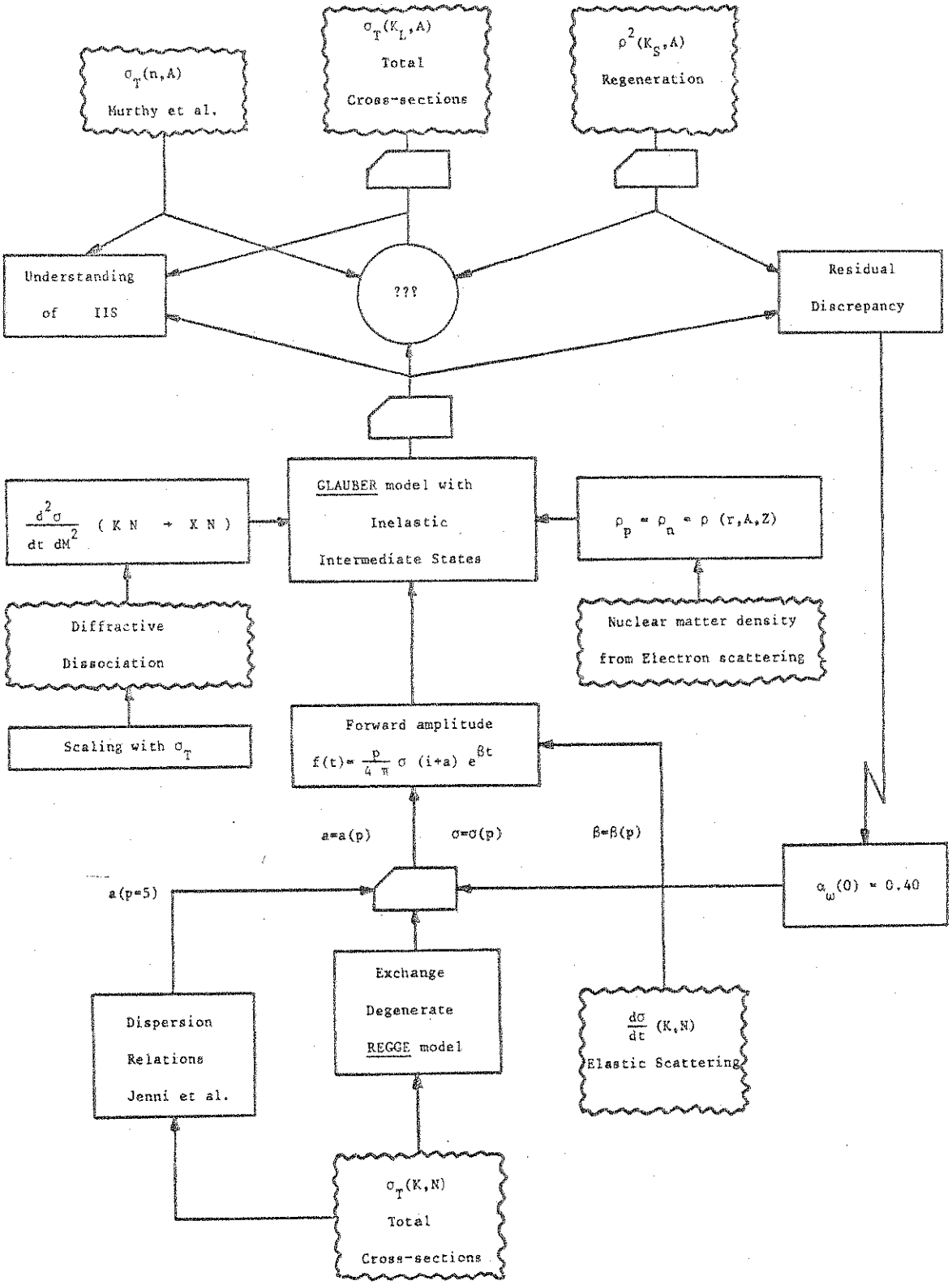

50
10
5
1
0.5
5
10
50
100
p [GeV/c]
|f(o) - f̄(o)| / p [mb]
Pb
Sn
Cu
Al
C
K_L + A → K_S + A (t=0)

Fig. 8.3 Analysis organigram.




ANALYSIS ORGANIGRAM

Fig. 8.4 Comparison of model prediction of neutron-nucleus total cross-sections with the data. The data compilation is from Ref.[41] .

– – – Glauber model without IIS.

——— Glauber model with IIS.

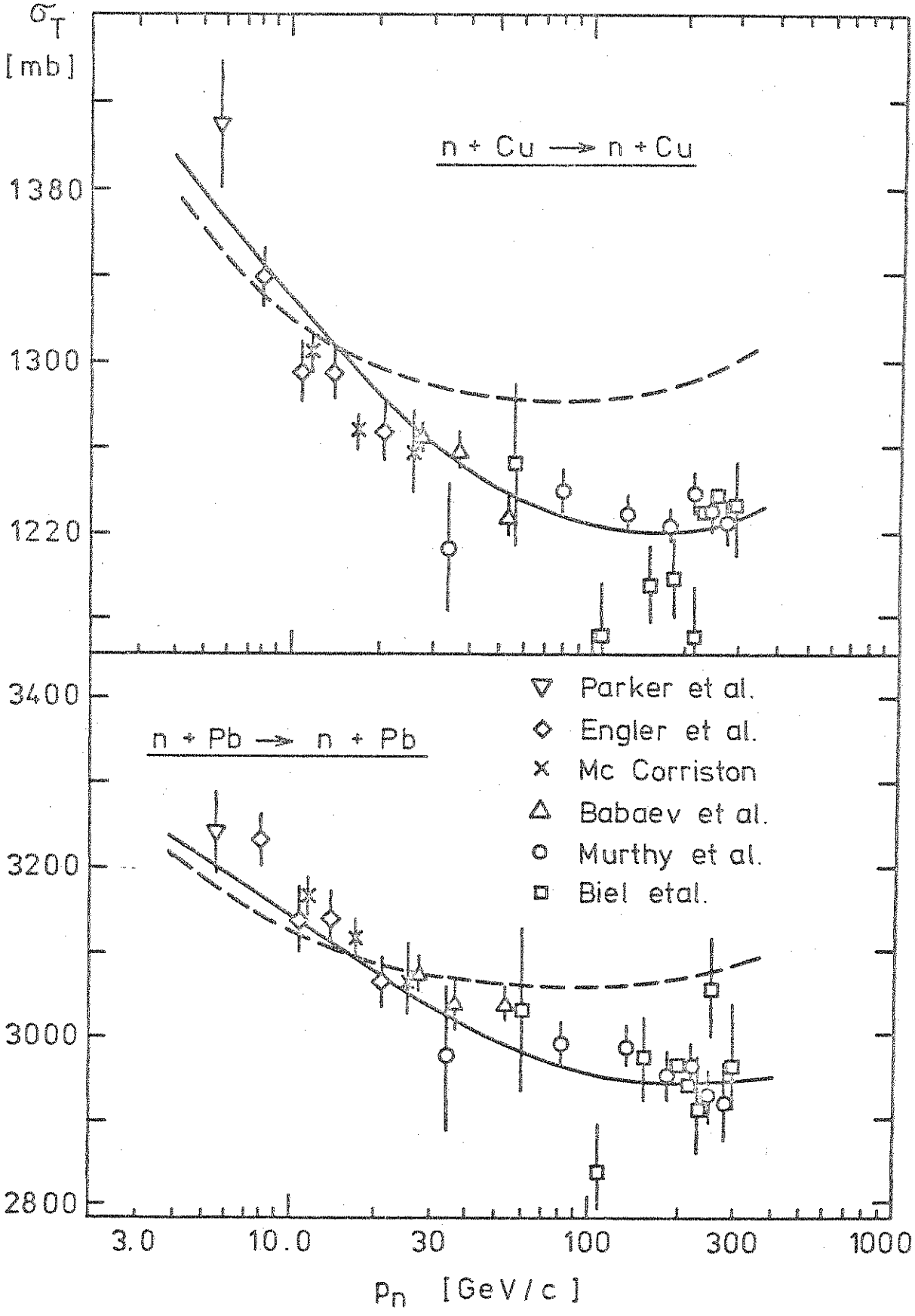

$\sigma_T$ [mb]
n + Cu ⟶ n + Cu
1380
1300
1220
n + Pb ⟶ n + Pb
3400
3200
3000
2800
Parker et al.
Engler et al.
Mc Corriston
Babaev et al.
Murthy et al.
Biel etal.
3.0
10.0
30
100
300
1000
$p_n$ [GeV/c]

Fig. 8.5 "Measured" inelastic screening defect of neutron-nucleus total cross-section at 200 GeV/c as a function of atomic weight. The solid line is our prediction (7.10). The data are from Ref.[2] .

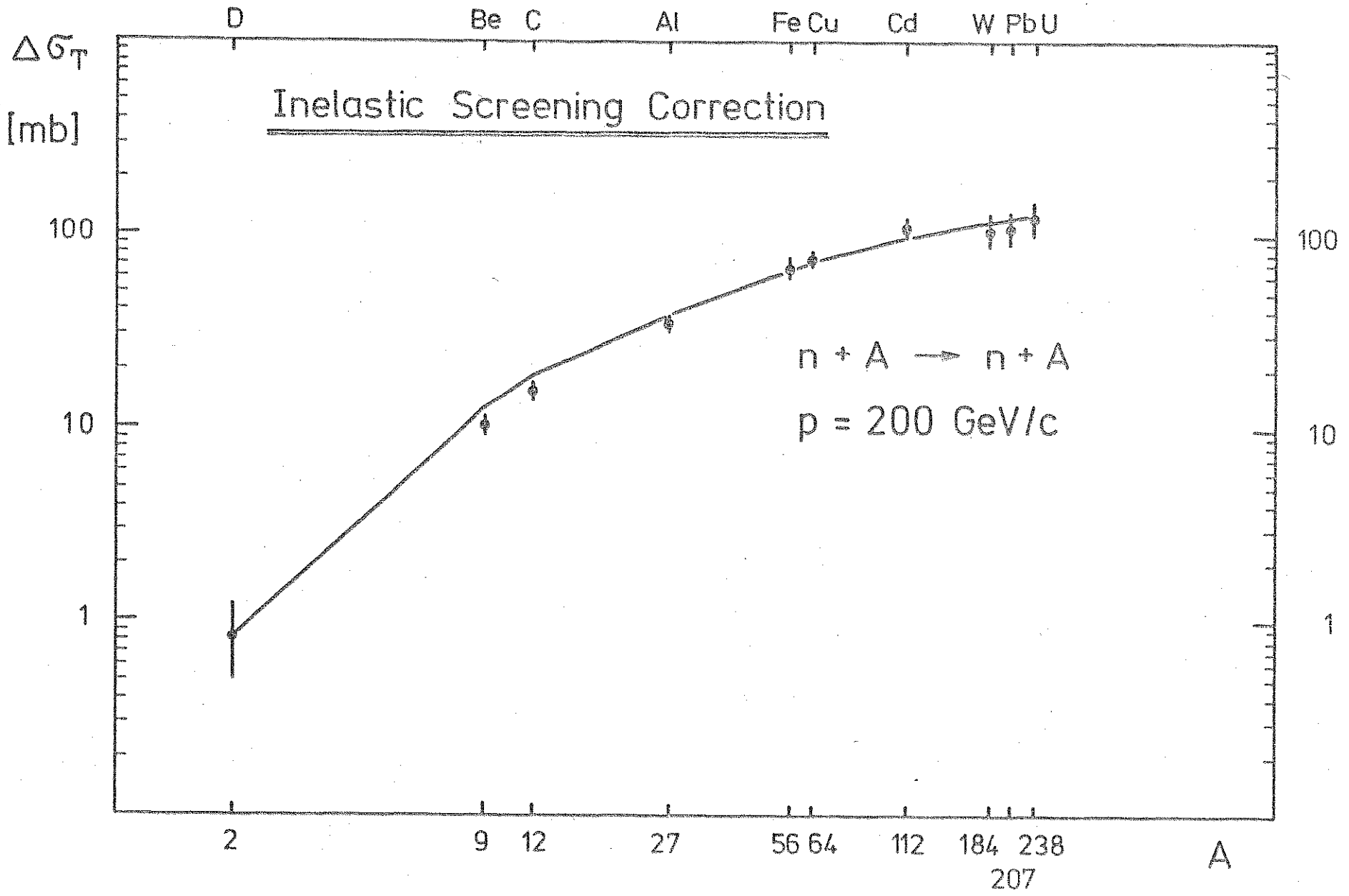

D
Be
C
Al
Fe
Cu
Cd
W
Pb
U
$\Delta\sigma_T$
[mb]
Inelastic Screening Correction
100
10
1
n + A → n + A
p = 200 GeV/c
2
9
12
27
56
64
112
184
207
238
A

Fig. 8.6 Comparison of model predictions of kaon-nucleus total cross-sections with the data. The data are as in Fig. 8.1.

--- Glauber model without IIS.

——— Glauber model with IIS.

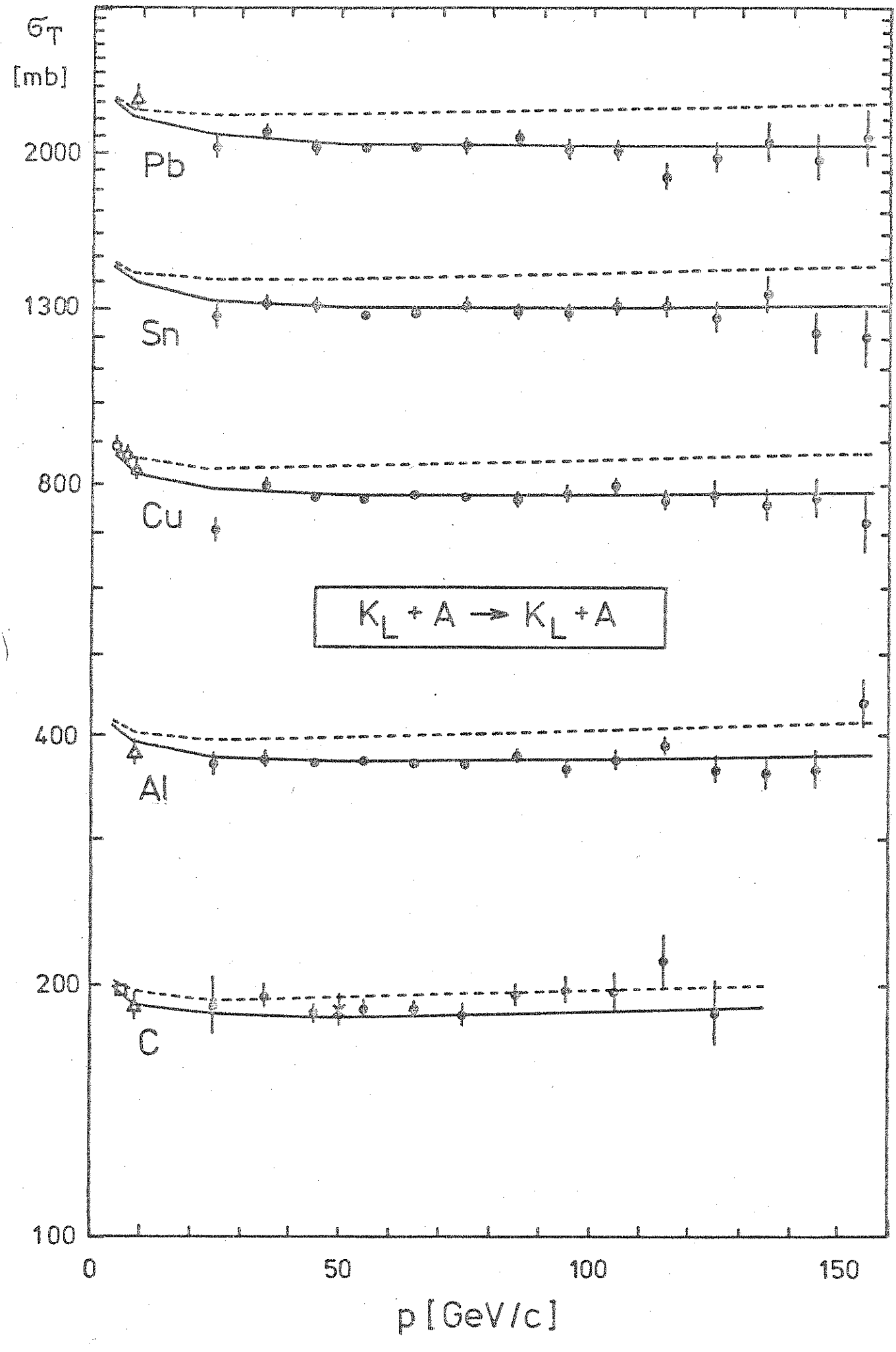

$\sigma_T$ [mb]
2000
1300
800
400
200
100
Pb
Sn
Cu
Al
C
$K_L + A \rightarrow K_L + A$
0
50
100
150
p [GeV/c]

Fig. 8.7 "Measured" inelastic screening defect of kaon-nucleus total cross-section at 50 GeV/c as a function of atomic weight. The solid line is our prediction (7.10).

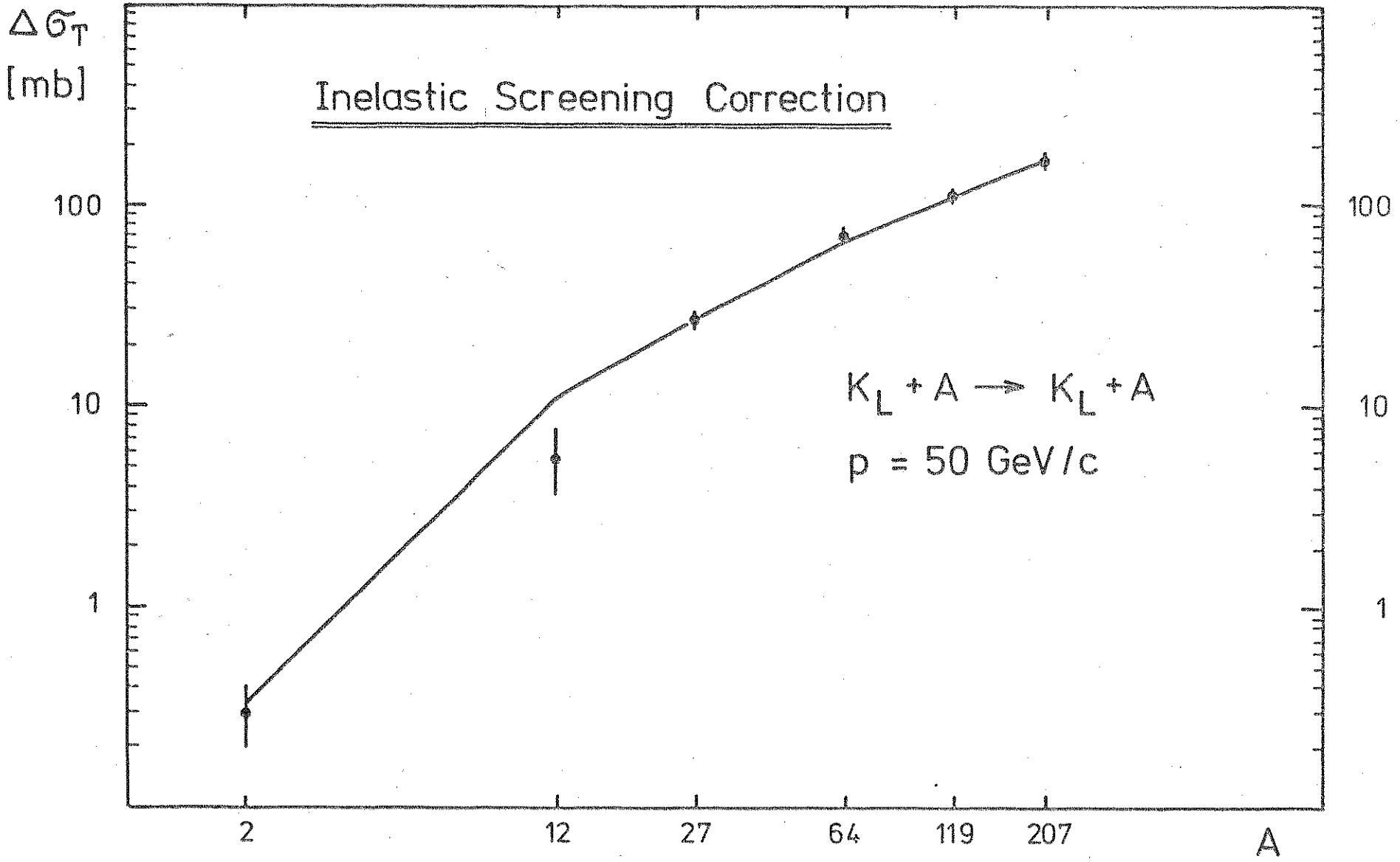

Δσ_T [mb]
Inelastic Screening Correction
100
10
1
K_L + A → K_L + A
p = 50 GeV/c
2
12
27
64
119
207
A

Fig. 8.8 Comparison of the inelastic screening correction at 50 GeV/c for kaons and neutrons as a function of atomic weight. In heavy nuclei the inelastic screening correction is much larger for kaons than for neutrons.

# Relative inelastic screening Correction

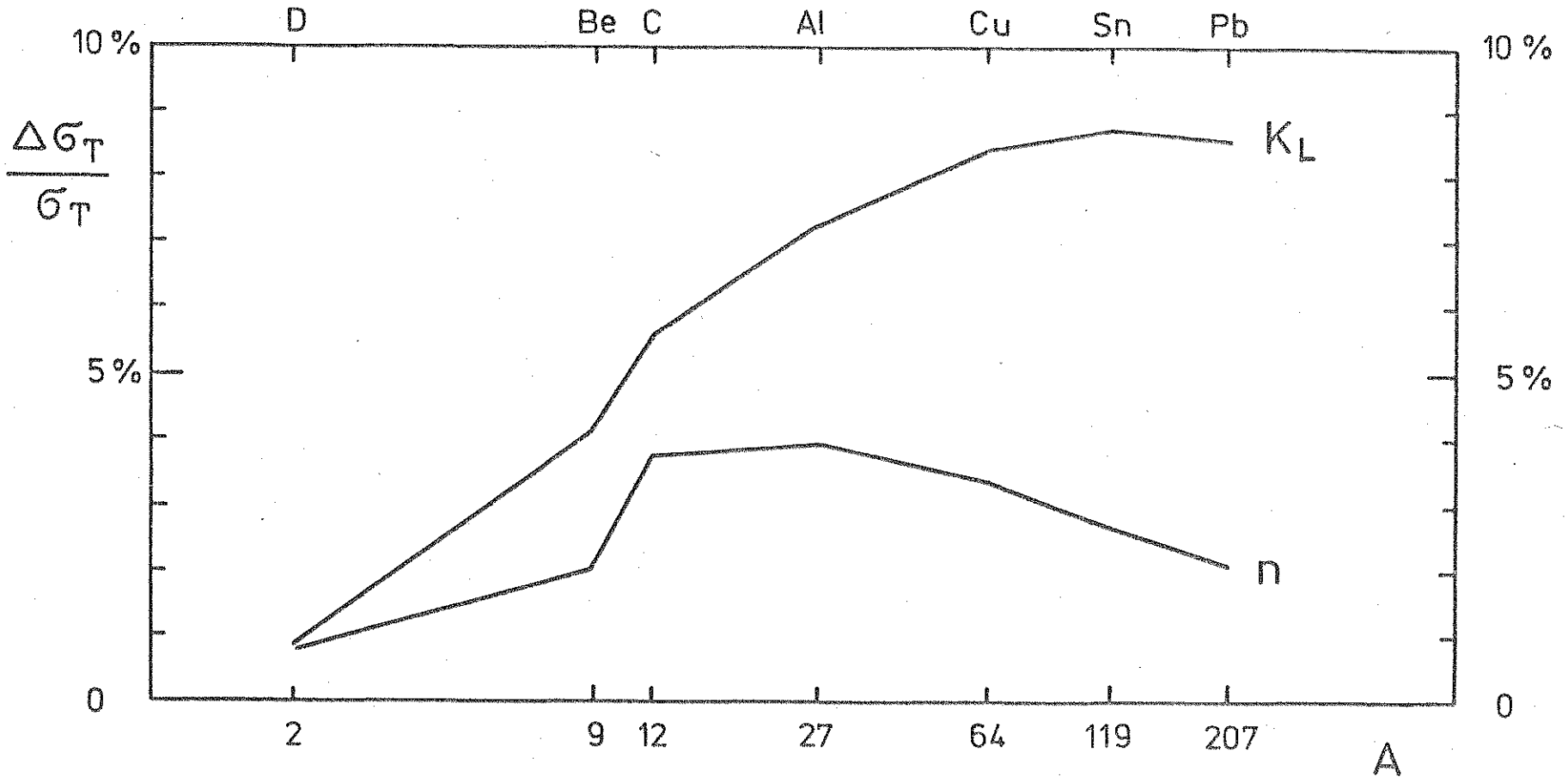


Fig. 8.9 Comparison of model predictions of $K_S$ coherent regeneration with the data. The input elementary kaon-nucleon amplitudes are taken from standard Regge fits and dispersion relation calculations. The Glauber model, even with the contribution of inelastic intermediate states, disagrees with the data. The data is as in Fig. 8.2 .

---Glauber model without IIS.

——Glauber model with IIS.

N.B.: The Glauber model input amplitudes parametrization is given in Table 8.8, fit (i) .

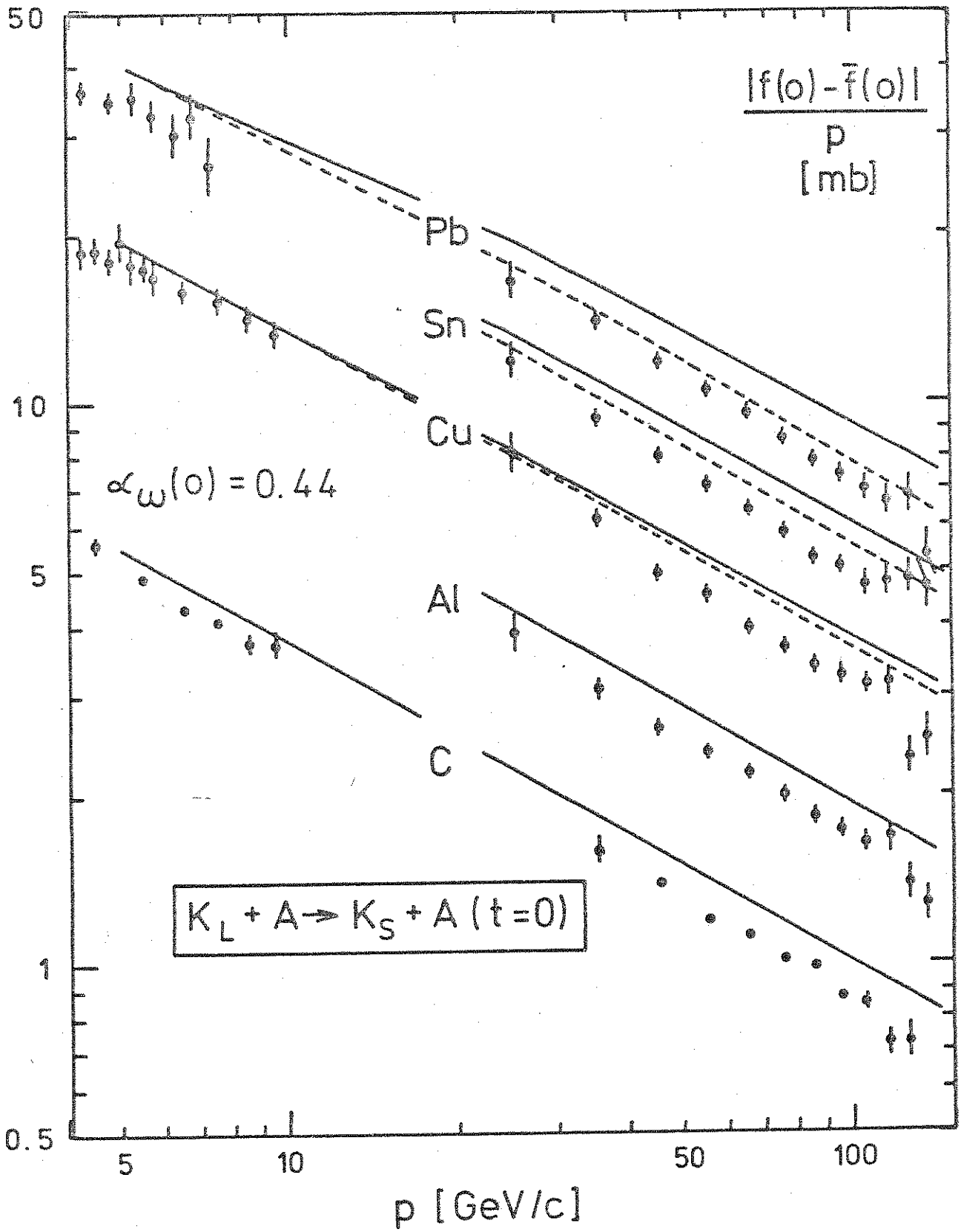

50
10
5
1
0.5
5
10
50
100
p [GeV/c]
$\frac{|f(0)-\bar{f}(0)|}{p}$ [mb]
Pb
Sn
Cu
Al
C
$\alpha_\omega(0) = 0.44$
$K_L + A \rightarrow K_S + A\ (t=0)$

Fig. 8.10 Comparison of model predictions of coherent $K_S$ regeneration with the data. The input elementary kaon-nucleon amplitudes are constrained to fit the carbon power law momentum dependence. The Glauber model with inelastic intermediate states is now in good agreement with the data. The data is the same as in Fig. 8.2 .

– – – Glauber model without IIS.

——— Glauber model with IIS.

N.B.: The Glauber model input amplitudes parametrization is given in Table 8.8, fit (iii) .

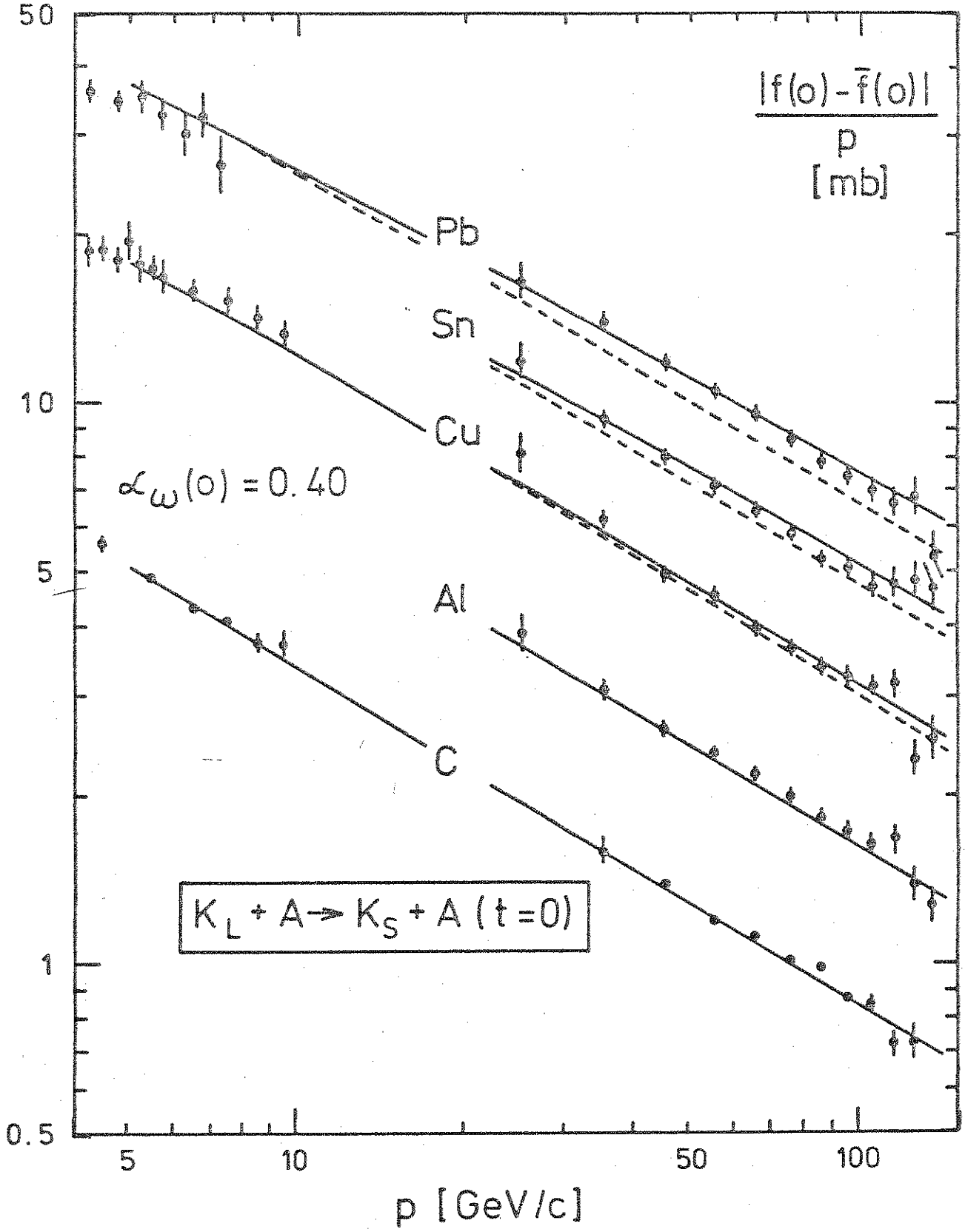
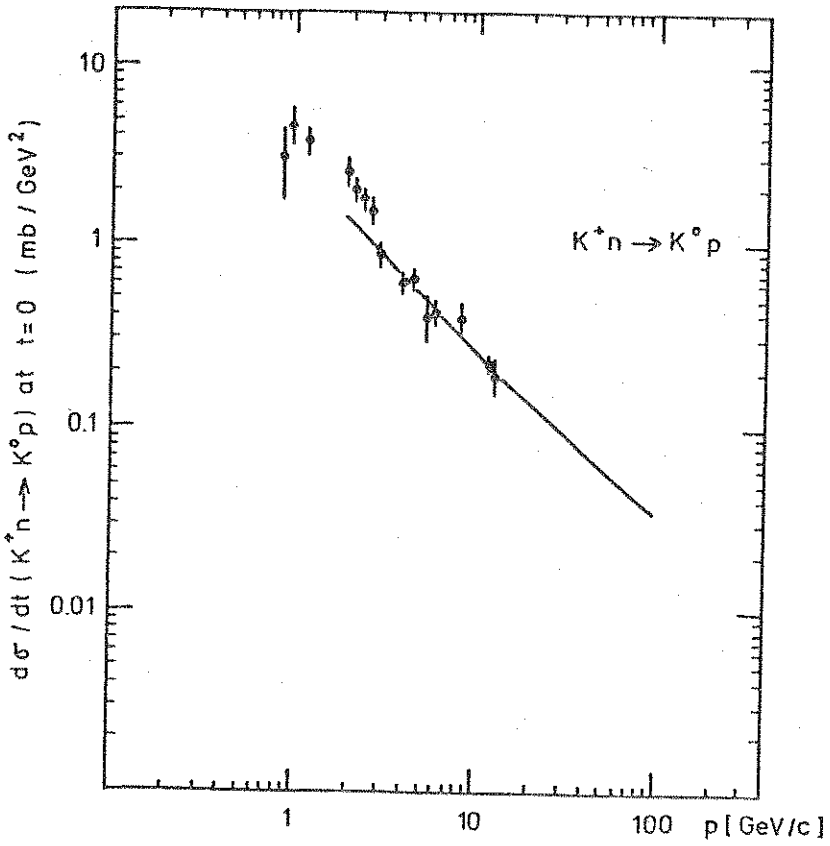

50
10
5
1
0.5
$\frac{|f(o)-\bar{f}(o)|}{p}$ [mb]
Pb
Sn
Cu
Al
C
$\alpha_\omega(o) = 0.40$
$K_L + A \rightarrow K_S + A$ (t = 0)
5
10
50
100
p [GeV/c]

Fig. B.1 Comparison of Regge model predictions of charge exchange reactions with the data. The data are from Ref.[31] .


10
1
0.1
0.01
1
10
100
p [GeV/c]
dσ/dt (K⁺n → K°p) at t=0 (mb/GeV²)
K⁺n → K°p

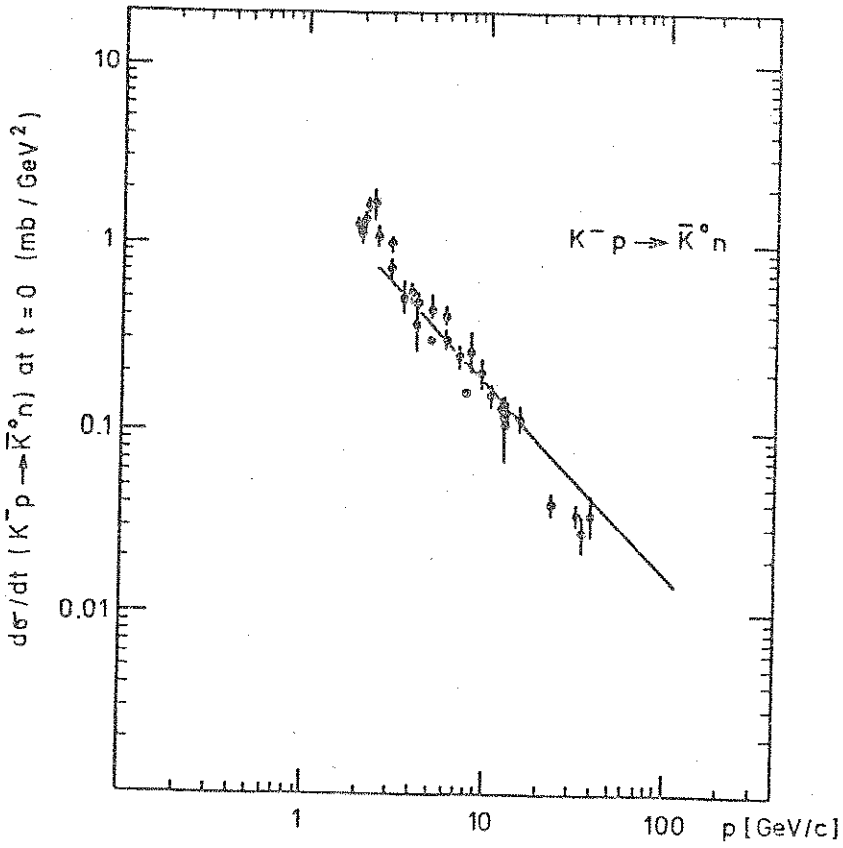

10
1
0.1
0.01
1
10
100
p [GeV/c]
dσ/dt (K⁻p → K̄°n) at t=0 (mb/GeV²)
K⁻p → K̄°n

Fig. B.2 Comparison of Regge model predictions of $K_S$ regeneration on proton with the data. The normal Regge prediction with $\alpha_\omega(0)=0.44$ agrees with the data, but the prediction constrained with $\alpha_\omega(0)=0.40$ (as required by $K_S$ regeneration on carbon) disagrees with the data.

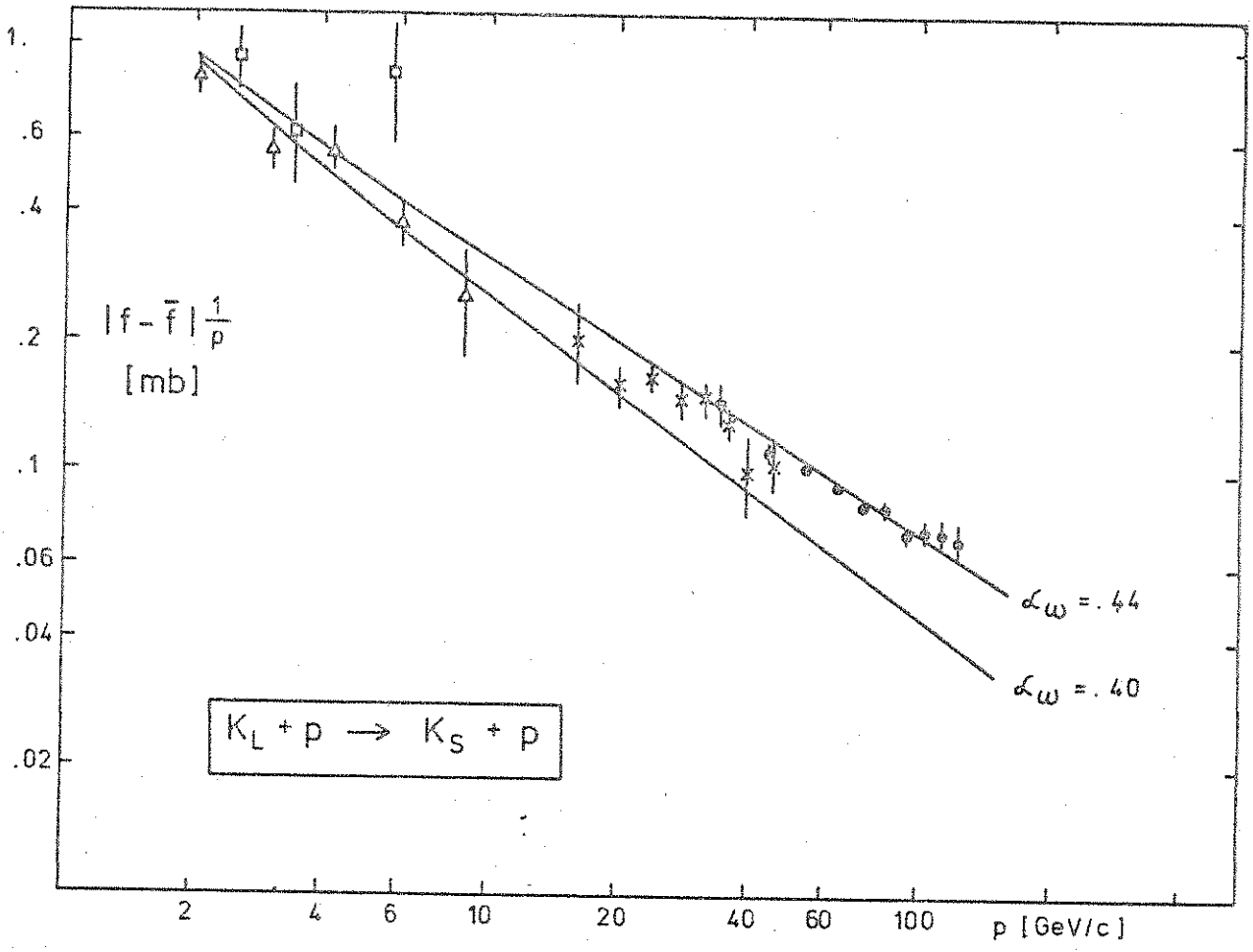
□ Ref.[52]

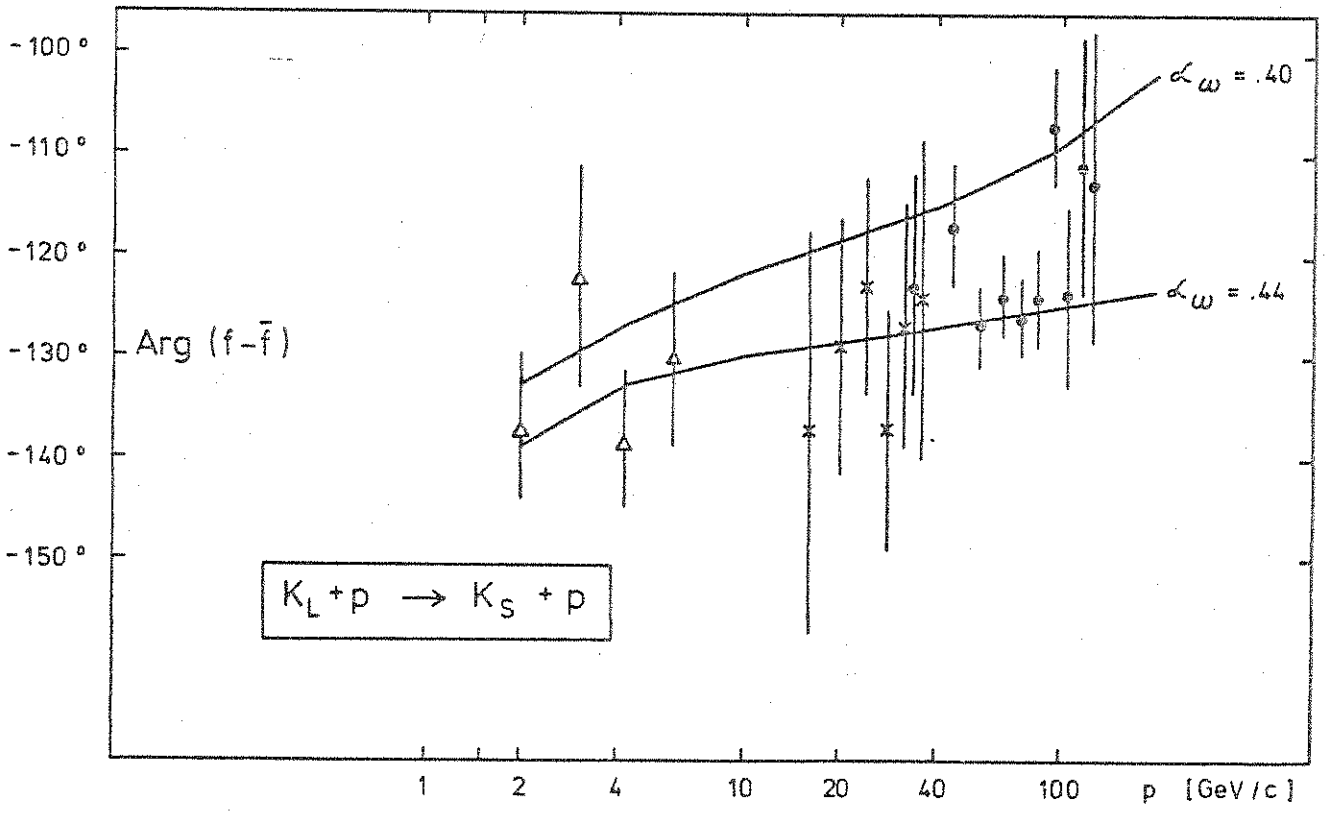
△ Ref.[53]

✕ Ref.[54]

• Ref.[14]

N.B.: The Regge fits used for these two predictions are respectively fit (i) and fit (iii) of Table 8.2 .


1.
.6
.4
.2
.1
.06
.04
.02
$|f-\bar{f}|\frac{1}{p}$
[mb]
$K_L + p \rightarrow K_S + p$
$\alpha_\omega = .44$
$\alpha_\omega = .40$
2
4
6
10
20
40
60
100
p [GeV/c]


-100°
-110°
-120°
-130°
-140°
-150°
Arg $(f-\bar{f})$
$K_L + p \rightarrow K_S + p$
$\alpha_\omega = .40$
$\alpha_\omega = .44$
1
2
4
10
20
40
100
p [GeV/c]

CURRICULUM VITAE

I was born on the 29th of March 1948 in Brig (VS) . In 1958 I moved with my family to Lausanne. I attended the secondary school, and later the Gymnasium where I obtained the baccalaureat in 1967. I then immatriculated at the faculty of Sciences of the University of Lausanne, and graduated in physics in 1972. Since then I have been working at CERN until 1975, and thereafter, under the sponsorship of Prof. V.L. Telegdi, at Fermilab near Chicago until 1977. Currently I am working at CERN in the ETH-Ecole Polytechnique-Strasbourg collaboration.