# DETERMINATION OF THE CROSS SECTION
# OF THE PROTON, PION AND NEUTRON INELASTIC INTERACTION
# WITH LEAD AND CARBON NUCLEI AT 0.5 - 5.0 TEV ENERGIES
## (PION Experiment)

V.V.AVAKIAN, G.V.KARAGJOZIAN, E.A.MAMIDJANIAN,
M.I.KEROPIAN, R.M.MARTIROSOV, G.G.OVSEPIAN, S.O.SOKHOYAN

Yerevan Physics Institute, Markarian st. 2
375036 Yerevan, Armenia, USSR

## ABSTRACT

Experimental results on the cross section of the single pion, proton and neutron inelastic interaction with carbon and lead nuclei in the 0.5-5.0 TeV energy interval obtained on the PION installation (mount.Aragats, Armenia, 3250 m) are presented. For this purpose the $N_\pi / N_p$ and $\sigma^{in}_{pFe} / \sigma^{in}_{\pi Fe}$ ratios measured directly on the installation as well as the calculated $\sigma^{in}_{pA} / \sigma^{in}_{\pi A}$ dependence on the target nucleus atomic number were used.

The PION installation combining an X-ray transition radiation multimodule detector (XTR detector) and an ionization calorimeter (IC) is shown in fig.1. The detailed description of the installation is given in /1/. 3 rows of multiwire proportional chambers (MWPC) identical to the chambers located in the XTR detector were used as detectors of the hadron interaction with the graphite nuclei. The thickness of the two graphite layers is 12 cm. The interactions in lead were registered by two rows of ionization chambers located under 3 cm (I layer) and 2 cm (II layer) of lead in the upper part of the IC.

To determine $\sigma^{in}$ with the C and Pb nuclei, events were chosen that satisfied the following selection criteria: the energy release in the IC should be higher than 500 GeV;

the axis of the nuclear-electro-
magnetic cascades (NEMC) should
be within the solid angle of the
installation (its geometric fac-
tor is $G = 1,28 \ m^2 sr$); the ion-
ization distribution in each row
of the ionization chambers should
have one maximum at a distance of
20 cm from the IC edge ( $\sim$ two
chamber diameters); the air ac-
companiment density should not
exceed 1 part./m (the hadron
"singleness" condition).

In selecting the events iden-
tified as interactions in the
graphite target the fulfillment
of two additional criteria was



Fig. 1

required. The energy release in the interaction detector
under the graphite target should correspond to the passage
of $\succ$ 2 relativistic particles, and the summary energy re-
lease under the first layer should exceed 100 relativistic
particles.

The additional condition for selecting the events ident-
ified as interactions in lead was the presence of energy
release in the second row of ionization chambers in the
absence of energy release in the first row.

According to these criteria 548 neutral and 876 charged
hadrons having interacted in graphite as well as 1364 neut-
ral and 1090 charged hadrons identified as having interact-
ed in the second layer of lead were selected.

In determining the inelastic interaction cross sections
corrections were introduced for "albedo" particles, the
difference in the angular distribution of charged and neut-
ral hadrons, the contribution of the cascades generated by
muons, the transition effect Pb – ionization chamber wall.
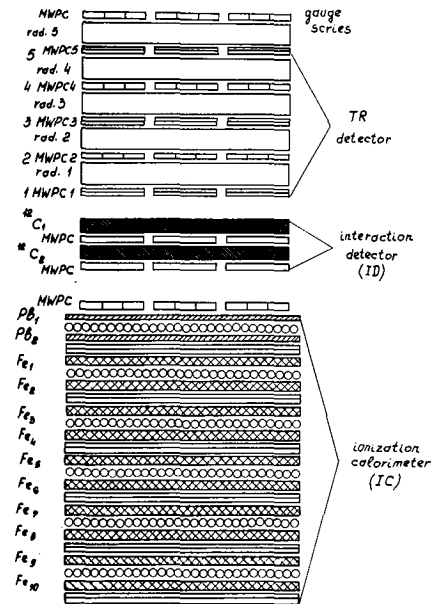The measured cross sections of charged and neutral hadron

interactions with the  C  and  Pb  nuclei are plotted in
Table 1.                                                Table 1

|  | 500–1000 GeV | 1000–2000 GeV | 2000 GeV |
|---|---|---|---|
| $\sigma_{nc}^{in}$ | 254±21 | 263±28 | 261±34 |
| $\sigma_{chc}^{in}$ | 214±19 | 228±21 | 247±36 |
| $\sigma_{Pc}^{in}$ | 236±23 | 236±30 | 255±39 |
| $\sigma_{\pi c}^{in}$ | 179±18 | 179±23 | 193±30 |
| $\sigma_{nPb}^{in}$ | 1980±60 | 2100±81 | 2215±104 |
| $\sigma_{chPb}^{in}$ | 1693±80 | 1762±94 | 1890±114 |
| $\sigma_{PPb}^{in}$ | 1762±108 | 1809±101 | 1916±116 |
| $\sigma_{\pi Pb}$ | 1587±89 | 1630±83 | 1726±97 |

By means of these data the $\sigma^{in}$   of pions and protons
with the carbon and lead nuclei were determined. For this
purpose we have used the calculated curve of the ratio
$\sigma_{PA}^{in} / \sigma_{\pi A}^{in}$   dependence on the nucleus atomic number obtain-
ed in /2/ according to which $f(A) = \sigma_{PA}^{in} / \sigma_{\pi A}^{in}$   is practi-
cally independent of energy. The experiment shows a good
agreement with the calculated curve, $\sigma_{PP}^{in} / \sigma_{\pi P}^{in}$  = 1.61 ±
± 0.03  at  E = 345 GeV//3/, and $\sigma_{PFe}^{in} / \sigma_{\pi Fe}^{in}$ = 1.19 ± 0.05
for  E = 1000 GeV /4/. On the PION installation the pion-
to-proton ratio $N_{\pi}/N_p$   for various intervals of hadron
energy was directly measured /5/. The calculated values
of $\sigma_{PA}^{in} / \sigma_{\pi A}^{in}$  for the  C  and  Pb  nuclei are equal to
1.32 ± 0.4  and  1.11 ± 0.03, respectively. The final re-
vised data on the proton and pion cross sections are also
plotted in Table.1.

Figure 2 presents the experimental results on $\sigma_{Pc}^{in}$  and
$\sigma_{PPb}^{in}$   obtained both on accelerator /5/ and in cosmic
rays /6/. The curves denote the recalculation by the mul-
tiple scattering theory from the PP  to  PPb  and  PC in-
teractions.

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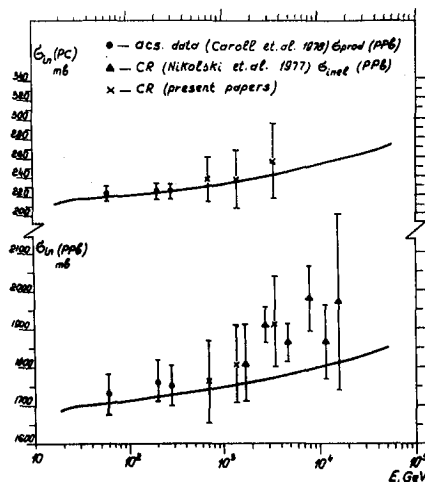


Fig. 2

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