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)

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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 $\sigma^{in}_{Pe}/\sigma^{in}_{Fe}$ 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 multmodule 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-electromagnetic cascades (NEMC) should be within the solid angle of the installation (its geometric factor is \( G = 1.28 \text{ m}^2\text{sr} \)); the ionization 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 accompaniment density should not exceed 1 part./m (the hadron "singleness" condition).

In selecting the events identified as interactions in the graphite target the fulfillment of two additional criteria was required. The energy release in the interaction detector under the graphite target should correspond to the passage of \( \geq 2 \) relativistic particles, and the summary energy release under the first layer should exceed 100 relativistic particles.

The additional condition for selecting the events identified 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 neutral and 1090 charged hadrons identified as having interacted 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 neutral hadrons, the contribution of the cascades generated by muons, the transition effect \( \text{Pb} - \text{ionization chamber wall} \). The measured cross sections of charged and neutral hadron
interactions with the C and Pb nuclei are plotted in Table 1.

Table 1

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<thead>
<tr>
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<tbody>
<tr>
<td>( \sigma_{NC}^{in} )</td>
<td>254±21</td>
<td>263±28</td>
<td>261±34</td>
</tr>
<tr>
<td>( \sigma_{CHC}^{in} )</td>
<td>214±19</td>
<td>228±21</td>
<td>247±36</td>
</tr>
<tr>
<td>( \sigma_{PC}^{in} )</td>
<td>236±23</td>
<td>236±30</td>
<td>255±39</td>
</tr>
<tr>
<td>( \sigma_{NC}^{in} )</td>
<td>179±18</td>
<td>179±23</td>
<td>193±30</td>
</tr>
<tr>
<td>( \sigma_{NPB}^{in} )</td>
<td>1980±60</td>
<td>2100±81</td>
<td>2215±104</td>
</tr>
<tr>
<td>( \sigma_{CHPB}^{in} )</td>
<td>1693±80</td>
<td>1762±94</td>
<td>1890±114</td>
</tr>
<tr>
<td>( \sigma_{PPP}^{in} )</td>
<td>1762±108</td>
<td>1809±101</td>
<td>1916±116</td>
</tr>
<tr>
<td>( \sigma_{\Pi PB}^{in} )</td>
<td>1587±89</td>
<td>1630±83</td>
<td>1726±97</td>
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</table>

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 \( \sigma_{PA}^{in} / \sigma_{JA}^{in} \) dependence on the nucleus atomic number obtained in /2/ according to which \( f(A) = \sigma_{PA}^{in} / \sigma_{JA}^{in} \) is practically independent of energy. The experiment shows a good agreement with the calculated curve, \( \sigma_{PA}^{in} / \sigma_{PP}^{in} = 1.61 \pm 0.03 \) at \( E = 345 \text{ GeV} / 3/ \), and \( \sigma_{PF}^{in} / \sigma_{\Pi F}^{in} = 1.19 \pm 0.05 \) for \( E = 1000 \text{ GeV} / 4/ \). 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 \( \sigma_{PA}^{in} / \sigma_{JA}^{in} \) for the C and Pb nuclei are equal to 1.32 ± 0.4 and 1.11 ± 0.03, respectively. The final revised 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 \( \sigma_{PP}^{in} \) obtained both on accelerator /5/ and in cosmic rays /6/. The curves denote the recalculation by the multiple scattering theory from the PP to PPB and PC interactions.
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/5/ Avakian V.V. et al., XVIII ICRC, Bangalore, 1983, 5, 263.