Calculation of Absorption Cross-Section For Negative Pion- Nucleus Collision at High Energy

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Introduction

Because of its light mass pion has been known to play an important role in the interactions between nucleons. The mechanism of the absorption of hadrons with complex nuclei has been studied by several physicists [1-5]. Much of the strongly interacting matter in the universe (nuclei) is best described in terms of nucleons and mesons. Therefore it is of fundamental importance to understand as quantitatively as possible the complicated but common situation in which a pion interacts with a nucleus. In contrast to more common probes of nuclei, such as protons and electrons, the pion is a boson and thus can be absorbed. However, the pion cannot be absorbed on a free nucleon and still conserve energy and momentum. The pion absorption is an excellent tool for the study of two-nucleon correlations in nuclei. Pion-Nucleus reactions can be very effective in testing the nuclear theories also.

In this present work we proposed a universal approach to calculate the absorption cross-sections for negative pions interacting with target nuclei. For obtaining better fit of the experimental data the values of the parameter σ_0 and α are adjusted by the method of least squares. Pion absorption cross-section is calculated for three groups of targets i.e. light nuclei, intermediate nuclei and heavy nuclei. All the cross-section calculated in the unit of milli-barn (mb).

Formulation

For calculating the absorption cross-section we use the black disc formula based on the Glauber multiple –scattering model [1,7-8] which is given by- $\sigma_{abs} = \sigma_0 A^{\alpha}$………… **(1)**

We modify the above formula by taking log of both sides. Now the above formula becomes-

$\log\sigma_{abs} = \alpha \log A + \log \sigma_0$ .... **(2)**

This is an equation of a straight line, the slop of the line gives the value of the parameter α, while the intercept of the line provides that of the parameter σ_0. We had applied the present approach for positive pion on target nuclei earlier [6].

Tables and Figures

Table 1: Values of Parameters σ_0 and α

E GeV	Target Nuclei	σ_{abs} (mb) Exp.	$\sigma_{abs.}$ (mb) Cal.	σ_0	α
6.65	Li^7	145±3	143.71	35.4	0.72
	Be^9	175±2	172.18		
	C^{12}	211±3	211.83		
	Al^{27}	384±5	379.83		
	Cu^{63}	712±10	699.19		
	Sn^{118}	1113±28	1098.49		
	Pb^{207}	1675±24	1646.26		
	U 238	……..	1820.12		
10.00	Li^7	132±2	132.52	31.4	0.74
	Be^9	162±2	159.62		
	C^{12}	197±3	197.51		
	Al^{27}	360±4	359.91		
	Cu^{63}	708±11	673.75		
	Sn^{118}	1095±22	1071.76		
	Pb^{207}	1675±33	1624.80		
	U238	1933±43	1801.35		
13.30	Li^7	135±2	134.21	32.43	0.73
	Be^9	163±2	161.25		
	C^{12}	200±3	198.92		
	Al^{27}	364±7	359.58		
	Cu^{63}	692±12	667.42		
	Sn^{118}	1069±30	1055.35		
	Pb^{207}	1613±45	1601.76		
	U238	……..	1761.16		
25.00	Li^7	127±3	123.96	29.37	0.74
	Be9	…….	149.27		
	C^{12}	187±4	184.71		
	Al^{27}	342±5	336.58		
	Cu^{63}	641±15	630.08		
	Sn118	…….	1002.30		
	Pb^{207}	1549±20	1519.49		
	U238	…….	1685.00		
40.00	Li^6	120	109.82	29.17	0.74
	Be^9	149	148.25		
	C^{12}	178	183.40		
	Al^{27}	332	334.27		
	Cu^{65}	630	640.32		
	Sn^{120}	1080	1007.85		
	Pb^{208}	1530	1518.25		
	U 239	1580	1678.47		

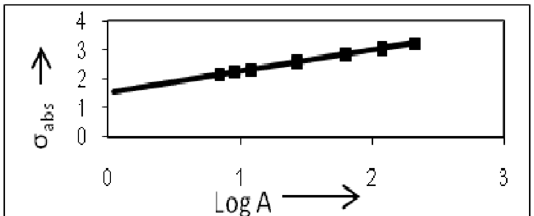

Fig. 1: Variation of σ_{abs} with 'A' at 6.65 GeV

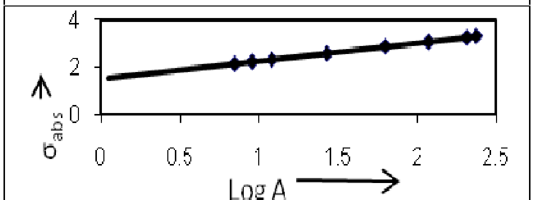

Fig. 2: Variation of σ_{abs} with 'A' at 10 GeV

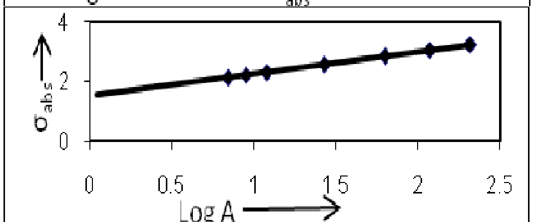

Fig. 3: Variation of σ_{abs} with 'A' at 13.3 GeV

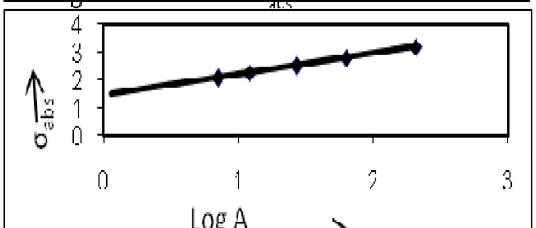

Fig. 4: Variation of σ_{abs} with 'A' a 25 GeV

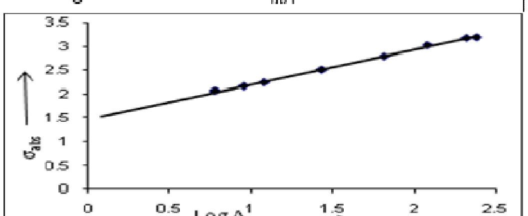

Fig. 5: Variation of σ_{abs} with 'A' at 40 GeV

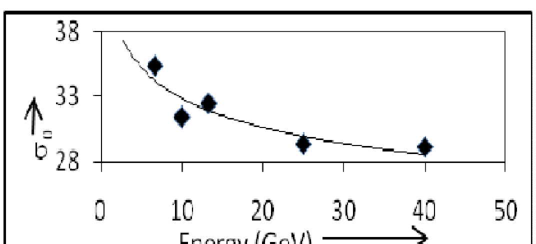

Fig. 6: Variation of σ_0 with Pion Energy

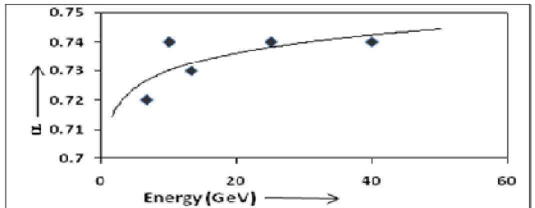

Fig. 7: Variation of α with Pion Energy

Result and Discussion

The results of the present work are presented in the Table-1 and Figs.(1-7). These results are applicable for the entire energy range. In the graph (1- 5) the variation of absoption cross-section with mass number 'A' is shown. From these plots it is clear that the absorption cross-sections of negative pions increases linearly with increasing mass number. While in the graph (6 & 7) the variation of parameters α, σ_0 with pion energy is shown. In the graph (6) the value of paramenter σ_0 decreases according power function with increasing energy of incident poin. In the graph (7) the value of paramenter α increases as the energy of pion increases.

In the present work we conclude that the present parametrezation of the absorption cross-section of pion interections with complex nuclei; minimize the limitations of earlier parameterization. Our approach can be applied to all the nuclei including light, medium and heavy particles over the entire energy range.

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