Nuclear charge-changing cross sections of 158 A GeV ^{208}Pb ions

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Extending former investigations of nuclear dissociation of 158 A GeV ^{208}Pb nuclei at the CERN SPS [1] we have now measured nuclear charge-changing cross sections. We have used carbon, aluminum, copper, tin, gold, and polyethylen (CH_2) targets with thicknesses corresponding to approximately 5% ... 20% charge-changing probability. Energy-deposition spectra of the incoming beam and the fragments produced in the targets were measured event by event with two multiple-sampling ionization chambers upstream and downstream from the targets. Total and partial charge-changing cross sections have been determined with experimental errors of typically $\pm 5 \ldots \pm 10\%$, mainly due to counting statistics and uncertainties in target thickness.

For target nuclei with low atomic number Z_T the nuclear charge-changing cross section is dominated by the hadronic contribution, whereas for heavier targets like Cu, Sn, and Au we observe a strong enhancement of the cross sections caused by the electromagnetic (EM) interaction. Both components can be disentangled due to the very different dependence on Z_T and the measured charge-changing cross sections can be reproduced using basic theoretical approaches which proved reliable at lower energies [3]. The total hadronic cross section was assumed to follow the geometrical prescription of Benesh *et al.* [4]. The total EM interaction cross section was calculated with the help of Weizsäcker-Williams equivalent-photon theory using total photoabsorption cross sections for ^{208}Pb, the same procedure using photonuclear cross sections yields the EM xn-removal cross sections [3]. Using an estimate for the (small) hadronic xn-removal component (which is of the order of 200mbarn), the total charge-changing cross sections are obtained by subtracting total (EM plus hadronic) xn-removal cross sections from the total (EM plus geometric) interaction cross sections. The results are plotted as the full line in figure 1 and agree reasonably well with the measured data.

It is interesting to note that at AGS energies (10.6 A GeV) the total charge changing cross sections for light target nuclei agree well with our data whereas in heavy target materials those cross sections are considerably smaller [5] than ours and can almost exclusively be accounted for by hadronic processes; the EM component leads only to neutron removal. At SPS energies, in contrary, our analysis shows that e. g. for Pb+Au, 13% of the EM cross section leads to a nuclear-charge change.

One particular charge-changing reaction is the nuclear-charge pickup of the Pb beam leading to Bi. As depicted in figure 2 the cross section for Bi production can become as large as 150 mb for Pb+Au. The major part of these cross sections is expected to stem from hadronic processes, similar to what was found near 1 A GeV [6]. The excess cross section for large-Z targets over nuclear-charge pickup measured for Au projectiles at 10.6 A GeV at the BNL AGS [5] indicates, however, that EM processes also contribute at the present energy of 158 A GeV. No theoretical model is available at present which can describe both the EM and hadronic components for charge pickup quantitatively.

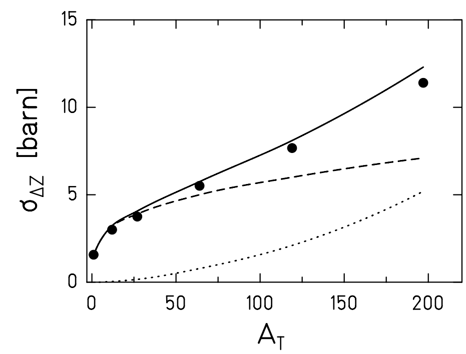

Figure 1: Total nuclear charge-changing cross section of 158 GeV/u Pb projectiles (full symbols) target mass number A_T. Dashed curve: hadronic cross section, dotted curve: electromagnetic contribution, solid curve: sum of both contributions

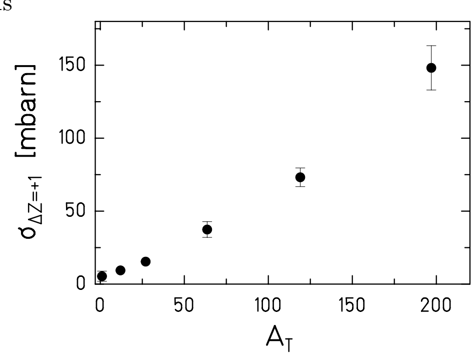

Figure 2: Nuclear-charge pickup cross section for 158 A GeV Pb (full symbols) as a function of the target mass number A_T.

References

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