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A NEW PRECISION METHOD FOR PERFORMING CARBON POLYETHYLENE SUBTRACTION IN HIGH ENERGY SCATTERING EXPERIMENTS

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Very often, information on scattering on free protons has been obtained by comparing scattering from polyethylene and carbon targets rather than using hydrogen targets. The advantages of doing so are many: Simplicity, high hydrogen density (0.14 g/cm^2 as compared to ~ 0.05 g/cm^2 for liquid hydrogen and 10^{-3} g/cm^2 for the hydrogen jet) and good geometry. The main problem in using such a method is in obtaining an accurate normalization of the data collected from poly and C in order to subtract properly the carbon contribution from the poly data. The main uncertainties in such normalization are usually due to: a) obtaining an accurate value for the total effective exposure of the two targets, b) loss of hydrogen from the polyethylene target.

The main problem for point a) is associated in measuring accurately a usually high beam intensity, which entails corrections arising from duty cycle non-uniformity. Such problems affect directly the beam intensity measurement and introduce additional problems in estimating the effective intensity due to the deadtimes in the electronics detecting scattering events.

Point b), although apparently trivially solvable by sample weighing and chemical analysis, also requires knowledge of the time history of the exposure in order to properly account for it. A method which partially reduces some of the difficulties of point a) is to measure instead radioactivity due only to carbon interactions. While this produces in principle a good measurement of the (total exposure) x (number of nuclei) in both targets, it still requires a knowledge of the time history of the exposure. This is due again to deadtime effects which are present in measuring scattering but not in measuring the induced activity. In addition, the induced activity is short-lived. Finally, the method is statistically limited.

During the early stages of an experiment to study inelastic proton-proton scattering by detecting slow recoils, we observed a very copious deuteron and triton production from proton carbon interactions. Since these deuterons and tritons are detected simultaneously with the elastic events, we have a perfect method to obtain the product (effective beam intensity) x (number of carbon nuclei) in poly and C.

Our experiment, as shown in Fig. 1, consists of having the external proton beam (200-400 GeV, ~ 10^{12}) at NAL pass through thin foils (~ 10 mg/cm) of polyethylene and carbon. Twenty telescopes each made of two solid state silicon detectors are located 1 m away from the target at angles between 45° and 90°. The first detector is 500 μ thick and the second is 5000 μ. The two detectors together give a dE/dx - E measurement and thus allow particle identification. Some early results obtained in September 1972 with a few millisecond effective spill are shown in Fig. 2. Four scatter plots are shown for two telescopes and two targets. The vertical axis in each case represents the energy loss in the thin counter, essentially dE/dx and the horizontal is the energy loss in the thick counter, essentially the total energy for particles not crossing the second counter. Points accumulate mostly on the correct correlation curve for protons. Such curve folds back toward smaller energy losses when faster protons completely cross the second detector. Protons up to 32 MeV kinetic energy stop, proton energies up to 100 MeV are measurable. Above the proton correlation curve, points are seen to accumulate in two more bands which indeed correspond to the correlation for deuterons and tritons. Also visible in Figs. 2a, b are the increased density of points along the proton correlation corresponding to elastic p-p scattering from free H_2 in poly. No such increase is observed in carbon. Figure 3 gives the actual measured cross section for the emission of protons, deuterons and tritons at 89° in the lab in 200 GeV proton-carbon interactions. Some relevant comments are: 1. The cross section measured is ~ 1000 times larger than the cross section for production of Be^7 nuclei, used to measure the induced activity. 2. The cross section for such fragments is roughly independent of angle and drops rapidly with lab energy of the fragment. The proposed method has thus the limitation of being usable only for thin targets otherwise absorption correction is necessary. 3. The method is completely independent from problems such as nuclear scattering in the detectors, deadtime corrections, etc. 4. In our particular application, the total nuclear scattering in the targets is of the order of 1%. The difference of such effects

for the two targets used in our experiment is less than 0.1%. 5. More fragments are produced than deuterons and tritons. Figure 3 shows the production of D^2, T^3, He^3, He^4 from 300 GeV p-C interactions. 6. The method described eliminates completely hydrogen-loss problems. It also reduces problems due to chemical impurities. We have performed an experiment using an aluminum target, and although we have not finished the analysis the ratios He^4:He^3:H^3:H^2:p appear very similar to those observed in C.

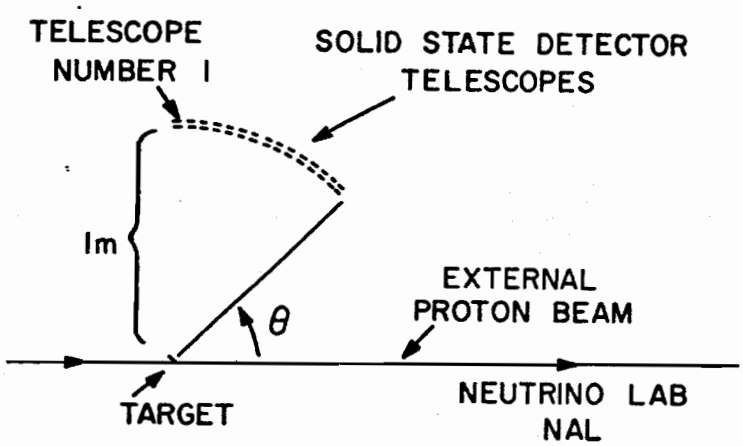

FIG. 1

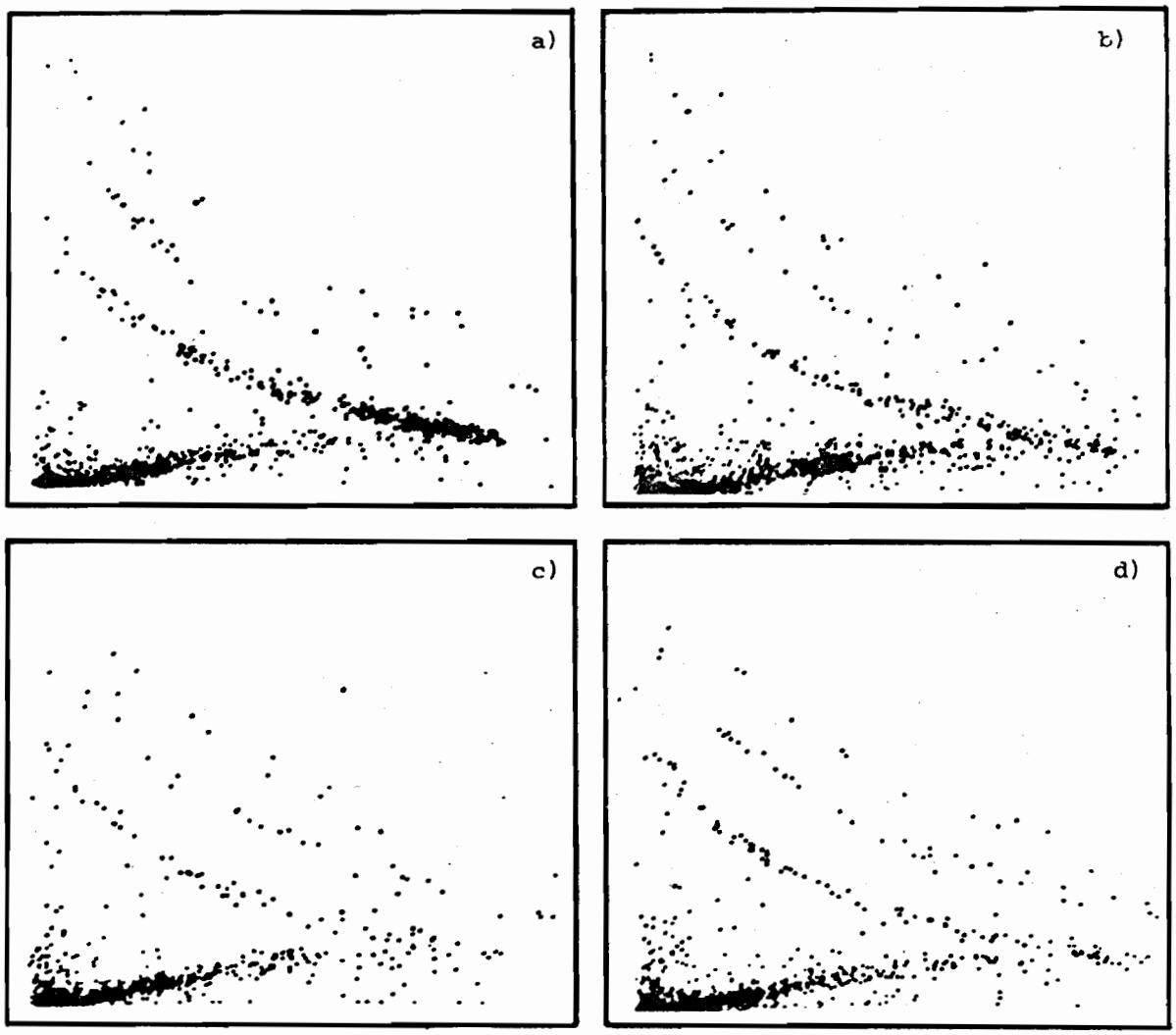

FIG. 2

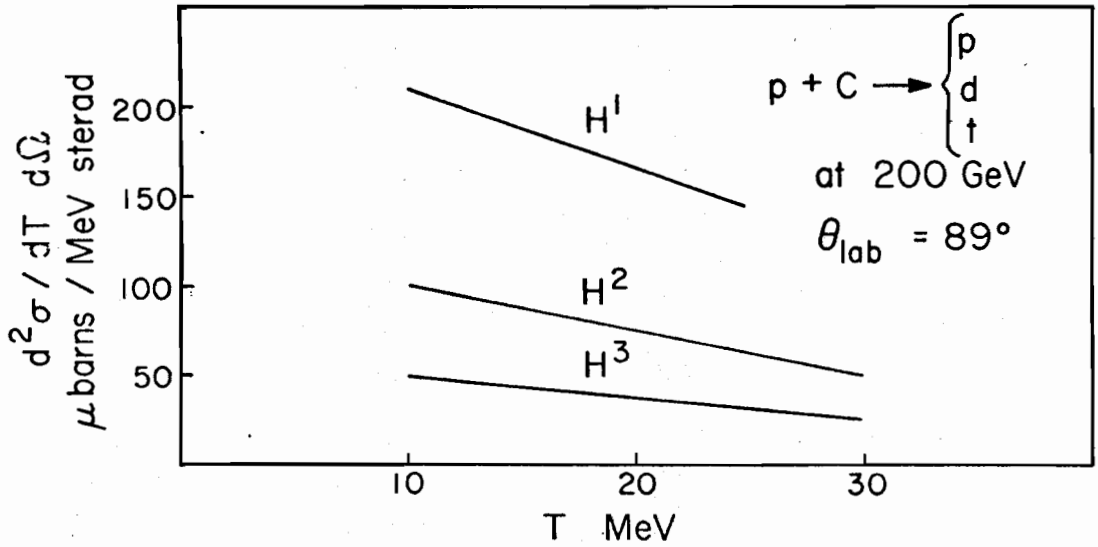
$d^2\sigma / dT\ d\Omega$
μbarns / MeV sterad
200
150
100
50
10
20
30
T MeV
H^1
H^2
H^3
p + C → {p, d, t}
at 200 GeV
θ_{lab} = 89°

FIG. 3

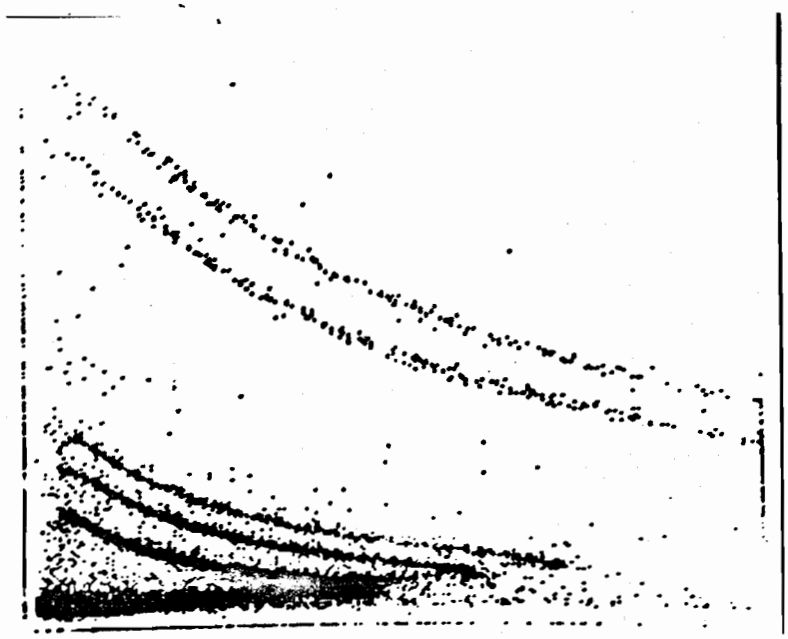

FIG. 4