MEASUREMENT OF THE TOTAL (p,π) CROSS SECTIONS THROUGH RESIDUAL ACTIVITY

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The residual activity measurement of pion production near threshold has centered on the $^{209}Bi(p,\pi^{\circ})$ ^{210}Po reaction with additional efforts at observing the (p,π^{+}) and (p,π^{-}) reactions. Radiochemical procedures for the separation of Bi, Po and At activities have been developed. The residual activity counted in all three pion producing reactions is ^{210}Po, formed directly or from the EC or β^{-} decay of ^{210}At and ^{210}Bi, respectively.

Monoisotopic Bismuth is ideal for a standard measurement of the total (p,π) cross section for a number of reasons. These are: a) Bismuth lacks spectroscopic impurities of higher Z elements (of those higher in Z only Th and U are "stable") and b) the reaction products $^{210}At(\pi^{-})$, $^{210}Po(\pi^{o})$ and $^{210}Bi(\pi^{+})$ are easily separated radiochemically and identified spectroscopically by alpha or gamma-ray counting. Initially we studied Po production from targets of various thicknesses (5, 25, 600 mg/cm^2) at proton energies of 125, 147 and 160 MeV and found substantial secondary isotope production, in particular from the (α,xn) reaction from thick targets.

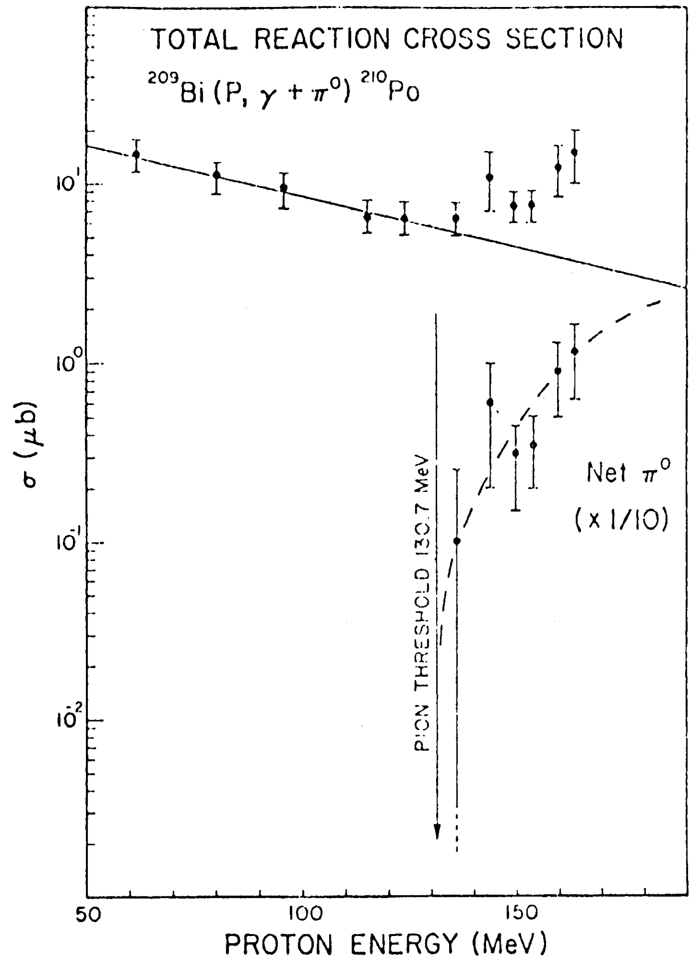

Figure 1. Net neutral pion production from protons on ^{209}Bi at intermediate energies. Below threshold the experimental points represent the proton radiative capture cross section. The net pion cross section with an uncertainty of about 20% was obtained by subtracting the extrapolated (p,γ) contribution.

The results of neutral pion production from protons on Bismuth near threshold are shown in Figure 1. The excitation function was obtained from measurements with proton energies in the range of 60-200 MeV. These results compare well with those obtained earlier by Shaw and Daly[1] in the 65-125 MeV range including one data point above pion threshold at 150 MeV. The uncertainty in our measurement is estimated to be about 30%.

Thick target (≃ 100 mg/cm^2) measurements of the ^{210}Po yields by Daly and Shaw[1] required a substantial reduction (≃ 50%) due to secondary reactions in order to obtain the net $(p,\gamma+\pi^{o})$ contribution. In our measurements we used thin 3-15 mg/cm^2 targets, thus substantially reducing the secondary contributions to less than 0.3 μb near pion threshold.

Results from two measurements at E_p = 183 MeV had indicated substantial ^{210}Po production of the order of 100 μb. However, simultaneous repeat measurements at 150 and 154 MeV also yielded ^{210}Po production rates of about 100 μb. Clearly these results were contaminated and, it is suspected, resulted from ^{210}Po tracer being used just prior to the four above measurements. The contaminations are of the order of 0.1 cps per sample. Aware of the possibility of contamination, subsequent radiochemical measurements at 174 MeV and 197 MeV were made using new glassware and materials. Runs prior to the tracer experiments are not suspected of being contaminated.

This radiochemical experiment is also being conducted at TRIUMF (D'Auria et al.[2]) in the energy range of 183-480 MeV. Results from bombardments at 183, 190, 200, 210, 237, 343, and 480 MeV should become available for comparison with the IUCF results soon. The excitation function in the region above threshold to about 200 MeV is most interesting as the shape can be used to test pion production models.

Yield measurements at 174 and 197 MeV were made by also determining the chemical yields using $\sim$ 1 cps ^{210}Po tracer. The method is simple. Two samples for each energy are irradiated, one is processed for ^{210}Po production and the second sample with tracer is used to determine the chemical yield and the production cross section for ^{208}Po. Subsequent measurements will also include ^{210}At yields with a radiochemical procedure that does not interfere with Po chemistry.

To investigate the $^{209}Bi(p,\pi^-)^{210}At$ reaction we have radiochemically separated Astatine (At) using the di-isopropyl ether extraction technique followed by spontaneous electroplating into Ag metal foils. The samples are then α-and γ-counted to determine the At production rates. Only one run, at 200 MeV, has been made using the new At/Po radiochemical scheme devised at TRIUMF,[2] which measures both Po and At, and determines the chemical yield of Po. Analysis of the decay results are required before we can quote At production rates.

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1) P.J. Daly and P.F.D. Shaw, Nucl. Phys. 56 (1964) 322

2) J.M. D'Auria, P. Jackson, T. Ward, and A. Yavin, Experiment 15, TRIUMF Ann. Rep. 1978.