SYSTEMATICS OF INCLUSIVE CHARGED PARTICLES PRODUCTION WITH MEDIUM ENERGY PROTONS

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The running has been completed on an experiment studying the charged particle spectra resulting from proton bombardment. Proton, deuteron, triton, helium-3 and alpha energy spectra were taken with ^{27}Al, ^{58}Ni, ^{62}Ni, and ^{208}Pb targets at angles ranging from 25^{o} to 150^{o}. Some representative spectra are shown in Figures 1 and 2. Measurements were made primarily at a bombarding energy of 165 MeV, although some data were also taken at 100 MeV.

Most of the spectra show a low energy peak, attributable to evaporation, as well as a distribution of fast particles whose shape varies strongly with angle. The proton evaporation peak is not apparent in the 100 MeV ^{208}Pb data and this is an indication that the average nuclear excitation energy, residual after the fast particles have been emitted, is low enough that the emitted protons cannot traverse the Coulomb barrier. Our 100 MeV data is in satisfactory agreement with that taken at 90 MeV and 100 MeV at Maryland.[1)]

At forward angles the low energy alpha peak from ^{208}Pb, which extends up to about 50 MeV, seems to be complex. At backward angles, the area under this peak is less and the average energy lower. Thus, two components are indicated: an isotropic evaporation peak centered at about 23 MeV and a forward peaked, higher energy component which may be classified as semi-direct. This latter component is not apparent in the alpha spectra from lighter targets.

Calculations have been made using the Monte Carlo code VEGAS[2)] for the preequilibrium phase of the reaction followed by evaporation, calculated using the code DFFMN.[3)] Calculated and experimental values for the evaporation peaks are given in Table 1, where the experimental values are obtained from the low energy peaks in the backward spectra which are assumed to be isotropic. It can be seen that the calculation systematically predicts too high yields for the complex particles, d, t, ^{3}He, α, by factors approaching 10.

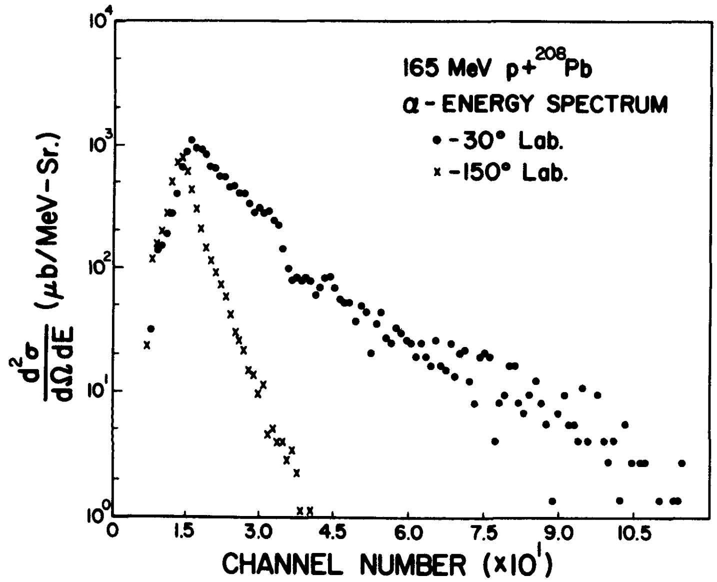

Figure 1.

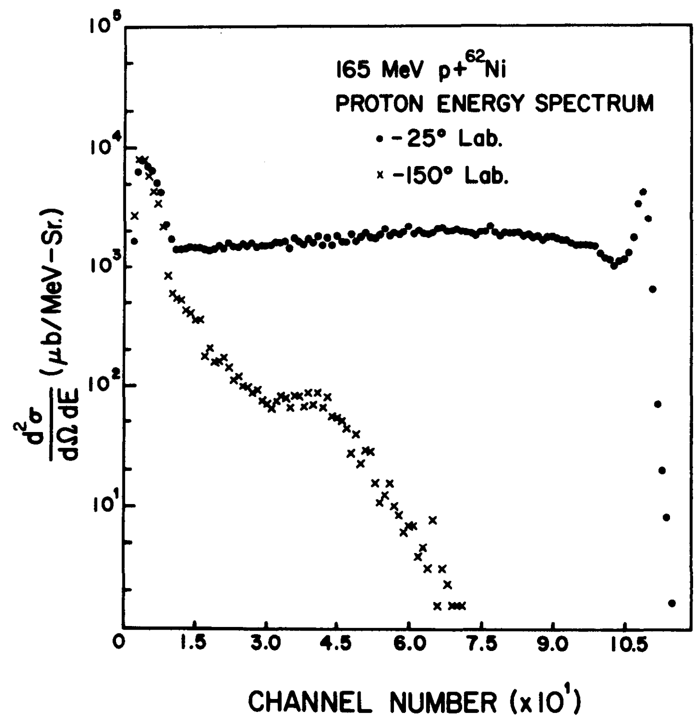

Figure 2.

Table 1.

Ep MeV	TARGET	Protons EXP	Protons CALC	Deuterons EXP	Deuterons CALC	Tritons EXP	Tritons CALC	^3He EXP	^3He CALC	α-particles EXP	α-particles CALC
165	^{27}Al	294	271	34	70	7.1	13.7		15.8		114
165	^{58}Ni	1177	872	52	111	2.5	15.2	8.5	21.5	79	105
165	^{62}Ni	694	664	71	267	15.7	88	4.6	34	84	269
165	^{208}Pb	319	179	56	95	29	38	4.9	1.7	92	61
100	^{62}Ni	425	358	40	98	10.7	26	5.6	8.3	7.8	138
100	^{208}Pb	< 100	74								

Where the yields vary strongly with bombarding energy, as for protons from ^{208}Pb of α's from ^{62}Ni, the calculations predict lesser variations.

For the fast particles, VEGAS only allows for the emission of protons and neutrons. Comparisons between calculation and experiment are more difficult to summarize as here we are dealing with a continuum, whose shape varies with angle. This analysis is not yet complete but it appears that while VEGAS does predict many of the observed trends in the data, there are significant discrepancies.

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2) I. Dustrovsky, Z. Fraenkel, G. Friedlander, Phys. Rev. 116, 683 (1959).

3) J.R. Wu, C.C. Chang, H.D. Holmgren, N.S. Wall, J.P. Didelez, C. Butterfield, Proceedings of 2nd Conference on Clustering Phenomenon in Nuclei, p. 360 (1975).