# The Yields of $^{133}Cs(\gamma, xn)$ and $^{133}Cs(\gamma, 2pxn)$ Reactions with 150, 200 and 250 MeV Bremsstrahlung

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The yields of the reactions $(\gamma, n)$, $(\gamma, 4n)$, $(\gamma, 6n)$, $(\gamma, 2p)$, $(\gamma, 2pn)$, $(\gamma, 2p5n)$, $(\gamma, 2p7n)$, $(\gamma, 2p8n)$, $(\gamma, 2p10n)$ and $(\gamma, 2p11n)$ in $^{133}Cs$ have been determined by the residual activity method in order to investigate the reactivity of high-energy bremsstrahlung photons with nuclei in heavy mass region.

Cesium chloride targets were irradiated by bremsstrahlung with maximum energies of 150, 200 and 250 MeV generated by the linear electron accelerator of Tohoku University. The radioactivity measurements were carried out on both the cesium and iodine fractions after radiochemical separation by using a lithium-drifted germanium detector with a sensitive volume of 36 cc coupled to a TMC 1024-channel pulse-height analyzer.

Of the iodine nuclides measured, $^{123}I$, $^{121}I$ and $^{120}I$ can be formed through decays of the corresponding xenon nuclides generated by $^{133}Cs(\gamma, pxn)$ reactions. In order to reduce such contributions, all irradiations were terminated in 1 hr, and separation was performed very rapidly.

The yield was calculated as the initial disintegration rate of a given radioactive cesium or iodine product. A corresponding saturation rate was computed and expressed relative to that of the $^{133}Cs(\gamma, n)^{132}Cs$ processes. The yield thus obtained are plotted against the difference in mass between the target and product nuclei at each excitation energy in Fig. 1. It can be seen that (1) the yield of cesium nuclides decreases almost exponentially with the number of emitted neutrons, and (2) the more deficient the iodine nuclides in neutron number, the higher their yields, and a yield maximum is found around mass number 123.

The mass number of the center of the stable valley of the nuclear energy surface for iodine ($Z=53$) can be estimated to be 125.[1] Thus the maximum obtained stays at 2 mass unit to the neutron-deficient side. The yield distribution curve shifts 1.5 mass units more towards the neutron-deficient side of the stability line than the photonuclear yield surface in the copper-to-arsenic mass region characterized by Halpern *et al.*[2] The high-energy nuclear reaction mechanism including the initial nucleon cascades and subsequent evaporation steps will be responsible for this behavior. The longer evaporation path will displace the products towards the neutron-deficient side of stability, and thus the fractional yield of heavier iodine nuclides will decrease.

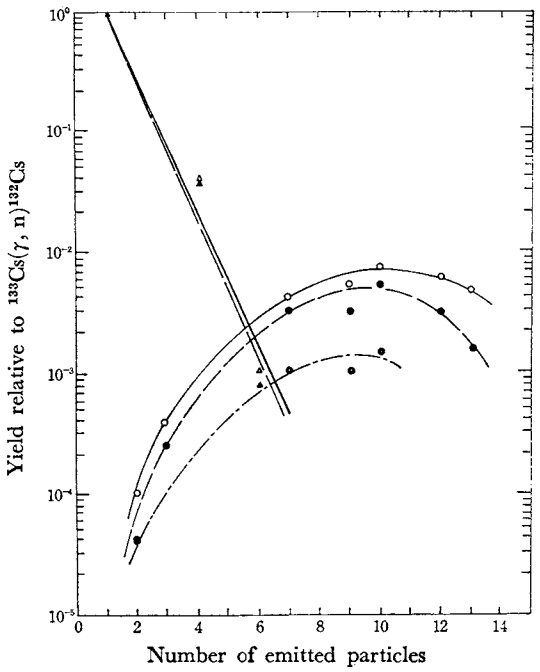


Fig. 1. The relation between yields and the number of emitted particles
△: $(\gamma,xn)$, 250 MeV ○: $(\gamma,2pxn)$, 250 MeV
▲: $(\gamma,xn)$, 200 MeV ●: $(\gamma,2pxn)$, 200 MeV
⊙: $(\gamma,2pxn)$, 150 MeV

The exponential decrease in the $(\gamma, xn)$ reaction yield *versus* the difference in mass between the target and product nuclei has been shown experimentally by photospallation work.[3-5] The yield for the $(\gamma, n)$ reaction of $^{133}Cs$ is much greater than that expected from yield surface considerations. This arises from the large contribution of photons in the giant resonance energy region to the production rate of $^{132}Cs$.

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