Other short-lived photoneutron sources have been investigated (reference C of Table 1). These include F^{20} (12s) + Be, Al^{28} (2.4m) + Be and Cl^{38} (37m) + Be, all of which have greater than 0.1 useful gamma ray per disintegration. (This is to be compared to Na^{24} with one gamma ray of 2.8 Mev per disintegration.) As^{76} (26.8h) + Be and As^{76} (26.8h) + D_2O provide relatively less efficient neutron sources with 0.1 and less than 0.01 useful gamma per disintegration, respectively.

In addition to using gamma radiation from specific radioisotopes the radiation from fission products may be used. Photoneutron yields from U^{235} fission products irradiating heavy water are described by S. Bernstein, W. M. Preston, G. Wolfe, R. E. Slattery in the Physical Review 71: 573 (1947) and also 72: 163 (1947).

Gamma radiation produced in betatron or Van de Graaf accelerators may be used to generate photoneutrons. Yield curves for Van de Graaf gammas on beryllium have been determined by M. L. Wiedenbeck, Phys. Rev. 69: 235 (1946).

1.3 NEUTRON SOURCES USING PARTICLE ACCELERATORS

The deuteron-deuteron reaction, $H^2(H^2,n)He^3$, can be used to produce neutrons. Deuterons, accelerated with any suitable source of electrostatic potential (e.g., Van de Graaf, Cockcroft-Walton, etc.), bombard a heavy ice or heavy paraffin target. Protons are produced at the same time by the reaction $H^2(H^2,p)H^3$, with approximately as many protons produced as neutrons. The $H^2(H^2,n)$ reaction being exothermic with $Q \sim +3.2$ Mev. accounts for fairly good yields at relatively low energies, Figure 3, since it is only necessary for the incident deuteron to penetrate the Coulomb barrier of the target deuteron, no extra energy for excitation being needed. Although the reaction has considerable advantage in yielding a reasonable number of monoenergetic neutrons for relatively low energies the practical impossibility of designing a suitable target limits the use of the reaction as a neutron source. (It must be remembered that practically all the deuterons are not successful in producing neutrons but, rather, generate heat in the target.)

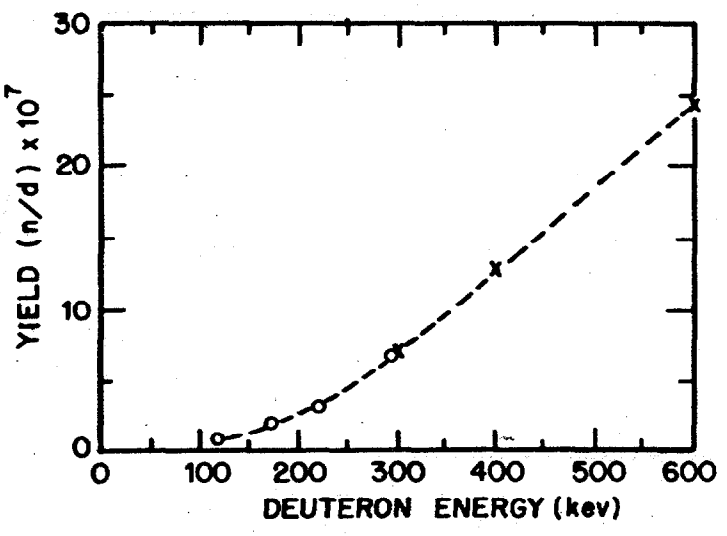

Figure 3

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