PRNC-43 PUERTO RICO NUCLEAR CENTER A SIMPLE DEVICE FOR HALF-LIFE MEASUREMENTS OF HIGH GAMMA RAY EMITTERS ---Page Break--- A Ginpla Device for Half-Life Measurements of High Gamma Rays Emitters! Bandle Orei2, J.P. Facetts, Santiago Pinto N.S. 7. Division work performed at Puerto Rico Nuclear Center, Mayaguez, P. R., under U. S. Atomic Energy Commission Contact AP-(40-1)-1855. May, 1964 ---Page Break--- "aspen, : 1 de Fy Facet, Santiago Pinto Puerto Rico Nuclear Center," National Science and Technology Division Haseaer, ABSTRACT The basic principle involved is the integration of deuterium by high energy gamma photons to produce fast neutrons, which are moderated by 15 optimal thermal masses of paraffin to achieve the best balance between moderation and capture. The moderated neutrons are detected by a counter. The counter consists of polyethylene bottles with a 2s diameter with B,0. The outer bottle has a diameter of 12.4 cm, the inner bottle is filled with paraffin and has a 1.8 cm hole critical to locate a BF counter. The resultant isotopes of Me™, 97, cat, MoM, AsT®, and Poston products from the PRM fuel elements have been measured. Presently Collaborating with the University of Puerto Rico for the Atomic Energy ---Page Break--- The results of other workers (*+7,3,4,5,8) with neutrons produced from the photointegration of deuterium indicate the possibility of studying some nuclear reactions, using a neutron source. For this, it is of interest to develop a simple neutron conversion device, which contributes to the cross section of the (y,n) reaction. In both cases, the incoming gamma ray interacts with only the proton. Fig. 1 shows the cross section for the disintegration of D by electric dipole absorption. The maximum cross section of 2.23 barns occurs at E= NG MeV. Monoenergetic rays produce a non-energetic group of neutrons. It can be seen that the energy (in MeV) of the emitted neutrons from a deuterium target is approximately equal to: a surf, - 9 {of the shared energy (in MeV) for the (γ,n) reaction, where, 2 and

8, it the photon energy up to 10 MeV. Since for 10D (D,γ) H reaction, § = 2.23 MeV, a rough estimate of the photoneutron energy in terms of the energy of the γ rays emitted from various radioisotopes can be obtained from eq. (1). Although most of the yields from 9 (n, p) have been obtained, these will change with the geometry and distance of the source from the detector. 1. B. Bell and G. Aitken, Phys. Rev. 79, 280 (1950) 2. R. Mobley and R. Laubenstein, Phys. Rev. 89, 509 (1950) 3. R. Shore, J. Heptner and A. Mann, Phys. Rev. B, 387 (1952) 4. W. Seaberg, Phys. Rev. 71, 497 (1947) 5. S. Russell, D. Sachs, A. Tittenters and R. Fields, Phys. Rev. 75, 545 (1958) 6. B. Beretain, M.S. Preston, G. 1? and R. Slattery, Phys. Rev. 71, 545 (1947) ---Page Break--- A. DESIGN OF THRESHOLD DETECTOR: Since neutrons coming from the photodisintegration of D have energies of the order of a fraction of a MeV, it is necessary to thermalize them prior to their detection with a BF_3 counter. An experiment was performed to estimate the optimum thickness of paraffin required for maximum number of neutrons detected. Fig. 2 shows a diagram of the experimental setup. Fig. 3 shows the experimental results and it was concluded that a maximum count rate was obtained with a paraffin thickness of about 7 cm. Using a thickness of 5.5 cm, a good balance between moderation and capture was achieved. Fig. 4 shows the details of construction of the threshold detector. It is made of two concentric polyethylene bottles with a 2m gap filled with D_2O. The outer bottle has a diameter of 12 cm. The inner bottle is filled with paraffin and a 1.8 cm hole drilled at the center to locate a BF_3 counter. 3. IRRADIATIONS: The γ-ray emitting isotopes were activated in the PANG reactor operated at the power level of 1 MW and at a flux of 2×10^{12} n/cm^2 sec. Either the swimming pool or the pneumatic system facilities were used. The activities obtained were up to 0.5 µCi. MATERIALS: The irradiated materials were analytical or reagent grade Na_2CO_3, Ye power, 080, §,

A,0,, Ss ant UD_(10,), .6H0. D. COUNTING PROCEDURES: Depending upon the source, each experiment was performed as follows: Determination of the background in the absence of the source. 2+ Determination of any contamination in the BF counter due to the γ radiation. It was noticed that at 1507. ---Page Break --- above the plateau, γ-rays affected the counter. 3. A system similar to the threshold detector, Tout without »,0 was placed near the source. If the source was not lesion products, the count rate due to photodisintegration in paraffin was negligible. If the gamma source was the £4 on products, waiting time was required for the decay of the delayed neutrons. RESULTS AND DISCUSSION Significant response of the detector to γ rays indicates that such photons are above the threshold of 2.23 MeV. In such a case, the detector can be used to measure accurately half-lives of individual or mixtures of γ emitters. Furthermore, this technique permits the investigation of new high energy γ rays. 8) He®* and Mn; The decay rate of these radionuclides was measured together. Both sources were placed in such a way that each radionuclide contributed to about the Fig. (5) shows the decay curve resolved into its components. The half-lives measured, 15 hr. for Na®* and 2.58 hr. for Mn agreed with those measured by standard procedures(7),) cat®: Mais tsocope was chosen to confirm the existence of the high energy γ ray recently reported'®) Fig. (6) shows the 7. D. Struminger, J. M. Hollender and G. 7. Sesborg. Rev. of Mod. Phys., 30, 585 (2958) 8. G. D. O'Keltey, N. H. Lazer, and Z. Sichler Phys. Rev. 101, 1059 (2996). ---Page Break --- decay curve. The half-life of 6.8 cm measured, agreed with that obtained by standard procedures. e) Ag'': Three γ rays over 2.25 MeV are observed. The time of irradiation was 4 hr, and the amount 1.5 g. The count rate was followed for 72 hr. Fig. (7) shows the decay curve; ok with that reported(?) 4) ST: A single experiment was performed irradiating sulfur. Since the sync session and the detector.

concentration of S are very low, the count rate after 95 min. irradiation was also low. Fig. (8) shows the decay curve of 5.2 min. measured, agreed with other reported data. Several irradiations were performed, using up to 10 g. of natural Se. No evidence was found of the existence of the gamma ray of 2.29 MeV. Three experiments were performed to study the fission products decay rate: With the reactor shut down, a survey was done with the detector in the pool to find a position where the background was about 109 c/min, then a fuel element from the reactor was placed at about 2 ft. from the detector. Fig. 9 shows the gross activity. R. Ghrats, R.A. Riced and R.V. Lieshart, Fuel. Phys. 25, 462 (1959) J. G. Snot and Y.C. Young, Much. Se, and ang. 5, 55 (1959) A.L. RG, Cochran and W. it, React. Phys. Rev. 115, 952 (1959) ---Page Break--- activity and the four components resolved from the curve. The half-lives of these components were 3 hr. 8 min. 6 hr. and 27 min. One gram of uranyl nitrate was irradiated for 1 min. Measurements were made 2 min. after irradiation so that the decay of the delayed neutrons would be negligible with respect to the longer-lived photoneutrons. Fig. 10 shows the gross activity and the three components resolved from the curve. The half-lives of these components were 27.5 min., 7.5 min., and 2.25 min. This experiment confirmed the existence of 27 min. activity and showed another activity much shorter than 2.25 min. The shorter ones were difficult to resolve because of the presence of delayed neutrons. To assign a nuclide to each measured half-life, the following characteristics of fission products were considered: Half-lives taken from the references were compared. Wi, Seelmann - Eggebrecht et al. - Taktik der Ait Strahlenschutz <2 Auflage -Richtlinien (1951) J. Bloneke and M. Tota = Om 2127 (1957) GM. iron: Atomic Energy set (Stated by %. 6. Tueckmur) 3-97 = Ba Jervorthe (1962) ---Page Break--- The radioisotopes with gamma rays over 2.25 MeV were chosen: In some cases, comprehensive data of

characteristics of the radioisotope Se not yet available show us slides with total disintegration energy over 2.23 MeV some chosen 4. The session yield of the isotope was also taken into account! 1.3 min: No quality with this half-life was reported. However, 7° and Xe8® with 7 1 2.25 MeV are known'*?), it can be assumed that these nuclides 9 and 2.8 stn., and gamma rays are measured together with other of shorter half-lives. It should be kept in mind that this half-life was difficult to resolve, due to the delayed neutrons activity. 1/2 + 7.5 min: It agrees with that reported for Sr and Ra®?, However, for these isotopes, gamma rays over 2.23 MeV are luminous. On the other hand, the total disintegration energy of these are 5.25 MeV and 4.16 MeV. D1/2 = 27.5 min: This can be attributed to a mixture of Ca9? (52 min.) and Y* (20 min.) Tie = 16 min: Also to a mixture of Kr®? and La? D1/2 = Mk hr.: This agreed with those reported for RaS and Sv, However, they have no gamma rays over 2.23 MeV reported. Pi/e +54 nr. The only radioisotope with high gamma ray over 2.23 MeV, and with half-life in the neighborhood of 5h hr., 40 min, with T1/2 +40 hr. The 5h hr. measured half-life can be 1B. A. G. Cameron, A revised semi-empirical Atomic Mass formula- CORP 690 (1958). ---Page Break--- explained for this isotope, only on the basis of an equilibrium with BeM° in the fission chain. In such a case, however, the La14? activity obtained in fission would be 5 times greater than that for 340mm, which is not easy to accept. Therefore, this half-life should be attributed to a new fission product, with gamma over 2.23 MeV, or an equilibrium with a daughter of these characteristics. Acknowledgment- The authors wish to thank Mr. E. Barcelo and his staff for the irradiations and assistance in the Reactor Building. ---Page Break--- IN MILIBARNES Fig. 1 4 = 1 ® 16 PHOTON ENERGY (MeV.) Photoelectric cross section of the deuteron. ---Page Break--- ---Page Break--- 3009} 8 ACTIVITY (e/m) Fig. 3 2 4 6 8 10 14 16 18 20 82 THICKNESS OF PARAFFIN (Cm.) Neutron attenuation

curve for obtaining the maximum paraffin thickness. ---Page Break--- THRESHOLD DETECTOR be asem a! am S aa NEUTRON DETECTOR 2.0 (3.04 THICKNESS POLYTHYLENE: ‘CONTAINER bh 2408 4 Fig. 4 Schematic Diagram of the detector, ---Page Break--- server oA Me. 5 “yee ‘TME “revs ‘Typical decay curve of Na** and Yn®. ---Page Break--- ACTIVITY (e/m) TIME (min) Fig. 6 Decay curve of CaT® ---Page Break--- activity (6/10 Pte. 7 TIME now Decay curve of AsT®. 28 ---Page Break--- ---Page Break--- ---Page Break--- activity (erm) Fig. 10 © % 36 3 TIME (min) Decay of the 1 min. exposure of U0_(WO,) 68_0.- Curve T: total activity: IT: extrapolated activity of T 1/2 = 27.7 ain.; ITT: extrapolated activity of T 1/2 = 7.8 ain; curve IV: activity of 2.3 min. ---Page Break---