LA-UR- 96-3452

CONF-970134--11

Title:

NEUTRON CHARGED PARTICLE REACTIONS IN CR-39
CALCULATED USING MCNP AND LAHET

RECEIVED

OCT 30 1996

OSTI

Author(s):

Hsiao-Hua Hsu, ESH-4
Robert T. Devine, ESH-4

MASTER

Submitted to:

30th Midyear Topical Meeting, Health Physics Society
Health Physics of Radiation Generating Machines
January 5-8, 1997 San Jose, CA

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

lm

Los Alamos
NATIONAL LABORATORY

Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by the University of California for the U.S. Department of Energy under contract W-7405-ENG-36. By acceptance of this article, the publisher recognizes that the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes. The Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy.

Form No. 836 R5
ST 2629 10/91

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

**Portions of this document may be illegible
in electronic image products. Images are
produced from the best available original
document.**

Neutron-Charged-Particle Reactions in CR-39

Calculated Using MCNP and LAHET

Hsiao-Hua Hsu and Robert T. Devine

Health Physics Measurements Group (ESH-4)

MS G761

Los Alamos National Laboratory

Los Alamos, New Mexico

Abstract

We have calculated the response of CR-39 (polyallyl-diglycol carbonate) in terms of charged particles produced per-unit-incident neutron for a foil of 2-cm diameter and 0.15-cm thick. We also calculated another set, using cylindrical slugs of lead of 2-cm diameter and 1-cm and 2-cm thick, with the foil positioned on the end of the slug so that the neutron beam had to pass through the lead. MCNP was used to calculate the responses in all three cases for energies from 0.1 MeV to 20 MeV. LEHET was applied to calculations from 0.1 MeV to 1000 MeV. The MCNP calculation yields $H(n,p)$, $C(m,\alpha)$, and $O(n,\alpha)$ reactions; the LAHET computation produces the sum of proton recoil and deuteron, triton, and alpha-particle production. The LAHET calculation indicates that the enhanced response due to $Pb(n,xn)$ production may prove useful in neutron spectroscopy.

Introduction

A problem in using Bonner spheres for the spectroscopy of neutron of energy greater than 20 MeV is that the response functions for differing polyethylene thicknesses become similar in shape, making the spectral unfolding quite difficult. The possibility that use of a neutron detector such as CR-39 that is sensitive to high-energy neutrons combined with a lead radiator that has a significant variation of cross section due to the $\text{Pb}(n,xn)$ reaction above 20 MeV, led to the theoretical investigation of the response of a CR-39 detector with lead in front of it.

Model

The response of CR-39 in terms of charged particles produced per-unit-incident neutron is calculated for a foil of 2-cm diameter and 0.15-cm thick. Another set of calculations were done using cylindrical slugs of lead of 2-cm diameter and 1-cm and 2-cm thick, with the foil positioned on the end of the slug so that the neutron beam had to pass through the lead. While this is not equivalent to a Bonner Sphere arrangement, it is close enough to make a test of the hypothetical response.

Method

Two transport code systems were used in this calculation: MCNP (Briesmeister 1988) and LAHET (Prael and Lichtenstein 1989). MCNP was used to calculate input energies from 0.1 MeV to 20 MeV. In the computation of input energies from 20 MeV to 1 GeV, LAHET was used

coupled to MCNP. We calculated the number of charged particle reactions per neutron selected from a uniform energy distribution in each energy bin. The output depends on which code was used to do the calculation: the MCNP calculation yielded the H(n,p), C(n,a), and O(n,a) reactions; the LAHET computation produced proton recoil and deuteron, triton, ^3He , and alpha-particle reactions as well as π^+ , π^0 , and π^- reactions.

Results

Results are expressed as the total number of reactions of a given type per incident neutron. The uncertainties of the proton and alpha results are less than 5%; deuteron, triton, and ^3He uncertainties are up to 25%; pion results are good to within 50% and are given merely to show the order of magnitude of competing processes and the energies at which they become significant. In Fig. 1, we show the effect of inserting differing amounts of lead in the beam on the number of proton reaction. Similarly, in Fig. 2, we present the effect on the number of alpha reactions. The next three figures show reactions with no lead, 1 cm of lead, and 2 cm of lead for all the reactions except pions. Table 1 gives pion production per-unit-incident neutron.

Lead (cm) particle	0			1			2		
	π^+	π^0	π^-	π^+	π^0	π^-	π^+	π^0	π^-
251-398 MeV	1.0D-5	2.5D-5	1.5D-5	1.5D-5	2.5D-5	1.0D-5	1.0D-5	1.5D-5	1.5D-5
398-631 MeV	7.0D-5	1.4D-4	1.9D-4	6.0D-5	1.3D-4	1.8D-4	3.9D-5	1.3D-4	1.6D-4
631-1000 MeV	1.8D-4	3.7D-4	5.3D-4	1.7D-4	3.6D-4	5.2D-4	1.3D-4	4.3D-4	5.0D-4

Table 1. Pion reaction per neutron

Discussion

Track-etch detectors are used as dosimeters to detect alpha particles and proton recoils from neutrons. There is sufficient evidence from the data presented in this paper to justify experimentation using these detectors at high energies. Exposure to a neutron spectrum with peak at 100 MeV should yield a significant difference among the three thicknesses of lead. The major difficulty in applying track-etch detectors at high energies will be in the determination of the energy response and the large angular dependence.

References

- Briesmeister, J.F MCNP—A general Monte Carlo N-Particle Transport Code (Version 4A). Los Alamos National Laboratory Report LA-12625; 1988.
- Prael, R. E.; Lichtenstein, H. User's guide to LCS: the LAHET code system. Los Alamos National Laboratory Report LA-UR-89-3014; 1989.

Fig. 1. Proton response of PN3 for differing lead thicknesses

Fig. 2. Alpha response of PN3 for differing lead thicknesses

Fig. 3. Response of PN3 with no lead in beam

Fig. 4. Response of PN3 with 1-cm lead in beam

Fig. 5. Response of PN3 with 2-cm lead in beam