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1954

# ORNL SUMMER SHIELDING SESSION

GALE YOUNG, Leader

## COLLECTION OF DATA FOR SHIELDING

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ORNL SUMMER SHIELDING SESSION

Gale Young, Leader

# COLLECTION OF DATA FOR SHIELDING

F. Friedman and H. Feshbach

Date Issued OCT 19 1949

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This report is one of a series on shielding and represents part of the work of a summer group working principally at Oak Ridge National Laboratory. Participants are drawn from Nuclear Development Associates (Navy contract), NEPA, Bureau of Ships and Bureau of Aeronautics (Navy Department), AEC, RAND, General Electric, Argonne and Oak Ridge National Laboratory.

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| E/Mev (Bombarding Energy) | 0.2 | | 0.6 | | | 1.5 | | | | 3.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\sigma_i$ | $\sigma_r$ | $\sigma_i$ | | $\sigma_r$ | $\sigma_i$ | | | | $\sigma_i$/barns | | |
| $\mathcal{E}$/Mev (Threshold Energy) | | | .16 | .35 | | .5 | .75 | 1.0 | 1.2 | .75 | 1.3 | 2.25 |
| U | 0-.75 | .15-.18 | 0 | 0.4 | 0.13 | 1.6 | 2.0 | 2.1 | 2.1 | 1.9 | 2.5 | 2.7 |
| $U^{235}$ | 0.7 ($\mathcal{E}$=.1) | | 0.8 | 1.1 | | 1.3 | 1.7 | | | 1.8 | 1.8 | 1.8 |
| Pb | 0 | 0 | 0 | 0 | 0 | 0 | | 0.4 | | .7 | 1.2 | 1.6 |
| Au | 0 | .41 | | | | | | | | 2.1* | 2.8* | 3.0* |
| W | 0-.6 | .10-.14 | 0 | 0.7 | | .9 | | 2.1 | | 1.4 | 2.4 | 2.8 |
| Ta | Estim. from La-83 | | | | | 1.4* | 2.0* | | 2.7* | | | |
| Cu | | .05 | | | | 0.3* | 0.6* | | 0.9* | .6* | 1.3* | 1.5* |
| Ni | | | | | | 0 | 0.1* | | 0.6* | | | |
| Co | | .04 | | | | 0 | 0.2* | | 0.8* | | | |
| Fe | 0 | 0 | 0 | 0 | | 0 | | 0.6 | | .3 | .7 | 1.1 |
| Al | | | | | | 0 | 0 | 0 | 0 | | | |
| C | | | 0 | 0 | | 0 | | 0 | | | | |
| $B^{11}$ | | | 0 | 0 | | 0 | 0 | 0 | 0 | | | |
| $B^{10}$ | | | 0 | 0 | | 0 | 0 | 0 | 0 | | | |
| Be | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| WC | | .10-.14 | 0 | 0.7 | | .9 | | 2.1 | | 1.4 | 2.4 | 2.8 |
| BeO | | | 0 | 0 | 0 | 0 | | 0 | | | | |

* Not corrected for multiple scattering.

| $\sigma_{tr}$ | | | | |
|---|---|---|---|---|
| | 0.2 Mev | 0.6 Mev | 1.5 Mev | 3.0 Mev |
| Be | | 3.4 | 1.4 | |
| B | | | | |
| $B^{10}$ | | 3.9* | 2.1* | |
| $B^{11}$ | | 2.1 | 2.2 | |
| C | | 2.8<br>2.5** | 1.8<br>1.8** | 1.7** |
| BeO | | 5.0<br>5.2** | 3.6<br>3.1** | 2.7** |
| Al | | 3.0<br>3.1** | 1.7 | 1.4<br>1.5** |
| Fe | 3.0 | 2.0<br>1.8** | 2.2<br>2.2** | 2.0<br>2.2** |
| W | 6.0 | 4.7<br>4.6** | 4.7<br>4.0** | 3.8<br>3.6** |
| Au | 6.4 | | | 3.7 |
| Pb | 7.0 | | | 4.1<br>3.6** |
| Cu | | 3.5** | 2.2** | 2.1** |
| Co | | 3.4** | 2.2** | 2.1** |
| Pb | | 4.4<br>4.4** | 3.4<br>3.1** | |
| Ni | | | 2.3** | |
| Ta | | | 3.9** | |

* Includes Absorption
** Not corrected for multiple scattering.

Li+D deuterons

Amaldi et al. Nuovo Cimento 3, 203, 1946

| | $\sigma_{total}$ | $\sigma_{total}$ (Sherr) |
|---|---|---|
| Be | .16±.04 b | |
| B | 1.16±.13 | |
| C | 1.23±.02 | 1.29 |
| O | | 1.60 |
| Mg | 1.83±.10 | |
| Al | 1.92±.09 | 1.85 |
| S | 1.58±.10 | |
| Cl | | 1.88 |
| Fe | 2.75±.09 | |
| Ni | 2.62±.09 | |
| Cu | 2.86±.15 | 2.50 |
| Zn | 3.03±.17 | |
| Se | 3.35±.2 | |
| Ag | 3.82±.13 | 3.70 |
| Cd | 4.25±.13 | |
| Sn | 4.52±.14 | |
| Sb | 4.35±.15 | |
| Au | 4.68±.9 | |
| Hg | 5.64±.24 | 5.25 |
| Pb | 5.05±.15 | |
| Bi | 5.17±.17 | |

Cu(n,2n) detectors - Threshold 11 Mev

| | $\sigma_{inelastic}$ |
|---|---|
| Al | .99 ± .04 b |
| Fe | 1.43 ± .05 |
| Hg | 2.47 ± .12 |
| Pb | 2.22 ± .05 |

## ($H^3$ + D) neutrons (14.5 Mev)

Gittings, Barschall, Everhart, P.R., May 15, 1949
LAMS-663, 1947

| | | | |
|---|---|---|---|
| Threshold detectors: | Cu(n,2n)Cu | Threshold | 11 Mev |
| | Al(n,p)Mg | " | 3 Mev |

| Detector | $\sigma_{inelastic}$ Cu | Al |
|---|---|---|
| Pb | 2.29 b | 2.20 b |
| U | 1.65 b | |

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## D-D neutrons (2.5 Mev)

H. H. Barschall and R. Ladenburg. P.R. 61, 129, 1942

Recoil detector.

Neutron energy 2.5 Mev

$4\pi 10^{24} \times \sigma$

| | $\theta = 100 \pm 20^\circ$ $\sigma_{elastic}$ | $45 \pm 10^\circ$ | $\sigma_{total}$ |
|---|---|---|---|
| C | 1.2 ± .2 | | 1.6 ± .3 |
| Al | 1.1 ± .2 | 3.4 ± .5 | 2.4 ± .3 |
| Fe | .6 ± .15 | 1.7 ± .3 | 3.1 ± .3 |
| Cu | .38 ± .1 | 1.4 ± .3 | 2.7 ± .3 |
| Zn | .68 ± .2 | 1.7 ± .3 | 3.0 ± .3 |
| Pb | 2.5 ± .4 | 5 ± .6 | 6.0 ± .7 |

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