

Lawrence Berkeley National Laboratory

Recent Work

Title

ANGULAR DISTRIBUTION OF FRAGMENTS FROM FISSION OF AU197 WITH CARBON IONS

Permalink

<https://escholarship.org/uc/item/0rg517pf>

Authors

Gordon, Glen E.

Larsh, Almon E.

Sikkeland, Torbjorn.

Publication Date

1959-12-01

UNIVERSITY OF
CALIFORNIA

Ernest O. Lawrence

*Radiation
Laboratory*

TWO-WEEK LOAN COPY

*This is a Library Circulating Copy
which may be borrowed for two weeks.
For a personal retention copy, call
Tech. Info. Division, Ext. 5545*

BERKELEY, CALIFORNIA

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal 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 its 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, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

" For Pub. Phys. Rev " ~~FOR PHYS. REV. COLLECT. XX~~

UNIVERSITY OF CALIFORNIA
Lawrence Radiation Laboratory
Berkeley, California
Contract No. W-7405-eng-48

ANGULAR DISTRIBUTION OF FRAGMENTS FROM
FISSION OF Au¹⁹⁷ WITH CARBON IONS

Glen E. Gordon, Almon E. Larsh, and Torbjørn Sikkeland

December, 1959

ANGULAR DISTRIBUTION OF FRAGMENTS FROM
FISSION OF Au¹⁹⁷ WITH CARBON IONS*

Glen E. Gordon, Almon E. Larsh, and Torbjørn Sikkeland

Lawrence Radiation Laboratory
University of California
Berkeley, California

January 1960

ABSTRACT

The kinetic energy and angular distribution of fragments from fission of Au¹⁹⁷ with 123- and 93-Mev carbon ions have been determined by observation of the fragments in gas scintillation and solid-state detectors. Between 20 deg and 160 deg in the center-of-mass system, both angular distributions lie slightly above a $1/\sin \theta$ curve, falling below it beyond those angles. The anisotropies $[\sigma(0^\circ)/\sigma(90^\circ)]$ are 4.7 and 3.8 for 123- and 93-Mev carbon ions, respectively. The most probable fragment kinetic energies in the center-of-mass system are 73 ± 3 Mev and 71 ± 3 Mev.

*This work was performed under the auspices of the U. S. Atomic Energy Commission.

ANGULAR DISTRIBUTION OF FRAGMENTS FROM
FISSION OF Au¹⁹⁷ WITH CARBON IONS*

Glen E. Gordon, Almon E. Larsh, and Torbjørn Sikkeland

Lawrence Radiation Laboratory
University of California
Berkeley, California

December, 1959

The kinetic energy and angular distribution of fragments from fission of Au¹⁹⁷ with 123- and 93-Mev C¹² ions have been determined by observation of the fragments in gas scintillation and solid-state detectors.

The fragments entered the scintillation chamber through a 1/4-in.-diam. window of 0.03-mil Ni foil supported against the vacuum by a 49%-transmission grid. The scintillating gas was argon which flowed through the chamber at 1 atmosphere. The chamber walls were coated with Tygon paint (reflector) and diphenyl stilbene (wave-length shifter). The face of the DuMont 6292 photomultiplier tube was also coated with diphenyl stilbene. Pulses from the photomultiplier tube were amplified before being analyzed by a Penco pulse height analyzer.

The energy scale was calibrated with a Cf²⁵² spontaneous-fission source. The values of the kinetic energies of the peaks of that spectrum were taken from the data of Fraser and Milton.¹ Corrections for energy loss of the fragments in passing through the window were made with the help of Fulmer's fragment range-energy data.²

The targets were 100 to 200 $\mu\text{g}/\text{cm}^2$ of Au vaporized onto 0.1-mil Al backing foil. Corrections for energy loss in the target material were made empirically by bombarding a series of targets of various thicknesses and extrapolating the energy to zero thickness.

*This work was supported by the U.S. Atomic Energy Commission.

The solid-state detector consisted of a p-n junction produced by diffusion of n-type impurity into one face of a p-type Si wafer. Charged particles passing through the depletion layer create electrons and holes. These are collected and the pulses are amplified and recorded as described above. The junction was reverse-biased by a 9-v potential. Under this condition, the edge of the depletion layer extended to $\sim 1.25\mu$ below the surface of the detector and had a total thickness of $\sim 30\mu$. The resolution and stability of the solid-state counter were much better than for the gas scintillation chamber. It should be possible to produce a solid-state detector in which the depletion layer extends to the surface.

The data were analyzed by assuming that the most probable kinetic energy represents the kinetic energy per fragment when symmetric division occurs. The plot of kinetic energy as a function of laboratory angle was fitted to calculated curves to obtain the values of the most probable kinetic energy per fragment in the center-of-mass system, and the ratio

$$\eta = v/V$$

where v is the velocity of the compound nucleus in the direction of the beam, and V is the velocity of the fragment in the moving system.

The analysis yields η values of 0.223 ± 0.01 and 0.190 ± 0.01 , and $E_K(\text{c.m.})$ values of 73 ± 3 Mev and 71 ± 3 Mev for 123- and 93-Mev bombardments, respectively. These η values were used to transform the laboratory angular distributions (Fig. 1) into the center-of-mass system (Fig. 2). Within experimental error, the η values represent full momentum transfer by the bombarding particle to the fissioning nucleus.

The following details of the results should be noted:

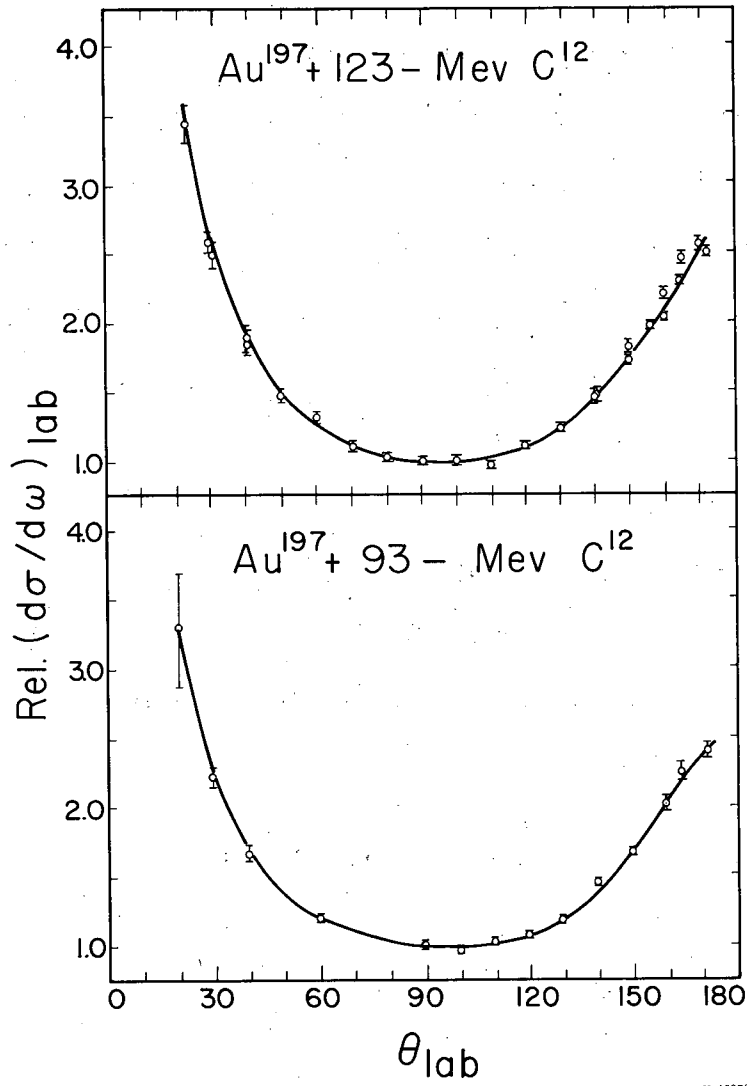
- (a) The center-of-mass angular distributions are symmetric about 90 deg, within experimental error.
- (b) Between 15 deg and 165 deg on the 123-Mev curve, the points lie somewhat above $1/\sin\theta$, in fair agreement with Griffin's predictions.³
- (c) The shape of the 93-Mev angular distribution near 0 deg and 180 deg is in better agreement with the predictions of Halpern and Strutinski⁴ than with those of Griffin.

Preliminary results with 160-Mev O^{16} on Au^{197} confirm the results of Quinton, Britt, Knox, and Anderson.⁵

The authors gratefully acknowledge the assistance of William Hansen, who prepared the solid-state detector, and of Albert Ghiorso, who made many helpful suggestions.

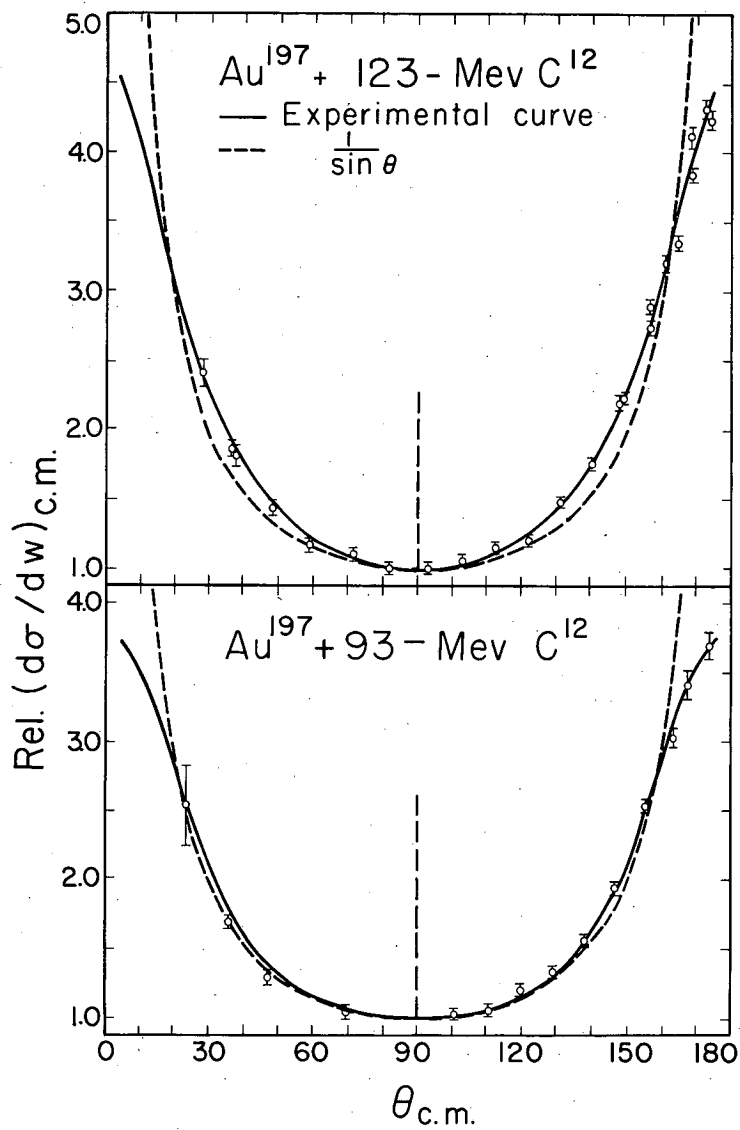
REFERENCES

1. J. S. Fraser and J. C. D. Milton, Proceedings of the Second International Conference on the Peaceful Uses of Atomic Energy (United Nations, Geneva, 1958), Vol. 15, p. 216.
2. Clyde Fulmer, Phys. Rev. 108, 1113 (1957).
3. James J. Griffin, Phys. Rev. (to be published).
4. I. Halpern and V. Strutinski, Proceedings of the Second International Conference on the Peaceful Uses of Atomic Energy (United Nations, Geneva, 1958), Vol. 15, p. 408.
5. Quinton, Britt, Knox, and Anderson, Bull. Am. Phys. Soc. II, 4, 414 (1959).



MU-18878

Fig. 1. Angular distribution of fission fragments in the laboratory system. Upper curve, Au¹⁹⁷ + 123-MeV C¹²; lower curve, Au¹⁹⁷ + 93-MeV C¹².



MU-18877

Fig. 2. Angular distribution of fission fragments in the center-of-mass system. Upper curve, $Au^{197} + 123\text{-Mev } C^{12}$; lower curve, $Au^{197} + 93\text{-Mev } C^{12}$.

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

- A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or
- B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.