MASTER

UCRL-70000
Preprint
CONF-660906-24

SEP 28 1966

1.00 50

UNIVERSITY OF CALIFORNIA
Lawrence Radiation Laboratory
Livermore, California

A STUDY OF FISSION γ RAYS USING A Ge(Li) DETECTOR IN CONJUNCTION WITH A BENT-CRYSTAL SPECTROMETER IN CAUCHOIS GEOMETRY

D. H. White
W. John
B. G. Saunders
D. J. Groves

July 20, 1966

This document is
PUBLICLY RELEASABLE
Barry Steele
Authorizing Official
Date: 6-19-07

RELEASED FOR ANNOUNCEMENT
IN NUCLEAR SCIENCE ABSTRACTS

LEGAL NOTICE

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.

This paper was prepared for submittal to the Proceedings of the International Conference on Nuclear Physics, Gatlinburg, Tenn., September 12-17, 1966.

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.

A Study of Fission γ Rays Using a Ge(Li) Detector in Conjunction with a Bent-Crystal Spectrometer in Cauchois Geometry*

D. H. White, W. John, B. G. Saunders and D. J. Groves

Lawrence Radiation Laboratory, University of California
Livermore, California

ABSTRACT

The high-resolution capability of the bent-quartz-crystal spectrometer in Cauchois geometry has been extended above 400 keV by replacing the photographic emulsion with a Ge(Li) detector and using multichannel pulse height analysis. By proper collimation at the focal circle, extended spectral bands of fission γ rays are recorded which are free of Compton edges and other secondary processes.

*Work performed under the auspices of the U. S. Atomic Energy Commission.

A Study of Fission γ Rays Using a Ge(Li) Detector in Conjunction with a Bent-Crystal Spectrometer in Cauchois Geometry

D. H. White, W. John, B. G. Saunders and D. J. Groves

Lawrence Radiation Laboratory, University of California
Livermore, California

A fissioning nucleus is generally a copious emitter of prompt and delayed γ rays. Most of the prompt gammas ($\tau < 1$ ns) are attributed to electromagnetic transitions in primary post-neutron-emission fragments. The delayed gammas ($\tau > 1$ ns) originate in metastable-state decays of primary fragments and transitions in β-decay products.

A program is presently underway at the Livermore Pool Type Reactor to study fission γ rays and x rays. Such a study should not only shed light on the fission process itself, but should also permit a nuclear spectroscopy study of very neutron-rich isotopes which are not normally accessible through any other reaction.

As a first part of this program, we have carried out a series of detailed measurements of the gamma spectrum produced by thermal fission of ^{235}U. For this purpose, we have combined the bent-quartz-crystal spectrometer with the lithium-drifted germanium detector so as to use each to its best advantage.

The resolution of the quartz crystal, bent in the 310 planes, varies as E^2. The Ge(Li) detector resolution varies as $E^{1/2}$, with an additional component at low energies due to system noise. The crossover point of these resolution curves is at about 400 keV, above which the Ge(Li) detector becomes rapidly

superior. The energy resolution of a bent-crystal spectrometer can be improved at higher energies by using a germanium crystal instead of quartz, and by using other planes or higher order reflection. However, we have found that above 400 keV, the intensity and background characteristics of the bent crystal also degenerate with respect to the Ge(Li) detector. Moreover, quantitative intensity measurements are difficult with the usual photographic emulsion detector.

The spectrum produced in a multichannel, pulse-height analyzer by a monoenergetic γ ray in Ge(Li), is generally characterized by a very sharp full energy peak due to complete absorption. Accompanying this peak at lower energy is a continuous distribution due mostly to gammas which are Compton-scattered out of the detector. The region between the full energy peak and the upper edge of the Compton distribution is relatively empty.

In complex spectra such as the fission gammas, the Compton distribution of high-energy gammas will generally obscure all but the most intense low-energy peaks. Even when an anticoincidence counter is used around the detector, the Ge(Li) spectrometer is limited by this effect.

Most of the difficulties are circumvented by combining the Ge(Li) detector with the bent-crystal spectrometer, as shown in Fig. 1. A lead collimator appropriately located on the focal circle permits a predetermined band of gamma energies to strike the Ge(Li) detector. The width of this band is chosen so that the upper Compton edges of all gammas in the selected group fall below the bottom of the band of peaks. The spectrum consists then of only a series of full-energy peaks (see Fig. 2).

The Cauchois geometry (extended source, focussed image) is especially favorable with respect to the duMond geometry (line source, extended detector)

in that a reasonably small detector may be used, and conveniently large spectral bands may be accumulated at each bent-crystal setting.

A series of overlapping bands have been recorded, covering a region from 160 to 880 keV. Background (including incoherent scattering in the quartz crystal and its holder) is recorded by repeating the run with the quartz crystal angle mis-set. The background subtracted data (see Fig. 2) are then attributed solely to correctly Bragg-reflected gammas.

Runs were also taken during reactor-down time. Observed gammas in this case are attributed to long-lived, β-decay products.

The energy scale is calibrated in each case by means of a linear pulser fed into the preamplifier. One or more known standard gamma sources are included in each pulser run, as well as in the corresponding fission-gamma run. These standards are usually selected to fall outside the selected gamma band. The precision is 0.1-0.3 keV in favorable cases.

Intensities within each segment are determined by the Ge(Li) measured efficiency and the known quartz-crystal reflectivity.

The overlap of bands allows a check on internal consistency and permits intensity normalization to a single scale. Since photographic emulsion measurements usually employed are not easily ammenable to quantitative intensity determination, the Ge(Li) measurements are useful well below 400 keV where the bent-crystal resolution is markedly superior.

A total of 123 gammas have been resolved in the region 160-880 keV. Of these, 16 have been attributed to long-lived, β-decay products. It is evident that many more gammas exist with intensities too low to resolve. The absence of supplementary information in the literature precludes, at present, our assigning the gammas to the respective neutron-rich isotopes.

The results of this series of measurements is to be published, and in the interim the list of gammas will be made available from the authors on request. The technique used has been convincingly shown to be extremely useful for the detailed study of very complex γ-ray spectra.

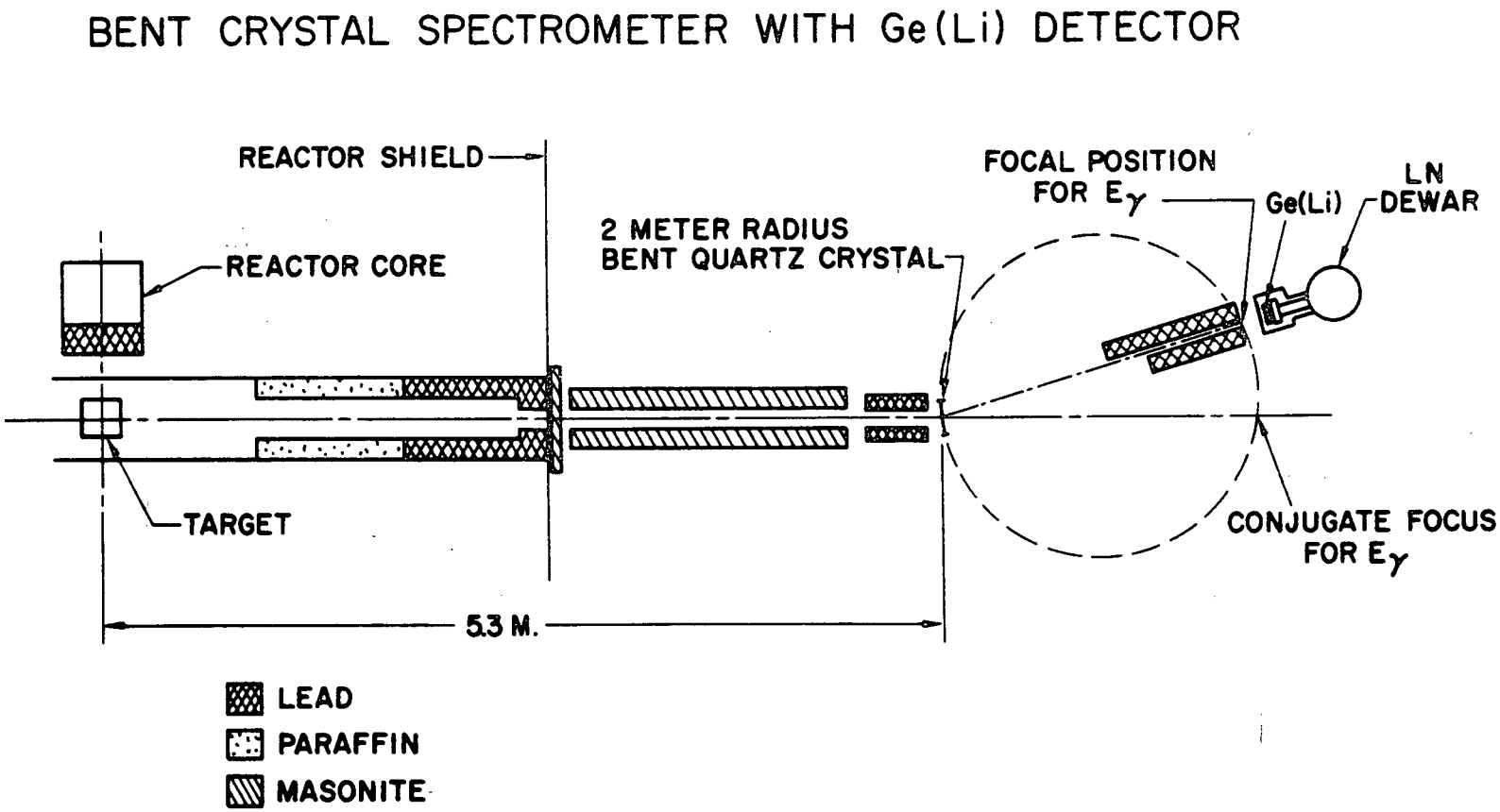

Fig. 1. Schematic diagram of the bent-quartz-crystal spectrometer used in conjunction with a Ge(Li) detector.

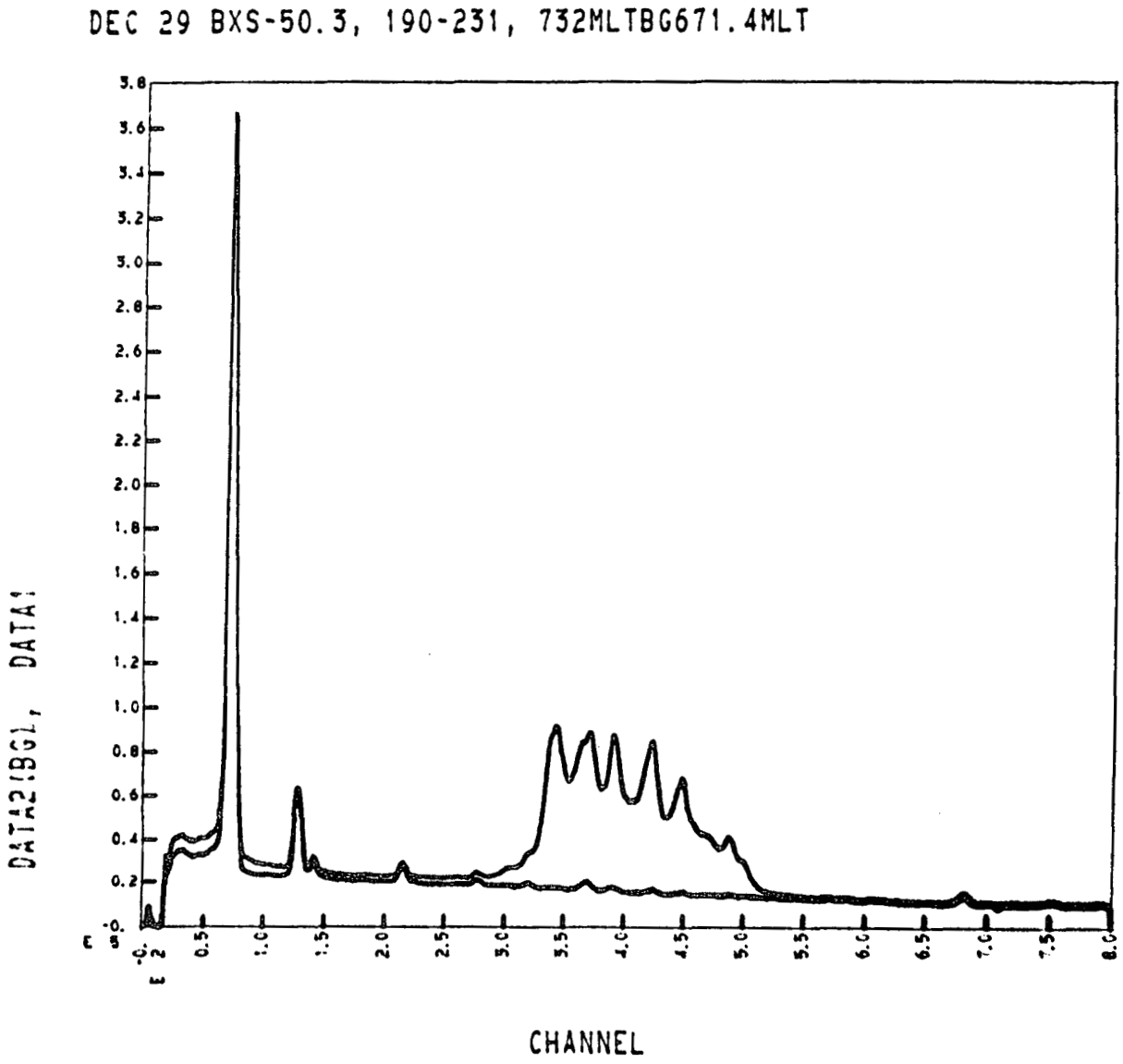

Fig. 2. A typical spectrum taken in the region 190-231 keV. The lower curve is taken with the bent-crystal angle mis-set. The peaks outside the main spectrum are due to calibration gammas and a pulser.

DISTRIBUTION

	No. Copies
LRL Internal Distribution,	
Information Department	30
D. White	10
Rose Moen	5
E. Goldberg	
R. Howerton	
J. Carothers	
LRL Berkeley,	
R. K. Wakerling	
Daniel Wilkes	
External Distribution,	
Division of Technical Information Extension, Oak Ridge	

LEGAL NOTICE

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.