

Lawrence Berkeley National Laboratory

LBL Publications

Title

The r-unit at 320 and 160 Mev

Permalink

<https://escholarship.org/uc/item/2w04q4s9>

Authors

McMillan, Edwin M

Blocker, Wade

Kenney, Robert W

Publication Date

1950-11-01

Copyright Information

This work is made available under the terms of a Creative Commons Attribution License, available at <https://creativecommons.org/licenses/by/4.0/>

UNIVERSITY OF CALIFORNIA -- BERKELEY

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*

RADIATION LABORATORY

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.

UNIVERSITY OF CALIFORNIA
Radiation Laboratory

Contract No. W-7405-eng-48

The r-unit at 320 and 160 Mev
Edwin M. McMillan, Wade Blocker, and Robert W. Kenney
November 10, 1950

Berkeley, California

-2-

INSTALLATIONNumber of Copies

Argonne National Laboratory	8
Armed Forces Special Weapons Project	1
Atomic Energy Commission - Washington	2
Battelle Memorial Institute	1
Brush Beryllium Company	1
Brookhaven National Laboratory	4
Bureau of Medicine and Surgery	1
Bureau of Ships	1
Carbide and Carbon Chemicals Division (K-25 Plant)	4
Carbide and Carbon Chemicals Division (Y-12 Plant)	4
Chicago Operations Office	1
Columbia University (J. K. Dunning)	1
Columbia University (G. Failla)	1
Dow Chemical Company	1
H. K. Ferguson Company	1
General Electric Company, Richland	3
Harshaw Chemical Corporation	1
Idaho Operations Office	1
Iowa State College	2
Kansas City Operations Branch	1
Kellex Corporation	2
Knolls Atomic Power Laboratory	4
Los Alamos Scientific Laboratory	3
Mallinckrodt Chemical Works	1
Massachusetts Institute of Technology (A. Gaudin)	1
Massachusetts Institute of Technology (A. R. Kaufmann)	1
Mound Laboratory	3
National Advisory Committee for Aeronautics	1
National Bureau of Standards	3
Naval Medical Research Institute	1
Naval Radiological Defense Laboratory	2
New Brunswick Laboratory	1
New York Operations Office	3
North American Aviation, Inc.	1
Oak Ridge National Laboratory	8
Patent Branch - Washington	1
Rand Corporation	1
Sandia Corporation	2
Santa Fe Operations Office	2
Sylvania Electric Products, Inc.	1
Technical Information Division (Oak Ridge)	15
Armament Division, Deputy for Research and Development (Capt. Glenn Davis)	1
Assistant for Atomic Energy, Deputy Chief of Staff (Col. Robert E. Greer)	1
Chief of Documents and Dissemination Branch (Col. J. E. Mallory)	1
USAF Assistant for Research Director of Research and Development, Deputy Chief of Staff (Col. B. G. Holzman)	1

Unclassified Distribution

-2a-

<u>INSTALLATION</u>	<u>Number of Copies</u>
Electronic Systems Division (Mr. E. C. Trafton)	1
Chief of Scientific Advisors (Dr. Theodore von Karman)	1
USAF, Eglin Air Force Base (Major A. C. Field)	1
USAF, Kirtland Air Force Base (Col. Marcus F. Cooper)	1
USAF, Maxwell Air Force Base (Col. F. N. Moyers)	1
USAF, NEPA Office	2
USAF, Offutt Air Force Base (Col. H. R. Sullivan, Jr.)	1
USAF Surgeon General, Medical Research Division (Col. A. P. Gagge)	1
USAF, Wright-Patterson Air Force Base (Rodney Nudenberg)	1
U. S. Army, Atomic Energy Branch (Lt. Col. A. W. Betts)	1
U. S. Army, Army Field Forces (Captain James Kerr)	1
U. S. Army, Commanding General, Chemical Corps Technical Command (Col. John A. MacLaughlin thru Mrs. Georgia S. Benjamin)	1
U. S. Army, Chief of Ordnance (Lt. Col. A. R. Del Campo)	1
U. S. Army, Commanding Officer, Watertown Arsenal (Col. Carroll H. Deitrick)	1
U. S. Army, Director of Operations Research (Dr. Ellis Johnston)	1
U. S. Army, Office of Engineers (Allen O'Leary)	1
U. S. Army, Office of the Chief Signal Officer (Curtis T. Clayton thru Maj. George C. Hunt)	1
U. S. Army, Office of the Surgeon General (Col. W. S. Stone)	1
U. S. Geological Survey (T. E. Nolan)	2
U. S. Public Health Service	1
University of California at Los Angeles	1
University of California Radiation Laboratory	5
University of Rochester	2
University of Washington	1
Western Reserve University	2
Westinghouse Electric Company	4
R. F. Bacher (California Institute of Technology)	1
Cornell University	1
Total	140

Information Division
 Radiation Laboratory
 University of California
 Berkeley, California

The r-unit at 320 and 160 Mev

Edwin M. McMillan, Wade Blocker, and Robert W. Kenney

Radiation Laboratory, Department of Physics
University of California, Berkeley, California

November 10, 1950

The r-unit is used today in at least two different ways: as a measure of radiation dosage, and as a measure of x-ray intensity. The meaning of the former is fairly well defined in terms of energy absorbed per gram of tissue, and the standard thimble chambers are calibrated to read in these terms. The meaning of the latter is much less clear. As originally defined, the r-unit referred to the ionization in air due to secondary electrons in equilibrium with the primary beam of x-rays. With low-energy x-rays equilibrium is easily attained since the range of the secondaries is small compared with the absorption distance of the primaries in air, but with high-energy x-rays this is no longer true. Since a clearly defined equilibrium no longer exists, the old definition must be abandoned and the question remains: what should the r-unit mean in connection with the intensity of a beam of high-energy x-rays?

It would seem that the definition must be arbitrary, that is, it must apply to some specified setup of the ionization chamber and its surroundings. Because of their convenience in use and universal availability, the Victoreen thimble chambers have been most widely used as measuring devices. Some workers have used these bare; some, in a block of plastic; some, inside a lead cylinder; and some, behind a lead sheet. Because of this ambiguity the r-unit has lost much of its value for x-ray measurements in the range of many Mev, and we believe that it should be replaced by absolute measurements in terms of energy flux or "effective number of quanta" (energy flux divided by upper limit quantum energy). However, it would be convenient to retain the r-unit, with a suitable

arbitrary definition, for rough measurements and for intercomparison of various x-ray sources.

Therefore we would like to suggest that a standard setup should be adopted, consisting of a Victoreen thimble chamber inside a lead cylinder with 1/8-inch wall thickness, 5/8-inch inside diameter, and 2-inch length. This arrangement was chosen because it is easily reproducible and because there is already considerable precedent for its use. It should be placed with its axis transverse to the beam direction and at a sufficient distance from the x-ray source that the intensity is reasonably uniform over a region at least an inch wide. The r-unit so specified can be calibrated in terms of absolute x-ray energy per unit area. To do this, a beam is defined by an aperture in a thick lead wall; the total energy flux in this beam is measured, and the Victoreen thimble reading in the center of the same beam is determined. The flux divided by the area of the beam at the Victoreen thimble gives the average intensity of the beam at this distance; this is multiplied by a factor, computed from the measured angular distribution in the beam, to get the central intensity.

Calibrations of this sort have been carried out for two energies, using the method of Blocker, Kenney, and Panofsky¹ for the flux measurements. The apertures are holes in a 9.57-inch thick lead wall placed 56.5 inches from the target; they are tapered to follow rays of the beam, and hole diameters of 1/2, 1, and 1-1/2 inches (at the small end) were used, with good internal consistency. Victoreen thimbles of 250 r, 100 r, and 25 r ratings (also with good agreement) were placed 337 inches from the target. A thin-walled integrating monitor chamber permanently mounted between the target and the aperture was useful in making the intercomparisons.

The results are given in the following table. The x-ray energies are

¹ W. Blocker, R. W. Kenney, and W. K. H. Panofsky, Phys. Rev. 79, 419 (1950)

accurate to about 2 percent, the calibrations to about 10 percent.

<u>x-ray energy</u>	<u>ergs/cm² r</u>	<u>Mev/cm² r</u>	<u>"effective quanta"/cm² r</u>
320 Mev	5.3×10^3	3.3×10^9	1.04×10^7
160 Mev	3.5×10^3	2.2×10^9	1.38×10^7

We find that our Victoreen setup gives 1.5 times the reading of that used by Kerst (thimble behind 1/8-inch lead sheet), and if allowance is made for this our result for 320 Mev is in good agreement with the absolute calorimetric measurement of Kerst and Price.² The r-unit mentioned in ref. 1 was defined in terms of Zeus meter readings, and was included only to show the order of magnitude of intensities used; it is in very poor agreement with thimble chamber readings and should not be used again.

The thimble chamber readings obtained in the course of the calibration, reduced to a standard distance by the inverse square law, indicate that the output of the Berkeley synchrotron is 1000 r per minute at one meter under best operating conditions. This is at full energy and with a pulse rate of six per second. Operation at this level has been maintained for periods of many hours.

The work described was performed under the auspices of the Atomic Energy Commission.

² D. W. Kerst and G. A. Price, Phys. Rev. 79, 725 (1950)