

Final Report

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September 1980 - August 1992

Contract No. DE-FG07-80ER10733

DOE Report No. DOE/ER/10733-12

**PARTICIPATION IN THE UNITED STATES DEPARTMENT
OF ENERGY REACTOR SHARING PROGRAM**

Submitted to:

U.S. Department of Energy
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois 60439

Attention: Ms. Renee L. Irwin, Contract Specialist

Submitted by:

R.U. Mulder
Director of Reactor Facility and Assistant Professor

P.E. Benneche
Reactor Services Supervisor

B. Hosticka
Research Scientist

Nuclear Reactor Facility
Department of Mechanical, Aerospace and Nuclear Engineering

SCHOOL OF ENGINEERING AND APPLIED SCIENCE
UNIVERSITY OF VIRGINIA
CHARLOTTESVILLE, VIRGINIA

SEAS Report No. UVA/527277/MANE93/112
December 1992

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TABLE OF CONTENTS

	<u>page</u>
I. INTRODUCTION	1
II. OBJECTIVES OF AND PARTICIPATION IN THE DOE REACTOR SHARING PROGRAM	2
A. Tours of UVA Reactor Facility by Colleges and Primary/Secondary Schools	3
B. Student Participation in Experiments	3
C. Student and Faculty Research Projects Conducted at UVA	4
D. Irradiation Services Offered to User Institutions	4
III. FINANCIAL REPORT	8
APPENDICES	9

TABLES AND LISTS

Table 1: Summary of Reactor Sharing Participation Sept. 1, 1991 - Aug. 31, 1992	5
List 1: Experiments Available Under the Reactor Sharing Program	6

SECTION I

INTRODUCTION

The University of Virginia Reactor Facility is an integral part of the Department of Mechanical, Aerospace and Nuclear Engineering and is used to support educational programs in engineering and science at the University of Virginia and at other area colleges and universities. The University of Virginia Research Reactor (UVAR) is the highest power (two megawatts thermal power) and one of the most utilized university research reactor in the mid-Atlantic states. A major objective of this facility is to support educational programs in the region.

The University of Virginia has received support under the U.S. Department of Energy (DOE) Reactor Sharing Program every year since 1978 to assist in meeting this objective. This report documents the major educational accomplishments under the Reactor Sharing Program for the period September 1991 through August 1992. This report is also to final report under this contract. Previous annual reports should be consulted if any information from those periods is desired. Additional information about the programs conducted at UVA under this contract may be found in the yearly requests for additional funds which have been submitted.

SECTION II

OBJECTIVES OF, AND PARTICIPATION IN, THE DEPARTMENT OF ENERGY REACTOR SHARING PROGRAM

The objective of the Department of Energy (DOE) supported Reactor Sharing Program is to extend the availability of university nuclear reactor facilities to non-reactor owning education institutions. The educational and research programs of these user institutions are enhanced by the use of the nuclear facilities. Many students receive their only exposure to the benefits and capabilities of nuclear energy during their visit to the University of Virginia (UVA) Reactor Facility.

Several methods have been used by the UVA Reactor Facility to achieve this objective. First, many college and secondary school groups toured the Reactor Facility and viewed the UVAR reactor and associated experimental facilities. Second, advanced undergraduate and graduate classes from area colleges and universities visited the facility to perform experiments in nuclear engineering and physics which would not be possible at the user institution. Third, irradiation and analysis services at the Facility have been made available for research by faculty and students from user institutions. Fourth, some institutions have received activated material from UVA for use at their institutions.

It is important to note that no funding is received for these services by UVA except through the DOE Reactor Sharing Program. Thus, it is likely that these educational projects would not have been initiated if Reactor Sharing funds were not available to cover the cost of the irradiation and personnel support required.

A. TOURS BY COLLEGES AND PRIMARY/SECONDARY SCHOOLS

By far the most popular activity offered under the Reactor Sharing Program at UVA are tours the reactor facility and associated laboratories. Many groups, either because of a lack of available time or a lack of the necessary background, do not desire to perform experiments but are most interested in a one to two hour tour. Much useful information can be conveyed during this time period and for many students this may be their only exposure to the research uses of nuclear fission.

B. STUDENT PARTICIPATION IN EXPERIMENTS

Periodically, letters are mailed to science and engineering departments at many colleges and universities in Virginia, Maryland, West Virginia and North Carolina informing them of the DOE sponsored Reactor Sharing Program. These institutions become aware through these announcements of the opportunities offered by the program and contact the University to gain assistance in their educational programs and research. These mailings will be repeated to ensure continued awareness of the program. This year, the program was again well received. Neutron activation analysis was the most utilized service both in terms of number of laboratories performed and specimens irradiated for research. Table 1 gives a listing of participants in the program for 1991-1992 and List 1 provides a summary of the available experiments. Included as Appendix items A through H are letters of correspondence with eight of the participating institutions.

C. STUDENT AND FACULTY RESEARCH PROJECTS CONDUCTED AT UVA

Initially, a major portion of the funds requested for the Reactor Sharing Program at the University of Virginia covered research projects for a single Virginia university. Over the last fourteen years the research has diversified. This year, one student spent 2.5 months over the summer at UVA working on a research project. The other college level research projects which were supported involved the irradiation of material at UVA but the use or analysis of this material was at the researcher's university (see section D. below).

D. IRRADIATION SERVICES OFFERED TO USER INSTITUTIONS

Commonly, researchers from outside institutions request that their materials be irradiated at UVA, either with neutrons or gamma-rays. These materials are then shipped to their institutions for analysis or use. Materials activated with neutrons are either analyzed on gamma-ray spectrographic equipment or the emitted radiation used in various experiments. The UVA cobalt-60 gamma-ray irradiation facilities can be used for sterilization, inducing mutation of biological materials or to study the effect of high doses of radiation, such as radiation damage on electronic components and the cross linking of polymers. This year researchers from Virginia Polytechnic University, James Madison University and Washington and Lee University, as well as a couple high schools utilized irradiation services.

TABLE 1

SUMMARY OF REACTOR SHARING PARTICIPATION
September 1, 1991 to August 31, 1992

University : Univ. of Virginia Location : Charlottesville, Virginia
 Program Director : Dr. Robert Mulder Telephone No. : (804) 982-5440
 Grant Number : DEFG0580ER10733 Reactor Type : 2 MW Pool Reactor (UVAR)

<u>Date</u>	<u>Researcher or Participating Institution</u>	<u>Instructor</u>	<u>Grade</u>	<u>Student/Teachers</u>	<u>Program Description</u>	<u>Direct Cost</u>
COLLEGES						
Oct. 92	Piedmont Va. Comm. College	R. Bratton	Col	85 / 6	Facility tours (5)	0.00
11/22/91	Va. Commonwealth Univ.	S. Herr	Col	9 / 1	Facility tour & laboratory	82.50
12/03/91	Va. Polytechnic Institute	D. Judge	Col	1 / 0	Sample gamma irradiation	0.00
12/06/91	Lynchburg College	N. Summerlin	Col	7 / 1	Facility tour & laboratory	15.00
02/28/92	James Madison University	D. Downey	Col	0 / 1	Sample neutron irradiation	57.50
03/26/92	Piedmont Va. Comm. College	R. Bratton	Col	21 / 2	Facility tours	0.00
Mar-Apr	Washington & Lee Univ.	J. Donaghy	Col	0 / 1	Sample gamma irradiations (3)	0.00
04/23/92	James Madison University	D. Downey	Col	0 / 1	Sample neutron irradiation	185.00
Jun-Jul	S.U.N.Y @ Geneseo	B. Emerling	Col	1 / 1	Research project	0.00
		SUBTOTAL		124 / 14		465.00**
PRIMARY/SECONDARY SCHOOLS						
Nov. 92	Murray High School	R. Estes	HS	14 / 2	Facility tour	0.00
02/11/92	West Springfield H.S.	S. Scholla	HS	3 / 1	Facility tour & laboratory	15.00
03/12/92	St. Annes - Belfield	L. Rodewald	HS	40 / 2	Facility tours (2)	0.00
05/11/92	Sharon Elementary School	D. Peters	ES	38 / 2	Facility tours (2)	0.00
May 92	Albemarle High School	D. Ridenour	HS	93 / 5	Facility tours (2)	0.00
05/21/92	G.W. Danville High School	J. Fesperman	HS	8 / 2	Facility tour	0.00
06/01/92	mixed high school group	M Coggins	HS	84 / 9	Facility tour	0.00
07/23/92	Gov's Prog., SW Va Comm C	-----	HS	17 / 1	Facility tour	0.00
07/28/92	Woodberry Forest	S. Daugherty	HS	19 / 3	Facility tour	0.00
07/31/92	High school physic teachers	B. Gordon	HS	0 / 14	Facility tour	0.00
07/09/92	Summer Program (youth)		MS	15 / 2	Facility tour	0.00
07/23/92	Summer Program (youth)		MS	15 / 2	Facility tour	0.00
07/28/92	Summer Program (youth)		MS	15 / 3	Facility tour	0.00
		SUBTOTAL		361 / 49		15.00

SUMMARY

	<u>Groups</u>	<u>Students</u>	<u>Teachers</u>
College:	8	124	14
Pre College:	16	361	49
Total:	24	485	63

Key to schools: Col = College, HS = High School, MS = Middle School, ES = Elementary School

** In addition to these charges, a total of \$1,255 in charges which were incurred last year were billed during this contract year.

LIST 1

EXPERIMENTS AVAILABLE UNDER THE REACTOR SHARING PROGRAM

1. Counting Statistics

Demonstration of the random nature of radioactive disintegrations at both low and high disintegration rates. Using a multiscaler or single channel scaler, a series of counts is taken of the decay of a long-lived radioactive source. The counting results are plotted in order to determine the type of statistical variation which is exhibited.

2. Radioisotope Decay and Half-Life Determination

Demonstration of radioactive decay and the determination of the half-life of a reactor produced or laboratory separated short-lived isotope. Complex decay schemes can also be investigated, such as the decay of two isotopes with different half-lives or decay of one isotope into the other.

3. Neutron Activation Analysis

Demonstration of trace element analysis by nuclear techniques. A specimen is activated and its constituents determined from the nature of its radioactive decay. Activation analysis of minerals, food, fingernails, hair, tissue, environmental samples and other samples can be performed.

4. Source Excited X-Ray Fluorescence Analysis

The analysis of a sample using an Americium-241 x-ray exciter source and a germanium low energy photon spectrometer can be demonstrated.

5. Industrial Applications of Radioisotopes

Thickness gauging, liquid level sensing and density measurements using beta, gamma and neutron sources can be demonstrated and used by students to experiment with a variety of determinations.

LIST 1 (continued)

6. Reactor Operating Characteristics

Students can start-up and operate the University of Virginia Reactor under the direction of a licensed member of the reactor staff. The determination of the negative temperature coefficient, measurement of the reactivity worth of a control rod and the prediction of the critical rod positions based upon subcritical count rates are just a few of the laboratories which students can complete using the reactor.

APPENDICES

George Washington High School
Danville, Virginia 24541

OFFICE OF THE PRINCIPAL

September 26, 1991

Dr. Paul E. Benneche
Reactor Services Supervisor
University of Virginia
Reactor Facility
Charlottesville, VA 22903-2442

Dear Dr. Benneche:

I wish to request a tour of the facility you have on the afternoon of May 23, 1991. You have given my students a very good lesson in research reactors after we tour a commercial reactor that morning.

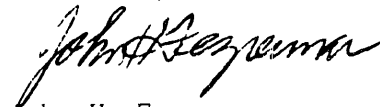
There will be approximately 10 students and myself for the tour. They get so much out of seeing an actual at work and hearing different ways it is used.

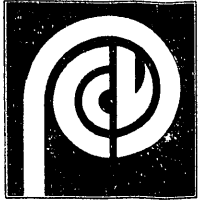
We could get to your facility around 2:00 PM on the 23rd and I would appreciate the tour effort once again. My mailing address is as follows:

John H. Fesperman
George Washington High School
701 Broad Street
Danville, VA 24541

Thank you in advance for your help.

Sincerely,


John H. Fesperman



Piedmont
Virginia
Community
College

Route 6, Box 1-A, Charlottesville, Virginia, 22901-8714, Tel. 804/977-3900

November 1, 1991

Paul Benreche
Reactor Services Supervisor
University of Virginia
Department of Nuclear Engineering
and Engineering Physics
Reactor Facility
Charlottesville, VA 22903-2442

Dear Paul,

I want to thank you on behalf of my chemistry students for conducting all of those tours of the University of Virginia Reactor Facility last week. I especially appreciate the way that you tailored the information to their level and background.

We now have close to a hundred additional citizens who are informed about nuclear science.

Sincerely,

A handwritten signature in cursive script, appearing to read 'Ray'.

Raymond F. Bratton
Professor of Chemistry

mw





Department of Entomology

College of Agriculture and Life Sciences
Blacksburg, Virginia 24061-0319 USA
(703) 231-6341 Fax: (703) 982-6050
Bitnet: ent4@vtvm1

1 December 1991

Dr. Paul Benneche
Department of Nuclear Engineering
Reactor Facility
University of Virginia
Charlottesville, VA 22903

Dear Paul:

I would appreciate it if you could sterilize the four containers that I have sent you in the styrofoam cooler. Each vessel contains 4.0 microcuries of ^{14}C -ring-labelled atrazine, 10 g of peat moss, and approximately 0.5 ug/g atrazine. Two of the vessels are bottles which I imagine will not be difficult to sterilize, however, the other two vessels are specially constructed glassware for the experiment. They are less than 2.5 inches in diameter, and I hope that they fit in the reactor. Please, contact me if there is a problem.

There is no particular urgency to sterilize these vessels and get them back to me. If however, it is longer than a day after you receive them, could you keep them cool ($< 4^{\circ}\text{C}$) until you get to them? Afterwards, you do not need to keep them refrigerated or need to pack them on ice or dry-ice for the trip back to Virginia Tech. Please send them to me care of:

Doug Smiley, Radiation Safety, Room 104, Health and Safety Bulding #459,
Virginia Tech, Blacksburg, VA, 24061.

I do appreciate the service that you and your Department provide, and in future articles corresponding to research with the sterilized vessels, your services will be mentioned with my pleasure. Please inform me of any instructions that would make future packages for sterilization easier for you.

Sincerely,

David Judge

encl. 4 glass vessels containing 4.0 microcuries of ^{14}C -atrazine in 10 g peat moss with 0.5 ppb unlabelled atrazine.

cc. Doug Smiley
Donald Mullins

LYNCHBURG COLLEGE
IN VIRGINIA

1501 LAKESIDE DRIVE
LYNCHBURG, VIRGINIA 24501-3199

(804) 522-8100

December 14, 1991

Mr. Bouvard Hosticka
Department of Nuclear Engineering
Reactor Facility
University of Virginia
Charlottesville, VA 22901

Dear Bo:

Thank you once again for the opportunity afforded my students by the Reactor Sharing Program at UVa. My nuclear chemistry class very much enjoyed getting to see equipment they had learned about in class. I imagine that we will both be certain that sight is the only sense involved the next time we learn about thin beryllium windows!

Thanks again for your significant contribution to our educational program.

Sincerely,



Neal Sumerlin, Professor and Chairman
Chemistry Department



Virginia Commonwealth University

Paul Benneche
Reactor Services Supervisor
University of Virginia
Department of Nuclear Engineering & Engineering Physics
Reactor Facility
Charlottesville, Virginia 22093-2442

January 28, 1992

Dear Dr. Benneche,

I wish to thank you and the Reactor Facility staff for the tour and laboratory experiment/demonstration provided for my Modern Physics Laboratory students on November 22, 1992. The students thoroughly enjoyed the entire program and, judging from their enthusiasm and general interest, found it to be a real educational experience.

The faculty in the VCU Physics Department is made up largely of solid state physicists and there is no ongoing research in the area of nuclear physics. The Reactor Sharing Program at UVA provides an excellent opportunity for VCU students to gain a hands on look at nuclear physics and broaden their scope of physics research. I feel that this is an outstanding program and have incorporated a tour of the reactor facility into my Modern Physics Laboratory course syllabus as a required field trip.

Thank you again for your cooperation and hospitality, I hope to see you again next fall.

Sincerely,

A handwritten signature in black ink, appearing to read "S. L. Herr".

Steven L. Herr
Assistant Professor



James Madison University
Department of Chemistry

March 2, 1992

Bo Hostika
Nuclear Reactor Facility
University of Virginia
Charlottesville, Va

Dear Bo:

I am writing to express my appreciation for your conducting a tour for my nuclear chemistry class on Friday February 28. As always, you did a very good job and I am certain that the class found the tour very informative and educational. The reactor start up was particularly well received and I think the neutron activation analysis of selenium in horse hooves was a good way to demonstrate the value of a reactor in elemental analysis. As part of the course I require the students to conduct a project of their own design. You may recall, a few years ago one student irradiated soil samples for mercury analysis. Another project involved a study of the equilibrium between Zr-95 & 97 and daughters using reactor irradiated zirconium. I don't know if any projects this year will involve reactor irradiations, but if this is the case, I will call you to discuss to see if it is possible for us to have some irradiation done and discuss the details.

Again, thank you for taking the time to give us the very good tour. I am sure that the students benefitted greatly by the opportunity to see a real reactor in operation.

Sincerely,

A handwritten signature in cursive script that reads 'Dan'.

Daniel M. Downey, Ph.D.
Associate Professor



Piedmont
Virginia
Community
College

Route 6, Box 1-A, Charlottesville, Virginia, 22901-8714, Tel. 804/977-3900

April 3, 1992

Bouvard Hosticka
Research Scientist
University of Virginia
Department of Nuclear Engineering
and Engineering Physics
Reactor Facility
Charlottesville, VA 22903-2442

Dear Bo,

On behalf of my Chemistry 111 students, as well as Rick and myself, I want to thank you for the tour of the University of Virginia Reactor Facility last week. We especially appreciate the special efforts that you made for us. Doing the tour in the evening and leaving the reactor operating beyond normal shut-down call for special thanks.

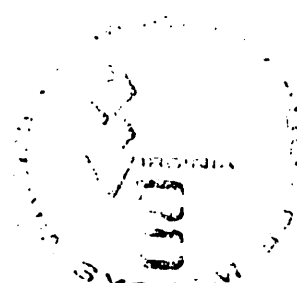
If you have printed information on experiments that could be done with students such as mine, I would appreciate having a copy.

Sincerely,

A handwritten signature in cursive script that reads "Ray".

Raymond F. Bratton
Professor of Chemistry

mw



Dear Paul,

Aug. 20, 1992

I want to thank you for all of the time you spent helping me with my project over the summer. I really believe I learned a lot and that was the primary reason I applied to be a part of the REL program. I only wish I could have given a better final presentation than I did. I've been asked to give my presentation to fellow students and faculty when I return to Geneseo this fall. I'm really looking forward to it. I'm sure to do a better job because now I know what things to do and not to do.

Enjoy the rest of the summer,
Thanks again.

Sincerely,
Bridget M. Emending

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Chicago Operations Office
9800 South Cass Avenue
Argonne, IL 60439

Attention: Renee L. Irwin
Contract Specialist

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5 Dr. Larry Barker, Program Manager
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6 - 7 R. U. Mulder

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