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C00-1805-1

ANNUAL REPORT

ACQUISITION OF THE ANL 4-MEV ELECTROSTATIC ACCELERATOR

Contract No. AT(11-1)-1805

September 30, 1974

I. Introduction

This is the first annual report covering the activities under the above contract during the period September 1, 1973 through August 31, 1974. Additional comments are included concerning developments between the acquisition of the accelerator in 1968 and the beginning of the reporting period.

For background information, one should consult the proposal made to the USAEC by D. R. Dixon, M. W. Hill, and G. L. Jensen entitled "Acquisition of the ANL 4-MeV Electrostatic Accelerator" and dated April, 1968.

II. Experimental Facilities

The accelerator was shipped to Brigham Young University in June, 1968 and placed in the laboratory building late that year. Upon completion of the laboratory in 1969, assembly of the accelerator and installation of auxiliary equipment commenced. The work was done largely by part-time student employees under the supervision of the principal investigator and with assistance from shop personnel in the Department of Physics and Astronomy. The initial installation consisted of the basic accelerator and vacuum system received from Argonne National Laboratory together with BYU-supplied equipment including an operating console and control equipment, vacuum gauges, a television system for reading meters in the high-voltage terminal, and gas storage and handling equipment including a compressor, storage tanks and transfer plumbing.

Initial plans called for the use of a rather simple beam-transport system using some components available in the laboratory. It became evident, however, that such a system would rather seriously limit the usefulness of the accelerator, so the decision was made to purchase a complete new system using high-quality commercial components. Budgetary limitations required that the project be spread out over a three-year period with deliveries being made from 1971 through 1973. By September 1, 1973, the accelerator was operating with reasonable consistency and the basic beam-transport components were in place and operational. At this time the beginning of the four-year research program was declared.

During the year specifically covered by this report, the principal activities were further improvements on the accelerator and associated equipment and development of the experimental programs using the BYU 2-MeV

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Van de Graaff accelerator. The main items included in the first category were (1) replacement of accelerator focus power supply with a more reliable commercial unit, and (2) replacement of accelerator ion source and associated radio-frequency oscillator with commercial units to provide more reliable operation and a higher fraction of protons in the beam. In the second category were (1) installation and test of remaining beam-transport apparatus, (2) installation of a gas-drying system for the insulating gas, (3) repair of several pieces of equipment which were defective when received from the factory, and (4) improvement of a target-evaporating system and development of target fabrication techniques (Ref. 1).

III. Experimental Programs

A. Programs in the Original Proposal

Of the three research projects described in the proposal of 1968, there has been considerable activity on that involving the use of the Los Alamos Scientific Laboratory velocity gauge to measure absolute calibration energies. This instrument was received at BYU but was subsequently shipped to the University of Zürich in Switzerland where it was in use during 1970 through 1972. Upon the return of the apparatus to BYU it was set up and put into operation at our 2-MeV Van de Graaff laboratory with the help of Dr. Hans Gubler from University of Zürich who spent six weeks in our laboratory on the project.

There has been no activity on the other two proposed research areas which are a study of gamma rays from neutron inelastic scattering or capture and a measurement of neutron radiative capture cross sections. Both of these experiments require the use of a pulsed neutron source which is not now available in our laboratories.

Since the original proposal was made in 1968, there has been considerable change in emphasis in nuclear research programs with more attention being given to applied research. In addition, we find our manpower level considerably below that anticipated, largely because of the sharp drop in the number of graduate students in the program. Because of these two factors we would like to request, in connection with this report, that permission be granted by the AEC to change the research categories to those described in the next section.

B. Proposed Substitute Programs

1. Fission-product studies

In these studies, uranium or plutonium nuclei are bombarded by neutrons of various energies up to about 1 MeV. The yields of radioactive fission products are measured by detecting gamma rays emitted as these products decay. These yields will be used in calculating the operating characteristics of thermal and fast breeder reactors. Neutrons for these experiments would be supplied in the thermal region by the BYU model L-77 nuclear reactor, in the intermediate-energy region by the 2-MeV accelerator and at higher energies by

the Argonne 4-MeV accelerator. Dr. Vern Rogers, Adjunct Professor of Physics at BYU and employee of Intelcom Rad Tec in San Diego is cooperating with BYU personnel in these studies. Some work has been done on this project with results being reported in a thesis by Jensen (Ref. 2).

2. Trace-element analysis using x-ray fluorescence

Samples of interest in environmental, biological, and medical studies are bombarded by protons which disturb the low-lying electronic structure of the atoms. Characteristic x-rays which are subsequently produced are detected by lithium-drifted silicon detectors. Elements with concentrations as low as one part per million can be detected by this method. This project has been under development at BYU for several years under the direction of Dr. N. F. Mangelson of the Department of Chemistry and Dr. M. W. Hill of the Department of Physics and Astronomy with cooperation from many other individuals and groups. The work is currently being done with the 2-MeV accelerator and has involved interaction with several governmental agencies and groups in a variety of disciplines. References 3 - 5 describe some of this work. We desire to use the 4-MeV Argonne accelerator in future work since the increased energy will increase the sensitivity of the method to certain elements, and target preparation will be simplified. In addition, there is some prospect that the volume of work may exceed the capability of the 2-MeV accelerator.

3. Study of proton-capture gamma rays

In these reactions, target nuclei absorb protons from the accelerator beam and subsequently emit gamma rays. These rays are detected by lithium-drifted germanium or sodium iodide detectors. Gamma-ray production may be measured as a function of proton energy or, for a given proton energy, gamma-ray energy spectra and/or angular distributions may be measured. Analysis of the data produces information on the energy, spin, and parity of the excited states in the product nuclei. Comparison of the properties of isobaric analog states in mirror nuclei produces valuable theoretical information on the charge independence of nuclear forces.

Experiments in this category have been carried out at BYU using aluminum, iron, and manganese targets. Results have been reported in several theses and a publication (Refs. 6 - 8). Dr. G. L. Jensen has recently been particularly active in these experiments and the analysis of the data. In several experiments of this type it would be advantageous to extend the measurements to higher proton energies which would be available from the Argonne accelerator.

In the first two programs outlined above, there is considerable practical interest and, in the case of the third one, theoretical interest. In each case the higher particle energies of the larger accelerator are needed. They all involve the measurement and analysis of x-rays or gamma rays. We are particularly well equipped to make this kind of measurement. In addition to the equipment listed in the original proposal, we now have additional detectors and a 4096-channel pulse-height analyzer with a PDP-11 digital computer and considerable peripheral equipment for use in collection and analysis of data. The experiments can be done with a continuous beam from the accelerator and thus there would be no need to develop pulsed-beam capability.

In view of the above considerations, we feel that we would be able to make more significant contributions to problems of current importance if we were to undertake these experiments rather than the ones originally proposed.

IV. Financial

The sum of \$10,000 was appropriated for the shipping and initial installation of the accelerator. Approximately \$100,000 was expended for the beam-transport system. For our nuclear program as a whole, about \$6,000 annually is available from the departmental budget for capital equipment with occasional larger sums being available. An estimated one-half of this has been expended for the Argonne accelerator and related equipment. Approximately \$3,000 annually has been available for supplies on a similar basis. All of these funds have been supplied by Brigham Young University.

V. Manpower

Faculty manpower has been spent approximately as outlined in the 1968 proposal with most of the effort of the principal investigator going directly to the accelerator and associated systems while the associate investigators have been more concerned with the related experimental programs. Averaged over the entire period, we have had the one-third time services of a machinist, a vacuum technician, and an electronics technician. Part-time student assistance has been available at the rate of about 20 man-hours per week, averaged over the calendar year. We can expect continued effort of the project about as outlined above except that the availability of student help depends on students in the program and is presently somewhat uncertain.

VI. Future Activities

Plans for the coming reporting year include maintenance of the accelerator in good operating condition, improvement of the operation of the beam transport system, careful energy calibration of the overall system, and use of the accelerator in collection of data on at least two of the experimental programs.

Dwight R. Dixon, Principal Investigator

Max W. Hill, Associate Investigator

Gary L. Jensen, Associate Investigator

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