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John R. Huizenga

JOHN HUIZENGA AT THE N.S.R.L.

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The first experiments at the University of Rochester's, Nuclear Structure Research Laboratory were carried out in early November of 1966 and the accelerator itself was officially accepted in April of 1967. The laboratory's inception was a result of an idea of Robert Marshack and Bruce French of the Department of Physics and Astronomy at Rochester. Marshack was then the head of the Department and their idea was that the small cyclotron which had been used during the period of the 1950's and 1960's needed replacement with a more modern accelerator if the Physics Department at the University was to continue as one of the leaders in the field of nuclear science. A proposal was submitted to three federal agencies in February 1962. These agencies included the then Atomic Energy Commission, The Office of Naval Research, and the National Science Foundation. The proposal was accepted by the latter organization, the National Science Foundation and NSRL has flourished in nuclear science since that time.

Most recently the accelerator is undergoing an upgrade to increase its terminal potential from approximately 12 MV to 18 MV. This upgrade will continue to keep the laboratory at the forefront of heavy ion physics for some time to come.

It is interesting to note that the proposal finally accepted by the National Science Foundation included a section on the study of Nuclear Chemistry, as it was then called, and it noted that there were a number of experiments that were possible with a model MP tandem which could be readily performed using radio chemical techniques. At that time, Nuclear Chemistry still involved real chemistry as contrasted to the present status of the field where it is unarguably real physics. The proposal went on to note that the University of Rochester's Chemistry Department had interests along a variety of lines that could involve the proposed accelerator. One of these for example was the study of statistical models of nuclear reactions at excitation energies below 50 MeV. The measurements envisaged included excitation function data and range measurements of residual nuclides both of which would require radio-chemical techniques and the studies of the spectra of evaporated particles particularly from rare types of reactions. The latter, it was pointed out, would employ standard nuclear physics detection methods and would involve a more direct collaboration between the Departments of Chemistry and of Physics and Astronomy. It went on to say that another class of experiments of direct interest to the Department of

Chemistry was the field of fission physics. It was proposed to carry out radio-chemical fission yield studies in the region of atomic number from 70 to 83 using heavy-ion beams from the tandem at, or better still above, the Coulomb barrier. It noted finally that radio-chemical techniques might provide a valuable auxiliary tool for studying isotopes well removed from the line of beta stability. The nuclear properties of such isotopes were little known and were of great interest. Heavy-ion bombardment followed by rapid radio-chemical separation might well provide a method of preparing these isotopes and thus enhance the observation of some of their properties. I might say at this point that, as far as I know, no radio-chemical techniques were ever employed by the members of the Chemistry Department who worked at the NSRL and right from the beginning the distinction between Nuclear Chemistry and Nuclear Physics which, even at that time, was beginning to blur disappeared completely.

At the time this initial proposal was being prepared, almost a quarter of a century ago, Marshall Blann was the only member of the Chemistry Department whose field was nuclear science and he played a major role in the planning of the laboratory and in its subsequent use. He will saing more about that in the talk which follows after the break.

The first annual progress report published by the laboratory came out in 1967 and covered the first 14 months of operation of the tandem accelerator. It noted that the research facilities of the laboratory were employed as well as by members of the Physics Department by two Nuclear Chemistry groups, one under the direction of Marshall Blann and the other under John Huizenga both of whom were supported by the U.S. Atomic Energy Commission. It noted that their use of the facility constituted approximately 20% of the time and although this progress report was primarily issued for the National Science Foundation, their work was included as well because of the key role they played in the life of the laboratory.

Two early instrumental developments at the laboratory played a major role in the research program of John Huizenga and his group. The first was the installation of an intense negative-helium source. This source used a duoplasmatron to produce several milliamps of positive helium ions and a lithium vapor charge exchange canal for the production of negative helium ions. It was possible using the source to obtain as much as two or three microamps of doubly charged helium at the target at the entrance to the Enge split-pole magnetic spectrometer. The second piece of experimental apparatus which came into operation almost immediately the accelerator began running was this Enge split-pole magnetic spectrometer. It employed as a detector photographic plates on the focal plane of the camera. An enormous amount of nuclear data was collected using this device. In particular, one of John Huizenga's research associates, Thomas Elze, and he performed a whole series of experiments involving the

(^{3}He,α) reaction. This is a reaction which can be accurately described as one in which the incident ^{3}He particle picks up a single neutron from the target nucleus and measurement of the alpha particle angular distributions gives information on the angular momentum of the levels of the residual nucleus. One of the first such reactions to be studied was ^{3}He incident on ^{232}Th. The bombarding energy was 30 MeV and a large number of levels in ^{231}Th were studied. Spins of these levels could be identified by comparing the angular distributions obtained with DWBA calculations and thereby identifying the orbital angular momentum of the neutron which was picked up in the reaction. They could then be assigned to various rotational bands according to the Nilsson level scheme. Many of these neutron states in heavy elements arise from orbitals such as the 1j15/2, 1i11/2 and 2g9/2 shell model states. These contain large components of high angular momentum in their wave functions. Such states are strongly populated in the (^{3}He,α) reaction.

In addition to (^{3}He,α) reactions, Huizenga also studied the (3He,d) reaction. In this case, a single proton is added to the target nucleus and provides information on the proton states of the residual nucleus. The targets, again, were ones in the actinide region in the periodic table which, up until this time, had been subjected to very little study. To my mind, one of the most interesting measurements carried out by Huizenga's group in the early days of the Nuclear Structure Research Laboratory was of single proton states in ^{249}Bk studied by both the (^{3}He,d) reaction on ^{248}Cm and the (^{4}He,t) reaction on the same target. This data was combined with results of studies of the gamma decay of ^{253}Es and the beta decay of ^{249}Cm to obtain a more complete picture of the nucleus ^{249}Bk. Particular interest centered on the energy of the expected single particle proton state which should be primarily of f5/2 character and should therefore, in the spherical limit, originate above the Z=114 shell closure. It was suggested that its identification would provide information on the size of the shell gap at that proton number and therefore on the stability of possible superheavy elements.

In 1973 a new reaction mechanism involving heavy ions was discovered. This was the phenomenon of strongly damped collisions and Huizenga and his collaborators immediately became interested in it. They began carrying out experiments on this unexpected nuclear interaction, but unfortunately, no longer at the Nuclear Structure Research Laboratory, since higher heavy-ion beam energies than we were able to produce were required. Most of his research was moved to the Lawrence Berkeley Laboratory using the SuperHILAC accelerator. Huizenga quickly became a leader in the study of these strongly damped collisions both in the experimental measurements and in the theoretical descriptions of this completely new and unexpected phenomenon. Although this did remove his group from direct use of the MP tandem at the University of Rochester's Nuclear Structure Research Laboratory, his interaction with the laboratory continued as it had before in a very important and fruitful way.

When Huizenga was first appointed as a full professor in the Department of Chemistry at the University of Rochester he was also simultaneously given a joint appointment as a full professor in the Department of Physics and Astronomy. In this capacity, he attended meetings of the Physics and Astronomy Steering Committee particularly when questions came up in that committee on matters concerning the Nuclear Structure Research Laboratory. Perhaps it would be worth noting here that the laboratory has always been a separate entity in the College of Arts and Science. The director of the laboratory reports directly to the Dean of the College. Faculty members in the laboratory, however, hold tenure in their respective departments such as Chemistry or Physics and Astronomy and most recently in the Geology Department. Although the laboratory is not part of either the Chemistry Department or the Department of Physics and Astronomy, it obviously has close ties with both of these departments. In particular the question of faculty appointments in either of those departments whose primary research areas are at the laboratory are made by the departments themselves. Huizenga's knowledge of the field of nuclear science and of the researchers in that field, particularly the younger people in the field, has been of great benefit in making such appointments in the Physics Department.

He continues to play a considerable, vital, interactive role in the affairs of the laboratory but the fact that his research program is carried out at other laboratories does diminish his direct impact to some extent. The upgrade presently being carried out on the tandem accelerator at the laboratory has a very profound significance, not only in terms of extending the lifetime of frontier research in heavy-ion nuclear science at the Nuclear Structure Research Laboratory, but also because it will enable Huizenga and his collaborators to do more of their research work here at Rochester. We look forward to many years of continued collaboration in nuclear science between members of the Department of Physics and Astronomy and the Department of Chemistry.