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Review

Tribute to the Spirit of Keage

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During 1988 and 1989, it was my honor and pleasure to study and work at the Keage Laborarory of the Kyoto University Institute for Chemical Research, to be present during the transition to the new Accelerator Laboratory on the Uji campus, and to participate in the dedication ceremony for the new facility. My brief return this year in February 1990 rounds out a full decade of personal contact with prof. H. Takekoshi and his staff and students, and of fruitful work between our two laboratories. It has been an exciting and fruitful decate for accelerator technology.

In the late 1970's and early 1980's Los Alamos had embarked on a program called PIon Generator for Mecical Irradiation (PIGMI), with the goal of using the experience gained with the Los Alamos Meson Physics Facility (LAMPF) to design a more compact, efficient, and inexpensive linear accelerator to produce pions for use in cancer therapy. The prestige of Prof. Yukawa, who discovered the pion, and his own unfortunate illness from cancer, resulted in a strong interest in the PIGMI program in Japan, and the Yomiuri Shimbun sponsored a program of participation by two Japanese researchers each year ··· one a medical researcher working directly with the patient treatment program using the LAMPF beam, and the other an accelerator technologist.

In this way started a long series of visiting researchers, and for ten years, we fortunate at Los Alamos to have someone visiting our group from various institutions of Japan.

Y. Iwashita came in 1981, and worked with us for three years in total at Los Alamos[1)-3)]. At that time, the principle of the radiofrequency quadrupole (RFQ) accelerator had just been proven in experimental tests outside the Soviet Union, where it had been invented and tested earlier[4)]. This device was a breakthrough in the acceleration of low-velocity ion beams, achieving the long-sought dream of being able to accelerate ion beams from an ion source to a few MeV with close to full capture and very little loss of beam quality. The RFQ is essentially a transverse focusing device, able to confine a charged particle beam of any energy along its axis by the strong focusing action of a quadrupolar, electrostatic focusing field generated in it. This transverse focusing field is then perturbed to produce a longitudinal bunching and accelerating field that accelerates an injected ion beam. The resulting rf field in the RFQ takes on a repetitive pattern, called cells. Because the energy of the ion beam is low, the cells are short, and a structure of reasonable lenght can contain many cells.

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The properties of the cells are changed slowly along the RFQ to produce first a bunching action and then acceleration. Thus, this ingenious circuit allows an almost adiabatic handling of the ion beam, and that is why its transmission and beam-quality preserving characteristics are so remarkable.

The RFQ revolutionized the development of ion accelerators. Everything had to be learned and developed about it - theoretical and analytical models, simulation models, and fully operational hardware. We stirred the interest and help of other laboratories around the world, and the Keage Laboratory was among the first to start exploring the possibilities as part of its quest to build a kaon factory. Soon, experimental models were in use at Keage and various aspects of the RFQ were investigated[5].

At Los Alamos, work on accelerator structure modeling codes was being pushed hard. The SUPERFISH code, the first two-dimensional code to handle structures with cylindrical symmetry and modes without azimuthal variations, was being extended to "2 1/2" dimensions for handling modes with azimuthal variations (still in cylindrically symmetric structures). Y. Iwashita worked on development of the integral equations necessary in one approach to this problem, leading to a code called ULTRAFISH[6]. Subsequently, these codes have been extended to fully three-dimensional modeling in the MAFIA / POISSON code group.

The work at Keage progressed, and construction of a 7 MeV proton linear accelerator began, with an RFQ up to 2 Mev, followed by a drift-tube linac[7),8)]. New ground was also being broken in drift-tube linacs, especially with the introduction of permanent-magnet quadrupole focusing elements in the drift-tubes. Keage researchers made numerous innovative and efficient contributions to the manufacturing and precision measurement techniques[9)–14)].

In another work, typical of the pioneering outlook, yet another new type of low-velocity ion accelerator (again suggested by Soviet researchers) has been under study - the class of alternating-phase-focused linear accelerators. These devices also make use of only the rf fields for both focusing and acceleration, depending on complex methods of perturbation and hardware realization whose systematic application is not well understood outside the USSR, but whose performance, as cited in their literature, promises advantages in some application areas such as heavy-ion acceleration. Initial investigations by H. Okamoto[15] on the formulation of the beam dynamics in such devices resulted in a new approach to their characterization, and it is hoped that further development and hardware tests will be possible in the future.

The 7 MeV linac[16] is now being brought into operation at the Accelerator Laboratory in Uji. The Keage building remains as an important part of the cultural heritage of Kyoto and Japan, for its past glories as the site of the first hydroelectric power plant in Japan, the site of the influential and long-lived cyclotron, and the place where many students were well-trained by immersion in pioneering aspects of accelerator technology.

Prof. H. Takekoshi, whose retirement we celebrate with this issue, was a key figure in all these activities. May the Uji Laboratory and the spirit of Keage that fostered it live long.

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