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FOREIGN TRIP REPORT

ORNL/FTR-2927

DATE: July 6, 1988

SUBJECT: Report of Foreign Travel by G. D. Alton, Staff Physicist, Physics Division

TO: Alexander Zucker

FROM: G. D. Alton

PURPOSE

To visit the National Laboratory for High Energy Physics (KEK), Tsukuba, Japan, for the primary purpose of testing the response of the University of Tsukuba tandem electrostatic accelerator to high-intensity (> 1 mA) pulsed heavy negative ion beams generated in the recently developed plasma sputter negative ion source; to participate in the Seventh International Conference on Ion Implantation Technology held in Kyoto, Japan, by chairing a session on ion sources and presenting an invited paper entitled "The Sputter Generation of High Intensity Negative Ion Beams." To visit the Institute for Nuclear Study, University of Tokyo, Tanashi-shi, Japan, and present a seminar entitled "A High Intensity Negative Ion Source: Formation Mechanisms and Performance."

SITES VISITED

5/16-6/4/88	National Laboratory for High Energy Physics (KEK)	Tsukuba, Japan	S. Fukumoto Y. Mori
6/5-11/88	Seventh International Conference on Ion Implantation Technology	Kyoto, Japan	T. Takagi I. Yamada
6/13/88	Institute for Nuclear Study (INS)	Tanashi-shi, Japan	M. Sekiguchi
6/14-15/88	National Laboratory for High Energy Physics (KEK)	Tsukuba, Japan	S. Fukumoto Y. Mori

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ABSTRACT

A working visit was made to the National Laboratory for High Energy Physics, Tsukuba, Japan, during the time periods 5/16-6/4/88 and 6/14-15/88 for the purposes of further evaluation of the high intensity plasma sputter negative ion source and to test the response of the University of Tsukuba 13-MV tandem accelerator to mA intensity level pulsed mode heavy negative ion beams. During the visit, the traveler worked in collaboration with Japanese scientists in installing and testing of the source on the University of Tsukuba tandem electrostatic accelerator injector. During the course of preliminary testing of the ion source and prior to actual injection into the accelerator, sparking began in one or more tube sections, which ultimately led to the decision to replace the damaged tube sections. This problem led to postponement of the scheduled tandem accelerator tests.

The traveler attended the Seventh International Conference on Ion Implantation Technology held in the International Conference Hall, Kyoto, Japan, on June 5-11, 1988, where he chaired a session on ion sources and presented an invited paper entitled "The Sputter Generation of High Intensity Negative Ion Beams."

Following the conference, the traveler was invited to visit the Institute for Nuclear Study, the University of Tokyo, Tanashi-shi, Japan, for the purpose of presenting a seminar entitled "A High Intensity Plasma Sputter Negative Ion Source: Formation Mechanisms and Performance."

This report summarizes the pertinent information and impressions gained during these visits.

KEK

A working visit was made to the National Laboratory for High Energy Physics (KEK), Tsukuba, Japan, during the time periods May 16-June 4 and June 14-15, 1988, for the primary purpose of testing the response of the University of Tsukuba 13-MV tandem electrostatic accelerator to high-intensity pulsed negative ion beams generated in the high-intensity plasma sputter negative ion source developed in collaboration with KEK personnel during a December 1987-January 1988 visit to KEK. For more specific details concerning the facilities within KEK and the high-intensity negative ion source, the reader is referred to the foreign trip reports issued following the June 1987 (ORNL/FTR-2573) and December 1987-January 1988 (ORNL/FTR-2809) visits to KEK.

During the interim between the December 1987-January 1988 visit and arrival at KEK for the subject period, the traveler, at the request of Harvey Wegner and Peter Thieberger of Brookhaven National Laboratory (BNL), initiated negotiations between KEK and BNL for the use of the KEK high-intensity plasma sputter negative ion source in testing the response of the BNL MP tandem accelerator to mA intensity level negative ion beams. BNL is extremely interested in the new source for heavy ion injection into the AGS when the booster/AGS ring is completed. Successful injection and acceleration of such beams through the MP tandem would also place the MP tandem in strong contention with the proposed electron beam ion source (EBIS)/linear accelerator combination for consideration as an injector into the relativistic heavy ion

collider (RHIC). The traveler and Japanese colleagues met with BNL high-energy physicists Lowenstein and Adair, members of the Japanese/American Collaboration Committee, who coincidentally were meeting at KEK to set up next year's budget for Japanese/American collaborative high-energy physics research. The purpose of this meeting was to establish the funding level necessary for testing of the BNL MP tandem with mA intensity pulsed negative ion beams from the KEK source and to include the project as one of the Japanese/American high-energy physics collaborative activities. The KEK ion source/MP tandem project was estimated to cost the equivalent of a three-man-year effort (3 million yen) to be budgeted through the Japanese/American High-Energy Physics Collaboration Group. Planned testing of the BNL MP tandem was tentatively set for August-September 1988. This activity will involve personnel from KEK, BNL, and the traveler.

While visiting KEK, the traveler assisted in installation of the high-intensity plasma sputter negative ion source on the injector at the University of Tsukuba tandem electrostatic accelerator. The adaption of the source to the Tsukuba tandem required extensive and expensive modifications to the Tsukuba tandem injector and source pumping system. During the course of the installation period, the Tsukuba tandem accelerator developed severe sparking conditions in one or more tube units and a noisy pelletron chain bearing. After more than one week's effort to find an external solution to the sparking problem by operating the tandem under lower gradient voltage conditions, a decision was made to replace the damaged tube section or sections. This forced a postponement of the scheduled high-intensity negative ion beam injection/tandem response experiments.

KEK has duplicated a volume H^- source based on the Los Alamos National Laboratory/Berkeley design for test and evaluation for possible use in conjunction with the proposed RFQ-injected high-intensity hadron facility described briefly by the traveler in a February 1988 foreign trip report. The proposed hadron facility will use an RFQ-injected 1 GeV linac. The volume source was built because it has a lower intrinsic emittance than the multi-cusp magnetic field H^- ion source. The limiting acceptance of the RFQ ($\leq 140\ \pi$ mm.mrad) and the need for high-intensity H^- ($I > 40$ mA) beams in this facility require that the transverse phase space (emittance) of the source used be less than or equal to $\varepsilon_n < 1\pi$ mm.mrad, where ε_n is normalized by $\beta = v/c$. The volume source, while meeting the phase space requirements, can only produce peak H^- currents of $I \simeq 3$ mA. Thus, the beam intensities from the new volume source appear to make the source unattractive for this application. Concentrated efforts to find a solution to this problem are under way.

A high-intensity positive ion plasma volume source has also been constructed. The source will be used to produce argon ion beams of $I \geq 100$ mA. The intended use of this multiple-aperture source will be to test the feasibility of sputter coating of rf superconducting cavities with Nb. The source is an axial extraction version of the multi-cusp magnetic field surface source with LaB_6 filaments positioned radially about the source body. The source runs extremely quiet and reportedly has a lifetime of ~ 300 hours for an arc voltage of 10 V and an arc current of 5-6 A.

Two major synchrotron accelerator-based radiological cancer research/treatment facilities are either under construction or under proposal in Japan.

The first of these facilities was begun in 1987 under the aegis of the National Institute for Radiological Science, which is funded by the Ministry of Science and Technology. The facility is now under construction at Chiba-shi, Chiba-ken. The synchrotron facility will utilize heavy ions (He through Ar) for cancer treatment and research. The cost of the entire complex (accelerator, treatment rooms, and administrative buildings is estimated at 36 x 10^9 yen (~ $288 M) and will be totally constructed underground.

A proton/synchrotron cancer treatment facility is also being proposed. If funded, the facility will be attached to the University of Tsukuba hospital for treatment of cancer patients. The present design calls for a proton synchrotron injected by a tandem accelerator which will provide 230-MeV protons for radiation cancer therapy. The estimated cost of the accelerator alone will be 2.5 x 10^9 yen (~ $20 M) with at least another 2.5 x 10^9 yen (~ $20 M) required for treatment facilities and equipment. This facility will be funded through the Ministry of Education and Culture. Professor Sadayoshi Fukumoto of KEK is in charge of the design of the synchrotron.

THE SEVENTH INTERNATIONAL CONFERENCE ON ION IMPLANTATION TECHNOLOGY

The traveler attended the Seventh International Conference on Ion Implantation Technology held at the Kyoto International Hall, Kyoto, Japan, June 5-11, 1988, where he chaired a session on ion sources and presented an invited paper entitled "The Sputter Generation of Negative Ion Beams." The Conference was well organized and executed efficiently in typical Japanese fashion. The Conference is held biennially with the objectives of providing information on the process requirements for ion implantation, the design and performance of ion implantation equipment for industrial applications, as well as new materials fabrication, and the performance of new implantation devices. The Conference was attended by ~ 450 people from more than 23 countries. More than 250 technical papers were presented on a variety of subjects. Sessions were held on Ion Sources, Ion Beam Transport, Ion Implantation and Ion Beam Interactions with Solids, Ion Implantation Equipment for VLSI and Advanced Materials, Applications for New Materials and Devices, Emerging Processes for VLS, and Advanced Materials and Special Topics. In addition to the traveler's paper, invited papers were presented by Bill Appleton, Acting Associate Director of Physical Sciences, and Jim Williams of the Solid State Division of ORNL. The ORNL papers were all well received.

INSTITUTE FOR NUCLEAR STUDY (INS)

Following the Seventh International Conference on Ion Implantation Technology, the traveler was invited on June 13 by the Institute for Nuclear Study, the University of Tokyo, Tanashi-shi, to present an informal seminar entitled "A High-Intensity Plasma Sputter Heavy Negative Ion Source: Formation Mechanisms and Performance." The seminar was well attended and prompted many questions concerning the new high-intensity negative ion source recently developed in collaboration with KEK scientists, particularly related to its potential for use with heavy ion synchrotron applications such as in conjunction with the TARN II synchrotron at INS. For details regarding the

TARN II project, the reader is referred to ORNL/FTR-2573 associated with a June 1987 visit to that facility by the traveler.

Following the seminar, the traveler was given a brief tour of the TARN II facility and a close look at the new ECR source under development at INS.

Moderate progress has been made toward completion of the TARN II heavy ion synchrotron since the traveler's June 1987 visit to the INS. Specifically, the magnet for the electron beam cooler has been fabricated and the cooler system installed within the magnet. The electron beam cooling section of the synchrotron is mounted on a track so that the total section can be withdrawn from the ring for servicing or repair. The electron beam cooler was designed and constructed over a three-year period with funds allocated at the rate of 40 x 10^6 yen per year (~ $320 K/year) by the Ministry of Education and Culture. Progress toward completion of TARN II has been seriously impeded by the lack of funds for the project. However, the Ministry of Education and Culture has recently agreed to provide funds in the amount of 260 x 10^6 yen (~ $2.1 x 10^6) per year for a two-to-three-year period for completion of the project. The principal work remaining for completion appears to be in the assembly and testing of the synchrotron. All major components appear to be fabricated and delivered.

Professor M. Sekiguchi has recently completed the design and construction of a two-stage ECR source which is now undergoing testing. The source is a conventional two-stage design equipped with a 6.4-GHz parallel rf power feed system for plasma generation within the first and second stages. The source employs standard water-cooled solenoid magnets to provide mirror magnetic field confinement and separation of the two stages. Radial plasma confinement within a particular stage is effected by a sextupole magnetic field produced by samarium-cobalt permanent magnets arranged circumferentially about the stainless steel vacuum chamber. Each stage is independently pumped by means of 1500 L/s turbomolecular systems. The source was designed and constructed over a two-year period. First discharge and extraction tests were initiated in June of this year. The source will be used to inject into the K = 68 cyclotron which, in turn, will serve as the injector for the TARN II synchrotron.

APPENDIX A

ITINERARY

5/12-13/88	Travel from Kingston, Tennessee, to Tsukuba, Japan, via plane
5/14-15	Weekend
5/16-6/4	National Laboratory for High Energy Physics, Tsukuba, Japan
6/4	Travel to Kyoto, Japan
6/5-11	Seventh International Conference on Ion Implantation Technology, Kyoto, Japan
6/12	Travel to Tanashi-shi, Japan
6/13	Institute of Nuclear Studies (INS), Tanashi-shi, Japan
6/13	Travel to Tsukuba, Japan
6/14-15	National Laboratory for High Energy Physics, Tsukuba, Japan
6/16	Travel to Kingston, Tennessee, via plane

APPENDIX B

PERSONS CONTACTED

National Laboratory for High Energy Physics

S. Fukumoto, Group Leader, 12-GeV Proton Synchrotron
Y. Mori, Ion Source Physicist
S. Ozaki, Director, Accelerators Division

Seventh International Ion Implantation Conference

T. Takagi, Conference Chairman
I. Yamada, Conference Secretary

Institute of Nuclear Studies

M. Sekiguchi, Accelerator Physicist

APPENDIX C

DOCUMENTS RECEIVED

Engineering drawings of the volume plasma discharge positive ion source.

DISTRIBUTION

1. G. J. Bradley, Assistant Secretary for International Affairs, DOE, Washington
2. Wilmont N. Hess, Associate Director for High Energy and Nuclear Physics, Office of Energy Research, DOE, Washington
3. D. L. Hendrie, Director of Nuclear Physics, Office of High Energy and Nuclear Physics, Office of Energy Research, DOE, Washington
4. Director, Division of Safeguards and Security, DOE, Washington
5. Director, Division of International Security Affairs, DOE, Washington
6. J. A. Lenhard, DOE/ORO
7. D. J. Cook, Director, Division of Safeguards and Security, DOE/ORO
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38-39. Laboratory Records Department
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Destination(s) and Dates for Which Trip Report Being Submitted: 5/16-6/4/88, Tsukuba; 6/5-11/88, Kyoto; 6/13/88, Tanashi-shi; 6/14-15/88, Tsukuba; Japan

Name of Traveler: G. D. Alton

Joint Trip Report: ☐ Yes

■ No

If so, Name of Other Traveler(s):

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BEGINNING OF RECORD
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