STATUS OF THE SIAM PHOTON LABORATORY

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Abstract

The Present status of the Siam Photon Laboratory is reported. The assembly of the accelerator complex with a 1 GeV storage ring has been completed. The commissioning of the accelerator complex has just started. However, there remain some problems to be solved. The work of conceptual design and the determination of the specifications of the undulator to be installed in the storage ring have been completed. The installation of the first two beam lines has started already. Other items such as the infrastructure reformation, the organization development, and the human resources development are also described.

1. INTRODUCTION

The synchrotron radiation research project of Thailand is referred to as the Siam Photon Project. The contents of this project have been reported in many places [1-4]. This Project aims at promoting the scientific and technological level of Thailand to that of the world frontier in the field of the accelerator technology, materials science, the utilization of brilliant soft and hard x-rays in industrial processing, and life sciences. The Siam Photon Project comprises

(1) Building an accelerator complex consisting of a 1.0 GeV light source storage ring, a 1.0 GeV booster synchrotron and a 40 MeV injector linac, along with the beam transport lines between the component accelerators,
(2) Building associated beam lines and experimental stations,
(3) Fulfilling the experimental researches using the beam lines,
(4) Training and educating young scientists and engineers using the constructed light source facilities to make them experts in the relevant research fields.

The Siam Photon Project is promoted by the Ministry of Science Technology and Environment (MOSTE). This government agency established the National Synchrotron Research Center (NSRC) to realize the Siam Photon Project. NSRC is located in the campus of the Suranaree University of Technology at Nakhon Ratchasima, about 250 km to the north east of Bangkok. NSRC is under the supervision of MOSTE
and not a completely autonomous entity. The Executive Committee (NSRC Board) of MOSTE is the decision making sector. The construction of NSRC Laboratory building was completed in November 1999.

The accelerator complex was the reformed SORTEC accelerator system that was owned by the SORTEC Laboratory in Tsukuba, Japan [1-4]. The SORTEC accelerator system was dismantled and the components were transferred to NSRC in 1996. Among the component accelerators of the accelerator complex, the injector linac and the booster synchrotron were not reformed and the ones with original structures were used in the Siam Photon Source. The original SORTEC storage ring was designed to be optimized for the microlithography research and not quite suitable for the general scientific researches. Thus, the storage ring structure was changed to be suitable for the scientific use [1-4]. The storage ring was reformed so that it has four long straight sections and the beam natural emittance one seventh as small as that of the original SORTEC storage ring. Reformed portions are

(1) Change in the magnet lattice from the quadrupole doublet lattice to the double bend achromat (DBA) lattice,
(2) The addition of quadruple magnets, sextuple magnets and steering magnets,
(3) The addition of four long straight sections for insertion devices,
(4) The renewal of the machine control system,
(5) The renewal of the vacuum chambers.

In addition to these, the structure of the high energy beam transport (HBT) line connecting the synchrotron with the storage ring was changed. In this part, the electron beam is deflected twice horizontally. The bending angles are kept to be small so that the beam profile is not deformed much. The HBT line is deflected also twice vertically, once upward and then downward toward the horizontal direction. Thus, not only bending magnets are replaced but a few focusing and steering magnets are added to the HBT line. On the other hand, the low energy beam transport (LBT) line connecting the linac to the synchrotron was not reformed. It has the magnet lattice structure of the DBA lattice. The line is equipped with a Faraday cup for the measurements of the spectrum of the electron beam.

Among the component accelerators in the accelerator complex, the linac and the synchrotron were installed underground. This facilitates the radiation shielding and the beam injection to the storage ring from the inside of

the ring. By the injection from the inside, all the space around the storage ring can be used for experiments. Because the synchrotron is installed underground and the storage ring on the ground level, the HBT line has to be deflected twice vertically as mentioned before. The technical details have been reported elsewhere.

In the past five years, NSRC has grown as a research organization and its size expanded several times larger as compared with that four years ago. In addition to the scientific and technological issues, the description of the organization as an administration body appears also to be pertinent here. Another important issue to be considered is the infrastructure. An advanced facility is supported by a good infrastructure system. This point shall also be mentioned. In this report, the present status of the Siam Photon Project is described.

2. NSRC ORGANIZATION

NSRC has been growing steadily and its organization has been changing so far. It is still changing. The organization consists of two major sectors, the Administration Sector and the Technical Sector, as is the case in ordinary research institutes.

The Administration Sector is just ordinary one. It has several groups:

- General Administration and Secretariat Section,
- Procurement Section,
- Account Section,
- Planning Section,
- Personnel Section,
- Publicity Section
- Library,

Among the sections described above, the publicity section is founded for the purpose to publicize the activity of NSRC to people in the country. At present, this section is carrying out the work for the publication of a periodical and the preparation of the NSRC introduction by means of the multimedia presentation.

The Library started with about 1800 books and some old back numbers of Physical Review donated by the Institute of Solid State Physics, University of Tokyo. Newly issued books are being collected. The subscription of several important international journals pertaining to the purpose of NSRC will start soon. The construction of the new library room in the head quarters building has been completed. The number of the staff members of the Administration Sector is 21.

Technical Sector consists of three groups, the Machine Group, the Beam Line Group and the Technical Support Group. Each group has several subgroups. The Machine Group comprises the following subgroups:

- Linac and Low Energy Beam Transport Line Group
- Synchrotron and Storage Ring Group
- Machine Control Group
- Electronics Group
- Insertion Device and Beam Analysis Group
- Machine Support Group

The missions of these subgroups are obvious from their names. The Technical Sectors have subgroups different from ones shown above. They are:

- Vacuum Engineering Group
- RF Acceleration Group
- Magnet Group

The members of these subgroups belong to the subgroups classified according to the component accelerators. The Synchrotron and Storage Ring Group also maintains the HBT line. The numbers of the staff members of the Machine Group is 18.

The Beam Line Group consists of three subgroups,

- VUV-SX Spectroscopy Group
- X-ray Utilization Group,
- Beam Line Instrumentation Group,

The VUV-SX Spectroscopy Group deals with the construction of the beamline for the experiments with vacuum ultraviolet light and soft X-rays. The photoemission experimental station is handled by this group. The Group will carry out the research work using the beam line. The X-ray Utilization Group deals with the construction of the beam lines for experiments using X-rays and will carry out experimental researches using the beam lines. At present, the members of this group are carrying out sample preparation. The work is for attaining the technique to crystallize proteins. In order to assist the construction work, the Beam Line Instrumentation group carries out the necessary hardware work. The number of the staff members of the Beam Line Group is 12.

The Technical Support Group deals mainly with the maintenance and reformation of the building and utilities. The Technical Support Group comprises four subgroups,

- Water Facilities Group,
- Electricity Facilities Group,
- Building Maintenance Group,
- Air Conditioning System Group,

The total number of the staff members of the Technical Support Group is 11.

The number of the staff members of Technical Sector is 41. The total number of staff members in NSRC is 62. This number shall be increased to 78 in the future.

3. RESEARCHES, REPORT AND PUBLICITY

Since the Siam Photon Laboratory is still in the construction stage, the scientific investigations of materials using synchrotron radiation have not started yet. Research work having been carried out so far is mostly on the design studies. More practically, they are on the

beam dynamics calculations, the design work for the machine control system, characteristics measurements and related analyses of the RF acceleration systems, and the beam line design work. The total number of the publications in the past five years including the status reports is 30. We expect that routine scientific research will start early in 2002.

Regarding publicity, NSRC issues regular News Letters monthly. Four brochures explaining NSRC are available. NSRC has issued small books on the Applications of Synchrotron Radiation. A diskette for the multimedia presentation of the Siam Photon Project and the Siam Photon Laboratory is also available. NSRC has the home page on the website: http://www.nsrc.or.th/. Most of the materials described above are written in Thai, for the public relation to the Thai people including these involved in research work and educational activities is more important for the Siam Photon Project than that to the outside of the country.

4. MACHINE REASSEMBLY

The machine assembly work has been almost finished. The preparatory machine commissioning work has started in August this year. The machine assembly work proceeded in the following way:

(1) The building was surveyed so that we mark standard reference points in the accelerator rooms. The component accelerators are installed and aligned according to the settled reference points.
(2) The installation and alignment were first carried out on the synchrotron and then on the linac and LBT line. The installation and alignment of the storage ring were carried out after the component accelerators and the LBT line in the underground rooms were aligned.
(3) The HBT line was aligned after all the component accelerators were aligned.
(4) The baking of the vacuum chambers of the storage ring was carried out after the machine had been aligned. At present, the pressure inside the vacuum chamber is in the range of 10^{-11} Torr.
(5) Almost at the same time as the installation work was underway, the performance of various power supplies and controllers were inspected. Broken components were either repaired or replaced.
(6) Major wiring work was carried out at the same time as (5).
(7) The installation of the new machine control system was implemented after the main hardware work had been finished [5,6].
(8) In the very last stage of the reassembly work, radiation monitors were installed and their performances were examined.

Up to the present, the proper operation of the linac and the LBT line was confirmed. During the course of the operation test, we found many troubles caused by the degradation of components. They were repaired except one in the machine control system. It is the synchronous pulse generator. In this case, a unit consisting of a partly repaired panel and newly built components is serving as the synchronous pulse generator. With this unit, the beam injection operation can be carried out. This will be mentioned later.

The performance test and characteristics measurements have been carried out on the RF acceleration systems of the accelerator complex including that of the linac. The complete investigation with the electron beam load has not yet been accomplished, but the performance and characteristics measurements made so far indicate that beam filling will be achievable. At present, the construction of a very final portion of the radiation safety system is underway.

5. TROUBLES

Since the original SORTEC machine was built 13 years ago and the dismantled components remained unused over 5 years, some component elements such as power supplies and controllers are found not to work properly. During the course of the reassembling work, all the components were examined carefully and broken parts were either replaced or repaired. More definitely, examples are as follows:

- The degradation in lubricant in mechanical components like fans for cooling.
- Rust or corrosion in the water supply systems.
- Incorrect indication of meters such as pressure gauges and flow meters.
- The breakdown of the 5th harmonics filter associated with the synchrotron power supply.
- The breakdown of ion pump controllers.
- The breakdown of water temperature controllers.
- The breakdown of the component circuits of some magnet power supplies.
- The leak in the RF tuner bellows.
- The breakdown of the synchronous pulse generator in the machine control system.

The troubles in the synchronous pulse generator are the most serious one. The source of the troubles of the synchronous pulse generator appear to be two fold. One was caused by the death of a battery supplying power to circuit boards. The memories input in them disappeared. The other is the breakdown of the software storage part of a computer installed in the synchronous pulse generator. The parts of the lost memories were repaired by replacing the batteries and inputting the memories. However, a part of the computer installed in the synchronous pulse generator could not be repaired. Thus, the SORTEC timer system was abandoned. Instead, a new timer system has been made. The work has not been completed yet. At present, the repaired part of the old

synchronous pulse generator and a part of the newly built system are combined together to generate a synchronous pulses switching the beam injection system.

Troubles occurred also in the aluminum vacuum chambers. Some of them were cracked during transportation. They were not fatal and welded again.

Another serious problem is the heterogeneous floor settlement in the machine room. In the case of the synchrotron room, the difference of the floor level that moved in 4 months amounted up to 5 mm. The synchrotron was realigned. The similar heterogeneous floor settlement was found in the storage ring room, although the amount of the floor shift was smaller. As a measure for this, the electron beam location adjustment by the use of steering magnets is considered. In spite of repeated inspection work, the cause of the heterogeneous floor settlement has not yet been clarified.

Some other troubles in utilities were found. They are mostly in the water supply systems. One of the troubles for which we spent plenty of time for repairing is the corrosion of the tubes of the pure water supply. Rust was found at many welded parts. The causes were the use of improper welding rods and poor workmanship. All the welded parts were cut off and welded newly. About three months were spent for this repair work.

Another serious problem in utilities is the blowing out of fuses in a static condenser unit in the power supply line. This occurred twice. We have the doubt that the breakdown of the 5th harmonics filter mentioned above is related with the cause of the blowing out of the fuses in the static condenser unit. Various measurements are underway to find the cause and the measures. A headache source is an occasional power failure. We use a combination of UPS and a diesel generator. We are increasing the capacity of the UPS system.

6. INSERTION DEVICE DESIGN

The conceptual design work for the undulator to be installed in the storage ring has been finished. The undulator is planer and of the Hallback type. It has only one pair of magnet array. It is designed to generate light covering the spectral range from 20 eV to 600 eV using the 1st to 3rd harmonics lines. If we use up to the 5th harmonies line, we can expand the available spectral range to about 800 eV. The period length is 64 mm and total length is 2.5 m.

The vacuum chamber in the undulator part of the storage ring is made of stainless steel. We decided to use the vacuum chamber made of stainless steel in spite of the fact that other parts of the storage ring vacuum chambers are made of aluminum, because the stainless steel chamber is mechanically stronger than the aluminum chamber and the vertical chamber width can be made smaller. Thus we obtain a stronger magnetic field and a shorter wavelength cut off. The minimum magnet gap is 28 mm. Other details of the features of the undulator are not described here.

7. BEAM LINES

The construction of the first two beam lines is under way. [8,9] One of the beam lines is for the electron beam monitor with visible light (direct observation of the electron beam by synchrotron light). The other is for photoemission experiments. The construction of the beam line components was performed by TOYAMA in Japan. The assembly work on the site starts around September 10. The optical elements such as mirrors and gratings are supplied by Karls Zeiss. They are made of silicon crystals.

The construction of the photoemission experimental station has completed by VACUUM GENATOR in UK. The assembly work on the site will start in October.

The monochromator used is of the constant deflection angle type with the non-linearly varied spacing plane grating. An average resolving power of 5,000 is attained. Monochamatized light is focused on a sample as a small spot.

The photoemission system enables us to carry out the angled resolved photoemission measurements. At the initial stage we plan to do measurements at room temperature.

8. ASSOCIATED LABORATORY

In addition to the synchrotron radiation experiment building, NSRC owns the main building. In this building we have the administration office and some rooms for experiment preparation. The structure of the building has recently been reformed to certain extent. The number of office rooms for engineers and technicians has been increased much. We have a lecture hall and a library. There are five rooms for preparatory work. One room is used for the stock room. The machine shop is under construction.

9. HUMAN RESOURCES DEVELOPMENT AND SCHOOLS FOR TRAINING

In the fulfillment of the Siam Photon Project, the human resources development has been an important target of the project. One urgent issue is to train the engineers, scientists and technician in a short period regarding the items necessary urgently. The supply of the skilled manpower is the most important issue. So far, we have implemented some possible ways for this. One is the dispatch of engineers and scientists to advanced facilities

outside the country for a short period. The major facilities were KEK and SPring 8 in Japan.

NSRC and these two organizations have established the agreement on the collaboration on research and training. We also sent our engineers to factories where the newly added products were produced. The companies being concerned with so far are TOSHIBA for the control system, MISUBISHI Electric for the magnet system, ISHIKAWAJIMA HEAVY INDUSTRIES for the vacuum system, TOYAMA for the beam line optical system and VACUUM GENERATOR for the photoelectron spectrometer system.

The second is to educate graduate school students. This is being fulfilled by the Suranaree University of Technology. The students were sent to the graduate schools in Japan for carrying out the thesis experiments. This is implemented according to the graduate school education agreements with relevant universities. At present, we have this sort of collaboration agreement with the Graduate University for Advanced Studies and Tohoku University. The number of universities with which we will have the collaboration agreement will be increased in the near future. NSRC also prepare the scholarship to send the staff members to graduate schools in foreign countries.

The third is to invite experts from advanced facilities over the world. About ten experts have visited Thailand for this purpose. The number does not include those of the lecturers in ac-hoc schools for training. Three schools for training have been held so far. One is the general school for the applications of synchrotron radiation. Other two are for special topics: Protein crystallography and photoemission. NSRC has performed 22 seminars for the applications of synchrotron radiation over the country in the past one year.

10. FUTURE PROSPECTS

NSRC is considering to install superconducting magnet wigglers to produce X-rays in the near future. X-ray experiments under consideration are protein crystallography, ordinary X-ray diffraction experiments, XAFS measurements and materials characterization. The design work of the associated beam line has not yet started. The conceptual design work for the superconducting wiggler will start soon. In the future, one more beam line for the VUV-SX spectroscopy will be built.

Because of the financial difficulty, the practical start of the next five year plan will be delayed at least for a year. Concerning the accelerator complex, major work must be on the insertion device construction. Machine maintenance and refinement work also occupies the important situation. The new beam line construction continues also.

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