Current Status of TPS Construction

The civil-engineering project of TPS has finally been completed (Fig. 1). The final inspection for acceptance was performed in November 2013, after which the building was formally handed over to NSRRC. The permit to occupy the TPS building was granted by the government authority in September. After obtaining this permit, the installation of some accelerator components has immediately begun inside the TPS building (Fig. 2). Because of severe contamination from dust in the air inside the new TPS building, a full-scale installation would begin from February 2014 when the dust settles and is cleaned. For the designs of components of TPS accelerator, one can refer to NSRRC annual activity reports from year 2008 to 2012.

Fig. 1: A bird's-eye view of the TPS building.

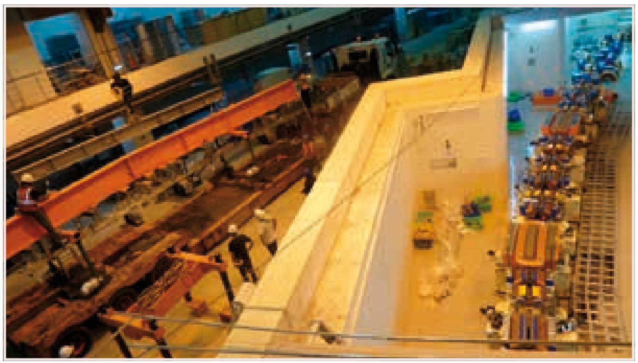

Fig. 2: Accelerator components were moved into the shielding tunnel in TPS.

The utility system has been installed during the construction of the TPS building. In December 2013 a preliminary inspection for acceptance of the utility system was made. After some final improvements it will be completed within six months. The total power capacity of TPS is estimated about 12.5 MW. There are four AC electric power substations distributed in the outer zone and eight in the inner zone of TPS building. All power stations and the main wiring work were completed during year 2013. By the end of that year, Taiwan Power Company provided 2 MW of power to the TPS building for the installation of accelerator components. The main pipes of chilled water, hot water and de-ionized water were installed. The main equipment of the de-ionized water system was installed in the new utility building. In the TPS building, 48 manifolds for de-ionized water are located on both sides of 24 Control Instrumentation Areas (CIA). The water resistance is maintained larger than 10 Ω; the pH will be controlled within 7 ± 0.5 and the concentration of oxygen within 10 ppb. The equipment to process the de-ionized water treatment is shown in Figs. 3 and 4. The equipment installation and piping work of the air-conditioning system were also accomplished. The fire alarm and extinguisher systems of the utility building and storage ring building have also passed the government test, which allows one to work inside the new building.

The 150-MeV Linac is a standalone system manufactured by Research Instruments GmbH. It was installed temporarily and tested in a test facility in 2011. This Linac was planned to be re-installed in the designated area in the TPS building beginning from February 2014. A re-commissioning will be held in May 2014.

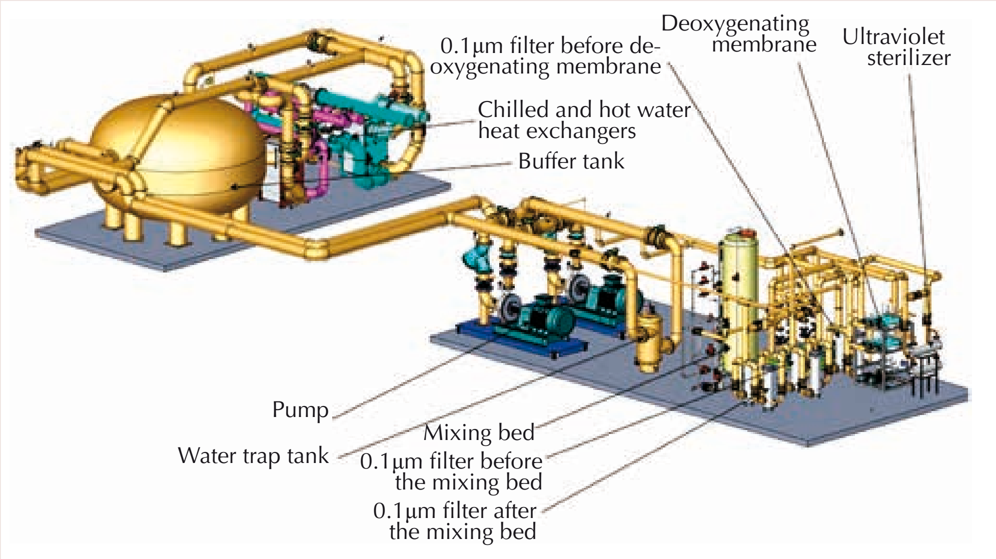

Fig. 3: Process of de-ionized water treatment.

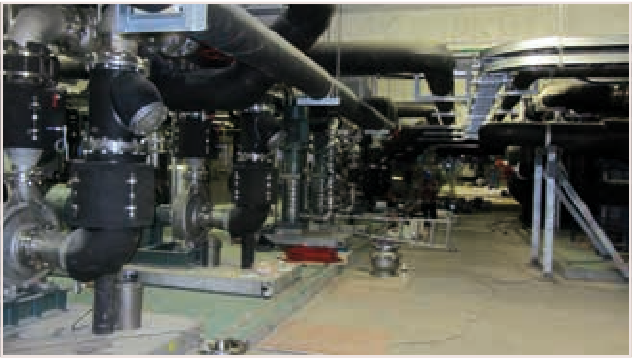

Fig. 4: The main pumping system for circulation of de-ionized water.

During the construction of TPS, a thorough survey network was established directly after the topping layer of the tunnel ground was grouted. The survey data for the entire ring of the tunnel for more than a year showed that the variations of positions fell within 3 - 10 mm in various areas because of the seasonal variation of temperature, the shrinkage of cement and the sectional ground grouting. A measurement of the TPS ground vibration, begun also after the major civil construction of TPS building, showed an evident influence of the local traffic and culture noise. The installation of pedestals and girders of the storage ring and booster wall brackets have begun since January 2013. By December 2013, more than 80 % of the pedestal and girder work was completed. In the first quarter of 2014, all installation of pedestals and girders is expected to be completed.

All twenty-four arc-cell vacuum chambers of 14 m in length for the electron storage ring have been assembled and baked to an ultra-high vacuum. The ultimate pressure of each cell attained 3×10^{-11} torr after baking, and most of them have vacuum better than 5×10^{-9} torr after vacuum sealing. The vacuum chambers for the straight sections have been installed and baked to attain an ultimate pressure less than 5×10^{-11} torr. All these chambers have been transported from the assembly factory to the TPS accelerator tunnel and installed on the pre-aligned girders with a precision about 0.1 mm, Fig. 5. All beam position monitors (BPM) for the storage ring in the arc sections and the straight sections have also been installed. Most elliptical stainless steel vacuum tubes of thickness 0.7 mm for the booster accelerator have been manufactured. All BPM ducts and pumping chambers in the vacuum chamber of the booster have also been manufactured and welded. The vacuum chambers for the ring injection septum, booster extraction septum, booster injection kicker, and ring injection kickers have been manufactured and tested

Fig. 5: Installation of a 14-m vacuum cell on the girders.

with pulsed magnets. All control racks and interlock systems for the storage ring and booster vacuum systems have already been installed in the 24 CIA.

The magnets of the storage ring and the booster were delivered to NSRRC by the end of September 2013. The verification of dimensions and field mapping of all these magnets were completed by the end of December 2013 at NSRRC. All power supplies for the magnets were delivered to NSRRC and tested; their performances were all within specification and will be ready for the installation in the second quarter of 2014.

After the helium cryogenic plant passed a performance test in January 2013, NSRRC accepted it from the vendor. Figure 6 shows the process of the cryogenic system. The liquefier and the dewar were relocated in the utility area inside the TPS building in July 2013 (Fig. 7). The system to transfer liquid-nitrogen was already completed; the liquid-helium transfer system should be installed by the end of May 2014. In July 2014 the liquid-helium supply will be ready for the SRF cavity. Three Petra cavities of copper type have been tested off-site at high power: one is for booster commissioning and its long term operation; the other two are for the storage ring commissioning with the beam current up to 100 mA. Three SRF modules have also been tested at high power and liquid-helium temperature with performance better than originally expected, $Q_o \geq 10^9$ at 2.4 MV, Fig. 8. The final assembly and testing of SRF electronics and water manifolds for SRF operation were completed. The installation and testing of the cryogenic piping for the SRF system is expected to begin from April 2014 and to be completed before the end of July 2014.

By December 2013, most hardware and software of the control system were ready for installation, but only limited activity was performed in the TPS site because of the environmental conditions inside the building. A full-scale installation of the control system has begun since spring 2014. A fiber network for the control system and a computer network were already installed. Computing instrumentation was installed at the network/server room. The EPICS will be used to provide the control software infrastructure to build a distributed control system for the accelerator of TPS.

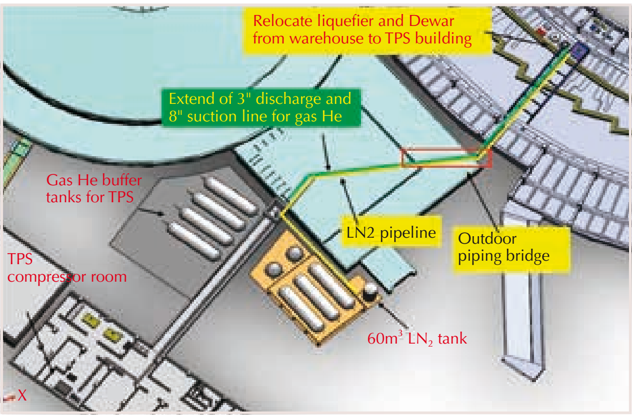

Fig. 6: The cryogenic system.

Fig. 7: The liquefier, 7000-L dewar and interconnecting piping in the TPS utility area.

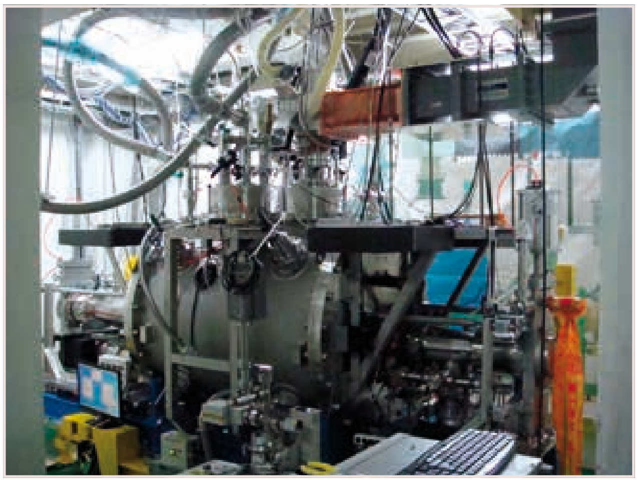

Fig. 8: SRF module and transmitter under testing in the laboratory.

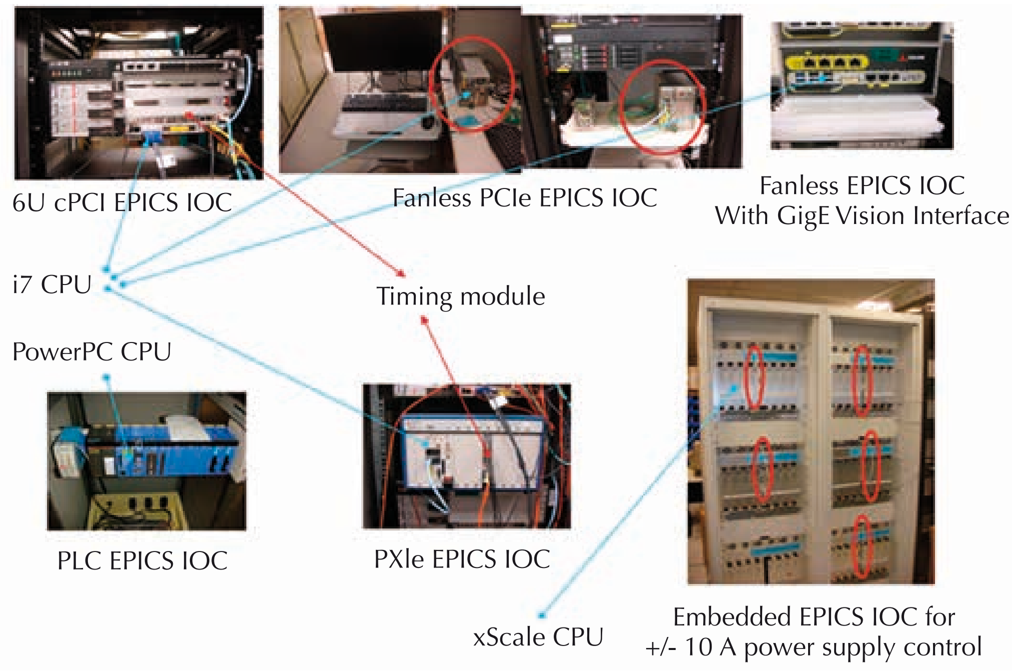

Fig. 9: EPICS IOC available for TPS accelerator controls.

About 250 sets of EPICS IOC will be installed for the TPS control system (Fig. 9), of which most have already been installed on site. The event-based timing system for TPS was already set up. The intensive tests of the short-term performance and long-term reliability for all power supplies and the control interface that will be used to control the accelerator have been undertaken. The tests of the BPM electronics (Fig. 10) have been performed to ensure that they fulfil the requirements. The fast orbit feedback algorithm was developed with the FPGA modules on the BPM platform; a full-scale test is planned in the second quarter of 2014. The installation of bunch-by-bunch feedback electronics, the filling-pattern monitor for the storage ring and the booster synchrotron, and the tuning monitor for the booster are in progress. The implementation of control systems for phase-I insertion devices is also in progress.

Fig. 10: BPM electronics and corrector power supplies installed at TPS equipment area for testing.

Seven front ends will be constructed for TPS in phase I. The general front-end design for an insertion device is shown in Fig. 11. Each front end has a heavy metal shutter (HMS), photon absorber (PAB), mask, X-ray beam-position monitor (XBPM), pre-mask and interlock subsystems. By the end of 2013, five HMS, four PAB, five masks, eight interlock subsystems, seven XBPM and a pre-mask subsystem were delivered.

For phase I, seven sets of IU22, one set of EPU46 and two sets of EPU48 are planned to be installed in seven separate straight sections. The in-vacuum undulators, seven IU22 with period length 22 mm, are constructed. Among these undulators, two have length 2 m and five have length 3 m. Two 2-m IU have already been delivered and tested at NSRRC. One IU22-3m and one IUT22-3m were delivered to NSRRC in December 2013; their acceptance test is planned in the first quarter of 2014. Both IU22-3m-2 and IU22-3m-3 will be delivered to NSRRC in December 2014. The EPU46 has also been delivered to NSRRC; the performance of its mechanical structure was improved and the magnetic field was shimmed by the Magnet Group of NSRRC. It is ready for installation in a 7-m straight section in 2014. The construction of two sets of EPU48 is in progress, to be completed in year 2014.

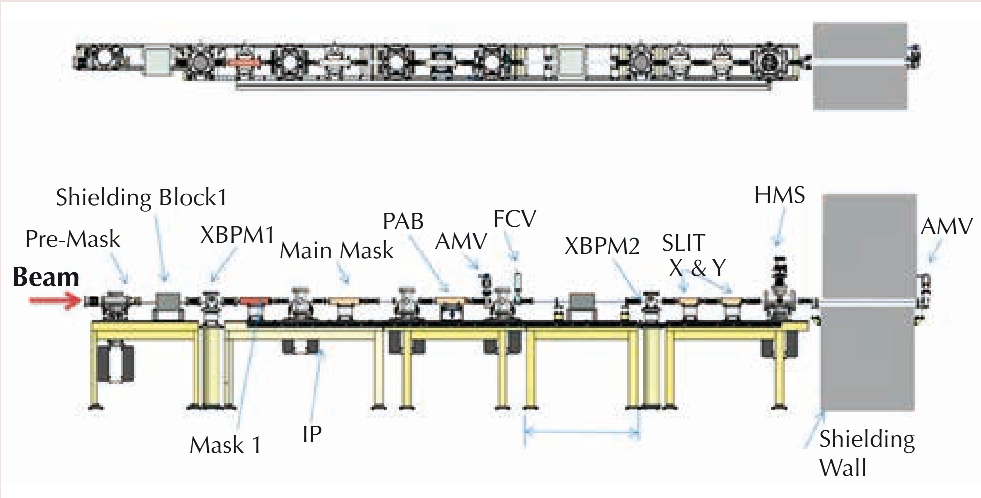

Fig. 11: General ID front-end design.

Highly Precise Temperature Control and Energy Saving for an Air-conditioning System

In an advanced accelerator facility, the performance of the accelerator and any experimental setup are sensitive to thermal effects. The utility system must be designed and constructed carefully to maintain the environment at a stable temperature. During the construction of the TPS building, the concept of a Green Building has been implemented. Decreasing energy consumption is thus an objective toward which NSRRC's Utility Group is striving. The heating, ventilation and air-conditioning (HVAC) system of the utility system has as its function to regulate the thermal energy to maintain a suitable temperature. The components of the HVAC system include dampers, supply and exhaust fans, filters, humidifiers, dehumidifiers, heating and cooling coils, pumps, valves, ducts and various sensors. All these components play a role in affecting directly the control of energy consumption of the HVAC system. Several methods of recovering heat have been studied in the HVAC system to save energy efficiently. A popular approach is to use a run-around coil in the air handling unit (AHU); this method is shown to be effective and can yield a significant saving of energy. The Utility Group has applied this method to a local AHU to maintain the temperature with a fluctuation less than ± 0.05 °C and to produce an energy saving up to 50 %.[1, 2] This method will be subsequently applied to the AHU in the TPS building as an energy saving measure.

In a regular AHU, two heat exchangers serve to adjust the temperature and to decrease the level of humidity in the air. When warm air passes the first cooling coil of the heat exchanger, the heat is carried away by the water, and water molecules in the air