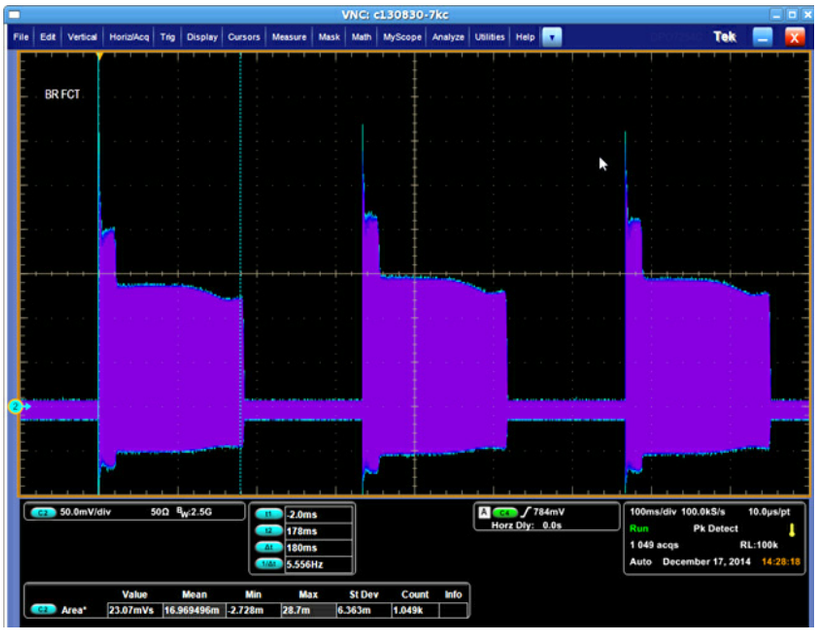
First Synchrotron Light of Taiwan Photon Source

On the last day of 2014, the newly completed second accelerator of the National Synchrotron Radiation Research Center (NSRRC), Taiwan Photon Source (TPS), delivered its first synchrotron light in the early afternoon. The electron beam energy of the TPS circulating in the storage ring has reached the design value of 3 GeV, and the stored beam current has achieved over 5 mA, marking a significant milestone for Taiwan's new synchrotron light source. After nearly five years of construction and development efforts in full scale, the successful commissioning of TPS will forever change the course of scientific research in Taiwan.



The accumulated beam in the TPS booster ring on December 16, 2014.

Construction of the TPS

The TPS construction project is fully supported by Taiwan's Ministry of Science and Technology (MOST) and its groundbreaking was held on February 7, 2010. Currently, the NSRRC has over 2,000 users, the largest number of users among all large-scaled scientific research facilities administered by MOST, who use it to conduct their research experiments using its first accelerator, the Taiwan Light Source (TLS). With the addition of the TPS, the largest experimental facility for multi-discipline cutting-edge research in Taiwan, the NSRRC aims to be one of the world's brightest synchrotron X-ray providers. The hope is that the TPS will create new scientific research opportunities, enhance Taiwan's academic competitiveness, and assist the high-tech industry in improving its R&D capability. The TPS is equipped with an accelerator of 3 GeV electron energy and a low-emittance synchrotron storage ring of 518.4 meters in circumference. The storage ring and the booster ring are designed in a concentric fashion and housed in a donut-shaped building next to a smaller circular building where the existing 1.5-GeV TLS sits. The dual rings will serve scientists worldwide who are in need of photons ranging from IR to hard X-ray spectrums for conducting experiments.

The first light from the storage ring was delivered on December 31, 2014.

The TPS team has overcome many unexpected challenges since day one. In order to meet the target milestone of commissioning by the end of 2014, civil construction and accelerator installation had to proceed simultaneously. With the existing administration building located in the center of the TPS construction work zone, the required standard of labor safety was scaled up and the coordination of construction traffic movement was a constant issue. Partial beneficial occupancy of the linac building and ring tunnel needed to

Table 1: Design of Taiwan Photon Source

Energy [GeV]: 3
High Brilliance ~ 10^{21} photon/s/mm^2/mrad^2/0.1% ($\Delta\lambda/\lambda$)
High flux with a maximum beam current [mA]: 500
Horizontal emittance [nm-rad]: 1.6
Storage ring circumference [m]: 518.4
Straight section: 12 m * 6 + 7 m * 18
Cell: 24 double-bend achromat (DBA)
Beam lifetime [hours] > 10
Operation mode: Top-up
Beam lines: 7 (phase I)

occur in the beginning of 2014 for the installation of ring components. Once pedestal paving and installation of piping and cable trays began, power supply and utilities were brought in, followed by setting up the booster ring and subsystems in the storage ring. After using alignment as the final tuning to target the exact position of each component, tests of integrated hardware for TPS commissioning were scheduled for the last quarter of 2014.

Since both the civil construction and the manufacturing of the accelerator proceeded in parallel, the TPS team needed to conduct acceptance tests of most subsystems off-site due to the compact and limited space in the NSRRC campus. They stored, disassembled, and moved the subsystems back to the TPS storage ring, and assembled and tested the subsystems again. As a result, the process nearly doubled the effort and work time, resulting in the TPS team, in most cases, operating on a 24-hour shift in order to maintain the given milestone and budget. The installation schedule was also determined by the availability of magnets. Thus, a two-step installation was implemented. In the first half of the ring, bare girders were in place first, followed by the installation of the magnets once delivered and then the vacuum chambers. For the second half of the ring, girders with pre-mounted magnets were installed and then the vacuum chambers followed.

The aerial view of the NSRRC showing the TPS (larger ring) and the TLS (smaller ring).

Commissioning and First Light

The TPS initiated its commissioning of the booster ring officially on December 12, 2014 after four months of hardware testing and improvement. The electron beam was accelerated to 3 GeV on December 16 and the booster's efficiency reached more than 60% after one day. The commissioning of the storage ring began on December 29. On the next day, the commissioning team injected the beam into the storage ring and the electrons completed circulating one cycle. The 3 GeV electron beam, with a stored current of 1 mA, was achieved and the first synchrotron light was observed in the early afternoon of December 31. Shortly, the stored current reached 5 mA in the late afternoon, right before the shutdown of the TPS for the New Year holiday. As of early February, the TPS stored beam current has increased to 100 mA.

The design of accelerators and components, quality control for subsystems, alignment for all components, integrated diagnostics and control systems, and various types of magnets is of a very high standard, resulting in speedy commissioning in the booster ring and the storage ring. In 2015, NSRRC will install two superconducting RF cavities for increasing the stored current up to 500 mA and 10 undulators. Five of seven Phase-I photon beamlines and their experimental stations will be completed for commissioning in 2015, with the remainder following in 2016. ■

NSRRC staff celebrates the successful TPS commissioning.

Diana Lin, Chien-Te Chen,
and Gwo-Huei Luo
National Synchrotron Radiation Research Center
Hsinchu, Taiwan