Status of the TPS Phase-I Beamlines

There are seven beamlines and their associated end stations being built under phase I of the TPS experimental facility buildup. Certain beamlines have branch beamlines and more than one end stations. They all use undulators as their light sources. Each beamline will be dedicated to one of the following seven experimental techniques: protein microcrystallography, resonant soft X-ray scattering, submicron soft X-ray spectroscopy, coherent X-ray scattering, submicron X-ray diffraction, X-ray nanoprobe, and temporally coherent X-ray diffraction.

Energy range, focus size, energy resolution, brilliance, and coherence of the light beam required by the experimental techniques and research goals dictate the specifications of the undulators and beamline optics for end stations using them. Resonant soft X-ray scattering relies on an intense photon flux for its success. Coherent X-ray scattering and temporally coherent X-ray diffraction require light sources of a high brilliance to deliver their promised performances. In light of these, these three beamlines are each equipped with two tandem

Table 1: Major parameters of the undulators for the TPS phase-I beamlines.

Beam-line code	Beamline name	Undulator								
		Type	Number	Effective length‡ (m)	Magnet period (mm)	Effective number of magnet periods	Smallest magnet gap (mm)	Maximum magnetic field# (T)	Largest deflection parameter	Photon energy range* (keV)
05A	Protein Microcrystallography	IU22	1	3.08	22	140	7†	0.76	1.56	5.7 - 20
41A	Resonant Soft X-ray Scattering	EPU48	2	3.22	48	67	13	V: 0.83 H: 0.55	V: 3.72 H: 2.47	0.40 - 1.50
45A	Submicron Soft X-ray Spectroscopy	EPU46	1	3.77	46	82	15§	V: 0.73 H: 0.47	V: 3.14 H: 2.02	0.35 - 1.50
25A	Coherent X-ray Scattering	IU22	2	3.08 2.09	22	140 95	7†	0.76 0.74	1.56 1.52	5 - 20
21A	Submicron X-ray Diffraction	IUT22	1	3.08	22	140	7† taper allowed	0.76	1.56	7 - 25
23A	X-ray Nanoprobe	IU22	1	3.08	22	140	7†	0.76	1.56	4 - 15
09A	Temporally Coherent X-ray Diffraction	IU22	2	3.08 2.09	22	140 95	7†	0.76 0.74	1.56 1.52	5.6 - 25

‡ Magnetic regions with fields below the effective field and shieldings at both ends of the magnetic array are not included. Also, this is not the length of the vacuum chamber housing the undulator.

\# Measured values. V denotes the vertical direction, and H the horizontal direction.

* Usable energy range of the light beam after passing through the beamline optics.

† Ultimate goal: 5 mm.

§ Ultimate goal: 13.5 mm.

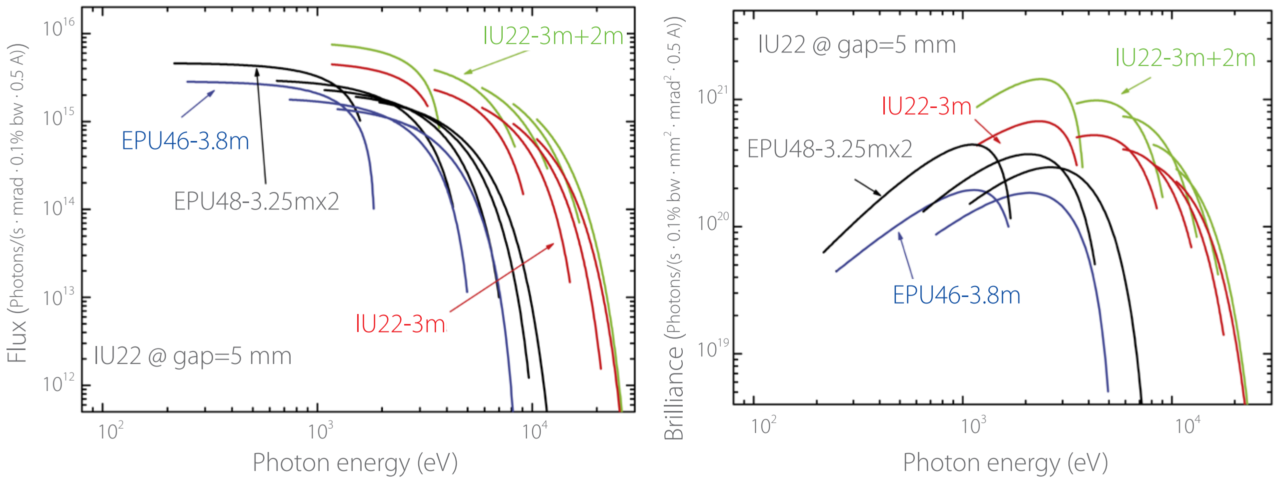

Fig. 1: The photon fluxes and brilliances of the undulators and undulator pairs for the TPS phase-I beamlines, each as a function of the photon energy.

undulators as their light sources, as the photon flux and thus brilliance of an undulator are proportional to the square of the number of the magnet period. The longer the magnet (the greater number of the magnet period), the higher flux and brilliance an undulator can provide.

Among the seven beamlines, two (resonant soft X-ray scattering and submicron soft X-ray spectroscopy) use elliptically polarized undulators, and one (submicron X-ray diffraction) uses an undulator capable of being tapered. In the tapered mode of operation, the undulator's magnet gap gets progressively bigger along the electron beam path, and the light fluxes of the fundamental and harmonic peaks of the undulator will be reduced and re-distributed in between their peaks, making the flux distribution more uniform across the photon energy range, to facilitate acquisition of the Laue diffraction image.

Listed in Table 1 are the major parameters of the undulators for the TPS phase-I experimental facilities. All together, the seven beamlines use two EPU48, one EPU46, one 3.08-meter long IUT22, four 3.08-meter long IU22, and two 2.09-meter long IU22 undulator modules. The light fluxes and brilliances of these undulators prior to entering the beamlines are plotted in Fig. 1. (The flux and brilliance of the IUT22, when not tapered, are the same as those of the IU22, and therefore are not plotted separately.)

2014 at the NSRRC ended on a high note, as the TPS storage ring achieved a stored electron beam current above 1 mA at the design energy of 3 GeV after only a short period of commissioning. The beam current was raised subsequently within a few days to 50 mA to clean the vacuum chamber walls through photodesorption. In early April, 2015, the storage ring will be shut down, and the undulators and superconducting RF cavities will be installed in the storage ring. Phase two of the TPS storage ring commissioning will begin in early September, 2015.

Installation of the beamline optics and end stations will kick into high gear starting in February, 2015. Five of the seven beamlines and their associated end stations will have finished their commissioning at the end of 2015. The other two beamlines (X-ray nanoprobe and temporally coherent X-ray diffraction) and their associated end stations are scheduled to finish their commissioning at the end of June and in mid-August, 2016, respectively. Figure 2 displays the overall implementation schedules of the seven beamlines. (Reported by Kai-Dee Lee)

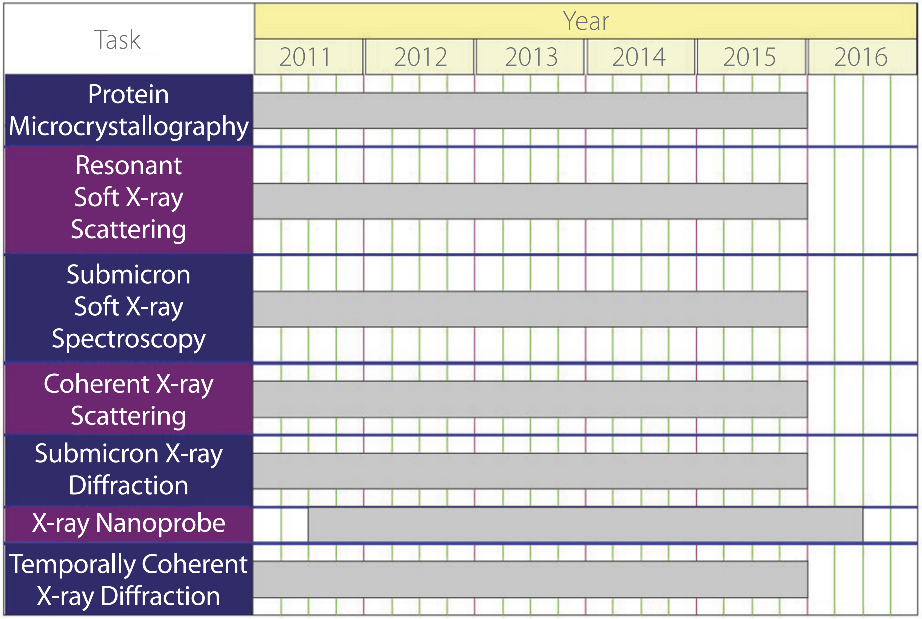

Fig. 2: The overall schedules, from design, manufacture, installation, to commissioning of the seven TPS phase-I beamlines and their associated undulators and end stations.