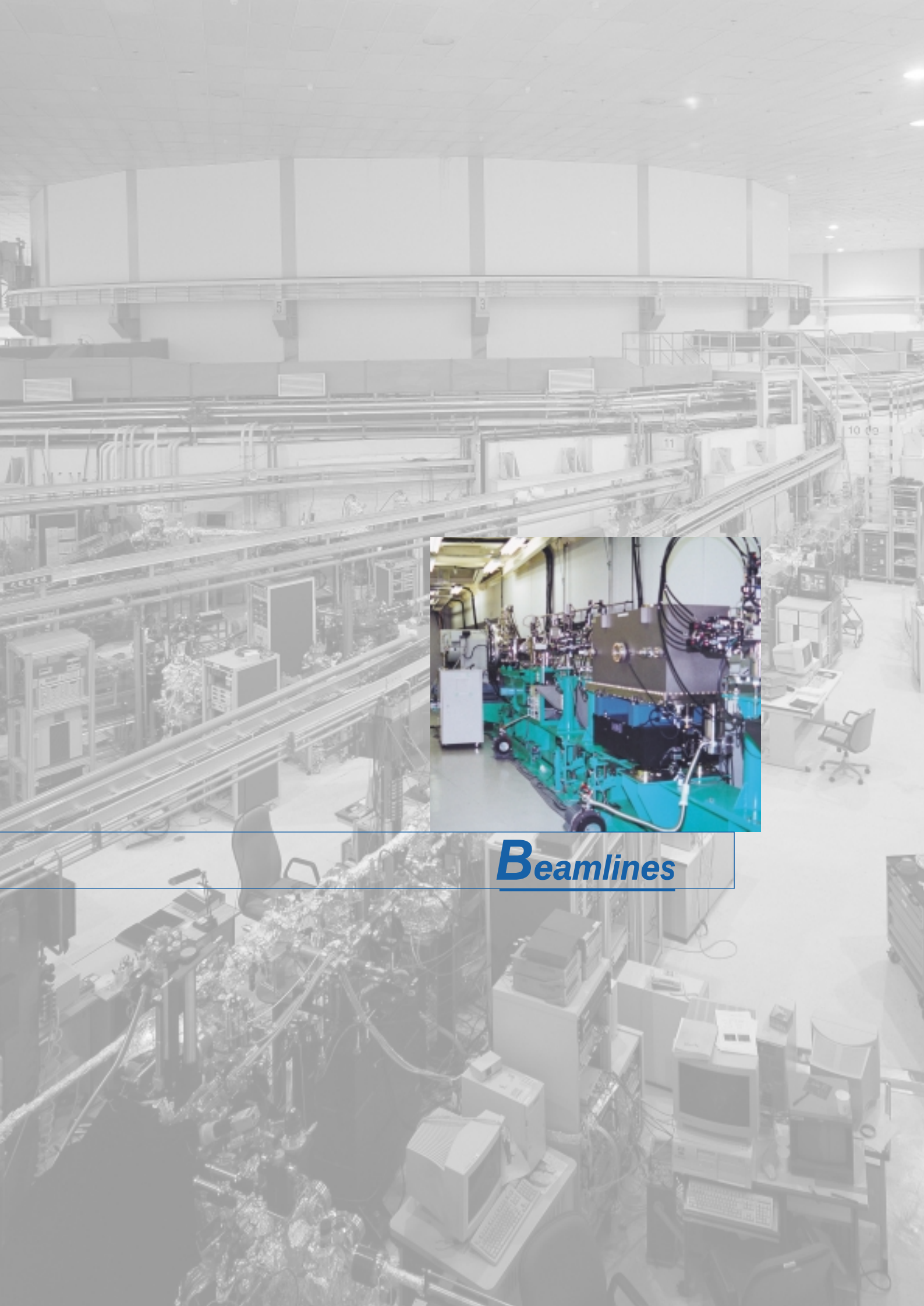

Beamlines

Beamlines

In 2000, TLS had opened three additional beamlines to the users: the wiggler-A (17A), the HF-CGM (03A), and the U5 spectroscopy (09A-b). Five beamlines were also completed in construction and entered into commissioning phase: the EPU-SGM (05B), the U9-WL (21A), the U9-CGM (21B), the IR (14A), and the SP8-12B2 (at SPring-8) beamlines. *Table 1* gives a summary of the beamline status at SRRC and *Figure 1* is a schematic layout of the beamlines at TLS.

The Taiwan Contract Beamline Project at SPring-8, Japan has been in good progress. The bending magnet beamline SP8-12B2 had the first light in the hutch on Oct. 4, 2000. We now proceed to construct the undulator line SP8-12XU.

At TLS, there are now a total of 20 beamlines with finished construction. For beamline development, we are at the corner point that beamlines for VUV and soft X-ray are mostly finished, on both the bending magnet and the undulator ports. With the anticipated installations of the superconducting wavelength shifter and the superconducting multi-pole wiggler in TLS in the coming years, our future attention of beamline development will turn mainly to the hard X-ray beamlines.

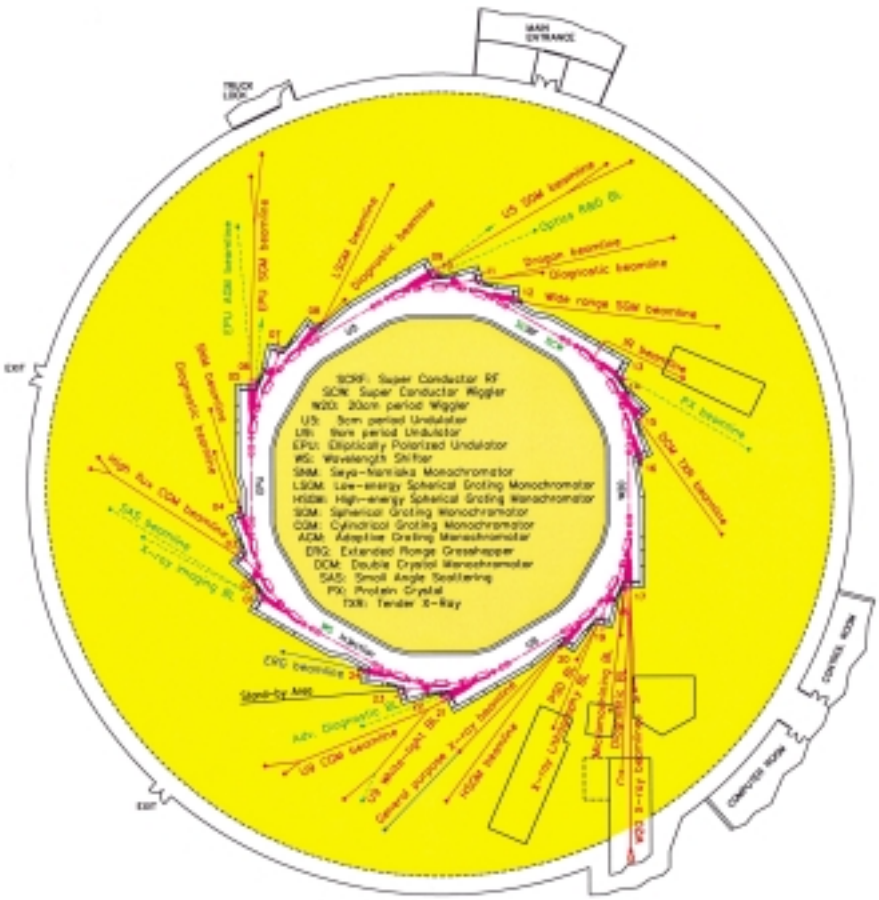

Figure 1 The layout of the TLS beamlines.

Beamline Commissioning

The commission of the EPU-SGM (05B) beamline is nearly completed and the beamline is partially open to users. The performance of the EPU-SGM beamline has been measured in terms of undulator source characteristics, photon flux, energy resolution, and degree of circular polarization. The photon flux obtained at this beamline is slightly below the theoretical value. The energy resolution measured at several photon energies reaches the designed values as shown in *Figures 2 and 3*. The degree of circular polarization calculated from the spin-resolved photoemission spectra of Pt ($4f_{7/2,5/2}$), as shown in *Figure 4*, reaches the theoretical value of greater than 95% in the first harmonic spectrum of the EPU source.

The U9-WL (21A) beamline has achieved a flux of greater than 10^{16} p/s at the end-station. A gas cell designed for removing the high-order undulator light has been installed. The beamline is already equipped with a chemical dynamics end-station by the Institute of Atomic and Molecular Science, Academia Sinica.

The completion of the U9-CGM (21B) beamline was delayed until the first designed grating was received in July. A world-record energy resolving power of 100,000 at 16 eV has been obtained, as shown in *Figure 5*. Two other gratings were delivered near the end of the year. The commission of this beamline will be continued in 2001 with partial opening for users.

The construction of the IR (14A) beamline was completed in the summer. However, the measured flux has not reached the designed value yet. The overall performance has encountered difficulty from noise problem. An on-line feedback system is being studied for solving the noise problem.

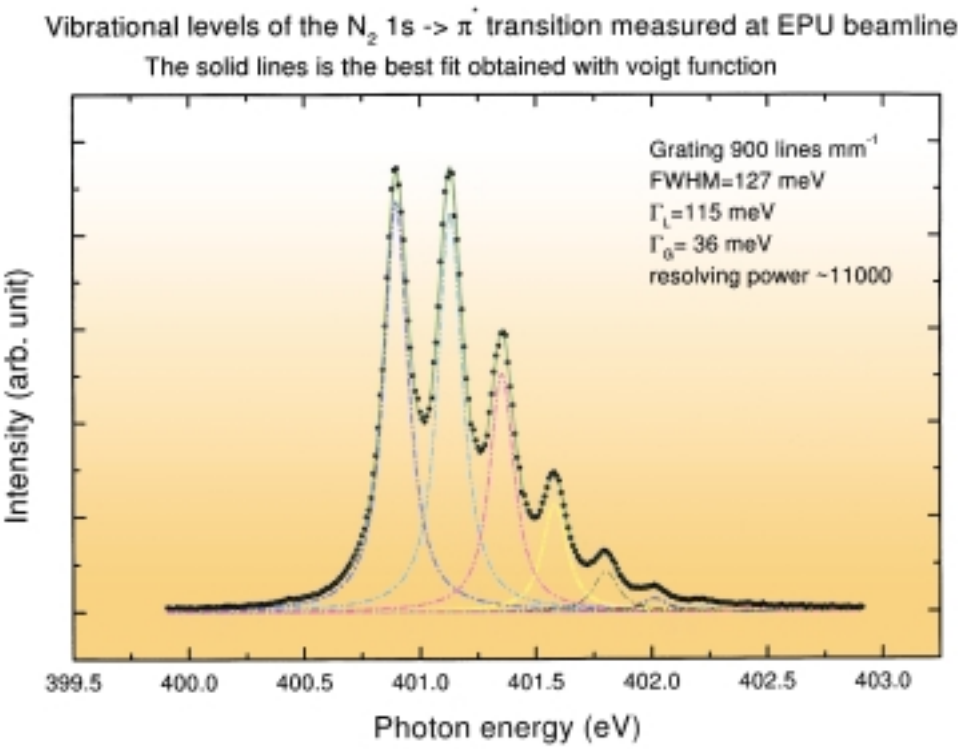

Figure 2 The N_2 gas 1S absorption spectrum measured at the EPU-SGM beamline, obtained by 900 l/mm grating with slits openings of 5/5 μm. Note that a world-record energy resolving power of > 11,000 were obtained.

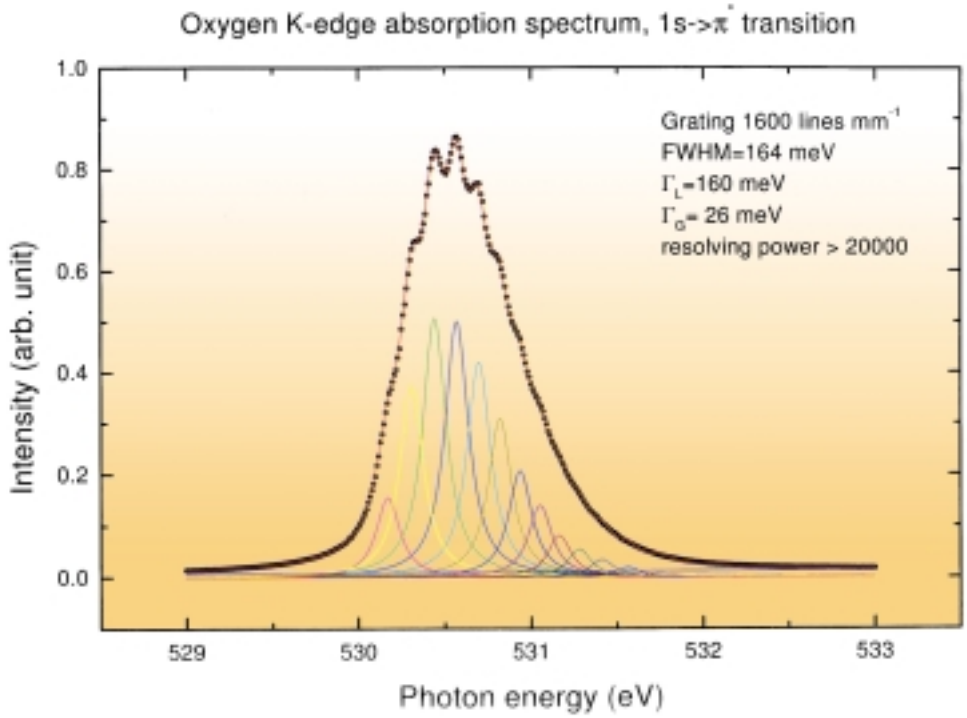

Figure 3 *The O_2 gas 1S absorption spectrum measured at the EPU-SGM beamline, obtained by 1600 l/mm grating with slits openings of 5/5 μm. An excellent energy resolving power of > 20,000 was obtained.*

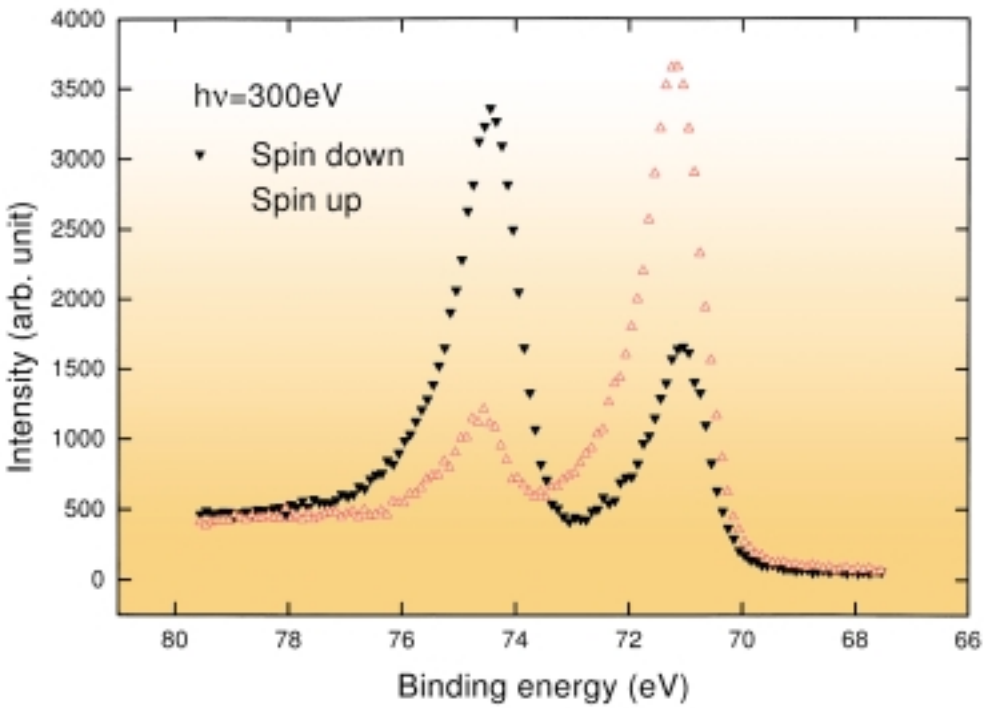

Figure 4 *The spin resolved Pt $4f_{7/2}$ and $4f_{5/2}$ photoemission spectra measured at the EPU-SGM beamline. Note that the degree of the circular polarization calculated is greater than 95%.*

New Beamlines

The development of new beamline for VUV and soft X-ray research is near the end. The remaining work is to add two branched lines on the undulator ports, one on EPU for soft X-ray emission spectroscopy (05A) and one on U9-WL for molecular science (21A-b).

The demand for hard X-ray experiments by Taiwan users is increasing and expected to surpass what the current X-ray beamlines can support. Therefore, in addition to the Spring-8 collaboration, we will install a superconductor wavelength shifter (WS) and a superconductor wiggle (SW) using the remaining space available on the TLS storage ring. We plan to build three beamlines on the WS port and two beamlines on the SW port, for advanced materials and biostructural research *(Table 1)*. The works for the X-ray facilities on WS are planned for years 2002 - 2003 and that on SW for 2003 - 2004.

X-ray Beamlines at SPring-8

The Taiwan Contract Beamlines Project at SPring-8, SP8-12B2 and SP8-12XU has progressed on schedule. The construction of the SP8-12B2 beamline was completed in October and commission began afterwards. The in-vacuum X-ray undulator and the front-end for SP8-12XU beamline were installed in the storage ring in the summer of 2000. We also completed the design of SP8-12XU and its construction is expected to be finished in late 2001. *Figure 6* shows the optical layout of these two beamlines.

The SP8-12B2 beamline provides the following operational modes:

1. Direct white beam mode, either focused or unfocused.
2. Monochromatic beam in the low to medium energy ranges (5 < E < 25 keV) with DCM, CM, and FM in place ($\Delta E/E \cong 10^{-4}$).
3. Monochromatic beam in the high-energy region (25 < E < 90 keV) with only DCM in

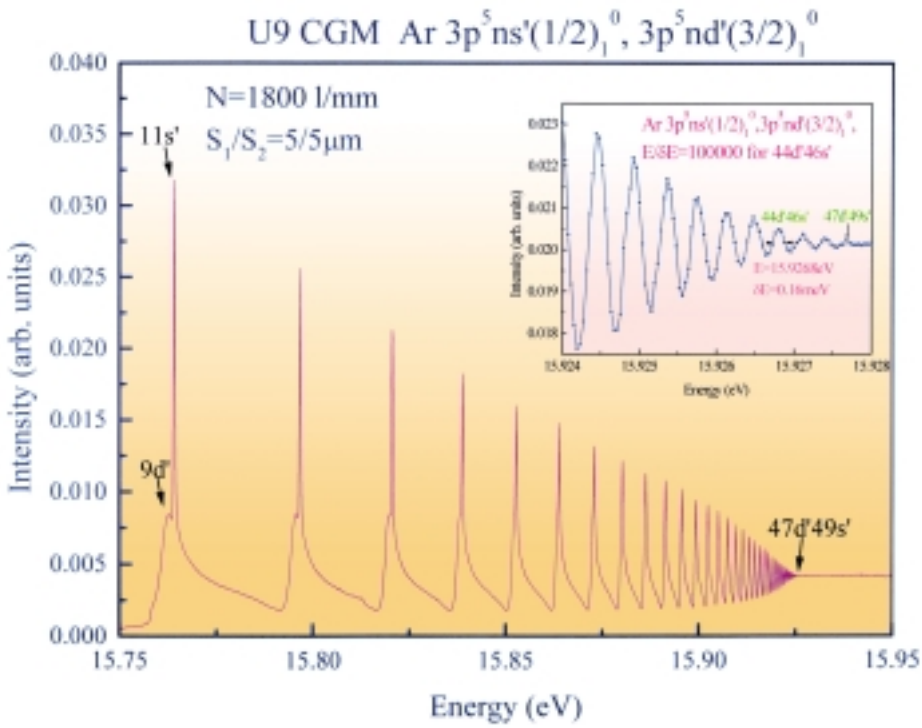

Figure 5 The Ar 3s3p6np transition series measured at the U9-CGM beamline, obtained by 1800 l/mm grating with slit openings of 5/5 μm. A world- record energy resolving power of 100,000 was obtained.

place ($\Delta E/E \cong 10^{-4}$).

At present, two experimental stations, an EXAFS station and a six-circle diffractometer, are already in operation. *Figure 7* shows the first two EXAFS spectra. This beamline will be partially open to the general users in May 2001. A micro-beam X-ray stage and a protein crystallography station will be implemented on this beamline in 2001.

The SP8-12XU beamline is designed to exploit the undulator hard X-ray source at SPring-8 for experiments in inelastic X-ray scattering with high-E resolution and elastic X-ray scattering with high-Q resolution. This beamline consists of a cryogenically cooled double-crystal pre-monochromator, a super high precision collimating mirror, a four-bounce high-resolution monochromator, a phase retarding device, and a focusing mirror. The compound reflective lens (CRL) will also be employed to provide desirable beam collimating and hence high performance in the photon energies greater than 13 keV. The layout of the beamline was modified to accommodate a diffraction end-station after the High Resolution Monochromator, as shown in *Figure 6*. Note that a diamond crystal monochromator will be installed at the upstream of the line to provide a side-branch beamline for fixed energy diffraction experiments.

As shown in *Figure 8*, four operational modes are available on the SP8-12XU. Although not shown, a medium resolution mode for the diffraction end-station is also possible when only the DCM is in use.

The phase I construction of SP8-12XU beamline will start in the spring of 2001 and will be ready for commission in late fall of 2001. Our scientific goal of phase I is to achieve an energy resolution 10 to 100 meV with a photon flux of 10^{14} p/s. The beamline layout also allows a phase II development in which a backscattering ultra-high-resolution monochromator can provide an energy resolution of sub meV.

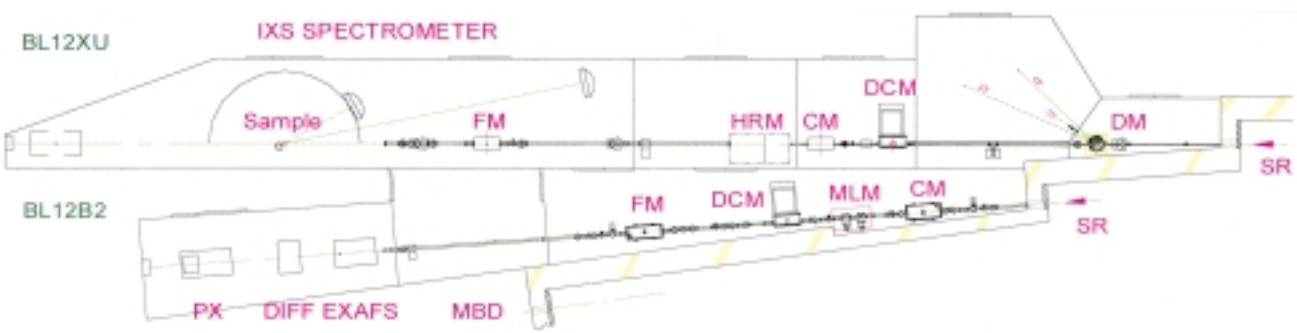

Figure 6 The layout of SP8-12B2 and SP8-12XU beamlines located at SPring-8.

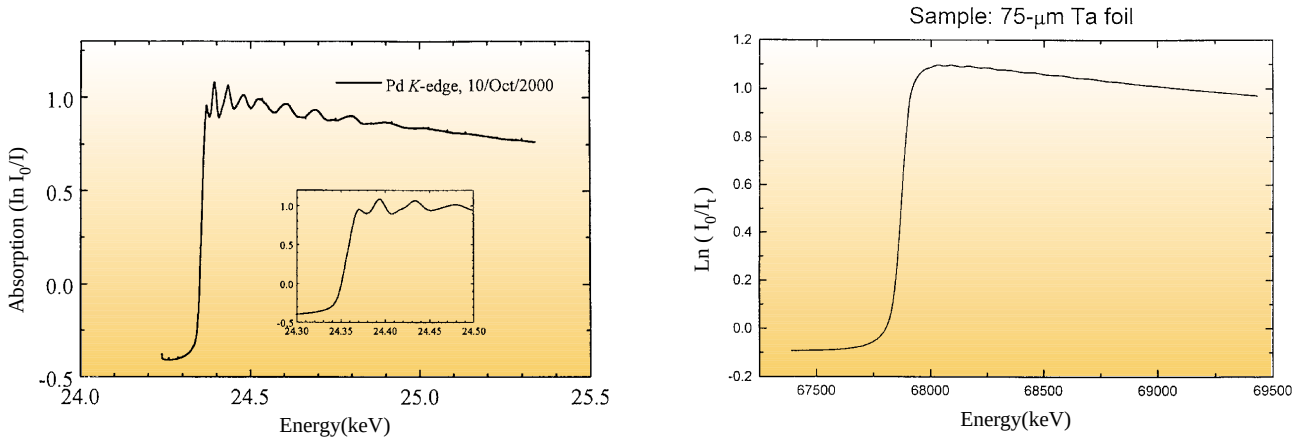

Figure 7 The first two EXAFS spectra of Pd and Ta thin films obtained at the SP8-12B2 beamline.

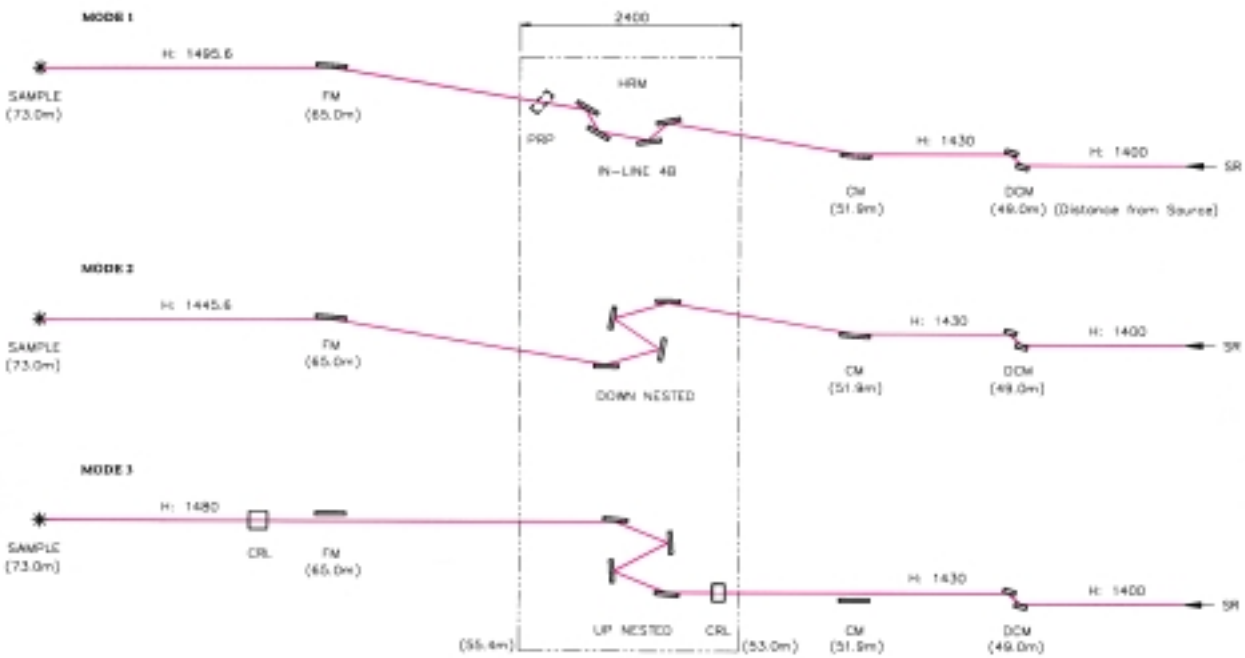

Figure 8 The four operational modes of the SP8-12XU beamline.

Table 1 Status of SRRC Beamlines

B.L. No.	Source	Mono. Type	Energy Range (eV)	Res. Power E/ΔE	Applications
Beamlines in Operation/Commission					
03A	BM	CGM	4-40	50000	Spectroscopy: PES, ARPES, PAS
04A	BM	none	visible light		Diagnostic: Beam size and stability
04B	BM	SNM	4-40	5000	Spectroscopy: PES, ARPES, PAS
05B	EPU5.6	SGM	60-1500	20000	Magnetic Studies: MCD, XPS, SXS
08A	BM	SGM	15-200	20000	Spectroscopy: PES, ARPES, XPS, PAS
08B	BM	none	< 1000		Diagnostic: Beam stability
09A	U5	SGM	60-1500	10000	Spectro./Microscopy: PES, XPS, SXS
11A	EPBM	SGM	8-1500	10000	Spectroscopy: MCD, PES, XPS, SXS
11B	BM	none	< 1000		Diagnostic: Beam stability
12A	BM	SGM	10-1500	30000	Spectroscopy: PES, ARPES, SXS, MCD
14A	BM	FTIR	2-20μm (mid IR)		IR Microscopy
15B	BM	DCM	1 k-9 k	7000	XAS, EXAFS, Diffraction
17A	W20	BTCM	4 k-15 k	1000	Powder Diffraction
17B	W20	DCM	4 k-15 k	7000	Scattering, Diffraction
17C	W20	DCM	4 k-15 k	7000	EXAFS, XAS
18A	BM	none	< 1000		Diagnostic: Beam stability
18B	BM	none	> 500		Micro-machining
19A	BM	none	800-1800		X-ray Lithography
19B	BM	none	white light		Photon Stimulated Desorption
20A	BM	SGM	110-1500	10000	Spectroscopy: PES, XPS, MCD, XAS
20B	BM	DCM	4 k-12 k	5000	PRT/Multi-purpose: (N)EXAFS
21A-a	U9	none	4-500	50	Chemical Dynamics
21B	U9	CGM	4-100	60000	Atom. Molecular Science; PAS, XPS
SP8-12B2	BM	DCM	5 k-70 k	7000	Diffraction, Scattering, XAS
Beamlines under Construction					
24A		BM	ERG	20-1200	2000 PRT/Spectroscopy
SP8-12XU	U3.2	DCM	5 k-30 k	1000000	Inelastic X-ray Scattering
Beamlines under Design					
01A	WS	DCM	4 k-30 k	7000	Powder Diffraction, XAS
01B	WS	DCM	4 k-30 k	7000	Scattering, SAXS
01C	WS	DCM	4 k-30 k	7000	X-ray Imaging
05A	EPU	AGM	50-1200	10000	Soft X-ray Emission Spectroscopy
13A & B	SW	DCM	4 k-30 k	7000	Protein Crystallography
21A-b	U9	none	4-500	50	Molecular Science

BM:	Bending Magnet	BTCM:	Bent Triangular Crystal Monochromator
CGM:	Cylindrical Grating Monochromator	DCM:	Double Crystal Monochromator
EPBM:	Elliptical Polarized Bending Magnet	EPU5.6:	Elliptical Polarized Undulator with 5.6 cm magnet period
SGM:	Spherical Grating Monochromator	SNM:	Seya-Namioka Monochromator
SP8:	SPring-8	Ux:	Undulators with x cm magnet periods
W20:	Wiggler with 20 cm magnet period	WS:	Wavelength Shifter
SW:	Superconductor Wiggler	AGM:	Adaptive Grating Monochromator