APCST ID (BL12XU)

1. Introduction

This beamline is part of the Taiwan X-ray facility at SPring-8, and is designed to exploit the unique characteristics of SPring-8 as a high-energy and high-brilliance X-ray source. It will be a dedicated beamline for inelastic X-ray scattering (IXS) with variable energy resolution *from* high (0.1 – 1 eV) *to* ultra-high (1 – 10 meV) resolution regimes. A secondary purpose is for high Q-resolution scattering and X-ray physics and optics.

The conceptual design has now been completed. The hutches and utilities have been constructed together with those for the APCST bending-magnet beamline BL12B2. In the present article, we will briefly describe the scientific program, and the key concepts and components of the beamline.

2. Scientific Program

Three classes of IXS experiments are planned:

- *High-resolution inelastic X-ray scattering*: The focus is on the study of single-particle as well as collective electronic excitations in a variety of materials.
- *High-resolution X-ray resonant Raman scattering*: The emphasis is to explore the large resonant enhancement of the inelastic scattering cross sections to study high-Z elements where strong sample absorption still poses a major problem.
- *Ultra-high-resolution inelastic X-ray scattering*: The focus is on the study of lattice dynamics in bio materials and very low energy electronic excitations in strongly correlated systems.

We further plan to extend both high and ultra-high resolution IXS to studies of materials under high pressure, high magnetic fields, and extreme temperatures. The focus is on the pressure-induced phase transitions of materials.

The scientific program for high Q-resolution scattering will be for general purposes, and will include crystallography, surface scattering, magnetic scattering, small angle scattering, and coherent scattering. For X-ray physics and optics, the projects currently planned are micro focussing optics, fast timing optics, and non-linear multi-photon X-ray effects.

3. Beamline Overview

This beamline takes X-ray photons from a SPring-8 standard insertion device with a magnet period of 32 mm [1]. The front end is modified from the SPring-8 standard to handle up to 18 kW of total power [2]. This gives us the option of changing the undulator to gain more flux in the future.

The beamline is divided functionally into two parts (Fig.1). Part I consists of a single-bounce diamond monochromator located 41 m from the source point and a side hutch, where a monochromatic beam of 1-eV energy width will be provided for crystallography and high Q-resolution (fixed energy) scattering experiments. The diamond monochromator employs four scattering geometries using semitransparent diamond (111) and (100) crystals [3] in order to cover a wide energy range of 7.8 – 32 keV with a scattering angle range of 25 – 45 degrees. The end station will be a custom-built diffractometer installed on a movable stage along a circular track to maintain a constant distance from the diamond monochromator over the entire scattering angle range.

Part II is the main part of the beamline, which will be dedicated for inelastic X-ray scattering experiments with high and ultra-high energy resolution. It takes the photon beam transmitted through the diamond monochromator, and contains five major optical elements (Fig. 1). They include a high heat-load double-crystal monochromator (DCM), a collimating mirror/CRL (compound refractive lens), a high-resolution monochromator (HRM), a phase retarding plate, and a focussing mirror/CRL. Naturally, the main beamline also offers the possibilities for (variable energy) high Q-resolution scattering, coherent scattering, and imaging experiments. The high-heat load DCM will be cryogenically cooled to accept the full power of the central cone radiation of the undulator. It will be based on existing devices recently demonstrated at SPring-8 [4]. The collimating mirror collimates the pre-monochromatised beam in order to improve the throughput and the energy resolution of the output beam from the HRM. The relative energy bandwidth ($\Delta E/E$) of the HRM will be in the range of 10^{-5} to 10^{-7}. This can be accomplished by using a design that allows for easy exchange of channel-cut crystal pairs from either a two-bounce to an in-line or nested four-bounce crystal monochromator [5]. The phase retarding plate is used only to generate circularly polarised light for magnetic studies. The HRM will be accommodated on a high-precision optics table with temperature acclimatisation to $\leq \pm$ 0.01 K at room temperature in order to achieve stable output beam at 10-meV energy resolution. Finally the focusing mirror/CRL focuses the beam onto the sample position of the spectrometer.

The main beamline will be optimised to operate in two regimes. The first regime uses primary beam energies in the range of 5 – 15 keV with an energy resolution in the order of 0.1 – 1 eV, whereas the second regime employs 20 – 30 keV photons with an energy bandwidth in the order of 10 – 100 meV. The beamline layout remains practically the same with changes only to the choice of crystals in the HRM and the analyser. A few HRM options will be made available to facilitate different experiments. Furthermore, Be CRL's will be used to replace the collimating and focussing mirrors for operations above

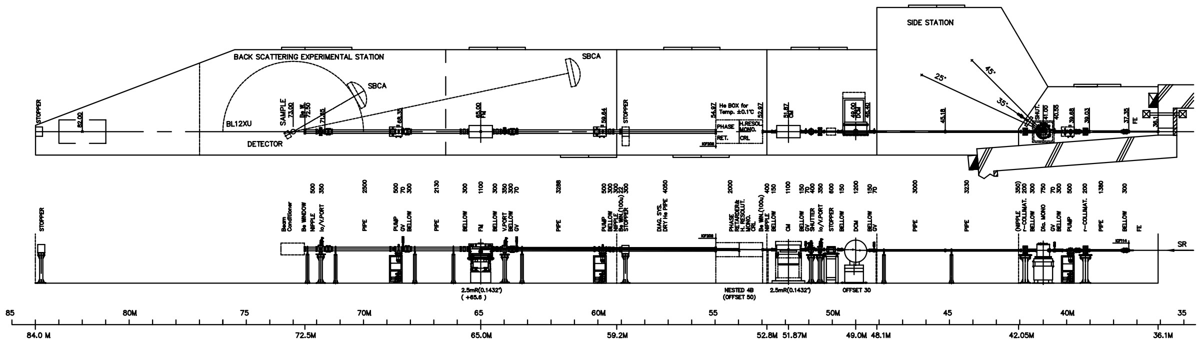

Fig. 1. BL12XU beamline layout

20 keV for their better performance at this energy range, [6,7] particularly with energy resolution around 10 meV. To achieve 1-meV energy resolution, a backscattering monochromator is planned and will be installed at the end of the beamline [8].

The spectrometer for the main beamline will be a triple-axis spectrometer with both a horizontal and a vertical arm. The length of both arms will be 3 m.

Spherical crystal analysers will be used to analyse the scattered photons. The radius of the analyser can be chosen to be 1, 2 and 3 m, depending on the resolution requirement of the experiment. The sample and the detector will be placed on the Rowland circle of the analyser. The hutch dimension allows both arms to cover almost 180 degrees of the scattering angle. The horizontal arm length will be extended to 12 m in the future in conjunction with the backscattering monochromator for 1-meV resolution experiments.
To achieve efficient analysis of the scattered photons, the analyser crystals should be chosen to have a resolution that matches the energy bandwidth of the impinging beam. Analyser crystals with 1-meV energy resolution have been demonstrated [9]. We are now investigating ways to improve the efficiency and to broaden the analysed energy width to 10 – 100 meV for a 20 – 30 keV incident beam.

4. Schedule

Construction of the main beamline will begin in the 2nd half of 2000. We aim to finish all construction work by the end of the extended summer shutdownin 2001, and begin the commissioning in September 2001.

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Light Source	
Type	In-vacuum planar undulator
Magnet period	$\lambda_u = 32$ mm
Number of periods	$N_u = 140$
Peak brilliance	1.2×10^{20}(E=8.8keV@100 mA) photons/s/mrad^2/mm^2/0.1% bw
Source size	$\sigma_x = 384\mu$m, $\sigma_y = 6.8\ \mu$m
Source divergence	$\sigma'_x = 15.6\ \mu$rad, $\sigma'_y = 1.75\ \mu$rad

X-rays at Sample	
Energy range	5 – 35 keV
Energy resolution	10 – 1000 meV
Photon flux	10^9 – 10^{11} photons/s/meV
Beam size (FWHM)	100 μm (H) × 50 μm (V)

Facilities in Experimental Station (Planned)

- Custom-built 6-cycle diffractometer in side hutch
- IXS spectrometer with both a horizontal arm and a vertical arm, arm length 3 m
- Huber Eulerian cradle 512.1 for crystalline samples and cryostat mount
- Huber arc 5204.2 for heavy loads
- Diamond anvil cells
- Cryostat
- Magnet
- Various sample chamberss