Present Status of Beamline 08W for High Energy Inelastic Scattering

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1. Introduction

The BL08W beamline is mainly dedicated to high-energy inelastic scattering (Compton scattering) experiments [1, 2]. In such experiments, a photon energy higher than 100 keV is utilized. High-energy photons are suitable for these experiments involving materials containing heavier atoms than 3d elements.

A wiggler was chosen as the high-energy photon source. The schematic layout of the beamline is shown in Fig. 1. In the white beam hutch (optics hutch), the two kinds of monochromators exist. One covers energy range from 100 keV to 150 keV, which is introduced to a monochromatic beam hutch B for high-resolution Compton scattering experiments. The other is around 300 keV and is introduced to a monochromatic beam hutch A for magnetic Compton scattering experiments [3-5].

2. Beamline description

2.1 Insertion device and Front end

The insertion device is an elliptic multi-pole wiggler (EMPW), with parameters l= 12 cm, Ky = 11.2, Kx = 0~1.1, N = 37, L = 4.5 m and a total power of 18 kW for Kx = 0. It is out of vaccuum type. In the first phase of the beamtime, the ID operation has been performed for a gap wider than 30 mm. In the near future, it will be narrowed to 20 mm, the value originally designed. The front end has graphite and aluminum filters to reduce useless photons at energies lower than 100 keV.

2.2 Optics

A 300 keV monochromator and a 100-150 keV monochromator were installed in the white beam hutch in 1997. Both monochromators were designed for a single crystal arrangement. The 100-150 keV monochromator is doubly-bent. Symmetric Johann type Si 400 reflection has been used in the first phase and in the future an asymmetrically-cut crystal will be used. The crystal surface is set horizontally. It is bent to obtain a vertically focused beam at the position given by q/p = 1, where p and q are distances from the source to crystal and crystal to focal point, respectively. In the sagittal direction, the crystal is bent with a fixed radius (q/p = 1/3).

An asymmetric Johann type has been employed for the 300 keV monochromator. Si 771 reflection is used with asymmetry angle of about one degree to make crystal length smaller and focal point forward. The crystal surface is vertical. It focuses a vertically-diverged beam.

We use Bragg geometry instead of Laue geometry because we can get an efficiently-focused beam for both monochromators. The focal spot size is expected to be about 0.5 x 0.5 mm^2 for the 100-150 keV beam from a ray tracing calculation. For the 300 keV beam, it will be described later in this report. Four-point crystal benders are used for both kinds of monochromators.

In the first phase (from October 1997) only the beam from the 300 keV monochromator was available in monochromatic beam hutch A. The beam from the 100-150 keV monochromator will be introduced to moncochromatic beam hutch B in 1998 and experiments will be possible at the begining of 1999.

As the first experiment on the beam time, characterization of the 300 keV monochromator was performed. The detail results will be described later in this report. The photon energy available from the 300 keV monochromator was from 274 keV to 300 keV. Total photon flux is estimated to be about 1 x 10^9 photons/s for the condition of the stored current, I = 20 mA, and the ID gap width of 30 mm. The total photon flux can be increased to about 80 times as large as the above value by adopting an ID gap width 20 mm and increasing the stored current up to 100 mA. The focused beam spot size at the sample position has been verified to be about 1-2 mm (width) x 3 mm (height) at 274 keV.

2.3 Shielding

The radiation problem is serious in this beamline because the wiggler source gives relatively high-energy x-rays. Compton scattering is dominant and will continuously deposit about 100 W in the other components such as the vacuum vessel, bender, stages, etc. A water-cooled system surrounds the crystal. The primary crystal shield consists of a water-cooled rectangular Cu tube aligned around the crystal and a crystal holder parallel to the beam axis. As a secondary shield, a water-cooled Cu skin of 5 mm in thickness is adjusted inside the vacuum vessel. A third one is 20 mm thick lead which covers the outside of the vacuum vessel. The local lead shielding means the white beam hutch lead shielding can be made thinner.

3. Detectors

An SSD (Ge) detector was used for magnetic Comptonscattering experiments. From typical data on the magnetic Compton profile (MCP) for Fe, the resolution was estimated to be 0.55 a. u. in the momentum space at 274 keV. By using Ge detectors in a 10-set, the resolution can be expected to be about 0.4 a. u. Ten-segmentted Ge detectors having a better energy resolution will be available in 1998, and is expected to achieve a momentum resolution of 0.4 a. u..

4. Other available instrumentation

A super-conducting magnet was installed in hutch A for the magnetic Compton scattering experiments. We could change the external magnetic field up to ±3 T with a frequency of 0.2 Hz. The temperature of a sample could be changed from 9 K to room temperature. A sample space in the cryostat was 5 mm long and 10 mm in diameter.

There is an optical table with a size of 2 x 1 m^2 in area and 0.8 m in height. On the table Al plates of 10 mm in thickness can be set to adjust the Ge detectors. The beam height is 1.4 m from the ground floor.

5. Preliminary experiments

The 100-150 keV beam is not available. Accordingly, the following experiments in hutch A were performed by using the 300 keV beam in 1997.

(1) Characterization of the 300 keV monochromator.

(2) Measurement of the polarization degree of circular polarized x-rays with the magnetic Compton profile (MCP) for Fe.

(3) Measurement of MCP with changing polarization helicity of the circularly of the incident beam.

(4) Measurement of MCP for Co crystal with changing polarity of the super-conducting magnet.

(5) Experimental study on a multi-Compton scattering process for high-energy x-rays.

The details of the experimental results are described later in this report separately. From experiments on the magnetic Compton scattering, we could obtain the following results at 274 keV. (1) The 300 keV beam was successfully focused to be about 1-2 mm x 3 mm. (2) The degree of circular polarization was 0.78 at 274 keV with ID parameters of $Kx = 0.6$ and $Ky = 9.9$. (3) The count rate at the Compton peak was 3 x 10^4 counts/channel/hour (this was not Magnetic Compton profile). (4) Magnetic Compton effect on Fe was estimated to be [I(+)-I(-)]/[I(+)+I(-)] = 1.6% for 274 keV photons, where I(+) and I(-) are the cases when the magnetization vectors are parallel and unti-parallel to the incident beam vector, respectively. It should be noted that the data was obtained under the conditions of $I = 20$ mA and ID gap width of 30 mm.

References

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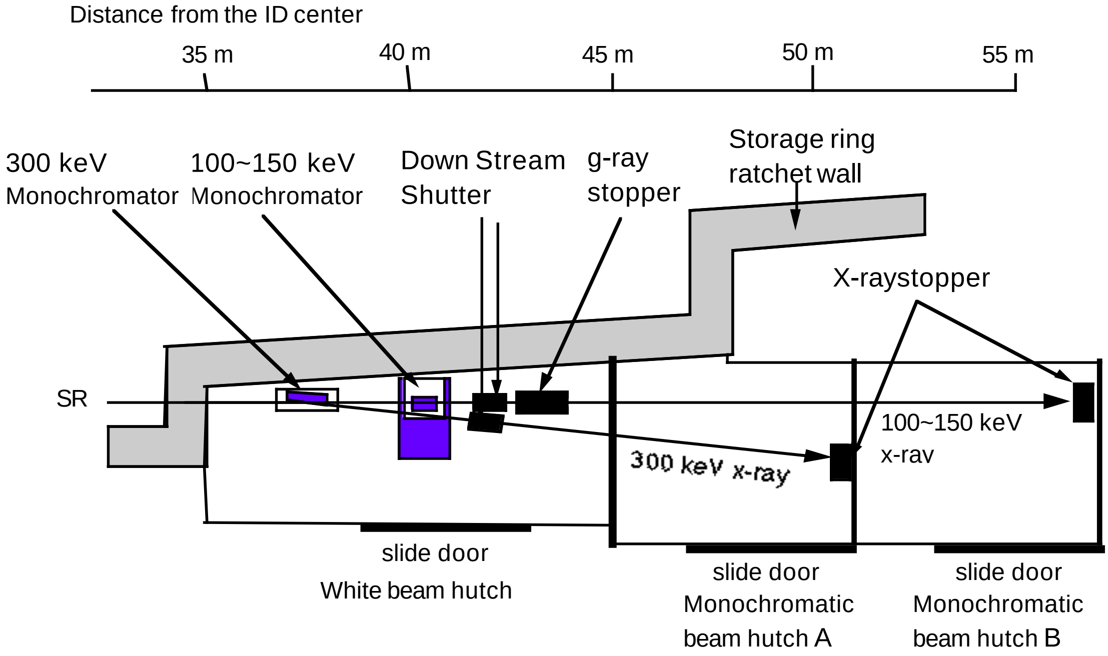

Fig. 1 Schematic layout of the beamline 08W.

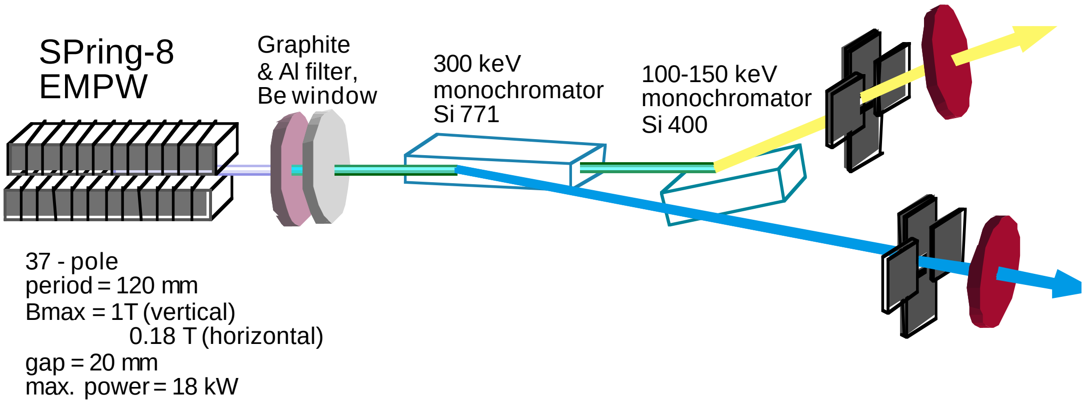

Fig. 2 Conceptional diagram of the beamline optics.