

BL11XU JAERI Materials Science II

This beamline is designed for the various kinds of studies on Mössbauer spectroscopy, high-pressure sciences, inelastic X-ray spectroscopy, surface sciences, and so on. In the experimental hutch 1, to conduct an experiment on inelastic scattering and microscopic spectroscopy using nuclear resonant scattering, high precision goniometers and versatile goniometers are equipped on a vibration-proof table and be smoothly moved by air pads. In the same hutch, an XAFS experimental system is available for XAFS studies. The experimental hutch 2 is dedicated for resonant inelastic X-ray scattering experiments of typical energy resolution 0.1~1 eV. Electronic excitations in highly correlated electron systems are major target of this hutch. The third experimental hutch is equipped with an X-ray diffractometer connected with a molecular-beam-epitaxy chamber. This instrument is designed for in situ studies on III-V group semiconductor surfaces. The main applications are (i) surface crystallography under molecular beam epitaxy conditions and (ii) studies on growth dynamics.

**Area of research**

- Nuclear Resonant Scattering
- Surface and interface structure with MBE
- Inelastic scattering
- XAFS

**Keywords**

*Scientific field*

Mössbauer spectroscopy, Nuclear resonant scattering, XAFS, Lanthanide, Resonant inelastic X-ray scattering, Molecular beam epitaxy, Surface X-ray diffraction

*Equipment*

X-ray spectrometer, Surface X-ray diffractometer

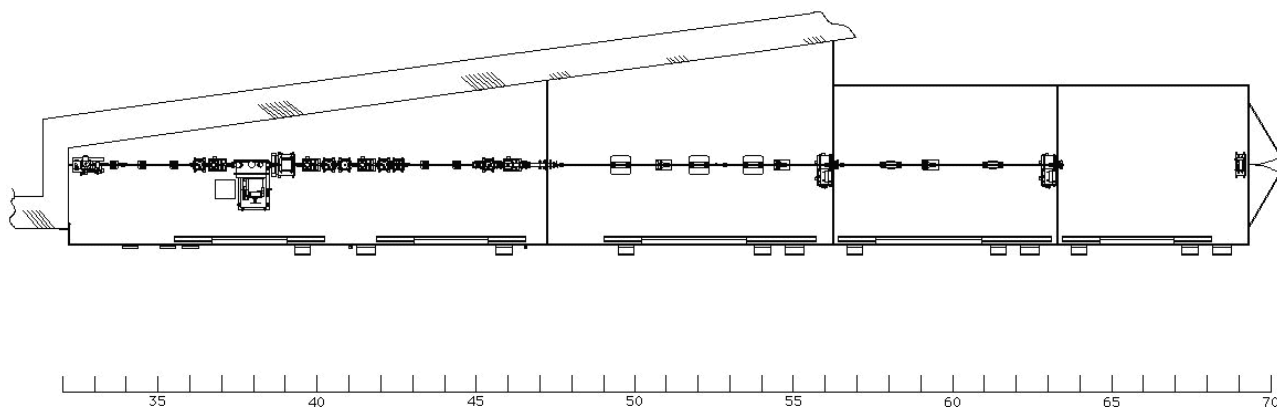
**Source and optics**

• Source

- In-vacuum undulator
  - Undulator period,  $\lambda_u$  : 32 mm
  - Number of periods,  $N_{\text{period}}$  : 140
  - Energy range : 6 ~ 70 keV

• Optics

- Monochromator
  - Multi-crystal switching system
  - Si (111) & Si (311)
  - Cryogenically cooling system
- Mirror
  - Pt and Rh coated SiO<sub>2</sub> mirror

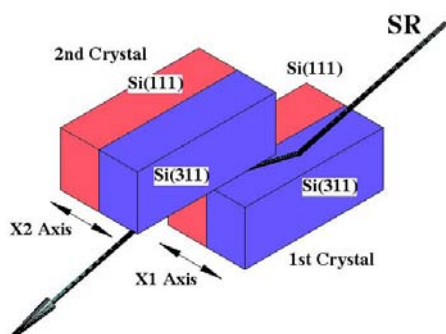


Schematic view of the beamline, BL11XU

## X-rays at sample

Energy range 6 ~ 70 keV

Energy resolution  $\Delta E/E \sim 10^{-4}$

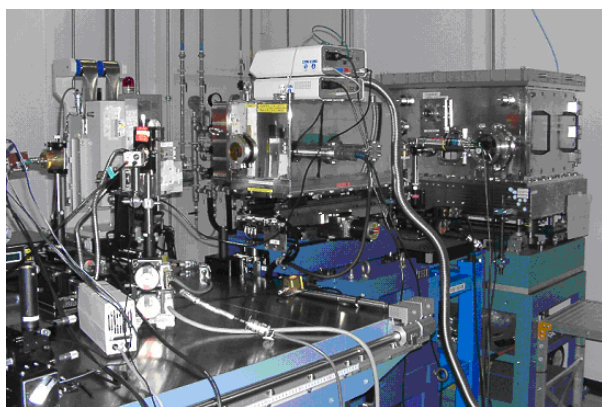


Principle of the multi-crystal switching system

## Experimental stations

### Hutch 1, upstream space

As the most cutting-edge methods in materials science using nuclear methods, we intensively make studies of electronic states, spin structures and vibrational modes using nuclear resonant scattering. In BL11XU (Hutch 1, upstream space), by using the high-resolution monochromators, we can perform the inelastic nuclear resonant scattering and nuclear forward scattering experiments for various Mössbauer nuclei such as  $^{57}\text{Fe}$ ,  $^{119}\text{Sn}$ ,  $^{40}\text{K}$  and so forth. Furthermore, Mössbauer micro-spectroscopy has been realized by using X-ray focusing optics (see photograph). These devices make enable to carry out following materials science researches: electronic and phonon states of iron oxides, high-Tc superconductors, low dimensional conducting materials and even nano-structured materials.



Scanning type synchrotron radiation Mössbauer microscope in BL11XU

### Hutch 1, downstream space

In BL11XU (Hutch 1, downstream space), the structural analysis of lanthanides compounds related to separation of radioactive waste is performed. Using an undulator, the

XAFS experiment using extensive energy and high flux X-rays is available. Low- and high-temperature experiment is also possible using a cryogenically cooling device and an electric furnace. The equipment of the following can be used:

Detector: NaI(Tl), Ge-SSD, Ionization chamber (5 cm, 17 cm, 31 cm)

Gas: Nitrogen, Nitrogen+Argon, Argon, Krypton, Xenon

### Hutch 2

Resonant inelastic X-ray scattering experiments of photon energies 6~10 keV are available in the experimental hutch 2. Typical energy resolution is 0.1~1 eV with energy transfers up to about 10 eV, which is suitable for investigating valence electron excitations of highly correlated electron systems. The spectrometer consists of a high-resolution monochromator, a focusing mirror and a spectrometer with a 2-m-long analyzer-arm operating in the horizontal scattering plane. The analyzer is a spherically bent Si or Ge crystal. High field (8 T) and low temperature (10 K) experiments are available using a super-conducting magnet and a closed-cycle He refrigerator.

Inelastic X-ray scattering spectrometer

Spherical analyzer

8-T super-conducting magnet

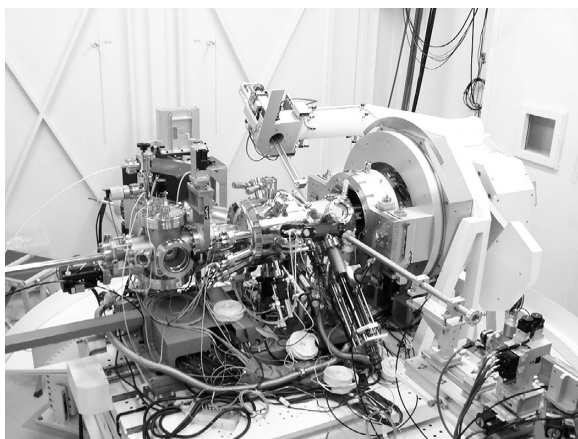
Closed-cycle He refrigerator



Inelastic X-ray scattering spectrometer

### Hutch 3

A surface X-ray diffractometer connected with an MBE chamber is placed in the experimental hutch 3. The diffractometer is the 4+2 type, which has four axes for orienting the sample and two axes for positioning the detector. On the  $\theta$  table, an xyz stage is mounted to locate the sample surface at the rotation center. The MBE chamber is equipped with five Knudsen cells and the RHEED system. The Be windows welded onto the chamber allow the incoming and outgoing angles up to 45 degrees measured from the sample surface and the in-plane scattering angle up to 120 degrees. Available detectors are an NaI scintillation counter; a PIN photodiode and an X-ray CCD camera.



Photograph of the surface X-ray diffractometer in hutch 3

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