SPring-8 BL35XU Review Committee Report on High Resolution Inelastic Scattering (BL35XU)

Report for Director General of Japan Synchrotron Radiation Research Institute

M. Arai (Japan Atomic Energy Agency), Chair
E. Matsubara (Kyoto University)
G. Ruocco (Universita' di Roma)
J. M. Tranquada (Brookhaven National Lab.)
N. Wakabayashi (Keio Univeristy)
Y. Tokura (University of Tokyo)

Japan Synchrotron Radiation Research Institute (JASRI)

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1. Introduction

The beamline review committee meeting on the High Resolution Inelastic Scattering (BL35X) beamline was held at the SPring-8 site on November 7-8, 2005. The BL35XU Beamline Report and SPring-8 Overview 2005 had been sent to the committee members, and individual review reports from the members were submitted to the JASRI. Four Japanese members attended the meeting. First, the JASRI provided guidance on the beamline review and gave an overview of SPring-8, and then JASRI staff took us for a beamline tour. The beamline responsible explained the outline of the beamline facilities, selected scientific activities, and future strategy, and then the committee and JASRI staff had an open forum. This report was put together on the basis of the discussions among the Japanese members, referring to the individual review reports from professor G. Ruocco and professor J. M. Tranquada.

2. Current Status of Beamline and Experimental Facilities

BL35XU is a beamline for the study of dynamics in materials using inelastic X-ray scattering (IXS). The installed X-ray spectrometer attains an energy resolution of better than 10^{-7} at an incident X-ray energy of approximately 20 keV, and realizes spectroscopic measurements of energy transfer at a resolution of meV, thus far only accessible to neutron scattering measurements. The X-ray spectrometer enables observation of acoustic modes below Q=1.0 $Å^{-1}$ in liquids and glassy materials, which are inaccessible to neutron scattering because of its kinematical limit. Furthermore, a newly synthesized compound with a small volume can be measured using well-focused X-ray beams. The predominance of IXS in these fields will continue even after third-generation neutron sources, such as J-PARC, start to operate.

The IXS spectrometer is one of the few of such apparatuses existing worldwide and has achieved highest performance after overcoming technical hurdles since 2001. The back scattering monochromator is the best choice because of both its simple structure and the large space in the experimental hall, which is advantageous to the SPring-8 facility. A key to this success is the successful fabrication of delicate analyzer crystals. Furthermore, the spectrometer employs a three x four analyzer array and has advantage over the spectrometers in ESRF in terms of data-accumulation efficiency. Combined with a newly developed multi channel CZT detector to simultaneously gather data at 12

different Q-points, the spectrometer has achieved its goal. The overall performance achieved is highly evaluated. In particular, the development of analyzer crystals and detectors in collaboration with top-class Japanese companies is notable.

3. Research Activities

IXS should cover measurements of low-Q regions in liquids and glasses, which are inaccessible to neutron scattering because of its kinematical limit. Although this field is not yet mature in Japan, some of the on-going research on typical materials is noteworthy. In Europe, there are many experienced scientists in this field, and this situation is reflected in the research outputs at BL35XU by European users. In the future, more similar-level publications by Japanese scientists are expected.

By making use of focused X-ray beams, there are some noteworthy outputs of research using small single crystals, particularly the studies of phonons in novel superconductors. Furthermore, using twin-free samples, remarkable results have been obtained from the study of phonons in oxide superconductors. These results are highly evaluated on the whole since they are inaccessible to neutron scattering.

The number of papers is small compared with that for other beamlines. This is attributed to the fact of IXS that one research project needs longer beamtimes than other experimental methods. Nevertheless, there are many publications from top-class journals, showing that the research outputs are of high quality.

After third-generation, high-brilliance synchrotron radiation facilities were constructed, IXS has been used in research fields for which thus far neutron scattering was unrivaled as an experimental tool. In the context of complementary uses, the availability of the spectrometer at BL35XU is of great significance.

4. User Support

The support of in-house staff is essential to performing an experiment because of the apparatus being highly specialized and the limited number of experienced scientists in Japan. The user support by in-house staff at BL35XU is highly evaluated, which is

reflected in the results of the survey of users. The beamline is equipped with data-gathering and data-analysis software.

The committee admits that one experiment needs many shifts and thus the number of experiments performed within a year is limited. We think it is a time to press for further improvement in data quality and then to publish research results with great impact. We recommend that the JASRI should select more stringently research proposals with great significance, and to allow increased flexibility in their execution, allowing proposals to be executed over longer periods of time.

The support from in-house staff is indispensable during the early stage since it is a specialized apparatus for most users. It is a time to allow experienced users to carry out their experiments with detailed manuals since the experimental procedure has been fixed on the basis of gained experience after four years of operation. In the future, in addition to user support, the in-house staff should conduct their own research with a new idea toward creating a new field of science, exploring new research fields with the IXS techniques and developing new data-analysis methods.

5. Future Strategies for Instrumentation and Research

The committee judges that BL35XU has achieved the initial goal regarding the facility's performance. In the future, development of new analyzers and monochromators made of quartz should continue since higher performance is expected. We suggest an international collaboration with ESRF and APS regarding the development of quartz analyzers and monochromators. Introduction of a motorized cryostat carrier is urgent since sample positioning is important. Microfocusing of incident X-rays using a KB mirror system is essential to widen the application of the IXS methods in the future.

Development of software programs to simulate an experiment in advance and to analyze data in real time is an important task at BL35XU. The committee thinks that these software programs should be developed in collaboration with theoretical scientists in other institutions, rather than employing new staff for theory.

Future research using the spectrometer is on dynamics in a small-Q and finite-energy region, phonon observation in micro crystals and IXS experiments under extreme

conditions.

From medium- and long-term perspectives, the JASRI should consider construction of a new IXS beamline with a long undulator to explore new research fields such as phonon microscopy and dispersion relations in electronic excitation.

An effort to invite new users is also needed to produce more outputs with world-class quality using this top caliber apparatus. For this purpose, publicizing the apparatus's performance and publishing the obtained results are effective, in addition to organizing a workshop to establish closer cooperation with users by discussing the future of research at BL35XU.

The BL35XU beamline has been well managed and maintained by the SPring-8 staff. It is important to bring up young scientists in this field in order to maintain the current performance of the beamline.

6. Summary

The committee recognizes that BL35XU has achieved the highest performance worldwide as a high-resolution IXS beamline and we give a high evaluation to the beamline. World-class papers have been published over the past four years and the research activities have been making satisfactory progress. We expect a large increase in the number of users by effectively publishing the obtained results. We recommend that the JASRI should improve the apparatus substantially or begin to discuss the necessity of a next IXS beamline. We expect that the new apparatus for IXS should be designed on the basis of a new idea, in the same way that BL35XU was designed, and that new fields of science would be discovered, which are accessible only to the newly designed apparatus.