Commissioning Activities at Beamline 4.0.2, the Elliptically Polarizing Undulator Beamline for Magnetic Spectroscopy

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INTRODUCTION

This year marked the achievement of several milestones for beamline 4.0.2, the first ALS undulator beamline for the direct production of circularly and elliptically polarized x-rays. The first experiment with the elliptically polarizing undulator (EPU) was performed, using the "white light" beam of the undulator.[1] The long awaited monochromator from Oxford Instruments was repaired and installed. The beamline optics were installed and first light was received at the end stations. Finally, the first high resolution spectra have now been obtained. [2] This report describes the results of some of the commissioning activities, in particular the first measurements of the polarization and the spectral resolution of the new beamline.

BEAMLINE DESCRIPTION

The design adopted for beamline 4.0.2 is a variable-included angle, plane-grating monochromator. This design provides a wide energy range, good efficiency, and high spectral resolution. A schematic diagram of the beamline appears in figure 1.

RESOLUTION TESTS

The spectral resolution of the beamline was evaluated using the N_2 1s-π^* absorption at 401 eV. Figure 2 shows the experimental data (x's) and a 6 peak Voigt lineshape fit (dotted line) to the data. The natural linewidth (Lorentzian component) of the peaks was fixed at 120 mV, while the Gaussian component was varied to determine the instrumental contribution to the linewidth.

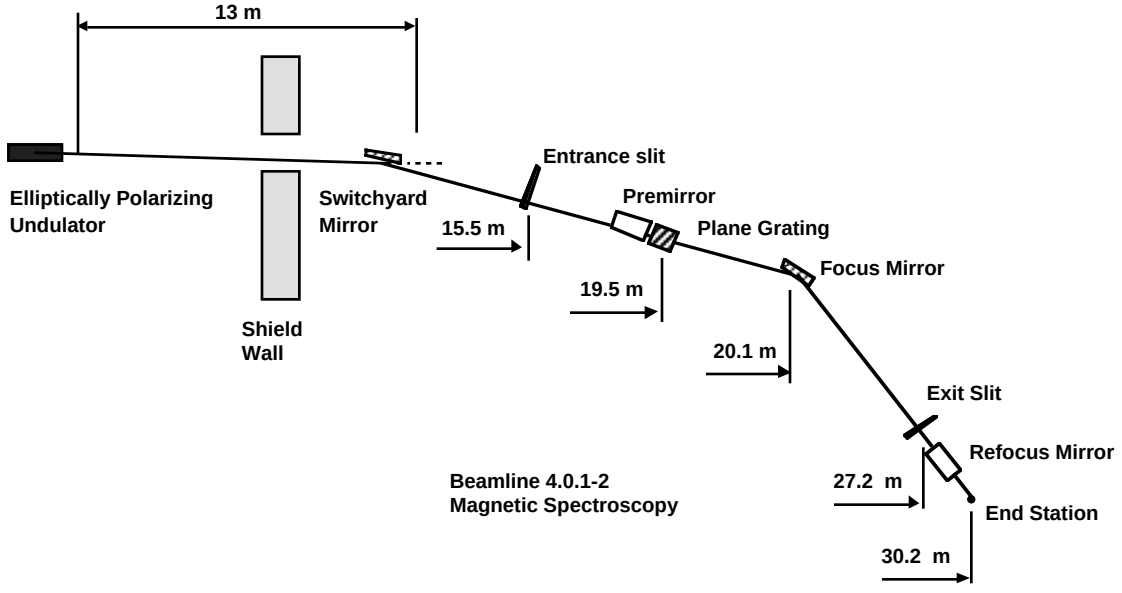

Figure 1. Schematic Diagram of BL4.0.2, the EPU beamline optimized for magnetic spectroscopy.

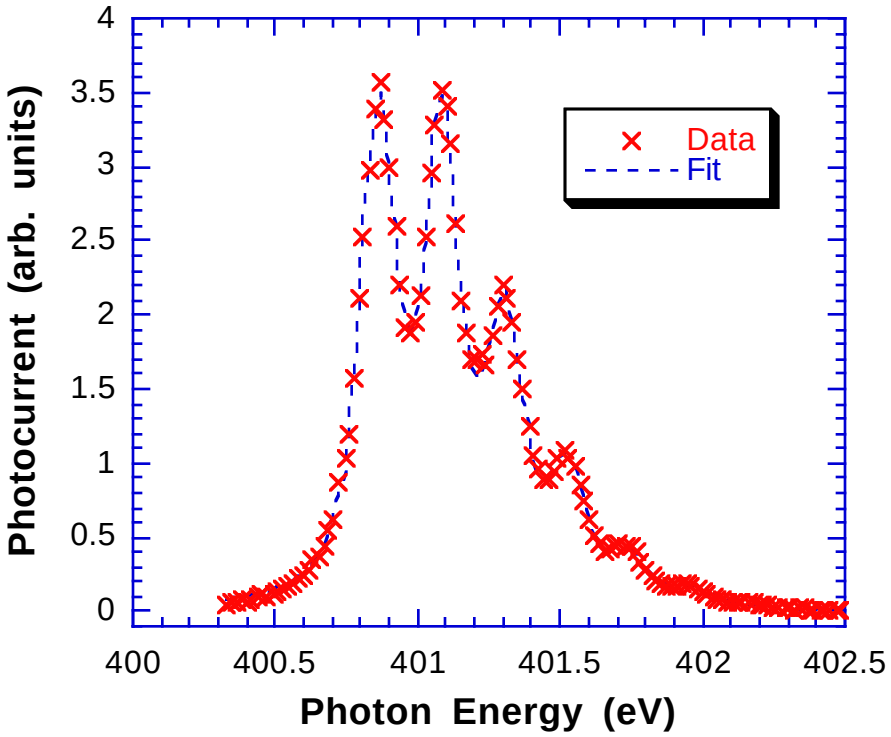

Figure 2 High resolution spectrum of N_2, demonstrating a resolving power ≥6000.

This analysis yields a spectral resolving power ≥ 6000, our design goal. This spectrum was obtained under high heat load conditions (1.9 GeV, >300 mA storage ring current, and full illumination of the optics) and with entrance and exit slit widths of approximately 25 µm. We continue to optimize the alignment of the monochromator and anticipate improvements to the performance.

POLARIZATION MEASUREMENTS

To determine the polarization characteristics of the beamline, a multilayer reflection polarimeter [3] was used to analyze the x-rays. Figure 3 shows the results of measurements made at 700 eV. As can be seen, the degree of linear and circular polarization (P_L and P_C respectively) varies as a function of the z shift of the EPU diagonal magnet rows. At z=0, $P_L \approx 1$, showing that the x-rays are completely linearly polarized, in this case horizontally. As z increases, P_L goes down while P_C increases, until at z=15.5 mm, $P_C \approx 1$ and $P_L \approx 0$, showing that x-rays are circularly polarized. At z> 15.5 mm, we have an increasing linearly polarized component until at z=25, the beam is again completely linearly polarized. However, with this z value, the direction of polarization is vertical rather than horizontal as with z=0. For z<0, the pattern is repeated, but the circular polarization component is of the opposite helicity, e.g. left circularly polarized instead of right circularly polarized. These measurements were obtained at an energy of 700 eV and show that the beamline can deliver both linearly and elliptically polarized x-rays under user control. Additional measurements of the polarization properties are currently underway to better characterize the beamline performance.

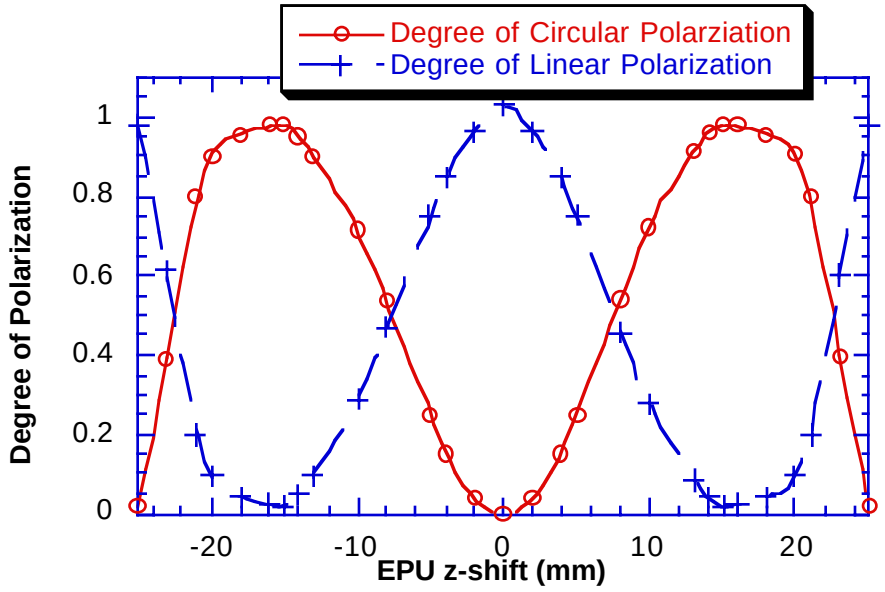

Figure 3. Analysis of the x-ray polarization at BL4.0.2. As the EPU z position (the position of the adjustable magnet rows) is varied from 0 to 25 mm, the polarization changes from linear ($P_L \approx 1$ and $P_C \approx 0$), to elliptical to circular ($P_L \approx 0$ and $P_C \approx 1$) and then back to linear.

ACKNOWLEDGMENTS

Thanks to the entire ALS staff for making this beamline operational. From the Insertion Device group which designed, fabricated, and tested our undulator, the first ALS EPU; to the Experimental Systems and Scientific Support Groups for valuable insights to the design concepts for the beamline; to the Engineering groups who translated these concepts to hardware; to the Technical Support groups who took the hardware and made it work, to the Accelerator Physics and Control groups who made it possible to run our experiments without dumping the beam or destroying our equipment; and finally, to the ALS administrative staff and management who supported the effort from conception to fruition, this beamline is a tribute to the excellence of the individuals who make up this organization.

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