STATUS AND DEVELOPMENT OF THE ALS*

D. Robin and B. Feinberg LBNL, Berkeley, 94720, USA

Abstract

The ALS is in a phase of rapid development. This past year the ALS served over 1000 users and that number is expected triple in the next three years. Currently there are seven insertion devices in operation including an Elliptically Polarizing Undulator (EPU) that mechanically shifts between left and right circularly polarized radiation at 0.5 Hz. A third harmonic cavity system has been installed and is providing longer lifetimes. A number of important machine developments are underway such as the inclusion of three superconducting magnets for the generation of high brightness, broadband, high energy photons; a fast orbit feedback system for improved orbit stability; and the inclusion of a second elliptically polarizing undulator. Future development plans include installation of more EPUs, and a narrow gap short period insertion device. In addition, several "complementary" sources are being studied such as a storage ring to produce far infrared radiation and sources to generate femtosecond x-ray pulses. In this paper we present an overview of the current operational performance and developmental plan for the ALS. users.

1 INTRODUCTION

The Advanced Light Source (ALS) is a third generation synchrotron light source located at Lawrence Berkeley National Laboratory. The ALS was commissioned in 1993 with first light to users in 1994. Since then, the number and diversity of users has been rapidly growing. Currently the ALS is serving more than 1000 users and that number is projected to triple in three years.

Fig. 1 shows the beamlines as of June 2001. There exists 29 beamlines — 10 insertion device beamlines and 19 bending magnet beamlines. Note that 26 of these beamlines can operate simultaneously. The experiments performed on these beamlines use radiation ranging from infrared (20 microns) to hard x-rays (0.5 Angstroms). Many experiments also require control of the polarization of the radiation. As seen in Fig. 1 there are 7 insertion devices: 1 wiggler, 5 planer undulators and 1 elliptically polarizing undulator (EPU). The EPU is different from the planer undulators in that it can produce left or right circular polarization or linear polarization with arbitrary orientation.

The ALS is presently in a period of major construction. Over the last couple of years 20 new beamline projects are currently either operational (7), being commissioned (4), under construction (7), or being designed (2). In the near future there is a plan to replace 3 of the ALS 1.3 Tesla normal conducting magnets with 3 superconducting magnets (Superbends) [1]. The Superbends are located in sectors 4, 8, and 12 as shown in Fig. 1. These magnets will generate high flux, high brightness, harder x-rays that will extend the capabilities of the ALS. Each of the Superbends will produce 4 beamlines for a total of 12 new beamlines. In addtion to the Superbends a second EPU is being constructed and will be installed in straight 11.

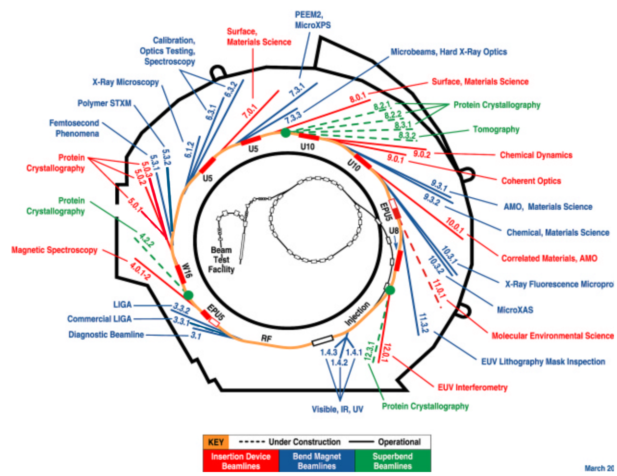

Figure 1: Beamlines at the ALS as of June 2001

Beyond these planned upgrades of the storage ring, other upgrades of the facility are being considered: including a high field insertion device to be placed in straight 6 for generating ultra short x-ray pulses, a dedicated ring for the generation of mid to far infrared radiation, and a dedicated facility for generating high flux ultra short x-ray pulses.

The mission of the ALS staff is to satisfy the needs of the present and future ALS user community. This is a very challenging mission because as the ALS is developed with more insertion devices (particularly EPUs), more narrow gap chambers, and harmonic cavities, the ALS becomes more complicated to operate. Nevertheless the ALS staff continues to maintain and improve the reliability and quality of the beam, ensure upgrades go in smoothly, and plan for future upgrades of the facility.

2 OPERATIONS STATUS

Fig. 2 is a plot of the number of user hours and instrumentation hours as a function of the fiscal year. One can see in Fig. 2 that the number of user hours has grown from 2000 hours per year in 1994 to almost 6000 hours per year

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in 1999. In spite of this fast growth the availability of the facility has remained high — about 95%. The availability of the facility is defined as the delivered versus scheduled time and is plotted in Fig. 3.

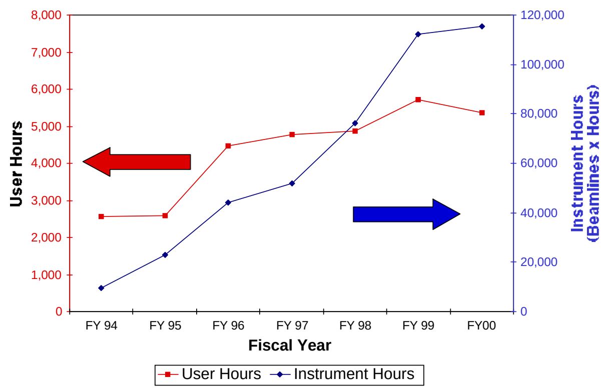

Figure 2: User hours and instrument hours versus fiscal year.

2.1 Reliability

In order to maintain such a high degree of reliability the ALS puts a large effort on operations monitoring [2]. As part of this effort, each week the accelerator physics, operations, engineering and controls groups meet to discuss the previous week's performance. Archive data is reviewed and problems and solutions are discussed. In particular all causes of beam loss, orbit and beamsize instabilities, and changes in lifetime are reviewed. This close monitoring of operations has resulted in early detection and fixes of problems and improved reliability of the machine.

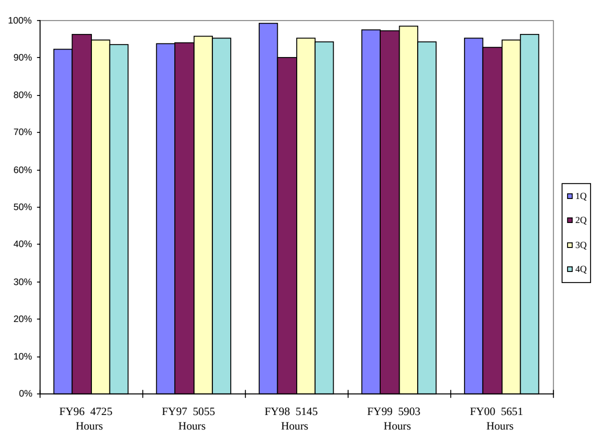

Figure 3: Availability of the ALS versus fiscal year.

2.2 Past Performance Improvements

In addition to improving and maintaining the reliability of the machine there have been significant improvements in the performance of the machine since initial operation. Table 1 lists several of the improvements. As seen in the table there have been improvements in beam size and beam orbit stability, lifetime [3, 4], and the beam dynamics [5].

Table 1: Improvements in performance of the ALS

Initial Operation	**Present Operation**
Large unstable multibunch oscillations - Energy oscillations $\sim$ 10 times natural energy spread ($\sim$0.8%)	Longitudinal and transverse feedback stabilization - natural energy spread ($\sim$0.08%)
No control of vertical beam size	Vertical beam size adjusted with skew quadrupoles - Typical operation with 3% coupling, - ID Tune-feed forward
Large orbit motion - 100 μm horizontal and vertical (σ_x = 250 μm, σ_y = 30 μm), - 500 μm errors from ID gap changes	Small orbit motion - temperature stabilization - ID feed-forward - global orbit feedback - 10 μm horizontal and 5 μm vertical orbit motion (over a day) - 2.6 μm horizontal and 1.2 μm vertical orbit motion ($>$ 0.1 Hz)
Magnet field errors - 40% β-beating - erratic injection efficiency	Measurement and correction of field errors - less than 3% β-beating - improved injection efficiency - improved momentum acceptance
Small single bunch currents with large parasitic bunch contamination - greater than 1% contamination	Large single bunch currents with small parasitic bunch contamination - 14 mA to 30 mA - less than 0.01% contamination
No vertical beam size control - greater than 25% variation with ID gap motion	Vertical beam size control - less than 1% variation with ID gap motion (Except EPU)
Short beam lifetimes - 5 hours (1.9 GeV, 400 mA, 3% coupling, 276/328 bunches)	Longer beam lifetimes - 8 hours (1.9 GeV, 400 mA, 3% coupling, 276/328 bunches)

One of the most significant improvements in the last year was the implementation of a tune feedforward system for the insertion devices. Changes in the insertion device gaps cause changes in the betatron tune which if left uncompensated will result in changes in the vertical beam size. By compensating the tuneshift the stability of the beam size is dramatically improved. Fig. 4 shows the effect of insertion device motion and vertical beam size changes on January 27, 2000, before the feedforward was implemented and on July 13, 2000, after the tune feedforward system was implemented. The improvement is dramatic.

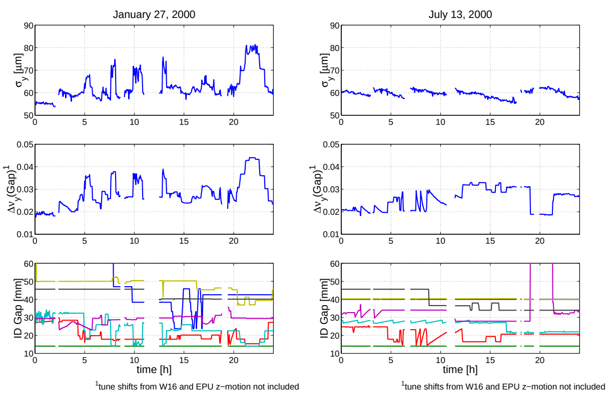

Figure 4: Vertical beamsize changes versus insertion device gap motion before (left) and after (right) tunefeedforward was implemented.

The ALS would like to further improve the beam size and beam orbit stability. To improve the beam size stability the ALS is planning to implement a fast tune feedforward for the EPU, a continuous tune measurement system, and a slow beam size feedback. To improve the orbit stability, the ALS is planning to increase the orbit feed back from 1 Hz to 1 kHz[6]. This requires an upgrade in the present control system, providing better synchronization between BPMs and correctors, feedback and feedforward loops. The initial stage of the upgrade is planned for the Fall 2001 shutdown.

3 FUTURE EXPANSION OF THE FACILITY

In addition to the planned upgrades the ALS is studying other possible upgrades. At present there is a facility providing ultra short x-ray pulses using a laser slicing technique [7, 8]. The source of the radiation is bend magnet 5.3 (see Fig. 1). The ALS is studying the possibility of enhancing the flux of the ultra short source by installing a superconducting wiggler in straight 6. This would increase the flux by 2 orders of magnitude over the present bend magnet source. A design study is being carried out between the ALS and AFRD's superconducting magnet program. Beyond this source LBNL is studying the feasibility of a dedicated ultra fast x-ray facility based on a recirculating linac [9].

Another possible expansion of the facility that is being considered is the construction of a dedicated infrared ring to be sited on top of the booster shielding [10]. Currently there exists a large community of mid infrared users. The present beamline (1.4) is fully booked. In addition this beam line is a poor source of far infrared radiation because the small vacuum chamber aperture severely limits the flux. Therefore to provide capacity for the growing community and enhance the capability for a new user community the ALS has embarked on a feasibility study of a dedicated mid to far infrared source. It is designed to produce radiation from 1 μm to 1mm.

4 SUMMARY

The plans of the ALS are in line with the needs of the present and future user community. The ALS is maintaining and improving the performance of the storage ring, enhancing the capabilities of the facility with Superbends, EPUs, and the development of an ultra short pulse x-ray facility, as well as planning for sources to complement the facility.

5 ACKNOWLEDGEMENTS

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