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Gary F. Krebs
Accelerator and Fusion Research Division

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Gary F. Krebs

Advanced Light Source
Accelerator and Fusion Research Division
Ernest Orlando Lawrence Berkeley National Laboratory
University of California
Berkeley, California 94720

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Measurement of Storage Ring Motion at the Advanced Light Source*

Gary F. Krebs, E.O. Lawrence Berkeley National Laboratory, Berkeley, California 94720, U.S.A.

Abstract

The mechanical stability of the Advanced Light Source storage ring is examined over a period of 1.5 years from the point of view of floor motion. The storage ring beam position monitor stability is examined under various operating conditions.

1 INTRODUCTION

The Advanced Light Source (ALS) at the E.O. Lawrence Berkeley National Laboratory is a third generation synchrotron x-ray source[1]. The ALS, shown schematically in Figure 1, has a 50 MeV LINAC and a 1.5 GeV booster and 2.1 GeV storage ring.

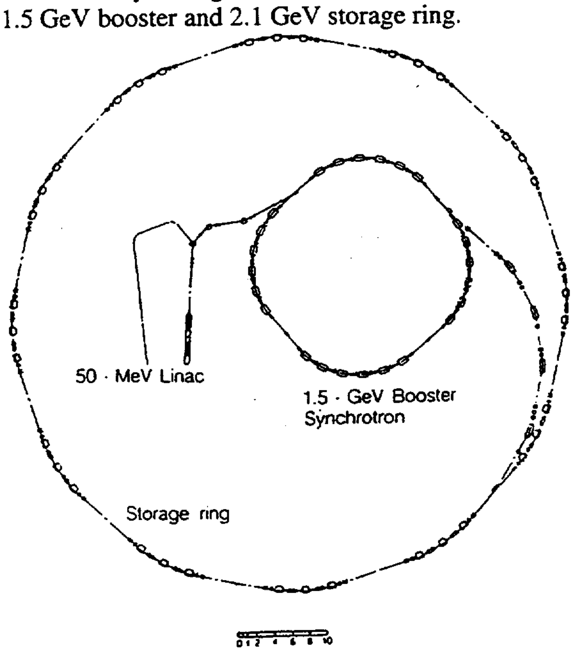

Figure 1
The ALS accelerators system

To produce a stable and bright electron beam, long term mechanical alignment and stability of the magnets over the 200 m circumference storage ring must be maintained. In order to track the electron beam, a system of over 100 Beam Position Monitors (BPM) are mounted in the storage ring vacuum chambers. Characteristics of the storage ring motion and vacuum chamber BPM motion have been measured and are presented in this paper.

2 STORAGE RING MOTION

To accomplish accurate alignment of the storage ring magnets, a reference network of 36 monuments was created. The monuments are imbedded in an 18 inch thick concrete floor. The angles and distances between monuments are measured with theodolites and mekometers, respectively, to determine their coordinates relative to an arbitrary chosen origin. Magnet positions around the 12 sectors of the storage ring are then referenced and aligned to the monuments. Some 200 storage ring magnets are mounted on a system of 12 moveable sector girders such that after initial alignment on the girder, future storage ring alignment can be achieved by aligning the girders alone.

Since September 1995 storage ring monument elevation surveys have been carried out nearly every month in an effort to characterize floor, and hence nearby, magnet/girder motion. Monument elevations were measured with 30 μm accuracy. The changes in elevation of the 36 storage ring monuments are shown in Figures 2a-2d from the period September 1995 to March 1997. We find the storage ring monuments have dropped in elevation as much as 1.2 mm in sectors 6 and 7, see Figure 2d. Over the period represented in Figure 2a-d, a great deal of floor loading has occurred. Insertion devices weighing

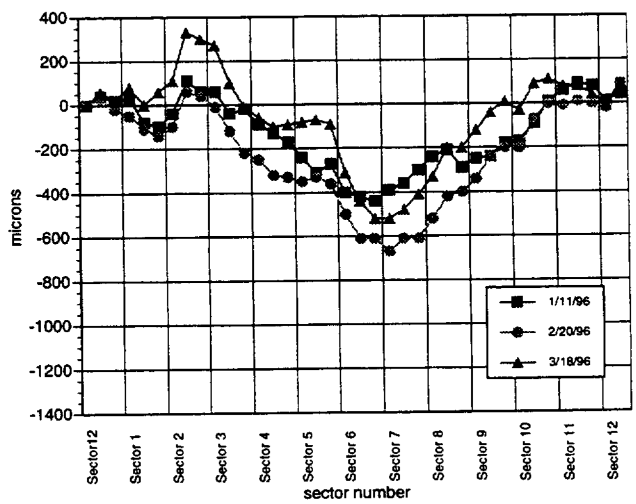

Figure 2a
Elevation changes around the storage ring

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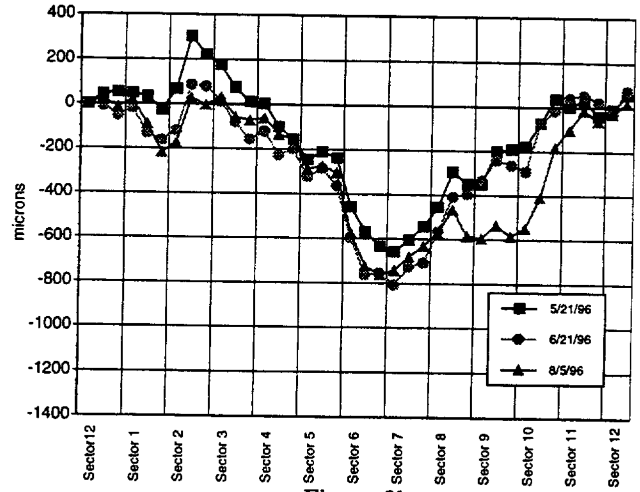

Figure 2b

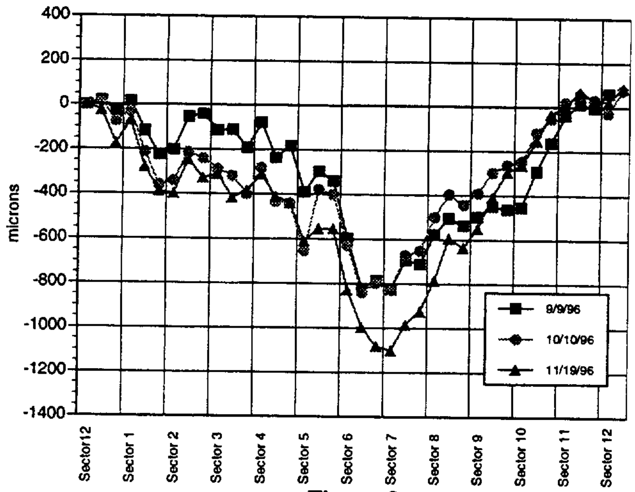

Figure 2c

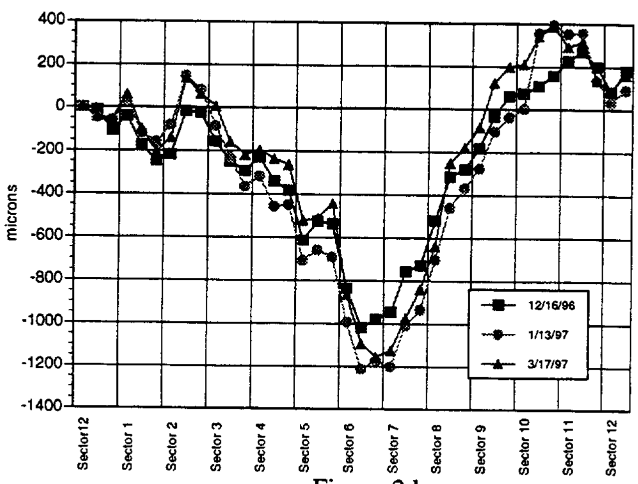

Figure 2d

30 tons each, were added to the storage ring in sectors 9 and 5 in 5/94 and 4/96, respectively. In Figure 2a,2d we observe a characteristic drop followed by a rise in monument elevations during the rainy winter months. In Figures 3a-3d the average of each sectors three monuments elevations is shown over the same time period. Sectors 10 and 11 are the most stable sectors as shown in Figure 3d. Operationally, the storage ring requires smoothness magnet-to-magnet to function optimally. Since the magnets were aligned on their girders relative to their ideal position to within 150 µm and remain stable, what remains is to maintain girder-to-girder smoothness as floor motion occurs. Figure 2a-d shows the smoothness monument-to-monument and, by extension, girder-to-girder to be typically better than 100 µm. A system of beam position corrector magnets around the storage ring can correct for girder-to-girder misalignments up to a few hundred microns. As the beam corrector magnet field limits are approached, the storage ring must be realigned.

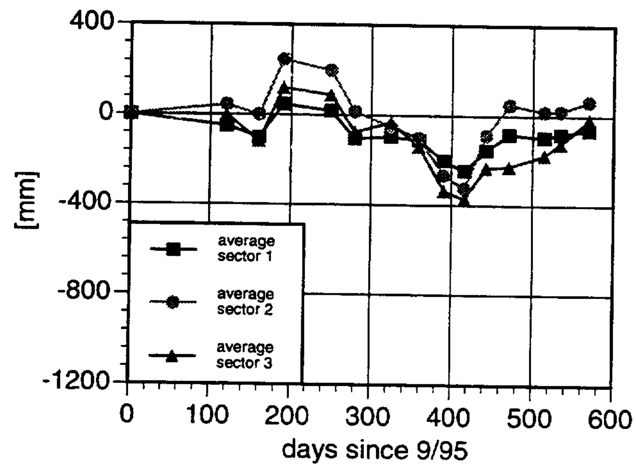

Figure 3a

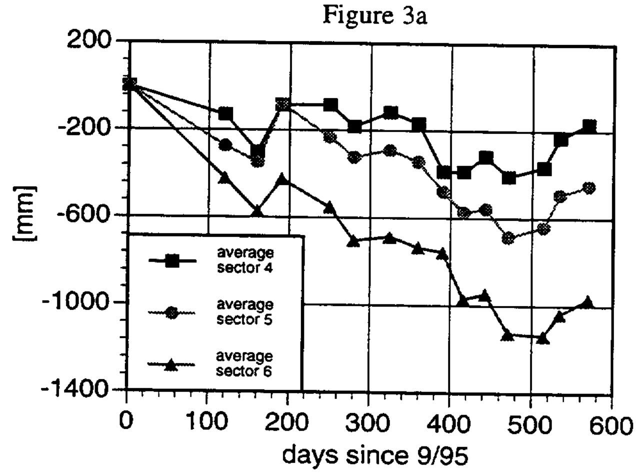

Figure 3b

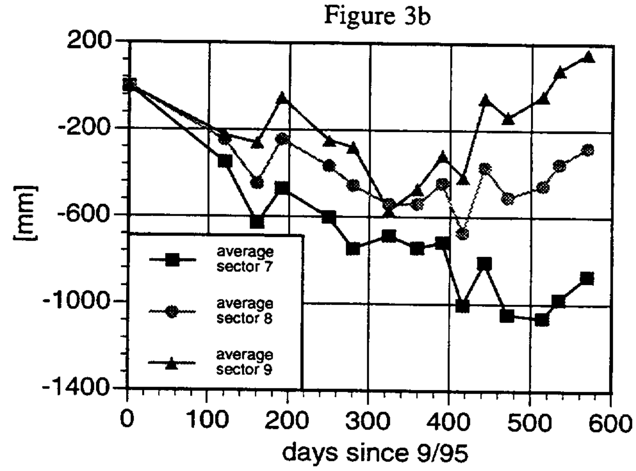

Figure 3c

Elevation changes at the storage ring

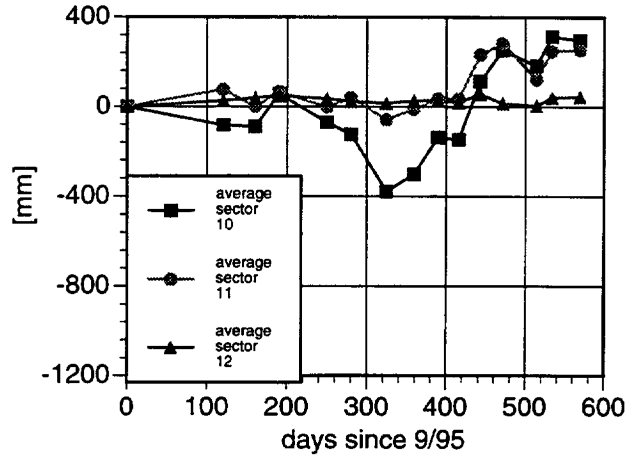

Figure 3d
Elevation changes at the storage ring

3 BEAM POSITION MONITOR MOTION

The BPM allow accelerator operators to track the electron beam through the magnet lattice, make corrections and compare the electron beam location to various influences and models. Beam stability is affected by many different parameters. Here at the ALS we have found such things as overhead crane usage, earthquakes and air temperature stability inside the storage ring tunnel to be some of the influences effecting the trajectory of the electron beam[2]. In addition to real motion of the electron beam, there is also 'false beam motion' that occurs when the BPM themselves move. Since the BPM are assumed fixed in location, this effect appears as beam motion. The BPM are located inside the storage ring vacuum tanks which are mounted in an overconstrained mode directly to the sector girders. Measuring the motion of the BPM relative to the girder was carried out using 1 μm precision dial indicators[3]. The motion occurs due to heating of the vacuum chamber from synchrotron light and stray electrons. Figure 3 shows the motion the BPM undergoes during routine operation of the storage ring. A typical storage ring cycle lasts about 4 hours and begins with filling the ring to about 400 ma of electrons. During this process heating of the vacuum tank is at its maximum. Over the cycle period, the electrons decay down to about 200 ma. At this point the heating is at a minimum. The temperature change produces maximum 15 μm horizontal and 8 μm vertical position changes in the BPM location. Aside from the initial filling process, the change in BPM position is about 4 μm/hr horizontally and 1 μm/hr vertically. The effect is clearly seen in Figure 4 where a 24 hour time period is covered and 3 fills or cycles of the storage ring occur.

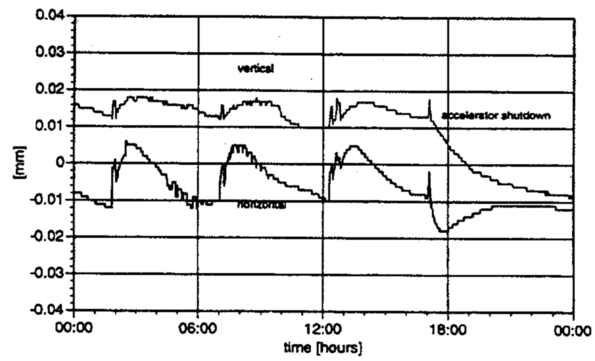

Figure 4
Vacuum chamber position change fill-to-fill

The baseline for this heating and cooling cycle is affected by the air temperature inside the storage ring tunnel. Temperatures inside the tunnel are usually maintained to within ± 0.5 °C. (Changes in temperature inside the storage ring tunnel affect the length and orientation of the storage ring and produce real beam motion which is far larger (100-500 μm) than this effect. At the end of a weekly operation cycle as the storage ring is routinely shut down for preventive maintenance, we see the horizontal and vertical positions relative to the girder change as much as 30 μm. When the machine is brought back on, a similar motion occurs in the opposite direction. This stabilization period typically lasts about 8 hours. Electrically the BPM are considered to be repeatable to ≤5 μm[4]. However, such inherent electrical accuracy may be unnecessary when the mechanical stability of the BPM is far larger.

4 CONCLUSIONS

Monitoring the alignment of third generation synchrotron storage rings is important in order to maintain a high quality electron beam. Periodic realignments are typically required approximately every 24 months at the ALS. In determining the electrons position in the storage ring many factors affect the repeatability of the BPM. Mechanical stability due to electron beam effects are important when considering the overall accuracy of the ALS storage ring BPM system.

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REFERENCES

(1) 1-2 GeV Synchrotron Radiation Source (conceptual design report) LBNL Pub. 5172
(2) Orbit stability of the ALS storage ring.R.Keller et al. PAC Vancouver, 1997
(3) Mitutoyo digimatic indicator 543-523A
(4) Private communication with Jim Hinkson, ALS.