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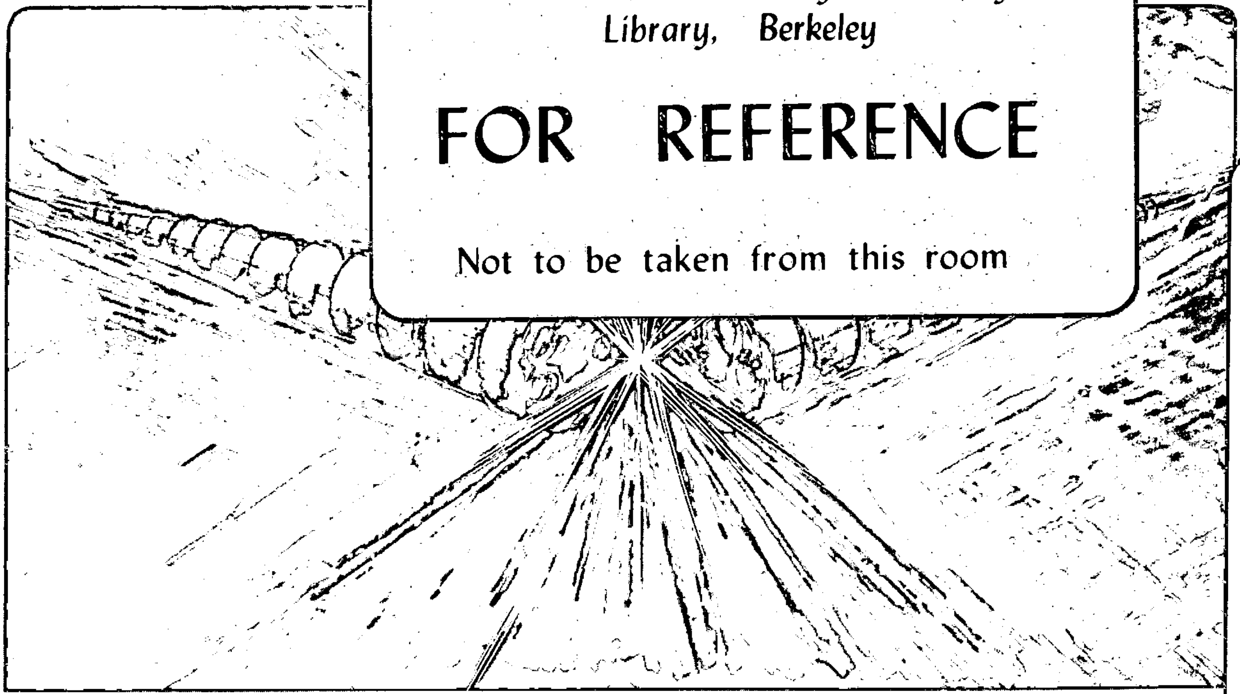

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Commissioning Experiences of the ALS Booster Synchrotron

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Because of the construction and installation activities during normal working hours, injector commissioning activities have been limited to the evenings.

IV. Injection Studies

Parameters of the injected beam are summarized in Table 2. Linac operation is very reliable at these operating conditions. Energy spread is mainly due to the energy droop in the subsequent bunches and is high because (1) the beam loading compensation has not been implemented, and (2) the bunching system has not been fully optimized yet. We have a beam collimator for energy selection in the linac-to-booster transfer line. The collimator was left wide open in the present experiment for the initial tuning purpose.

Table 2
Injected Beam Parameters

Beam energy	45 MeV
Charge per bunch	0.1 nC
Separation between bunches	8 ns
Number of bunches	20 pulses
Energy spread	±2%
Repetition rate	1 Hz

The booster lattice was set up according to the "nominal tune" column in Table 3.

Table 3
Two Typical Operating Points of the Booster

	nominal tune	low tune
Betatron Tune		
Horizontal	6.264	5.764
Vertical	2.789	2.480
Momentum Compaction	0.0408	0.0466
Chromaticity		
Horizontal	-11.2	-8.31
Vertical	-4.79	-4.69
Emittance [nm, unnorm]	0.15	0.18
Quadrupole *kL* [1/m]		
Focusing	0.830	0.787
Defocusing	0.504	0.471
Sextupole *kL* [1/m^2]		
Focusing	0.971	0.867
Defocusing	1.183	0.989

for quadrupoles $k = (dB/dx) / [B\rho]$
for sextupoles $k = (d^2B/dx^2) / 2 [B\rho]$

Injection from the 50–MeV linear accelerator is via a fast kicker magnet [12] utilizing the well-established single-turn, on-axis injection technique. The fast kicker consists of two 25–cm modules and provides a 60–mrad kick to the injected beam onto the booster beam axes. The injection kicker has a 150–nsec flat top, with rise and fall times of about 100 nsec. Each module has a pulse flatness of ±0.5 %. When fully commissioned, the entire 150 nsec period will have a flatness of < ±0.5 %.

Booster instrumentation includes 5 TV monitor stations, 32 beam-position monitors (BPMs), travelling wave electrodes (TWEs) [13], and one beam-intensity monitor (DCCT). A TV monitor station consists of a Chromox 6 fluorescent screen and a CCD camera. A BPM utilizes 4 button monitors and is similar to the ALS storage ring BPM system [14].

We first observed the injected beam on the fluorescent screen located on the down-stream side 1005 mm from the center of the kicker magnet where the dispersion is still very small. (The lattice functions at the screen are: horizontal $\alpha = 3.93$; $\beta = 8.45$ m; $\eta = 0.12$ m; vertical $\alpha = -1.53$; $\beta = 3.37$ m.) The beam centroid moved about 6 mm as expected when the kicker amplitude was varied by about 10%.

Next, we observed the beam with one of the BPMs located 5586 mm from the center of the kicker magnet. This BPM is located immediately after the focusing quadrupole in which the dispersion function is very large ($z = 5.3425$ m; horizontal $\alpha = 4.23$; $\beta = 9.17$ m; $\eta = 1.05$ m; vertical $\alpha = 1.98$; $\beta = 6.07$ m.) We observed that more than half of the 20 bunches were already lost at this location.

Finally, we observed the circulating beam using one of the TWEs in the third quadrant. Figure 1 shows that only the first 3 bunches survived up to the third quadrant. It also shows that about half of the beam intensity was lost by the next turn.

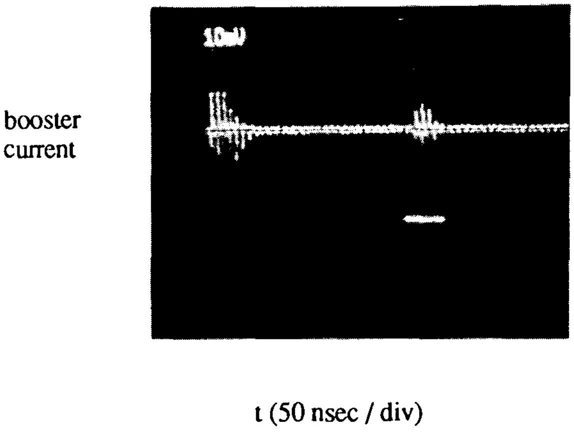

Figure 1. TWE signal showing electron bunches for the first two turns. [XBB 915-3445]

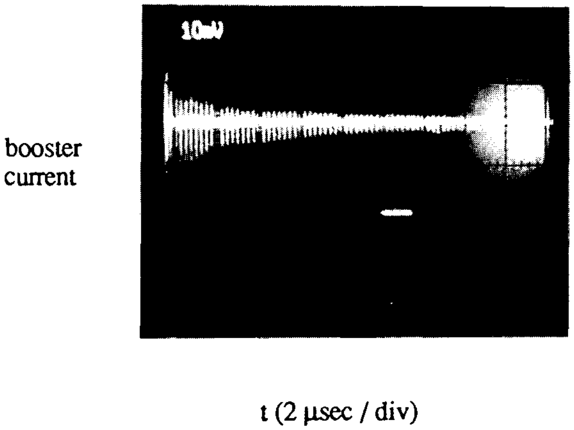

Figure 2. TWE signal showing electron bunches for the first 20 µsec. [XBB 915-3446]

Figure 2 shows the TWE signal for the first 20 µsec. It shows that the rapid beam loss during the first few turns is followed by a slower beam decay. Circulating beam was visible for about 400 turns.

V. Summary and Discussions

We were actually surprised to observe that the beam survived as long as it did with neither steering magnets nor the rf cavity energized. Rapid beam loss was expected from the beginning because of (1) the large energy spread in the injected beam; (2) large closed-orbit distortion; and (3) imperfect flatness of the injection kicker wave form. Our beam stay-clear specifications are summarized in Table 4.

Table 4
Beam Stay-Clear Specifications
[mm rms]

	At 50 MeV	At 1.5 GeV
Beam Size	3.6	1.3
Dispersion	3.5	0.7
Energy Spread [%]	(0.3)	(0.06)
Closed Orbit distortion		
before correction	6.0	6.0
after correction§	0.3	0.3
Quadratic Sum		
before correction	7.8	6.2
after correction§	5.0	1.5
Pipe Size	±30.0	±30.0

§ requires corrector strength of 0.5 rmad rms

We expect the specifications will be met in the near future as we finish aligning the rest of the magnets, execute beam loading compensation, tune the linac for a smaller energy spread, and flatten the kicker pulse. We will be able to implement orbit corrections and tune fitting as soon as the rf system and the timing system come on line.

Components necessary for beam acceleration are to be in place by late June. The extraction system is expected to be on line in September, and the booster-to-storage-ring transfer line in October 1991. Storage ring injection is expected to occur in Spring 1992.

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