STATUS AND EARLY COMMISSIONING OF THE PEP-II HIGH ENERGY RING

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Abstract

The High Energy Ring of the PEP-II B-Factory has been constructed in the PEP tunnel. It is now beginning beam commissioning. This report will address the status of the ring systems and our experience in commissioning the systems as well as the first beam running.

1 INTRODUCTION

The High Energy Ring (HER)[1] of the PEP-II *B*-Factory[2] is a 9-GeV electron storage ring designed for 1 A beam current in 1658 bunches. It has been built at SLAC in the existing PEP tunnel, using mostly existing PEP magnets that have been refurbished. A state-of-the-art copper vacuum system is capable of handling up to 3 A beam current. 5 rf stations with 4 cavities each will deliver up to 14 MV at 476 MHz, sufficient for 1.15 cm bunch length at 1 A beam current.[3] Figure 1 shows a layout of the ring and the ring parameters are given in Table 1. The HER is complemented by the 3.1-GeV Low Energy Ring (LER)[4], which is on a construction schedule roughly one year later than the HER.

Table 1: HER Parameters

Circumference	2199.32	m
Energy	9	GeV
Beam Current	0.99	A
Tunes ν_x, ν_y	24.62, 23.64	
β_x^*, β_y^*	33, 1.5	cm
harmonic number	3492	
Synchr. tune ν_s	0.0049	
Bunch Length	1.15	cm

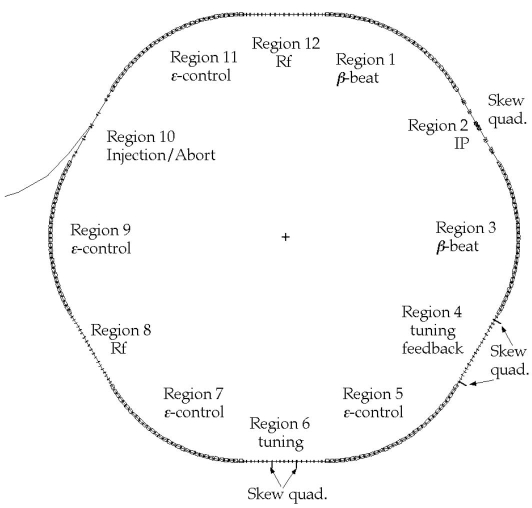

Figure 1: Layout of the High Energy Ring

As of this conference, the accelerator systems for the HER have been installed. A temporary beam pipe is bridging the interaction Region 2, to be replaced with the final vacuum system during installation of the LER. In the meantime, a sophisticated set of background detectors has been installed, thus allowing an early assessment of the backgrounds produced by the HER.

2 SYSTEMS COMMISSIONING

2.1 Magnets and power supplies

In order to provide flexibility in tuning the ring, the magnet system consists of 18 magnet strings that span the whole ring and about 100 locally controlled magnets that are individually powered or in small groups. All magnets have been individually measured and typically have max. $10^{-4}\ldots10^{-3}$ field deviation across the beam-stay-clear aperture. The power supplies and controllers are specified at 10^{-4} accuracy for drift and noise.

Commissioning of this system has been proceeding fairly smoothly. Each supply was first checked in the lab, installed and checked out according to a specified plan with hi-potting and polarity checks preceding initial turn-on of the supplies. The availability of a working control system turned out to be of great help, in fact, checkout of each supply also verified the database entries for the particular magnets involved.

Once checked out, as much long-term testing as possible was carried out. In this way, a sporadic tripping problem of the intermediate supplies was identified and addressed without using any beam time. These runs also confirmed the excellent stability of the system; Fig. 2 shows an example of current variation for a typical supply over about 13 hours.

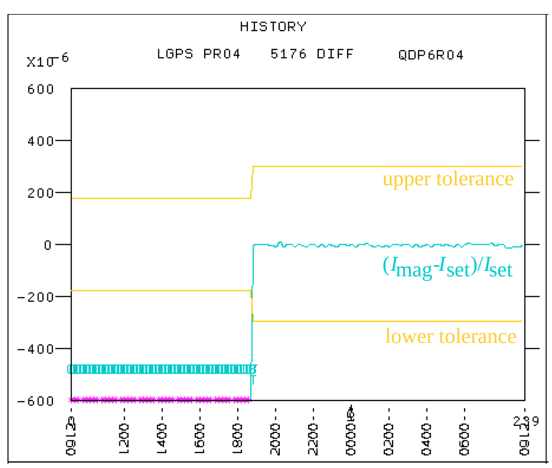

Figure 2: Power supply relative current variation *vs* time

2.2 Vacuum System

Completion and pump-down of the vacuum system proceeded by region. In order to reduce the risk of contamination, installation was done under a constant flow of dry N_2 and using "filtered-air showers." Pump-downs proceeded using cart-mounted turbo pumps for roughing down to the 10^{-6} torr level. Following thorough leak checking the ion pumps were turned on one by one. Pressure in the system is measured by monitoring the pump currents; typically pressures below 10^{-8} torr were achieved after 24 hours as shown in Fig. 3.

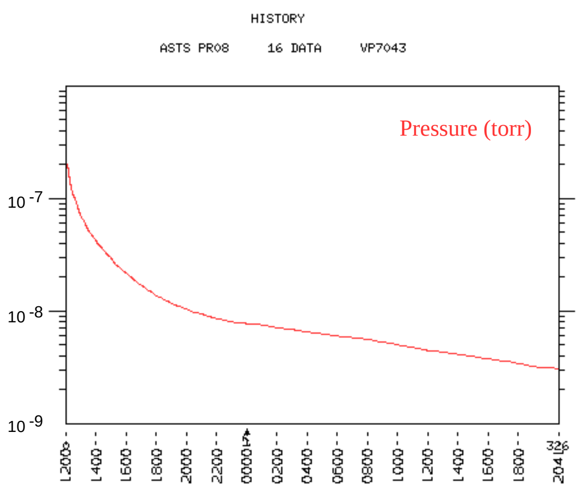

Figure 3: Initial pump down curve for Region 8.

Besides the regular ion pumps there are distributed ion pumps in each arc dipole and NEG pumps in the arc-to-straight transitions as well as in Region 2. These pumps have not yet been activated.

23 Beam Diagnostics

The beam diagnostics system of the HER consists of about 300 button-type beam position monitors (BPM), 100 beam loss monitors (BLM), a dc current transformer, a bunch-current monitor and a synchrotron-light monitor. It is described in detail in another contribution to this conference.[5] The BPM processors are capable of turn-by-turn readout for 1024 turns. Self-calibration and -test capability aids trouble shooting.

The BLM system uses lead-shielded Cherenkov detectors mounted close to the beam line at strategic locations. The processor module is capable of detecting losses over a 10^6 dynamic range by either charge-integrating the PMT output (high losses) or counting pulses (low losses). Each channel can trigger a beam abort if enabled.

2.4 Feedback Systems

Advanced digital broad-band feedback systems have been constructed and installed for both the transverse and longitudinal plane. These are described in detail in other contributions to this conference.[6,7]

3 FIRST BEAM RESULTS

On May 10, 1997, an electron beam was successfully injected and taken through about 1/3 of the ring into a temporary dump located at Region 2. Figure 4 shows a screen photo of the beam spot observed. This has allowed us to begin commissioning of the BPM and the BLM systems as well as assessing the state of the magnet system. Two of the five rf stations are also operational; however, their effect on the beam has not yet been studied.

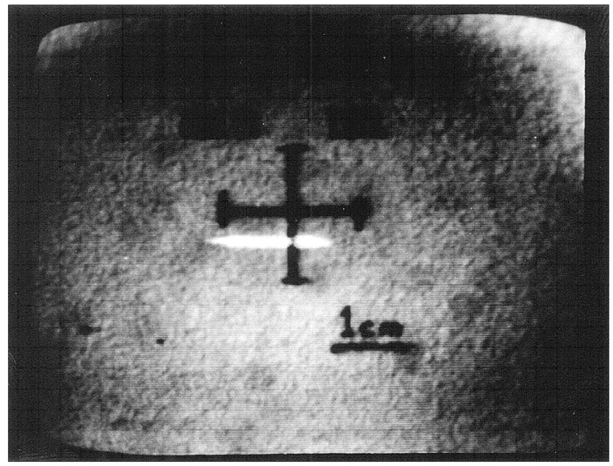

Figure 4: First beam spot observed at the Region 2 dump

3.1 Beam diagnostics

Checkout and timing of the BPM system was the first major task and proceeded fairly smoothly. The timing curves exhibited the expected width of about 40 ns; an unexpected oscillation on top of the distribution was tracked to firmware and corrected. The beam-loss monitors have a gated channel specifically synchronized with the injection timing with a few hundred μs width, these were also timed easily.

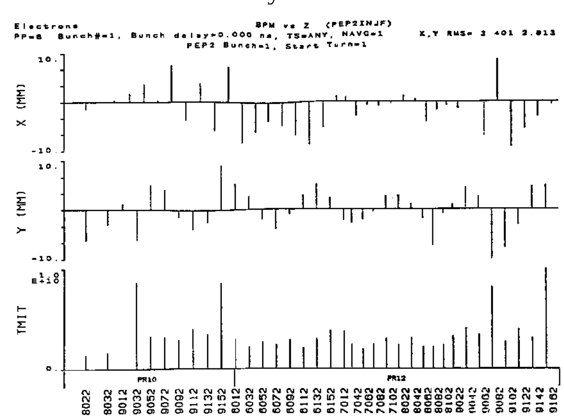

Figure 5: Beam trajectory from injection to Region 2

3.2 Magnet system

The beam was first "parked" on a dump just upstream of the injection region and then injected into the ring using the dc bump magnets only. Once the launch conditions were established the beam made it around the ring to the dump at Region 2 without using any corrector magnets, indicating the absence of any gross alignment errors. Fig. 5 shows the recorded beam orbit trajectory.

Quadrupole settings were checked in two ways: By recording a difference orbit for two different launch conditions a betatron oscillation was be displayed and compared to the on-line model. The agreement is rather good indicating that the magnet settings are not far off the design values. The dispersion function was determined by taking the difference orbit for beams of different energy; the result showed the dispersion being small in the straight section Region 12 and up to 1.25 m in the arcs; in fair agreement with the model values of 0 (straight) and 1.5 m.

Even though the injection kicker was not required for this run, it was activated and its timing set. Fig. 6 shows a timing curve taken, the kicker rise time was determined to be about 300 ns with a total pulse width of just over 1 µs; in good agreement with the expectation. The kicker field strength was found from R_{12} measurements to be 8-10 Gm/kV, consistent with lab measurements (the uncertainty is due to the still uncertain BPM calibration).

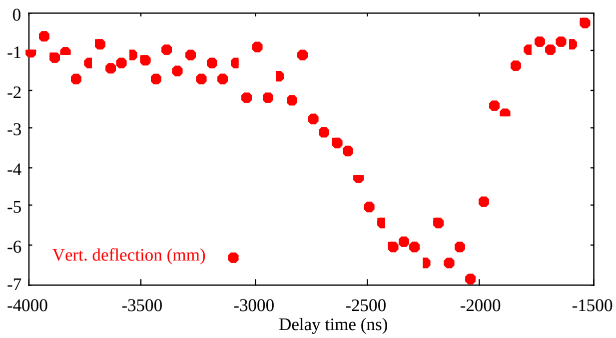

Figure 6: Injection kicker timing curve

3.3 Vacuum system

The vacuum system performed well during the run; beam intensities were still too low to see any significant effect on the gas pressure.

The machine aperture was scanned vertically using the injection bump magnets (which are strong enough to scan the whole aperture of the ring, while individual orbit correctors are not). Fig. 7 shows the result of such a scan; as the transmission drops BLMs downstream of the location of the beam loss show a clear and unambiguous response.

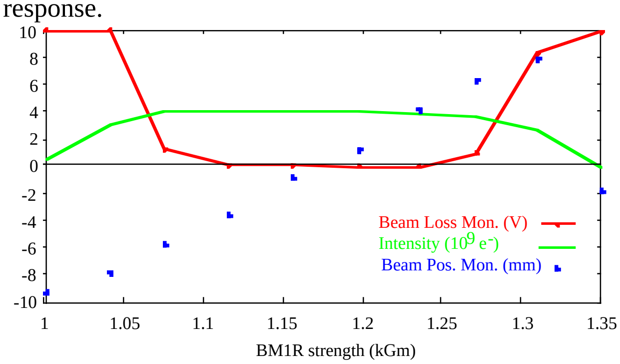

Figure 7: Vertical aperture scan

These scans also provided for a consistency check of the BPM calibration: From the lattice model, the R_{12} coefficients (x/x') from the injection bumps to the point of beam loss were calculated and indicated a vertical aperture of about 45 mm, close to the chamber height of 50 mm. The Figure also shows the reading of a nearby BPM, indicating a maximum excursion of only 10 mm. Since it was already determined that the magnet excitations were roughly correct, this pointed to a calibration error for the BPMs. That was later corroborated by more detailed R_{12} measurements and traced to an omission of a scale factor in the database.

The horizontal aperture was scanned in a similar fashion using the Lambertson septum.

4 SUMMARY AND CONCLUSIONS

With a successful sector test the PEP-II High Energy Ring has entered the commissioning phase. As of the time of the conference the status is as follows:

- Magnet and vacuum system appear to be in good shape with no significant problems uncovered. The alignment of the machine appears to be good.
- Physical aperture of the sector tested is as expected.
- The injection kicker is working and timed in.
- BPM and BLM diagnostics in 1/3 of the ring have been commissioned and appear basically sound.
- Beam trajectories under various conditions indicate that the magnet settings are close to their design values.

5 ACKNOWLEDGMENTS

The commissioning of the HER is done fully integrated with regular SLAC operations. The authors would like to thank the Accelerator Dept. and SLAC Operations for their enthusiastic support, without which our first run would not have been as successful as it was.

Completing the HER installation in time was achieved by a heroic effort of a large number of employees, especially those associated with vacuum work and with installation. Without their dedication the ring would not have been ready for beam commissioning.

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