Orbit Monitoring in the SLC

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Abstract

Beam orbits in the SLC are monitored in real time and the data is stored for future trend and correlation analysis. A background process acquires Beam Position Monitor (BPM) and Toroid data on a periodic basis and saves the general quantities such as orbit RMS and beam intensity in addition to the individual readings. Some of this data is archived by the SLC History Buffer facility and the rest is saved in files for later analysis. This has permitted the tracing of interaction point instabilities to specific devices as far away as the damping rings. In addition, the data is displayed for the operators both in summary and in full form. The different displays can be configured from the control consoles.

Introduction

During operation of the SLC, orbit stability is essential to maintaining low emittance beams and providing pulse to pulse reproducibility at the interaction point. In addition, long term histories of beam orbits have been useful in identifying device drifts and instabilities. Software has been developed that permits both realtime and offline continuous monitoring and analysis of the beam orbits in all parts of the machine. Several separate software modules used for logging and display have been incorporated into a unified orbit monitoring application[1].

Software Organization

The main program, BPM Sampler, is one of a set of batch processes which support updating summary displays in the SLC control room. The BPM Sampler generates orbit displays while other processes display summaries of general machine status, machine and personnel protection systems, and klystron population. History displays of beam intensity and luminosity are also available. All processes have the same skeleton which supports regularly scheduled monitoring and displays and responds to commands from the consoles or other SLC programs. These commands select which display will be presented on a particular monitor and specify the refresh time and other parameters. Any display may be selected on any of the ten monitors currently available in the control room. These are either RGB monitors driven from a Matrox board in the control console microcomputers, or DEC[1] VT1300 X Window terminals connected via Ethernet. Figure 1 shows the general data flow between these components.

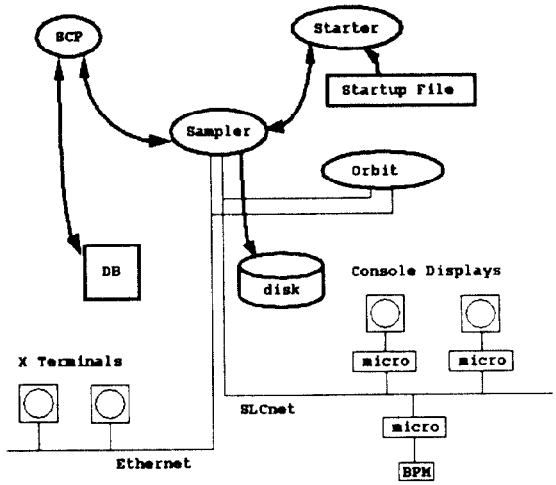

Figure 1: General Data Flow

In addition to the orbit displays, the BPM Sampler performs routine logging of beam orbits and intensities to the online SLC database or to disk files for later analysis. For specified regions of the machine, it also calculates and logs both the RMS of the absolute orbit and the RMS of the difference orbit with respect to a previously saved reference orbit. This reference or Gold orbit is usually an orbit which is known to minimize tails or transmission losses. The BPM Sampler also supports user requests for special purpose orbit acquisitions to disk file. These acquisitions are specified from the console and typically accumulate a few hundred orbits over a short duration.

Displays

The primary SLC orbit displays show the beam position and intensity as a function of location along the beam line. For the summary display monitors, the user may select to view any of the electron or positron bunches in predetermined ranges of the machine, as shown in Figure 2. The

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[1] DEC is a registered trademark of Digital Equipment Corporation

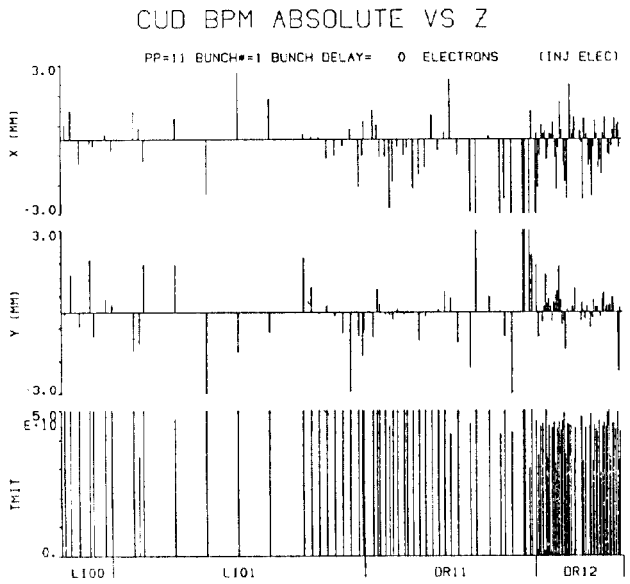

Figure 2: Typical BPM Sampler Display

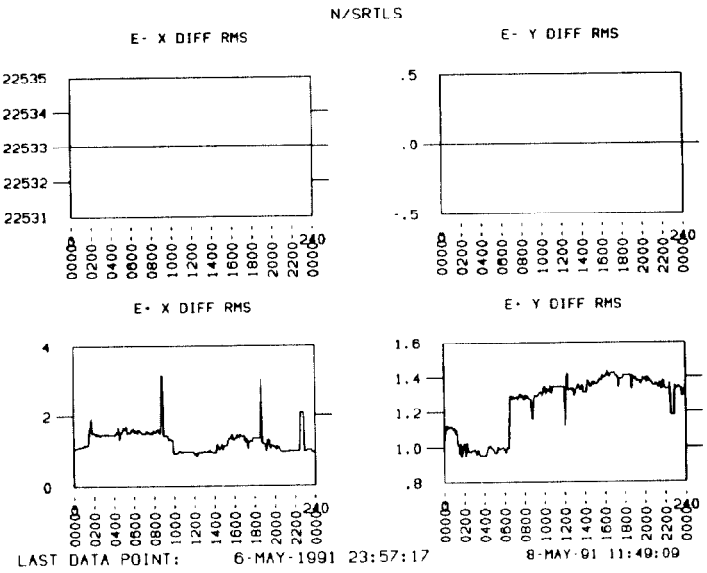

Figure 4: Orbit RMS History Buffer Display

positions may be displayed either as absolute orbits, or as differences with respect to the Gold reference orbit.

A separate display process, the SLC Orbit process, uses data calculated and logged by the BPM Sampler to present a summary of the whole machine, see Figure 3. The SLC Orbit Display summarizes the RMS values of the beam orbits calculated by the BPM Sampler. The RMS of the orbit with respect to the Gold reference orbit is displayed in numeric as well as bar graph format. The bar graph allows the operators to check at a glance whether the current orbit deviates significantly from the specified Gold orbit. At any particular time the SLC Orbit Display shows one particle beam's difference orbit RMS values for a section of the machine. At intervals of few seconds the display is updated with RMS information for a different beam and region.

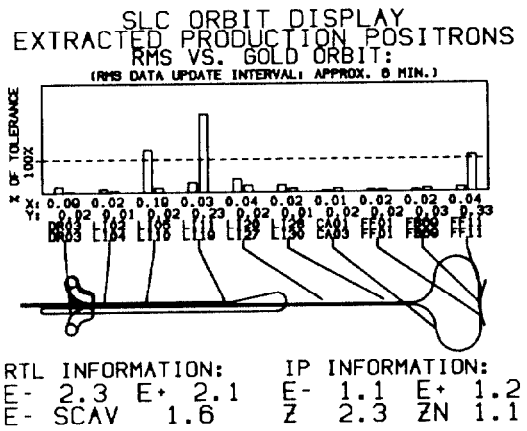

Figure 3: SLC Orbit Display

Data Logging

Data acquired by the BPM Sampler is logged by two different methods to support both offline analysis and online history buffers. When the amount of data is small, as for Toroid readings of beam intensity or diagnostic data from gated Analog to Digital Converters, it is stored directly in the online SLC database. The overall RMS of the orbit for sections of the machine is also calculated and logged to the database. This data is then periodically archived by the SLC History Buffer [2] software which provides both recent and long term data for display from the consoles, as in Figure 4.

For the larger quantities of data required for the actual orbits, the data is written out to disk files in raw format, and later converted to Matlab format so it can be analyzed offline.

Control

There are three separate paths used to control the acquisitions and displays of the BPM Sampler. The displays are controlled interactively from the SLC Control Program (SCP) through a general interface which supports all of the background display processes. The periodic data acquisition and logging is specified in control files. Special purpose user acquisitions are requested interactively from the console.

Display Control

The monitors of the Updating Display system are not dedicated to a single type of display, but rather are shared with the other related display processes. From the con-

sole, a user is provided with a common interface to select any of the displays for a particular monitor, or to modify the refresh rate or other parameters. When a display on a monitor is changed, the SCP is responsible for notifying all relevant processes via mailbox communication links. The online SLC database is shared by the consoles and display processes and contains the information necessary to define the monitors and displays. The display processes allow the same display to be selected on any number of monitors.

Acquisition and Logging Control

The periodic acquisition and logging of data is controlled via a text control file. This file specifies whether the orbit for a particular section of the machine should be logged to disk along with selected values from the SLC database. It also specifies whether beam intensities from toroids or other beam-related diagnostic devices should be logged to the database, and whether orbit RMS should be calculated and logged for sections of the machine. The file is parsed using the DEC Command Language Interface (CLI) utilities which provide a syntax familiar to users of the system. A separate initialization process reads the text file that describes the data and pertinent acquisition parameters and sends the information as mailbox requests to the BPM Sampler.

Special User Acquisition Control

Since the periodic acquisitions are scheduled to update rather infrequently, the BPM Sampler also supports user requests for special acquisitions at a high data rate for a limited period of time. This functionality was originally provided by a separate program which could not be controlled from the consoles. To aid in further analysis, auxiliary information from the SLC database may be collected synchronously with the orbit data and also logged. All of the resulting data files are formatted for later processing by Matlab.

Applications

The BPM Sampler together with the online SLC History Buffers provides the capability to correlate orbit and intensity fluctuations with data from other devices or diagnostics throughout the SLC. Using the data that has been logged to disk files, it is possible to track a single pulse (where BPM multiplexing permits) through most of the machine. This has been used successfully to trace instabilities at the IP to their origin at the Damping Ring kickers, as shown in Figure 5.

Conclusions

The updated and generalized BPM Sampler software has provided a variety of extremely useful tools for the analysis

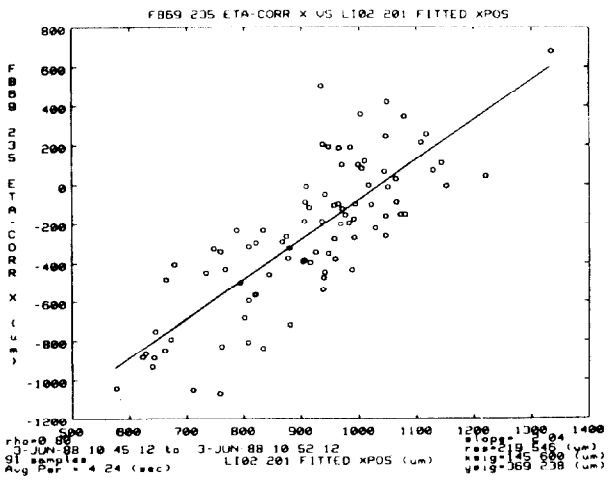

Figure 5: Correlation between kicker and IP

of the performance of the SLC. History buffers provide correlations of beam orbits and intensities with diurnal drifts or device variations. Synchronous orbit data has been analyzed to identify and correct sources of jitter throughout the machine. In addition, the current implementation has greatly improved the user interface for controlling acquisitions and facilitated the support of new summary displays to present the orbit information clearly and concisely to the operators of the SLC.

References

[1] M Flores III. CUD BPM Displays. Internal SLAC document, August 1987.

[2] Ralph Johnson. Stanford Linear Collider History Data Facility. In *Proceedings of the 1989 IEEE Particle Accelerator Conference*, 1989.