# AUTOMATIC SOFTWARE PROCESSES AT THE APS

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*Abstract*

The Advanced Photon Source (APS) storage ring is a third-generation X-ray synchrotron radiation user facility. Many automatic execution and correction software tools have been developed to increase productivity and reduce potential human errors. These include: the injection/top-up script, Procedure Execution Manager (PEM), orbit correction configuration and execution tool, and beam steering. We will present the applications and benefits of these software tools in this paper.

## 1 INTRODUCTION

The APS uses a wide variety of tools to automate processes and assist operators. These tools expedite processes, reduce human error, and increase machine repeatability. However, these tools are not designed to eliminate the human element to operations, merely to facilitate machine operations. Each machine has its own level of automation, but automatic processes are available for each machine.

## 2 INJECTION HANDLING

A script created in Tcl/Tk called the bunch train handles the storage ring injection process (see Fig. 1). The bunch train script allows users to select bunch fill pattern, injection mode, current limits for the beam position monitor (BPM) timing bunch, and normal bunch train. Certain injection parameters are selectable as well. For top-up injection, the options list expands to include current tolerance, target current, injection interval, and the number of linac bunches used.

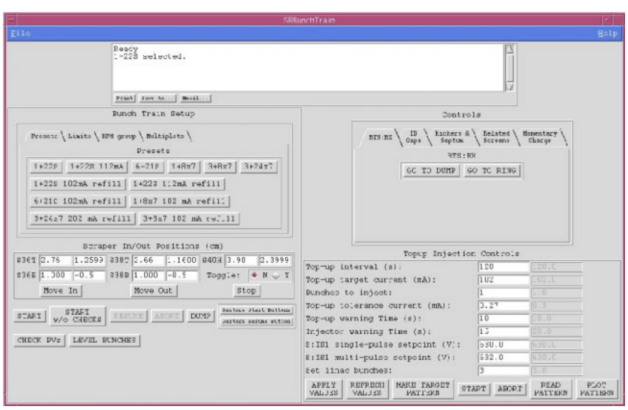

Figure 1: Storage ring bunch train.

The APS storage ring has three commonly used injection modes: fill from zero, fill on fill, and top-up. In a fill from zero, storage ring current starts at a value of zero and injection occurs in two stages. The first stage is the filling of the BPM timing bunch. This injection provides a concentrated level of beam to trigger the BPMs. The fill resumes with the remaining buckets, depending on the selected fill pattern. A fill on fill is essentially the same as a fill from zero, except there is beam in the ring. During a fill on fill, beamline x-ray shutters may or may not be open. We use BPM sum signals for the timing group, instead of the total current value. Total current is the monitoring variable for the remainder of the fill. Top-up injection operates at a fixed 120-second interval. A bucket selection process monitors the buckets and selects the weakest bunch. Injecting into the weakest bunch ensures a uniform fill distribution. The top-up process issues a twenty-second warning and enables the injectors' pulsed supplies. At the designated time, one of two things happens: the storage ring septa and kickers fire for one pulse or, if current is at or above the target threshold, the pulse cycle is skipped. The top-up process also performs calculations based on beam current. If the current is significantly greater than the target current, the script recalculates the interval automatically to a higher multiple of 120 seconds.

The bunch train script checks for abnormal conditions in the beam transfer line, radio frequency (rf) systems, user insertion devices (ID), and the machine protection system (MPS) before injection. During sustained injections (fill from zero and fill on fill), we use a process monitoring system to monitor storage ring radiation monitor levels. If any radiation monitor exceeds a preset limit, the script suspends the injection and allows operators to troubleshoot and correct potential efficiency problems.

## 3 USER ORBIT STEERING

### *3.1 User Orbit Steering*

The APS routinely performs user orbit steering. Because of the complexity of steering manually, we use an automated steering tool. The local steering script is a Procedure Execution Manager (PEM) that saves existing BPM and corrector setpoints, zeros out orbit errors by transferring present orbit to BPM setpoints, and prompts for desired beamline and steering parameters. A setpoint change is applied to the local BPMs, and the orbit correction algorithm adjusts the steering correctors to bring the error back to zero. The PEM then stores the new local BPM and corrector setpoints. After steering, the tool restores BPM setpoints of the nonsteered sectors.

### *3.2 Orbit Correction and Reconfiguration Program*

The APS storage ring has approximately 500 BPMs, including broad and narrow band, rf BPMs and X-ray BPMs. The orbit correction program uses 80 correctors (two per sector) in each plane and all known good BPMs for orbit correction. Due to failures or erroneous readings, the operators need to be able to modify the orbit configuration quickly and conveniently in order to be able to add or remove BPM and/or correctors from the system matrix. An Orbit Correction Configuration tool facilitates these changes. The tool graphically represents the orbit configuration and allows changes to in-use components through the use of check boxes. Nonfunctional BPMs are entered at the start of a run or when a failure occurs and are disabled in the selection boxes (see Fig. 2).

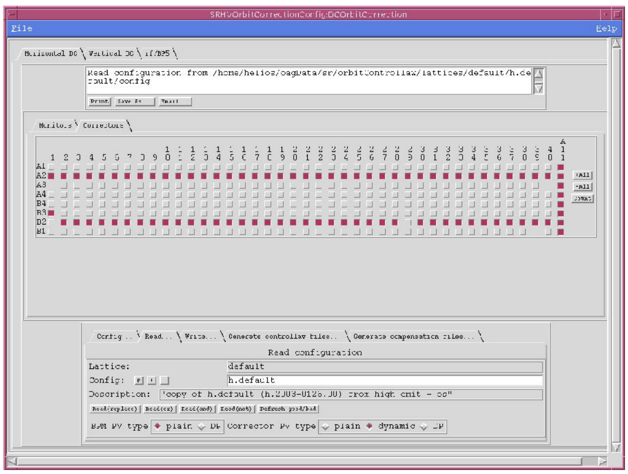


Figure 2: Storage ring orbit configuration tool.

## 4 MAGNET CONDITIONING

Magnet standardization and conditioning is a relatively straightforward process. The magnets are cycled through their full operating range a number of times to clear residual fields and reset the magnets' hystereses. Operators select the number of cycles or length of time for standardization. At the APS, the complications arise due to the fact that the bending magnets have auxiliary trim correction windings. The trim winding current must be zeroed before standardization. The APS conditioning program restores an operator-selected lattice configuration after finishing the selected cycles.

## 5 LINAC STARTUP AND SHUTDOWN

While all of the machines at the APS use PEMs, none rely on them as extensively as the linac. The linac serves the dual role of providing beam for storage ring injection and providing beam for the Low-Energy Undulator Test Line (LEUTL). To accomplish this, the linac uses either of two rf guns or a photocathode gun. While the linac PEMs' original purpose was to switch back and forth between the guns, their functions have been expanded to include linac start up and shutdown.

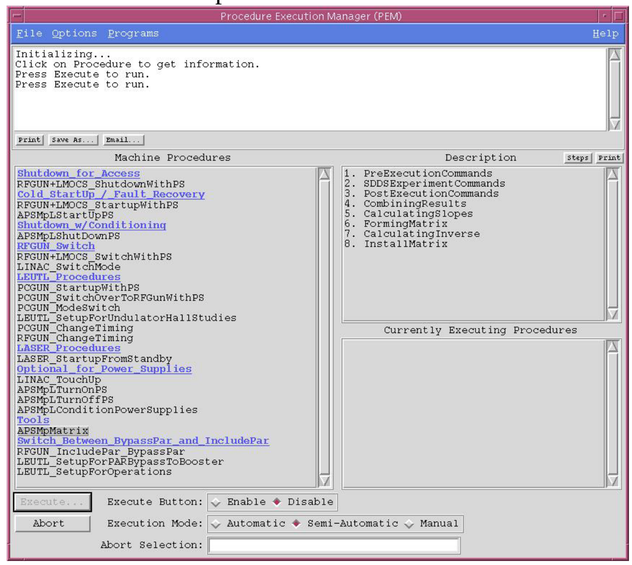


Figure 3: Linac Procedure Execution Manager (PEM).

The linac start up PEM (see Fig. 3) is a comprehensive application that accomplishes all of the following: resets interlocks, opens gate valves, turns on and conditions power supplies, restores a configuration file, turns on the modulators and brings them up to power, and warms up the rf gun cathode heater. In general, the only operator action required is to start the PEM and verify beam transport.

The linac shutdown PEM sets all power supply and rf values to zero, turns off the equipment, and closes gate valves.

## 6 WORKSPACE SETUP UTILITY

The APS Main Control Room (MCR) operates the three injectors, main storage ring, and rf systems via a group of Sun workstations. Because of the number of possible control functions available, each category of machine is run from a separate workstation. Each one of these workstations displays information in several formats including EPICS display screens, Array Display Tools (ADTs), alarm handlers, strip-tools, and applications written in Tcl/Tk. There are also workstations that display comfort information, but are not actively used for operation. Setting up each workstation manually is a prohibitive task that is very time consuming. The workspace setup tool allows operators to initiate the workspace setup based on machine or workstation (see Fig. 4). The tool is a TCL application that reads information contained in application resource and configuration files, automatically opens the screens and views, and places them in a predetermined combination of workspace and geography.

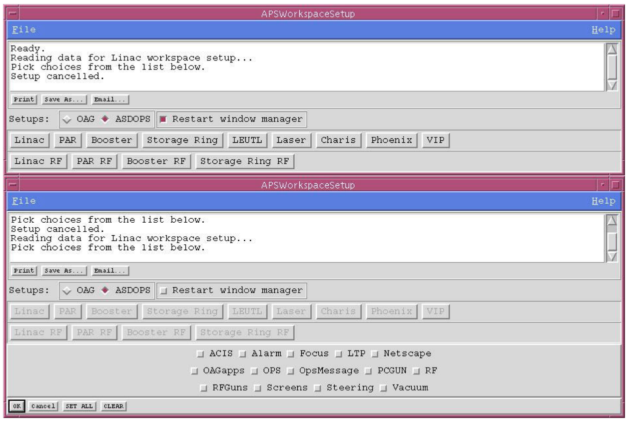


Figure 4: Machine workspace setup tool.

# 7 CONCLUSION

This is a small sample of the automated processes in use during daily operation at the APS. There are many more applications, but they all fall into the general categories listed above. The tools act as operator aids and are very useful in a variety of applications. The Operations Analysis Group created the tools to assist the operators, improve machine operating efficiency, and performance.

# 8 REFERENCES


[1] Claude Saunders, PEM - Procedure Execution Manager, September 25, 1996, http://www.aps.anl.gov/asd/oag/manuals/APSPEM/APSPEM4.html.

[2] L. Emery, M. Borland, “Advances in Orbit Drift Correction in the Advanced Photon Source Storage Ring,” Proceedings of PAC97, Vancouver, BC, Canada, pp. 742-744, 1998.

[3] APS Control System High-Level Applications, http://www.aps.anl.gov/asd/oag/applications/OAGapps.pdf.


# 9 ACKNOWLEGEMENT


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