HOW WE DO BUSINESS AT APS *

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Abstract

The Advanced Photon Source (APS) storage ring is a third-generation dedicated X-ray synchrotron radiation user facility, which has been in operation since 1996. We report the organization of the operations team, machine performance, operation modes, user beam schedule, user interaction, and other aspects of APS.

1 THE APS FACILITY

The APS storage ring is a 7-GeV electron storage ring. The present operating current is 100 mA. Its injector consists of a 650-MeV electron linear accelerator, a 450-MeV electron accumulator ring (PAR) and a 7-GeV booster synchrotron. Commissioning of the storage ring started in 1995 and regular operation began in 1996.

Performance of the storage ring has been improving continuously over the past years. For the first run period of FY2003, APS reached a record high availability of 99.06% and mean time between faults (MTBF) of 71.76 hours. Figures 1 to 3 show the operational statistics from FY98 through the first run of FY03.

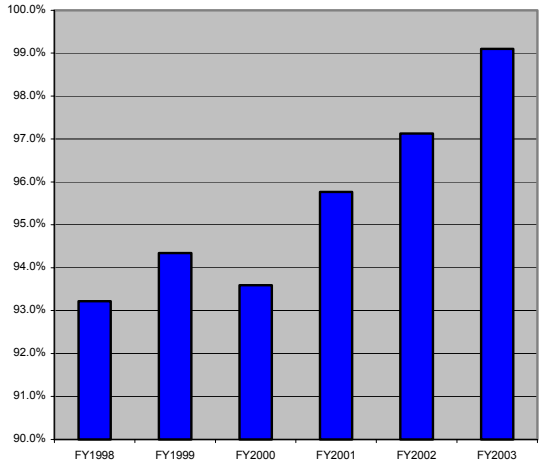

Fig. 1 User beam availability.

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2 THE OPERATIONS GROUP

As a U.S. Department of Energy (DOE) facility, the organization and standards of APS operations must comply with the requirements and guidelines of DOE Order 5480.19, "Conduct of Operations Requirements for DOE Facilities."

The APS has three divisions: the Accelerator Operations Division (AOD), the Accelerator Systems Division (ASD), and the Experimental Facilities Division (XFD).

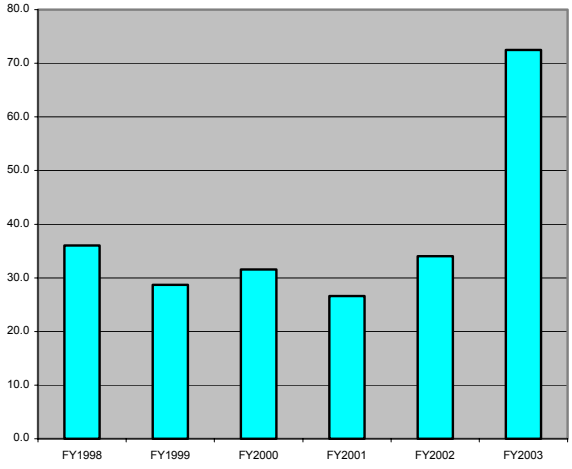

Fig. 2 Mean time between faults.

The AOD is responsible for the operation of the accelerator facilities, experimental area, and site-wide infrastructure. The ASD is responsible for maintenance, upgrading, development of accelerator subsystems, as well as research in the accelerator field. The XFD is responsible for insertion device and beamline instrumentation support, new device development, and X-ray research.

The Operations Group (OPS) is a part of AOD, responsible for daily operation of the APS storage ring and its injectors. The OPS Group interacts directly with other groups, in particular the Experimental Floor Operations Group (EFO), Operations Analysis Group,

Beam Diagnostics Group, RF Group, Electrical Systems Group, and Controls Group.

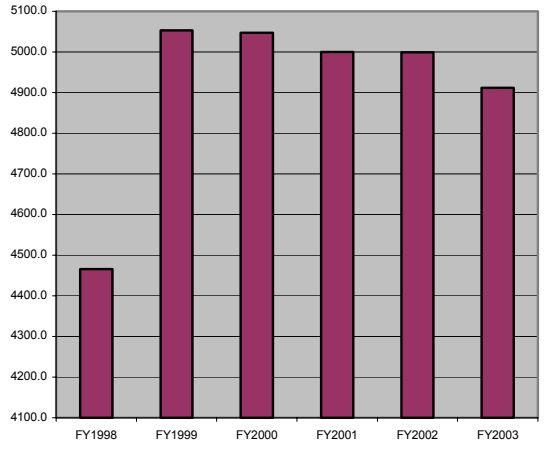

Fig. 3 Scheduled user hours.

The OPS Group currently has 22 members, including the group leader, the group secretary, five staff members, five crew chiefs, and 11 operators. All the accelerators are operated from one central location --- the main control room (MCR).

The operators are divided into five crews. Crews work on a 3-shift rotation with one backup week and one rest week. On weekends, the shifts change to 12 hours to allow operators more time with their families. The backup week is intended for operators to work on their training, interact with staff members, work on projects, and participate in other daily activities. On 40 hour per week base, our operators spend 84% of their time on shift work.

The on-shift crew is responsible for machine operation, shift event logging, fault reporting, and tunnel safety handling. The technical systems groups provide on-call support and perform repairs. During a user run, the crews are required to perform certain off-hour repair tasks, such as magnet power supply swapping, rf station switching, etc.

Our operator turnover rate fluctuates from year to year with an average of 15% in recent years. The turnover rate is affected by many factors such as rotating shift schedules, lack of career advancement opportunities, and general employment conditions. The overall mean and median years of experience are 2.7 years and 4.1 years, respectively. The crew chiefs have an average of 7.8 years of experience. New hires typically have some college education and several years of industrial experience.

Maintaining a well focused, consistently performing, and motivated operations team is probably the biggest challenge for the OPS Group.

3 THE MAIN CONTROL ROOM

The MCR is the center of many machine-related activities. The size of the MCR is about 2000 ft^2, with three control consoles forming a circle at the center of MCR. Two of the consoles are dedicated to operations. One of them serves as a comfort display and work area for machine studies. There are 11 double-head Sun workstations, several video monitors, and a few oscilloscopes.

The control system is a distributed control system consisting of Sun workstations, VME-based IOCs and EPICS software.

4 OPERATOR TRAINING

The training required for operator qualification is divided into three categories: the Argonne-specified training program, general operations training, and accelerator-specific training. Argonne and APS provide training courses for the first two categories, such as tunnel safety, electrical safety, emergency response, radiation safety, computer security, etc. The OPS Group provides accelerator-specific training.

A new operator is required to complete qualification on all four accelerators within two years. On-shift training and self-guided training are the primary methods. Training documents and courses are developed by responsible operations staff and technical systems groups. Videotapes of the training courses are available for viewing. Crew chiefs and qualified operators conduct on-shift training. Qualification tests are administered by OPS staff members. Re-qualification is required every two years after initial qualification. Average qualification time is 12.2 months from date of hire.

5 OPERATIONS LOGBOOK

The operations logbook exists in both electronic and paper form. The crews enter logbook entries using FrameMaker software. A hardcopy is printed at the end of each shift. Online web pages are automatically generated from the FrameMaker file and updated periodically.

The electronic logbook mainly serves as a communication tool. The hardcopies are kept for archival purposes. A search tool is used to review and reconstruct past events.

6 OPERATION MODES

Various storage ring operation modes are developed to serve various user requirements. The following are the current operation modes:

- Top-up, low emittance, 1+1x22 singlets fill pattern
- Top-up, low emittance, 1+ 7x8 hybrids fill pattern
- Non-top-up, high emittance, 1+1x22 singlets fill pattern
- Non-top-up, low emittance, 324 bunch fill pattern

Top-up injection mode provides higher average photon flux and better stability of both storage ring and beamline. Lower emittance and higher photon brightness can also be achieved without beam lifetime concern. Top-up mode is scheduled for 75% of the time.

Non-top-up mode is mainly scheduled to provide injector beam time for parasitic injector study, operator training, and injector maintenance and improvement. High emittance lattice or multiple-bunch fill patterns are used in order to increase beam lifetime. Refill is performed twice a day.

The bunch fill pattern typically has one BPM bunch for BPM timing, and either singlets or multiple bunch trains for beamline users.

New lattices and fill patterns are still being developed to accommodate increasingly diverse user demands.

7 USER INTERACTION

The on-shift crew provides machine status information with the users through web pages, logbook entries, and PA announcements. User requests, such as beam orbit steering, are passed on to the crew via the EFO Group. If necessary, a direct contact between OPS staff members and beamline users is established to resolve a request.

8 MAINTENANCE PROGRAM

Given the budget constraints and the unpredictability of many accelerator components, it is hard to form a uniform maintenance strategy. Our approach is a combination of "run it until it breaks" and preventive. Many types of equipment, such as storage ring rf stations, magnet power supplies, and control system equipment, have swappable spare units. Offline maintenance can be performed. Preventive maintenance is performed on storage ring dipole, kicker, and septum supplies, which do not have spares. Periodic preventive maintenance is performed on mechanical and electrical equipment, where maintenance standards are available.

We are considering development of trend-analysis-based failure prediction in order to facilitate preventive maintenance.

The OPS Group's responsibilities are mainly in the areas of work approval, scheduling, coordination, and record keeping. The systems groups submit maintenance requests, perform work, and verify the functioning of equipment.

9 SOFTWARE TOOLS

Many software tools have been developed to assist the operators, which have contributed to better efficiency, productivity, and consistency. These include:

- Work request system
- RM&D system (repair, maintenance and development)
- Downtime report tool
- Operation statistics tool
- OPS Group mail list server/archive
- Automatic work station configuration tool
- Save/restore/compare tool for machine configuration
- Procedure Execution Manager
- Scope waveform archiving and configuration tool
- Data monitoring and review

10 DOWNTIME STATISTICS

Downtime statistics are part of the performance monitoring and improvement mechanism. The APS management has set an overall goal of 95% availability and an MTBF of 48 hours. Every group is also assigned a downtime allowance and an MTBF goal.

Storage ring faults and downtimes are automatically logged. The OPS Group performs downtime analyses and posts downtime statistics on a weekly basis. Disputed items are discussed, resolved, and corrected.

11 CONCLUSION

The APS storage ring operation performance is consistent and continuously improving. The organization, training, operational procedures, and methods implemented by the Operations Group are successful and effective.