The APS Light Source

The APS Light Source

The APS continues its commitment to providing users with a reliable source of high-brilliance x-ray beams while innovating the future technologies that will keep x-ray science at the forefront of research.

Light Source Operations

In calendar year (CY) 2003, the APS scheduled 5,129 h for user operations and delivered 4,959.6 h. The emphasis continues to be on meeting established reliability goals of availability greater than 95% with a mean-time-between-faults (MTBF) rate of greater than 50 h. Orbit stability is also a very high priority, and this year progress was made in this area. The APS continues to utilize a schedule of three long runs and three extended maintenance periods, first employed in 2002.

Beam Availability & MTBF

During 2003, accelerator operations, as quantified by availability and MTBF, remained at the high levels achieved in 2002 (see Table 1). The APS has, since 2000, routinely exceeded the goal of 95% availability. Efforts have focused on maintaining this level of availability while reducing the number of faults. These efforts have resulted in two consecutive years of operation exceeding 40 h MTBF. Considerable improvements have been made to the radio-frequency (rf) and power-supply systems, traditionally high contributors to the fault rate. A significant factor in consistently meeting accelerator availability goals has been the high availability and MTBF of the high-power electrical systems (rf systems and magnet power supplies). The technical complexity and power levels of the rf systems and the large number of critical magnet power supplies in the storage ring (close to 1,400 individual units) present tremendous reliability challenges for the storage ring. Nevertheless, fault rates have improved considerably over recent years, and both rf and magnet power systems have consistently exceeded 99% availability (remarkably, the rf systems have exceeded 99% availability for the past *18 consecutive user runs*).

These improvements can be attributed in large part to the pragmatic and rigorous approach taken in analyzing and addressing problems and the proactive efforts to identify and resolve potential problems before they cause downtime. Causes (and duration) of user-beam downtime due to accelerator equipment problems have been tracked and analyzed dating back to the inception of operations. Beginning in 2003, the Experimental Floor Operations (EFO) Group began also main-

Table 1. Operations statistics—CY 2003.

	CY2002				CY2003
Run number		Run 03-1	Run 03-2	Run 03-3	
Start		1/29/03	5/28/03	10/01/03	
End		4/20/03	8/25/03	12/22/03	
Total hours scheduled (h)	5328	1647	1816	1666	5129
Beam available for users (h)	5208.7	1598.8	138.5	1622.3	4959.6
Beam availability (%)	97.8	97.1	95.7	97.4	96.7
Total downtime (h)	119.3	48.2	77.5	43.7	169.4
Average current (mA)	96.8	98.4	100.1	101.2	99.8
Number of faults	121	45	42	29	116
Mean time between faults (h)	43.0	35.5	41.4	55.9	42.8
Mean time to recovery (h)	0.99	1.07	1.85	1.51	1.46
Injector availability in top-up (%)	97.1	94.9	98.6	97.1	97.1

taining statistics on downtime incurred by beamlines due to systems failures [see: "Reducing Beamline Downtime" in the following section on APS Users]. To this end, the APS made increased use of periodic machine intervention periods for problem resolution. Examples of such rigor include detailed daily monitoring of rf system behavior to detect potential problems early and the automatic replacement of storage ring converters following transient trips so as to prevent recurring trips. A great deal of effort has also gone into identifying and replacing weak components, such as power-converter-control power supplies, and to reducing susceptibility to electromagnetic interference in the rf systems. As engineering improvements have been identified and implemented, they have been subjected to ever increasing quality assurance and workmanship standards, so as to minimize the chance of introducing new problems as old problems are resolved.

The local weather during the summer of 2003 was particularly stormy, leading to interruptions with longer than normal recovery times. This contributed to the increase in mean time to recovery during the summer 2003 run. The injector systems, needed every two minutes during top-up operation, were available 97.1% of the time, unchanged from 2002.

During 2003, user operations were scheduled for 5,129 h, and accelerator studies (including machine turn-on and operator training) for 1,315 h. The remaining 2,316 h were used for maintenance and scheduled machine repairs.

User Operation Fill Patterns

Various storage ring operation modes have been developed to meet different user-beam requirements. The operating modes used in 2003 were:

- Top-up, low emittance, 24 singlets fill pattern
- Top-up, low emittance, 1 + 7 x 8 hybrid (singlet) fill pattern
- Non-top-up, high emittance, 24 singlets fill pattern
- Non-top-up, low emittance, 324 multibunch

Top-up injection mode (injecting beam into the storage ring every two minutes) provides higher average photon flux and better beam stability for both the storage ring and the beamlines. Lower emittance and higher photon brightness can also be achieved without concerns about beam lifetime. Top-up mode is used for 75% of scheduled user beam time.

Non-top-up mode (refilling the storage ring twice every 24 hours) is mainly used to provide injector beam time for parasitic injector study, operator training, and injector maintenance and improvement. Early in 2003, the singlet fill pattern with the high-emittance lattice was used during non-top-up. This was changed in April to a 324-multibunch pattern, as explained in the next section.

The hybrid singlet pattern is used by the timing community to perform dynamical biological, chemical, and condensed matter/materials science studies.

Beam current is normally 100 mA for all modes, although incrementally higher beam currents are planned for the future.

The percentages of scheduled hours for each of the operation modes are shown in Fig. 1.

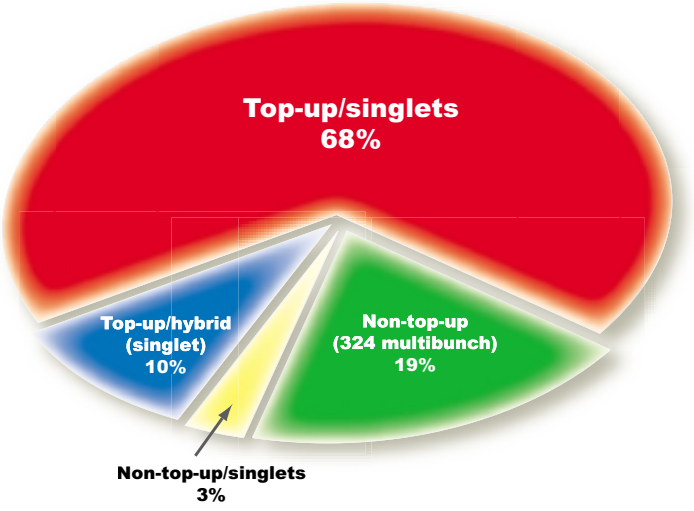

Fig. 1. Calendar year 2003 scheduled time for different operating modes.