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SLAC ACCELERATOR OPERATIONS REPORT: 1995-1997*

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Abstract

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Operational statistics for the linear accelerator programs at SLAC are presented, including run-time records for SLC and the fixed-target programs. Also included are summaries of reliability and maintenance-related statistics.

1 PROGRAM CHRONOLOGY

The SLAC linear accelerator programs and hardware reliability statistics for January 1992 through March 1995 were presented in Reference [1]. This paper extends that analysis through April 1997, for the periods of linac operation summarized in Table 1. Scheduled off times in this table were relatively long periods needed for major installations and upgrades. Time periods when the accelerator was off for holidays are not listed.

ESA runs were periods when polarized electrons were delivered to fixed-target experiments E154 and E155 in the End Station A experimental hall. The ESA run in 1995 was the first to use the A-Line transport system following its upgrade to full 50 GeV capability, and is described in greater detail in Reference [2]. The FFTB runs were periods of low repetition rate (30 Hz) operation in which damped electrons were delivered to the Final Focus Test Beam facility for experiment E144. SLC machine development included extended periods of pre-run system turn-on, new system commissioning, and experiments to characterize and improve the performance of various accelerator systems. SLD logging refers to periods of SLC operation dedicated to producing Z particles with the SLD detector on and recording data.

During the period from August 12 to 19, 1996, the primary beam was delivered to ASSET, a station in the linac tunnel downstream of the damping rings used for testing prototype accelerator structures. This program, which was intended to develop the testing facility as well as to test an actual prototype structure, was essentially a week of continuous tuning and machine studies. The ASSET test, while considered very successful, is not discussed further in this paper because of its short duration and because it offers little additional insight into the overall reliability of the accelerator facility.

In addition to the primary programs discussed in this paper, a parasitic electron beam was operated for parts of May and June, 1996, during the SLD run. This beam, which was generated by converting bremsstrahlung radiation from linac collimators when the SLC was operating, had no adverse impact on the primary program and is not reflected in the statistics presented below. The goal of this program was to characterize the parasitic electron beam, including measuring the achievable flux and energy range, for use in future applications.

Time period	Program
1 Apr 95 - 10 Sep 95	Scheduled off. Rebuild A-Line. Install PEP e^- inject transport line.
11 Sep 95 - 30 Sep 95	Check out / turn on at 30 Hz.
1 Oct 95 - 30 Nov 95	ESA run - E154.
10 Dec 95 - 23 Dec 95	FFTB run - E144.
2 Jan 95 - 10 Feb 96	SLC machine development.
12 Feb 96 - 31 Mar 96	NDR fire and recovery.
1 Apr 96 - 31 Jul 96	SLD logging.
1 Aug 96 - 12 Aug 96	FFTB run - E144.
19 Aug 96 - 3 Feb 97	Scheduled off. Prepare for fixed target program. Install PEP positron inject transport line.
4 Feb 97 - 28 Feb 97	Turn on, commission A-Line and PEP e^- inject line.
1 Mar 97 - 30 Apr 97	ESA run - E155.

Table 1. SLAC program chronology April 1995 through April 1997.

2 TIME ACCOUNTING

Time accounting records were kept by the accelerator operators, who recorded the number of hours devoted to each of the categories in the first column of Table 2 at the end of each eight hour shift. The experimental runs summarized in this table included only the time periods dedicated to logging data in the indicated detector and excluded pre-run turn on and commissioning time. The run periods began when the accelerator and the detector were ready to begin production data collection and continued until the detector was scheduled to shut down. The SLC/SLD program in 1996 was originally scheduled to begin in February; however, a fire in the north damping ring vault delayed this program while repairs were made, and useful luminosity was not delivered to the SLD detector until April. For purposes of this paper, we

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have taken April 1 as the scheduled starting date and have not included the time period in February and March 1996 in computing the run statistics presented below.

	ESA 95	FFTB 9 5	SLD 9 6	FFTB 9 6	ESA 9 7
Exp't Logging	70%	54%	45%	60%	63%
Machine Develop.	1%	5%	12%	3%	3%
Alternate Program	4%	3%	3%	5%	7%
Tuning	8%	7%	14%	10%	5%
Unsched. Down	10%	24%	23%	16%	11%
Sched. Off	7%	8%	3%	6%	11%
Total Hours	1465	336	2927	288	1463

Table 2. SLAC primary linac program run time accounting 1995-1997.

The "experiment logging" category is defined as the time when a suitable beam (or colliding beams) was available to the scheduled experiment, and the detector equipment was active and recording data. Machine development in Table 2 included brief (<1 day) interruptions to data logging, usually dedicated to measuring accelerator system parameters and implementing improvements. The extended periods of scheduled machine development work listed in Table 1 are not included here. Alternate programs were brief tests or experiments scheduled on short notice when the primary program could not be carried out as planned. This typically happened when some accelerator subsystem critical to the primary program was undergoing repairs while other accelerator systems, such as the injector system and the electron damping systems, were operating normally. During the ESA runs, most of the alternate program time was used for testing and commissioning the new PEP electron injection transport line.

Tuning is defined as any time when no specific hardware or software systems were known to be malfunctioning, yet the beam properties did not meet the requirements of the scheduled program. Typically this was the time spent by operators and accelerator physicists measuring and correcting beam parameters. Unscheduled down time was logged when a system or component failed, rendering the beam unusable for either the main experiment or an alternate program. Scheduled off represents planned interruptions to the primary experimental program, typically for maintenance and minor upgrades or for adjustments to existing systems. The extended scheduled off periods shown in Table 1 are not included here, nor are holiday periods.

The improvements in beam polarization achieved in 1993 - 94 proved invaluable for the programs in the time period reported here. The polarization delivered to the ESA experiments was typically 82 to 83 percent. The polarization delivered to the SLD experiment was slightly degraded by the more complex transport system (including the SLC electron damping ring and arc), but was typically 73 to 79 percent at the collision point. During the 1996 SLC run, approximately 52 thousand Z particles were recorded by the SLD detector. This corresponds to an average luminosity of 39.6 Z's per hour, although the peak luminosity improved over the course of the run, and at times reached 100 Z's per hour.

3 HARDWARE RELIABILITY

Hardware availability, defined here in terms of time when the accelerator hardware is not broken, is a measure of the overall reliability of the accelerator systems needed to carry out the accelerator program. The hardware availability, mean time to failure, and mean time to repair are listed in Table 3 for each of the major accelerator programs. These quantities are defined as follows:

Availability = 1- (Downtime / Scheduled Operating Hours).
Mean Time To Failure (MTTF) = Sched hrs / # of Failures.
Mean Time To Repair (MTTR) = Downtime / # of Failures.

	Availability	MTTF	MTTR
SLC 1993	82.8 %	7.7	1.3
SLC 1994	80.7 %	8.5	1.6
SLC 1996	79.0 %	10.7	2.2
ESA 1993	93.3 %	12.7	0.9
ESA 1995	92.0 %	21.2	1.7
ESA 1997	89.4 %	10.9	1.2
FFTB 1995	83.6 %	15.6	2.6
FFTB 1996	83.7 %	16.0	2.6

Table 3. SLAC hardware reliability summary.

Hardware failures as defined in this section are those failures that noticeably interrupt or impede a scheduled running program and do not require testing or inspections to locate. As these data indicate, the hardware availability was consistently better during ESA and FFTB operation than during SLC operation. This was mainly because the ESA and FFTB programs required only electrons (no positrons) and thus required fewer active devices. SLC and ESA data from Reference [1] for 1993 and 1994 are also included for comparison.

The availability values are significantly higher than the experiment logging values in Table 2. For the SLD program, this difference arises primarily because of the substantial time required to tune the SLC and to carry out the machine development activities needed to meet performance goals. For the ESA experiments, the difference is due almost entirely to the time lost when the targets were unable to accept the beam. Experiments E154 and E155 both used sophisticated polarized targets that required frequent attention for maintenance and processing, sometimes scheduled, and sometimes not. The time when the targets were unavailable is counted under a combination of the other categories in Table 2. During target interruptions to E155, the PEP injection line was tested (alternate program), the linac pulse length was stretched (machine development), and safety systems were tested and certified in preparation for SLC and PEP operations (scheduled off).

4 ACKNOWLEDGMENTS

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REFERENCES

[1] 'SLAC Accelerator Operations Report: 1992-1995', R. Erickson, C.W. Allen, T.K. Inman, W. Linebarger, and M. Stanek, SLAC-PUB-95-6895, May 1995. Presented at *16th IEEE Particle Accelerator Conference* (PAC 95) *and International Conference on High Energy Accelerators*, Dallas, Texas, 1-5 May 1995.

[2] 'First Operation of the Upgraded SLAC A-Line', R. Erickson, S. Anderson, A. Baker, S. DeBarger, T.K. Inman, R. Iverson, H. Smith, and M. Stanek, SLAC-PUB-95-7177, October 1996. Presented at the *Fifth European Particle Accelerator Conference* (EPAC96), Barcelona, Spain, June 10-14, 1996.