Status Report on Operation of the Daresbury SRS after Recent Additions and Upgrades.

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Abstract

Details on recent SRS performance statistics and operational parameters are presented. The method of down time analysis is described and brief details are given on a series of measures that are directed towards the improvement of reliability of the source for users.

1. INTRODUCTION

The SRS was substantially upgraded in 1987 with a higher brightness lattice (HBL) and required further lattice modifications in 1991 when the 6 Tesla superconducting wiggler was installed [1,2]. In addition to these major facility enhancements, continuous review of all principle accelerator systems has resulted in several other improvement programmes which are briefly reviewed in this paper.

Typical operating modes and parameters are presented together with a summary of performance statistics. An analysis in detail of these statistics indicates where further developments are necessary to achieve improved source reliability for users.

2. FACILITY DESCRIPTION

The SRS is a 2 GeV electron storage ring of 96m circumference supporting 9 dipole beam lines, 2 superconducting wiggler beam lines and 1 undulator beam line. There are a total of 39 experimental stations of which 5 are still under construction. The SRS has a medium emittance (0.1 mm.mrad) FODO lattice, a 500 MHz RF system and is injected at 10 Hz from a 600 MeV booster synchrotron and a 12 MeV linac.

3. TYPICAL OPERATING REGIME

The SRS is operated for users in either multibunch or single bunch mode. In multibunch mode all 160 RF buckets are equally filled and the lattice is run at Qr = 6.19 and Qv at 3.35. Beam currents in excess of 300 mA are possible with lifetimes of up to 35 hours depending on the condition of the storage ring vacuum. The machine is filled once every 24 hours when the lifetime exceeds 25 hours and every 12 hours otherwise.

In single bunch mode a single RF bucket is filled and levels of contamination in adjacent buckets of 0.1% are routinely achieved. Qr is set at 4.21 and the radial/vertical tune split is reduced to blow up the vertical source size and increase the bunch volume thereby increasing the Touschek lifetime [3]. Single bunch currents of 40mA are easily attainable and the current.lifetime product is typically 350 ma.hours.

The SRS is scheduled to run for around 6000 hours each year with 600 hours single bunch operations, 600 hours accelerator physics and 4800 hours multibunch operations.

4. PERFORMANCE STATISTICS

The SRS has been operational for users since 1981 and Figure 1 gives an indication of performance over the last ten years. The two dips in scheduled hours are due to the major shutdowns for the HBL and the 6 T Wiggler installation. Table 1 gives a more detailed breakdown of performance for the last financial year. Efficiency is calculated after allowing 1 hour for each refill.

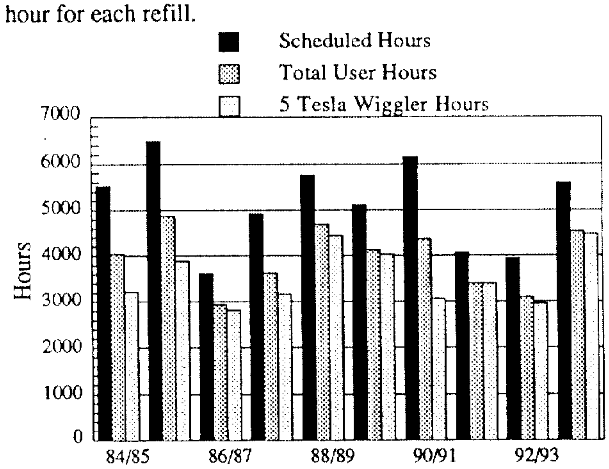

Fig 1. SRS Performance Summary over 10 Years. (HBL shutdown in FY 86/87, 6 T Wiggler shutdown in FY 92/93)

Multibunch Scheduled Hours	4936
Multibunch User Hours	4045
Number of Multibunch Fills	328
Multibunch Efficiency %	87.8
Single Bunch Scheduled Hours	648
Single Bunch User Hours	498
Number of Single Bunch Fills	42
Single Bunch Efficiency %	82.3
Accelerator Physics Hours	600
Shutdown Hours	2576
Fault Hours	606
Refill Hours including Steering	435
Average Multibunch Start Current (mA)	244
Average Multibunch Lifetime (hours)	20.3
Average Multibunch Beam Length (hours)	13.7

Table 1. SRS Performance Summary. 4/93 to 3/94.

Figures 2 and 3 show how the average start current and average beam lifetime have varied through the same year. The start currents were initially low due to problems with closed orbit control in the energy ramp following lattice modifications during the 6T wiggler installation shutdown. The ramp control software now incorporates automatic orbit adjustment software and currents of 300mA at 2 GeV are routine. Lifetime was below average following the shutdown but after three months of vacuum conditioning had approached the normal operating lifetime of the SRS which is 30 hours. However, brazed joint failure on a quadrupole vessel led to a deterioration in vacuum conditions and a consequent drop in lifetime.

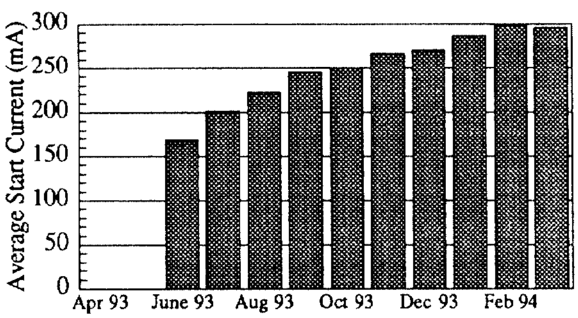

Figure 2. Growth in Start Current. 93/94

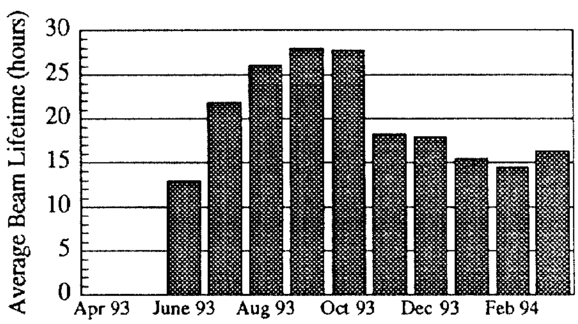

Figure 3. Stored beam Lifetime. 93/94

5. PERFORMANCE ANALYSIS

The introduction of formal Service Level Agreements with the facility users has emphasised the importance of accurate analysis of operational performance. Precise recording of performance is conducted by the operators in the facility control room. Using a computer spreadsheet, all scheduled time is entered into the following categories :

Accelerator inspection time
Injection and stack time
Ramp time
Steering time
User beam time
Fault time.

A numbered report is issued for each fault occurrence and the lost time is added to one of 16 further categories covering all accelerator systems. The data is processed monthly to allow summary tables to be analysed by the Accelerator Operations Committee. The information produced in this way is essential in determining the correct priorities for improvement programmes aimed at increasing the operational efficiency of the facility. Examples of the summaries produced are given in Tables 3 and 4.

MULTIBUNCH OPERATIONS	June 93	July 93	Aug 93	Sept 93
Scheduled Hours	480	520	624	600
User Hours	327	448	528	526
Fault Hours	159	30	62	37
Filling Hours	52	48	53	39
Number of Refills	36	45	37	30
Quoted Efficiency %	73.6	94.3	89.9	92.3

Table 2. Part of a Multibunch Performance Summary.

SYSTEM CATEGORY	HOURS LOST 6/93 to 2/94	%
Machine Vacuum Failure	162.3	30.2
Magnet Power Supplies	89.8	16.7
Mains Disturbance	88.1	16.4
Magnet and Absorber Water	29.8	5.5
RF System	26.9	5.0
RF Water	25.3	4.7
Beam Step Loss	23.9	4.5
Controls Software & CAMAC	18.4	3.4
Beam Port Hardware	18.1	3.4

Table 3. Part of a Fault Allocation Summary.

The high down time due to vacuum failure has been caused by the brazed joint problem on 'D' quadrupole vessels referred to earlier. There have been 4 such failures in the last 2 years brought about by the corrosive action of aggressive flux residues. To prevent disruption due to unplanned stoppages, a differential pumping unit which seals to the vacuum vessel around the leaking joint has been designed. This enables operations to continue with good lifetime until the vessel can be completely replaced in a scheduled shutdown.

6. IMPROVEMENTS PROGRAMMES

1. Beam Stability.

A major programme of work has been undertaken over the last 3 years to improve the position stability of the electron beam. This has involved replacement of the steering magnet control system, replacement of the electron position monitor readout electronics and the installation of tungsten vane photon position monitors on most beam lines. This work is extensively reported both at this Conference and elsewhere [4,5,6,7,8].

2. Power Converters for Storage Ring Magnets.

The existing power converters for the main storage ring magnet families are modified units purchased for experiments on the NINA accelerator in the 1960s. The reliability of these units has been slowly deteriorating to the point that they are now a major cause of accelerator down time. Purchase of modern power converters was initiated in 1992 and units of proven reliability on LEP were chosen. The sextupole magnets have been operating from these converters since March this year and the remainder of the storage ring magnets will be transferred to the new units in the forthcoming July shutdown [9].

3. Uninterruptable Power Supplies (UPS).

The incidence of beam loss due to disturbances on the local power grid has increased significantly in the last 12 months. The power company has introduced auto-reclose switch gear which requires the reduction of fault current trip levels. Given this change and the consequent high position of mains disturbances on the fault allocation table, the installation of UPS on the facility is being researched. It will not be possible to provide sufficient capacity to prevent beam loss, but with careful positioning of lower capacity units on critical circuits (the control room, control systems and cryoplant) the lost time due to mains disturbance could be reduced to the time taken to refill the accelerator. It is intended to install the first such unit within the next 12 months.

4. RF Systems.

Elderly sections of the RF system are also becoming unreliable and are now due for modernisation. Systems that will be completely replaced or refurbished this year include all cavity water temperature control hardware, cavity power monitoring, cavity tune control and phase shifter electronics. Some modifications have already been incorporated into the klystron equipment cubicle containing modulating anode control voltage circuits and 50KV DC switch and crowbar circuits. However, a PLC based design to replace all klystron control systems is now being prepared.

5. Refill Procedures.

Methods of reducing the refill overhead are kept under continuous review. At present the operators inspect the storage ring hardware once each day to identify incipient problems. Consideration has been given to discontinuing this 15 minute procedure as problems are rarely identified in this way and all systems are well interlocked. However, the practise has been retained because of the opportunity it provides for beam line personnel to enter the tunnel for rapid adjustments or equipment checks on front ends.

The dipole ramp from 600MeV to 2GeV takes 16 minutes and is limited by the motorised systems driving the 3 phase regulators in the old power converters. The introduction of the new power converters in August will provide the opportunity to reduce this time to less than 3 minutes. Preparatory work on implementation of fast ramps has now started..

6. Stored Beam Purity Measurement.

The principle cause of lost time in single bunch operations has been the necessity to dump new beams and refill because the purity level has been unacceptable to users (>0.1%). The resolution of the dissector used to measure purity in the synchrotron light monitor (SLM) at injection energy is only good enough to guarantee purity at the 0.5% level.

In July a new SLM mirror vessel will be installed with better silicon carbide mirror cooling and precision position adjustment mechanisms. In addition a full photon counting system to the same specification as that used by single bunch users will be commissioned and will allow purity measurement to 1 ppm at injection energy. A single ramp will in future, therefore, be sufficient to guarantee acceptable user conditions. It will also be possible to investigate in detail the leakage of charge to adjacent bunches in the duration of a stored beam.

7. Gapped Beam Operation.

A method of filling the storage ring with a 20% gap in the fill structure has been developed in accelerator physics time. This technique stops vertical source size blow up at higher currents by preventing ion trapping and will be introduced into user operations in August this year.

7. CONCLUSIONS

After fourteen years of operation, the SRS continues to provide a highly efficient service for the user community. Recent replacements of the beam steering and position monitoring systems have now been commissioned and will provide much improved source stability. Rigorous analysis of lost time statistics informs a process of continuous review on the reliability of all accelerator systems. Several improvement programmes consequent on this have been described.

8. REFERENCES.

[1] V P Suller et al., "SRS-2: Performance and Achievements" in Proc IEEE 1989 Part Accs Conf, Chicago, March 1989.

[2] M V Poole et al., "Update on Commissioning and Operations with the Second Superconducting Wiggler at Daresbury". These Proceedings.

[3] J A Clarke et al., "Electron Beam Lifetimes in the Daresbury SRS". These Proceedings.

[4] W R Rawlinson et al., "Development of a VME based Control System for the SRS Orbit Feedback Project. These Proceedings.

[5] R J Smith et al., "Design and Implementation of a Down Conversion Orbit Measurement Technique" These Proceeding

[6] G Mrotzek et al., "Photon Monitors on the Radiation Beam Lines of the SRS at Daresbury". These Proceedings.

[7] P D Quinn et al., "High Resolution Vertical Beam Stabilisation on the SRS". These Proceedings.

[8] B G Martlew et al., "Development of a Global Feedback System for the SRS at Daresbury". These Proceedings.

[9] D E Poole et al., "Upgrading the Main Magnet Power Supplies of the Daresbury SRS". These Proceedings.