High Resolution Stabilisation of Vertical Photon Beam Position in SRS Beam Lines

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Abstract

Following the installation and commissioning of a new high resolution steering magnet control system and high precision photon monitors on the SRS beam lines, automatic feedback control of vertical position is now in routine operational use. Orbit correction bumps can be set to micron level accuracy and this matches the resolution of the tungsten vane photon monitoring system. This paper describes the application of the new systems, particularly on the 5 Tesla Wiggler beam line, and demonstrates the nature of the improvements achieved.

1. INTRODUCTION

The new steering magnet control systems and photon position monitoring systems are the subject of other papers at this conference [1,2]. First use of these systems to implement automatic control of vertical position on an SRS beamline took place in September 1993 [3] and routine stabilisation of 2 beam lines had been established by December 1993.

This paper describes briefly how automatic control is achieved and reviews the commissioning procedure for a beam line. The drift behaviour of the 5 Tesla Wiggler beam line is presented with and without correction to demonstrate the nature of the improvements obtainable with the new systems.

2. METHOD OF VERTICAL CORRECTION.

The major vertical position stability problem for SRS users is one of slow drift over the duration of a beam. Typical drifts observed on this time scale are ± 50 µm and ± 10 µrads. Measurements of fast vertical movement have been made in the range from 0.1 Hz to 1 kHz by looking at tungsten vane monitor (TVM) outputs with a spectrum analyser. No signal in excess of 2 µm peak to peak has been observed.

The correction algorithm is repeated measurement of the photon beam position followed by calculation and application of a local vertical bump. The interval over which the bump is applied in LSB steps and the repetition rate of the correction process are both easily set in software. Repetition rates of 30 seconds and heavily averaged TVM position readings are generally used for long term drift correction.

3. COMMISSIONING A BEAM LINE

A stable beam which has been stored for over 24 hours is preferred for setting up servo operation. The ratios for the chosen local 3 magnet bump are first checked by monitoring the entire orbit on the electron position monitors as different amplitudes of bump are applied. If necessary the ratios are adjusted empirically. The calibration factor of the TVM is determined by scanning it through the beam and plotting position against encoder readings. The local bump is then calibrated by plotting bump setting against TVM output with the monitor in a fixed position. All values determined are then entered into a servo configuration file. The software also allows traps to be set for maximum applied bump in a single correction and maximum applied bump integral over all corrections. The effectiveness of servo operation for different repetition rates, bump set rates and monitor averaging is then assessed by measuring the position noise at the TVM in the presence of a large vertical error on the electron orbit induced by ramping the clearing electrode voltage.

4. VERTICAL DRIFT ON BEAMLINE 9.

The recent availability of 1 micron resolution vertical source position data from the new electron BPM system [4] together with the high resolution output of a TVM at 15m from the source on the 5 Tesla Wiggler beam line 9 allows the position and angle drift of the source to be measured. Figures 1 and 2 show typical results with no automatic correction system operating. Most of the beam movement occurs in the first 3 hours following the ramp. The magnitude of both the position and angle change over this period depends on the time that the storage ring magnets have been at 600 MeV levels or off in the refill period.

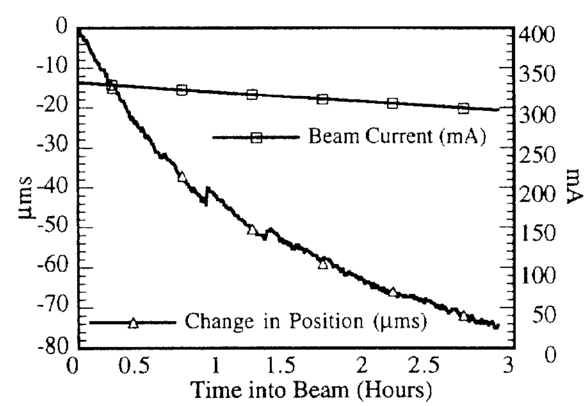

Figure 1. Change in source position.

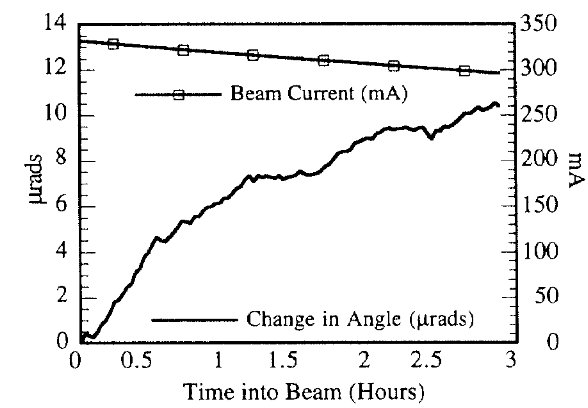

Figure 2. Change in source angle.

The positioning of the steering magnets in the SRS lattice does not allow independent correction of position and angle at the wiggler without substantially affecting neighbouring dipole beam lines. Ideally a local bump which reduces source position while increasing source angle would be chosen to correct this line but this also interacts strongly with the upstream dipole source location. The bump chosen for operational safety in the first instance, therefore, has no interaction on neighbouring lines but applies position and angle correction in the same sense. Figures 3 and 4 demonstrate the effect of this bump.

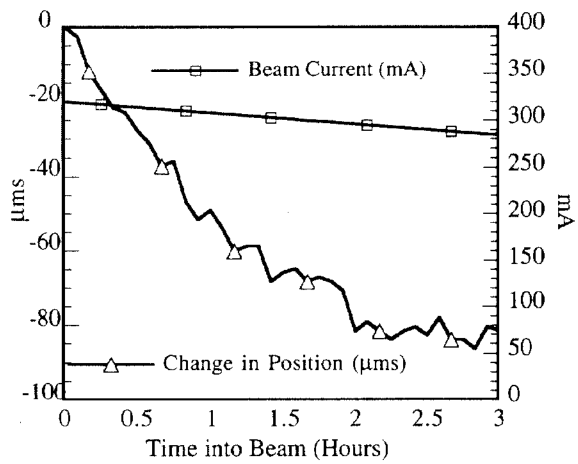

Figure 3. Change in source position.

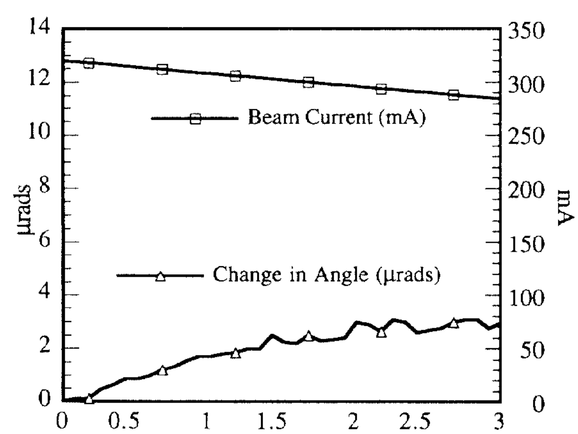

Figure 4. Change in source angle.

In summary, the effect of the servo is to make a small (10%) increase in position drift but to reduce the angular drift by a factor of 3 or more. Figures 5 and 6 show that the effect of the servo is to shift the pivot point of the drift from a point 6 m from the source to the position of the TVM at 15m.

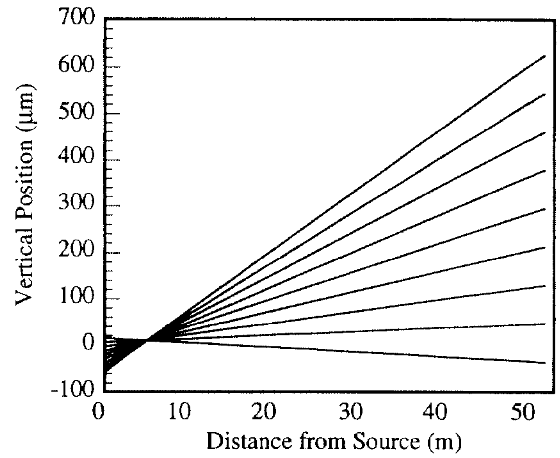

Figure 5. Photon beam position on line 9 showing pivot point at 6 m with servo off.

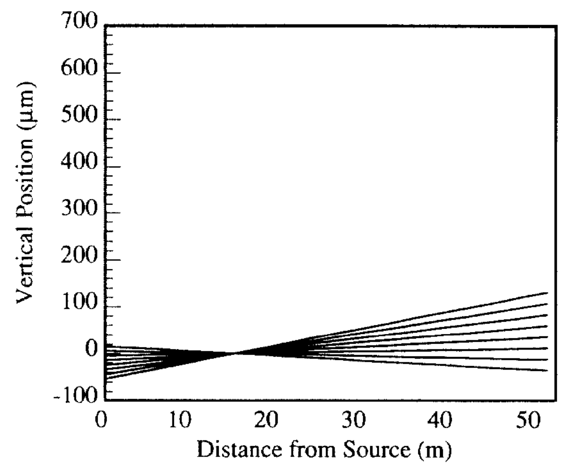

Figure 6. Photon beam position on line 9 showing pivot point at 15 m with servo on.

For this reason it is beneficial to place the TVM at the greatest distance from the source possible but always in front of any experimental station shutters.

5. DRIFT MODELLING.

A simulation using the lattice model has been carried out of the effect of random errors in the positions of all storage ring quadrupoles on position and angle change at the 5 Tesla wiggler. Each point in figure 7 represents the deviation from nominal of position and angle of the beam for 500 different random combinations of quadrupole errors. The RMS quadrupole error is set at 10 µm. The expected correlation between position and angle is observed and the experimental ratio between position and angle change (-0.14) is within the spread of values suggested by this simulation.

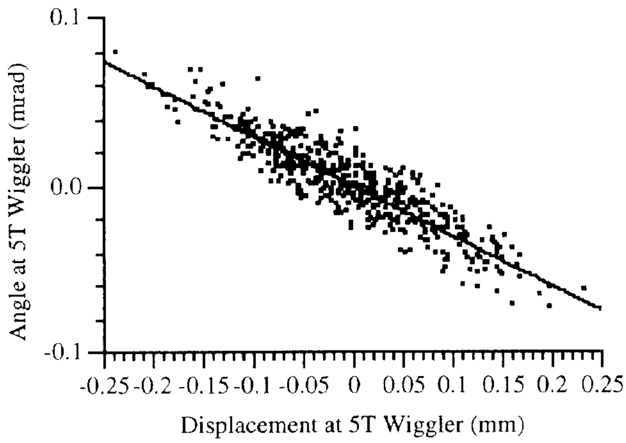

Figure 7. Theoretical correlation between electron beam position and angle in line 9.

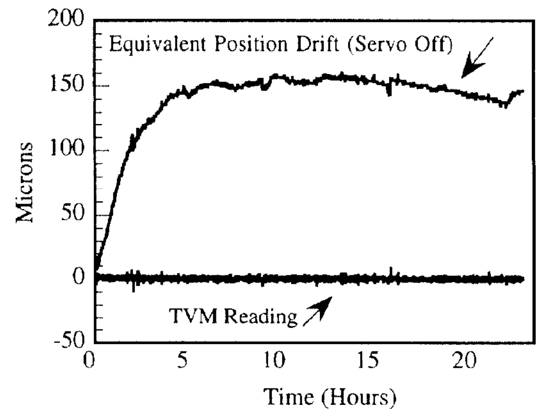

Figure 9. Stabilisation of the beam on line 5.

6. RECENT RESULTS

Simultaneous local vertical servo operation is now used routinely on the 5 Tesla wiggler line and the 10 pole undulator line. The system has proved to be very reliable and typical results are shown in Figures 8 and 9. The equivalent beam drift is back calculated from the total bump applied to keep the TVM reading at zero.

The beam position in the SRS occasionally jumps by up to 20 or 30 microns due to magnet movement or power supply instability. An example of such a jump can be seen in Figure 8 and demonstrates that the servo system lets through the leading edge of step changes. The fastest correction rate available at present is 0.1 Hz.

There is considerable scope for further development of local feedback systems. Within the next 12 months the system will be commissioned with a further 6 beam lines and the problem of interaction between individual adjacent lines on insertions and dipoles will have to be solved. Although it is not presently a user requirement, it will also be interesting to push the system to the highest possible correction rates.

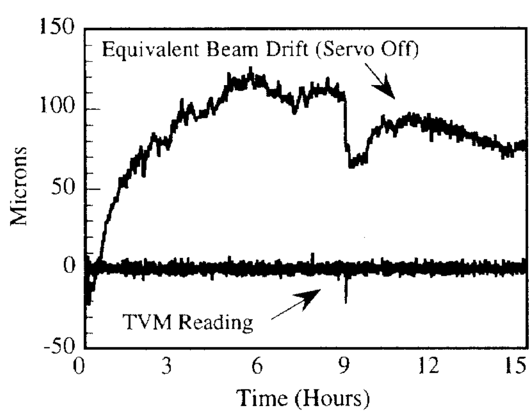

Figure 8. Stabilisation of the beam on line 9.

7. CONCLUSIONS

Following commissioning of new steering and photon position monitor systems, local automatic position control has been introduced into routine operations on two beam lines at the SRS. Large reductions in beam angle drift have been achieved by effectively shifting the pivot point of the drift from a position close to the machine to the photon monitor.

The system is being extended to cover all beam lines. Global automatic vertical and horizontal position control based on electron monitor output has now been demonstrated [5] and experiments to verify satisfactory simultaneous global and local feedback are planned for late 1994.

8. REFERENCES

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

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

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