Photon Beam Position Monitors on the SRS at Daresbury

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Abstract

Accurate and reliable photon beam position monitors are essential for the successful operation of synchrotron radiation source beamlines. At the SRS as far as possible a standard design has been adopted and following prototype studies this comprises a tungsten vane monitor (TVM). This paper reviews the position monitors installed so far and includes detailed performance characteristics that have been established.

1. INTRODUCTION

A programme to install one or more photon beam position monitors in the SRS VUV and X-ray beamlines is currently being implemented. The aim is to improve the measurement of the vertical beam position and in conjunction with a feedback system the vertical stability of the photon beam. Good UHV performance, high sensitivity and reliability [1-3] as well as successful operation of a prototype [4] led to the choice of a tungsten vane photo-emission type monitor .

2. PHOTON BEAM MONITORS

2.1 General

As far as possible a standard design for the mechanical drive unit , the drive electronics and the log-ratio amplifier was adopted to minimise design and installation time as well as spares . Each TVM has a drive unit attached to allow for easy calibration of the monitor. All the beam position monitors are calibrated and monitored from the main control room. Log-ratio signals are transmitted via twisted pair cables to reduce low frequency noise pickup. All drives are controlled via serial RS 232 C link.

2.2 Drive Unit

The drive unit consists of a high precision lead screw driven by a stepper motor via a 20:1 reduction low backlash gearbox and incorporating a 400 line optical encoder providing a positional resolution of 1 μm. The detector head is connected to a slide arrangement which is coupled to the lead screw via a preloaded ball screw. Total system backlash was measured to around 20 - 40 μm for the first 3 units but has been reduced in later units to generally better than 10 μm. A Baumer switch provides an absolute zero reference point for the drive unit. Positional repeatability is better than 3 μm (from zero reference to any position) with a displacement of 0.625 μm per step. Fig. 1 shows the equivalent TVM output while stepping the monitor in 6 μm steps through the beam.

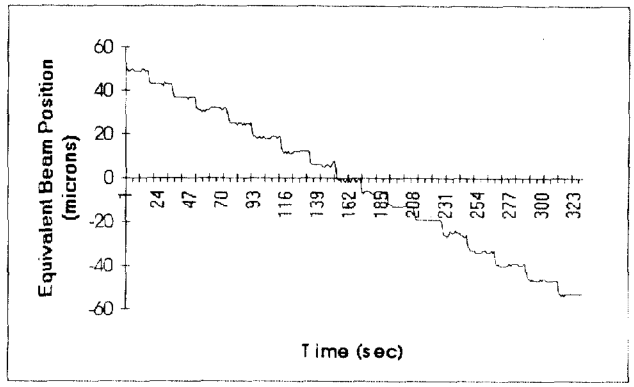

Fig. 1 TVM beamline 2 , 6 μm step plot

2.3 Detector Head

The detector head (Fig. 2) is a water cooled copper block with two vertical tungsten blades insulated from the block with beryllium oxide shims to provide good thermal conductivity, while at the same time maintaining good electrical isolation. The block is itself isolated from ground and can therefore be biased independently from the blades. In the VUV beamlines 3 and 5 installation in the horizontal unused part of the beam was not possible and the head was modified to a yoke shape so that no part of the beam was obstructed. The blade gaps for an opening angle of 250 μrad are set to between 1 and 2 σ at λ_c with the total length of the two blades plus gap amounting to 10 σ. The blade thickness is 0.5 mm for the beamlines installed at the beginning of the programme (beamlines 1 and 9) and where a small shadow is important (beamlines 3 and 5). All other later TVM's have 1mm blades installed.

2.4 Amplifiers

The signals from the tungsten vanes are fed into a purpose built log-ratio amplifier to provide a linear signal output for the feedback system. A standard unit is used for all TVM's and is described in more detail elsewhere [5]. The unit has proved reliable and was successfully operated at vane currents as low as 42 pA (Single Bunch mode, 5 mA beam current).

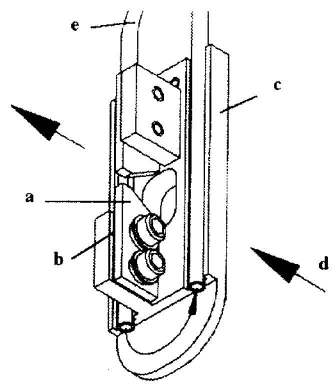

Fig. 2 : Detector Head a: Tungsten Blades b: Be Shims c: Copper Block d: Photon Beam e: Water Cooling

2.5 Locations and Present Status

The monitors were placed at a maximum distance from the tangent point in order to minimise any angular effects of the feedback operation. The present steering system does not allow for independent adjustment of position and angle. The incorporation into a feedback system also made it necessary to place the TVM's in front of any user controlled or personal safety beam line devices which can alter the monitor output such as station shutters or variable apertures. The majority of the present locations represent a compromise between these requirements. In addition locations in an unused part of the horizontal radiation fan were chosen whenever possible. Table 1 gives a summary of the location and status of the existing monitor installation. All commissioned monitors are now used routinely for beam steering after each refill.

Table 1 : TVM Status

Beam Line	Distance from TP (m)	Status
1	8.462	not commissioned
2	7.323	commissioned
3	12.100	commissioned
4	7.961	commissioned
5	6.840	local feedback active
6	8.002	not installed , planned July 94
7	9.325	commissioned
8	26.724	commissioned
9	13.100	local feedback active
13	4.005	test facility
16.3	17.857	not installed , planned late 94

2.6 Filters

A 125 μm Be window was incorporated in front of the tungsten blades with the exception of the VUV beamlines 3 and 5 . In these cases no position with unused horizontal fan could be identified. Beamlines 8 and 9 already incorporate a 1mm beryllium window in the line, thereby effectively cutting of any photons below about 1 keV and making the TVM's sensitive to only the hard x-rays.

3. MONITOR OPERATION

3.1 Bias

All TVM's were calibrated with a variety of vane and block bias voltages, typical bias profiles are shown in Fig. 3 and 4. A negative block or positive vane bias increases the output sensitivity through suppression of low energy electrons. As can be seen from Fig. 3 and 4 the calibration is sensitive to relatively small changes in bias voltage. For the calibration all positional changes were in the same direction to minimise mechanical backlash effects. A least squares fit procedure was used to obtain the log-ratio sensitivity . The bias was

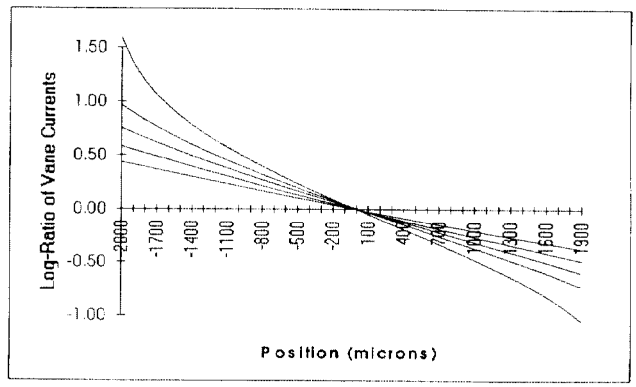

Fig. 3 Block bias sensitivity of log-ratio output. From top : -15 V,-9V, -6V,-3V and 0 V bias. Beamline 3.

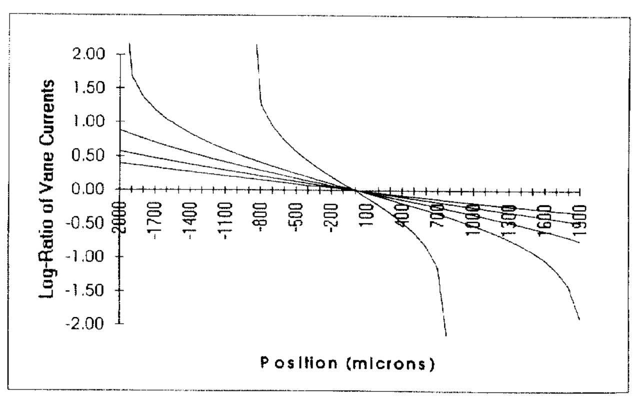

Fig. 4 Vane bias sensitivity of log-ratio output. From top : +15V, +9V,+6V,+3V and 0V bias. Beamline 3.

then configured such as to provide maximum sensitivity while maintaining good linearity over ~ 1mm beam movement.

3.2 Dynamic Stability

To test the dynamic stability of the TVM's, i.e. the dependence of the TVM position output on the SRS machine current, the current was reduced over a period of several minutes with the aid of the machine collimators. This was carried out at the end of a user shift when the beam was relatively stable and position drift was less likely to be due to thermally induced movement of the machine [6]. This is shown in Fig. 5. While it is difficult to separate real beam movement from the position drift due to beam current reduction it seems that some monitors show a lower dynamic stability than others. This might be related to differences in the operation of the TVM's such as the bias or filter configuration and is currently being investigated with the aim to achieve the same dynamic stability for all monitors.

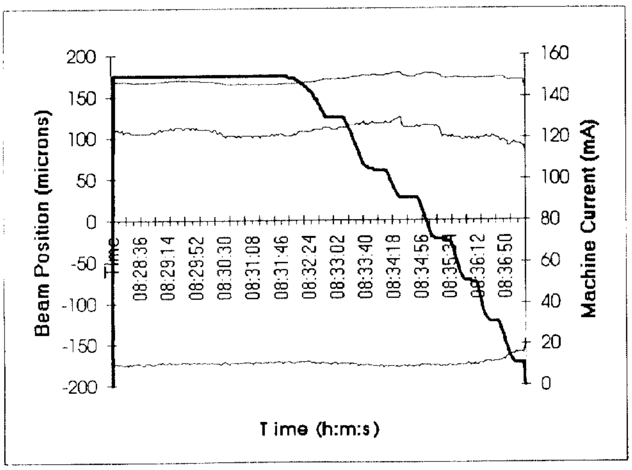

Fig. 5 Dynamic TVM behaviour. From top : B/L 2 , B/L 7 and B/L 3 , heavy line indicates machine current .

At the same time the behaviour of the log-ratio output sensitivity, i.e. the slope in Fig. 3 and 4, was tested by calibrating the TVM's at different machine currents over a period of several days. The change over a typical refill-to-refill cycle (i.e. about 150 mA) is below 10 % of the log-ratio sensitivity. The main cause for this dependence is believed to be the smaller source size at smaller machine currents which increases the TVM output sensitivity. As the local feedback servos the beam to the monitor zero position this variation has only a very small effect on the feedback operation.

3.3 Operational Problems

The only problems encountered were those where the TVM's had been installed in relative close proximity to other beamline devices such as valves and apertures. On beamline 7 the close proximity to a user controlled valve produces a change in TVM position output due to either backscattered radiation or secondary electrons whenever the valve is operated. This will be rectified in due course. On beamline 4 the close proximity of an aperture plate required the use of a relatively large bias for the TVM to operate and also produced a slightly non-linear output, however this will have a negligible effect on any future feedback operation.

4. CONCLUSION

The TVM's have up to now proved reliable and are able to provide accurate and continuous data on the photon beam position. Photon beam steering has been facilitated , is more accurate and less time consuming thereby increasing machine efficiency. Incorporation into a local feedback system has been successful with improved vertical stability. However further investigation into dynamic monitor stability is required. The installation of the TVM's has formed part of a wider programme of improvements dedicated to the reduction of source movement. The electron beam position monitor processing electronics have been completely replaced to give a source position resolution of <5 μm and the steering magnet control system has been upgraded into a VME system providing substantial localised processing power and 16 bit resolution. The first trials of global vertical and horizontal feedback have been completed successfully and stabilisation of the closed orbit to ± 7 μm from electron monitor output has been demonstrated. Preparation of global feedback and its combination with local feedback for user operation will take place in the next 6 months.

5. REFERENCES

[1] E.D.Johnson , T.Oversluizen "Compact high flux photon beam position monitor ", Rev.Sci.Instr. , pp 60 , Vol. 60 7 Month , 1989

[2] Shu et al. "The APS X-ray undulator photon beam position monitor and tests at CHESS and NSLS " Nucl. Instr. and Meth. , pp 56-62 , A319 (1992) ,

[3] T.Warwick et al.. " Prototype photon position monitors for undulator beams at the Advanced Light Source " , Rev. Sci. Instr. , pp.550-553 , Vol. 63 , 1 Month , 1992

[4] P.D.Quinn et al. "An Advanced Steering System for the SRS at Daresbury " , 3rd European Particle Accelarator Conference (EPAC) , 1992

[5] M.Dufau "An Improved Dual Channel Photo-Current Amplifier for Wire and Vane Beam Position Monitors" Daresbury Internal Report SRS/TDN/91/02

[6] J.A.Balmer , L.A.Welbourne " A Study of Thermally Induced Movement in SRS Storage Ring Quadrupole Magnets" These Proceedings