AN UPDATE ON THE DIAMOND LIGHT SOURCE PROJECT

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Abstract

A review of the main design features of the proposed 3GeV DIAMOND Light Source is underway as a precursor to a full design study that would lead to a decision on capital approval. Several possible alterations to the lattice layout are under consideration, in particular an increase in symmetry from the previous 2-fold racetrack geometry to improve the non-linear behaviour and to give greater optics flexibility. Another requirement is to ensure that the RF and injection systems can be located in only one straight each, leaving the remainder for a variety of insertion devices. The principal parameters of the newly optimised lattice are presented together with the considerations leading to their selection.

1 INTRODUCTION

In order to meet the future demand for Synchrotron Radiation in the UK a proposal is being developed to replace the SRS, the present national synchrotron radiation facility, with DIAMOND, a 3rd-generation light source facility. The requirements of the user community are for a sufficient number of insertion device sources (IDs), both undulators optimised for soft X-ray photons from 100 eV to 3 keV, and multipole wigglers producing high flux up to 30 keV; the dipole magnets will be useful subsidiary sources. In addition, some provision for long IDs (>10m) is also desired. The DIAMOND proposal is for a 3GeV, 16-cell storage ring with differing length ID straights. In a previous paper a racetrack lattice comprising 2x20m straights and 14x6m straights was presented [1]. After a review of the design parameters it has been decided to consider a modification to the lattice layout, the basic design of which is presented here.

In order to accommodate all the injection elements in one straight and all the RF components in another (each taking approximately 8m of space) the lattice has been modified to include four long straights, two of which will be used for the injection and RF, leaving two for long IDs. This has the dual advantage of freeing an additional short straight for insertion devices whilst improving the non-linear dynamics of the lattice.

2 STORAGE RING LATTICE

The lattice is a double-bend achromat structure composed of 16 cells arranged in four superperiods, each superperiod containing insertion straight types in the following order:

Long - Short (Low β_x) - Short (High β_x) - Short (Low β_x)

The achromat layout and the 6m short ID straights have been preserved from the racetrack lattice, taking account of the engineering requirements [2]. The new long straights were initially matched to preserve the previous working point of (18.73,6.86), before exploring the tune diagram for best non-linear behaviour.

2.1 Working Point Choice

Preliminary work has been performed on a new working point, the properties of which are summarised in Table 1; lattice functions for one octant of the lattice are shown in Figure 1. The vertical beta function in the dipoles has been reduced to ~20m from ~28m in the racetrack lattice [2], giving better source properties.

This first working point is designed for zero dispersion in the ID straights, and gives an emittance 2.2 times the theoretical minimum (6.45 nm.rad); this is comparable with that obtained by other synchrotron light sources. Further work will examine non-zero (but small) dispersion optics, with the prospect of a factor of 3 reduction in emittance [3].

Table 1: Main operating point properties.

Energy [GeV]	3
Circumference [m]	340.8
Straight Lengths [m]	4x11, 12x6
Harmonic Number	568
RF Frequency [MHz]	500
Natural Emittance [nm.rad]	14.3
Betatron Tunes Q_x, Q_y	18.28, 6.33
Natural Chromaticities Q'_x, Q'_y	-54, -18
Momentum Compaction Factor	0.00843

Several possible areas near the starting working point of (18.73, 6.86) were studied, in particular the region $18<Q_x<18.5$, $6<Q_y<6.5$, choosing those which possessed reasonably small tune shifts with momentum with only the two families of chromatic sextupoles. Optimisation of the harmonic sextupoles was then performed for each likely working point using the HARMON module of MAD [4] to minimise both tune shifts with amplitude and contributions from resonances. Careful selection of initial conditions is necessary to obtain good solutions from the minimisation. Tune shifts with momentum for the chosen point are shown in Figure 2 for the case with optimised harmonic sextupoles, and in the working diagram shown in Figure 3. Particles are stable to well over ±3%.

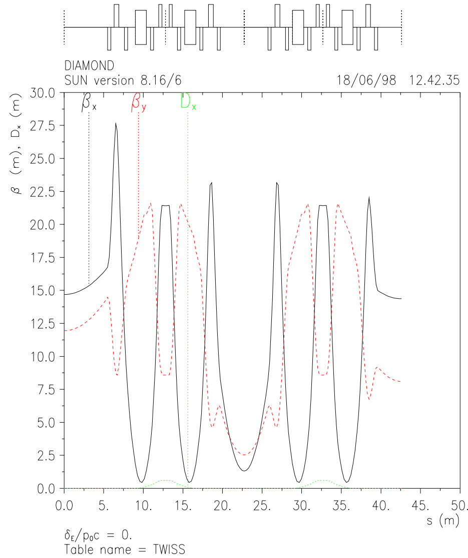

Figure 1: Twiss and dispersion functions for one octant.

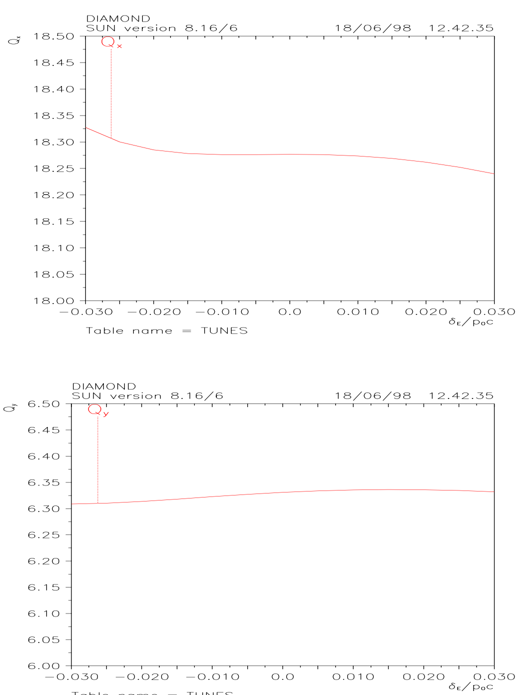

Figure 2: Horizontal and vertical tune shifts with momentum up to ±3%.

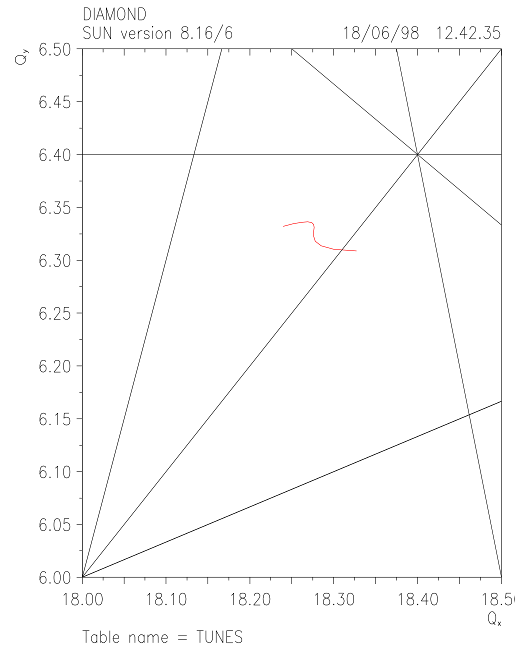

Figure 3: Working diagram showing tune shifts up to ±3%; resonances up to order 5 are plotted.

2.2 *Dynamic Aperture*

After sextupole compensation the dynamic aperture was estimated by tracking test particles. The dynamic acceptance for the present working point is shown in Figure 4; this compares favourably to the dynamic acceptance of the racetrack lattice, shown in Figure 5. The dynamic aperture (shown in Figure 6 at the centre of the long straight sections) is already very promising, and may be further improved by more exploration of the working diagram.

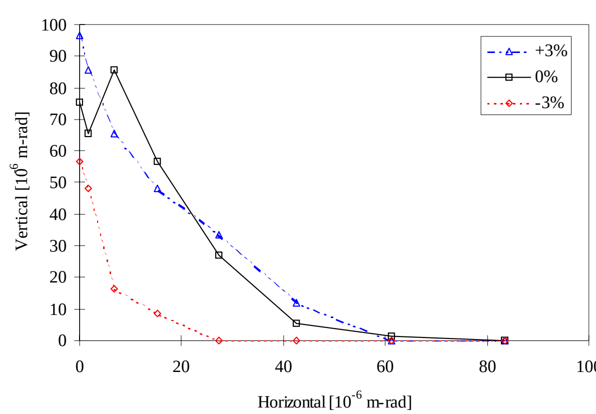

Figure 4: Dynamic acceptance for on-momentum and ±3% off-momentum particles (tracked with MAD for 200 turns using 4th-order Lie method [4]).

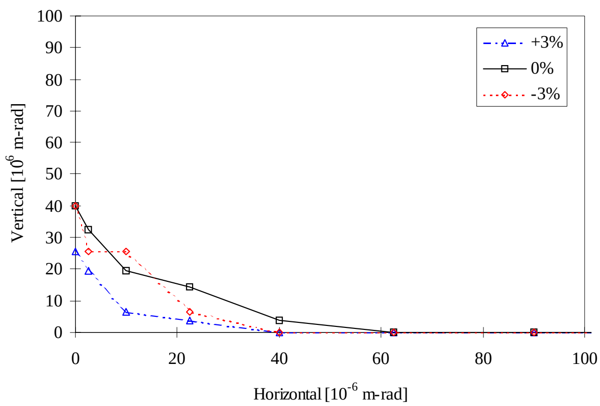

Figure 5: Racetrack Lattice - dynamic acceptance for on-momentum and ±3% off-momentum particles (tracked with MAD for 200 turns using 4th-order Lie method).

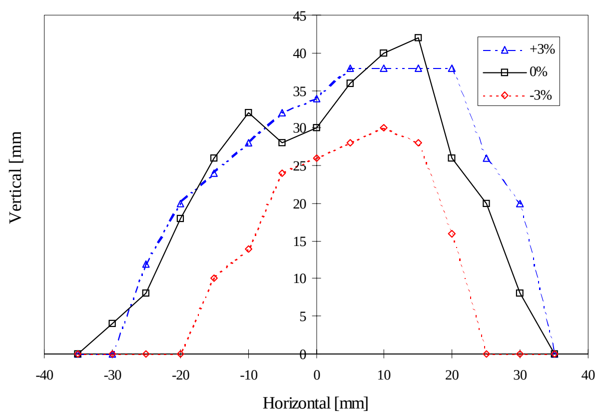

Figure 6: Dynamic aperture for on-momentum and ±3% off-momentum particles (tracked with MAD for 200 turns using 4th-order Lie method), observed at centre of long straight section ($\beta_x = 14.7$ m , $\beta_y = 12.0$ m).

3 STATUS AND OUTLOOK

Studies on the new lattice layout are continuing, and will explore other possible working areas, including the evaluation of distributed dispersion options. The effects of errors and their correction will be carefully studied. The performance of a 20 cell DBA lattice with a slightly greater circumference will also be considered.

The scientific case for the DIAMOND facility has been reviewed and endorsed by those Research Councils who will fund its exploitation. An outline of the spend profile for its construction is included in the UK government's review of spending, but a decision has not yet been taken. If a positive outcome results, a full design study could start in 1999 with the facility coming into operation with 15 equipped beamlines in 2005.

4 ACKNOWLEDGEMENTS

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[4] H. Grote and F.C. Iselin, "The MAD Program", CERN/SL/90-13 (1995).