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STATUS OF THE DIAMOND LIGHT SOURCE PROJECT

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Abstract

The DIAMOND 3rd generation light source project has completed its design definition and moved into the procurement phase. A detailed description and parameters are presented of the 3 GeV, 562 m circumference, 24 cell electron storage ring; the calculated performance of the insertion devices; the initial suite of beamlines. Important design issues are highlighted and technical solutions are discussed.

1 INTRODUCTION

The progress and evolution of the DIAMOND light source project has been regularly reported at accelerator conferences [1] [2] since its original conception in 1992. After EPAC 2000 a full scale definition of the design specification was undertaken and has been completed with the production of a design report [3].

A joint venture company has recently been formed (DIAMOND Light Source Ltd) with funding and responsibility to construct, commission, and operate the facility at the RAL site and therefore the project has formally entered the procurement phase.

2 DESIGN SPECIFICATION

The design has now been refined such that the facility can expect to provide a world-leading performance for a medium energy third generation synchrotron light source. It will use a 3 GeV, 24 DBA cell, 6 fold structure which has been optimised to generate an electron beam of extremely high brightness (emittance 2.7 nm-rad) with excellent dynamic properties permitting long beam lifetimes (10–20 hrs). The circumference of 562 m will accommodate 18 insertion devices up to 5 m long with an additional 4 up to 8m. A further 20 beams of somewhat lower brightness will be able to be exploited using the storage ring dipole magnet sources. The principal parameters are listed in table 1 and a plan view of DIAMOND is shown in figure 1.

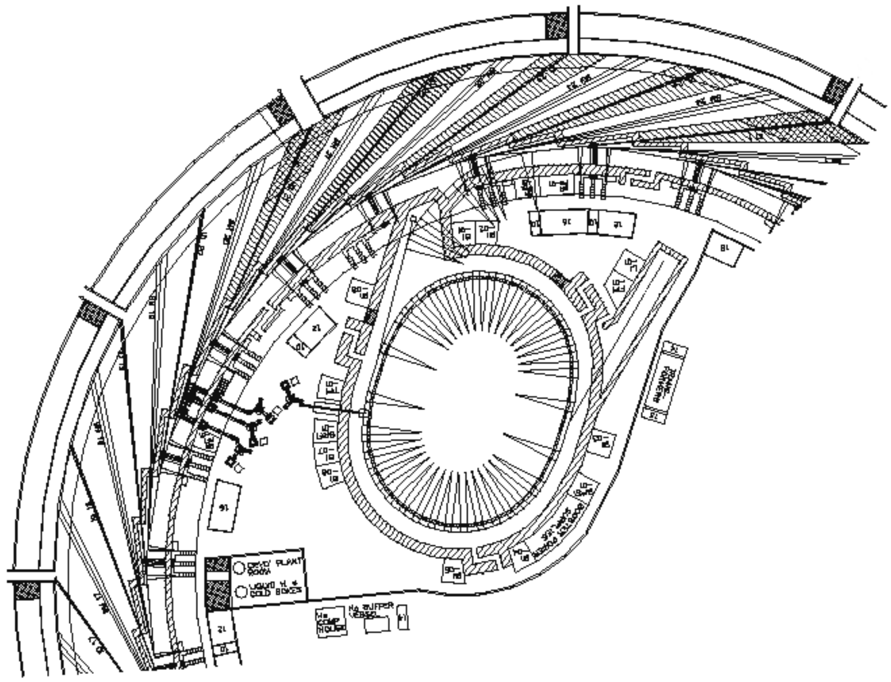

Figure 1. Part plan view of the DIAMOND facility showing linac, booster, storage ring and beamlines.

Table 1. Principal design parameters

Energy	3 GeV
Circumference	561.6 m
Lattice	24 x DBA, 6 fold symmetry
Max length for IDs	18 x 5 m; 4 x 8 m
Injection energy	3 GeV
Beam current	300 mA
Lifetime	10-20 hrs
Emittance; horiz, vert	2.7, 0.03 nm-rad
Bunch length (fwhm)	25.6 ps
Source sizes (fwhm) 5 m straight, h x v 8 m straight, h x v dipole magnet, h x v	 290 μm x 15 μm 421 μm x 30 μm 127 μm x 56 μm

3 BUILDING STABILITY

To make full use of the brightness characteristics of a 3rd generation light source it is necessary that the beam source points and the foci at the experiments do not move excessively. The movement, which can arise from long-term motion and vibrations of the building foundations, is specified to be less than 10% of the beam dimensions and is typically a few microns in the vertical plane. Simulations have shown that with an orbit correction scheme of a reasonable scale, the beam movement can be corrected if a foundation stability for the storage ring of 0.1 mm per year over a distance of 10 m is achieved. The related experimental floor stability needs to be about 0.25 mm.

This stability performance is onerous to guarantee and depends on the ground conditions. It is expected that it can be met at the RAL site by a storage ring concrete slab thickness of 0.9 m, an experimental floor slab of 0.6 m, and a distributed set of piles connecting the slabs to a chalk stratum at a depth of 12 m. It is predicted that a physical realignment of the storage ring will be needed twice a year.

4 LATTICE

The basic lattice structure [4] uses DBA cells in a configuration which is similar to many other light sources. The long straights for the IDs are matched by quadrupole triplets which allow the different lengths of 5 and 8 m to be accommodated with minimal beta modulation. Additionally, each of the 240 quadrupoles will be individually powered so that the lattice will have flexibility in the future for adopting different optics, including adjustment of beta functions to suit particular insertion devices.

The sextupoles are arranged in 2 chromatic and 6 harmonic families and the phase advances between them have been set as far as possible to minimise the non-linear perturbations which arise. This has resulted in predictions for excellent dynamic aperture behaviour which extends to off-momentum particles of ±4%. Such a high acceptance is needed for good beam lifetime.

As is well known, by setting a small dispersion in the long straights of a DBA lattice, a factor 3 lower emittance can be realised than with the zero dispersion optic,. This has been utilised for the preferred DIAMOND operating mode and the main optimisation has been carried out for the tune point shown in table 2. The lattice functions are shown in figure 2. The zero dispersion optic has also been thoroughly studied because it may possibly be used if particular IDs would benefit.

Table 2. Lattice parameters at operating tune point

Maximum horizontal beta function [m]	22.6
Maximum vertical beta function [m]	26.6
Maximum dispersion [m]	0.311
Horizontal beta function, 8 m straight [m]	10.0
Vertical beta function, 8 m straight [m]	5.8
Horizontal beta functions, 5 m straight [m]	4.7
Vertical beta functions, 5 m straight [m]	1.5
Dispersion, 8 m straight [m]	0.072
Dispersion, 5 m straight [m]	0.052
Horizontal tune	27.226
Vertical tune	12.36
Natural horizontal chromaticity	-79
Natural vertical chromaticity	-35
Natural emittance [nm rad]	2.74
Momentum compaction	0.00017
Energy spread	0.000961
Radial damping time [ms]	11.2
Vertical damping time [ms]	11.2
Longitudinal damping time [ms]	5.6

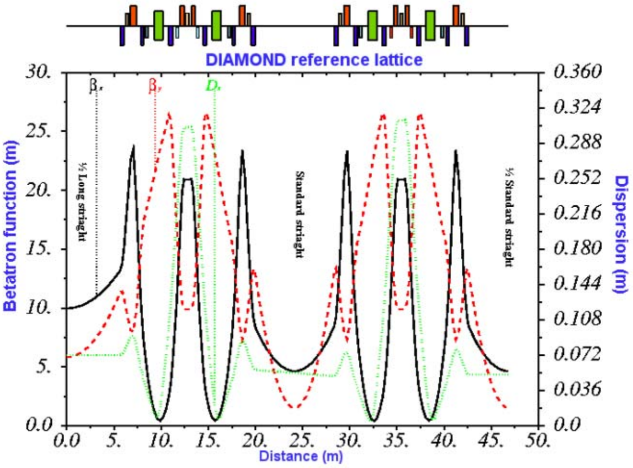

Figure 2. Lattice functions for the finite dispersion optic

5 RADIO FREQUENCY

The radio frequency systems in both the booster and storage ring will operate at 500 MHz, with the linac at an exact multiple of 6 (3 GHz) to permit precise phase locking of all systems. To alleviate the problem of instabilities driven by higher order modes, it has been decided to use a superconducting rf system for the storage ring [5]. Using data from tested SC rf systems at both KEK and CESR it has been shown that all coupled bunch mode thresholds will be substantially raised. The specific SC rf system to be used will be selected in response to offers made by commercial suppliers.

6 IDS AND BEAMLINES

The DIAMOND facility is specified to include an initial complement of 7 beamlines, with others to be added regularly in sequential phases. The first 8 beamlines have been agreed after consultation with the research community. Each will have an ID source whose parameters have been selected to optimise the photon spectrum for the intended research programme [6]. These are presented in table 3 and the calculated brightness spectra are shown in figure 3. Figure 3 demonstrates the very high brightness which will be generated over the photon energy range from 30 eV to 20 keV.

7 TIMESCALE

From April 2002 funding has been released for the procurement phase of the facility, through the DIAMOND Light Source Company Ltd. A start on the buildings will be made in March 2003 and it is planned to commence installation of the accelerators from July 2004. It is intended to commission them by the middle of 2006 with beams becoming available for research later in that year.

REFERENCES

[1] M W Poole et al, “Evolution of the DIAMOND Light Source”, EPAC’2000, Vienna, June 2000.

[2] J A Clarke et al, “The DIAMOND Project: An Advanced Light Source for the UK”, PAC’01, Chicago, June 2001, pp227-229.

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[4] S L Smith et al, “Optimisation of the DIAMOND Storage Ring Lattice”, EPAC’02, Paris, June 2002.

[5] D M Dykes et al, “Superconducting RF Systems for Light Sources”, EPAC’2000, Vienna, June 2000.

[6] J A Clarke et al, “The Initial Insertion Devices for the DIAMOND Light Source”, EPAC’02, Paris, June 2002.

Table 3. Parameters of the initial IDs.

Name	Beamline	Technology	B_{Max} (T)	K_{Max}	Period (mm)	$N_{Periods}$	Length (m)
MPW60	VHE	SC MPW	3.5	19.6	60	16	1.0
U33	Materials	Und	0.54	1.66	33	149	5.0
U23 IV a	PX	In Vac Und	0.70	1.49	23	85	2.0
U23 IV b	PX	In Vac Und	0.70	1.49	23	85	2.0
U23 IV c	PX	In Vac Und	0.70	1.49	23	85	2.0
U27 IV	XAS	In Vac Und	0.80	2.02	27	72	2.0
HU64	SXR	Helical Und	0.57	3.4	64	75	5.0
U27	NCD	Und	0.70	1.76	27	72	2.0

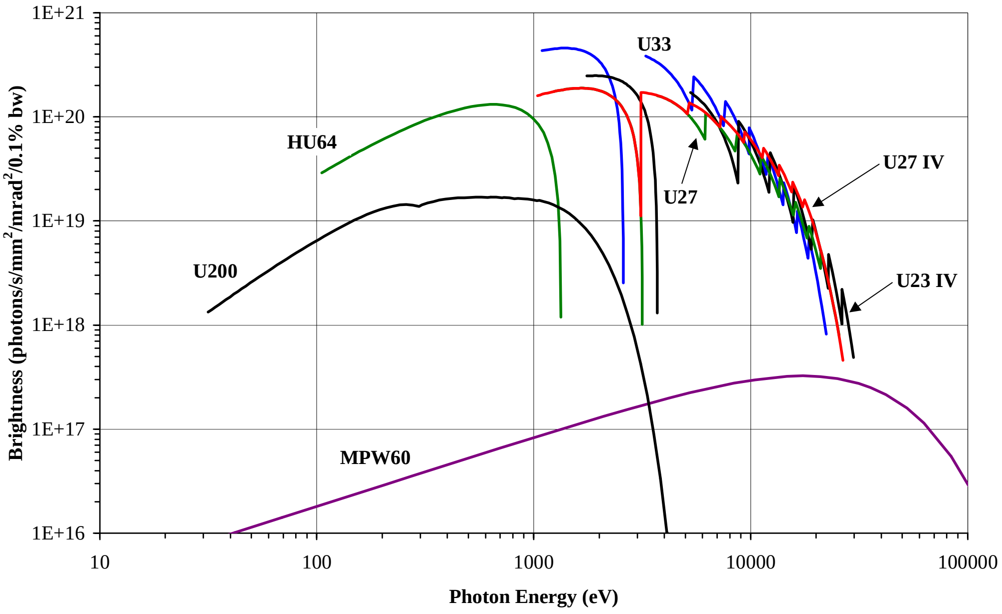

Figure 3. Calculated Brightness Spectra for the initial IDs and an example 200 mm period undulator.