POSSIBLE INSERTION DEVICES FOR THE DIAMOND LIGHT SOURCE

J. A. Clarke, Daresbury Laboratory, Warrington, WA4 4AD, UK

Abstract

DIAMOND is a 3 GeV synchrotron light source that is planned to replace the 2 GeV SRS at Daresbury. It must satisfy a very broad range of future users including the UK academic community, research funded by the Wellcome Trust, significant requirements of the French government supported science and other applications, including industrial and commercial ones. As with all 3rd generation light sources the primary beamlines will be based on state of the art insertion devices. These devices will need to provide very high brightness from below 100 eV to up to 20 keV and moderate brightness but very high flux beyond 20 keV and up to at least 100 keV. To meet these demands several types of insertion device will need to be provided - planar undulators, multipole wigglers, wavelength shifters as well as more exotic devices for providing variable photon polarisation. This paper describes the devices currently being assumed.

1 INTRODUCTION

DIAMOND is a 3rd generation light source project that will be built in the UK [1]. The project has three funding partners; the British and French Governments and the Wellcome Trust, a UK based life sciences charity. The scientific needs of all three partners must be met by the insertion devices and so they have to span a very broad photon range with internationally competitive photon beam qualities. The insertion devices will need to provide extremely high brightness from below 100 eV to up to 20 keV and moderate brightness but very high flux beyond 20 keV and up to at least 100 keV. To meet these demands several types of insertion device will need to be provided - planar undulators, multipole wigglers and wavelength shifters. There is also a major requirement for variable photon polarisation over this whole wavelength range.

2 DIAMOND PARAMETERS

The present DIAMOND design has an energy of 3 GeV and 24 cells. Six of the cells have a free straight length of 9.36 m of which it is expected that 8 m will be available for IDs, the other 18 cells have a free straight length of 5.86 m with 4.5 m of this available for IDs. Since the lattice is of the double bend achromat type there are 48 dipoles (each of 1.4 T). However, due to engineering and beamline layout constraints only approximately half of these will be available to be used for synchrotron radiation experiments. The lattice has an exceptionally small emittance of 2.5 nm rad, the consequent beam sizes and divergences at the major source points are given in Table 1. More details on the lattice can be found in [2].

Table 1. DIAMOND electron beam size ($\sigma_{x,y}$) and divergences ($\sigma'_{x,y}$) at the centre of the ID straights and the dipole. A coupling of 1% has been assumed.

	4.5 m Straight	8.0 m Straight	Centre of Dipole
σ_x (μm)	79.9	166.0	33
σ'_x (μrad)	35.0	15.6	89
σ_y (μm)	7.8	15.6	23
σ'_y (μrad)	3.1	1.6	4.5

Lifetime calculations have indicated that a vertical magnet gap of 15 mm should be possible for the full length of the 4.5 m straight. Short period devices will be able to have a minimum gap of 10 mm, but only over the central 2 m of the straight section [3]. It is envisaged at present that the 8 m straight will be used for low field, longer period devices and so the gap will not be so critical. At present a gap of 20 mm is being assumed for the 8 m straights.

3 INSERTION DEVICES

No beamlines have been formally decided yet for the DIAMOND light source and so it is not possible to finalise the design of any of the IDs. However, a portfolio of undulators, multipole wigglers and wavelength shifters has been assembled using justifiable assumptions so that the potential users of the new project are well informed of what it will be capable of.

3.1 Very High Brightness Photons

One of the major requirements of the DIAMOND light source is that very high brightness photons are available for protein crystallography. Typical photon energy requirements for this thriving community are in the range 10 - 15 keV and beyond. The high brightness required is only achievable in a light source from undulators. In the DIAMOND project, short period undulators with small gaps and high harmonic output are required to reach much beyond 10 keV. An international workshop was held at Daresbury in 1999 to discuss the feasibility of such small gap, high harmonic devices [4]. The workshop concluded that operating with gaps in the range of 5 to 10 mm was feasible and that harmonics up to and beyond the 11th could usefully be exploited. This important conclusion enabled the project to state with confidence that very high brightness photons would be available from DIAMOND in the range 10 - 15 keV.

Figure 1 shows the photon brightness for the present complement of undulators. It can be seen that brightness beyond 10^{20} photons/s/mm^2/mrad^2/0.1% will be achieved over the wide operating range of 400 eV to 7000 eV. Table 2 gives details of the undulators that are presented in figure 1. The useful photon range that is given in the table is defined (somewhat artificially) as being that which has a photon brightness of greater than 10^{18} photons/s/mm^2/mrad^2/0.1%.

Table 2. DIAMOND Undulator Parameters. $N_{periods}$ is the number of periods, B_{max} is the maximum on-axis field and K_{max} is the maximum deflection parameter.

Name	U24	U36	U48	U80	U200
Period (mm)	24	36	48	80	200
$N_{periods}$	83	125	93	56	40
Length (m)	2.0	4.5	4.5	4.5	8.0
Min. Gap (mm)	10	15	15	15	20
B_{max} (T)	0.60	0.60	0.84	0.67	0.27
K_{max}	1.4	2.0	3.8	5.0	5.1
Photon Range (keV)	1.8 - 3.6, 5.6 - 22	0.8 - 19	0.2 - 14	0.08 - 8	0.03 - 2.7

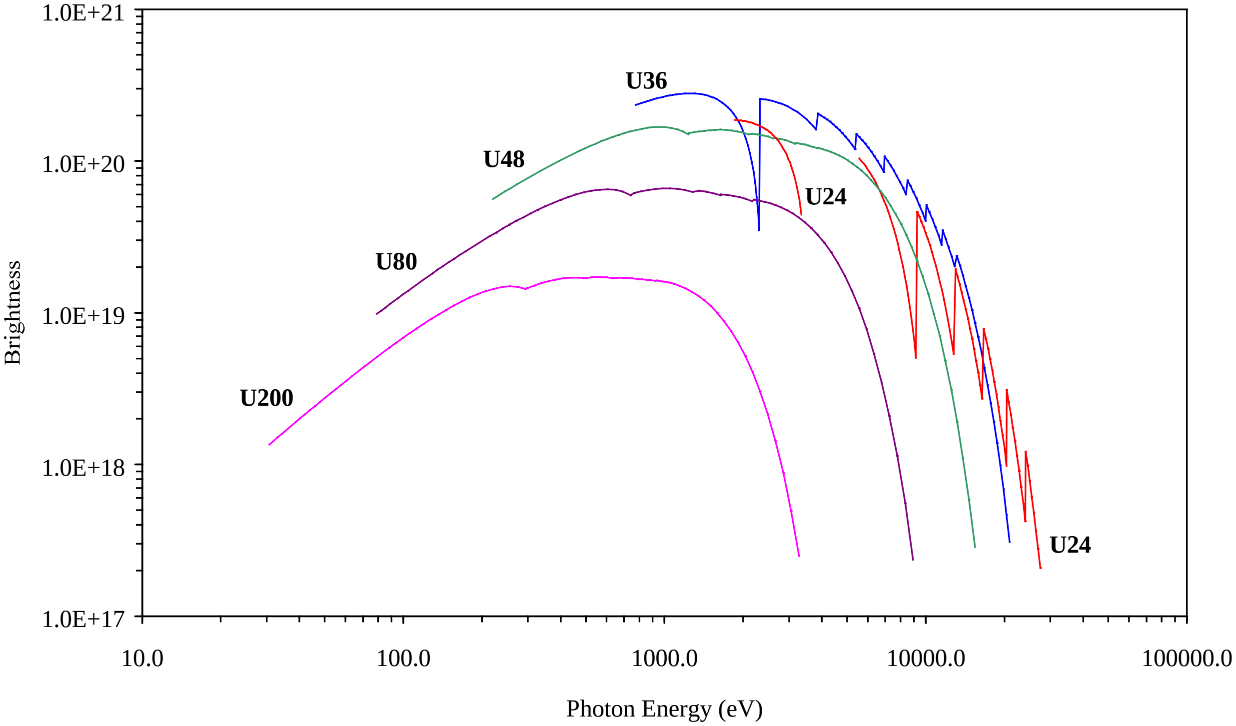

Figure 1. Photon brightness (units of photons/s/mm^2/mrad^2/0.1%) for the present complement of DIAMOND undulators with a beam current of 300 mA.

3.2 High Flux Beyond 20 keV

There is a requirement for medium brightness but very high flux photons beyond 20 keV and up to as high as perhaps 100 keV. This will be met by a combination of multipole wigglers and wavelength shifters. Again, the exact requirements for particular beamlines is unknown at present so different possibilities are being explored. Figure 2 gives the photon flux that would be available from two of the undulators presented earlier, two further IDs and the bending magnet. The 1.6 T multipole wiggler has 45 periods, each 100 mm long. The wavelength shifter is a single pole 6 T superconducting magnet. There is considerable interest at present in having a higher field multipole wiggler of between about 3 and 4 T. Possible designs will need to be explored in the near future to assess this requirement.

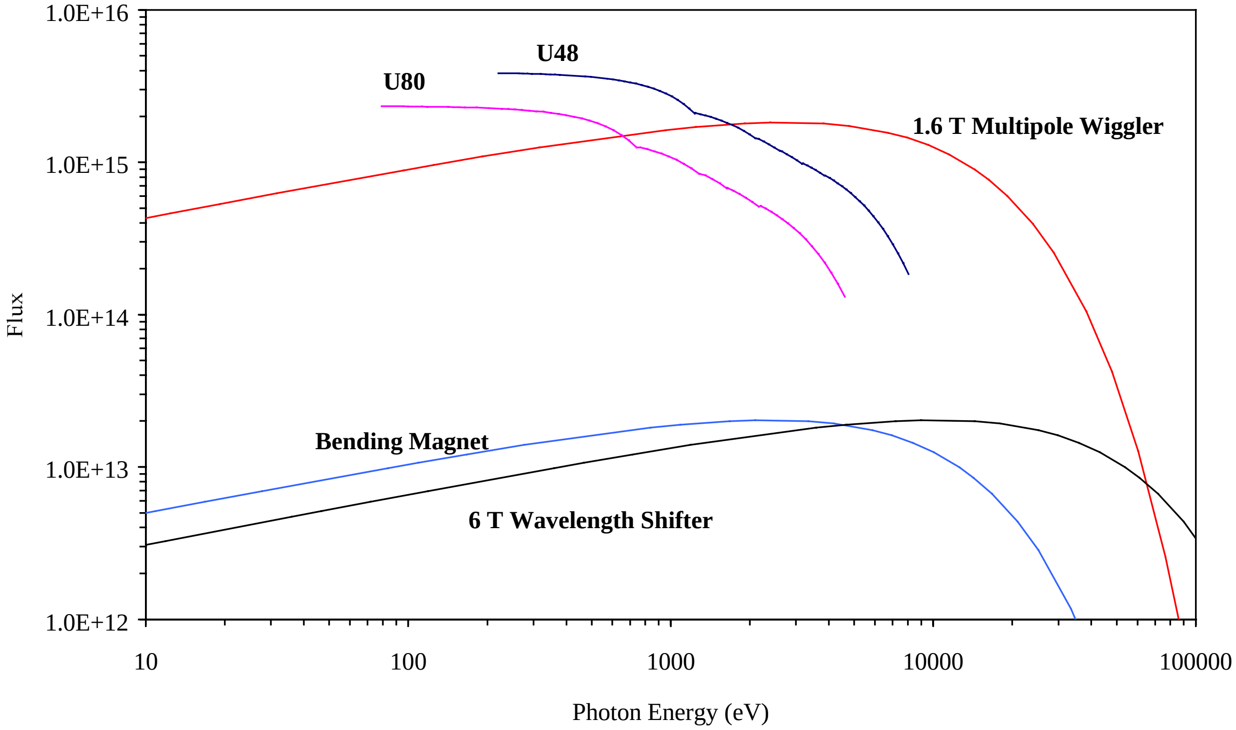

Figure 2. Photon flux (units of photons/s/0.1%) for DIAMOND with a beam current of 300 mA. The bending magnet, multipole wiggler and wavelength shifter flux is given per horizontal mrad.

3.3 Polarisation

There is a significant demand already for light of variable polarisation to be available over a wide range of the spectrum. At present it seems that the greatest demand for variable polarisation will be at the low energy end of the spectrum (below 100 eV to 2 keV) and this will be best met by helical undulators, probably of the Apple II type [5]. However, it is likely that an asymmetric wiggler will be needed for high energy photons of left and right helicity.

3.4 Two IDs Per Straight

Although DIAMOND will have 22 free straight sections available for IDs the user demand is expected to be so high that serious consideration is already being given to having two independent IDs in some straights. This will allow 2 simultaneous experiments per straight and could effectively double the capacity of the source. The electron beam within the straight section would be carefully steered so that the photon beams from the two IDs would be separated by a small angle. Several ‘chicane’ schemes are possible and these will be assessed in the future design study to decide which is the most advantageous.

Separate ID modules of approximately 2 m in length are being assumed at present as this fits in nicely with the requirement to have 2 independent IDs in the 4.5 m drift spaces and also with having ‘single’ 8 m IDs in the longer straights (made up of 4 modules).

REFERENCES

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