PLANS FOR A 2ND INSERTION DEVICE IN CAMD

M Fedurin, P Jines, D Launey, T Miller, V Suller, Y Wang; CAMD, Baton Rouge LA 70806, USA.

Abstract

To allow the possible installation of a 2nd Insertion Device in the CAMD Light Source, the lattice optic needs to be changed. The present configuration has a small vertical beta function in the long straight section containing the 7 Tesla wiggler. The new optic will give a small vertical beta at two long straight sections which are diametrically opposite. Test results with the new optic are presented together with the measured beam parameters. These data are used to predict the photon beam performance for an Insertion Device which could be installed.

INTRODUCTION

The CAMD Light Source was originally intended as a Lithography facility for microstructures [1] but since coming into operation in 1992 its use for research has steadily broadened. At the present time 15 beamlines are in use for spectroscopy, spectro-microscopy, micro-tomography, molecular and crystal structure determination and for microfabrication. [2]

The source was conceived as a 2nd generation facility of moderate brightness using a 4 cell Chasman-Green lattice. The normal beam operating energy is 1.3 GeV. At the injection energy of 200 MeV the lattice is operated in a fully symmetric zero dispersion mode, which is also used during the energy ramp.

In 1998 a 3 pole wavelength shifter [3] was installed whose maximum field is 7 Tesla. This is used to provide hard X-rays for ultra-deep lithography, protein crystallography and other hard X-ray science. To increase the brightness, after the energy ramp is completed the optic is changed to one with finite dispersion in the long straights. This reduces the natural horizontal emittance by about a factor of 2 to 150 nm.rads. In addition the optic is configured to produce a small value of the vertical beta function at the center of the wiggler in order to increase the flux density of the source point. This is known as the minibeta optic.[4]

The wavelength shifter is located in one of the 4 long straights which each have a free length of about 2.5 m. One of these straights contains the injection septum magnet and another contains the single RF cavity. The remaining straight is not presently used. These features may be seen in fig 1 which is a diagram of the CAMD facility.

To enable the lattice to operate in the minibeta configuration, the F and D quadrupoles in the wavelength shifter straight are connected to independent power supplies. In addition these quadrupoles are adjusted to compensate for the focusing effects of the wavelength shifter and so maintain the beta values close to the optimum minibeta.

At the end of the energy ramp the settings for the minibeta are applied smoothly in synchronism as the wavelength shifter is energized without loss of beam current.

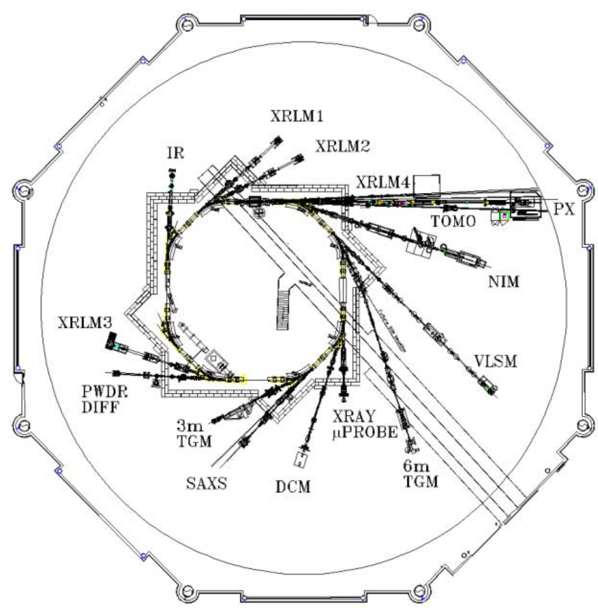

Figure 1: A general view of the CAMD facility.

A SECOND INSERTION DEVICE

Because one of the long straights is unoccupied consideration has been given to the possibility of installing a 2nd Insertion Device (ID) in CAMD. In principle this could be either a wavelength shifter, a multipole wiggler or an undulator. Given that the existing wavelength shifter already provides sufficient coverage of the hard X-ray spectrum and that the CAMD research program has strong emphasis in the soft X-ray region it was decided to base plans on a multipole wiggler. This will be optimized to generate high flux density in the photon energy range 1 – 4 keV and would be designed to serve several beamlines simultaneously.

The requirement for high flux density from the 2nd ID implies that the beta values at the source point should be small to give small beam size. Although a minibeta can in principle be arranged at both the existing 7 Tesla ID and the adjoining vacant straight section it is not very practical. Furthermore the asymmetric periodicity which would result in the storage ring is not desirable. For these reasons it has been decided to locate the 2nd ID in the straight section diametrically opposite the 7 Tesla ID.

The straight chosen for the 2nd ID presently contains the single DORIS type RF cavity and this must be relocated to give sufficient space for the ID. It is intended to move the RF cavity to the unoccupied straight where it would still be close to the power source and auxiliaries and it will only be necessary to rearrange and lengthen the waveguide.

The additional radiation loss in the 2nd ID may limit the beam current which can be maintained at 1.3 GeV, depending on its detailed design. There are several possible ways of overcoming such a limitation such as installing a higher power klystron, or adjusting the RF coupling factor. It would also be possible to install the 2nd RF cavity, which is held as a spare, in the same straight. A decision on these alternatives has not yet been made, pending a final design of the 2nd ID.

DOUBLE MINIBETA OPTIC

The design of a lattice optic producing double minibeta has been explored. Several options have been identified, but the most suitable version has a betatron tune quite close to the present working point and has low emittance. The lattice functions of this optic, based on the lattice model which has been developed for CAMD, is shown in fig 2.

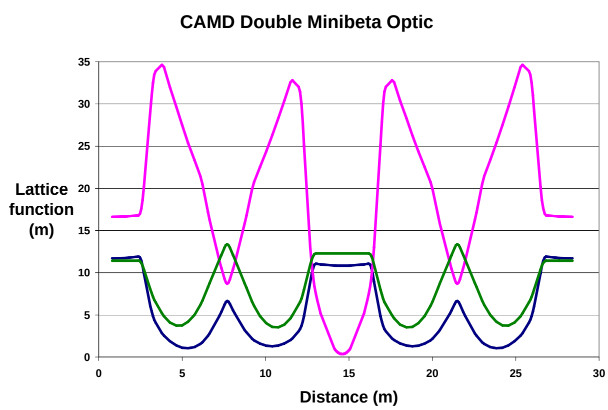

Figure 2: Double mini beta optic for CAMD. Half the circumference is shown. The vertical beta is shown red, the horizontal beta is blue and the dispersion x10 is green.

The double minibeta optic has tune values of Qh=3.23; Qv=1.30 which are very comparable with the normal tunes of Qh=3.24; Qv=1.15. The natural horizontal emittance is calculated as 110 nm.rad but that will increase to 170 nm.rad when the 7 Tesla ID is on. There will be a further emittance growth owing to the 2nd ID, estimated as about 10% depending on the field level. The peak value of the vertical beta function is seen to increase from the present value of 25 m to 35 m and that will result in a slight growth in the vertical beam size, which is not expected to be a problem.

This double minibeta optic has been tested experimentally during dedicated beam studies at CAMD. The quadrupole power supplies were reconnected so that the quadrupoles in diametrically opposed straights were in the same families. It proved to be simple to migrate from the symmetric zero dispersion optic at the end of the energy ramp to the new optic.

The values of the lattice functions in the double minibeta optic were measured experimentally by means of the active shunts which are connected across each individual quadrupole. [5] The horizontal and vertical average beta function at each quadrupole were calculated from the resulting tune shifts. The dispersion function also was measured by offsetting the RF and measuring the shift of the beam orbit. The beta function measurements are shown in fig 3 and the dispersion in fig 4.

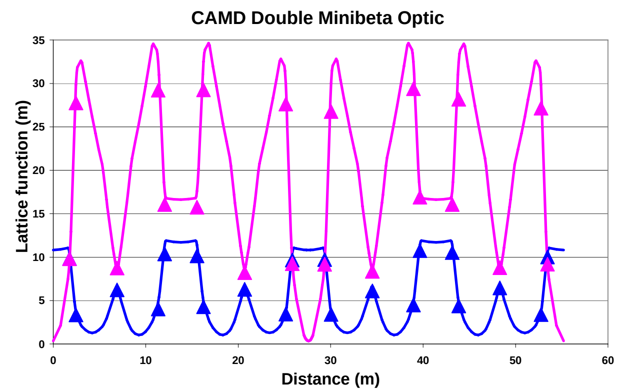

Figure 3: The calculated beta functions compared with the measured values averaged over each quadrupole. The vertical beta is shown red, the horizontal beta is blue.

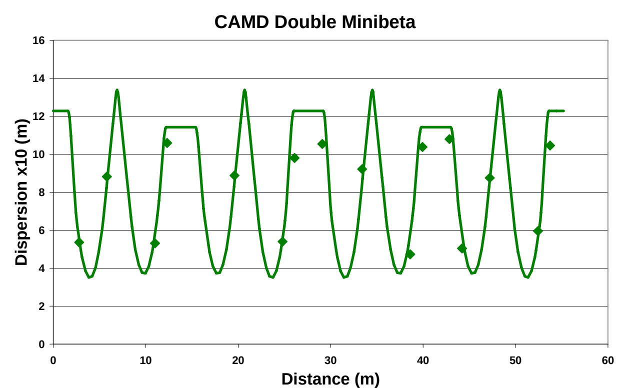

Figure 4: The calculated dispersion function x10 compared with the measured values.

It can be seen from figs 3 & 4 that the lattice functions as measured are in close agreement with the predictions of the lattice model using quadrupole gradients derived from the real magnet currents. These results give confidence that the lattice can be effectively modeled with good accuracy and optimized to give best performance when both IDs are in operation.

PROPOSED MULTIPOLE WIGGLER

An innovative superconducting multipole wiggler has been proposed for the 2nd CAMD ID by N Mesentsev of the Budker Institute, Novosibirsk, Russia. This device would allow the flux from the ID either to be concentrated into one straight ahead beam line or alternatively to be shared equally between 3 beamlines. This would be achieved by subdividing the multipole wiggler into 3 equal sections with bump correctors between each section and at both ends of the device. Each section would consist of 23 full poles with a half pole at each end. Without the bump correctors energized the entire flux from the ID would be delivered into the forward direction. By powering the bump correctors the 1st and 3rd sections would be deflected at ± 8 mr and could serve independent beamlines set at these angles. The magnetic field configuration is shown in fig 5.

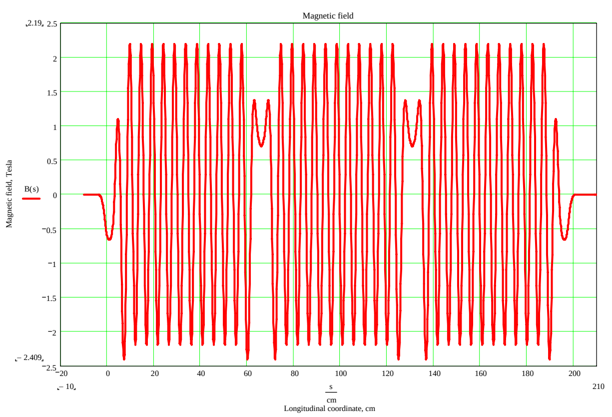

Figure 5: Magnetic field in the Multipole wiggler with the bump correctors energized.

The multipole wiggler has been optimized to generate flux in the 1 4 keV photon energy range. To do this it will have peak fields in the full poles of 2.2 Tesla and the length of a full period will be 42 mm. Each section will contain 11 full periods together with a half pole at each end. The overall length of the ID including its cryostat will enable it to be located in the 2.5 m free space of a CAMD long straight.

The spectral flux density which will be available from the 3 combined sections of this multipole wiggler is shown in fig 6. For comparison the flux density from a CAMD dipole and the 7 Tesla wavelength shifter are also shown. It is apparent that the multipole wiggler will be an excellent source of radiation in the range 1-5 keV with an increased flux density a factor 100 times greater than available from a CAMD dipole.

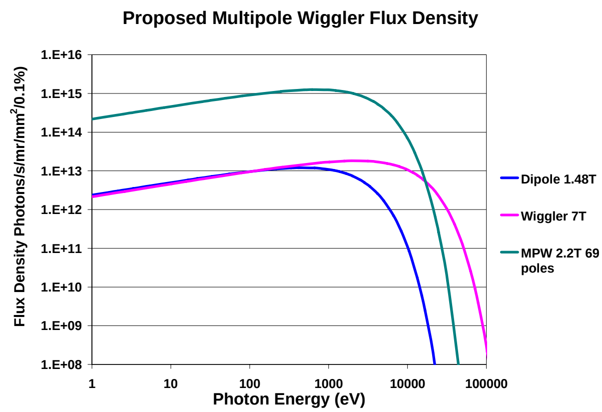

Figure 6: The flux density from the proposed multipole wiggler, the 7 Tesla wavelength shifter and the CAMD dipoles for a beam current of 250 mA.

At the present time the proposed multipole wiggler is not funded but a proposal is being drawn up which would include the ID, the machine modifications and the beamline with experimental station. This will be submitted to the funding authorities available to CAMD as part of a general proposal to increase the level of financial support.

ACKNOWLEDGMENT

The contribution by N Mesentsev of the BINP, Novsosibirsk, Russia in providing the design of the proposed multipole wiggler is gratefully acknowledged.

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