CAMD LOW BETA CONFIGURATION FOR THE 7 TESLA WIGGLER

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Abstract

The photon beam from 7 Tesla wavelength shifter wiggler is available since April, 2002 for Protein Crystallography beamline of CAMD storage ring, operating at 1.3GeV. To improve the property of the photon beam from the wiggler, a low beta function configuration in the wiggler straight section has been developed. Different electron beam optics configurations for wiggler operations are described. Response matrix analysis and tune derivatives tools were applied for low beta configuration studies.

7 TESLA WIGGLER COMMISSIONING

The CAMD storage ring magnetic lattice is a 4 period Chasman-Green type: the optical functions are shown in Figure 1. The electron beam is accumulated from a Linac at 180 MeV and then accelerated at 1.3 GeV, which is the normal operating energy, even tough the ring can reach 1.5 GeV. The 7 Tesla wiggler [1] was installed in a zero dispersion straight in September 1998. A magnetic field of 6.5 Tesla was achieved at that time, but at an operating energy of 1.5 GeV. The wiggler field was ramped from zero to the required level of 7 TESLA at top energy. The focusing effect of the wiggler was compensated with 2 families of q-pole (QF & QD) by keeping the betatron tunes constant. Later on, the currents of the 4 q-poles in the wiggler straight section (QFW & QDW) were shunted to measure the wiggler perturbation on the optics and to correct the betatron tunes. Due to the current limitation in the shunts, the optics perturbation was fully compensated up to 5 Tesla. The field level of 7 Tesla was empirically reached in winter 2002, by using the 4 families of q-poles to correct the tunes.

Table 1: Wiggler normalized gradients, in vertical and horizontal planes, at various magnetic field.

Magnetic field (Tesla)	**Wiggler focusing**	
	Ky (m-2)	**Kx (m-2)**
2	0.0071	0.0087
3	0.0104	0.0211
4	0.0316	0.0211
5	0.064	0.0146
6	0.110	-0.0035
7	0.169	-0.030

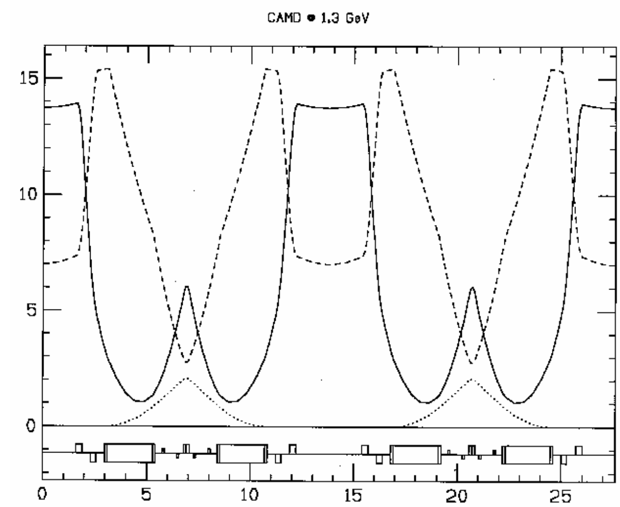

Figure 1 Standard optical functions for half ring. Solid and dashed lines are the horizontal and vertical beta functions respectively, while the points represent the dispersion function. All the scales are in meters.

This achievement allowed to evaluate the wiggler normalized gradients (Ky and Kx) by using tune response matrix analysis. Ky and Kx are listed in Table 1, while the perturbed optical functions are shown in Figure 2.

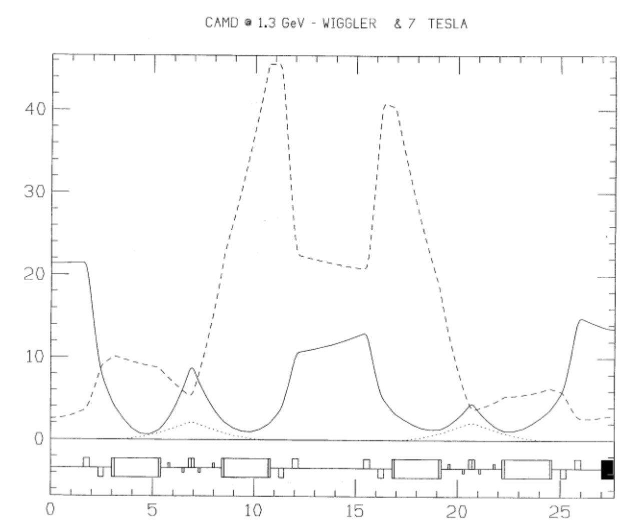

Figure 2 Optical functions for half ring with the focusing effect of the wiggler uncorrected. Black spot in the right is the wiggler location.

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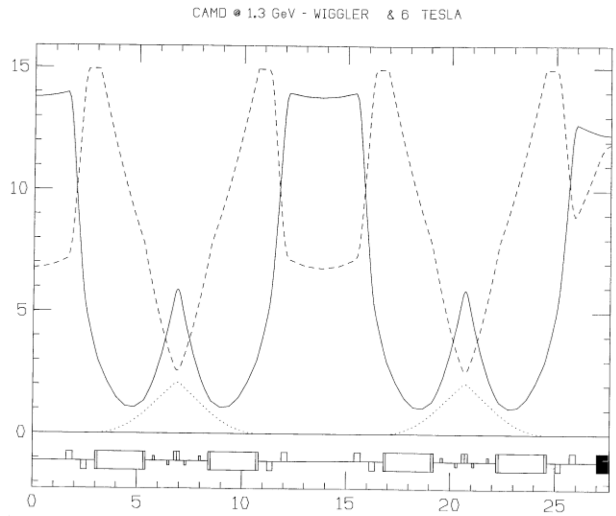

Figure 3 Shunted configuration. Vertical beta function increases in the wiggler straight

OPTICS MATCHING

There are 3 ways to compensate the optical functions perturbed by the wiggler, by keeping the same betatron tunes:

- The currents of QFW and QDW, in the wiggler straight section, are shunted (decreased) [2]: the vertical beta function increase in the wiggler straight section (see Figure 3);
- Low beta configuration in the wiggler straight section (see Figure 4). In this case it is necessary to substantially increase the currents of QFW & QDW.
- Low beta configuration in the wiggler straight section with non-zero dispersion in the straights (see Figure 5).

In order to satisfy the wiggler synchrotron light users request all these solutions were implemented and commissioned. We summarize in the following the main results of the commissioning.

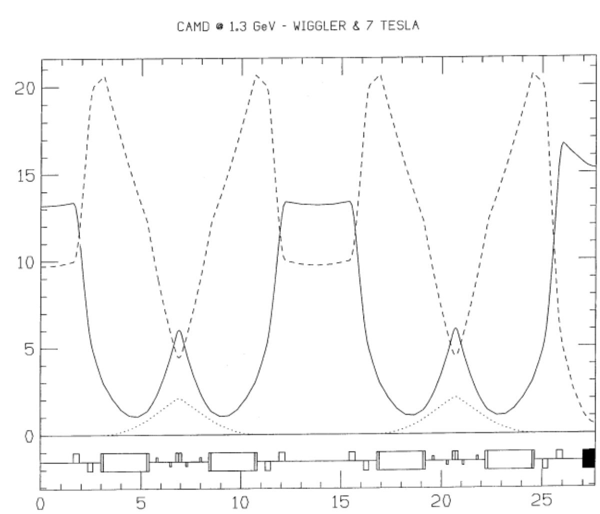

Figure 4. Low beta with zero η-function

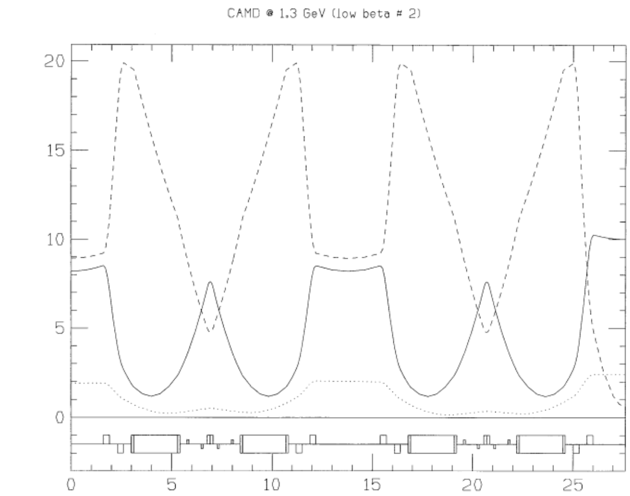

Figure 5. Low beta configuration with non zero η-function. No wiggler field in this plot

LOW BETA STUDIES

The wiggler commissioning was based on the adoption of an experimental model of CAMD storage ring, which reproduces pretty well the variation of the betatron tunes as function of the q-pole strengths, and on the use of the response matrix analysis technique [2] in the vertical plane. In CAMD the vertical trims are integrated in the defocusing (QD) and achromatic(QA) quadrupoles, while the BPM (20) are located near each quadrupole around the ring. Figure 6 and Figure 7 show the BPM signal versus trims kick for the 4-fold Chasman-Green standard lattice as given by the model and as measured. Let us point out that what is important, when one compares Figure 6 and Figure 7 is the relative shape of the BPM signal and not the absolute value.

The BPM are organized in families with the same amplitude as predicted by the model. To make the wiggler commissioning easier we measured also the tune response matrix and built the "beta-knob". This means varying four variables (the strength of QF, QD, QFW, QDW) and keeping the vertical and horizontal betatron

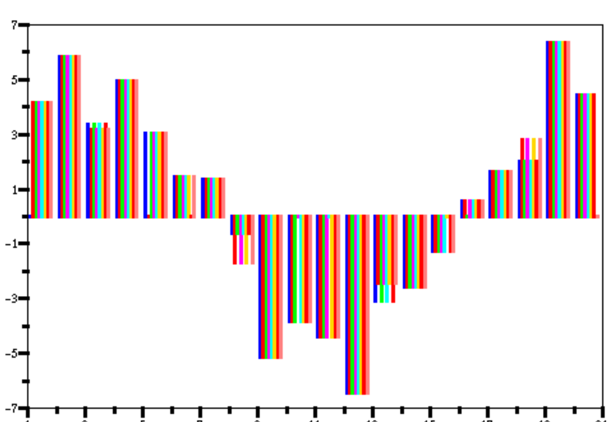

Figure 6 Theoretical response matrix for the standard lattice. 20 PUE reading organized in coloured 8 trims families

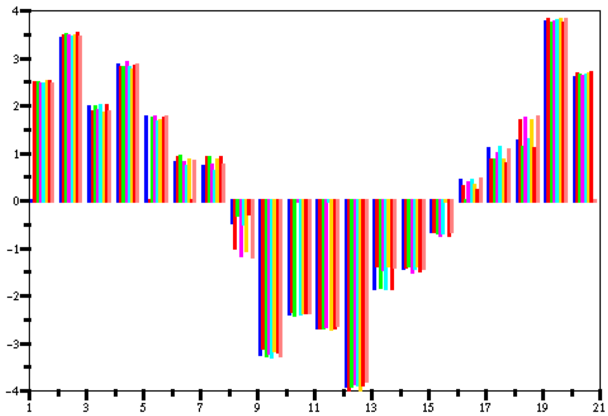

Figure 7 Measured response matrix for the standard lattice

tunes constant. Under the condition of constant tunes we have 2 free variables that we use to find the best match between theoretical and experimental response matrix.

Low beta with zero dispersion function.

This configuration was commissioned up to 7 Tesla, with good shape of beta functions. The beam lifetime was 20 hrs at 6 Tesla and dropped to 6 hrs at 7 Tesla.

Due to the poor beam lifetime at 7 Tesla we decided to investigate the next solution with non zero dispersion.

Low beta with non zero dispersion function.

The configuration with dispersion in "dispersion free" straight sections was implemented (Figure 5). In this configuration the beam equilibrium emittance is a factor 2 lower than the emittance in the standard configuration, therefore the beam emittance grow due to the wiggler is compensated by this emittance reduction.

Figure 8 show the theoretical response matrix while in Figure 9 and Figure 10 the measured response matrix are plotted.

This configuration, with the wiggler field at 7 Tesla, is routinely in operation with a beam lifetime of 30 hrs at 70 mA of stored current.

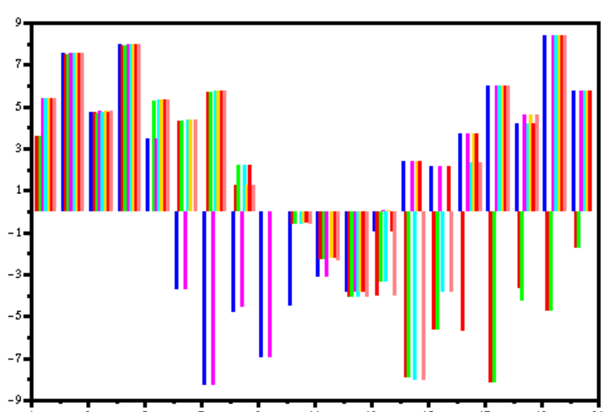

Figure 8. Theoretical response matrix of non zero dispersion function low beta configuration.

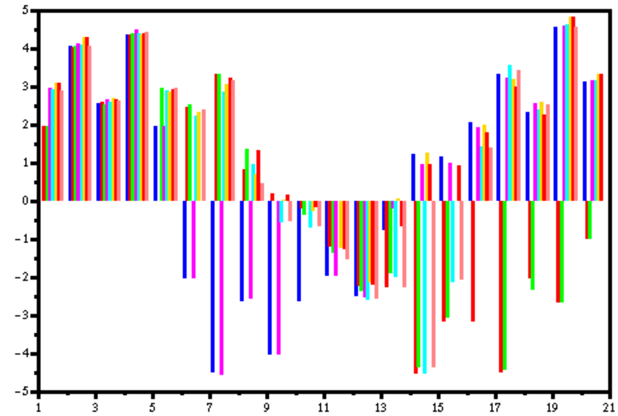

Figure 9. Measured response matrix of non zero dispersion function low beta configuration without wiggler.

This configuration still need a refinement of the wiggler model which takes in account the dispersive part and a measurement of the beam emittance.

CONCLUSION

A low-beta optics configuration has been designed and implemented at CAMD to routinely operate a 7 Tesla wiggler at 1.3 GeV.

The commissioning has been carried out by the technique of vertical response matrix analysis together with tunes measurement ("beta-knob")

REFERENCES

[1] Borovikov V.M. and all “Superconducting 7 Tesla Wiggler for LSU CAMD”, Journal of Synchrotron Radiation, Vol.5, Part3, pp440-442(1998)

[2] B.Craft “A novel SC Wiggler for PX” http://ssils.ssrc.ac.cn/symposium/Insertion_Devices.html (2001)

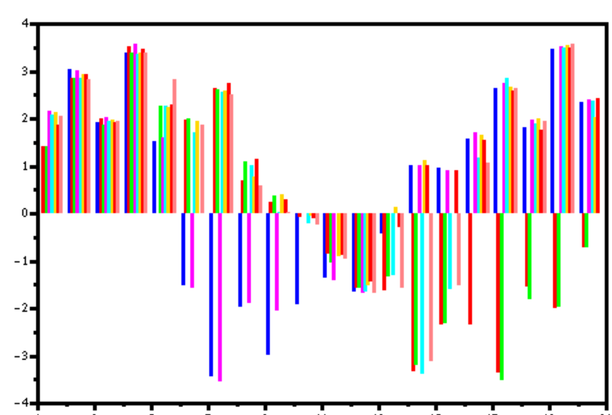

Figure 10 Measured response matrix of non zero dispersion function low beta configuration with the wiggler at 7 Tesla.