

PREDICTED EFFECT OF THE MEASURED HIGH ORDER MAGNETIC MULTIPOLE IN THE ALBA STORAGE RING

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Abstract

The effect of the measured multipole component of the magnets of the ALBA storage ring has been evaluated. The effect predicted in the performance of the light source is expected to be negligible. However, to compensate any possible influence, together with the predicted influence of the insertion devices, a new working point and setting of the sextupole families has been selected.

INTRODUCTION

ALBA is third generation synchrotron light source under construction close to Barcelona, Spain. The commissioning of the storage ring is planned for the third quarter of 2010, and installation of most of the components of the storage ring is finished, with the commissioning of the Booster synchrotron has already started.

Studies performed about the impact of the measured magnetic high order multipoles of the magnets of the ALBA lattice, as well as the ones concerning the effect of the insertion devices [1, 2, 3], have shown that the selected working point of ALBA was not optimal, due to the effect of a coupling resonance. In this paper, the effect of the multipoles in the old and the new working point is reviewed, as well as the procedure to select the new working point and sextupole settings. A more detailed study can be obtained from the authors [4].

MULTIPOLE COMPONENT OF THE MAGNETS

The magnets of the storage ring can be divided in two groups:

- Straight magnets: Sextupole and quadrupole magnets, manufactured by the Brudker Institute of Nuclear Physics.
- Curved magnets: The bending magnet, manufactured by Danphysick.

Extensive measures have been made of all the magnets installed in the storage ring. In the case of the the straight magnets, the multipole components of each one of the sextupoles and quadrupoles have been measured at BINP, with extra additional measurements performed at Soleil and Brookhaven. Results vary slightly between the families of of different length (quadrupoles of 200 mm, 260 mm and 500 mm; sextupoles of 120 mm and 220 mm). Figure 1 shows the normal multipole component of quadrupoles and

sextupoles for the measurements performed at BINP. The values measured at Soleil shows a reduction of these values by a factor 2. In the case of the curved magnets, only the dipolar, quadrupolar and sextupolar component along the ideal trajectory were consider (figure 2). In order to incorporate the effect of the longitudinal variation in the simulations, a sliced model of the bending magnet has been implement in the AT model.

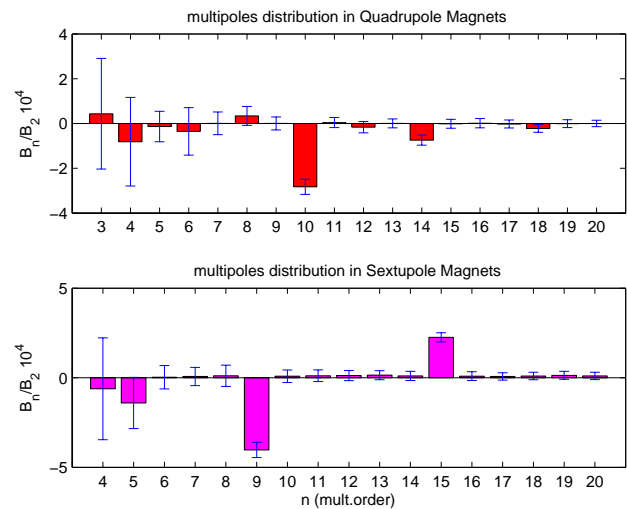


Figure 1: Normal multipole components for quadrupole and sextupole magnets.

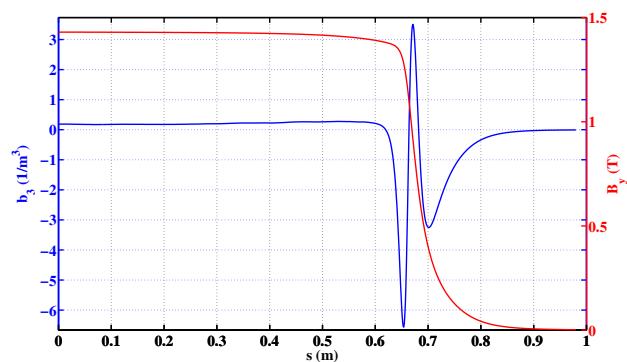


Figure 2: Dipolar (red) and sextupolar (blue) component along the reference trajectory for one half of the reference dipole.

Effect on the Lattice

20 different cases of multipole errors were studied, described by the statistic show in figure 1. Figure 3 shows the dynamic aperture for the ideal lattice case, the inclusion of

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multipoles case, and for the case of scaling the multipoles a factor ten, at different energy deviations. Figure 4 shows the effect on the multipoles in the on momentum frequency map, for the real distribution of multipoles (the multipoles assigned to each magnet in the model of the machine correspond to the ones of the equivalent magnet installed in the storage ring) in the lattice. The effect in the dynamic aperture (and energy acceptance) for the nominal case of the multipoles is minimal, and even with an increase of a factor 10 in the value of the multipole components (as shown in Table 1). When including the effect of the physical limitation, the effect of the multipoles is even smaller. However in the frequency map, the excitation of a coupling resonance can be appreciated. This resonance can have drastic effects when other effects are considered (larger orbit errors, effect of the insertion devices). Moving the working point farther away from it, and changing the shape of the tune shifts with the amplitudes (using a different excitation in the sextupoles) could reduce possible negative effects of the resonance.

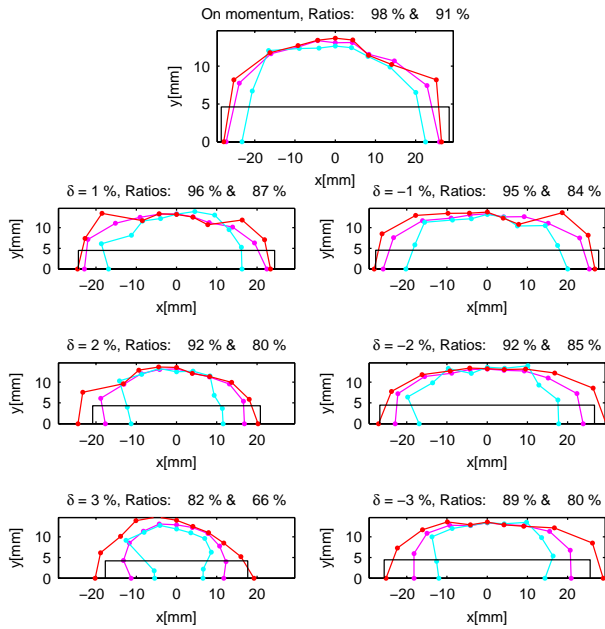


Figure 3: Dynamic aperture, excluding physical limitations, at different energy deviation, for the original working point, including multipoles. The red line is the DA for the best case, the cyan one for the minimum DA case, and the magenta the average of the 20 cases.

NEW WORKING POINT

In order to avoid the possible reduction of the dynamic aperture due to the coupling, a new working point and sextupole scheme has been selected.

Method of Optimization

The method of optimization is comprised of two steps:

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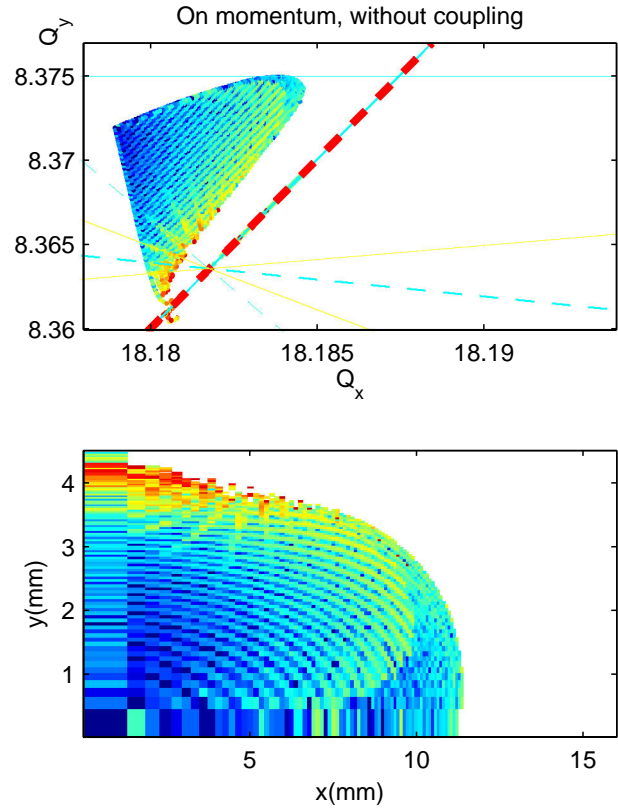


Figure 4: On momentum frequency map for the original working point, including the effect of the multipoles, for the realistic case, including physical apertures. The limiting resonance is the skew systematic $2Q_x + Q_y = 28$.

Table 1: Reduction in the Dynamic Aperture area (in percentage) for different momentum deviations and for different scaling of the multipoles, in the case of including all the high order multipoles or only the main allowed components.

Factor	-3.00%		0%		-3.00%	
	All	Main	All	Main	All	Main
x 0.5	76	83	94	99	92	94
x 1	69	73	88	93	88	91
x 3	54	55	74	75	76	79
x 5	45	45	62	63	62	65
x 10	32	32	43	43	39	41

1. Finding several new set of sextupoles settings in the original working point.
2. Explore the dynamic aperture for different working point in the tune region in the neighborhood of the original working point for this new set of sextupoles.

The original working point (18.179, 8.372) and setting of the sextupoles for ALBA was selected to provide a small emittance with good dynamic aperture, by trying to minimize the absolute value of the tune shift with the amplitudes, and the second order contributions to the chromatic-

ity. However, the direction of the tune shift with amplitudes were not taken in account. In this new optimization, 9 new set of sextupoles have been calculated. Each one of this sets is based in the original one, keep the chromaticities to the nominal (+1,+1), but each trying to steer the tune shift footprint in different regions of the working diagram, while keeping the absolute value of the tune shift as small as possible, avoiding foldings of the frequency map, and trying to keep the tunes shift as linear as possible.

Once the new settings of the sextupoles are found, the tune region around the original working point, is scan in order to find the working point with the largest dynamic aperture and energy acceptance. The new working point selected is (18.149, 8.378). The changes in the quadrupoles strength are small, of only a few percent of the value and the optics is preserved. The largest change in the sextupoles is of the order of 10%, well inside of the range allowed by the magnet and the power supplies.

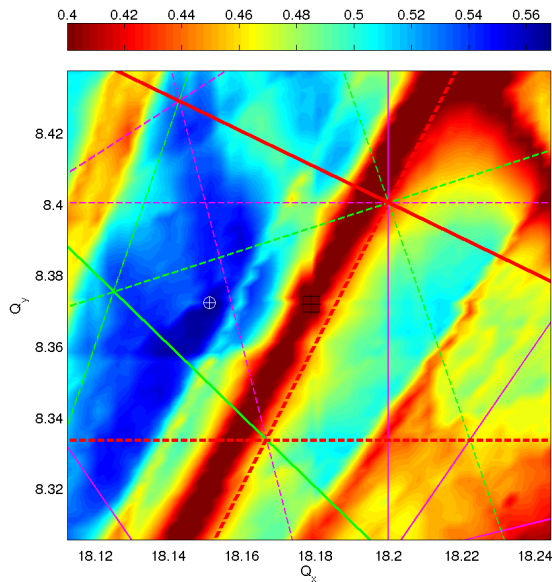


Figure 5: Dynamic aperture scan for the sextupole configuration selected. The original working point (18.179, 8.372) is marked by crossed black square. The new working point (18.149, 8.378) is marked by the crossed white circle. The color represents the product of the area of the dynamic aperture for the on-energy case, and the $\pm 3\% \delta_p$ cases ($\Delta = DA(0) \times DA(3\%) \times DA(-3\%)$).

Effect of the Multipoles

In this new working point, the effect of the multipoles have been studied, both for the statistical case of 20 machines, and for the realistic case. Figure 6 shows the new dynamic aperture and frequency map for this case, including orbit errors and correction, and physical limitations.

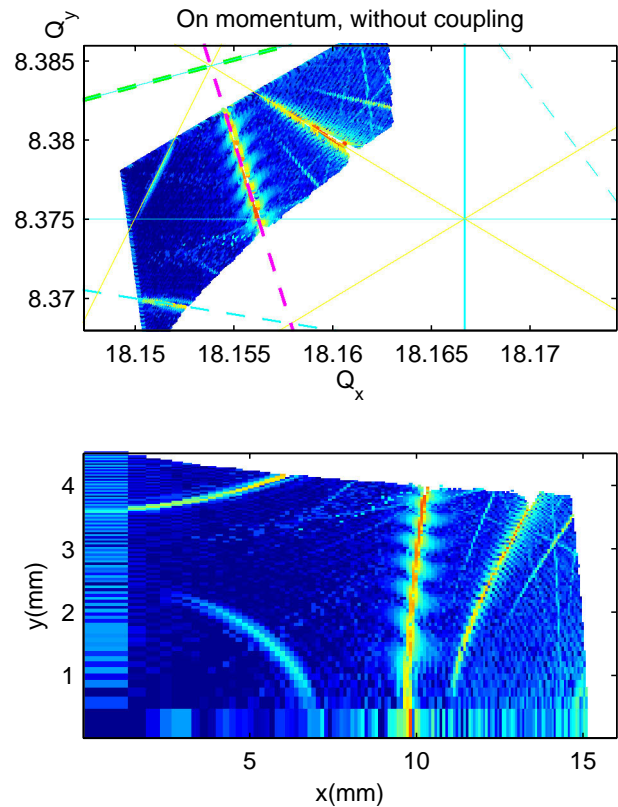


Figure 6: On momentum frequency map, including the effect of the multipoles, for the realistic case, for the new working point and sextupoles.

CONCLUSIONS

The lattice selected for ALBA is very robust respect realistic multipole errors. The expected effect of the manufactured magnets (in particular the sextupole and quadrupoles) high order multipoles is minimal, and their tolerances could be reduced by almost a factor 10 before degrading (in absence of other effects) the performance of the machine. Additionally, the new selected working point and sextupole arrangement improves the resistance to the effect of multipoles and others.

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