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Proposal of a correction scheme for KURRI 150 MeV FFAG

1 Concept

Previously [1], it was shown that scaling imperfections introduce an orbit distortion that increases the rms tune variations in both planes. However, the tune variations are strongly related to whether $k_F > k_D$ or the opposite. Essentially two regimes are distinguished:
•If $k_D < k_F$ then $\alpha_F(E)$ is strictly decreasing while $\alpha_D(E)$ is strictly increasing. Besides, the tune as a function of the radius is a decreasing function in both planes.
•If $k_D > k_F$ then $\alpha_F(E)$ is strictly increasing while $\alpha_D(E)$ is strictly decreasing. Besides, the tune as a function of the radius is an increasing function in both planes.
Thus, both magnets act in opposition *vis-à-vis* scaling imperfections.

Therefore, in the present note, a correction scheme is proposed: the idea is simply to introduce a perturbation of the field, every two sectors in order to counteract the already existing imperfections: thus the 12-fold symmetry of the FFAG is replaced by a 6-fold symmetry in the following way: let's note D_i (resp F_i) the Defocusing (resp Focusing) magnet with scaling factor k_{Di} (resp k_{Fi}). The idea of the correction system is to replace the original design $D_0F_0D_0$-$D_0F_0D_0$ by $D_0F_0D_0$-$D_1F_0D_1$ where k_{D1} is chosen in the following way:
If $k_{D0} > k_{F0}$ then $k_{D1} < k_{F0}$ and vice-versa (see Fig.(1)).
In this case, the phase advance of the combined two sectors (superperiod) will combine the two antagonistic effects of the scaling imperfections. The correction can be achieved by implementing trim coils along the radius of the D-magnet, the F-magnet or both, every two sectors.

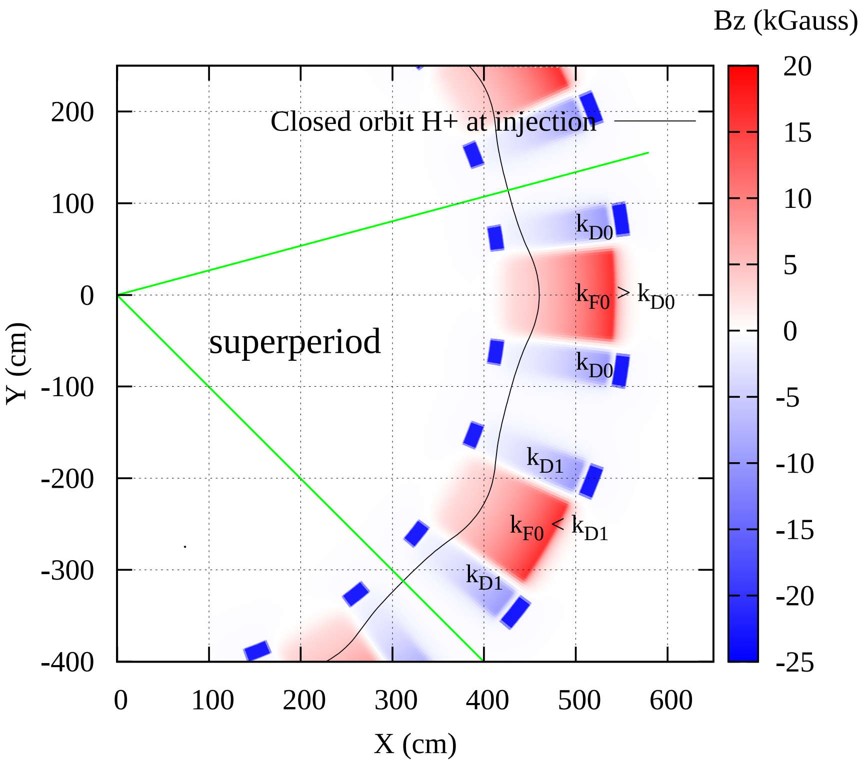

Figure 1: Correction scheme

2 Tracking results

In order to show the validity of the previous correction scheme, tracking in ZGOUBI was performed using built-in fieldmaps of DFD triplets where the average field indices of the F and D magnets, k_F and k_D, can be adjusted as illustrated in Fig.2. The results for two different test cases are shown in the figures below. As summarized in Table 1, implementing the correction scheme does reduce the tune variations in both cases.

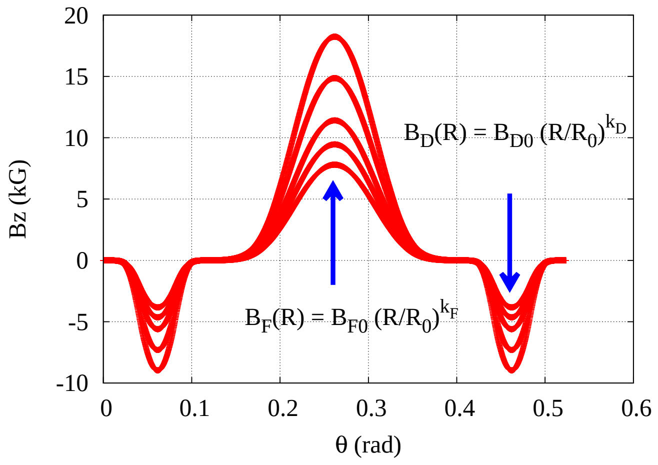

Figure 2: Magnetic field along several closed orbits.

	$\Delta\nu_x/\nu_x(\%)$		$\Delta\nu_y/\nu_y(\%)$	
	No correction	With correction	No correction	With correction
case 1	0.88	0.02	2.78	0.71
case 2	1.87	0.18	4.75	2.82

Table 1: Comparison of the tune variations per cell before and after the correction scheme is implemented.

Case1: Before correction, we choose $(k_{F0}, k_{D0}) = (7.6, 7.5)$. After correction, we choose $k_{D1} = 7.7$. The results are summarized in Figs. (3) and (4) below.

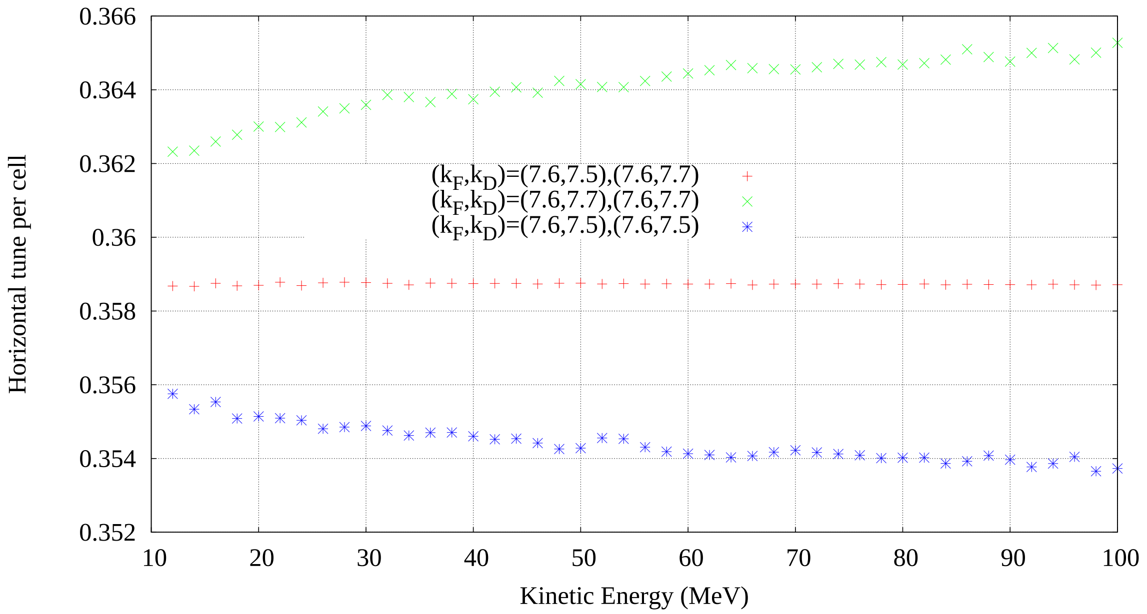

Figure 3: Case 1: Tune variations as a function of the energy before and after correction: the corrected scheme is shown in red where $(k_{F0}, k_{D0}) = (7.6, 7.5)$ and $(k_{F1}, k_{D1}) = (7.6, 7.7)$.

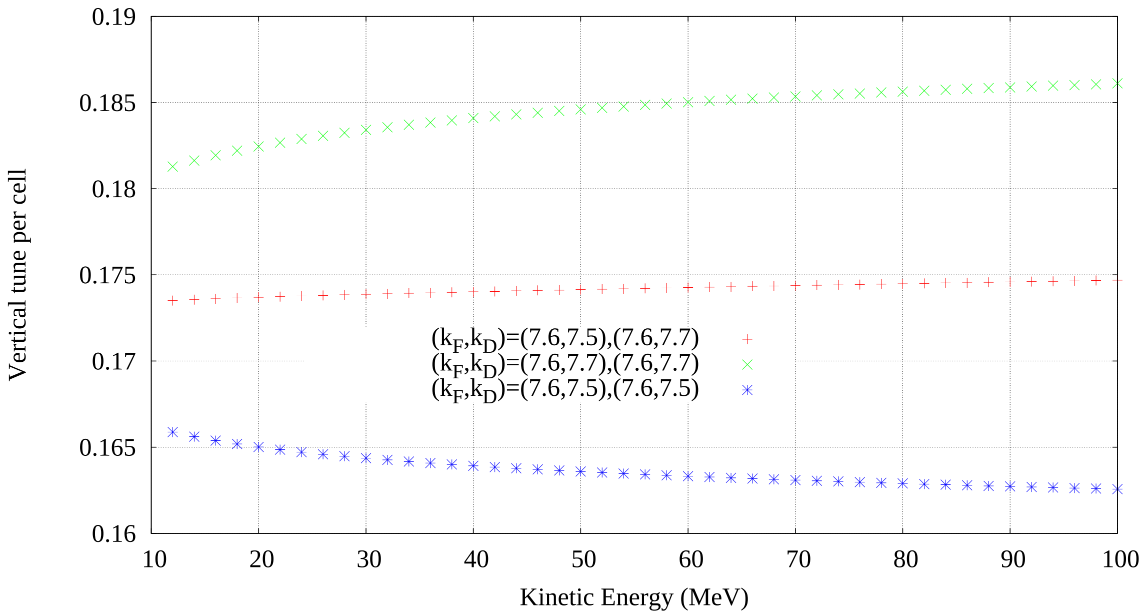

Figure 4: Case 1: Tune variations as a function of the energy before and after correction: the corrected scheme is shown in red where $(k_{F0}, k_{D0}) = (7.6, 7.5)$ and $(k_{F1}, k_{D1}) = (7.6, 7.7)$.

<u>Case2:</u> Before correction, we choose $(k_{F0}, k_{D0}) = (7.6, 7.8)$. After correction, we choose $k_{D1} = 7.5$. The results are summarized in Figs. (5) and (6) below.

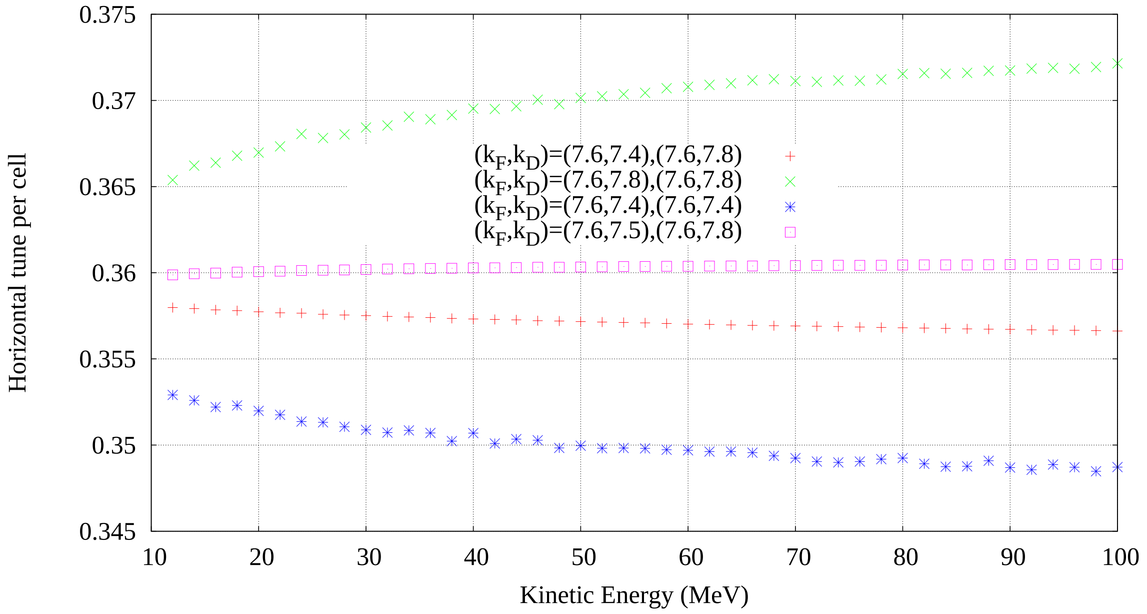

Figure 5: Case 2: Tune variations as a function of the energy before and after correction: the corrected scheme is shown in pink where $(k_{F0}, k_{D0}) = (7.6, 7.8)$ and $(k_{F1}, k_{D1}) = (7.6, 7.5)$.

References

[1] http://hadron.kek.jp/FFAG/colabo/meetings/kurri_paper_updated.pdf

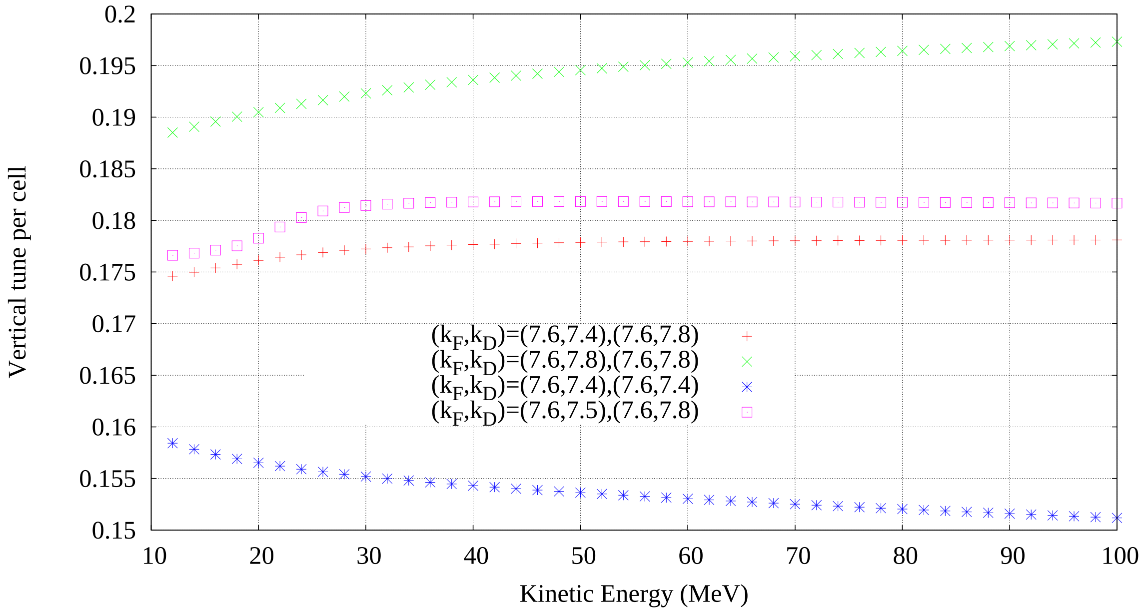

Figure 6: Case 2: Tune variations as a function of the energy before and after correction: the corrected scheme is shown in pink where $(k_{F0}, k_{D0}) = (7.6, 7.8)$ and $(k_{F1}, k_{D1}) = (7.6, 7.5)$.