Introduction to FODO4 lattice design of ILC DR

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FODO4a and FODO4b

FODO4 is a complete lattice design of ILC Damping Ring, which is composed of injection and extraction sections (including chicane), two equal RF (Wiggler) sections, and four arc sections, which was reported on ILC Fermi GDE Meeting held in October, 2007. Its MAD files have been posted on the following website:

https://wiki.lepp.cornell.edu/ilc/bin/view/Public/DampingRings/LatEvalPage

Now we are going to call that design as **FODO4a**, which main drawback is that the strength of two dipole magnets in the dispersion suppressor sections has to be adjusted slightly when the momentum compaction factor tuned between 2×10^{-4} and 6×10^{-4}. In that case the ring geometry will be changed when tuning the momentum compaction.

In order to fix this problem, the dispersion suppressor and other matching sections are re-designed. The dispersion suppressor of the previous 90 degree case is selected to be the baseline for **FODO4b** lattice. For other cases between 60 degree and 90 degree, the quads' strength in dispersion suppressor and other matching sections is matched to get dispersion free at the exit of dispersion suppressor (entrance of straight).

Now the new design is called as **FODO4b**, which hardware configuration is the same as **FODO4a**, but three additional power supplies were used for the quads in dispersion suppressor sections. For **FODO4b**, the momentum compaction can be freely tuned between 2×10^{-4} and 6×10^{-4}, by only changing the strength of quadrupoles, not changing strength of any dipole. We started **FODO4b** design just 7 days ago, so the optimization is still not finished. But certainly the dipole adjustment is no longer needed.

90 degree case of **FODO4a** is selected as the baseline for the new **FODO4b**. As the 90 degree case has already been optimized in detail before (by using FMA, harmonic sextupoles, and other techniques), its dynamic aperture and other beam dynamic issues are already in very good state. The dynamic aperture for other cases between 60-90 degree cases should also be OK.

Configuration of FODO4b

Quasi four-folder symmetry.
Four arc sections, each composed of 46 arc cells (each 29.4 m), and two dispersion suppressors (each 58.8 m).
Two straight sections for injection/extraction, each includes one septum and 21 stripline kicker. Also Chicane is added in these two sections.
The other two straight sections are used to accommodate RF cavities and wigglers, also the two shafts are placed here.

In all, there are 368 dipoles (each 2 m), **448** quadrupoles (most of them 0.2m or 0.3 m), **368** chromatic sextupoles (each 0.25 m), and 16 harmonic sextupoles (each 0.25 m).

Main parameters of FODO4b

The main parameters of three critical modes are listed below

Parameter	$\alpha_p=2\times10^{-4}$	$\alpha_p=4\times10^{-4}$	$\alpha_p=6\times10^{-4}$
Circumference [m]	6476.439	6476.439	6476.439
Harmonic number	14042	14042	14042
Energy [GeV]	5	5	5
Arc cell	FODO	FODO	FODO
Tune	58.29 / 57.25	46.28 / 47.24	40.29 / 41.25
Natural chromaticity	-74 / -73	-54 / -55	-48 / -49
Momentum compaction [10^{-4}]	2	4	6
Transverse damping time [ms]	25 / 25	25 / 25	25 / 25
Norm. Natural emittance [mm-mrad]	3.36	4.2	5.4
RF voltage [MV]	15	22	31
Synchrotron tune	0.038	0.061	0.091
Synchrotron phase [o]	145	157	164
RF frequency [MHz]	650	650	650
RF acceptance [%]	1.21	1.48	1.65
Natural bunch length [mm]	9	9	9
Natural energy spread [10^{-3}]	1.28	1.28	1.28
Max beta function [m] (FODO4a)	**100**	**100**	**100**
Max beta function [m] (FODO4b)	**100**	**106**	**147**
DA (Sigma_inj_e+) (FODO4a)	**5**	**9**	**11**
DA (Sigma_inj_e+) (FODO4b)	**5**	**8**	**10.5**

Conclusions

In summary, the advantages of FODO4b damping ring lattice over the baseline design OCS8 which is based on TME arc cells are:

1 Smaller number quadrupoles and sextupoles used (roughly two thirds), and lower cost.
2 Freely tunable momentum compaction factor in the range between 2×10^{-4} and 6×10^{-4}.
3 Good dynamic aperture.
4 Simpler layout, with only two wiggler sections and cryogenics shaft, no long Transport Line for cryogenics needed.

The work in next step and estimated time table may be:

Optimize the matching sections further, to have smaller beta functions (before 2008.03). Optimize the dynamic aperture further (before 2008.03).