

ATF2 Ultra-low beta studies

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CLIC WORKSHOP

Accelerator / Parameters & Design Activities session

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- 2 Multipole components of ATF2 magnets
- 3 Replacement of QF1FF
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ATF2 is meant to demonstrate the feasibility of the FFS based on the local chromaticity correction scheme

To this end, 2 lattices have been designed:

- **ATF2 Nominal lattice:** it is the scale-down version of the ILC FFS
- **ATF2 Ultra-low β^* lattice:** it is an even pushed β -optics lattice in order to reach a chromaticity comparable to that one of CLIC

Ideal Lattice	β_x^*	$\sigma_x^*(\text{rms})$	β_y^*	$\sigma_y^*(\text{rms})$	ξ_y
	[mm]	[μm]	[μm]	[nm]	[]
Nominal	4	3.2	100	37	≈ 10000
Ultra-low β^*	4	3.2	25	22	≈ 40000

As a result of intense work in 2012, ATF2 is getting closer to its first goal (**37 nm**) *

Experiencing with a higher chromaticity lattice would be very useful for both ILC & CLIC projects

* **ATF2 recent results**, presented by Dr. Glen White on Thursday during the Collaborations on Low Emittance Session

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MULTIPOLE COMPONENTS OF ATF2 MAGNETS

Multipole components

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Motivation

Multipole components of ATF2 magnets

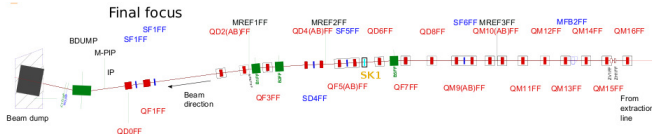
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The FFS of ATF2 is composed of 3 bending, 22 quadrupoles, 5 normal and 4 skew sextupoles magnets
Up to the 18th-pole component of the FFS magnets are included into the model



Lattice	β_y^* [μm]	σ_y^* [nm] (Mults OFF)	σ_y^* [nm] (Mults ON)
Nominal	100	37	67
Ultra-low β^*	25	22	80 [†]

- the 6-pole and 12-pole components of QF1FF are the most important contributors to the evaluated $\Delta\sigma_y^*$ for the ATF2-NL
- in addition, the 6-pole component of QD0FF notably increases σ_y^* for the ATF2-UL

[†]R. Tomás, H. Braun, J.P. Delahaye, E. Marín, D. Schulte, F. Zimmermann, "ATF2 Ultra-Low IP Betas Proposal", Proceedings of PAC09, Vancouver, May 2009, pp. 2540-2542

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REPLACEMENT OF QF1FF

Replacement of QF1FF

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In September 2012 it was proposed to replace the QF1FF magnet by a re-cycled PEPII quadrupole

	Unit	PEPII	QF1FF
Bore radius	[mm]	50	25
Iron length	[mm]	430	450
Total width	[mm]	646	450
Total height	[mm]	617	450
Weight	[Kg]	1181	400

Field quality of both quadrupole magnets (*tolerance*: $\Delta\sigma_y^* \leq 2\%$).

@ R=2 cm	Normal relative multipole component [10^{-5}]			
	Sextupolar	Octupolar	Decapolar	Dodecapolar
Tolerance	30	12	11	3.1
QF1FF	54	23	100	560
PEPII	-2.3	0.76	-0.12	-1.2

@ R=2 cm	Skew relative multipole component [10^{-5}]			
	Sextupolar	Octupolar	Decapolar	Dodecapolar
Tolerance	0.8	2.1	0.6	1.9
QF1FF	2.8	0.9	7.6	6.1
PEPII	0.3	0.9	0.3	-0.1

The PEP-II magnet was installed in November 2012



Obtained σ^* when replacing QF1FF by the LER quadrupole and optimizing the sextupoles:

ATF2 Nominal lattice

$$\sigma_x^* = 3.2 \mu\text{m}$$

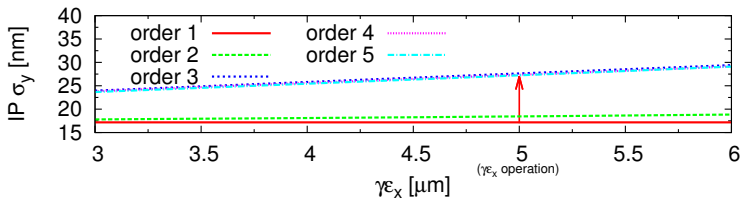
$$\sigma_y^* = 37 \text{ nm}$$

ATF2 Ultra-low lattice

$$\sigma_x^* = 3.2 \mu\text{m}$$

$$\sigma_y^* = 31 \text{ nm}$$

To further reduce σ_y^* of the ATF2 Ultra-low β^* lattice it would be required to replace QD0FF. Assuming the same multipole components of the PEP-II magnet for QD0FF:



ATF2 Ultra-low lattice with PEP-II FD:

$$\sigma_x^* = 3.2 \mu\text{m}$$

$$\sigma_y^* = 27 \text{ nm}$$

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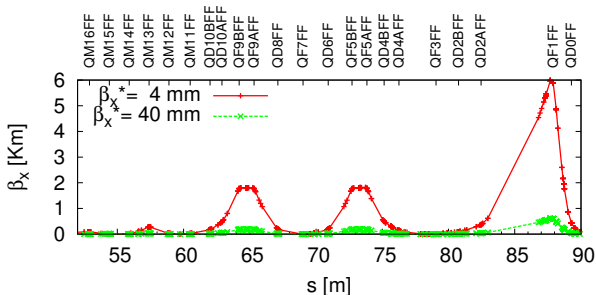
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MODIFYING THE OPTICS

Alternatively the impact of the multipole components can be reduced by increasing the β_x^*



The obtained σ_y^* when increasing β_x^* a factor 10, are:

ATF2 10Bx1.0By lattice[‡]
 $\sigma_y^* = 36 \text{ nm}$

ATF2 10Bx0.25By lattice
 $\sigma_y^* = 23 \text{ nm}$

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TUNING OF ATF2 LATTICES

- Tuning is the process of bringing the machine to its design performance under realistic error conditions
- The strategy for tuning the ATF2 lattices is based on a set of 10 linear \perp -knobs meant correct for the most important IP beam size aberrations (**waist shift, dispersion, coupling**)
- 100 simulated different machines with errors randomly assigned according to a Gaussian distribution of width σ_{error} are simulated

Error	σ_{error}
Transverse misalignments	$30 \mu\text{m}$
Transverse rotations	$300 \mu\text{rad}$
Magnet miss-powerings	10^{-4}

- The knobs are combinations of sextupole transverse displacements
- The tuning algorithm iteratively scans the knobs to bring σ^* to its design value

Tuning Knobs

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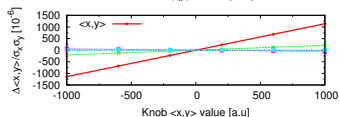
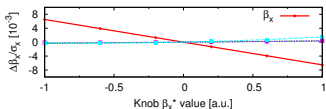
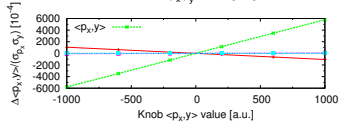
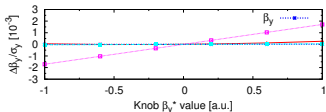
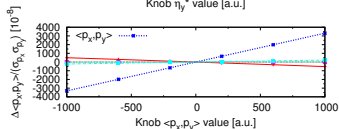
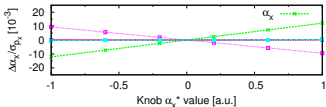
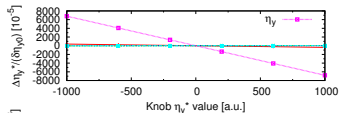
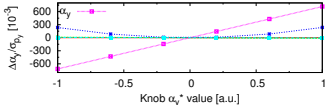
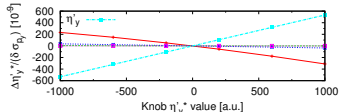
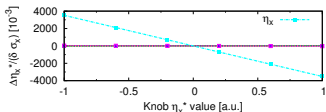
Replacement of QF1FF

Modifying the optics

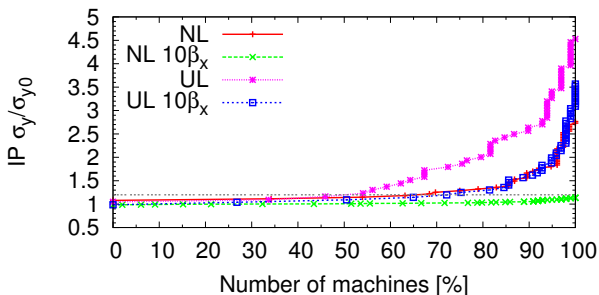
Tuning

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The designed knobs are: $\langle x, y \rangle$, $\langle p_x, y \rangle$, $\langle p_x, p_y \rangle$, η_y , η_{py} , α_x , α_y and η_x



Confidence level for ATF2 lattices and the corresponding $10\beta_x$ lattices:



ATF2 Lattice	# machines with $\sigma_y^*/\sigma_{y0}^* < 1.2$
Nominal	66
10Bx1.0By	100
Ultra-low	52
10Bx0.25By	73

Significant improvement of the tuning performance for the relaxed β_x optics for both lattices

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CONCLUSIONS

- Replacing the QF1FF magnet represented a step forward for the ATF2 lattices
- For the ATF2 Ultra-low β^* lattice we need to replace QD0FF to reach $\sigma_y^*=27\text{nm}$
- Increasing $10 \cdot \beta_x^*$ leads to a satisfactory design of both ATF2 lattices
- Satisfactory tuning results are obtained for the Nominal and $10 \cdot \beta_x^*$ optics
- but not for the ATF2 Ultra-low β^* lattice

Follow up:

- Improve the tuning performance of the ATF2 Ultra-low β^* lattice by designing non-linear tuning knobs based on the available skew sextupole magnets