Monochromatization Interaction Region Optics Design for Direct *s*-channel Production at FCC-ee

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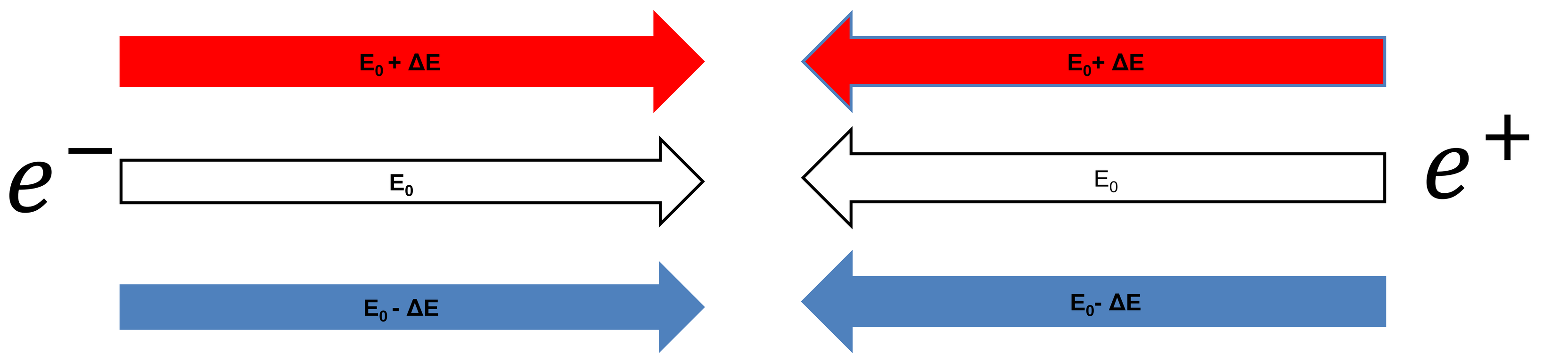
Abstract

One of the most fundamental measurements since the Higgs boson discovery, is the measurement of its Yukawa couplings. Such a measurement is only feasible, if the centre-of mass (CM) energy spread of the e^+e^- collisions can be reduced from ~50 MeV to a level comparable to the natural width of the Higgs boson of ~4 MeV. To reach such desired collision energy spread and improve the CM energy resolution in colliding-beam experiments, the concept of a monochromatic colliding mode has been proposed as a new mode of operation in FCC-ee. This monochromatization mode could be achieved by generating a nonzero dispersion function of opposite signs for the two beams, at the Interaction Point (IP). Several methods to implement a monochromatization colliding scheme are possible, in this paper we report the implementation of such a scheme by means of dipoles. More in detail a new Interaction Region (IR) optics design for FCC-ee at 125 Gev (direct Higgs *s*-channel production) has been designed and the first beam dynamics simulations are in progress.

Monochromatization Concept

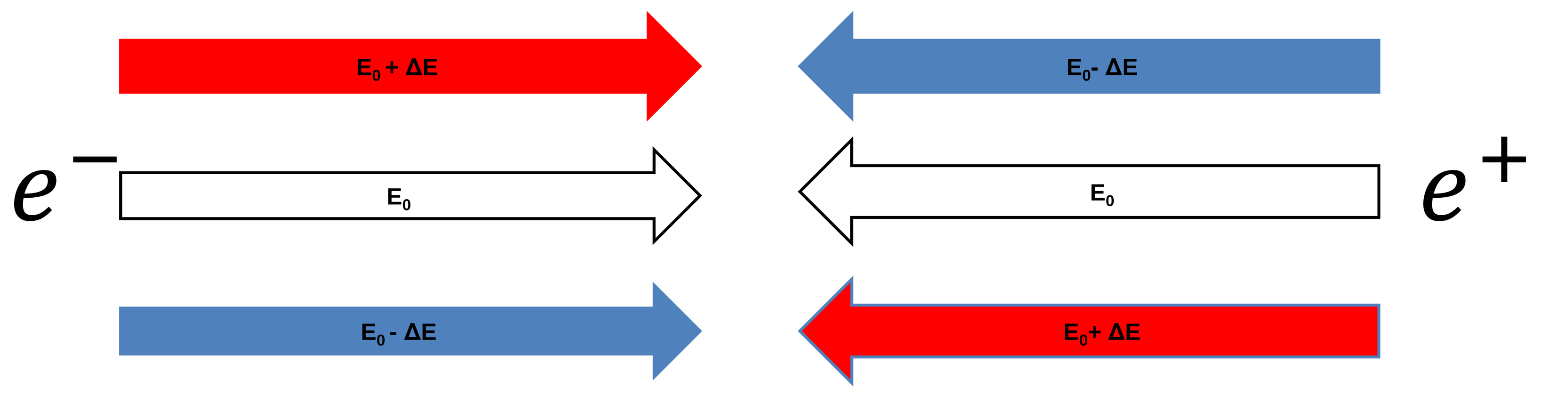
Standard mode



CM energy $w = 2(E_0 + \Delta E)$

Introducing a dispersion function of opposite signs for colliding beams at the interaction point (IP), will produce a correlation between particles transverse position and energy deviation.

Monochromatization mode



CM energy $w = 2E_0 + O(\Delta E)^2$

Monochromatization factor $\lambda = \left(1 + \sigma_\delta^2\left(\frac{D_x^{*2}}{\sigma_{x\beta}^{*2}} + \frac{D_y^{*2}}{\sigma_{y\beta}^{*2}}\right)\right)^{1/2}$

Monochromatization CM energy spread and **Luminosity**

$$\sigma_w = \frac{\Delta E}{\sqrt{2\lambda}} \qquad L_{mc} = \frac{L_{st}}{\lambda}$$

FCC-ee Monochromatization Self-Consistent Parameters

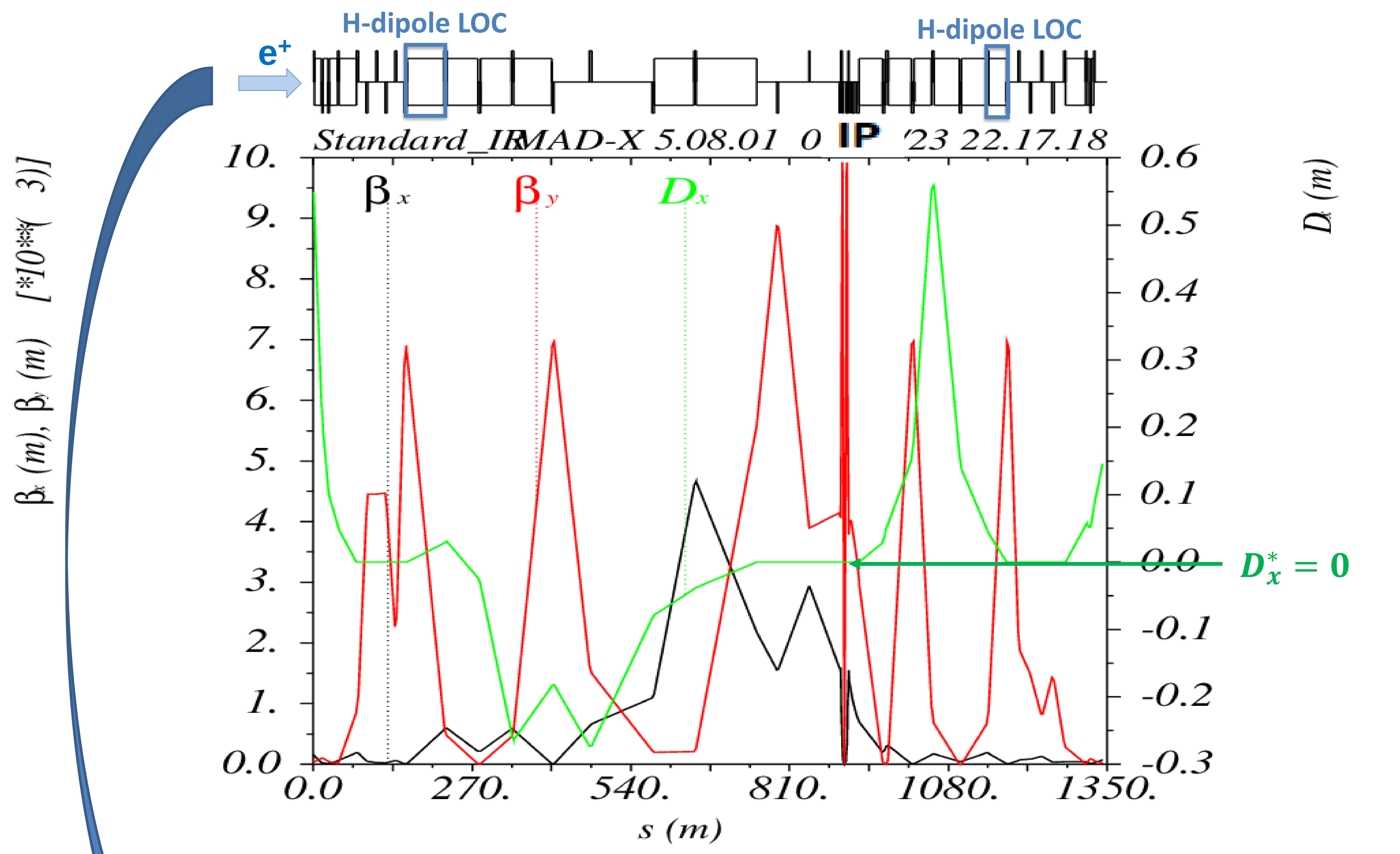
Parameters	Unit	Value
Centre-of-mass energy (W)	GeV	125
RMS emittance with BS ($\varepsilon_{x,y}$)	nm rad	2.5/0.002
RMS momentum deviation (σ_δ)	%	0.052
RMS bunch length (σ_b)	mm	3.3
Horizontal dispersion at IP (D_x^*)	m	0.105
IP beta function ($\beta_{x,y}^*$)	mm	90/1
Full crossing angle (θ_c)	mrad	30
Monochromatization factor (λ)	/	8.1
Luminosity per IP with BS (L_{mc})	$cm^{-2}s^{-1}$	2.6×10^{35}
RMS CM energy spread (σ_w)	MeV	13

Acknowledgements

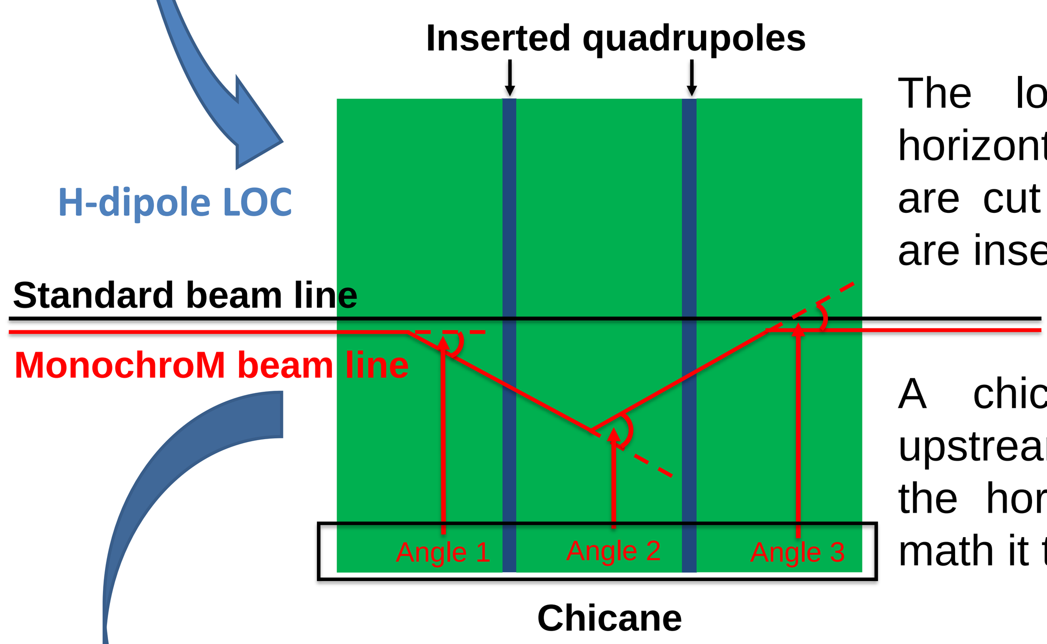
We would like to express our deepest thanks to A. Blondel (University of Geneva), D. Shatilov (BINP) and P. Raimondi (SLAC) for the invaluable discussions.

FCC-ee Monochromatization H-dipole scheme implementation

Standard FCC-ee IR optics



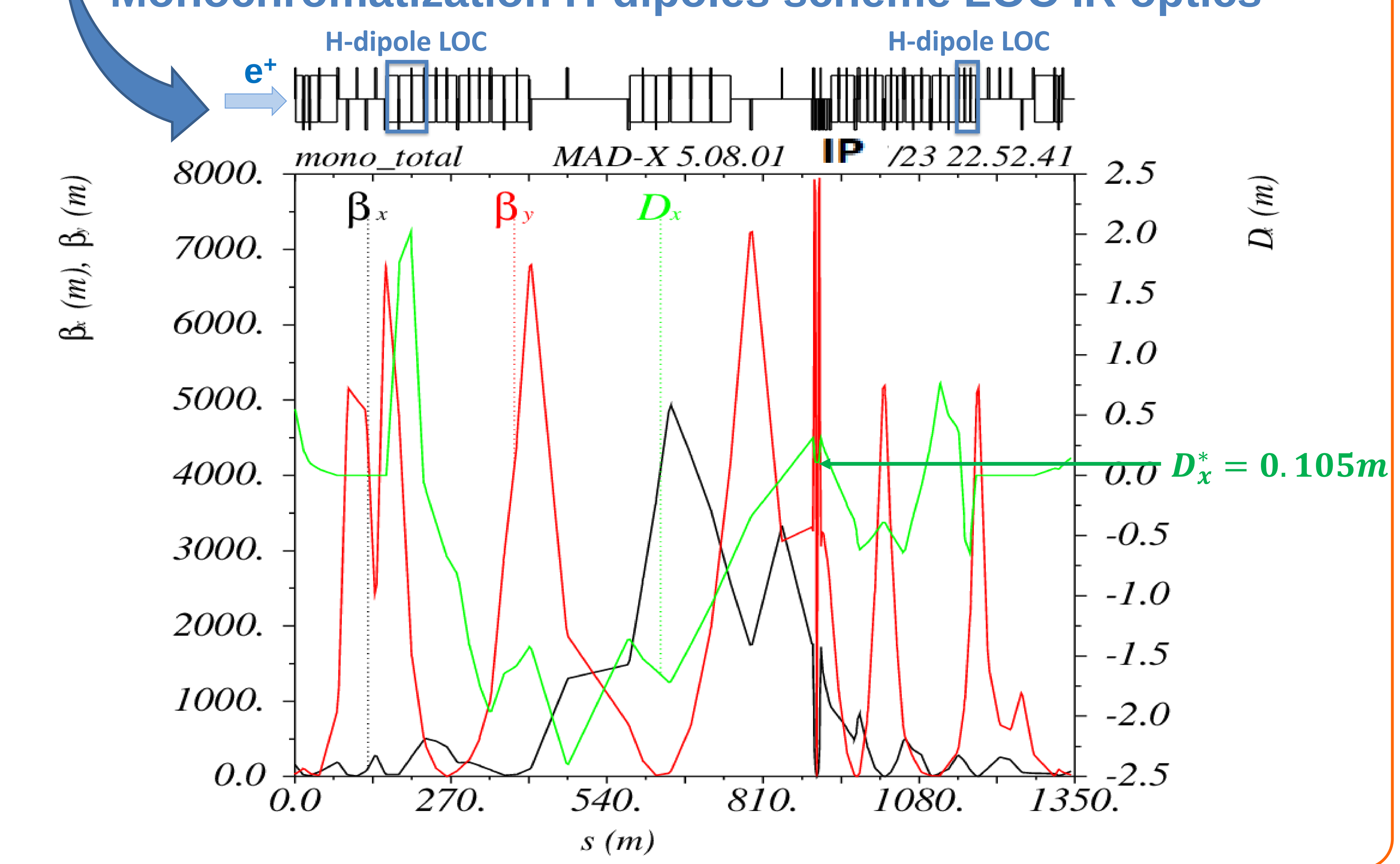
Monochromatization H-dipoles LOC scheme



The local vertical chromaticity (LOC) horizontal dipoles in the standard IR optics are cut in three pieces and quadrupoles are inserted between the pieces.

A chicane implemented in the last upstream and downstream dipoles create the horizontal dispersion at the IP and math it to the arc while keeping the orbit.

Monochromatization H-dipoles scheme LOC IR optics



Conclusion

A monochromatization IR optics has been designed for FCC-ee, the necessary horizontal dispersion at the IP has been created by means of the H-dipoles present in the LOC. Dispersion of 10 cm in the IP is able to reduce the energy spread at the level of 13 MeV. Beam dynamics simulations are ongoing to asses this new mode of operation.

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