RE-OPTIMIZATION OF THE FINAL FOCUS SYSTEM OPTICS WITH VERTICAL CHROMATIC CORRECTION

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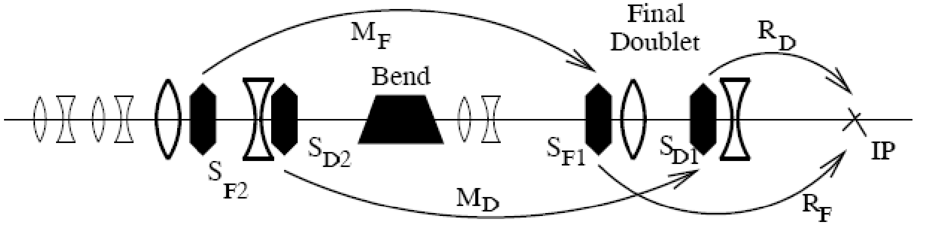
Introduction

- Final Focus System (FFS)
  - demagnify the beam to the required size at the IP
  - This can be done in a compact way based on a local chromatic correction.

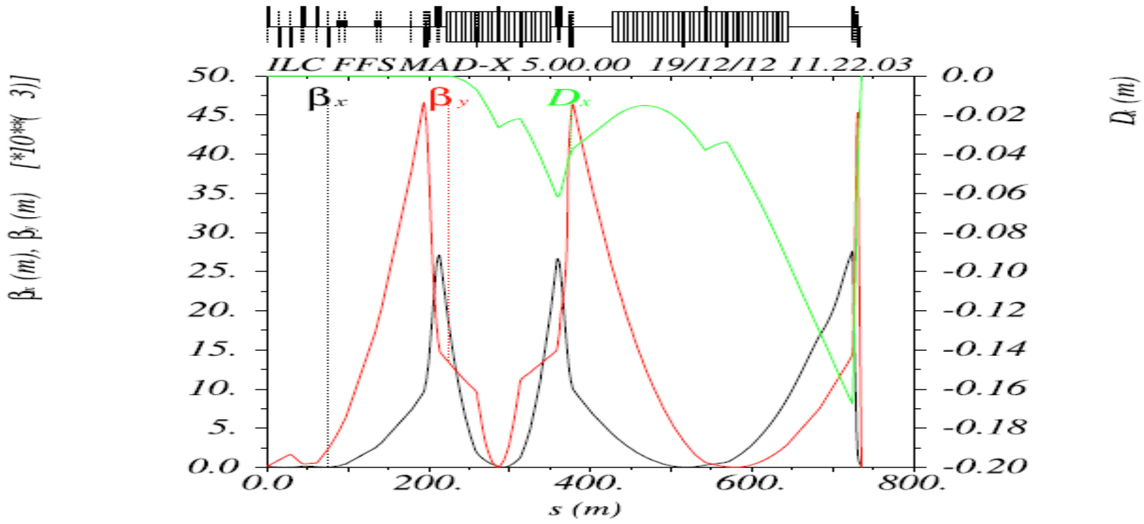
  (P. Raimondi and A. Seryi, SLAC-PUB-8460)



- In FFS (http://clicr.web.cern.ch/CLICr/ILC/):
  - Final doulet (QF1, QD0) provide focusing.
  - Two sextupoles (SF1, SD0) and a bend will locally cancel the chromaticity.
  - Two more sextupoles (SF5, SD4) to cancel geometric second order aberrations and high order terms
  - One more sextupole (SF6) helps to cancel higher order aberrations.
  - First peak of β function needed for T166 cancellation .
  - Matching quadrupoles (QM16-11) to match the incoming β function.

Introduction

- Idea of chromatic correction mainly in the vertical plane
  - for a small enough beam energy spread and enlarged βx*
  - chromaticity on horizontal plane will be smaller
  - It may be possible to get a smaller vertical beam size with chromatic correction mainly in the vertical plane using fewer sextupoles: 2 or 3 instead of 5
  - If it works, we will also not need the first peak of β, which will reduce overall vertical chromaticity. This can lead to a simpler and more compact FFS optics.



chromatic correction in both plane

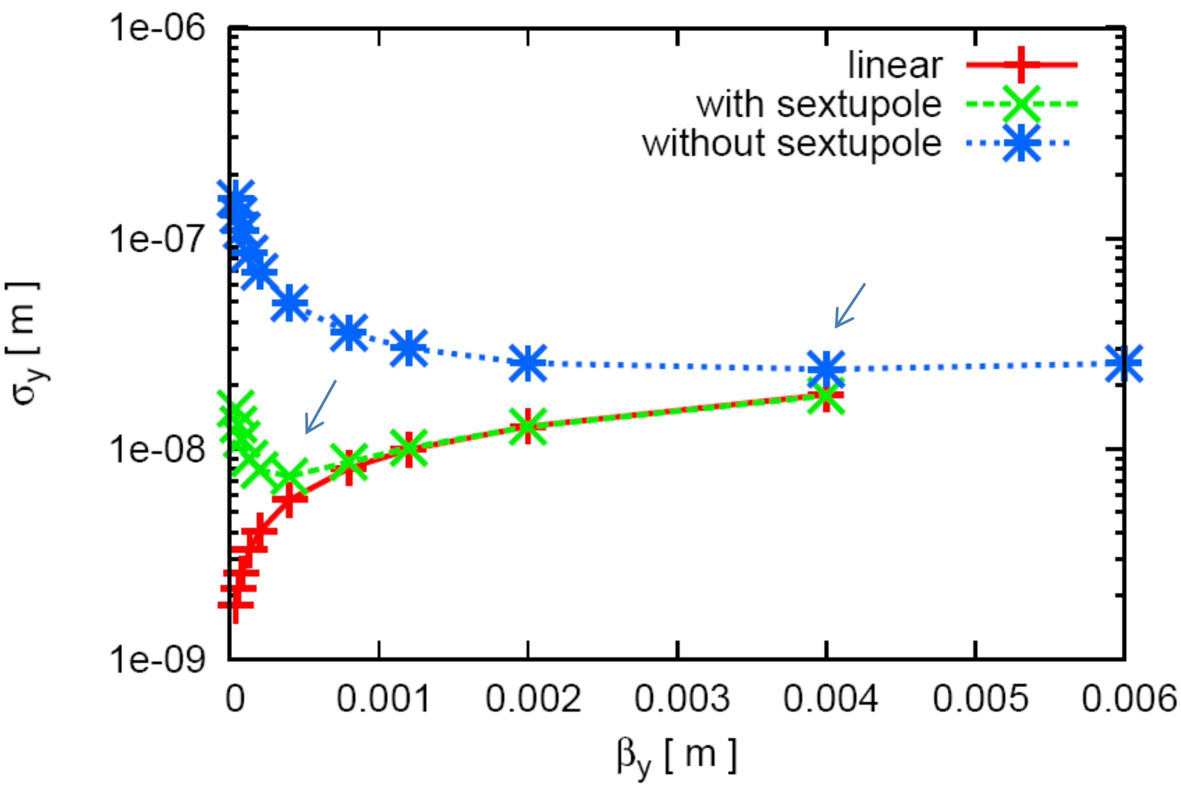
- Parameters at FFS Entrance :
  - βx= 86m, βy= 171m;
  - αx=-2.6, αy= -2.7;
  - Dx=0,Dpx=0;
  - emittxn=10um·rad, emittyn=40nm·rad; (same with BDS entrance)
  - σz=300um, $\sigma E/E0$=0.06%;

chromatic correction in both plane

- Working procedures:
- Slightly refit QF1
  - get $Dx^*=0$ (original -0.002m)
- Fit matching quadrupoles QMs
  - get wanted βx^*, βy^*
  - maintain $\alpha x^*=0$, $\alpha y^*=0$
- Fit sextupoles SD0, SF1, SD4, SF5, SF6
  - cancel T122, T126, T166, T342, and T346
- Tracking with MADX to get beam size

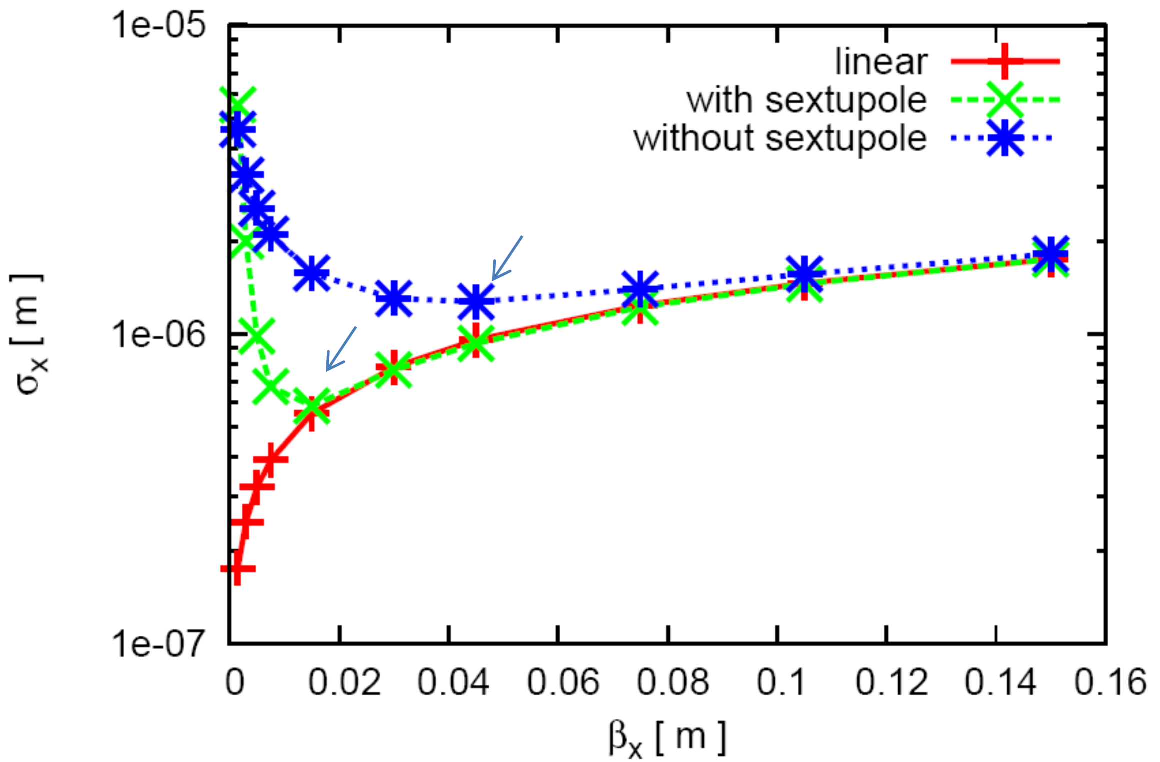
chromatic correction in both plane

- nominal βx*=15mm, variable βy*
  - without chromatic correction: σy* minimized when βy*=4mm --- focusing and chromaticity balanced
  - with chromatic correction: σy* minimized when βy*=0.4mm (nominal)



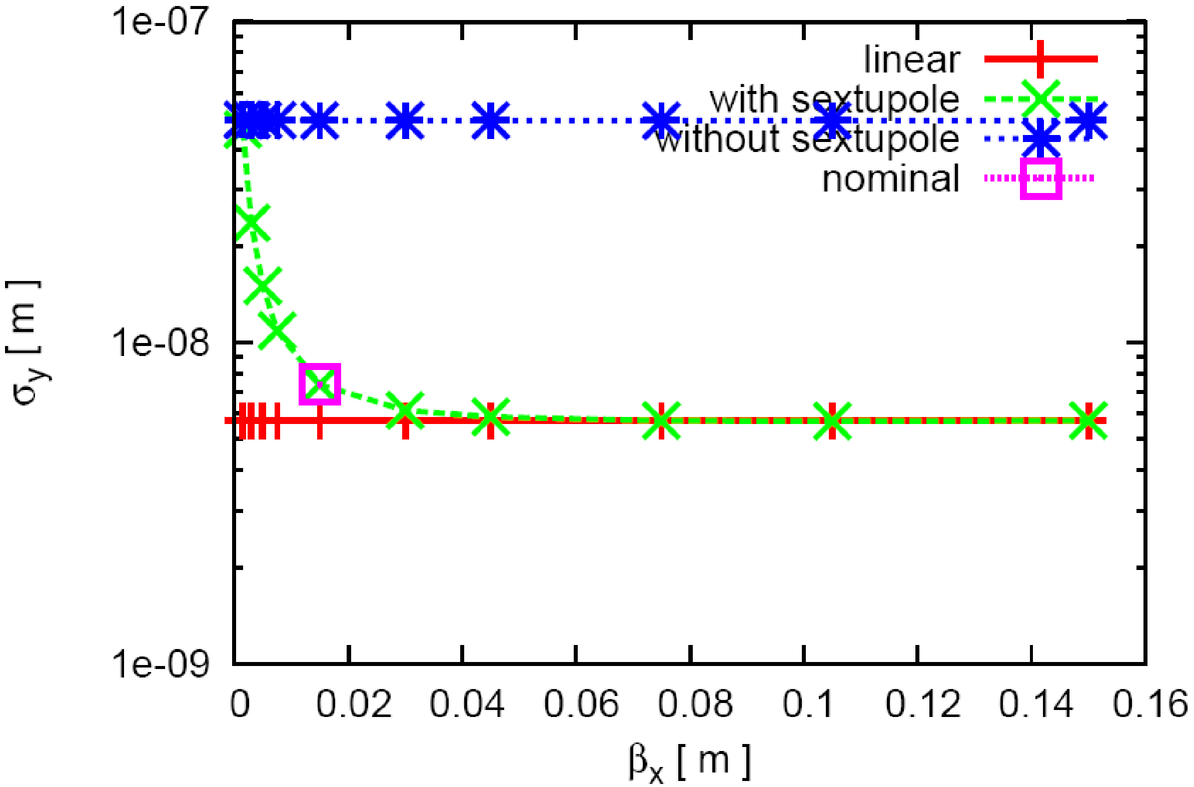
chromatic correction in both plane

- nominal βy*=0. 4mm, variable βx*
  - without chromatic correction: σx* minimized when βx*=45mm
  - with chromatic correction: σx* minimized when βx*=15mm (nominal)



chromatic correction in both plane

- nominal βy*=0. 4mm, variable βx*
  - Influence of variable βx* on σy*
  - Third order coupling aberrations enhance the vertical beam size for small βx*.

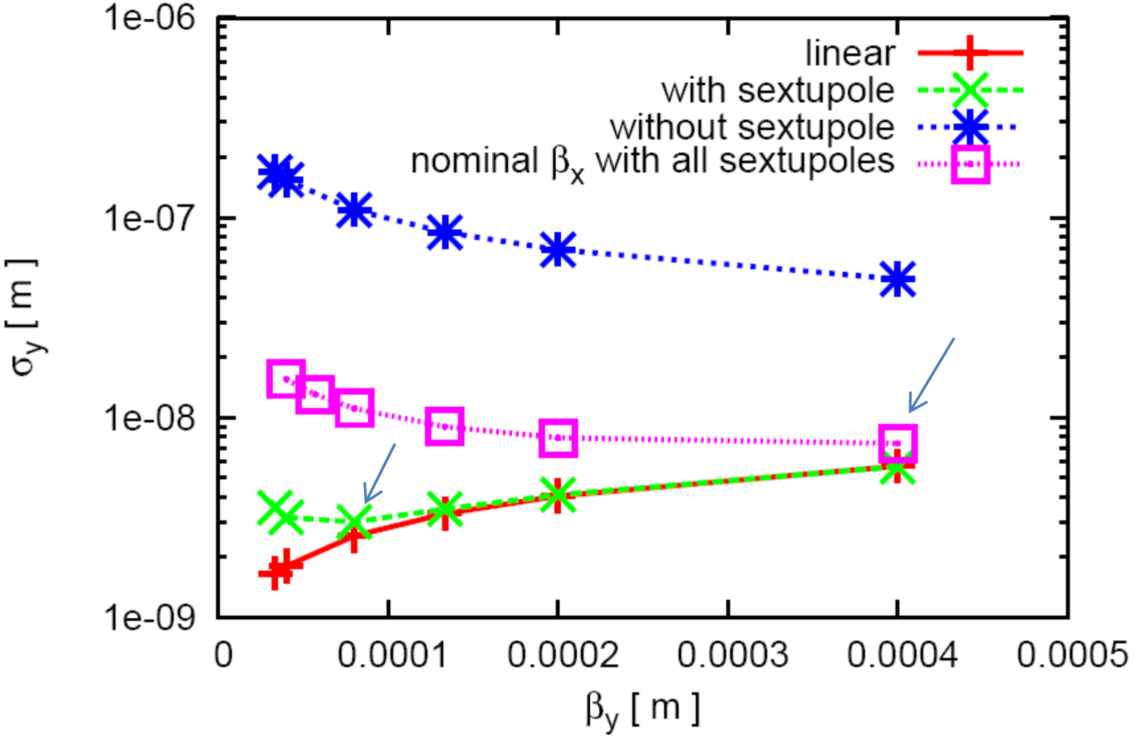


chromatic correction mainly in the vertical plane

- Working procedures:
- Fit matching quadrupoles QMs
  - get wanted βx^*, βy^*
  - maintain $\alpha x^*=0$, $\alpha y^*=0$
- Turn off SF1, SF5, SF6 and fit sextupoles SD0, SD4
  - cancel T342, T346
- Tracking with MADX to get beam size

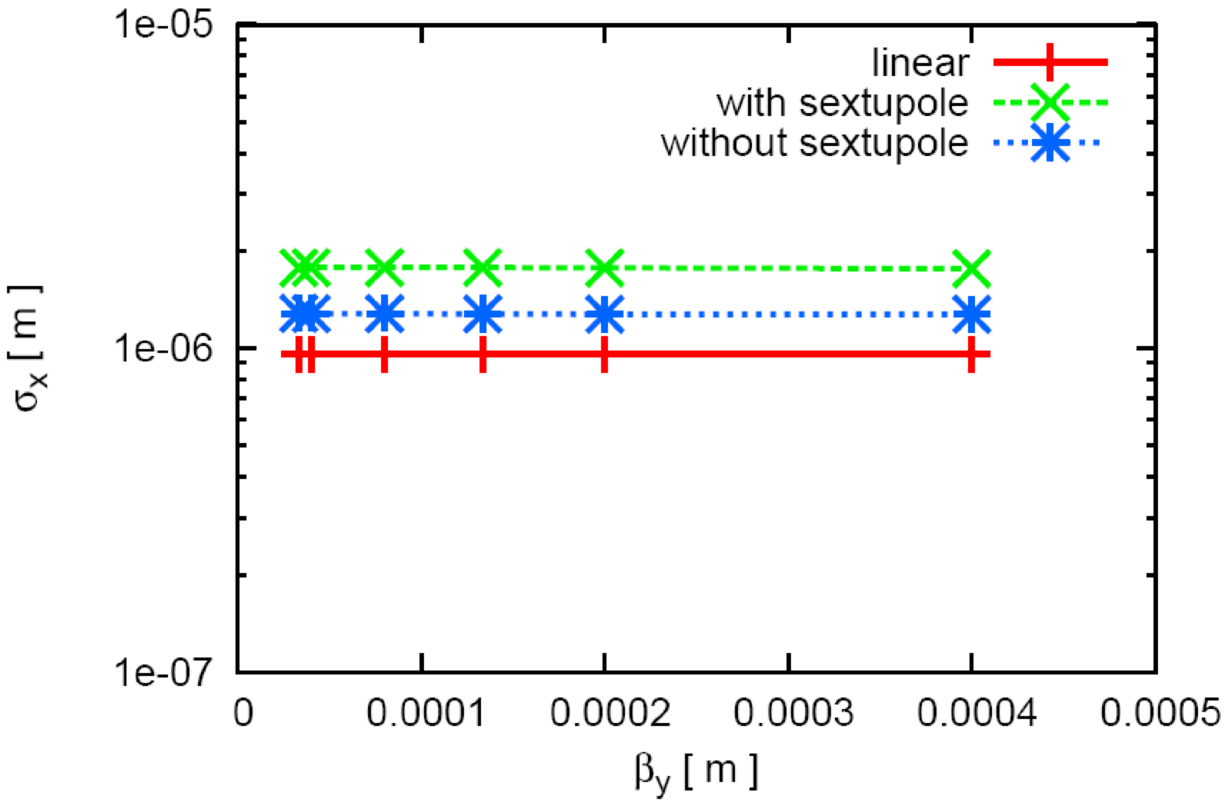
chromatic correction mainly in the vertical plane

- enlarged βx*=45mm, variable βy*
  - choose βx*=45mm: as without chromatic correction, σx* minimized
  - with chromatic correction mainly in the vertical plane (green line): σy* minimized when βy*= 0.08mm
  - σy*=0.4·σy_nom* (σx*=3·σx_nom*)
  - Luminosity recovery seems possible and there's room for optimization.



chromatic correction mainly in the vertical plane

- enlarged βx*=45mm, variable βy*
  - No Influence of variable βy* on σx*
  - σx* increased 2 times as the horizontal chromaticity contributions from SD0, SD4



Conclusions

- With chromatic correction in both plane
  - beam sizes minimized when β function are nominal values
- With chromatic correction mainly in vertical plane
  - Turn off SF1, SF5 and SF6 ; fit SD0, SD4 to cancel T342, T346
  - with enlarged β_x^*=45mm, beam sizes minimized when β_y^*=0.08mm: $\sigma_x^* = 3 \cdot \sigma_{x\_nom}^*$, $\sigma_y^* = 0.4 \cdot \sigma_{y\_nom}^*$
  - Luminosity recovery seems possible and there's room for optimization.

Outlook

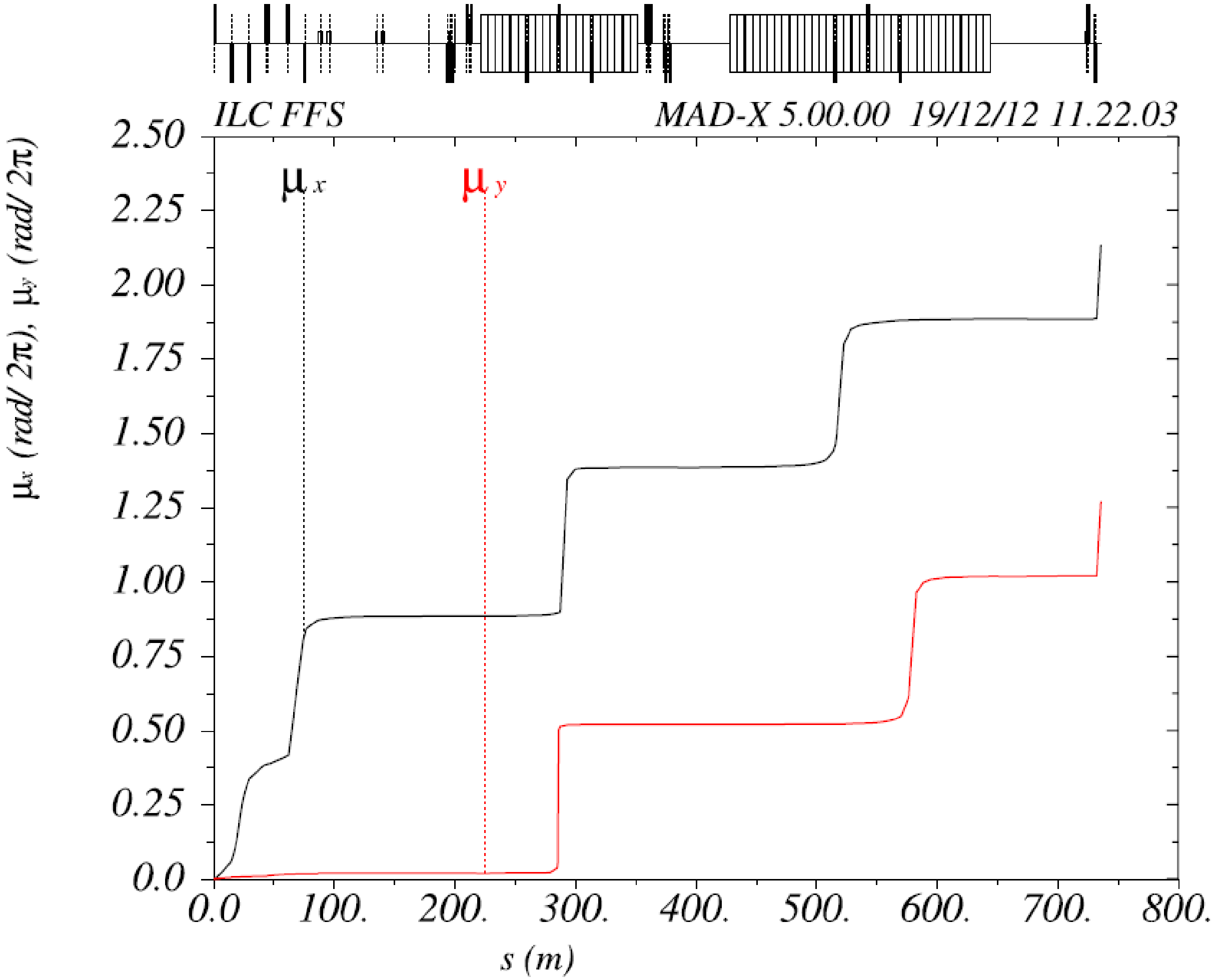
- Re-optimization with chromatic correction mainly in the vertical plane
  - minimize high order terms other than T342 and T346
  - try other fitting configuration of sextupoles
  - do it as function of energy spread
  - consider Oide effect
  - consider beam-beam induced radiation effects
  - study the optical correction strategy to mitigate static and dynamic imperfections
- Design a new alternative simplified optical system

Thanks

- Thanks a lot for Philip Bambade(LAL)'s guidance.
- Thanks a lot for Oscar Blanco(LAL), Sha Bai(IHEP) and Shan Liu(LAL)'s help on simulation.

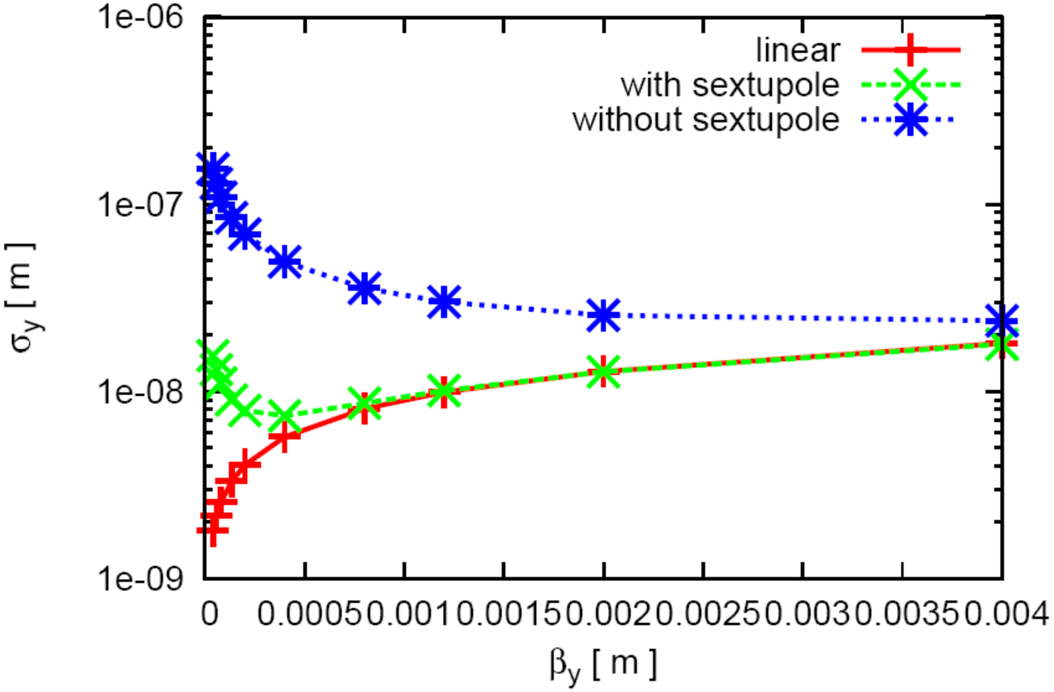
Reserved

Phase advance of FFS (QMs to IP)



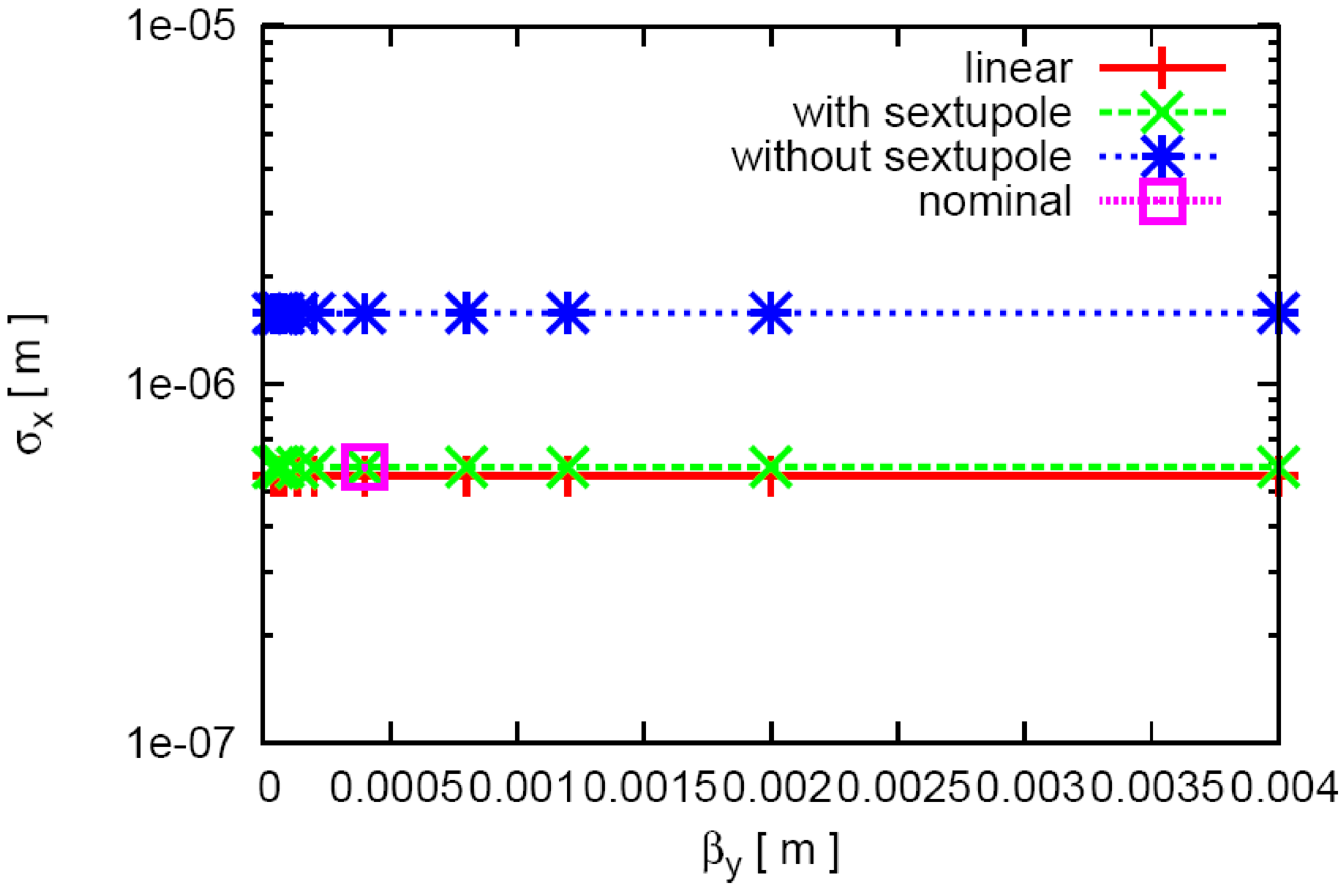
chromatic correction in both plane

- nominal βx*=15mm, variable βy*
  - linear beam size : without chromaticity; smaller with smaller βy*
  - without sextupole: with chromaticity but not corrected; There's a minimum where focusing and chromaticity balanced.
  - with sextupole: with chromaticity correction; minimum of sigmay* when βy*=0.4mm



chromatic correction in both plane

- nominal βx*=15mm, variable βy*
  - no influence of variable βy* on σx*



chromatic correction in both plane

- nominal βx* and βy*:
- Sextupoles refited
- Entrance :
  - betx= 86m, bety= 171m;
  - alfx=-2.6, alfy= -2.7;
  - dx=0,dpx=0;
  - emitxn=10um*rad, emityn=40nm*rad; (same with BDS entrance)
  - sigmaz=300um, sigmaE=0.06%;
- IP:
  - betx= 15mm, bety=0.4mm;
  - alfx=0, alfy=0;
  - dx=0 (original -0.002m; fit with QF1), dpx= 0.008;
  - emittx= 10.2um*rad, emitty= 47.5nm*rad;
  - sigmax=0.55um, sigmay= 5.7nm; (linear)
  - sigmax= 0.59um, sigmay=7.4nm; (track)