Current State of the Lattice Studies for the XFEL Injector

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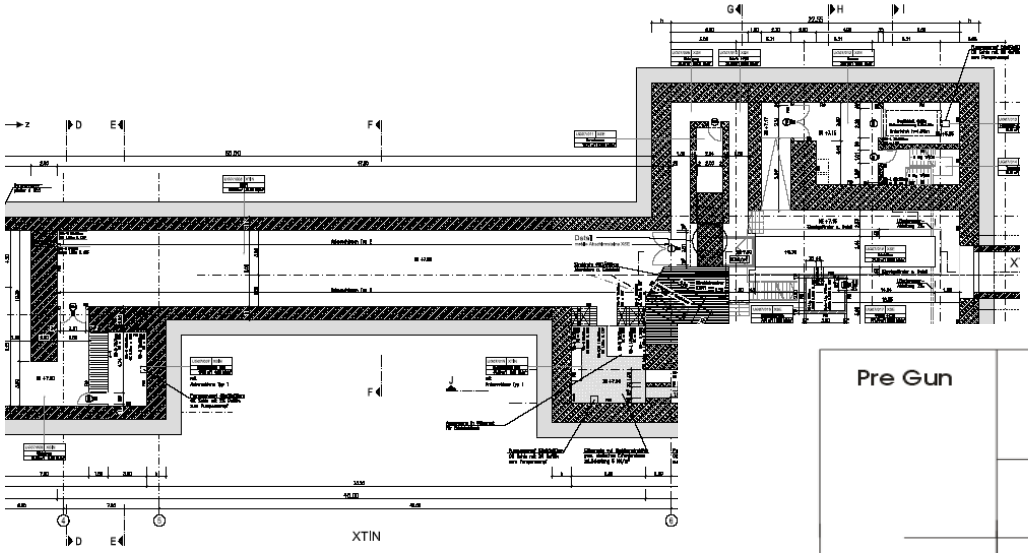
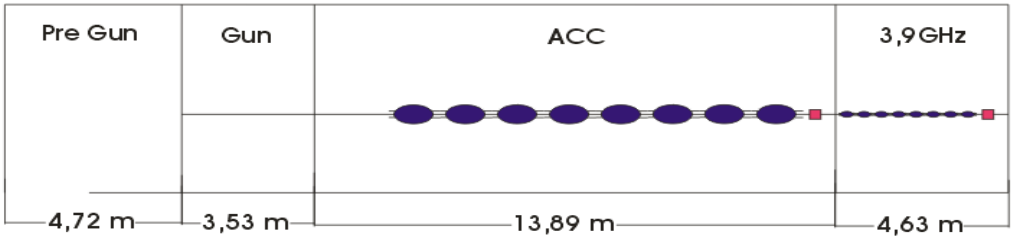
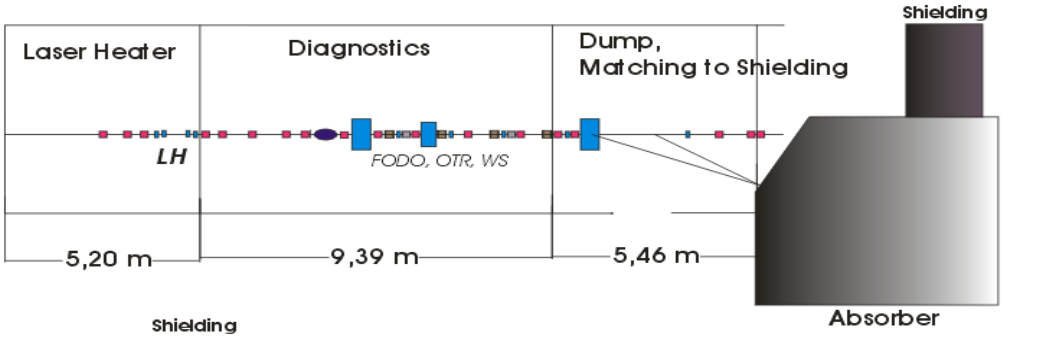
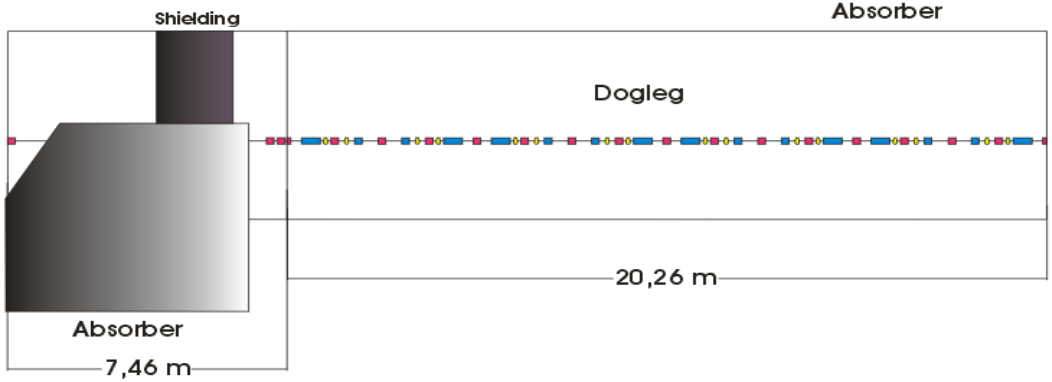
Injector Building & Lattice at Injector



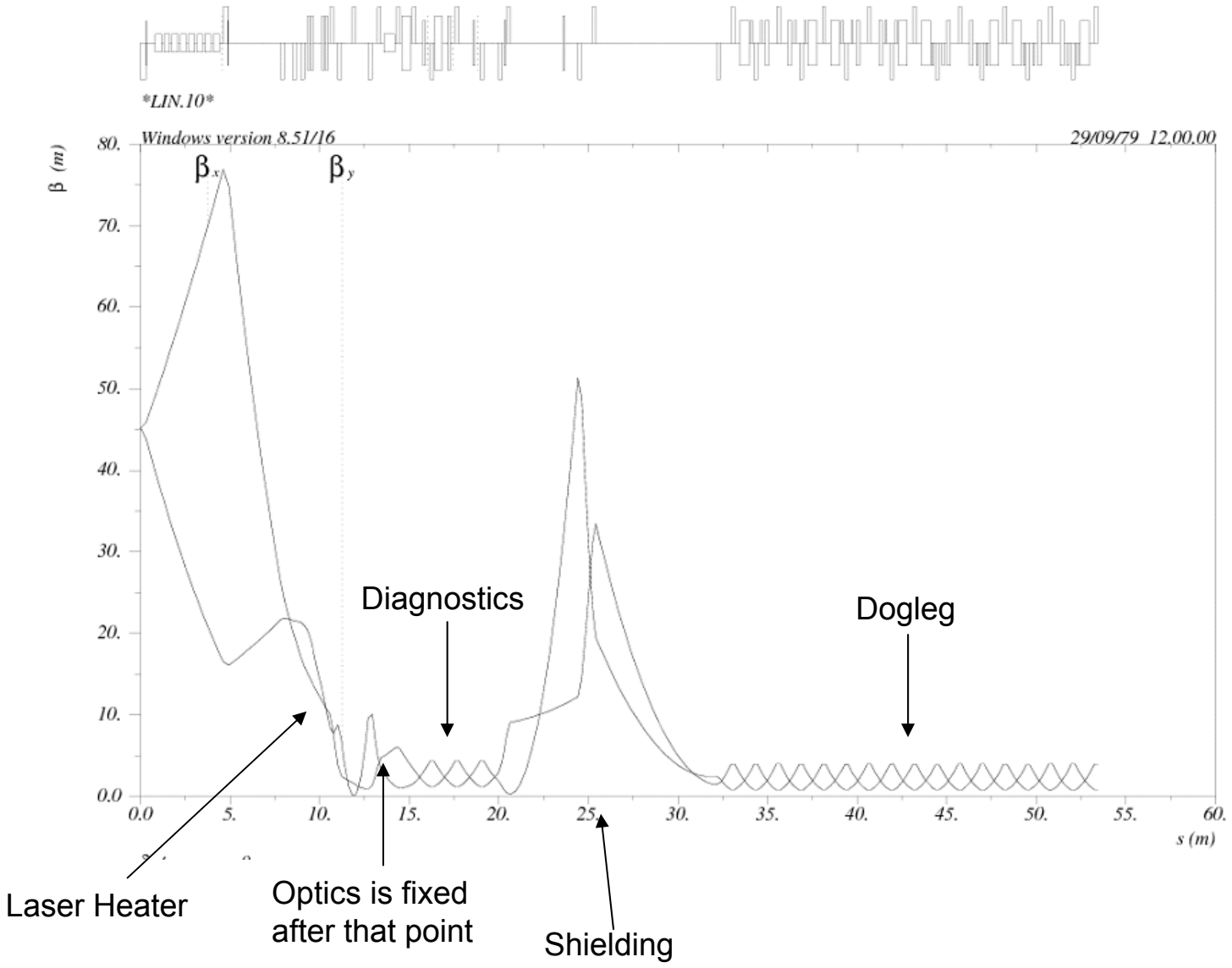






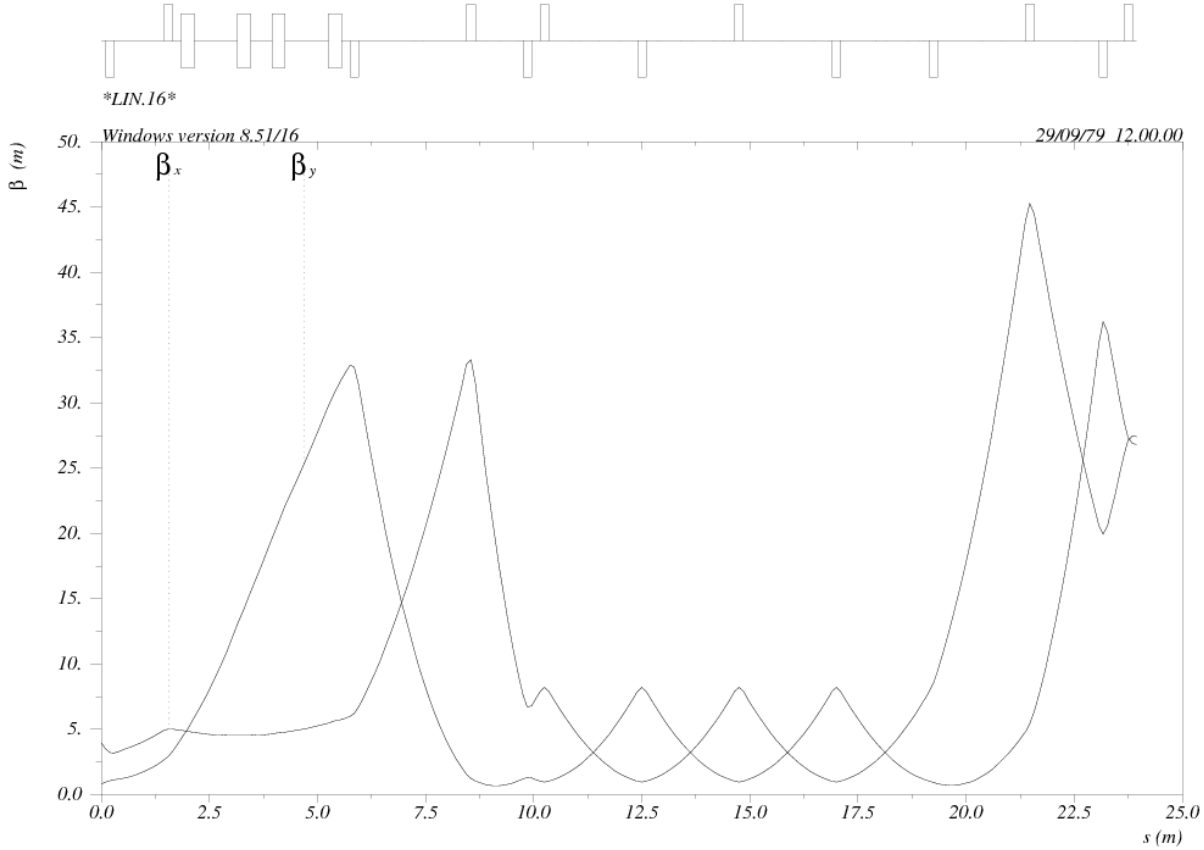
Gives place for:
- Gun
- ACC
- 3.9GHz RF
- Laser heater
- Diagnostics section
(1.5 76° FODO-cells with 4 OTR)
- TDS
- Spare place of about 3m for the dump exchange
- 6.5m long shielding
- 20m long Dogleg for the vertical Displacement of the beam (2.75m)

Optics at the XFEL Injector



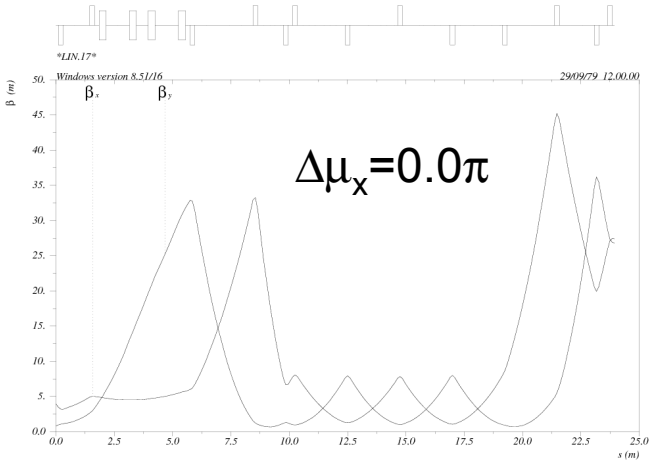
Optics after the Injector

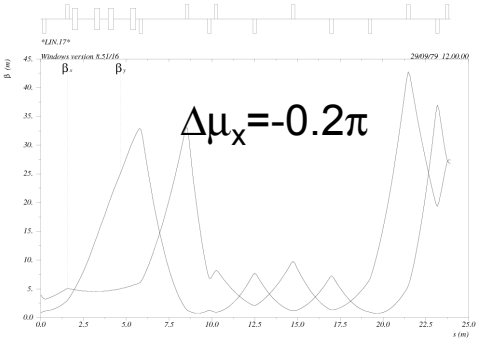
BC0, Phase Shifter & Matching to Linac

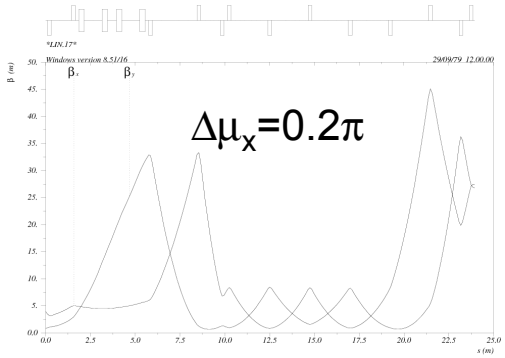


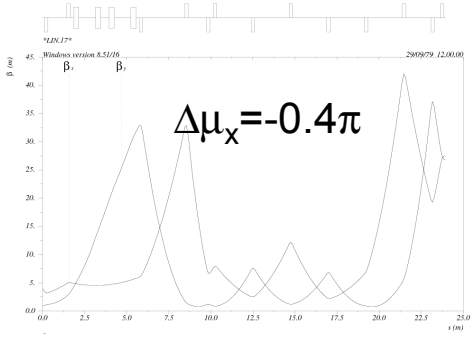
Phase shifter is set initialy as two FODO cells. Slightly deformations from the Ideal periodic solution lead to phase shift.

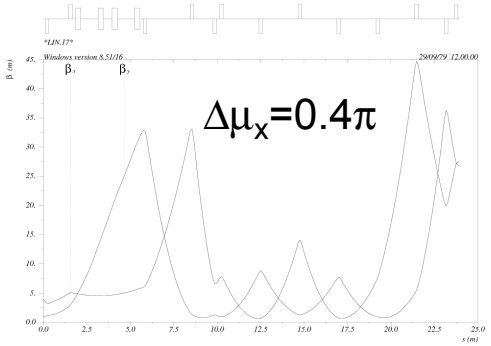
Phase Shifter



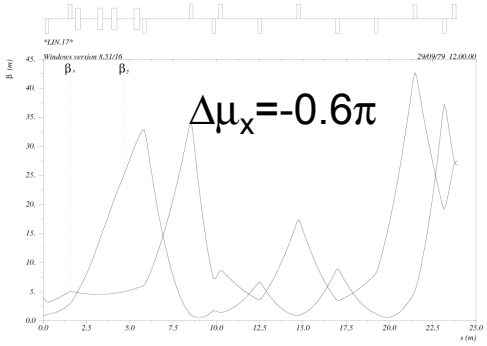


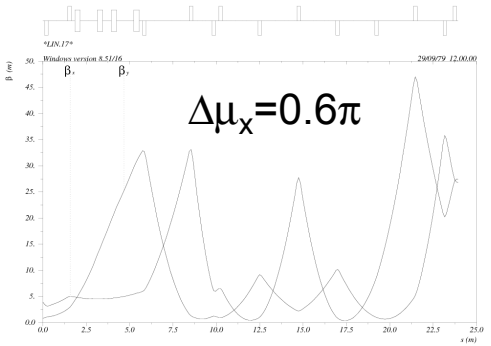




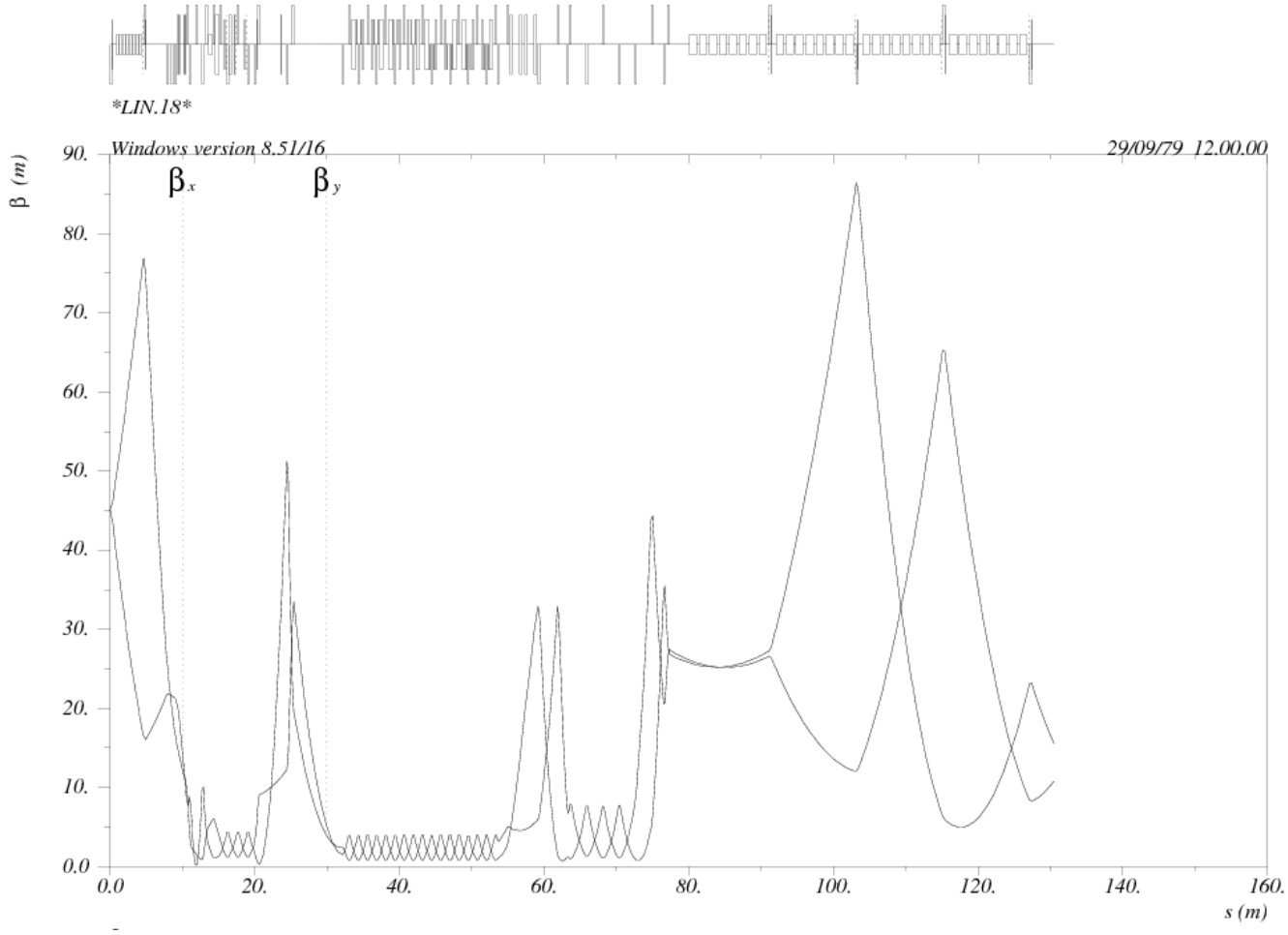


It becomes possible to change the phase advance by approximately π without significant aberrations by means of the phase shifter



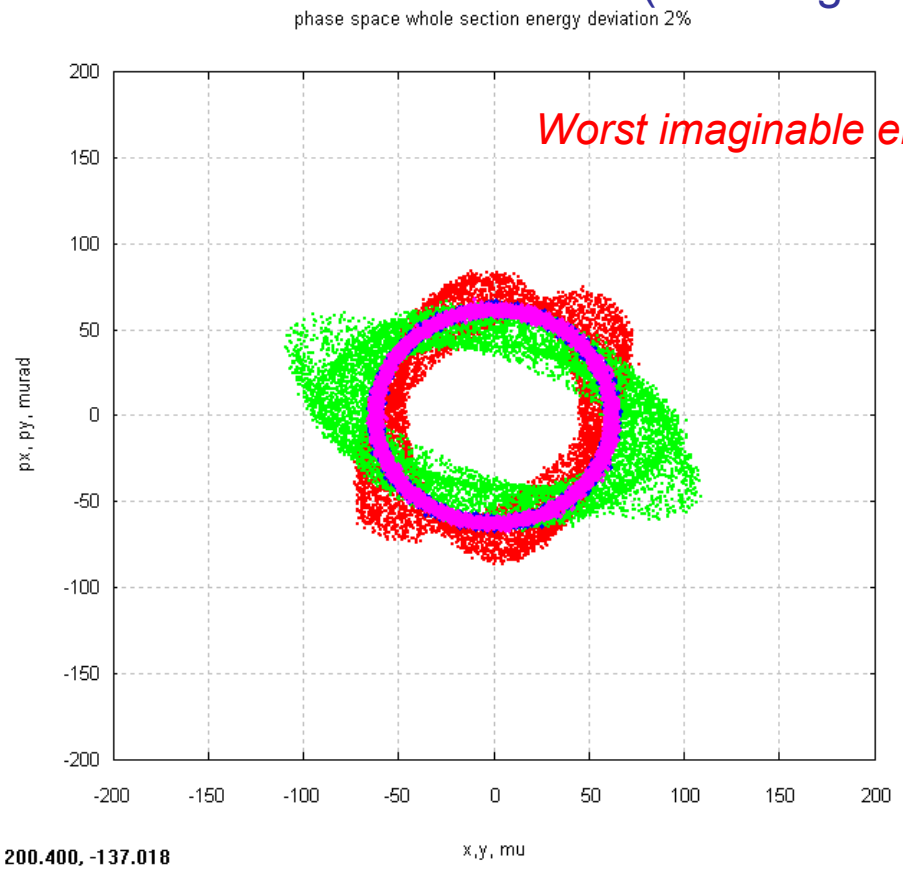


Optics up to Linac

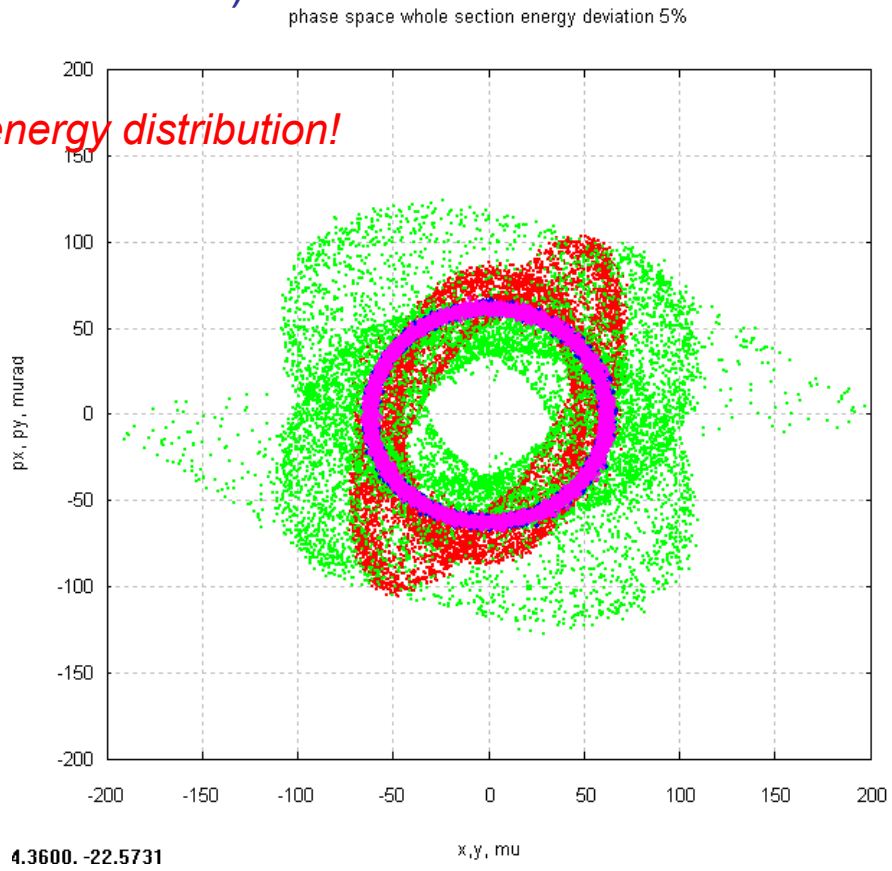


Whole lattice requires 48 quadrupoles! (without countering cold ones)

Chromatic Features of the whole Section (from Laser Heater to Linac)
(first rough estimations)



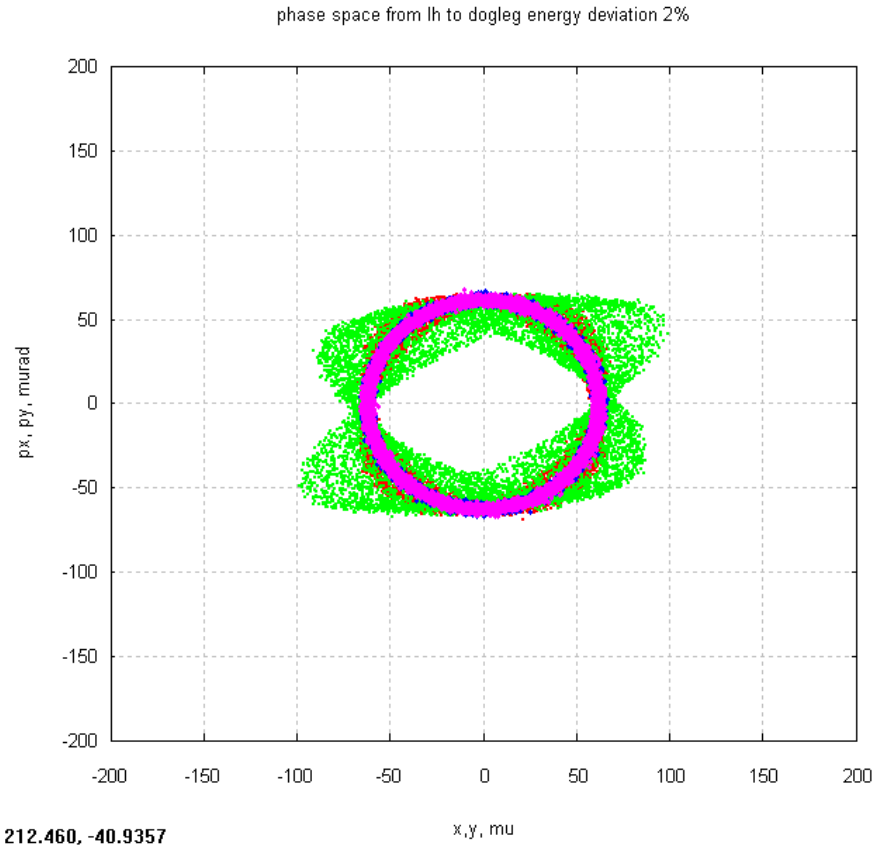
Worst imaginable energy distribution!

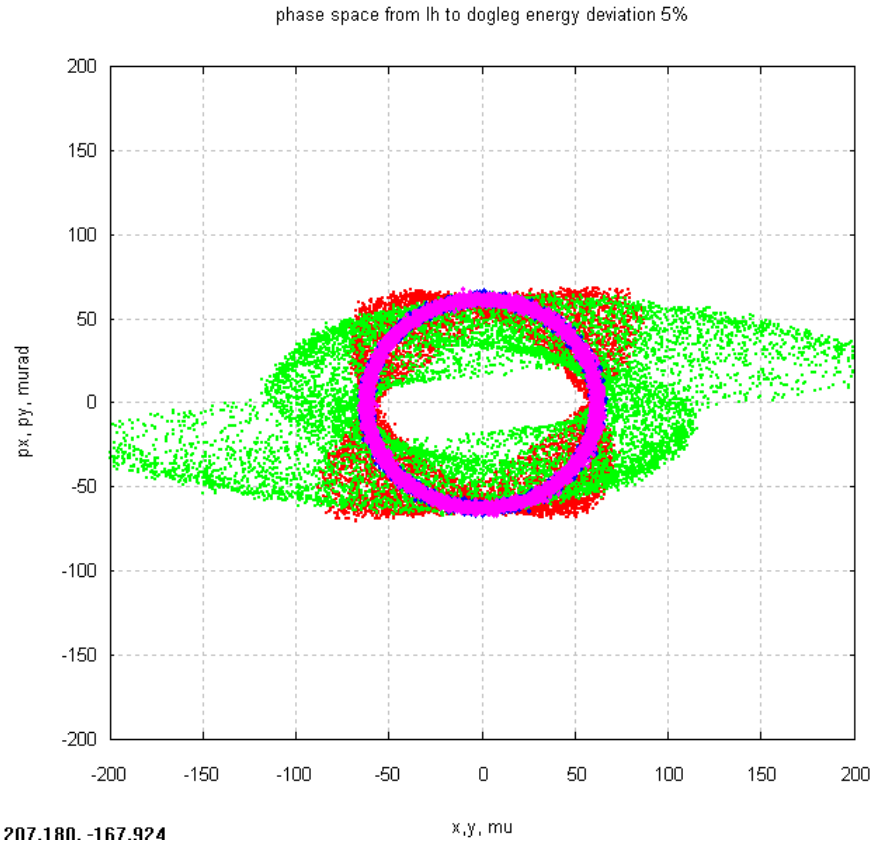


red, green – horizontal and vertical planes accordingly after running through the section

- 10000 particles with average norm. emittance of 0.96mu have been simulated
- Energy spread 2% → ε_x = 1.04mu, ε_y = 1.17mu, i.e. increase by 8.3% and 22% accordingly
- Energy spread 5% → ε_x = 1.21mu, ε_y = 1.66mu, i.e. increase by 26% and 73% accordingly

Chromatic Features: Laser Heater to Dogleg



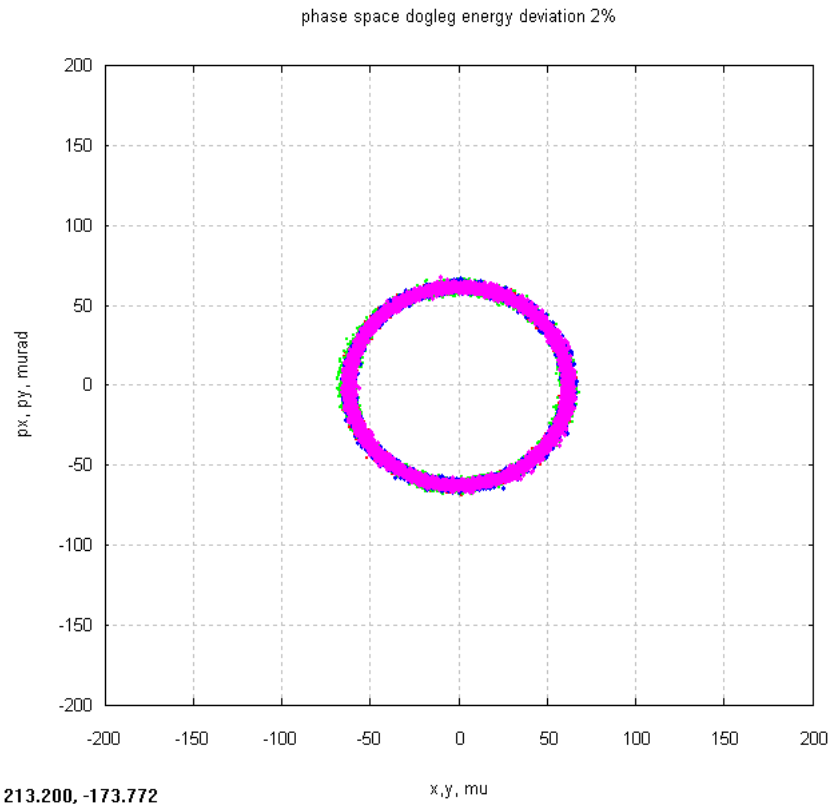


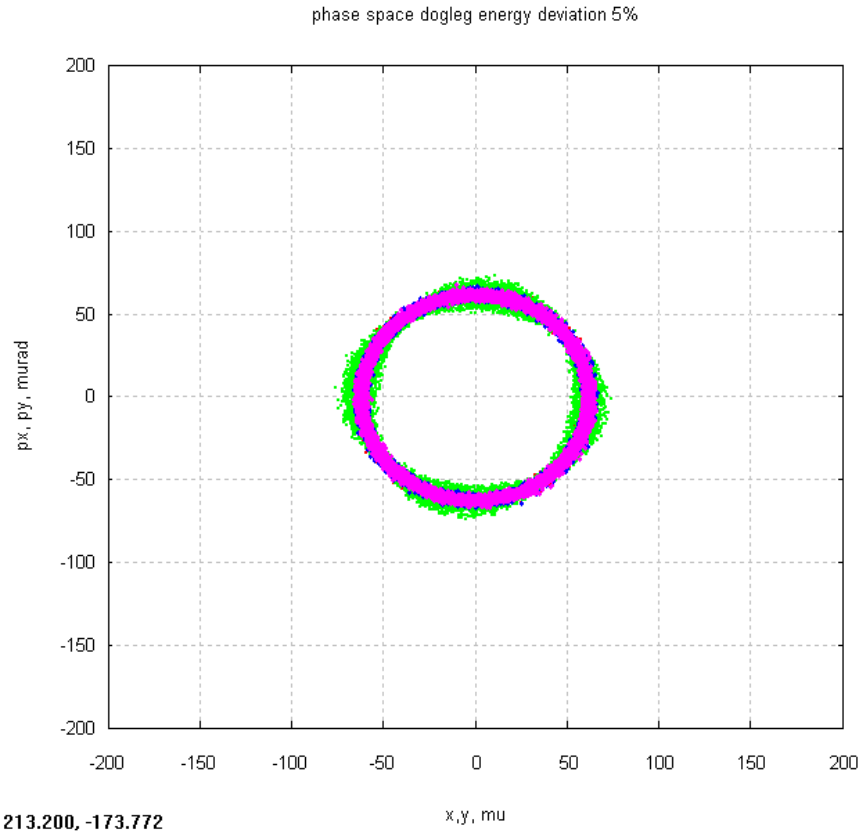
red, green – horizontal and vertical planes accordingly after running through the section

- 10000 particles with average norm. emittance of 0.96mu have been simulated
- Energy spread 2% → ε_x = 0.97mu, ε_y = 1.11mu, i.e. increase by 1.0% and 16% accordingly
- Energy spread 5% → ε_x = 1.07mu, ε_y = 2.01mu (?), i.e. increase by 11% and 109% accordingly

→ This part is the main source of the emittance blow up due to chromatic effects!

Chromatic Features: Dogleg

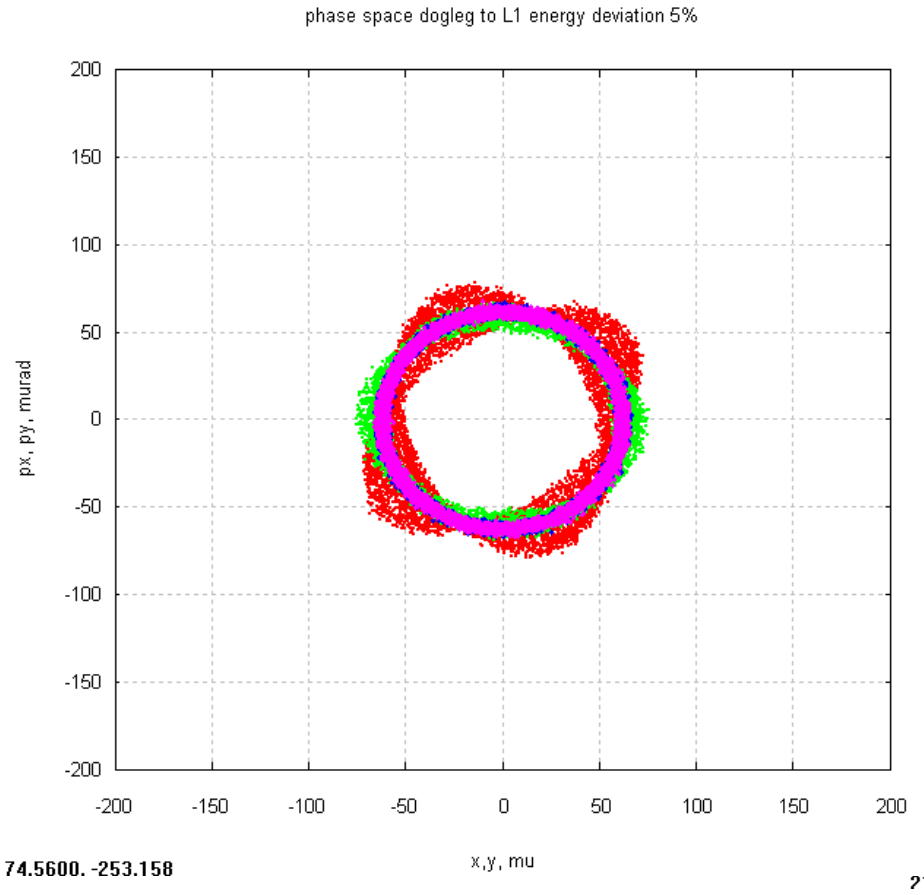


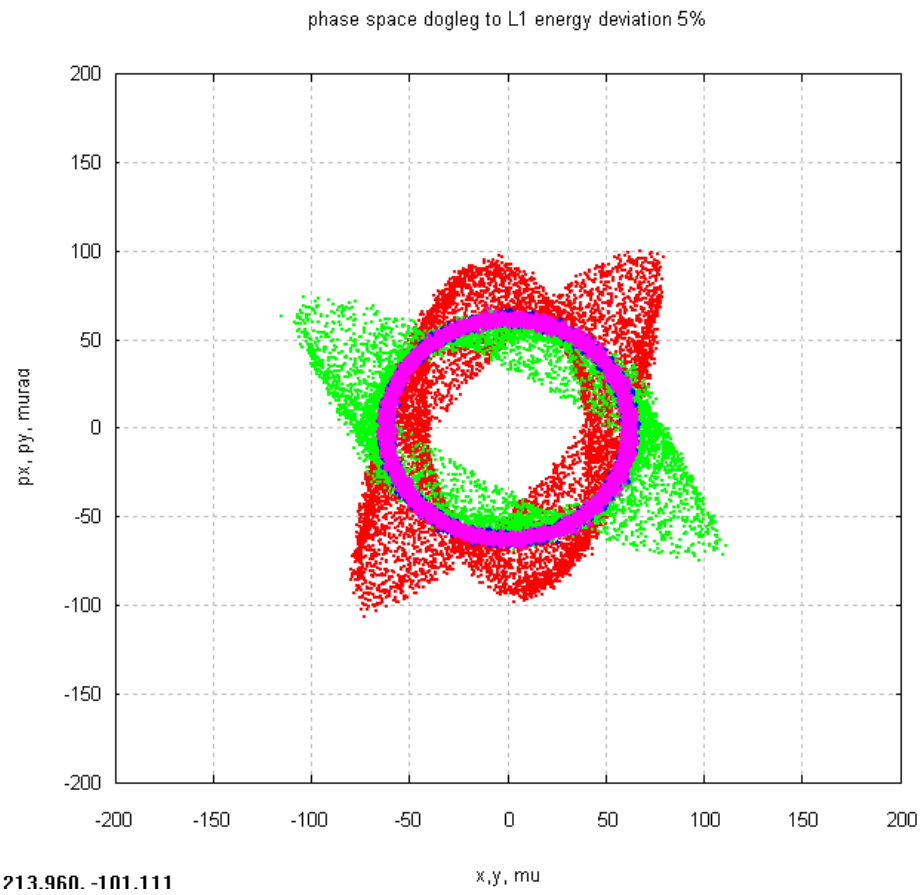


red, green – horizontal and vertical planes accordingly after running through the section

- 10000 particles with average norm. emittance of 0.96mu have been simulated
- Energy spread 2% → ε_x = 0.96mu, ε_y = 0.96mu, i.e. increase by 0.0% and 0.0% accordingly
- Energy spread 5% → ε_x = 0.96mu, ε_y = 0.97mu, i.e. increase by 0.0% and 1.0% accordingly

Chromatic Features: from Dogleg to Linac





red, green – horizontal and vertical planes accordingly after running through the section

- 10000 particles with average norm. emittance of 0.96mu have been simulated
- Energy spread 2% → ε_x = 1.00mu, ε_y = 0.97mu, i.e. increase by 4.2% and 1.0% accordingly
- Energy spread 5% → ε_x = 1.21mu, ε_y = 1.09mu, i.e. increase by 26% and 13.5% accordingly

Summary

- It is possible to house all desired components in the XFEL injector (like laser heater, OTR monitors, TDS) with reasonable optics functions.
- 48 warm quadrupoles are needed in that case
- Chromatic properties could become a problem. Hereby is the section downstream the dogleg the main source of the problems. Discussion about the expected energy spread of the beam needed.
- Chromatic properties were investigated under the assumption of the worst imaginable energy distribution (all energies have the same probability).More authentic simulations with more realistic energy distribution (gaussian) are ongoing.