Dispersion sensitivities for the XFEL

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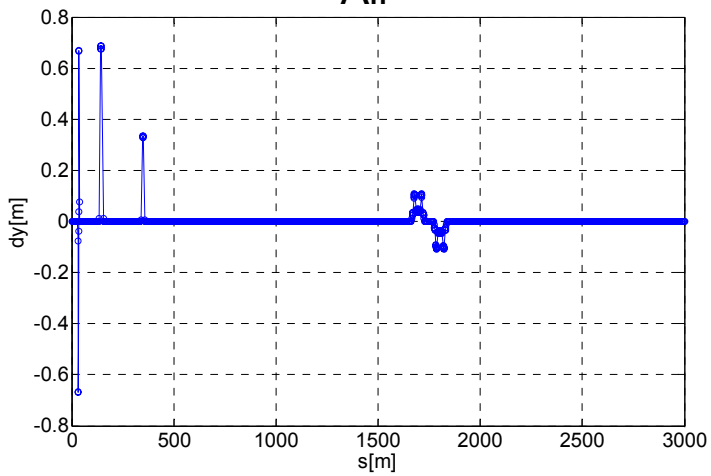
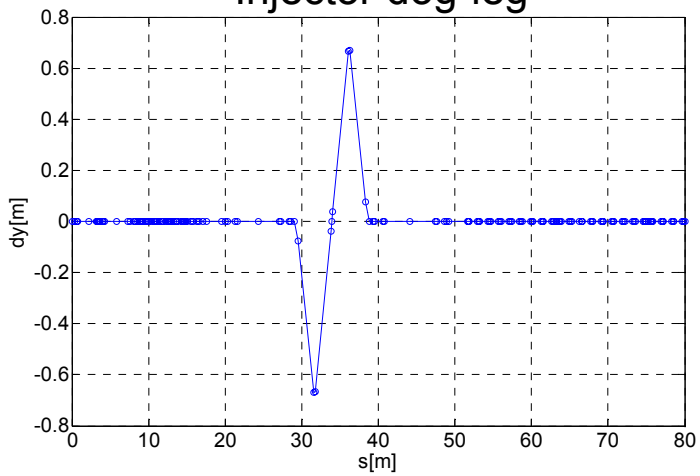
Design dispersion

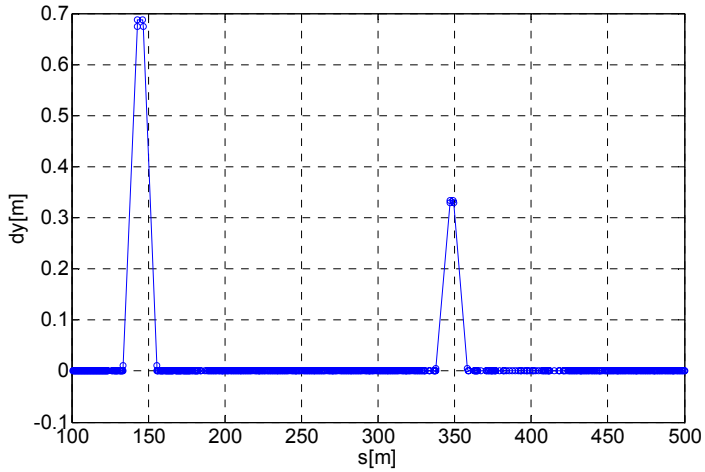
All



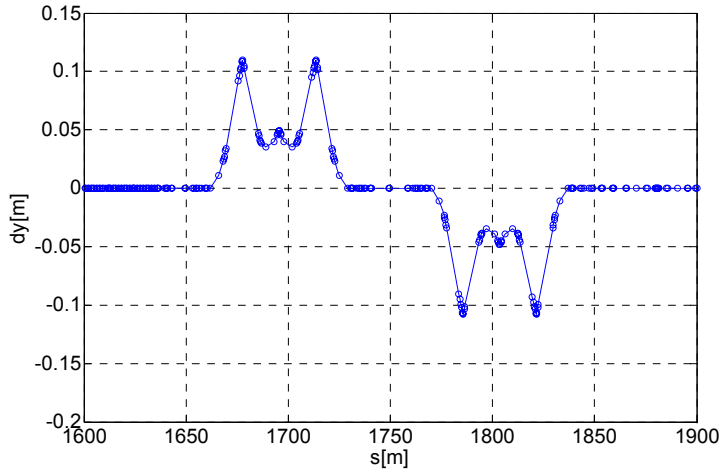
Injector dog-leg



Bunch compressor



Collimator



Overview

SECTIONS	Energy (GeV)	s (m) (in the following plots)
▪ Bunch compressor	0.130 → 2.1	0 → 370
▪ Main Linac	2.1 → 17.6	370 → 1590
▪ From collimator to undulator	17.6	1590 → 2080
▪ Undulator (SASE1)	17.6	2080 → 2280

ERROR SOURCES (amplitude of random Gaussian distribution cut at 3σ)

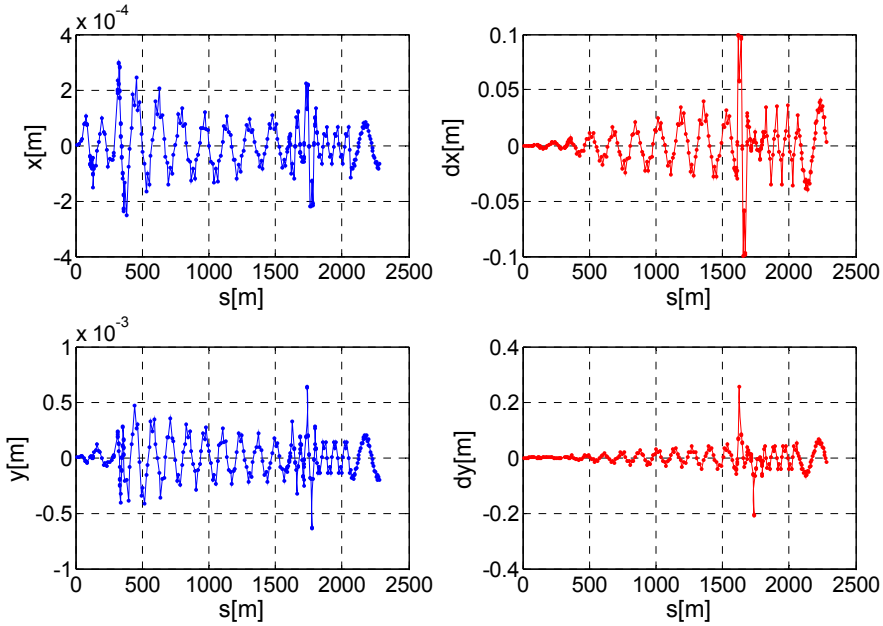
- Quad misalignments
- Dipole field errors
- Quadrupole field errors
- Quadrupole component in dipoles
- Cavity misalignments

- Presented dispersion numbers are rms values in the undulator section SASE1 for the different errors and sections
- Simulations have been done using **elegant**

Bunch compressor
Quad misalignment

Magnitude of the error = 10 μm

Orbit and dispersion for 1 seed



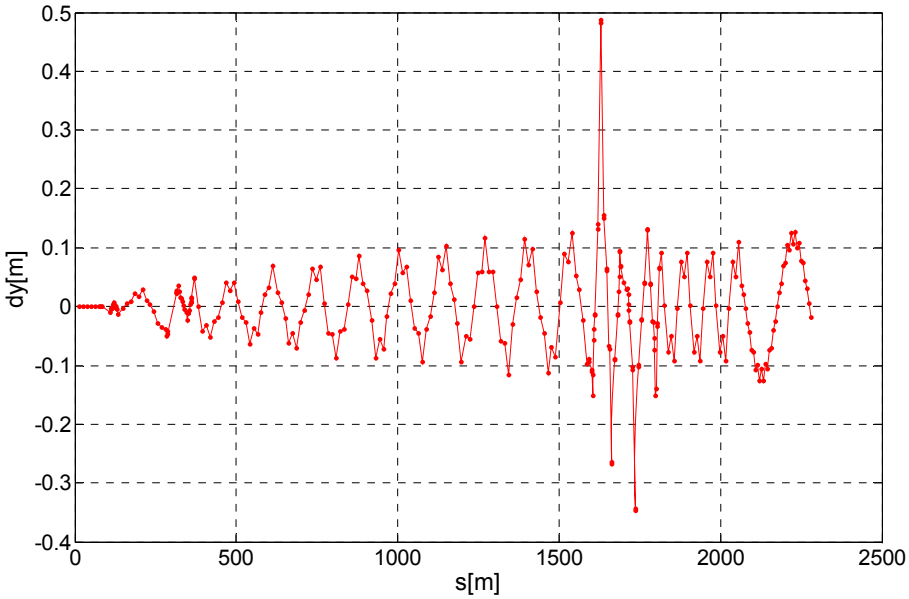
Average rms values for 200 seeds:

x = 0.07 mm
y = 0.06 mm
R_{16} = 27.16 mm
R_{36} = 22.06 mm

Bunch compressor
Dipole field error

Magnitude of the error = 1 %

Vertical dispersion for 1 seed



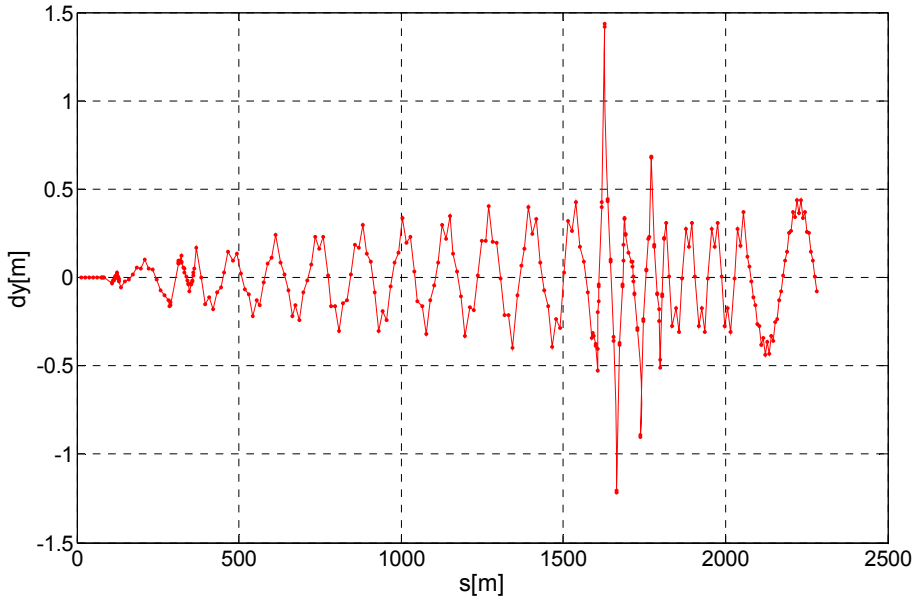
Average rms values for 200 seeds

R_{36} = 149.60 mm

Bunch compressor
Quad component in dipoles

Magnitude of the error = 0.01 m^{-2}

Vertical dispersion for 1 seed



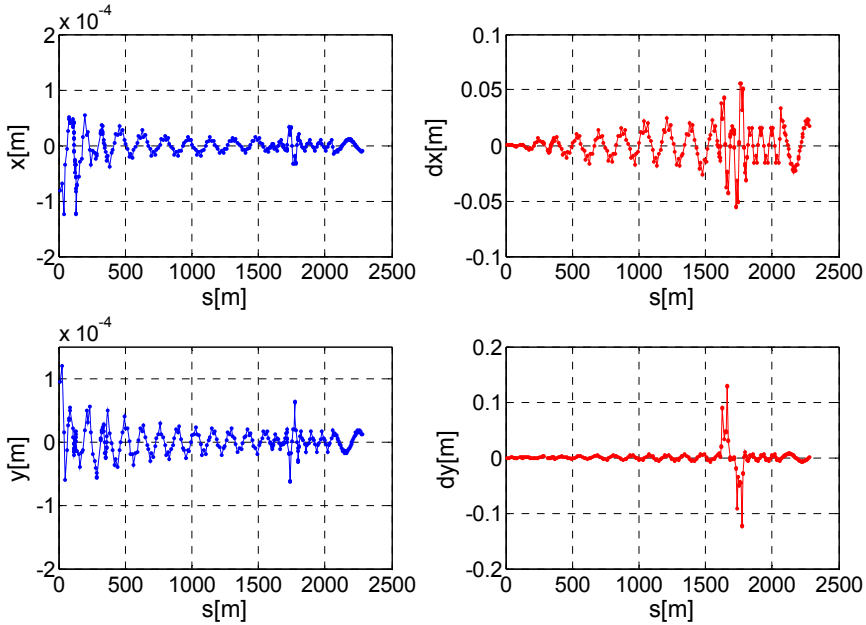
Average rms values for 200 seeds

R_{36} = 258.67 mm

Bunch compressor
Cavity misalignment

Magnitude of the error = 500 μm

Orbit and dispersion for 1 seed



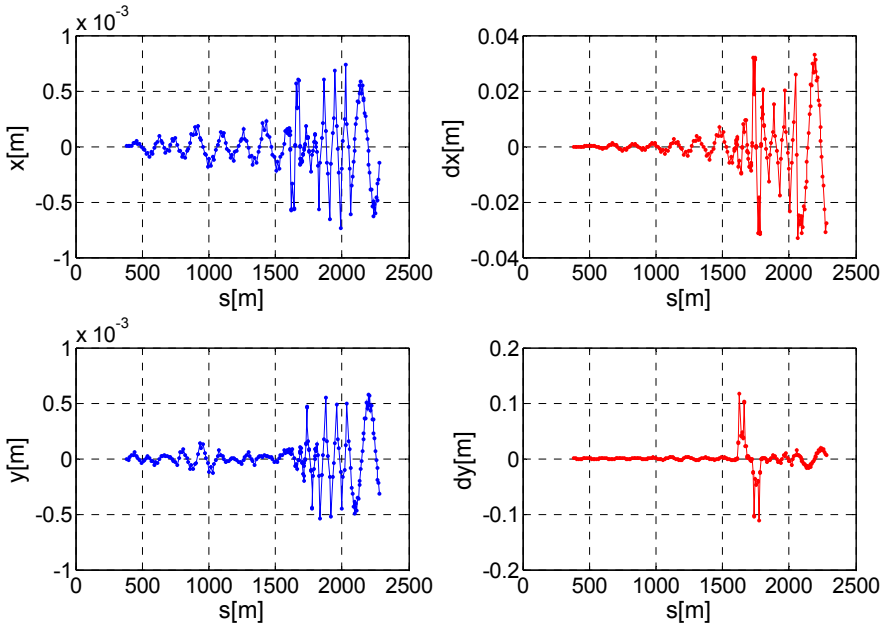
Average rms values for 200 seeds

x = 0.02 mm
y = 0.02 mm
R_{16} = 18.06 mm
R_{36} = 20.07 mm

Main linac
Quad misalignment

Magnitude of the error = 10 μm

Orbit and dispersion for 1 seed



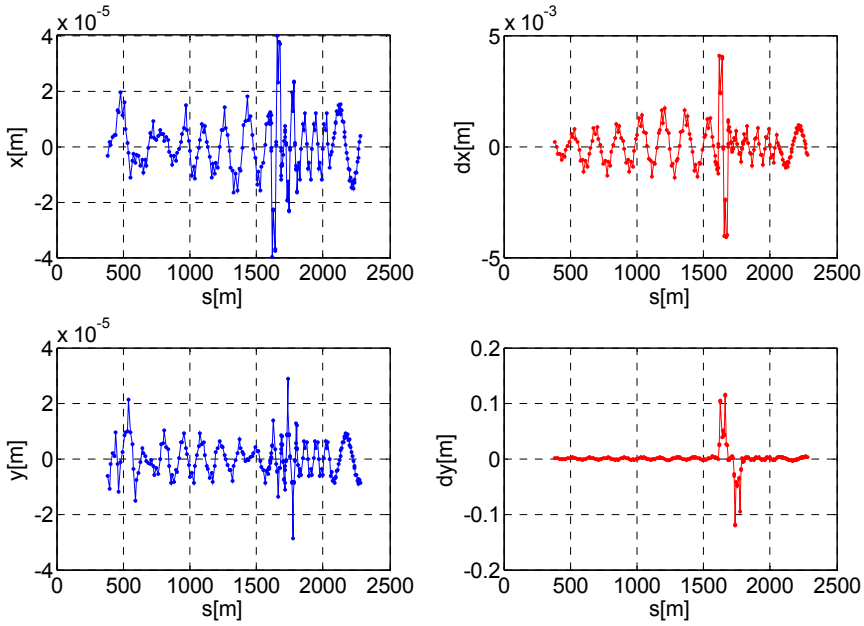
Average rms values for 200 seeds

x = 0.13 mm
y = 0.12 mm
R_{16} = 13.50 mm
R_{36} = 12.73 mm

Main linac
Cavity misalignment

Magnitude of the error = 500 μm

Orbit and dispersion for 1 seed



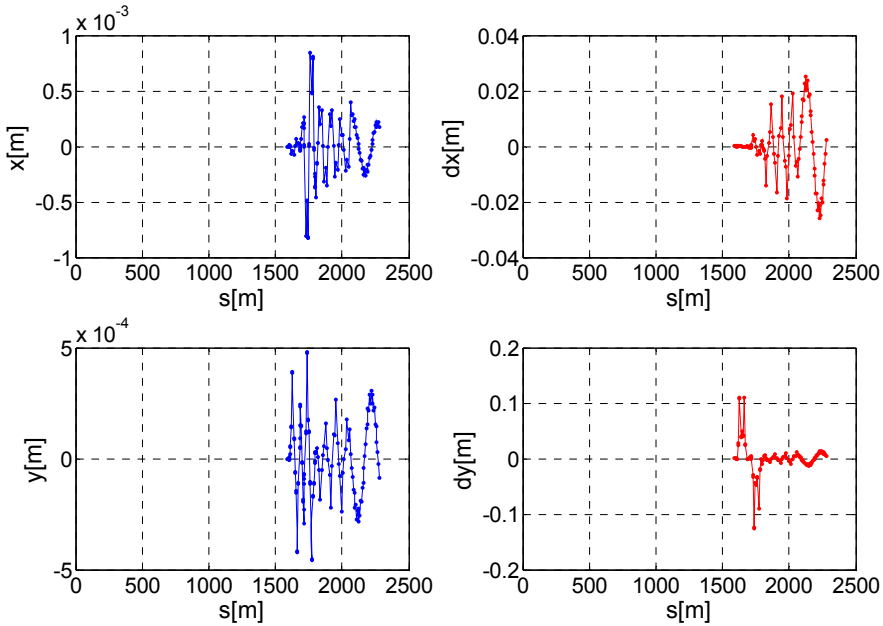
Average rms values for 200 seeds

x = 0.01 mm
y = 0.01 mm
R_{16} = 2.19 mm
R_{36} = 2.51 mm

From collimator to undulator
Quad misalignment

Magnitude of the error = 10 μm

Orbit and dispersion for 1 seed



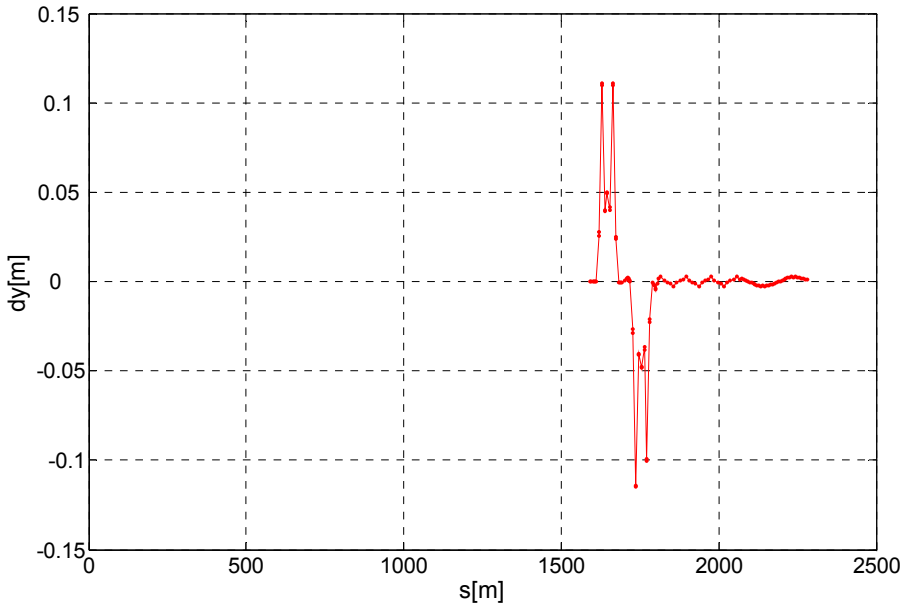
Average rms values for 200 seeds

x = 0.30 mm
y = 0.31 mm
R_{16} = 16.80 mm
R_{36} = 17.33 mm

From collimator to undulator
Dipole field error

Magnitude of the error = 1 %

Vertical dispersion for 1 seed



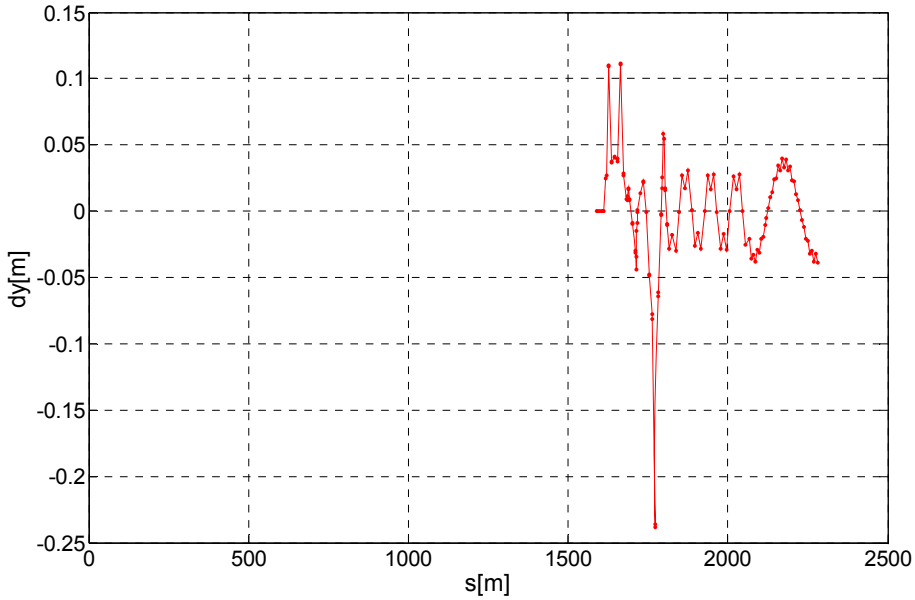
Average rms values for 200 seeds

R_{36} = 1.82 mm

From collimator to undulator
Quad field error

Magnitude of the error = 1 %

Vertical dispersion for 1 seed



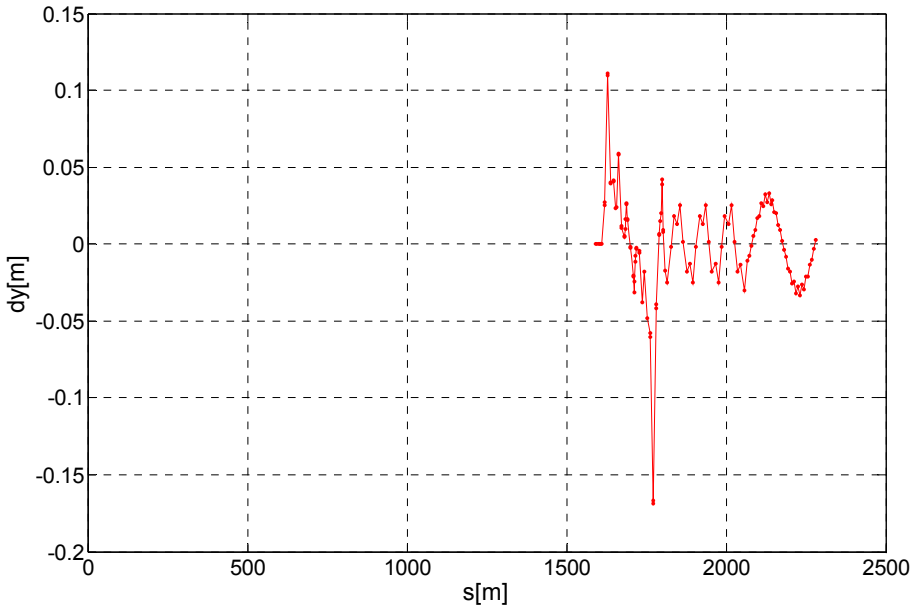
Average rms values for 200 seeds

R_{36} = 21.72 mm

From collimator to undulator
Quad component in dipoles

Magnitude of the error = 0.01 m^{-2}

Vertical dispersion for 1 seed



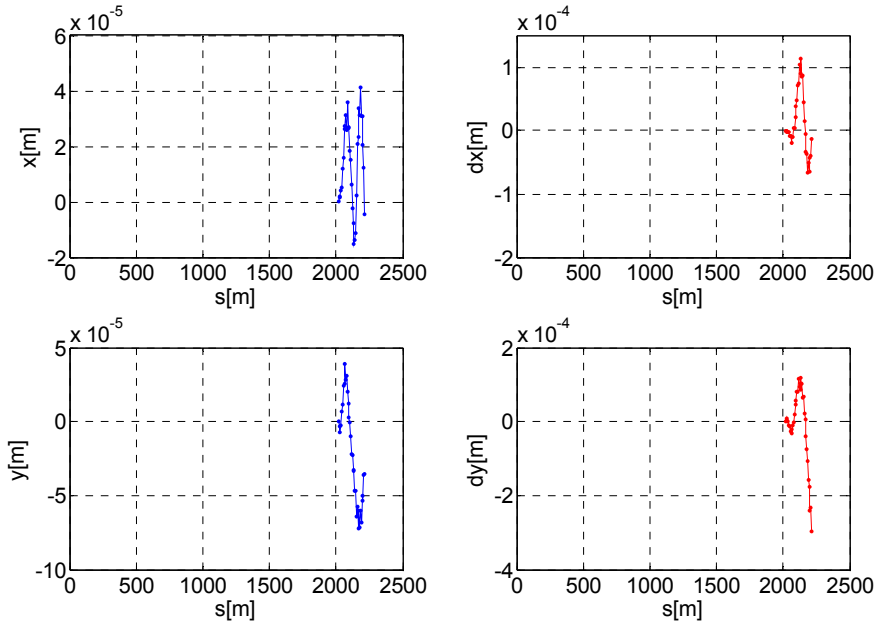
Average rms values for 100 seeds

R_{36} = 36.18 mm

UNDULATOR (SASE 1)
Quad misalignment

Magnitude of the error = 10 μm

Orbit and dispersion for 1 seed



Average rms values for 200 seeds

x = 0.05 mm
y = 0.05 mm
R_{16} = 0.13 mm
R_{36} = 0.14 mm

Summary table

Required error amount per type and zone to get **1 cm rms** dispersion in the **undulator** (SASE1). Mean values for **200** seeds.

Error \ zone	Bunch Compressor	Main Linac	From collimator to undulator	Undulator (SASE1)
Quad misalignment	**x = 4 μm** **y = 5 μm**	**x = 7 μm** **y = 8 μm**	**x = 6 μm** **y = 6 μm**	x = 0.8 mm y = 0.7 mm
Dipole field error	**0.07 %**	-	5.5 %	-
Quad field error	-	-	0.5 %	-
Cavity misalignment	x = 0.28 mm y = 0.25 mm	x = 2.28 mm y = 1.99 mm	-	-
Quad component in dipoles	**$4e^{-4}$ m^{-2}**	-	**$3e^{-3}$ m^{-2}**	-

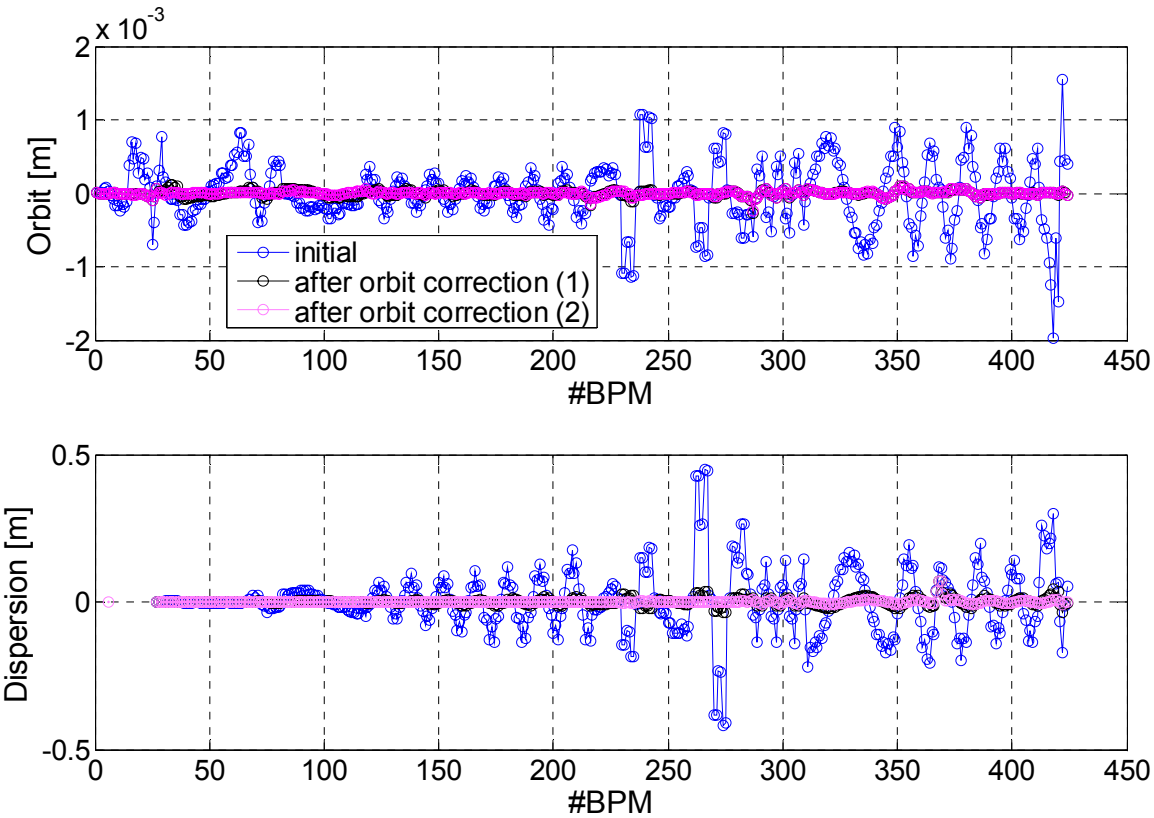
Multiple errors + orbit correction

Errors (1 seed)
- quad misalignment = 10μm
- quad field error = 1%
- dipole field error = 1%

Orbit correction:
156 / 136 available correctors (some missing)
~ 430 BPMs (quads)

Rms orbit
0.45 → 0.04 mm

Rms dispersion
118 → 6 mm



Multiple errors + orbit correction (another seed)

Errors (1 seed)
- quad misalignment = 10μm
- quad field error = 1%
- dipole field error = 1%

Orbit correction:
156 / 136 available correctors (some missing)
~ 430 BPMs (quads)

Rms orbit
0.12 → 0.03 mm

Rms dispersion
16 → 8 mm