Beam Based Alignment in the Undulator

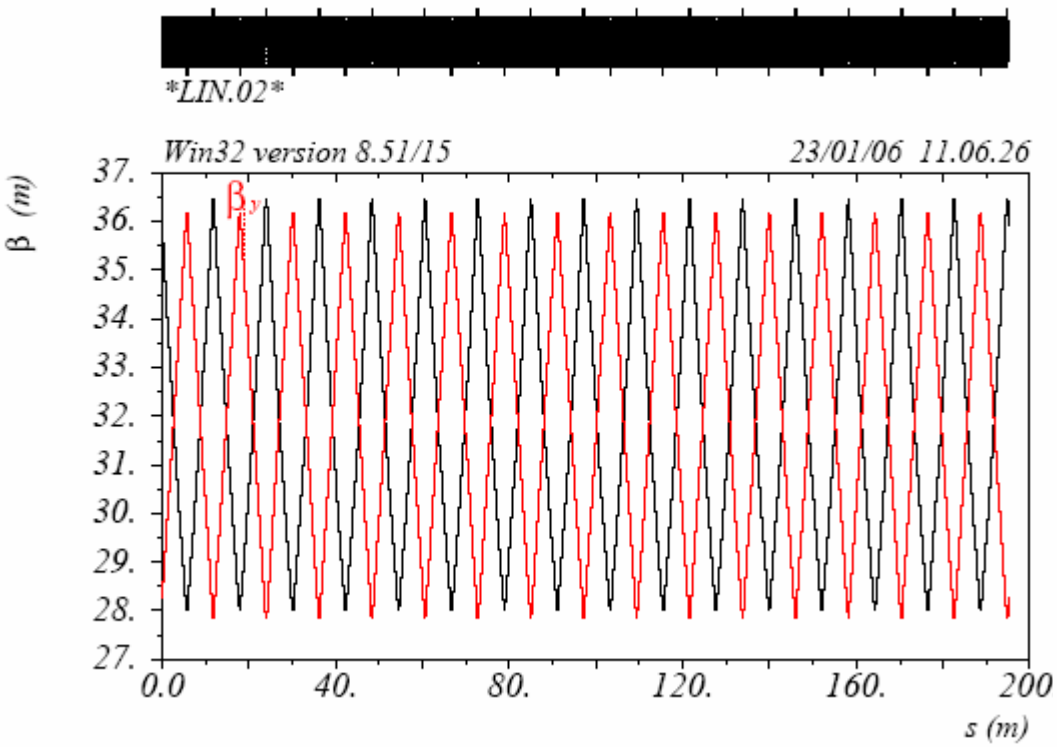
Winni Decking

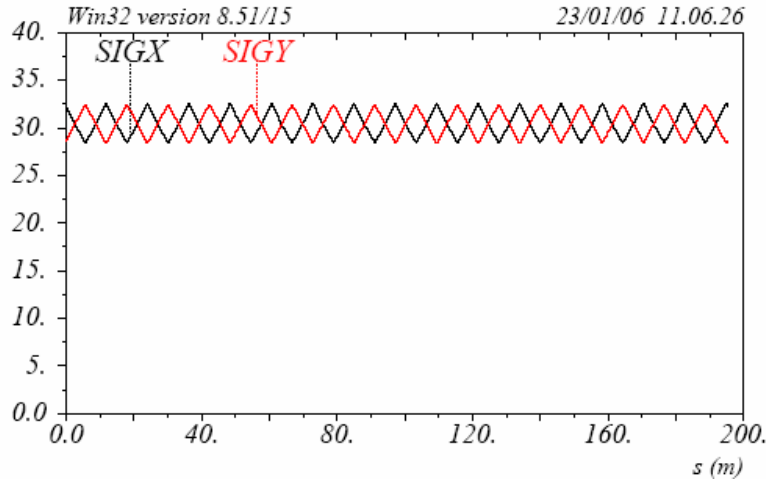
XFEI Beam Dynamics Meeting

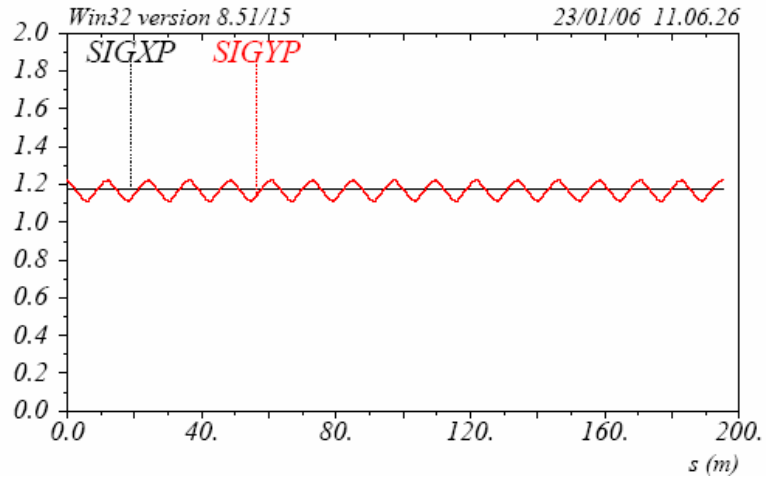
10.04.06

Assumptions

- Beam with ε_n=1 mm mrad, 17.5 GeV, $<\beta_{und}>\approx$30m







Optics in Undulator:

- $<\beta_{und}>$ ≈ 15-45m
- $\nu_{x,y}$ ≈ 50-15 deg
- kl ≈ 0.12-0.04 m^{-1}

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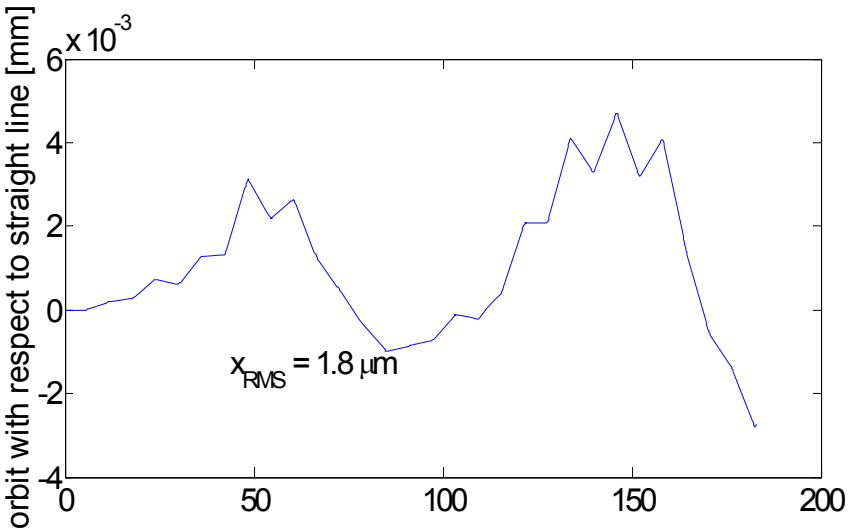
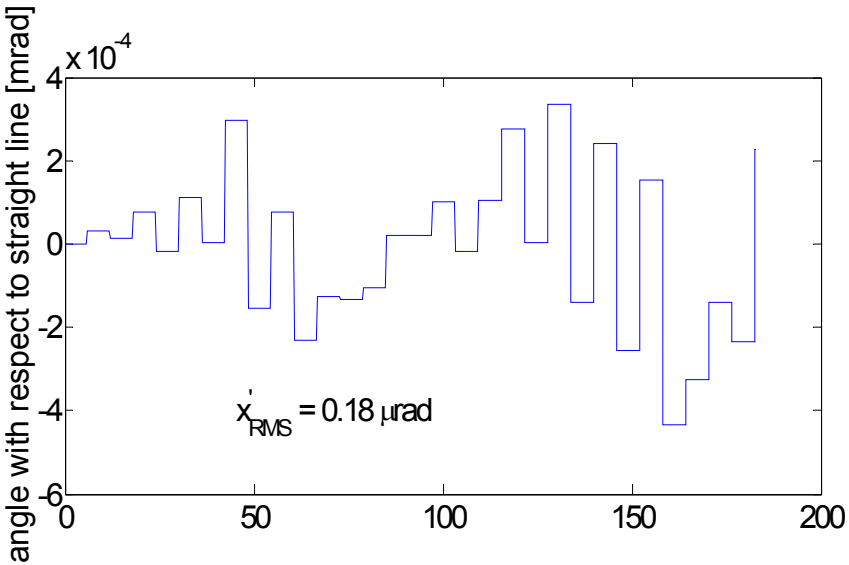
Trajectory Tolerances

	SASE	USER
x_{rms}	3 μm	
x'_{rms}	0.1 μrad	0.1 μrad
Timing		Measured to an accuracy < 30 fs

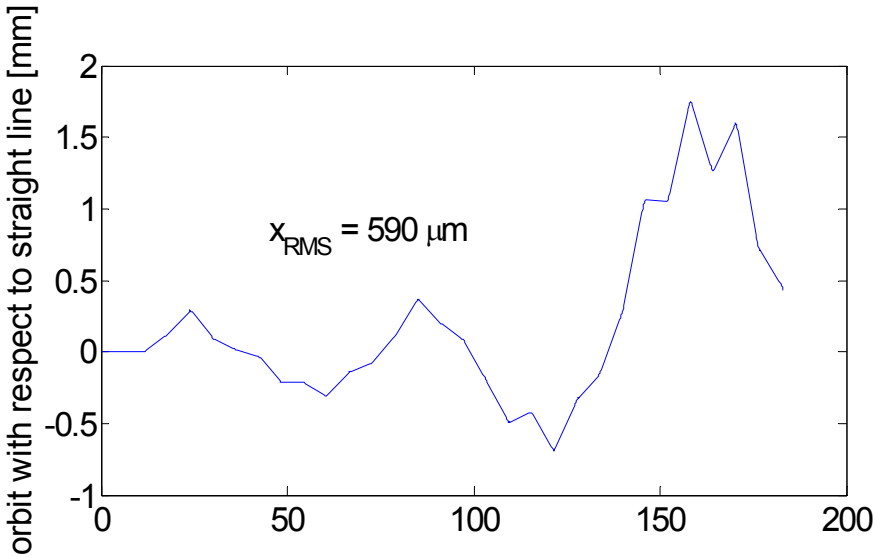
Unofficial quote: Conservative Assumption

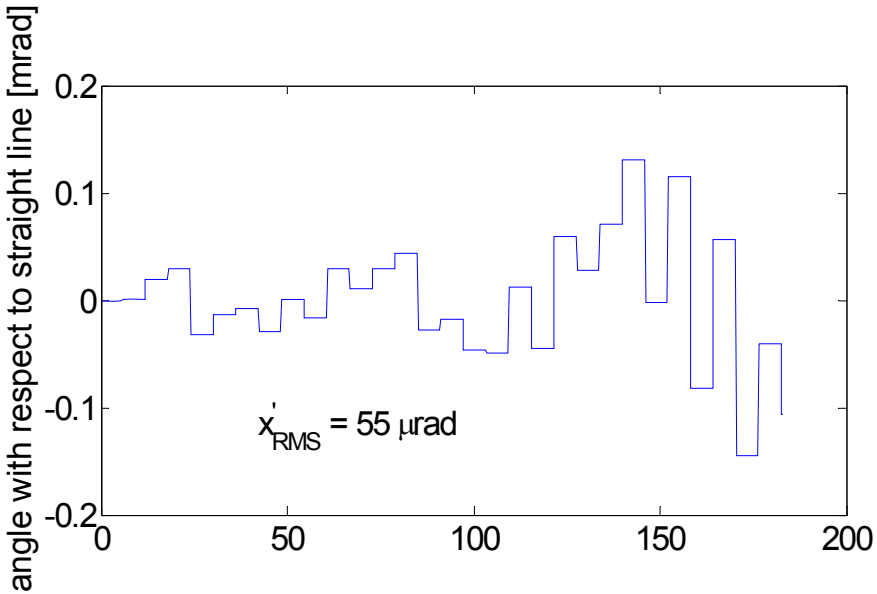
Alignment Tolerance Quadrupole





Quad$_{RMS}$=1 μm





Quad$_{RMS}$=200 μm

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Beam Based Alignment Methods

- Ballistic Correction:
  - find straight line through BPMs in the absence of quadrupole fields
  - switch on quadrupoles and steer towards this value

  - limited by BPM resolution
  - field free almost impossible
  - may require optics rematch
  - may lead to losses in undulator

Beam Based Alignment Methods

- Beam Based Alignment
  - vary quadrupole field strength and monitor BPM reading change downstream
  - change beam position in quadrupole (or quadrupole position) and redo

  - robust
  - time consuming
  - vulnerable against quad-center changes
  - only centers quad, no correction of other kicks

Beam Based Alignment Methods

- Dispersion Free Steering
  - measure off energy trajectory and determine dispersion
  - minimize dispersion (and orbit)

  - BPM resolution limited
  - no magnet changes required if within ± 3% energy band
  - corrects for all kicks

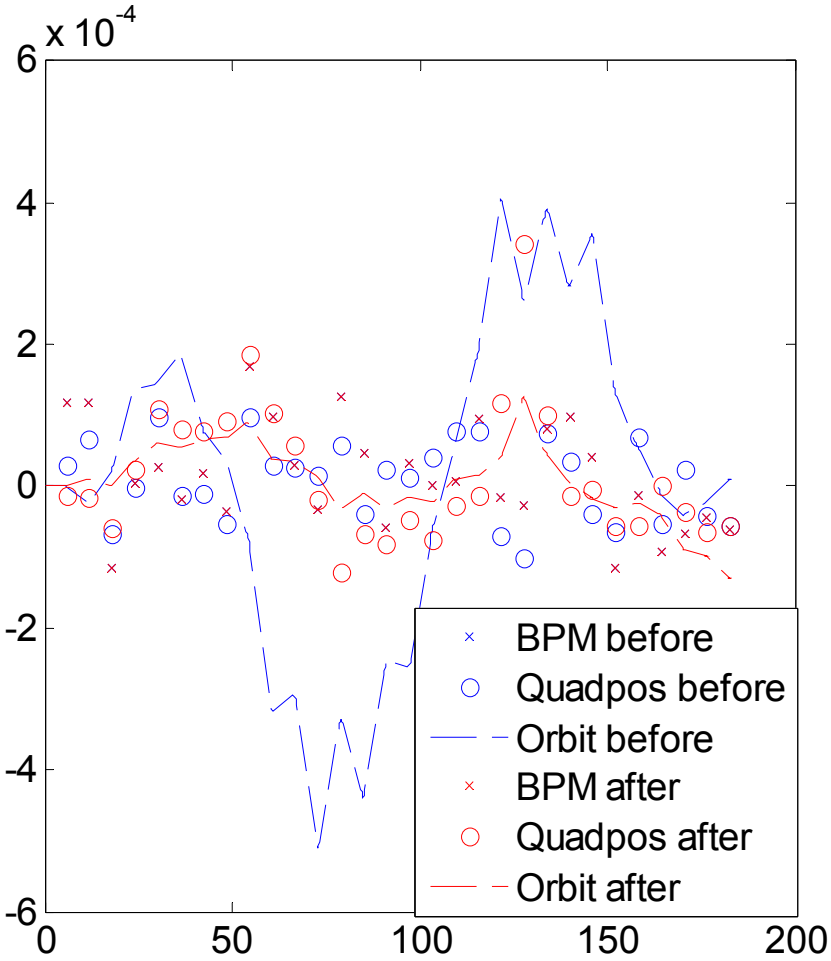
Simulations

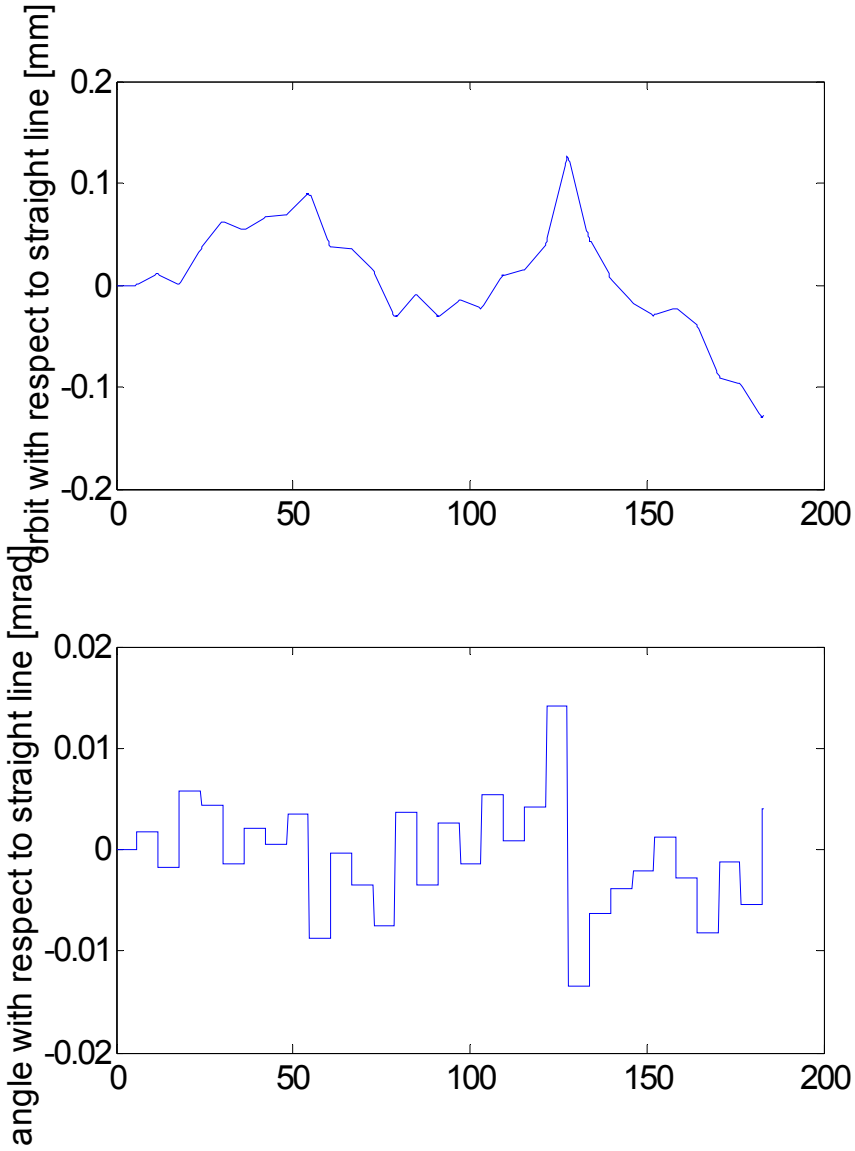
- $Quad_{RMS}$=100 μm
- BPM $Alignment_{RMS}$=100 μm
- BPM $Resolution_{RMS}$=0.1 - 1 μm

- Momentum change by ± 3 %

- MAD Optic Server
- MATLAB Orbit Correction toolbox (as used in TTF)

Simulation 1 μm BPM Resolution





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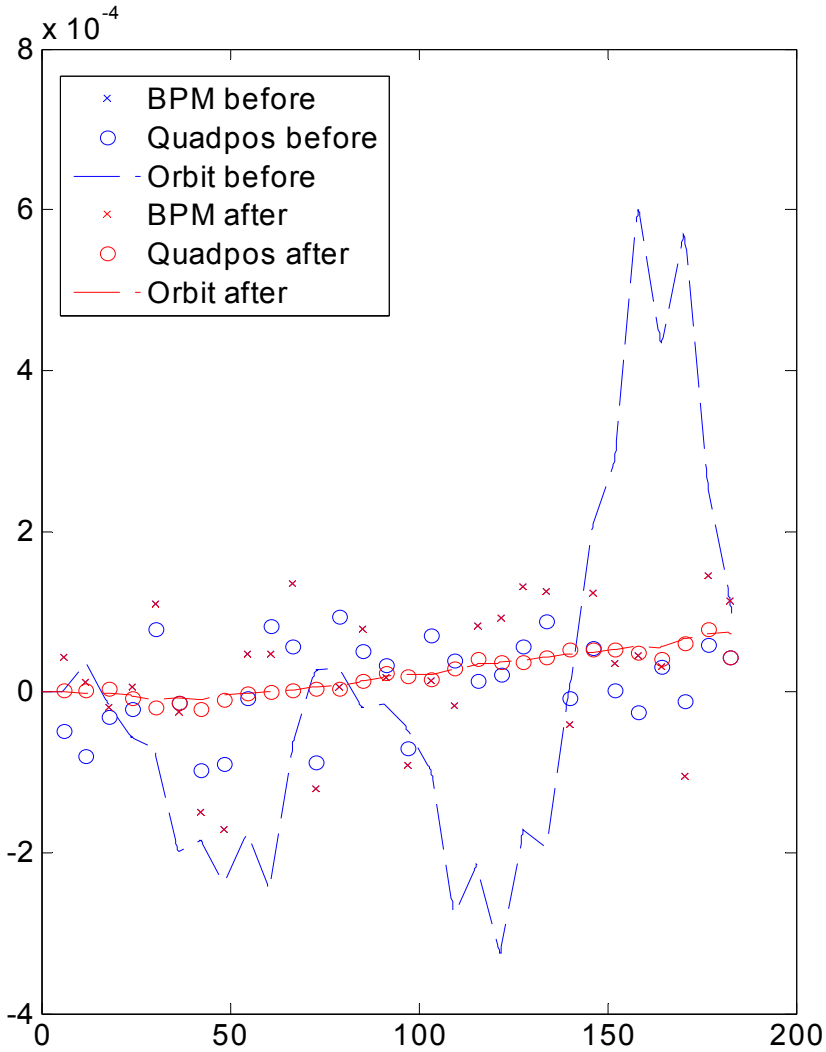
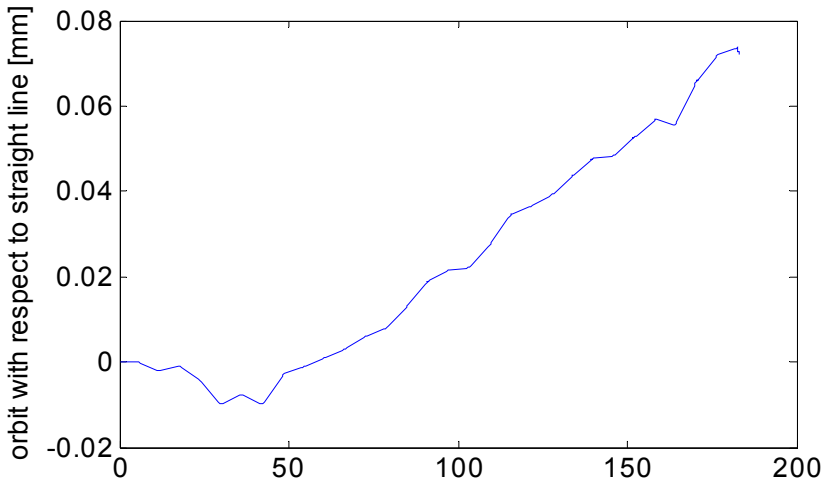
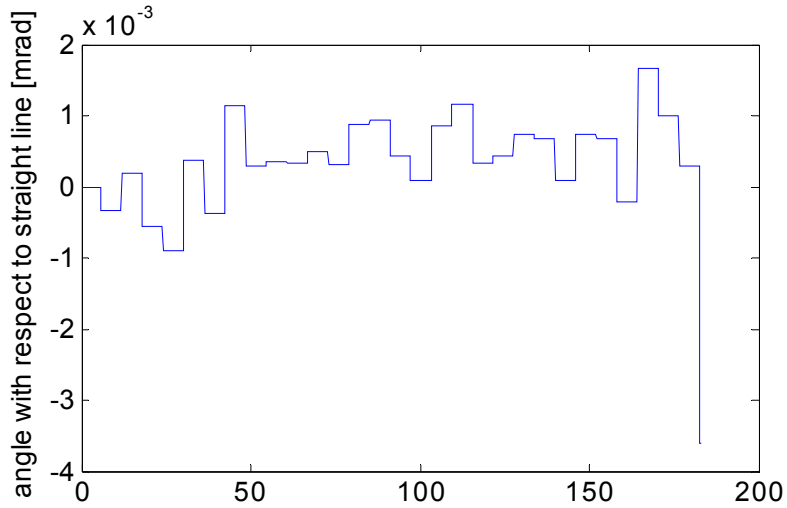
Simulation 0.1 μm BPM Resolution







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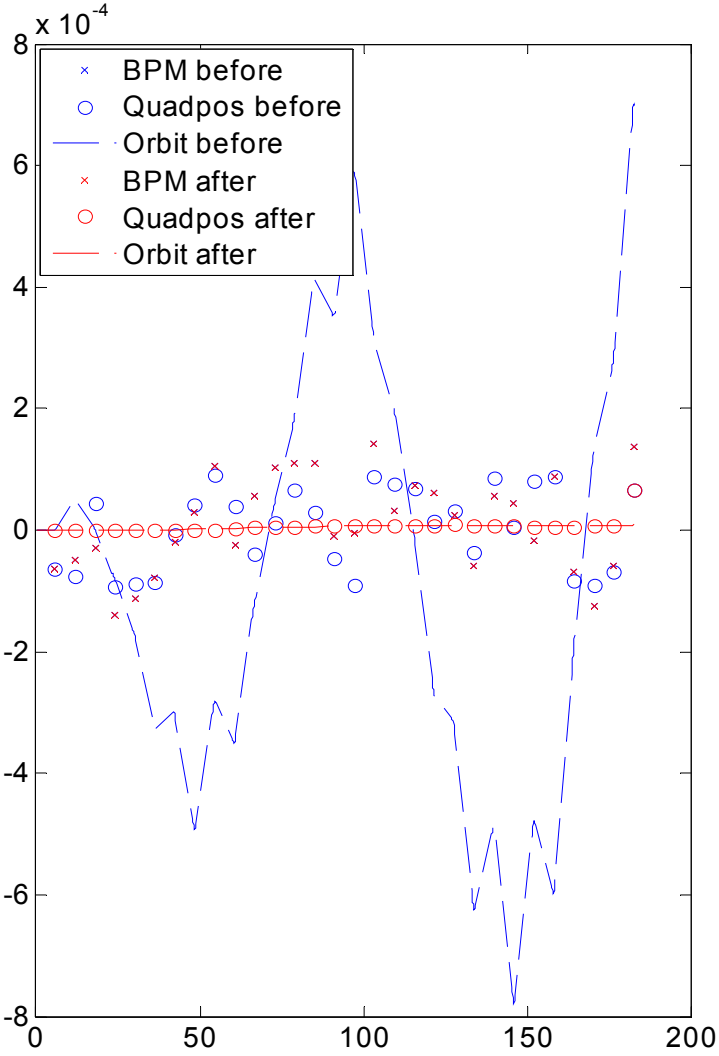
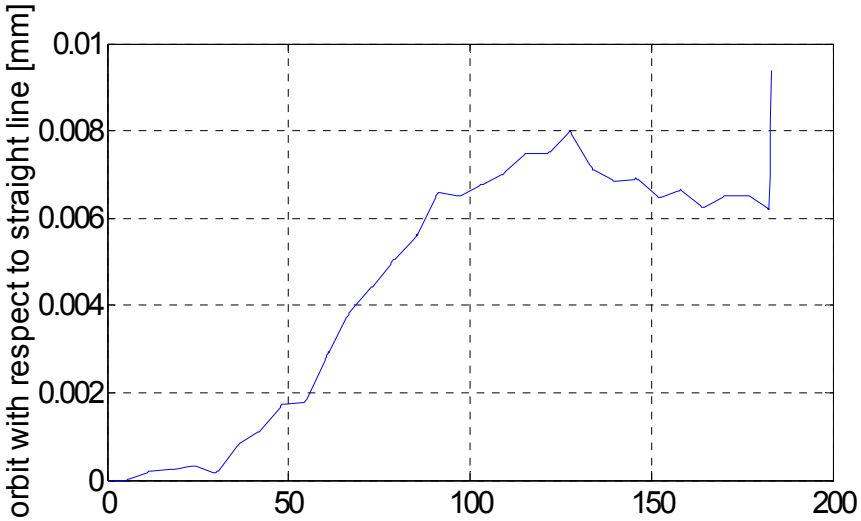
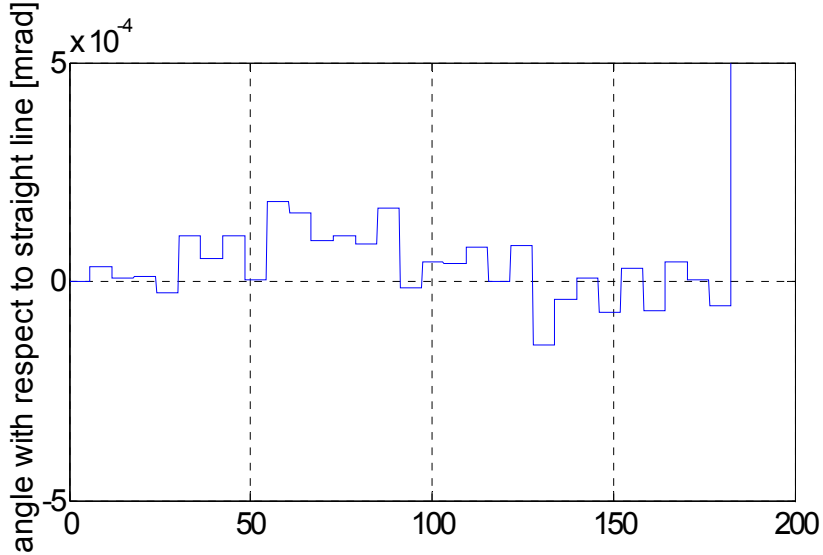
Simulation 0.01 μm BPM Resolution







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Summary

- Successful DFS needs BPM resolution of 10 nm
- Resolution maybe obtained by averaging
- Resolution can be relaxed with larger energy change, needs magnet scaling
- More simulations with more errors needed