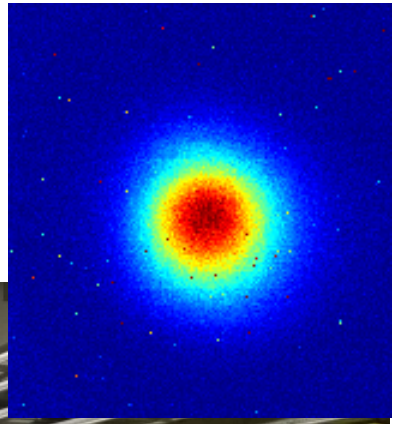
Simulation of FLASH1 performance



Bart Faatz
Hamburg, July 3, 2018

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

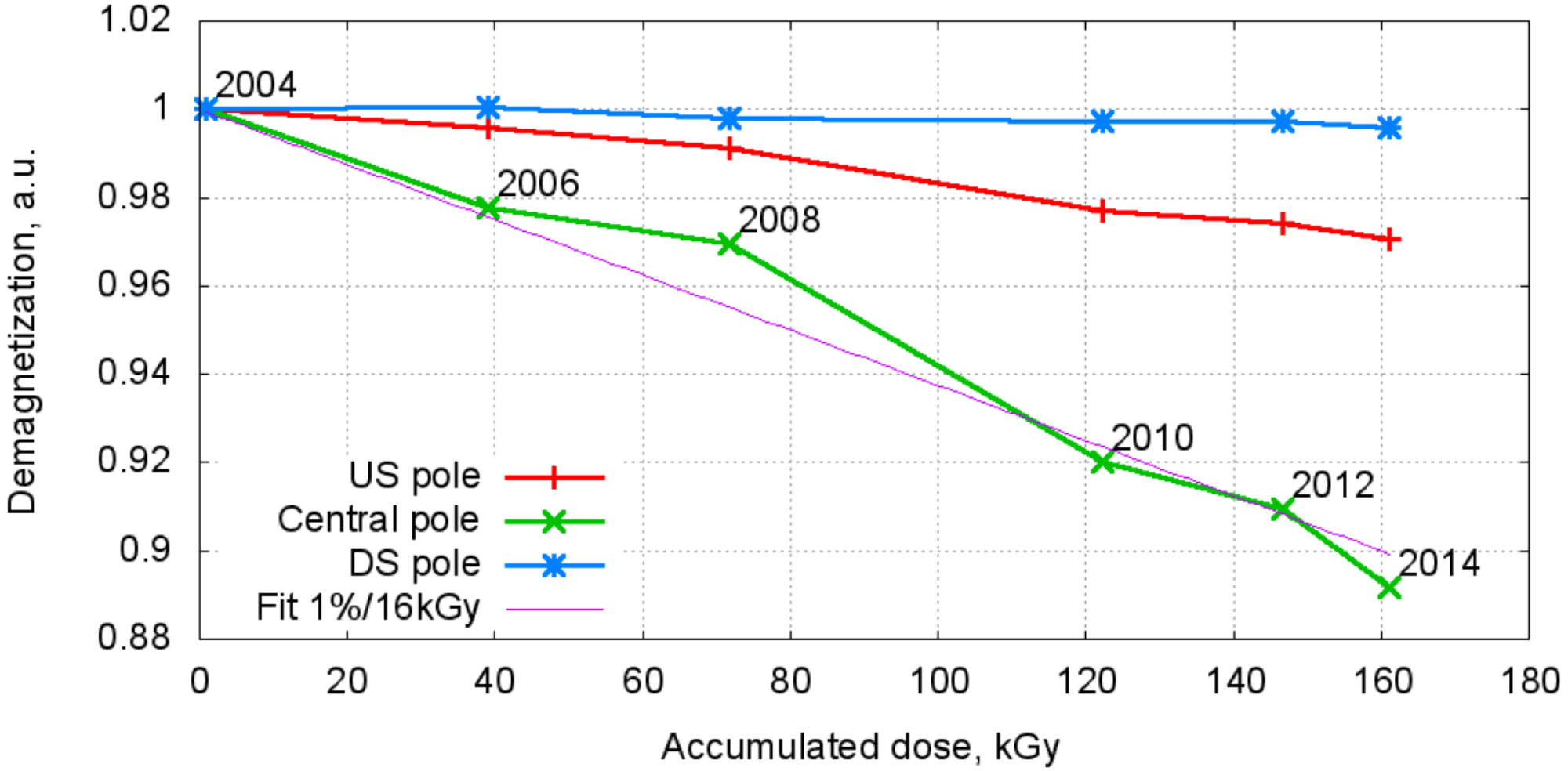
DESY.

Undulator damage estimate

- Every 2nd week, TLDs are taken out of the undulator of FLASH1 and FLASH2
- In FLASH1, there are 5 TLDs per undulator
- In front of the main undulator at FLASH1 and FLASH2 there is a sacrificial undulator with TLDs which is taken out regularly to measure the magnetic field
- These results are used as a basis for simulation of the FEL performance

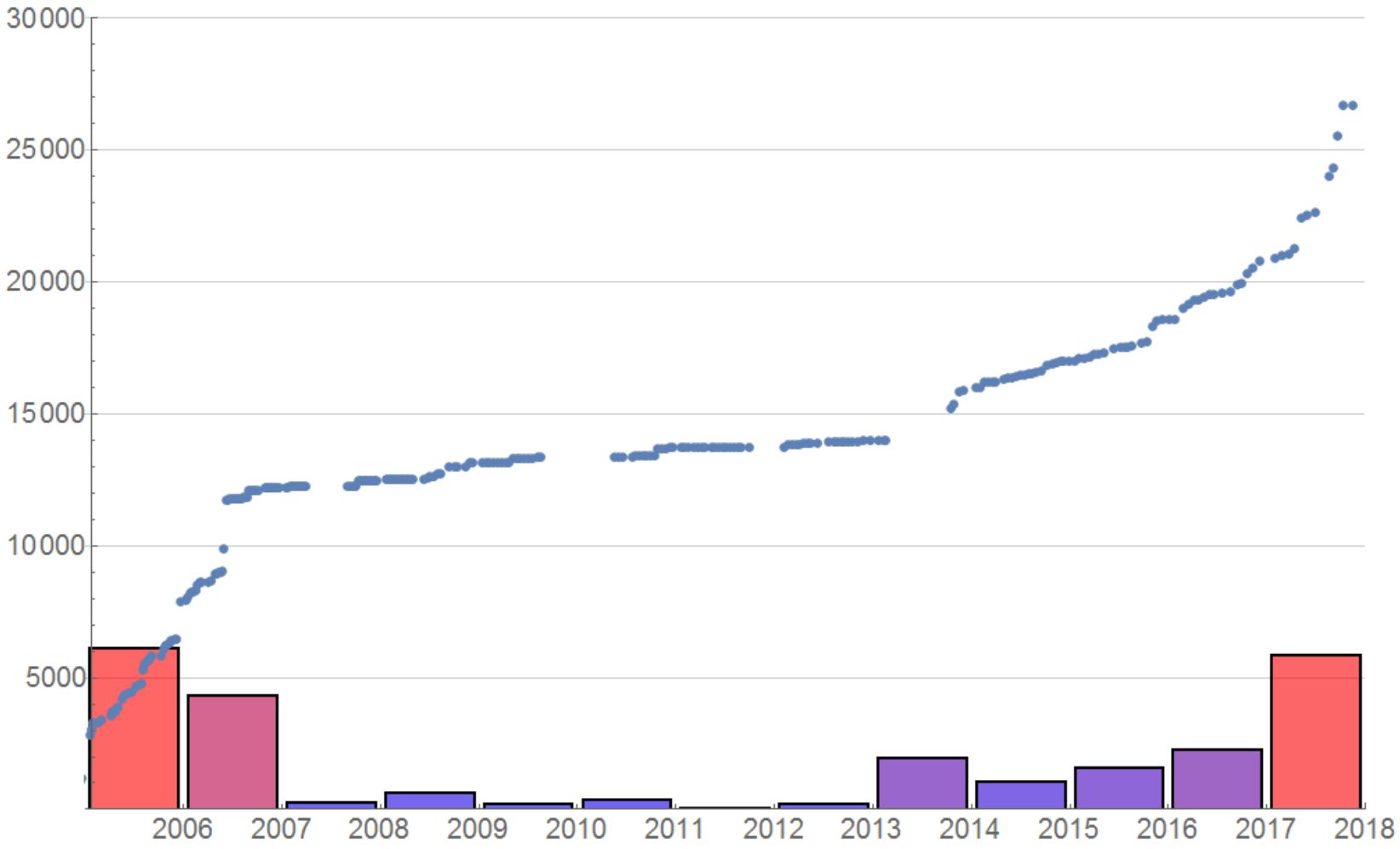
Results of TLD and demagnetization measurements FLASH1

The up- and downstream poles show less demagnetization as they have smaller magnets. Therefore demagnetization fields are lower than for the normal magnets in the center. In addition to that the downstream magnets are shielded by preceding poles



Losses at FLASH1 since startup

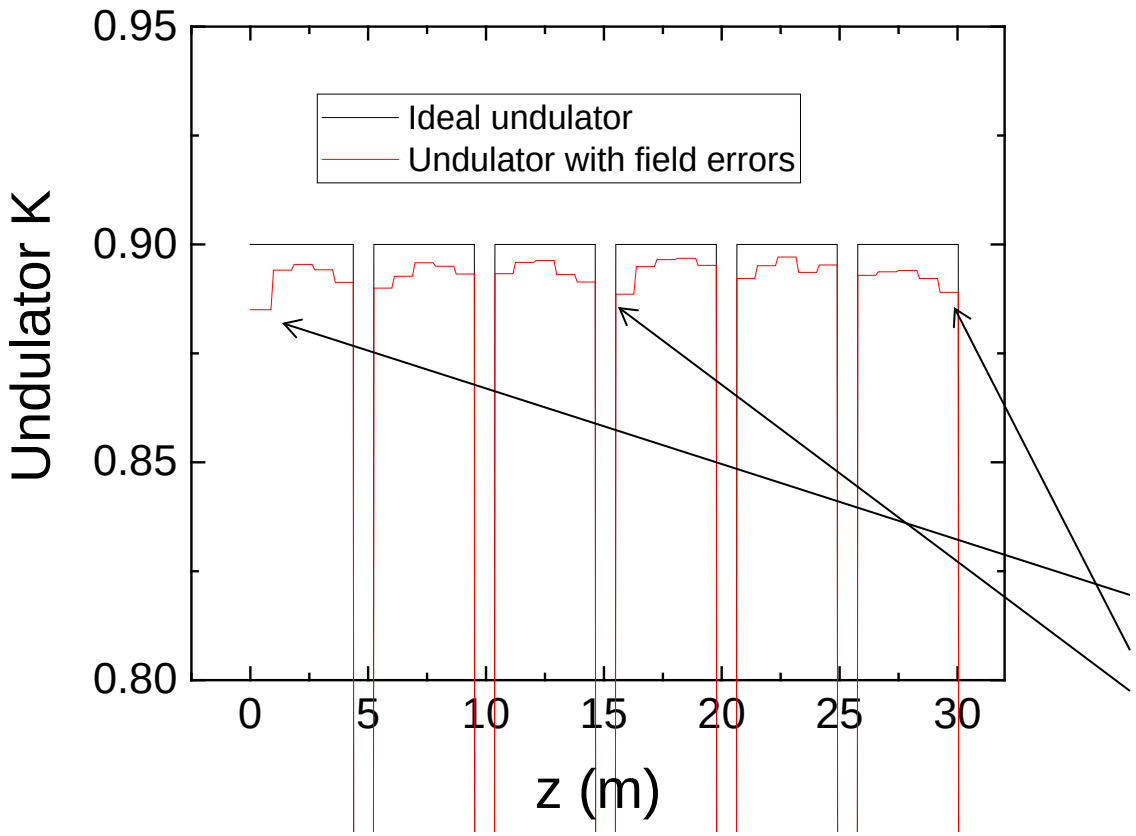
maximum loss (in Gy) in the undulator since the start of FLASH in 2005



Simulation parameter

- 1.23 ! Beam energy in GeV
- 2000.00 ! Beam current
- 0.140E-05 ! Normalized emittance
- 0.20000 ! Energy spread in MeV
- 0.100E-04 ! Bunch length
- 4.368x6 ! Undulator length
- 0.9 ! RMS K-value w/o errors (slightly higher than FLASH1 value)
- 0.894 ! Average RMS K-value with errors
- 72.0E-6 ! Beam size

Estimated field (reduction) due to radiation damage



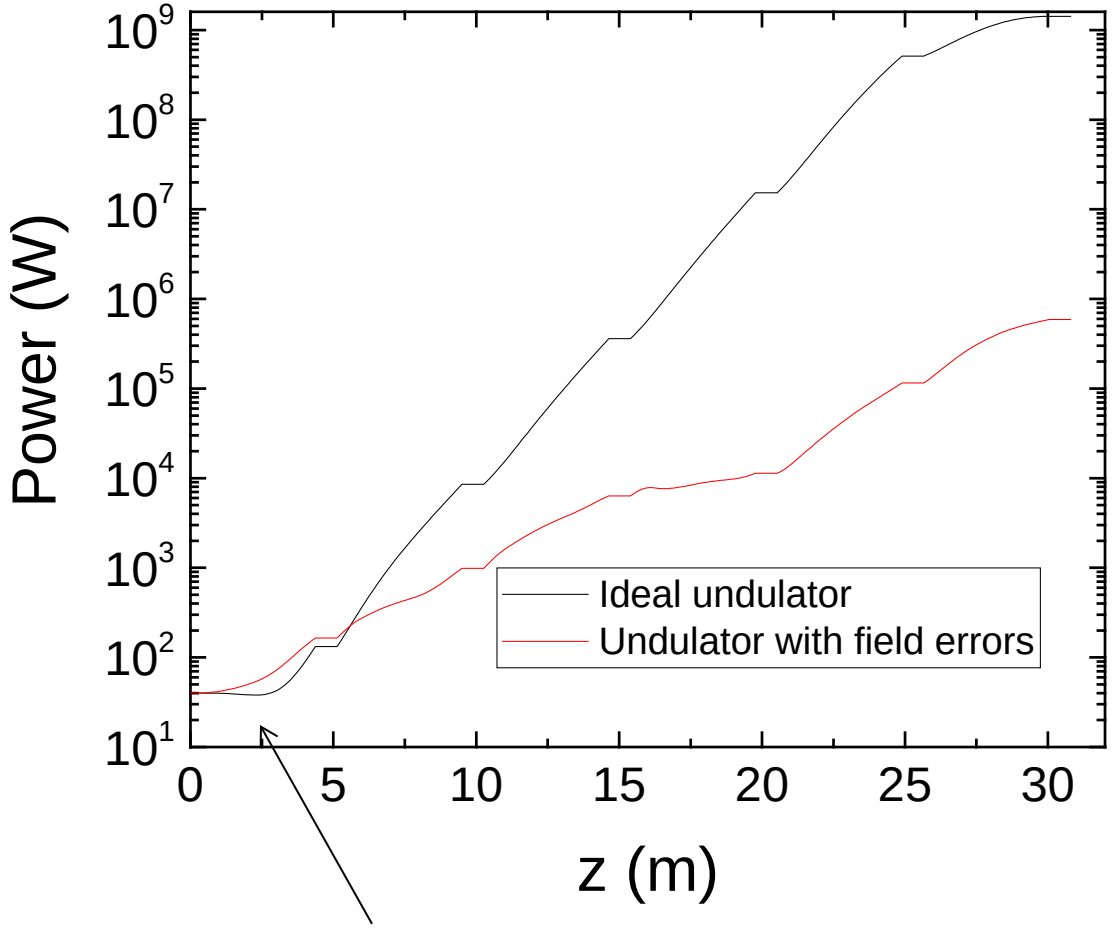
- Overall wavelength is shorter for the same energy.
- Local field loss cause reduced transverse overlap and loss of resonance conditions.

Each TLD value taken as value for 1/5 of undulator length.
K-reduction as step function (5 values per undulator).

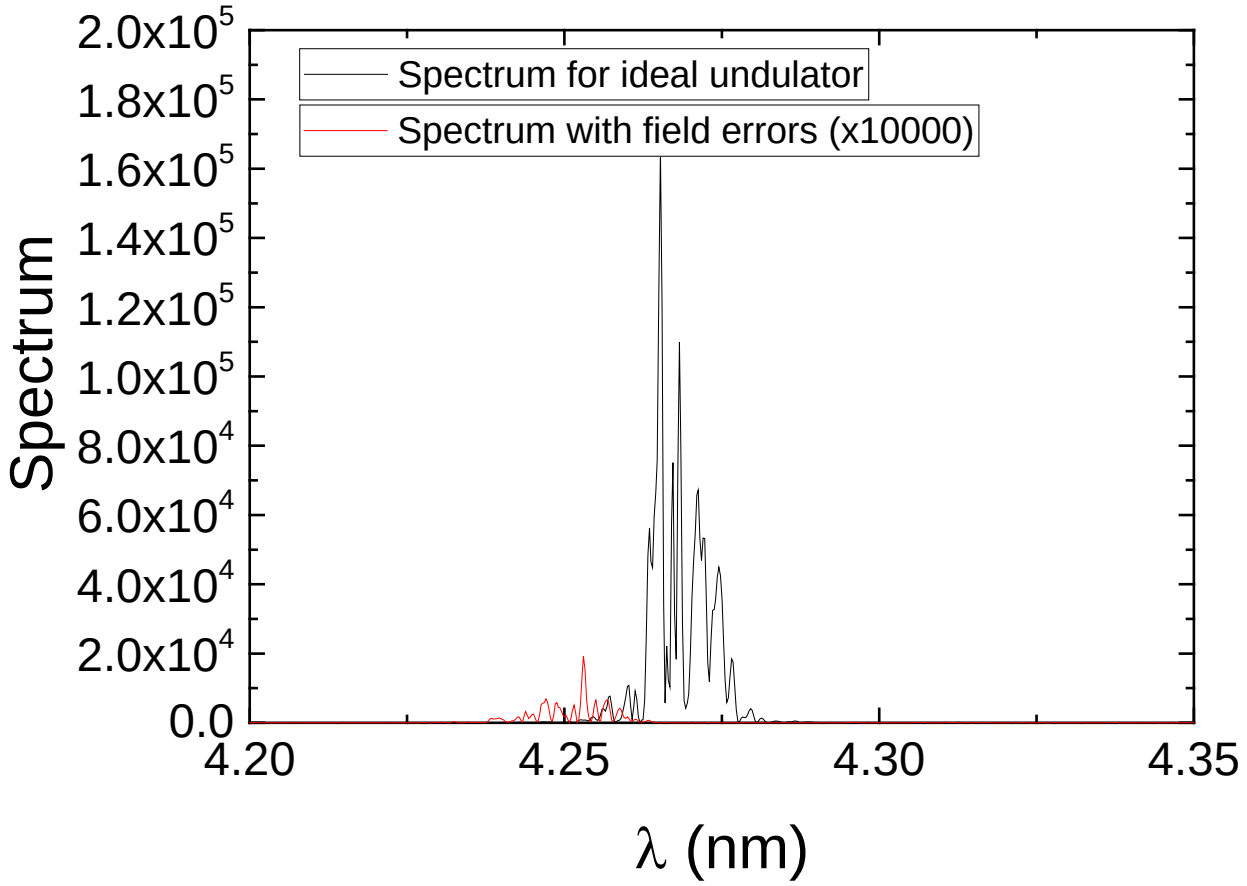
High losses in UND1 during initial startup (2005)
High losses in UND6 due to short in a Quad
High losses in UND3/4 occurred after startup summer 2017

Effect undulator errors.

Power growth (steady state, left) along undulator and spectrum at the end (time dependent, right)

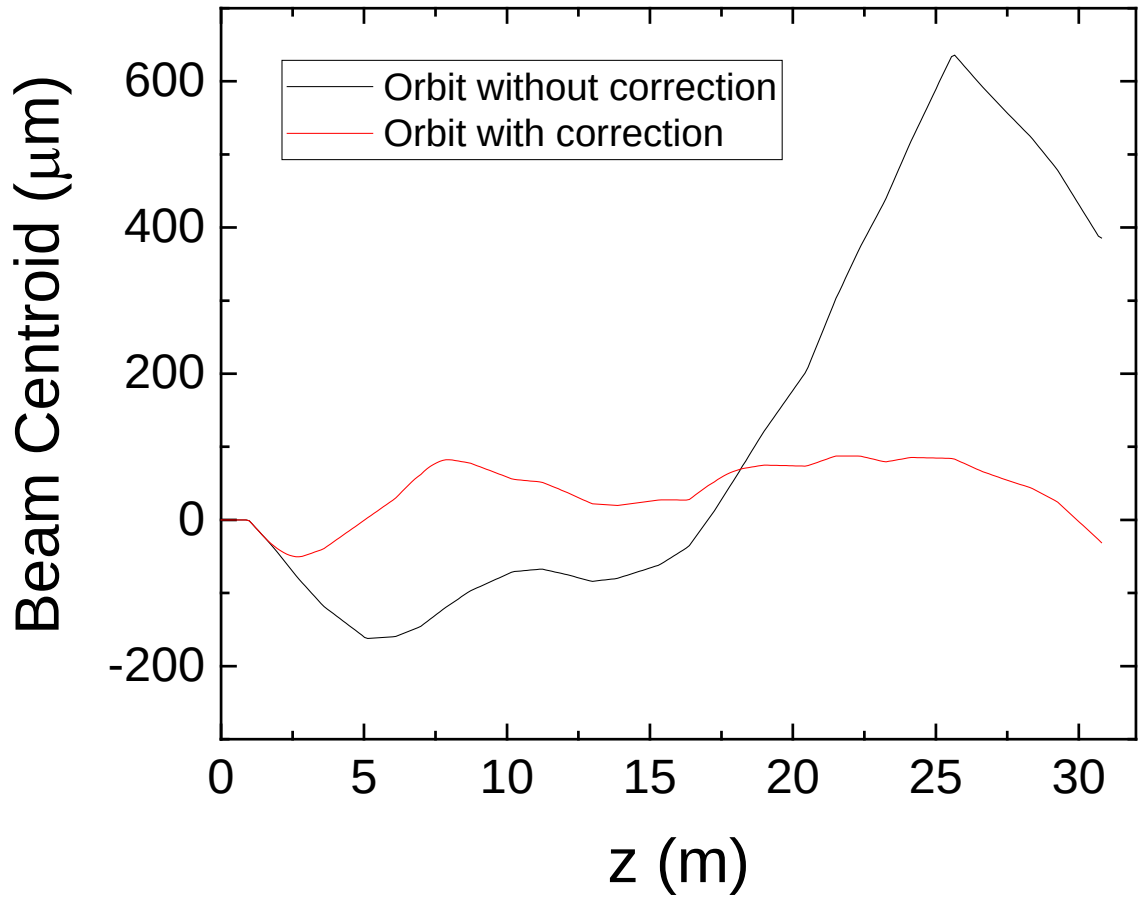


Different startup behavior due to wavelength shift (not correct in these steady state simulations)



Reduced transverse overlap

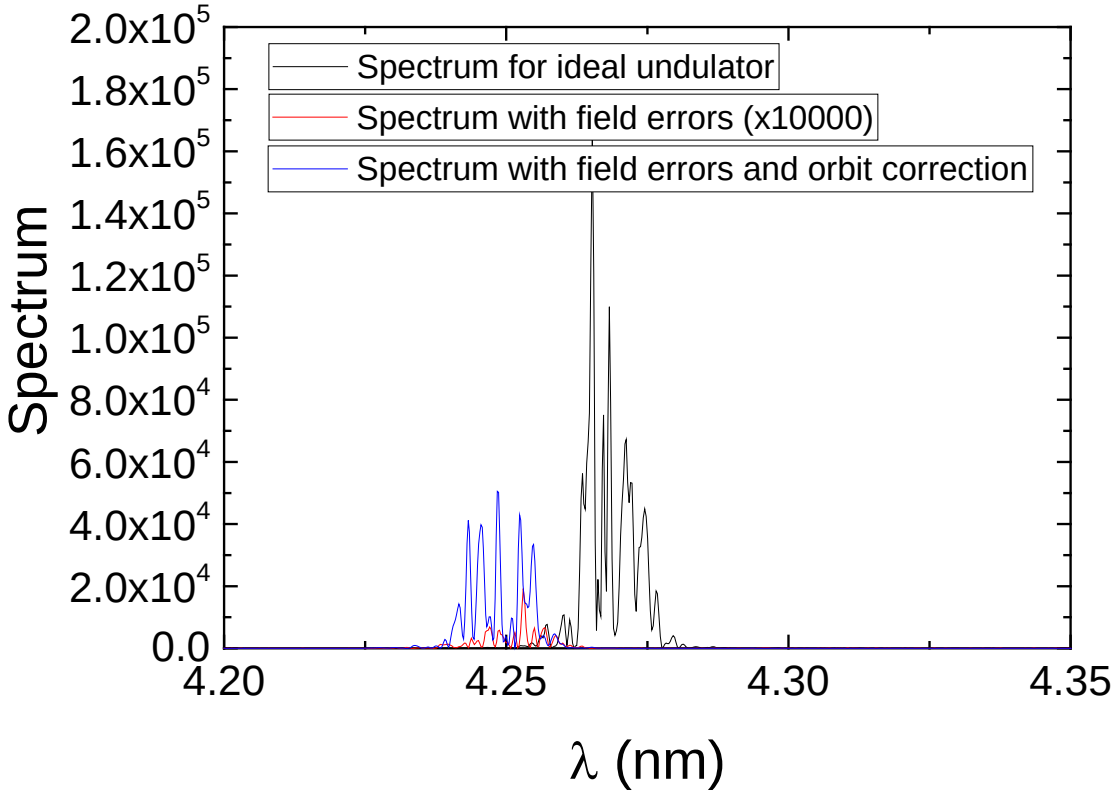
Use FLASH1 intra-undulator steerers to correct

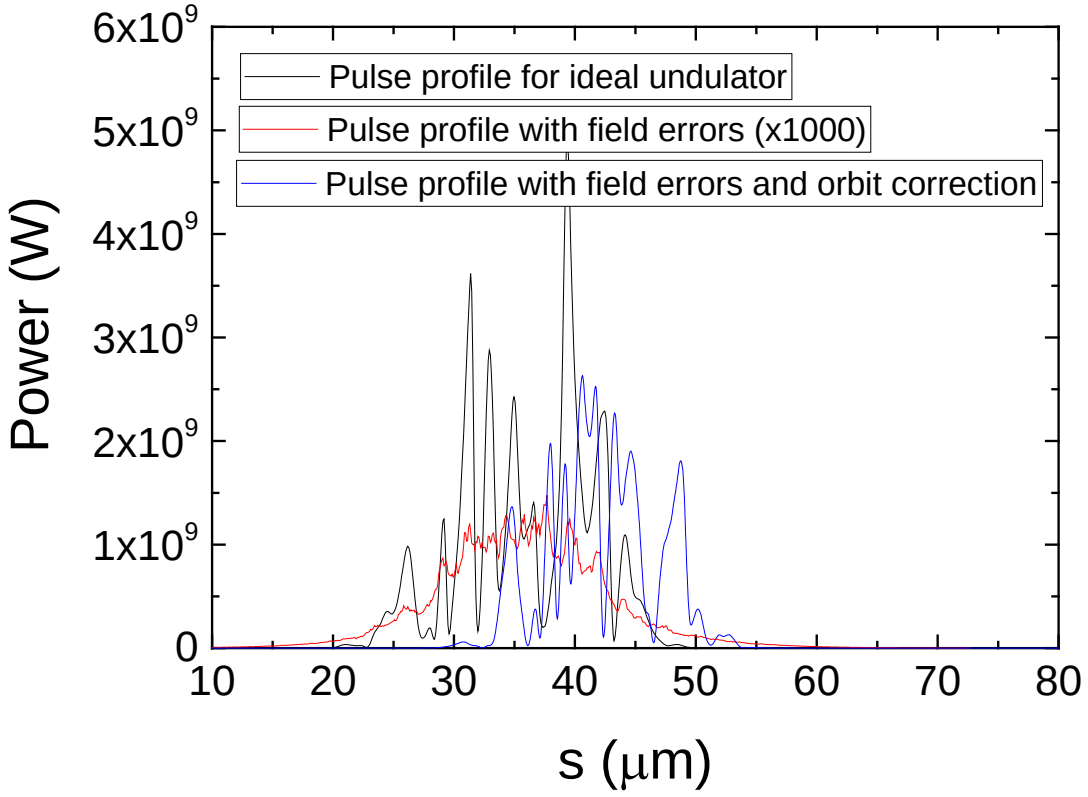


- In each undulator a 1.5 m long steerer.
- Orbit correction still deviating from ideal.
- Combination of quad movers and steerers will probably produce better results.

Performance reduction is still within limits

Mostly corrected by orbit correction





- Wavelength slightly shorter
- Pulse energy reduced by (correction is not optimized)

Conclusion

- Pulse energy is clearly reduced (for 4.2 nm).
- Unclear what the radiation pulse looks like for different magnetic field profile (smooth instead of steps).
- Combination of steerers and quad mover changes has not been tested but would probably improve the situation.
- What the effect is for long wavelengths (spectral broadening) has not been simulated.