Proposed Fringe Field Studies at the Cockcroft Institute

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Objectives

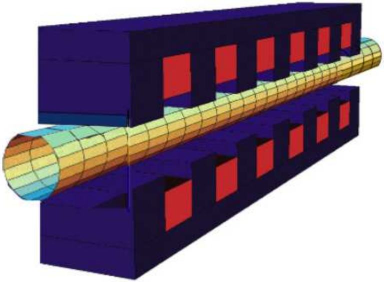
- Generate symplectic thin lens representation of the IT quad fringe fields
  - Implementation into sixtrack for DA studies
  - Compatibility with current error tables
- Representation of the main body should be left unchanged
  - Fringe field maps should not incorporate the quad component which is already included in the main body map
  - Use negative drift lengths to give the correct magnetic length
- Dipole fringe fields?

Computational Tools at the CI

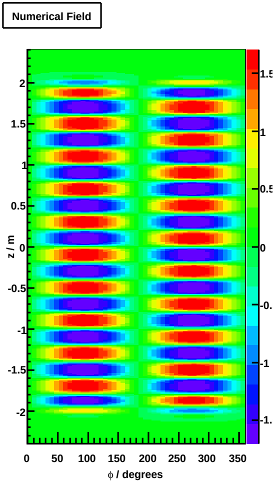
- Construct analytic descriptions of magnetic fields using Dragt's method of Generalised Gradients
- Integration using Wu-Forest-Robin symplectic integrator for straight elements
  - Numerical integration
  - Analytic integration (TPSA - not symplectic!)
- Integration using mixed-variable generating functions (A. Wolski)
- SAMM code to integrate fringe field maps into HL-LHC lattice + perform DA calculations

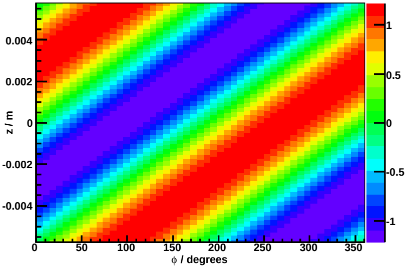
Analytic Field Descriptions

- Construct analytic descriptions of magnetic fields using Dragt's method of Generalised Gradients
  - Based on 3D numerical field maps
  - Deconstructs field into normal/skew multipole components

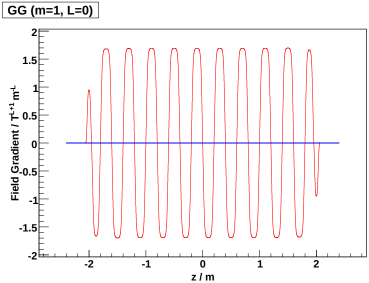


Surface Data - CeSR Wiggler, ILC Undulator





CeSR Wiggler Field Components



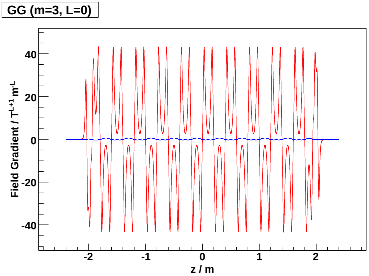


Figure: On-axis generalised gradients representing the dipole (left) and sextupole (right) components of the CeSR Wiggler

Integration

Numerical integration:

- Wu-Forest-Robin

Analytic:

- Differential Algebra code developed at CI as a fast alternative to COSY
- Used in different applications within CI - benchmarked
- Implemented in Wu-Forest-Robin integrator to generate Taylor map (order 6 in dynamical variable)
  - Can easily be increased up to order 9
- 'Beta' version available up to arbitrary order

Symplectic Integration with Generating Functions

- Technique developed by A. Wolski
  - Journal of Instrumentation, vol 7, P04013
- At each integration step, the map is represented by a mixed-variable generating function
  - Exact symplecticity is ensured
  - Map coefficients can be determined numerically (iterative technique)

SAMM computer code

- Particle tracking code
- MATLAB wrapper running C/CUDA routines
- Can parse MADX Lattices
- LHC lattice already implemented
- GPU used for multi-particle tracking (DA calculations)

Initial Evaluation of Fringe Field Affects

Using tools available at CI take a preliminary look at the effect of the fringe fields on the dynamic aperture

- Generate analytic description of quadruple fields from numerical data
- Generate transfer map (truncated at order ~ 6)
- Implement Map + HL-LHC lattice in SAMM
- Correct optics
- Generate frequency map (few hundred ~ 1000 turns)

Initial Evaluation of Fringe Field Affects

- Using tools available at CI take a preliminary look at the effect of the fringe fields on the dynamic aperture
- We expect we can make rapid progress here (if no surprises in the field data)
- Benchmarking of field accuracy, thin/thick lens effects, numerical precision, computation speed...
- Milestone before looking at main objectives

Symplectic Maps

- Numerical tracking (symplectic integrator)
  - WFR/RK
  - Speed optimisation/benchmarking?
- Symplectic maps from generating functions
  - Use truncated maps to give start point for iterative process
  - Speed optimisation/benchmarking?
- High order truncated Taylor map?
  - Ensure symplectic error << machine precision

Integration into Sixtrack

- Symplectic thin lens representation of fringe fields
- Compatible with error tables
- Split quad field from fringe field effects ?

MQXFC Field Data