

CODE COMPARISON AND LATTICE MODELS

Leon van Riesen-Haupt

Many thanks to:

Rogelio Tomas, Tobias Persson, Tessa Charles, Katsunobu Oide, Helmut Burkhardt, Frank Zimmermann, Michael Hofer

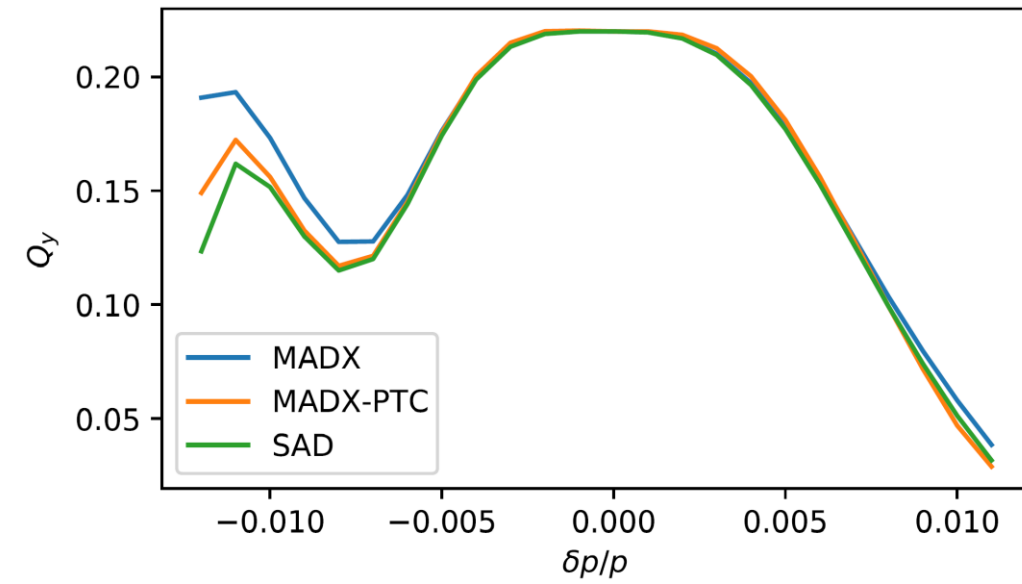
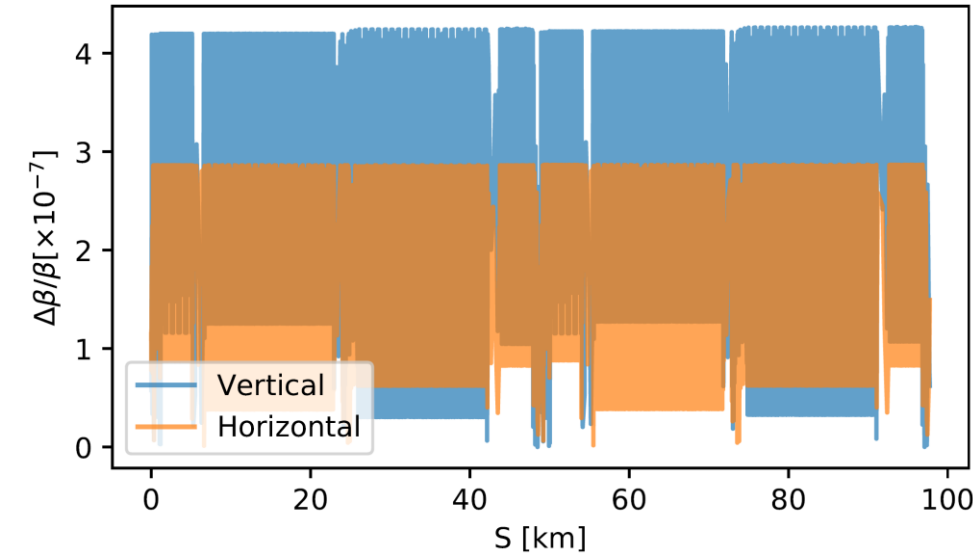


COMPARISON STUDIES

Comparison Studies – Optics

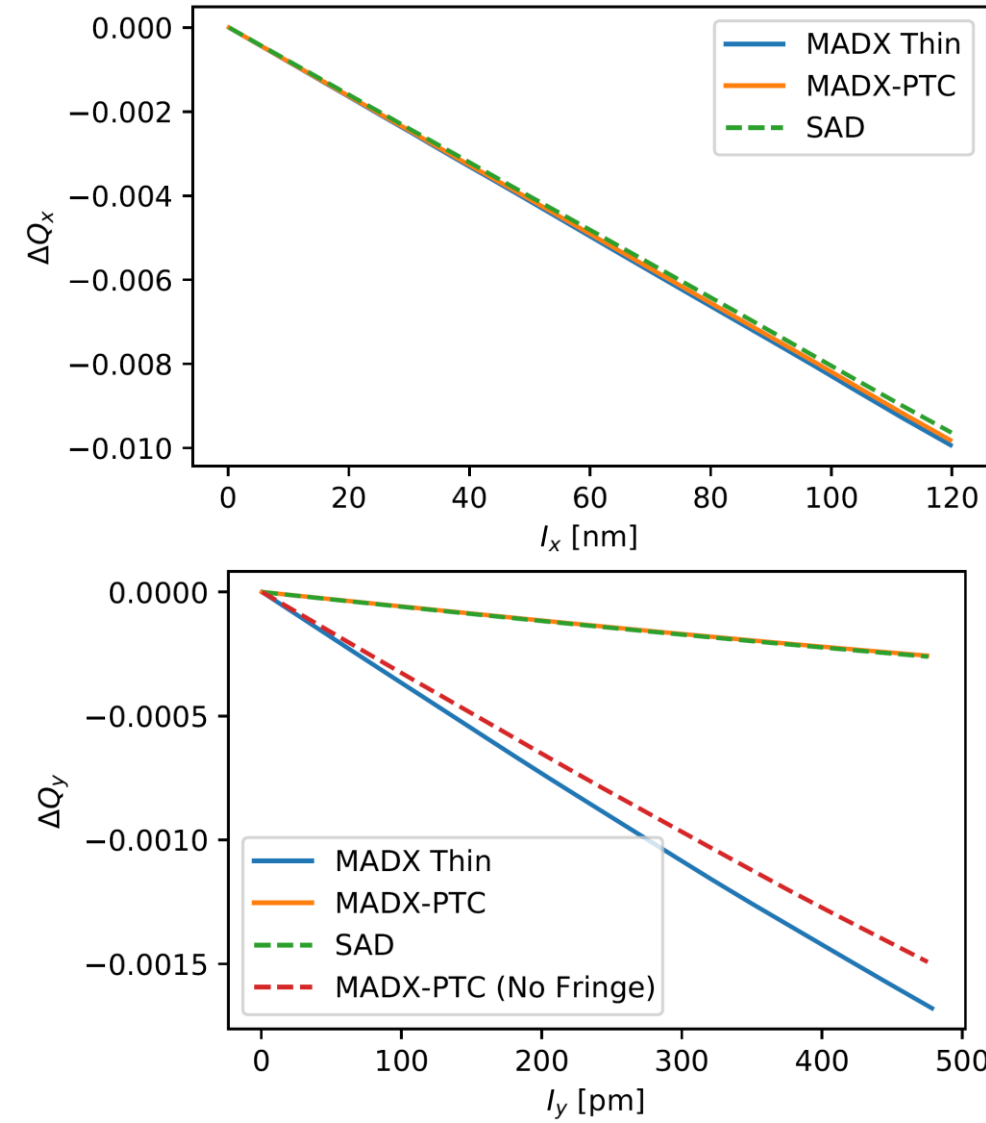
- **Comprehensive comparison studies**
 - Beating between linear optics
 - Momentum detuning
 - Very good agreement between SAD, MADX, MADX-PTC
- **Presented during IPAC'21**
 - TUPAB004
- **Essential for ensuring optics studies in both codes are compatible**
 - Testing that translation is accurate
 - Creating basic job files

β -beating between MADX and SAD



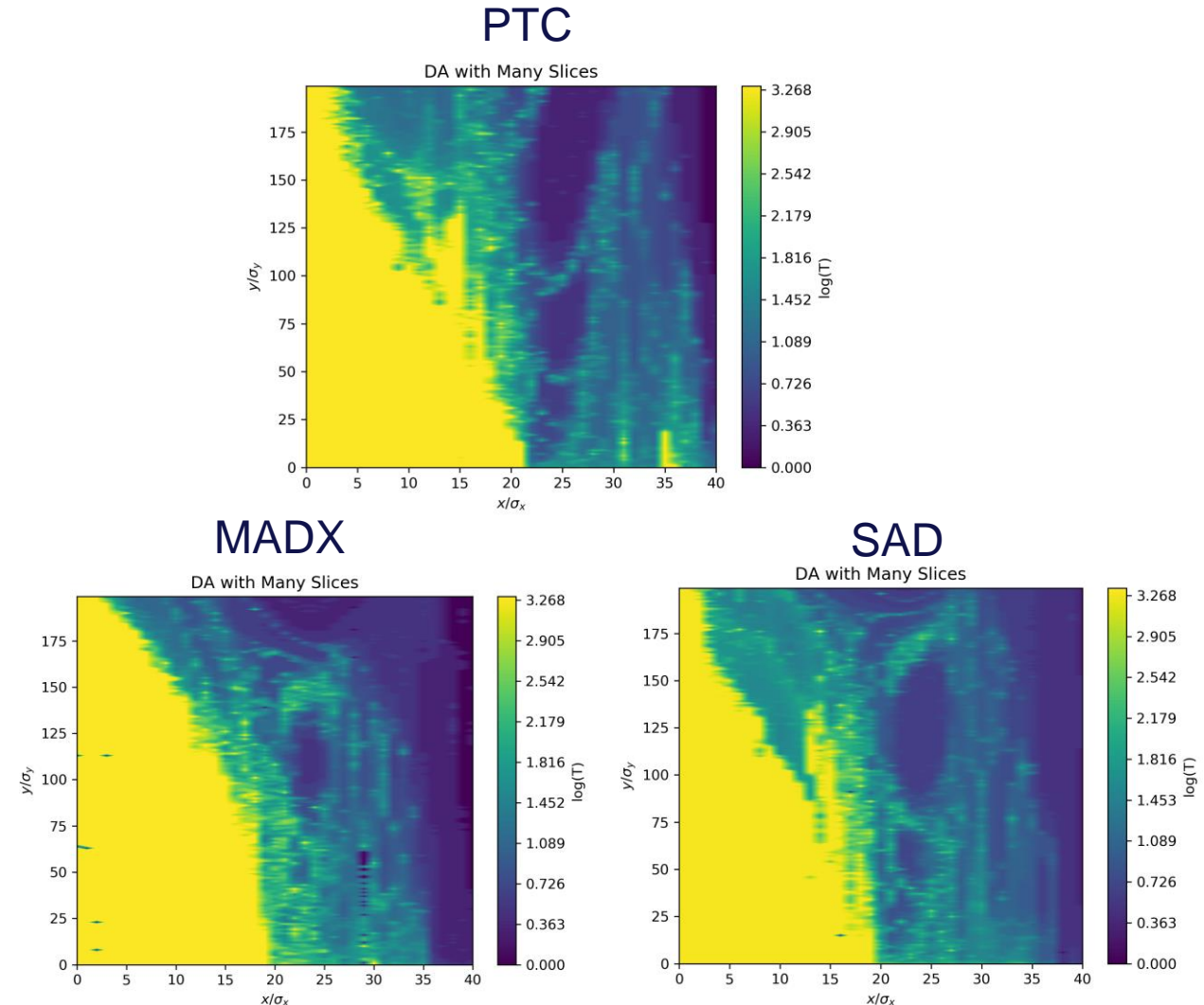
Comparison Studies – Tracking

- **Tracking to study amplitude detuning**
 - Also presented in IPAC'21 TUPAB004
 - Good convergence when many integration steps are used in IR magnets
 - Important information for DA tracking studies
 - Setting essential in MADX and SAD



Comparison Studies – DA from Tracking

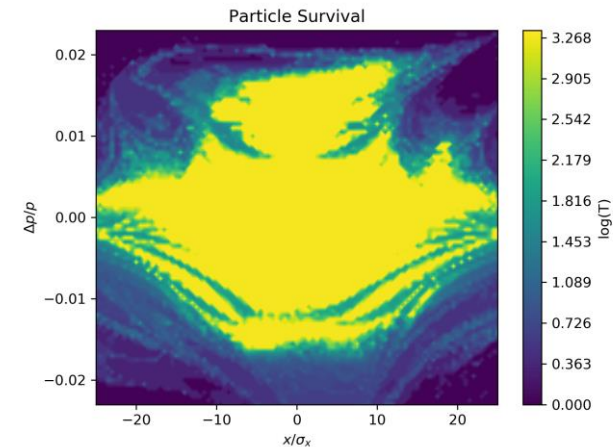
- **DA studies from tracking**
 - Using information and settings from amplitude detuning studies
 - Radiation turned off
 - Tracking acceptance
 - On- and off-momentum
- **Relatively good agreement between all three codes**
 - Used as basic example for tracking studies
 - Partially shown in FCC-ee optics meeting



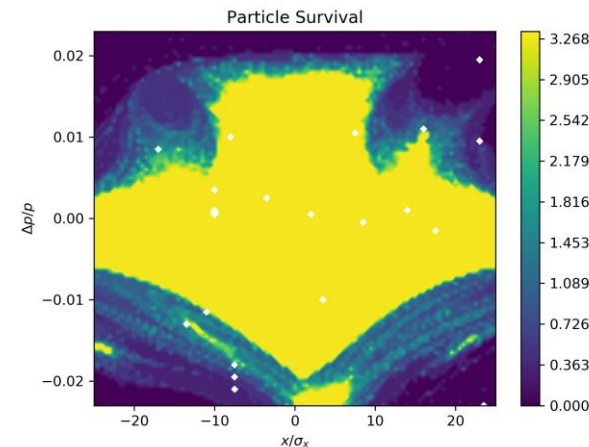
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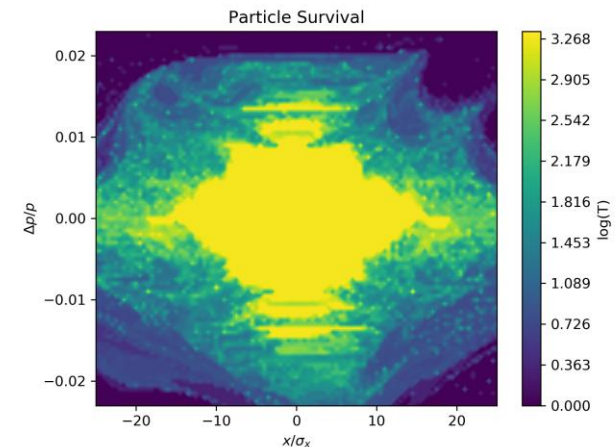
PTC



MADX



SAD

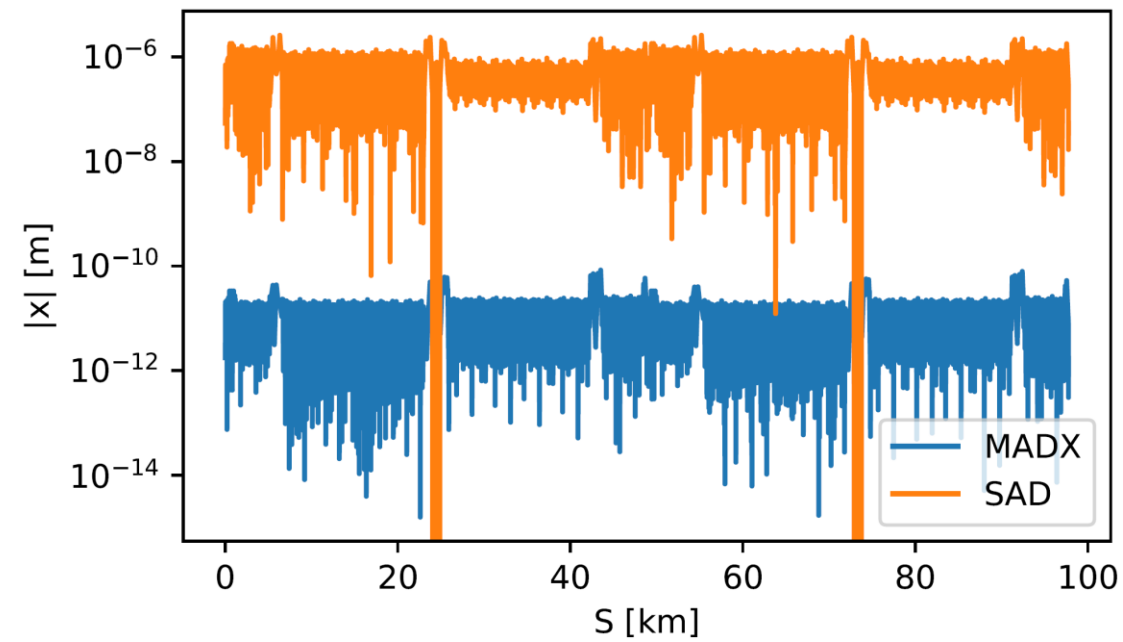
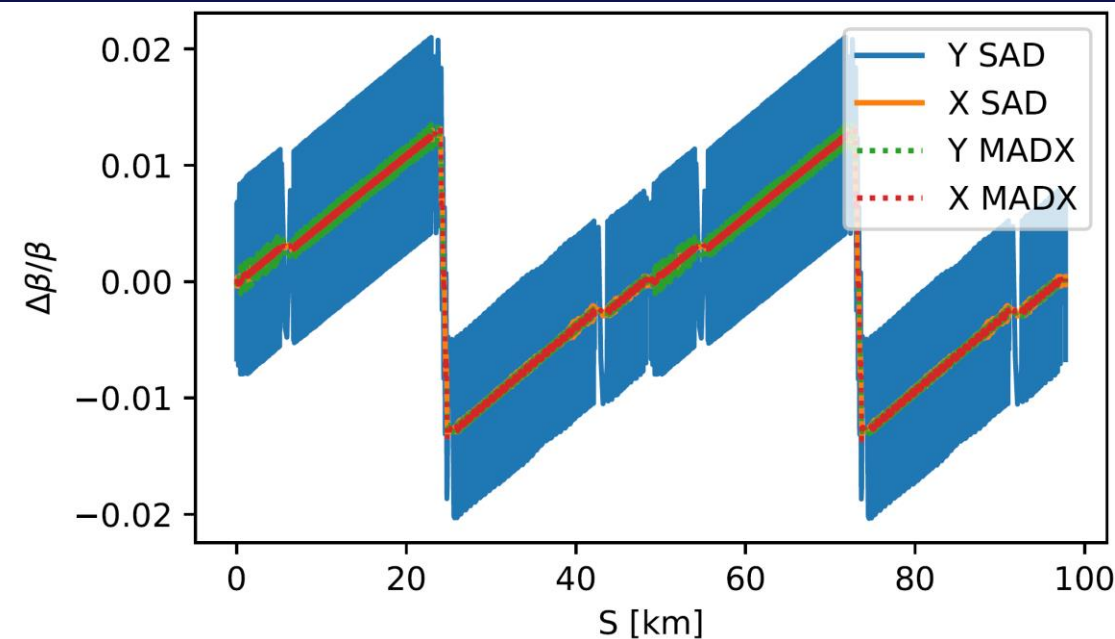




MADX FEATURES

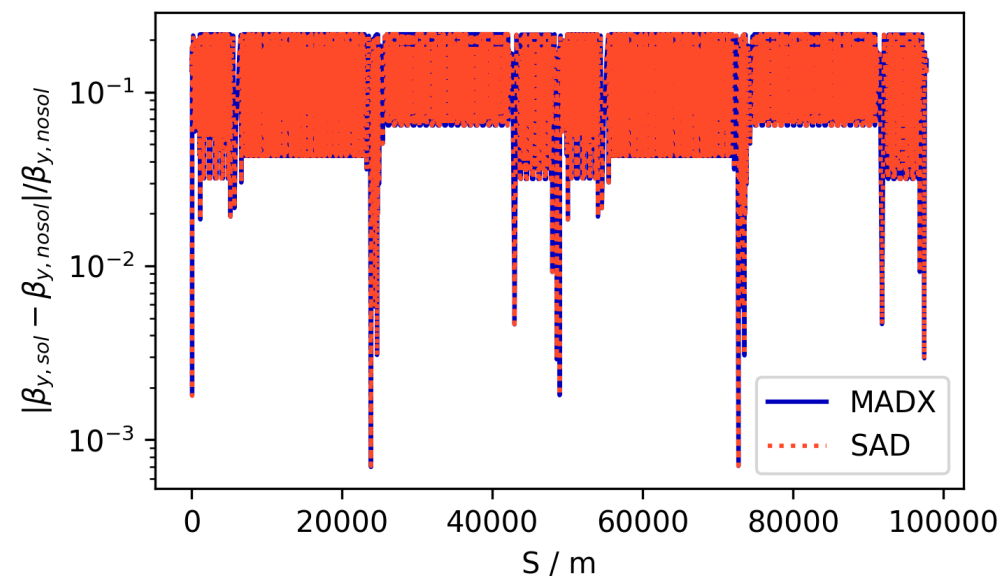
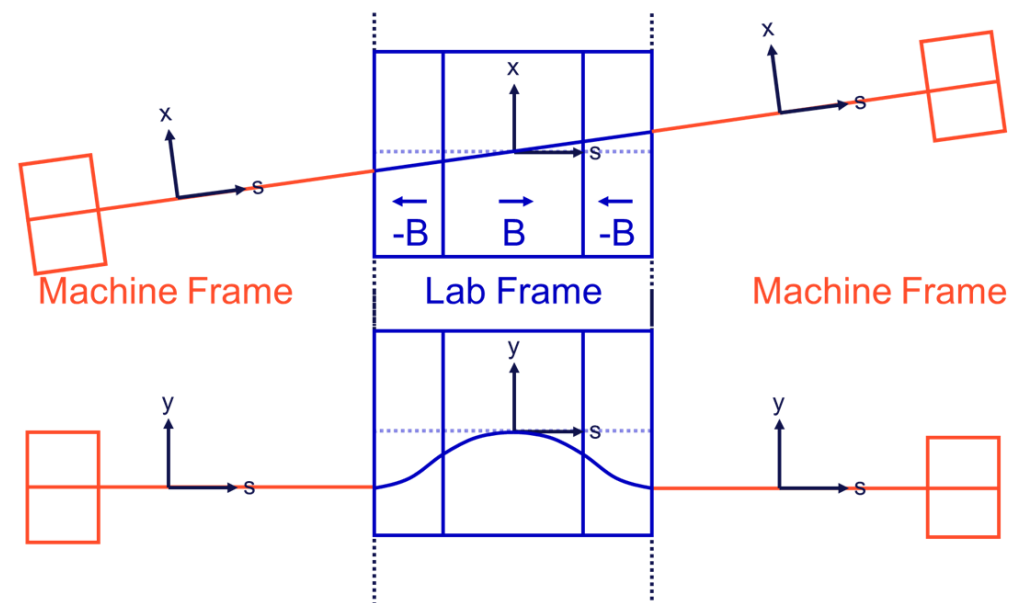
Tapering

- **Identified as a key need for FCC-ee**
 - Initially implemented in SAD but not MADX
 - Tapering scheme developed with T. Charles and implemented in MADX by T. Persson
 - Potential improvements identified by G. Roy – work ongoing
- **MADX implementation since 5.6.00**
 - Requires matching of cavities
 - Provides good emittance values
 - Minimises closed orbit and β beating



Tilted Solenoid

- **Different possibilities of how to implement Misaligned solenoid**
 - Misalign finite solenoid
 - Sliced solenoid with interleaved bends
 - Could interleave multipoles of “realistic solenoid”
 - Tilt of coordinate system (SAD-like approach)
 - (discussed in optics tuning meeting)
- **Able to reproduce SAD optics from SAD-like approach**
 - Presented in ABP meeting
- **Minor bugs due to rotation element and radiation in solenoid**
 - Actively investigated by T. Persson and A. Latina



Tilted Solenoid Strategies

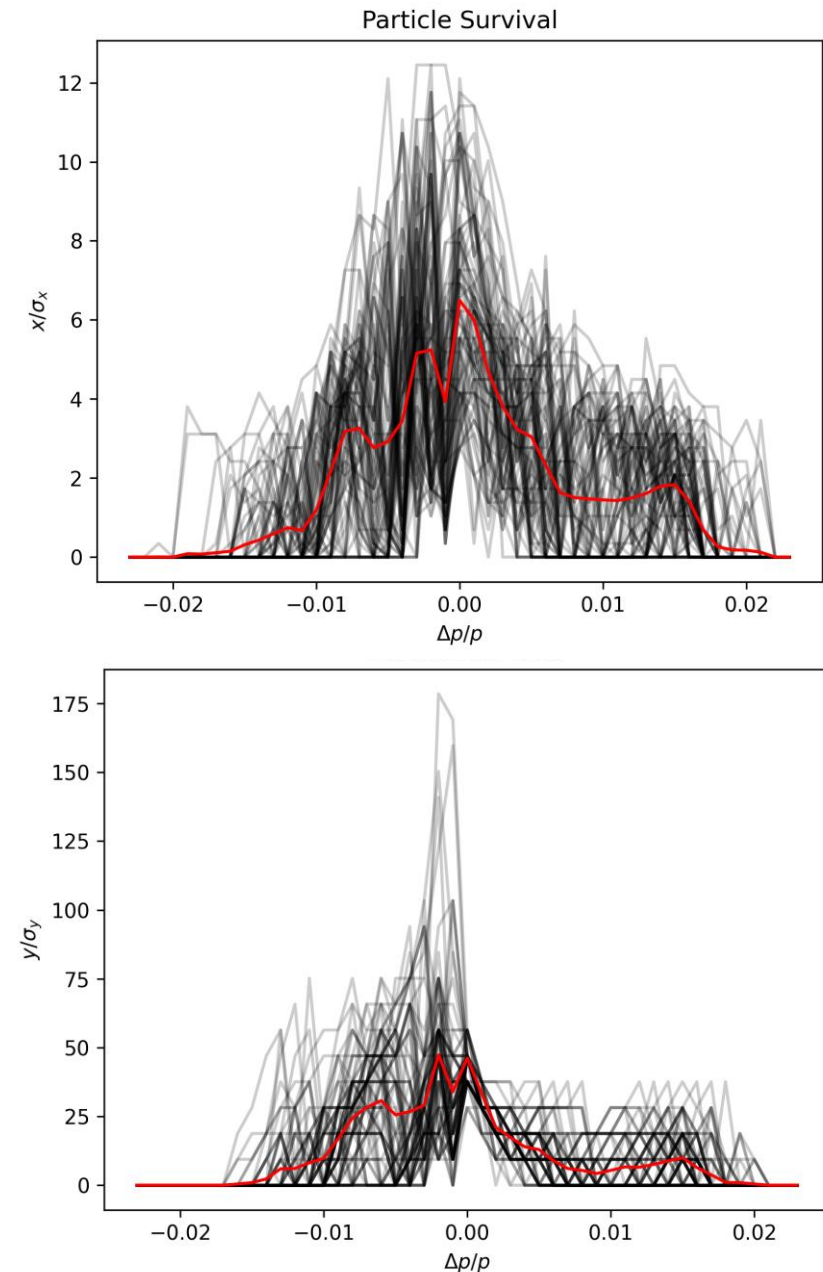
| Method | Benefits | Drawbacks | Example files |
|---|--|---|---|
| Misalignment of Solenoid Implemented like alignment errors | <ul style="list-style-type: none"> • Very simple • No need to change lattice file | <ul style="list-style-type: none"> • Radiation in solenoid not correct • Not SAD layout | /afs/cern.ch/work/l/Ivanries/public/for_tuning_studies/Misaligned_Solenoid |
| Sliced Solenoid interleaved with vertical bends angle = vertical dipole field | <ul style="list-style-type: none"> • Gives correct radiation | <ul style="list-style-type: none"> • Lattice has to be heavily modified • Not SAD layout | /afs/cern.ch/work/l/Ivanries/public/for_tuning_studies/Interleaved_Solenoid |
| Tilt through change of coordinate system Rotations and translations at solenoid entrance/exit | <ul style="list-style-type: none"> • Exact replication of SAD layout • Exact agreement with SAD optics | <ul style="list-style-type: none"> • Completely new lattice file from new translator • Rotation causes strange dispersion | /afs/cern.ch/work/l/Ivanries/public/for_tuning_studies/SAD_Style_Solenoid |



SELECTED APPLICATIONS

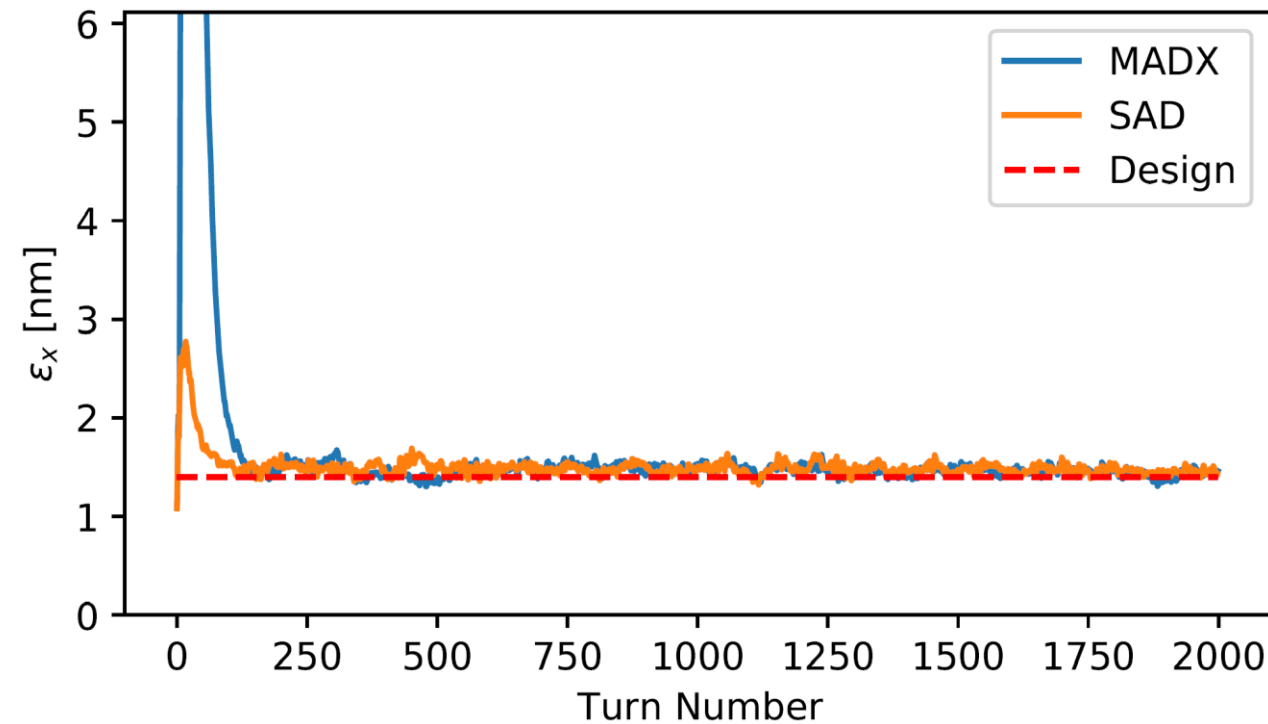
DA with Errors

- Using lattices with errors and corrections by T. Charles
- Using settings found during comparison studies
- Without radiation and no minimum coupling
- Results presented by T. Charles in FCC-ee Optics Meeting
 - First iteration
 - More in depth studies to follow, including studies with new corrections



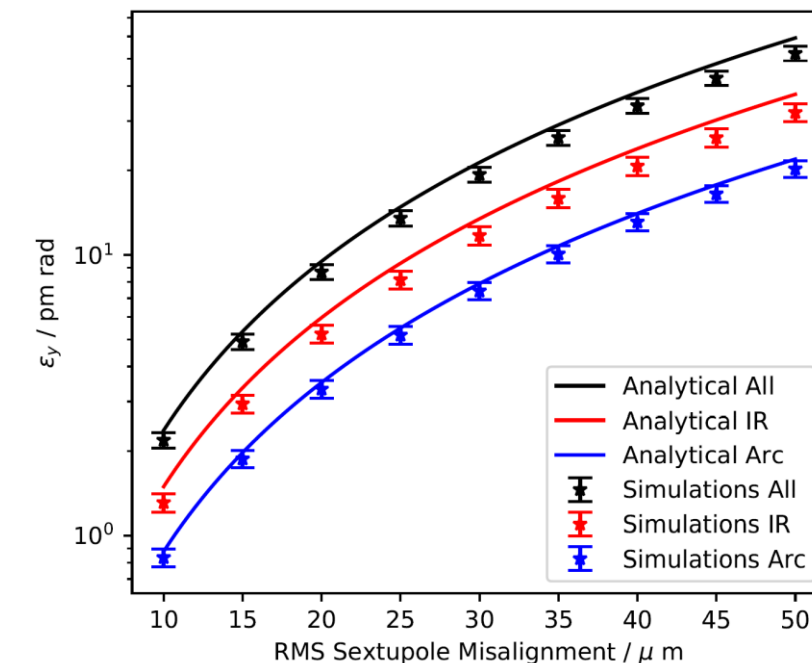
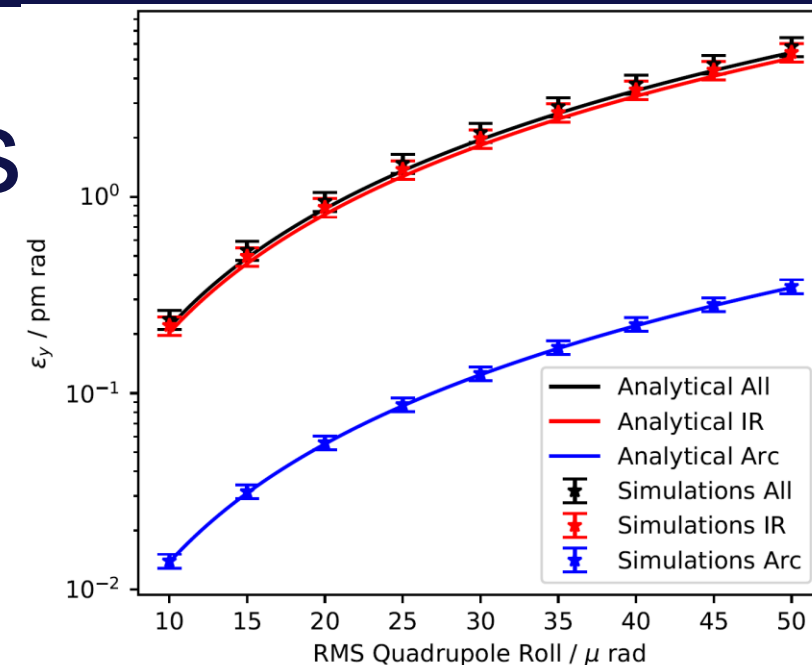
Tracking with Radiation

- **Tracking random particles to find emittance from tracking**
 - Using lattices tapered by MADX and SAD
 - Simulating damping and quantum excitations
 - Converges to design emittance
- **Presented in IPAC'21 TUPAB004**
- **Can be used to verify emittance results for more complex lattices**
 - Errors and corrections
 - Tilted solenoid



Analytical Emittance Estimates

- **Analytical emittance estimates**
 - Aim to identify magnets that need tighter tolerances
 - Using well established analytical expressions
 - Compared to simulations built on scripts by T. Charles
 - Presented in IPAC'21 TUPAB006
- **Very good agreement for quadrupole rolls and sextupole misalignments**
- **Effects of errors found to add linearly**
 - Investigation whether this applies to more complex configurations underway





CONCLUSIONS AND OUTLOOK

Conclusions and Outlook

- **Performed comprehensive comparison studies between MADX and SAD**
 - To establish baseline for further simulations
- **Important features brought to MADX**
 - E.g. tapering and tilted solenoid implementations
 - By adding to MADX or finding ways to implement by hand
- **Studies using MADX features and findings from comparisons**
 - Dynamic aperture, tracking in tapered lattices, analytical emittance estimates
- **Future work including:**
 - Model SKEKB IR in MADX
 - Expand on analytical emittance studies by including other types of errors
 - DA of new tuned lattices