

Modeling of spin-orbital dynamics in a storage ring

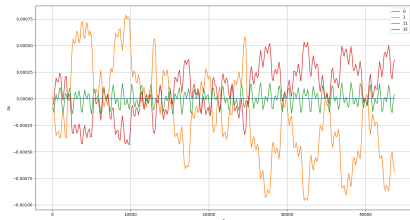
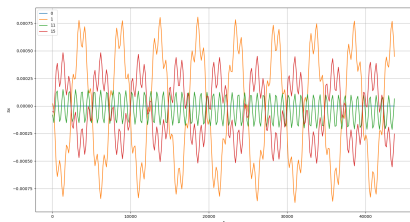
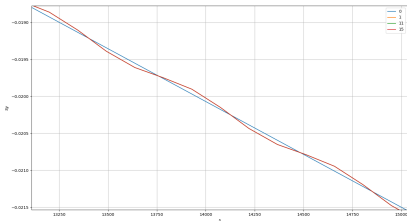
April 11, 2018

Python ODE integrator

- ▶ Integrates the equations of spin-orbital dynamics with `scipy::odeint`;
- ▶ Classes defining most commonly utilized accelerator elements (dipoles, quadrupoles, Wien filters, etc);
- ▶ Two versions of element positioning imperfections (tilting):
 - ▶ via computing the tilt matrix, and applying it to the computed field at run time (more general but time-consuming, doesn't preserve guiding field strength by default);
 - ▶ customized tilting for dipole, WF (less time-consuming, preserves the Lorentz force acting on the particle), and shift for quadrupole;
- ▶ Made up of three major classes:
 - `Lattice` for element management (e.g., tilting, section-plots);
 - `Tracker` handles integration proper, data backup into an `.hdf5` file;
 - `Log` output of `Tracker::track`; based off `numpy::recarray`, handles plotting.
- ▶ Vectorized RHS computation.

Example plots

- ▶ $S_x \sim s$ in FS lattice w/o tilt
- ▶ $S_x \sim s$ in FS structure w/
all elements tilted about \hat{s}
- ▶ $S_y \sim s$ in FS structure w/
elements randomly tilted
 $\text{Norm}(0, 10^{-4} \text{ rad})$



C++ ODE integrator

- ▶ Python not fast enough; a Frozen spin lattice of 397 elements takes 2 secs/turn to run. (Integration takes $3 - 7 \cdot 10^{-3}$ secs/element, depending on the field complexity.)
- ▶ Rewrote the program core in c++ with Boost::Odeint's integrator and Eigen Matrix for field and state type.
- ▶ Still speed and precision problems:
 - ▶ vectorizing code (via VexCL, most likely);
 - ▶ step-size control (this'll probably need redesigning state-type).

Tasks from supervisor

- ▶ Study effects of WF tilts (preserves Lorentz force) in FS lattice on S_x, S_y, S_z ;
- ▶ Same for quadrupole shifts (doesn't preserve LF);
- ▶ Study decoherence as a function of the initial beam distribution $(x, y, \delta W)$;
- ▶ Study optimal sextupole placement for the suppression of decoherence and chromaticity;
- ▶ Modeling of field calibration by effective gamma in the horizontal plane (CW/CCW procedure);

Decoherence test histograms

- ▶ 100 turns; 70 trials; 20-particle bunches: $x \sim N(0, 10^{-3})$,
 $y \sim N(0, 10^{-3})$, $dK \sim N(0, 10^{-4})$

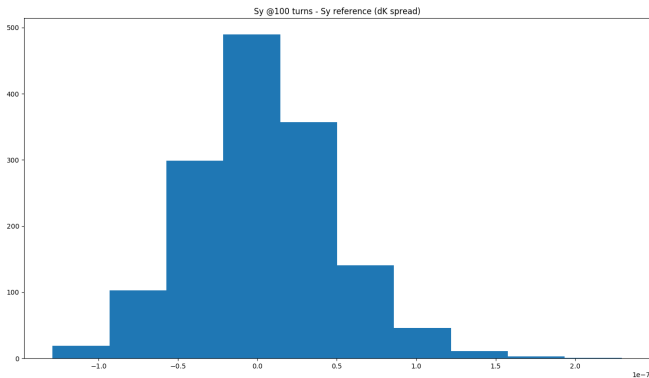


Figure: Histogram from $dK \sim N(0, 10^{-4})$ test

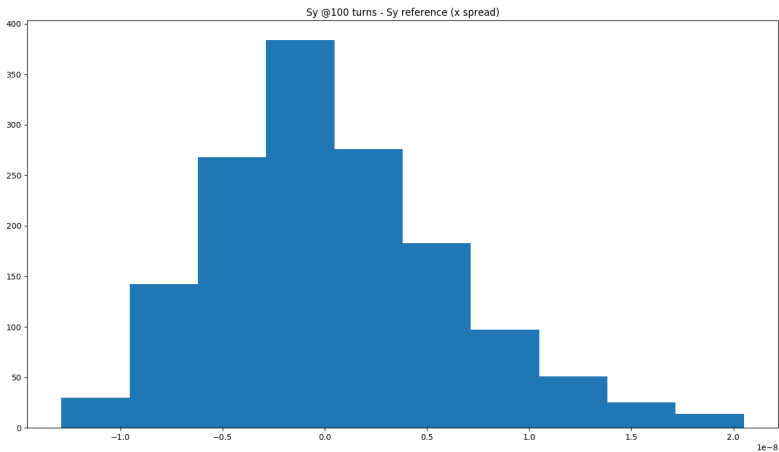


Figure: Histogram from $x \sim N(0, 10^{-3})$ test

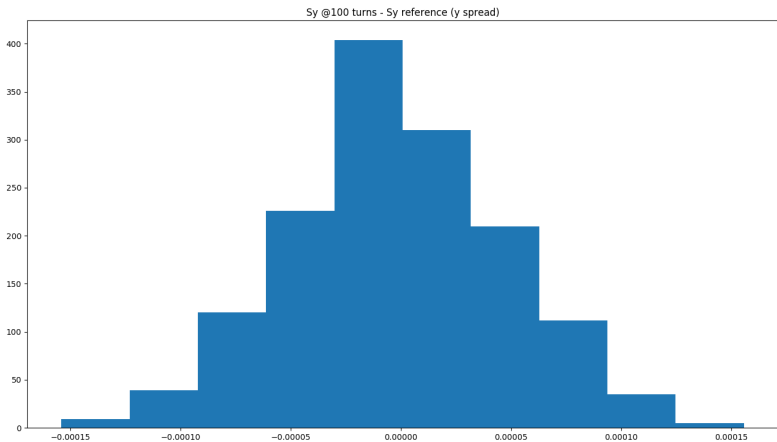


Figure: Histogram from $y \sim N(0, 10^{-3})$ test