Characterization of Equilibrium Emittance with Monte Carlo

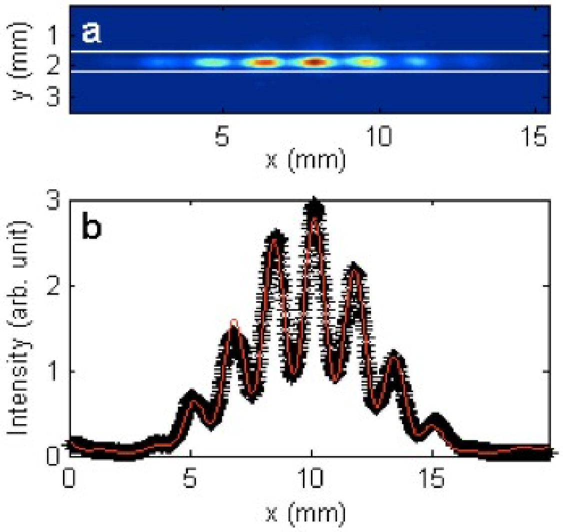
8/10/2012

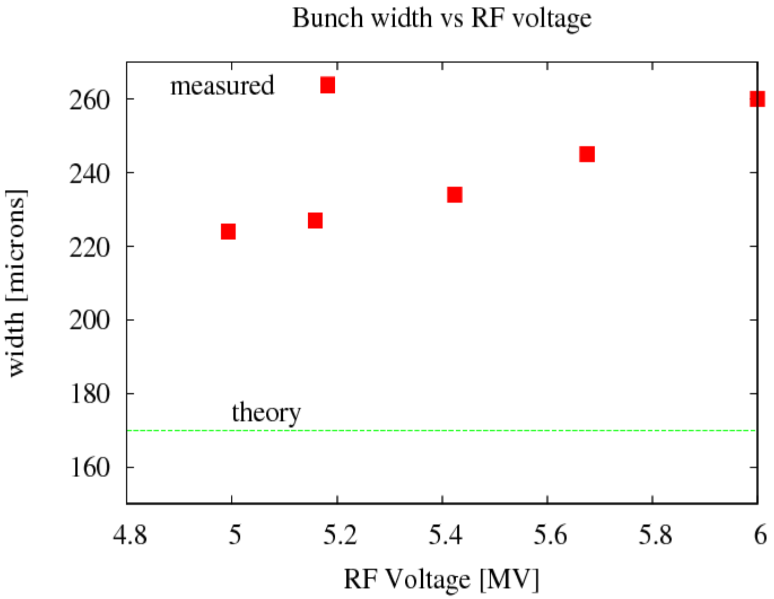
Zoey Warecki

for the CesrTA Collaboration

Motivations

- Analytic value of horizontal emittance: 2.6 nm
- Measured value from April 2012
  - Emittance$_x$ ~7 nm
  - Beam size changes with RF Voltage
- We want to resolve these discrepancies





Tao

- Analytically calculates the equilibrium emittance using Bmad subroutines
- Uses optic functions to compute radiation integrals
- Calculates emittance from radiation integrals

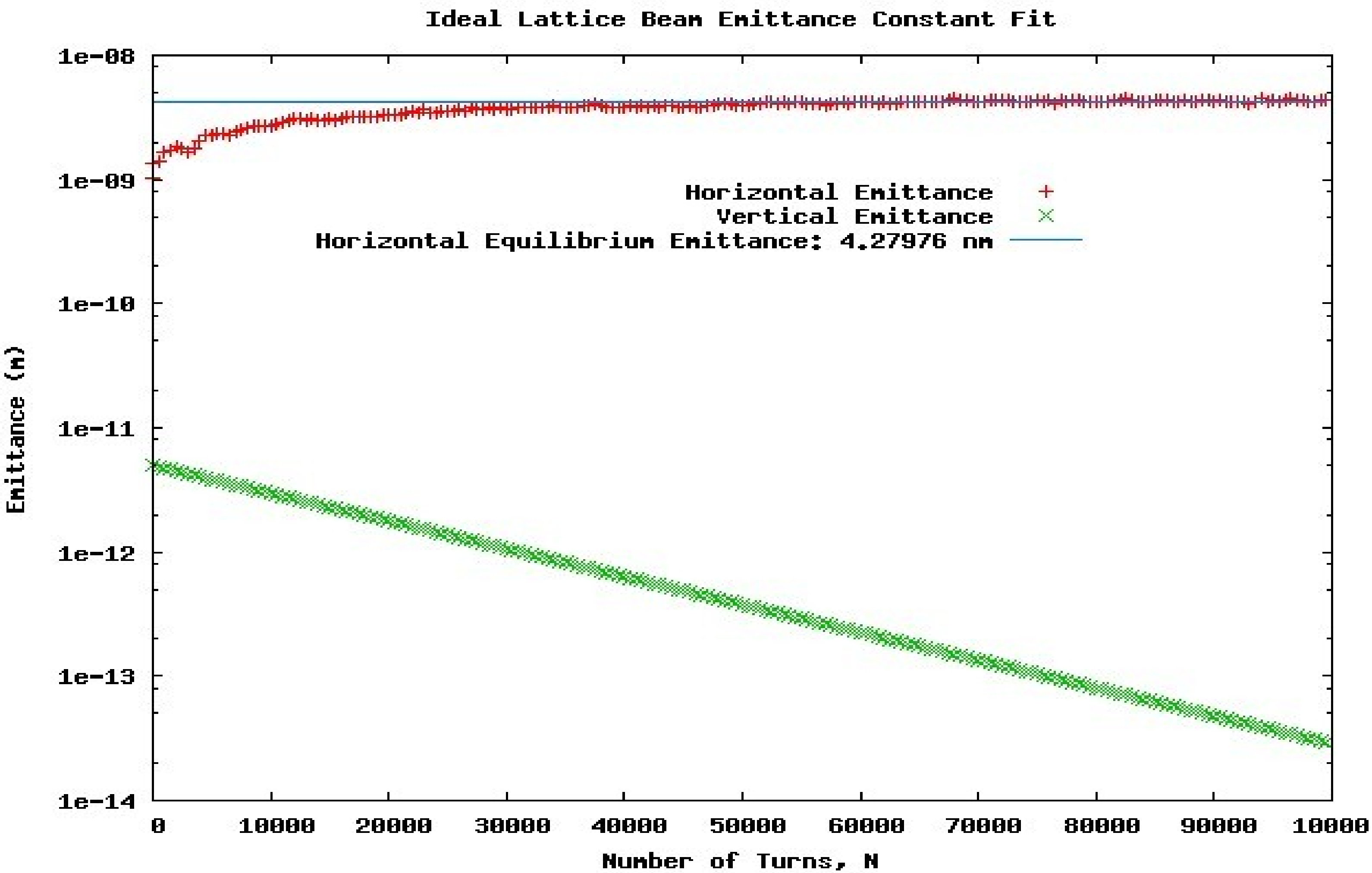
Element Summation with Fortran90

- Better understand emittance calculations and cross-check Tao
- Uses Bmad subroutines like Tao but manually calculates radiation integrals

Monte Carlo Simulation

- Statistically computes emittance
- Simulates a bunch going around the storage ring
  - Generate beam with a Gaussian distribution of particles
  - Track macro particles through the magnets
  - Recompute emittance based on evolved distribution of particles (using sigma matrix)
- By 100,000 turns (5 damping times, >99% damped) the emittance will equilibrate

Monte Carlo for ideal CesrTA lattice with Taylor Map



Wiggler Tracking Models

Different ways to track the particles as they go through the wigglers in ideal CesrTA lattice

– Compute radiation emission differently

Type of tracking method	Horizontal Emittance	% error from Tao (2.6 nm)
BDB	5.13 nm	93.7%
Taylor Map	4.28 nm	64.6%
Symplectic Lie	3.28 nm	26.2%

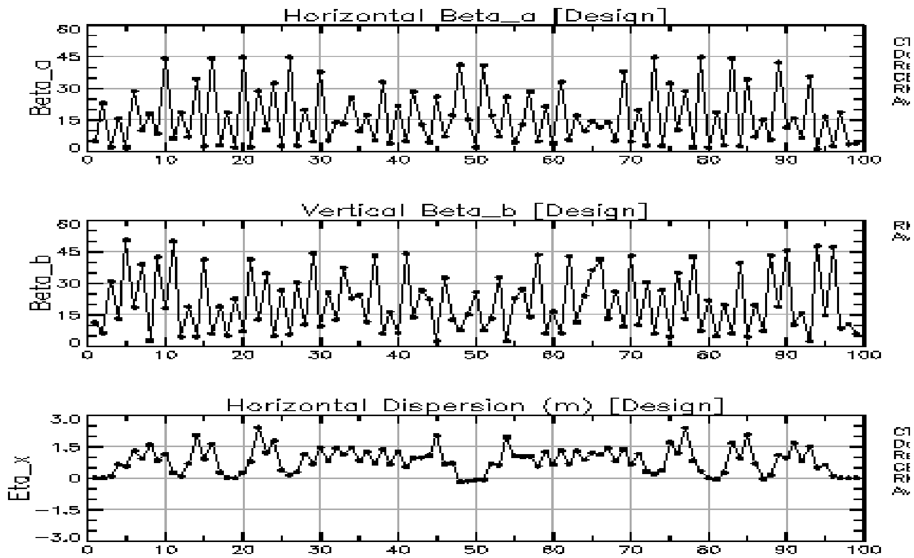
None of these agree...

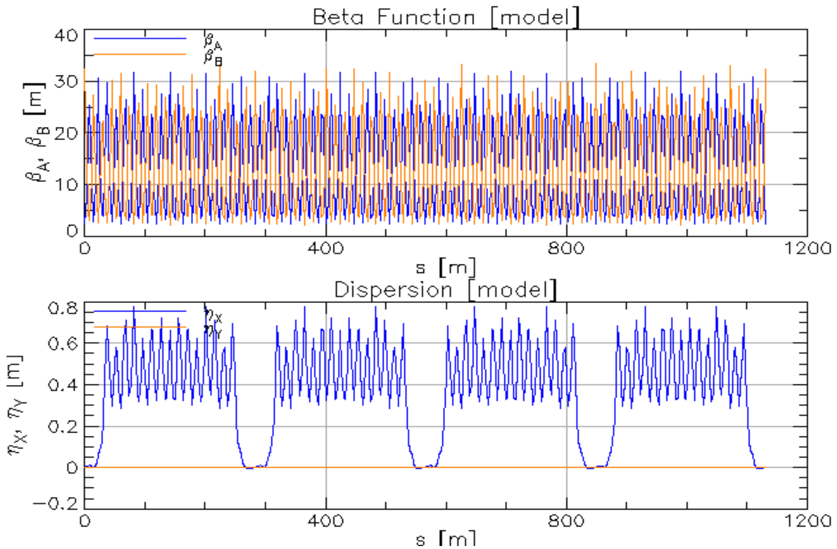
Because of complexities of CesrTA lattices, a simple lattice was introduced

- Tao: 14.51 nm
- Monte Carlo: 15.1 nm +/- 0.2 nm

CesrTA lattice

Simple lattice





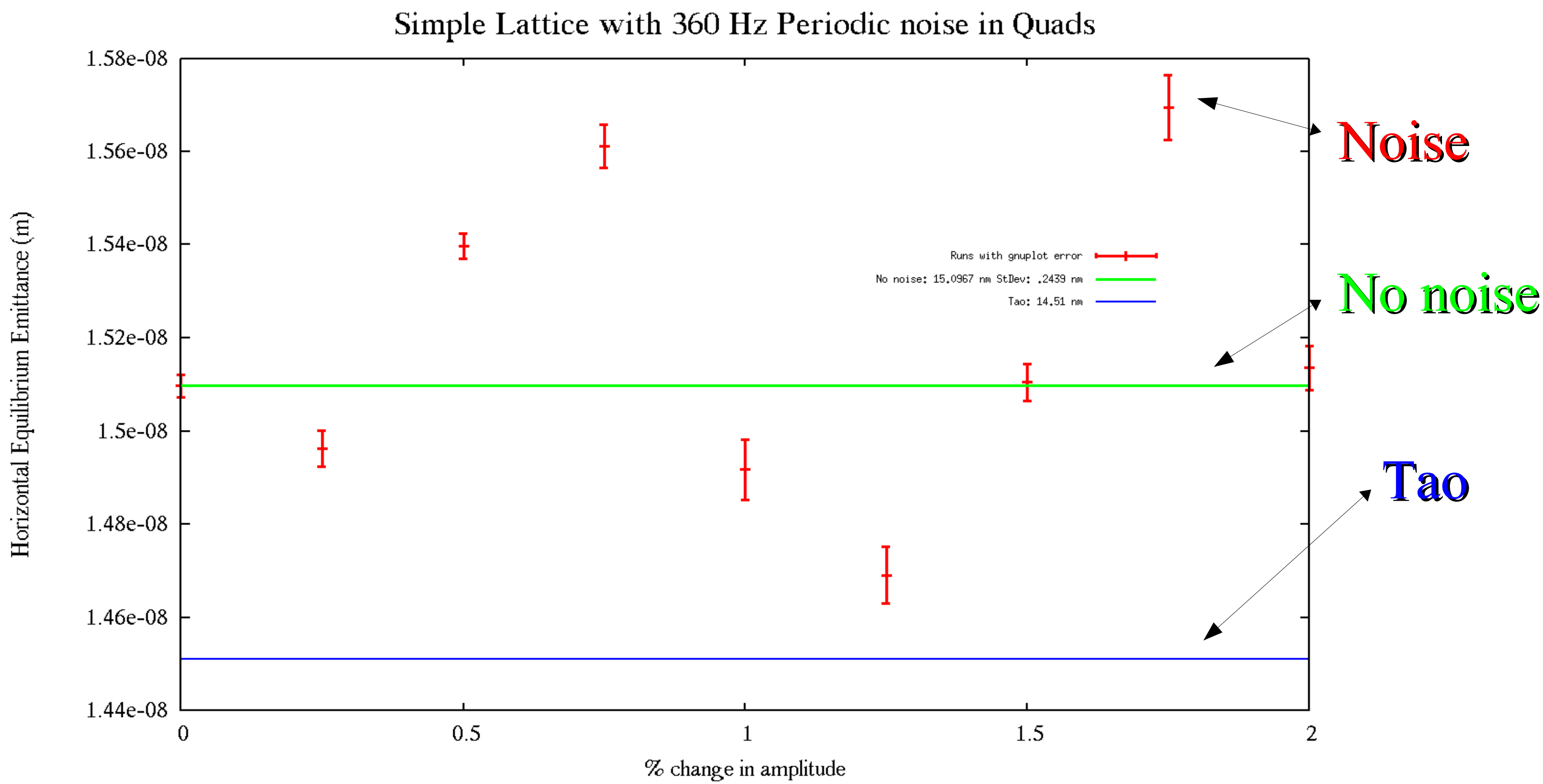
Testing Simple Lattice

Horizontal Emittances for different types of Lattices

Energy, # wigglers	Tao	Monte Carlo	Element Sum.	MC % err from Tao	ES % err from Tao
(5.3 GeV) no wigglers	14.51 (nm)	15.1 (nm) (Average)	14.57 (nm)	4.1%	0.41%
(5.3) w/ 1 wiggler	7.422	7.09	7.3728	4.5%	0.66%
(5.3) w/ 8 wigglers	3.99	3.98	3.8727	0.15%	3.0%
(2 GeV) no wigglers	2.255	2.27	2.264	0.84%	0.4%
(2) w/ 1 wiggler	1.510	1.48	1.1817	1.8%	20.1%
(2) w/ 8 wigglers	1.609	1.68	.962	4.9%	40%

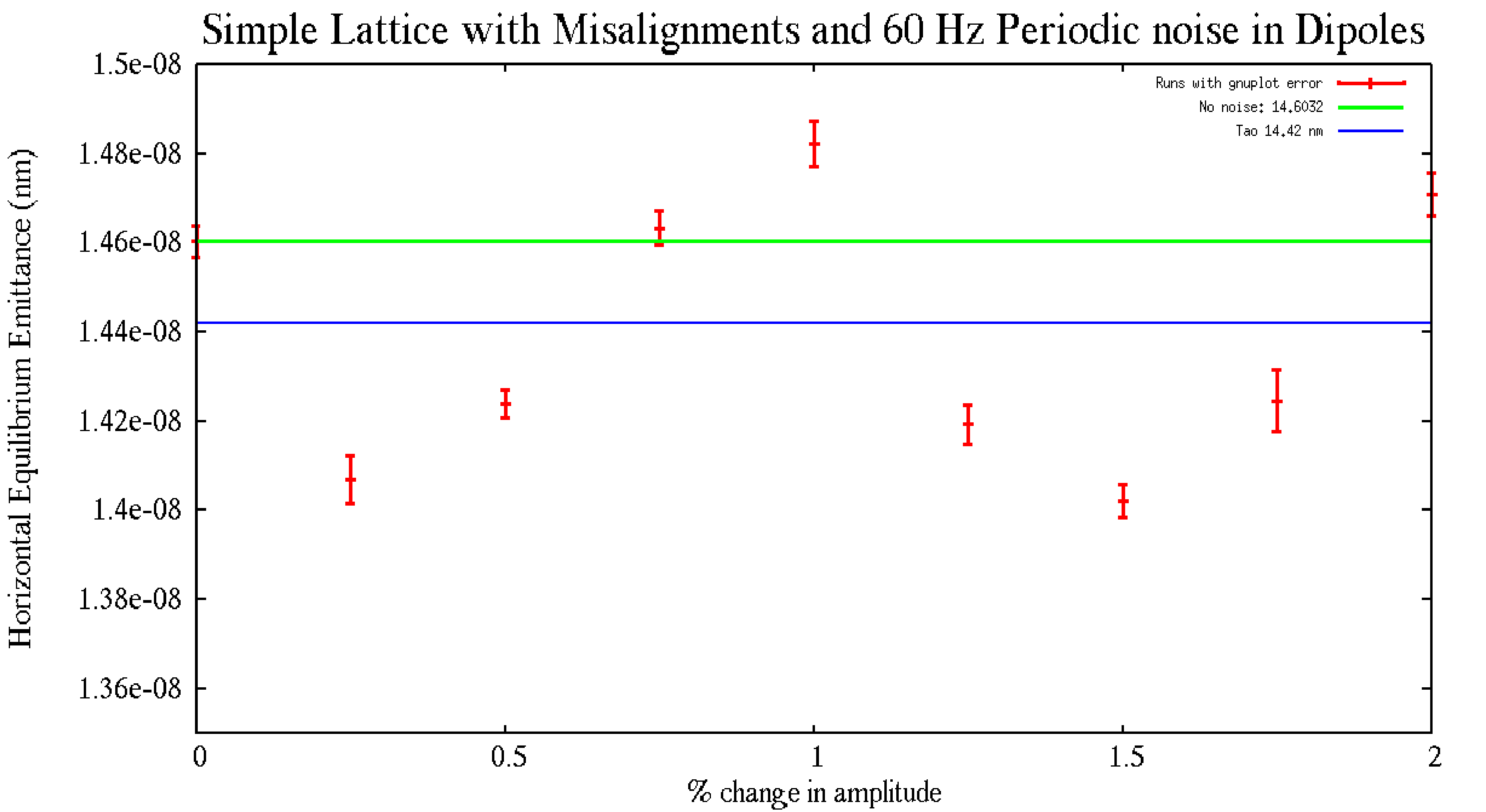
Effect of periodic noise on magnet strength

Ex: add 360 Hz to quad strength in the simple lattice



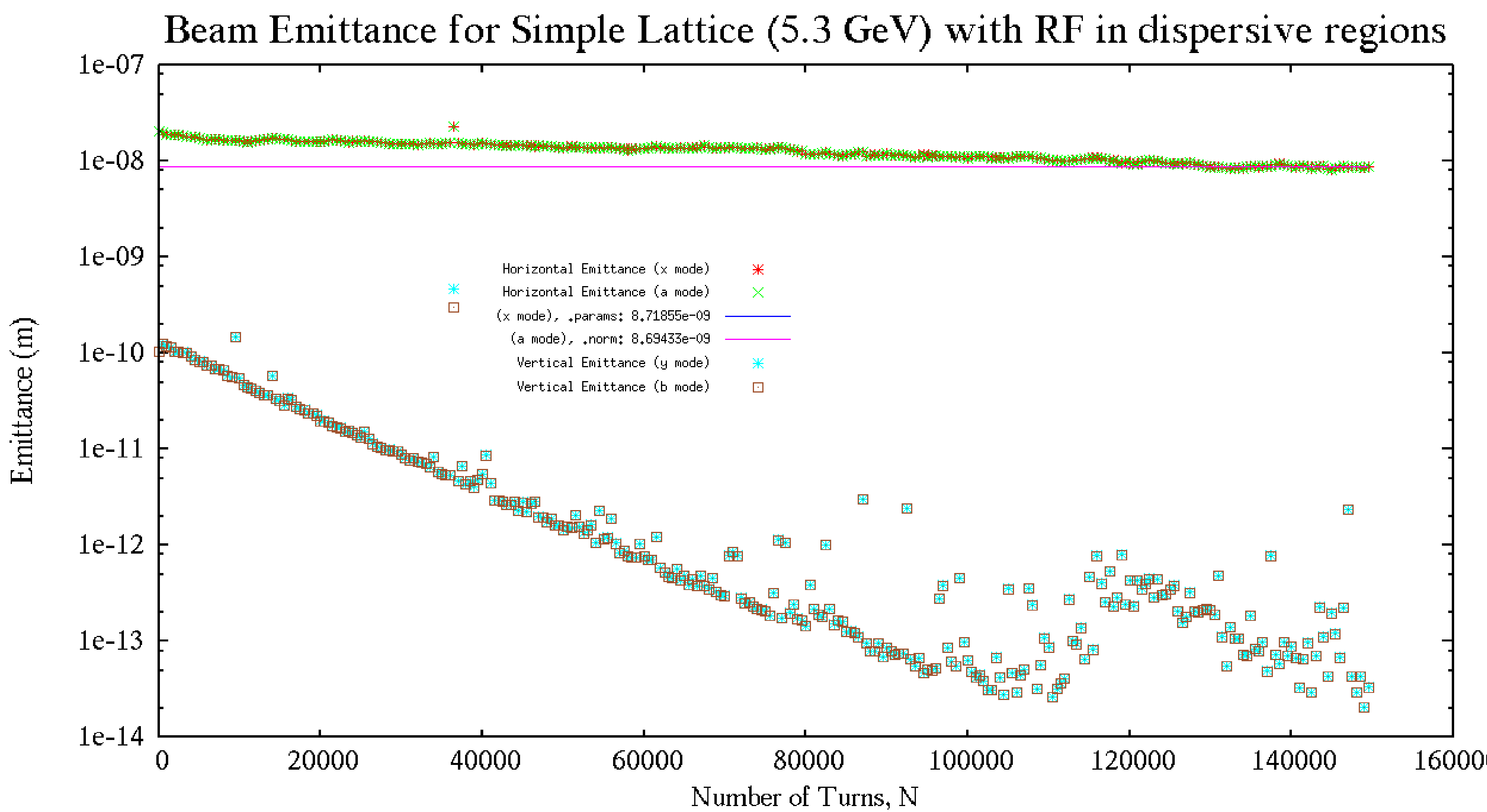
Periodic Noise

Ex: add 60 Hz noise to dipole strength in MA lattice



Dispersion in RF cavities

Tao: 20.6 nm, Monte Carlo: 8.71 nm



Results:

- For simple lattice, Tao & MC agree
- Wigglers do not contribute more than 5% to Tao/MC disagreements
- Candidate for other 20% disagreement
  - RF in dispersive region?
- 60Hz and 360Hz not a candidate for this level of disagreement

Future Work

Future Studies:

– More extensive testing of Monte Carlo simulations
– RF cavities in dispersive regions
– Connections to measured emittance

Acknowledgments

Thanks to:

Dave Rubin

Jim Shanks

Dave Sagan

NSF REU Program and CLASSE

Questions?