An update on the LET of the ILC Damping Rings

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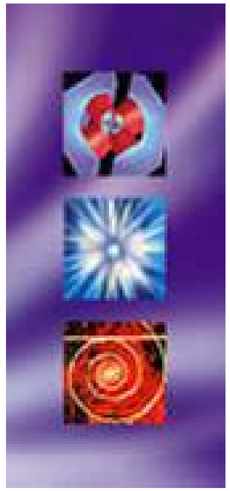


Introduction

- Low Emittance Tuning studies for the damping rings are based on analysing and designing:
  - An algorithm for correcting the closed orbit
  - An algorithm for correcting the vertical dispersion
  - An algorithm for correcting the coupling
- As well as investigating the algorithms themselves, the make-up of the correction hardware also needs to be defined:
  - The number of required BPMs (possibly for different algorithms)
  - The number of required correctors (for each of the algorithms)
  - The definitions of related hardware such as power supplies etc
- The results in this talk will be presented for the latest DCO lattice.

History

- The ILC DR lattice has undergone several iterations in the lifetime of EuroTeV
  - Started with 7 possible designs
  - Reduced to 1 or 2 designs (TME or FODO)
  - Finally reduced to one design (DCO lattice, FODO)
- The latest lattice has only been around for a few months
  - Design of the possible tunings still ongoing
  - Will use only the 72º lattice here...
- LET studies have been ongoing through all designs
  - Great for creating a large scale simulation framework
  - Constantly having to re-do certain tasks

Closed Orbit Correction

- Closed orbit correction is based around the use of SVD inversion of the orbit response matrix
- Uses (upto) all 690 BPMs and correctors situated at the, mostly arc, quadrupoles

- *The number of eigenvalues/weightings are optimised using simulations of the lattice with standard errors, and using a Simplex optimiser.*

Dispersion Correction

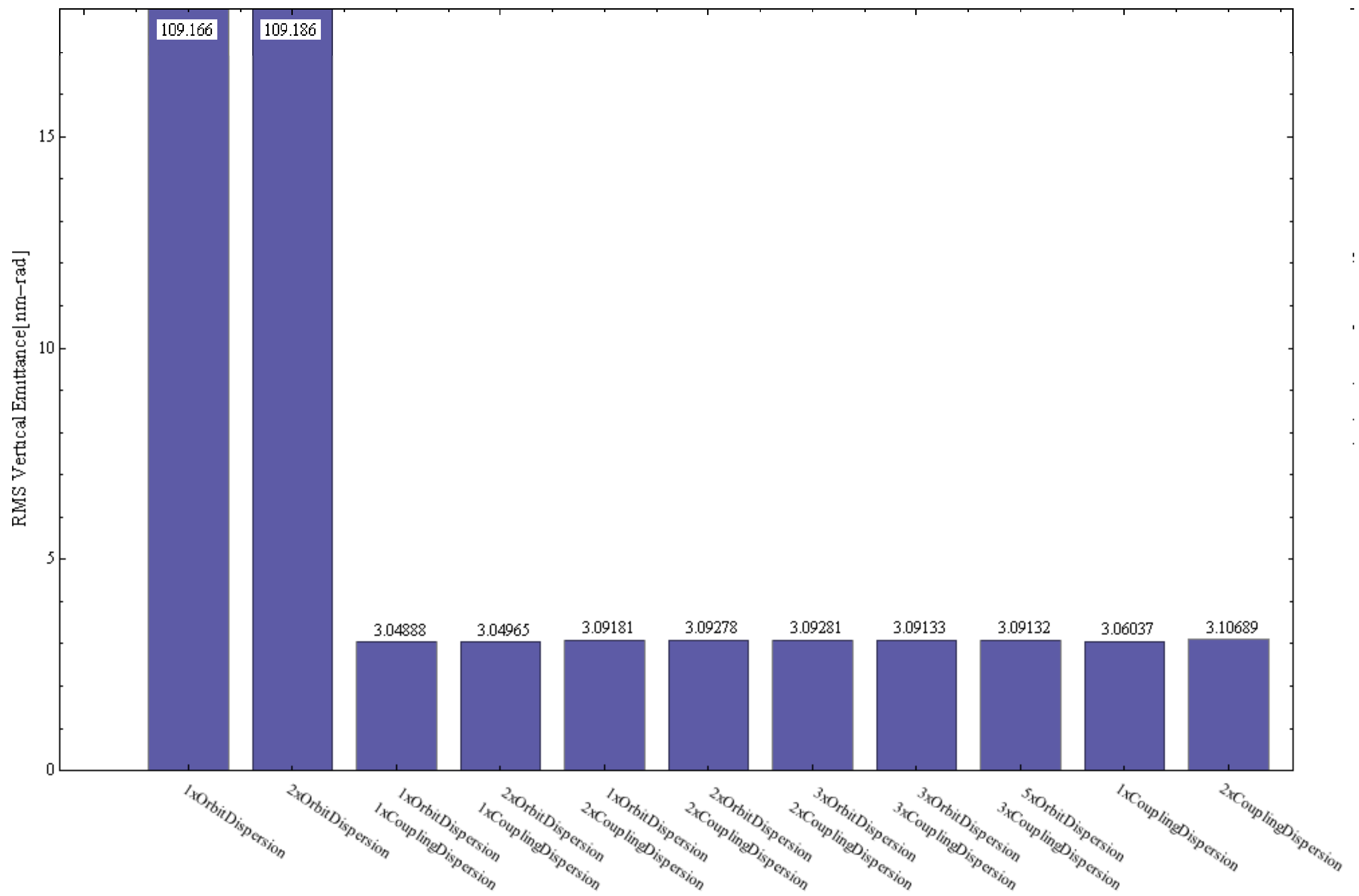
- Can correct the vertical dispersion either through dipole correctors or skew quadrupoles
- Dipole correctors:
  - Use same 690 correctors as for closed orbit correction
  - Added as an extra column in the orbit response matrix
  - Optimisation of both the number of eigenvalues and also the weighting between C.O. Correction and dispersion correction
- Skew Quadrupoles
  - Uses same correctors as for coupling correction
  - Response matrix is combined with coupling correction
  - Inverted separately, optimising eigenvalues and coupling to dispersion weighting

Coupling Correction

- Performed using skew quadrupoles at all the sextupoles (none of which are at zero dispersion!)
- Generate the cross-plane response matrix using 4 horizontal kickers placed at phases of MUX+MUY = π/2 and MUX-MUY = π/2, and all vertical BPMs
  - Generates a nSKEW*nBPM*nCORR response matrix!
- Inverted separately to vertical dispersion correction

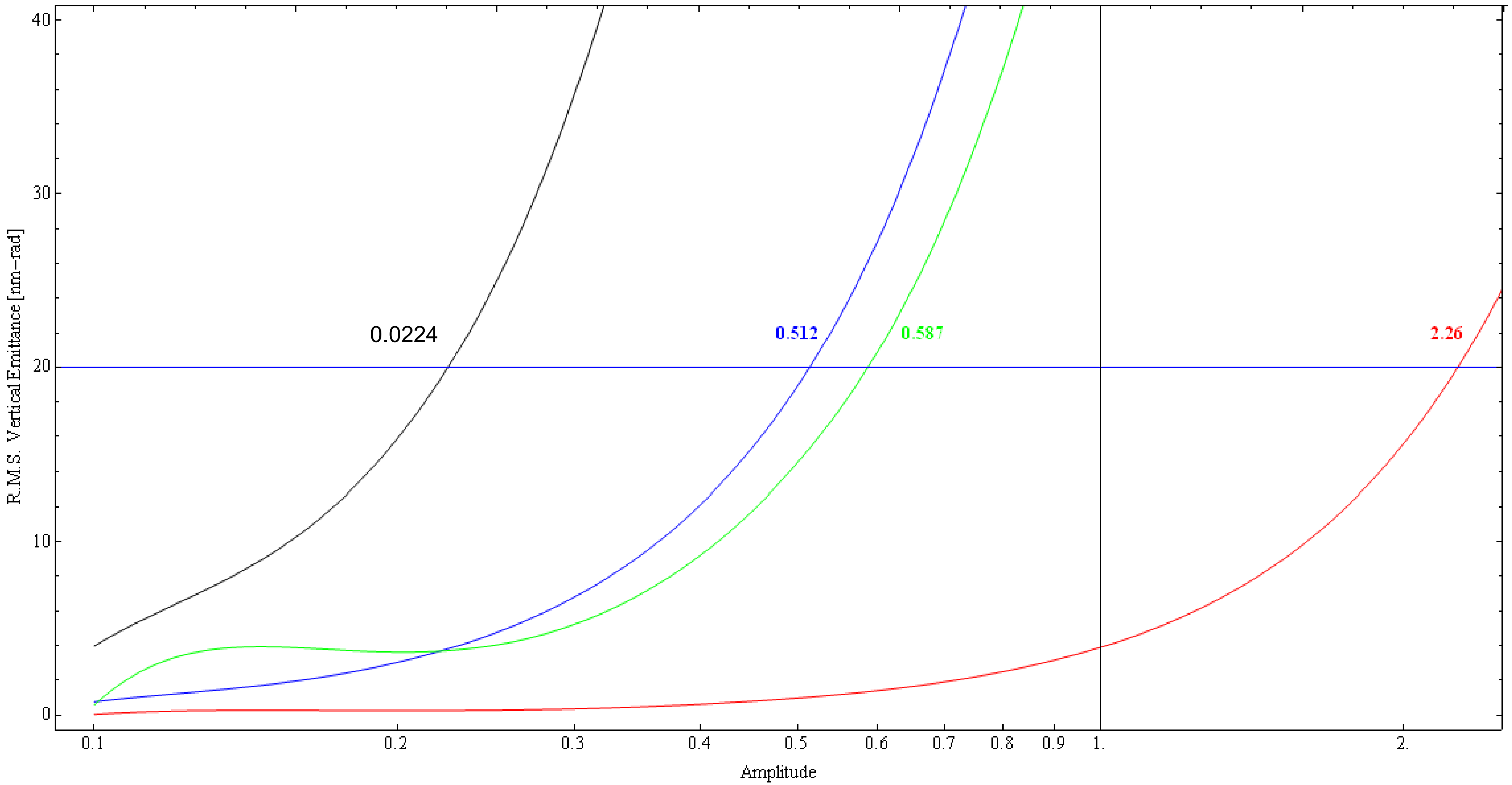
Comparison of the Various Options

- Investigated the extracted vertical emittance over 20 seeds, and for a variety of different correction options



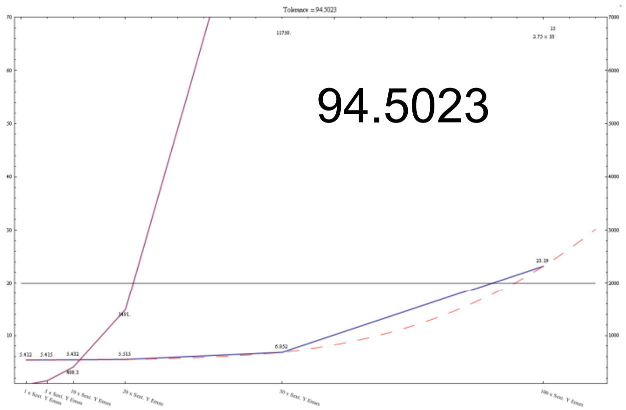
Emittance Tolerance Comparison

- Comparing CO correction vs. CO+Dispersion correction vs. CO+Combined Dispersion-Coupling correction



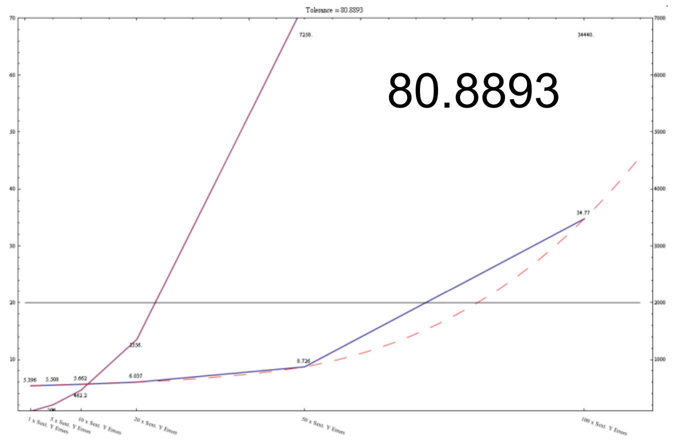
Extending the Coupling Response Matrix

- To try and eliminate effects from rotated BPMs, we can extend the coupling response matrix to also include the horizontal plane.
- Use the same 4 kickers...matrices now twice as large...
- Analysis gives roughly the same tolerances in most cases.



Vertical Plane Only

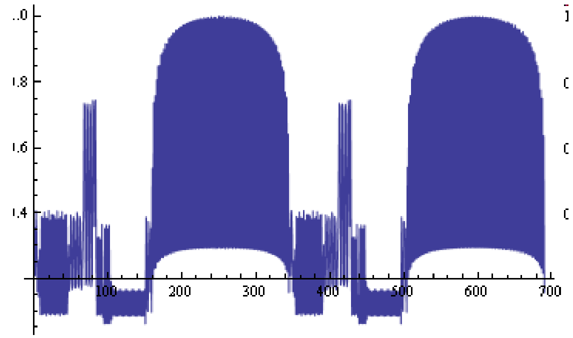
Sext Y



Both Planes

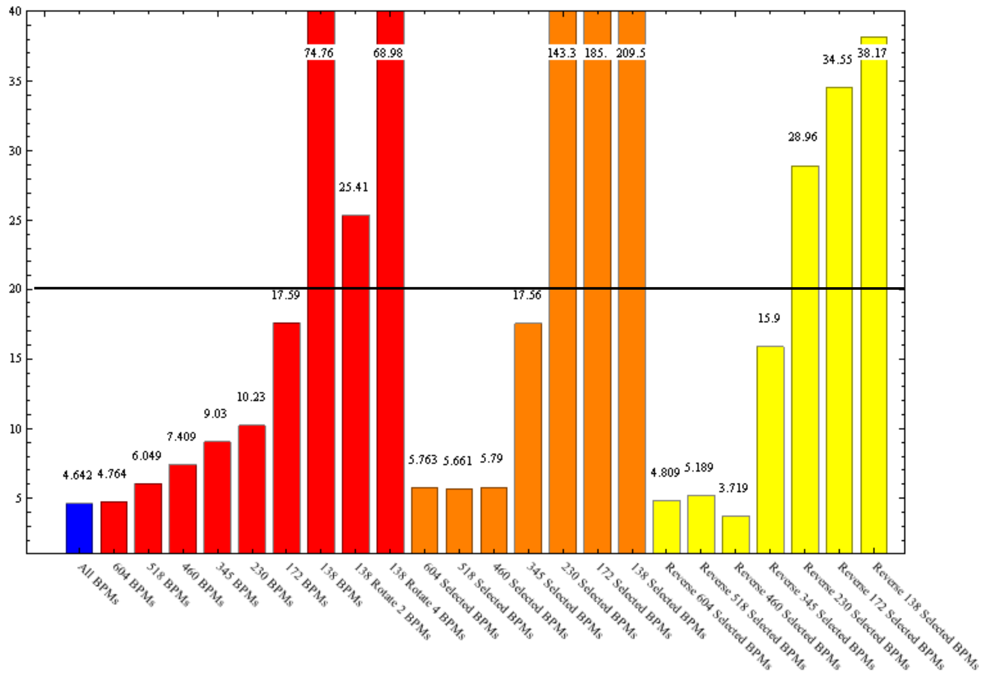
Investigating the Number of Required BPMs

- An important cost saving for the ILC DRs is to limit the number of monitors in the lattice (nominally 690)
- We can (attempt to) determine which BPMs to remove through several methods:
  - Analysis through SVD inversion:
  - Periodic removal of BPMs
  - Analysis of radiation sources

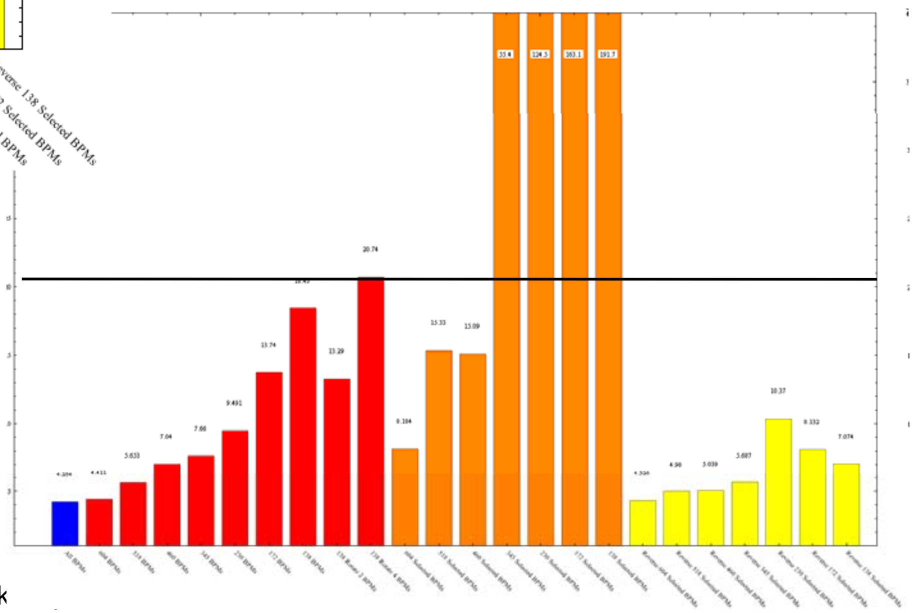


- In the following results we run the simulations over 20 random seeds, using all correctors
  - All matrices are re-inverted with a set value of the singularity rejection criterion

Periodic BPM Removal vs. SVD Efficiency

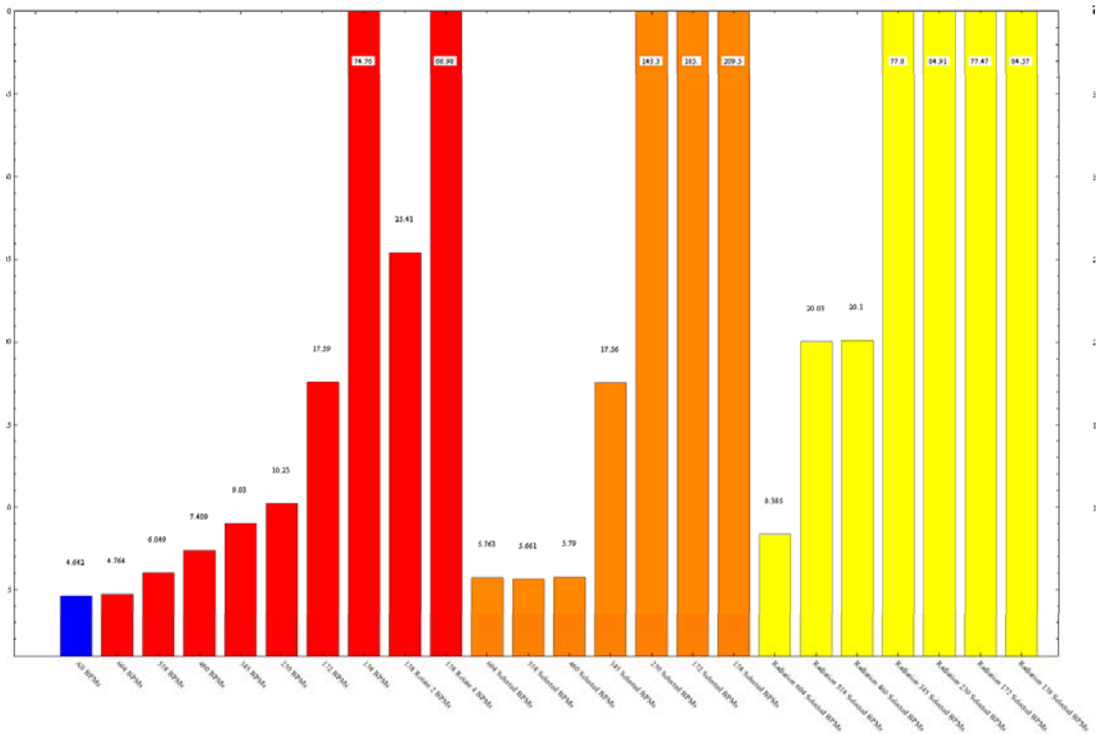


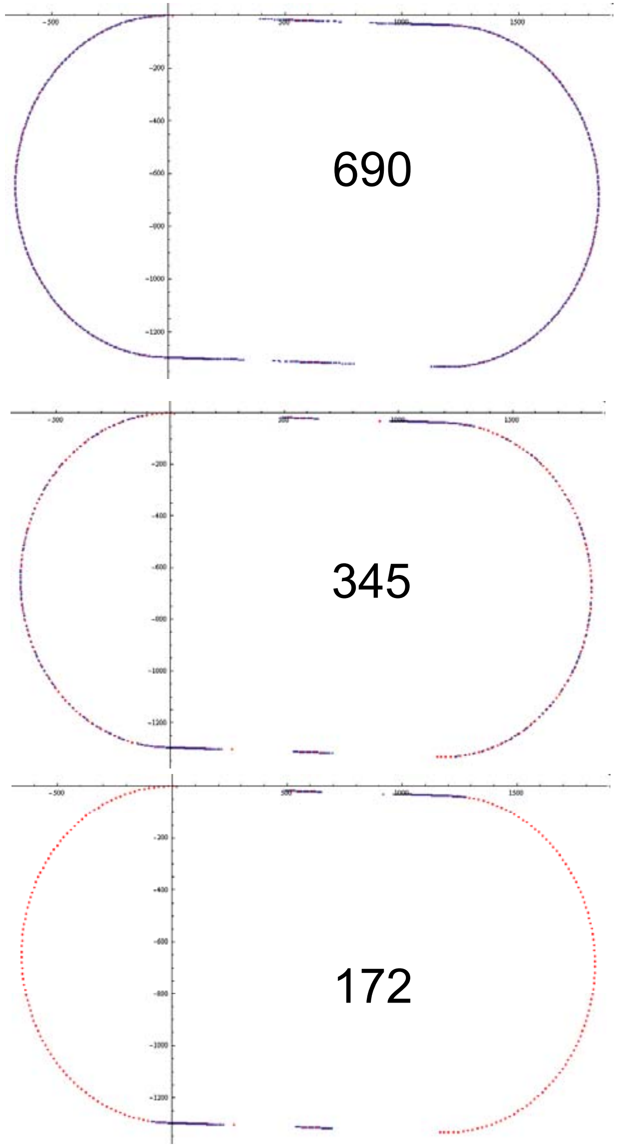
Single Plane Coupling Correction



Dual Plane Coupling Correction

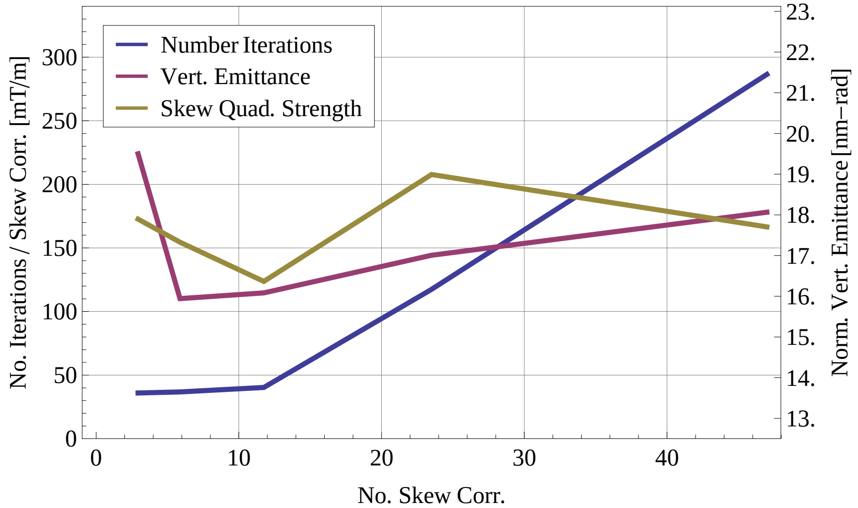
Radiation Sources BPM Analysis

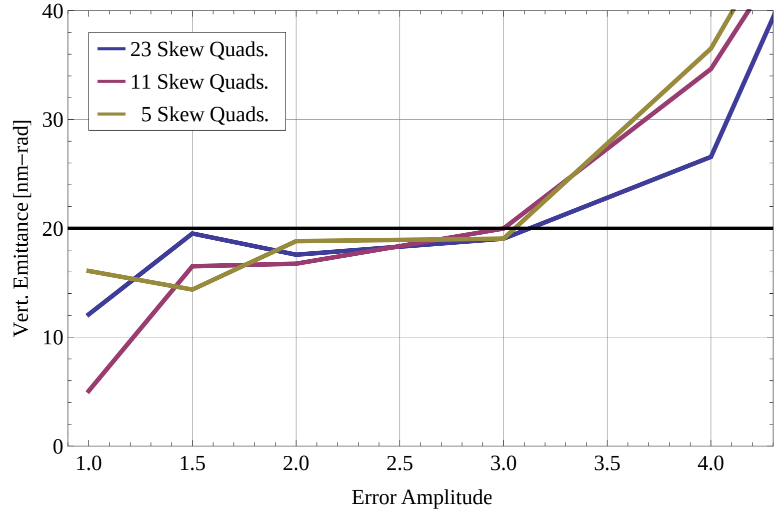




Investigating the Number of Required Correctors

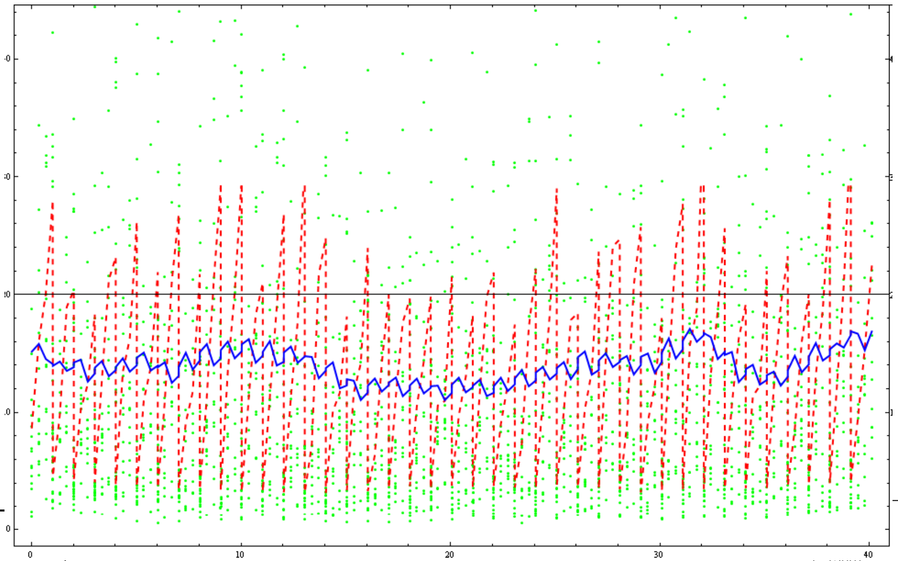
- As a first pass to investigate the minimum number of required skew quads we use a global optimiser
- Vary the number of corrs. Then use a Nelder-Mead Simplex to optimise on the extracted vertical emittance
  - No errors on emittance measurement
  - Purely proof-of-priniciple

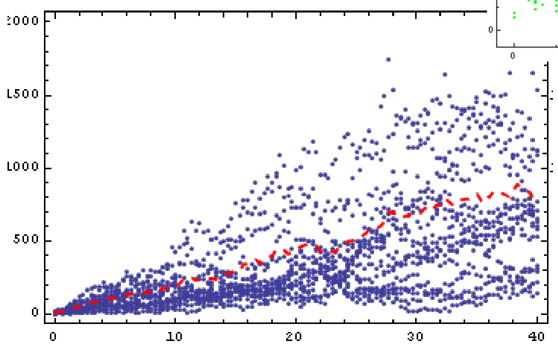


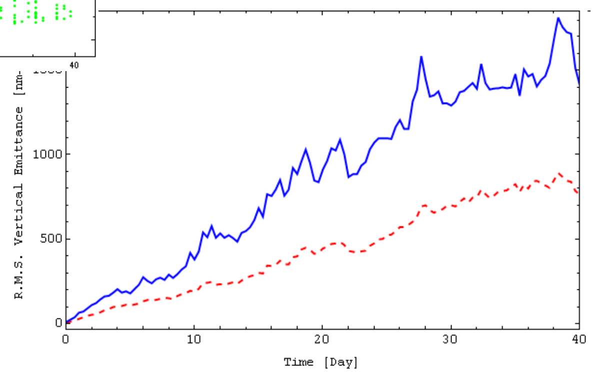


Ground Motion

- Apply a standard ATL model to the machine with an A value of 100µm/10m/year, include standard initial errors.
- Apply full correction every day:







Conclusions & Future Work

- Have a simulation set-up that performs full analysis of the LET for a tuning algorithm.
- Analysed the current 72º lattice in terms of tolerances to a variety of errors.
- First pass at estimating the limits on the number of correctors and monitors.
- Simplified ground motion model has also been taken into account.

- Would like to simulate and test this algorithm on the Cesr-TA lattice
  - Possible chance to experimentally verify later this year!