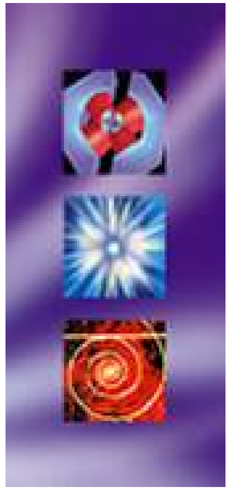
Update on Different Tuning Studies for the ILC

James Jones
ASTeC/Cockcroft Institute
Daresbury Laboratory



Introduction

- Previous work on tuning studies for the ILC BDS have concentrated on correcting the R and T matrix terms at the IP, as well as the linear beta functions and dispersion.
- Interested in other mechanisms to correct the IP aberrations that did not use this method.
- So far, have investigated 2 other methods
  - Correction of beam rotation matrix
  - ‘Dumb’ optimisation using generic optimisation tools
- All methods use translations/rotations/field changes in the final 5 sextupoles of the BDS.

Simulation

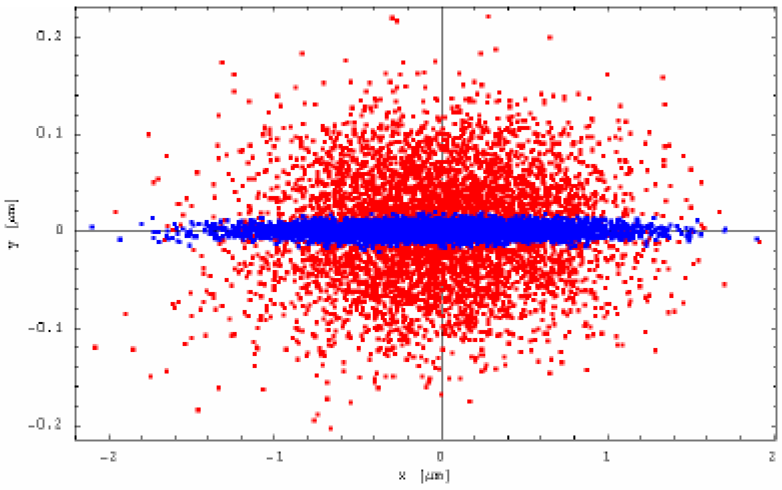
- Assume only the BDS with errors.
- Trajectory correction using SVD inverted response matrix. BPMS and correctors at every quadrupole and sextupole.
- Tuning knobs optimised using 1-Dimensional Nelder-Mead Simplex algorithm.
- Optimise on the 'luminosity' :

$$\sqrt{\left(\frac{x}{x_0}\right)^2 + 100\left(\frac{y}{y_0}\right)^2}$$

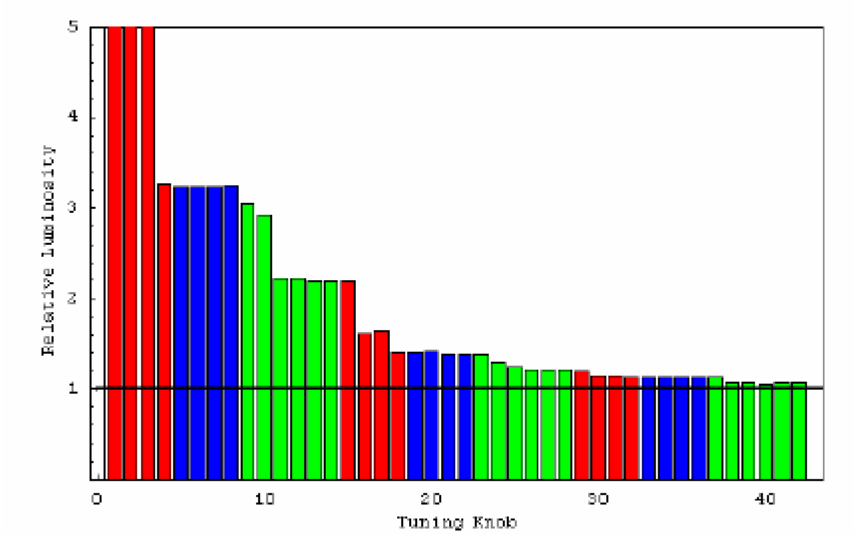
Traditional Approach

- 4 Linear knobs, 4 coupling knobs and 12 2nd order knobs created using all 4 degrees of freedom.
- Use genetic algorithm to optimise non-linear, or non-orthogonal knobs
- Performs adequately with reasonable errors

	Δx (μm)	Δy (μm)	ΔΨ (mrad)	ΔK/K
Quadrupole	30	30	0.1	10^{-6}
Sextupole	30	30	0.1	10^{-6}



1mrad QD0 Rotation



Beam Rotation Matrix

- Create tuning knobs from $beam_{err} \rightarrow beam_0$ rotation matrix:

$$R = beam_0^{-1}.beam_{err} - I$$

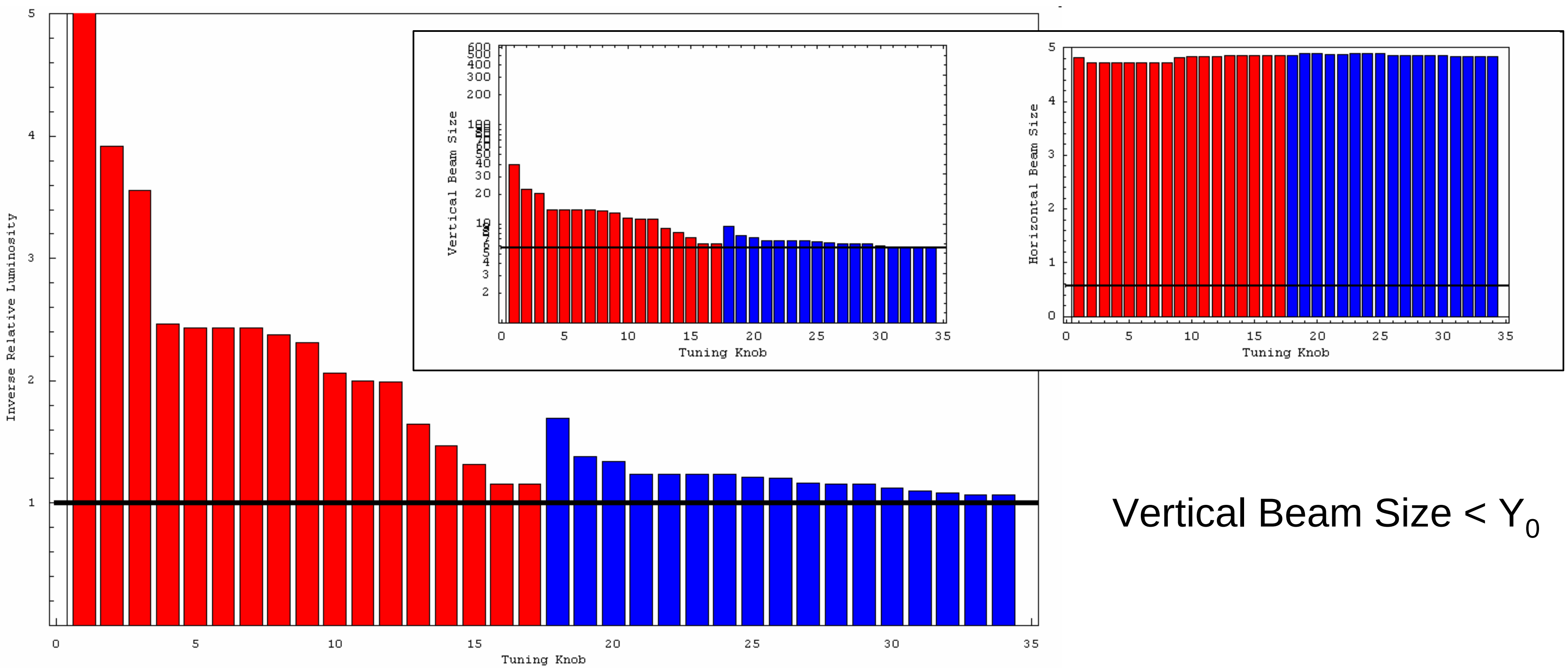
- Where the beams are normalised to 0 at the centre.
- From the 4 response matrices (one for each degree of freedom), tuning knobs are created.
- Have 36 (6x6) possible tuning knobs –
  - To improve orthogonality choose 17

dpx, dpx', dpy, dpy', xx, xx', xy, xy'

x'x, x'x', x'y, x'y', yx', yy, y'x, y'y, y'y'

Beam Rotation Matrix

- Results in simulation are better than the traditional method.



Vertical Beam Size < Y_0

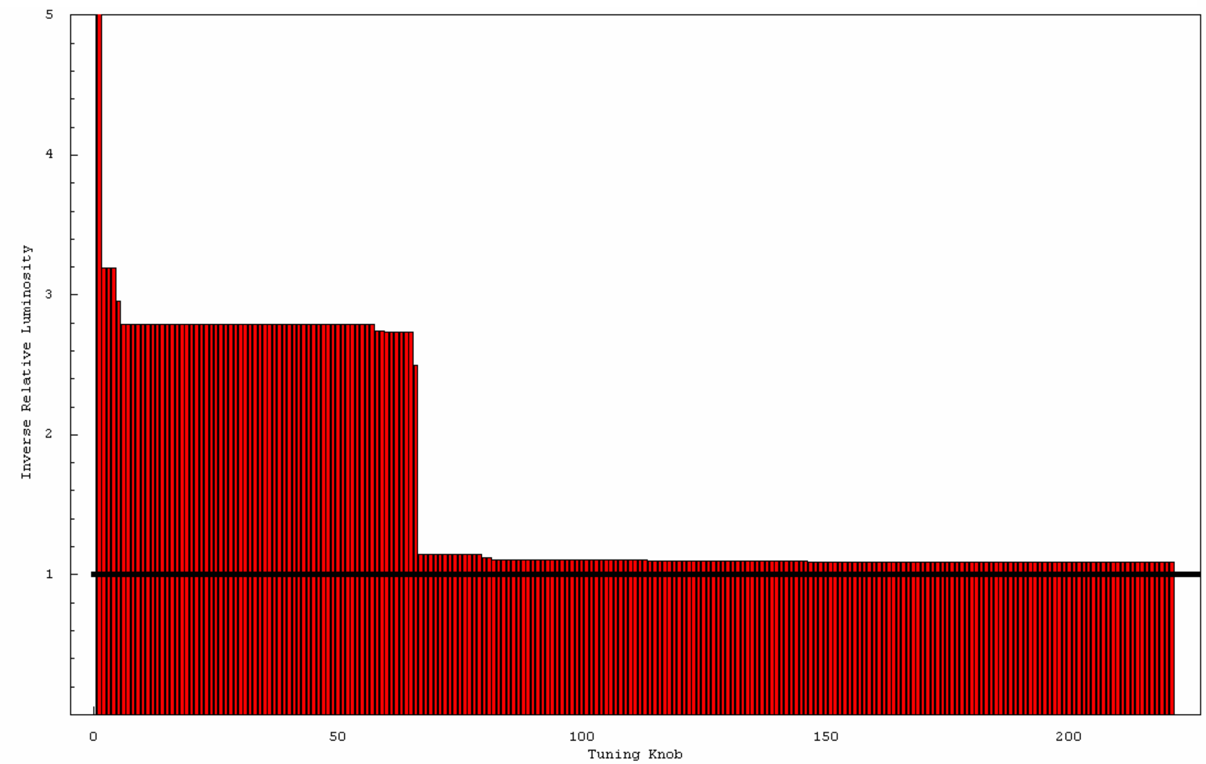
	DX	DY	DΨ	DK/K	Read Error
Quadrupole	50µm	20µm	0.1mrad	0.25%	~
Sextupole	50µm	20µm	0.3mrad	1%	~
BPM	*30µm*	*30µm*	~	~	*30µm*

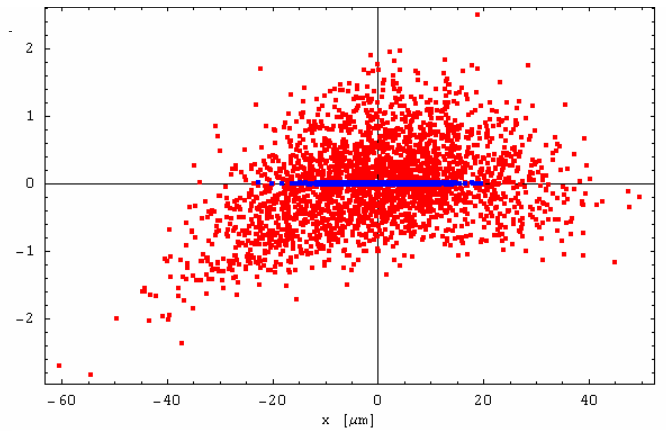
‘Dumb’ Optimisation

- An example of a ‘Dumb’ algorithm is to use a Simplex Algorithm to optimise the luminosity signal.
- Can implement in 2 ways:
  - Optimise all degrees of freedom at once
  - Optimise each degree of freedom separately
- The 1st option gives better results, but takes longer to converge
- Also, need to take into account machine safety –
  - Implies optimisation algorithm is machine specific and can get very complicated!
- ‘Dumb’ optimisation has been demonstrated on working machines

‘Dumb’ Optimisation

- Can use other optimisers such as Genetic Algorithm.
- Has (maybe) greater chance of finding optimum, but -
  - Machine protection issues more important as covers a wider spectrum of problem space.





With 21-Dimensional Simplex, many iterations required to converge shape.

Application of ILC Tuning to the ATF2

- Have several generic options for tuning of final-focus beam at IP – Traditional, Rotation Matrix, 'Dumb'.
- Obvious that the traditional method has a more theoretical framework, but…
- For such a complicated machine, it is unclear (to me) whether a more intuitive method, or a 'stupider' method may not have benefits!

- Would like to test these algorithms in a working machine to compare and contrast:
  - The ATF2 presents an ideal opportunity to provide some limited analysis of the viability of these methods
  - Compare pros and cons of various methods.