Tuning Knobs for ATF2:

An Update

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Introductions

Anthony Scarfe:

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Research Project:

Tuning and Alignment of ATF2 and ILC

Implemented Tuning Methods

Traditional

Fixing the transfer matrix of the beamline with corrector magnets

Beam-Rotation Matrix

Rotating the errored IP beam matrix into the nominal IP beam matrix

Dumb

Use Simplex algorithm and genetic algorithms to optimise the degrees of freedom of the beam

The Utilisation of DIMAD

Planned full research shift from MAD to DIMAD tracking codes.

DIMAD agrees with MAD in most cases

DIMAD tracking is better the MAD tracking in some situations

DIMAD has synchrotron radiation simulation options

MADInput package for Mathematica has been converted into DIMADInput package for Mathematica

DIMADInput Limitations

DIMAD cannot calculate the R and T matrices of a linear machine

MAD calculated R and T matrices are good enough for this work

Tracking and R and T matrix calculations can be separated and run in tandem

DIMAD will be used for the tracking, MAD will be used for R and T matrix calculations

The two codes will interact seamlessly

A Comparison Between Theoretical and Generated Tuning Knobs

Presently the tuning knobs are generated in such a way that the orthogonality is not easily viewable

A new section of Mathematica code has been written

It utilises DIMAD and the theoretically optimum tuning knobs

It displays the generated tuning knobs in an easy-to-read matrix style similar to the style of the theoretically optimum tuning knobs

This allows for the orthogonality to be checked with a quick glance

This dramatically speeds up the orthogonality testing phase

Results

- Analysed the effectiveness of the Beam Rotation Matrix method on the ATF2
- Not as effective as on the ILC
- A systematic analysis and production of Linear knobs in one dimension has been performed in order to understand the effectiveness of individual knobs
- This has been compared to ideal tuning knobs on both the ILC and the ATF2

Beam Rotation Matrix

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

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

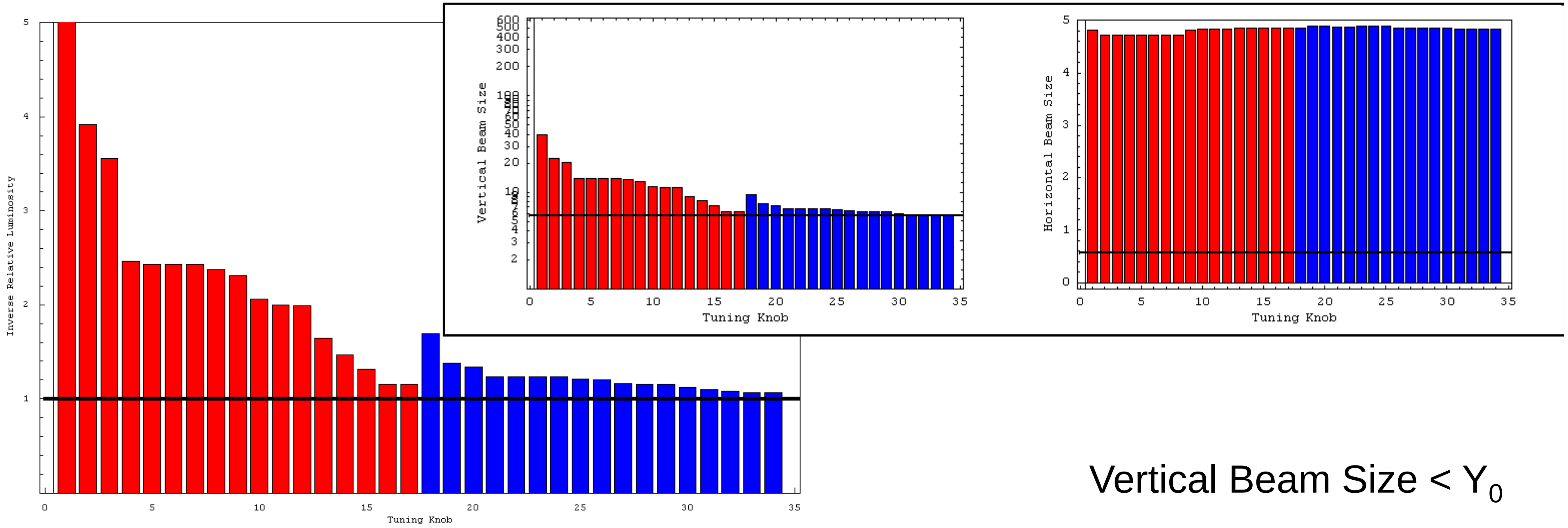
- Where the beams are normalised to 0 at the centre.
- From the 4 response matrices (one for each degree of freedom), tuning knobs are created.
- Have 36 (6x6) possible tuning knobs –
  - To improve orthogonality choose upto 17

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*

Problems

- As soon as ~orthogonal tuning knobs are used in a realistic simulation they do not give results as expected
- Previous work has shown that in theory the Beam Rotation Method can give good results
- Analysis of the tuning knobs used in this case show very non-orthogonal tuning knobs
- It would seem that correlations between the different planes is helping to improve the Luminosity
- However, it is unclear exactly what is going on...

Theoretical Tuning Knobs

- We can create theoretical tuning knobs simply using matrix multiplication on the beam matrix from the tracking code
- We find that (unsurprisingly) it is the vertical tuning knobs that dominate
  - If we look at individual knobs it seems that the horizontal plane has little effect
- This analysis ignores cross-correlations between the planes and does not address some of the complications that arise in the realistic scenario
- It does not seem that this method gives much insight into what is really going on...

Linearity of Tuning Knobs

- To create linear tuning knobs we use both a genetic algorithm and a Nelder-Mead simplex algorithm
  - The effectiveness of simple response matrix inversion is not good enough
- Linear knobs can be created relative to any number of other dimensions
  - As the number of knobs (and so dimensions) increases the orthogonality reduces drastically
- The optimum number of knobs is not clear (it depends on the choice of knobs) but about 6 would be a good limit

Linearity of Tuning Knobs with Errors

- Analysis of the orthogonality and linearity of the tuning knobs with errors on the sextupoles suggests that they should still work adequately
- However the linearity does fall off faster than without errors
- This does not seem to explain the lack of effectiveness of the tuning knobs

Future Plans

Replace the MADInput package with the DIMADInput package in all relevant tuning knob notebooks

Implement a wide range of tuning knob generation techniques, including novel approaches

Investigate the possibility of using Lie Algebra techniques to improve current tuning knobs

Run tuning experiments on the ATF

Publicly release the DIMADInput package for Mathematica