ATF2 Tuning Studies

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- Minimum beam pipe radius near IP
  - What will be the beam pipe size adjacent to this minimum pipe size? 20 mm diameter → 6 mm diameter
  - Is there a step change or a taper can be included?
- With the present simulations on setting up the tuning knobs, we can extract the centroid shift x,z at -250mm from the IP (focal point) to check for 6mm diameter.
- Need a better understanding of orbit correction mechanisms in entire line
  - Effects of extraction line on Final Focus line?

Investigations into tuning knobs

- Investigated the use of tuning knobs to optimise the extraction + FF line(s)
  - Method investigated so far is the creation of quadrupole and sextupole R-matrix "response matrices"
    - Generate R-matrix $Beam_{nominal} \rightarrow Beam_{sext/quad,n}$ for each Quad and Sext.
    - λ Invert total matrix using SVD (removing small eigenvalues)
    - λ Multiply new matrix by $Beam_{error}$ to determine changes in Quad's and Sext's needed to correct back to $beam_{nominal}$
    - λ Matrix uses transverse motion and field strengths.
  - λ Currently no additional weights in inversion – treats all 36 terms equally.

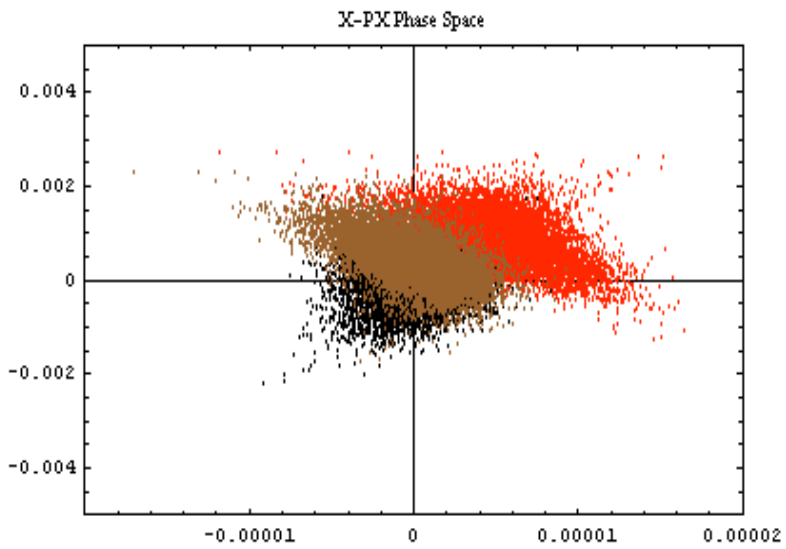
Testing of the tuning knobs

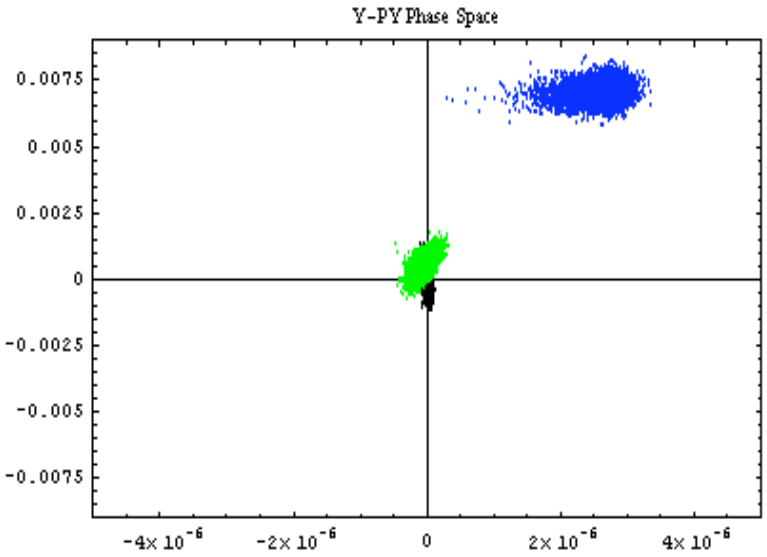
- All quadrupoles and sextupoles including extraction line (Gaussian cut at $\pm 3\sigma$) :
  - 10 μ position error
  - 10^{-4} field error
  - 10^{-4} roll error

- No errors on dipoles included at present

- Assumed all quadrupoles on movers to correct the orbit (correction performed *after* R-matrix correction)

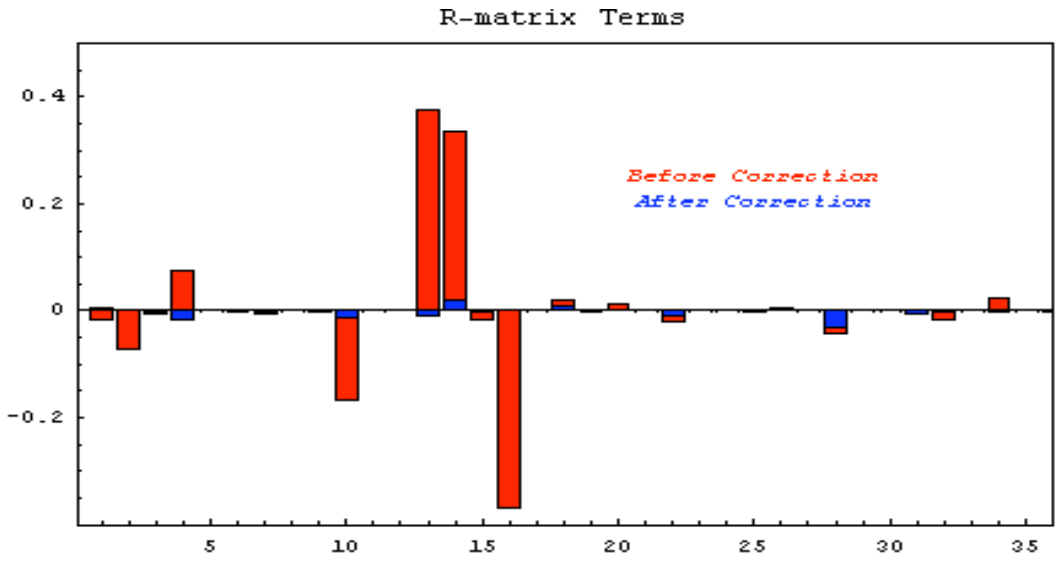
Testing of the tuning knobs





Brown – After Correction
Red – Before Correction

Green – After Correction
Blue – Before Correction



Generating individual tuning knobs

- Would like tuning knobs that modify individual component of beam R-matrix
- Look at all Quad and Sext magnets in different ratios and determine if they can create a change in single element of R-matrix.
- Currently take brute force method as starting point -
  - Add response matrix magnet A to response matrix magnet B, with multiplier

$$A + (m * B) = C$$

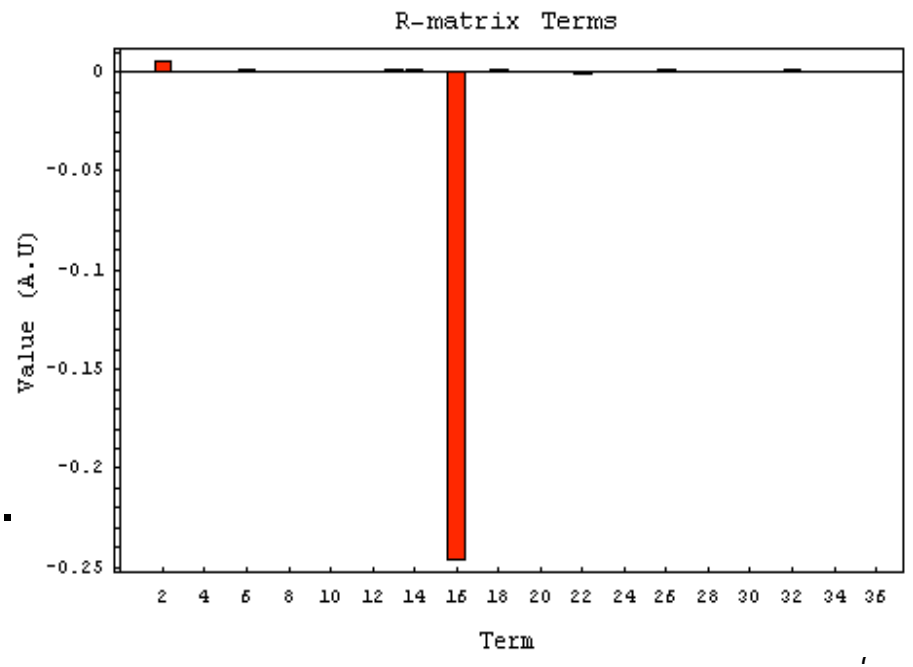
  - Look at ratio of biggest term in R-matrix to second biggest term.
  - If greater than ~2 can be used as knob…
  - Do for all combinations (if include all Quad and Sext == 10000 matrices)
- Can extend to 3 magnets (10^6 matrices – need to be smarter…!)
  - Will be lower if only include FF magnets…

First Test of Individual Tuning Knobs

Magnet No.	R-matrix term	Multiplier	Ratio Main term/Second Term
4 5	1 2	-4	8.58469
17 89	1 4	-10	2.37308
32 81	2 1	-0.3	2.10022
97 48	2 4	25	2.27665
80 65	3 1	-25	8.62214
95 67	3 2	1.5	5.25247
83 12	3 3	-15	2.16107
76 77	3 4	0.1	2833.06
74 37	3 5	1.5	2.82678
23 16	3 6	-10	2.78544
88 89	6 4	-9	4.33518

Optimum magnet ratios to produce individual tuning knobs (2-magnets)

Plot of {3,4} tuning knob, showing large ratio between primary and secondary terms.



Further Work on tuning knobs

- Need to provide a better all-in-one correction matrix that includes weights for the most important terms (which are ?)
  - Test under more realistic conditions
  - Only include Final Focus magnets (!)
  - Apply to the Kuroda-san's lattice

- Generate individual tuning knobs for important terms (again - ?)
  - Extend to 3 magnet knobs
  - Test the tuning knobs on a realistic lattice model