A Code for Optimising Triplet Layout

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INTRODUCTION

- The triplet is an integral part of collider interaction regions
- Often aim to optimise several triplet properties, including length and beam stay clear (BSC)
- Would take long to explore full parameter space
- Thin lenses can be used as first approximation

THIN LENS SOLUTION

- Can simplify system by using thin lenses
- Key property is that it focuses a far particle with \( x = 0 \) and arbitrary \( x' \) to \( x = 0 \) at interaction point

\[
\begin{pmatrix}
x_\text{exit} \\
x_{\text{in}}
\end{pmatrix} = \begin{pmatrix}
1 & m_{11} & m_{12} \\
0 & 1 & m_{21}
\end{pmatrix} \begin{pmatrix}
l_1 & t_1 & t_2 & t_3 & t_4
\end{pmatrix}
\]

- Can solve this analytically
- Also allows one to track the position, \( x \), of a particle at each lens to define BSC based figure of merit

\[
\text{FOM} = \frac{l_Q}{g^2}
\]

\( l_Q = \) length available for quadrupole and \( g = \) thin lens strength
- Can scan through large parameter space quickly

FINITE QUADRUPOLES

For precise BSC one needs to use finite quadrupoles. To first approximation \( g = kl_Q \) but has to be matched.

\[
g = kl_Q \quad \text{Matched}
\]

Finite quadrupoles need to be stronger:

PRECISE SCAN

- Use MADX [1] aperture module to work out BSC
- Computationally intensive
- Use FOM for first scan
- Precise scan around FOM maximum using PyMADX [2]

IMPLEMENTATION

This code was method was implemented to optimise FCC-hh triplet [3]. Tried to find shortest triplet with 15.5 \( \sigma \) BSC.

Imposed additional constraints:

\( l_Q1 = l_Q3 \)

Final drift = 45 m

7 m gaps between quadrupoles

Shielding to protect from collision debris needed [4]

Constraints can be modified if needed and code can be modified for other accelerators

CONCLUSION

- Created a code that uses thin lenses for an analytic FOM
- Use this to speed up parameter scans in order to optimise accelerator triplets

REFERENCES:

[3] L. van Riesen-Haupt et al. IPAC’17 TUPVA041
[4] J.L. Abelleira et al. IPAC’17 TUPVA037