Notes and References

[1] C. Rode, private communication.

[2] The specific solution is from

~douglas/../../../../prinzipal/usr/users/optics/IRFEL_optics/irapr96/baseline
/problems/simulation/mis617out

[3] D. Douglas, "Engineering Design Specifications for the IR FEL Driver Transport System", CEBAF-TN-96-026, 6 June 1996.

[4] D. Douglas, "Design Considerations for the IR FEL Upgrade", CEBAF-TN-96-031, 24 June 1996.

highest excitations arise in the quads QM14 through QM24, which are in the triplets immediately adjacent to the wiggler (where the beam is smallest). Given these comments and the information in Table1, the quadrupoles then naturally fall out into four classes. These are presented in Table 2.

Table 2: Quadrupole Class Break-out for IR FEL Driver

Class	Number	Quads	range of |k| (1/m^2)
large bore trim quads	8	QT11 - 22	0 to 1
low field interface quads	4	QM21, QB1, QB13, QB	0 to 3
mid-range quads	16	QM11-3; QM22,3; QB2-12	1.5 to 9
high-range quads	6	QM14-6; QM24-6	5 to 30

The "large bore trim quads" correspond to the QT quadrupoles planned for the IR demo project. The "low-field interface quads" correspond to QJ quadrupoles presently in use in the CEBA injector. The "mid-range quads" correspond to the QBjrs planned for the IR demo, and the "high-range quads" correspond to standard CEBA QB magnets. This categorization provides adequate focussing strength for operation from 42 MeV to 75 MeV with a maximum dynamic range of 6 to 1 in iron-dominated quads; the low field magnets are all Panofsky quads.

Recommendation

The desired limited dynamic range and upgradeability can be achieved by using quadrupoles as indicated in Table 2. The recommended distribution along the beam line is displayed in Figure 2.

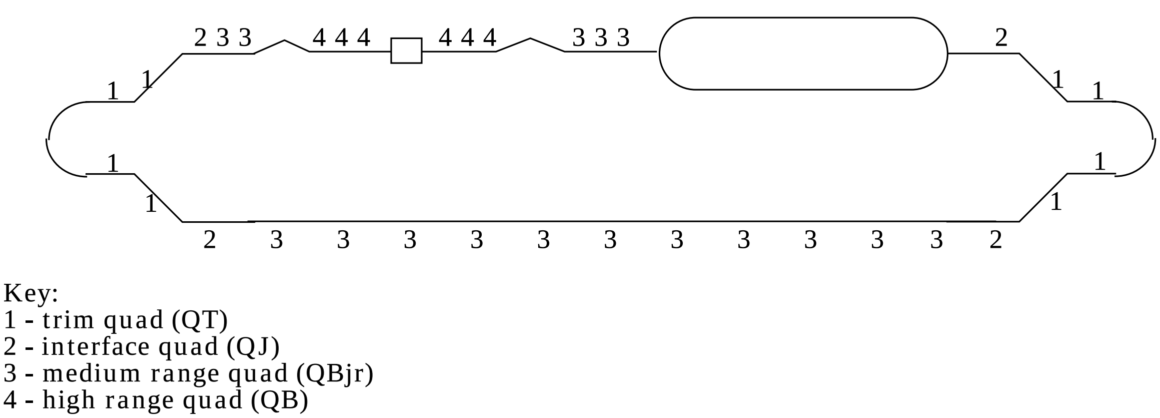

Figure 2: Distribution of quadrupole types in IR FEL driver transport system.

These quadrupole values are listed sequentially in Table 1. Nomenclature is as in the optics design documentation for the driver [3]. Upgrade scenarios for this machine envision optics that are a scaling of the 42 MeV optics to higher energy [4]. Table 1 therefore also provides a "75 MeV equivalent" k value for each quadrupole, established by multiplying the 42 MeV excitation by the ratio of the momenta at each energy (75.5/42.5 = 1.776)

Table 1: Quadrupole Excitations for IR FEL Driver at 42 and 75 MeV

Quad	k ($1/m^2$) @ 42 MeV	equivalent k ($1/m^2$) @ 75 MeV
matching telescopes		
QM11	-4.50	-7.99
QM12	1.87	3.32
QM13	1.95	3.46
QM14	-5.99	-10.64
QM15	10.51	18.67
QM16	-8.53	15.15
QM26	-13.11	-23.29
QM25	12.30	21.85
QM24	-7.00	-12.44
QM23	3.33	5.92
QM22	0	0
recirculation loop trim quads		
QT11 - QT22	±0.5	±0.89
"interface" quads		
QM21	-1.42	-2.52
QB1, QB13	-0.61	-1.08
QB2	0.125	0.22
"backleg" quads		
QB2 - QB12	±3.7	±6.57

We remark that all but the recirculation loop trim quads need only 5 cm (2") bore; the trims must have an aperture of at least 20 cm by 5 cm (8" x 2"). Observe that the

Quadrupole Dynamic Range in the IR FEL Driver

D. Douglas

Abstract

We examine the quadrupole excitation ranges required in the IR FEL driver transport system. Folding the operational ranges of these quadrupoles together with potential system upgrades from 42 to 75 MeV, we find that they can be classified into four groups, each with a dynamic range (ratio of peak to minimum field) of about 6 to 1. The excitation ranges in two of these groups correspond to existing CEBA designs (the QJ and QB styles); the remaining two groups correspond to quadruple types already planned for the IR FEL driver (the QT and "QB-jr" styles).

Introduction

Claus Rode recently observed that the IR FEL driver quadrupoles (the "QB-jrs") required a large dynamic range of 10 to 1 for 42 MeV operation, and would require even greater dynamic range if upgrades to 75 MeV were considered. He therefore asked me to determine if there exists a break-down of the transport line quadrupoles into more types, each with smaller dynamic range, and, moreover, if such a break-down could (even with the reduced dynamic range) support potential 75 MeV upgrades [1]. In the following, we find that such a breakout does exist, and is supported without introduction of any quadrupole styles other than those already in the CEBA inventory or currently planned as a part of the IR FEL demo project.

Discussion

Figure 1 presents quadrupole $k = B'/B\rho$ values for a typical IR FEL driver optics solution [2]. We note that the highest quadrupole excitations occur in the triplets adjacent to the wiggler (where the beam is smallest), the lowest arise in the trim quadrupoles in each recirculation "loop", and the remaining quadrupoles are midrange in excitation.

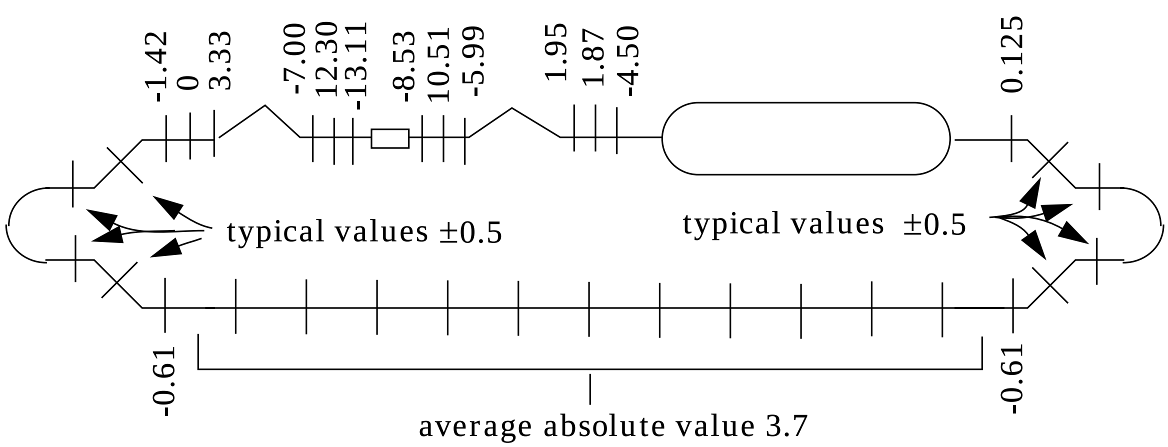

Figure 1: Quadrupole excitations (in 1/m^{-2}) for IR FEL transport system.