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MINI-BETA II

by

H. Newman

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IMPROVED PETRA MINI-BETA INSERTIONS FOR HIGHER BEAM ENERGY AND LUMINOSITY

An improved mini-beta system has been found which uses readily available conventional quadrupoles, and its properties and limitations have been investigated. A four-fold symmetric arrangement matched to MI8 optics is assumed. The new quadrupole arrangement is flexible and adaptible to PETRA operation at beam energies up to 23 GeV; minor adjustments of the system can be made to reduce the chromaticity (or increase the luminosity) over a broad range. The relationship between the linear chromaticity ξ_z and the luminosity gain relative to the present mini-beta set up is roughly linear, and it is not sensitive to the absolute k-values of the quadrupoles. The luminosity gain may be as high as a factor of two, but it depends critically on the maximum tolerable chromaticity and the assumed machine acceptance.

INTRODUCTION

The mini-beta insertions now installed at PETRA[1,2,3] ($\beta_x^* = 1.2$ m, $\beta_z^* = 0.08$ m at the interaction point) have resulted in an increase in the peak luminosity from 0.5 to $1.7 \times 10^{31}\,\mathrm{cm}^{-2}\mathrm{sec}^{-1}$ and in the maximum integrated luminosity accumulated by a PETRA experiment in a 24 hour day from approximately 135 to 650 nb^{-1}. The mini-beta design is based on an original idea by K. Steffen[3], and on a series of earlier reports and discussions[4]. The optics has been implemented by J. Rossbach[2]. The success of the present scheme has naturally stimulated continued discussions and reports [5,6,7] on the best means to achieve the highest luminosities during future PETRA operation.

This note examines the possibility of using readily available conventional quadrupoles for an improved set of mini-beta insertions at PETRA, which could be ready[8] in 1982 for running at beam energies upwards of 20 GeV. Another approach which uses small diameter superconducting quadrupoles has been considered elsewhere[7]. It is presumed that implementation of the more sophisticated superconducting solution will take considerably longer, and that it could follow installation of the improved conventional set up which is discussed in this report.

The study consists of results found on the analog-digital hybrid computer HRS 860[10], which were checked using the PETRA simulation PETROS[11]. PETROS also provided the linear chromaticities ξ_x and ξ_z corresponding to each solution. The PETROS output files have been kept at the DESY IBM computer center for further studies involving beam tracking, variation of optical parameters, etc. which are not covered by the present work.

THE SET-UP

The improved mini-beta arrangement, shown schematically in Fig. 1, consists of a variation of a design by Steffen[5] which uses a QA1 followed by three QD's on either side of each interaction point (I.P.). The QD's are assumed to be taken from the second DORIS ring and to be modified as for DORIS II. The free space for experimental apparatus is chosen as ± 2.86 m, according to preliminary information provided by the experimental collaborations[5,9]. A four-fold symmetric solution has been assumed, and problems of asymmetric machine operation are not considered.

CONSTRAINTS; DEFINITION OF THE PROBLEM

(1) The QA1 and QD geometrical aperture limitations are:

for QA, QA1 : E_x, $E_z \leq 60$ mm, $\sqrt{E_x E_z} \leq 46$ mm ($=R_I$),
for a modified QD : E_x, $E_z \leq 70$ mm $\sqrt{E_x E_z} \leq 51$ mm,

where E_x and E_z are the beam envelopes in the horizontal and vertical planes, and R_I refers to the radius of the inscribed circle tangent to the pole tips.

Another significant vertical aperture limitation is given by the good field region of the weak focussing (17%) bending magnets M4K:

$$E_x \leq 54 \text{ mm}, \quad E_z \leq 27 \text{ mm}.$$

The horizontal aperture is limited at the entrance to the Q1K quadrupoles to $E_x \leq 73$ mm.

(2) The maximum focussing strengths of the quadrupoles are limited by saturation of the pole pieces. Expressed in terms of $k(m^{-2})$, the limitations which are given by 3-4% saturation [12] at 20 GeV are:

$$\text{QA, QA1}: |k| \leq 0.2225$$

$$\text{QD}: \quad |k| \leq 0.2665,$$

where $k(m^{-2}) = 0.3 \frac{dB}{dx} \left[\text{Tesla}/\text{m}\right] / p(\text{GeV}/c)$ [13]. The above maximum value for QA and QA1 quadrupoles shows that the present mini-beta system with $\beta_z^* = 8$ cm is limited in this sense to 20.0 GeV. The saturation limitation is not absolute, of course, but PETRA operation with larger degrees of magnet saturation requires additional experience. Additional hardware and computer software for non-linear time dependence of the magnet currents during ramping may also be needed[14]. Higher levels of saturation have been previously encountered at DORIS.

(3) The dispersion at the interaction point D_x^* has been kept small. The hybrid computer does not constrain $\partial D_x^*/\partial x$ to be zero at the I.P. as does PETROS in its solution for the closed orbit. It was found empirically, however, that by restricting the hybrid computer to solutions such that $D_x^* < 1$ cm, the corresponding PETROS solution also gave $D_x^* < 1$ cm.

(4) Solutions involving high linear chromaticities are less desirable for several reasons:

(a) Experience and beam-tracking simulations have shown that correction of chromaticities with strong sextupole fields leads to enhanced non-linear effects, resulting in a highly non-linear momentum dependence of the tune shifts. This leads in turn to a reduction in the machine acceptance [2,15]. The non-linear components of the chromaticity ξ_z corresponding to the quadrupole and sextupole settings currently in use at PETRA are indeed limiting [16] the momentum acceptance to $\frac{\Delta p}{p} \simeq 0.7\%$ at 17 GeV. The machine momentum spread $\frac{\Delta p}{p}$ is proportional to the beam momentum p so that the machine acceptance for a given ξ_z is reduced as p increases. The ξ_z limit may therefore be the dominant factor which determines the maximum β_z usable in the mini-beta quadrupoles at energies above 17 GeV. As a consequence, the minimum β_z^* at the I.P. and the maximum luminosity obtainable could also be limited by the ξ_z limit [17].

(b) As discussed in Ref. 2, a reduction of the sextupole field strengths by use of large values of the dispersion function D_x in the arcs leads to larger emittances ε_x and a larger momentum compaction factor α. This results in a reduced maximum PETRA energy for a given amount of R.F.power.

In an initial response to this problem only solutions with $|\xi_z| \leq 110$ were considered[18] (for comparison: the original MI8 has $\xi_z = -76.5$; MI6 has $\xi_z = -95$). It was soon realized, however, that the background rates seen by experiments resulting from particles lost from the beam could be significantly reduced by using a modified MI8 optics with $\xi_z \simeq -65$ instead of -76.5. The approach to the problem of future mini-beta solutions was therefore made more general. A range of solutions was found so that the relation between ξ_z and the luminosity gain $\Delta L/L$ could be seen over a broad range of chromaticity values. The achievable luminosity gain is thus given as a function of the maximum tolerable ξ_z, which depends in turn on the state-of-the-art of handling non-linear effects in PETRA.

RESULTS

CASE 1

Figure 1 shows the results obtained for a series of solutions based on the following conservative assumptions:

(1) $\varepsilon_x^{MAX} = 30$ mm mrad, $\varepsilon_z^{MAX} = 8$ mm mrad, corresponding to the geometrical aperture of the machine, and

(2) $E_{BEAM}^{MAX} = 22$ GeV

The magnet settings $k(m^{-2})$ of all elements which are changed from the present MI8 optics are shown. Q4K is off in all solutions and M4K and M5K (the 17% and

83% bending magnets) are unchanged. The beam envelopes E_x and E_z are given at the entry and exit of each magnet and the value of $\sqrt{E_x E_z}$ is shown where it is largest. Underlined numbers approach the nominal magnet aperture limits, and numbers in a box slightly exceed the limit. The "luminosity gain factor" is a multiplicative factor relative to the present MI8. "Chromaticites" indicated are those given by PETROS as the vertical "linear chromaticity MODE II". For each case the beam envelopes E_x^* and E_z^* and the beta function values β_x^*, β_z^* at the I.P. are also given.

Cases 1(a)-1(e) represent a range of chromaticities and luminosity gain factors which has been obtained principally by varying Q5K. This has the effect of changing the E_z (and β_z) values with only small changes in the x envelope because $\partial E_x/\partial x$ is small in Q5K (as is E_x). This means that only minor adjustments in the QA1 or the QD's which focus in Z are needed to recover a periodic solution after each change in Q5K. The system is therefore very flexible and allows variations in β_z and ξ_z over a wide range. The intermediate beam waist in Q5K is achieved by strongly exciting Q0 and Q1 (which are of the "QA1" PETRA type). Q1 is seen to be at a similar level of saturation as QA1 in the figure. Exciting Q0 and Q1 less strongly leads to slightly higher luminosities for a given ξ_z (e.g. a gain factor of $\simeq$ 1.6 for ξ_z = -110) but such solutions are less flexible. It was found difficult to keep D_x^* small at the I.P. while varying ξ_z and respecting the magnet apertures with smaller |k| values in Q0 and Q1

Vertical aperture limits for solutions like case 1.a) - 1e) are only reached at $\xi_z \simeq -117$ in the mini-beta quadrupoles. The vertical aperture limit at the exit of M4K is reached at nearly the same ξ_z (see Appendix A).

CASE 2

Fig. 2 shows how the principle used in case 1 can be readily adapted when E_{BEAM}^{MAX}=23 GeV. A very high chromaticity and a lower chromaticity solution are shown. Once again, larger (more negative) k values in Q5K give lower chromaticities. Since Q5K is actually of the "QA" PETRA quadrupole type, very low chromaticities ξ_z (and corresponding lower luminosities) can be obtained without significant Q5K saturation.

CASE 3

The luminosity gain factor obtainable for a given ξ_z is also dependent on the machine acceptance assumed. Fig. 3 shows a series of solutions for high luminosity gains and high ξ_z. We assume ε_x^{MAX} = 20 mm mrad and ε_z^{MAX}= 5 mm mrad for this case, corresponding to a slightly optimistic estimate[19] of the machine acceptance as measured during machine shifts. It should be noted, however, that the effects of the extreme tails of the beam (many σ off the equilibrium orbit) are of no consequence in the machine acceptance measurements, but are crucial to the background conditions seen by the experiments. It is therefore possible that the beam envelope $E_x = \sqrt{\beta_x \varepsilon_x}$ cannot be as fully expanded in Q1K as is shown in Fig. 3, and it is reasonable to consider case 3 as an "optimistic" - and case 1 as a "pessimistic" - estimate of the gain factor achievable with acceptable background conditions for experiments, provided ξ_z is also chosen to be "sufficiently small" as previously discussed.

The solutions in case 3 have a significantly lower ξ_z for a given luminosity gain than those in case 1. This is obtained by increasing the beam envelope to make use of the full vertical aperture at the M4K exit. This leads to larger β_z values in the magnets which defocus in z, partially offsetting the contribution to ξ_z of the mini-beta quadrupoles closest to the interaction point.

CASE 4

Fig. 4 shows how lower chromaticity solutions are obtainable at E_{BEAM}^{MAX} = 23 GeV, following the methods introduced for case 1, for ε_x^{MAX} and ε_z^{MAX} as in case 3.

DISCUSSION

The relation between $^{\Delta L}/L$ ($\equiv$ 1 - luminosity gain factor)and ξ_z is shown in Fig. 5 for cases 1 and 2 corresponding to ε_x^{MAX} = 30 mm mrad and ε_z^{MAX} = 8 mm mrad, and in Fig. 6 for cases 3 and 4 corresponding to ε_x^{MAX} = 20 mm mrad and ε_z^{MAX} = 5 mm mrad. The arrows in Fig. 5 refer to the ξ_z values for MI8, MI6 and the "reference" limit discussed earlier, for the present mini-beta system. The straight lines in the figures are fits by eye to the E_{BEAM}^{MAX} = 23 GeV points. It is apparent that the ξ_z vs $^{\Delta L}/L$ relationship is quite linear and that the slope $d\xi_z/d\,(\frac{\Delta L}{L})$ depends little on E_{BEAM}^{MAX} over the range from 21.2 to 23 GeV, although it is sensitive to the machine acceptance assumed.

CONCLUSION AND FUTURE OUTLOOK

The improved mini-beta system proposed, which has been discussed in terms of a case study, can be used for PETRA operation up to the maximum feasible beam energy of 23 GeV. It is quite likely that a net luminosity gain could be realized, relative to what would be obtained if the present mini-beta insertion could operate at comparable energies (which indeed it cannot at the present β_z^*). The size of the luminosity gain will depend critically on the maximum tolerable chromaticity ξ_z, which will no doubt increase with time as non-linear effects from lattice imperfections and correcting sextupoles are better understood.

The flexibility of the proposed system allows one to maximize the luminosity by working near the ξ_z limit, or to decrease ξ_z in order to reduce backgrounds for the experiments. It will also clearly be useful during future studies of the chromaticity during machine shifts.

The principal advantage of this conventional scheme over the superconducting set-up[7] is in its cost and in the relative ease and speed of implementation. The luminosity gain factor ultimately achieved with the solutions discussed here could at best be a factor of two. The long term advantages of the superconducting system i.e. higher luminosites which result from much smaller β_x^* as well as β_z^* [20], and lower chromaticities, are clear. This proposal is therefore viewed as a forerunner, rather than a substitute, for the system proposed by K. Steffen and G.-A. Voss.

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ACKNOWLEDGEMENTS (cont.)

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16 R. Kose and D. Degèle, private communication.

17 This effect is considerably reduced in the superconducting solution presented in Ref. 7

18 Based on the advice and the machine studies of R. Kose et al.

19 R. Kose, private communication.

20 As pointed out in Ref. 7, beam-beam interaction simulations by Piwinsky indicate that β_z^* reductions below 3 times the bunch length are relatively ineffective in increasing the luminosity.

FIGURE CAPTIONS

1. Optics solutions for CASE 1; $\varepsilon_x^{MAX} = 30$ mm mrad, $\varepsilon_z^{MAX} = 8$ mm mrad, $E_{BEAM}^{MAX} = 22$ GeV.

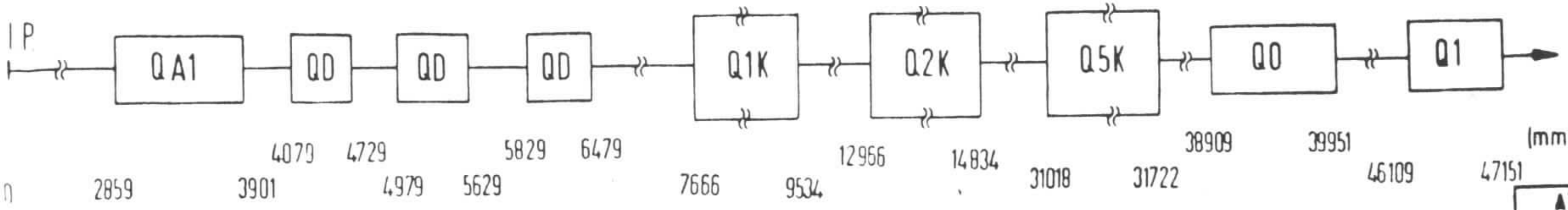
2. Optics solutions for CASE 2: $\varepsilon_x^{MAX} = 30$ mm mrad, $\varepsilon_z^{MAX} = 8$ mm mrad, $E_{BEAM}^{MAX} = 23$ GeV.

3. Solutions for CASE 3; $\varepsilon_x^{MAX} = 20$ mm mrad, $\varepsilon_z^{MAX} = 5$ mm mrad, $E_{BEAM}^{MAX} = 21.2 - 21.8$ GeV.

4. Solutions for CASE 4; $\varepsilon_x^{MAX} = 20$ mm mrad, $\varepsilon_z^{MAX} = 5$ mm mrad, $E_{BEAM}^{MAX} = 23$ GeV.

5. $|\xi_z|$ vs $^{\Delta L}/L$ for CASES 1 and 2.

6. $|\xi_z|$ vs $^{\Delta L}/L$ for CASES 3 and 4.



a)

k (m⁻²)	-.20213 -.24100 -.24100 .21149 .11022 -.00925 -.13338 .18161 -.20000
E_x(mm)	14.6 20.7 22.1 28.5 31.5 41.0 44.5 53.8 66.6 73.0 59.0 52.3 9.5 10.0 29.8 30.2 15.7
E_z(mm)	45.9 57.1 58.0 58.3 57.2 51.7 49.1 42.9 35.2 29.2 29.0 28.5 20.1 19.1 3.9 3.8 16.2
$(E_xE_z)^{1/2}$(mm)	48.0

$\mathcal{L}$ GAIN FACTOR 1.53 — Chromaticity -116.5

AT I.P: E_x^* = 6.581 mm, E_z^* = 0.490 mm, β_x^* = 1.44 m, β_z^* = 0.0310 m, E_{max} = 22 GeV

b)

k (m⁻²)	-.20171 -.24100 -.24100 .21149 .11017 -.00925 -.13836 .18161 -0.20000
E_x(mm)	14.6 20.8 22.2 28.6 31.5 41.0 44.6 53.8 66.6 73.1 59.1 52.4 9.5 10.0 29.8 30.2 15.7
E_z(mm)	43.6 54.3 55.1 55.4 54.4 49.1 46.7 40.8 33.5 27.9 27.8 27.4 20.0 19.1 3.9 3.8 16.2
$(E_xE_z)^{1/2}$(mm)	46.9

$\mathcal{L}$ GAIN FACTOR 1.46 — Chromaticity -107.7

E_x^* = 6.576 mm, E_z^* = 0.524 mm, β_x^* = 1.44 m, β_z^* = 0.0343 m, E_{max} = 22 GeV

c)

k (m⁻²)	-.20071 -.24100 -.24100 .21149 .10957 -.00842 -.14999 .18161 -0.20000
E_x(mm)	14.6 20.7 22.1 28.5 31.4 40.9 44.4 53.6 66.4 72.8 59.2 52.6 9.6 10.0 29.8 30.2 15.7
E_z(mm)	38.7 48.1 48.9 49.2 48.3 43.6 41.5 36.3 29.9 25.0 25.1 24.8 20.0 19.1 3.9 3.8 16.2
$(E_xE_z)^{1/2}$(mm)	44.1

$\mathcal{L}$ GAIN FACTOR 1.29 — Chromaticity -90.7

E_x^* = 6.588 mm, E_z^* = 0.591 mm, β_x^* = 1.45 m, β_z^* = 0.0437 m, E_{max} = 22 GeV

d)

k (m⁻²)	-.20071 -.24039 -.24039 .21149 .10945 -.00842 -.15769 .16161 -.20000
E_x(mm)	14.6 20.8 22.2 28.5 31.5 41.0 44.5 53.7 66.5 73.0 59.3 52.7 9.6 10.0 29.8 30.2 15.7
E_z(mm)	35.2 43.8 44.5 44.8 44.0 39.8 37.8 33.1 27.3 22.9 23.3 23.2 19.9 19.1 3.9 3.8 16.2
$(E_xE_z)^{1/2}$(mm)	42.2

$\mathcal{L}$ GAIN FACTOR 1.18 — Chromaticity -80.0

E_x^* = 6.567 mm, E_z^* = 0.649 mm, β_x^* = 1.44 m, β_z^* = 0.0527 m, E_{max} = 22 GeV

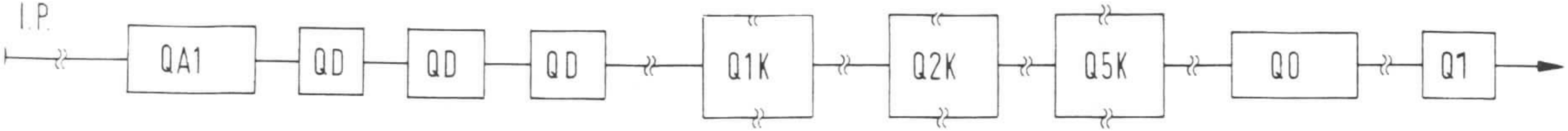
e)

k (m⁻²)	-.20071 -.23969 -.23969 .21149 .10910 -.00806 -.16640 .18161 -.20000
E_x(mm)	14.6 20.8 22.2 28.6 31.5 41.0 44.5 53.8 66.5 73.0 59.4 52.9 9.6 10.0 29.8 30.2 15.7
E_z(mm)	31.6 39.3 39.9 40.1 39.4 35.6 33.9 29.7 24.5 20.7 21.3 21.3 19.9 19.1 3.9 3.8 16.2
$(E_xE_z)^{1/2}$(mm)	40.0

$\mathcal{L}$ GAIN FACTOR 1.06 — Chromaticity -69.7

E_x^* = 6.555 mm, E_z^* = 0.725 mm, β_x^* = 1.43 m, β_z^* = 0.0657 m, E_{max} = 22 GeV

FIGURE 1



	k (m^{-2})	QA1	QD	QD	QD	Q1K	Q2K	Q5K	Q0	Q1
a)	k (m^{-2})	-.19296	-.23100	-.23100	.14850	.11760	-.00790	-.11800	.18161	-.19299
b)	k (m^{-2})	-.19296	-.23045	-.23045	.14850	.11715	-.00740	-.13179	.18161	-.19299

a)	E_x(mm)	14.3	20.1	21.4	27.4	30.2	39.0	42.3	51.5	65.5	73.0	59.4	52.8	9.5	9.9	29.1	29.5	15.7
a)	E_z(mm)	48.0	59.9	61.0	61.7	60.8	55.6	53.1	46.7	37.7	30.6	29.6	28.7	17.7	16.8	4.0	4.3	16.3
a)	$(E_x E_z)^{1/2}$(mm)								49.0									
b)	E_x(mm)	14.3	20.1	21.4	27.4	30.2	39.0	42.3	51.5	65.4	73.0	59.6	53.0	9.5	9.9	29.1	29.5	15.7
b)	E_z(mm)	42.8	53.4	54.3	55.0	54.2	49.5	47.4	41.6	33.7	27.5	26.8	26.0	17.7	16.8	4.0	4.3	16.3
b)	$(E_x E_z)^{1/2}$(mm)								46.3									

	ℒ GAIN FACTOR	Chromaticity	AT I.P.
a)	154	-124.2	$E_x^* = 6.850$ mm; $E_z^* = 0.477$ mm; $\beta_x^* = 1.564$ m; $\beta_z^* = 0.0284$ m; $E_{max} = 23$ GeV; $\varepsilon_x \varepsilon_z = 30 \cdot 8$ mm mrad
b)	137	-104.1	$E_x^* = 6.842$ mm; $E_z^* = 0.535$ mm; $\beta_x^* = 1.56$ m; $\beta_z^* = 0.0358$ m; $E_{max} = 23$ GeV; $\varepsilon_x \varepsilon_z = 30 \cdot 8$ mm mrad

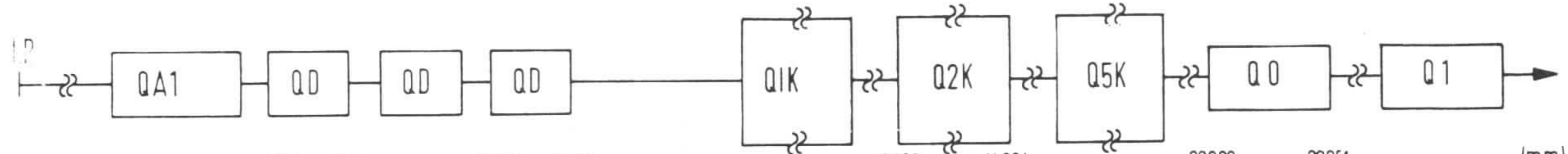
FIGURE 2

NOMINAL LIMITS

QA, QA1: $E_x, E_z \leq 60$ mm, $\sqrt{E_x E_z} \leq 46$ mm

QA : $E_x, E_z \leq 70$ mm, $\sqrt{E_x E_z} \leq 51$ mm

Q1K, Q2K : $E_x, E_z \leq 73$ mm



(mm)	0	2859	3901	4079	4729	4979	5629	5829	6479	7666	9534	12966	14834	31018	31722	38909	39951	46109	47151
K (m^{-2})		- .21021		-.24000		-.24000		.24000		.11401		-.02386		-.12393		.18915		-.21000	
E_x(mm)		14.3	20.9	22.4	29.2	32.3	42.1	45.8	55.1	67.3	72.3	54.8	47.4	7.0	7.3	25.1	25.4	12.9	
E_z(mm)		38.1	47.2	47.8	47.9	46.9	42.2	40.0	35.0	29.1	25.3	27.6	27.7	18.9	18.0	3.3	2.6	12.8	
$(E_x E_z)^{1/2}$(mm)									43.9										

GAIN FACTOR 2.05 PETROS CHROMATICITY -125.8 (for 4 I.R.'s) $\varepsilon_x \varepsilon_z = 20 \times 5$ mm.mrad; $E_x^* = 4.192$ mm; $E_z^* = 0.375$ mm; $\beta_x^* = 0.879$ m; $\beta_z^* = 0.0281$ m, $E_{max} \geq 21.2$ GeV

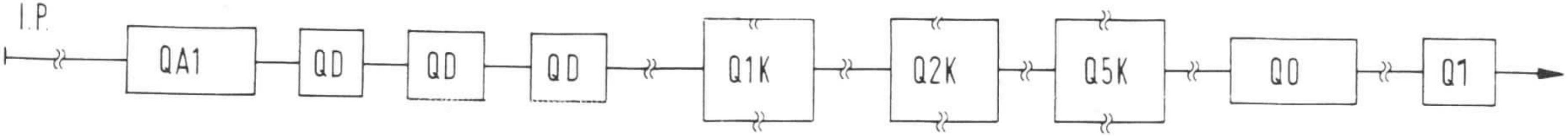
(mm)	0	2859	3901	4079	4729	4979	5629	5829	6479	7666	9534	12966	14834	31018	31722	38909	39951	46109	47151
K (m^{-2})		- .20415		-.24000		-.24000		.23000		.12121		-.03596		-.09522		.18475		-.20000	
E_x(mm)		14.5	21.2	22.7	29.4	32.5	42.5	46.1	55.6	68.2	72.8	52.5	44.6	7.4	7.8	24.3	24.6	12.8	
E_z(mm)		36.2	44.9	45.6	45.8	44.9	40.6	38.5	33.8	28.2	25.0	28.9	29.2	16.0	15.1	3.1	3.0	12.8	
$(E_x E_z)^{1/2}$(mm)									43.4										

GAIN FACTOR 1.97 PETROS CHROMATICITY -115.9 (for 4 I.R.'s) $\varepsilon_x \varepsilon_z = 20 \times 5$ mm.mrad; $E_x^* = 4.130$ mm; $E_z^* = 0.395$ mm; $\beta_x^* = 0.853$ m; $\beta_z^* = 0.0312$ m, $E_{max} \geq 21.8$ GeV

(mm)	0	2859	3901	4079	4729	4979	5629	5829	6479	7666	9534	12966	14834	31018	31722	38909	39951	46109	47151
K (m^{-2})		- .20412		-.24000		-.24000		.23520		.12158		-.03885		-.09544		.18369		-.02000	
E_x(mm)		14.5	21.3	22.8	29.6	32.8	42.8	46.5	56.0	68.5	72.8	51.9	43.9	7.5	7.9	24.3	24.6	12.8	
E_z(mm)		34.4	42.8	43.4	43.6	42.8	38.6	36.7	32.2	27.1	24.3	28.7	29.2	16.0	15.1	3.1	3.0	12.8	
$(E_x E_z)^{1/2}$(mm)									42.5										

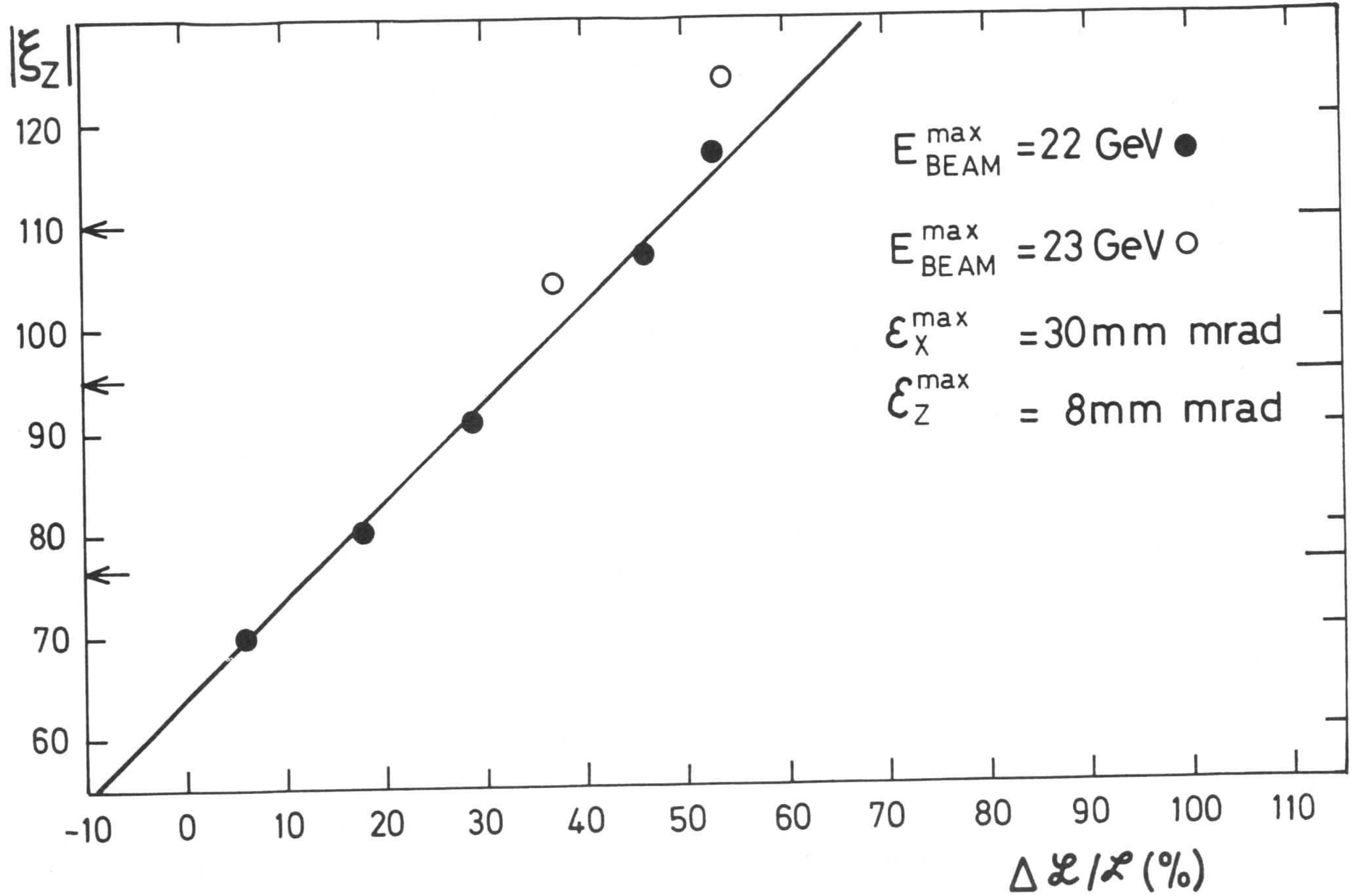
GAIN FACTOR 1.89 PETROS CHROMATICITY -107.7 (for 4 I.R.'s) $\varepsilon_x \varepsilon_z = 20 \times 5$ mm.mrad; $E_x^* = 4.096$ mm; $E_z^* = 0.415$ mm; $\beta_x^* = 0.838$ m; $\beta_z^* = 0.0345$ m; $E_{max} \geq 21.8$ GeV

FIGURE 3



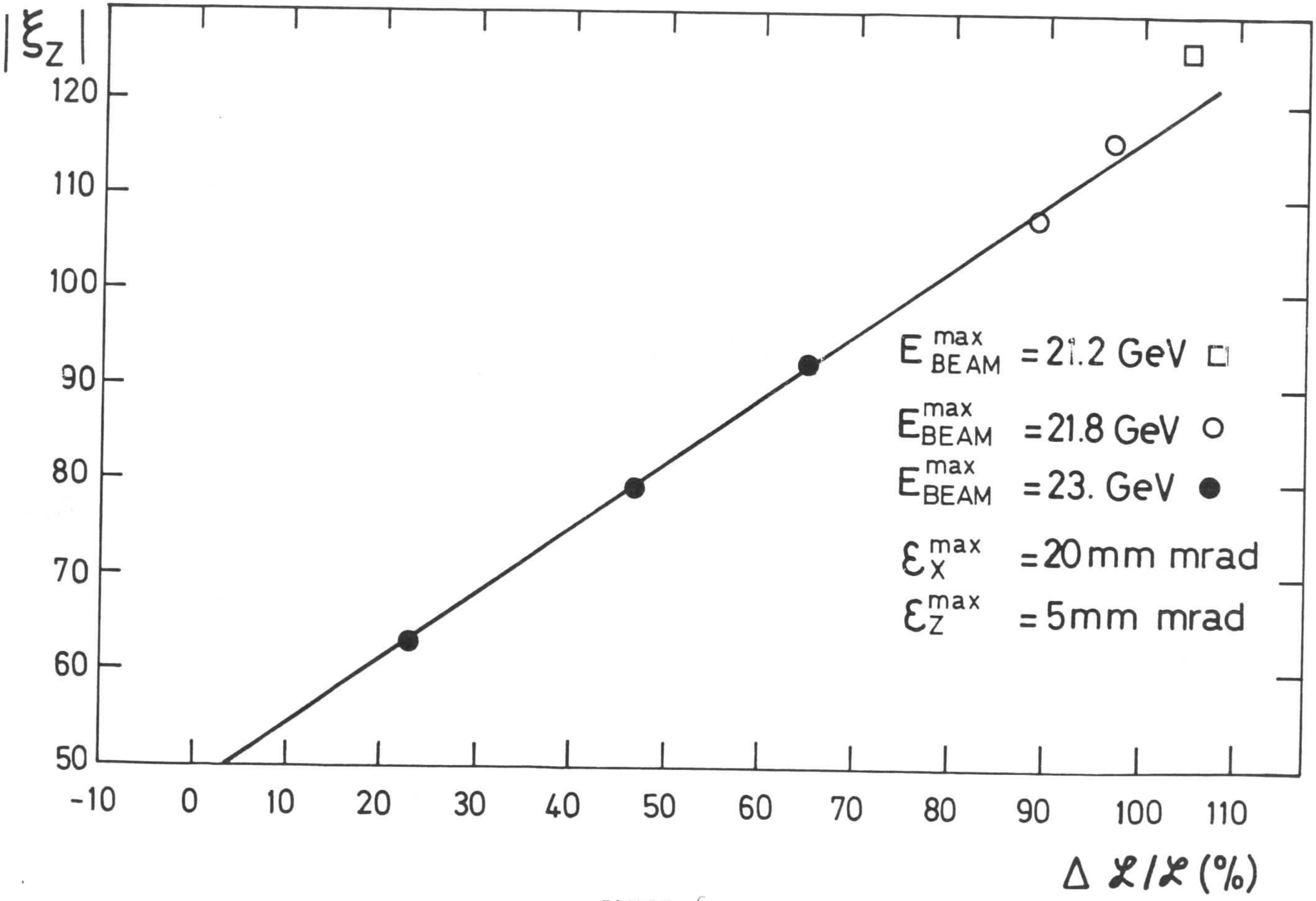
																												AT I.P.
a)	k (m^{-2})		-.19405			-.22700			-.22700			.15960			.13187			-.03885			-.09544			.18369			-.19399	$\varepsilon_x \varepsilon_z$ = 20 • 5 mm mrad E_x^* = 4.246 mm E_z^* = 0.460 mm β_x^* = 0.901 m β_z^* = 0.0423 m E_{max} = 23 GeV
	E_x (mm)	14.1		20.5	22.0		28.4	31.3		40.6	44.0		53.4	67.6		73.2 (boxed)	52.3		44.2	7.5		7.8	23.8		24.2	12.8		
	E_z (mm)	31.1		38.8	39.5		39.9	39.4		36.1	34.5		30.5	25.2		22.2	26.2		26.6	14.4		13.5	3.1		3.3	12.9		
	$(E_x E_z)^{1/2}$ (mm)												40.4																	
																						$\mathcal{L}$ GAIN FACTOR 1.65			Chromaticity -92.2				
b)	k (m^{-2})		-.19405			-.22710			-.22710			.16199			.13100			-.03782			-.11099			.18369			-.19399	$\varepsilon_x \varepsilon_z$ = 20 • 5 mm mrad E_x^* = 4.255 mm E_z^* = 0.513 mm β_x^* = 0.905 m β_z^* = 0.0526 m E_{max} = 23 GeV
	E_x (mm)	14.1		20.5	21.9		28.3	31.2		40.5	43.9		53.3	67.3		73.0	52.4		44.4	7.5		7.8	23.6		24.2	12.8		
	E_z (mm)	27.8		34.8	35.3		35.8	35.3		32.3	30.9		27.4	22.6		20.0	23.7		24.1	14.3		13.5	3.1		3.3	12.9		
	$(E_x E_z)^{1/2}$ (mm)												38.2																	
																						$\mathcal{L}$ GAIN FACTOR 1.47			Chromaticity -79.3				
c)	k (m^{-2})		-.19389			-.22700			-.22700			.16599			.12988			-.03668			-.13242			.18369			-.19399	$\varepsilon_x \varepsilon_z$ = 20 • 5 mm mrad E_x^* = 4.238 mm E_z^* = 0.618 mm β_x^* = 0.898 m β_z^* = 0.0764 m E_{max} = 23 GeV
	E_x (mm)	14.1		20.6	22.0		28.4	31.3		40.6	44.0		53.4	67.3		73.0	52.6		44.6	7.6		7.8	23.8		24.2	12.8		
	E_z (mm)	23.1		28.9	29.4		29.7	29.3		26.9	25.7		22.8	18.9		16.9	20.3		20.8	14.2		13.5	3.1		3.3	12.9		
	$(E_x E_z)^{1/2}$ (mm)												34.9																	
																						$\mathcal{L}$ GAIN FACTOR 1.23			Chromaticity -63.2				

FIGURE 4



|ξ_Z|
120
110
100
90
80
70
60
-10
0
10
20
30
40
50
60
70
80
90
100
110
ΔL/L (%)
E_BEAM^max = 22 GeV ●
E_BEAM^max = 23 GeV ○
ε_X^max = 30 mm mrad
ε_Z^max = 8 mm mrad

FIGURE 5



|ξ_Z|
120
110
100
90
80
70
60
50
-10
0
10
20
30
40
50
60
70
80
90
100
110
Δ ℒ/ℒ (%)
E BEAM max = 21.2 GeV □
E BEAM max = 21.8 GeV ○
E BEAM max = 23. GeV ●
ε X max = 20 mm mrad
ε Z max = 5 mm mrad

FIGURE 6

APPENDIX A

The proposed system was selected from a series of geometries and optics solutions by examination of more than a hundred alternatives on the hybrid computer. The digital solutions corresponding to each case presented in Figs. 1-4 are given here for completeness. Each line of the solution refers to the end of the magnet or drift space. The beam envelopes and slopes, the dispersion and its slope T_x and T_x' (denoted D_x in the text), and the betatron phases $Q1 \equiv \phi_x/2\pi$, $Q2 \equiv \phi_z/2\pi$ are given. Although the column T_x is labeled as mm, it corresponds to D_x in cm according to the usual definition.

CASE 1 (a)

	NR.	TYP	EX(MM)	EX'(MRAD)	EZ(MM)	EZ'(MRAD)	TX(MM)	TX'(MRAD)	Q1	Q2
Q1	0		15.47998	-1.48999	16.79981	1.21997	23.73926	-2.96997	0.0	0.0
	1	QUAD	15.72194	1.96078	16.24131	-2.27225	23.15578	1.82984	0.02125	0.00469
	2	DRIF	16.82270	2.07499	15.00537	-2.26307	24.15301	1.82984	0.03110	0.00754
	2	REMA 100%	29.58291	2.54113	4.02543	-1.20905	41.54099	4.63509	0.08366	0.13376
	3	DRIF	30.17590	2.54900	3.77226	-0.95596	42.62094	4.63509	0.08490	0.15335
Q0	3	QUAD	29.83582	-3.19079	3.86709	1.12397	43.16004	-3.61741	0.09025	0.25386
	4	DRIF	9.99449	-1.47724	19.07149	2.31668	17.16258	-3.61741	0.21888	0.39614
Q5K	4	QUAD	9.51806	0.13336	20.05976	0.47534	15.15821	-2.10833	0.25491	0.39846
	5	DRIF	10.03067	1.00361	20.48298	0.48214	13.29450	-2.10833	0.29970	0.40120
	5	REMA 83%	22.29168	2.85327	23.16668	0.51335	8.25464	0.23457	0.42803	0.41566
	6	DRIF	22.95575	2.87131	23.28591	0.51453	8.30906	0.23457	0.43020	0.41620
	6	DRIF	24.99402	2.91747	23.64937	0.51802	8.47419	0.23457	0.43606	0.41783
	7	DRIF	27.59339	2.96146	24.10914	0.52217	8.68154	0.23457	0.44218	0.41980
	7	REMA 17%	43.91689	3.07988	26.97724	0.54288	11.20122	0.70214	0.46344	0.43034
	8	DRIF	52.32707	3.10219	28.46530	0.55107	13.11104	0.70214	0.46909	0.43485
Q2K	8	QUAD	59.00966	4.07133	29.03572	0.05798	14.64185	0.94126	0.47200	0.43772
	9	DRIF	73.00287	4.08232	29.24998	0.06685	17.87215	0.94126	0.47580	0.44286
Q1K	9	QUAD	66.55907	-10.75877	35.19444	6.50006	16.19188	-2.68226	0.47752	0.44532
	10	DRIF	53.79160	-10.75375	42.91053	6.50136	13.00817	-2.68226	0.47910	0.44633
QD	10	QUAD	44.52137	-17.55713	49.13119	12.78160	10.71370	-4.32504	0.48038	0.44672
	11	DRIF	41.01022	-17.55482	51.68748	12.78170	9.84871	-4.32504	0.48090	0.44682
QD	11	QUAD	31.51437	-11.90925	57.24618	4.17676	7.49518	-2.97801	0.48335	0.44710
	12	DRIF	28.53805	-11.90089	58.29038	4.17684	6.75067	-2.97801	0.48467	0.44719
QD	12	QUAD	22.14674	-7.92668	58.01708	-5.01063	5.12857	-2.05541	0.48967	0.44743
	13	DRIF	20.73724	-7.91039	57.12522	-5.01057	4.76272	-2.05541	0.49152	0.44750
QA1	13	QUAD	14.59131	-4.06834	45.93864	-16.06677	3.07405	-1.24488	0.50860	0.44799
	14	DRIF	6.58133	0.00627	0.49789	-0.00542	-0.48492	-1.24488	0.68435	0.69621
	15	DRIF	8.01093	2.59894	16.07526	16.06000	-1.72980	-1.24488	0.78068	0.94134

CASE 1 (b)

	NR.	TYP	EX(MM)	EX'(MRAD)	EZ(MM)	EZ'(MRAD)	TX(MM)	TX'(MRAD)	Q1	Q2
	0		15.47998	-1.48999	16.79981	1.21997	23.73926	-2.96997	0.0	0.0
Q1	1	QUAD	15.72194	1.96078	16.24131	-2.27225	23.15578	1.82984	0.02125	0.00469
	2	DRIF	16.82270	2.07499	15.00537	-2.26307	24.15301	1.82984	0.03110	0.00754
	2	REMA 100%	29.58291	2.54113	4.02543	-1.20905	41.54099	4.63509	0.08366	0.13376
	3	DRIF	30.17590	2.54900	3.77226	-0.95596	42.62094	4.63509	0.08490	0.15335
Q0	3	QUAD	29.83582	-3.19079	3.86709	1.12397	43.16004	-3.61741	0.09025	0.25386
	4	DRIF	9.99449	-1.47724	19.07149	2.31668	17.16258	-3.61741	0.21888	0.39614
Q5K	4	QUAD	9.53000	0.16672	20.03581	0.40713	15.17858	-2.05130	0.25488	0.39846
	5	DRIF	10.06951	1.03016	20.39875	0.41397	13.36529	-2.05130	0.29944	0.40122
	5	REMA 83%	22.37333	2.85298	22.71846	0.44641	8.63224	0.29160	0.42653	0.41602
	6	DRIF	23.03731	2.87082	22.82217	0.44766	8.69989	0.29160	0.42868	0.41659
	6	DRIF	25.07507	2.91651	23.13863	0.45138	8.90517	0.29160	0.43450	0.41829
	7	DRIF	27.67341	2.96010	23.53962	0.45583	9.16294	0.29160	0.44058	0.42035
	7	REMA 17%	43.98672	3.07771	26.05590	0.47845	11.98946	0.75918	0.46175	0.43153
	8	DRIF	52.39084	3.09993	27.37001	0.48760	14.05441	0.75918	0.46738	0.43639
Q2K	8	QUAD	59.07018	4.07010	27.84074	0.01499	15.70760	1.01561	0.47028	0.43949
	9	DRIF	73.05910	4.08106	27.90962	0.02514	19.19305	1.01561	0.47408	0.44512
Q1K	9	QUAD	66.60876	-10.76440	33.50302	6.15380	17.39856	-2.87497	0.47580	0.44783
	10	DRIF	53.83461	-10.75939	40.80827	6.15531	13.98611	-2.87497	0.47738	0.44893
QD	10	QUAD	44.55885	-17.56836	46.70604	12.12673	11.52488	-4.64165	0.47865	0.44937
	11	DRIF	41.04545	-17.56606	49.13136	12.12684	10.59656	-4.64165	0.47917	0.44948
QD	11	QUAD	31.54398	-11.91548	54.40063	3.94865	8.07212	-3.19174	0.48161	0.44979
	12	DRIF	28.56610	-11.90715	55.38781	3.94875	7.27418	-3.19174	0.48294	0.44989
QD	12	QUAD	22.17206	-7.92891	55.11528	-4.78018	5.53767	-2.19670	0.48792	0.45016
	13	DRIF	20.76216	-7.91268	54.26444	-4.78011	5.14667	-2.19670	0.48977	0.45024
QA1	13	QUAD	14.61187	-4.07427	43.62933	-15.25896	3.34719	-1.32003	0.50680	0.45078
	14	DRIF	6.57556	-0.00379	0.52424	0.01802	-0.42664	-1.32003	0.68238	0.69905
	15	DRIF	8.00020	2.59870	15.26969	15.25107	-1.74667	-1.32003	0.77896	0.94340

CASE 1 (C)

	NR.	TYP	EX(MM)	EX'(MRAD)	EZ(MM)	EZ'(MRAD)	TX(MM)	TX'(MRAD)	Q1	Q2
Q1	0		15.47998	-1.48999	16.79981	1.21997	23.73926	-2.96997	0.0	0.0
	1	QUAD	15.72194	1.96078	16.24131	-2.27225	23.15578	1.82984	0.02125	0.00469
	2	DRIF	16.82270	2.07499	15.00537	-2.26307	24.15301	1.82984	0.03110	0.00754
	2	REMA 100%	29.58291	2.54113	4.02543	-1.20905	41.54099	4.63509	0.08366	0.13376
Q0	3	DRIF	30.17590	2.54900	3.77226	-0.95596	42.62094	4.63509	0.08490	0.15335
	3	QUAD	29.33582	-3.19079	3.86709	1.12397	43.16004	-3.61741	0.09025	0.25386
Q5K	4	DRIF	9.99449	-1.47724	19.07149	2.31668	17.16258	-3.61741	0.21888	0.39614
	4	QUAD	9.55789	0.24475	19.97992	0.24803	15.22619	-1.91791	0.25480	0.39847
	5	DRIF	10.16042	1.09258	20.20228	0.25501	13.53081	-1.91791	0.29882	0.40126
	5	REMA 83%	22.57196	2.85400	21.67358	0.29056	9.51529	0.42499	0.42305	0.41693
	6	DRIF	23.23612	2.87139	21.74116	0.29201	9.61389	0.42499	0.42517	0.41755
	6	DRIF	25.27386	2.91596	21.94825	0.29633	9.91307	0.42499	0.43089	0.41943
	7	DRIF	27.87125	2.95858	22.21254	0.30159	10.28874	0.42499	0.43688	0.42174
	7	REMA 17%	44.16924	3.07416	23.91344	0.32969	13.83286	0.89257	0.45781	0.43465
Q2K	8	DRIF	52.56334	3.09613	24.82685	0.34173	16.26062	0.89257	0.46341	0.44048
	8	QUAD	59.15852	3.98186	25.10560	-0.04405	18.17540	1.16256	0.46629	0.44428
Q1K	9	DRIF	72.84459	3.99283	24.97839	-0.03005	22.16519	1.16256	0.47009	0.45125
	9	QUAD	66.35408	-10.71902	29.85427	5.41525	20.09733	-3.30557	0.47182	0.45465
QD	10	DRIF	53.63381	-10.71396	36.28329	5.41739	16.17378	-3.30557	0.47341	0.45604
	10	QUAD	44.39607	-17.49769	41.49064	10.72445	13.33980	-5.34943	0.47470	0.45660
	11	DRIF	40.89681	-17.49536	43.63551	10.72462	12.26993	-5.34943	0.47522	0.45674
QD	11	QUAD	31.43448	-11.86469	48.28621	3.46370	9.36350	-3.66926	0.47768	0.45713
QD	12	DRIF	28.46931	-11.85628	49.15215	3.46384	8.44619	-3.66926	0.47901	0.45726
	12	QUAD	22.10404	-7.89047	48.88456	-4.28020	6.45416	-2.51202	0.48403	0.45760
QA1	13	DRIF	20.70099	-7.87410	48.12272	-4.28010	6.00704	-2.51202	0.48589	0.45770
	13	QUAD	14.57618	-4.06179	38.67445	-13.52429	3.95994	-1.48828	0.50301	0.45838
	14	DRIF	6.53840	0.01080	0.59146	-0.02238	-0.29488	-1.48828	0.67875	0.70569
	15	DRIF	8.01769	2.59492	13.53782	13.51296	-1.78316	-1.48828	0.77487	0.94899

CASE 1(d)

	NR.	TYP	EX(MM)	EX'(MRAD)	EZ(MM)	EZ'(MRAD)	TX(MM)	TX'(MRAD)	Q1	Q2
	0		15.47998	-1.48999	16.79981	1.21997	23.73926	-2.96997	0.0	0.0
Q1	1	QUAD	15.72194	1.96078	16.24131	-2.27225	23.15578	1.82984	0.02125	0.00469
	2	DRIF	16.82270	2.07499	15.00537	-2.26307	24.15301	1.82984	0.03110	0.00754
	2	REMA 100%	29.58291	2.54113	4.02543	-1.20905	41.54099	4.63509	0.08366	0.13376
	3	DRIF	30.17590	2.54900	3.77226	-0.95596	42.62094	4.63509	0.08490	0.15335
Q0	3	QUAD	29.83582	-3.19079	3.86709	1.12397	43.16004	-3.61741	0.09025	0.25386
	4	DRIF	9.99449	-1.47724	19.07149	2.31668	17.16258	-3.61741	0.21888	0.39614
Q5K	4	QUAD	9.57637	0.29647	19.94298	0.14293	15.25771	-1.82951	0.25476	0.39847
	5	DRIF	10.22074	1.13417	20.07246	0.15000	13.64047	-1.82951	0.29842	0.40128
	5	REMA 83%	22.70939	2.85599	20.98373	0.18784	10.10048	0.51338	0.42079	0.41757
	6	DRIF	23.37397	2.87306	21.02749	0.18944	10.21958	0.51338	0.42287	0.41824
	6	DRIF	25.41262	2.91688	21.16255	0.19424	10.58100	0.51338	0.42853	0.42026
	7	DRIF	28.01050	2.95884	21.33687	0.20014	11.03481	0.51338	0.43446	0.42275
	7	REMA 17%	44.30491	3.07300	22.50395	0.23285	15.05450	0.98096	0.45522	0.43703
	8	DRIF	52.69557	3.09478	23.15750	0.24749	17.72269	0.98096	0.46079	0.44368
Q2K	8	QUAD	59.29009	3.98251	23.28724	-0.10894	19.82494	1.27536	0.46365	0.44807
	9	DRIF	72.97826	3.99342	22.94367	-0.09115	24.20182	1.27536	0.46744	0.45625
Q1K	9	QUAD	66.47861	-10.72931	27.29349	4.89497	21.95926	-3.59950	0.46917	0.46030
	10	DRIF	53.74611	-10.72428	33.10541	4.89778	17.68683	-3.59950	0.47075	0.46197
QD	10	QUAD	44.49677	-17.52280	37.82701	9.73830	14.59753	-5.83524	0.47203	0.46264
	11	DRIF	40.99249	-17.52049	39.77466	9.73852	13.43049	-5.83524	0.47255	0.46281
QD	11	QUAD	31.51361	-11.89031	43.99540	3.13837	10.26092	-3.99980	0.47500	0.46328
	12	DRIF	28.54203	-11.88195	44.78002	3.13855	9.26097	-3.99980	0.47632	0.46344
QD	12	QUAD	22.16007	-7.91620	44.53099	-3.89830	7.09118	-2.73295	0.48131	0.46385
	13	DRIF	20.75243	-7.89995	43.83713	-3.89317	6.60473	-2.73295	0.48316	0.46396
Q1A	13	QUAD	14.60481	-4.08067	35.23120	-12.31888	4.38528	-1.60414	0.50021	0.46479
	14	DRIF	6.56671	0.01034	0.64930	-0.01806	-0.20076	-1.60414	0.67637	0.71162
	15	DRIF	8.00845	2.61504	12.33712	12.30389	-1.80490	-1.60414	0.77299	0.95348

CASE 1(e)

	NR.	TYP	EX(MM)	EX'(MRAD)	EZ(MM)	EZ'(MRAD)	TX(MM)	TX'(MRAD)	Q1	Q2
Q1	0		15.47998	-1.48999	16.79981	1.21997	23.73926	-2.96997	0.0	0.0
	1	QUAD	15.72194	1.96078	16.24131	-2.27225	23.15578	1.82984	0.02125	0.00469
	2	DRIF	16.82270	2.07499	15.00537	-2.26307	24.15301	1.82984	0.03110	0.00754
	2	REMA 100%	29.58291	2.54113	4.02543	-1.20905	41.54099	4.63509	0.08366	0.13376
Q0	3	DRIF	30.17590	2.54900	3.77226	-0.95596	42.62094	4.63509	0.08490	0.15335
	3	QUAD	29.83582	-3.19079	3.86709	1.12397	43.16004	-3.61741	0.09025	0.25386
Q5K	4	DRIF	9.99449	-1.47724	19.07149	2.31668	17.16258	-3.61741	0.21888	0.39614
	4	QUAD	9.59727	0.35505	19.90123	0.02424	15.29339	-1.72941	0.25470	0.39847
	5	DRIF	10.23910	1.18148	19.92583	0.03141	13.76463	-1.72941	0.29798	0.40131
	5	REMA 83%	22.87048	2.85948	20.20510	0.07210	10.76312	0.61348	0.41825	0.41836
	6	DRIF	23.53583	2.87620	20.22203	0.07390	10.90545	0.61348	0.42031	0.41908
	6	DRIF	25.57636	2.91915	20.27597	0.07933	11.33733	0.61348	0.42589	0.42127
	7	DRIF	28.17589	2.96034	20.34908	0.08608	11.87963	0.61348	0.43175	0.42400
	7	REMA 17%	44.47254	3.07282	20.91913	0.12530	16.43785	1.08106	0.45231	0.44011
Q2K	8	DRIF	52.86237	3.09438	21.28538	0.14384	19.37832	1.08106	0.45783	0.44790
	8	QUAD	59.42439	3.94730	21.26568	-0.16488	21.68034	1.38943	0.46069	0.45313
Q1K	9	DRIF	72.99165	3.95818	20.74006	-0.14114	26.44870	1.38943	0.46447	0.46304
	9	QUAD	66.47116	-10.71639	24.54582	4.34338	24.00606	-3.92121	0.46619	0.46801
QD	10	DRIF	53.75400	-10.71136	29.70372	4.34726	19.35177	-3.92121	0.46778	0.47009
	10	QUAD	44.51259	-17.51152	33.90914	8.68874	15.98262	-6.36817	0.46905	0.47092
	11	DRIF	41.01056	-17.50921	35.64689	8.68905	14.70901	-6.36817	0.46958	0.47113
QD	11	QUAD	31.53444	-11.89231	39.41037	2.79306	11.25060	-4.36283	0.47202	0.47171
QD	12	DRIF	28.56235	-11.88398	40.10866	2.79332	10.15989	-4.36283	0.47334	0.47191
	12	QUAD	22.17615	-7.92687	39.88023	-3.49025	7.79477	-2.97586	0.47833	0.47242
QA1	13	DRIF	20.76661	-7.91065	39.25900	-3.49007	7.26508	-2.97586	0.48017	0.47257
	13	QUAD	14.60887	-4.08976	31.55306	-11.03097	4.85650	-1.73082	0.49721	0.47360
	14	DRIF	6.55546	0.01945	0.72504	-0.00184	-0.09171	-1.73082	0.67382	0.71991
	15	DRIF	8.01076	2.63030	11.05755	11.01013	-1.82253	-1.73082	0.77060	0.95950

CASE 2 (a)

	NR.	TYP	EX(MM)	EX'(MRAD)	EZ(MM)	EZ'(MRAD)	TX(MM)	TX'(MRAD)	Q1	Q2
	0		15.47998	-1.48999	16.79981	1.21997	23.73926	-2.96997	0.0	0.0
Q1	1	QUAD	15.66315	1.84617	16.30450	-2.15378	23.06628	1.65577	0.02131	0.00468
	2	DRIF	16.70193	1.96226	15.13309	-2.14478	23.96864	1.65577	0.03126	0.00749
	2	REMA 100%	28.91912	2.44963	4.57883	-1.35373	40.42029	4.46102	0.08548	0.11415
	3	DRIF	29.49086	2.45805	4.28281	-1.18153	41.45968	4.46102	0.08678	0.12930
Q0	3	QUAD	29.12675	-3.14517	3.98470	0.63782	41.93593	-3.56199	0.09239	0.21350
	4	DRIF	9.86635	-1.30670	16.78120	2.05191	16.33673	-3.56199	0.22742	0.37821
Q5K	4	QUAD	9.47715	0.21002	17.72649	0.62031	14.28466	-2.29630	0.26404	0.38119
	5	DRIF	10.05981	1.08224	18.27918	0.63002	12.25480	-2.29630	0.30890	0.38466
	5	REMA 33%	22.57385	2.88070	21.79114	0.67157	6.20379	0.04660	0.43470	0.40190
	6	DRIF	23.24420	2.89807	21.94710	0.67299	6.21460	0.04660	0.43681	0.40251
	6	DRIF	25.30070	2.94255	22.42234	0.67712	6.24740	0.04660	0.44253	0.40433
	7	DRIF	27.92152	2.98499	23.02306	0.68194	6.28860	0.04660	0.44851	0.40651
	7	REMA 17%	44.35857	3.09954	26.75696	0.70445	7.79704	0.51418	0.46931	0.41764
	8	DRIF	52.82129	3.12122	28.68458	0.71265	9.19559	0.51418	0.47485	0.42216
Q2K	8	QUAD	59.41773	3.95708	29.61979	0.28627	10.28752	0.65760	0.47770	0.42494
	9	DRIF	73.01852	3.96794	30.61628	0.29432	12.54433	0.65760	0.48148	0.42976
Q1K	9	QUAD	65.46177	-11.77993	37.70746	7.55555	11.20347	-2.04380	0.48322	0.43197
	10	DRIF	51.48245	-11.77443	46.67621	7.55659	8.77758	-2.04380	0.48490	0.43282
QD	10	QUAD	42.30401	-16.31880	53.11147	12.34782	7.18906	-2.81843	0.48631	0.43316
	11	DRIF	39.04056	-16.31612	55.58101	12.34790	6.62539	-2.81843	0.48689	0.43325
QD	11	QUAD	30.18670	-11.14608	60.78703	3.54029	5.08942	-1.94605	0.48957	0.43349
	12	DRIF	27.40131	-11.13661	61.67212	3.54036	4.60291	-1.94605	0.49101	0.43357
QD	12	QUAD	21.40449	-7.45995	60.95113	-5.74073	3.54375	-1.33938	0.49639	0.43379
	13	DRIF	20.07822	-7.44196	59.92932	-5.74068	3.30535	-1.33938	0.49837	0.43385
QA1	13	QUAD	14.28164	-3.84323	47.98544	-16.78270	2.21282	-0.79411	0.51637	0.43430
	14	DRIF	6.84958	-0.00668	0.47666	-0.03077	-0.05745	-0.79411	0.68652	0.68243
	15	DRIF	8.12454	2.35548	16.78942	16.77676	-0.85156	-0.79411	0.77713	0.92820

CASE 2 (b)

	NR.	TYP	EX(MM)	EX'(MRAD)	EZ(MM)	EZ'(MRAD)	TX(MM)	TX'(MRAD)	Q1	Q2
	0		15.47998	-1.48999	16.79981	1.21997	23.73926	-2.96997	0.0	0.0
Q1	1	QUAD	15.66315	1.84617	16.30450	-2.15378	23.06628	1.65577	0.02131	0.00468
	2	DRIF	16.70193	1.96226	15.13309	-2.14478	23.96864	1.65577	0.03126	0.00749
	2	REMA 100%	28.91912	2.44963	4.57883	-1.35373	40.42029	4.46102	0.08548	0.11415
	3	DRIF	29.49086	2.45805	4.28281	-1.18153	41.45968	4.46102	0.08678	0.12930
Q0	3	QUAD	29.12675	-3.14517	3.98470	0.63782	41.93593	-3.56199	0.09239	0.21350
	4	DRIF	9.86635	-1.30670	16.78120	2.05191	16.33673	-3.56199	0.22742	0.37821
Q5K	4	QUAD	9.50985	0.30150	17.66810	0.45383	14.33819	-2.14671	0.26395	0.38120
	5	DRIF	10.16630	1.15525	18.07371	0.46374	12.44055	-2.14671	0.30818	0.38472
	5	REMA 83%	22.81056	2.88321	20.70103	0.50960	7.19423	0.19618	0.43068	0.40307
	6	DRIF	23.48143	2.90005	20.81945	0.51126	7.23974	0.19618	0.43275	0.40376
	6	DRIF	25.53885	2.94325	21.18109	0.51613	7.37785	0.19618	0.43835	0.40579
	7	DRIF	28.15975	2.98456	21.63991	0.52189	7.55128	0.19618	0.44422	0.40824
	7	REMA 17%	44.58620	3.09675	24.52817	0.55006	9.86448	0.66376	0.46474	0.42116
	8	DRIF	53.04084	3.11812	26.03943	0.56085	11.66990	0.66376	0.47023	0.42659
Q2K	8	QUAD	59.58624	3.90440	26.75323	0.20166	13.06613	0.83436	0.47306	0.42999
	9	DRIF	73.00614	3.91522	27.46448	0.21269	15.92957	0.83436	0.47683	0.43594
Q1K	9	QUAD	65.41529	-11.76352	33.70169	6.69081	14.23770	-2.58367	0.47857	0.43868
	10	DRIF	51.45545	-11.75801	41.64430	6.69226	11.17102	-2.58367	0.48026	0.43976
QD	10	QUAD	42.28842	-16.30031	47.35324	10.96559	9.16055	-3.57006	0.48167	0.44018
	11	DRIF	39.02866	-16.29763	49.54634	10.96570	8.44655	-3.57006	0.48225	0.44029
QD	11	QUAD	30.18225	-11.14095	54.16653	3.13486	6.50272	-2.45945	0.48493	0.44060
	12	DRIF	27.39814	-11.13148	54.95026	3.13496	5.88786	-2.45945	0.48637	0.44070
QD	12	QUAD	21.40161	-7.46383	54.30175	-5.11417	4.55213	-1.68383	0.49175	0.44098
	13	DRIF	20.07464	-7.44583	53.39147	-5.11410	4.25242	-1.68383	0.49373	0.44105
QA1	13	QUAD	14.27360	-3.84802	42.75099	-14.95133	2.88925	-0.97814	0.51174	0.44162
	14	DRIF	6.84213	0.00530	0.53503	-0.00341	0.09286	-0.97814	0.68237	0.68959
	15	DRIF	8.13093	2.36885	14.96195	14.94294	-0.88528	-0.97814	0.77302	0.93393

CASE 3 (a)

	NR.	TYP	EX(MM)	EX'(MRAD)	EZ(MM)	EZ'(MRAD)	TX(MM)	TX'(MRAD)	Q1	Q2
	0		12.63965	-1.21698	13.27979	0.96448	23.73926	-2.96997	0.0	0.0
Q1	1	QUAD	12.90545	1.73464	12.76720	-1.92934	23.28379	2.07919	0.02118	0.00471
	2	DRIF	13.87652	1.82575	11.71769	-1.92189	24.41691	2.07919	0.03087	0.00761
	2	REMA 100%	24.93354	2.18340	2.67517	-0.62125	43.14618	4.88443	0.08119	0.17179
	3	DRIF	25.44295	2.18923	2.56762	-0.29526	44.28422	4.88443	0.08236	0.19892
Q0	3	QUAD	25.09115	-2.85271	3.27793	1.52903	44.73137	-4.04091	0.08738	0.30954
	4	DRIF	7.34021	-1.16155	17.99202	2.14182	15.69026	-4.04091	0.22988	0.41381
Q5K	4	QUAD	7.01369	0.24706	18.93572	0.52541	13.30065	-2.78268	0.27444	0.41544
	5	DRIF	7.65879	1.17182	19.40157	0.52855	10.84083	-2.78268	0.32781	0.41735
	5	REMA 83%	19.30621	2.67821	22.28293	0.54143	2.17337	-0.43979	0.45330	0.42726
	6	DRIF	20.42888	2.68961	22.40860	0.54195	2.07134	-0.43979	0.45512	0.42763
	6	DRIF	22.33295	2.71855	22.79066	0.54347	1.76174	-0.43979	0.46003	0.42873
	7	DRIF	24.74874	2.74580	23.27188	0.54528	1.37298	-0.43979	0.46513	0.43005
	7	REMA 17%	39.75918	2.81770	26.23067	0.55412	0.26475	0.02779	0.48256	0.43707
	8	DRIF	47.44297	2.83104	27.74270	0.55759	0.34035	0.02779	0.48715	0.44004
Q2K	8	QUAD	54.70982	5.09993	27.62480	-0.68294	0.40726	0.04434	0.48947	0.44196
	9	DRIF	72.31303	5.10548	25.28866	-0.67829	0.55943	0.04434	0.49223	0.44587
Q1K	9	QUAD	67.31860	-10.27436	29.13776	4.93498	0.52924	-0.07559	0.49337	0.44802
	10	DRIF	55.12456	-10.27225	34.99593	4.93589	0.43952	-0.07559	0.49439	0.44895
QD	10	QUAD	45.78931	-18.20856	40.04812	10.74058	0.36912	-0.13920	0.49520	0.44932
	11	DRIF	42.14774	-18.20761	42.19621	10.74065	0.34128	-0.13920	0.49553	0.44942
QD	11	QUAD	32.26836	-12.44650	46.93897	3.72906	0.26672	-0.09217	0.49707	0.44967
	12	DRIF	29.15714	-12.44303	47.87125	3.72912	0.24367	-0.09217	0.49792	0.44976
QD	12	QUAD	22.42722	-8.43723	47.84788	-3.80042	0.19520	-0.05823	0.50114	0.44998
	13	DRIF	20.92604	-8.43022	47.17143	-3.80038	0.18484	-0.05823	0.50234	0.45005
QA1	13	QUAD	14.27517	-4.56119	38.07899	-13.31840	0.14333	-0.02295	0.51388	0.45049
	14	DRIF	4.19154	-0.00536	0.37540	0.01836	0.07771	-0.02295	0.71627	0.69914
	15	DRIF	6.34755	3.58325	13.32486	13.31376	0.05475	-0.02295	0.85166	0.94444

CASE 3 (b)

	NR.	TYP	EX(MM)	EX'(MRAD)	EZ(MM)	EZ'(MRAD)	TX(MM)	TX'(MRAD)	Q1	Q2
	0		12.63965	-1.21698	13.27979	0.96448	23.73926	-2.96997	0.0	0.0
Q1	1	QUAD	12.83679	1.60058	12.83843	-1.79603	23.15578	1.82984	0.02125	0.00469
	2	DRIF	13.73535	1.69383	11.86153	-1.78878	24.15301	1.82984	0.03110	0.00754
	2	REMA 100%	24.15211	2.07450	3.18295	-0.95568	41.54099	4.63509	0.08366	0.13375
	3	DRIF	24.63621	2.08092	2.98282	-0.75571	42.62094	4.63509	0.08491	0.15333
Q0	3	QUAD	24.31668	-2.68376	3.06202	0.89611	43.08718	-3.75520	0.09026	0.25371
	4	DRIF	7.76090	-1.11266	15.09997	1.83296	16.09943	-3.75520	0.22807	0.39538
Q5K	4	QUAD	7.38520	0.05760	16.02701	0.79023	13.81636	-2.75647	0.26788	0.39768
	5	DRIF	7.81195	0.88471	16.72782	0.79527	11.37973	-2.75647	0.31745	0.40030
	5	REMA 83%	18.64691	2.48734	21.06314	0.81384	2.85330	-0.41357	0.44970	0.41246
	6	DRIF	19.22557	2.50101	21.25201	0.81445	2.75735	-0.41357	0.45176	0.41288
	6	DRIF	20.99901	2.53577	21.82600	0.81621	2.46621	-0.41357	0.45732	0.41408
	7	DRIF	23.25580	2.56359	22.54841	0.81823	2.10063	-0.41357	0.46308	0.41551
	7	REMA 17%	37.36203	2.65531	26.97656	0.82714	1.13344	0.05401	0.48284	0.42255
	8	DRIF	44.60818	2.67137	29.23071	0.83021	1.28035	0.05401	0.48803	0.42530
Q2K	8	QUAD	52.53851	5.90749	28.93604	-1.14239	1.46454	0.14526	0.49062	0.42702
	9	DRIF	72.82407	5.91337	25.02251	-1.13797	1.96304	0.14526	0.49348	0.43079
Q1K	9	QUAD	68.24461	-10.64238	28.22723	4.68911	1.81496	-0.29818	0.49459	0.43305
	10	DRIF	55.61372	-10.64034	33.79363	4.69012	1.46103	-0.29818	0.49559	0.43404
QD	10	QUAD	46.12938	-18.30563	38.54714	10.05443	1.19993	-0.49871	0.49638	0.43444
	11	DRIF	42.46839	-18.30471	40.55801	10.05451	1.10019	-0.49871	0.49671	0.43454
QD	11	QUAD	32.54118	-12.49782	44.94464	3.32870	0.82677	-0.34967	0.49823	0.43482
	12	DRIF	29.41713	-12.49444	45.77683	3.32877	0.73936	-0.34967	0.49906	0.43492
QD	12	QUAD	22.66639	-8.45049	45.60290	-3.85939	0.54602	-0.25025	0.50222	0.43516
	13	DRIF	21.16283	-8.44371	44.91596	-3.85935	0.50148	-0.25025	0.50340	0.43523
QA1	13	QUAD	14.46115	-4.64075	36.15487	-12.64487	0.28760	-0.16783	0.51465	0.43572
	14	DRIF	4.13017	-0.01737	0.39539	-0.00973	-0.19222	-0.16783	0.71798	0.68386
	15	DRIF	6.35328	3.67960	12.65150	12.63945	-0.36006	-0.16783	0.85592	0.92901

CASE 3 (C)

	NO.	TYP	EX(MM)	EX'(MRAD)	EZ(MM)	EZ'(MRAD)	TX(MM)	TX'(MRAD)	Q1	Q2
	0		12.63965	-1.21698	13.27979	0.96448	23.73926	-2.96997	0.0	0.0
Q1	1	QUAD	12.33679	1.60058	12.83843	-1.79603	23.15578	1.82984	0.02125	0.00469
	2	DRIF	13.73535	1.69383	11.86153	-1.78878	24.15301	1.82984	0.03110	0.00754
	2	REMA 100%	24.15211	2.07450	3.18295	-0.95568	41.54099	4.63509	0.08366	0.13375
	3	DRIF	24.63621	2.08092	2.98282	-0.75571	42.62094	4.63509	0.08491	0.15333
Q0	3	QUAD	24.33070	-2.65737	3.06052	0.89342	43.11164	-3.70895	0.09026	0.25374
	4	DRIF	7.89137	-1.14668	15.09137	1.83233	16.45627	-3.70895	0.22489	0.39562
Q5K	4	QUAD	7.48483	0.00254	16.01732	0.78778	14.21533	-2.68261	0.26350	0.39792
	5	DRIF	7.85083	0.80635	16.71598	0.79283	11.84398	-2.68261	0.31214	0.40055
	5	REMA 83%	18.34012	2.43942	21.03833	0.81145	3.71483	-0.33972	0.44645	0.41274
	6	DRIF	18.90775	2.45380	21.22665	0.31207	3.63601	-0.33972	0.44857	0.41315
	6	DRIF	20.64860	2.49035	21.79896	0.81384	3.39686	-0.33972	0.45432	0.41436
	7	DRIF	22.86603	2.52437	22.51923	0.81587	3.09656	-0.33972	0.46028	0.41579
	7	REMA 17%	36.75196	2.61607	26.93482	0.82431	2.52668	0.12786	0.48071	0.42285
	8	DRIF	43.89257	2.63294	29.18266	0.82790	2.87446	0.12786	0.48608	0.42561
Q2K	8	QUAD	51.93875	6.07842	28.74044	-1.29600	3.31578	0.34997	0.48875	0.42734
	9	DRIF	72.81118	6.08441	24.30007	-1.29133	4.51683	0.34997	0.49163	0.43125
Q1K	9	QUAD	68.48568	-10.55065	27.05604	4.34550	4.20062	-0.67647	0.49274	0.43367
	10	DRIF	55.96365	-10.54864	32.21469	4.34666	3.39769	-0.67647	0.49373	0.43476
QD	10	QUAD	46.46306	-18.44158	36.70104	9.57172	2.79781	-1.15401	0.49451	0.43520
	11	DRIF	42.77488	-18.44068	38.61536	9.57182	2.56701	-1.15401	0.49483	0.43532
QD	11	QUAD	32.77344	-12.59222	42.79120	3.16826	1.93542	-0.80576	0.49633	0.43562
	12	DRIF	29.62577	-12.58891	43.58327	3.16833	1.73398	-0.80576	0.49715	0.43573
QD	12	QUAD	22.82315	-8.51703	43.41710	-3.67530	1.29000	-0.57187	0.50027	0.43600
	13	DRIF	21.30774	-8.51038	42.76292	-3.67525	1.18821	-0.57187	0.50143	0.43607
QA1	13	QUAD	14.54933	-4.68520	34.42159	-12.03826	0.70419	-0.37425	0.51254	0.43662
	14	DRIF	4.09610	-0.00209	0.41531	-0.01602	-0.36576	-0.37425	0.71705	0.68449
	15	DRIF	6.37194	3.74017	12.04575	12.03198	-0.74001	-0.37425	0.85600	0.92921

CASE 4(a)

	NR.	TYP	EX(MM)	EX'(MRAD)	EZ(MM)	EZ'(MRAD)	TX(MM)	TX'(MRAD)	Q1	Q2
	0		12.63965	-1.21698	13.27979	0.96448	23.73926	-2.96997	0.0	0.0
Q1	1	QUAD	12.79564	1.52033	12.88126	-1.71577	23.07904	1.68058	0.02130	0.00468
	2	DRIF	13.65080	1.61491	11.94807	-1.70863	23.99493	1.68058	0.03124	0.00750
	2	REMA 100%	23.68721	2.01037	3.55491	-1.05822	40.58005	4.48583	0.08522	0.11665
	3	DRIF	24.15641	2.01718	3.32455	-0.91442	41.62522	4.48583	0.08652	0.13236
Q0	3	QUAD	23.83457	-2.62442	3.12872	0.55858	42.06317	-3.65925	0.09209	0.21897
	4	DRIF	7.81683	-1.02243	13.52529	1.65205	15.76498	-3.65925	0.23233	0.38042
Q5K	4	QUAD	7.50000	0.13205	14.36286	0.71792	13.54289	-2.67855	0.27124	0.38328
	5	DRIF	7.97316	0.91454	15.00064	0.72491	11.17512	-2.67855	0.31901	0.38654
	5	REMA 83%	18.66299	2.44543	18.98136	0.75142	3.06784	-0.33565	0.44763	0.40160
	6	DRIF	19.23192	2.45908	19.15578	0.75226	2.98997	-0.33565	0.44969	0.40211
	6	DRIF	20.97585	2.49388	19.68621	0.75466	2.75367	-0.33565	0.45525	0.40359
	7	DRIF	23.19569	2.52688	20.35455	0.75742	2.45697	-0.33565	0.46103	0.40535
	7	REMA 17%	37.08123	2.61489	24.46489	0.76949	1.90895	0.13193	0.48099	0.41395
	8	DRIF	44.21800	2.63134	26.56370	0.77360	2.26779	0.13193	0.48627	0.41728
Q2K	8	QUAD	52.28330	6.10072	26.19840	-1.16028	2.67528	0.30928	0.48890	0.41937
	9	DRIF	73.23203	6.10660	22.22610	-1.15615	3.73671	0.30928	0.49176	0.42406
Q1K	9	QUAD	67.57392	-11.93042	25.21759	4.47871	3.44393	-0.61065	0.49287	0.42692
	10	DRIF	53.41426	-11.92821	30.53451	4.48011	2.71912	-0.61065	0.49392	0.42815
QD	10	QUAD	43.95774	-17.00513	34.51482	7.83582	2.23549	-0.86909	0.49479	0.42864
	11	DRIF	40.55687	-17.00407	36.08197	7.83593	2.06168	-0.86909	0.49514	0.42877
QD	11	QUAD	31.28889	-11.73982	39.37792	2.22437	1.58736	-0.60202	0.49680	0.42913
	12	DRIF	28.35439	-11.73604	39.93403	2.22447	1.43685	-0.60202	0.49770	0.42926
QD	12	QUAD	21.97901	-8.03504	39.45733	-3.67951	1.10871	-0.41571	0.50107	0.42958
	13	DRIF	20.54946	-8.02762	38.80240	-3.67944	1.03471	-0.41571	0.50233	0.42967
QA1	13	QUAD	14.13000	-4.49302	31.08567	-10.87104	0.69710	-0.24364	0.51416	0.43034
	14	DRIF	4.24567	-0.01077	0.45989	0.00519	0.00055	-0.24364	0.71523	0.67806
	15	DRIF	6.33442	3.49597	10.88217	10.86252	-0.24309	-0.24364	0.84869	0.92125

CASE 4 (b)

	NR.	TYP	EX(MM)	EX'(MRAD)	EZ(MM)	EZ'(MRAD)	TX(MM)	TX'(MRAD)	Q1	Q2
	0		12.63965	-1.21698	13.27979	0.96448	23.73926	-2.96997	0.0	0.0
Q1	1	QUAD	12.79564	1.52033	12.88126	-1.71577	23.07904	1.68058	0.02130	0.00468
	2	DRIF	13.65080	1.61491	11.94807	-1.70863	23.99493	1.68058	0.03124	0.00750
	2	REMA 100%	23.68721	2.01037	3.55491	-1.05822	40.58005	4.48583	0.08522	0.11665
	3	DRIF	24.15641	2.01718	3.32455	-0.91442	41.62522	4.48583	0.08652	0.13236
Q0	3	QUAD	23.83457	-2.62442	3.12872	0.55858	42.06317	-3.65925	0.09209	0.21897
	4	DRIF	7.81683	-1.02243	13.52529	1.65205	15.76498	-3.65925	0.23233	0.38042
Q5K	4	QUAD	7.52914	0.21332	14.30971	0.56609	13.60082	-2.51725	0.27114	0.38328
	5	DRIF	8.06702	0.97729	14.81334	0.57326	11.37564	-2.51725	0.31814	0.38660
	5	REMA 83%	18.85218	2.44463	17.98522	0.60273	4.13604	-0.17436	0.44322	0.40270
	6	DRIF	19.42088	2.45788	18.12516	0.60372	4.09559	-0.17436	0.44524	0.40327
	6	DRIF	21.16360	2.49171	18.55119	0.60657	3.97284	-0.17436	0.45069	0.40493
	7	DRIF	23.38114	2.52389	19.08886	0.60989	3.81872	-0.17436	0.45638	0.40692
	7	REMA 17%	37.24470	2.61024	22.41412	0.62507	4.13847	0.29322	0.47609	0.41693
	8	DRIF	44.36852	2.62650	24.12192	0.63048	4.93603	0.29322	0.48133	0.42093
Q2K	8	QUAD	52.35000	6.01227	23.70291	-1.07412	5.82514	0.66917	0.48395	0.42348
	9	DRIF	72.99520	-6.01816	20.02973	-1.06580	8.12166	0.66917	0.48681	0.42923
Q1K	9	QUAD	67.34465	-11.83576	22.64403	3.97036	7.49204	-1.31741	0.48793	0.43276
	10	DRIF	53.29735	-11.83354	27.35790	3.97229	5.92834	-1.31741	0.48898	0.43429
QD	10	QUAD	43.88022	-16.97683	30.91121	7.02333	4.88004	-1.88972	0.48985	0.43491
	11	DRIF	40.48501	-16.97576	32.31587	7.02348	4.50210	-1.88972	0.49021	0.43507
QD	11	QUAD	31.23306	-11.71855	35.27064	1.99536	3.47177	-1.30586	0.49188	0.43551
	12	DRIF	28.30387	-11.71474	35.76950	1.99550	3.14531	-1.30586	0.49278	0.43567
QD	12	QUAD	21.94069	-8.01857	35.34373	-3.29508	2.43497	-0.89727	0.49616	0.43607
	13	DRIF	20.51408	-8.01110	34.75723	-3.29497	2.27526	-0.89727	0.49742	0.43619
QA1	13	QUAD	14.10884	-4.48170	27.84599	-9.73666	1.55105	-0.51709	0.50930	0.43702
	14	DRIF	4.25485	-0.01510	0.51344	-0.00993	0.07275	-0.51709	0.71003	0.68392
	15	DRIF	6.33012	3.48032	9.75131	9.72480	-0.44434	-0.51709	0.84323	0.92570

CASE4 (C)

	NR.	TYP	EX(MM)	EX'(MRAD)	EZ(MM)	EZ'(MRAD)	TX(MM)	TX'(MRAD)	Q1	Q2
	0		12.63965	-1.21698	13.27979	0.96448	23.73926	-2.96997	0.0	0.0
Q1	1	QUAD	12.79564	1.52033	12.88126	-1.71577	23.07904	1.68058	0.02130	0.00468
	2	DRIF	13.65080	1.61491	11.94807	-1.70863	23.99493	1.68058	0.03124	0.00750
	2	REMA 100%	23.68721	2.04037	3.55491	-1.05822	40.58005	4.48583	0.08522	0.11665
	3	DRIF	24.15641	2.01718	3.32455	-0.91442	41.62522	4.48583	0.08652	0.13236
Q0	3	QUAD	23.83457	-2.62442	3.12872	0.55858	42.06317	-3.65925	0.09209	0.21897
	4	DRIF	7.81683	-1.02243	13.52529	1.65205	15.76498	-3.65925	0.23233	0.38042
Q5K	4	QUAD	7.56937	0.32575	14.23655	0.35742	13.68081	-2.29419	0.27100	0.38329
	5	DRIF	8.19712	1.06511	14.55581	0.36483	11.65281	-2.29419	0.31698	0.38669
	5	REMA 83%	19.13695	2.44852	16.61762	0.39918	5.61314	0.04871	0.43727	0.40442
	6	DRIF	19.70649	2.46120	16.71037	0.40043	5.62444	0.04871	0.43923	0.40509
	6	DRIF	21.45103	2.49364	16.99357	0.40411	5.65872	0.04871	0.44453	0.40706
	7	DRIF	23.66968	2.52459	17.35274	0.40847	5.70178	0.04871	0.45007	0.40945
	7	REMA 17%	37.52795	2.60835	19.61144	0.42990	7.22156	0.51629	0.46940	0.42204
	8	DRIF	44.64612	2.62428	20.79232	0.43816	8.62584	0.51629	0.47456	0.42735
Q2K	8	QUAD	52.56451	5.94391	20.27460	-0.98644	10.17205	1.15691	0.47715	0.43080
	9	DRIF	72.97500	5.94977	16.91042	-0.97287	14.14243	1.15691	0.48000	0.43877
Q1K	9	QUAD	67.34978	-11.74329	18.94072	3.22763	13.05861	-2.27316	0.48112	0.44377
	10	DRIF	53.41223	-11.74107	22.77392	3.23096	10.36048	-2.27316	0.48217	0.44596
QD	10	QUAD	44.00816	-17.02529	25.70231	5.83210	8.53897	-3.29874	0.48304	0.44685
	11	DRIF	40.60325	-17.02423	26.86874	5.83238	7.87924	-3.29874	0.48340	0.44708
QD	11	QUAD	31.32420	-11.75403	29.32153	1.65430	6.08150	-2.27696	0.48505	0.44773
	12	DRIF	28.38615	-11.75025	29.73514	1.65454	5.51226	-2.27696	0.48595	0.44796
QD	12	QUAD	22.00290	-8.04524	29.37916	-2.74110	4.27492	-1.56064	0.48931	0.44854
	13	DRIF	20.57154	-8.03784	28.89128	-2.74092	3.99714	-1.56064	0.49056	0.44871
QA1	13	QUAD	14.14176	-4.50280	23.14697	-8.09044	2.74148	-0.89161	0.50238	0.44991
	14	DRIF	4.23758	0.00121	0.61779	-0.01061	0.19245	-0.89161	0.70399	0.69545
	15	DRIF	6.34371	3.51221	8.11607	8.06985	-0.69916	-0.89161	0.83752	0.93353