# LOW BETA e p INTERACTION GEOMETRY WITH INTERLACED FOCUSING FOR ELECTRONS AND PROTONS

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ABSTRACT

In trying to scale previously adopted ep interaction geometries[1] to higher energies, the increasing dimensions make it more and more difficult to obtain a small proton beta function at the interaction point. To overcome this difficulty, the interlaced focusing scheme is suggested here and illustrated in a 30/900 GeV design example. The scheme, in this case, reduces the proton beta function by an order of magnitude.

## PROBLEM

For electron storage rings with conventional rf, the energy scales with about the square root of the radius[2], while for proton rings it scales, of course, linearly. Thus, with the two machines in the same tunnel, the ratio $E_p/E_e$ increases with the tunnel size. For a tunnel length of 6 km, for example, the ratio is 30, with electron and proton energies of 30 GeV and 900 GeV, respectively. This large energy ratio allows to separate the beams, after head-on collision, by a common bending magnet that bends the electron beam away from the almost unaffected proton beam. At higher energies, however, this magnet gets longer and must be placed further away for shielding the interaction point (I.P.) against its synchrotron radiation. When assuming that only after this magnet, where the beams are already separated, the first proton quadrupole can be placed, it will be far away from the I.P. and thus cannot produce a sufficiently small beta function at this point. In our example of the 6 km ring, the quadrupole distance will be of the order of 45 m. Then, for a $\beta_{max}$ = 750 m at the quadrupole, the minimum beta will be $\beta^*$ = 2.7 m while, for maximum luminosity, is should be about equal to the minimum bunch length, i.e. an order of magnitude smaller.

## INTERLACED FOCUSING

This raises the question whether one cannot place the proton quadrupoles before the separating magnet in spite of the fact that their focusing strength for the electrons is terribly large. It turns out that this is indeed possible if, at the positions of the proton quadrupoles, the electrons are focused into very narrow beam waists. The proton quadrupoles, then, act on the electron beam as sort of field lenses that do not strongly affect the electron focusing.

DESIGN EXAMPLE

As an exploratory quantitative example*), a design layout for 30 GeV electrons and 900 GeV protons is given in the attached tables and Fig. 1. It shows that, with interlaced focusing, vertical beta functions of 25 cm for the protons and 15 cm for the electrons can be obtained, with maximum beta values of 300 m for the electrons and 900 m for the protons. Fig. 2 shows a preliminary magnet layout of the interaction region, with longitudinal electron spin at the I.P.

## REFERENCES


1) e.g. E. Daßkowski, D. Kohaupt, K. Steffen, G.A. Voss, DESY 78/02 (Jan. 1978)

2) e.g. K. Steffen, Internal Report DESY PET-79/03 (March 1979)


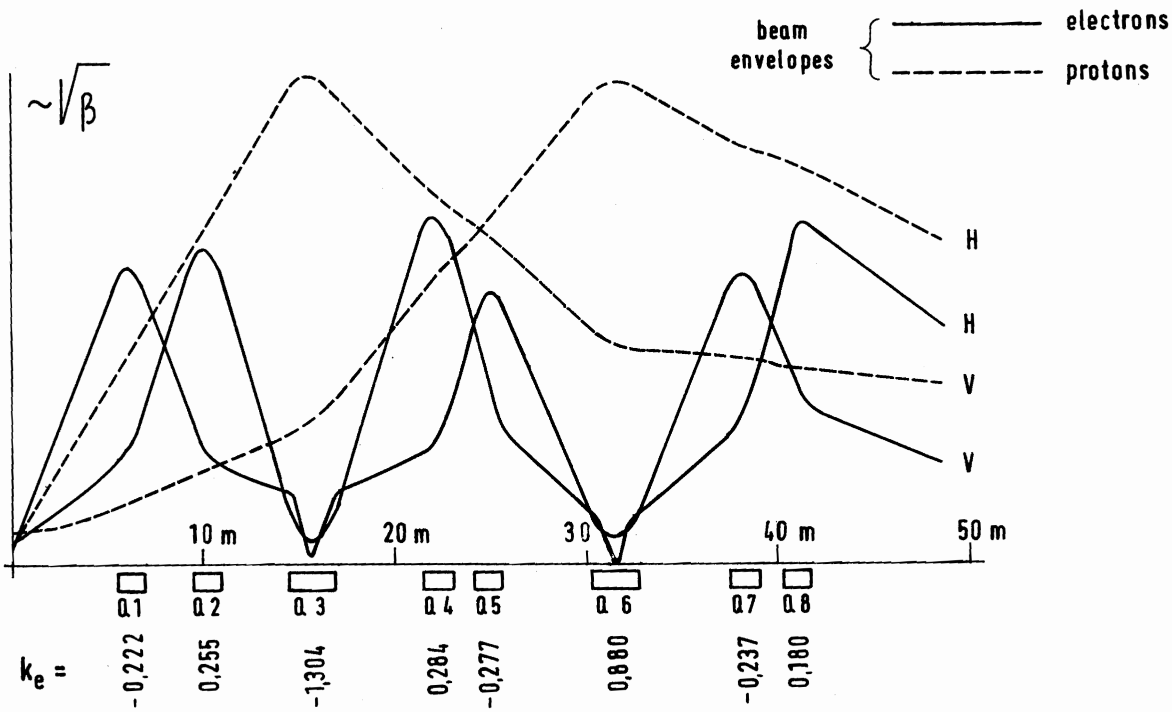


Fig. 1 Interlaced focusing

*) using the DESY beam transport hybrid computer.

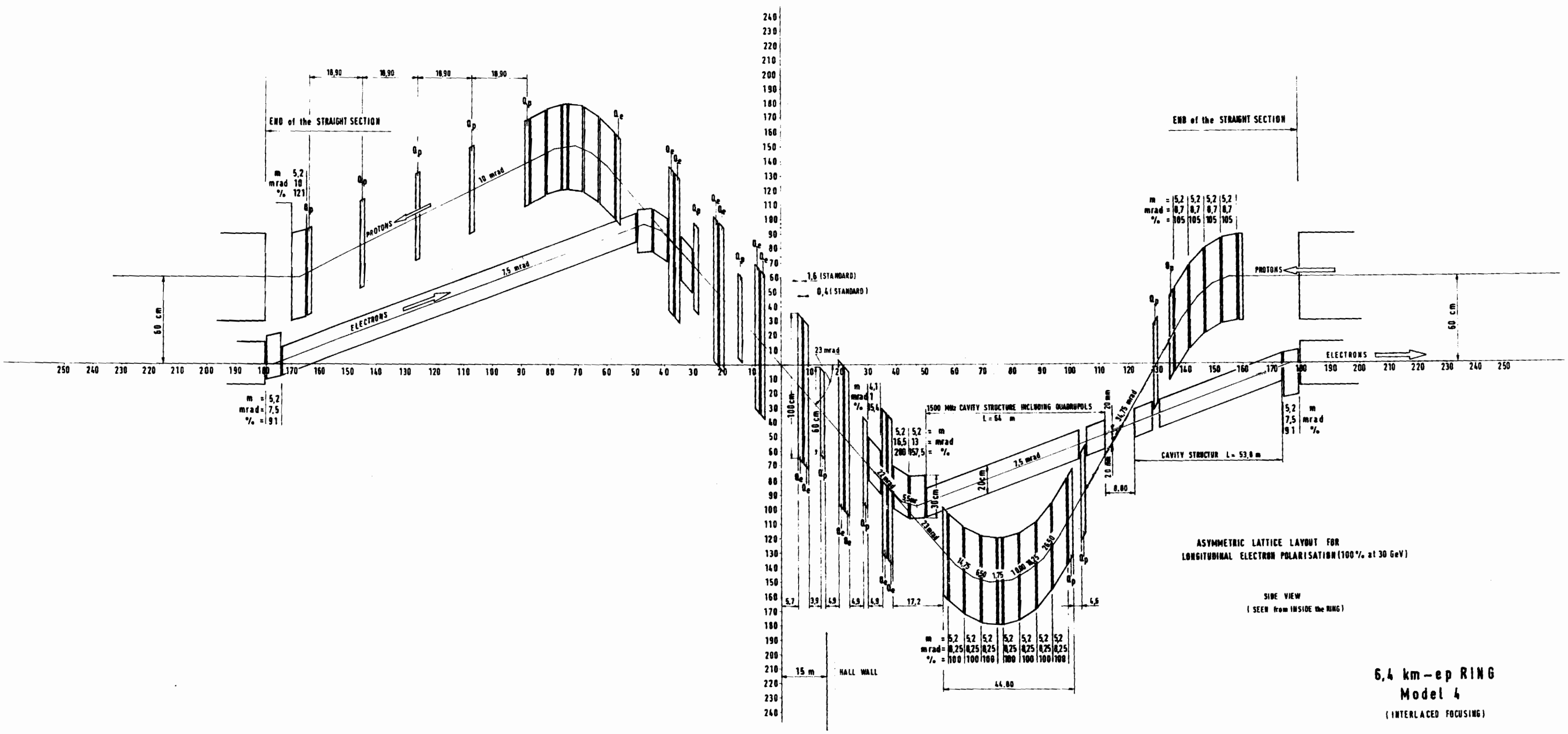


Fig. 2 ep interaction region with interlaced focusing and longitudinal electron spin

## Table 1

Interlaced focusing, electrons

Lattice:

| | TYP | DRIF(M) | L(M) | K(1/M*M) |
|---|---|---|---|---|
| 1 | QUAD | 5.69995 | 1.59998 | -0.22202 |
| 2 | QUAD | 2.39990 | 1.59998 | 0.25529 |
| 3 | QUAD | 3.39990 | 2.59998 | -1.30396 |
| 4 | QUAD | 4.39990 | 1.59998 | 0.28374 |
| 5 | QUAD | 1.00000 | 1.59998 | -0.27669 |
| 6 | QUAD | 4.39990 | 2.59998 | 0.87997 |
| 7 | QUAD | 4.59985 | 1.59998 | -0.23671 |
| 8 | QUAD | 1.00000 | 1.59998 | 0.17999 |
| 9 | DRIF | 5.50000 | 1.00000 | 0.00000 |

Envelopes:

EPS (MM*MRAD) = 100.0000 100.0000
CHR.ABERR. = 0 0

| NR. | TYP | EX(MM) | EX'(MRAD) | EZ(MM) | EZ'(MRAD) |
|---|---|---|---|---|---|
| 0 | | 12.00000 | 0.00000 | 4.00000 | 0.00000 |
| 1 | DRIF | 48.99195 | 8.07949 | 142.55492 | 24.99016 |
| 1 | QUAD | 77.85590 | 29.67649 | 140.23233 | -27.75457 |
| 2 | DRIF | 149.10845 | 29.69670 | 73.64395 | -27.73050 |
| 2 | QUAD | 145.48942 | -33.97140 | 49.74540 | -3.73678 |
| 3 | DRIF | 30.08086 | -33.81534 | 37.66598 | -3.30999 |
| 3 | QUAD | 28.91600 | 32.44930 | 37.60606 | 4.10057 |
| 4 | DRIF | 172.36270 | 32.62790 | 56.86482 | 4.55996 |
| 4 | QUAD | 159.57556 | -47.63253 | 87.06653 | 35.43959 |
| 5 | DRIF | 111.94478 | -47.62828 | 122.51150 | 35.44880 |
| 5 | QUAD | 68.48078 | -9.86554 | 131.88533 | -24.43151 |
| 6 | DRIF | 25.88347 | -9.19429 | 24.61618 | -24.10334 |
| 6 | QUAD | 26.22208 | 8.33019 | 24.94792 | 24.41056 |
| 7 | DRIF | 66.88121 | 9.03880 | 138.46601 | 24.72693 |
| 7 | QUAD | 104.18974 | 39.92231 | 134.28014 | -29.69233 |
| 8 | DRIF | 144.11525 | 39.92782 | 104.59046 | -29.68628 |
| 8 | QUAD | 171.26139 | -7.30802 | 78.41348 | -4.27896 |
| 9 | DRIF | 131.10664 | -7.29152 | 55.32560 | -4.08276 |
| 9 | DRIF | 123.81747 | -7.28668 | 51.27471 | -4.01650 |

Table 2

Interlaced focusing, protons

Lattice:

| | TYP | DRIF(M) | L(M) | K(1/M*M) |
|---|---|---|---|---|
| 1 | QUAD | 5.69995 | 1.59998 | -0.00760 |
| 2 | QUAD | 2.39990 | 1.59998 | 0.00840 |
| 3 | QUAD | 3.39990 | 2.59998 | -0.04347 |
| 4 | QUAD | 4.39990 | 1.59998 | 0.00953 |
| 5 | QUAD | 1.00000 | 1.59998 | -0.00937 |
| 6 | QUAD | 4.19995 | 2.59998 | 0.02933 |
| 7 | QUAD | 4.39990 | 1.59998 | -0.00893 |
| 8 | QUAD | 1.00000 | 1.59998 | 0.00713 |
| 9 | DRIF | 5.50000 | 1.00000 | 0.00000 |

Envelopes:

EPS (MM*MRAD) = 100.0000 100.0000
CHR.ABERR. = 0 0

| NR. | TYP | EX(MM) | EX'(MRAD) | EZ(MM) | EZ'(MRAD) |
|---|---|---|---|---|---|
| 0 | | 20.00000 | 0.00000 | 5.00000 | 0.00000 |
| 1 | DRIF | 34.81718 | 4.09277 | 114.10863 | 19.98079 |
| 1 | QUAD | 41.97993 | 4.84831 | 144.87240 | 18.41124 |
| 2 | DRIF | 53.91932 | 5.07355 | 189.06485 | 18.41659 |
| 2 | QUAD | 61.50025 | 4.38027 | 220.67469 | 21.16695 |
| 3 | DRIF | 76.59249 | 4.48620 | 292.64431 | 21.16904 |
| 3 | QUAD | 100.43072 | 14.29240 | 303.07541 | -13.34251 |
| 4 | DRIF | 163.37462 | 14.31396 | 244.37395 | -13.34032 |
| 4 | QUAD | 184.19747 | 11.66188 | 225.93066 | -9.76096 |
| 5 | DRIF | 195.86010 | 11.66334 | 216.17015 | -9.76003 |
| 5 | QUAD | 216.95106 | 14.75334 | 198.03071 | -12.86920 |
| 6 | DRIF | 278.92110 | 14.75619 | 143.99630 | -12.86037 |
| 6 | QUAD | 288.83703 | -7.25494 | 123.96976 | -2.79765 |
| 7 | DRIF | 256.92050 | -7.25276 | 111.71675 | -2.77061 |
| 7 | QUAD | 248.21491 | -3.65010 | 106.03585 | -4.31677 |
| 8 | DRIF | 244.56514 | -3.64943 | 101.72345 | -4.30784 |
| 8 | QUAD | 236.51628 | -6.39648 | 95.75277 | -3.16647 |
| 9 | DRIF | 201.34908 | -6.39117 | 78.54746 | -3.08163 |
| 9 | DRIF | 194.95854 | -6.38988 | 75.47657 | -3.05971 |