

Accelerator physics colde comparison

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AD/AP/Tech.Note No. 8

ACCELERATOR DEVELOPMENT DEPARTMENT

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Accelerator Physics Technical Note No. 8

"ACCELERATOR PHYSICS CODE COMPARISON"

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ABSTRACT

We present a comparison between results obtained from accelerator physics codes used in the design and analysis of accelerators.

I. INTRODUCTION

Comparison of accelerator codes have been the topic of investigation and speculation by many (for sample notes on code comparisons see past issues of the Proceedings of Accelerator conferences). There are several beam optics programs that have been considered as standard codes for design and analysis of accelerators. For example, we have used programs SYNCH (as standard) and MAD for the design and analysis of the AGS - Booster and the proposed Super Conducting Super Collider (SSC).

In Section II, we Tabulate the parameters obtained from the recent Vax - Version of SYNCH* (Table I) for comparison with those obtained from program MAD - Versions 6.01 (Table II) and 4.03 (Table III) for the same sample (AGS - Booster) lattice. Comparison of the parameters in Tables I-III (e.g. items 6) shows a good agreement between the values of the tune shifts (Q_x, Q_z), lattice functions etc. for $\Delta(P)/P = 0$ but somewhat differs for $\Delta(P)/P \neq 0$. The difference become larger when the sextupoles (e.g. Eddy Current) are included in the input lattices since they are handled differently by these programs.

Table II, was obtained using the recent Vax Version of SYNCH* which includes the correction to the chromaticity calculation that was not included (and was inaccurate) in the CDC and previous VAX versions of SYNCH. The effect of the chromaticity calculation correction is two fold:

- 1) In finding the closed orbit for off momentum, CDC - Version produces the wrong bending angles except for zero - gradient rectangular magnet.
- 2) In computing chromaticity for bending magnets with nonzero exit and entrance angle one term in the chromaticity formula had the wrong sign, resulting in the wrong sextupole strength correction.

Thus, we recommend the use of the parameters obtained from the corrected Version of SYNCH for the design, analysis or code comparison, since the data produced from the CDC Version of SYNCH is inaccurate.

In conclusion, the parameters obtained from several beam optics programs agree for $\text{DELTA}(P)/P = 0$, but there still are differences in the results obtained from programs SYNCH [1] and MAD [2] for $\text{DELTA}(P)/P \neq 0$.

Acknowledgement

We thank Dr. E. Courant for the information on SYNCH and note that, this code comparison was made at his recommendation for the presentation at the Oct. 15, 1987 A.P. meeting.

* available in `BNLDAG::DUA0:[PARSA1.SYNCH]SYNSEP.EXE`

[1]. A. A. Garren, principal author.

[2]. F. C. Iselin, principal author.

TABLE I

SYNCH VAX - Version 987

SYNCH RUN BST AGS-BOOSTER 14-OCT-87 15:40:17

1. DELTA(P)/P = -0.0100 :

| | | | | | |
|-----------------|------------|-------------|----------------|-------------|----------|
| CIRCUMFERENCE = | 201.6976 M | QX = | 4.87006 | QY = | 4.88460 |
| | | QX' = | -5.03758 | QY' = | -5.60968 |
| | | THEIX = | 6.28318530 RAD | | |
| | | THEIY = | 0.00000000 RAD | | |
| | | GAMMA(TR) = | (5.03887, | 0.00000) | |
| RADIUS = | 32.1012 M | BETX(21) = | 13.84289 | BETY(18) = | 13.65464 |
| (DS/S)/(DP/P) = | 0.0393852 | DY(52) = | 0.00000 | | |
| MAXIMA | --- | BETX(18) = | 3.50410 | BETY(47) = | 3.63202 |
| DX(35) = | 3.00980 | DY(52) = | 0.00000 | | |
| MINIMA | --- | BETX(1) = | 0.44193 | DY(52) = | 0.00000 |
| DX(1) = | 0.44193 | XCO(1) = | -4.89001 | YCO(52) = | 0.00000 |
| MAXIMA | | XCO(35) = | -29.66112 | YCO(52) = | 0.00000 |
| MINIMA | | | | | |

2. DELTA(P)/P = -0.00800 :

| | | | | | |
|-----------------|------------|-------------|----------------|-------------|----------|
| CIRCUMFERENCE = | 201.7137 M | QX = | 4.85992 | QY = | 4.87337 |
| | | QX' = | -5.01543 | QY' = | -5.54011 |
| | | THEIX = | 6.28318530 RAD | | |
| | | THEIY = | 0.00000000 RAD | | |
| | | GAMMA(TR) = | (5.00544, | 0.00000) | |
| RADIUS = | 32.1037 M | BETX(21) = | 13.84715 | BETY(18) = | 13.65237 |
| (DS/S)/(DP/P) = | 0.0399131 | DY(52) = | 0.00000 | | |
| MAXIMA | --- | BETX(18) = | 3.51844 | BETY(47) = | 3.64632 |
| DX(35) = | 2.99672 | DY(52) = | 0.00000 | | |
| MINIMA | --- | BETX(52) = | 0.46227 | DY(52) = | 0.00000 |
| DX(52) = | 0.46227 | XCO(52) = | -3.99552 | YCO(52) = | 0.00000 |
| MAXIMA | | XCO(35) = | -23.70182 | YCO(52) = | 0.00000 |
| MINIMA | | | | | |

3. DELTA(P)/P = -0.00600 :

| | | | | | |
|-----------------|------------|-------------|----------------|-------------|----------|
| CIRCUMFERENCE = | 201.7300 M | QX = | 4.84985 | QY = | 4.86229 |
| | | QX' = | -4.99358 | QY' = | -5.47090 |
| | | THEIX = | 6.28318530 RAD | | |
| | | THEIY = | 0.00000000 RAD | | |
| | | GAMMA(TR) = | (4.97302, | 0.00000) | |
| RADIUS = | 32.1063 M | BETX(21) = | 13.85156 | BETY(18) = | 13.65018 |
| (DS/S)/(DP/P) = | 0.0404352 | DY(52) = | 0.00000 | | |
| MAXIMA | --- | BETX(18) = | 3.53273 | BETY(47) = | 3.66060 |
| DX(35) = | 2.98438 | DY(52) = | 0.00000 | | |
| MINIMA | --- | BETX(52) = | 0.48223 | DY(52) = | 0.00000 |
| DX(52) = | 0.48223 | XCO(52) = | -3.05855 | YCO(52) = | 0.00000 |
| MAXIMA | | XCO(35) = | -17.75746 | YCO(52) = | 0.00000 |
| MINIMA | | | | | |

4. DELTA(P)/P = -0.00400:

CIRCUMFERENCE = 201.7465 M QX = 4.83984 QY = 4.85137
 QX' = -4.97202 QY' = -5.40198
 THETX = 6.28318530 RAD
 THETY = 0.00000000 RAD
 RADIUS = 32.1089 M GAMMA(TR)=(4.94155, 0.00000)
 (DS/S)/(DP/P)= 0.0409518
 MAXIMA --- BETX(21) = 13.85613 BETY(18) = 13.64807
 DX(35) = 2.97275 DY(52) = 0.00000
 MINIMA --- BETX(18) = 3.54698 BETY(47) = 3.67487
 DX(52) = 0.50183 DY(52) = 0.00000
 MAXIMA XCO(52)= -2.07984 YCO(52)= 0.00000
 MINIMA XCO(35)= -11.82661 YCO(52)= 0.00000

5. DELTA(P)/P = -0.00200

CIRCUMFERENCE = 201.7632 M QX = 4.82989 QY = 4.84061
 THETX = 6.28318530 RAD
 THETY = 0.00000000 RAD
 RADIUS = 32.1116 M GAMMA(TR)=(4.91098, 0.00000)
 (DS/S)/(DP/P)= 0.0414633
 MAXIMA --- BETX(21) = 13.86084 BETY(18) = 13.64603
 DX(35) = 2.96178 DY(52) = 0.00000
 MINIMA --- BETX(18) = 3.56119 BETY(47) = 3.68911
 DX(52) = 0.52109 DY(52) = 0.00000
 MAXIMA XCO(52)= -1.06010 YCO(52)= 0.00000
 MINIMA XCO(35)= -5.90789 YCO(52)= 0.00000

6. DELTA(P)/P = 0.0000

CIRCUMFERENCE = 201.7800 M QX = 4.82000 QY = 4.83000
 QX' = -4.92970 QY' = -5.26488
 THETX = 6.28318530 RAD
 THETY = 0.00000000 RAD
 RADIUS = 32.1143 M GAMMA(TR)=(4.88124, 0.00000)
 (DS/S)/(DP/P)= 0.0419701
 MAXIMA --- BETX(21) = 13.86571 BETY(52) = 13.64403
 DX(35) = 2.95145 DY(52) = 0.00000
 MINIMA --- BETX(18) = 3.57537 BETY(35) = 3.70334
 DX(1) = 0.54003 DY(52) = 0.00000
 MAXIMA XCO(52)= 0.00000 YCO(52)= 0.00000
 MINIMA XCO(35)= 0.00000 YCO(52)= 0.00000

7. DELTA(P)/P = 0.00200

CIRCUMFERENCE = 201.7970 M QX = 4.81017 QY = 4.81955
 QX' = -4.90893 QY' = -5.19663
 THETX = 6.28318530 RAD
 THETY = 0.00000000 RAD
 RADIUS = 32.1170 M GAMMA(TR)=(4.85229, 0.00000)
 (DS/S)/(DP/P)= 0.0424725
 MAXIMA --- BETX(21) = 13.87071 BETY(52) = 13.65707
 DX(35) = 2.94173 DY(52) = 0.00000

MINIMA --- BETX(18) = 3.58950 BETY(21) = 3.71581
 DX(52) = 0.55866 DY(52) = 0.00000
 MAXIMA XCO(35) = 5.89831 YCO(52) = 0.00000
 MINIMA XCO(52) = 1.09981 YCO(52) = 0.00000

8. DELTA(P)/P = 0.00400

CIRCUMFERENCE = 201.8142 M QX = 4.80040 QY = 4.80925
 QX' = -4.88841 QY' = -5.12853
 THETX = 6.28318530 RAD
 THETY = 0.00000000 RAD
 RADIUS = 32.1197 M
 (DS/S)/(DP/P) = 0.0429707 GAMMA(TR) = (4.82407, 0.00000)
 MAXIMA --- BETX(21) = 13.87587 BETY(52) = 13.67025
 DX(35) = 2.93261 DY(52) = 0.00000
 MINIMA --- BETX(18) = 3.60361 BETY(21) = 3.72813
 DX(52) = 0.57700 DY(52) = 0.00000
 MAXIMA XCO(35) = 11.78824 YCO(52) = 0.00000
 MINIMA XCO(52) = 2.23873 YCO(52) = 0.00000

9. DELTA(P)/P = 0.00600

CIRCUMFERENCE = 201.8316 M QX = 4.79069 QY = 4.79911
 QX' = -4.86812 QY' = -5.06055
 THETX = 6.28318530 RAD
 THETY = 0.00000000 RAD
 RADIUS = 32.1225 M
 (DS/S)/(DP/P) = 0.0434650 GAMMA(TR) = (4.79656, 0.00000)
 MAXIMA --- BETX(21) = 13.88116 BETY(52) = 13.68358
 DX(35) = 2.92405 DY(52) = 0.00000
 MINIMA --- BETX(18) = 3.61768 BETY(21) = 3.74028
 DX(52) = 0.59506 DY(52) = 0.00000
 MAXIMA XCO(35) = 17.67094 YCO(52) = 0.00000
 MINIMA XCO(52) = 3.41617 YCO(52) = 0.00000

10. DELTA(P)/P = 0.00800

CIRCUMFERENCE = 201.8492 M QX = 4.78104 QY = 4.78913
 QX' = -4.84806 QY' = -4.99265
 THETX = 6.28318530 RAD
 THETY = 0.00000000 RAD
 RADIUS = 32.1253 M
 (DS/S)/(DP/P) = 0.0439557 GAMMA(TR) = (4.76971, 0.00000)
 MAXIMA --- BETX(21) = 13.88659 BETY(52) = 13.69704
 DX(35) = 2.91603 DY(52) = 0.00000
 MINIMA --- BETX(18) = 3.63171 BETY(21) = 3.75227
 DX(52) = 0.61285 DY(52) = 0.00000
 MAXIMA XCO(35) = 23.54750 YCO(52) = 0.00000
 MINIMA XCO(52) = 4.63157 YCO(52) = 0.00000

11. DELTA(P)/P = 0.01000

| | | | | | |
|-----------------|-----------------|-----------|-------------|----------|-------------------|
| CIRCUMFERENCE = | 201.8669 M | QX = | 4.77144 | QY = | 4.77930 |
| | | QX' = | -4.82823 | QY' = | -4.92482 |
| | | THEIX = | 6.28318530 | | RAD |
| | | THEIY = | 0.00000000 | | RAD |
| | RADIUS = | 32.1281 M | | | |
| | (DS/S)/(DP/P) = | 0.0444431 | | | |
| | | | GAMMA(TR) = | (| 4.74349, 0.00000) |
| MAXIMA | --- BETX(21) = | 13.89216 | BETX(52) = | 13.71064 | |
| DX(35) = | 2.90853 | DY(52) = | 0.00000 | | |
| MINIMA | --- BETX(18) = | 3.64572 | BETX(21) = | 3.76410 | |
| DX(52) = | 0.63039 | DY(52) = | 0.00000 | | |
| MAXIMA | XCO(35) = | 29.41897 | YCO(52) = | 0.00000 | |
| MINIMA | XCO(52) = | 5.88440 | YCO(52) = | 0.00000 | |

END OF SYNCH RUN BST

TABLE II

"MAD" VERSION 6.01/03:

MAD6.01 OUTPUT FOR THE BOOSTER LATTICE WITHOUT SEXTUPOLES [SF, SD, SV=0]

1. For DELTA(P)/P = -0.01:

| | | |
|---------------------------|-------------------------|------------------------|
| TOTAL LENGTH = 201.780000 | QX = 4.869524 | QY = 4.882689 |
| | QX' = -4.974135 | QY' = -5.314419 |
| ALFA = 0.397978E-01 | BETAX(MAX) = 13.981287 | BETAY(MAX) = 13.795012 |
| GAMMA(TR) = 5.012688 | DX(MAX) = 3.039104 | DY(MAX) = 0.000000 |
| | XCO(MAX) = 29.938897 | YCO(MAX) = 0.000000 |
| | XCO(R.M.S.) = 16.640292 | YCO(R.M.S.) = 0.000000 |

2. FOR DELTA(P)/P = -0.008000:

| | | |
|---------------------------|-------------------------|------------------------|
| TOTAL LENGTH = 201.780000 | QX = 4.859582 | QY = 4.872144 |
| | QX' = -4.965049 | QY' = -5.304147 |
| ALFA = 0.402414E-01 | BETAX(MAX) = 13.957912 | BETAY(MAX) = 13.764037 |
| GAMMA(TR) = 4.984983 | DX(MAX) = 3.020217 | DY(MAX) = 0.000000 |
| | XCO(MAX) = 23.879696 | YCO(MAX) = 0.000000 |
| | XCO(R.M.S.) = 13.311186 | YCO(R.M.S.) = 0.000000 |

3. FOR DELTA(P)/P = -0.006000:

| | | |
|---------------------------|------------------------|------------------------|
| TOTAL LENGTH = 201.780000 | QX = 4.849659 | QY = 4.861603 |
| | QX' = -4.956066 | QY' = -5.294075 |
| ALFA = 0.406801E-01 | BETAX(MAX) = 13.934668 | BETAY(MAX) = 13.733463 |
| GAMMA(TR) = 4.958030 | DX(MAX) = 3.002033 | DY(MAX) = 0.000000 |
| | XCO(MAX) = 17.857561 | YCO(MAX) = 0.000000 |
| | XCO(R.M.S.) = 9.983220 | YCO(R.M.S.) = 0.000000 |

4. FOR DELTA(P)/P = -0.004000:

| | | |
|---------------------------|------------------------|------------------------|
| TOTAL LENGTH = 201.780000 | QX = 4.839755 | QY = 4.851065 |
| | QX' = -4.947183 | QY' = -5.284184 |
| ALFA = 0.411142E-01 | BETAX(MAX) = 13.911553 | BETAY(MAX) = 13.703278 |
| GAMMA(TR) = 4.931783 | DX(MAX) = 2.984527 | DY(MAX) = 0.000000 |
| | XCO(MAX) = 11.871112 | YCO(MAX) = 0.000000 |
| | XCO(R.M.S.) = 6.655764 | YCO(R.M.S.) = 0.000000 |

5. FOR DELTA(P)/P = -0.002000:

| | | |
|---------------------------|------------------------|------------------------|
| TOTAL LENGTH = 201.780000 | QX = 4.829868 | QY = 4.840531 |
| | QX' = -4.938396 | QY' = -5.274457 |
| ALFA = 0.415441E-01 | BETAX(MAX) = 13.888567 | BETAY(MAX) = 13.673471 |
| GAMMA(TR) = 4.906198 | DX(MAX) = 2.967673 | DY(MAX) = 0.000000 |

XCO(MAX) = 5.919019 YCO(MAX) = 0.000000
 XCO(R.M.S.) = 3.328215 YCO(R.M.S.) = 0.000000

6. FOR DELTA(P)/P = 0.000000:

TOTAL LENGTH = 201.780000 QX = 4.820000 QY = 4.829999
 QX' = -4.929702 QY' = -5.264883
 ALFA = 0.419701E-01 BETAX(MAX) = 13.865707 BETAY(MAX) = 13.644032
 GAMMA(TR) = 4.881238 DX(MAX) = 2.951449 DY(MAX) = 0.000000
 XCO(MAX) = 0.000000 YCO(MAX) = 0.000000
 XCO(R.M.S.) = 0.000000 YCO(R.M.S.) = 0.000000

7. FOR DELTA(P)/P = 0.002000:

TOTAL LENGTH = 201.780000 QX = 4.810150 QY = 4.819471
 QX' = -4.921099 QY' = -5.255452
 ALFA = 0.423924E-01 BETAX(MAX) = 13.842974 BETAY(MAX) = 13.629735
 GAMMA(TR) = 4.856865 DX(MAX) = 2.935830 DY(MAX) = 0.000000
 XCO(MAX) = 5.887179 YCO(MAX) = 0.000000
 XCO(R.M.S.) = 3.329428 YCO(R.M.S.) = 0.000000

8. FOR DELTA(P)/P = 0.004000:

TOTAL LENGTH = 201.780000 QX = 4.800317 QY = 4.808946
 QX' = -4.912583 QY' = -5.246156
 ALFA = 0.428113E-01 BETAX(MAX) = 13.820366 BETAY(MAX) = 13.615495
 GAMMA(TR) = 4.833046 DX(MAX) = 2.920797 DY(MAX) = 0.000000
 XCO(MAX) = 11.743710 YCO(MAX) = 0.000000
 XCO(R.M.S.) = 6.660591 YCO(R.M.S.) = 0.000000

9. FOR DELTA(P)/P = 0.006000:

TOTAL LENGTH = 201.780000 QX = 4.790501 QY = 4.798424
 QX' = -4.904152 QY' = -5.236988
 ALFA = 0.432270E-01 BETAX(MAX) = 13.797883 BETAY(MAX) = 13.601316
 GAMMA(TR) = 4.809750 DX(MAX) = 2.906327 DY(MAX) = 0.000000
 XCO(MAX) = 17.570742 YCO(MAX) = 0.000000
 XCO(R.M.S.) = 9.993989 YCO(R.M.S.) = 0.000000

10. FOR DELTA(P)/P = 0.008000:

TOTAL LENGTH = 201.780000 QX = 4.780703 QY = 4.787905
 QX' = -4.895804 QY' = -5.227943
 ALFA = 0.436398E-01 BETAX(MAX) = 13.775524 BETAY(MAX) = 13.587203
 GAMMA(TR) = 4.786948 DX(MAX) = 2.892402 DY(MAX) = 0.000000
 XCO(MAX) = 23.369382 YCO(MAX) = 0.000000
 XCO(R.M.S.) = 13.330097 YCO(R.M.S.) = 0.000000

11. FOR DELTA(P)/P = 0.010000 :

TOTAL LENGTH = 201.780000 QX = 4.770922 QY = 4.777389
 QX' = -4.887536 QY' = -5.219016
 ALFA = 0.440499E-01 BETAX(MAX) = 13.753287 BETAY(MAX) = 13.573160
 GAMMA(TR) = 4.764614 DX(MAX) = 2.879003 DY(MAX) = 0.000000
 XCO(MAX) = 29.140701 YCO(MAX) = 0.000000
 XCO(R.M.S.) = 16.669372 YCO(R.M.S.) = 0.000000

TABLE III

"MAD" VERSIN 4.03

MAD403 OUTPUT FOR AGS BOOSTER LATTICE WITHOUT SEXTUPOLES [SF,SD,SV=0]

1. FOR DELTA(P)/P = -0.010000 :

TOTAL LENGTH = 201.780000 QX = 4.869536 QY = 4.882249
 QX' = -4.974658 QY' = -5.291287
 ALFA = 0.397978E-01 BETAX(MAX) = 13.981250 BETAY(MAX) = 13.796343
 GAMMA(TR) = 5.012688 DX(MAX) = 3.039108 DY(MAX) = 0.000000

2. FOR DELTA(P)/P = -0.008000 :

TOTAL LENGTH = 201.780000 QX = 4.859589 QY = 4.871899
 QX' = -4.965323 QY' = -5.292399
 ALFA = 0.402414E-01 BETAX(MAX) = 13.957891 BETAY(MAX) = 13.764777
 GAMMA(TR) = 4.984983 DX(MAX) = 3.020219 DY(MAX) = 0.000000

3. FOR DELTA(P)/P = -0.006000 :

TOTAL LENGTH = 201.780000 QX = 4.849663 QY = 4.861481
 QX' = -4.956193 QY' = -5.288761
 ALFA = 0.406801E-01 BETAX(MAX) = 13.934657 BETAY(MAX) = 13.733831
 GAMMA(TR) = 4.958030 DX(MAX) = 3.002034 DY(MAX) = 0.000000

4. FOR DELTA(P)/P = -0.004000 :

TOTAL LENGTH = 201.780000 QX = 4.839756 QY = 4.851017
 QX' = -4.947229 QY' = -5.282268
 ALFA = 0.411142E-01 BETAX(MAX) = 13.911549 BETAY(MAX) = 13.703424
 GAMMA(TR) = 4.931783 DX(MAX) = 2.984527 DY(MAX) = 0.000000

5. FOR DELTA(P)/P = -0.002000 :

| | | |
|---------------------------|------------------------|------------------------|
| TOTAL LENGTH = 201.780000 | QX = 4.829869 | QY = 4.840520 |
| | QX' = -4.938405 | QY' = -5.274067 |
| ALFA = 0.415441E-01 | BETAX(MAX) = 13.888566 | BETAY(MAX) = 13.673504 |
| GAMMA(TR) = 4.906198 | DX(MAX) = 2.967673 | DY(MAX) = 0.000000 |

6. FOR DELTA(P)/P = 0.000000 :

| | | |
|---------------------------|------------------------|------------------------|
| TOTAL LENGTH = 201.780000 | QX = 4.820000 | QY = 4.829999 |
| | QX' = -4.929702 | QY' = -5.264883 |
| ALFA = 0.419701E-01 | BETAX(MAX) = 13.865707 | BETAY(MAX) = 13.644032 |
| GAMMA(TR) = 4.881238 | DX(MAX) = 2.951449 | DY(MAX) = 0.000000 |

7. FOR DELTA(P)/P = 0.002000:

| | | |
|---------------------------|------------------------|------------------------|
| TOTAL LENGTH = 201.780000 | QX = 4.810150 | QY = 4.819462 |
| | QX' = -4.921105 | QY' = -5.255196 |
| ALFA = 0.423924E-01 | BETAX(MAX) = 13.842973 | BETAY(MAX) = 13.629764 |
| GAMMA(TR) = 4.856865 | DX(MAX) = 2.935830 | DY(MAX) = 0.000000 |

8. BEAM DELTA(P)/P = 0.004000:

| | | |
|---------------------------|------------------------|------------------------|
| TOTAL LENGTH = 201.780000 | QX = 4.800318 | QY = 4.808910 |
| | QX' = -4.912603 | QY' = -5.245338 |
| ALFA = 0.428113E-01 | BETAX(MAX) = 13.820363 | BETAY(MAX) = 13.615603 |
| GAMMA(TR) = 4.833046 | DX(MAX) = 2.920797 | DY(MAX) = 0.000000 |

9. FOR DELTA(P)/P = 0.006000:

| | | |
|---------------------------|------------------------|------------------------|
| TOTAL LENGTH = 201.780000 | QX = 4.790504 | QY = 4.798347 |
| | QX' = -4.904188 | QY' = -5.235560 |
| ALFA = 0.432270E-01 | BETAX(MAX) = 13.797876 | BETAY(MAX) = 13.601548 |
| GAMMA(TR) = 4.809750 | DX(MAX) = 2.906328 | DY(MAX) = 0.000000 |

10. FOR DELTA(P)/P = 0.008000 :

| | | |
|---------------------------|------------------------|------------------------|
| TOTAL LENGTH = 201.780000 | QX = 4.780707 | QY = 4.787774 |
| | QX' = -4.895849 | QY' = -5.226062 |
| ALFA = 0.436398E-01 | BETAX(MAX) = 13.775511 | BETAY(MAX) = 13.587601 |
| GAMMA(TR) = 4.786948 | DX(MAX) = 2.892404 | DY(MAX) = 0.000000 |

11. FOR DELTA(P)/P = 0.010000 :

| | | |
|---------------------------|------------------------|------------------------|
| TOTAL LENGTH = 201.780000 | QX = 4.770928 | QY = 4.777190 |
| | QX' = -4.887580 | QY' = -5.21701 |
| ALFA = 0.440499E-01 | BETAX(MAX) = 13.753267 | BETAY(MAX) = 13.573763 |
| GAMMA(TR) = 4.764614 | DX(MAX) = 2.879005 | DY(MAX) = 0.000000 |
