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The NSNS Accumulator Ring

A. G. Ruggiero

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Collider Accelerator Department

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U.S. Department of Energy

USDOE Office of Science (SC)

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ALTERNATING GRADIENT SYNCHROTRON DEPARTMENT
BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 11973

The NSNS Accumulator Ring*

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Abstract

This report describes the design of the Accumulator Ring for the National Spallation Neutron Source.

Choice of the Periodicity

The Accumulator Ring has a threefold periodicity. Each period has a mirror symmetry. Each period is made of an arc and a long straight section. The threefold periodicity has been chosen to accommodate the following three main functions: injection from the Linac, extraction to the Target, and beam compression by the RF system. Moreover the triangular shape allows a natural orientation of the Ring with respect to the Linac and the Target area as shown in Figure 1. The distribution of the functions are shown in Figure 2. Included are also the location of beam scrapers and collimators to remove unwanted beam halo, both in the betatron and in the momentum phase space. Betatron scraping requires a space in the Accumulator lattice with no dispersion. We have required thus that the long straight sections, where injection, extraction and beam compression occur are dispersionless. Betatron scraping can then be accomplished at both ends of the long straight sections. Momentum scraping on the other end requires a region with large dispersion which can be made to appear naturally in the middle of the arcs. The layout of half of a period of the Accumulator Ring is given in Figure 3, and a list of general parameters in Table 1.

Choice of the Ring Circumference

The circumference of the Ring has been chosen so that the frequency f_L of the RFQ which shapes the beam in front of the Linac, is exactly a multiple of the revolution frequency f_0, that is

$$f_L = n_L f_0 \qquad (1)$$

Moreover, to avoid beam losses during the capture of the beam at injection and compression, the beam is chopped by a ratio q. We required also that an integral number of Linac bunches are injected into the Ring at all time, to allow an exact overposition of the beam turn-after-turn. Not only this simplifies the conceptual design of the Ring and of the injection process, but also provides some useful RF triggering signals which can be used for the reliable operation of the Ring.

* Work performed under the auspices of the U.S. Department of Energy

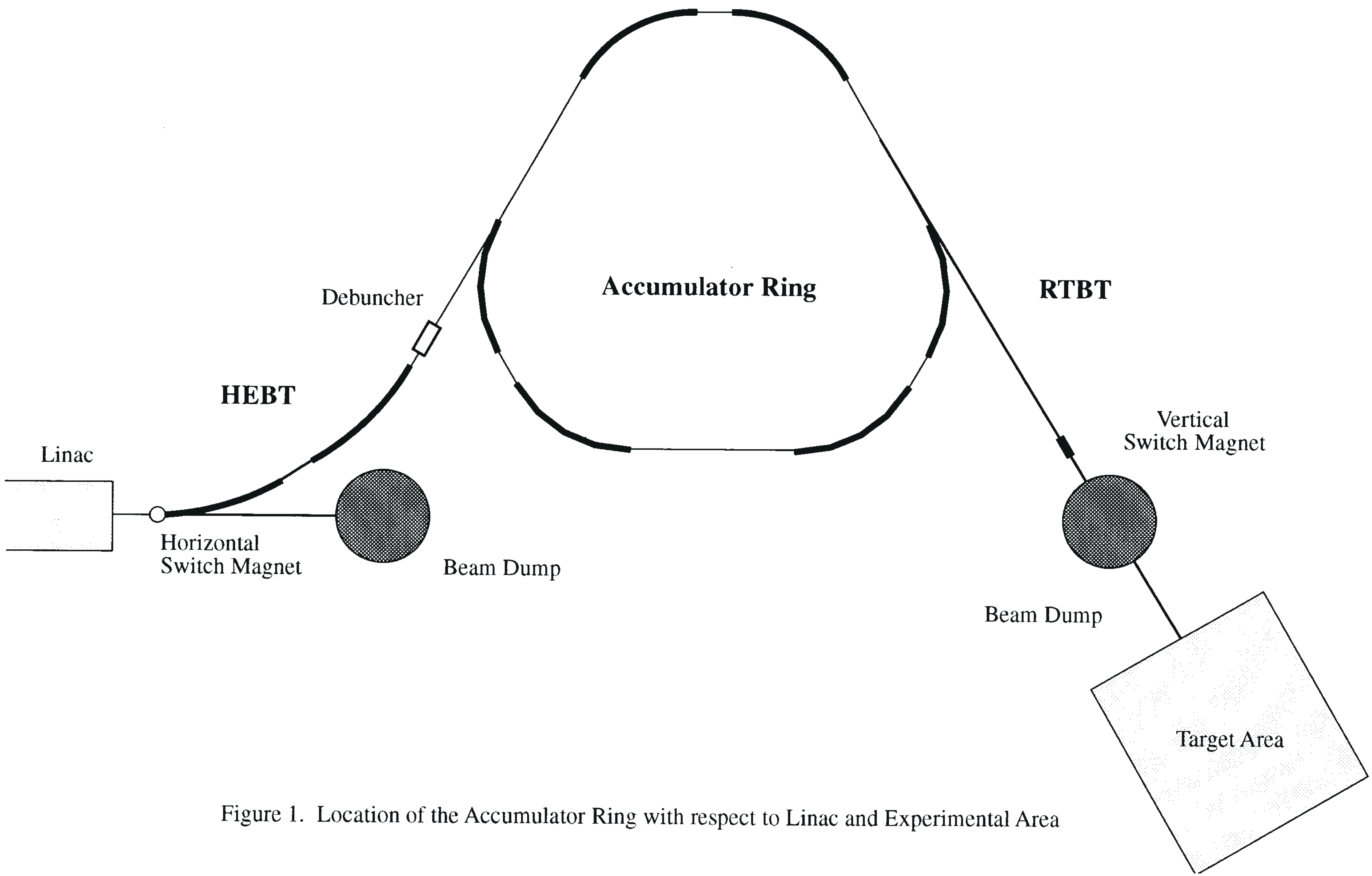

Figure 1. Location of the Accumulator Ring with respect to Linac and Experimental Area

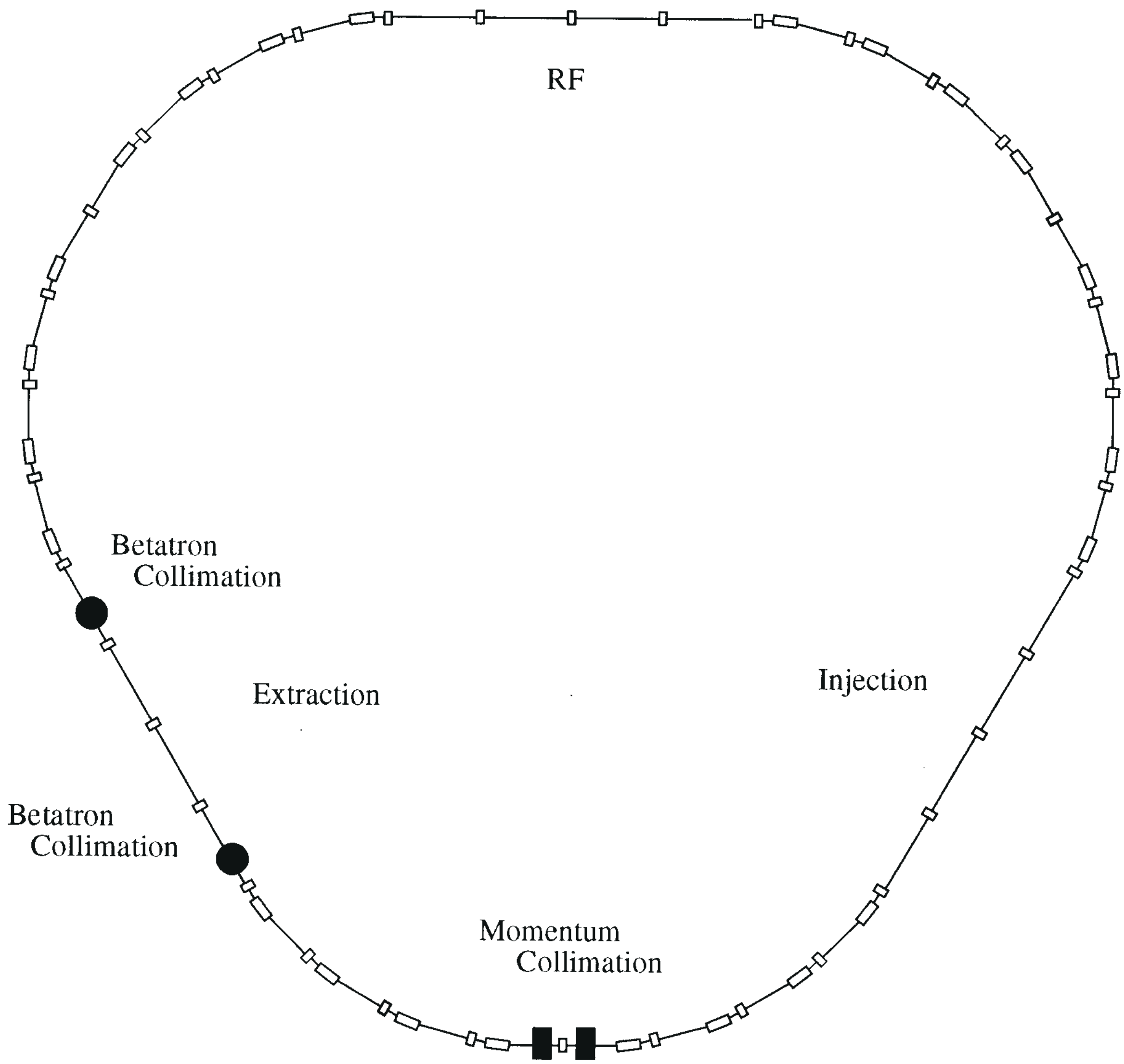

Figure 2. The Accumulator Ring

The second condition is

$$qf_L \quad = \quad n_q\, f_0 \tag{2}$$

so that $q\, n_L = n_q$. We have chosen $q = 0.65$, $n_L = 320$, and $n_q = 208$. The last is the number of Linac bunches injected in the Ring in one turn. Since $f_L = 402.5$ MHz, we derive for the revolution frequency $f_0 = 1.258$ MHz; that is, for a 1.0 GeV beam, a circumference $2\pi R = 208.558$ m.

Table 1: NSNS Accumulator Ring

Kinetic Energy	1.0 GeV
Magnetic Rigidity	5.657 T m
Circumference	208.558 m
Periodicity	3 w/ mirror symmetry
Structure	18 FODO Cells
β_{max}	24.0 m
η_{max}	7.95 m
Betatron Tunes, H/V	3.82 / 3.78
Transition Energy, γ_T	3.422
Natural Chromaticity, H/V	-0.928 / -0.958

Choice of the Lattice

To guarantee the stability of the motion, we have chosen a sequence of FODO cells covering entirely the circumference of the Ring. The total number of FODO cells is 18, with an arc made of 4 cells and a long straight section of 2 cells. The phase advance per cell is about 90^o in the horizontal plane, which allows to adjust the dispersion to the desired values in the two regions: zero in the insertion and large in the middle of the arc. The exact dispersion matching is eventually provided by placing properly the dipole magnet at different distance from the quadrupoles at the two sides. The layout of an empty FODO cell in the insertion is shown in Figure 4a, whereas Figure 4b shows a FODO cells with bending magnets. To accommodate enough space for the insertion of the beam scrapers at both sides of the central quadrupole, there is a mirror symmetry of the dipole magnet distribution around the middle of the arc, as shown in Figure 4c.

Choice of the Betatron Tunes

With a phase advance of about 90^o per cell, the natural choice of the betatron tune, for a ring with 18 FODO cells, is around 4. We have chosen more precisely $\nu_H = 3.82$ and $\nu_V = 3.78$, which are just under integral values. These values correspond to no space-charge effects. With space-charge effects included, a tune depression as large as 0.2 is to be added to both planes, which shifts the two operation tunes to around 3.6. The shift will not cause crossing of any major first or second order resonance. Systematic low-order resonances are also avoided as displayed in the tune-diagram of Figure 5. Other resulting parameters, like transition energy and natural chromaticity are given in Table 1.

The Lattice Functions

The lattice functions, β_H, β_V, and dispersion η are plotted in Figure 3. The behavior of the dispersion is as expected according to the requirements. The vertical amplitude function β_V has a periodicity which follows exactly that of the 18 FODO cells. On the other end, the horizontal amplitude function β_H exhibits a gross mismatch and a periodicity of only 3. The mismatch is caused by the fewer number of dipole magnets (24), and thus by the large focussing effect in the horizontal plane due to the sharp curvature. To avoid excessive mismatch which could appear also in the vertical plane, we have assumed sector magnets with zero entrance and exit angles. The specification for the dipole magnets are summarized in Table 2, and those of the quadrupole magnets in Table 3. A complete output of SYNCH is attached to the end of the paper.

Table 2: Dipole Magnets (B)

Total Number	24
Type	frame, sector, curved
Length, m	1.5 m
Bending Field	9.874 kG
Bending Angle	15°
Bending Radius	5.730 m
Gap Dimension	19.5 cm
Pole Width	50 cm
Sagitta	19.523 cm

Space Charge Effects

The space-charge tune-depression is calculated according to the formula

$$\Delta\nu = N r_p / 2 \beta^2 \gamma^3 B \varepsilon \qquad (3)$$

where $r_p = 1.535 \times 10^{-18}$ m is the classical proton radius. For an average power of 2 MW at the

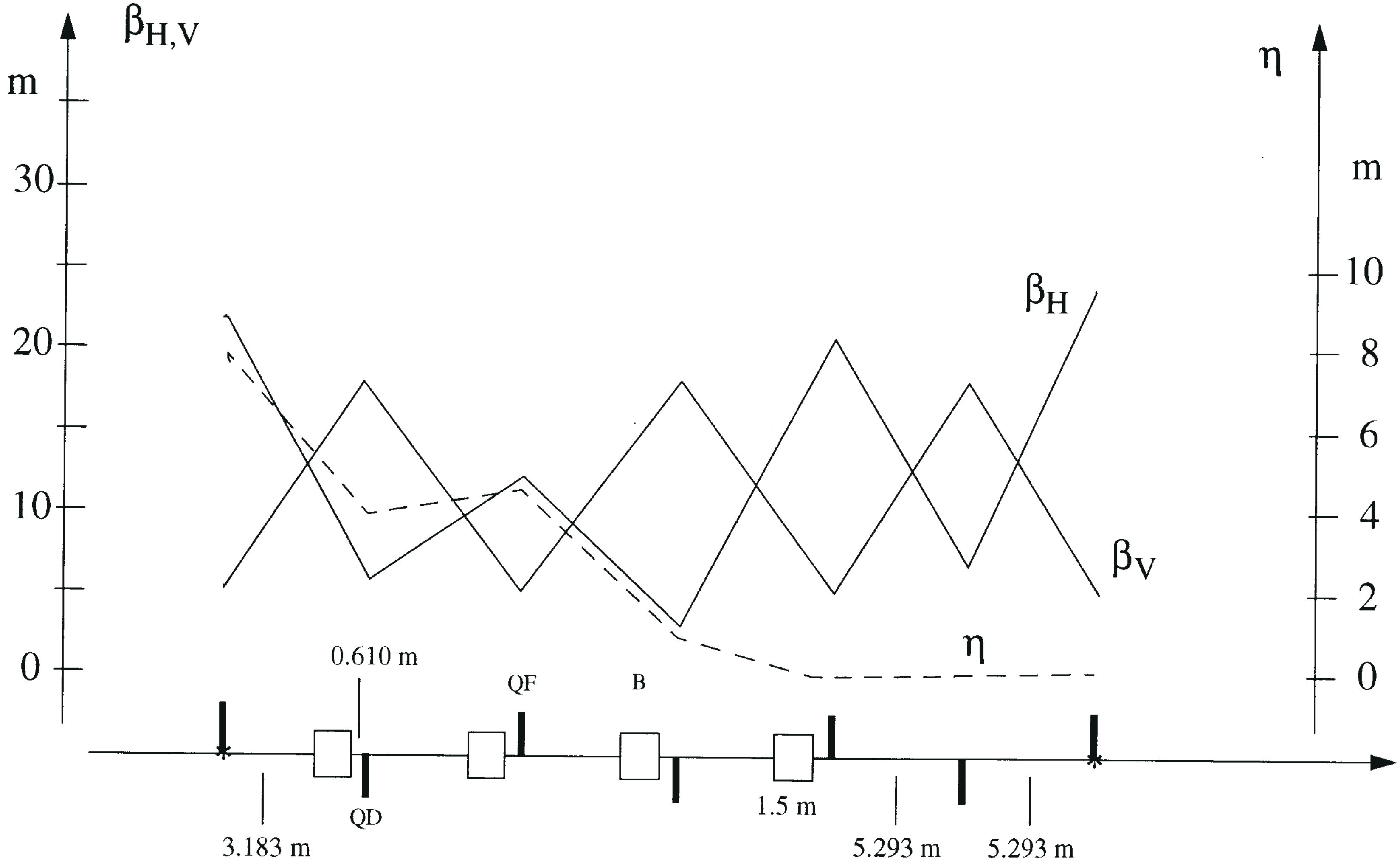

Figure 3. Half-Period Lattice Functions and Structure

repetition rate of 60 Hz, the total number of protons is N = 2.084 x 10^{14}. With a bunching factor B = 0.324, at the kinetic energy of 1.0 GeV, a tune depression $\Delta\nu$ = 0.2 is obtained with a full beam emittance of 116.4 π mm mrad.

At the same time the beam full momentum spread at the end of the rf capture is $\Delta p/p = \pm 0.87\%$. This corresponds to a single total bunch area of 10 eV-s and a peak rf voltage of 30 kV. Such beam longitudinal dimension is also required for the stability versus resistive-wall type of coherent longitudinal oscillations. There is a beam clear gap of 280 nanosecond for the fast extraction kicker rise time.

Table 3: Quadrupole Magnets (QF, QD)

Total Number: QF small	12
QF large	6
QD	18
Length	0.50 m
Gradient: QF	0.209 kG / cm
QD	0.237 kG / cm
Internal Diameter: QF small	24 cm
QF large	36 cm
QD	24 cm

Magnet Aperture Requirement

The size of the vacuum chamber should be such to allow a betatron acceptance which is 4 times the full betatron emittance, that is $A_{H,V}$ = 470 π mm mrad. Similarly, in the horizontal plane, space should be allowed for a momentum aperture which is twice the beam full momentum spread, that is $\Delta p/p = \pm 1.74\%$. The total aperture envelope, obtained by taking the quadratic combination of the betatron and the momentum aperture is plotted in Figure 6 along one-half of a superperiod. Taking into account a total of 3.5 cm for the vacuum chamber thickness, it is seen that the gap of the bending magnets is 19.5 cm. The bore diameter of all quadrupole magnets is 24 cm, except those in the middle of the arcs and in the middle of the insertions which have an internal diameter of 36 cm.

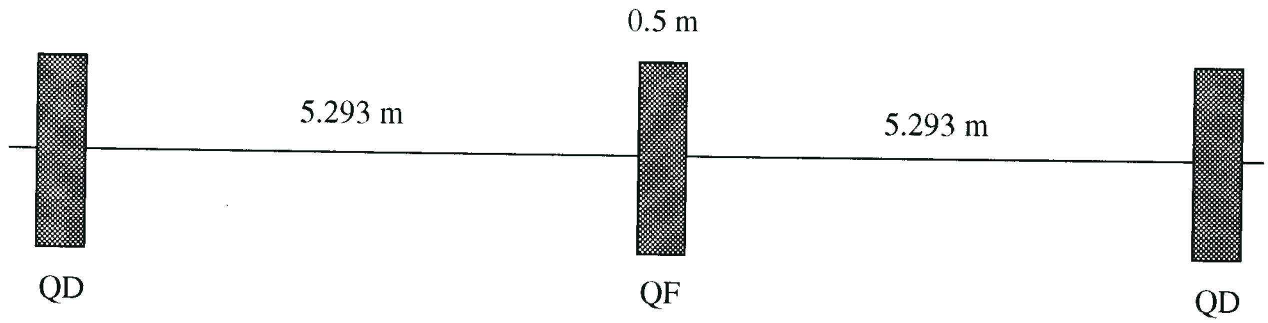

Figure 4a. Structure of an Empty FODO Cell

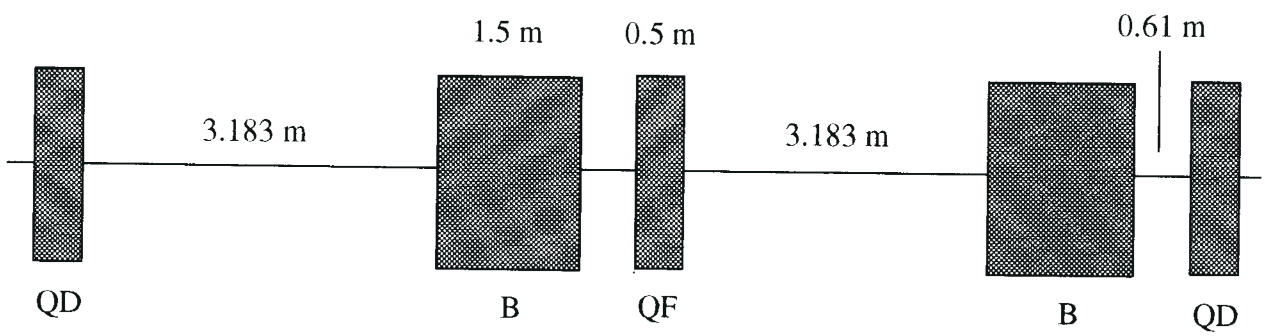

Figure 4b. Structure of a Bending FODO Cell

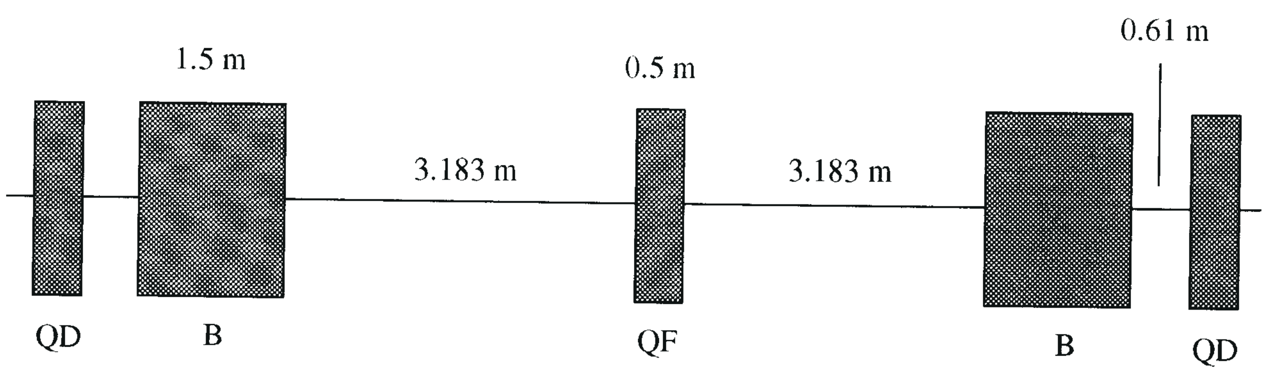

Figure 4c. The FODO cell in the middle of the Arc

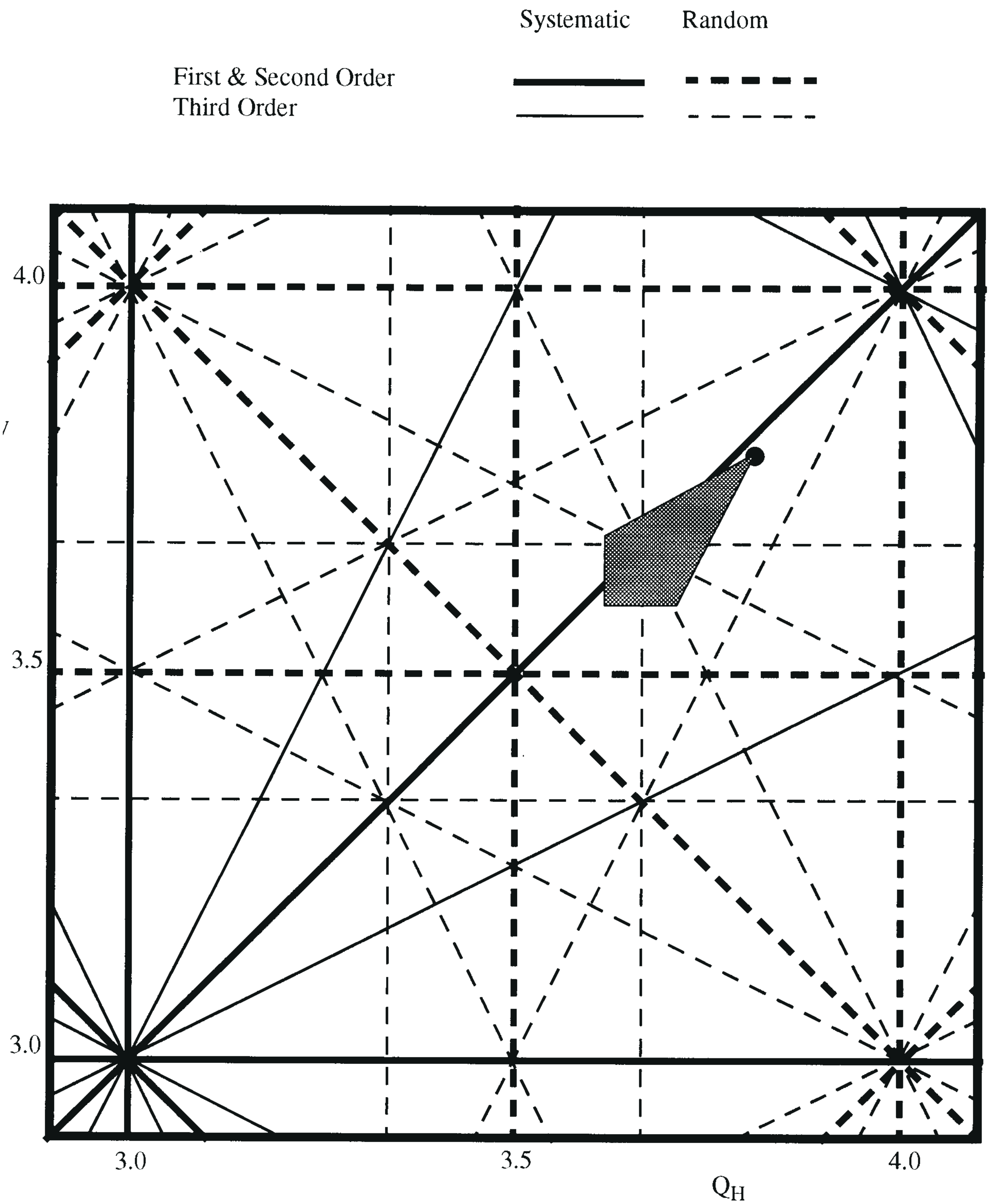

Figure 5. The Betatron-Tune Diagram

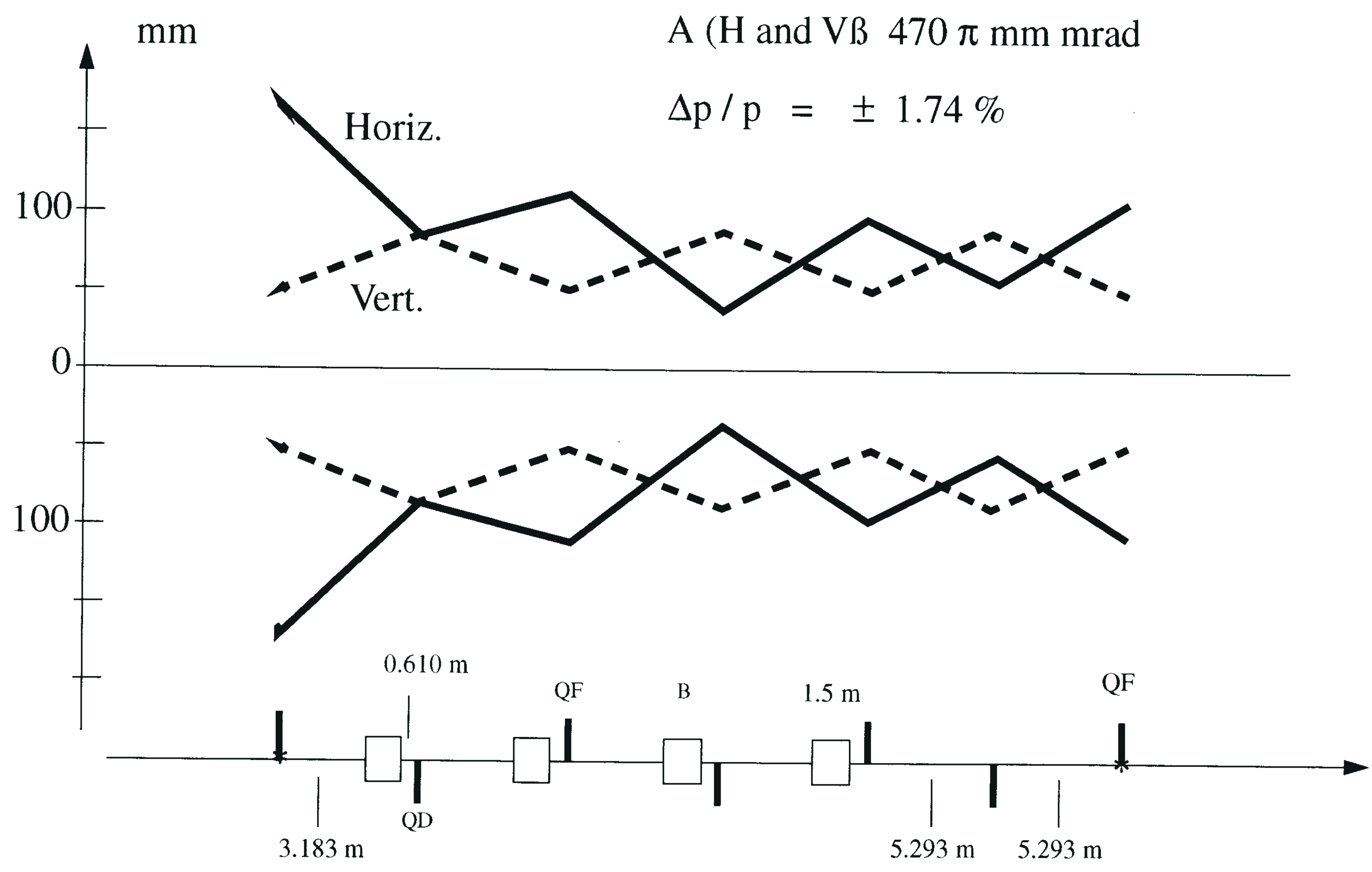

Figure 6. Half-Period full Aperture Requirements

```
==========================================================================================================
***  RFQ    =       //  402.5
***  NF     =       //  320.
***  KE     =       //  1.0
***  RE     =       //  0.93826
***  PER    =       //  3.0
***  SYM    =       //  1.0
***  ND     =       //  4.0
***  BL     =       //  1.50
***  BC     =       //  3.3356
***  C      =       //  299.7925
***  QL     =       //  0.25
***  DL     =       //  0.61
***  EMC    =       //  470.
***  DPT    =       //  17.4
***  FOIL   =       //  0.0
***  FOID   =       //  0.20
***  T0     CALC    //  RCL  NF   RCL  RFQ  /
***  GM     CALC    //  RCL  KE   RCL  RE   /    1.0  +
***  BT     CALC    //  1.0  RCL  GM   X*X  1/X  -    SQRT
***  CIRC   CALC    //  RCL  C    RCL  BT   *    RCL  T0   *
***  NCL    CALC    //  RCL  ND   0.5  *    1.0  +
 *                  //  RCL  PER  *    RCL  SYM  1.0  +    *
***  CL     CALC    //  RCL  CIRC RCL  NCL  /    2.0  /
***  LL     CALC    //  RCL  CL   RCL  QL   2.0  *    -
***  OL     CALC    //  RCL  LL   RCL  BL   -    RCL  DL   -
   ---+----1----+----2----+----3----+----4----+----5----+----6----+----7----+
***  P      CALC    //  RCL  RE   RCL  BT   *    RCL  GM   *
***  BR     CALC    //  RCL  BC   RCL  P    *
***  RHO    CALC    //  1.0  RCL  SYM  +    RCL  BL   *    RCL  ND   *
 *                  //  RCL  PER  *    0.5  *    PI   /
***  ANG    CALC    //  360. RCL  ND   /    RCL  PER  /
 *                  //  RCL  SYM  1.0  +    /
***  ANR    CALC    //  PI   180. /    RCL  ANG  *
***  SAG    CALC    //  1.   RCL  ANR  COS  -    RCL  RHO  *    100. *
***  BZ     CALC    //  RCL  BR   RCL  RHO  /
***  LONS   CALC    //  RCL  LL   RCL  FOIL -    RCL  FOID -
***         PRNT    //  KE   RE   PER  SYM  ND
----------------------------------------------------------------------------------------------------------
VARIABLE  1 OF TYPE 5 (LQ  STORAGE)
     KE              RE              PER             SYM             ND
     1.000000000     0.938260000     3.000000000     1.000000000     4.000000000
----------------------------------------------------------------------------------------------------------
***         PRNT    //  GM   BT   P    BR   RHO
----------------------------------------------------------------------------------------------------------
VARIABLE  1 OF TYPE 5 (LQ  STORAGE)
     GM              BT              P               BR              RHO
     2.065802656     0.875027427     1.696030660     5.657279870     5.729577951
----------------------------------------------------------------------------------------------------------
***         PRNT    //  CL   QL   LL   OL   BL
----------------------------------------------------------------------------------------------------------
VARIABLE  1 OF TYPE 5 (LQ  STORAGE)
     CL              QL              LL              OL              BL
     5.793273371     0.250000000     5.293273371     3.183273371     1.500000000
----------------------------------------------------------------------------------------------------------
***         PRNT    //  CIRC BC   BZ   NCL
----------------------------------------------------------------------------------------------------------
VARIABLE  1 OF TYPE 5 (LQ  STORAGE)
     CIRC            BC              BZ              NCL
     208.557841350   3.335600000     0.987381604     18.000000000
----------------------------------------------------------------------------------------------------------
```

```
***           PRNT          //  ANG  SAG  FOIL LONS
-------------------------------------------------------------------------------------------------------
VARIABLE  1 OF TYPE 5 (LQ  STORAGE)
      ANG                 SAG                   FOIL                  LONS
      15.000000000        19.523063440          0.000000000           5.093273371
-------------------------------------------------------------------------------------------------------

    ---+----1----+----2----+----3----+----4----+----5----+----6----+----7----+

***   O       DRF           //  OL
***   L       DRF           //  LL
***   D       DRF           //  DL
***   S       DRF           //  LONS
***   F       DRF           //  FOIL
***   DF      DRF           //  FOID

***   B       MAG           //  BL                  BR         BZ

    ---+----1----+----2----+----3----+----4----+----5----+----6----+----7----+

***   MUX     =             //  3.82      /         6.
***   MUY     =             //  3.78      /         6.
***           PRNT          //  MUX  MUY
-------------------------------------------------------------------------------------------------------
VARIABLE  1 OF TYPE 5 (LQ  STORAGE)
      MUX                 MUY
      0.636666667         0.630000000
-------------------------------------------------------------------------------------------------------
***   GF      =             //  0.369831
***   GD      =             //  -.418487

***   .C      BML           //  QF   D    B    O    QD
  *                         //  QD   D    B    O    QF
***   .CE     BML           //  F    QF   DF   S    QD   QD   L    QF
***   .PER    BML           //  .CE  .C   .C


***   TUNE    SUB     0   0 //
.......................................................................................................
***   QF      MAG           //  QL        GF        1.
***   QD      MAG           //  QL        GD        1.
***   MP      MMM           //  .PER
***           END     0   0 //
.......................................................................................................


***   FQ      FITQ          //  TUNE MP   GF   GD       1    1MUX        MUY

PARAMETER REPLACEMENTS MADE BY FITTING
      1  OF GF    =        0.369830644472            1  OF GD    =      -0.418486858755
***   RING    CYC         -3 //  .PER
```

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
0	0.000	0.00000	0.00000	23.97644	4.95028	-0.00191	0.00000	0.0000	0.00000	0.00000	0.00000	0.00000
1 F	0.000	0.00000	0.00000	23.97644	4.95028	-0.00191	0.00000	0.0000	0.00000	0.00000	0.00000	0.00000
2 QF	0.250	0.00167	0.00797	23.42908	5.07831	-0.00189	0.00000	0.0000	2.17254	-0.51606	0.00018	0.00000
3 DF	0.450	0.00306	0.01411	22.56983	5.29471	-0.00185	0.00000	0.0000	2.12371	-0.56593	0.00018	0.00000
4 S	5.543	0.06814	0.10277	7.26985	17.52832	-0.00096	0.00000	0.0000	0.88025	-1.83598	0.00018	0.00000
5 QD	5.793	0.07373	0.10500	7.02921	17.99136	-0.00092	0.00000	0.0000	0.09068	0.00000	0.00008	0.00000
6 QD	6.043	0.07936	0.10723	7.17758	17.52832	-0.00092	0.00000	0.0000	-0.68932	1.83598	-0.00002	0.00000
7 L	11.337	0.15173	0.20203	20.23361	5.07831	-0.00102	0.00000	0.0000	-1.77721	0.51606	-0.00002	0.00000
8 QF	11.587	0.15367	0.21000	20.65724	4.95028	-0.00101	0.00000	0.0000	0.09578	0.00000	0.00008	0.00000
9 QF	11.837	0.15562	0.21797	20.13930	5.07831	-0.00098	0.00000	0.0000	1.95998	-0.51606	0.00017	0.00000

10 D	12.447	0.16074	0.23590	17.83758	5.80069	-0.00088	0.00000	0.0000	1.81334	-0.66817	0.00017	0.000
11 B	13.947	0.17691	0.27043	11.97651	8.36626	0.19463	0.00000	0.0169	2.00436	-1.04221	0.25902	0.000
12 O	17.130	0.25923	0.31277	3.46090	17.52832	1.01916	0.00000	0.0169	0.67075	-1.83598	0.25902	0.000
13 QD	17.380	0.27118	0.31500	3.23737	17.99136	1.09756	0.00000	0.0169	0.23115	0.00000	0.36951	0.000
14 QD	17.630	0.28356	0.31723	3.22570	17.52832	1.20472	0.00000	0.0169	-0.18407	1.83598	0.48968	0.000
15 D	18.240	0.31232	0.32314	3.56953	15.38121	1.50343	0.00000	0.0169	-0.37958	1.68387	0.48968	0.000
16 B	19.740	0.36869	0.34163	5.12266	10.89064	2.37359	0.00000	0.5187	-0.63208	1.30984	0.66390	0.000
17 O	22.923	0.43548	0.41203	11.91524	5.07831	4.48696	0.00000	0.5187	-1.50176	0.51606	0.66390	0.000
18 QF	23.173	0.43874	0.42000	12.39825	4.95028	4.60054	0.00000	0.5187	-0.41536	0.00000	0.24298	0.000
19 QF	23.423	0.44195	0.42797	12.32423	5.07831	4.60799	0.00000	0.5187	0.70914	-0.51606	-0.18354	0.000
20 D	24.033	0.45010	0.44590	11.50445	5.80069	4.49603	0.00000	0.5187	0.63476	-0.66817	-0.18354	0.000
21 B	25.533	0.47315	0.48043	9.18352	8.36626	4.26589	0.00000	1.6636	0.87702	-1.04221	-0.12156	0.000
22 O	28.716	0.54669	0.52277	5.55206	17.52832	3.87893	0.00000	1.6636	0.26378	-1.83598	-0.12156	0.000
23 QD	28.966	0.55387	0.52500	5.57649	17.99136	3.89924	0.00000	1.6636	-0.36236	0.00000	0.28444	0.000
24 QD	29.216	0.56083	0.52723	5.92077	17.52832	4.02177	0.00000	1.6636	-1.02674	1.83598	0.69789	0.000
25 D	29.826	0.57561	0.53314	7.30249	15.38121	4.44748	0.00000	1.6636	-1.23837	1.68387	0.69789	0.000
26 B	31.326	0.60192	0.55163	11.12394	10.89064	5.52608	0.00000	2.9680	-1.25079	1.30984	0.73203	0.000
27 O	34.510	0.63498	0.62203	21.42326	5.07831	7.85632	0.00000	2.9680	-1.98466	0.51606	0.73203	0.000
28 QF	34.760	0.63680	0.63000	21.92329	4.95028	7.94800	0.00000	2.9680	0.00000	0.00000	0.00000	0.000
29 REFL	69.519	1.27361	1.26000	23.97644	4.95028	-0.00191	0.00000	5.9360	0.00000	0.00000	0.00000	0.000

```
CIRCUMFERENCE =    208.5578 M         THETX =   6.28318531 RAD      NUX =    3.82083      DNUX/(DP/P) =   -3.54948
       RADIUS =     33.1930 M         THETY =   0.00000000 RAD      NUY =    3.78000      DNUY/(DP/P) =   -3.59927
 (DS/S)/(DP/P)=   0.0853862            TGAM=(   3.42221,     0.00000)

MAXIMA   --- BETX(   29) =    23.97644    BETY(   13) =    17.99136    XEQ(   28) =    7.94800    YEQ(   29) =    0.00000
MINIMA   --- BETX(   14) =     3.22570    BETY(   28) =     4.95028    XEQ(   29) =   -0.00191    YEQ(   29) =    0.00000
---------------------------------------------------------------------------------------------------------------------

    ---+----1----+----2----+----3----+----4----+----5----+----6----+----7----+

***  EMT   BVAL         //            1.       EMC       EMC       DPT      1.

  EMITTANCES UNNORMALIZED  (MM-MRAD)
     EPSX = 470.000000    EPSY = 470.000000    EPSL =  17.400000        SIGL =   1.000000 MM    SIGP =  17.400000 (0/00)
---------------------------------------------------------------------------------------------------------------------
***  ENV   CYAE       -3 //  .PER EMT   1.
---------------------------------------------------------------------------------------------------------------------
 BEAM ENVELOPES (MM,MRAD)
   EMITTANCES (MM-MRAD) --- EPSX = 470.000000    EPSXCO =  0.000000     EPSL =    17.400000
                            EPSY = 470.000000    EPSYCO =  0.000000     SIGP =  17.400000 (0/00)
   XTOT = SQRT(XB*XB + XP*XP) + XCO,   ETC.
+
                                                                            DISPLACEMENT =  1.00*SIGMA
```

POS	S	XB	XP	XCO	XTOT	YB	YP	YCO	YTOT	XPRTOT	YPRTOT
0	0.0000	106.1552	-0.0332	0.0000	106.1552	48.2352	0.0000	0.0000	48.2352	4.4275	9.7439
1 F	0.0000	106.1552	-0.0332	0.0000	106.1552	48.2352	0.0000	0.0000	48.2352	4.4275	9.7439
2 QF	0.2500	104.9365	-0.0328	0.0000	104.9365	48.8550	0.0000	0.0000	48.8550	10.7119	10.8258
3 DF	0.4500	102.9943	-0.0322	0.0000	102.9943	49.8850	0.0000	0.0000	49.8850	10.7119	10.8258
4 S	5.5433	58.4536	-0.0166	0.0000	58.4536	90.7651	0.0000	0.0000	90.7651	10.7119	10.8258
5 QD	5.7933	57.4781	-0.0161	0.0000	57.4781	91.9562	0.0000	0.0000	91.9562	8.2106	5.1111
6 QD	6.0433	58.0815	-0.0160	0.0000	58.0815	90.7651	0.0000	0.0000	90.7651	9.8283	10.8258
7 L	11.3365	97.5182	-0.0177	0.0000	97.5182	48.8550	0.0000	0.0000	48.8550	9.8283	10.8258
8 QF	11.5865	98.5338	-0.0175	0.0000	98.5338	48.2352	0.0000	0.0000	48.2352	4.7918	9.7439
9 QF	11.8365	97.2907	-0.0170	0.0000	97.2907	48.8550	0.0000	0.0000	48.8550	10.6296	10.8258
10 D	12.4465	91.5623	-0.0152	0.0000	91.5623	52.2142	0.0000	0.0000	52.2142	10.6296	10.8258
11 B	13.9465	75.0264	3.3866	0.0000	75.1028	62.7068	0.0000	0.0000	62.7068	14.7382	10.8258
12 O	17.1298	40.3314	17.7335	0.0000	44.0579	90.7651	0.0000	0.0000	90.7651	14.7382	10.8258
13 QD	17.3798	39.0072	19.0975	0.0000	43.4313	91.9562	0.0000	0.0000	91.9562	13.9382	5.1111

14	QD	17.6298	38.9369	20.9622	0.0000	44.2210	90.7651	0.0000	0.0000	90.7651	14.9412	10.8258
15	D	18.2398	40.9595	26.1597	0.0000	48.6005	85.0245	0.0000	0.0000	85.0245	14.9412	10.8258
16	B	19.7398	49.0678	41.3005	0.0000	64.1356	71.5444	0.0000	0.0000	71.5444	16.1818	10.8258
17	O	22.9231	74.8342	78.0732	0.0000	108.1461	48.8550	0.0000	0.0000	48.8550	16.1818	10.8258
18	QF	23.1731	76.3359	80.0495	0.0000	110.6123	48.2352	0.0000	0.0000	48.2352	7.8946	9.7439
19	QF	23.4231	76.1077	80.1790	0.0000	110.5489	48.8550	0.0000	0.0000	48.8550	8.2166	10.8258
20	D	24.0331	73.5329	78.2309	0.0000	107.3647	52.2142	0.0000	0.0000	52.2142	8.2166	10.8258
21	B	25.5331	65.6982	74.2265	0.0000	99.1253	62.7068	0.0000	0.0000	62.7068	9.7477	10.8258
22	O	28.7164	51.0830	67.4933	0.0000	84.6453	90.7651	0.0000	0.0000	90.7651	9.7477	10.8258
23	QD	28.9664	51.1952	67.8468	0.0000	84.9950	91.9562	0.0000	0.0000	91.9562	10.9473	5.1111
24	QD	29.2164	52.7519	69.9787	0.0000	87.6344	90.7651	0.0000	0.0000	90.7651	17.6217	10.8258
25	D	29.8264	58.5847	77.3861	0.0000	97.0607	85.0245	0.0000	0.0000	85.0245	17.6217	10.8258
26	B	31.3264	72.3067	96.1539	0.0000	120.3072	71.5444	0.0000	0.0000	71.5444	16.4496	10.8258
27	O	34.5096	100.3441	136.7000	0.0000	169.5755	48.8550	0.0000	0.0000	48.8550	16.4496	10.8258
28	QF	34.7596	101.5083	138.2953	0.0000	171.5504	48.2352	0.0000	0.0000	48.2352	4.6302	9.7439
29	REFL	69.5193	106.1552	-0.0332	0.0000	106.1552	48.2352	0.0000	0.0000	48.2352	4.4275	9.7439

```
---+----1----+----2----+----3----+----4----+----5----+----6----+----7----+

***        FIN          // CORE USE SUMMARY                    MAXIMUM       USED   UNUSED
                           INFF   (ELEMENT DEFINITIONS)       2000(INFMAX)     91     1909
                           FLIB  (F.P. DATA AND STORAGE)      5000(IFLMAX)     67     4933
                           ILIB  (INTEGER DATA)               1000   (IMAX)     9      991
                           CHLIB(CHARACTER DATA)              5000(ICHMAX)    425     4575
                           SFLIB(F.P.CHARACTER DATA)          5000(ISFMAX)     67     4933
                           LQFIL(CALCULATED DATA)            30000 (IQMAX)   1177    28823
   ARRAY DIMENSIONS ARE SET IN COMMON FILES BINFF.CCC, BSTORE.CCC, CSTORE.CCC

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END OF SYNCH RUN AGR
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