DAΦNE TECHNICAL NOTE

INFN - LNF, Accelerator Division

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Note: **L-1**

HIGH EMITTANCE LATTICE FOR DAΦNE

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1 - STORAGE RINGS

The layout of the machine is shown in Fig. 1. The two rings cross in the horizontal plane in two points and have a symmetry axis so that the two interaction regions have the same magnetic structure and the same optical functions. Two different experiments can be used alternatively at the maximum luminosity or at the same time with a reduction of a factor ~ √2, at least, on the luminosity. Each ring consists of two parts: an inner one named "short" hereafter and an outer one named "long", which are symmetric and have a very similar structure.

The storage ring lattice can be divided in three regions: the low-β insertions, the achromats and the zero dispersion regions.

The lattice of the achromat is a four-period modified Chasman-Green[1)] type. This kind of lattice is commonly used for low emittance, high periodicity machines and its main limitation comes from the chromaticity correction which, because of the small value of the dispersion function, requires strong sextupoles and consequently produces rather small dynamic apertures. In our case this is however not a serious problem because the periodicity is only 4, the lattice is tuned for high emittance and the dispersion is therefore comparatively high.

To increase the radiated energy per turn, a 2 m long, 1.9 T normal-conducting wiggler is incorporated into each achromat. Because the wiggler is in a high dispersion region a rather large emittance of 10^{-6} m-rad is obtained. The emittance value can be adjusted by tuning the dispersion function in the wiggler region.

For the wigglers normal conducting magnets are used to avoid the strong field non linearities created by short bending radius superconducting devices. According to our experience it is instead rather easy task to achieve a very good field quality in a normal wiggler by making the poles wide enough and by shimming.

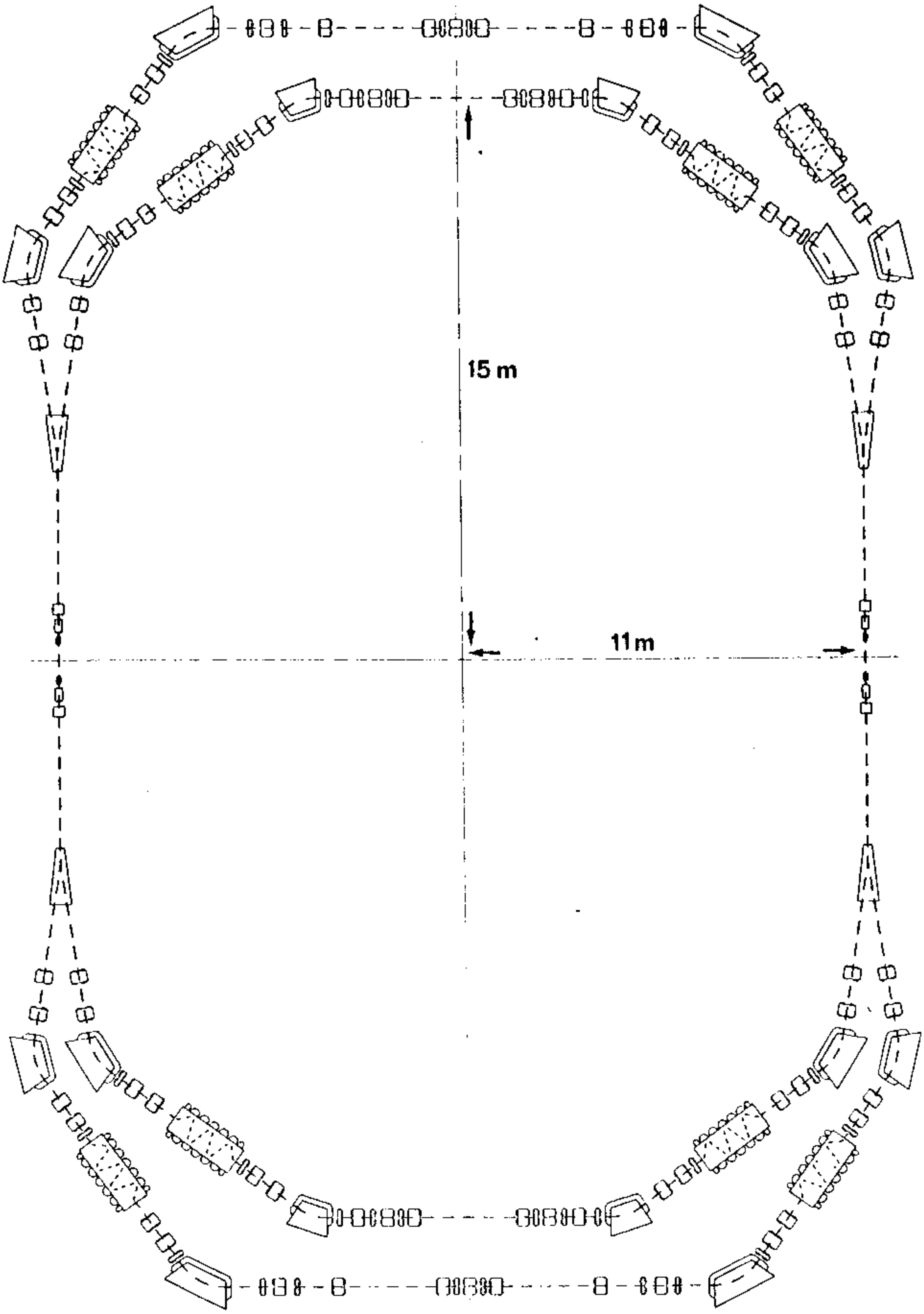

Fig. 1 *- Storage rings magnetic layout.*

The non dispersive regions in between the achromats are different for the short and the long section. They provide space for injection, RF cavity, diagnostics, etc. and allow a good flexibility in changing the tunes of the machine.

Different computer codes: LEDA[2)], MAD[3)], NOLISY[4)] have been used to design the storage ring. **Table I** reproduces the output of the LEDA code with the list of the lattice elements. The element names are given for the electron ring starting from the interaction point IP1 and moving clockwise in the short section.

2 - BEAM OPTICS

2. 1 - Low-β insertion

The low-β insertion is one of the most crucial parts of the Φ-Factory design because of the constraints imposed by the experimental apparatus and by the horizontal separation required at a short distance from the interaction point (IP) because of the short bunch-to-bunch longitudinal distance L_b.

The experimental apparatus, not yet completely defined, has of course to cover the largest possible solid angle; a solenoidal field of ≈ .5 ÷ 1. kG over a length of approximately 5 meters on each side of the IP is also required. The beam trajectory will be actively shielded from solenoidal field, with the exception of ± 0.5 m around the IP where the vacuum chamber wall must be very thin and no active or passive shield can be used.

The most serious constraint posed by the experimental apparatus on the design of the low-β insertion is the requirement of a large unencumbered solid angle around the IP. A tentative agreement has been reached with the users on a low-β insertion confined to a cone of half-aperture angle $\theta = 8.5^o$, over a length of ± 5 m from the IP. The distance of the first quadrupole from the IP is 43.3 cm and the quadrupole maximum outer diameter $Ø_Q$ is given by:

$$Ø_Q = 2 \cdot \tan(8.5^o) \cdot 43.3 \text{ cm} = 12.9 \text{ cm}$$

The relevant parameters for this section are as follows:

$$\kappa_\beta = \frac{\beta_y}{\beta_x} = .01 \qquad \beta_y = 4.5 \text{ cm} \qquad \beta_x = 4.5 \text{ m}$$

The low-β insertion consists of a quadrupole triplet followed by a long drift (L_d = 3.5 m) and a special designed split field magnet. The β-functions in this region are shown in Fig. 2. Let us point out that the first quadrupole is rather weak and focussing in the horizontal plane. This provides better control over the β functions and keeps the horizontal beam size small inside the quadrupole triplet and along the rest of the insertion.

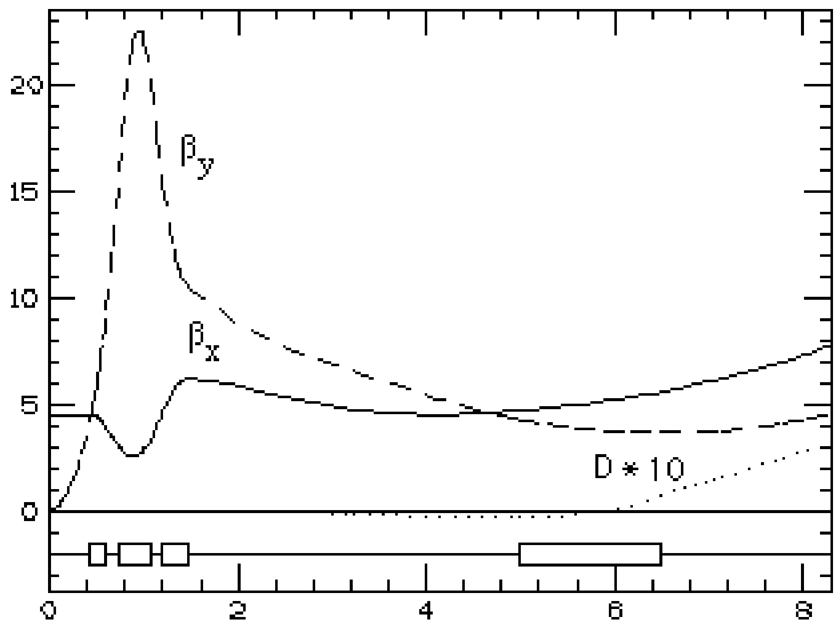

Fig. 2 *- β-functions in the low-β insertion.*

The total length of the insertion is ~ 13 m, much smaller than that required for the vertical separated rings adopted in the previous design(5). Let us point out that the low-β insertions give the largest contribution to the ring chromaticity:

	low-β insertions	complete ring
ξ_x	-1.12	- 4.76
ξ_y	-10.32	-17.76

Due to the crossing angle the two beams pass off axis inside the quadrupoles and horizontal dispersion is created. The half separation Δx between the two beams in the low-β insertion follows the trajectory plotted in Fig. 3. In Fig. 4 the horizontal and vertical beam sizes in the same region are plotted.

The parameter Δx and the horizontal beam size are given in **Table II** at the parasitic crossing points for a frequency of 380.44 MHz, that corresponds to the harmonic number h = 120.

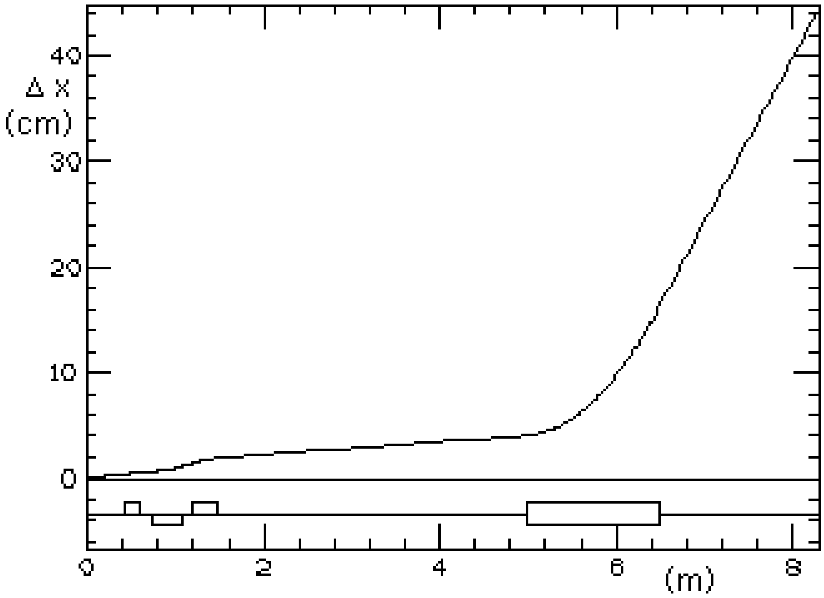

Fig. 3 - *Half-separation* Δx *in the low-*β *insertion.*

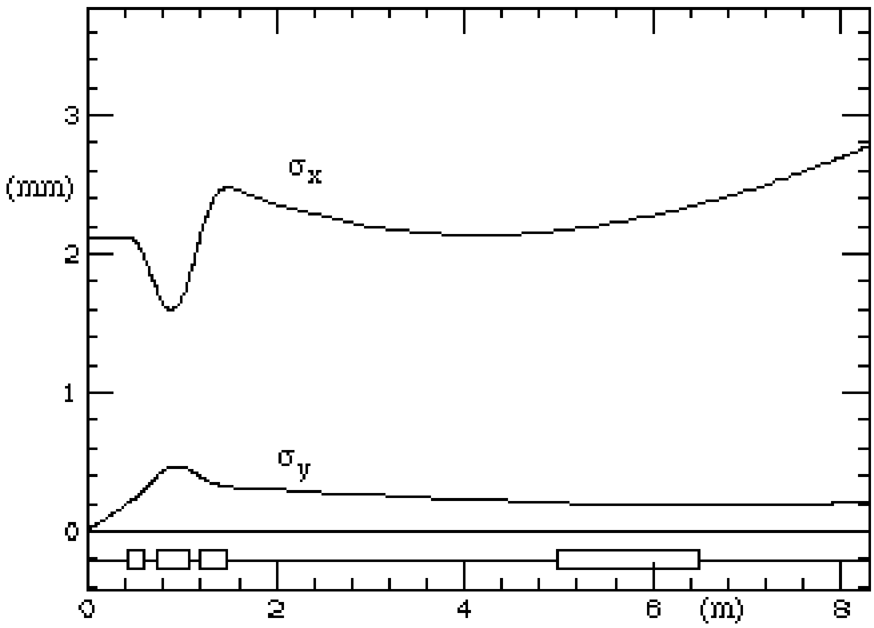

Fig. 4 - *Horizontal and vertical r.m.s. beam sizes along the low-*β *insertion.*

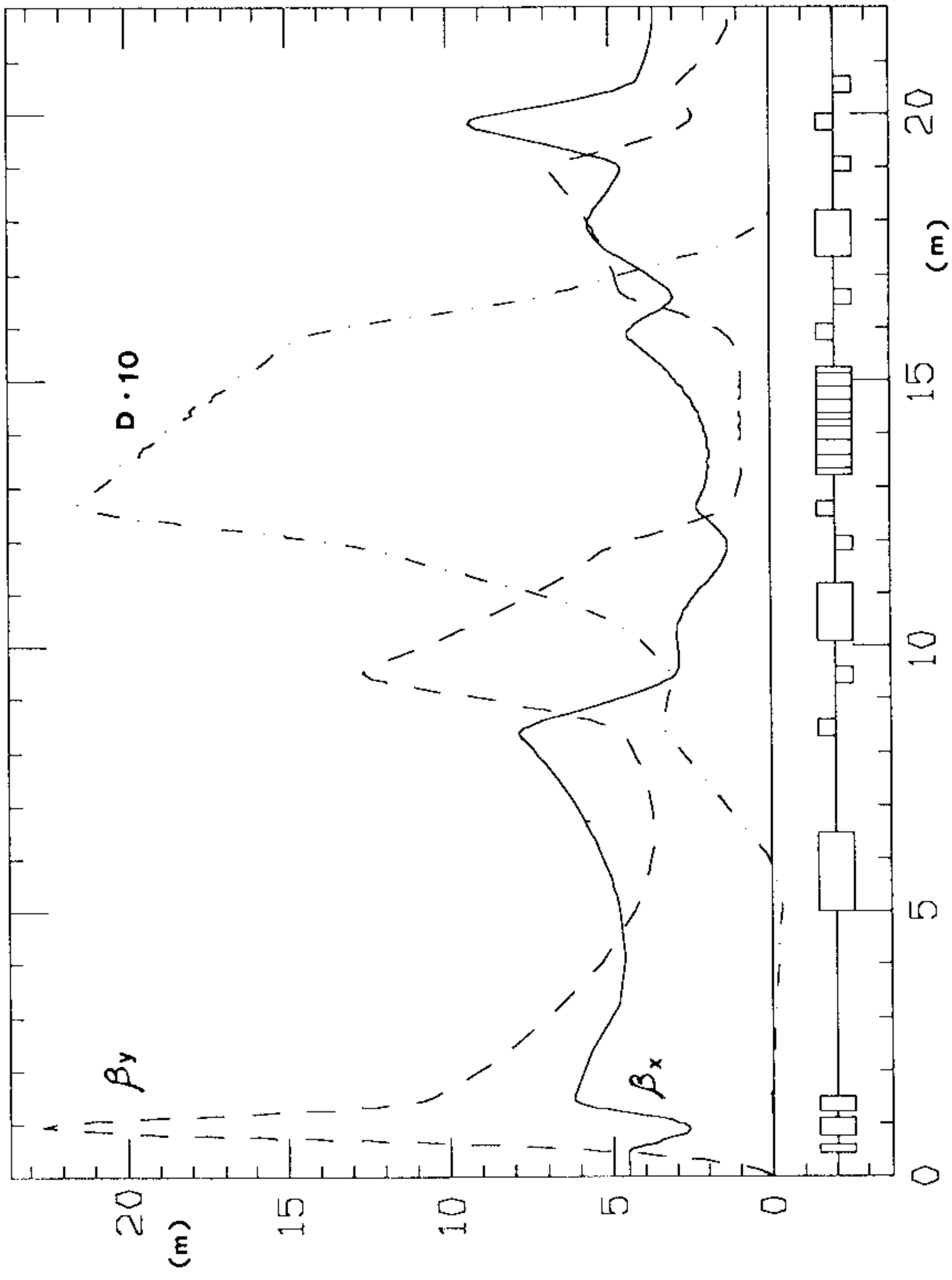

***Fig. 5** - Optical functions for 1/2 of the **short** section of the ring.*

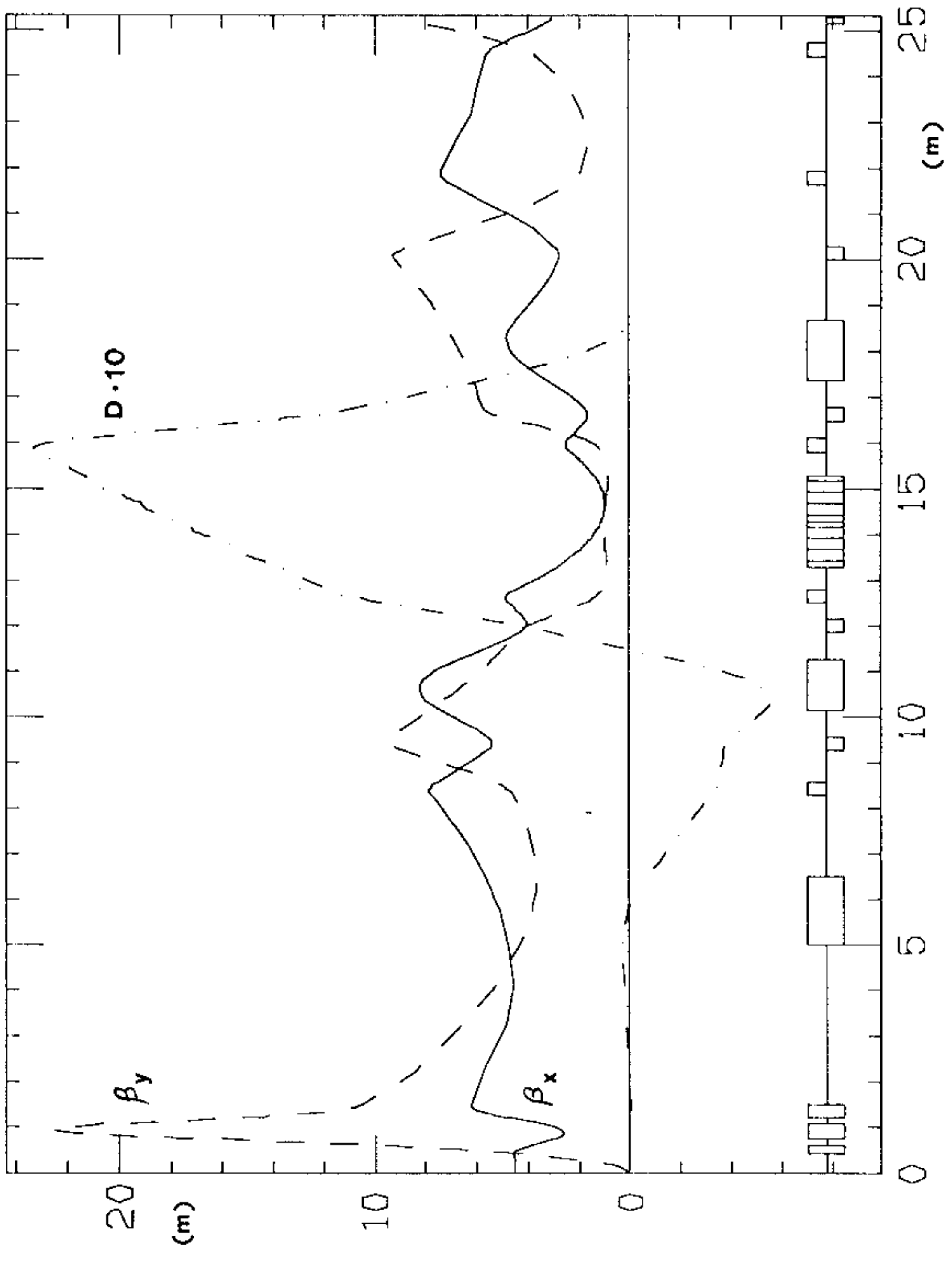

Fig. 6 *- Optical functions for 1/2 of the* ***long*** *section of the ring.*

The aperture of the first three quadrupoles has to allow for good beam lifetime, moreover the beam separation and at the same time the outer dimensions are restricted by the experimental apparatus. In **Table III** the maximum allowable outer diameter, the horizontal beam size and the half separation Δx between the beam centers are given at the entrance of each quadrupole. The mechanical design of these quadrupoles, is still under study; at the moment the most likely solution foresees the use of permanent magnets.

2. 2 - The achromats

The low-β insertion is connected to the main arcs by a matching section consisting of a long drift and two quadrupoles. The length of the drift (L_d = 1.8 m) is chosen in order to have a good separation between the first quadrupoles of the two rings. In this section, at $\pi/2$ horizontal betatron phase advance from the IP, there is room for the crab-cavity if necessary. In this region there is a dispersion created by the low β quadrupoles and by the split field magnet, which has opposite sign in the short and long parts of the ring. This makes the achromat slightly asymmetric.

Moreover the two dipoles of the achromat do not have the same bending angle: the angle of the dipole nearer to the low-β insertion is exactly $\pi/4$, while the other one is lengthened (shortened) in the long (short) arc to compensate the total angle due to the crossing, the low-β triplet and the separator magnet. In this way we get a good separation H between the two rings without increasing the circumference (H=1.5 m at the entrance of the bending nearer to the low-β insertion and larger in the rest of the ring).

The optical functions of the ring from the IP to the symmetry point are shown in Figs 5, 6 respectively for the short and long section. In **Table IV** the MAD output for the half ring optical functions (short + long) is given. A complete parameter list is given in **Table V**. The dispersion and the horizontal β-function in the wiggler magnet are adjusted in order to have the required emittance, the contribution of the bending magnets to the emittance is negligible. The value of the vertical β-function in the wiggler is the eigenvalue of the wiggler transport matrix. The optical functions are quite smooth and the relative chromaticity in the achromats is ~ 1.

2. 3 - The zero dispersion insertions

The value of the horizontal betatron number in the achromats (more precisely between the centers of the two extreme dipoles) is fixed by the condition of having zero dispersion, therefore all the flexibility in changing the tunes is obtained in the zero dispersion insertions.

That's why in this version of the lattice we have used only 2 quadrupoles in the matching region and 6 (8) in the short (long) insertions.

The short insertion has a 2.6 m long drift space with rather small β_x suitable for the RF cavity. The long insertion has space for injection septum and kickers, diagnostics and also free space for future developments.

3 - DYNAMIC APERTURE

The main problem when correcting the chromaticity, is that the non linear sextupolar fields needed bring to a strong reduction of the beam stability area. In general, the higher the chromaticity to be corrected the smaller is the dynamic aperture. In practice, in presence of many sextupole families, the quickest way to determine the maximum amplitude for stable particles is to track them for many turns in the machine, and study the behaviour of their trajectories and their tune values for different sextupole configurations.

For our machine, the study of the dynamic aperture with the computer code Patricia has been performed[6]. The lattice has a low horizontal chromaticity (ξ_x = -4.76), but a high vertical one (ξ_y = -17.76), due to the strong quadrupole triplet in the low-β region. The strong sextupoles needed to correct the chromaticity are indeed the main limiting effects on the dynamic aperture. Two families have been used to this purpose, equal in the "short" and "long" achromats, even though the β-functions are slightly different.

The position of the chosen working point in the tune diagram (see Fig. 7), where resonance lines up to the sixth order are shown, being far from the main dangerous resonances, is very favourable. We then expect that tune shift effects will not have serious consequences on the beam stability.

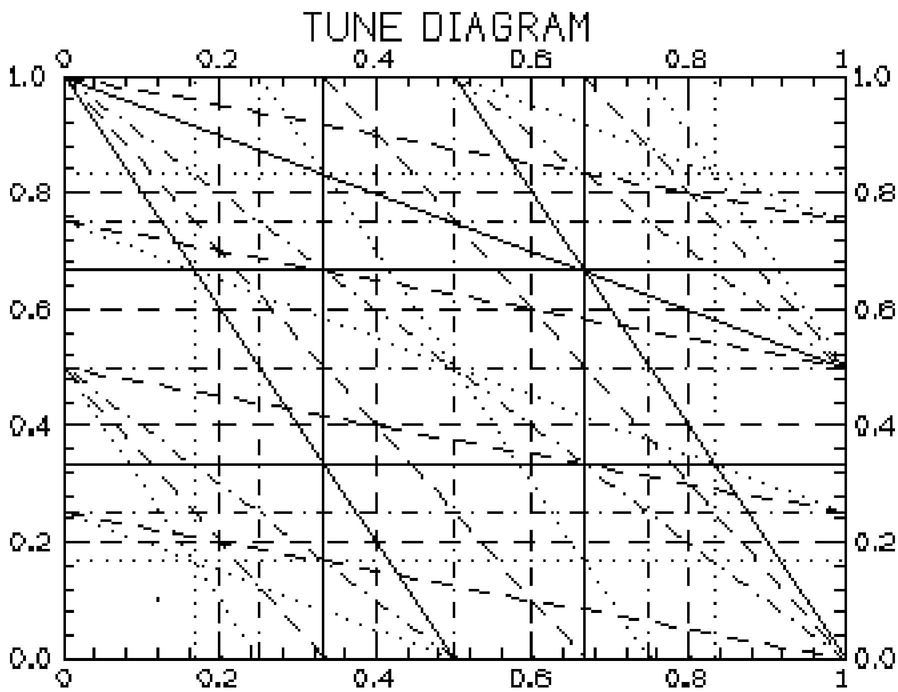

Fig. 7 *- Tune diagram showing the lattice working point.*

With the two families configuration, the tunes behaviour as a function of the particle momentum deviation $\Delta p/p$ and of the particle amplitude in number of sigmas is shown in Figs 8, 9, 10, where only the fractional part of the tunes is plotted. As a consequence of the flatness of the tunes behaviour vs. $\Delta p/p$, (-.02 in x plane and +.01 in y), no more sextupole families have been added in the achromats. Anyway to check the momentum acceptance of the lattice and ensure a good Touschek lifetime, a careful study of the dynamic aperture for off-momentum particles is needed.

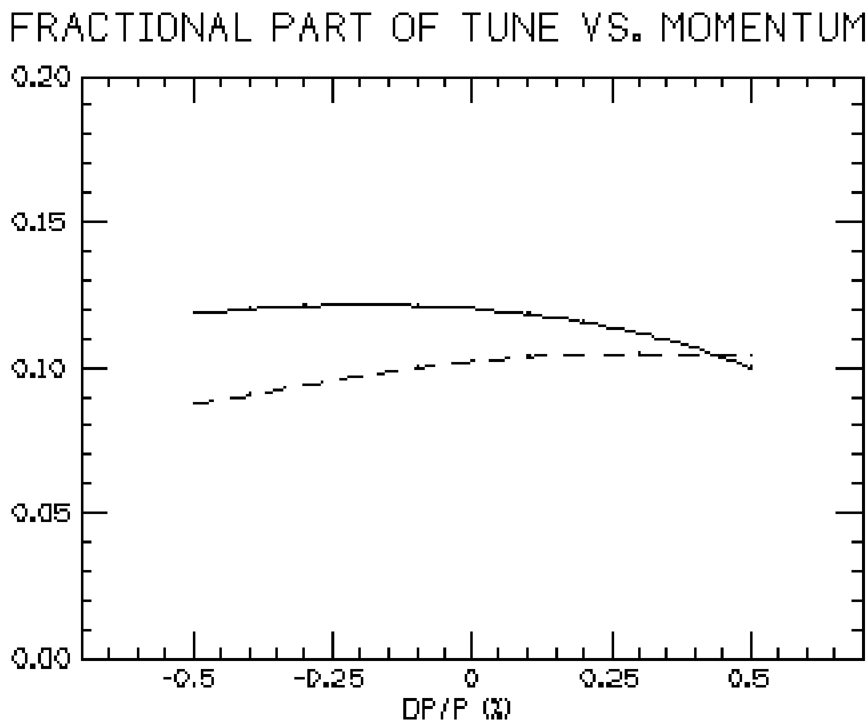

***Fig. 8**- Fractional part of horizontal and vertical tunes vs. $\Delta p/p$.*

To correct the tune-shift for particles with large oscillation amplitudes, a hard work of sextupoles optimization in the dispersion free regions has been performed. Being the lattice quite compact, the space available for the sextupoles is not large, since the regions from the low-β insertions to the septa must be kept free. As a consequence of that, a sextupole family has been inserted also in the drift where probably an injection kicker will be installed. In this case a further study of the particle trajectories at the injection, with the sextupole on, has to be done.

The first configuration giving a satisfactory dynamic aperture in both planes is shown in **Table VI**, where the gradient G in the last column is calculated for .1 m long sextupoles. In Figs 9, 10 are plotted the tune behaviour as a function of the particle amplitude in number of sigma for this sextupole configuration.

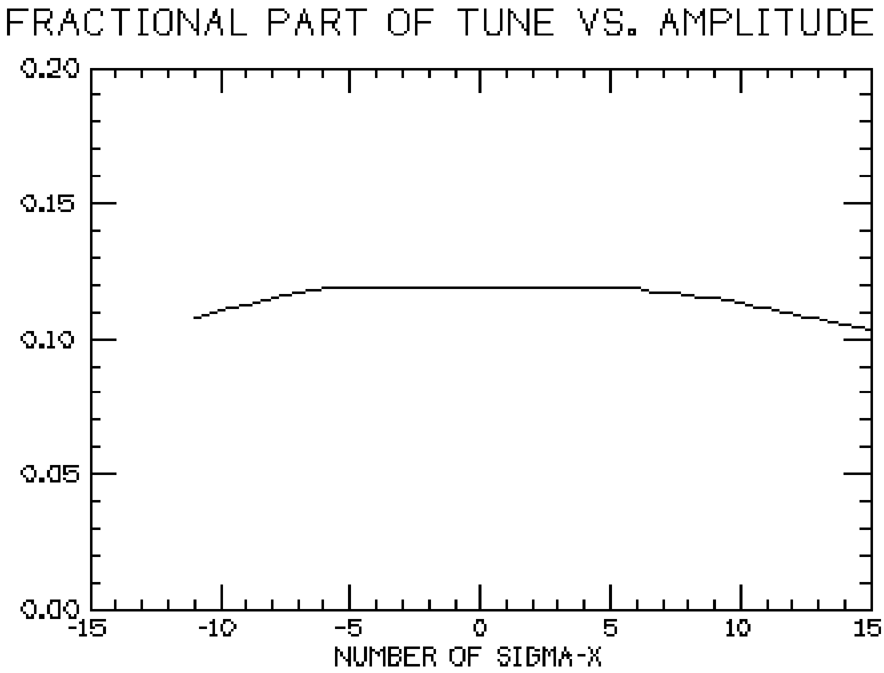

Fig. 9 *- Fractional part of the horizontal tune vs. amplitude (off coupling).*

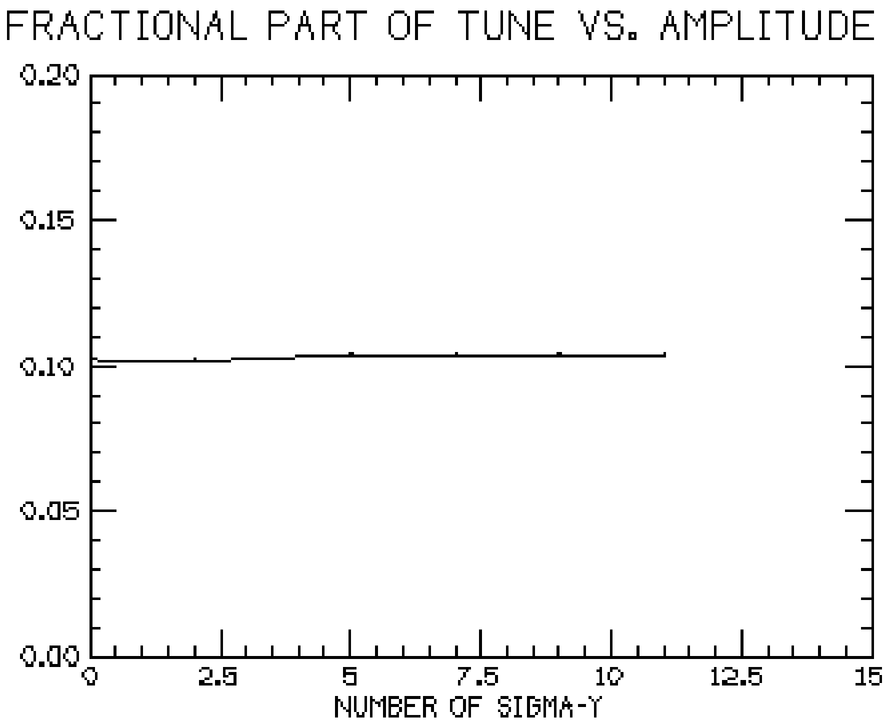

Fig. 10 *- Fractional part of the vertical tune vs. amplitude (full coupling).*

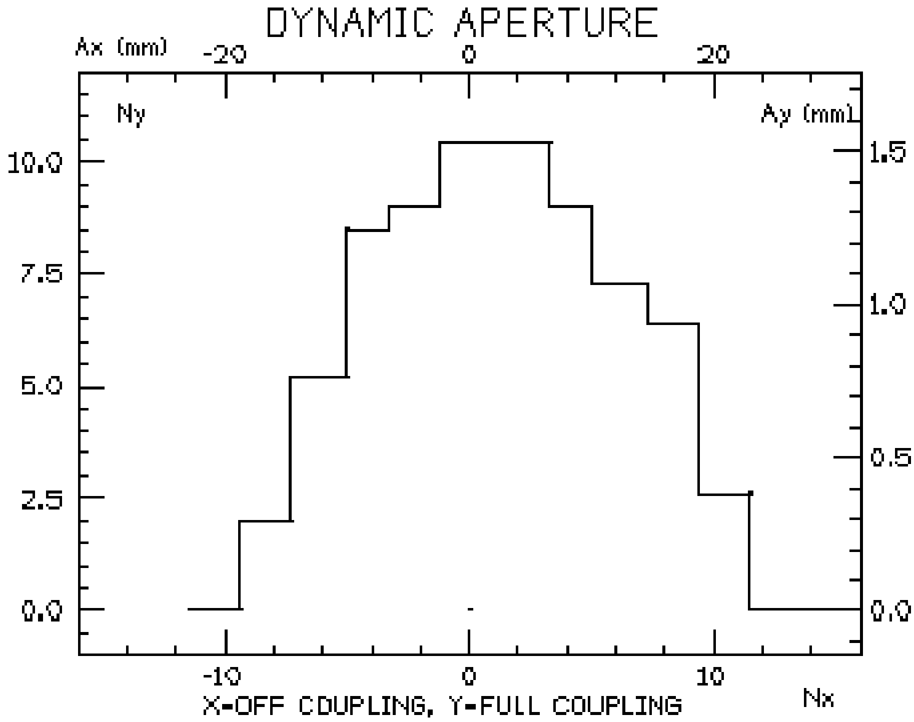

Fig. 11 *- Dynamic aperture for on-momentum particles.*

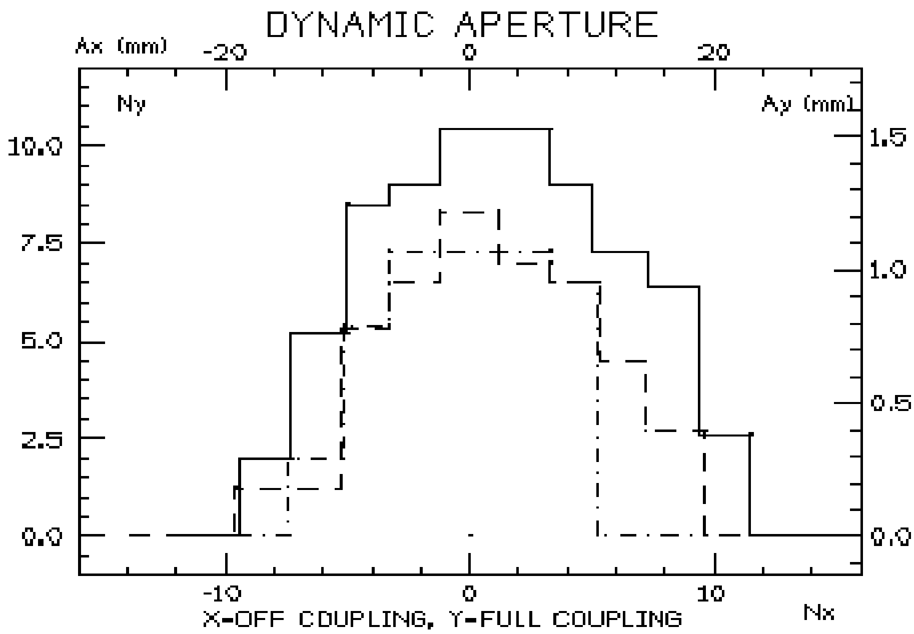

Fig. 12 *- Dynamic aperture for off-momentum particles.*

SOLID LINE:	$\Delta p / p =$ 0.
DASHED LINE:	$\Delta p / p =$ -.5%
DOT-DASHED LINE:	$\Delta p / p =$ +.5%

The resulting aperture, computed at the IP, ranges from -24mm (12 σ_x) to +31 mm (16 σ_x) in horizontal (off coupling) and from 0. to 1.5 mm (11 σ_y) in vertical (full coupling), and it is shown in Fig. 11. Quantum lifetime aperture requests are well fitted in this area.

With the same configuration, in Fig. 12 is reported the dynamic aperture for off-momentum particles, for a deviation $\Delta p/p$= -.5% (dashed line) and $\Delta p/p$ = +.5% (dot-dashed line), plotted for comparison on the unperturbed one (solid line). Since the reduction of the stable area is not very large, we expect to have good beam lifetimes as predicted by the tunes behaviour.

Finally, it is possible to improve the chromaticity correction, and then the dynamic aperture, changing the β-functions in the achromats, where they are now not much separated. This work is still in progress.

4 - INJECTION APERTURE

For injection it is foreseen to implement a conventional full energy scheme based on a thin septum and a fast closed orbit bump produced by four kicker magnets in the horizontal plane.

Injection parameters are still under study, anyway we can give an estimate of the required apertures based on simple assumptions.

We assume D_x = 0. and α_x = 0. at the injection septum. The aperture A required to accommodate the injected beam is given by (see Fig. 13):

$$A = R^2 / \beta = (d + \Delta s + 2\sqrt{\varepsilon_i \beta_i})^2 / \beta$$

where:

ε_i	emittance of the incoming beam
β_i	β-function of the incoming beam
β	β-function at the injection point in the ring
Δs	septum thickness
d	septum - bumped c.o. x_b distance.

We assume $d = 4\sigma_x = 4\sqrt{\varepsilon\beta}$, where ε is the emittance of the stored beam: $\varepsilon = 10^{-6}$ m rad. Neglecting the septum thikness:

$$A = (4\sqrt{\varepsilon} + 2\sqrt{\varepsilon_i \beta_i / \beta})^2$$

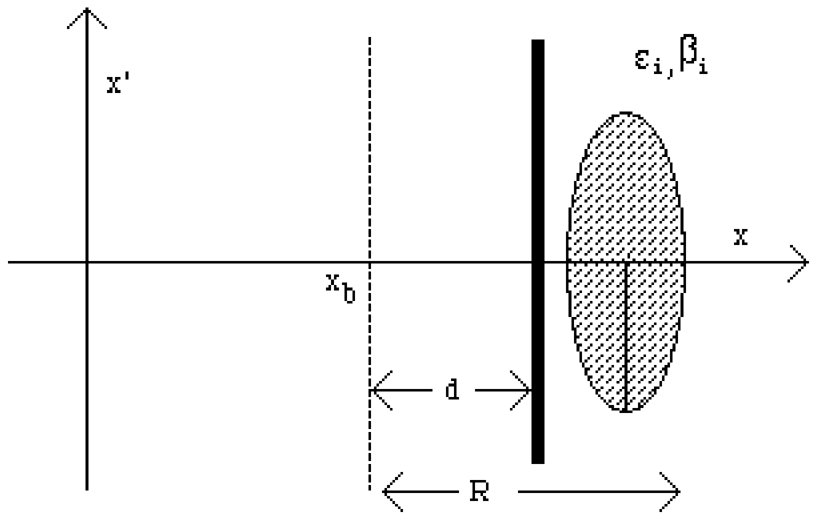

Fig. 13 *- Horizontal phase space at injection point.*

To estimate the required aperture we take a typical value of emittance from a positron linac:

ε_i = 10^{-5} m rad

β_i/β = .5 nearly the optimum value for our case[7, 8],

getting:

$$A = 7\ 10^{-5}\ \text{m rad}.$$

In case of injection from a damping ring, as it turns out to be the most convenient option, the emittance of the injected beam is much smaller, e.g. $\varepsilon_i = 2\ 10^{-7}$ m rad, and we get:

$$A = 2\ 10^{-5}\ \text{m rad}.$$

With this value we are well inside the dynamic aperture also for off energy particles. This is a strong argument in favour of the use of a damping ring instead of direct linac injection.

The horizontal and vertical r.m.s. beam size are shown in Fig. 14 for the following characteristic parameters:

ε_x = $2\ 10^{-5}$ m rad

ε_y = 10^{-6} m rad

$\Delta p/p$ = .5%

The required error closed orbit allowance on the aperture can be of a few millimiters only.

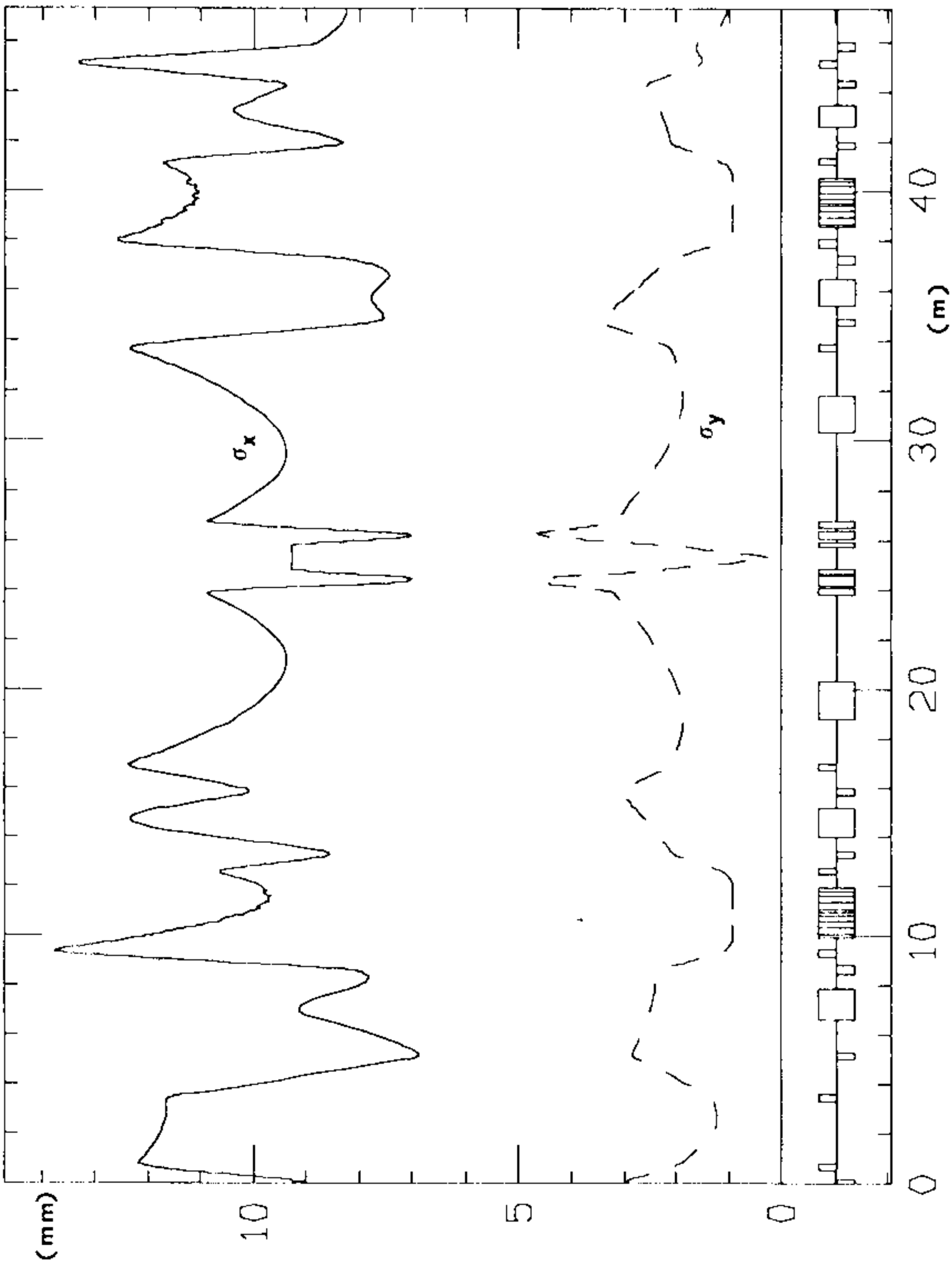

***Fig. 14** - Horizontal and vertical r.m.s. beam sizes for:*
ε_x = 2 10^{-5}, ε_y = 10^{-6}, $\Delta p/p$=5 10^{-3}.

References

[1] R.Chasman, G. K. Green and M. Rowe, IEEE Trans. Nucl. Sci., NS 22 (1975).

[2] J.B. Murphy and G. Vignola, "LEDA: A computer code for linear lattices" (Unpublished).

[3] F.C. Iselin, J. Niederer, "The MAD program", CERN/LEP-TH/87-33 (1987).

[4] M. Bassetti, "NOLISY: solution of a non-linear system of equations" (Unpublished).

[5] "Proposal for a Φ-Factory" LNF-90/031(R) (1990).

[6] H. Wiedemann, "Users guide for Patricia version 85.5", SSRL ACD-Note 29 (1985).

[7] S. Tazzari, "Apertures for injection", Adone internal memo EI-4.

[8] M. Preger, "Determinazione della massima area di un ellisse inscritta in un segmento circolare ", Adone internal memo T-106.

TABLE I - LEDA output

DAFNE (12/10/90)

ENERGY (MEV)	510.0	
B*RO (TESLA*METERS)	1.70	
TOTAL BENDING ANGLE (H-V)	0.914156371D+03	0.0000000000D+00
NUMBER OF PERIODS	1	
PERIOD LENGTH (m)	0.945602906D+02	
TOTAL LENGTH (m)	0.945602906D+02	

ACHIEVED CONVERGENCE = 0.232362772D+00

WHOLE LATTICE

	TYPE	LENGTH	K2(M-2)	RADIUS
	IP1	0.0000000000D+00	0.0000000000D+00	0.0000000000D+00
1	D01A	0.433000000D+00	0.000000000D+00	0.0000000000D+00
2	QF1A *	0.180000000D+00	0.500018013D+01	0.000000000D+00
3	D02A	0.130000000D+00	0.000000000D+00	0.000000000D+00
4	QD2A *	0.340000000D+00	0.734532121D+01	0.000000000D+00
5	D03A	0.130000000D+00	0.000000000D+00	0.000000000D+00
6	QF3A *	0.280000000D+00	0.407978079D+01	0.000000000D+00
7	D04A	0.350000000D+01	0.0000000000D+00	0.0000000000D+00
8	SEPA	0.150000000D+01	0.000000000D+00	0.100000000D+02
9	D01E	0.130000000D+01	0.000000000D+00	0.000000000D+00
10	D02E	0.500000000D+00	0.000000000D+00	0.000000000D+00
11	QF1E	0.300000000D+00	0.177520000D+01	0.000000000D+00
12	D03E	0.700000000D+00	0.000000000D+00	0.000000000D+00
13	QD2E	0.300000000D+00	0.197190000D+01	0.000000000D+00
14	D04E	0.500000000D+00	0.000000000D+00	0.000000000D+00
15	B01E	0.110000000D+01	0.000000000D+00	0.140056350D+01
16	D05E	0.250000000D+00	0.0000000000D+00	0.000000000D+00
17	SD1E	0.100000000D+00	0.119501800D+02	0.000000000D+00
18	D06E	0.250000000D+00	0.000000000D+00	0.000000000D+00
19	QD3E	0.300000000D+00	0.184110000D+01	0.0000000000D+00
20	D07E	0.350000000D+00	0.000000000D+00	0.000000000D+00
21	QF4E	0.300000000D+00	0.249640000D+01	0.0000000000D+00
22	D08E	0.5000000000D+00	0.000000000D+00	0.000000000D+00
23	BW1E	2.0000000000D+00	0.0000000000D+00	0.900000000D+00
24	D09E	0.200000000D+00	0.0000000000D+00	0.000000000D+00
25	SF2E	0.100000000D+00	0.731293000D+01	0.000000000D+00
26	D10E	0.200000000D+00	0.0000000000D+00	0.000000000D+00
27	QF5E	0.300000000D+00	0.208705343D+01	0.000000000D+00
28	D11E	0.370000000D+00	0.0000000000D+00	0.000000000D+00
29	QD6E	0.300000000D+00	0.232222952D+01	0.000000000D+00
30	D12E	0.600000000D+00	0.0000000000D+00	0.000000000D+00
31	B02E	0.881378810D+00	0.000000000D+00	0.140056350D+01
32	D13E	0.300000000D+00	0.000000000D+00	0.000000000D+00
33	SD3E	0.100000000D+00	0.600000000D+01	0.000000000D+00
34	D14E	0.300000000D+00	0.000000000D+00	0.0000000000D+00
35	QD7E	0.300000000D+00	0.226951000D+01	0.000000000D+00
36	D15E	0.200000000D+00	0.000000000D+00	0.000000000D+00
37	SF4E	0.100000000D+00	0.100000000D+01	0.000000000D+00
38	D16E	0.200000000D+00	0.000000000D+00	0.000000000D+00
40	QF8E	0.300000000D+00	0.326637729D+01	0.000000000D+00
41	D17E	0.150000000D+00	0.000000000D+00	0.000000000D+00
42	SF5E	0.100000000D+00	0.200000000D+01	0.000000000D+00
43	D18E	0.150000000D+00	0.0000000000D+00	0.000000000D+00
44	QD9E	0.300000000D+00	0.219623924D+01	0.000000000D+00
45	D19E	0.129818500D+01	0.0000000000D+00	0.000000000D+00
46	D20E	0.129818500D+01	0.000000000D+00	0.0000000000D+00
47	QD10E	0.300000000D+00	0.219623924D+01	0.000000000D+00
48	D21E	0.150000000D+00	0.000000000D+00	0.000000000D+00
49	SF6E	0.100000000D+00	0.200000000D+01	0.000000000D+00
50	D22E	0.150000000D+00	0.000000000D+00	0.000000000D+00
51	QF11E	0.300000000D+00	0.326637729D+01	0.000000000D+00
52	D23E	0.200000000D+00	0.000000000D+00	0.000000000D+00
53	SF7E	0.100000000D+00	0.100000000D+01	0.000000000D+00
54	D24E	0.200000000D+00	0.000000000D+00	0.000000000D+00
55	QD12E	0.300000000D+00	0.226951000D+01	0.000000000D+00
56	D25E	0.300000000D+00	0.000000000D+00	0.000000000D+00
57	SD8E	0.100000000D+00	0.300000000D+01	0.000000000D+00

58	D26E	0.300000000D+00	0.000000000D+00	0.000000000D+00
59	B03E	0.881378810D+00	0.000000000D+00	0.140056350D+01
60	D27E	0.600000000D+00	0.000000000D+00	0.000000000D+00
61	QD13E	0.300000000D+00	0.232222952D+01	0.000000000D+00
62	D28E	0.370000000D+00	0.000000000D+00	0.000000000D+00
63	QF14E	0.300000000D+00	0.208705343D+01	0.000000000D+00
64	D29E	0.200000000D+00	0.000000000D+00	0.000000000D+00
65	SF9E	0.100000000D+00	0.731293000D+01	0.000000000D+00
66	D30E	0.200000000D+00	0.000000000D+00	0.000000000D+00
67	BW2E	2.000000000D+00	0.000000000D+00	0.900000000D+00
68	D31E	0.500000000D+00	0.000000000D+00	0.000000000D+00
69	QF15E	0.300000000D+00	0.249640000D+01	0.000000000D+00
70	D32E	0.350000000D+00	0.000000000D+00	0.000000000D+00
71	QD16E	0.300000000D+00	0.184110000D+01	0.000000000D+00
72	D33E	0.250000000D+00	0.000000000D+00	0.000000000D+00
73	SD10E	0.100000000D+00	0.119501800D+02	0.000000000D+00
74	D34E	0.250000000D+00	0.000000000D+00	0.000000000D+00
75	B04E	0.110000000D+01	0.000000000D+00	0.140056350D+01
76	D35E	0.500000000D+00	0.000000000D+00	0.000000000D+00
77	QD17E	0.300000000D+00	0.197190000D+01	0.000000000D+00
78	D36E	0.700000000D+00	0.000000000D+00	0.000000000D+00
79	QF18E	0.300000000D+00	0.177520000D+01	0.000000000D+00
80	D37E	0.500000000D+00	0.000000000D+00	0.000000000D+00
81	D38E	0.130000000D+01	0.000000000D+00	0.000000000D+00
82	SEPB	0.150000000D+01	0.000000000D+00	0.100000000D+02
83	D04B	0.350000000D+01	0.000000000D+00	0.000000000D+00
84	QF3B *	0.280000000D+00	0.407978079D+01	0.000000000D+00
85	D03B	0.130000000D+00	0.000000000D+00	0.000000000D+00
86	QD2B *	0.340000000D+00	0.734532121D+01	0.000000000D+00
87	D02B	0.130000000D+00	0.000000000D+00	0.000000000D+00
88	QF1B *	0.180000000D+00	0.500018013D+01	0.000000000D+00
89	D01B	0.433000000D+00	0.000000000D+00	0.000000000D+00
	IP2	0.000000000D+00	0.000000000D+00	0.000000000D+00
90	D01C	0.433000000D+00	0.000000000D+00	0.000000000D+00
91	QF1C *	0.180000000D+00	0.500018013D+01	0.000000000D+00
92	D02C	0.130000000D+00	0.000000000D+00	0.000000000D+00
93	QD2C *	0.340000000D+00	0.734532121D+01	0.000000000D+00
94	D03C	0.130000000D+00	0.000000000D+00	0.000000000D+00
95	QF3C *	0.280000000D+00	0.407978079D+01	0.000000000D+00
96	D04C	0.350000000D+01	0.000000000D+00	0.000000000D+00
97	SEPC	0.150000000D+01	0.000000000D+00	-0.100000000D+02
98	D39E	0.130000000D+01	0.000000000D+00	0.000000000D+00
99	D40E	0.500000000D+00	0.000000000D+00	0.000000000D+00
100	QF19E	0.300000000D+00	0.110500000D+01	0.000000000D+00
101	D41E	0.700000000D+00	0.000000000D+00	0.000000000D+00
102	QD20E	0.300000000D+00	0.161675000D+01	0.000000000D+00
103	D42E	0.560000000D+00	0.000000000D+00	0.000000000D+00
104	B05E	0.110000000D+01	0.000000000D+00	0.140056350D+01
105	D43E	0.600000000D+00	0.000000000D+00	0.000000000D+00
106	QD21E	0.300000000D+00	0.199345000D+01	0.000000000D+00
107	D44E	0.350000000D+00	0.000000000D+00	0.000000000D+00
108	QF22E	0.300000000D+00	0.212846000D+01	0.000000000D+00
109	D45E	0.200000000D+00	0.000000000D+00	0.000000000D+00
110	SF11E	0.100000000D+00	0.731293000D+01	0.000000000D+00
111	D46E	0.200000000D+00	0.000000000D+00	0.000000000D+00
112	BW3E	2.000000000D+00	0.000000000D+00	0.900000000D+00
113	D47E	0.500000000D+00	0.000000000D+00	0.000000000D+00
114	QF23E	0.300000000D+00	0.320069000D+01	0.000000000D+00
115	D48E	0.370000000D+00	0.000000000D+00	0.000000000D+00
116	QD24E	0.300000000D+00	0.272940000D+01	0.000000000D+00
117	D49E	0.250000000D+00	0.000000000D+00	0.000000000D+00
118	SD12E	0.100000000D+00	0.119501800D+02	0.000000000D+00
119	D50E	0.250000000D+00	0.000000000D+00	0.000000000D+00
120	B06E	0.131862150D+01	0.000000000D+00	0.140056350D+01
121	D51E	0.950000000D+00	0.000000000D+00	0.000000000D+00
122	SF13E	0.100000000D+00	0.120000000D+02	0.000000000D+00
123	D52E	0.250000000D+00	0.000000000D+00	0.000000000D+00
124	QD25E	0.300000000D+00	0.144175000D+01	0.000000000D+00
125	D53E	0.292000000D+00	0.000000000D+00	0.000000000D+00
126	SD14E	0.100000000D+00	0.500000000D+01	0.000000000D+00
127	D54E	0.950000000D+00	0.000000000D+00	0.000000000D+00

128	QF26E	0.300000000D+00	0.987362000D+00	0.000000000D+00
129	D55E	0.250000000D+01	0.000000000D+00	0.000000000D+00
130	QF27E	0.300000000D+00	0.161559000D+01	0.000000000D+00
131	D56E	0.153960000D+00	0.000000000D+00	0.000000000D+00
132	SD15E	0.100000000D+00	0.400000000D+01	0.000000000D+00
133	D57E	0.150000000D+00	0.000000000D+00	0.000000000D+00
134	QD28E	0.150000000D+00	0.369949000D+01	0.000000000D+00
135	QD28E	0.150000000D+00	0.369949000D+01	0.000000000D+00
136	D58E	0.150000000D+00	0.000000000D+00	0.000000000D+00
137	SD16E	0.100000000D+00	0.300000000D+01	0.000000000D+00
138	D59E	0.153960000D+00	0.000000000D+00	0.000000000D+00
139	QF29E	0.300000000D+00	0.161559000D+01	0.000000000D+00
140	D60E	0.250000000D+01	0.000000000D+00	0.000000000D+00
141	QF30E	0.300000000D+00	0.987362000D+00	0.000000000D+00
142	D61E	0.950000000D+00	0.000000000D+00	0.000000000D+00
143	SD17E	0.100000000D+00	0.400000000D+01	0.000000000D+00
144	D62E	0.292000000D+00	0.000000000D+00	0.000000000D+00
145	QD31E	0.300000000D+00	0.144175000D+01	0.000000000D+00
146	D63E	0.250000000D+00	0.000000000D+00	0.000000000D+00
147	SF18E	0.100000000D+00	0.130000000D+02	0.000000000D+00
148	D64E	0.950000000D+00	0.000000000D+00	0.000000000D+00
149	B07E	0.131862150D+01	0.000000000D+00	0.140056350D+01
150	D65E	0.250000000D+00	0.000000000D+00	0.000000000D+00
151	SD19E	0.100000000D+00	0.119501800D+02	0.000000000D+00
152	D66E	0.250000000D+00	0.000000000D+00	0.000000000D+00
153	QD32E	0.300000000D+00	0.272940000D+01	0.000000000D+00
154	D67E	0.370000000D+00	0.000000000D+00	0.000000000D+00
155	QF33E	0.300000000D+00	0.320069000D+01	0.000000000D+00
156	D68E	0.500000000D+00	0.000000000D+00	0.000000000D+00
157	BW4E	2.000000000D+00	0.000000000D+00	0.900000000D+00
158	D69E	0.200000000D+00	0.000000000D+00	0.000000000D+00
159	SF20E	0.100000000D+00	0.731293000D+01	0.000000000D+00
160	D70E	0.200000000D+00	0.000000000D+00	0.000000000D+00
161	QF34E	0.300000000D+00	0.212846000D+01	0.000000000D+00
162	D71E	0.350000000D+00	0.000000000D+00	0.000000000D+00
163	QD35E	0.300000000D+00	0.199345000D+01	0.000000000D+00
164	D72E	0.600000000D+00	0.000000000D+00	0.000000000D+00
165	B08E	0.110000000D+01	0.000000000D+00	0.140056350D+01
166	D73E	0.560000000D+00	0.000000000D+00	0.000000000D+00
167	QD36E	0.300000000D+00	0.161675000D+01	0.000000000D+00
168	D74E	0.700000000D+00	0.000000000D+00	0.000000000D+00
169	QF37E	0.300000000D+00	0.110500000D+01	0.000000000D+00
170	D75E	0.500000000D+00	0.000000000D+00	0.000000000D+00
171	D76E	0.130000000D+01	0.000000000D+00	0.000000000D+00
172	SEPD	0.150000000D+01	0.000000000D+00	-0.100000000D+02
173	D04D	0.350000000D+01	0.000000000D+00	0.000000000D+00
174	QF3D *	0.280000000D+00	0.407978079D+01	0.000000000D+00
175	D03D	0.130000000D+00	0.000000000D+00	0.000000000D+00
176	QD2D *	0.340000000D+00	0.734532121D+01	0.000000000D+00
177	D02D	0.130000000D+00	0.000000000D+00	0.000000000D+00
178	QF1D *	0.180000000D+00	0.500018013D+01	0.000000000D+00
179	D01D	0.433000000D+00	0.000000000D+00	0.000000000D+00
	IP1	0.000000000D+00	0.000000000D+00	0.000000000D+00

* The quadrupoles of the low-beta triplet can be computed as gradient bending magnets for a displaced orbit (10mrad crossing angle).

QF1A	0.180000000D+00	-0.768347680D+04	-0.392000000D+02
QD2A	0.340000000D+00	0.194057889D+04	0.162540000D+02
QF3A	0.280000000D+00	-0.781464060D+03	-0.138400000D+02

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    DAFNE      (12/10/90)


   PARAMETERS :

    QX - QZ                     4.120       6.102
   tunes/period                 4.120       6.102
 ETA0  (H/V) - BX0   - BZ0   0.0000E+00  0.0000E+00   4.500        0.4500E-01
ETAMAX (H/V) - BXMAX - BZMAX  2.349       0.0000E+00   9.332         22.61
ETAMIN (H/V) - BXMIN - BZMIN -.5451       0.0000E+00   1.043        0.4500E-01
 <ETA> (H/V) - <BX>  - <BZ>  0.3756       0.0000E+00   4.566         5.103

   SYNCHROTRON RADIATION INTEGRALS (R.H.HELM et al.) :

    I1(H-V) (meters)          0.640654001D+00   0.000000000D+00
    I2(H-V) (1/meters)        0.144341908D+02   0.000000000D+00
    I3(H-V) (1/meters**2)     0.141838160D+02   0.000000000D+00
    I4(H-V) (1/meters)        0.356673589D+00   0.000000000D+00
    I5(H-V) (1/meters)        0.349798241D+02   0.000000000D+00

   MOM. COMPACTION              0.6775E-02
   U0 (H-V-Tot) (KeV)            13.75      0.0000E+00   13.75
   D (H-V)                      0.2471E-01  0.0000E+00
   JS,JX,JZ                      2.025     0.9753      1.000
   DAMPINGS(ms)                  11.56      23.99      23.40
   REL. R.M.S. ENERGY-SPREAD  0.4309E-03
   EMITTANCE(H-V) (m-rad)       0.9504E-06  0.0000E+00

   CHROMATICITIES (M.BASSETTI LEP NOTE 504) :

   BENDING        -4.567      -12.95      0.0000E+00  0.0000E+00
   EDGE            1.457      -.7209      0.0000E+00  0.0000E+00
   QUADRUPOLE     -1.655      -4.093
   TOTAL CROM.    -4.766      -17.76

    TRANSFER MATRIX FOR ONE FULL PERIOD

         0.728152414D+00    0.289816311D+01    -0.569818058D-05
        -0.162100629D+00    0.728152414D+00    -0.339778134D-05

         0.801513549D+00    0.570914977D+01
        -0.626320985D-01    0.801513549D+00
```

TABLE II

	S(m)	σ_x (mm)	Δx (mm)
1	.39	2.12	3.94
2	.79	1.65	6.73
3	1.18	2.08	14.4
4	1.58	2.45	20.3
5	1.97	2.37	22.7

TABLE III

$Ø_Q$(mm)	σ_x(mm)	Δx(mm)	
QF1A (QF1B,QF1C,QF1D)	129.4	2.12	4.33
QD2A (QD2B,QD2C,QD2D)	222.1	1.73	6.42
QF3A (QF3B,QF3C,QF3D)	362.6	2.15	15.24

TABLE IV - Optical functions - MAD output

Horizontal Crossing   "MAD" VERSION: 4.03   RUN: 00/00/00 00:
TWISS PARAMETERS FOR BEAM LINE "HALF"   DELTA(P)/P = 0.000000   SYMM = F   PAGE 1

POS. NO.	ELEMENT NAME	OCC. NO.	DIST [M]	BETAX [M]	ALFAX	MUX [2PI]	X(CO) [MM]	X'(CO) [MRAD]	DX [M]	DX'	BETAY [M]	ALFAY	MUY [2PI]	Y(CO) [MM]	Y'(CO) [MRAD]	DY [M]	DY'
				HORIZONTAL							VERTICAL						
BEGIN	HALF	1	0.000	3.568	0.000	0.000	0.000	0.000	0.000	0.000	1.164	0.000	0.000	0.000	0.000	0.000	0.000
BEGIN	HSHORT	1	0.000	3.568	0.000	0.000	0.000	0.000	0.000	0.000	1.164	0.000	0.000	0.000	0.000	0.000	0.000
BEGIN	ARC2B	1	0.000	3.568	0.000	0.000	0.000	0.000	0.000	0.000	1.164	0.000	0.000	0.000	0.000	0.000	0.000
1	D20E	1	1.298	4.040	-0.364	0.056	0.000	0.000	0.000	0.000	2.612	-1.115	0.134	0.000	0.000	0.000	0.000
2	QD10E	1	1.598	5.168	-3.640	0.066	0.000	0.000	0.000	0.000	2.785	0.575	0.151	0.000	0.000	0.000	0.000
3	D21E	1	1.748	6.322	-4.053	0.071	0.000	0.000	0.000	0.000	2.624	0.503	0.160	0.000	0.000	0.000	0.000
4	SF6E	1	1.848	7.160	-4.329	0.073	0.000	0.000	0.000	0.000	2.528	0.456	0.166	0.000	0.000	0.000	0.000
5	D22E	1	1.998	8.521	-4.743	0.076	0.000	0.000	0.000	0.000	2.402	0.384	0.176	0.000	0.000	0.000	0.000
6	QF11E	1	2.298	8.797	3.916	0.081	0.000	0.000	0.000	0.000	2.949	-2.383	0.194	0.000	0.000	0.000	0.000
7	D23E	1	2.498	7.305	3.544	0.085	0.000	0.000	0.000	0.000	3.993	-2.836	0.204	0.000	0.000	0.000	0.000
8	SF7E	1	2.598	6.614	3.359	0.087	0.000	0.000	0.000	0.000	4.583	-3.063	0.207	0.000	0.000	0.000	0.000
9	D24E	1	2.798	5.345	2.987	0.093	0.000	0.000	0.000	0.000	5.898	-3.515	0.214	0.000	0.000	0.000	0.000
10	QD12E	1	3.098	4.646	-0.498	0.103	0.000	0.000	0.000	0.000	6.797	0.726	0.221	0.000	0.000	0.000	0.000
11	D25E	1	3.398	4.969	-0.579	0.113	0.000	0.000	0.000	0.000	6.382	0.658	0.228	0.000	0.000	0.000	0.000
12	SD8E	1	3.498	5.087	-0.606	0.116	0.000	0.000	0.000	0.000	6.253	0.636	0.231	0.000	0.000	0.000	0.000
13	D26E	1	3.798	5.475	-0.687	0.125	0.000	0.000	0.000	0.000	5.891	0.569	0.238	0.000	0.000	0.000	0.000
14	B03E	1	4.680	4.676	1.470	0.151	0.000	0.000	0.268	0.589	5.064	0.371	0.264	0.000	0.000	0.000	0.000
15	D27E	1	5.280	3.155	1.065	0.176	0.000	0.000	0.621	0.589	4.700	0.236	0.284	0.000	0.000	0.000	0.000
16	QD13E	1	5.580	3.196	-1.208	0.191	0.000	0.000	0.870	1.099	3.680	2.922	0.295	0.000	0.000	0.000	0.000
17	D28E	1	5.950	4.195	-1.493	0.208	0.000	0.000	1.277	1.099	1.873	1.963	0.317	0.000	0.000	0.000	0.000
18	QF14E	1	6.250	4.308	1.140	0.218	0.000	0.000	1.479	0.223	1.164	0.544	0.351	0.000	0.000	0.000	0.000
19	D29E	1	6.450	3.874	1.033	0.226	0.000	0.000	1.523	0.223	0.991	0.322	0.381	0.000	0.000	0.000	0.000
20	SF9E	1	6.550	3.672	0.980	0.231	0.000	0.000	1.545	0.223	0.938	0.210	0.397	0.000	0.000	0.000	0.000
21	D30E	1	6.750	3.301	0.873	0.240	0.000	0.000	1.590	0.223	0.898	-0.012	0.432	0.000	0.000	0.000	0.000
END	ARC2B	1	6.750	3.301	0.873	0.240	0.000	0.000	1.590	0.223	0.898	-0.012	0.432	0.000	0.000	0.000	0.000
BEGIN	BW2E	1	6.750	3.301	0.873	0.240	0.000	0.000	1.590	0.223	0.898	-0.012	0.432	0.000	0.000	0.000	0.000
BEGIN	M1WIG	1	6.750	3.301	0.873	0.240	0.000	0.000	1.590	0.223	0.898	-0.012	0.432	0.000	0.000	0.000	0.000
22	BWI	1	6.875	3.092	0.807	0.246	0.000	0.000	1.626	0.362	0.901	-0.013	0.455	0.000	0.000	0.000	0.000
23	BWM	1	7.125	2.726	0.675	0.259	0.000	0.000	1.681	0.082	0.908	-0.014	0.499	0.000	0.000	0.000	0.000
24	BWP	1	7.375	2.426	0.543	0.275	0.000	0.000	1.736	0.362	0.915	-0.010	0.543	0.000	0.000	0.000	0.000
25	BWM	2	7.625	2.190	0.411	0.292	0.000	0.000	1.791	0.082	0.918	-0.004	0.587	0.000	0.000	0.000	0.000
26	BWP1	1	7.750	2.138	0.346	0.301	0.000	0.000	1.827	0.220	0.901	0.000	0.609	0.000	0.000	0.000	0.000
END	M1WIG	1	7.750	2.138	0.346	0.301	0.000	0.000	1.827	0.220	0.901	0.000	0.609	0.000	0.000	0.000	0.000
BEGIN	M2WIG	1	7.750	2.138	0.346	0.301	0.000	0.000	1.827	0.220	0.901	0.000	0.609	0.000	0.000	0.000	0.000
27	BWP2	1	7.875	2.020	0.280	0.310	0.000	0.000	1.846	0.362	0.918	0.004	0.631	0.000	0.000	0.000	0.000
28	BWM	3	8.125	1.914	0.148	0.331	0.000	0.000	1.901	0.082	0.914	0.010	0.675	0.000	0.000	0.000	0.000
29	BWP	2	8.375	1.874	0.016	0.351	0.000	0.000	1.956	0.362	0.908	0.014	0.719	0.000	0.000	0.000	0.000
30	BWM	4	8.625	1.898	-0.116	0.372	0.000	0.000	2.010	0.082	0.901	0.013	0.764	0.000	0.000	0.000	0.000
31	BWI	2	8.750	1.935	-0.182	0.383	0.000	0.000	2.029	0.222	0.898	0.012	0.786	0.000	0.000	0.000	0.000
END	M2WIG	1	8.750	1.935	-0.182	0.383	0.000	0.000	2.029	0.222	0.898	0.012	0.786	0.000	0.000	0.000	0.000
END	BW2E	1	8.750	1.935	-0.182	0.383	0.000	0.000	2.029	0.222	0.898	0.012	0.786	0.000	0.000	0.000	0.000
BEGIN	ARC1B	1	8.750	1.935	-0.182	0.383	0.000	0.000	2.029	0.222	0.898	0.012	0.786	0.000	0.000	0.000	0.000
32	D31E	1	9.250	2.251	-0.449	0.421	0.000	0.000	2.140	0.222	1.164	-0.545	0.868	0.000	0.000	0.000	0.000
33	QF15E	1	9.550	2.057	1.045	0.443	0.000	0.000	1.968	-1.346	1.932	-2.204	0.901	0.000	0.000	0.000	0.000
34	D32E	1	9.900	1.450	0.689	0.475	0.000	0.000	1.497	-1.346	3.846	-3.264	0.921	0.000	0.000	0.000	0.000
35	QD16E	1	10.200	1.340	-0.302	0.510	0.000	0.000	1.208	-0.610	5.250	-1.156	0.932	0.000	0.000	0.000	0.000
36	D33E	1	10.450	1.542	-0.506	0.538	0.000	0.000	1.055	-0.610	5.856	-1.267	0.939	0.000	0.000	0.000	0.000
37	SD10E	1	10.550	1.651	-0.587	0.548	0.000	0.000	0.994	-0.610	6.114	-1.311	0.941	0.000	0.000	0.000	0.000
38	D34E	1	10.800	1.996	-0.791	0.570	0.000	0.000	0.842	-0.610	6.797	-1.423	0.948	0.000	0.000	0.000	0.000
39	B04E	1	11.900	2.904	0.142	0.638	0.000	0.000	0.402	-0.149	10.465	-1.912	0.968	0.000	0.000	0.000	0.000

Horizontal Crossing "MAD" VERSION: 4.03 RUN: 00/00/00 00:00:00
TWISS PARAMETERS FOR BEAM LINE "HALF" DELTA(P)/P = 0.000000 SYMM = F PAGE 2

POS. NO.	ELEMENT NAME	OCC. NO.	DIST [M]	BETAX [M]	ALFAX	MUX [2PI]	X(CO) [MM]	X'(CO) [MRAD]	DX [M]	DX'	BETAY [M]	ALFAY	MUY [2PI]	Y(CO) [MM]	Y'(CO) [MRAD]	DY [M]	DY'
40	D35E	1	12.400	2.849	-0.033	0.666	0.000	0.000	0.327	-0.149	12.489	-2.134	0.975	0.000	0.000	0.000	0.000
41	QD17E	1	12.700	3.442	-2.057	0.681	0.000	0.000	0.311	0.037	11.572	5.005	0.979	0.000	0.000	0.000	0.000
42	D36E	1	13.400	7.065	-3.120	0.704	0.000	0.000	0.337	0.037	5.668	3.429	0.993	0.000	0.000	0.000	0.000
43	QF18E	1	13.700	7.804	0.791	0.710	0.000	0.000	0.321	-0.140	4.552	0.485	1.003	0.000	0.000	0.000	0.000
44	D37E	1	14.200	7.065	0.687	0.721	0.000	0.000	0.251	-0.140	4.136	0.349	1.021	0.000	0.000	0.000	0.000
45	D38E	1	15.500	5.632	0.416	0.754	0.000	0.000	0.068	-0.140	3.686	-0.004	1.075	0.000	0.000	0.000	0.000
END	ARC1B	1	15.500	5.632	0.416	0.754	0.000	0.000	0.068	-0.140	3.686	-0.004	1.075	0.000	0.000	0.000	0.000
BEGIN	LBETB	1	15.500	5.632	0.416	0.754	0.000	0.000	0.068	-0.140	3.686	-0.004	1.075	0.000	0.000	0.000	0.000
46	SEPB	1	17.000	4.743	0.173	0.801	0.000	0.000	-0.030	0.010	4.307	-0.410	1.137	0.000	0.000	0.000	0.000
47	D04B	1	20.500	6.193	-0.587	0.912	0.000	0.000	0.003	0.010	10.504	-1.360	1.224	0.000	0.000	0.000	0.000
48	QF3B	1	20.780	4.691	5.367	0.920	0.000	0.000	0.003	-0.015	15.196	-17.146	1.227	0.000	0.000	0.000	0.000
49	D03B	1	20.910	3.403	4.541	0.925	0.000	0.000	0.001	-0.015	19.982	-19.670	1.229	0.000	0.000	0.000	0.000
50	QD2B	1	21.250	3.017	-3.100	0.945	0.000	0.000	-0.001	0.004	15.972	27.919	1.231	0.000	0.000	0.000	0.000
51	D02B	1	21.380	3.882	-3.558	0.951	0.000	0.000	0.000	0.004	9.539	21.567	1.233	0.000	0.000	0.000	0.000
52	QF1B	1	21.560	4.541	0.096	0.958	0.000	0.000	0.000	0.000	4.210	9.620	1.237	0.000	0.000	0.000	0.000
53	D01B	1	21.993	4.500	0.000	0.973	0.000	0.000	0.000	0.000	0.045	0.000	1.471	0.000	0.000	0.000	0.000
54	IP2	1	21.993	4.500	0.000	0.973	0.000	0.000	0.000	0.000	0.045	0.000	1.471	0.000	0.000	0.000	0.000
END	LBETB	1	21.993	4.500	0.000	0.973	0.000	0.000	0.000	0.000	0.045	0.000	1.471	0.000	0.000	0.000	0.000
END	HSHORT	1	21.993	4.500	0.000	0.973	0.000	0.000	0.000	0.000	0.045	0.000	1.471	0.000	0.000	0.000	0.000
BEGIN	HLONG	1	21.993	4.500	0.000	0.973	0.000	0.000	0.000	0.000	0.045	0.000	1.471	0.000	0.000	0.000	0.000
BEGIN	LBETC	1	21.993	4.500	0.000	0.973	0.000	0.000	0.000	0.000	0.045	0.000	1.471	0.000	0.000	0.000	0.000
55	D01C	1	22.426	4.541	-0.096	0.988	0.000	0.000	0.000	0.000	4.211	-9.620	1.705	0.000	0.000	0.000	0.000
56	QF1C	1	22.606	3.882	3.558	0.995	0.000	0.000	0.000	0.004	9.540	-21.567	1.709	0.000	0.000	0.000	0.000
57	D02C	1	22.736	3.017	3.100	1.001	0.000	0.000	0.001	0.004	15.973	-27.919	1.711	0.000	0.000	0.000	0.000
58	QD2C	1	23.076	3.403	-4.541	1.020	0.000	0.000	-0.001	-0.015	19.982	19.670	1.713	0.000	0.000	0.000	0.000
59	D03C	1	23.206	4.691	-5.367	1.025	0.000	0.000	-0.003	-0.015	15.196	17.147	1.715	0.000	0.000	0.000	0.000
60	QF3C	1	23.486	6.193	0.587	1.033	0.000	0.000	-0.003	0.010	10.504	1.360	1.718	0.000	0.000	0.000	0.000
61	D04C	1	26.986	4.743	-0.173	1.145	0.000	0.000	0.030	0.010	4.307	0.410	1.805	0.000	0.000	0.000	0.000
62	SEPC	1	28.486	5.632	-0.416	1.192	0.000	0.000	-0.068	-0.140	3.686	0.004	1.867	0.000	0.000	0.000	0.000
END	LBETC	1	28.486	5.632	-0.416	1.192	0.000	0.000	-0.068	-0.140	3.686	0.004	1.867	0.000	0.000	0.000	0.000
BEGIN	ARC1C	1	28.486	5.632	-0.416	1.192	0.000	0.000	-0.068	-0.140	3.686	0.004	1.867	0.000	0.000	0.000	0.000
63	D39E	1	29.786	7.065	-0.687	1.225	0.000	0.000	-0.251	-0.140	4.135	-0.349	1.921	0.000	0.000	0.000	0.000
64	D40E	1	30.286	7.804	-0.791	1.235	0.000	0.000	-0.321	-0.140	4.552	-0.485	1.939	0.000	0.000	0.000	0.000
65	QF19E	1	30.586	7.515	1.722	1.242	0.000	0.000	-0.347	-0.029	5.356	-2.283	1.949	0.000	0.000	0.000	0.000
66	D41E	1	31.286	5.363	1.353	1.259	0.000	0.000	-0.367	-0.029	9.120	-3.094	1.965	0.000	0.000	0.000	0.000
67	QD20E	1	31.586	5.339	-1.269	1.268	0.000	0.000	-0.403	-0.213	9.637	1.455	1.970	0.000	0.000	0.000	0.000
68	D42E	1	32.146	6.914	-1.543	1.283	0.000	0.000	-0.522	-0.213	8.109	1.274	1.980	0.000	0.000	0.000	0.000
69	B05E	1	33.246	6.098	2.126	1.307	0.000	0.000	-0.170	0.820	5.698	0.918	2.006	0.000	0.000	0.000	0.000
70	D43E	1	33.846	3.873	1.583	1.327	0.000	0.000	0.322	0.820	4.713	0.724	2.025	0.000	0.000	0.000	0.000
71	QD21E	1	34.146	3.629	-0.723	1.340	0.000	0.000	0.604	1.093	3.560	2.887	2.036	0.000	0.000	0.000	0.000
72	D44E	1	34.496	4.187	-0.870	1.354	0.000	0.000	0.987	1.093	1.860	1.969	2.058	0.000	0.000	0.000	0.000
73	QF22E	1	34.796	3.928	1.677	1.366	0.000	0.000	1.211	0.380	1.153	0.536	2.091	0.000	0.000	0.000	0.000
74	D45E	1	34.996	3.296	1.483	1.375	0.000	0.000	1.287	0.380	0.983	0.313	2.122	0.000	0.000	0.000	0.000
75	SF11E	1	35.096	3.009	1.386	1.380	0.000	0.000	1.325	0.380	0.932	0.201	2.138	0.000	0.000	0.000	0.000
76	D46E	1	35.296	2.493	1.192	1.391	0.000	0.000	1.401	0.380	0.896	-0.022	2.173	0.000	0.000	0.000	0.000
END	ARC1C	1	35.296	2.493	1.192	1.391	0.000	0.000	1.401	0.380	0.896	-0.022	2.173	0.000	0.000	0.000	0.000
BEGIN	BW3E	1	35.296	2.493	1.192	1.391	0.000	0.000	1.401	0.380	0.896	-0.022	2.173	0.000	0.000	0.000	0.000
BEGIN	M1WIG	2	35.296	2.493	1.192	1.391	0.000	0.000	1.401	0.380	0.896	-0.022	2.173	0.000	0.000	0.000	0.000
77	BWI	3	35.421	2.211	1.071	1.400	0.000	0.000	1.457	0.519	0.901	-0.023	2.196	0.000	0.000	0.000	0.000
78	BWM	5	35.671	1.742	0.831	1.420	0.000	0.000	1.551	0.239	0.913	-0.022	2.240	0.000	0.000	0.000	0.000

Horizontal Crossing   "MAD" VERSION: 4.03   RUN: 00/00/00 00:00:00
TWISS PARAMETERS FOR BEAM LINE "HALF"   DELTA(P)/P =   0.000000   SYMM = F   PAGE   3

POS. NO.	ELEMENT NAME	OCC. NO.	DIST [M]	BETAX [M]	ALFAX	MUX [2PI]	X(CO) [MM]	X'(CO) [MRAD]	DX [M]	DX'	BETAY [M]	ALFAY	MUY [2PI]	Y(CO) [MM]	Y'(CO) [MRAD]	DY [M]	DY'
79	BWP	3	35.921	1.391	0.592	1.445	0.000	0.000	1.644	0.519	0.923	-0.015	2.284	0.000	0.000	0.000	0.000
80	BWM	6	36.171	1.158	0.352	1.476	0.000	0.000	1.738	0.239	0.927	-0.003	2.327	0.000	0.000	0.000	0.000
81	BWP1	2	36.296	1.107	0.232	1.494	0.000	0.000	1.793	0.375	0.909	0.004	2.349	0.000	0.000	0.000	0.000
END	M1WIG	2	36.296	1.107	0.232	1.494	0.000	0.000	1.793	0.375	0.909	0.004	2.349	0.000	0.000	0.000	0.000
BEGIN	M2WIG	2	36.296	1.107	0.232	1.494	0.000	0.000	1.793	0.375	0.909	0.004	2.349	0.000	0.000	0.000	0.000
82	BWP2	2	36.421	1.043	0.113	1.512	0.000	0.000	1.831	0.519	0.925	0.010	2.371	0.000	0.000	0.000	0.000
83	BWM	7	36.671	1.047	-0.127	1.550	0.000	0.000	1.925	0.239	0.918	0.020	2.415	0.000	0.000	0.000	0.000
84	BWP	4	36.921	1.169	-0.367	1.586	0.000	0.000	2.018	0.519	0.906	0.023	2.459	0.000	0.000	0.000	0.000
85	BWM	8	37.171	1.409	-0.606	1.617	0.000	0.000	2.112	0.239	0.895	0.020	2.504	0.000	0.000	0.000	0.000
86	BWI	4	37.296	1.575	-0.727	1.630	0.000	0.000	2.150	0.378	0.890	0.017	2.526	0.000	0.000	0.000	0.000
END	M2WIG	2	37.296	1.575	-0.727	1.630	0.000	0.000	2.150	0.378	0.890	0.017	2.526	0.000	0.000	0.000	0.000
END	BW3E	1	37.296	1.575	-0.727	1.630	0.000	0.000	2.150	0.378	0.890	0.017	2.526	0.000	0.000	0.000	0.000
BEGIN	ARC2C	1	37.296	1.575	-0.727	1.630	0.000	0.000	2.150	0.378	0.890	0.017	2.526	0.000	0.000	0.000	0.000
87	D47E	1	37.796	2.545	-1.213	1.671	0.000	0.000	2.339	0.378	1.154	-0.544	2.608	0.000	0.000	0.000	0.000
88	QF23E	1	38.096	2.554	1.184	1.688	0.000	0.000	2.118	-1.815	2.024	-2.629	2.641	0.000	0.000	0.000	0.000
89	D48E	1	38.466	1.807	0.836	1.716	0.000	0.000	1.447	-1.815	4.504	-4.074	2.661	0.000	0.000	0.000	0.000
90	QD24E	1	38.766	1.793	-0.784	1.744	0.000	0.000	1.061	-0.808	5.873	-0.108	2.670	0.000	0.000	0.000	0.000
91	D49E	1	39.016	2.241	-1.009	1.764	0.000	0.000	0.859	-0.808	5.937	-0.151	2.676	0.000	0.000	0.000	0.000
92	SD12E	1	39.116	2.452	-1.099	1.770	0.000	0.000	0.778	-0.808	5.969	-0.168	2.679	0.000	0.000	0.000	0.000
93	D50E	1	39.366	3.057	-1.324	1.785	0.000	0.000	0.576	-0.808	6.064	-0.211	2.686	0.000	0.000	0.000	0.000
94	B06E	1	40.684	3.978	0.845	1.838	0.000	0.000	0.000	0.000	6.921	-0.438	2.718	0.000	0.000	0.000	0.000
95	D51E	1	41.634	2.761	0.436	1.884	0.000	0.000	0.000	0.000	7.909	-0.602	2.739	0.000	0.000	0.000	0.000
96	SF13E	1	41.734	2.678	0.393	1.890	0.000	0.000	0.000	0.000	8.031	-0.619	2.741	0.000	0.000	0.000	0.000
97	D52E	1	41.984	2.509	0.285	1.905	0.000	0.000	0.000	0.000	8.352	-0.662	2.746	0.000	0.000	0.000	0.000
98	QD25E	1	42.284	2.703	-0.960	1.924	0.000	0.000	0.000	0.000	7.693	2.763	2.751	0.000	0.000	0.000	0.000
99	D53E	1	42.576	3.324	-1.168	1.939	0.000	0.000	0.000	0.000	6.175	2.435	2.758	0.000	0.000	0.000	0.000
100	SD14E	1	42.676	3.565	-1.239	1.944	0.000	0.000	0.000	0.000	5.699	2.323	2.761	0.000	0.000	0.000	0.000
101	D54E	1	43.626	6.560	-1.914	1.976	0.000	0.000	0.000	0.000	2.299	1.257	2.803	0.000	0.000	0.000	0.000
102	QF26E	1	43.926	7.138	0.045	1.982	0.000	0.000	0.000	0.000	1.813	0.408	2.827	0.000	0.000	0.000	0.000
103	D55E	1	46.426	7.789	-0.306	2.037	0.000	0.000	0.000	0.000	3.794	-1.200	3.028	0.000	0.000	0.000	0.000
104	QF27E	1	46.726	6.888	3.160	2.043	0.000	0.000	0.000	0.000	5.225	-3.801	3.039	0.000	0.000	0.000	0.000
105	D56E	1	46.880	5.953	2.915	2.047	0.000	0.000	0.000	0.000	6.466	-4.256	3.043	0.000	0.000	0.000	0.000
106	SD15E	1	46.980	5.386	2.755	2.050	0.000	0.000	0.000	0.000	7.346	-4.551	3.045	0.000	0.000	0.000	0.000
107	D57E	1	47.130	4.595	2.516	2.055	0.000	0.000	0.000	0.000	8.778	-4.995	3.048	0.000	0.000	0.000	0.000
108	QD28E	1	47.280	4.228	0.000	2.060	0.000	0.000	0.000	0.000	9.549	0.000	3.051	0.000	0.000	0.000	0.000
END	ARC2C	1	47.280	4.228	0.000	2.060	0.000	0.000	0.000	0.000	9.549	0.000	3.051	0.000	0.000	0.000	0.000
END	HLONG	1	47.280	4.228	0.000	2.060	0.000	0.000	0.000	0.000	9.549	0.000	3.051	0.000	0.000	0.000	0.000
END	HALF	1	47.280	4.228	0.000	2.060	0.000	0.000	0.000	0.000	9.549	0.000	3.051	0.000	0.000	0.000	0.000

TOTAL LENGTH =	47.280145				
		MUX =	2.060098	MUY =	3.050996
		MUX' =	3.354276	MUY' =	-3.339868
		BETAX(MAX) =	8.796845	BETAY(MAX) =	19.982105
		DX(MAX) =	2.339198	DY(MAX) =	0.000000

... END OF "TWISS" COMMAND, ELAPSED CPU TIME =   0.000 SECONDS

TABLE V- Parameter list

Energy (MeV)	510.		
Circumference (m)	94.56	β_y @ IP (m)	.045
Dipole b. radius (m)	1.400	β_x @ IP (m)	4.5
Wiggler b. radius(m)	0.9	κ_β	.01
Wiggler length (m)	2.0		
Wiggler period (m)	0.5		
Horizontal β-tune	4.12	σ_y @ IP (mm)	.021
Vertical β-tune	6.10	σ_x @ IP (mm)	2.11
Natural chromaticities:			
Horizontal	-4.8	Crossing half angle (mrad)	10.0
Vertical	-17.8		
		Damping times (msec):	
Mom. compaction	.0068	τ_s	11.6
I_2 (m^{-1})	14.4	τ_x	24.0
I_3 (m^{-2})	14.2	τ_y	23.4
Energy loss/turn (KeV) :			
Bend. magnets	4.27	F_{RF} (MHz)	380.44
Wigglers	9.41	Harmonic number	120
Septa	.057	Max. N^{er} Part./bunch	9.10^{10}
Low β q-poles	.011	N^{er} of bunches	1 ÷ 120
	______	V_{RF} (KV) @ Z/n = 2 Ω	241
Total	13.75	@ Z/n = 1 Ω	122
		Par. losses (KeV/Ω)	4.0
		Bunch length σ_z (cm)	3.0
Nat. emit. (m-rad) :	$.95\ 10^{-6}$	Bunch peak curr. (A)	57
		Max. av. curr./bunch(mA)	46
Relative rms en. spread	$4.31\ 10^{-4}$	Max. total av.curr.(A)	5.5
		Max.synch.power/beam(KW)	75.6

TABLE VI - Sextupoles configuration

**** MULTIPOLE-STRUCTURE IN ONE FULL-SUPERPERIOD ****

	J	MULTIPOLE	<BETX(m)>	<BETY(m)>	< MUX>	< MUY>	<ETAX(m)>	Ks(m-2)	G(T/m2)
1. MULTIPOLE AT: J =	22	SD1E	1.595	5.983	0.429	0.531	1.025	11.95018	203.5
2. MULTIPOLE AT: J =	39	SF2E	3.771	0.962	0.744	1.082	1.534	-7.31293	124.3
3. MULTIPOLE AT: J =	48	SD3E	5.027	6.318	0.859	1.242	0.000	6.00000	102.0
4. MULTIPOLE AT: J =	52	SF4E	6.955	4.283	0.887	1.265	0.000	-1.00000	17.0
5. MULTIPOLE AT: J =	56	SF5E	6.735	2.575	0.901	1.308	0.000	-2.00000	34.0
6. MULTIPOLE AT: J =	66	SF6E	6.735	2.575	1.045	1.634	0.000	-2.00000	34.0
7. MULTIPOLE AT: J =	70	SF7E	6.955	4.283	1.059	1.677	0.000	-1.00000	17.0
8. MULTIPOLE AT: J =	74	SD8E	5.027	6.318	1.087	1.700	0.000	3.00000	51.0
9. MULTIPOLE AT: J =	83	SF9E	3.771	0.962	1.201	1.860	1.534	-7.31293	124.3
10. MULTIPOLE AT: J =	100	SD10E	1.595	5.983	1.516	2.411	1.025	11.95018	203.5
11. MULTIPOLE AT: J =	147	SF11E	3.150	0.955	2.350	3.601	1.306	-7.31293	124.3
12. MULTIPOLE AT: J =	164	SD12E	2.344	5.954	2.740	4.149	0.819	11.95018	203.5
13. MULTIPOLE AT: J =	168	SF13E	2.718	7.971	2.860	4.211	0.000	-12.00000	204.0
14. MULTIPOLE AT: J =	172	SD14E	3.443	5.936	2.915	4.230	0.000	5.00000	85.0
15. MULTIPOLE AT: J =	181	SD15E	5.666	6.897	3.021	4.515	0.000	4.00000	68.0
16. MULTIPOLE AT: J =	186	SD16E	5.666	6.897	3.045	4.529	0.000	3.00000	51.0
17. MULTIPOLE AT: J =	195	SD17E	3.443	5.936	3.151	4.814	0.000	4.00000	68.0
18. MULTIPOLE AT: J =	199	SF18E	3.509	7.201	3.243	4.848	0.000	-13.00000	221.0
19. MULTIPOLE AT: J =	203	SD19E	2.344	5.954	3.326	4.895	0.819	11.95018	203.5
20. MULTIPOLE AT: J =	220	SF20E	3.150	0.955	3.716	5.443	1.306	-7.31293	124.3

TOTAL NUMBER OF MULTIPOLES IN STORAGE RING: 20