DAΦNE TECHNICAL NOTE

INFN - LNF, Accelerator Division

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Note: **L-2**

DAΦNE ACCUMULATOR RING DYNAMIC APERTURE

M. E. Biagini

To optimize injection efficiency it has been chosen to inject in DAΦNE a damped beam from an accumulator ring(1), instead of a Linac beam. For efficiency we mean here reducing radiation losses at injection in the main ring, and injecting without saturation the high currents needed with a shorter bunch length, smaller emittance and energy spread.

To increase the injection rate in the storage ring, it is very important to have a big energy acceptance for small and large amplitude particles in the accumulator. To study the dynamic apertures in different cases the program Patricia(2) has been used. The unperturbed tunes of the machine are Q_x = 2.89 and Q_y = 1.13. The natural chromaticity is -4.43 in the horizontal plane and -4.08 in the vertical one. All calculations have been performed for a chromaticity value corrected to +1 in both planes.

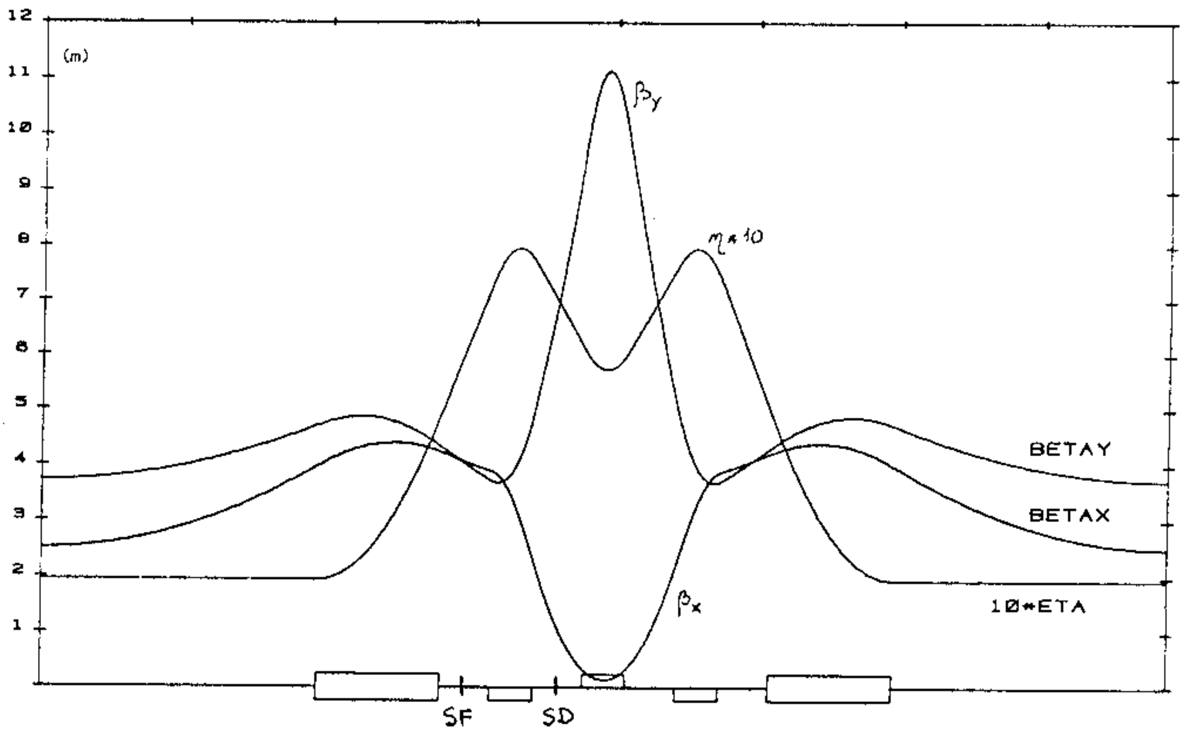

Fig. 1- *Optical functions for one fourth of the machine.*

Two different sextupoles arrangements have been studied. First, to set the chromaticity to the wanted value, two families have been inserted in each period (configuration A). Fig. 1 shows the optical functions for one fourth of the lattice, with the sextupoles locations for this configuration.

Since the free space available between the quadrupoles does not seem sufficient to accommodate concentrated sextupoles, a second configuration has been studied, with distributed sextupole fields inside the quadrupoles (configuration B).

Tabs. I and II give the sextupoles strengths for the two cases. The gradients are calculated for the first case with .2 m and for the second with .3 m long sextupoles.

TABLE I - Sextupole strengths for configuration A.

	J	MULTIPOLE	<BETX(M)>	<BETY(M)>	<PHIX>	<PHIY>	<ETAX(M)>	SM(1/M**2)	G(T/M**2)
1. MULTIPOLE AT: J =	5	SF	4.041	3.992	0.143	0.112	0.614	-9.07587	77.1
2. MULTIPOLE AT: J =	9	SD	1.034	7.226	0.183	0.136	0.687	7.70211	65.5

TOTAL NUMBER OF MULTIPOLES IN STORAGE RING: 8

		WITHOUT SEXTUPOLES		WITH SPEC.SEXTUPOLES		WITH ALL SEXTUPOLES		CHROMATICITY WANTED
CHROMATICITY IN X	=	-4.43358	*	-4.43358	*	1.00000	*	1.00000
CHROMATICITY IN Y	=	-4.07637	*	-4.07637	*	1.00000	*	1.00000

TABLE II - Sextupole strengths for configuration B.

	J	MULTIPOLE	<BETX(M)>	<BETY(M)>	<PHIX>	<PHIY>	<ETAX(M)>	SM(1/M**2)	G(T/M**2)
1. MULTIPOLE AT: J =	7	SF	3.361	3.882	0.157	0.126	0.794	-3.28371	18.6
2. MULTIPOLE AT: J =	12	SD	0.137	11.133	0.361	0.141	0.571	5.68707	32.2
3. MULTIPOLE AT: J =	17	SF	3.361	3.882	0.566	0.157	0.794	-3.28371	18.6

TOTAL NUMBER OF MULTIPOLES IN STORAGE RING: 12

		WITHOUT SEXTUPOLES		WITH SPEC.SEXTUPOLES		WITH ALL SEXTUPOLES		CHROMATICITY WANTED
CHROMATICITY IN X	=	-4.43358	*	-4.43358	*	1.00000	*	1.00000
CHROMATICITY IN Y	=	-4.07637	*	-4.07637	*	1.00000	*	1.00000

Since the energy acceptance required in the accumulator is $\Delta p/p \approx$ 1.5%, the tune behaviour for particles with energy deviation up to this value have been calculated, as shown in Figs. (2a) and (2b) for the two configurations respectively. The tune behaviour for the two cases are almost the same.

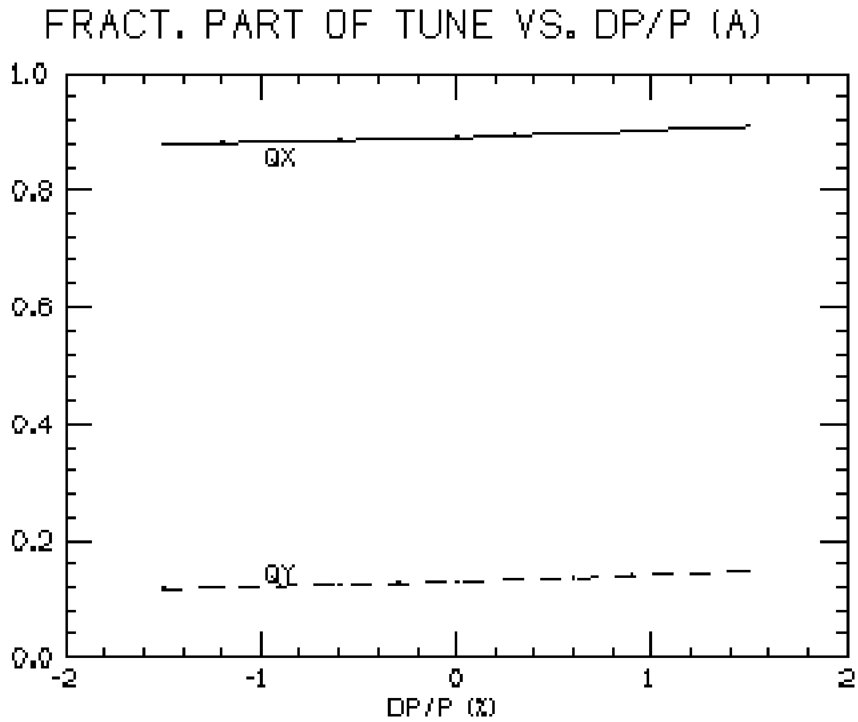

Fig. 2 *a)- Fract. part of horizontal and vertical tunes vs. Δp/p. Conf. A.*

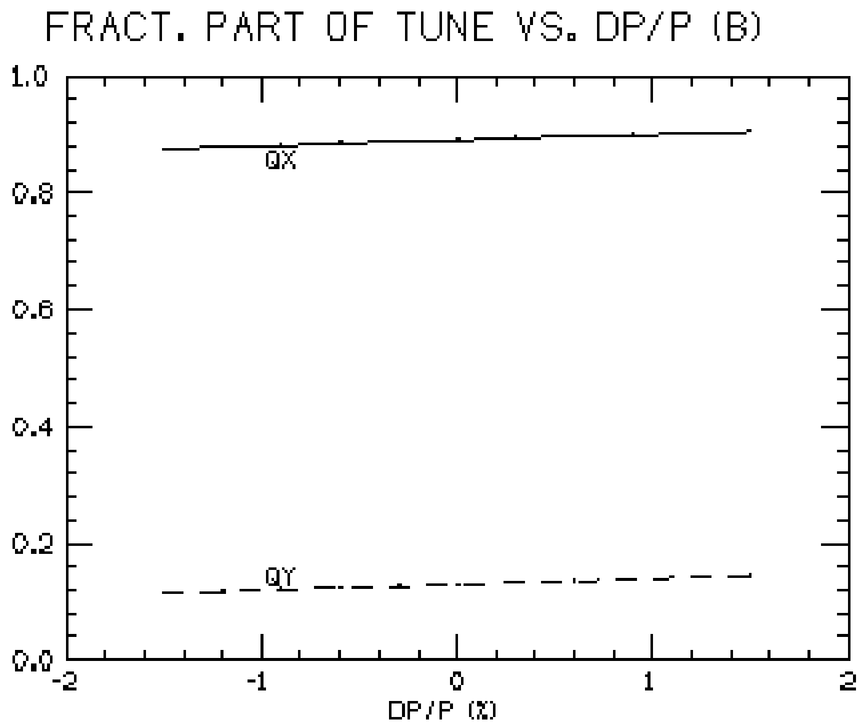

Fig. 2 *b)- Fract. part of horizontal and vertical tunes vs. Δp/p. Conf. B.*

Figs. (3a) and (3b) show the betas and dispersion behaviours vs. $\Delta p/p$.

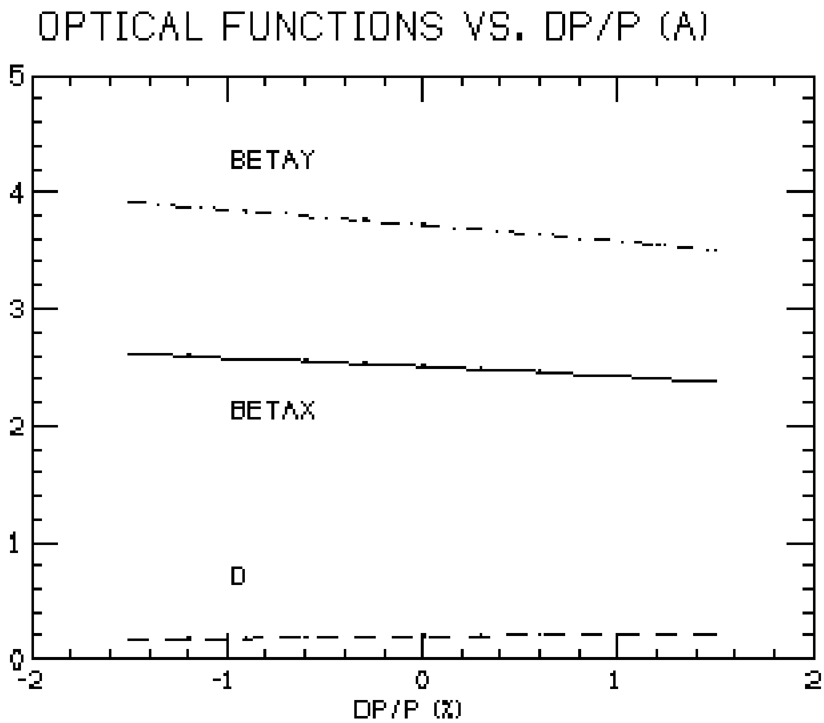

Fig. 3 *a)- Optical functions vs. $\Delta p/p$:. Conf. A.*

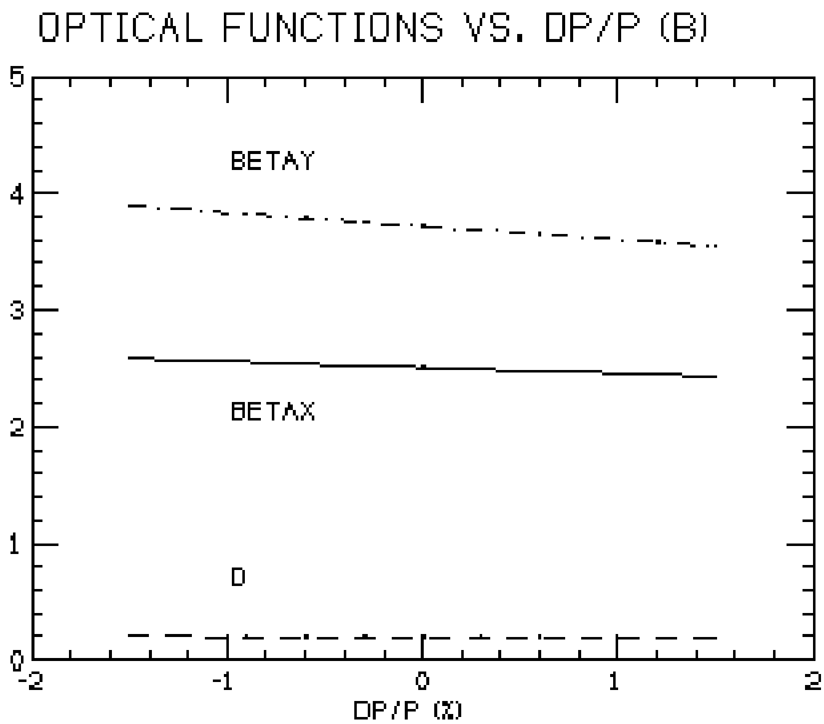

Fig. 3 *b)- Optical functions vs. $\Delta p/p$:. Conf. B.*

Tracking of particles over 1000 turns (about 1/100 of the transverse damping time) has been performed, showing that the dynamic aperture is very large in both cases, even if, of course, configuration β is favourite since it corresponds to a local chromaticity correction.

For comparison, the two cases are shown in Fig.4, where the aperture in mm is also shown. The aperture, in both cases, it is adequate to accommodate the incoming beam without efficiency losses.

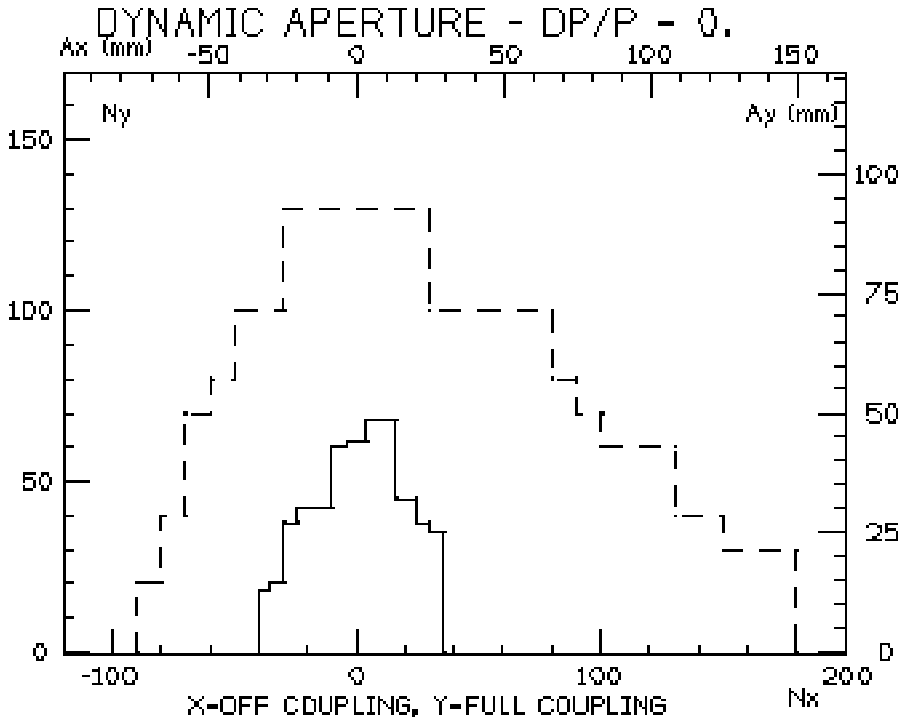

Fig. *4 - Dynamic aperture for on-momentum particles:*
Configuration A : solid line
Configuration B : dashed line

For the most favourable configuration (B), a study of the dynamic aperture, in number of sigmas, for off momentum particles has been carried out, as shown in Fig. 5. The $\Delta p/p$=1.5% value corresponds to particles with a 38 σ_p momentum deviation. The tune behaviour for particles with different amplitudes and for different momentum deviations, has been studied.

The results are shown in Fig. 6 for the horizontal plane and in Fig. 7 for the vertical one.

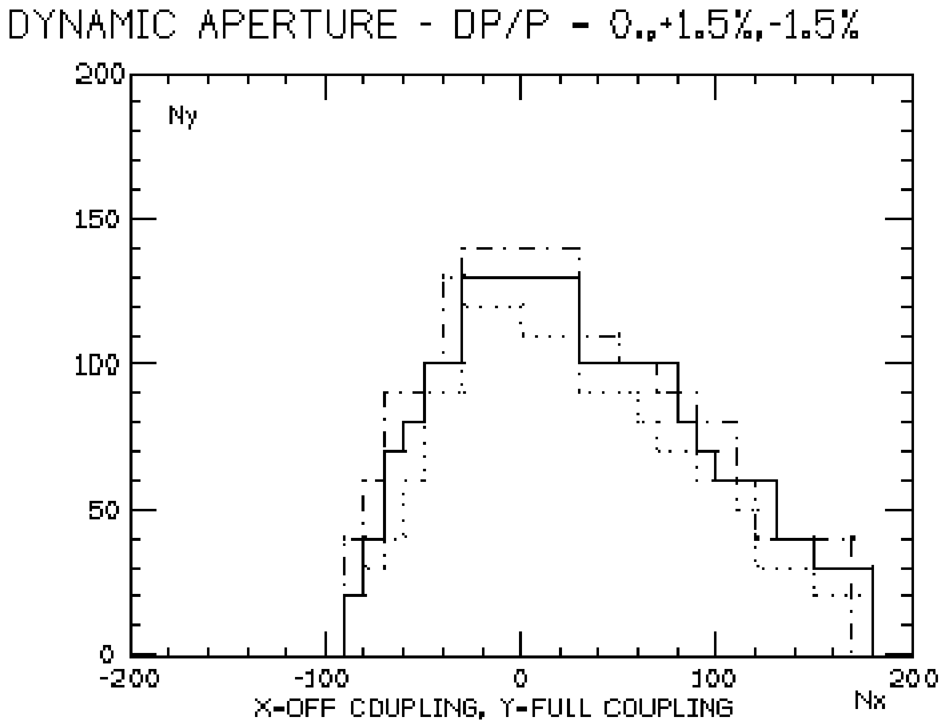

Fig. 5 - *Dynamic aperture for off-momentum particles (Configuration B):*
SOLID LINE: $\Delta p/p=0$. DOTTED LINE: $\Delta p/p=+1.5\%$ DOT-DASHED LINE: $\Delta p/p=-1.5\%$

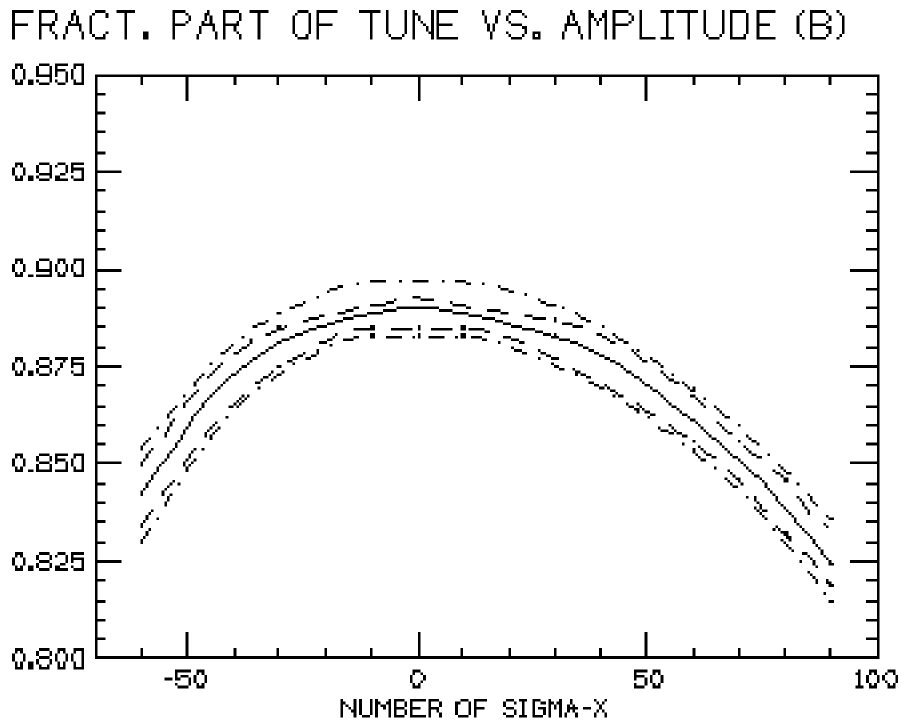

Fig. 6 - *Horizontal tune shift on amplitude for off-momentum particles (Configuration B):*
SOLID LINE: $\Delta p/p=0$. DASHED LINE: $\Delta p/p=1\%$ DOT-DASHED LINE: $\Delta p/p=1.5\%$

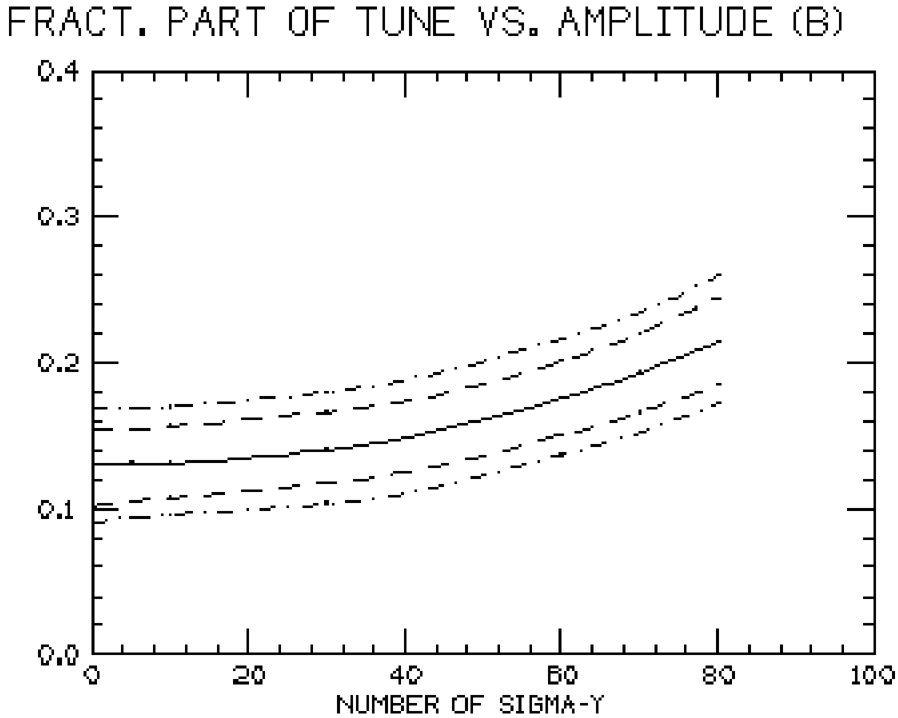

Fig. 7 - *Vertical tune shift on amplitude for off-momentum particles (Configuration B):*
SOLID LINE: $\Delta p/p=0.$ DASHED LINE: $\Delta p/p=1\%$ DOT-DASHED LINE: $\Delta p/p=1.5\%$

References

(1) M. Preger, "A positron and electron accumulator for DAΦNE", DAΦNE Technical Note I-1 (1990).

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