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ISR PERFORMANCE REPORT

Run 1073, both rings at 22 GeV, 12.11.79, 13-24 hrs

Abstract

In order to increase the beam-beam tune-shift of a bunched beam colliding with a coasting beam in the ISR, the values of β_V^* for the bunched beam were increased by retuning the machine and powering the tuning quads. For the measured tunes, the AGS program yields values of β_V^* = 50 m in all 8 intersections. With the final effective height of 5.7 mm, this should yield a beam-beam tune-shift of 4.2 x 10^{-3} per intersection. The measured tune-shift was considerably less, and corresponds to only 2.4 x 10^{-3} per intersection for small amplitude particles. The luminosity decayed with about 19%/hour, of which about 12% are explained by the decay of the current in the bunched beam which was close to a 3rd order resonance. In order to decide whether the residual 7% were due to beam-beam effect, the experiment will be repeated under the same conditions.

Experiment

1. The working line for ring 2 had been previously calculated with AGS and is shown in Table 1. It should have given a β_V^* of 60 m in all 8 intersections. Attempts to inject directly onto that line were unsuccessful. It was then decided to reduce Q_V in steps, and optimize injection and orbits every time. Q_V values close to the desired 8.09 could be reached in this manner but the bunches were lost when accelerated from injection to central orbit.

2. The injection was then moved as close as possible to central orbit (- 6 mm), and the procedure was repeated. At injection, Q_V = 8.108 and Q_H = 8.716 was obtained. The chromaticity was measured by accelerating bunches up to 38 mm, and readjusted to Q_V' = 1.75, Q_H' = 0.7. A stack of about 1 A could be made in ring 2.

3. In the meantime, ring 1 had been prepared for making a large stack at ELSA working line. During stacking in ring 1, we attempted to measure β_v^* in ring 2. Since there were no quadrupoles available near the intersections for a direct measurement (the low-beta lenses cannot be used for small changes close to zero), the vertical phase-shift across the intersections was measured by exciting the beam transversely and comparing two pick-up signals with the FFT. The resulting values of 150 to 175^o, somewhat lower than the originally calculated 120^o, indicating a somewhat smaller value of β_v^*. This is in agreement with AGS output for the actually reached values of the tunes, which yielded β_v^* = 50 m.

4. During stacking in ring 1, and with the beam excited transversely, the current in ring 2 decayed quite rapidly. After 36 A had been reached in ring 1, another stack of about 1 A was made in ring 2 and scraped down to obtain the beam height. At the scraper (β_V = 90 m according to AGS) the h_{eff} was 9 mm, and about 50% shaving was used to make a new stack of 460 mA in ring 2. After the stack was made, with less than 3 hours left for the experiment, the beam in ring 1 was suddenly lost due to unknown causes.

5. A new stack of 32 A was made in ring 1, with 60% shaving, and luminosity optimization was performed in all intersections. The values obtained for h_{eff} were quite low, but some intersections were rather irregular and could not be fitted with a Gaussian. Increasing the step-size of the luminosity program, all intersections could be centred and monitor constants calculated. The average h_{eff} was still only 4 mm and should have yielded a tune-shift of 5.2 x 10^{-3}.

6. With only half an hour left, a bunched beam of 70 mA was injected in ring 2 and luminosity measurement attempted. Unfortunately, the computer got stuck at that moment and could only be used after it was switched off and on again. Luminosity and current decay was then measured during a half-hour extension of the run and are shown in Table 2.

7. At the end of the run, the vertical tune was again measured with RF excitation before and after dumping the beam in ring 1. The tune-shift obtained in this manner was 0.0136 for all intersections, or 1.7×10^{-3} per intersection. Counting for the usual 30% reduction due to finite betatron amplitudes, this yields 2.4×10^{-3} for the small amplitude particles. The effective length had increased to 5.7 mm before the measurement corresponding to 4.2×10^{-3}. This discrepancy may be due to blow-up of the beam during the tune-measurement and/or due to smaller β_v^* than expected.

8. The luminosity decay rate was analysed and was found to be 19.2 ± 4% per hour, while the current decayed by 12.4 ± 0.8%. Even including the accuracy due to the rather short integration time of 110 secs (± 3%), there seems to be a somewhat faster decay of luminosity. The current decay was probably due to the close proximity of a 3rd and 4th order resonance. Adding the inconsistency of the measured and calculated values of ΔQ, and the fact that the initial luminosity decay could not be monitored, it appears desirable to repeat the experiment under the same conditions in the next run foreseen for beam-beam effects.

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Table 1

High β_v^* working line
(computer values)

	$K(m^{-2})$	(% for 22 GeV)
QT1	-.0026	3.67
2	.0006	- 0.80
3	-.0015	2.16
4	-.0008	1.13
5	.0059	- 9.55
6	.0036	- 5.80
7	.0017	- 2.35
8	-.0152	21.30

		$K'(m^{-3})$
F	-.03914	-.0288
D	+.03726	.0103
FS	-	-.1257
DS	-	.1142

(odd/even)

$\beta_v^* = 60/60$ m $\hat{\beta}_v = 196$ m

$\beta_H^* = 20/22$ m $\hat{\beta}_H = 44$ m

$D^* = 2.63/1.85$ m $\hat{D} = 2.76$ m

$Q_v = 8.09$, $Q_v' = 1.6$ $\Delta Q_v = -.50$, $\Delta Q_v' = +1.85$

$Q_H = 8.773$, $Q_H' = 1.6$ $\Delta Q_H = +.12$, $\Delta Q_H' = -.35$

(shift from SP line)

Table 2

Luminosity Decay

t(sec)	L (10^{28} cm^{-2} s^{-1})	$I_2 I_2 (A^2)$	h_{eff} (mm)
0	4.51	2.397	5.31
125	4.41	2.371	5.39
245	4.44	"	5.34
365	4.44	2.346	5.29
505	–	2.320	–
891	4.48	"	5.18
1011	4.24	2.294	5.41
1131	4.34	"	5.23
1251	4.37	"	5.25
1371	4.25	2.268	5.34
1491	4.09	"	5.55
1611	4.11	2.243	5.46
1731	3.95	"	5.68

initial value — linear decay (sec^{-1}) — (correlation coefficient)

$$L = (4.430 \pm .055) - (2.434 \pm 0.501) \times 10^{-4}\ t(\mathrm{sec}), \quad r = 0.84$$

$$I_1 I_2 = (2.384 \pm .005) - (8.208 \pm 0.514) \times 10^{-5}\ t(\mathrm{sec}), \quad r = 0.98$$

$$\frac{dL}{dt} = -\ 19.2\% \pm 4.0\%$$

$$\frac{dI_1 I_2}{dt} = -\ 12.4\% \pm 0.8\%$$

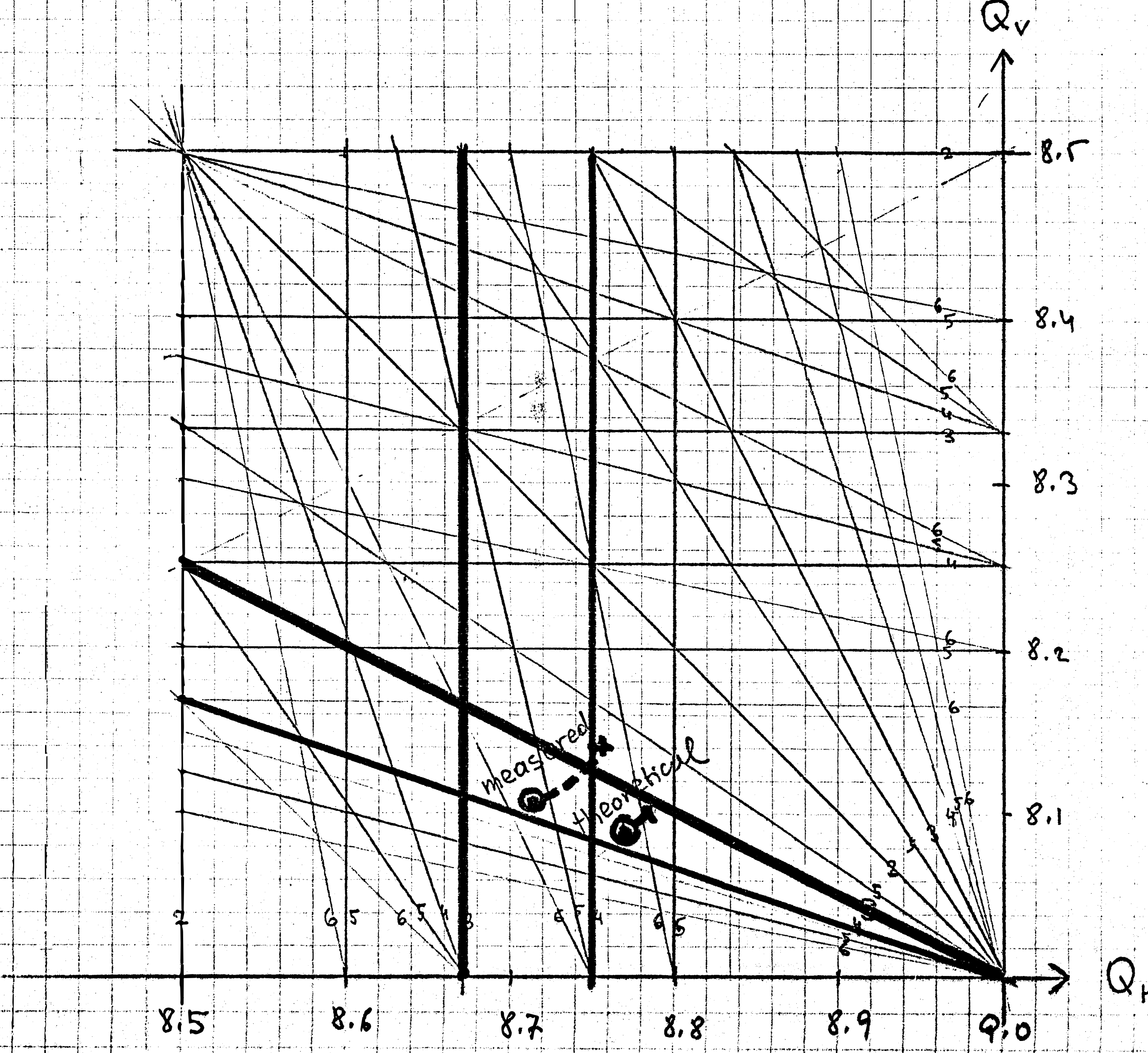

FIG. 1: Working points for high-β machine

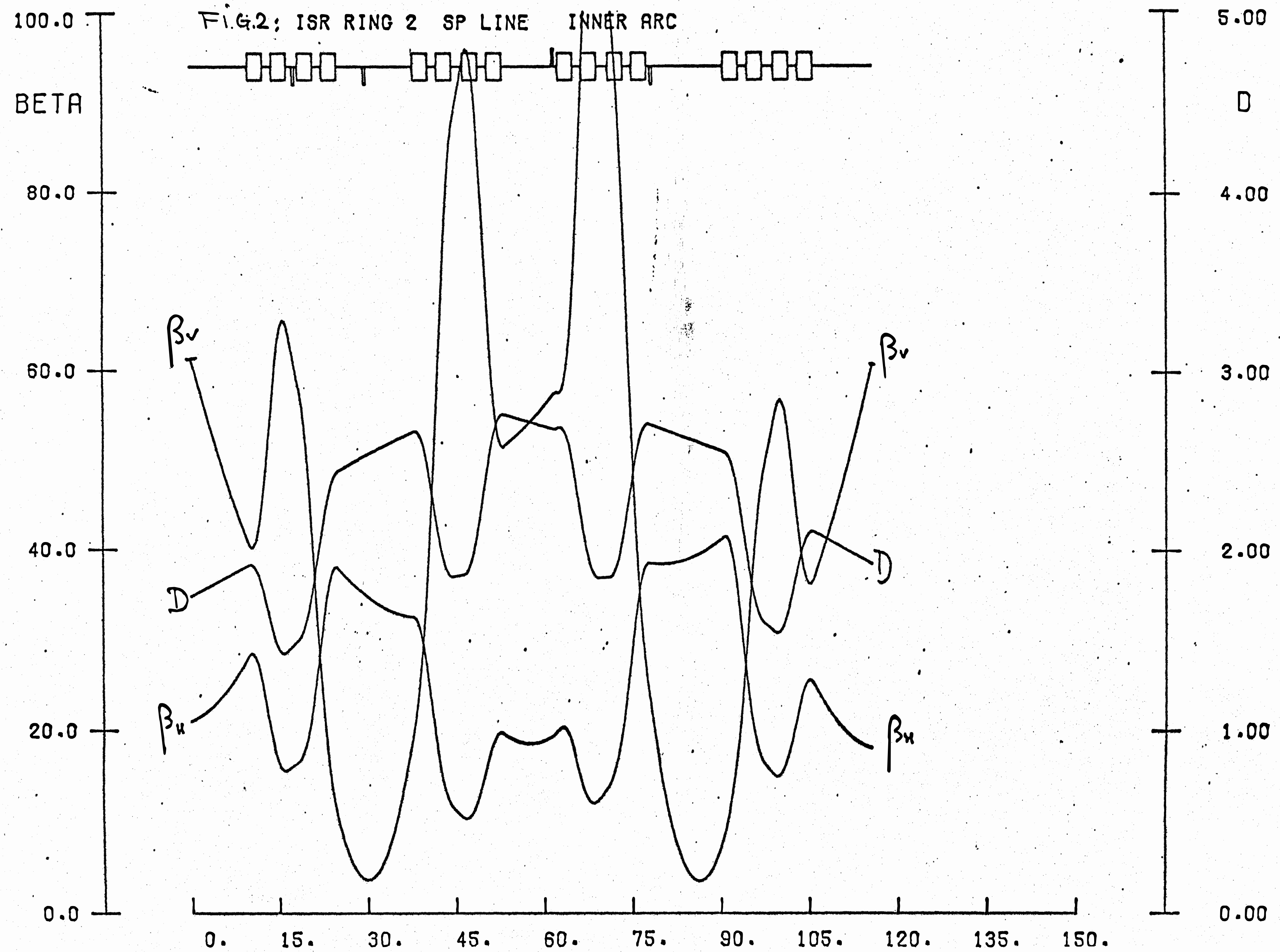
FIG.2; ISR RING 2 SP LINE INNER ARC
BETA
D
100.0
80.0
60.0
40.0
20.0
0.0
5.00
4.00
3.00
2.00
1.00
0.00
0.
15.
30.
45.
60.
75.
90.
105.
120.
135.
150.
βv
D
βH

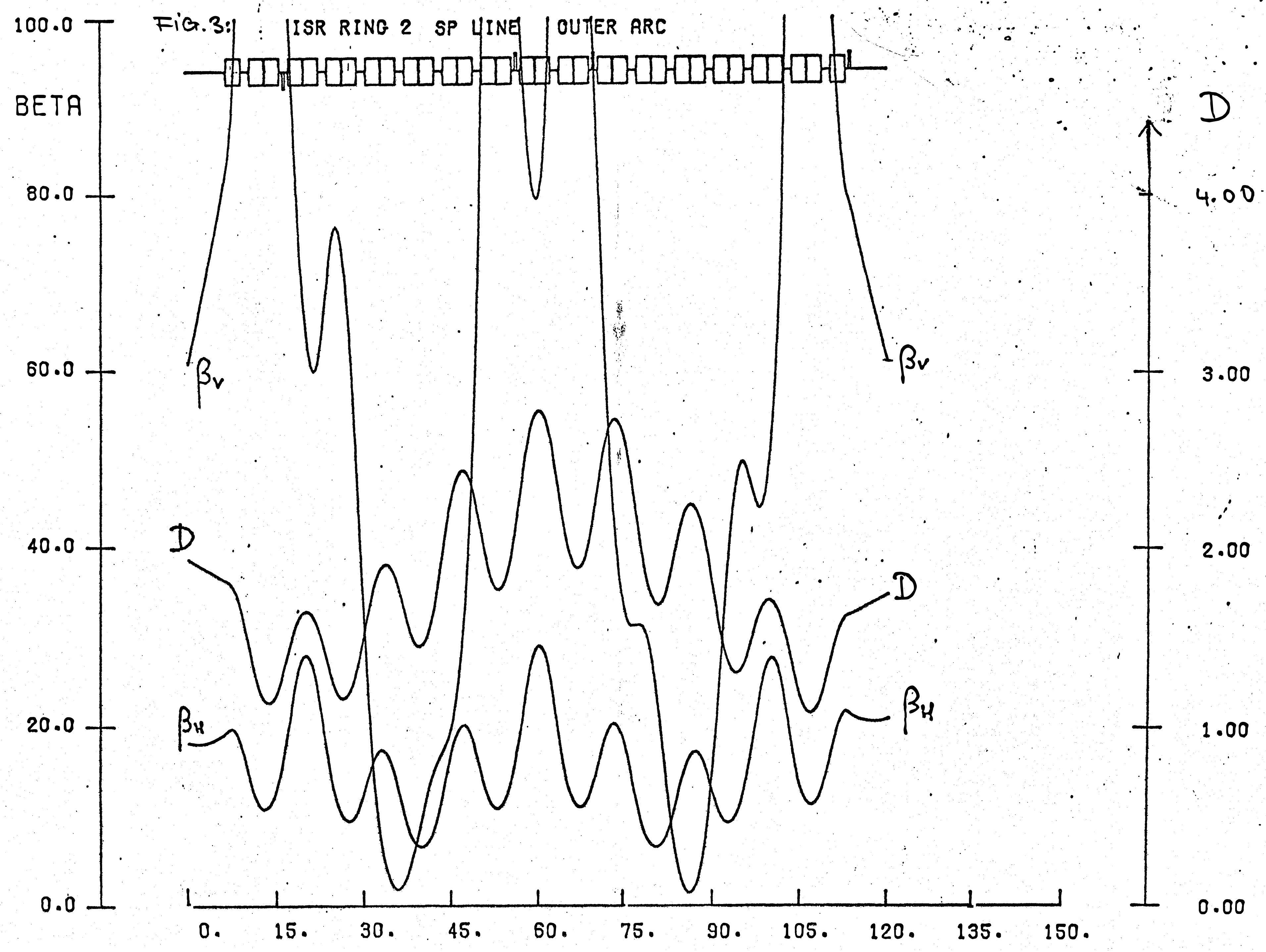

FIG.3: ISR RING 2 SP LINE OUTER ARC
BETA
100.0
80.0
60.0
40.0
20.0
0.0
D
4.00
3.00
2.00
1.00
0.00
β_V
β_V
D
D
β_H
β_H
0.
15.
30.
45.
60.
75.
90.
105.
120.
135.
150.