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ISR PERFORMANCE REPORT

Run 1015, 22.3.79, 26 GeV/c, rings 1 and 2

Run 1017, 26.3.79, 26 GeV/c, rings 1 and 2

First running-in tests of the OAFM system.

1. CONCLUSIONS

The OAFM system is operational for physics.

The working line is unperturbed, and the horizontal and vertical closed orbits behave as foreseen. Resonance excitation is negligible compared to that coming from the beam-beam effect, for orders > 6. Fifth and sixth order resonances are excited to an extent which is several times that of the basic machine (as was found for the I1 solenoid), but this does not create a problem. The coupling excited by the OAFM appears to be in agreement with the predicted value, which is considerably less than that present "naturally" in the ISR.

It appears to be possible to correct the beam tilt produced by the system by judicious use of a few radial field magnets (machine). This works at least as well as the skew quadrupoles which were installed as part of the OAFM system, and it is proposed that the method be used instead of that using the skew quads, because using the latter would excite further coupling which would itself need to be compensated elsewhere.

2. EFFECT OF THE OAFM ON THE CLOSED ORBITS

Both rings were set up for the ELSA working line and the closed orbits were corrected at $\bar{x} \cong -40$ mm, centre and + 40 mm and recorded. The OAFM was put on to 100 % and the dipole compensators were set to the calculated levels (see Fig. 1) of 41.0 % (upstream) and 23.9 % (downstream). Orbits were recorded. Residual distortion was reduced to be as little as possible using the skew quadrupoles (30 %), and by using the closed orbit correction programme COCO (at the top). Results were recorded. A synoptic comparison of the closed orbits with and without the OAFM is given in table I. It can be seen that the correction of tilt using the (machine) radial field magnets gives slightly more satisfactory results than that using the dedicated skew quadrupoles. For this reason, and because the excitation of the dedicated skew quadrupoles would produce an unwanted coupling term which would itself need to be corrected outside the intersection (by means of the ISR skew quadrupole scheme), it was decided to continue the programme using the radial field magnets to make the final correction. The required current settings for the various magnets are given in table II.

Whereas the agreement between measurements of the horizontal closed orbit with and without the OAFM on (Fig. 2) is almost perfect (differences are visible only at the top of the stack, and these are of the order of 0.2 mm), it should be noted that while being adequate for normal use, the vertical closed orbit is slightly different. (An illustration of this small mismatch is given in Fig. 3.) This difference could be reduced by slight adjustment of the dipole compensator settings. The necessary analysis is under way and the modified settings will be tested in a future M.D. run, so that maximum luminosity may be maintained in all intersections when the OAFM is put off or on during a run.

3. RESONANCE EXCITATION

Scans were made with and without the corrected OAFM system. The examples shown in Figure 4 illustrates well the excitation of the fifth and sixth order resonances due to the OAFM, while Figure 5 shows that this excitation remains smaller than the one due to a stack in the other ring. In the run 1017, extensive use was made of the FFT apparatus to hunt for higher order (> 6) resonance excitation in the stacks. It was ascertained that the excitation of these higher order resonances by the OAFM system is negligible compared with that produced by the beam-beam effect. Some relevant scans are shown in Figure 6, where the resonance excitation due to magnet fields is hardly visible, compared with the one due to a beam of 10 A or more. The light drift of the signals taken with a constant central frequency is due to the vertical beam-beam tune shift.

4. STACKING

No problems whatsoever were encountered stacking 30 A beams in both rings with the OAFM (compensated) on. Longitudinal Schottky scans of the stacks are shown in Fig. 7. This Figure also shows that no resonances are visible in the horizontal response of the FFT.

5. COUPLING

During run 1015, the coupling has been carefully measured in order to estimate the vector C due to the OAFM magnet and to calculate the correct compensations. At first the coupling of R1 was compensated with skew quadrupoles as well as possible, the OAFM being turned off. When the OAFM was on, a new measurement of C was performed, which corresponds to the OAFM vector. This vector was found to be .0028 long with a phase of − 105°. Since the measuring accuracy of the coupling meter cannot be better than 10^{-3}, this value is consistent with the value of $|C|$ = .0037 which was calculated using the OAFM field maps.

By then switching off all the skew quadrupoles, the total coupling in the presence of the OAFM has been measured in both rings. It was found to be $|C|$ = .0094 with a phase of − 140° in ring 1 and $|C|$ = .0125 with a phase of − 145° in ring 2. The correction which was put in the machine corresponds to

$C_{real} = + .007$ $\quad$ $C_{im} = .006$ $\quad$ for ring 1

$C_{real} = .010$ $\quad$ $C_{im} = .007$ $\quad$ for ring 2

and the residual coupling was found in run 1017 to be smaller than .003.

This same correction can be considered to apply whether or not the OAFM is being used.

It has been noted that the coupling meter cannot give a good direct measurement when C is smaller than $\sim$ .005, but that small vectors can be deduced from measurements done with the additions of real and imaginary C-components. A fit on these measurements shows that, if the created real components are effectively real, the created imaginary components are slightly inclined by an angle of the order of 10°. This has been investigated in run 1027 and will be described in another report.

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TABLE I

COMPARISON OF CLOSED ORBITS WITH AND WITHOUT THE OAFM
(RUN 1015, 26 GeV/c)

		PEAK-TO-PEAK (AND R.M.S.) DISTORTION					
		VERTICAL			HORIZONTAL		
	RADIAL POSITION	−40	0	+40	−40	0	+40
	CONDITION	(ALL VALUES IN MM)			(ALL VALUES IN MM)		
RING 1	OAFM OFF	8.5 (1.6)	5.8 (1.2)	7.8 (1.5)	11.6 (2.6)	7.4 (1.8)	6.0 (1.5)
	ON *	8.9 (1.5)	6.8 (1.7)	16.0 (4.4)	11.1 (2.6)	6.4 (1.7)	7.1 (1.7)
	+ SKEW (30%)	9.9 (2.2)	7.3 (1.9)	8.9 (2.1)	10.4 (2.5)	6.7 (1.8)	7.2 (1.7)
	+ 1H617 (−8.4%)	8.8 (2.0)	7.5 (1.7)	8.2 (1.9)	10.2 (2.4)	6.7 (1.7)	8.2 (1.9)
RING 2	OAFM OFF	6.2 (1.3)	5.9 (1.2)	5.7 (1.2)	12.5 (2.8)	8.3 (2.0)	8.4 (2.0)
	ON *	5.7 (1.4)	5.9 (1.4)	13.6 (3.5)	12.1 (2.7)	8.0 (2.1)	9.0 (2.1)
	+ SKEW (30%)	7.5 (1.9)	5.5 (1.4)	7.5 (1.9)	11.7 (2.7)	8.2 (2.1)	9.4 (2.1)
	+ 2H648 (−4.3%) AND 2H716 (−6.5%)	5.8 (1.3)	5.0 (1.1)	6.6 (1.5)	11.9 (2.7)	7.9 (2.1)	8.6 (2.0)

* OAFM EXCITED TO 100%, UPSTREAM COMPENSATOR TO 41.0% AND DOWNSTREAM COMPENSATOR TO 23.9%; AS CALCULATED USING FIELD MAPS AND TRACKING

CHANGE+ IN PEAK-TO-PEAK VERTICAL CLOSED ORBIT DISTORTION WHICH CAN BE ATTRIBUTED TO THE OAFM SYSTEM (AVERAGED OVER BOTH RINGS)

	RADIAL POSITION [MM] −40	0	+40
(A): OAFM WITH DEDICATED DIPOLE COMPENSATORS ONLY	0.5	0.5	8.5
(B): (A) WITH CORRECTION USING SKEW QUADS IN I8	1.6	1.0	1.5
(C): (A) WITH CORRECTION USING H-DIPOLES (RING)	0.4	1.3	0.6

+CHANGE MAY BE A WORSENING OR AN IMPROVEMENT, DEPENDING ON ORIGINAL ORBIT

TABLE II

CURRENT SETTINGS FOR OAFM COMPENSATION

OAFM +100 %

RING 1	1AFC1	+ 41.0 %
	1AFC3	+ 23.9 %
	1H617 *	- 8.4 %
RING 2	2AFC2	+ 41.0 %
	2AFC4	+ 23.9 %
	2H648 *	- 4.3 %
	2H716 *	- 6.5 %

* RADIAL FIELD MAGNETS MAY ALREADY BE EXCITED EITHER TO CORRECT MACHINE ORBITS WITHOUT THE OAFM OR FOR BUMPS. IN SUCH CASES FIGURES QUOTED INDICATE THE CHANGE REQUIRED.

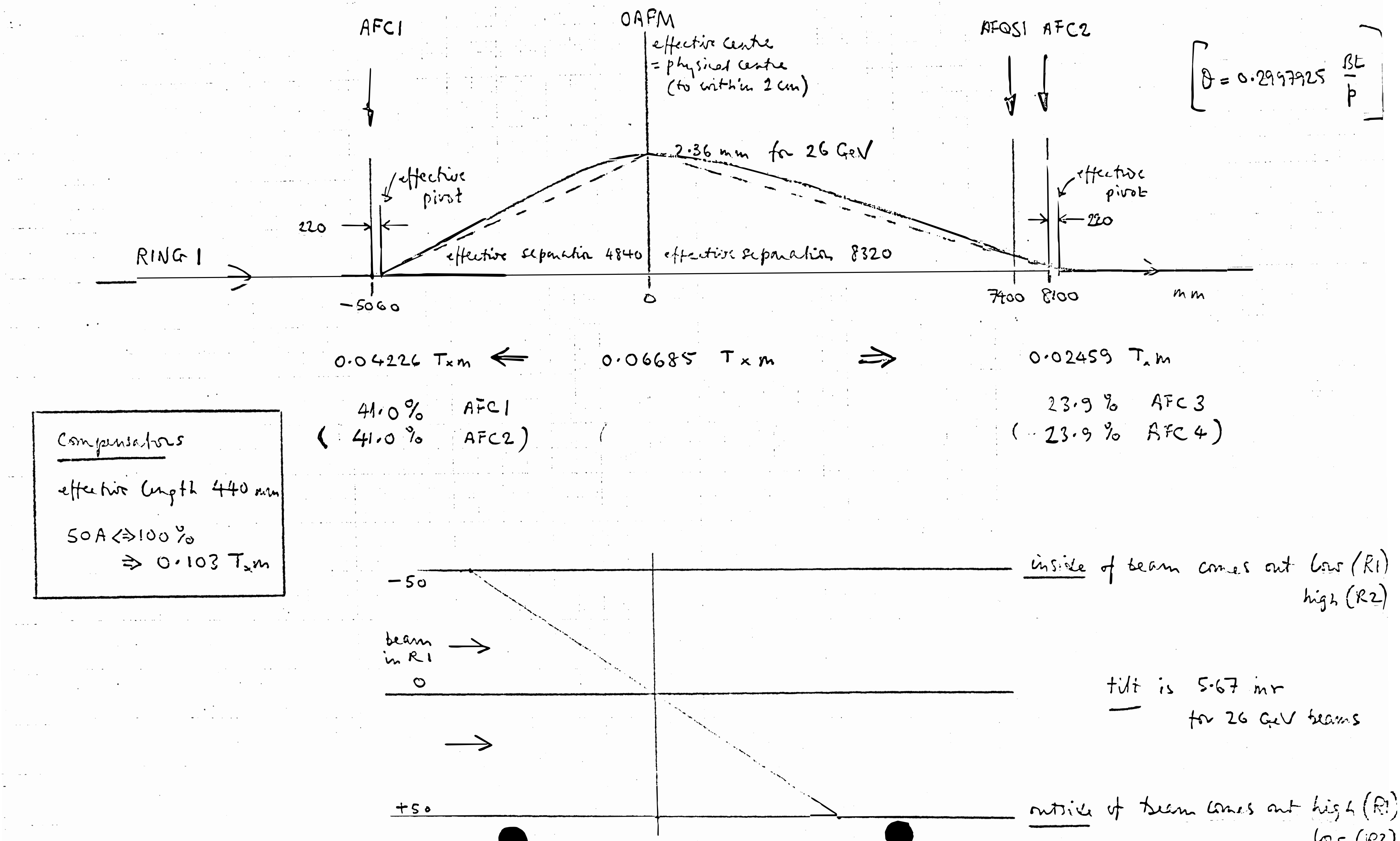


FIG. 1 : Vertical orbit deviations with the OAFM and the compensators.

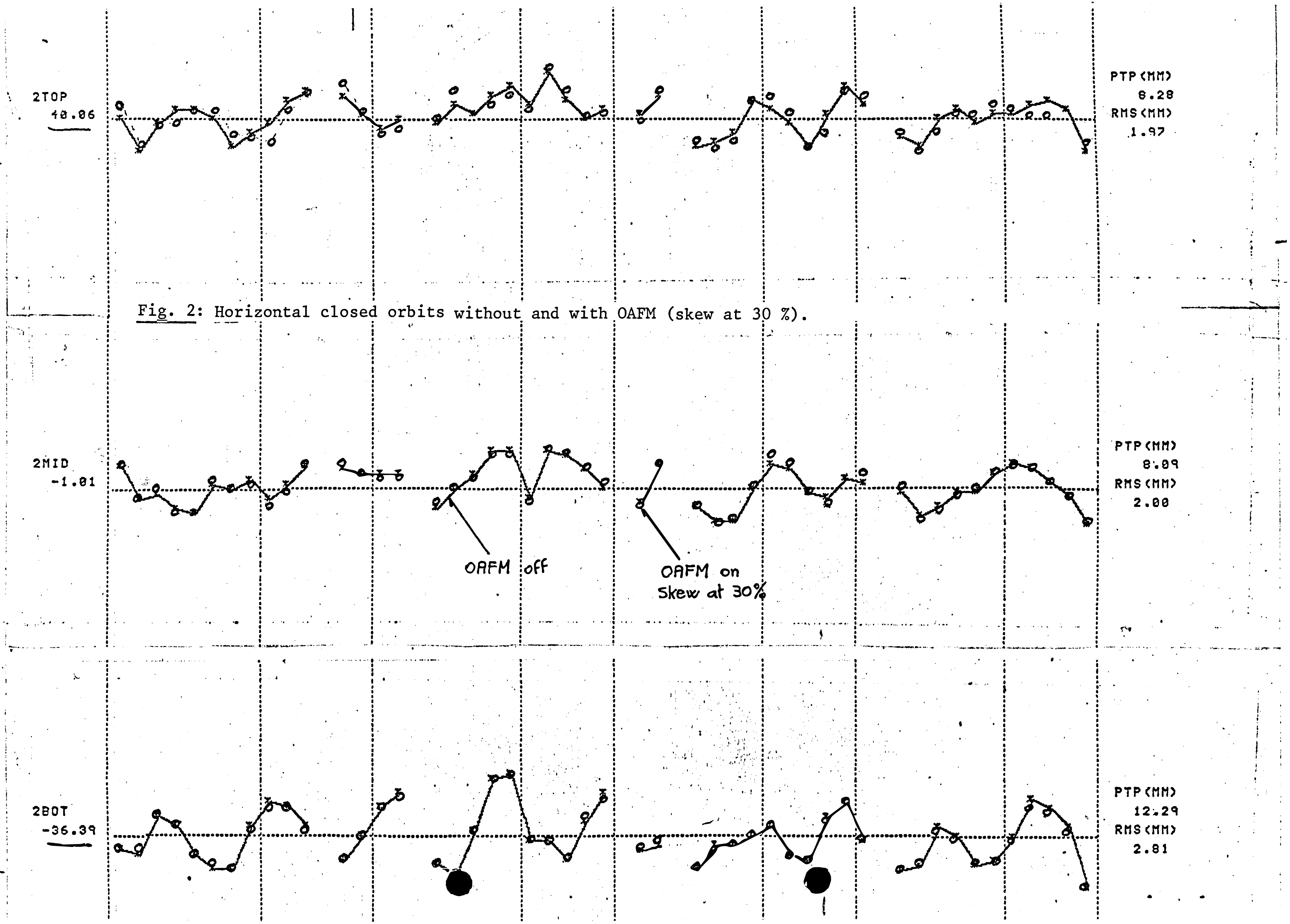


Fig. 2: Horizontal closed orbits without and with OAFM (skew at 30 %).

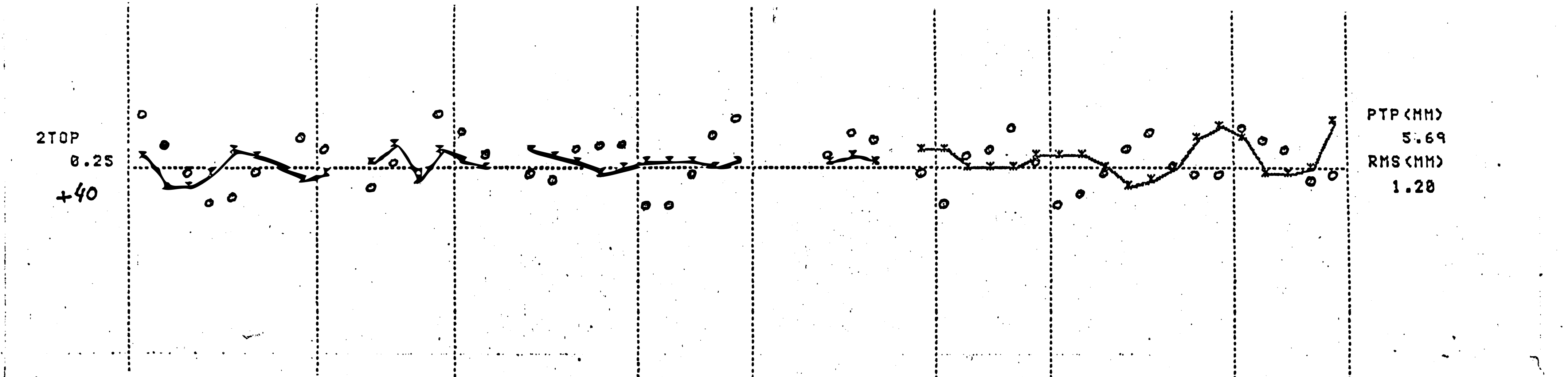
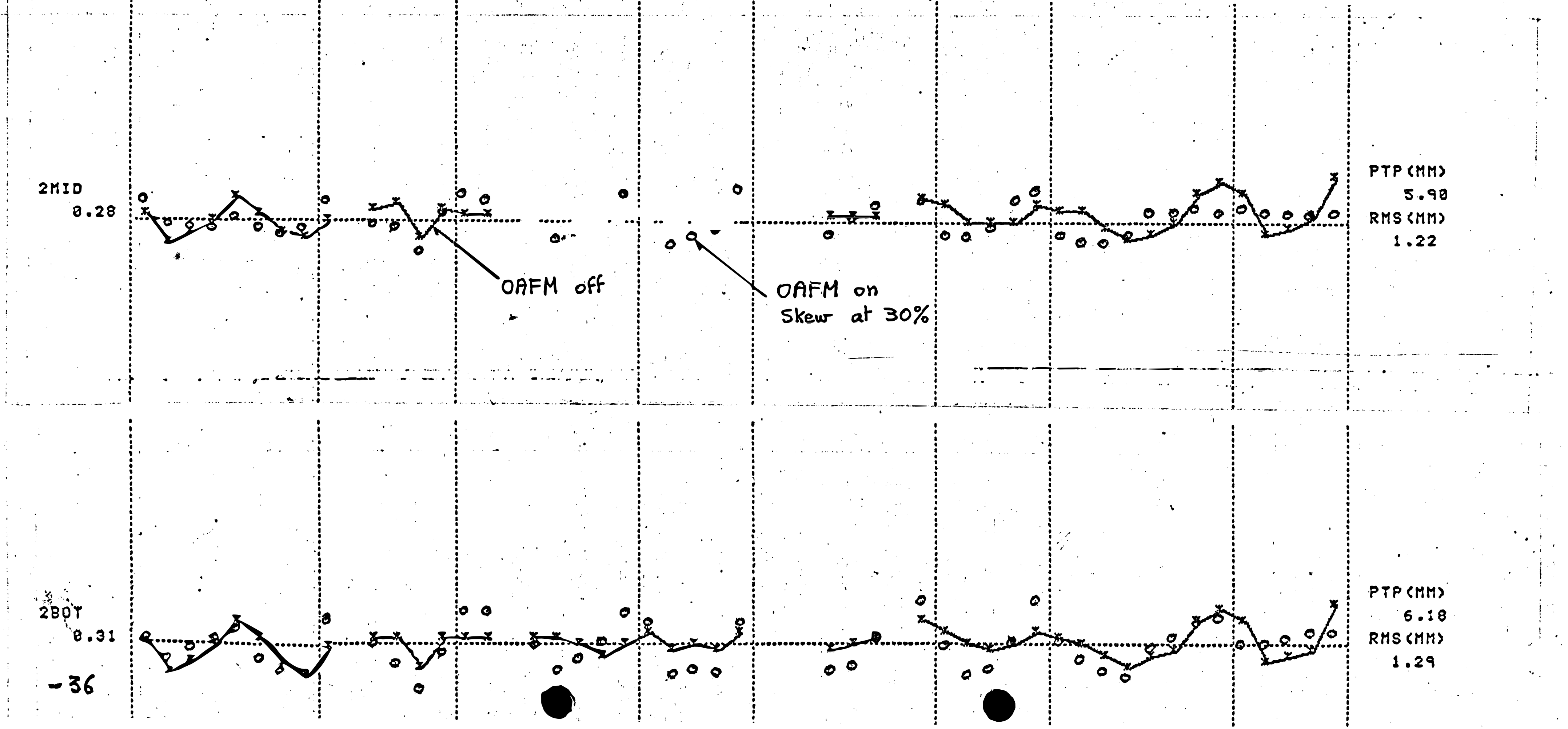


Fig. 3: Vertical closed orbits without and with OAFM (skew at 30 %).



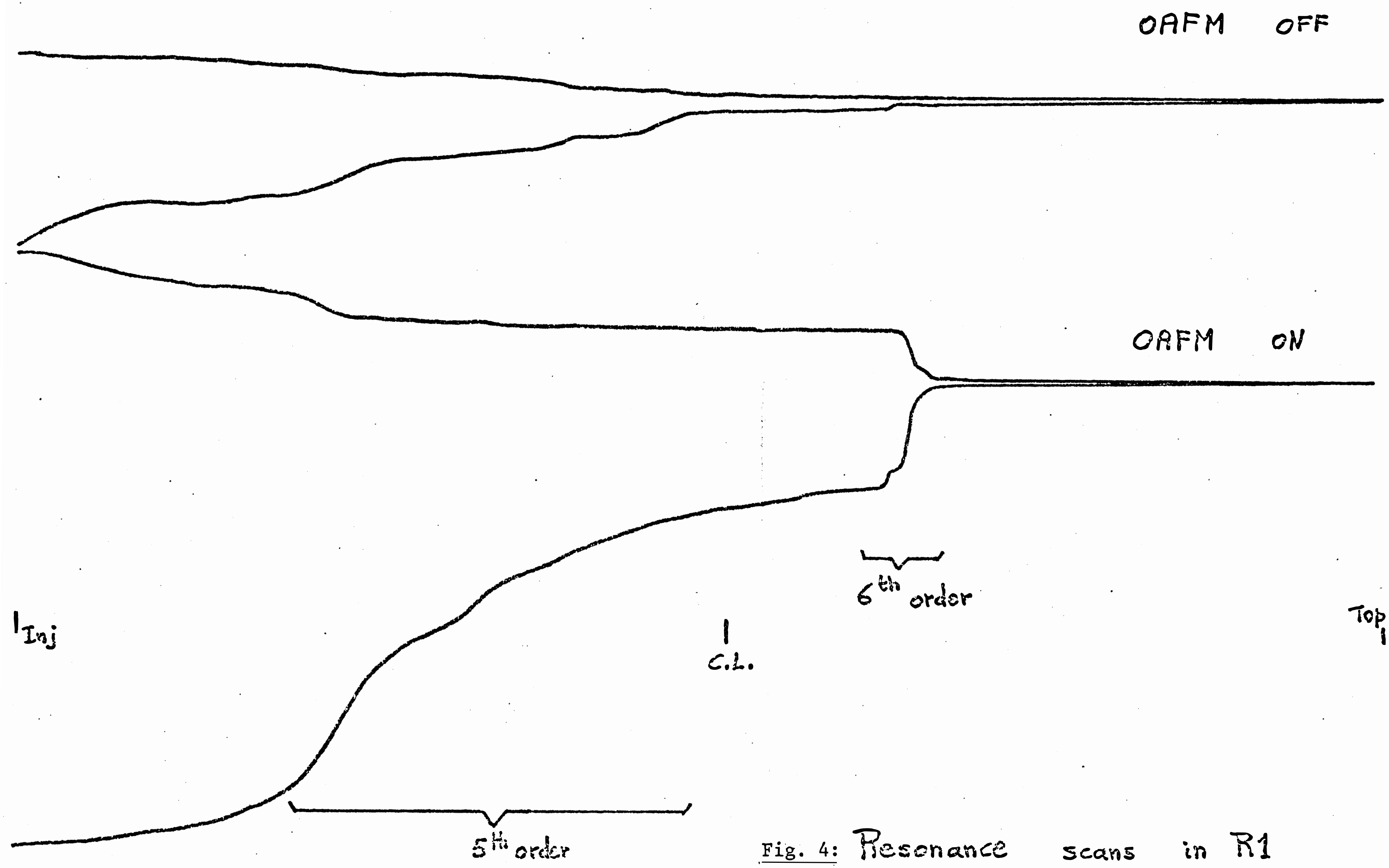


Fig. 4: Resonance scans in R1

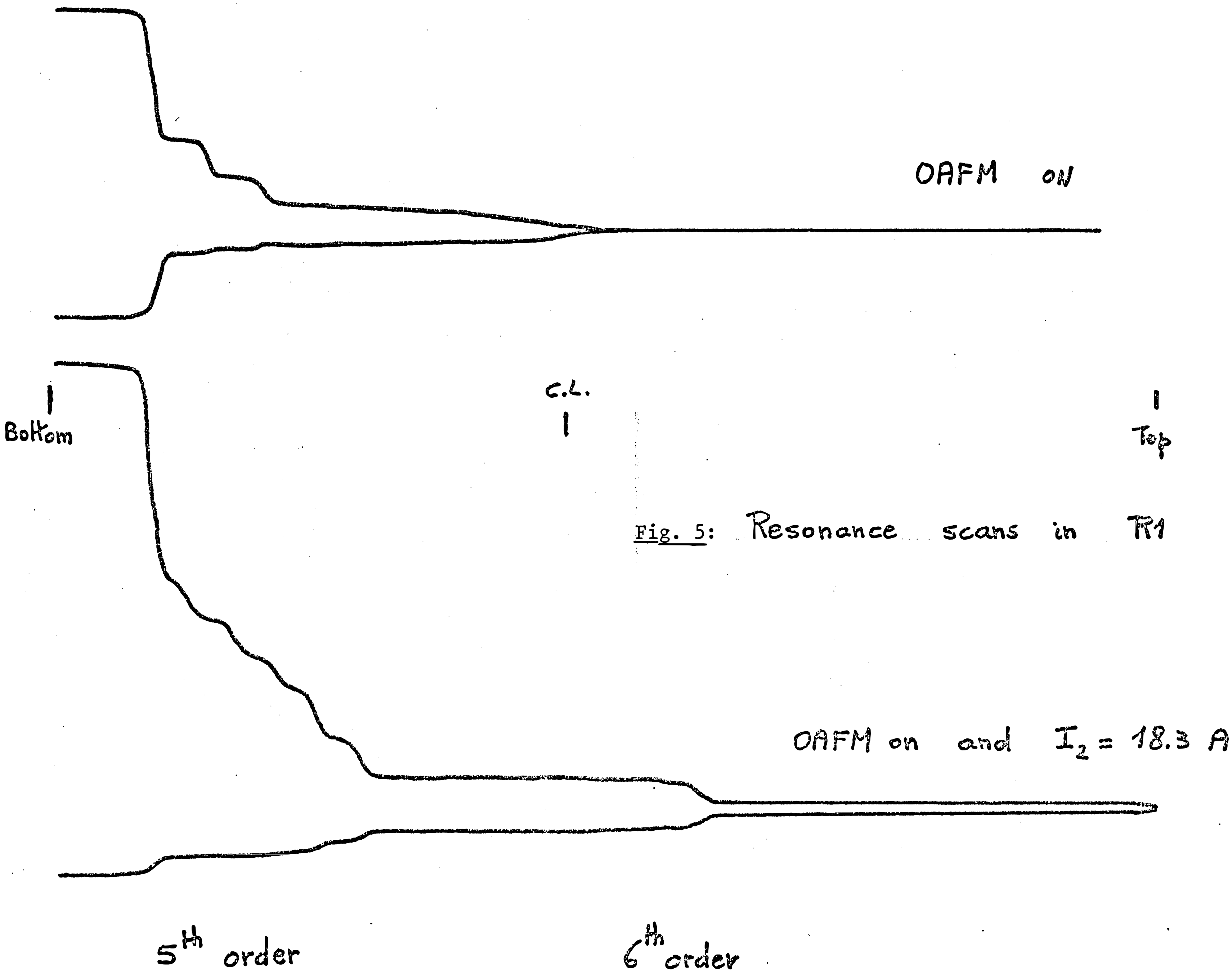


Fig. 5: Resonance scans in TR1

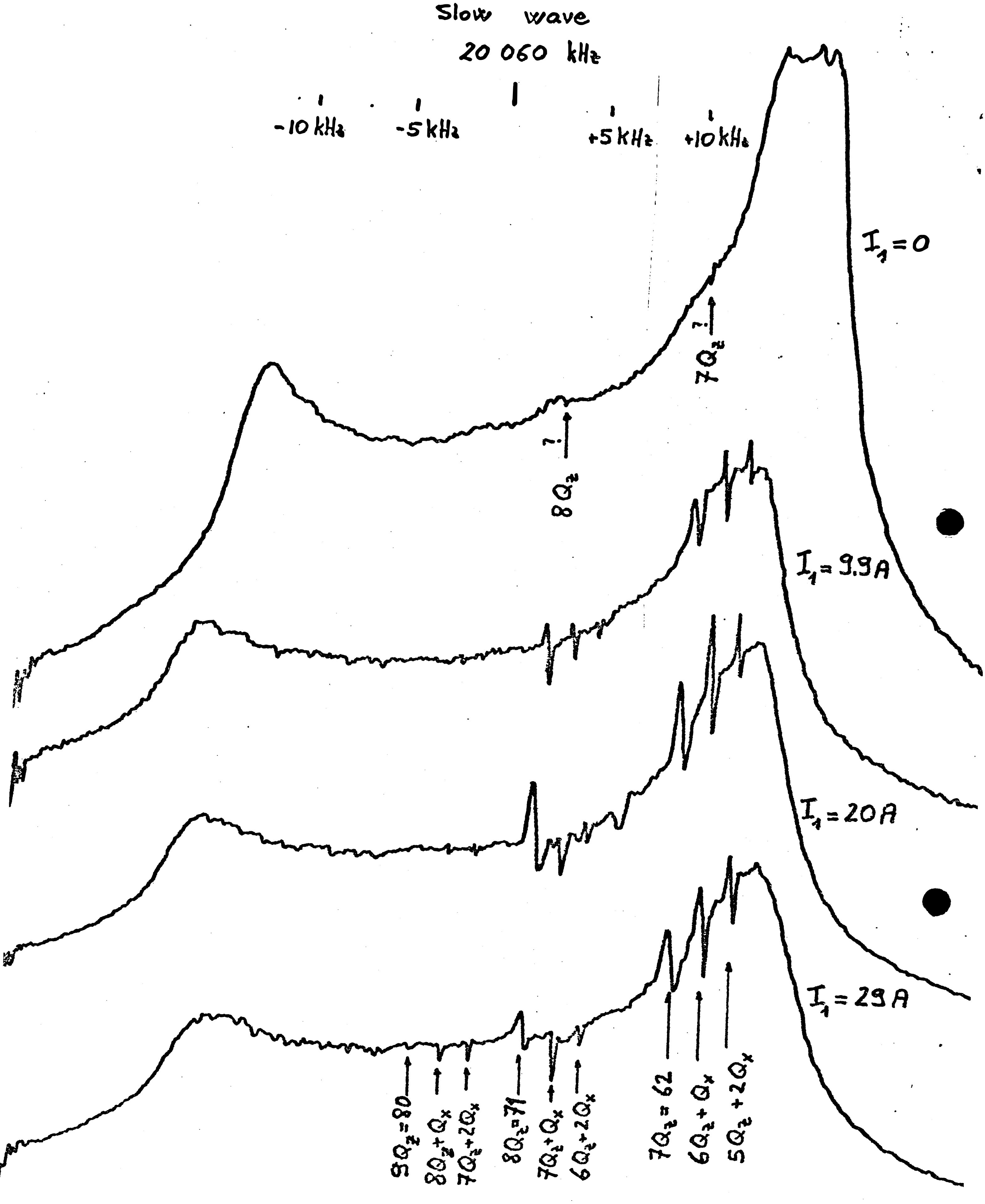


Fig. 6: Vertical amplitude of FFT in R2 (30A)
OAFM ON . Variable current in R1

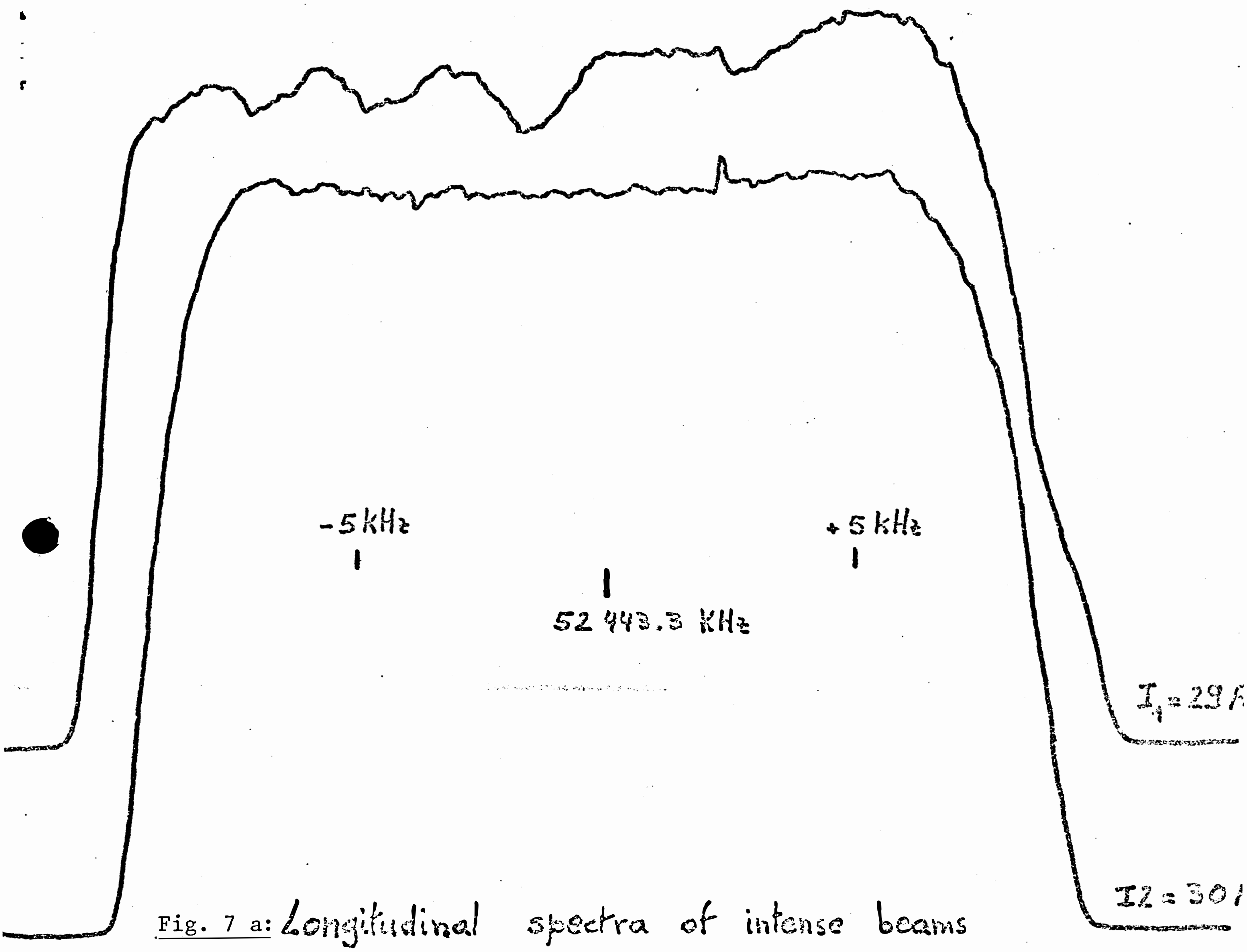


Fig. 7 a: Longitudinal spectra of intense beams
OAFM ON

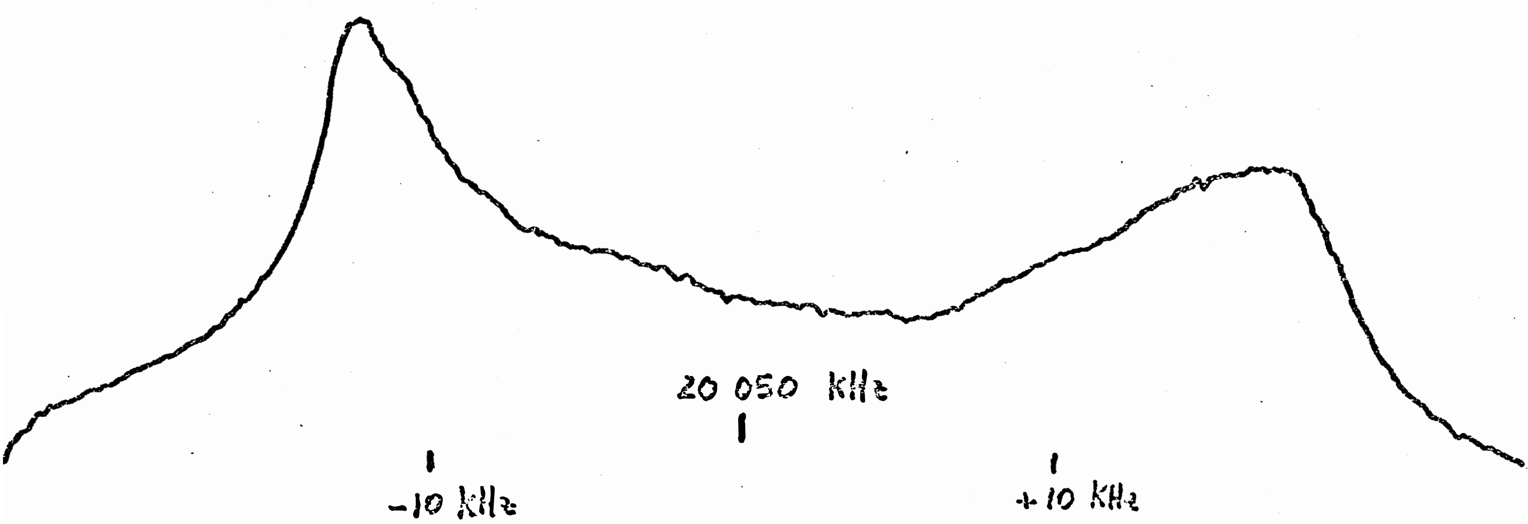


Fig. 7 b: Horizontal amplitude of FFT in R2 (slow wave)
OAFM ON