A

ISR-MA/LR/JPG/rh 12th March 1971

ISR RUNNING-IN

Run 33 - 10 March 1971 - 22 GeV/c - 4 bunches

First part: 12.00 - 15.00 h - Ring 1

(and beginning of Run 34 - 20 bunches)

1. General conditions

The purpose of this run was to create and study at 22 GeV/c the same working lines which have been found possible for high intensity stacks at 15 GeV/c in run 31, namely

for 15 GeV/c
(DANA, 1.8, 1.5
(DORA, 1.5, 1
(GINA, -1.5, 1
(FATA, 1.5, 1

The argument of the PFW corrections and the sextupole currents which gave these lines, were calculated for 22 GeV/c in the following way:

- The Q shifts to apply at 22 GeV/c are the ones used at 15 GeV/c corrected by the difference in the central values at 22 GeV/C and 15 GeV/c:

$$\Delta Q_H^{22\ GeV/c} = \Delta Q_H^{15\ GeV/c} + 0.009$$

$$\Delta Q_V^{22\ GeV/c} = \Delta Q_V^{15\ GeV/c} + 0.011$$

- The sextupolar corrections were calculated by assuming the total $\frac{dQ}{dp/p}$ at the working lines to be the same at 15 GeV/c and 22 GeV/c, thus giving:

$$\Delta\left(\frac{dQ_H}{dp/p}\right)^{22\ GeV/c} = \Delta\left(\frac{dQ_H}{dp/p}\right)^{15\ GeV/c} + 1.1$$

$$\Delta\left(\frac{dQ_V}{dp/p}\right)^{22\ GeV/c} = \Delta\left(\frac{dQ_V}{dp/p}\right)^{15\ GeV/c} - 1.45$$

- The arguments of the PFW ($\Delta G\ell_F$ or $\Delta G\ell_D$) and the sextupole currents were calculated using the formulae deduced from measurements at 15 GeV/c (run 24) in which the coefficients were increased proportionally to the momentum.

2. Bare machine

- At the nominal field corresponding to $p_{display}$ = 22.467 GeV/c, two measurements of the revolution frequency were taken giving respectively -33.8 mm and -33.5 mm for the averaged position of the injection orbit.
- Then the position of the orbit in the PU station was measured by J. Borer with his new computerized system.
- The Q measurements made on a single shot beam displaced at several radial positions by changing the main field (see Fig. 1) confirm the values obtained in the third part of run 25.
- A scan of the aperture (see Fig. 2) at the rate of 0.3 cm/s shows a 5 % loss at $\langle\Delta r\rangle$ = 16 to 18 mm for 3 Q_V = 26 (in the same conditions at 15 GeV/c, this loss was found much stronger). A 4 % loss was found back at injection which might correspond to the 5th order resonance 5 Q_V = 43.

3. Line: DANA 2.9, 0.05 (see Fig. 1)

PFW settings	ΔQ_H = 0	Arguments	$\Delta(G\ell)_F$ = -0.945 T	
	ΔQ_V = -0.050		$\Delta(G\ell)_D$ = -1.818 T	
Sexupole settings	$\Delta Q'_H = \Delta\frac{dQ_H}{dp/p}$ = 2.9	Currents	S_F = 24.85 %	
	$\Delta Q'_V = \Delta\frac{dQ_V}{dp/p}$ = 0.05		S_D = 9.52 %	
Measured at CL with sextupoles	Q_H = 8.801			
	Q_V = 8.594			

The losses which occurred during a scan of the aperture (see Fig. 3) are very similar to those observed at 15 GeV/c (see Fig. 4 in the report of run 31).

4. Line: DORA, 2.6, -0.45 (see Fig. 1)

PFW settings	$\Delta Q_H = 0$	Arguments	$\Delta(G\ell)_F = -0.567$ T	
	$\Delta Q_V = -0.03$		$\Delta(G\ell)_D = -1.091$ T	
Sextupole settings	$\Delta Q'_H = 2.6$	Currents	$S_F = 21.13$ %	
	$\Delta Q'_V = -0.45$		$S_D = 4.72$ %	
Measured at CL with sextupoles	$Q_H = 8.807$			
	$Q_V = 8.614$			

The scan (see Fig. 4) gave the same type of losses which had been observed at 15 GeV/c (Fig. 5 in the report of run 31).

5. Line: GINA, -0.4, -0.45 (see Fig. 1)

Contrary to what had been done at 15 GeV/c, no use of Terwilliger quadrupoles was made, their correction being included in the PFW settings.

PFW settings	$\Delta Q_H = -0.093$	Arguments	$\Delta(G\ell)_F = -5.646$ T	
	$\Delta Q_V = -0.038$		$\Delta(G\ell)_D = -3.884$ T	
Sextupole settings	$\Delta Q'_H = -0.4$	Currents	$S_F = -4.46$ %	
	$\Delta Q'_V = -0.45$		$S_D = -4.72$ %	
Measured at CL with sextupoles	$Q_H = 8.717$			
	$Q_V = 8.606$			

No loss appeared in the scan from injection to +40 mm (see Fig. 5); a 50 % loss appeared only at +42 mm, probably for $2\,Q_V + Q_H = 26$.

6. Line: FATA, 2.6, -0.45 (see Fig. 1)

PFW settings	ΔQ_H = -0.186	Arguments	$\Delta(G\ell)_F$ = -10.686 T	
	ΔQ_V = -0.044		$\Delta(G\ell)_D$ = - 6.604 T	
Sextupole settings	$\Delta Q'_H$ = 2.6	Currents	S_F = 21.13 %	
	$\Delta Q'_V$ = -0.45		S_D = 4.72 %	
Measured at CL	Q_H = 8.623			
with sextupoles	Q_V = 8.599			

In this scan (see Fig. 6), the losses appeared at the same resonance lines as at 15 GeV/c.

7. Conclusion

The working lines investigated at 15 GeV/c have been successfully set at 22 GeV/c using calculated values of PFW and localised sextupole currents.

The correspondence between these lines and the expected ones is very good and confirms the validity of a calculation of the corrections using the formulae derived at 15 GeV/c and a scaling factor equal to the ratio of momenta.

The slight difference which exists between the working curves at 15 and 22 GeV/c is due to the difference in the shapes of the Q versus momentum curves of the bare machine for these two different momenta.

The loss patterns found in the scans are very similar to those obtained at 15 GeV/c and correspond to the same resonance lines.

8. Setting up working lines in run 34 (20 bunches)

After the second part of run 33 (4 bunches), in which PFW and auxiliary magnet settings had been changed in order to perform experiments on injection into the bare machine with orbit bumps, working lines had to be set up again for 20-bunch operation in run 34. It is known that 20-bunch injection setting are often somewhat different from those for 4 bunches. Moreover, during these injection adjustments, the main power supply of Ring 1 fell out and had to be restored. Therefore, it was interesting to see how accurately the working lines found in the first part of run 33 could be reproduced in run 34.

First, working line GINA, -0.4, -0.45, with p_c = 22.467 GeV/C was set up. The following Q values were measured, as a function of radial position:

$\langle\Delta r\rangle$	Q_H	Q_V
-33	.745	.557
0	.718	.604
+33	.688	.646
+38	.681	.654

These values fall very well on the curve of Fig. 1, plotted after the measurements in run 33. The values at injection (-33 mm) and at centreline are within 0.002 of the previous measurements. A scan across the aperture from injection to +38 mm showed no loss (Fig. 7).

Later, working line DANA, 2.9, 0.05, was set, with equal success.

At last, the $\frac{dQ_H}{dp}$ at the same point DANA was increased somewhat in order to suppress instabilities of "brickwall" type which seemed to appear above 3 A. The new line DANA, 3.4, 0.05, obtained with S_F = 29.11; S_D = 11.59, was expected to produce a Q_H value of .770 at injection. The measured value was .771.

In conclusion, the reproducibility of the working lines, for a given central momentum p_c, seems rather good.

Operational remark

The beginning of run 33 was delayed by difficulties with PS ejection (the program of ejection being stopped every time one tried to inject a single shot). During the run, single shot injection was obtained by using the repetitive injection and dumping programme and suppressing the dump command after the first effective injection. Some other delays occurred during this part of the run, notably the main power supply tripped out for no apparent reason and there was a temporary fault in the power supply of the compensation windings.

L. Resegotti
J.P. Gourber

Distribution:

ISR Parameter Committee
ISR Running-in Executive Committee
Engineers-in-Charge
Sc.staff ISR-MA
Mr. M. Höfert HP
Mr. E. Brouzet MPS

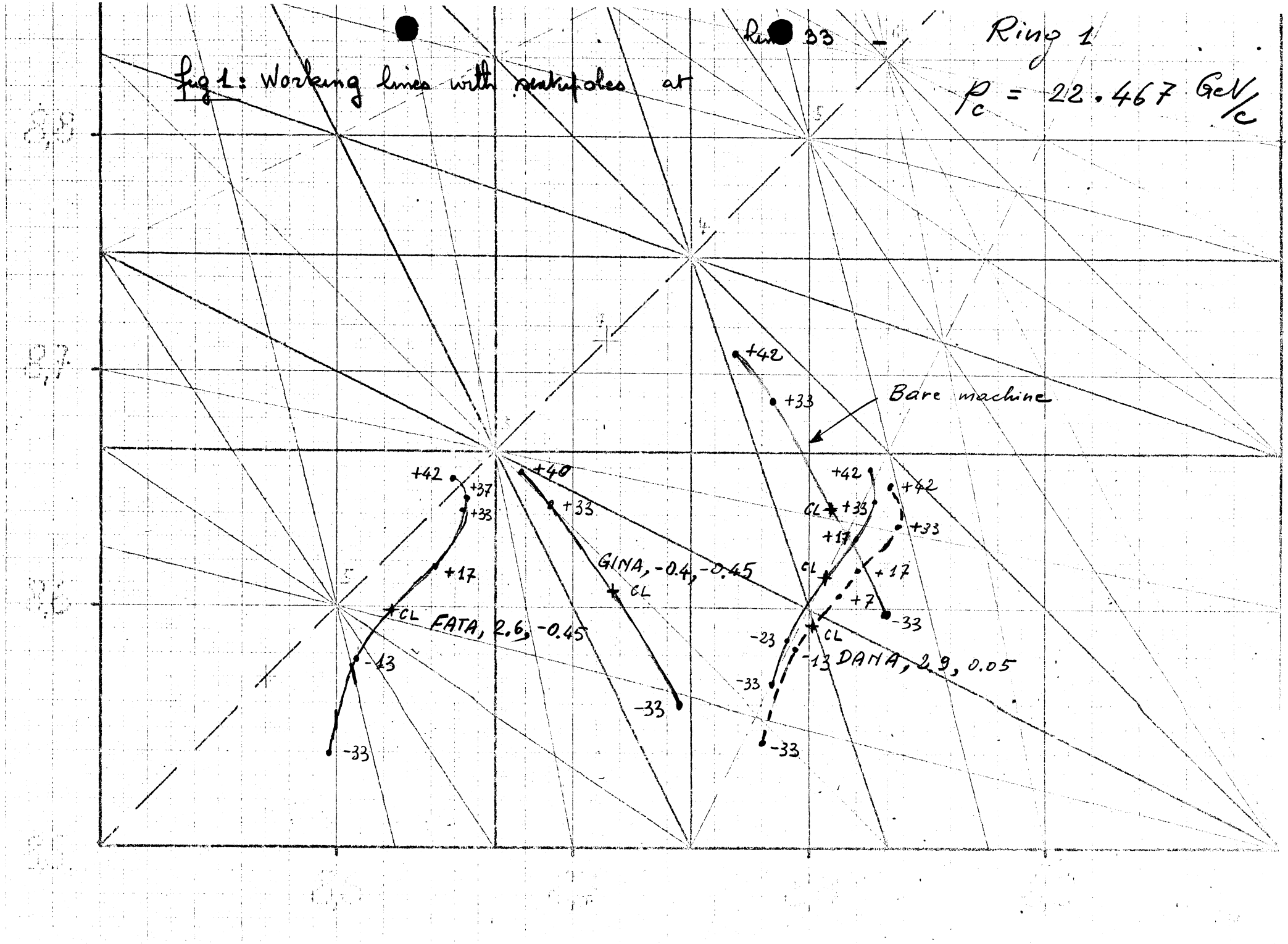

Run 33 – Ring 1
p_c = 22.467 GeV/c
fig 1: Working lines with peakingfoles at
Bare machine
+42
+33
+42
+37
+33
+17
CL FATA, 2.6, -0.45
-13
-33
+40
+33
GINA, -0.4, -0.45
CL
-33
+42
CL +33
+17
CL
+42
+33
+17
+7
-33
-23
-13
CL
DANA, 2.9, 0.05
-33
-33

Figure 2 – Run 33 – Ring 1 BARE MACHINE

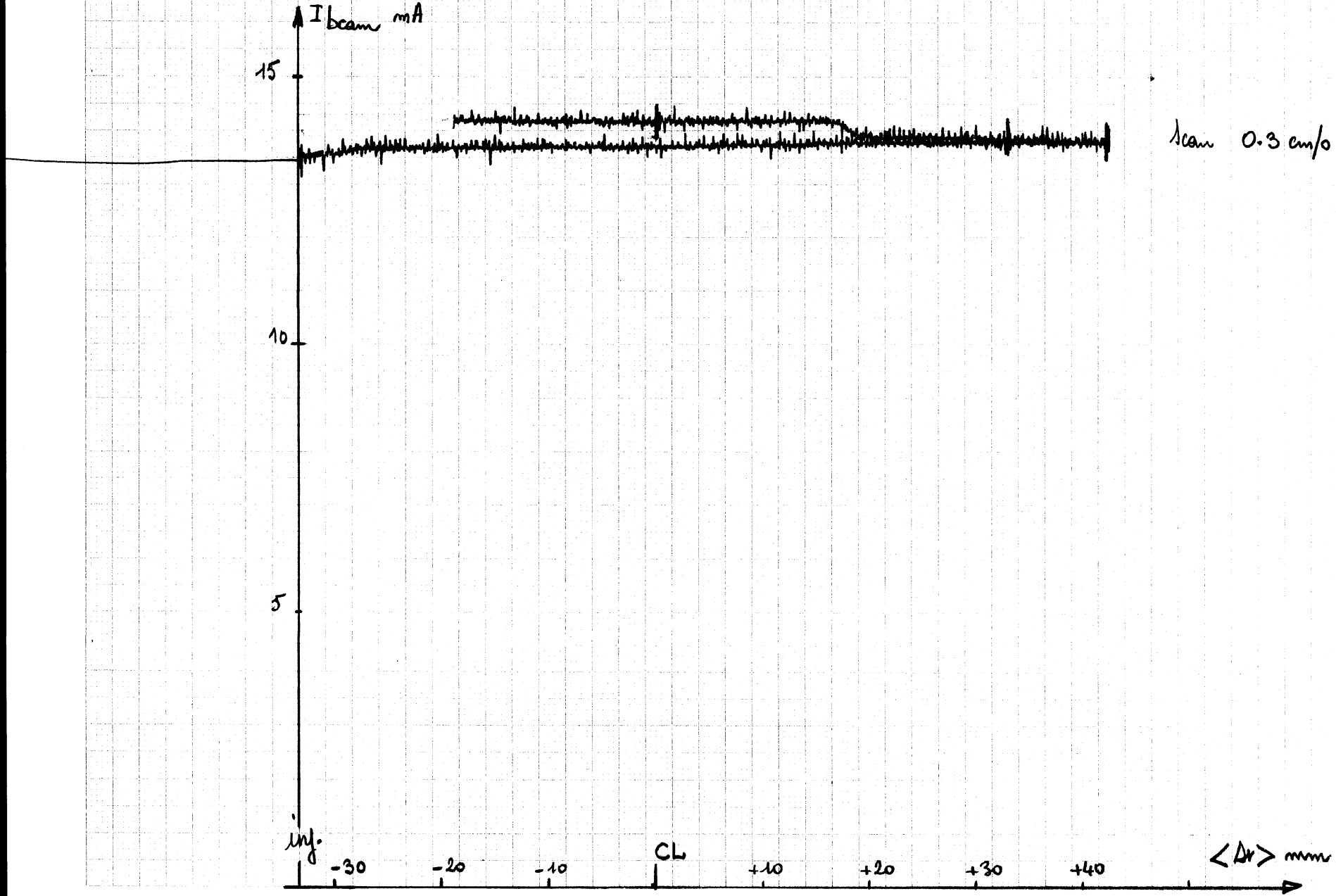


figure 3 – Run 33 Ring 1 DANA $\begin{cases} \Delta Q_H = 0 & \Delta Q_V = -0.050 \\ \Delta Q'_H = 2.9 & \Delta Q'_V = 0.050 \end{cases}$ $S_F = 24.85\%$ $S_D = 9.52\%$

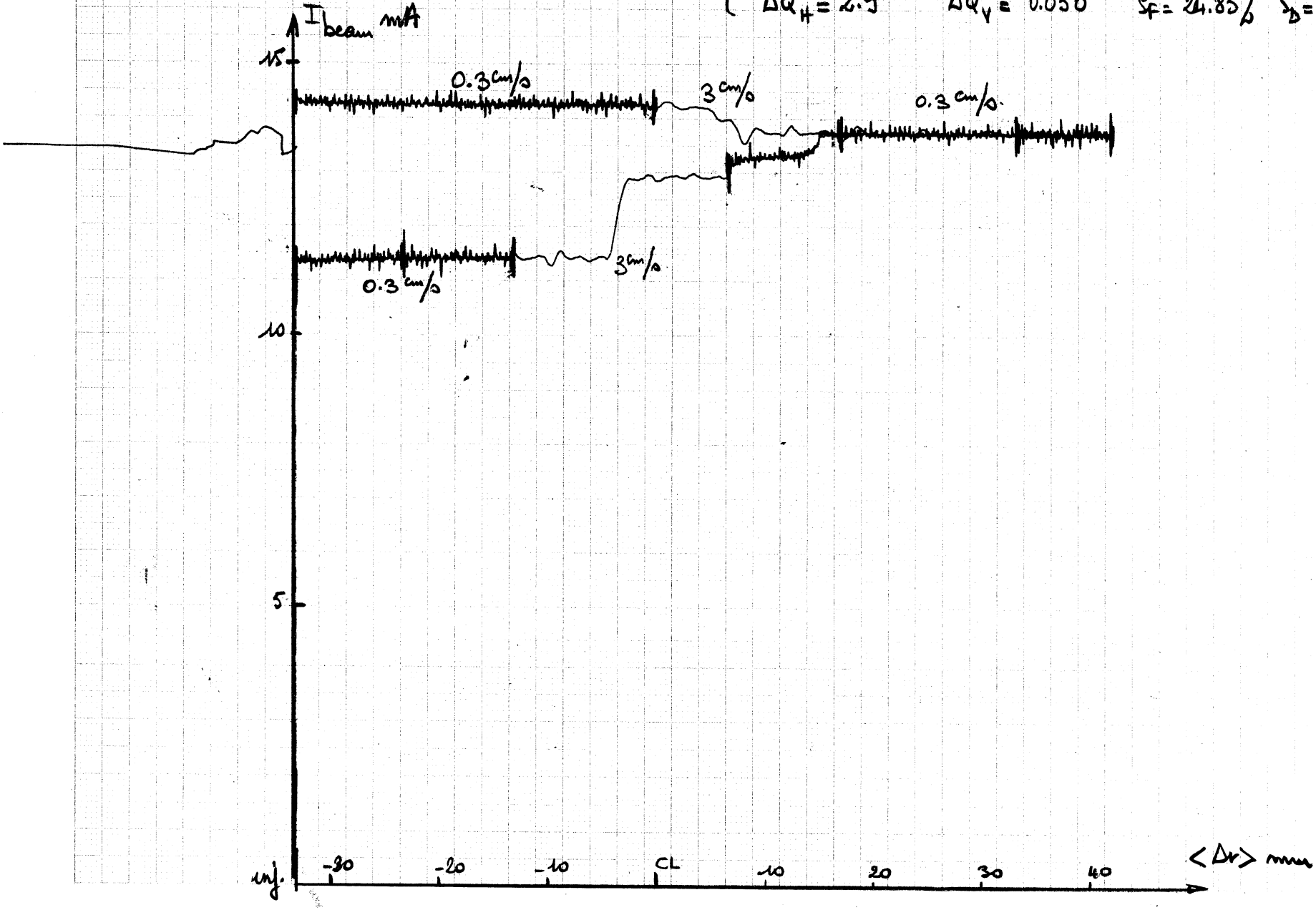


Figure 4 - Run 33 - Ring 1 DORA $\begin{cases} \Delta Q_H = 0 & \Delta Q_V = -0.03 \\ \Delta Q'_H = 2.6 & \Delta Q'_V = -0.45 \end{cases}$ $S_F = 21.13\%$ $S_D = 4.72\%$

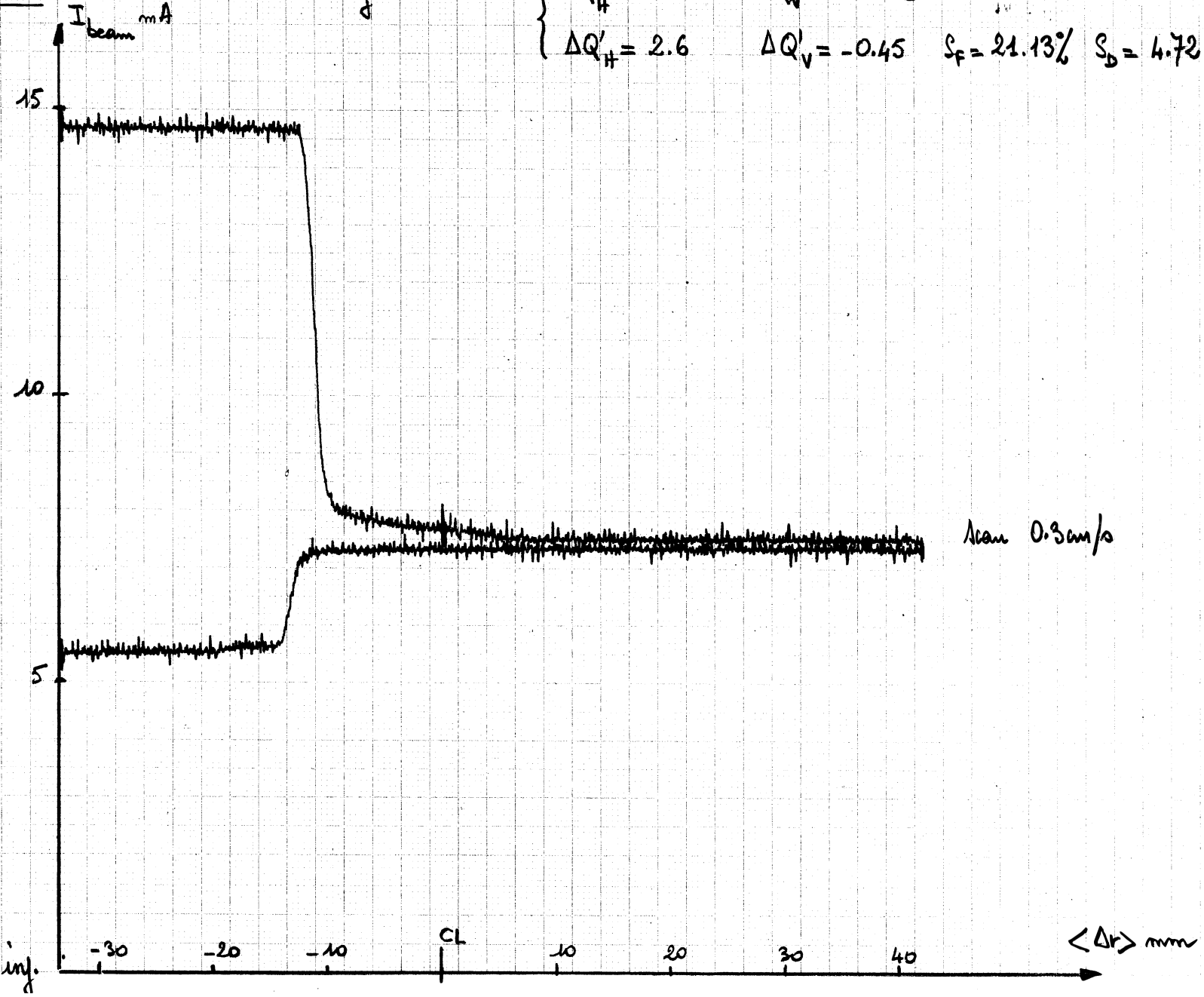


figure 5 -

Run 33 Rnig 1 GINA $\begin{cases} \Delta Q_H = -0.093 & \Delta Q_V = -0.038 \\ \Delta Q'_H = -0.4 & \Delta Q'_V = -0.45 \quad S_F = -4.46\% \quad S_D = -4.72\% \end{cases}$

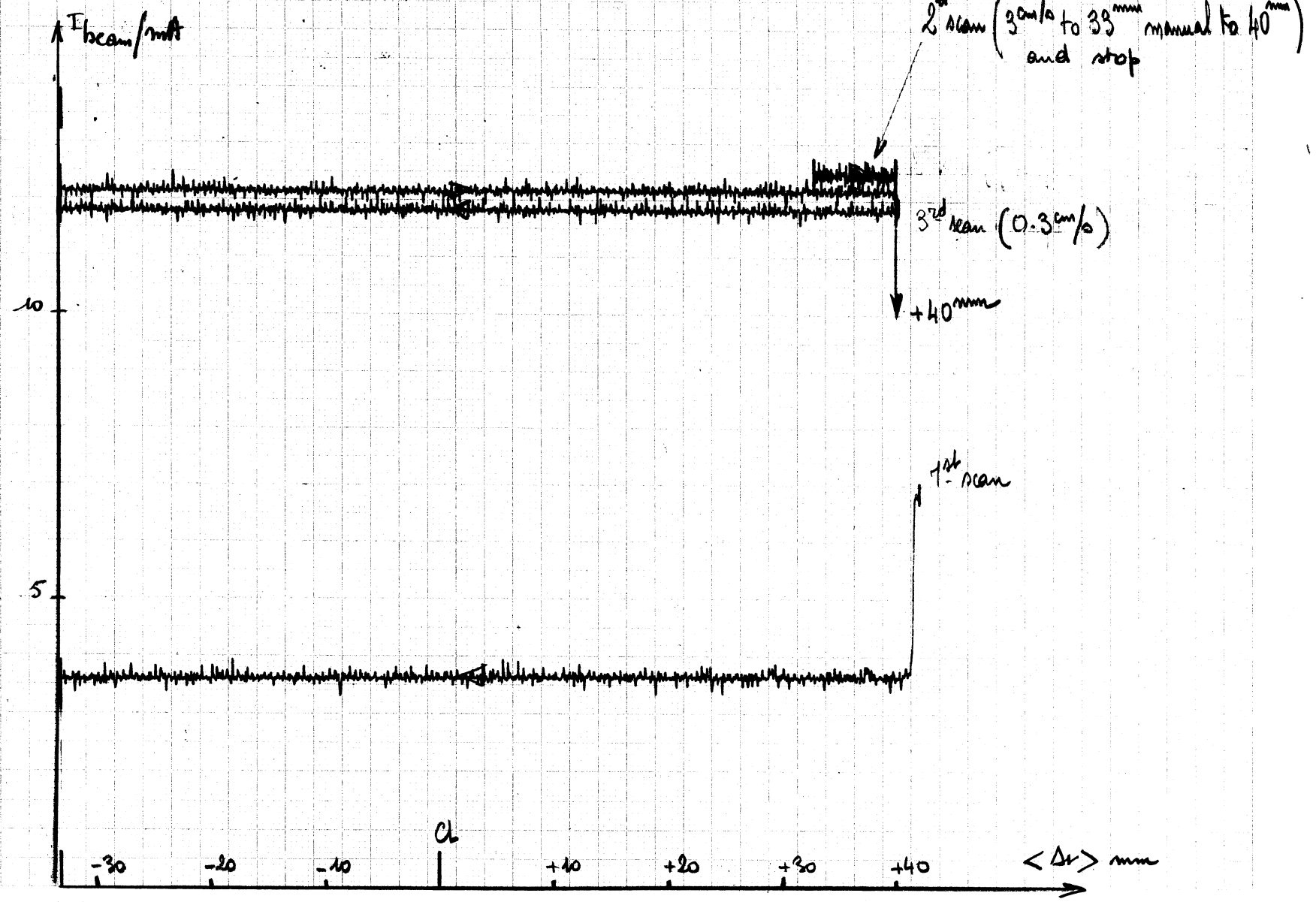
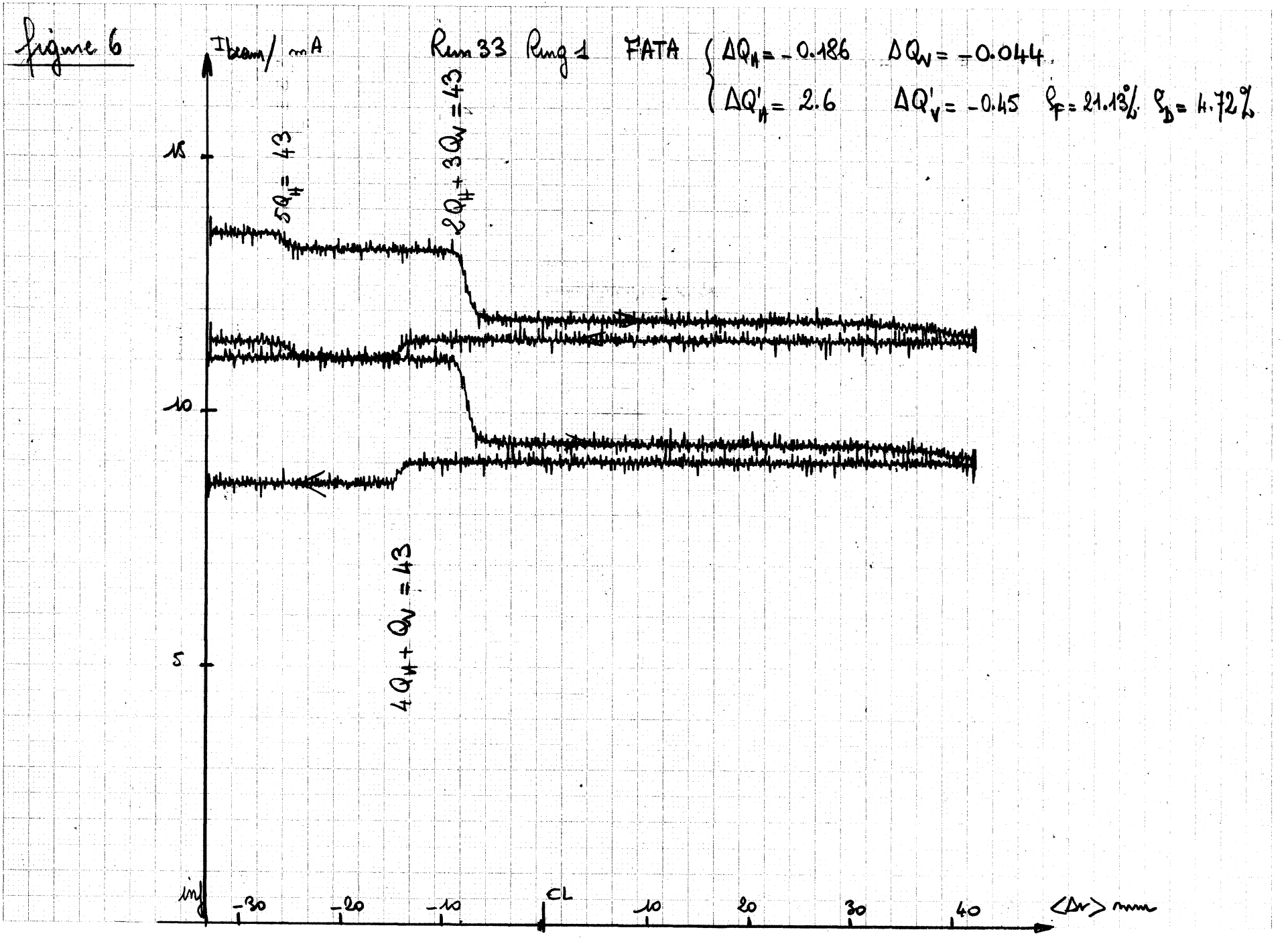


figure 6



- figure 7 -

Run 34 - Ring 1 - $p_c = 22.4676$ GeV/c

Line GIHA, -0.4, -0.45

80 - 33
+27

10/3/71 at 19.30