ISR-MA/JPG/rh

13th August 1971

ISR RUNNING-IN

Run 95 - 9 August 1971

Ring 2 - 26 GeV/c - 20 bunches

Q measurements using RF acceleration to displace the beam

The purpose of this 2 hour experiment, performed in close collaboration with S. Hansen, was to measure the differences in the Q values when the beam is displaced across the vacuum chamber using RF acceleration instead of field variation (ramp generator).

- In case of field variation, the actual position of the beam was determined from the field display reading $p_{\text{field display}}$ using the formula :

$$x = \langle\alpha\rangle \frac{p_{PS} - p_{\text{field display}}}{p_{\text{field display}}}$$

with $\langle\alpha\rangle$ = 1.867 m

p_{PS} = 26.067 GeV/c (this value being such that $x_{\text{injection}}$ calculated in this way coincides with the value deduced from a revolution frequency measurement).

- In case of RF acceleration at constant field level (p_{display} = 26.512 GeV/c), the final beam position was calculated from the measurement of the revolution frequency using GEORGE program. The sequence was the following :

  Injection of a PS pulse - trapping - full and reduced voltage acceleration to a given position - stop of acceleration and triggering of the revolution frequency measurement - switching off the RF - measurement of the Q values on the debunched beam (Q meter with kicks).

Line 26FA

Results are given in Fig. 1. The deviation between the two curves was somewhat unexpected, and we performed many verifications to detect any possible measuring errors :

- Q measurement on the bunched beam by keeping RF on
- Suppression of the closed orbit correction in line 26FA
- Scraping the horizontal beam halo by using many times the beam probes (first measurement -6.8 mm/+45.5 mm; last measurement +18.7 mm/+42.6 mm)
- RF scanning to confirm the beam position
- Introducing in the Q meter the injection revolution frequency instead of the final frequency.

The results contained in Fig. 1 were confirmed to within 1 or 2 digits in the third decimal.

Line 26CL

The same measurements have been made for x = +35.6 mm using line 15CL (see Fig. 1). The Q shift is similar to that found with 26FA.

Conclusion

These results probably explain some of the strange observations made at 26 GeV/c (brickwall effects with horizontal filter output when using 26FA, for instance ...). The working lines already set up at 26 GeV/c have to be corrected and their final adjustment has to be made using RF acceleration.

The analysis contained in the Appendix shows that these Q shifts, whether RF acceleration or field change is being used, are in good quantitative agreement with the results of a calculation which is based on the variation of the magnetic properties of the machine when the field slightly varies.

J.P. Gourber

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APPENDIX

a) Qualitatively

For small variations the Q values can be considered as depending linearily on two effective field indexes $\left(\frac{n}{p}\right)_F$ and $\left(\frac{n}{p}\right)_D$, each of them being the sum of two terms :

$$\frac{n}{p} = \left(\frac{G}{B_o}\right)_{profile} + \frac{G_{COR}}{B_o}$$

$\frac{G}{B_o}$ is the field index of the magnet profile itself. The second term results from the additional gradient G_{COR} introduced by the correcting elements (PFW, sextupoles, etc.).

At low field level, when the main field B_o is decreased to displace the beam, the profile field index $\frac{G}{B_o}$ remains constant. The Q shifts, with respect to the procedure which uses RF acceleration, result only from the variation of the second term $\frac{G_{COR}}{B_o}$ (G_{COR} remaining constant), and they are small because only slight corrections are applied.

At high field level, these effects are much bigger because of saturation effects which introduce a variation of the first term $\frac{G}{B_o}$ with B_o and require a large PFW correction whatever working line is used. Consequently, these effects must be rather independent of the working line.

b) Quantitatively

When the field B_o is reduced to displace the beam to the position x (x being measured positively from the central orbit to the outside of the ring), one can deduce from the field display readings the variations of Q_H and Q_V and of their first and second derivatives with respect to $\frac{\Delta p}{p} = \frac{x}{<\alpha>}$. The additional variation $\Delta Q'$ which results from the use of the localised sextupoles is not measured by the field display system and must be added :

$$\Delta Q'^{\,H\ or\ V}_{sext.} = Q'^{\,H\ or\ V}_{given\ by\ sext.} \cdot \frac{-\Delta B_o}{B_o}$$

The variation $\Delta Q(x)$ when field change is used instead of RF acceleration is given by the formula :

$$\Delta Q(x)_{HorV} = \Delta Q_{H\ or\ V} + \Delta Q'_{H\ or\ V} \cdot \frac{\Delta p}{p} + \frac{1}{2}\,\Delta Q''_{H\ or\ V} \cdot \left(\frac{\Delta p}{p}\right)^2$$

- For 26FA the calculation gives

$$\Delta Q_H\ (x = 35.6\ \text{mm}) = +0.088$$

$$\Delta Q_V\ (x = 35.6\ \text{mm}) = -0.048$$

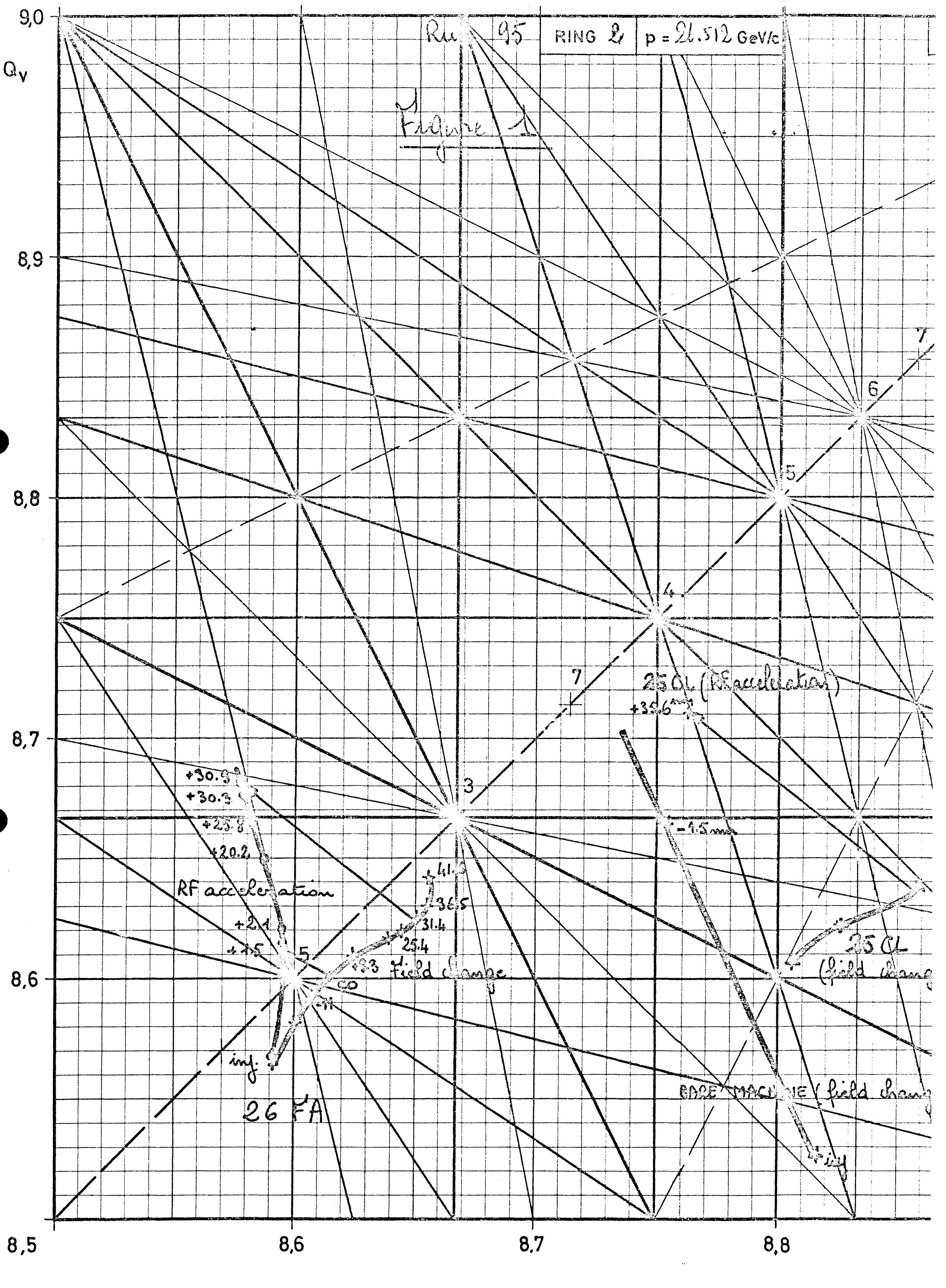
values which are in good agreement with the results of Fig. 1.

- For the bare machine one obtains

$$\Delta Q_H\ (x = +30.3\ \text{mm}) = +0.067$$

$$\Delta Q_V\ (x = +30.3\ \text{mm}) = -0.031$$

values from which one can conclude that the major effect at 26 GeV/c comes from the variation of the field index of the profile itself.


Run 95
RING 2
p = 21.512 GeV/c
Figure 1
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8,8
8,7
8,6
8,5
Q_V
8,6
8,7
8,8
3
4
5
6
7
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+25.8
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RF acceleration
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