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Subject Measurement of Chromaticities and Eddy Current Effects at Low Fields

Observations

We have measured the chromaticity early in the cycle for different values of $\dot{B}$, by measuring the horizontal and vertical tunes as a function of radius. Starting with the normal magnetic cycle, we measured at P = 0.65, 1.0 and 3.0 GeV/c (4, 4, and 15 ms Gauss respectively). Next we extended the front porch by 100 ms, allowing a measurement at 3 GeV/c with $\dot{B}$ = 4 Gs/ms. Finally, we decreased the rate of the field rise on the injection porch to 2 Gs/ms and measured the chromaticity at 0.65 and 1.0 GeV/c. The result of the measurements is given in Figures 1-3. The chromaticities, as determined from the measurements, are calculated according to $\xi = 20\ \Delta Q/\Delta R$, with ΔR in centimeters as determined by the PUE system. Eventually, the numbers should be corrected for a small calibration error in the PUE system (Ref. 1). The results are summarized in Table I.

Table I

P GeV/C	$\dot{B}$ Gs/ms	ξ_H	ξ_V
0.65	4	-1.5	-1.4
	2	-2.2	-0.75
1.0	4	-2.3	-0.9
	2	-3.2	-0.45
3.0	15	-2.0	-1.25
	4	-3.0	-0.65

Evaluation of the Measurements

The results at P = 0.65 GeV/c may be compared with numbers obtained with PIP (Ref. 2), $\xi_H = -1.5$ and $\xi_V = -0.9$ for $\dot{B} = 4.3$ Gs/ms, $P = P_{inj} = 0.644$ GeV/c, and with results obtained with BEAM (Ref. 3), $\xi_H = -2.4$ and $\xi_V = +0.2$ for $\dot{B} = 0$.

Comparison with with a measurement at a 1.7 GeV/c flattop, $\xi_H = -4.0$ and $\xi_V = 0$ (Ref. 4) by interpolating and extrapolating the results from Figures 2 and 3 also shows a reasonable agreement.

Assuming that the chromaticity is composed of the following components (Ref. 5):

- The natural chromaticity ξ_N, assumed to be constant (Ref. 5)
- The remanent field chromaticity ξ_R, which attenuates as 1/B or 1/P
- A term caused by eddy currents ξ_E, attenuated as $\dot{B}/B$ or $\dot{B}/P$

We arrive at

$$\xi = \xi_N + \xi_R \cdot 1/P + \xi_E \cdot \dot{B}/P.$$

Analysis of the data, using this expression, has yielded the following results, see Table II (P in GeV/c, $\dot{B}$ in Gs/ms).

Table II

	Horizontal	Vertical
ξ_N	−3.64 ± 0.30	−0.29 ± 0.16
ξ_R	0.21 ± 0.37	0.12 ± 0.17
ξ_E	0.32 ± 0.09	−0.20 ± 0.24

Conclusions and Remarks

- The horizontal measurement at 1 GeV/c is mainly responsible for the large errors bars in the horizontal results. Using only the measurements at 0.65 GeV/c and 3.0 GeV/c the horizontal numbers read:

  $\xi_N = -3.33 \pm 0.10$, $\xi_R = 0.2 \pm 0.06$, and $\xi_E = 0.25 \pm 0.02$

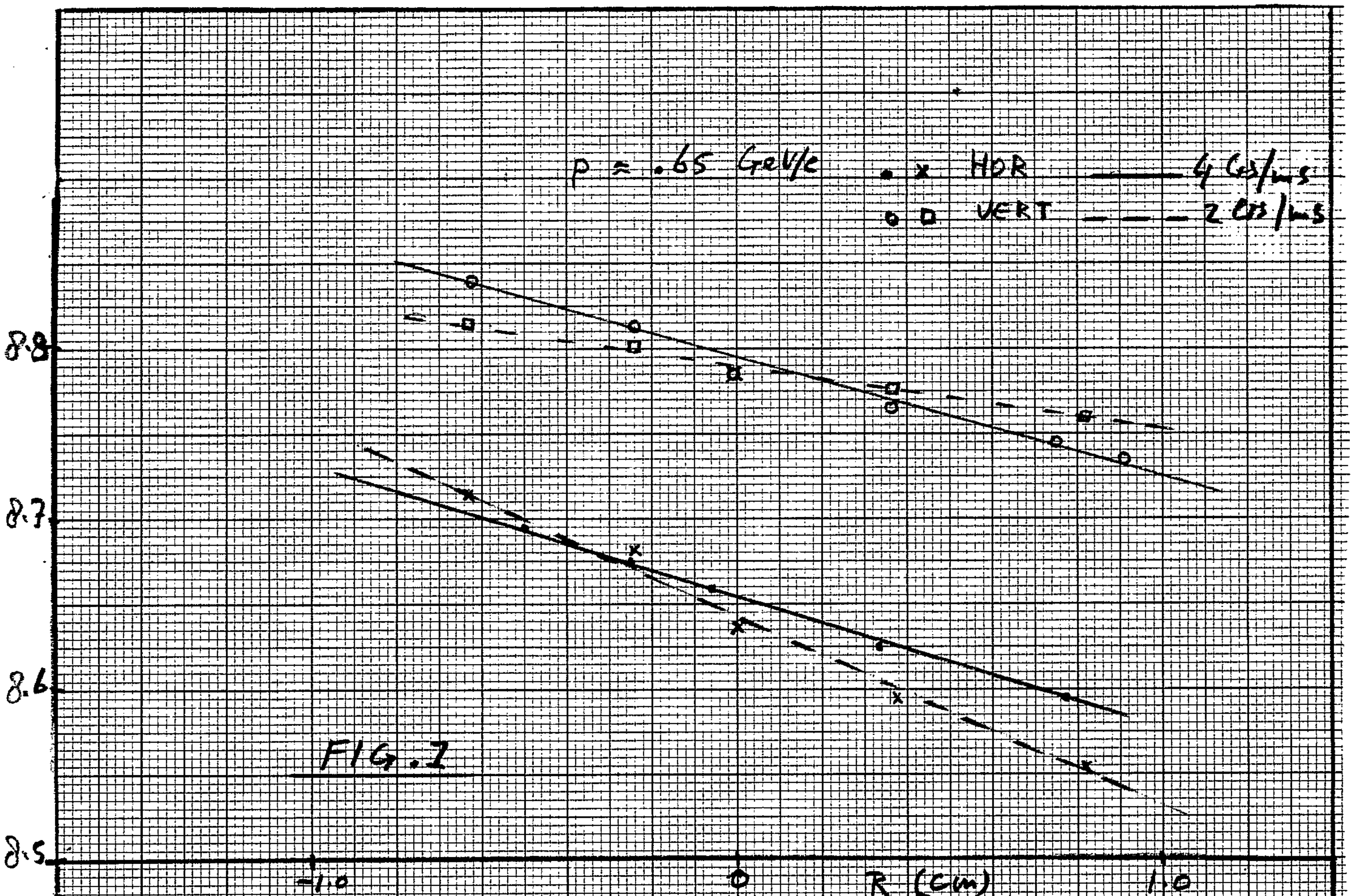
- The contribution of the remanent field is small in both planes. Because of the large error bars, however, the extrapolation of the results to heavy ion injection field (90 Gauss) yields poor precision.

- The evaluation of the natural chromaticity gives encouraging results.

References

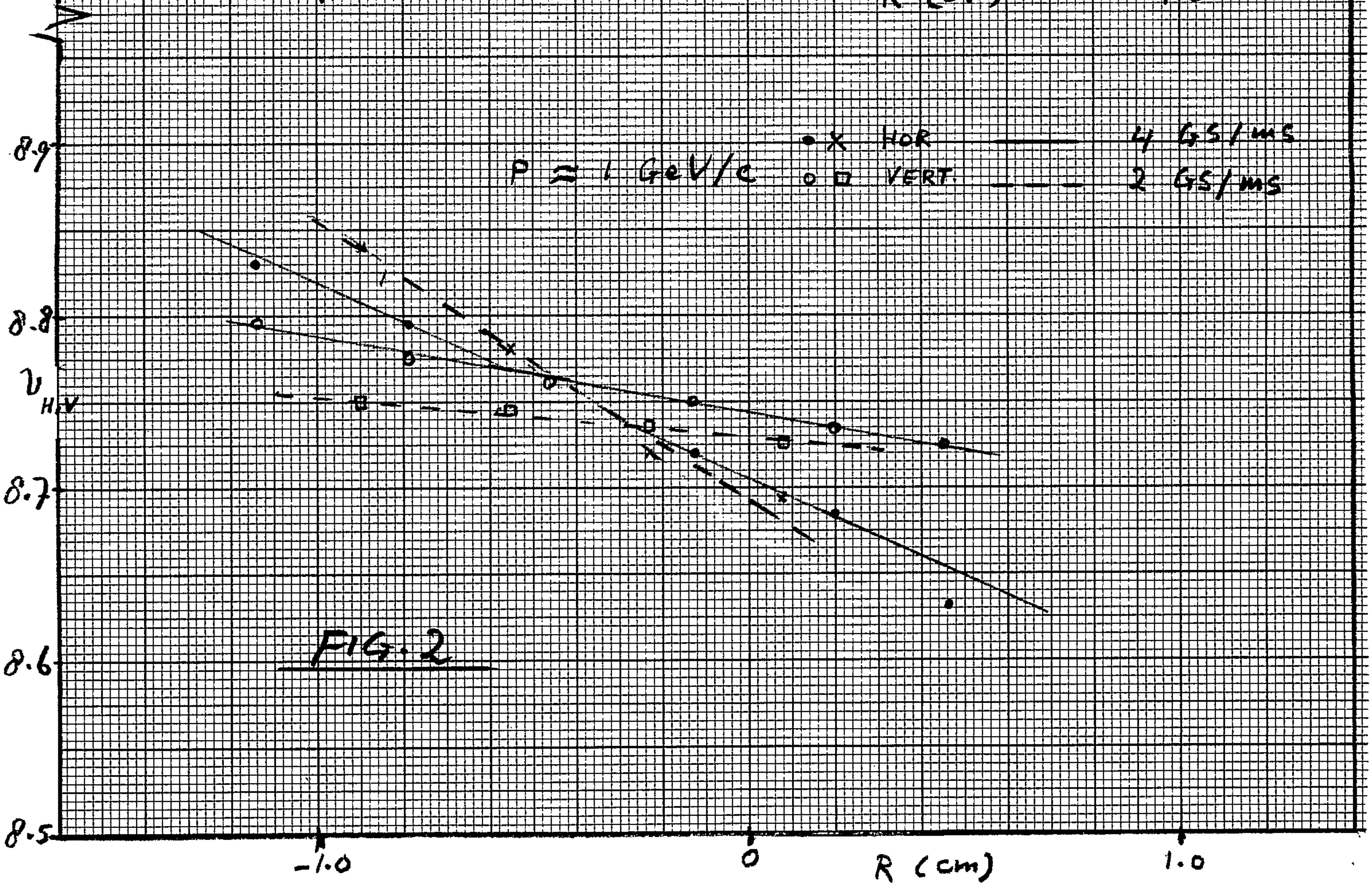
1. E. Bleser, AGS Studies Report No. 202.
2. C. Gardner, L. Ahrens, IEEE-NS32 (1985), 1888.
3. C. Gardner, private communication.
4. L. Ahrens, AGS Studies Repport No. 201.
5. E.J.N. Wilson, CERN 77-13, p. 111.

mvh



P ≈ .65 GeV/c
• x HOR —— 4 GS/ms
o □ VERT — — 2 GS/ms
8.8
8.7
8.6
8.5
-1.0
R (cm)
1.0

FIG. 1



• x HOR —— 4 GS/ms
P ≈ 1 GeV/c
o □ VERT — — 2 GS/ms
8.9
8.8
$\nu_{H,V}$
8.7
8.6
8.5
-1.0
R (cm)
1.0

FIG. 2

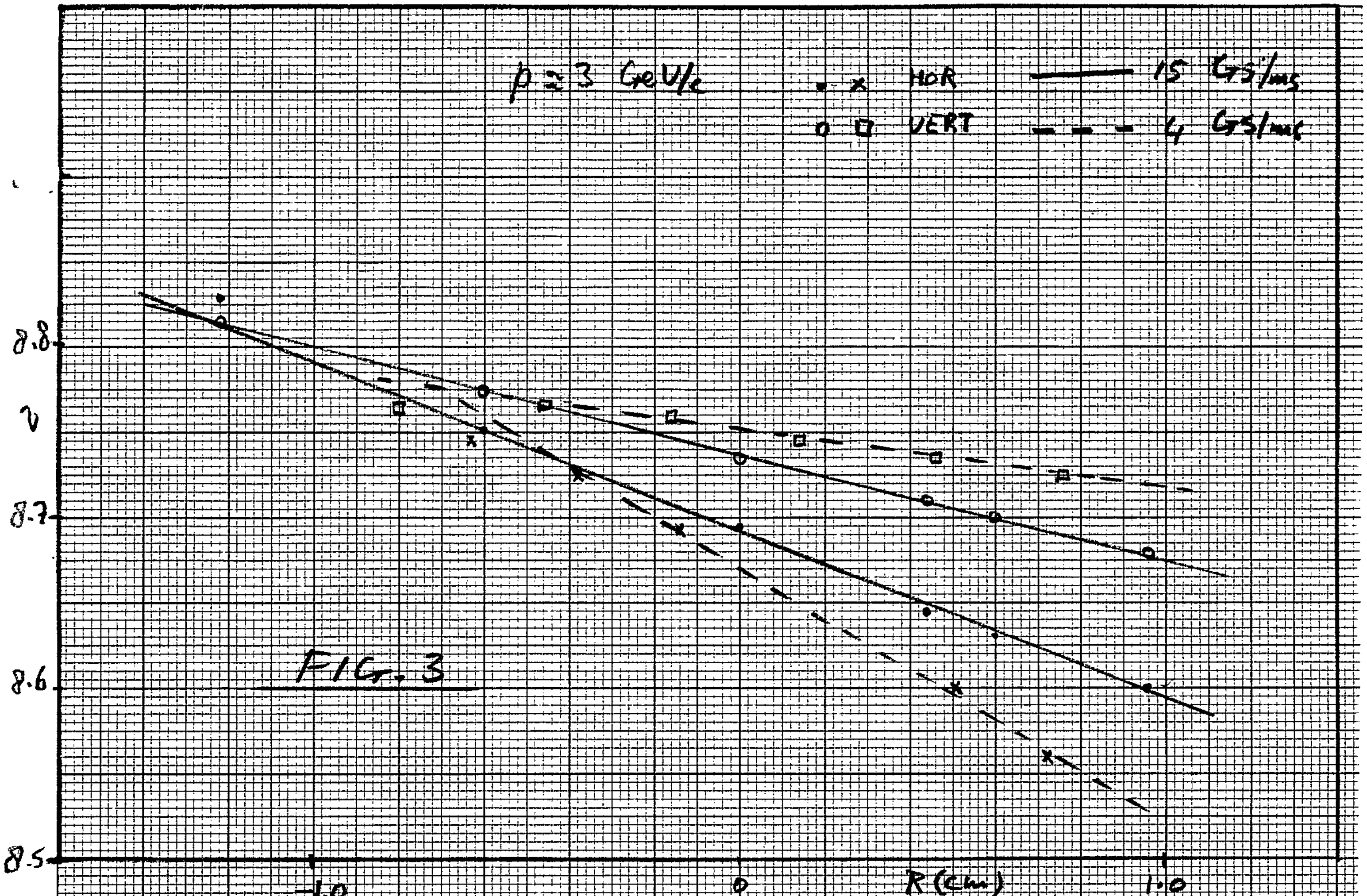


FIG. 3