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RELATION BETWEEN THE B-PULSE TRAIN AND THE KINETIC ENERGY OF THE PROTONS

Recently I have been told that there is a discrepancy between the indication of the field value and the kinetic energy of the circulating protons. This is true for the following reasons:

a) The distributed B value corresponds to B_o (for definitions see PS/Int. MM 59-5) because it is a punctual measurement on the 101st unit.

b) The relation for the particle momentum is, of course, related to the B_o value integrated over the length of the magnet.

$$P_o = e \cdot \bar{B}_o \cdot R_o$$

$$L_m \cdot \bar{\bar{B}}_o = B_o \cdot L_{equivalent} \qquad L_m = 4{,}4 \text{ m} = \text{constant}$$

c) Since the equivalent length varies due to saturation effects, the relation between B_o and $\bar{B}_o$ is non linear. The equivalent length of the magnet decreases with increasing field and therefore with the particle momentum. Therefore the indicated B_o value suggests a too high particle momentum.

Two possibilities are possible for a future modification of the B pulse train fabrication:

1. Introduction of a long (3 meters) search coil in the reference unit. This is the best solution, because the indication would be valid for all rates of rise of the PS field (except the

3 ... 6 Gauss due to the eddy current in vacuum chambers and P.F.W. corrections)

2. Digital correction on the integrator output by substraction (resp. addition) of pulses in the up-down counter for the B indication.

Illustrations (taken from the report PS/Int. MM 59-5) :

1) Definitions

2) Field distribution along a magnet half

3) Magnetisation curve

4) Users handbook F2 p. 3

A new calibration of the B pulse train will be made during the shut-down summer 1968.

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corresponding current I, the dynamic field B_0 in the second block from the junction and the average dynamic field $\bar{B}_0$ as defined in appendix I.

Table 1

K	I (A)	B_0 (Wb/m^2)	$\bar{B}_0$ (Wb/m^2)
1	24,5	0,0058	-
2	53,5	0,01300	0,01304
3	159,9	0,03983	0,03993
4	1144	0,2840	0,2840
5	2442	0,6086	0,6080
6	4025	1,000	0,9942
7	4899	1,201	1,186
8	6396	1,442	1,419

1. ACKNOWLEDGEMENT.

It is a pleasure to thank here Miss Ann Beard, who took care of virtually all reducing of measurement data for this report.

2. DESCRIPTION OF THE UNIT.

Except where stated differently, the measured unit was of the U-type. A sketch can be found in Fig. 1. It was composed of girder, blocks and coils from the actual production and assembled to the final dimensions.

3. AZIMUTHAL VARIATION OF THE FIELD AND THE GRADIENT ON THE EQUILIBRIUM ORBIT.

3.1. $B = B(\theta)$ point by point. Fig. 2

The figure shows the situation in a radially defocusing half sector for various excitation levels. The radially focusing half sector yields a similar picture but for the width of the gaps.

14. APPENDIX I: SUMMARY OF DEFINITIONS AND FORMULAE.

A collection of adopted definitions and formulae is given for easy reference. Note that the definition of the equivalent length for focusing at the junction is different from the one given in MM 24.

14.1. The Magnetic Bending Length of a Unit.

It can be seen from Fig. 1 that, for medium excitation, the field on the equilibrium orbit does hardly change with θ save at the joints between blocks and at the ends of the unit. A magnetic length is therefore defined at excitation level (4). $i = 1144\ A \quad B_o = \bar{B}_o = 2840$ Gauss $\quad L_m = 4{,}4$ m.

$$L_m = \frac{\int B\,(\theta)\, d\,\theta}{B_o} \qquad (1)$$

where B_o is the field in the centre of the second block from the junction in the open half section. The integral is taken along the equilibrium orbit.

14.2. The Mean Field Density $\bar{B}_o$

The mean field density of a unit on the equilibrium orbit as related to the ideal particle momentum p_o by

$$p_o = e \cdot \bar{B}_o \cdot R_o$$

where e is the electric charge of the proton and R_o the radius of curvature of the units, is defined as,

$$\bar{B}_o = \frac{\int B\,(\theta)\, d\,\theta}{L_m} \qquad (2)$$

14.3. The Field Index n.

The undisturbed field index, i.e. far from ends, gaps and junction is there given by

$$n = \frac{R_o}{B_o} \cdot \frac{\partial B}{\partial r} \qquad (3)$$

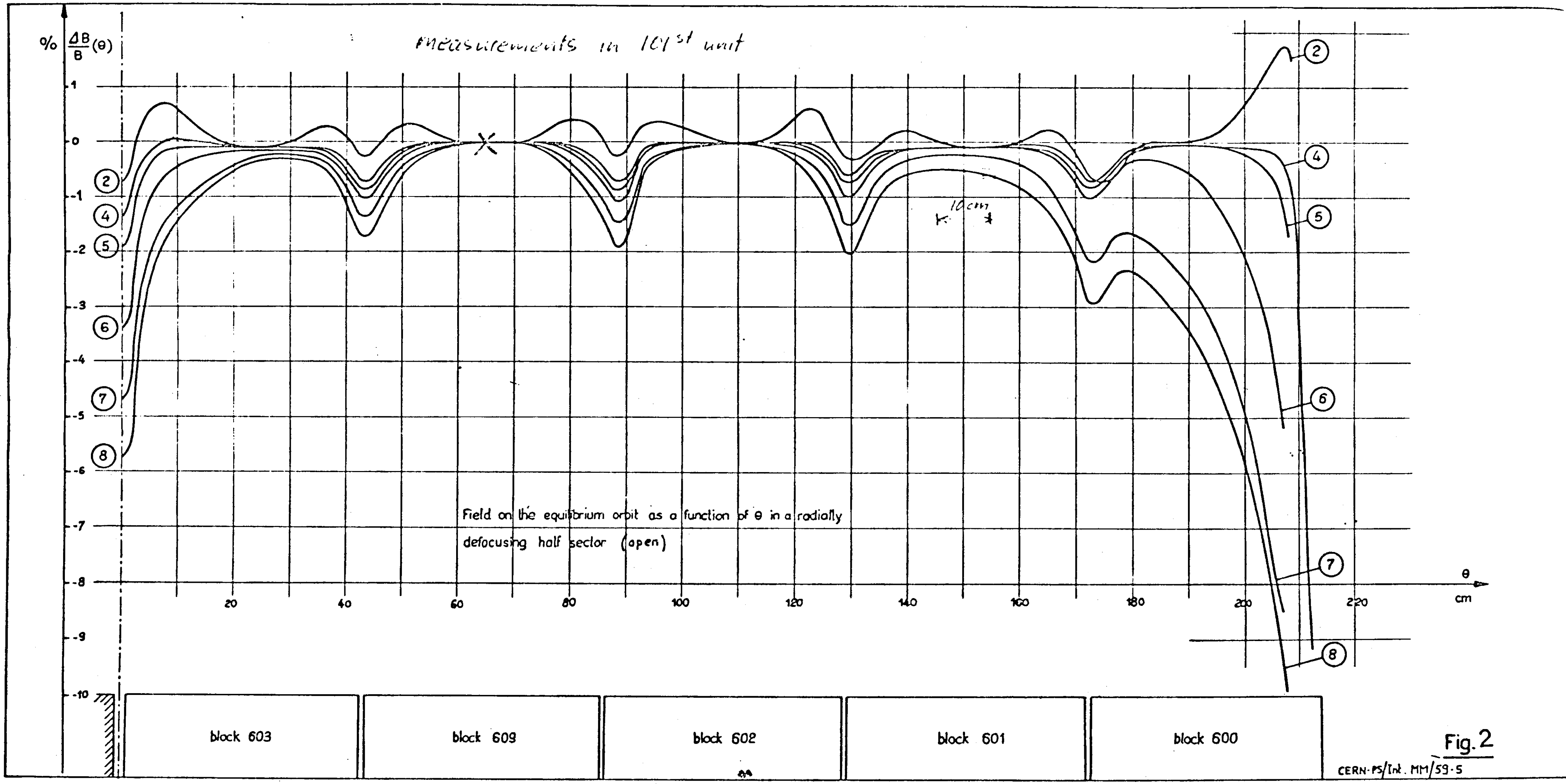

Fig. 2

CERN-PS/Int. MM/59-5

<u>Table 1</u> (See F 2 page 2 for explanation)

cp [GeV]	E_{kin} [GeV]	E_{tot} [GeV]	$\bar{B}$ [kG]	B [No. of pulses] (*)	Δ B	Rise time(**) [ms]
1.000	0.433	1.371	0.476	46	47	32
2.000	1.271	2.209	0.952	93	48	67
3.000	2.205	3.143	1.428	141	48	102
4.000	3.170	4.108	1.904	189	47	139
5.000	4.149	5.087	2.380	236	48	175
6.000	5.135	6.073	2.856	284	47	212
7.000	6.124	7.062	3.332	331	48	248
8.000	7.117	8.055	3.808	379	47	285
9.000	8.111	9.049	4.284	427	48	324
10.000	9.106	10.044	4.760	475	48	362
11.000	10.102	11.040	5.236	523	48	401
12.000	11.098	12.036	5.712	571	48	439
13.000	12.096	13.034	6.188	619	48	480
14.000	13.093	14.031	6.664	667	48	521
15.000	14.091	15.029	7.140	715	48	562
16.000	15.089	16.027	7.616	763	48	603
17.000	16.088	17.026	8.092	811	48	645
18.000	17.086	18.024	8.568	859	48	688
19.000	18.085	19.023	9.044	907	48	730
20.000	19.084	20.022	9.520	955	49	775
21.000	20.083	21.021	9.996	1004	49	819
22.000	21.082	22.020	10.472	1053	48	867
23.000	22.081	23.019	10.948	1101	49	915
24.000	23.080	24.018	11.424	1150	50	963
25.000	24.079	25.017	11.900	1200	49	1011
26.000	25.079	26.017	12.375	1249	48	1058
27.000	26.078	27.016	12.851	1297	48	1109
28.000	27.078	28.016	13.327	1345	48	1160
29.000	28.077	29.015	13.803	1393	49	1217
30.000	29.076	30.014	14.279	1442	49	----

(*) See F 2 page 1, H 1 and H 2 for explanation.

(**) Approximate values (± 2 ms).