Fermilab

TM-814
0427.020

THE MOMENTUM OF MAIN RING BEAM AS A FUNCTION OF MAGNET CURRENT

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October, 1978

All main ring magnets are compared to a reference magnet before being installed. The reference magnet used is a four foot model of a main ring magnet originally built to test laminations. The reference magnet and the magnet to be tested are placed in series and excited with current ramped to 6500 amps at a rate of 1500 amps/sec. The current is measured with a transductor. Two turns of 2 mil tungsten wire wrapped around 1.0045 inch quartz crystals with a turns-area of .3098 meter^2-turns is placed inside the main ring magnet. The advantage of this "stretched wire probe" is that the coil extends out past the end plates and a value of exactly 239 inches length is used for the turns-area number of the probe. Thus we circumvent the problem of finding the magnetic length. The reference magnet probe consists of a coil wrapped around a form epoxied in the center of the reference magnet. The reference probe has a turns-area of .5569 meter^2-turns. The probes are connected in two separate ways, as shown in figure 1, such that the "Excitation % Difference":

$$\frac{B - Bref}{B} \quad (100);$$

can be determined. The reference coil output runs through a

divider network, not shown, to yield a signal proportional to B-BREF in the "bucked" configuration. The magnet is first ramped several times to establish a remanent field. It is then ramped two more times while data is taken in the "unbucked" mode at 100, 1000,2000,3000,4000,5000,6000, and 6500 amps. The integrator is checked for drift and the two runs are compared to insure consistency. The computer calculates the field in kilogauss and prints the results. The magnets are again ramped twice more while the bucked data is collected. The two sets of data are again compared and the excitation percentage difference is printed. This data is kept at the magnet facility for every magnet in main ring.

Dean Krause recently measured the reference magnet field with an NMR probe, Table I. I averaged the data from 120 magnets. Sixty B1 magnets, 30 having serial numbers between 1000 to 1500 and 30 with serial numbers between 1500 and 2000. Likewise with the B2's 30 with serial numbers between 2000 to 2500 and 30 with serial numbers between 2500 and 3000. This data may be found in Table 2.

In main ring there are 378 B1 magnets and 396 B2 magnets for a total of 774 bending magnets. A 239 inch length yeilds a magnetic radius ρ = 747.813 meters which in turn yields the momentum -field relation

$$P\ (GeV/c) = 22.4189\ (GeV/c)/KGAUSS$$

The average remanent field is 15 gauss and included in the table and graphs. The error I show on the graphs assumes a transductor current error of 2 amps, an error of 2 gauss from the reference magnet measurement, and the standard deviation of the 120 magnets sampled.

I performed a lest squares fit and then determined and plotted the difference between the line and each data point. To find the

momentum of the beam for a given main ring magnet current simply calculate the value predicted with the equation of the line, given on the graph, and add the Δ value obtained from the graph. The downward slope of Δ for currents greator than 3800 amps is due to the saturation of the magnets. For convenience I included a graph to convert from momentum to current. Also, included is a graph of the percentage difference between B1 and B2 magnets.

References

Personal communications with: Dean Krause, Ryuji Yamada, Chuck Schmidt and Shoroku Ohnuma.

FIGURE 1

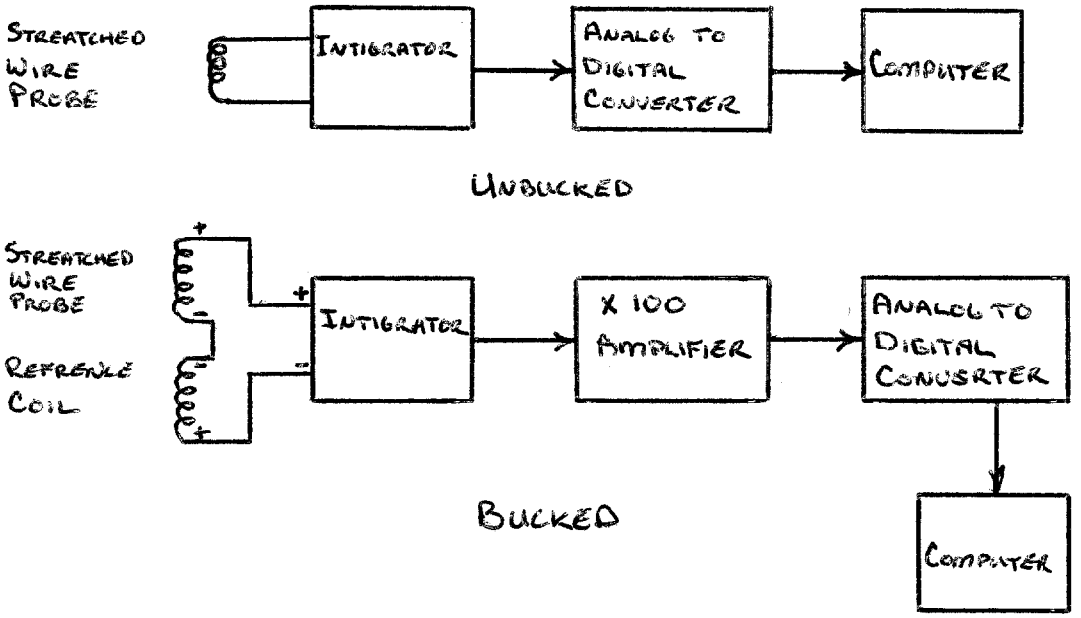
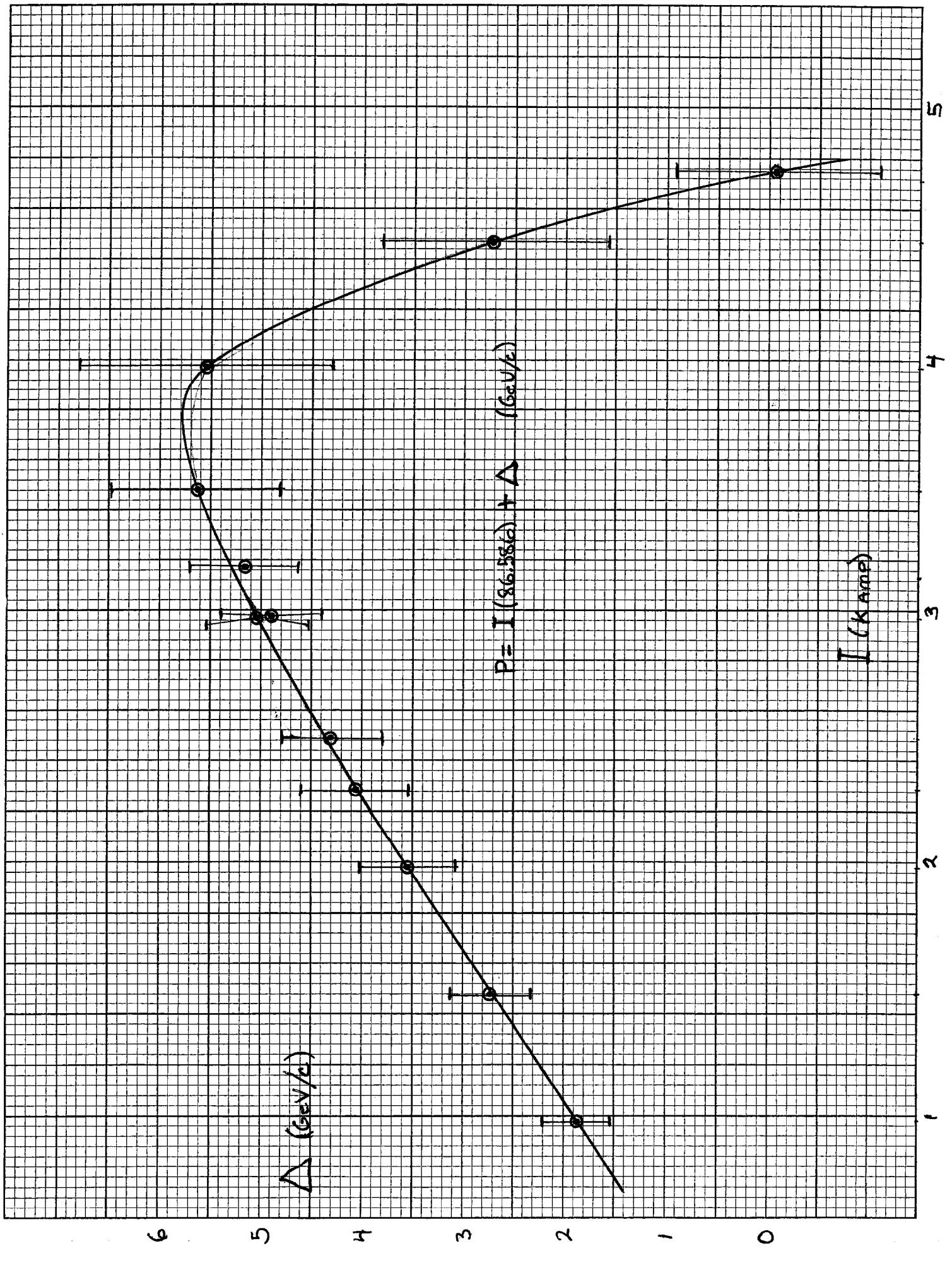


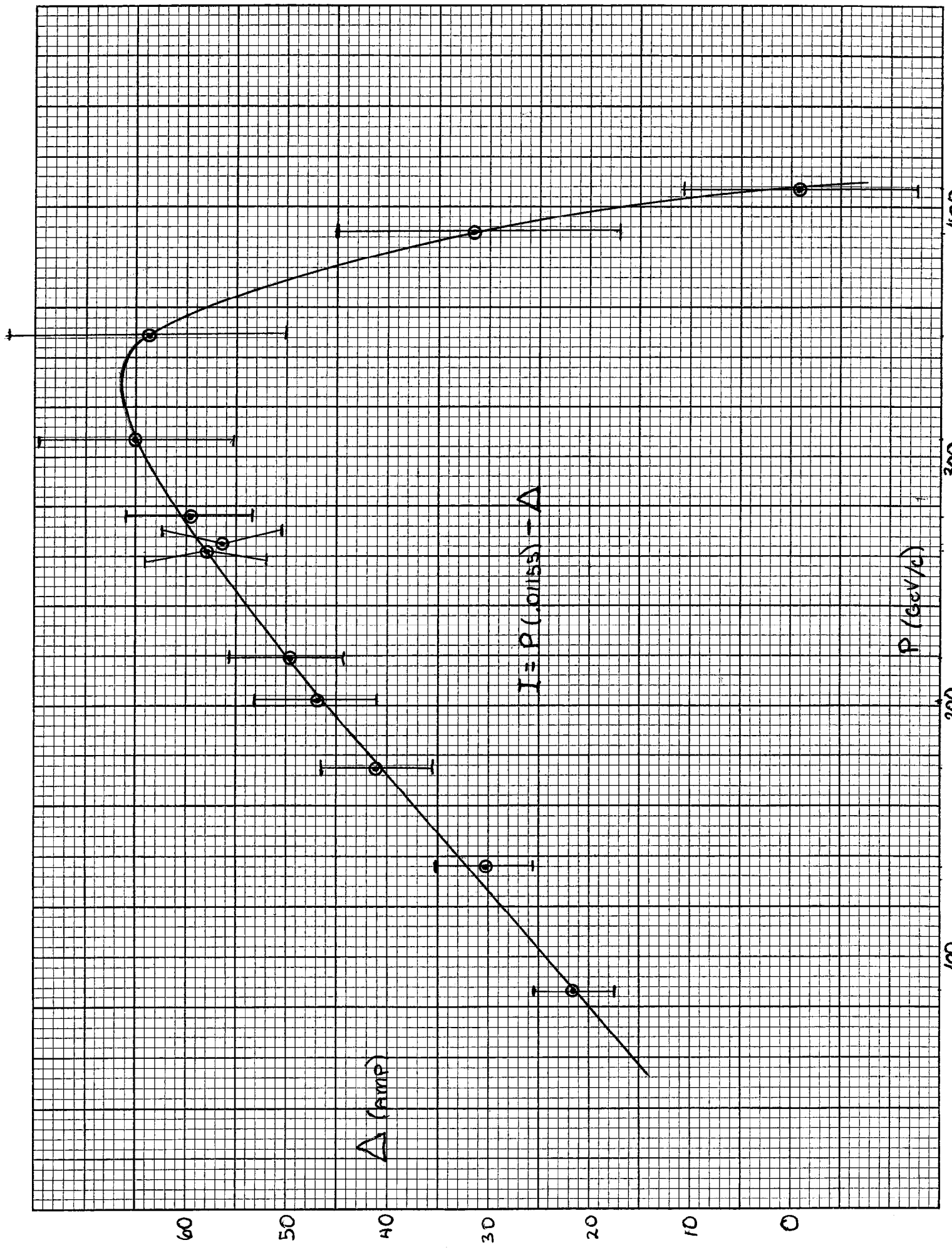
TABLE I

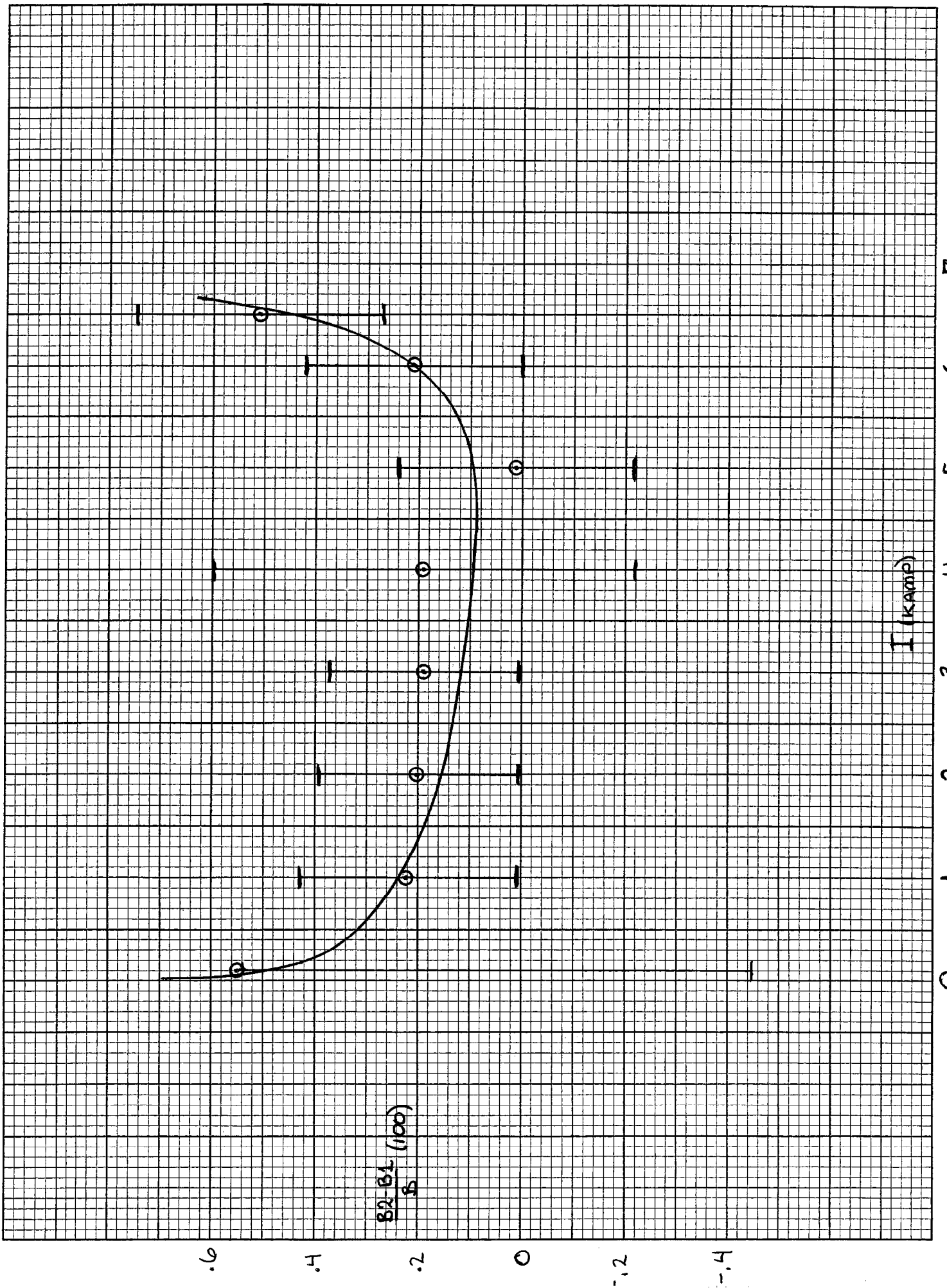
I (KAMP)	BREF (kGAUSS)	B-MAIN RING (kGAUSS)	P-MAIN RING (GeV/c)
.982	3.863	3.860	86.9
1.478	5.809	5.808	130.6
1.980	7.787	7.790	175.0
2.286	8.990	8.994	202.0
2.490	9.785	9.791	219.9
2.969	11.674	11.573	262.1
2.975	11.693	11.693	262.5
3.129	12.278	12.298	275.1
3.477	13.623	13.665	306.7
3.969	15.452	15.562	349.2
4.469	17.120	17.368	389.7
4.707	17.858	18.161	407.5

TABLE II

I (KAMP)	Excitation % Difference (%)
.100	-.328
1.000	-.071
2.000	.042
3.000	.123
4.000	.746
5.000	1.884
6.000	1.879
6.500	1.597


P = I (86.58 G) + Δ (GeV/c)
I (K Amp)
Δ (GeV/c)
1
2
3
4
5
6
5
4
3
2
1
0


400
300
200
100
P (GeV/c)
T = P(.015) - Δ
60
50
40
30
20
10
0
Δ (AMP)


I (KAMP)
0
1
2
3
4
5
6
7
$\frac{B2-B1}{B_1}(100)$
.6
.4
.2
0
-.2
-.4