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Orbits Produced by Individual Extraction Bump Magnets

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Subject: ORBITS PRODUCED BY INDIVIDUAL EXTRACTION BUMP MAGNETS

Summary

Analysis of the orbits produced by the individual extraction bump magnets indicate that the Booster position monitors (BPM's) are very good and have a relative rms accuracy significantly better than 0.5 millimeters.

Experiment

The extraction bump magnets (F2, F4, F7, A1) were powered individually at nominal currents of 100 and 200 Amperes and the resulting beam orbits were measured as was the unperturbed orbit.

Analysis

The output of a BPM can be characterized as:

$$X(BPM) = a + b * X(beam) + \text{higher terms}$$

The BPM's have been set up to be very linear inside of plus or minus 30 mm. so we can ignore higher order terms for the present. The orbits considered will be difference orbits wherein we subtract the unperturbed orbit from the bumped orbit and therefore the constant a term disappears from the analysis. In this note we are thus considering in effect the value of the b term in the equation and the reproducibility of the BPM readings.

The data points in Figures 1, 2, and 3 show difference orbits for three of the bump magnets excited to about 200 Amperes. The curves are fitted to the data using the formula:

$$X(s) = K * \cos[phi(s)] * \sqrt{[beta(s)*beta(k)]} / [2 * \sin(\pi * Q)] + disp(s) * dP/P$$

where phi(s), beta(s), and disp(s) are the usual machine functions as calculated by MAD, and K, Q, and dP/P are the constants found by the fitting procedure and represent the angle imparted by the bump magnet, the tune of the machine, and momentum offset of the beam. In this note we shall not evaluate the magnet calibrations but only discuss the quality of the fit.

It is apparent from inspecting the three figures that this simple formula gives a remarkably good fit to the data points. Table 1 summarizes the results.

TABLE 1. FITTED RESULTS

MAGNET	F2	F4	F7	UNITS
NOMINAL CURRENT	200	200	200	AMPERES
R^2	0.99898	0.99895	0.99697	CORR COEF
BUMP ANGLE	1.65	1.815	1.641	mr
TUNE	4.805	4.81	4.8	
dP/P	1.1	1.2	1.1	0.001
RMS ERROR: MEAS – FIT	0.32	0.38	0.49	MM

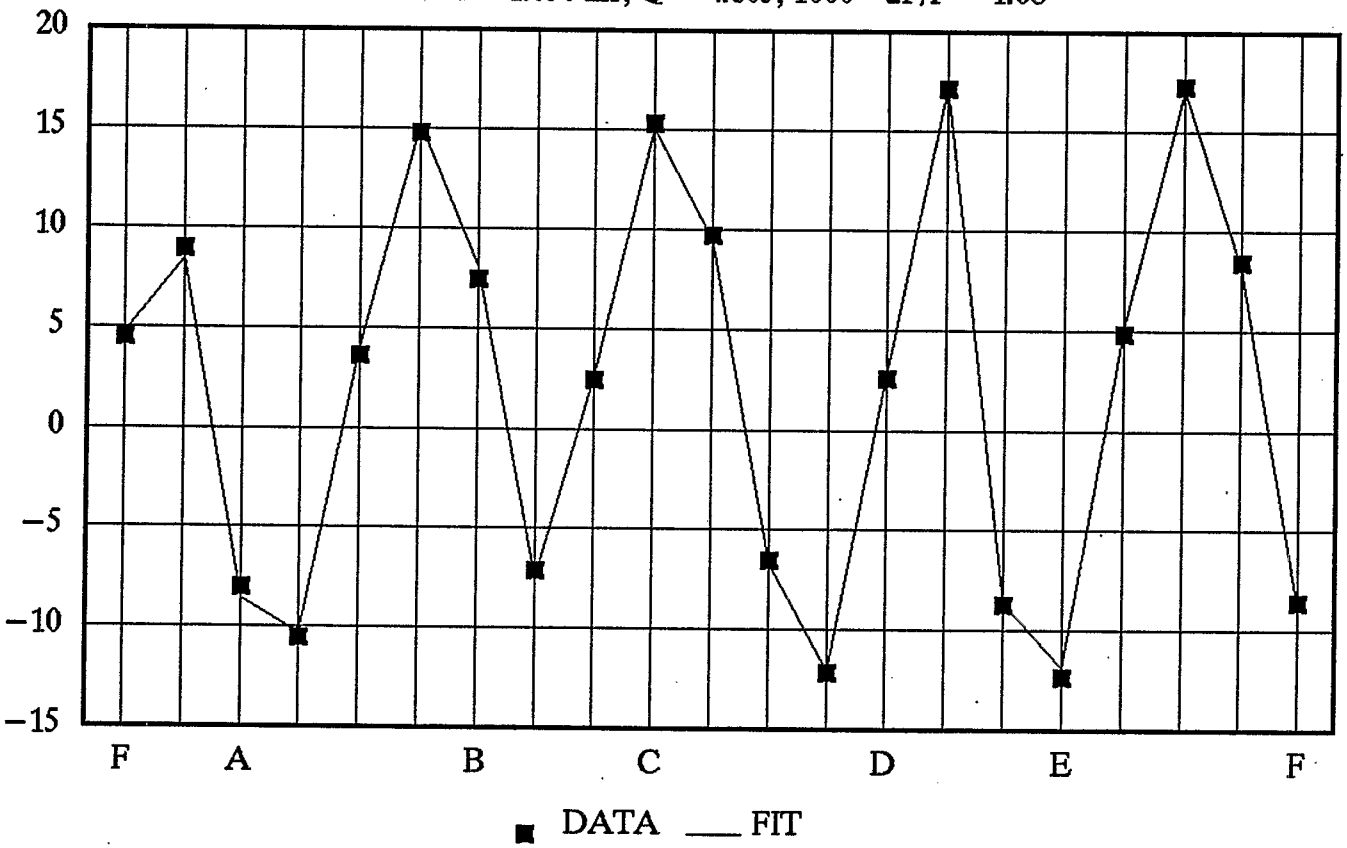
Conclusion

We have nothing to say about the absolute offsets of the BPM's, nor can we say anything about the B6 BPM which was not in the system, but otherwise we can say that the BPM's are remarkably good. The rms error on a difference orbit measurement is less than 0.4 mm. which means that the rms error on an individual BPM reading is about 0.25 mm. In other words the b term in the first equation is very very close to a value of +1 for each of the 21 BPM's evaluated.

There is much more information to be derived from this experiment and hopefully it will be.

F2 KICK

KICK = 1.650 mr; Q = 4.805; 1000 * dP/P = 1.08



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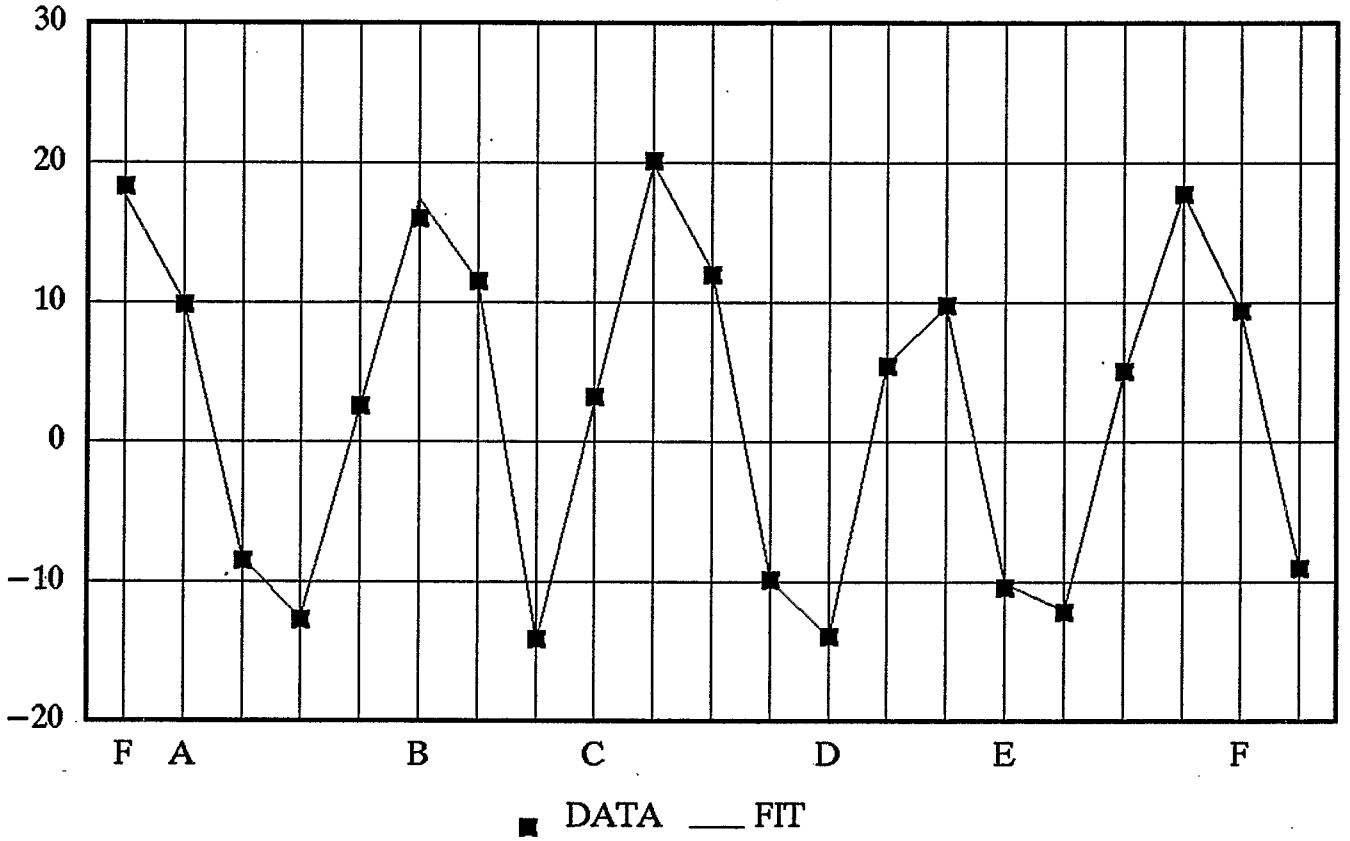
F4 KICK

KICK = 1.815 mr; Q = 4.810; 1000 * dP/P = 1.23



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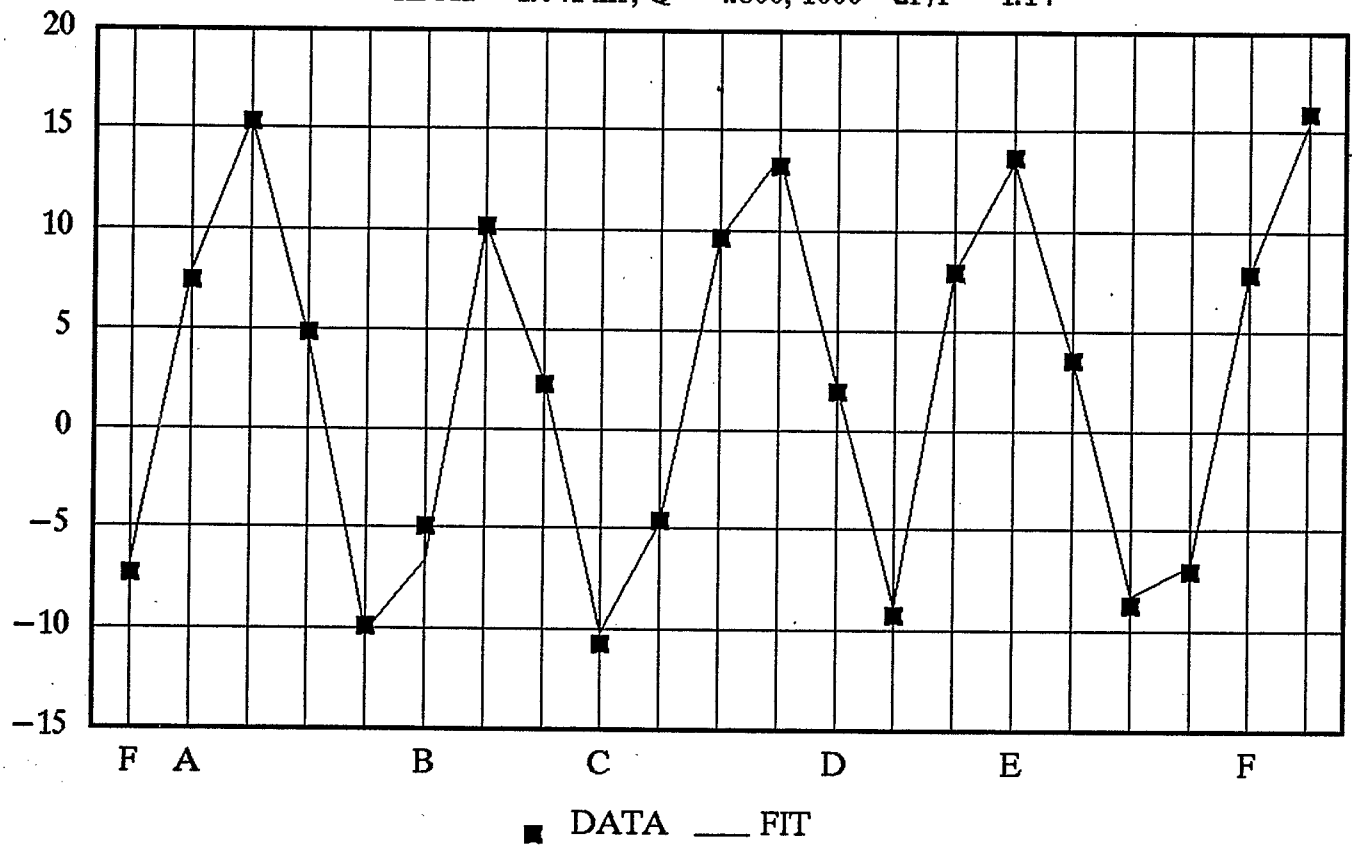
F7 KICK

KICK = 1.641 mr; Q = 4.800; 1000 * dP/P = 1.14



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