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Calibration ofÿ Booster Extraction Bump Magnets

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AGS STUDIES REPORT

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Subject: Calibration of Booster Extraction Bump Magnets

Summary

The four Booster extraction bump magnets were powered individually and the resulting orbits measured. The amplitudes of these orbits give the bump angles produced by the magnets and thus the magnet calibration.

Experiment

The extraction bumps 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. In AGS Studies Report No. 266 (July 31, 1992), we analyzed the data and concluded that for difference orbits, the BPMs give very good results. Table 1 of that note gave results for the first three magnets at 200 Amperes. Table 1 of this note is similar, but gives the results for all four magnets at both 200 and 100 Amperes.

TABLE 1. FITTED RESULTS

MAGNET	F2	F4	F7	A1	UNITS
NOMINAL CURRENT	200	200	200	200	AMPERES
R^2	0.99898	0.99895	0.99697	0.99810	CORR COEF
BUMP ANGLE	1.650	1.815	1.641	1.725	mr
TUNE	4.805	4.810	4.800	4.815	
dP/P	1.1	1.2	1.1	1.03	0.001
RMS ERROR: MEAS – FIT	0.32	0.38	0.49	0.42	MM
NOMINAL CURRENT	100	100	100	100	AMPERES
R^2	0.9988	0.9981	0.9987	0.9963	CORR COEF
BUMP ANGLE	0.812	0.922	0.705	0.770	mr
TUNE	4.815	4.805	4.805	4.815	
dP/P	0.03	1.54	1.11	1.1	0.001
RMS ERROR: MEAS – FIT	0.17	0.25	0.15	0.72	MM

Analysis

For each of the eight cases, the tune is a fitted parameter. Averaging over all eight cases, we get for the tune:

$$Q = 4.809 \pm 0.005.$$

All the data was presumably taken at this tune and, since the calculated bump amplitude depends on the tune, we must adjust the results to this tune. In general:

$$K = a + b * (Q - c) + d * (Q - c)^2.$$

K is the bump angle of the magnet in milliradians, Q is the average tune, found above, a and c are the fitted bump angle and tune tabulated in Table 1, and b and d are fitted constants found from detailed analysis and tabulated in Table 2. Figure 1 is a typical plot showing how the fitted bump angle depends on the assumed tune.

TABLE 2. BUMP vs TUNE – FITTED PARAMETERS

MAGNET	F2	F4	F7	A1	UNITS
NOMINAL CURRENT	200	200	200	200	AMPERES
a	1.651	1.815	1.641	1.726	mr
b	−7.631	−8.696	−7.23	−8.6	mr
c	4.805	4.81	4.8	4.815	
d	−12.799	−9.873	−10.714	−11.644	mr
NOMINAL CURRENT	100	100	100	100	AMPERES
a	0.812	0.922	0.705	0.77	mr
b	−4.032	−4.284	−3.218	−3.842	mr
c	4.815	4.805	4.805	4.815	
d	−5.37	−4.843	−4.313	−5.167	mr

Using the average Q, and the equation above, gives our best estimate of the bump angles for each of the eight cases, tabulated in Table 3. These numbers are slightly different from best individual fits given in Table 1, since we have specified the tune.

There are three ways of determining the current in the magnet. They will be evaluated in a different note. The best seems to be reading on a digital scope the analogue signal derived from the magnet current. We assume this reading has good accuracy and is linearly proportional to the current since Figure 2, which plots bump amplitude versus analogue signal, gives a very good fit.

TABLE 3. BUMP AMPLITUDE & ANALOGUE SIGNALS

MAGNET	F2	F4	F7	A1	UNITS
NOMINAL CURRENT	200	200	200	200	AMPERES
K	1.622	1.826	1.577	1.779	mr
ANALOGUE SIGNAL	1.78	2.05	1.74	1.95	VOLTS
NOMINAL CURRENT	100	100	100	100	AMPERES
K	0.837	0.906	0.676	0.794	mr
ANALOGUE SIGNAL	0.88	1.04	0.76	0.89	VOLTS

Conclusion

Our conclusion is that all four extraction bumps are identical as a function of current. At extraction, the bump amplitude in milliradians is given by:

$$K = [0.904\ (\pm\ 0.018)] * V,$$

where V is the voltage of the analog signal read on the digital scope with an unterminated input. The point of this note is that the system gives very good accuracy, precision, and reproducibility, and we know precisely what the extraction bump is doing.

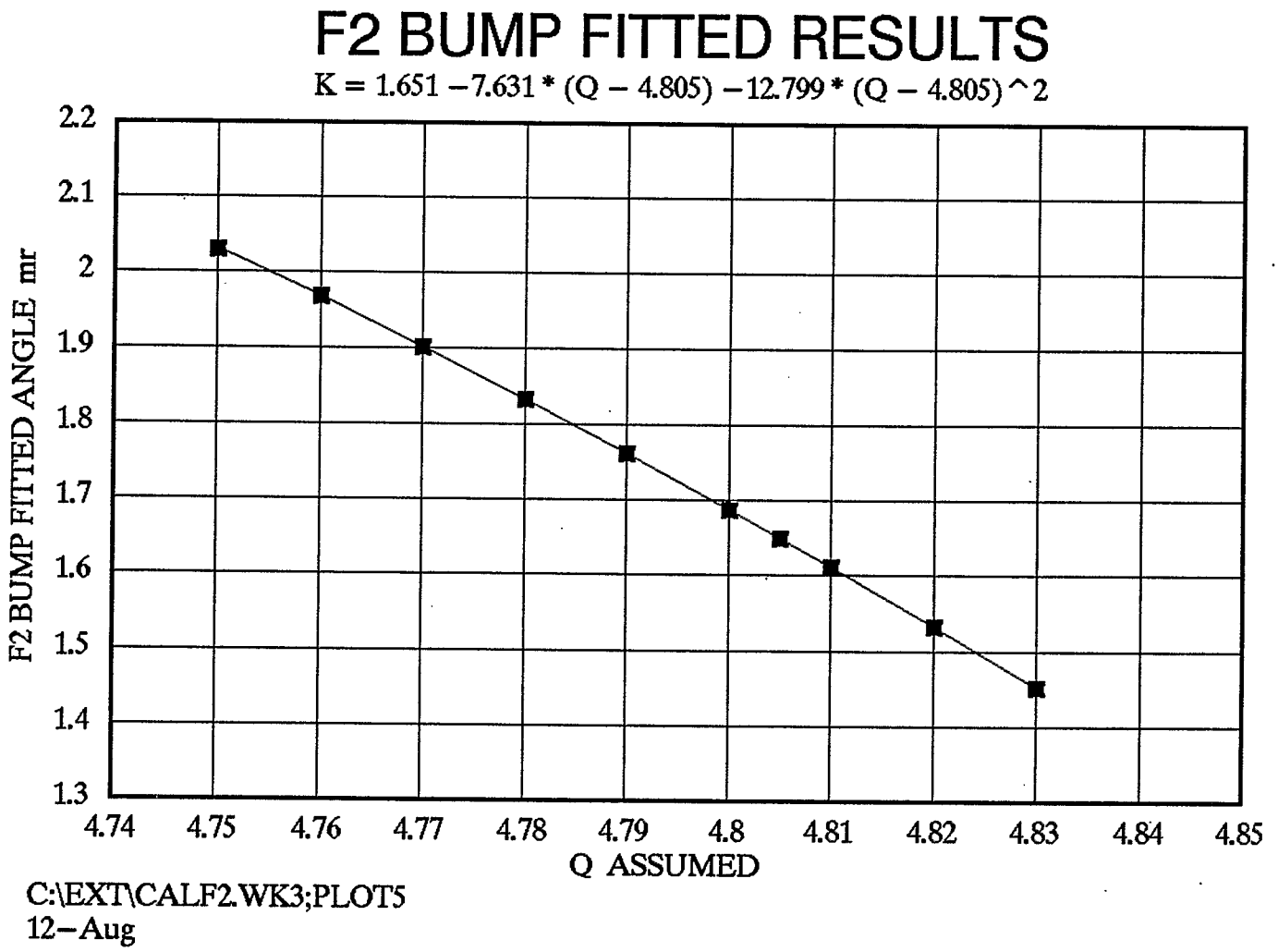
F2 BUMP FITTED RESULTS
K = 1.651 −7.631 * (Q − 4.805) −12.799 * (Q − 4.805) ^ 2
F2 BUMP FITTED ANGLE mr
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
4.74
4.75
4.76
4.77
4.78
4.79
4.8
4.81
4.82
4.83
4.84
4.85
Q ASSUMED
C:\EXT\CALF2.WK3;PLOT5
12−Aug

FIGURE 1

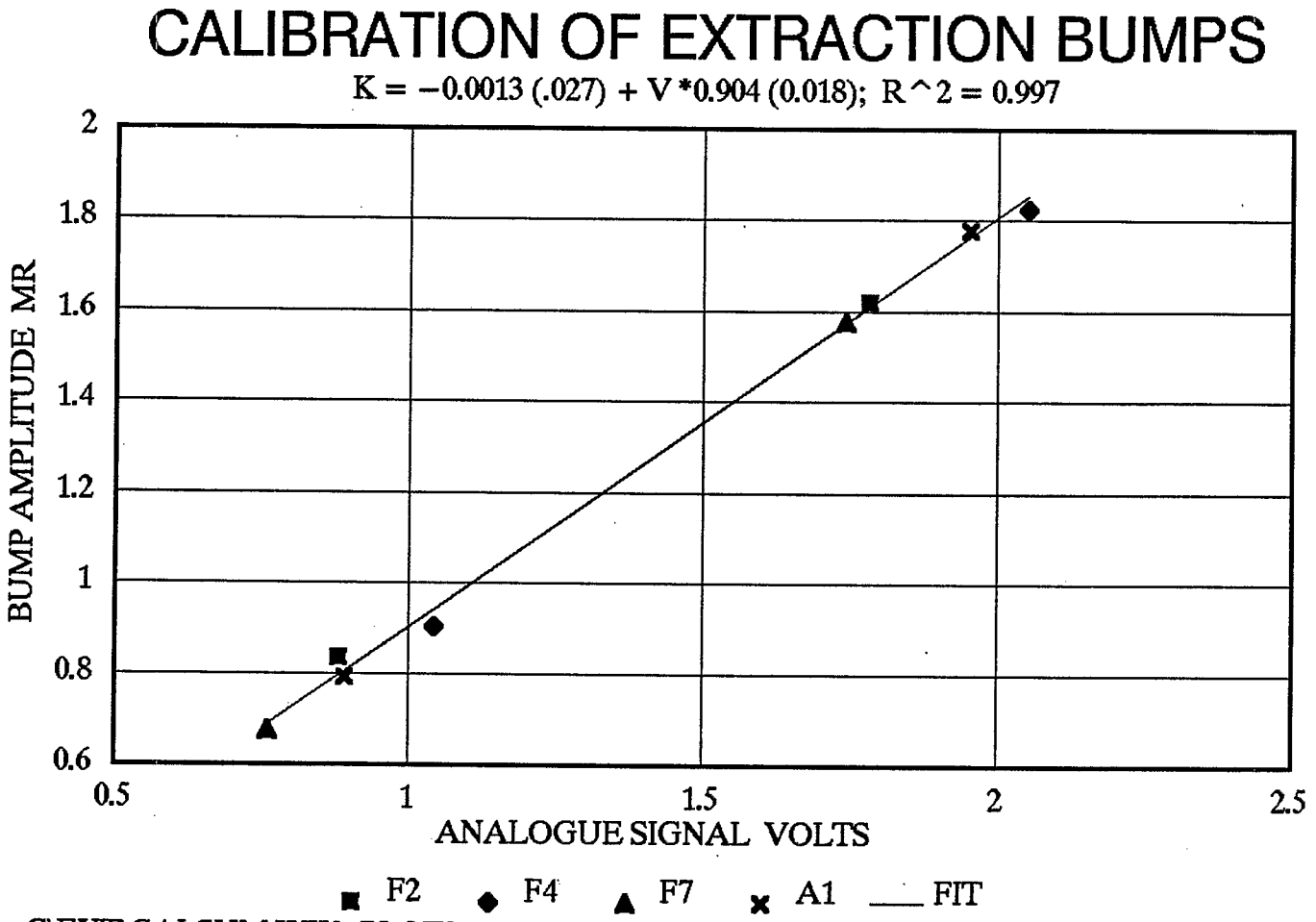
CALIBRATION OF EXTRACTION BUMPS
K = −0.0013 (.027) + V *0.904 (0.018); R^2 = 0.997
BUMP AMPLITUDE MR
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.5
1
1.5
2
2.5
ANALOGUE SIGNAL VOLTS
F2
F4
F7
A1
FIT
C\EXT\CALSUM.WK3; PLOT3
12−Aug

FIGURE 2