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Further Studies of the Fast Injection Bump

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Observations and Conclusions

The purpose of the present study was to answer some of the questions raised in a previous study (AGS Studies Report #171) and to investigate further the dependence of the A13-B7 bump residuals on the relative amplitudes of the A13 and B7 kicks.

The general set-up and technique was similar to that of the previous study except that the bump was refired some 30 ms after injection rather than simply extending it beyond its normal off time. The Linac pulse width was reduced so that 2-4 x 10^{12} protons were stacked in the AGS and the beam was accelerated for 30 ms to insure sufficient bunching and intensity to obtain an orbit. Using the ring PUE system (NORB and ORBED programs) with an external sample trigger 32 ms after peaker, a reference orbit was taken without refiring the bump. Then with the same orbit trigger, another orbit was taken with the bump refired at the orbit sample time. Subtracting the reference orbit from this orbit one then obtains a measure of the effect of the A13 and B7 kicks on the equilibrium orbit (E.O.). We note that since this effect is measured 30 ms after injection, it must be scaled up by the ratio (380/250 = 1.5) of the field at the trigger time (1800 Gauss clock counts ≃ 380 Guass) to the field at injection (250 Gauss) to obtain the effect of the kicks on the E.O. at injection.

Table I and Figure 1 show the ninth harmonic of the E.O. as a function of the ratio $(B7/A13)^2$ of the kick currents squared. Because of the location and width (one-half lambda) of the A13-B7 bump and since the tune $\nu \simeq 9$, we expect the bump to contribute approximately 1/18 of its amplitude to the sin component of the ninth harmonic and very little to the cos component. Thus, the cos component is a measure of the amplitude of the E.O. residuals. Table I and Figure 1 then show that the residuals are minimized for $(B7/A13)^2 \simeq 1.75 \pm 0.20$ which in turn implies that the ratio of the betatron functions $(\beta_{A13}/\beta_{B7}) \simeq 1.75 \pm 0.20$. (The standard machine model gives approximately 2.) This result is consistent with that obtained in Studies Report #171 (see above). The sin component of the residuals appears to vary very little with the ratio $(B7/A13)^2$.

Tables II and III show that vertical and horizontal tune sweeps of approximately 0.05 have little effect on the amplitude of the bump or the residuals. For larger tune excursions, one does expect to see these amplitudes change--especially near integer tunes. We also note that there appears to be some correlation between the bump height and the beam intensity which indicates some dependence of the PUE system calibration on beam intensity.

Table IV and Figure II summarize the results of our search for any dependence of the horizontal tune (ν_H) on the bump height. Both the table and figure show that a sweep of the bump height over the range 5.0-16.0 mm has little effect on the measured horizontal tune. Also shown are the PIP measurements of the position and angle (with respect to the E.O.) at the foil corresponding to the various bump heights. As the bump height increases, the measured position at the foil should decrease by the same amount. In Figure II we see that the postion at the foil decreases by 15 mm when the bump height increases by 12 mm. The difference of 3 mm seen here is presumably due to a difference in the calibrations of the E.O. and PIP PUE's. As expected, the angle at the foil measured by PIP does not change as the bump is moved out. We note that at bump increments of + 600 and + 800, beam losses of approximatley 50% were observed over the first two turns (with Linac pulse width approximately 2 μs) and PIP was able to obtain a fit to the data only if these two turns were omitted. The resulting fitted parameters differed markedly from what one would have expected. This is perhaps due to the disruption of the average position of the protons in the bunch after a loss has occurred. In any case, the difference in fitted parameters upon omitting turns should be further studied with PIP data we have saved.

Table I

Ratio of Kick Currents Squared $(B7/A13)^2$	Bump Height (mm)	Ninth Harmonic (mm) Due to Kicks: Raw $(\sin^2+\cos^2)^{1/2}$	Bump Induced Portion Subtracted: Sin	Cos
1.31	8.7	1.2	-0.3	0.9
1.61	9.2	0.8	-0.3	0.3
1.69	8.2	0.8		
1.75	8.3	0.8	-0.3	0.0
1.98	9.2	0.8		
2.05	8.1	1.0		
2.32	9.2	1.1	-0.3	-0.7

(Intensity ≈ 2×10^{12} ppp; $\nu_H = 8.706$)

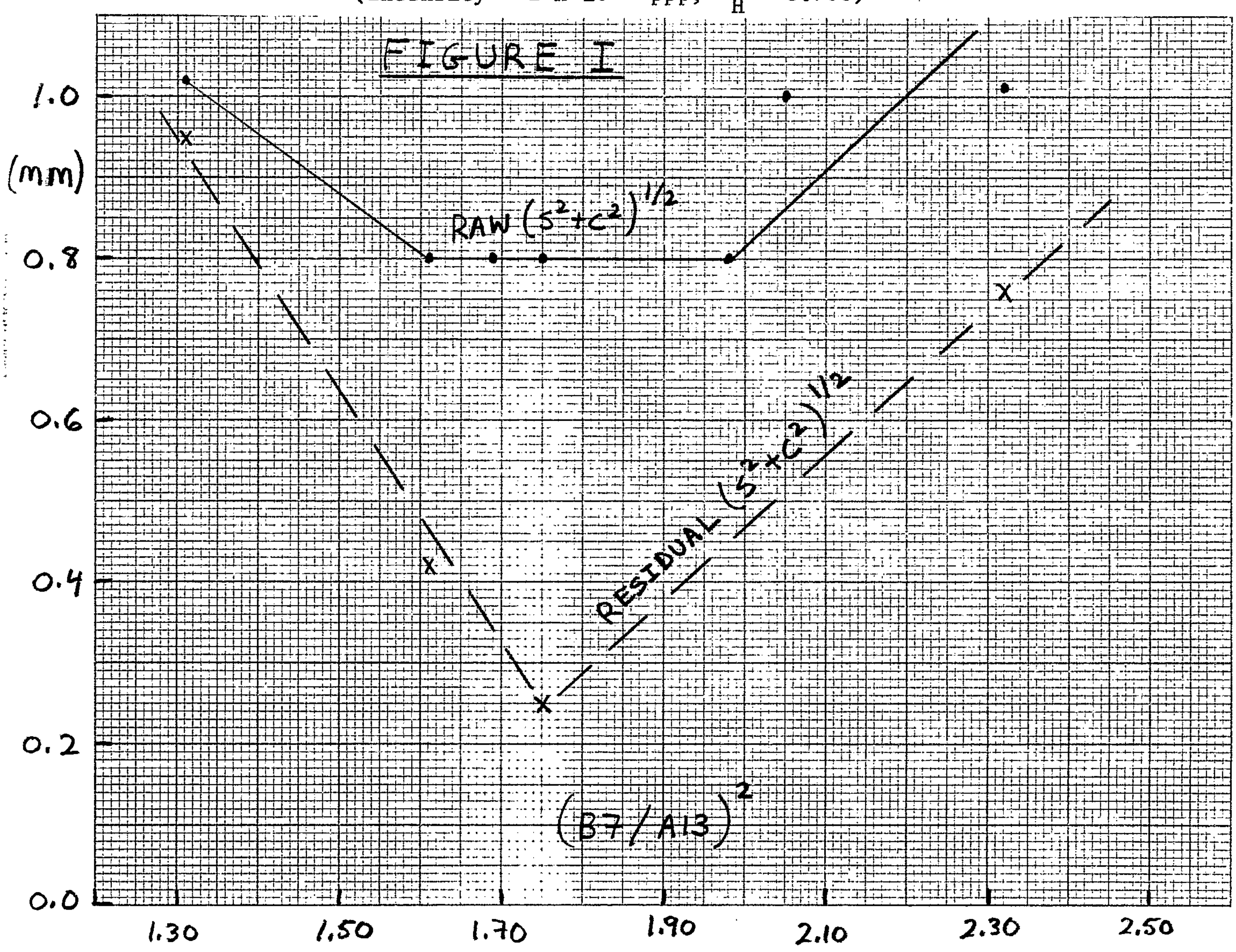


Table II

Measured Tunes ν_V ±.002	ν_H ±.002	Beam Intensity (ppp/10^{12})	Bump Height (mm)	Ninth Harmonic (mm) Due to Kicks: Raw	Bump Induced Portion Subtracted: Sin	Cos
8.881	8.706	2.4	8.9	0.7	−0.2	−0.2
8.865	8.698	1.9	8.7	0.9	−0.3	−0.3
8.846	8.693	1.7	8.3	0.9	−0.3	−0.4
8.846	8.693	2.8	9.6	0.7	−0.2	−0.2

Table III

Measured Tunes ν_V ±.002	ν_H ±.002	Beam Intensity (ppp/10^{12})	Bump Height (mm)	Ninth Harmonic (mm) Due to Kicks: Raw	Bump Induced Portion Subtracted: Sin	Cos
8.882	8.703	2.4	8.9	0.7	−0.2	−0.2
8.889	8.680	3.5	10.3	0.7	−0.1	−0.2
8.891	8.652	3.4	10.7	0.9	−0.3	−0.1

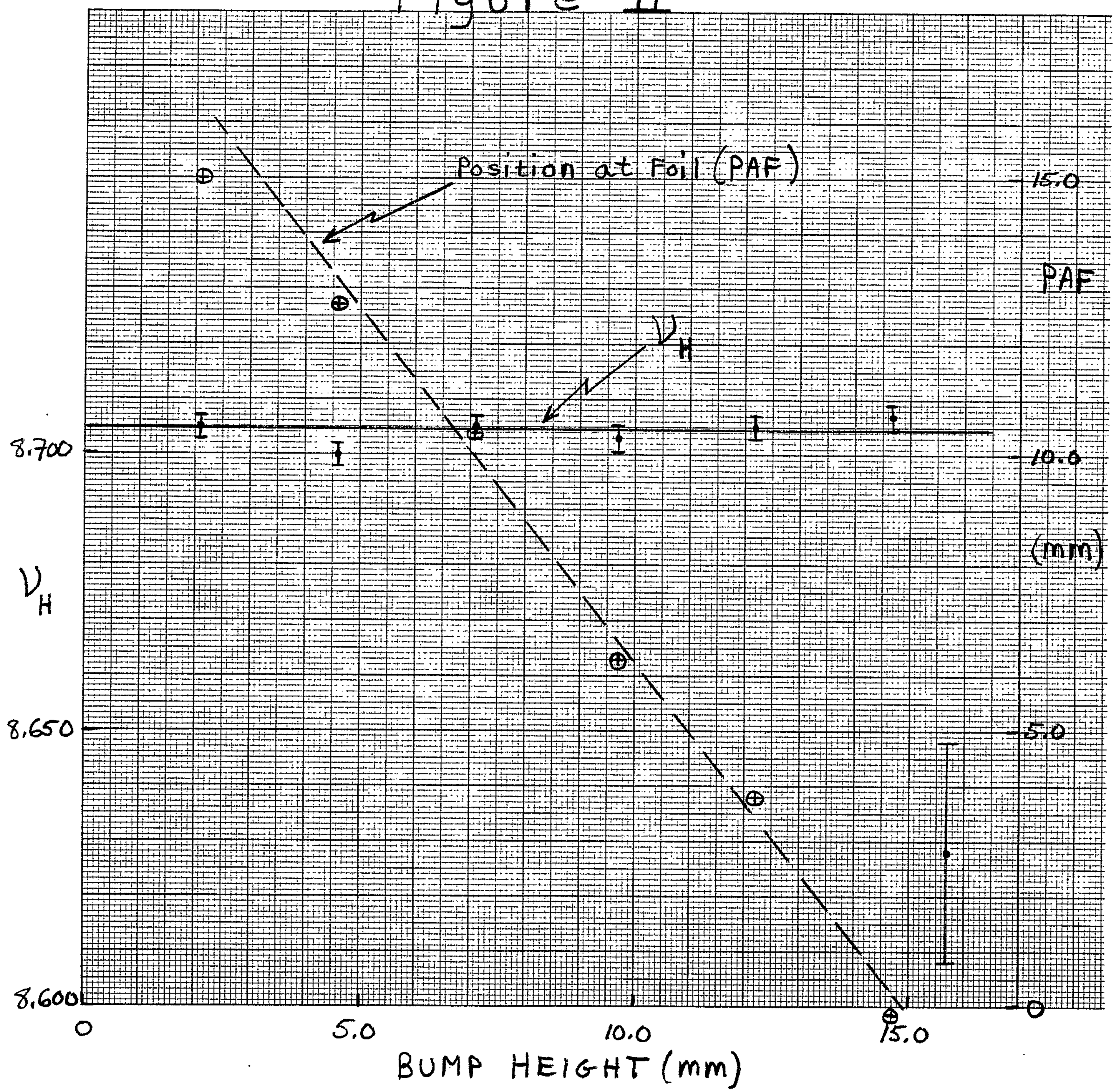
(Data taken with $(B7/A13)^2 = 1.75$)

Table IV

Bump Increment	Bump Height (mm)	Ratio of Kick Currents Squared $(B7/A13)^2$	PIP Measurements: ν_H $\pm.002$	PIP Measurements: Position at Foil (mm) ±1.0	PIP Measurements: Angle at Foil (mm) $\pm.05$	Ninth Harmonic (mm) Due to Kicks: Raw	Ninth Harmonic (mm) Due to Kicks: Bump Induced Portion Subtracted: Sin	Ninth Harmonic (mm) Due to Kicks: Bump Induced Portion Subtracted: Cos
-600	2.1*	1.96	8.705	15.0	0.59	---	---	---
-400	4.6*	1.93	8.700	12.7	0.53	---	---	---
-200	7.1	1.86	8.705	10.4	0.54	0.6	-0.2	-0.2
-100	7.8	1.90	---	--	--	0.7	-0.2	-0.2
0	9.7	1.82	8.703	6.3	0.50	0.7	-0.2	-0.3
+100	11.5	1.64	---	--	--	0.7	-0.1	-0.2
+200	12.2	1.84	8.705	3.8	0.51	0.8	-0.1	-0.2
+400	14.7*	1.76	8.707	-0.3	0.48	---	---	---
+600	--	1.91	8.704**	--**	--**	---	---	---
+800	15.7	1.80	8.628**	--**	--**	1.2	-0.2	-0.3

*Extrapolated.
**Beam loss over first two turns observed here.

Figure II


Position at Foil (PAF)
ν_H
8.700
8.650
8.600
ν_H
15.0
PAF
10.0
(mm)
5.0
0
0
5.0
10.0
15.0
BUMP HEIGHT (mm)