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The Fast Injection Bump and Machine Tunes

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Subject(s) The Fast Injection Bump and Machine Tunes

Observations and Conclusions

The fast injection bump, which allows the AGS equilibrium orbit (E.O.) at the injection stripping foil to be radially controlled and in particular rapidly moved away from the foil once the Linac beam pulse is completed, continues to be an unexploited degree of freedom in the injection process. A gradual increase in applicable beam diagnostics (PIP and the E.O. PUE program) make the study of the bump a reasonable early step in a general understandig of injection.

Since the commissioning of H^- injection, and indeed before, studies of relative amplitudes of the two kicks ("A13" and "B7") necessary to give minimal residuals have yielded what appear to be non-reproducible results. However, parameters such as machine tune, intensity, and bump amplitude have been different for the different measurements. As a start toward clearing up the situation, this study attempted to correlate bump residuals with the machine tunes.

The injection set up (HEBT steering, equilibrium orbit steering, tunes, etc.) was left as it had been set for HEP. The Linac pulse width was reduced so that 6×10^{12} protons were stacked in the AGS. The beam was accelerated for 30 ms. The effect of the A and B injection kicks on the E.O. was measured using the ring PUE system (NORB and ORBED programs) with an external trigger 500 μs after injection was finished (and the bump turned off). Sufficient bunching (rf on) has occurred by this time to get an orbit. The bump was then extended for 600 μs beyond its normal off time and another orbit taken. The difference between these orbits showed the effect of the bump (see Figure 1). The relative amplitudes of the two kicks was then adjusted to minimize the residuals. The initial ratio (I_B/I_A) of 1.9 gave a 0.6 cm peak residual, at a ratio of 1.3 $\pm$0.05 the residual was a minimum at 0.1 cm. This would imply, by the simplest model a ratio of betatron functions ($\beta_{B7}/\beta/_{A13}$) = $(1.3)^2 = 1.7$ and the standard machine model gives approximately 2. Next different orbits were obtained for three tune settings. The tunes were adjusted using the nu-quad array and measured usig PIP. Table I gives a summary of the results. Case 1 is the starting situation, Case 2 attempted to apply a horizontal tune shift, and Case 3 a vertical.

PIP and the equation relating tune to quadrupole strengths and calibrations agreed well as to the tune shifts. The residuals have a spatial variation $\alpha \cos(\nu\theta+\Phi)$ so the ninth harmonic $\alpha \cos(9\theta+\Phi')$ is dominant and its amplitude can be used as a measure of residual. A perfect bump would contribute approximately 1/18 of its amplitude to a ninth harmonic, so this is subtracted from the measured ninth.

Aside from the tunes and the qualitative behavior of the bump and residual waves, the information gathered shows, on first pass, contradictory and/or ridiculous information. In particular, the PUE data reports large changes in horizontal E.O. when the vertical tune is changed, PIP sees none within errors. The PUE data sees a large change in horizontal residuals with vertical tune. The PUE results are somewhat suspect at least as to normalization since the beam is presumably not fully bunched and it was noted that the captured intensity varied significantly with changes in ν_v. The PIP readings are taken 600 μs before the PUE's and for a minute intensity beam relative to the PUE beam.

Despite these strange effects, the PUE data, if taken as a relative monitor only, did not see a strong variation in bump residual with tune. A search for such a variation was the study motivation.

The next step in this effort is to obtain some predictions via the BEAM program for bump-machine interaction. On the experimental side, an attempt will be made to reproduce the anomalous effects seen above. The bumps can be refired after bunching is complete. An experimental study of residuals vs. bump amplitude is also straightforward.

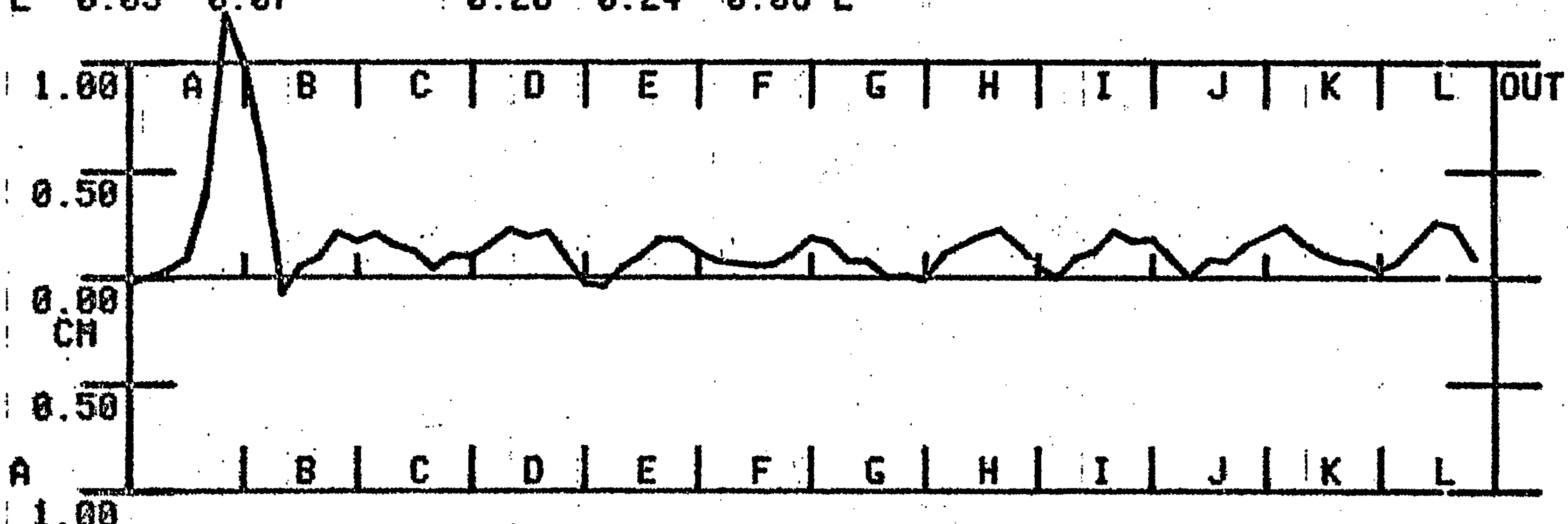
mvh-AHRENS/STUDY

8-JAN-85 06:25 HOR. ORBIT @ 55 EXTNL NAVE: 5 HARMONIC ANALYSIS
***** DIFFERENCE DATA USING FILE IJJ *****
NORMALIZED BY L20CT = 581
AVERAGE POS= -0.221

A	-0.03		0.03	0.08	0.40	1.23	A
B	1.00	0.59	-0.07	0.05	0.10	0.21	B
C	0.17	0.21	0.15	0.12	0.04	0.10	C
D	0.09	0.16	0.22	0.19	0.21	0.09	D
E	-0.03	-0.04	0.04	0.10	0.18	0.17	E
F	0.11	0.07		0.05	0.06	0.11	F
G	0.19	0.16	0.07	0.07	0.00	0.00	G
H	-0.02	0.11		0.19	0.23	0.14	H
I	0.05	-0.00	0.10	0.12	0.22	0.17	I
J	0.17	0.08	-0.00	0.08	0.07	0.15	J
K		0.24	0.16	0.10	0.07	0.06	K
L	0.03	0.07		0.26	0.24	0.08	L

N	SIN	COS	AMP
8	-0.05	-0.03	0.061
9	-0.13	-0.07	0.148
10	-0.06	0.02	0.061

H-1420 V 1650
we null as best we can



R(RESTART),E(EXIT),S(SAVE FILE),N(NO OUTPUT),L(LOOP),C(NORMC),<CR>(LOOP ONCE):

Figure 1

TABLE I

Case	Nu-Quad Setting NUQHB	Nu-Quad Setting NUQVB	Measured Tunes νH ±.002	Measured Tunes νV ±002	Δν Meas. H	Δν Meas. V	Δν Cal. H	Δν Cal. V
1	-1420	1650	8.789	8.909	—	—	—	—
2	- 820	1350	8.675	8.908	-.114	-.001	-.113	0
3	-1120	1050	8.786	8.803	-.003	-.106	0	-.113

	E.O. Motion at Foil (PIP) Horizontal Pos. mm	Horizontal Angle mr	Vertical Pos. mm	Vertical Angle mr	E.O. Motion at <A18,B2> (PUE) Horizontal (mm)
1	—	—	—	—	—
2	1.7±1	.05±.04	-2±1	+.03±.05	+.3
3	0.8±1	.03±.04	-1±.9	-.18±.04	-2.1

	Ninth Harmonic (mm) Due to Kicks Raw	Ninth Harmonic (mm) Due to Kicks Bump Induced Portion Subtracted	Bump Peak (mm)	Ninth Harmonic Residule/Peak
1	1.4	0.7	12	6%
2	0.94	0.34	10.6	3%
3	1.2	0.8	7	11%