BNL-104055-2014-TECH
AGS.SN178;BNL-104055-2014-IR

Injection Orbit Correction for Polarized Proton Acceleration

L. Ahrens

April 1985

Collider Accelerator Department
Brookhaven National Laboratory

U.S. Department of Energy
USDOE Office of Science (SC)

Number 178

AGS Studies Report

Date(s) April 18, 1985 Time(s) 1330-2000

Experimenter(s) L. Ahrens, L. Ratner, J. Skelly

Reported by L. Ahrens

Subject Injection Orbit Correction for Polarized Proton Acceleration

Objective

Replace the normal vertical injection equilibrium orbit correction system (96 independently controlled dc power supplies and magnets, ± 2 Amp current range 2 mA (10 bit) adjustment precision) with the system used for polarized proton (PP) acceleration (same 96 magnets, different power supplies, these pulsed, ± 8 Amp current range, 80 mA (7 bit) adjustment precision). Adjust the pulsed system such that it contains an injection pulse which adequately reproduces the field normally generated-namely that which allows the AGS to continue accelerating high intensity beam. As a confirmation, the measured vertical orbit should be approximately unchanged. This procedure if successful yields two important gains: (1) the vertical dipoles can be used during polarized proton running to correct the vertical orbit rather than going in with no control as we have in the past; and (2) the possibility will exist for exercising the polarized proton system for extended periods prior to commissioning period.

Procedure

The problem with using the PP dipole system in this mode at injection is associated with the required precision. Adjustment of the 9th harmonic is occasionally done to the least count (2 mA) level with the normal system. In order to increase the precision of the PP system fewer dipoles were powered - 12 (= 1/8) in this study improving the effective precision from 80 mA to 10 mA.

In addition to tuning the 9th harmonic (cancelling a horizontal dipole field with azimuthal dependence $A_9 \cos 9\Theta + B_9 \sin 9\Theta$, $\Theta = s/R$, s = azimuthal distance around ring, R = average radius, s = 0 at the beginning of the "A" superperiod) the 8th was tuned, and 3/2 λ bumps were applied around a few of the polarized proton quadrupoles just as they are with the usual system. Table 1 gives the magnetic corrections in effect with the normal system, the predicted corrections with the PP system, and the "tuned" values giving the greatest intensity. With <u>no</u>

changes in any other AGS parameters, these dipole settings resulted in a reduction in accelerated intensity from 1.4×10^{13} to 1.3×10^{13}. The machine was less stable than with the normal system, and problems with noise in the A10 house were aggravated - presumably due to beam losses in the injection region. Figure 1 gives the vertical equilibrium orbit with the normal dipole system, Figure 2 is the orbit using the PP system as optimized for intensity, and Figure 3 the difference between these orbits.

From Figure 3 (note the full scale is 2 mm), the 8th is seen to be essentially identical between the two systems, the 9th different by .05 cm in the sine component and -.03 cm in the cosine component. The 3/2 λ bumps at the 15 straight sections were not extensively tuned due to the increase in noise in the A10 house which interacts with the RLRM ring radiation system which is the diagnostic most useful for bump tuning. This may explain why slightly different harmonic yielded maximum intensity, and why the intensity was a bit lower. It was also true, as expected, that the precision was not quite fine enough, single count changes in command affected the beam, which may explain also the reduced machine stability.

Conclusions and Plans

The harmonic values required to recover intensity were approximately those expected without taking into account the particular spacing of the dipoles in the calculation. The machine behaved in a predictable manner.

Noise problems of two sorts affected the effort. The A10 house equipment and the RLRM showed typical noise related problems. Also the rf system displayed a noise problem known and temporarily corrected during the last polarized proton run related to grounds between MCR and the rf building and the E10 house. The old fix will be re-installed.

A further reduction of the number of dipoles used from twelve to six may be possible, increasing the sensitivity but also creating a richer mix of unwanted harmonics. This will be tried.

The real objective for doing all of this - to allow the PP system to be exercised, pulsing through its 40 odd resonances, while HEP continued - was achieved. The system was exercised and the above mentioned noise problems and some diagnostic problems were uncovered. The PP system appeared to shift its overall calibration at one point during the exercise. This is not understood, the numbers quoted were taken in the second and apparently stable state.

Special thanks to G. Murdock who kept the dipole hardware working, and to A. Abola who managed to bring up the software needed to learn the harmonic state of the normal dipole system.

Table 1

	8th harmonic cosine	8th harmonic sine	9th harmonic cosine	9th harmonic sine
Normal System Command 4000 = 2 Amps	-222	-114	-220	-191
Corresponding Current (96 dipoles)	-111 mA	- 57 mA	-110 mA	- 96 mA
Approximate Current if 12 dipoles	-888 mA	-456 mA	-880 mA	-768 mA
PP Predicted Command 127 = 10 Amps	- 11	- 6	- 11	- 10
Observed Cmd for max intensity	- 17	- 11	- 13	- 14

DATA FROM REFERENCE FILE INJ
18-APR-85 13:36 VER. ORBIT @ 57 CMPTR NAVEN10
NORMALIZED BY L20CT = 1910
AVERAGE POS= -0.059

A	-0.23	-0.19	0.10	-0.11		A
B	-0.73	-0.22	0.11	-0.19	-0.05	B
C	-0.03	-0.18		0.23	-0.20	C
D	0.13	-0.06	0.00	-0.19	-0.32	D
E	-0.06	0.05	0.12	-0.27	-0.23	E
F	0.03	0.16		-0.06	-0.01	F
G	0.00	-0.10	-0.26	-0.10	-0.20	G
H		0.21		-0.18	-0.25	H
I	0.13	0.19	-0.07	-0.10	-0.04	I
J	-0.18	0.17		-0.21	-0.26	J
K	0.00	-0.14	0.27	0.12	0.14	K
L	-0.08	0.12	0.00	-0.02	0.00	L

HARMONIC ANALYSIS

	SIN	COS	AMP
5	-0.01	0.03	0.029
6	-0.02	-0.00	0.019
7	0.04	0.01	0.038
8	-0.00	0.06	0.056
9	0.10	0.02	0.100
10	-0.01	-0.00	0.008
11	-0.01	-0.06	0.064
12	0.07	-0.11	0.134
13	-0.06	-0.04	0.070
14	-0.02	0.00	0.020
15	-0.02	-0.04	0.051
16	-0.05	0.03	0.059
17	-0.00	0.01	0.006

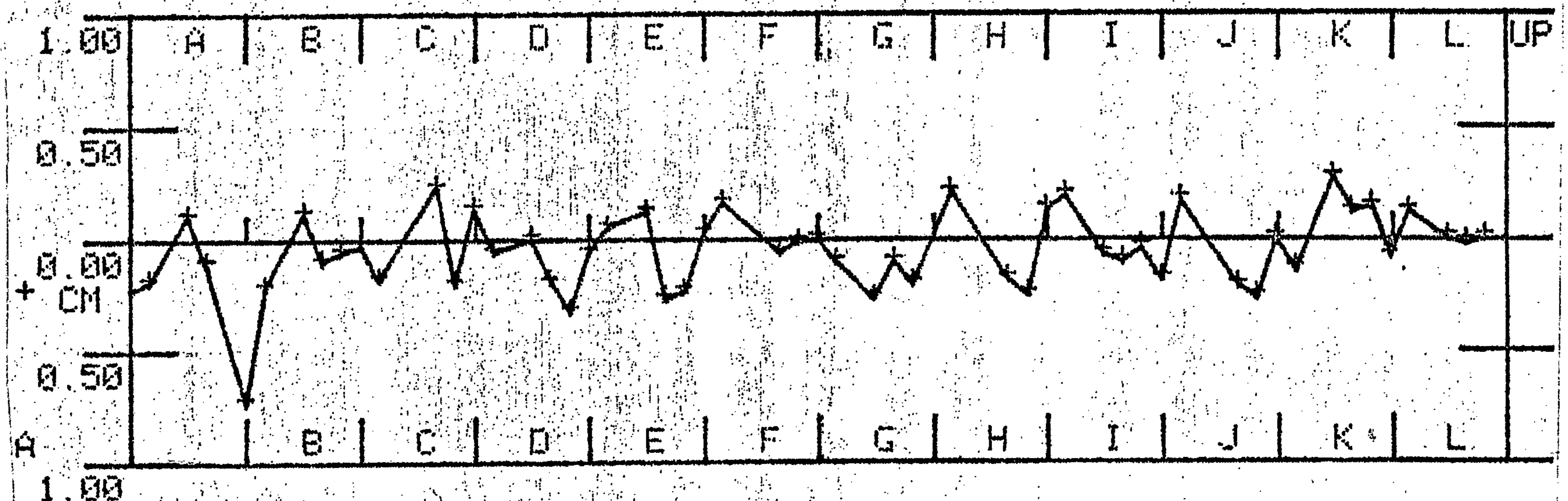


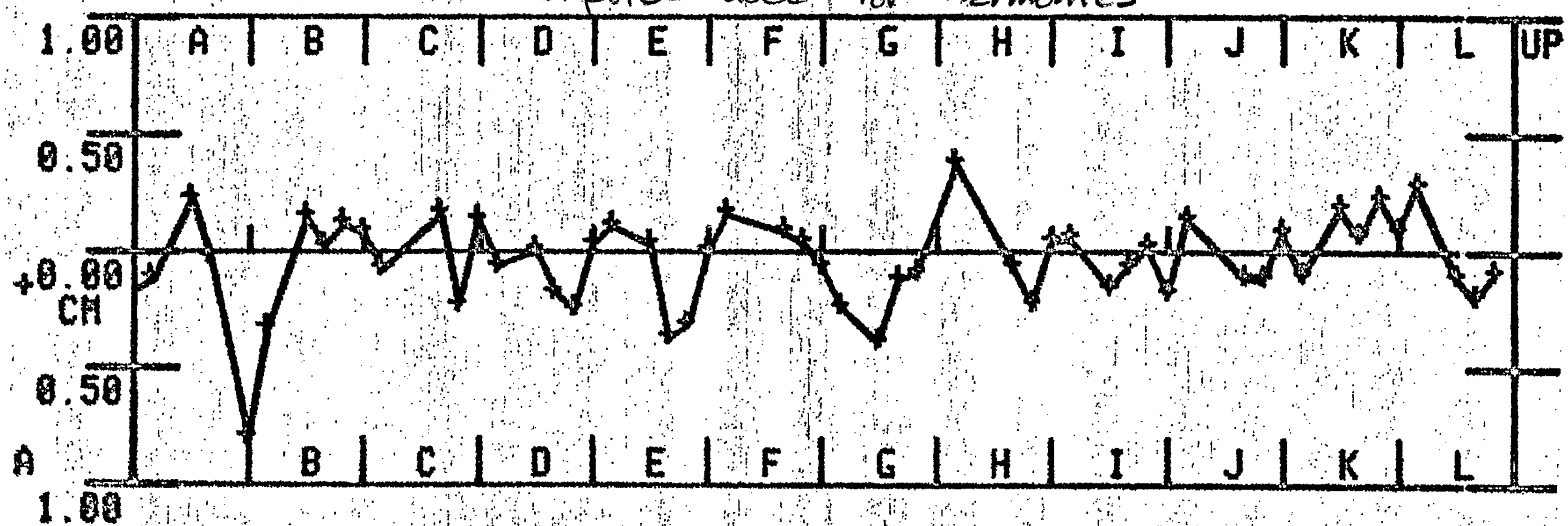
Figure 1 Original vert. equil. orbit
4 ms after inj

18-APR-85 19:42 VER. ORBIT @ 57 CMPTR NAVE:10 HARMONIC ANALYSIS
NORMALIZED BY L20CT = 1656
AVERAGE POS= -0.045

A	-0.16	-0.12	0.22	-0.03		A
B	-0.80	-0.33	0.14	0.02	0.11	B
C	0.08	-0.08		0.16	-0.23	C
D	0.13	-0.07	0.00	-0.18	-0.25	D
E	0.03	0.11	0.03	-0.37	-0.31	E
F	-0.00	0.16		0.08	0.03	F
G	-0.07	-0.24	-0.39	-0.12	-0.09	G
H		0.37		-0.07	-0.23	H
I	0.04	0.06	-0.15	-0.07	0.01	I
J	-0.18	0.13		-0.11	-0.12	J
K	0.08	-0.10	0.18	0.06	0.22	K
L	0.09	0.28	-0.11	-0.20	-0.09	L

N	SIN	COS	AMP
5	0.00	0.06	0.056
6	-0.06	0.01	0.064
7	0.12	-0.01	0.117
8	-0.01	0.03	0.035
9	0.14	-0.02	0.142
10	0.01	-0.04	0.038
11	0.02	-0.05	0.053
12	0.07	-0.08	0.107
13	-0.05	-0.04	0.069
14	-0.01	0.01	0.019
15	-0.02	-0.03	0.040
16	-0.05	0.03	0.057
17	-0.00	0.00	0.002

12 dipoles used for harmonics



Vert orbit using Polarized Proton dipole system

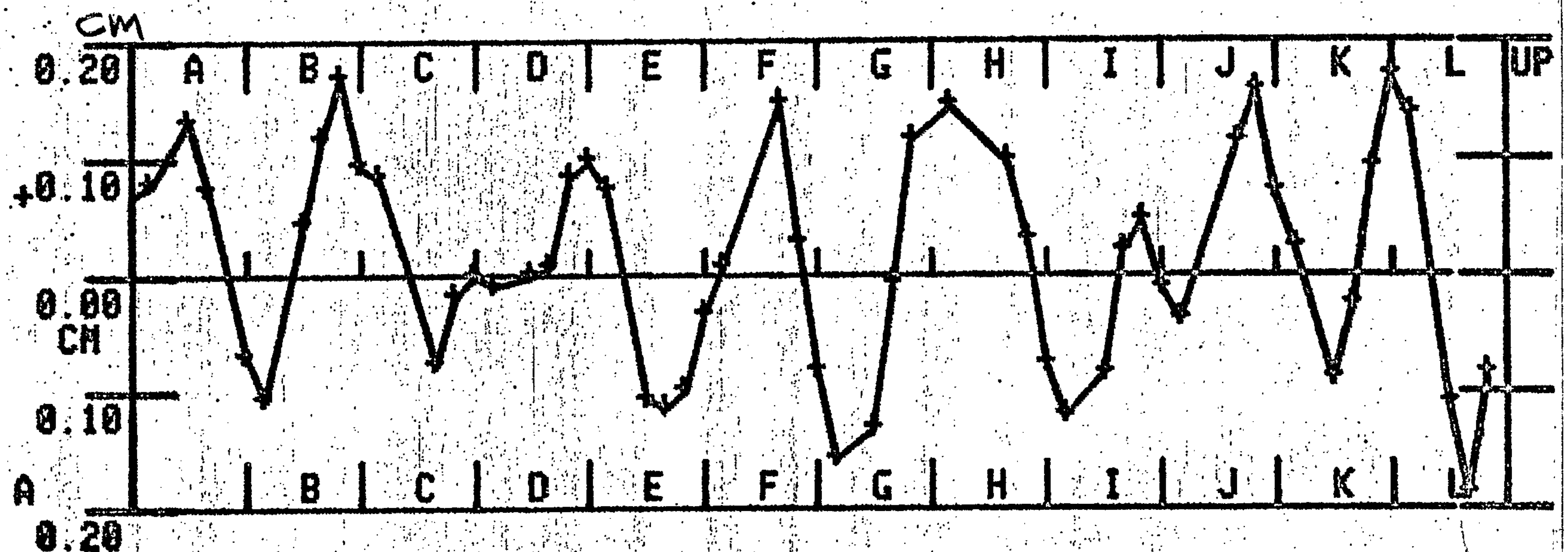
Fig. 2

- 5 -

10-APR-85 19:45 VER. ORBIT @ 57 CMPTR NAVE:10 HARMONIC ANALYSIS
***** DIFFERENCE DATA USING FILE INJ *****
NORM BY L20CT = 1655 REFER L20CT = 1910
AVERAGE POS= -0.047

A	0.07	0.08	0.13	0.07		A
B	-0.07	-0.11	0.04	0.12	0.17	B
C	0.09	0.08		-0.08	-0.02	C
D	-0.00	-0.01	-0.00	0.01	0.08	D
E	0.10	0.07	-0.11	-0.11	-0.10	E
F	-0.03	0.01		0.15	0.03	F
G	-0.08	-0.16	-0.13	-0.01	0.11	G
H		0.14		0.10	0.03	H
I	-0.08	-0.12	-0.08	0.02	0.05	I
J	-0.01	-0.04		0.11	0.16	J
K	0.07	0.02	-0.09	-0.03	0.09	K
L	0.17	0.14	-0.11	-0.19	-0.09	L

N	SIN	COS	AMP
5	0.02	0.03	0.034
6	-0.05	0.01	0.046
7	0.08	-0.01	0.080
8	-0.00	-0.02	0.025
9	0.05	-0.03	0.062
10	0.02	-0.03	0.037
11	0.02	0.01	0.026
12	-0.01	0.03	0.030
13	0.00	-0.01	0.009
14	0.00	0.01	0.009
15	0.00	0.01	0.007
16	0.00	0.00	0.004
17	-0.00	-0.00	0.005



(PP orbit) − (original orbit)

Fig 3