BNL-104165-2014-TECH

AGS.SN289;BNL-104165-2014-IR

Stopband Correction of the AGS Booster Integer Coupling (Qx+Qp=9) Correction Data

C. Gardner

April 1993

Collider Accelerator Department

Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

DISCLAIMER

AGS Complex Machine Studies

(AGS Studies Report No. 289)

Stopband Correction of the AGS Booster Integer Coupling (Qx+Qy=9) Correction Data

Study Period: April 1, 11, 23, 1993

Participants: C. Gardner and Y. Shoji

Reported by: Y. Shoji

Machine:				
	April 01:	User3	10 Turns	Low dB/dt Injection
	April 11:	User1	5 Turns	High dB/dt Injection
	April 23:	User3	5 Turns	1.7 kG dB/dt=0 Porch

Aim: Correction of the integer coupling sum resonance Qx+Qy=9.

All data points on Qx+Qy=9 correction currents; N(cos9XY) and N(sin9XY) are listed in Table I.

Table I Qx+Qy=9 correction current data list.

date / T (ms)	B (kG)	dB/dt (G/ms)	dRset (cm)	N(cos9XY)	N(sin9XY)	crossing speed (dQ/ms)	residual loss(%) /cross times
last year [Gardner, AGS SR-273]							
	3.6	0	?	290	90		
Apr.01	u3	10turns		Qy=4.6 fix, change Qx			
40	1.62	20	?	10 ± 5	25 ± 5	0.01	9/?
61	2.89	72	?	-120 ±10	240 ±10	?	8/?

Apr.11 u1 5t Qx,Qy= 4.44,4.62 --> 4.38 4.56

35	1.80	70	?	130 ±15	-60 ±15	?	29 /?
55	3.34	70	?	190 ±20	-30 ±10	?	38 /?
75	4.74	70	?	275 ±15	20 ±10	?	5 /?
88	5.25	33	?	295 ±10	35 ±10	?	0.6/?

Apr.23 u3 Qy=4.6 All sextupole = 0 A, Dump Bump = OFF

80	1.7	0	-0.4	-65 ± 5	54 ± 5	0.014	32/?
			0.4	-48 ± 2	39 ± 1		29/?
			1.2	-38 ± 2	32 ± 2		22/?

I B and dB/dt Dependence

B and dB/dt dependence of correction currents; N(cos9XY) and N(sin9XY) were measured on April 11. The data points were fitted with functions;

$$\begin{aligned} N(\cos 9XY) &= Co + Cb\,B + Cbt\,dB/dt \\ N(\sin 9XY) &= So + Sb\,B + Sbt\,dB/dt\,. \end{aligned} \qquad (1)$$

Here Co, Cb, Cbt, So, Sb and Sbt were fitting parameters. The unit of B and dB/dt were kG and G/ms=kG/s, respectively. The result were;

$$\begin{aligned} Co &= 35 \pm 55 & So &= -111 \pm 45 \\ Cb &= 49.2 \pm 7.2 & Sb &= 28.5 \pm 6.0 \\ Cbt &= 0.04 \pm 0.53 & Sbt &= -0.11 \pm 0.41 \\ X^2 &= 0.50 & X^2 &= 0.79 \end{aligned} \qquad (2)$$

The correction currents has off-set term (remanent field) and B term (magnet construction and alignment) but less dB/dt term (eddy current and back-leg windings). The dB/dt term N(cos0XY), correction current for Qx-Qy=0, was also negligibly small after the change of C5 back-leg winding [W. Van Asselt, AGS schedule meeting]. Then we conclude that there are negligibly small skew quadrupole errors which are proportional to dB/dt.

II Dependence on dR

On April 23 dR (momentum change) dependence of N(cos9XY) and N(sin9XY) were measured on the dB/dt=0 porch. The data points, listed in Table I, were fitted with functions;

$$N(\cos 9XY) = Co + Cr\ dRset$$
$$N(\sin 9XY) = So + Sr\ dRset. \qquad (3)$$

The results were:

Co =	-55.2 +2.4	So =	43.7 +1.6
Cr =	14.8 +2.8	Sr =	-10.6 +2.5
X^2 =	1.09	X^2 =	1.94

(4)

The linear fits (3) were not so bad. The results show the existence of dR dependent term, which explains the residual loss of Qx+Qy=9 correction. We need (6n-3)th skew sextupole strings to cancel Cr and Sr.

III Consistency of Each Data Point

We calculated the correction currents from the parameters (2) for the B and dB/dt on April 1 and at the fit (4). We also calculated the correction currents from the parameters (4) for dRset=0.4cm. They are listed and compared with the measured currents in Table II.

Table II Consistency of each data points.

B (kG)	1.62	2.89	1.7
dB/dt (G/ms)	20	72	0
measured on April 1			
N(cos9XY)	10 ± 5	-120 ±10	
N(sin9XY)	25 ± 5	240 ±10	
calculated from (4); dRset=0.4			
N(cos9XY)			-49 ± 3
N(cos9XY)			48 ± 2
calculated from (2)			
N(cos9XY)	115 ±57	180 ±70	84 ±57
N(sin9XY)	-67 ±47	-37 ±57	-63 ±47
change of dB/dt term			
δN(cos9XY)/δ(dB/dt)	-5.3 ±2.9	-4.2 ±1.0	
δN(sin9XY)/δ(dB/dt)	4.6 ±2.4	3.8 ±0.8	

The inconsistency of parameters (2) and data points measured on April 1 is explained by the change of C5 back-leg winding, which might have changed the dB/dt term. The difference between measured and calculated were divided by dB/dt. The results were listed in the bottom of Table II. The data at B=1.62kG, dB/dt=20G/ms and the data at B=2.89kG, dB/dt=70G/ms gave the same values within the errors. And the phase of dB/dt term; $\delta N(\sin 9XY)/\delta N(\cos 9XY)$, which was the ratio of $\delta N(\sin 9XY)/\delta(dB/dt)$ and $\delta N(\cos 9XY)/\delta(dB/dt)$, was

$$\delta N(\sin 9XY)/\delta N(\cos 9XY) \quad = \quad -0.89 \pm 0.29 \,. \qquad (5)$$

This value is close to the calculated phase of C5 back-leg winding;

$$\delta N(\sin 9XY)/\delta N(\cos 9XY) \quad = \quad -0.5 \,.$$

The change was proportional to dB/dt and was on the phase of C5 back-leg winding.

The inconsistency of parameters (2) and (4) can not be explained. If we assume dRset=10cm two results meet each other. But dRset could not be such a large value. The chromaticities and orbits were not the same for these two cases. But we are not sure whether these could have changed the correction current.