

# Stopband Correction of the AGS Booster Integer Coupling ( $Q_x+Q_p=9$ ) Correction Data

C. Gardner

April 1993

Collider Accelerator Department  
**Brookhaven National Laboratory**

**U.S. Department of Energy**

USDOE Office of Science (SC)

Notice: This technical note has been authored by employees of Brookhaven Science Associates, LLC under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy. The publisher by accepting the technical note for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this technical note, or allow others to do so, for United States Government purposes.

## **DISCLAIMER**

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

AGS Complex Machine Studies			
(AGS Studies Report No. 289)			
Stopband Correction of the AGS Booster Integer Coupling ( $Q_x + Q_y = 9$ ) Correction Data			
<b>Study Period:</b> April 1, 11, 23, 1993			
<b>Participants:</b> C. Gardner and Y. Shoji			
<b>Reported by:</b> Y. Shoji			
<b>Machine:</b> 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			
<b>Aim:</b> Correction of the integer coupling sum resonance $Q_x + Q_y = 9$ .			

All data points on  $Q_x + Q_y = 9$  correction currents;  $N(\cos 9XY)$  and  $N(\sin 9XY)$  are listed in Table I.

Table I  $Q_x + Q_y = 9$  correction current data list.

date							residual
-----						crossing	loss(%)
T	B	dB/dt	dRset	N(cos9XY)	N(sin9XY)	speed	/cross
(ms)	(kG)	(G/ms)	(cm)			(dQ/ms)	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 $\pm$ 15	-60 $\pm$ 15	?	29 /?
55	3.34	70	?	190 $\pm$ 20	-30 $\pm$ 10	?	38 /?
75	4.74	70	?	275 $\pm$ 15	20 $\pm$ 10	?	5 /?
88	5.25	33	?	295 $\pm$ 10	35 $\pm$ 10	?	0.6/?

Apr.23	u3	Qy=4.6	All sextupole = 0 A, Dump Bump = OFF				
80	1.7	0	-0.4	-65 $\pm$ 5	54 $\pm$ 5	0.014	32/?
			0.4	-48 $\pm$ 2	39 $\pm$ 1		29/?
			1.2	-38 $\pm$ 2	32 $\pm$ 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;

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

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;

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

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  $N(\cos 9XY)$  and  $N(\sin 9XY)$  were measured on the  $dB/dt=0$  porch. The data points, listed in Table I, were fitted with functions;

$$\begin{aligned} N(\cos 9XY) &= Co + Cr \, dR_{set} \\ N(\sin 9XY) &= So + Sr \, dR_{set}. \end{aligned} \quad (3)$$

The results were:

$$\begin{aligned} Co &= -55.2 \pm 2.4 & So &= 43.7 \pm 1.6 \\ Cr &= 14.8 \pm 2.8 & Sr &= -10.6 \pm 2.5 \\ X^2 &= 1.09 & X^2 &= 1.94 \end{aligned} \quad (4)$$

The linear fits (3) were not so bad. The results show the existence of dR dependent term, which explains the residual loss of  $Q_x+Q_y=9$  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  $dR_{set}=0.4\text{cm}$ . 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			
$N(\cos 9XY)$	$10 \pm 5$	$-120 \pm 10$	
$N(\sin 9XY)$	$25 \pm 5$	$240 \pm 10$	
calculated from (4); $dR_{set}=0.4$			
$N(\cos 9XY)$			$-49 \pm 3$
$N(\sin 9XY)$			$48 \pm 2$
calculated from (2)			
$N(\cos 9XY)$	$115 \pm 57$	$180 \pm 70$	$84 \pm 57$
$N(\sin 9XY)$	$-67 \pm 47$	$-37 \pm 57$	$-63 \pm 47$
change of $dB/dt$ term			
$\delta N(\cos 9XY)/\delta(dB/dt)$	$-5.3 \pm 2.9$	$-4.2 \pm 1.0$	
$\delta N(\sin 9XY)/\delta(dB/dt)$	$4.6 \pm 2.4$	$3.8 \pm 0.8$	

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

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

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

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

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.