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Present Order of Magnets in the AGS Ring, with B.dl Offsets

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Technical Note

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R.E. Thorn

June 5, 1986

TECHNICAL NOTE
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1. INTRODUCTION

When the AGS magnets were originally put in the ring, results from the magnetic measurements were used to determine the "stacking order" in the ring and the radial offsets for each magnet. Now that we are doing a radial survey (ref 1) and may do a radial realignment, it is important that this data be taken into account again. Over the years, magnet replacements have shuffled the magnets from their original order and brought in the magnets that used to be the spares. Thus the old publications of this data (ref 2-3) have to be brought up to date.

The present order of the magnets in the ring -- which "magnet name" is in which "ring location" -- was checked by walking around the ring and reading the numbers stamped in the backleg of each magnet.

The description of the magnetic measurement data and the rationale for how it is used is given below. The data are listed in Table 1, ordered by magnet name, and in Table 2, ordered by location in the ring. Table 3 summarizes the changes that have been made to the original magnet order.

2. B.DL AT 5000 GAUSS

At a set current, the integrated B.dl along the equilibrium orbit should be the same for all members of each class (A, B, or C) of magnet. The line determined from the socket holes on the top of the magnet does not satisfy this requirement, due to variations in the gap, the steel, the length of the magnet, and the placement of the socket holes relative to the gap. Since the magnets are gradient magnets, the B.dl at a given current can be changed by moving the magnet sideways. The data in reference 2 are the radial offsets of the magnet sockets from the design positions in the ring such that the B.dl values along the equilibrium orbit are uniform, within each class, at a fixed current corresponding to about 5000 gauss. The sign convention used is that positive offsets mean that the socket is to be moved away from the center of the ring. These offsets also effect a slight rotation so the orbit is parallel to the front face of the magnet.

The definition of the offsets is as shown in Figure 1. Note that half the magnets in each superperiod have their gaps facing outward, and half inward, so the offsets for the surveyors to use - "upstream and downstream", "in and out" - will depend on position in the ring.

Note that magnet B1, which was originally a spare but now is in use, seems to have no magnetic measurement data. (In compendia of mechanical data, it is referred to as B-1A, but I have not found anyone who remembers why.) Magnet B1 was used as the reference magnet for the rest of the B series; the reference magnets for the A and C series were themselves measured by using another magnet for the reference.

3. REMANENT FIELD

Since the variations in remanent field are larger (percentagewise) than the variations at higher fields, the original stacking order of the magnets in the ring was designed to reduce the low order harmonics introduced by the remanent field at injection. With the present low field dipole correction system (and higher energy injection) this is no longer as important; the remanent field data is nevertheless included here for the sake of completeness.

The remanent field numbers are the offsets, in mils from the 5000 gauss centerline defined above, which give a uniform B.dl for the remanent field. The sign of the effect is, as best I can determine, such that a positive number means that the remanent field is higher than the standard. The remanent field gradient is about 1.5 gauss/inch (2.1 g/in) for classes A and B (class C), with a central field of about 16 gauss.

The remanent field for the class A magnets (but not classes B and C) were found in reference 3; the class B and C numbers were found compiled on sheets in the data books. They are, apparently, not exactly the same as were used in figuring the stacking order in reference 3 because several magnets are interchanged in rank from that implied by the reference 3 order. The differences are only a few mils, however, much less than the variation in multiple measurements.

REFERENCES

1. R. E. Thern, "The 1985 Horizontal Survey. Part II. Magnets", AGS Accelerator Division Technical Note No. 253, May 30, 1986.
2. J. P. Palmer and R. H. Phillips, "Summary of Magnetic Measurements of Classes A, B, and C Magnets Reduced to Equivalent Radial Offset Corrections on the AGS Ring", Accelerator Development Department Internal Report JPP/RHP-2, July 17, 1959. This report covers the magnets that were originally placed in the ring. Over the years the magnets have been shuffled and the spares brought in; the offsets for the spares were found in the data books with the help of J. Weisenbloom.
3. E. D. Courant, "Stacking Order for Class A and Class B Magnets in the AGS", Accelerator Development Department Internal Report EDC-29, March 6, 1959, and "Stacking Order of Class C Magnets in the AGS", Report EDC-30, May 25, 1959.

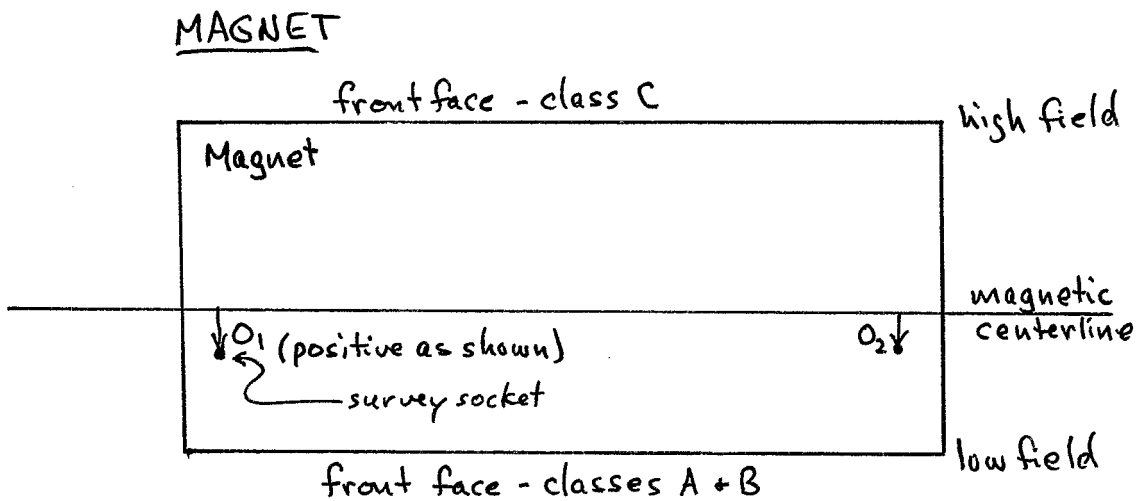
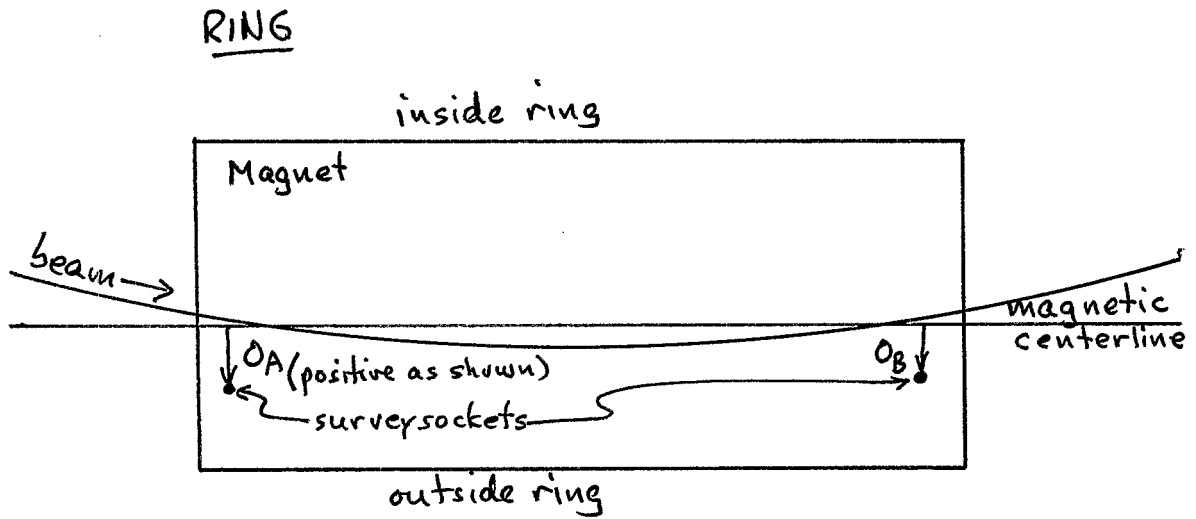


Figure 1. Definitions of the offsets, in the magnet coordinate system, and in the ring coordinate system. The convention is that the two are the same for magnets with their wide gap (low-field side) facing outward, i.e., the defocussing magnets (class C in the first half of each superperiod, classes A and B in the second). For the other magnets, the offsets are interchanged and the signs reversed.

Table 1a. Magnet list ordered by magnet name for class A magnets. The offsets, in mils, are from the socket holes to a magnetic centerline which has the same B.dI for all members of a class (at a set current corresponding to about 5000 gauss). Xrem is the offset, in mils from the above centerline, needed to make the remanent field the same as in the reference magnet. The asterisk (*) denotes that the magnet is in a location different from its original location. NA = data not available. "Spare" denotes magnets not in the ring, and "242" denotes the magnet under the Siemens power room.

Mag. name	Ring loc.	Mag. offset		Xrem	Mag. name	Ring loc.	Mag. offset		Xrem
		off1	off2				off1	off2	
A01	B-05	-7	23	166	A31	J-05	-14	32	146
A02	K-16	3	37	28	A32	K-05	-4	12	155
A03	I-15	5	8	86	A33	G-05	-9	26	111
A04	H-06 *	-8	19	13	A34	I-16	8	3	33
A05	D-06	0	22	-6	A35	E-06	3	23	11
A06	J-15	-3	31	96	A36	C-15	-6	16	96
A07	J-16	22	22	30	A37	H-15	-8	33	75
A08	L-06	1	14	-34	A38	D-16	1	21	32
A09	C-16	3	28	28	A39	B-15	14	24	99
A10	B-16	-13	32	22	A40	L-05	0	14	187
A11	K-06	-16	22	-19	A41	K-15	-13	32	97
A12	J-06	6	9	-15	A42	A-05	-10	27	197
A13	B-06	-5	30	-20	A43	H-05	-8	17	132
A14	G-06	-11	21	14	A44	F-05	-12	23	131
A15	F-06 *	6	34	-118	A45	A-15	4	12	111
A16	G-16	1	34	65	A46	E-05	-9	26	132
A17	spare*	-8	15	11	A47	C-05	-1	15	155
A18	A-06	-23	23	-58	A48	D-05	-19	23	140
A19	A-16	11	17	15	A49	"242"*	-9	34	65
A20	I-05	0	9	137	A50	E-16	-10	22	34
A21	F-16	-11	28	46					
A22	H-16	8	12	38					
A23	G-15 *	0	20	-120					
A24	I-06	10	39	-5					
A25	F-15	-9	24	70					
A26	L-15	0	10	102					
A27	C-06	-12	12	-16					
A28	L-16	-15	8	20					
A29	D-15	-1	40	88					
A30	E-15	2	13	80					

Table 1b. Magnet list ordered by magnet name for class B magnets.

Mag. name	Ring loc.	Mag. offset off1	Mag. offset off2	Xrem	Mag. name	Ring loc.	Mag. offset off1	Mag. offset off2	Xrem
B01	B-01 *	NA	NA	NA	B51	D-10	0	11	-48
B02	J-09	-3	4	151	B52	B-20	6	2	6
B03	G-12 *	4	16	64	B53	I-11 *	10	2	76
B04	K-12	18	18	11	B54	C-01	-16	11	152
B05	K-20	8	8	2	B55	D-12	3	5	34
B06	L-01	-22	20	185	B56	G-09	-14	10	114
B07	L-11	-10	21	105	B57	C-19	-16	4	92
B08	G-20	-4	5	61	B58	C-09	-13	12	148
B09	K-09	-1	9	180	B59	D-09	4	14	136
B10	F-20	0	15	61	B60	G-19 *	-2	8	62
B11	E-01	-2	0	123	B61	C-02	-5	6	-77
B12	B-11 *	-11	19	71	B62	H-10	-8	10	-45
B13	G-10	7	-3	-26	B63	D-19	2	8	81
B14	H-01	8	15	118	B64	B-12	-13	11	1
B15	J-20	2	-4	23	B65	H-19 *	-6	4	82
B16	F-01 *	9	2	214	B66	A-10	-6	15	-130
B17	B-09	-4	4	176	B67	H-20 *	-6	16	43
B18	B-19	-4	5	102	B68	A-20 *	-6	12	72
B19	I-19 *	-3	-10	80	B69	I-10	-21	17	-48
B20	I-20	-3	-1	41	B70	B-10	-18	18	-85
B21	H-11	-8	0	73	B71	K-01 *	10	5	-78
B22	J-12	-12	-2	32	B72	G-02	-6	3	-23
B23	L-12	-7	3	-6	B73	H-12	-10	3	50
B24	A-02	5	-19	-163	B74	spare*	-6	5	-13
B25	J-11	10	-6	86	B75	H-09	-10	1	122
B26	C-10	-1	10	-64	B76	D-11	-12	20	84
B27	D-20	-12	5	41	B77	A-01 *	-4	0	182
B28	L-02	3	3	-129	B78	C-20	-13	6	30
B29	I-01	3	0	125	B79	A-19	7	6	105
B30	K-02 *	2	1	160	B80	L-19	-2	11	106
B31	E-11 *	4	13	51	B81	I-12 *	-4	5	46
B32	K-19	6	16	103	B82	E-12	1	8	45
B33	C-12	-13	16	20	B83	F-19	-2	18	66
B34	E-20	-7	26	47	B84	F-09	-10	12	113
B35	I-02	-15	16	-47	B85	spare*	-3	15	114
B36	A-09	4	3	206	B86	E-19	5	4	75
B37	J-02	1	0	-64	B87	I-09	-3	8	139
B38	D-02	-8	9	-59	B88	K-11	0	-11	101
B39	F-10	-2	17	-26	B89	F-12 *	-2	12	79
B40	J-19	-12	12	93	B90	L-10	-6	11	-131
B41	G-01	3	8	113	B91	F-11 *	-18	4	-206
B42	G-11 *	-12	7	104	B92	J-01	-13	9	141
B43	E-10	1	6	-41	B93	E-09	-1	11	120
B44	J-10	-4	12	-74	B94	C-11	-2	7	99
B45	H-02	14	21	-31	B95	B-02	-11	21	-110
B46	L-20	10	4	-15	B96	K-10	-8	2	-107
B47	A-11	6	6	107	B97	A-12	2	4	-18
B48	E-02	-13	6	-47	B98	F-02	-14	11	-28
B49	D-01	-8	9	140					
B50	L-09	2	10	207					

Table 1c. Magnet list ordered by magnet name for class C magnets.

Mag. name	Ring loc.	Mag. offset off1	Mag. offset off2	Xrem	Mag. name	Ring loc.	Mag. offset off1	Mag. offset off2	Xrem
C01	A-07	-10	-30	53	C51	L-18	-6	-8	-91
C02	L-03	1	-3	54	C52	F-03	-2	-4	24
C03	B-04	-4	-12	-13	C53	J-14	3	-13	-46
C04	F-17	-21	-21	59	C54	K-03	-5	-23	47
C05	J-13	5	-17	93	C55	D-08	-15	7	6
C06	J-08	-15	-7	-2	C56	H-18	-13	-27	-32
C07	I-03	-14	-18	36	C57	B-18	-5	-5	-64
C08	F-18	-27	1	-23	C58	C-14	-15	-3	-60
C09	G-08	-21	-11	15	C59	D-13	-28	-12	90
C10	K-04	-29	1	-6	C60	B-07	-11	-17	48
C11	F-14	-8	-6	-28	C61	H-03	-22	-14	27
C12	D-18	-7	-5	-38	C62	J-17	-17	-25	95
C13	I-18	-1	-17	-40	C63	G-17	-23	-13	63
C14	A-18	-3	-11	-87	C64	D-17	-10	-8	85
C15	L-14	-21	-7	-86	C65	K-13	-23	5	105
C16	E-17	-23	3	73	C66	I-13	-21	-29	83
C17	D-04	-8	14	6	C67	C-18	-22	-16	-48
C18	H-14	-25	-3	-30	C68	D-07	-19	-27	36
C19	A-14	-6	-14	-128	C69	C-13	-28	0	104
C20	E-18	-25	-11	-33	C70	J-07	-10	-4	46
C21	spare*	-11	-9	19	C71	I-07	-35	-11	38
C22	L-08	-16	-8	-22	C72	L-13	-12	-36	120
C23	F-07 *	-3	-7	-150	C73	E-13	-28	-20	82
C24	J-03	-17	-21	41	C74	F-13	-19	-15	67
C25	G-04	-23	-23	17	C75	H-13	-29	-13	69
C26	spare	-9	3	-147	C76	H-07	-23	-23	28
C27	D-14	-4	-28	-42	C77	L-17	-17	-7	138
C28	I-04	-14	-24	10	C78	K-17	-10	-24	109
C29	A-04	-4	-6	-21	C79	L-07	-27	-1	57
C30	K-14	-5	-19	-62	C80	A-17	-6	-22	131
C31	J-04	-15	1	4	C81	E-04	-26	-2	9
C32	G-18	-14	-24	-25	C82	J-18	-12	-14	-56
C33	H-04	-11	-1	7	C83	L-04	-6	-4	-12
C34	B-17	-23	-9	110	C84	C-04	-1	-15	-5
C35	G-13	-11	-3	58	C85	B-08	-2	-6	-6
C36	D-03	-8	-2	40	C86	C-08	-10	-10	3
C37	A-13	-18	-20	143	C87	G-03	10	-12	18
C38	H-17	-19	-9	79	C88	B-14	-24	2	-78
C39	G-07	-16	0	25	C89	F-08	6	-8	15
C40	K-07	-3	-19	50	C90	I-17	-15	11	90
C41	F-04	-30	4	13	C91	A-08	0	4	-18
C42	A-03	-17	-5	56	C92	K-08	-27	-5	-9
C43	G-14	-8	2	-21	C93	E-03	1	-11	32
C44	I-14	-12	-12	-38	C94	H-08	-29	21	10
C45	C-03	-18	-6	47	C95	E-08	1	-5	9
C46	C-07	-12	-10	44	C96	B-03	-38	0	52
C47	I-08	-24	-6	5	C97	E-07	6	-4	28
C48	B-13	-12	-8	111	C98	E-14	-7	25	-33
C49	C-17	-8	-6	94					
C50	K-18	-15	-13	-66					

Table 2. Magnet names and offsets, ordered by location in ring. The asterisk (*) denotes that a location has a magnet different from the original stacking order. NA = data not available.

Ring loc.	Mag name		Ring offset	
			offA	offB
A-01	B77	*	0	4
A-02	B24		19	-5
A-03	C42		-17	-5
A-04	C29		-4	-6
A-05	A42		-27	10
A-06	A18		-23	23
A-07	C01		-10	-30
A-08	C91		0	4
A-09	B36		-3	-4
A-10	B66		-15	6
A-11	B47		6	6
A-12	B97		2	4
A-13	C37		20	18
A-14	C19		14	6
A-15	A45		4	12
A-16	A19		11	17
A-17	C80		22	6
A-18	C14		11	3
A-19	B79		7	6
A-20	B68	*	-6	12
B-01	B01	*	NA	NA
B-02	B95		-21	11
B-03	C96		-38	0
B-04	C03		-4	-12
B-05	A01		-23	7
B-06	A13		-30	5
B-07	C60		-11	-17
B-08	C85		-2	-6
B-09	B17		-4	4
B-10	B70		-18	18
B-11	B12	*	-11	19
B-12	B64		-13	11
B-13	C48		8	12
B-14	C88		-2	24
B-15	A39		14	24
B-16	A10		-13	32
B-17	C34		9	23
B-18	C57		5	5
B-19	B18		-4	5
B-20	B52		6	2
C-01	B54		-11	16
C-02	B61		-6	5
C-03	C45		-18	-6
C-04	C84		-1	-15
C-05	A47		-15	1
C-06	A27		-12	12
C-07	C46		-12	-10
C-08	C86		-10	-10
C-09	B58		-12	13
C-10	B26		-10	1
C-11	B94		-2	7
C-12	B33		-13	16
C-13	C69		0	28
C-14	C58		3	15
C-15	A36		-6	16
C-16	A09		3	28
C-17	C49		6	8
C-18	C67		16	22
C-19	B57		-16	4
C-20	B78		-13	6
D-01	B49		-9	8
D-02	B38		-9	8
D-03	C36		-8	-2
D-04	C17		-8	14
D-05	A48		-23	19
D-06	A05		-22	0
D-07	C68		-19	-27
D-08	C55		-15	7
D-09	B59		-14	-4
D-10	B51		-11	0
D-11	B76		-12	20
D-12	B55		3	5
D-13	C59		12	28
D-14	C27		28	4
D-15	A29		-1	40
D-16	A38		1	21
D-17	C64		8	10
D-18	C12		5	7
D-19	B63		2	8
D-20	B27		-12	5

Table 2 (continued).

Ring	Mag	Ring offset	
loc. name		offA	offB
E-01	B11	0	2
E-02	B48	-6	13
E-03	C93	1	-11
E-04	C81	-26	-2
E-05	A46	-26	9
E-06	A35	-23	-3
E-07	C97	6	-4
E-08	C95	1	-5
E-09	B93	-11	1
E-10	B43	-6	-1
E-11	B31 *	4	13
E-12	B82	1	8
E-13	C73	20	28
E-14	C98	-25	7
E-15	A30	2	13
E-16	A50	-10	22
E-17	C16	-3	23
E-18	C20	11	25
E-19	B86	5	4
E-20	B34	-7	26
F-01	B16 *	-2	-9
F-02	B98	-11	14
F-03	C52	-2	-4
F-04	C41	-30	4
F-05	A44	-23	12
F-06	A15 *	-34	-6
F-07	C23 *	-3	-7
F-08	C89	6	-8
F-09	B84	-12	10
F-10	B39	-17	2
F-11	B91 *	-18	4
F-12	B89 *	-2	12
F-13	C74	15	19
F-14	C11	6	8
F-15	A25	-9	24
F-16	A21	-11	28
F-17	C04	21	21
F-18	C08	-1	27
F-19	B83	-2	18
F-20	B10	0	15
G-01	B41	-8	-3
G-02	B72	-3	6
G-03	C87	10	-12
G-04	C25	-23	-23
G-05	A33	-26	9
G-06	A14	-21	11
G-07	C39	-16	0
G-08	C09	-21	-11
G-09	B56	-10	14
G-10	B13	3	-7
G-11	B42 *	-12	7
G-12	B03 *	4	16
G-13	C35	3	11
G-14	C43	-2	8
G-15	A23 *	0	20
G-16	A16	1	34
G-17	C63	13	23
G-18	C32	24	14
G-19	B60 *	-2	8
G-20	B08	-4	5
H-01	B14	-15	-8
H-02	B45	-21	-14
H-03	C61	-22	-14
H-04	C33	-11	-1
H-05	A43	-17	8
H-06	A04 *	-19	8
H-07	C76	-23	-23
H-08	C94	-29	21
H-09	B75	-1	10
H-10	B62	-10	8
H-11	B21	-8	0
H-12	B73	-10	3
H-13	C75	13	29
H-14	C18	3	25
H-15	A37	-8	33
H-16	A22	8	12
H-17	C38	9	19
H-18	C56	27	13
H-19	B65 *	-6	4
H-20	B67 *	-6	16

Table 2 (continued).

Ring loc. name	Mag	Ring offset	
		offA	offB
I-01	B29	0	-3
I-02	B35	-16	15
I-03	C07	-14	-18
I-04	C28	-14	-24
I-05	A20	-9	0
I-06	A24	-39	-10
I-07	C71	-35	-11
I-08	C47	-24	-6
I-09	B87	-8	3
I-10	B69	-17	21
I-11	B53 *	10	2
I-12	B81 *	-4	5
I-13	C66	29	21
I-14	C44	12	12
I-15	A03	5	8
I-16	A34	8	3
I-17	C90	-11	15
I-18	C13	17	1
I-19	B19 *	-3	-10
I-20	B20	-3	-1
J-01	B92	-9	13
J-02	B37	0	-1
J-03	C24	-17	-21
J-04	C31	-15	1
J-05	A31	-32	14
J-06	A12	-9	-6
J-07	C70	-10	-4
J-08	C06	-15	-7
J-09	B02	-4	3
J-10	B44	-12	4
J-11	B25	10	-6
J-12	B22	-12	-2
J-13	C05	17	-5
J-14	C53	13	-3
J-15	A06	-3	31
J-16	A07	22	22
J-17	C62	25	17
J-18	C82	14	12
J-19	B40	-12	12
J-20	B15	2	-4
K-01	B71 *	-5	-10
K-02	B30 *	-1	-2
K-03	C54	-5	-23
K-04	C10	-29	1
K-05	A32	-12	4
K-06	A11	-22	16
K-07	C40	-3	-19
K-08	C92	-27	-5
K-09	B09	-9	1
K-10	B96	-2	8
K-11	B88	0	-11
K-12	B04	18	18
K-13	C65	-5	23
K-14	C30	19	5
K-15	A41	-13	32
K-16	A02	3	37
K-17	C78	24	10
K-18	C50	13	15
K-19	B32	6	16
K-20	B05	8	8
L-01	B06	-20	22
L-02	B28	-3	-3
L-03	C02	1	-3
L-04	C83	-6	-4
L-05	A40	-14	0
L-06	A08	-14	-1
L-07	C79	-27	-1
L-08	C22	-16	-8
L-09	B50	-10	-2
L-10	B90	-11	6
L-11	B07	-10	21
L-12	B23	-7	3
L-13	C72	36	12
L-14	C15	7	21
L-15	A26	0	10
L-16	A28	-15	8
L-17	C77	7	17
L-18	C51	8	6
L-19	B80	-2	11
L-20	B46	10	4
spare	A17 *		
"242"	A49 *		
spare	B74 *		
spare	B85 *		
spare	C21 *		
spare	C26		

Table 3. Summary of magnet changes.

Ring loc.	Original magnet	Present magnet
A-01	B16	B77
A-20	B74	B68
B-01	B77	B01
B-11	B42	B12
E-11	B89	B31
F-01	B85	B16
F-06	A04	A15
F-07	C21	C23
F-11	B68	B91
F-12	B31	B89
G-11	B03	B42
G-12	B60	B03
G-15	A49	A23
G-19	B12	B60
H-06	A17	A04
H-19	B53	B65
H-20	B81	B67
I-11	B19	B53
I-12	B67	B81
I-19	B65	B19
K-01	B30	B71
K-02	B71	B30
spares:	A15	A17
	A23	A49
	B01	B74
	B91	B85
	C23	C21
	C26	C26