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AGS Main Magnets Moved and BPM Survey - Summer 2003

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Introduction

During the summer of 2003 the AGS magnets were repositioned vertically and a subset horizontally, and the locations of the BPM (beam position monitor) cans were remeasured. Vertically the magnets were realigned to a "smooth" elevation curve. The horizontal adjustments involved only eight magnets, and were made to remove an intentionally added (December 1994) equilibrium orbit bump that shifted the circulating beam close to the E20 "beam catcher". The catcher was a massive beam collimator located in the E20 straight section that has since been removed from the AGS ring, replaced by th "J10 Dump". This note details these magnet moves and measurements, including the methods used - for the record. The ordering is: **I. Vertical Realignment, II. Horizontal Repositioning, and III. PUE Location Resurvey.**

I. Vertical Realignment

Using the Leica DNA03 digital level, every AGS ring dipole, from the A to L super periods, was surveyed at least three times. Using the Starnet program, a fit was done on the data and the vertical elevations of the dipoles were obtained. A projected "ideal" elevation curve for the AGS ring was produced. This curve removed any abrupt position changes but allowed low harmonic motion. The point was to reach a reasonable compromise between a machine that was vertically "perfect" - achieving which would have involved more time and risk than we could afford - and one that would not significantly distort the equilibrium orbit. Using the T-shaped leveling fixture, the AGS ring dipoles were first leveled and then elevations set to the projected ideal elevation. Every dipole was then again surveyed at least three times using the same method and a final elevation for the AGS ring dipoles was obtained from Starnet.

Initial Surveying Procedure

Using the Leica DNA03 digital level in combination with AGS control points and the two and three meter rods, scales, and a dial gauge, the elevations of the dipoles were obtained. Using the backsight-foresight-backsight-foresight method, the six ring dipoles between the two control points were surveyed with the digital level. The acquired data was saved to a flash card and transferred to the Survey Group’s network drive. This was done at least three times for every ring dipole.

Analysis

Using a visual basic program, the data was then extracted from the GSI format (**G**eo **S**erial **I**nterface) into the correct format for use with the Starnet program. Using Starnet’s least squares routines, the survey data is analyzed and final elevations are outputted. Finally, a table of adjustment deltas was generated between the actual elevation and the desired (projected) elevation to use as a guide for the height adjustment of the dipoles. The desired elevations were arrived at in discussions between the Survey Group and AGS accelerator physicists. After the initial survey, the magnet elevations were graphed. A desired profile was drawn on top of the graph that basically averaged out the localized peaks while maintaining a smooth gentle curve through the

AGS that resulted in a +/- 2 mm deviation around 9 θ. A set of offsets from the actual initial data and the desired curve were calculated and used to position each dipole in the AGS ring.

Leveling the Dipoles

Starting with the A super period, the leveling T-shaped fixture was laid across the top of the dipoles, so that the three ends of the 'T' were resting on the corresponding pads on top of the dipole. Two stride levels were placed atop the leveling fixture, one along the length of the dipole to measure pitch and the other across the width of the dipole to measure the roll. The dipoles are adjusted manually in height by the use of three jacks that are not always directly under the corresponding pad on top of the dipole. A dial gauge was placed beneath the dipole as close to an outside jack as possible so that it can be read and set to zero. The pitch was adjusted first until the corresponding stride level appears level. The roll was taken out with the remaining two jacks until its' stride levels appeared level. Note that the position of the pads atop the dipoles change every magnet so that there are either one or two pads on the 'outside' (most accessible side) of the magnet.

Adjusting the Dipole Elevations

Once the dipole is deemed level, the elevation is adjusted to the desired height. Using the table of deltas for the particular dipole, the jack directly under the pad is adjusted first to the correct delta by noting the deflection in the scale that was placed beneath the dipole. A second jack is used to take out the pitch that was just introduced by the delta adjustment. Finally, the third jack is adjusted to take out the roll and make the dipole level. This was done again for every dipole in the AGS ring.

Re-checking the Elevations.

The elevations of the adjusted magnets were again taken at least three times using the Leica DNA03 digital level and then subsequently analyzed with Starnet using the same methods as the initial survey. We found some errors due to a poor setting of the scale on the dipole, etc. When this occurred the dipole was re-adjusted and a survey was done on the dipole and surrounding dipoles. Note that differences in ceiling height in the G super period and the few ceiling shielding blocks that were removed for maintenance purposes during the shutdown, affected the data due to air turbulence.

One Crazy Magnet

For completeness, and to explain why apparent perfection is perhaps not worth the price, mention is made of one rogue magnet whose initial coordinates were so far away from the norm that the "before" position for this magnet does not show up - is off scale - in the next graph. The H7 dipole deviated enormously from lying in the average vertical plane. The (upstream / middle / downstream) plates measured (+.126 / -.161 / +.024) inches. So this magnet had a very large roll and pitch. At the end of the repositioning this magnet was aligned with its peers. How the magnet came to be so far off is not understood - but it was. Past procedures for aligning the ring have followed very much the same rules as the effort reported here.

The Numbers

The following plot (and **Appendix I**) give the actual numbers taken.

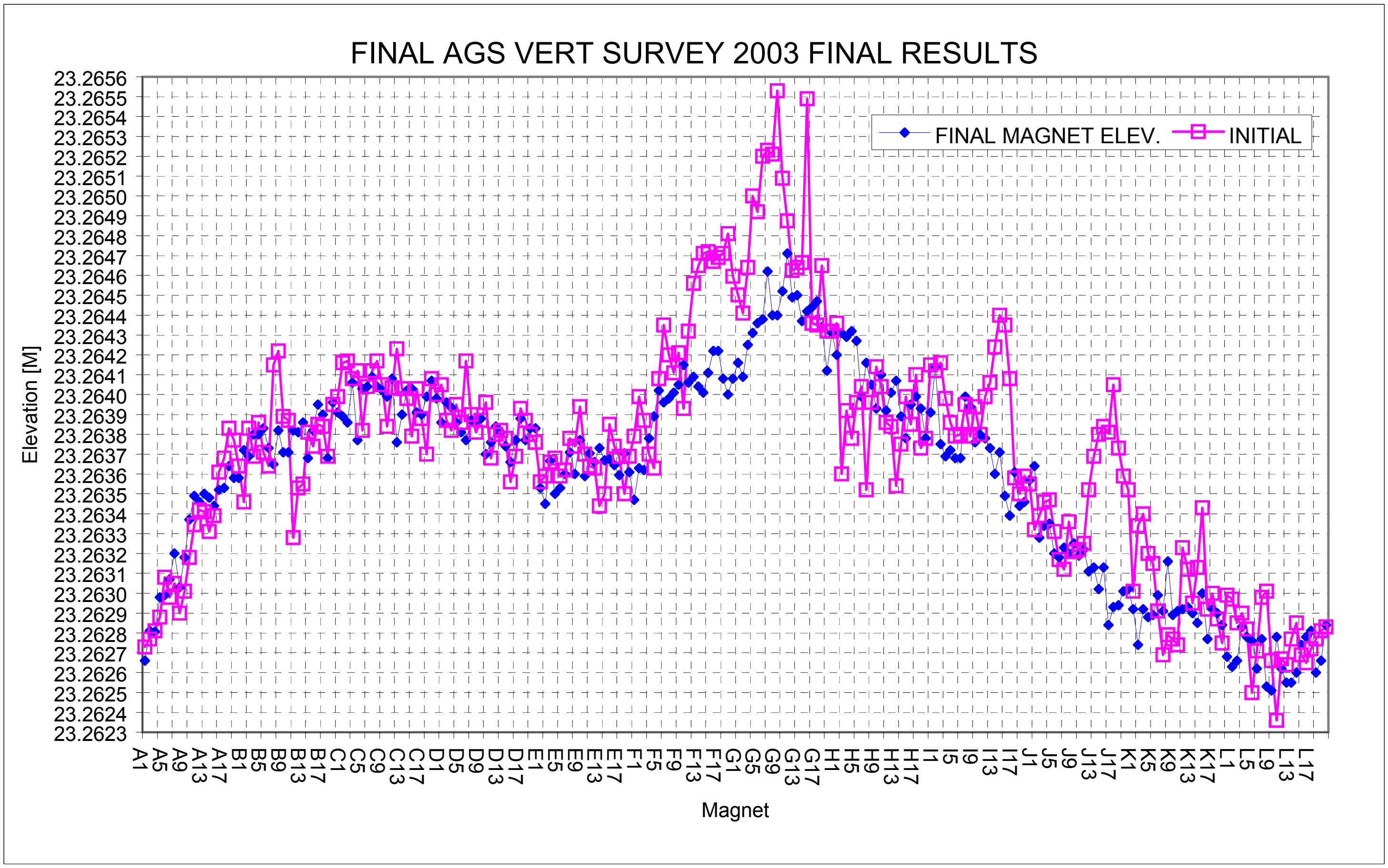

Figure 1. Through the re-iterative process of adjustments, surveying, and analysis using Starnet, the initial and final elevations of all the dipoles in the AGS were determined.

II. Horizontal Repositioning

The second AGS magnet repositioning during the summer of 2003 involved the horizontal positions of a handful of AGS main magnets. These had been intentionally misplaced in December of 1994 in order to bump the AGS beam (high intensity proton beam) into the then new E20 beam catcher. The moves made in 1994 had a slightly complicated history that is explained here in an attempt to reduce confusion. This follows a memo from Roy Thern to Frank Karl, dated 31Dec94.

Based on calculations of the bump amplitude required to aperture the injecting beam slightly at the catcher, eight AGS main magnets, four pairs, were shifted to create a 3/2 lambda bump with an inward max at E20. The original shifts (17 Dec 94) worked well at injection, but when slow extraction was attempted the distortion resulted in an aperture on the extracting beam. A second set of shifts, undoing half of the original ones, was then carried out (31Dec94) and the machine was left in that horizontal state until the moves of 2003 described here.

The original move (17Dec94):

magnets	direction	motion (inches)
D19&20	in	0.136
E13&14	in	0.100
F07&08	out	0.114
G01&02	out	0.120

where "in" means movement to smaller machine radius, away from the aisle.

The additional move to undo half of this (31Dec94):

magnets	direction	motion (inches)
D19&20	out	0.068
E13&14	out	0.050
F07&08	in	0.057
G01&02	in	0.060

During the summer of 2003 then, the second step in this dance was simply repeated yet again, resulting in the main magnets being returned to their original positions - in this relative sense. That is, these moves were all done "locally", using dial gauges to measure the changes being applied. There are sextupole magnets downstream of the #13 and #7 main magnets. The exact history of their repositioning is not described. During the 2004 shutdown (long after all of the moves described in this note), the sextupoles are all being repositioned relative to their neighbor magnets according to the standard procedures that know nothing about these magnet moves and so their horizontal locations should be proper.

III. PUE Position Resurvey

The equilibrium orbit measuring system in the AGS involves detectors (PUEs = pick-up electrodes) whose locations relative to the design orbit are not strongly constrained. In many machines - e.g. the AGS Booster and in RHIC (with some noteworthy exceptions) the mechanical assembly detecting the beam position is well locked to adjacent quadrupoles. In the combined-function AGS this situation does not pertain. The positions of the PUEs are not well constrained by the geometry and so measuring the locations of the PUE cans is required. Further, with the passing of time, a revisit of these measurements is required. This business is the subject of AGS Tech notes #183 and #452. A review of the latest in this work is included as **Appendix II**. The current table of offsets is given in **Appendix III**.

Appendix I

2003 Vertical Magnet Survey
(meters)

MAGNET	INITIAL	FINAL MAGNET ELEV.
A1	23.26273	23.26266
A2	23.26277	23.26281
A3	23.26281	23.26281
A4	23.26288	23.26298
A5	23.26308	23.26299
A6	23.26298	23.26307
A7	23.26305	23.26320
A8	23.26290	23.26303
A9	23.26301	23.26318
A10	23.26318	23.26337
A11	23.26335	23.26349
A12	23.26342	23.26346
A13	23.26341	23.26350
A14	23.26331	23.26348
A15	23.26339	23.26344
A16	23.26361	23.26352
A17	23.26368	23.26353
A18	23.26383	23.26364
A19	23.26377	23.26358
A20	23.26364	23.26358
B1	23.26346	23.26372
B2	23.26383	23.26369
B3	23.26369	23.26380
B4	23.26386	23.26380
B5	23.26371	23.26383
B6	23.26364	23.26373
B7	23.26415	23.26365
B8	23.26422	23.26382
B9	23.26389	23.26371
B10	23.26387	23.26371
B11	23.26328	23.26382
B12	23.26353	23.26381
B13	23.26355	23.26386
B14	23.26381	23.26368
B15	23.26374	23.26382
B16	23.26385	23.26395
B17	23.26384	23.26390
B18	23.26369	23.26368
B19	23.26395	23.26396

MAGNET	INITIAL	FINAL MAGNET ELEV.
B20	23.26399	23.26391
C1	23.26416	23.26389
C2	23.26417	23.26386
C3	23.26408	23.26406
C4	23.26412	23.26377
C5	23.26382	23.26403
C6	23.26404	23.26404
C7	23.26412	23.26409
C8	23.26417	23.26404
C9	23.26405	23.26402
C10	23.26384	23.26399
C11	23.26404	23.26408
C12	23.26423	23.26376
C13	23.26403	23.26390
C14	23.26398	23.26402
C15	23.26379	23.26403
C16	23.26403	23.26391
C17	23.26388	23.26390
C18	23.26370	23.26399
C19	23.26408	23.26407
C20	23.26400	23.26398
D1	23.26405	23.26386
D2	23.26387	23.26396
D3	23.26382	23.26394
D4	23.26395	23.26386
D5	23.26386	23.26381
D6	23.26417	23.26377
D7	23.26390	23.26387
D8	23.26381	23.26387
D9	23.26387	23.26388
D10	23.26396	23.26370
D11	23.26368	23.26376
D12	23.26380	23.26384
D13	23.26382	23.26381
D14	23.26378	23.26374
D15	23.26356	23.26366
D16	23.26369	23.26377
D17	23.26393	23.26388
D18	23.26387	23.26377

MAGNET	INITIAL	FINAL MAGNET ELEV.
D19	23.26380	23.26383
D20	23.26376	23.26383
E1	23.26356	23.26353
E2	23.26359	23.26345
E3	23.26366	23.26367
E4	23.26368	23.26350
E5	23.26359	23.26353
E6	23.26362	23.26360
E7	23.26378	23.26371
E8	23.26374	23.26360
E9	23.26394	23.26377
E10	23.26370	23.26359
E11	23.26364	23.26371
E12	23.26363	23.26366
E13	23.26344	23.26373
E14	23.26350	23.26367
E15	23.26385	23.26368
E16	23.26374	23.26365
E17	23.26369	23.26360
E18	23.26350	23.26371
E19	23.26369	23.26361
E20	23.26379	23.26347
F1	23.26399	23.26363
F2	23.26387	23.26362
F3	23.26370	23.26378
F4	23.26363	23.26389
F5	23.26408	23.26402
F6	23.26435	23.26396
F7	23.26420	23.26398
F8	23.26411	23.26401
F9	23.26421	23.26405
F10	23.26393	23.26415
F11	23.26432	23.26406
F12	23.26456	23.26409
F13	23.26465	23.26404
F14	23.26471	23.26401
F15	23.26472	23.26411
F16	23.26467	23.26422
F17	23.26469	23.26422
F18	23.26471	23.26408
F19	23.26481	23.26400
F20	23.26460	23.26408
G1	23.26450	23.26416
G2	23.26441	23.26409
G3	23.26464	23.26425

MAGNET	INITIAL	FINAL MAGNET ELEV.
G4	23.26500	23.26431
G5	23.26492	23.26436
G6	23.26520	23.26438
G7	23.26523	23.26462
G8	23.26521	23.26440
G9	23.26553	23.26440
G10	23.26509	23.26452
G11	23.26488	23.26471
G12	23.26463	23.26449
G13	23.26464	23.26450
G14	23.26467	23.26437
G15	23.26549	23.26442
G16	23.26436	23.26444
G17	23.26435	23.26447
G18	23.26465	23.26434
G19	23.26432	23.26412
G20	23.26432	23.26431
H1	23.26436	23.26420
H2	23.26360	23.26431
H3	23.26392	23.26429
H4	23.26378	23.26432
H5	23.26396	23.26427
H6	23.26404	23.26399
H7	23.26352	23.26416
H8	23.26396	23.26405
H9	23.26414	23.26393
H10	23.26404	23.26410
H11	23.26386	23.26392
H12	23.26384	23.26401
H13	23.26354	23.26407
H14	23.26375	23.26389
H15	23.26399	23.26378
H16	23.26385	23.26395
H17	23.26410	23.26399
H18	23.26373	23.26393
H19	23.26378	23.26378
H20	23.26415	23.26391
I1	23.26412	23.26414
I2	23.26416	23.26375
I3	23.26398	23.26369
I4	23.26386	23.26372
I5	23.26379	23.26368
I6	23.26380	23.26368
I7	23.26395	23.26399
I8	23.26379	23.26394

MAGNET	INITIAL	FINAL MAGNET ELEV.
I9	23.26394	23.26376
I10	23.26380	23.26380
I11	23.26399	23.26378
I12	23.26406	23.26373
I13	23.26424	23.26360
I14	23.26440	23.26371
I15	23.26435	23.26349
I16	23.26408	23.26339
I17	23.26358	23.26361
I18	23.26350	23.26344
I19	23.26359	23.26346
I20	23.26355	23.26357
J1	23.26332	23.26364
J2	23.26339	23.26328
J3	23.26346	23.26334
J4	23.26347	23.26335
J5	23.26331	23.26320
J6	23.26317	23.26318
J7	23.26312	23.26323
J8	23.26336	23.26320
J9	23.26321	23.26325
J10	23.26322	23.26319
J11	23.26325	23.26322
J12	23.26352	23.26311
J13	23.26369	23.26313
J14	23.26380	23.26302
J15	23.26384	23.26313
J16	23.26381	23.26284
J17	23.26405	23.26293
J18	23.26373	23.26294
J19	23.26359	23.26301
J20	23.26352	23.26302
K1	23.26301	23.26292
K2	23.26334	23.26274
K3	23.26340	23.26292
K4	23.26320	23.26288
K5	23.26315	23.26289
K6	23.26291	23.26299
K7	23.26269	23.26291
K8	23.26279	23.26316
K9	23.26277	23.26289
K10	23.26274	23.26291
K11	23.26323	23.26292
K12	23.26312	23.26293
K13	23.26295	23.26290

MAGNET	INITIAL	FINAL MAGNET ELEV.
K14	23.26313	23.26285
K15	23.26343	23.26300
K16	23.26292	23.26277
K17	23.26300	23.26292
K18	23.26287	23.26290
K19	23.26275	23.26284
K20	23.26299	23.26268
L1	23.26297	23.26263
L2	23.26285	23.26266
L3	23.26290	23.26283
L4	23.26282	23.26278
L5	23.26250	23.26276
L6	23.26271	23.26262
L7	23.26298	23.26277
L8	23.26301	23.26253
L9	23.26266	23.26251
L10	23.26236	23.26278
L11	23.26267	23.26262
L12	23.26264	23.26255
L13	23.26277	23.26255
L14	23.26285	23.26260
L15	23.26269	23.26274
L16	23.26265	23.26278
L17	23.26272	23.26281
L18	23.26277	23.26260
L19	23.26281	23.26266
L20	23.26283	23.26284

Appendix II

AGS BPM Positions - A Continuing Saga. Leif Ahrens, Margaret Harvey Oct 2004

This note goes through all the steps in the present spreadsheets that connect measured mechanical and electrical parameters with the final offsets entered into the database. In part this is motivated by a certain pain I experienced when I got to looking closely a few weeks ago at the active 'trod file' (the offset numbers applies to raw position measurements in the AGS Orbit Display Application Program), which clearly had a sign error - the worst thing that can happen in the dead reckoning business. To explain, the centers of the horizontal pue (pick-up electrode) cans are located "outside" of the desired beam position by about 10 mm - due to details of the AGS ring geometry. On the other hand, the centers of the vertical pue's are measured to tend to fall below the desired beam position by varying, of order one mm, amounts. This is explained again as associated with the positioning geometry, this time because the chambers tend to rest on the (vertically symmetric, but sloping) magnet laminations. Gravity provides the asymmetric bias. So the trod file, carrying out its job of correcting the raw position reported by the electronics for these offsets should move that raw horizontal position "out" and the raw vertical "down". A raw BPM (beam position monitor = pue pair + electronics perhaps + software) report indicating that the beam is centered, equal signals from the two plates, would require that the beam be outside and low. If one expects that '+' corresponds to 'up' and 'out', (which for the AGS orbit system it does), then the applied corrections must have opposite signs for horizontal and vertical. The painful observation mentioned above was simply that they had the same sign. A general sign change had crept into the system, apparently in early 2001, and then persisted to the present. A resurvey occurred in connection with the 2003 magnet survey/repositioning described in the attached note. We review and check things now, and an updated trod file has been added to the AGS Orbit Display application database.

The "dead reckoning" is reviewed, in the context of the database spread sheet - see also AGS T.N. #452. The dead reckoning is broken up into three pieces labeled jig, xray, and capacitance.

First the "jig" correction: An ideal pue vacuum "can" lies concentric along the extension of the "socket line" (line connecting the socket holes = survey holes) of the upstream magnet. A mechanical construction (the Jig) references the PUE can to the "socket holes" in the magnets adjacent to the straight section. The present jig is the "new" geometry - rotated by 45 degrees around the longitudinal axis away from (hori/vert) to allow the measuring pins to actually contact the can.

Some essential but trivial details. PUEs are located in number 2,4,8,12,14, and 18 straight sections of each of the twelve AGS superperiods. The pin-positioning micrometers read .500 (inches - inches everywhere till we finally convert to mm. at the end) for a perfectly positioned PUE can (in a number 4 or 14 straight section). On the spreadsheet, Mic "in" is the reading taken on the catwalk side of the beam; mic "out" is the reading from the micrometer located on the aisle side. The micrometer pins move down at 45% from the vertical as they are wound in. The number reported by the micrometer decreases as the micrometer is wound in.

The first spreadsheet manipulation is to subtract the .500. The results are listed as X' and Y' in the spreadsheet, where X' is the report from the micrometer on the aisle side. (Note there is a column reversal in->y', out->x' to achieve this). Historically the small motion of the vacuum chamber being measured by the survey pin before it would free wheel was added in to the horizontal measurement as a correction at this point. The chamber was not expected to move vertically. With the rotated jig geometry, this correction (which was measured to be about .005 inches) is ignored.

So at this point, equal negative numbers for x' and y' correspond to the vacuum chamber being physically low. X' negative and Y' positive corresponds to the vacuum chamber being physically shifted toward the center of the ring - moved inward.

Now (the next two columns) we rotate into the usual x,y coordinates. The signs are set so that positive means the can is displaced from ideal 'up' and 'out'. The jig angle is taken to be exactly 45 degrees. Higher order effects causing the offset in one plane to affect the position measured in the other are ignored. (The can diameter is 7.75 inches).

Next (see Bleser AGS Tech note # 215 (1985) we account for the fact that because the upstream-downstream magnet geometry referenced by the jig is different at the different PUE locations, a perfectly positioned PUE will report slightly different jig readings at different straight sections. This is strictly a horizontal effect. The geometry of the ring causes a fixed jig (we change nothing about the jig itself as we move from one ring location to another) that is measuring perfectly located PUE cans (in all cases the perfect can is concentric with the extension of the socket line associated with the upstream magnet), to nevertheless see one offset at straight sections (#2 and #12), a different offset for (#4 and #14) and yet another offset for (#8 and #18). By construction the jig reports 0.500 from both micrometers for a perfectly positioned PUE can at a #4 (or #14) straight section. After the 0.500 subtraction mentioned above, and rotation to usual x-y coordinates, the perfect can reports 0.000 both x and y for #4 or #14. The situation is necessarily different then for (#2 and #12) and different again for (#8 and #18). We need to get the magnitudes and the signs right. The answer from the old note was that a perfect can will report +.033" in a #8 or #18, and -.066" in a #2 or #12. Revisiting this offset for the new jig, the relevant offsets are about +.024" for #8 and -.057" for #2. These false offsets need to be subtracted from the raw numbers. (Another error in the old analysis discovered during this pass was that the correction described here was applies to both of the measured (i.e. primed) coordinates instead of being applied to the horizontal after rotating. So both planes were slightly corrupted)

We agonize on the sign question. The final spreadsheet jig numbers give the can position, positive is up and out, of the can center relative to a perfect situation. A beam centered in a high can will cause the electronics to report 0.000 and so needs to have its electronic position increased - by the amount the can is high. By the same argument, a beam centered in a can which itself is shifted to the outside by some amount needs to have its electronic position increased by that amount. The jig final numbers should be added to the raw position determination.

Moving to the capacitance sheet: what is measured is the capacitance at the vacuum feed through, (historically called the "stupakoff" - I think the word referred to a particular manufacturer of feed throughs), for the channels labeled in the ring as 1,2,3,4. The rules to turn these into up, down, in and out are given in the spreadsheet. The pue geometry gets rotated by 180 degrees going from the first half of a superperiod to the second half. The spreadsheet rule: (1,2,3,4) correspond to (bottom, top, out, in) for 02, 04, and 08; and then (top, bottom, in, out) for 12, 14 and 18. For a given pair of signals (i.e. "out" and "in") the quantity difference over sum: (out-in)/(out+in) is calculated. For equal capacitors this gives zero. If the outer capacitor is larger than the inner, a centered beam - equal charge on the two plates - will generate a smaller voltage on the outer than the inner and hence give a false position - to the inside - and so need a corresponding increase. The magnitude of the offset, to first order, is just the (difference over sum) times the pue geometric factor - which is about 40 mm for the AGS pues. The offsets as reported should then be added to the measured position to correct for the false offset. Note: an earlier electronics system for the AGS system did not normalize each pue set (i.e the four plates at C4) individually but only in an average way. Because of this, a set with an average capacitance different from the ring average required a gain correction. With the new (mid 1990's) electronics, this correction is no longer appropriate and has finally been removed.

The final correction (given in the "xray" sheet) is again strictly horizontal, this time due to our ideally located pue cans being outside of the ideal orbit. A beam reporting in raw data that it is centered in a pue is infact outside - by a lot, of order ten mm. The raw reported position needs to be increased.

And if we measure "noise" (on average zero in electronics - no beam in the machine) we expect it will show up (after our correction) as being outside. Since the pues tend to be physically low, by the same reasoning we expect a noise signal will typically be reported as low, though this is a less significant effect than the horizontal.

We have added a "final" sign change to both horizontal and vertical, due to the way the AGS Orbit Display Application Program deals with these numbers. The program actually subtracts the Trod offsets from the measured position.

Appendix III.

pue	jig vert mm	cap vert mm	net vert offset mm (invrt sign)	jig hori mm	cap hori mm	xray mm	net hori offset mm [invrt sign]
a2	-7.69	0.89	6.79	4.30	0.67	10.68	-15.65
a4	-1.64	0.88	0.76	0.03	0.63	10.15	-10.80
a8	-1.91	0.85	1.07	-4.75	-0.13	10.15	-5.26
a12	-0.95	1.83	-0.87	-0.65	0.75	7.78	-7.88
a14	-2.37	-0.55	2.92	0.07	-0.76	10.15	-9.46
a18	-0.95	-0.79	1.74	-2.60	-0.44	10.15	-7.10
b2	-1.71	0.51	1.20	-1.52	-0.44	7.78	-5.82
b4	-3.31	-1.93	5.25	7.52	2.23	10.15	-19.89
b8	-2.16	0.39	1.77	-1.48	0.10	10.15	-8.76
b12	1.13	1.08	-2.22	-0.80	0.14	7.78	-7.12
b14	-2.05	0.85	1.20	-7.79	-0.68	10.15	-1.67
b18	-2.49	-0.02	2.51	0.31	0.08	10.15	-10.53
c2	-0.61	-0.86	1.47	0.84	0.69	7.78	-9.31
c4	-1.33	-1.38	2.72	0.40	0.84	10.15	-11.39
c8	-2.71	-0.26	2.97	-2.17	-0.66	10.15	-7.32
c12	0.22	0.15	-0.37	0.34	-0.93	7.78	-7.19
c14	-2.65	-0.06	2.71	-1.61	0.61	10.15	-9.15
c18	-2.33	-0.47	2.79	-1.53	0.02	10.15	-8.64
d2	-3.25	-0.46	3.71	0.62	0.40	7.78	-8.80
d4	-1.83	0.96	0.87	1.11	0.57	10.15	-11.83
d8	-1.22	0.11	1.11	-1.26	0.00	10.15	-8.88
d12	-1.40	-0.02	1.42	1.70	-0.80	7.78	-8.68
d14	-1.92	-0.04	1.97	-1.96	0.51	10.15	-8.70
d18	-1.18	0.44	0.74	-1.07	-0.31	10.15	-8.76
e2	-2.78	-0.32	3.10	-1.52	0.06	7.78	-6.32
e4	-3.30	0.33	2.96	1.09	0.77	10.15	-12.01
e8	0.00	0.82	-0.82	-0.61	0.67	10.15	-10.21
e12	-0.83	-0.11	0.93	0.91	-0.15	7.78	-8.54
e14	-2.52	-0.46	2.98	-2.58	-0.88	10.15	-6.68
e18	-2.32	0.04	2.27	-0.66	0.49	10.15	-9.98
f2	-0.55	0.61	-0.06	-0.05	0.67	7.78	-8.41
f4	-1.50	0.33	1.18	-1.15	-0.82	10.15	-8.17
f8	-10.83	0.00	10.83	-0.74	0.00	10.15	-9.41
f12	-0.42	-0.59	1.01	-1.37	0.05	7.78	-6.46

f14	-0.85	0.44	0.41	-5.80	-0.81	10.15	-3.53
f18	-0.50	2.92	-2.41	-4.35	-1.99	10.15	-3.81
g2	-1.92	-0.96	2.88	-0.47	0.02	7.78	-7.32
g4	-3.07	-0.51	3.58	1.35	-1.62	10.15	-9.87
g8	-2.39	-1.73	4.12	-0.48	-0.41	10.15	-9.25
g12	-0.93	1.81	-0.88	0.11	-0.22	7.78	-7.66
g14	-2.66	0.24	2.42	-2.01	-0.41	10.15	-7.72
g18	-0.16	0.15	0.01	-2.24	-0.23	10.15	-7.67
h2	-2.20	0.09	2.11	-0.82	-0.29	7.78	-6.67
h4	-2.43	1.37	1.06	2.33	0.38	10.15	-12.85
h8	-0.54	1.09	-0.54	1.33	-1.07	8.64	-8.89
h12	2.10	0.02	-2.12	0.68	-0.03	7.78	-8.43
h14	-1.86	-1.36	3.22	-3.08	0.00	10.15	-7.07
h18	-1.96	0.49	1.46	-1.96	-0.61	10.15	-7.58
i2	-1.90	-2.88	4.78	-2.97	0.59	7.78	-5.40
i4	-1.65	0.30	1.35	-0.65	0.15	10.15	-9.65
i8	-2.44	0.19	2.25	-0.93	-0.31	10.15	-8.91
i12	0.57	-0.33	-0.24	-0.85	0.33	7.78	-7.25
i14	-1.72	-0.07	1.80	1.80	0.12	10.15	-12.06
i18	-2.08	0.18	1.90	-1.12	0.42	10.15	-9.45
j2	-1.92	0.28	1.64	1.07	-0.23	7.78	-8.62
j4	-2.14	0.00	2.14	1.17	-0.25	10.15	-11.07
j8	-2.75	0.51	2.24	-2.03	-0.48	10.15	-7.63
j12	-1.33	-1.92	3.25	0.05	1.56	7.78	-9.39
j14	-1.29	0.86	0.43	-2.30	-1.08	10.15	-6.77
j18	-2.66	0.91	1.76	-0.51	0.08	10.15	-9.71
k2	-0.36	-0.19	0.55	0.51	-0.35	7.78	-7.94
k4	-2.21	-1.51	3.72	0.88	-0.89	10.15	-10.13
k8	-0.67	-0.59	1.26	-1.62	0.26	10.15	-8.78
k12	-1.57	0.28	1.29	0.09	-0.40	7.78	-7.48
k14	-1.10	0.13	0.97	-0.88	0.53	10.15	-9.79
k18	-3.02	0.52	2.50	0.61	-0.52	10.15	-10.24
l2	0.48	-0.24	-0.24	1.79	0.46	7.78	-10.03
l4	-2.50	0.69	1.81	-0.67	-0.06	10.15	-9.42
l8	-2.46	0.61	1.85	-2.03	0.39	10.15	-8.50
l12	0.26	-0.11	-0.15	-1.83	0.08	7.78	-6.03
l14	-2.60	-0.89	3.49	-2.86	0.66	10.15	-7.94
l18	-2.01	-0.05	2.06	-0.14	-0.62	10.15	-9.39