LAB TEST RESULTS FOR THE FOS DETECTOR PERFORMANCE IN A VARIABLE EXTERNAL MAGNETIC FIELD

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Abstract

Using lab test results from spare FOS Digicon detectors, we have extended the model for the expected behavior of the FOS detectors in an external magnetic field to account for anomalies seen in the SV FOS detector test proposal ET3138. Our lab measurements on the spare FOS Blue detector shows high sensitivity to external magnetic fields of 167 microns per gauss. This over sensitivity to external magnetic fields is similar to that for the orbiting Red detector of 147 microns per gauss. A study of the fabrication history of the FOS detector build shows that this spare Blue detector magnetics is from the same 1985 vintage as is the orbital FOS Red detector magnetics. Further we find from our lab measurements that the FOS detector's susceptability to image displacement by external magnetic fields is strongly affected by FOS degaussing activity. The amount of image shift caused by a degauss is proportional to the difference in the external magnetic field that has occurred since the previous degauss. For the spare FOS Blue detector, the proportionality constant is 61 microns per gauss. The sign of image shift caused by an FOS degauss is opposite to the direction of the external magnetic field change between the degausses. This results in an apparent detector external field sensitivity factor of 106 microns/gauss with degaussing before each positional measurement for the FOS spare Blue detector. This new understanding of the FOS geomagnetic image motion phenomena should allow the optimal removal of the effect from FOS data. Also our lab test results show that the GHRS degauss is considerably more effective than the FOS degauss procedure in suppressing the Digicon Detector's past magnetic history.

I. INTRODUCTION

This report details a laboratory study on the unexpected large influence of the Earth's magnetic field on the FOS Red detector. Since a technique has been developed to suppress the resulting unwanted image shift in the FOS detector data, the summary results in the abstract are all that need to be read in this report by most readers.

FOS flight data has indicated that for a particular observation the image motion caused by leakage of the Earth's magnetic field into the FOS Red detector is proportional to the magnetic field vector along the diode array direction (Junkkarinen *et al.* 1990). It is demonstrated that the proportionality constant, called the GIM factor, is approximately 147 microns per gauss of the external magnetic field component parallel to the digicon diode array. It was further shown that most of this unwanted image motion could be removed from FOS data by reading out the FOS data every few minutes and then shifting the image back to a fixed origin in post processing reduction. The amount of corrective shift for each readout is simply the GIM factor multiplied by the calculated value of the

Earth's magnetic field component along the diode array at the orbital position of the observation.

However recent orbital data from the GIM observation proposal (ET3138) shows that the influence of the Earth's magnetic field on the FOS detector is more complicated than previously seen and that a single sensitivity factor is not sufficient to model the phenomena. The new data from observation (ET3138) shows that the GIM sensitivity factor can be dependent on the specific FOS observation mode. Proposal ET3138 was comprised of two separate FOS setups: first a sequential repetition of standard spectral scans and then a repetition of Target acquisition maps of the LED internally illuminated 0.3 arcsec entrance aperture. For each set of these two different modes of observations, it was shown that a single, respective GIM factor accurately removed the image shift. It was speculated at the time that the GIM factor was different for each mode because of the different type of data acquisition activities for each mode. The GIM factor decreased 59% from 147 microns/gauss for the observations of spectra to 87 microns/gauss for the observation of the FOS entrance aperture.

A summary of the Orbital GIM results is shown in table 1. The last column entitled "readout type" summarizes the differences in operations for each separate observation.

TABLE 1

TEST	GIMP Factor (microns/gauss)	PMFA Temp. (c)	Readout Type
GIM Proposal (aperture) ET3138	86.5	-6.6	31.2 second aperture scan, 4 x-steps 24 y-steps every 3 minutes, degauss every 3 minutes
GIM Proposal (spectra) ET3138	144.0	-6.5	rapid readout mode for 95 minutes, one degauss at beginning of observation
Science Spectra (UM675)	143.2	-7.4	3 separate 2000 second accumulation mode spectra each separated in time by about 90 minutes, one degauss at beginning of each 2000s accumulation
Science Spectra (CSO38)	151.7	-7.2	3 separate 1920 second accumulation mode spectra each separated in time by about 90 minutes, one degauss at beginning of each 1920s accumulation

As a working hypothesis, we speculate that the residual field in the PMFA structure is being reduced by a degauss cycle. This would explain why the TA map GIM factor with its many sequential degaussings is smaller than the science spectra GIM factor. Without continuous degaussing, the residual PMFA field caused by the aligning of the magnetic domains along the Earth's magnetic field lines is usually adding to the Earth's field component and enhancing the Earth's field deflection effect in the digicon.

Note that this is about what we would expect from the theory of permeable material (Scott 1959) and is only a surprise since our shield on the orbiting Red detector doesn't work very well. In fact one of these references (Freake and Thorp 1971) recommends designing shielded magnetic field free regions with internal coils (such as the FOS deflection coils) so that a degauss pattern can be performed. This reference says that an internal degauss in effect improves the magnetic shield by removing the induced magnetization field originating from the surrounding shield structure.

However in order to determine the exact cause for the GIM factor variability and develop a predictive model, we have set up an external magnetic field laboratory test on the spare FOS Blue detector. In the following section (section II), we discuss the FOS detector magnetics. In section III we present our recent laboratory test set-up and data from the Helmholtz coil in section III. In section IV we discuss the data relative to detector performance.

II. DIGICON FOS MAGNETICS PERFORMANCE

Figure 1 shows the FOS sensor head with the magnetic shield as the outer housing of the interior Permanent Magnetic Focus Assembly (PMFA). The PMFA structure included the magnetic shield and was procured as a complete unit from the PMFA manufacturer. The procurement specification for external field attenuation factor "A" is 140; however we thought this was so important at the time that we added that A>300 as a design goal. Our years of ground based telescope science observations (Beaver *et al.* 1976) demonstrated the importance of a good magnetic shield around the Digicon detector. The ground based Digicons were generally mounted at the cassegrain focus of the telescope and, of course, would move relative to the Earth's field as the telescope tracted. The shields were manufactured from 3 stacked layers of progressively higher permeability mu metal. The attenuation factor for these inexpensive ground based telescope Digicon shields would measure out to be around 100.

Penetration of an external time varying magnetic field into the Digicon tube region leads to image drift. The penetrating magnetic field deflects the Digicon electron image as it transits along the 15 centimeter acceleration space between the photocathode and the diode array target. The size of the deflection is determined by the same equation as that for image shift utilizing our deflection coils, i.e.

$$D = (B / A) \times (L / F) \quad \text{Formula 1}$$

where D is the image movement at the diode target
B is the external magnetic field component parallel to the diode array
A is the shield attenuation factor
L is the digicon tube length (15 cm)
F is the digicon magnetic focus field (105 gauss)

A figure of merit for the the detector sensitivity "S" to image motion caused by an external magnetic field is given in microns per gauss from the formula

$$S = L/(A \times F) \quad \text{Formula 2}$$

Substituting A=140 into formula 2, gives a specification sensitivity of 10 microns per one gauss of external magnetic field change.

Now by analyzing the character of the Earth's dipole field for orbits of the HST, it is found that the maximum peak amplitude variation is about 0.6 gauss at 2 cycles per orbit (Junkkarinen *et al.* 1990). Thus we would hope to see, at most, an image shift of 6 microns (0.12 diode resolution element) as the detector orbits the Earth.

Our orbital FOS SV data for the Red detector image motion from science data indicates that the Red detector external magnetic field sensitivity is about 147 microns/gauss with a calculated attenuation factor of only 9.7. However the orbiting Blue detector external field sensitivity is somewhat better at 35 microns per gauss with a calculated attenuation factor of 41. The Earth field at the HST spacecraft is determined by using a GSFC code.

The first set of magnetics developed for the FOS was used in the Design Verification Unit (DVU). This unit was extensively tested at the FOS prime contractor and UCSD with the result of A=140 for the DVU. Indeed at the time the PMFA manufacturer used this information to negotiate a reduction in the external attenuation specification from $A \geq 160$ to $A \geq 140$.

The manufacturing history for each of the FOS flight detector Permanent Magnet Focus Assemblies is the following:

1. The orbiting Blue detector PMFA in the HST was fabricated in the Original flight build in 1980. This PMFA is also referred to as Serial #1 magnetics in the build documents.

2. The orbiting Red detector PMFA in the HST was fabricated in the Spares flight build in 1985.

3. The spare Blue detector PMFA in storage at UCSD was fabricated in 1985 as part of the Spares flight build in 1985.

4. The spare Red detector PMFA in storage at UCSD was fabricated in 1980 as part of the Original flight build in 1980. This PMFA is also referred to as Serial #2 magnetics in the build documents.

The FOS prime contractor has looked into the procurement details for the FOS magnetics. Extensive magnetics testing was done on both 1980 units. Results are the following from this 1980 test date:

Serial #1 magnetics (again 1980 build) on HST Blue detector -
Measured attenuation factor is A=330
Serial #2 magnetics (again 1980 build) on spare F1 Red detector -
Measured attenuation factor is A=200

In this case the external field attenuation factor was measured directly (presumably with with a gauss meter and external field) by the FOS prime contractor's Magnetics Lab at the component level in 1980. The manufacturer of the FOS Permanent Magnetic Focus Assembly, which includes the shield, did not perform any external field attenuation tests on the magnetic shield at the component level or at the system level.

Recent lab measurements (using laboratory Helmholtz coils) on our FOS stored detectors indicate the stored Blue detector (with 1985 magnetics) sensitivity to external fields is 167 microns per gauss with a calculated attenuation factor of 8.6. However the ground stored Red detector sensitivity factor is closer to specification at 14 microns per gauss with a calculated attenuation factor of 102. Here, calculated attenuation is inferred from the image shift caused by a known field developed by the surrounding Helmholtz coil setup.

Evidently the 1985 spare magnetics was not measured for the external field attenuation factor. However the PMFA manufacturer says that they used the qualified material from the 1980 vintage lot for fabrication of the 1985 spare PMFA's. Thus the mu metal magnetic shield material is from the same lot as the successful 1980 shields were fabricated.

The PMFA manufacturer has suggested a possible cause for the loss of shield performance in the 1985 magnetics. Evidently the shields were manufactured slightly undersized in diameter for that 1985 fabrication. In order to slip each shield (basically a mu metal cylinder) onto the PMFA structure (another smaller diameter cylinder), the shield had to be hammered into place with a rubber mallet. Now to be an effective magnetic shield, mu metal must be annealed. This procedure is done on the shield before installation onto the PMFA, since annealing requires a temperature cycle up to near the melting point of the mu metal in a hydrogen furnace. Unfortunately, any sharp impacts on the annealed mu metal can reverse the annealing process and degrade the performance of the shield to reject external magnetic fields. So it is likely that, for the 1985 vintage, the shields were seriously degraded during the hammering placement onto the PMFA's, assuming they had been properly annealed in the first place.

The PMFA manufacturer has roughly calculated that the self shielding from the permeable material making up the PMFA should be around 10. It is evident that for the 1985 build FOS detectors, the magnetic shields are not very functional as magnetic shields.

The reader probably asks why the discrepancy between the 1980 serial #2 A=200 measurement and the recent spare Red detector lab measurement of A=102. One possible explanation for the difference is that each measurement was made with a different technique, with the recent lab measurement technique directly relevant to our data taking situation. Probably the 1980 measurement was made only at the center of the magnetics where the shielding would be at the peak value whereas the UCSD lab direct technique in effect integrates the attenuation factor along the central axis of the magnetics for 15 cm.

An additional factor accounting for the difference between the orbital shield performance of the in orbit Blue detector (A=41) and the ground measurement (A=330) is the temperature difference. In orbit the shield is at -10 degrees centigrade whereas the FOS prime contractor measurements were performed at room temperature. The shield performance can be expected to be reduced by as much as a factor of 2 by this 30 degree cooler operating point.

Thus a review of the FOS detector build program along with orbital and lab tests shows that for the 1985 spares build both detectors are about fifteen times below specification for attenuation of an external magnetic field; the in orbit Red detector and "ground" spare Blue detector are from this 1985 build. However, for the original 1980 build, the detector shields are functional, although below specification; the HST/FOS orbiting Blue detector and "ground" spare Red detector are from this 1980 detector build. Table 2 summarizes the various FOS PMFA results quoted here.

TABLE 2
FOS PMFA Performance Results

	Vintage	External Field Attenuator Factor	External Field Sensitivity Factor (Microns/Gauss)	PMFA Temp.	Comments
In Orbit	Serial #1	330	4	~25	From gaussmeter measurement
Blue Detector	1980 Build	41	35	<-10	From image shift technique
In Orbit Red Detector	1985 Spares Build	9.7	147	<-10	From image shift technique
On Ground Spare Blue Detector	1985 Spares Build	8.6	167	~25	From image shift technique
On Ground	Serial #2	200	7	~25	From gaussmeter measurement
Spare Red Detector	1980 Build	102	14	~25	From image shift technique
DVU (Design Verification Unit)	1980 Build	140	10	~25	From gaussmeter measurement These are specification values

A. FOS and GHRS Detector Degauss Schedules

During development of the HST detectors, it was discovered that after large currents to the Digicon XY deflection coils, the image would return to a slightly offset position from the original starting location. The problem was determined to be hysteresis in the reluctor rings of the PMFA structure. To overcome this unacceptabe variation of the image origin, a degauss procedure is performed after large deflection. Two different degauss techniques were developed.

For the FOS instrument the degauss procedure consists of a spiral to zero deflection starting from 4096. Each reduction at the end of an individual spiral is by 128 until 2176 is reached, then the deflection is reduced by a factor of 2 until 2048 is reached. The FOS degauss performs in about 0.5 second. Note that 0.0 deflection current is a setting of 2048 into the deflection coil digital to analog converter.

The GHRS program developed a considerably simpler algorithm to overcome detector hysteresis. The GHRS initializes hysteresis by driving both X and Y deflections to their extreme positions of 4096 and 0. These hysteresis deflections ensure that the deflections follow a fixed hysteresus curve when setting to an image location. It should be noted that the GHRS deflection system outputs 4 times the magnetic field than the FOS deflection system at maximum deflection.

III. LABORATORY EXTERNAL MAGNETIC FIELD SETUP AND TEST DATA

The purpose of this lab setup is to determine the FOS detector image positional sensitivity to changing external magnetic fields. Additionally we want to measure the effects of various detector operational modes on the detector image stability in changing external magnetic fields.

The entire experiment was controlled by an IBM AT attached to a CAMAC crate to take the data and two 12 bit Digital to Analog coverters used to control the respective currents in the digicon XY deflection coil and an external Helmholtz coil. The current as well as the magnetic field were measured digitally and monitored for each experiment.

The FOS spare Blue detector was situated in the middle of two 42″ diameter coils that were 21″ apart, producing a uniform parallel field with less than 10% drop off at the center of each coil relative to the center of the Helmholtz coil set. This was confirmed by measuring the field with a digital gaussmeter. The magnetic field from the Helmholtz coil was found to have a linear relationship to the current placed inside the coils. The Helmholtz coil field was oriented parallel to the diode array. The Earth's magnetic field was oriented parallel to the axis of the PMFA in order to minimize its effects on these measurements.

An optical projector imaged a long slit onto the digicon photocathode; the slit's long axis was oriented perpendicular to the diode array. This produced a 70 micron wide focused beam of light at the digicon photocathode that covered the entire height of the diode array, so all Y locations yielded the same central X location. Each A/D represented a distance of 15.7 microns or approximately 3 A/D steps per diode. The xsweeps were

20 steps in length (6.2 diodes), so the data appeared in a gaussian like curve. A simple averaging program gave centering results within a tenth of a step (a 30th of a diode).

The entire experiment was controlled by a program coded in the BASIC language that was used for previous experiments of the same nature. It was modified to include the two HST degauss algorithms and to make it completely automated for a more realistic simulation of an HST orbit.

The IBM computer automatically increments the Helmholtz coil current, supplies current commands to the detector X,Y deflecton coils to degauss the detector and to scan the projected slit image for positional information. The positional information is then stored onto disk along with the commanded degauss schedule.

The test files taken with this FOS spare Blue detector setup shown in figures 2 to 7 are described as follows:

XSWEEP_RHP_01.* data set shown in figure 2 is the measured peak position at every 0.031 gauss step into the Helmholtz coil as determined by an xsweep of the digicon deflection coils. No degausses were performed in this test. The GIMP coefficient from this test is 167 microns/gauss. This is to be compared with the no degauss HST/FOS observations with a GIM coefficient of approximately 147 microns/gauss.

The XSWEEP_ALTYSWEEP_RHP_02.* scan shown in figure 2 is a set of positional measurements every 0.31 gauss with an additional ysweep followed by a positional measurement every 0.062 gauss. The ysweep is a scan of -471 microns to 471 microns in the direction perpendicular to the diode array axis. This data was taken to show the insensitivity of the x-position origin to a ysweep similar to that in the aperture segment of proposal ET3138.

The TOOTH01.* scan shown in figure 3 is a positional measurement followed by an FOS degauss and a positional measurement at the same point every 0.031 gauss to 0.31 gauss external field; this pattern is then reversed to 0.0 gauss.

The TOOTH02.* scan shown in figure 4 is a positional measurement every 0.031 gauss and an FOS degauss followed by a positional measurement every 0.062 gauss to 0.31 gauss external field; this pattern is then reversed to 0.0 gauss.

BIG3.* data set shown in figure 5 is positional data taken at two points of 0.155 gauss and 0.31 gauss followed by a degauss and positional xsweep at the 0.31 gauss point. The scan is then reversed down to 0.0 gauss with positional measurements at 0.155 gauss and 0.0 gauss followed by a degauss and positional measurement at the final 0.0 gauss level.

HUGE.* data set shown in figure 6 starts with positional data taken at two points of 0.31 and 0.62 gauss followed by a degauss and positional data at the 0.62 gauss point. The scan is then reversed with positional data at 0.31 and 0.0 gauss followed by a degauss and positional measurement at the final 0.0 gauss level.

The GBIG20.* scan shown in figure 7 is positional data taken at the sequential points of 0.31 gauss and 0.62 gauss followed by a GHRS type degauss and positional measurement at the 0.62 gauss data point. The scan is then reversed with positional data at 0.31 and 0.0 gauss followed by a GHRS type degauss and positional measurement at the final 0.0 gauss level. This scan is of course the same as shown in figure 6 (HUGE.*) except a GHRS type degauss is substituted for the FOS degauss. Note the much larger jump that occurs with a GHRS type degauss than an FOS type degauss.

We have measured the average step size for each degauss spacing shown in figures 3 through 7. The results are listed in table 3 and plotted in figure 8. The data fits nicely to a straight line with a slope which we call the "Degauss Factor". The FOS and GHRS degauss factors are 61 microns/gauss and 96 microns per gauss, respectively.

TABLE 3
Average Size of the Image Shift for Various Degauss Spacings for FOS Spare Blue Detector

Degauss Spacing	Degauss Image Shift	
	FOS	GHRS
(gauss)	(microns)	(microns)
0.031	3.22	3.90
0.062	4.14	6.75
0.186	11.96	not done
0.31	18.75	30.0
0.62	38.1	57.0

The GHRS results shown in table 3 and figure 8 come from scans like the previously discussed FOS scans except that the GHRS degauss type is performed rather than the FOS. An example of one of these GHRS scans, GBIG20.*, is shown in figure 7. Since the GHRS degauss results come from using the GHRS degauss schedule on the FOS magnetics, they can only be considered as a general indication of what could be expected from GHRS magnetics.

The level of experimental error in these laboratory measurements is most clearly seen in the TOOTH01.* data set of figure 3. This scan took the longest time to complete of all the scans discussed. To perform the automated sequence of 21 Helmholtz coil current increments, each followed by a positional measurement, a degauss, and another positional measurement, took about 20 minutes. By the time this pattern returned to 0.0 gauss Helmholtz coil field, a drift of some 3 microns evidently occurred. This is the magnitude of the image drifts generally measured in this experimental setup by repetitively measuring the slit position over a long period of time at 0.0 gauss in the Helmholtz coil. Since this experimental setup is not magnetically shielded or vibrationally dampened, data at this several micron level is undoubtedly varied somewhat by purely terrestrial effects. However since we are averaging many differences in the form of image shifts caused by degausses, it is believed that most of these drift effects are likely averaged out of the results shown in table 3.

IV. DISCUSSION

Figure 2 clearly shows that performing Y-stepping during an acquisition pattern similar to the GIM proposal TA section has a negligible effect on the GIM factor. However as seen in figures 3 to 7, degaussing leads to a significant alteration of the GIM behavior.

If we assume a sinusoidal type of variation in the Earth's orbital field at 2 cycles per 90 minute orbit with peak amplitude of 0.3 gauss, then very roughly, we would expect to see a B-field rate of change of average .08 gauss per 3 minutes of orbit. Thus the 0.062 gauss increment data in our data set TOOTH02.* shown in figure 4 most closely simulates the Y-sweep TA section in the GIM proposal ET3138.

Note that after a degauss, the shift in image position always follows the "no degauss" GIM coefficient. The degauss simply changes the starting position. This is most clearly seen in figure 4.

A computer study of the GIM effect for various orbits at different degauss rates shows that a single constant still fits our data to the variation of the Earth's magnetic field. This new factor is simply the "no degauss" GIM Factor minus the Degauss Factor. This can be graphically seen from overlaying the TOOTH01.* data in figure 3 onto the TOOTH02.* data of figure 4. The slopes given by the points after the degauss are essentially the same even though there is a factor of two difference in the degauss rate. Thus the calculated lab GIM factor for an acquisition with continuous degaussing is 167-61 = 106 microns/gauss for the FOS and 167-96 = 71 microns/gauss for the GHRS degauss. In the TA section of the SV GIM proposal, the degauss occurred every 3 minutes with a resulting anomalous GIM coefficient of 86.5 microns/gauss versus 147 microns/gauss from observations with a single beginning degauss.

Although the lab GIM coefficient is not exactly the same as the orbital result, it can be expected that the shielding performance of each PMFA will vary somewhat within a batch series. However it should also be noted that the lab and orbital Degauss Factors are numerically close at 61 and 60 microns/gauss, respectively. This near equality of Degauss Factors is probably more than coincidental.

The continous degaussing GIM coefficient obtained by substituting the GHRS degauss schedule for the FOS is some 30% less than the FOS GIM coefficient. As previously noted the GHRS degauss maximum defection magnetic field output is 4 times that of the FOS. Evidently, the resulting high GHRS magnetic field during the degauss cycle leads to a more efficient removal of the detector's previous magnetic history than for the FOS degauss schedule. Note that a GHRS type scan with the lower FOS current levels gave a Degauss Factor similar to that from an FOS type degauss.

The significance of the Degauss Factor can be judged by considering the maximum image jump that would result if a degauss separation occured at Earth's field minimum and Earth's field maximum. This maximum separation of some 0.6 gauss would lead to a jump in the FOS image position of 0.6 * 61= 37 microns or about 0.73 diode. This is graphically displayed in the data set Huge.* of figure 6. Thus for typical FOS science operations with one degauss at the beginning, the difference in absolute spectral position would be expected to vary over a 0.7 diode range from observation to observation.

The new real time FOS GIM algorithm will compensate for the Earth's magnetic field by moving the Digicon image every 30 seconds according to a model based on the "no degauss" GIM coefficient. Thus the relative XY-scale should remain fixed during an observation. But an addition of a degauss before the observation may be required to remove the XY origin shift caused by any previous large XY deflection steps. In any event inclusion of a correction for this degauss effect into the existing GIM ground reduction software should be possible, but will require keeping track of FOS degauss activity.

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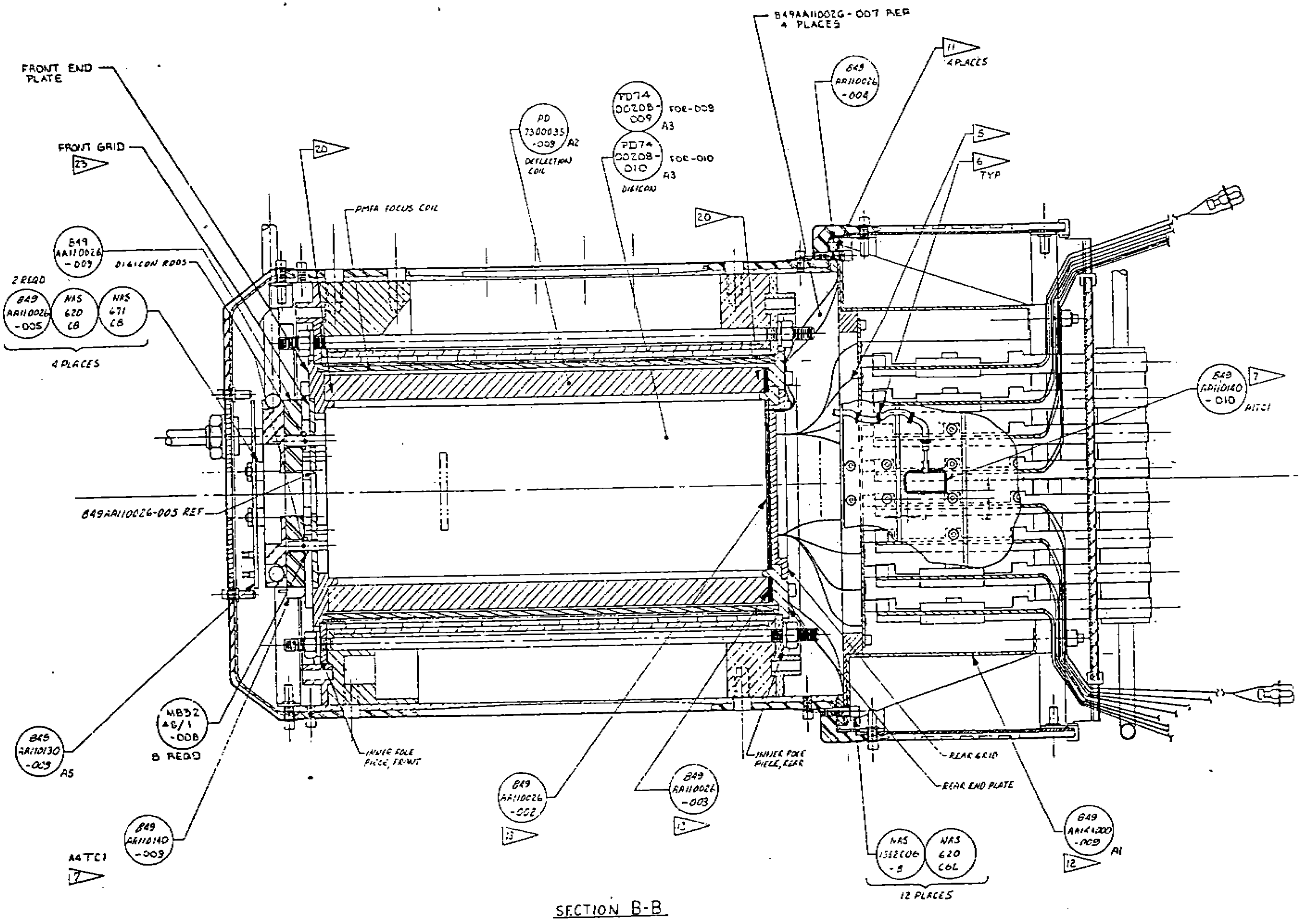

Figure 1: This illustration shows the FOS detecter head with Permanent Magnet Focus Assembly with outer mu metal shield, central Digicon tube and preamplifier electronics.

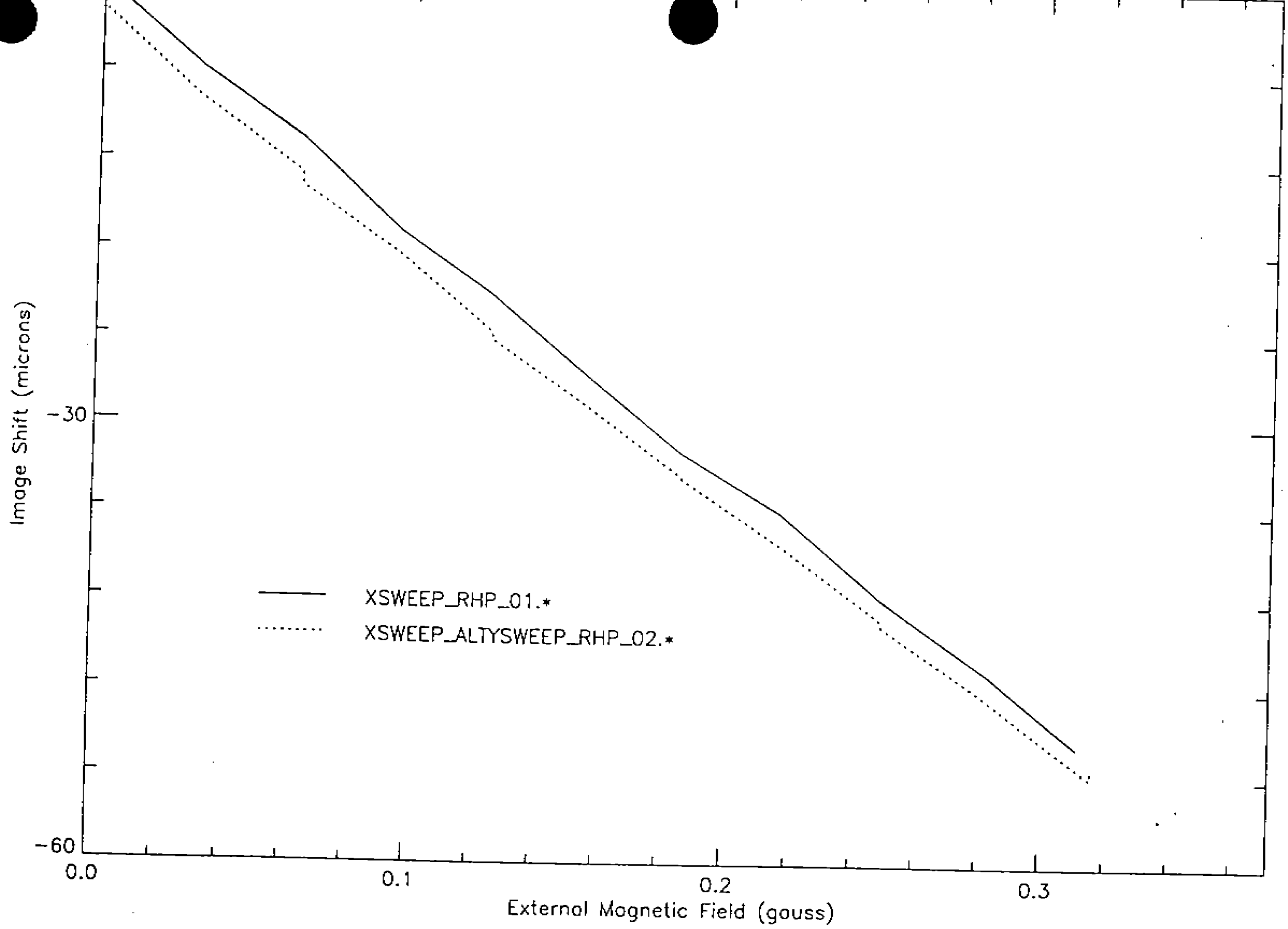

Figure 2: XSWEEP_RHP_01.* is a set of positional measurements every 0.031 gauss of external magnetic field parallel to the diode array, starting from 0.0 gauss and ending at 0.31 gauss. This scan has no degausses. XSWEEP_ALTYSWEEP_RHP_02.* scan is a set of positional measurements every 0.31 gauss with an additional ysweep followed by a positional measurement every 0.062 gauss. The ysweep is a scan of -471 microns to 471 microns in the direction perpendicular to the diode array axis. This data was taken to show the insensitivity of the x-position origin to a ysweep like that in the aperture segment of proposal ET3138.

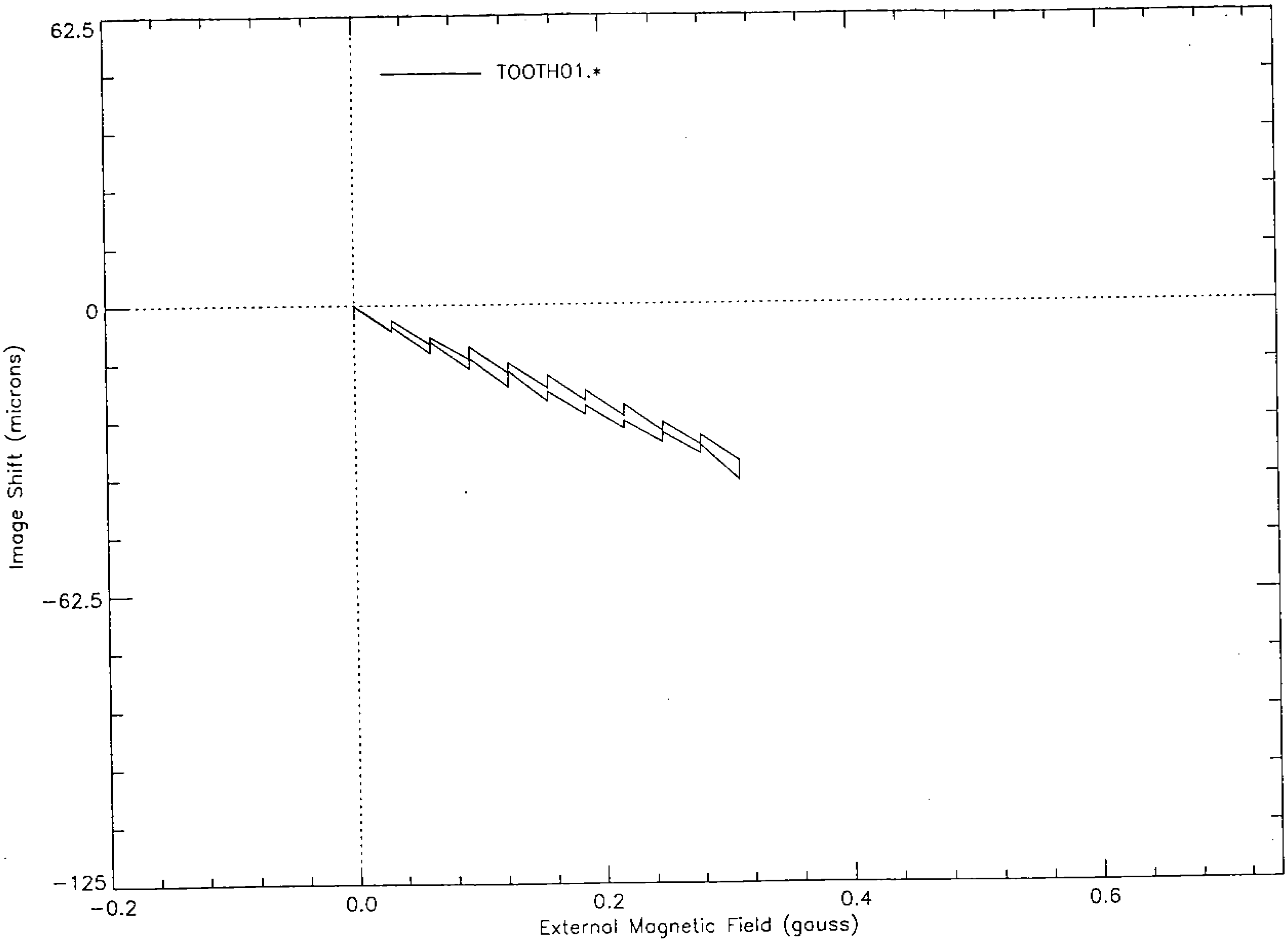

Figure 3: The TOOTH01.* scan is a positional measurement followed by an FOS degauss and a positional measurement at the same point every 0.031 gauss to 0.31 gauss external field; this pattern is then reversed to 0.0 gauss. Note that these resulting small 3 micron size jumps are clearly at the limit of the detection capability of this experimental setup.

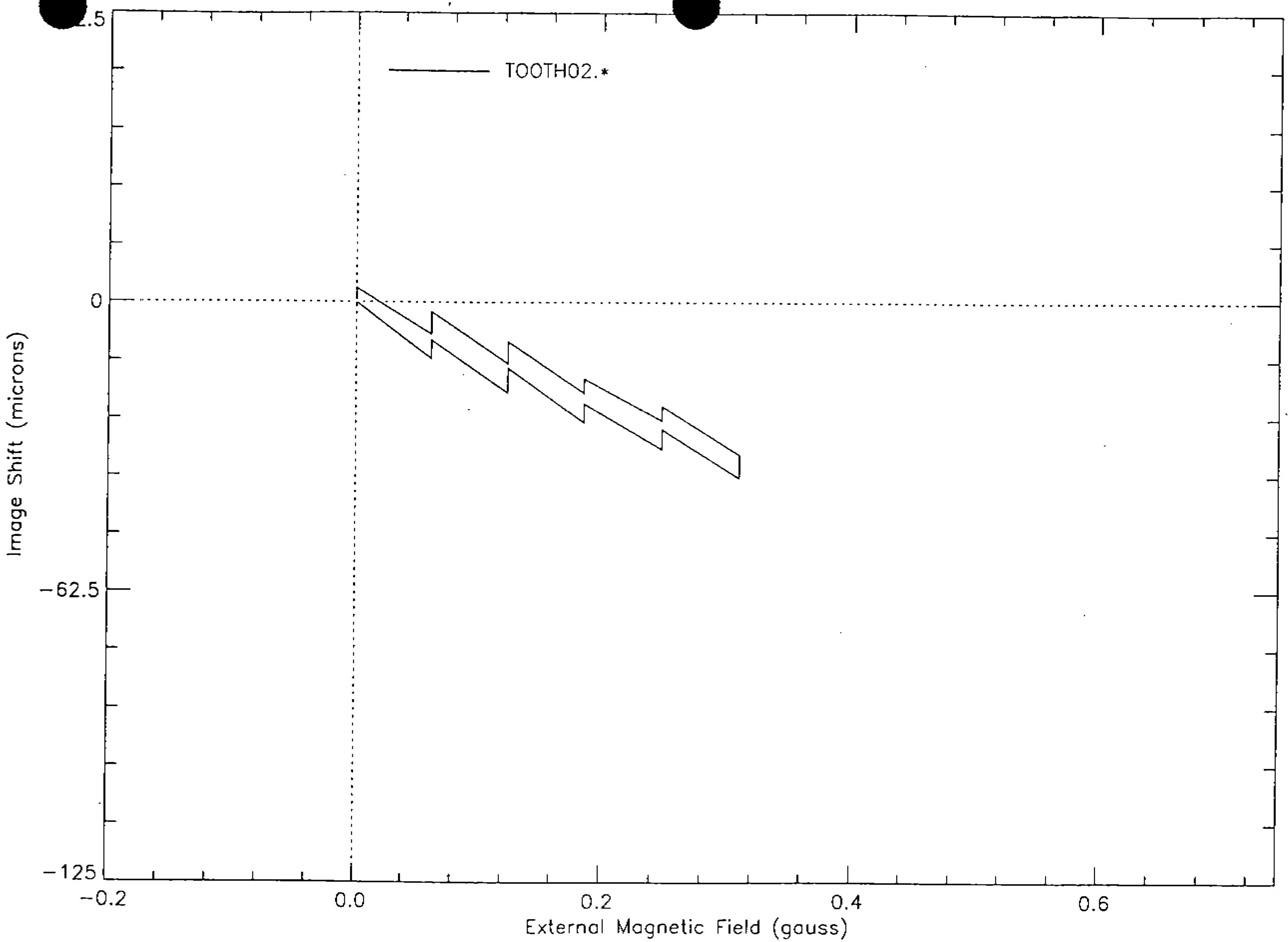

Figure 4: The TOOTH02.* scan is a positional measurement every 0.031 gauss and an FOS degauss followed by a positional measurement every 0.062 gauss to 0.31 gauss external field; this pattern is then reversed to 0.0 gauss. This scan is believed to most closely simulate the 3 minute degauss pattern that occurred in orbit for the TA section of the GIM proposal.

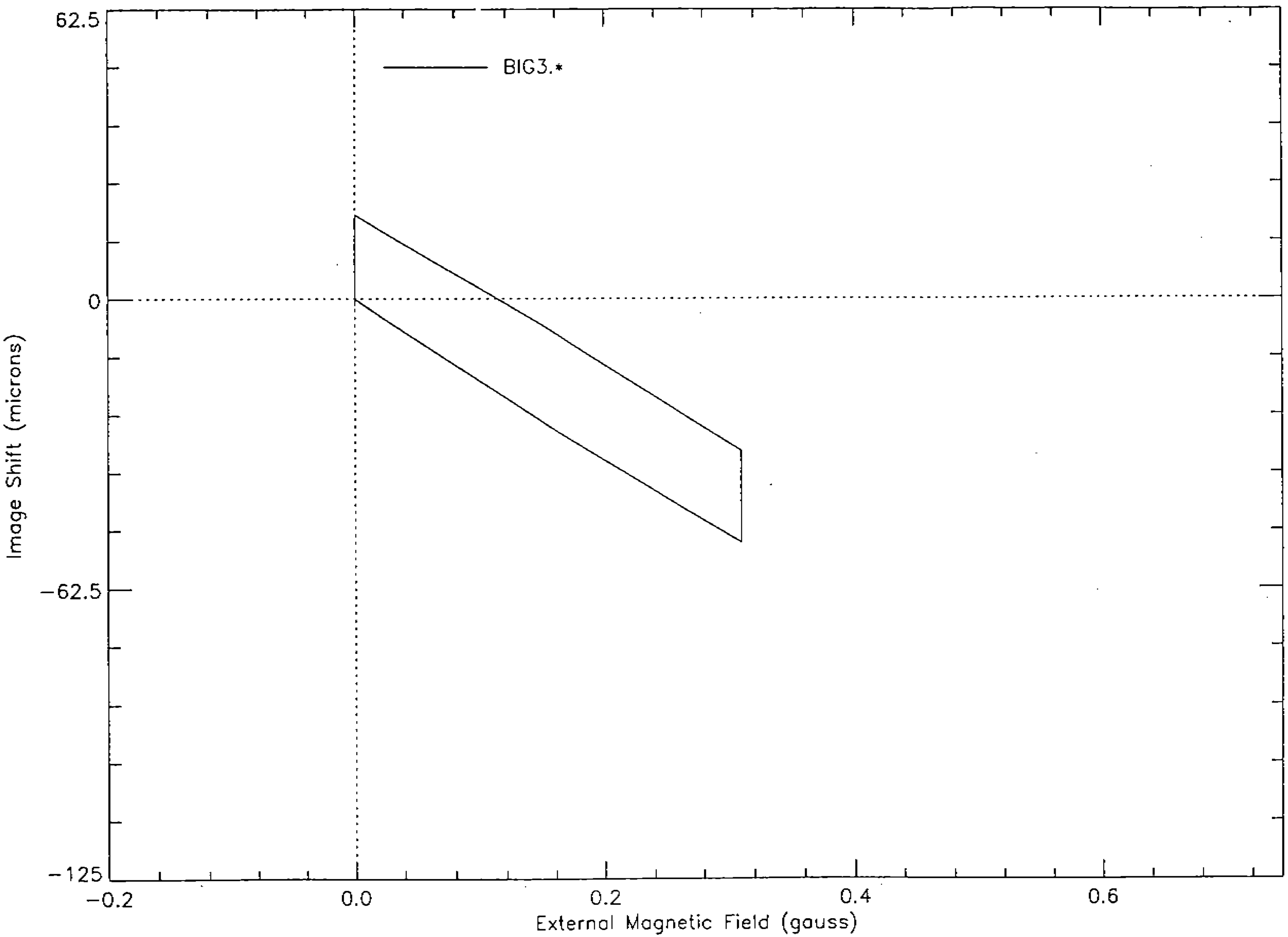

Figure 5: The BIG3.* scan is positional data taken at two points of 0.155 gauss and 0.31 gauss followed by a degauss and positional sweep at the 0.31 gauss point. The scan is then reversed with positional measurements at 0.155 gauss and 0.0 gauss followed by an FOS degauss and positional measurement at the final 0.0 gauss level. Note the similarity of the BIG3.* curve to a hysteresis plot.

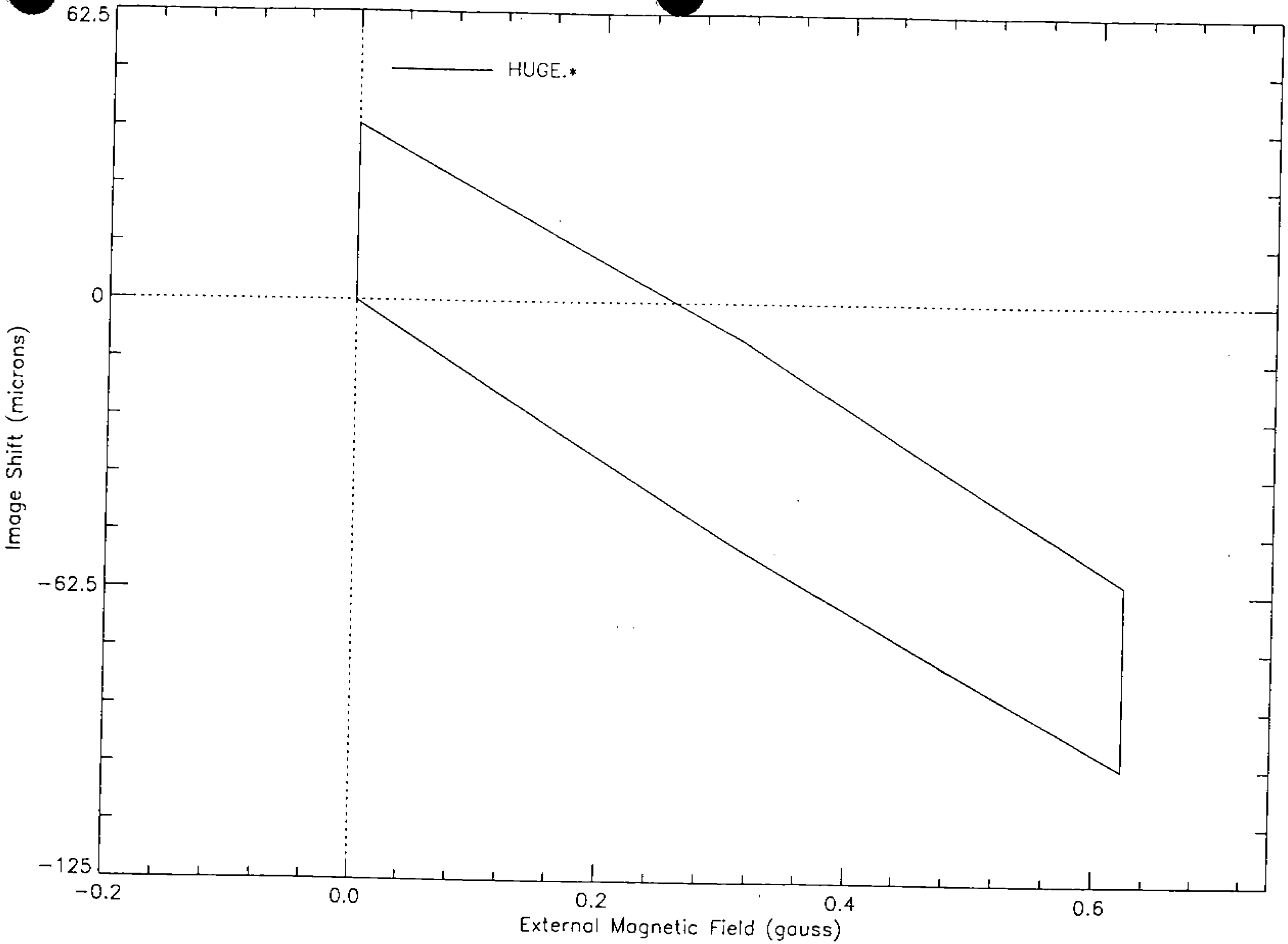

Figure 6: HUGE.* scan is positional data taken at the two sequential points of 0.31 gauss and 0.62 gauss followed by a degauss and positional measurement at the 0.62 gauss data point. The scan is then reversed with positional data at 0.31 and 0.0 gauss followed by an FOS degauss and positional measurement at the final 0.0 gauss level.

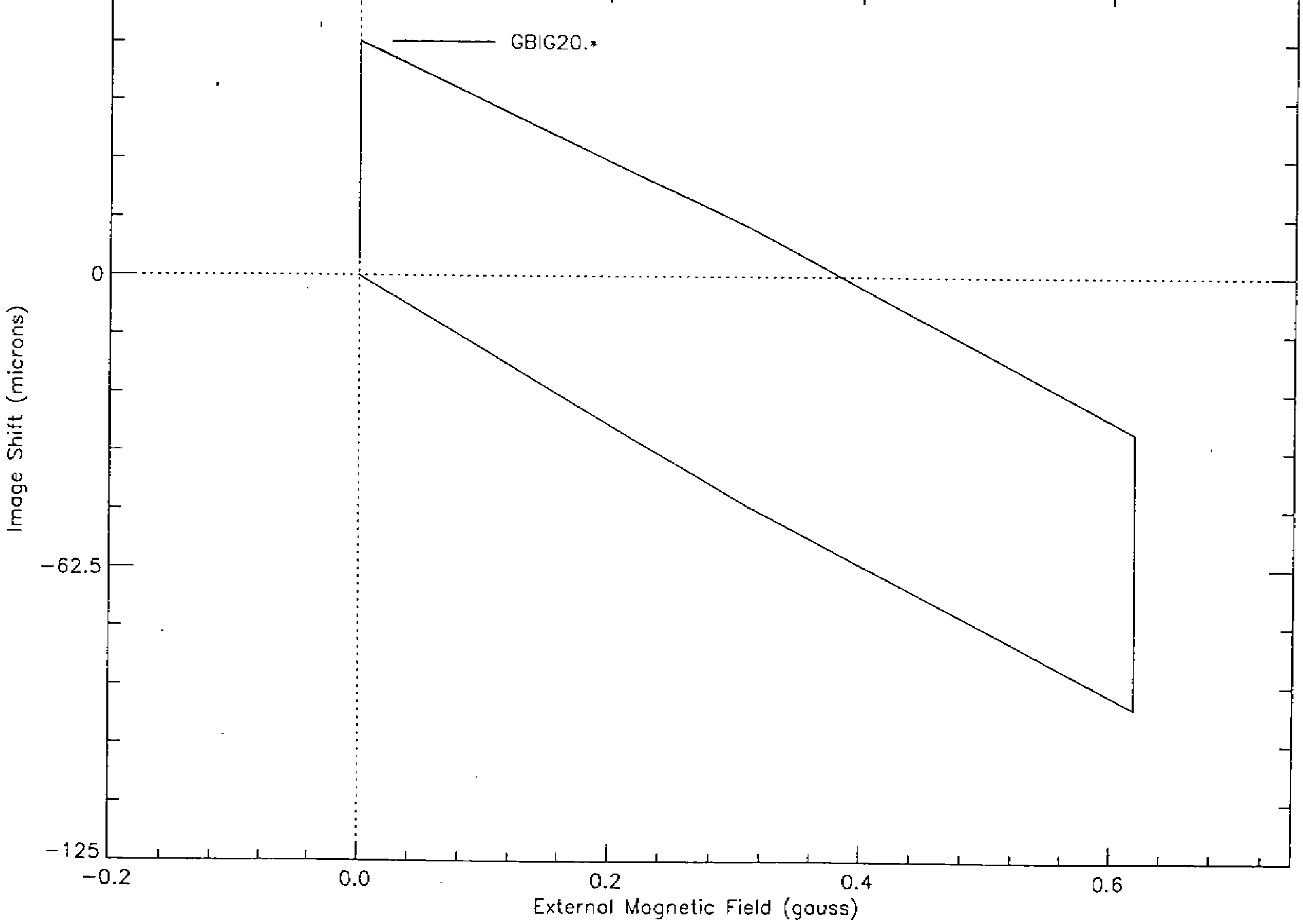

Figure 7: GBIG20.* scan is positional data taken at the sequential points of 0.31 gauss and 0.62 gauss followed by a GHRS type degauss and positional measurement at the 0.62 gauss data point. The scan is then reversed with positional data at 0.31 and 0.0 gauss followed by a GHRS type degauss and positional measurement at the final 0.0 gauss level. This scan is of course the same as shown in figure 6 (HUGE.*) except a GHRS type degauss is substituted for the FOS degauss. Note the much larger jump that occurs with a GHRS type degauss than an FOS type degauss.

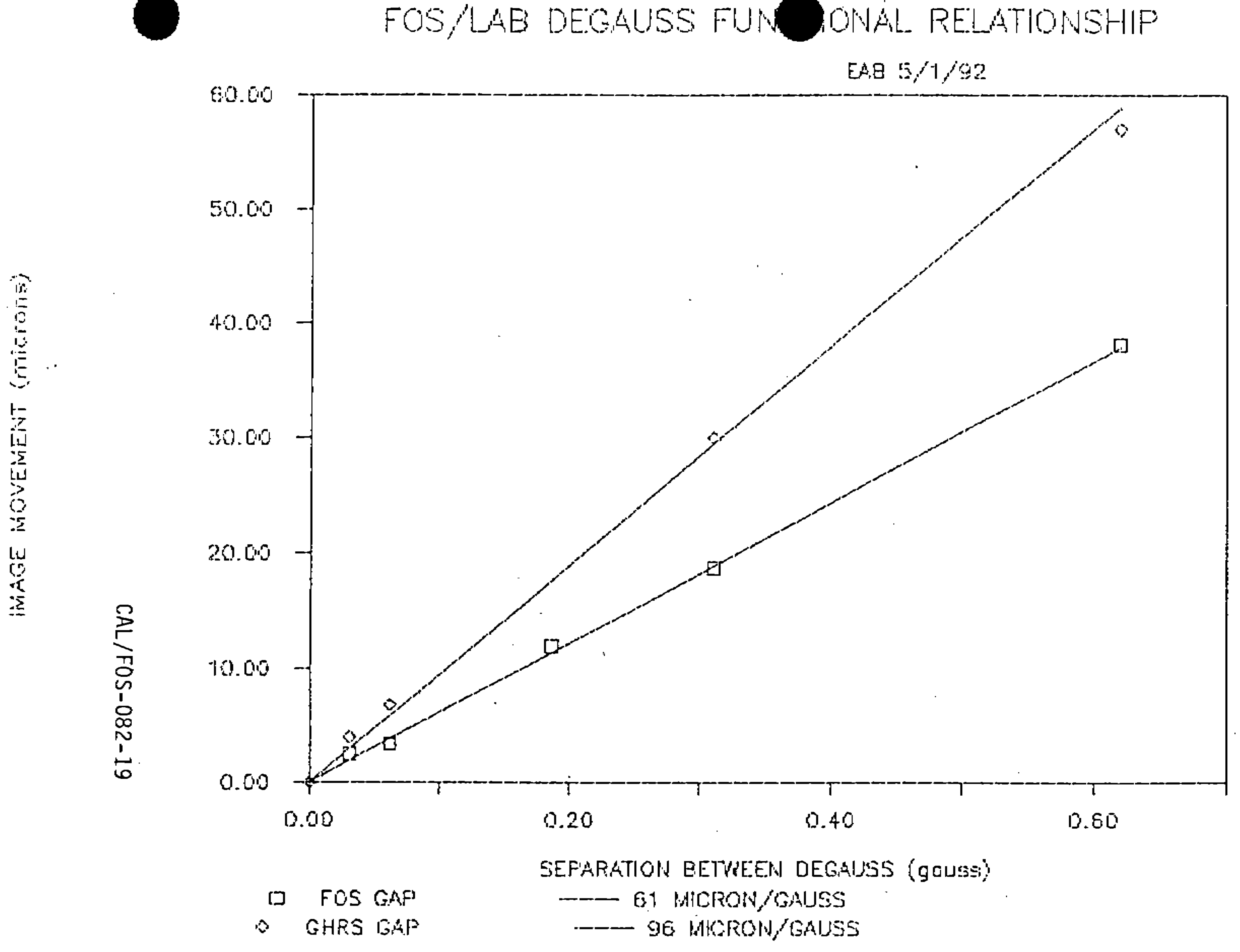

Figure 8: This is a plot of the size of the origin shift in microns versus the difference in external magnetic field between the previous degauss and the present degauss. Two straight line fits with slopes of 61 microns/gauss and 96 microns/gauss are overlayed on the FOS and GHRS data, respectively.