Applications of

Two-Dimensional

Vidicon Photometry:

Venus

by

Philip Henry Schaller, Jr.

Submitted in
Partial Fulfillment
of the Requirements for the
Degree of Master of Science

at the

Massachusetts Institute of
Technology

June, 1973

Department of Earth and Planetary Sciences, May 11, 1973

Certified by: ______________________________

Accepted by: ______________________________
Chairman, Departmental Committee on Graduate
Students

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ACKNOWLEDGEMENTS

I would like to thank my advisor, Thomas B. McCord, and all my friends at MITPAL for their help. Also, thanks go to R. Beebe and others at the New Mexico University for supplying their photographic plates for comparison.

A. INTRODUCTION

The vidicon tube and the theory of its operation, and an operating camera and data system have been described by McCord and Westphal (1972). The hardware and software systems have been described in detail by Kunin (1972). This thesis describes one application of the vidicon system to as astronomical problem.

It has been known for some time that the planet Venus exhibits a featureless shroud of clouds in the visible portion of the spectrum. In the ultraviolet portion, however, features are visible (Boyer and Guerin 1969) (Scott and Reese 1972). These features, and in particular the curious "Y"-shaped cloud which rotates around the planet in approximately four days, are of extremely low contrast. Conventional photographic pictures are printed on high contrast paper to bring out the low contrast clouds. The vidicon system is ideally suited for this problem for three reasons.

1) The system has a wide dynamic range, incorporating many gray levels.

2) The system is linear over this wide dynamic range.

3) The data are already in digital form.

Analyses of the vidicon images are simple using a computer.

The vidicon images presented in this thesis were taken using the Kitt Peak National Observatory 84" telescope on April 23, 24, 25, and 26, 1972. The first night the instrument was mounted at the Coude focus. The other nights it was mounted at the Cassegrain focus. Film photographs were taken the same nights at the New Mexico State University.

Thirteen vidicon images were selected for study in this thesis. These represent the best pictures at each of the several wavelengths taken during each night of the run. On the first night (the only Coude pictures) the Y-shaped cloud had apparently rotated out of view. The second night many quality pictures were obtained at .358, .383, and .402 microns. The cloud is clearly visible on this night although only one of the branches of the Y is seen. The third night only three pictures were obtained and were of less quality than the night before. The final night all pictures were taken through infared filters (see figures 1-13).

Figures 14 through 17 are the best pictures taken with conventional photographic plates during each night of the run. They are all at .37 microns. Correspondence with the vidicon pictures should be noted. They also show only one branch of the Y cloud and confirm the phase of the cloud during this time. The approximately four-day rotation can be observed, noting that the cloud was rotated out of view on the night of the 23rd. These pictures, however, are not suitable for entering into the rotation rate controversy of 4 or 4.5 days (Boyer and Guerin 1969) (Scott and Reese 1972).

Various image processing techniques were developed in the course of this thesis research which were used to enhance the cloud features above the background planet. The remainder of this thesis is devoted to a description of these techniques and their application to the Venus cloud problem. While the data were not taken for the purpose of this thesis, a good deal of it was usable. Although no great scientific problems were solved, it is hoped that this work will be the guide for future Venus research.

B. GRAY SCALE EXPANSION

To make such low contrast features such as the Y cloud on Venus more visible, various image enhancements can be performed on the computer. The first of these attempts at contrast enhancement is gray scale expansion. The vidicon system has 256 gray levels. The actual feature may extend over only tens of gray levels. These gray levels are linearly expanded over the full 0 to 255 range. Points elsewhere in the picture falling below 0 are set to 0 and those rising above 255 are set to 255.

As the contrast is enhanced (see figures 18-22), two effects are noticeable. 1) The size of the image decreases until under almost total contrast enhancement the image almost disappears. This is due to less and less of the image falling into the selected range of gray levels for total expansion. 2) Artificial contours are introduced by the quantization noise. When only a few gray levels are used to cover the entire range of light levels, noticeable (to the eye) distinct changes in light level are visible across the image. While the original pictures had eight bits of gray resolution, every contrast enhancement of a factor of two reduces the number of significant bits by one. Thus these contours are not inherent to the actual image (which is continuous), but are introduced by the necessity of making arbitrary decision levels in digitizing the data.

Since our object data is at one end of the gray scale, a logarithmic enhancement built into the film converter was also tried. (see figures 23-27) The resulting images do not show much improvement. The vidicon system also contains a routine to contrast enhance an overexposed image without loss of precision, as well as the normal overexposed image reducing routines.

C. IMAGE REFLECTION AND ROTATION

The usual method of mapping a feature which appears only at selected wavelengths is to divide the picture at one of the selected wavelengths by the same scene at another, but featureless, wavelength. In this case, however, this cannot be done. The scattering function of the CO_2 atmosphere, which is superimposed on the feature, is a strong function of wavelength and hence cannot be divided out.

As noted before, only one branch of the Y seems to be visible on this occasion. The southern hemisphere can be divided by the northern hemisphere at the same wavelength (using the same picture, obviously), and thus eliminate the CO_2 scattering function. (This assumes a certain symmetry about the function, of course.) The vidicon system now contains a routine to reflect a picture about an arbitrary axis in the plane of the picture. The problems of such a reflection on a discrete grid of points are obvious, but the results are remarkably good. Note that the proper combination of two reflections can produce an arbitrary rotation about an axis perpendicular to the plane of the picture.

The reflected image of Venus is divided by the original and then contrast enhanced. (see figures 28-42) Two things are now immediately obvious. 1) There is a symmetry about the reflection axis. Where the image is dark on one side, it is light on the other side and vice versa. So in the same picture we have the southern hemisphere divided by the northern hemisphere juxtaposed with the northern hemisphere divided by the southern hemisphere. 2) There is an edge effect to this process. The reflection, while good, is not perfect and the limbs of the planet in the two images (original and reflected) do not match up exactly. Since the light level changes rapidly across the limb, the division process greatly enhances the edge. Contrast enhancement makes it worse. The problems of contrast enhancement mentioned in the previous section also apply here.

D. LAPLACIAN IMAGE

Another method of enhancing low contrast features is that of the Laplacian. Being a second derivative operator, the Laplacian is not sensitive to overall reflectivity levels or their uniform variations. It yields only changes in reflectivity variations. These are most often due to fine detail in the image.

The discrete Laplacian is performed on the image by subtracting the average level of the right nearest neighbors of a point from the level of the point. (Rosenfeld 1969) The resultant values are then contrast enhanced. (see figures 43-55) The absolute values of the Laplacian may also be used for display. (see figures 56-68)

Two items are noticeable in these pictures. 1) The ones taken at the Cassegrain focus show a considerable edge effect whereas the Coude pictures do not. This is due to our now enlarged raster (nine points instead of one) when taking the Laplacian. In the Cassegrain images the entire disk of the planet is approximately 32 points wide, while the Coude images show a disk 128 points wide. Since the Coude image is of smaller scale and the limb varies more slowly, the effect of the larger raster is not noticeable.

One might try to circumvent this purely mechanical problem by enlarging the smaller picture in the computer before taking the Laplacian. Two methods of enlarging are common and both have problems. a) Each point is mapped into, say, four points at the same gray level. Its

problem is graininess. The Laplacian pictures appear grainy enough without making them worse by this method.
b) Each of the four points in the enlarged picture can be interpolated in gray level between the positions of the original gray levels. This is an expensive process and does not yield enough quality to make it worthwhile. Frequently, artificial contours are introduced and are enhanced by the Laplacian process. Both these methods suffer from the problems associated with displaying a supposedly continuous function on a discrete grid. (see previous section)

2) The second branch of the Y cloud is now discernable. This has been unnoticed by any of the previously mentioned methods, which shows the power of this technique.

E. INTENSITY TRAVERSES

While the CO_2 scattering function is a complication for the purpose of observing the Y cloud, it is interesting in its own right. (see Appendix) This data is presented in the format of intensity traverses. The intensity of the image is scanned along a line perpendicular to the planet's terminator. All plots begin with the limb on the left and end with the terminator on the right. The organization of these 117 intensity traverses is first by image and then by latitude. In order there are nine plots for each of the thirteen previously mentioned selected images corresponding to figures one through thirteen, respectively. In each set of nine, the plots start at the northern end of the planet and end at the southern end. Note that in some cases, the first or last plot misses the planet altogether. The fifth plot in the sequence is reliably along the equator. The lines of traverse are as close to being at equivalent latitudes as is possible on a discrete grid, and very close in equivalent distance. A normalized distance scale, as well as the start and end points for each traverse, is given. Note that the traverses were taken before correction due to the mirror image reflection by the Cassegrain focus. This is apparent in the absolute coordinates only. Also note that the plots of the Coude images span about 128 points, making the Coude traverses appear smoother.

For interpretation, the plots at similiar latitudes, but through different filters, may be overlayed to show the wavelength dependence of the CO_2 scattering function. Small features, such as the Y cloud, seem to be masked by the small sampling rate when the cloud was visible.

F. CONCLUSIONS

The first data from the two-dimensional vidicon photometer are at least as good as that obtainable from conventional photographic film techniques. Further processing to bring out desired features is readily and easily done through computer techniques. These techniques produce better and cleaner results with more and more sophisticated methods. The next method to be tried should be some form of high pass filtering in the spatial frequency domain. Noise filtering can easily be done along with this.

Further observations of Venus with the vidicon system should span at least five nights in order to see one complete cloud cycle. The image should be as large as possible without reaching the edge of the target. Since the cloud feature spans just 10 or 20 gray levels out of 200, the exposure should be such that the brightest part of the image is near the top of the gray scale range. Overexposed images should be retaken, as it is at best difficult to retrieve the information. Images should be taken at several wavelengths during each night and repeated on the other nights. Adequate logging of the setup of the observations and the data taken will ease the burden of the data reduction.

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FIGURE CAPTIONS

North is to the top and east is to the right, unless otherwise noted. (Planetocentric coordinates)

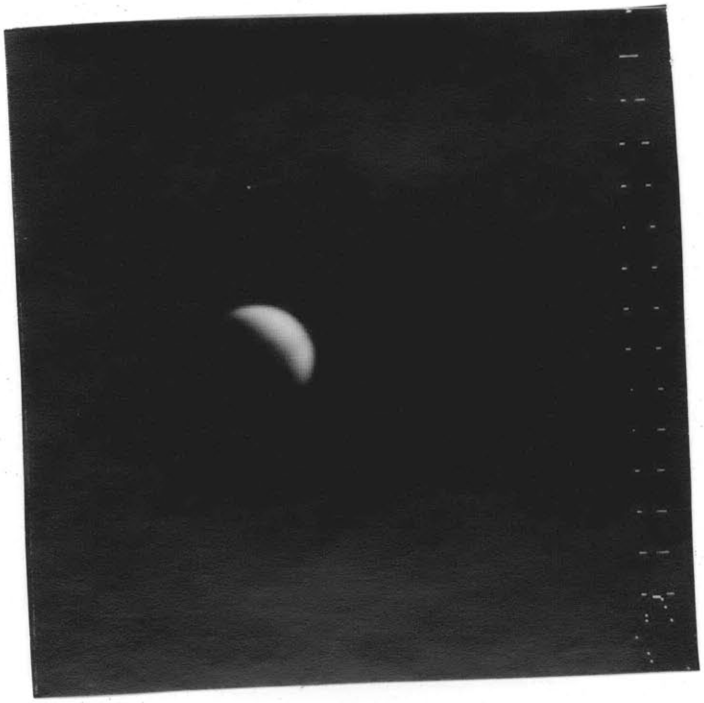
1	4/24/72	Filter:	.358	microns	
2	4/23/72	"	.383	"	
3	4/24/72	"	.383	"	
4	4/25/72	"	.383	"	
5	4/23/72	"	.402	"	
6	4/24/72	"	.402	"	
7	4/23/72	"	.564	"	
8	4/26/72	"	.906	"	Note: double exposure
9	4/26/72	"	.948	"	
10	4/26/72	"	1.00		
11	4/26/72	"	1.05	"	
12	4/26/72	"	H_B		
13	4/26/72	"	1.10	microns	
14	4/22/72	"	.37	"	New Mexico State University
15	4/23/72	"	.37	"	"
16	4/24/72	"	.37	"	"
17	4/25/72	"	.37	"	"

18	gray levels	10 to 200 of figure 3
19	"	60 to 200 "
20	"	100 to 200 "
21	"	160 to 200 "
22	"	130 to 200 "
23	figure 18	with logarithmic enhancement

24	figure 19 with logarithmic enhancement	
25	figure 20 "	
26	figure 21 "	
27	figure 22 "	
28	same as figure 3	
29	reflection of figure 28	
30	figure 28 divided by figure 29	
31	gray levels 10 to 245 of figure 30	
32	" 20 to 235 "	
33	" 30 to 225 "	
34	" 40 to 215 "	
35	" 50 to 205 "	
36	" 60 to 195 "	
37	" 70 to 185 "	
38	" 80 to 175 "	
39	" 90 to 165 "	
40	" 100 to 155 "	
41	" 110 to 145 "	
42	" 120 to 135 "	
43	Laplacian of figure 1	Note: second branch of Y cloud
44	" 2	
45	" 3	Note: second branch of Y cloud
46	" 4	
47	" 5	
48	" 6	
49	" 7	
50	" 8	

51	Laplacian of figure 9	
52	" 10	
53	" 11	
54	" 12	
55	" 13	
56	Absolute value of Laplacian of figure 1	
57	"	2
58	"	3
59	"	4
60	"	5
61	"	6
62	"	7
63	"	8
64	"	9
65	"	10
66	"	11
67	"	12
68	"	13

FIGURES



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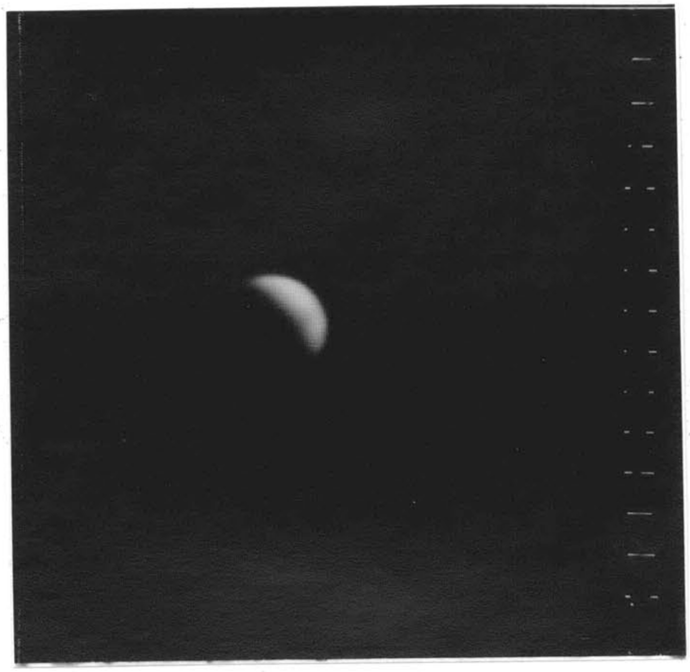

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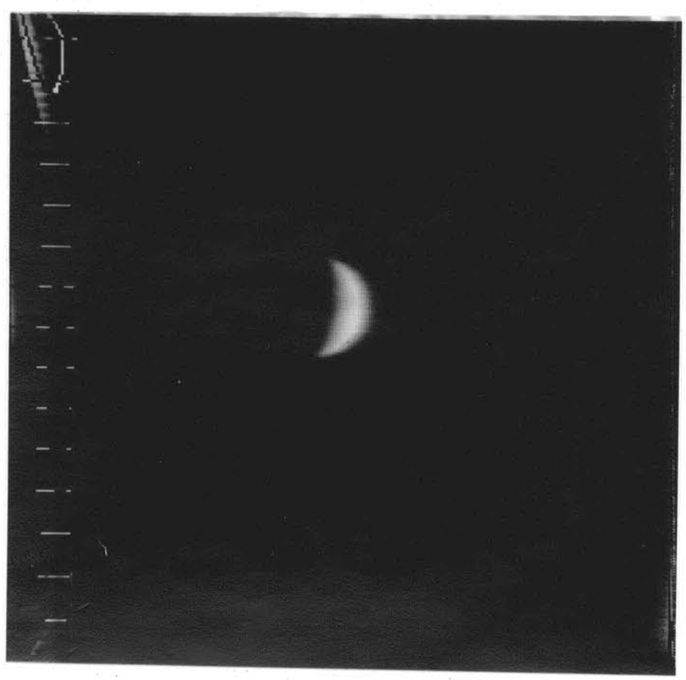

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Figure 5

Figure 6

Figure 7

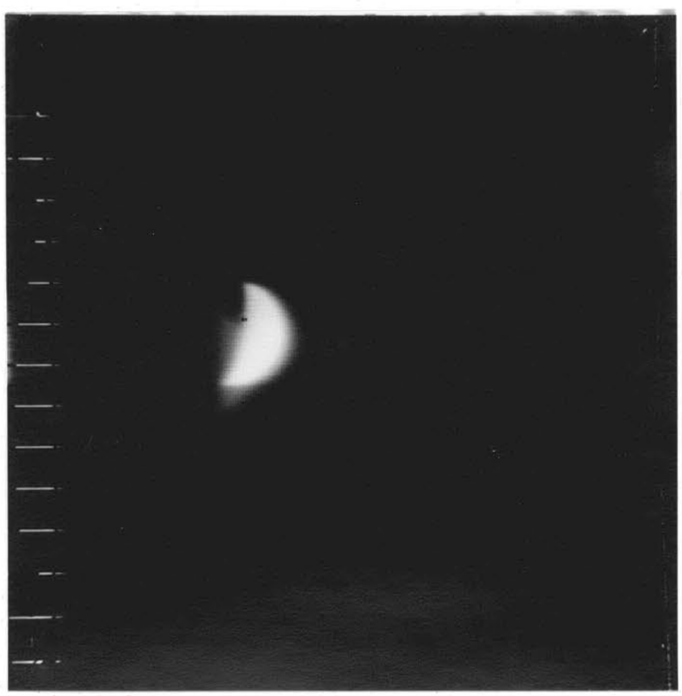

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Figure 9

Figure 10

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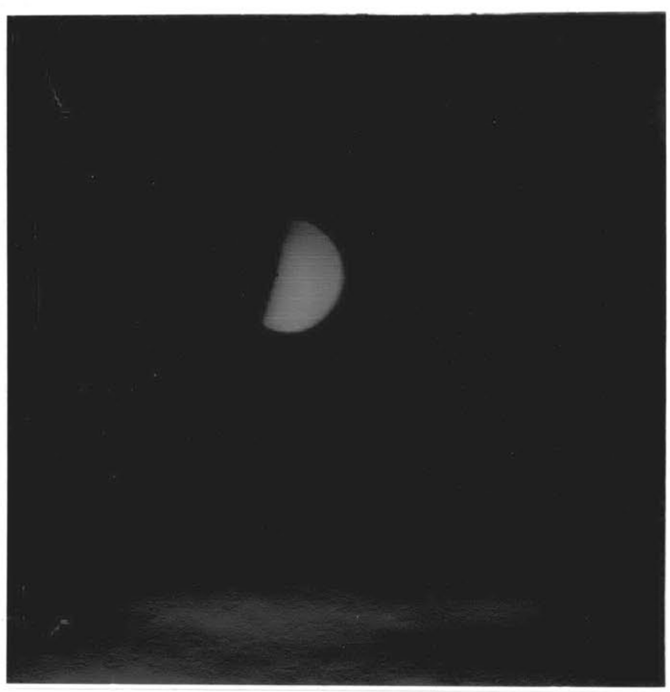

Figure 12

Figure 13

Figure 14

Figure 15

Figure 16

Figure 17

Figure 18

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Figure 20

Figure 21

Figure 22

Figure 23

Figure 24

Figure 25

Figure 26

Figure 27

Figure 28

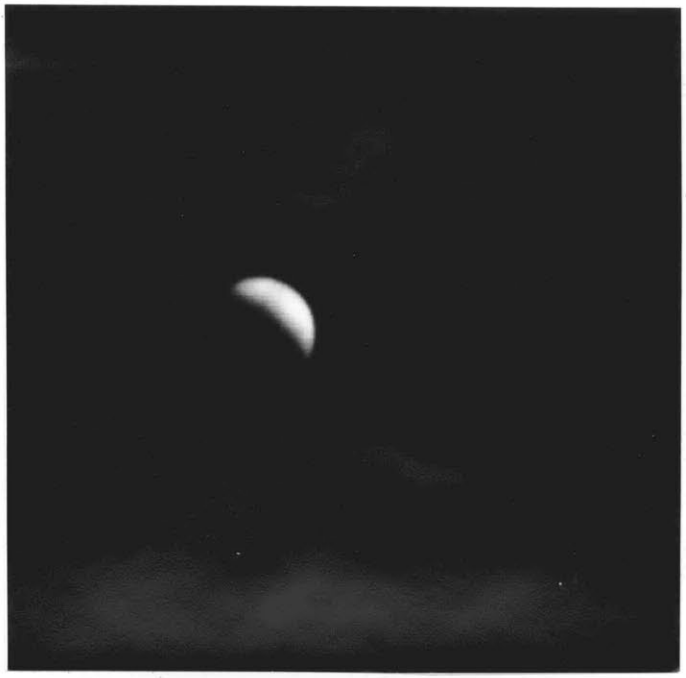

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Figure 31

Figure 32

Figure 33

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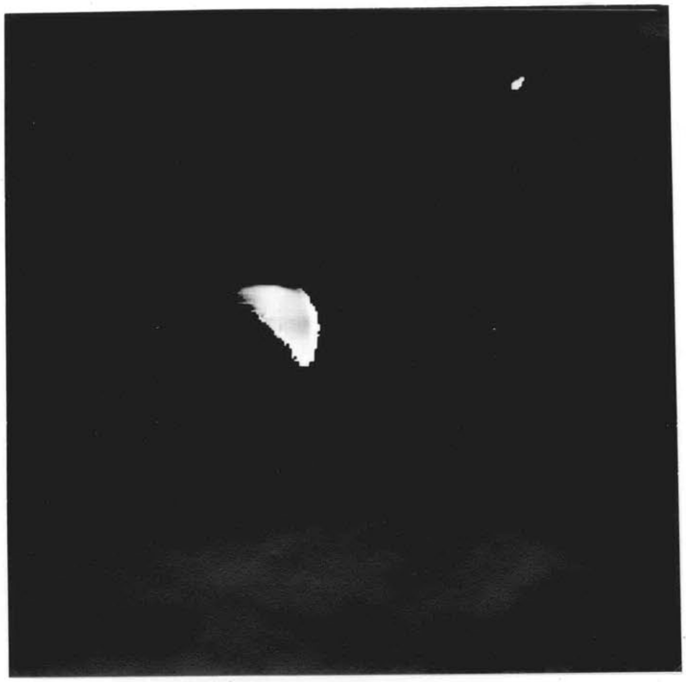

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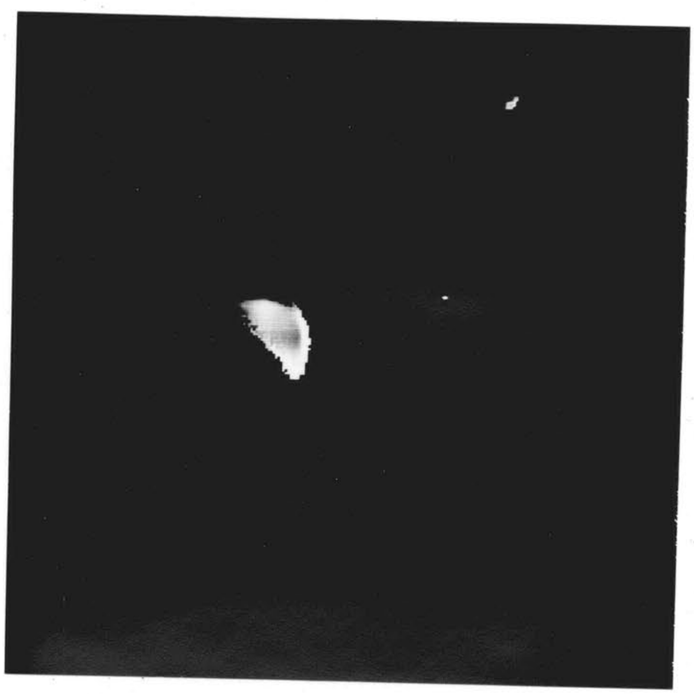

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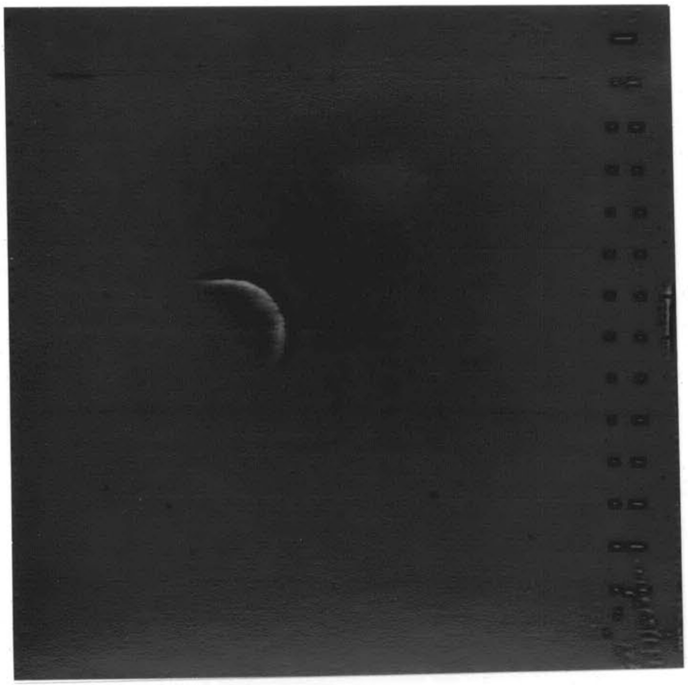
Figure 39

Figure 40

Figure 41

Figure 42



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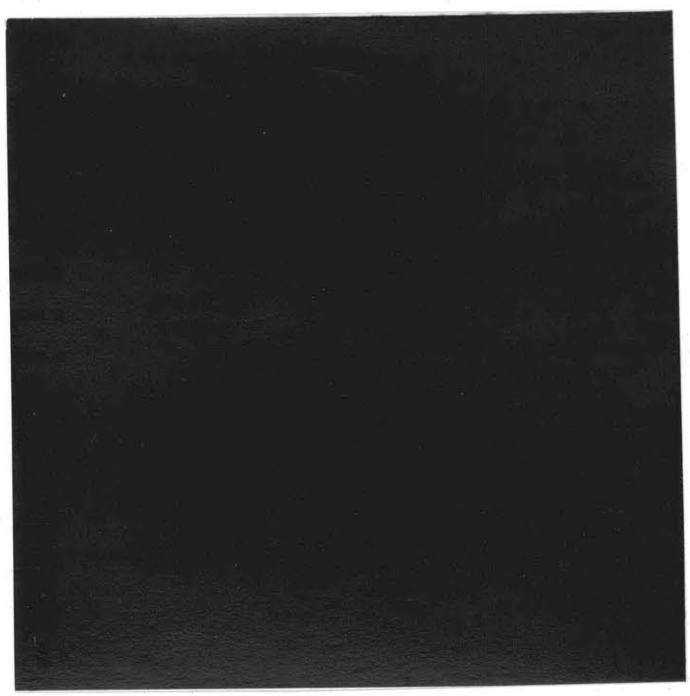

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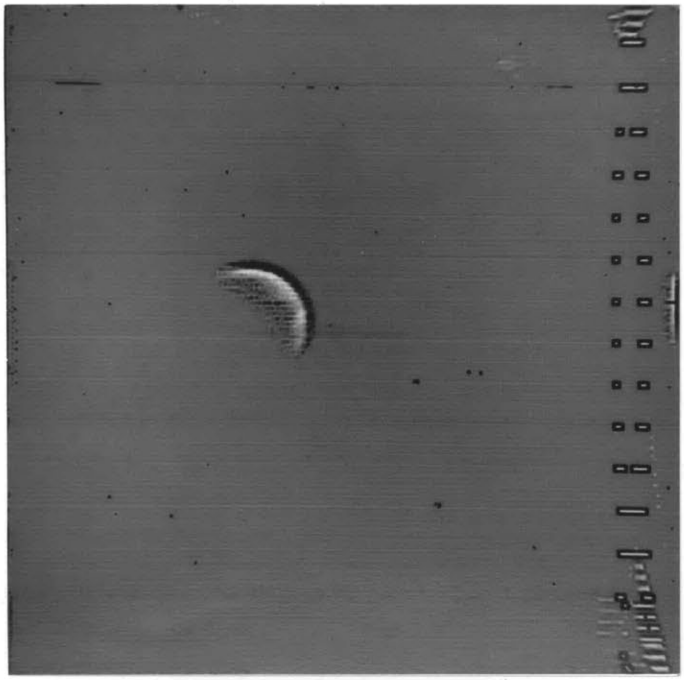

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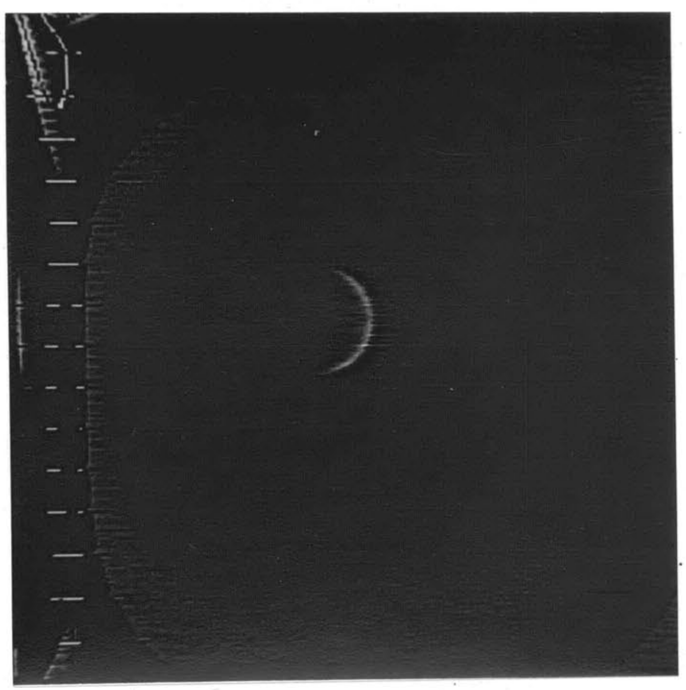

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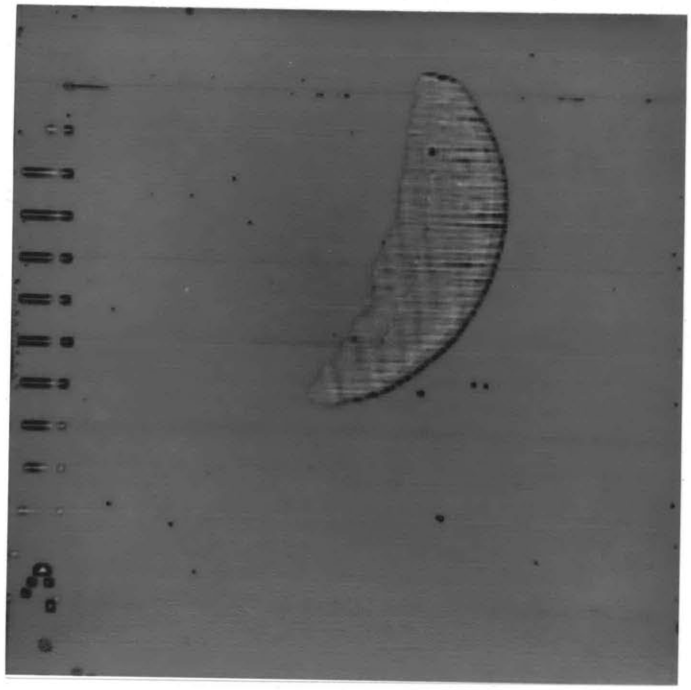

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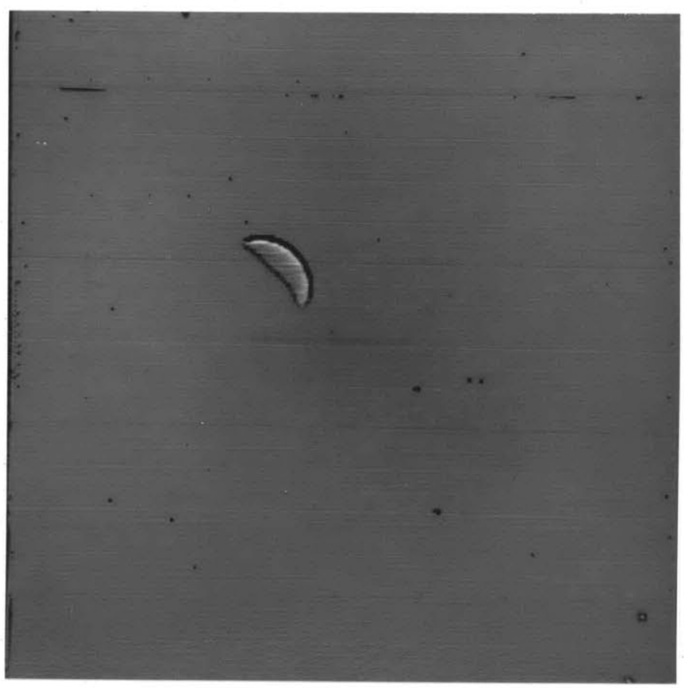

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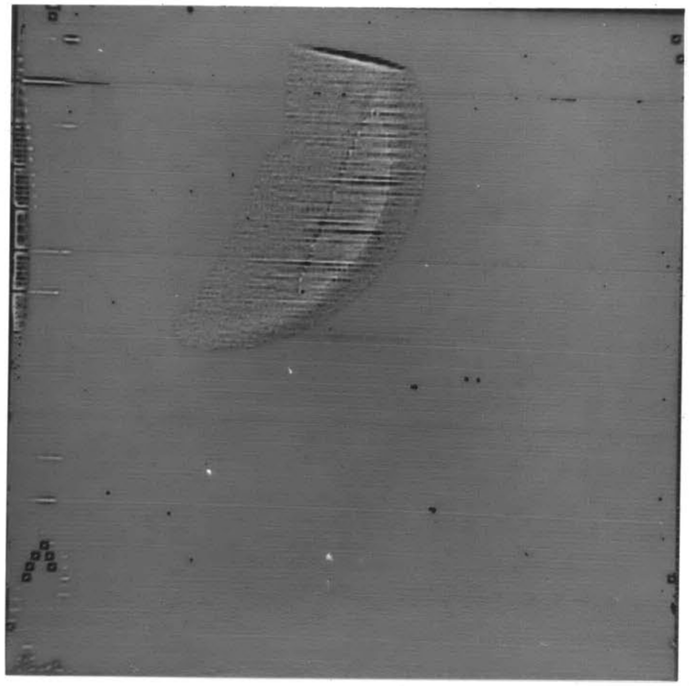

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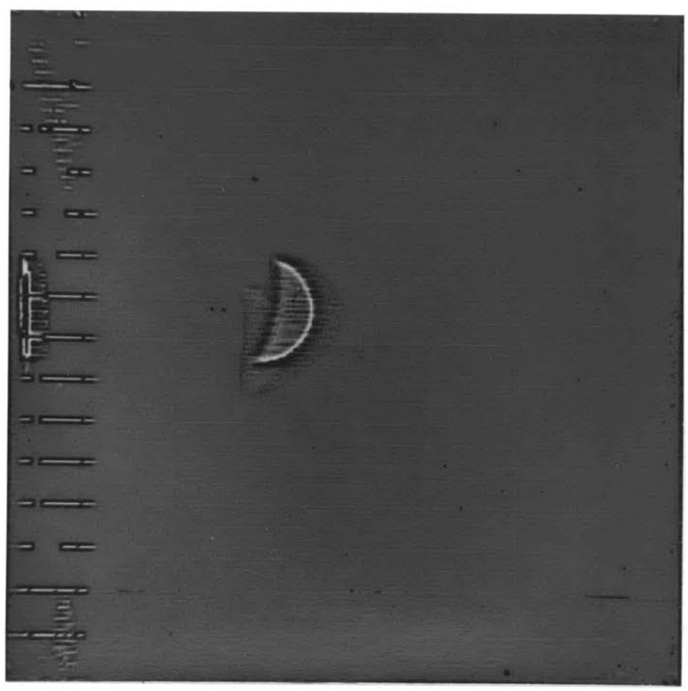

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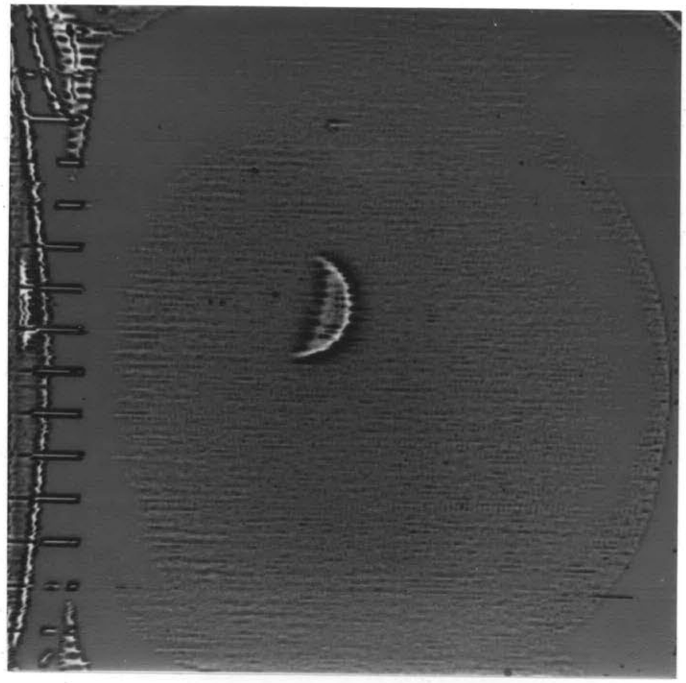

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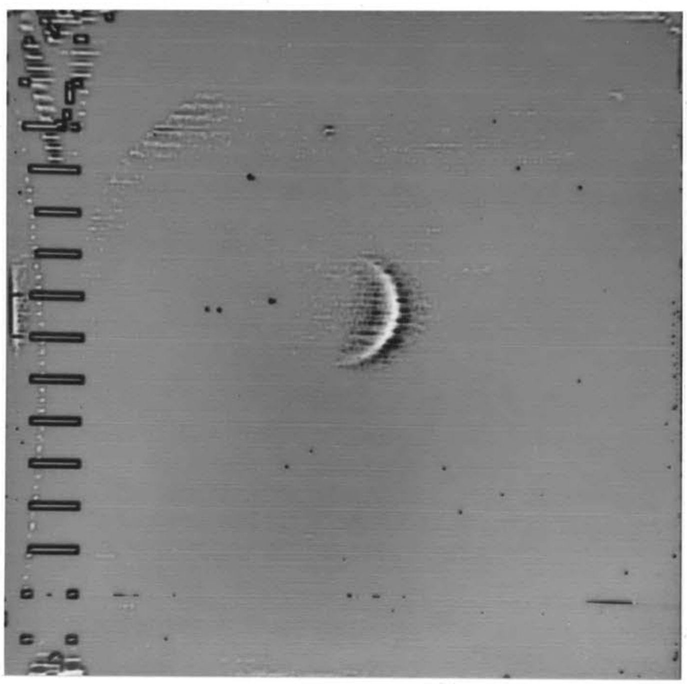

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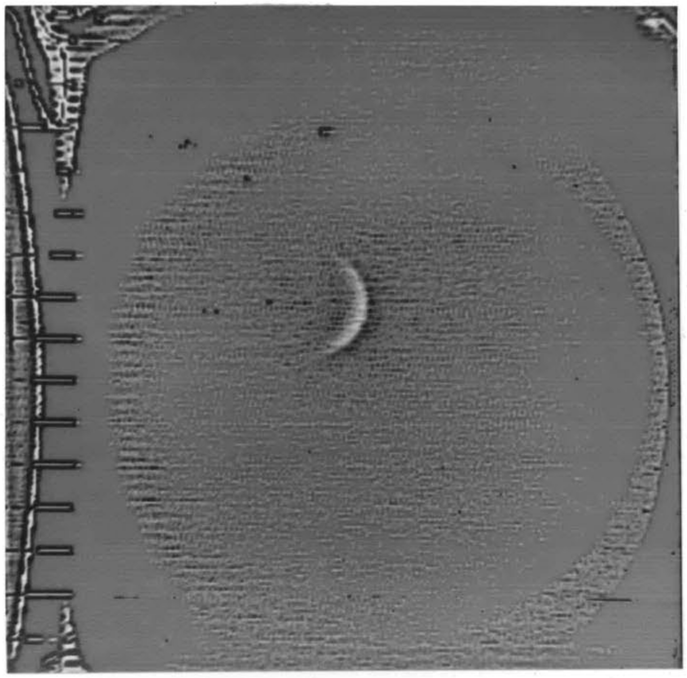

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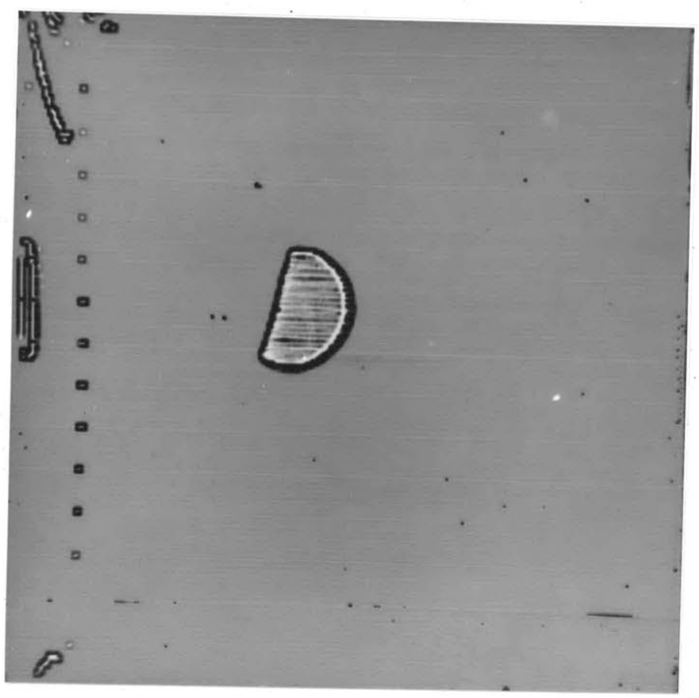

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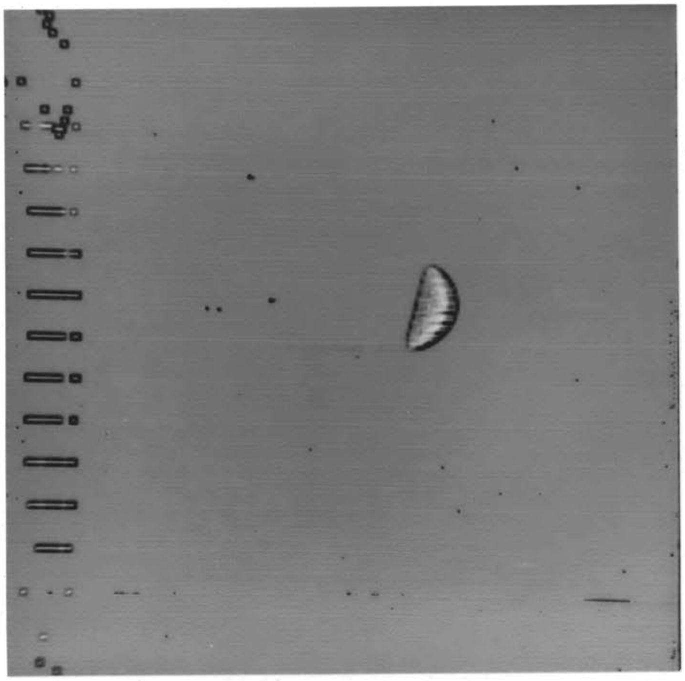

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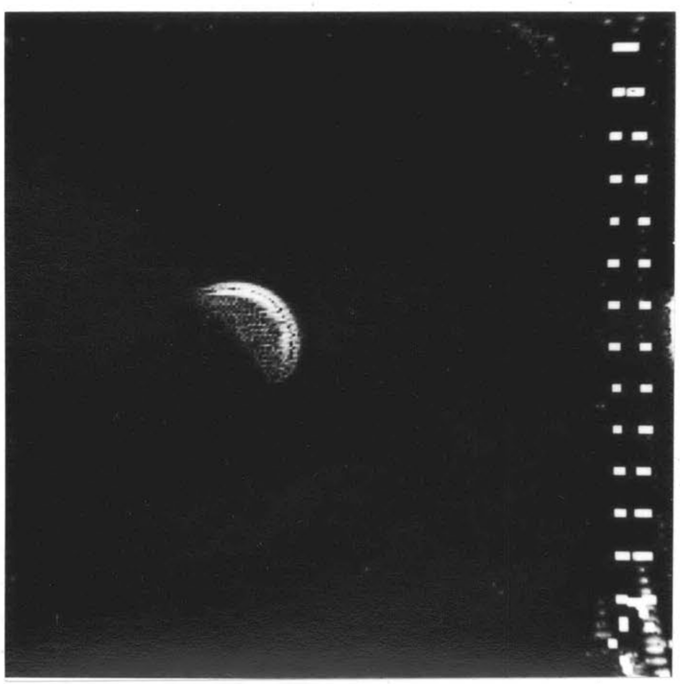

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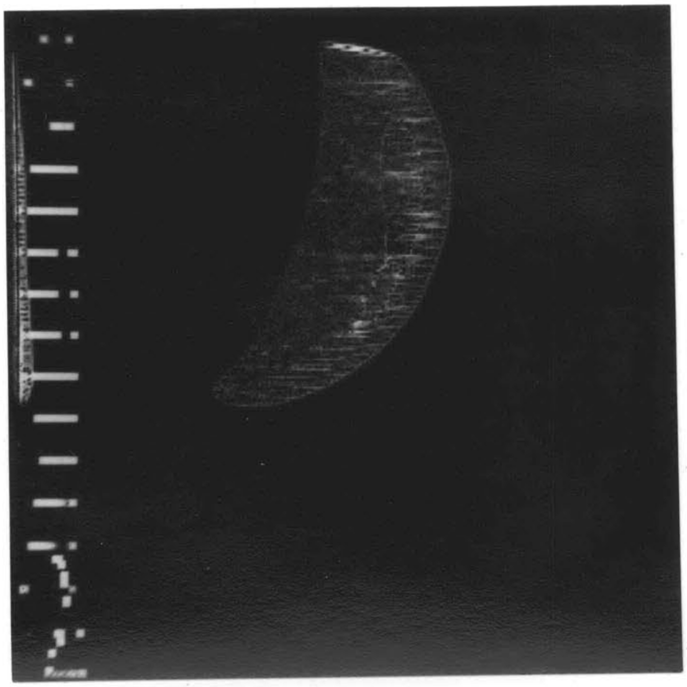

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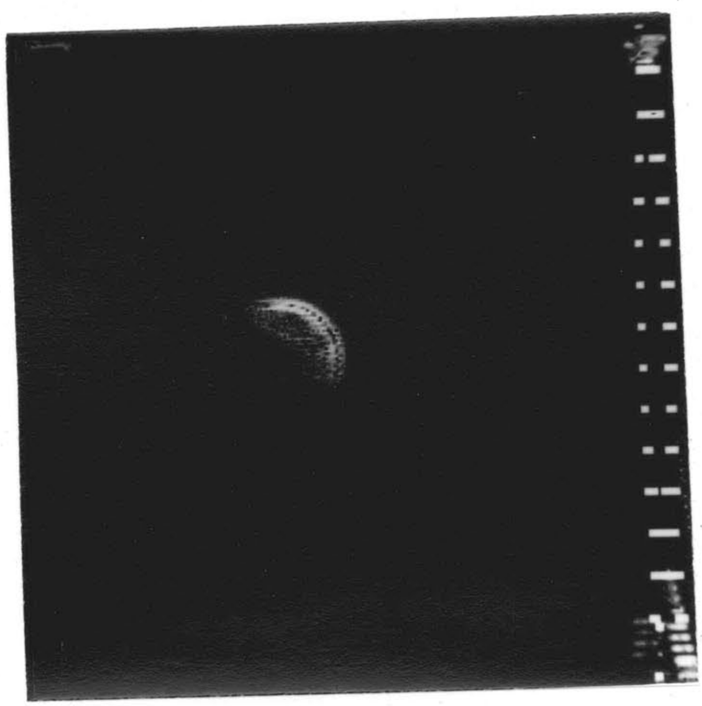

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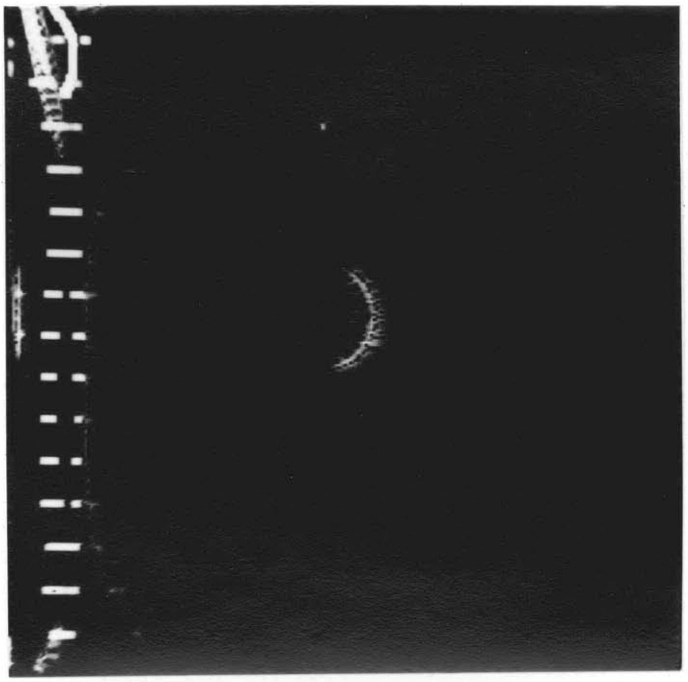

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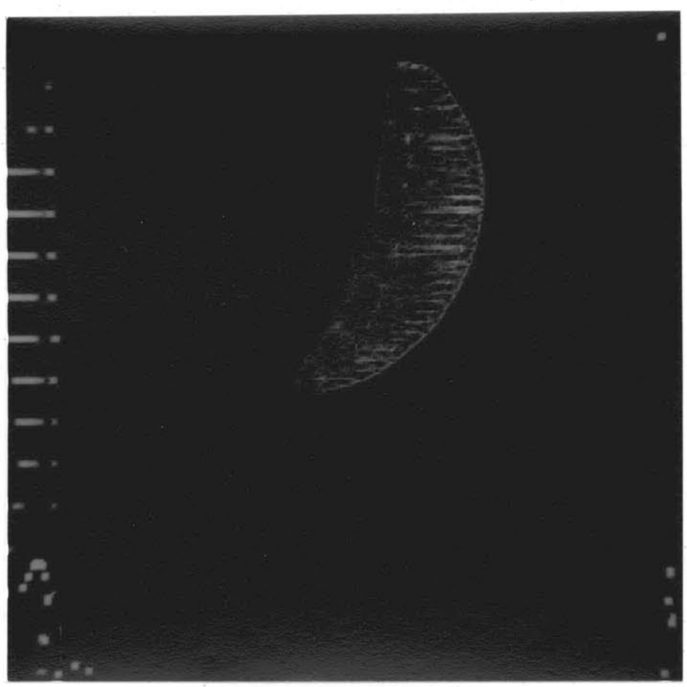

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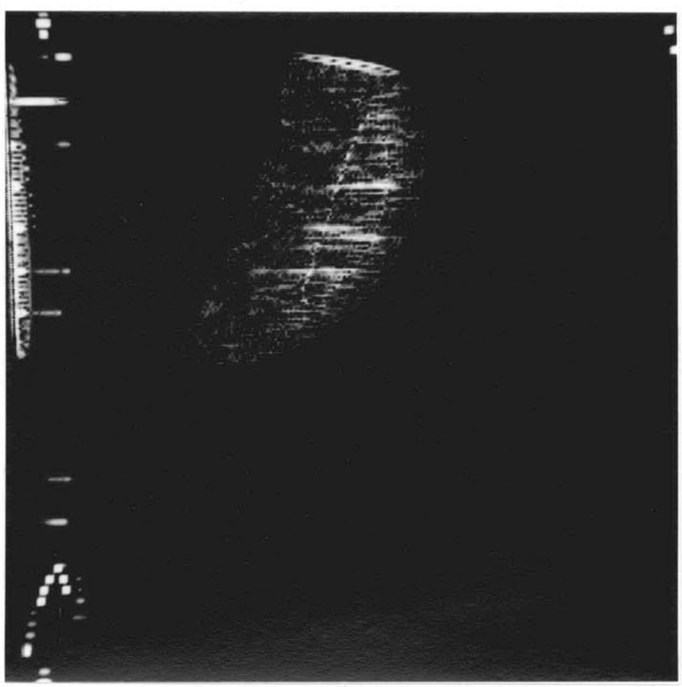

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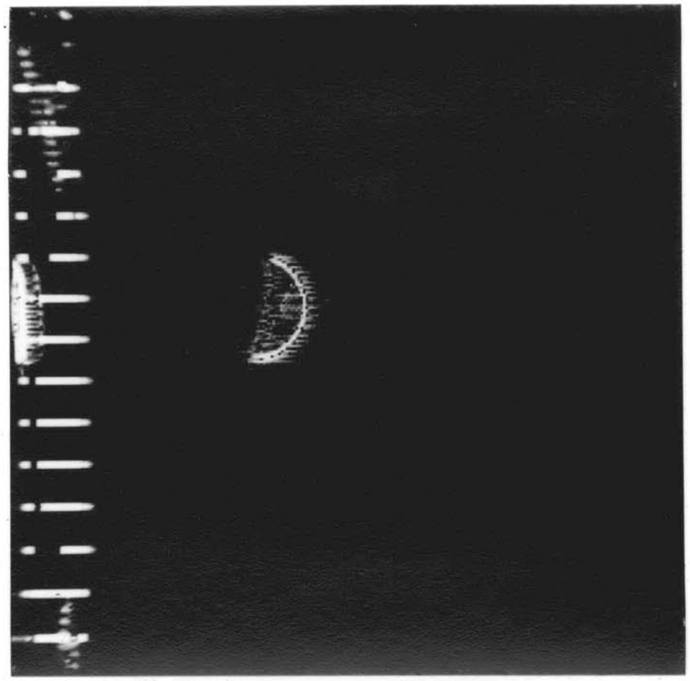

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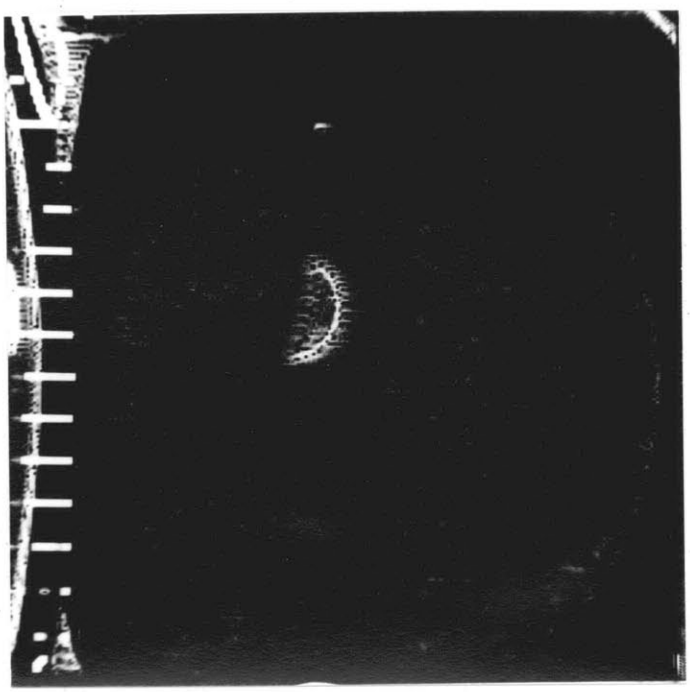

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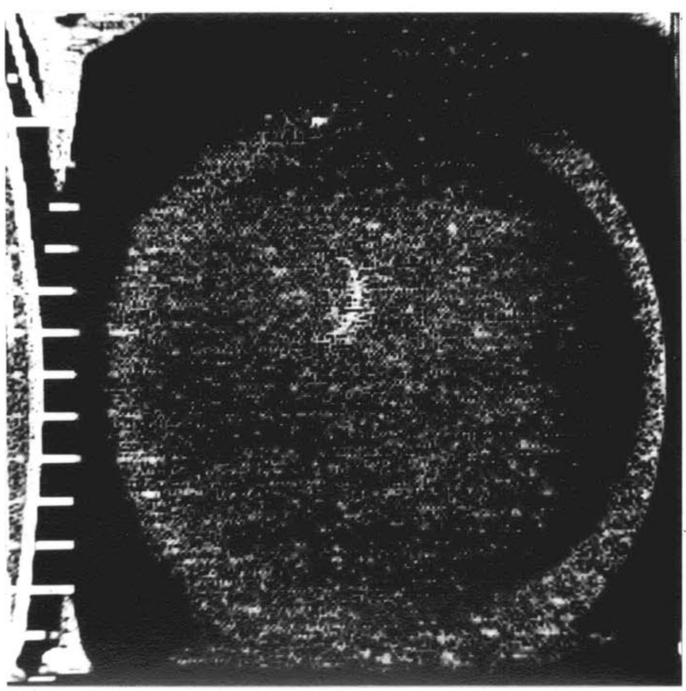

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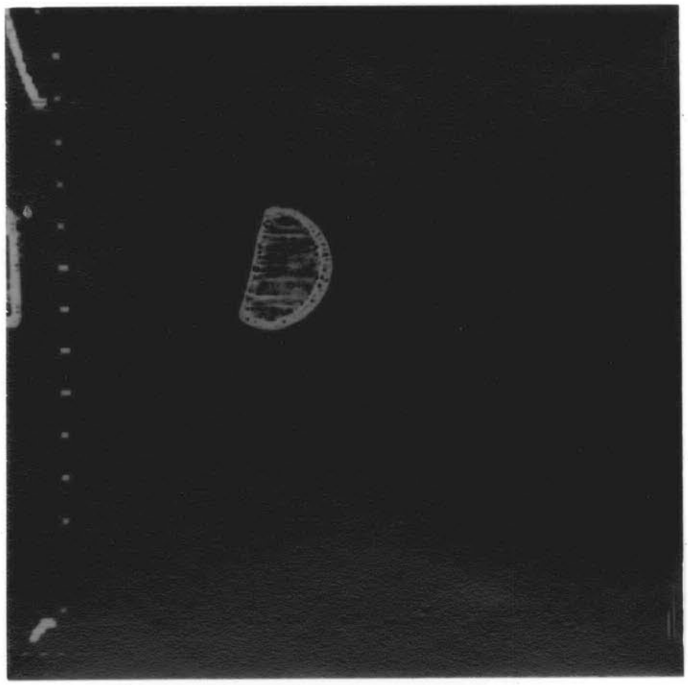

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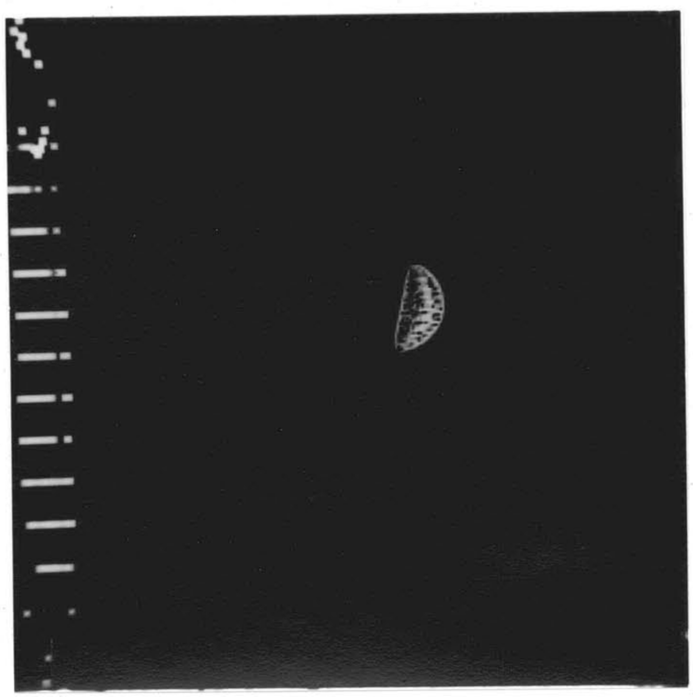
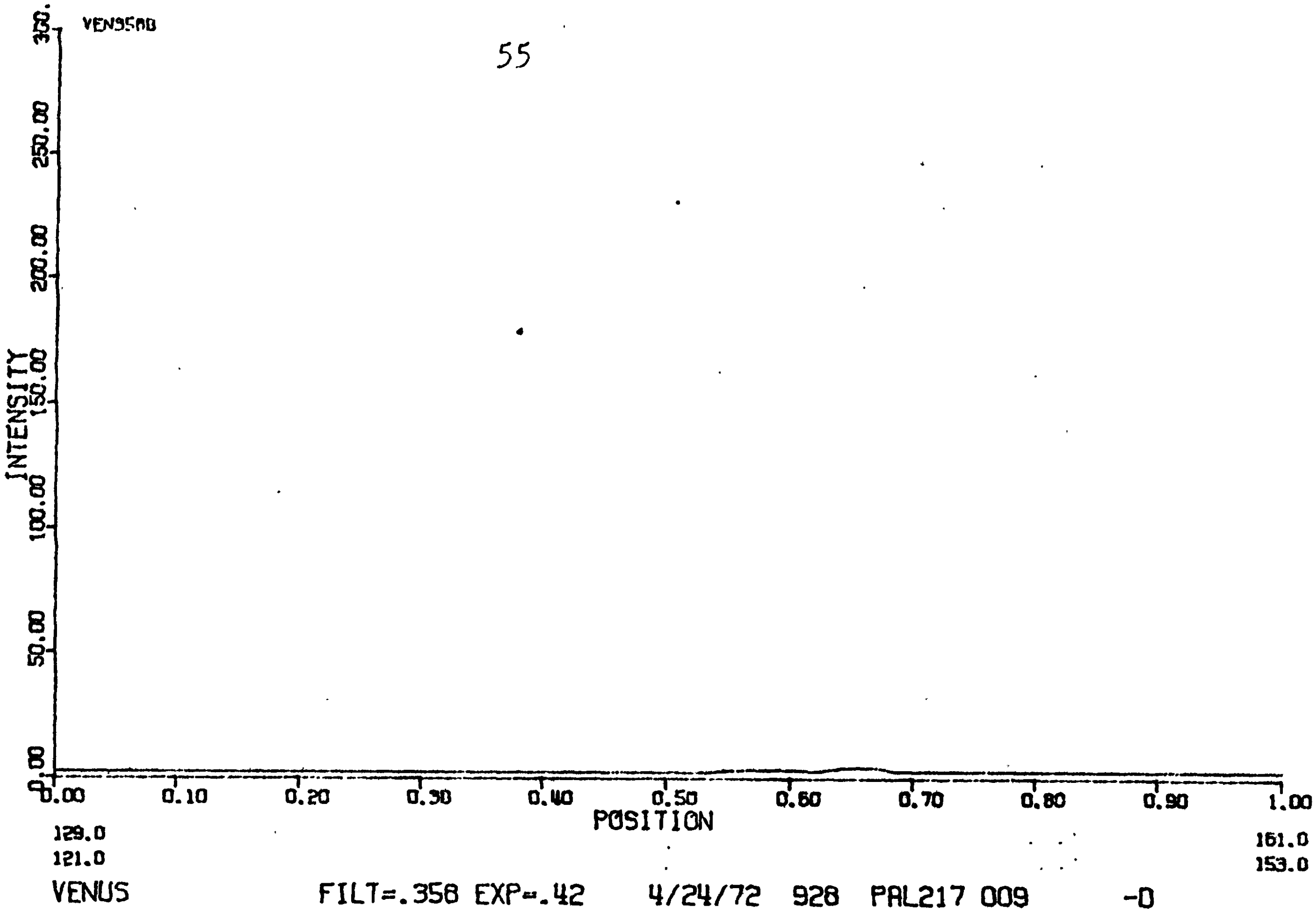


Figure 68

APPENDIX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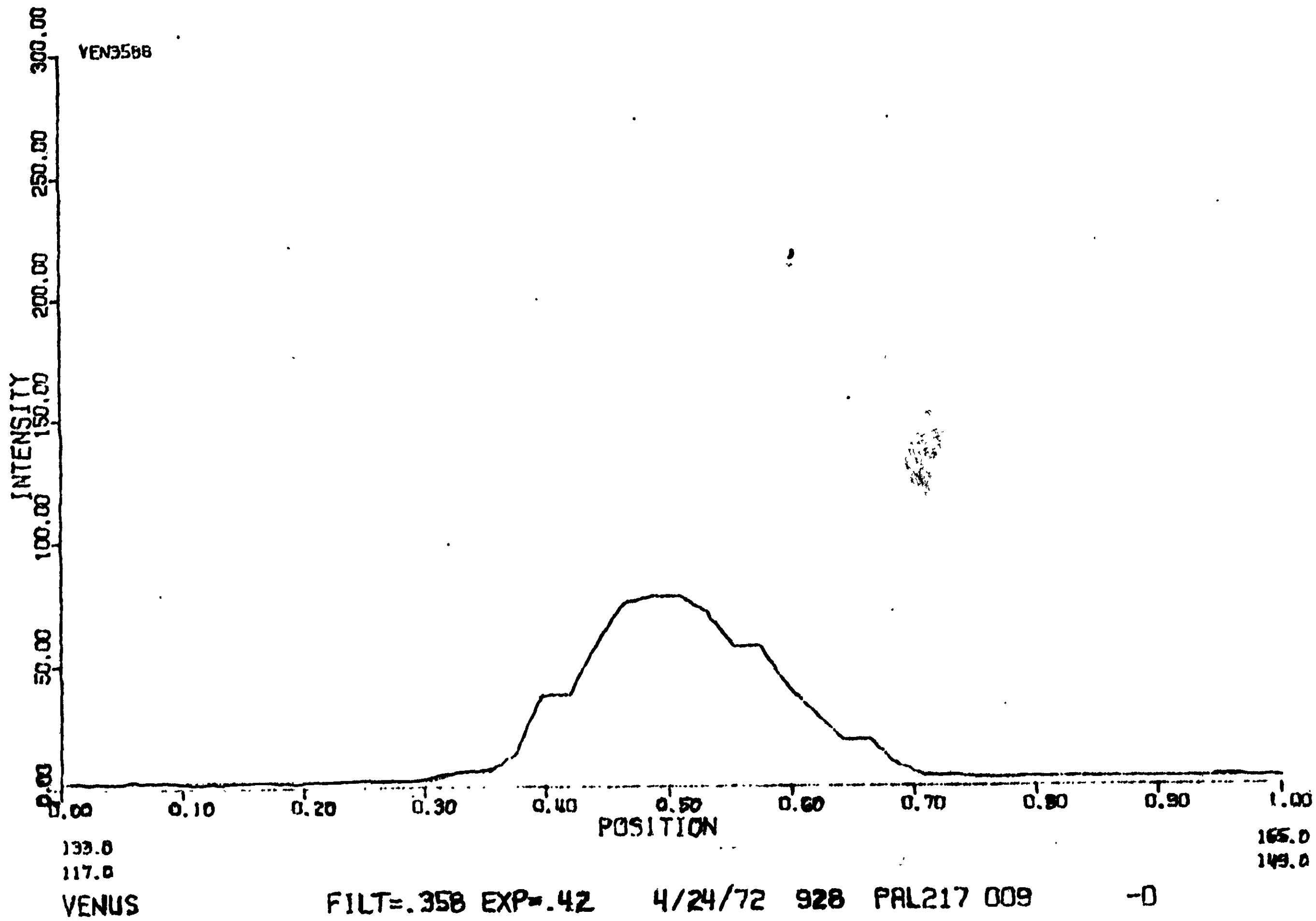
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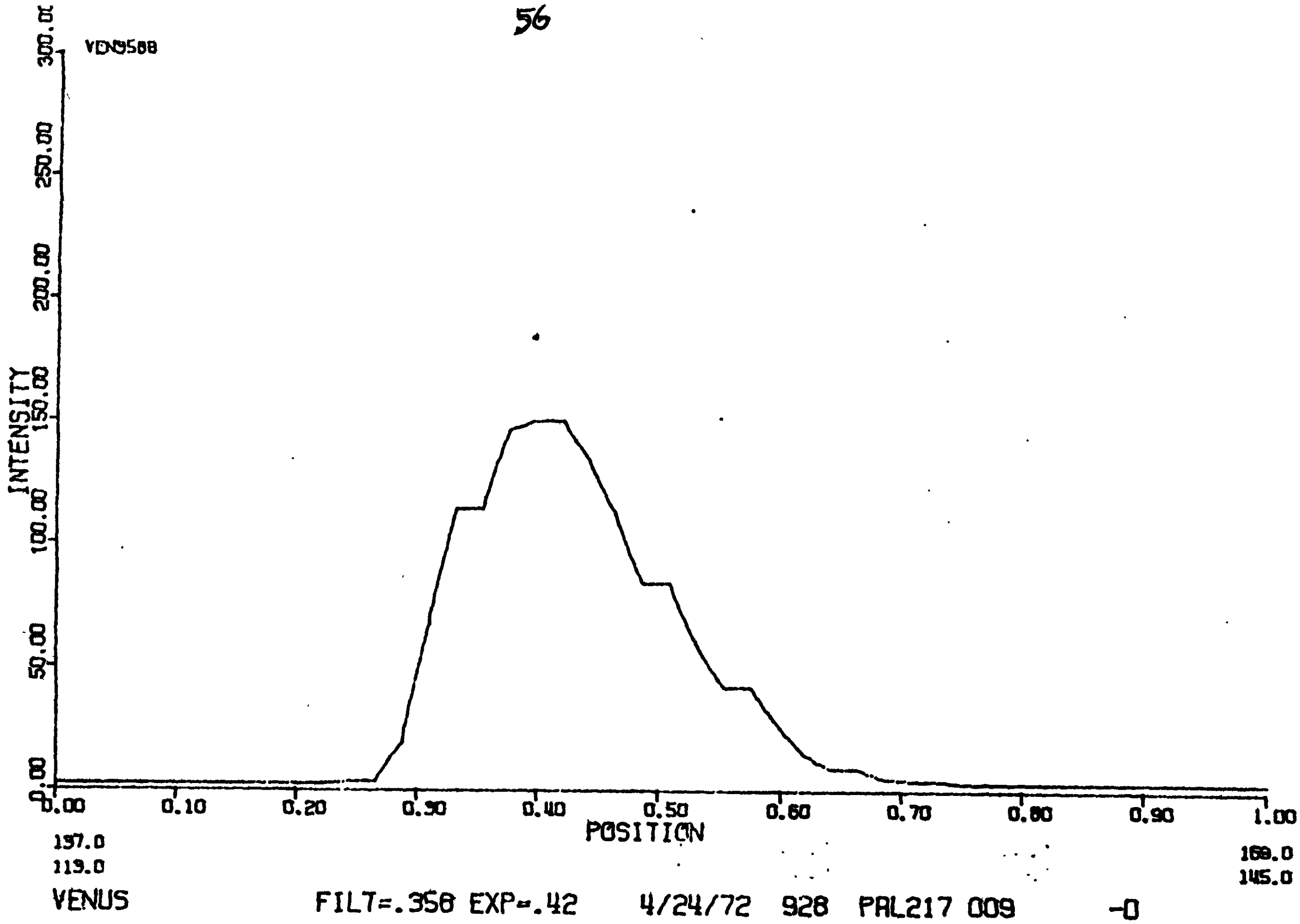
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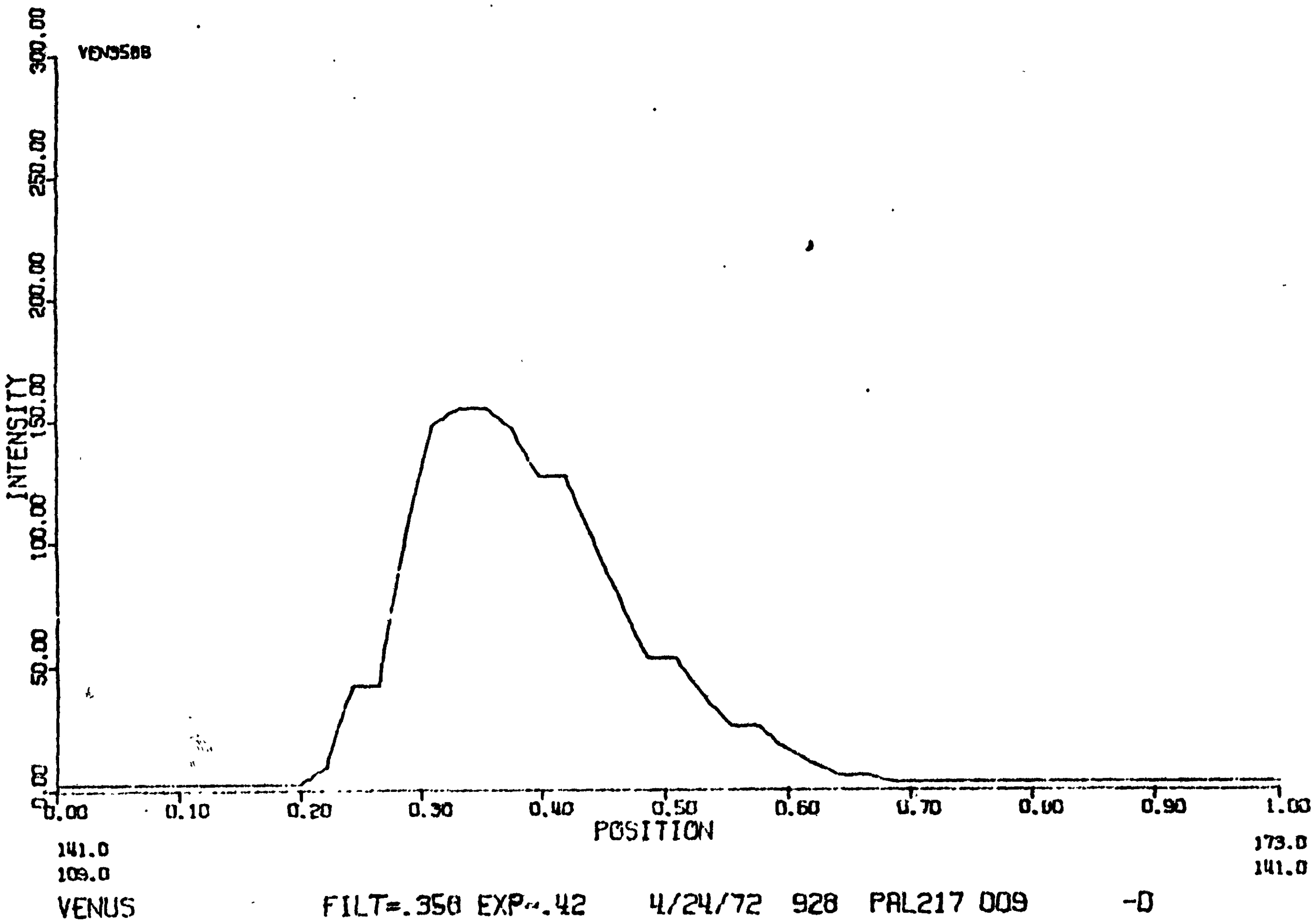
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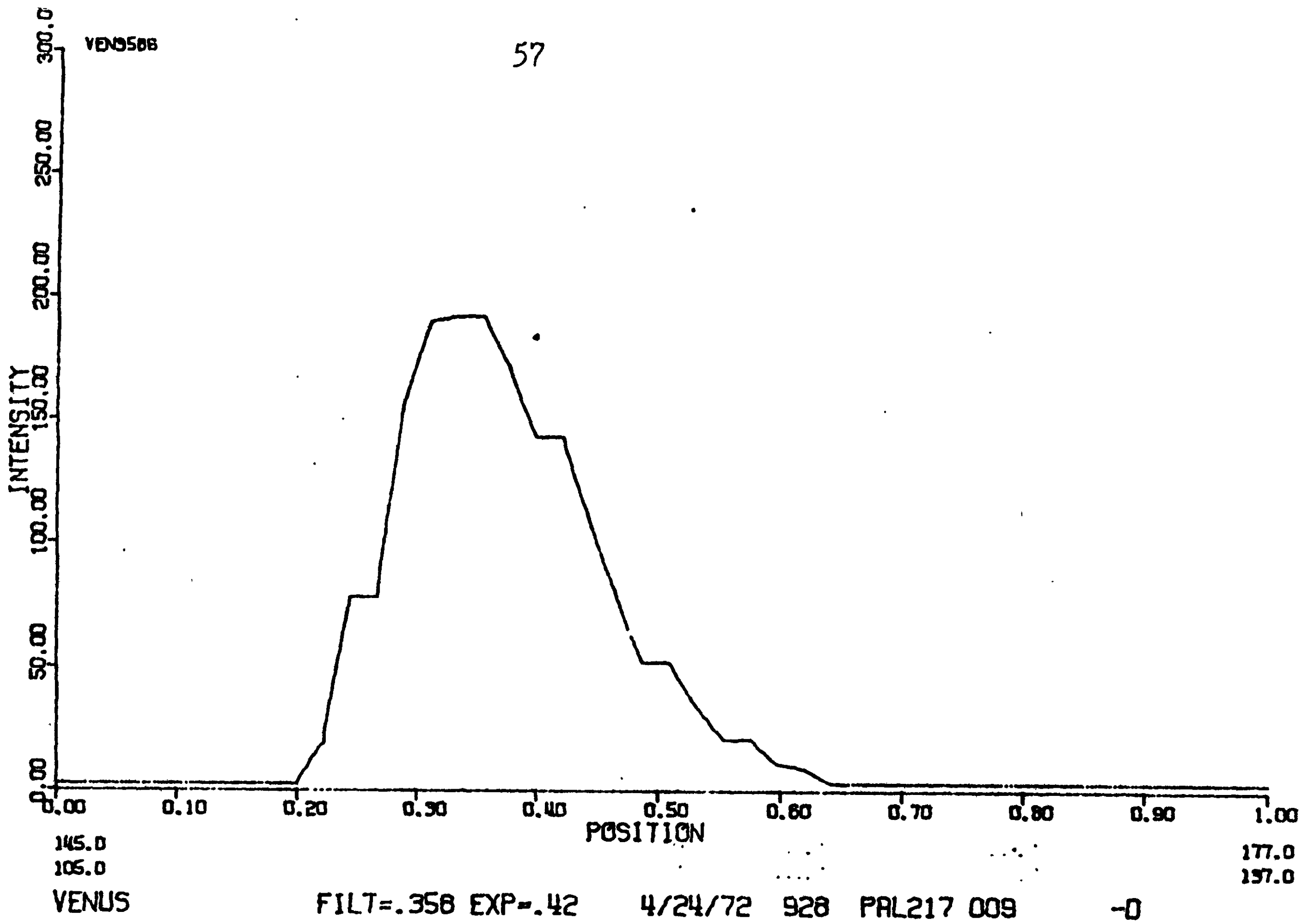
141.0
VENUS
FILT=.350 EXP=.42 4/24/72 928 PAL217 009 -0


VEN3588
INTENSITY
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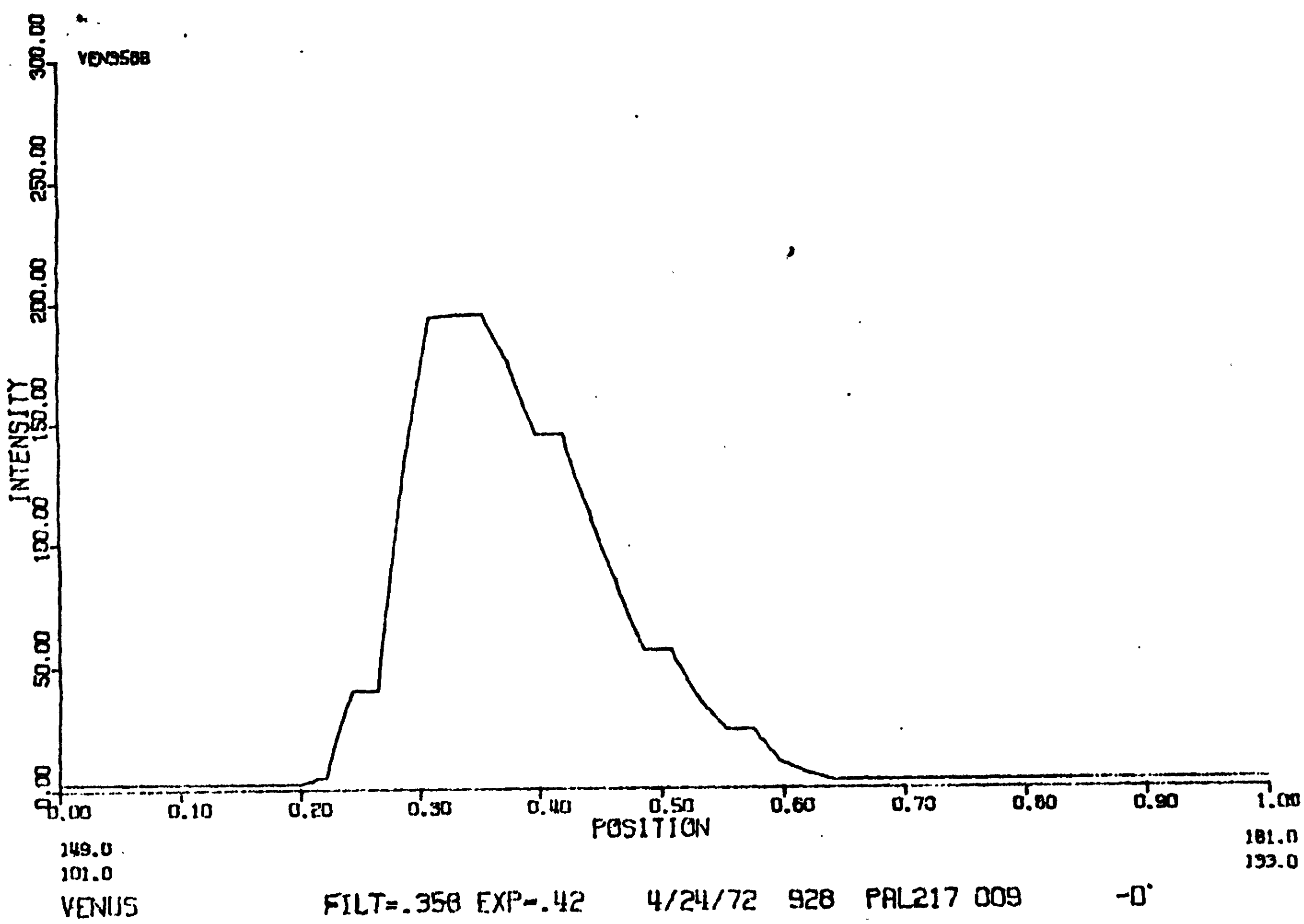
200.00
150.00
100.00
50.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
POSITION
145.0
105.0
177.0
137.0
VENUS
FILT=.358 EXP=.42
4/24/72
928
PAL217 009
-0


VEN3588
INTENSITY
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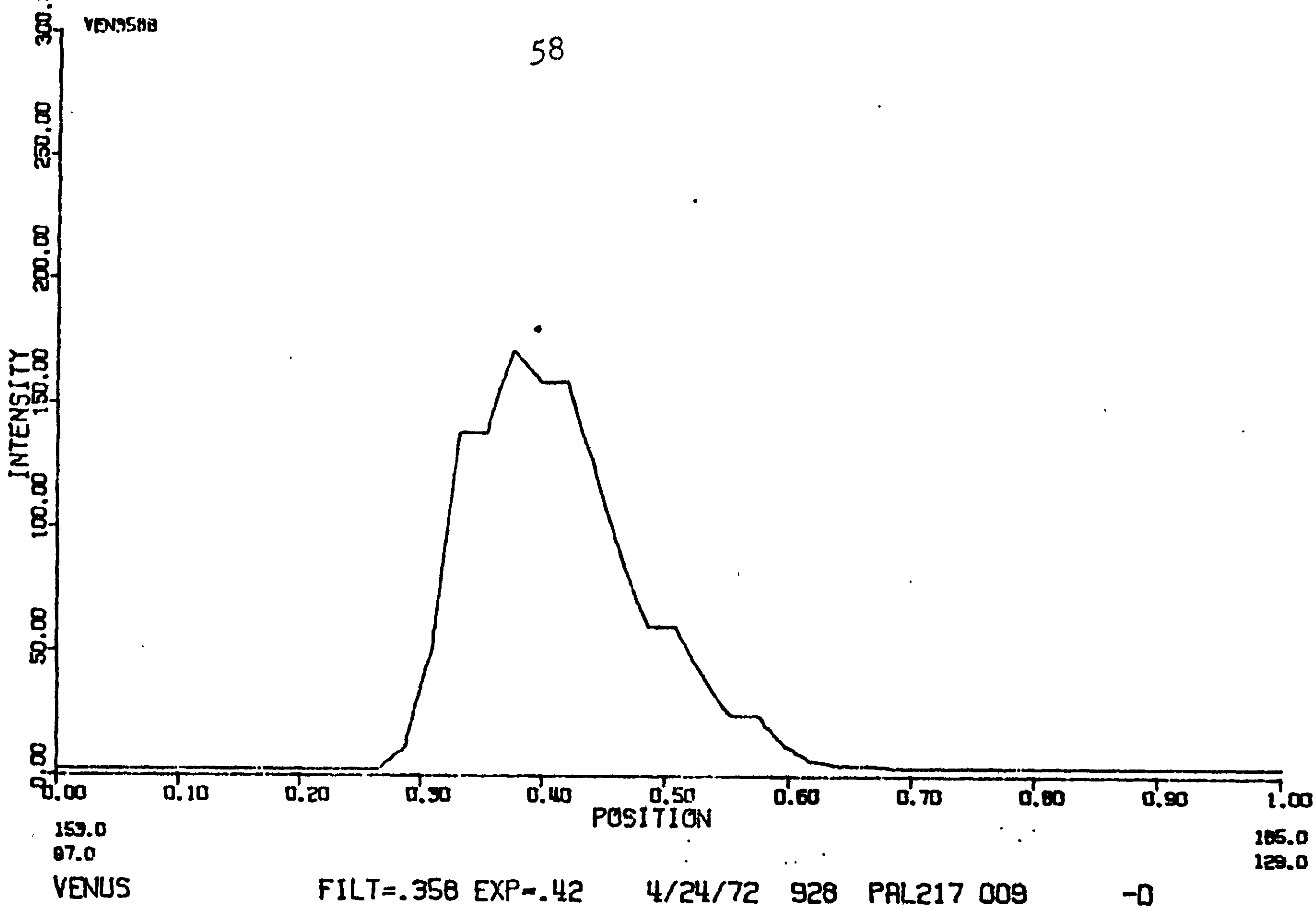
200.00
150.00
100.00
50.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
POSITION
149.0
101.0
181.0
133.0
VENUS
FILT=.358 EXP=.42
4/24/72
928
PAL217 009
-0



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INTENSITY
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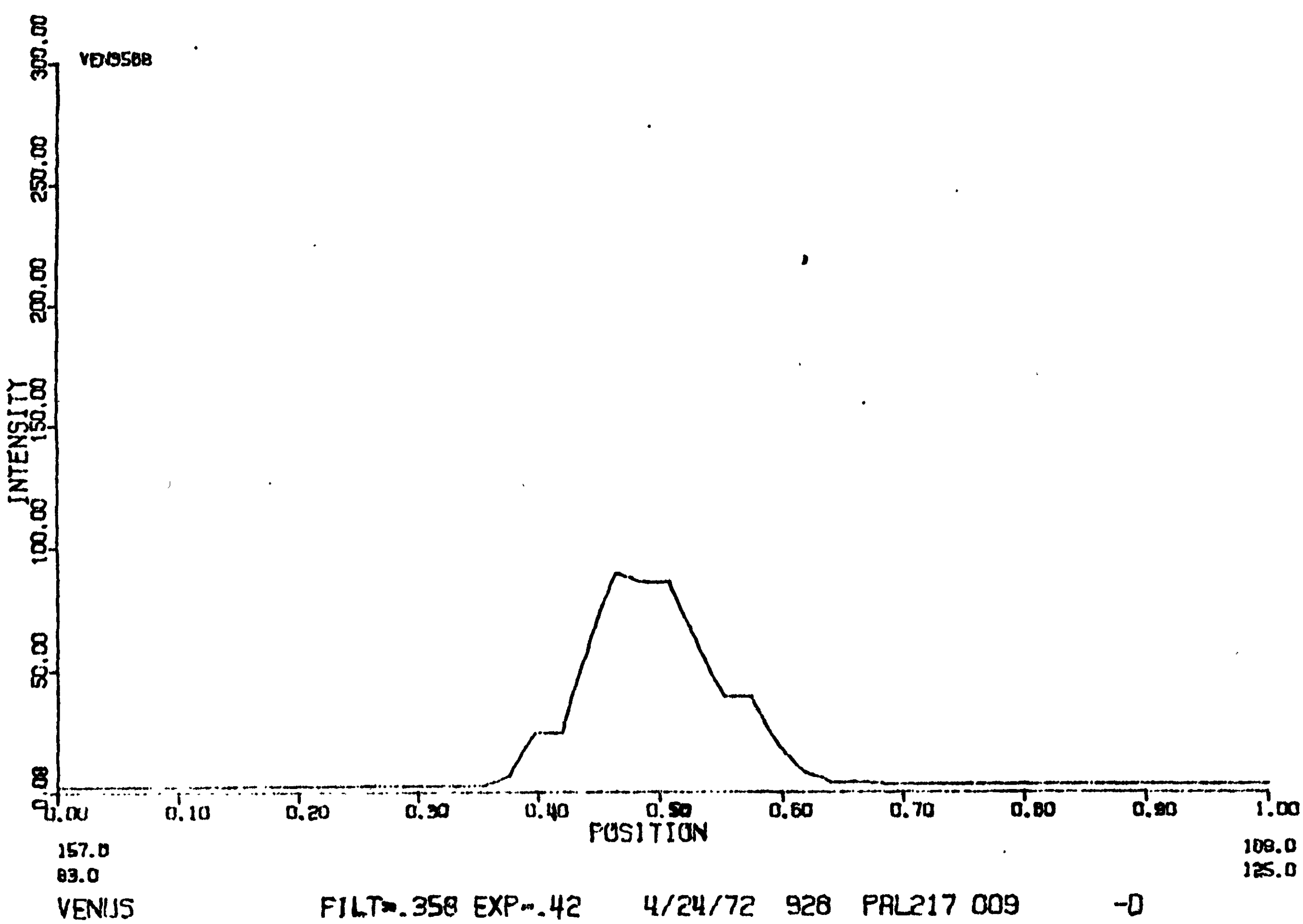
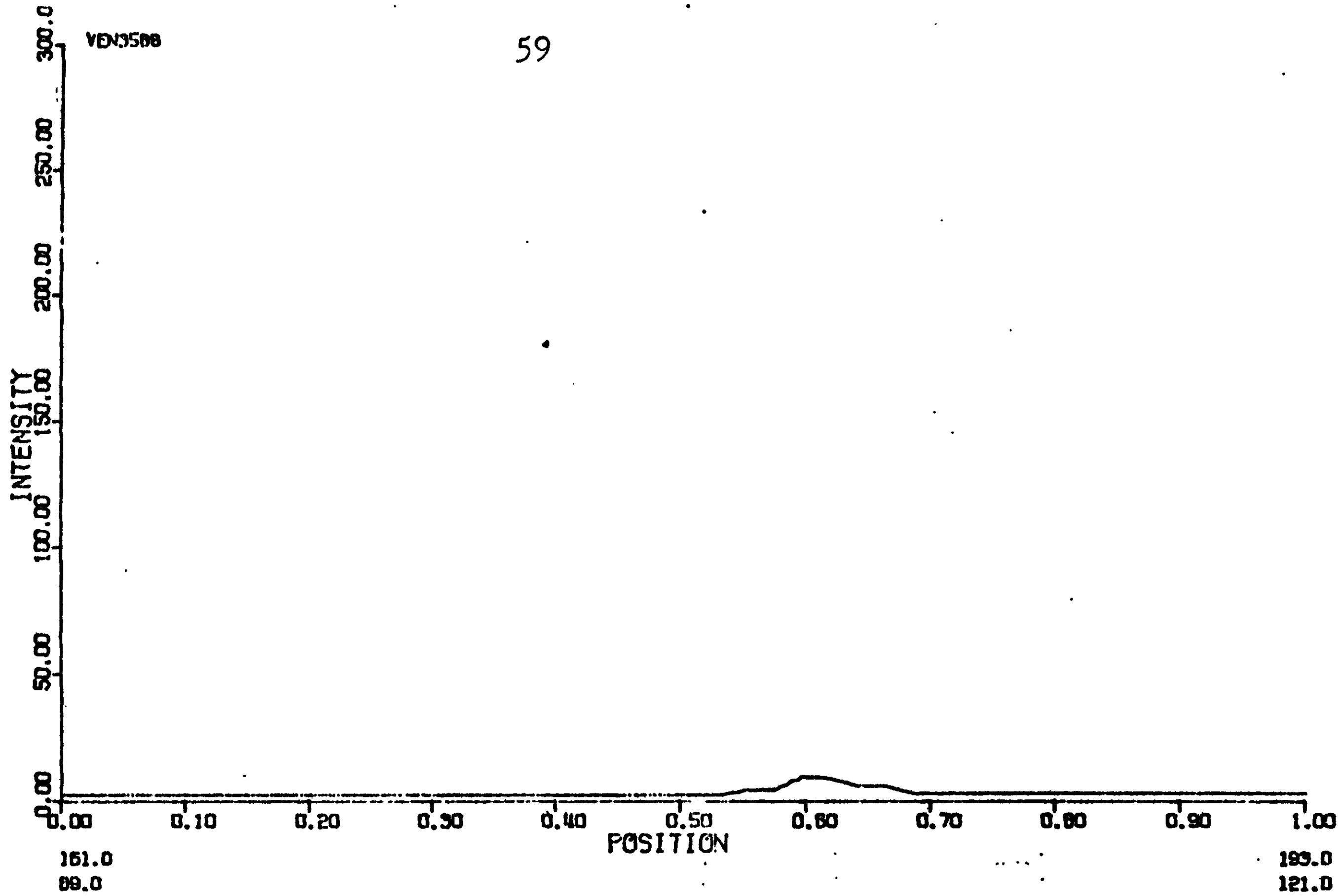
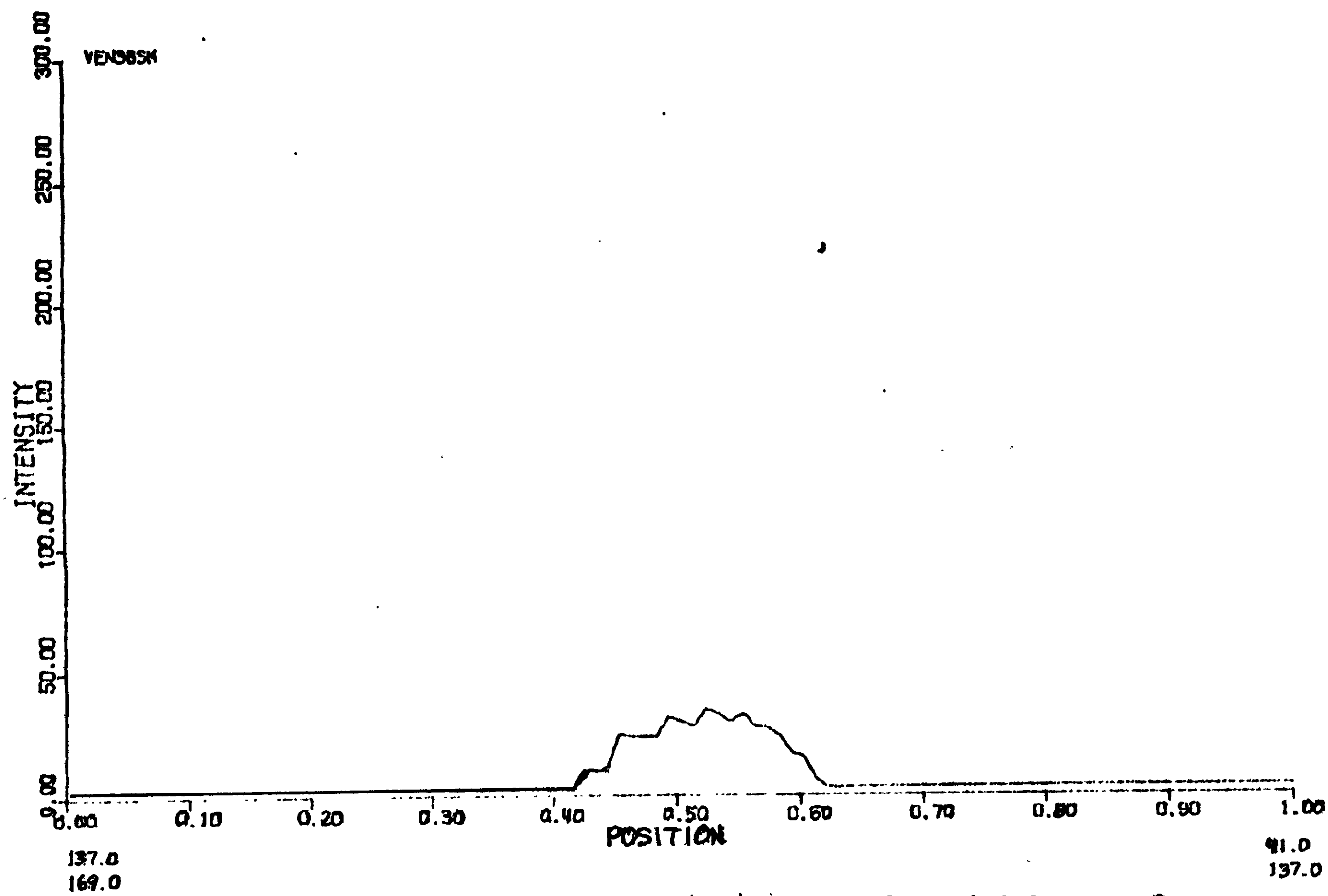
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
153.0
87.0
185.0
129.0
VENUS FILT=.358 EXP=.42 4/24/72 928 PAL217 009 -D



VEN9588
INTENSITY
0.00 50.00 100.00 150.00 200.00 250.00 300.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
157.0
83.0
109.0
125.0
VENUS FILT=.358 EXP=.42 4/24/72 928 PAL217 009 -D



VENUS FILT=.358 EXP=.42 4/24/72 928 PAL217 009 -0



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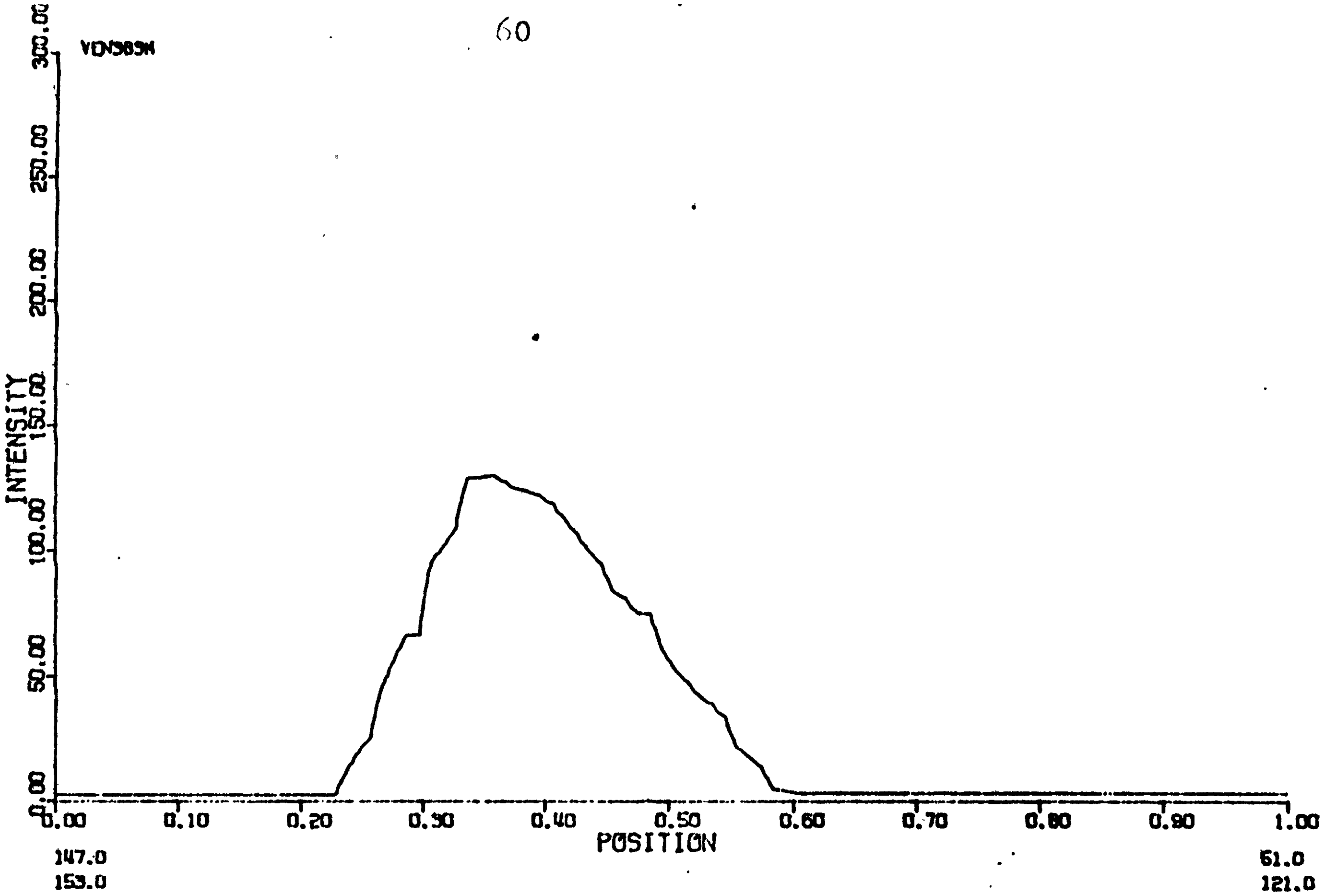
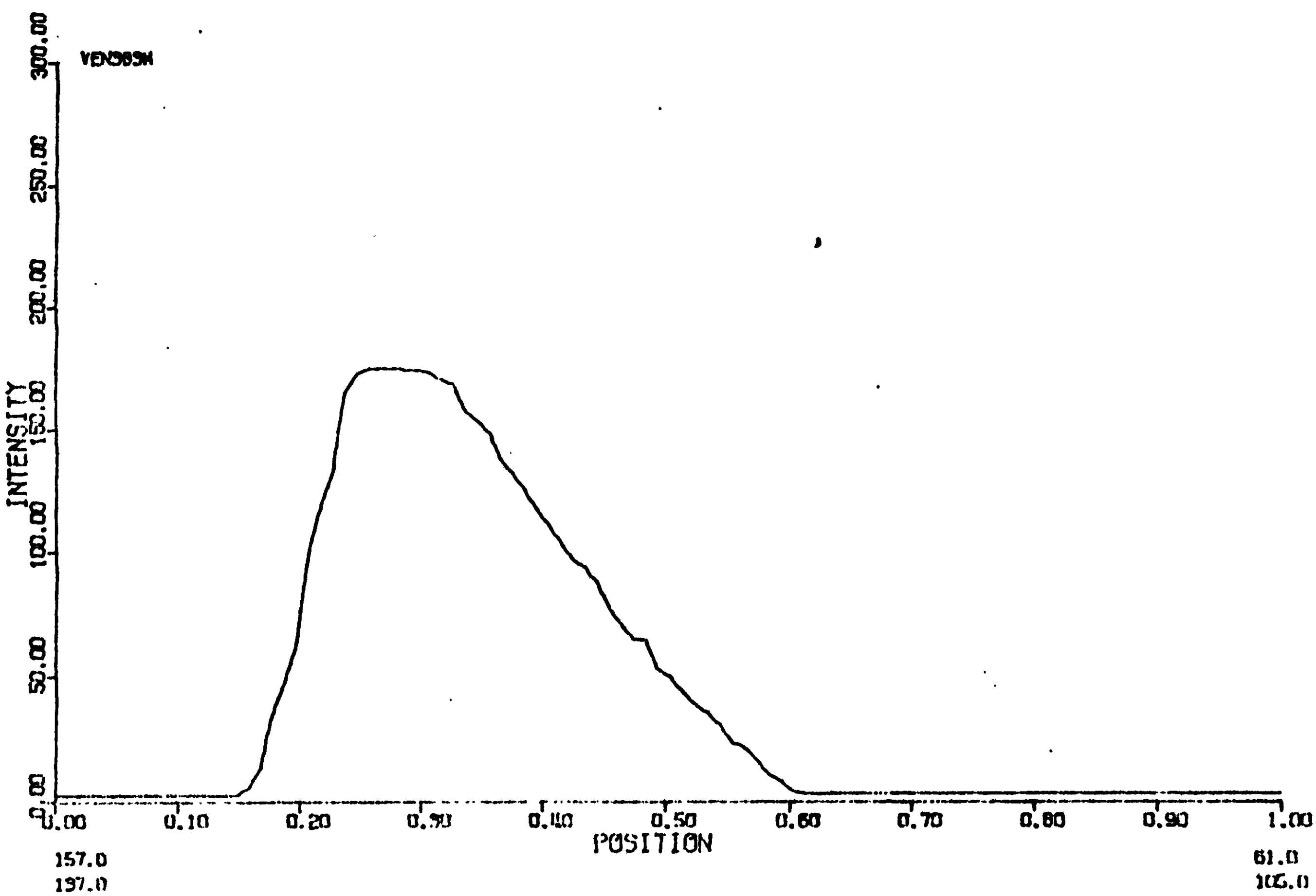
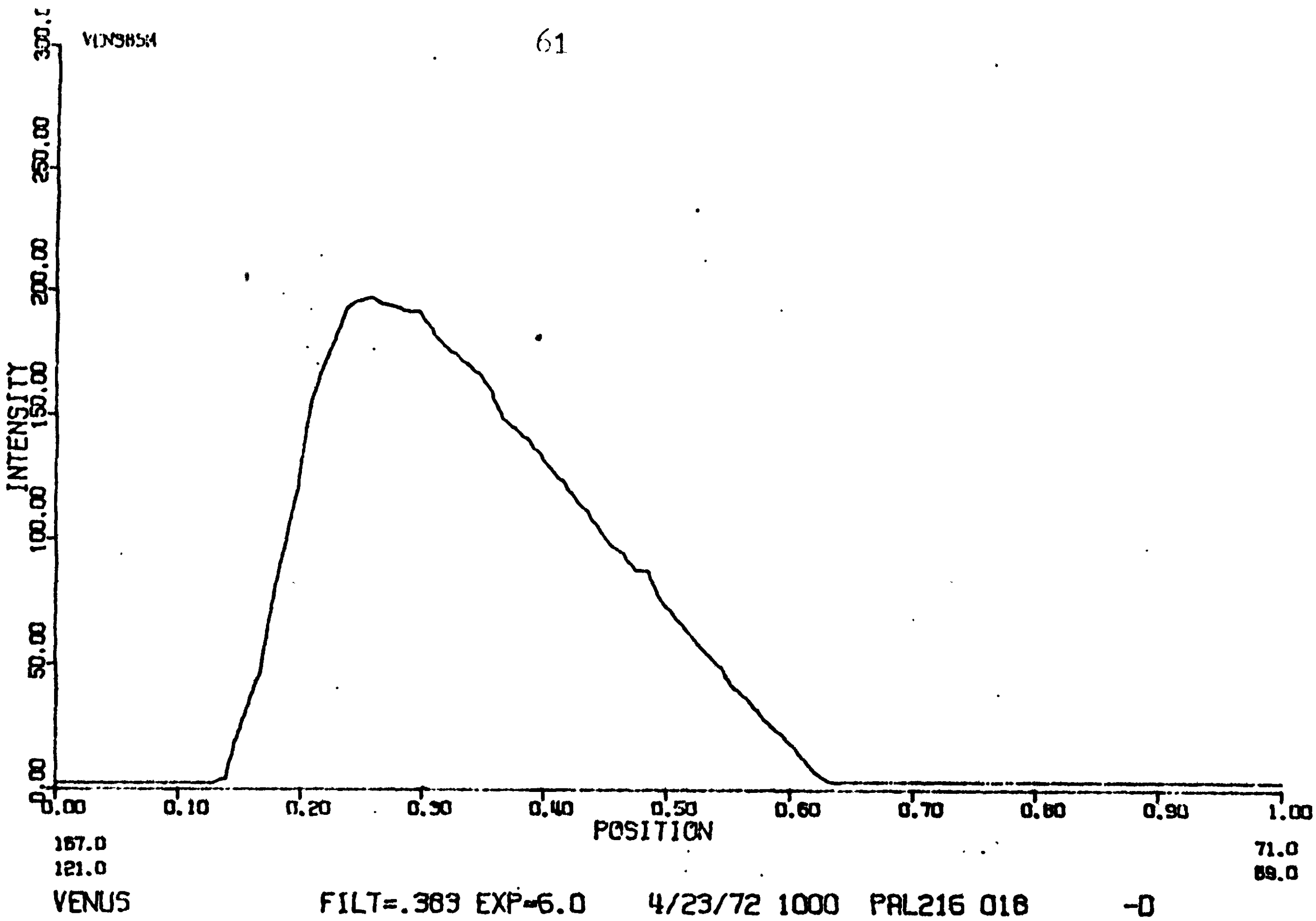


VENUS FILT=.383 EXP=6.0 4/23/72 1000 PAL216 018 -D



VENUS FILT=.383 EXP=6.0 4/23/72 1008 PAL216 018 -D


VEN385M
INTENSITY
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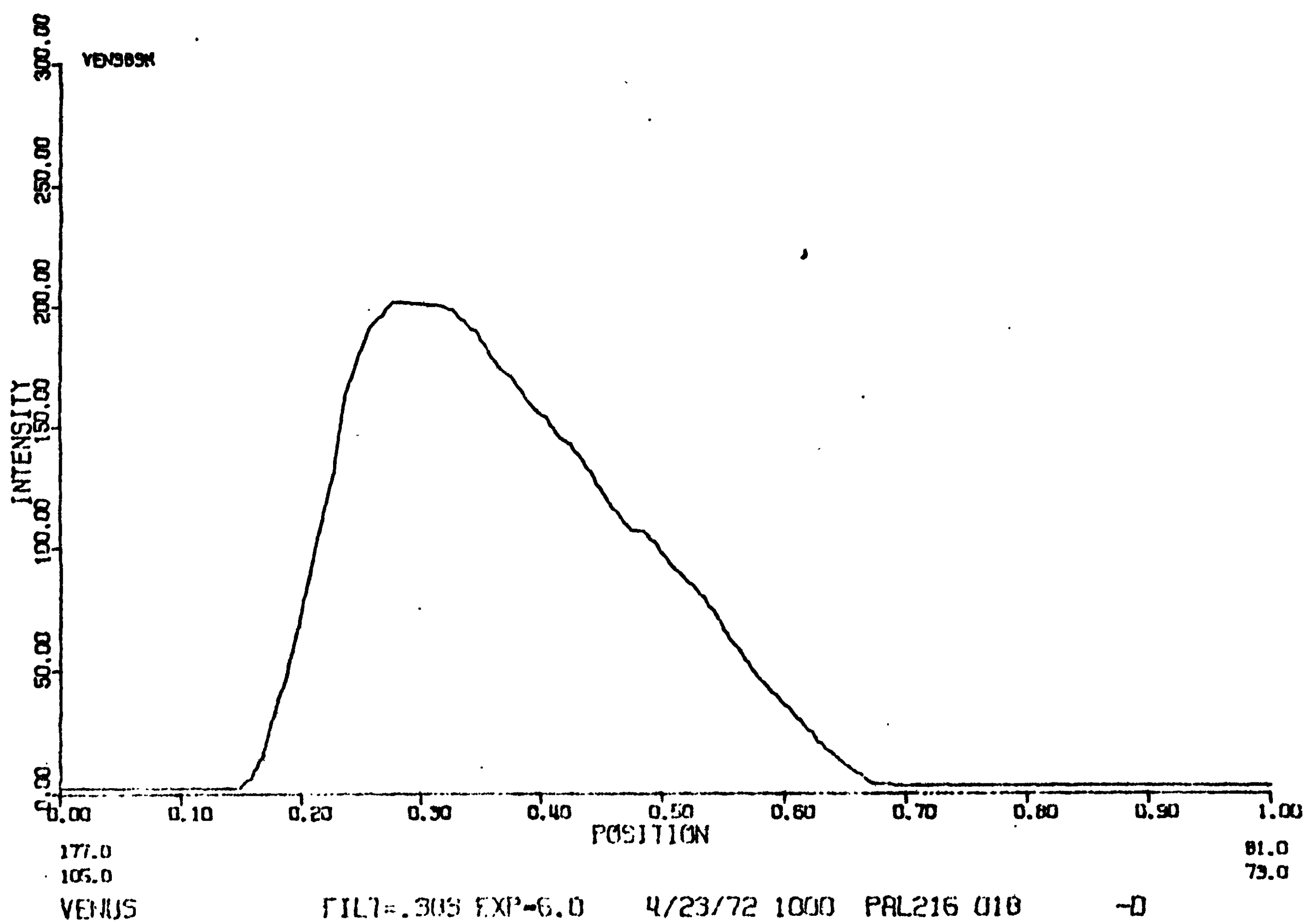
50.00
100.00
150.00
200.00
250.00
300.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
167.0
121.0
71.0
69.0
VENUS
FILT=.383 EXP=6.0 4/23/72 1000 PAL216 018 -D


VEN389M
INTENSITY
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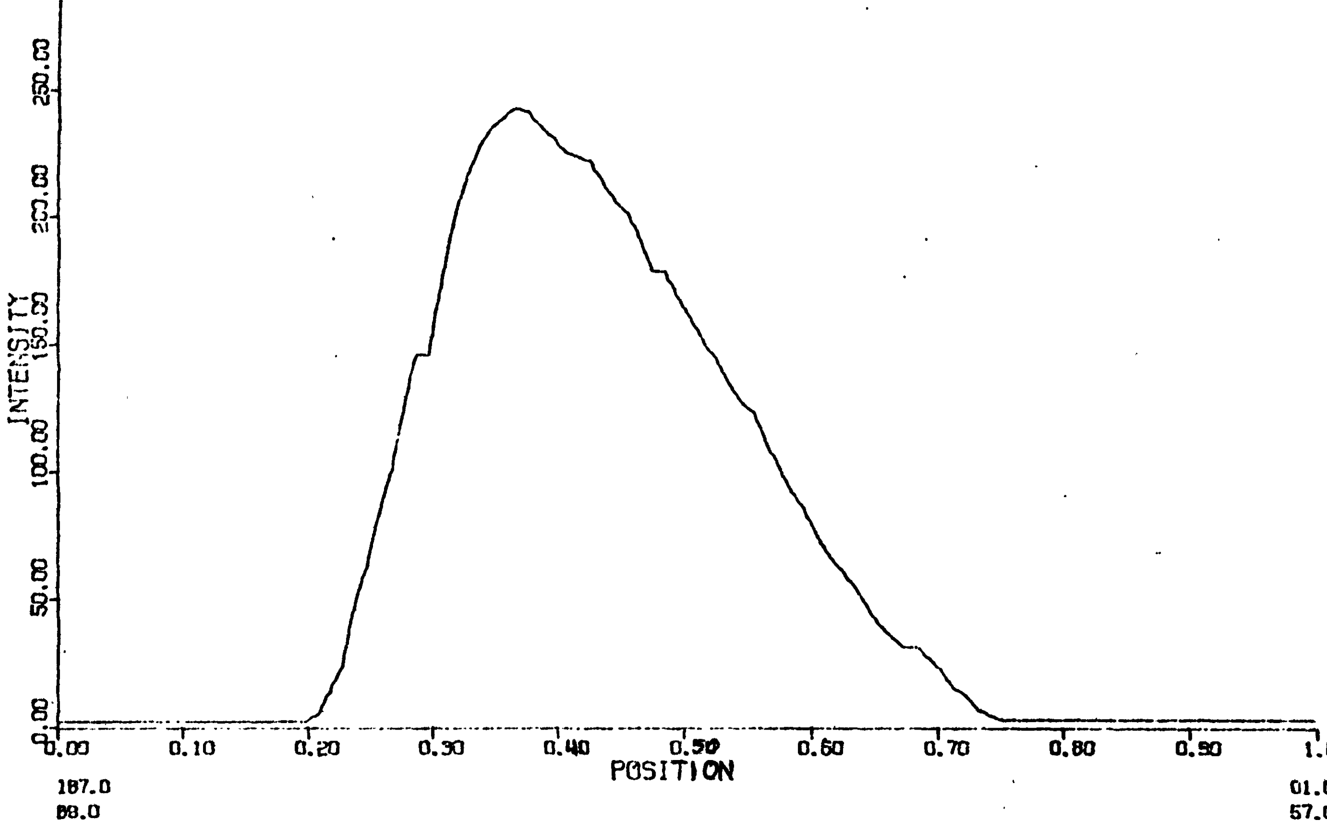
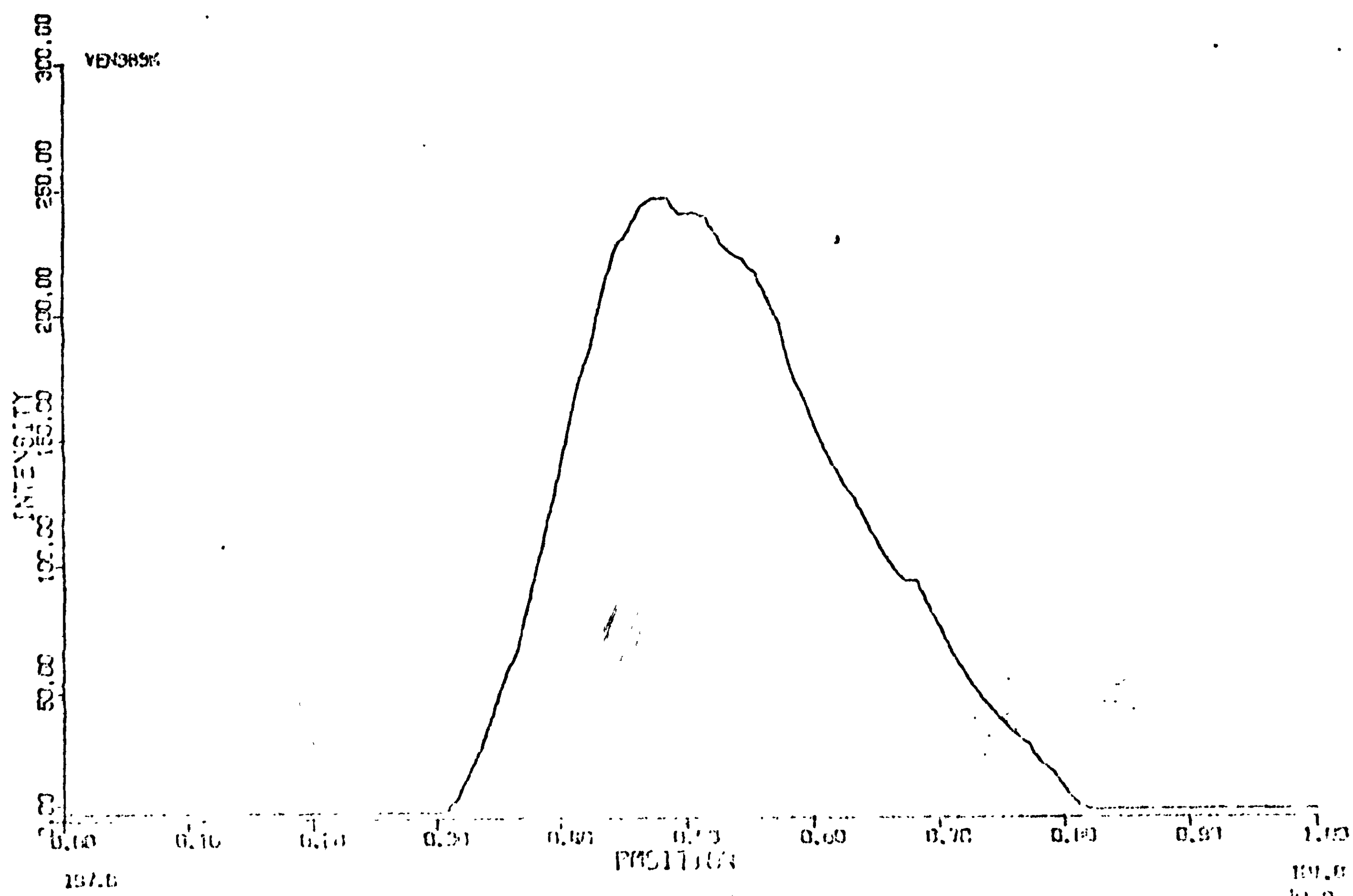
50.00
100.00
150.00
200.00
250.00
300.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
177.0
105.0
81.0
73.0
VENUS
FILT=.389 EXP=6.0 4/23/72 1000 PAL216 018 -D



VENUS FILT=.383 EXP-6.0 4/23/72 1000 PRL216 018 -D



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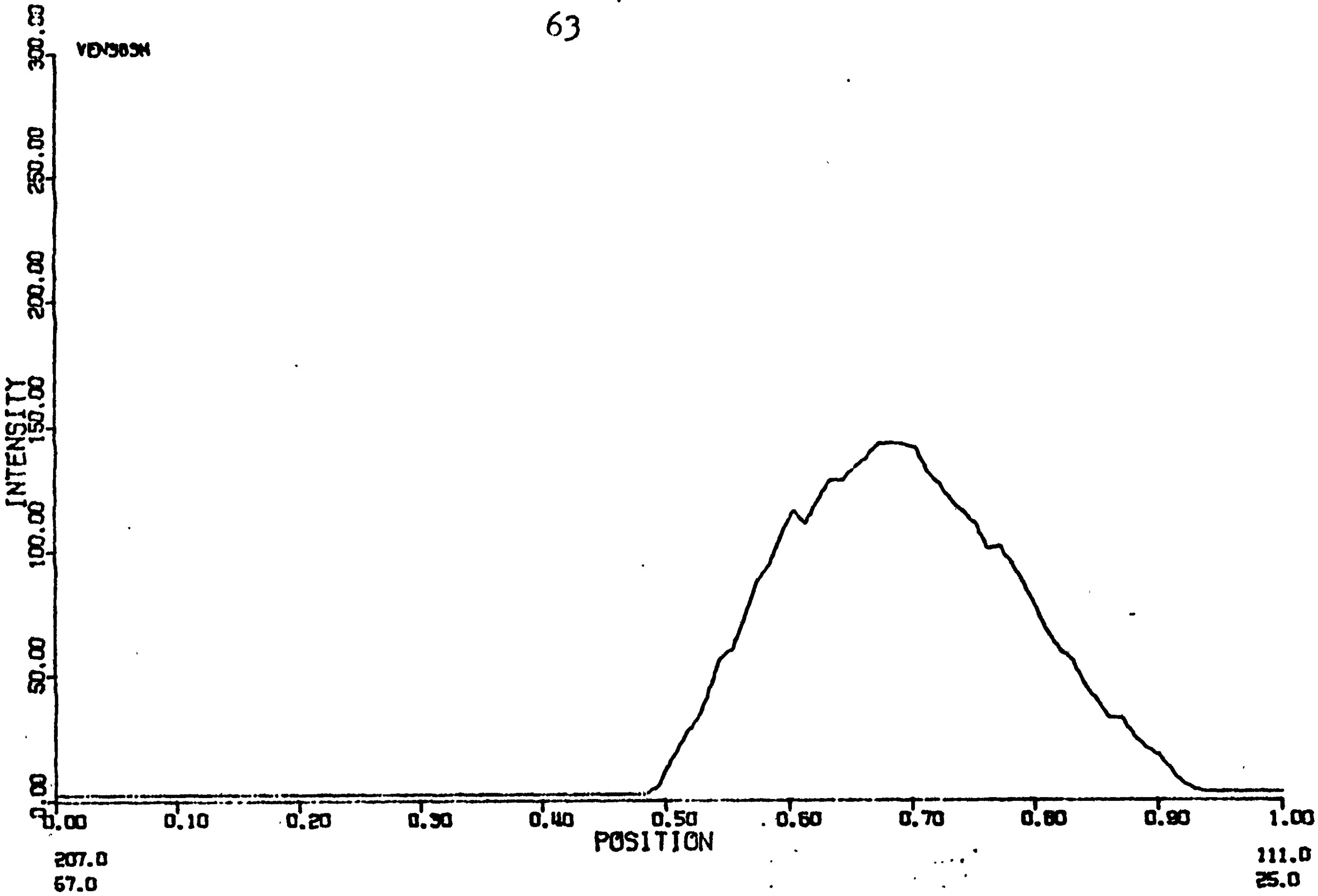
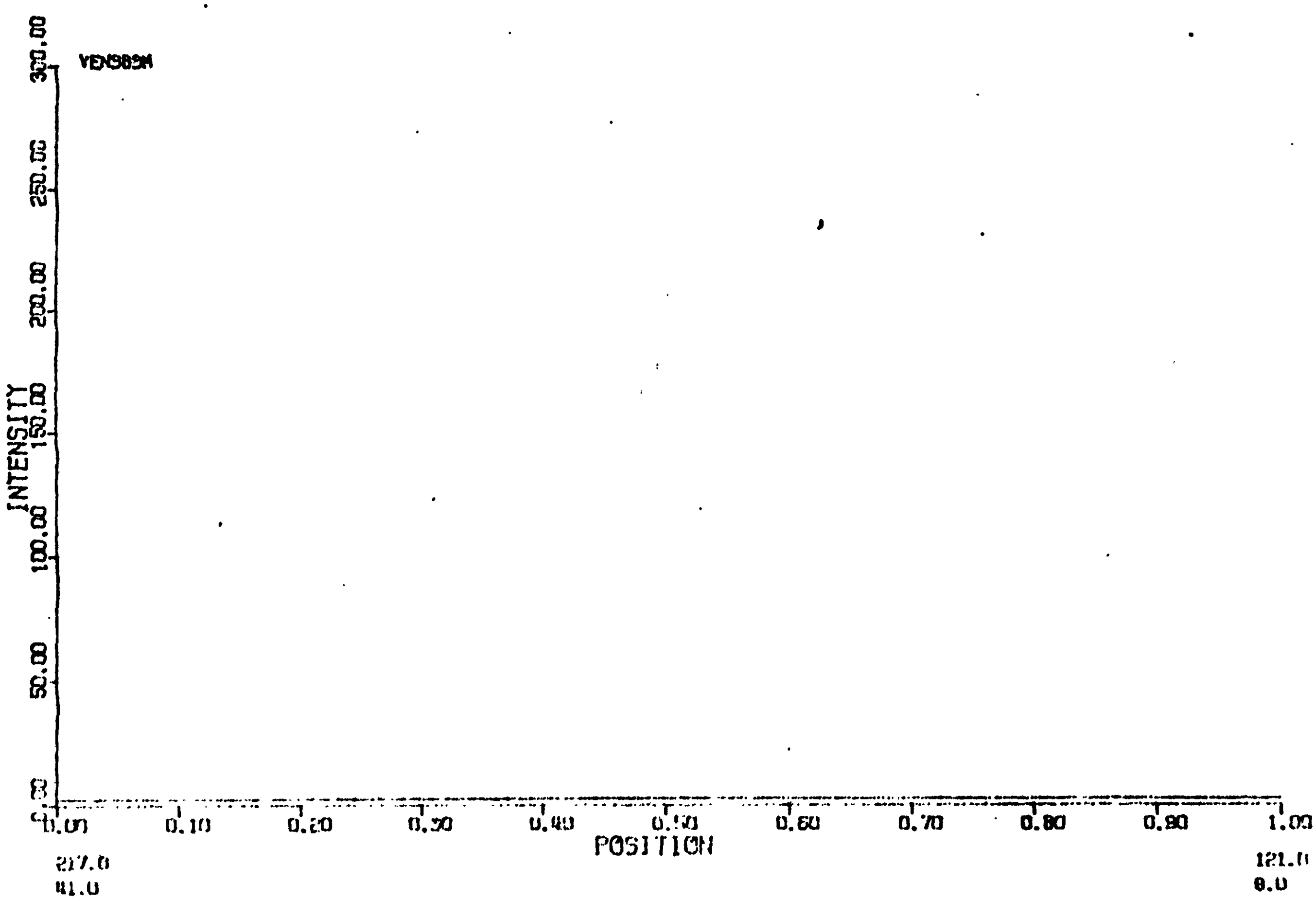
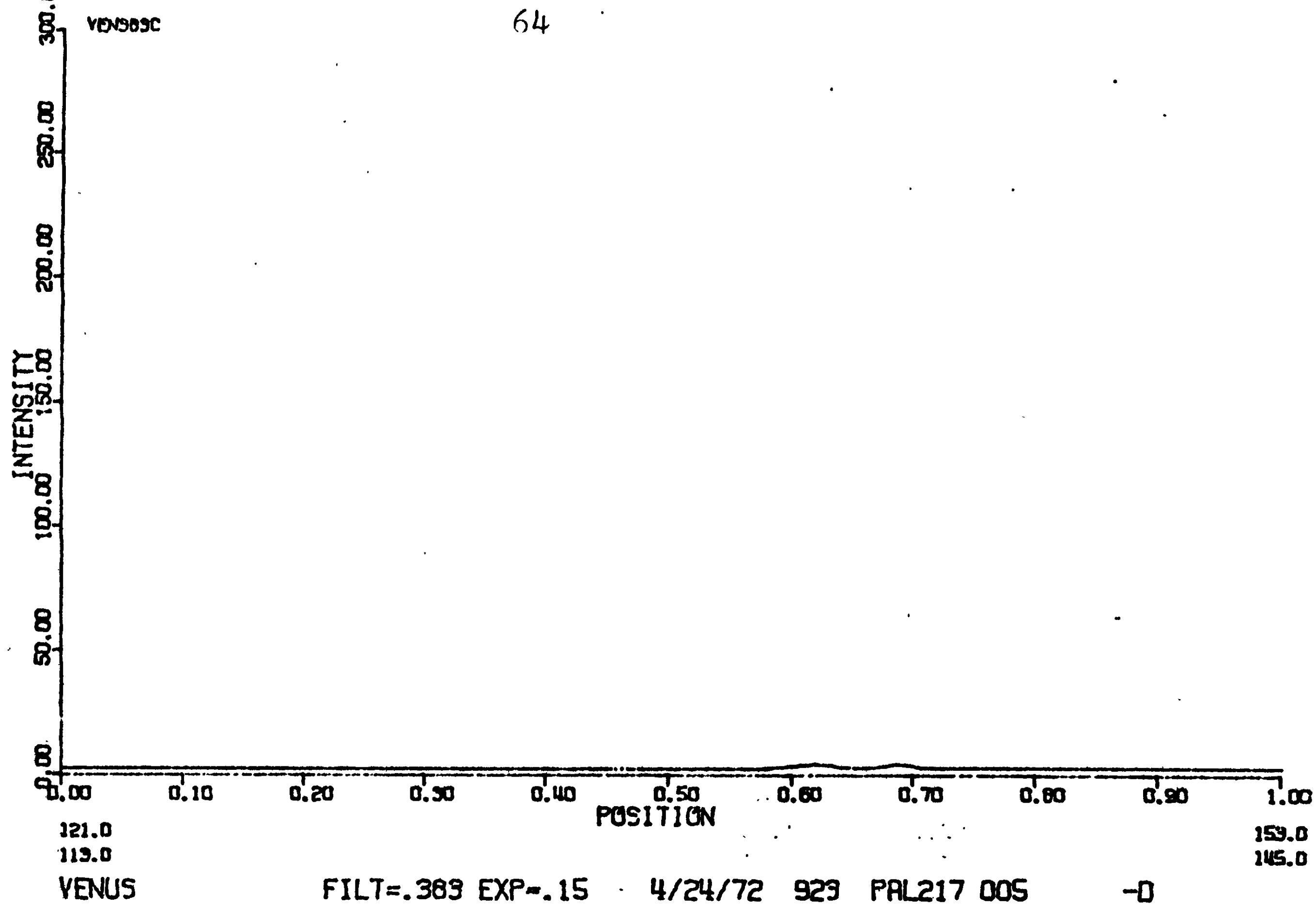
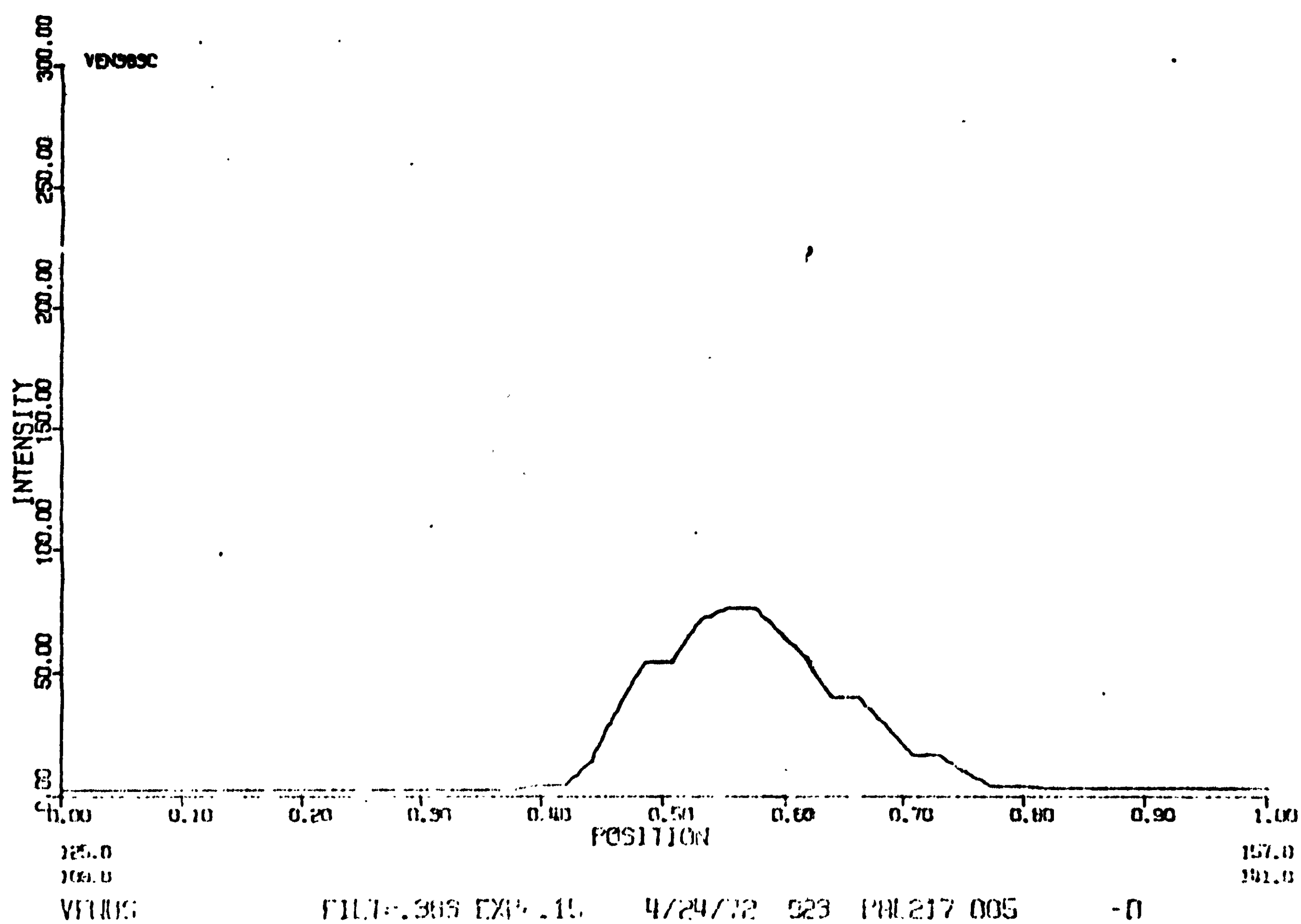
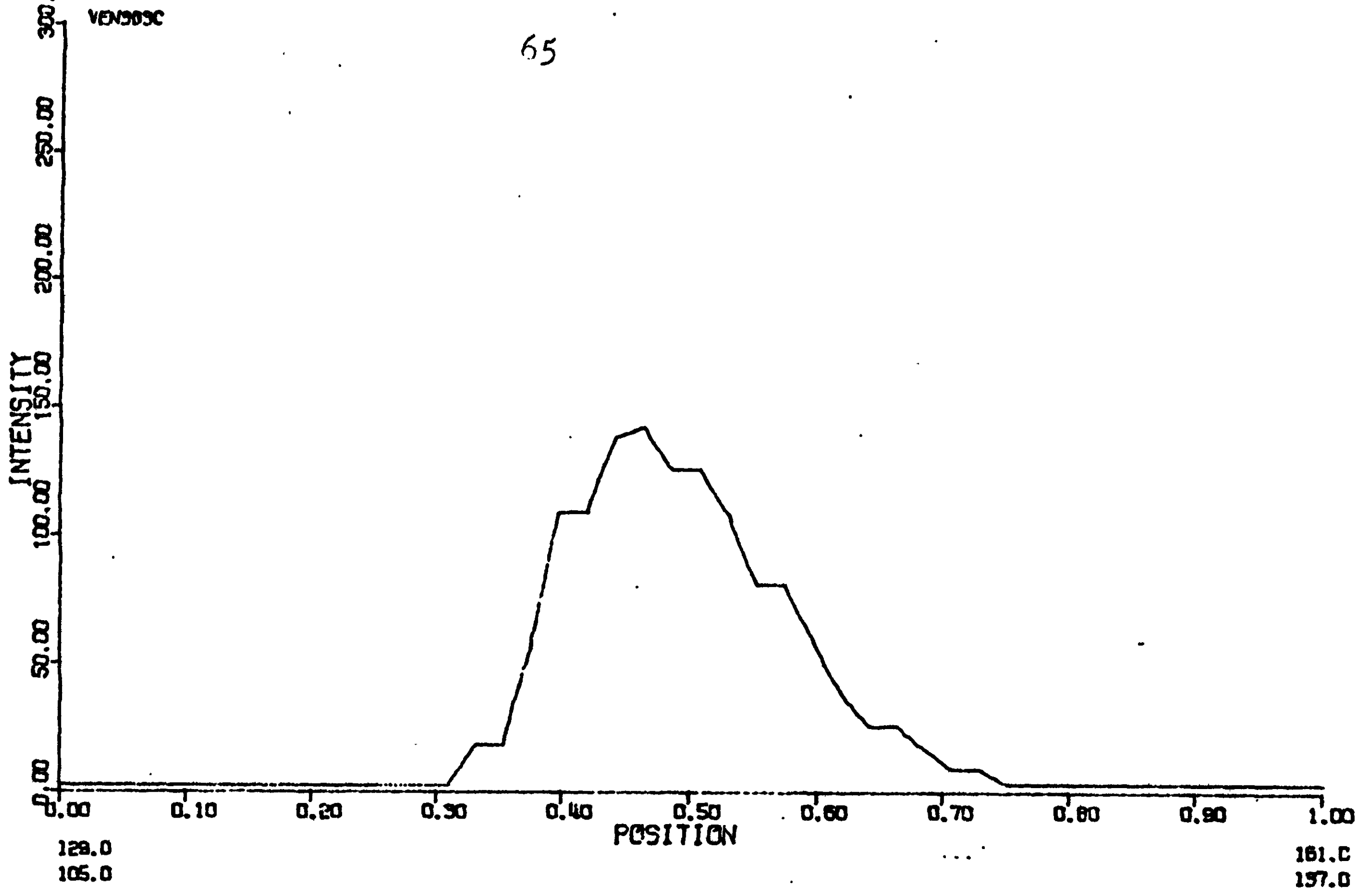


VENUS FILT=.389 EXP=6.0 4/23/72 1000 PAL216 018 -D




VEN383C
INTENSITY
POSITION
121.0
113.0
153.0
145.0
VENUS FILT=.383 EXP=.15 4/24/72 923 PAL217 005 -D


VEN383C
INTENSITY
POSITION
VENUS FILT=.383 EXP .15 4/24/72 923 PAL217 005 -D



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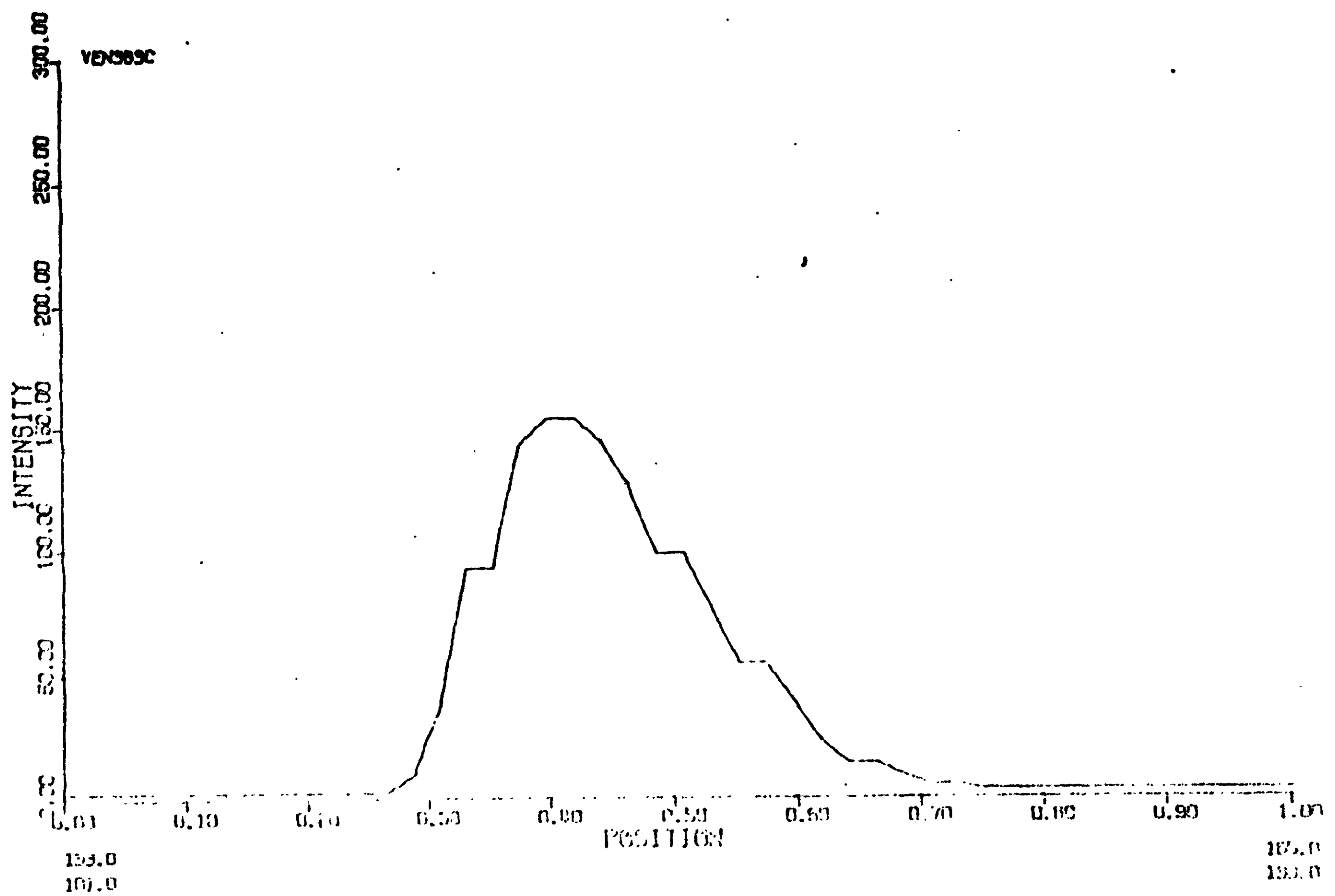
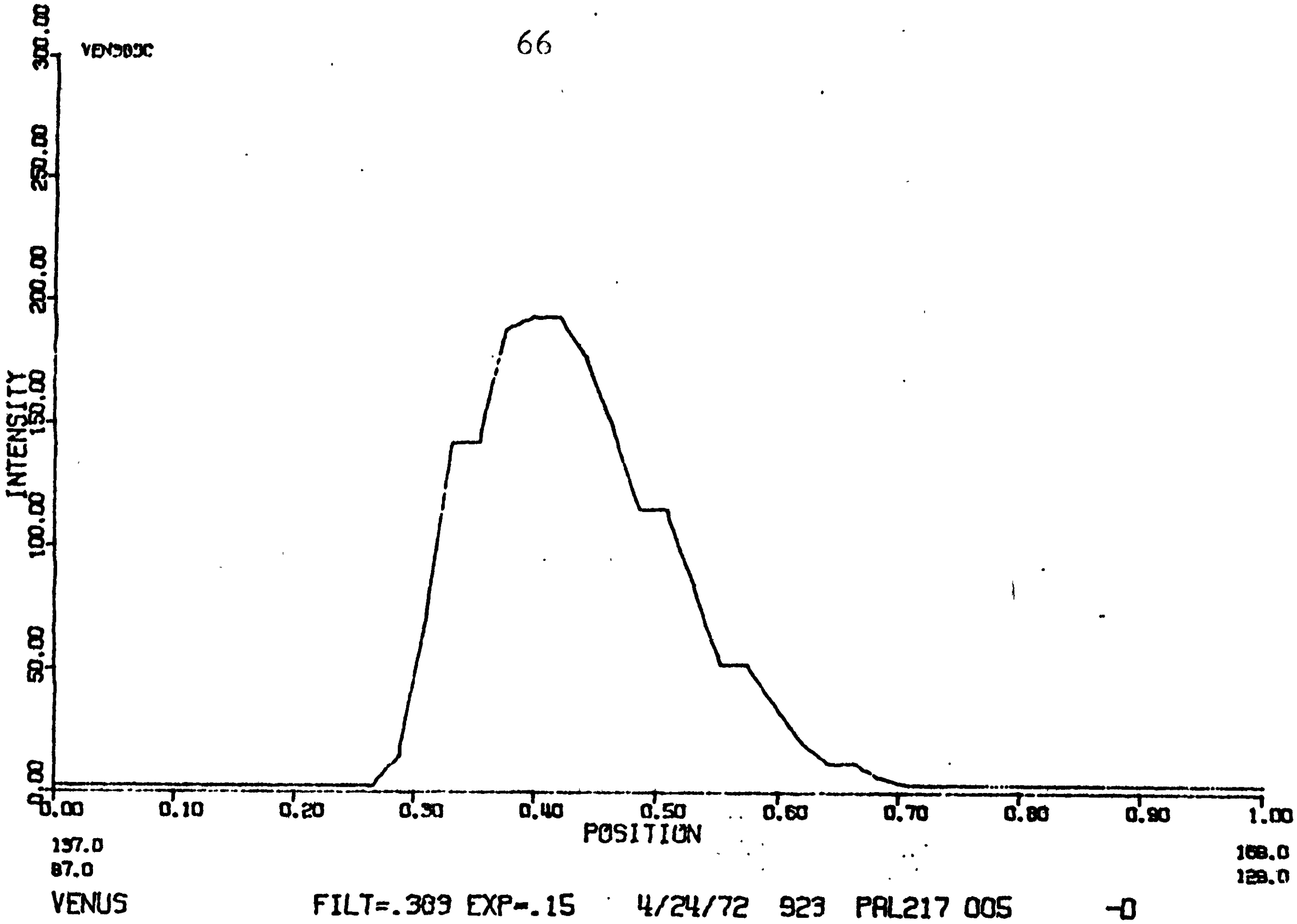


VENUS FILT=.383 EXP=.15 4/24/72 923 PAL217 005 -0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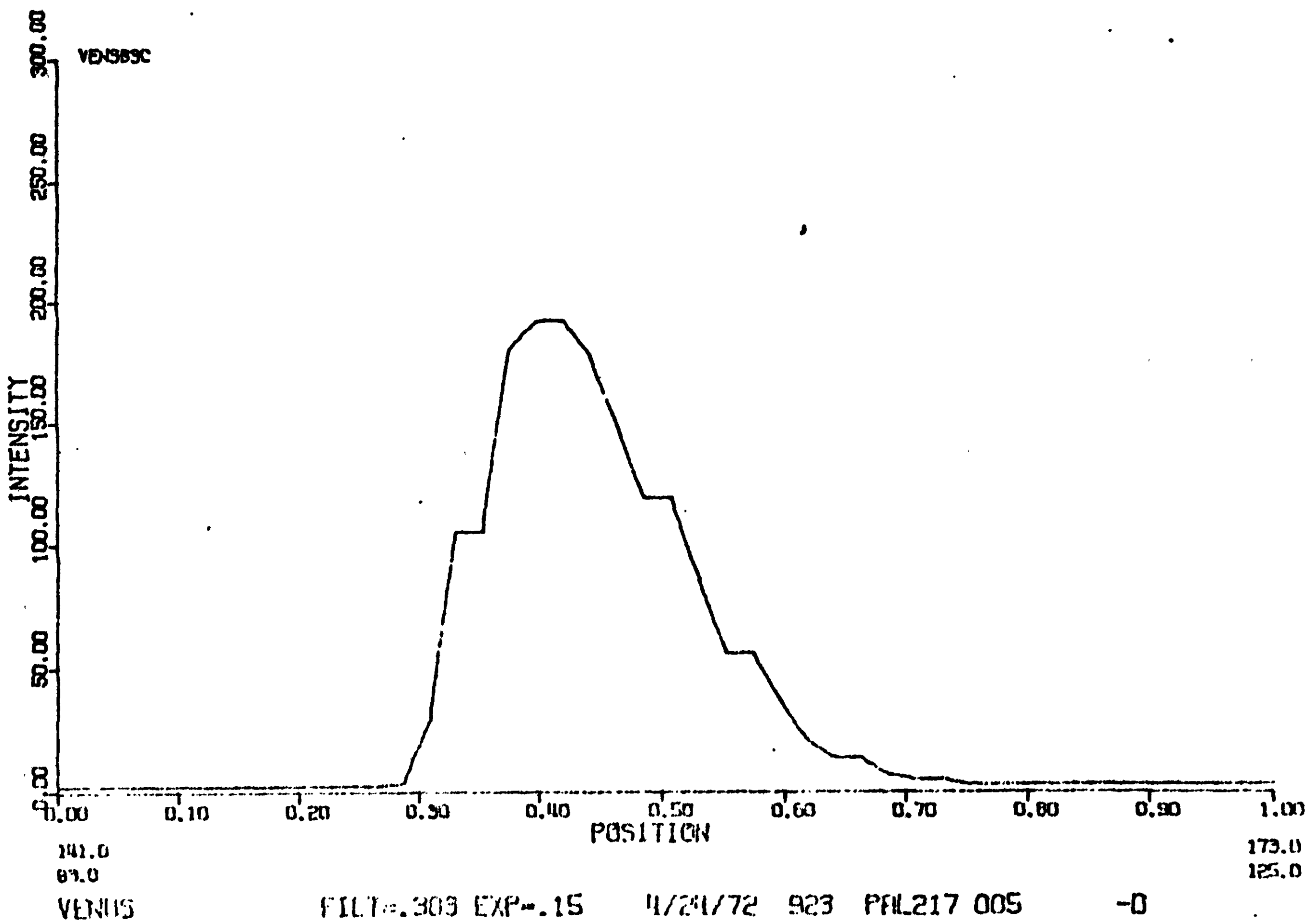
0.00
50.00
100.00
150.00
200.00
250.00
300.00
POSITION
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
137.0
87.0
168.0
128.0
VENUS FILT=.309 EXP=.15 4/24/72 923 PAL217 005 -D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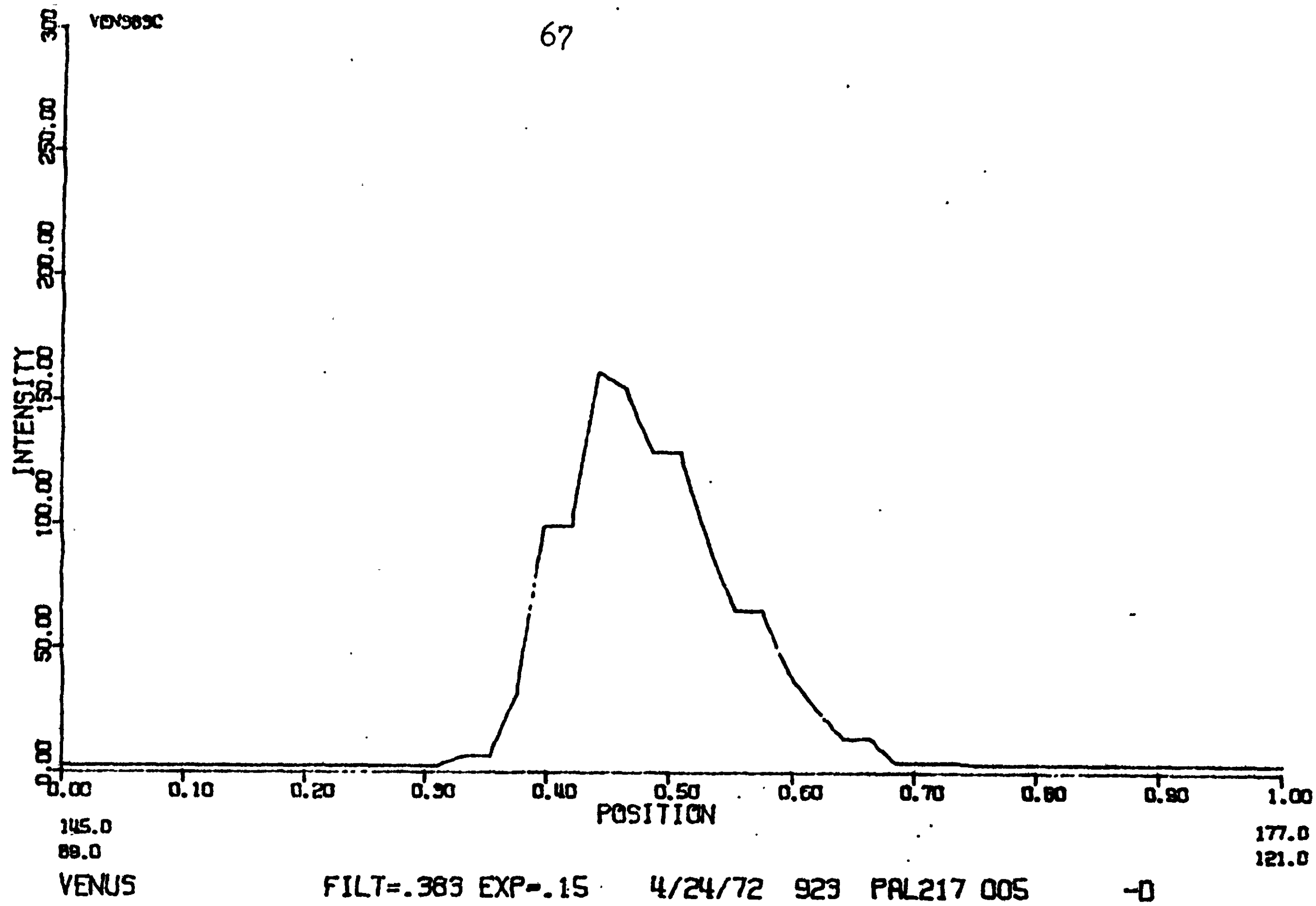
0.00
50.00
100.00
150.00
200.00
250.00
300.00
POSITION
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
141.0
173.0
125.0
VENUS FILT=.309 EXP=.15 4/24/72 923 PAL217 005 -D


VEN383C
INTENSITY
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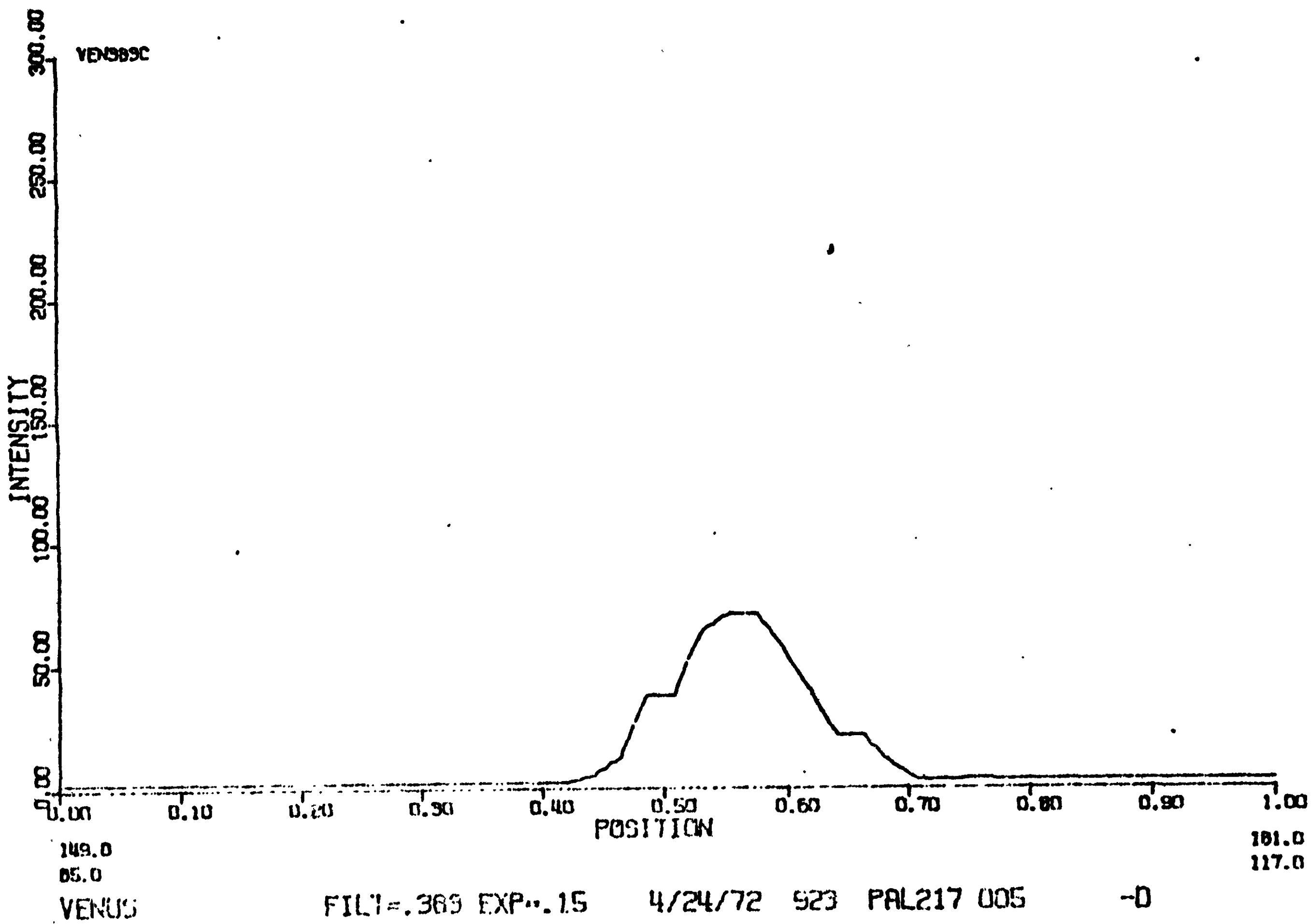
50.00
100.00
150.00
200.00
250.00
300
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
POSITION
145.0
89.0
177.0
121.0
VENUS
FILT=.383 EXP=.15 4/24/72 923 PAL217 005 -D


VEN383C
INTENSITY
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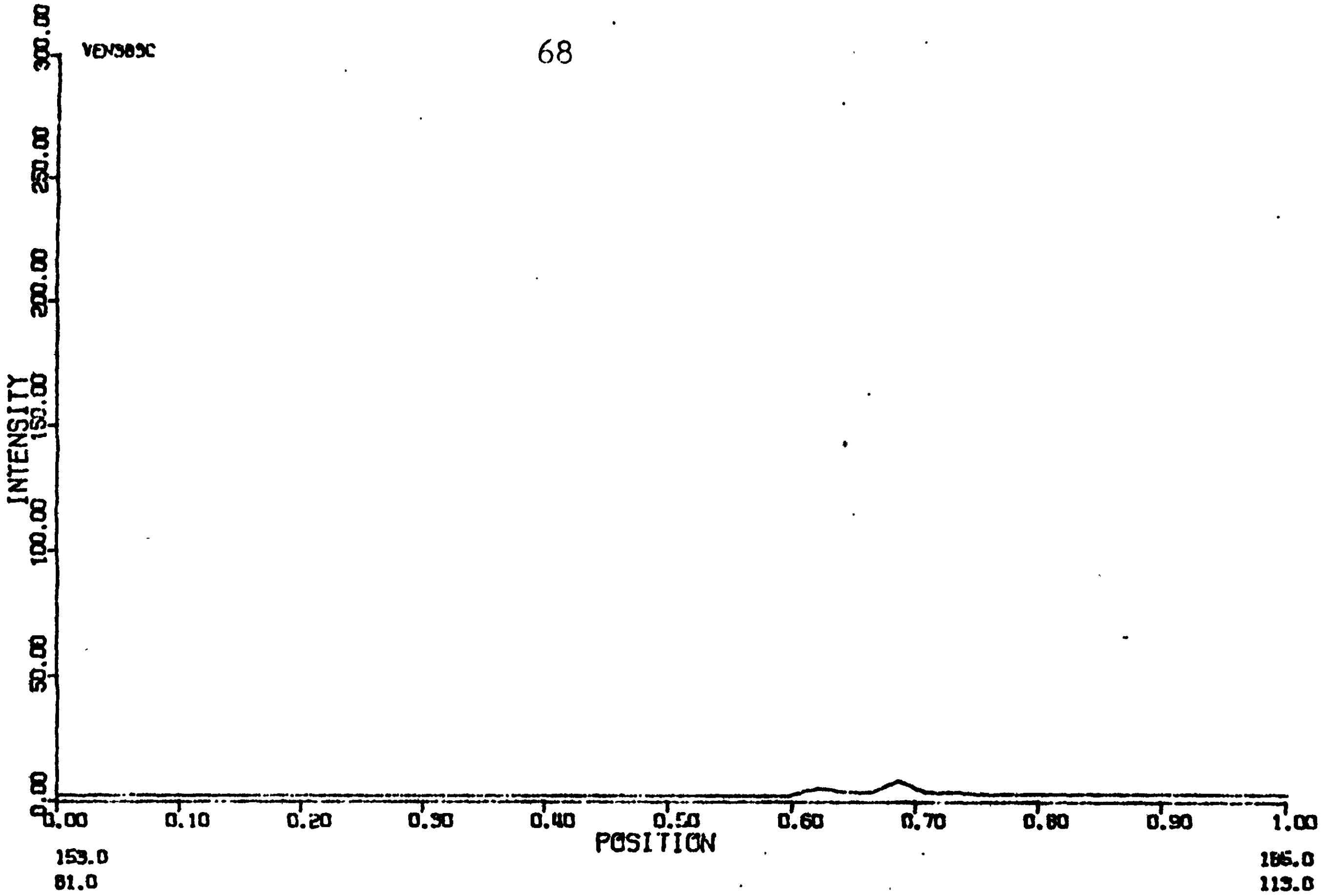
100.00
150.00
200.00
250.00
300.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
POSITION
149.0
85.0
181.0
117.0
VENUS
FILT=.383 EXP=.15 4/24/72 923 PAL217 005 -D



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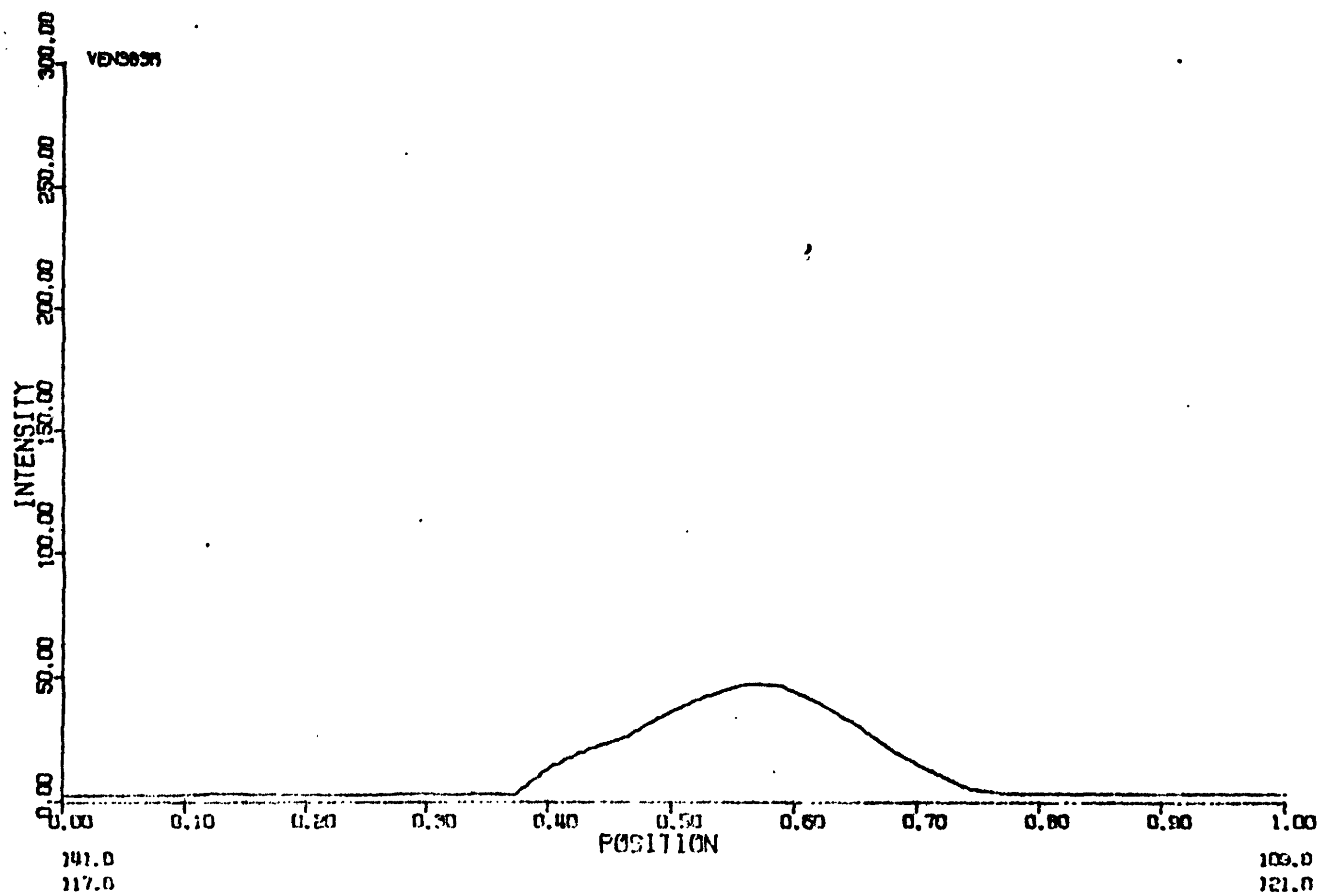
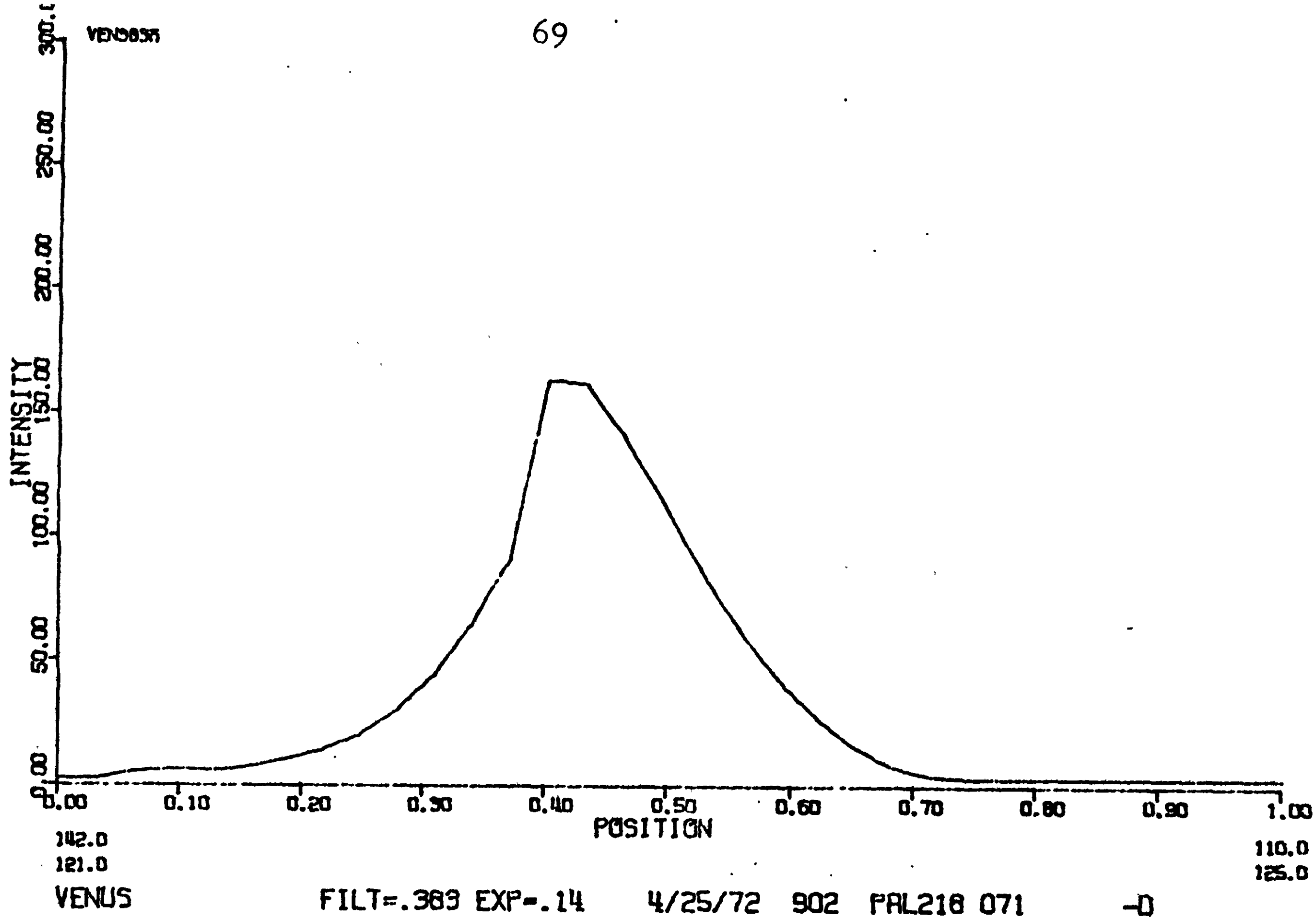


VENUS FILT=.389 EXP=.14 4/25/72 902 PAL218 071 -D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0.00
INTENSITY
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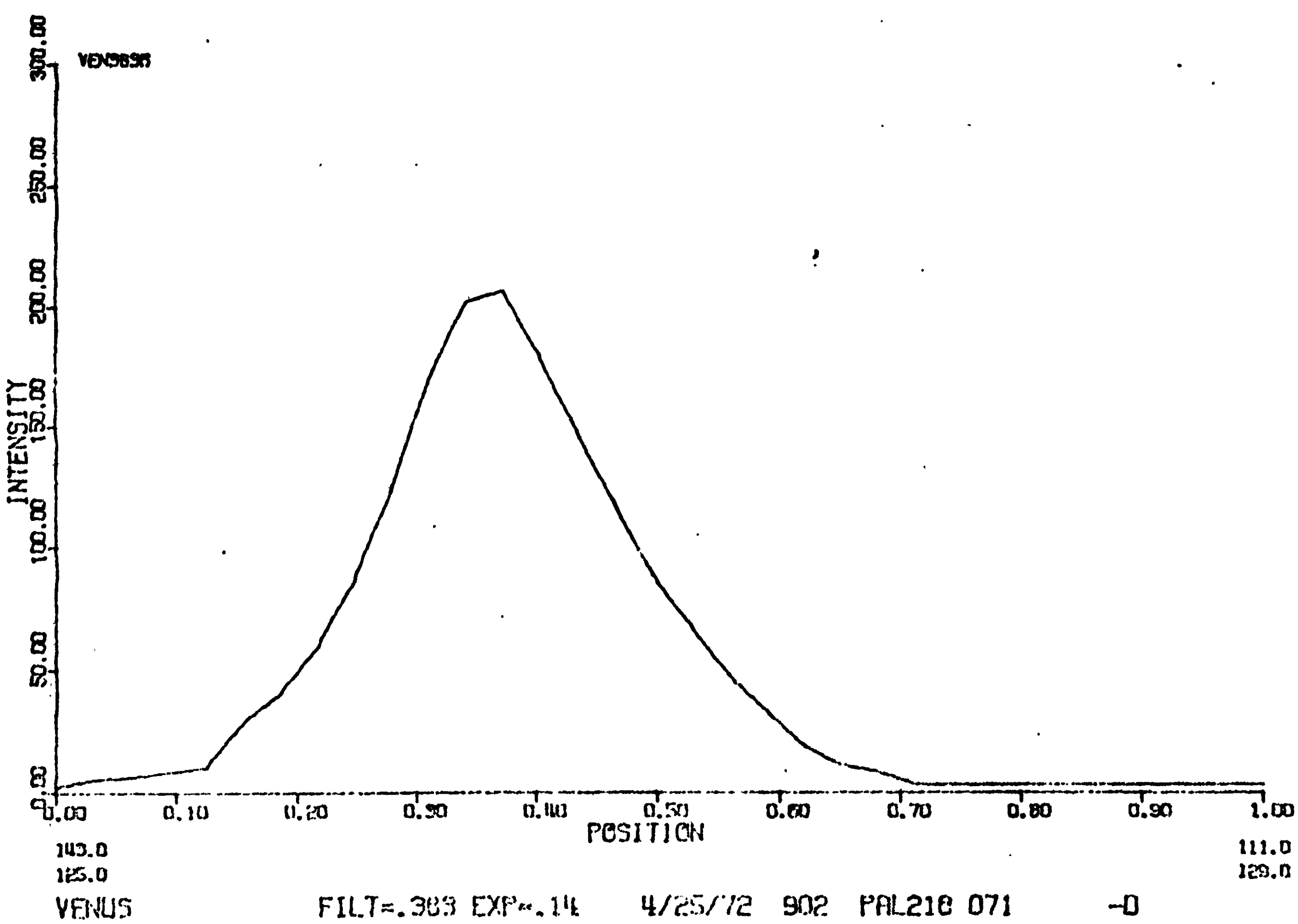
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
POSITION
142.0
121.0
110.0
125.0
VENUS
FILT=.383 EXP=.14
4/25/72 902 PAL218 071
-D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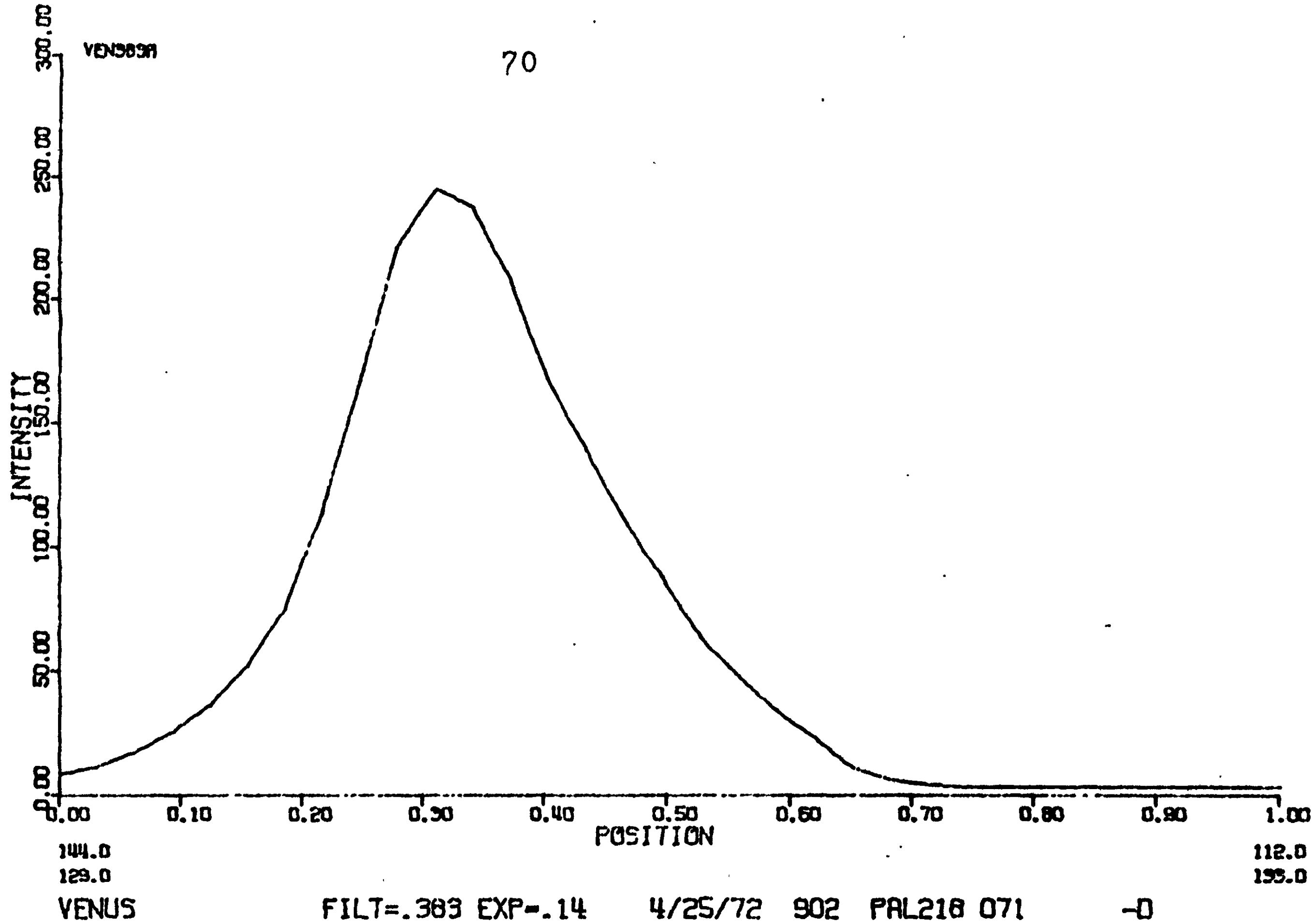
150.00
100.00
50.00
0.00
INTENSITY
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
POSITION
143.0
125.0
111.0
129.0
VENUS
FILT=.383 EXP=.14
4/25/72 902 PAL218 071
-D


VEN383A
INTENSITY
POSITION
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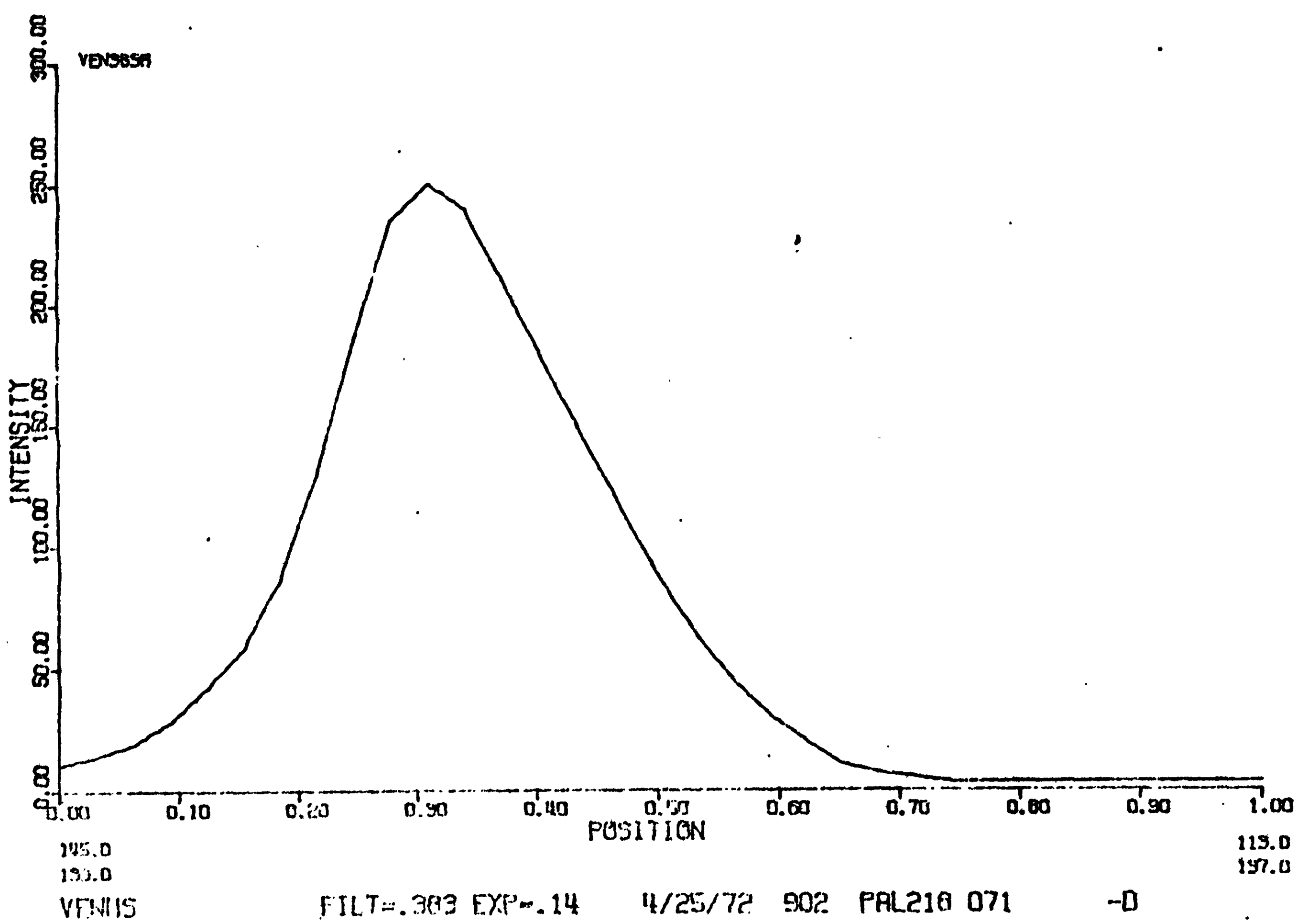
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
144.0
129.0
112.0
135.0
VENUS FILT=.383 EXP=.14 4/25/72 902 PAL218 071 -D


VEN385A
INTENSITY
POSITION
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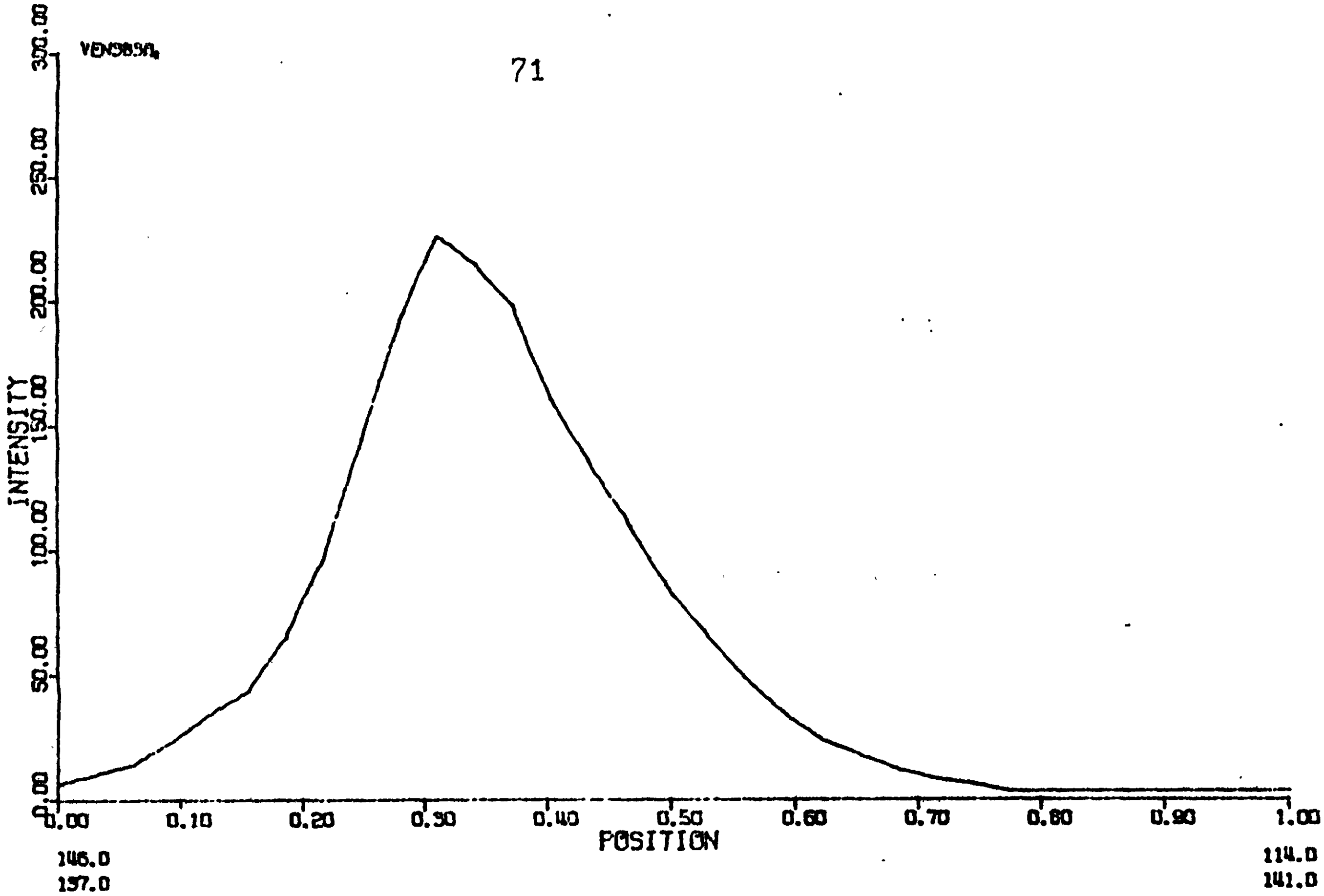
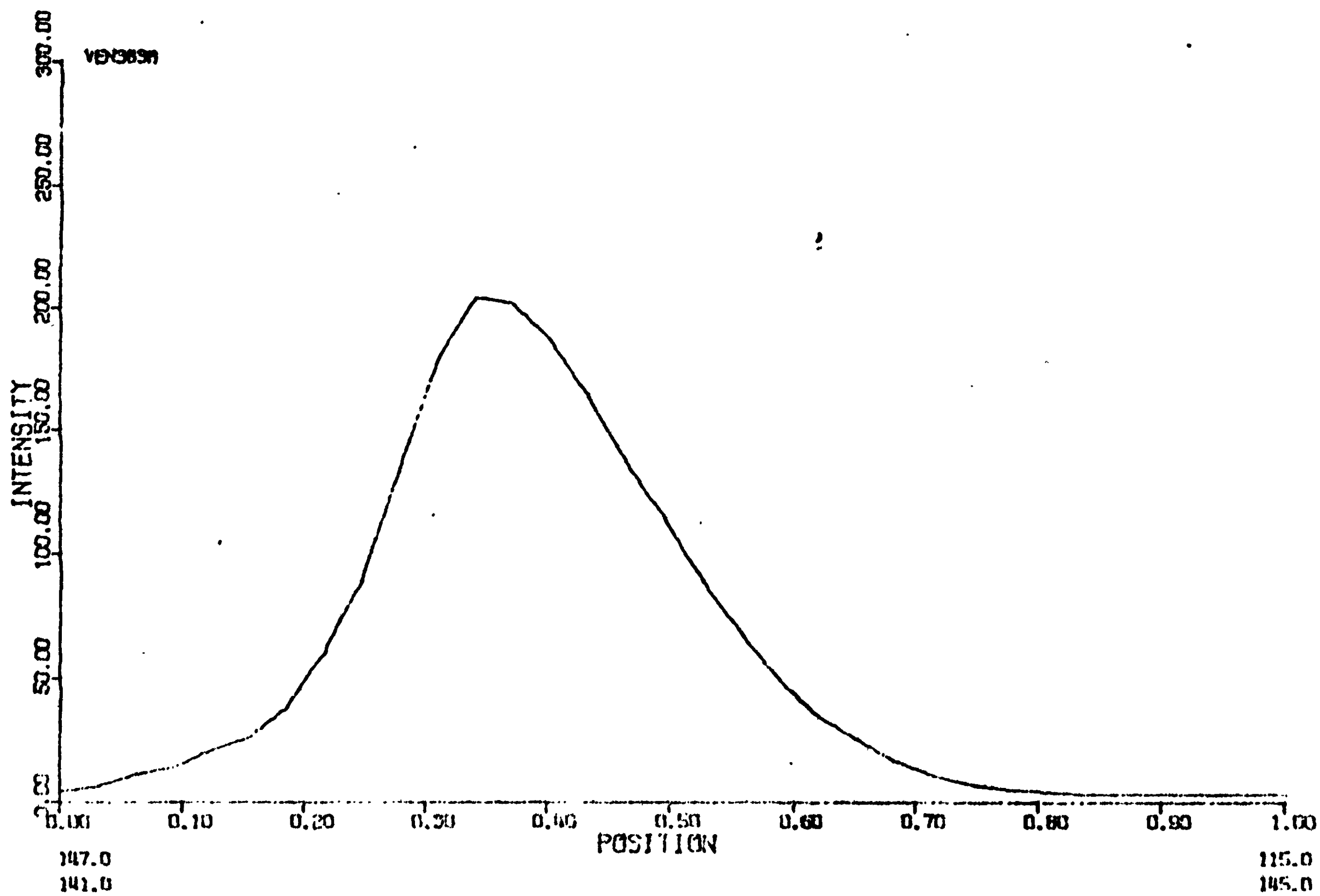
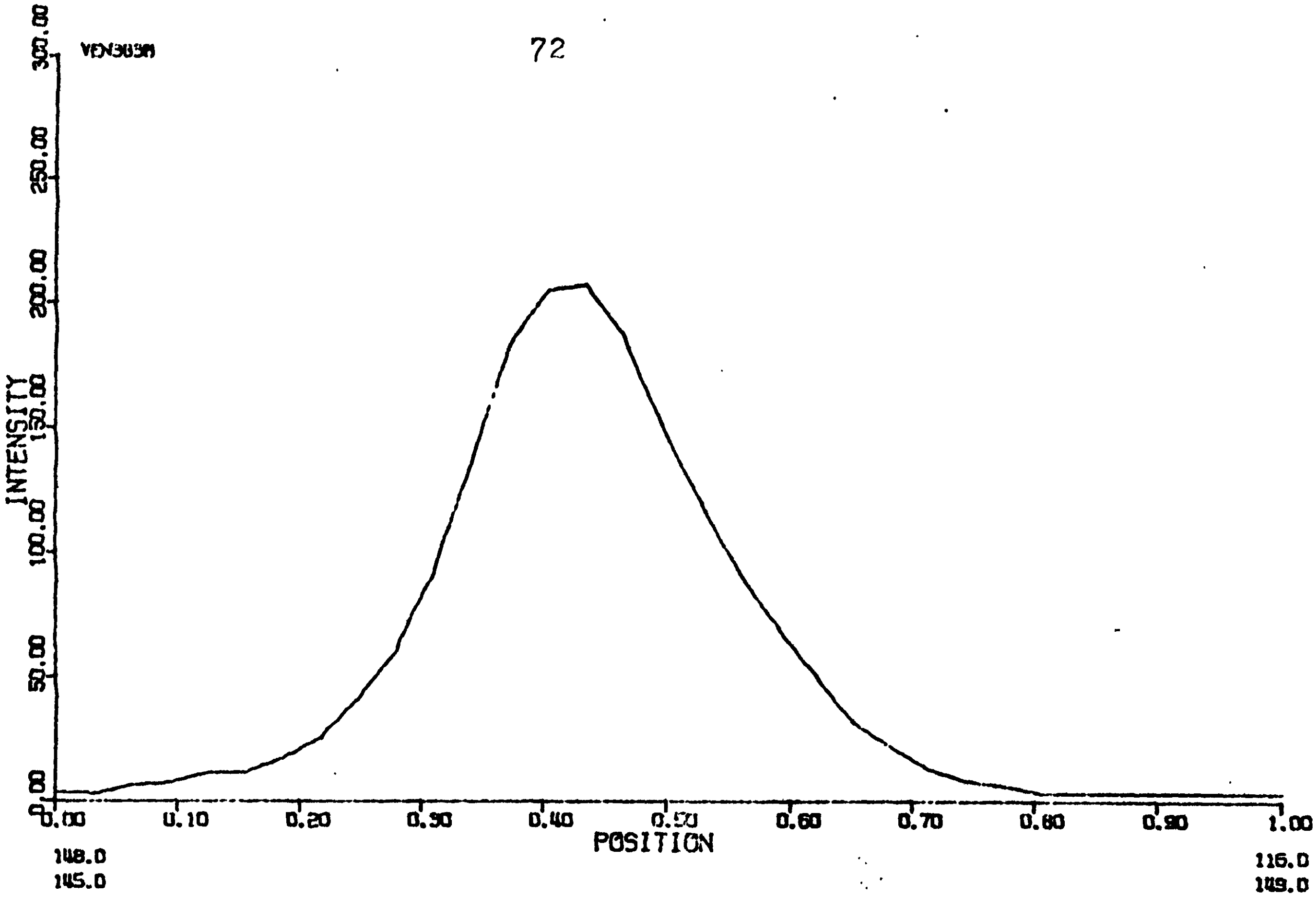
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
145.0
130.0
113.0
137.0
VENUS FILT=.383 EXP=.14 4/25/72 902 PAL218 071 -D



VENUS FILT=.383 EXP=.14 4/25/72 902 PAL216 071 -0



VENUS FILT=.383 EXP=.14 4/25/72 902 PAL216 071 -0



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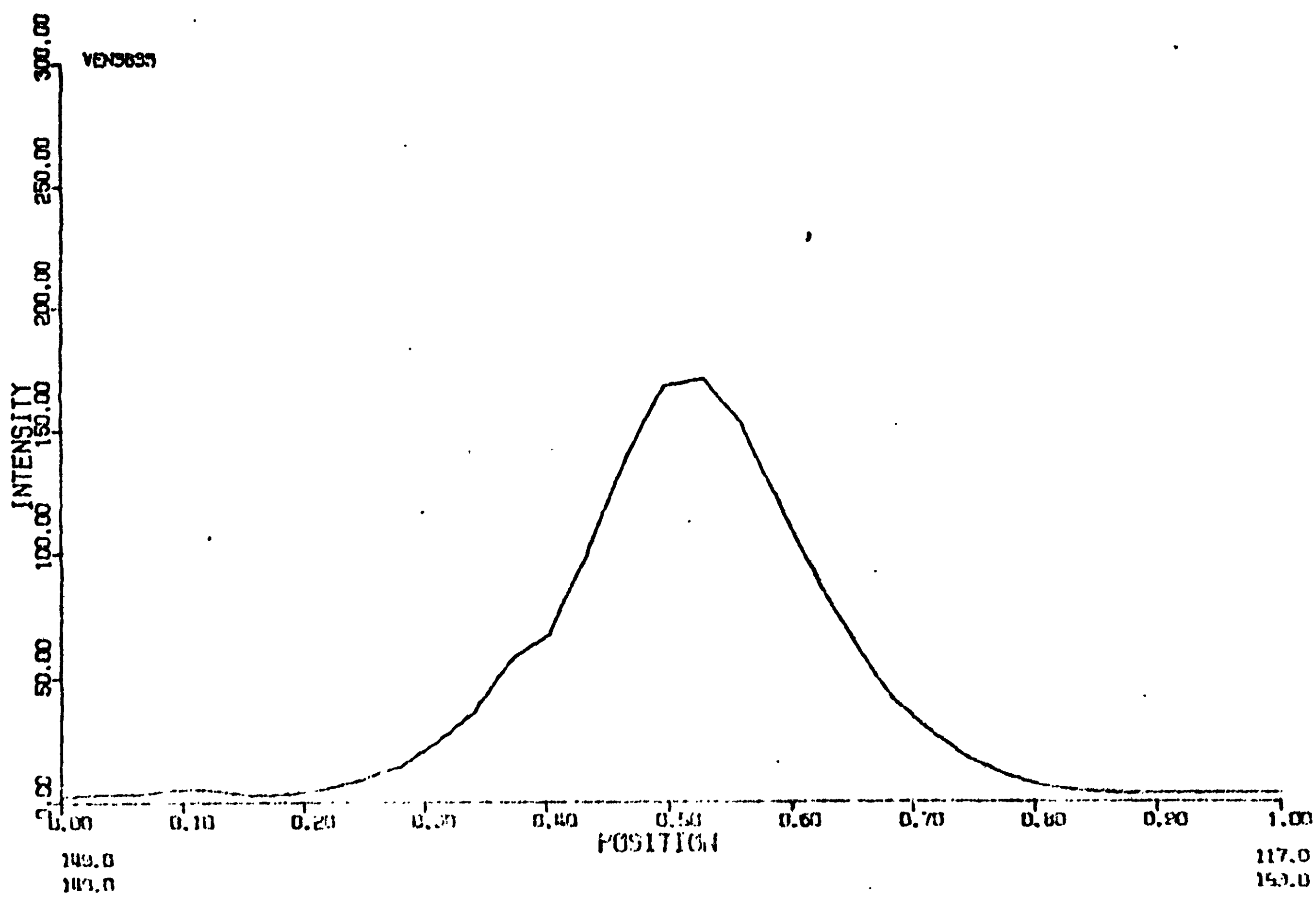
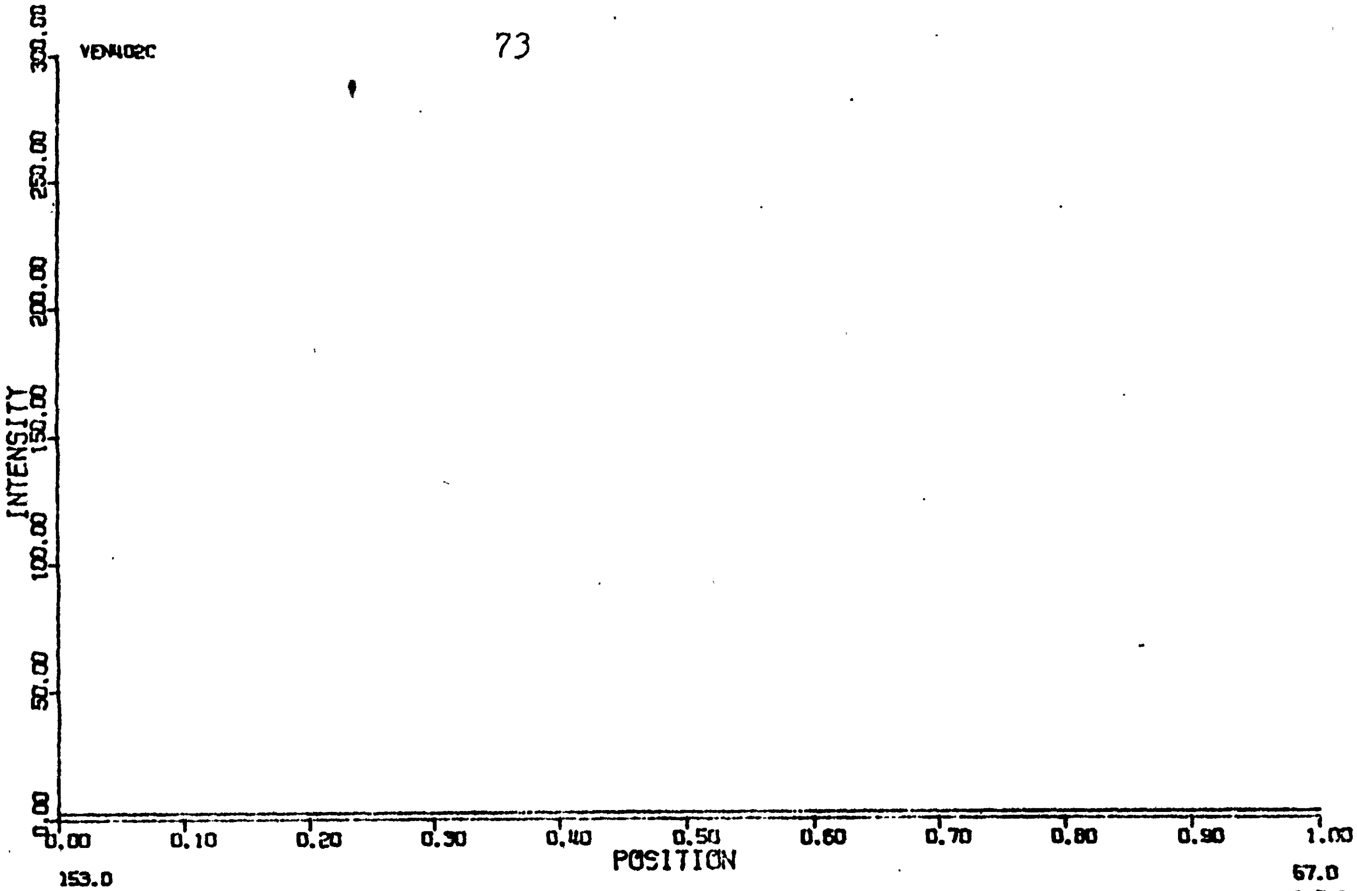


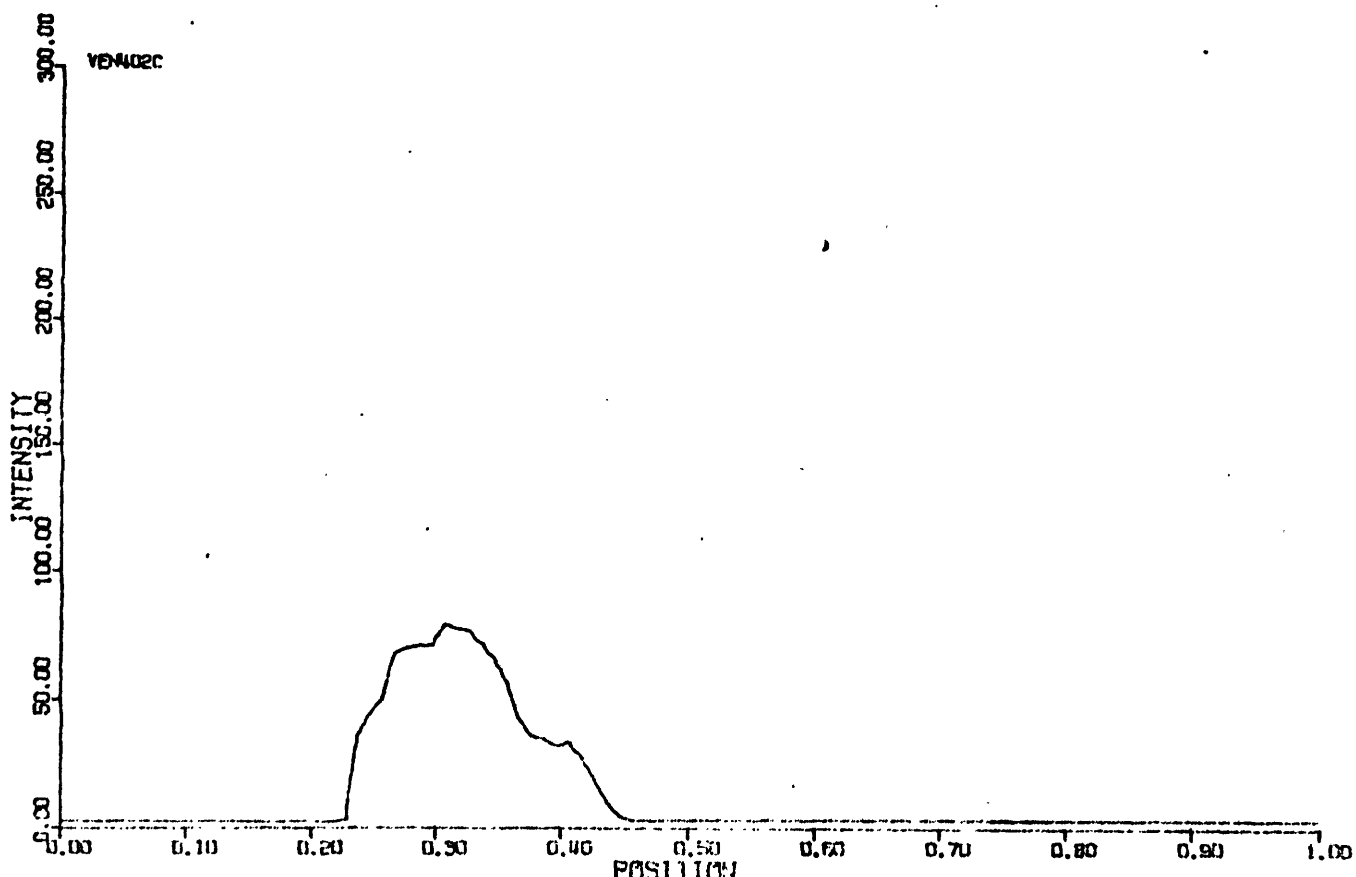
VENUS FILT=.303 EXP=.14 4/25/72 902 PAL218 071 -D



153.0
188.0

67.0
157.0

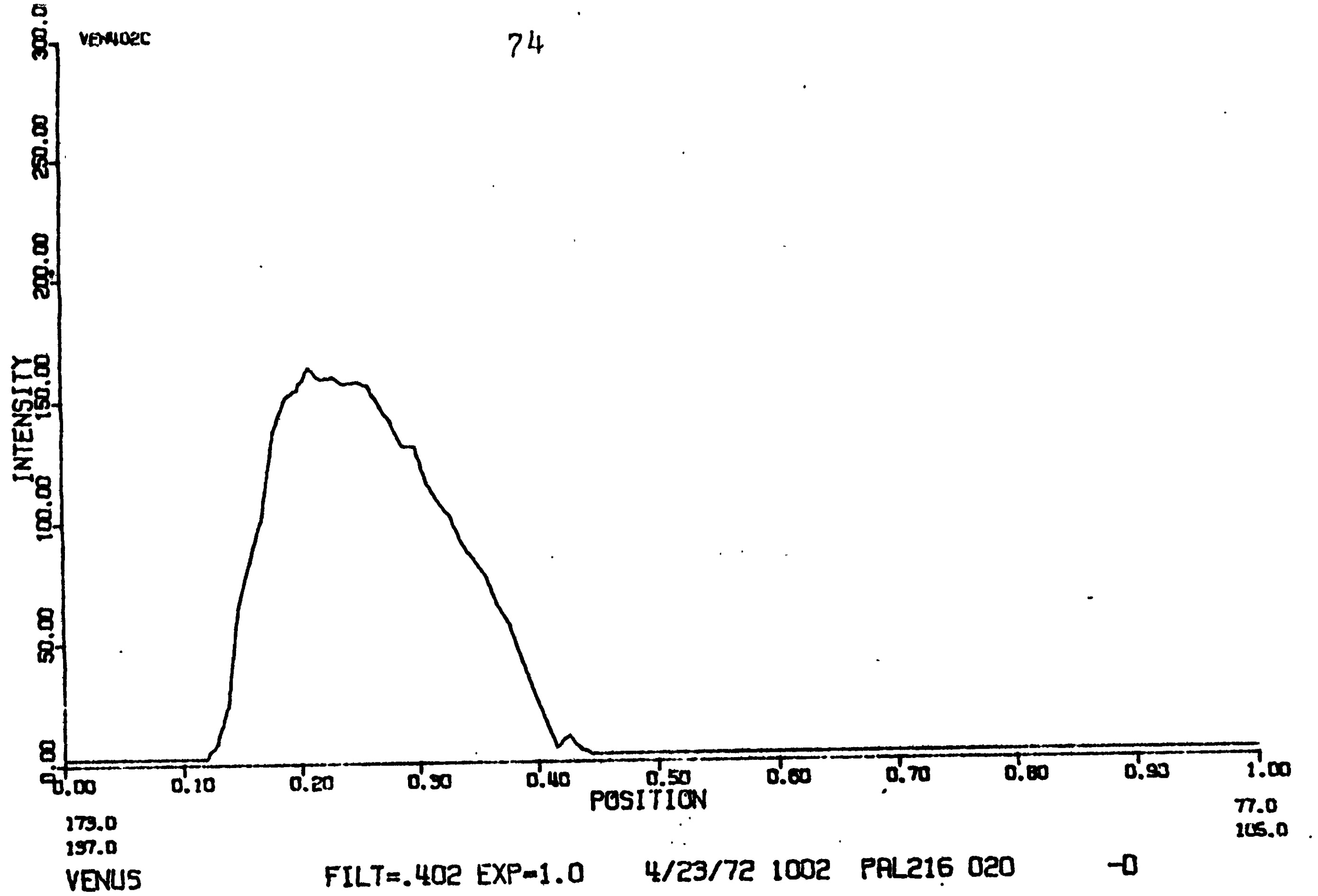
VENUS FILT=.402 EXP=1.0 4/23/72 1002 PAL216 020 -0



163.0
153.0

67.0
121.0

VENUS FILT=.402 EXP=1.0 4/23/72 1002 PAL216 020 -0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100.00
50.00
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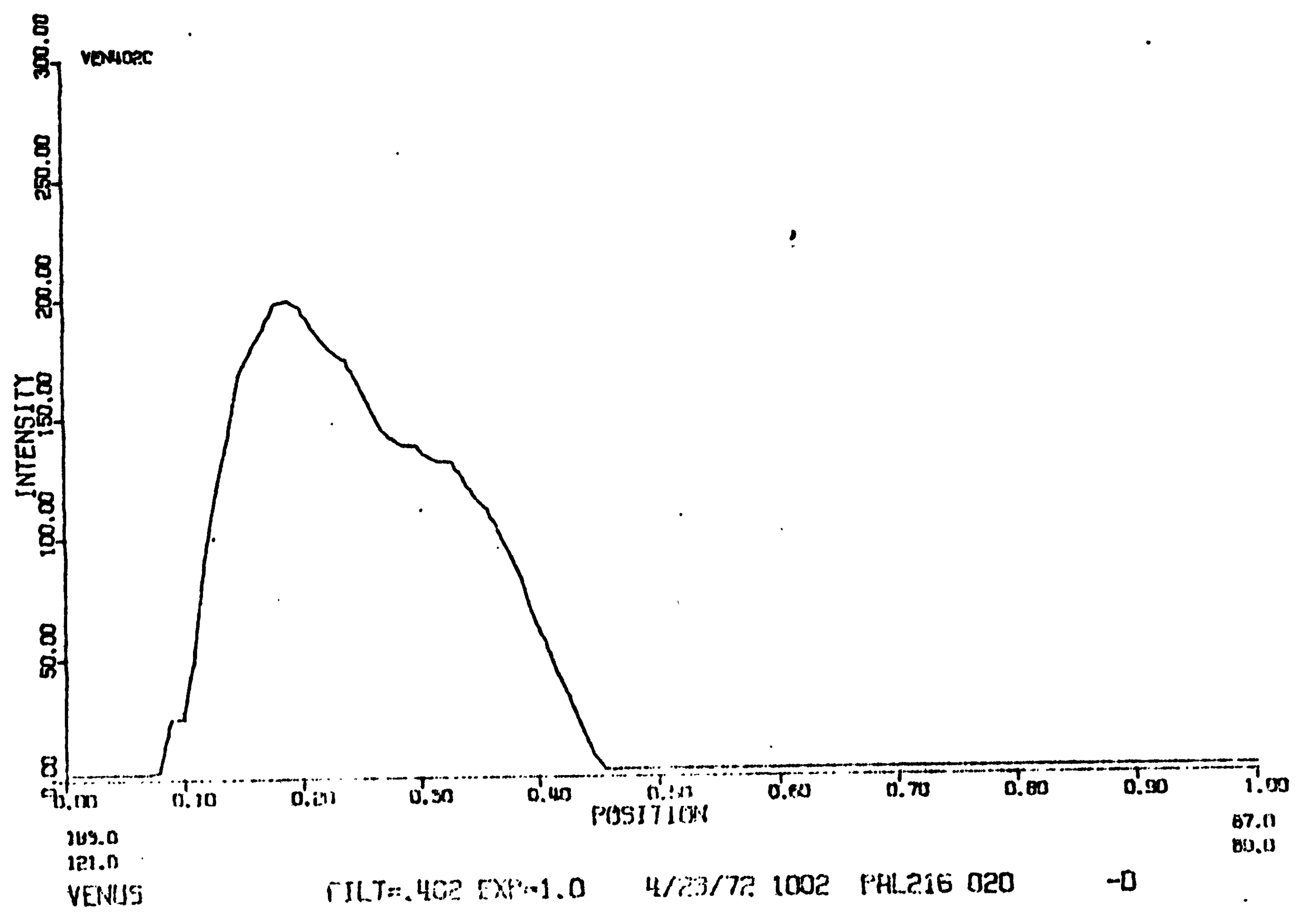
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
POSITION
173.0
197.0
77.0
105.0
VENUS
FILT=.402 EXP=1.0
4/23/72 1002
PAL216 020
-0


VEN402C
INTENSITY
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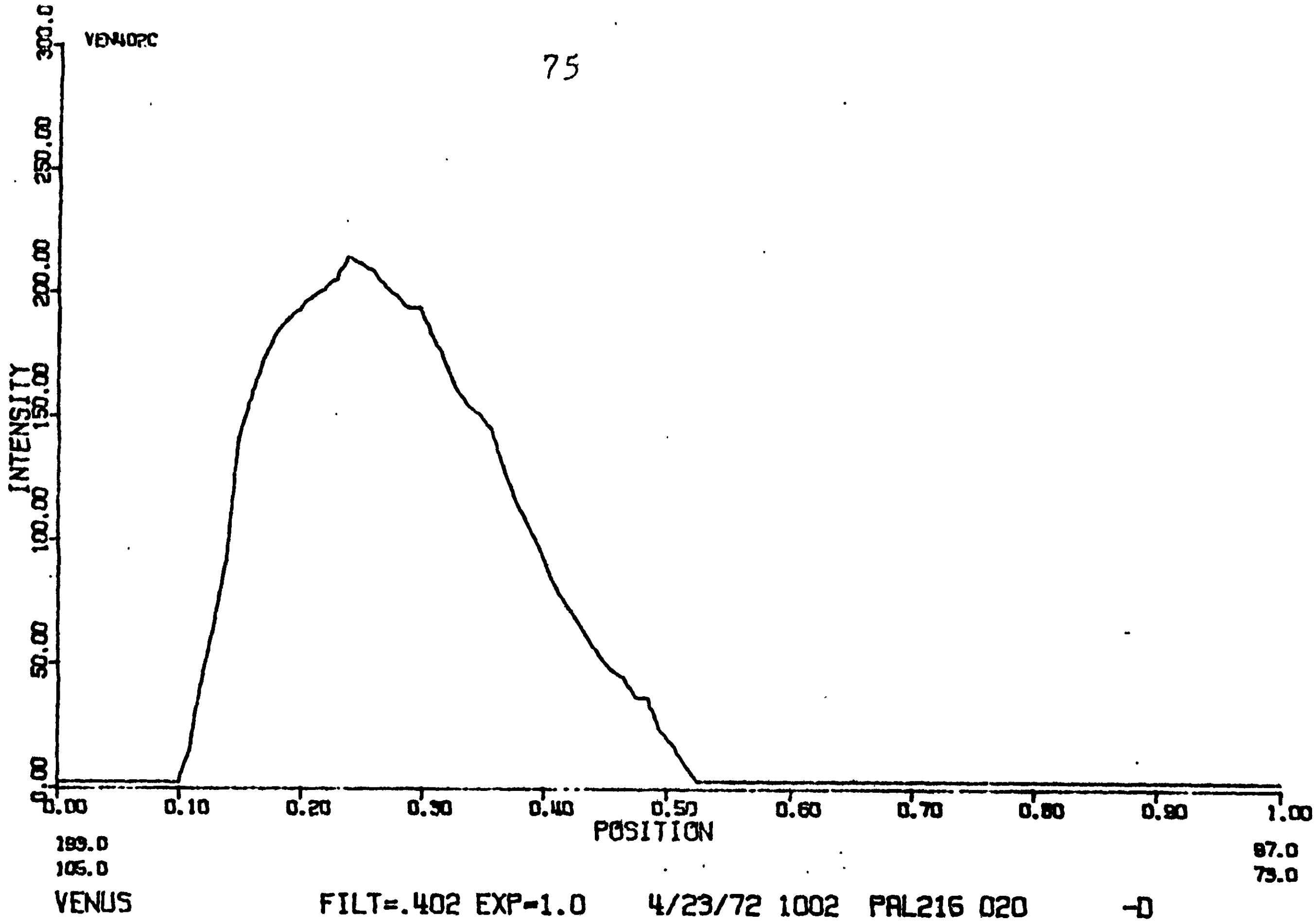
150.00
100.00
50.00
0.10
0.30
0.40
0.60
0.70
0.80
0.90
1.00
POSITION
105.0
121.0
67.0
VENUS
FILT=.402 EXP=1.0
4/23/72 1002
PAL216 020
-0


VEN402C
INTENSITY
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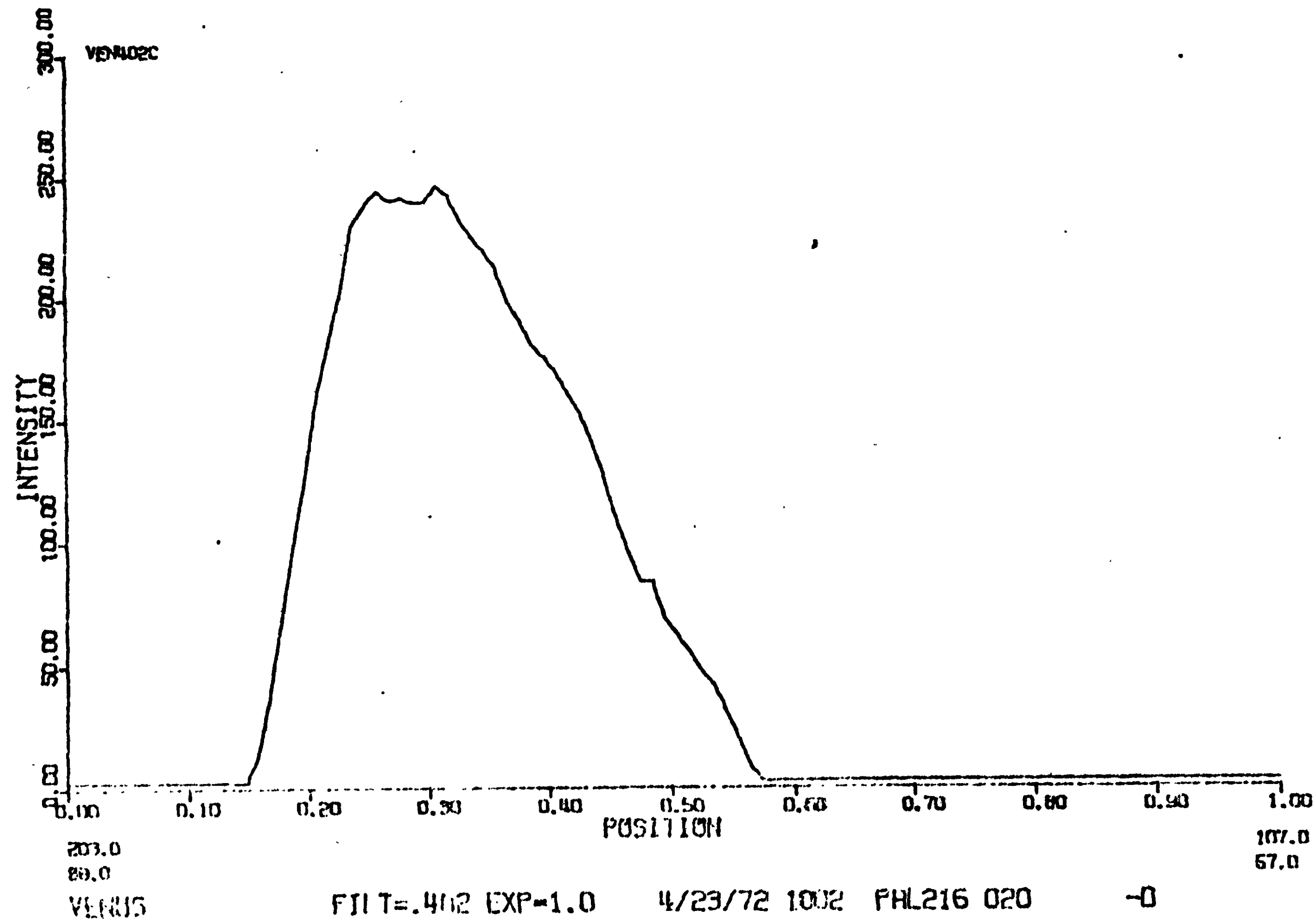
200.00
150.00
100.00
50.00
0.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
189.0
105.0
87.0
73.0
VENUS
FILT=.402 EXP=1.0 4/23/72 1002 PAL216 020 -D


VEN402C
INTENSITY
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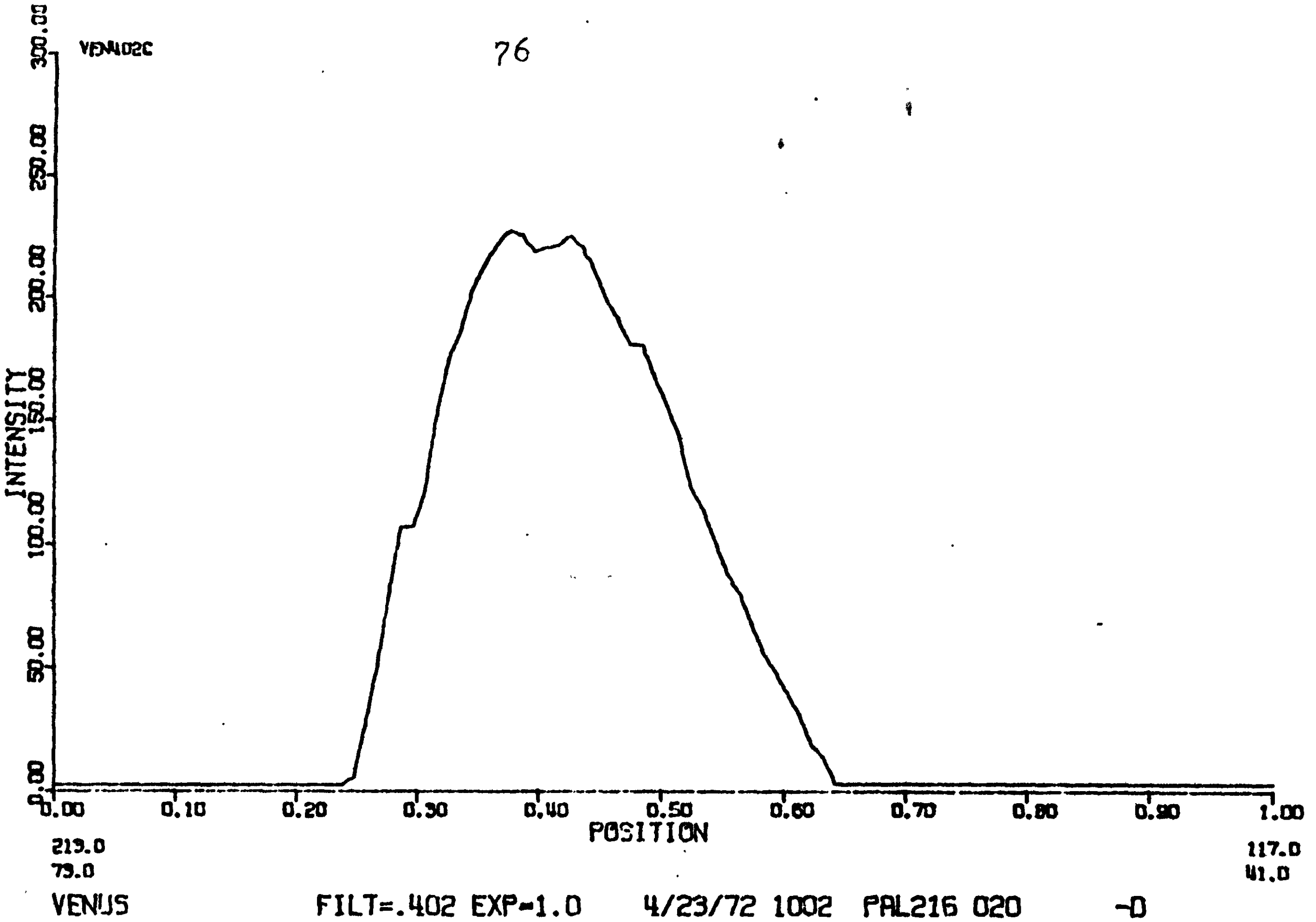
200.00
150.00
100.00
50.00
0.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
203.0
80.0
107.0
67.0
VENUS
FILT=.402 EXP=1.0 4/23/72 1002 PAL216 020 -D


VEN402C
INTENSITY
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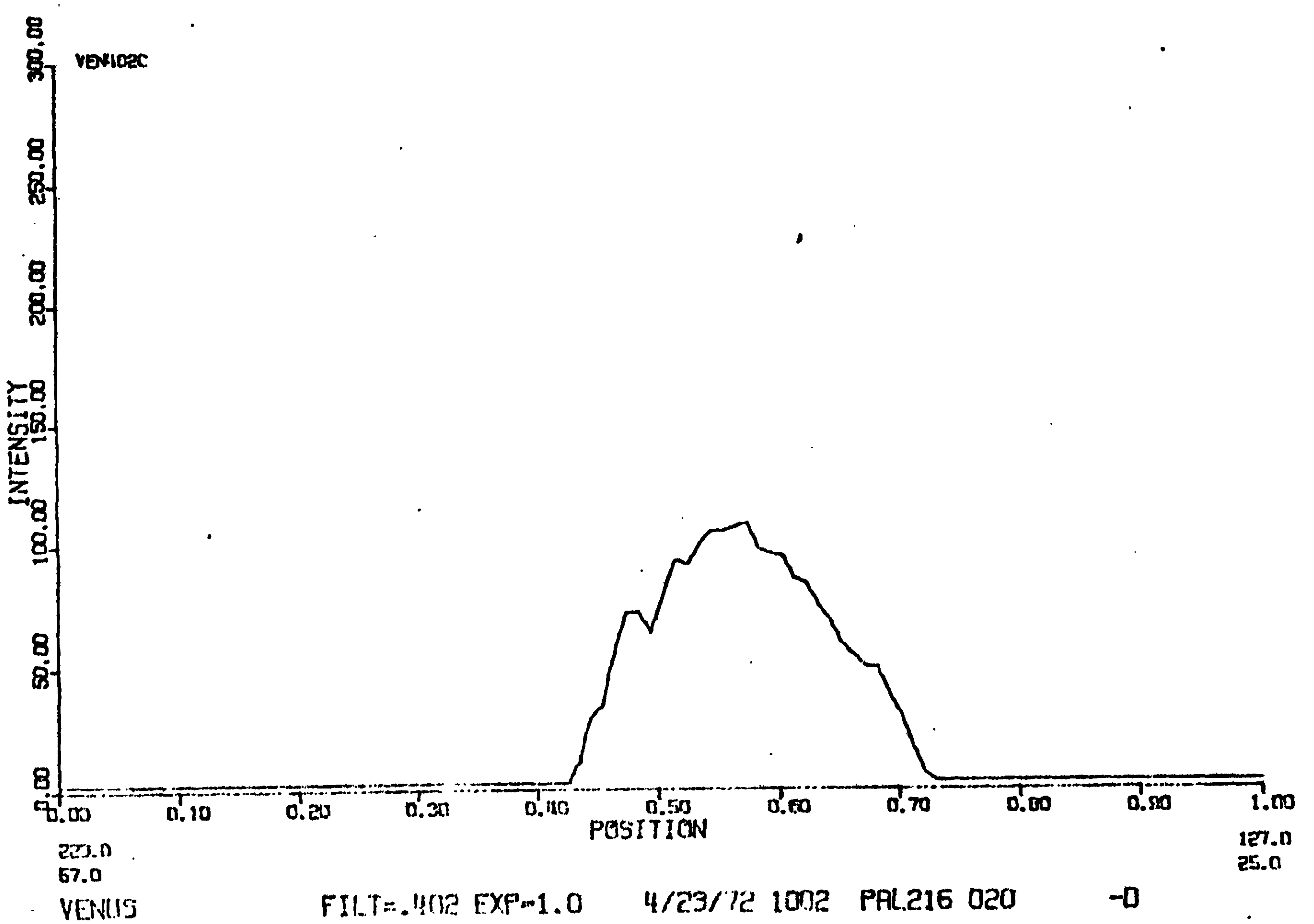
200.00
150.00
100.00
50.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
POSITION
213.0
73.0
117.0
41.0
VENUS
FILT=.402 EXP=1.0
4/23/72 1002
PAL216 020
-D


VEN402C
INTENSITY
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200.00
150.00
100.00
50.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
POSITION
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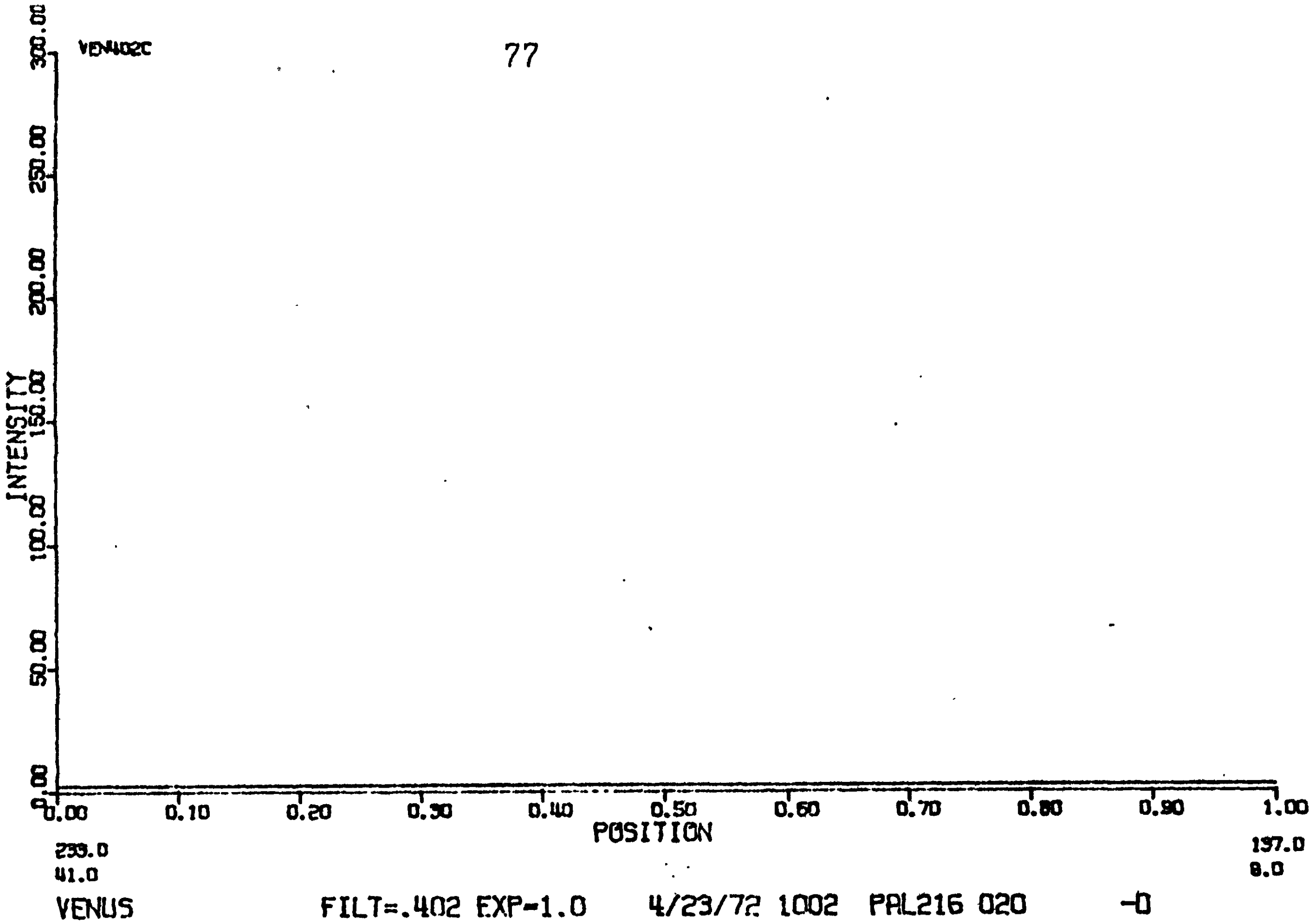
127.0
25.0
VENUS
FILT=.402 EXP=1.0
4/23/72 1002
PAL216 020
-D


VEN402C
INTENSITY
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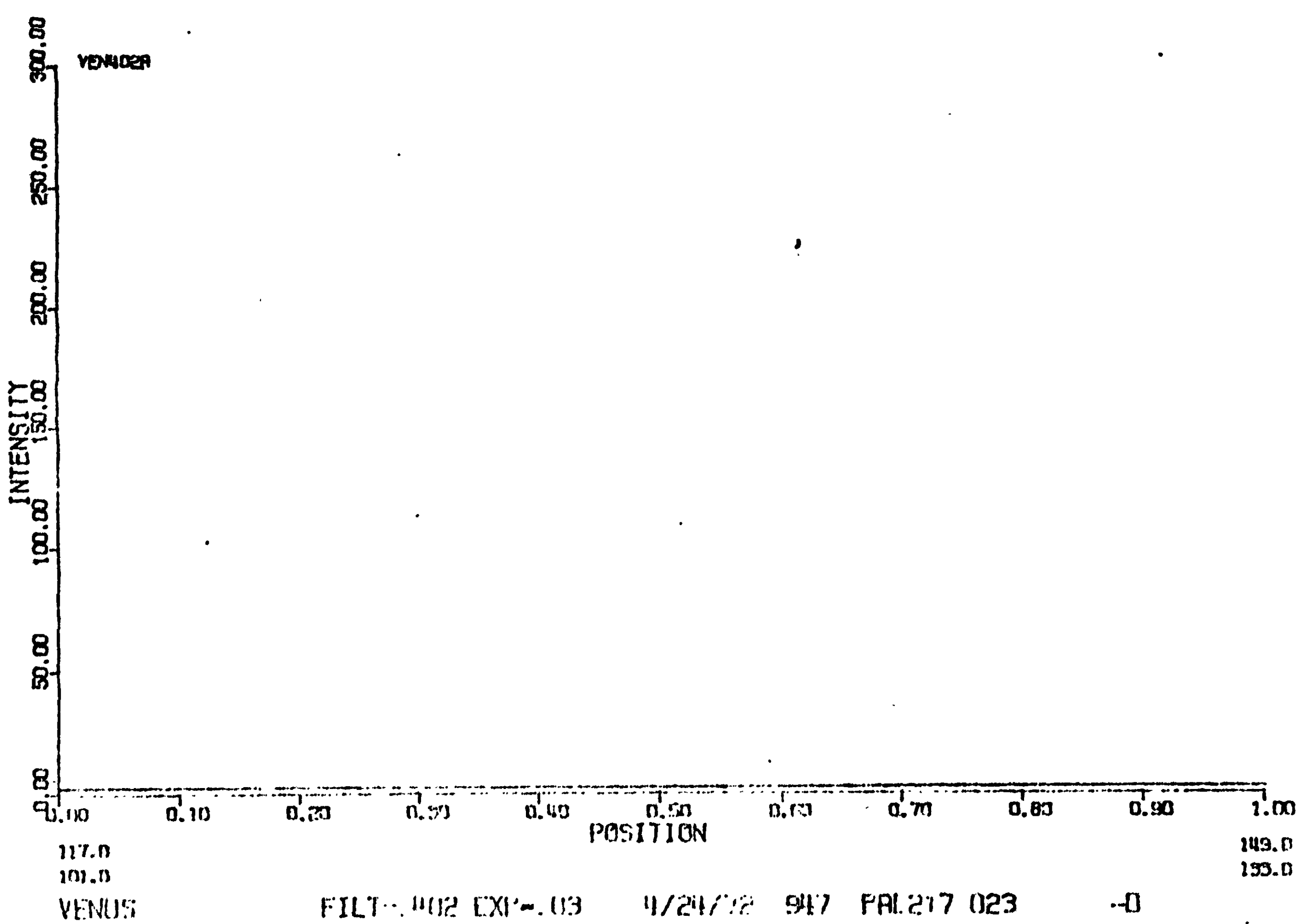
200.00
150.00
100.00
50.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
POSITION
233.0
41.0
137.0
9.0
VENUS
FILT=.402 EXP=1.0
4/23/72 1002
PAL216 020
-0


VEN402A
INTENSITY
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200.00
150.00
100.00
50.00
0.10
0.20
0.30
0.40
0.50
0.70
0.80
0.90
1.00
POSITION
117.0
101.0
149.0
133.0
VENUS
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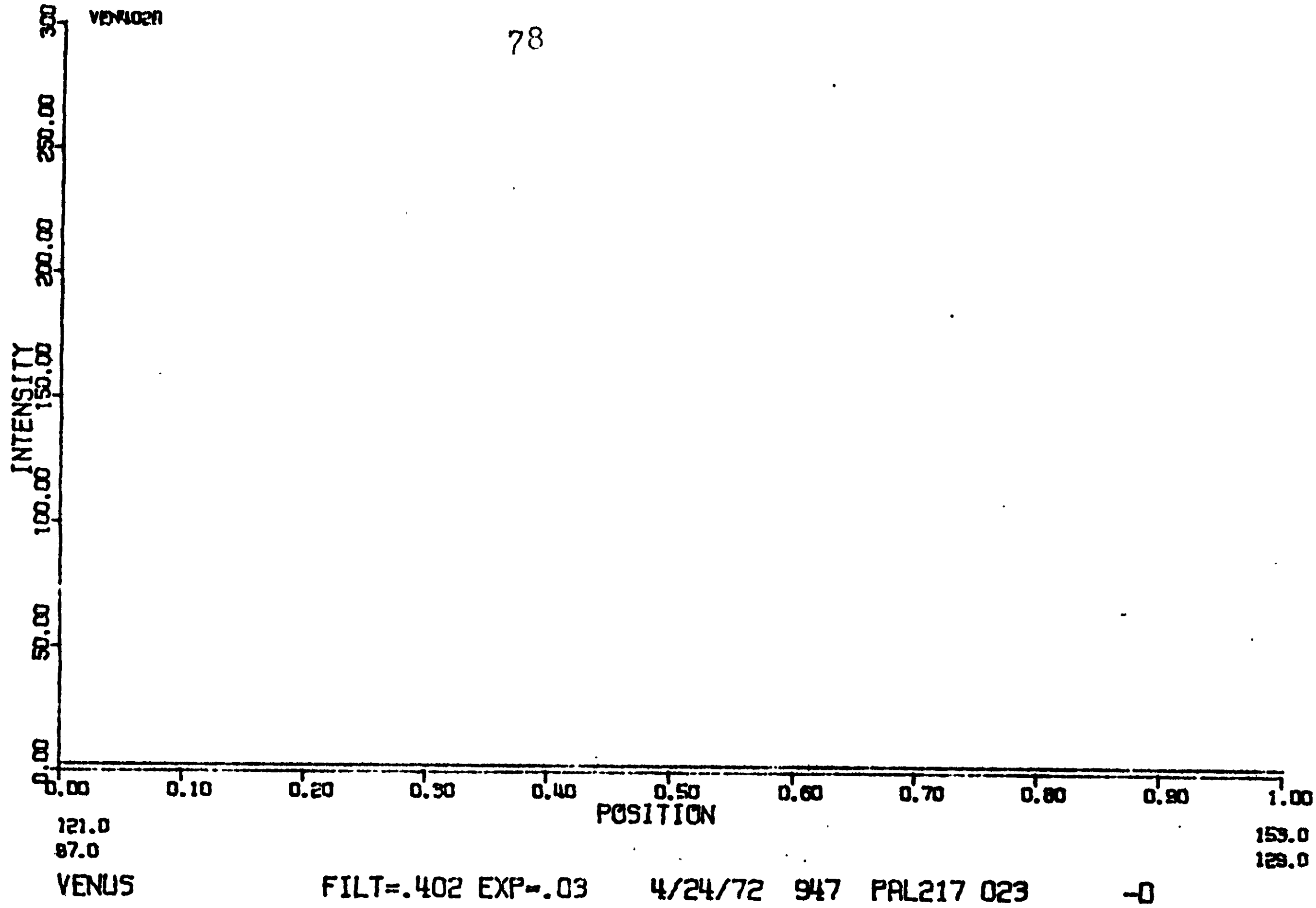
PAL217 023
-0


VEN402A
INTENSITY
POSITION
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121.0
87.0
153.0
129.0
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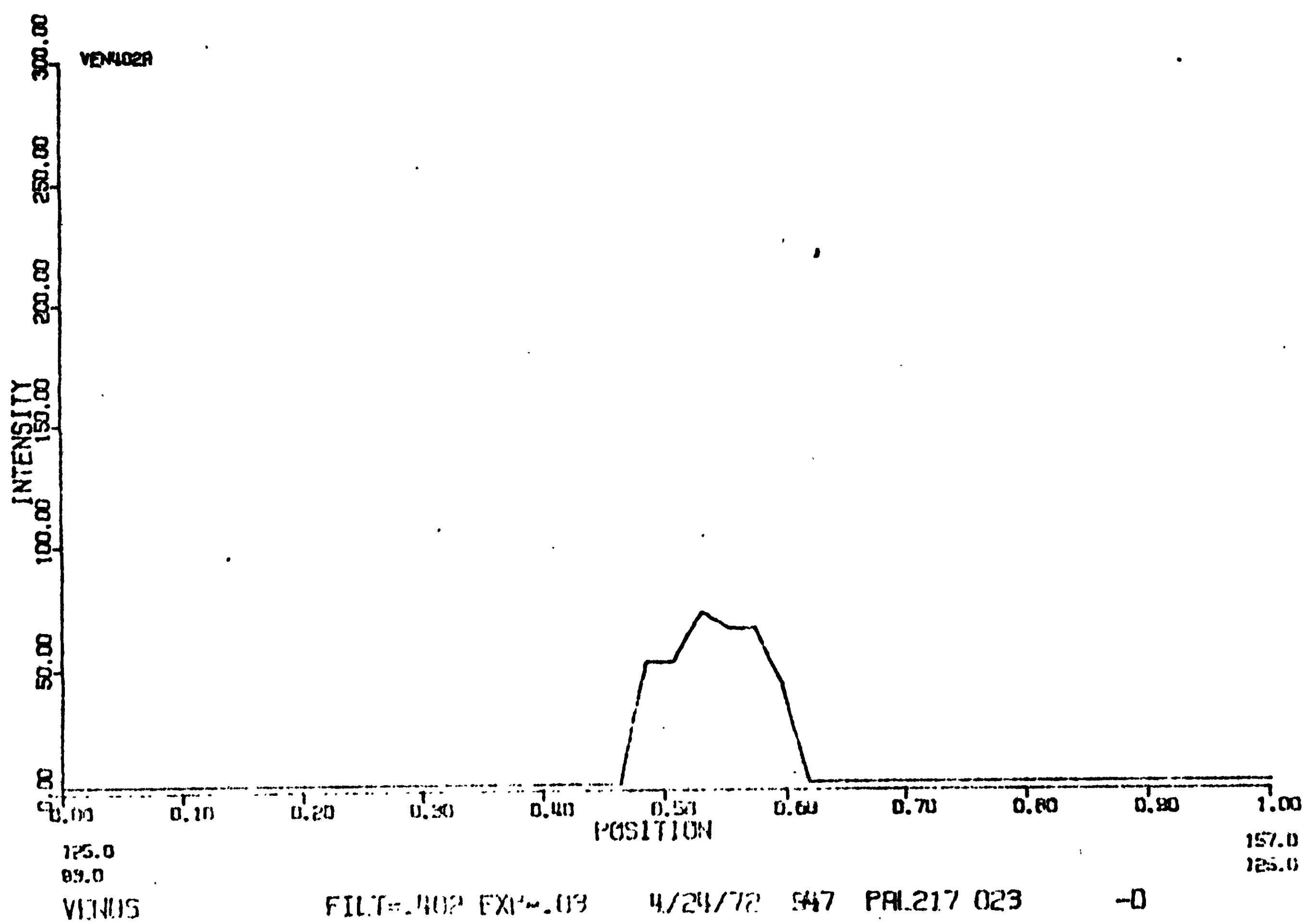
VEN402A
INTENSITY
POSITION
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
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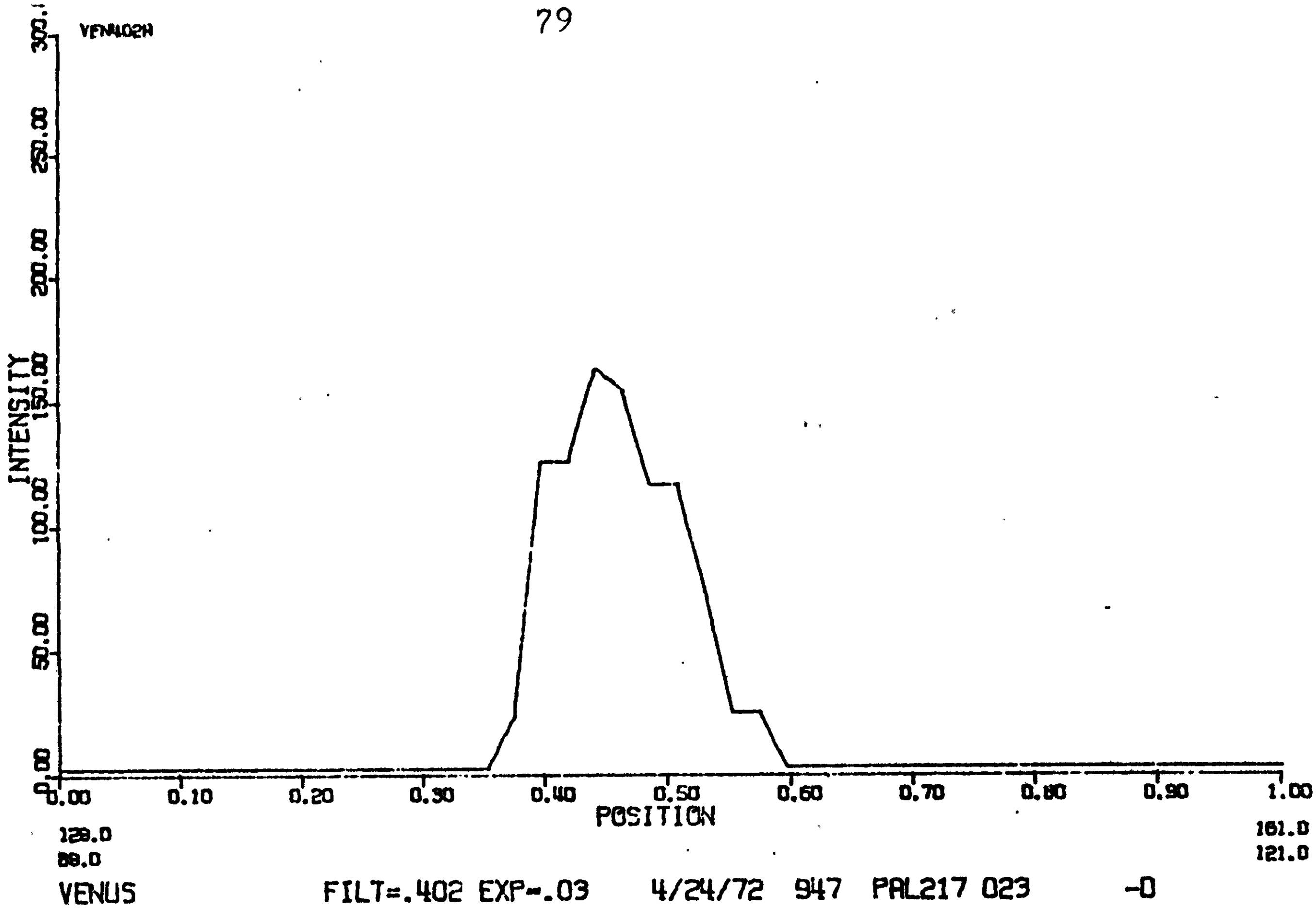
157.0
125.0
VENUS FILT=.402 EXP=.03 4/24/72 947 PAL217 023 -0


VEN402A
INTENSITY
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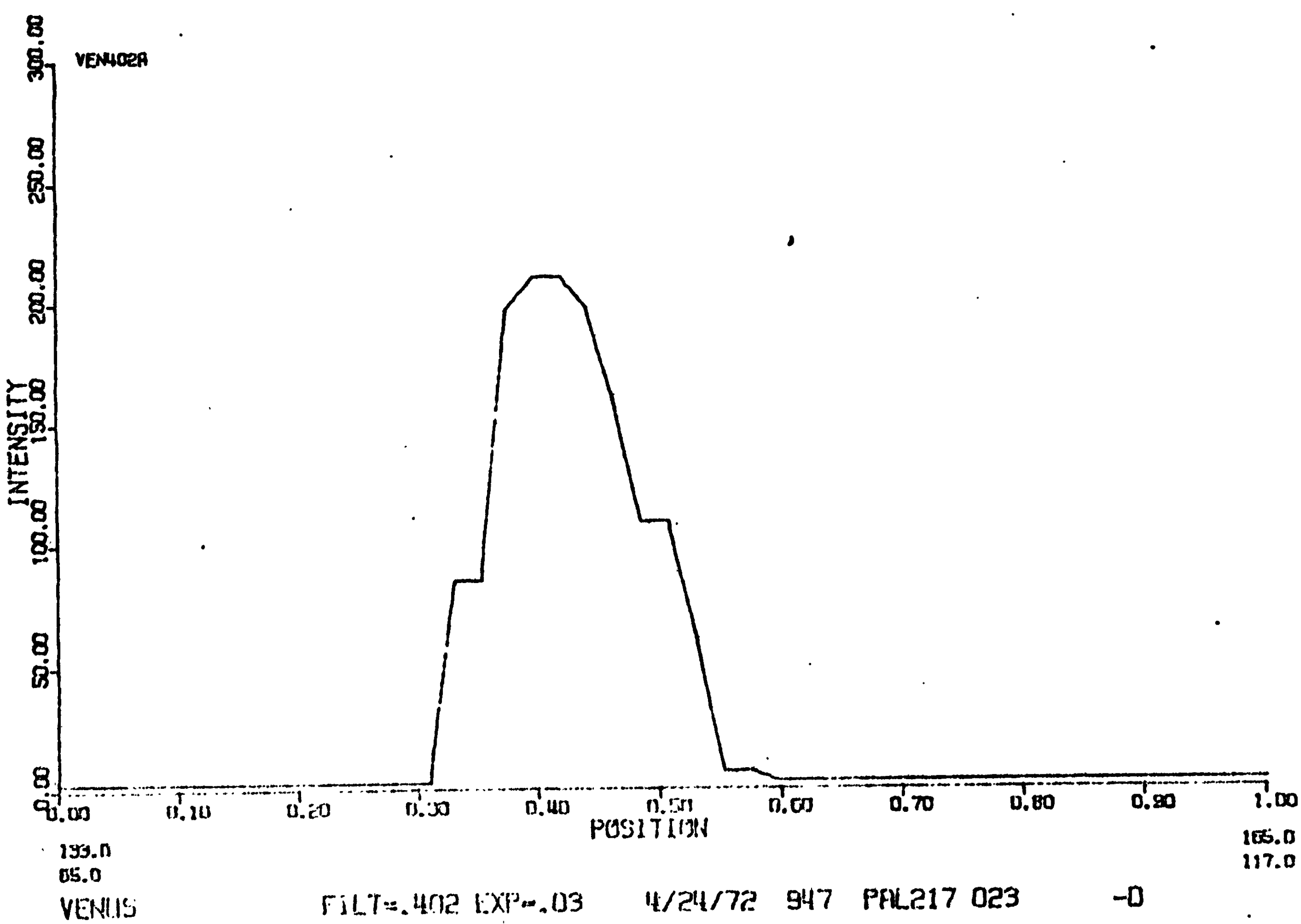
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
129.0
89.0
161.0
121.0
VENUS FILT=.402 EXP=.03 4/24/72 947 PAL217 023 -0


VEN402A
INTENSITY
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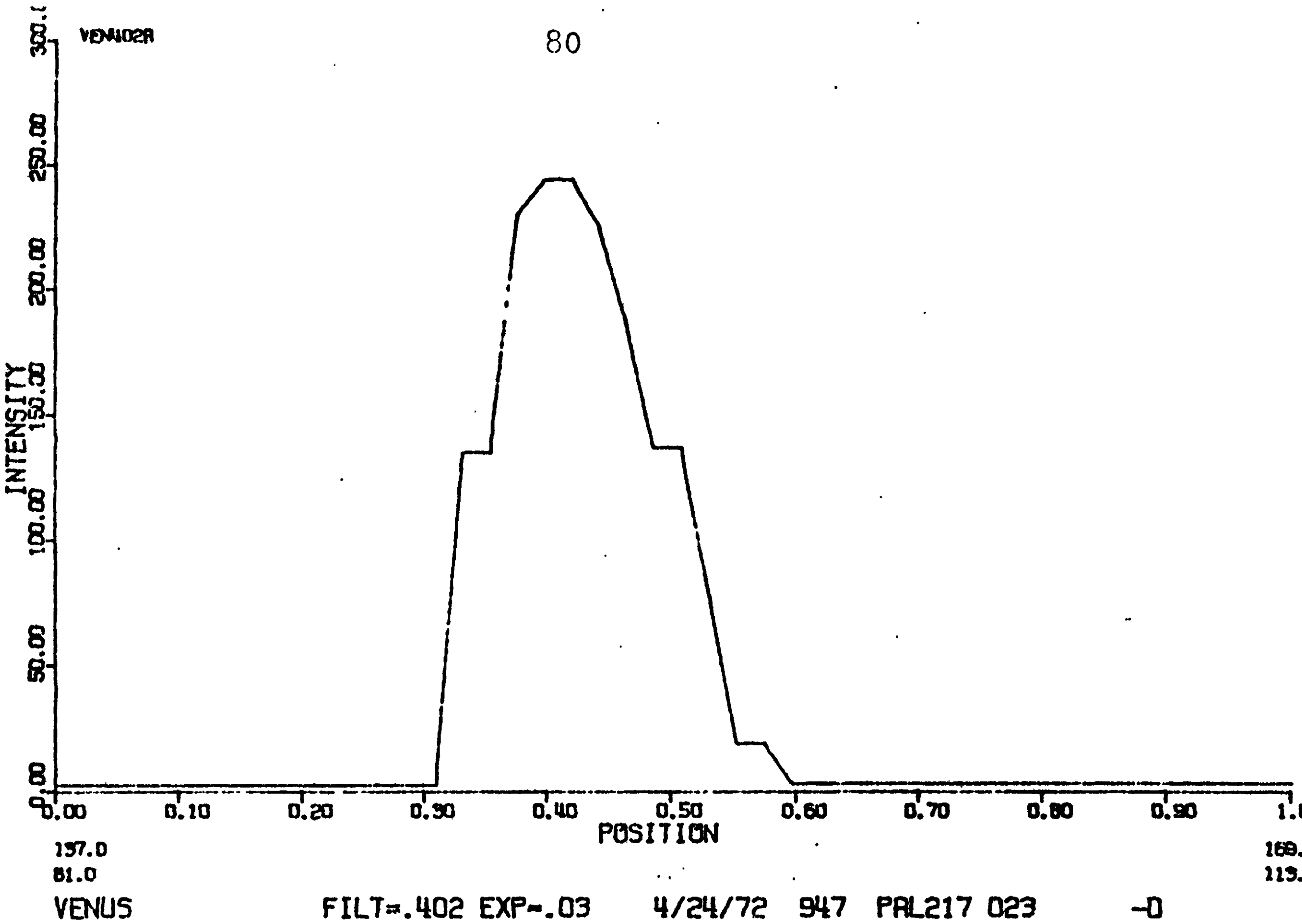
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
133.0
85.0
165.0
117.0
VENUS FILT=.402 EXP=.03 4/24/72 947 PAL217 023 -0


VEN402A
INTENSITY
POSITION
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169.0
115.0
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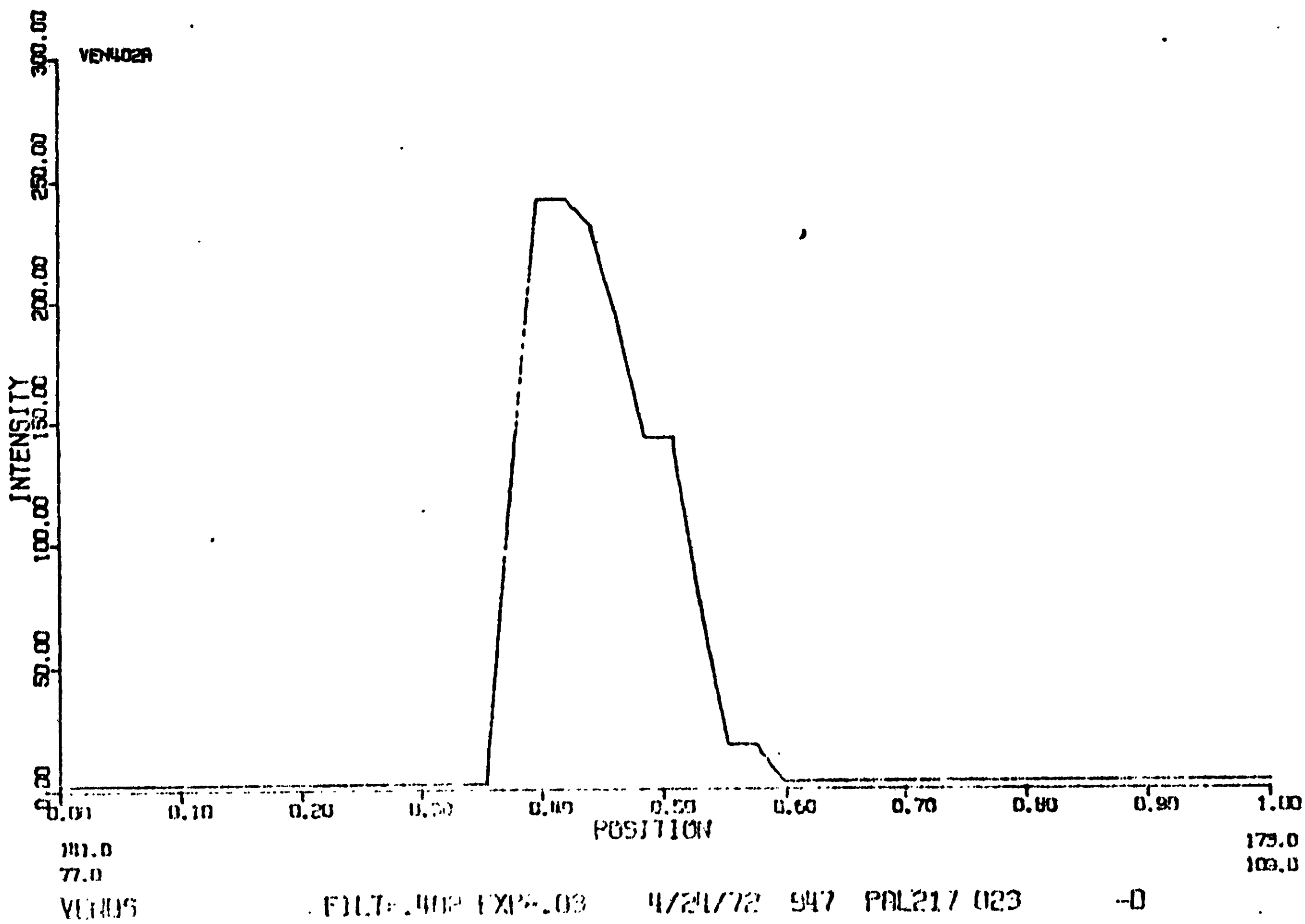
VEN402A
INTENSITY
POSITION
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175.0
103.0
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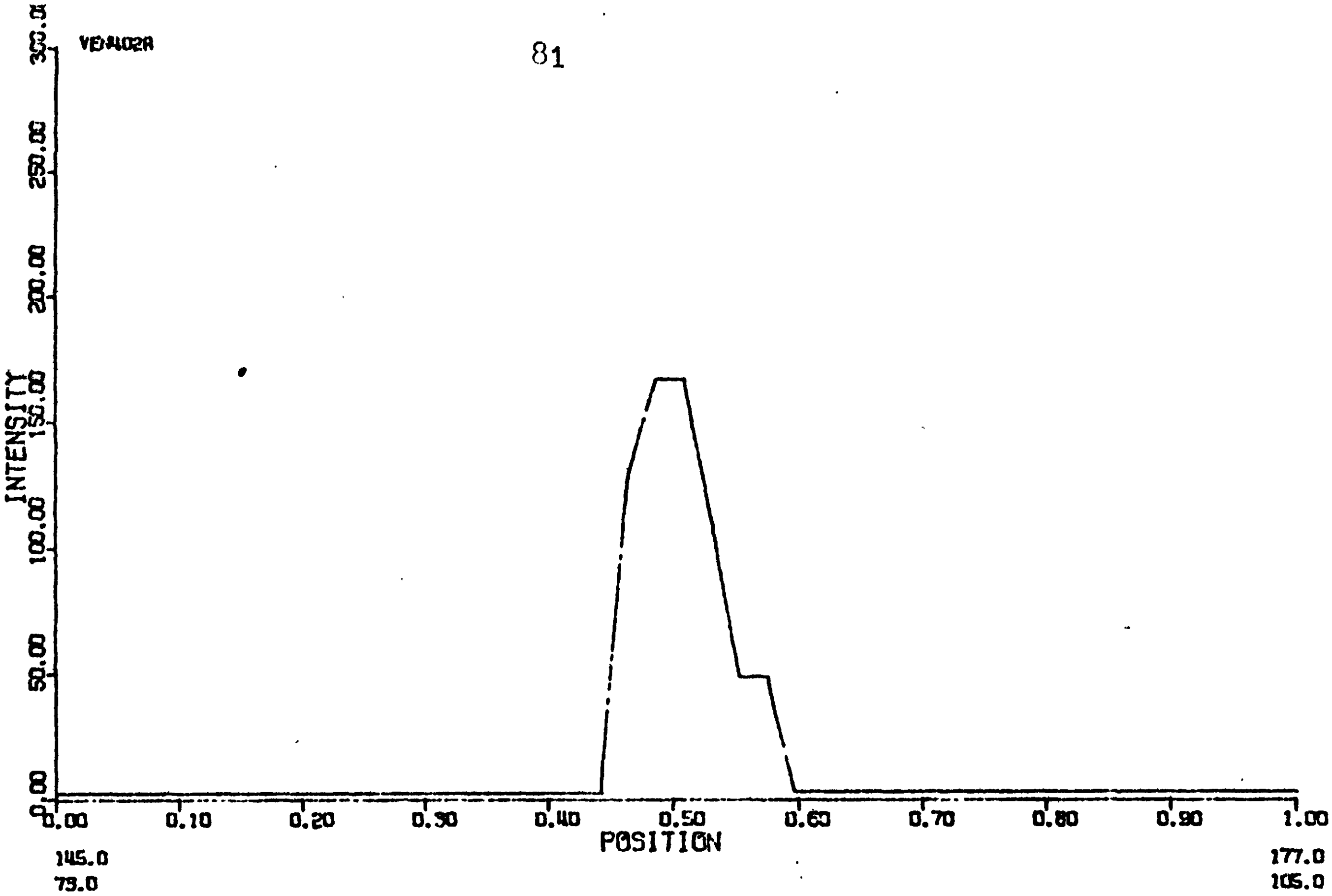

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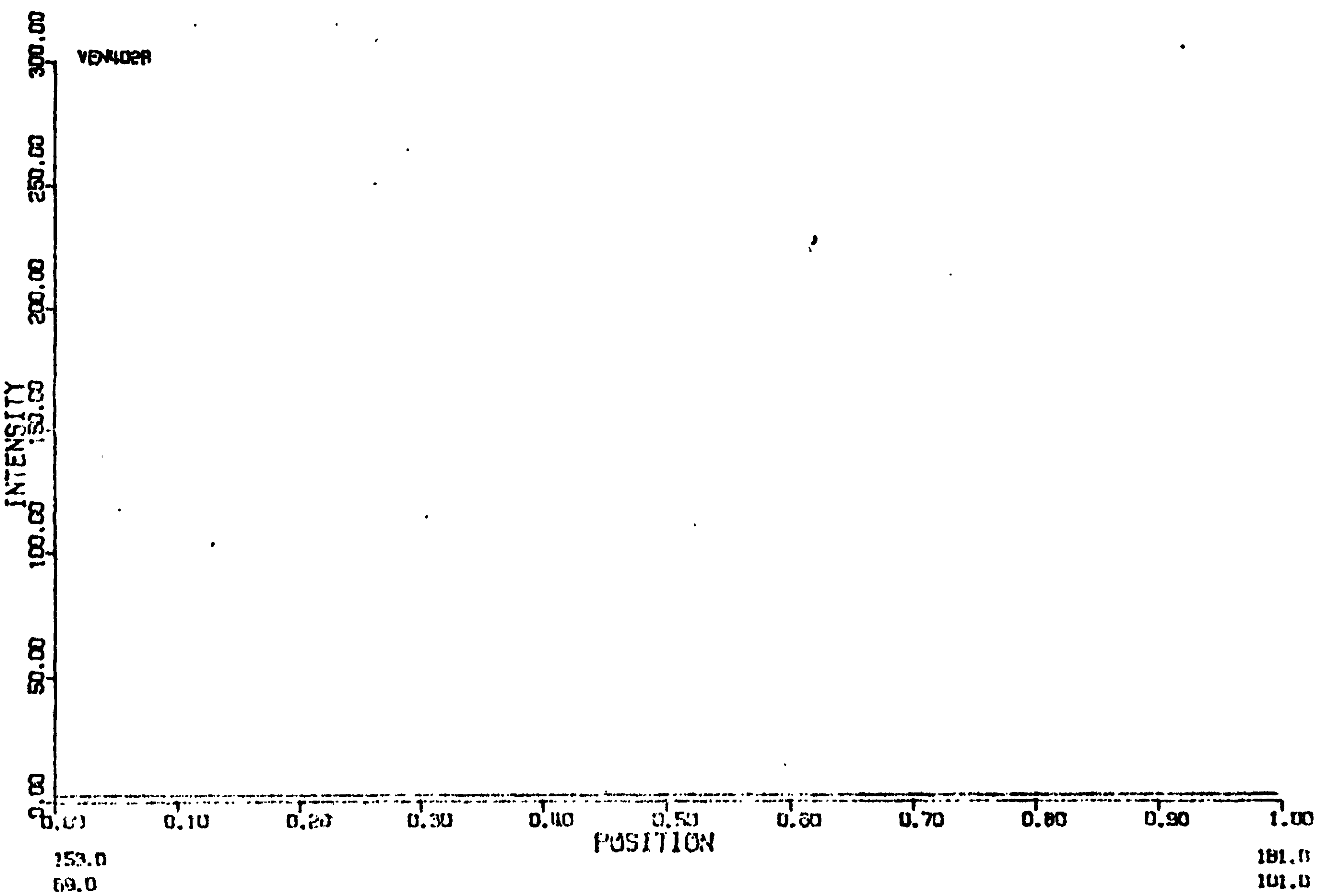

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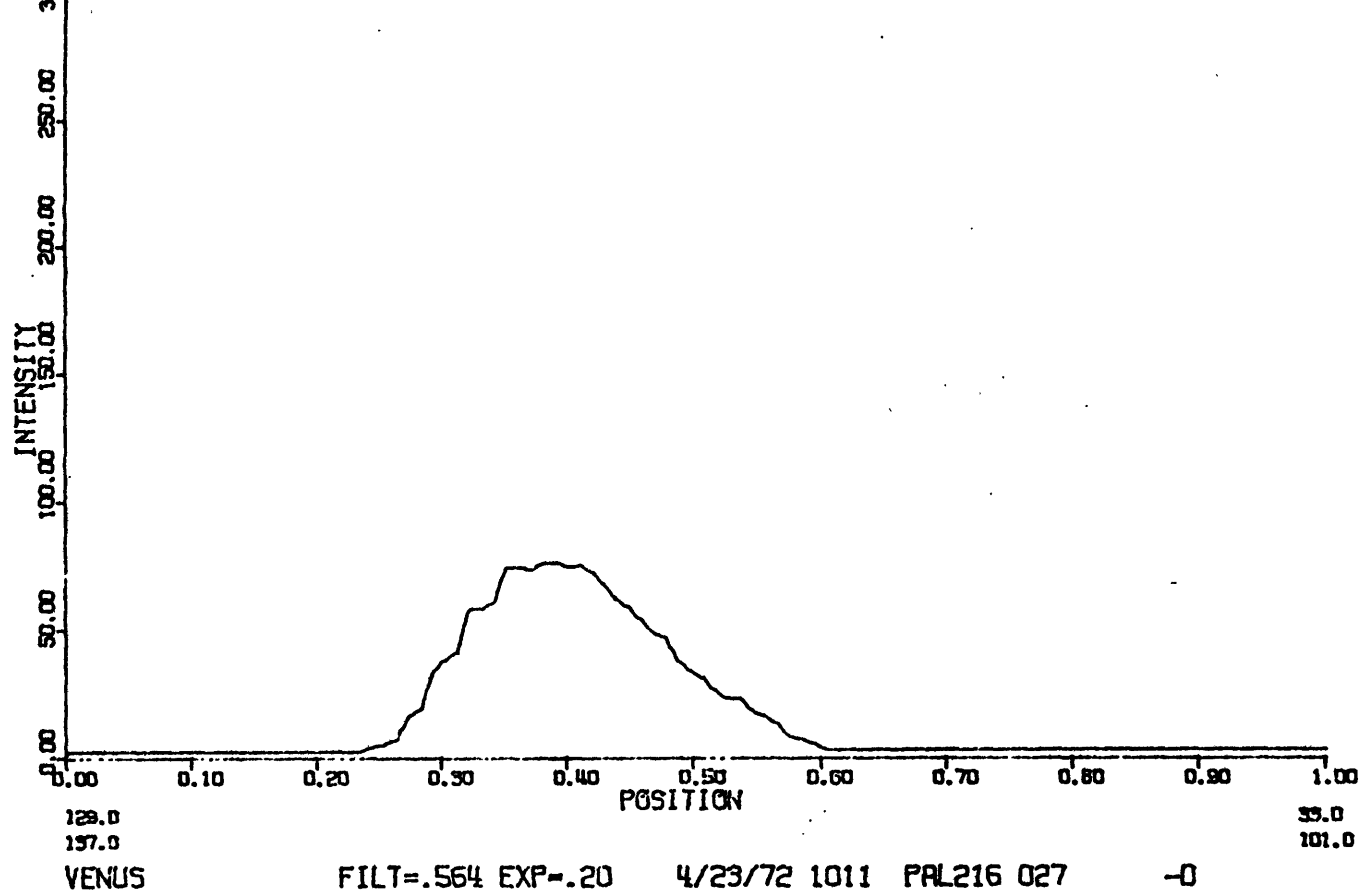
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INTENSITY
POSITION
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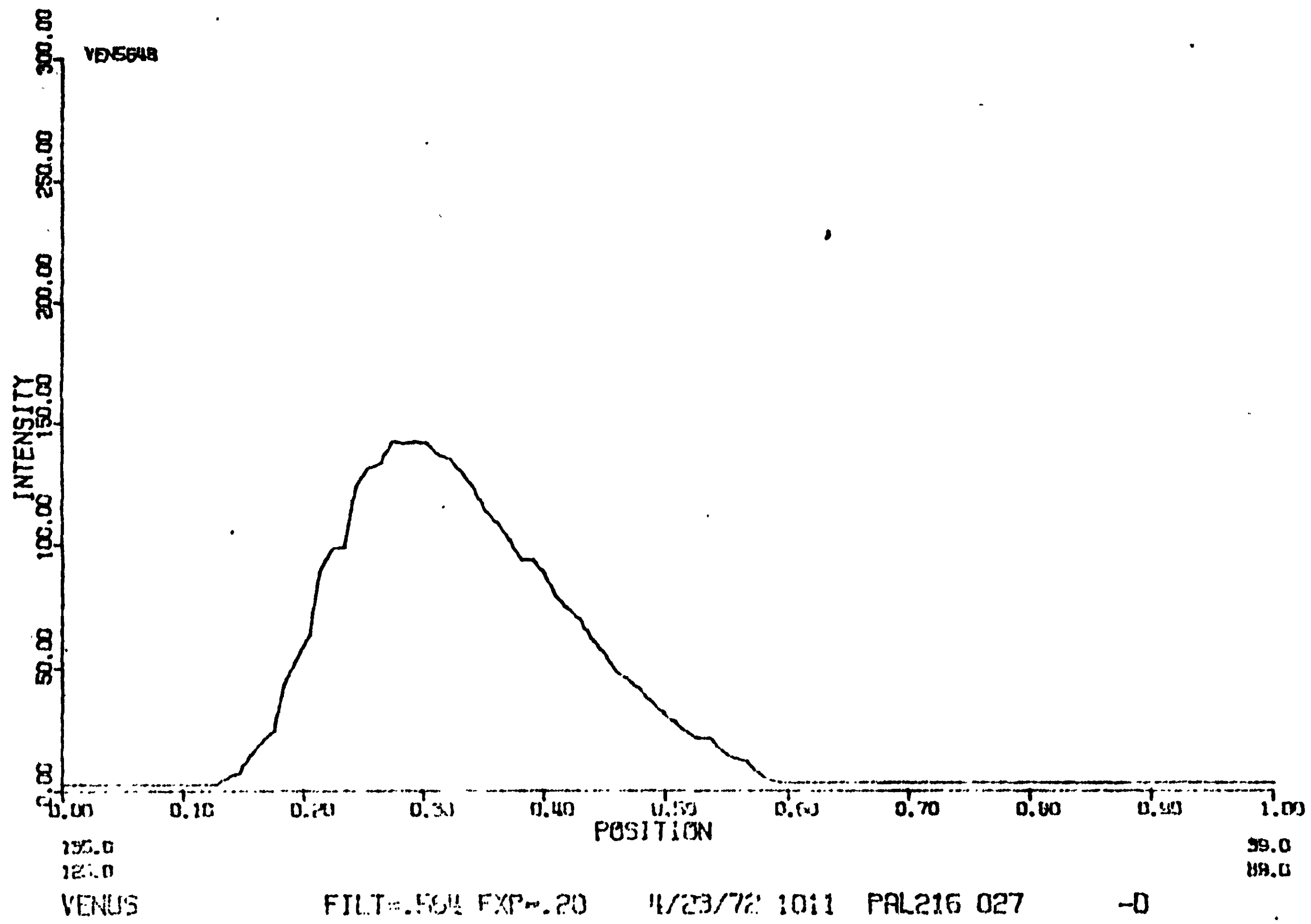
50.00 100.00 150.00 200.00 250.00
129.0
157.0
39.0
101.0
VENUS FILT=.564 EXP=.20 4/23/72 1011 PAL216 027 -0


VENS648
INTENSITY
POSITION
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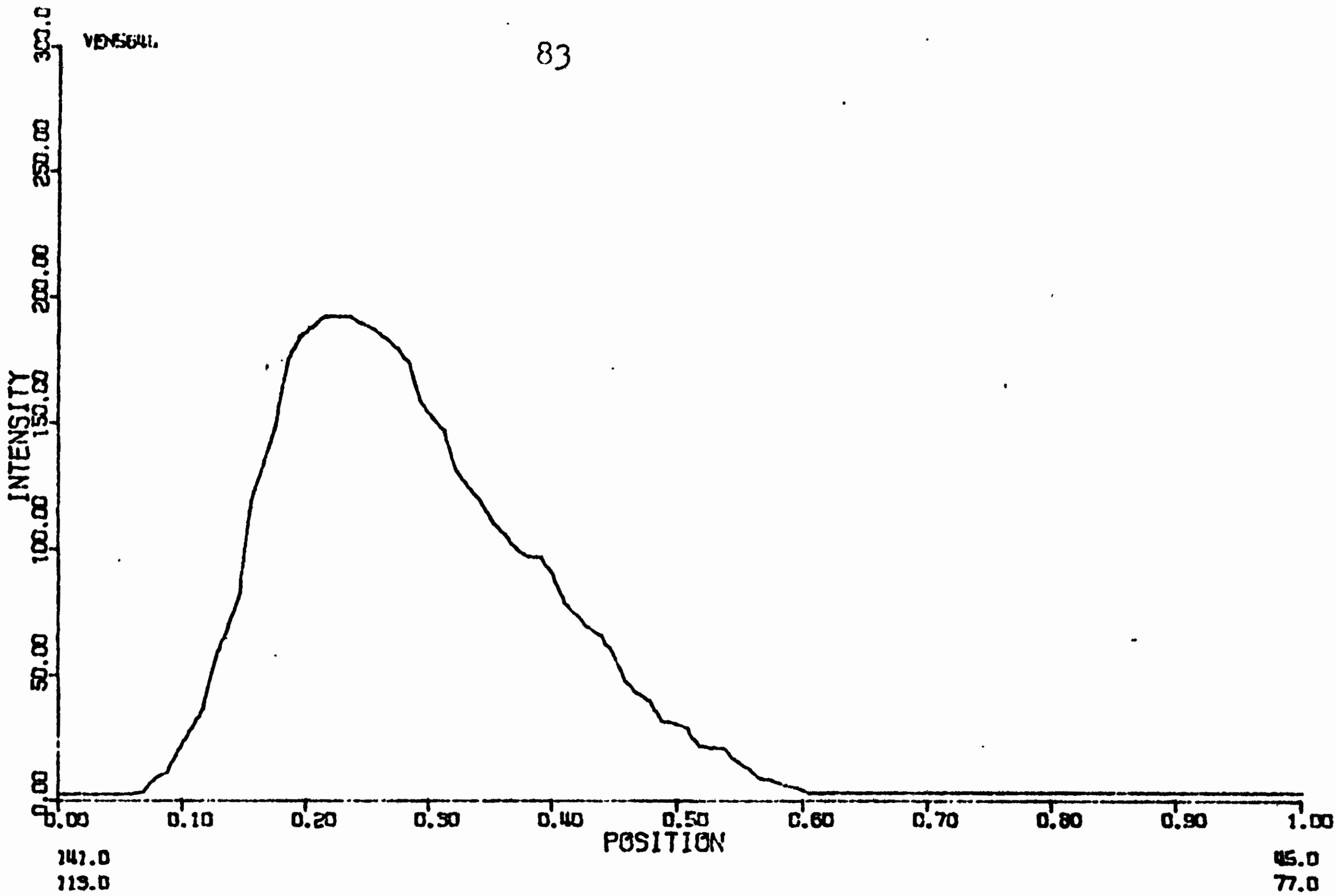
39.0
88.0
VENUS FILT=.564 EXP=.20 4/23/72 1011 PAL216 027 -0



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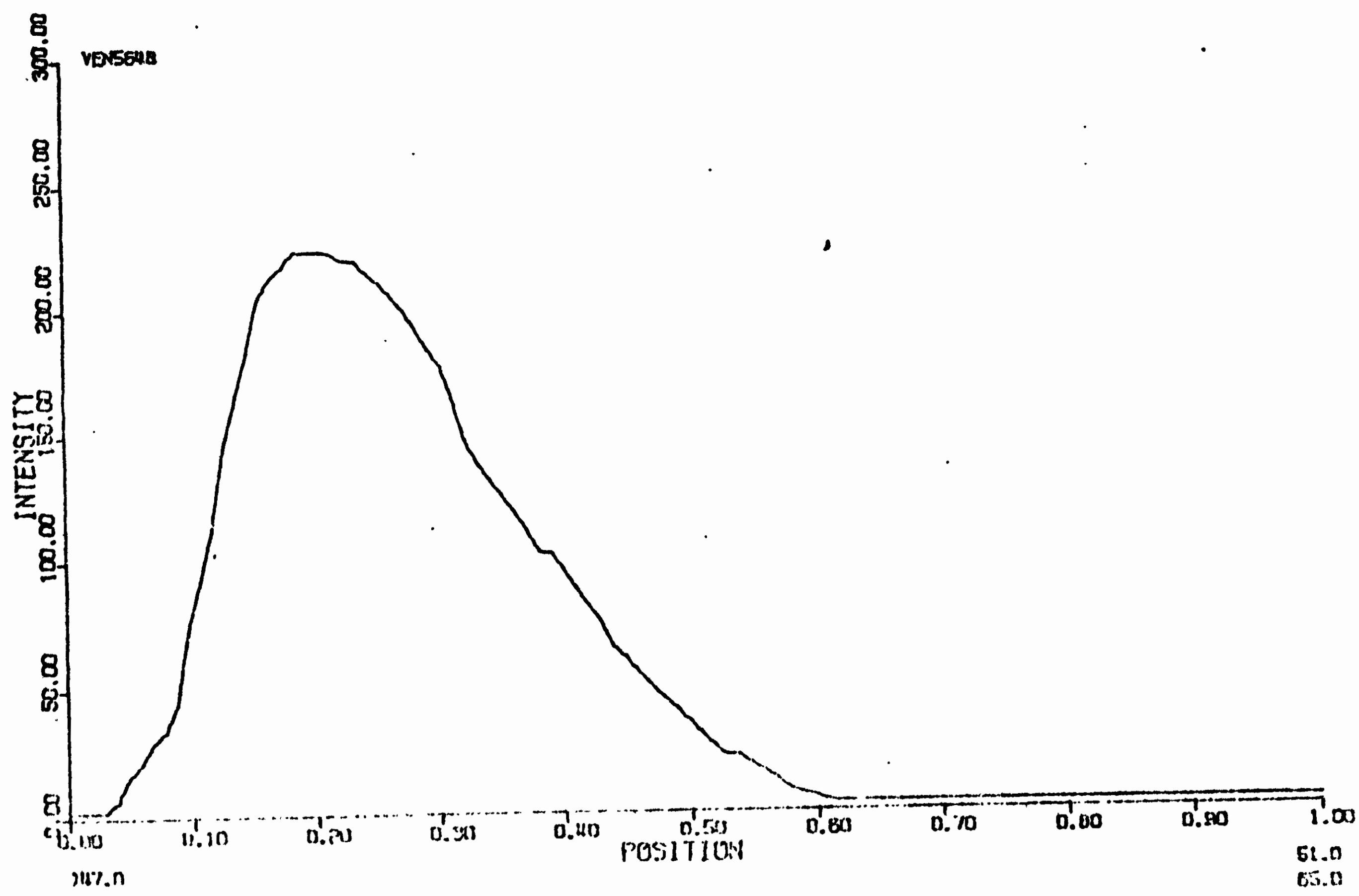
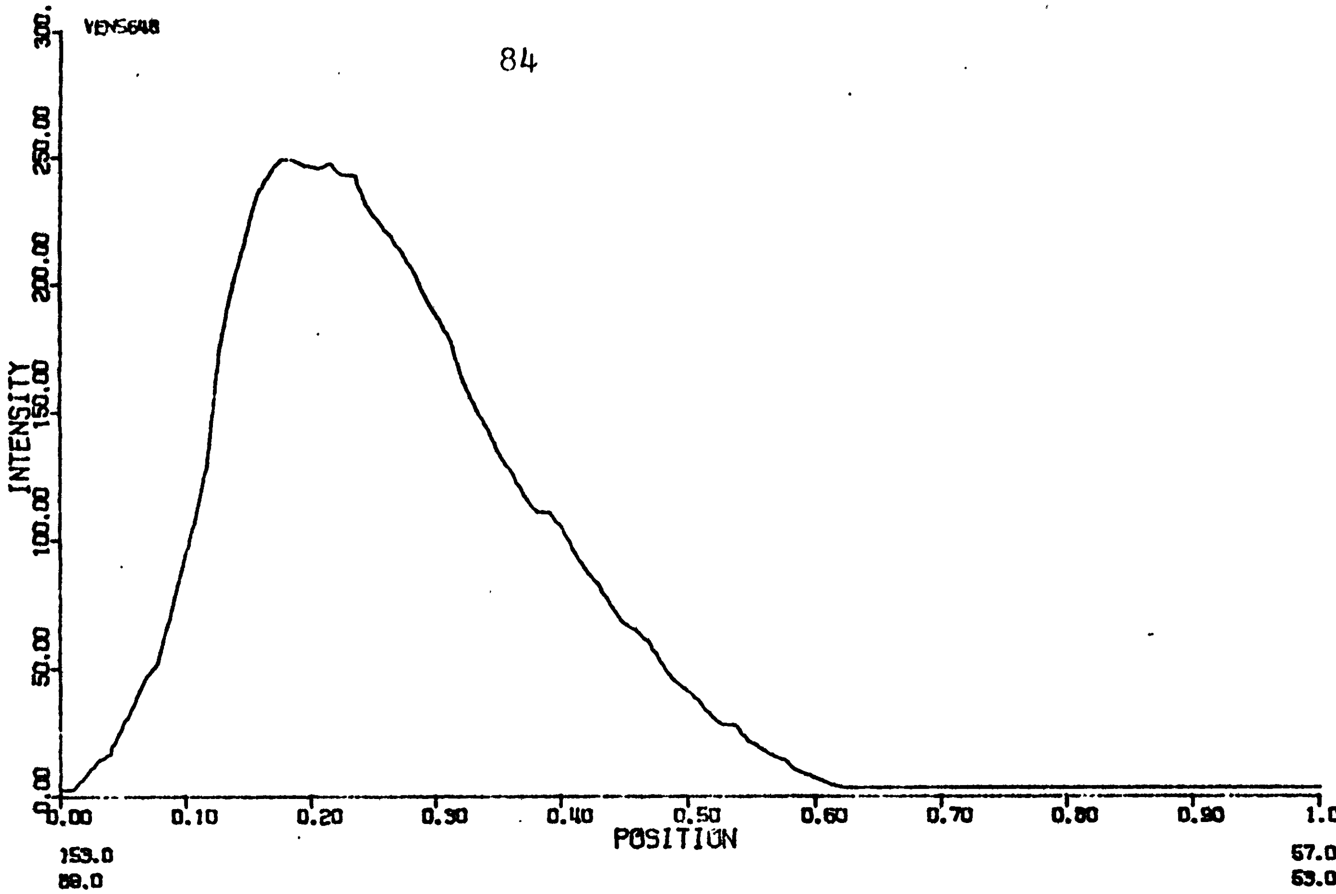
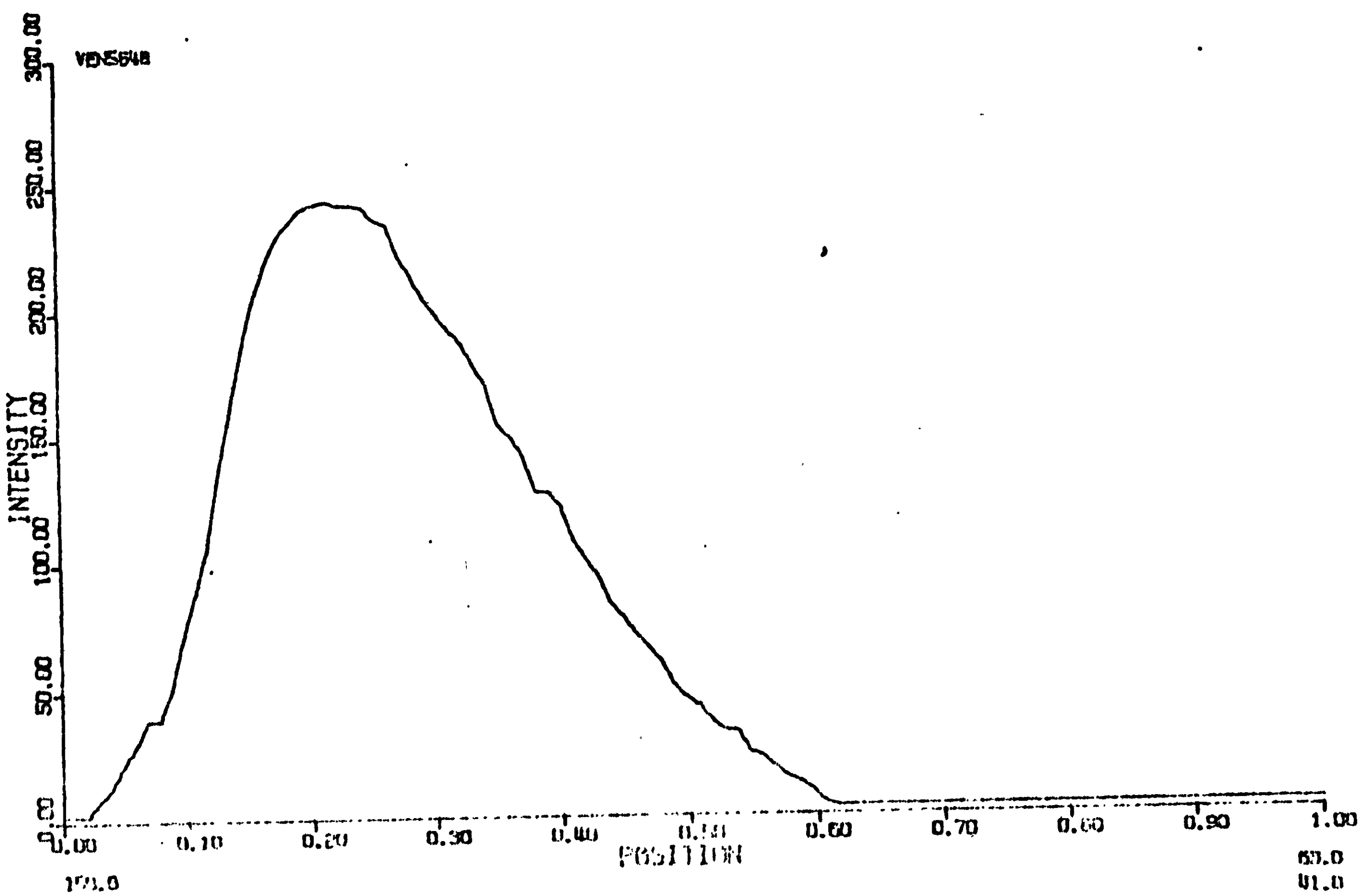


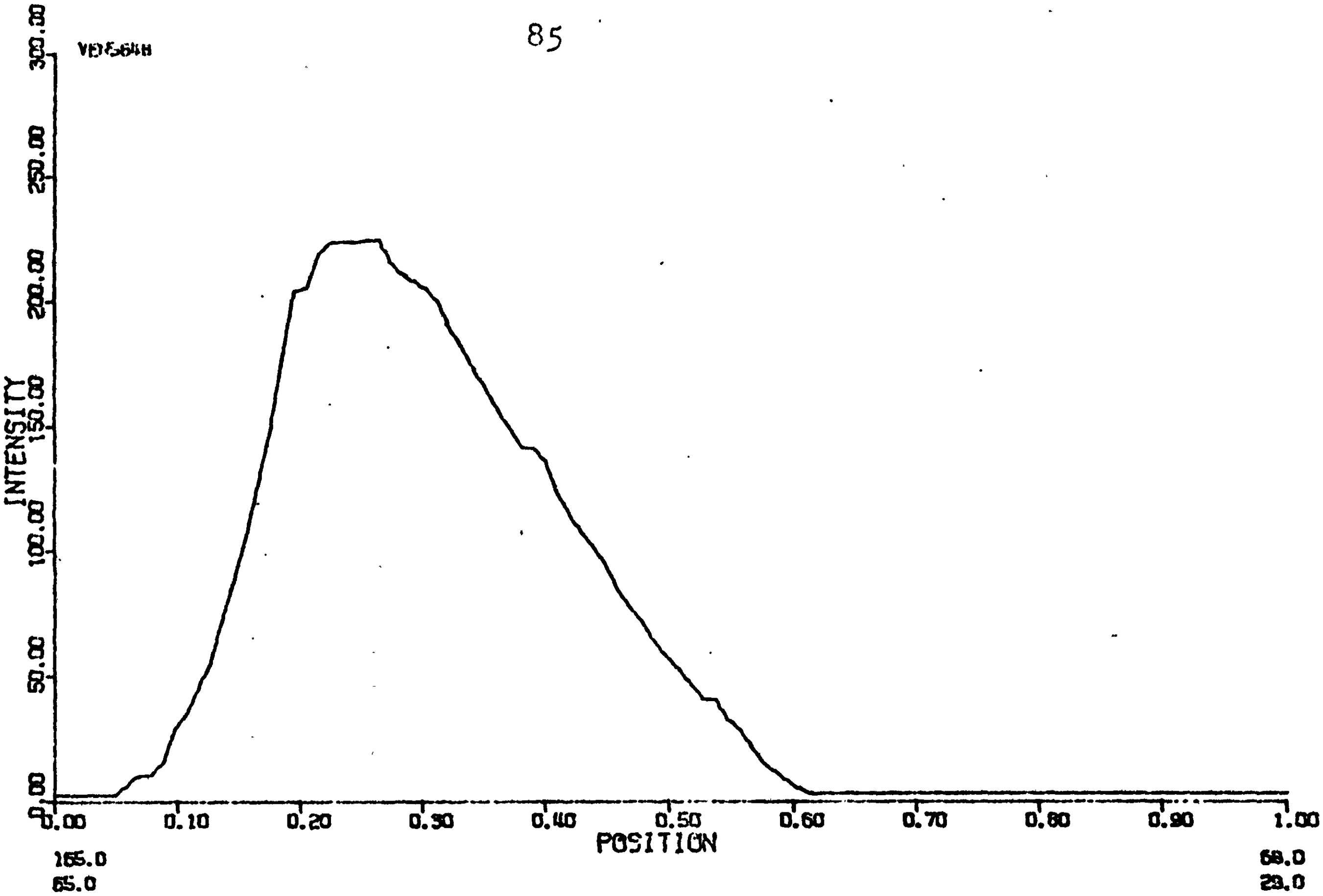
VENUS FILT=.[illegible] EXP=.20 4/23/72 1011 PAL216 027 -D



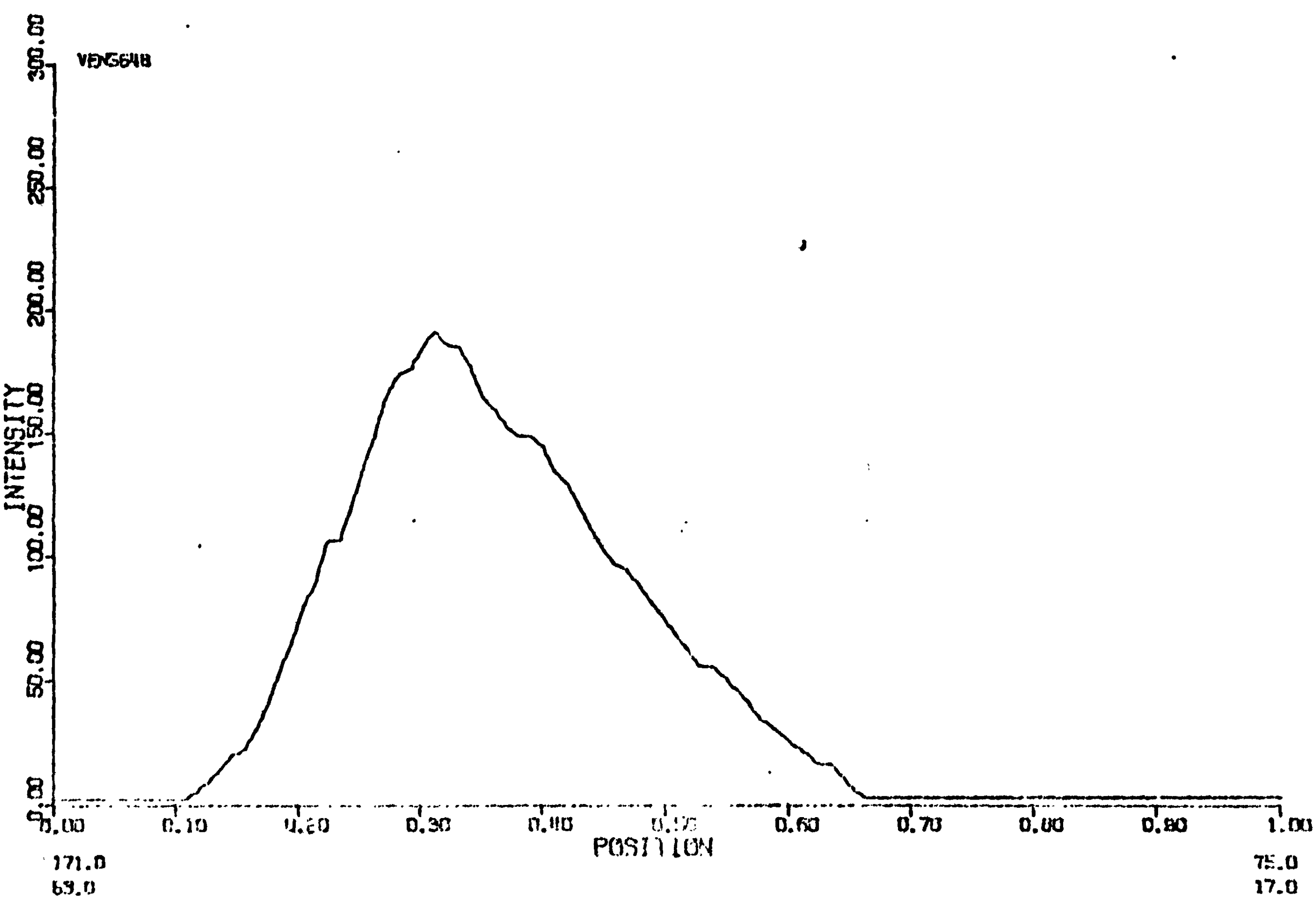
VENUS FILT=.564 EXP=.20 4/23/72 1011 PAL216 027 -0



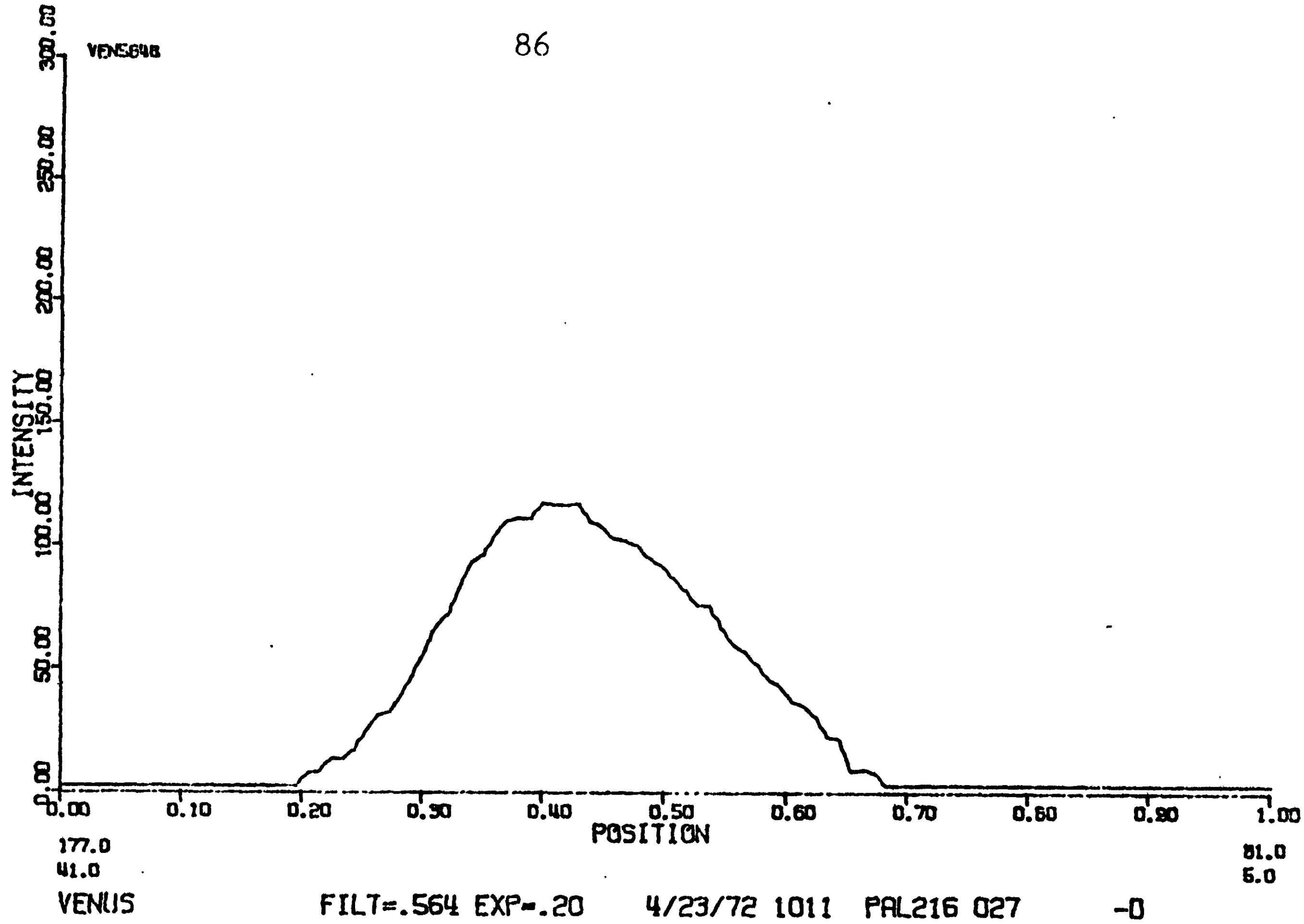
VENUS FILT=.568 EXP=.20 4/23/72 1011 PAL216 027 -0



VENUS FILT=.564 EXP=.20 4/23/72 1011 PAL216 027 —0



VENUS FILT=.564 EXP=.20 4/23/72 1011 PAL216 027 —0


VEN564B
INTENSITY
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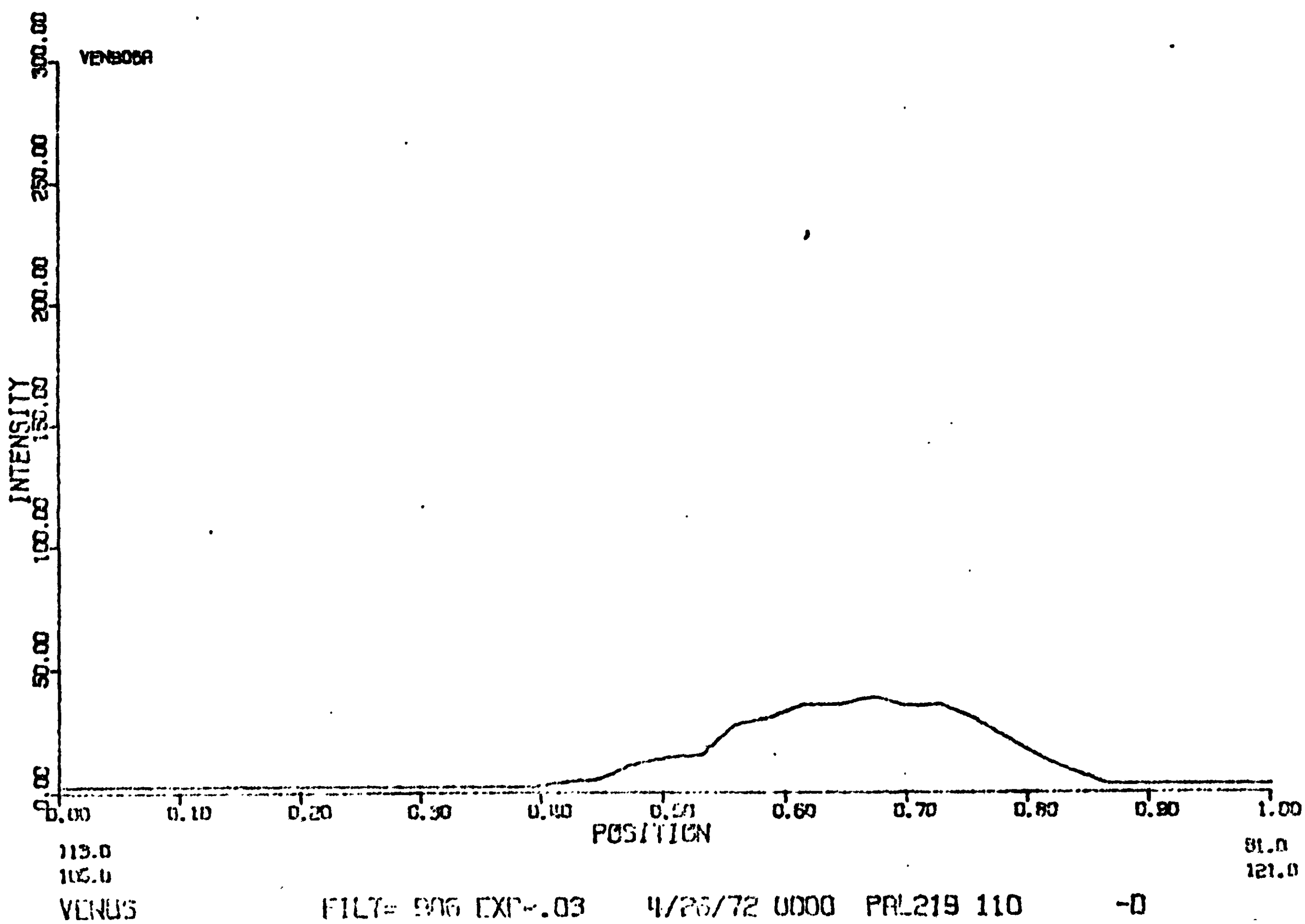
250.00
200.00
150.00
100.00
50.00
0.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
177.0
41.0
81.0
6.0
VENUS FILT=.564 EXP=.20 4/23/72 1011 PAL216 027 -0


VEN806A
INTENSITY
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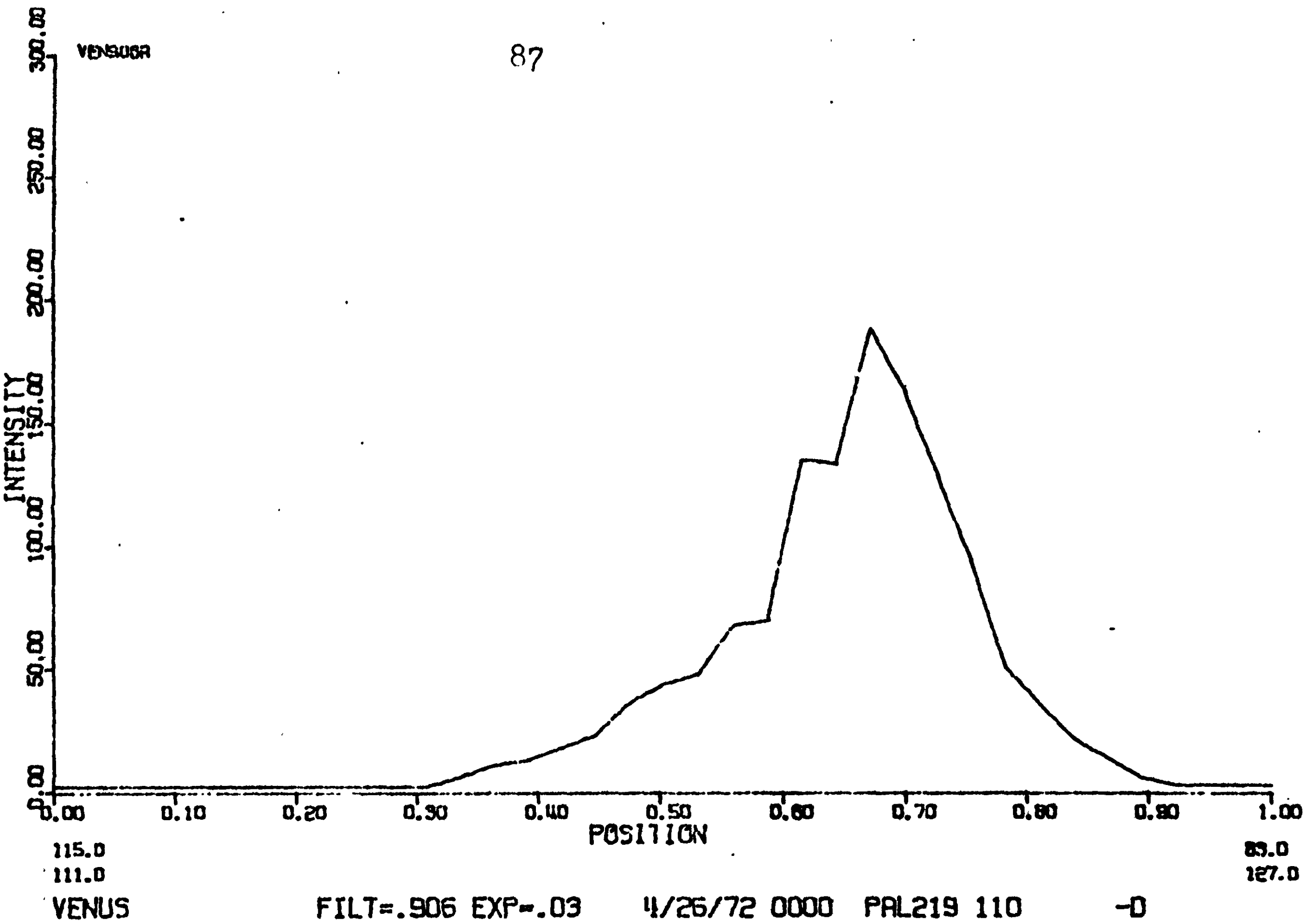
250.00
200.00
150.00
100.00
50.00
0.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
113.0
105.0
81.0
121.0
VENUS FILT=.806 EXP=.03 4/26/72 0000 PAL219 110 -0


VENS06A
INTENSITY
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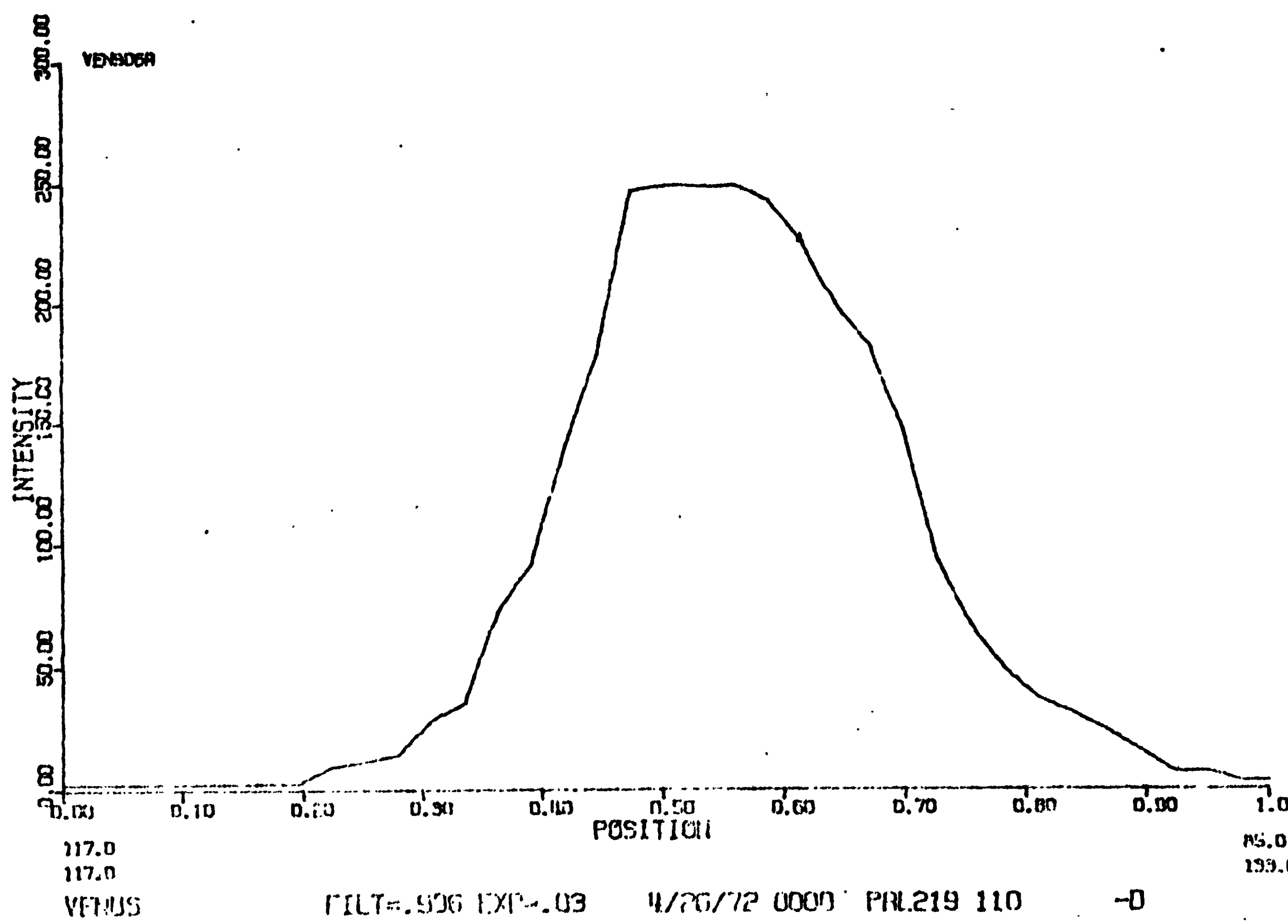
50.00
100.00
150.00
200.00
250.00
300.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
115.0
111.0
85.0
127.0
VENUS FILT=.906 EXP=.03 4/26/72 0000 PAL219 110 -0


VENS06A
INTENSITY
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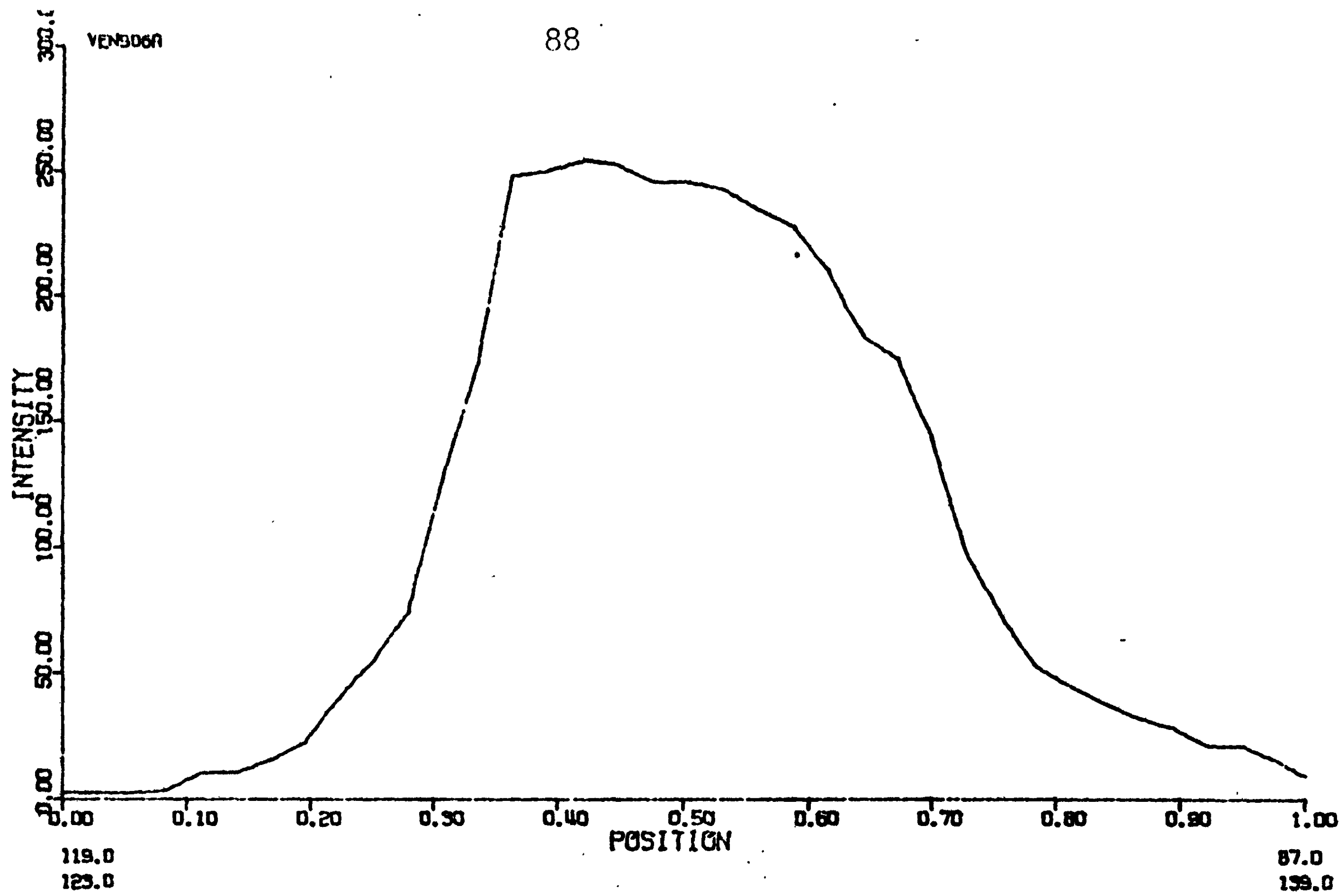
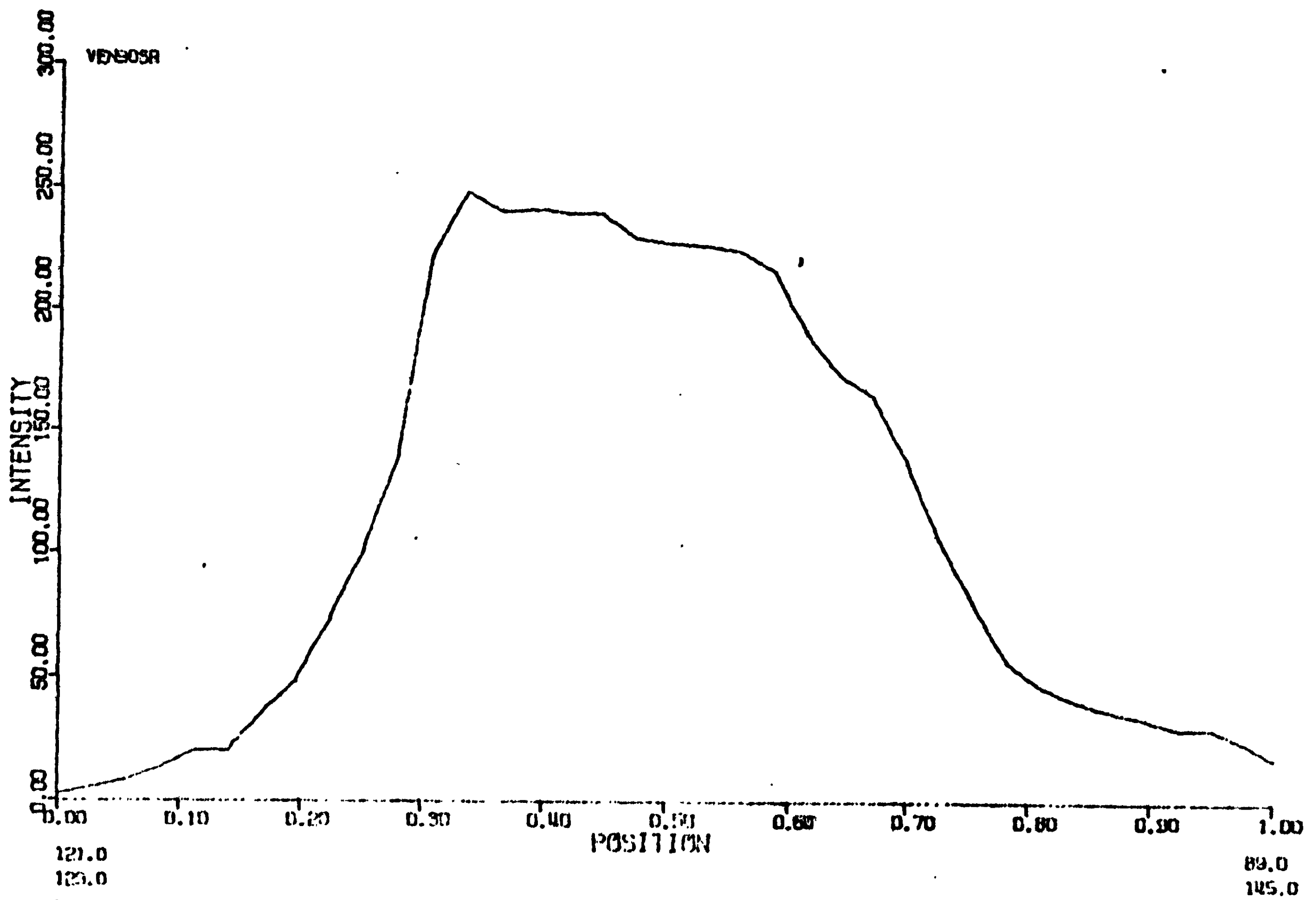
50.00
100.00
150.00
200.00
250.00
300.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
117.0
117.0
85.0
133.0
VENUS FILT=.906 EXP=.03 4/26/72 0000 PAL219 110 -0



VENUS FILT=.906 EXP=.03 4/26/72 0000 PAL219 110 -D



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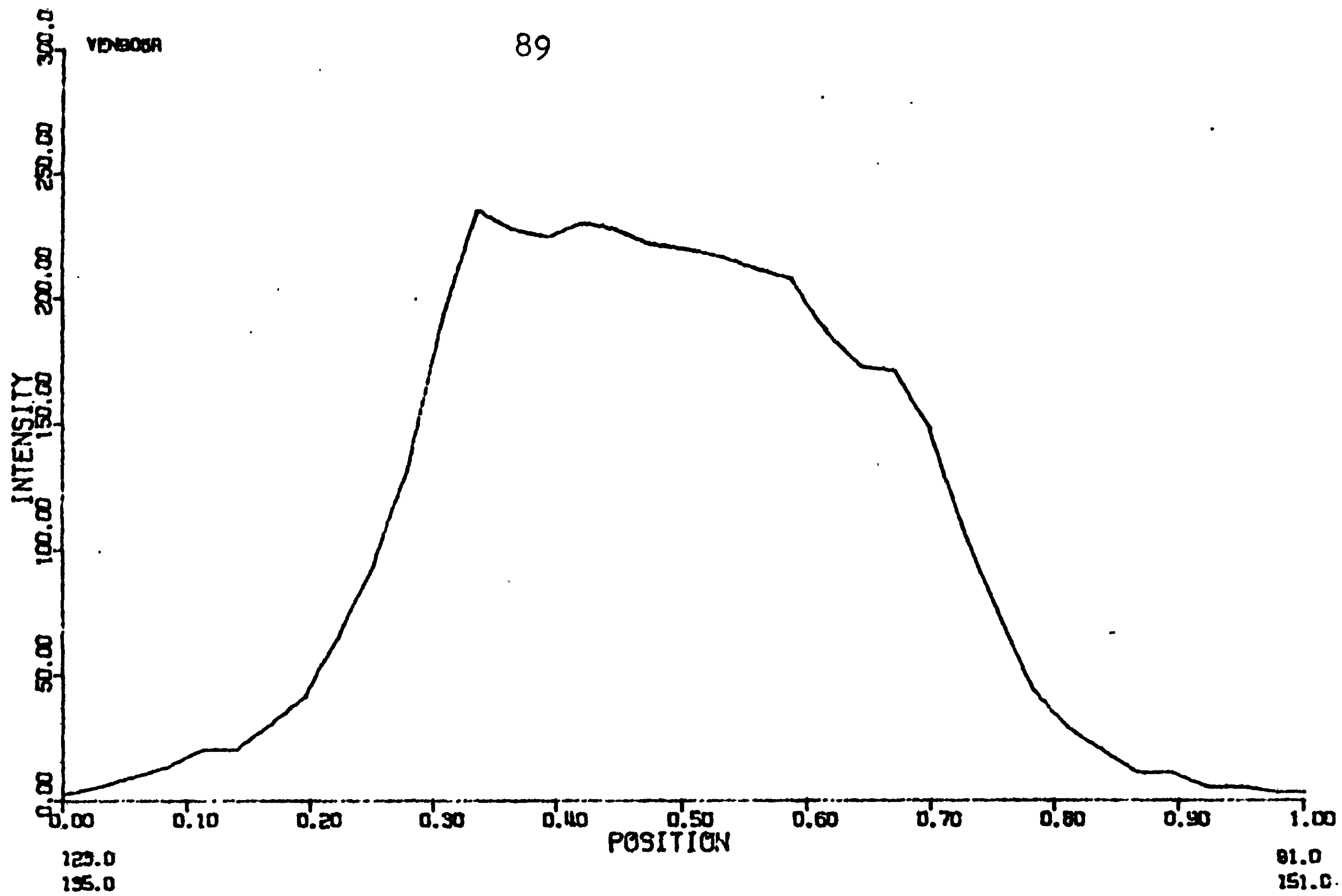

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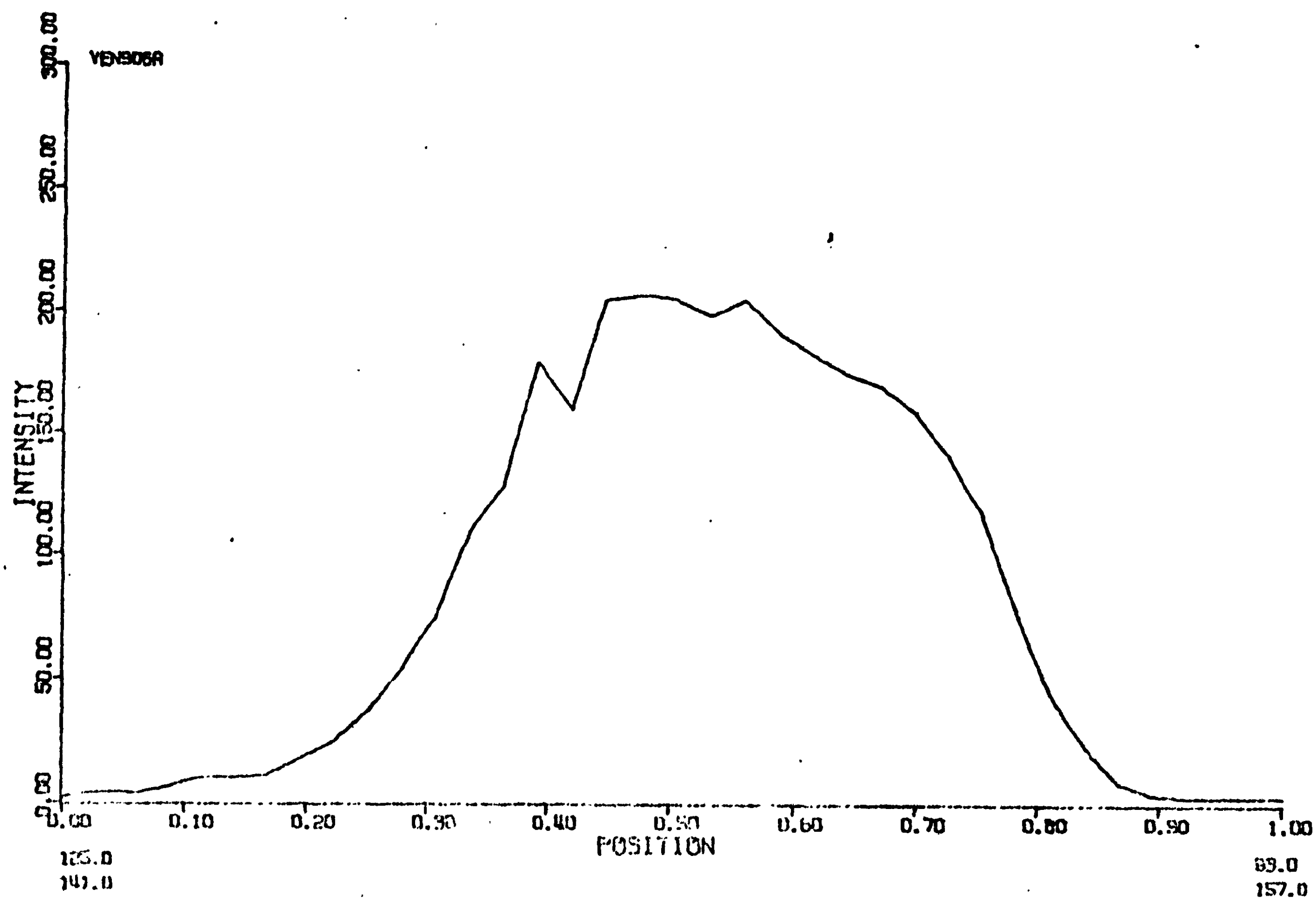

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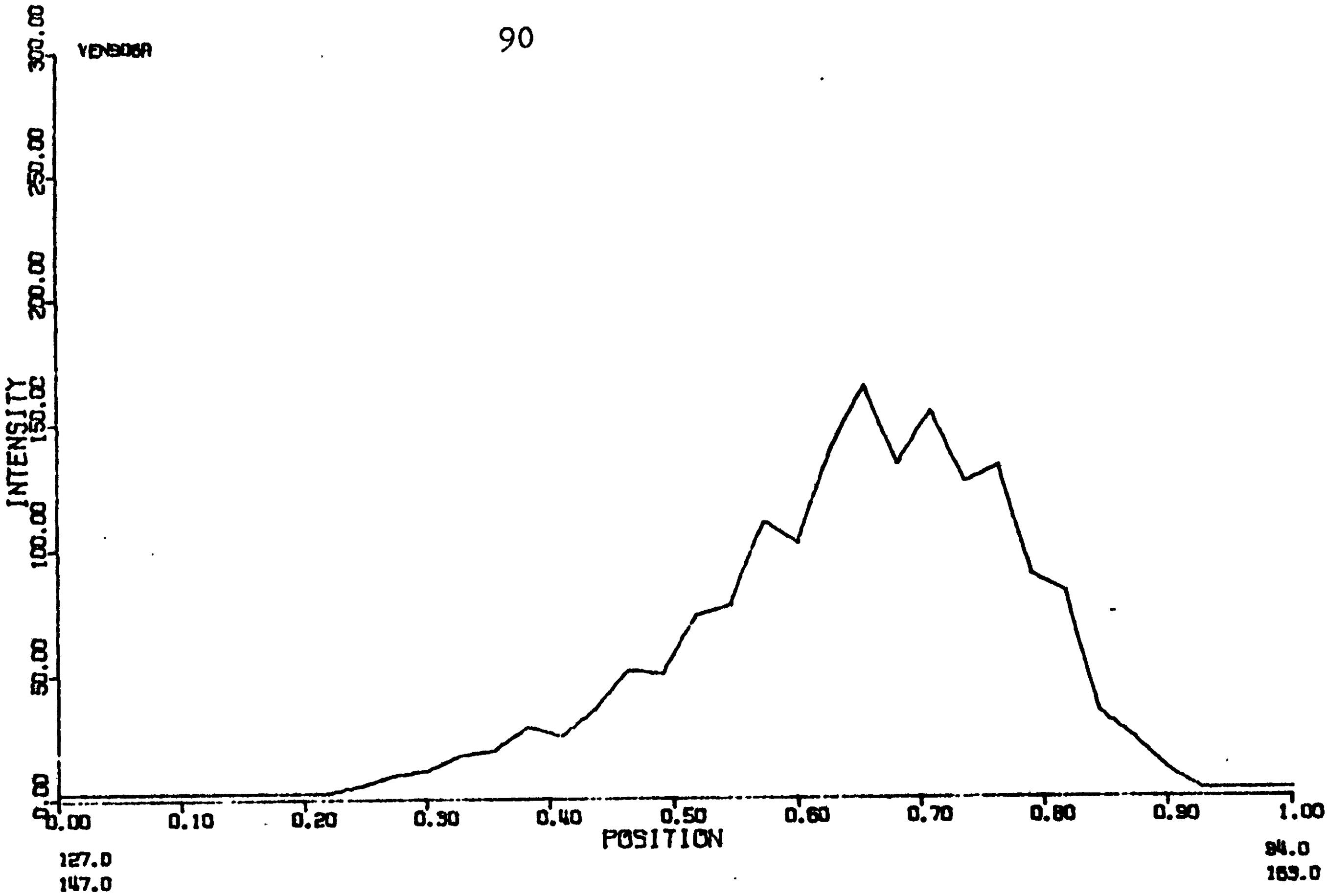

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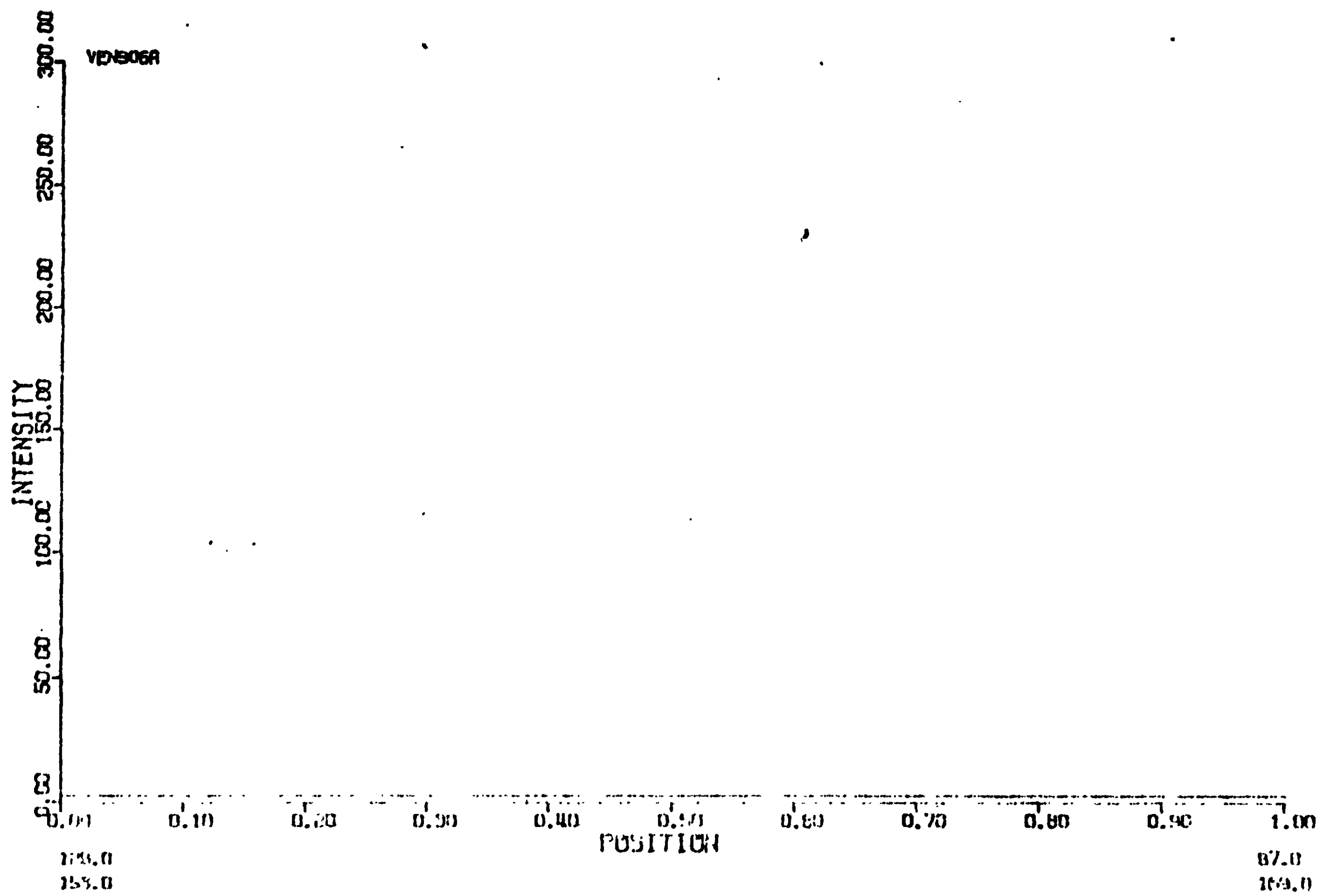
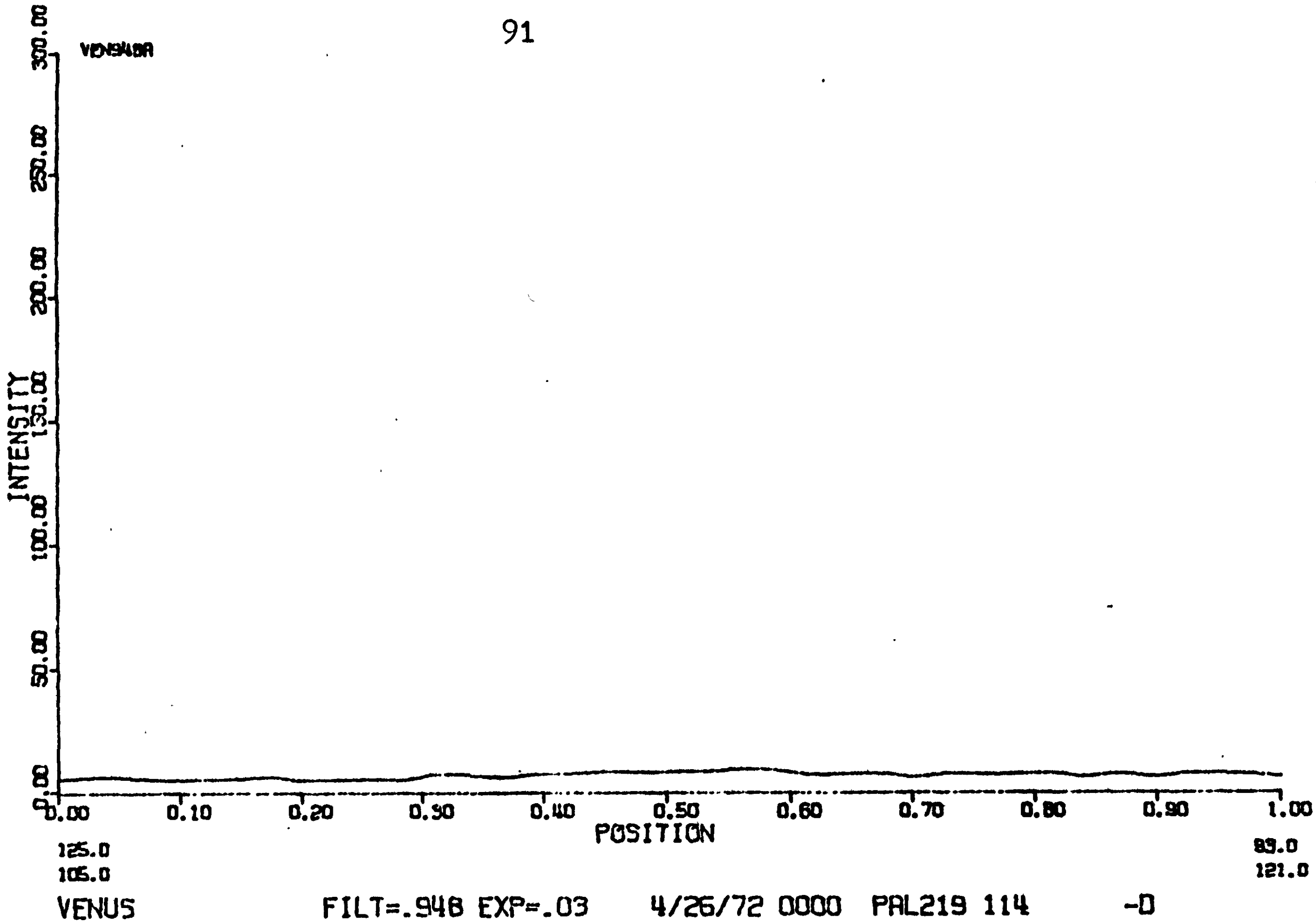


VENUS FILT=.906 EXP=.03 4/26/72 0000 PAL219 110 -0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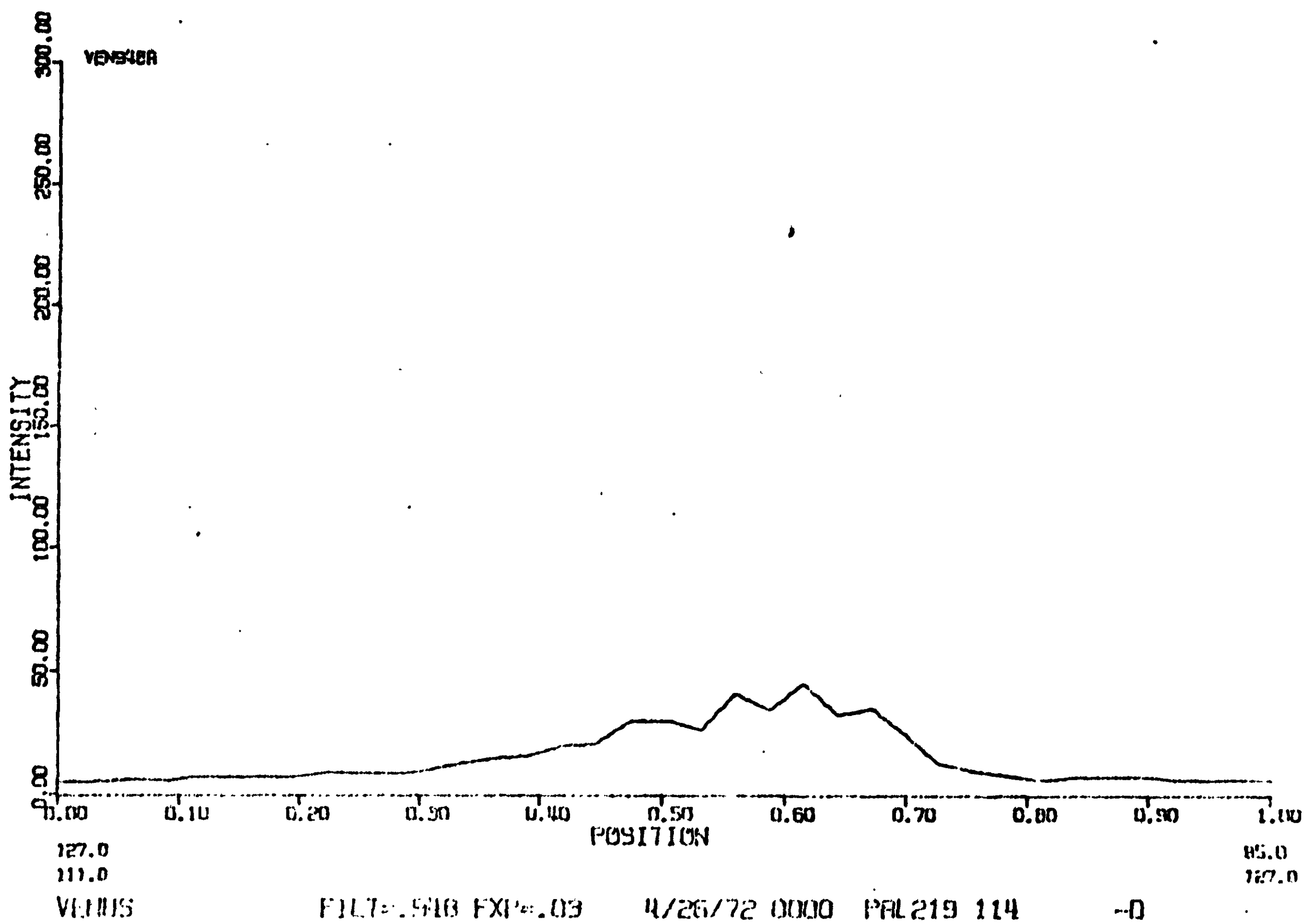
150.00
200.00
250.00
300.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
125.0
105.0
83.0
121.0
VENUS FILT=.948 EXP=.03 4/26/72 0000 PAL219 114 -D


VEN948A
INTENSITY
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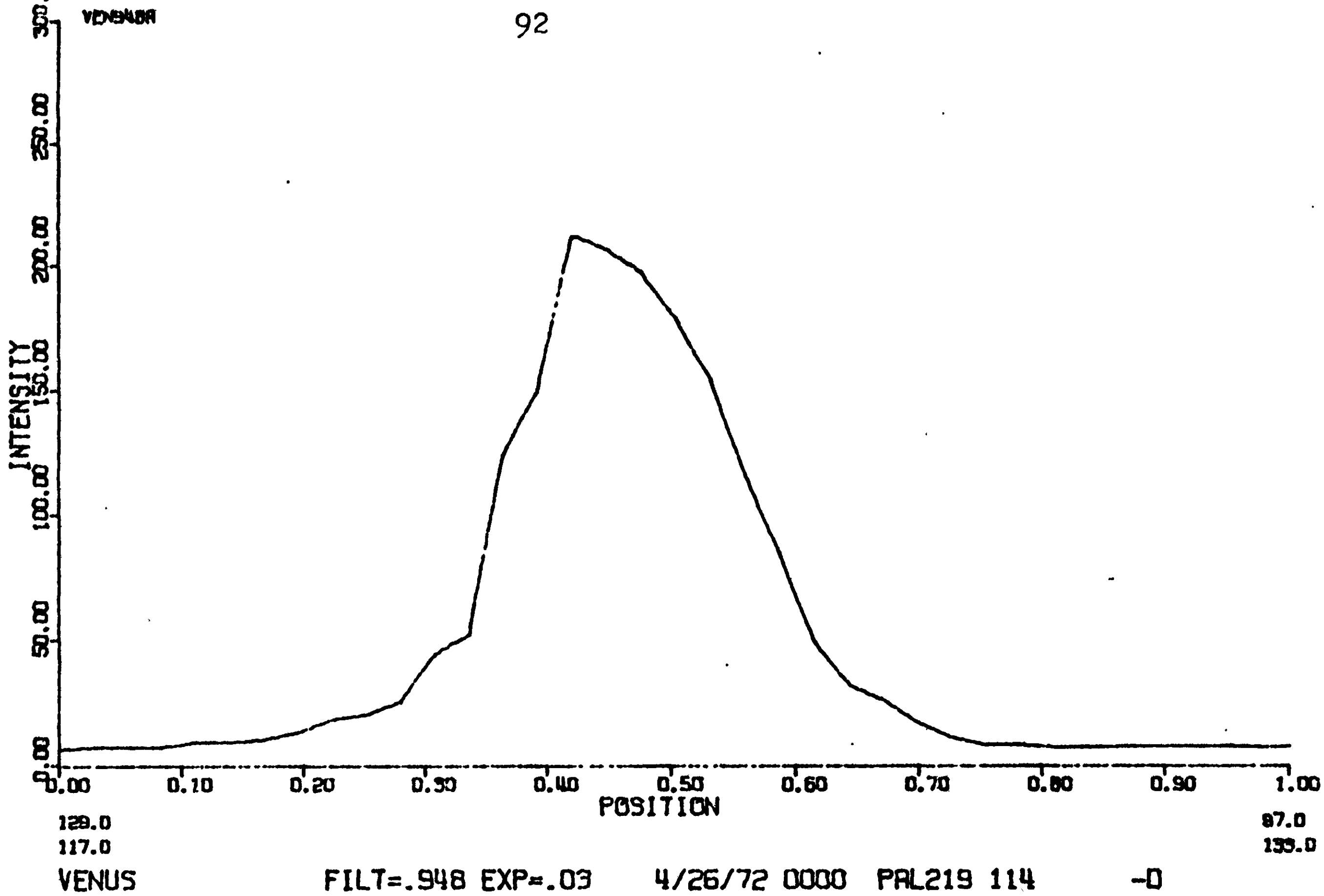
100.00
150.00
200.00
250.00
300.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
127.0
111.0
85.0
127.0
VENUS FILT=.948 EXP=.03 4/26/72 0000 PAL219 114 -D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INTENSITY
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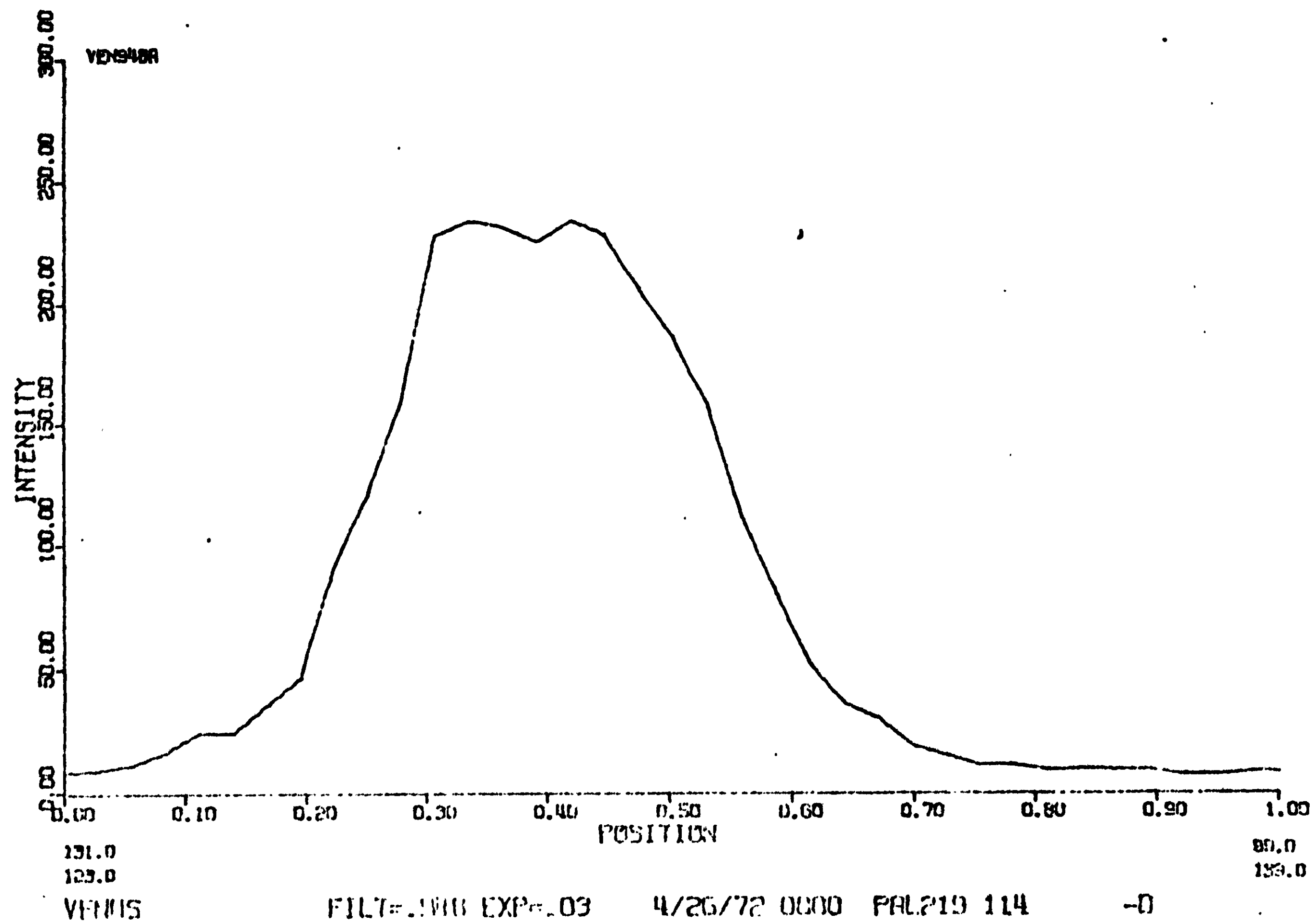
150.00
200.00
250.00
300.
POSITION
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
129.0
117.0
97.0
139.0
VENUS FILT=.948 EXP=.03 4/26/72 0000 PAL219 114 -0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INTENSITY
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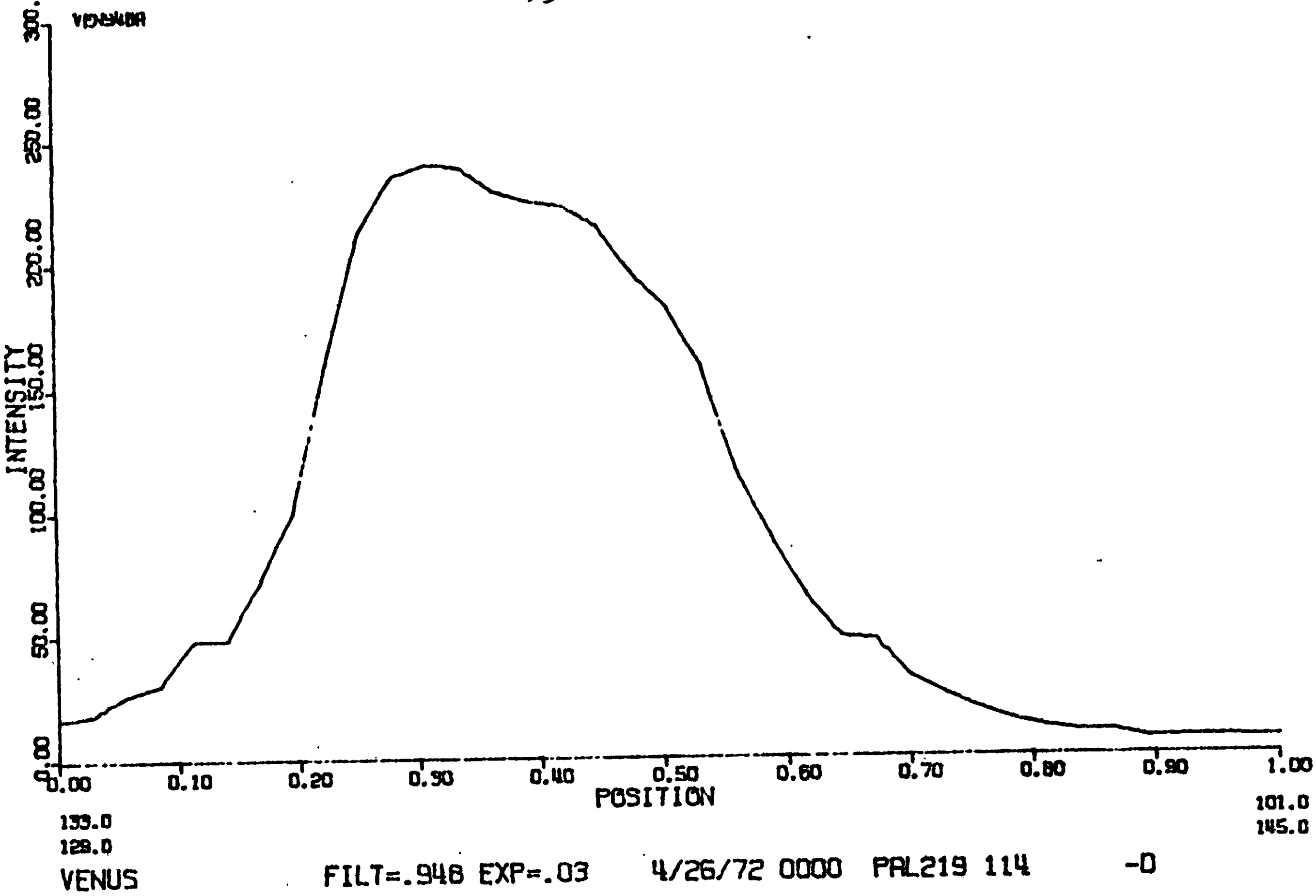
150.00
200.00
250.00
300.00
POSITION
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
131.0
129.0
89.0
139.0
VENUS EXP=.03 4/26/72 0000 PAL219 114 -0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0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
POSITION
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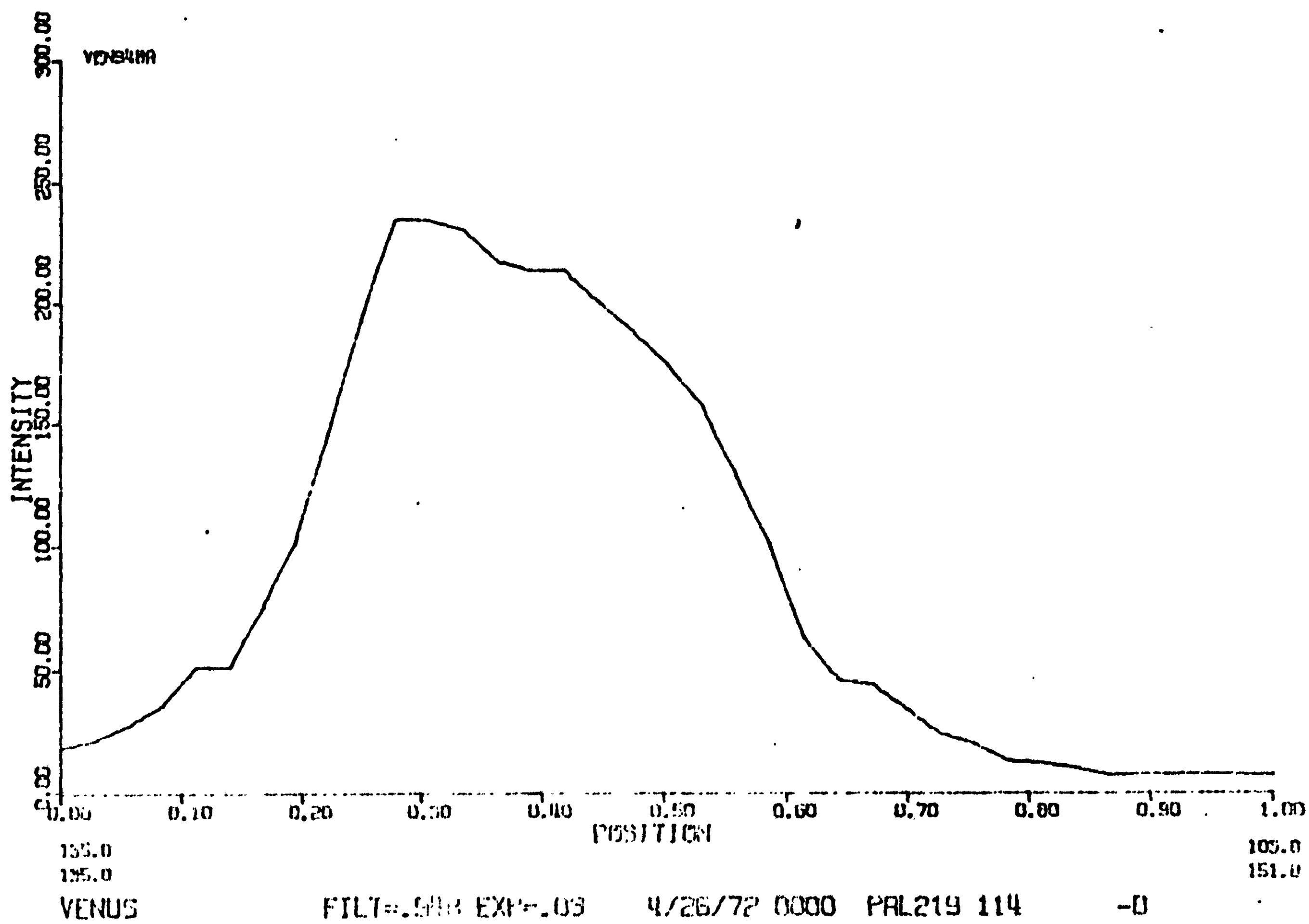
128.0
101.0
145.0
VENUS
FILT=.948 EXP=.03
4/26/72 0000
PAL219 114
-D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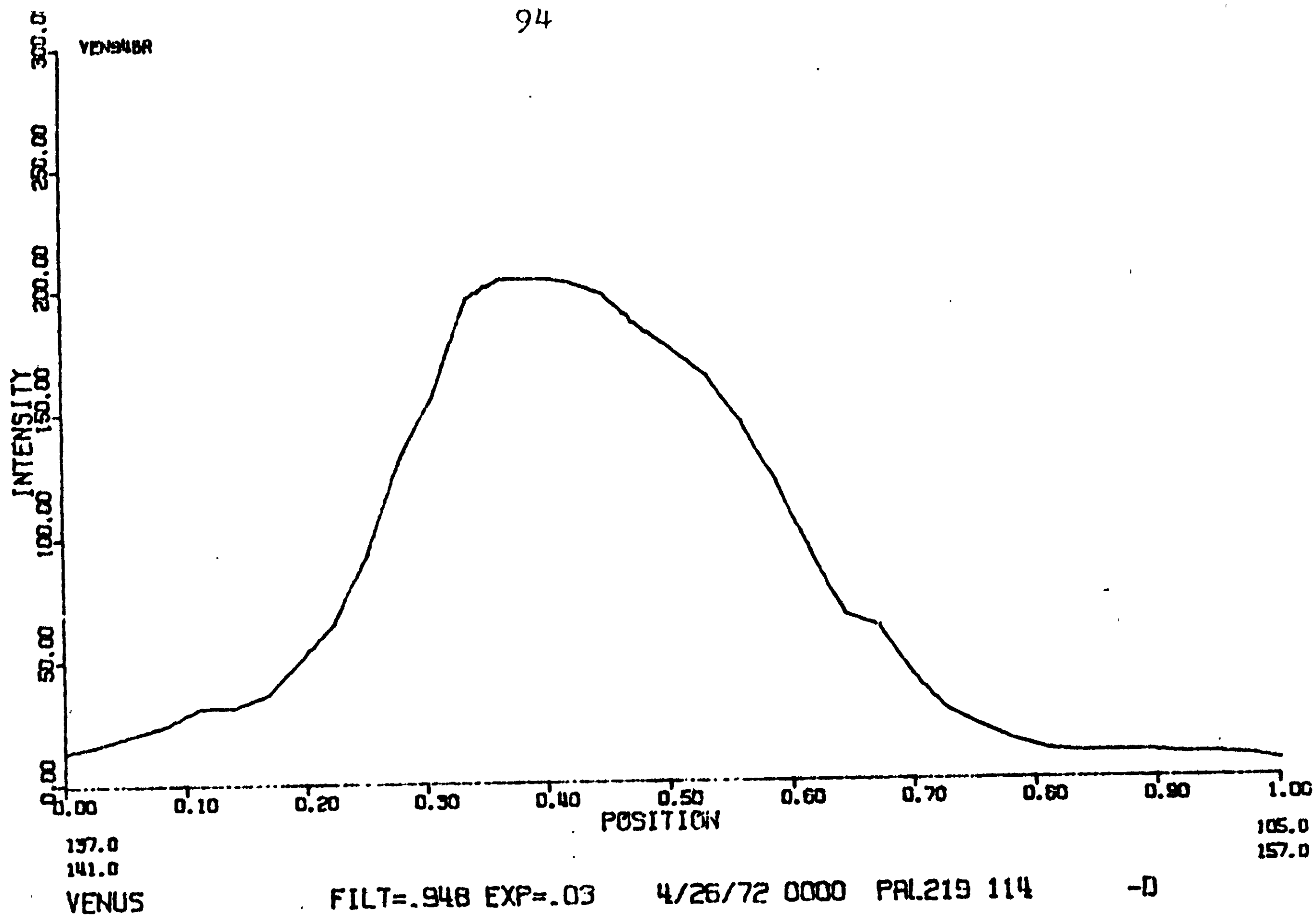
50.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
POSITION
105.0
151.0
VENUS
4/26/72 0000
PAL219 114
-D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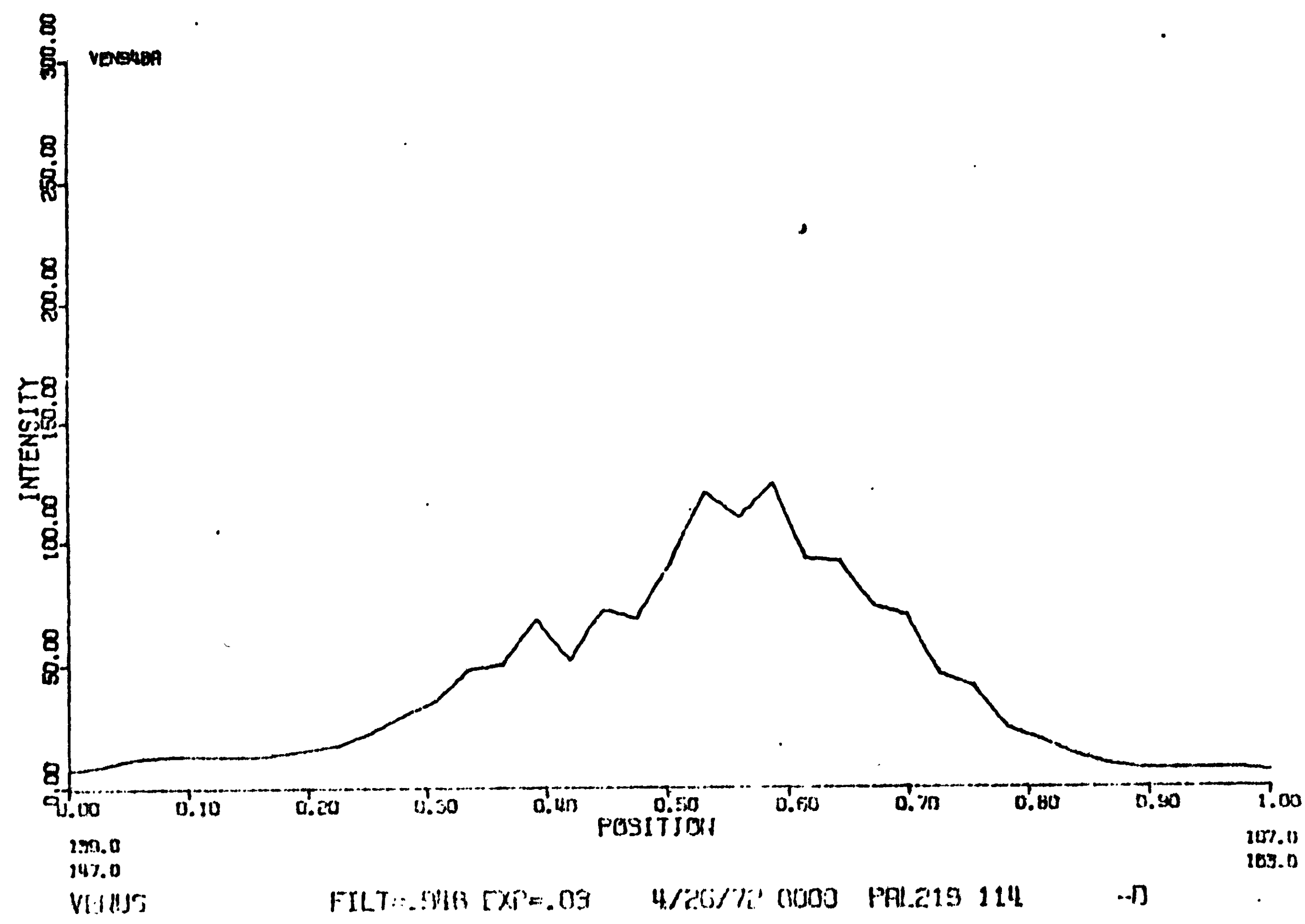
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
POSITION
137.0
141.0
105.0
157.0
VENUS
FILT=.948 EXP=.03
4/26/72 0000
PAL219 114
-D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INTENSITY
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50.00
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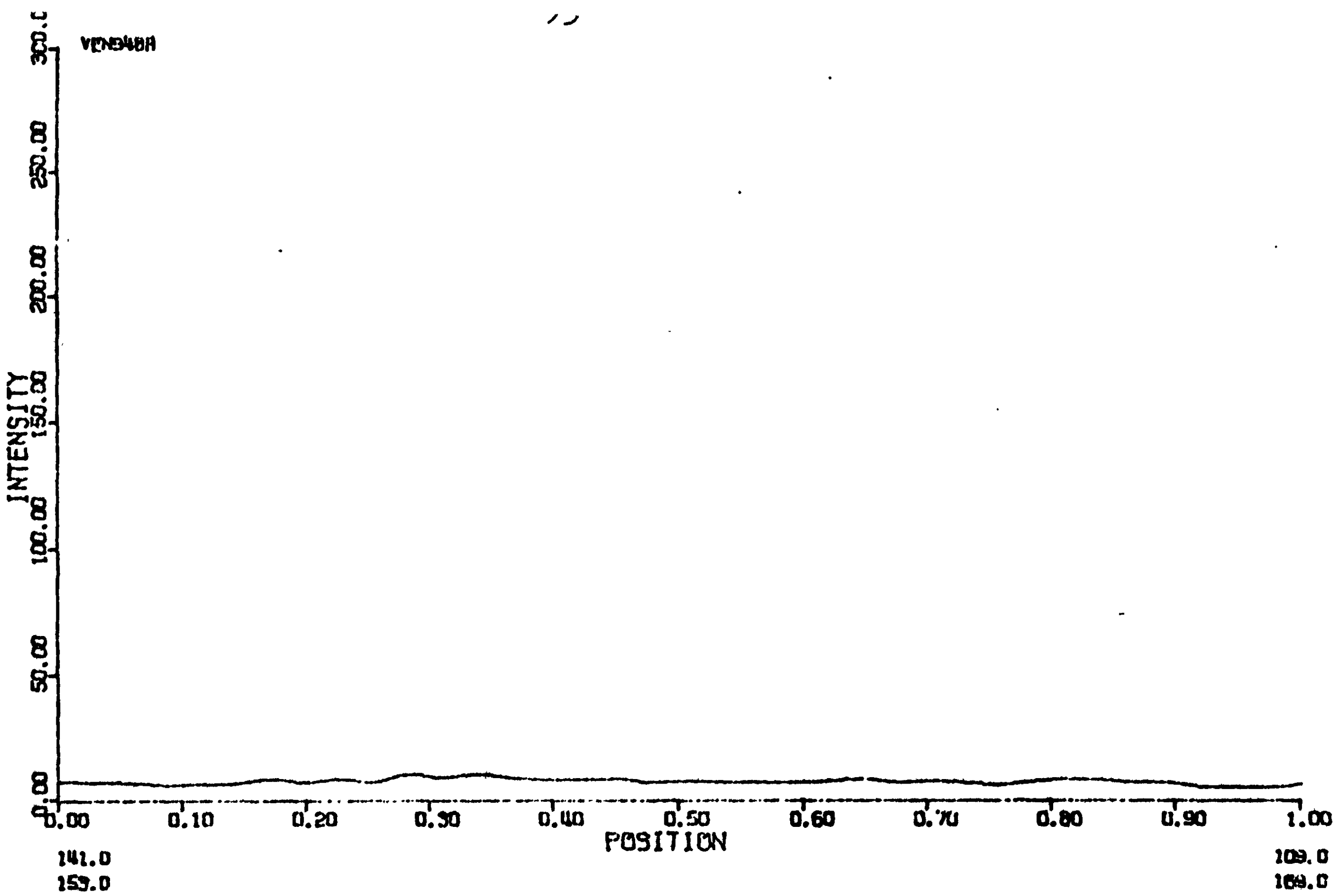
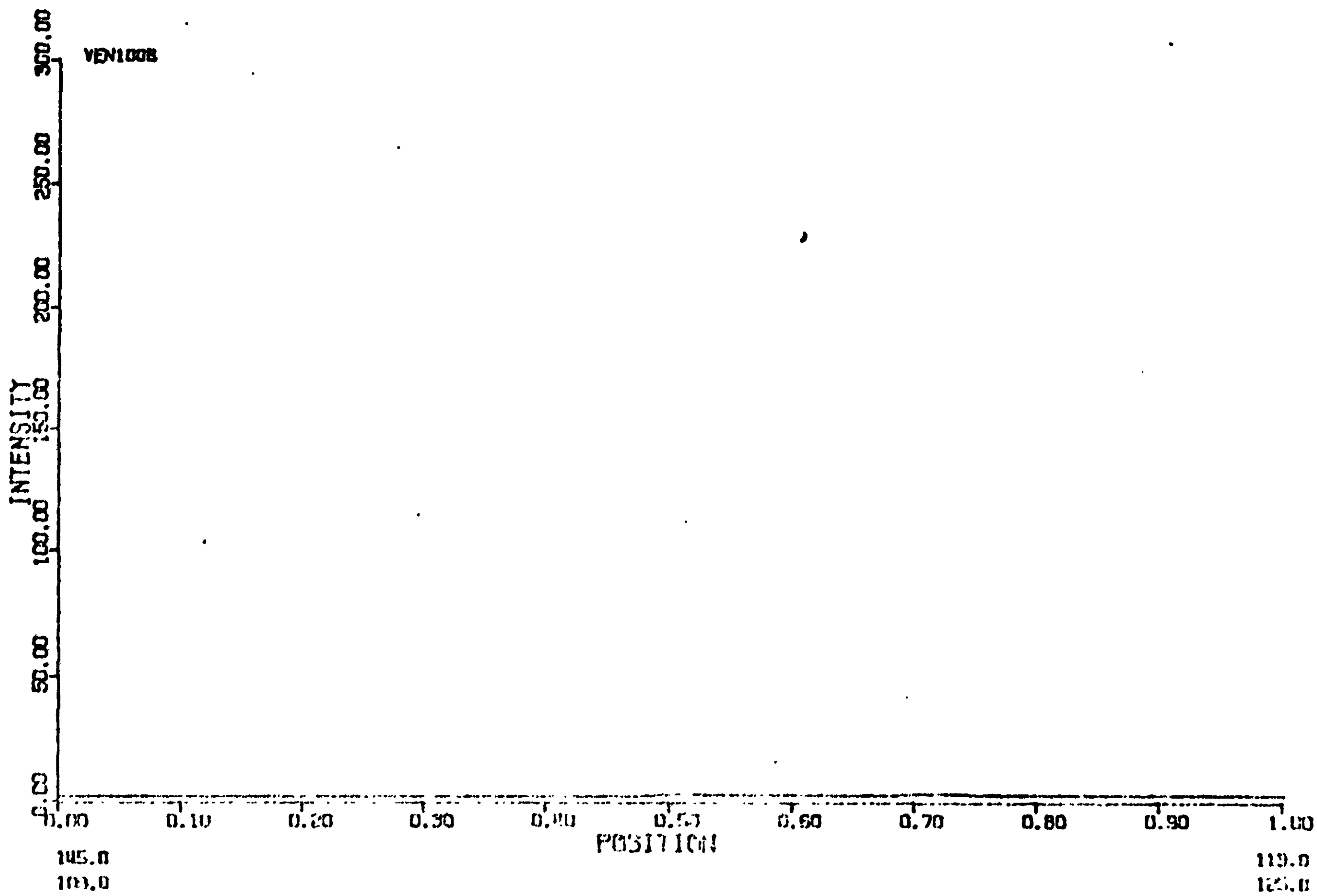
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
POSITION
107.0
163.0
VENUS
4/26/72 0000
PAL219 114
-D



VENUS FILT=.948 EXP=.03 4/26/72 0000 PAL219 114 -D



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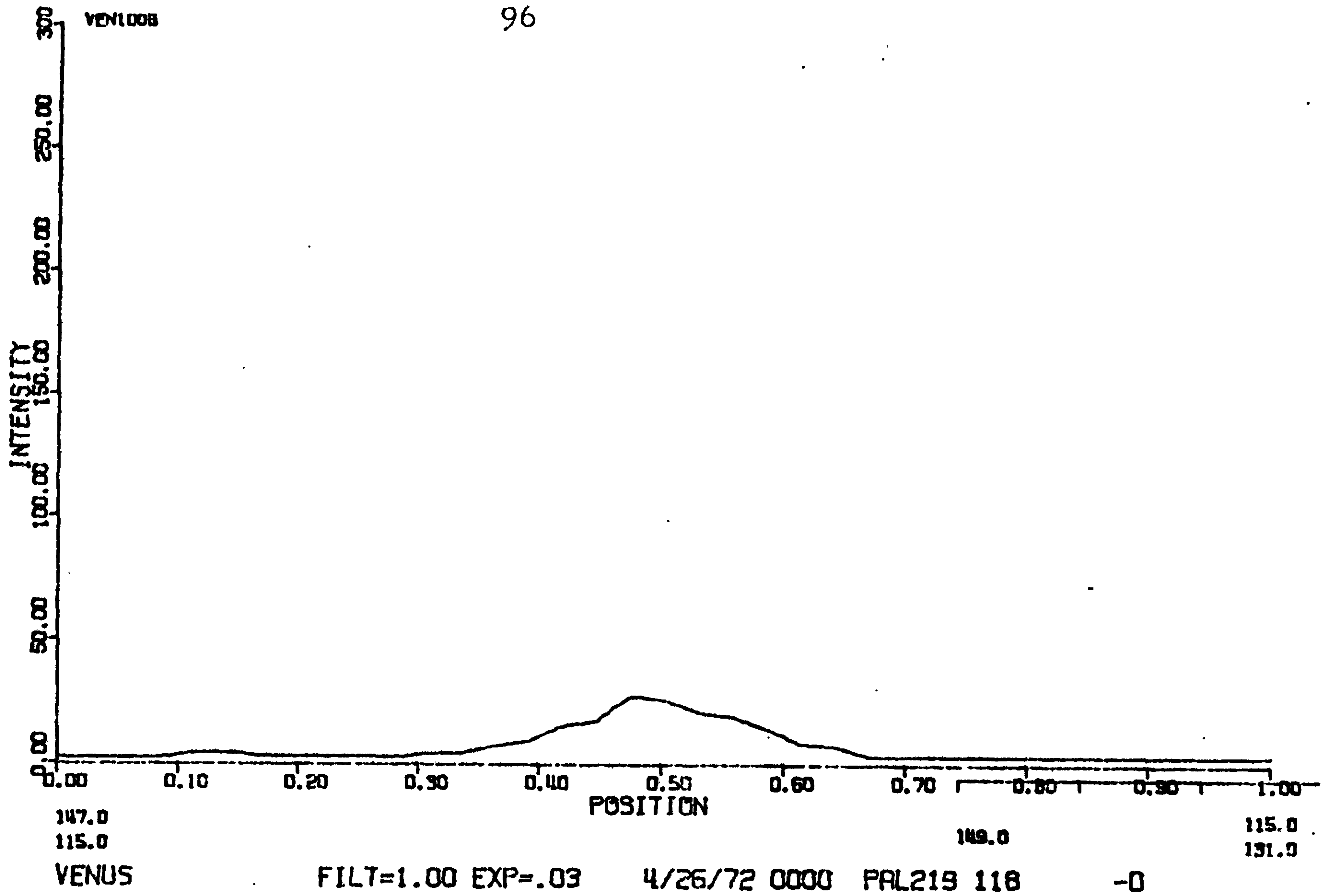
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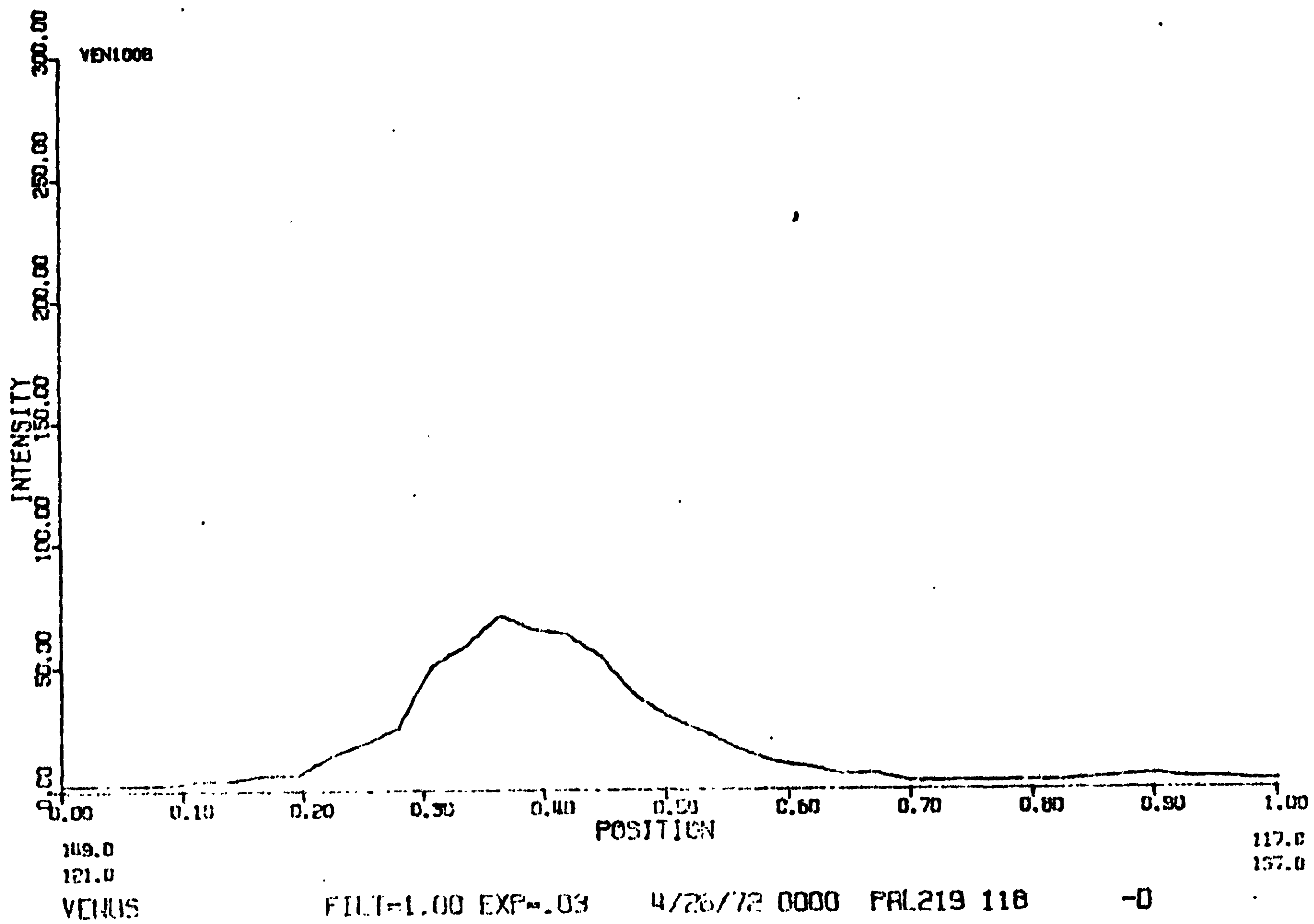
150.00
200.00
250.00
300
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
147.0
115.0
149.0
115.0
131.0
VENUS FILT=1.00 EXP=.03 4/26/72 0000 PAL219 118 -0


VEN1008
INTENSITY
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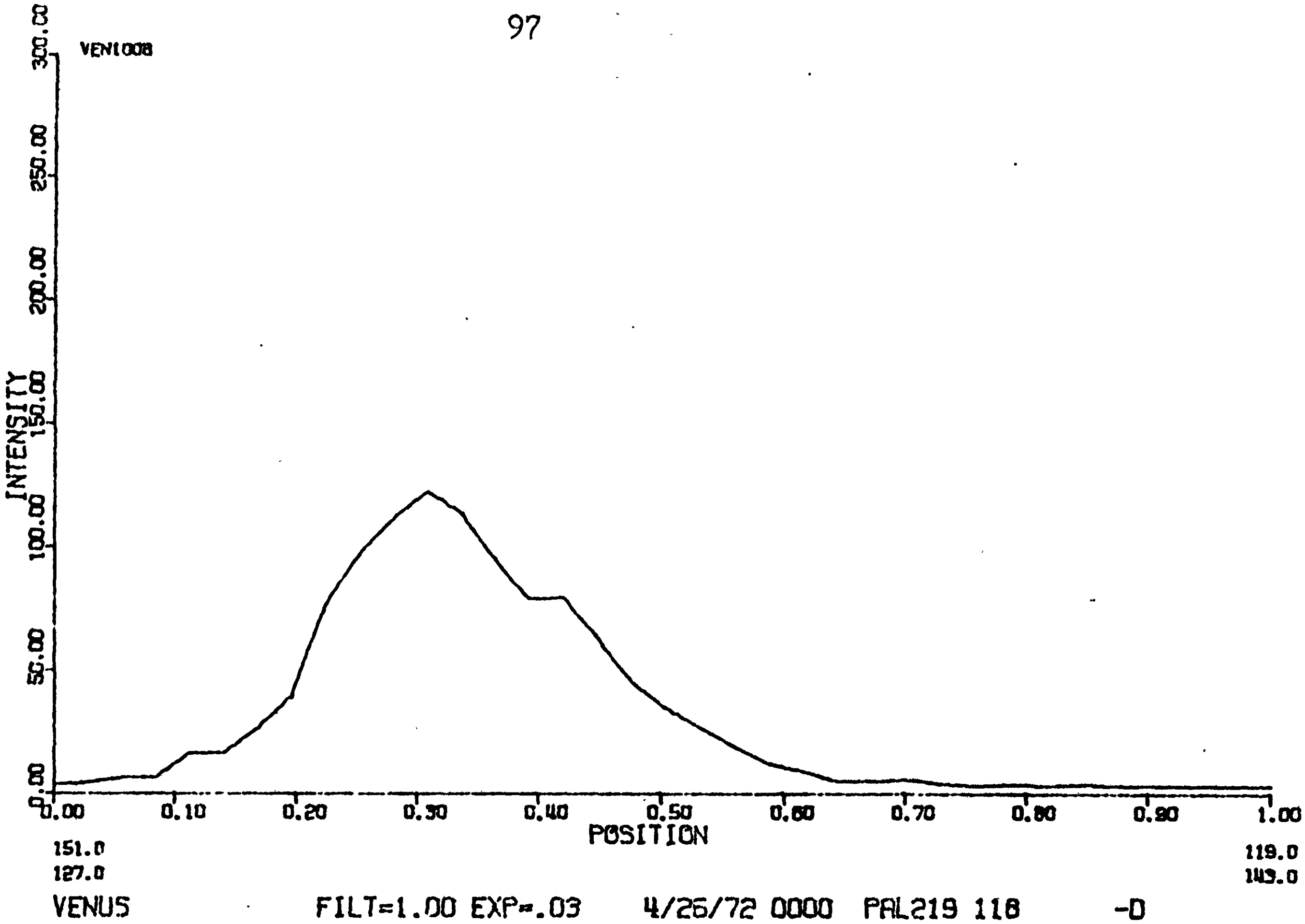
100.00
150.00
200.00
250.00
300.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
149.0
121.0
117.0
137.0
VENUS FILT=1.00 EXP=.03 4/26/72 0000 PAL219 118 -0


VEN1008
INTENSITY
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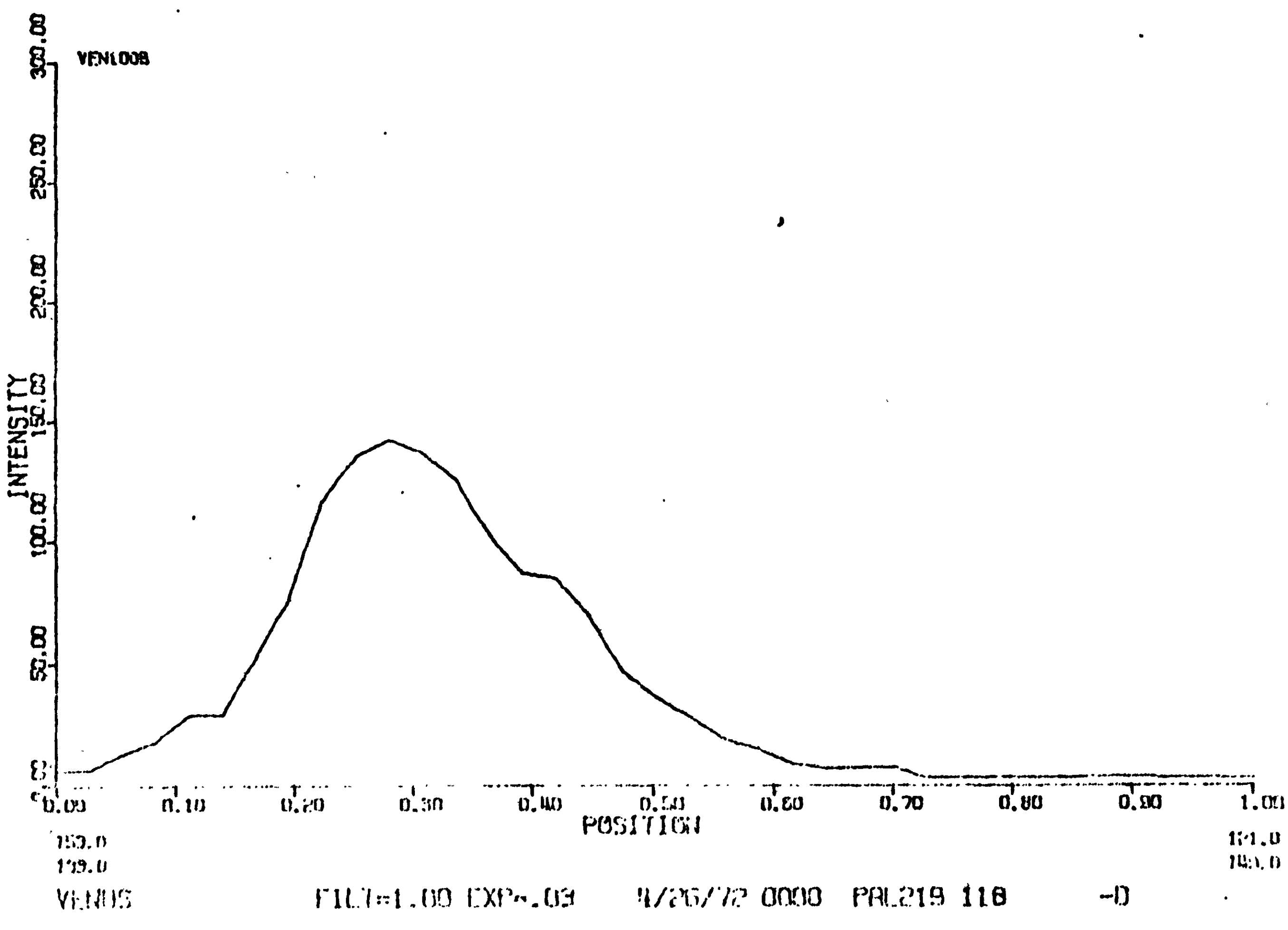
50.00
100.00
150.00
200.00
250.00
300.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
151.0
127.0
119.0
143.0
VENUS FILT=1.00 EXP=.03 4/26/72 0000 PAL219 118 -D


VEN1008
INTENSITY
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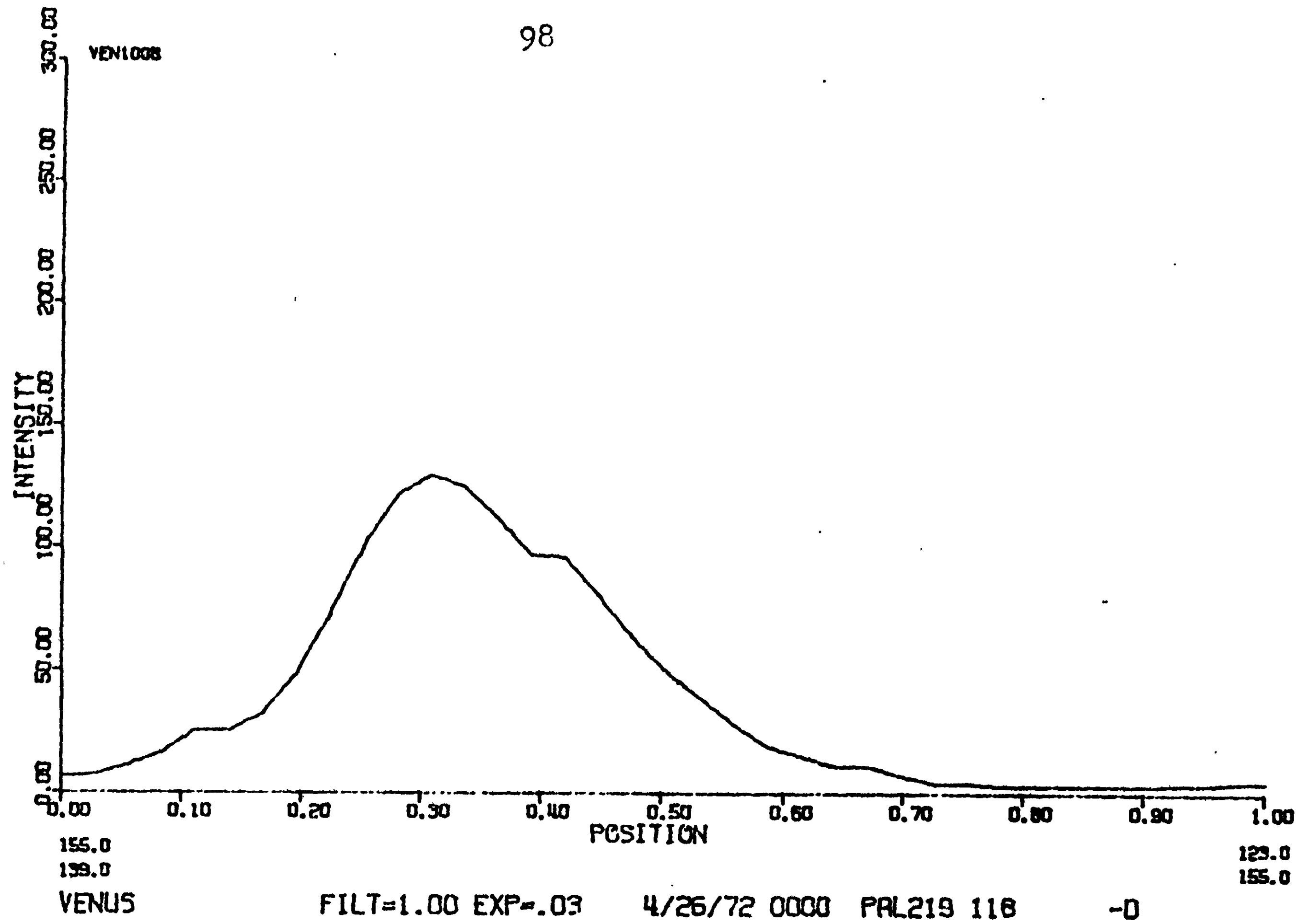
150.00
200.00
250.00
300.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
VENUS FILT=1.00 EXP=.03 4/26/72 0000 PAL219 118 -D


VEN1008
INTENSITY
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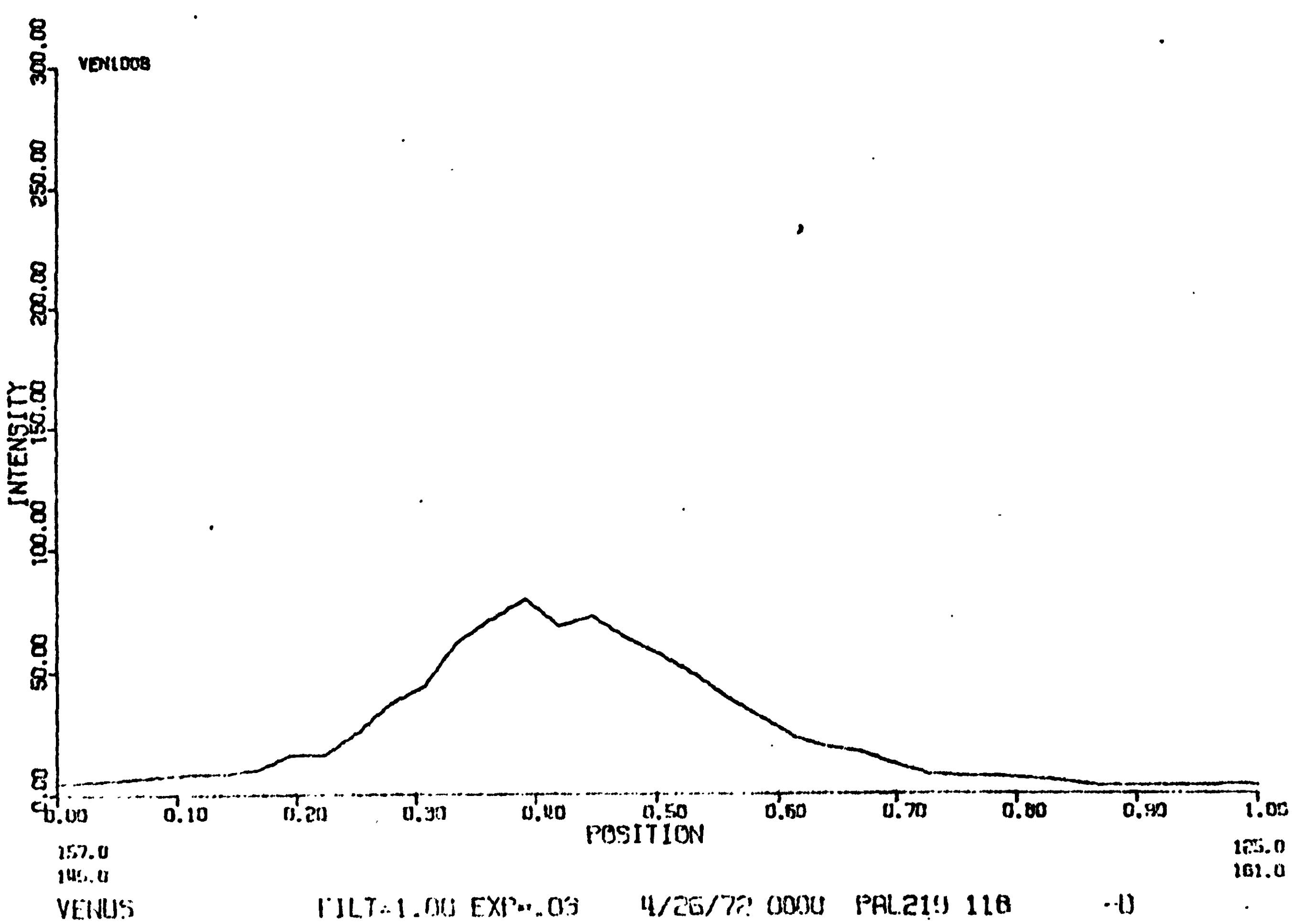
100.00
150.00
200.00
250.00
300.00
POSITION
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
155.0
139.0
129.0
155.0
VENUS
FILT=1.00 EXP=.03
4/26/72 0000
PAL219 118
-D


VEN1008
INTENSITY
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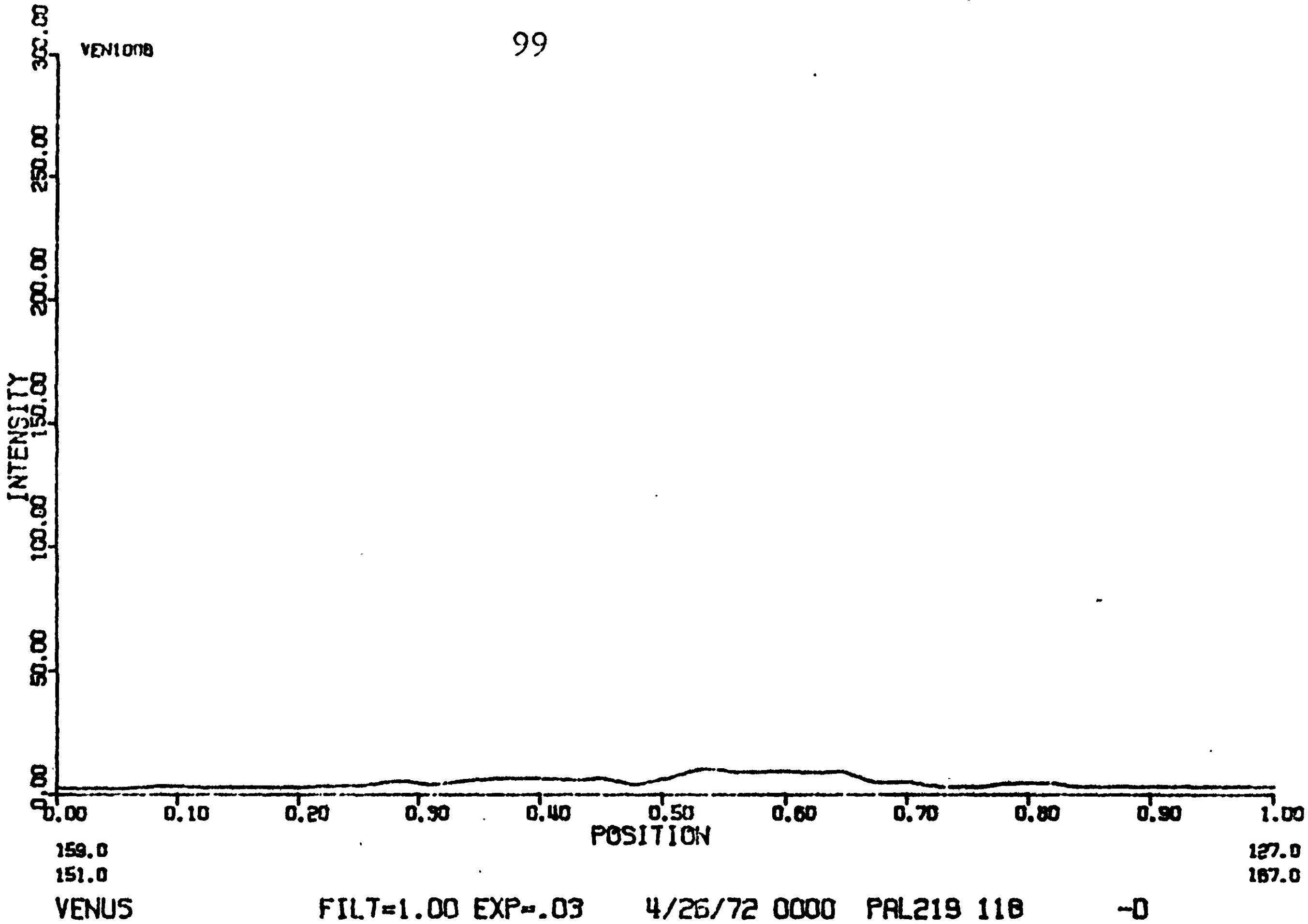
50.00
100.00
150.00
200.00
250.00
300.00
POSITION
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
157.0
145.0
125.0
161.0
VENUS
FILT=1.00 EXP=.03
4/26/72 0000
PAL219 118
-D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POSITION
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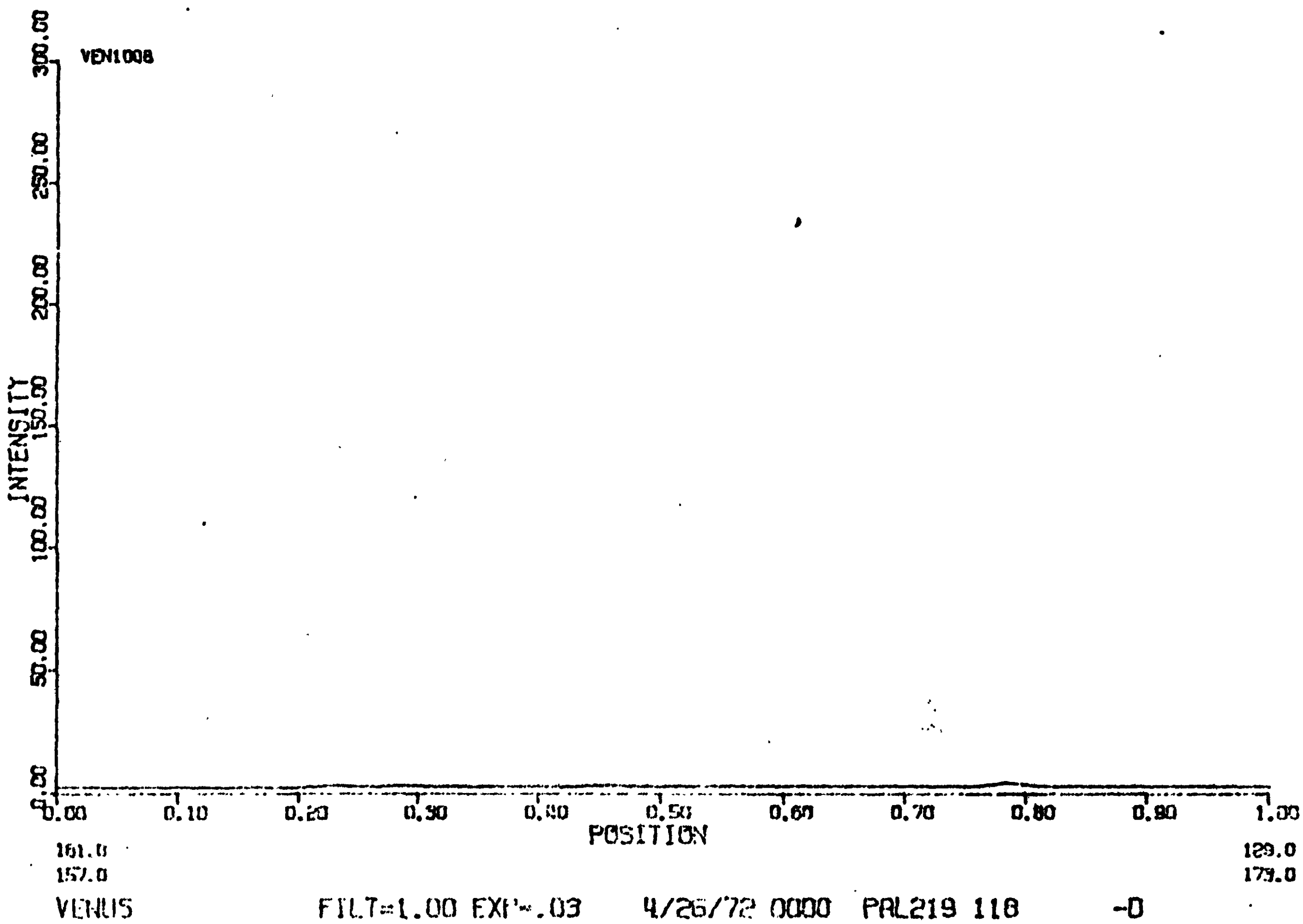
127.0
187.0
VENUS FILT=1.00 EXP=.03 4/26/72 0000 PAL219 118 -0


VEN1008
INTENSITY
POSITION
161.0
157.0
129.0
179.0
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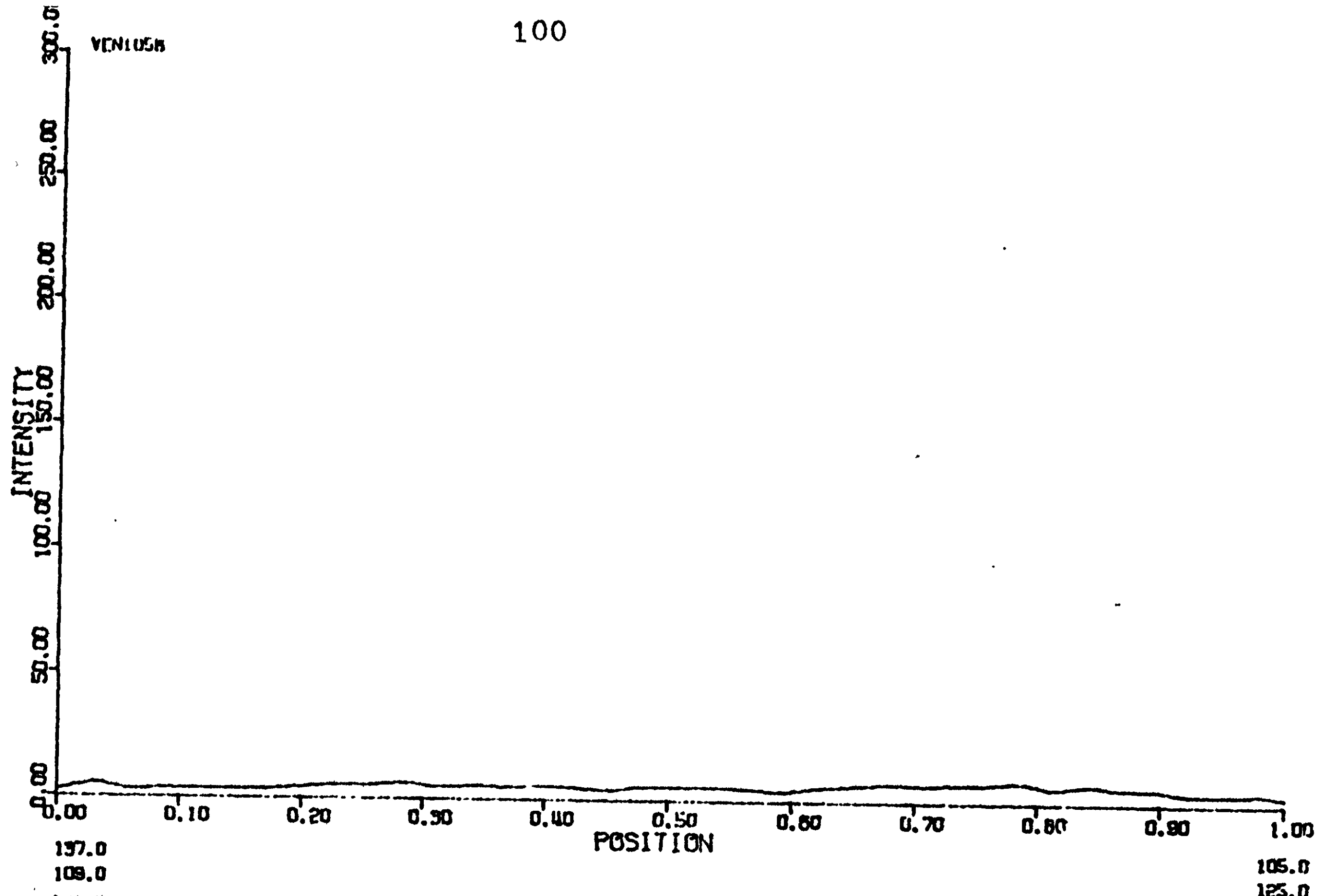

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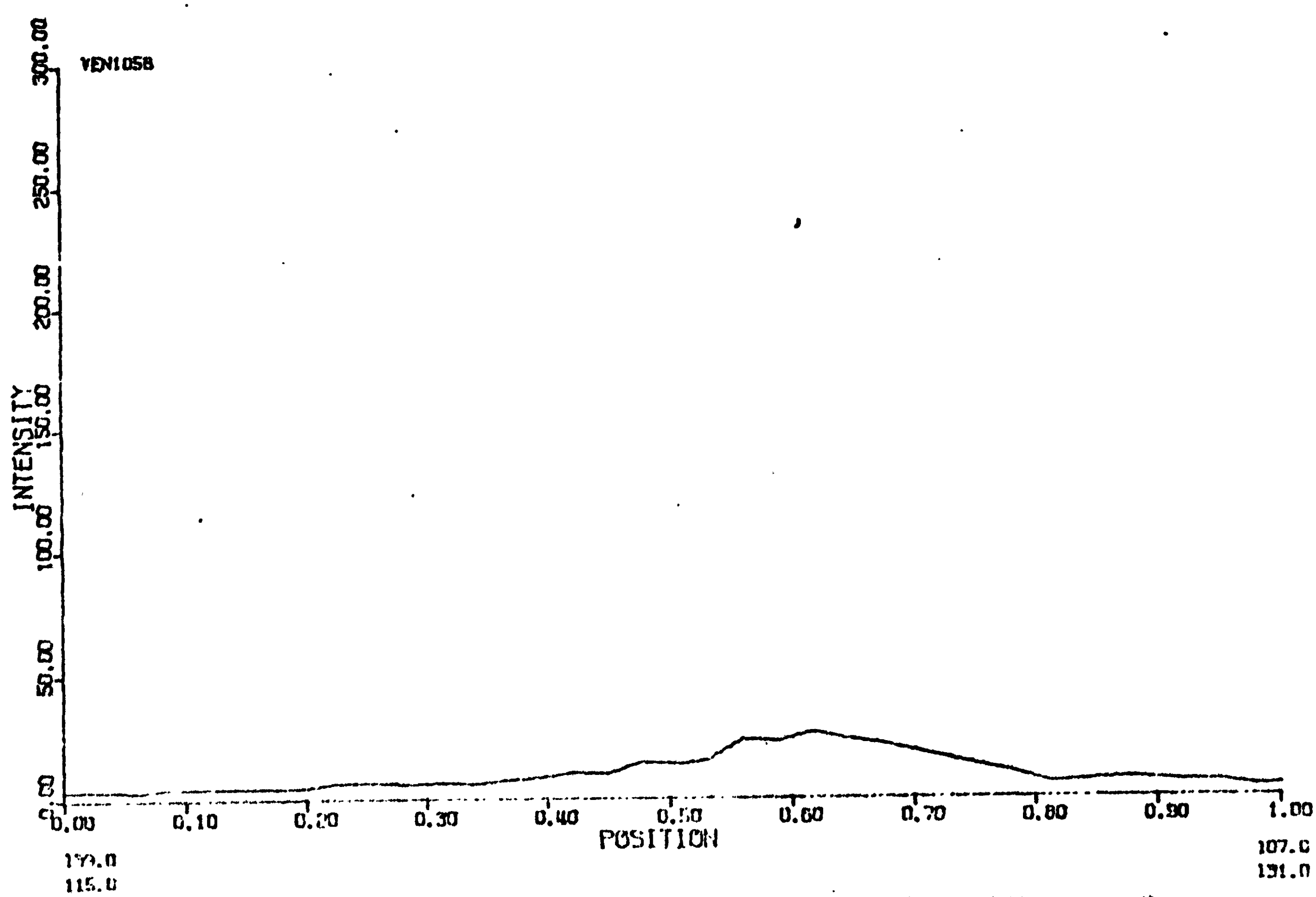

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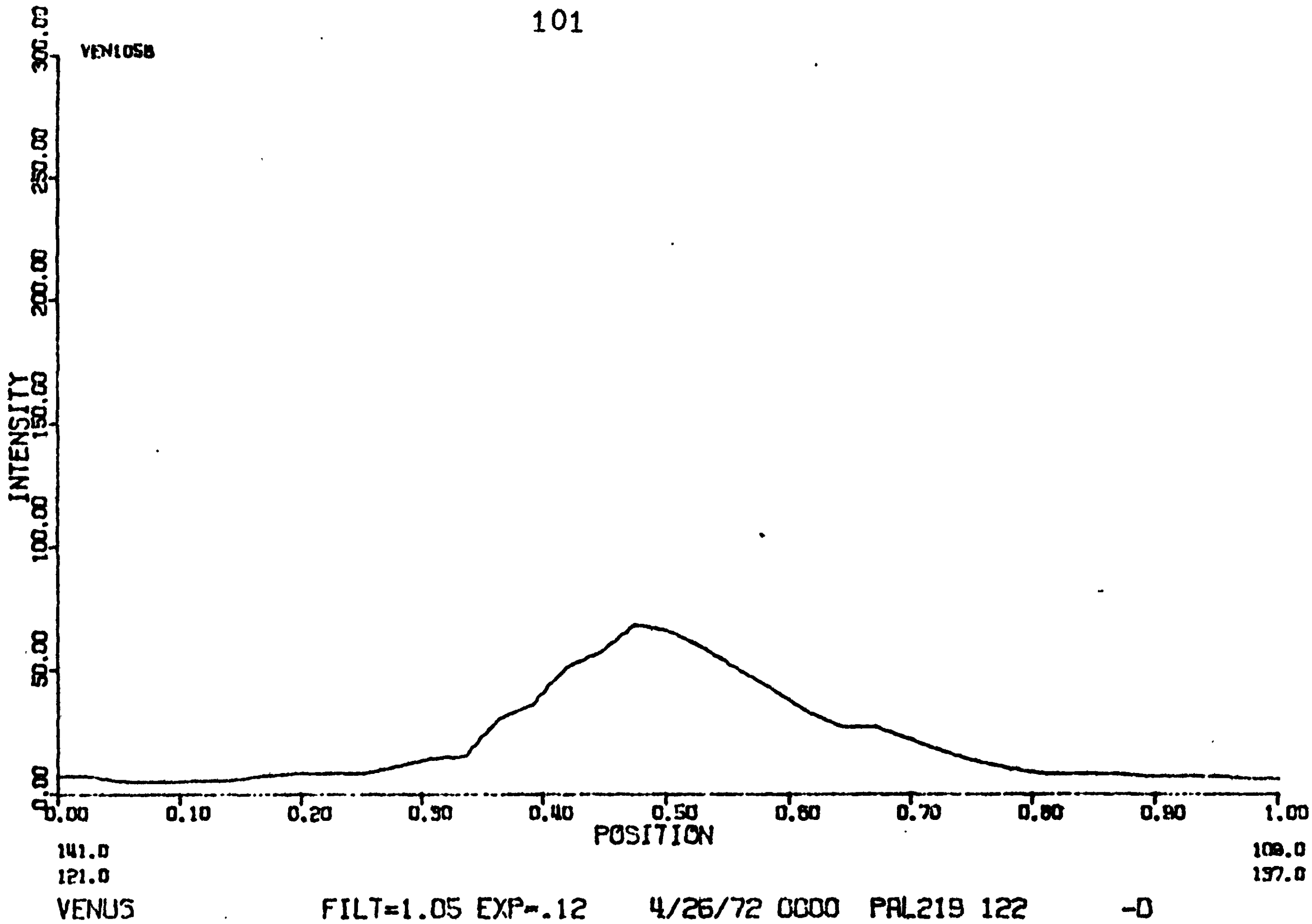
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POSITION
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109.0
137.0
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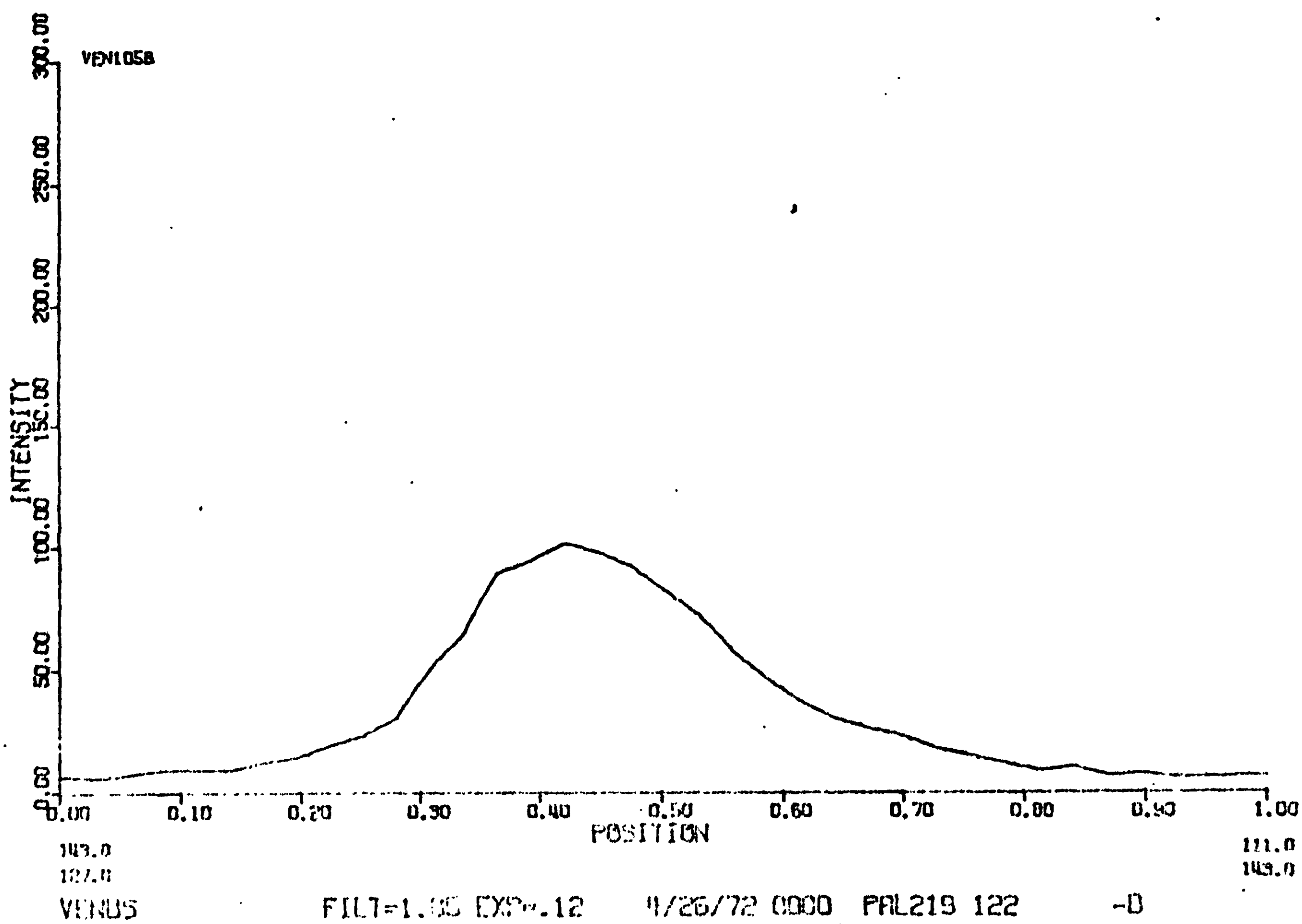
VEN1058
INTENSITY
POSITION
143.0
127.0
111.0
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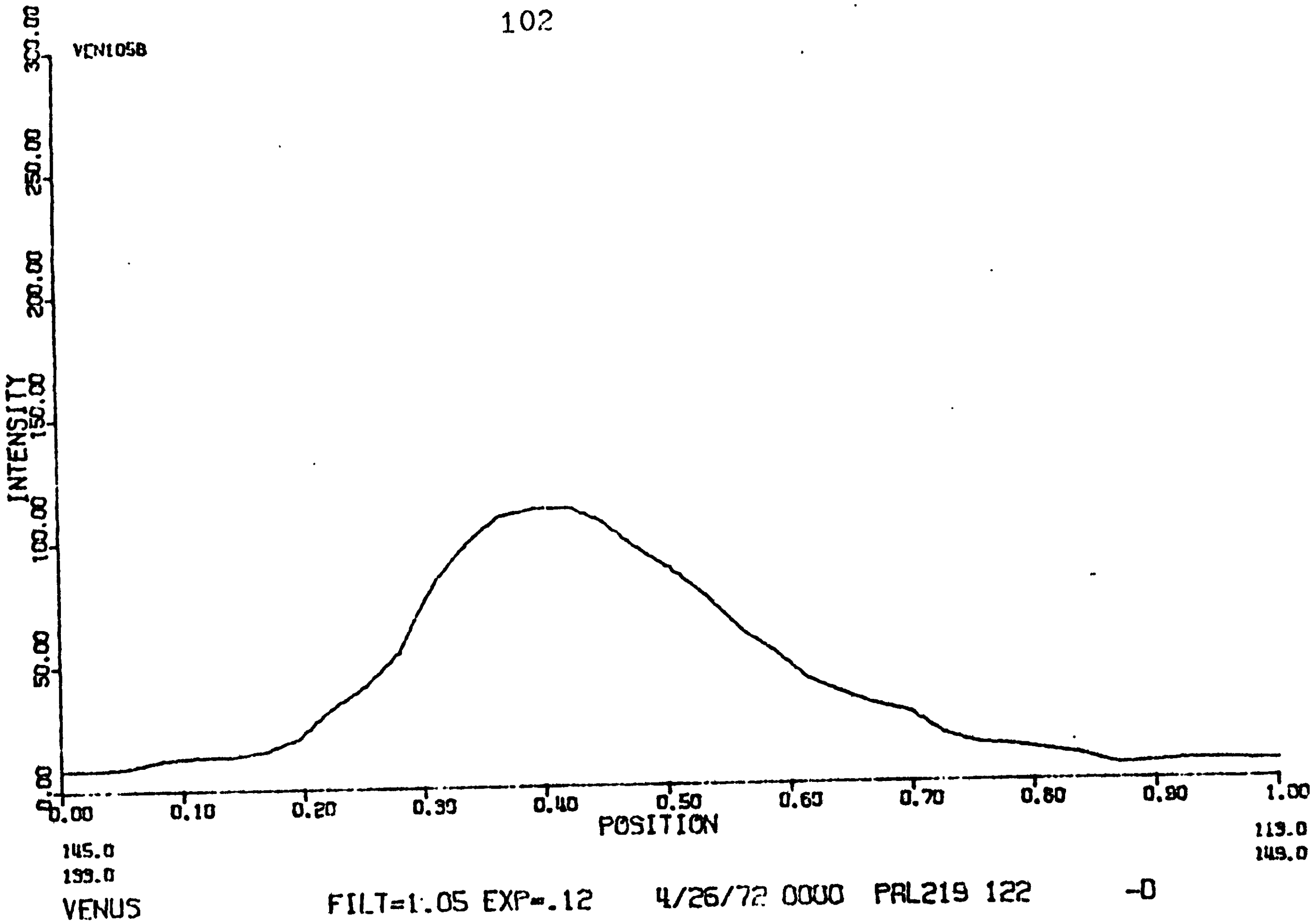
VEN1058
INTENSITY
POSITION
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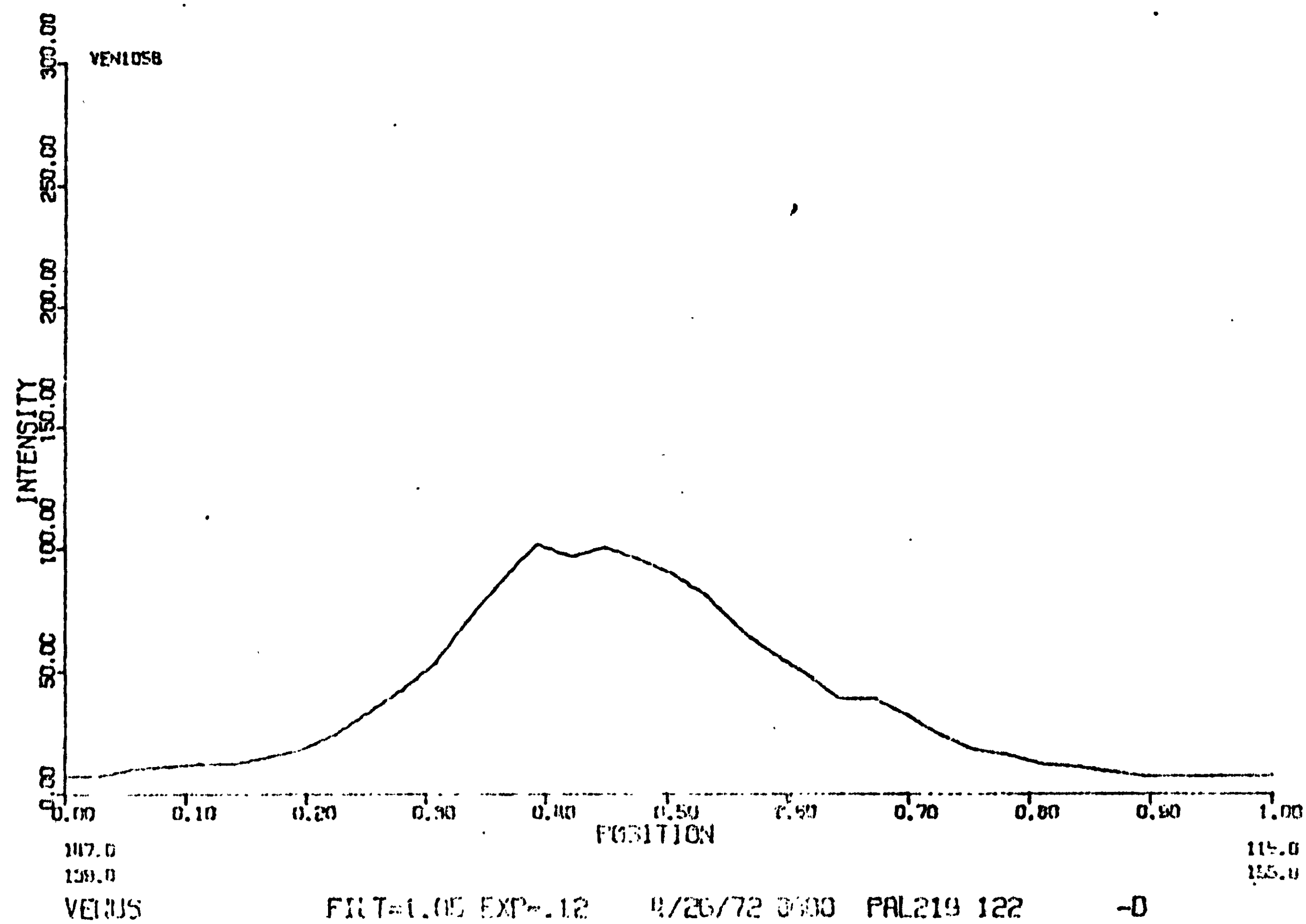
113.0
149.0
VENUS
FILT=1.05 EXP=.12
4/26/72 0000 PAL219 122
-D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POSITION
VENUS
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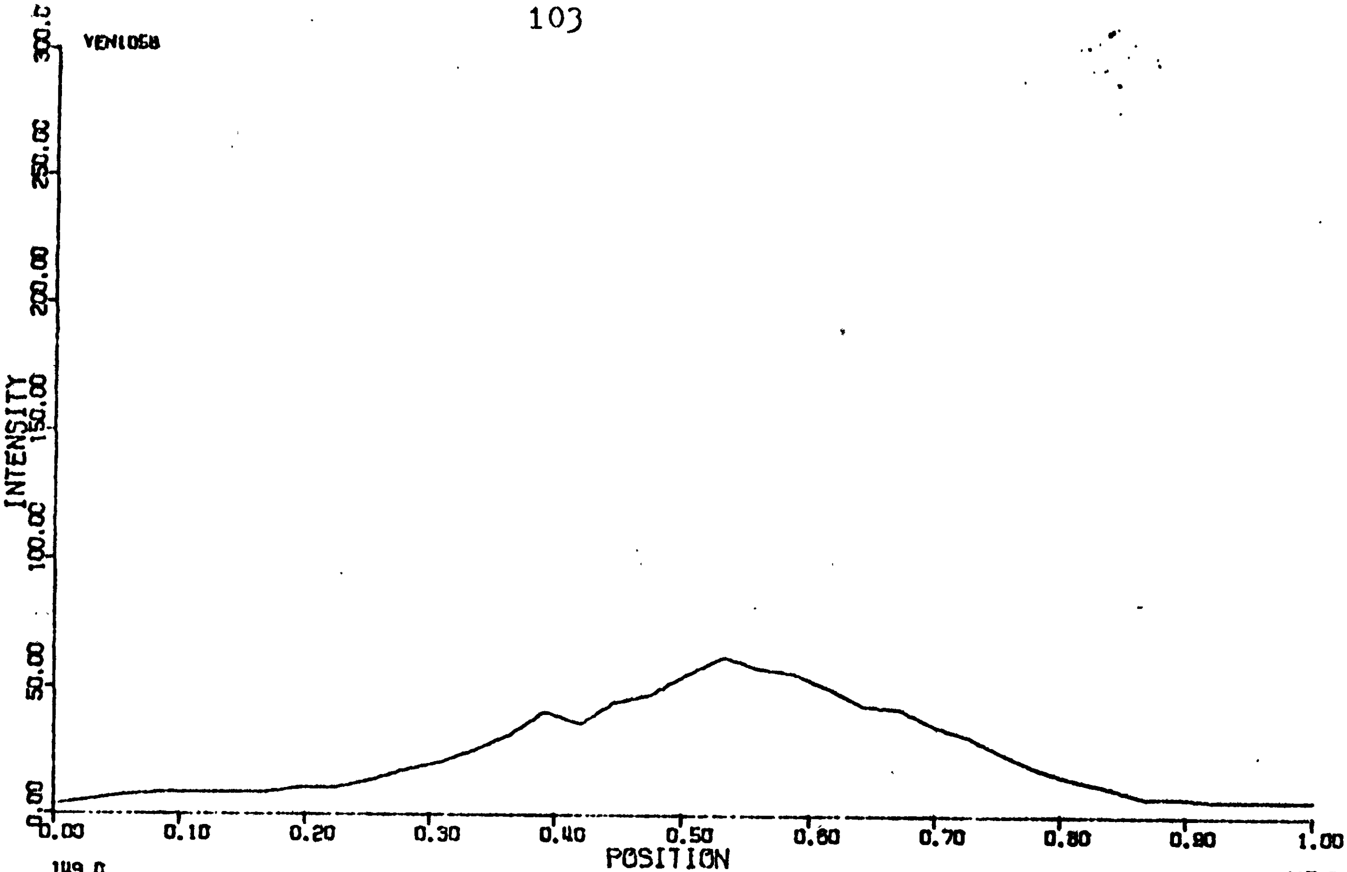
-D



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117.0
161.0

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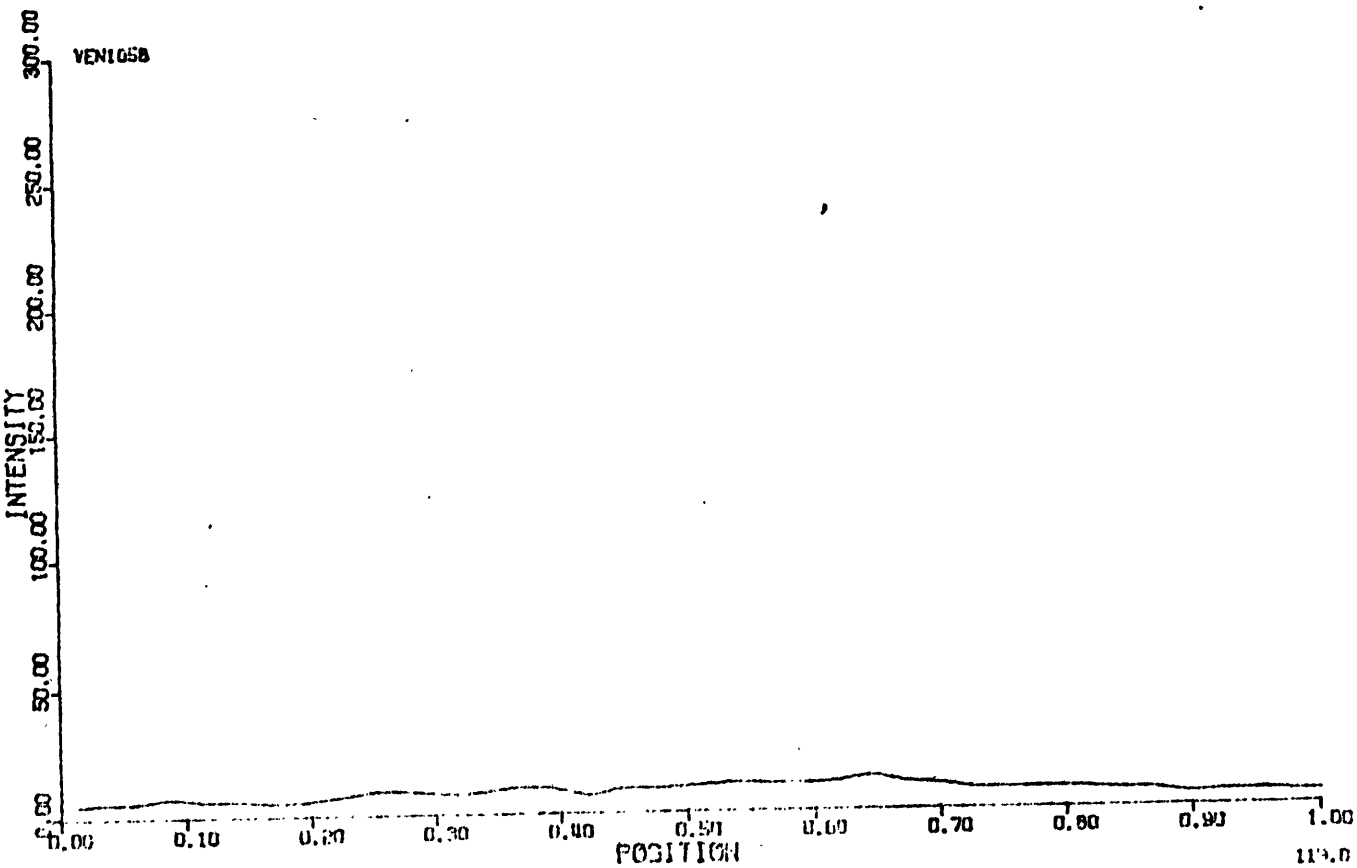

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151.0
151.0

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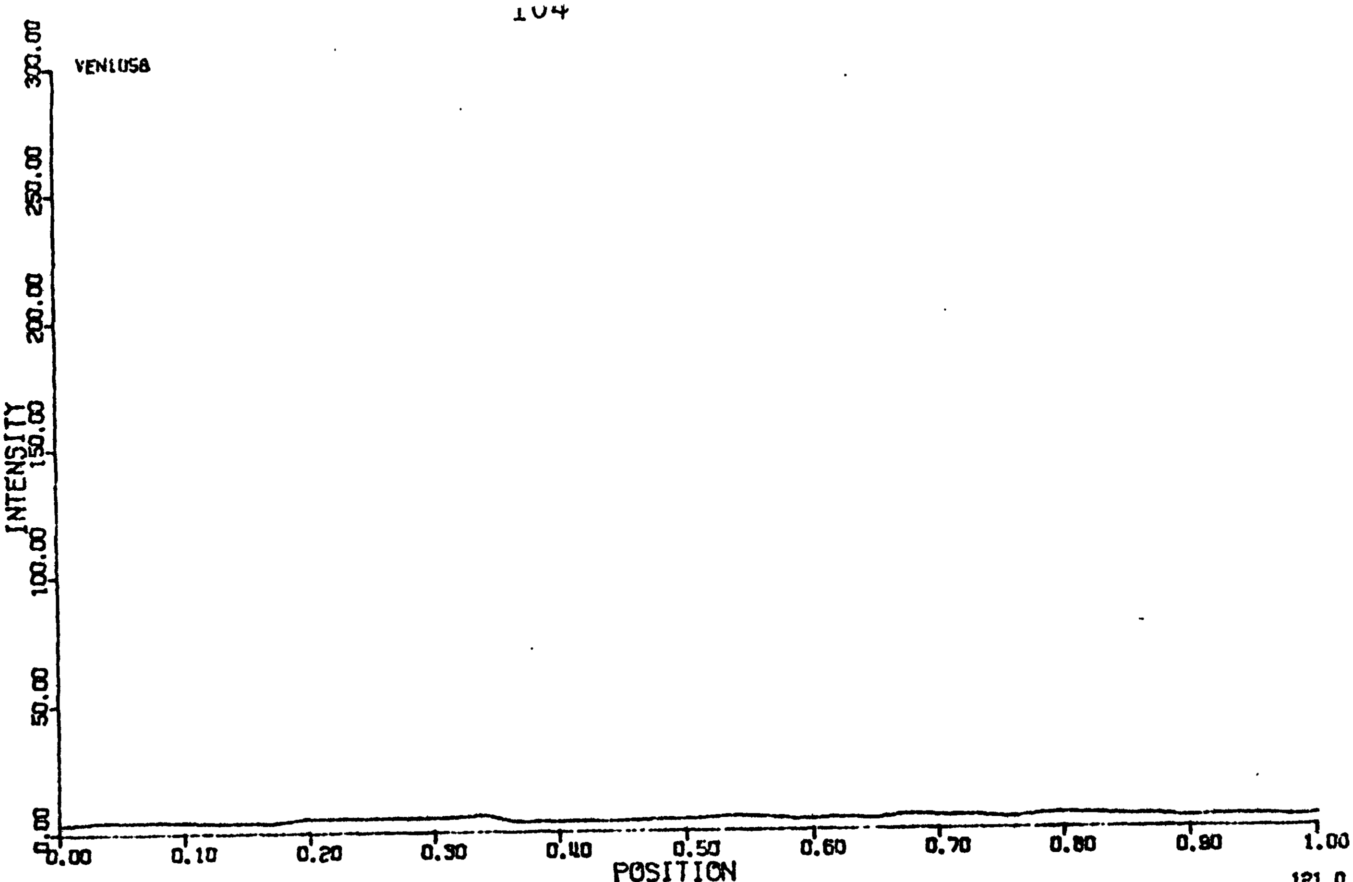
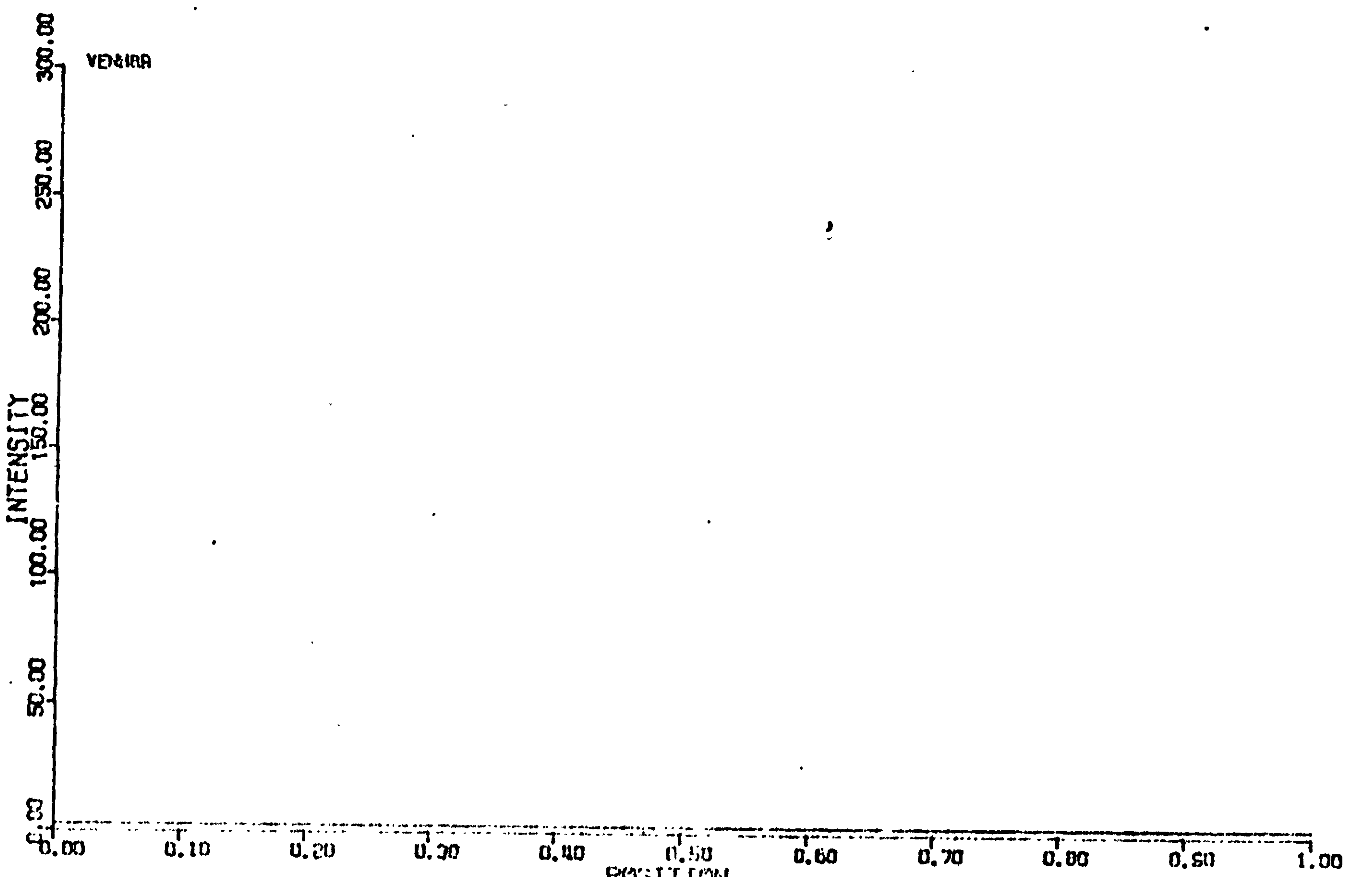


153.0
157.0
VENUS FILT=1.05 EXP=.12 4/26/72 0000 PAL219 122 -D
121.0
173.0



117.0
100.0
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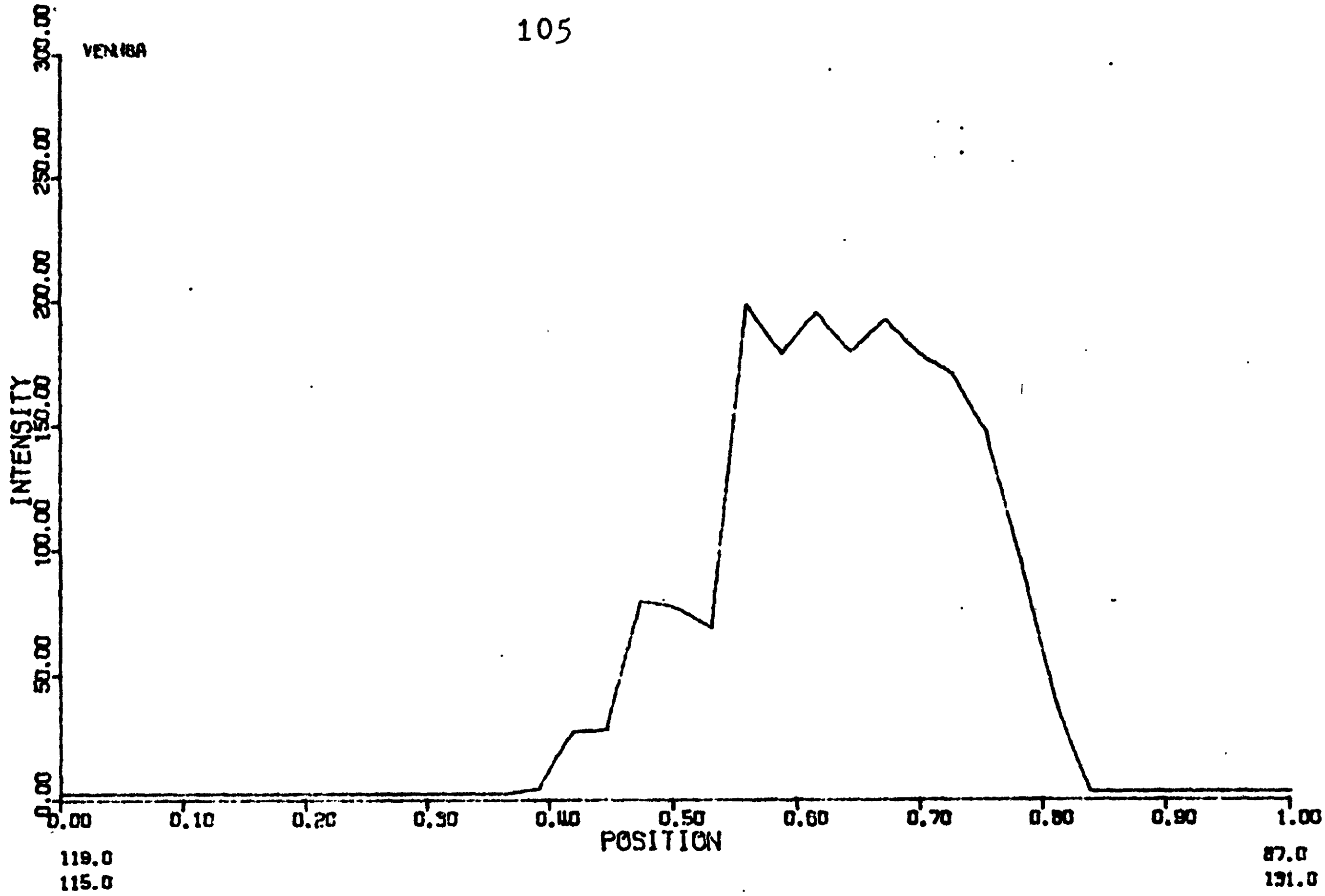
65.0
125.0



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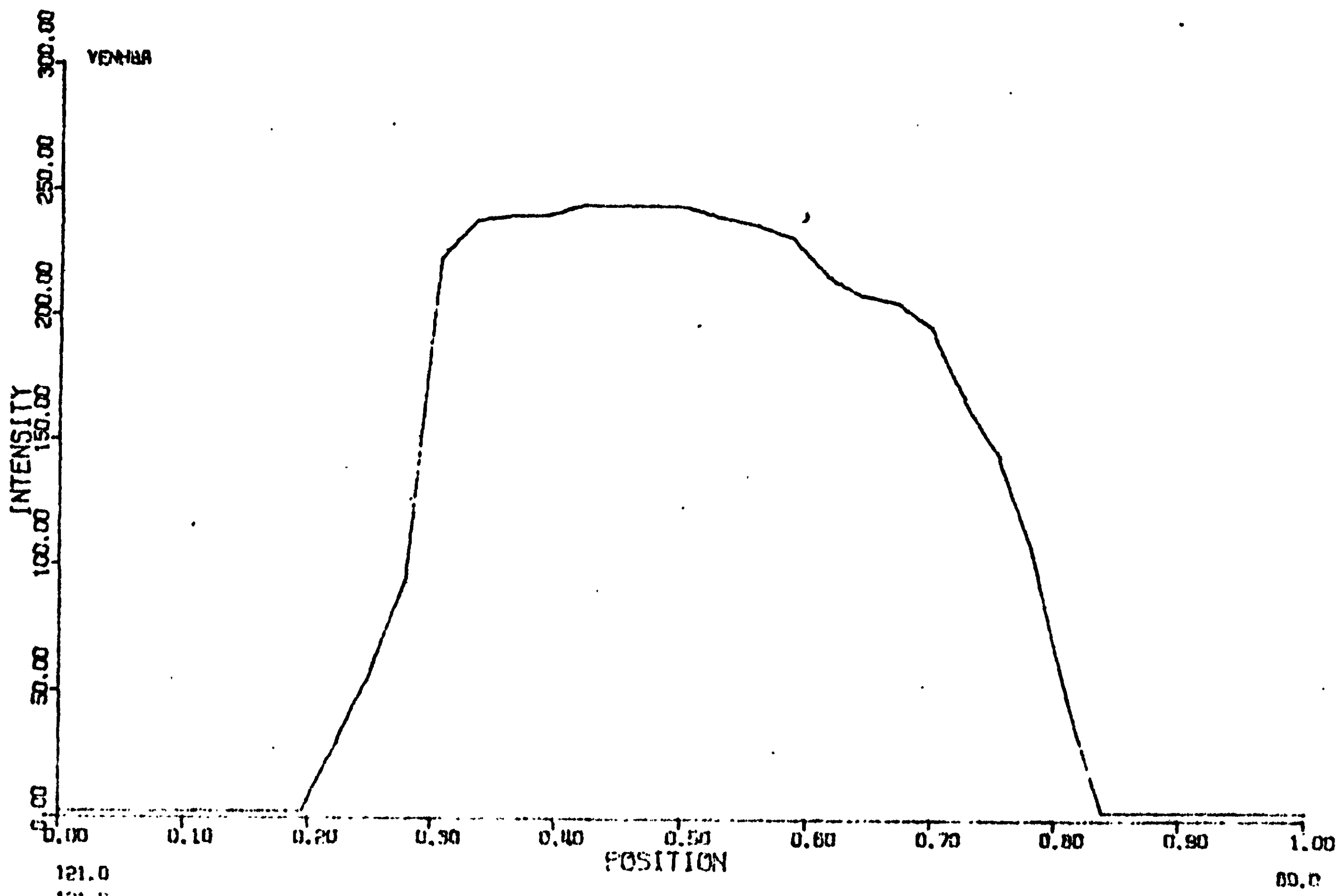

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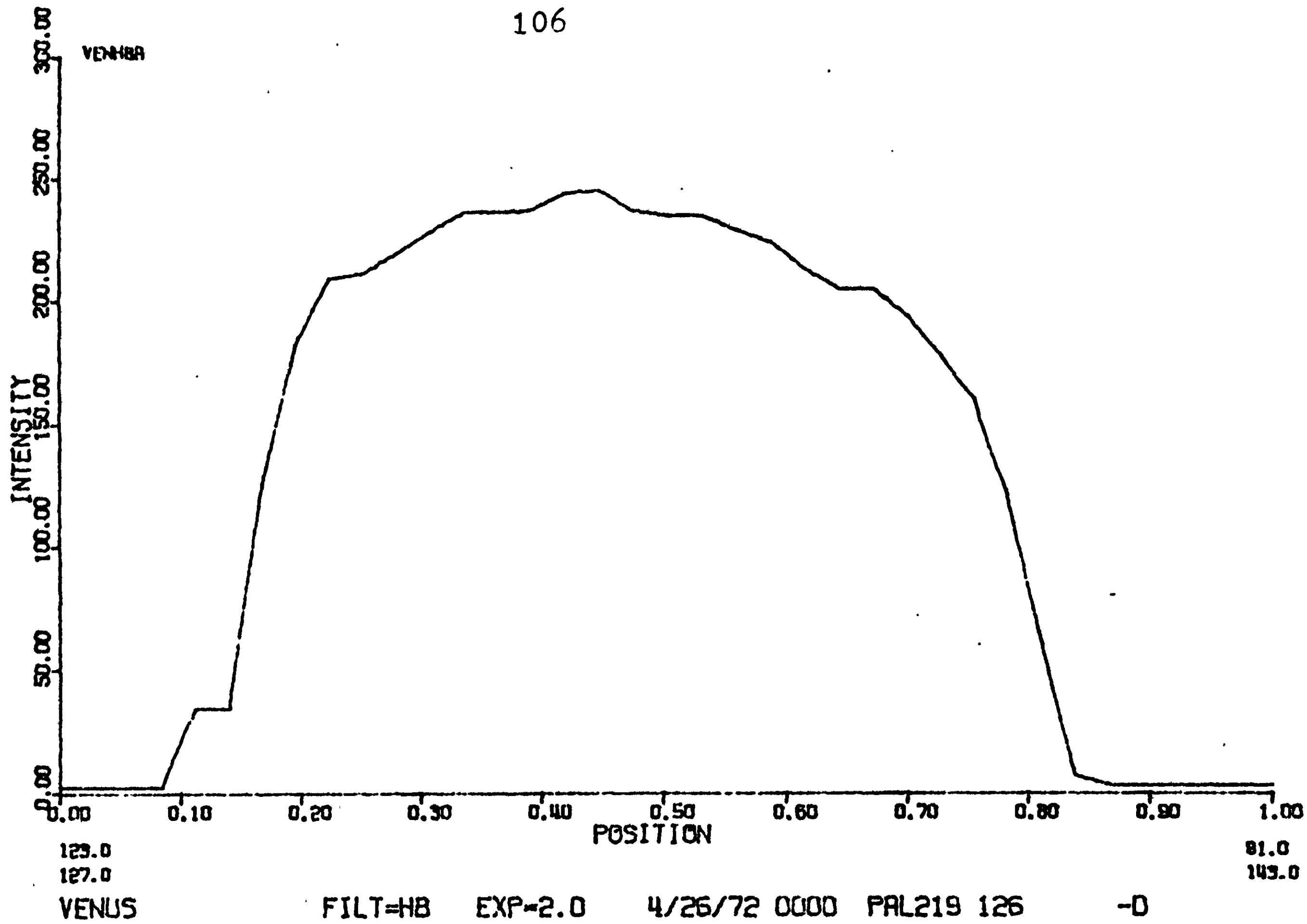
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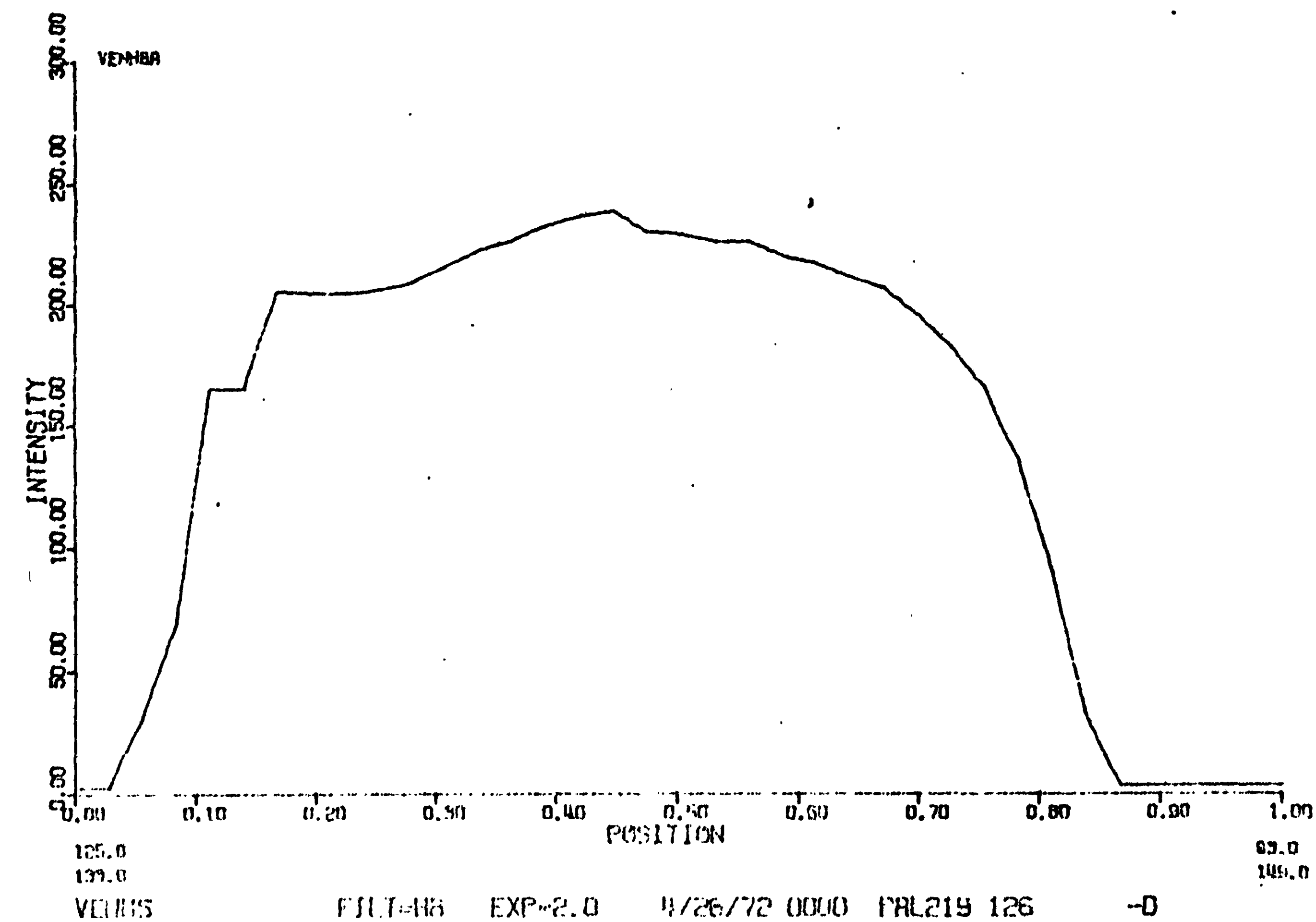
POSITION
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
129.0
127.0
91.0
143.0
VENUS FILT=HB EXP=2.0 4/26/72 0000 PAL219 126 -D


VENHBA
INTENSITY
0.00 50.00 100.00 150.00 200.00 250.00 300.00
POSITION
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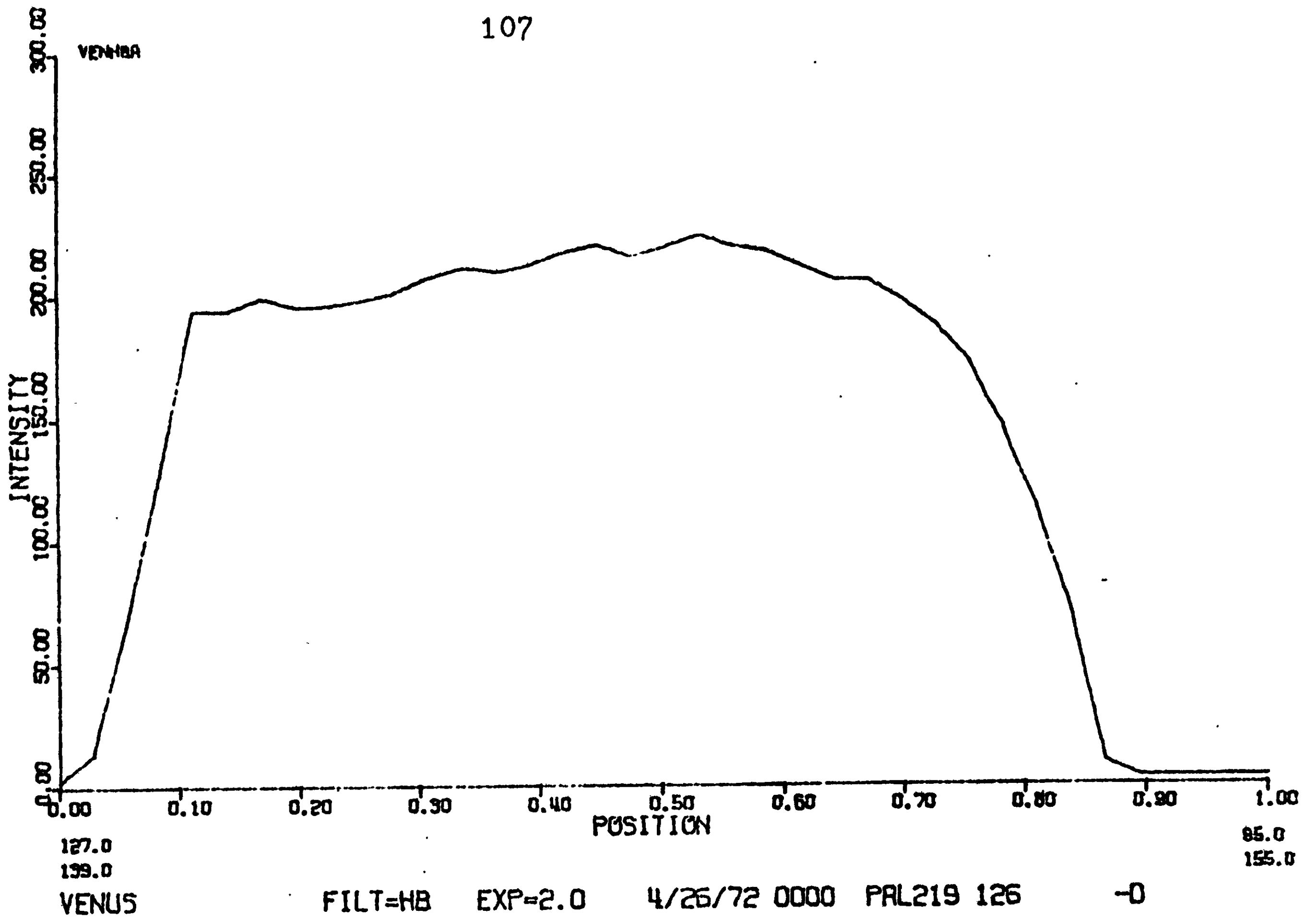
VENUS FILT=HB EXP=2.0 4/26/72 0000 PAL219 126 -D


VENHBA
INTENSITY
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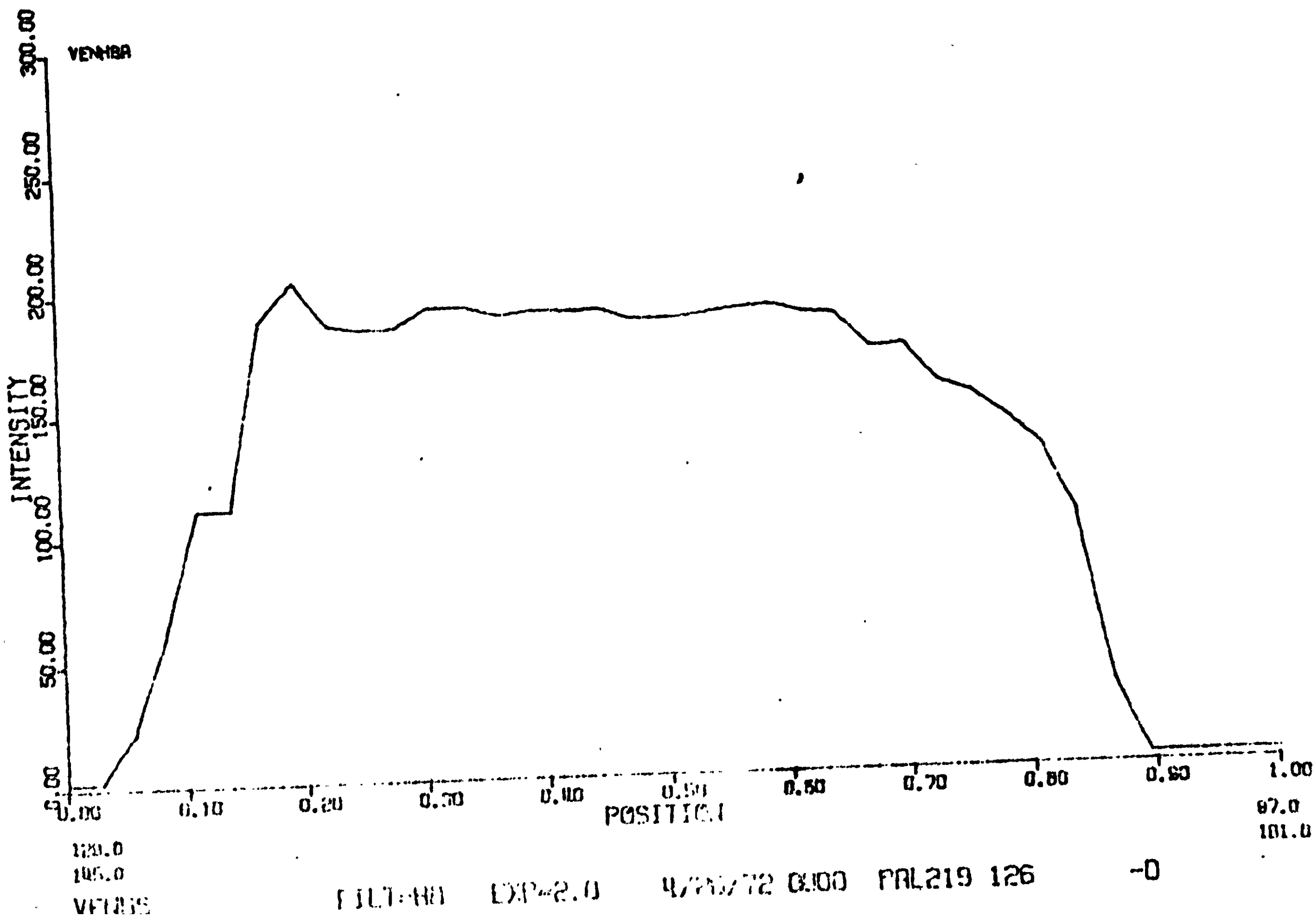
50.00
100.00
150.00
200.00
250.00
300.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
POSITION
127.0
139.0
85.0
155.0
VENUS
FILT=HB EXP=2.0 4/26/72 0000 PAL219 126 -0


VENHBA
INTENSITY
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200.00
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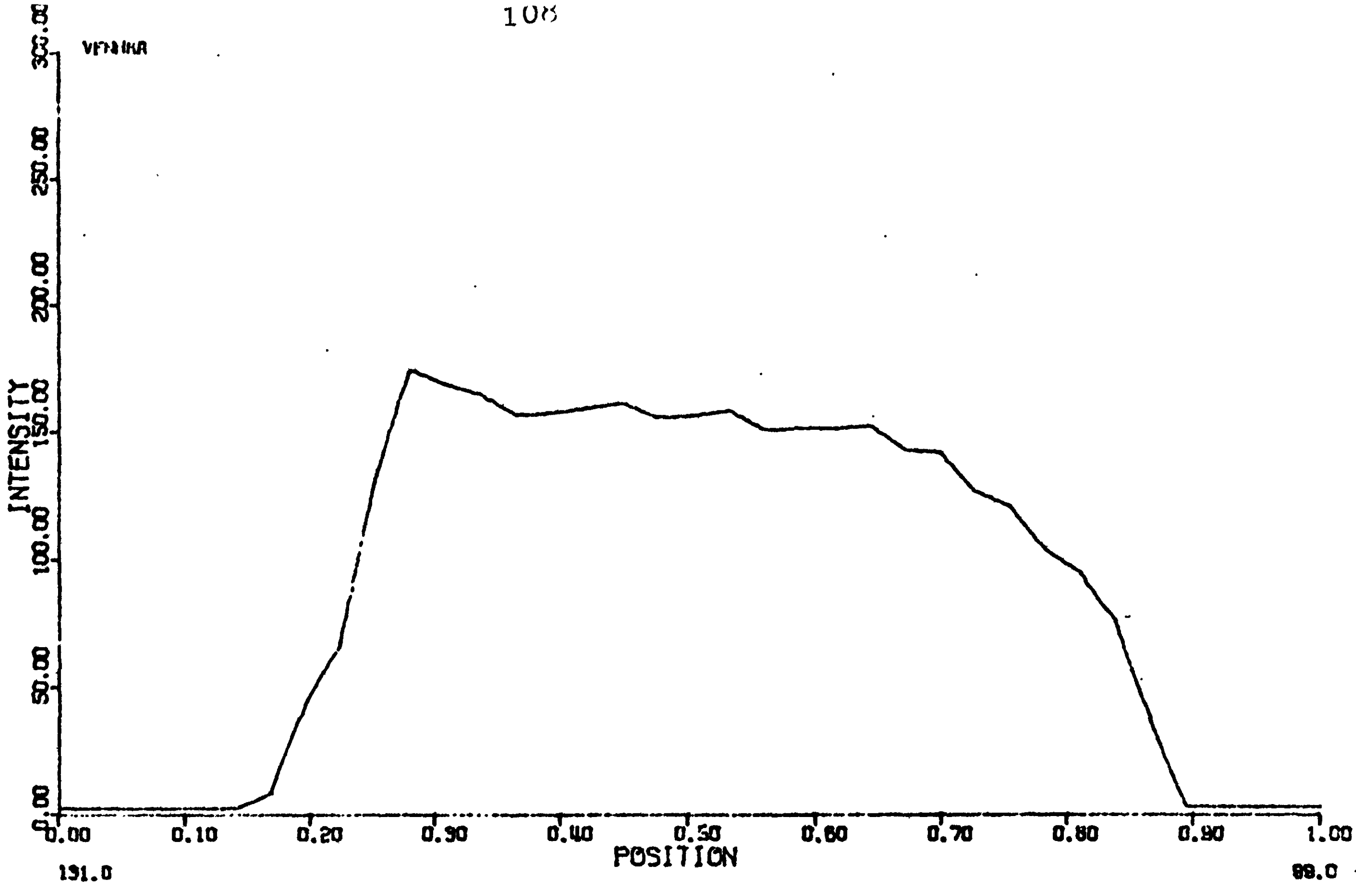
300.00
0.60
0.70
0.80
0.90
1.00
97.0
101.0
PAL219 126 -0



131.0 89.0
151.0 167.0
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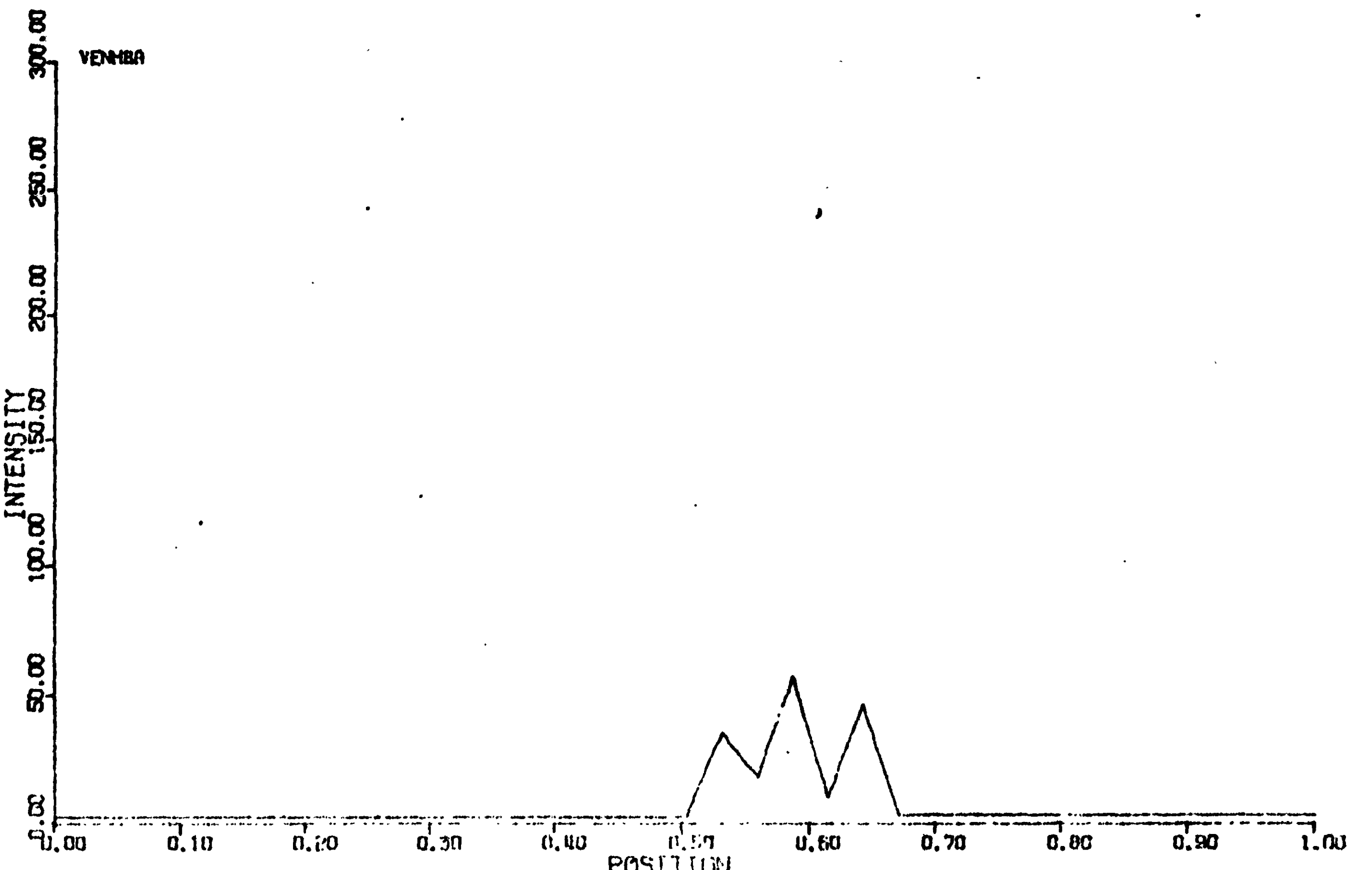

139.0 101.0
157.0 179.0
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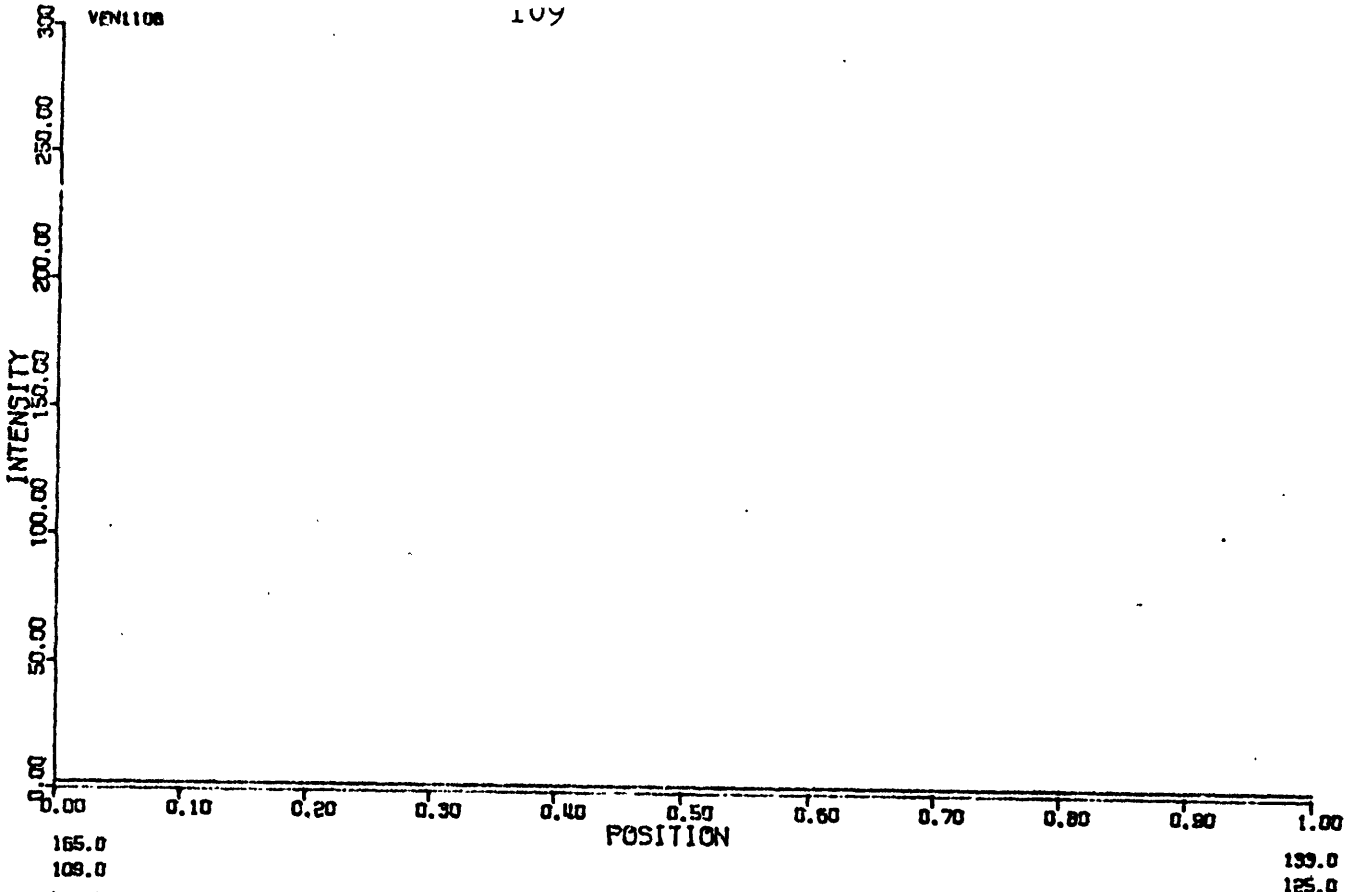

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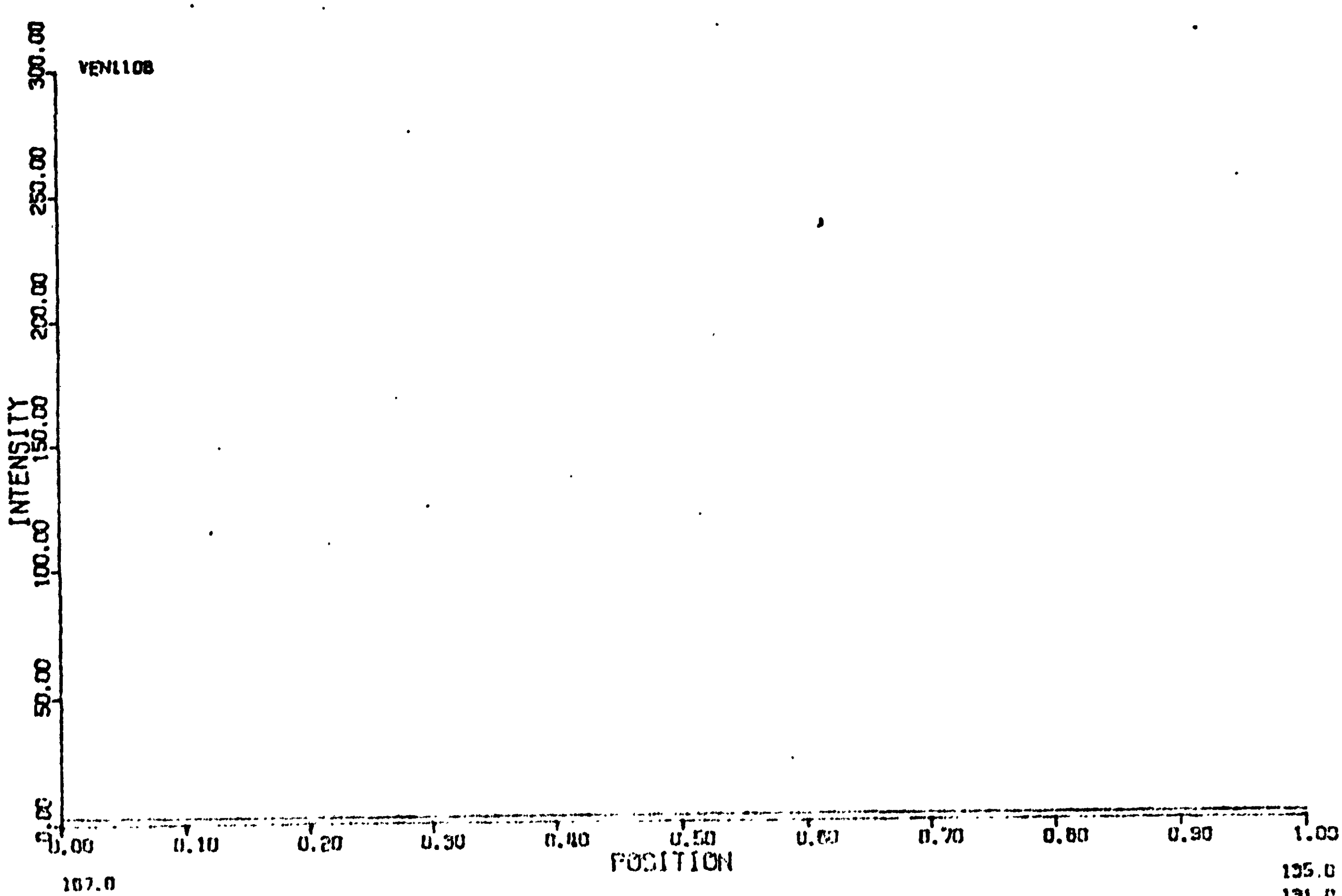
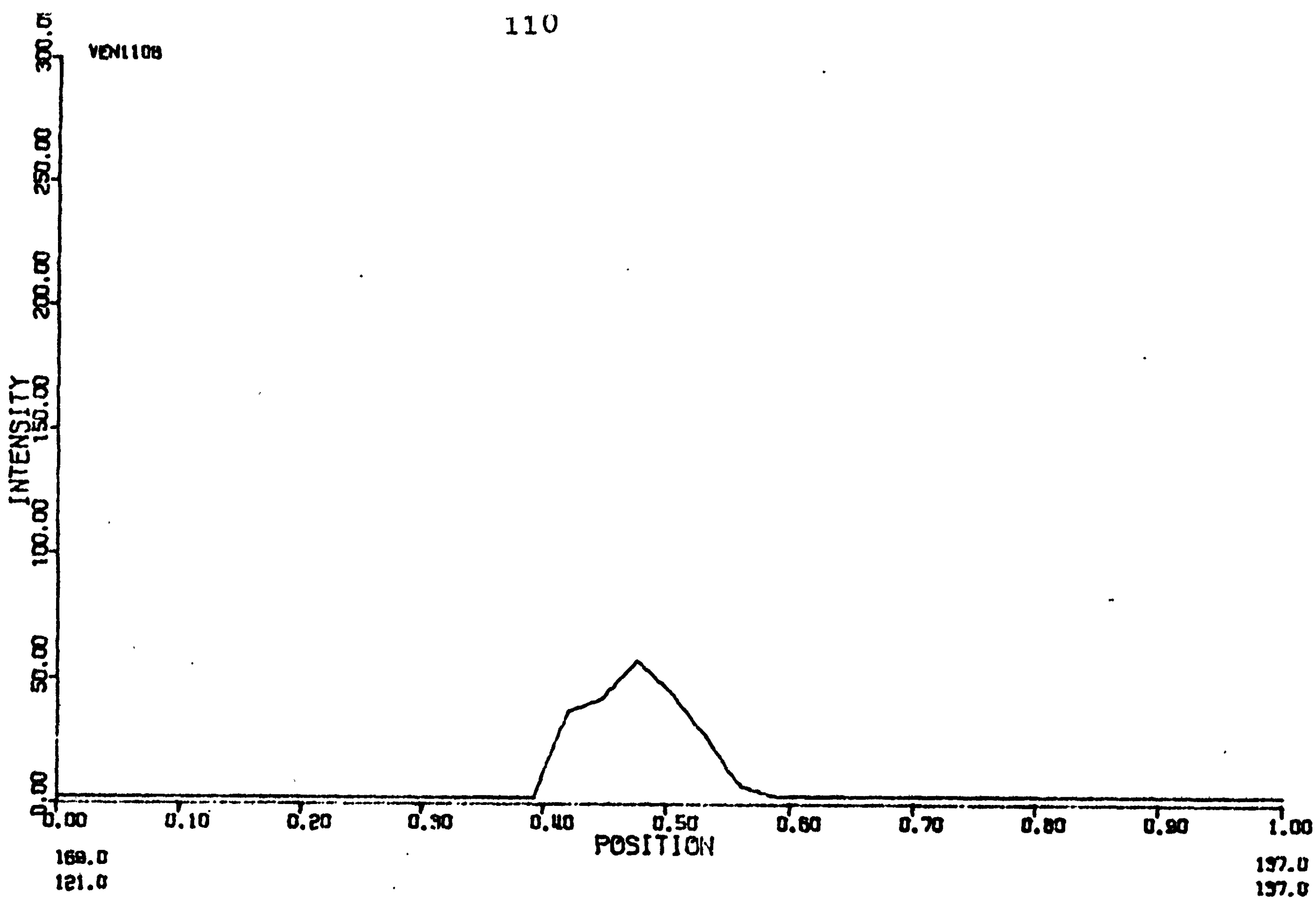


VENUS FILT=1.10 EXP=1.2 4/26/72 0000 PRL219 130 -D



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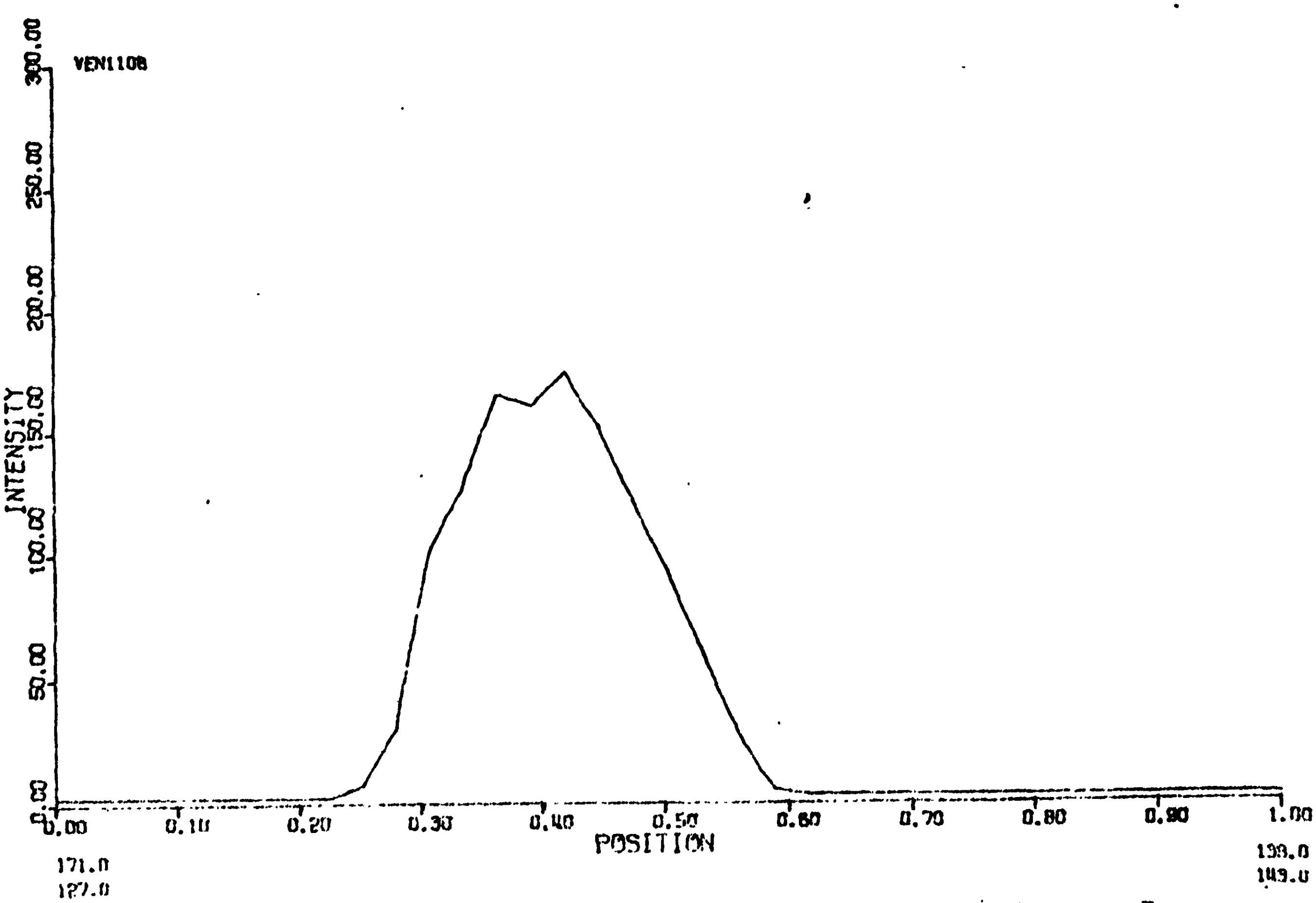

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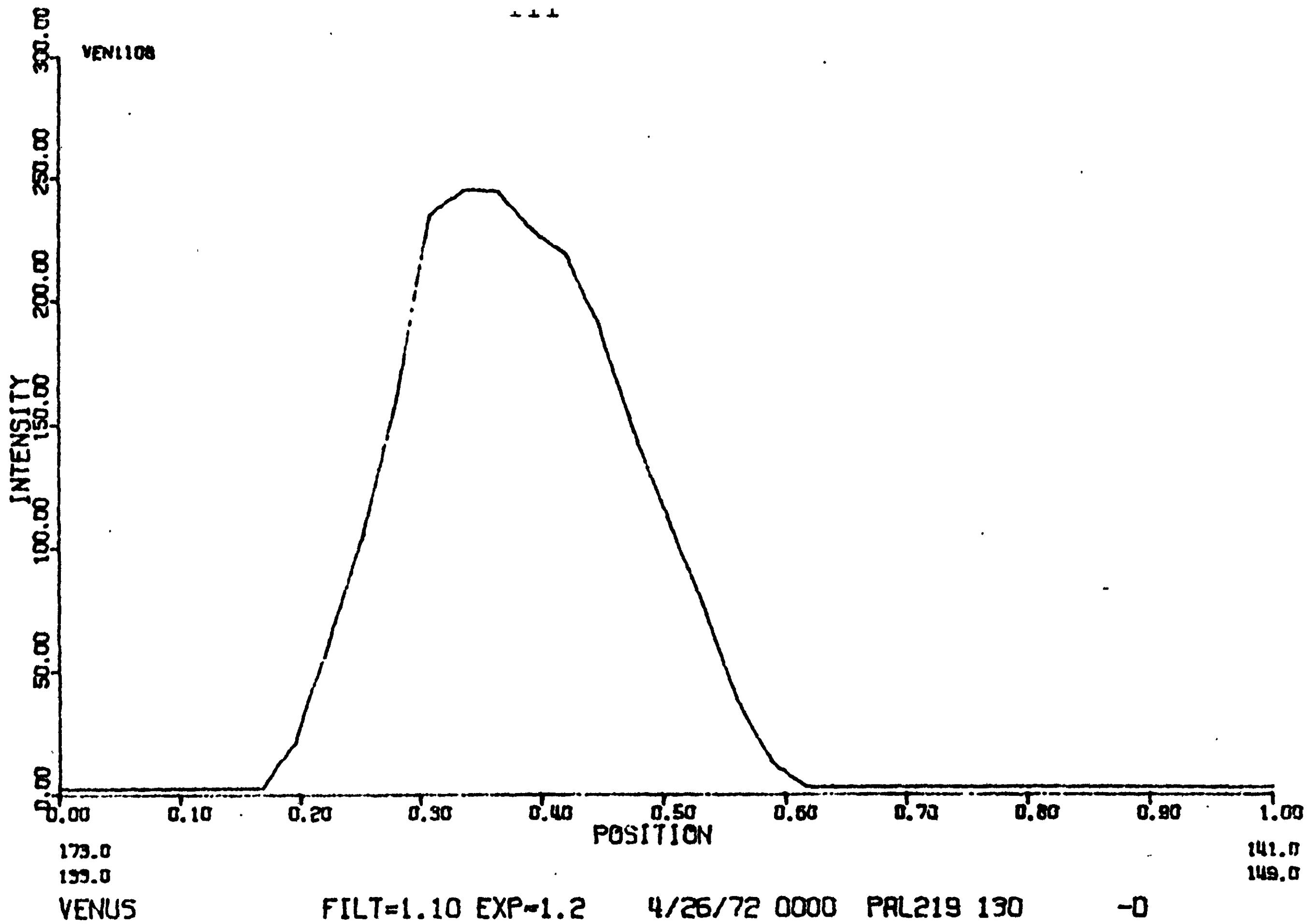
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200.00
250.00
300.00
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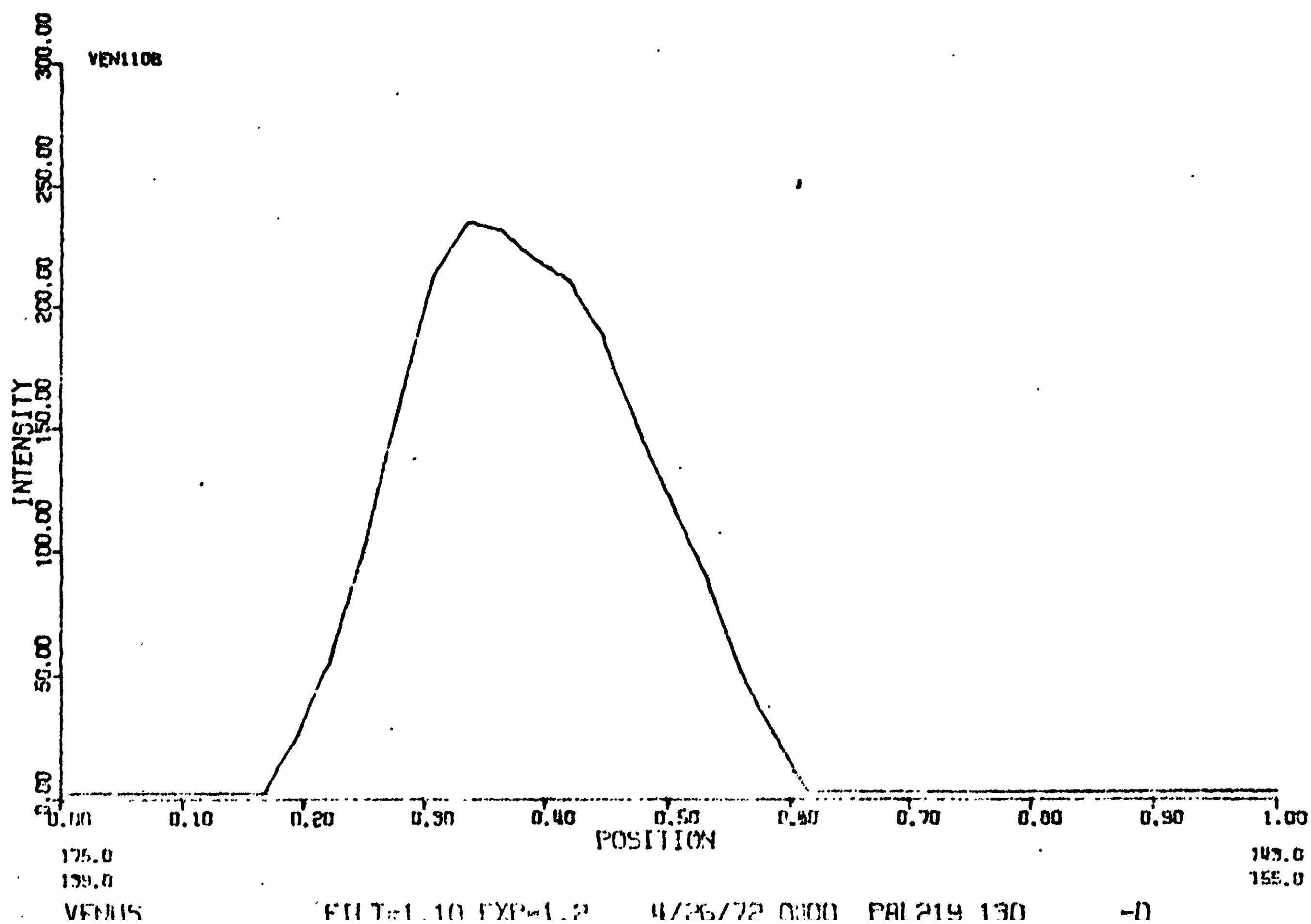
POSITION
173.0
133.0
141.0
149.0
VENUS FILT=1.10 EXP=1.2 4/26/72 0000 PAL219 130 -0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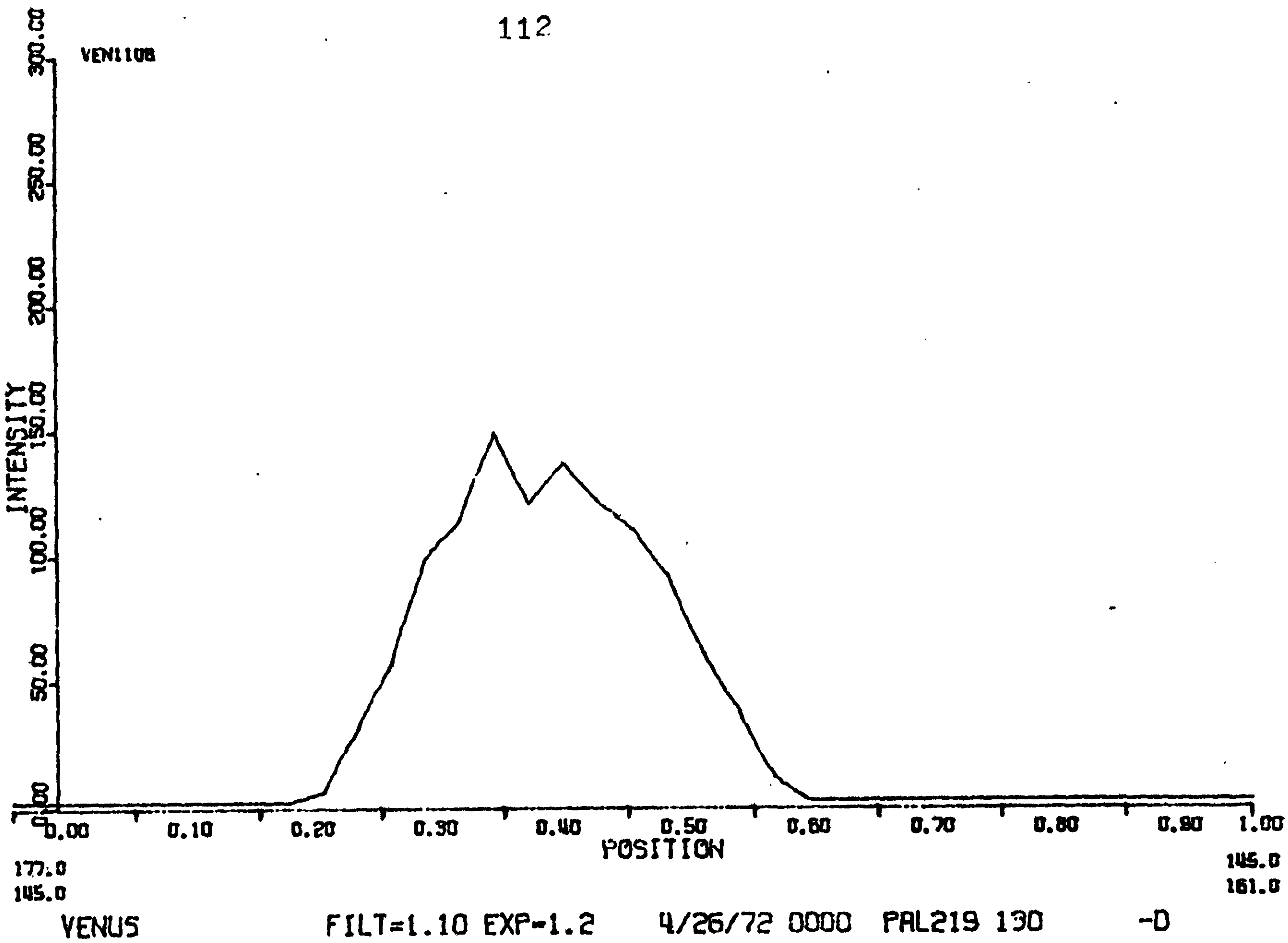
150.00
200.00
250.00
300.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
175.0
139.0
143.0
155.0
VENUS FILT=1.10 EXP=1.2 4/26/72 0000 PAL219 130 -0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0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
POSITION
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145.0
145.0
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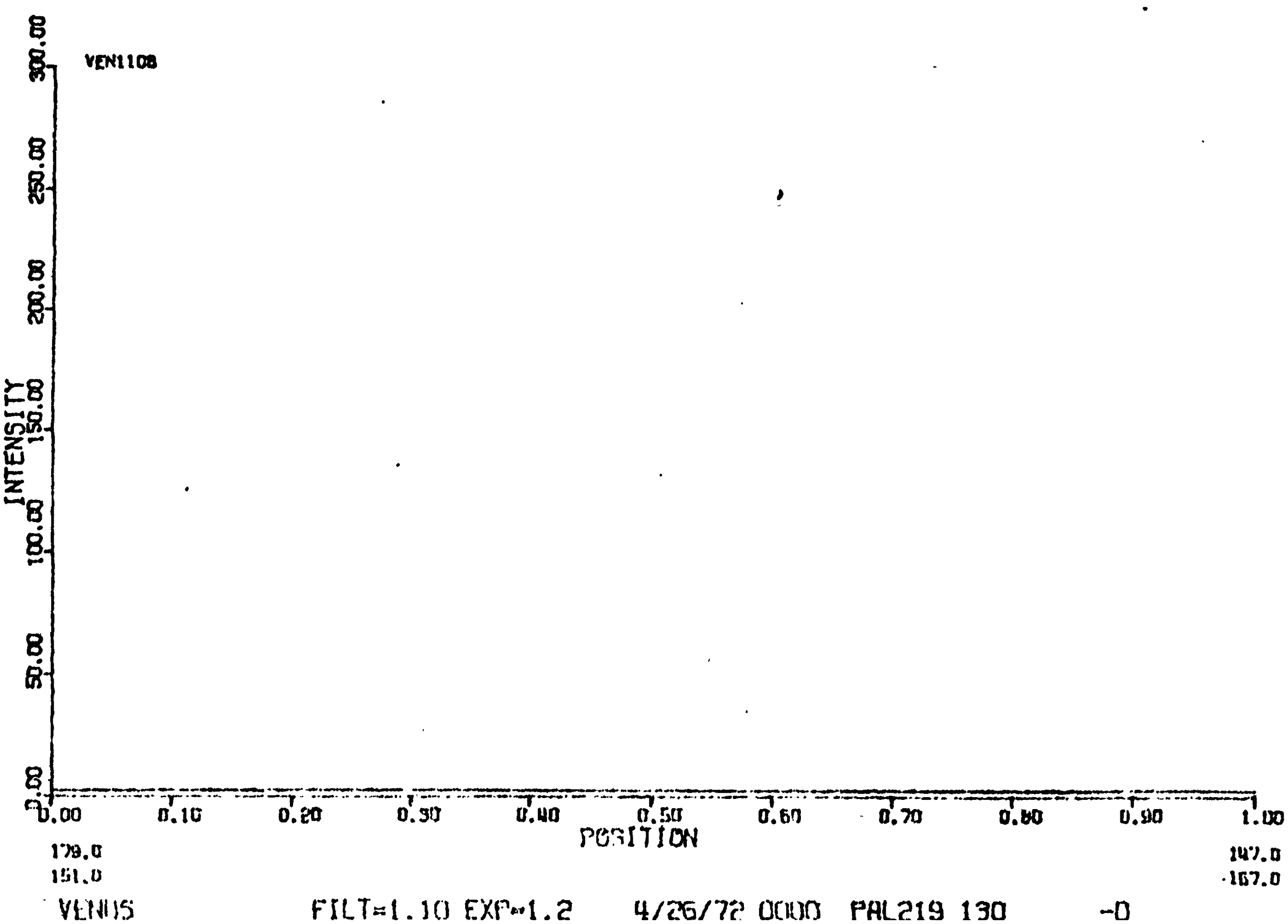
VEN1108
INTENSITY
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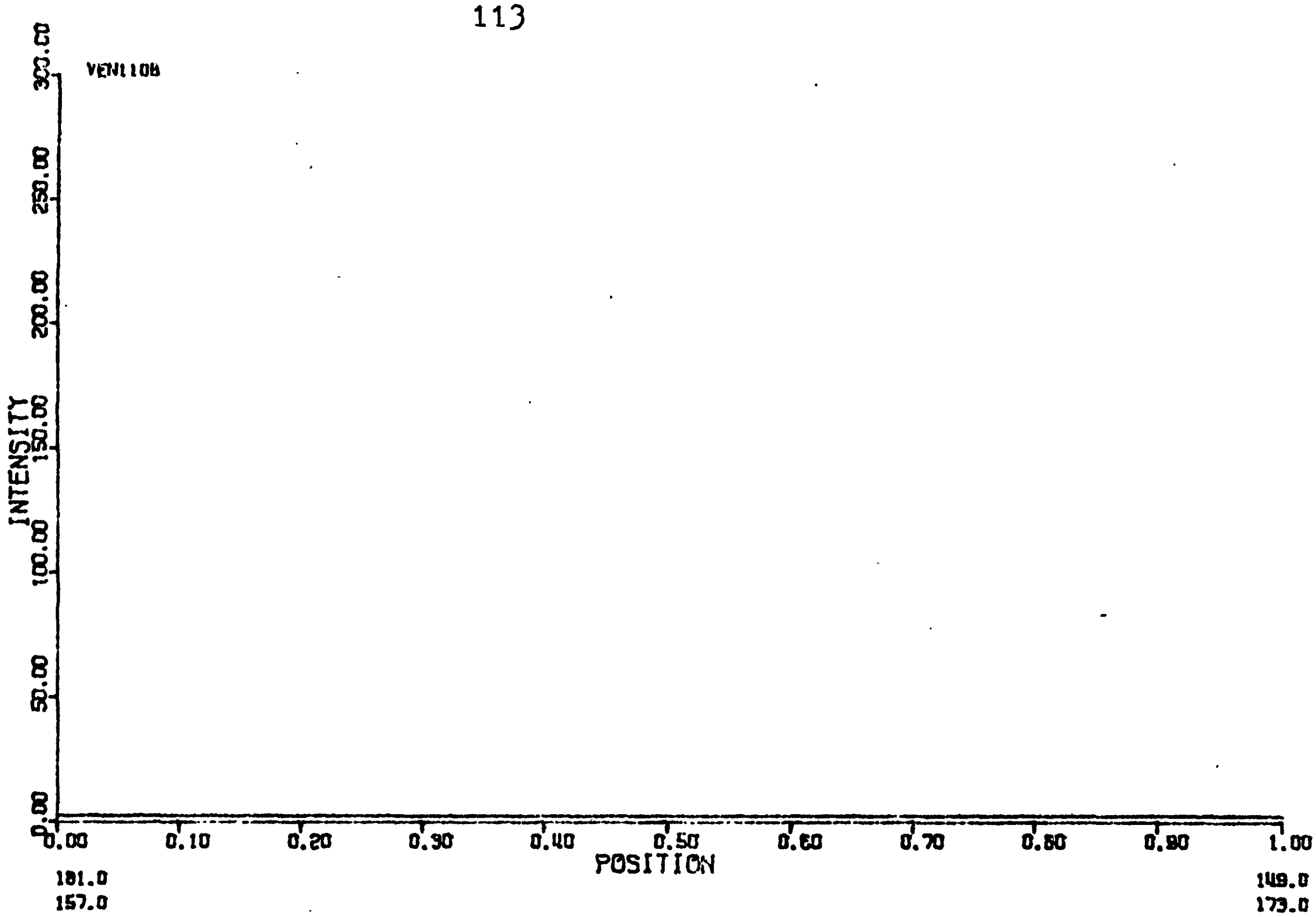
POSITION
179.0
151.0
147.0
-167.0
VENUS FILT=1.10 EXP=1.2 4/26/72 0000 PAL219 130 -D



VENUS FILT=1.10 EXP=1.2 4/26/72 0000 PAL219 130 -0