VLA SCIENTIFIC MEMO #165

Telescope Placement at the VLA for Better Single Configuration Imaging

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I. Introduction

The compact D configuration of the VLA has shortest spacings which are quite naturally constrained by the minimum practical inter-telescope separation of about 45 meters so that projected spacings of almost 25 meters (i.e. the dish diameter) are regularly observed. With this information and the help of deconvolution, source structures approaching the size of the primary beam of the telescope can be successfully reconstructed. The more extended VLA configurations were designed with the concept of scaling incorporated into the choice of telescope stations so that each larger configuration is about a factor 3.3 larger. While such a concept has some simple mathematical appeal, the natural central gap in coverage of the D configuration becomes an increasingly large and unnatural hole if all telescope locations are simply scaled in going from one configuration to the next. Observers who wish to image relatively large objects at a higher resolution than that provided by the D configuration, have generally been forced to request additional observing time in the more compact configurations in order to successfully recover a reliable image. Since the surface brightness sensitivity in such cases is strongly limited by the largest configuration used, it is generally only necessary to obtain short integrations (in principal scaling as the relative area or about 1/10) in each smaller configuration. Although this procedure is now regularly done, it is not terribly satisfactory. Someone wishing B configuration resolution of a source subtending much of the primary beam must request, be scheduled and calibrate three separate observations spread over about one calender year and then finally combine (with the additional annoyance of relative calibration) the three databases. It seems much more efficient, for all those involved in this process, if the need for multi-configuration observations could be done away with. In addition to the question of convenience and efficiency, the observation of time variable phenomenon like those on the Sun and in Cas A, would clearly benefit even more from a general solution to this problem.

II. Suggested Configurations

With the motivation outlined above I've looked at how the existing telescope stations of the VLA site might be used to provide single epoch, self-contained databases for successful imaging at a desired resolution. A small amount of experimentation with the station locations of the Green Book together with the AIPS tasks UVSIM, MX and FFT led me to conclude that plugging the short spacing hole of the C, B and A configurations could only be done at some price in either intermediate spacing coverage or resolution. Rather than sacrificing coverage at intermediate spacings, I've chosen to concentrate on options in which at most one outermost telescope per arm is relocated. Simple, but effective refinements to the existing configurations are described below.

The coverage of the C-configuration can very easily be modified to provide good continuous sampling down to projected spacings of one dish diameter by simply taking the outermost North arm telescope (at N18) and placing it at station N1. The inner Fourier plane of the existing and suggested C configurations are shown in Figures 1 and 2 for a six hour integration (-3 to $+3$ hours of hour angle) at declinations 60, 20 and -20 degrees. The penalty for enhanced coverage at small spacings is minimal in this case, effecting only the north-south synthesized beam size at low declinations where one would probably opt for a CnB hybrid in any event.

In the B-configuration the central gap in coverage is rather larger, requiring the use of three telescopes to adequately fill it. The most satisfactory arrangement seems to be the symmetric replacement of each outer station (W36, E36 and N36) with the inner locations W2, E2 and N1. The inner Fourier planes of the existing and suggested B configurations are shown in Figures 3 and 4, as above, for a six hour integration (-3 to $+3$ hours) at declinations 60, 20 and -20 degrees. There is a penalty in resolution of about 18% as illustrated in the outer Fourier plane coverages shown in Figure 5.

The A-configuration coverage can similarly be repaired with the three outer telescopes. In view of the large number of independant image pixels which would contain information under the circumstances of interest, a 12 hour observation (-6 to $+6$ hours) was assumed for calculation of coverages. A reasonable solution seems to be the placement of the outer telescopes (from W72, E72 and N72) on the inner locations W4, E2 and N1. Inner Fourier plane coverages are shown in Figures 6 and 7 for the existing and suggested A configurations, while a similar penalty in resolution (to that seen above) of about 18% is apparent from the outer Fourier plane coverage shown in Figure 8.

III. Conclusion

At a modest penalty in spatial resolution (with respect to current configurations), the existing telescope stations of the VLA can be used to give good continuous spatial frequency coverage down to the projected spacings of a dish diameter in single epoch observations. The same strategy now employed of using the next larger configuration of the north arm relative to the east and west arms can of course also be used at low declinations.

FIGURE CAPTIONS

Figure 1a,b,c The inner UV plane coverage for an observation from -3 to $+3$ hours of hour angle at declinations of (a) 60, (b) 20 and (c) -20 degrees using the **existing** C configuration. The elevation limit is 10 degrees and no shadowed data is included. Note the central hole in coverage due to the lack of the shortest projected spacings.

Figure 2a,b,c As in Figure 1 but for the **modified** C configuration discussed here. (Only the outermost north arm telescope has been moved from N18 to N1.) Note the filling of the central hole in coverage with only a small loss of North-South resolution at the most southerly declinations.

Figure 3a,b,c The inner UV plane coverage for an observation from -3 to $+3$ hours of hour angle at declinations of (a) 60, (b) 20 and (c) -20 degrees using the **existing** B configuration. The elevation limit is 10 degrees and no shadowed data is included. Note the rather larger central hole in coverage relative to Figure 1.

Figure 4a,b,c As in Figure 3 but for the **modified** B configuration discussed here. (The outermost telescope of each arm has been moved in to W2, E2 and N1.) Note the filling of the central hole in coverage.

Figure 5a,b The outer UV plane coverage of the (a) **existing** and (b) **modified** B configurations is contrasted. The six hours of coverage as in Figures 3 and 4 has been gridded with uniform weight and tapered to 30% at 55 kiloλ. The maximum observed spacing is reduced by 18% from 55 to 45 kiloλ in the modified configuration.

Figure 6a,b,c The inner UV plane coverage for an observation from -6 to $+6$ hours of hour angle at declinations of (a) 60, (b) 20 and (c) -20 degrees using the **existing** A configuration. The elevation limit is 10 degrees and no shadowed data is included. Note the extremely large central hole in coverage relative to Figure 1.

Figure 7a,b,c As in Figure 6 but for the **modified** A configuration discussed here. (The outermost telescope of each arm has been moved in to W4, E2 and N1.) Note the filling of the central hole in coverage.

Figure 8a,b The outer UV plane coverage of the (a) **existing** and (b) **modified** A configurations is contrasted. The twelve hours of coverage as in Figures 6 and 7 has been gridded with uniform weight and tapered to 30% at 180 kiloλ. The maximum observed spacing is reduced by 17% from 183 to 149 kiloλ in the modified configuration.

Figure 1a

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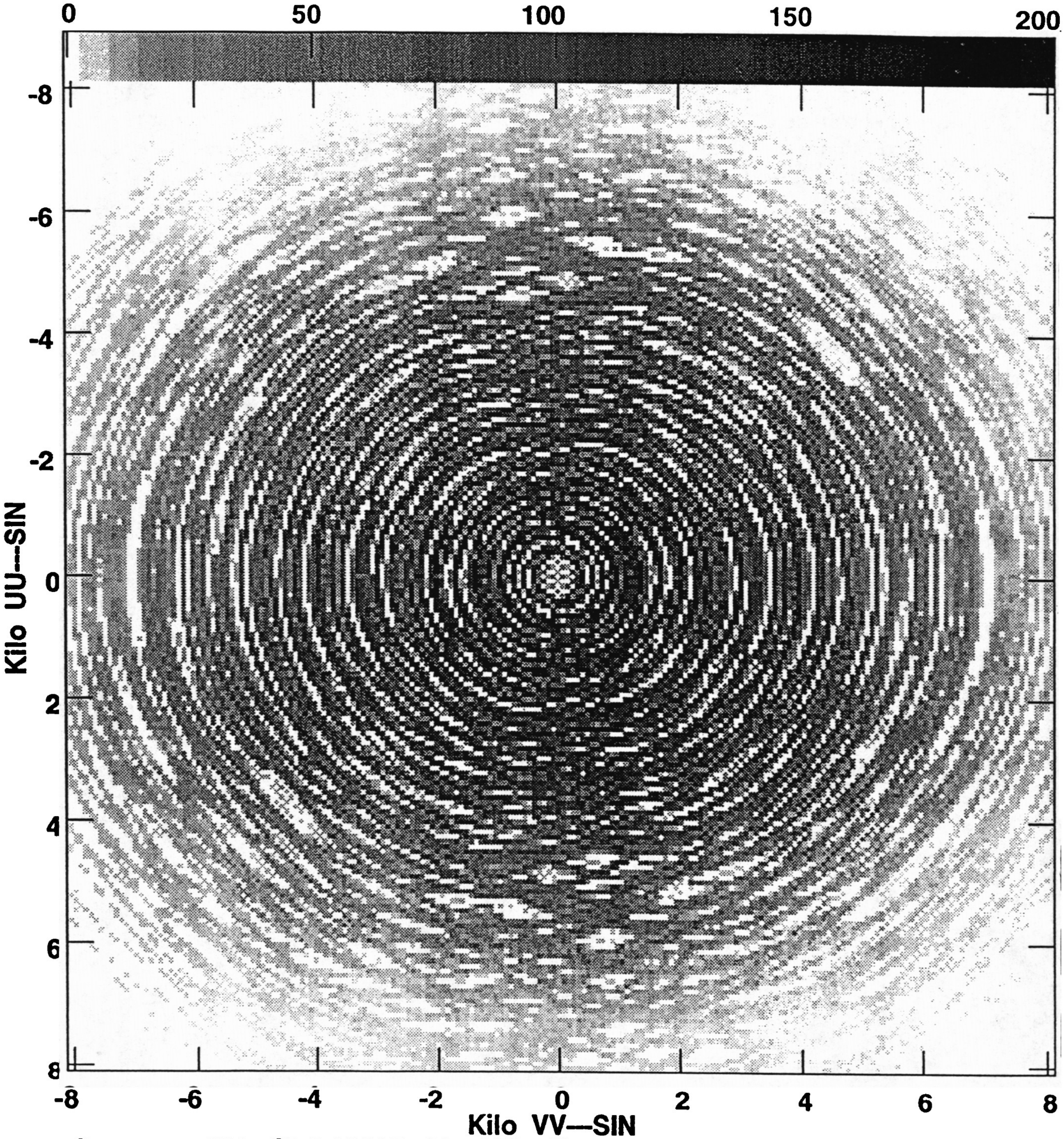

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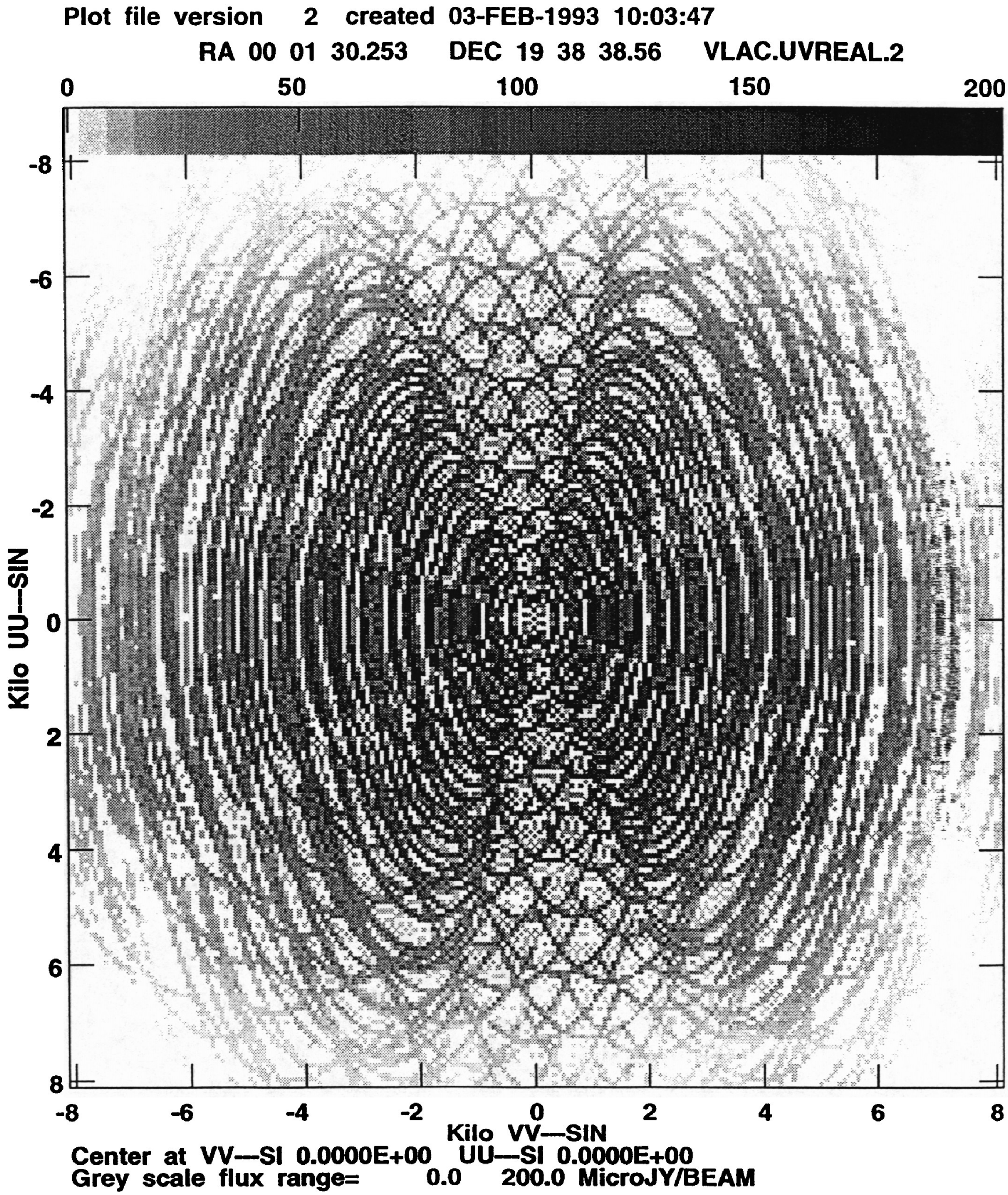
Figure 1b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Kilo VV---SIN
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Figure 1c

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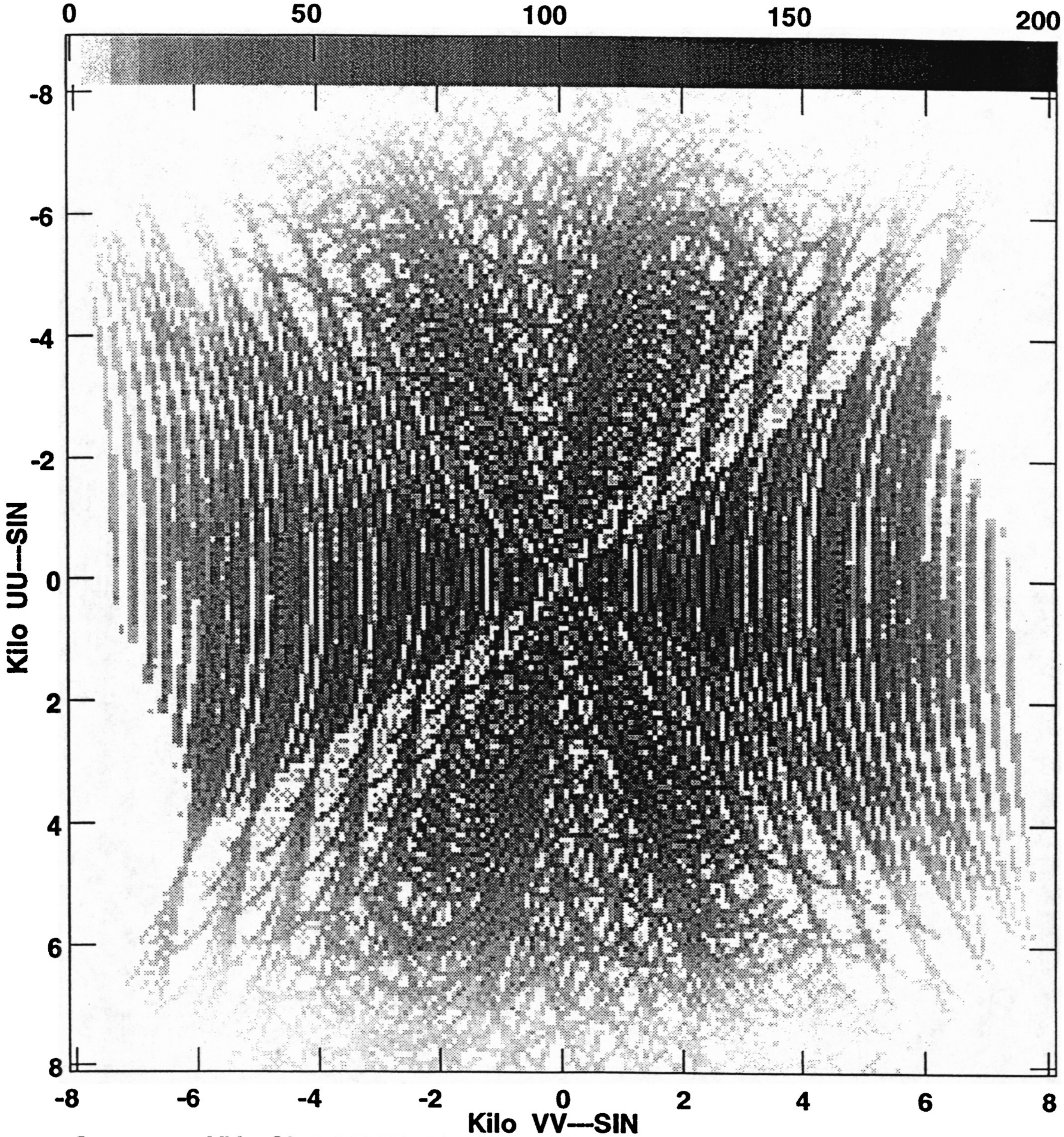

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Figure 2a

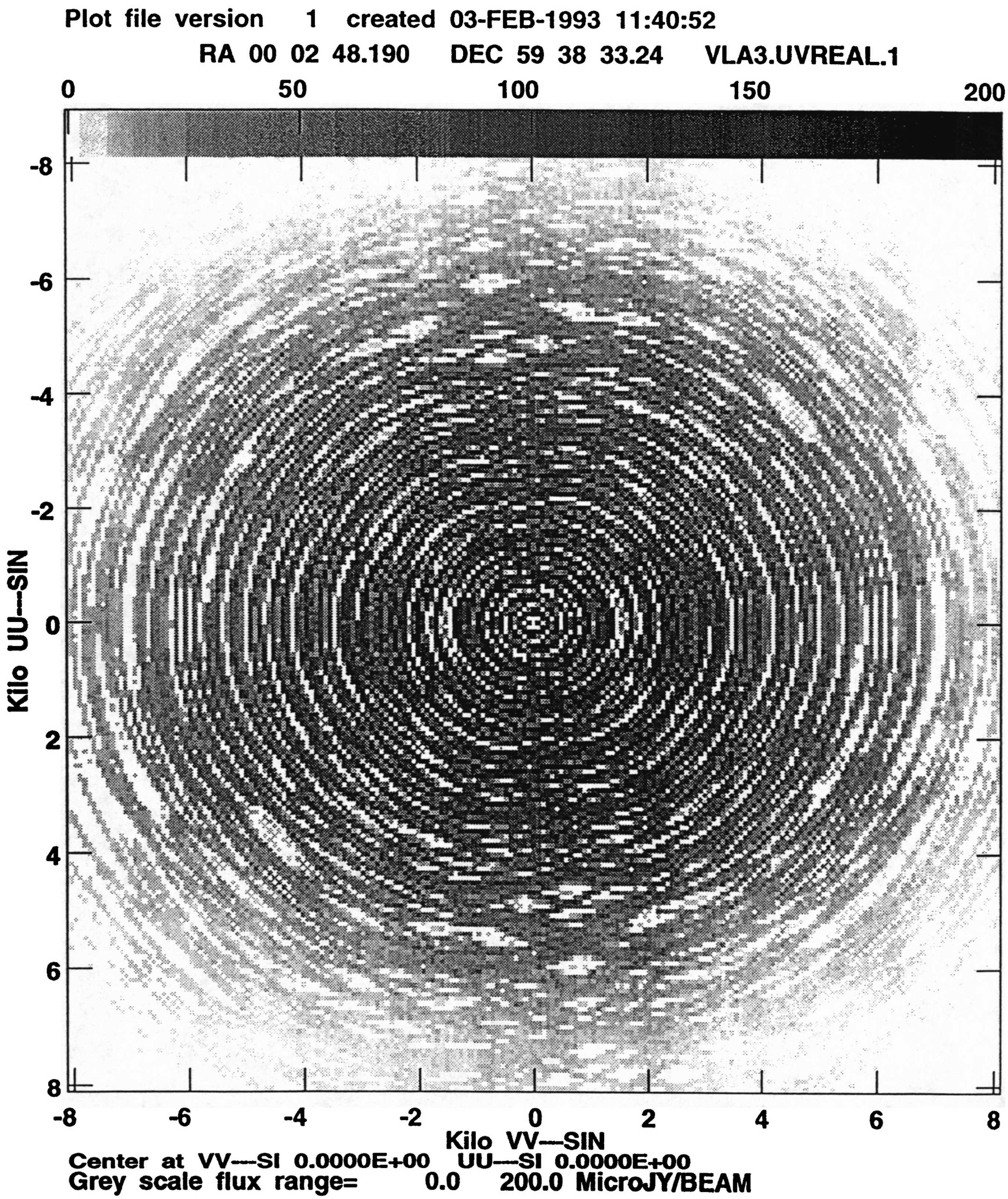

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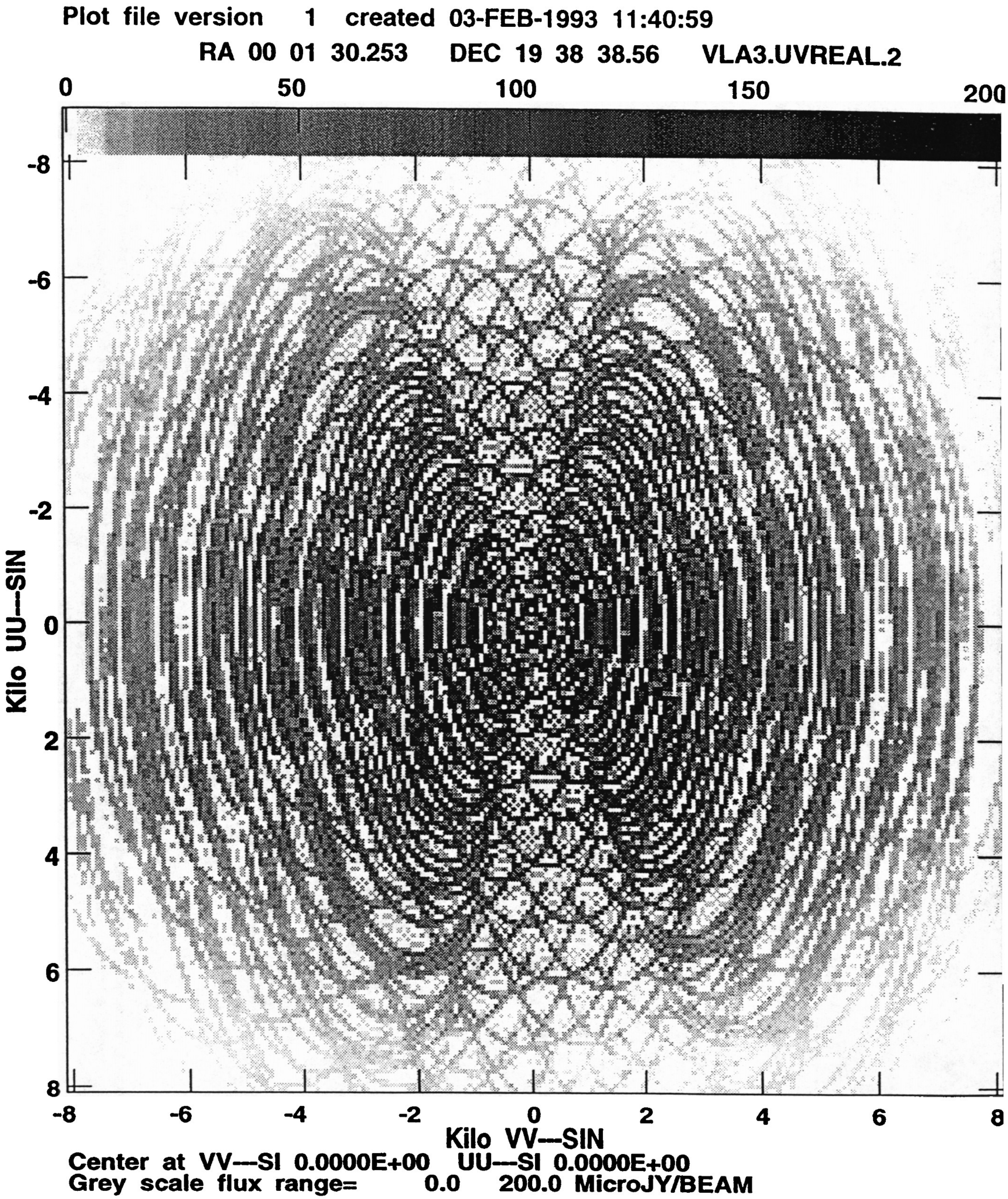
Figure 2b



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Kilo UU---SIN
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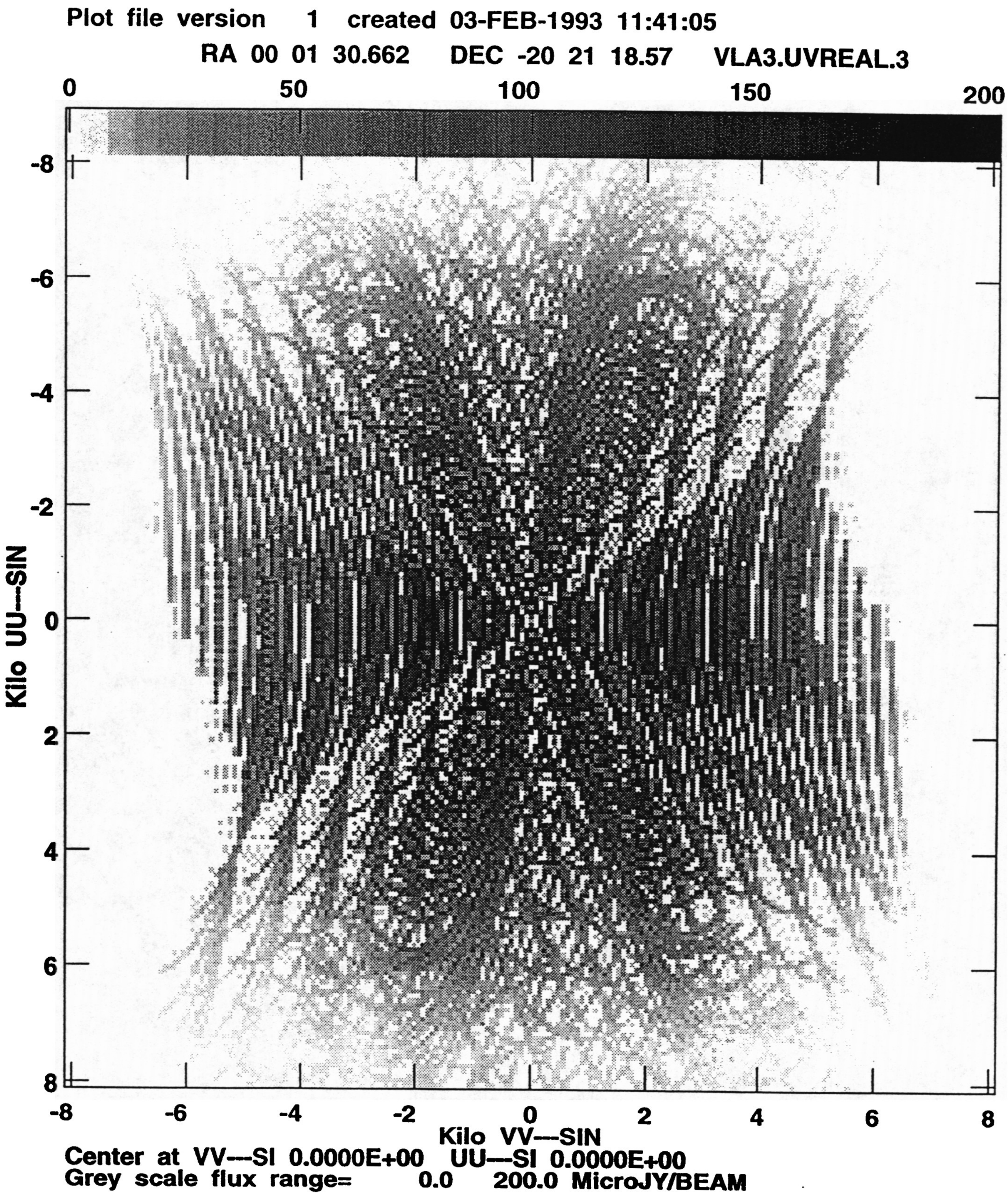
Figure 2c



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Kilo UU---SIN
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Figure 3a

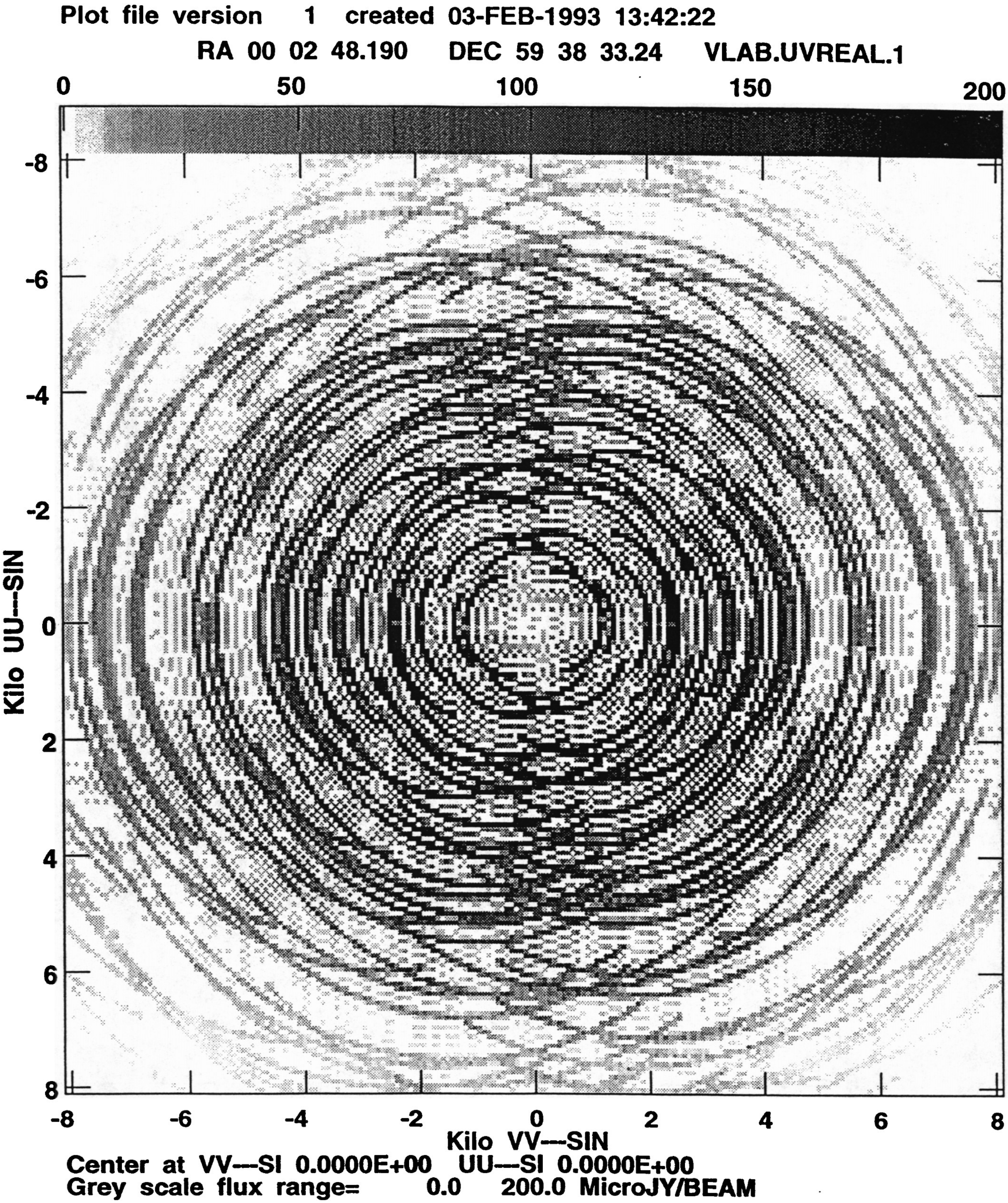

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Figure 3b

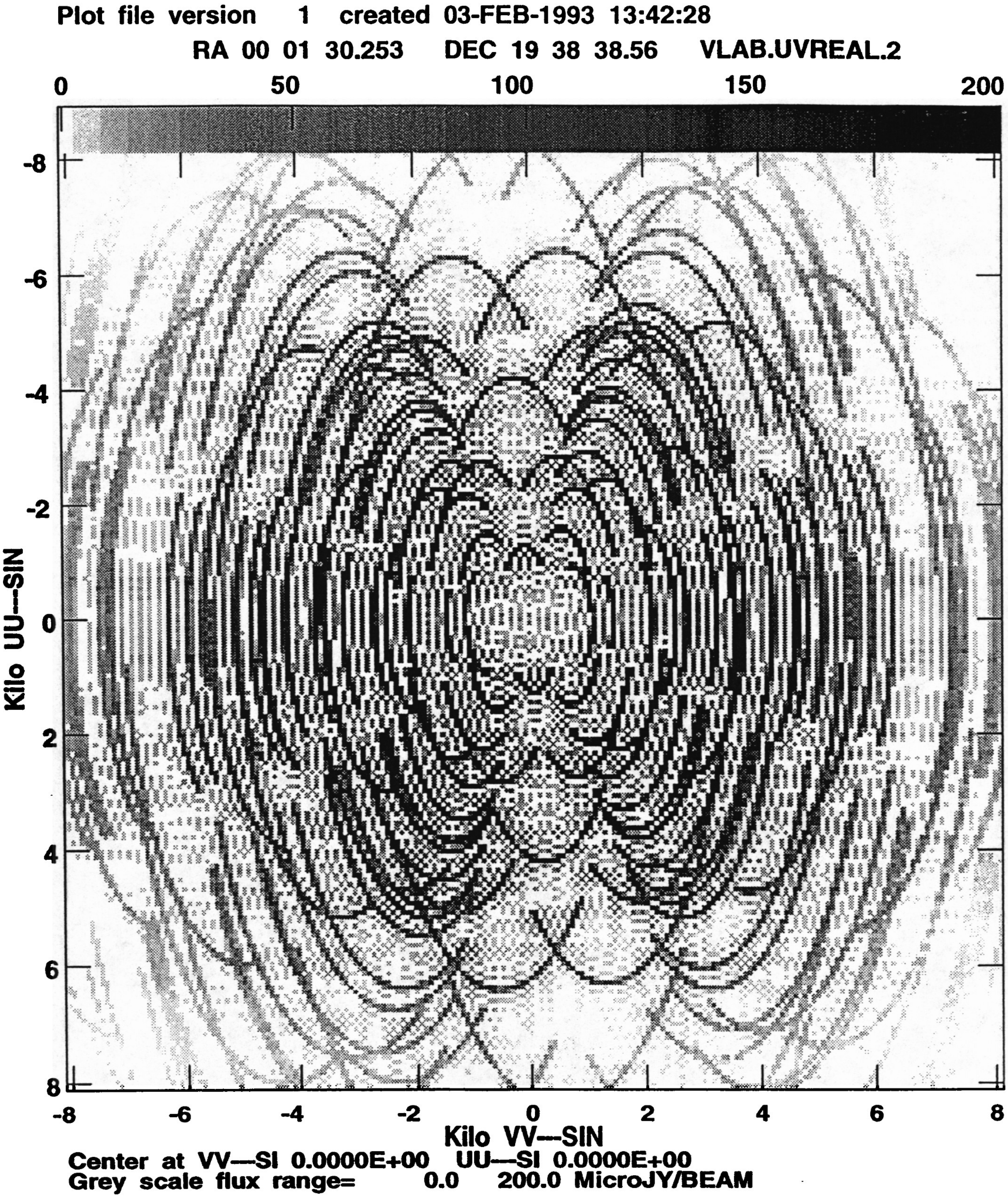

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Figure 3c

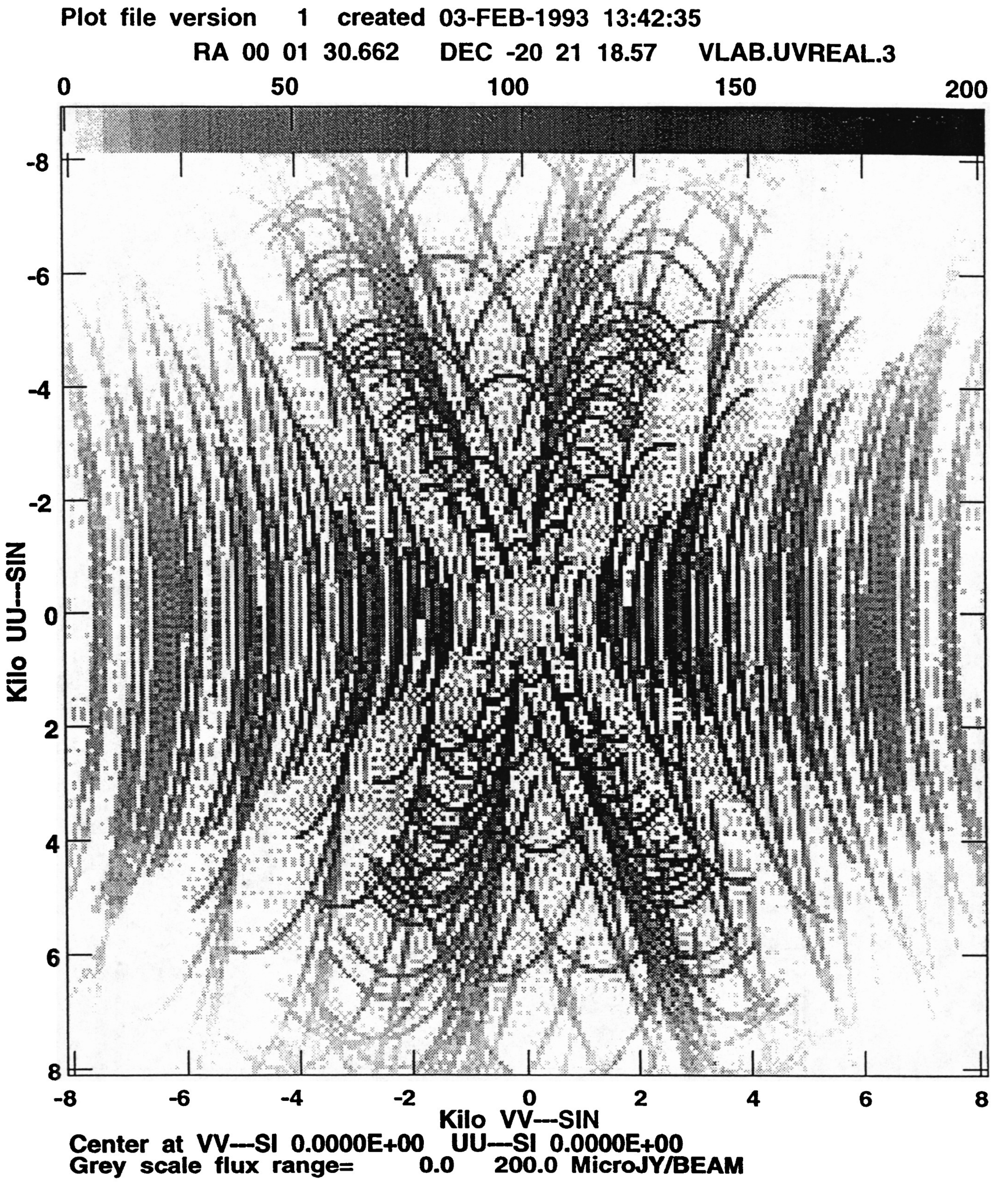
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Figure 4a

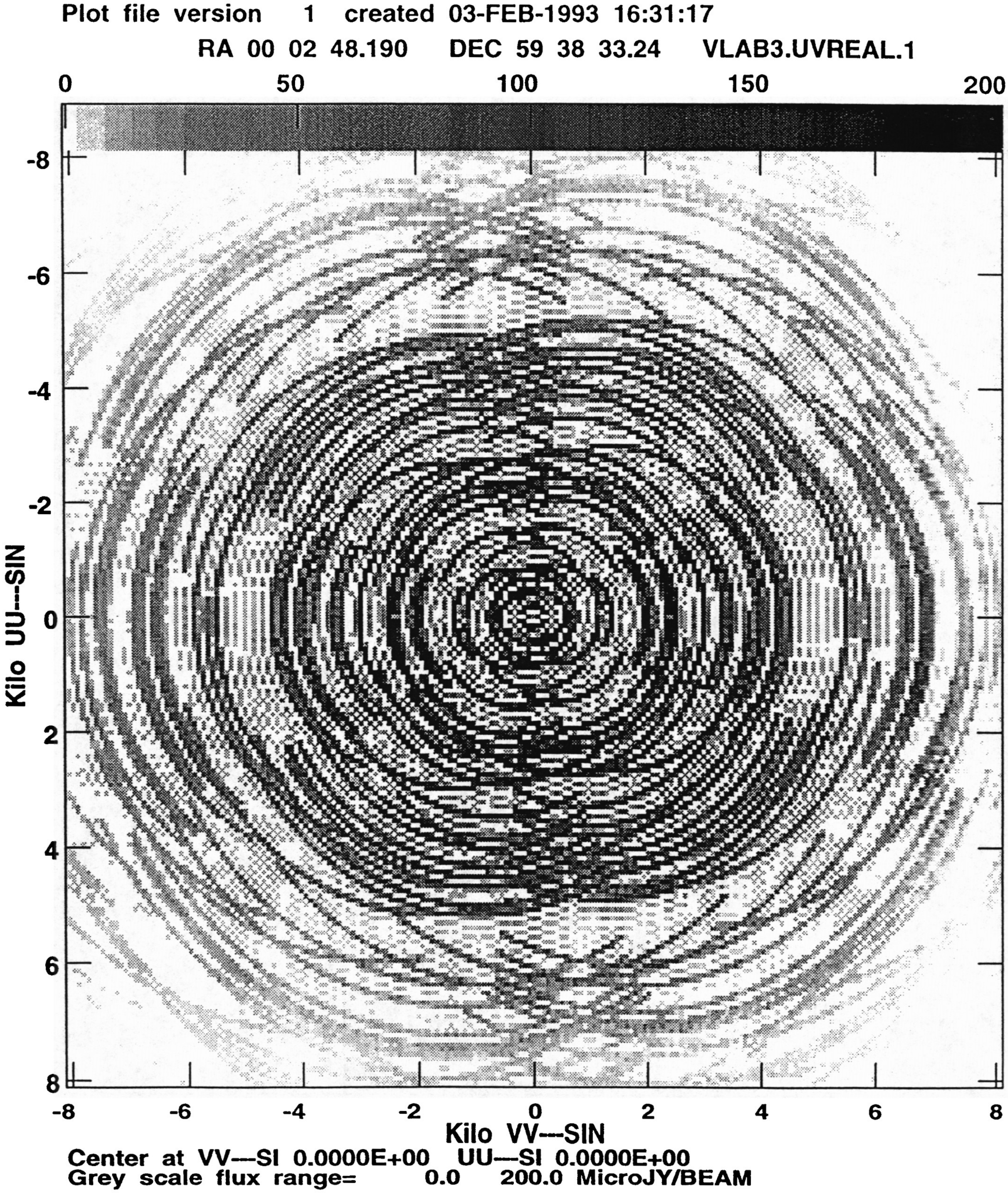
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Figure 4b

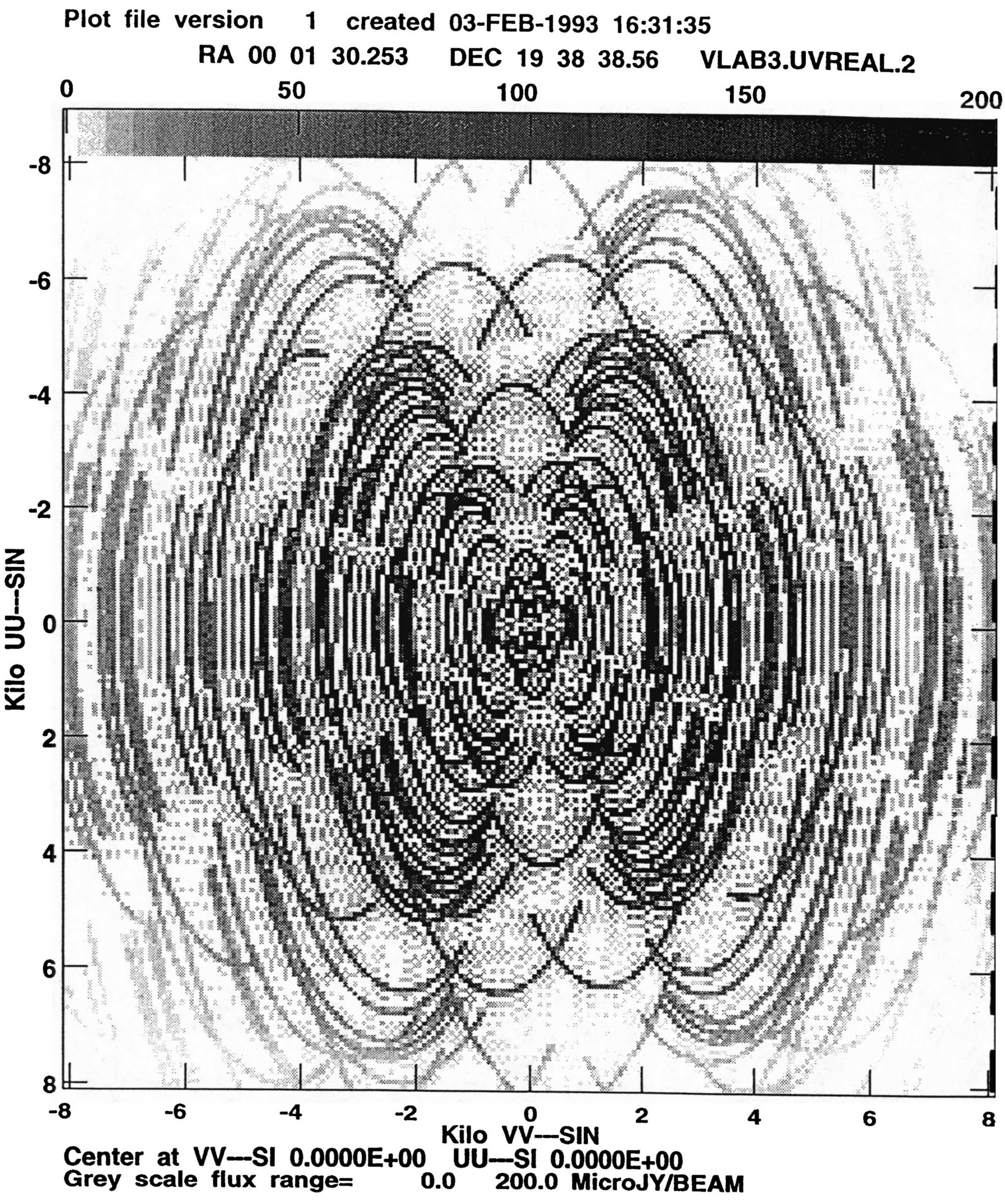
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Figure 4c

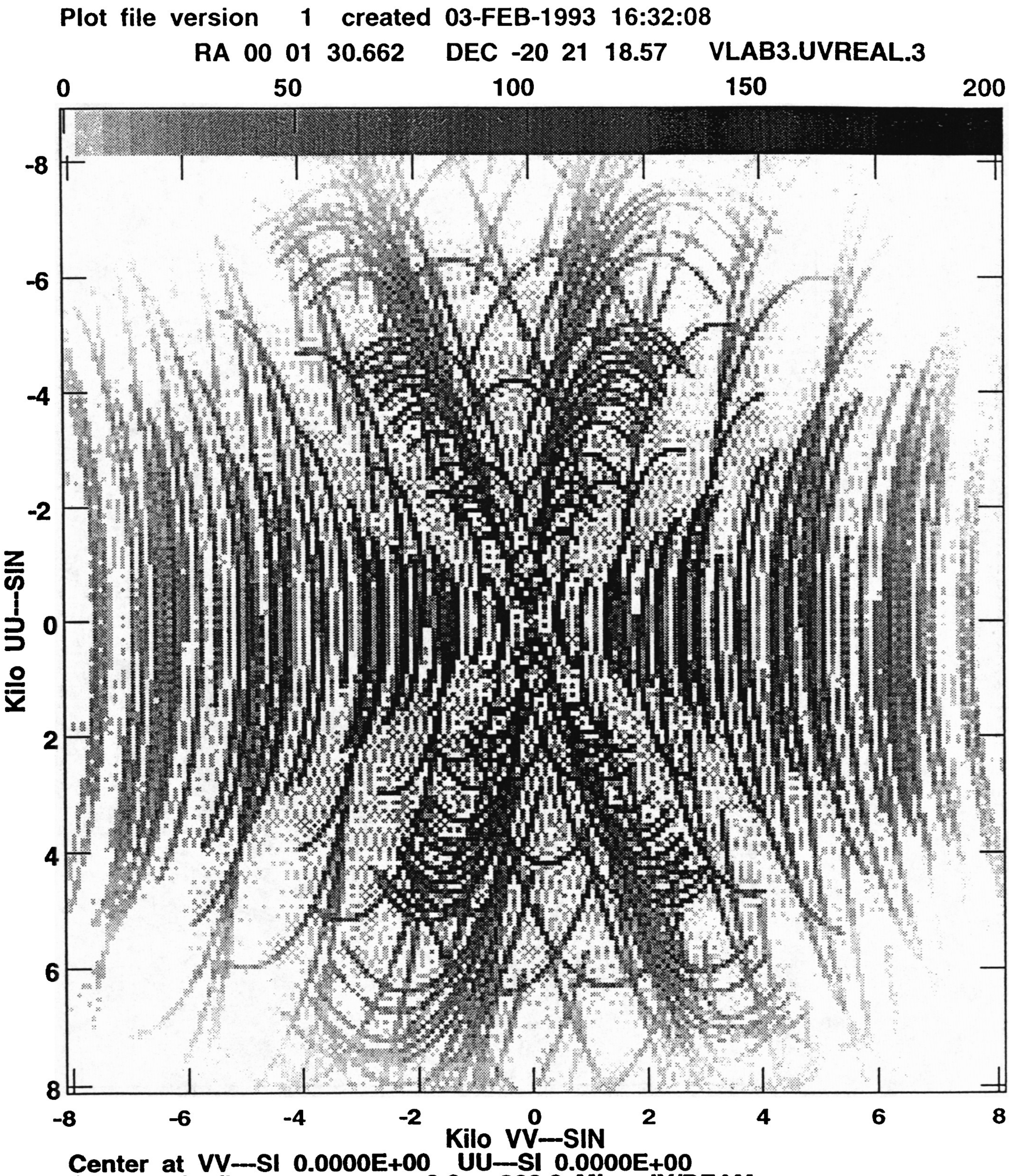

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Figure 5a

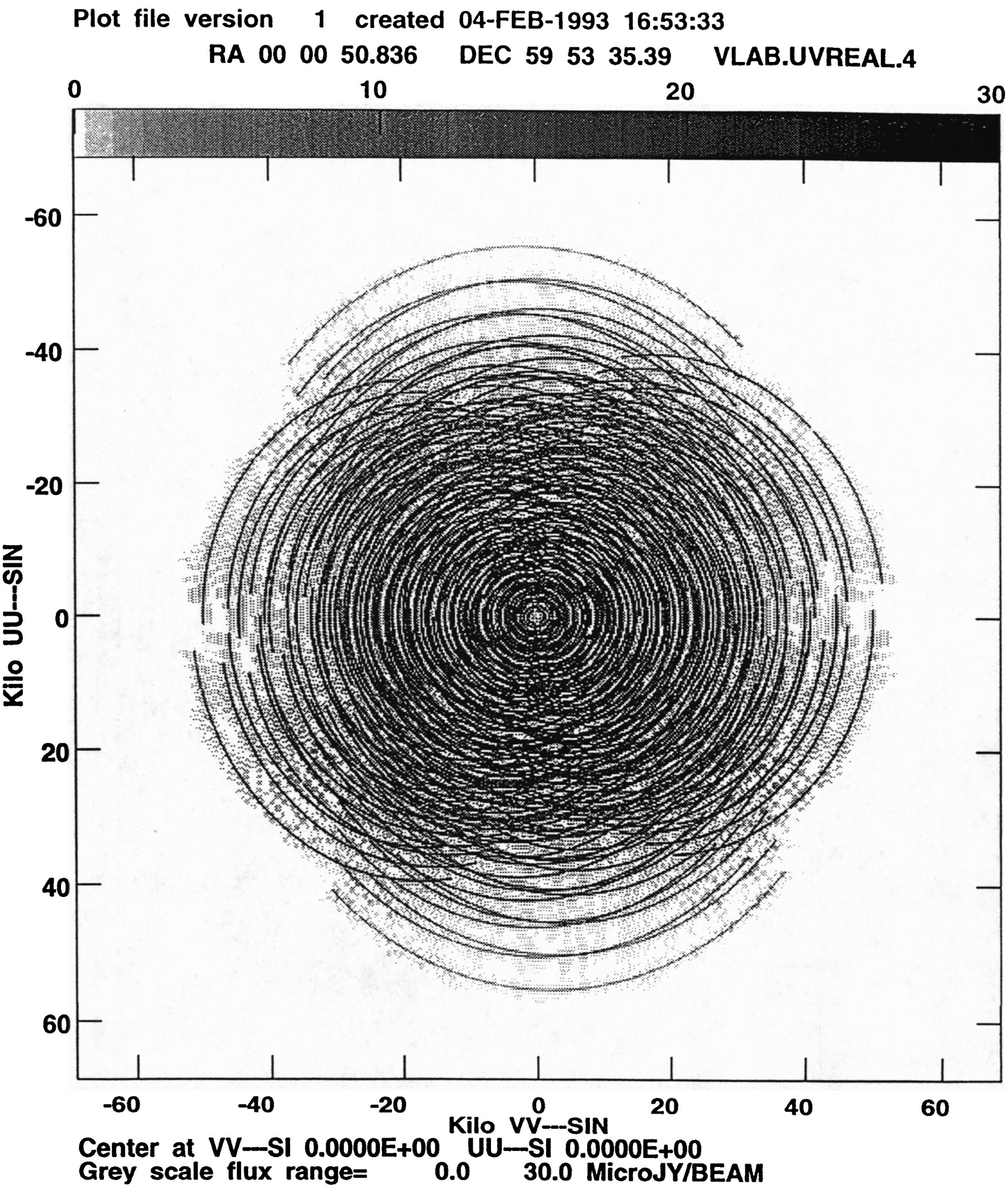

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Figure 5b

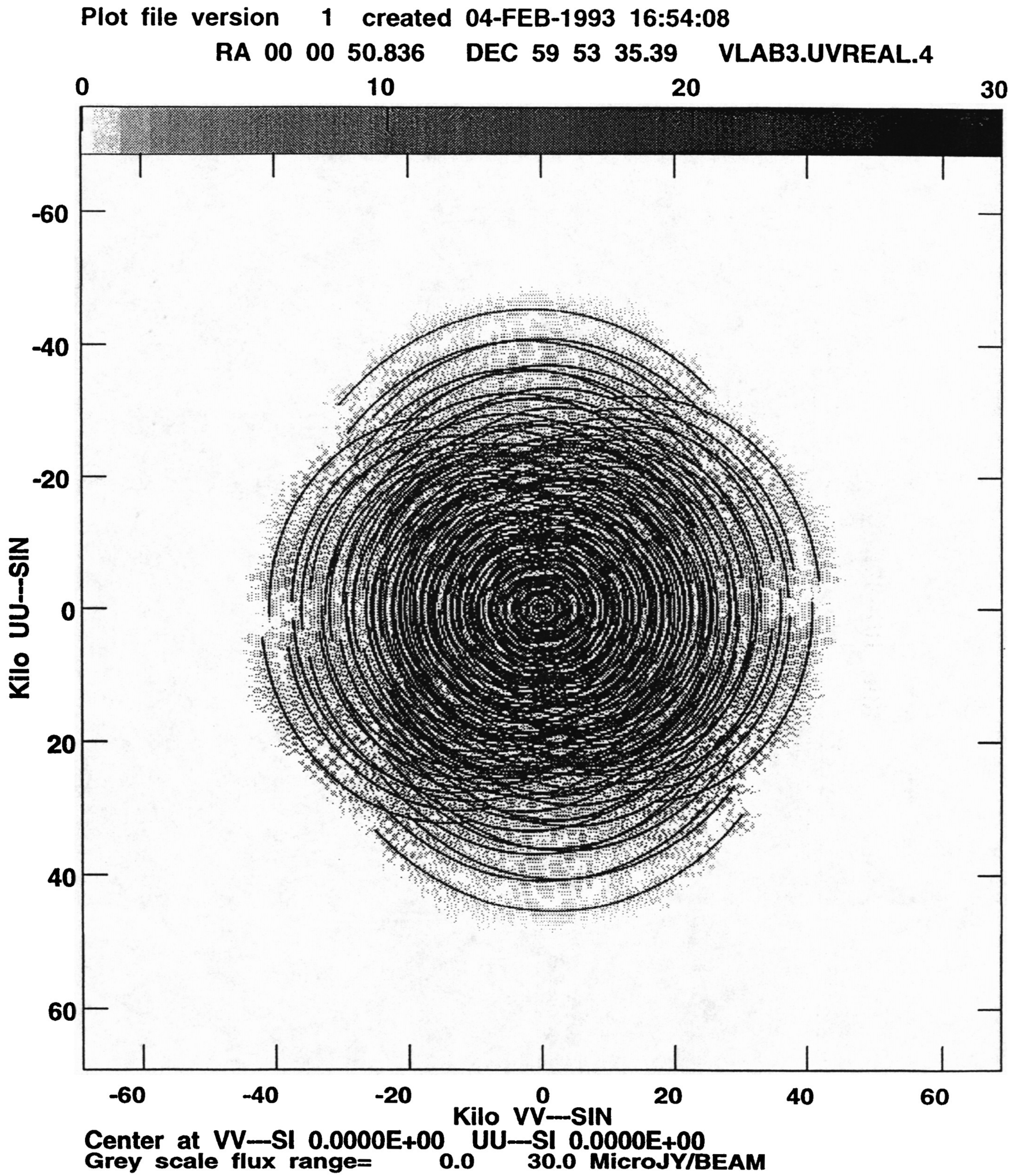

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Figure 6a

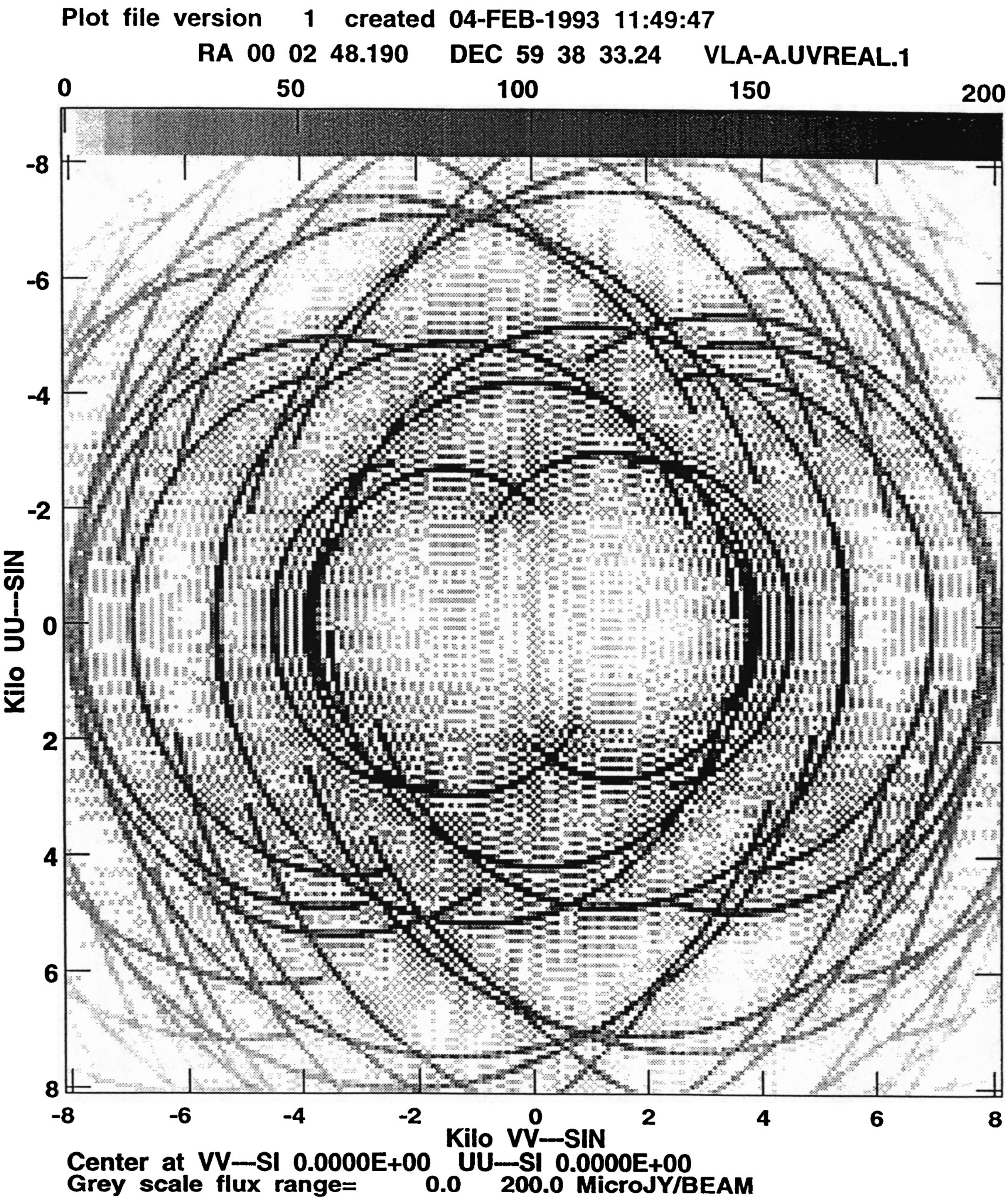
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Figure 6b

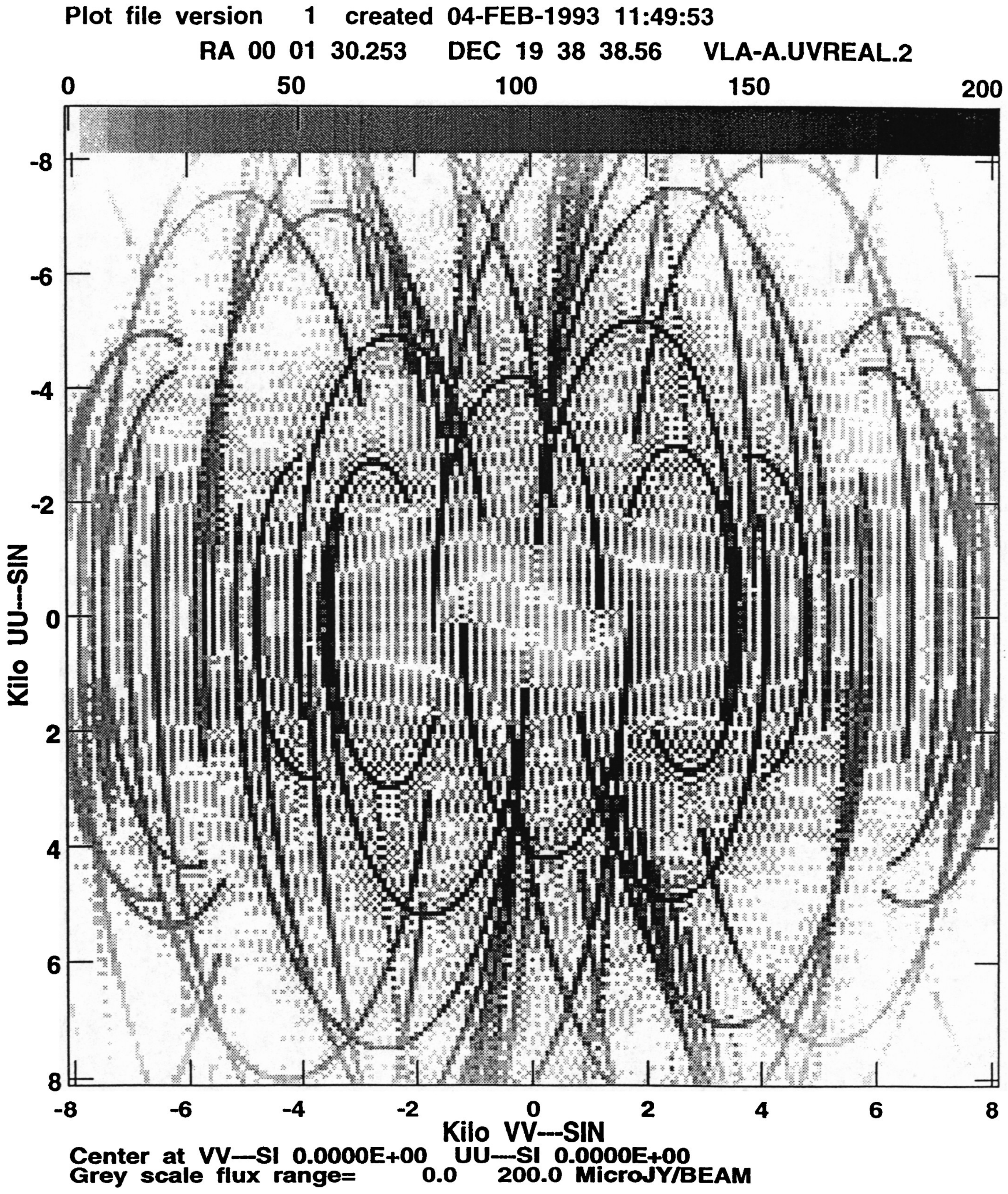

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Figure 6c

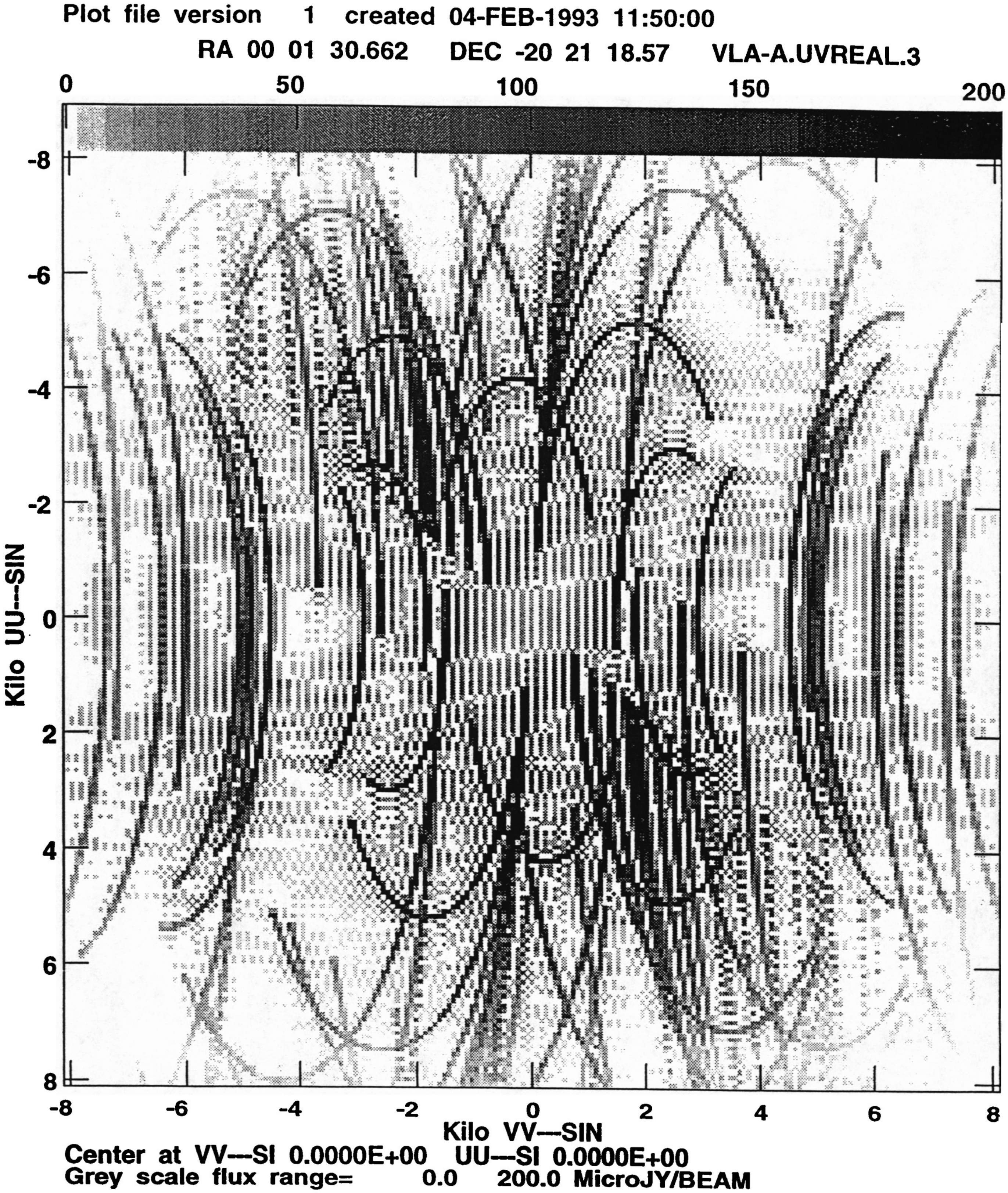

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Figure 7a

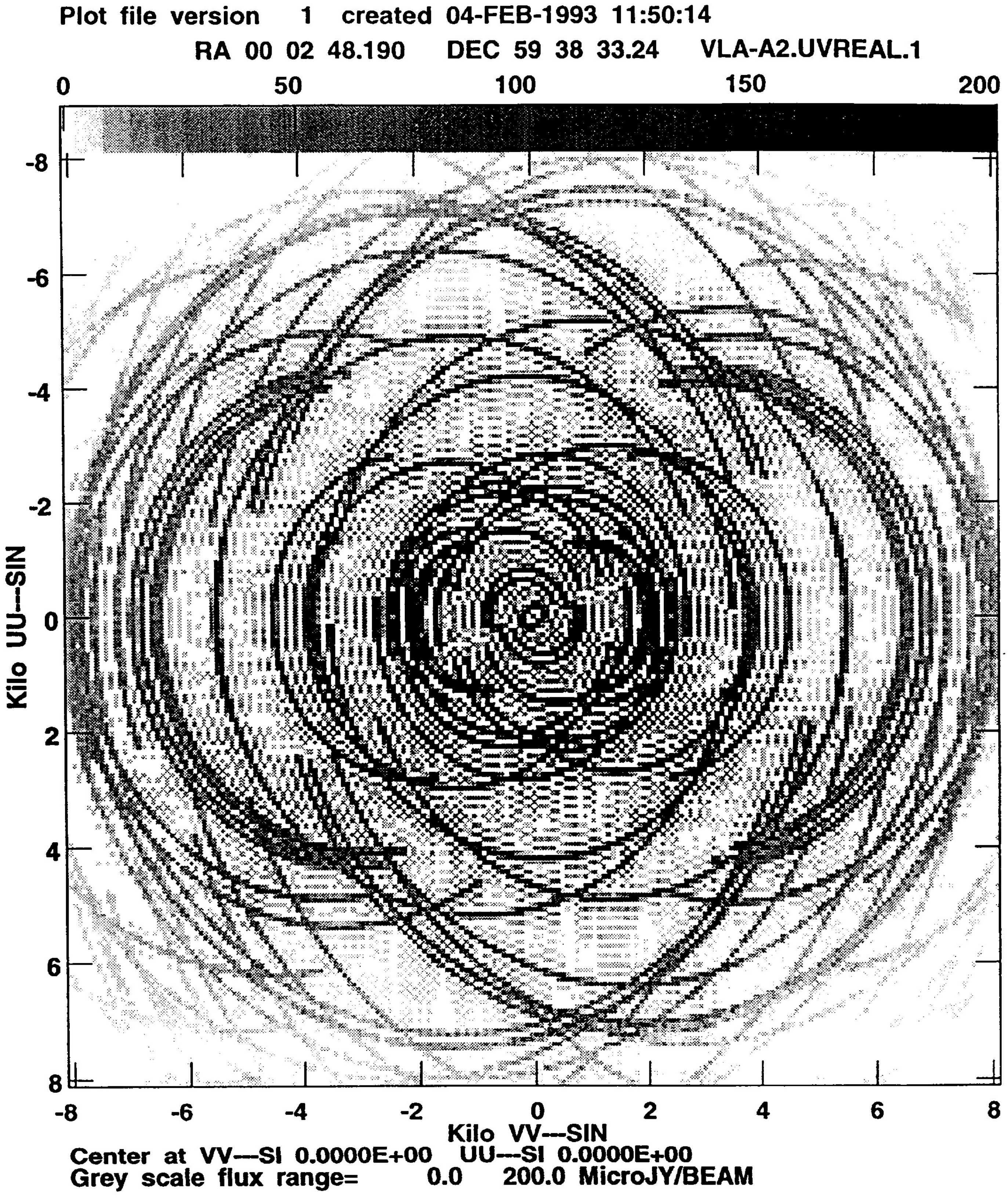
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Figure 7b

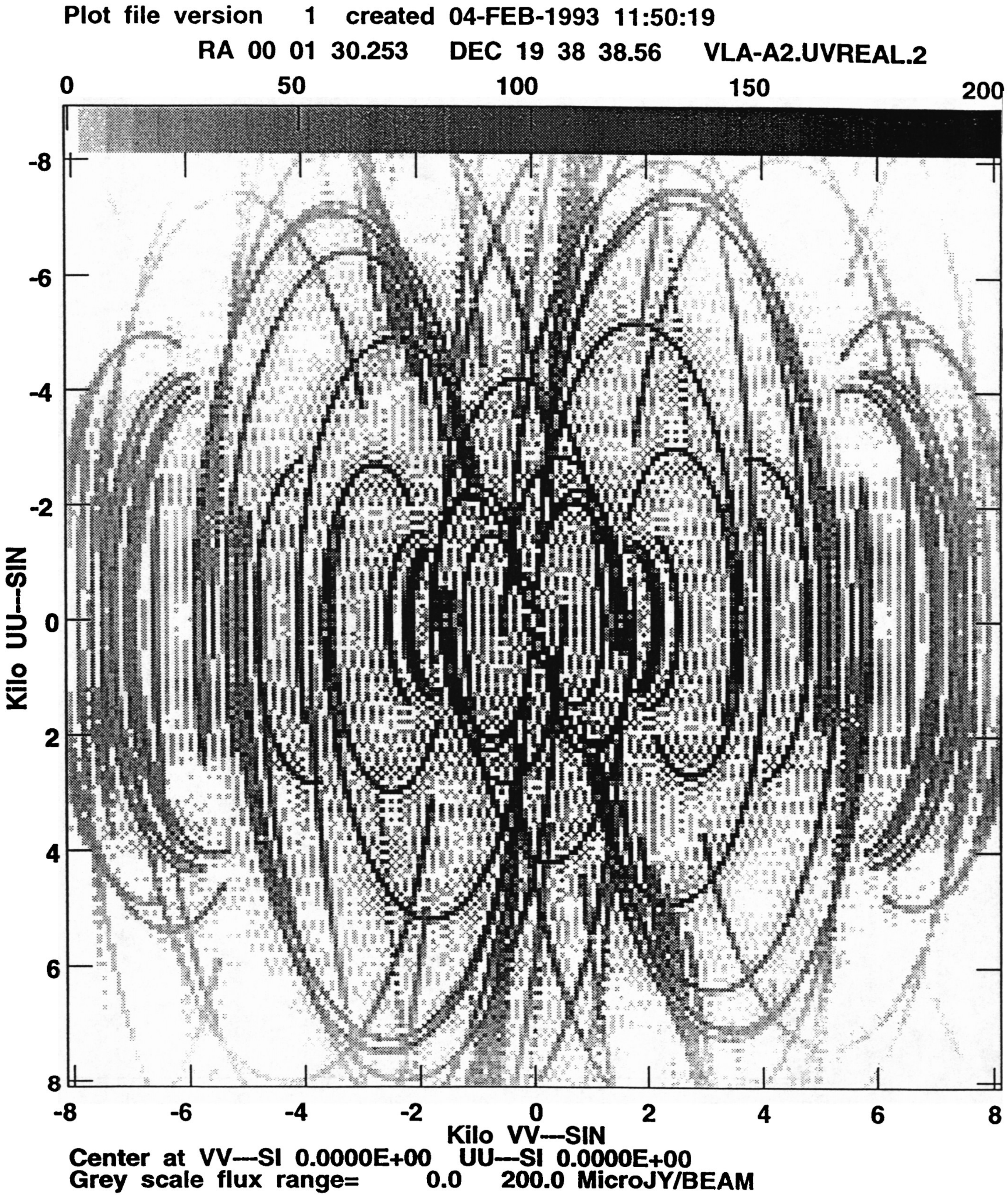
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Figure 7c

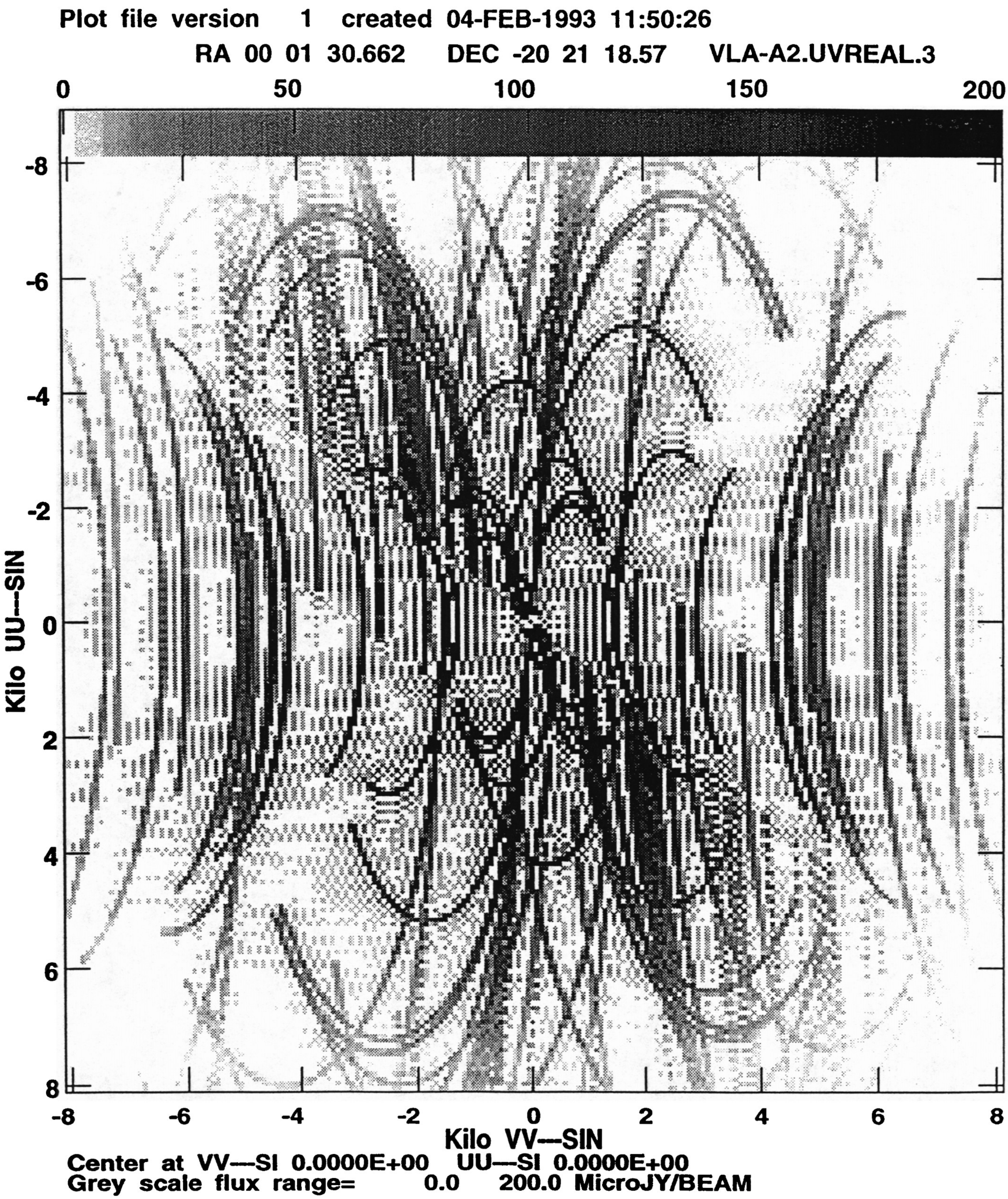

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Figure 8a

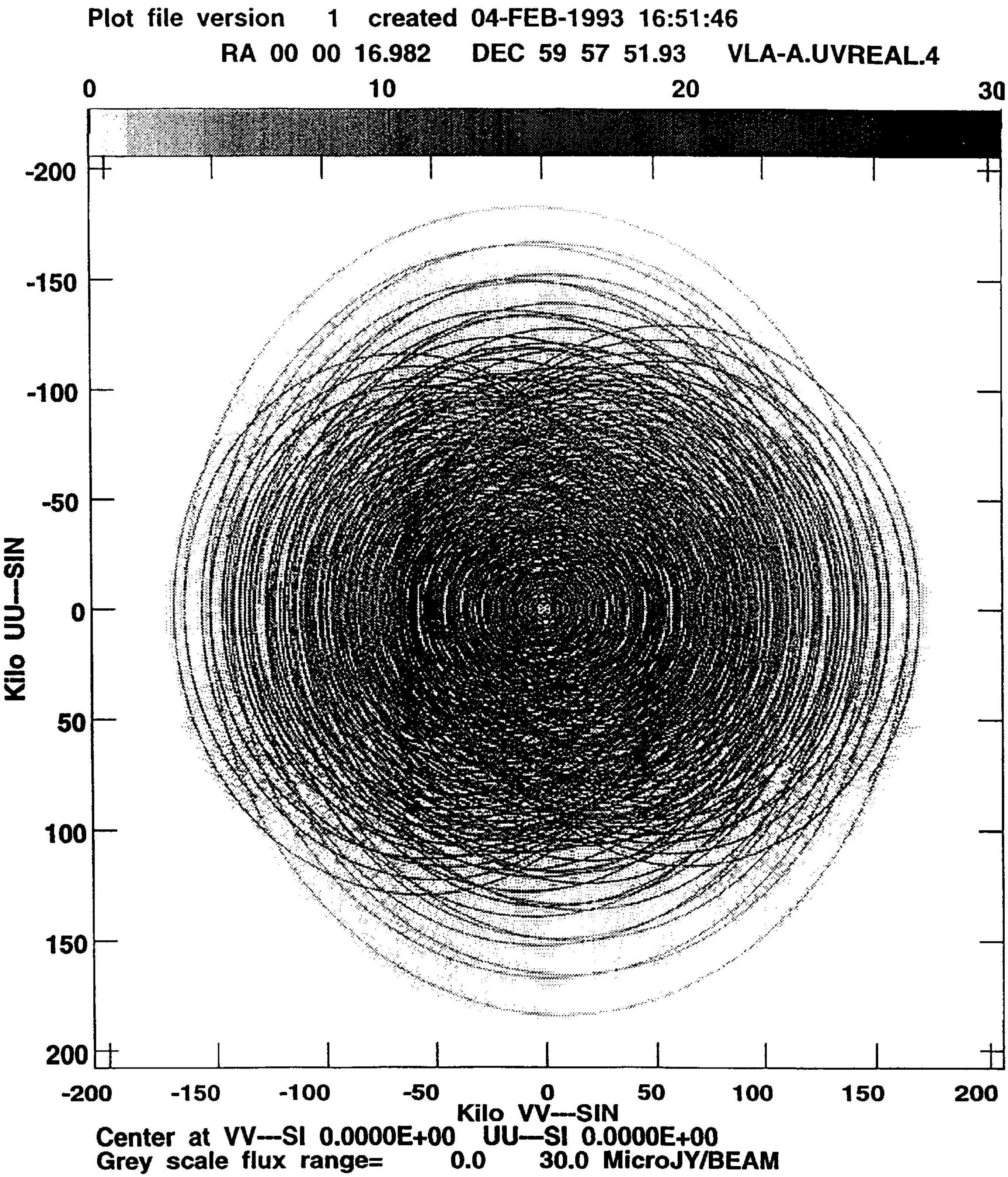

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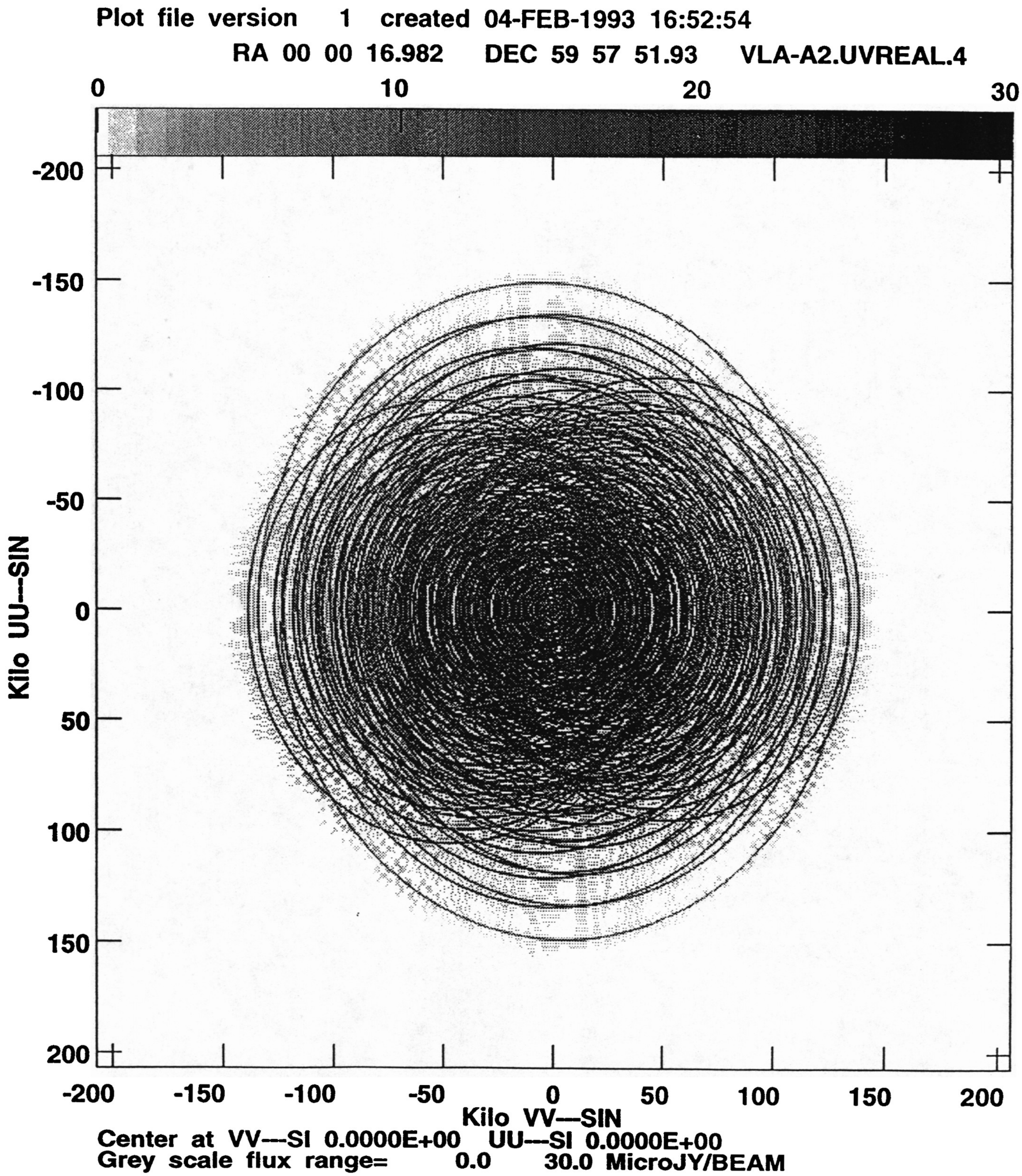
Figure 8b



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