# Amplitude Test of the 4IF Mode

VLA Test Memorandum No. 161

David Mehringer

7 February 1992

Amplitude Test of the 4 IF Mode
David Mehringer
7 February 1992

## 1. Motivation

I was motivated to do a test of the 4 IF mode because of the results of an observation my colleagues and I did in March of 1991 (VLA program AM320). We observed 6 cm $H_2CO$ absorption toward the Galactic Center star forming region Sgr B. In our set-up, IFs A and B had a bandwidth of 1.5625 MHz (97 km $s^{-1}$) and IFs C and D had a bandwidth of 3.125 MHz (190 km $s^{-1}$). IFs A and C were centered at +40 km $s^{-1}$ and IFs B and D were centered at –40 km $s^{-1}$. Because the region we observed lies near the Galactic Center, many clouds are present at a large range of velocities. In addition, Sgr B is extended, so much so that three 6 cm fields were needed to adequately cover the entire region. In all fields, continuum emission was apparent beyond the half power radius of the primary beam. Because of these reasons, the narrow band IFs (A and B) had no line free channels common to all sources in a given field. We thus encountered the problem of having to use an unconventional method for continuum subtraction. One of the first things we tried was to use the line free channels in the wide band IFs (C and D) as the continuum level for the narrow band IFs. However, we found that this was not a good solution because, at some positions, the maximum in the narrow band spectrum was higher than the value at the same position in the wide band continuum map. The wide band continuum should have been an accurate representation of the true continuum, because the wide band continuum was made from channels where no absorption was present. We therefore expected the peak in the narrow band line cube to be equal to or less than the peak in the wide band continuum (recall that this was an experiment to measure *absorption*). In addition, the relative difference between the continuum level in the narrow and wide band IFs tended to increase with distance from the pointing position, becoming as much as 10% near the half power radius of the primary beam. Figures 1a and 1b illustrate this problem. Figure 1a is an IF A spectrum taken at a relatively bright continuum feature. The peak is 3.59 Jy/beam. Figure 1b is an IF C spectrum taken at the same area as in Fig. 1a. The peak here is 3.34 Jy/beam. The relative difference between these two peaks is about 7%. It turns out that the difference in continuum level was due to beam squint. IFs A and B are sensitive to RCP radiation and IFs C and D are sensitive to LCP radiation. Because the subreflectors used on the VLA antennas are asymmetric, the pointing positions for IFs which are sensitive to different senses of circularly polarized radiation are slightly different. The relative amplitude difference becomes larger as the distance from the pointing position increases because the of primary beam attenuation differences for each IF. I decided to do a test observation to test if the continuum levels in IFs sensitive to the *same* sense of circularly polarized radiation are the same. This report describes this test, as well as my recommendations for using the 4 IF mode.

## 2. Introduction

I observed the point source 2251+158 (1950) which has a flux density of 10.00 Jy at 6 cm (VLA Calibrator Manual). I used the raster mode (VLA Computer Memo #182) to point at several positions offset from this source, so that the primary beam pattern for each IF could be traced. The pointings traced out an 11 by 11 grid centered on the position of the source. The pointings were approximately 70″ apart. The grid was inclined

25° with respect to the direction of increasing azimuth. The integration time was 20 sec and there were to have been five integrations per point (however, this didn't happen, see below).

During the first half of the run the A and B IFs had a bandwidth of 1.5625 MHz (64 channels) and the C and D IFs had a bandwidth of 3.125 MHz (32 channels). For the second half of the run, the A and B IFs had a bandwidth of 3.125 MHz and the C and D IFs had a bandwidth of 1.5625 MHz. This was done to investigate the possibility of amplitude variations as a function of bandwidth.

## 3. Problems

There were three main problems with the observation. First, I had wanted all IFs to be centered at the same frequency. Instead, their low frequency edges were coincident. This was because I had specified fluke settings instead of velocities in the observe file. Had I specified velocities, the band centers would have been coincident. This was only a minor problem.

Second, the raster mode does not work correctly if one has integration times longer than 10 sec. I discovered this after the observation. Ken Sowinski ran part of my program during software time and confirmed this. The result of this problem was that instead of five integrations per point, there were only two or three in most cases.

The third and biggest problem was the relatively large pointing error due to the fact that there had been a substantial snowfall the night before. This error was approximately 2.5′ and may have varied during the observation. The evidence for the variation in this error comes from the fact that the calibrated gains of most antennas tended to decrease during the run.

## 4. Results

Amplitude contour plots of the resulting grids for channel zero data of each IF are shown in Fig. 2a-d. The assumed amplitude of the center point is 10.00 Jy. This, of course, should be the maximum in these plots had there not been a pointing error. As can be seen, the maximum in all of these plots occurs at a point removed from the center.

There are no significant amplitude differences between IFs which are sensitive to the same sense of circularly polarized radiation. A grid of values for IF A amplitude minus IF B amplitude is shown in Fig. 3a, and a similar grid for IF C amplitude minus IF D amplitude is shown in Fig. 3b. The values are in mJy and a point labeled by ":::" is one where there were no data taken.

Beam squint was readily apparent. Figure 4 shows a plot of the percentage difference between IF A amplitude and IF C amplitude. As can be seen, there is a general increase from left to right, which indicates the presence of beam squint. The observation was set up so that one axis of the grid would be parallel to the line joining the RCP and LCP feeds. For the 6 cm feeds, the angle between this line and the direction of increasing azimuth is 25°. Thus, it is no coincidence that the numbers in column 6 are all near or equal to zero.

## 5. Recommendations

I have a few recommendations for observers interested in employing the 4 IF mode in this highly nonstandard fashion. First of all, one should not be concerned about the problems described in Section 1 if the object of interest is a point source located at the pointing position and/or if there will be enough line free channels in each IF to use as a continuum level. For observers who think they may have a similar situation to the one described here, one solution might be to use a set-up where IFs sensitive to the same sense of circularly polarized radiation have different bandwidths. For example, recall that the set-up described in the Section 1 had the following features:

| | | |
|---|---|---|
| IF A (RCP) | 1.5625 MHz bandwidth | centered at +40 km $s^{-1}$ |
| IF B (RCP) | 1.5625 MHz bandwidth | centered at –40 km $s^{-1}$ |
| IF C (LCP) | 3.125 MHz bandwidth | centered at +40 km $s^{-1}$ |
| IF D (LCP) | 3.125 MHz bandwidth | centered at –40 km $s^{-1}$. |

An alternative to this set-up that would have solved the problems listed in Section 1 would have been:

| | | |
|---|---|---|
| IF A (RCP) | 1.5625 MHz bandwidth | centered at +40 km $s^{-1}$ |
| IF B (RCP) | 3.125 MHz bandwidth | centered at –40 km $s^{-1}$ |
| IF C (LCP) | 3.125 MHz bandwidth | centered at +40 km $s^{-1}$ |
| IF D (LCP) | 1.5625 MHz bandwidth | centered at –40 km $s^{-1}$. |

In this set-up, IFs A and D would have had no line free channels and IFs B and C would have had line free channels. The continuum made from the line free channels of IF B could have been subtracted from the IF A database, and the continuum made from the line free channels of IF C could have been subtracted from the IF D database.

Other, important restrictions on the set-up described here are given in an NRAO Newsletter item (no. 47, 1 April 1991) by Elias Brinks. Because the low frequency edges of IFs A and C and of IFs B and D are not coincident, the fringe rate for IFs B and C is calculated using the wrong frequency. This effect causes decorrelation within an integration time for long baselines and/or large differences in bandwidth due to phase winding in IFs B and C. However, assuming the decorrelation per unit integration time is negligible, the phase winding can be corrected by using CLCOR when calibrating. This program can correct for the phase winding in IFs B and C. In summary, this mode should only be considered if there is no other way to achieve the scientific objectives. Observers who decide that they must use this mode to achieve their scientific objectives should contact Elias Brinks (505 835-7029) well in advance of the observation to discuss the feasibility and possible limitations.

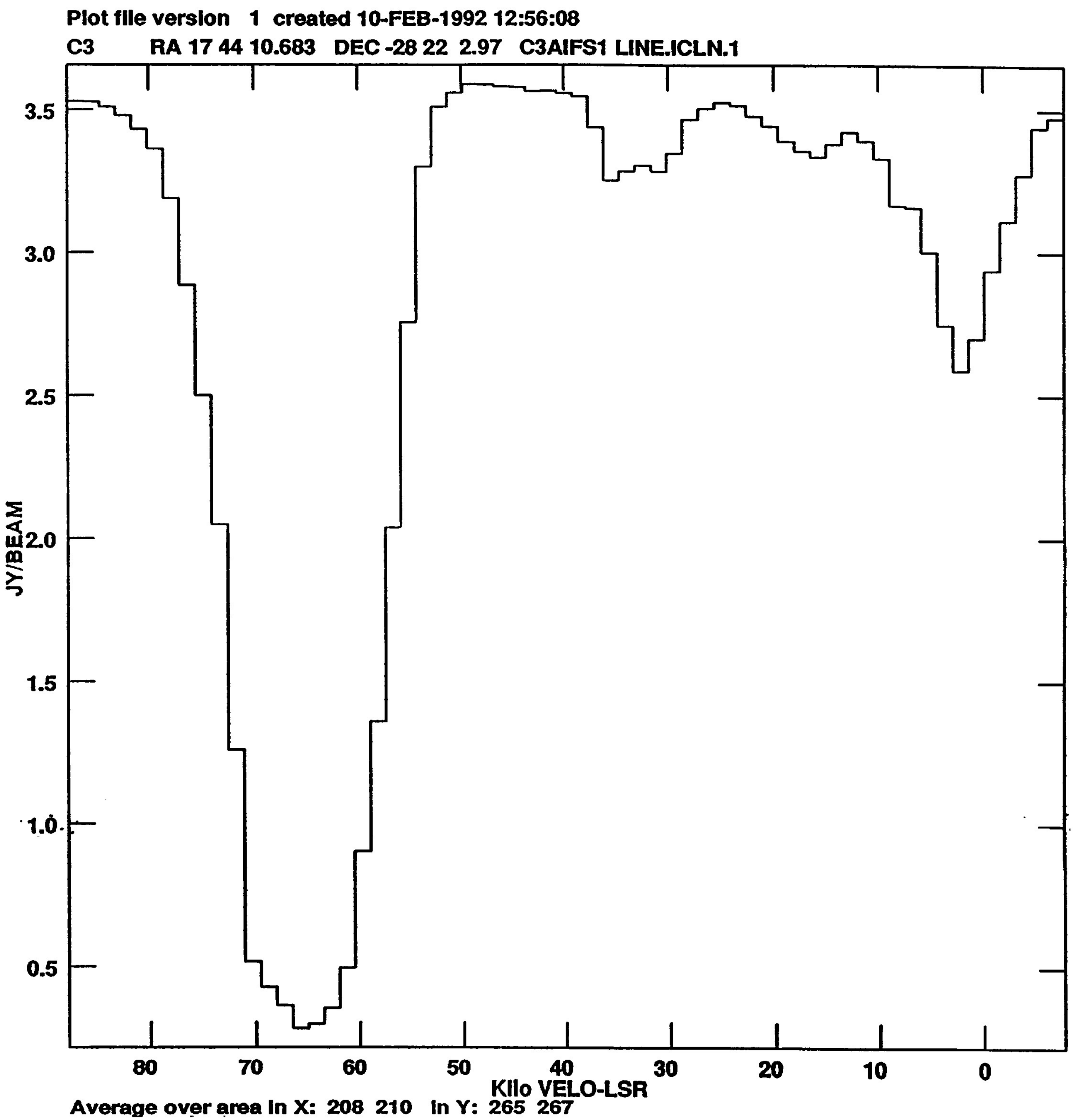


Figure 1a: $H_2CO$ spectrum taken using IF A (RCP) data. The maximum is 3.59 mJy/beam.

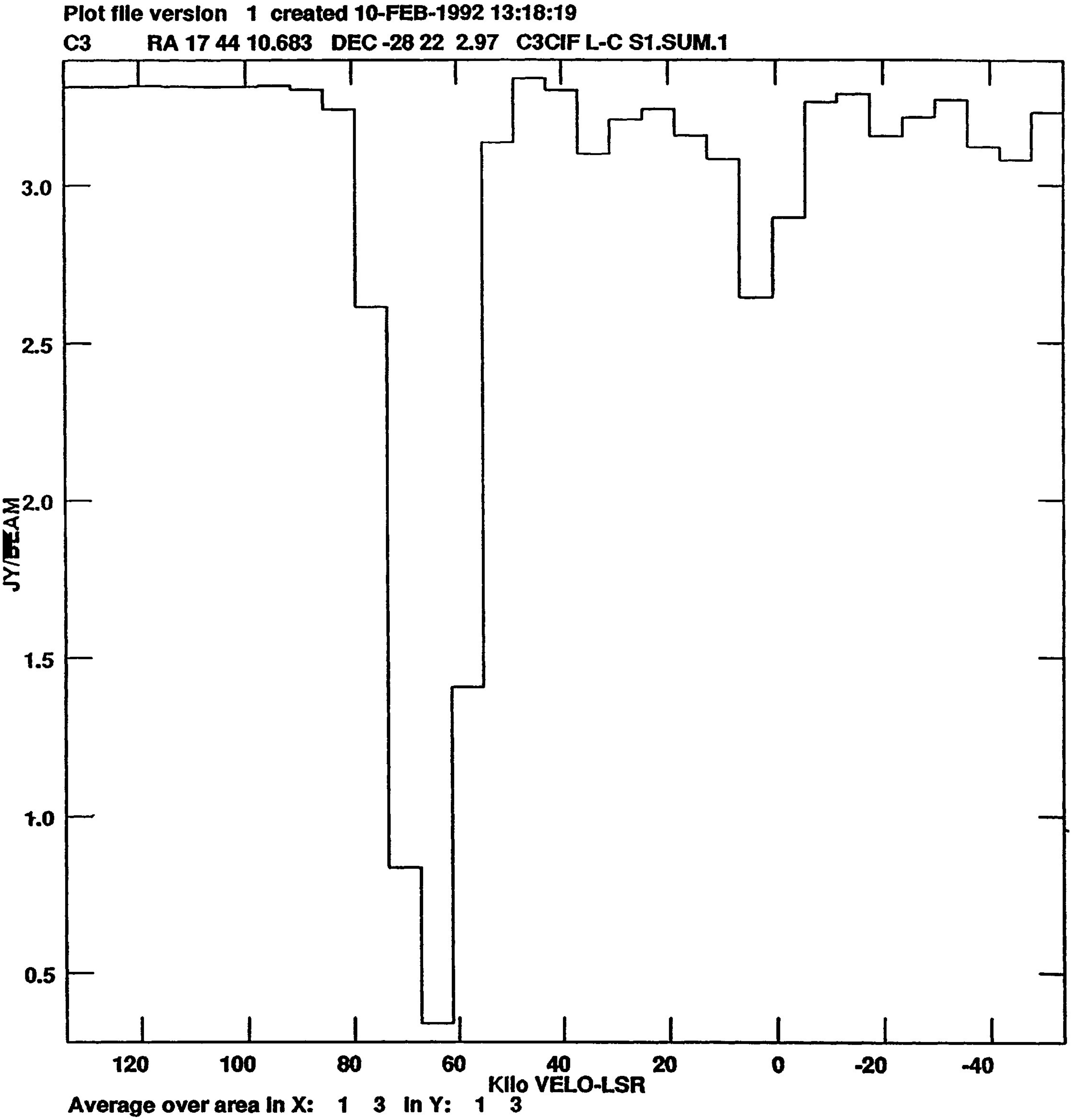


Figure 1b: IF C (LCP) $H_2CO$ spectrum taken over the same area as in Fig. 1a. The maximum is 3.34 mJy/beam, or about 7% less than the maximum in Fig. 1a.

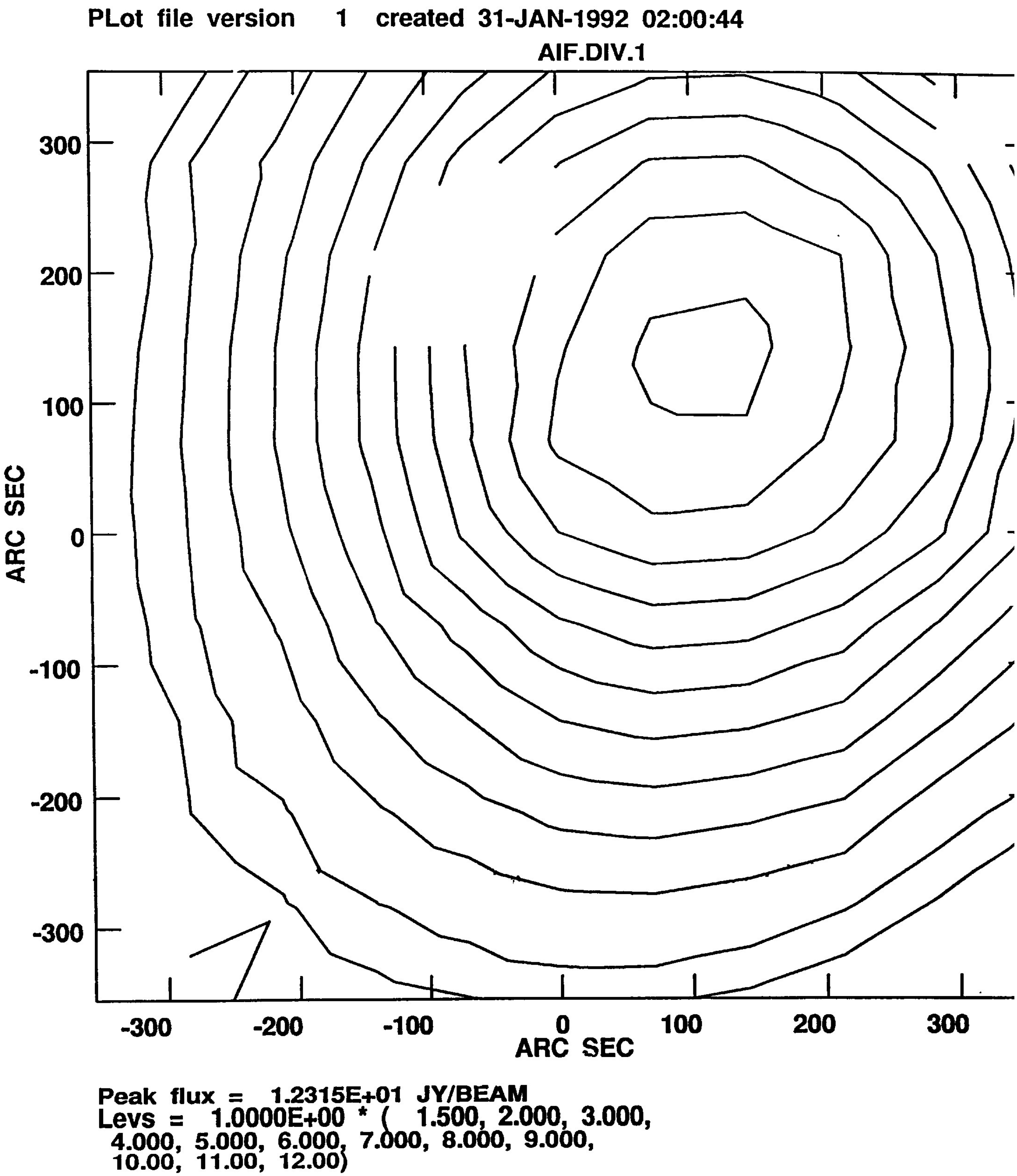


Figure 2a: Contour plot of IF A amplitude. The maximum occurs at a point removed from the center because of the ≈2.5′ pointing error. The broken contours near (-50,200) because no data was taken here.

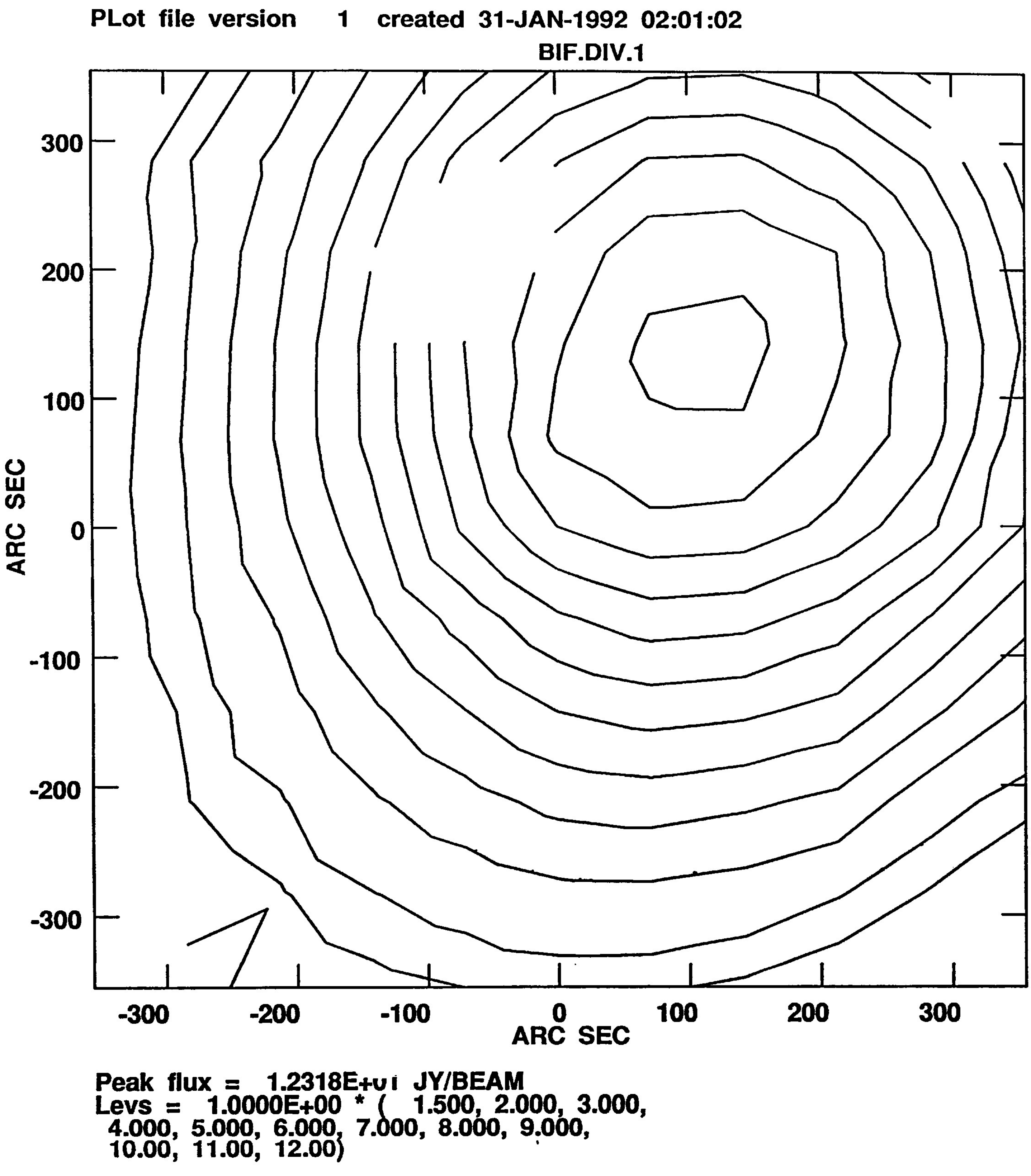


Figure 2b: Contour plot of IF B amplitude. The maximum occurs at a point removed from the center because of the ≈2.5′ pointing error. The broken contours near (-50,200) because no data was taken here.

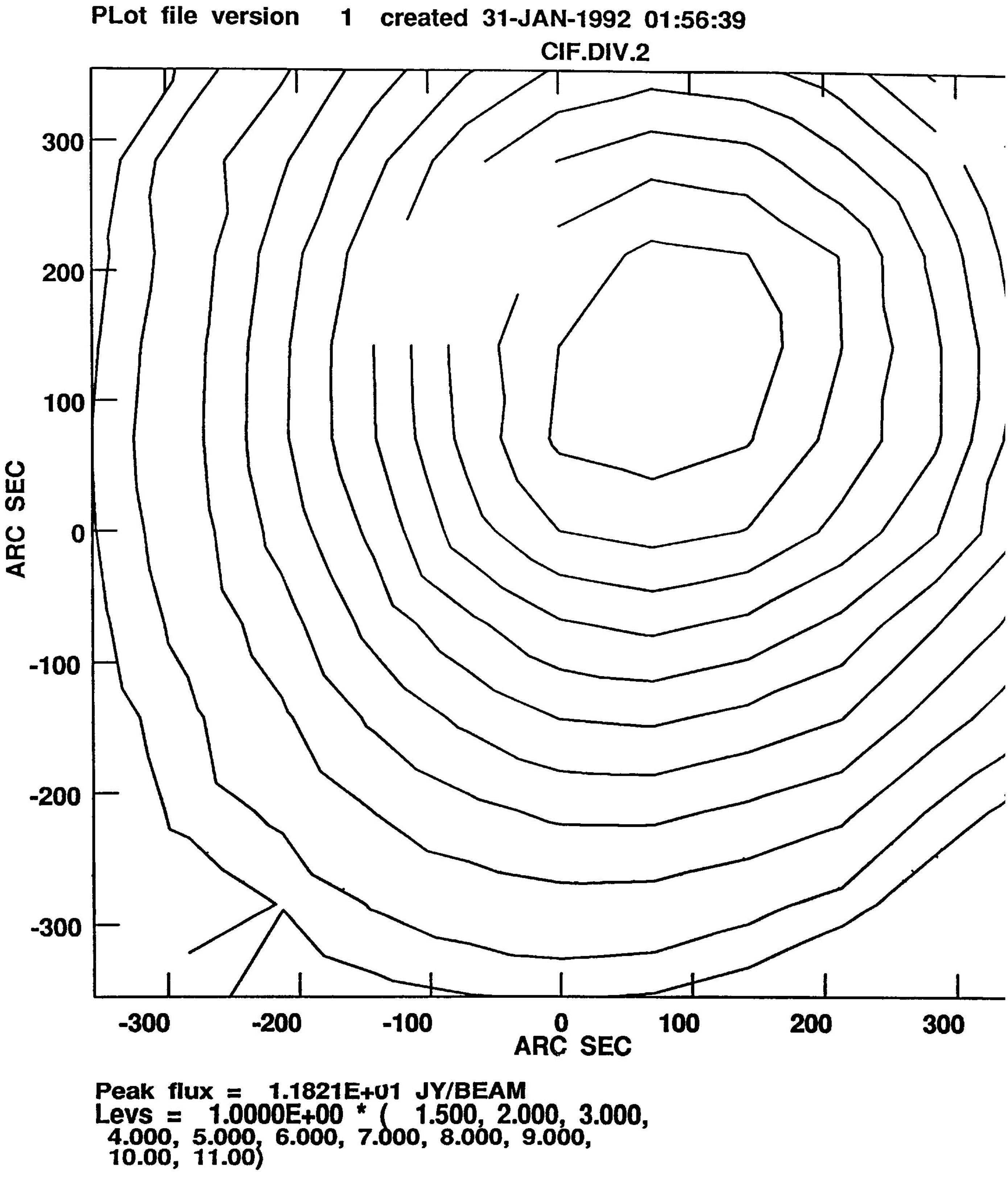


Figure 2c: Contour plot of IF C amplitude. The maximum occurs at a point removed from the center because of the ≈2.5′ pointing error. The broken contours near (-50,200) because no data was taken here.

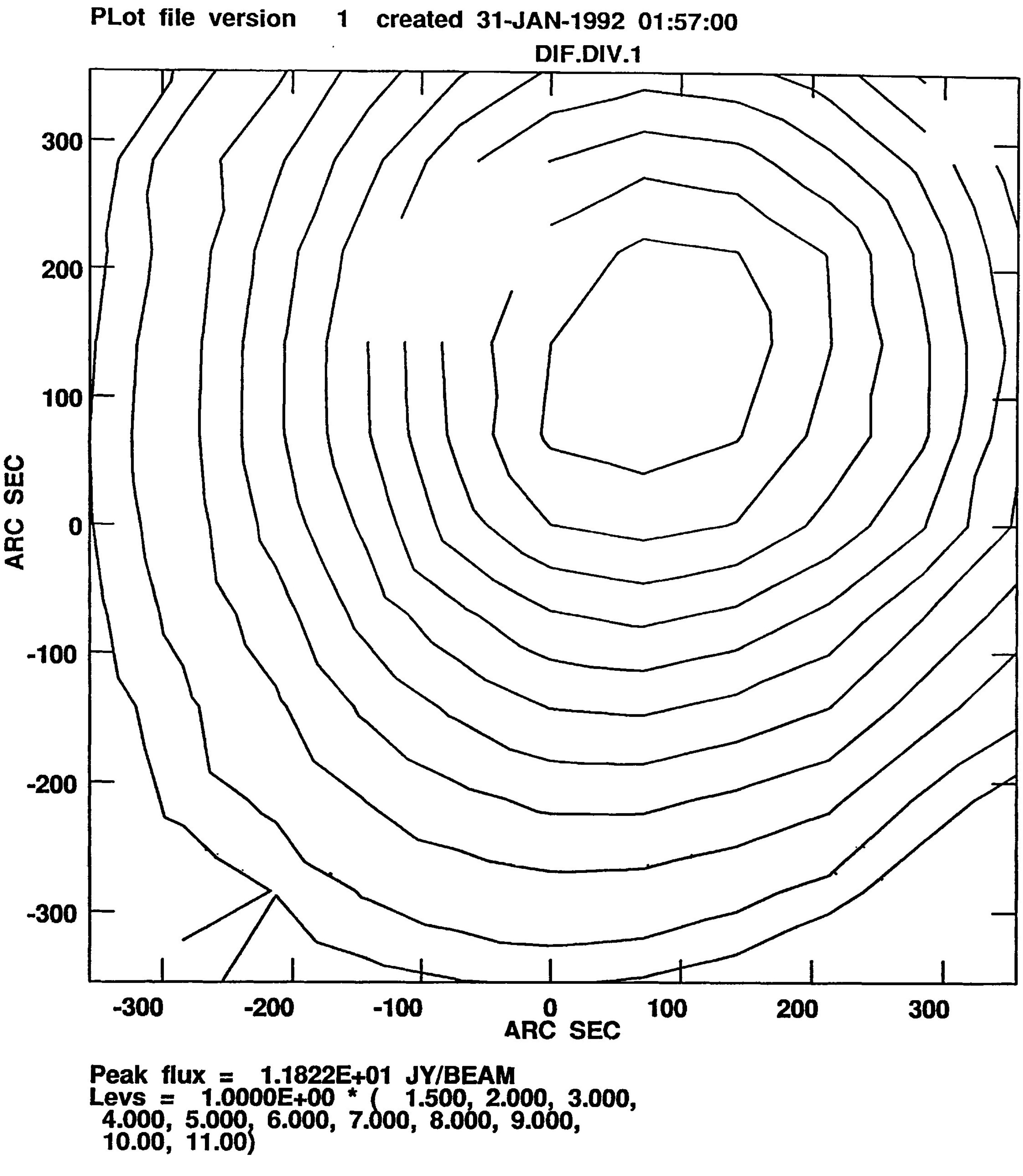


Figure 2d: Contour plot of IF D amplitude. The maximum occurs at a point removed from the center because of the ≈2.5′ pointing error. The broken contours near (-50,200) because no data was taken here.

| Row | 1 | | 3 | | 5 | | 7 | | 9 | | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | -3 | 8 | 4 | 5 | 7 | 3 | 4 | 5 | 5 | 4 | ::: |
| 10 | -6 | 0 | 0 | 5 | 11 | 6 | 4 | 3 | 5 | 5 | 0 |
| 9 | -2 | -2 | -2 | -4 | ::: | -1 | 4 | -1 | -1 | 10 | 2 |
| 8 | 4 | 2 | -6 | -5 | 0 | -4 | -8 | -3 | 12 | 0 | 1 |
| 7 | 8 | -1 | 0 | 1 | 8 | -3 | 9 | 10 | 13 | 15 | 10 |
| 6 | -15 | -3 | -11 | 12 | -2 | 0 | 6 | -1 | 10 | 10 | 4 |
| 5 | 3 | -7 | 3 | -9 | -4 | -9 | 2 | 9 | -4 | 4 | 3 |
| 4 | -1 | -9 | -4 | 8 | -13 | 5 | -4 | -8 | -5 | -15 | -1 |
| 3 | -2 | 11 | -8 | -16 | 1 | -8 | -13 | 10 | 0 | 21 | 3 |
| 2 | -16 | 3 | -6 | -23 | -24 | -4 | 16 | -11 | 18 | -18 | -4 |
| 1 | ::: | 12 | -3 | -1 | -23 | -14 | -6 | -4 | -12 | 1 | ::: |

Column

Figure 3a: Amplitude difference (in mJy) between IF A and IF B. Both are sensitive to RCP radiation. A ":::" indicates a point where no data were taken.

| Row | 1 | | 3 | | 5 | | 7 | | 9 | | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 0 | 5 | 2 | 3 | 0 | 2 | 1 | -1 | 1 | 3 | ::: |
| 10 | -5 | 0 | -2 | 7 | -5 | 4 | -3 | 0 | -3 | -3 | -9 |
| 9 | -1 | -1 | 1 | 7 | ::: | 1 | -2 | 2 | 11 | 2 | -8 |
| 8 | -4 | -5 | -7 | -2 | 15 | -2 | 0 | 7 | -13 | 2 | -6 |
| 7 | 9 | 13 | 10 | 5 | 1 | 9 | -7 | 5 | -2 | -5 | 3 |
| 6 | -5 | 2 | -5 | 2 | -12 | 0 | 13 | 9 | 0 | -6 | -5 |
| 5 | 3 | 0 | 2 | -6 | -5 | -2 | -2 | -4 | -2 | -5 | -8 |
| 4 | -1 | 8 | 2 | -14 | 8 | -4 | -6 | 0 | 13 | -6 | -8 |
| 3 | 2 | -2 | -4 | -10 | -4 | -12 | 3 | 6 | 28 | 10 | 2 |
| 2 | 14 | 5 | 6 | -12 | -8 | -8 | 5 | -3 | 1 | 1 | -9 |
| 1 | ::: | 11 | 6 | 9 | -1 | -2 | 14 | -7 | -3 | -1 | ::: |

Column

Figure 3b: Amplitude difference (in mJy) between IF C and IF D. Both are sensitive to LCP radiation.

| Row | 1 | | 3 | | 5 | | 7 | | 9 | | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | -29 | -31 | -20 | -12 | -6 | 0 | 3 | 8 | 11 | 16 | ::: |
| 10 | -48 | -28 | -18 | -11 | -5 | -1 | 4 | 7 | 11 | 14 | 19 |
| 9 | -46 | -30 | -19 | -11 | ::: | -1 | 3 | 6 | 9 | 14 | 19 |
| 8 | -43 | -29 | -18 | -11 | -6 | -1 | 3 | 6 | 10 | 13 | 18 |
| 7 | -41 | -29 | -18 | -11 | -5 | 0 | 3 | 7 | 10 | 13 | 19 |
| 6 | -32 | -25 | -17 | -10 | -5 | 0 | 4 | 6 | 11 | 14 | 19 |
| 5 | -25 | -22 | -16 | -10 | -5 | -1 | 3 | 7 | 11 | 15 | 19 |
| 4 | -18 | -18 | -14 | -9 | -6 | 0 | 4 | 8 | 11 | 16 | 22 |
| 3 | -9 | -12 | -13 | -6 | -4 | 1 | 4 | 9 | 13 | 21 | 26 |
| 2 | -2 | -2 | -7 | -6 | -3 | 3 | 6 | 11 | 16 | 23 | 33 |
| 1 | ::: | 2 | 0 | -1 | 0 | 4 | 8 | 16 | 26 | 31 | ::: |

Column

Figure 4: Percentage amplitude difference between IF A and IF C. The general increase from left to right indicates the presence of beam spuint.