

Starting Out With AIPS Tutorial

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This tutorial session is intended to get people familiar with the basic concepts of radio interferometry. The student will be introduced to interferometry data, visibilities, the (u,v) plane, calibration, and imaging.

Step 1 --- Figure Out What to Observe (Reduce)

I decided to try to make an image of the Sun, as the Solar KSP is a significant part of GLOW. The NRAO image archive has a nice image of the Sun at 1400 MHz located at <http://images.nrao.edu/8>



Image courtesy of NRAO/AUI

Let's try to reduce the data ourselves.

Step 2 --- Download the Data From the Archive

Conveniently, the NRAO image archive gives details about the observations used to make the image, so I downloaded the data from the NRAO data archive, making sure to select the "AIPS friendly" filename option.

This has resulted in two files on my hard drive in my current directory:

```
ls -l
total 54164
-rw-r-- 1 anderson zeall 21002240 2008-11-11 14:40 GD_1
-rw-r-- 1 anderson zeall 34392064 2008-11-11 14:41 GD_2
```

You should be able to download them from [GD_1](#) and [GD_2](#).

While you are there, grab the new set of commands from [Sun.txt](#).

Step 3 --- Start up AIPS

aips

I have chosen to use user ID 100, at semi-random selection.

At first, most of the arcane syntax used to enter commands to AIPS will be difficult. As this is a tutorial session which intends to teach you about radio interferometry, and not how to use AIPS, we will gloss over the technical challenges of interacting with AIPS.

In AIPS you the user interact with something called POPS. You give POPS information by setting variables called ADVERBS to specific values. You can tell POPS which TASK you plan to run by setting a TASK ADVERB. If you want to check the values of ADVERBs for the current TASK, you ask for INPUTS. Because POPS will try to figure out what you mean if you only input the first few letters of an ADVERB or VERB, you can often abbreviate this to just INP. Also note that since AIPS is case-insensitive by default, you could also just type inp. If you want help on a specific topic, ask for HELP. If you want even more explanation for something, say EXPLAIN. If you don't know what it is you are trying to do, but you have some vague notion, say APROPOS SOMETHING. Note that apostrophes, and in certain locations, the lack of an apostrophe are significant.

```
dowait=true  
dohist=1  
docrt=132  
dotv=1
```

Step 4 --- Initial look at data

FILLM

The AIPS task to read raw VLA data into AIPS is called FILLM.

```
task 'fillm'  
datain = 'PWD:GD_  
nfiles=0  
ncount=2  
vlamode='S '  
band 'l'  
doweight=10  
doconcat=true  
douvcomp=0  
cparm(2)=16  
cparm(4)=28  
cparm(8)=10./60  
dparm 0  
bparm 0
```

```

timer 0
calcode ' '
clron
outdisk 1
go

```

This sets us up to read the data, sets the VLA mode to Solar, tells AIPS not to change the source if the position appears to be moving (which the Sun does), sets the shadowing limit to 28 meters, and sets the CL table interval to 10 seconds.

Header information

```

indisk 1
pcat

```

```

AIPS 1: Catalog on disk 1
AIPS 1:  Cat Usid Mapname      Class  Seq Pt      Last access      Stat
AIPS 1:   1  100 19810926      .L BAND.      1 UV 14-NOV-2008 21:35:31

```

```

getn 1
imhe

```

```

AIPS 1: Image=MULTI      (UV)      Filename=19810926      .L BAND.      1
AIPS 1: Telescope=VLA      Receiver=VLA
AIPS 1: Observer=GD      User #= 100
AIPS 1: Observ. date=26-SEP-1981      Map date=14-NOV-2008
AIPS 1: # visibilities      556884      Sort order TB
AIPS 1: Rand axes: UU-L-SIN VV-L-SIN WW-L-SIN BASELINE TIME1
AIPS 1:      SOURCE  FREQSEL
AIPS 1: -----
AIPS 1: Type      Pixels      Coord value      at Pixel      Coord incr      Rotat
AIPS 1: COMPLEX      3      1.0000000E+00      1.00      1.0000000E+00      0.00
AIPS 1: STOKES      4      -1.0000000E+00      1.00      -1.0000000E+00      0.00
AIPS 1: FREQ      1      1.4461500E+09      1.00      1.2500000E+07      0.00
AIPS 1: IF      1      1.0000000E+00      1.00      1.0000000E+00      0.00
AIPS 1: RA      1      00 00 00.000      1.00      3600.000      0.00
AIPS 1: DEC      1      00 00 00.000      1.00      3600.000      0.00
AIPS 1: -----
AIPS 1: Coordinate equinox      0.00
AIPS 1: Maximum version number of extension files of type HI is      1
AIPS 1: Maximum version number of extension files of type AN is      1
AIPS 1: Maximum version number of extension files of type NX is      1
AIPS 1: Maximum version number of extension files of type SU is      1
AIPS 1: Maximum version number of extension files of type FQ is      1
AIPS 1: Maximum version number of extension files of type CL is      1
AIPS 1: Maximum version number of extension files of type TY is      1
AIPS 1: Maximum version number of extension files of type WX is      1
AIPS 1: Maximum version number of extension files of type OF is      1
AIPS 1: Keyword = 'CORRMODE' value = ' '

```

AIPS 1: Keyword = 'VLAIIFS ' value = 'AC '
AIPS 1: Keyword = 'CORRC0EF' value = -1

LISTR --- scan listing

```
task 'listr'
indi 1
getn 1
optype 'scan'
docrt=132
flagver 0
sources ' '
stokes ' '
docalib 0
gainuse 1
dopol -1
dparm 0
go
```

vlb054 LISTR(31DEC10) 100 21-OCT-2010 17:17:44 Page 1
File = 19810926 .L BAND. 1 Vol = 1 Userid = 100
Freq = 1.446150006 GHz Ncor = 4 No. vis = 421247
Scan summary listing

Scan	Source	Qual	Calcode	Sub	Timerange	FrqID
START VIS	END VIS					
1 1148-001		: 0000	C	1	0/13:53:25 - 0/13:53:25	1
1 0						
2 1148-001		: 0000	C	1	0/13:53:35 - 0/13:54:35	1
1 1113						
3 SUN		: 0000		1	0/13:59:15 - 0/13:59:35	1
1114 1575						
4 SUN		: 0000		1	0/14:05:25 - 0/14:09:35	1
1576 5952						
5 1148-001		: 0000	C	1	0/14:18:25 - 0/14:19:35	1
5953 7738						
6 SUN		: 0000		1	0/14:20:25 - 0/14:24:35	1
7739 12262						
7 SUN		: 0000		1	0/14:30:25 - 0/14:34:35	1
12263 17489						
8 1148-001		: 0000	C	1	0/14:43:25 - 0/14:44:35	1
17490 19470						
9 SUN		: 0000		1	0/14:45:25 - 0/14:49:35	1
19471 25116						
10 SUN		: 0000		1	0/14:55:25 - 0/14:59:25	1
25117 30808						
11 1148-001		: 0000	C	1	0/15:08:15 - 0/15:09:25	1
30809 32950						

12 SUN	: 0000	1	0/15:10:15 -	0/15:14:25	1
32951 39133					
13 SUN	: 0000	1	0/15:20:15 -	0/15:24:25	1
39134 45646					
14 1148-001	: 0000 C	1	0/15:33:15 -	0/15:34:25	1
45647 47809					
15 SUN	: 0000	1	0/15:35:15 -	0/15:39:25	1
47810 54604					
16 SUN	: 0000	1	0/15:45:15 -	0/15:49:25	1
54605 61507					
17 1148-001	: 0000 C	1	0/15:58:15 -	0/15:59:25	1
61508 63889					
18 SUN	: 0000	1	0/16:00:15 -	0/16:04:15	1
63890 70412					
19 SUN	: 0000	1	0/16:10:05 -	0/16:14:15	1
70413 77315					
20 1148-001	: 0000 C	1	0/16:23:05 -	0/16:24:15	1
77316 79905					
21 SUN	: 0000	1	0/16:25:05 -	0/16:29:15	1
79906 88655					
22 SUN	: 0000	1	0/16:35:05 -	0/16:39:15	1
88656 97490					
23 1148-001	: 0000 C	1	0/16:48:05 -	0/16:49:15	1
97491 100105					
24 SUN	: 0000	1	0/16:50:05 -	0/16:54:15	1
100106 108820					
25 SUN	: 0000	1	0/17:00:05 -	0/17:04:05	1
108821 117377					
26 1148-001	: 0000 C	1	0/17:12:55 -	0/17:14:05	1
117378 119783					
27 SUN	: 0000	1	0/17:14:55 -	0/17:19:05	1
119784 128650					
28 SUN	: 0000	1	0/17:24:55 -	0/17:29:05	1
128651 137604					
29 1148-001	: 0000 C	1	0/17:37:55 -	0/17:39:05	1
137605 140174					
30 SUN	: 0000	1	0/17:39:45 -	0/17:44:25	1
140175 149746					
31 SUN	: 0000	1	0/17:50:25 -	0/17:54:05	1
149747 157443					
32 1148-001	: 0000 C	1	0/18:02:45 -	0/18:03:55	1
157444 159899					
33 SUN	: 0000	1	0/18:04:45 -	0/18:08:55	1
159900 168765					
34 SUN	: 0000	1	0/18:14:45 -	0/18:18:55	1
168766 177673					
35 1148-001	: 0000 C	1	0/18:27:45 -	0/18:28:55	1
177674 180284					
36 SUN	: 0000	1	0/18:29:45 -	0/18:33:55	1
180285 189114					
37 SUN	: 0000	1	0/18:39:45 -	0/18:44:05	1

189115	198018						
38 1148-001		: 0000	C	1	0/18:52:45 -	0/18:53:55	1
198019	200001						
39 SUN		: 0000		1	0/18:54:45 -	0/18:59:05	1
200002	207881						
40 SUN		: 0000		1	0/19:04:35 -	0/19:08:45	1
207882	215830						
41 1148-001		: 0000	C	1	0/19:17:35 -	0/19:18:45	1
215831	218097						
42 SUN		: 0000		1	0/19:19:35 -	0/19:23:45	1
218098	226243						
43 SUN		: 0000		1	0/19:29:35 -	0/19:33:45	1
226244	234459						
44 1148-001		: 0000	C	1	0/19:42:35 -	0/19:43:45	1
234460	236808						
45 SUN		: 0000		1	0/19:44:35 -	0/19:53:05	1
236809	254363						
46 SUN		: 0000		1	0/19:54:35 -	0/19:58:45	1
254364	262370						
47 1148-001		: 0000	C	1	0/20:07:25 -	0/20:08:35	1
262371	264690						
48 SUN		: 0000		1	0/20:09:25 -	0/20:13:35	1
264691	273237						
49 SUN		: 0000		1	0/20:19:25 -	0/20:23:35	1
273238	282125						
50 1148-001		: 0000	C	1	0/20:32:25 -	0/20:33:35	1
282126	284658						
51 SUN		: 0000		1	0/20:34:25 -	0/20:38:35	1
284659	293283						
52 SUN		: 0000		1	0/20:44:25 -	0/20:48:35	1
293284	302134						
53 1148-001		: 0000	C	1	0/20:57:25 -	0/20:58:35	1
302135	304634						
54 SUN		: 0000		1	0/20:59:25 -	0/21:03:35	1
304635	313358						
55 SUN		: 0000		1	0/21:09:15 -	0/21:13:25	1
313359	322246						
56 1148-001		: 0000	C	1	0/21:22:15 -	0/21:23:25	1
322247	324222						
57 SUN		: 0000		1	0/21:24:15 -	0/21:28:25	1
324223	333221						
58 SUN		: 0000		1	0/21:34:15 -	0/21:38:25	1
333222	341392						
59 1148-001		: 0000	C	1	0/21:47:15 -	0/21:48:25	1
341393	343406						
60 SUN		: 0000		1	0/21:49:15 -	0/21:53:25	1
343407	350399						
61 SUN		: 0000		1	0/21:59:15 -	0/22:03:25	1
350400	357289						
62 1148-001		: 0000	C	1	0/22:12:05 -	0/22:13:15	1

357290	359048					
63 SUN		: 0000		1	0/22:14:05 - 0/22:18:15	1
359049	365542					
64 SUN		: 0000		1	0/22:24:05 - 0/22:28:15	1
365543	372227					
65 1148-001		: 0000	C	1	0/22:37:05 - 0/22:38:15	1
372228	373947					
66 SUN		: 0000		1	0/22:39:05 - 0/22:43:15	1
373948	380876					
67 SUN		: 0000		1	0/22:49:05 - 0/22:53:25	1
380877	387324					
68 1148-001		: 0000	C	1	0/23:02:05 - 0/23:03:15	1
387325	388927					
69 SUN		: 0000		1	0/23:04:05 - 0/23:08:05	1
388928	394642					
70 SUN		: 0000		1	0/23:13:55 - 0/23:18:05	1
394643	401050					
71 1148-001		: 0000	C	1	0/23:26:55 - 0/23:28:05	1
401051	402397					
72 SUN		: 0000		1	0/23:28:55 - 0/23:33:05	1
402398	407527					
73 SUN		: 0000		1	0/23:38:55 - 0/23:43:05	1
407528	412709					
74 1148-001		: 0000	C	1	0/23:51:55 - 0/23:53:05	1
412710	413612					
75 SUN		: 0000		1	0/23:54:05 - 0/23:58:05	1
413613	418616					
76 SUN		: 0000		1	1/00:07:35 - 1/00:07:55	1
418617	419028					
77 3C286		: 0000	B	1	1/00:21:45 - 1/00:22:55	1
419029	421247					

Source summary

Velocity type = ' ' Definition = ' '

ID	Source	Qual	Calcode	RA(0.0)	Dec(0.0)	IFlux
QFlux	UFlux	VFlux	No. vis			
1	1148-001	: 0000	C	11:48:10.1300	-00:07:13.300	0.000
0.000	0.000	0.000	52089			
2	SUN	: 0000		12:10:30.1272	-01:08:22.648	0.000
0.000	0.000	0.000	366939			
3	3C286	: 0000	B	13:28:49.6570	30:45:58.640	0.000
0.000	0.000	0.000	2219			

ID	Source	Freq(GHz)	Velocity(Km/s)	Rest freq (GHz)
1	All Sources	1.4462	0.0000	0.0000

Frequency Table summary

FQID	IF#	Freq(GHz)	BW(kHz)	Ch.Sep(kHz)	Sideband
1	1	1.44615001	12500.0010	12500.0010	1

AIPS 1: Resumes

PRTAN

Print the Antenna positions — useful for thinking about calibration.

go prtan

```

vlb054    PRTAN(31DEC08)    100    14-NOV-2008  21:45:10    Page    1
File=19810926    .L BAND.    1    An.ver=    1    Vol= 1    User= 100
Array= VLA          Freq= 1446.150006 MHz    Ref.date= 26-SEP-1981

Array reference position in meters (Earth centered)
Array BX= -1601185.36500    BY= -5041977.54700    BZ= 3554875.87000
Polar X = 0.00000 Polar Y = 0.00000 arcsec
Earth rotation rate = 360.9856449713 degrees / IAT day
GST at UT=0 = 364.7139688925 degrees
UT1-UTC= 0.0000000 Data time(IAT )-UTC= 0.0000000 seconds
Solutions not yet determined for a particular FREQID

Ant 1 = VLA:_N2 BX= -30.0602 BY= -4.7835 BZ= 45.7022
Mount=ALAZ Axis offset= 0.0000 meters IFA IFB
Feed polarization type = R L

Ant 2 = VLA:_E5 BX= 51.8719 BY= 195.8466 BZ= -75.1013
Mount=ALAZ Axis offset= 0.0000 meters IFA IFB
Feed polarization type = R L

Ant 3 = VLA:_E9 BX= 139.6430 BY= 536.8956 BZ= -207.7424
Mount=ALAZ Axis offset= -0.0033 meters IFA IFB
Feed polarization type = R L

Ant 4 = VLA:_E6 BX= 70.6548 BY= 267.7575 BZ= -102.8996
Mount=ALAZ Axis offset= 0.0078 meters IFA IFB
Feed polarization type = R L

Ant 5 = VLA:_N3 BX= -52.4373 BY= -8.2629 BZ= 78.6643
Mount=ALAZ Axis offset= 0.0000 meters IFA IFB
Feed polarization type = R L

Ant 6 = VLA:_W2 BX= 14.7735 BY= -37.1404 BZ= -20.2135
Mount=ALAZ Axis offset= 0.0000 meters IFA IFB
Feed polarization type = R L

Ant 7 = VLA:_W3 BX= 28.9195 BY= -74.4876 BZ= -41.0524
Mount=ALAZ Axis offset= -0.0036 meters IFA IFB
Feed polarization type = R L

Ant 8 = VLA:_W1 BX= 22.9920 BY= 3.4974 BZ= -32.4864
Mount=ALAZ Axis offset= 0.0084 meters IFA IFB

```

Feed polarization type =	R	L
Ant 9 = VLA:_E2 BX= 11.3328 BY= 40.6638 BZ= -15.1624		
Mount=ALAZ Axis offset= 0.0000 meters	IFA	IFB
Feed polarization type =	R	L
Ant 10 = VLA:_OUT BX= 0.0000 BY= 0.0000 BZ= 0.0000		
Mount=ALAZ Axis offset= 0.0000 meters	IFA	IFB
Feed polarization type =	R	L
Ant 11 = VLA:_E8 BX= 114.4257 BY= 438.6941 BZ= -169.4880		
Mount=ALAZ Axis offset= 0.0048 meters	IFA	IFB
Feed polarization type =	R	L
Ant 12 = VLA:_E3 BX= 21.9945 BY= 81.5250 BZ= -30.9498		
Mount=ALAZ Axis offset= 0.0000 meters	IFA	IFB
Feed polarization type =	R	L
Ant 13 = VLA:_E7 BX= 91.5227 BY= 348.8871 BZ= -134.4449		
Mount=ALAZ Axis offset= 0.0000 meters	IFA	IFB
Feed polarization type =	R	L
Ant 14 = VLA:_W7 BX= 121.6261 BY= -319.1264 BZ= -177.5842		
Mount=ALAZ Axis offset= 0.0000 meters	IFA	IFB
Feed polarization type =	R	L
Ant 15 = VLA:_W9 BX= 186.8061 BY= -491.1158 BZ= -273.5624		
Mount=ALAZ Axis offset= 0.0000 meters	IFA	IFB
Feed polarization type =	R	L
Ant 16 = VLA:_E4 BX= 35.6150 BY= 133.6310 BZ= -51.1099		
Mount=ALAZ Axis offset= -0.0051 meters	IFA	IFB
Feed polarization type =	R	L
Ant 17 = VLA:_W8 BX= 152.7524 BY= -401.2839 BZ= -223.4146		
Mount=ALAZ Axis offset= 0.0000 meters	IFA	IFB
Feed polarization type =	R	L
Ant 18 = VLA:_E1 BX= 45.3386 BY= 7.0026 BZ= -65.4888		
Mount=ALAZ Axis offset= 0.0000 meters	IFA	IFB
Feed polarization type =	R	L
Ant 19 = VLA:_N7 BX= -193.6105 BY= -30.2503 BZ= 286.4580		
Mount=ALAZ Axis offset= -0.0030 meters	IFA	IFB
Feed polarization type =	R	L
Ant 20 = VLA:_N1 BX= 0.6703 BY= 0.0144 BZ= 0.5135		
Mount=ALAZ Axis offset= 0.0045 meters	IFA	IFB
Feed polarization type =	R	L
Ant 21 = VLA:_N8 BX= -243.6039 BY= -38.0389 BZ= 360.0340		

Mount=ALAZ	Axis offset=	0.0000 meters	IFA	IFB
Feed polarization type =			R	L
Ant 22 = VLA:_W5	BX=	68.6012	BY=	-179.2282
Mount=ALAZ	Axis offset=	0.0000 meters	IFA	IFB
Feed polarization type =			R	L
Ant 23 = VLA:_N5	BX=	-108.4301	BY=	-16.9862
Mount=ALAZ	Axis offset=	0.0000 meters	IFA	IFB
Feed polarization type =			R	L
Ant 24 = VLA:_N9	BX=	-298.3837	BY=	-46.5620
Mount=ALAZ	Axis offset=	0.0000 meters	IFA	IFB
Feed polarization type =			R	L
Ant 25 = VLA:_N6	BX=	-148.4545	BY=	-23.2162
Mount=ALAZ	Axis offset=	0.0000 meters	IFA	IFB
Feed polarization type =			R	L
Ant 26 = VLA:_N4	BX=	-74.8318	BY=	-11.7331
Mount=ALAZ	Axis offset=	0.0000 meters	IFA	IFB
Feed polarization type =			R	L
Ant 27 = VLA:_W6	BX=	93.5170	BY=	-245.0012
Mount=ALAZ	Axis offset=	0.0000 meters	IFA	IFB
Feed polarization type =			R	L
Ant 28 = VLA:_W4	BX=	46.9220	BY=	-122.0267
Mount=ALAZ	Axis offset=	0.0000 meters	IFA	IFB
Feed polarization type =			R	L
Ant 29 = VPT:_OUT	BX=	0.0000	BY=	0.0000
Mount=ALAZ	Axis offset=	0.0000 meters	IFA	IFB
Feed polarization type =			R	L

Location Of VLA Antennas

N9	(24)
N8	(21)
N7	(19)
N6	(25)
N5	(23)
N4	(26)
N3	(5)
N2	(1)
N1	(20)
(8) W1	E1 (18)
(6) W2	E2 (9)
(7) W3	E3 (12)
(28) W4	E4 (16)

```

                (22) W5
                (27) W6
                (14) W7
                (17) W8
            (15) W9
                VLA:_OUT (10)
                VPT:_OUT (29)

```

AIPS 1: Resumes

The really important part for you, the data reducer, is the antenna layout at the bottom. This tells you in a nice graphical form where each antenna is located. This helps you to figure out which baselines are small, and which baselines are long. This is also useful for figuring out other things related to antenna position and baseline direction.

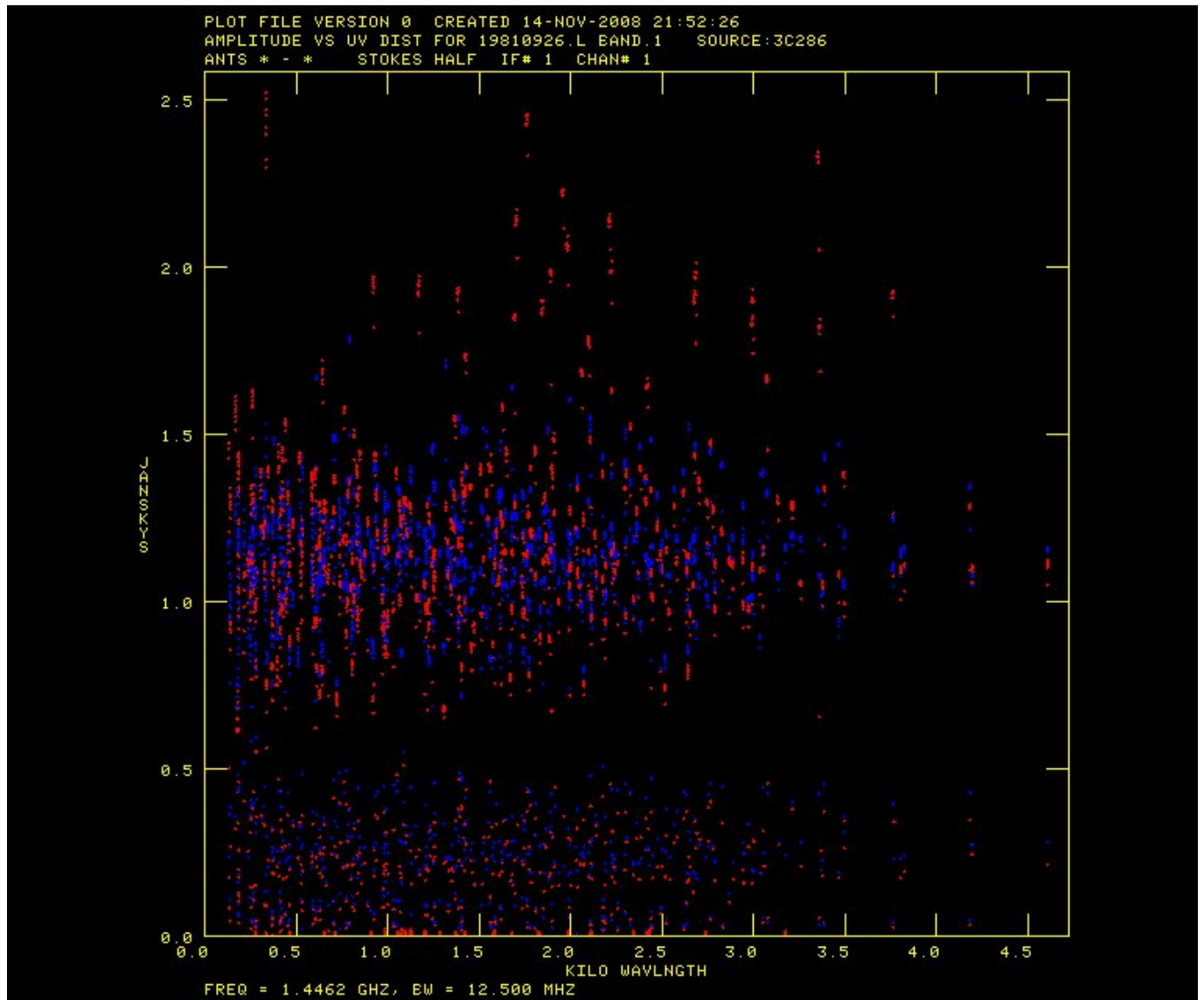
UVPLT

Let's have a look at the information about the visibilities.

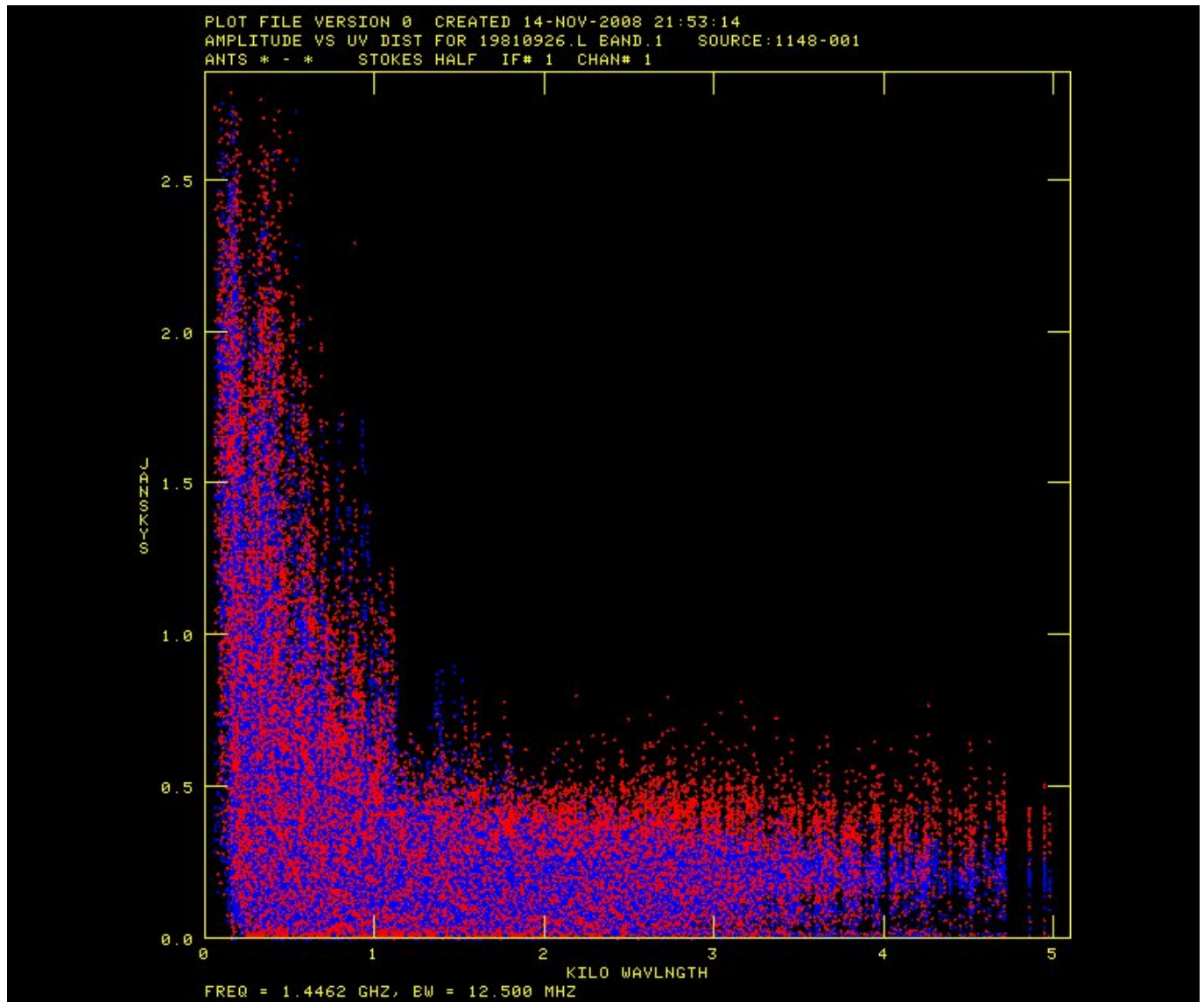
```

task 'uvplt'
source '3c286',' '
stokes 'half'
calcode ' '
uvrange 0
antennas 0
basel 0
xinc 1
aparm 0
bparm 0
doweight 1
refant 3
do3col 1
dotv 1
tvinit
go

```

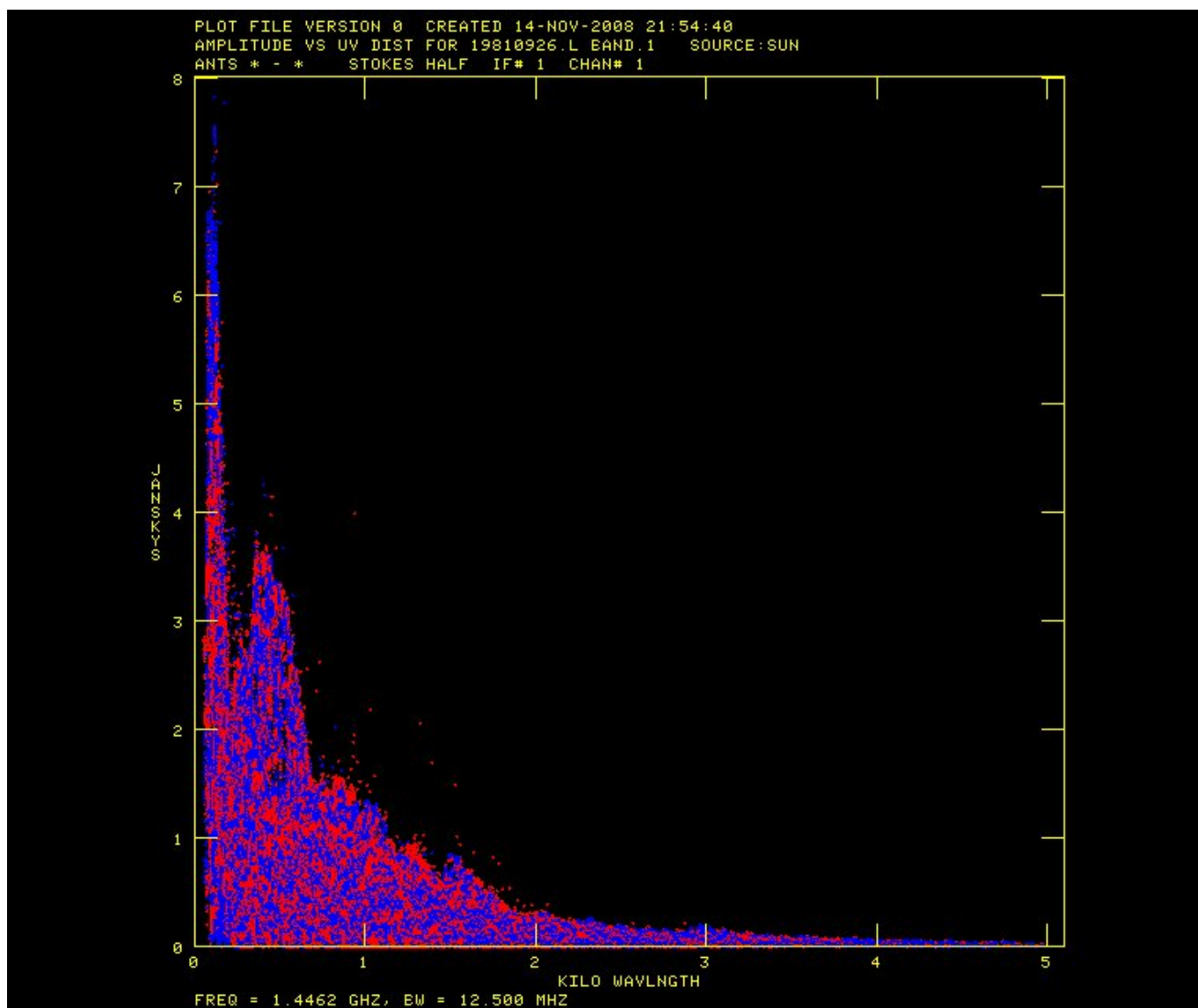


source '1148-001', ' '
go

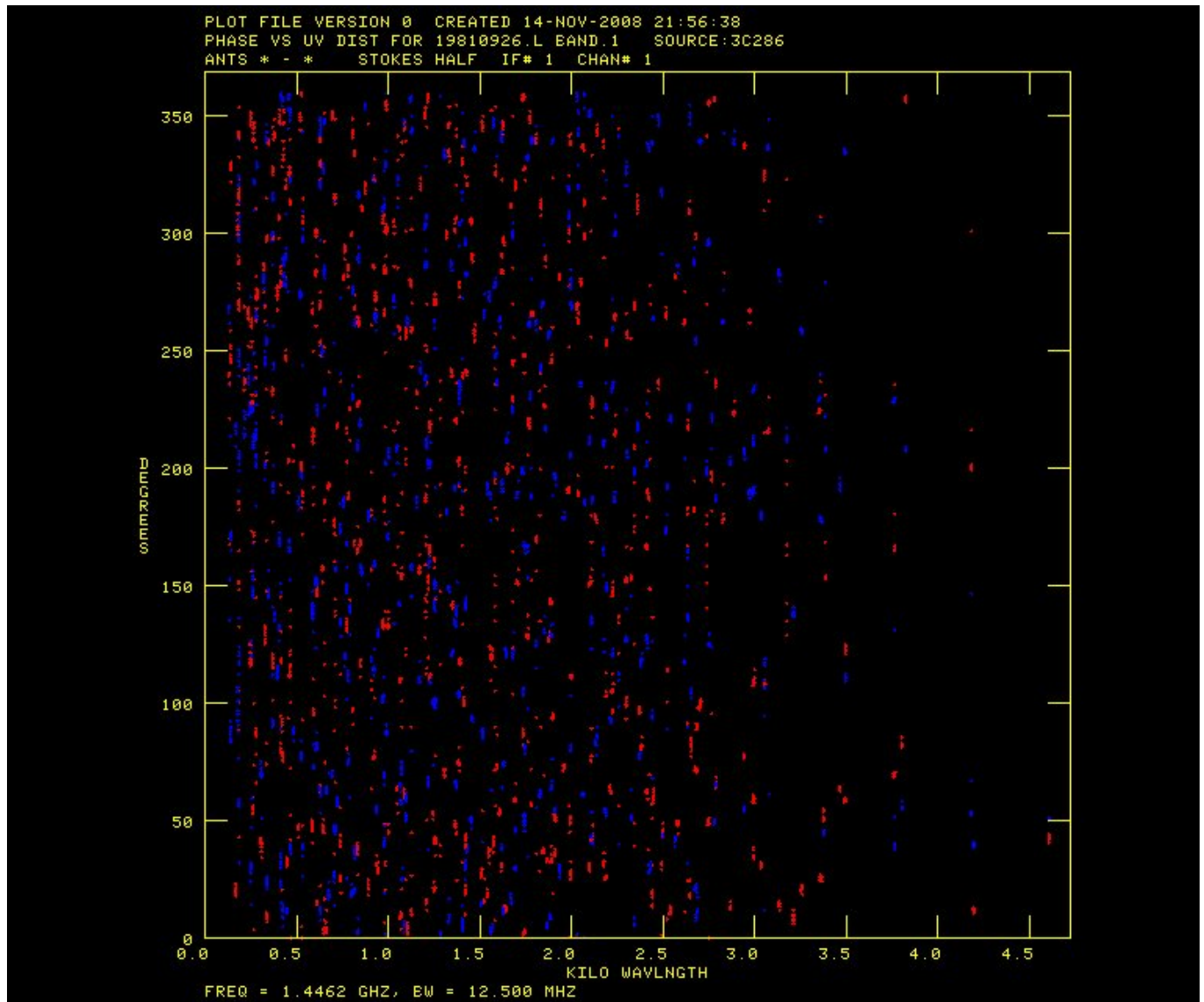


Warning: the next step will take a long time. You are free to skip this, and just look at the picture.

```
source 'sun', ' '
go
```

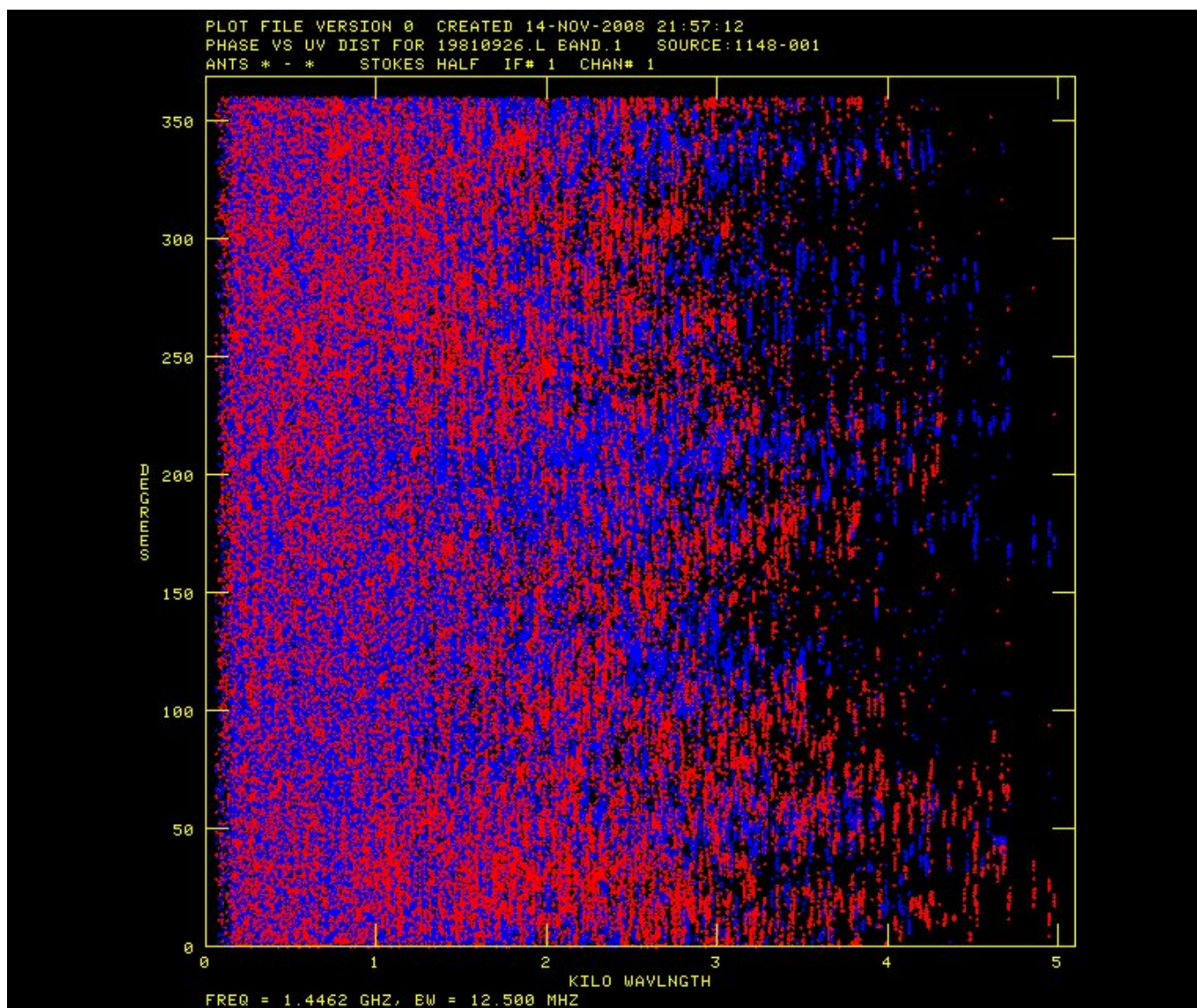


```
source '3c286', ' '  
bparm 0 2  
go
```

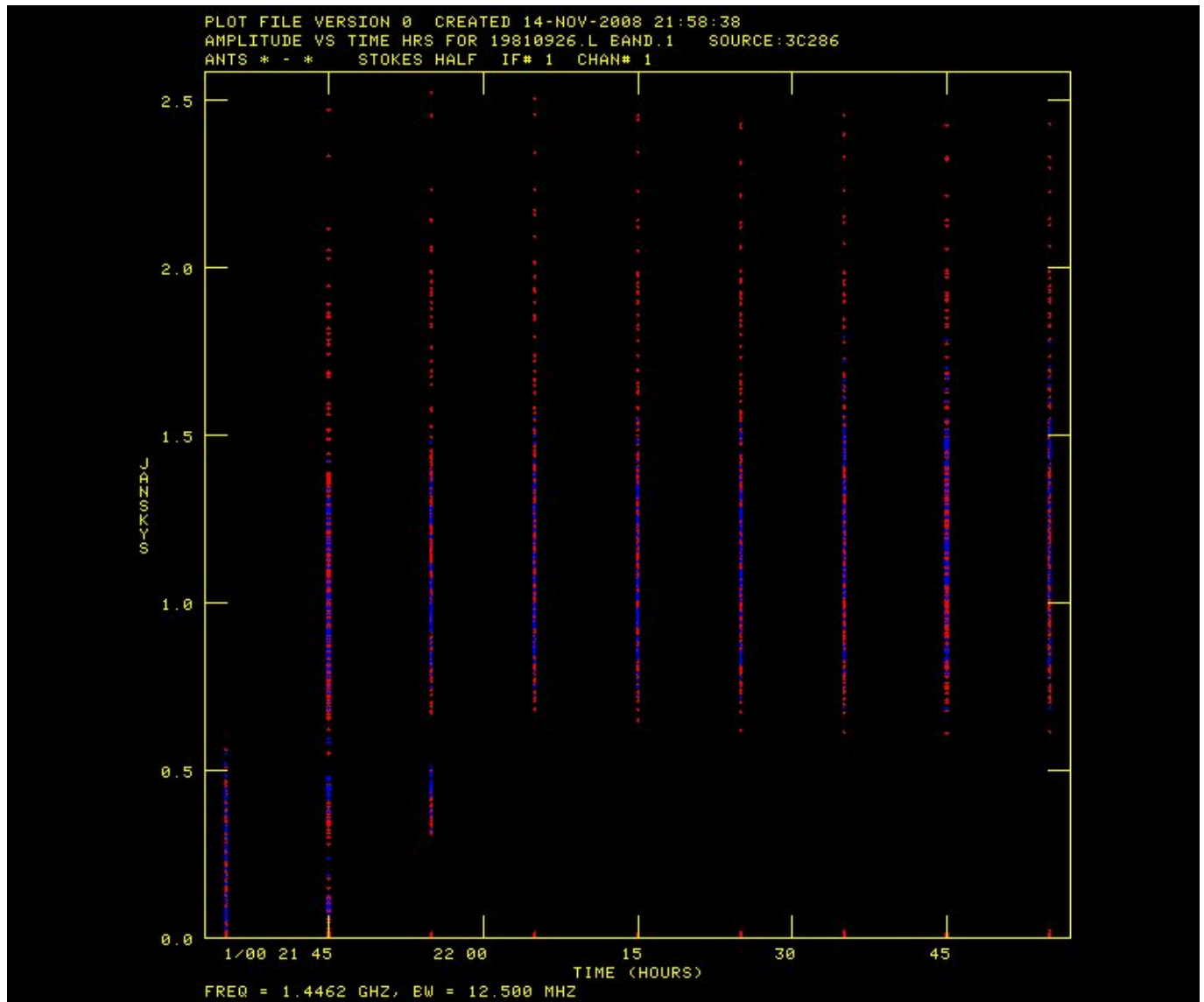


source '1148-001', ' '

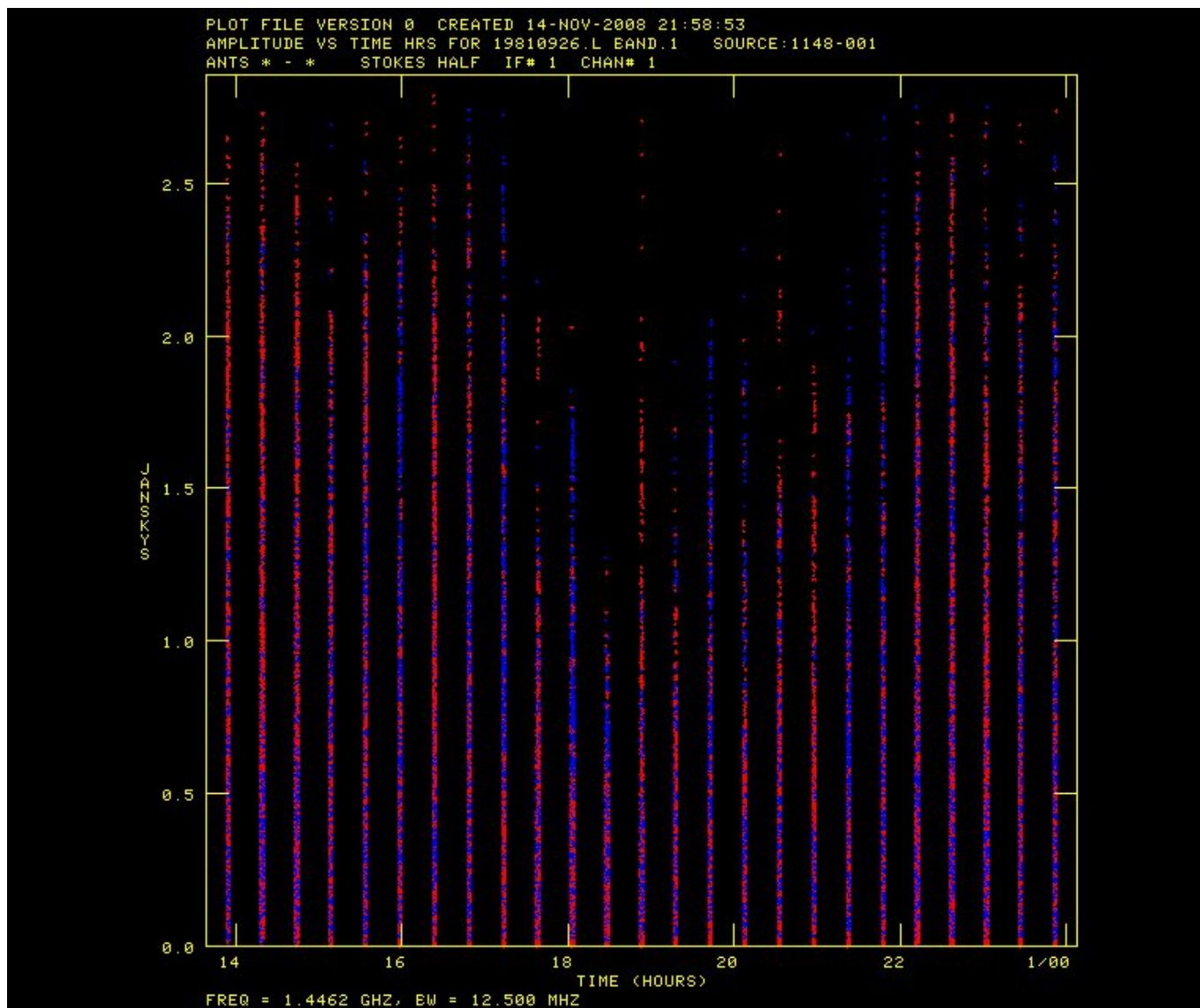
go



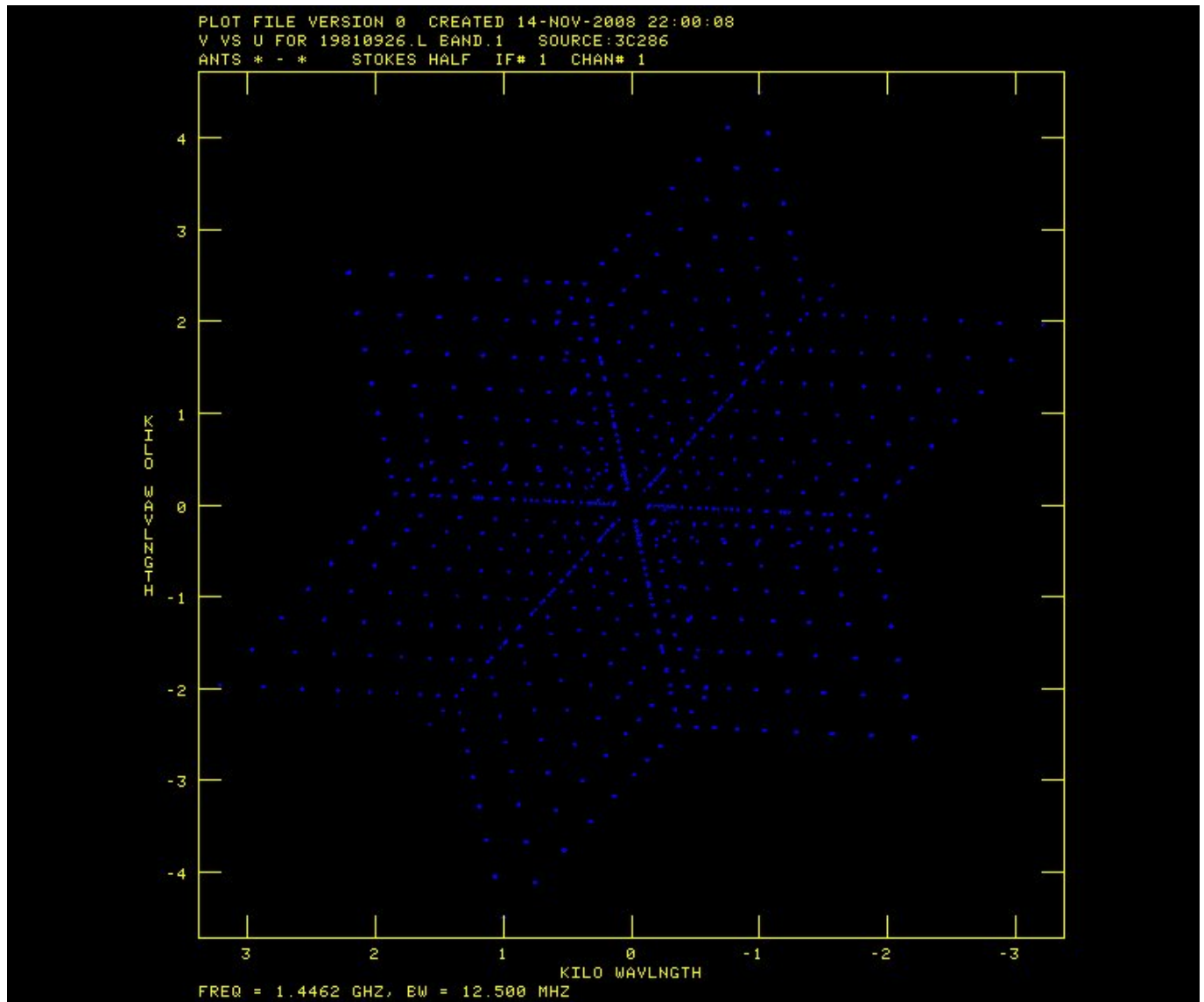
```
source '3c286', ' '  
bparm 11 1  
go
```



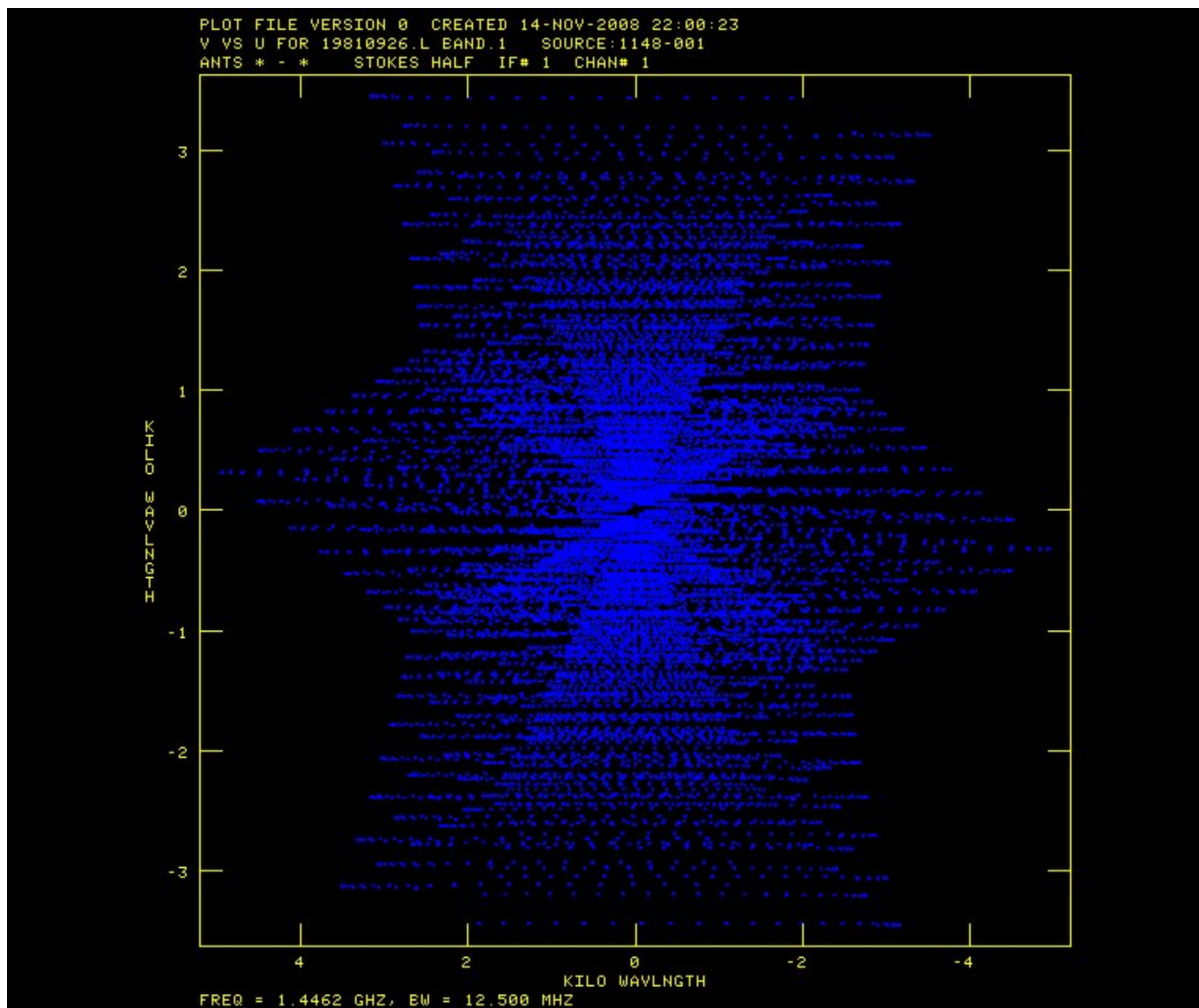
source '1148-001', ' '
 go



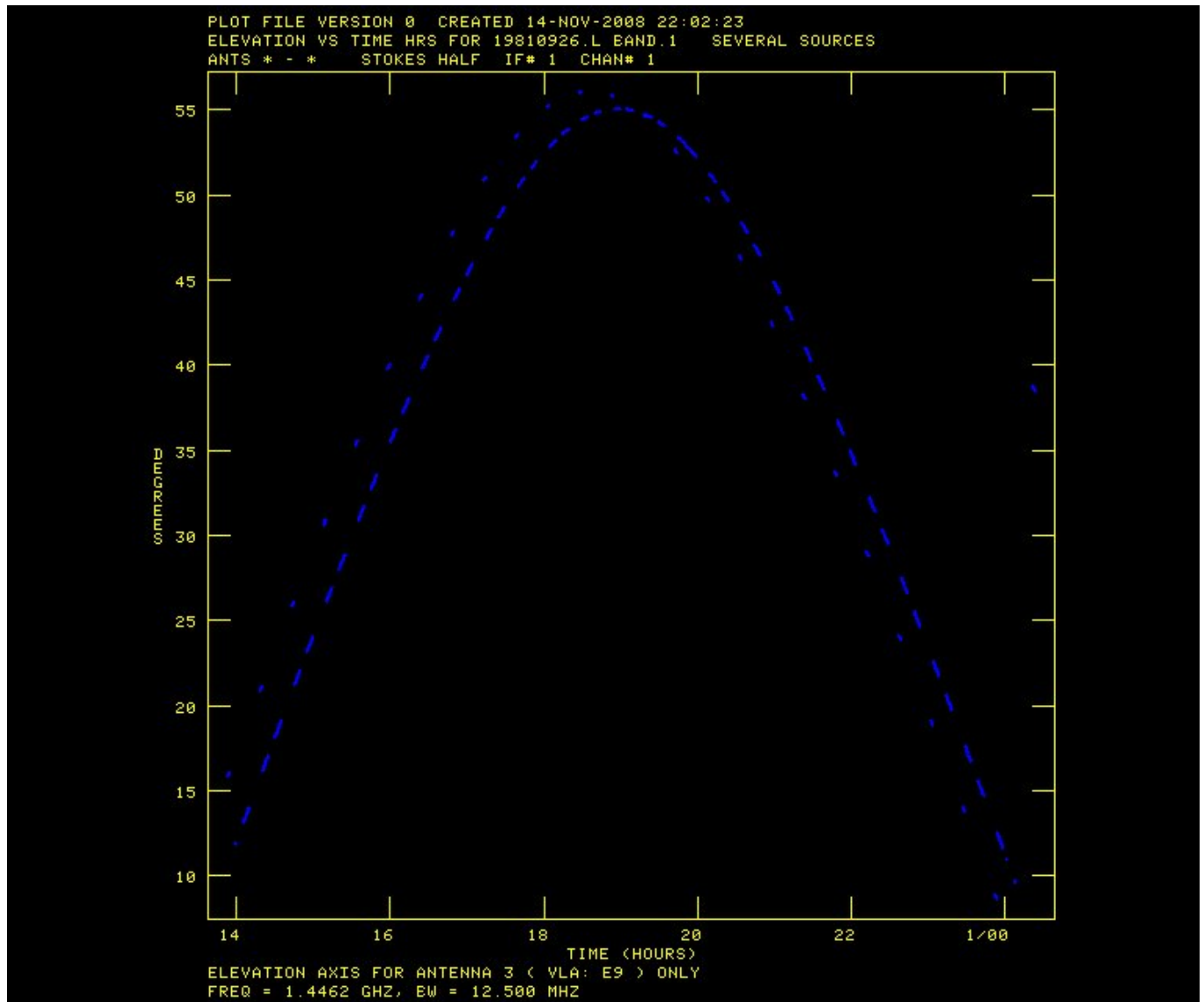
source '3c286', '
bparm 6 7
go



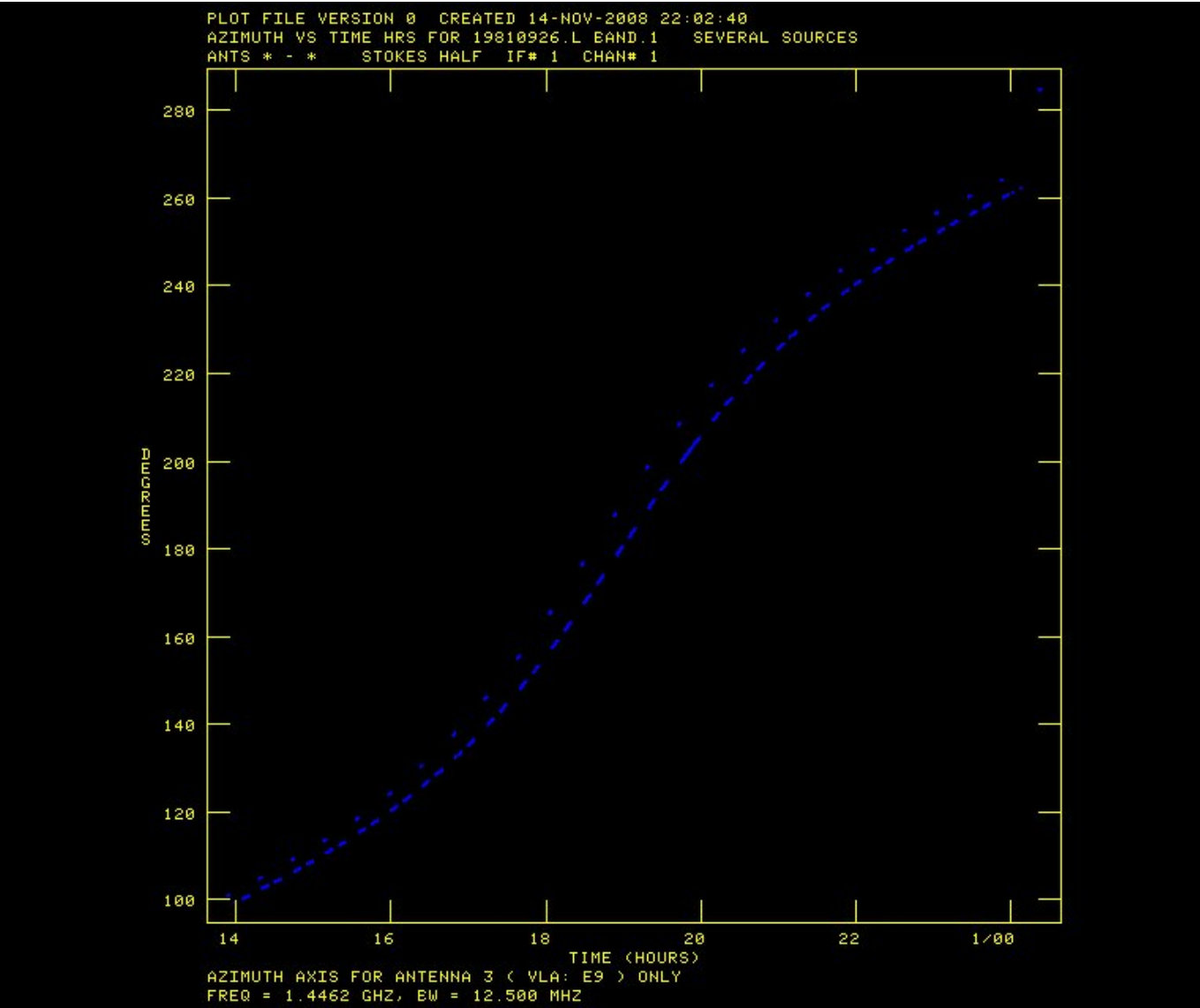
source '1148-001', ' '
 go



```
source ' '
bparm 11 15
xinc 50
go
```



bparm 11 18
go



LISTR

Now let's look at the raw visibility numbers.

```
xinc 1
task 'listr'
optype 'list'
source '3c286', ' '
stokes ' '
bif 0
eif 0
flagver 0
dparm 0
antenna 3,0
go
```

vlb054	LISTR(31DEC08)	100	14-NOV-2008	22:05:45	Page	1
File = 19810926	.L BAND.	1	Vol = 1	Userid = 100	Channels =	1- 1

```

IF = 1
Freq= 1.446150006 GHz   Ncor= 1   No. vis=      3159
Stokes = RR   Subarray = 1

Source=3C286           : 0000, Stokes=RR , IF= 1, Chans= 1- 1
Flux = 0.0000 Jy, Calcode = B , Freq = 1.446150006 GHz
Amplitudes, 1000 = 1.000 Jy, averging type = Vector

Baselines      1 3 2 3 3 4 3 5 3 6 3 7 3 8 3 9 310 311 312 313 314 315 316
317 318 319 320 321 322 323 324 325 326 327 328 329
1/00:21:35 293 259 258 282 45 360 431 333      563 326 247 264 256 469
287 127 283 84 56 455 12 344 307 313 321 347
Amplitudes, 1000 = 10.000 Jy, averging type = Vector
1/00:21:45 195 180 182 168 15 212 234 203      247 135 160 177 169 187
174 156 178 129 66 205 1 185 186 189 158 158
1/00:21:55 206 196 194 176 67 223 246 214      252 139 169 192 183 193
183 185 190 188 205 214 1 192 199 199 165 168
1/00:22:05 209 197 197 179 165 223 246 217      251 144 172 193 185 194
186 186 193 190 235 216 1 193 201 202 167 169
1/00:22:15 205 194 196 178 198 223 244 214      246 140 170 189 182 193
183 186 190 190 235 212 0 193 198 199 164 169
1/00:22:25 206 192 197 177 196 222 243 214      242 139 165 189 180 193
183 184 190 186 231 212 1 191 197 199 164 168
1/00:22:35 207 195 196 178 198 223 246 215      240 140 166 192 182 192
184 185 190 190 233 214 0 192 199 199 165 168
1/00:22:45 206 192 192 177 199 222 243 213      232 141 168 191 183 190
183 185 191 187 233 214 1 191 197 198 164 169
1/00:22:55 206 193 195 179 199 223 243 213      230 140 170 190 182 193
183 185 190 186 233 215 1 191 197 199 164 169
AIPS 1: Resumes

```

Flagging

Just enter these commands. We can talk later about why they needed to be applied.

```

task 'uvflg'
antenna 23,0
basel 0
timer 0
aparm 0
opcode 'flag'
reason 'bad ant'
dohist 1
go
antenna 26,0
timer 0 18 29 0 0 20 7 20
go
timer 0 0 0 0 0 15 8 10

```

```
go
timer 0 21 48 30 0 22 37 10
go
antenna 25,0
timer 0 22 38 20 1 0 21 50
go
```

More LISTR, now on the phase calibrator

```
task 'listr'
optype 'list'
source '1148-001', ' '
stokes ' '
calcode ' '
bif 0
eif 0
timer 0
flagver 0
dparm 0
antenna 3,0
go
```

```
v1b054    LISTR(31DEC08)    100    14-NOV-2008  22:35:27    Page    1
File = 19810926    .L BAND.    1 Vol = 1  Userid = 100    Channels = 1-    1
IF = 1
Freq= 1.446150006 GHz    Ncor= 1    No. vis=    84072
Stokes = RR    Subarray = 1
Applying flag table 1
```

```
Source=1148-001    : 0000, Stokes=RR , IF= 1, Chans= 1-    1
Flux = 0.0000 Jy, Calcode = C , Freq = 1.446150006 GHz
Amplitudes, 1000 = 10.000 Jy, averging type = Vector
```

Baselines	1	3	2	3	3	4	3	5	3	6	3	7	3	8	3	9	310	311	312	313	314	315	316
317	318	319	320	321	322	323	324	325	326	327	328	329											
0/13:53:55	57	126	58	53				86	123	73			195	32	57	13	23	66					
30	36	27	75	30	89		24	20	28	45	103												
0/13:54:05	67	134	66	24				65	155	47			213	26	66	28	28	92					
30	53	35	60	26	63		28	33	55	77	103												
0/13:54:15	43	124	77	29	43	26	144	44					184	36	77	40	29	96					
19	39	29	34	31	34		26	34	76	62	134												
0/13:54:25	6	104	91	62	40	68	96	73					177	59	93	30	30	87					
35	4	26	41	45	78		32	31	74	14	139												
0/13:54:35	28	84	94	70	21	93	69	80					191	56	104	19	31	61					
34	50	31	68	42	94		31	24	41	46	99												

```
Source=1148-001    : 0000, Stokes=RR , IF= 1, Chans= 1-    1
```

Flux = 0.0000 Jy, Calcode = C , Freq = 1.446150006 GHz
 Amplitudes, 1000 = 10.000 Jy, averging type = Vector

Baselines	1	3	2	3	3	4	3	5	3	6	3	7	3	8	3	9	310	311	312	313	314	315	316
317 318 319 320 321 322 323 324 325 326 327 328 329																							
0/14:18:25	37	65	58	31					101	107	83						230	68	57	35	34	81	
33 90 40 56 18 32					32	45	69	32	47														
0/14:18:35	4	65	55	22			78	85	80								191	67	58	28	28	78	
26 58 28 58 33 50					29	39	28	17	39														
0/14:18:45	36	62	56	30	17	32	45	47									128	48	57	28	32	61	
32 48 24 31 44 48					34	26	18	29	17														
0/14:18:55	54	54	70	40	24	39	15	18									194	27	61	30	36	28	
33 80 34 6 45 27					34	25	52	36	35														
0/14:19:05	48	27	87	54	30	90	70	24									176	21	56	29	47	14	
39 114 42 29 50 42					43	44	63	24	47														
0/14:19:15	38	7	105	40	33	117	116	67									113	59	63	42	43	51	
44 105 45 70 51 62					44	58	66	29	39														
0/14:19:25	23	48	112	35	30	75	117	92									198	80	50	46	44	84	
46 57 38 74 59 63					47	48	21	50	30														
0/14:19:35	58	72	99	36	26	39	70	66									123	60	31	38	40	86	
34 35 41 42 49 31					42	27	33	46	35														

Source=1148-001 : 0000, Stokes=RR , IF= 1, Chans= 1- 1
 Flux = 0.0000 Jy, Calcode = C , Freq = 1.446150006 GHz
 Amplitudes, 1000 = 10.000 Jy, averging type = Vector

Baselines	1	3	2	3	3	4	3	5	3	6	3	7	3	8	3	9	310	311	312	313	314	315	316
317 318 319 320 321 322 323 324 325 326 327 328 329																							
0/14:43:25	32	32	95	40					47	27	55						237	14	83	30	33	58	
31 33 38 40 20 35					34	35	13	28	35														
0/14:43:35	34	56	91	30			44	48	60								173	29	80	34	33	46	
32 29 36 38 35 37					34	33	38	29	37														
0/14:43:45	27	59	103	14	27	21	51	54									130	51	66	25	25	72	
24 23 22 14 27 26					21	23	48	23	26														
0/14:43:55	22	49	112	29	24	18	35	23									182	49	43	19	26	95	
23 30 20 9 30 28					27	22	32	20	21														
0/14:44:05	39	59	141	41	28	42	36	2									163	35	32	32	33	112	
31 32 37 35 41 35					34	35	29	30	30														
0/14:44:15	36	49	157	37	23	50	28	29									179	16	17	31	32	98	
32 31 38 44 36 34					29	33	18	28	35														
0/14:44:25	27	28	159	25	22	37	38	54									200	17	17	30	29	71	
28 26 27 38 33 31					27	28	36	28	31														
0/14:44:35	28	1	150	20	31	23	47	60									242	39	22	29	30	42	
28 29 27 22 39 34					30	29	51	28	27														

Source=1148-001 : 0000, Stokes=RR , IF= 1, Chans= 1- 1
 Flux = 0.0000 Jy, Calcode = C , Freq = 1.446150006 GHz
 Amplitudes, 1000 = 10.000 Jy, averging type = Vector

Baselines	1	3	2	3	3	4	3	5	3	6	3	7	3	8	3	9	310	311	312	313	314	315	316
317 318 319 320 321 322 323 324 325 326 327 328 329																							

0/15:08:15	17	35	52	25		33	42	35		148	14	29	28	29	49
29	31	30	27	15	38		29	32	35	25	33				
0/15:08:25	29	38	64	22		27	33	32		146	14	38	27	25	52
25	31	33	18	29	30		27	22	23	22	35				
0/15:08:35	33	25	70	27	23	25	27	25		135	25	35	21	25	49
21	29	26	17	30	25		24	19	18	18	29				
0/15:08:45	50	35	91	34	35	42	44	43		185	32	52	37	34	49
34	34	30	38	45	40		36	39	43	33	33				
0/15:08:55	30	28	84	30	32	37	43	34		188	26	53	32	33	26
32	26	29	42	37	40		32	36	41	27	26				
0/15:09:05	21	27	72	28	31	37	46	35		185	26	56	31	32	9
31	27	37	36	37	39		32	30	35	29	35				

dparm 1,0
go

vlb054	LISTR(31DEC08)	100	14-NOV-2008	22:36:24	Page	1
File = 19810926	.L BAND.	1	Vol = 1	Userid = 100	Channels = 1-	1
IF = 1						
Freq= 1.446150006 GHz	Ncor= 1	No. vis=	84072			
Stokes = RR	Subarray = 1					
Applying flag table	1					
Source=1148-001	: 0000,	Stokes=RR	, IF= 1,	Chans= 1-	1	
Flux = 0.0000 Jy,	Calcode = C	, Freq = 1.446150006 GHz				
Phase, 1000 = 1000.00 degrees,	averaging type = Vector					
Baselines	1 3 2 3 3 4 3 5 3 6 3 7 3 8 3 9 310 311 312 313 314 315 316					
317 318 319 320 321 322 323 324 325 326 327 328 329						
0/13:53:55	-154 176 177-145	82 59 -83	-35-118 -77 101 41 3			
59 63 114 69 -97 80	76 88 -57 67 121					
0/13:54:05	163 138-130 -83	141 119 -21	-20 -30 -50 52 43 52			
78 97 122 122-106 147	78 88 46 166-137					
0/13:54:15	127 100 -91 65-134-101 172 78	-173 44 -26 79 44 90				
51 137 129-158-129 -79	72 102 95-124 -55					
0/13:54:25	118 61 -61 125 -91 13-128 145	172 105 -3 99 45 126				
51-125 122 -51-119 21	73 111 140 2 12					
0/13:54:35	-125 9 -32 168 -49 68 -31-164	161 144 17 64 39 167				
75 31 115 12-106 79	77 97-174 142 90					
Source=1148-001	: 0000,	Stokes=RR	, IF= 1,	Chans= 1-	1	
Flux = 0.0000 Jy,	Calcode = C	, Freq = 1.446150006 GHz				
Phase, 1000 = 1000.00 degrees,	averaging type = Vector					
Baselines	1 3 2 3 3 4 3 5 3 6 3 7 3 8 3 9 310 311 312 313 314 315 316					
317 318 319 320 321 322 323 324 325 326 327 328 329						
0/14:18:25	135 174 69 167	66 121-173	51 109 26 75 39 58			
61 136 118 27-117 30	73 88 140-157 -8					

```

0/14:18:35 -72 153 124 160      123 168-128      93 145 32 67 42 93
49-154 126 72-128 56      67 111-158 177 13
0/14:18:45 -131 132 173 146-116-171-153 -91      147-177 42 68 36 129
50 -56 105 107-120 83      73 112 25 160 -43
0/14:18:55 -165 103-132 149-123 -19 -9 -18      6-122 55 73 40 167
61 23 101-175-110 89      76 81 66-175 -41
0/14:19:05 162 87 -88 160-120 46 81 143      -37 33 72 73 37 23
53 78 112 -3-118 46      73 83 112-159 -16
0/14:19:15 141 -86 -66 164-116 89 113 174      -114 69 87 66 40 22
49 120 122 26-126 54      73 98 143 165 -7
0/14:19:25 -137-143 -42 155-114 141 151-151      118 111 94 69 35 50
56 167 112 65-120 78      73 111 155 166 -18
0/14:19:35 -139-164 -20 142-130 -91-161-118      166 144 107 72 37 79
55 -66 99 109-114 88      78 99 37-168 -38

```

Source=1148-001 : 0000, Stokes=RR , IF= 1, Chans= 1- 1
 Flux = 0.0000 Jy, Calcode = C , Freq = 1.446150006 GHz
 Phase, 1000 = 1000.00 degrees, averging type = Vector

```

Baselines      1 3 2 3 3 4 3 5 3 6 3 7 3 8 3 9 310 311 312 313 314 315 316
317 318 319 320 321 322 323 324 325 326 327 328 329
0/14:43:25 -174-121 103 162      65 109 166      41 37 70 66 32-169
49 86 97 42-121 64      64 91 89-178 -29
0/14:43:35 -169-148 150 173      81 104-159      138 70 88 65 32 -85
48 76 109 66-129 60      67 92 71 178 -20
0/14:43:45 -165-171-168 150-127 97 120-123      116 107 114 64 28 -20
54 69 109 87-132 61      56 94 90 170 -18
0/14:43:55 -170 163-127 133-123 58 147 -84      90 142 139 68 35 32
53 74 91 6-133 61      58 85 121 175 -25
0/14:44:05 -177 139 -92 148-112 53 149 -32      72 177 164 69 35 70
47 82 97 19-127 64      64 90 134-174 -30
0/14:44:15 180 123 -62 162-122 68 116 147      62-116-143 65 32 105
54 81 109 35-124 64      66 90 87 175 -30
0/14:44:25 -176 101 -37 168-136 85 105 177      51 15 -85 66 30 145
50 76 112 59-132 57      64 88 72 171 -20
0/14:44:35 -162 105 -7 146-133 79 117-152      41 68 -46 68 30-163
47 71 96 67-132 61      59 87 97 173 -24

```

Source=1148-001 : 0000, Stokes=RR , IF= 1, Chans= 1- 1
 Flux = 0.0000 Jy, Calcode = C , Freq = 1.446150006 GHz
 Phase, 1000 = 1000.00 degrees, averging type = Vector

```

Baselines      1 3 2 3 3 4 3 5 3 6 3 7 3 8 3 9 310 311 312 313 314 315 316
317 318 319 320 321 322 323 324 325 326 327 328 329
0/15:08:15 -152 172-105 148      73 125-161      -32 127 -46 69 28 39
48 65 87 38-129 62      62 93 108 179 -40
0/15:08:25 -136 152 -86 139      76 126-157      -27 89 -36 66 28 63
53 80 95 41-139 66      61 96 114 175 -30
0/15:08:35 -164 140 -63 149-130 64 135-148      -15 107 -11 67 22 87
50 78 114 9-134 60      67 80 93 177 -17
0/15:08:45 178 144 -39 151-126 66 128-148      -3 119 9 68 28 106

```

51	90	108	12-127	58		65	82	91-177	-16								
	0/15:08:55	167	150	-18		151-124	70	124-149		9	132	23	69	27	121		
48	70	87	27-127	57		62	87	101-179	-33								
	0/15:09:05	-160	162	3		151-129	72	126-157		21	135	33	65	28	74		
51	48	93	40-134	67		61	96	111	177	-36							

Calibration

SETJY

```
task 'setjy'
source '3c286', ' '
optype 'calc'
aparm 0
aparm(2)=4
zerosp 0
go
```

```
vlb054> SETJY1: Task SETJY (release of 31DEC10) begins
vlb054> SETJY1: **WARNING: OPCODE=CALC AND FREQID = -1
vlb054> SETJY1: FREQID WILL BE RESET TO 1, CHECK YOUR RESULTS CAREFULLY
vlb054> SETJY1: A source model for this calibrator is available
vlb054> SETJY1: Consult the help file for CALRD for assistance
vlb054> SETJY1: / Flux calculated using known spectrum
vlb054> SETJY1: BIF = 1 EIF = 1 /Range of IFs
vlb054> SETJY1: '3C286 ' IF = 1 FLUX =14.6428 (Jy calcd)
vlb054> SETJY1: / Using (1995.2) VLA or Reynolds (1934-638) coefficients
vlb054> SETJY1: Appears to have ended successfully
vlb054> SETJY1: vlb054 31DEC10 TST: Cpu= 0.0 Real= 0
```

CALRD

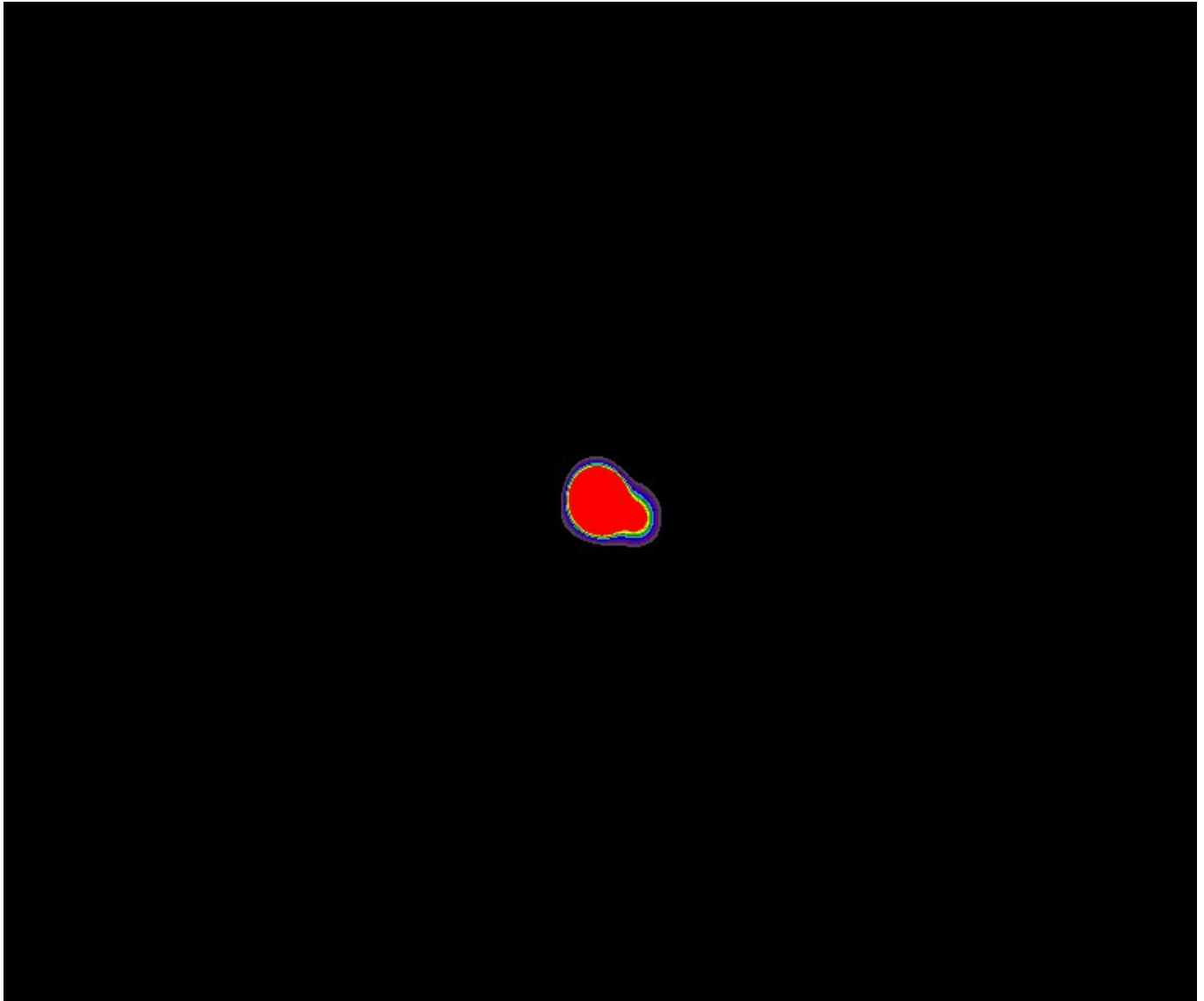
```
task 'calrd'  
object '3c286'  
band 'l'  
go
```

```
vlb054> CALRD1: Task CALRD (release of 31DEC08) begins
vlb054> CALRD1: Reading disk file AIPSTARS:3C286_L.MODEL
vlb054> CALRD1: Create 3C286_L .MODEL . 1 (MA) on disk 1 cno 2
vlb054> CALRD1: Appears to have ended successfully
vlb054> CALRD1: vlb054 31DEC08 TST: Cpu= 0.0 Real= 0
```

So it looks like the calibration data image was put into catalog entry number 2.

Let's have a look at it.

```
getn 2  
tvinit  
tvlod  
tvfiddle
```



UVFIX

The sky positions (RA and Dec) were entered as coordinates of date, because the Sun is a moving object. However, they were entered in an odd fashion which means that the current software has trouble dealing with the calibration image for proper calibration. Run the fix program.

```
task 'uvfix'  
getn 1  
clon  
shift 0  
uvfixprm 0  
go
```

UVFIX change in April means we have to regenerate NX table

```
task 'indxr'  
getn 3  
cparm 0  
cparm(3)= -1  
bparm 0  
go
```

CALIB

First, we do the amplitude calibrator.

```
task 'calib'  
getn 3  
calsour '3c286',' '  
uvrange 0  
antennas 0  
timer 0  
refant 24  
weightit 1  
in2di 1  
get2n 2  
ncomp 0  
solmode 'A&P'  
aparm 0  
aparm(6) 2  
minamper 10  
minphser 10  
docalib 1  
gainuse 1  
solint 30  
solsub 2  
cparm 0  
cparm(3) 10  
cparm(4) 10  
soltype ' '  
clrmsg  
go  
clrmsg
```

Next, the phase calibrator.

```
calsour '1148-001',' '  
clr2n  
uvrange 1.5,0  
solint 0  
go
```

clrmsg

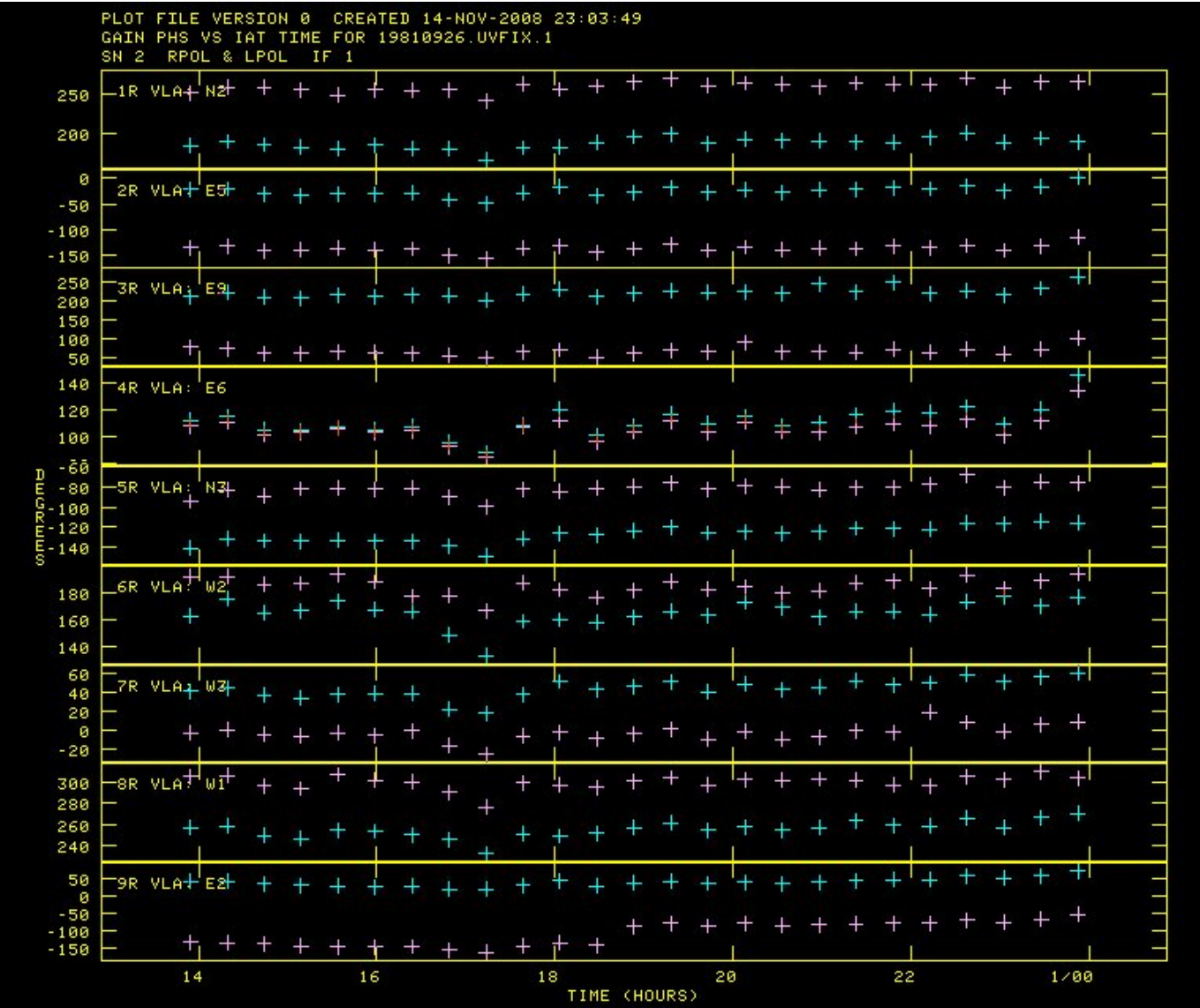
SNPLT

Look at the amplitude calibrator results.

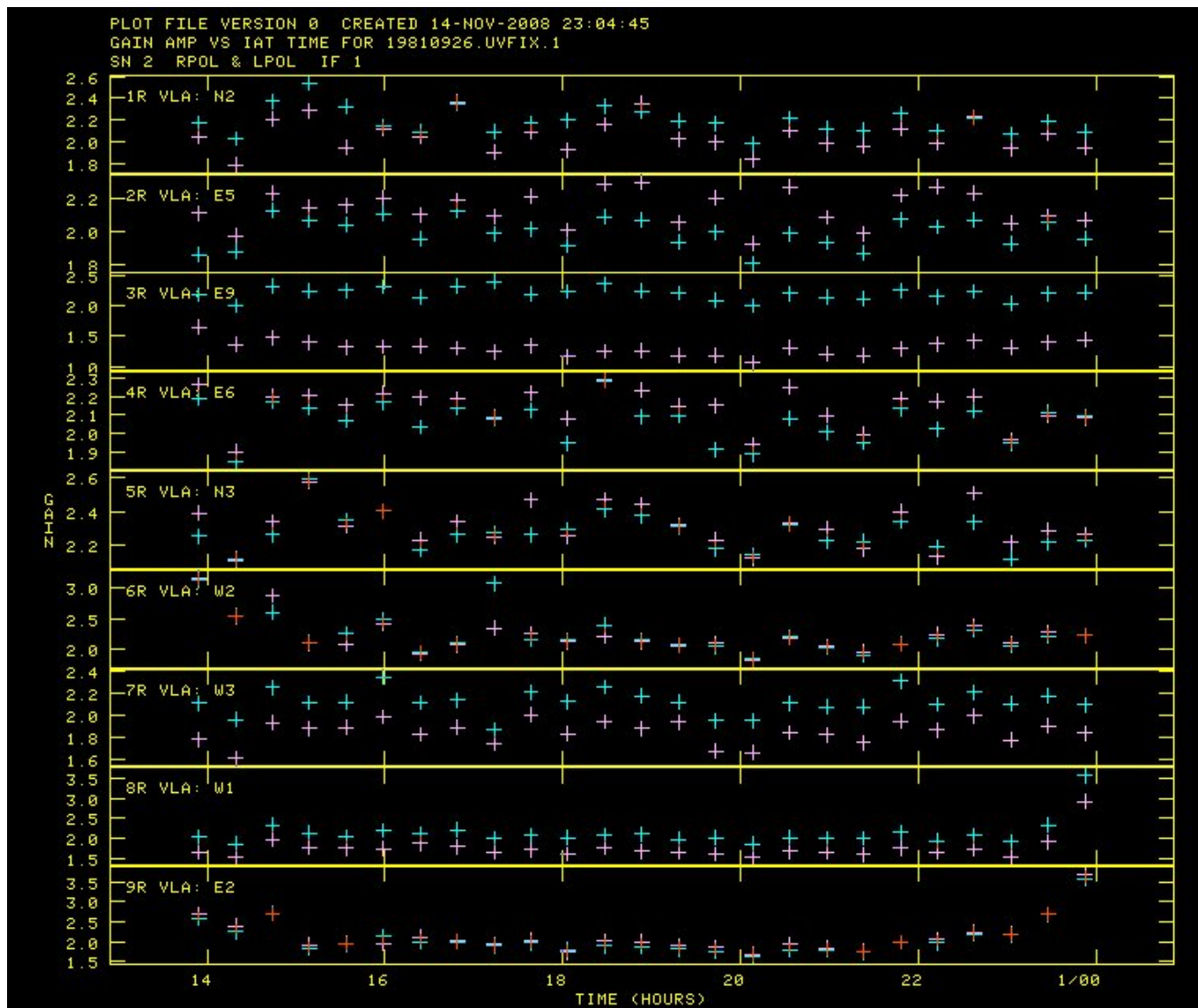
```
task 'snplt'  
source ' '  
inver 1  
inext 'sn'  
stokes ' '  
optype 'phas'  
opcode 'alsi'  
xinc 1  
nplots 9  
antenna 0  
timer 0  
tvinit  
dotv 1  
go  
optype 'amp'  
go
```

Look at the phase calibrator results.

```
inver 2  
optype 'phas'  
go
```



optype 'amp'
go



GETJY

Now we need to transfer the amplitude calibration information from the amplitude calibrator to the phase calibrator.

```
task 'getjy'
sources '1148-001',' '
calsour '3c286',' '
calcode ' '
bif 0
eif 0
antenna 0
timer 0
snver 0
go
```

```
vlb054> GETJY1: Task GETJY (release of 31DEC08) begins
vlb054> GETJY1: Source:Qual      CALCODE IF Flux (Jy)
vlb054> GETJY1: 1148-001      : 0 C 1 2.90731 +/- 0.04192
```

```
vlb054> GETJY1: Appears to have ended successfully
vlb054> GETJY1: vlb054          31DEC08 TST: Cpu=          0.0  Real=          0
```

2.9 Jy agrees relatively well with the rough value given by the VLA calibrator list.

```
1150-003   J2000   A 11h50m43.870761s -00d23'54.204900"   Aug01
1148-001   B1950   A 11h48m10.124900s -00d07'13.164000"
-----
BAND          A B C D      FLUX(Jy)      UVMIN(kL)  UVMAX(kL)
=====
 20cm         L  P P P P      2.80                      visplot
   6cm         C  P P P P      1.92
 3.7cm         X  P P P P      1.25                      visplot
   2cm         U  P P P P      1.40
 1.3cm         K  S S S S      0.63                      visplot
 0.7cm         Q  W W W W      0.65 ' '
```

Redo the CALIB calibration for the phase calibrator

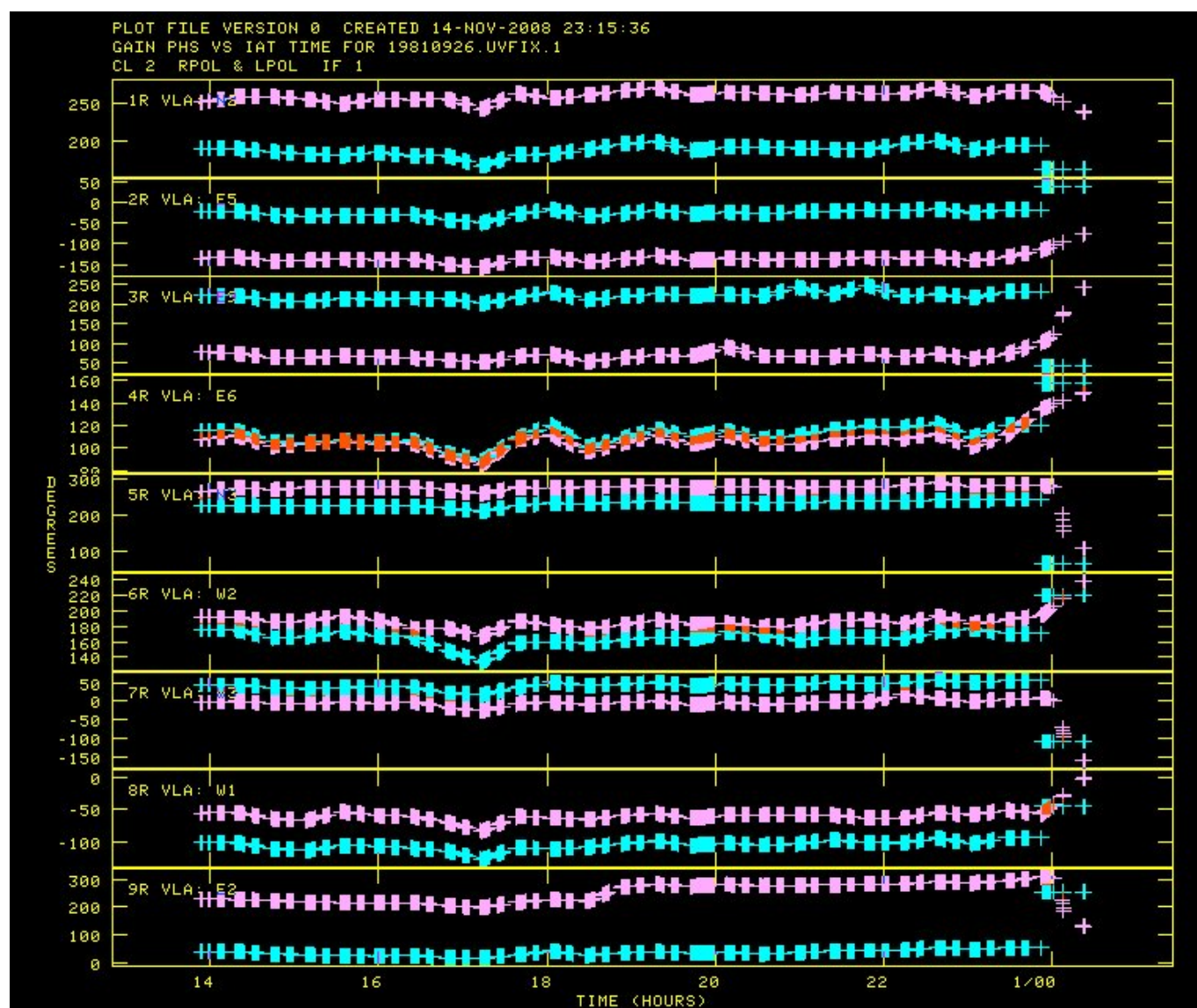
```
inext 'sn'
inver 2
extdest
tget calib
go
clrmsg
```

Apply the calibration to all sources, both amplitude and phase

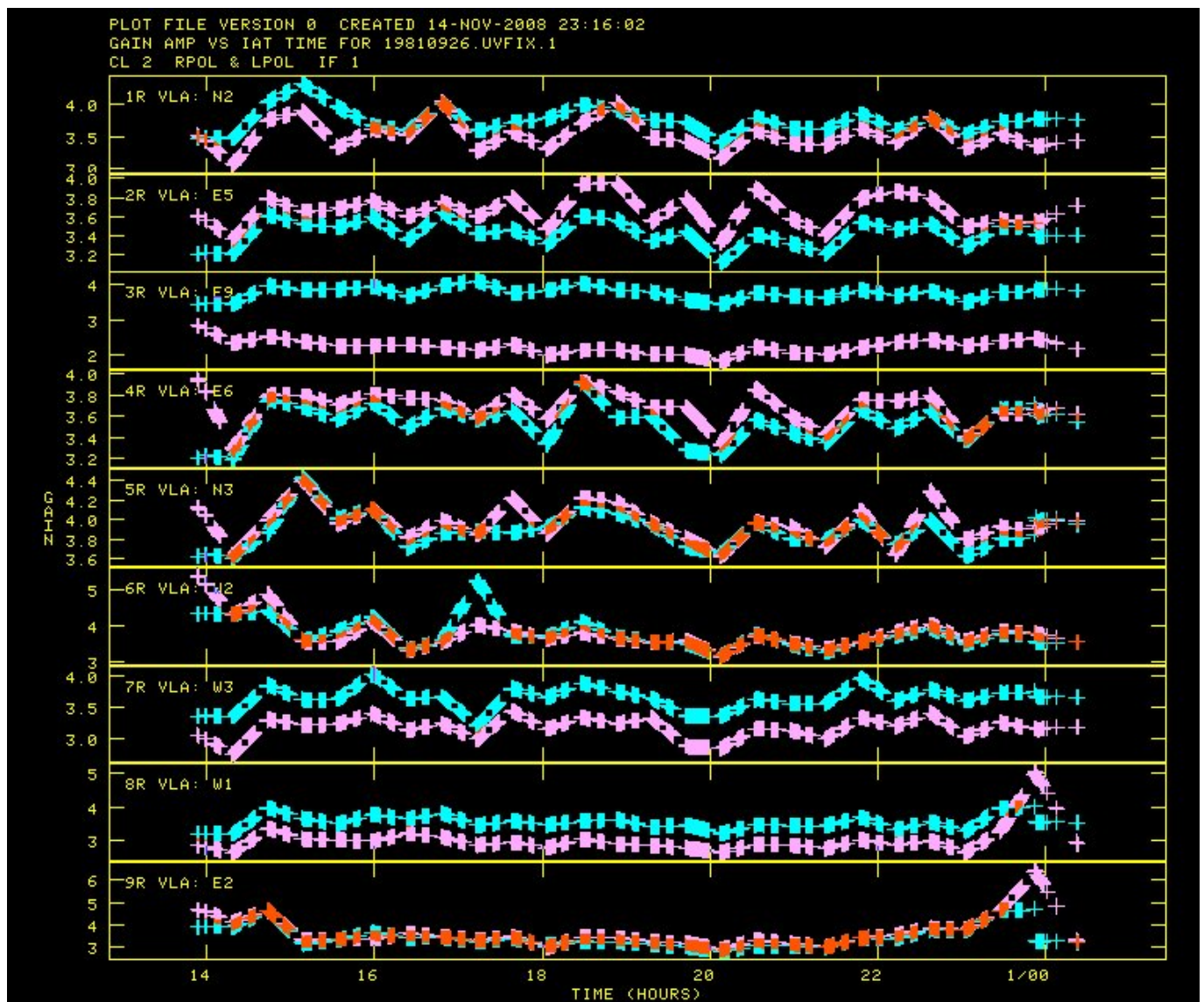
```
task 'clcal'
getn 3
sources ' '
calsour '3c286','1148-001',' '
calcode ' '
opcode 'cali'
gainver 1
gainuse 2
refant 24
bparm 0
interpol '2pt'
timer 0
antenna 0
doblank 1
go
```

Check the calibration results

```
task 'snplt'
source ' '
inver 2
inext 'cl'
stokes ' '
optype 'phas'
opcode 'alsi'
xinc 1
nplots 9
antenna 0
timer 0
tvinit
dotv 1
go
```



```
optype 'amp'
go
```



Test Imaging

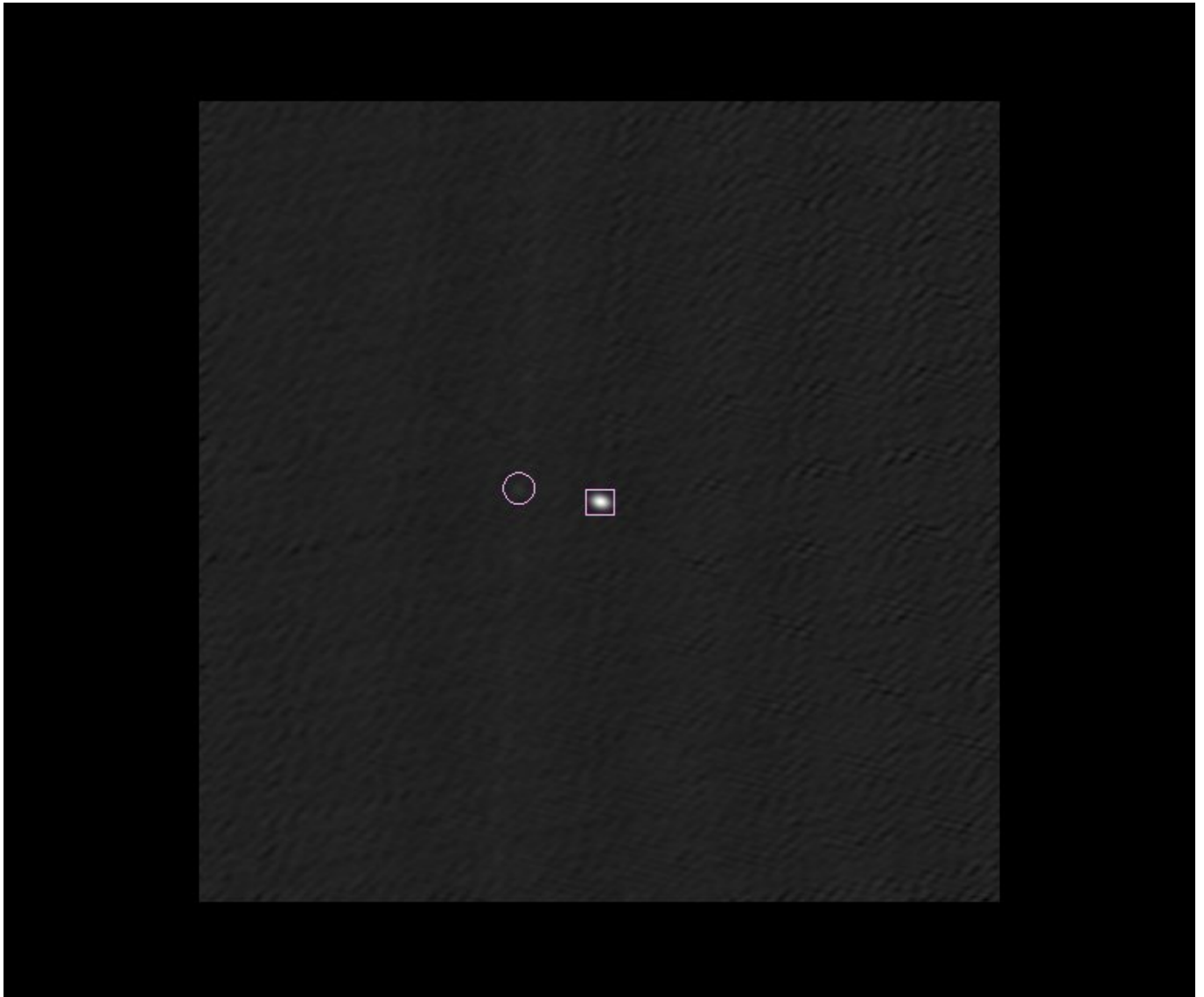
Amplitude Calibrator

Ok, let's start with a few test images. First, we will image the amplitude calibrator. Because of the funny epoch conversion stuff, it is not quite at the center where it is expected. This is not a problem.

```
task 'imagr'
getn 3
source '3c286', ' '
uvrange 0
docalib 1
gainuse 2
stokes 'i'
cellsize 10,10
imsize 512,512
```

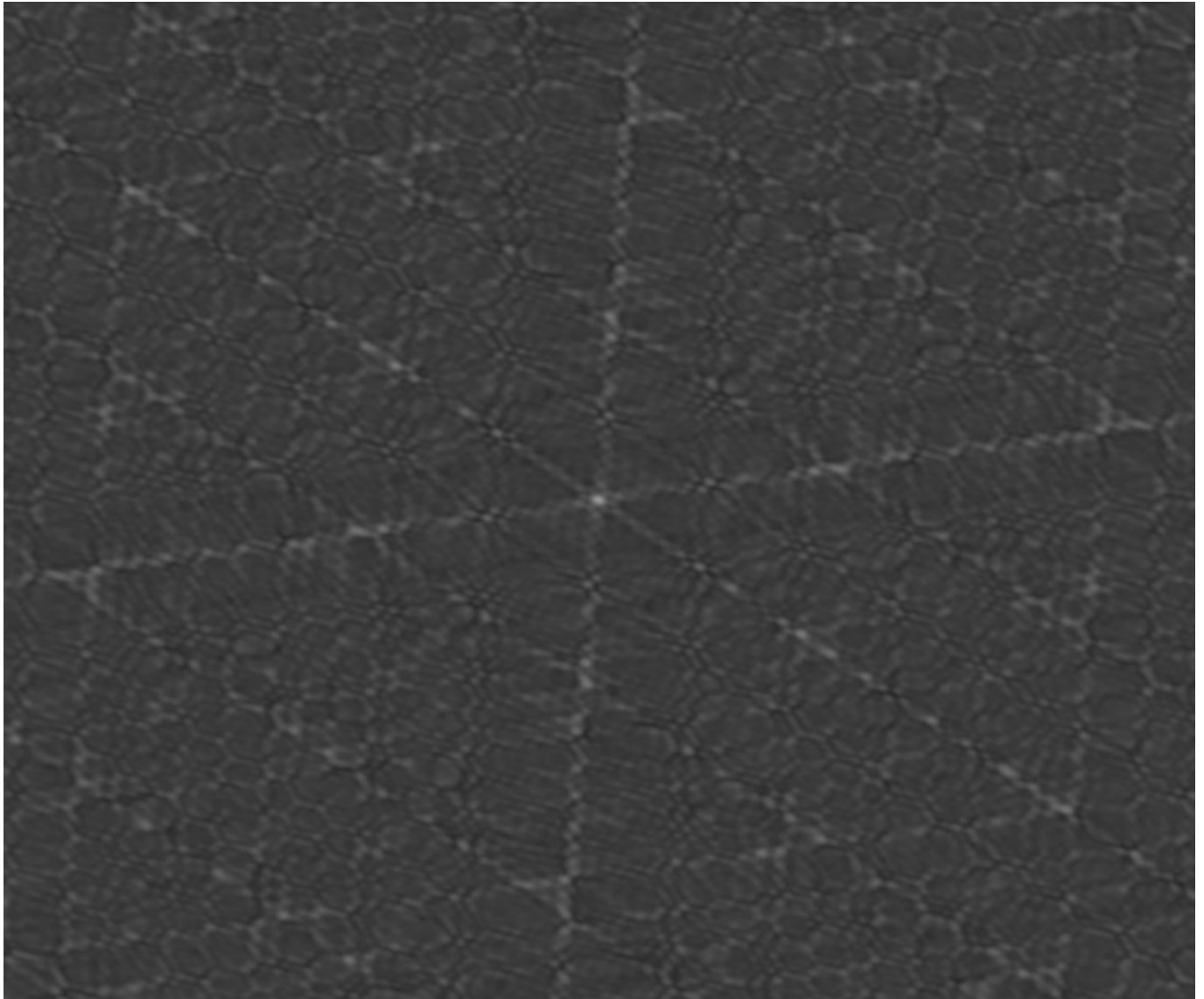
```
antenna 0
niter 10000
overlap 1
D03DIMAG 1
rashift 1800.00,0
decshift -920.00,0
go
clrmsg
```

After you have cleaned it a bit, this is what it looks like.



And this is the point spread function of the actual observations (called the dirty beam). It looks like the amplitude calibrator image before you started cleaning. Why?

```
getn 5
tvinit
tvlod
tvfiddle
```



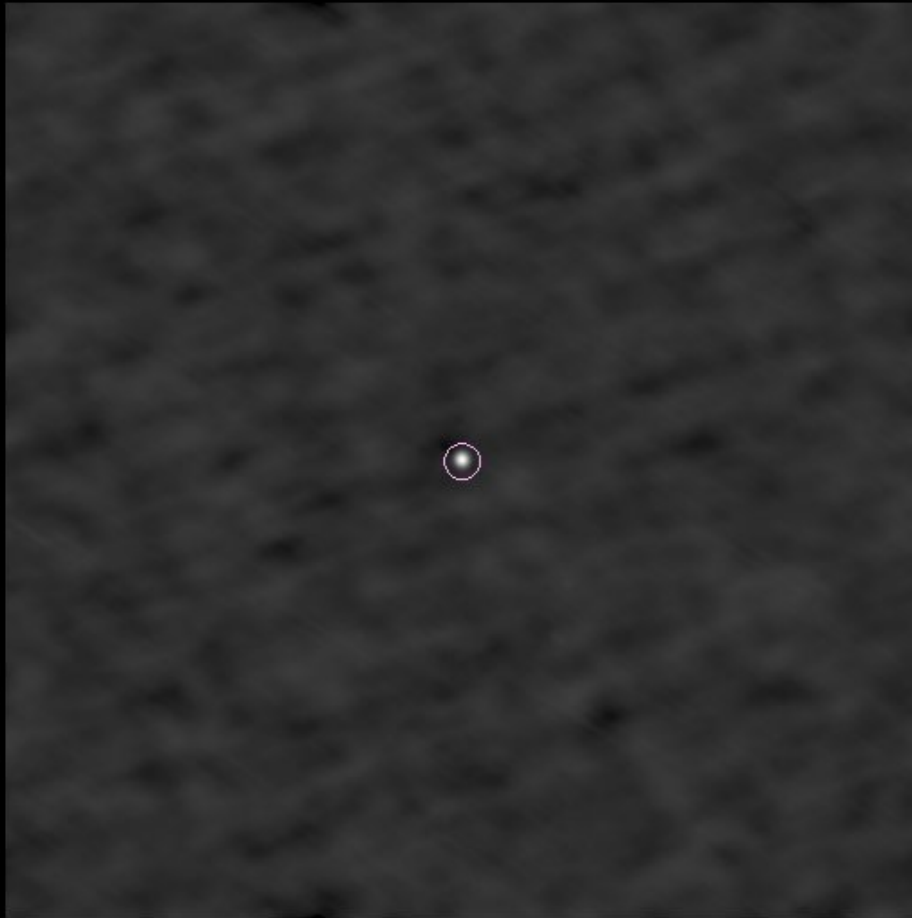
Phase Calibrator

Ok, clean up after ourselves

```
getn 5;zap  
getn 6;zap
```

Now do the imaging and light cleaning

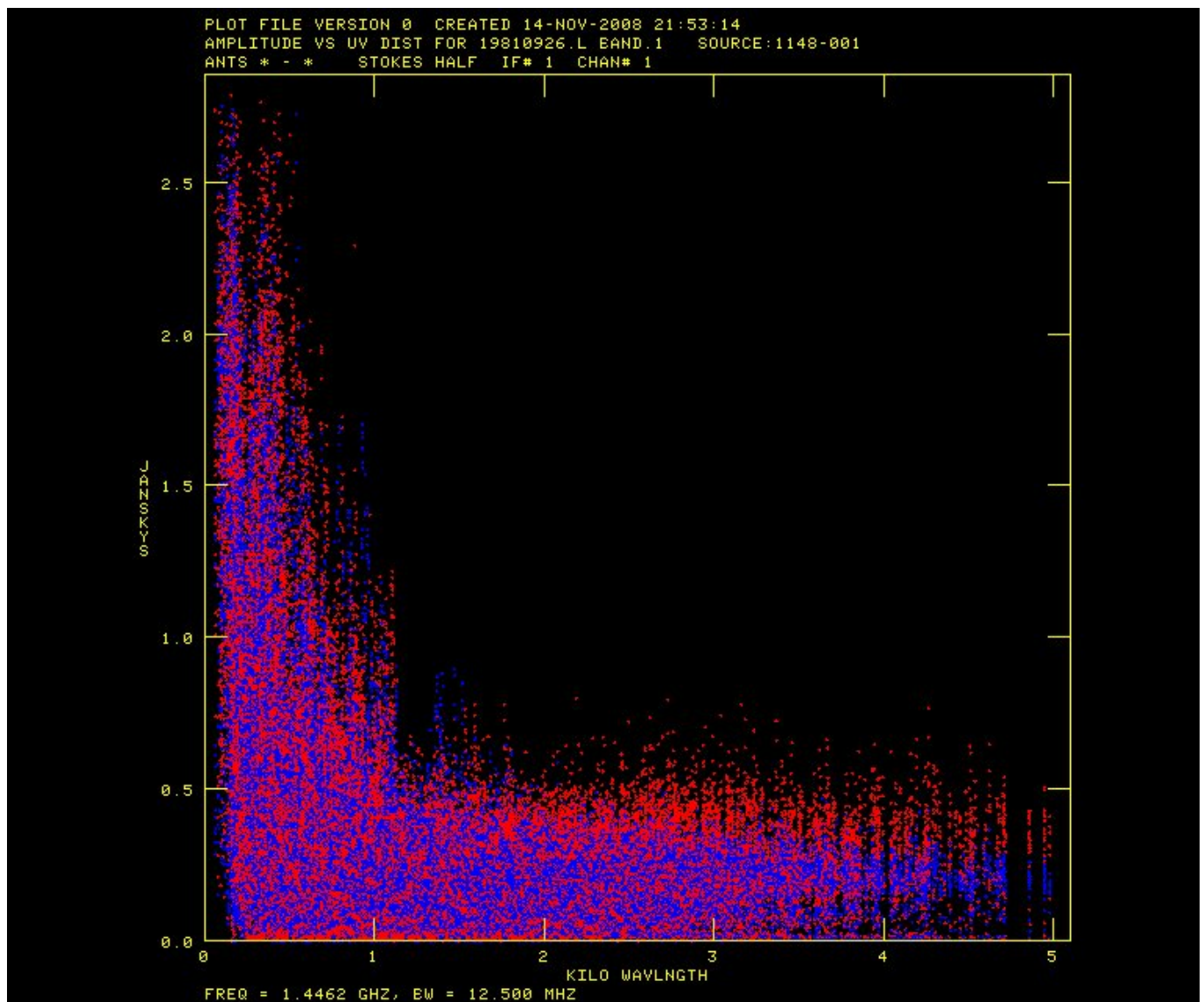
```
tget imagr  
source '1148-001',' '  
rashift 0  
decshift 0  
go
```



Note that in this image, there is a lot of large-scale junk. Why?

And here is the dirty beam. Notice how the dirty beam looks like the initial image of the phase calibrator before you began to clean it. Why?

```
getn 5  
tvinit  
tvlod  
tvfiddle
```



Imaging the Sun

Ok, to do the best job, we need to separate the Sun data from the rest of the dataset. First, cleanup after the phase calibrator imaging.

```
getn 5;zap  
getn 6;zap
```

SPLIT

```
task 'split'  
getn 3  
source 'sun',' '  
timer 0  
stokes ' '
```

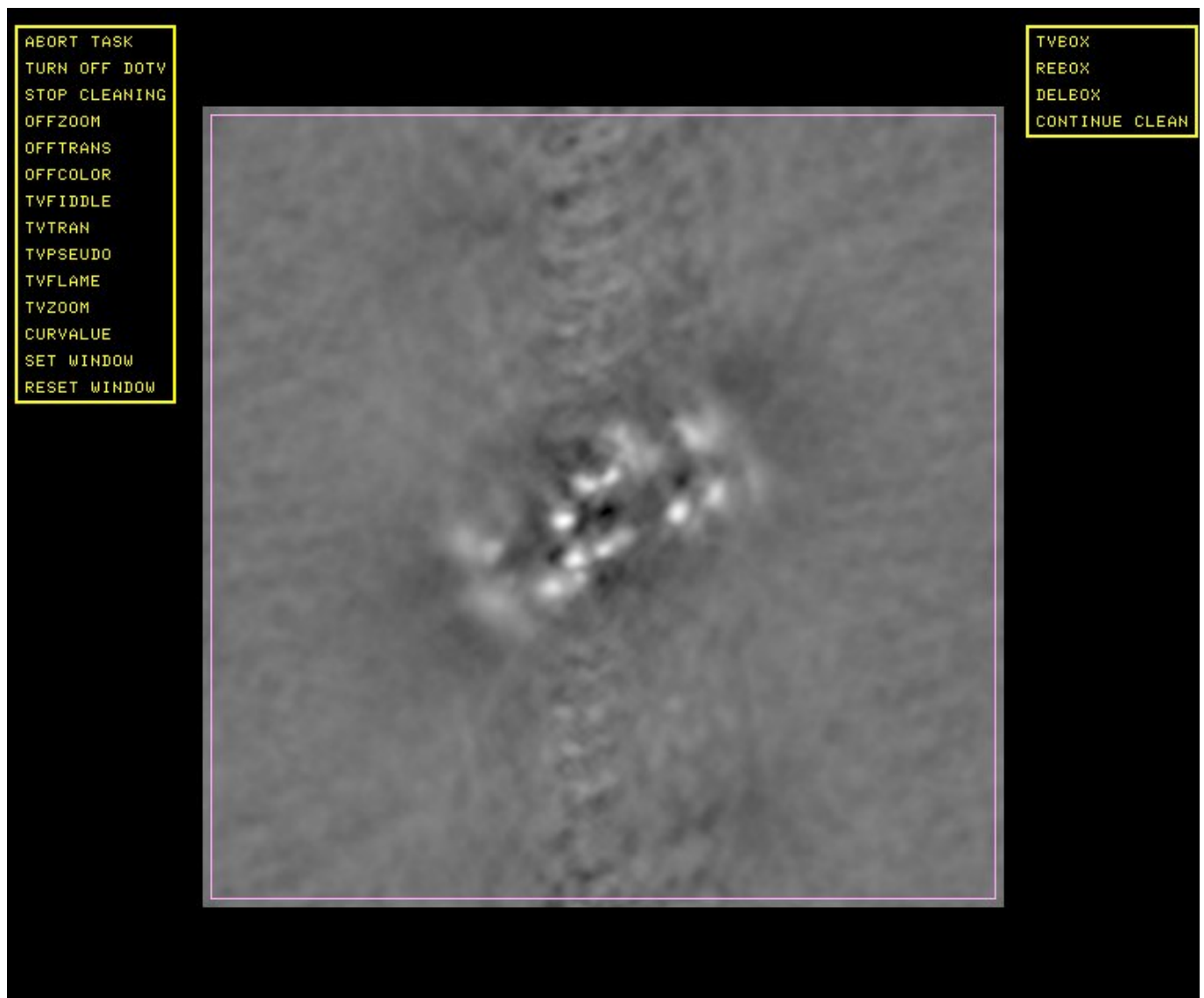
```
aparm 0  
go
```

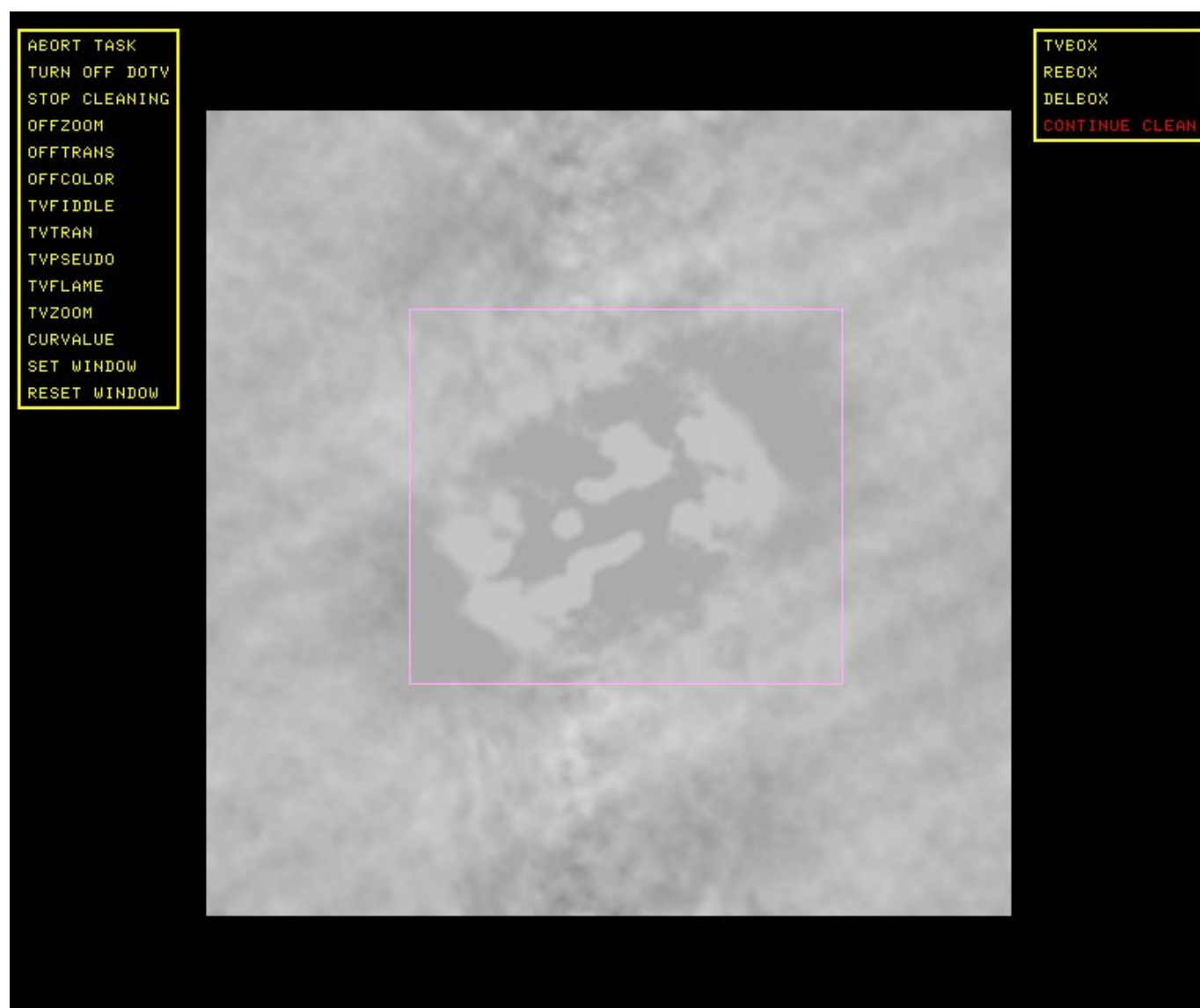
IMAGR

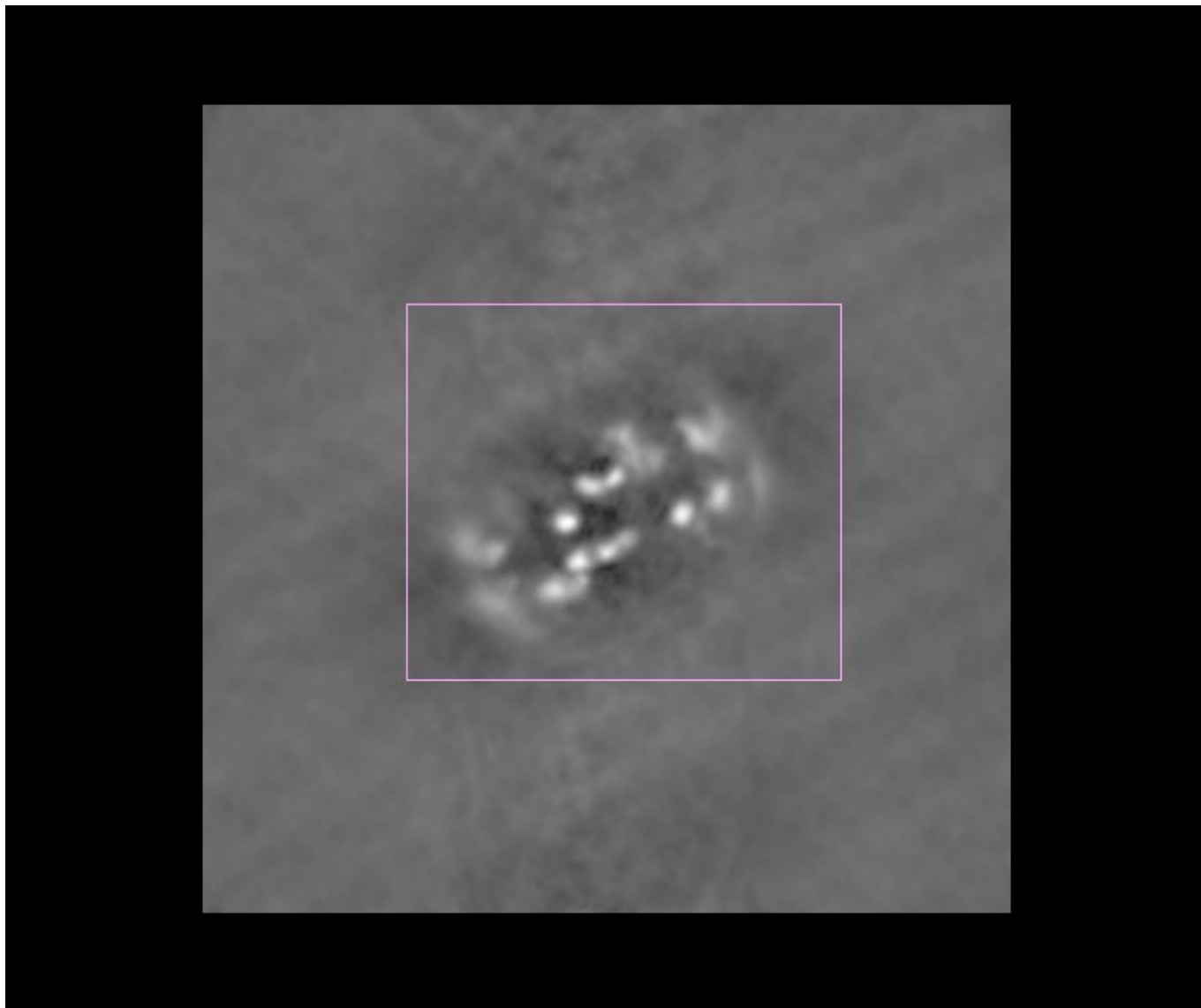
Now do an initial imaging and cleaning step.

```
tget imagr  
getn 4  
source ' '  
docalib 0  
gainuse 1  
go
```

Here are some of the stages of my cleaning.







Self-Calibration

Ok, let's do some self-calibration. This is just the same as “normal” calibration, except that you are saying to yourself that you are less confident that you know what the source is supposed to look like.

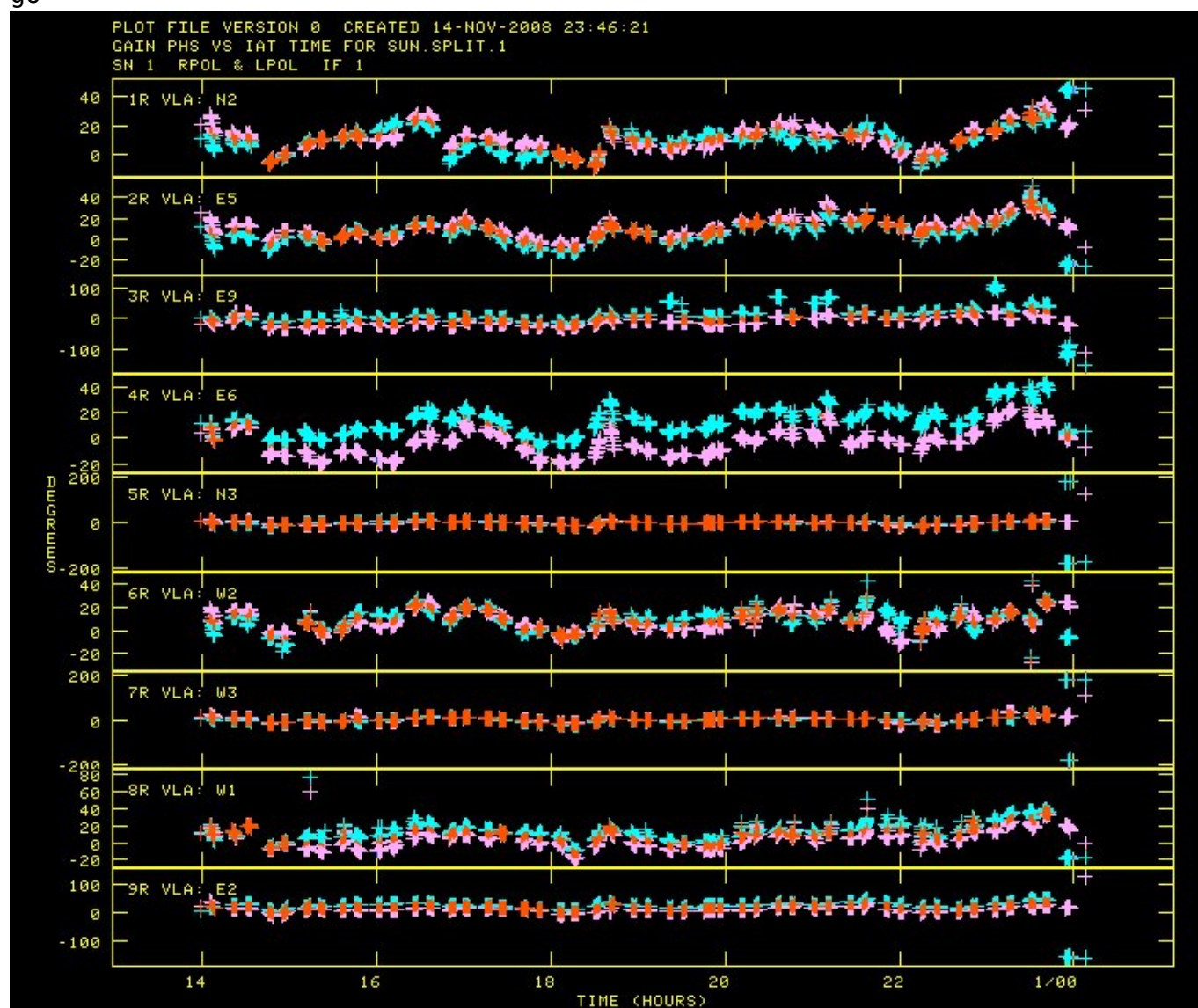
We run exactly the same calibration software, in exactly the same manner. Because the phase calibrator was resolved at short spacings, and because it is quite difficult for us to clean the extended emission, I limit the (u,v) coverage. Note that this also is only doing phase calibration, not amplitude calibration.

```
tget calib
getn 4
get2n 7
solint 30/60
solmode 'p!a'
docalib 0
uvrange 0.5,0
calsour ' '
inver 0
```

```
snver 0
go
clrmsg
```

Check the results

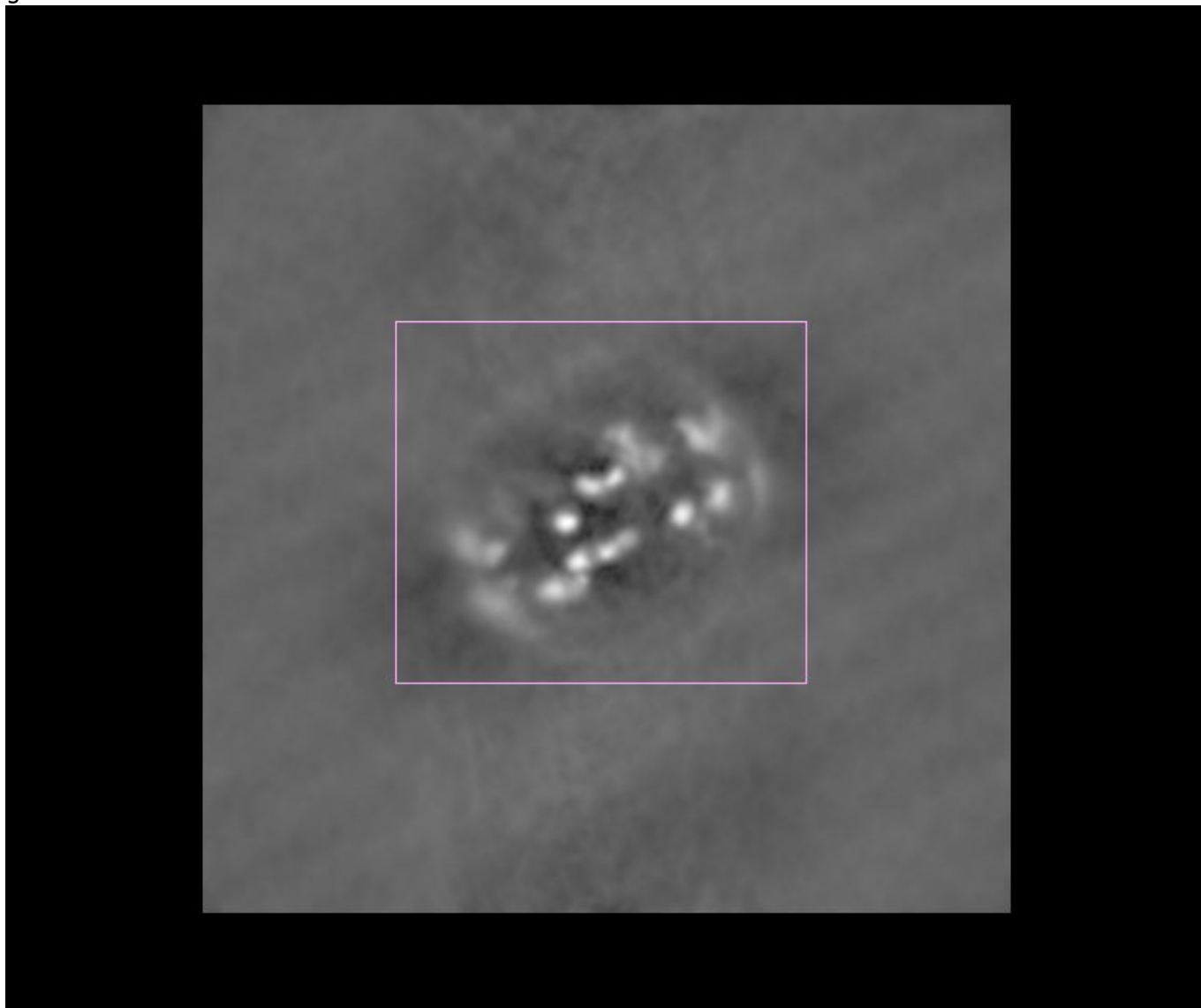
```
task 'snplt'
inext 'sn'
inver 1
stokes ' '
optype 'phas'
tvinit
go
```



Note some of the really large phase deviations! The phase calibration was not perfect.

Image again, using the new calibration

```
getn 5;zap  
getn 6;zap  
getn 7;zap  
tget imagr  
docalib 1  
gainuse 1  
go
```



This one is a bit better.

More Self-Calibration

But we can do more. Now let's do both amplitude and phase calibration. First, we do a phase-only self-calibration on short timescales, to get rid of the phase jitter.

Phase Self-Cal

```
tget calib
getn 4
get2n 7
solint 20/60
solmode 'p!a'
docalib 0
uvrange 0.5,0
calsour ' '
inver 0
snver 0
go
clrmsg
```

Check

```
task 'snplt'
inext 'sn'
inver 2
stokes ' '
optype 'phas'
tvinit
go
```

Amplitude Self-Cal

Doing both phase and amplitude calibration requires far more from the data S/N. It is best to have a longer time interval for amplitude calibration.

```
tget calib
getn 5
solint 20
solmode 'A&P'
cparm(2) 1
go
clrmsg
```

Check

```
task 'snplt'
inext 'sn'
inver 1
stokes ' '
optype 'phas'
```

```
tvinit  
go  
otype 'amp'  
go
```

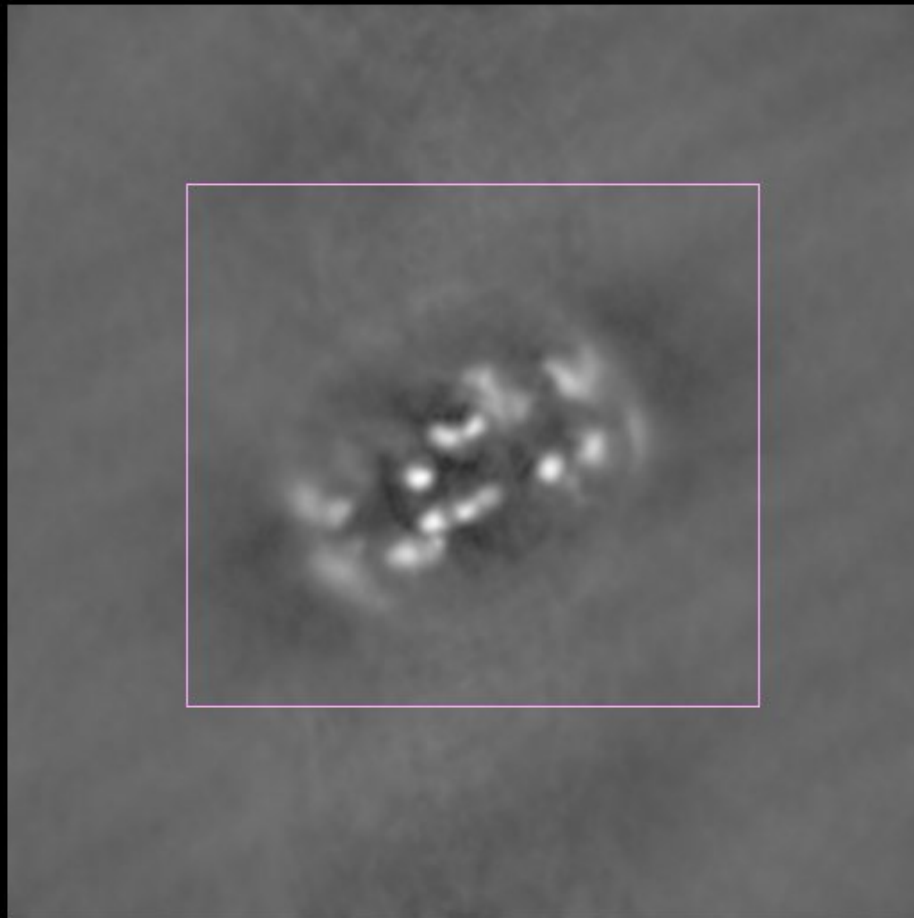
Cleanup

Clean up the files. But save the initial “CALIB” uv dataset! It is the one with the current amplitude calibration information.

```
getn 6;zap  
getn 7;zap  
getn 8;zap
```

Final Imaging

```
tget imagr  
getn 5  
docalib 1  
gainuse 1
```



Discussion

What have you learned?

Does your image look like this image? 

What is different?

Have a look at <http://images.nrao.edu/8> and see what additional information was used to generate the NRAO web image. How would such additional information change your image?

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