

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
```

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.

Step 4 --- Initial look at data

FILLM

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

```
dowait=true
dohist=1
docrt=132
dotv=1
task 'fillm'
default
datain = 'PWD:GD_
nfiles=0
ncount=2
vlamode='S '
doweight=10
doconcat=true
douvcomp=0
cparm(2)=16
cparm(4)=28
cparm(8)=10./60
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

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 2

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 = 'VLAIFS ' value = 'AC '
AIPS 1: Keyword = 'CORRCOEF' value = -1
```

LISTR --- scan listing

```
default listr
task 'listr'
indi 1
getn 2
optype 'scan'
docrt=132
go
```

vlb054 LISTR(31DEC08) 100 14-NOV-2008 21:42:46 Page 1
File = 19810926 .L BAND. 1 Vol = 1 Userid = 100
Freq = 1.446150006 GHz Ncor = 4 No. vis = 556884
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	351					
2	1148-001	: 0000	C	1	0/13:53:35 - 0/13:54:35	1
352	2808					
3	SUN	: 0000		1	0/13:59:05 - 0/13:59:35	1
2809	4212					
4	SUN	: 0000		1	0/14:05:15 - 0/14:09:35	1
4213	13689					
5	1148-001	: 0000	C	1	0/14:18:05 - 0/14:19:35	1
13690	17199					
6	SUN	: 0000		1	0/14:20:15 - 0/14:24:35	1
17200	26676					
7	SUN	: 0000		1	0/14:30:05 - 0/14:34:35	1
26677	36504					
8	1148-001	: 0000	C	1	0/14:43:05 - 0/14:44:35	1
36505	40014					
9	SUN	: 0000		1	0/14:45:15 - 0/14:49:35	1
40015	49491					
10	SUN	: 0000		1	0/14:55:05 - 0/14:59:25	1
49492	58968					
11	1148-001	: 0000	C	1	0/15:07:55 - 0/15:09:25	1
58969	62478					
12	SUN	: 0000		1	0/15:10:05 - 0/15:14:25	1
62479	71955					
13	SUN	: 0000		1	0/15:19:55 - 0/15:24:25	1
71956	81783					
14	1148-001	: 0000	C	1	0/15:32:55 - 0/15:34:25	1
81784	85293					
15	SUN	: 0000		1	0/15:35:05 - 0/15:39:25	1
85294	94770					
16	SUN	: 0000		1	0/15:44:55 - 0/15:49:25	1
94771	104598					
17	1148-001	: 0000	C	1	0/15:57:55 - 0/15:59:25	1
104599	108108					
18	SUN	: 0000		1	0/16:00:05 - 0/16:04:15	1
108109	117234					
19	SUN	: 0000		1	0/16:09:45 - 0/16:14:15	1
117235	127062					
20	1148-001	: 0000	C	1	0/16:22:45 - 0/16:24:15	1
127063	130572					
21	SUN	: 0000		1	0/16:24:55 - 0/16:29:15	1
130573	140049					

22 SUN	: 0000	1	0/16:34:45 -	0/16:39:15	1
140050 149877					
23 1148-001	: 0000 C	1	0/16:47:45 -	0/16:49:15	1
149878 153387					
24 SUN	: 0000	1	0/16:49:55 -	0/16:54:15	1
153388 162864					
25 SUN	: 0000	1	0/16:59:45 -	0/17:04:05	1
162865 172341					
26 1148-001	: 0000 C	1	0/17:12:35 -	0/17:14:05	1
172342 175851					
27 SUN	: 0000	1	0/17:14:45 -	0/17:19:05	1
175852 185328					
28 SUN	: 0000	1	0/17:24:35 -	0/17:29:05	1
185329 195156					
29 1148-001	: 0000 C	1	0/17:37:35 -	0/17:39:05	1
195157 198666					
30 SUN	: 0000	1	0/17:39:45 -	0/17:44:25	1
198667 208845					
31 SUN	: 0000	1	0/17:50:15 -	0/17:54:05	1
208846 217269					
32 1148-001	: 0000 C	1	0/18:02:25 -	0/18:03:55	1
217270 220779					
33 SUN	: 0000	1	0/18:04:35 -	0/18:08:55	1
220780 230256					
34 SUN	: 0000	1	0/18:14:25 -	0/18:18:55	1
230257 240084					
35 1148-001	: 0000 C	1	0/18:27:25 -	0/18:28:55	1
240085 243594					
36 SUN	: 0000	1	0/18:29:35 -	0/18:33:55	1
243595 253071					
37 SUN	: 0000	1	0/18:39:35 -	0/18:44:05	1
253072 262899					
38 1148-001	: 0000 C	1	0/18:52:35 -	0/18:53:55	1
262900 266058					
39 SUN	: 0000	1	0/18:54:45 -	0/18:59:05	1
266059 275535					
40 SUN	: 0000	1	0/19:04:25 -	0/19:08:45	1
275536 285012					
41 1148-001	: 0000 C	1	0/19:17:25 -	0/19:18:45	1
285013 288171					
42 SUN	: 0000	1	0/19:19:25 -	0/19:23:45	1
288172 297648					
43 SUN	: 0000	1	0/19:29:15 -	0/19:33:45	1
297649 307476					
44 1148-001	: 0000 C	1	0/19:42:15 -	0/19:43:45	1
307477 310986					
45 SUN	: 0000	1	0/19:44:25 -	0/19:53:05	1
310987 329589					
46 SUN	: 0000	1	0/19:54:25 -	0/19:58:45	1
329590 339066					
47 1148-001	: 0000 C	1	0/20:07:05 -	0/20:08:35	1

339067	342576					
48 SUN		: 0000	1	0/20:09:15 -	0/20:13:35	1
342577	352053					
49 SUN		: 0000	1	0/20:19:05 -	0/20:23:35	1
352054	361881					
50 1148-001		: 0000 C	1	0/20:32:05 -	0/20:33:35	1
361882	365391					
51 SUN		: 0000	1	0/20:34:15 -	0/20:38:35	1
365392	374868					
52 SUN		: 0000	1	0/20:44:05 -	0/20:48:35	1
374869	384696					
53 1148-001		: 0000 C	1	0/20:57:05 -	0/20:58:35	1
384697	388206					
54 SUN		: 0000	1	0/20:59:15 -	0/21:03:35	1
388207	397657					
55 SUN		: 0000	1	0/21:08:55 -	0/21:13:25	1
397658	407485					
56 1148-001		: 0000 C	1	0/21:21:55 -	0/21:23:25	1
407486	410969					
57 SUN		: 0000	1	0/21:24:05 -	0/21:28:25	1
410970	420446					
58 SUN		: 0000	1	0/21:33:55 -	0/21:38:25	1
420447	430274					
59 1148-001		: 0000 C	1	0/21:47:05 -	0/21:48:25	1
430275	433433					
60 SUN		: 0000	1	0/21:49:05 -	0/21:53:25	1
433434	442858					
61 SUN		: 0000	1	0/21:58:55 -	0/22:03:25	1
442859	452686					
62 1148-001		: 0000 C	1	0/22:11:45 -	0/22:13:15	1
452687	456196					
63 SUN		: 0000	1	0/22:13:55 -	0/22:18:15	1
456197	465647					
64 SUN		: 0000	1	0/22:23:55 -	0/22:28:15	1
465648	475124					
65 1148-001		: 0000 C	1	0/22:36:55 -	0/22:38:15	1
475125	478283					
66 SUN		: 0000	1	0/22:38:55 -	0/22:43:15	1
478284	487734					
67 SUN		: 0000	1	0/22:48:55 -	0/22:53:25	1
487735	497562					
68 1148-001		: 0000 C	1	0/23:01:55 -	0/23:03:15	1
497563	500721					
69 SUN		: 0000	1	0/23:03:55 -	0/23:08:05	1
500722	509847					
70 SUN		: 0000	1	0/23:13:45 -	0/23:18:05	1
509848	519324					
71 1148-001		: 0000 C	1	0/23:26:45 -	0/23:28:05	1
519325	522249					
72 SUN		: 0000	1	0/23:28:45 -	0/23:33:05	1

```
522250      531700
  73 SUN                      : 0000          1  0/23:38:45 -  0/23:43:05      1
531701      540450
  74 1148-001                  : 0000   C      1  0/23:51:45 -  0/23:53:05      1
540451      543350
  75 SUN                      : 0000          1  0/23:53:45 -  0/23:58:05      1
543351      552125
  76 SUN                      : 0000          1  1/00:01:15 -  1/00:01:15      1
552126      552450
  77 SUN                      : 0000          1  1/00:07:25 -  1/00:07:55      1
552451      553725
  78 3C286                    : 0000   B      1  1/00:21:35 -  1/00:22:55      1
553726      556884

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    84072
  2 SUN          : 0000          12:10:30.1272 -01:08:22.648    0.000
0.000   0.000   0.000   469653
  3 3C286        : 0000   B      13:28:49.6570  30:45:58.640    0.000
0.000   0.000   0.000    3159

  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.

```
getn 2
go prtan
```

```
vlb054      PRTAN(31DEC08)      100      11-NOV-2008  18:53:09      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

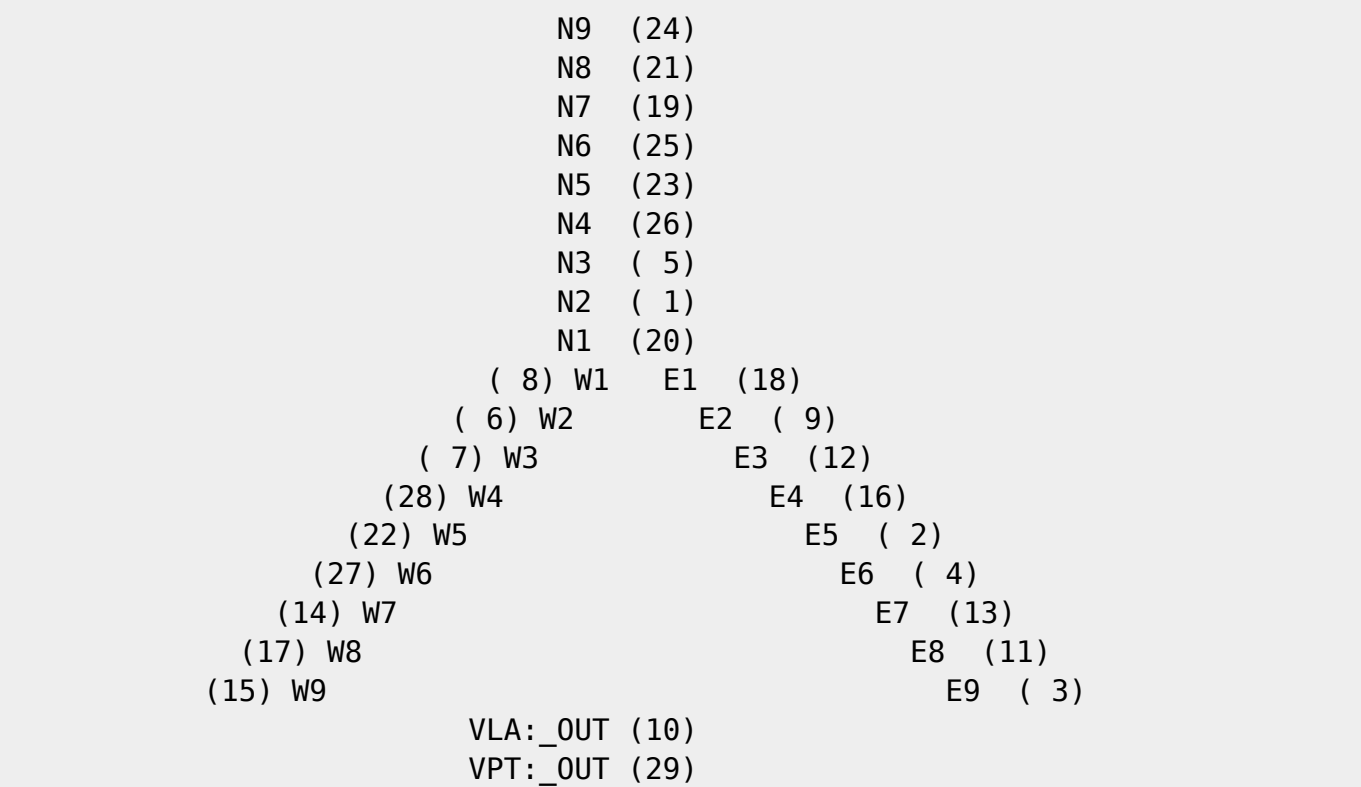
Ant 11 = VLA:_E8 BX= 114.4257 BY= 438.6941 BZ= -169.4880
Mount=ALAZ Axis offset= 0.0048 meters IFA IFB
Feed polarization type = R L

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 BZ= -99.5242		
Mount=ALAZ Axis offset= 0.0000 meters	IFA	IFB
Feed polarization type =	R	L
Ant 23 = VLA:_N5 BX= -108.4301 BY= -16.9862 BZ= 161.0152		
Mount=ALAZ Axis offset= 0.0000 meters	IFA	IFB
Feed polarization type =	R	L
Ant 24 = VLA:_N9 BX= -298.3837 BY= -46.5620 BZ= 440.6260		
Mount=ALAZ Axis offset= 0.0000 meters	IFA	IFB
Feed polarization type =	R	L
Ant 25 = VLA:_N6 BX= -148.4545 BY= -23.2162 BZ= 219.9871		

Mount=ALAZ	Axis offset=	0.0000 meters	IFA	IFB	
Feed polarization type =			R	L	
Ant 26 = VLA:_N4	BX=	-74.8318	BY=	-11.7331 BZ=	111.6208
Mount=ALAZ	Axis offset=	0.0000 meters	IFA	IFB	
Feed polarization type =			R	L	
Ant 27 = VLA:_W6	BX=	93.5170	BY=	-245.0012 BZ=	-136.2284
Mount=ALAZ	Axis offset=	0.0000 meters	IFA	IFB	
Feed polarization type =			R	L	
Ant 28 = VLA:_W4	BX=	46.9220	BY=	-122.0267 BZ=	-67.6047
Mount=ALAZ	Axis offset=	0.0000 meters	IFA	IFB	
Feed polarization type =			R	L	
Ant 29 = VPT:_OUT	BX=	0.0000	BY=	0.0000 BZ=	0.0000
Mount=ALAZ	Axis offset=	0.0000 meters	IFA	IFB	
Feed polarization type =			R	L	

Location Of VLA Antennas



AIPS 1: Resumes

SETJY

```
task 'setjy'  
source '3c286', ' '  
optype 'calc'
```

```
aparm(2)=3
go
```

```
vlb054> SETJY1: Task SETJY (release of 31DEC08) 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 may be available
vlb054> SETJY1: Use the verb CALDIR to see if there is one
vlb054> SETJY1: / Flux calculated using known spectrum
vlb054> SETJY1: BIF = 1 EIF = 1 /Range of IFs
vlb054> SETJY1: '3C286' IF = 1 FLUX =14.5979 (Jy calcd)
vlb054> SETJY1: / Using (1990) VLA or Reynolds (1934-638) coefficients
vlb054> SETJY1: Appears to have ended successfully
vlb054> SETJY1: vlb054 31DEC08 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 5
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 5.

CALIB

```
task 'calib'
getn 2
calsour '3c286',' '
uvrange 0
antennas 0
refant 24
weightit 1
in2di 1
get2n 5
ncomp 0
solmode 'A&P'
aparm(6) 2
minamper 10
minphser 10
docalib 1
```

```
solint 1  
solsub 2  
cparm(3) 10  
cparm(4) 10
```

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