

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.

LISTR --- scan listing

First, let's check out which file we need.

pcat

```
AIPS 1: Catalog on disk 1
AIPS 1:  Cat Usid Mapname      Class  Seq  Pt      Last access      Stat
AIPS 1:   1  100 19810926      .C BAND.    1  UV  11-NOV-2008 18:44:06
AIPS 1:   2  100 19810926      .L BAND.    1  UV  11-NOV-2008 18:46:44
AIPS 1:   3  100 19810926      .C BAND.    2  UV  11-NOV-2008 18:40:21
AIPS 1:   4  100 19810926      .L BAND.    2  UV  11-NOV-2008 18:40:21
```

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

```
AIPS 1: Got(1)  disk= 1  user= 100  type=UV  19810926.L BAND.1
vlb054  LISTR(31DEC08)  100  11-NOV-2008 18:46:44  Page  1
File = 19810926  .L BAND.  1 Vol = 1  Userid = 100
Freq = 1.446150006 GHz  Ncor = 4  No. vis = 278465
Scan summary listing
```

Scan	Source	Qual	Calcode	Sub	Timerange	FrqID
START VIS	END VIS					
1 1148-001		: 0000	C	1	0/13:53:25 - 0/13:54:35	1
1 2195						
2 SUN		: 0000		1	0/13:59:15 - 0/13:59:35	1
2196 3150						
3 1148-001		: 0000	C	1	0/14:18:05 - 0/14:19:35	1
3151 5809						
4 SUN		: 0000		1	0/14:20:25 - 0/14:24:35	1
5810 14662						
5 1148-001		: 0000	C	1	0/14:43:05 - 0/14:44:35	1
14663 17320						
6 SUN		: 0000		1	0/14:45:25 - 0/14:49:35	1
17321 25867						
7 1148-001		: 0000	C	1	0/15:07:55 - 0/15:09:25	1
25868 28503						
8 SUN		: 0000		1	0/15:10:15 - 0/15:14:25	1
28504 37058						
9 1148-001		: 0000	C	1	0/15:32:55 - 0/15:34:25	1
37059 39716						
10 SUN		: 0000		1	0/15:35:15 - 0/15:39:25	1
39717 48338						
11 1148-001		: 0000	C	1	0/15:57:55 - 0/15:59:25	1
48339 50720						
12 SUN		: 0000		1	0/16:00:15 - 0/16:04:15	1
50721 58994						

13	1148-001	:	0000	C	1	0/16:22:45	-	0/16:24:15	1
58995	61584								
14	SUN	:	0000		1	0/16:25:05	-	0/16:29:15	1
61585	70334								
15	1148-001	:	0000	C	1	0/16:47:45	-	0/16:49:15	1
70335	72949								
16	SUN	:	0000		1	0/16:50:05	-	0/16:54:15	1
72950	81664								
17	1148-001	:	0000	C	1	0/17:12:35	-	0/17:12:35	1
81665	81664								
18	1148-001	:	0000	C	1	0/17:12:45	-	0/17:14:05	1
81665	84070								
19	SUN	:	0000		1	0/17:14:55	-	0/17:19:05	1
84071	92937								
20	1148-001	:	0000	C	1	0/17:37:35	-	0/17:39:05	1
92938	95507								
21	SUN	:	0000		1	0/17:39:45	-	0/17:44:25	1
95508	105079								
22	1148-001	:	0000	C	1	0/18:02:25	-	0/18:03:55	1
105080	107535								
23	SUN	:	0000		1	0/18:04:45	-	0/18:08:55	1
107536	116401								
24	1148-001	:	0000	C	1	0/18:27:25	-	0/18:28:55	1
116402	119012								
25	SUN	:	0000		1	0/18:29:45	-	0/18:33:55	1
119013	127842								
26	1148-001	:	0000	C	1	0/18:52:35	-	0/18:53:55	1
127843	129825								
27	SUN	:	0000		1	0/18:54:45	-	0/18:59:05	1
129826	137705								
28	1148-001	:	0000	C	1	0/19:17:25	-	0/19:18:45	1
137706	139972								
29	SUN	:	0000		1	0/19:19:35	-	0/19:23:45	1
139973	148118								
30	1148-001	:	0000	C	1	0/19:42:15	-	0/19:43:45	1
148119	150467								
31	SUN	:	0000		1	0/19:44:35	-	0/19:53:05	1
150468	168022								
32	1148-001	:	0000	C	1	0/20:07:05	-	0/20:08:35	1
168023	170342								
33	SUN	:	0000		1	0/20:09:25	-	0/20:13:35	1
170343	178889								
34	1148-001	:	0000	C	1	0/20:32:05	-	0/20:33:35	1
178890	181422								
35	SUN	:	0000		1	0/20:34:25	-	0/20:38:35	1
181423	190047								
36	1148-001	:	0000	C	1	0/20:57:05	-	0/20:58:35	1
190048	192547								
37	SUN	:	0000		1	0/20:59:25	-	0/21:03:35	1
192548	201271								

38 1148-001	: 0000	C	1	0/21:21:55 -	0/21:23:25	1
201272 203709						
39 SUN	: 0000		1	0/21:24:15 -	0/21:28:25	1
203710 212708						
40 1148-001	: 0000	C	1	0/21:47:05 -	0/21:48:25	1
212709 215193						
41 SUN	: 0000		1	0/21:49:15 -	0/21:53:25	1
215194 224112						
42 1148-001	: 0000	C	1	0/22:11:45 -	0/22:13:15	1
224113 226323						
43 SUN	: 0000		1	0/22:14:05 -	0/22:18:15	1
226324 234634						
44 1148-001	: 0000	C	1	0/22:36:55 -	0/22:38:15	1
234635 236916						
45 SUN	: 0000		1	0/22:39:05 -	0/22:43:15	1
236917 245740						
46 1148-001	: 0000	C	1	0/23:01:55 -	0/23:03:15	1
245741 248122						
47 SUN	: 0000		1	0/23:04:05 -	0/23:08:05	1
248123 256112						
48 1148-001	: 0000	C	1	0/23:26:45 -	0/23:28:05	1
256113 258141						
49 SUN	: 0000		1	0/23:28:55 -	0/23:33:05	1
258142 265941						
50 1148-001	: 0000	C	1	0/23:51:45 -	0/23:53:05	1
265942 267662						
51 SUN	: 0000		1	0/23:54:05 -	0/23:58:05	1
267663 275388						
52 SUN	: 0000		1	1/00:07:25 -	1/00:07:55	1
275389 276069						
53 3C286	: 0000	B	1	1/00:21:35 -	1/00:22:55	1
276070 278465						

Source summary

Velocity type = ' ' Definition = ' '

ID	Source	Qual	Calcode	RA(0.0)	Dec(0.0)	IFlux
1	1148-001	: 0000	C	11:48:10.1300	-00:07:13.300	0.000
0.000	0.000	0.000	59936			
2	SUN	: 0000		12:10:30.1272	-01:08:22.648	0.000
0.000	0.000	0.000	216133			
3	3C286	: 0000	B	13:28:49.6570	30:45:58.640	0.000
0.000	0.000	0.000	2396			

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

getn 4
go

AIPS 1: Got(1) disk= 1 user= 100 type=UV 19810926.L BAND.2
v1b054 LISTR(31DEC08) 100 11-NOV-2008 18:49:17 Page 1
File = 19810926 .L BAND. 2 Vol = 1 Userid = 100
Freq = 1.446150006 GHz Ncor = 4 No. vis = 207072
Scan summary listing

Scan	Source	Qual	Calcode	Sub	Timerange	FrqID
START VIS	END VIS					
1 SUN		: 0000		1	0/14:05:15 - 0/14:09:35	1
1	8935					
2 SUN		: 0000		1	0/14:30:05 - 0/14:34:35	1
8936	17885					
3 SUN		: 0000		1	0/14:55:05 - 0/14:59:25	1
17886	26458					
4 SUN		: 0000		1	0/15:19:55 - 0/15:24:25	1
26459	35408					
5 SUN		: 0000		1	0/15:44:55 - 0/15:49:25	1
35409	44108					
6 SUN		: 0000		1	0/16:09:45 - 0/16:14:15	1
44109	52834					
7 SUN		: 0000		1	0/16:34:45 - 0/16:39:15	1
52835	61669					
8 SUN		: 0000		1	0/16:59:45 - 0/17:04:05	1
61670	70226					
9 SUN		: 0000		1	0/17:24:35 - 0/17:29:05	1
70227	79180					
10 SUN		: 0000		1	0/17:50:15 - 0/17:54:05	1
79181	86877					
11 SUN		: 0000		1	0/18:14:25 - 0/18:18:55	1
86878	95785					
12 SUN		: 0000		1	0/18:39:35 - 0/18:44:05	1
95786	104689					
13 SUN		: 0000		1	0/19:04:25 - 0/19:08:45	1
104690	112638					
14 SUN		: 0000		1	0/19:29:15 - 0/19:33:45	1
112639	120854					
15 SUN		: 0000		1	0/19:54:25 - 0/19:58:45	1
120855	128861					
16 SUN		: 0000		1	0/20:19:05 - 0/20:23:35	1
128862	137749					
17 SUN		: 0000		1	0/20:44:05 - 0/20:48:35	1
137750	146600					
18 SUN		: 0000		1	0/21:08:55 - 0/21:13:25	1
146601	155488					

19 SUN
155489 164306

: 0000

1 0/21:33:55 - 0/21:38:25 1

20 SUN
164307 173005

: 0000

1 0/21:58:55 - 0/22:03:25 1

21 SUN
173006 181479

: 0000

1 0/22:23:55 - 0/22:28:15 1

22 SUN
181480 190299

: 0000

1 0/22:48:55 - 0/22:53:25 1

23 SUN
190300 199102

: 0000

1 0/23:13:45 - 0/23:18:05 1

24 SUN
199103 207072

: 0000

1 0/23:38:45 - 0/23:43:05 1

25 SUN
207073 207072

: 0000

1 1/00:01:15 - 1/00:01:15 1

Source summary

Velocity type = ' ' Definition = ' '

ID	Source	Qual	Calcode	RA(0.0)	Dec(0.0)	IFlux
QFlux	UFlux	VFlux	No. vis			
1	SUN	: 0000		12:10:30.1272	-01:08:22.648	0.000
0.000	0.000	0.000	207072			

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

```

          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          E5 ( 2)
(27) W6          E6 ( 4)
(14) W7          E7 (13)
(17) W8          E8 (11)
(15) W9          E9 ( 3)

      VLA:_OUT (10)
      VPT:_OUT (29)

```

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
```

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