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 archane 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
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   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
 vlb054    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             : 0000           1  0/21:33:55 -   0/21:38:25     1
155489     164306
  20 SUN             : 0000           1  0/21:58:55 -   0/22:03:25     1
164307     173005
  21 SUN             : 0000           1  0/22:23:55 -   0/22:28:15     1
173006     181479
  22 SUN             : 0000           1  0/22:48:55 -   0/22:53:25     1
181480     190299
  23 SUN             : 0000           1  0/23:13:45 -   0/23:18:05     1
190300     199102
  24 SUN             : 0000           1  0/23:38:45 -   0/23:43:05     1
199103     207072
  25 SUN             : 0000           1  1/00:01:15 -   1/00:01:15     1
207073     207072

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
```

```
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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