GLOW Interferometry Tutorial: Wednesday

We will reduce the 3C129 polarization continuum dataset from the 2008 NRAO summer school. (See http://casa.nrao.edu/Tutorial/SIworkshop2008/) The summer school used CASA for the data reduction. You are welcome to try to use CASA for the data reduction on your own (but see also the warnings about what to do what CASA crashes frequently), but we will do the basic reduction in AIPS.

2010 Nov 16: JMA updated for 31DEC10 AIPS

Web Image of 3C129

Wide-field 90 cm image of the large head-tail radio galaxy 3C129 (right). The bright source at the left is 3C129.1. From Lane et al., AJ, 123, 2985, 2002.

The 5 GHz observations being reduced here will only look at the central, brightest, portion of this source.

Data Reduction

Remember, the purpose f this exercise is not to teach you how to reduce radio interferometry data with AIPS. Consider all of the arcane incantations below as just that, magic incantations. You should instead try to figure out what each step is actually doing to the data. The AIPS Cookbook has quite a bit of information to help guide you. Check out chapters 4 and 5. (Note that you probably have a copy of the cookbook in your local AIPS installation if you don't have full web access.) However, at some of the most important points, the cookbook is relatively useless for **understanding what is going on**, as opposed to knowing which buttons to push, so ask your tutorial leader for help in this area.

Download the data from http://casa.nrao.edu/Data/VLA/3C129/3c129data.tgz and untar it in some directory. (If you are in Garching, there should be a local copy. Ask Sven.) Then, from that same directory, start aips. Login with a new user ID number.

Basic Environment

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

Load the raw data: FILLM

```
task 'fillm'
default
nfiles 0
prtlev 0
datain 'PWD:AT166_
doconcat true
clron
doweight 10
ncount 2
cparm(4)=28
cparm(8)=10./60
go
```

Check where it went. You will need the C band version at 5 GHz

```
pcat
getn 4
imhe
```

Print out some useful information

```
task 'listr'
default
getn 4
optype 'scan'
doweight 1
go
```

```
AIPS 1: Got(1)   disk= 1  user= 101   type=UV   19940725.C BAND.2
 vlb054    LISTR(31DEC08)    101     13-NOV-2008  15:25:41    Page    1
File = 19940725    .C BAND.   2 Vol = 1  Userid =  101
Freq =  4.885100000 GHz   Ncor =  4   No. vis =    216975
Scan summary listing

Scan      Source      Qual  Calcode Sub         Timerange          FrqID
START VIS  END VIS
   1 2345-167        : 0003  A        1  0/07:41:45 -   0/07:43:25     1
1       2917
   2 A2597           : 0003           1  0/08:00:25 -   0/08:02:35     1
2918       6788
   3 2345-167        : 0003  A        1  0/08:21:05 -   0/08:22:45     1
6789       9709
   4 A2597           : 0003           1  0/08:39:45 -   0/08:41:55     1
9710      13605
```

```
   5 2345-167        : 0003  A        1  0/09:00:25 -   0/09:02:05     1
13606      16505
   6 A2597           : 0003           1  0/09:19:05 -   0/09:21:15     1
16506      20401
   7 2345-167        : 0003  A        1  0/09:39:45 -   0/09:41:25     1
20402      23322
   8 A2597           : 0003           1  0/09:58:25 -   0/10:00:35     1
23323      27218
   9 2345-167        : 0003  A        1  0/10:19:05 -   0/10:20:45     1
27219      30140
  10 A2597           : 0003           1  0/10:37:45 -   0/10:39:55     1
30141      34036
  11 2345-167        : 0003  A        1  0/10:58:25 -   0/11:00:05     1
34037      36957
  12 A2597           : 0003           1  0/11:17:05 -   0/11:19:15     1
36958      40832
  13 2345-167        : 0003  A        1  0/11:37:45 -   0/11:39:25     1
40833      43702
  14 0420+417        : 0003  B        1  0/11:48:25 -   0/11:50:05     1
43703      46624
  15 3C129           : 0003           1  0/12:12:55 -   0/12:23:05     1
46625      66120
  16 0420+417        : 0003  B        1  0/12:27:25 -   0/12:29:05     1
66121      69041
  17 3C129           : 0003           1  0/12:50:05 -   0/12:56:05     1
69042      80412
  18 3C129           : 0003           1  0/12:56:25 -   0/13:00:15     1
80413      88498
  19 0420+417        : 0003  B        1  0/13:04:35 -   0/13:06:15     1
88499      91419
  20 3C129           : 0003           1  0/13:29:05 -   0/13:39:15     1
91420     109415
  21 0420+417        : 0003  B        1  0/13:43:35 -   0/13:45:15     1
109416     112112
  22 3C129           : 0003           1  0/14:06:15 -   0/14:16:25     1
112113     130108
  23 0420+417        : 0003  B        1  0/14:20:45 -   0/14:22:25     1
130109     132636
  24 3C129           : 0003           1  0/14:45:15 -   0/14:55:25     1
132637     150081
  25 0420+417        : 0003  B        1  0/14:59:45 -   0/15:01:25     1
150082     152778
  26 3C129           : 0003           1  0/15:18:25 -   0/15:25:35     1
152779     164366
  27 0420+417        : 0003  B        1  0/15:30:05 -   0/15:31:45     1
164367     166846
  28 3C129           : 0003           1  0/15:55:05 -   0/16:05:15     1
166847     183403
  29 0420+417        : 0003  B        1  0/16:10:05 -   0/16:11:45     1
183404     185861
  30 3C129           : 0003           1  0/16:34:55 -   0/16:45:05     1
```

```
185862     203522
  31 0420+417        : 0003  B        1  0/16:49:35 -   0/16:51:15     1
203523     206216
  32 0518+165        : 0003  C        1  0/17:06:35 -   0/17:09:45     1
206217     211608
  33 0134+329        : 0003  C        1  0/17:21:45 -   0/17:24:55     1
211609     216975

Source summary
Velocity type = '        '    Definition = '        '

  ID Source           Qual  Calcode RA(1950.0)     Dec(1950.0)   IFlux
QFlux   UFlux   VFlux  No. vis
   1 2345-167        : 0003   A     23:45:27.6823 -16:47:52.600   0.000
0.000   0.000   0.000   20372
             IF( 2)                                               0.000
0.000   0.000   0.000
   2 A2597           : 0003         23:22:43.7000 -12:23:56.000   0.000
0.000   0.000   0.000   23330
             IF( 2)                                               0.000
0.000   0.000   0.000
   3 0420+417        : 0003   B     04:20:27.9370  41:43:08.045   0.000
0.000   0.000   0.000   24318
             IF( 2)                                               0.000
0.000   0.000   0.000
   4 3C129           : 0003         04:45:31.6950  44:55:19.950   0.000
0.000   0.000   0.000  138196
             IF( 2)                                               0.000
0.000   0.000   0.000
   5 0518+165        : 0003   C     05:18:16.5320  16:35:26.900   0.000
0.000   0.000   0.000    5392
             IF( 2)                                               0.000
0.000   0.000   0.000
   6 0134+329        : 0003   C     01:34:49.8320  32:54:20.520   0.000
0.000   0.000   0.000    5367
             IF( 2)                                               0.000
0.000   0.000   0.000

  ID Source           Freq(GHz) Velocity(Km/s) Rest freq (GHz)
   1 All Sources         4.8851         0.0000          0.0000
     IF(  2)             4.5851         0.0000          0.0000

Frequency Table summary
FQID IF#      Freq(GHz)      BW(kHz)   Ch.Sep(kHz)  Sideband
   1   1       4.88510000   50000.0039  50000.0039      1
       2       4.58510000   50000.0039  50000.0039      1
AIPS 1: Resumes
```

Where are the antennas located?

```
go prtan
```

```
                    Location Of VLA Antennas

                             N36 (26)
                             N32 ( 1)
                             N28 (19)
                             N24 (11)
                             N20 (15)
                             N16 (25)
                             N12 (13)
                             N8  (27)
                             N4  (14)
                          (12) W4   E4  (22)
                        ( 8) W8       E8  ( 4)
                      ( 3) W12          E12 (16)
                    (28) W16              E16 ( 7)
                  ( 2) W20                  E20 (17)
                (21) W24                      E24 (24)
              (10) W28                          E28 ( 5)
            (18) W32                              E32 (23)
          (20) W36                                  E36 ( 6)
                        VLA:_OUT ( 9)
                        VPT:_OUT (29)
```

Flag some bad data. Just run the commands.

```
task 'uvflg'
default
dohist 1
getn 4
antenna 1,0
basel 0
timer 0 13 45 20 0 15 0 0
stokes ' '
opcode 'flag'
reason 'bad ant'
outfgver 1
go
antenna 14,0
timer 0 16 50 50 0 16 51 0
go
timer 0
```

Investigate the data

Plots

```
task 'uvplt'
source '0518+165',' '
calcode ' '
stokes 'half'
timer 0
uvrange 0
bif 0
eif 0
docalib 0
gainuse 1
bparm 0 1
do3col 1
dotv 1
tvinit
go
source '0134+329',' '
tvinit
go
source '0420+417', ' '
tvinit
go
source '3C129', ' '
tvinit
go
bparm 6 7
source '0518+165',' '
tvinit
go
source '0134+329',' '
tvinit
go
source '0420+417', ' '
tvinit
go
source '3C129', ' '
tvinit
go
bparm 0
```

Raw visibilities

```
task 'listr'
optype 'list'
```

```
antenna 22,0
basel 0
sources ' '
calcode '*'
bif 0
eif 0
docalib 0
```

Start the calibration

Set the flux values of the known calibrators

```
task 'setjy'
default
getn 4
source '0518+165',' '
bif 0
eif 0
optype 'calc'
aparm(2) 2
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: 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 =  2 /Range of IFs
vlb054> SETJY1: '0518+165        ' IF =  1 FLUX = 3.7742 (Jy calcd)
vlb054> SETJY1: '0518+165        ' IF =  2 FLUX = 3.9464 (Jy calcd)
vlb054> SETJY1: / Using (1995.2) VLA or Reynolds (1934-638) coefficients
vlb054> SETJY1: Appears to have ended successfully
vlb054> SETJY1: vlb054       31DEC08 TST: Cpu=       0.0  Real=       0
```

```
bif 1
eif 1
optype ' '
zerosp 3.7742, 0.380, -0.153, 0.0
go
bif 2
eif 2
zerosp 3.9464, 0.397, -0.161, 0.0
go

bif 0
```

```
eif 0
zerosp 0
optype 'calc'
source = '0134+329',' '
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: 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 =  2 /Range of IFs
vlb054> SETJY1: '0134+329        ' IF =  1 FLUX = 5.4891 (Jy calcd)
vlb054> SETJY1: '0134+329        ' IF =  2 FLUX = 5.8249 (Jy calcd)
vlb054> SETJY1: / Using (1995.2) VLA or Reynolds (1934-638) coefficients
vlb054> SETJY1: Appears to have ended successfully
vlb054> SETJY1: vlb054       31DEC08 TST: Cpu=       0.0  Real=       0
```

Get images (and thus clean components) for the calibrators

```
task 'calrd'
object '3c138'
band 'c'
go

object '3c48'
band 'c'
go

pcat
```

```
AIPS 1: Catalog on disk  1
AIPS 1:  Cat Usid Mapname      Class   Seq  Pt     Last access      Stat
AIPS 1:    1  101 19940725    .C BAND.    1 UV 13-NOV-2008 15:24:44
AIPS 1:    2  101 19940725    .X BAND.    1 UV 13-NOV-2008 15:23:05
AIPS 1:    3  101 19940725    .X BAND.    2 UV 13-NOV-2008 16:01:14
AIPS 1:    4  101 19940725    .C BAND.    2 UV 13-NOV-2008 16:06:34
AIPS 1:    5  101 19940725    .U BAND.    1 UV 13-NOV-2008 15:23:05
AIPS 1:    6  101 3C138_C     .MODEL .    1 MA 13-NOV-2008 16:09:02
AIPS 1:    7  101 3C48_C      .MODEL .    1 MA 13-NOV-2008 16:09:22
```

Convert them to the coordinate system used for the observations

```
task 'eposw'
```

```
getn 6
eposw
getn 7
eposw
```

Do the actual calibration. Start with 3C138

```
task 'calib'
default
getn 4
calsour '0518+165',' '
uvrange 0
antenna 0
refant 22
minamper 10
minphser 10
weightit 1
get2n 6
ncomp 0
solmode 'A&P'
aparm(6) 2
solint 2
solsub 2
cparm(3) 10
cparm(4) 10
go
clrmsg
```

Calibrate 3C48

```
calsour '0134+329',' '
get2n 7
go
clrmsg
```

Calibrate the phase calibrator

```
clr2n
calsour '0420+417', ' '
solint 0
uvrange 20 0
go
clrmsg
```

Check the results

```
task 'snplt'
antenna 0
stokes ' '
inext 'sn'
inver 1
sources ' '
timer 0
optype 'amp'
opcode 'alsi'
do3col 1
dotv 1
nplots 9
tvinit
go
optype 'phas'
go
inver 2
optype 'amp'
go
optype 'phas'
go
inver 3
optype 'amp'
go
optype 'phas'
go
```

Apply the calibration to the phase calibrator

```
task 'getjy'
sources '0420+417', ' '
calsour '0518+165','0134+329',' '
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: 0420+417        :  3   B     1    1.46472 +/-   0.00304
vlb054> GETJY1:                               2    1.46512 +/-   0.00341
vlb054> GETJY1: Appears to have ended successfully
```

```
vlb054> GETJY1: vlb054       31DEC08 TST: Cpu=       0.0  Real=       0
```

Redo the phase calibrator calibration

Now that the flux density of the phase calibrator has been found, redo its calibration (just to make sure there are no remnants of some subtle assumptions about its flux density left in AIPS).

```
inext 'sn'
inver 3
extdest
inver 0
tget calib
go
clrmsg
```

Apply the calibration to all sources of interest.

```
task 'clcal'
sources '0518+165','0134+329','0420+417', '3C129', ' '
calsour '0518+165','0134+329','0420+417', ' '
opcode 'cali'
gainver 1
gainuse 2
refant 22
interp '2pt'
doblank 1
go
```

Have a look at the calibration

Plots

```
task 'uvplt'
docalib 1
gainuse 2
source '0420+417', ' '
stokes 'half'
aparm 0
bparm 0 1
doweight 1
uvrange 0
tvinit
go
```

Start the polarization calibration

Check the parallactic angle change

```
task 'listr'
sources '0518+165','0134+329','0420+417', ' '
inext 'cl'
inver 2
optype 'gain'
dparm 9,0
go
```

Make a backup of calibration values, in case we mess up

```
task 'tasav'
clro
go
```

Now do the polarization calibration using the phase calibrator

```
task 'pcal'
calsour '0420+417', ' '
timer 0
antenna 0
uvrange 20,0
bif 0
eif 0
docalib 1
gainuse 2
clr2n
pmodel 0
solint 3
soltype 'appr'
prtlev 1
refant 22
bparm 0
cparm 0
go
clrmsg
```

```
vlb054> PCAL 1: Calibration source   1
vlb054> PCAL 1:   Q+iU=(  -0.01035,   0.03766) +/- (  0.000106,  0.000106)
Jy
vlb054> PCAL 1:   Pol. inten. =   0.03905 +/-  0.000150 Jy, angle =  52.68
+/-
```

```
vlb054>         0.078 deg
vlb054> PCAL 1: 0420+417         I,Q,U,V =   1.4647 -0.01035  0.03766
0.00000 J
vlb054>         y
vlb054> PCAL 1: Calibration source   1
vlb054> PCAL 1:   Q+iU=(  -0.03423,   0.00815) +/- (  0.000114,  0.000114)
Jy
vlb054> PCAL 1:   Pol. inten. =   0.03519 +/-  0.000161 Jy, angle =  83.31
+/-
vlb054>         0.093 deg
vlb054> PCAL 1: 0420+417         I,Q,U,V =   1.4651 -0.03423  0.00815
0.00000 J
vlb054>         y
```

Using the calibration, check the difference between polarizations on a polarized calibrator

```
task 'rldif'
source '0518+165', ' '
timer 0
antenna 0
uvrange 0,45
docalib 1
gainuse 2
dopol true
go
```

```
Ampscalar average of matrix  =   -30.19(  0.081) sigma =  1.160
Ampscalar average of matrix  =    33.93(  0.097) sigma =  1.389
```

```
outputs
```

```
AIPS 1: RLDIF:  Task to return Right - Left phase difference
AIPS 1: Adverbs     Values                 Comments
AIPS 1: ------------------------------------------------------------------
AIPS 1: CLCORPRM    -30.1863     33.9257   R-L phase difference returned
AIPS 1:            *rest 0
```

Another save, just in case

```
task 'tasav'
clro
go
```

What is the angle supposed to be for this calibrator?

Polarization data for C band from http://www.vla.nrao.edu/astro/calib/polar/1999/

Correct number is -21.71

Correct the measured values

```
for i=1 to 2;clcorp(i) = -21.71 - clcorp(i);end
```

Apply them

```
task 'clcor'
source ' '
antenna 0
timer 0
bif 0
eif 0
gainver 2
gainuse 0
opcode 'polr'
stokes 'l'
go
```

Check that the angles match what we expect

```
task 'rldif'
source '0518+165', ' '
timer 0
antenna 0
uvrange 0,45
docalib 1
gainuse 3
dopol true
go
```

Look at what AIPS gave back

```
outputs
```

```
AIPS 1: RLDIF:  Task to return Right - Left phase difference
AIPS 1: Adverbs     Values                  Comments
AIPS 1: ------------------------------------------------------------------
AIPS 1: CLCORPRM    -21.71      -21.71     R-L phase difference returned
AIPS 1:            *rest 0
```

```
################
```

Now start with the smaller array data. Load it in

FILLM

```
task 'fillm'
default
nfiles 2
prtlev 0
datain 'PWD:AT166_
doconcat true
clron
doweight 10
ncount 1
cparm(4)=28
cparm(8)=10./60
go
```

Check where it went

```
pcat
```

```
AIPS 1: Catalog on disk  1
AIPS 1:  Cat Usid Mapname      Class   Seq  Pt     Last access      Stat
AIPS 1:    1  101 19940725    .C BAND.    1 UV 13-NOV-2008 17:24:12
AIPS 1:    2  101 19940725    .X BAND.    1 UV 13-NOV-2008 17:24:13
AIPS 1:    3  101 19940725    .X BAND.    2 UV 13-NOV-2008 17:24:13
AIPS 1:    4  101 19940725    .C BAND.    2 UV 13-NOV-2008 17:24:13
AIPS 1:    5  101 19940725    .U BAND.    1 UV 13-NOV-2008 17:24:13
AIPS 1:    6  101 3C138_C     .MODEL .    1 MA 13-NOV-2008 16:16:53
AIPS 1:    7  101 3C48_C      .MODEL .    1 MA 13-NOV-2008 16:19:09
AIPS 1:    8  101 19940725    .TASAV .    1 UV 13-NOV-2008 17:24:13
AIPS 1:    9  101 19940725    .TASAV .    2 UV 13-NOV-2008 17:24:13
AIPS 1:   10  101 19941103    .C BAND.    1 UV 13-NOV-2008 17:24:36
AIPS 1:   11  101 19941103    .X BAND.    1 UV 13-NOV-2008 17:24:36
AIPS 1:   12  101 19941103    .X BAND.    2 UV 13-NOV-2008 17:24:36
AIPS 1:   13  101 19941103    .C BAND.    2 UV 13-NOV-2008 17:24:36
```

Makre sure we have the right one

```
getn 13
imhe
```

Get the scan information

```
task 'listr'
```

```
default
getn 13
optype 'scan'
doweight 1
go
```

```
 vlb054    LISTR(31DEC08)    101     13-NOV-2008  17:25:15    Page    1
File = 19941103    .C BAND.   2 Vol = 1  Userid =  101
Freq =  4.885100000 GHz   Ncor =  4   No. vis =     52167
Scan summary listing

Scan      Source      Qual  Calcode Sub         Timerange          FrqID
START VIS  END VIS
   1 0134+329        : 0003  C        1  0/04:05:15 -   0/04:07:25     1
1         36
   2 0420+417        : 0003  B        1  0/07:33:35 -   0/07:35:15     1
37       3169
   3 0518+165        : 0003  C        1  0/07:42:35 -   0/07:45:45     1
3170       9457
   4 3C129           : 0003           1  0/08:18:05 -   0/08:23:25     1
9458      20308
   5 0420+417        : 0003  B        1  0/08:27:35 -   0/08:29:15     1
20309      22845
   6 0420+417        : 0003  B        1  0/08:49:25 -   0/08:51:05     1
22846      25972
   7 3C129           : 0003           1  0/09:07:05 -   0/09:12:25     1
25973      35132
   8 0420+417        : 0003  B        1  0/09:17:05 -   0/09:18:45     1
35133      38213
   9 3C129           : 0003           1  0/09:40:25 -   0/09:45:05     1
38214      47664
  10 0420+417        : 0003  B        1  0/09:49:35 -   0/09:51:55     1
47665      52167

Source summary
Velocity type = '        '    Definition = '        '

  ID Source           Qual  Calcode RA(1950.0)     Dec(1950.0)   IFlux
QFlux   UFlux   VFlux  No. vis
   1 0134+329        : 0003   C     01:34:49.8320  32:54:20.520   0.000
0.000   0.000   0.000      36
             IF( 2)                                               0.000
0.000   0.000   0.000
   2 0420+417        : 0003   B     04:20:27.9370  41:43:08.045   0.000
0.000   0.000   0.000   16381
             IF( 2)                                               0.000
0.000   0.000   0.000
   3 0518+165        : 0003   C     05:18:16.5320  16:35:26.900   0.000
0.000   0.000   0.000    6288
             IF( 2)                                               0.000
```

```
0.000   0.000   0.000
   4 3C129           : 0003         04:45:31.6950  44:55:19.950   0.000
0.000   0.000   0.000   29462
             IF( 2)                                                0.000
0.000   0.000   0.000

  ID Source            Freq(GHz) Velocity(Km/s) Rest freq (GHz)
   1 All Sources          4.8851         0.0000          0.0000
     IF(  2)              4.5851         0.0000          0.0000

Frequency Table summary
FQID IF#      Freq(GHz)      BW(kHz)   Ch.Sep(kHz)  Sideband
   1   1       4.88510000   50000.0039  50000.0039      1
       2       4.58510000   50000.0039  50000.0039      1
AIPS 1: Resumes
```

Get antenna positions

go prtan

```
                     Location Of VLA Antennas

                              N18 (26)
                              N16 ( 1)
                              N14 ( 9)
                              N12 (11)
                              N10 (15)
                              N8  (27)
                              N6  (25)
                              N4  (14)
                              N2  (13)
                           ( 3) W2   E2  ( 4)
                         (12) W4       E4  (22)
                       (21) W6           E6  (16)
                     ( 8) W8               E8  (17)
                   ( 2) W10                  E10 (24)
                 (10) W12                      E12 ( 5)
               (18) W14                          E14 (23)
             (28) W16                              E16 ( 7)
           (20) W18                                  E18 ( 6)
                           VLA:_OUT (19)
                           VPT:_OUT (29)
AIPS 1: Resumes
```

Flag some bad data. Just run the commands and think about this later.

```
task 'uvflg'
default
dohist 1
getn 13
antenna 0
basel 0
timer 0 0 0 0 0 4 8 0
stokes ' '
opcode 'flag'
reason 'bad scan'
outfgver 1
go
timer 0 8 18 0 0 8 30 0
go
antenna 0
timer 0 9 10 0 0 9 15 0
go
reason 'bad ant
antenna 4,0
timer 0
```

Check out some properties of the raw data

Plots

```
task 'uvplt'
source '0518+165',' '
calcode ' '
stokes 'half'
timer 0
uvrange 0
bif 0
eif 0
docalib 0
gainuse 1
bparm 0 1
do3col 1
dotv 1
tvinit
go
source '0420+417', ' '
tvinit
go
source '3C129', ' '
tvinit
go
bparm 6 7
```

```
source '0518+165',' '
tvinit
go
source '0420+417', ' '
tvinit
go
source '3C129', ' '
tvinit
go
bparm 0
```

Raw numbers

```
task 'listr'
optype 'list'
antenna 4,0
basel 0
sources ' '
calcode '*'
bif 0
eif 0
docalib 0
stokes ' '
dparm 0
go
```

Begin the calibration

Apply the flux densities for the known calibrators

```
task 'setjy'
default
getn 13
source '0518+165',' '
bif 0
eif 0
optype 'calc'
aparm(2) 2
go
```

```
vlb054> SETJY1: BIF =  1 EIF =  2 /Range of IFs
vlb054> SETJY1: '0518+165        ' IF =  1 FLUX = 3.7742 (Jy calcd)
vlb054> SETJY1: '0518+165        ' IF =  2 FLUX = 3.9464 (Jy calcd)
vlb054> SETJY1: / Using (1995.2) VLA or Reynolds (1934-638) coefficients
```

```
bif 1
eif 1
```

```
optype ' '
zerosp 3.7742, 0.380, -0.153, 0.0
go
bif 2
eif 2
zerosp 3.9464, 0.397, -0.161, 0.0
go

bif 0
eif 0
zerosp 0
optype 'calc'
```

Run the calibration for 3C138

```
task 'calib'
default
getn 13
calsour '0518+165',' '
uvrange 0
antenna 0
refant 4
minamper 10
minphser 10
weightit 1
get2n 6
ncomp 0
solmode 'A&P'
aparm(6) 2
solint 2
solsub 2
cparm(3) 10
cparm(4) 10
go
clrmsg
```

Calibrate the phase calibrator

```
clr2n
calsour '0420+417', ' '
solint 0
uvrange 0
go
clrmsg
```

Check the results

```
task 'snplt'
antenna 0
stokes ' '
inext 'sn'
inver 1
sources ' '
timer 0
optype 'amp'
opcode 'alsi'
do3col 1
dotv 1
nplots 9
tvinit
go
optype 'phas'
go
inver 2
optype 'amp'
go
optype 'phas'
go
```

Use the amplitude calibrator to get the phase calibrator flux density

```
task 'getjy'
sources '0420+417', ' '
calsour '0518+165',' '
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: 0420+417        :  3   B     1    1.33893 +/-   0.00641
vlb054> GETJY1:                               2    1.34714 +/-   0.00525
vlb054> GETJY1: Appears to have ended successfully
vlb054> GETJY1: vlb054       31DEC08 TST: Cpu=       0.0  Real=       0
```

Redo the phase calibrator calibration

Now that we know the flux density of the phase calibrator, run through its calibration again, just to be

sure AIPS doesn't have some information left around from calibrating before with an unknown flux density.

```
inext 'sn'
inver 2
extdest
inver 0
tget calib
go
clrmsg
```

Apply the calibration to all sources

```
task 'clcal'
sources '0518+165','0420+417', '3C129', ' '
calsour '0518+165','0420+417', ' '
opcode 'cali'
gainver 1
gainuse 2
refant 4
interp '2pt'
doblank 1
go
```

Check the results

Plots

```
task 'uvplt'
docalib 1
gainuse 2
source '0420+417', ' '
stokes 'half'
aparm 0
bparm 0 1
doweight 1
uvrange 0
tvinit
go
```

Now start the polarization calibration

Check the paralactic angles

```
task 'listr'
sources '0518+165','0420+417', ' '
inext 'cl'
inver 2
optype 'gain'
dparm 9,0
go
```

Make a backup of calibration information

```
task 'tasav'
clro
go
```

Run the polarization calibration on the phase calibrator

```
task 'pcal'
calsour '0420+417', ' '
timer 0
antenna 0
uvrange 0
bif 0
eif 0
docalib 1
gainuse 2
clr2n
pmodel 0
solint 3
soltype 'appr'
prtlev 1
refant 4
bparm 0
cparm 0
go
clrmsg
```

```
vlb054> PCAL 1: Calibration source   1
vlb054> PCAL 1:   Q+iU=(   0.00444,  -0.04706) +/- (  0.000273,  0.000273)
Jy
vlb054> PCAL 1:   Pol. inten. =   0.04727 +/-  0.000386 Jy, angle = -42.30
+/-
vlb054>         0.165 deg
vlb054> PCAL 1: 0420+417         I,Q,U,V =   1.3389  0.00444 -0.04706
0.00000 J
vlb054>         y
vlb054> PCAL 1: Calibration source   1
```

```
vlb054> PCAL 1:   Q+iU=(   0.02002,   0.03901) +/- (  0.000277,  0.000277)
Jy
vlb054> PCAL 1:   Pol. inten. =   0.04385 +/-  0.000392 Jy, angle =  31.42
+/-
vlb054>         0.181 deg
vlb054> PCAL 1: 0420+417         I,Q,U,V =   1.3471  0.02002  0.03901
0.00000 J
vlb054>         y
```

Check the phase difference between polarizations on a polarization calibrator

```
task 'rldif'
source '0518+165', ' '
timer 0
antenna 0
uvrange 0,45
docalib 1
gainuse 2
dopol true
go
```

```
outputs
```

```
AIPS 1: RLDIF:  Task to return Right - Left phase difference
AIPS 1: Adverbs     Values                 Comments
AIPS 1: ------------------------------------------------------------------
AIPS 1: CLCORPRM    132.6554    -74.984    R-L phase difference returned
AIPS 1:            *rest 0
```

Make backups again

```
task 'tasav'
clro
go
```

Find out what the polarization angle on the sky is supposed to be

Polarization data for C band from http://www.vla.nrao.edu/astro/calib/polar/1999/

Correct number is -21.71

Correct the measured values

```
for i=1 to 2;clcorp(i) = -21.71 - clcorp(i);end
```

Apply the corrections

```
task 'clcor'
source ' '
antenna 0
timer 0
bif 0
eif 0
gainver 2
gainuse 0
opcode 'polr'
stokes 'l'
go
```

Check that the angles are now correct

```
task 'rldif'
source '0518+165', ' '
timer 0
antenna 0
uvrange 0,45
docalib 1
gainuse 3
dopol true
go
```

outputs

```
AIPS 1: RLDIF:  Task to return Right - Left phase difference
AIPS 1: Adverbs     Values                 Comments
AIPS 1: ------------------------------------------------------------------
AIPS 1: CLCORPRM    -21.71      -21.71     R-L phase difference returned
AIPS 1:            *rest 0
```

```
############################
```

Work on just the target data now

Run SPLIT on the two datasets

```
task 'split'
getn 4
source '3C129', ' '
timer 0
bif 0
eif 0
```

```
docalib 1
gainuse 3
dopol true
stokes ' '
douvcomp false
aparm 0
go
getn 13
go
clrmsg
```

Check for where the new datafiles are stored

```
pcat
```

```
AIPS 1: Catalog on disk  1
AIPS 1:  Cat Usid Mapname      Class   Seq  Pt     Last access      Stat
AIPS 1:    1  101 19940725    .C BAND.    1 UV 13-NOV-2008 17:24:12
AIPS 1:    2  101 19940725    .X BAND.    1 UV 13-NOV-2008 17:24:13
AIPS 1:    3  101 19940725    .X BAND.    2 UV 13-NOV-2008 17:24:13
AIPS 1:    4  101 19940725    .C BAND.    2 UV 13-NOV-2008 18:24:07
AIPS 1:    5  101 19940725    .U BAND.    1 UV 13-NOV-2008 17:24:13
AIPS 1:    6  101 3C138_C     .MODEL .    1 MA 13-NOV-2008 17:51:33
AIPS 1:    7  101 3C48_C      .MODEL .    1 MA 13-NOV-2008 16:19:09
AIPS 1:    8  101 19940725    .TASAV .    1 UV 13-NOV-2008 17:24:13
AIPS 1:    9  101 19940725    .TASAV .    2 UV 13-NOV-2008 17:24:13
AIPS 1:   10  101 19941103    .C BAND.    1 UV 13-NOV-2008 17:24:36
AIPS 1:   11  101 19941103    .X BAND.    1 UV 13-NOV-2008 17:24:36
AIPS 1:   12  101 19941103    .X BAND.    2 UV 13-NOV-2008 17:24:36
AIPS 1:   13  101 19941103    .C BAND.    2 UV 13-NOV-2008 18:24:18
AIPS 1:   14  101 19941103    .TASAV .    1 UV 13-NOV-2008 17:54:20
AIPS 1:   15  101 19941103    .TASAV .    2 UV 13-NOV-2008 17:56:30
AIPS 1:   16  101 3C129       .SPLIT .    1 UV 13-NOV-2008 18:24:07
AIPS 1:   17  101 3C129       .SPLIT .    2 UV 13-NOV-2008 18:24:18
```

Combine the two different observations into one big one

```
task 'dbcon'
getn 16
get2n 17
go
pcat
```

```
AIPS 1:   18  101 3C129       .DBCON .    1 UV 13-NOV-2008 18:28:31
```

Imaging

IMAGR is the standard imaging tool for AIPS

This will start up an imaging/cleaning session. Draw boxes and clean the source structure. Do this for all 4 Stokes parameters. (Unfortunately, IMAGR requires separate runs for the different Stokes parameters.)

```
task 'imagr'
getn 18
stokes 'i'
dopol 0
cellsize 0.25,0.25
imsize 2048,2048
clr2n
do3dimag 1
docalib 0
uvrange 0
niter 20000
overlap 1
go
clrmsg
stokes 'q'
go
clrmsg
stokes 'u'
go
clrmsg
stokes 'v'
go
clrmsg
```

Check where the files went

pcat

```
AIPS 1:   29  101 3C129       .IBM001.    3 MA 13-NOV-2008 19:46:00
AIPS 1:   30  101 3C129       .ICL001.    5 MA 13-NOV-2008 19:46:00
AIPS 1:   31  101 3C129       .QBM001.    1 MA 13-NOV-2008 19:47:30
AIPS 1:   32  101 3C129       .QCL001.    1 MA 13-NOV-2008 19:47:30
AIPS 1:   33  101 3C129       .UBM001.    1 MA 13-NOV-2008 19:49:06
AIPS 1:   34  101 3C129       .UCL001.    1 MA 13-NOV-2008 19:49:06
AIPS 1:   35  101 3C129       .VBM001.    1 MA 13-NOV-2008 19:49:39
AIPS 1:   36  101 3C129       .VCL001.    1 MA 13-NOV-2008 19:49:39
```

Polarization images

Combine Q and U to get linear polarization

```
task 'comb'
opcode 'polc'
getn 32
get2n 34
aparm 0
bparm(1) 28E-6
bparm(2) 28E-6
go
```

Get the linear polarization angle

```
opcode 'pola'
go
```

Check where file went

```
pcat
```

```
AIPS 1:   28  101 3C129       .PPOLC .    1 MA 13-NOV-2008 19:59:45
AIPS 1:   37  101 3C129       .PANG  .    1 MA 13-NOV-2008 20:00:28
```

Look at the images

Linear Polarization

```
getn 28
tvinit
tvlod
tvfiddle
tvstat
```

```
AIPS 1: Mean= 1.3417E-05 rms= 2.8180E-05 JY/BEAM   over  178694. pixels
```

Polarization Angle

```
getn 37
tvinit
tvlod
```

```
tvfiddle
```

I

```
getn 30
tvinit
tvlod
tvfiddle
tvstat
```

Clip the data so we only see information where there is good S/N

```
task 'comb'
getn 37
get2n 28
opcode 'clip'
aparm(1) 100E-6
aparm(10) 100E-6
bparm 0
outclass 'PANGC'
go
task 'comb'
getn 28
get2n 28
opcode 'clip'
aparm(1) 100E-6
aparm(10) 100E-6
bparm 0
outclass 'POLCC'
go
```

Check where these files went

```
pcat
```

```
AIPS 1:   38  101 3C129       .PANGC .    1 MA 13-NOV-2008 20:31:21
AIPS 1:   39  101 3C129       .POLCC .    1 MA 13-NOV-2008 20:31:21
```

Look at the polarization angle

```
getn 38
tvinit
tvlod
tvfiddle
```

Plotting your data

Plot I contours and P greyscale

```
task 'kntr'
getn 30
get2n 28
docont 1
dogrey 2
dovect 0
pixrange 0 1E-3
clev 28E-6
levs=-16,-8,8,16,32,64,128,256,512,1024
dowedge true
cbplot 1
dotv 1
blc 950 950
trc 1500 1500
go
```

Plot I contours and colors for polarization angle

```
task 'pcntr'
getn 30
get2n 32
get3n 34
docont 1
dogrey 2
dovect 1
pixrange 0 1E-3
clev 28E-6
levs=-16,-8,8,16,32,64,128,256,512,1024
factor 5
pol3col 1
pcut 80E-6
icut 0
dowedge 0
cbplot 1
dotv 1
blc 950 950
trc 1500 1500
go
```

Final Images