

GLOW Interferometry Tutorial: Wednesday

We will reduce the 3C129 polarization continuum dataset from the 2008 NRAO summer school. (See <http://casa.nrao.edu/Tutorial/Slworkshop2008/>) 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 of 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
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.

```

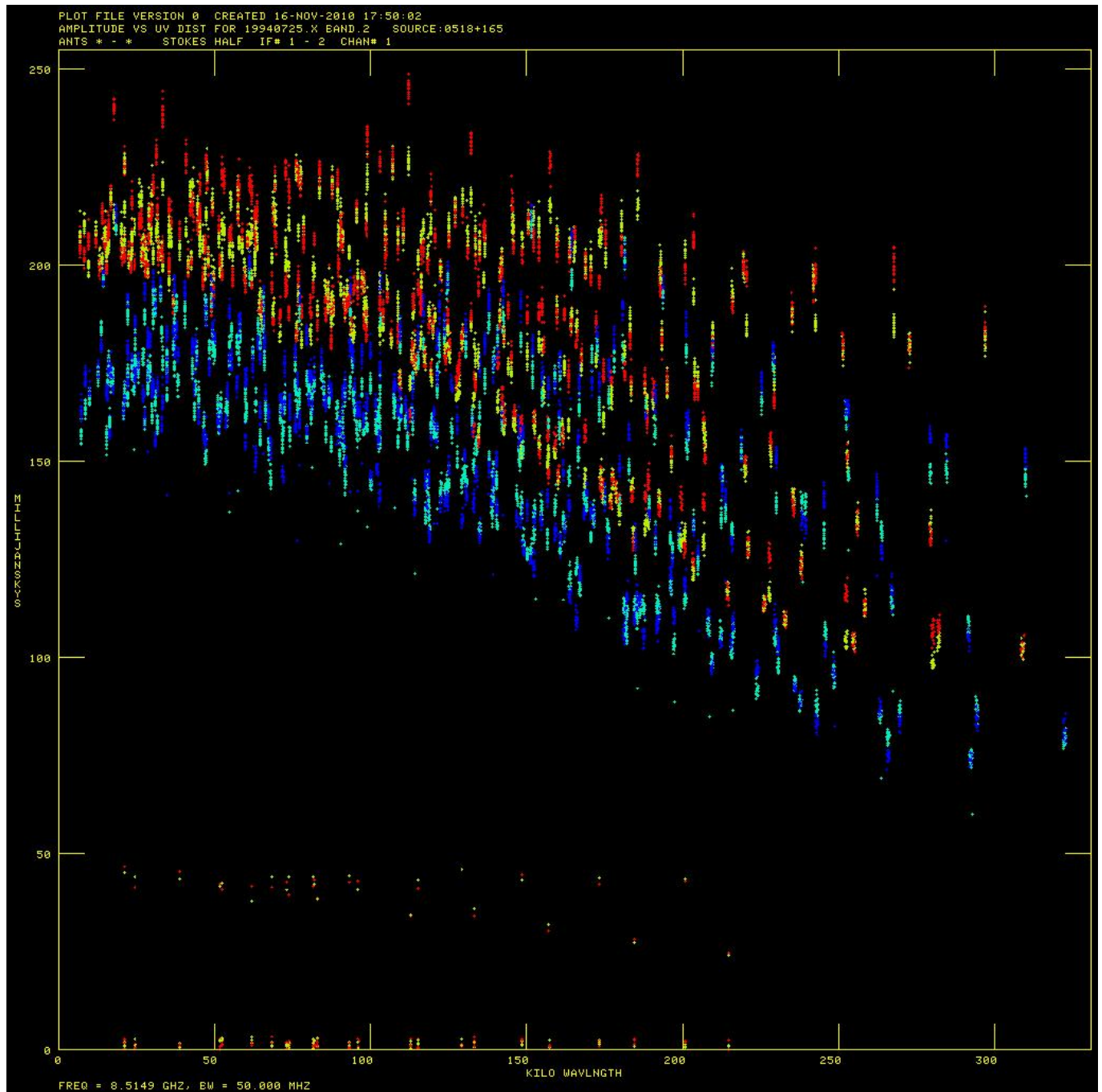
task 'uvflg'
default
dohist 1
getn 4
antenna 1,0
basel 0
timer 0 13 45 20 0 15 0 0
stokes ' '
opcode 'flag'
reason 'bad ant'
outfgver 1
go
antenna 14,0
timer 0 16 50 50 0 16 51 0
go
timer 0

```

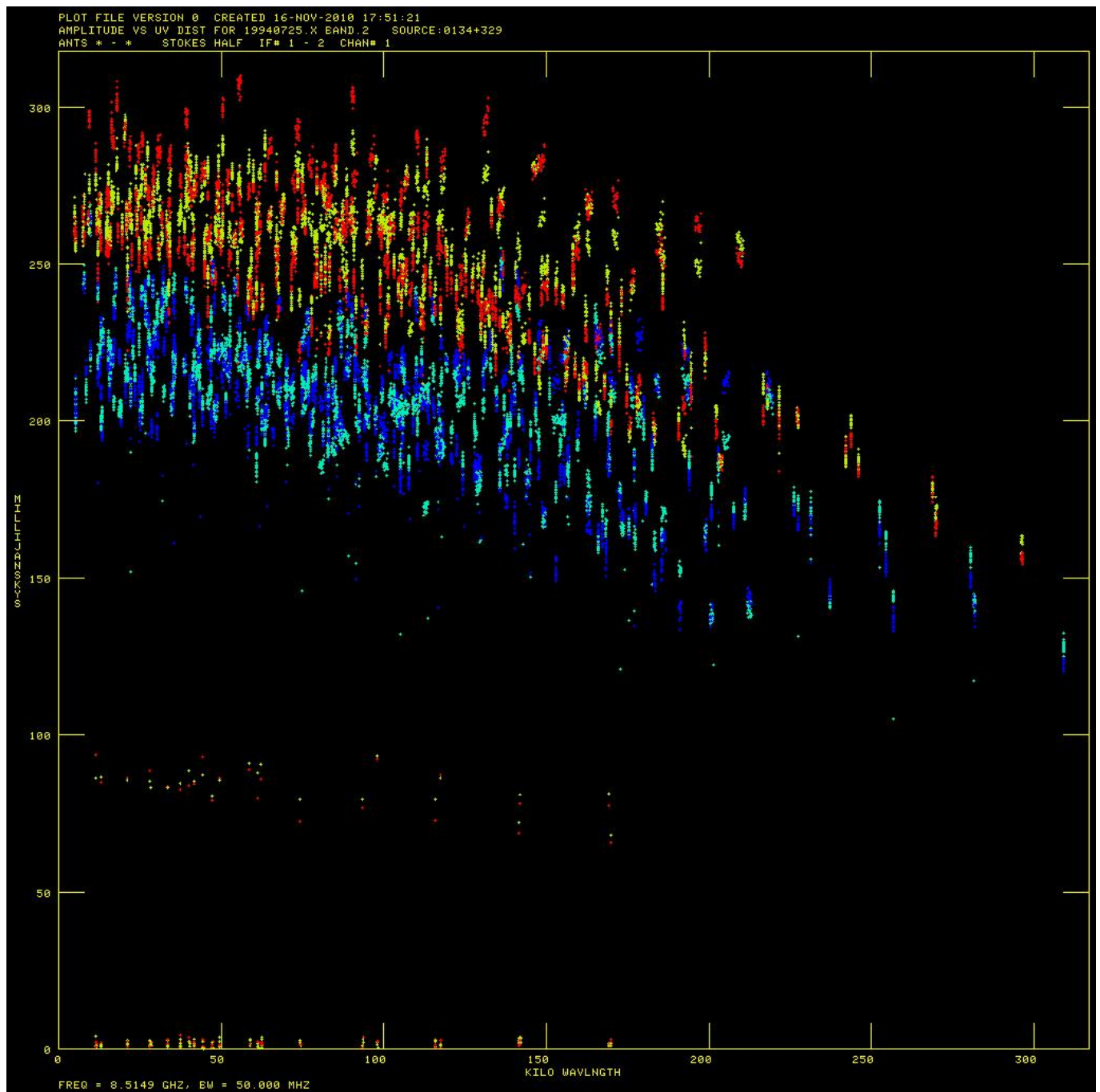
Investigate the data

Plots

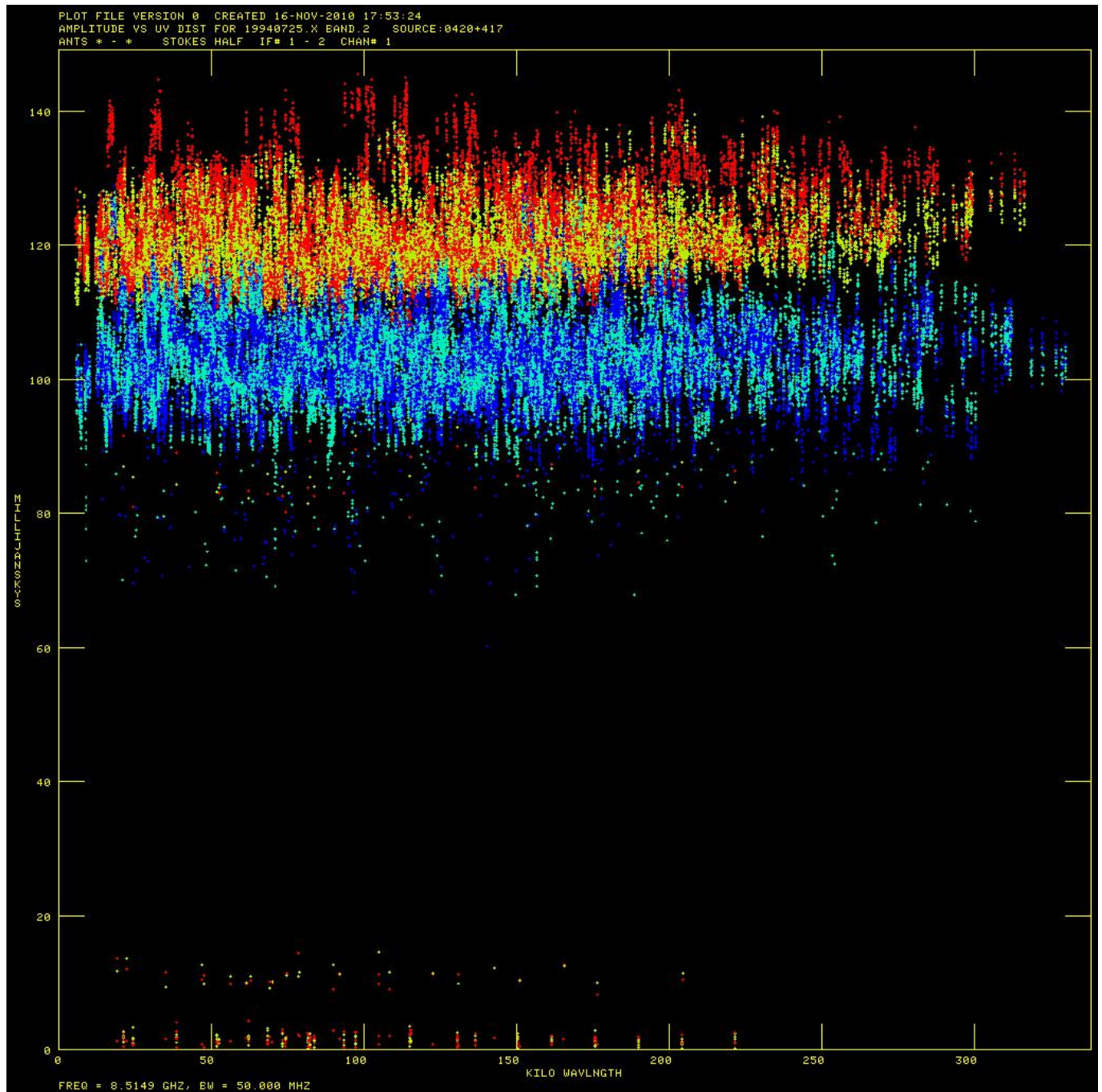
```
task 'uvplt'  
source '0518+165', ' '  
calcode ' '  
stokes 'half'  
timer 0  
uvrange 0  
bif 0  
eif 0  
docalib 0  
gainuse 1  
bparm 0 1  
do3col 1  
dotv 1  
tvinit  
go
```



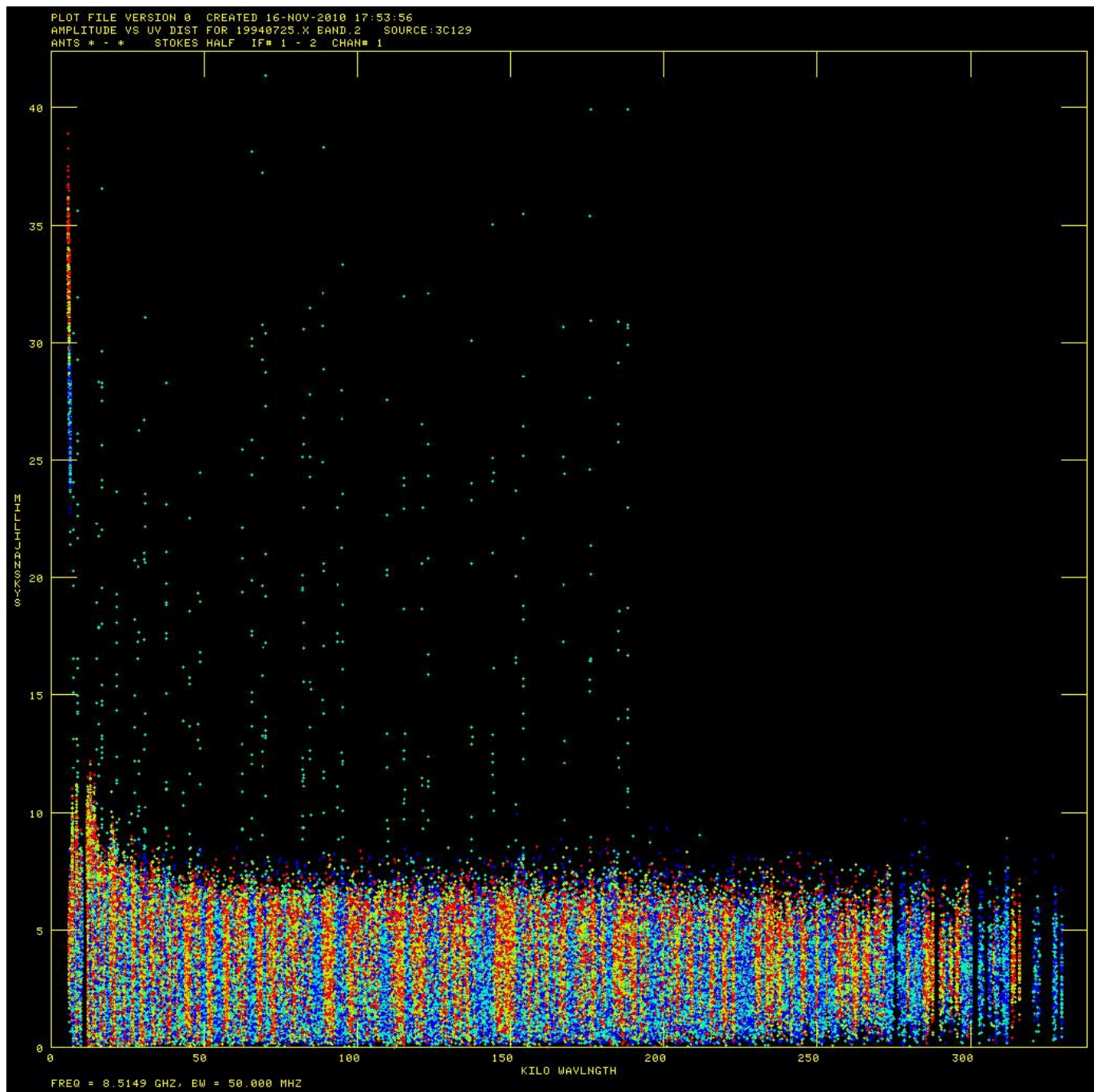
```
source '0134+329', ' '
tvinit
go
```



source '0420+417', ' '
tvinit
go



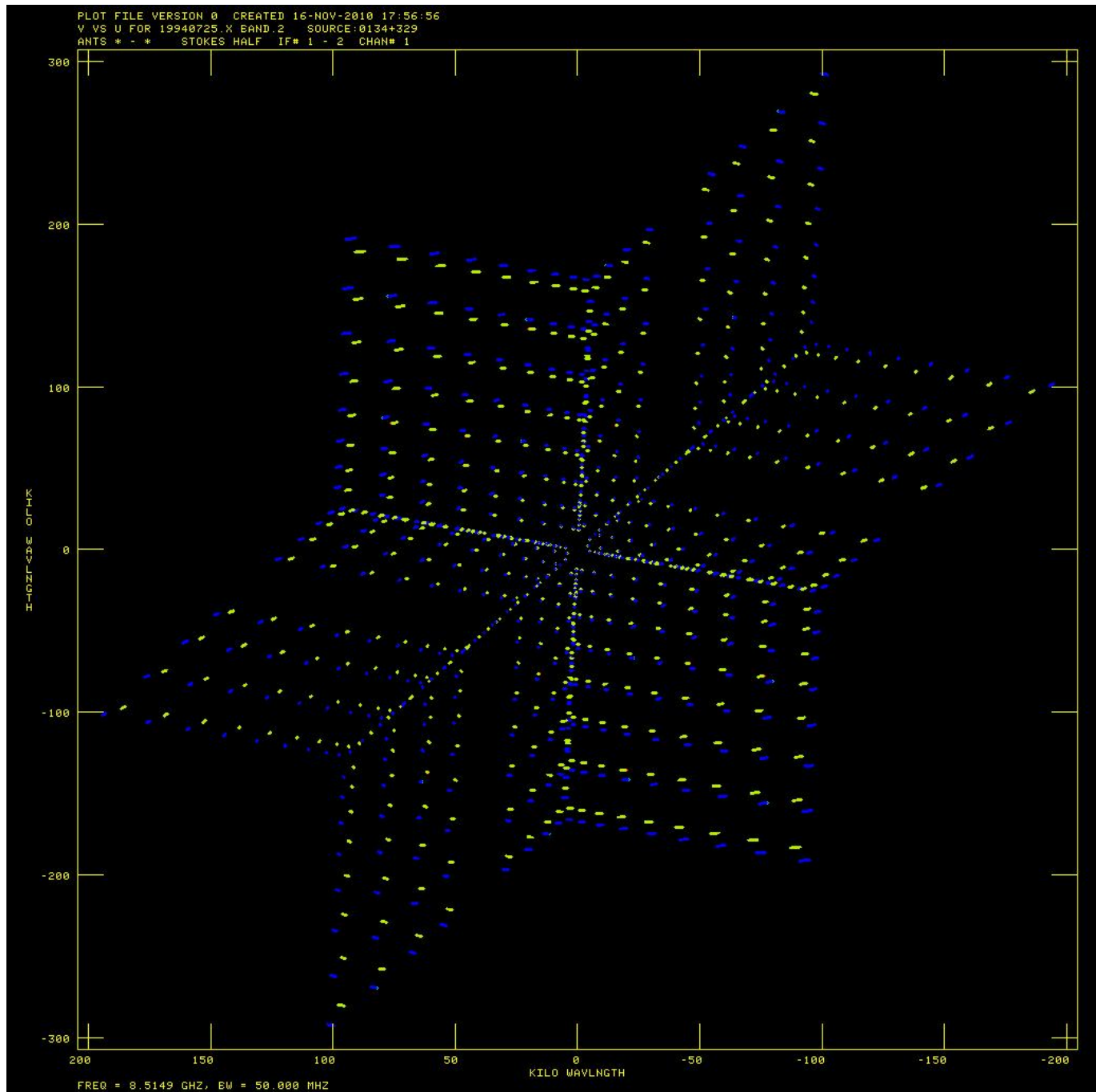
```
source '3C129', ' '  
tvinit  
go
```



```
bparm 6 7  
source '0518+165', ' '  
tvinit  
go
```



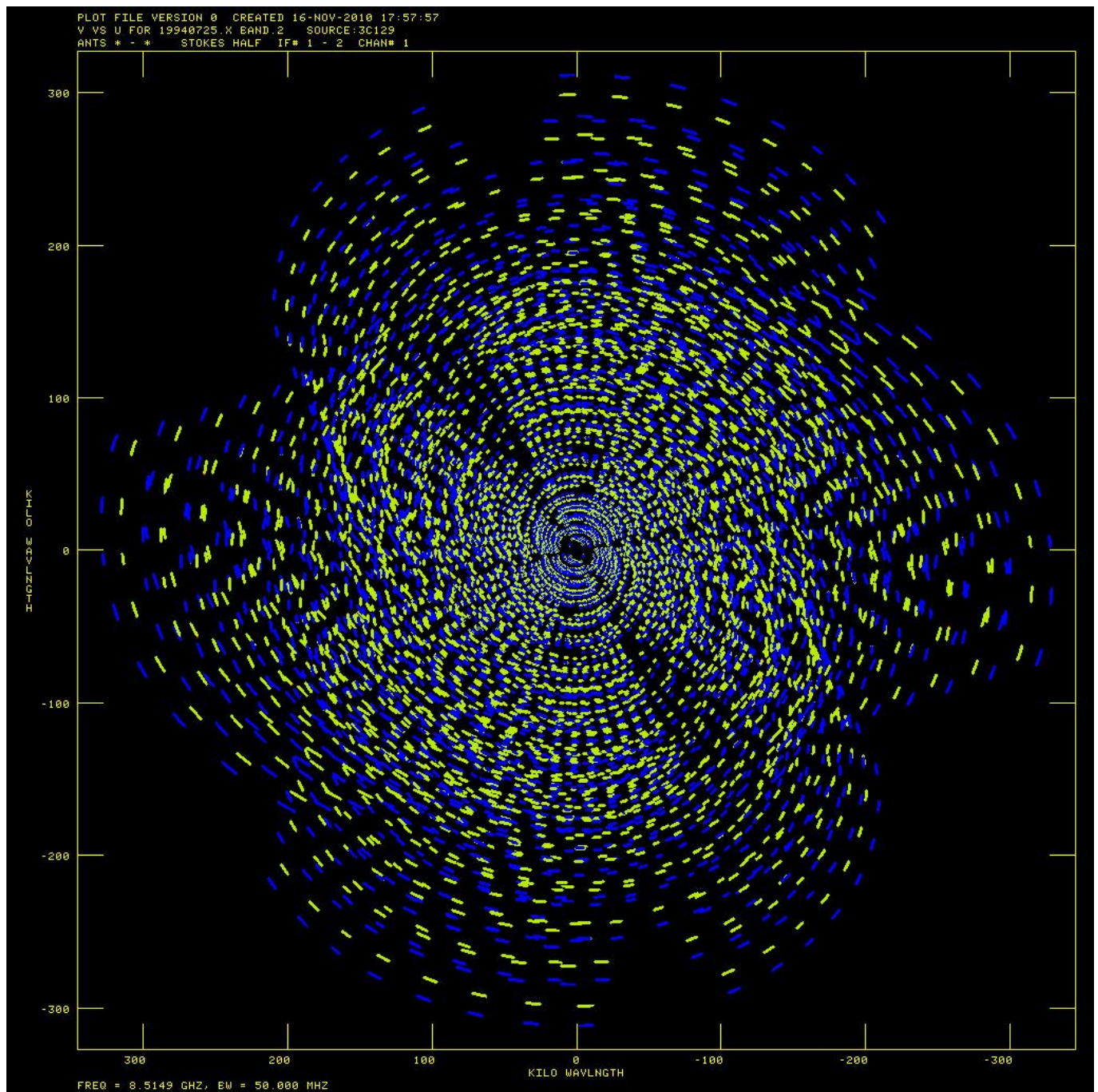
```
source '0134+329', ' '
tvinit
go
```



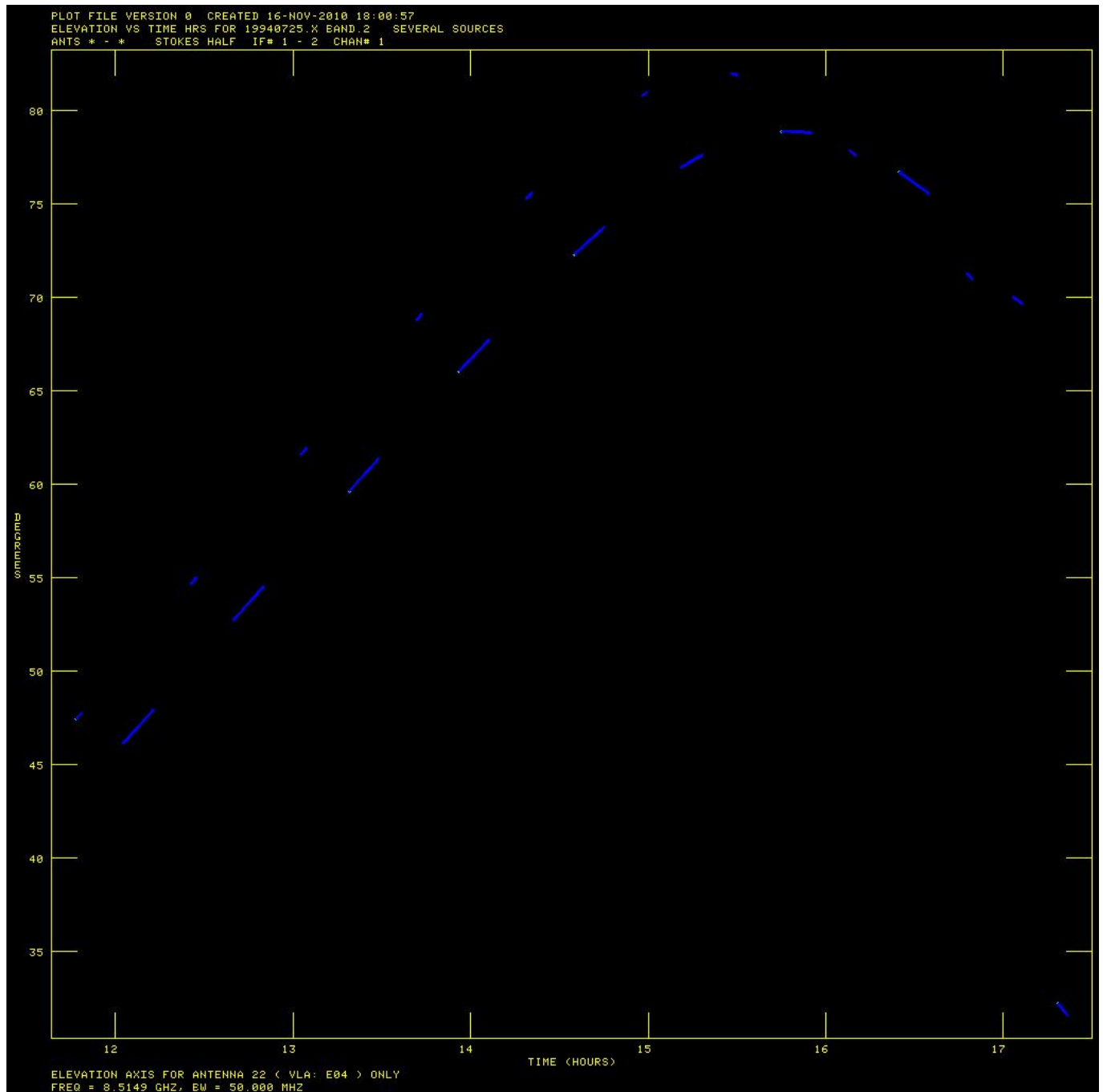
source '0420+417', ' '
tvinit
go



```
source '3C129', ' '
tvinit
go
```



```
bparm 11,15,0  
sources '0518+165','0134+329','0420+417','3C129',' '  
xinc=10  
go
```



bparm 11,16,0
go



```
xinc=1  
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  
clormsg
```

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
prtleve 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'  
doblack 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 parallactic 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
```

clrmsh

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	.PP0LC	.	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

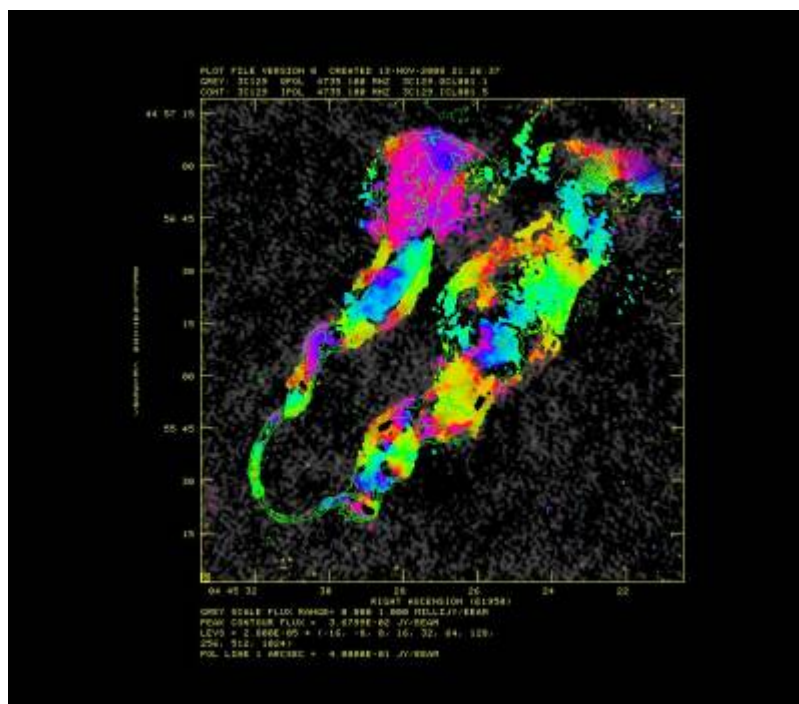
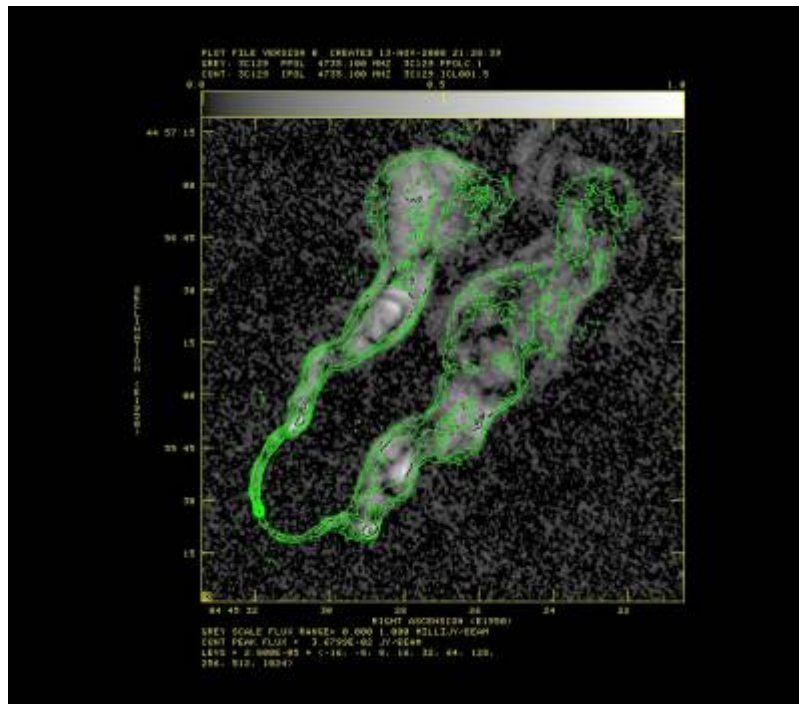
```
task 'kntr'
getn 30
get2n 28
docont 1
dogrey 2
dovect 0
```

```
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



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