How
to calibrate, flag and transform 21cm line data from the WSRT using NEWSTAR

Marc Verheijen

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Contents

1 Introduction.

This document describes how to calibrate by means of the NEWSTAR software package a single 12 hour 21cm line observation using the calibrators observed before and after the actual 12 hour measurement. In this case the observations were done with 128 channels.

This document was written during a period in which the NEWSTAR package is constantly updated and improved. For this reason the program keywords and output might sometimes deviate from the release that you are using. Especially the parts about interactive flagging of the raw UV data which is at this moment quite primitive.

2 Calibration of the data.

2.1 Reading the data from tape into a .SCN file.

We will start with reading the data of both calibrators and the actual 12 hour measurement from a DAT tape into a single .SCN file.

```
/dz1/users/verheyen/U6713/DWARFDATA> exe nscan

OPTION (LOAD,DUMP,FROM_OLD,TO_OLD,COPY,REGROUP,UVFITS,PFITS,
         CVX,NVS,WERR,AERR,QUIT) = QUIT: load
INPUT_UNIT (0,1,2,3,4,5,6,7,8,9,D) (input 'tape' unit) =
           "": 8

 Volume W93001 mounted on unit 8

INTEGRATION_TIME (integration time (sec)) = 120: 120
OUTPUT_SCN_NODE (output 'node' name) = "": U6713
 Creating node U6713

 Specify parameters for job 1:

INPUT_LABELS (input tape labels) = *: 1
POINTING_SETS (mosaick field nr(s)) = *: *
CHANNELS (frequ channel nr(s)) = *: *
POLARISATION (XYX,XY,Y,X,YX) (polarisation(s)) = XYX: xy
HAB_OFFSET (start-offset in sec) = 0: 0

 Specify parameters for job 2:

INPUT_LABELS (input tape labels) = "": 2
POINTING_SETS (mosaick field nr(s)) = *: *
CHANNELS (frequ channel nr(s)) = *: *
POLARISATION (XYX,XY,Y,X,YX) (polarisation(s)) = XY: xy
HAB_OFFSET (start-offset in sec) = 0: 0

 Specify parameters for job 3:

INPUT_LABELS (input tape labels) = "": 3
POINTING_SETS (mosaick field nr(s)) = *: *
CHANNELS (frequ channel nr(s)) = *: *
```

```
POLARISATION (XYX,XY,Y,X,YX) (polarisation(s)) = XY:  [xy]
HAB_OFFSET (start-offset in sec) = 0:  [0]

 Specify parameters for job 4:

INPUT_LABELS (input tape labels) = "":  [<CR>]

 Job 1: Group 0
    Label   1: Sub-group 0.0
      OH     1: 0.0.0          RA=   84.68128 Dec=   49.82856
       Ch.   0: 0.0.0.0        F= 1416.11011 B=    2.32500
       Ch.   1: 0.0.0.1        F= 1417.34058 B=     .03906
       Ch.   2: 0.0.0.2        F= 1417.32104 B=     .03906
       Ch.   3: 0.0.0.3        F= 1417.30151 B=     .03906

         .    .     .                .                .
         .    .     .                .                .
         .    .     .                .                .

       Ch. 124: 0.0.0.124      F= 1414.93823 B=     .03906
       Ch. 125: 0.0.0.125      F= 1414.91870 B=     .03906
       Ch. 126: 0.0.0.126      F= 1414.89917 B=     .03906
       Ch. 127: 0.0.0.127      F= 1414.87964 B=     .03906

 Job 2: Group 1
    Label   2: Sub-group 1.0
      OH     1: 1.0.0          RA=  175.44167 Dec=   49.11306
       Ch.   0: 1.0.0.0        F= 1416.11011 B=    2.32500
       Ch.   1: 1.0.0.1        F= 1417.34058 B=     .03906
       Ch.   2: 1.0.0.2        F= 1417.32104 B=     .03906
       Ch.   3: 1.0.0.3        F= 1417.30151 B=     .03906

         .    .     .                .                .
         .    .     .                .                .
         .    .     .                .                .

       Ch. 124: 1.0.0.124      F= 1414.93823 B=     .03906
       Ch. 125: 1.0.0.125      F= 1414.91870 B=     .03906
       Ch. 126: 1.0.0.126      F= 1414.89917 B=     .03906
       Ch. 127: 1.0.0.127      F= 1414.87964 B=     .03906

 Job 3: Group 2
    Label   3: Sub-group 2.0
      OH     1: 2.0.0          RA=  212.38933 Dec=   52.43700
       Ch.   0: 2.0.0.0        F= 1416.11011 B=    2.32500
       Ch.   1: 2.0.0.1        F= 1417.34058 B=     .03906
       Ch.   2: 2.0.0.2        F= 1417.32104 B=     .03906
       Ch.   3: 2.0.0.3        F= 1417.30151 B=     .03906

         .    .     .                .                .
         .    .     .                .                .
         .    .     .                .                .

       Ch. 124: 2.0.0.124      F= 1414.93823 B=     .03906
       Ch. 125: 2.0.0.125      F= 1414.91870 B=     .03906
       Ch. 126: 2.0.0.126      F= 1414.89917 B=     .03906
       Ch. 127: 2.0.0.127      F= 1414.87964 B=     .03906

File description of node U6713:

Created: 30-Jul-1993 14:17  Revision(0): 30-Jul-1993 14:17
File contains 384 datasectors in 3 groups and has version 1


File layout:
```

```
0.0         contains    1 fields,  128 channels and    1 sectors for 3C147
1.0         contains    1 fields,  128 channels and    1 sectors for UGC6713
2.0         contains    1 fields,  128 channels and    1 sectors for 3C295
```

The final .SCN file contains the observations in chronological order. Groups 0 and 2 contain the calibrators while group 1 contains the actual 12 hour measurement.

2.2 A first correction and inspection of the UV data from the calibrators.

We will start with a first preliminary adjustment of the observed visibilities of the calibrators to the predicted visibilities using accurate and well established models for the calibrators. Adjusting the visibilities is achieved using the selfcal method which, by means of a fitting procedure, provides corrections for the gains and phases in such a way that the observed but corrected visibilities match the predicted ones. The models that are being used contain the accurate positions and fluxes of the sources in the field.

In our first attempt to find these corrections we will use all the data from a calibrator source including possible correlator spikes (CS's) and electromagnetic interference (EMI). These bad data however, might influence the solutions for the gain and phase corrections as found by the fitting procedure. If so, these bad data must be removed by flagging them in the .SCN file. Having done so, we can get better solutions for the gain and phase corrections by applying the selfcal method again on the cleaned data.

To be able to identify bad data we will inspect the so called Interferometer vs Hour Angle (IFRHA) maps. Since EMI and CS may be frequency and polarisation dependent we will make those maps for each channel and each polarisation. To get a better contrast we have to subtract the strong continuum sources using a model (i.e. positions and fluxes) of the sources in the field.

First we have to copy the models for the two calibrators into the current directory.

```
/dz1/users/verheyen/U6713/DWARFDATA> cp ../../CAL_MODELS/3C147_21CM.MDL .
/dz1/users/verheyen/U6713/DWARFDATA> cp ../../CAL_MODELS/3C295_21CM.MDL .
/dz1/users/verheyen/U6713/DWARFDATA> ll
total 159856
-rwxr-xr-x   1 verheyen kapteyn     1136 Jul 30 14:31 3C147_21CM.MDL
-rwxr-xr-x   1 verheyen kapteyn      800 Jul 30 14:31 3C295_21CM.MDL
-rw-r--r--   1 verheyen kapteyn    27661 Jul 30 14:28 NSC930730141601A.LOG
lrwxr-xr-x   1 verheyen kapteyn       20 Jul 30 14:28 NSCAN.LOG -> NSC930730141601A.LOG
-rwxr--r--   1 verheyen kapteyn 81761360 Jul 30 14:28 U6713.SCN
```

Now we will apply the selfcal method on the calibrator data which might contain bad data samples. Although we don't know if and where bad data samples are present, we will a priori discard interferometer 9A because it almost always suffers from EMI from the sun.

In this example we will only show the result for the first calibrator, i.e. 3C147. The procedure is analogous for the other calibrator except of course that we must read an other model.

```
/dz1/users/verheyen/U6713/DWARFDATA> exe ncalib

OPTION (REDUNDANCY,POLAR,SET,SHOW,QUIT) = QUIT: redundancy
SCN_MODE (input/output 'node' name) = "": U6713
LOOPS (niter,Setincr  ....) = "": 128,...1
SCN_SETS (Set(s) to do:  g.o.f.c.s ) = "": 0.0.0.0
POLARISATION (XYX,XY,Y,X,YX) (polarisation(s)) = XYX: xy
MODEL_OPTION (READ,WRITE,CLEAR,ZERO,SHOW,LIST,RSHOW,RLIST,
          TOT,ADD,CALIB,EDIT,FEDIT,MERGE,SORT,FSORT,DEL,
          DNCLOW,DCLOW,DAREA,QUIT) = QUIT: read
INPUT_MDL_MODE (input 'node' name) = "": 3C147_21CM
MODEL_OPTION (READ,WRITE,CLEAR,ZERO,SHOW,LIST,RSHOW,RLIST,
          TOT,ADD,CALIB,EDIT,FEDIT,MERGE,SORT,FSORT,DEL,
          DNCLOW,DCLOW,DAREA,QUIT) = QUIT: quit

 10 sources in list

MODEL_ACTION (MERGE,ADD,NEW,TEMPORARY,INCREMENT,BAND,NOBAND,
          TIME,NOTIME,INPOL,NOINPOL) = MERGE,BAND,TIME,NOINPOL:
           temporary
MWEIGHT_TYPE (STEP,GAUSSIAN,TRIANGLE,ISTEP,IGAUSSIAN,ITRIANGLE)
          = STEP: step
MWEIGHT_DATA (centre, halfwidth in m) = 0,100000: 0,100000
ALIGN_OPTION (SELFCAL,ALIGN) (type) = SELFCAL: selfcal

 Selfcalibration selected

HA_RANGE (DEG) (HA range) = *: *
HA_INTEGRATION (Integration time sec) = *: *
 All cross interferometers pre-selected
SELECT_IFRS (Select/de-select ifrs) = "": -ff,-mm,-9a

   0123456789ABCD
 0 ----------++++
 1  ---------++++
 2   --------++++
 3    -------++++
 4     ------++++
 5      -----++++
 6       ----++++
 7        ---++++
 8         --++++
 9          --+++
 A           ----
 B            ---
 C             --
 D              -
SELECT_IFRS (Select/de-select ifrs) = "": <CR>
SHOW_LEVEL (Level of type, print output) = 1,2: 1,2
QDETAILS (more details?) = NO: no
 Sector: 0.0.0.0

 X average amplitude= 5254.841 (15.569)
 Y average amplitude= 5429.507 (98.566)

 X overall noise (gain, phase in W.U.):     10.6      7.7
 Y overall noise (gain, phase in W.U.):     10.2      9.0
```

```
Sector: 0.0.0.1

X average amplitude= 4392.560 (57.049)
Y average amplitude= 4580.672 (113.309)

X overall noise (gain, phase in W.U.):     84.6     82.4
Y overall noise (gain, phase in W.U.):     94.6    110.3

Sector: 0.0.0.2

                              .
                              .
                              .
                              .
                              .

Sector: 0.0.0.126

X average amplitude= 137.895 (4.858)
Y average amplitude= 143.808 (5.334)

X overall noise (gain, phase in W.U.):    932.3    844.6
Y overall noise (gain, phase in W.U.):    820.5    825.4

Sector: 0.0.0.127
 -12.76Y Complex solution too slow

X average amplitude= 95.073 (4.199)
Y average amplitude= 99.194 (5.255)

X overall noise (gain, phase in W.U.):   1335.0   1347.4
Y overall noise (gain, phase in W.U.):   1346.6   1398.3
```

The gain and phase corrections found for each telescope as well as the residuals from the fit for each interferometer can be plotted. This can be done for each channel but we will do so only for channel 64. The results for the telescope corrections are shown in figure 1 and the residuals for each interferometer are shown in figure 2.

```
/dz1/users/verheyen/U6713/DWARFDATA> exe nplot
OPTION (MAP,DATA,MODEL,TELESCOPE,RESIDUAL,QUIT) = QUIT: telescope
PLOTTER (QMS,QMSP,REGIS,FREGIS,EPS,EPP,PSL,PSP, EAL,EAP,
         PAL,PAP,BIT1,BIT2,BIT3,X11,USE1,USE2) (plotter
         to use) = PSP: X11
IFR_MODE (NORMAL,SPECTRAL,SORT) = NORMAL: normal
SCN_NODE (input/output 'node' name) = "": U6713
LOOPS (niter,Setincr  ....) = "": <CR>
SCN_SETS (Set(s) to do:  g.o.f.c.s ) = "": 0.0.0.64
HA_RANGE (DEG) (HA range) = *: *
POLARISATION (XYX,XY,Y,X,YX) (polarisation(s)) = XY: xy
TELESCOPES (Telescope(s) to select) = *: *
DATA_TYPES (AMPLITUDE,PHASE,COSINE,SINE) (data types to
         plot) = AMPLITUDE,PHASE: amplitude,phase
SCALE_AMPL (plot scale W.U./mm or %/mm) = 4: 1
SCALE_PHASE (plot scale in W.U./mm or deg./mm) = 2: 2
HA_SCALE (HA plot scale degree/cm) = 15: 3
OPTION (MAP,DATA,MODEL,TELESCOPE,RESIDUAL,QUIT) = QUIT: residual
```

```
PLOTTER (QMS,QMSP,REGIS,FREGIS,EPS,EPP,PSL,PSP, EAL,EAP,
         PAL,PAP,BIT1,BIT2,BIT3,X11,USE1,USE2) (plotter
         to use) = X11: X11
IFR_MODE (NORMAL,SPECTRAL,SORT) = NORMAL: normal
SCN_MODE (input/output 'node' name) = U6713: U6713
LOOPS (niter,Setincr  ....) = "": <CR>
SCN_SETS (Set(s) to do:  g.o.f.c.s ) = "0.0.0.64": 0.0.0.64
HA_RANGE (DEG) (HA range) = *: *
POLARISATION (XYX,XY,Y,X,YX) (polarisation(s)) = XY: xy
MODEL_OPTION (READ,WRITE,CLEAR,ZERO,SHOW,LIST,RSHOW,RLIST,
         TOT,ADD,CALIB,EDIT,FEDIT,MERGE,SORT,FSORT,DEL,
         DNCLOW,DCLOW,DAREA,QUIT) = QUIT: read
INPUT_MDL_NODE (input 'node' name) = "": 3C147_21CM
MODEL_OPTION (READ,WRITE,CLEAR,ZERO,SHOW,LIST,RSHOW,RLIST,
         TOT,ADD,CALIB,EDIT,FEDIT,MERGE,SORT,FSORT,DEL,
         DNCLOW,DCLOW,DAREA,QUIT) = QUIT: quit

 10 sources in list

MODEL_ACTION (MERGE,ADD,NEW,TEMPORARY,INCREMENT,BAND,NOBAND,
         TIME,NOTIME,INPOL,NOINPOL) = MERGE,BAND,TIME,NOINPOL:
          temporary
 All fixed/movable interferometers pre-selected
SELECT_IFRS (Select/de-select ifrs) = "": -ff,-mm

   0123456789ABCD
 0 ----------++++
 1  ----------++++
 2   ---------++++
 3    --------++++
 4     -------++++
 5      ------++++
 6       -----++++
 7        ----++++
 8         ---++++
 9          --++++
 A           -++++
 B            ----
 C             ---
 D              --
SELECT_IFRS (Select/de-select ifrs) = "": <CR>
DATA_TYPES (AMPLITUDE,PHASE,COSINE,SINE) (data types to
         plot) = AMPLITUDE,PHASE: amplitude,phase
SCALE_AMPL (plot scale W.U./mm or %/mm) = 201.4199: 100
SCALE_PHASE (plot scale in W.U./mm or deg./mm) = 194.2984:
          100
HA_SCALE (HA plot scale degree/cm) = 15: 3
OPTION (MAP,DATA,MODEL,TELESCOPE,RESIDUAL,QUIT) = QUIT: quit
```

From figure 1 we see that the YY polarisation of telescope 7 suffers from strong gain variations. We may ask ourselves whether these variations are caused by the telescope and thus influence all 4 baselines 7A, 7B, 7C and 7D, or whether it originates in the correlator and occurs in only 1 baseline associated with telescope 7.

In the first case, the gain corrections for telescope 7 can not be improved since they are intrinsically connected to the telescope. In that case we must cope with 4 noisy baselines. In the second case we can improve the gain corrections for telescope

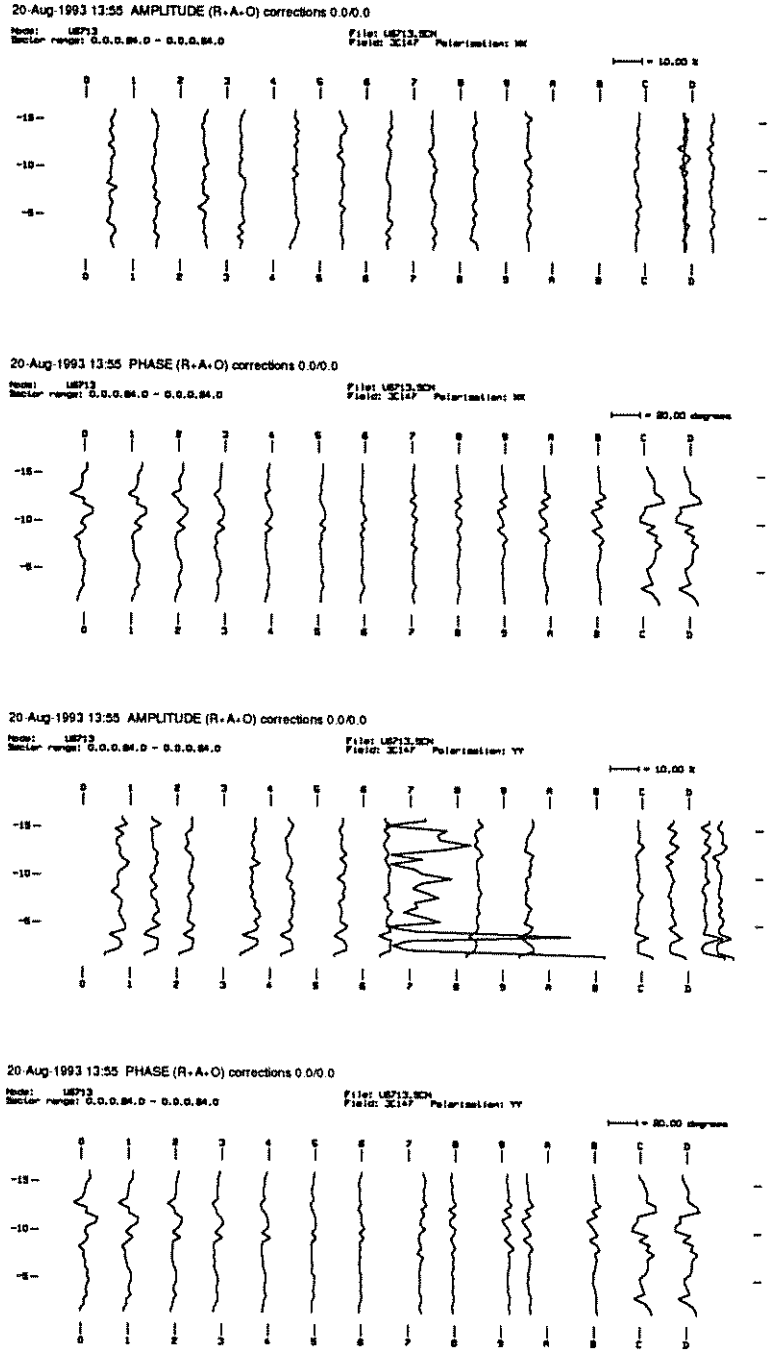

Figure 1: Telescope corrections for the gains and phases for XX and YY derived with the SELFCAL method using a model of the field. Note that the bad behaviour of telescope 7 at the YY polarisation influences the solutions for the other telscopes.

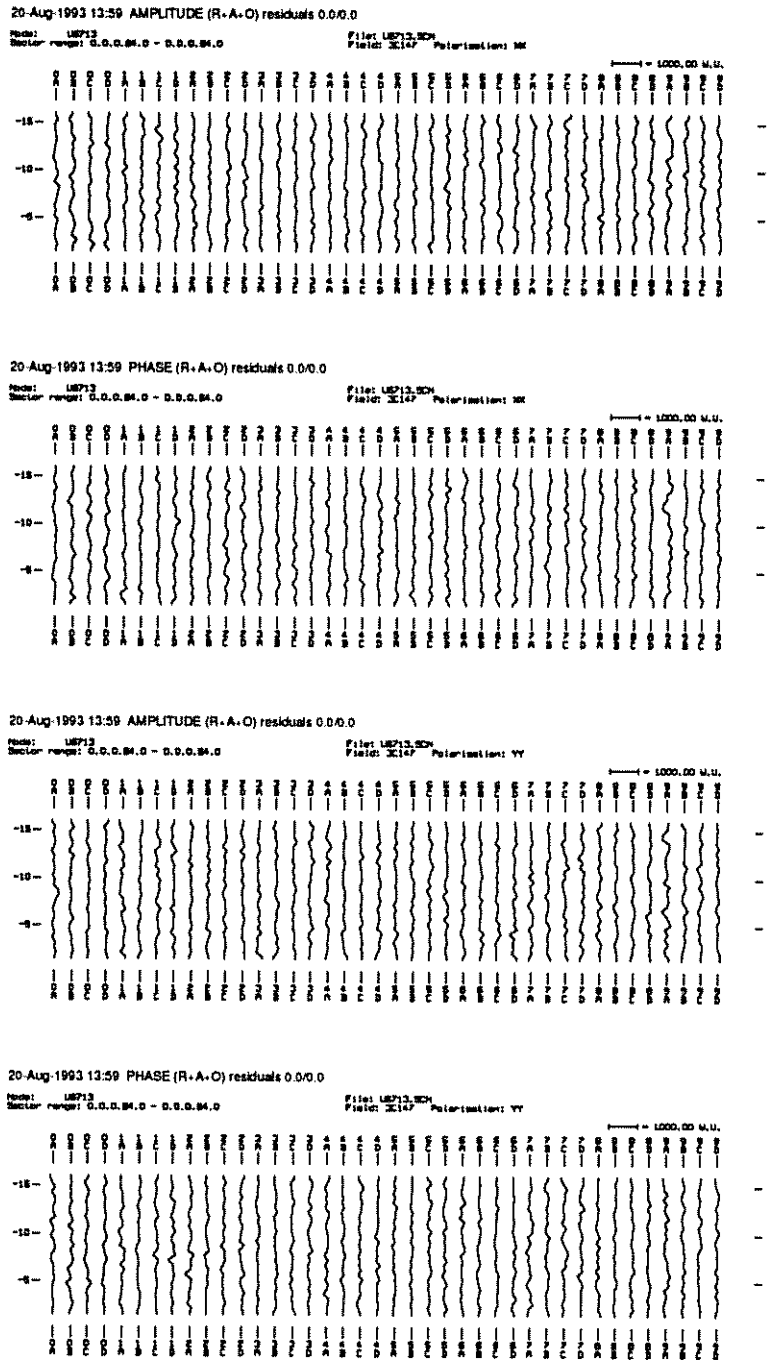

Figure 2: Interferometer residuals from fitting a model for the calibrator to the observed visibilities.

7 by applying the selfcal method again while ignoring the corrupted baseline.

Figure 2 helps us to decide with which case we are dealing. Inspection of the residuals of the fit for the baselines 7A, 7B, 7C and 7D shows that all four baselines have nearly equal residuals with average values very close to zero. This implies that the variations originate at the telescope and not in the correlator. Although telescope 7 is quite noisy or 'hot', we still can determine an average gain correction. However, we might discard the two strong peaks at the end of the observation because they influences the solutions for the other telescopes. In the next section we will show how to delete telescope 7 from the last part of the observation.

The effect of a correlator based error is illustrated in figure 3 in which the XX amplitude corrections and residuals are shown for another observation of the same calibrator. In this case the derived telescope corrections don't look suspicious but inspection of the residuals after subtraction of the model shows that baseline 7A is clearly offset from zero. In that case a better telescope correction might be derived by ommitting interferometer 7A and applying selfcal again.

Plotting the corrections and residuals however is not very efficient if we want to trace frequency dependent malfunctions. Therefor, we will make IFRHA maps while subtracting the model. We can display those maps of the residuals in a movie loop.

```
/dz1/users/verheyen/U6713/DWARFDATA> exe nmap

OPTION (MAKE,SHOW,FIDDLE,W16FITS,W32FITS,WRLFITS,FROM_OLD,
         TO_OLD,CVX,NVS,QUIT) = QUIT: make

LOOPS (niter,Setincr  ....) = "": 128,...1

 Input data:
SCN_NODE (input/output 'node' name) = "": U6713
SCN_SETS (Set(s) to do:  g.o.f.c.s ) = "": 0.0.0.0
HA_RANGE (DEG) (HA range) = *: *
 All fixed/movable interferometers pre-selected
SELECT_IFRS (Select/de-select ifrs) = "": -ff,-mm

   0123456789ABCD
 0 ----------++++
 1  ----------++++
 2   ----------++++
 3    ----------++++
 4     ----------++++
 5      ----------++++
 6       ----------++++
 7        ----------++++
 8         ----------++++
 9          ----------++++
 A           ----------
 B            ----------
 C             ----------
 D              ----------
SELECT_IFRS (Select/de-select ifrs) = "":  < CR >
SCN_NODE (input/output 'node' name) = "":  < CR >
USER_COMMENT (map comment) = "":  < CR >

 Map properties:
UV_COORDINATES (UV,BASHA,IFRHA) (coordinate type) = UV: IFRHA
```

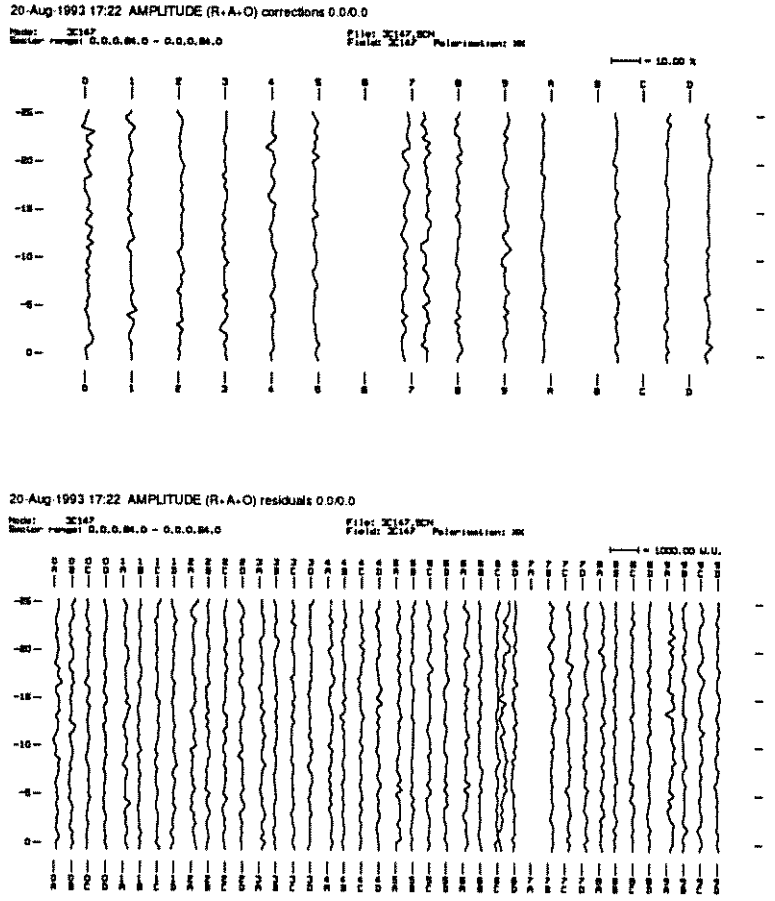

Figure 3: Illustration of the effect of a correlator based error on the results of a selfcal application.

```
HA_RESOLUTION (DEG) (HA bin width) = 0.50137 DEG:  0.5
IFR_RESOLUTION (interferometer separation) = 1:  1
FT_SIZE (FFT size) = 211,361:  211,361
OUT_SIZE (Output size) = 211,361:  211,361
QMAPS (More map details?) = NO:  no

 Data manipulations:
QDATAS (More data handling details?) = NO:  no
SUBTRACT (Source subtraction?) = NO:  yes
MODEL_OPTION (READ,WRITE,CLEAR,ZERO,SHOW,LIST,RSHOW,RLIST,
          TOT,ADD,CALIB,EDIT,FEDIT,MERGE,SORT,FSORT,DEL,
          DNCLOW,DCLOW,DAREA,QUIT) = QUIT:  read
INPUT_MDL_NODE (input 'node' name) = "":  3C147_21CM
MODEL_OPTION (READ,WRITE,CLEAR,ZERO,SHOW,LIST,RSHOW,RLIST,
          TOT,ADD,CALIB,EDIT,FEDIT,MERGE,SORT,FSORT,DEL,
          DNCLOW,DCLOW,DAREA,QUIT) = QUIT:  quit

 10 sources in list

MODEL_ACTION (MERGE,ADD,NEW,TEMPORARY,INCREMENT,BAND,NOBAND,
          TIME,NOTIME,INPOL,NOINPOL) = MERGE,BAND,TIME,NOINPOL:
           temporary

 Output files:
MAP_POLAR (XX,XY,YX,YY,I,Q,U,V,L,XXI,XYI,YXI,YYI,II,QI,UI,
          VI,LI) (polarisation info) = XX:  xx,yy
MAP_COORD (B1950_J2000,APPARENT,REFERENCE,AREFERENCE) (type
          of map coord.) = B1950_J2000:  B1950_J2000
OUTPUT (MAP,AP,COVER,REAL,IMAG,AMPL,PHASE) (Output types)
          = AMPL,PHASE:  ampl
OUTPUT_WMP_NODE (output 'node' name) = "":  3C147IFRHA
 Creating node 3C147IFRHA

 Sorting at 17:43:15 (Wall: 00:00:00.00  CPU: 00:00:00.00  I/O: 0 P/F:
0)
 Scan node U6713 started at 17:43:15
 Sector 0.0.0.0 started at 17:43:15

                                .
                                .
                                .
                                .
                                .

 End at 17:48:13 (Wall: 00:04:58.69  CPU: 00:03:14.00  I/O: 0  P/F:0)
```

Now we can visually inspect the UV data. Since the calibrator was observed for only a small hour angle range, we can select this range by AREA=. This will improve the resolution while diplaying the maps.

```
/dz1/users/verheyen/U6713/DWARFDATA>  exe ngids

OPTION (LOAD,GCLEAR,POINTS,FLAG,UFLAG,UNLOAD,WRITE,CLEAR,
          QUIT) = LOAD:  load
INPUT_WMP_NODE (input 'node' name) = "":  3C147IFRHA
WMP_SETS (Set(s) to do:  g.f.c.p.t.m) = "":  0.0.0-127.0.5
AREA (l,m,dl,dm) = 0,0,364,106:  -15,0,40,106
```

```
 Area(s) selected:
 Total    : l= -15, m= 0, dl= 40, dm= 106

MAP_COMPRESS (factor) = 1:  1
MAP_RANGE (minimum,maximum data value) = 0.1340293,8360.636:
           -100,1000
 Set 0.0.0.0.5.0 will be loaded
 Set 0.0.1.0.5.0 will be loaded
 Set 0.0.2.0.5.0 will be loaded
 Set 0.0.3.0.5.0 will be loaded
 Set 0.0.4.0.5.0 will be loaded
             .
             .
             .
             .
             .
 Set 0.0.124.0.5.0 will be loaded
 Set 0.0.125.0.5.0 will be loaded
 Set 0.0.126.0.5.0 will be loaded
 Set 0.0.127.0.5.0 will be loaded
OPTION (LOAD,GCLEAR,POINTS,FLAG,UFLAG,UNLOAD,WRITE,CLEAR,
         QUIT) = QUIT:  quit
```

In the same way we can inspect the YY polarisation in this .WMP file (g.f.c.p.t.m=0.0.0-127.1.5). It turns out that there are no CS's or EMI present in this observation of 3C147. An error free IFRHA map of 3C147 is shown in figure 4.

Inspection of the second calibrator 3C295 shows that a correlator spike occurred in one scan on baseline 2C at the XX polarisation (see figure 4b). However, for this interferometer we can use the rest of the data to compute the correction. Therefore we don't want to flag this interferometer entirely.

2.3 Flagging the bad UV data of the calibrators.

First we will show how to identify and flag the correlator spike in the observation of 3C295. Then we will flag telescope 7 in the observation of 3C147. The identification can be done by loading a map in which the spike is very obvious (channel 8) into NGIDS (OPTION=LOAD). Then we will zoom in on the spike using the GIDS menu. Next we will identify the interferometer and scan (OPTION=FLAG) using the cursor. Finally we write the position into an ascii file (OPTION=WRITE) which might be edited if necessary.

```
/dz1/users/verheyen/U6713/DWARFDATA> exe ngids

OPTION (LOAD,GCLEAR,POINTS,FLAG,UFLAG,UNLOAD,WRITE,CLEAR,
         QUIT) = LOAD:  load
INPUT_WMP_NODE (input 'node' name) = "":  3C295IFRHA
WMP_SETS (Set(s) to do:  g.f.c.p.t.m) = "":  0.0.8.0.5
AREA (l,m,dl,dm) = 0,0,364,106:  122,0,40,106

 Area(s) selected:
 Total    : l= 122, m= 0, dl= 40, dm= 106

MAP_COMPRESS (factor) = 1:  1
```

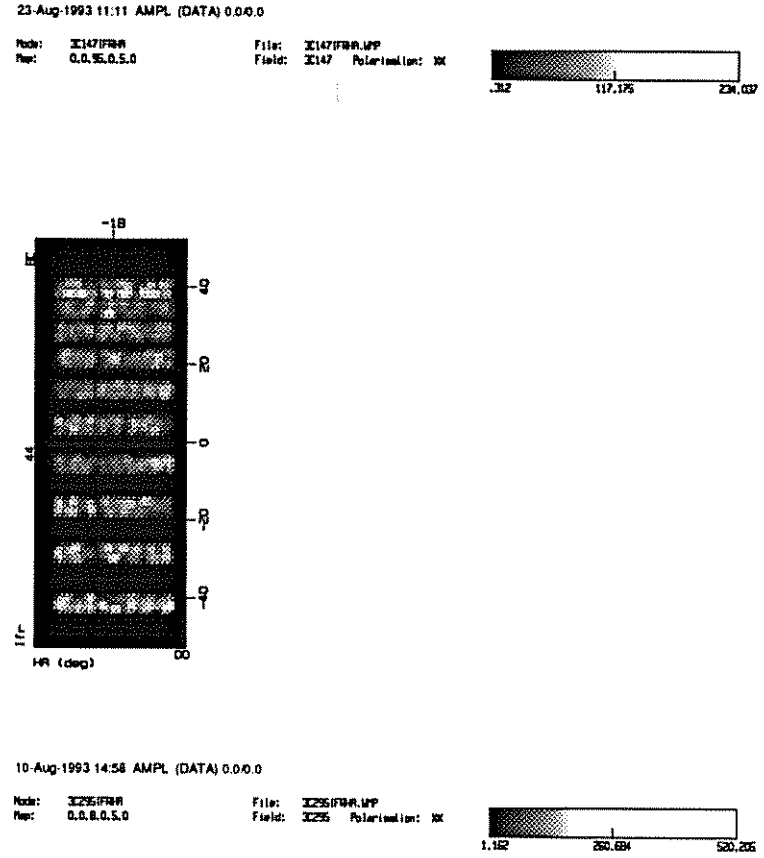

Figure 4: IFRHA maps. A) Channel 95 for the XX polarisation of 3C147 (upper panel). Note the noisy behaviour of baseline 9A. B) Channel 8 for the XX polarisation of 3C295 (lower panel).

```
MAP_RANGE (minimum,maximum data value) = 1.161745,520.2054:
           -100,1000
 Set 0.0.8.0.5.0 will be loaded
OPTION (LOAD,GCLEAR,POINTS,FLAG,UFLAG,UNLOAD,WRITE,CLEAR,
         QUIT) = QUIT:  flag
   127,   -16:    520.21 WU at (2C,       63.5)
OPTION (LOAD,GCLEAR,POINTS,FLAG,UFLAG,UNLOAD,WRITE,CLEAR,
         QUIT) = QUIT:  write
OUTPUT_FILE (output filename) = "FLAG.LOG":  3C295XX.FLAG
 1 entries in file 3C295XX.FLAG
OPTION (LOAD,GCLEAR,POINTS,FLAG,UFLAG,UNLOAD,WRITE,CLEAR,
         QUIT) = QUIT:  quit
```

The ascii file looks like

```
!+ Flagging file 3C295XX.FLAG
!  Created by VERHEYEN on 930809 at 18:32:09 at zanstra
!  Flags:
!       MAN : 80  CLIP: 40  MOIS: 20  ADD : 10
!       SHAD: 08  U3  : 04  U2  : 02  U1  : 01
!  Types:
!       00:  Interprete Ifr field as interferometer
!       01:  Interprete Ifr field as baselines in m
!  Data following an ! are seen as comments
!  Remaining fields have format:
!       *:          all values
!       value:      single value
!       val1=val2:  value range (inclusive)
!
!-
!Flag  Type  Channel       Hour-angle          Ifr         Pol
80     00    *             63.45               2C          *
```

We see that all channels and all polarisations can be flagged for the specified hour angle and interferometer. However, since the spike only occurs in the XX polarisation and not in the YY polarisation we might edit this ascii file and replace '*' by 'XX' for the Pol(arisation). This might allow us in the future to replace the flagged XX data point by the YY value assuming that the radiation in unpolarized. This is not worthwhile for a single spike or a single interferometer but if there is a lot of data missing for one polarisation, this procedure may help us to recover the UV coverage and improve the antenna pattern. The trade-off is an increase of the noise by a factor $\sqrt{2}$. In this case we will not replace the missing polarisation data.

Finally after editing the file and replacing '*' by 'XX' we can use this ascii file to actually flag this point. (At the time this document was prepared, August 12 1993, the program NFLAG can not interprete 2C as the specified interferometer and 2C should be replaced by C2 in the ascii file!)

```
/dz1/users/verheyen/U6713/DWARFDATA>  exe nflag

OPTION (SHOW,FLAG,QUIT) = QUIT:  flag
FLAG_OPTION (FLAG,CLEAR,LOAD,UNLOAD,WRITE,READ,QUIT) = FLAG:
           read
INPUT_FILE (input filename) = "FLAG.LOG":  3C295XX.FLAG
 1 entries in list
```

```
FLAG_OPTION (FLAG,CLEAR,LOAD,UNLOAD,WRITE,READ,QUIT) = FLAG:
          flag
INPUT_SCN_NODE (input 'node' name) = "":  U6713
SCN_SETS (Set(s) to do:  g.o.f.c.s ) = "":  2.0.0.0-127
POLARISATION (XYX,XY,Y,X,YX) (polarisation(s)) = XYX:  xy
 All auto/cross interferometers pre-selected
SELECT_IFRS (Select/de-select ifrs) = "":  -ff,-mm

   0123456789ABCD
 0 +----------++++
 1  +---------++++
 2   +--------++++
 3    +-------++++
 4     +------++++
 5      +-----++++
 6       +----++++
 7        +---++++
 8         +--++++
 9          +-++++
 A           +++++
 B            +---
 C             +--
 D              +-
SELECT_IFRS (Select/de-select ifrs) = "":  <CR>
HA_RANGE (DEG) (HA range) = *:  *
FLAG_MODE (FLAG,UNFLAG,CORR,NOCORR,SHOW,NOSHOW,FHEAD,FDATA,
          NOFORCE,UFLAG,CONT,NEXT,NODE,QUIT) = FLAG:  show
FLAG_MODE (FLAG,UNFLAG,CORR,NOCORR,SHOW,NOSHOW,FHEAD,FDATA,
          NOFORCE,UFLAG,CONT,NEXT,NODE,QUIT) = FLAG:  flag
FLAG_MODE (FLAG,UNFLAG,CORR,NOCORR,SHOW,NOSHOW,FHEAD,FDATA,
          NOFORCE,UFLAG,CONT,NEXT,NODE,QUIT) = CONT:  cont
 Current modes: FLAG     SHOW      UNFILLED  NOCORRECT
OPERATION_0 (ALL,HA,>,<,MAX,ANOISE,RNOISE,XRN,YRN,XAN,YAN,
          IFR,CLIP,RRESID,ARESID,CONT,MODE,NEXT,NODE,QUIT)
          = MODE:  cont
OPERATION_1 (TOTEL,TODATA,TOHEAD,GET,PUT,CONT,MODE,NEXT,
          NODE,QUIT) = MODE:  put
 1 entries in list
 Flagging individual UV points
PUT_RANGE (chan,HA,ifr,pol) = ".",".",".",".":  <CR>
 HA    63.50 interferometers flagged for sector 2.0.0.0.0
 HA    63.50 interferometers flagged for sector 2.0.0.1.0
 HA    63.50 interferometers flagged for sector 2.0.0.2.0
 HA    63.50 interferometers flagged for sector 2.0.0.3.0

                                .
                                .
                                .
                                .
                                .

 HA    63.50 interferometers flagged for sector 2.0.0.124.0
 HA    63.50 interferometers flagged for sector 2.0.0.125.0
 HA    63.50 interferometers flagged for sector 2.0.0.126.0
 HA    63.50 interferometers flagged for sector 2.0.0.127.0
 Current modes: FLAG     SHOW      UNFILLED  NOCORRECT
OPERATION_1 (TOTEL,TODATA,TOHEAD,GET,PUT,CONT,MODE,NEXT,
          NODE,QUIT) = MODE:  quit
FLAG_OPTION (FLAG,CLEAR,LOAD,UNLOAD,WRITE,READ,QUIT) = QUIT:
          quit
OPTION (SHOW,FLAG,QUIT) = QUIT:  quit
```

If we like we can check whether the data has been flagged indeed. This can be done in two ways. First we can specify a hypercube and count the total number of flags for a certain baseline in that hypercube. We can also look more specific at the data directly and inspect the weight assigned to each data sample. A negative weight means that the data is flagged.

```
/dz1/users/verheyen/U6713/DWARFDATA> exe nflag

OPTION (SHOW,FLAG,QUIT) = QUIT: show
INPUT_SCN_NODE (input 'node' name) = "": u6713

 File description of node U6713:

 Created: 30-Jul-1993 14:17  Revision(73): 12-Aug-1993 12:16
 File contains 384 datasectors in 3 groups and has version 1

FILE_ACTION (LAYOUT,SHOW,EDIT,CONT,QUIT) = CONT: cont
```

```
SCN_SETS (Set(s) to do:  g.o.f.c.s ) = "":  2.0.0.64.0

  Sector 2.0.0.64.0(#320) - 3C295 - Channel 64 - 26 scans - 2 polarisations

 RA (date)    212.7803 deg    HA(start)      54.98 deg    Obs.day         207
 DEC(date)     52.2367 deg    HA(end)        67.51 deg    Obs.year         93
 RA (1950)    212.3893 deg    HA(step)         .50 deg    Epoch         1993.57
 DEC(1950)     52.4370 deg    HA(average)      .50 deg    Volgnummer 9303622
 Frequency  1416.1101 MHz     # of ifrs      40           Backend          2
 Bandwidth     .0391 MHz      Prec. rot.      -.22 deg    Pointing Set     0
                                                          MJD(start)   49194.87898

 Telescope positions 9, A, B, C, D = 1296, 1332, 1404, 2628, 2700
 REDUN M.E.        .0,       .0,       .0,       .0
 ALIGN M.E.     48.0,     46.5,     48.7,     46.3

SECTOR_ACTION (NEXT,IFRS,NAME,FLAGS,SHOW,EDIT,CONT,QUIT)
         = CONT:  flags
HA_RANGE (DEG) (HA range) = *:  *
POLARISATION (XYX,XY,Y,X,YX) (polarisation(s)) = XYX:  xy

                                Flag count
         0   1   2   3   4   5   6   7   8   9   A   B   C   D  .
         .   .   .   .   .   .   .   .   .   .   .   .   .   .  0
     0   .   .   .   .   .   .   .   .   .   .   .   .   .   .  1
     1   .   .   .   .   .   .   .   .   .   .   .   .   1   .  2
     2   .   .   .   .   .   .   .   .   .   .   .   .   .   .  3
     3   .   .   .   .   .   .   .   .   .   .   .   .   .   .  4
     4   .   .   .   .   .   .   .   .   .   .   .   .   .   .  5
     5   .   .   .   .   .   .   .   .   .   .   .   .   .   .  6
     6   .   .   .   .   .   .   .   .   .   .   .   .   .   .  7
     7   .   .   .   .   .   .   .   .   .   .   .   .   .   .  8
     8   .   .   .   .   .   .   .   .   .   .   .   .   .   .  9
     9   .   .   .   .   .   .   .   .   .   .   .   .   .   .  A
     A  52  52  52  52  52  52  52  52  52  52   .   .   .   .  B
     B  52  52  52  52  52  52  52  52  52  52   .   .   .   .  C
     C  52  52  52  52  52  52  52  52  52  52   .   .   .   .  D
     D  52  52  52  52  52  52  52  52  52  52   .   .   .   .  .
         0   1   2   3   4   5   6   7   8   9   A   B   C   D  .
                               Data count

SCN_SETS (Set(s) to do:  g.o.f.c.s ) = "":  2.0.0.64

  Sector 2.0.0.64.0(#320) - 3C295 - Channel 64 - 26 scans - 2 polarisations

 RA (date)    212.7803 deg    HA(start)      54.98 deg    Obs.day         207
 DEC(date)     52.2367 deg    HA(end)        67.51 deg    Obs.year         93
 RA (1950)    212.3893 deg    HA(step)         .50 deg    Epoch         1993.57
 DEC(1950)     52.4370 deg    HA(average)      .50 deg    Volgnummer 9303622
 Frequency  1416.1101 MHz     # of ifrs      40           Backend          2
 Bandwidth     .0391 MHz      Prec. rot.      -.22 deg    Pointing Set     0
                                                          MJD(start)   49194.87898

 Telescope positions 9, A, B, C, D = 1296, 1332, 1404, 2628, 2700
 REDUN M.E.        .0,       .0,       .0,       .0
 ALIGN M.E.     48.0,     46.5,     48.7,     46.3

SECTOR_ACTION (NEXT,IFRS,NAME,FLAGS,SHOW,EDIT,CONT,QUIT)
         = CONT:  cont
```

```
SCAN_ACTION (XX,XY,YX,YY,ha,>[n],<[n],S,D,A,W,T,E,Q) = ">":
          63

 HA           62.9983 deg    Maximum     7723.00 W.U.   Bits      00000000
 Extinction    1.00000       Refraction     1.00000     Faraday          .0 deg
 Red. noise:       .00,        .00,        .00,        .00
 Align noise:    55.44,      49.69,      39.94,      46.18

SCAN_ACTION (XX,XY,YX,YY,ha,>[n],<[n],S,D,A,W,T,E,Q) = ">":
          W

                          XX Data weight (*1.0000)
        0    1    2    3    4    5    6    7    8    9    A    B    C    D  .
        .    .    .    .    .    .    .    .    .    .  105  240  186  202  0
    0   .    .    .    .    .    .    .    .    .    .  111  255  198  214  1
    1   .    .    .    .    .    .    .    .    .    .  119  272  210  228  2
    2   .    .    .    .    .    .    .    .    .    .  139  318  247  267  3
    3   .    .    .    .    .    .    .    .    .    .  136  310  240  260  4
    4   .    .    .    .    .    .    .    .    .    .  133  303  235  254  5
    5   .    .    .    .    .    .    .    .    .    .  111  255  198  214  6
    6   .    .    .    .    .    .    .    .    .    .  120  274  213  230  7
    7   .    .    .    .    .    .    .    .    .    .  140  319  248  268  8
    8   .    .    .    .    .    .    .    .    .    .  125  285  222  239  9
    9   .    .    .    .    .    .    .    .    .    .    .    .    .    .  A
    A   .    .    .    .    .    .    .    .    .    .    .    .    .    .  B
    B   .    .    .    .    .    .    .    .    .    .    .    .    .    .  C
    C   .    .    .    .    .    .    .    .    .    .    .    .    .    .  D
    D   .    .    .    .    .    .    .    .    .    .    .    .    .    .  .
        0    1    2    3    4    5    6    7    8    9    A    B    C    D  .
                              XX Data flags

SCAN_ACTION (XX,XY,YX,YY,ha,>[n],<[n],S,D,A,W,T,E,Q) = ">": <CR>

 HA           63.4996 deg    Maximum     7537.00 W.U.   Bits      00000000
 Extinction    1.00000       Refraction     1.00000     Faraday          .0 deg
 Red. noise:       .00,        .00,        .00,        .00
 Align noise:    49.19,      34.15,      60.05,      45.24

SCAN_ACTION (XX,XY,YX,YY,ha,>[n],<[n],S,D,A,W,T,E,Q) = ">":
          W

                          XX Data weight (*1.0000)
        0    1    2    3    4    5    6    7    8    9    A    B    C    D  .
        .    .    .    .    .    .    .    .    .    .  105  240  186  202  0
    0   .    .    .    .    .    .    .    .    .    .  111  255  198  214  1
    1   .    .    .    .    .    .    .    .    .    .  119  272 -210  228  2
    2   .    .    .    .    .    .    .    .    .    .  139  318  247  267  3
    3   .    .    .    .    .    .    .    .    .    .  136  310  240  260  4
    4   .    .    .    .    .    .    .    .    .    .  133  303  235  254  5
    5   .    .    .    .    .    .    .    .    .    .  111  255  198  214  6
    6   .    .    .    .    .    .    .    .    .    .  120  274  213  230  7
    7   .    .    .    .    .    .    .    .    .    .  140  319  248  268  8
    8   .    .    .    .    .    .    .    .    .    .  125  285  222  239  9
    9   .    .    .    .    .    .    .    .    .    .    .    .    .    .  A
    A   .    .    .    .    .    .    .    .    .    .    .    .    .    .  B
    B   .    .    .    .    .    .    .    .    .    .    .    .    .    .  C
    C   .    .   01    .    .    .    .    .    .    .    .    .    .    .  D
    D   .    .    .    .    .    .    .    .    .    .    .    .    .    .  .
        0    1    2    3    4    5    6    7    8    9    A    B    C    D  .
                              XX Data flags
```

```
SCAN_ACTION (XX,XY,YX,YY,ha,>[n],<[n],S,D,A,W,T,E,Q) = ">":  <CR>

 HA           64.0010 deg    Maximum     7548.00 W.U.   Bits       00000000
 Extinction    1.00000       Refraction     1.00000     Faraday          .0 deg
 Red. noise:       .00,        .00,        .00,        .00
 Align noise:    53.89,      47.84,      57.90,      42.21

SCAN_ACTION (XX,XY,YX,YY,ha,>[n],<[n],S,D,A,W,T,E,Q) = ">":
          w

                          XX Data weight (*1.0000)
        0    1    2    3    4    5    6    7    8    9    A    B    C    D  .
        .    .    .    .    .    .    .    .    .    .  105  240  186  202  0
    0   .    .    .    .    .    .    .    .    .    .  111  255  198  214  1
    1   .    .    .    .    .    .    .    .    .    .  119  272  210  228  2
    2   .    .    .    .    .    .    .    .    .    .  139  318  247  267  3
    3   .    .    .    .    .    .    .    .    .    .  136  310  240  260  4
    4   .    .    .    .    .    .    .    .    .    .  133  303  235  254  5
    5   .    .    .    .    .    .    .    .    .    .  111  255  198  214  6
    6   .    .    .    .    .    .    .    .    .    .  120  274  213  230  7
    7   .    .    .    .    .    .    .    .    .    .  140  319  248  268  8
    8   .    .    .    .    .    .    .    .    .    .  125  285  222  239  9
    9   .    .    .    .    .    .    .    .    .    .    .    .    .    .  A
    A   .    .    .    .    .    .    .    .    .    .    .    .    .    .  B
    B   .    .    .    .    .    .    .    .    .    .    .    .    .    .  C
    C   .    .    .    .    .    .    .    .    .    .    .    .    .    .  D
    D   .    .    .    .    .    .    .    .    .    .    .    .    .    .  .
        0    1    2    3    4    5    6    7    8    9    A    B    C    D  .
                              XX Data flags

SCAN_ACTION (XX,XY,YX,YY,ha,>[n],<[n],S,D,A,W,T,E,Q) = ">":
          63

 HA           62.9983 deg    Maximum     7723.00 W.U.   Bits       00000000
 Extinction    1.00000       Refraction     1.00000     Faraday          .0 deg
 Red. noise:       .00,        .00,        .00,        .00
 Align noise:    55.44,      49.69,      39.94,      46.18

SCAN_ACTION (XX,XY,YX,YY,ha,>[n],<[n],S,D,A,W,T,E,Q) = ">":
          yy
SCAN_ACTION (XX,XY,YX,YY,ha,>[n],<[n],S,D,A,W,T,E,Q) = ">":
          w

                          YY Data weight (*1.0000)
        0    1    2    3    4    5    6    7    8    9    A    B    C    D  .
        .    .    .    .    .    .    .    .    .    .  110  280  219  230  0
    0   .    .    .    .    .    .    .    .    .    .   93  237  185  194  1
    1   .    .    .    .    .    .    .    .    .    .  114  292  228  239  2
    2   .    .    .    .    .    .    .    .    .    .  105  269  210  222  3
    3   .    .    .    .    .    .    .    .    .    .  115  293  229  240  4
    4   .    .    .    .    .    .    .    .    .    .  115  294  230  242  5
    5   .    .    .    .    .    .    .    .    .    .  109  278  218  229  6
    6   .    .    .    .    .    .    .    .    .    .  100  255  200  210  7
    7   .    .    .    .    .    .    .    .    .    .  115  294  230  242  8
    8   .    .    .    .    .    .    .    .    .    .  108  274  214  225  9
    9   .    .    .    .    .    .    .    .    .    .    .    .    .    .  A
    A   .    .    .    .    .    .    .    .    .    .    .    .    .    .  B
    B   .    .    .    .    .    .    .    .    .    .    .    .    .    .  C
    C   .    .    .    .    .    .    .    .    .    .    .    .    .    .  D
    D   .    .    .    .    .    .    .    .    .    .    .    .    .    .  .
        0    1    2    3    4    5    6    7    8    9    A    B    C    D  .
                              YY Data flags
```

```
SCAN_ACTION (XX,XY,YX,YY,ha,>[n],<[n],S,D,A,W,T,E,Q) = ">": <CR>

 HA           63.4996 deg    Maximum     7537.00 W.U.   Bits      00000000
 Extinction    1.00000       Refraction     1.00000     Faraday          .0 deg
 Red. noise:       .00,        .00,        .00,        .00
 Align noise:    49.19,      34.15,      60.05,      45.24

SCAN_ACTION (XX,XY,YX,YY,ha,>[n],<[n],S,D,A,W,T,E,Q) = ">":
          w

                        YY Data weight (*1.0000)
        0   1   2   3   4   5   6   7   8   9   A   B   C   D .
        .   .   .   .   .   .   .   .   .   .  110 280 219 230 0
    0   .   .   .   .   .   .   .   .   .   .   93 237 185 194 1
    1   .   .   .   .   .   .   .   .   .   .  114 292 228 239 2
    2   .   .   .   .   .   .   .   .   .   .  105 269 210 222 3
    3   .   .   .   .   .   .   .   .   .   .  115 293 229 240 4
    4   .   .   .   .   .   .   .   .   .   .  115 294 230 242 5
    5   .   .   .   .   .   .   .   .   .   .  109 278 218 229 6
    6   .   .   .   .   .   .   .   .   .   .  100 255 200 210 7
    7   .   .   .   .   .   .   .   .   .   .  115 294 230 242 8
    8   .   .   .   .   .   .   .   .   .   .  108 274 214 225 9
    9   .   .   .   .   .   .   .   .   .   .   .   .   .   .  A
    A   .   .   .   .   .   .   .   .   .   .   .   .   .   .  B
    B   .   .   .   .   .   .   .   .   .   .   .   .   .   .  C
    C   .   .   .   .   .   .   .   .   .   .   .   .   .   .  D
    D   .   .   .   .   .   .   .   .   .   .   .   .   .   .  .
        0   1   2   3   4   5   6   7   8   9   A   B   C   D  .
                          YY Data flags

SCAN_ACTION (XX,XY,YX,YY,ha,>[n],<[n],S,D,A,W,T,E,Q) = ">": <CR>

 HA           64.0010 deg    Maximum     7548.00 W.U.   Bits      00000000
 Extinction    1.00000       Refraction     1.00000     Faraday          .0 deg
 Red. noise:       .00,        .00,        .00,        .00
 Align noise:    53.89,      47.84,      57.90,      42.21

SCAN_ACTION (XX,XY,YX,YY,ha,>[n],<[n],S,D,A,W,T,E,Q) = ">":
          w

                        YY Data weight (*1.0000)
        0   1   2   3   4   5   6   7   8   9   A   B   C   D .
        .   .   .   .   .   .   .   .   .   .  110 280 219 230 0
    0   .   .   .   .   .   .   .   .   .   .   93 237 185 194 1
    1   .   .   .   .   .   .   .   .   .   .  114 292 228 239 2
    2   .   .   .   .   .   .   .   .   .   .  105 269 210 222 3
    3   .   .   .   .   .   .   .   .   .   .  115 293 229 240 4
    4   .   .   .   .   .   .   .   .   .   .  115 294 230 242 5
    5   .   .   .   .   .   .   .   .   .   .  109 278 218 229 6
    6   .   .   .   .   .   .   .   .   .   .  100 255 200 210 7
    7   .   .   .   .   .   .   .   .   .   .  115 294 230 242 8
    8   .   .   .   .   .   .   .   .   .   .  108 274 214 225 9
    9   .   .   .   .   .   .   .   .   .   .   .   .   .   .  A
    A   .   .   .   .   .   .   .   .   .   .   .   .   .   .  B
    B   .   .   .   .   .   .   .   .   .   .   .   .   .   .  C
    C   .   .   .   .   .   .   .   .   .   .   .   .   .   .  D
    D   .   .   .   .   .   .   .   .   .   .   .   .   .   .  .
        0   1   2   3   4   5   6   7   8   9   A   B   C   D  .
                          YY Data flags

SCAN_ACTION (XX,XY,YX,YY,ha,>[n],<[n],S,D,A,W,T,E,Q) = ">":
          q
SECTOR_ACTION (NEXT,IFRS,NAME,FLAGS,SHOW,EDIT,CONT,QUIT)
         = CONT: quit
```

```
FILE_ACTION (LAYOUT,SHOW,EDIT,CONT,QUIT) = CONT: quit
INPUT_SCN_NODE (input 'node' name) = "": <CR>
OPTION (SHOW,FLAG,QUIT) = QUIT: quit
```

In the first table we can see that 1 flag has been set for 2C somewhere in the hypercube. Looking into more detail and inspecting the 6 following tables we see that the flag has indeed been set for the XX polarisation at hour angle 63.50 degrees.

Finally we will flag telescope 7. From figure 1 we see that the noise in the YY polarisation increases at hour angles less then 5 degrees. To flag this data range we can make a simple ascii file called 3C147YY.FLAG which only contains the lines

```
01      00      *          -5.00=90.00          A7          YY
01      00      *          -5.00=90.00          B7          YY
01      00      *          -5.00=90.00          C7          YY
01      00      *          -5.00=90.00          D7          YY
```

so only the hour angles less the -5 degrees will be flagged for the YY polarisation of telescope 7. We can put these flags to the data as is outlined before.

2.4 Determining improved telescope corrections for the calibrators.

Now that we got rid of bad data samples we can use the selfcal mechanism again to correct the gains and phases for each telescope such that they coincide with the predicted gains and phases for the model. First we have to set the previously determined corrections back to zero. For 3C147 we have to do this only for the YY polarisation.

```
/dz1/users/verheyen/U6713/DWARFDATA> exe ncalib

OPTION (REDUNDANCY,POLAR,SET,SHOW,QUIT) = QUIT: set
SET_OPTION (ZERO,MANUAL,COPY,CCOPY,LINE,EXT,REF,IREF,CLK,
          FAR,POLE,DX,DY,DZ,FREQ,SHIFT,RENORM,QUIT) = QUIT:
            zero
ZERO (ALL,NONE,RED,ALG,OTH,EXT,REF,CLK,FAR,NOGAIN,NOPHASE)
          (zero corrections) = NONE: all
SCN_NODE (input/output 'node' name) = "": U6713
SCN_SETS (Set(s) to do:  g.o.f.c.s ) = "": 0.0.0.*
POLARISATION (XYX,XY,Y,X,YX) (polarisation(s)) = XYX: y
HA_RANGE (DEG) (HA range) = *: *
OPTION (REDUNDANCY,POLAR,SET,SHOW,QUIT) = QUIT: quit
```

Now we can run selfcal again.

```
/dz1/users/verheyen/U6713/DWARFDATA> exe ncalib

OPTION (REDUNDANCY,POLAR,SET,SHOW,QUIT) = QUIT: redundancy
SCN_NODE (input/output 'node' name) = "": U6713
LOOPS (niter,Setincr  ....) = "": 128,...1
```

```
SCN_SETS (Set(s) to do:  g.o.f.c.s ) = "": 0.0.0.0
POLARISATION (XYI,XY,Y,X,YX) (polarisation(s)) = XYI: y
MODEL_OPTION (READ,WRITE,CLEAR,ZERO,SHOW,LIST,RSHOW,RLIST,
          TOT,ADD,CALIB,EDIT,FEDIT,MERGE,SORT,FSORT,DEL,
          DNCLOW,DCLOW,DAREA,QUIT) = QUIT: read
INPUT_MDL_NODE (input 'node' name) = "": 3C147_21CM
MODEL_OPTION (READ,WRITE,CLEAR,ZERO,SHOW,LIST,RSHOW,RLIST,
          TOT,ADD,CALIB,EDIT,FEDIT,MERGE,SORT,FSORT,DEL,
          DNCLOW,DCLOW,DAREA,QUIT) = QUIT: quit

 10 sources in list

MODEL_ACTION (MERGE,ADD,NEW,TEMPORARY,INCREMENT,BAND,NOBAND,
          TIME,NOTIME,INPOL,NOINPOL) = MERGE,BAND,TIME,NOINPOL:
          temporary
MWEIGHT_TYPE (STEP,GAUSSIAN,TRIANGLE,ISTEP,IGAUSSIAN,ITRIANGLE)
          = STEP: step
MWEIGHT_DATA (centre, halfwidth in m) = 0,100000: 0,100000
ALIGN_OPTION (SELFCAL,ALIGN) (type) = SELFCAL: selfcal

 Selfcalibration selected

HA_RANGE (DEG) (HA range) = *: *
HA_INTEGRATION (Integration time sec) = *: *
 All cross interferometers pre-selected
SELECT_IFRS (Select/de-select ifrs) = "": -ff,-mm,-9a

   0123456789ABCD
 0 ----------++++
 1  ---------++++
 2   --------++++
 3    -------++++
 4     ------++++
 5      -----++++
 6       ----++++
 7        ---++++
 8         --++++
 9          --+++
 A           ----
 B            ---
 C             --
 D              -
SELECT_IFRS (Select/de-select ifrs) = "": <CR>
SHOW_LEVEL (Level of type, print output) = 1,2: 1,2
QDETAILS (more details?) = NO: no
 Sector: 0.0.0.0

 Y average amplitude= 5429.507 (98.566)

 Y overall noise (gain, phase in W.U.):     10.2      9.0

 Sector: 0.0.0.1

 Y average amplitude= 4580.672 (113.309)

 Y overall noise (gain, phase in W.U.):     94.6    110.3

 Sector: 0.0.0.2

                                .
                                .
                                .
                                .
```

```
Sector: 0.0.0.126

Y average amplitude= 143.808 (5.334)

Y overall noise (gain, phase in W.U.):    820.5    825.4

Sector: 0.0.0.127
 -12.76Y Complex solution too slow

Y average amplitude= 99.194 (5.255)

Y overall noise (gain, phase in W.U.):   1346.6   1398.3
```

Plotting the new corrections again as a function of time we see in figure 5 that for 3C147 the corrections for 7YY are partly set to zero because all the baselines attached to telescope 7 are flagged for hour angles less then -5 degrees. Note that in that hour angle range a better solution is found for the other telescopes.

```
/dz1/users/verheyen/U6713/DWARFDATA> exe nplot

OPTION (MAP,DATA,MODEL,TELESCOPE,RESIDUAL,QUIT) = QUIT:
 telescope
PLOTTER (QMS,QMSP,REGIS,FREGIS,EPS,EPP,PSL,PSP, EAL,EAP,
          PAL,PAP,BIT1,BIT2,BIT3,X11,USE1,USE2) (plotter
          to use) = PSP:  x11
IFR_MODE (NORMAL,SPECTRAL,SORT) = NORMAL:  normal
SCN_NODE (input/output 'node' name) = "":  U6713
LOOPS (niter,Setincr  ....) = "":  < CR >
SCN_SETS (Set(s) to do:  g.o.f.c.s ) = "":  0.0.0.0
HA_RANGE (DEG) (HA range) = *:  *
POLARISATION (XYX,XY,Y,X,YX) (polarisation(s)) = XY:  xy
TELESCOPES (Telescope(s) to select) = *:  *
DATA_TYPES (AMPLITUDE,PHASE,COSINE,SINE) (data types to
          plot) = AMPLITUDE,PHASE:  amplitude,phase
SCALE_AMPL (plot scale W.U./mm or %/mm) = 4:  1
SCALE_PHASE (plot scale in W.U./mm or deg./mm) = 2:  2
HA_SCALE (HA plot scale degree/cm) = 15:  3
OPTION (MAP,DATA,MODEL,TELESCOPE,RESIDUAL,QUIT) = QUIT:
 quit
```

The output of nplot shows the following figures (see figure 5).

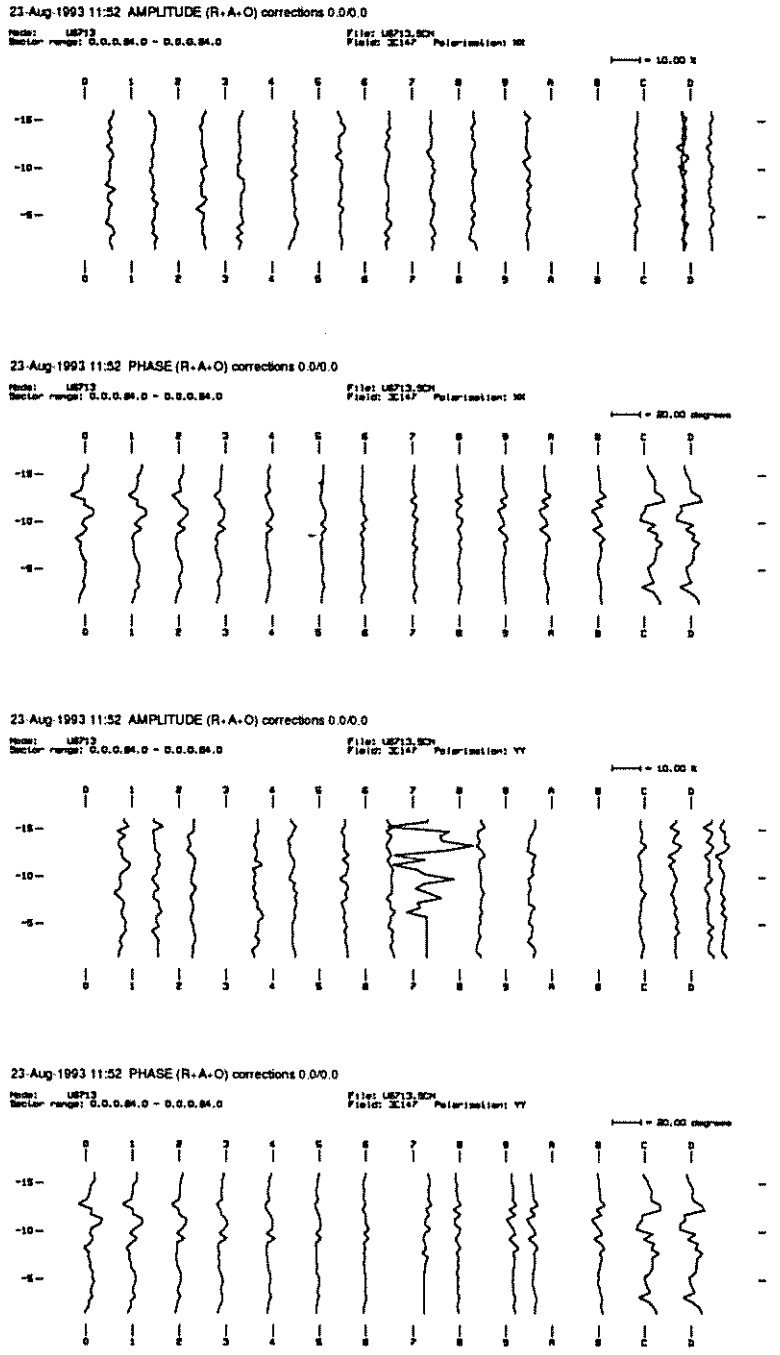

Figure 5: Newly derived telescope corrections for the gains and phases for XX and YY with the SELFCAL method using a model of the field. Note that telescope 7YY has been discarded and that a better solution is found for the other telscopes.

The same calibration procedure must be repeated for the second calibrator 3C295 with the flagged correlator spike.

2.5 Copy the corrections from the calibrators to the observation in between.

Now we can copy the corrections as found for the two calibrators to the observation in between. This will be done in such a way that the corrections from the calibrators will be averaged and weighted by the integration time.

There are two possibilities to be considered. First we can weigh and copy the corrections from each of the channels of the calibrators to the corresponding channels of the actual measurement. In this way we can correct for variations in the bandpass. The other possibility is to copy the corrections from 'channel 0' of the calibrators to each channel of the actual measurement. In this way we make use of the better signal-to-noise ratio of the 'continuum' channel but we also assume that the bandpass is flat.

Which procedure is the best is not yet clear to me (at august 12, 1993). In the following example I will copy the corrections channelwise to allow for passband variations.

```
/dz1/users/verheyen/U6713/DWARFDATA> exe ncalib

OPTION (REDUNDANCY,POLAR,SET,SHOW,QUIT) = QUIT: set
SET_OPTION (ZERO,MANUAL,COPY,CCOPY,LINE,EXT,REF,IREF,CLK,
          FAR,POLE,DX,DY,DZ,FREQ,SHIFT,RENORM,QUIT) = QUIT:
           copy
SCN_NODE (input/output 'node' name) = "": U6713
LOOPS (niter,Setincr  ....) = "": 128,...1
SCN_SETS (Set(s) to do:  g.o.f.c.s ) = "": 1.0.0.0
POLARISATION (XYX,XY,Y,X,YX) (polarisation(s)) = XYX: xy
HA_RANGE (DEG) (HA range) = *: *
USE_SCN_NODE (input node name) = *: U6713
USE_SCN_SETS (Set(s) of input uv-data Sectors:  g.o.f.c.s
          ) = "": 0-2:2.0.0.0
```

3 Flagging the bad UV data of the 12 hour measurement.

3.1 Make a model of the strongest continuum sources.

Before we inspect the raw UV data of the actual 12 hour measurement we would like to increase the contrast between EMI and CS on one hand and any signal on the other hand. Therefor we will subtract any strong continuum sources in the field.

First we have to find those sources and make a model of the field. We will start by first making a map of the field. We can make use of channel 0 since this 'channel' has

the highest signal-to-noise and we are only interested in continuum sources. Besides, any frequency dependent EMI or CS's will be averaged out in the 'continuum' channel.

```
/dz1/users/verheyen/U6713/DWARFDATA> exe nmap

OPTION (MAKE,SHOW,FIDDLE,W16FITS,W32FITS,WRLFITS,FROM_OLD,
         TO_OLD,CVX,NVS,QUIT) = QUIT: make

LOOPS (niter,Setincr  ....) = "": <CR>

 Input data:
SCN_NODE (input/output 'node' name) = "": U6713
SCN_SETS (Set(s) to do:  g.o.f.c.s ) = "": 1.0.0.0
HA_RANGE (DEG) (HA range) = *: -90,90
 All fixed/movable interferometers pre-selected
SELECT_IFRS (Select/de-select ifrs) = "": -ff,-mm,-7

   0123456789ABCD
 0 ----------++++
 1  ---------++++
 2   --------++++
 3    -------++++
 4     ------++++
 5      -----++++
 6       ----++++
 7        -------
 8         --++++
 9          -++++
 A           ----
 B            ---
 C             --
 D              -
SELECT_IFRS (Select/de-select ifrs) = "": <CR>
SCN_NODE (input/output 'node' name) = "": <CR>
USER_COMMENT (map comment) = "": <CR>

 Map properties:
UV_COORDINATES (UV,BASHA,IFRHA) (coordinate type) = UV:
 uv
FT_SIZE (FFT size) = 512,512: 1024,1024
OUT_SIZE (Output size) = 1024,1024: 1024,1024
FIELD_SIZE (DEG) (Fieldsize (deg)) = 1.2 DEG,1.2 DEG: 1.4222,1.4222
QMAPS (More map details?) = NO: no

 Data manipulations:
QDATAS (More data handling details?) = NO: no
SUBTRACT (Source subtraction?) = NO: no

 Output files:
MAP_POLAR (XX,XY,YX,YY,I,Q,U,V,L,XXI,XYI,YXI,YYI,II,QI,UI,
         VI,LI) (polarisation info) = XX: i
MAP_COORD (B1950_J2000,APPARENT,REFERENCE,AREFERENCE) (type
         of map coord.) = B1950_J2000: B1950_J2000
OUTPUT (MAP,AP,COVER,REAL,IMAG,AMPL,PHASE) (Output types)
         = MAP,AP: map

OUTPUT_WMP_NODE (output 'node' name) = "": Chan0
 Creating node CHAN0

 Sorting at 13:14:43 (Wall: 00:00:00.00  CPU: 00:00:00.00  I/O: 0  P/F: 0)
 Scan node U6713 started at 13:14:43
 Sector 1.0.0.0 started at 13:14:43
```

```
Convolving at 13:14:47 (Wall: 00:00:04.17   CPU: 00:00:01.00  I/O: 0  P/F: 0)
Transposing at 13:14:58 (Wall: 00:00:15.38  CPU: 00:00:12.00  I/O: 0  P/F: 0)


Description of the map produced:

0.0.0.0.0.0(#0) type MAP in node CHAN0

Field: UGC6713                          User comment:
RA: 175.44167 deg  Dec: 49.11306 deg    Epoch: 1950.0  Frequency: 1416 MHz

RA (1950)   175.44167 deg                              Obs.day          207
Dec(1950)    49.11306 deg                              Obs.year          93
Frequency  1416.11011 MHz                              Epoch         1993.57
Bandwidth     2.32500 MHz                              Map epoch     1950.00

Type: MAP(I)                            Size: 1024*1024   FFT size: 1024*1024
Fieldsize: 1.4208*1.4208 deg            Grid step: 5.00*5.00 arcsec
                                        Fieldshift: .00*.00 arcsec
Maximum: 74.94 W.U. at 171,15           Minimum: -7.97 W.U.at 91,-107

Input baselines: 36                     Input Map(s): 1   Input points: 12902
Normalisation: 16263.4                  Noise: .877 W.U.

Gaussian taper; Expsinc convolution( corrected); Not clipped; No subtractions;0

0.0.0.0.0.0(#0) type MAP in node CHAN0


Finished at 13:15:44 (Wall: 00:01:00.72  CPU: 00:00:42.00  I/O: 0  P/F: 0)

End at 13:15:44 (Wall: 00:01:00.87  CPU: 00:00:43.00  I/O: 0  P/F: 0)
```

Now we can display the map with ngids in the following way:

```
/dz1/users/verheyen/U6713/DWARFDATA> exe ngids

OPTION (LOAD,GCLEAR,POINTS,FLAG,UFLAG,UNLOAD,WRITE,CLEAR,
         QUIT) = LOAD: load
INPUT_WMP_NODE (input 'node' name) = "": chan0
WMP_SETS (Set(s) to do:  g.f.c.p.t.m) = "": 0.0.0.0.0
AREA (l,m,dl,dm) = 0,0,1024,1024: <CR>

 Area(s) selected:
 Total   : l= 0, m= 0, dl= 1024, dm= 1024

MAP_COMPRESS (factor) = 1: <CR>
MAP_RANGE (minimum,maximum data value) = -7.971013,74.94247:
           -5,5
 Set 0.0.0.0.0.0 will be loaded
OPTION (LOAD,GCLEAR,POINTS,FLAG,UFLAG,UNLOAD,WRITE,CLEAR,
         QUIT) = QUIT: quit
```

What we see is the following map (see figure 6).

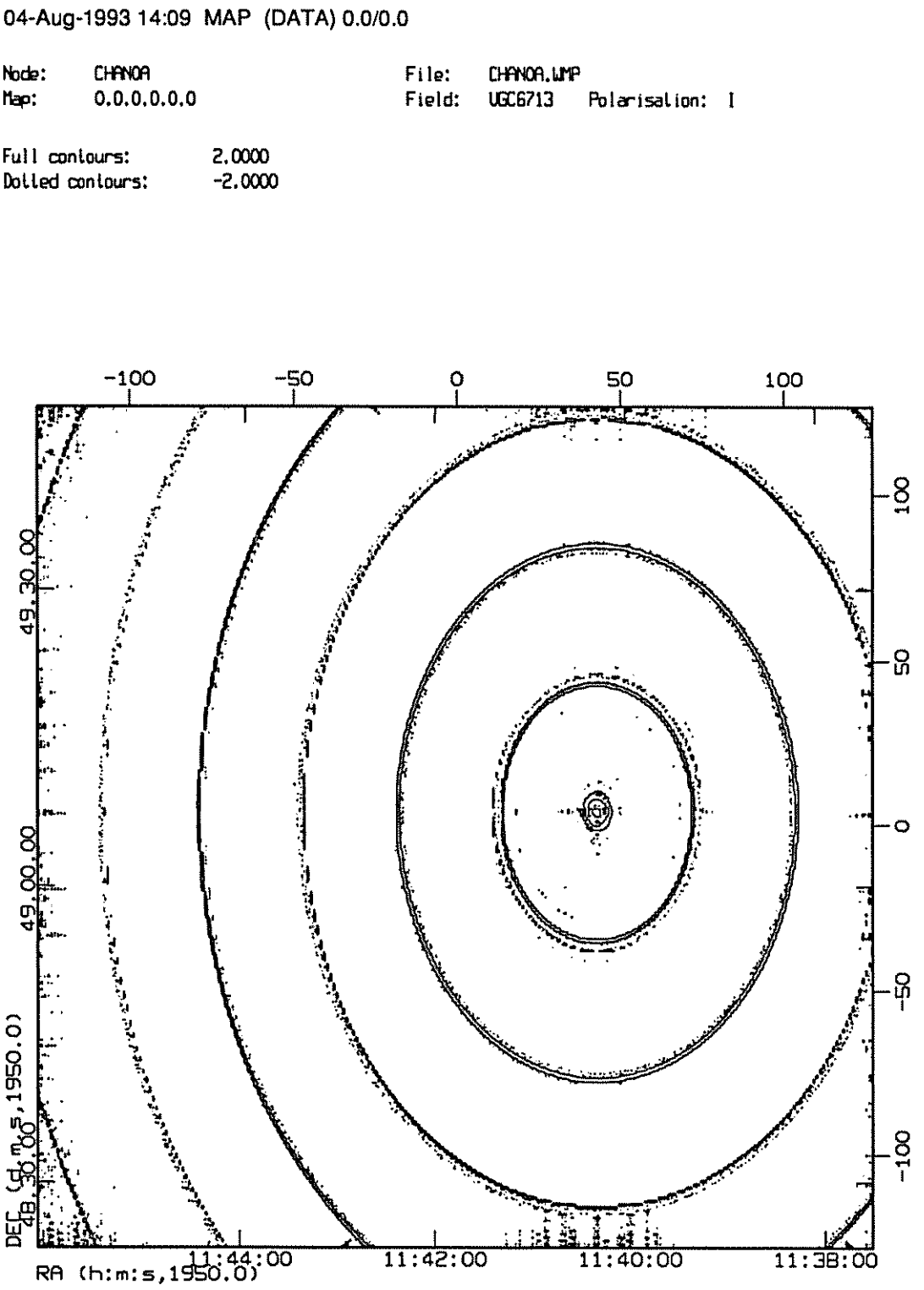

Figure 6: A map of 'channel 0'. The field is dominated by a single strong continuum source.

It is clear that the map is dominated by a very strong continuum source. To get a better detection of correlator spikes and interference in an automated way this strong continuum source must be subtracted first. To achieve this we first make a model of the continuum source.

A close inspection of the map (ZOOM and playing with the colors in GIDS) shows that the source is slightly extended so a single gaussian will probably not be good enough. We should try to model this source with several gaussian point sources.

The program NMODEL is able to find gaussian point sources in a map given certain criteria. One of the criteria is the minimum amplitude of the gaussian in terms of a fraction of the maximum value in the map. The default is 10% to avoid picking up parts of the grating ring of the strongest source. We can also specify the maximum number of components.

The components found must be saved in a file to be retrieved later.

```
/dz1/users/verheyen/U6713/DWARFDATA> exe nmodel

ACTION (HANDLE,HELP,FIND,UPDATE,XUPDATE,FROM_OLD,TO_OLD,
        CONVERT,BEAM,DEBEAM,SAVE,GET,NVS,CVXL,QUIT) =
        HANDLE: find
FIND_TYPE (POS,ABS,MANUAL,QUIT) = POS: pos
WMP_NODE (input/output 'node' name) = "": chan0
WMP_SETS (Set(s) to do:  g.f.c.p.t.m) = "": 0.0.0.0.0
AREA (Area l,m,dl,dm) = 0,0,1024,1024: 0,0,1024,1024
AREA (Area l,m,dl,dm) = "": <CR>

 Area(s) selected:
 Total   : l= 0, m= 0, dl= 1024, dm= 1024

MAP_LIMIT (relative limit) = 0.1: 0.1
MAX_NUMBER (maximum number to add) = 20: 20
ID_START (identification number) = 1000: 1000
MODEL_OPTION (READ,WRITE,CLEAR,ZERO,SHOW,LIST,RSHOW,RLIST,
        TOT,ADD,CALIB,EDIT,FEDIT,MERGE,SORT,FSORT,DEL,
        DNCLOW,DCLOW,DAREA,QUIT) = QUIT: show
SOURCE_RANGE (Source number range) = *:

   #       I         l         m        ID      Q     U     V     long  short   PA
          W.U.    arcsec    arcsec             %     %     %     arcsec arcsec deg

 Sources at epoch 1950 at 11:41:46.00, 49.06.47.0, 1416.110 MHz

    1    72.053   854.24    76.08  1000-00    .0    .0   .00    .00    .00    0


 1 sources (0 deleted) with 72.053 W.U. (Max= 72.053, Min= 72.053)

MODEL_OPTION (READ,WRITE,CLEAR,ZERO,SHOW,LIST,RSHOW,RLIST,
        TOT,ADD,CALIB,EDIT,FEDIT,MERGE,SORT,FSORT,DEL,
        DNCLOW,DCLOW,DAREA,QUIT) = QUIT: write
OUTPUT_MDL_NODE (output 'node' name) = "": u6713cont0
MODEL_OPTION (READ,WRITE,CLEAR,ZERO,SHOW,LIST,RSHOW,RLIST,
        TOT,ADD,CALIB,EDIT,FEDIT,MERGE,SORT,FSORT,DEL,
        DNCLOW,DCLOW,DAREA,QUIT) = QUIT: quit

 1 sources in list
ACTION (HANDLE,HELP,FIND,UPDATE,XUPDATE,FROM_OLD,TO_OLD,
```

```
CONVERT,BEAM,DEBEAM,SAVE,GET,NVS,CVXL,QUIT) =
QUIT: quit
```

We see that only 1 source has been found. Probably, after subtraction of the fitted gaussian, the residuals had a lower amplitude then 10% of the original maximum.

3.2 Make IFRHA maps of the continuum subtracted UV data.

Now we can make maps of the UV data in which the continuum source is subtracted. It is sufficient to do this for the amplitude only but we will make maps for both polarisations i.e. XX and YY.

```
/dz1/users/verheyen/W4183/DWARFDATA> exe nmap

OPTION (MAKE,SHOW,FIDDLE,W16FITS,W32FITS,WRLFITS,FROM_OLD,
         TO_OLD,CVX,NVS,QUIT) = QUIT: make

LOOPS (niter,Setincr  ....) = "": 128,...1

 Input data:
SCN_NODE (input/output 'node' name) = "": U6713
SCN_SETS (Set(s) to do:  g.o.f.c.s ) = "": 1.0.0.0
HA_RANGE (DEG) (HA range) = *: *
 All fixed/movable interferometers pre-selected
SELECT_IFRS (Select/de-select ifrs) = "": -ff,-mm

   0123456789ABCD
 0 ----------++++
 1  ---------++++
 2   --------++++
 3    -------++++
 4     ------++++
 5      -----++++
 6       ----++++
 7        ---++++
 8         --++++
 9          -++++
 A           ----
 B            ---
 C             --
 D              -
SELECT_IFRS (Select/de-select ifrs) = "": <CR>
SCN_NODE (input/output 'node' name) = "": <CR>
USER_COMMENT (map comment) = "": <CR>

 Map properties:
UV_COORDINATES (UV,BASHA,IFRHA) (coordinate type) = UV: ifrha
HA_RESOLUTION (DEG) (HA bin width) = 0.50137 DEG: 0.5
IFR_RESOLUTION (interferometer separation) = 1: 1
FT_SIZE (FFT size) = 211,361: 211,361
OUT_SIZE (Output size) = 211,361: 211,361
QMAPS (More map details?) = NO: no

 Data manipulations:
QDATAS (More data handling details?) = NO: no
```

```
SUBTRACT (Source subtraction?) = NO: [yes]
MODEL_OPTION (READ,WRITE,CLEAR,ZERO,SHOW,LIST,RSHOW,RLIST,
         TOT,ADD,CALIB,EDIT,FEDIT,MERGE,SORT,FSORT,DEL,
         DNCLOW,DCLOW,DAREA,QUIT) = QUIT: [read]
INPUT_MDL_NODE (input 'node' name) = "": [U6713cont0]
MODEL_OPTION (READ,WRITE,CLEAR,ZERO,SHOW,LIST,RSHOW,RLIST,
         TOT,ADD,CALIB,EDIT,FEDIT,MERGE,SORT,FSORT,DEL,
         DNCLOW,DCLOW,DAREA,QUIT) = QUIT: [show]
SOURCE_RANGE (Source number range) = *: [*]

    #       I         l         m        ID      Q     U     V     long  short   PA
           W.U.    arcsec    arcsec              %     %     %    arcsec arcsec deg

 Sources at epoch 1950 at 11:41:46.00, 49.06.47.0, 1416.110 MHz

     1    72.053   854.24    76.08  1000-00     .0    .0   .00     .00   .00    0

 1 sources (0 deleted) with 72.053 W.U. (Max= 72.053, Min= 72.053)

MODEL_OPTION (READ,WRITE,CLEAR,ZERO,SHOW,LIST,RSHOW,RLIST,
         TOT,ADD,CALIB,EDIT,FEDIT,MERGE,SORT,FSORT,DEL,
         DNCLOW,DCLOW,DAREA,QUIT) = QUIT: [quit]

 1 sources in list

MODEL_ACTION (MERGE,ADD,NEW,TEMPORARY,INCREMENT,BAND,NOBAND,
         TIME,NOTIME,INPOL,NOINPOL) = MERGE,BAND,TIME,NOINPOL:
          [temporary]

 Output files:
MAP_POLAR (XX,XY,YX,YY,I,Q,U,V,L,XXI,XYI,YXI,YYI,II,QI,UI,
         VI,LI) (polarisation info) = XX: [xx,yy]
MAP_COORD (B1950_J2000,APPARENT,REFERENCE,AREFERENCE) (type
         of map coord.) = B1950_J2000: [B1950_J2000]
OUTPUT (MAP,AP,COVER,REAL,IMAG,AMPL,PHASE) (Output types)
         = AMPL,PHASE: [ampl]
OUTPUT_WMP_NODE (output 'node' name) = "": [U6713ifrha]
 Creating node U6713IFRHA

 Sorting at 19:14:18 (Wall: 00:00:00.00  CPU: 00:00:00.00  I/O: 0  P/F: 0)
 Scan node U6713 started at 19:14:18
 Sector 1.0.0.0 started at 19:14:18

                                    .
                                    .
                                    .
                                    .
                                    .

 End at 19:25:52 (Wall: 00:11:33.76  CPU: 00:09:44.00  I/O: 0  P/F: 0)
```

We can now inspect the IFRHA maps for both polarisations in the same way as we inspected the IFRHA maps for the calibrators using a movie loop in GIDS. In a previous section it was shown how to flag datapoints in an interactive way using gids. Now we will flag datapoint in an automated way using a clip method on the corrected data.

Unfortunately for tutorial purposes, the present 12 hour measurement of U6713 did not suffer from correlator spikes or interference. Therefor, CS's and EMI is demonstrated with an observation of N4183 during which telescope 7 was out of order.

If there are correlator spikes present we see them as flickering dots because in most cases they are frequency dependent. A typical pattern of spikes is shown in figure 7a. They occur in a few discrete scans and are typically but not always 2^n-wise grouped at regularly spaced interferometers although 'isolated' spikes occur as well.

A signature of interference is shown in figure 7b. This EMI is only present in the channels 32, 64 and 96 at the beginning and the end of the observation in the interferometers 0B and especially 4B. Therefor, it completely vanishes in averaged maps like 'channel 0' but it really messes up those 3 channels so we need to remove it.

3.3 Clipping the UV data.

By playing with the colors we can get a reasonable feeling for the noise level to determine a suitable clip level. In general, for a single 12 hour measurement with a bandwidth of 2.5 MHz, 128 channels and an integration time of 120 seconds, a clip level of 300 W.U. in corrected XX or YY amplitude is appropriate. If we apply the clip level we should avoid the first and last channels of the bandpass because the noise increases very strongly in those channels due to lack of sensitivity. In case we are dealing with 128 channels we should not consider the channels 0-4 and 115-127.

At the moment (August 16, 1993) the following problem still remains to be solved. Clipping the data is done in the .SCN file on the amplitude of the data which might only be corrected for gain (and phase) corrections from the calibrators. Subtraction of continuum emission from strong sources in the field is not yet possible for the data in a .SCN file. So, if we determine the clip level from continuum subtracted IFRHA maps, it might not be applicable to the (corrected) non continuum subtracted .SCN data.

```
/dz1/users/verheyen/N4183/DWARFDATA> exe nflag

OPTION (SHOW,FLAG,QUIT) = QUIT:  flag
FLAG_OPTION (FLAG,CLEAR,LOAD,UNLOAD,WRITE,READ,QUIT) = FLAG:
           flag
INPUT_SCN_MODE (input 'node' name) = "":  N4183
SCN_SETS (Set(s) to do:  g.o.f.c.s ) = "":  1.0.0.5-114
POLARISATION (XYI,XY,Y,X,YX) (polarisation(s)) = XYX:  xy
 All auto/cross interferometers pre-selected
SELECT_IFRS (Select/de-select ifrs) = "":  -ff,-mm,-9a

   0123456789ABCD
 0 +----------++++
 1  +---------++++
 2   +--------++++
 3    +-------++++
 4     +------++++
 5      +-----++++
 6       +----++++
 7        +---++++
 8         +--++++
 9          +-+++
 A           +---
 B            +--
```

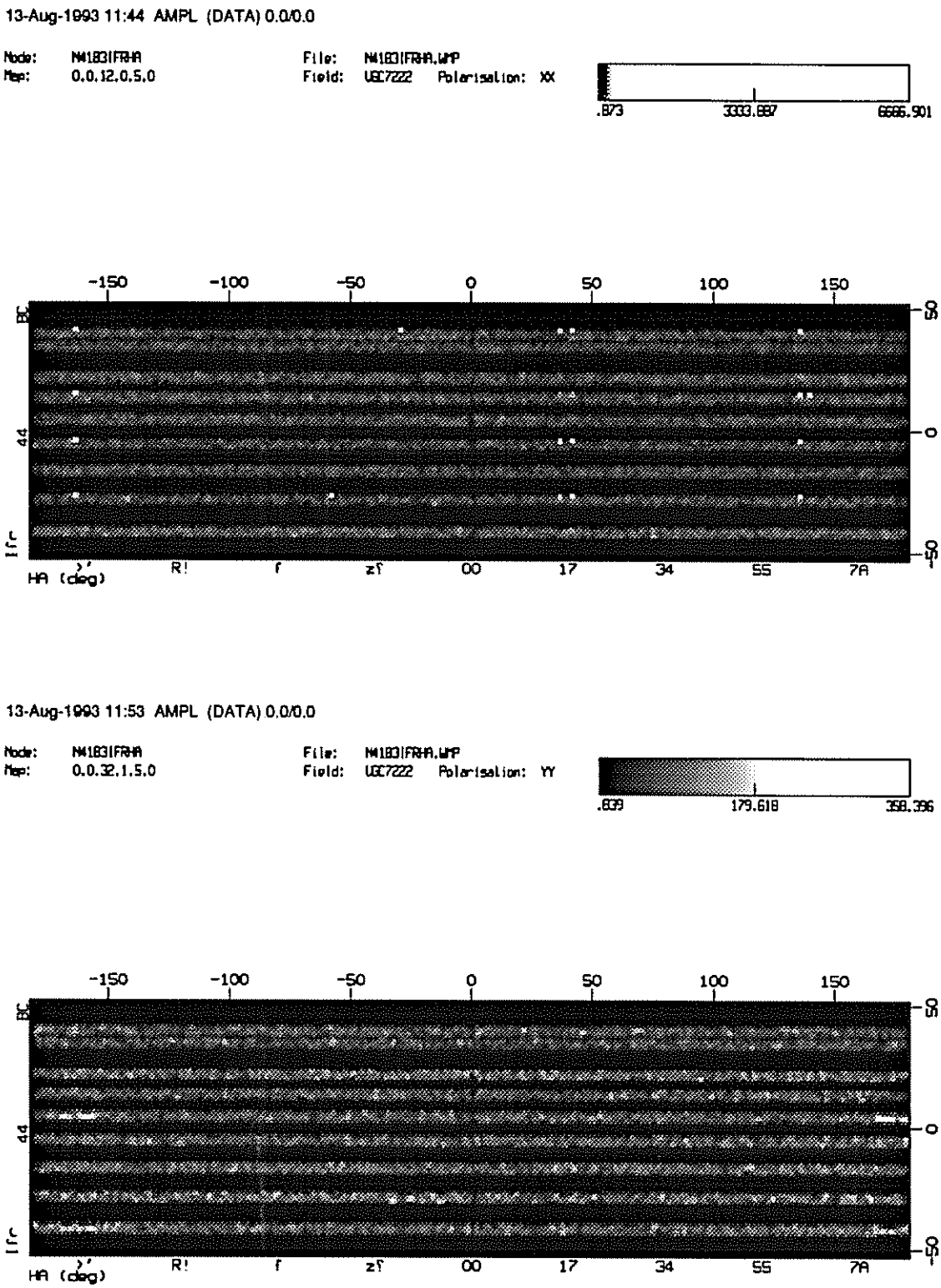

Figure 7: a) IFRHA map of channel 12 for the XX polarisation of N4183 (upper panel). b) IFRHA map of channel 32 for the YY polarisation of N4183 (lower panel).

```
 C             +-
 D              +
SELECT_IFRS (Select/de-select ifrs) = "": <CR>
HA_RANGE (DEG) (HA range) = *: *
FLAG_MODE (FLAG,UNFLAG,CORR,NOCORR,SHOW,NOSHOW,FHEAD,FDATA,
          NOFORCE,UFLAG,CONT,NEXT,MODE,QUIT) = FLAG: fdata
FLAG_MODE (FLAG,UNFLAG,CORR,NOCORR,SHOW,NOSHOW,FHEAD,FDATA,
          NOFORCE,UFLAG,CONT,NEXT,MODE,QUIT) = FLAG: corr
FLAG_MODE (FLAG,UNFLAG,CORR,NOCORR,SHOW,NOSHOW,FHEAD,FDATA,
          NOFORCE,UFLAG,CONT,NEXT,MODE,QUIT) = FLAG: show
FLAG_MODE (FLAG,UNFLAG,CORR,NOCORR,SHOW,NOSHOW,FHEAD,FDATA,
          NOFORCE,UFLAG,CONT,NEXT,MODE,QUIT) = FLAG: flag
FLAG_MODE (FLAG,UNFLAG,CORR,NOCORR,SHOW,NOSHOW,FHEAD,FDATA,
          NOFORCE,UFLAG,CONT,NEXT,MODE,QUIT) = CONT: cont
 Current modes: FLAG     SHOW      DFORCE    CORRECT
OPERATION_0 (ALL,HA,>,<,MAX,ANOISE,RNOISE,XRN,YRN,XAN,YAN,
          IFR,CLIP,RRESID,ARESID,CONT,MODE,NEXT,NODE,QUIT)
          = MODE: clip
 CRIT(0): mean=     .00 rms=     .00 rmsms=    .000 wtot=      .0
 CRIT(1): mean= 264.48 rms= 404.13 rmsms=305.561 wtot=39600.0
LIMITS ((un-)flag limits) = -.1E+39,-.1E+39: 300,1000000
 HA  -81.47 interferometers flagged for sector 1.0.0.5.0
 HA  -71.95 interferometers flagged for sector 1.0.0.5.0
 HA  -28.83 interferometers flagged for sector 1.0.0.5.0
 HA  -20.81 interferometers flagged for sector 1.0.0.5.0
 HA  -14.29 interferometers flagged for sector 1.0.0.5.0
 HA    -.75 interferometers flagged for sector 1.0.0.5.0
 HA   18.30 interferometers flagged for sector 1.0.0.5.0
 HA   20.81 interferometers flagged for sector 1.0.0.5.0
 HA   51.89 interferometers flagged for sector 1.0.0.5.0
 HA   67.93 interferometers flagged for sector 1.0.0.5.0
 HA   69.94 interferometers flagged for sector 1.0.0.5.0
 HA  -81.47 interferometers flagged for sector 1.0.0.6.0
 HA  -71.95 interferometers flagged for sector 1.0.0.6.0
 HA  -28.83 interferometers flagged for sector 1.0.0.6.0
 HA   18.30 interferometers flagged for sector 1.0.0.6.0

                              .
                              .
                              .
                              .
                              .

 HA   67.93 interferometers flagged for sector 1.0.0.113.0
 HA   69.94 interferometers flagged for sector 1.0.0.113.0
 HA  -43.37 interferometers flagged for sector 1.0.0.114.0
 HA  -28.83 interferometers flagged for sector 1.0.0.114.0
 HA  -14.29 interferometers flagged for sector 1.0.0.114.0
 HA   20.81 interferometers flagged for sector 1.0.0.114.0
 HA   67.93 interferometers flagged for sector 1.0.0.114.0
 HA   69.94 interferometers flagged for sector 1.0.0.114.0
 Current modes: FLAG     SHOW      DFORCE    CORRECT
OPERATION_0 (ALL,HA,>,<,MAX,ANOISE,RNOISE,XRN,YRN,XAN,YAN,
          IFR,CLIP,RRESID,ARESID,CONT,MODE,NEXT,NODE,QUIT)
          = MODE: cont
OPERATION_1 (TOTEL,TODATA,TOHEAD,GET,PUT,CONT,MODE,NEXT,
          NODE,QUIT) = MODE: get
 Getting flags from individual UV points
 HA  -81.47 got for sector 1.0.0.5.0
 HA  -71.95 got for sector 1.0.0.5.0
 HA  -28.83 got for sector 1.0.0.5.0
 HA  -20.81 got for sector 1.0.0.5.0
 HA  -14.29 got for sector 1.0.0.5.0

                              .
```

```
 HA   69.94 got for sector 1.0.0.113.0
 HA  -43.37 got for sector 1.0.0.114.0
 HA  -28.83 got for sector 1.0.0.114.0
 HA  -14.29 got for sector 1.0.0.114.0
 HA   20.81 got for sector 1.0.0.114.0
 HA   67.93 got for sector 1.0.0.114.0
 HA   69.94 got for sector 1.0.0.114.0
 Current modes: FLAG     SHOW      DFORCE    CORRECT
OPERATION_1 (TOTEL,TODATA,TOHEAD,GET,PUT,CONT,MODE,NEXT,
          MODE,QUIT) = MODE:  quit
FLAG_OPTION (FLAG,CLEAR,LOAD,UNLOAD,WRITE,READ,QUIT) = QUIT:
            write
OUTPUT_FILE (output filename) = "FLAG.LOG":  N4183xy.flag
 1195 entries in file N4183XY.FLAG
FLAG_OPTION (FLAG,CLEAR,LOAD,UNLOAD,WRITE,READ,QUIT) = QUIT:
            quit
OPTION (SHOW,FLAG,QUIT) = QUIT:  quit
```

The ascii file N4183XY.FLAG which is produced contains 1195 flag specifications and looks like

```
!+ Flagging file N4183XY.FLAG
!  Created by VERHEYEN on 930816 at 16:26:19 at zanstra
!  Flags:
!       MAN : 80  CLIP: 40  NOIS: 20  ADD : 10
!       SHAD: 08  U3  : 04  U2  : 02  U1  : 01
!  Types:
!       00:  Interprete Ifr field as interferometer
!       01:  Interprete Ifr field as baselines in m
!  Data following an ! are seen as comments
!  Remaining fields have format:
!       *:          all values
!       value:      single value
!       val1=val2:  value range (inclusive)
!
!-
!Flag  Type  Channel       Hour-angle          Ifr         Pol
40      00    5             -81.47              D9          XX
40      00    5             -81.47              D5          XX
40      00    5             -81.47              D3          XX
40      00    5             -81.47              D1          XX
40      00    5             -71.95              D6          YY
40      00    5             -28.83              D1          XX
40      00    5             -20.81              D4          YY
40      00    5             -14.29              D9          XX
40      00    5             -.75                B9          YY
40      00    5             18.30               D9          XX

 .      .     .               .                  .           .
 .      .     .               .                  .           .
 .      .     .               .                  .           .
 .      .     .               .                  .           .
 .      .     .               .                  .           .

40      00    114           -28.83              D1          XX
40      00    114           -14.29              D9          XX
40      00    114           20.81               D9          XX
40      00    114           20.81               D3          XX
```

```
40      00      114             67.93           D9          XX
40      00      114             67.93           D5          XX
40      00      114             67.93           D3          XX
40      00      114             67.93           D1          XX
40      00      114             69.94           D5          XX
```

Inspection of the entire ascii file, which is too long to be printed here, shows that a correlates spike at a given hour angle and interferometer is specified for each channel seperately. Furtermore, we see for instance in channel 5 that a spike is detected at a hour angle of 18.30 degrees in interferometer 9D for the XX polarisation. However, this spike is not detected in channel 114. Therefor, for each Hour_angle-Ifr-Pol combination that occurs in the file we must replace the channel number by a '*'. This can be done with the following fortran program which also sorts the found combinations on increasing hour angle.

```
C
C This program sorts a list of flags provided as an ascii file by the
C newstar program NFLAG.  It replaces a specified channelnumber by a '*'
C and checks whether a certain HA-Ifr-Pol combination occurred at another
C channel.  If so, that flag becomes unnecessary and the line will be
C removed.  Finally the flags are ordered by increasing hour angle.
C

      PROGRAM flagsort

      INTEGER      j,k,n
      REAL         HA,HAlist(33000),HAtemp
      CHARACTER    new
      CHARACTER*2  Ifr,Ifrlist(33000),Pol,Pollist(33000)
      CHARACTER*2  Flag,Type,Ifrtemp,Poltemp
      CHARACTER*3  Channel
      CHARACTER*12 filename
      CHARACTER*70 header

 100  format(a2,5x,a2,4x,a3,11x,f6.2,14x,a2,10x,a2)

C
C Get the name of the ascii-file to be sorted.
C

      Write(*,*) 'File to sort :'
      Read(*,'(a12)') filename

      Open(1,file=filename,status='old')
      Open(2,file='FLAG.SORT',status='new')

C
C Copy the header of the ascii-file and add the comment that the new
C sorted list it is extracted from another file.
C

      Write(2,'(a31,a12)') '! This list was extracted from ',filename
      Do j=1,16
        Read(1,'(a70)') header
        Write(2,'(a70)') header
       EndDo

C
C Read the first line from the ascii file.
C
```

```
      Read(1,100) Flag,Type,Channel,HA,Ifr,Pol
      HAlist(1) = HA
      Ifrlist(1) = Ifr
      Pollist(1) = Pol

C
C Read the other lines and check whether the flag at that line
C occurred before at another channel.  If not, add it to the list of new
C flags.
C

      n=1
      Do k=1,33000

        Read(1,100,END=200) Flag,Type,Channel,HA,Ifr,Pol
        new = 'y'

        Do j=1,n
          If (( (HA.EQ.HAlist(j)).AND.(Ifr.EQ.Ifrlist(j)) ).AND.
     .                                      (Pol.EQ.Pollist(j)) ) Then
            new = 'n'
           EndIf
         EndDo

        If (new.EQ.'y') Then
          n = n+1
          HAlist(n) = HA
          Ifrlist(n) = Ifr
          Pollist(n) = Pol
         EndIf

       EndDo

 200  Close(1)

C
C Sort the new reduced flaglist in order of increasing hour angle.
C

      Do k=1,n-1
        Do l=k,n
          If (HAlist(l).LT.HAlist(k)) Then
            HAtemp = HAlist(k)
            HAlist(k) = HAlist(l)
            HAlist(l) = HAtemp
            Ifrtemp = Ifrlist(k)
            Ifrlist(k) = Ifrlist(l)
            Ifrlist(l) = Ifrtemp
            Poltemp = Pollist(k)
            Pollist(k) = Pollist(l)
            Pollist(l) = Poltemp
           EndIf
         EndDo
       EndDo

C
C Write the new flag list to an ascii file.
C

      Channel = '*  '

      Do k=1,n
        Write(2,100) Flag,Type,Channel,HAlist(k),Ifrlist(k),Pollist(k)
       EndDo

      Close(2)
```

```
End
```

The result of this program is an ascci file called FLAG.SORT which looks like

```
! This list was extracted from M4183XY.FLAG
!+ Flagging file M4183XY.FLAG
!  Created by VERHEYEN on 930816 at 16:26:19 at zanstra
!  Flags:
!       MAN : 80  CLIP: 40  MOIS: 20  ADD : 10
!       SHAD: 08  U3  : 04  U2  : 02  U1  : 01
!  Types:
!       00:  Interprete Ifr field as interferometer
!       01:  Interprete Ifr field as baselines in m
!  Data following an ! are seen as comments
!  Remaining fields have format:
!       *:          all values
!       value:      single value
!       val1=val2:  value range (inclusive)
!
!-
!Flag  Type  Channel       Hour-angle          Ifr         Pol
40      00    *             -83.98              B4          YY
40      00    *             -82.48              A6          XX
40      00    *             -81.97              C6          XX
40      00    *             -81.47              D1          XX
40      00    *             -81.47              D9          XX
40      00    *             -81.47              D5          XX
40      00    *             -81.47              D3          XX
40      00    *             -80.47              B4          YY
40      00    *             -79.47              B0          YY
40      00    *             -78.97              A2          XX
40      00    *             -78.97              B0          YY
40      00    *             -78.47              A6          XX
40      00    *             -78.47              B0          YY
40      00    *             -77.96              B0          YY
40      00    *             -77.96              A2          XX
40      00    *             -77.96              A6          XX
40      00    *             -71.95              D6          YY
40      00    *             -70.44              C0          XX
40      00    *             -67.94              C5          XX
40      00    *             -66.43              D5          YY
40      00    *             -62.92              D6          XX
40      00    *             -54.90              C8          XX
40      00    *             -51.89              C5          YY
40      00    *             -50.89              D1          YY
40      00    *             -47.38              D1          YY
40      00    *             -43.37              D0          XX
40      00    *             -42.37              D8          YY
40      00    *             -28.83              D1          XX
40      00    *             -28.33              C1          YY
40      00    *             -20.81              D4          YY
40      00    *             -19.30              D0          XX
40      00    *             -17.80              D2          YY
40      00    *             -14.29              D9          XX
40      00    *              -3.26              C1          YY
40      00    *              -2.76              A3          XX
40      00    *              -2.76              D6          XX
40      00    *               -.75              B9          YY
40      00    *               3.76              D1          YY
40      00    *               3.76              D6          XX
40      00    *               4.76              D1          YY
40      00    *               7.77              A8          YY
40      00    *               9.27              D1          YY
40      00    *              18.30              D5          XX
40      00    *              18.30              D3          XX
```

```
40    00    *          18.30          D1          XX
40    00    *          18.30          D9          XX
40    00    *          20.81          D5          XX
40    00    *          20.81          D3          XX
40    00    *          20.81          D1          XX
40    00    *          20.81          D9          XX
40    00    *          21.81          C2          XX
40    00    *          30.33          C1          YY
40    00    *          34.84          C3          YY
40    00    *          37.35          D9          XX
40    00    *          39.36          D8          YY
40    00    *          42.36          D2          XX
40    00    *          48.38          D1          YY
40    00    *          50.39          D4          YY
40    00    *          51.89          D8          YY
40    00    *          53.39          D1          XX
40    00    *          53.39          D6          XX
40    00    *          53.90          B0          XX
40    00    *          53.90          C1          YY
40    00    *          66.43          D3          YY
40    00    *          67.93          D3          XX
40    00    *          67.93          D1          XX
40    00    *          67.93          D9          XX
40    00    *          67.93          D5          XX
40    00    *          68.94          D2          YY
40    00    *          69.94          D5          XX
40    00    *          74.95          D9          YY
40    00    *          83.48          B9          YY
40    00    *          83.98          A6          XX
40    00    *          83.98          B4          YY
40    00    *          84.48          A6          XX
40    00    *          84.48          B0          YY
40    00    *          84.48          B4          YY
40    00    *          84.48          A2          XX
40    00    *          84.98          A6          XX
40    00    *          84.98          B4          YY
40    00    *          85.48          B0          YY
40    00    *          85.98          C5          XX
40    00    *          86.49          A6          XX
40    00    *          86.99          B4          YY
40    00    *          89.99          A6          XX
```

The number of entries has been reduced from 1195 to 85. A close inspection of the ascii file FLAG.SORT shows that the EMI which can be seen in figure 7b is hardly picked up by the clipping procedure. The signature of this EMI is merely a few sigma enhancement extended over a range of hour angles. However, the effect of show up clearly in the maps of channels 32, 64 and 96. The EMI is detected in the hour angle ranges (-85^d,-75^d) and ($+80^d$,$+90^d$) for the interferometers 2A and 6A in case of the XX polarisation and 0B and 4B for YY. Therefor, we must add the following lines to FLAG.SORT.

```
01    00    *        -85.=-75.        A2          XX
01    00    *        -85.=-75.        A6          XX
01    00    *         80.=90.         A2          XX
01    00    *         80.=90.         A6          XX
01    00    *        -85.=-75.        B0          YY
01    00    *        -85.=-57.        B4          YY
01    00    *         80.=90.         B0          YY
01    00    *         80.=90.         B4          YY
```

Now we can actually flag the data with this improved list.

```
/dz1/users/verheyen/N4183/DWARFDATA> exe nflag

OPTION (SHOW,FLAG,QUIT) = QUIT:  flag
FLAG_OPTION (FLAG,CLEAR,LOAD,UNLOAD,WRITE,READ,QUIT) = FLAG:
           read
INPUT_FILE (input filename) = "FLAG.LOG":  FLAG.SORT
 101 entries in list
FLAG_OPTION (FLAG,CLEAR,LOAD,UNLOAD,WRITE,READ,QUIT) = FLAG:
           flag
INPUT_SCN_NODE (input 'node' name) = "":  N4183
SCN_SETS (Set(s) to do:  g.o.f.c.s ) = "":  1.0.0.*
POLARISATION (XYX,XY,Y,X,YX) (polarisation(s)) = XYX:  xy
 All auto/cross interferometers pre-selected
SELECT_IFRS (Select/de-select ifrs) = "":  -ff,-mm,-9a

   0123456789ABCD
 0 +----------++++
 1  +---------++++
 2   +--------++++
 3    +-------++++
 4     +------++++
 5      +-----++++
 6       +----++++
 7        +---++++
 8         +--++++
 9          +-+++
 A           +---
 B            +--
 C             +-
 D              +
SELECT_IFRS (Select/de-select ifrs) = "":  <CR>
HA_RANGE (DEG) (HA range) = *:  *
FLAG_MODE (FLAG,UNFLAG,CORR,NOCORR,SHOW,NOSHOW,FHEAD,FDATA,
          NOFORCE,UFLAG,CONT,NEXT,NODE,QUIT) = FLAG:  fdata
FLAG_MODE (FLAG,UNFLAG,CORR,NOCORR,SHOW,NOSHOW,FHEAD,FDATA,
          NOFORCE,UFLAG,CONT,NEXT,NODE,QUIT) = FLAG:  show
FLAG_MODE (FLAG,UNFLAG,CORR,NOCORR,SHOW,NOSHOW,FHEAD,FDATA,
          NOFORCE,UFLAG,CONT,NEXT,NODE,QUIT) = FLAG:  flag
FLAG_MODE (FLAG,UNFLAG,CORR,NOCORR,SHOW,NOSHOW,FHEAD,FDATA,
          NOFORCE,UFLAG,CONT,NEXT,NODE,QUIT) = CONT:  cont
 Current modes: FLAG     SHOW      DFORCE    NOCORRECT
OPERATION_0 (ALL,HA,>,<,MAX,ANOISE,RNOISE,XRN,YRN,XAN,YAN,
          IFR,CLIP,RRESID,ARESID,CONT,MODE,NEXT,NODE,QUIT)
          = MODE:  cont
OPERATION_1 (TOTEL,TODATA,TOHEAD,GET,PUT,CONT,MODE,NEXT,
          NODE,QUIT) = MODE:  put
 101 entries in list
 Flagging individual UV points
PUT_RANGE (chan,HA,ifr,pol) = ".",".",".",".":  <CR>
 HA  -84.98 interferometers flagged for sector 1.0.0.0.0
 HA  -84.48 interferometers flagged for sector 1.0.0.0.0
 HA  -83.98 interferometers flagged for sector 1.0.0.0.0
 HA  -83.48 interferometers flagged for sector 1.0.0.0.0
 HA  -82.98 interferometers flagged for sector 1.0.0.0.0
 HA  -82.48 interferometers flagged for sector 1.0.0.0.0
 HA  -81.97 interferometers flagged for sector 1.0.0.0.0
 HA  -81.47 interferometers flagged for sector 1.0.0.0.0
 HA  -80.97 interferometers flagged for sector 1.0.0.0.0
```

```
 HA    85.98 interferometers flagged for sector 1.0.0.127.0
 HA    86.49 interferometers flagged for sector 1.0.0.127.0
 HA    86.99 interferometers flagged for sector 1.0.0.127.0
 HA    87.49 interferometers flagged for sector 1.0.0.127.0
 HA    87.99 interferometers flagged for sector 1.0.0.127.0
 HA    88.49 interferometers flagged for sector 1.0.0.127.0
 HA    88.99 interferometers flagged for sector 1.0.0.127.0
 HA    89.49 interferometers flagged for sector 1.0.0.127.0
 HA    89.99 interferometers flagged for sector 1.0.0.127.0
 Current modes: FLAG     SHOW      DFORCE    NOCORRECT
OPERATION_1 (TOTEL,TODATA,TOHEAD,GET,PUT,CONT,MODE,NEXT,
          MODE,QUIT) = MODE: [quit]
FLAG_OPTION (FLAG,CLEAR,LOAD,UNLOAD,WRITE,READ,QUIT) = QUIT:
           [quit]
OPTION (SHOW,FLAG,QUIT) = QUIT: [quit]
```

This procedure of putting the flags on the data takes 2 hours and 32 minutes on a HP720 (!). We can check whether all the CS's and EMI is removed by making IFRHA maps for XX and YY of all the channels and inspect them with NGIDS.

4 Transforming the data.

4.1 Making the sky maps and antenna patterns.

Finally we can use the calibrated and edited data to transform them into sky maps. At this moment some decisions must be made about the size of the pixels and the map, the use and size of a taper, the number and size of the antenna paterns etc.

We will choose the pixel size such that we sample the synthesized beam best, i.e. about 2.2 pixels per beam in each direction. This will result in pixel sizes of 5 arcsec in right ascension and $\frac{5}{sin\delta}$ arcsec in declination. Making maps of 512×512 pixels results in a field size of $0.71111 \times \frac{0.71111}{sin\delta}$ degrees. However, when specifying the fieldsize at the keyword FIELDSIZE= you should always consider the FFT-size and *not* the OUT-size when relating the desired pixelsize to the resulting fieldsize through the pixel size of the map. So, altough the OUT-size is 512×512 pixels and the pixels size is 5 arcsec in RA, the FIELDSIZE you must specify is then 1024×5 arcsec! The edge of the field in RA will be at the position where the sensitivity of the primary beam has decreased until about 42% of its maximum.

To be able to clean the maps properly, the antenna patterns to be used should be twice as large as the maps (1024×1024 pixels). This implies that the FFT size for the maps should also be 1024×1024 to avoid aliasing which is incompatible with the antenna patterns.

The baseline taper will be a gaussian with a width of 2293 meters. This width is such that the tapervalue at the longest baseline has decreased by $\frac{1}{e}$.

In the following example many default values were chosen just to show the various options.

```
/dz1/users/verheyen/N4183/DWARFDATA> exe nmap

OPTION (MAKE,SHOW,FIDDLE,W16FITS,W32FITS,WRLFITS,FROM_OLD,
         TO_OLD,CVX,NVS,QUIT) = QUIT:  make

LOOPS (niter,Setincr  ....) = "":  128,...1

 Input data:
SCN_NODE (input/output 'node' name) = "":  N4183
SCN_SETS (Set(s) to do:  g.o.f.c.s ) = "":  1.0.0.0
HA_RANGE (DEG) (HA range) = *:  -90,90
 All fixed/movable interferometers pre-selected
SELECT_IFRS (Select/de-select ifrs) = "":  -ff,-mm

   0123456789ABCD
 0 ----------++++
 1  ---------++++
 2   --------++++
 3    -------++++
 4     ------++++
 5      -----++++
 6       ----++++
 7        ---++++
 8         --++++
 9          -++++
 A           ----
 B            ---
 C             --
 D              -
SELECT_IFRS (Select/de-select ifrs) = "":  <CR>
SCN_NODE (input/output 'node' name) = "":  <CR>
USER_COMMENT (map comment) = "":  <CR>

 Map properties:
UV_COORDINATES (UV,BASHA,IFRHA) (coordinate type) = UV:  uv
FT_SIZE (FFT size) = 512,256:  1024,1024
OUT_SIZE (Output size) = 1024,1024:  512,512
FIELD_SIZE (DEG) (Fieldsize (deg)) = 1.2 DEG,1.2 DEG:  1.42222,2.04824
QMAPS (More map details?) = NO:  yes
UNIFORM (NATURAL,STANDARD,FULL) (Uniform coverage) = STANDARD:
           standard
TAPER (GAUSS,LINEAR,NATURAL,OVERR,RGAUSS) (Taper type) =
          GAUSS:  gauss
TAPER_VALUE (M) (Taper width) = 2548 M:  2293
CWEIGHT_TYPE (GAUSS,LINEAR,NATURAL) (Circular weight type)
         = NATURAL:  natural
CONVOLVE (GAUSS,BOX,P4ROL,P6ROL,EXPSINC) (Convolution type)
         = EXPSINC:  expsinc
DECONVOLVE (Correct for convolution?) = YES:  yes

 Data manipulations:
QDATAS (More data handling details?) = NO:  yes
USER_DATA (STANDARD,MODEL) (Data to use) = STANDARD:  standard
UV_AREA (M) (Select UV area) = *:  *
CLIPPING (Clipping?) = NO:  no
FIELD_SHIFT (Field shift) = 0,0:  0,0
DATA_TYPE (NORMAL,COS,SIN,AMPL,PHASE) (Use of data) = NORMAL:
           normal
SUBTRACT (Source subtraction?) = NO:  no
```

```
 Output files:
MAP_POLAR (XX,XY,YX,YY,I,Q,U,V,L,XXI,XYI,YXI,YYI,II,QI,UI,
          VI,LI) (polarisation info) = XX: [i]
MAP_COORD (B1950_J2000,APPARENT,REFERENCE,AREFERENCE) (type
          of map coord.) = B1950_J2000: [B1950_J2000]
OUTPUT (MAP,AP,COVER,REAL,IMAG,AMPL,PHASE) (Output types)
          = MAP,AP: [map]
OUTPUT_WMP_NODE (output 'node' name) = "": [N4183map]
 Creating node N4183MAP

 Sorting at 20:45:25 (Wall: 00:00:00.00  CPU: 00:00:00.00  I/O: 0  P/F: 0)
 Scan node N4183 started at 20:45:25
 Sector 1.0.0.0 started at 20:45:25
 Convolving at 20:45:29 (Wall: 00:00:04.03  CPU: 00:00:01.00  I/O: 0  P/F: 0)
 Transposing at 20:45:35 (Wall: 00:00:10.09  CPU: 00:00:07.00  I/O: 0  P/F: 0)

 Description of the map produced:

 0.0.0.0.0.0(#0) type MAP in node N4183MAP

 Field: UGC7222                      User comment:
 RA: 182.69583 deg  Dec: 43.97639 deg  Epoch: 1950.0  Frequency: 1416 MHz

 RA (1950)   182.69583 deg                          Obs.day         214
 Dec(1950)    43.97639 deg                          Obs.year         93
 Frequency  1415.94946 MHz                          Epoch        1993.59
 Bandwidth     2.32500 MHz                          Map epoch    1950.00

 Type: MAP(I)                        Size: 512*512     FFT size: 1024*1024
 Fieldsize: .7097*1.0221 deg         Grid step: 5.00*7.20 arcsec
                                     Fieldshift: .00*.00 arcsec
 Maximum: 12.54 W.U. at -61,-58      Minimum: -1.66 W.U.at 60,-45

 Input baselines: 40                 Input Map(s): 1   Input points: 12690
 Normalisation: 14370.9              Noise: .165 W.U.

 Gaussian taper; Expsinc convolution( corrected); Not clipped; No subtractions; 0

 0.0.0.0.0.0(#0) type MAP in node N4183MAP


 Finished at 20:45:50 (Wall: 00:00:24.42  CPU: 00:00:19.00  I/O: 0  P/F: 0)

 Sorting at 20:45:50 (Wall: 00:00:24.59  CPU: 00:00:19.00  I/O: 0  P/F: 0)
 Scan node N4183 started at 20:45:50
 Sector 1.0.0.1 started at 20:45:50

                                     .
                                     .
                                     .
                                     .
                                     .

 End at 21:31:36 (Wall: 00:46:10.42  CPU: 00:42:50.00  I/O: 0  P/F: 0)
```

Because the grating rings scale with frequency, in principle we would need a separate antenna pattern for each channel. However, it is sufficient to make a few, say 5, antenna patterns equally spread over the passband, If we are dealing with 128 channels the antenna patterns should be calculated at the channels 14, 39, 64, 89 and 114.

```
/dz1/users/verheyen/N4183/DWARFDATA> [exe nmap]
```

```
OPTION (MAKE,SHOW,FIDDLE,W16FITS,W32FITS,WRLFITS,FROM_OLD,
          TO_OLD,CVX,NVS,QUIT) = QUIT: [make]

LOOPS (niter,Setincr  ....) = "": [5,...25]

 Input data:
SCN_NODE (input/output 'node' name) = "": [N4183]
SCN_SETS (Set(s) to do:  g.o.f.c.s ) = "": [1.0.0.14]
HA_RANGE (DEG) (HA range) = *: [-90,90]
 All fixed/movable interferometers pre-selected
SELECT_IFRS (Select/de-select ifrs) = "": [-ff,-mm]

   0123456789ABCD
 0 ----------++++
 1  ---------++++
 2   --------++++
 3    -------++++
 4     ------++++
 5      -----++++
 6       ----++++
 7        ---++++
 8         --++++
 9          -++++
 A           ----
 B            ---
 C             --
 D              -
SELECT_IFRS (Select/de-select ifrs) = "": [< CR >]
SCN_NODE (input/output 'node' name) = "": [< CR >]
USER_COMMENT (map comment) = "": [< CR >]

 Map properties:
UV_COORDINATES (UV,BASHA,IFRHA) (coordinate type) = UV: [uv]
FT_SIZE (FFT size) = 512,256: [1024,1024]
OUT_SIZE (Output size) = 1024,1024: [1024,1024]
FIELD_SIZE (DEG) (Fieldsize (deg)) = 1.2 DEG,1.2 DEG: [1.42222,2.04824]
QMAPS (More map details?) = NO: [yes]
UNIFORM (NATURAL,STANDARD,FULL) (Uniform coverage) =STANDARD:
          [standard]
TAPER (GAUSS,LINEAR,NATURAL,OVERR,RGAUSS) (Taper type) =
          GAUSS: [gauss]
TAPER_VALUE (M) (Taper width) = 2548 M: [2293]
CWEIGHT_TYPE (GAUSS,LINEAR,NATURAL) (Circular weight type)
          = NATURAL: [natural]
CONVOLVE (GAUSS,BOX,P4ROL,P6ROL,EXPSINC) (Convolution type)
          = EXPSINC: [expsinc]
DECONVOLVE (Correct for convolution?) = YES: [yes]

 Data manipulations:
QDATAS (More data handling details?) = NO: [no]
SUBTRACT (Source subtraction?) = NO: [no]

 Output files:
MAP_POLAR (XX,XY,YX,YY,I,Q,U,V,L,XXI,XYI,YXI,YYI,II,QI,UI,
          VI,LI) (polarisation info) = XX: [i]
MAP_COORD (B1950_J2000,APPARENT,REFERENCE,AREFERENCE) (type
          of map coord.) = B1950_J2000: [B1950_ J2000]
OUTPUT (MAP,AP,COVER,REAL,IMAG,AMPL,PHASE) (Output types)
          = MAP,AP: [ap]
OUTPUT_WMP_NODE (output 'node' name) = "": [N4183ap]
```

```
Creating node N4183AF

Sorting at 22:20:07 (Wall: 00:00:00.00  CPU: 00:00:00.00  I/O: 0  P/F: 0)
Scan node N4183 started at 22:20:08
Sector 1.0.0.14 started at 22:20:08

                                .
                                .
                                .
                                .
                                .

End at 22:24:54 (Wall: 00:04:46.87  CPU: 00:03:17.00  I/O: 0  P/F: 0)
```

A result of the transformation is shown in figure 8 which displays a part of channel 81. This map is not cleaned and the continuum is also not subtracted. This map can be plotted following

```
/dz1/users/verheyen/N4183/DWARFDATA> exe nplot

OPTION (MAP,DATA,MODEL,TELESCOPE,RESIDUAL,QUIT) = QUIT:  map
PLOTTER (QMS,QMSP,REGIS,FREGIS,EPS,EPP,PSL,PSP, EAL,EAP,
         PAL,PAP,BIT1,BIT2,BIT3,X11,USE1,USE2) (plotter
         to use) = PSP:  x11
WMP_NODE (input/output 'node' name) = "": N4183map
LOOPS (niter,Setincr  ....) = "":  1,...1
WMP_SETS (Set(s) to do:  g.f.c.p.t.m) = "":  0.0.81
 Map:  0.0.81.0.0.0
PLOT_TYPE (CONT,HALF,POL,RULE) (plot types) = CONT,HALF:
           cont,half
DATA_TYPE (DATA,SLOPE) (data types to plot) = DATA: data
AREA (Area l,m,dl,dm) = 0,0,512,512:  10,15,70,70

 Area(s) selected:
 Total   : l= 10, m= 15, dl= 70, dm= 70


 Noise= .4400 W.U.

 Range: -1.910516, 3.629950
SIZE (plot size) = 1,1:  1,1
FULL_CONT (contour values) = 1,1.41421,2,2.82843:
 0.6,1.2,1.8,2.4,3.0,3.6
DOT_CONT (contour values) = -1,-1.41421:  -0.6
HALFTONE (NONE,CONTINUE,STEP,PATTERN) (halftone type) =
         NONE:  continue
RANGE (halftone range) = -1.910516,3.62995:  0.6,3.6
TRANSFORM (transmission curve) = "":  <CR>
COORD (NONE,DLM,LM,DRADEC,RADEC,DDEGREE,DEGREE) (axis annotation)
         = NONE:  radec
COORD_TYPE (TICK,DOTTED,FULL) (axis type) = TICK:  tick
PLOT_POSITIONS (NO,YES) (show sources) = NO:  no
OPTION (MAP,DATA,MODEL,TELESCOPE,RESIDUAL,QUIT) = QUIT:  quit
```

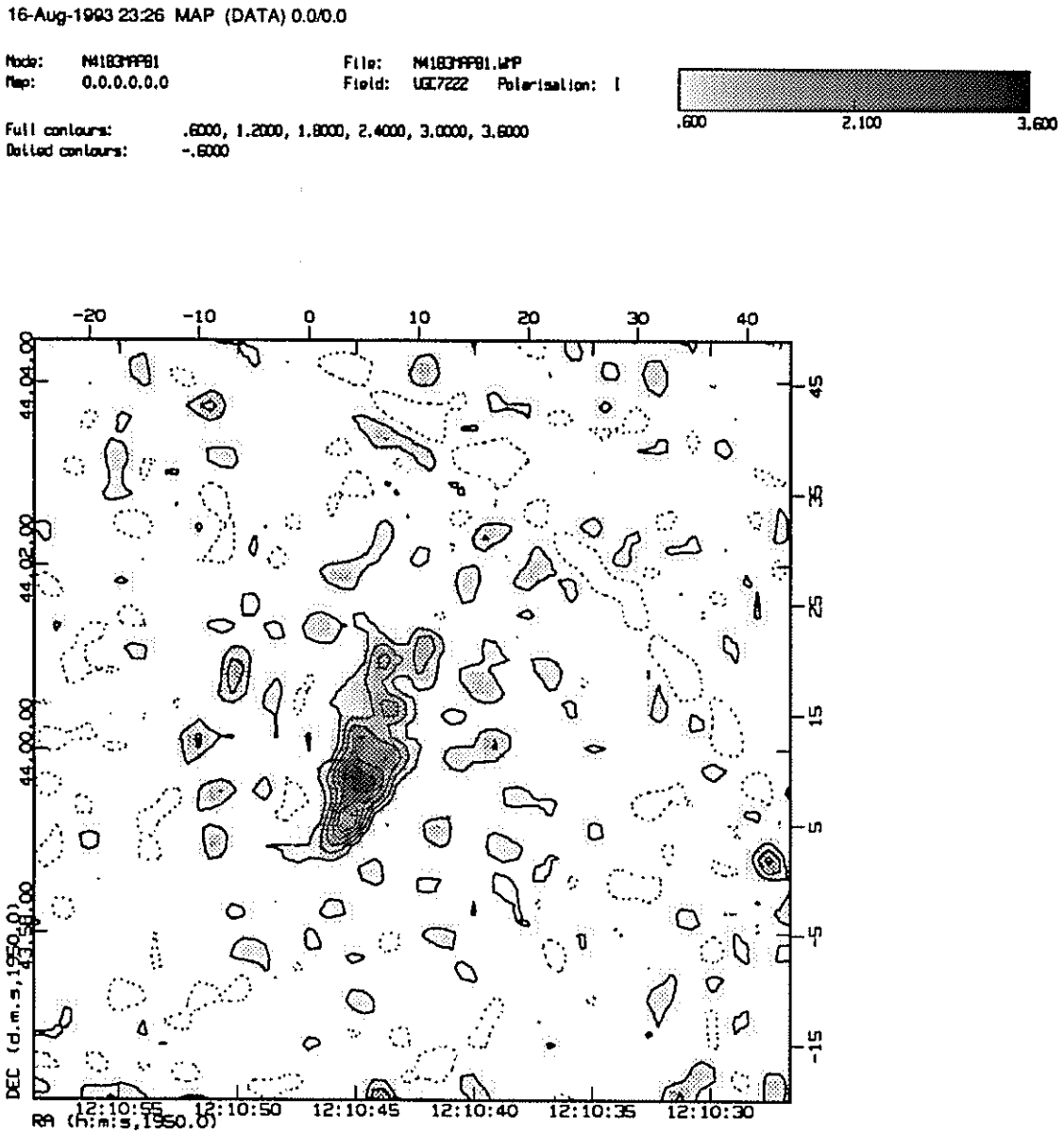

Figure 8: Contour and grayscale map of channel 81 containing 21cm line emission from N4183.

4.2 Writing the data in FITS format.

Finally we can write the maps and antenna patterns in the format of a FITS cube to export the data to an image reduction software package like GIPSY. For a single 12 hour measurement without high dynamic range requirement it is sufficient to write the fits cube with a 16 bit precision. This would save a lot of disk space as well. However, it is recommended to write the antenna patterns with a 32 bits precision.

```
/dz1/users/verheyen/N4183/DWARFDATA> exe nmap

OPTION (MAKE,SHOW,FIDDLE,W16FITS,W32FITS,WRLFITS,FROM_OLD,
        TO_OLD,CVX,NVS,QUIT) = QUIT: w16fits
INPUT_WMP_NODE (input 'node' name) = "": N4183map
WMP_SETS (Set(s) to do:  g.f.c.p.t.m) = "": 0.0.1-127.0.0
CUBIC (Make line cube?) = NO: yes
OUTPUT_UNIT (0,1,2,3,4,5,6,7,8,9,D) (output 'tape' unit)
        = D: d
FITS_SCALE (JY,WU) = JY: wu
FILENAME (filename) = "": fitsmaps
OUTPUT_LABEL (output label) = *: <CR>
 Writing 0.0.1.0.0.0 to file/label FITSMAPS.000001
COMMENT (Tape comment) = "": <CR>
```

When writing the antenna pattern in a FITS cube we must remember that the channel numbers in the .WMP file no longer correspond to the original numbers in the .SCN file.

```
/dz1/users/verheyen/N4183/DWARFDATA> exe nmap

OPTION (MAKE,SHOW,FIDDLE,W16FITS,W32FITS,WRLFITS,FROM_OLD,
        TO_OLD,CVX,NVS,QUIT) = QUIT: w32fits
INPUT_WMP_NODE (input 'node' name) = "": N4183ap
WMP_SETS (Set(s) to do:  g.f.c.p.t.m) = "": 0.0.0-100:25
CUBIC (Make line cube?) = NO: yes
OUTPUT_UNIT (0,1,2,3,4,5,6,7,8,9,D) (output 'tape' unit)
        = D: d
FITS_SCALE (JY,WU) = JY: wu
FILENAME (filename) = "": fitsap
OUTPUT_LABEL (output label) = *: <CR>
 Writing 0.0.0.0.1.0 to file/label FITSAP.000001
COMMENT (Tape comment) = "": <CR>
```