

Combining Arrays

e-MERLIN+EVLA
EVN+e-MERLIN

Different EVLA or ALMA
configurations

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CASA

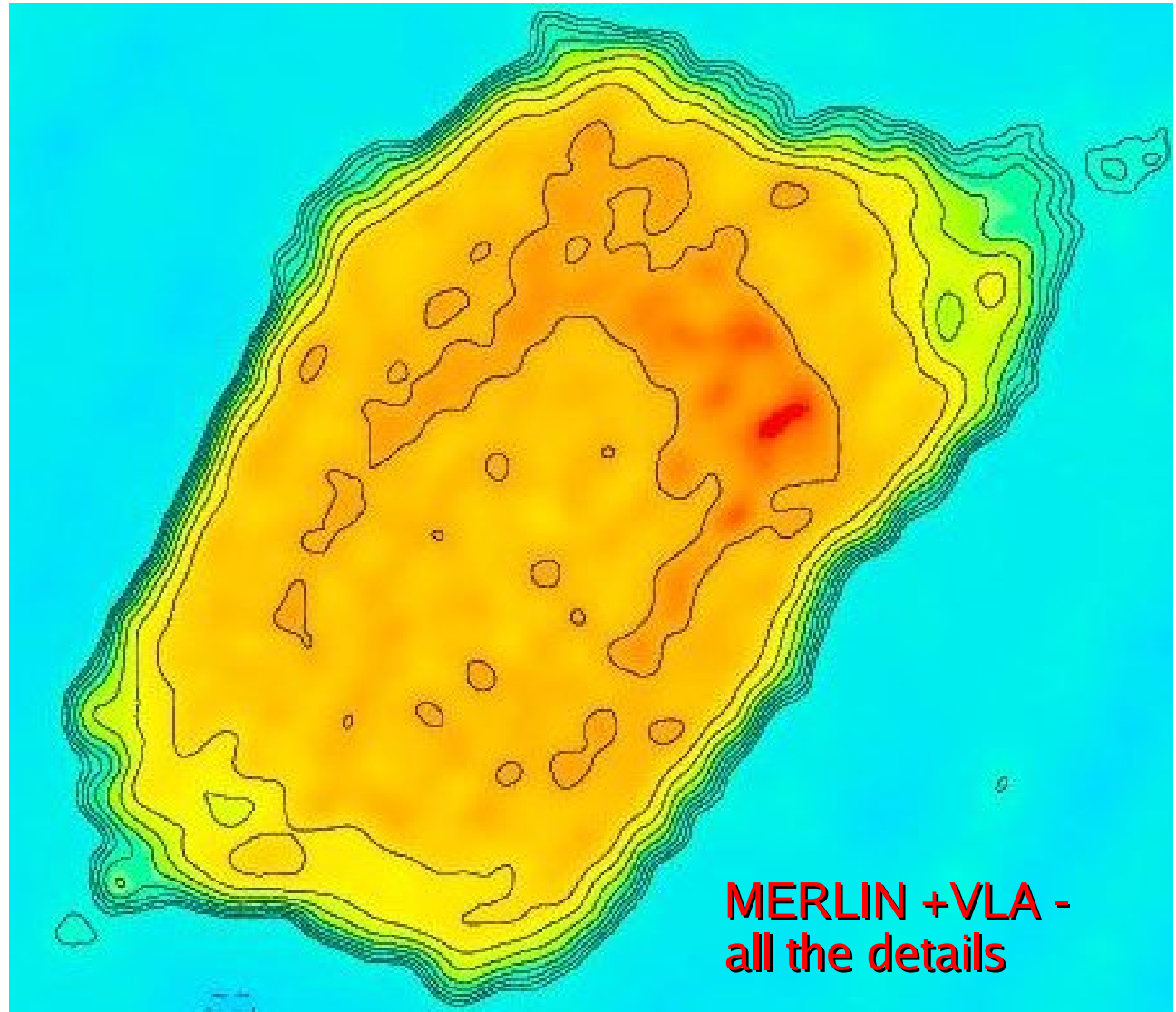
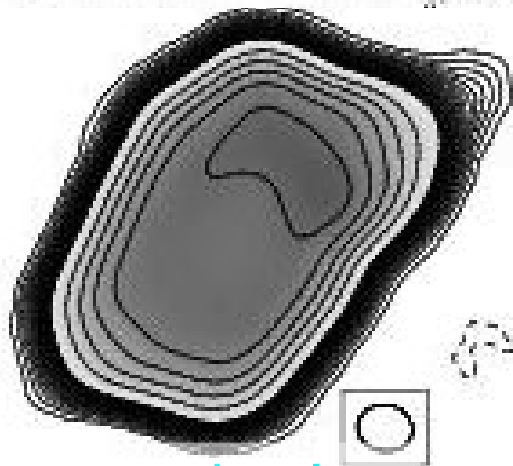


AIPS

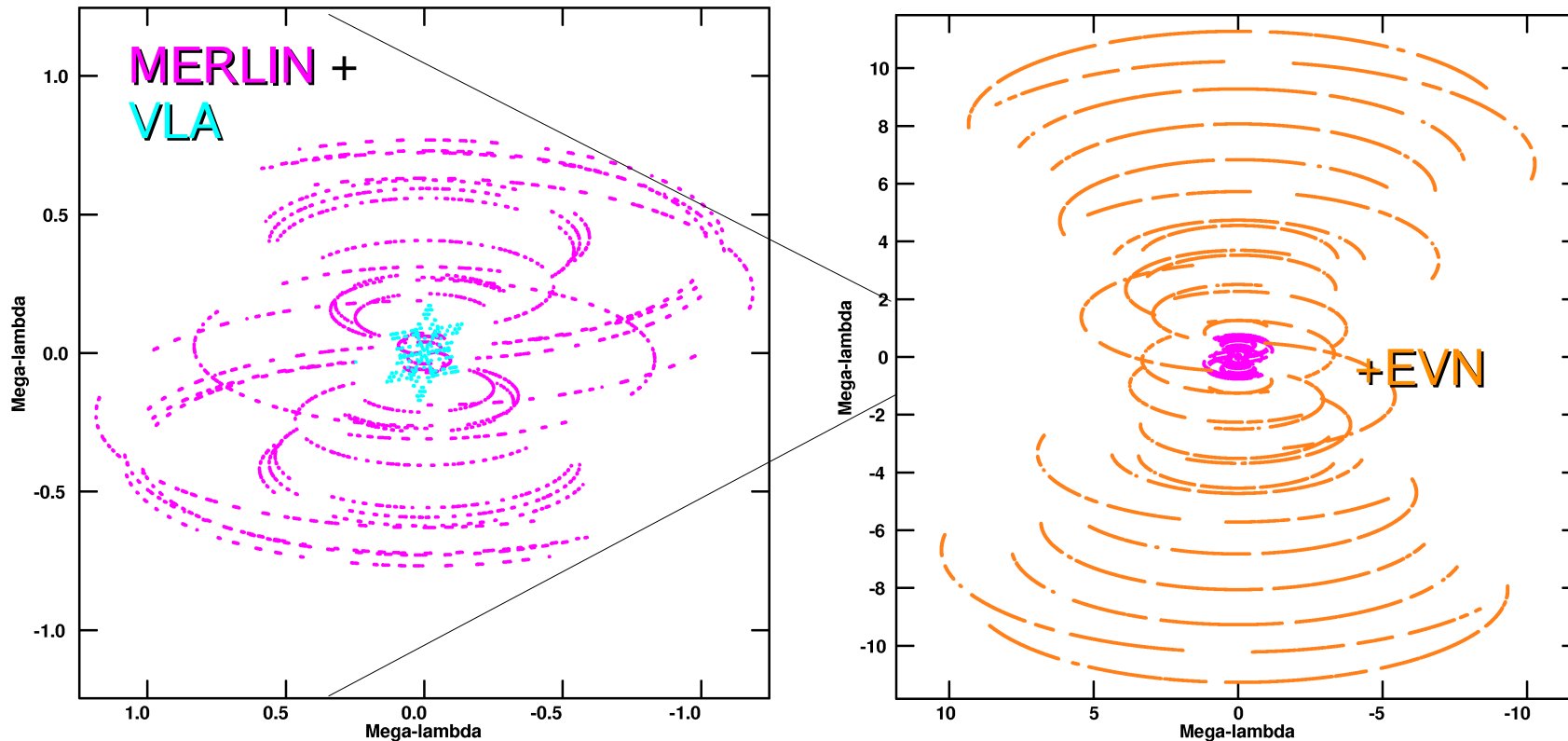
The University of Manchester
Jodrell Bank
Observatory



Filling the aperture - NGC 7027



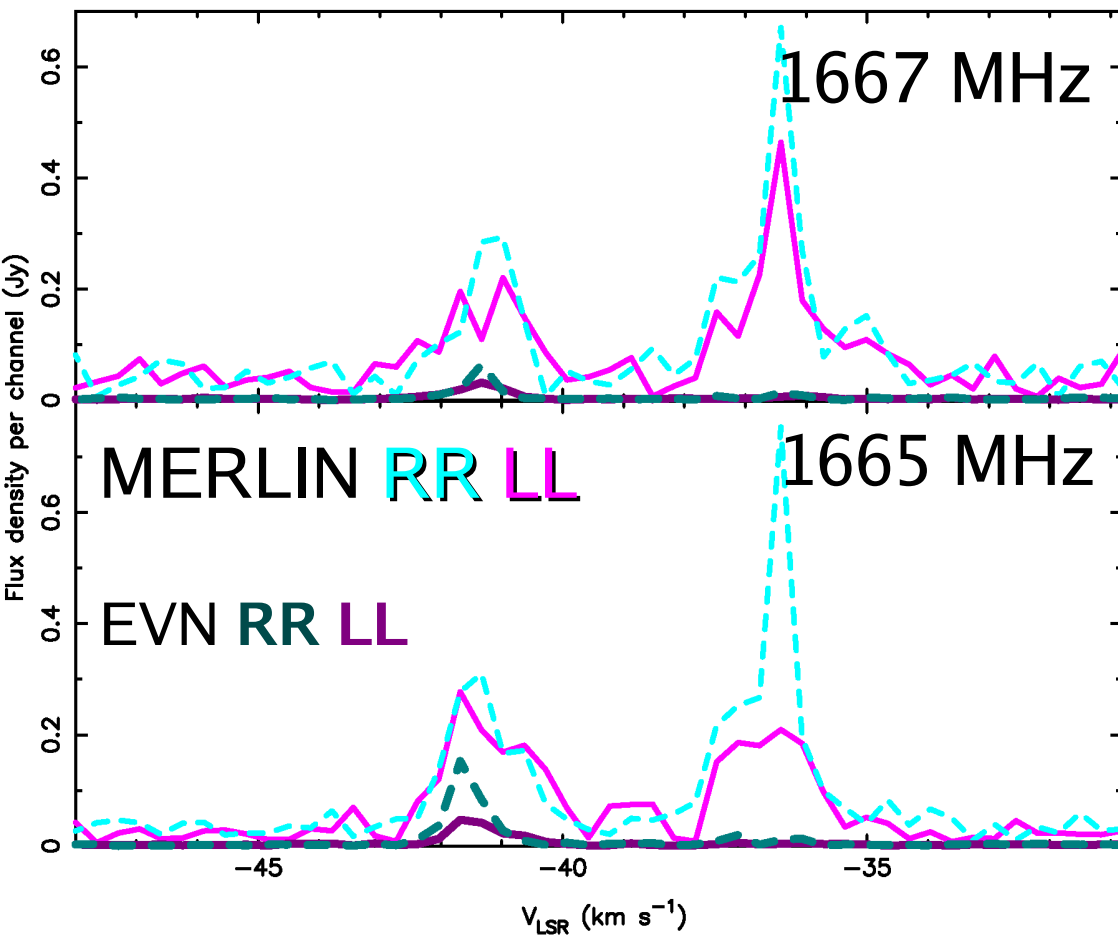
Improving aperture (uv) coverage



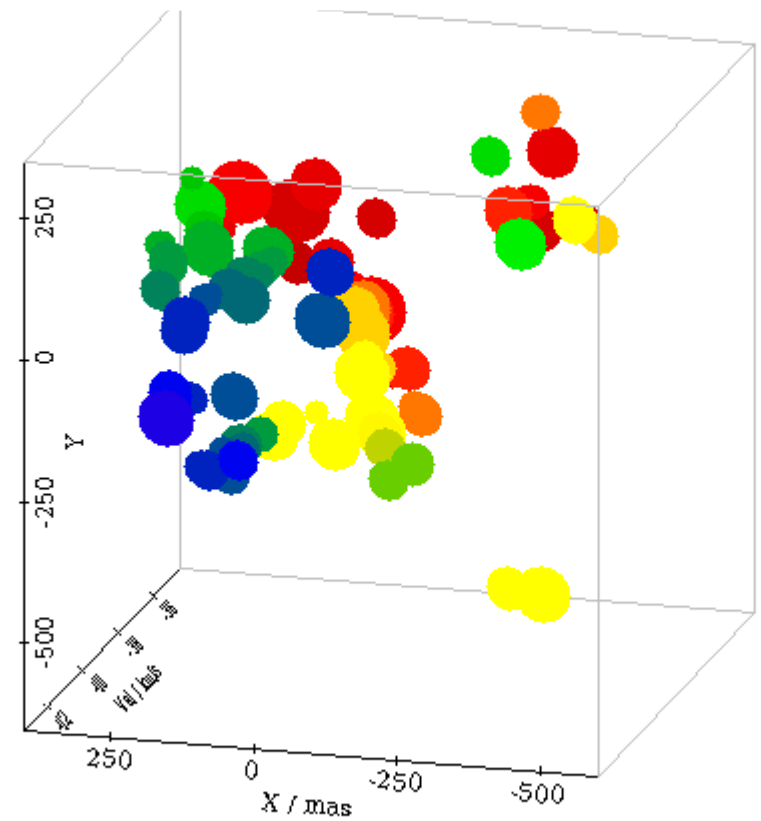
- Less of a problem for new broad bands
 - But still important for high-resolution/high frequency
 - Vital for spectral line

U Ori Masers MERLIN+EVN

- R_{OH} mainline shell ~ 3 MERLIN beams
- EVN resolves-out 10-90%
- Combine best of both!

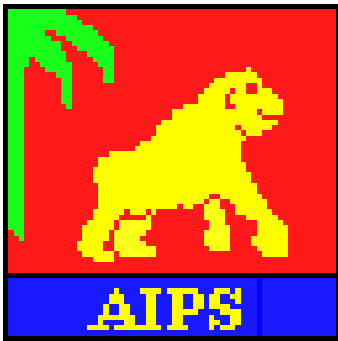


MERLIN+EVN OH



Aligning data from two arrays

- Compare flux on overlapping baselines
- Check position
 - Ideally observed with same phase-reference source
 - Correct coords, UVFIX or self-cal:
 - Make image from high-res data, tapered to use short baselines in common with low-res data
 - Use to self-cal low-res data
 - Useful for bright sources with multiple peaks
- Frequency:
 - Lines: same spectral config., at fixed ν if possible
 - Allow for spectral index if continuum at dif. ν
 - May combine different continuum configs
 - In map plane (dirty maps) or uv data in CASA
- Can add in single-dish data ('feathering')

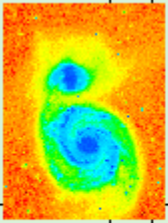


Astronomical Image Processing System

- Originated by NRAO for VLA in 1978
 - Fortran, C
 - Limited built-in scripting/math operations
 - Recent python wrapper (Parseltongue)
 - Now most widely used package for cm-wave
 - VLA, MERLIN, most VLBI ... many more interferometers
 - Some support for single dish
 - Recognises other images e.g. HST, X-ray...
 - Very wide functionality from calibration to analysis
- Binary releases for Linux/Unix, Mac o/s
 - Local compilation possible but rarely needed



- Standard astronomical data format:
 - UVFITS or IDI FITS for visibility data
 - Image files for 1, 2, 3+ D images
 - Unfortunately several dialects
 - AIPS uses FITS
 - CASA can read/export some FITS
- Structure of FITS file
 - Header
 - (Binary) data
 - Extension tables
 - Fortunately there are tools
 - IMHEAD in AIPS or CASA



FITS

The Astronomical
Image and Table Format

- Sta

- Str

```
Flex xterm
SIMPLE = T /
BITPIX = -32 /
NAXIS = 4 /
NAXIS1 = 66 /
NAXIS2 = 66 /
NAXIS3 = 280 /
NAXIS4 = 1 /
EXTEND = T /Tables following main image
BLOCKED = T /Tape may be blocked
OBJECT = 'SPER' /Source name
TELESCOP = 'MERLIN2' /
INSTRUME = /
OBSERVER = /
DATE-OBS = '1999-05-25' /Obs start date YYYY-MM-DD
DATE-MAP = '2000-01-11' /Last processing date YYYY-MM-DD
BSCALE = 1.000000000000E+00 /REAL = TAPE * BSCALE + BZERO
BZERO = 0.000000000000E+00 /
BUNIT = 'JY/BEAM' /Units of flux
EPOCH = 1.9500000000E+03 /Epoch of RA DEC
VELREF = 257 />256 RADIO, 1 LSR 2 HEL 3 OBS
ALTRVAL = 1.66710997656E+09 /Alternate FREQ/VEL ref value
ALTRPIX = -1.3900000000E+02 /Alternate FREQ/VEL ref pixel
OBSRA = 3.48128515485E+01 /Antenna pointing RA
OBSDEC = 5.83592651738E+01 /Antenna pointing DEC
RESTFREQ = 1.66735906400E+09 /Rest frequency
DATAMAX = 5.355936050E+00 /Maximum pixel value
DATAMIN = -5.429587513E-02 /Minimum pixel value
CTYPE1 = 'RA---SIN' /
CRVAL1 = 3.48128515485E+01 /
CDELTA1 = -1.111111123E-05 /
CRPIX1 = 3.300000000E+01 /
CROTA1 = 0.000000000E+00 /
CTYPE2 = 'DEC--SIN' /
CRVAL2 = 5.83592651738E+01 /
CDELTA2 = 1.111111123E-05 /
CRPIX2 = 3.400000000E+01 /
CROTA2 = 0.000000000E+00 /
CTYPE3 = 'VELO-LSR' /
CRVAL3 = 6.28035946778E+03 /
CDELTA3 = -1.756092529E+02 /
CRPIX3 = -1.390000000E+02 /
CROTA3 = 0.000000000E+00 /
CTYPE4 = 'STOKES' /
CRVAL4 = 1.00000000000E+00 /
CDELTA4 = 1.000000000E+00 /
CRPIX4 = 1.000000000E+00 /
CROTA4 = 0.000000000E+00 /
HISTORY AIPS HEADER2 WTNOISE = 1.03E
--More--(0%)
```

FITS Header

– Fortunately there are tools

- IMHEAD in AIPS or CASA


```

>getn 20;imh
AIPS 1: Got(1) disk= 1 user= 89 type=MA MKN273_MER.ICL001.1
AIPS 1: Image=MKN273A (MA) Filename=MKN273_MER .ICL001. 1
AIPS 1: Telescope=MERLIN2 Receiver=
AIPS 1: Observer= User #= 89
AIPS 1: Observ. date=14-FEB-2004 Map date=19-AUG-2009
AIPS 1: Minimum=-4.29469685E-04 Maximum= 7.45257037E-03 JY/BEAM
AIPS 1:

```

Axes
 Pos
 Pos
 Hz
 1 = 1 = total
 intensity

Axis	Units	Pixel	Coord value	at Pixel	Coord incr	Rotat
Pos	--SIN	512	13 44 42.142	256.00	-0.015000	0.00
Pos	--SIN	512	55 53 13.150	257.00	0.015000	0.00
Hz	Q	1	4.9929902E+09	1.00	1.2000000E+07	0.00
1 = 1 = total intensity	KES	1	1.0000000E+00	1.00	1.0000000E+00	0.00

```

AIPS 1: coordinate equinox 2000.00
AIPS 1: Map type=NORMAL Number of iterations= 1000
AIPS 1: Conv size= 0.13732 X 0.06835 Position angle= -22.69
AIPS 1: Rest freq 0.000 Vel type: OPTICAL wrt LSR
AIPS 1: Alt ref. value -4.20762E+05 wrt pixel 8.00
AIPS 1: Maximum version number of extension files of type CC is 1
AIPS 1: Maximum version number of extension files of type HI is 1
AIPS 1: Keyword = 'CCFLUX ' value = 4.341595E-02
AIPS 1: Keyword = 'CCTOTAL ' value = 4.341595E-02
AIPS 1: Keyword = 'PARANGLE' value = -1.239448E+02
AIPS 1: Keyword = 'ZENANGLE' value = 6.472005E+00

```

```

>tvlo;tvzoom;tvps

```



AIPS overview

- Use recent version (Dec10 in these examples)
- Start: type `>aips`
- Starts an environment in your xterm
 - Additional TV, message and Tek (plot) windows
 - Try `>aips tv=local` if problems using TV
 - Occasionally (dis)connecting from internet messes up
 - Limited number of instances can be run at once
- Enter an **AIPS Number** `>1` (make a note of it)
 - Convenient to use a different number per dataset
 - Multi-user systems may have allocated numbers

AIPS jargon

- Major operations are performed using **Tasks**
 - **FITLD** loads data, **CALIB** performs calibration etc.
- Input parameters to **Tasks** are set by **Verbs**
 - **>Task 'CALIB'; CALSOUR 'MKN273'; SOLINT 1**
 - Words/names in 'inverted commas'; numbers bare
 - *Not* case sensitive, in general
 - Inside AIPS, 12-character limit on file/source names
- To set all defaults: **>RESTORE 0**
 - **Beware: will give values typical for VLA data**
 - You will have to set parameters suitable for your data
- To exit and kill all AIPS windows: **>KLEENEX**

Starting AIPS

```
[amsr@KALI INTERFERO]# aips tv=local
START_AIPS: Will use or start first available Unix Socket based TV
START_AIPS: User data area assignments:
  (Using global default file /home/amsr/aips/DAQ0/DADEVS.LIST for DADEVS.PL)
  Disk 1 (1) is /home/amsr/aips/DATA/KALI_1

START_AIPS: Starting TPMON daemons on KALI asynchronously...
Starting up 31DEC09 AIPS with normal priority
Begin the one true AIPS number 1 (release of 31DEC09) at priority = 0
AIPS 1: You are not on a local TV device, welcome stranger
AIPS 1: You are assigned TV device/server 2
AIPS 1: You are assigned graphics device/server 2
AIPS 1: Enter user ID number
289
AIPS 1:                               31DEC09 AIPS:
AIPS 1:      Copyright (C) 1995-2009 Associated Universities, Inc.
AIPS 1:      AIPS comes with ABSOLUTELY NO WARRANTY;
AIPS 1:      for details, type HELP GNUGPL
AIPS 1: This is free software, and you are welcome to redistribute it
AIPS 1: under certain conditions; type EXPLAIN GNUGPL for details.
AIPS 1: Previous session command-line history recovered.
AIPS 1: TAB-key completions enabled. type HELP README for details.
AIPS 1:
>
```



```

AIPS_TEKSP
Enter TEKSERV, Unix (local) domain

```

xterm

```

[amsr@KALI INTERFERO]$ aips tv=local
START_AIPS: Will use or start first available Unix Socket base
START_AIPS: Your initial AIPS printer is the
START_AIPS: - system name , AIPS type

START_AIPS: User data area assignments:
(Using global default file /home/amsr/aips/DA00/DADEVS.LIS
Disk 1 (1) is /home/amsr/aips/DATA/KALI_1

Tape assignments:
Tape 1 is REMOTE
Tape 2 is REMOTE

START_AIPS: I am GUESSING you are at a workstation called ka
START_AIPS: - but have chosen to run the TV locally on KALI
START_AIPS: Starting TV servers on kali asynchronously
START_AIPS: - WITH Unix Sockets as requested...
START_AIPS: Starting TPMON daemons on KALI asynchronously...
Starting up 31DEC09 AIPS with normal priority

UNIXSERVERS: Start TV LOCK daemon TVSRV1 on kali
Begin the one true AIPS number 1 (release of 31DEC09) at priority = 0
STARTPMON: [KALI] Starting TPMON1 with output SUPPRESSED
UNIXSERVERS: Start XAS1 on kali, DISPLAY :0.0

```

AIPS_MSGSRV_1

```

MSGserver: Starting AIPS task logging, Unix (local) domain
hostna> task #: Message
-----

```

Loading data into AIPS

```
xterm
>task 'FITLD'
>inp
AIPS 1: FITLD: Task to store an image or UV data from a FITS tape
AIPS 1: Adverbs      Values      Comments
-----
AIPS 1: INTAPE       1          Input tape drive # (0 => 1)
AIPS 1: NFILES       0          # of files to advance on tape
AIPS 1: DATAIN      *all ' '    Disk file name
AIPS 1: OUTNAME      ' '        File name (name)
AIPS 1: OUTCLASS    ' '        File name (class)
AIPS 1: OUTSEQ       0          File name (seq. #)
AIPS 1:              0 => highest unique number
AIPS 1:              => matching (on VLBA)
AIPS 1:              -1 => FITS tape value
AIPS 1: OUTDISK     1          Disk drive # (0 => any)
AIPS 1: OPTYPE      ' '        Type of data to load,
AIPS 1:              ' ' => all types
AIPS 1:              'UV' => UV data
AIPS 1:              'IM' => images
AIPS 1: NCOUNT     0          Number of files to load.
AIPS 1: DOTABLE     1          True (1,0) means load tables
AIPS 1:              for images.
AIPS 1: DOUVCOMP    1          >0 => compressed data (FITS)
AIPS 1: DOCONCAT    -1         >0 -> if VLBA correlator data
AIPS 1:              append data to existing
AIPS 1:              files, or if no appropriate
AIPS 1: ** press RETURN for more, enter Q or next line to quit print **
#
```



Loading data into AIPS

The image shows two xterm windows. The left window displays the AIPS command-line interface with the following text:

```
>task 'FITLD'  
>inp  
AIPS 1: FITLD: Task to score an image or UV data from a FITS tape  
AIPS 1: Adverbs  
AIPS 1: -----  
AIPS 1: INTAPE  
AIPS 1: NFILES  
AIPS 1: DATAIN  
AIPS 1: OUTNAME  
AIPS 1: OUTCLASS  
AIPS 1: OUTSEQ  
AIPS 1:  
AIPS 1: OUTDISK  
AIPS 1: OPTYPE  
AIPS 1:  
AIPS 1: NCOUNT  
AIPS 1: DOTABLE  
AIPS 1:  
AIPS 1: DOUVCOMP  
AIPS 1: DOCONCAT  
AIPS 1:  
AIPS 1: ** press RETURN for more, enter Q or next line to quit print **  
#
```

The right window displays the AIPS command-line interface with the following text:

```
>datain 'PWD:MKN273_MER.FITS'  
>douvcomp -1  
>inp  
AIPS 1: FITLD: Task to score an image or UV data from a FITS tape  
AIPS 1: Adverbs      Values      Comments  
AIPS 1: -----  
AIPS 1: INTAPE          1          Input tape drive # (0 => 1)  
AIPS 1: NFILES          0          # of files to advance on tape  
AIPS 1: DATAIN        'PWD:MKN273_MER.FITS'  Disk file name  
AIPS 1: OUTNAME        ' '          File name (name)  
AIPS 1: OUTCLASS      ' '          File name (class)  
AIPS 1: OUTSEQ         0          File name (seq. #)  
AIPS 1:                0 => highest unique number  
AIPS 1:                => matching (on VLBA)  
AIPS 1:                -1 => FITS tape value  
AIPS 1: OUTDISK         1          Disk drive # (0 => any)  
AIPS 1: OPTYPE         ' '          Type of data to load,  
AIPS 1:                ' ' => all types  
AIPS 1:                'UV' => UV data  
AIPS 1:                'IM' => images  
AIPS 1: NCOUNT         0          Number of files to load.  
AIPS 1: DOTABLE         1          True (1,0) means load tables  
AIPS 1:                for images.  
AIPS 1: DOUVCOMP        -1         >0 => compressed data (FITS)  
AIPS 1: ** press RETURN for more, enter Q or next line to quit print **  
#go
```

Red circles highlight the 'task' and 'inp' commands in the left window, and the 'datain' and 'inp' commands in the right window. Green circles highlight the 'DATAIN' and 'DOUVCOMP' parameters in the right window's parameter list.

Where does AIPS put data?

The image shows two terminal windows. The top window, titled 'AIPS_MSGSRV_1', shows a list of tasks and their messages. The bottom window, titled 'xterm', shows the execution of a command to list files in a specific directory.

Terminal 1 (AIPS_MSGSRV_1):

```
hostna> task #: Message
-----
KALI > FITLD1: Task FIT
KALI > FITLD1: Found MK
KALI > FITLD1: Create M
KALI > FITLD1:
KALI > FITLD1: Check
KALI > FITLD1: Observer
KALI > FITLD1: Observ.
KALI > FITLD1: # visibi
KALI > FITLD1: Rand axe
KALI > FITLD1: -----
KALI > FITLD1: Type
KALI > FITLD1: COMPLEX
KALI > FITLD1: STOKES
KALI > FITLD1: FREQ
KALI > FITLD1: IF
KALI > FITLD1: RA
KALI > FITLD1: DEC
KALI > FITLD1: -----
KALI > FITLD1: Coordinat
KALI > FITLD1: Rest fre
KALI > FITLD1: Alt ref.
KALI > FITLD1: Maximum
KALI > FITLD1: Maximum
KALI > FITLD1: Maximum version number of extension files of type BL is 1
KALI > FITLD1: Maximum version number of extension files of type FG is 1
KALI > FITLD1: Appears to have ended successfully
KALI > FITLD1: kali 31DEC09 TST: Cpu= 0.1 Real= 0 IO= 4
```

Terminal 2 (xterm):

```
[amsr@KALI ~]$ ls /home/amsr/aips/DATA/KALI_1/
AND001001.010: CCD005046.00R; CCD00A067.02H; CCD00M01Y.00U; FGD002001.05K;
AND001001.023: CCD005047.00R; CCD00A06Z.0RQ; CCD00M01Z.00U; FGD002001.00U;
AND001001.02H: CCD005048.00R; CCD00A070.02H; CCD00M020.00U; FGD002001.00X;
AND001001.05K: CCD005049.00R; CCD00A070.0RQ; CCD00M021.00U; FGD002001.0P0;
AND001001.0II: CCD00504A.00R; CCD00A071.02H; CCD00M022.00U; FGD002001.0RN;
AND001001.0M8: CCD00504B.00R; CCD00A071.0RQ; CCD00M023.00U; FGD002001.1CN;
AND001001.00W: CCD00504C.00R; CCD00A072.02H; CCD00M024.00U; FGD002001.556;
AND001001.00X: CCD00504D.00R; CCD00A072.0RQ; CCD00M025.00U; FGD002002.00U;
AND001001.0P0: CCD00504E.00R; CCD00A073.02H; CCD00M026.00U; FGD003001.01D;
AND001001.000: CCD00504F.00R; CCD00A073.02H; CCD00M027.00U; FGD003001.02H;
AND001001.001: CCD00504G.00R; CCD00A074.02H; CCD00M028.00U; FGD003001.00W;
AND001001.002: CCD00504H.00R; CCD00A074.02H; CCD00M029.00U; FGD003001.00X;
AND001001.003: CCD00504I.00R; CCD00A075.02H; CCD00M02A.00U; FGD003001.0P0;
AND001001.0RS: CCD00504J.00R; CCD00A075.0RQ; CCD00M02B.00U; FGD003001.0RQ;
AND001001.0UK: CCD00504K.00R; CCD00A076.02H; CCD00M02C.00U; FGD003001.0UK;
AND001001.0XC: CCD00504L.00R; CCD00A076.0RQ; CCD00M02D.00U; FGD003001.1CN;
AND001001.118: CCD00504M.00R; CCD00A077.02H; CCD00M02E.00U; FGD003002.02H;
AND001001.1CN: CCD00504N.00R; CCD00A077.0RQ; CCD00M02F.00U; FGD003003.02H;
AND001001.556: CCD00504O.00R; CCD00A078.02H; CCD00M02G.00U; FGD004001.05K;
AND001002.0RJ: CCD00504P.00R; CCD00A078.0RQ; CCD00M02H.00U; FGD004001.0G0;
```

Annotations:

- A green oval highlights the window title 'AIPS_MSGSRV_1'.
- A cyan oval highlights the command 'ls /home/amsr/aips/DATA/KALI_1/' in the xterm window.
- A cyan box contains the text: 'Actual data location - usually no need to look there'.
- A green oval highlights the message 'Appears to have ended successfully' in the AIPS_MSGSRV_1 window.



Where does AIPS put data?

```
hostna> task #: Mess
-----
KALI > FITLD1: Task
KALI > FITLD1: Four
KALI > FITLD1: Crea
KALI > FITLD1:
KALI > FITLD1: Che
KALI > FITLD1: Obse
KALI > FITLD1: # vi
KALI > FITLD1: Rand
KALI > FITLD1: ----
KALI > FITLD1: Type
KALI > FITLD1: COMP
KALI > FITLD1: STOK
KALI > FITLD1: FREQ
KALI > FITLD1: IF
KALI > FITLD1: RA
KALI > FITLD1: DEC
KALI > FITLD1: ----
KALI > FITLD1: Coord
KALI > FITLD1: Rest
KALI > FITLD1: Alt
KALI > FITLD1: Maxi
KALI > FITLD1: Maxi
KALI > FITLD1: Maxi
KALI > FITLD1: Maximum version number of extension files of type FG is 1
KALI > FITLD1: Appears to have ended successfully
KALI > FITLD1: kali 31DEC09 TST: Cpu= 0.1 Real= 0 IO= 4
```

AIPS_MSGSRV_1

```
#pcat
AIPS 1: Catalog on disk 1
AIPS 1: Cat Usid Mapname
AIPS 1: 1 89 SPER_67 .UVDATA. 1 UV 30-AUG-2009 14:46:53
AIPS 1: 2 89 SPNCALS_67 .UVDATA. 1 UV 16-AUG-2009 16:39:01
AIPS 1: 3 89 SPWCALS .UVDATA. 1 UV 17-AUG-2009 09:55:03
AIPS 1: 4 89 SPER_67 .TASAV . 1 UV 17-AUG-2009 09:55:03
AIPS 1: 5 89 0200+539 .ICL001. 1 MA 18-AUG-2009 21:37:14
AIPS 1: 6 89 SPER_332 .LBM001. 1 MA 18-AUG-2009 21:37:14
AIPS 1: 7 89 SPER_332 .LCLO01. 1 MA 18-AUG-2009 21:37:14
AIPS 1: 8 89 SPER_67 .WTMOD . 1 UV 18-AUG-2009 21:37:14
AIPS 1: 9 89 SPER_67 .ICL001. 1 MA 18-AUG-2009 21:37:14
AIPS 1: 10 89 SPER_67 .QCLO01. 1 MA 18-AUG-2009 21:37:17
AIPS 1: 11 89 SPER_67 .UCL001. 1 MA 18-AUG-2009 21:37:17
AIPS 1: 12 89 MKN273_EVN .UVDATA. 1 UV 19-AUG-2009 14:49:36
AIPS 1: 13 89 MKN273_MER .UVDATA. 1 UV 30-AUG-2009 15:10:15
AIPS 1: 14 89 MKN273_EVN .UVMOD . 1 UV 19-AUG-2009 22:05:19
AIPS 1: 15 89 M273_ME_.002.DBCON . 1 UV 20-AUG-2009 16:48:34
AIPS 1: 16 89 MKN273_EVN .IBM001. 1 MA 19-AUG-2009 14:13:57
AIPS 1: 17 89 MKN273_EVN .ICL001. 1 MA 19-AUG-2009 14:47:56
AIPS 1: ** press RETURN for more, enter Q or next line to quit print **
#
```

Data are accessed via the AIPS catalogue.

Maximum version number of extension files of type FG is 1
Appears to have ended successfully



What's in the data?

```
xterm
```

```
#pcat
AIPS 1: catalog on disk 1
AIPS 1:  Cat Usid Mapname      Class  Seq Pt   Last access      Stat
AIPS 1:   1   89 SPER_67      .UVDATA.  1 UV 30-AUG-2009 14:46:53
AIPS 1:   2   89 SPNCALS_67  .UVDATA.  1 UV 16-AUG-2009 16:39:01
AIPS 1:   3   89 SPNCALS_67  .UVDATA.  1 UV 17-AUG-2009 09:55:03
AIPS 1:   4   89 SPER_67      .ASAV.    1 UV 17-AUG-2009 09:55:03
AIPS 1:   5   89 SPER_67      .ICL001.  1 MA 18-AUG-2009 21:37:14
AIPS 1:   6   89 SPER_67      .BM001.  1 MA 18-AUG-2009 21:37:14
AIPS 1:   7   89 SPER_332    .LCL001.  1 MA 18-AUG-2009 21:37:14
AIPS 1:   8   89 SPER_67      .WTMOD.   1 UV 18-AUG-2009 21:37:14
AIPS 1:   9   89 SPER_67      .ICL001.  1 MA 18-AUG-2009 21:37:14
AIPS 1:  10   89 SPER_67      .QCLO01.  1 MA 18-AUG-2009 21:37:17
AIPS 1:  11   89 SPER_67      .UCL001.  1 MA 18-AUG-2009 21:37:17
AIPS 1:  12   89 MKN273_EVN  .UVDATA.  1 UV 19-AUG-2009 14:49:36
AIPS 1:  13   89 MKN273_MER  .UVDATA.  1 UV 30-AUG-2009 15:10:15
AIPS 1:  14   89 MKN273_EVN  .WTMOD.   1 UV 19-AUG-2009 22:05:19
AIPS 1:  15   89 M273_ME_002.DBCON.  1 UV 20-AUG-2009 16:48:34
AIPS 1:  16   89 MKN273_EVN  .IBM001.  1 MA 19-AUG-2009 14:13:57
AIPS 1:  17   89 MKN273_EVN  .ICL001.  1 MA 19-AUG-2009 14:47:56
AIPS 1:  ** press RETURN for more, enter Q or next line to quit print **
#
```

You can select data by name or catalogue number

What's in the data?

```
#pcat
AIPS 1: Catalog on disk
AIPS 1: Cat Usid Mapr
AIPS 1: 1 89 SPER
AIPS 1: 2 89 SPNO
AIPS 1: 3 89 SPWD
```

You can select data name or catalogue

```
AIPS 1: 7 89 SPER
AIPS 1: 8 89 SPER
AIPS 1: 9 89 SPER
AIPS 1: 10 89 SPER
AIPS 1: 11 89 SPER
AIPS 1: 12 89 MKN2
AIPS 1: 13 89 MKN2
AIPS 1: 14 89 MKN2
AIPS 1: 15 89 M273
AIPS 1: 16 89 MKN2
AIPS 1: 17 89 MKN2
AIPS 1: ** press RETURN
#
```

```
#getn 13
```

```
AIPS 1: Got(1) disk= 1 user= 89 type=UV MKN273_MER.UVDATA 1
```

```
>imh
```

Check file header

```
AIPS 1: 1: Filename=MKN273_MER.UVDATA 1
AIPS 1: Telescope=MERLIN2 Receiver=
AIPS 1: Observer= User#= 89
AIPS 1: Observ. date=14-FEB-2004 Map date=19-AUG-2009
AIPS 1: # visibilities 40882 Sort order TB
AIPS 1: Rand axes: UU-L WV-L WW-L BASELINE TIME1
```

```
AIPS 1: -----
AIPS 1: Type Pixels Coord value at Pixel Coord incr Rotat
AIPS 1: COMPLEX 3 0.0000000E+00 1.00 1.0000000E+00 0.00
AIPS 1: STOKES 4 -1.0000000E+00 1.00 -1.0000000E+00 0.00
AIPS 1: FREQ 1 4.9944900E+09 1.12 1.2000000E+07 0.00
AIPS 1: IF 1 1.0000000E+00 1.00 1.0000000E+00 0.00
AIPS 1: RA 1 13 44 42.142 1.00 3600.000 0.00
AIPS 1: DEC 1 55 53 13.150 1.00 3600.000 0.00
AIPS 1: -----
```

```
AIPS 1: Coordinate equinox 2000.00
AIPS 1: Rest freq 0.000 Vel type: OPTICAL wrt LSR
AIPS 1: Alt ref. value -4.20762E+05 wrt pixel 8.00
AIPS 1: Maximum version number of extension files of type HI is 1
AIPS 1: Maximum version number of extension files of type AN is 1
AIPS 1: Maximum version number of extension files of type BL is 1
AIPS 1: Maximum version number of extension files of type FG is 1
AIPS 1: Keyword = 'MAXABSU' value = -1.000000E+00
```

Type	Name	Class	Seq. No.
------	------	-------	----------

type=UV MKN273_MER.UVDATA.1

UV data header

```

AIPS 1: Image=MKN273A (UV)      Filename=MKN273_MER .UVDATA. 1
AIPS 1: Telescope=MERLIN2       Receiver=
AIPS 1: Observer=              User #= 89
AIPS 1: Observ. date=14-FEB-2004 Map date=19-AUG-2009
AIPS 1: # visibilities 40882     Sort order TB
AIPS 1: Rand axes: UU-L VV-L WW-L BASELINE TIME1
AIPS 1: -----

```

Axes:
Visibilities

Amp, ϕ , weight
LL RR LR RL
Hz
Sub-band
Pos
Pos

Type	Pixels	Coord value	at Pixel	Coord incr	Rotat
COMPLEX	3	0.0000000E+00	1.00	1.0000000E+00	0.00
STOKES	4	-1.0000000E+00	1.00	-1.0000000E+00	0.00
FREQ	1	4.9944900E+09	1.12	1.2000000E+07	0.00
IF	1	1.0000000E+00	1.00	1.0000000E+00	0.00
RA	1	13 44 42.142	1.00	3600.000	0.00
DEC	1	55 53 13.150	1.00	3600.000	0.00

```

AIPS 1: -----
AIPS 1: Coordinate equinox 2000.00
AIPS 1: Rest freq 0.000 Vel type: OP
AIPS 1: Alt ref. value -4.20762E+05 wrt pixel
AIPS 1: Maximum version number of extension files of type HI is 1
AIPS 1: Maximum version number of extension files of type AN is 1
AIPS 1: Maximum version number of extension files of type BL is 1
AIPS 1: Maximum version number of extension files of type FG is 1
AIPS 1: Keyword = 'MAXABSU ' value = -1.0000000E+00

```

Extension tables

Image data

Type	Name	Class	Seq. No.
------	------	-------	----------

```

= 89 type=MA MKN273_MER.ICL001.1
Filename=MKN273_MER .ICL001. 1
Receiver=
User #= 89
Map date=19-AUG-2009
Maximum= 7.45257037E-03 JY/BEAM

```

```

AIPS 1: Observer=
AIPS 1: Observ. date=14-FEB-2004
AIPS 1: Minimum=-4.29469685E-04

```

```

User #= 89
Map date=19-AUG-2009
Maximum= 7.45257037E-03 JY/BEAM

```

Axes
 Pos
 Pos
 Hz
 1 = I = total
 intensity

Axes	Type	Pixels	Coord value	at Pixel	Coord incr	Rotat
Pos	RA---SIN	512	13 44 42.142	256.00	-0.015000	0.00
Pos	DEC--SIN	512	55 53 13.150	257.00	0.015000	0.00
Hz	FREQ	1	4.9929902E+09	1.00	1.2000000E+07	0.00
	STOKES	1	1.0000000E+00	1.00	1.0000000E+00	0.00

```

Coordinate equinox 2000.00
AIPS 1: Restoring beam Maj, Min (arcsec), position angle (degrees)
AIPS 1: Conv size= 0.13732 X 0.06835 Position angle= -22.69
AIPS 1: Rest freq 0.000 Vel type: OPTICAL rest LSR
AIPS 1: Alt ref. value -4.20762E+05 wrt pixel
AIPS 1: Maximum version number of extension files of type CC is 1
AIPS 1: Maximum version number of extension files of type HI is 1
AIPS 1: Keyword = 'CCFLUX ' value = 4.341595E-02
AIPS 1: Keyword = 'CCTOTAL ' value = 4.341595E-02
AIPS 1: Keyword = 'PARANGLE' value = -1.239448E+02
AIPS 1: Keyword = 'ZENANGLE' value = 6.472005E+00

```

Extension tables

>tvlo;tvzoom;tvps

Inspect an image



Image data

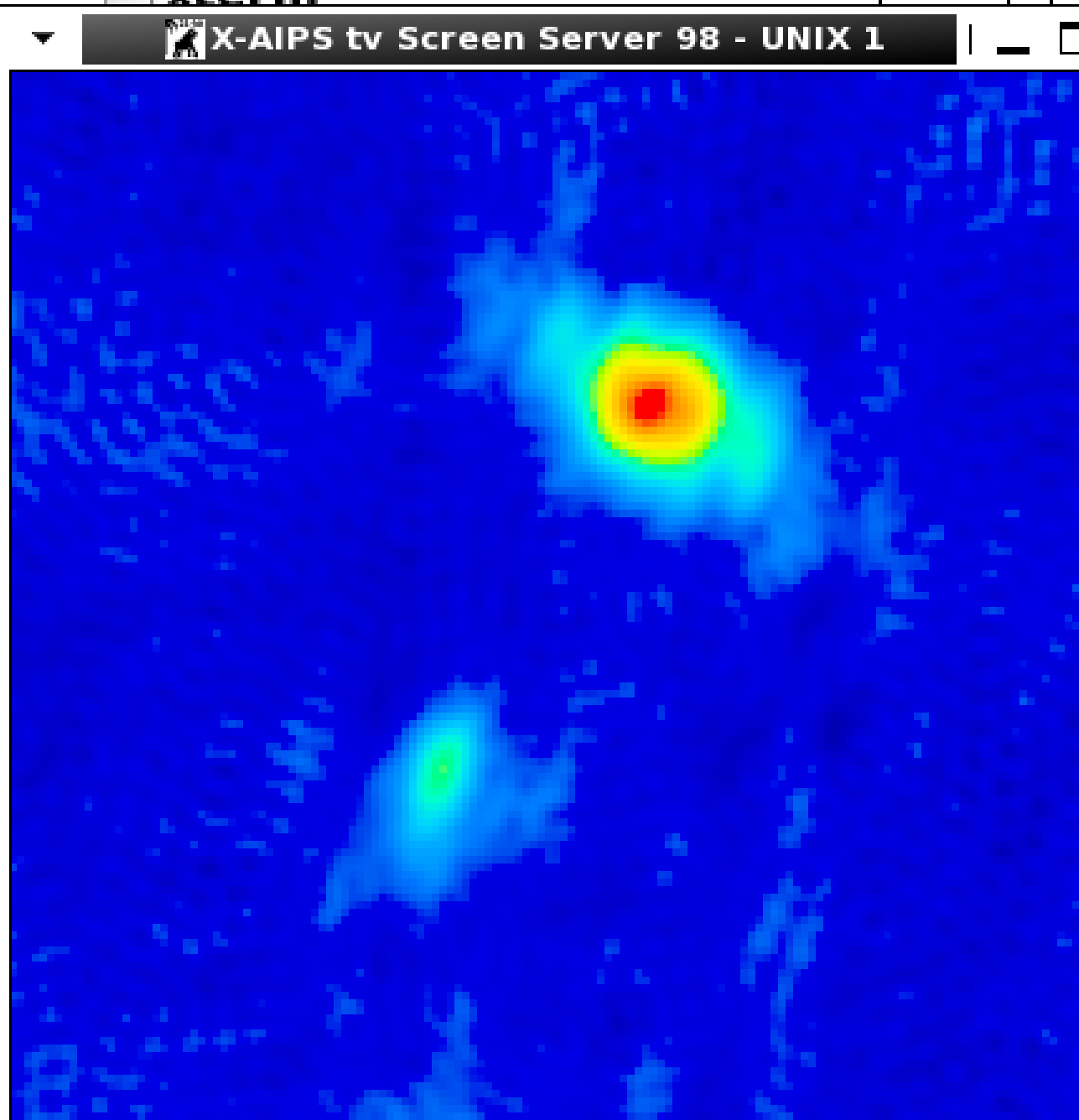
```
AIPS 1: Observer=  
AIPS 1: Observ. date=14  
AIPS 1: Minimum=-4.2946  
AIPS 1: -----
```

```
  Axes * Type      Pixels  
  Pos  * RA---SIN   512  
  Pos  * DEC--SIN   512  
  Hz   * FREQ       1  
  STOKES * STOKES    1  
  -----
```

1 = I = total intensity

```
AIPS 1: Coordinate equi  
AIPS 1: Restoring beam  
AIPS 1: Conv size= 0.13  
AIPS 1: Rest freq  
AIPS 1: Alt ref. value  
AIPS 1: Maximum version  
AIPS 1: Maximum version  
AIPS 1: Keyword = 'CCFL  
AIPS 1: Keyword = 'CCTO  
AIPS 1: Keyword = 'PARANGLE value = 1.253440E+02  
AIPS 1: Keyword = 'ZENANGLE' value = 6.472005E+00
```

```
>tvlo;tvzoom;tvps
```



Inspect an image

Making a plot file

```
xterm
```

```
#
AIPS 1: IN3NAME      ''      (name) blank => INNAME
AIPS 1: IN3CLASS    ''      (class) blank => 'PPOL'
AIPS 1: IN3SEQ      0       (seq. #) 0 => high
AIPS 1: IN3DISK     0       Disk drive #, 0 => any
AIPS 1:             Polarization angle image:
AIPS 1: IN4NAME      ''      (name) blank => INNAME
AIPS 1: IN4CLASS    ''      (class) blank => 'PPOL'
AIPS 1: IN4SEQ      0       (seq. #) 0 => high
AIPS 1: IN4DISK     0       Disk drive #, 0 => any
AIPS 1: BLC         137     153  Bottom left corner of first
AIPS 1:             image. 0 => 1
AIPS 1:             1       1
AIPS 1:             1       1
AIPS 1: TRC         397     375  Top right corner of first
AIPS 1:             1       1  image; 0=>entire image
AIPS 1:             1       1  Multiple planes of a cube
AIPS 1:             1       1  will be plotted in panels.
AIPS 1: ZINC        1       Increment on 3rd axis of
AIPS 1:             1       1st and possibly 2nd image
AIPS 1: NY          0       Number of planes along
AIPS 1:             0       vertical side of plot
AIPS 1: ** press RETURN for more, enter Q or next line to quit print **
#
```

Use TVWIN again to set box around source

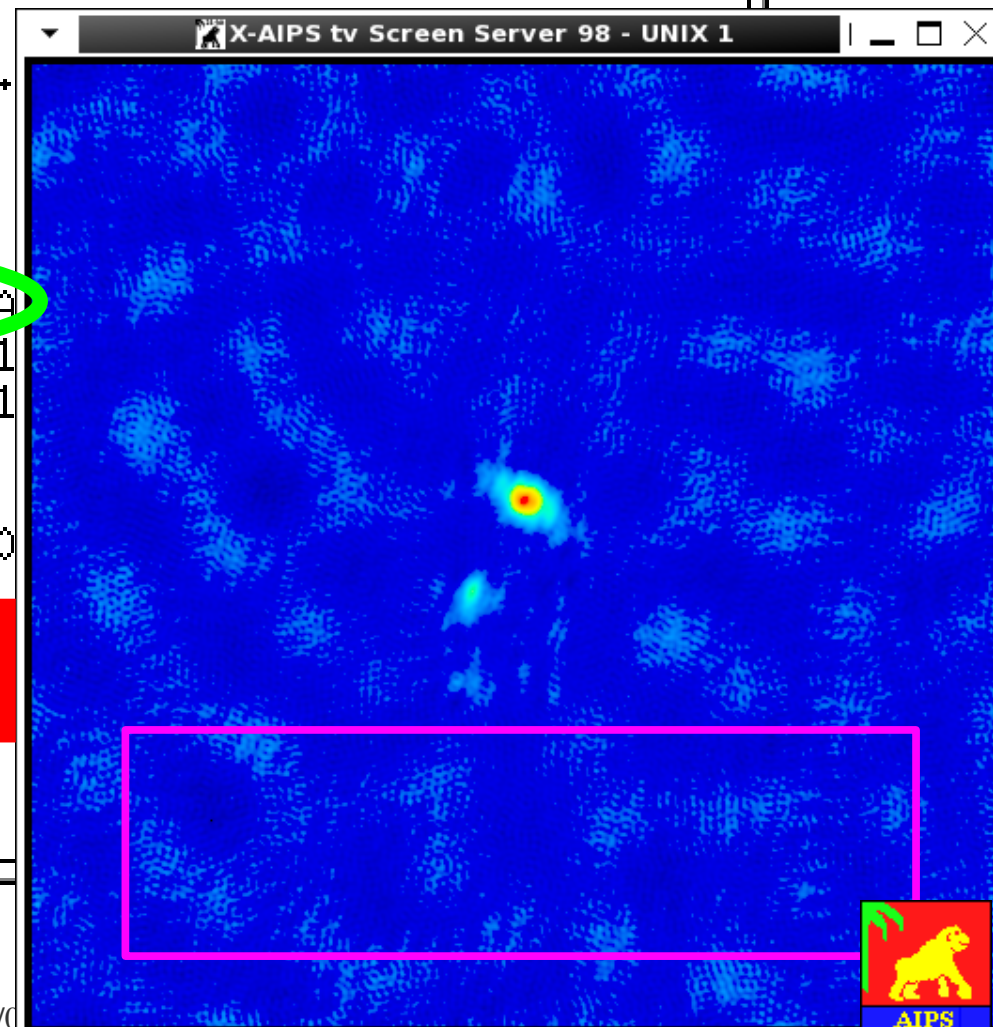
Making a plot file

```
xterm
>getn 20
AIPS 1: Got(1) disk=1 user=89 type=MA MKN273_MER.ICL001.1
>twwin
AIPS 1: Set B.L.C. + button N, B, or C to change to T.R.C.
AIPS 1: Button D to kill and exit
AIPS 1: Set T.R.C. : button A or B to repeat B.
AIPS 1: Button C or D to exit
AIPS 1: 1.00
AIPS 1: 1.00
>IMSTAT
AIPS 1: Mean=-1.0078E-04 rms=1.0025E-04 JY/BEAM
AIPS 1: Maximum=4.0536E-04 at 127 140 1
AIPS 1: Skypos: RA 13 44 42.37202 DEC 55 53 11
AIPS 1: Skypos: IPOL 4992.990 MHZ
AIPS 1: Minimum=-4.2947E-04 at 96 110 1
AIPS 1: Skypos: RA 13 44 42.42729 DEC 55 53 10
AIPS 1: Skypos: IPOL 4992.990 MHZ
AIPS 1: Flux dens
>CLEV=3*PIXSTD
>TYPE CLEV
AIPS 1: 0.0003008
>
```

Set box outside source

Measure noise in box

Use built-in math to set base contour level



Making a plot file

```

#
AIPS 1: IN3NA
AIPS 1: IN3CL
AIPS 1: IN3SE
AIPS 1: IN3DI
AIPS 1:
AIPS 1: IN4NA
AIPS 1: IN4CL
AIPS 1: IN4SE
AIPS 1: IN4DI
AIPS 1: BLC
AIPS 1:
AIPS 1: TRC
AIPS 1:
AIPS 1: ZINC
AIPS 1:
AIPS 1: NY
AIPS 1:
AIPS 1: ** pr
#
#

```

Base contour level already set

```

#
AIPS 1:
AIPS 1:
AIPS 1:
AIPS 1:
AIPS 1:
AIPS 1:
AIPS 1: PLEV 0
AIPS 1: CLEV 3.008E-04
AIPS 1:
AIPS 1: LEVS -1 1
AIPS 1: 2 4
AIPS 1: 32 64
AIPS 1: CON3COL 0
AIPS 1: FACTOR 0
AIPS 1:
AIPS 1: ROTATE 0
AIPS 1:
AIPS 1: XINC 1
AIPS 1: YINC 1
AIPS 1: *** press RETURN for more, enter Q or next line to quit print ***
#

```

to center, 5 rel to subim cen
6 pixels, 7-10 as 3-6 with
only tick labels
<0 -> no date/time
special values for RGBLEVS
0 => images must line up
(see HELP DOALIGN)
Percent of peak for levs.
Absolute value for levs
(used only if PLEV = 0).
Contour levels (up to 30).
8 16
*rest 0
Color the contours by plane
Mult. factor for Pol vector
(see HELP)
Angle to rotate Pol vector
(in degrees)
X-inc. of Pol vectors, 0=>1
Y-inc. of Pol vectors, 0=>1



Making a plot file

Two xterm windows are shown. The left window displays a list of AIPS commands. The right window displays the help text for the 'go kntr' command.

```

#
AIPS 1: IN3NA
AIPS 1: IN3CL
AIPS 1: IN3SE
AIPS 1: IN3DI
AIPS 1:
AIPS 1: IN4NA
AIPS 1: IN4CL
AIPS 1: IN4SE
AIPS 1: IN4DI
AIPS 1: BLC
AIPS 1:
AIPS 1: TRC
AIPS 1:
AIPS 1:
AIPS 1: ZINC
AIPS 1:
AIPS 1: NY
AIPS 1:
AIPS 1: ** pr
#

```

```

#
AIPS 1: to center, 5 rel to subim cen
#
AIPS 1:
AIPS 1:
AIPS 1: LABEL 0
AIPS 1:
AIPS 1:
AIPS 1:
AIPS 1:
AIPS 1:
AIPS 1: DOTV -1
AIPS 1:
AIPS 1: TVCHAN 1
AIPS 1: GRCHAN 0
AIPS 1: ** press RETURN for more, enter Q or next line to quit print **
#
AIPS 1: DODARK 1
AIPS 1: DARKLINE 0.33
AIPS 1:
AIPS 1: RGBLEVS
AIPS 1: TVCO
AIPS 1:
AIPS 1:

```

to center, 5 rel to subim cen

16-20 as 1-5 scribbled on
-n < 0 => n, but no other
drawing in beam-plot area
0->label each pane with the
pane number
1->label each with coordinate
2->label each with coordinate
relative to reference
-1->do not label each pane
> 0 Do plot on the TV, else
make a plot file
TV channel for grey plots
Graphics channel 0 => 1.
** press RETURN for more, enter Q or next line to quit print **

#

Plot dark vectors as black?
Switch to dark lines when
grey-scale > DARKLINE 0-1
Color each value of LEVS
TV pixel location of bottom
left corner of image 0=> self
scale, non 0 => pixel scale.

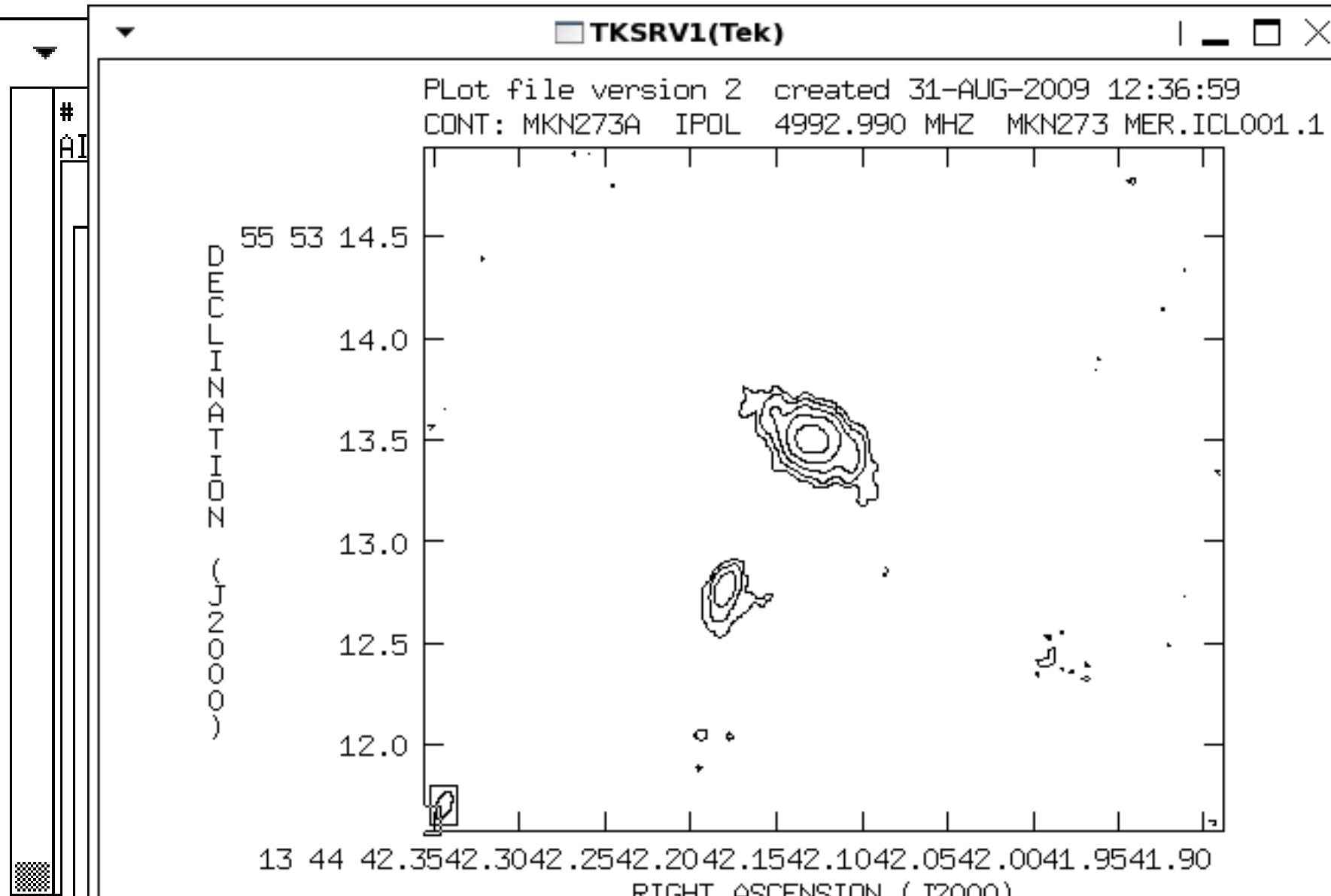
Make contour plot and display

go kntr;go tkpl



Making a plot file

#	
AIPS 1:	IN3NA
AIPS 1:	IN3CL
AIPS 1:	IN3SE
AIPS 1:	IN3DI
AIPS 1:	
AIPS 1:	IN4NA
AIPS 1:	IN4CL
AIPS 1:	IN4SE
AIPS 1:	IN4DI
AIPS 1:	BLC
AIPS 1:	
AIPS 1:	TRC
AIPS 1:	
AIPS 1:	ZINC
AIPS 1:	
AIPS 1:	NY
AIPS 1:	
AIPS 1:	** pr



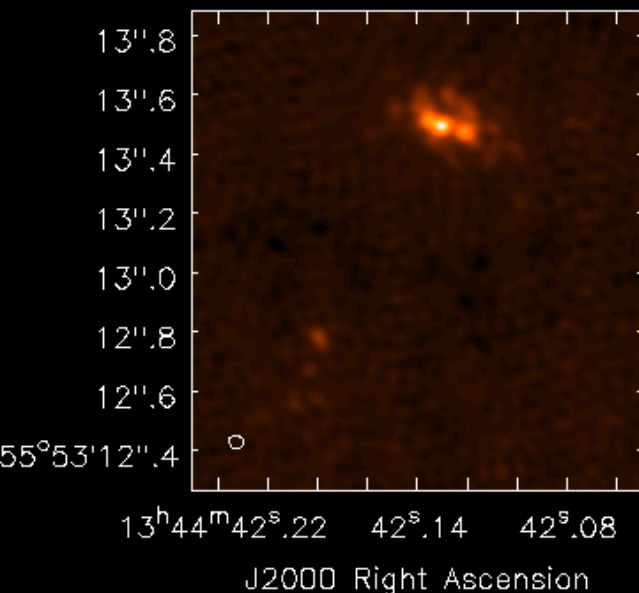
Combining Arrays

- MERLIN+EVN - Markarian 273
 - Data already calibrated separately in 2 SPLIT files
 - Check properties in common (check *uv* data)
 - Phase-ref and pointing position ✓
 - Frequency and spectral configuration ✓
 - Flux density scale ✗
 - Correct flux density
 - Select suitable weights, combine data and image
 - Tweak weightings to improve resolution *or* sensitivity
- AIPS needed to provide user-friendly tasks
 - For rescaling amplitudes & changing weights
 - (essential for delay & rate cal, see Mark's session)
 - Can go back to CASA for advanced imaging

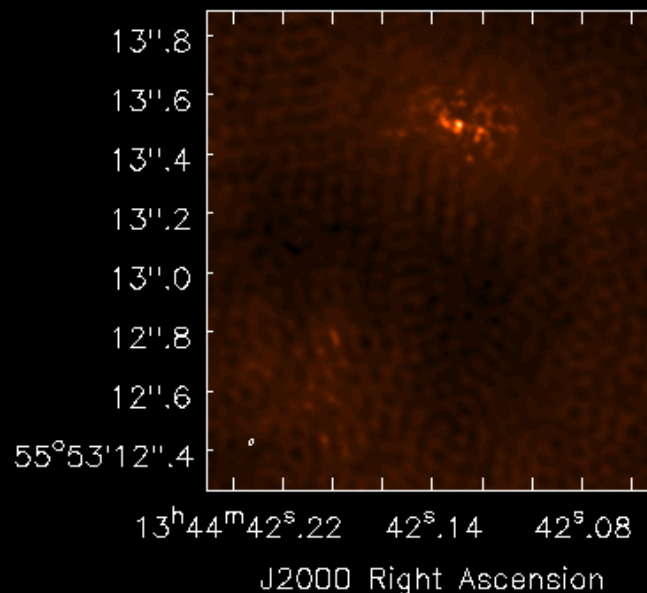
MRK 273 MERLIN+EVN

- Calibrate/combine in AIPS, image in CASA
– more options to bring up extended emission

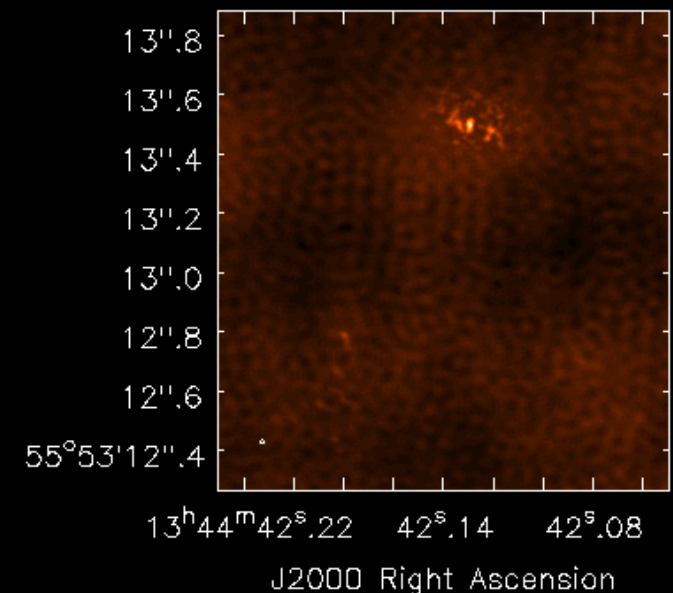
1:1 ratio



1:500 ratio



1:500 using CASA
multi-scale clean



See faint SW emission