

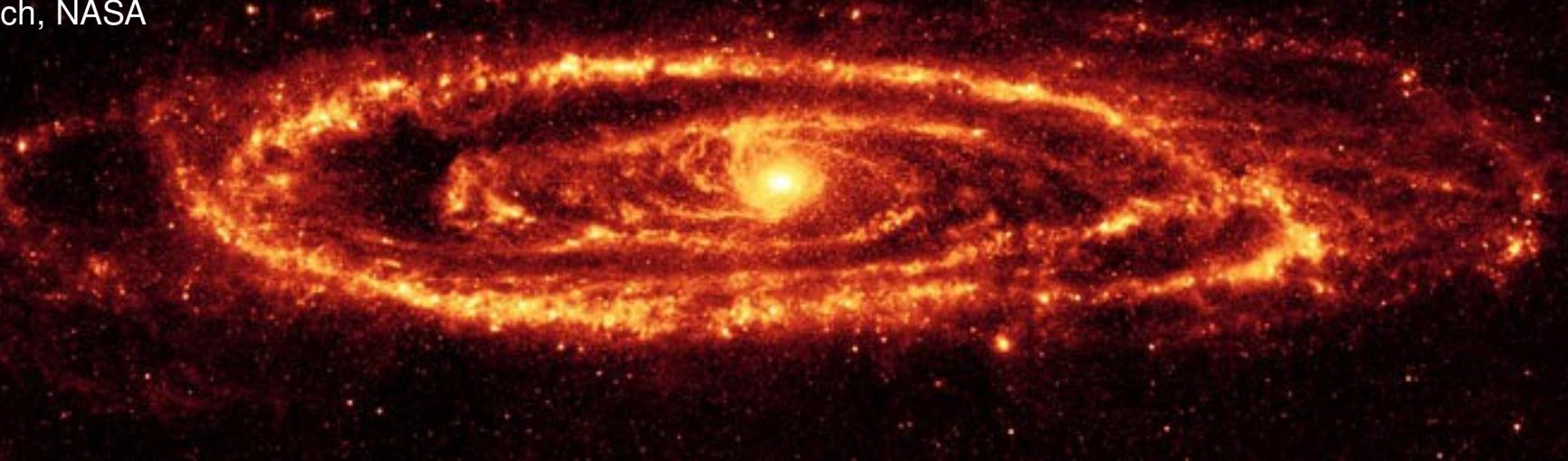
# Wide-field VLBI imaging of M31 nearby galaxies



Megan Argo  
ASTRON

18 hours, 11,000 exposures  
Credit: K. Gordon (U. Arizona),  
JPL-Caltech, NASA

Spitzer 24 microns



330 individual images  
100' by 50' (200,000 by 100,000 ly)  
Credit: NASA/Swift/Stefan Immler (GSFC) and Erin Grand (UMCP)

Swift UVOT

# Existing radio surveys

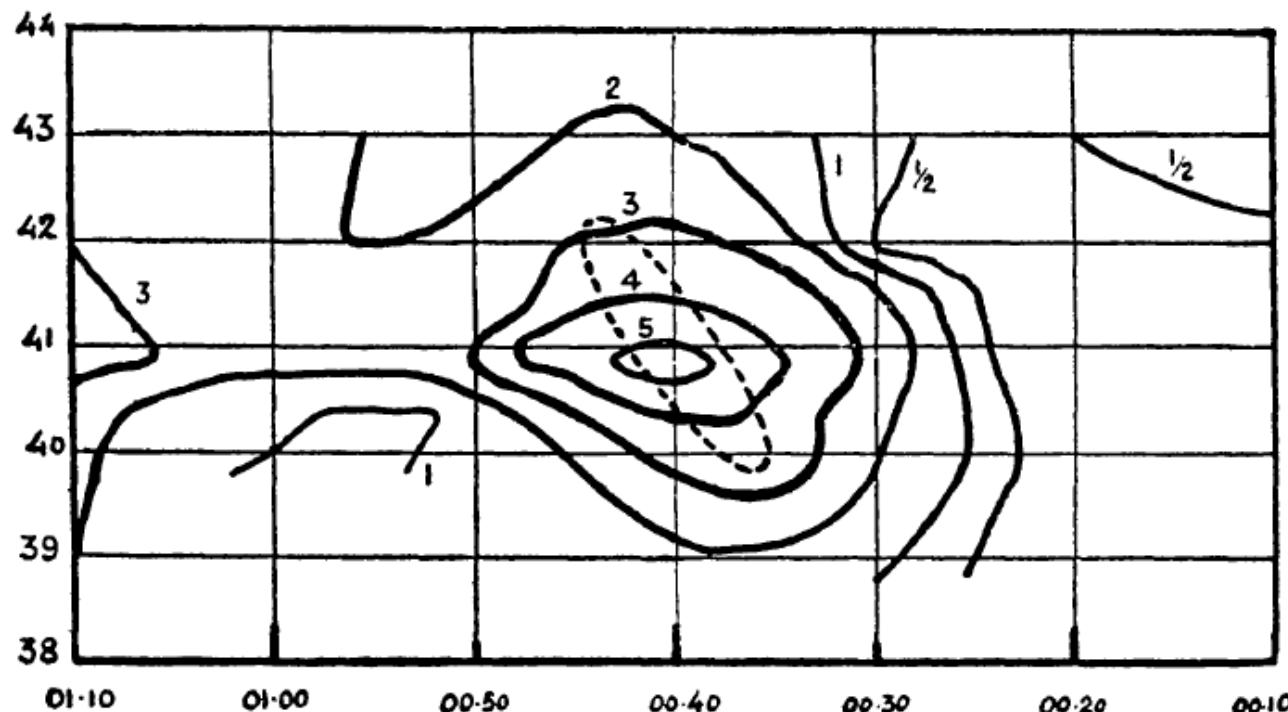


FIG. 4.—Contours of radio-frequency flux observed near the source in Andromeda with a 2-degree beam. (1 unit =  $10^{-25}$  watts/square metre/c.p.s.  $\lambda = 1.89$  metres.)

The contours do not represent the absolute intensity of the radio flux at each point. As explained in the text the gradient of background flux in declination has been removed and the contours show the intensity for each point above the background flux at  $00^{\text{h}} 40^{\text{m}}$  R.A. The gradient of background flux in right ascension has not been removed and therefore distorts the contours.

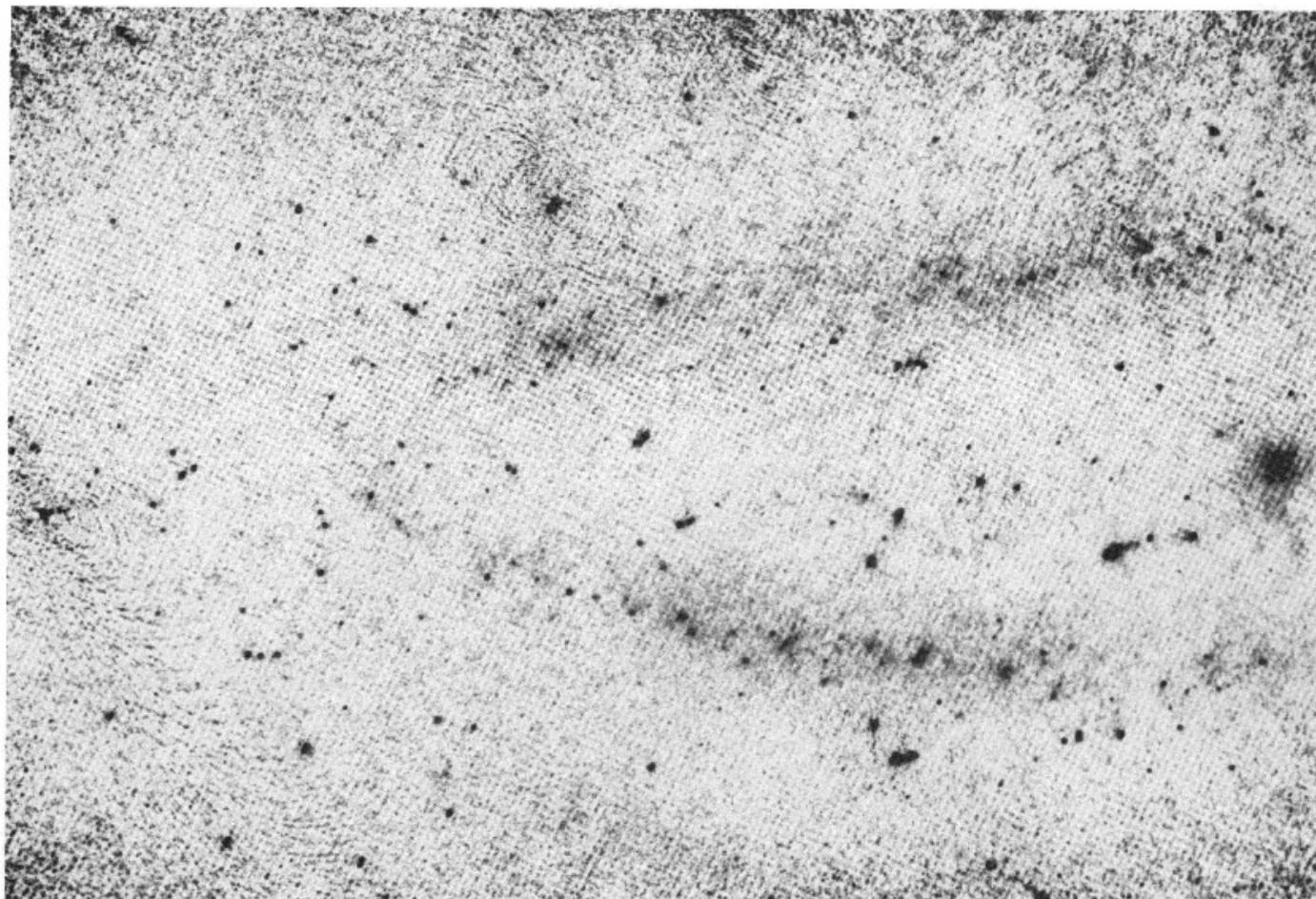
The broken line shows the outline of the nebula derived from a photograph.

Ordinates : Declination (degrees north).

Abscissae : Right ascension (1 division represents 10 minutes).

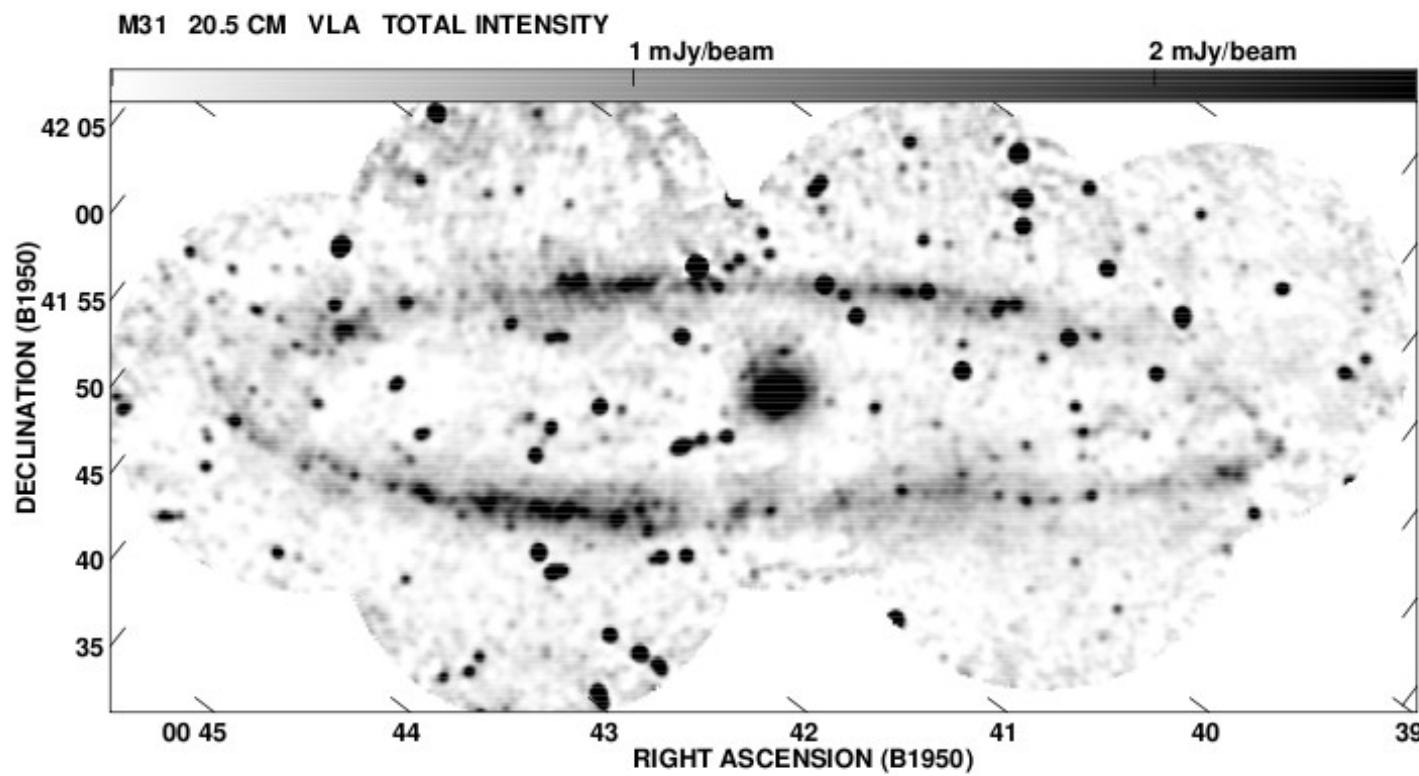
# Existing radio surveys

VLA B-, C- and D-configs, 10 pointings, 5", 30 $\mu$ Jy/bm



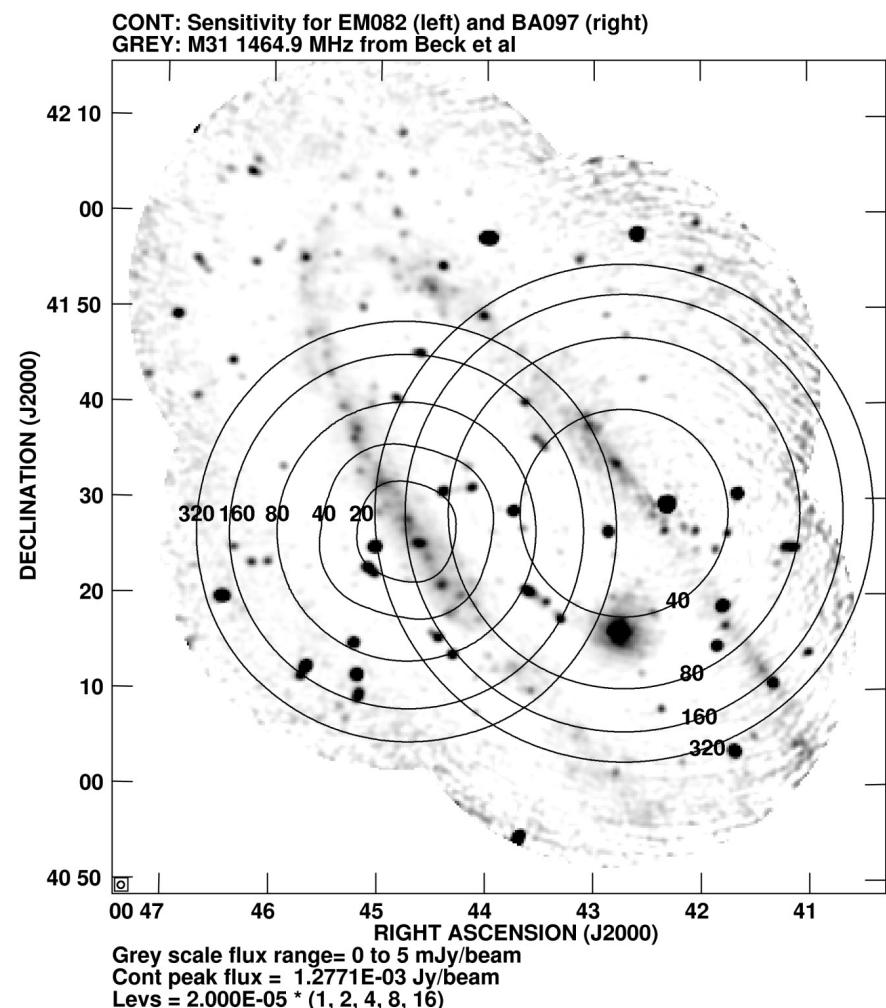
# Existing radio surveys

VLA D-config, 7 pointings, 20cm, 45", 75 $\mu$ Jy/bm



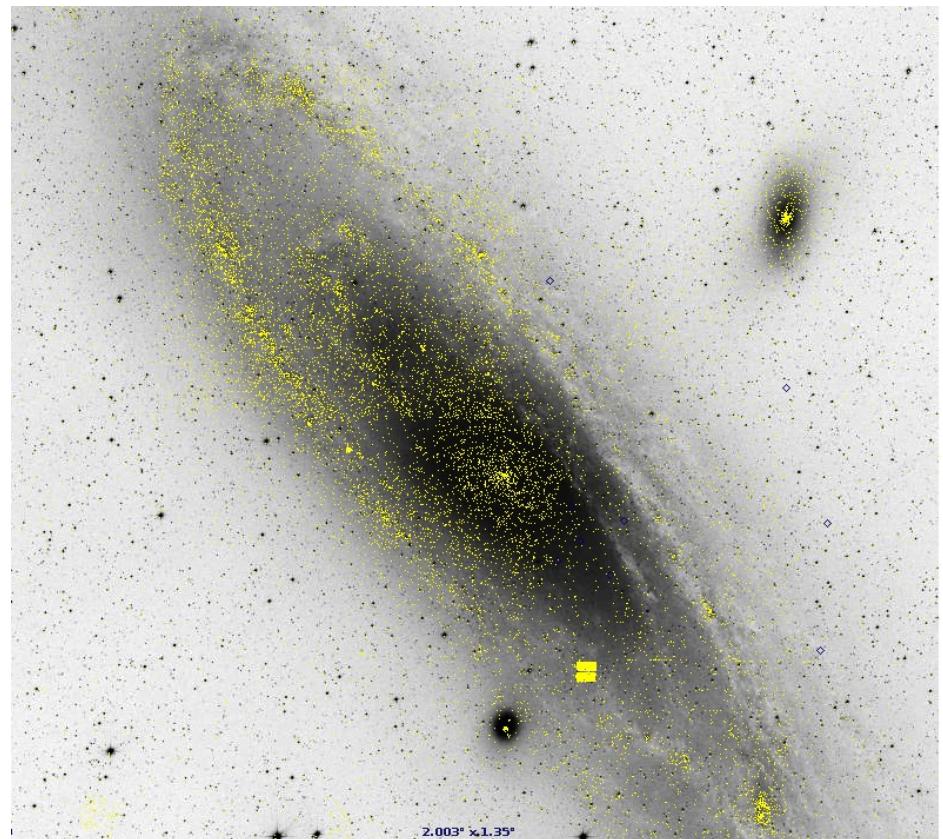
# Observations

- VLBA single pointing, 8 hours, 4 IFs, 16 MHz, nodding to J0038+4137 ( $\sim 1^\circ$ ), observed July 4<sup>th</sup> 2010
- EVN four pointings spaced 7.5', 8 hours, same phase cal, observed June 7<sup>th</sup> 2010
- Sensitivities: see right  
and Morgan, J., 2010 PoS(10th EVN Symposium)091
- First-look at the VLBA data



# Where to correlate?

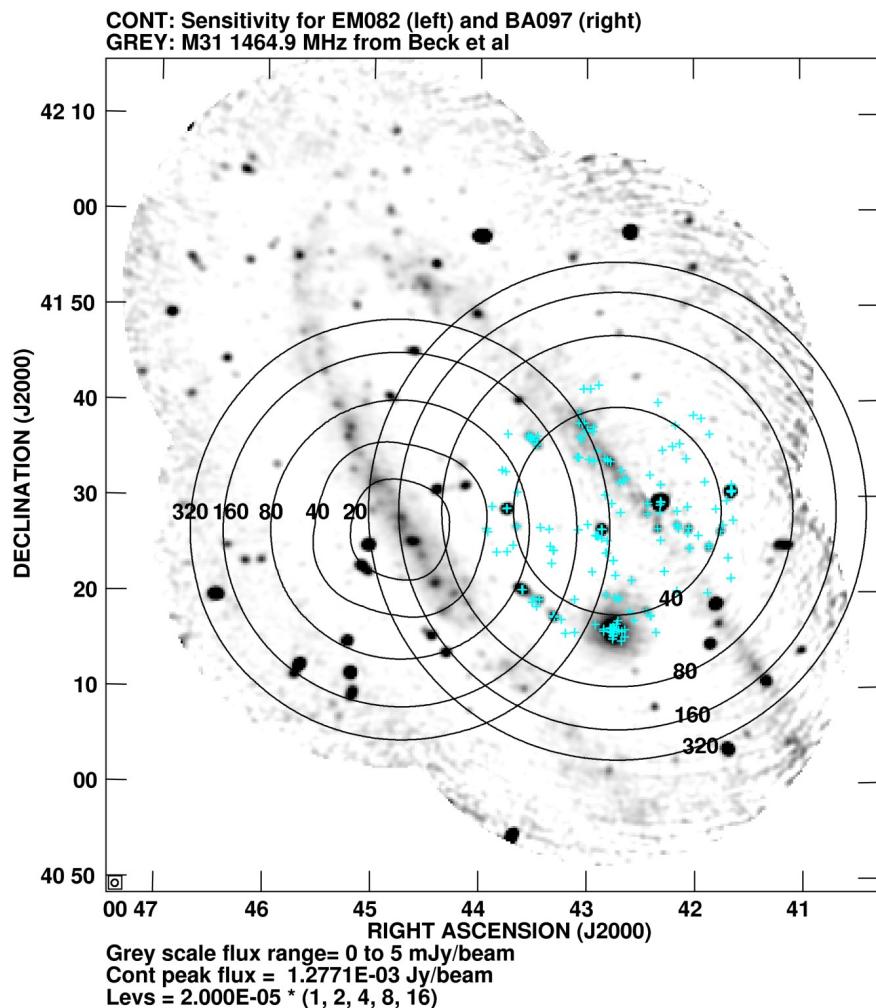
- Catalogues from NED (inc. NVSS + Beck and Braun sources)
- 1533(!) objects within  $\sim 0.5^\circ$  of the VLBA pointing centre
- Reject anything unlikely to be radio bright
- Reject duplicates
- List of 192 sources for a first pass



Targeted phase  
centres (first pass)

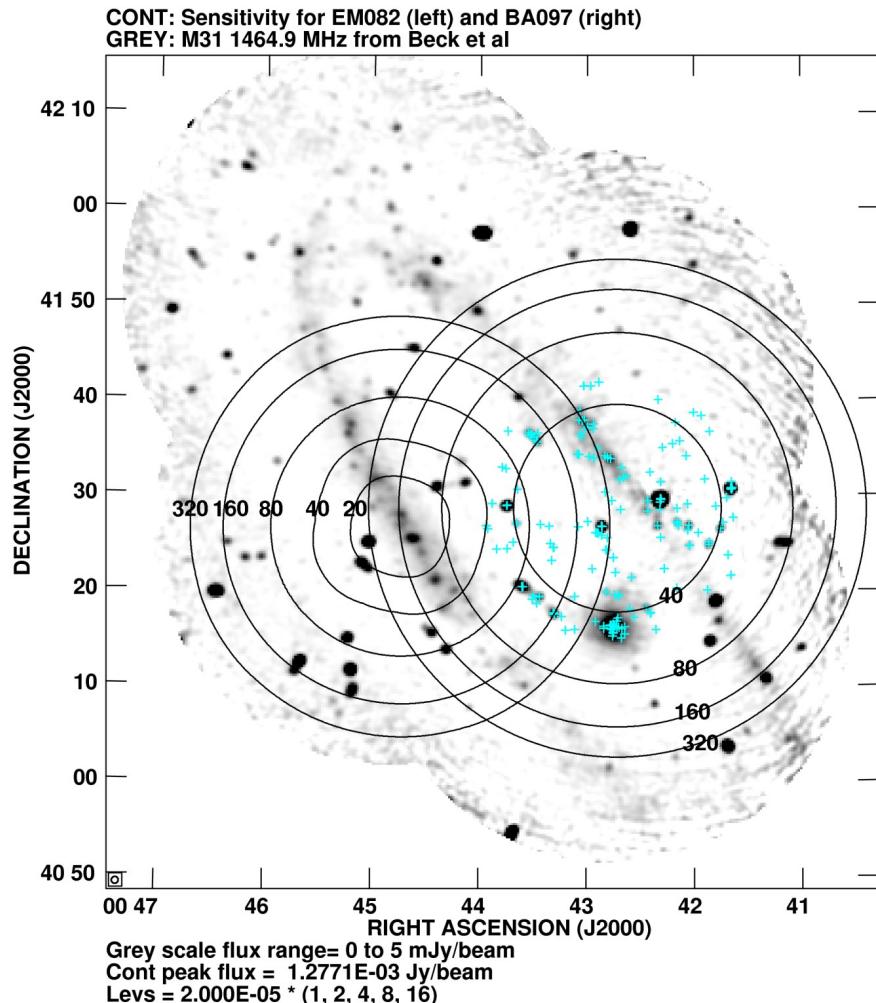
- ◆ EVN targets
- ◇ VLBA targets

# The (VLBA) story so far



- Baseband data (~15TB) shipped to Curtin, loaded onto cluster
- Correlated at 192 phase centres with DiFX (128 ch/IF)
- Flagging and calibration (mostly) on dataset correlated in Socorro
- Pipelined calibration and imaging of each new dataset
- Image out to several arcseconds

# Calibration and pipeline



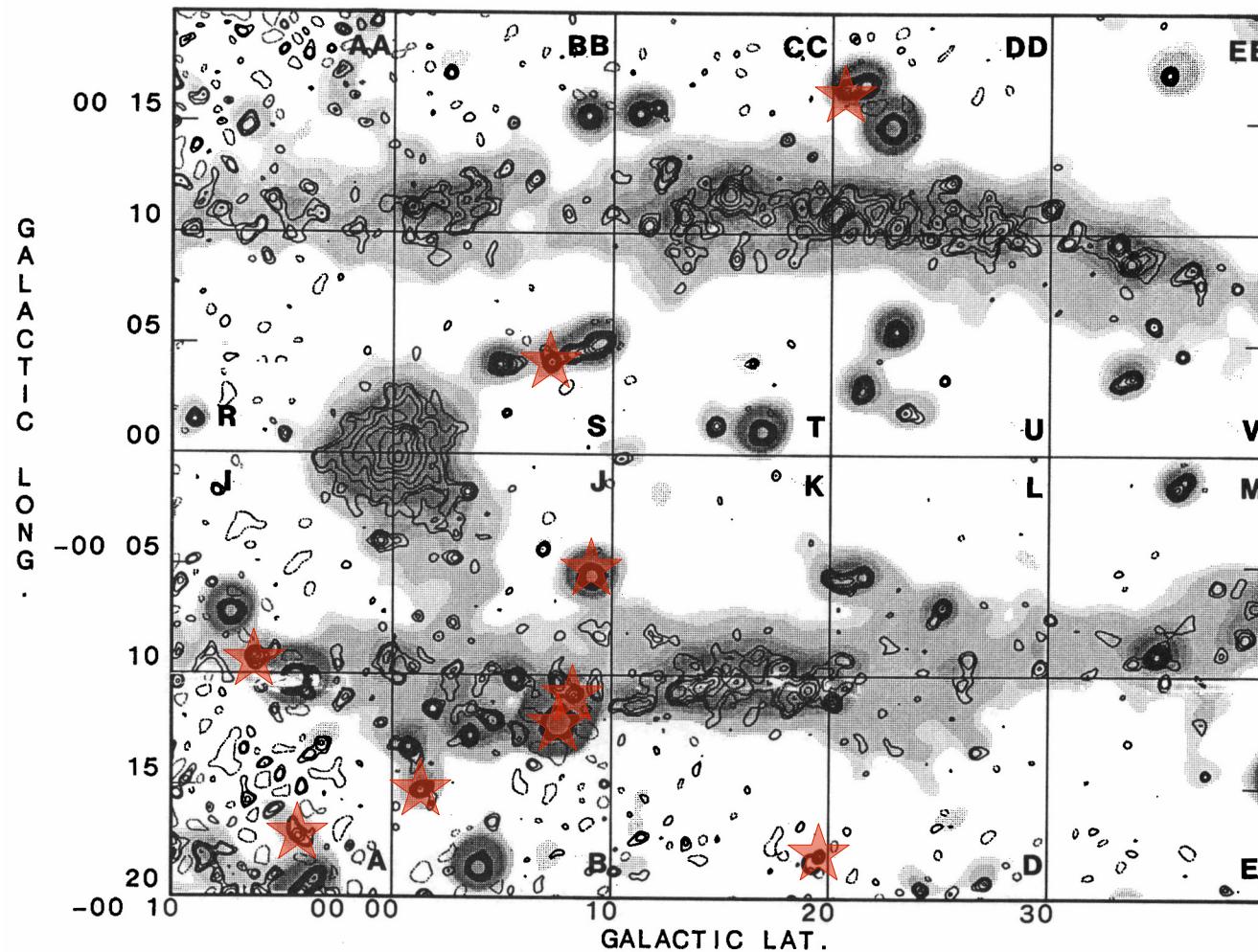
- Pipeline\* applies flagging and calibration carried out using dataset correlated in Socorro
- Calibration follows standard recipe for VLBA datasets
- Mostly works
- Flagging is not perfect – some bad data may remain

\*thank goodness for ParselTongue

# Detections?

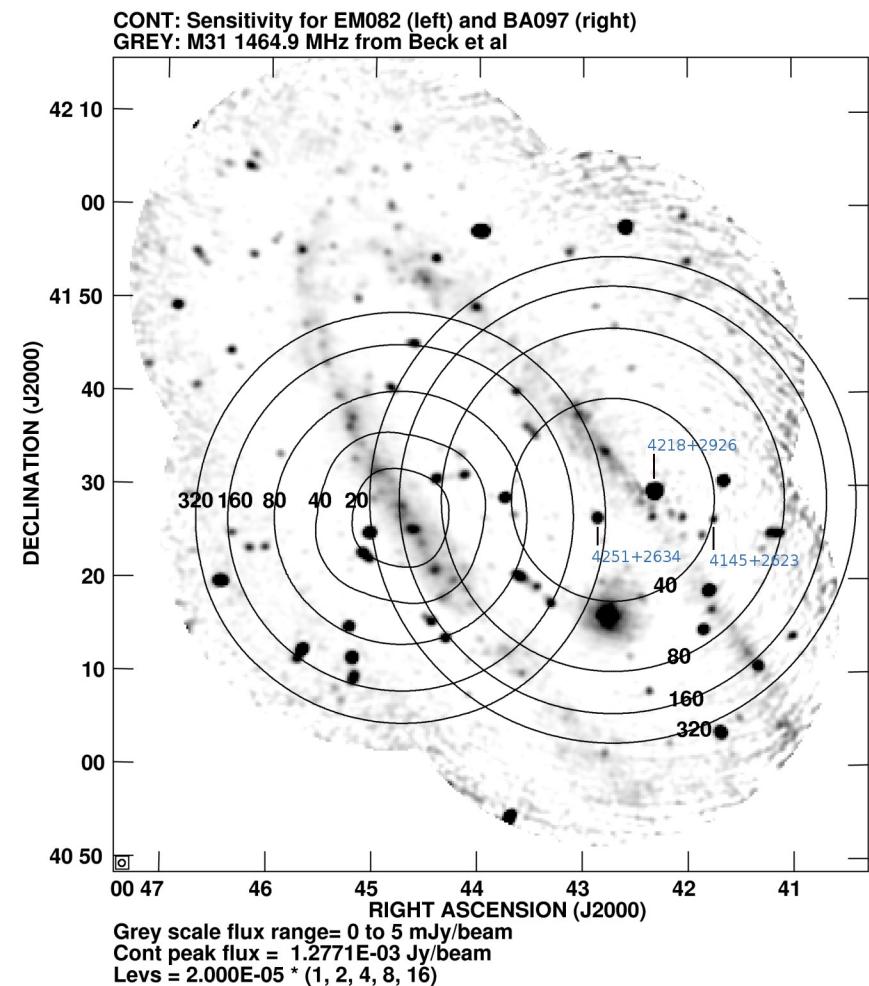
# Detections!

10 above  $8\sigma$  (~5%)



# Detections!\*

- 4145+2623
  - NVSS: 5.2mJy
  - BA097: 1mJy ( $\sim 5\sigma$ )
- 4251+2633
  - NVSS: 24mJy
  - Beck98: 22mJy
  - BA097: 2mJy
- 4218+2926
  - NVSS: 372 mJy
  - Beck98: 307mJy
  - BA097: 1mJy + 2mJy



# Detections!

Name	Peak flux	NVSS	36W	37W	GLG	$\alpha(1412:610)$
4251+2634	15.9	x	197	144	11	-0.5 ***
4225+2918	0.89	-	-	123	-	
4218+2926	5.9	x	185	115	19	-0.7 ***
4145+2623	4.1	x	168	92	21	-0.05
4326+1911	2.3	-	210A	158B	5	-2.4
4232+4236	1.0	x	191	129	46	-1.7
4146+1639	0.96	x	-	93	16	
4118+2317	1.0	-	-	80	-	
4035+3510	0.82	x	133	60	69	+0.5
4504+2236	0.63	x	254	207	-	-0.8

NVSS: VLA 1.4 GHz (Condon et al 1998)

36W: Westerbork 1412 MHz (Walterbos et al 1985)

37W: Westerbork 610 MHz (Bystedt et al 1984)

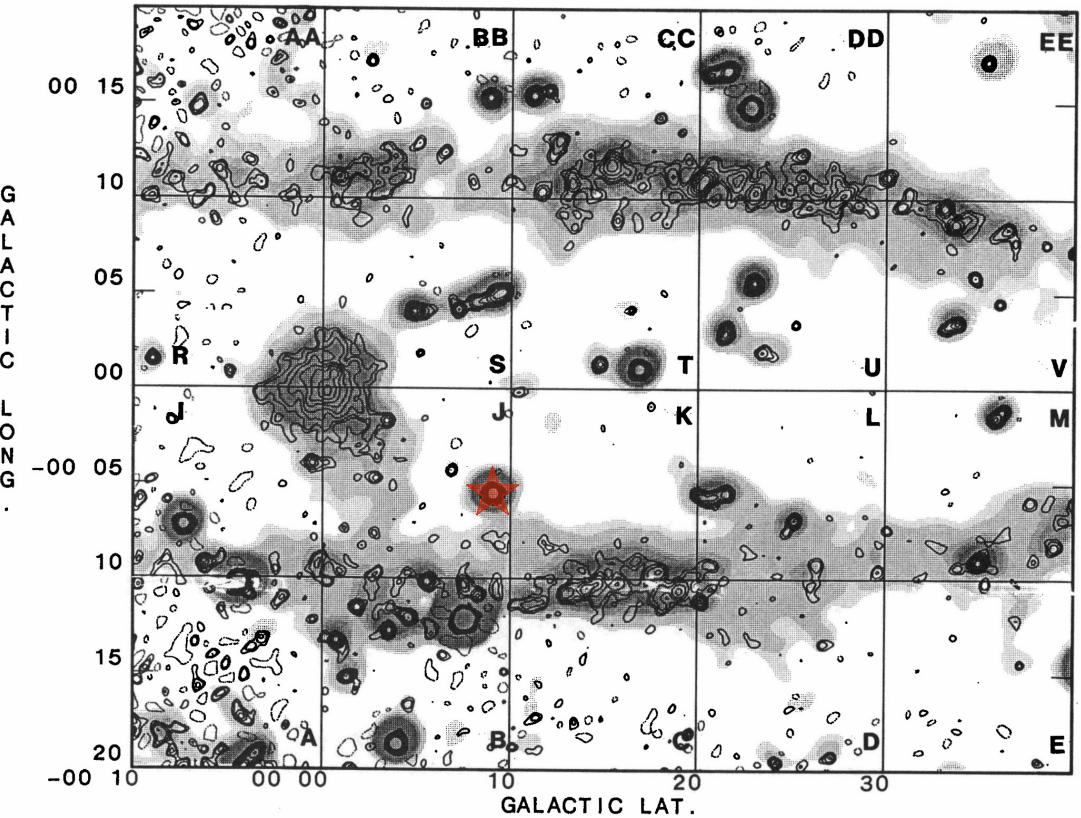
GLG: VLA 325 MHz (Gelfand et al 2004 & 2005)

# 4251+2634

SNR/PWN/ESE  
candidate in GLG...

70xCrab (radio)  
0.1xCrab (X-ray)

Need higher  
resolution imaging  
to confirm...

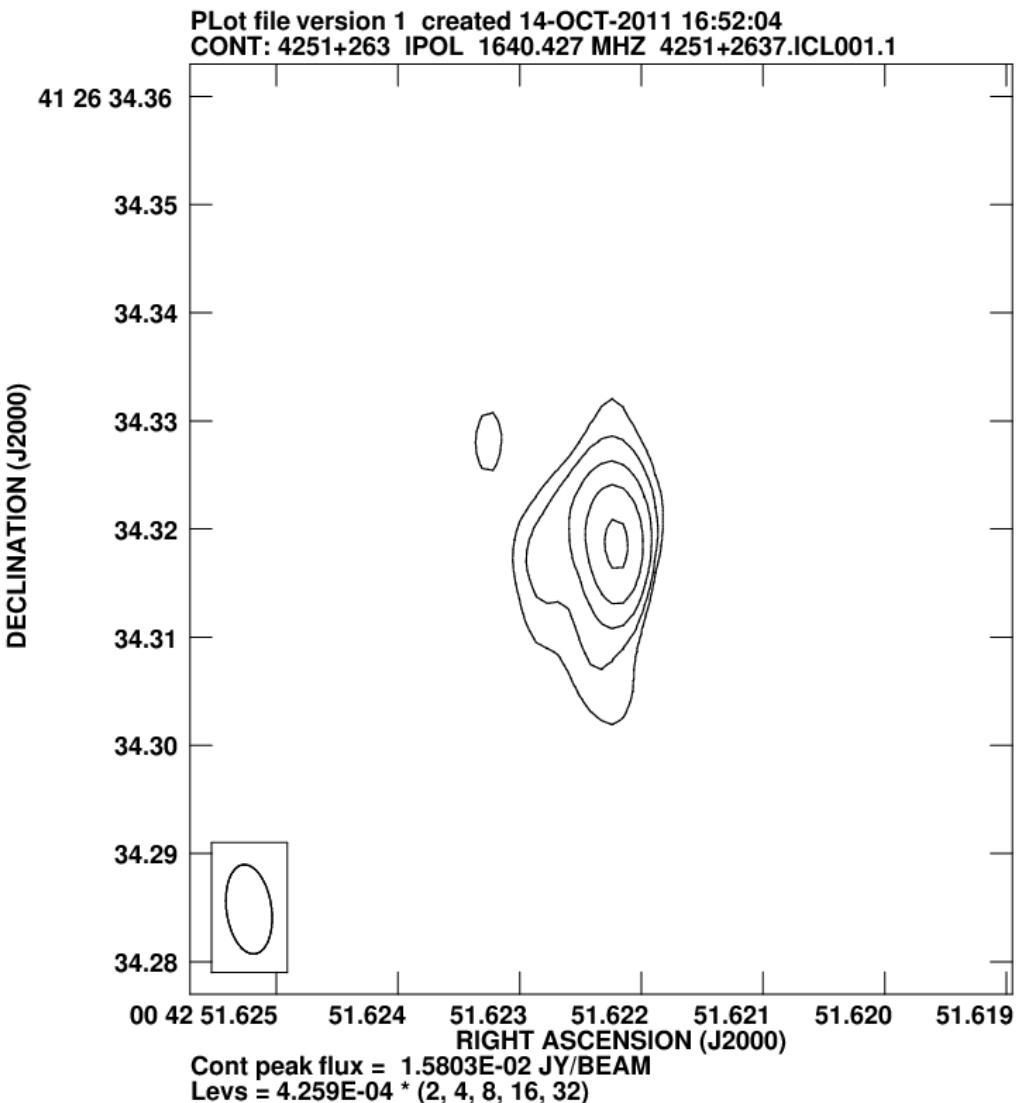


# 4251+2634

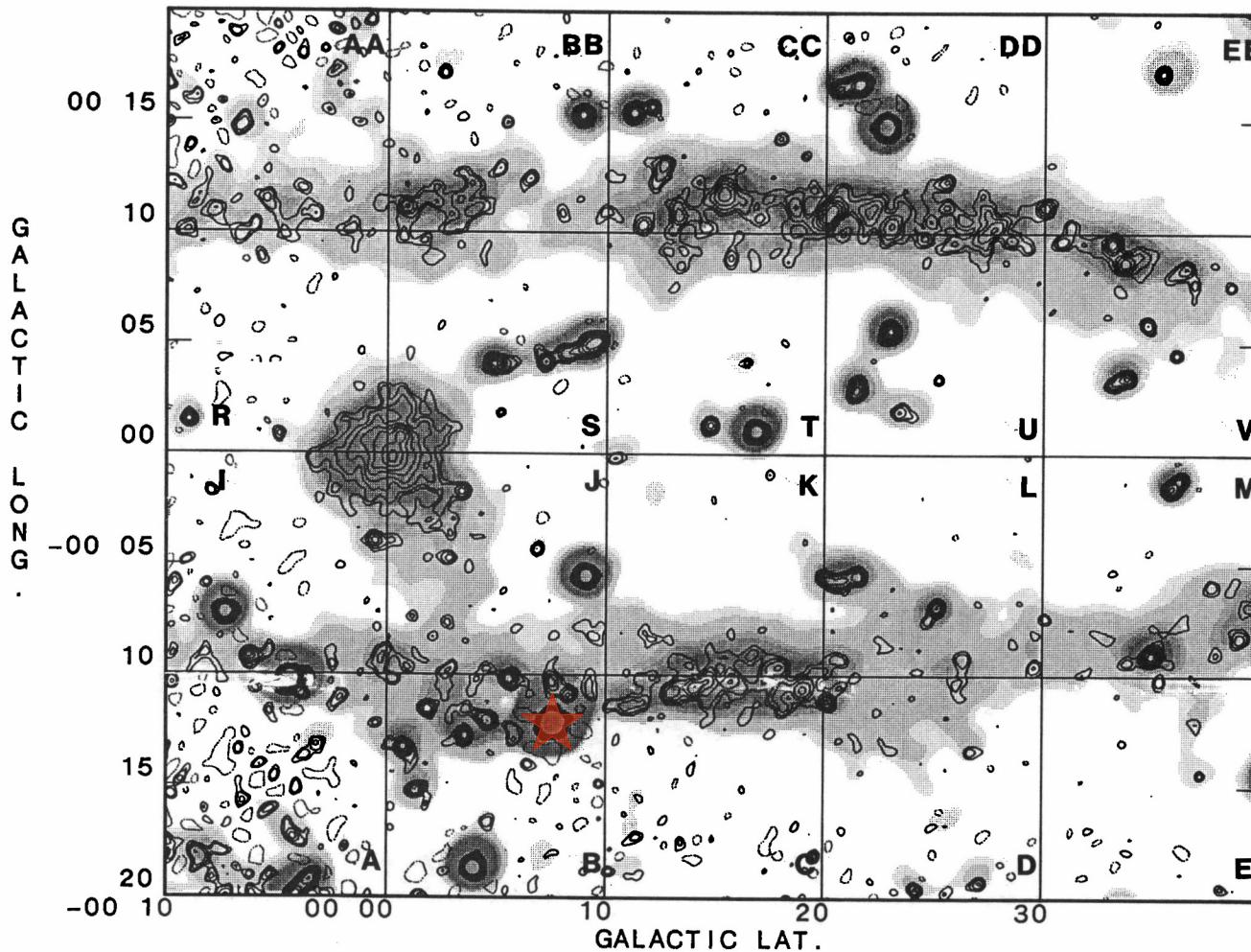
SNR/PWN/ESE  
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70xCrab (radio)  
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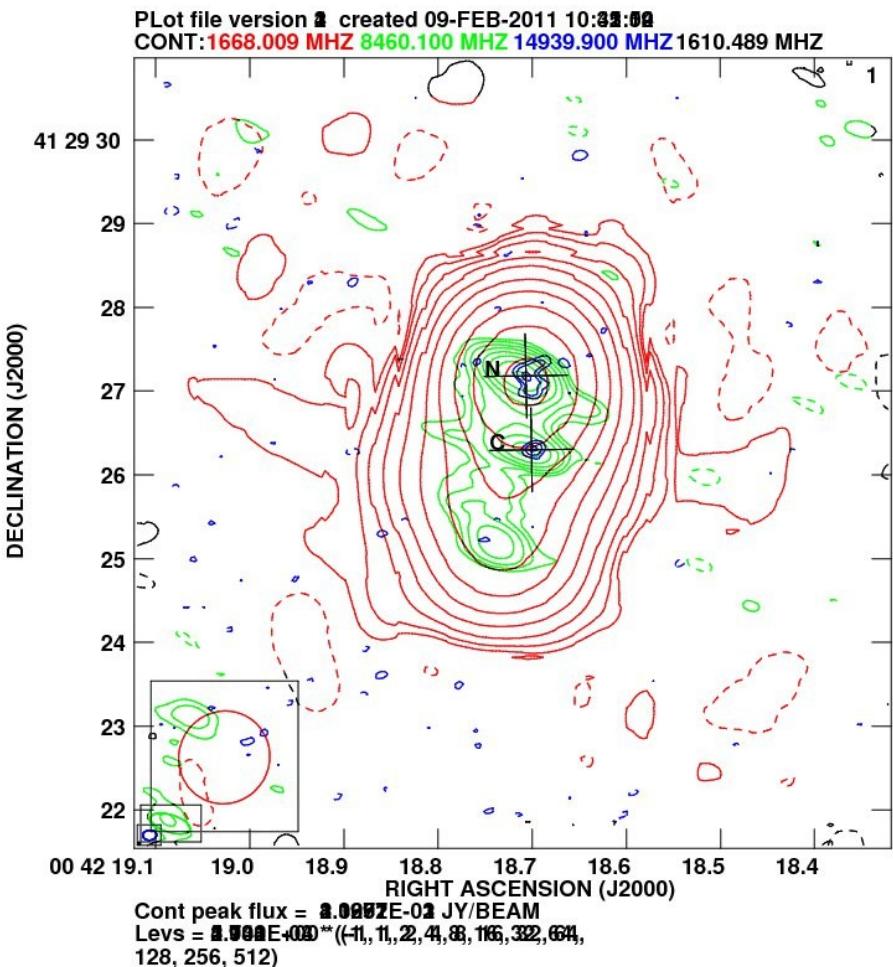


# 4218+2926



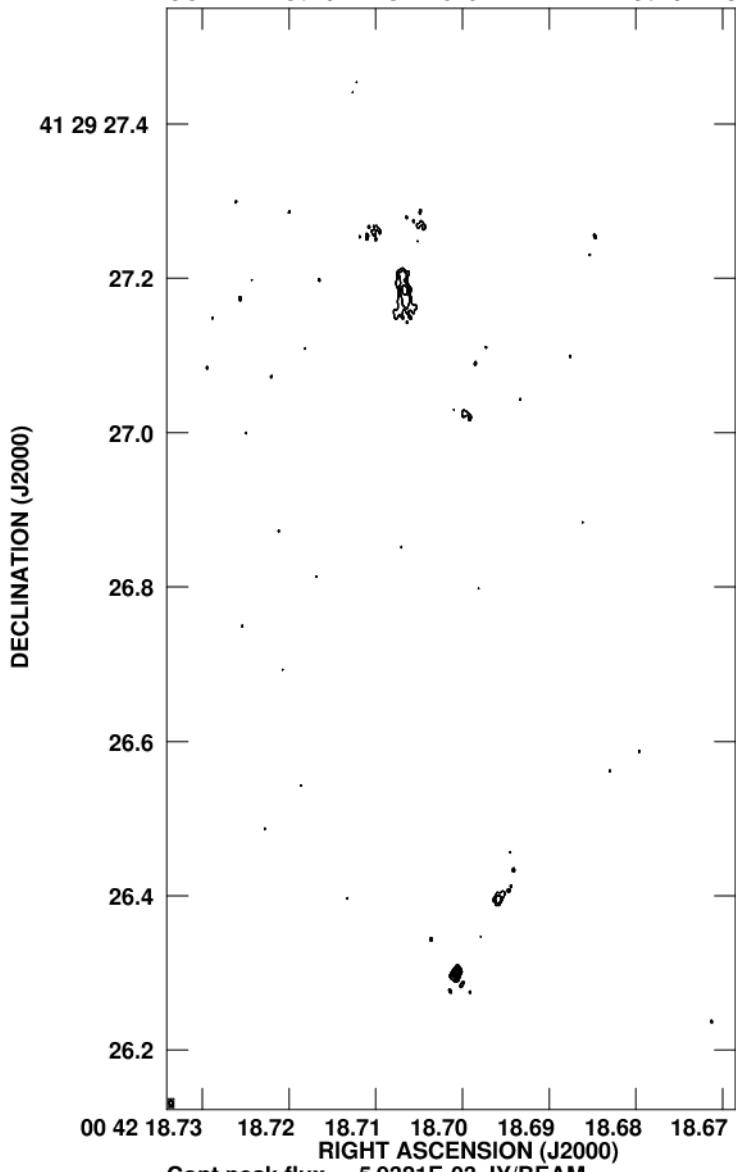
# 4218+2926

- Brightest VLA source in the field.
- MERLIN phase cal.
- VLBA detection – multiple components.

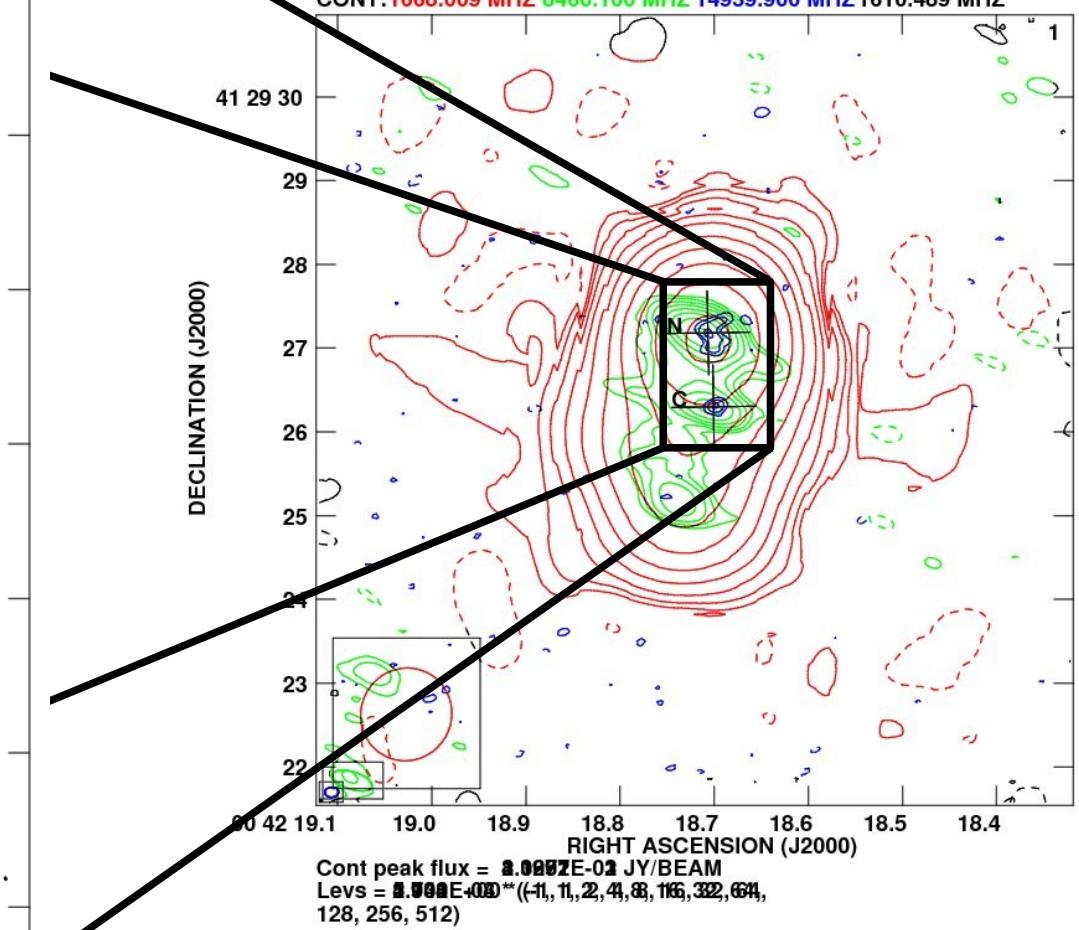


# 4218+2926

PLot file version 1 created 15-OCT-2011 18:56:16  
CONT: 4218+292 IPOL 1640.427 MHZ 4218+2927.ICL

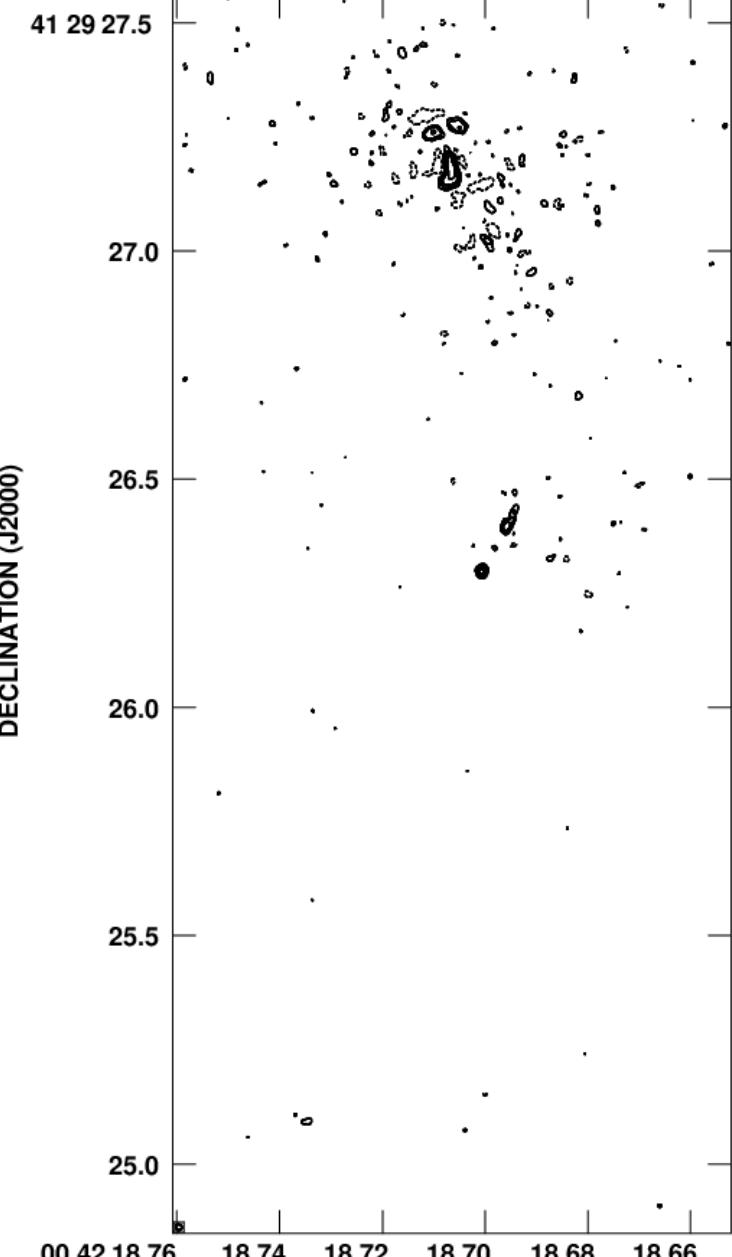


PLot file version 2 created 09-FEB-2011 10:33:52  
CONT: 1668.009 MHZ 8460.100 MHZ 14939.900 MHZ 1610.489 MHZ



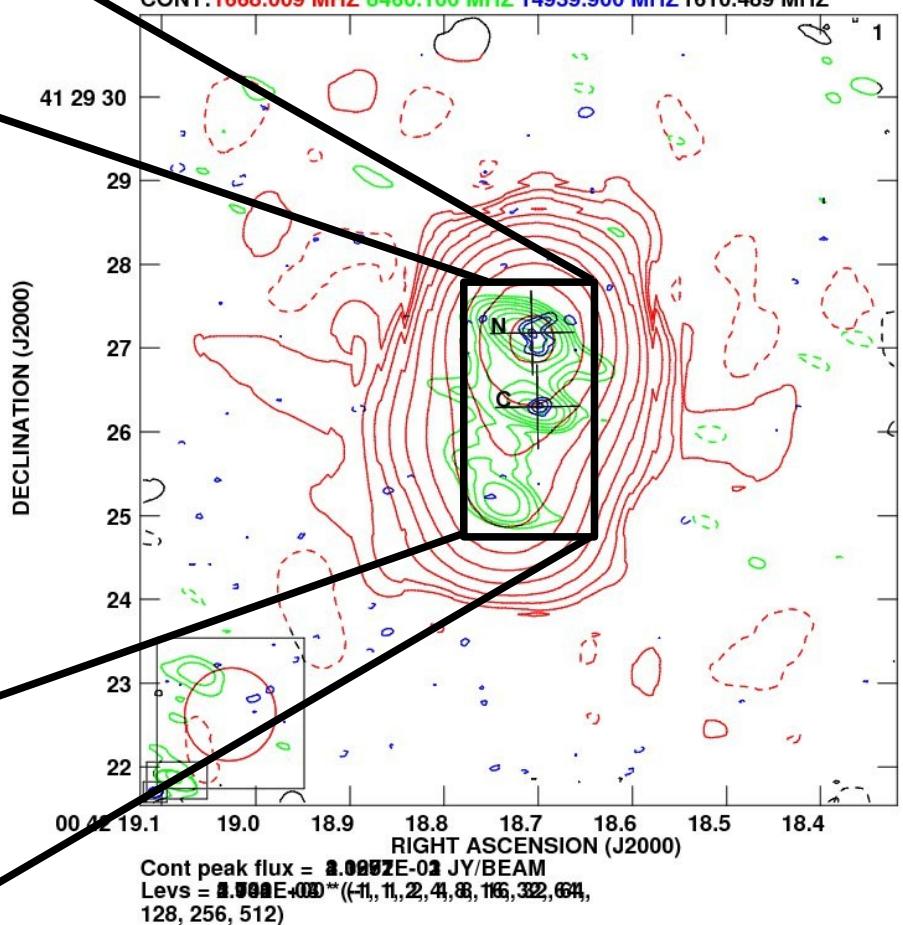
Cont peak flux = 2.0002E-02 JY/BEAM  
Levs = 1.000E-03 \*\* (-11, 11, 2, 41, 8, 16)

Plot file version 1 created 07-NOV-2011 18:54:  
CONT: 4218+292 IPOL 1640.427 MHZ 4218+29



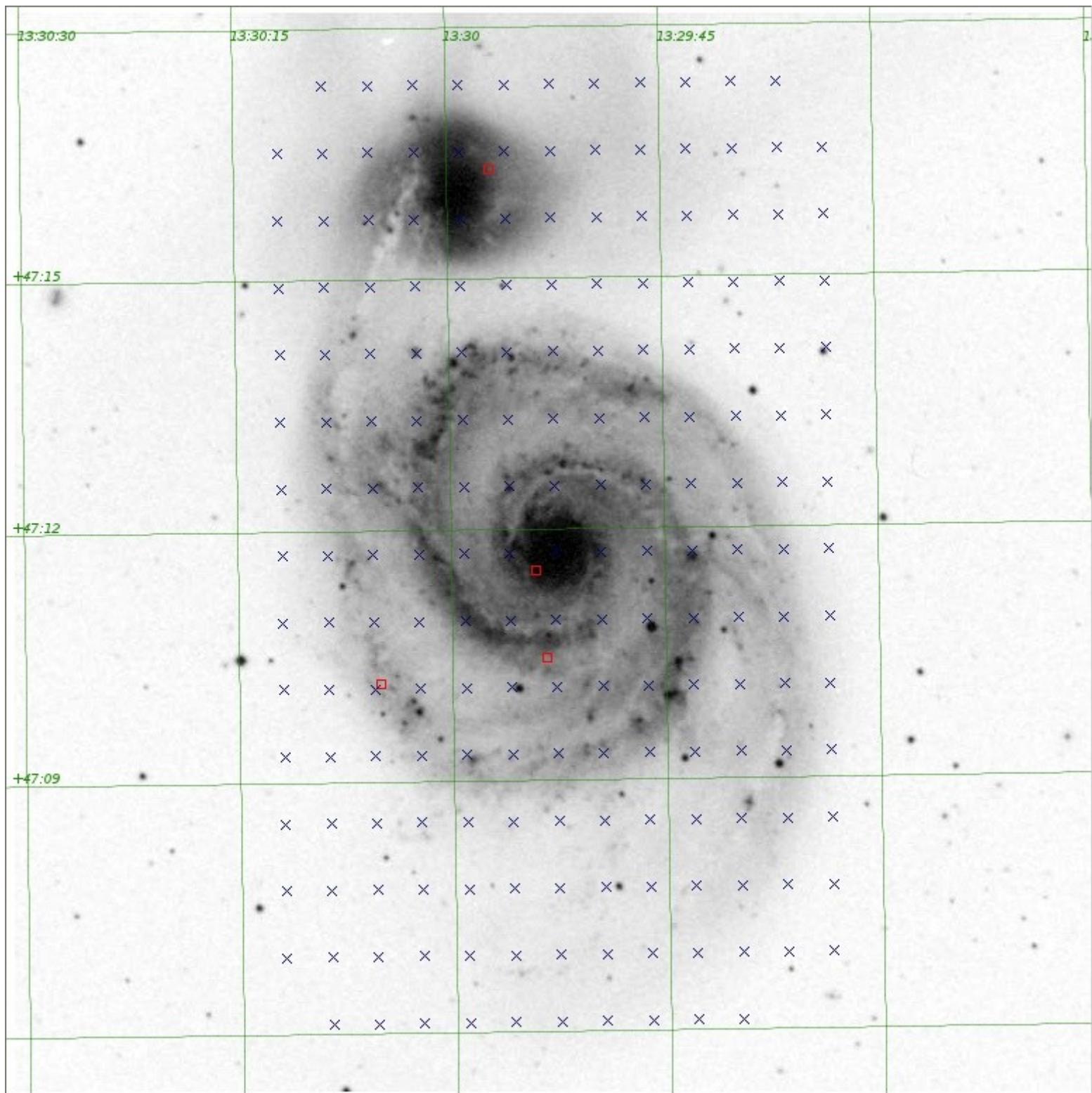
218+2926

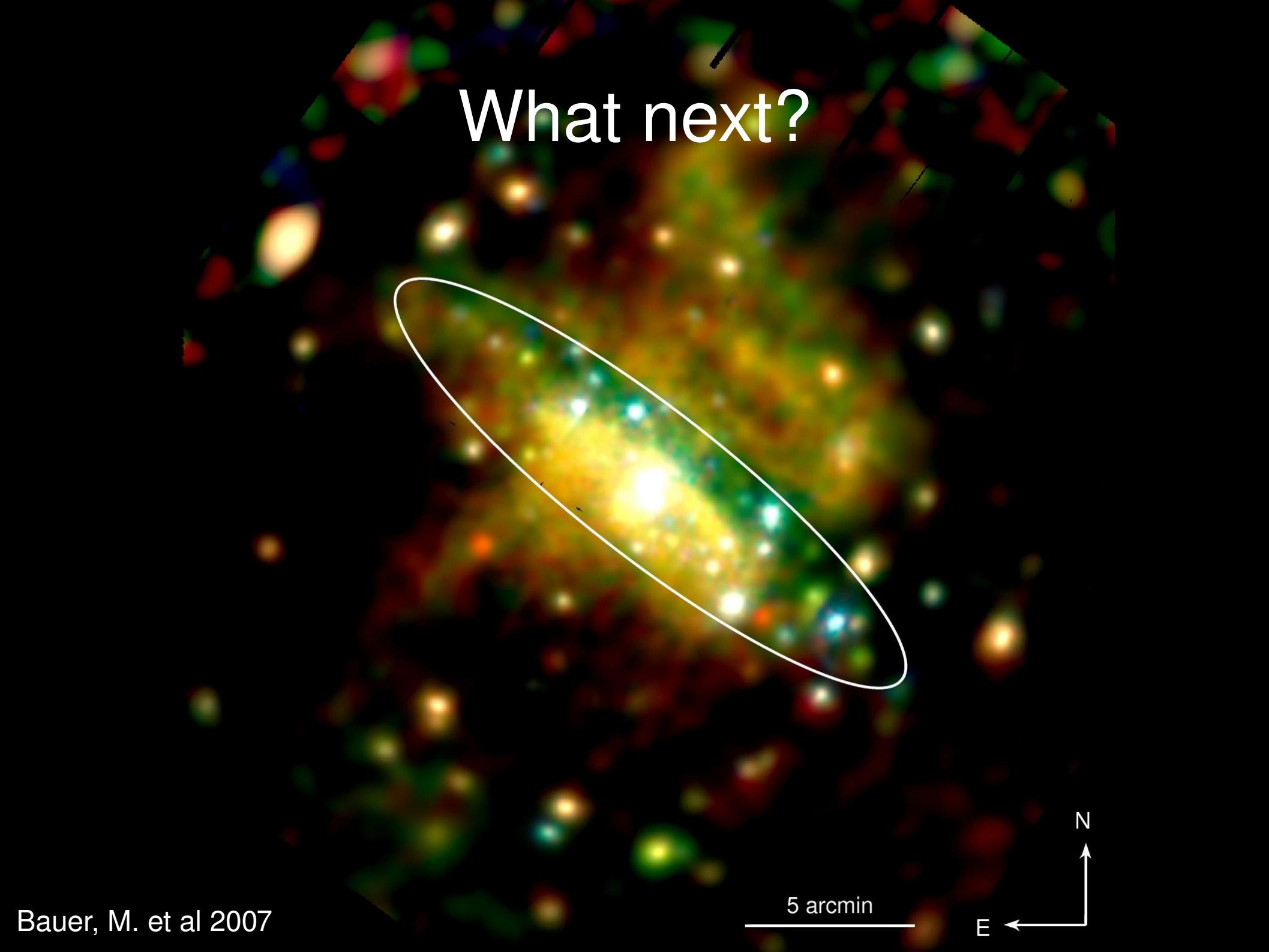
Plot file version 2 created 09-FEB-2011 10:33:52  
CONT: 1668.009 MHZ 8460.100 MHZ 14939.900 MHZ 1610.489 MHZ



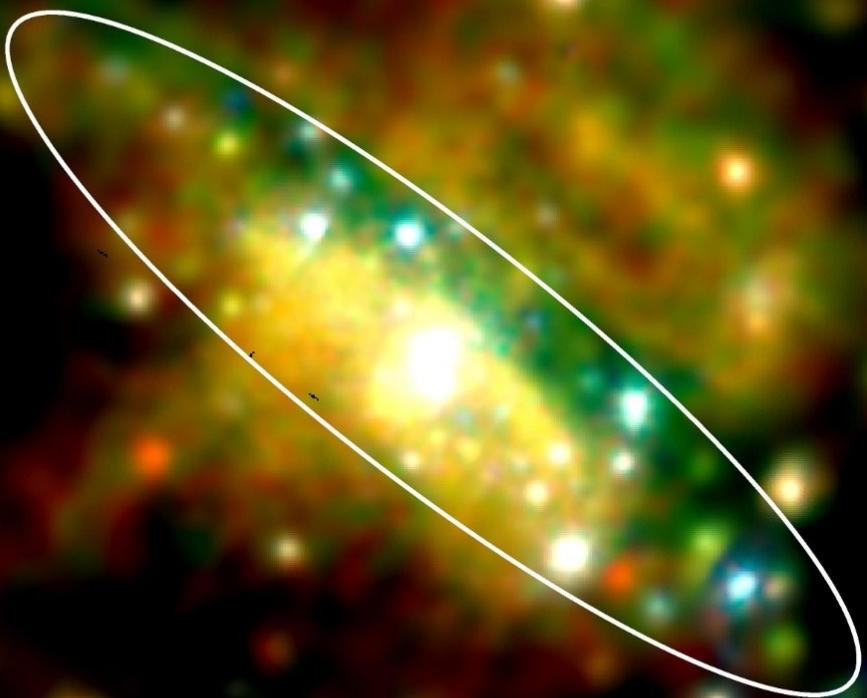
# What next?

- More sources with refined (in-beam?) calibration
  - Follow up detected sources
  - Mostly AGN candidates so far
- EVN re-correlation
  - Now complete, but not processed
- Ultimately image the entire field
  - Image and search for sources
  - Compare overlapping regions





What next?



5 arcmin

N  
E ←