ATCA Observing Strategies

Making good decisions

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1. Continuum Observations

- Frequencies
- Angular resolution
- Array configurations
- Integration times
- Calibration strategies
- Interference and confusion

ATCA - cm continuum observations

λ (cm):	3		6		13		20	
ν (GHz):	8.0	9.2	4.4	6.7	2.2	2.5	1.25	1.78

- Bandwidth = 128 MHz split into 32 spectral channels
- Switching between bands is straightforward
- Allows for simultaneous observations at 3+6 cm and 13+20 cm

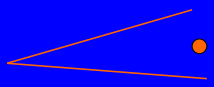
Frequency Considerations

- image resolution
- do you want spectral indices?
- is emission thermal or non-thermal?
- system performance
- confusion and interference
- phase stability

Choice of ATCA band(s) is usually SCIENCE DRIVEN

Angular resolution and array choice

For point source:



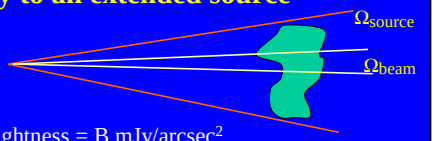
True flux density = S (mJy)

In image plane measure:
apparent brightness = S (mJy/beam area)
rms noise = ΔI (mJy/beam area)

signal/noise = S/ ΔI

Sensitivity to a point source is the same for all baselines

Sensitivity to an extended source

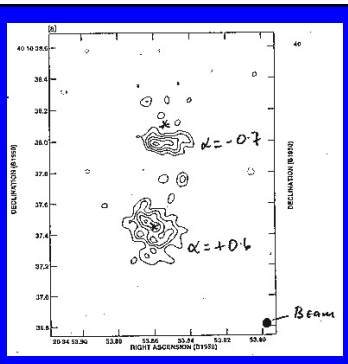


True source brightness = B mJy/arcsec^2
Beam area = Ω_B (For a Gaussian beam, $\Omega_{B=}$ 1.13 θ_x θ_y)

In image plane, apparent brightness = B Ω_B (mJy/beam area)

Signal/noise = B $\Omega_{B/}$ ΔI (∝ beam area)

If beam area < source size then the sensitivity to extended emission is reduced.



WR 147

MERLIN: - total flux density = 20 mJy
VLA: - total flux density = 36 mJy

Choosing best configurations

- Smallest angular structure → longest baseline
- Largest angular structure → shortest baseline
- Determine full size of full region for image
- Select best matched array configurations

ATCA Array Configurations

Large number available - baselines from 30 m to 6 km

For complex sources - advisable to use two or more configurations

For available configurations and recommended array combinations see the

"Guide to Observations with the Compact Array"

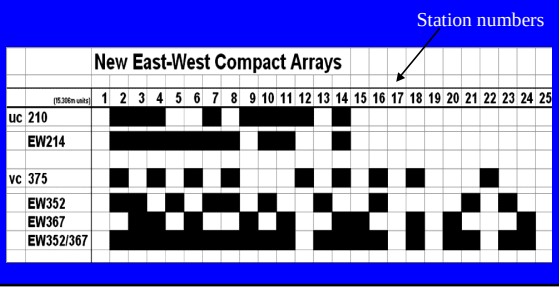
2002 Array configurations

	Term 1	Term 2	Term 3
6A	■		■
6B	■		
6C		■	
1.5A	■		■
1.5B		■	
750A	■		■
750B		■	
750D			
EW352		■	
EW367	■		■

Some 'wildcard' arrays may also be available

Two new configurations - EW 352 and EW 367

EW 352 + EW 367 provides almost uniform coverage for baselines from 30 m to 370 m.



Integration times

Thermal noise at image centre :

$\Delta I_{th} \alpha 1 / (n_{bas} . bandwidth . T. n_{pol})^{0.5}$

F ~ 1.0 for natural weighting
F ~ 1.5 for uniform weighting

Example: BW = 128 MHz, Npol = 2

T = 12 hours, ΔI_{th} ~ 0.025 mJy
T = 10 mins, ΔI_{th} ~ 0.21 mJy

Sensitivity calculator - www.atnf.csiro.au/observers/docs/at_sens

In practise, to reach the thermal noise, need to have a well-sampled u-v plane.

Largest well-imaged structure at 6 cm

Array	6-km	1.5-km	750-m
Time	Size (arcsec)		
25 days	360	-	-
4 days	160	240	480
1 day	80	115	230
10 mins (1-d)	20	40	80

'Short-cut' detection experiments

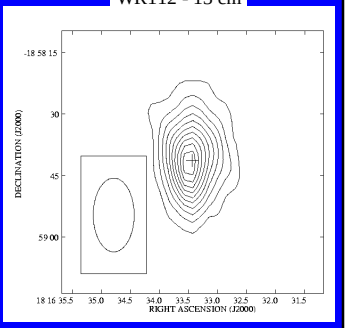
For 'point-like' sources can reach near-thermal noise with short integration times. To do this:

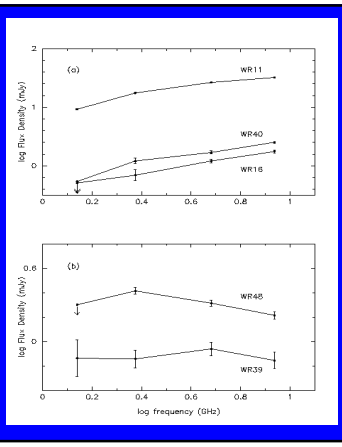
- Split the total time into a large number of short cuts
- Distribute cuts over the hour angle range of the source. This will reduce the sidelobes from other sources in the field

Detection of stellar winds from WR stars

Band	rms (mJy)	time (mins)
3	0.1 ‣ 0.2	70
6	0.1 ‣ 0.6	70
13	0.1 ‣ 1.2	70
20	0.2 ‣ 1.3	70

WR112 - 13 cm





Radio continuum spectra for WR stars

Confusion

- any other astronomical source that contributes to emission
- may be within the primary beam or in sidelobes
- degrades final images - higher noise in images
- may give spurious “detections”

Confusion..

Number of extragalactic sources per square arcmin:

N (Sobs > S) $= 0.032\ S^{-1.3}$ at 6 cm
$= 0.10\ S^{-0.9}$ at 20 cm

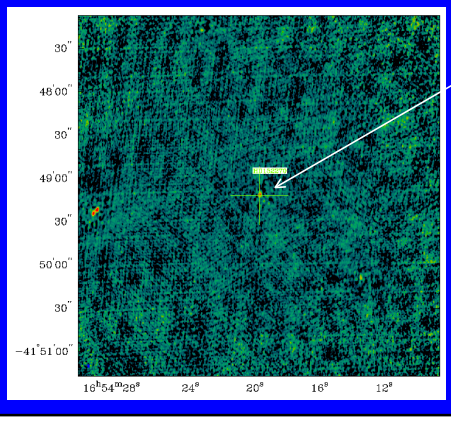
(Ledden et al. 1980)

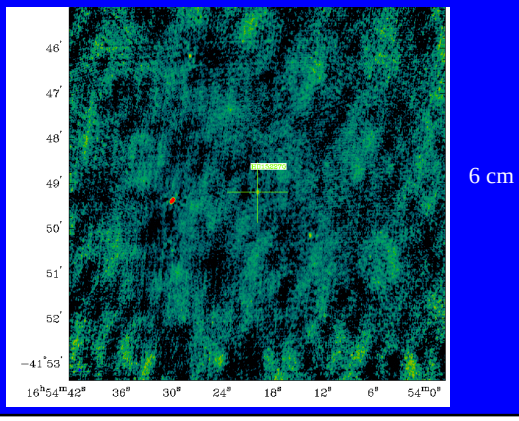
Examples: At 20 cm, primary beam ~ 1000 arcmin^2

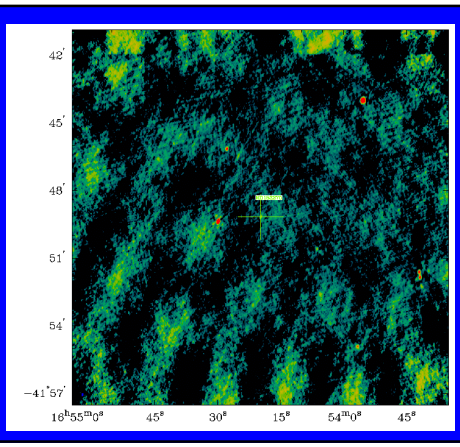
N >20 mJy ~ 7

N > 160 mJy ~ 1

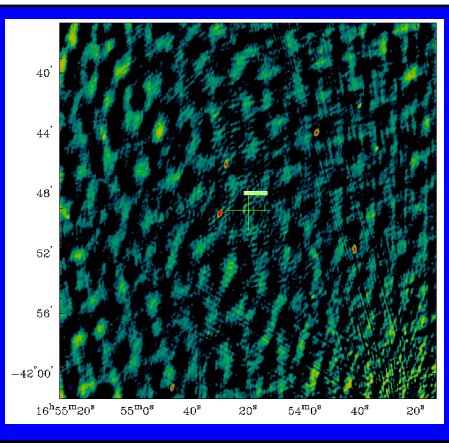
At 3 cm expect ~ one source > 0.4 mJy in primary beam







13 cm

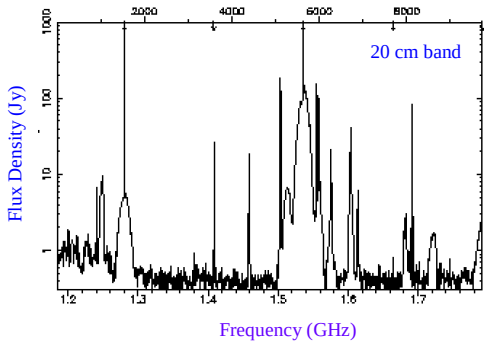


20 cm

Some Strategies for Confusion

- Move pointing centre away from strong confusing source
  -- to minimize the primary beam response
- For short cut experiements - use multiple cuts
  -- improves the dirty beam characteristics
- Make a low resolution image of a large region
- Identify and CLEAN sources within field-of-view
- Be careful with marginal detections - are they just sidelobes?

Interference



Interference...

characteristics

- time variable
- short bursts -- large angular scale map errors
- worst on short baselines

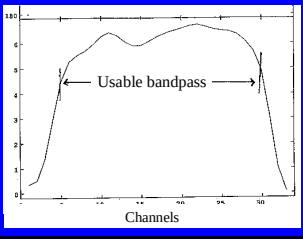
strategies

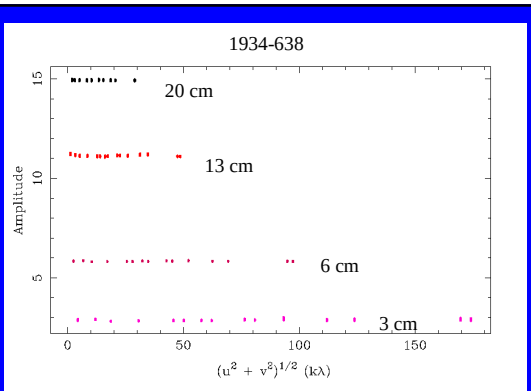
- avoid the sun
- choose clean part of band - check with local staff
- use long exposures or multiple cuts
- use longer baselines
- edit data

Calibrations for cm observations

1. **Primary Calibration** - set the absolute flux scale using 1934-638. Observe at least once for each frequency/set up used.

2. **Bandpass calibration** – correct for instrumental bandpass. Use 1934-638 or any strong calibration source.





Calibrations…

- **Secondary Calibration** - correct for instrumental and atmospheric amplitude and phase variations.

Choose calibrators which are:

Strong (> 1 Jy)
Close to source (< 10 degrees)
Unresolved on all baselines (point source)
Have accurate positions

www.narrabri.atnf.csiro.au/calibrators

Calibrations…

Calibration sources are typically observed for:

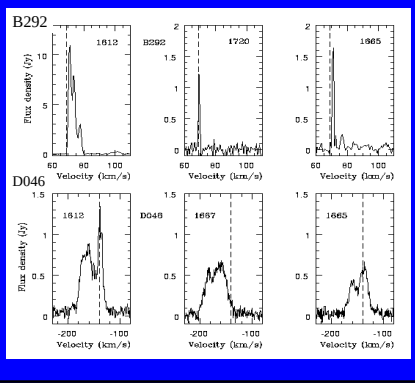
3 to 5 mins every 15 - 30 mins at 3, 6 cm

3 to 5 mins every 30 - 60 mins at 13, 20 cm

-- Check --

Do phases vary by < 20° between calibration observations? If phase stability is poor then calibrate more often.

2. Spectral Line Observations



OH maser spectra for two evolved stars at 1612, 1665, 1667 and 1720 MHz

Spectral Lines…

Setting the frequency

- Find rest frequency for the specific transition (OH, H_2O, methanol, SiO…)
- Correct rest frequency for galaxy redshift or motion in our Galaxy
- At ATCA – set frequency to nearest integer MHz
- The ATCA has no on-line Doppler tracking – convert frequencies to velocities off-line (CVEL)

ATCA spectral line options

Bandwidth (MHz)

4	8	16	32	64	128

Highest resolution

Channels (maximum number)

P=1	4096	2048	1024	512	256	128
P=2	2048	1024	512	256	128	64
P=4	1024	512	256	128	64	32

Continuum

Spectral Lines…

For spectral line observations – choose:

Bandwidth – large enough for total velocity range allow for bandpass edges

Correlator configuration – with enough channels for required velocity resolution

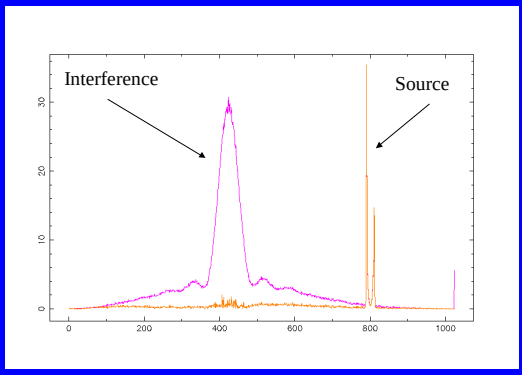
You may need to compromise between these requirements.

Spectral Lines…

Strategies for interference

- Observe with longer baselines (1612 MHz interference is much lower for B > 1 km)
- Use multiple cuts – delete bad data
- Remove interference after observations – try fitting high order polynomials through data

Interference mitigation at 1612 MHz (Kesteven)



3. Writing proposals

ATNF Observing Terms

Deadline	Term dates	Term name
15 Oct	Jan-Apr	JANT
15 Feb	May-Aug	MAYT
15 Jun	Sep-Dec	SEPT

Preparing Proposals

- Check the proposal and position archives – does the data already exist?
- Check the array configurations for the term
- Use the "Guide to observations with the Compact Array" for detailed information on the ATCA

www.atnf.csiro.au/observers

- Consult web pages for up to date observers information

Writing Proposals

- Give a well argued scientific case
- For continuing projects – give a progress report & include a list of all publications for project
- Explain your choice of arrays and justify the time requested
- Use a font size of at least 10. Include figures in black & white with good labels and captions
- Submit the proposal on time!

ATCA OH 1612 MHz maser detections: BW = 4 MHz, 1024 channels