



Observing Strategies

Shari Breen (and thanks to Max Voronkov)

30 September 2014

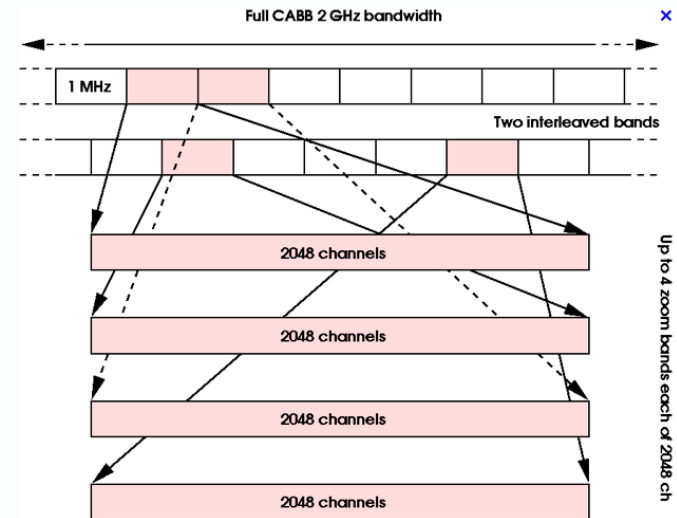
ASTRONOMY AND SPACE SCIENCE

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Outline

- Why is a good observing strategy important?
- Things to think about
 - What, when, for how long, frequency, array, overheads, CABB mode?
- Observing
 - The simple cm case
 - Slightly less simple cases
 - The mm case
 - Spectral lines



The importance of a good strategy

- Starts taking shape at the proposal stage
- Good telescopes are generally oversubscribed (ATCA usually by 2 – 3 times)
- Need to have a good plan to get good data that meets your science goals
- Make sure you are familiar with the current status of the instrument

OPAL links

- [OPAL Users Guide](#)
- [Cover sheet editor](#)
- [Source list editor](#)
- [Observations table editor](#)
- [Search proposals](#)
- [Preview a proposal](#)
- [List and access your proposals](#)
- [Contact us](#)

Shari.Breen@csiro.au

ATNF access

- [Update your details](#)
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ATOA

ATNF Online Proposal Applications & Links

Welcome to OPAL, the [Australia Telescope National Facility](#) online proposal system.

For 2012 OCTS, the ATNF will be accepting proposals for the Australia Telescope Compact Array, Parkes, Tidbinbilla and the Long Baseline Array. **Mopra proposals are not requested for this semester.**

The ATNF is not currently accepting telescope proposals. Please be aware that any proposals you construct are not guaranteed to be valid for the next proposal round.

To submit a proposal, you must have a [registered OPAL account](#).

OPAL proposals generally require three components:

1. A *cover sheet* created with the [cover sheet editor](#).
2. An *observations table* created with the [observations table editor](#).
3. A *scientific justification* in PDF format (<10 megabytes and not more than three pages in total — see [the science case requirements](#)) created by any tool you wish to use. This is not required for projects that have pre-graded project status.

See the full information on [ATNF Telescope Applications](#).

In particular please read the web information on the [current status of the ATNF telescopes](#).

OPAL supports Firefox and Internet Explorer. [More about OPAL](#).

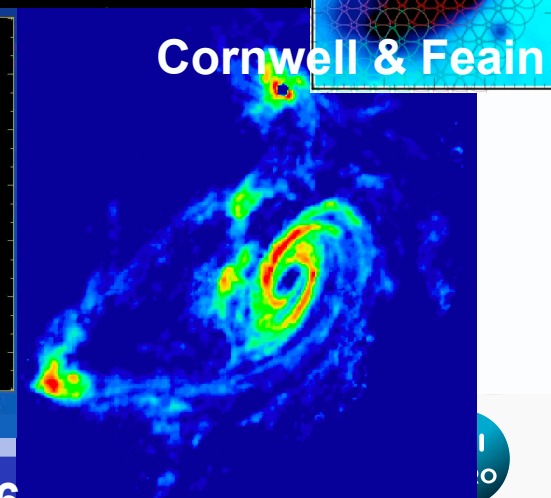
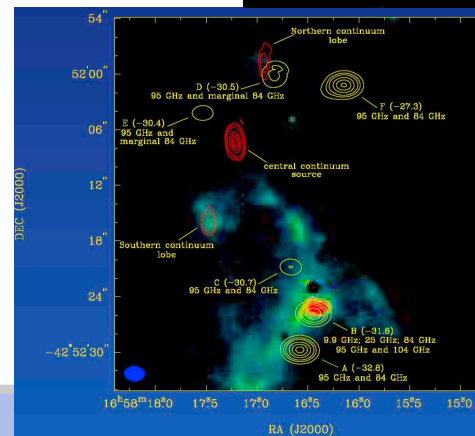
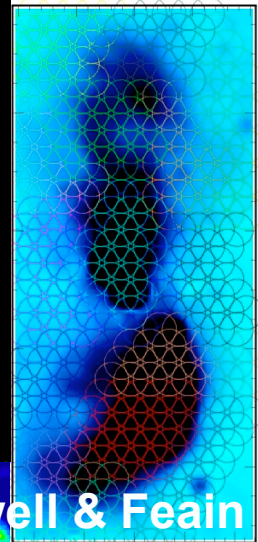
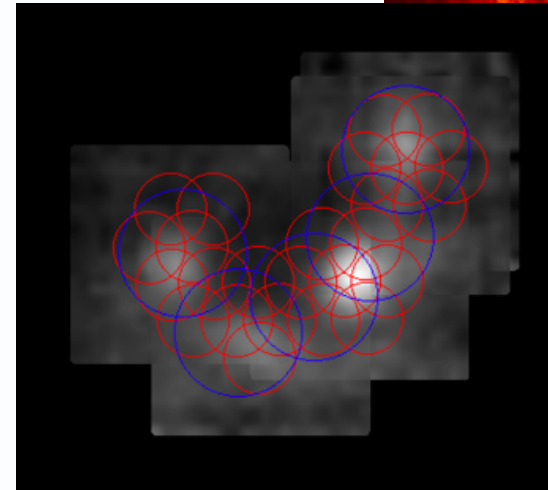
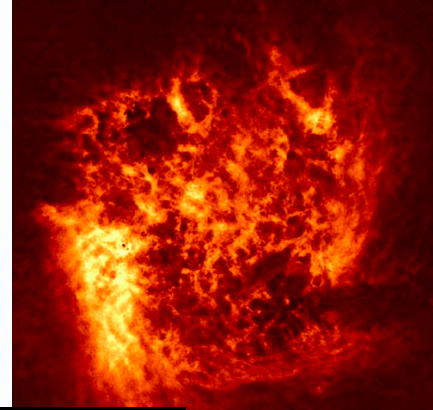
```
graph TD; A[Prepares files  
Cover sheet  
Observations table  
Science case] --> B[Preview proposal]; B --> C[Submit proposal to OPAL]; C --> D[OPAL Access  
List submissions  
Download proposals]; D --> A;
```

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Things to think about – 1) What?

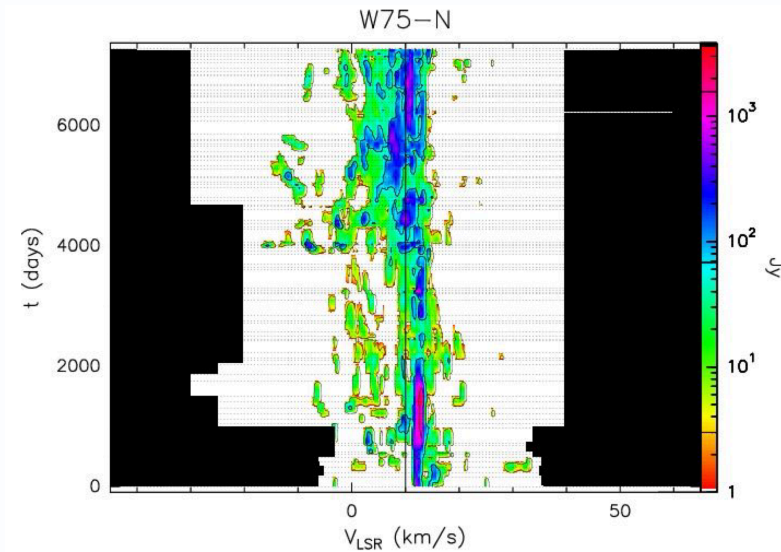
- Strategy dependent on science/object!
 - Complicated extended structure? → might need multiple array configs and single dish data
 - Point source? → a handful of short cuts over several hours might be enough
 - Know where your object is and just need a flux measurement or spectrum? → 1 short observation might be enough
- Shadowing?
- Confusion?
- Location?
- Mosaic? (primary beam λ/D)
- Continuum and/or spectral line?

Kim et al.

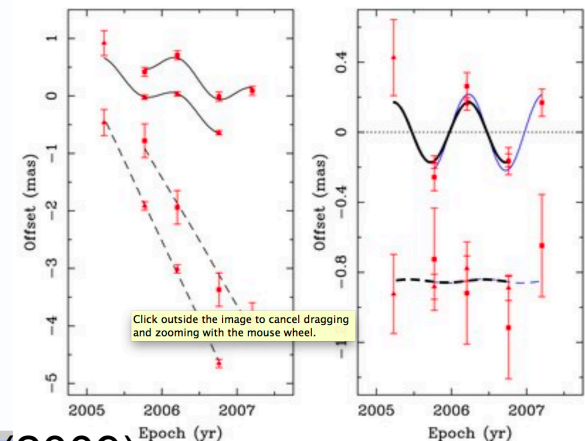


Things to think about – 2) When?

- Variable source?
 - observe when it is expected to be bright
 - Or track the flux with observations spread over multiple epochs
- Coordination with other telescopes?
- Weather?
 - Atmosphere generally more stable at night
→ better mm observing
 - Generally less interference at night at the lower frequencies too (man made and solar)
 - Thunderstorms during afternoon in summer



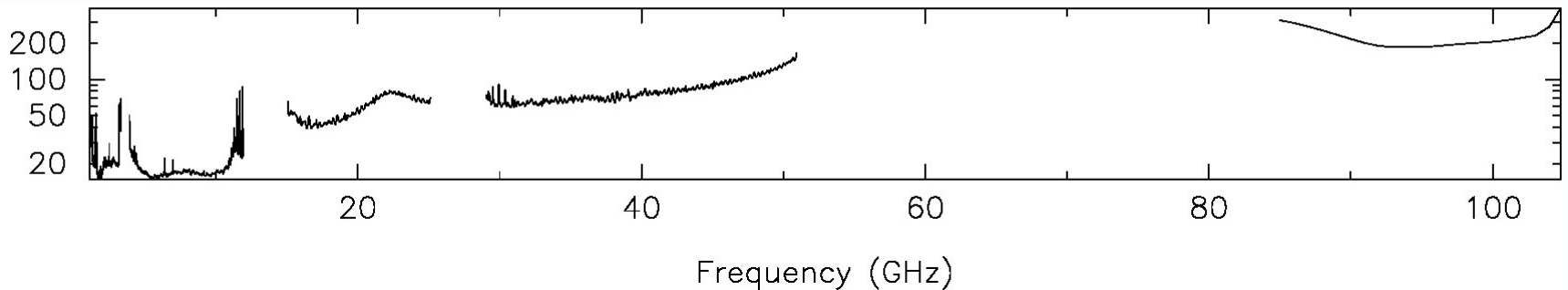
Felli et al. (2007)



Sanna et al. (2009)

Things to think about – 3) Frequency?

- Usually driven by science
 - Lines?
 - Remember to consider how the telescope performs at different frequencies
 - Spread the 2 IFs as far apart as possible, or continuous coverage?
 - Take the receiver limitations into consideration (e.g. the 13cm receiver works between 1.1 and 3.1 GHz)
 - ‘Standard’ continuum frequencies



Band	IF1 (MHz)	IF2 (MHz)
16cm	2100	2100
4cm	5500	9000
15mm	17000	19000
7mm (LSB)	33000	35000
7mm (USB)	43000	45000
3mm	93000	95000

Things to think about – 4) For how long?

- Mostly dictated by required sensitivity
 - Effective BW and spectral resolution
- UV coverage (e.g. bright spectral lines)
 - Short integrations across a range of hour angles increases overheads BUT may be the most efficient use of time to cover many sources

Parameters

Continuum centre frequency:	<input type="text"/>	MHz	✖
Specific zoom frequency:	<input type="text"/>	MHz	
Maximum baseline and configuration:	<input type="text" value="Please select..."/>		✖
Include CA06?:	<input type="text" value="Yes"/>		✔
Number of 4cm receivers:	<input type="text" value="1"/>		✔
CABB frequency resolution:	<input type="text" value="Please select..."/>		✖
Zoom channels to concatenate:	<input type="text" value="1"/>		✔
Source Declination:	<input type="text" value="-30"/>	degrees	✔
Integration Time:	<input type="text" value="720"/>	minutes	✔
Elevation Limit:	<input type="text" value="12"/>	degrees	✔
Hour-angle Limit:	<input type="text" value="6"/>	hours	✔
Line Rest Frequency:	<input type="text"/>	GHz	
	<input type="text"/>	<input type="button" value="Set"/>	
Image Weighting Scheme:	<input type="text" value="Natural"/>		✔
Smoothing filter width:	<input type="text" value="1"/>		✔
Discard self-generated birdies?:	<input type="text" value="No"/>		✔
Discard known RFI frequency bands?:	<input type="text" value="No"/>		✔
Number of edge channels to discard:	<input type="text" value="0"/>		✔
<input type="button" value="Calculate Sensitivity"/>			
<input type="button" value="Reset to Defaults"/>		<input type="button" value="Save as Defaults"/>	

http://www.narrabri.atnf.csiro.au/myatca/sensitivity_calculator_advanced.html

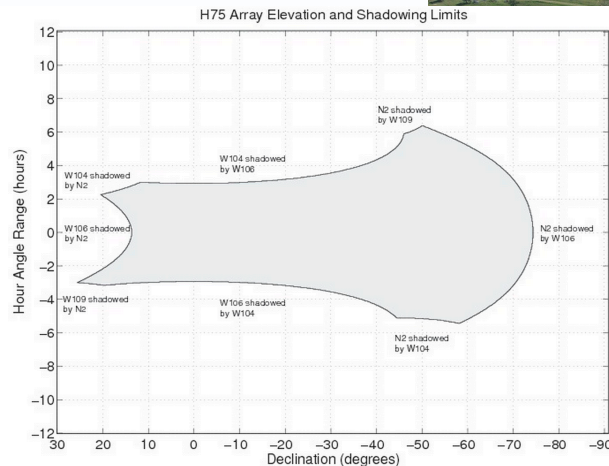
Things to think about – 5) Array?

- Dictated by:
 - the resolution required
 - uv-coverage requirements (specific arrays work well together – 6A, 6C, 1.5B, 1.5D)
 - What's offered
 - Where your source is – shadowing?



Semester	2010APRS	2010OCTS	2011APRS	2011OCTS	2012APRS
Array					
6A	•	•	•	•	•
6B			•		
6C	•			•	
6D					•
1.5A				•	
1.5B		•			•
1.5C			•		
1.5D	•			•	
750A		•			•
750B			•		
750C	•			•	
750D		•		•	
EW367		•		•	
EW352	•	•	•	•	•
H214	•	•	•	•	•
H168	•		•	•	•
H75	•		•		•

Table 1.3: Array configurations that will be offered in future semesters.



Things to think about – 6) Calibration and other overheads?

- Primary (flux) calibration
 - 1934-638 (or Uranus/Mars at mm)
- Bandpass calibration
 - 1934-638 strong enough at most cm wavelengths
 - 1253-055 or 1921-293 often used at higher frequencies
- Phase calibration (~2min every 40min)
 - Unresolved, strongish source within about 10 degrees of target
- Pointing calibration
 - Carried out every hour at all mm frequencies on a source within ~20 degrees of target
- Other overheads
 - Set up, slewing,.....



Things to think about – 7) CABB mode?

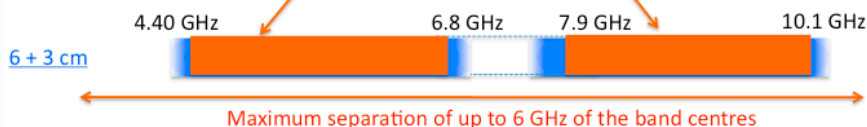
- Two x 2 GHz wide IFs (2048 x 1 MHz channels)
 - Where you can put them depends on the frequency



CABB in the cm bands

8 GHz CABB range over which two 2-GHz bands can be positioned

2 x 2-GHz bandwidth with full Stokes. Either 2048 x 1MHz channels or 32 x 64MHz channels.



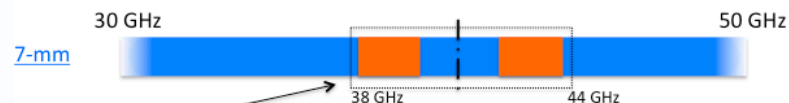
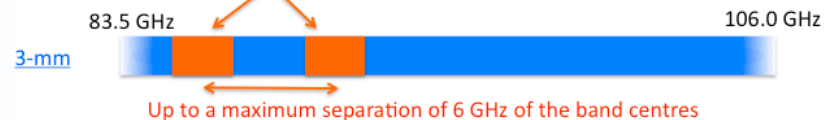
Note: It is possible to observe at 6 and 3 cm simultaneously by placing 1 frequency setting (IF) in each receiver band. It is also possible to place 2 IFs in the 6-cm band



CABB in the mm bands

8 GHz CABB range over which two 2-GHz bands can be positioned

2 x 2-GHz bandwidth with full Stokes. Either 2048 x 1MHz channels or 32 x 64 MHz

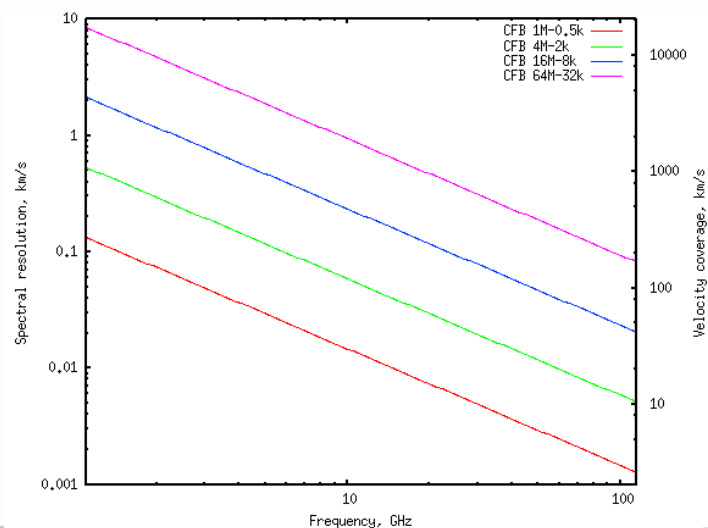
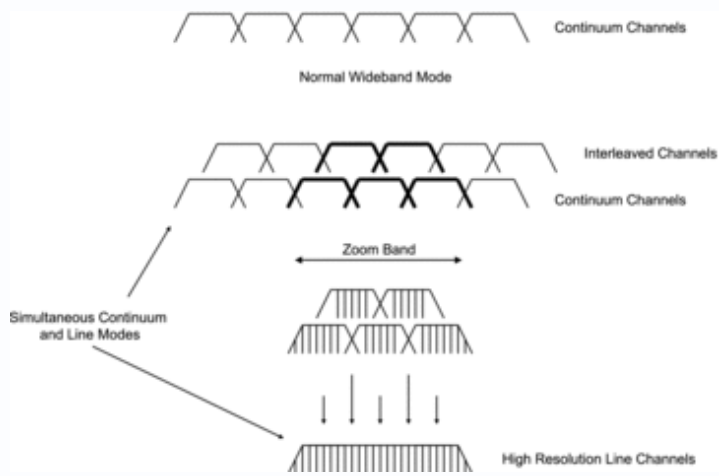
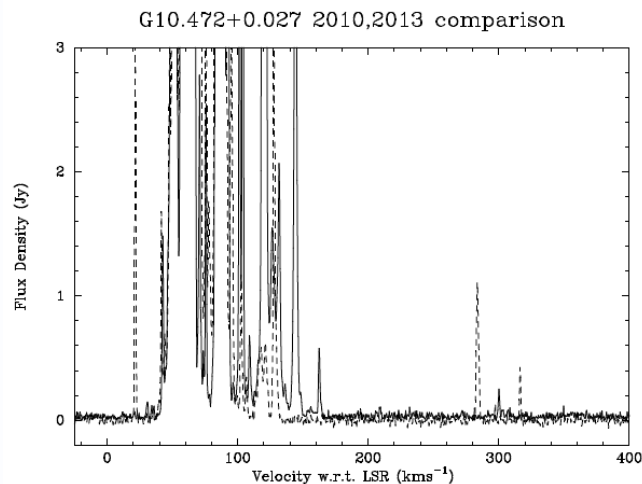


Note: For the 7-mm system both 2GHz band centres must be either greater than 41 GHz (the point at which the conversion changes from lower side-band to upper side-band) or both less than 41 GHz.



Things to think about – 7) CABB mode?

- Optional zoom windows (currently 32 x 1 MHz zooms or 64 MHz zooms each with 2048 channels)
- Concatenate zoom windows for more velocity coverage
- What mode depends on velocity res/coverage needed



Schedule files <https://www.narrabri.atnf.csiro.au/observing/sched/cabb/>

CABB Scheduler - c2639-h214.sch

Sched Listing

File Edit Tools

Scan Parameters

Source: x1710-269

RA (hms): 17:13:31.276

Dec (dms): -26:58:52.523

Epoch: J2000

CalCode: C

ScanLength: 00:02:00

ScanType: Point

Pointing: Update

Observer: JillRathborne

Project: C2639

Time: 12:00:00

TimeCode: LST

Date: 24/09/2012

Calibrator Selection

Distance	Name	Right Ascension	Declination	Flux-23100	Flux-24500
0.00	1710-269	17:13:31.2756	-26:58:52.523	1.08	1.14
1.18	1709-281	17:12:57.0055	-28:09:33.056	14263237288980.66	15127675912555.24
2.94	1657-261	17:00:53.15405	-26:10:51.72510.65		0.69
5.73	1647-296	16:50:39.54414	-29:43:46.95492.08		2.20
6.78	1714-336	17:17:36.0300	-33:42:08.764	7.42	7.87
7.38	1742-289	17:45:40.0383	-29:00:28.069	88.92	94.31
7.99	1741-312	17:44:23.5826	-31:16:35.986	0.70	0.74
8.74	1748-253	17:51:51.26304	-25:24:00.06060.16		0.16
9.54	1706-174	17:09:34.34538	-17:28:53.36480.44		0.46
10.50	1752-225	17:55:26.2847	-22:32:10.593	0.38	0.40
10.81	1622-297	16:26:6.020838	-29:51:26.97111.80		1.91
10.84	1622-297	16:26:6.020838	-29:51:26.97111.80		1.91

Cancel

Freq1 23100MHz
Freq2 24500MHz

CABB Scheduler - c2639-h214.sch

Sched Listing

#	Source	Cal	RA	Dec	Epoch	Time(LST)	ScanLength	Az	EI	Drive	ScanType	Pointing	Freq-1	Freq-2
1	x1710-269	C	17:13:31.276	-26:58:52.523	J2000	12:00:00	00:02:00	109:07:19.3	22:25:08.5	00:03:22	Point	Update	23100	24500
2	1710-269	C	17:13:31.276	-26:58:52.523	J2000	12:02:01	00:01:30	108:55:40.0	22:49:41.5	00:00:00	Dwell	Offset	23100	24500
3	g025+02_24		17:45:59.489	-28:44:37.050	J2000	12:03:31	00:10:30	113:39:10.3	17:19:37.9	00:00:23	Mosaic	Offset	23100	24500
4	1710-269	C	17:13:31.276	-26:58:52.523	J2000	12:14:02	00:01:30	107:46:27.6	25:17:35.0	00:00:23	Dwell	Offset	23100	24500
5	g025+02_24		17:45:59.489	-28:44:37.050	J2000	12:15:55	00:10:30	112:26:18.0	19:47:33.6	00:00:23	Mosaic	Offset	23100	24500
6	1710-269	C	17:13:31.276	-26:58:52.523	J2000	12:26:27	00:01:30	106:36:13.2	27:51:09.6	00:00:23	Dwell	Offset	23100	24500
7	g025+02_24		17:45:59.489	-28:44:37.050	J2000	12:28:21	00:10:30	111:15:17.0	22:16:49.2	00:00:23	Mosaic	Offset	23100	24500
8	1710-269	C	17:13:31.276	-26:58:52.523	J2000	12:38:52	00:01:30	105:26:56.5	30:25:43.0	00:00:23	Dwell	Offset	23100	24500
9	g025+02_24		17:45:59.489	-28:44:37.050	J2000	12:40:46	00:10:30	110:05:57.6	24:47:19.0	00:00:23	Mosaic	Offset	23100	24500
10	1710-269	C	17:13:31.276	-26:58:52.523	J2000	12:51:18	00:01:30	104:18:24.9	33:01:10.8	00:00:24	Dwell	Offset	23100	24500
11	g025+02_24		17:45:59.489	-28:44:37.050	J2000	12:53:11	00:10:30	108:58:10.6	27:18:57.5	00:00:24	Mosaic	Offset	23100	24500

Schedule files – adding line observations...

CABB Scheduler - c2986_7_12.sch

Sched Listing Frequency Zoom Range

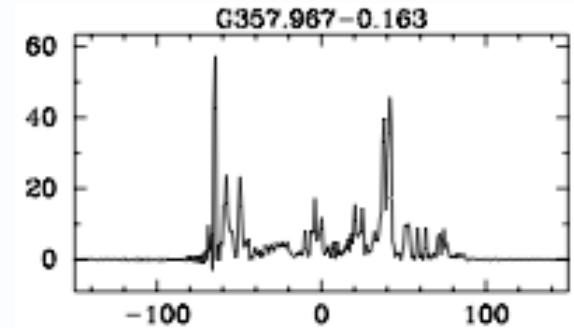
File Edit Tools

Scan Parameters
 Freq1 43400MHz
 Freq2 49000MHz

Velocity Calculator
 Source Velocity: 10 LSR Radio
 Spectral Line: CS carbon monosulfide (48990.964 MHz)
 Rest Frequency: 48990
 Observatory Velocity: 16.431
 Sky Frequency: 48985.681
 Zoom band Frequency: 49000

Line	Continuum (MHz)	Fixed	Chn.BW (MHz)	Vel.Res. (km/s)	Vel.Range (km/s)	#Channels
1	48136		6	0.19	398.6	2048
2	48200		8	0.19	398.1	Velo
3	48360		13	0.19	396.7	Velo
4	48648		22	0.19	394.4	Velo
5	49000		33	0.19	391.6	Velo
6						Velo
7						Velo
8						Velo
9						Velo
10						Velo
11						Velo
12						Velo
13						Velo
14						Velo
15						Velo
16						Velo

New Scan Search Cal
Delete Pick Source



CABB Scheduler - c2986_7_12.sch

Sched Listing Frequency Zoom Range

Enter a comma separated list of rest freq in (MHz):

24934.382, 24928.707, 24933.468, 24959.0789, 25018.1225, 25124.8719, 22235.08, 44069, 48990

Note: Please fill in CatVel for all the sources for the calculation to work correctly. And make sure you save the changes.

#	Source	24934.382	24928.707	24933.468	24959.0789	25018.1225	25124.8719	22235.08	44069	48990
1	bubble_22ghz	Zoom 6	Zoom 6	Zoom 6	Zoom 6	Zoom 8	Zoom 7	Zoom 1	X	X
2	7mm_bubble	X	X	X	X	X	X	X	Zoom 6	Zoom 11
3	7mm_bubble	X	X	X	X	X	X	X	Zoom 6	Zoom 11
4	7mm_bubble	X	X	X	X	X	X	X	Zoom 6	Zoom 11
5	7mm_bubble	X	X	X	X	X	X	X	Zoom 6	Zoom 11

Need to calculate sky frequencies

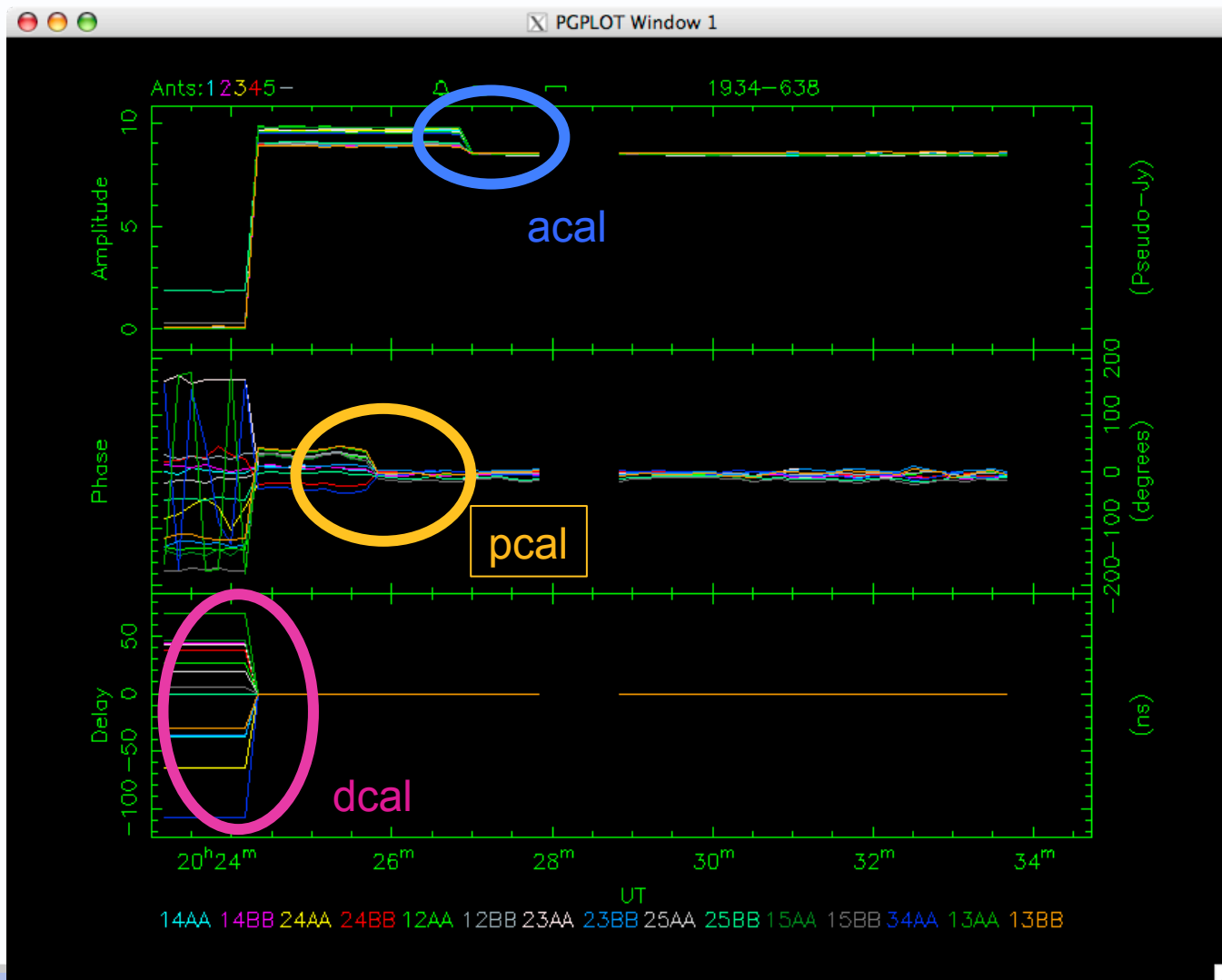
- All done by the CABB scheduler

Observing – the simple cm case

- If you are prepared the actual observing is not hard
- A simple cm continuum observation of a single source may go something like
 - Observe 1934-638
 - Do initial array calibration (delays, phases, amplitudes; dcal, pcal, acal)
 - Close junk file
 - Track 1934-638 for primary and bandpass calibration (~10min)
 - Go to target schedule which contains
 - Phase calibrator (~2min)
 - Target (~20min)
 - Loop through target schedule until the end (start 1/99)



Calibrating the array



The less simple cases

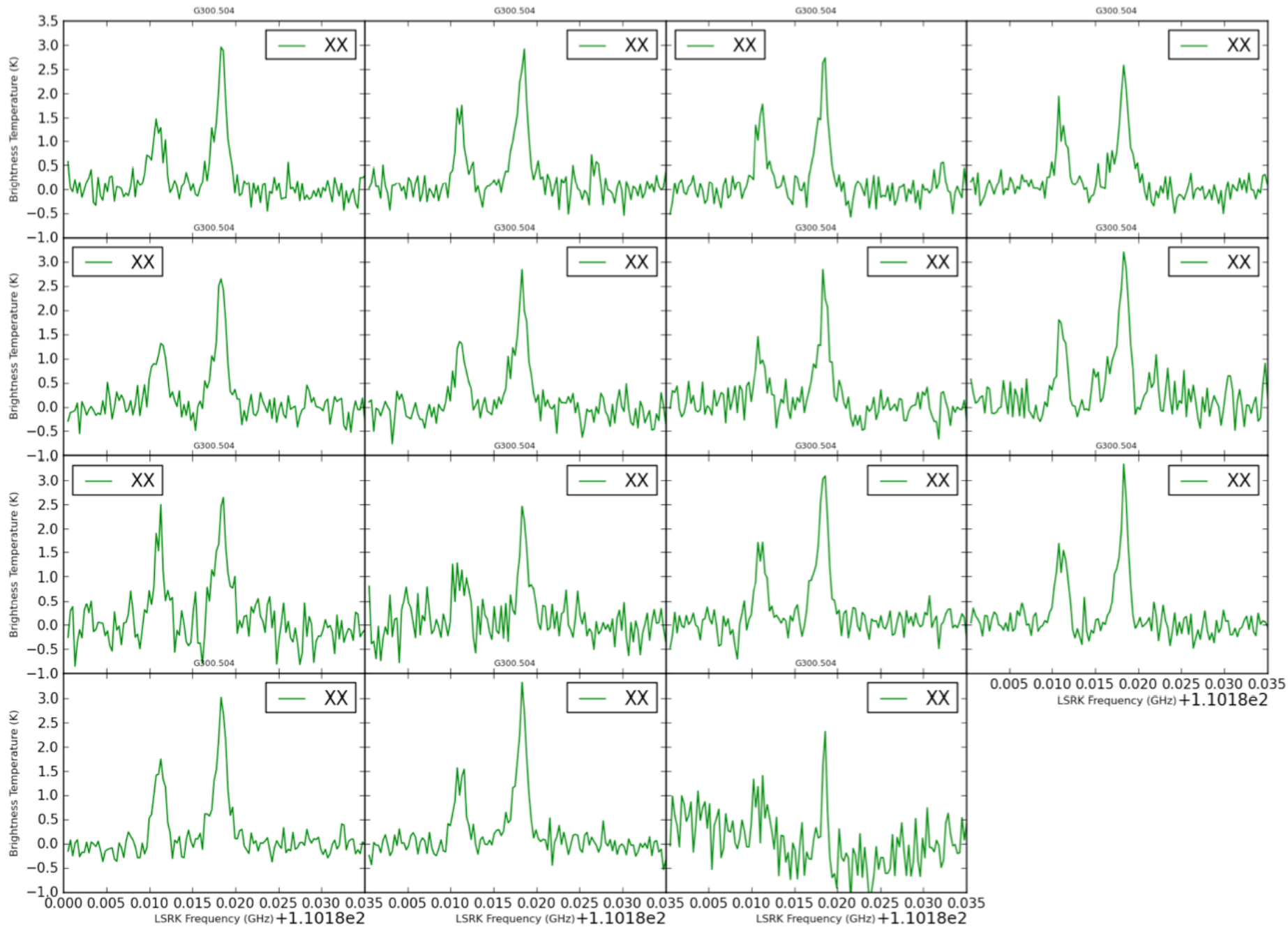
- Lower frequencies (~ 2.1 GHz)
 - Second IF is redundant
 - Lots of interference \rightarrow need to choose channel range for calibration carefully (set “tvchan”)
 - More chance of confusion
- Higher frequencies
 - 1934-638 gets too weak for setup and bandpass \rightarrow use a stronger source (e.g. 0537-441, 1253-055, 1921-293)
 - Observe 1934-638 or a planet for primary calibration

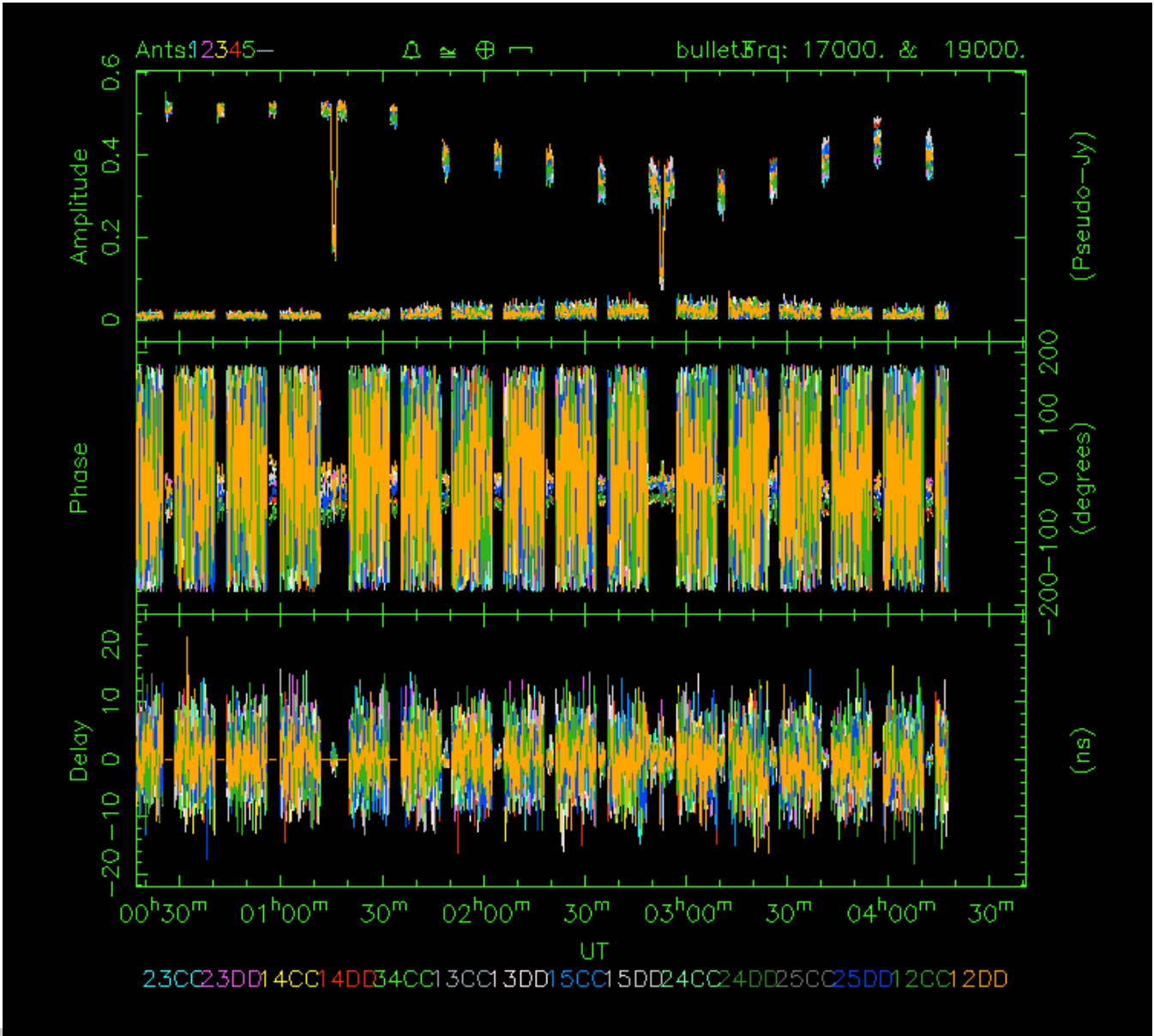


mm observing – the least simple case

- Everything becomes more difficult at mm frequencies
 - Atmospheric opacity increases T_{sys} and attenuates signal
 - Not as many bright calibrator sources
 - Instrument stability is more difficult to maintain
 - Antenna accuracy is less
 - The FOV is smaller
- To overcome some of these difficulties we usually only observe during the winter months (60-65 % chance of suitable 3mm weather) or during the night (esp at 12 or 7mm).



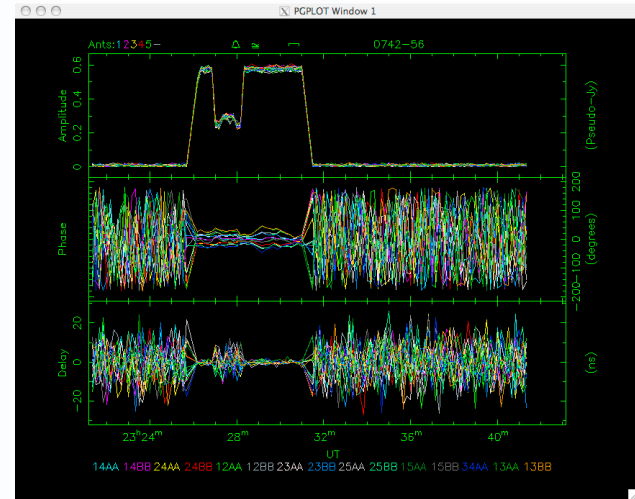




Observing at mm frequencies

- Observe a strong calibrator (e.g. 0537-441, 1253-055 or 1921-295)

- Calibrate delays (dcal)
- Do a pointing (can choose specs)
- Calibrate phase (pcal)
- Calibrate amplitudes (acal or paddle at 3mm)



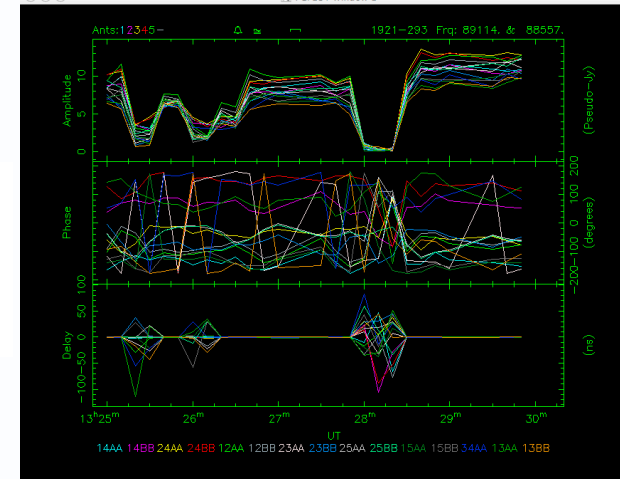
- Observe either 1934-638 (at 12 or 7mm) or a planet (at 3mm) for primary calibration
 - Pointing first (1934-638 or source nearby planet)
- Target observations
 - Include a pointing once an hour (ideally on a strong source within ~20 degrees)

Paddle scans

- Measure T_{sys} and correct for the atmosphere at 3mm
- Place an ambient load in front of receiver horn for 30 sec
- Gives T_{sys} corrected for the current atmospheric conditions

$$T_{\text{sys}}^{\text{eff}} = (300 \text{ K}) \frac{P_{\text{sky}}}{P_{\text{paddle}} - P_{\text{sky}}}$$

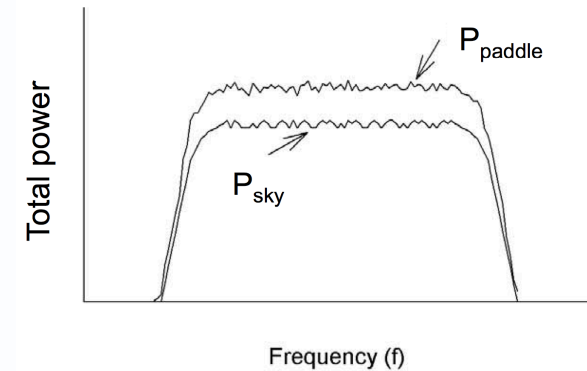
- Every 15-20min
- Before primary and bandpass calibrators



CABB Scheduler - c2639-sio.sch

Sched Listing

#	Source	Cal	RA	Dec	Epoch	Time(LST)	ScanLength	Az	EI	Drive	ScanType	Pointing	Freq-1	Freq-2
1	x1730-130	C	17:33:02.706	-13:04:49.548	J2000	12:00:00	00:01:30	98:11:44.5	12:08:12.0	00:03:54	Point	Update	85908	87400
2	1730-130	C	17:33:02.706	-13:04:49.548	J2000	12:01:30	00:01:30	98:00:57.2	12:27:29.0	00:00:00	Paddle	Offset	85908	87400
3	1730-130	C	17:33:02.706	-13:04:49.548	J2000	12:03:00	00:01:30	97:50:10.0	12:46:46.4	00:00:00	Dwell	Offset	85908	87400
4	g025+02_86		17:46:02.704	-28:44:09.110	J2000	12:04:31	00:12:00	113:33:09.5	17:30:32.4	00:00:34	Mosaic	Offset	85908	87400
5	1730-130	C	17:33:02.706	-13:04:49.548	J2000	12:16:33	00:01:30	96:13:05.9	15:40:44.6	00:00:34	Paddle	Offset	85908	87400
6	1730-130	C	17:33:02.706	-13:04:49.548	J2000	12:18:03	00:01:30	96:02:18.0	16:00:06.6	00:00:00	Dwell	Offset	85908	87400
7	g025+02_86		17:46:02.704	-28:44:09.110	J2000	12:19:33	00:12:00	112:05:16.7	20:30:03.9	00:00:34	Mosaic	Offset	85908	87400
8	1730-130	C	17:33:02.706	-13:04:49.548	J2000	12:31:35	00:01:30	94:24:48.8	18:54:40.1	00:00:35	Paddle	Offset	85908	87400
9	1730-130	C	17:33:02.706	-13:04:49.548	J2000	12:33:05	00:01:30	94:13:56.1	19:14:05.4	00:00:00	Dwell	Offset	85908	87400
10	g025+02_86		17:46:02.704	-28:44:09.110	J2000	12:34:36	00:12:00	110:40:05.0	23:31:26.1	00:00:35	Mosaic	Offset	85908	87400
11	1730-130	C	17:33:02.706	-13:04:49.548	J2000	12:46:38	00:01:30	92:35:22.0	22:09:04.0	00:00:35	Paddle	Offset	85908	87400
12	1730-130	C	17:33:02.706	-13:04:49.548	J2000	12:48:08	00:01:30	92:24:19.6	22:28:31.5	00:00:00	Dwell	Offset	85908	87400
13	g025+02_86		17:46:02.704	-28:44:09.110	J2000	12:49:38	00:12:00	109:17:17.2	26:34:29.0	00:00:35	Mosaic	Offset	85908	87400



How do we measure t_{sys} and correct for the atmosphere at 3mm?

If you forget to calibrate the phases during your setup (pcal) are your observations ruined?

What are the two main ways the atmosphere makes it difficult to detect signals at mm wavelengths?

What are the two main ways the atmosphere makes it difficult to detect signals at mm wavelengths?

What are the different CABB modes?

What is shadowing and when is it a problem?

At what frequency are pointing observations required and why?

**How far from your target source
can your phase calibrator be?**

**In what band does interference
cause the biggest problem?**

What do you think the most important things to consider when formulating your observing strategy are?

Summary and further information

- Have a plan and make sure it is a good one!
- Different science goals require different strategies so think carefully about what is required
- See ATCA webpage for further information: <http://www.narrabri.atnf.csiro.au/observing/>

Observing guides

- [CABB page](#)
- [General Users Guide](#)
- [Remote observing guide](#)
- [Guide to ATCA observing terminals](#)
- [Antenna array configurations and stations](#)
- [VLBI](#)
- [JEEEA Special Issue \("green book"\) on the ATCA](#)

Observing support tools

- [Calibrator manual](#) and planet positions
- [Calibrator cycle time calculator](#)
- [Observing characteristics calculator \(including sensitivity\) \(Old Calculator\) \(User-friendly Calculator\)](#)
- [CABB Scheduler, the scheduling program](#)
- [Velocity to frequency calculator and spectral line rest frequencies](#)
- [Shadowing diagrams](#)
- [Virtual radio interferometer](#) - simulate Fourier coverage.
- [Weather](#) (forecasts as well as present and past weather data)
- [Interference, solar activity.](#)
- [Satellite Interference Tool \(SaRFis\).](#)
- [COORD](#)
- [COCO](#) (HEASARC version of the coordinate conversion form)
- [Interactive Observability Chart Plotter.](#)

Thank you

Astronomy and Space Science

Shari Breen | DECRA Fellow

t +61 2 9123 4325

e Shari.Breen@csiro.au

w www.atnf.csiro.au

CSIRO ASTRONOMY AND SPACE SCIENCE

www.csiro.au

