



Image: D. Smyth

Observing Strategies

Shari Breen | Bolton Fellow (and thanks to Max)

25 September 2012

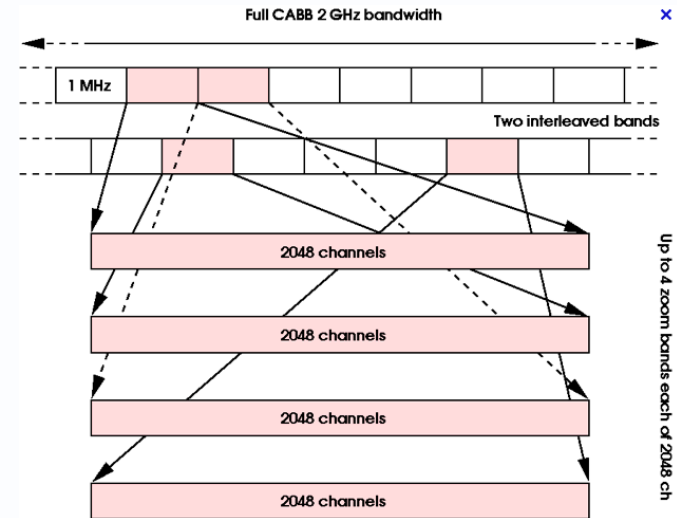
ASTRONOMY AND SPACE SCIENCE

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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

- 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
 - Starts taking shape at the proposal stage
 - 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.

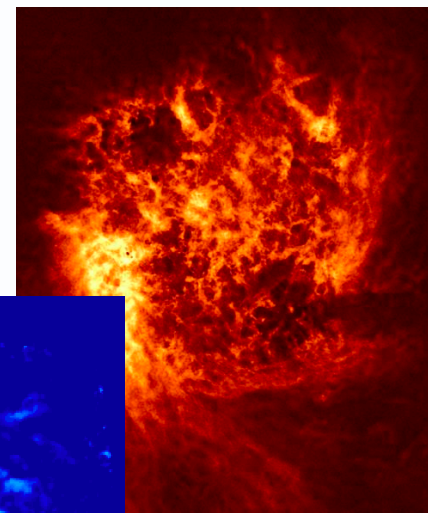
In particular please read the web information on the [current status of the ATNF telescopes](#).

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

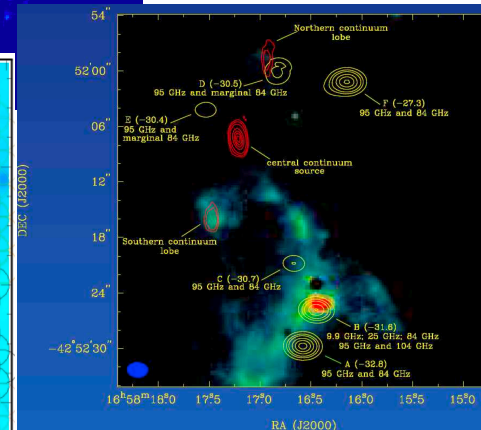
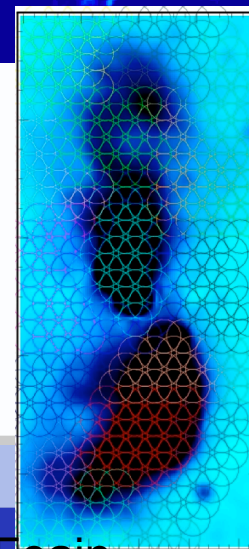
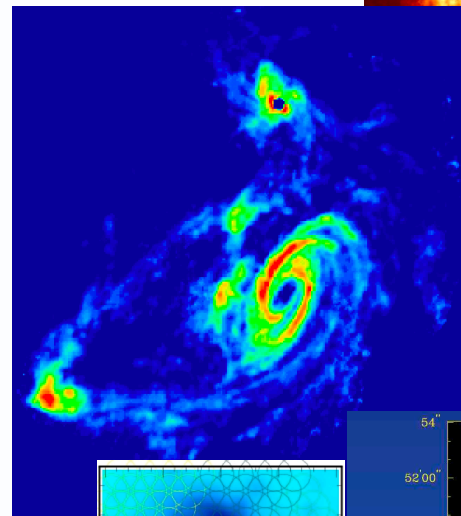
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Things to think about – 1) What?

- 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?



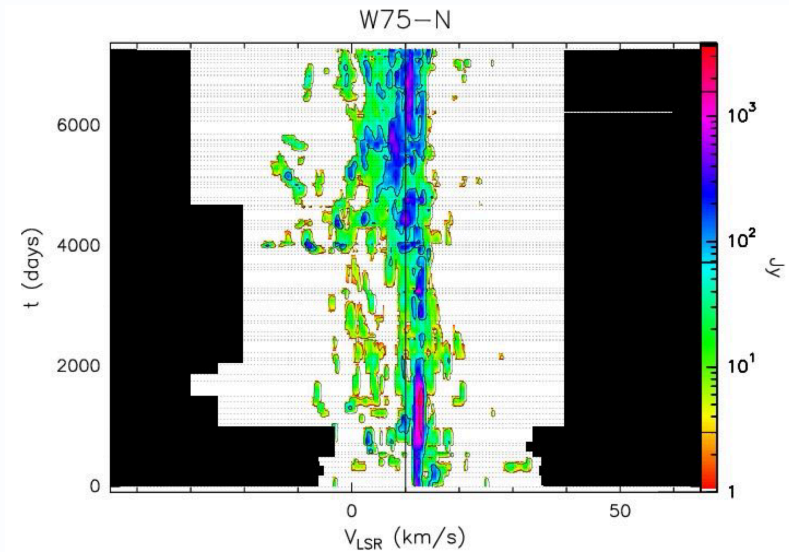
Kim et al.



Voronkov et al. 2006

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
- 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

Things to think about – 3) 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

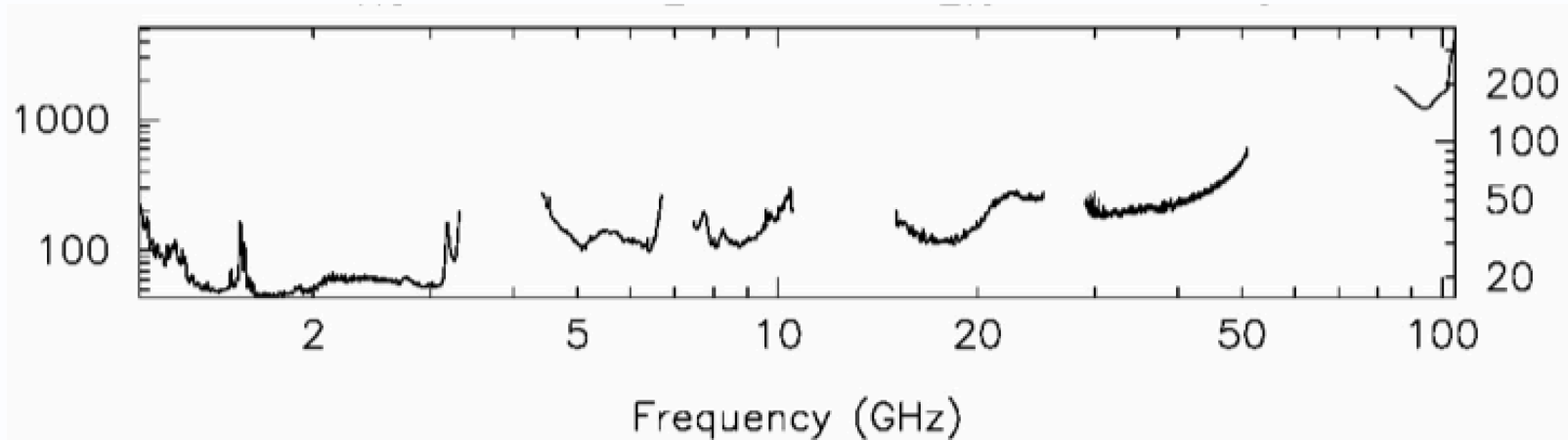
Parameters

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 – 4) Frequency?

- Usually driven by science
 - Remember to consider how the telescope performs at different frequencies
 - Spread the 2 lfs 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)



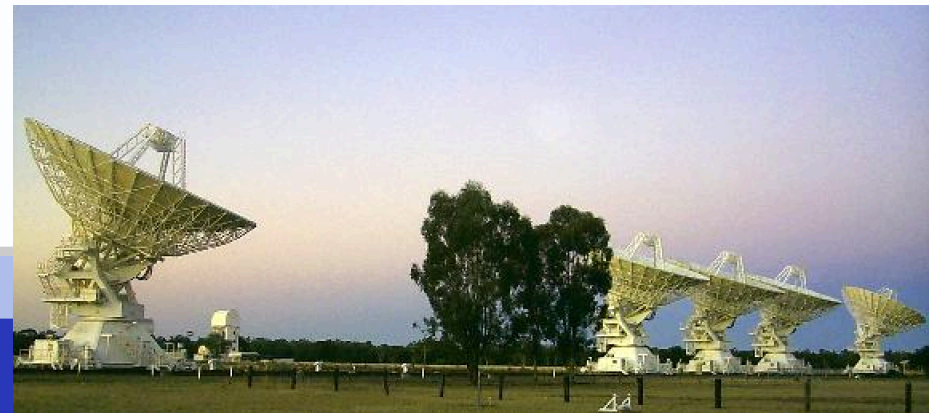
Things to think about – 5) Array?

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



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?

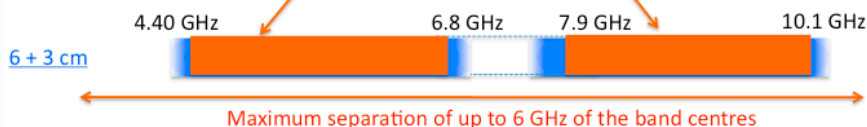
- Two x 2 GHz wide IFs (2048 x 1 MHz channels)
 - Where you can put them depends on the frequency



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

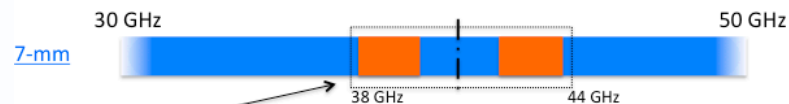
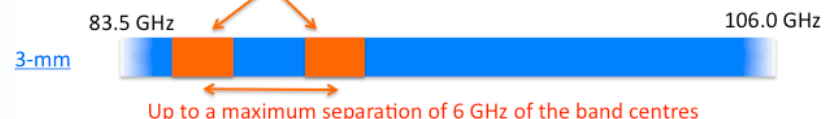


Effective observing bandwidth is 2.0 GHz (with some reduction due to RFI)

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

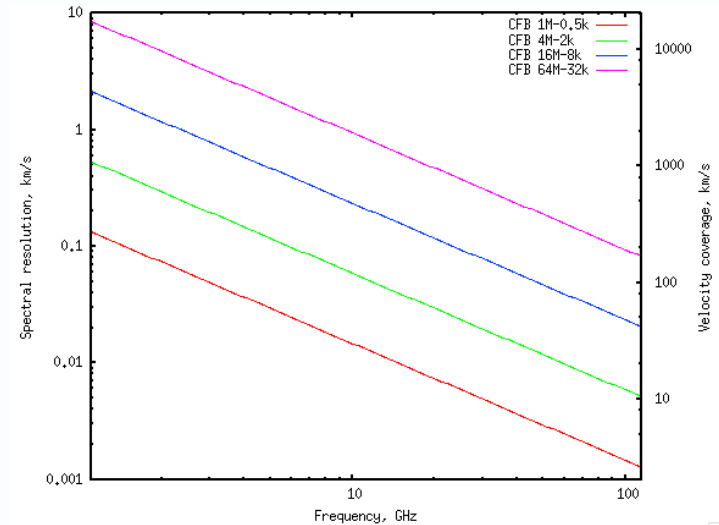
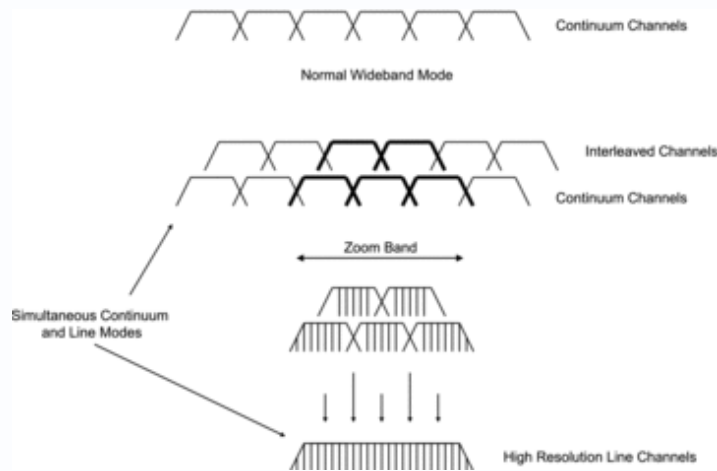


Note: For the 7-mm system both 2GHz band centres must be either greater than 41 GHz (the point at which the conversion changes from lower side-band to upper side-band) or both less than 41 GHz.



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



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: JIIIrathborne

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

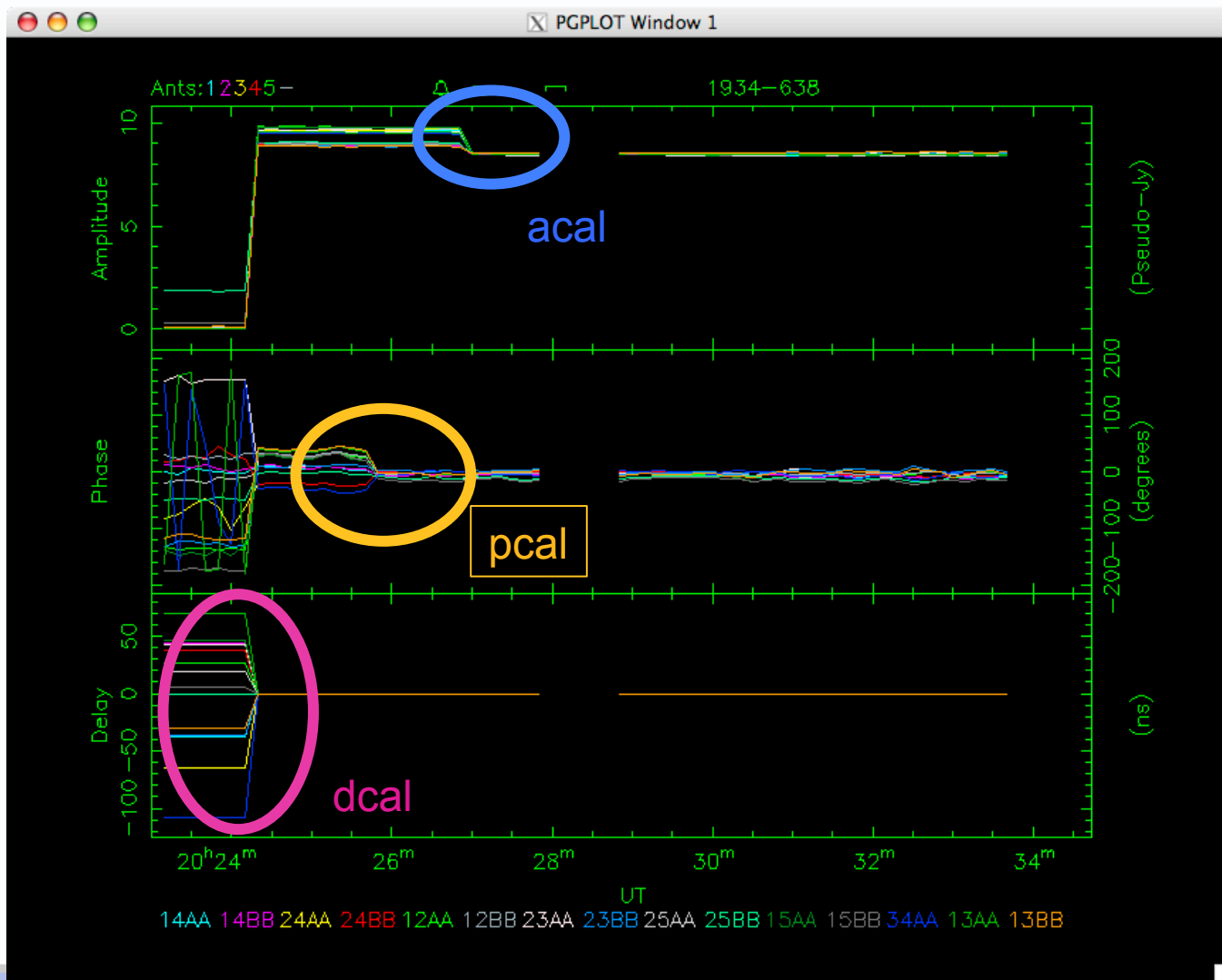
#	Source	Cal	RA	Dec	Epoch	Time(LST)	ScanLength	Az	EI	Drive	ScanType	Pointing	Freq-1	Freq-2
1	x1710-269	C	17:13:31.276	-26:58:52.523	J2000	12:00:00	00:02:00	109:07:19.3	22:25:08.5	00:03:22	Point	Update	23100	24500
2	1710-269	C	17:13:31.276	-26:58:52.523	J2000	12:02:01	00:01:30	108:55:40.0	22:49:41.5	00:00:00	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

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

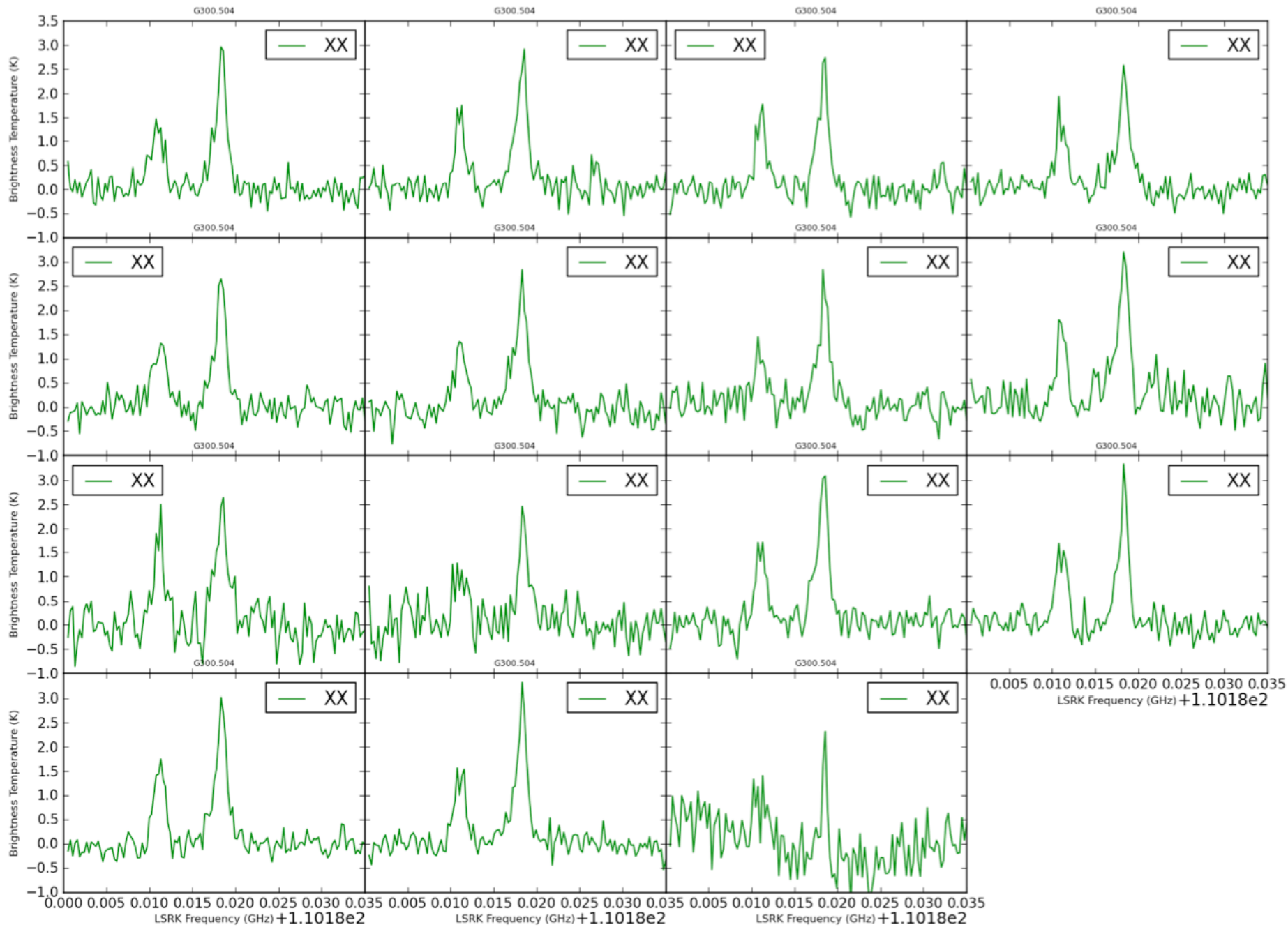
- Lower frequencies (~ 2.1 GHz)
 - Second IF is redundant
 - Lots of interference \rightarrow need to choose channel range for calibration carefully (set “tvchan”)
 - More chance of confusion
- Higher frequencies
 - 1934-638 gets too weak for setup and bandpass \rightarrow use a stronger source (e.g.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

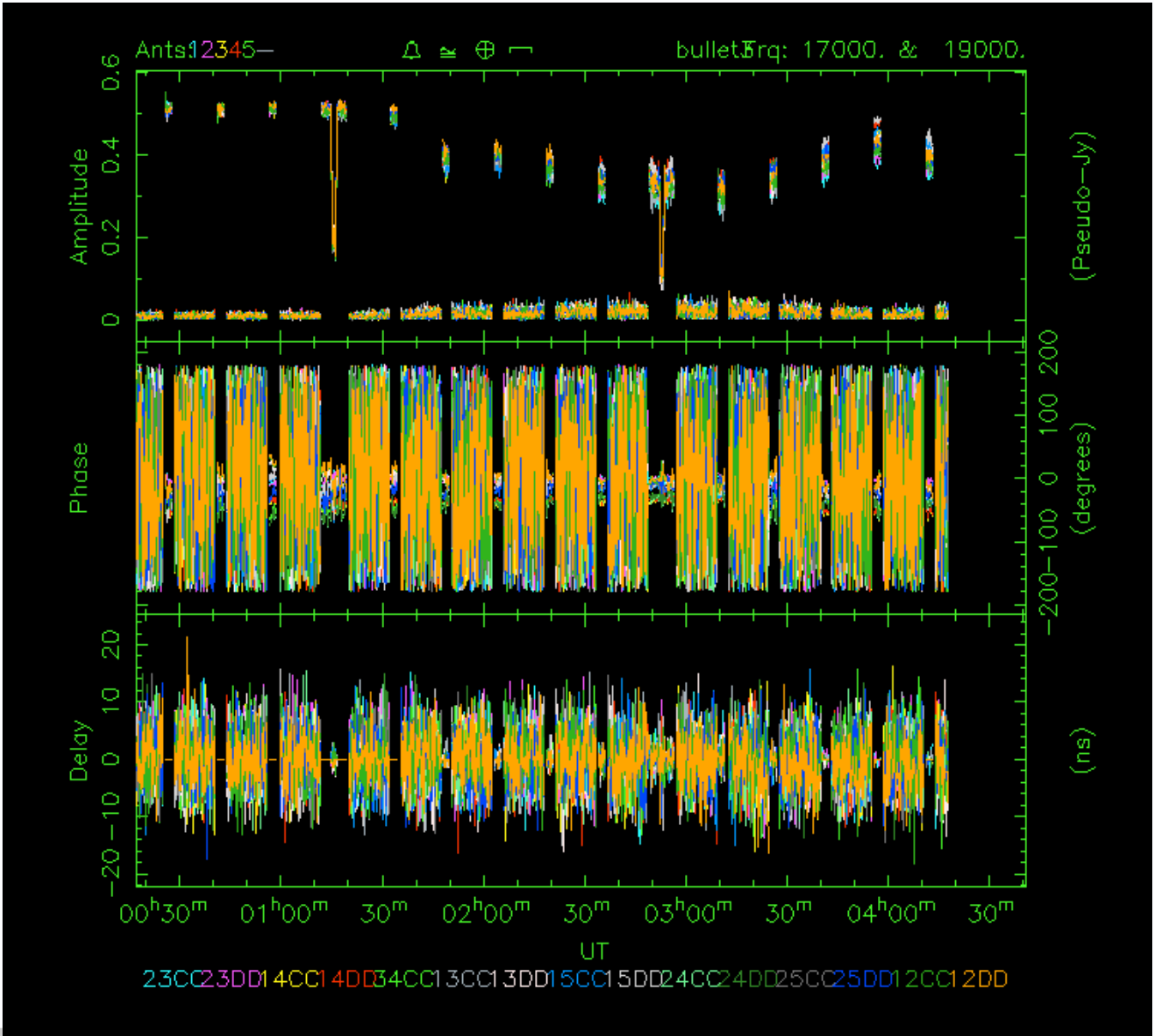


MM observing – the least simple case

- 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).



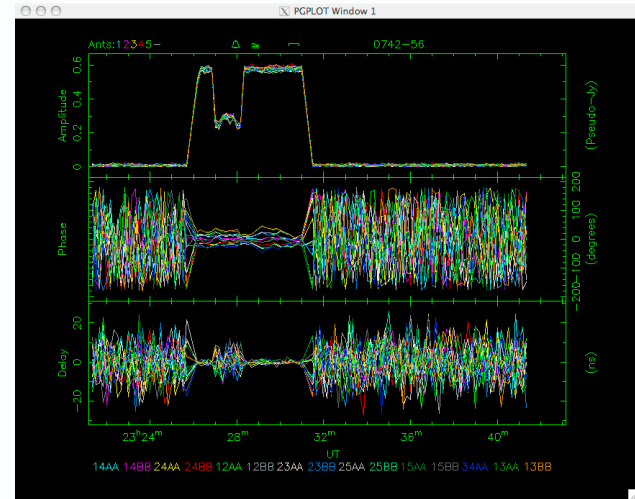




Observing at mm frequencies

- 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)



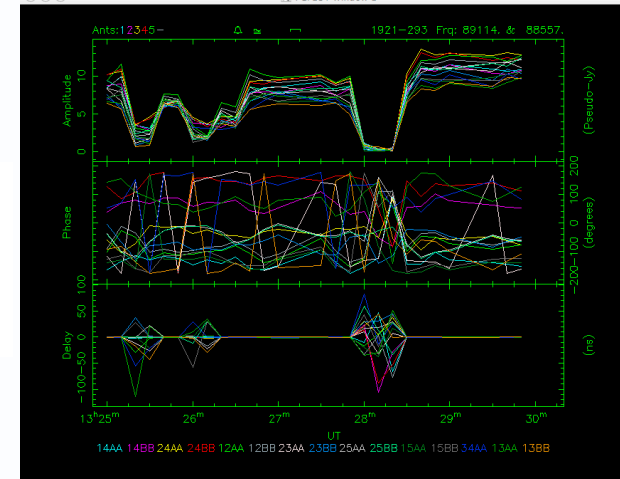
- Observe either 1934-638 (at 12 or 7mm) or a planet (at 3mm) for primary calibration
 - Pointing first (1934-638 or source nearby planet)
- Target observations
 - Include a pointing once an hour (ideally on a strong source within ~20 degrees)

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

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

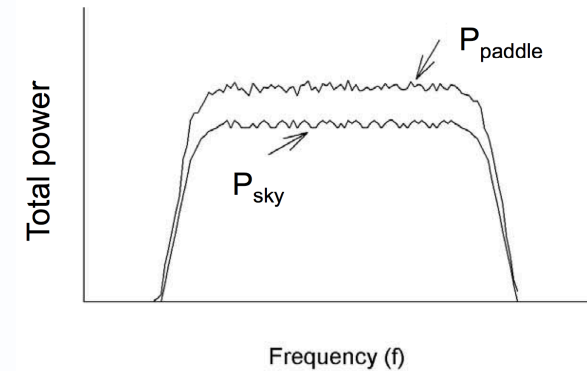
- Every 15-20min
- Before primary and bandpass calibrators



CABB Scheduler - c2639-sio.sch

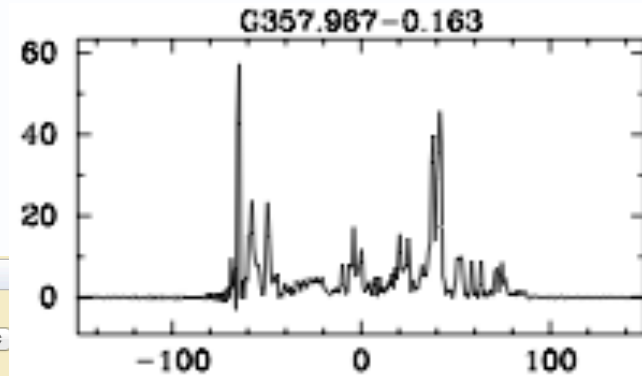
Sched Listing

#	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



Spectral line observations

- Require use of zoom modes for higher spectral resolution
 - Which mode depends on what velocity resolution/coverage required
- Need to calculate sky frequencies
 - All done by the CABB scheduler



File Edit Tools

1. x1710-269
2. 1710-269
3. g025+02_24
4. 1710-269
5. g025+02_24
6. 1710-269
7. g025+02_24
8. 1710-269
9. g025+02_24
10. 1710-269
11. g025+02_24

Scan Parameters

Freq1 23100MHz

Continuum (MHz)	Fixed	Chn.BW (MHz)	Vel.Res. (km/s)	Vel.Range (km/s)	#Channels
23100	<input checked="" type="radio"/>	64	831	26579	32
Line	Channel	Width			
1 23708	<input type="radio"/>	14	0.4	809.3	Velo
2 23868	<input type="radio"/>	9	0.39	803.9	Velo
3 22236	<input type="radio"/>	60	0.42	862.9	Velo
4 23452	<input type="radio"/>	22	0.4	818.1	Velo
5 23132	<input type="radio"/>	32	0.41	829.4	Velo
6	<input type="radio"/>				Velo
7	<input type="radio"/>				Velo
8	<input type="radio"/>				Velo
9	<input type="radio"/>				Velo
10	<input type="radio"/>				Velo
11	<input type="radio"/>				Velo
12	<input type="radio"/>				Velo
13	<input type="radio"/>				Velo
14	<input type="radio"/>				Velo
15	<input type="radio"/>				Velo
16	<input type="radio"/>				Velo

Freq2 24500MHz

Velocity Calculator

Source Velocity

Spectral Line

Rest Frequency

Observatory Velocity 0.0

Sky Frequency 0.0

Zoom band

Frequency

Cancel Apply

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?

Why do we usually use a short array to observe extended emission?

What is shadowing and when is it a problem?

At what frequency are pointing observations required?

**How far from your target source
should 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 \(including sensitivity\) \(Old Calculator\) \(User-friendly Calculator\)](#)
- [CABBScheduler, 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 | Bolton Fellow

t +61 2 9123 4325
e Shari.Breen@csiro.au
w www.atnf.csiro.au

CSIRO ASTRONOMY AND SPACE SCIENCE
www.csiro.au

