Cycle 12 Observing Capabilities

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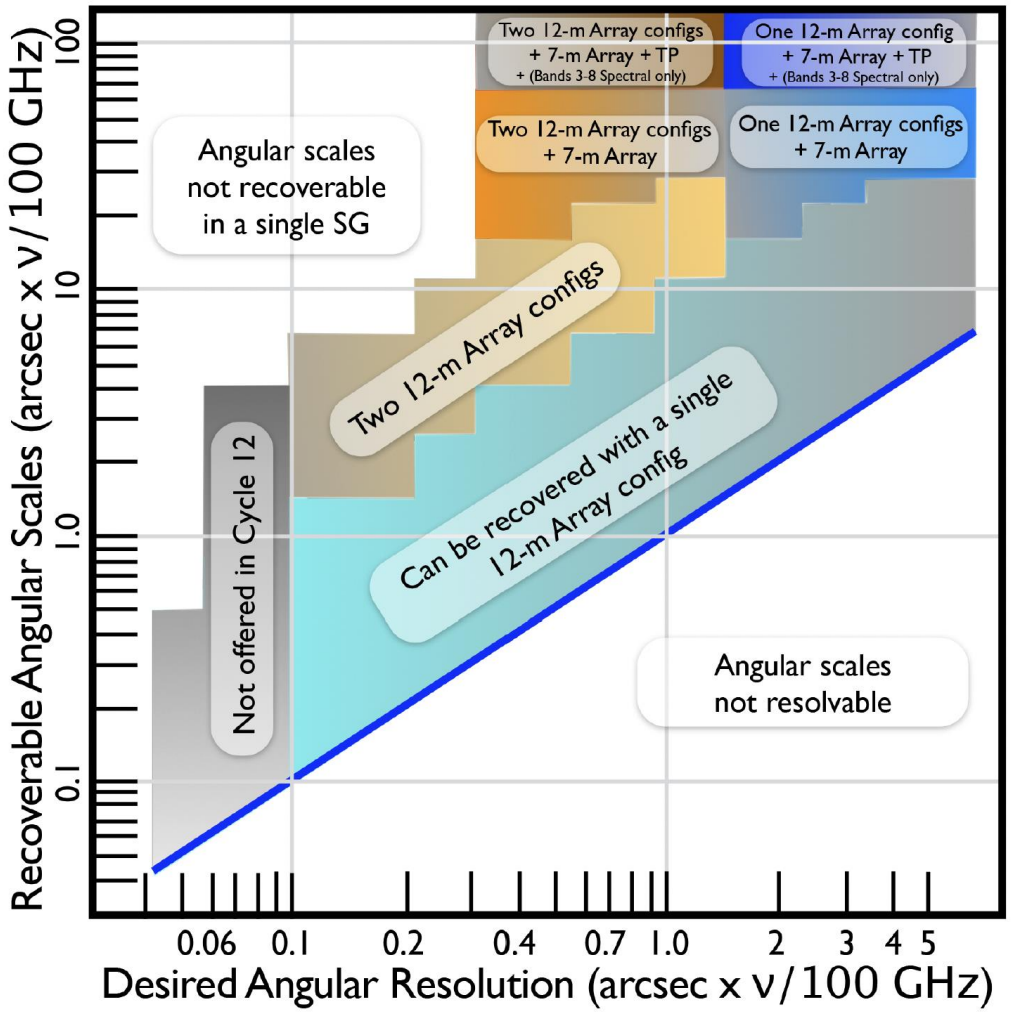
1. ALMA Basics

ALMA Arrays

See Cycle 12 "A Primer"

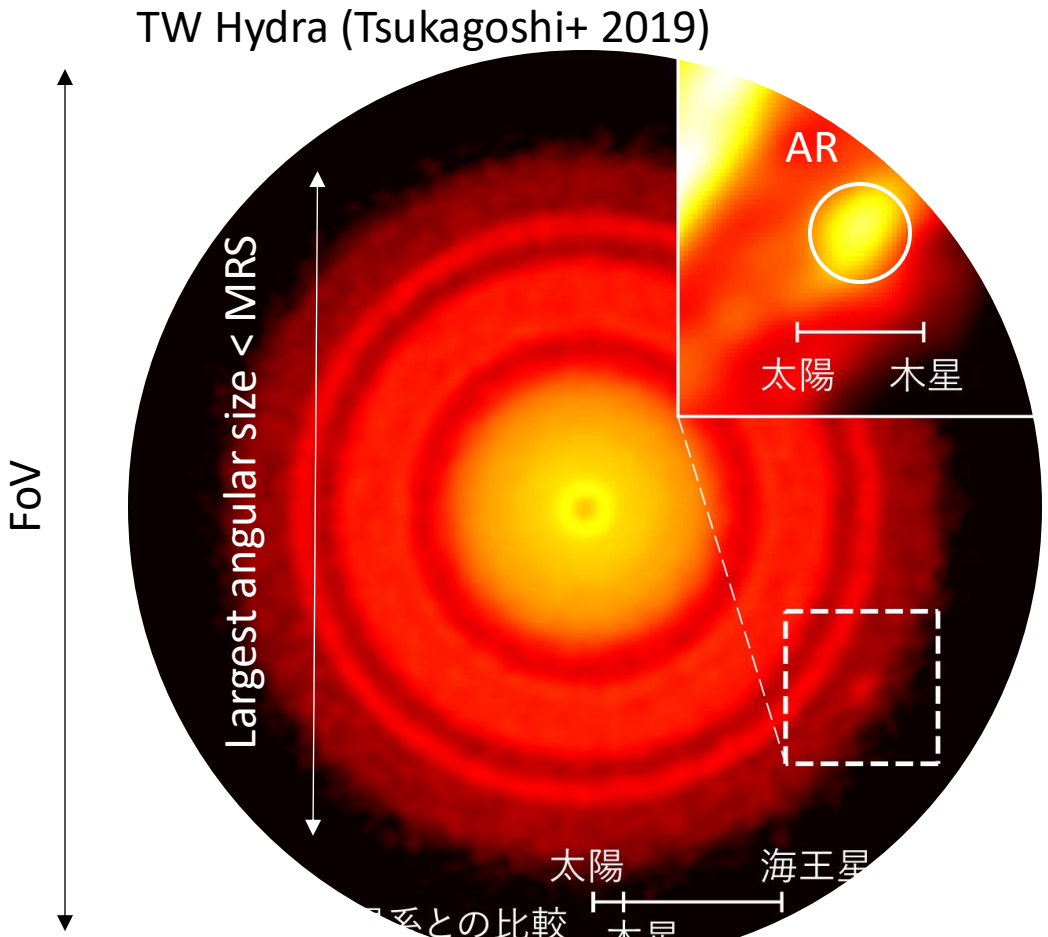


50 antennas for 12-m Array
12 antennas of 7-m Array
4 12-m antennas for single-dish observations
(Total Power; TP)

} ACA

*Band 1 TP is not provided in Cycle 12

Three Important Angular Scales



Smoothly distributed emission over the disk with some variation.

Angular Resolution (AR)

- Resolution element of image
- Determined by the maximum baseline length (λ/D_{max})

Maximum Recoverable Scale (MRS)

- The largest structure that can be imaged without missing flux
- Determined by the minimum baseline length (λ/D_{min})

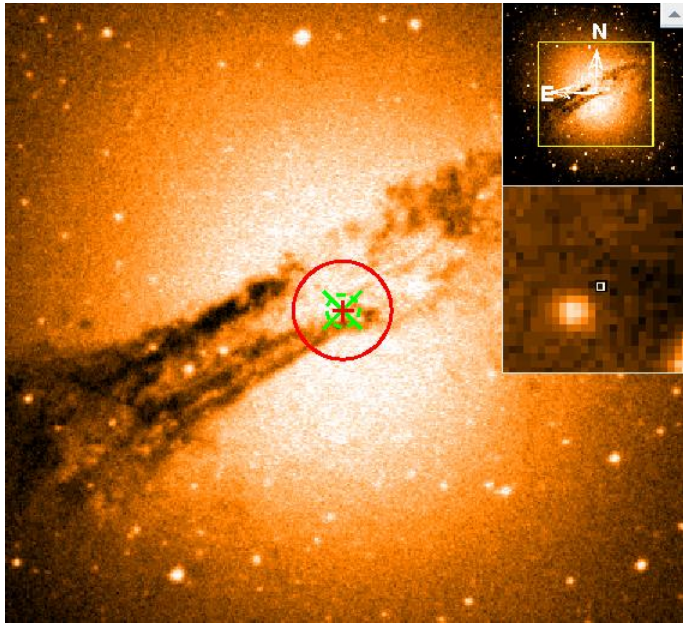
Field of View (FoV)

- FoV of a single telescope pointing
- Equal to antenna beam size

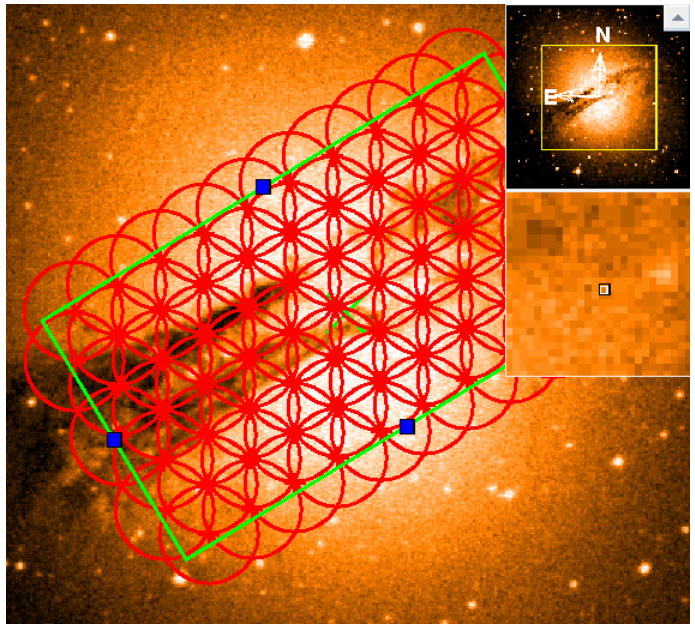
Mosaicking / Multiple Pointing

- Angular structure that is larger than single pointing FoV, or multiple sources spread over a larger area, must be mosaicked or used multiple-pointing observations.

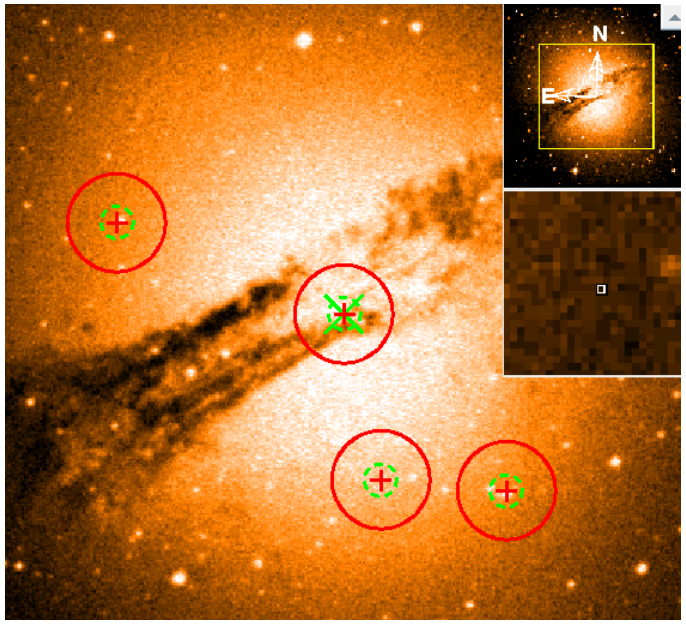
Single pointing



Mosaicking

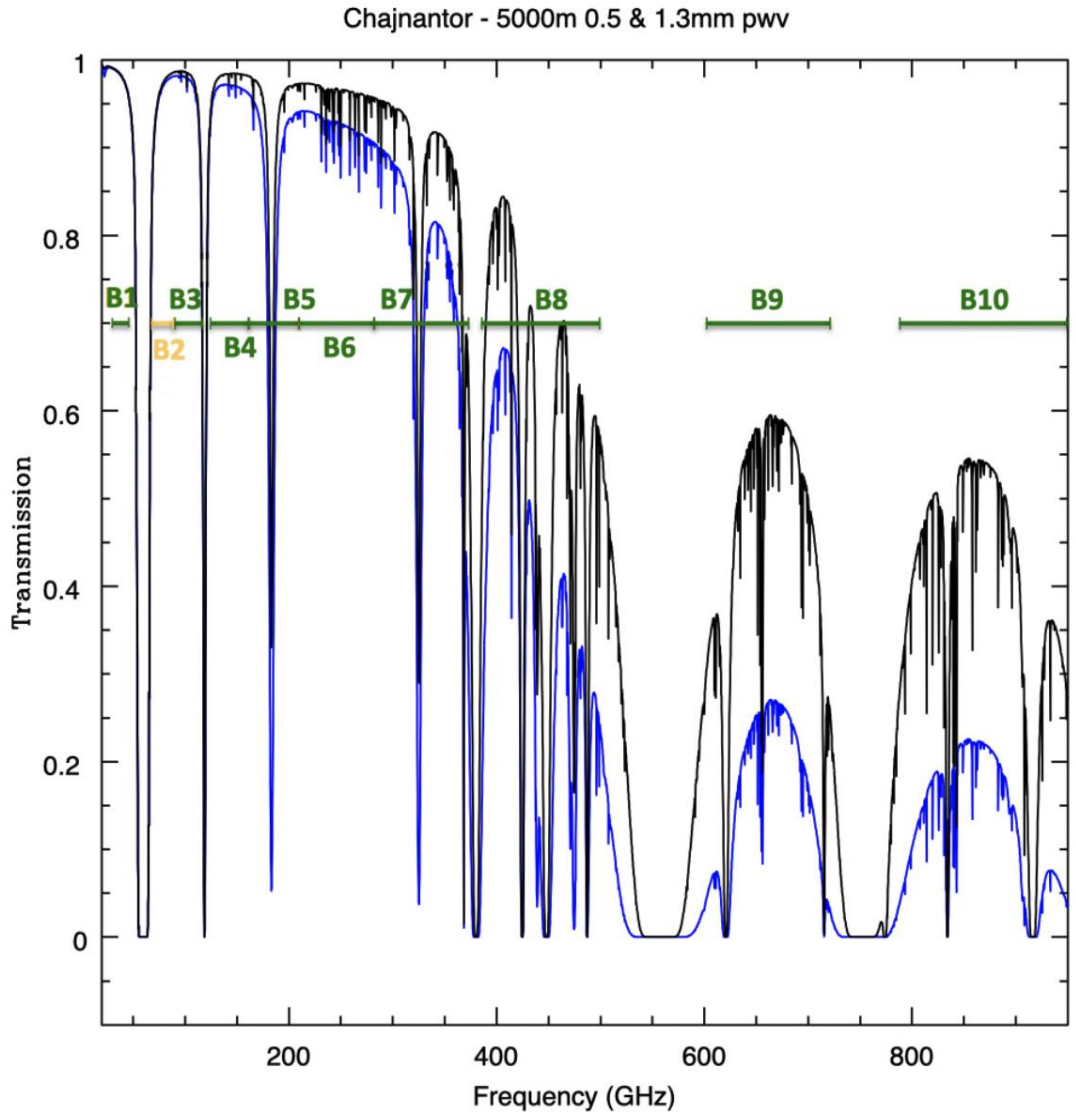


Multiple pointing



Frequency Bands

- 10 receiver bands (Band 2 is unavailable now)
- Multiple band data cannot be taken simultaneously in a single execution
  (except for B2B phase transfer)
- Atmospheric opacity and phase stability tends to be poor at higher frequencies and at frequencies near water absorption lines
  - ✓Requires good weather condition



Receivers

Band	Frequency range (GHz)	Wavelength range (mm)	Intermediate Frequency (IF) range (GHz)	Type
1	35 – 50	8.5 – 6	4 – 12	SSB
3	84 – 116	3.6 – 2.6	4 – 8	2SB
4	125 – 163	2.4 – 1.8	4 – 8	2SB
5	158 – 211	1.9 – 1.4	4 – 8	2SB
6	211 – 275	1.4 – 1.1	4.5 – 10	2SB
7	275 – 373	1.1 – 0.8	4 – 8	2SB
8	385 – 500	0.78 – 0.60	4 – 8	2SB
9	602 – 720	0.50 – 0.42	4 – 12	DSB
10	787 – 950	0.38 – 0.32	4 – 12	DSB

Frequency vs. Weather

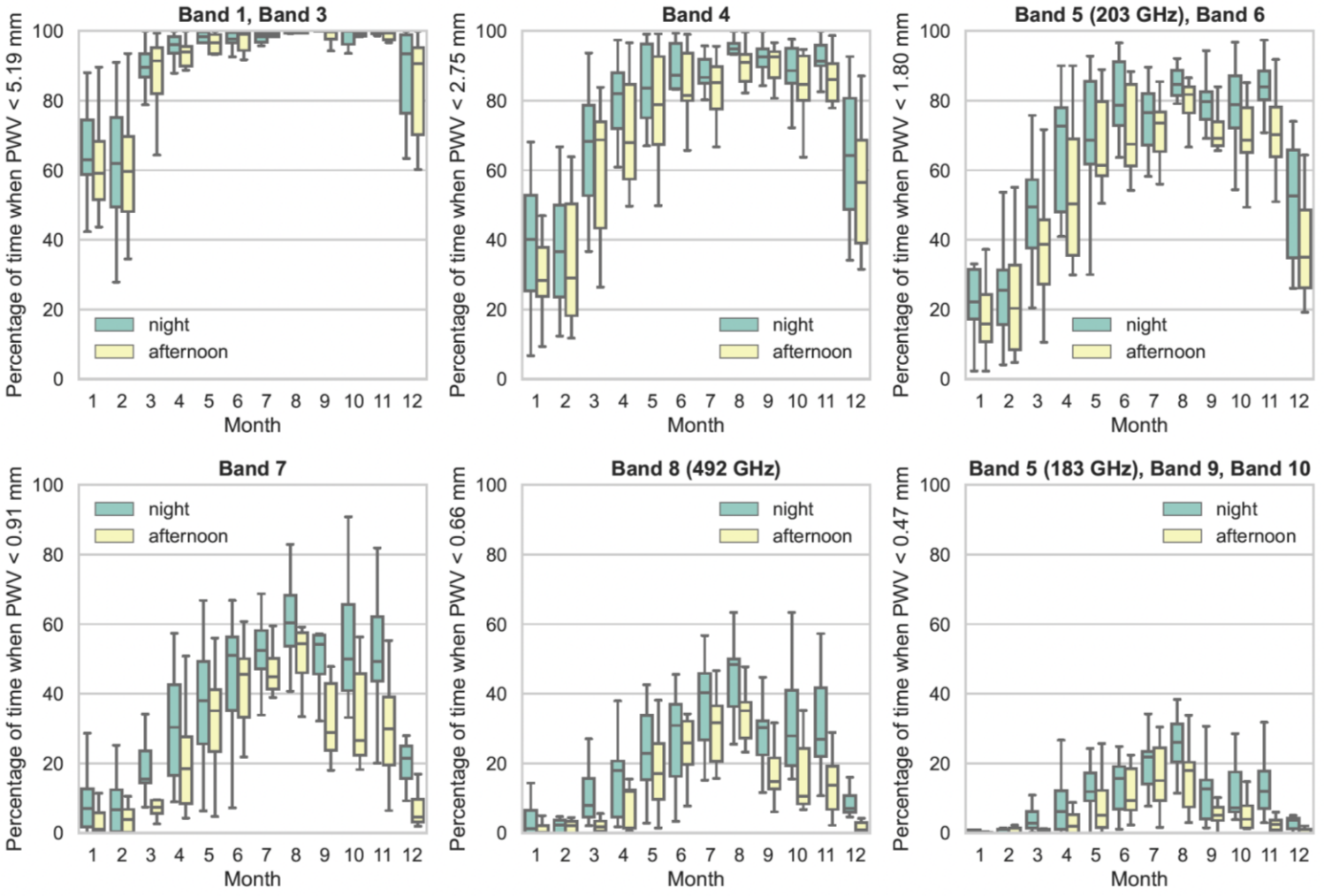
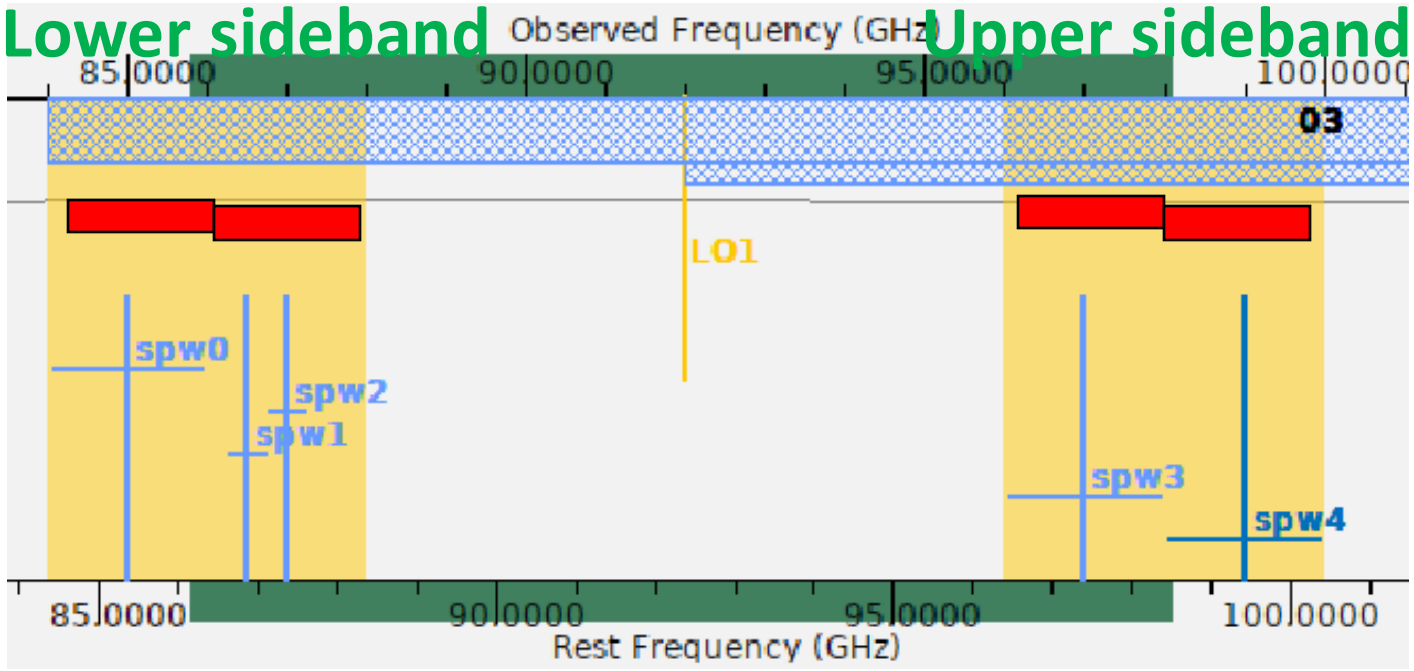
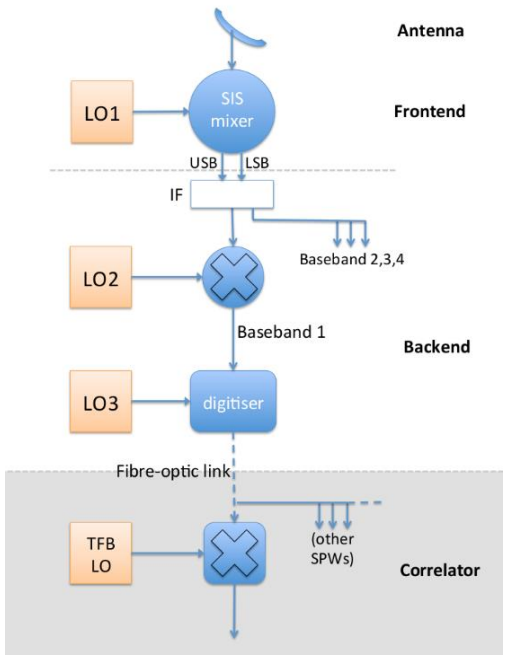


Figure 3: The percentage of time when the PWV is below the observing thresholds adopted for the various ALMA bands for afternoon (yellow; based on 17:00–21:00 UTC and night (green; based on 01:00–05:00 UTC) and for an elevation of 60 degrees. The horizontal line within the box indicates the median. Boundaries of the box indicate the 25^{th}- and 75^{th}-percentile, and the whiskers indicate the highest and lowest values of the results. The data were obtained with the APEX weather station, ALMA measurements, and weather forecast data between January 2010 and January 2022.

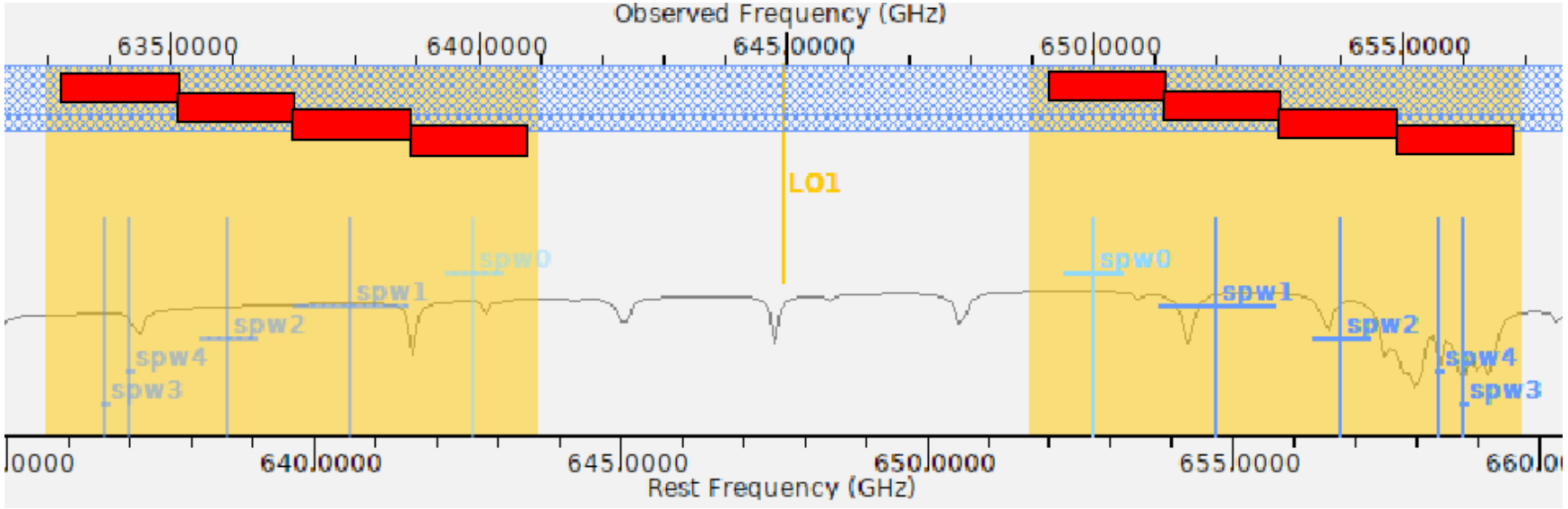
Instantaneous frequency coverage (B3-8)

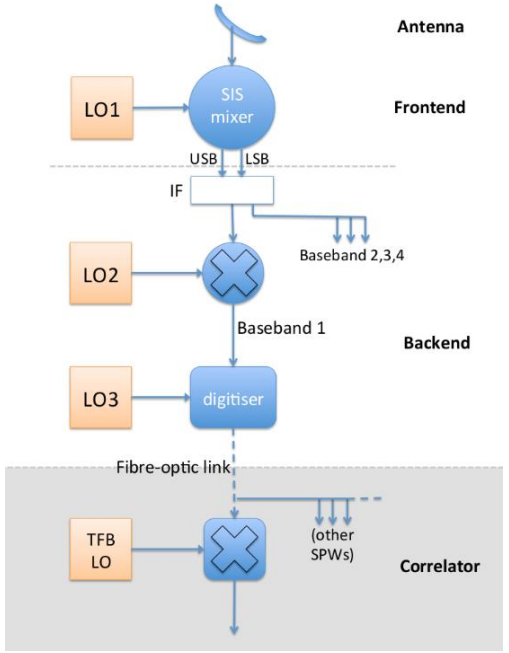




- ALMA receives signals in two sidebands (green-ish color).
- Up to four basebands with 2-GHz width can be placed either in a sideband or two sidebands. (Red boxes. Not possible to put 3 in one sideband and 1 in the other.)
- Up to four spectral windows (spws) in each of basebands (blue-ish bars) .
- Each spw forms a final contiguous spectrum (You will not receive data outside of spws)

Instantaneous frequency coverage (B9-10)

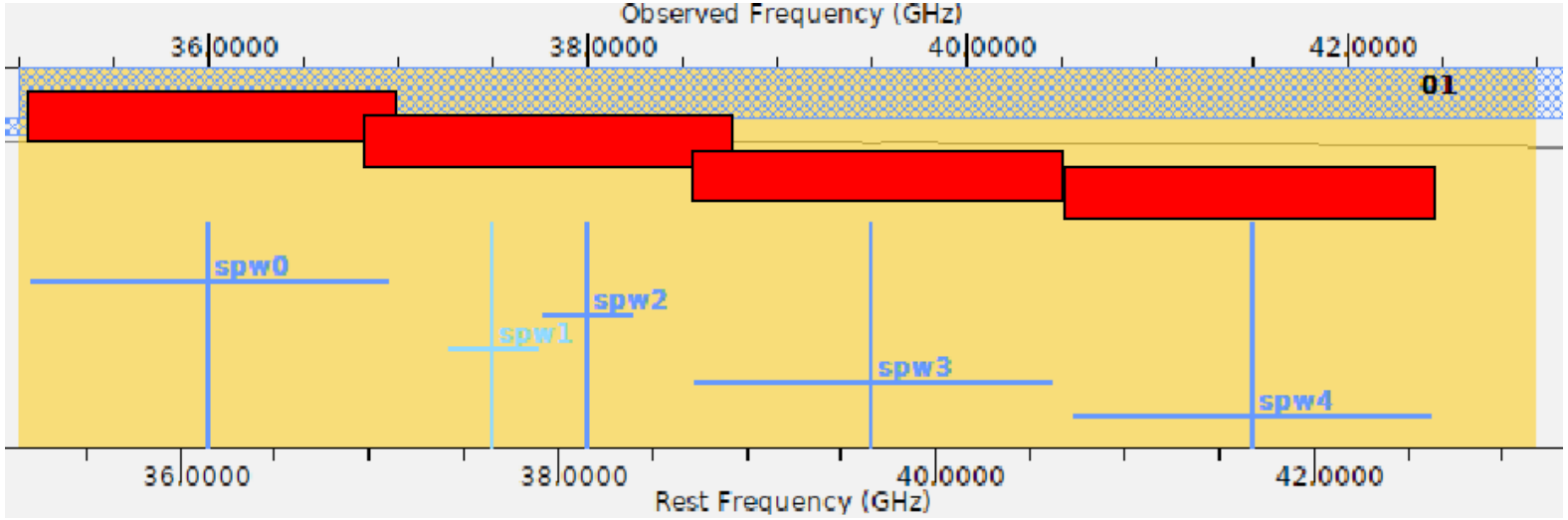


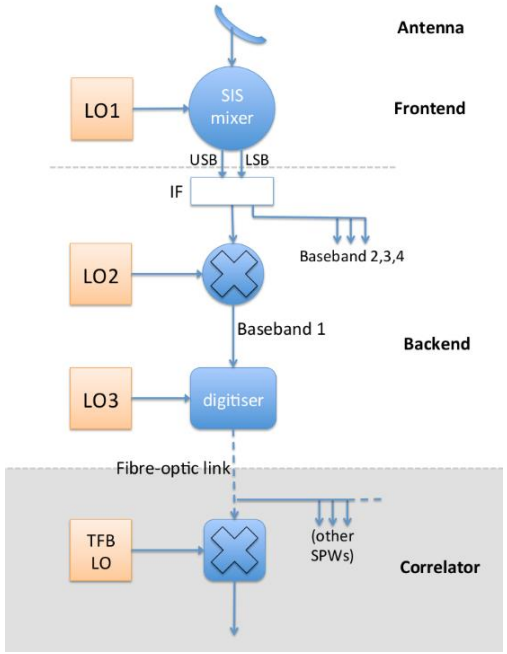


- For Bands 9 and 10 (Double Sideband system), up to four basebands can be placed in a sideband. The same number of basebands is automatically placed in an opposite sideband.
- Allows to place up to four spectral windows (spws) in each of basebands (blue-ish bars) .
- You may suppress one sideband by using LO-offsetting only if TDM or FDM with 1.875GHz BW is selected.

Instantaneous frequency coverage (B1)

Single sideband





- Band 1 employs single-sideband system (SSB).
- Up to 4 basebands with 2-GHz width are placed in a sideband.
- Allows to place up to four spectral windows (spws) in each of these basebands (blue-ish bars) .

Frequency Resolution

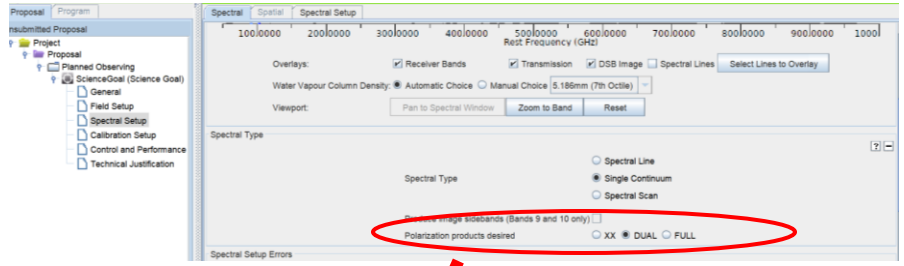
The 4x4 bit modes

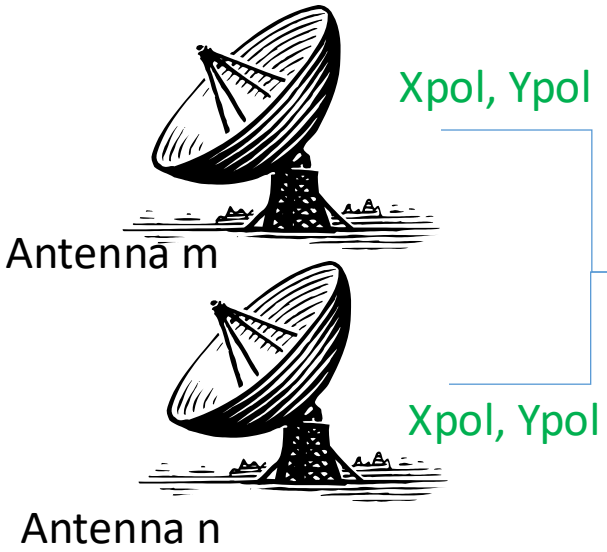
- ✓ are only available for the 64-input Correlator
- ✓ provide higher correlator efficiency for a given spectral resolution and integration time compared with the 2x2 bit mode

Bandwidth (MHz)	Channel spacing (MHz)	Spectral resolution (MHz)	Number of channels	Correlator mode	Bit Mode
1875	15.6	31.2	120	TDM	
938	0.976	1.952	960	FDM	4x4
1875	0.488	0.976	3840	FDM	2x2
469	0.488	0.976	960	FDM	4x4
938	0.244	0.488	3840	FDM	2x2
234	0.244	0.488	960	FDM	4x4
469	0.122	0.244	3840	FDM	2x2
117	0.122	0.244	960	FDM	4x4
234	0.061	0.122	3840	FDM	2x2
58.6	0.061	0.122	960	FDM	4x4
117	0.0305	0.061	3840	FDM	2x2
58.6	0.0153	0.0305	3840	FDM	2x2

Polarization

OT⇒





ALMA correlator

$$X_m X_n^* = I + Q \rightarrow \text{XX}$$
$$Y_m Y_n^* = I - Q$$
$$X_m Y_n^* = U + iV$$
$$Y_m X_n^* = U - iV$$

Dual

Full

- ALMA can provide full polarization products (XX, YY, XY, YX) so that one can produce Stokes I, Q, U, and V images.
- At least ~3-hrs observation is required to calibrate instrumental polarization.

2. Cycle 12 Capabilities

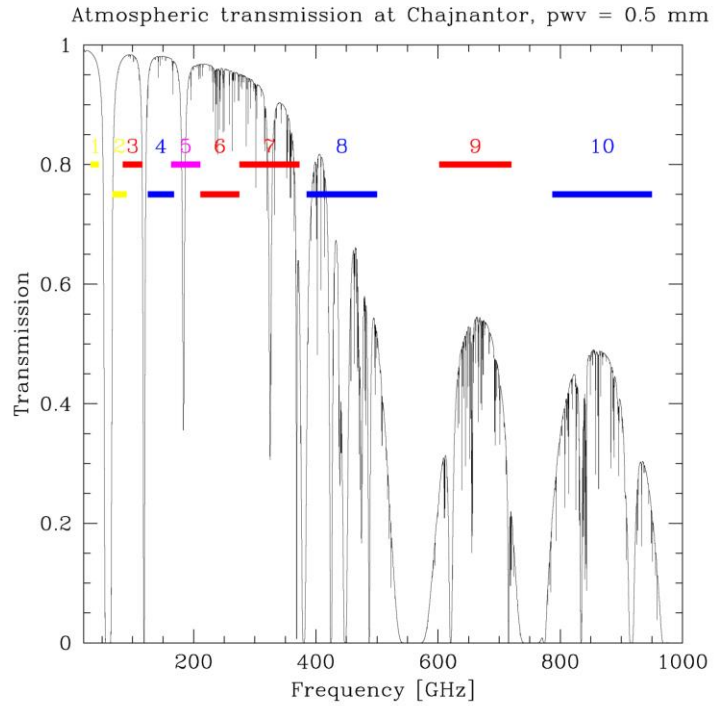
What's New in Cycle 12?

- Full-polarization in Band 1 on the 7-m Array with a single pointing
  - ✓ The polarization accuracy and capability will be the same as in Bands 3-7
- Improved Active Phasing for VLBI observations
  - ✓ The flux density thresholds for active phasing is reduced by sqrt(8) relative to the thresholds in Cycle 11
- Multi-epoch monitoring with the EHT in Band 6 (see Section 3.4)
- Band-to-Band (B2B) calibration allowed for Large Programs
  - ✓ Regular programs may continue to propose for B2B as in previous cycles

Capabilities Offered in Cycle 12

(Section 4.2 of Cycle 12 Proposer's Guide)

- **Number of antennas**
  - **≧43 antennas in the 12-m Array.**
  - **≧10 7-m antennas (for short baselines) and 3 12-m antennas (for single dish) in the ACA.**
- **Receiver bands**
  - **Bands 1, 3, 4, 5, 6, 7, 8, 9, and 10.**
- **12-m Array Configurations**
  - **C-1 through C-8**
- **Single-dish spectral-line observations are provided in Bands 3 through 8**



Configuration

		Band	1	3	4	5	6	7	8	9	10
Config.	$\mathbf{L_{max}}$	**Freq. (GHz)**	**40**	**100**	**150**	**185**	**230**	**345**	**460**	**650**	**870**
	$\mathbf{L_{min}}$										
7-m	**45 m**	θ_{res} (arcsec)	31.8	12.7	8.47	6.87	5.52	3.68	2.76	1.95	1.46
	9 m	θ_{MRS} (arcsec)	167	66.7	44.5	36.1	29.0	19.3	14.5	10.3	7.67
C-1	**161 m**	θ_{res} (arcsec)	7.98	3.19	2.13	1.73	1.39	0.93	0.69	0.49	0.37
	15 m	θ_{MRS} (arcsec)	71.2	28.5	19.0	15.4	12.4	8.25	6.19	4.38	3.27
C-2	**314 m**	θ_{res} (arcsec)	7.63	3.05	2.04	1.65	1.33	0.88	0.66	0.47	0.35
	15 m	θ_{MRS} (arcsec)	56.5	22.6	15.0	12.2	9.81	6.54	4.90	3.47	2.59
C-3	**500 m**	θ_{res} (arcsec)	5.38	2.15	1.43	1.16	0.94	0.62	0.47	0.33	0.25
	15 m	θ_{MRS} (arcsec)	40.5	16.2	10.8	8.73	7.02	4.68	3.51	2.48	1.86
C-4	**784 m**	θ_{res} (arcsec)	3.26	1.30	0.87	0.71	0.57	0.38	0.28	0.20	0.15
	15 m	θ_{MRS} (arcsec)	28.0	11.2	7.50	6.08	4.89	3.26	2.44	1.73	1.29
C-5	**1.4 km**	θ_{res} (arcsec)	2.01	0.80	0.54	0.43	0.35	0.23	0.17	0.12	0.092
	15 m	θ_{MRS} (arcsec)	16.8	6.70	4.47	3.62	2.91	1.94	1.46	1.03	0.77
C-6	**2.5 km**	θ_{res} (arcsec)	1.16	0.47	0.31	0.25	0.20	0.13	0.10	0.072	0.054
	15 m	θ_{MRS} (arcsec)	10.3	4.11	2.74	2.22	1.78	1.19	0.89	0.63	0.47
C-7	**3.6 km**	θ_{res} (arcsec)	0.70	0.28	0.19	0.15	0.12	0.081	0.061	0.043	0.032
	64 m	θ_{MRS} (arcsec)	6.45	2.58	1.72	1.40	1.12	0.75	0.56	0.40	0.30
C-8	**8.5 km**	θ_{res} (arcsec)	0.40	0.16	0.11	0.087	0.070	0.047	0.035	0.025	0.019
	110 m	θ_{MRS} (arcsec)	3.55	1.42	0.95	0.77	0.62	0.41	0.31	0.22	0.16

See Technical Handbook

Config. Schedule

Start date	Configuration	Longest baseline	LST for best observing conditions
2025 October 1	C-8	8.5 km	∼ 22—10 h
2025 October 20	C-7	3.6 km	∼ 23—11 h
2025 November 10	C-6	2.5 km	∼ 1—13 h
2025 December 1	C-5	1.4 km	∼ 2—14 h
2025 December 20	C-4	0.78 km	∼ 4—15 h
2026 January 10	C-3	0.50 km	∼ 5—17 h
2026 February 1	*No observations due to maintenance*		
2026 March 1	C-1	0.16 km	∼ 8—21 h
2026 March 26	C-2	0.31 km	∼ 9—23 h
2026 April 20	C-3	0.50 km	∼ 11—0 h
2026 May 10	C-4	0.78 km	∼ 12—2 h
2026 May 31	C-5	1.4 km	∼ 13—4 h
2026 June 23	C-6	2.5 km	∼ 15—6 h
2026 July 28	C-5	1.4 km	∼ 17—7 h
2026 August 18	C-4	0.78 km	∼ 19—8 h
2026 September 10	C-3	0.50 km	∼ 20—9 h

Notes on 4x4-bits (introduced from Cycle 10)

- User can choose 2x2-bits or 4x4-bits in the Spectral Setup.
- 4x4-bits provide a better sensitivity at fixed spectral resolution and integration time.
- This mode is only allowed for the 5 FDM setups with the 12-m and 7-m array.
- 4x4-bits mode cannot be used in the same baseband with 2x2 bit modes, but a mixture of basebands using 4x4 and basebands using 2x2 is allowed.

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1875	15.6	31.2	120	TDM	
938	0.976	1.952	960	FDM	4x4
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117	0.0305	0.061	3840	FDM	2x2
58.6	0.0153	0.0305	3840	FDM	2x2

Cycle 12 Documents

Call for Proposals

Documentation supporting the current ALMA Call for Proposals – **Cycle 12**. Documents from previous Cycles are provided here.

principles-review-process

Document	Description
ALMA Proposer's Guide	Contains all pertinent information regarding the ALMA Call for Proposals
ALMA Technical Handbook	A comprehensive description of the ALMA observatory and its components
ALMA Users' Policies	The long-term core policies for use of the ALMA and ALMA data by the science community
Observing With ALMA - A Primer	Introduction to interferometry and how to use ALMA
ALMA Proposal Template	Zip files containing the proposal templates in LaTeX format. Recommended but not mandatory
ALMA Proposal Review Process	A detailed description of the ALMA Proposal Review Process
Principles of the ALMA Proposal Review Process	The latest version of the Principles of the ALMA Proposal Review Process

Phase 1 & 2

ALMA Phase 1 (observing proposal) and Phase 2 (telescope runfiles for accepted proposals) materials are submitted through the ALMA Observing Tool (OT). Below are documentation which will aid the created and submitted of Phase 1 and Phase 2 with the OT.

Document	Description
OT Quickstart	A Quick Start Guide for using the Observing Tool
OT User Manual	Describes how to use the Observing Tool for preparing ALMA proposals
OT Reference Manual	An in-depth description of the Observing Tool
Video Tutorials	Video how-to for the Observing Tool

https://almascience.nao.ac.jp/documents-and-tools