Cycle 8 2021 Observing Capabilities

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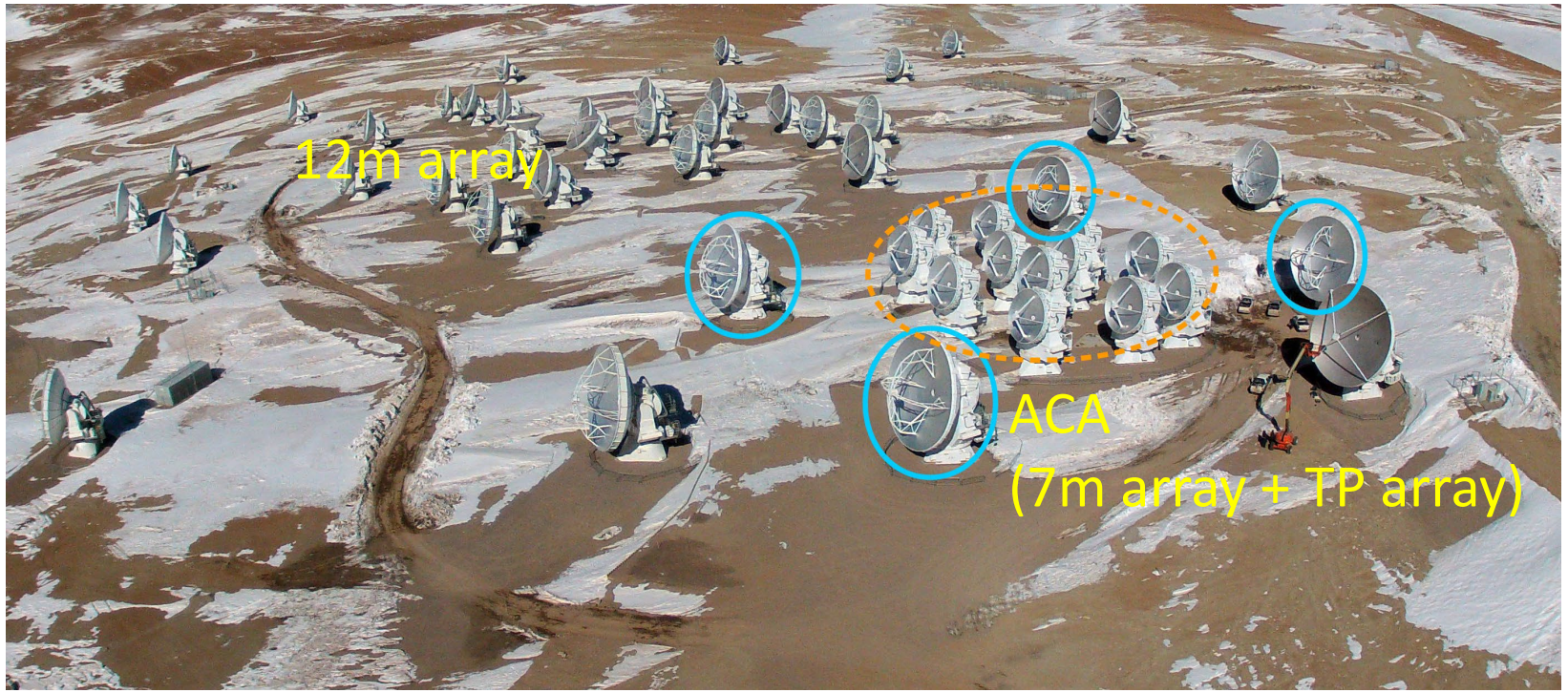
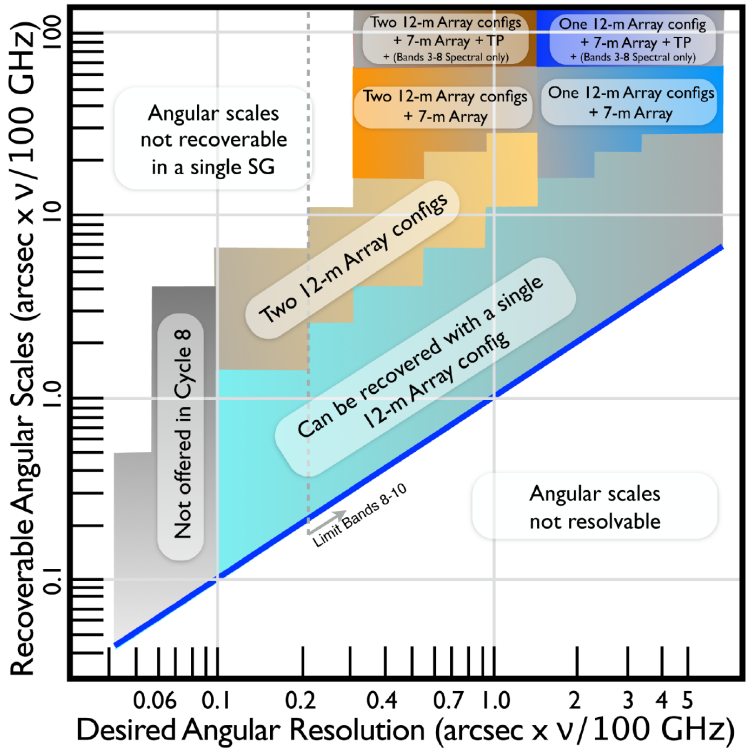
1. ALMA Basics

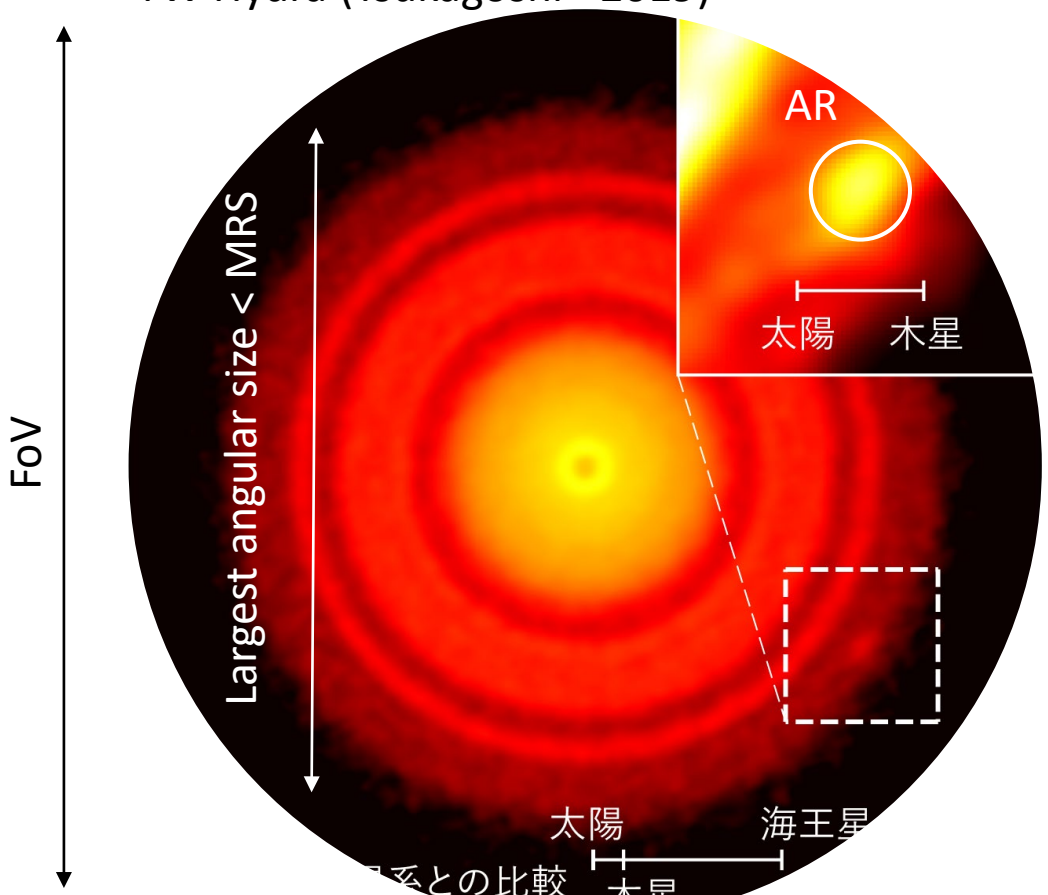
ALMA Arrays


12m array
ACA
(7m array + TP array)


Two 12-m Array configs + 7-m Array + TP + (Bands 3-8 Spectral only)
One 12-m Array config + 7-m Array + TP + (Bands 3-8 Spectral only)
Two 12-m Array configs + 7-m Array
One 12-m Array configs + 7-m Array
Angular scales not recoverable in a single SG
Two 12-m Array configs
Can be recovered with a single 12-m Array config
Not offered in Cycle 8
Limit Bands 8-10
Angular scales not resolvable
Recoverable Angular Scales (arcsec x ν/100 GHz)
100
10
1.0
0.1
0.06 0.1 0.2 0.4 0.7 1.0 2 3 4 5
Desired Angular Resolution (arcsec x ν/100 GHz)

Three Important Angular Scales

TW Hydra (Tsukagoshi+ 2019)



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})

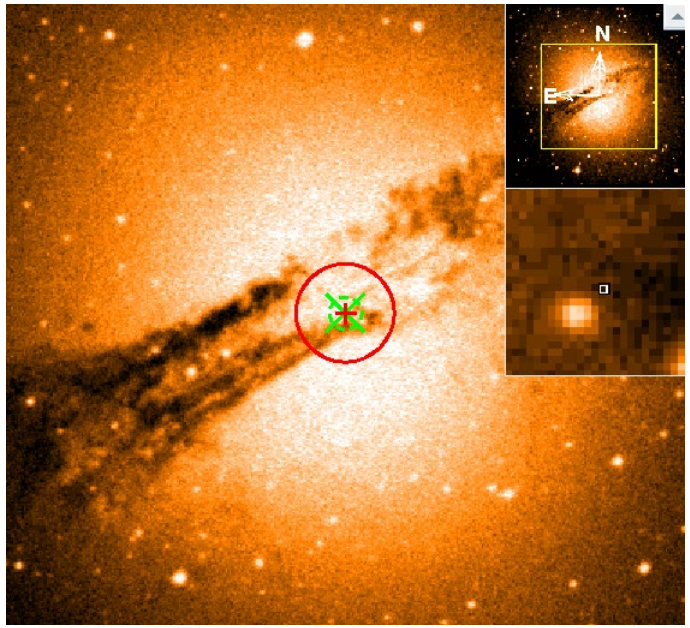
Field of View (FoV)

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

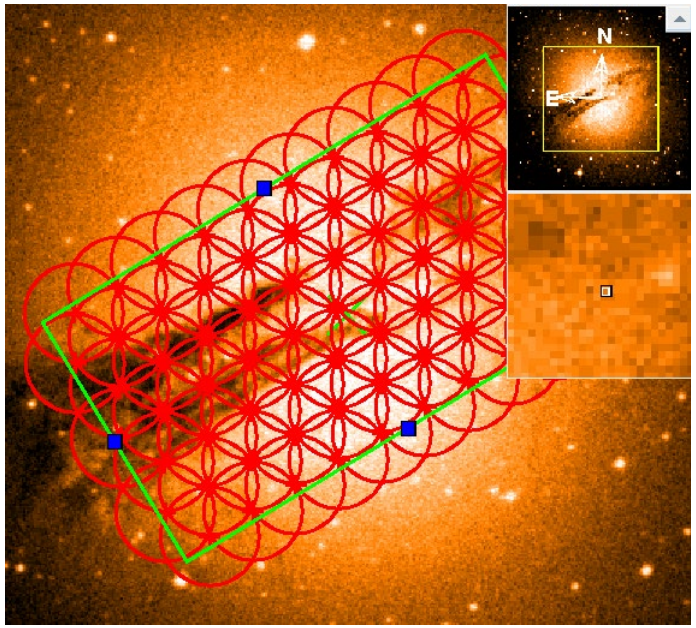
Mosaicking / Multiple Pointing

- Sources larger than single pointing FoV, or multiple sources spread over a larger area, must be mosaiced together using multiple pointings.

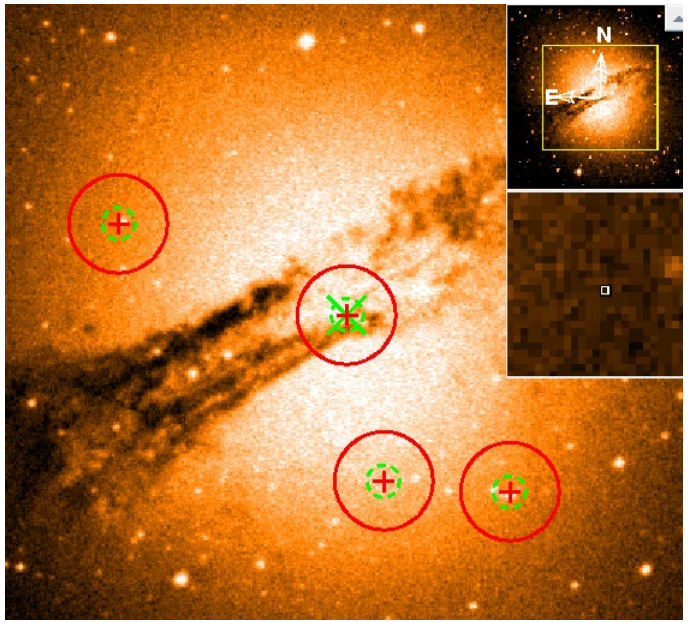
Single pointing



Mosaicking

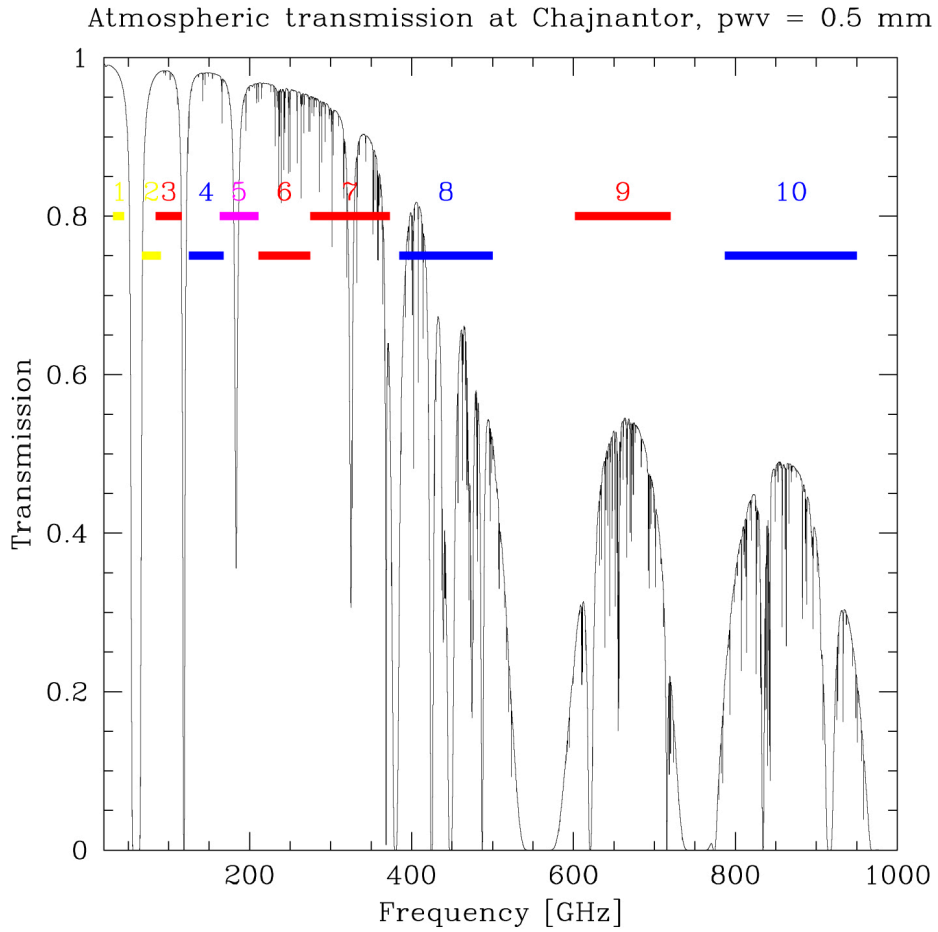


Multiple pointing



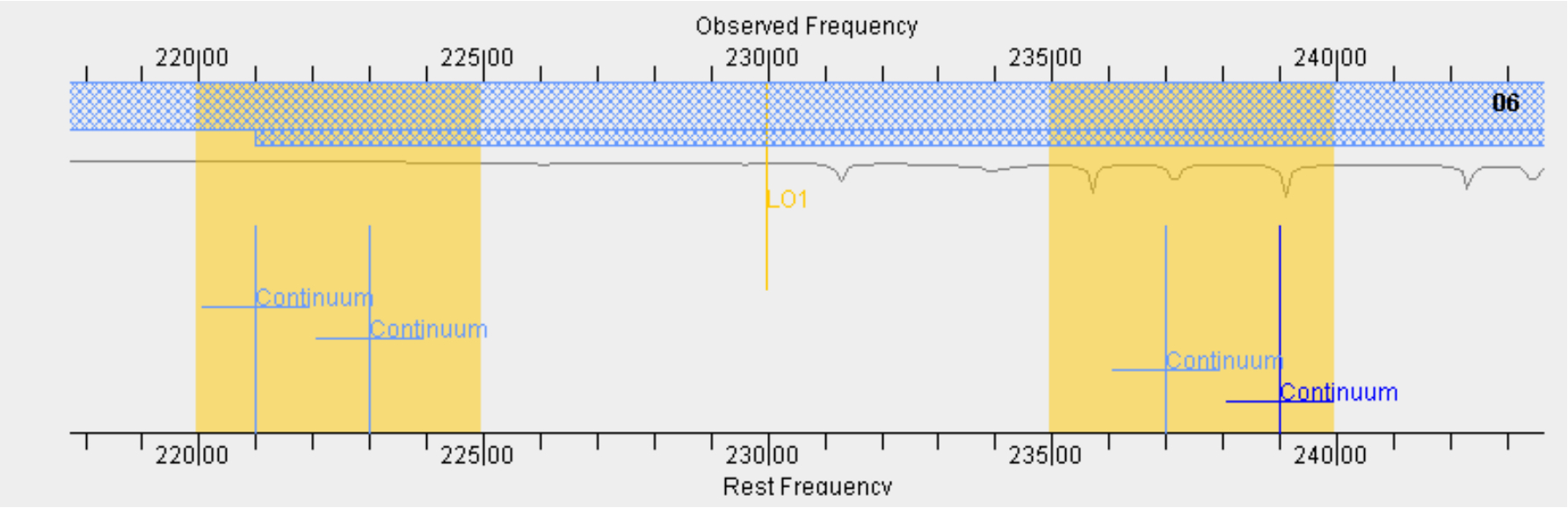
Frequency Bands

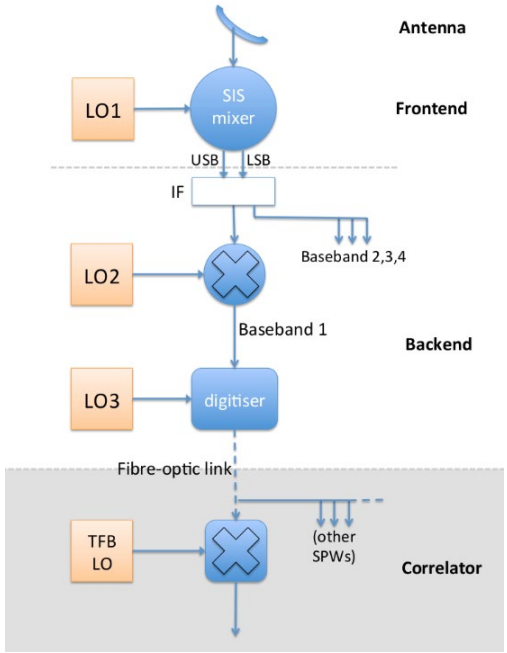
- 10 receiver bands (Band 1&2 will be available future)
- Atmospheric opacity and phase stability tends to be poor at higher frequencies and at frequencies near water absorption lines.
  - Requires good weather condition



Band	Frequency range (GHz)	Type
1	31.3– 45	SSB
2	67 – 90	SSB
3	84 –116	2SB
4	125 –163	2SB
5	163 –211	2SB
6	211 –275	2SB
7	275 –373	2SB
8	385 –500	2SB
9	602 –720	DSB
10	787 –950	DSB

Instantaneous frequency coverage

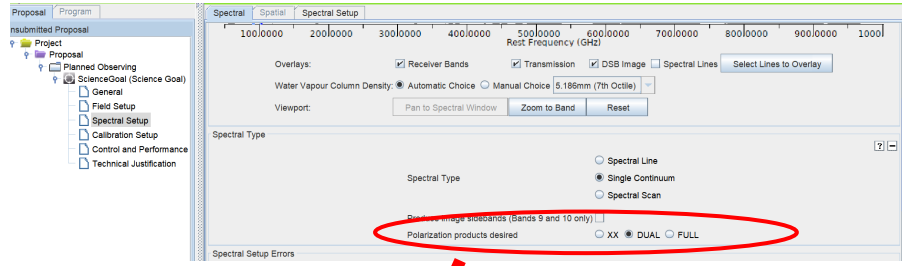


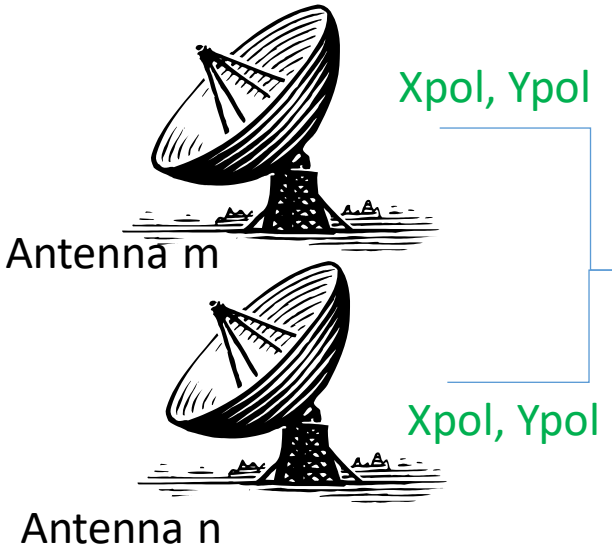


- ALMA receives signals in two sidebands (green-ish color)
- Up to four basebands can be placed either in a sideband or two sidebands
- Possible to place up to four spectral windows (spws) within each of these basebands (blue-ish bars)
- Each spw forms a final contiguous spectrum (You will not receive data outside of spws)

Polarization

OT⇒





ALMA correlator

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

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 calibration instrumental polarization.

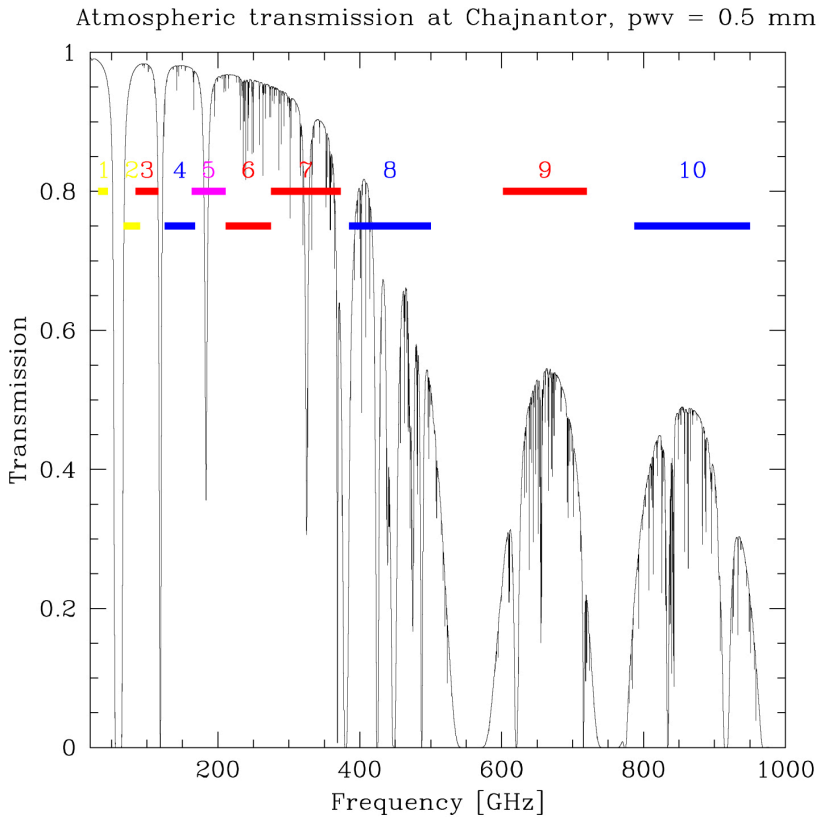
2. Cycle 8 2021 Capabilities

New in Cycle 8

- **Solar observations in Band 5 in Configurations C-1, 2, 3**
- **Bands 9 and 10 with the stand-alone 7-m Array**
- **Spectral scans with the 7-m Array**
- **Mosaicking of continuum linear polarization observations (Bands 3 to 7) with the 12-m Array**
- **Stand-along 7m polarization (single field/multiple pointing, linear, Bands 3-7, only in main call)**
- **VLBI observations of faint science targets (A passive-phasing mode that allows observations of fainter VLBI targets with a correlated flux density < 500 mJy)**
- **Observations of pulsars using the 12-m Array as a single dish**

Antennas, Receiver Bands

- **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 3, 4, 5, 6, 7, 8, 9, and 10.**



Configuration

- **Maximum baselines for the antenna configurations will vary from 0.16 km to 8.5 km. Configurations C-9 and C-10 will not be offered in Cycle 8 2021.**
- **Maximum baselines of 3.6 km for Bands 8, 9 and 10**
- **Maximum baselines of 8.5 km for Bands 3 to 7**

Config	Lmax		Band 3	Band 4	Band 5	Band 6	Band 7	Band 8	Band 9	Band 10
	Lmin		100 GHz	150 GHz	183 GHz	230 GHz	345 GHz	460 GHz	650 GHz	870 GHz
7-m Array	45 m	AR	12.5″	8.4″	6.8″	5.4″	3.6″	2.7″	1.9″	1.4″
	9 m	MRS	66.7″	44.5″	36.1″	29.0″	19.3″	14.5″	10.3″	7.7″
C43-1	161 m	AR	3.4″	2.3″	1.8″	1.5″	1.0″	0.74″	0.52″	0.39″
	15 m	MRS	28.5″	19.0″	15.4″	12.4″	8.3″	6.2″	4.4″	3.3″
C43-2	314 m	AR	2.3″	1.5″	1.2″	1.0″	0.67″	0.50″	0.35″	0.26″
	15 m	MRS	22.6″	15.0″	12.2″	9.8″	6.5″	4.9″	3.5″	2.6″
C43-3	500 m	AR	1.4″	0.94″	0.77″	0.62″	0.41″	0.31″	0.22″	0.16″
	15 m	MRS	16.2″	10.8″	8.7″	7.0″	4.7″	3.5″	2.5″	1.9″
C43-4	784 m	AR	0.92″	0.61″	0.50″	0.40″	0.27″	0.20″	0.14″	0.11″
	15 m	MRS	11.2″	7.5″	6.1″	4.9″	3.3″	2.4″	1.7″	1.3″
C43-5	1.4 km	AR	0.54″	0.36″	0.30″	0.24″	0.16″	0.12″	0.084″	0.063″
	15 m	MRS	6.7″	4.5″	3.6″	2.9″	1.9″	1.5″	1.0″	0.77″
C43-6	2.5 km	AR	0.31″	0.20″	0.16″	0.13″	0.089″	0.067″	0.047″	0.035″
	15 m	MRS	4.1″	2.7″	2.2″	1.8″	1.2″	0.89″	0.63″	0.47″
C43-7	3.6 km	AR	0.21″	0.14″	0.11″	0.092″	0.061″	0.046″	0.033″	0.024″
	64 m	MRS	2.6″	1.7″	1.4″	1.1″	0.75″	0.56″	0.40″	0.30″
C43-8	8.5 km	AR	0.096″	0.064″	0.052″	0.042″	0.028″	N/A	N/A	N/A
	110 m	MRS	1.4″	0.95″	0.77″	0.62″	0.41″			
C43-9	13.9 km	AR	Not offered in Cycle 8							
	368 m	MRS								
C43-10	16.2 km	AR								
	244 m	MRS								

tart date	Configuration	Longest baseline	LST for best observing conditions
2021 October 1	C-8	8.5 km	~ 22—10 h
2021 October 20	C-7	3.6 km	~ 23—11 h
2021 November 20	C-6	2.5 km	~ 1—13 h
2021 December 1	C-5	1.4 km	~ 2—14 h
2021 December 20	C-4	0.78 km	~ 4—15 h
2022 January 10	C-3	0.50 km	~ 5—17 h
2022 February 1	No observations due to maintenance		
2022 March 1	C-1	0.16 km	~ 8—21 h
2022 March 20	C-2	0.31 km	~ 9—23 h
2022 April 20	C-3	0.50 km	~ 11—0 h
2022 May 20	C-4	0.78 km	~ 12—2 h
2022 June 20	C-5	1.4 km	~ 13—4 h
2022 July 11	C-6	2.5 km	~15—6 h
2022 July 30	C-5	1.4 km	~17—7 h
2022 August 20	C-4	0.78 km	~19—8 h
2022 September 10	C-3	0.50 km	~20—9 h

Basic Observing Modes

- **Regular**
  - **Spectral line and continuum observations with the 12-m Array and the 7-m Array in all bands**
  - **Single field interferometry (all bands) and mosaics (Bands 3 to 9) with the 12-m Array and the 7-m Array**
  - **Single dish spectral line observations in Bands 3 to 8**
- **VLBI/pulsar in phase-up mode**
- **Target of Opportunity**
- **Large program**
  - **>50 hours for 12m array**
  - **>150 hours for 7m array**

Polarization

I said spectral line polarimetry is also allowed for 12m mosaicking at the meeting, but it is not true. Only continuum linear polarimetry is allowed for 12m mosaicking. Sorry for confusion.

- **12m**
  - **Single pointing (within 1/3 of primary beam) of continuum and spectral line polarimetry are offered in Bands 3-7 for linear polarization.**
  - **Only continuum linear polarimetry for mosaicking.**
  - **Only single pointing within 1/10 of primary beam is offered in Bands 3-7 for circular polarization.**
  - **Systematic error (minimum detectable degree of polarization)**
    - **Linear polarization: 0.1-0.2% of peak Stokes I flux within 1/3 of PB in both continuum and spectral line observations. The error will be slightly worse at the outside of 1/3 PB for mosaicking case (TBA).**
    - **Circular polarization: 1.8% of peak Stokes I flux in both continuum and spectral resolution observations.**
- **7m**
  - **Only single pointing (<1/3 PB) or multiple pointings (each of pointing with 1<3 PB FoV), linear polarization of continuum and spectral line is offered in Bands 3-7. No circular polarization, no mosaicking.**
  - **The systematic error is the same as the 12m case.**
  - **Data combination of 12m and 7m will not be supported.**

VLBI

- VLBI observations in Bands 3 & 6 will be conducted using a “campaign mode” (acutual date will be set after the proposal review).
- New to Cycle 8 2021, VLBI observations will be permitted for science targets with correlated flux densities < 0.5 Jy through use of apassive phasingmode. The user must select a bright (>0.5 Jy) phase calibrator (phasor), ideally within 6 or 3 degrees of the science target.
- The proposers are required to enter a VLBI total time requested.
- ALMA’s VLBI observing window in a given cycle will not exceed two weeks, so if multi-epoch observations are requested, they must fit within that time frame and the total time request must be the aggregate time of all observations.

Pulsar observations

- **Users can propose pulsar observations with the aid of phase-up mode that works as “a large single dish”.**
- **Only pulsar-science projects will be accepted for this mode.**
- **Both time domain data in PSRFITS format and standard interferometric data will be provided.**
- **Time resolution of time domain data is an integer multiple of 8 μs.**

Solar Observations

- Proposals will be accepted for ALMA interferometric and Total Power observations.
  - Will be conducted only during the periods when the 12-m Array is in one of the allowed configurations for the requested band, namely C-1 to C-4 for Band 3, C-1 to C-3 for Band 5, C-1 to C-3 for Band 6, and C-1 to C-2 for Band 7.
  - The interferometric component of Solar observations will be conducted using a special combined array comprising both 12-m and 7-m antennas.
- Only proposals for continuum observations in Bands 3, 5, 6 and 7 will be accepted.
- Observations may be performed using dual linear polarization (XX, YY) or single polarization (XX) correlations; full polarization measurements are not currently offered

Q&A at the meeting

- Q: Is the passive phasing (target source flux < 500mJy) also applicable for spectral line VLBI?
  A: Spectral line VLBI is not offered in Cycle 8 2021.
- Q: Is it possible to put 3 spws in one baseband and 1 spw in another baseband in the same sideband?
  A: Yes, it is possible.