EUROPEAN ARC
ALMA Regional Centre

ALMA Capabilities

A brief overview of ALMA observing capabilities

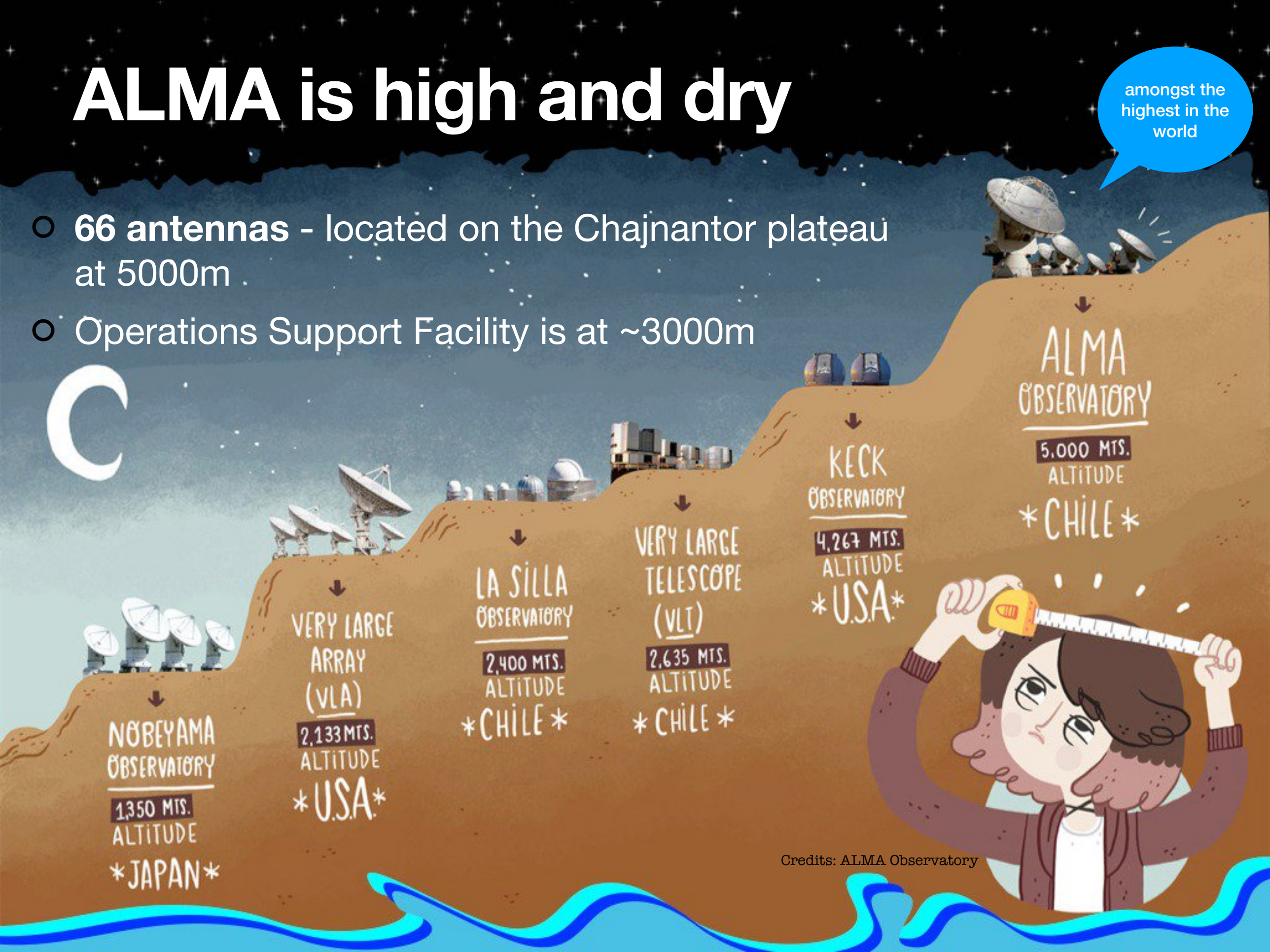
Luke Maud - ESO - Garching

SPANISH
ALMA Days

18-20 February 2025, La Laguna, Tenerife, Spain

ALMA is high and dry

- **66 antennas** - located on the Chajnantor plateau at 5000m
- Operations Support Facility is at ~3000m



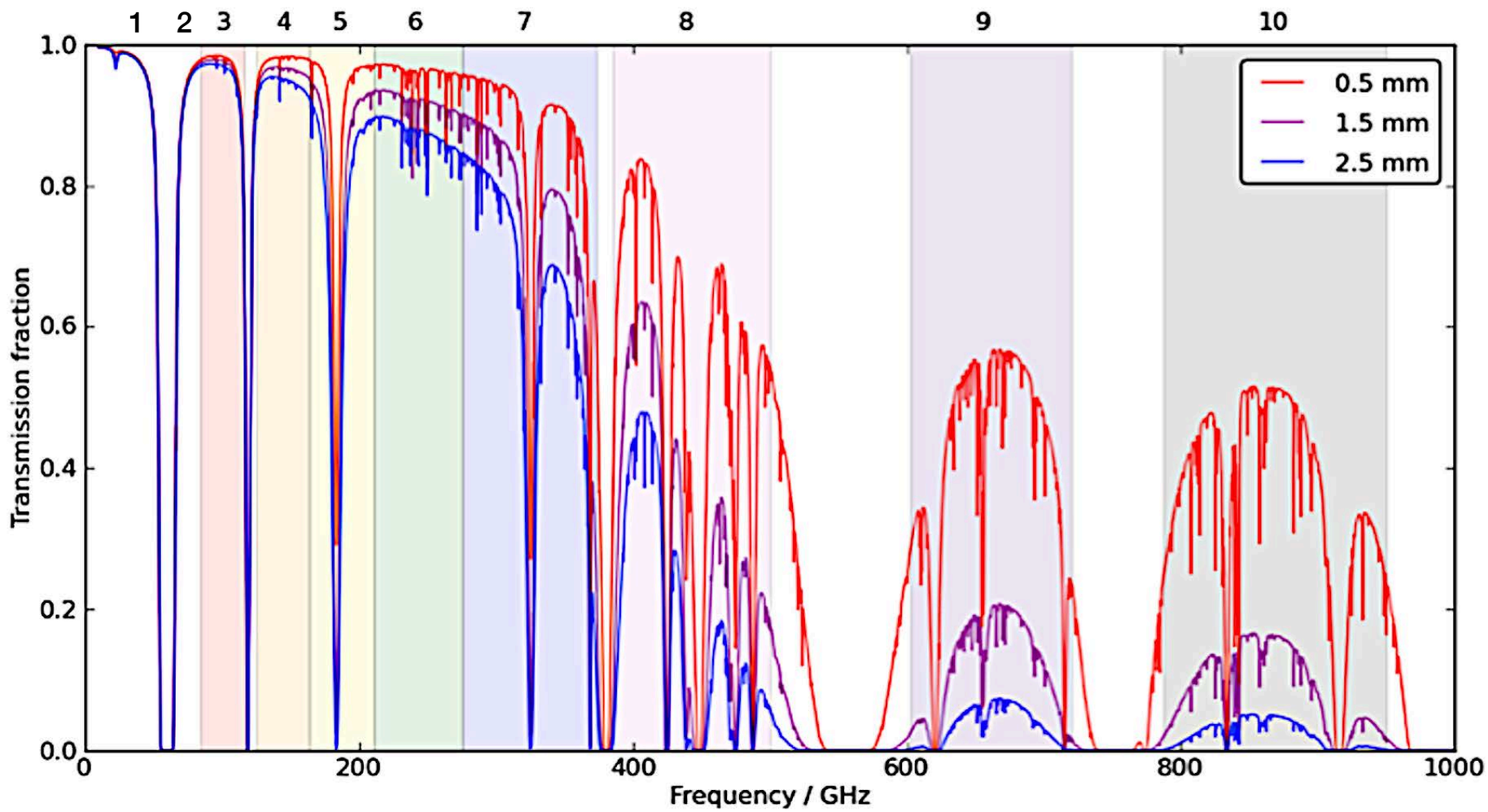
Credits: ALMA Observatory

ALMA is high and dry

"High Frequency" bands required the lowest PWV (<0.8mm). ALMA is the ground based interferometer capable of these frequencies

- **PWV** - precipitable water vapour content
  - has to be low for good transmission
- **Bands (1-10)** - 31.3 to 950 GHz frequency coverage
  - 8.5 to 0.32 mm wavelength coverage

Vast coverage of dust continuum, molecules (inc. complex organic), recombination lines, atomic lines, high redshift galaxies



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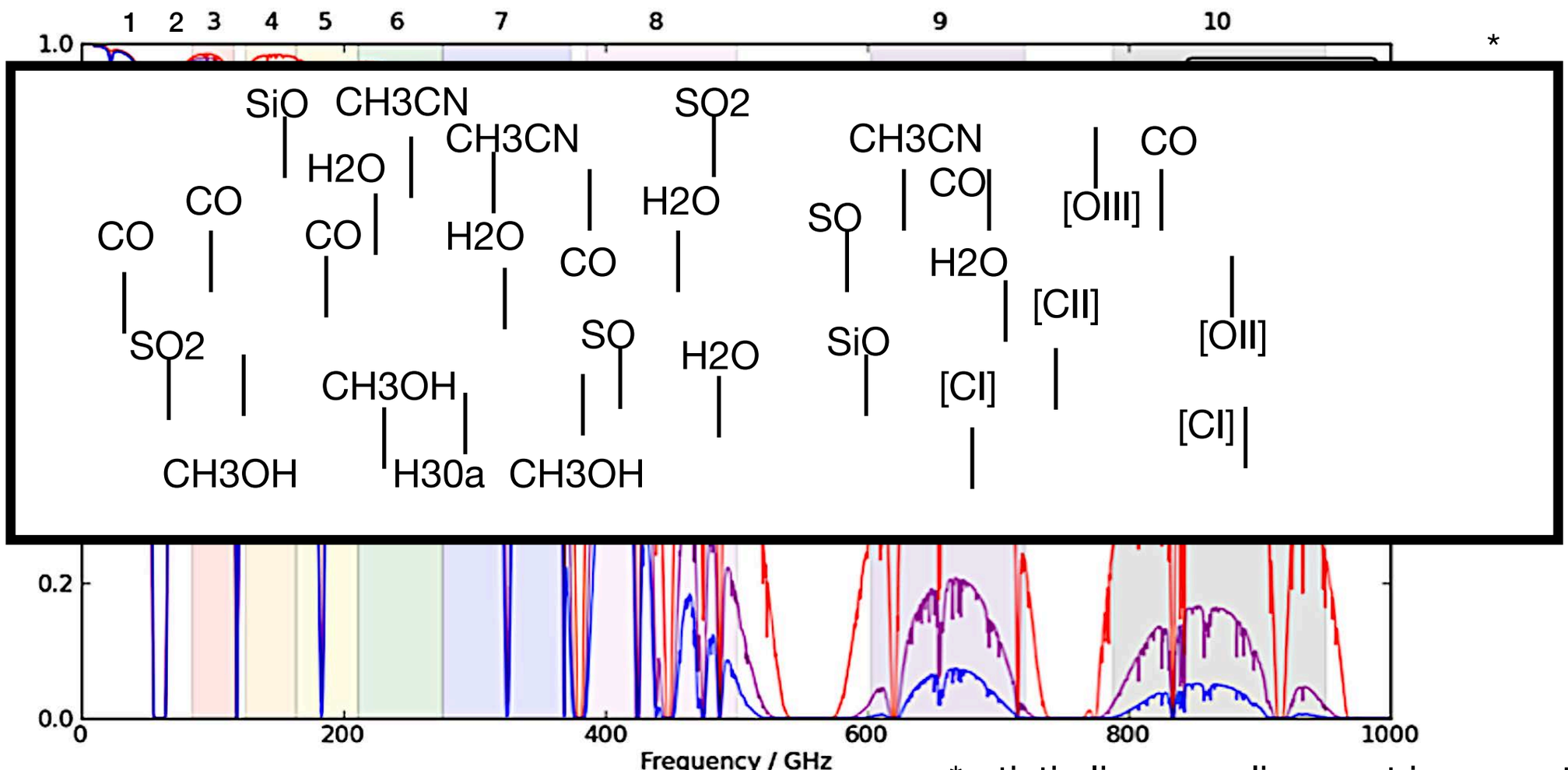
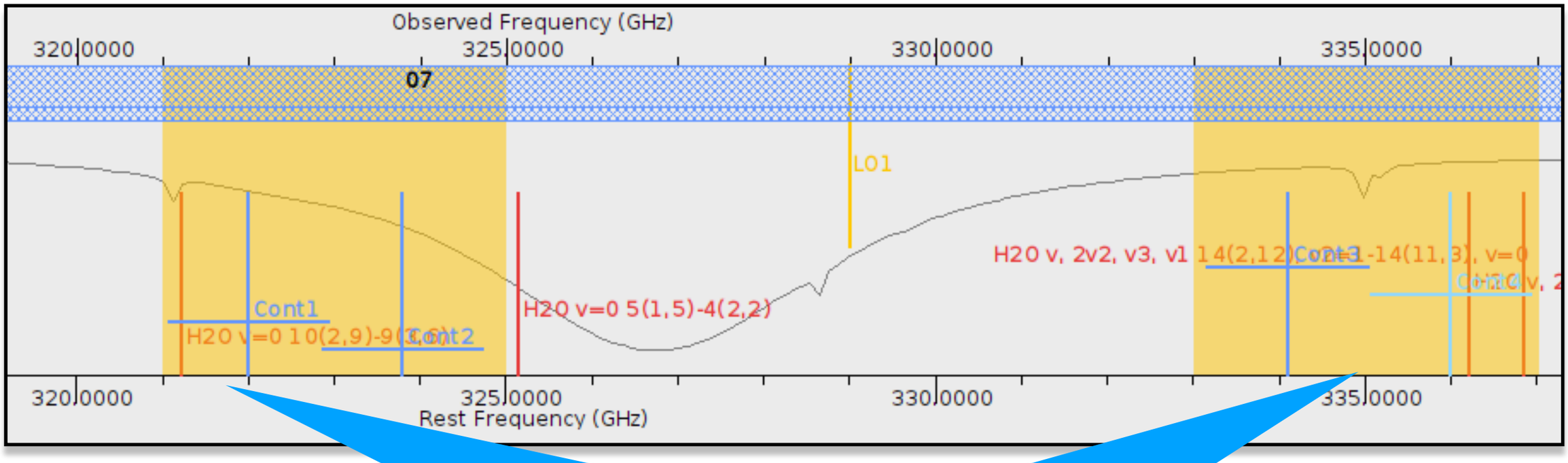


*artistic licence - lines not in correct places

ALMA allows a versatile spectral setup*

- **Four configurable basebands** - 58 MHz to ~2GHz spectral windows
  - Spectral Window width vs resolution tradeoff / division
- **Frequency (spectral) resolution** - ‘channels’ divide over the bandwidth
  - can be as narrow as 30 kHz

~0.3km/s (Band 1) to ~0.01 km/s (Band 10)



single
setup with 4 wide ~2GHz
SpWs trying to cover H_2O

*ALMA WSU upgrade transforms this

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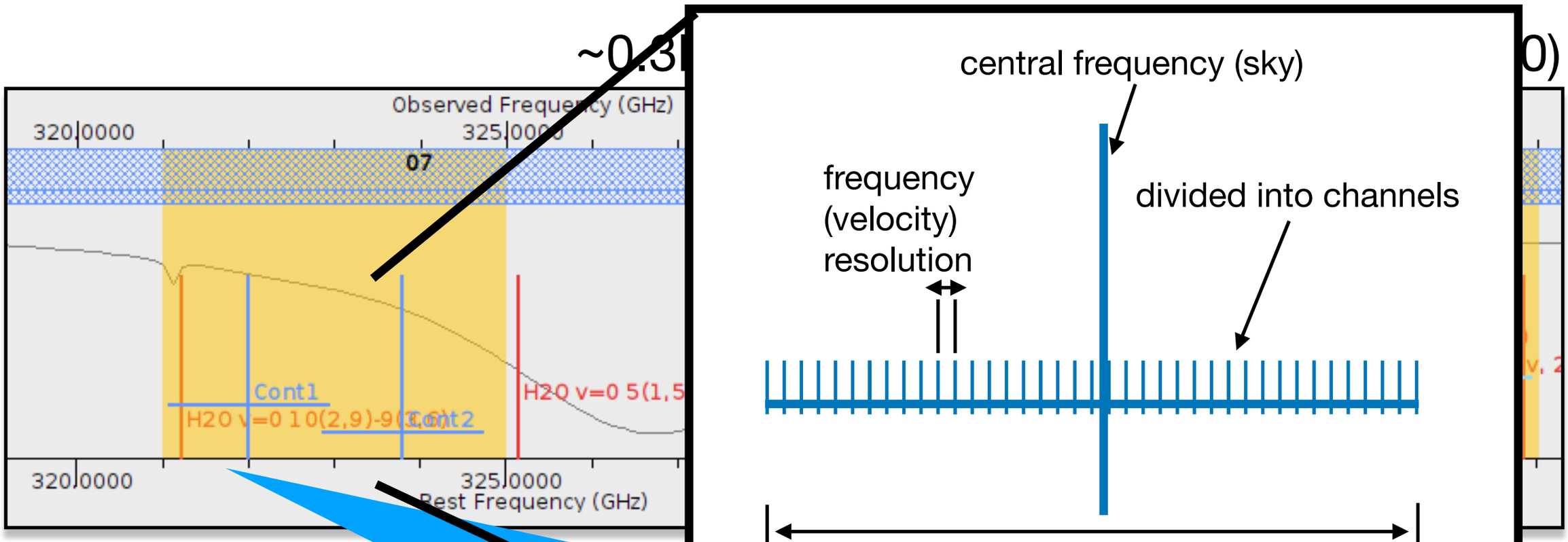

setup with 4 wide ~2GHz SpWs trying to cover H_2O

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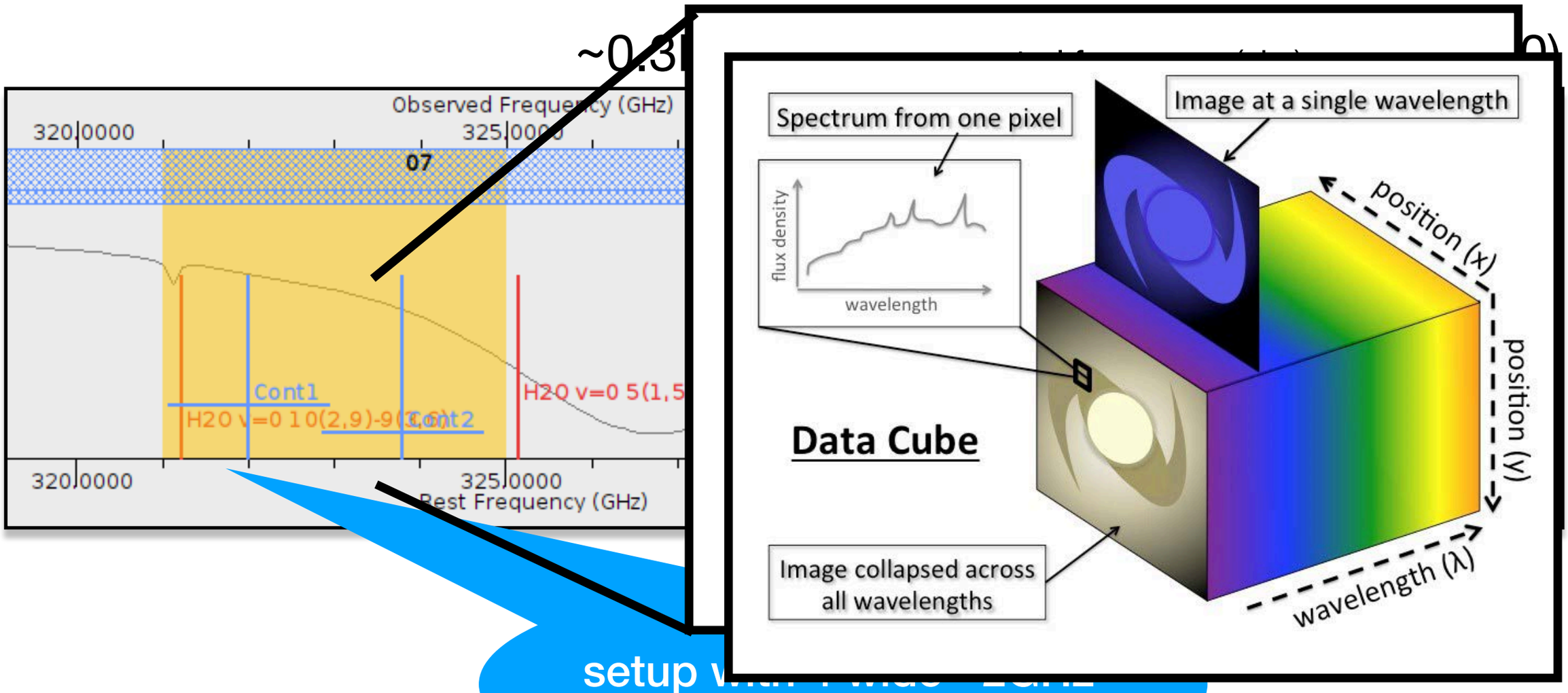
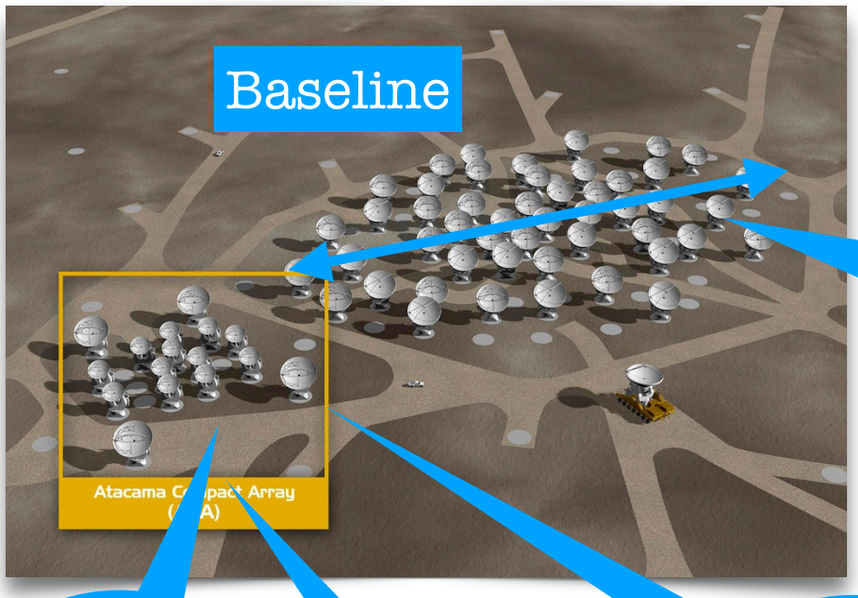


setup w… SpWs trying to cover H_2O

*ALMA WSU upgrade transforms this

ALMA can zoom in, or zoom out

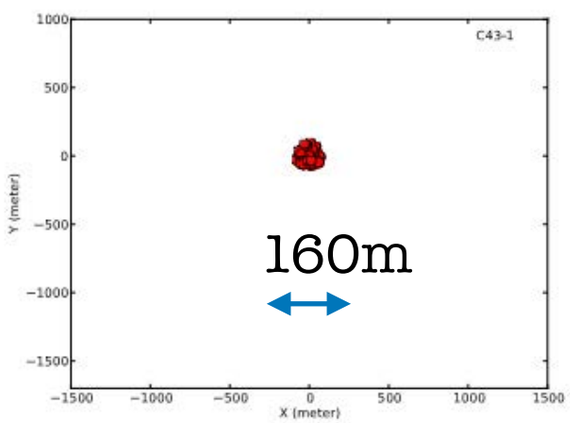


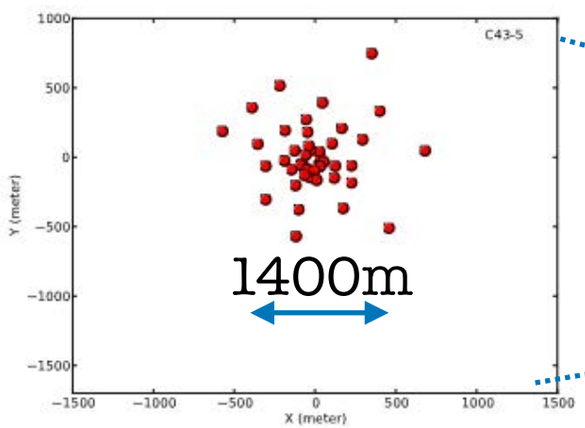
- **Spatial resolution** - 0.005" to 8.45" (12m)

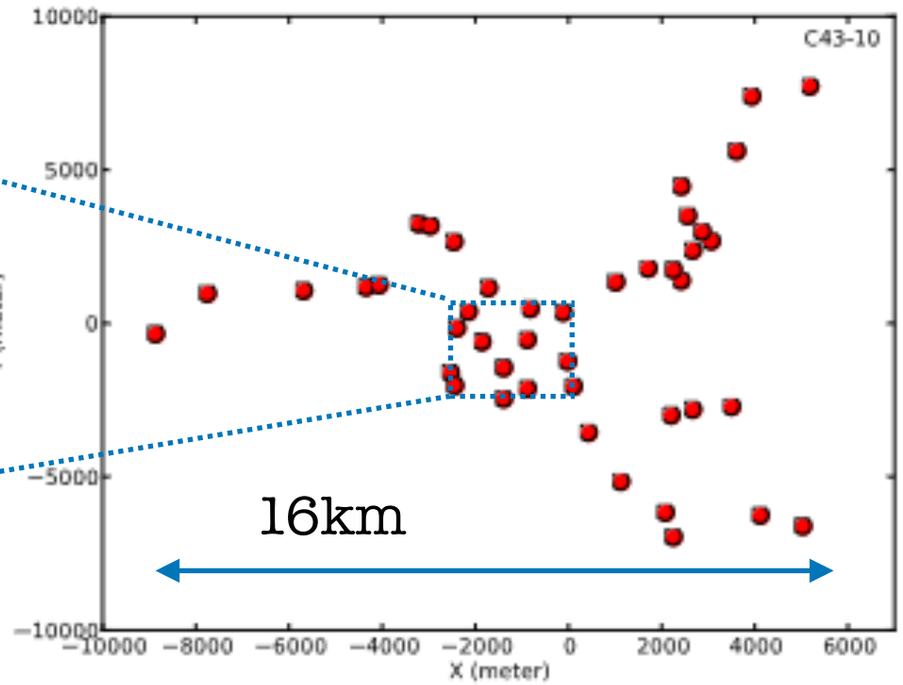
  ~ λ / B - 1.44" to 31.5" (ACA)

  Band dependent

- **Configurations** - up to ten array setups over an observing Cycle (year) C-1 to C-10







For galactic astronomy - useful to know

Size (AU) = Distance (PC) x Angular Resolution (arcsec)

Shows:
Angular Resolution (θres): finest detail
Maximal recoverable scale (θMRS):
Largest scale the “array” can see

long baselines are reaching few AU scales for nearby protoplanetary disks

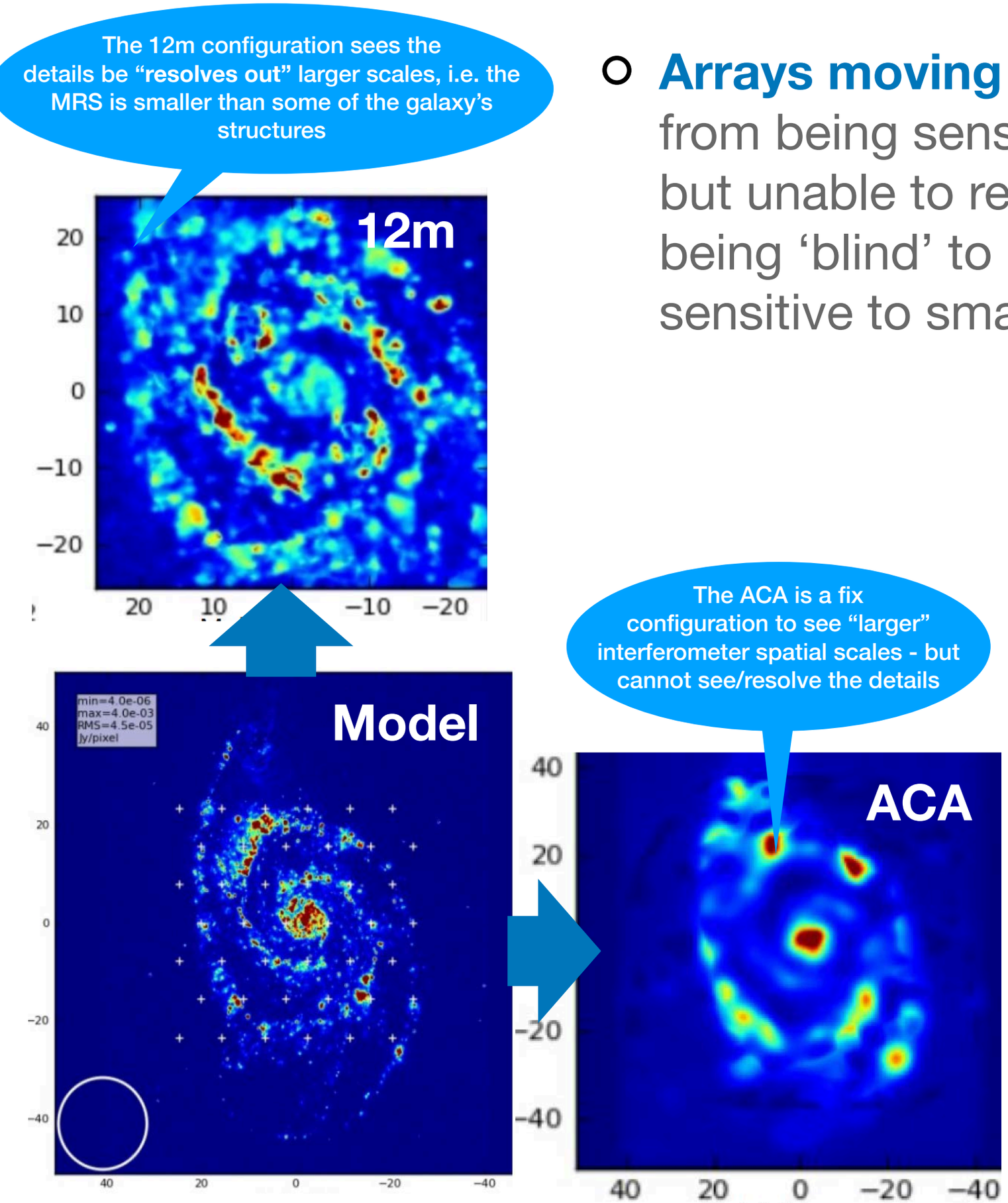
	Band	1	3	4	5	6	7	8	9	10
	Frequency (GHz)	40	100	150	185	230	345	460	650	870
Configuration										
7-m	θ_{res} (arcsec)	31.5	12.5	8.35	6.77	5.45	3.63	2.72	1.93	1.44
	θ_{MRS} (arcsec)	167	66.7	44.5	36.1	29.0	19.3	14.5	10.3	7.67
C43-1	θ_{res} (arcsec)	8.45	3.38	2.25	1.83	1.47	0.98	0.74	0.52	0.39
	θ_{MRS} (arcsec)	71.2	28.5	19.0	15.4	12.4	8.25	6.19	4.38	3.27
C43-2	θ_{res} (arcsec)	5.75	2.30	1.53	1.24	1.00	0.67	0.50	0.35	0.26
	θ_{MRS} (arcsec)	56.5	22.6	15.0	12.2	9.81	6.54	4.90	3.47	2.59
C43-3	θ_{res} (arcsec)	3.55	1.42	0.94	0.77	0.62	0.41	0.31	0.22	0.16
	θ_{MRS} (arcsec)	40.5	16.2	10.8	8.73	7.02	4.68	3.51	2.48	1.86
C43-4	θ_{res} (arcsec)	2.30	0.92	0.61	0.50	0.40	0.27	0.20	0.14	0.11
	θ_{MRS} (arcsec)	28.0	11.2	7.50	6.08	4.89	3.26	2.44	1.73	1.29
C43-5	θ_{res} (arcsec)	1.38	0.55	0.36	0.30	0.24	0.16	0.12	0.084	0.063
	θ_{MRS} (arcsec)	16.8	6.70	4.47	3.62	2.91	1.94	1.46	1.03	0.77
C43-6	θ_{res} (arcsec)	0.78	0.31	0.20	0.17	0.13	0.089	0.067	0.047	0.035
	θ_{MRS} (arcsec)	10.3	4.11	2.74	2.22	1.78	1.19	0.89	0.63	0.47
C43-7	θ_{res} (arcsec)	0.53	0.21	0.14	0.11	0.092	0.061	0.046	0.033	0.024
	θ_{MRS} (arcsec)	6.45	2.58	1.72	1.40	1.12	0.75	0.56	0.40	0.30
C43-8	θ_{res} (arcsec)	0.24	0.096	0.064	0.052	0.042	0.028	0.021	0.015	0.011
	θ_{MRS} (arcsec)	3.55	1.42	0.95	0.77	0.62	0.41	0.31	0.22	0.16
C43-9	θ_{res} (arcsec)	0.14	0.057	0.038	0.031	0.025	0.017	0.012	0.0088	0.0066
	θ_{MRS} (arcsec)	2.03	0.81	0.54	0.44	0.35	0.24	0.18	0.13	0.093
C43-10	θ_{res} (arcsec)	0.11	0.042	0.028	0.023	0.018	0.012	0.0091	0.0065	0.0048
	θ_{MRS} (arcsec)	1.25	0.50	0.33	0.27	0.22	0.14	0.11	0.077	0.057

ACA remains in a fixed configuration

Highest frequencies and longest baseline offer the ‘finest’ angular resolution for zooming in

https://almascience.eso.org/documents-and-tools/cycle11/alma-technical-handbook

- **Arrays moving from C-1 to C-10** - move from being sensitive to large spatial scales but unable to resolve small features to being ‘blind’ to large scales but very sensitive to small spatial scales



Credits: Elisabetta Luizzo - Italian ARC node

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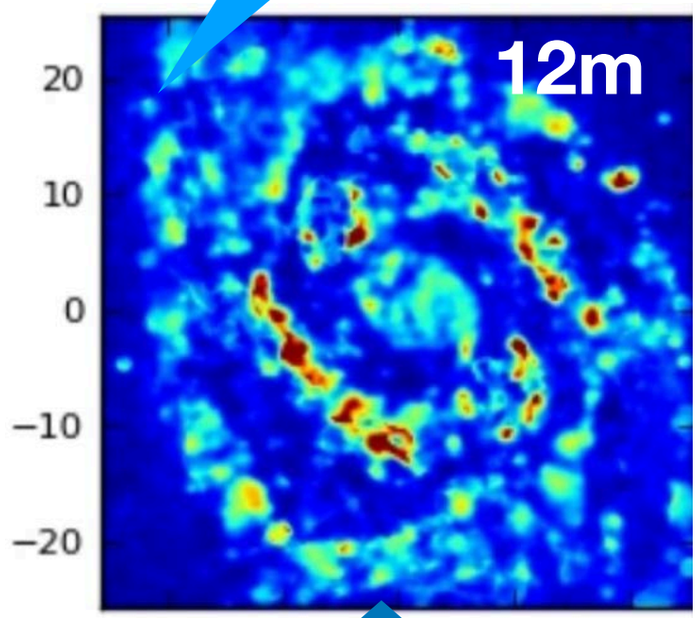
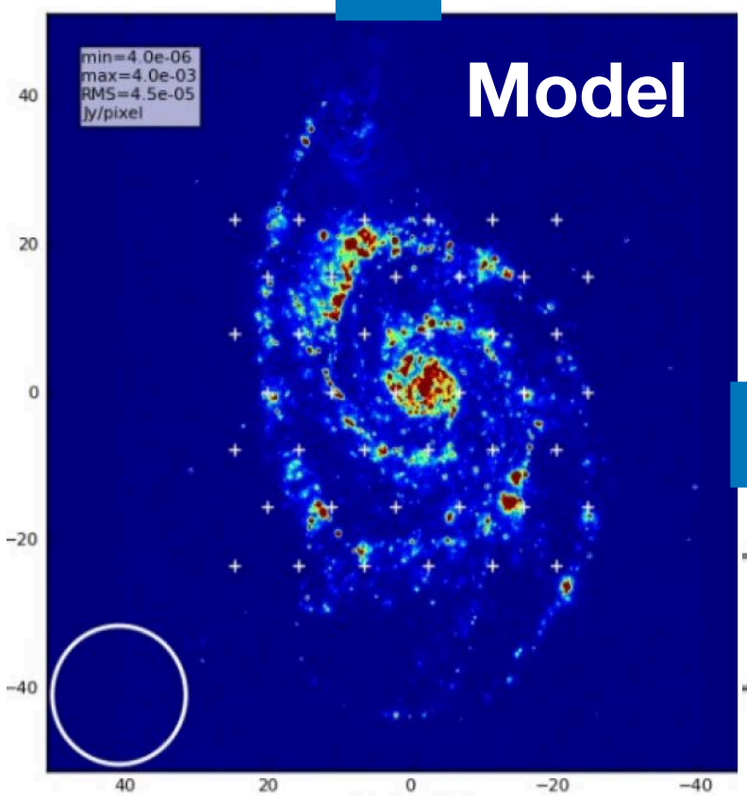
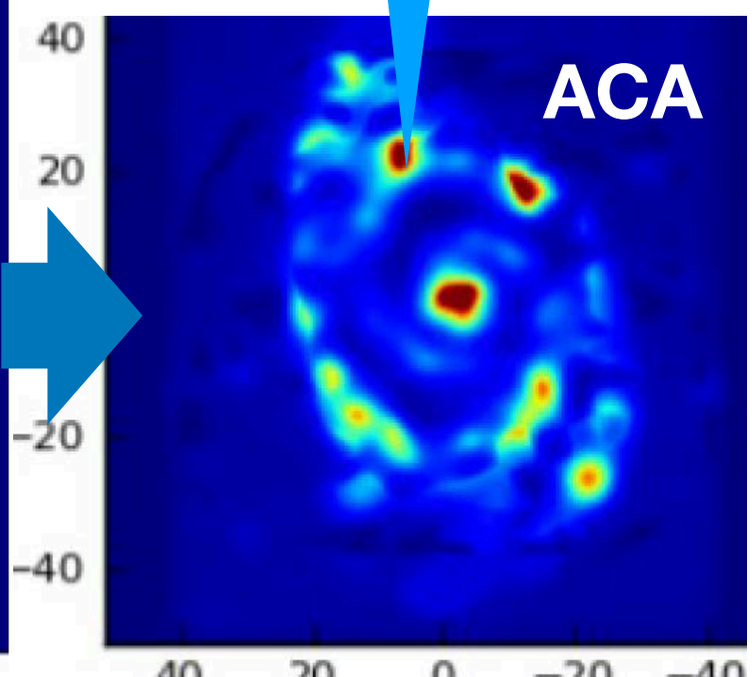
- **Array combination** - adding more than one main array, and/or including the ACA to correctly recover all spatial scales

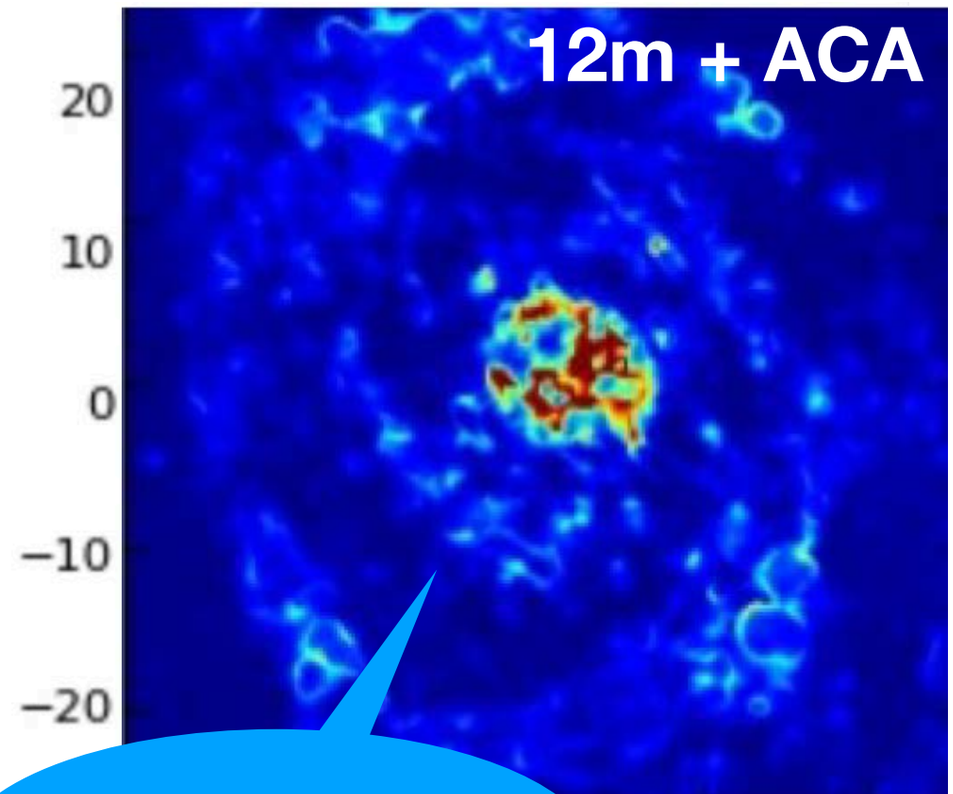
The 12m configuration sees the details be **“resolves out”** larger scales, i.e. the MRS is smaller than some of the galaxy’s structures





The ACA is a fix configuration to see “larger” interferometer spatial scales - but cannot see/resolve the details





Recovers the flux and the details

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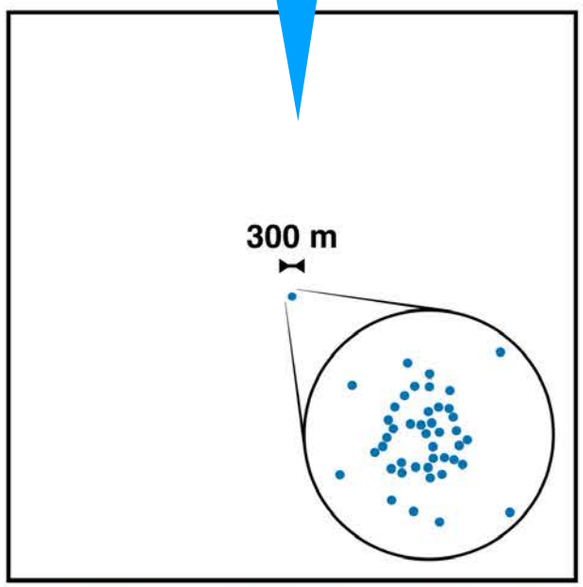
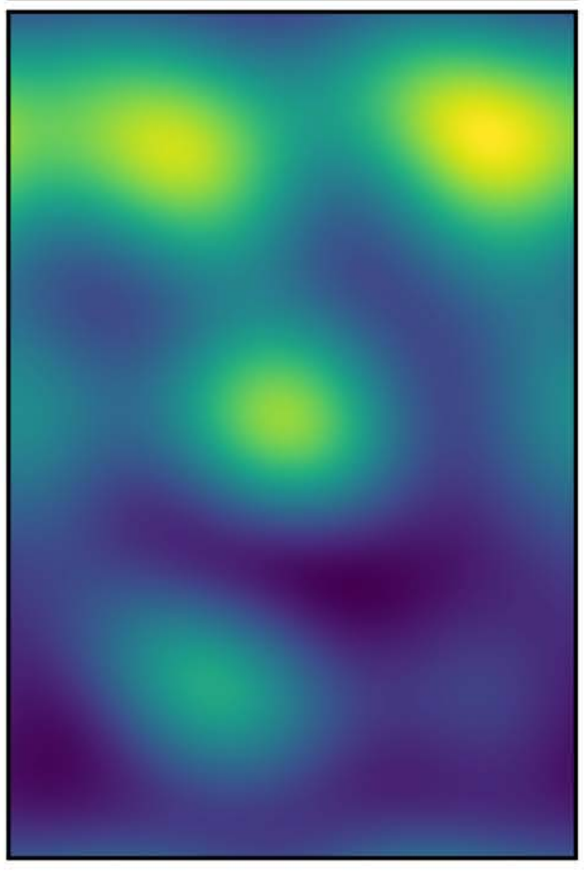
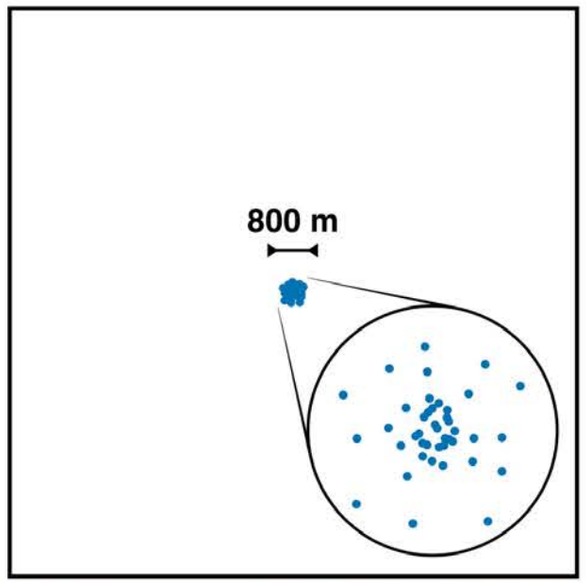
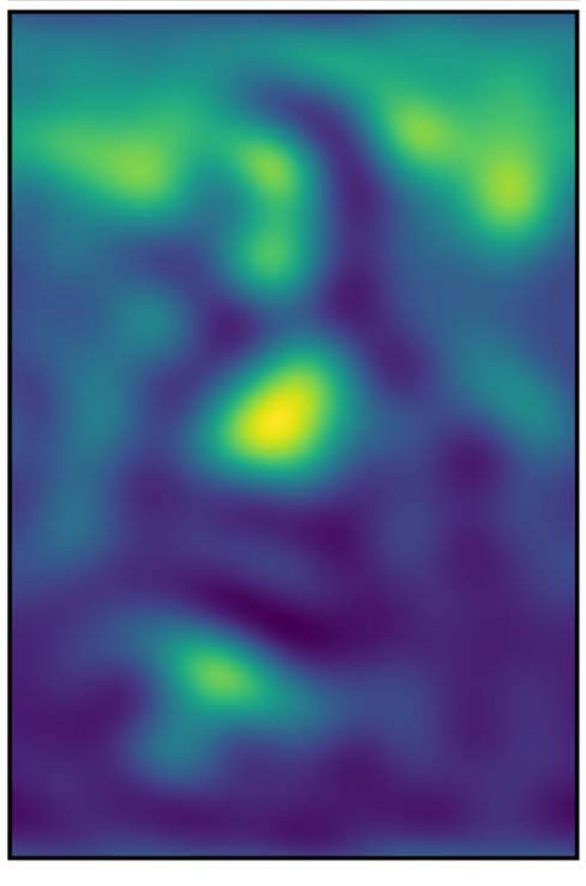
Large scales only - no details

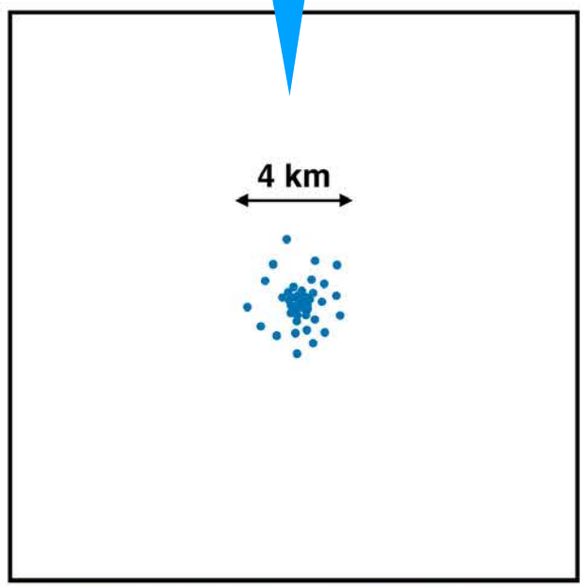




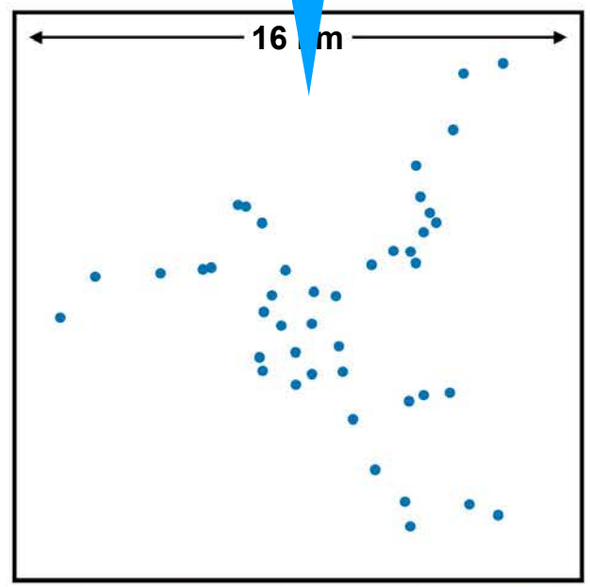




Almost idea, but still blurry

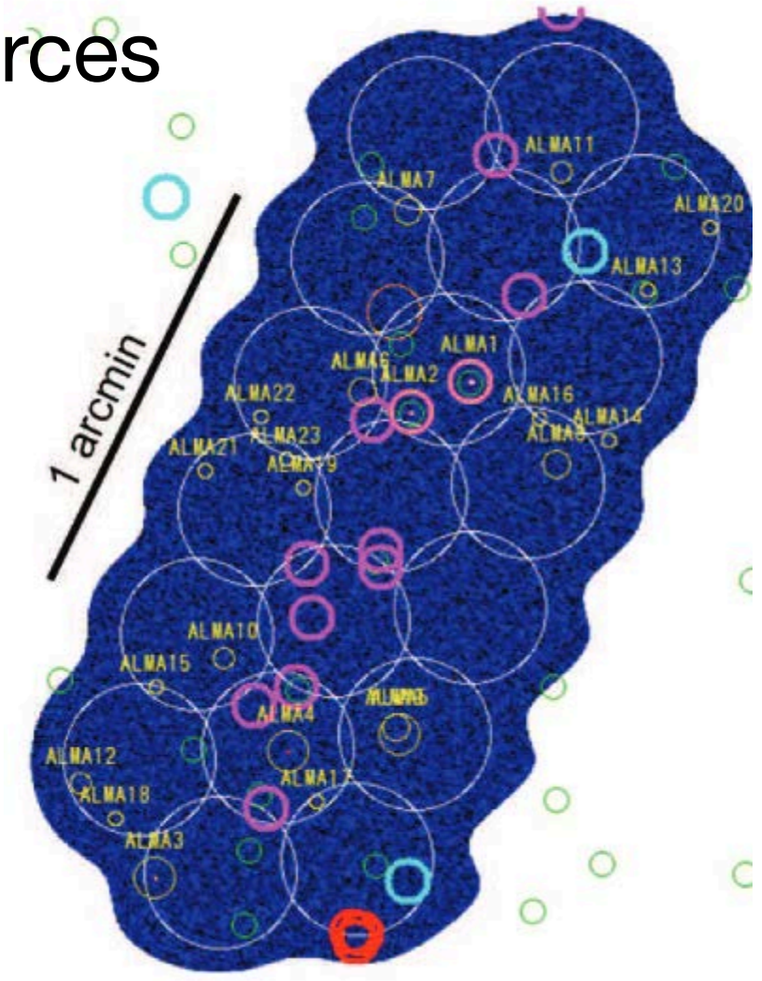


Now only the very sharpest details, Lost the larger scale - relates to MRS



ALMA has many modes

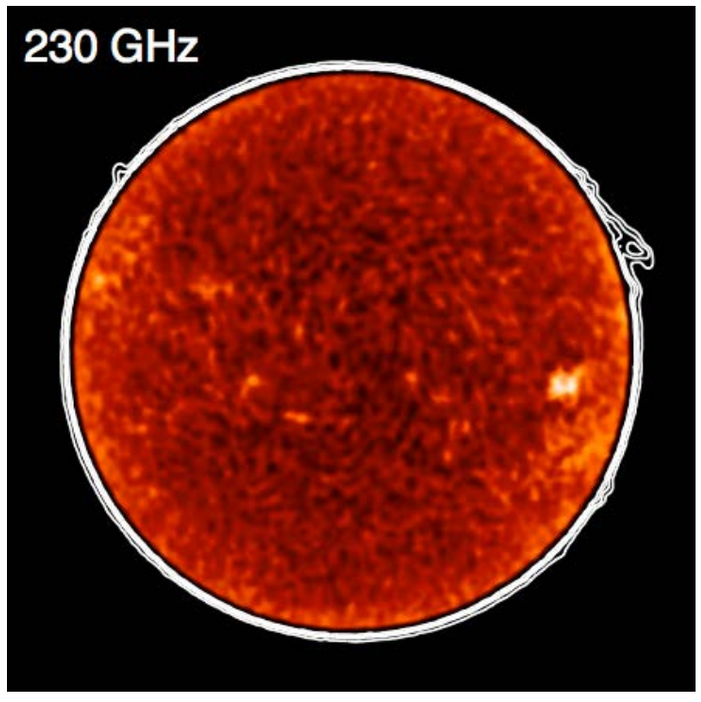
- ***What would you like to observe?***
  - **Single** or **multi-pointing** and **multiple** targets
    - One observation for one or more sources
    - Field of view is ~ **λ** / dish diameter
  - **Mosaics** (up to 150 pointings)
    - Large scale extended region, a molecular cloud or a galaxy
  - Many spatial scales
    - **12m** + **ACA, inc. Total Power**
    - **ACA “stand-alone”**
      - **+ Simultaneous**



Credits: Candles Survey

ALMA has many modes

- ***What would you like to observe?***
  - Standard observations **- intensity**
  - **Full stokes** polarisation (magnetic fields etc)
- **Spectra scans**
  - Full coverage over an entire Band
- **Ephemeris**
  - Tracking of moving,
    e.g. solar system sources
- **Solar observations**
  - Looking directly into the sun
  - Also with full stokes polarisation



Credits: almascience.eso.org

ALMA has many modes

- ***What would you like to observe?***
  - With other instruments in a **Joint** proposal
  - Using **VLBI** with telescopes around the world
- In an ALMA **Large Program**
  - Over **50h** with the **12m** array or over **150h** with the **ACA**
- **Pulsars**
  - special mode to combine all dishes
- Very accurate positions
  - **Astrometry** for most accurate positions

Credits: EHT

THANK YOU - any questions ???

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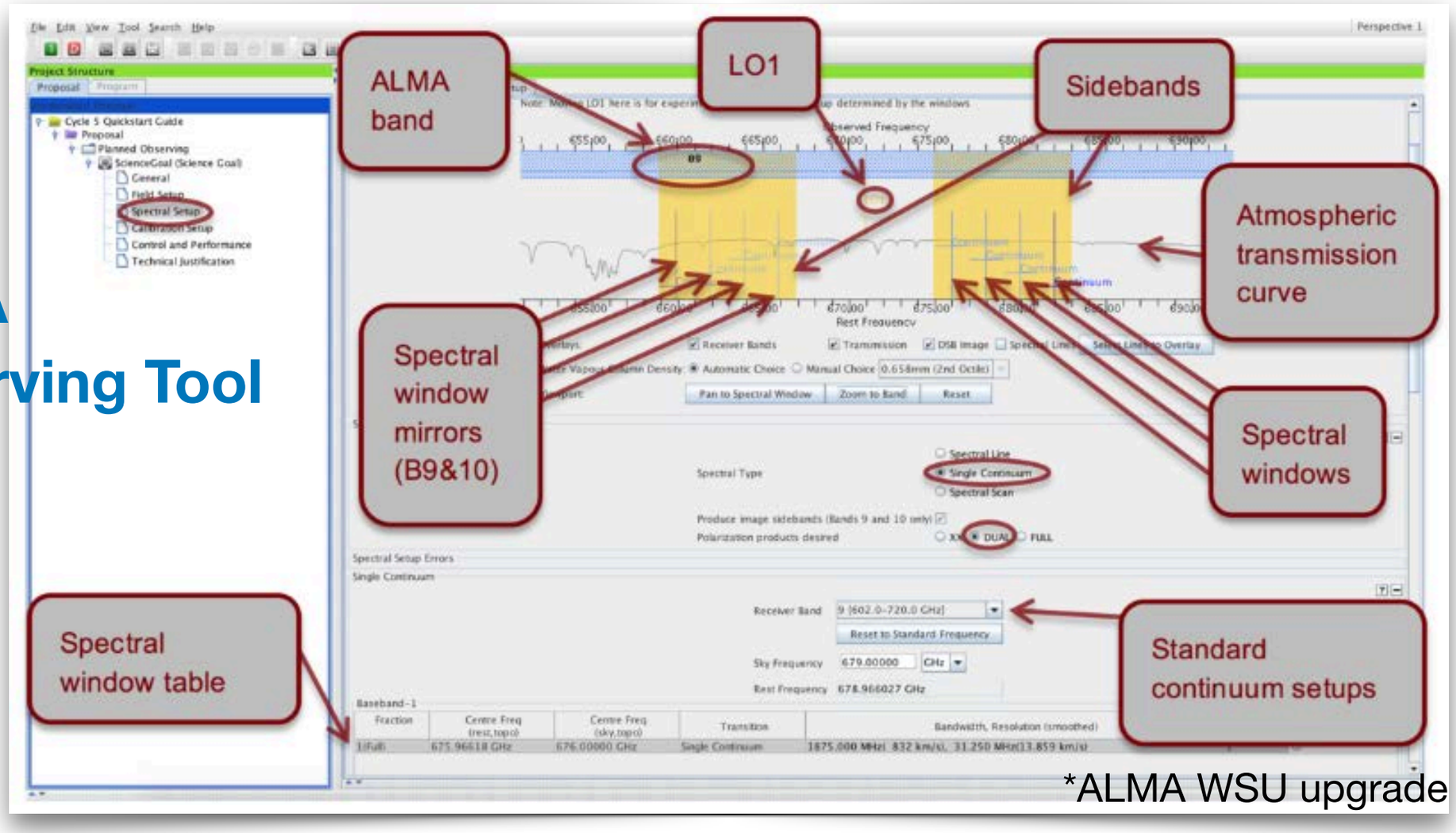
ALMA Observing Tool



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