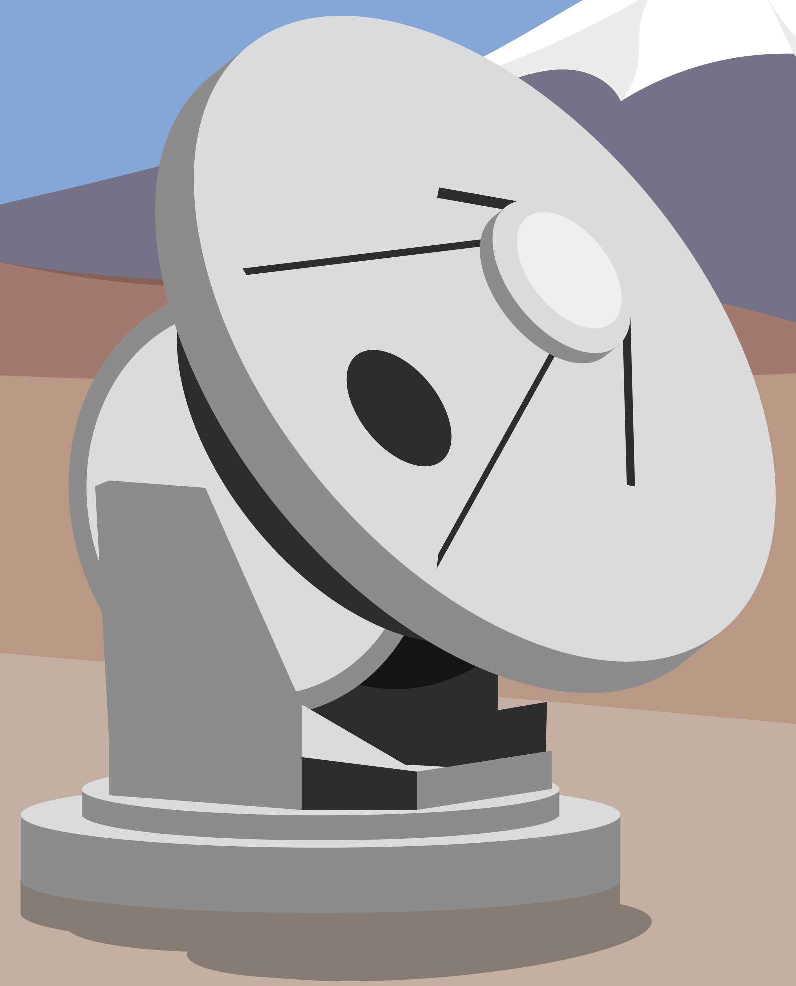
AtLAST has received funding from the European Union's Horizon Europe and Horizon2020 research and innovation programmes under grant agreements No. 101188037 and No. 951815.

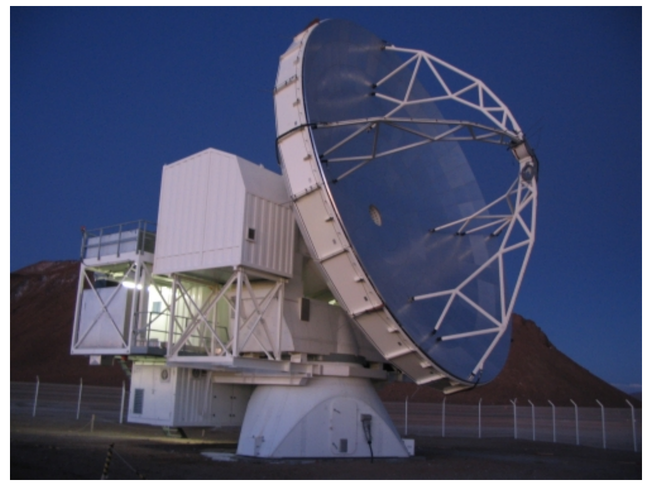


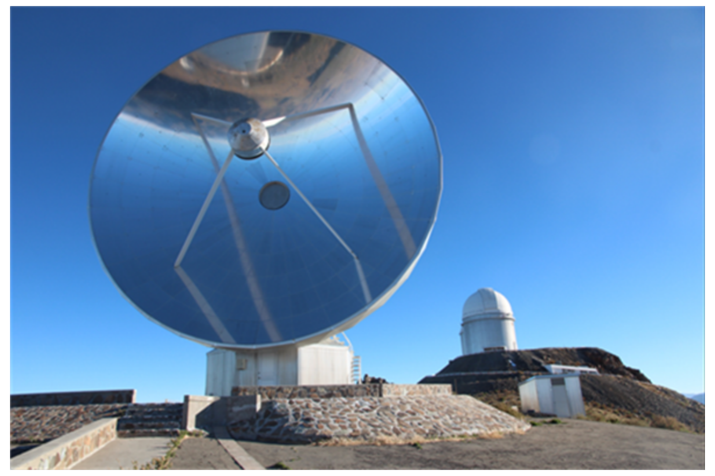
AtLAST in a Single-dish Context

Andreas Lundgren, LAM, Marseille

12 May 2025, Amphithéâtre Pierre-Gilles de Gennes, Paris

Why AtLAST?





Single dish telescopes

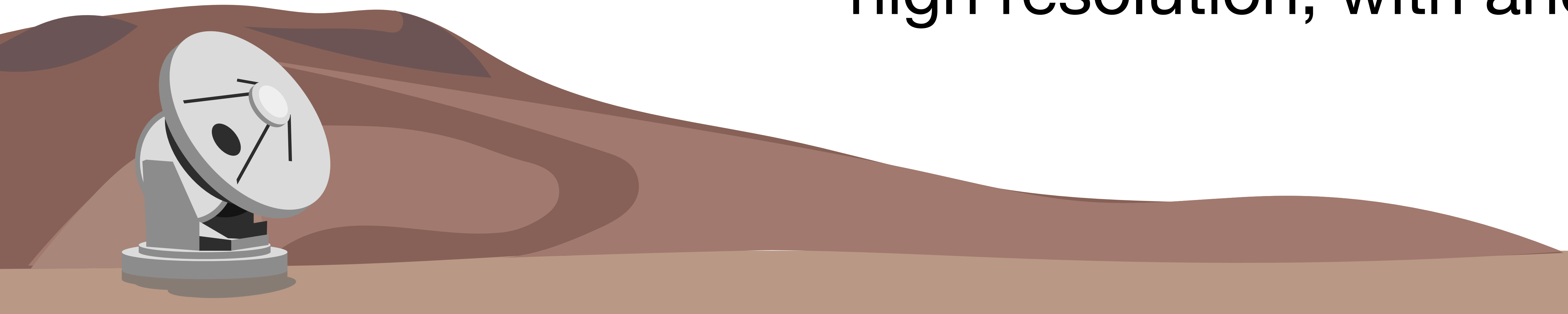
Relatively low resolution
Small collecting area
Small FoV

Interferometers

Very high resolution
Tiny FoV
Insensitive to extended emission



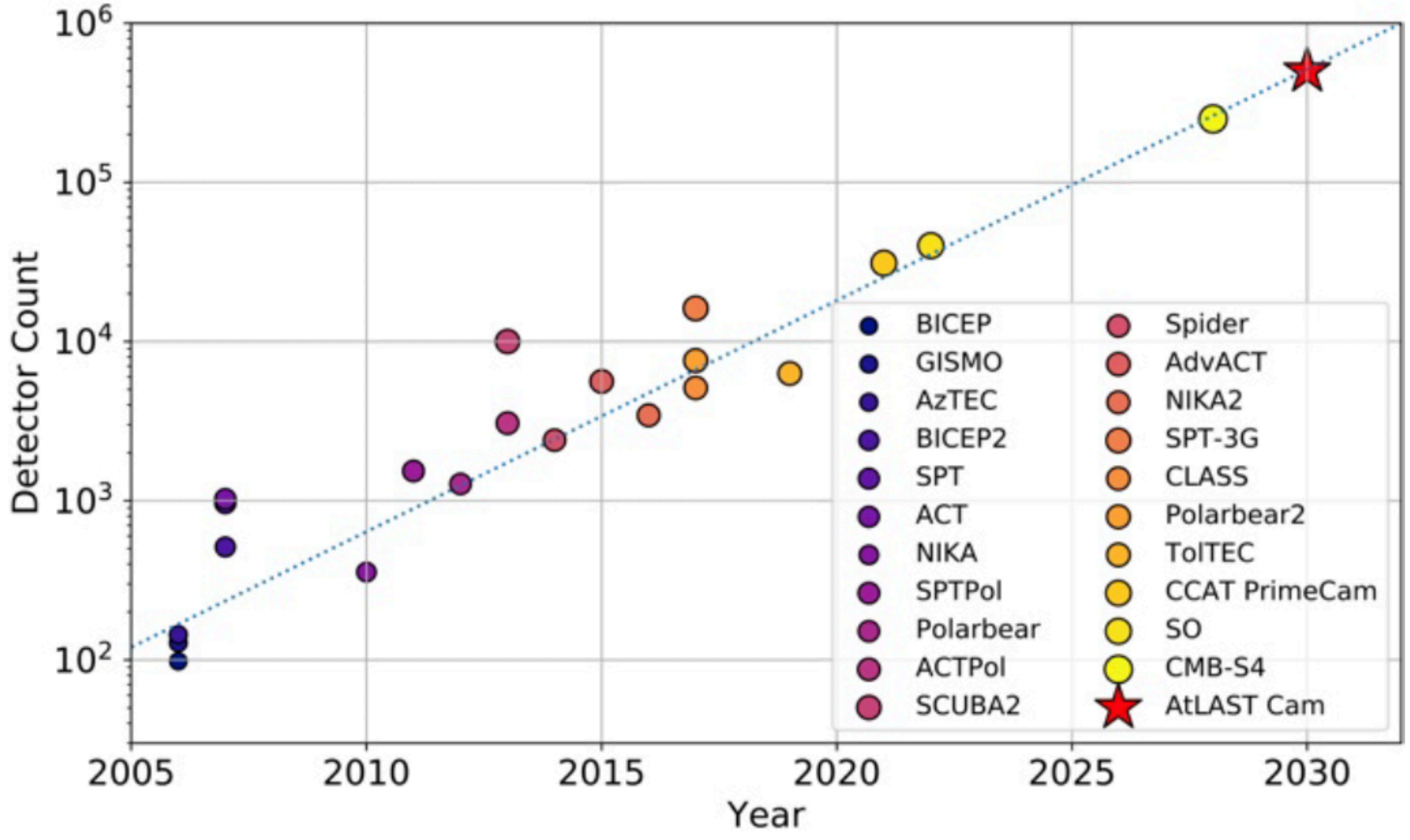
The next step: A a filled aperture telescope that provides high resolution, with and a large field of view



Future for detectors

Moores law

Compilation of submm detector counts vs year using a variety of technologies. Extrapolation suggest megapixel camera will be operative by 2032



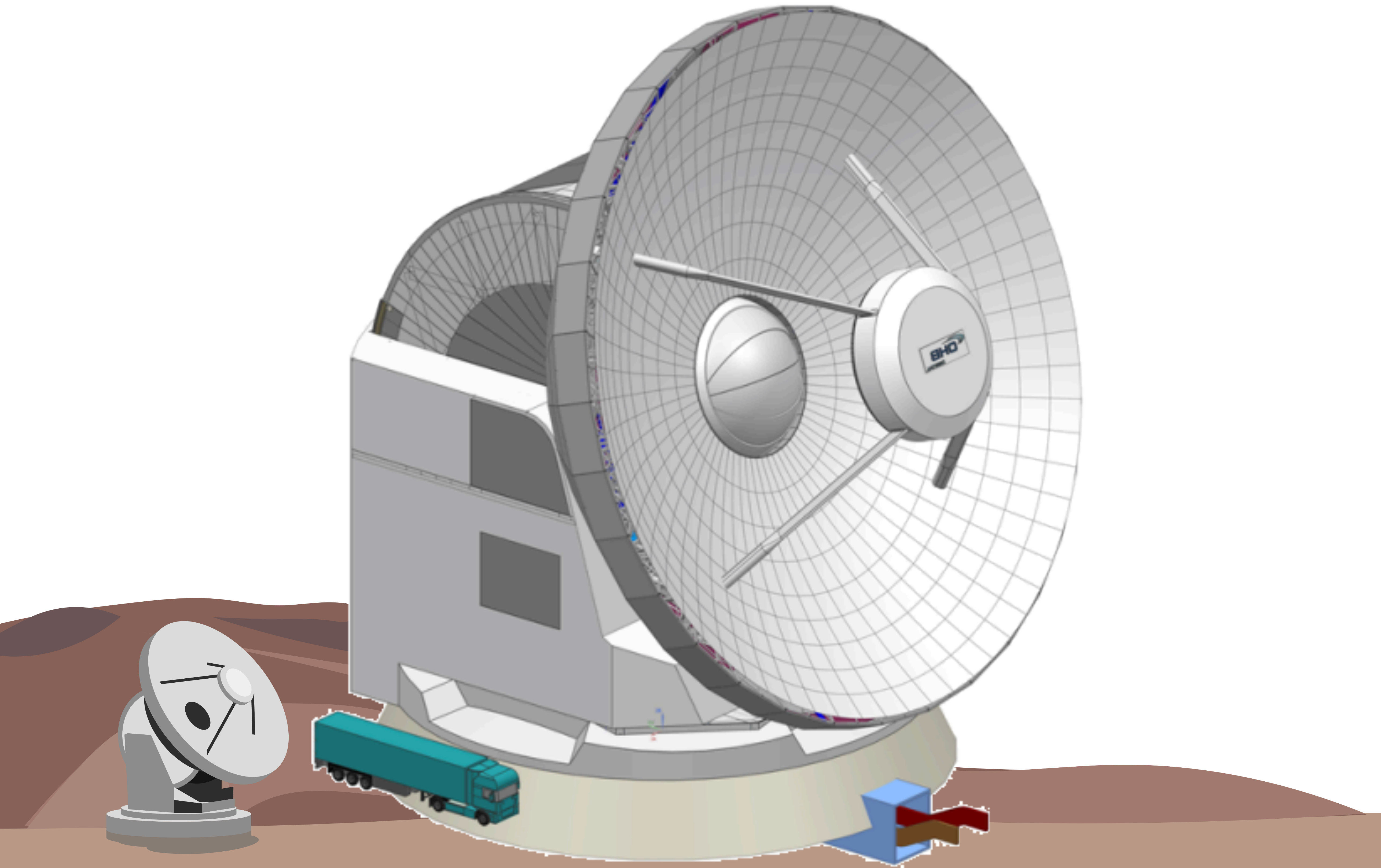
Antenna

Characteristics

A&A, 694, A142 (2025)

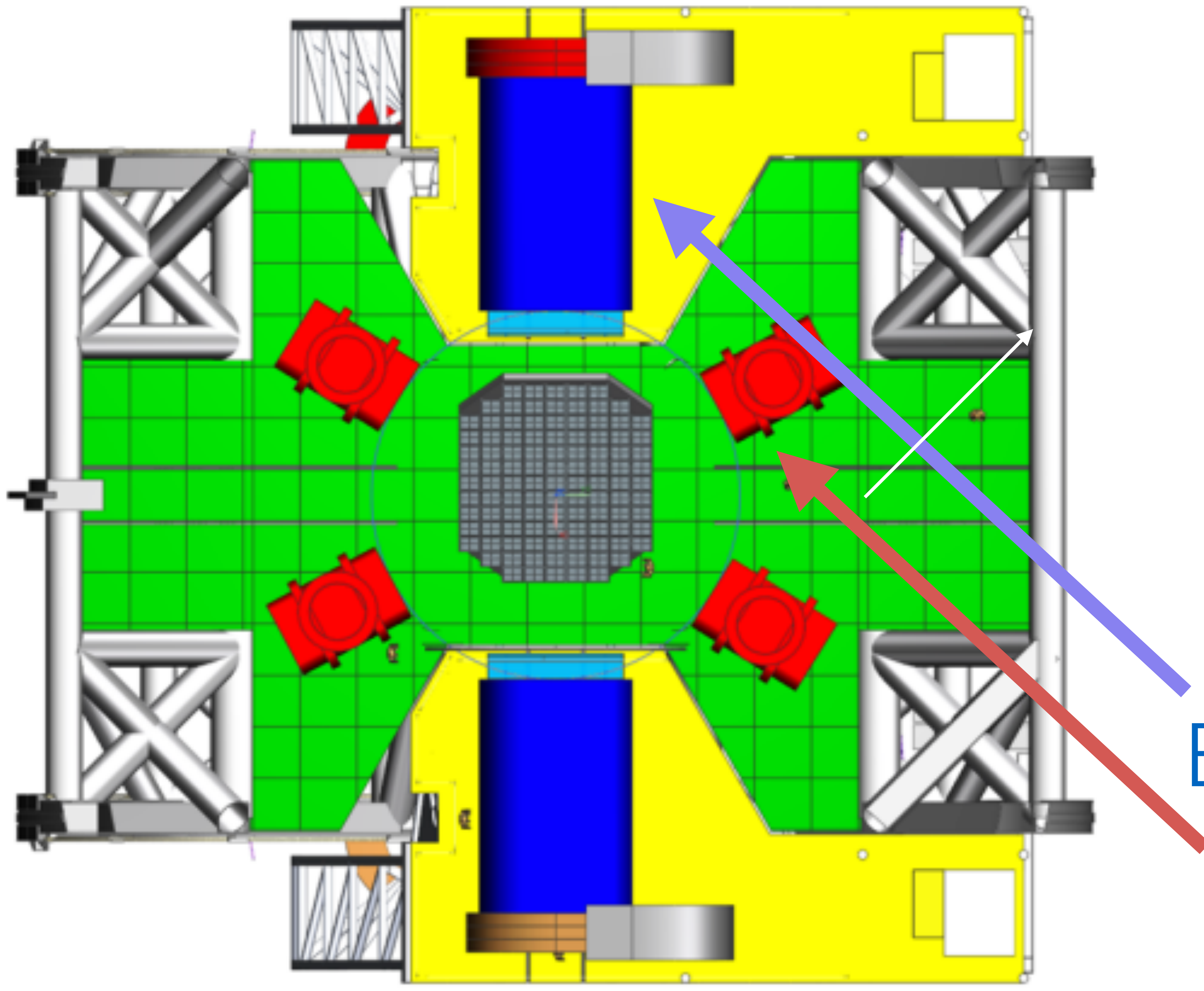
The conceptual design of the 50-meter Atacama Large Aperture Submillimeter Telescope (AtLAST)

Tony Mroczkowski[1,★], Patricio A. Gallardo[2], Martin Timpe[3], Aleksej Kiselev[3], Manuel Groh[3], Hans Kaercher[4], Matthias Reichert[3], Claudia Cicone[5], Roberto Puddu[6], Pierre Dubois-dit-Bonclaude[3], Daniel Bok[3], Erik Dahl[3], Mike Macintosh[7], Simon Dicker[8], Isabelle Viole[9], Sabrina Sartori[9], Guillermo Andrés Valenzuela Venegas[9], Marianne Zeyringer[9], Michael Niemack[10,11], Sergio Poppi[12], Rodrigo Olguin[13], Evanthia Hatziminaoglou[1,14,15], Carlos De Breuck[1], Pamela Klaassen[7], Francisco Miguel Montenegro-Montes[1,16], and Thomas Zimmerer[3]



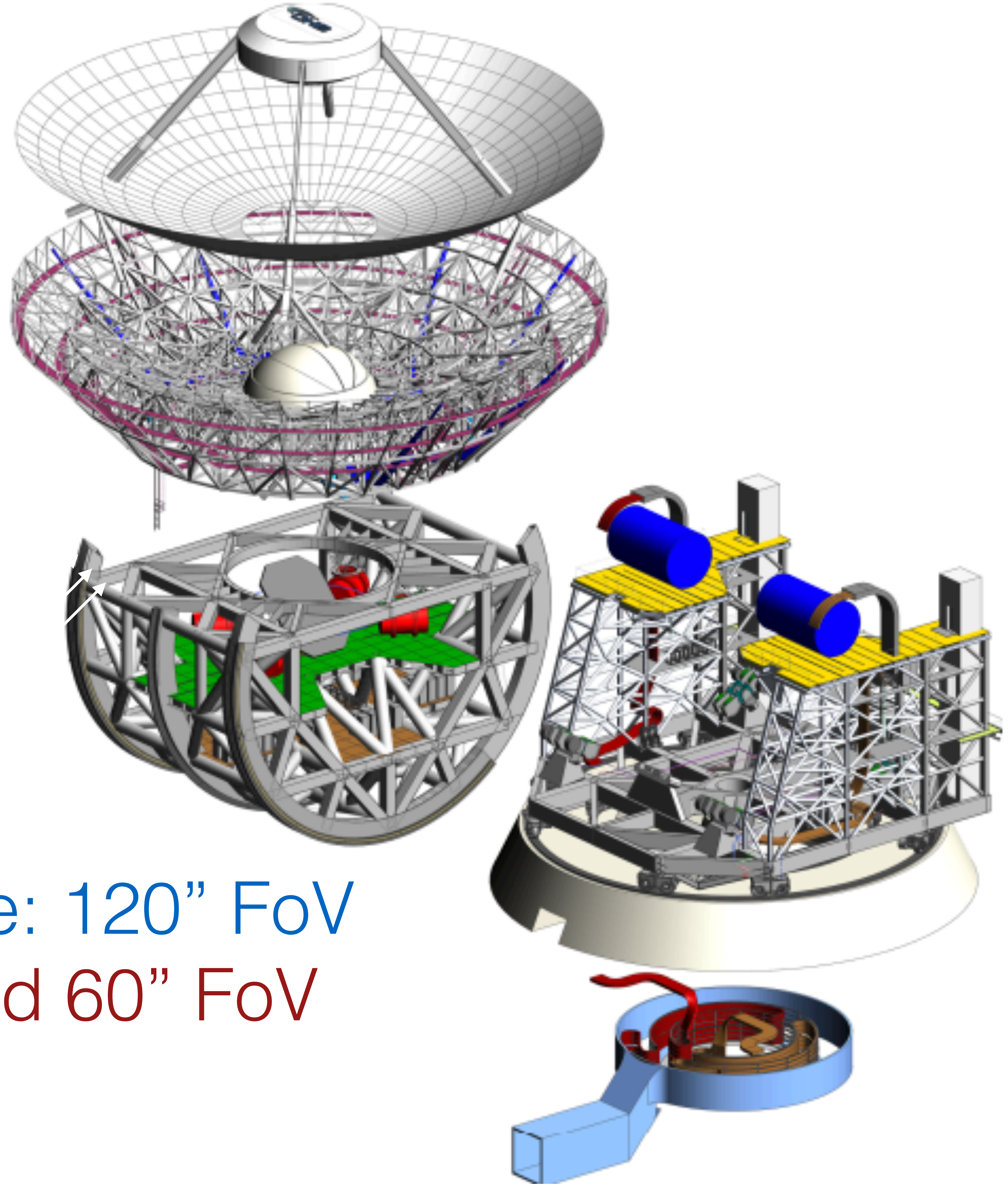
Parameter	Value
Wavelength (λ) range	0.3–10 mm
Primary mirror diameter	50 m
Field of view (FoV)	2° $(1^\circ)^{(\dagger)}$
Number of instruments	≥ 5
Effective focal length	≈ 100 m
Number of mirrors	≤ 4
Number of segments	≈ 400
Sizes of segments	≈ 5 m^2
Total collecting area	≈ 2000 m^2
Optical surface accuracy	20–30 μm
Surface coating	similar to ALMA
Optical design	Cassegrain-Nasmyth
Description of active optics	active surface + metrology
Actuator precision	≈ 10 μm
Mechanical pointing accuracy$^{(\star)}$	$2\farcs5$
Scan speed	$3^\circ \mathrm{s}^{-1}$
Acceleration	$1^\circ \mathrm{s}^{-2}$
Elevation (EL) range	20°–90°
Azimuthal (AZ) range	$\pm 270^\circ$
Mount type	AZ-EL
Support structure material	Steel and invar

AtLAST Field-of-view



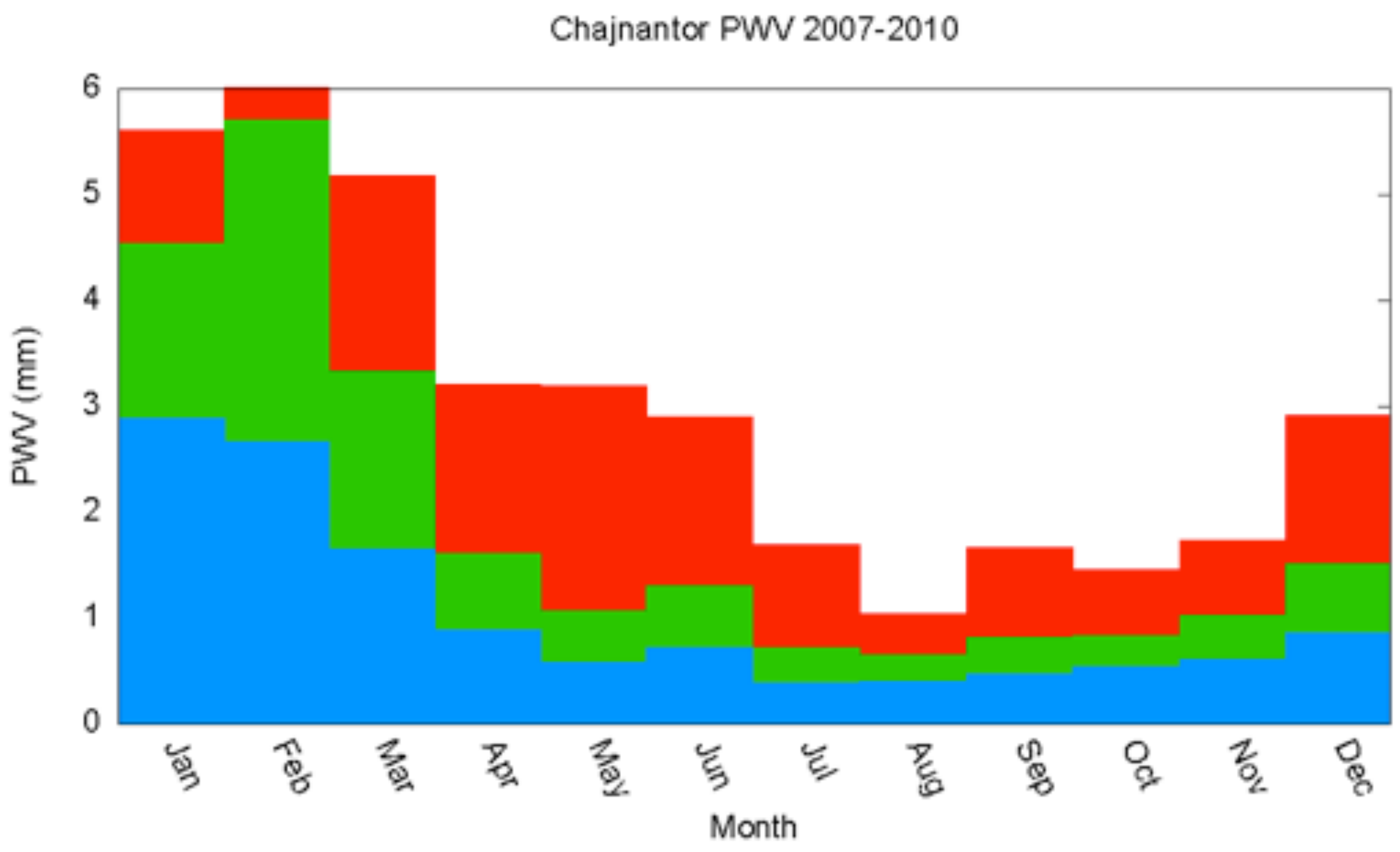
Blue: 120” FoV

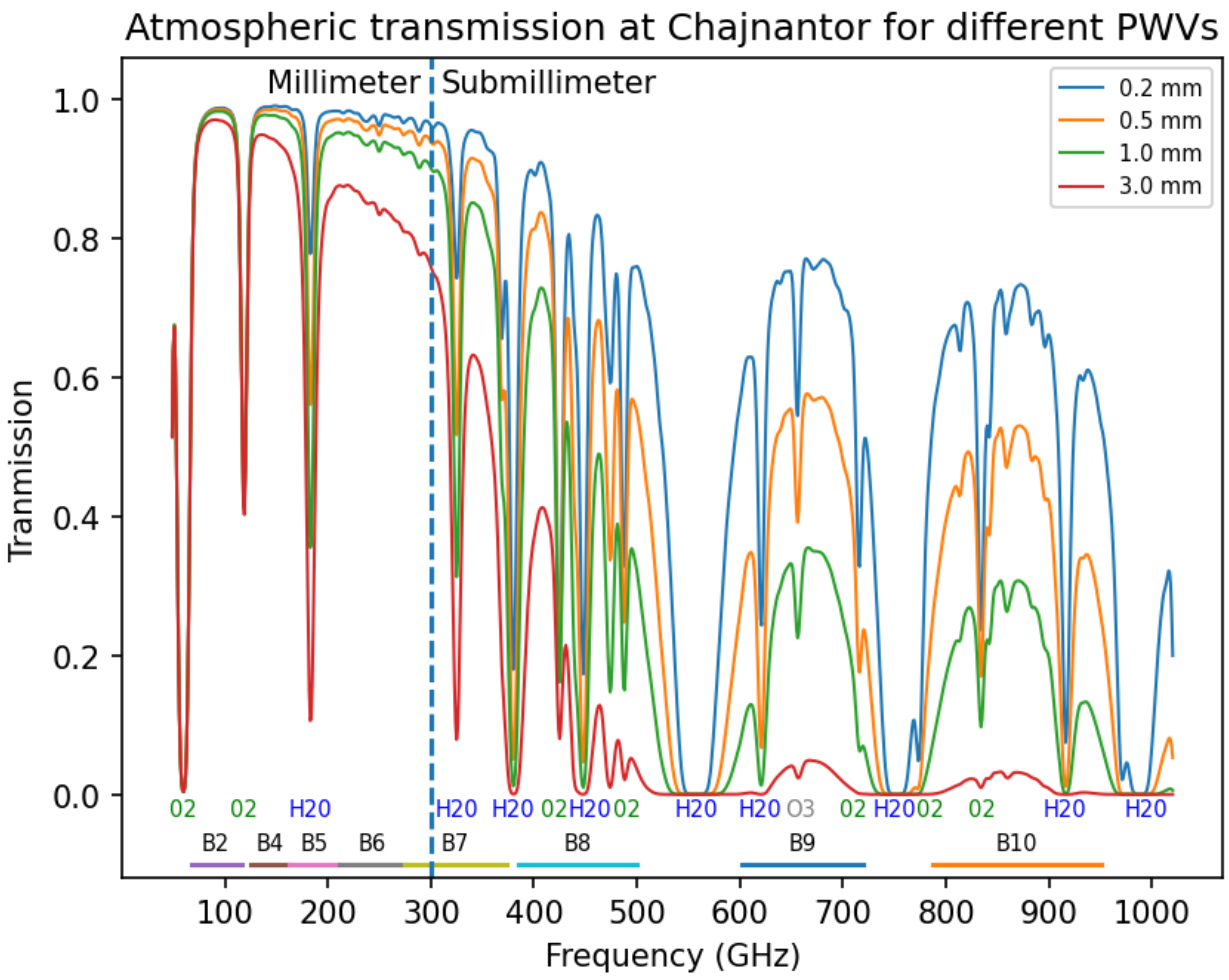
Red 60” FoV



Transmission at Chajnantor

Millimeter and submillimeter





Submillimeter single dish telescopes

1. Larger than 10 m
2. Capable of observing at submillimeter wavelengths (site, instruments and surface)
3. In operation, or in relocation

10 antennas worldwide (please let me know if I missed any)

5 antennas in the northern hemisphere, 3 in the southern, and 2 being relocated (to and within the southern hemisphere)

All of these antennas has contributed greatly to the submillimeter science.

Three frequency ranges

SEST *(AMT)*

Swedish-ESO Submillimetre Telescope *(Africa Millimetre Telescope)*

15 m, 78 - 268 (363) GHz

2350 m, La Silla, Chile

1987 - 2003, Sweden and ESO (and Finland)

In 2026 it will be relocated to The Gamsberg Mountain, in Namibia

First mm-telescope in Africa, and 20% of the time will be devoted to EHT observations

APEX

Atacama Pathfinder Experiment

12 m, 67 - 950 (1100, 1500) GHz

5050 m, Chajnantor, Chile

2004 - 2022: MPIfR, ESO, Sweden
2023- present: MPIfR

Essential for AtLAST: Staff with know-how and a platform for instrument testing.

IRAM 30m telescope

30 m, 100 - 375 GHz

2850 m, Granada, Spain

1984 - present: IRAM

Also a possible platform for testing AtLAST instrumentation

LMT

Large Millimeter Telescope

50 m, 75 - 280 (350) GHz

4850 m, Sierra Negra, Mexico

2011 - present: INAOE and Amherst

SPT
South Pole Telescope

10 m, 90 - 220 (345) GHz,
offset Gregorian design

2900 m, South Pole

2007 - present: NSF

JCMT

James Clerk Maxwell Telescope

15 m, 86 - 680 GHz

4092 m, Mauna Kea, Hawaii

1987 - 2015: UK, Canada, Netherlands
2015 - present: East Asian Observatory

SMT (formerly HHT)

UArizona ARO Submillimeter Telescope

10 m, 205 - 370 GHz

3170 m, Arizona, USA

1993 - 2004: MPIfR and ARO
2004 - present: ARO

GLT

Greenland Telescope

84 - 377 GHz

76 m, Pituffik Space Base, Greenland. Plans to move to Summit Station (3210 m)

2017 - present: ASIAA, CFA, NRAO, and Haystack

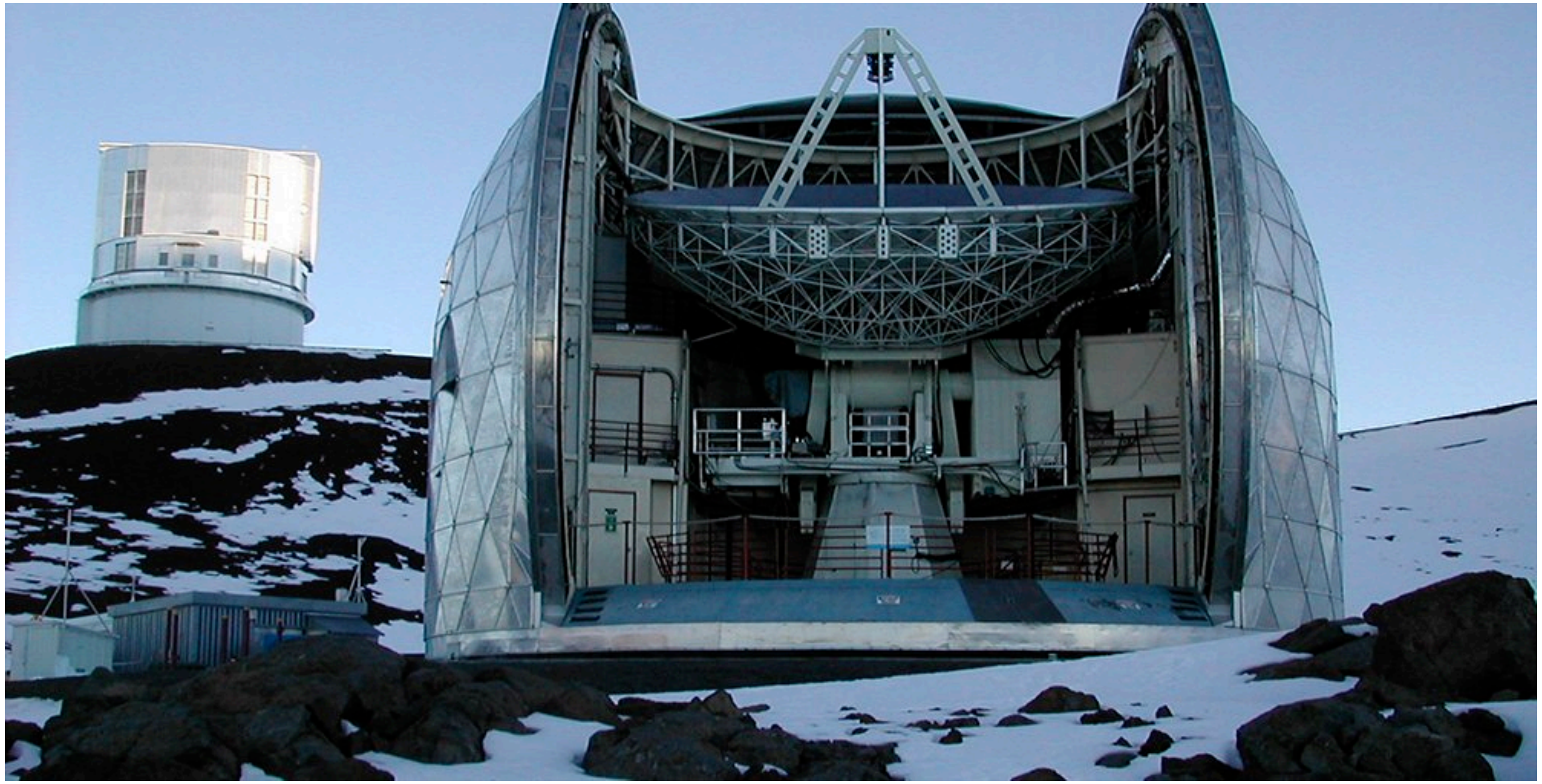
CSO (LCT)

Caltech Submillimeter Observatory (Leighton Chajnantor Telescope)

10.4 m, 177 - 920 GHz

4140 m, Mauna Kea, Hawaii
dismantled July 2024, to be relocated to the CCAT site, Chajnantor, Chile (5600 m), operations start 2027

1987 - 2015 (Caltech)



ASTE

Atacama Submillimeter Telescope Experiment

10 m, 240 - 460 (950) GHz

4860, Pampa La Bola, Chile

2004 - present: NAOJ

The only antenna not in the EHT array

Throughput - AΩ

Throughput = Antenna area (m^2) x Field-of-view area (deg^2)

- For APEX:
  - 12 meter and 18 arcminutes:
  - Throughput (AΩ) = 8 m^2deg^2
  - Beams at 1 mm: 2700

- For APEX Nasmyth Cabin:
  - 12 meter and 35 arcseconds
  - Throughput (AΩ) = 0.01 m^2deg^2
  - Beams at 1 mm: 3

Antennas @ 1mm (300 GHz)

Comparison to capable single dish antennas

	LMT	IRAM 30m	APEX (+6)	SPT	AtLAST
Frq range (GHz)	75 - 350	100 - 375	150 - 950	75 - 300	30 - 1000
Wl range (mm)	4 - 0.85	3 - 0.8	2 - 0.2	4 - 1	10 - 0.3
Diameter (m)	50	30	12	10	50
FoV (arcmin)	1.5	7	18	110	120
Surf acc (mu)	70	65	15	25	25
HPBW (“)	5.0	8.3	20.6	24.8	5.0
AΩ (m^2 deg^2)	1	8	8	210	6100
Beams at 1mm	330	2600	2700	71 000	2 100 000

Antennas @ ALMA B9 (0.44 mm, 681 GHz)

Comparison to capable single dish antennas

	ASTE	LCT	JCMT	APEX	AtLAST
Instruments	ASTE camera	?	SCUBA2	SEPIA, CHAMP, ARTEMIS	AtLASTCAM?
Diameter (m)	10	10.5	15	12	50
FoV (arcmin)	7.5	8	12	18	60
HPBW (“)	10.9	10.4	7.3	9.1	2.2
AΩ (m^2 deg^2)	1.0	1.2	5.6	8	1542
Beams at 0.44 mm	1700	2140	9800	14 200	2 730 000

Antennas @ ALMA B10 (0.35 mm, 857 GHz)

Comparison to capable single dish antennas

	LCT	APEX	AtLAST
Instruments	?	CHAMP, ARTEMIS, A-MKID	AtLASTCAM
Diameter (m)	10.5	12	50
FoV (arcmin)	8	18	60
HPBW (“)	8.3	7.2	1.7
AΩ (m^2 deg^2)	1.2	8	1542
Beams at 0.35 mm	3400	22 400	4 300 000

AtLAST for ALMA

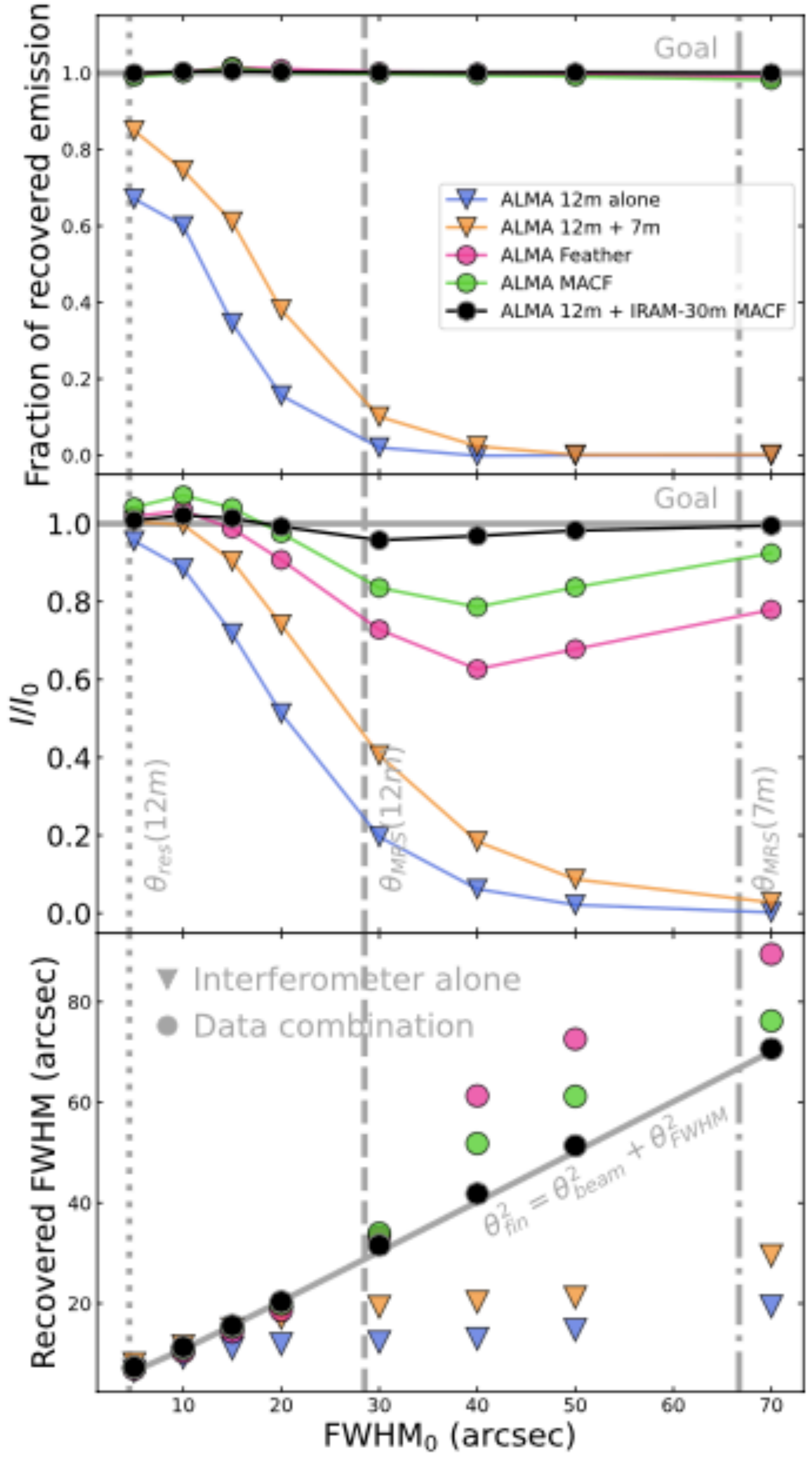
A study focused on impact on ISM studies

AtLAST will be crucial for future ISM studies, both as stand-alone and in combination with ALMA

All derived physical properties (column densities, masses and FWHMs) of resolved ISM structures are strongly biased in interferometric alone observations even below the MRS.

The true sky emission is only recovered after data combination including short-spacing information

The combination of ALMA data with larger SD (such as AtLAST) produces significantly better results (<10% error) than with current 7m + TP data.



Bonanomi et al., accepted, arXiv 2405.09290

AtLAST for EHT

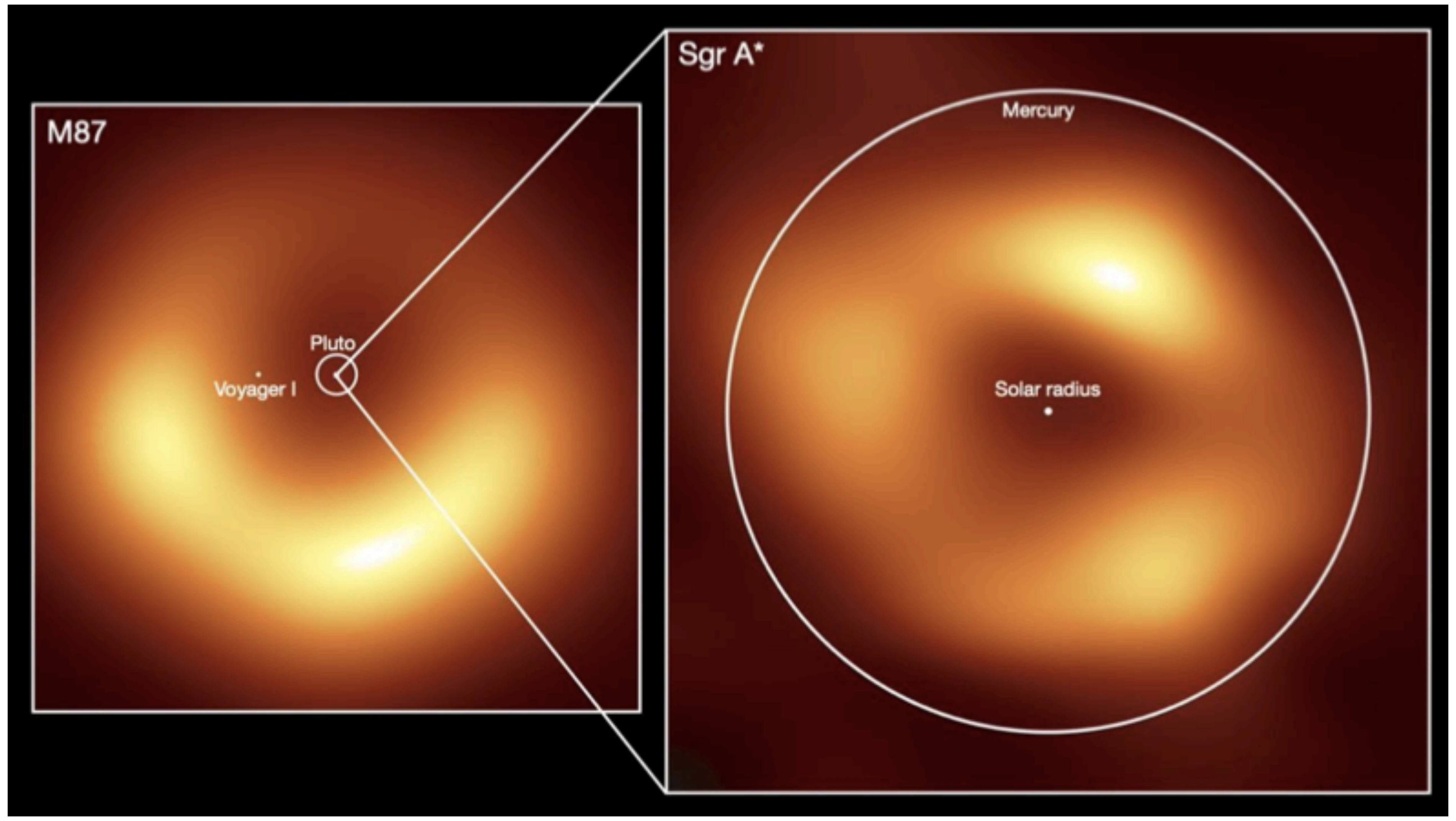
and GMVA

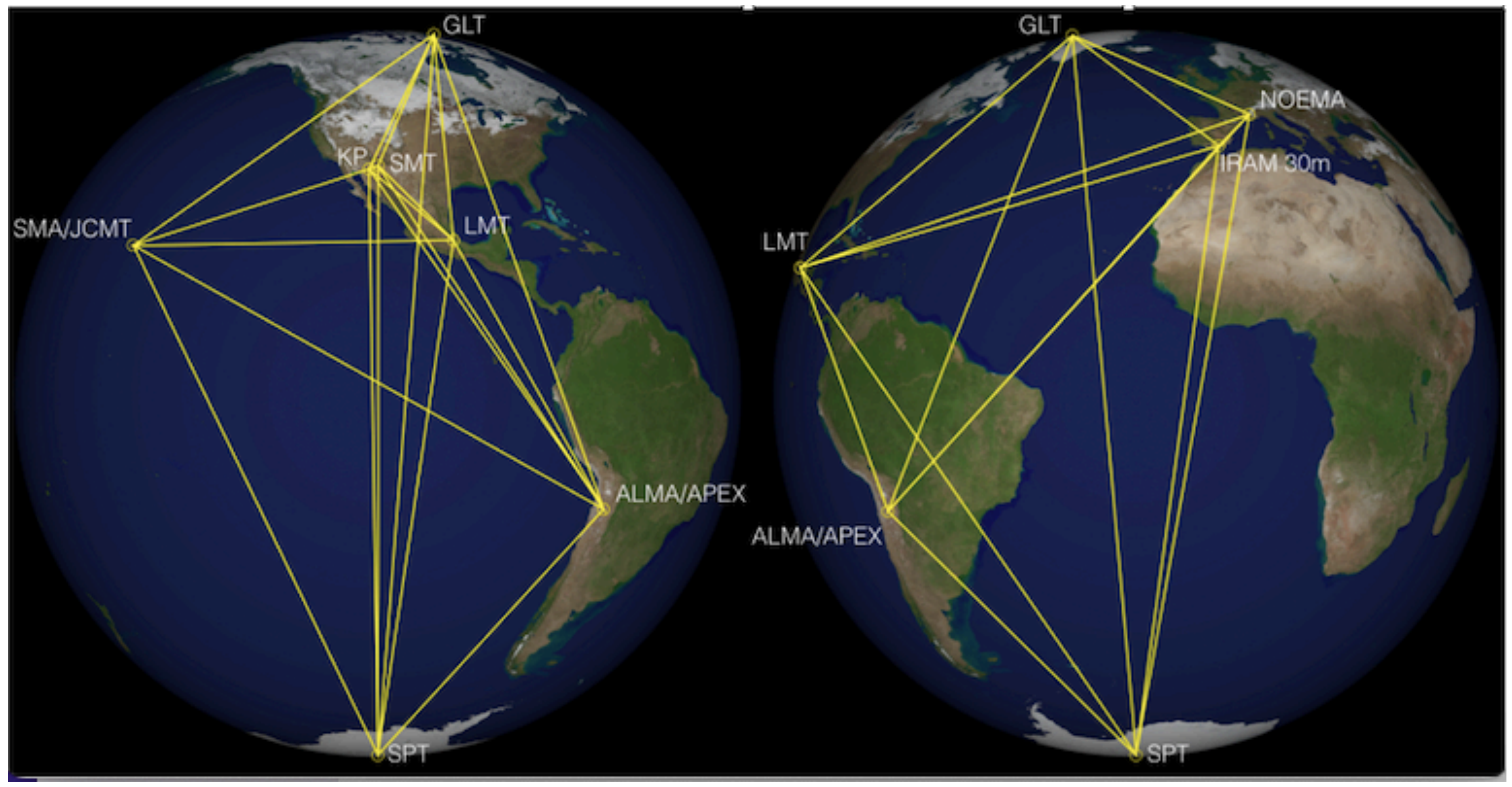
A key design aspect of the EHT array is the use of small and large aperture telescopes to form a dense interferometric network. The large-aperture telescopes will work as sensitive **anchor stations.**

A large and filled aperture telescope at Chajnantor, with its excellent observing conditions, will play a vital role as a high-sensitivity key anchor station will potentially have better time and frequency agility than phased ALMA.

AtLAST will have a system-equivalent flux density (SEFD) that is going to 30% of ALMA, slightly better than NOEMA, and orders-of-magnitude better than other most other EHT stations (e.g. APEX)

AtLAST thus has strong potential to be a key element for next generation millimeter/submillimeter VLBI arrays and allow them to achieve a range of new science goals requiring highly sensitive, multi-frequency, time-agile observations.





Akiyama et al. Millimeter/Submillimeter VLBI with a Next Generation Large Radio Telescope in the Atacama Desert. Galaxies (2022)

Summary

AtLAST will provide

A large mm and submm single dish facility in the southern hemisphere

Unprecedented angular resolution data with a filled aperture at frequencies > 400 GHz

With orders-of-magnitude more receivers, an unprecedented mapping speed

A platform a tremendous throughput, which will stimulate mm and submm receiver development

Improve data quality of other projects, such as ALMA and EHT