Funded by
the European Union

This project has received funding from the European Union's Horizon Europe and Horizon2020 research and innovation programmes under grant agreements No. 101188037 (AtLAST2) and No. 951815 (AtLAST). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Research Executive Agency. Neither the European Union nor the European Research Executive Agency can be held responsible for them

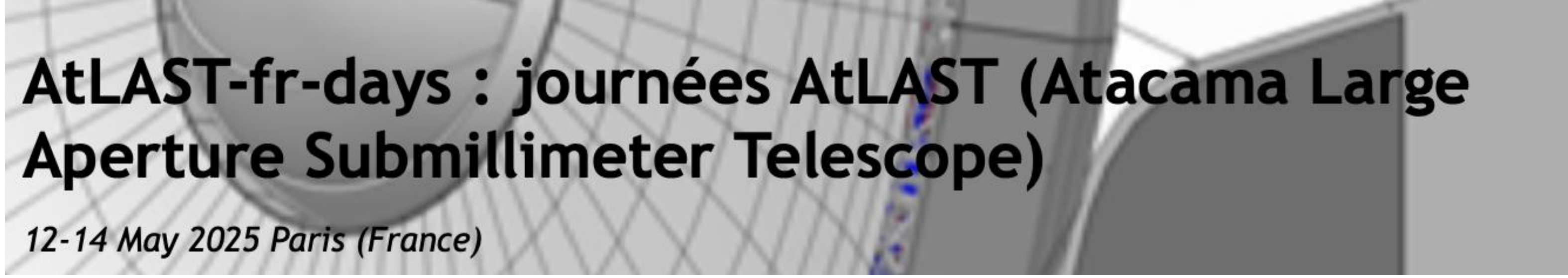
The Atacama Large Aperture Submillimeter Telescope (AtLAST)

Prof. Claudia Cicone - University of Oslo

Project Coordinator

Paris, 12 May 2025

Guiding questions



1. Status of the AtLAST Project
   - What progress has been made at the European level in defining the scientific and technical scope of AtLAST? → My talk + Tony's, Carlos' and Sabrina's will cover this
   - What are the current timelines and milestones for its development, including its inclusion in the ESO strategic roadmap? → I will cover milestones of EU project(s). French community can really help with ESO application, we should discuss this

2. Scientific Potential of AtLAST
   - What transformational scientific breakthroughs can AtLAST enable across disciplines, particularly in the areas of star formation, galaxy evolution, astrochemistry, and cosmology? → Need contribution from French community! This is ongoing work, what has been done so far was aiming at setting technical requirements
   - How can AtLAST serve as a multi-disciplinary instrument, engaging scientists beyond the traditional submillimeter and millimeter-wave astronomy communities? → These are key goals of the AtLAST EU project(s) see this + Tony's talk, we need input + help from French community

5. Environmental and Societal Considerations
   - Is it responsible to develop a large-scale observatory in the context of a global climatic crisis? → Central question for us, introduced in this talk and further covered in Sabrina's
   - How does AtLAST integrate environmental sustainability into its design, particularly in its use of renewable energy and its goal to minimize environmental impact? → Introduced in this talk, see also Sabrina's and Tony's talks
   - Can AtLAST serve as a model for rationalizing global observatory infrastructure, reducing redundancy while enhancing global scientific output? → This is among the stated objectives of the EU project(s), will touch on this but we need input and opinions from French users and community

+ 0. AtLAST's rationale → I will start my talk by addressing this

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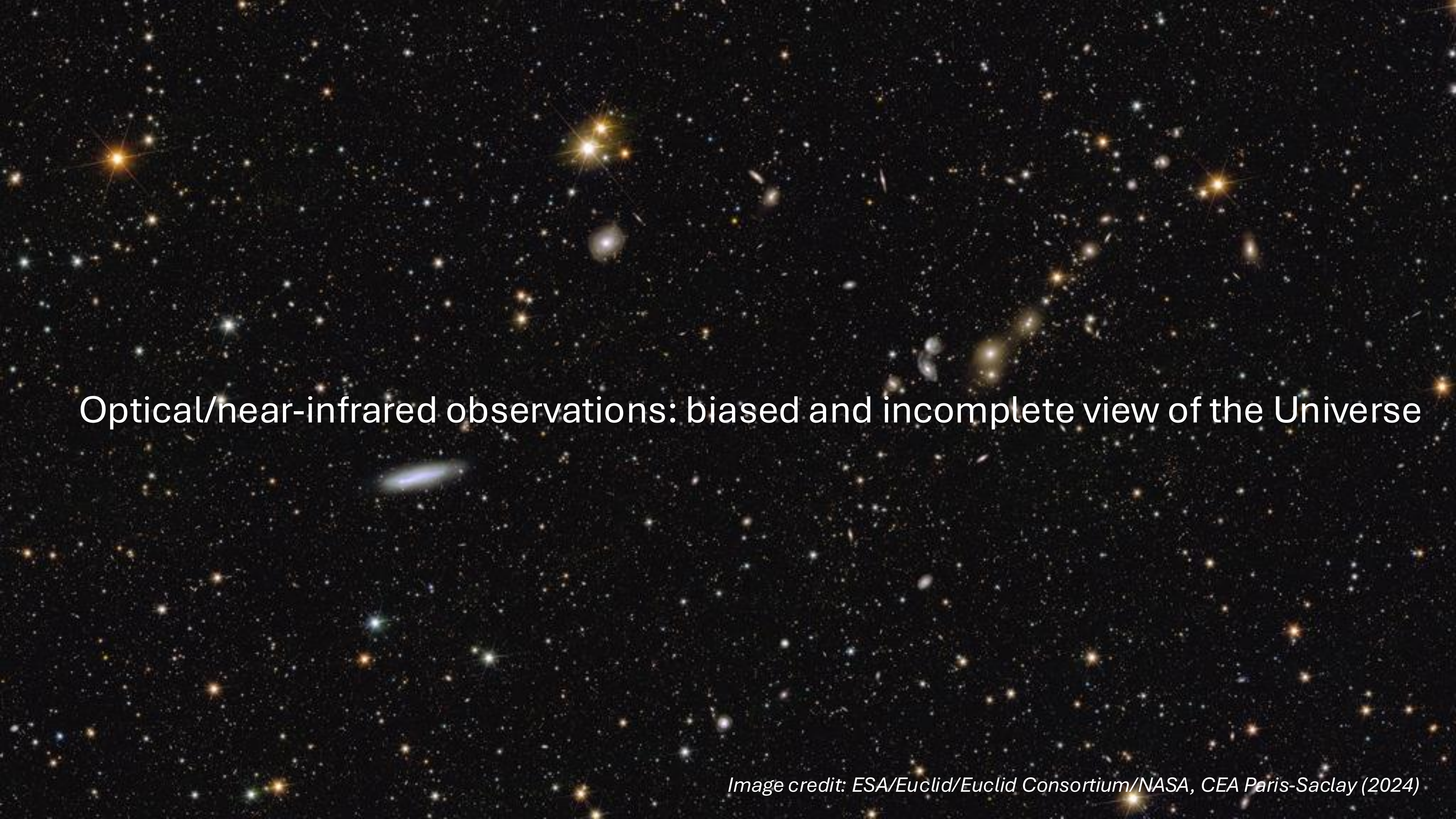
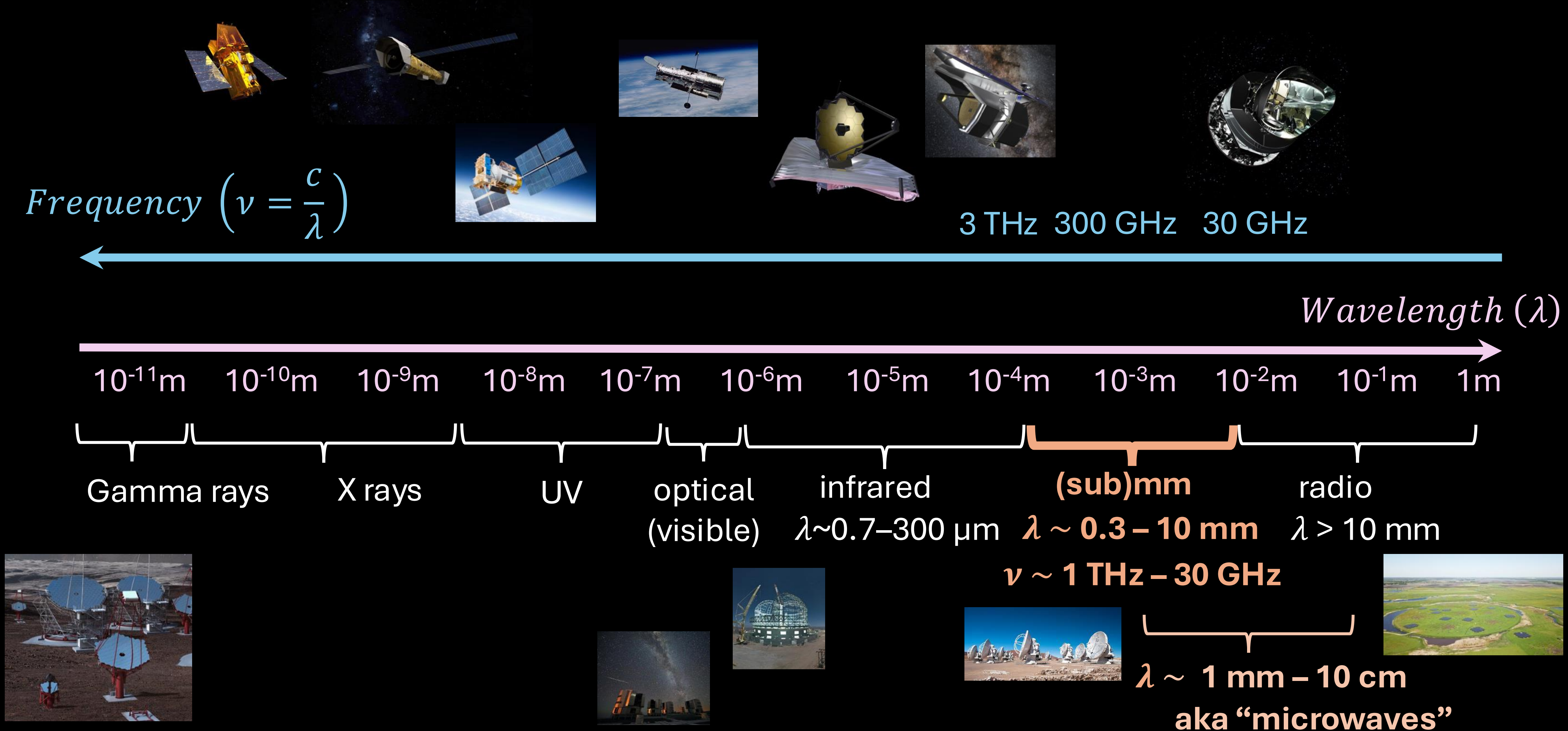
Part I – AtLAST’s rationale



Optical/near-infrared observations: biased and incomplete view of the Universe

Image credit: ESA/Euclid/Euclid Consortium/NASA, CEA Paris-Saclay (2024)

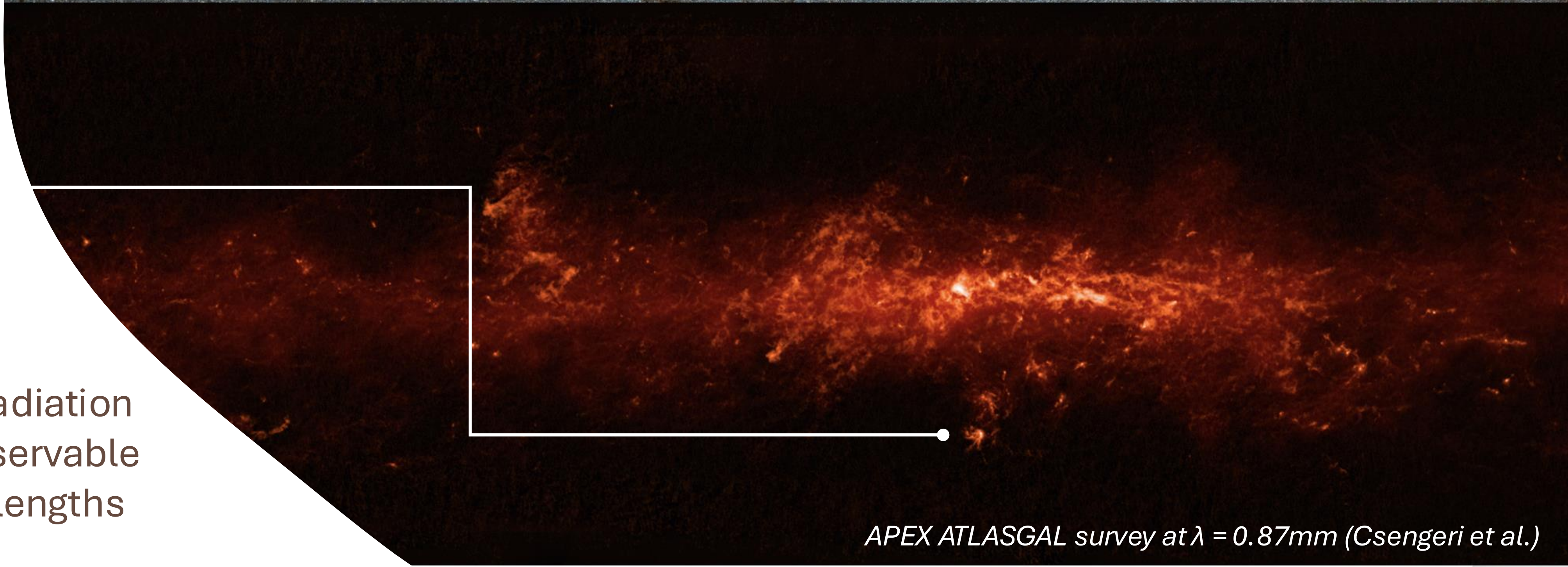
The sub-millimeter / millimeter window



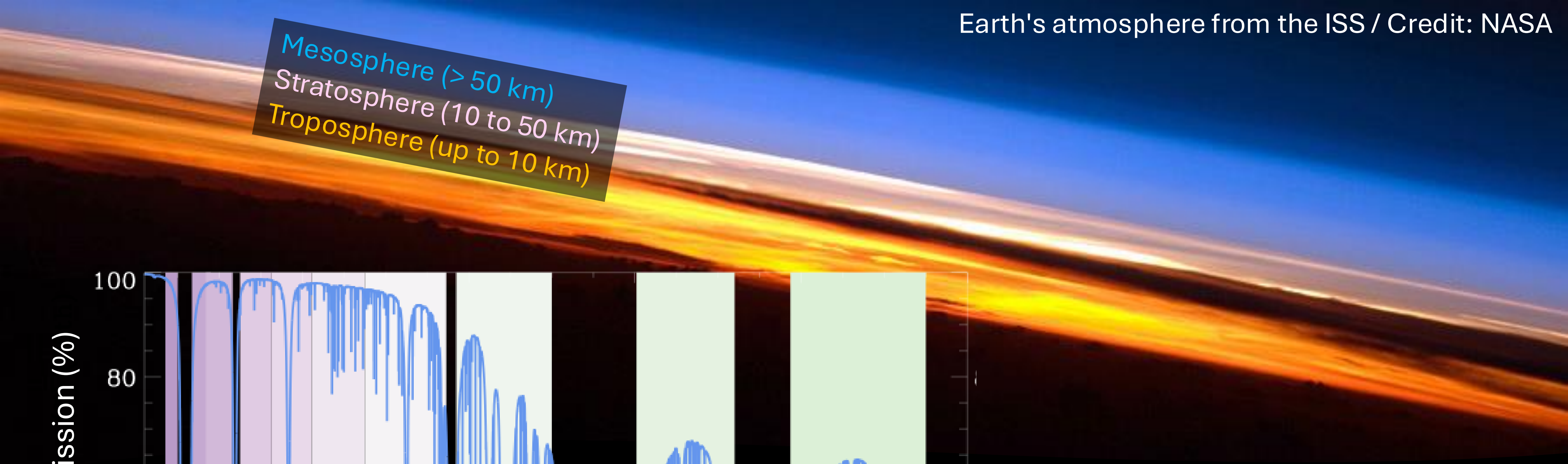
The Milky Way

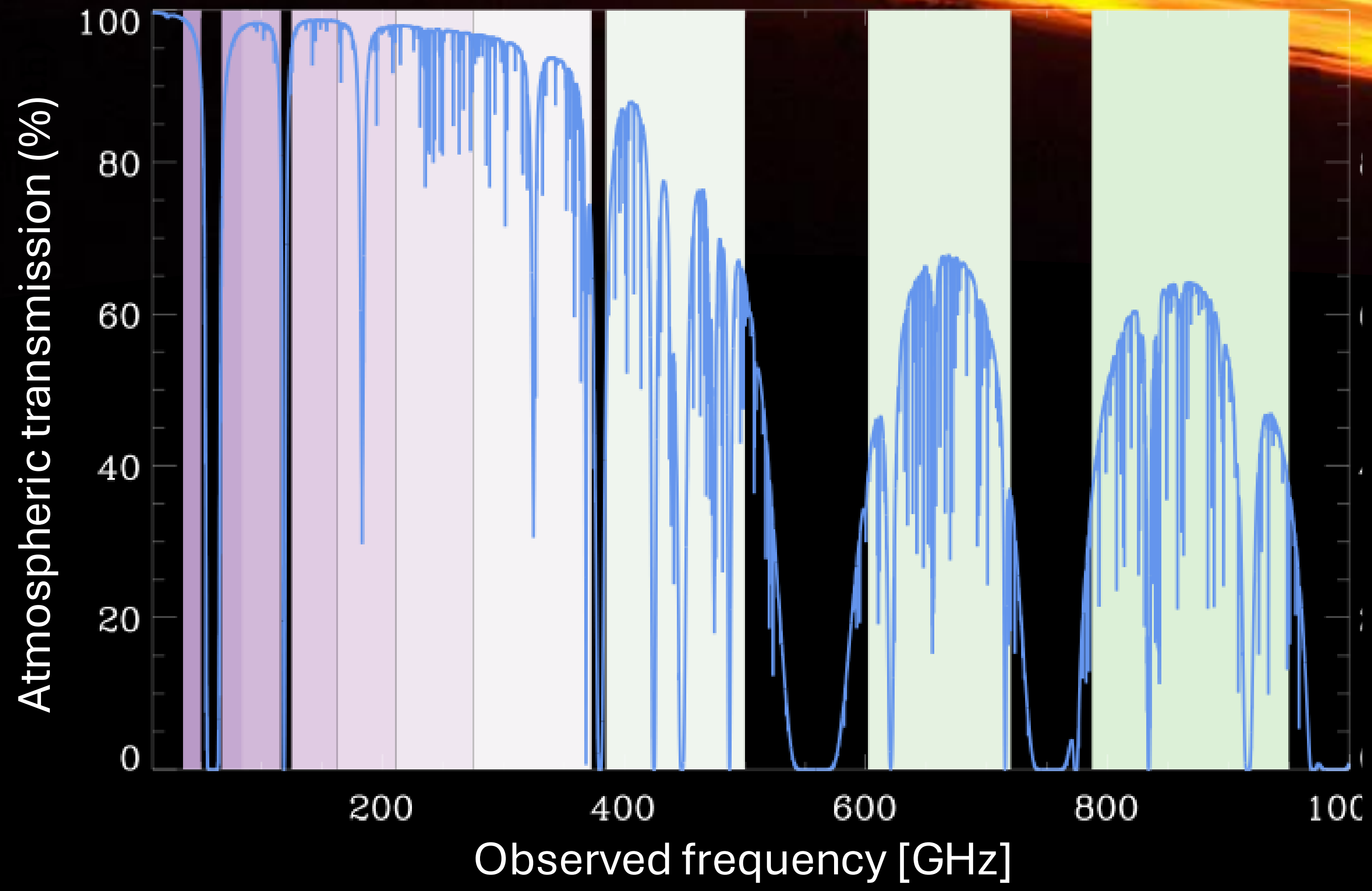
Regions that are rich in gas and dust, especially if cold and dense, are invisible in UV/optical/IR light

The same dust and gas that absorb optical/IR light shine in the (sub-)mm



About 50% of the radiation from galaxies is observable at (sub-)mm wavelengths





Water and other molecules in the troposphere absorb (sub-)mm light

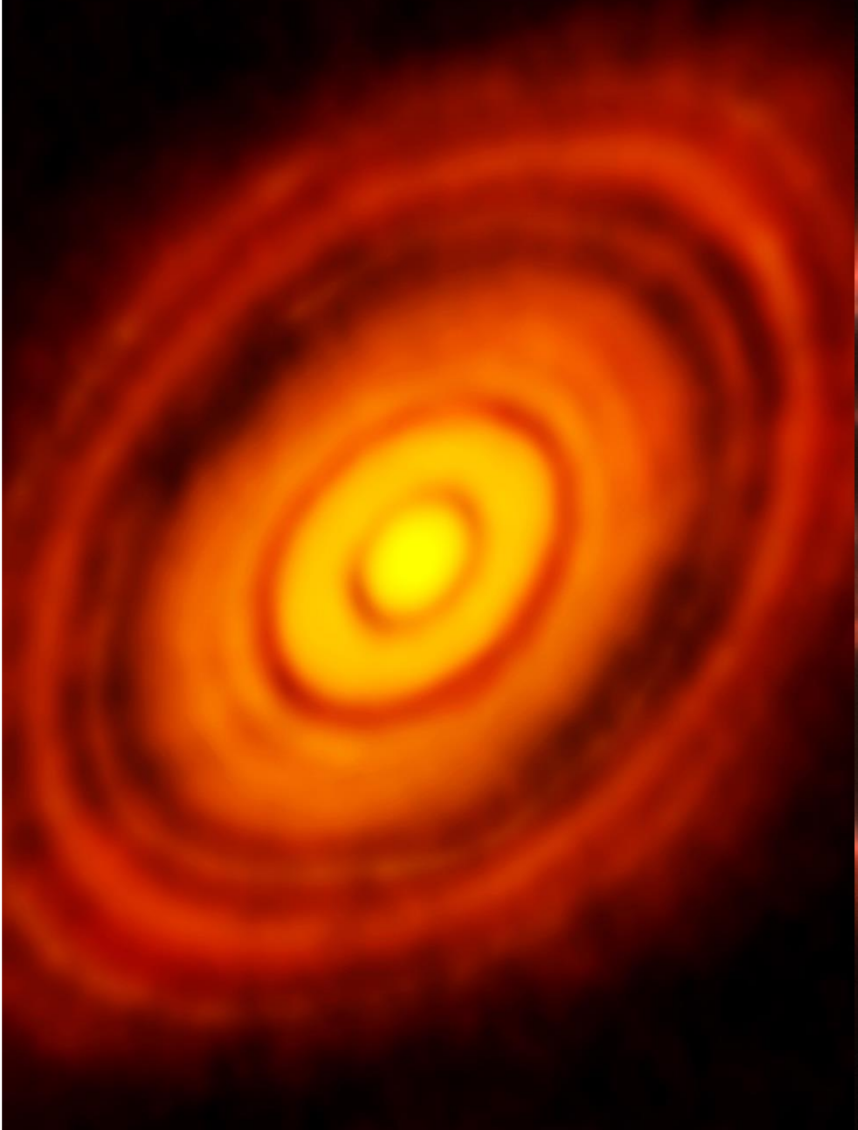
Astronomical observations are only possible from high, extremely dry sites, especially at high frequencies > 300 GHz (λ < 1 mm)

The Chajnantor Plateau in the Chilean Atacama desert

- ~ 5050 meters above sea level
- Extremely dry site: sub-mm observations possible all year long
- Hosts the best sub-mm observatories in the world: **ALMA**, APEX, ASTE, and, in a few years, CCAT

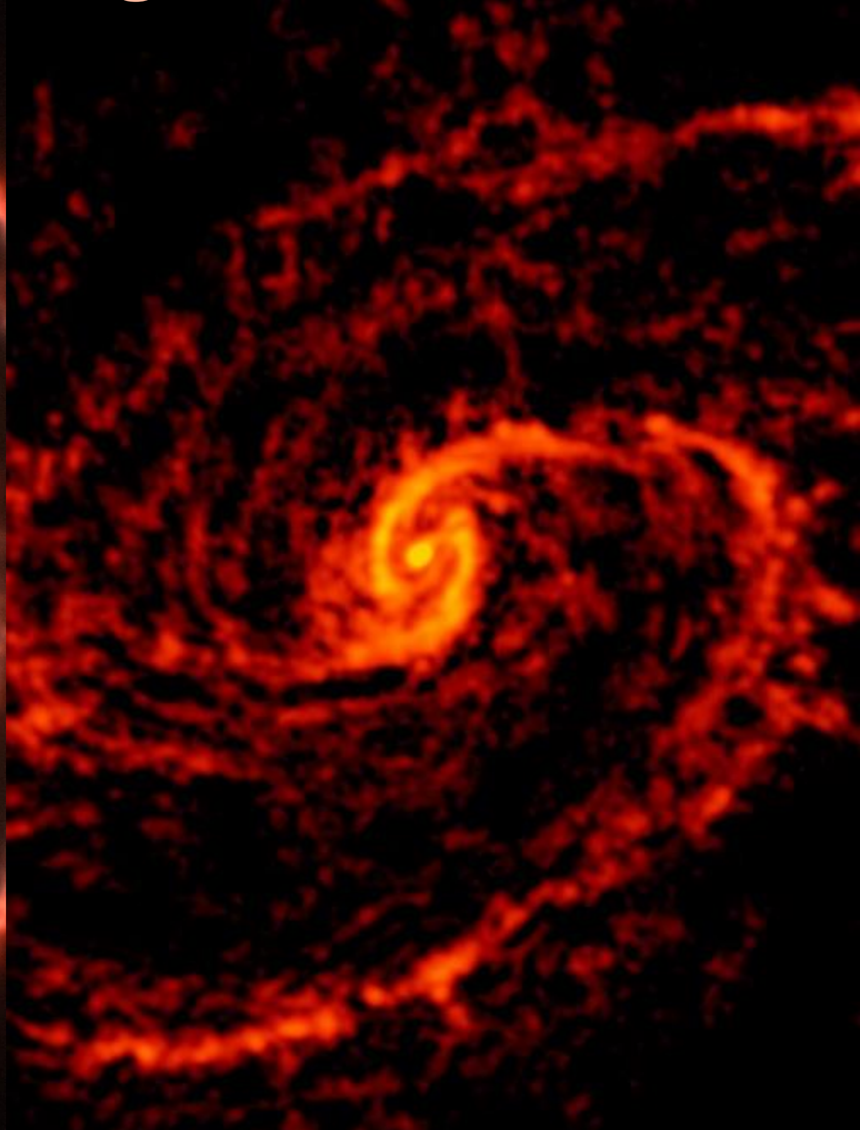
Credit: AtLAST team (P. Gallardo)

ALMA's detailed view: exceptionally high angular resolution



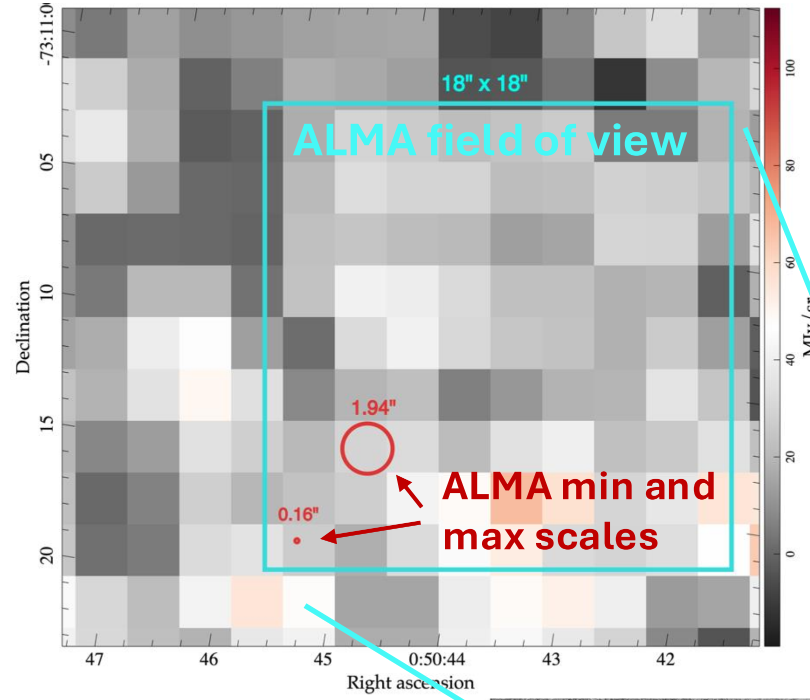
HL Tauri protoplanetary disk
Credit: ALMA (ESO/NAOJ/NRAO)

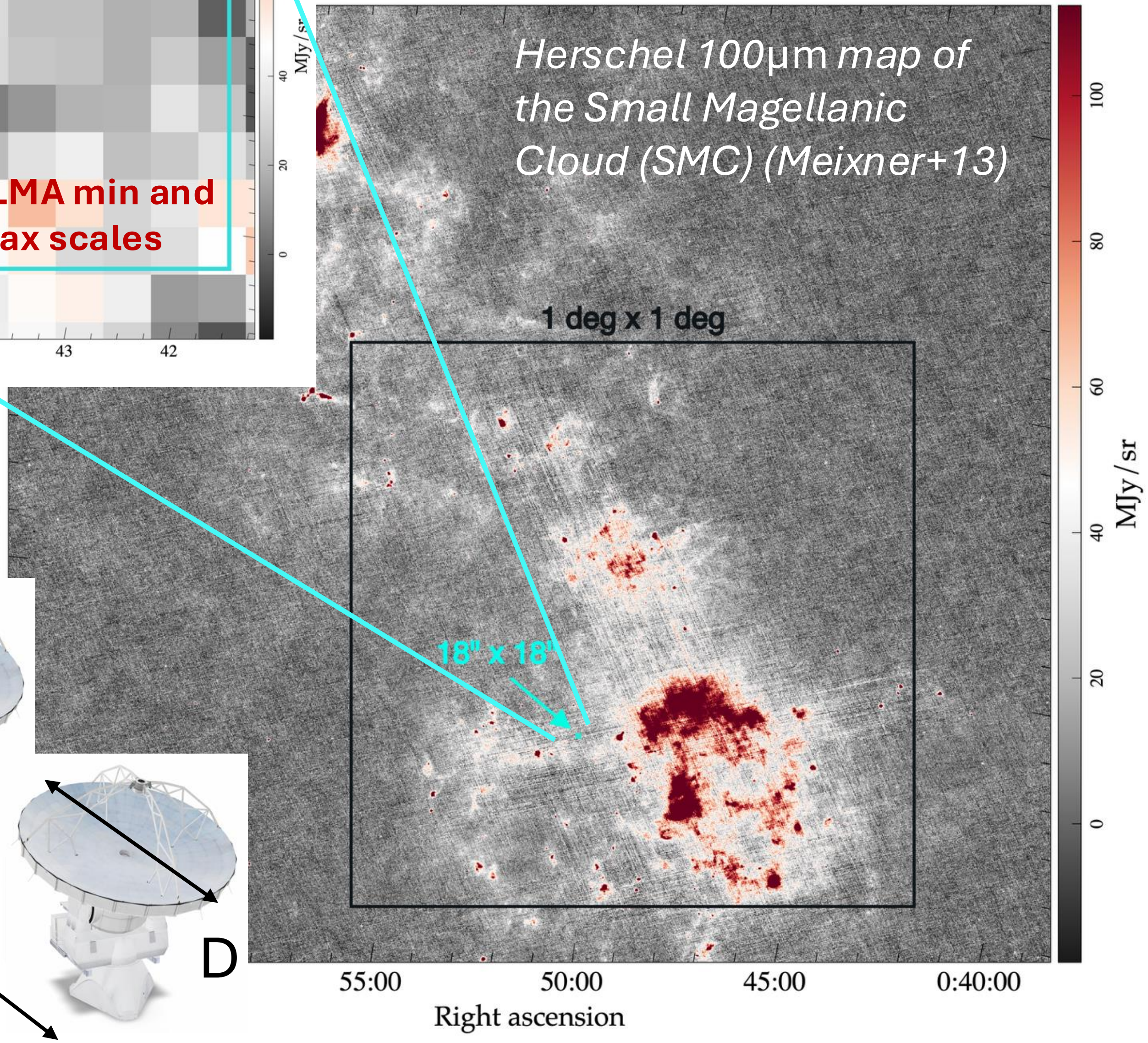
Red giant star R Sculptoris
M. Maercker et al.

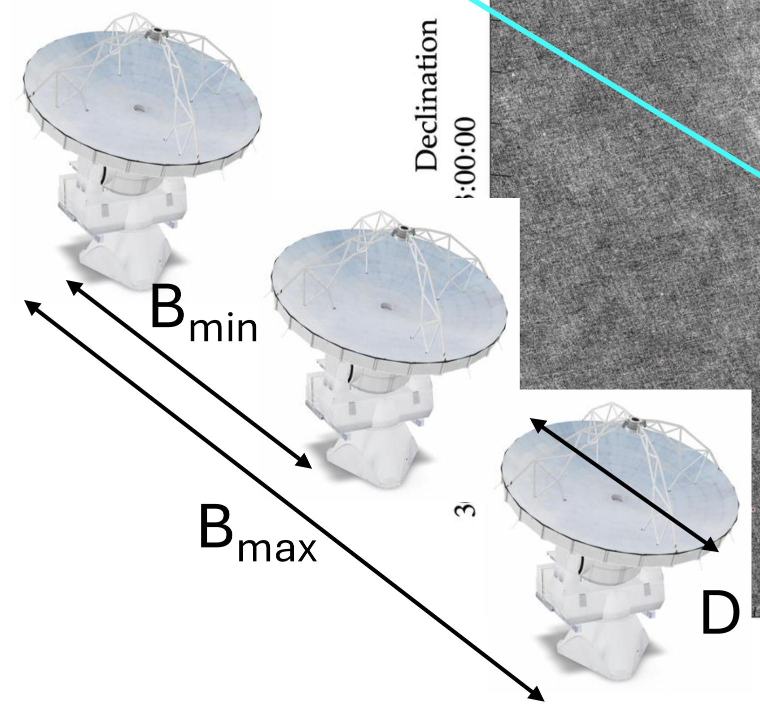


The galaxy NGC4321
PHANGS-ALMA survey, B. Saxton

ALMA is great at resolving small details but cannot capture large scales nor efficiently map nearby galaxies







ALMA is sensitive to a range of scales between $\Delta\theta_{min} \sim \lambda / B_{max}$ and $\Delta\theta_{max} \sim \lambda / B_{min}$ within an area of the sky that is $\Delta\theta_{field\ of\ view} \sim \lambda / D$

At λ = 870 µm (345 GHz), in the intermediate C-5 array configuration (B_{min}=15m, B_{max}=1.4km):

$\Delta\theta_{min} \sim 0.16''$

$\Delta\theta_{max} \sim 1.94''$

$\Delta\theta_{field\ of\ view} \sim 18''$ (5.5 pc)

→ impossible for ALMA to observe nearby galaxies such as the SMC which are the local benchmarks to test our theoretical models

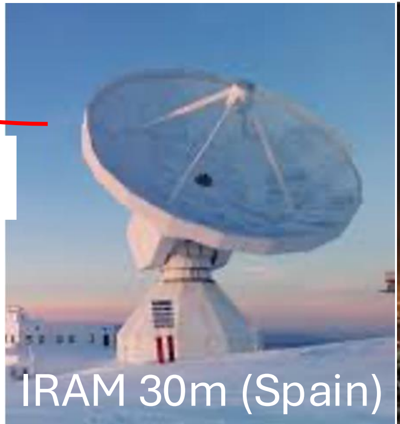
Why AtLAST? Filling the gap(s)

1. Gap in angular scales from ALMA (< 1 '') to current single-dish sub-mm telescopes APEX, CCAT etc (several 10'' up to ~ arcmin)
2. Gap in sensitivity: large aperture needed to discover/detect faint sources
3. Gap in sub-mm capabilities: existing large aperture (D $\gtrsim$ 30m) single dishes (IRAM30m, LMT) cannot observe λ <1mm due to their site and/or design
4. Gap in mapping speed: wide-field telescopes such as CCAT and SO have small apertures: lower angular resolution (~arcmin) and sensitivity
5. Synergy with ALMA: AtLAST can improve ALMA's outputs by (i) providing new targets (ii) single-dish/interferometric data combination (iii) participating in long-baseline interferometric campaigns (e.g. Event Horizon Telescope)

AtLAST here!

- discover faint sources
- high-res, multi-λ surveys
- deep maps
- time-domain/transients
- Improved EHT/VLBI

λ <1mm



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Part II – Status of AtLAST

1st EU project: H2020 AtLAST design study (2021-24)

HORIZON 2020

Towards an Atacama Large Aperture Submillimeter Telescope

Fact Sheet | Results in Brief | Reporting | Results

DE EN ES FR IT PL

Scanning the universe with submillimetre astronomy

The design of a state-of-the-art telescope will help astronomers answer some key questions about the universe – while addressing energy demand and local community needs.

SPACE

© Diogo José/stock.adobe.com

Project Information

AtLAST
Grant agreement ID: 951815

Project website

DOI
10.3030/951815

Project closed

EC signature date
3 July 2020

Start date 1 March 2021
End date 31 August 2024

Funded under
EXCELLENT SCIENCE - Research Infrastructures

Total cost
€ 3 519 461,25

EU contribution
€ 3 519 461,25

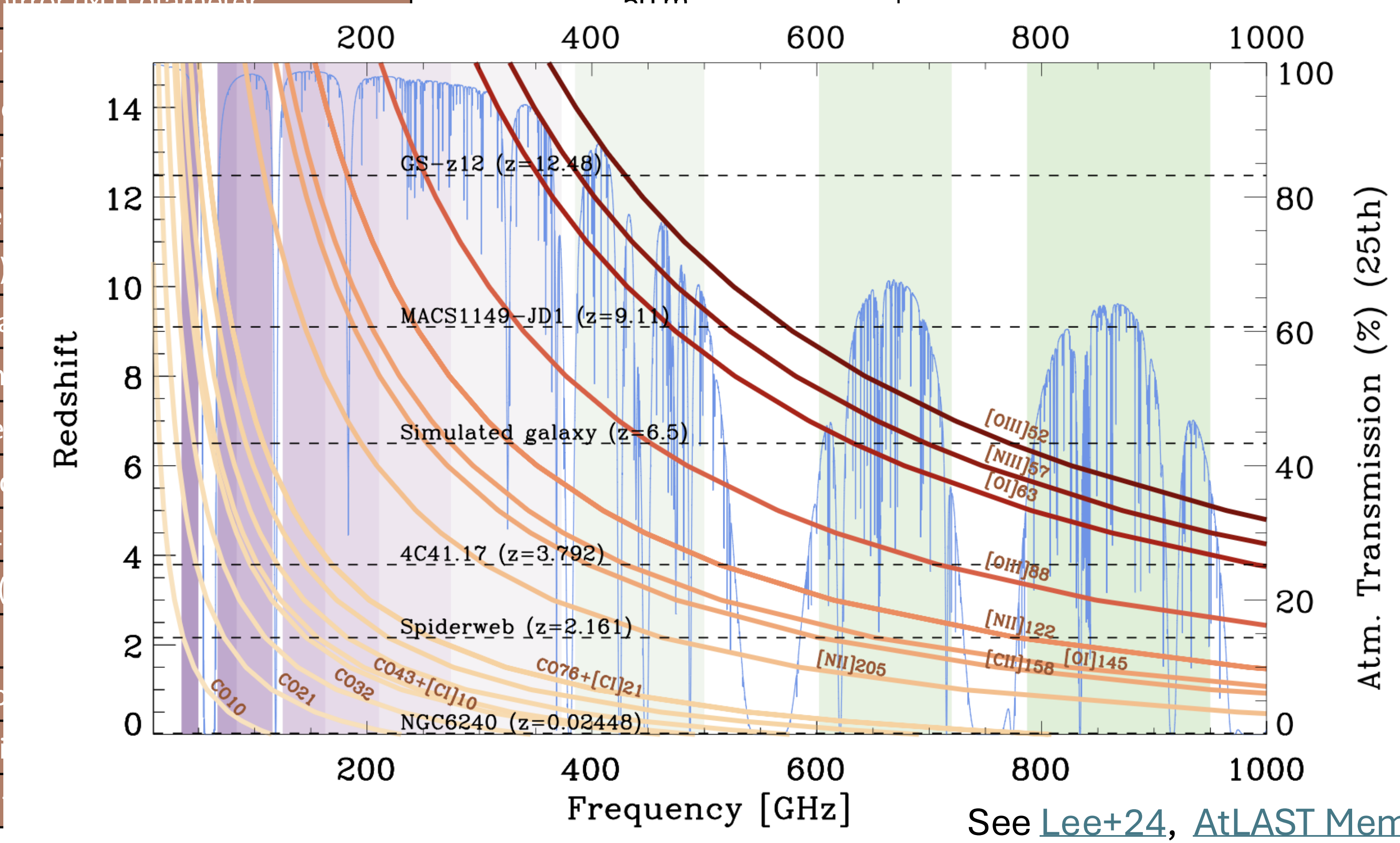
Coordinated by
UNIVERSITETET I OSLO
Norway

- >32 refereed papers in fields of **Astrophysics** (theoretical, experimental), **Renewable Energy,** and **Statistics** (machine learning):
  - 8 science case papers in Open Research Europe collection
  - Telescope design: Mroczkowski et al. (2025, A&A)
- **8 conference papers** (SPIE, URSI) covering optical design, instrumentation, etc.
- **9 AtLAST memos**
- **1 book chapter** in "Energy justice in Latin America"
- **4 PhD + 8 Master** theses
- **43 person years** (FTE)
- **76 team members** by 2024

Check all public outputs on the AtLAST website: Publications, Memo series

AtLAST’s technical specs: what drives them?

Parameter	Value
Wavelength (λ) range	0.3 -10 mm
Primary mirror (M1) diameter	50 m
Secondar	
Field of vi	
Number o	
Optical de	
Night(Day)	
Mechanica	
Astronom	
Solar obse	
Scan spee	
Accelerat	
Elevation (	
Azimutha	
Mount typ	
Site locati	
Site eleva	



1) FIR lines shift into sub-mm windows at high-z: high-z frontier of the Universe (synergy with JWST, ELT)

2) High frequency lines (high-J CO, [CI], etc) in local Universe: current facilities struggle with sensitivity (except ALMA but only for small areas ~1”) and with FoV → missing flux and/or non detections

3) HDO $1_{1,1} – 0_{0,0}$ line at 894 GHz of interest for studying origin of water in comets Cordiner+24

See Lee+24, AtLAST Memo#5 (Booth et al. 2024)

AtLAST’s technical specs: what drives them?

Parameter	Value
Wavelength (λ) range	0.3 -10 mm
Primary mirror (M1) diameter	$\boxed{50\ \mathrm{m}}$
Secondary mirror (M2) diameter	12 m
Field of view (FoV)	2°(1°)
Number of instrument mount points	6
Optical design	Ritchey-Chrétien
Night(Day)-time half wavefront error	20 (30) μm
Mechanical pointing accuracy	2.5 arcsec
Astronomically-corrected pointing	< 0.5 arcsec
Solar observations	Yes
Scan speed	3°/s
Acceleration	1°/s²
Elevation (EL) range	20° to 90°
Azimuthal (AZ) range	$\pm$ 270°
Mount type	AZ-EL
Site location	22°58'52"S, 67°45'56"W
Site elevation	≈5000 m

- D=50m → 1.5” at 350 μm; 3.5” at 0.8 mm (diffraction-limited)

- D = 50m to beat confusion limit of high-z galaxy surveys and resolve >80% of Cosmic Infrared Background at λ<1.3mm. Detect typical (e.g. MW-mass) galaxies from z=0 to z=5 i.e. over 90% of age of Universe (van Kampen+24)
    - >x10,000 times lower conf limit than Herschel
    - x100 lower conf limit than 10m-class SD
    - x1.8 times lower conf limit than a 40m dish

- D = 50m to resolve star forming cores (0.1pc size) out to 4 kpc distance in our Galaxy (Klaassen+24)

- D>43m needed for proper overlap in visibilities between ALMA and AtLAST for data combination (Frayer, 2017)

See AtLAST Memo#5 (Booth et al. 2024)

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Azimuthal (AZ) range	± 270°
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Site elevation	≈5000 m

Structures > FoV get filtered out:

- Cold gas (and dust?) in circumgalactic medium (CGM): diffuse, low surface brightness → need not to resolve out ~ deg scales (Lee+24)
- Sunyaev–Zeldovich signal on scales of ~1 deg, instantaneous FoV of >1 deg^2 needed (Di Mascolo+24)

Requirement of instantaneous mapping:

- Sun = 0.5 deg across → 1 deg FoV allows mapping whole Sun in one shot, at high temporal cadence (Wedemeyer+24)

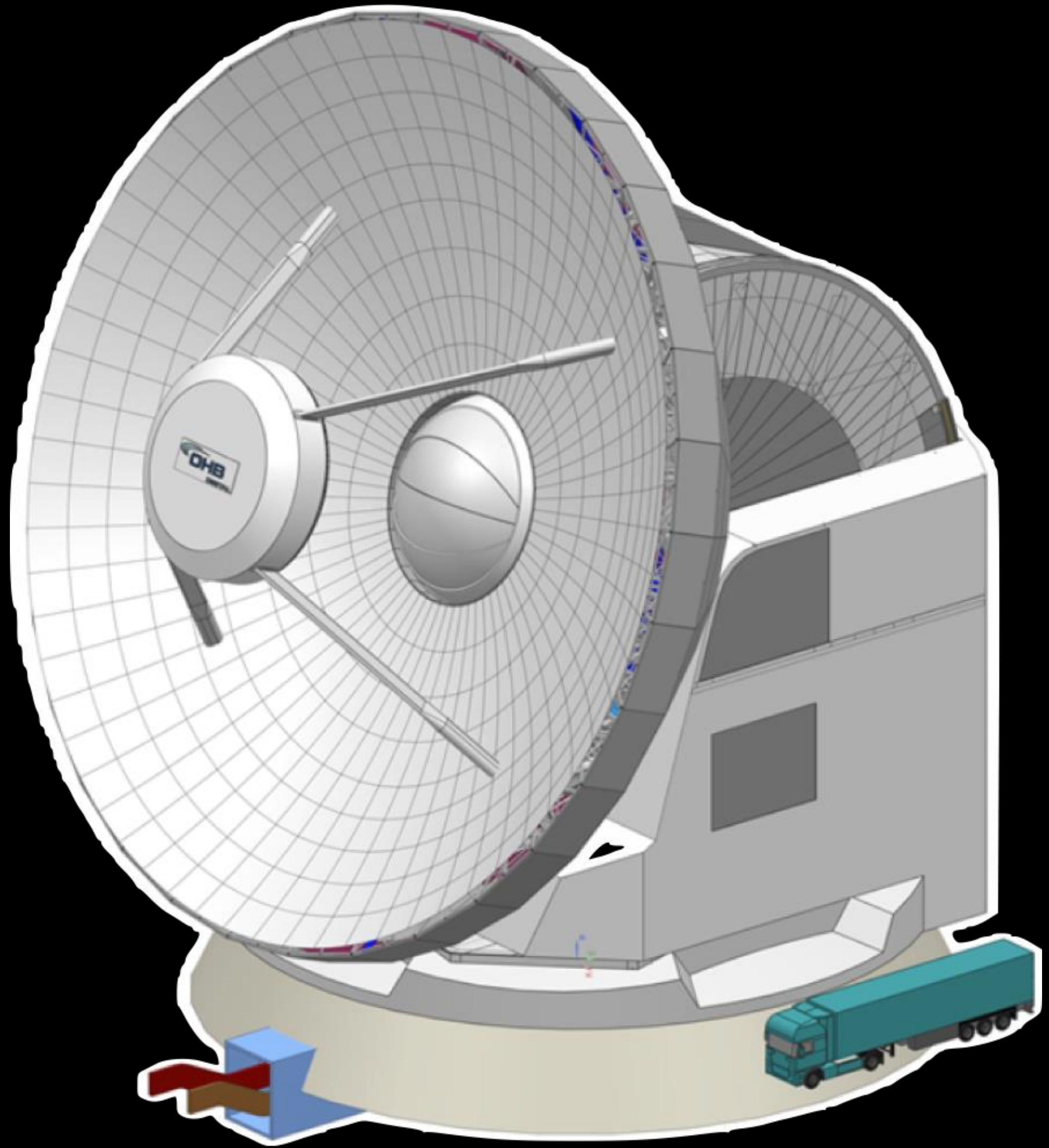
Large filled FoV increases mapping speed:

- Extragalactic surveys want to cover >1000 deg^2
- Galactic plane survey wants to cover 540 deg^2 (full plane visible from Southern hemisphere, +- 1 deg above and below midplane)
- Larger FoV increases coverage of transient phenomena (+ overlap with CTA, GWs, etc)

See AtLAST Memo#5 (Booth et al. 2024)

What is AtLAST?

1. A next-generation single-dish astronomical observatory with a 50-meter diameter and a wide field of view (1-2 deg)
→ requires a UNIQUE, cutting edge design



What is AtLAST?

1. A next-generation single-dish astronomical observatory with a 50-meter diameter and a wide field of view (1-2 deg)
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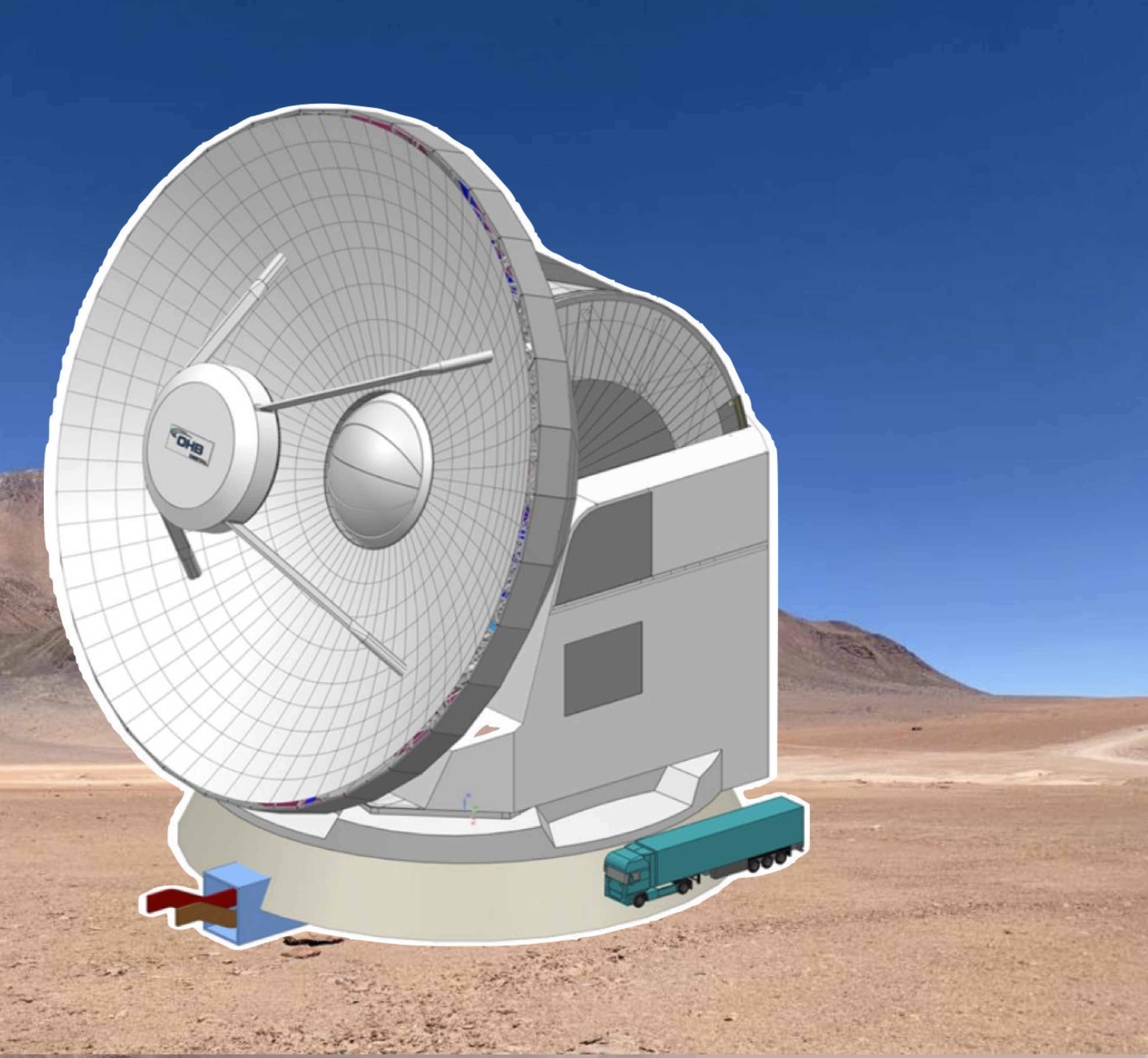
2. Capable of observing the full sub-mm wavelength range: 10mm to 350μm
→ requires a HIGH and DRY SITE
→ requires a HIGH surface accuracy (20μm)
→ complex technology
→ a site with low wind



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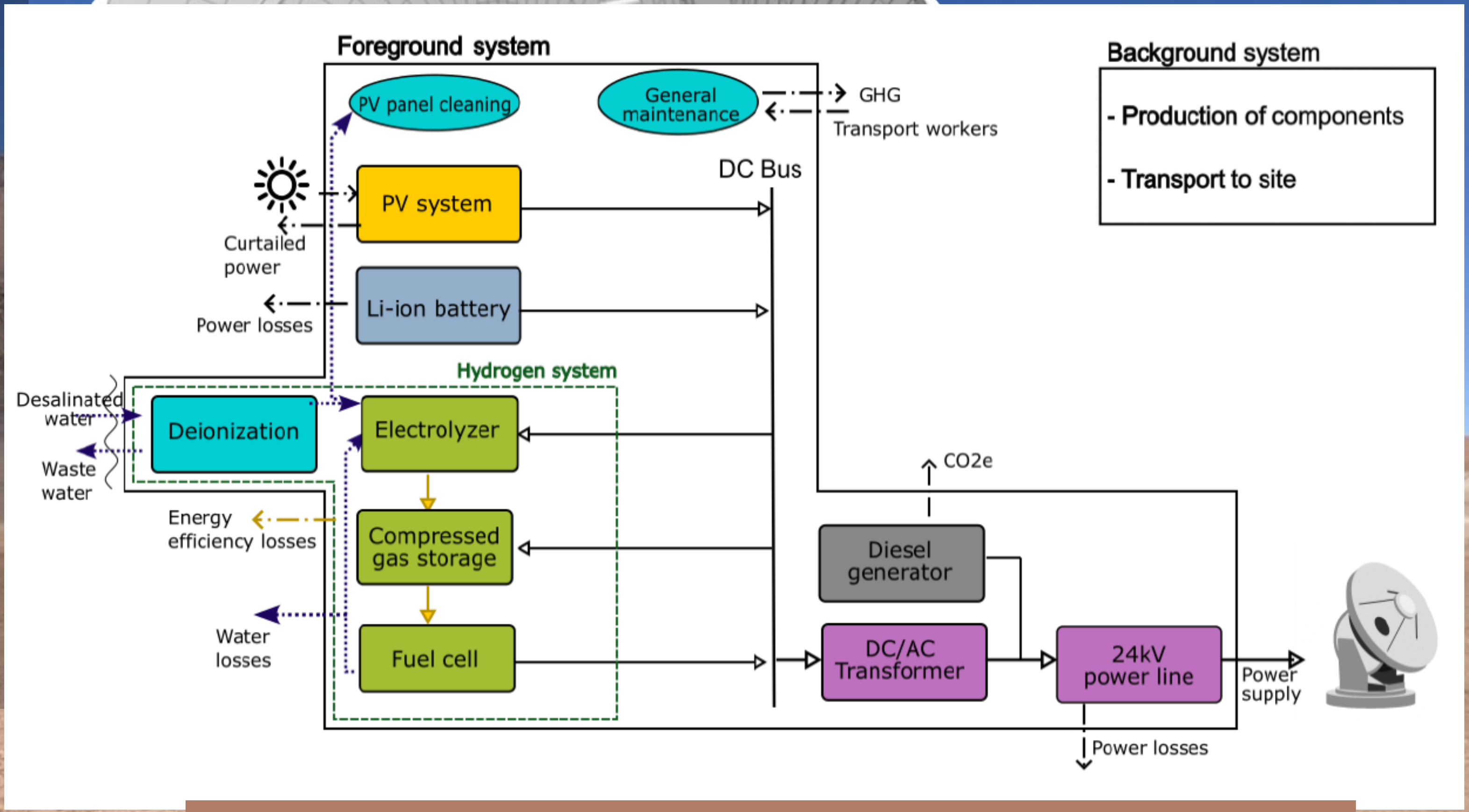
3. Environmentally sustainable
→ tailored renewable energy system



Viole et al. (2023, 2024a, 2024b); Valenzuela-Venegas et al. (2024)

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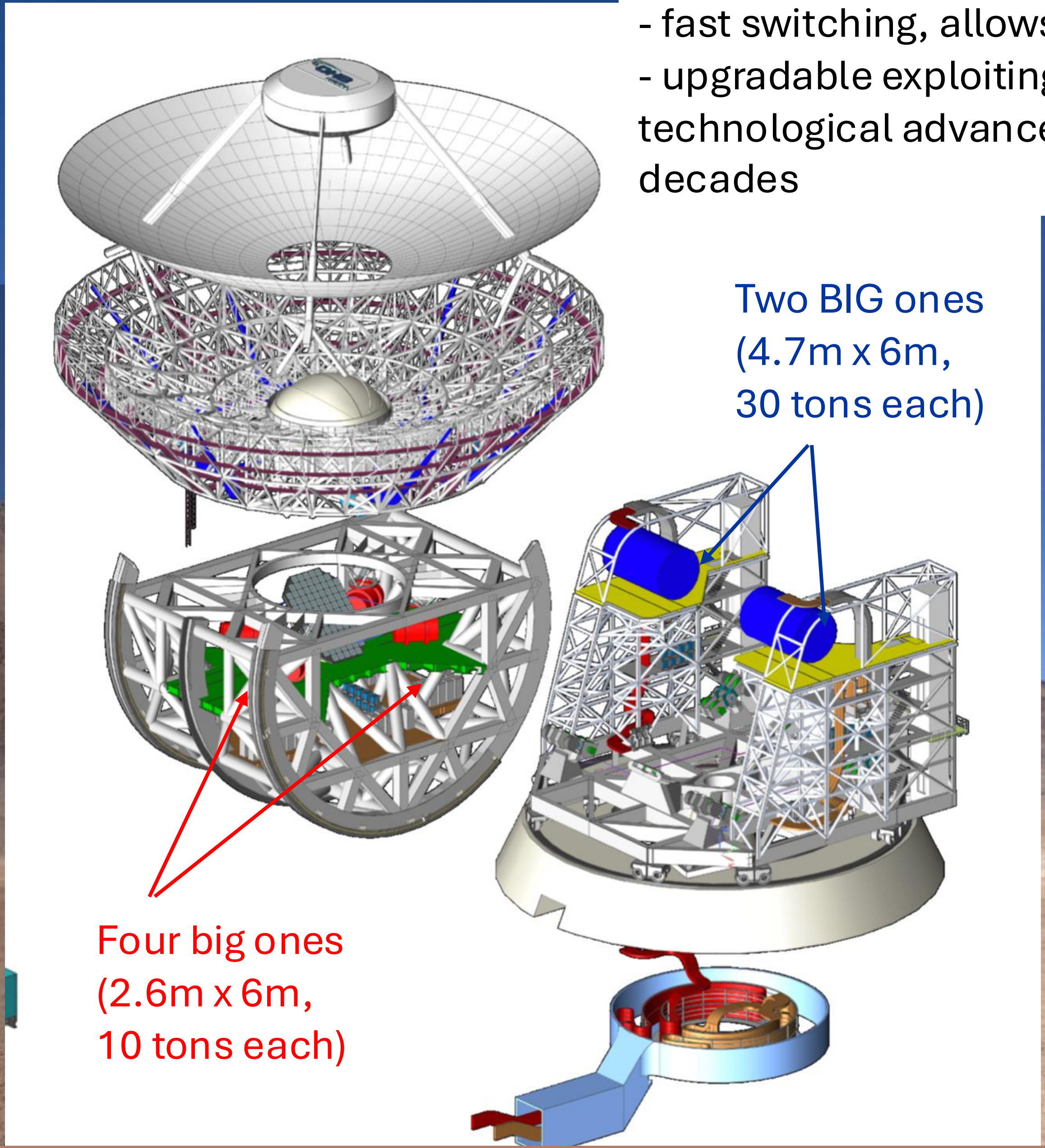
4. Serving a wide community of users for >50 years (long-term sustainability)

AtLAST can house 6 instruments:
- fast switching, allows multiple science
- upgradable exploiting new technological advances in coming decades



Mroczkowski et al. (2025, A&A), Reichert et al. (2024, SPIE), AtLAST memos #3, #4

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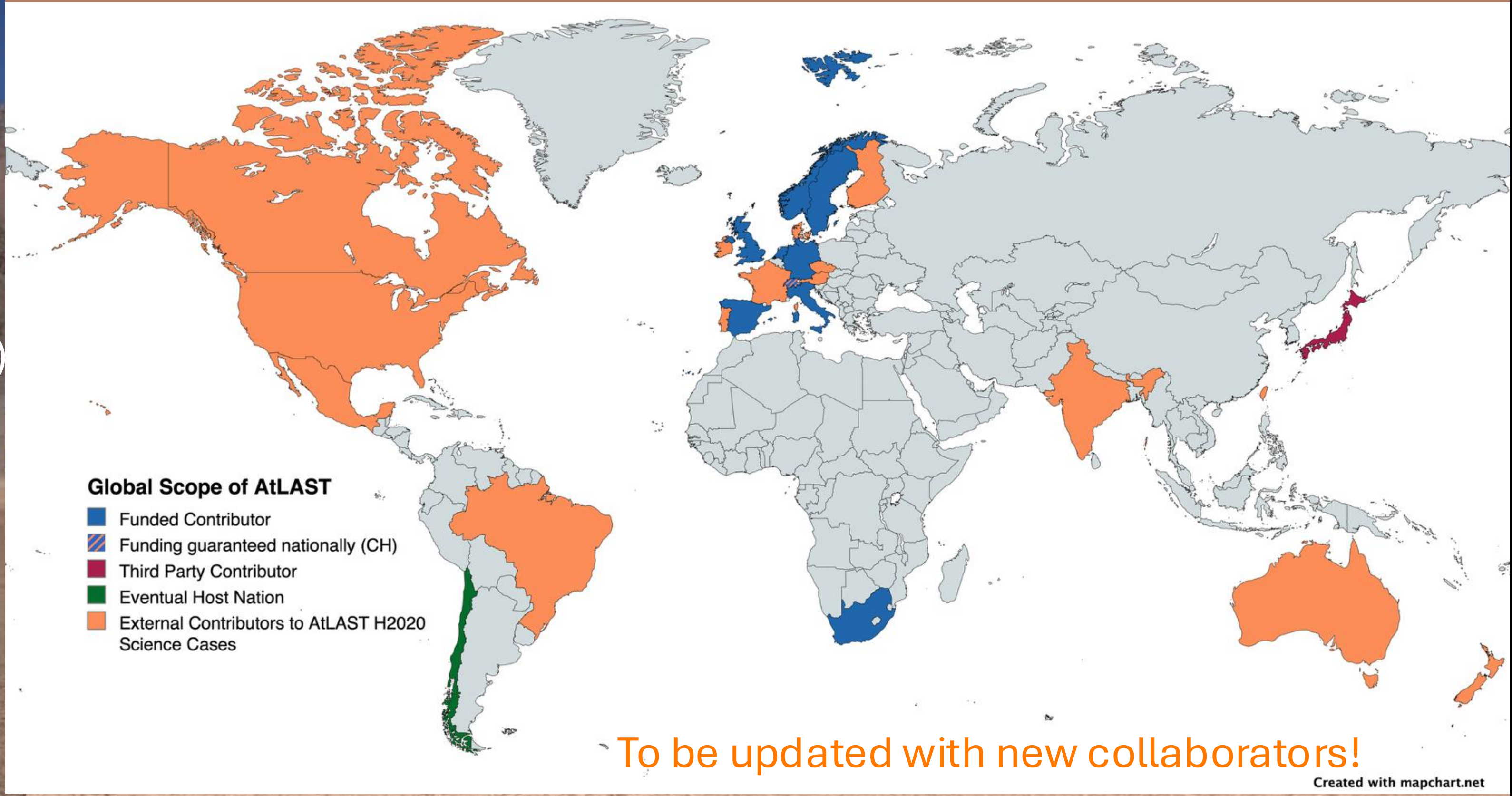
Global scope of AtLAST: distribution of partners and collaborators in 2024



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  → complex technology
  → a site with low wind

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→ tailored renewable energy system

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AtLAST operations plan

Science users at the core, to maximise science output

See AtLAST Memos #6 and #7

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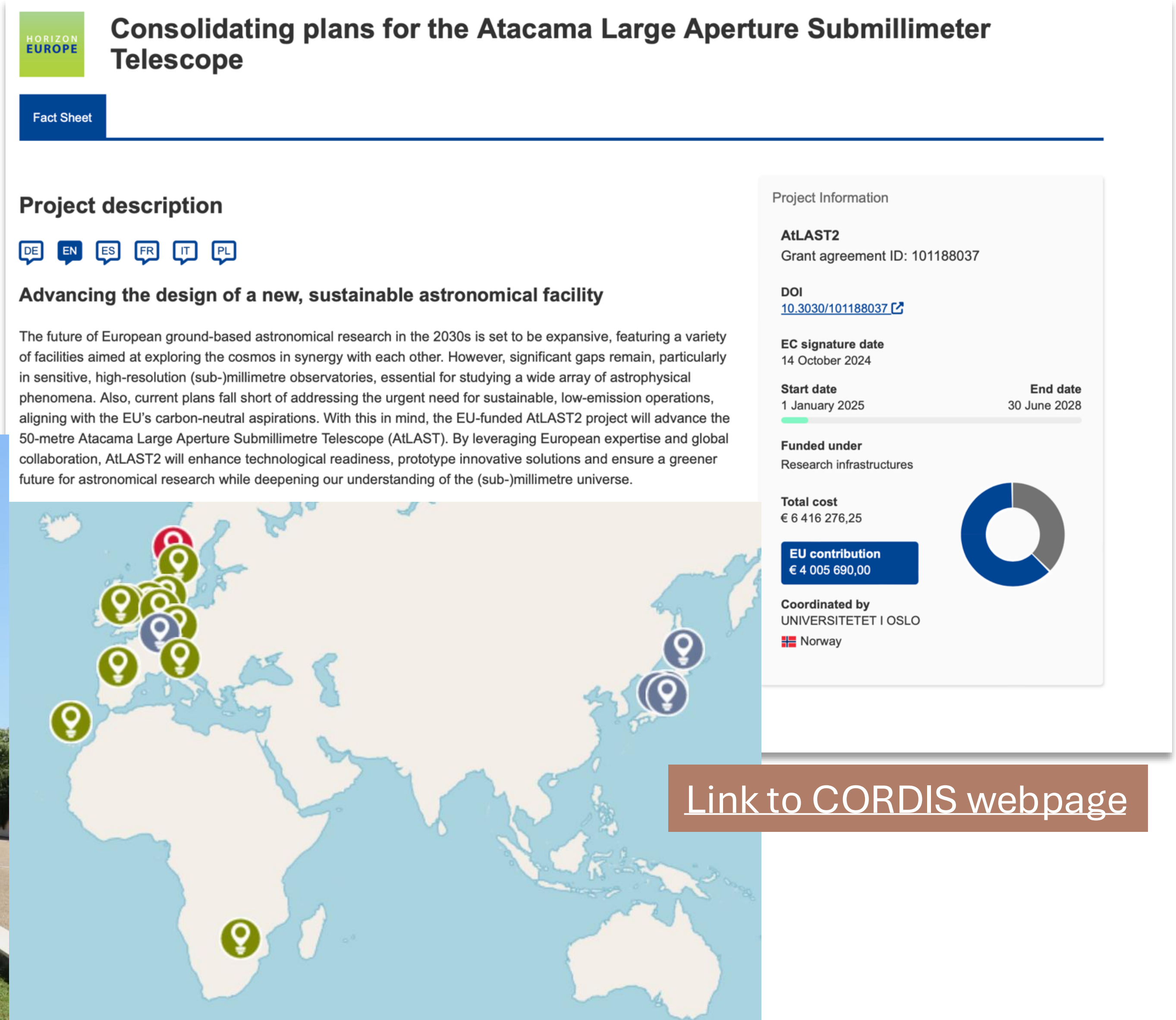
Part III – The plan for 2025-2028

New Horizon Europe AtLAST2 project (2025-28)

- Larger than H2020 design study in team size and scope, many new partners, but same coordinator and large overlap of "core" team (WP leaders)
- As of today, **150 AtLAST2 team members** (not including all science contributors) → **Possible to join through non-disclosure agreements (NDAs)**

AtLAST2 kick-off meeting - 28-30 April 2025



HORIZON EUROPE

Consolidating plans for the Atacama Large Aperture Submillimeter Telescope

Fact Sheet

Project description

DE EN ES FR IT PL

Advancing the design of a new, sustainable astronomical facility

The future of European ground-based astronomical research in the 2030s is set to be expansive, featuring a variety of facilities aimed at exploring the cosmos in synergy with each other. However, significant gaps remain, particularly in sensitive, high-resolution (sub-)millimetre observatories, essential for studying a wide array of astrophysical phenomena. Also, current plans fall short of addressing the urgent need for sustainable, low-emission operations, aligning with the EU's carbon-neutral aspirations. With this in mind, the EU-funded AtLAST2 project will advance the 50-metre Atacama Large Aperture Submillimetre Telescope (AtLAST). By leveraging European expertise and global collaboration, AtLAST2 will enhance technological readiness, prototype innovative solutions and ensure a greener future for astronomical research while deepening our understanding of the (sub-)millimetre universe.

Project Information

AtLAST2
Grant agreement ID: 101188037

DOI
10.3030/101188037

EC signature date
14 October 2024

Start date 1 January 2025 — **End date** 30 June 2028

Funded under
Research infrastructures

Total cost
€ 6 416 276,25

EU contribution
€ 4 005 690,00

Coordinated by
UNIVERSITETET I OSLO
Norway

Link to CORDIS webpage

A selection (*) of AtLAST2 activities

(*) **Among those that I think are most relevant to the French community**, not including topics to be covered by Tony Mroczkowski, Carlos De Breuck, and Sabrina Sartori in their talks

WP1 - Coordination, community engagement, and impacts

WP1 leader - C. Cicone

Stephen Molyneux co-lead of WP1.2 from Oct2025

Science Reference Plan (WP1.2): Collection of ambitious science cases and corresponding observing strategies to be carried out by AtLAST once operational. Developed through community coordination. Goals: 1) refine observing strategies 2) evaluate science impacts of AtLAST while remaining current with astronomical discoveries 3) create a prepared user base ready to maximize AtLAST's scientific potential

→ **Need help from French community! Some already involved (e.g. B. Magnelli, C. Bot)**

High-level governance and business report for funding bodies: strategic confidential report that builds on study done in H2020 project and updates it to accommodate a broader use base and new conditions

→ **Would be valuable to include lessons learned from IRAM, etc.**

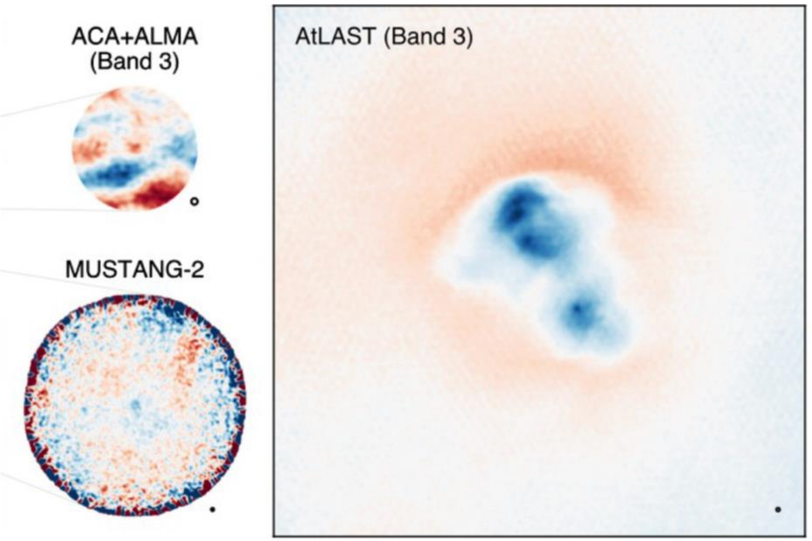
ESO Expanding Horizon application

Letter of intent 1st Dec 2026,

Application due 1st June 2027

→ **Need French community's support!**

AtLAST conference, May 2024



Di Mascolo et al. 2024 (SZ case)

Evanthia Hatziminaoglou (ESO/IAC)

Francisco Montenegro Montes (UCM)

WP4 - Operations

- **Sustainable operations models** based on the principle of remote distributed operations, using AI-assisted monitoring and scheduling
- **Data flow platform:** high-level requirements for software components and interfaces necessary for the facilitation of the end-to-end data flow (project preparation, data acquisition, quick data check and calibration, quality assurance, data processing, delivery)
- **Models for supporting users** throughout >50 years AtLAST lifetime and maximise scientific outputs. *1) PI and observatory projects, 2) coordinated observations with other large facilities 3) reacting to and triggering alerts for transients*

→ With 1) leading role at IRAM operations, 2) strong involvement in ALMA and 3) recognised expertise within the International Virtual Observatory Alliance, the French community is ready to support the vision of AtLAST. We are looking forward to working with you towards making AtLAST a reality. Join us!

WP7 - Pathfinders

Get in touch if you can contribute to WP7

WP7.1 — Site characterisation (C. de Breuck)
WP7.2 — Integration of energy systems (M. Hudoba de Badyn)
WP7.3 — Instruments and control systems (D. Muders)
WP7.4 — Observing techniques (F. Wyrowski)

- **Site characterization:** publication of wind data collected by the AtLAST weather towers at the two sites over several years + soil data for preferred site II
- Testing performance and durability of **renewable energy systems** designed for AtLAST in the extreme Atacama conditions using APEX
- Testing on APEX the **energy recovery system** developed by OHB DC for AtLAST
- APEX open for testing prototype instruments, their components, interfaces, control systems, data transfer protocols that can be useful for AtLAST
- **Codes and methods for wide-field observations:** methods for producing wide-field sub-mm maps. Investigate anticipated challenges e.g. sidelobe deconvolution, interferom. + single dish continuum data combination, etc.

WP7 leader: Amelie Saintonge (MPIfR)

→ **We should explore ways of bringing the French community into this**

→ **IRAM 30m would be very valuable for testing wide-field mapping techniques and refine SD+interf data combination methods**

12-m APEX (sub–mm, Chile)

64-m SRT (mm/radio up to 90GHz, Sardinia)

Environmental, societal,+ considerations

AtLAST as a model for rationalizing astronomy infrastructures:

- Merger of Japanese (LST) and European-led efforts → 1 unique facility
- Science drivers, telescope & instrumentation specs, operation plan, renewable energy system: all look at **a >50 years lifespan of the facility**
- Use of APEX and SRT as pathfinders, pushing further upgrades and extending their lifetime thanks to implementation of new AtLAST technologies
- Operations plan and budget plan envisage sharing of infrastructure, knowhow, and testing instruments on nearby observatories (ALMA, APEX, ASTE, etc)
- Opportunities for strong synergies and cooperation with other observatories: sharing infrastructure (roads, cables, buildings), sharing renewable energy (also with San Pedro and local stakeholders), new idea: sharing instrumentation lab?

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