Funded by
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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

Roma, 15 May 2025

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

- **>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

All public outputs on AtLAST website: Publications, Memo series

New Horizon Europe AtLAST2 project (2025-28)

HORIZON EUROPE

Consolidating plans for the Atacama Large Aperture Submillimeter Telescope

Link to CORDIS webpage

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.

Show the project objective

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

- Larger than H2020 design study in team size and scope, many new partners **including INAF (OA Cagliari)**
- As of today, **150 AtLAST2 team members** (not including all science contributors) → **Possible to join through non-disclosure agreements (NDAs)**

1) AtLAST's renewable energy system/ sustainability study and 2) synergies with SRT are of particular interest for INAF

MEDIA INAF
Il notiziario online dell'Istituto nazionale di astrofisica

HOME CATEGORIE GALLERY MEDIAINAF TV INAF

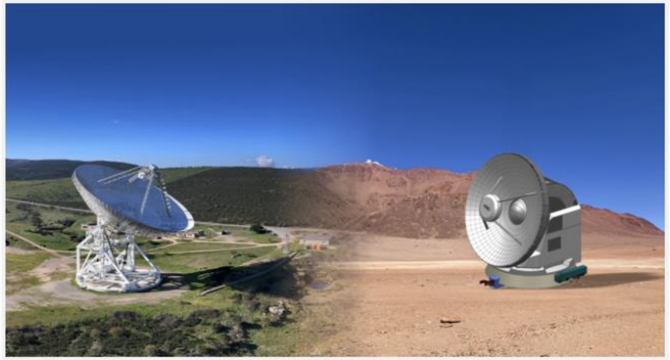
UNA GRANDE FACILITY ASTRONOMICA ENERGETICAMENTE AUTOSUFFICIENTE

AtLast, una parabola da 50 metri sulle Ande cilene

Atacama Large Aperture Submillimeter Telescope (AtLast) è il nome di un radiotelescopio per microonde e lontano infrarosso (da 35 a 950 GHz) che un consorzio internazionale – coordinato da Claudia Cicone dell'Università di Oslo e del quale fa parte anche l'Inaf – sta progettando e vorrebbe costruire nel nord del Cile. Il primo meeting della seconda fase del progetto è in corso in questi giorni a Cagliari

Paolo Soletta 30/04/2025

Grazie agli oltre cinquemila metri sul livello del mare, alla lontananza di altre fonti luminose e al bassissimo tasso di umidità dell'aria, il cielo del deserto di Atacama, nelle Ande cilene, è universalmente riconosciuto come il migliore per le osservazioni astronomiche. È in questo scenario unico, già sede di numerosi strumenti astronomici, che un consorzio internazionale coordinato dall'astrofisica italiana Claudia Cicone, oggi all'Università di Oslo, ha in mente di costruire AtLast (Atacama Large Aperture Submillimeter Telescope), un radiotelescopio rivoluzionario sotto molteplici aspetti. Dopo aver beneficiato di fondi Horizon 2020, il progetto – presentato in uno studio pubblicato a febbraio 2025 – inaugura la "fase due" con fondi della nuova programmazione europea.



A sinistra il Sardinia Radio Telescope (64 metri di diametro) nel territorio di San Basilio, in Sardegna. A destra un rendering del telescopio AtLast (50 metri di diametro) nel sito in cui ne è prevista l'effettiva costruzione, il plateau del Chajnantor nel deserto di Atacama, in Cile. Crediti: Mroczkowski et al. (2025)., C. Cicone (UiO/AtLast), P. Soletta (Inaf)

MEDIA INAF
Il notiziario online dell'Istituto nazionale di astrofisica

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CON UN COMMENTO DI CRISTIANA SPINGOLA DI "INAF GREEN"

Osservatori astronomici per una transizione verde

In che modo i sistemi energetici per gli osservatori astronomici possono diventare rinnovabili e inclusivi? Risponde a questa domanda uno studio, pubblicato su Nature Sustainability e guidato dall'Università di Oslo, che suggerisce un modello virtuoso di comunità energetica e contribuisce ad aprire la strada a uno sviluppo win-win dei nuovi progetti di infrastrutture astronomiche

Rossella Spiga 28/10/2024

Le infrastrutture astronomiche di nuova generazione spingono il loro sguardo al cielo con sempre maggiore dettaglio, alla ricerca di risposte ai misteri ancora irrisolti del cosmo. Affinché le osservazioni del cielo possano essere disturbate il meno possibile dalle luci e dalla turbolenza atmosferica, è necessario costruire i telescopi nelle zone più remote e buie del pianeta. È possibile farlo con un occhio di riguardo verso l'ambiente, e ancora meglio, contribuendo al fabbisogno energetico del territorio e delle comunità locali? In che modo i sistemi energetici per gli osservatori astronomici possono diventare rinnovabili e inclusivi? A rispondere a queste domande è uno studio pubblicato l'11 ottobre su *Nature Sustainability*, che suggerisce un modello virtuoso di comunità energetica e contribuisce ad aprire la strada a uno sviluppo *win-win* dei nuovi progetti di infrastrutture astronomiche.

L'impianto solare di Chañares nel deserto cileno di Atacama, in Cile. Crediti: Enel Green Power

Guidato dall'università di Oslo, lo studio dimostra che l'integrazione di fonti di energia rinnovabile nella realizzazione del telescopio AtLast (Atacama Large Aperture Submillimeter Telescope) – nel deserto di Atacama, in Cile – permetterebbe non solo alla comunità astronomica dell'altopiano di Chajnantor di usufruire di sistemi energetici più sostenibili, ma coprirebbe il 66 per cento del fabbisogno energetico della comunità vicina di San Pedro de Atacama. Quest[...] di soluzione energetica ridurrebbe la dipendenza locale dai combustibili fossili e

Sticki

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

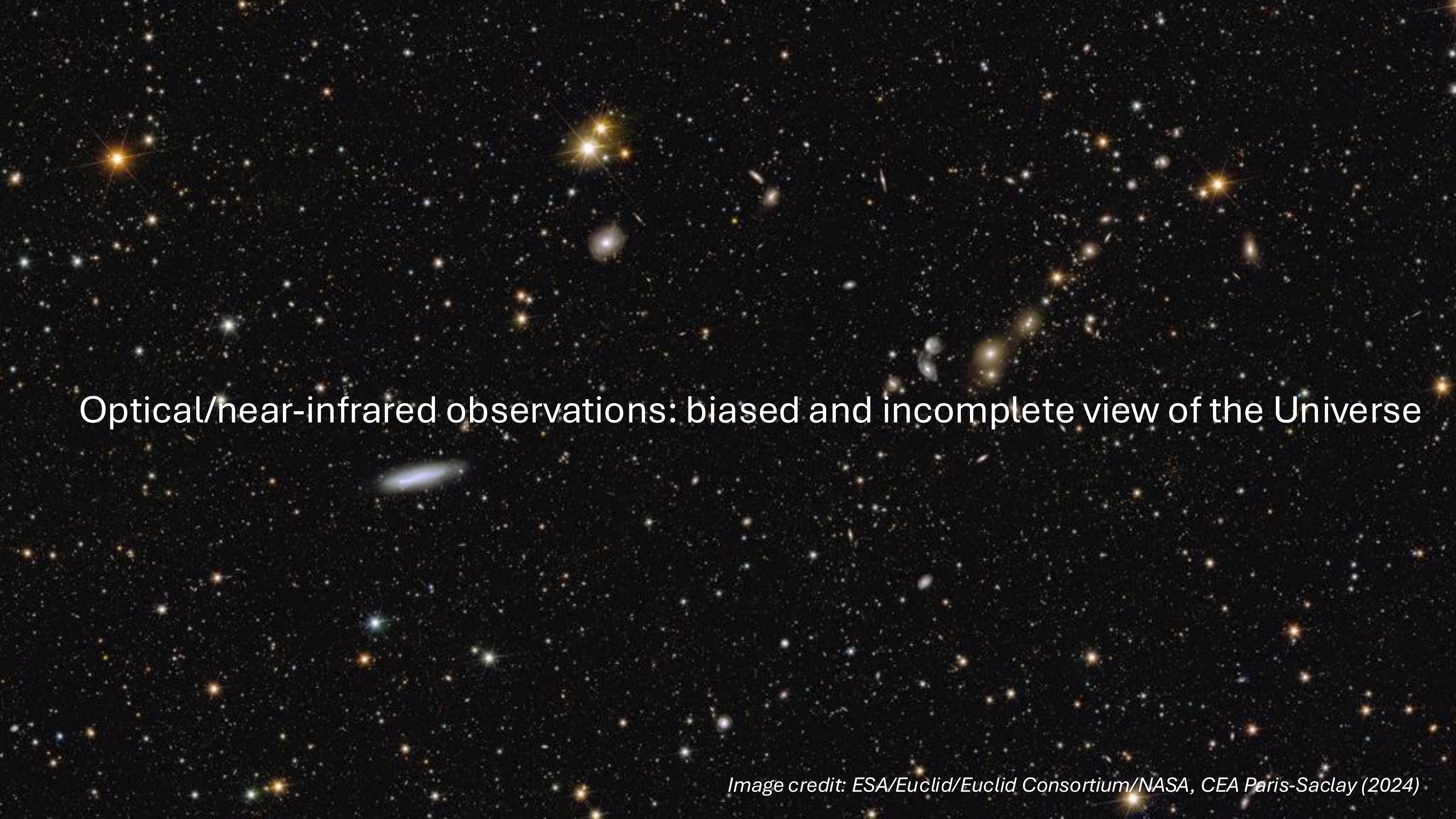
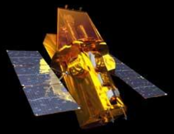
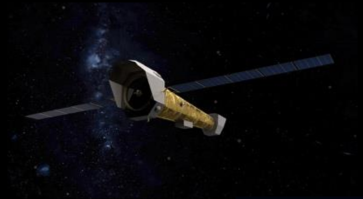
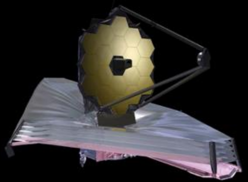
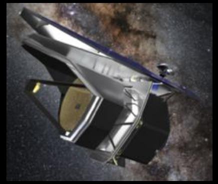


Image credit: ESA/Euclid/Euclid Consortium/NASA, CEA Paris-Saclay (2024)

The sub-millimeter / millimeter window


$Frequency\ \left(\nu = \frac{c}{\lambda}\right)$

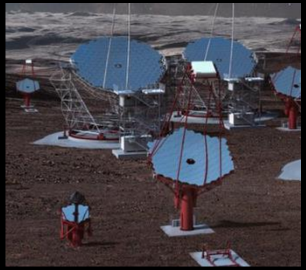
3 THz 300 GHz 30 GHz

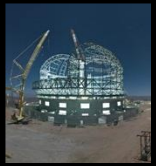
$Wavelength\ (\lambda)$

10^{-11}m 10^{-10}m 10^{-9}m 10^{-8}m 10^{-7}m 10^{-6}m 10^{-5}m 10^{-4}m 10^{-3}m 10^{-2}m 10^{-1}m 1m

Gamma rays | X rays | UV | optical (visible) | infrared λ~0.7–300 μm | **(sub)mm** **$\lambda \sim$ 0.3 – 10 mm** | radio λ > 10 mm

$\nu \sim$ 1 THz – 30 GHz





$\lambda \sim$ 1 mm – 10 cm

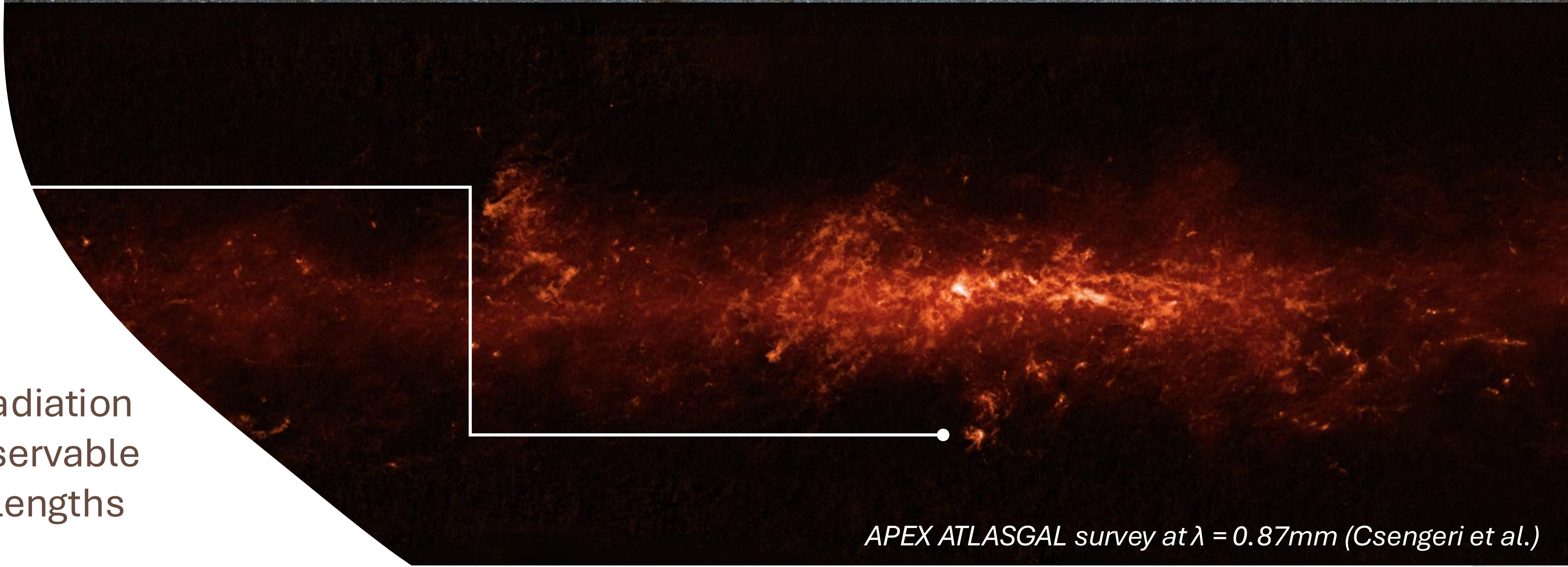
aka "microwaves"

The Milky Way

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

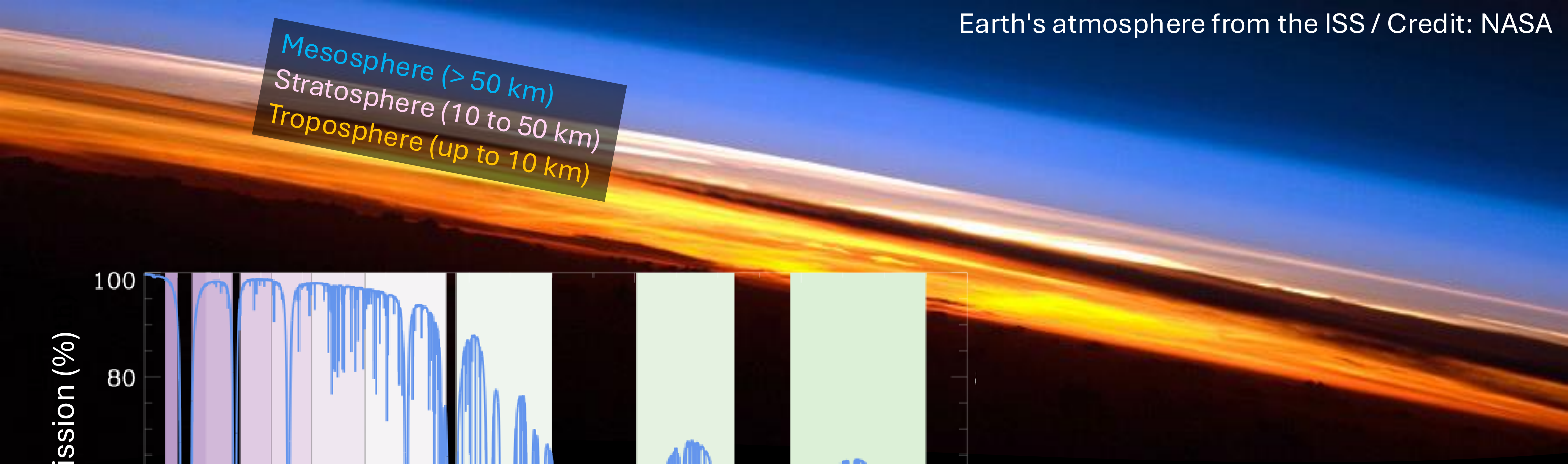
ESO/VISTA VVV survey at λ ~1.5-2 μm (Minniti et al.)

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

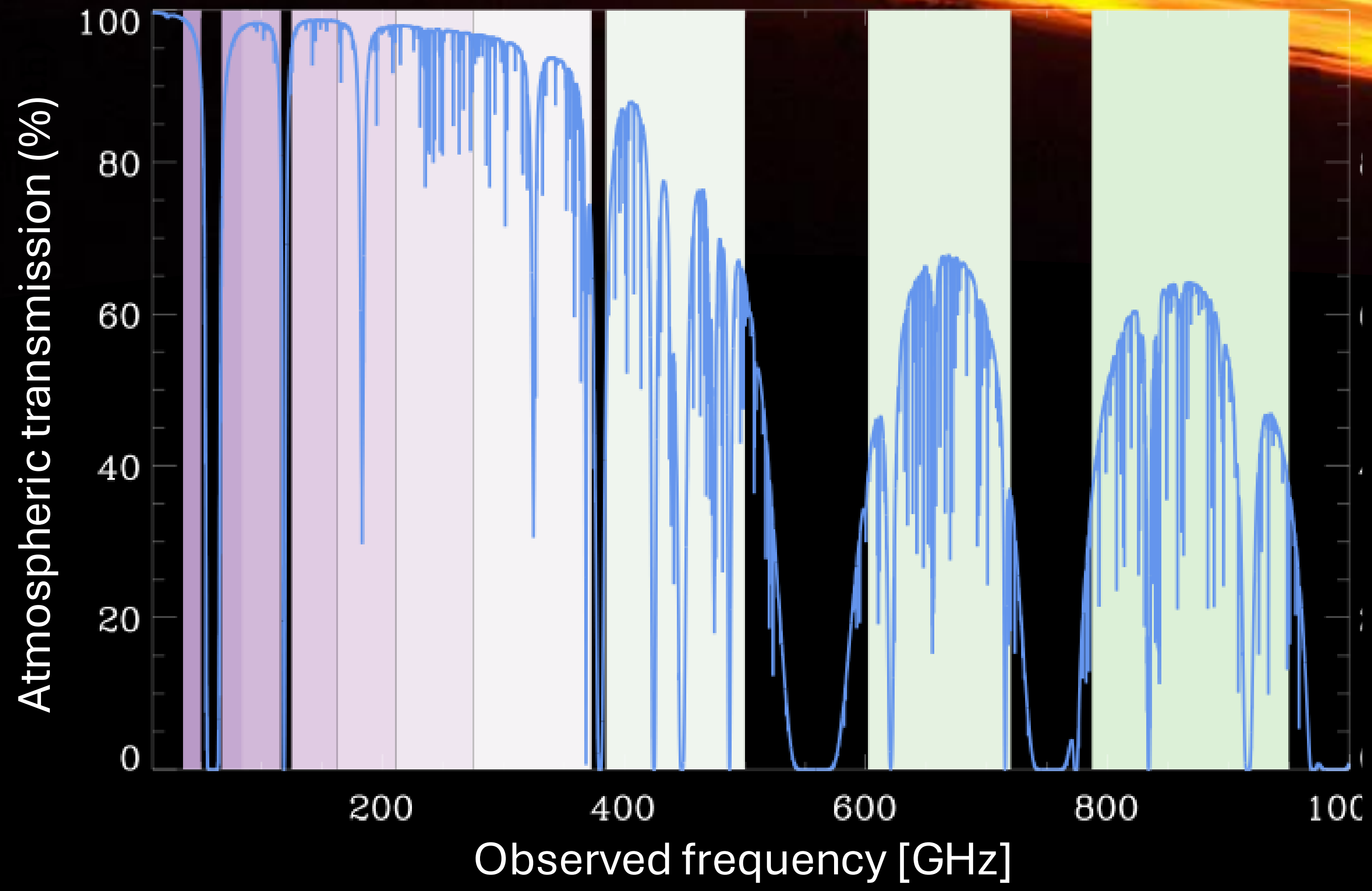


APEX ATLASGAL survey at λ = 0.87mm (Csengeri et al.)

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



Earth's atmosphere from the ISS / Credit: NASA



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

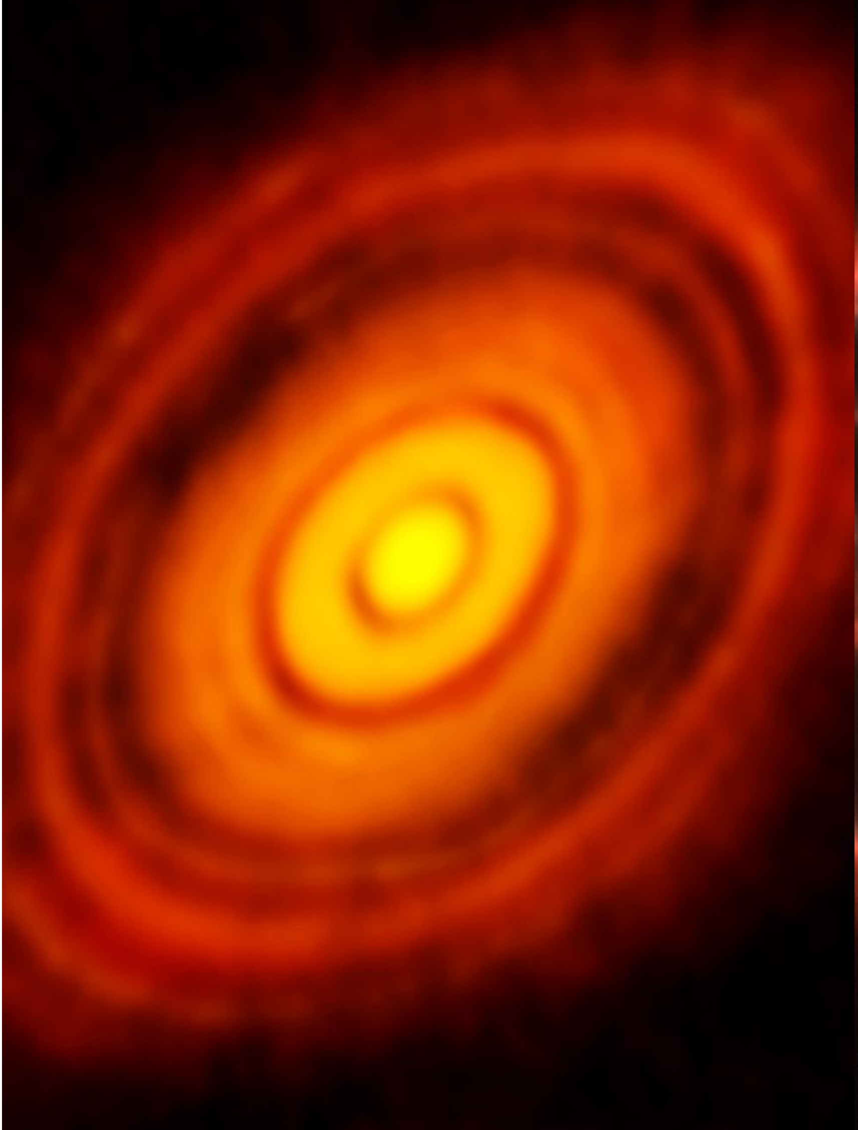
Astronomical observations are only possible from high, extremely dry sites, especially at high frequencies > 300 GHz (λ < 1 mm)

The Chajnantor Plateau in the Chilean Atacama desert

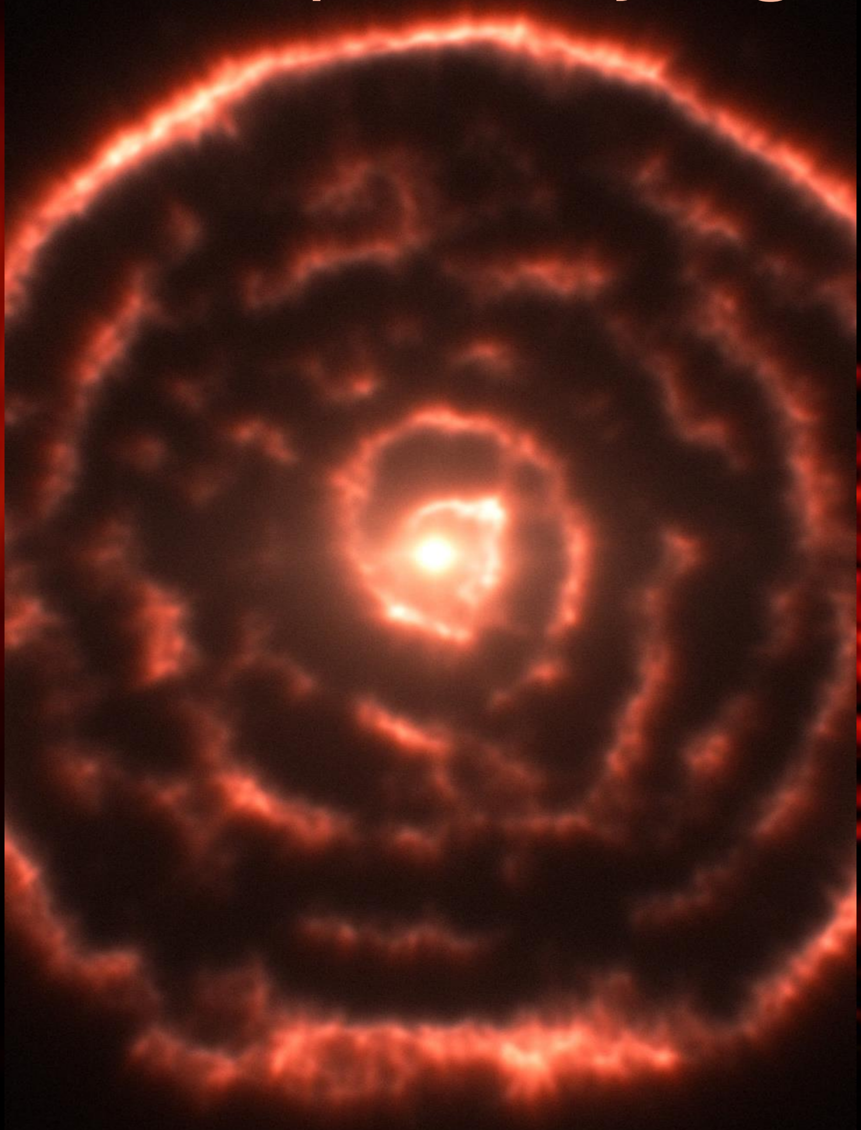
- ~ 5050 meters above sea level
- Extremely dry site: sub-mm observations possible all year long
- Hosts the best sub-mm observatories in the world: **ALMA**, APEX, ASTE, and, in a few years, CCAT

Credit: AtLAST team (P. Gallardo)

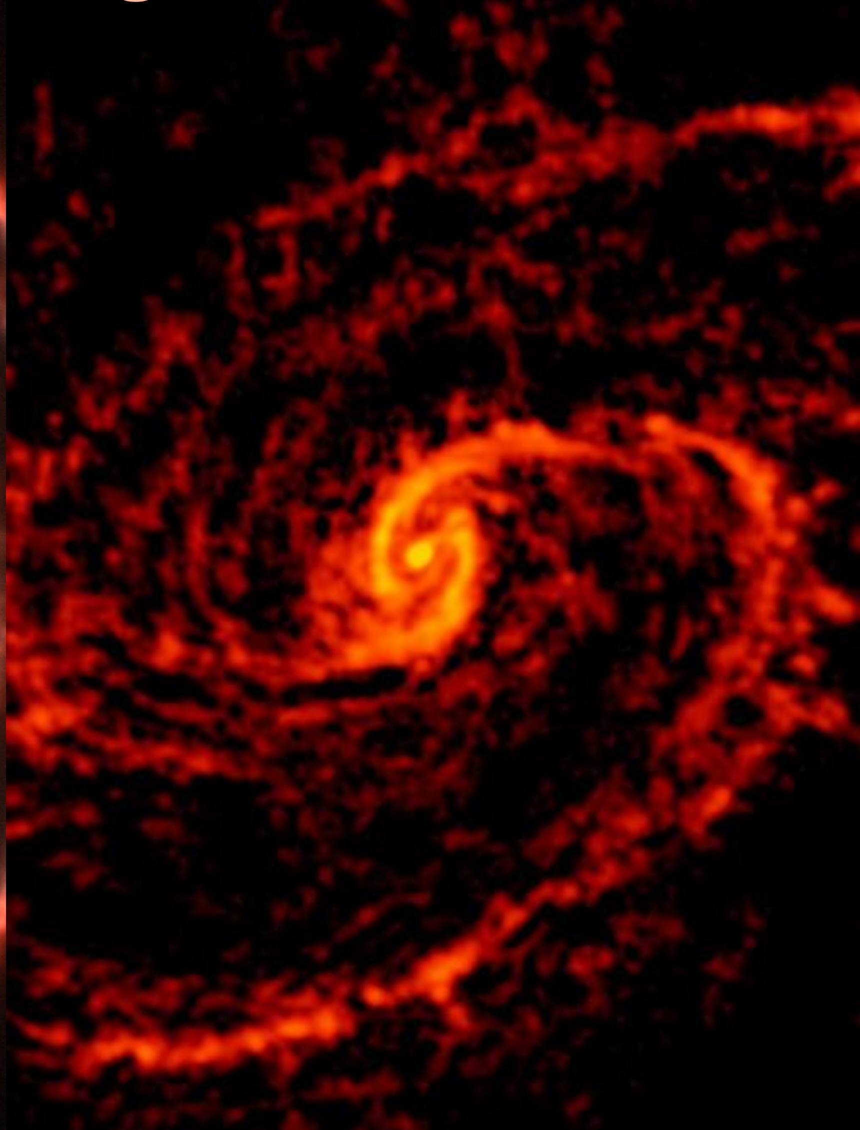
ALMA's detailed view: exceptionally high angular resolution



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

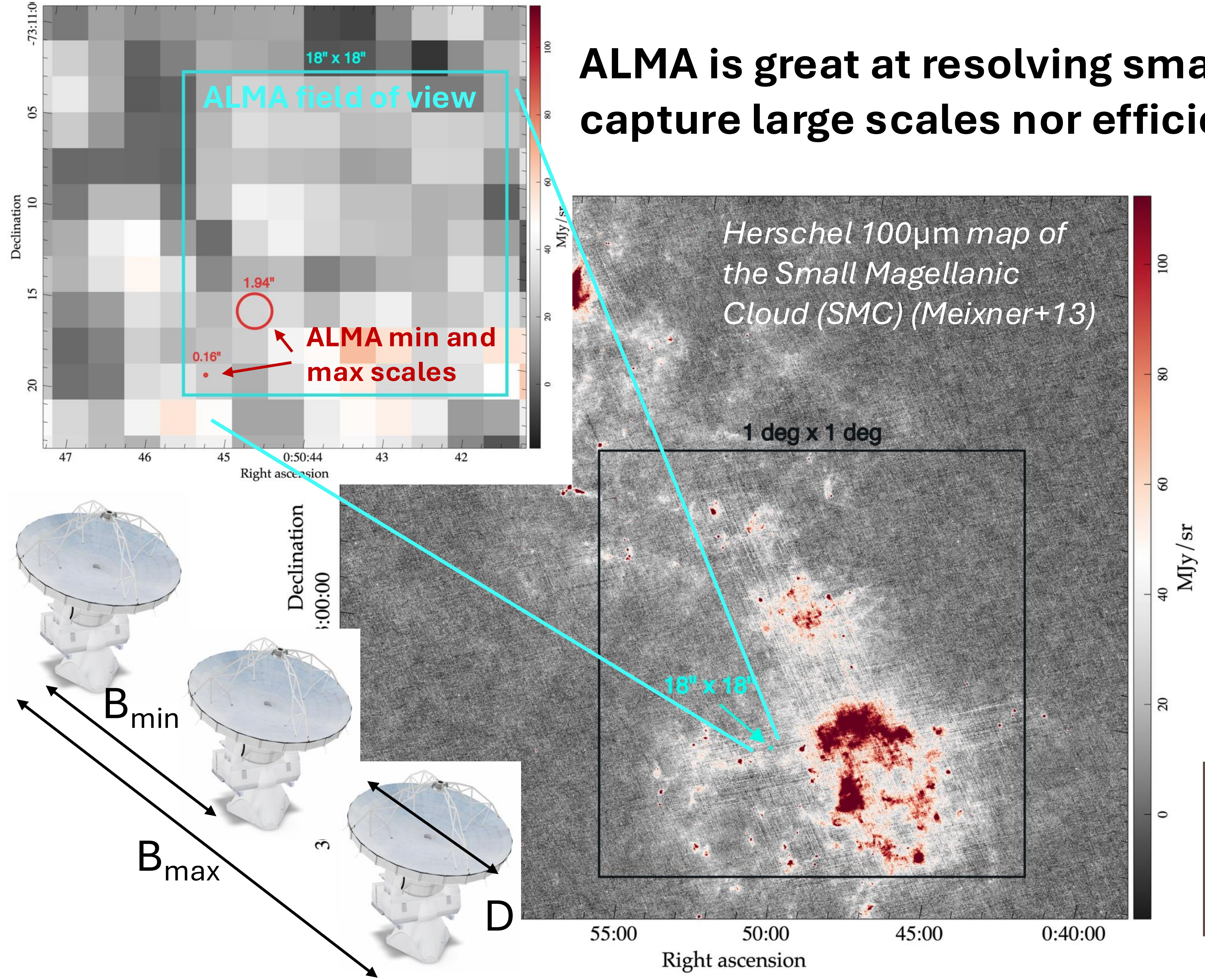


Red giant star R Sculptoris
M. Maercker et al.



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)

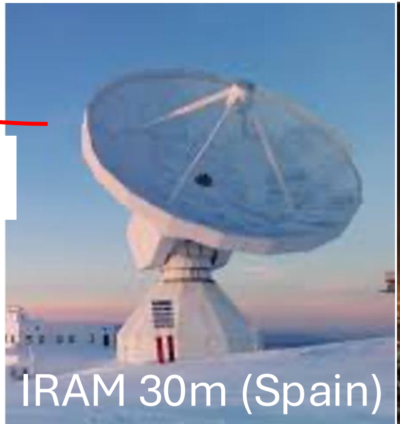
→ impossible for ALMA to observe nearby galaxies such as the SMC which are the local benchmarks to test our theoretical models

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)

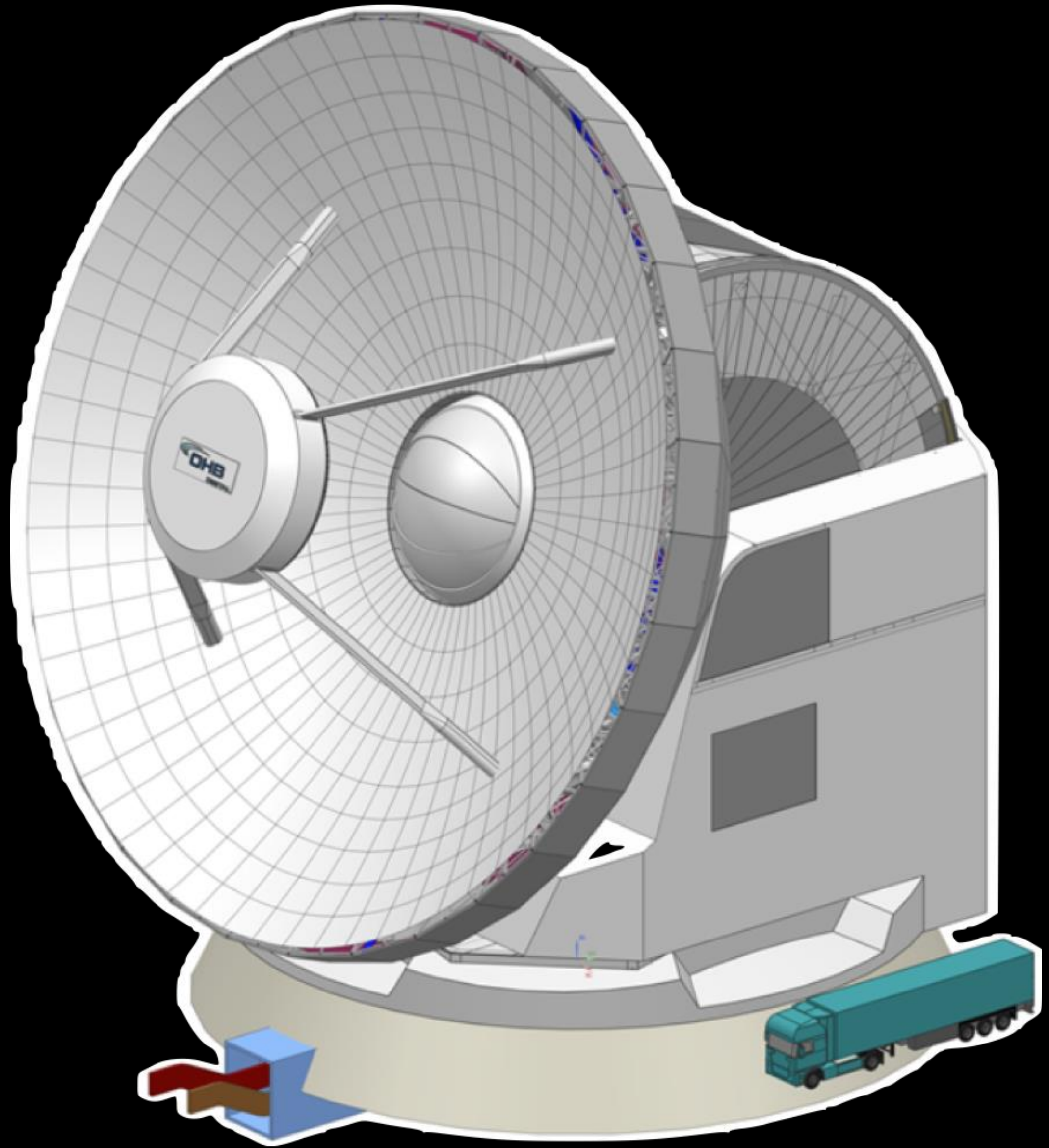
AtLAST here!
- discover faint sources
- high-res, multi-λ surveys
- deep maps
- time-domain/transients
- Improved EHT/VLBI

λ <1mm

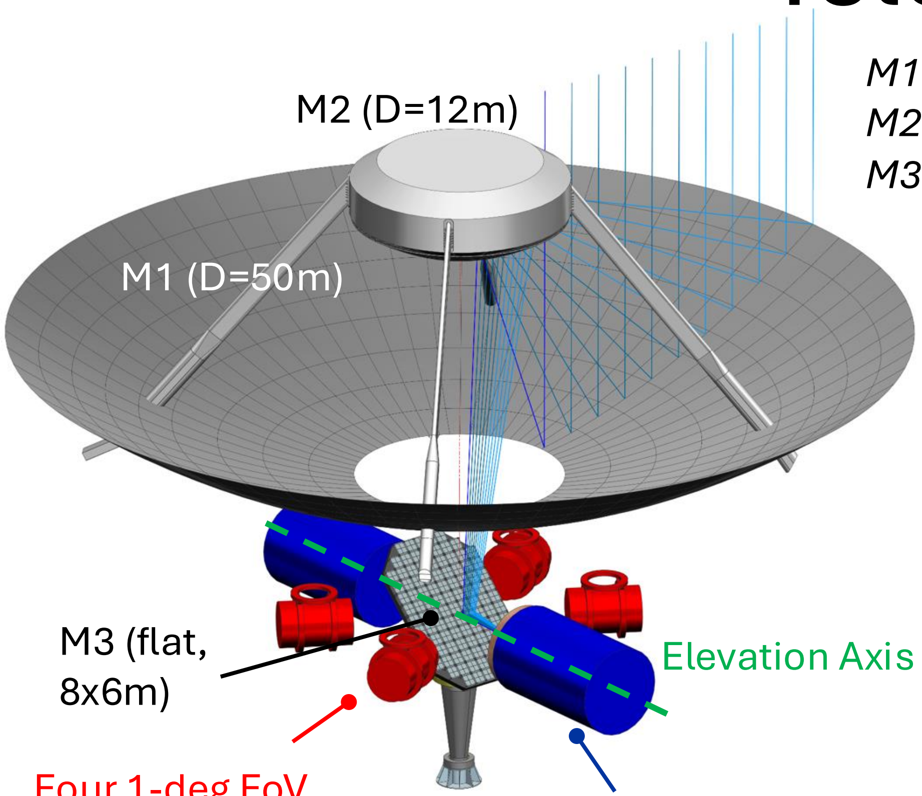


What is AtLAST?

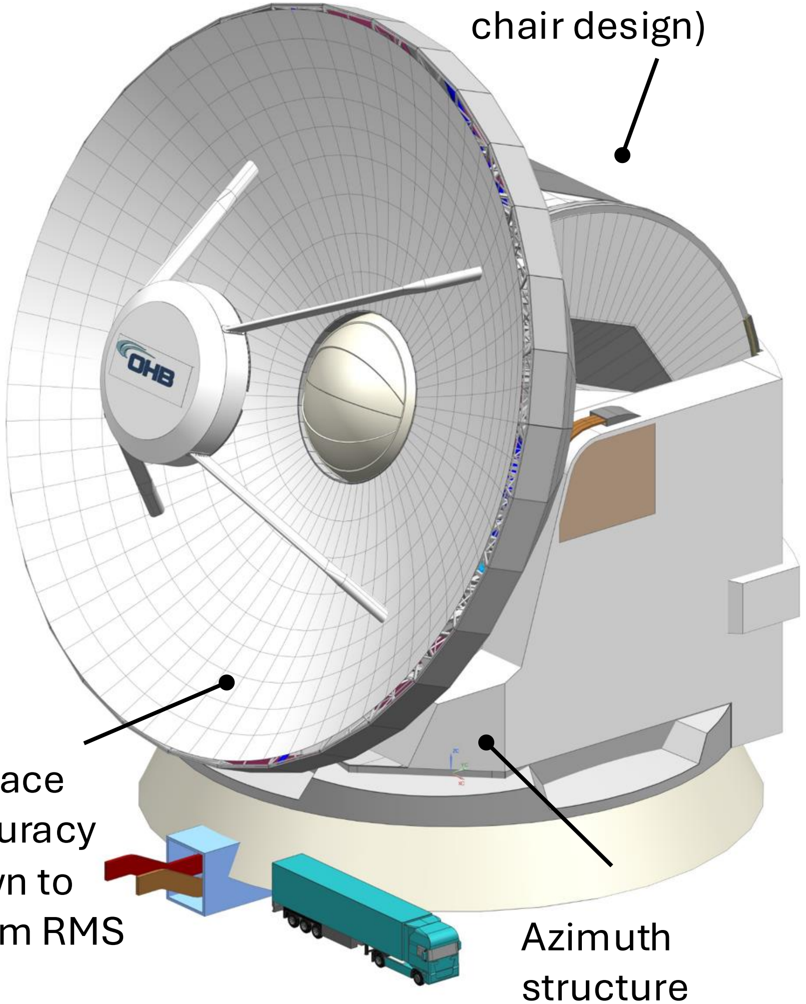
1. A next-generation single-dish astronomical observatory with a 50-meter diameter and a wide field of view (1-2 deg)
→ requires a UNIQUE, cutting edge design



Telescope Design



M1=Primary mirror
M2=Secondary mirror
M3=Tertiary mirror



Ritchey Crétien optical design
Hills 2021 (AtLAST memo#1)
Gallardo+2024 SPIE
Puddu+2024 SPIE

Unique combination of sensitivity, resolution, and mapping speed

Continuum sensitivity ~ ALMA/WSU but with up to 10^5 x mapping speed once focal plane fully populated

Unprecedented cabin space: serves broad and diverse poll of users for decades

Mroczkowski+2025 A&A
Reichert+2024 SPIE
Mroczkowski+2023 URSI

→ energy recovery system (recovers ~85% of 1.7MW peak drive power) goes beyond initial requirements
Kiselev+2024 SPIE

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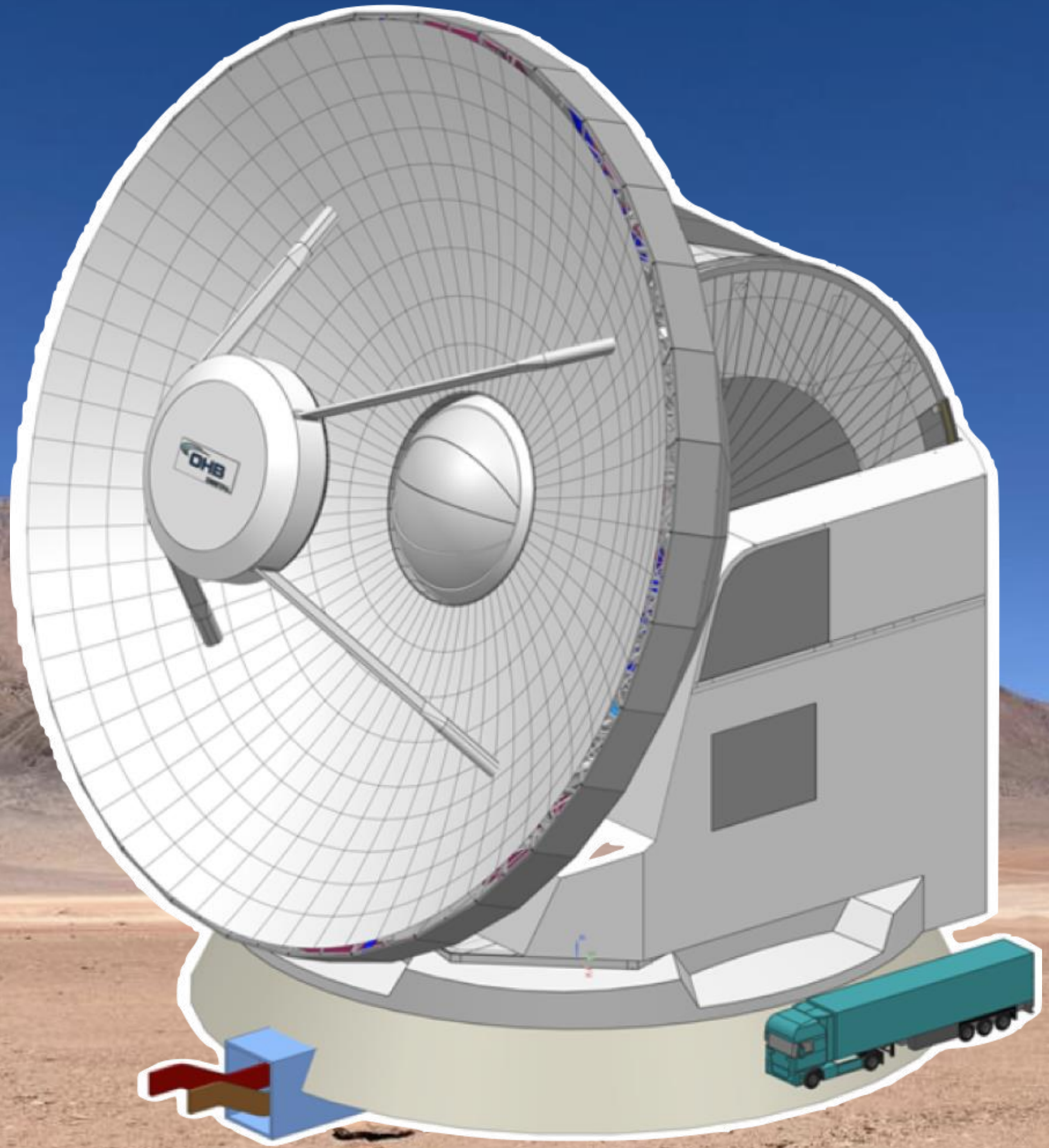
→ requires a HIGH and DRY SITE
→ requires a HIGH surface accuracy (20µm)
→ complex technology
→ a site with low wind



Planned demonstration of key technologies on SRT

WP3+WP2 of AtLAST2 will deliver **AtLAST design matured** to preliminary-design review level, with crucial technologies at TRL= 4-5

A. Technology demonstration:

1) Elevation axis systems
2) Energy recovery system (+ testing on SRT and APEX)
3) Elaboration on metrology possibilities (for pointing and refining M1 surface accuracy) + tests on SRT

B. Design consolidation: Conceptual design review (ongoing), and preliminary design review in 2028. Led by Jason Spyromilio at ESO (telescope scientist for ELT)

C. First light instrumentation concepts: detailed planning for optics, detectors, amplifiers, and associated cost models, with performance specifications covering frequencies, bandwidths, and spectral resolutions tailored to meet science forecasting needs. → Led by Tony Mroczkowski (ESO), in collaboration with >20 instrumentation teams around the world (inc. Sapienza/MISTRAL team)

OHB DIGITAL

+ INAF / SRT,
+ MPIfR /APEX
+ ESO
+ CSIC ICE
+ 20 institutes

OHB Digital Connect team

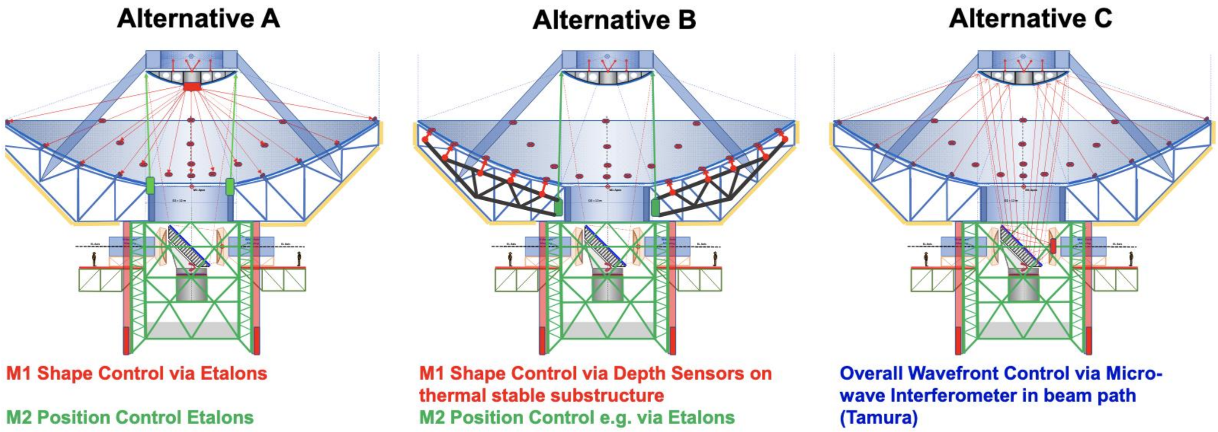
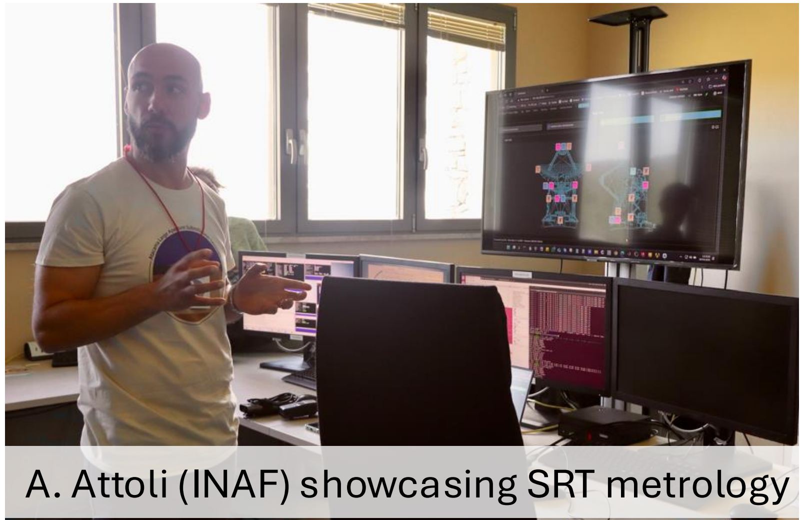


Figure 11: Alternatives for a metrology system

Sergio Poppi, INAF & SRT



A. Attoli (INAF) showcasing SRT metrology

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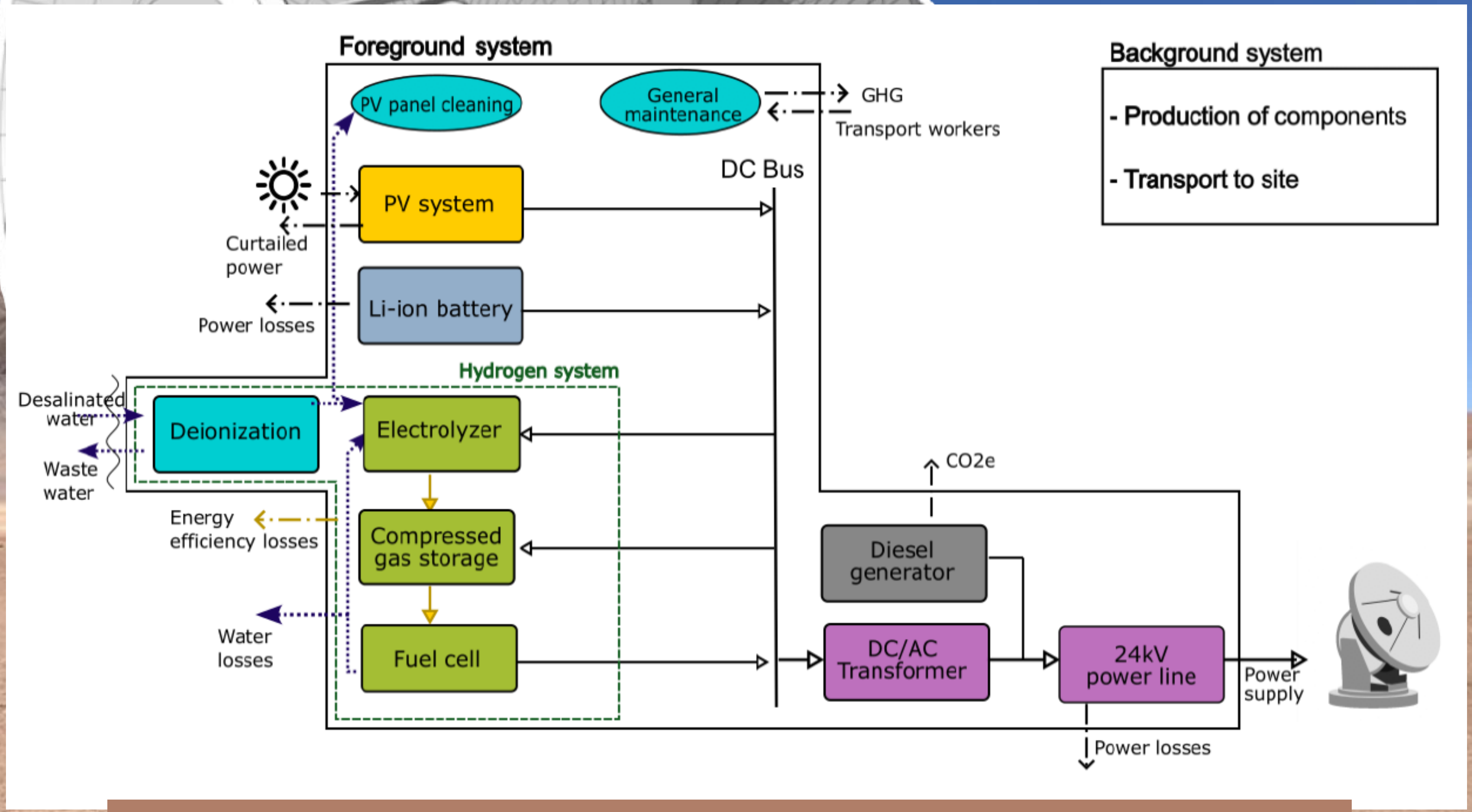
→ tailored renewable energy system

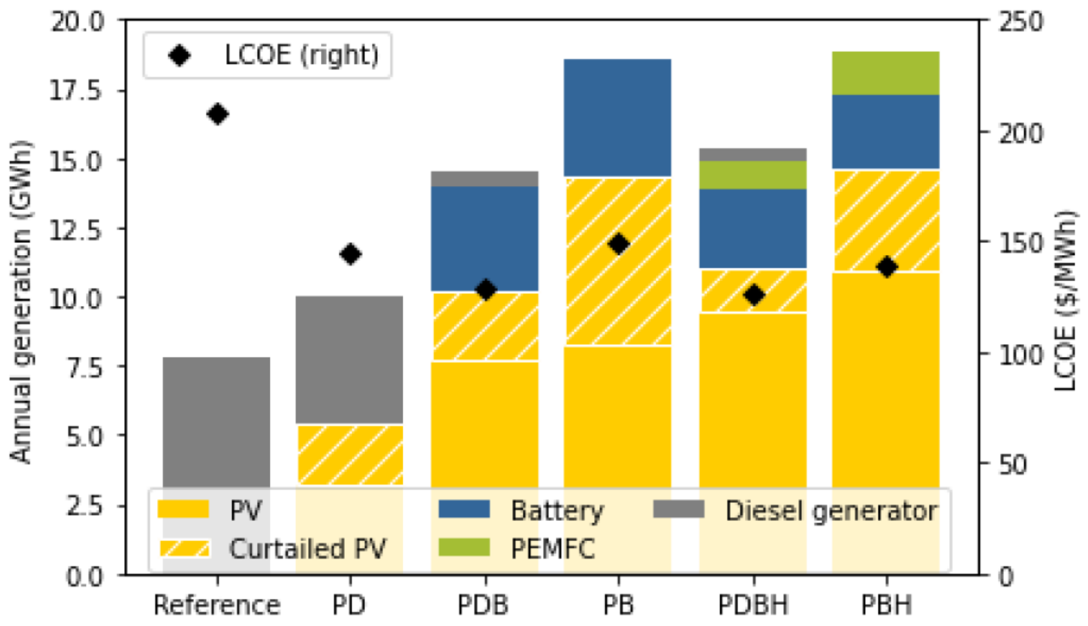
Sabrina Sartori's team at the University of Oslo + Swiss company GRZ Technologies + MPIfR/APEX team



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

Energy and Sustainability

- **Priorities: 1) minimizing carbon emissions, 2) reducing overall power system costs, and 3) fostering good relations with local communities for equitable use of resources**
- High power demand of facility (~1.3MW, peaks 3MW) but located on one of most solar-irradiated sites on Earth
- AtLAST needs highly reliable power 24/7: must mitigate for high shares of intermittent renewable energy sources
- An off-grid energy system using solar panels during the day, hybrid storage (green hydrogen and batteries) at night, and a <10% backup diesel gives the best trade-off:
  - the **most economical energy in 2030** (116 $/MWh levelised cost of electricity)
  - **reduction of CO_2 emissions by 95%** compared to 100% diesel
  - a **reduced mineral resource depletion and water use** comparable to 100% renewables scenario



- Viole, Valenzuela-Venegas+23, Energy
- Viole+24a, Int J Life Cycle Asses
- Viole+24b, Applied Energy
- Valenzuela-Venegas+24, Nat. Sustain
- Valenzuela+24 AtLAST Memo#8
- Velasco Herrejon+25 chapter in "Energy justice in Latin America" book

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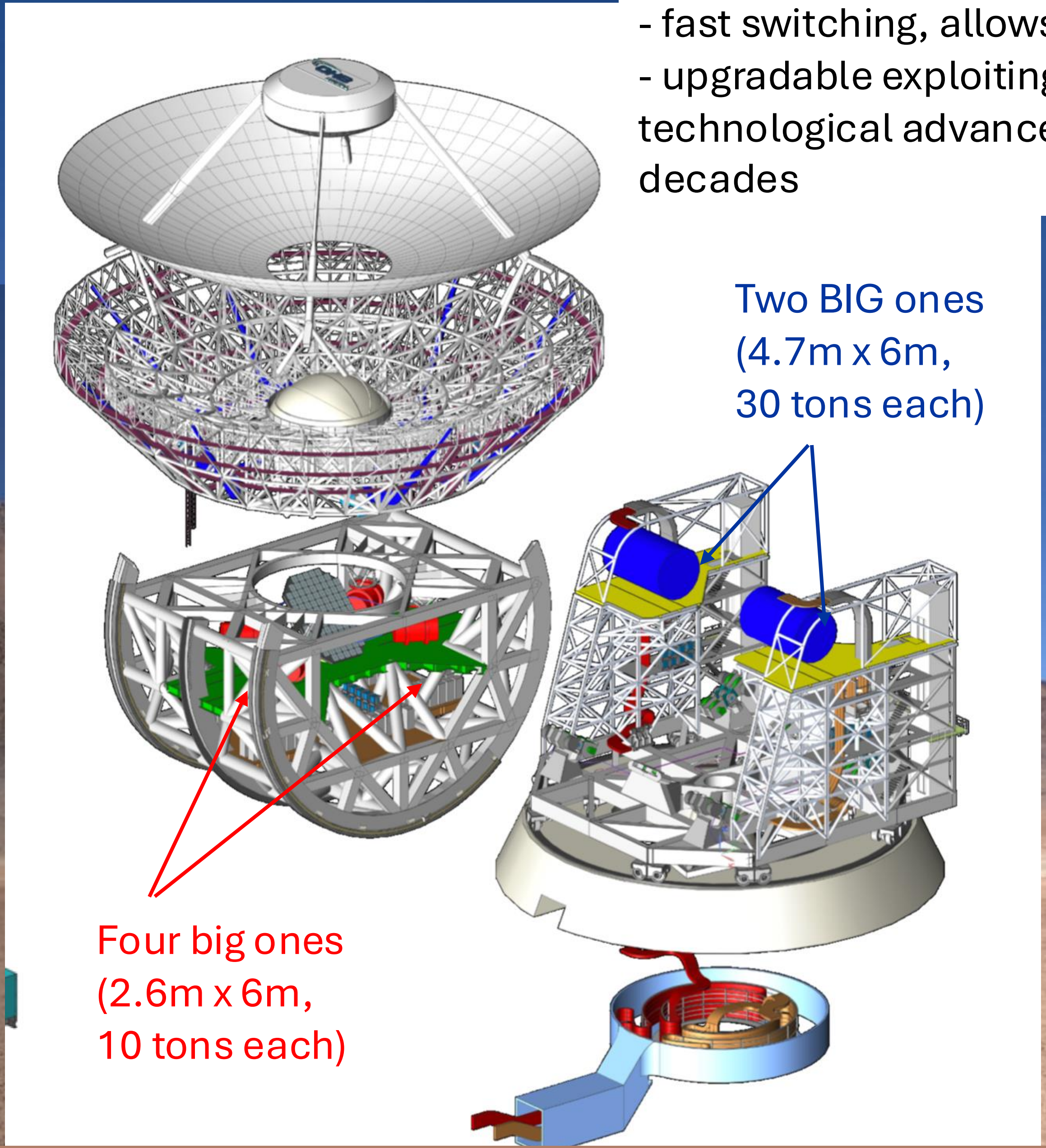
4. Serving a wide community of users for >50 years (long-term sustainability)

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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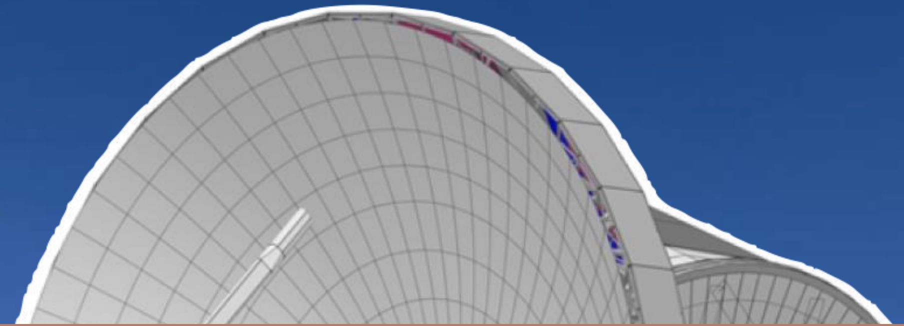
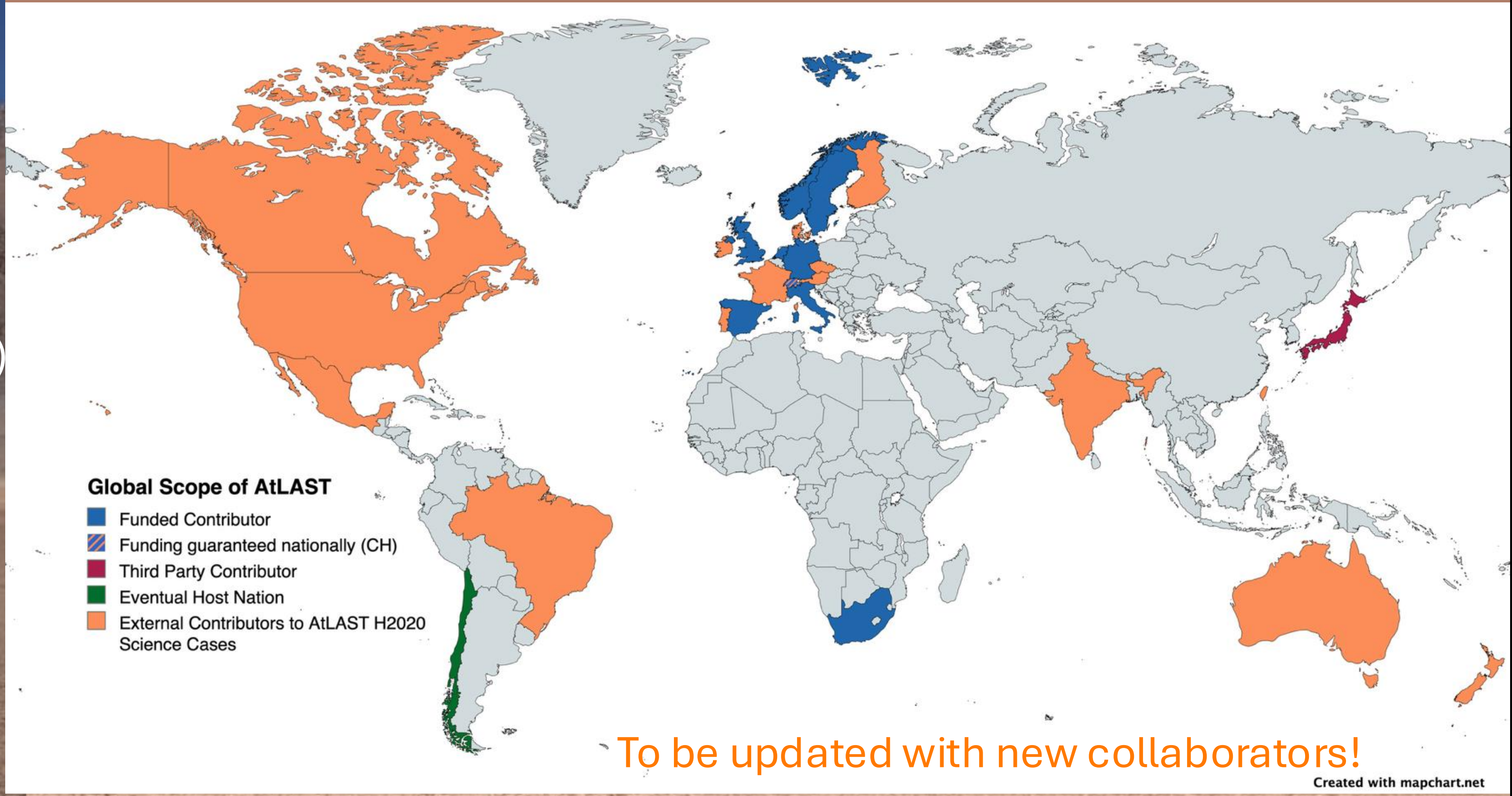


Global scope of AtLAST: distribution of partners and collaborators in 2024



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AtLAST operations plan

Science users at the core, to maximise science output

See AtLAST Memos #6 and #7

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 and knowhow with 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?

Funded by the European Union

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