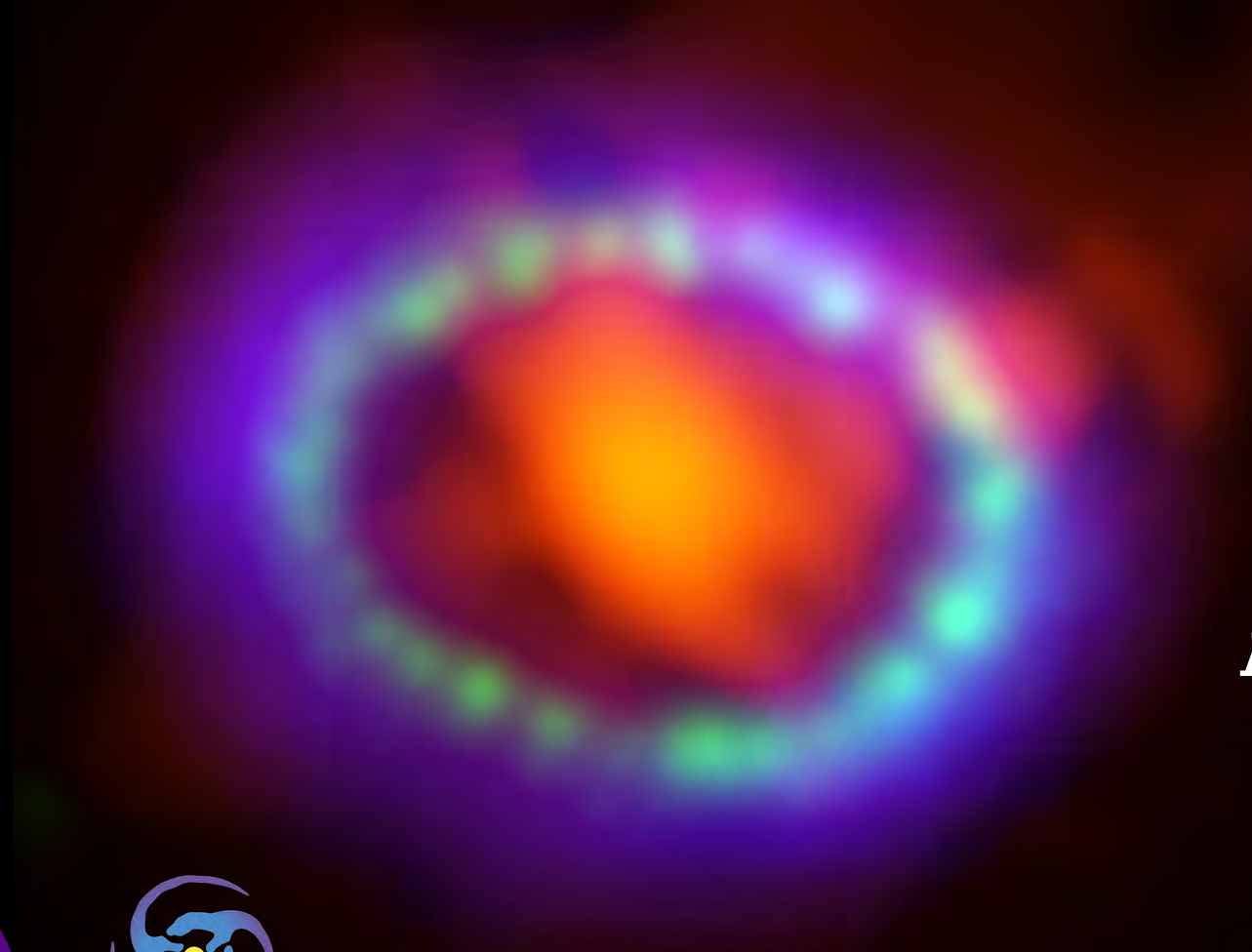
ARCHIVAL SCIENCE OVERVIEW



Anelise Audibert - IAC
Spanish ALMA Days
Tenerife - IACTEC
18-20 February 2025

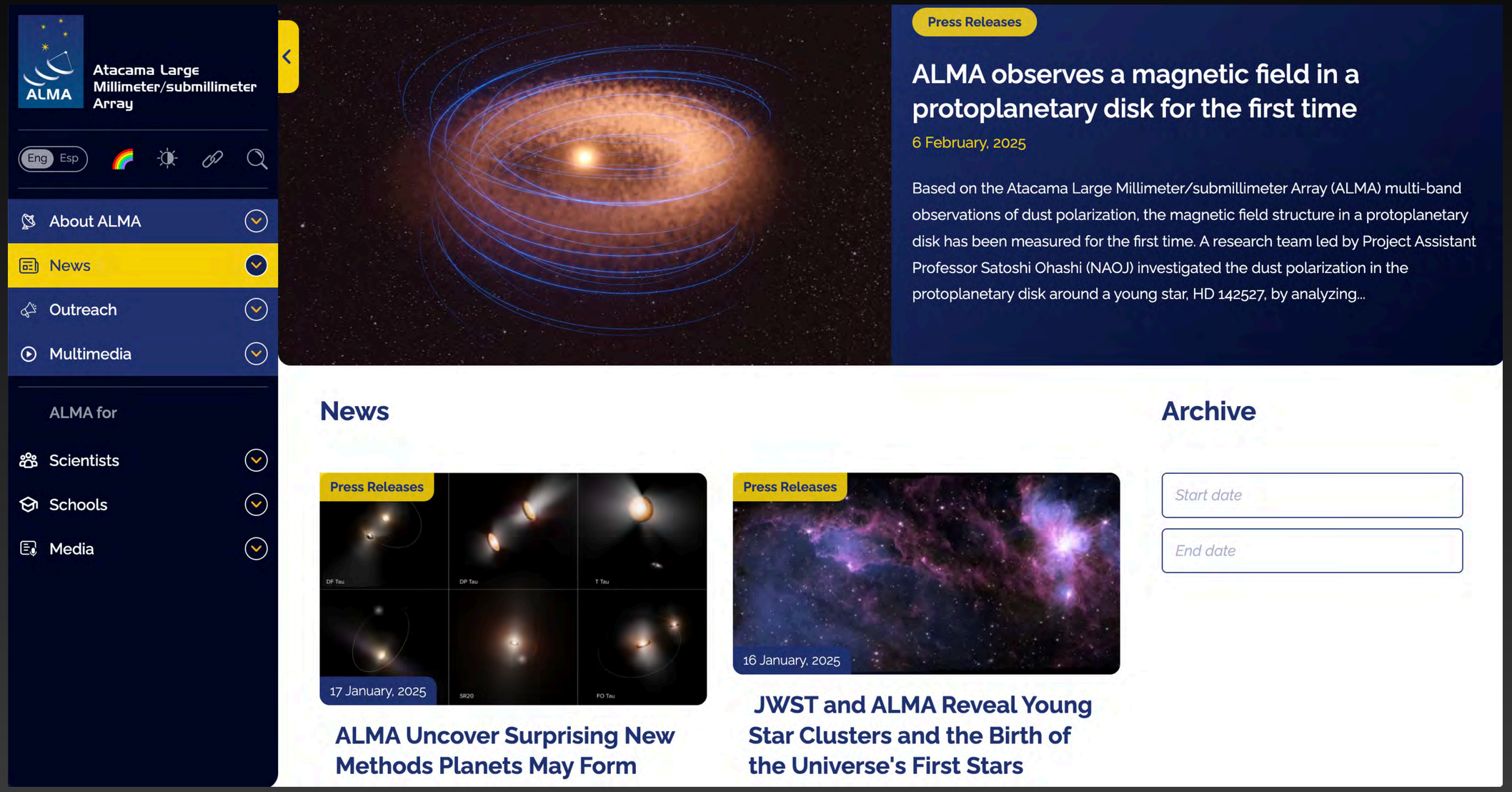
ExGal-Twin

Funded by the European Union

ALMA NEWS

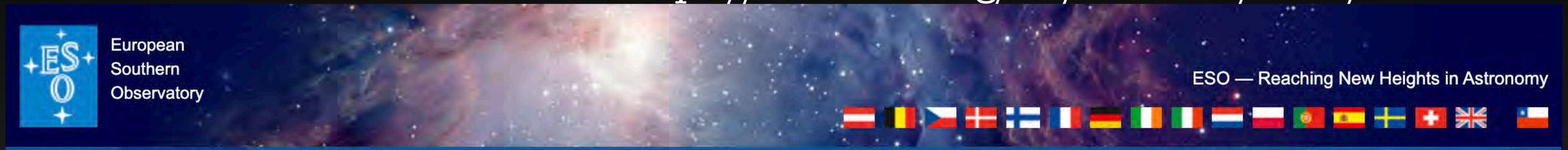
ALMA OBSERVATORY

https://www.almaobservatory.org/en/news/



ESO PORTAL

https://www.eso.org/sci/facilities/alma/news.html



EUROPEAN ARC
ALMA Regional Centre

ALMA News

ALMA News and Announcements

- **European ARC Annoucements**. Regularly the European ARC Network publishes information on on-going activities at the ARC Nodes for the ALMA programme.
- **European ARC Newsletter**. The newsletter contains an overview of the recent technnical and scientific developmens for the ALMA programme. The newsletter aims at the European ALMA user community.

Local ALMA Science News is also available from the East Asian Local News pages (NAOJ) and the North American Local News pages (NRAO).

Please also check the Lastest News on the ALMA Science Portal about observing, data releases, software products, etc.

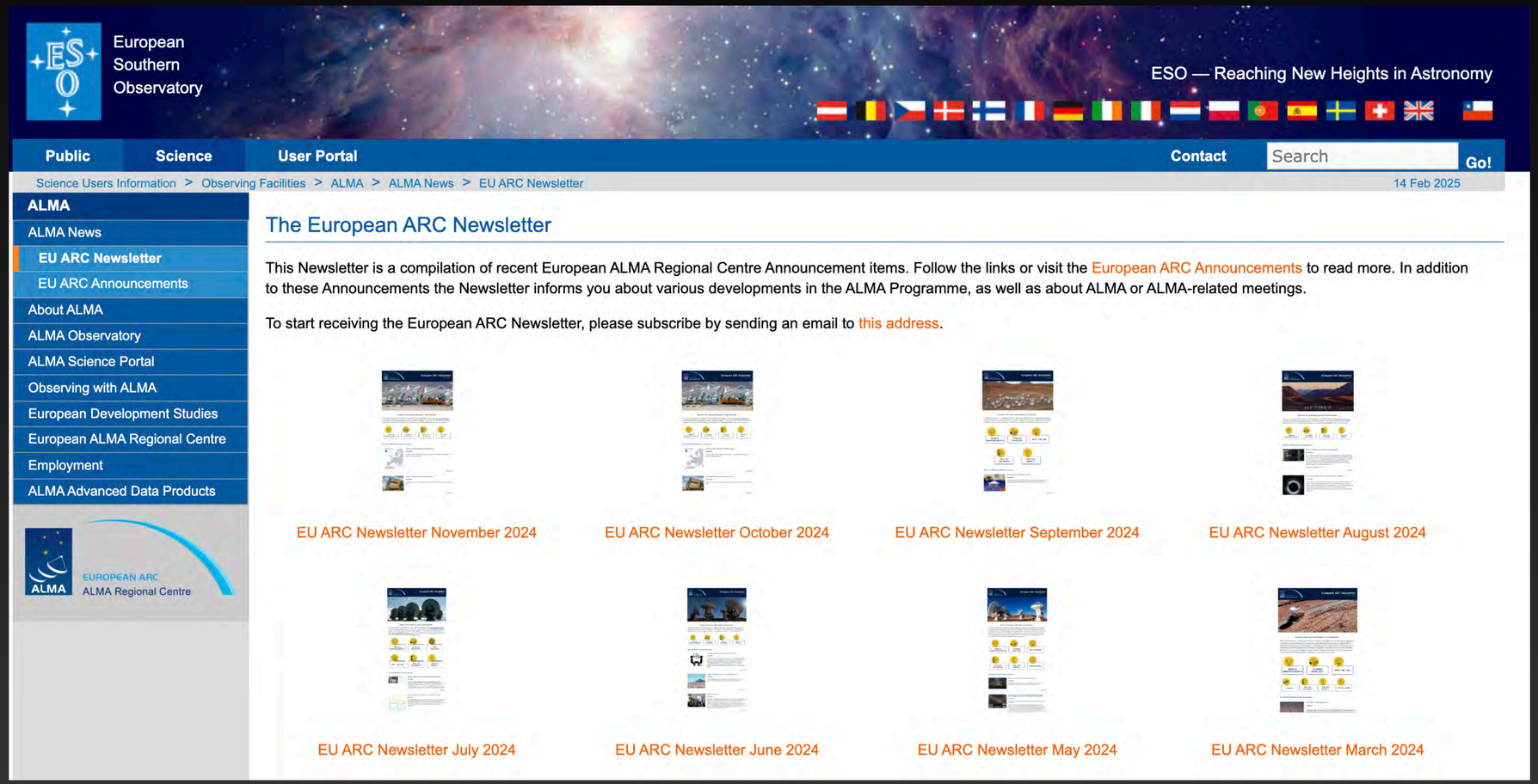
ALMA for the Public

- Press Releases please check the Observatory Press Releases
- Announcements: Please check the Observatory Announcements page

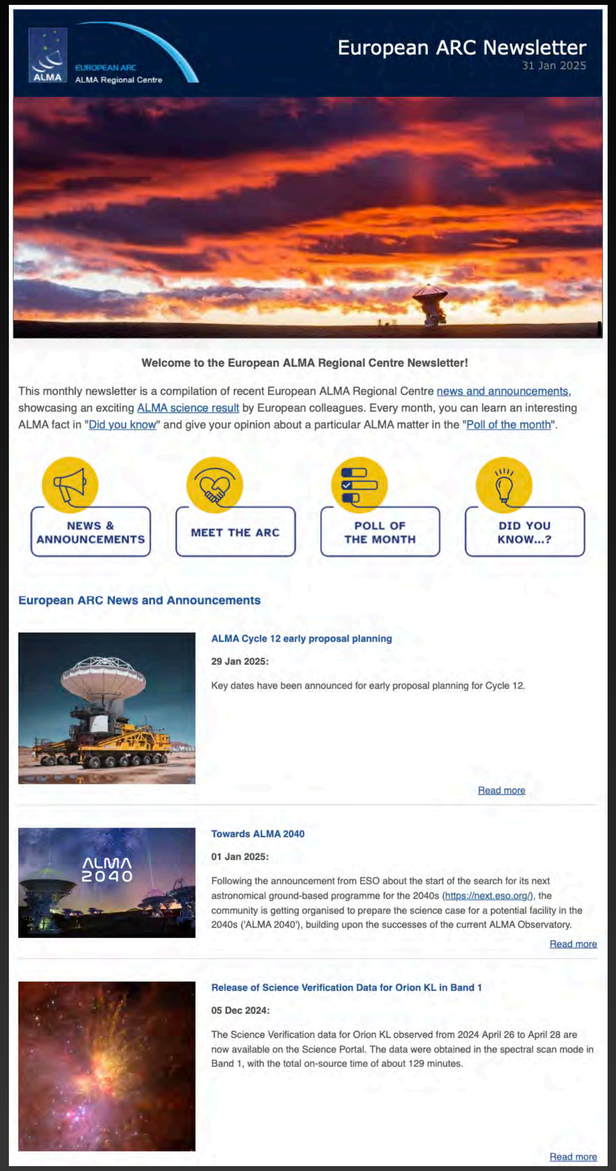
Quick Links

- ALMA Web site: The main ALMA Web site maintained by the Joint ALMA Observatory.
- ALMA Science Portal: The primary web interface between ALMA and the science community.
- ALMA Helpdesk: Please use the Helpdesk to contact us for questions of any kind.

EUROPEAN ARC NEWSLETTER

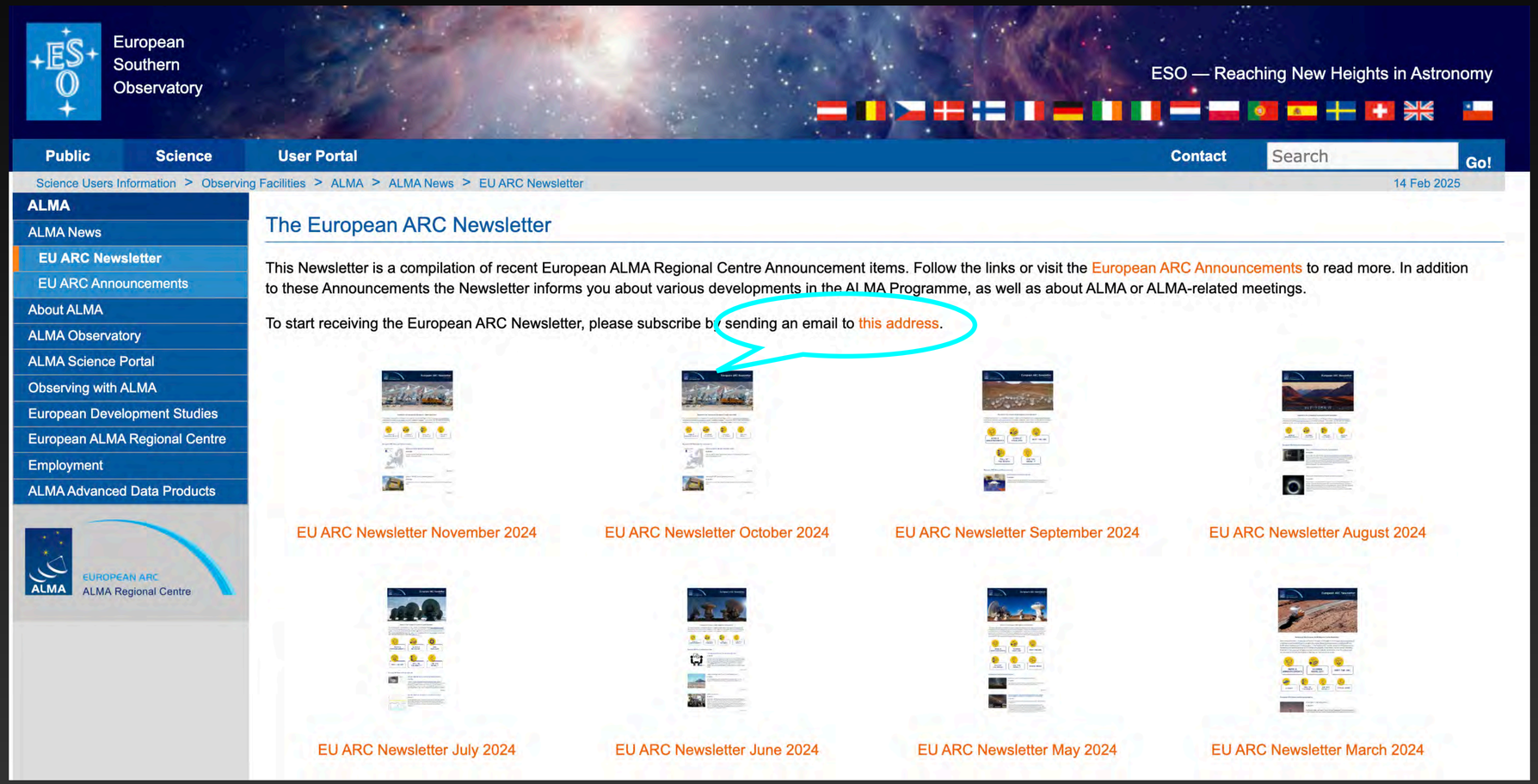


https://www.eso.org/sci/facilities/alma/news/arc-newsletter.html



Monthly newsletter

EUROPEAN ARC NEWSLETTER



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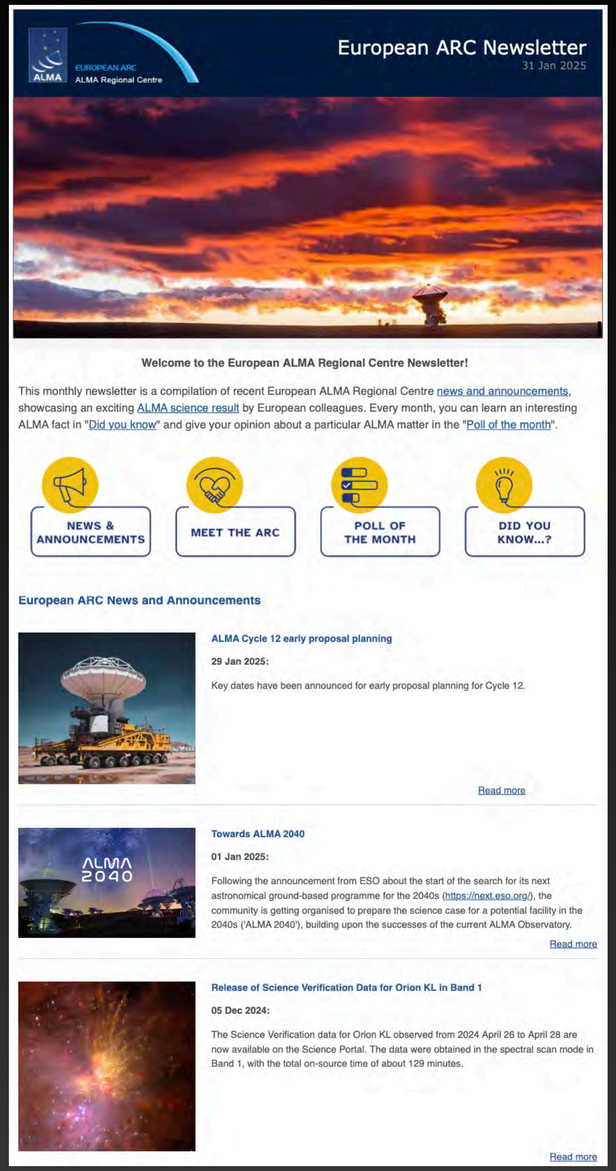
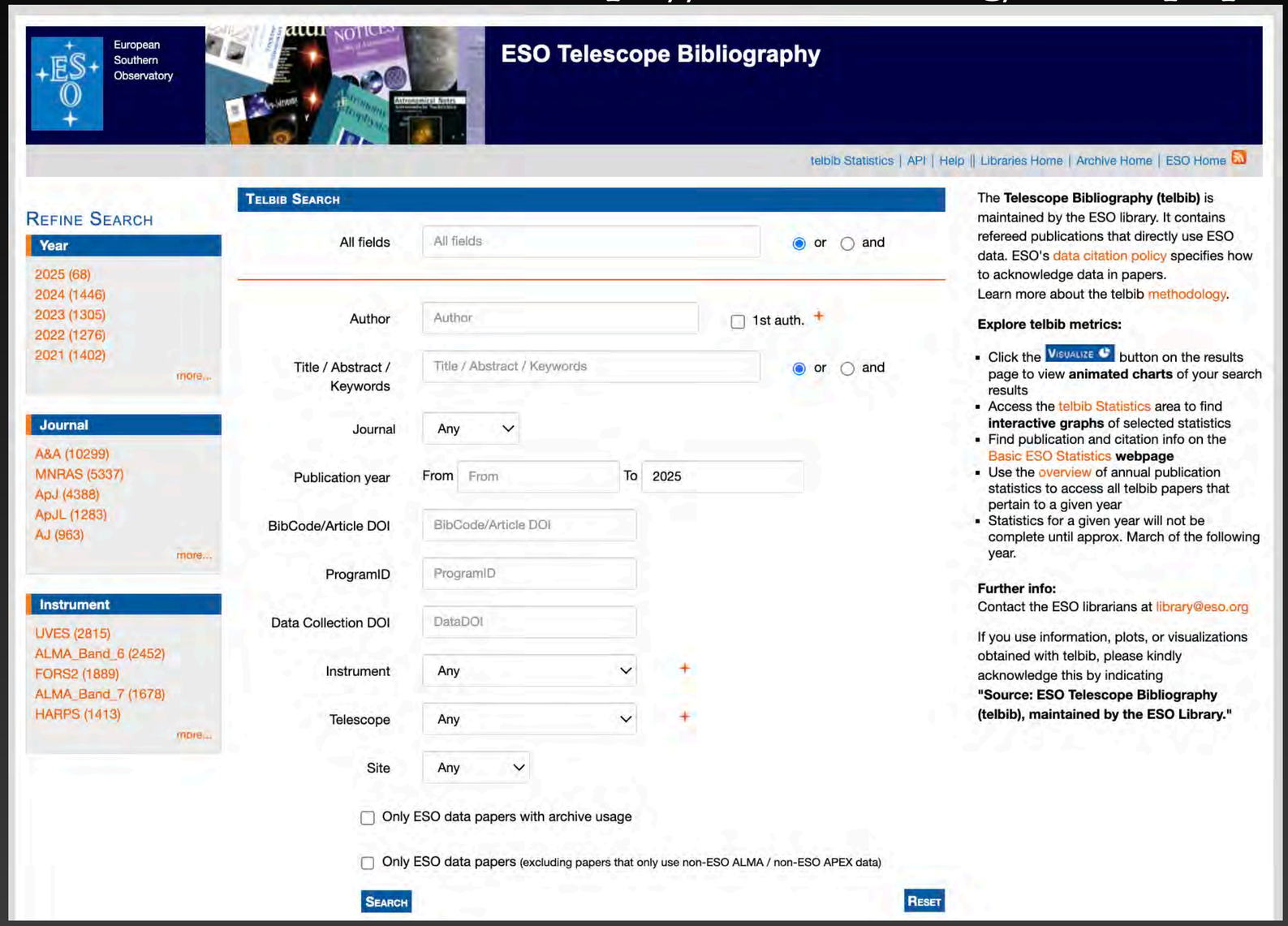


Monthly newsletter

ESO TELBIB

https://telbib.eso.org/index.php



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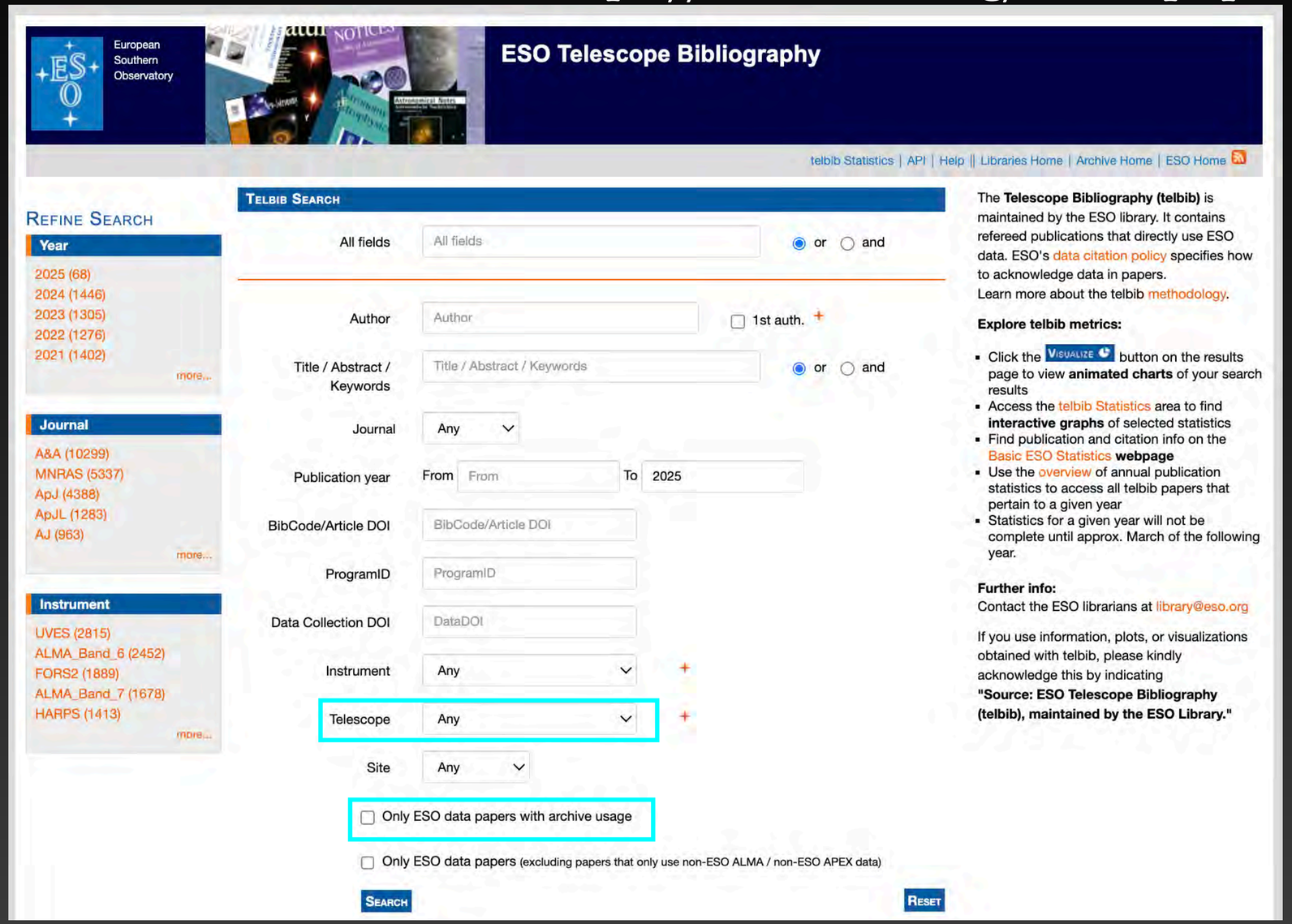

ESO TELBIB

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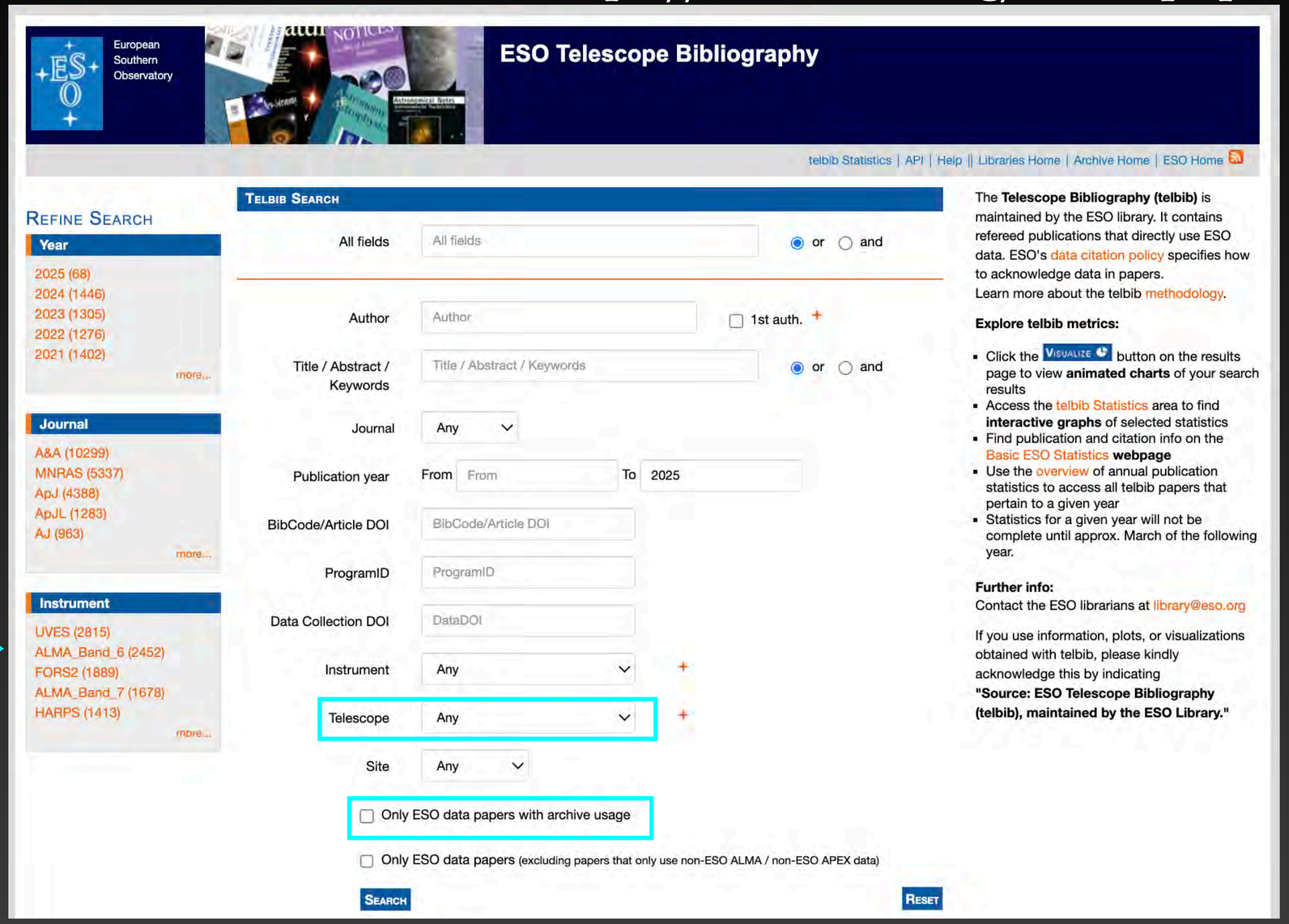
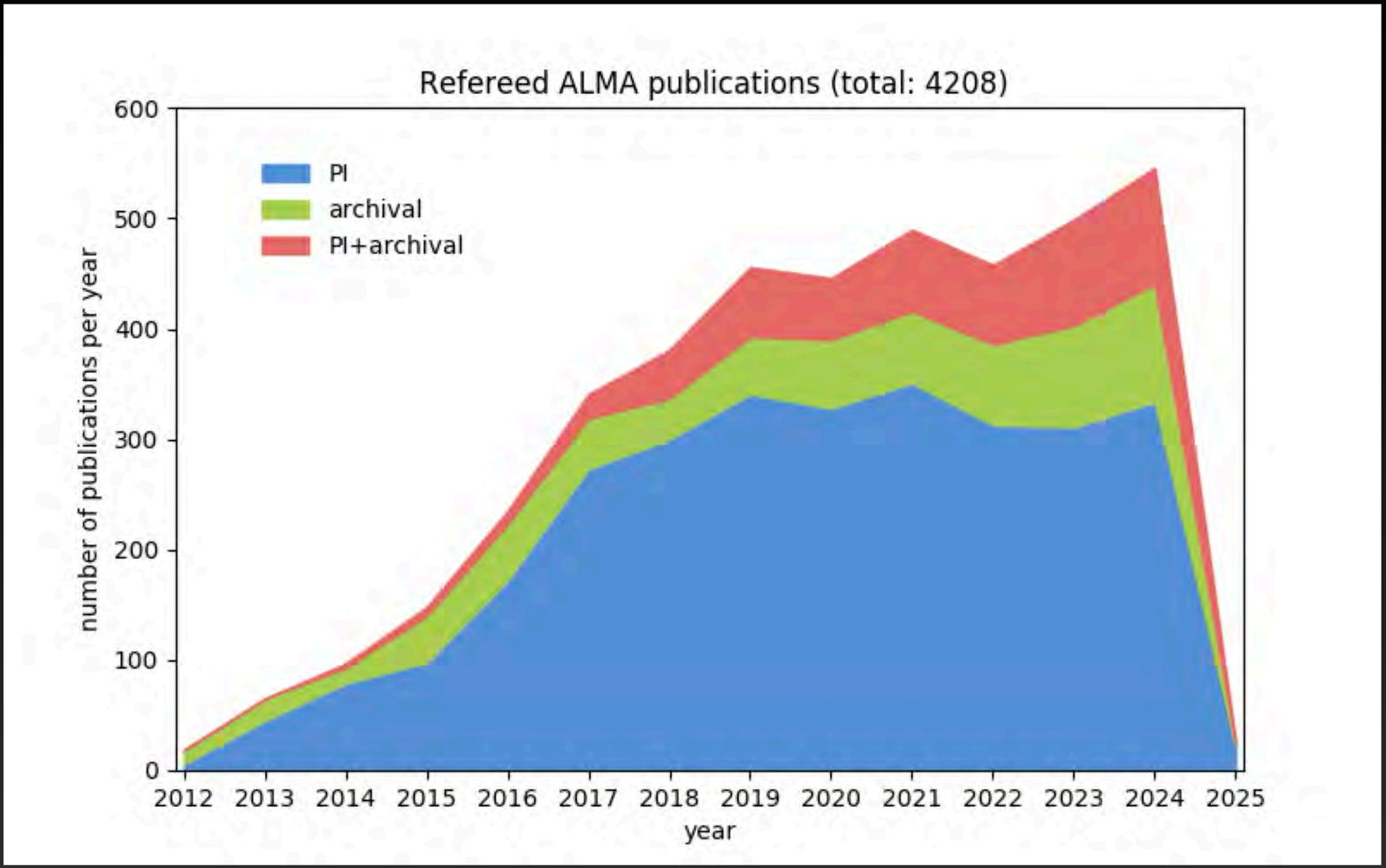
836 results for
ALMA telescope
+
archive only or
archive and PI



-13% of all publications in Nature involve the use of archival data (9% exclusively on such data)

-publications using of either purely **archival data** or **archival+ PI data** accounted for an impressive fraction of all ALMA publications



Astronomy community has an ever-growing opportunity to leverage ALMA's extensive archive

LOCAL AND HIGH-Z GALAXIES

What's robbing galaxies of their star-forming gas?

The Virgo Environment Traced In CO (VERTICO) survey: physical mechanisms perturbing molecular gas disks and star formation in dense environments

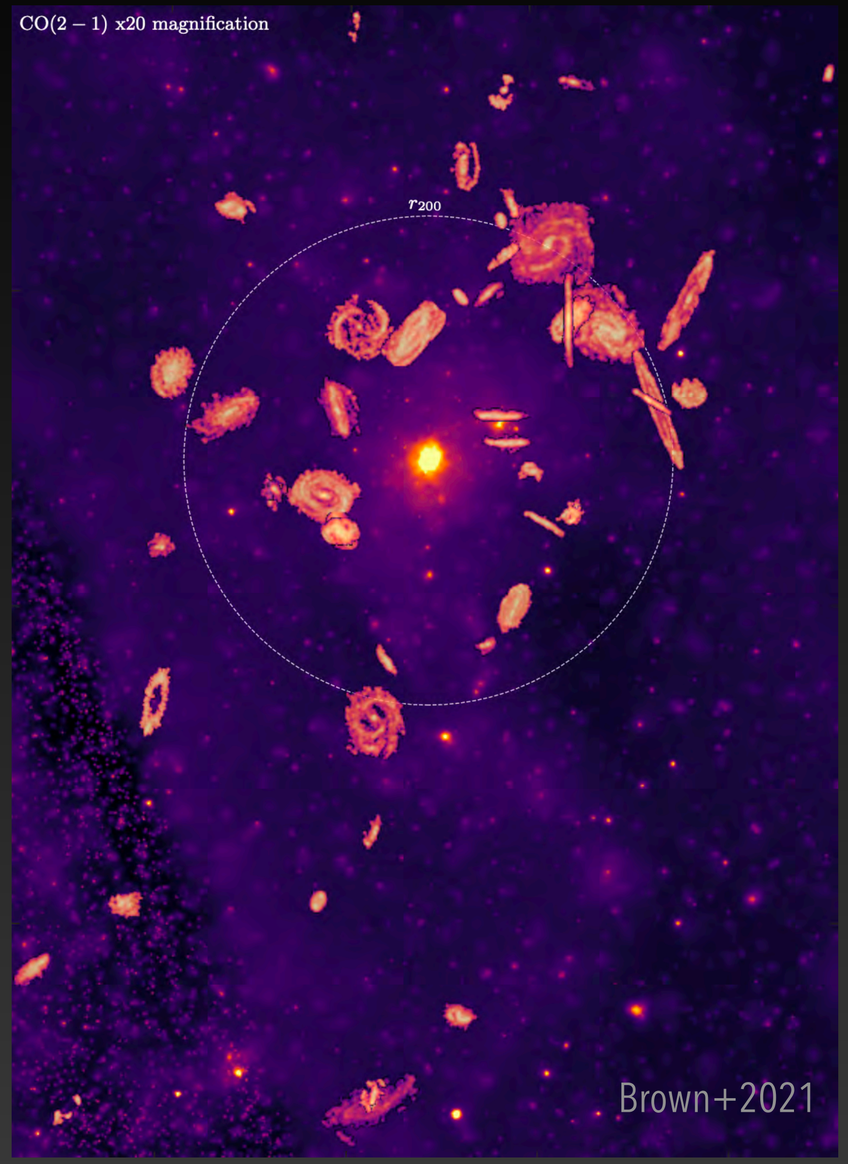
-Virgo Cluster: nearest massive galaxy cluster to the Local Group

-51 galaxies with ACA (7m+TP): 36 targets in CO(2-1) and ALMA Band 6 continuum + 15 from ALMA archive at ~8" (~0.7kpc)

-gas morphology and kinematics reveal imprint of stellar structures (**spiral arms, bars, bulges**) and environmental processes (**warps, tails, depletion**)

-ram pressure stripping: violent external mechanisms can quench star formation (Watts+2023,Brown+2023)

GAS RESERVOIRS OF 51 GALAXIES IN THE VIRGO CLUSTER



Article: "VERTICO: The Virgo Environment Traced In CO Survey" Brown et al 2021, *ApJS*

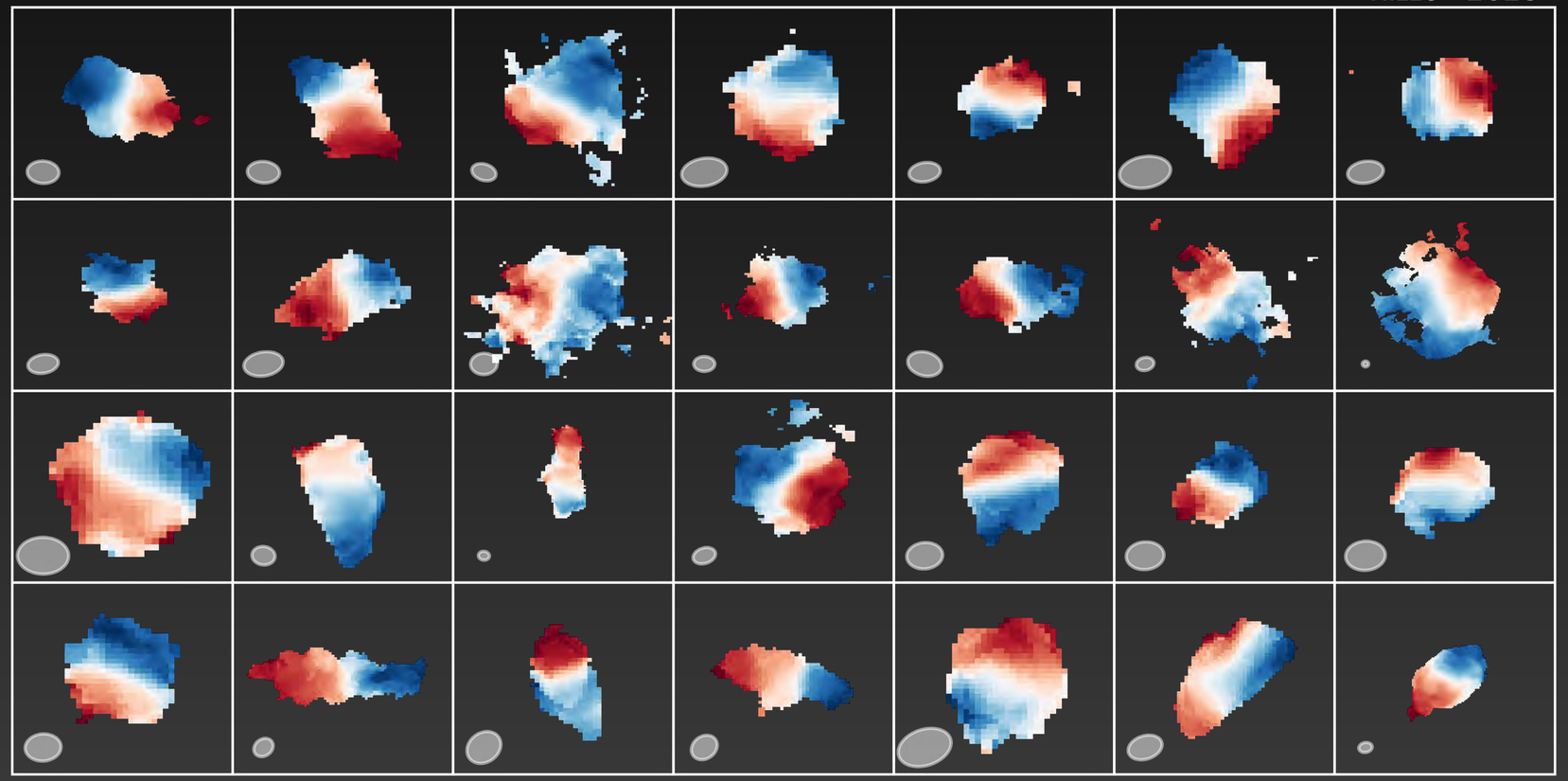
ALPAKA: Archival Large Program to Advance Kinematic Analysis

High-resolution (~0.25″) observations of CO and [CI] emission lines of star-forming galaxies at z=0.5−3.5

≈147h integration time for 28 star-forming galaxies spanning 7 Gyr cosmic time

-28 ALMA archive: 19 show rotating disks (v/σ~10)

Rizzo+2023



Article: “The ALMA-ALPAKA survey. I. High-resolution CO and [CI] kinematics of star-forming galaxies at z = 0.5-3.5” Rizzo et al 2023, *A&A*

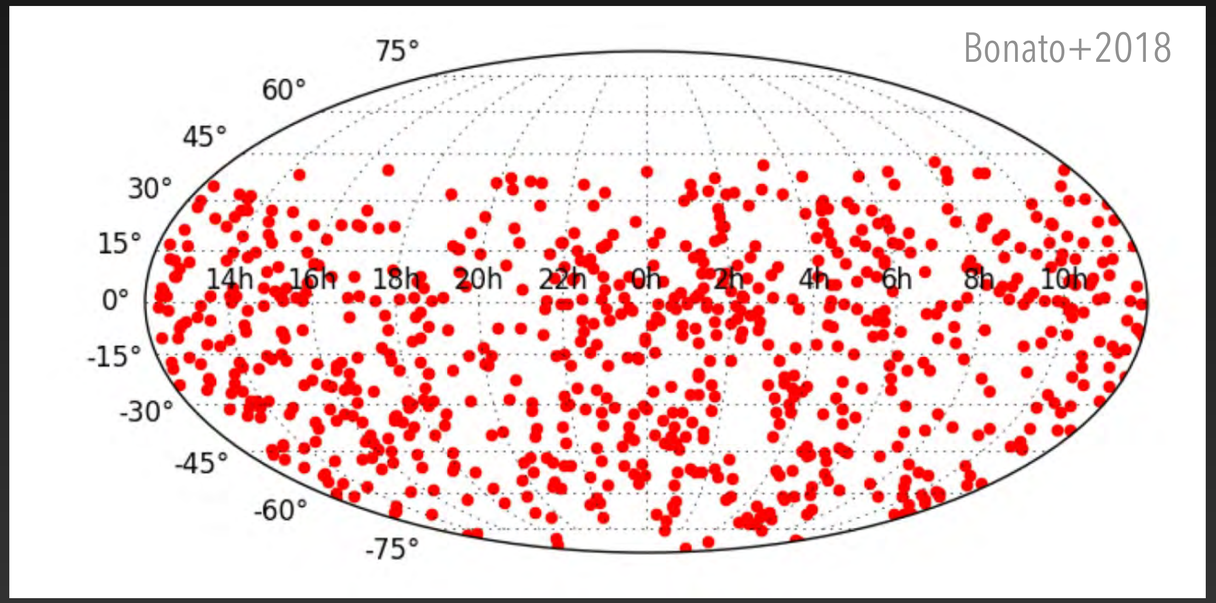
Surveying the universe with ALMA calibration observations

ALMACAL

-Over 800 ALMA calibrators randomly distributed over the sky

-About 600 calibrators have a measured redshift.

Most at z < 1.5 with up to z = 3



-sky coverage ~800 arcmin^2 (Band 3) to 1 arcmin^2 (Band 9)

-total ALMACAL observation time to date ~2000h

-ALMACAL dataset grows with each ALMA science observation

Articles: “ALMACAL I: first dual-band number counts from a deep and wide ALMA submillimeter survey, free from cosmic variance” Oteo et al. 2016, *ApJ*
“ALMACAL IV: a catalogue of alma calibrator continuum observations” Bonato et al. 2018, *MNRAS*

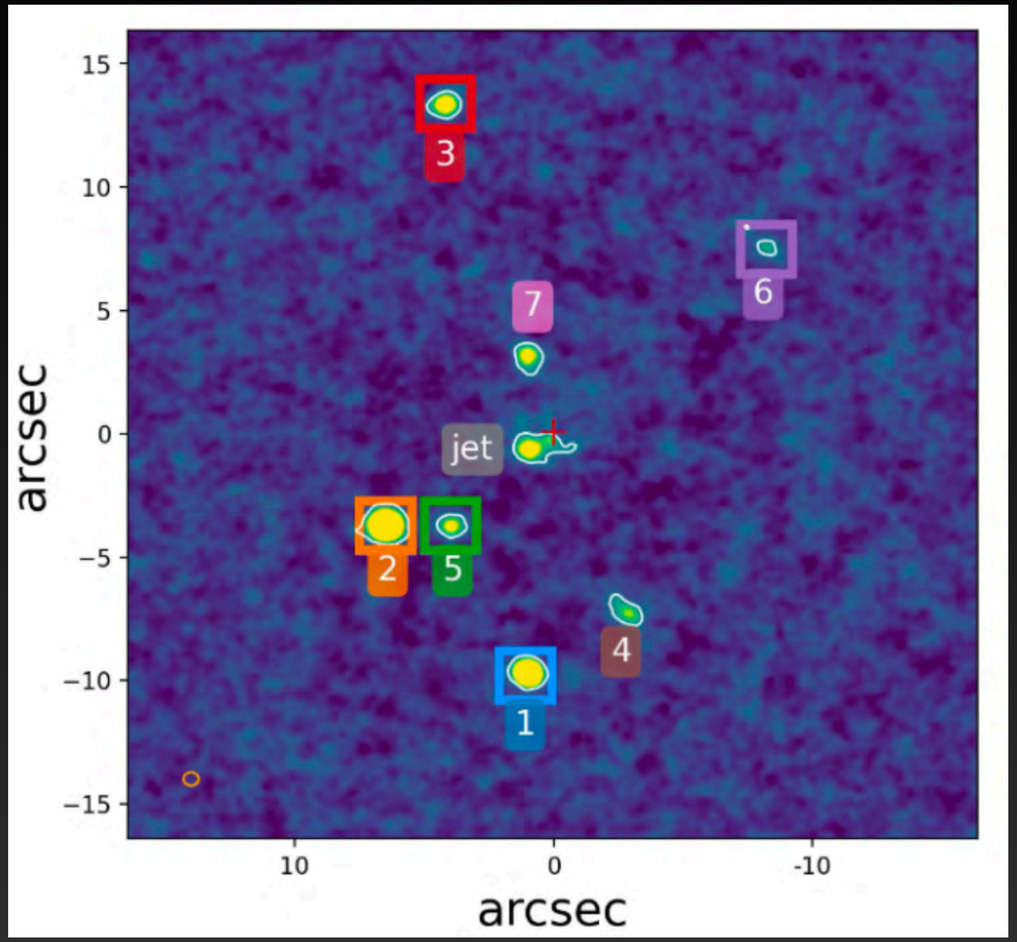
Over-densities as signposts for proto-clusters? a cautionary tale

ALMACAL produced several scientific results (13 papers so far)

-serendipitous discovery of an extremely dense region around blazar J0217−0820 at z = 0.6

-8.6h of ALMACAL data accumulated from band 3 to band 7

-over-density, δgal ≃ 8, is comparable to extreme proto-cluster cores



ALMACAL

Chen+2023

Article: “ALMACAL XI: over-densities as signposts for proto-clusters? A cautionary tale” Chen et al. 2023, *A&A*

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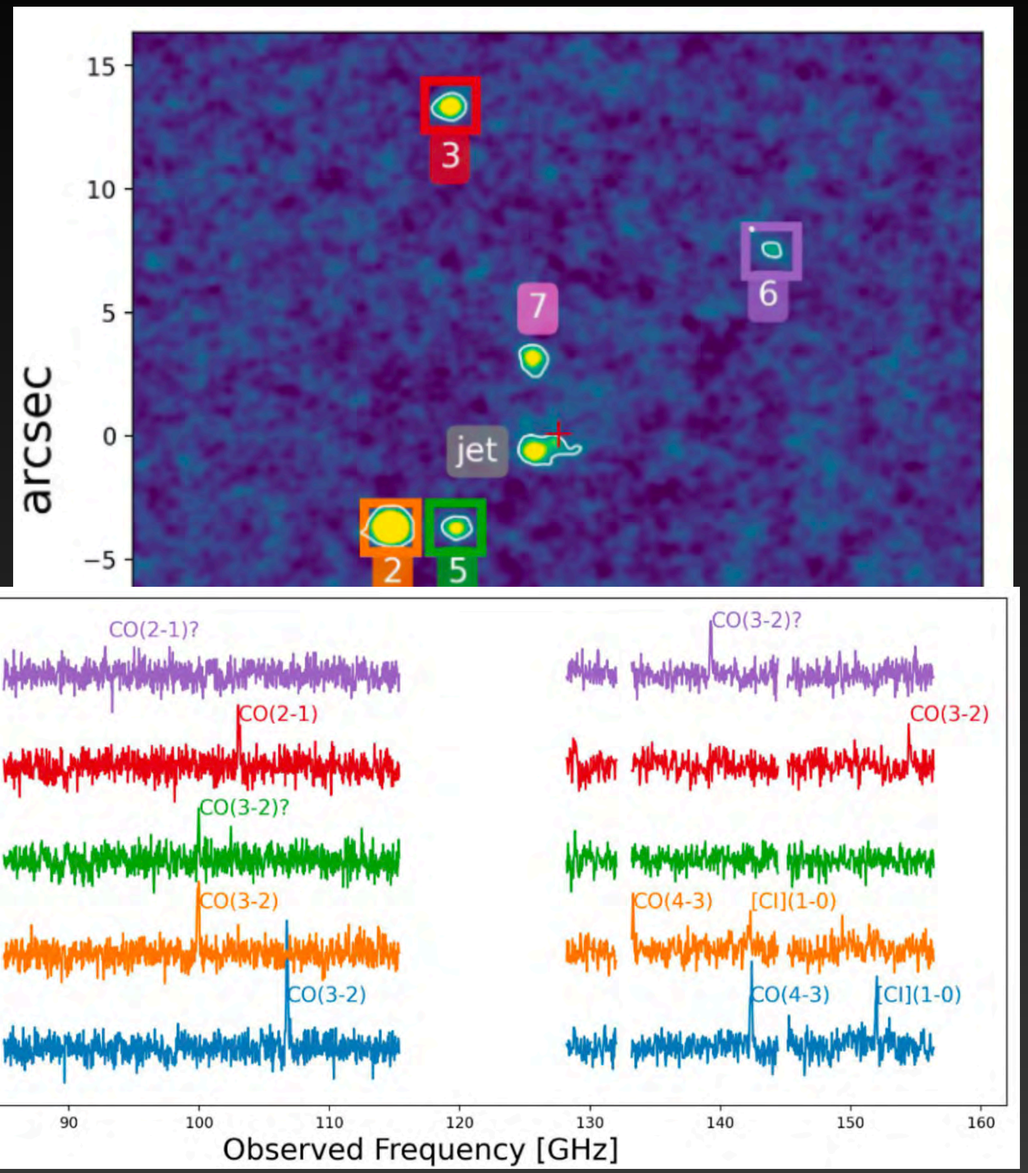
-central blazar at z = 0.6, surrounding dusty starbursts located at 4 different z

-almost entirely due to chance alignments



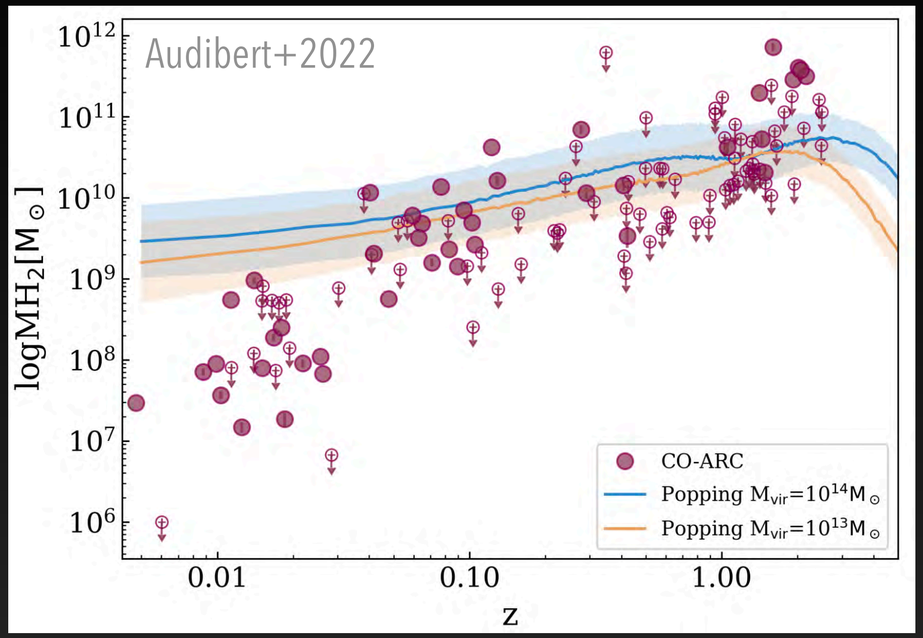
Article: “ALMACAL XI: over-densities as signposts for proto-clusters? A cautionary tale” Chen et al. 2023, *A&A*

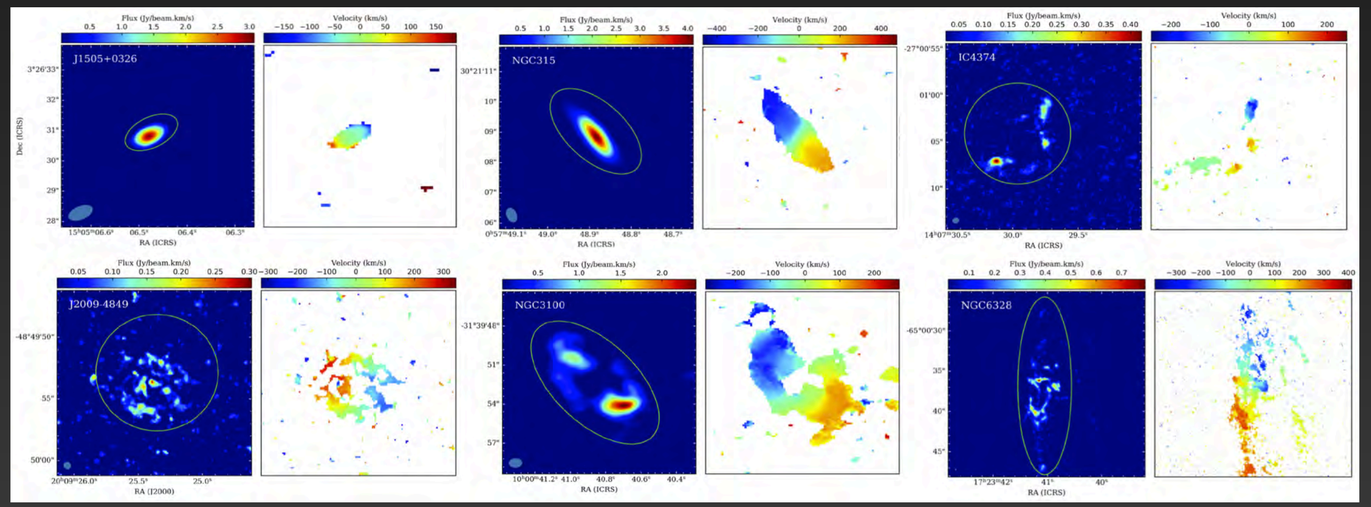
ARC-CO: molecular gas in radio galaxies

Evolution of gas reservoirs in radio galaxies (RGs) with redshift in the ALMA Radio-source Catalogue (ARC)

-ALMA calibrators and targets with CO emission in the spectral coverage (up to J=4) up to z<2.5

-66 RGs observed with ALMA: **ARC-CO** +54 from literature; total sample of **120 RGs**





-variety of morphologies and kinematics: rotating disks, rings, irregular/disturbed kinematics

-**The first local CO LF of RGs is 2 to 3 orders of magnitude lower than normal and star-forming galaxies**

Article: “CO in the ALMA Radio-source Catalogue (ARC): The molecular gas content of radio galaxies as a function of z” Audibert et al. 2022, *A&A*

A variety of quasars morphologies and environments

Catalogue of submillimetre (submm) detections of DR14 Sloan Digital Sky Survey quasars that lie in the aggregate ALMA footprint observed since ALMA Cycle 0

-fluxes are extracted using the ALMA Data Mining Toolkit (S/N>3.5)

-catalogue of 376 entries, corresponding to 275 unique quasars

-interesting targets found in the process, i.e. **lensed** or **jetted** quasars as well as quasars with nearby **submm counterparts** are highlighted, to facilitate further studies or follow up observations

Article: “ALMA High-Level Data Products: Submm counterparts of SDSS quasars in the ALMA footprint” Wong et al. 2023, *MNRAS*

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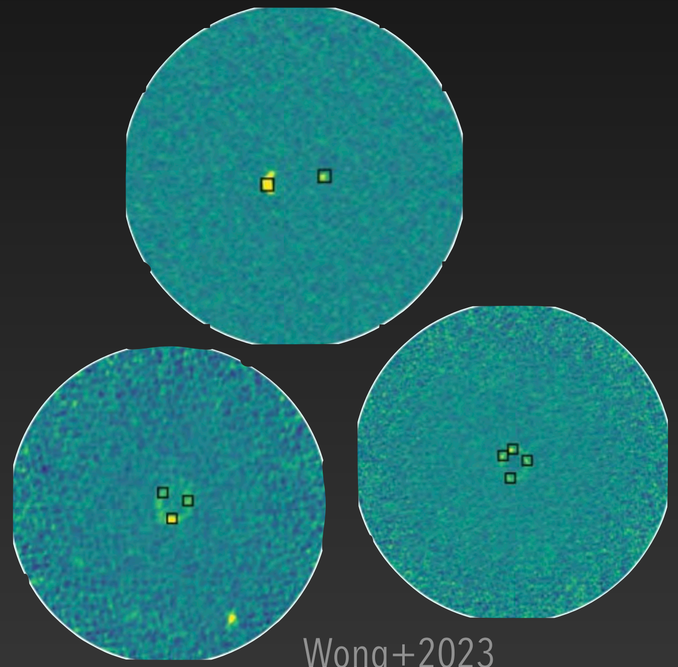

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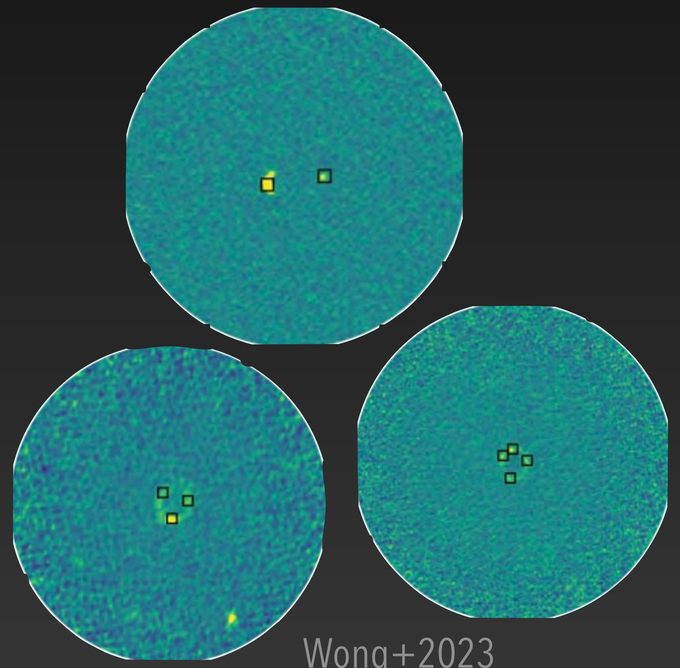

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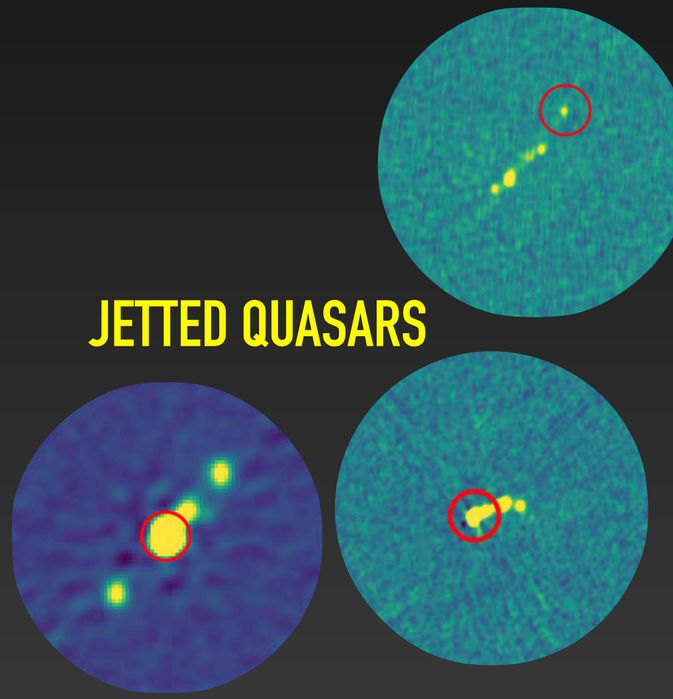
JETTED QUASARS



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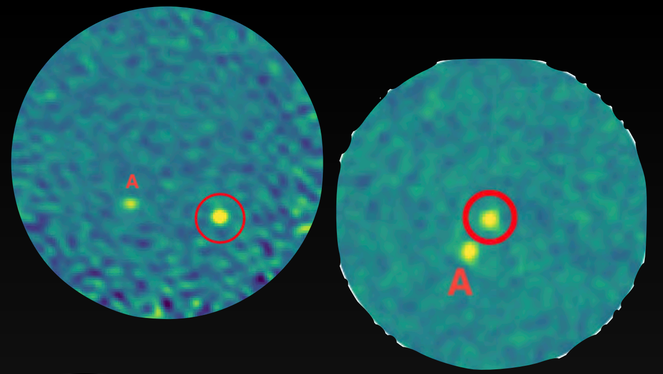
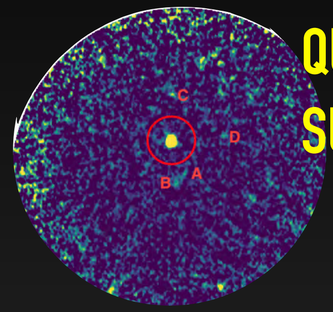
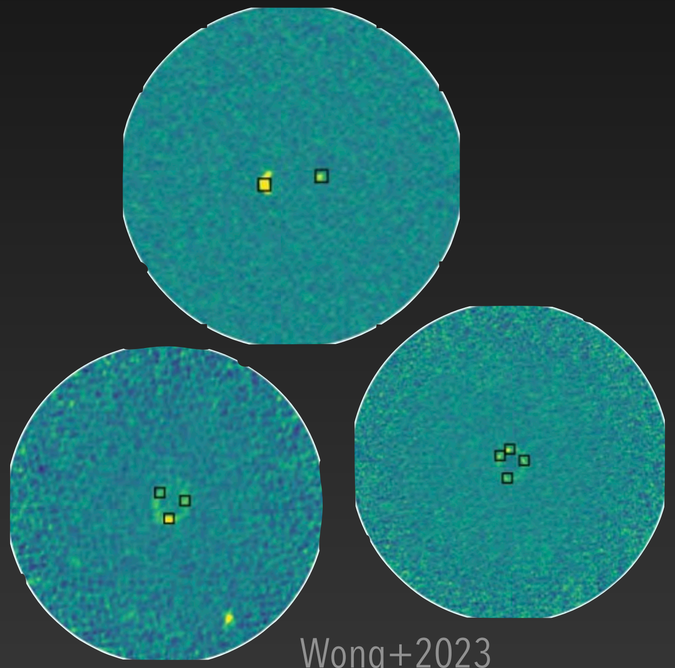




QUASARS WITH SUBMM COMPANIONS

LENSED QUASARS



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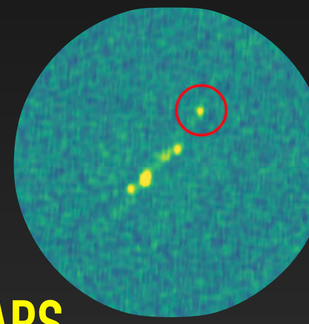

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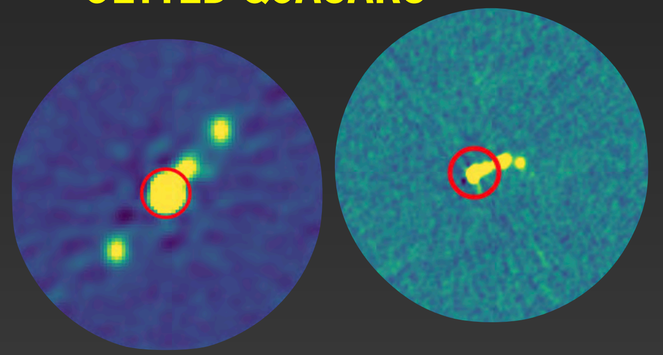

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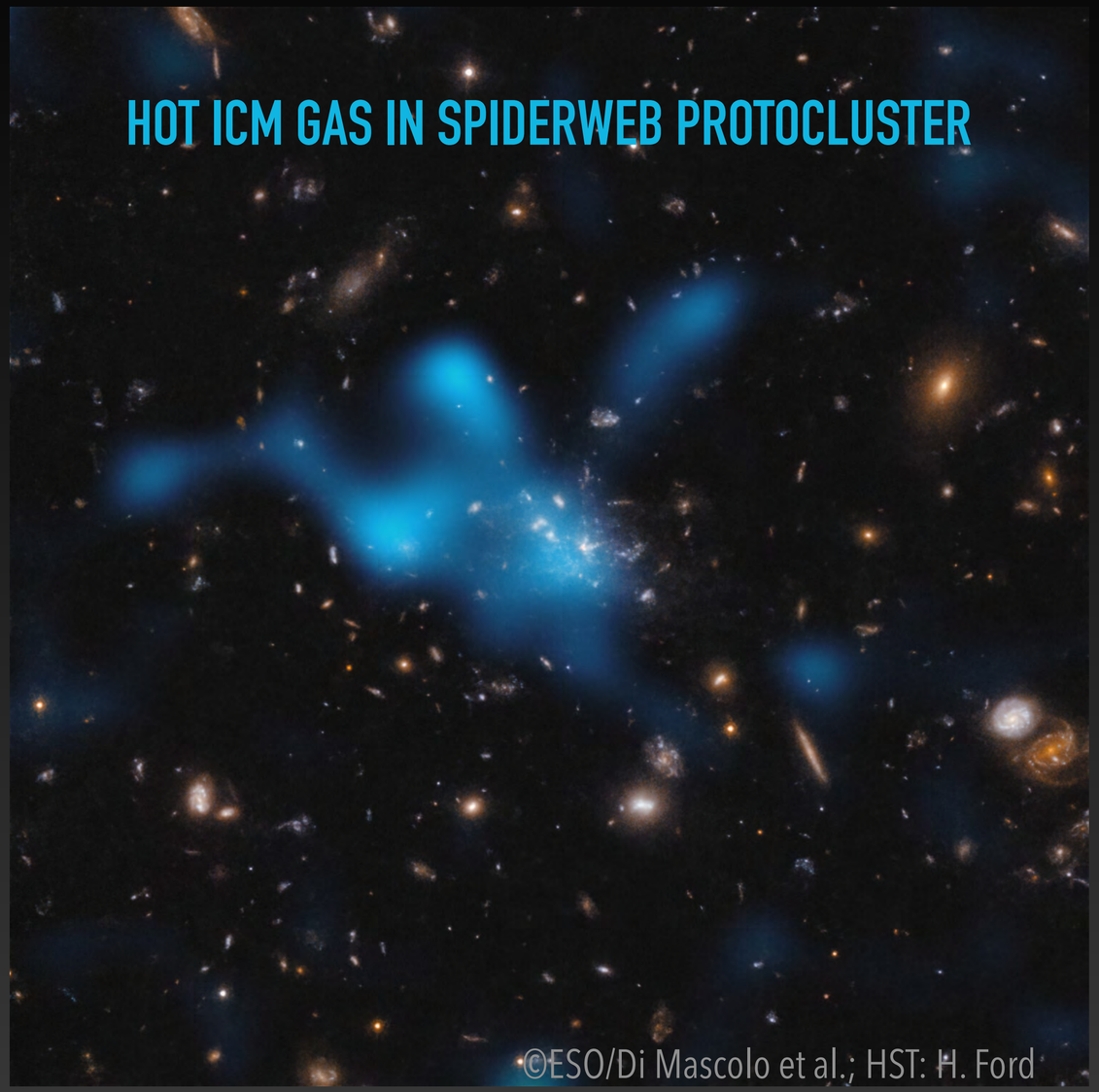
Birth of a galaxy cluster at redshift ~2



Most distant measurement of the large reservoir of hot gas in the still-forming galaxy cluster around the Spiderweb galaxy

-cosmological simulations have predicted the presence of hot gas in protoclusters

-proprietary Band 3 + archival Band 4 observations

-thermal Sunyaev-Zeldovich (SZ) effect in the direction of a protocluster, reveals the ICM thermal energy

-$M_{\text{hot gas}} = 1000 \times M_{\text{cold gas}}$

-Spiderweb protocluster is expected to turn into a massive galaxy cluster in ~10Gyr

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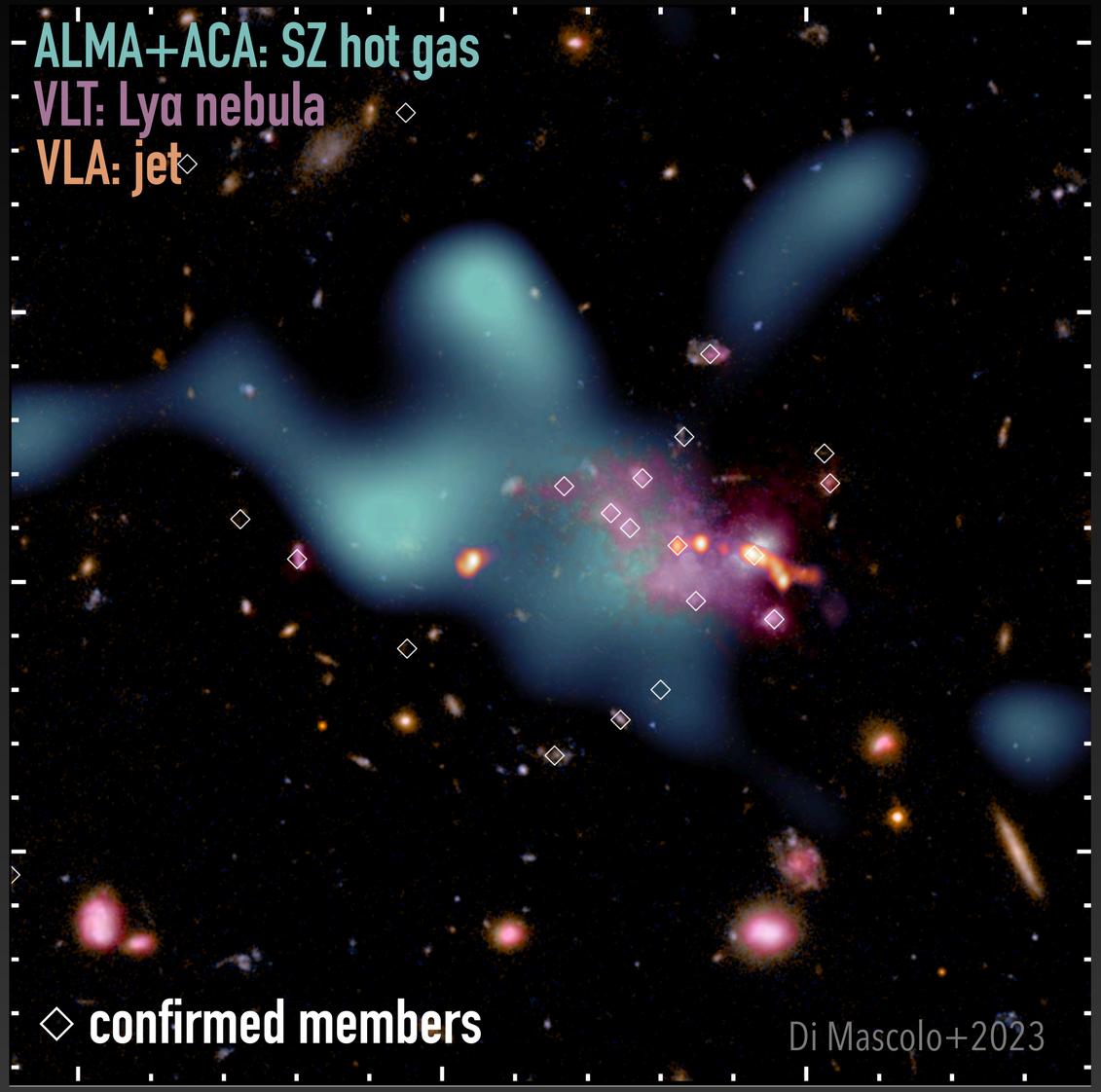

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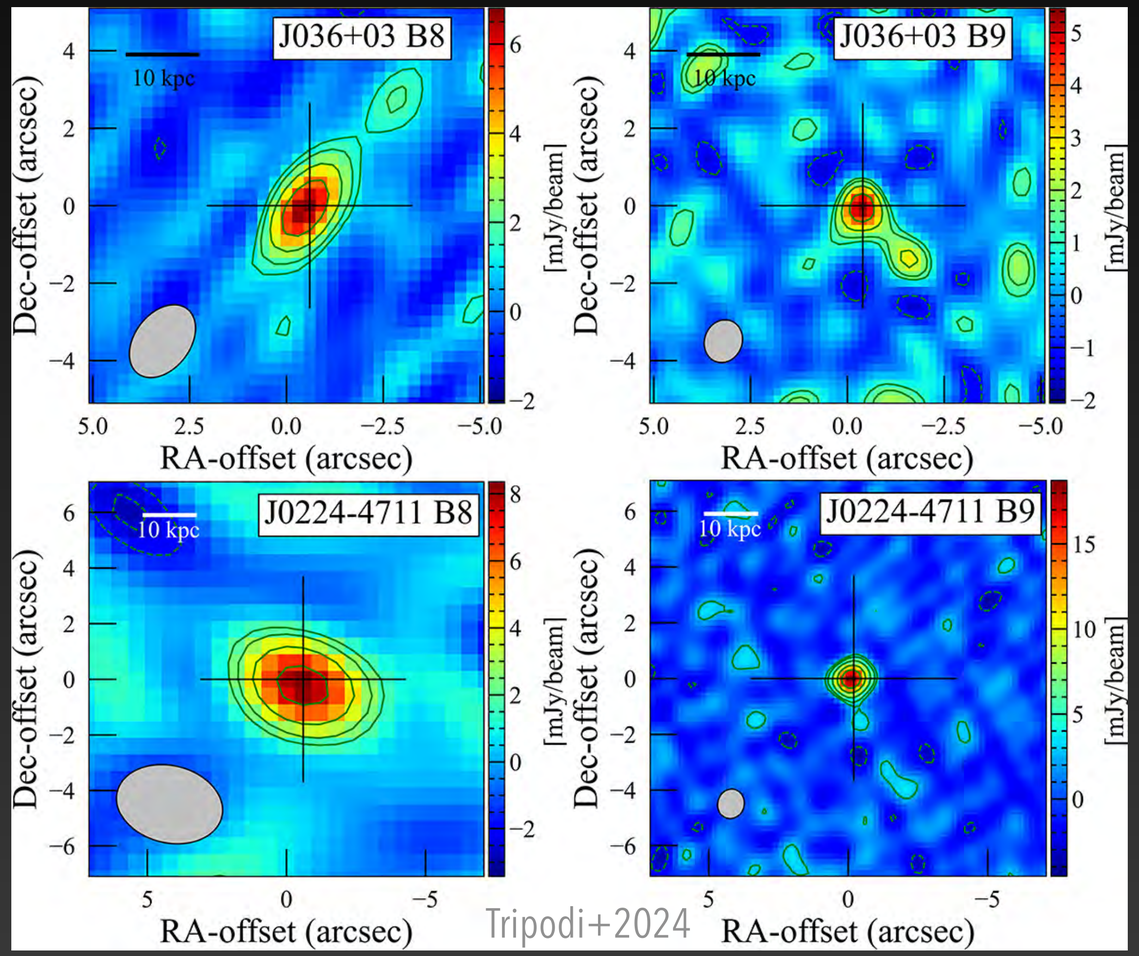
HYPERION: HYPerluminous QSOs at the Epoch of ReionizatION

ALMA CONTINUUM OBSERVATIONS



Tripodi+2024

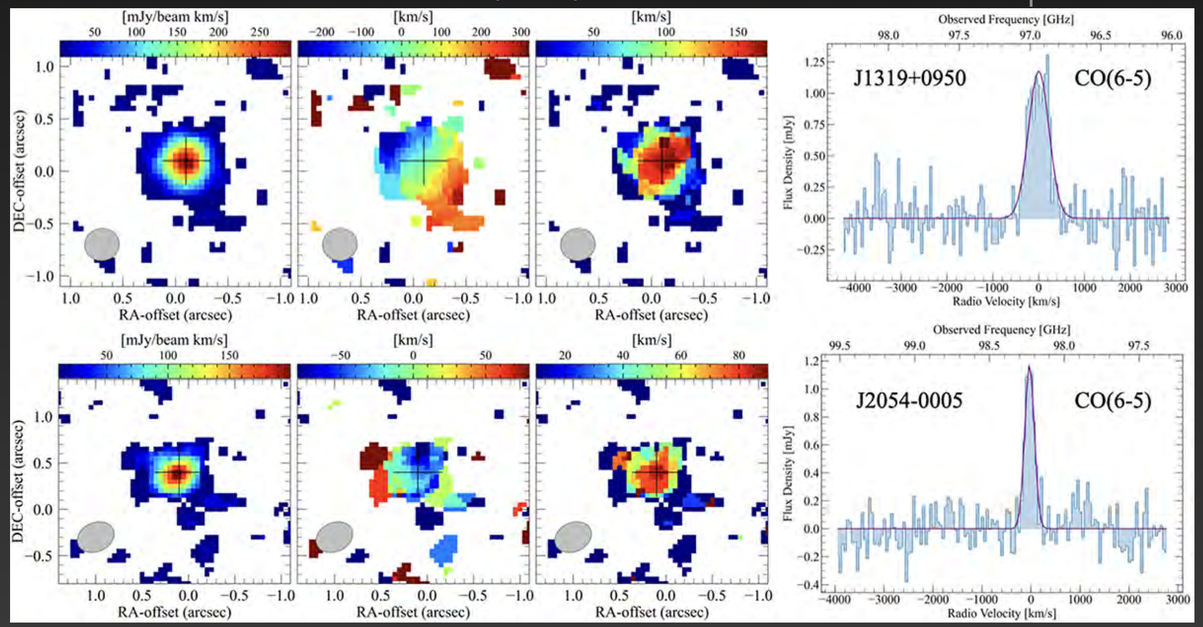
-QSO z>6 sample from Zappacosta+2023

-CO(6-5) and CO(7-6) in 4 QSOs: $M_{mol} \sim 10^{10}\ M_\odot$

-proprietary+archival ALMA observations in band 8 & 9: dust properties and SFR of 4QSOs for the first time

ALMA CO(6–5) OBSERVATIONS

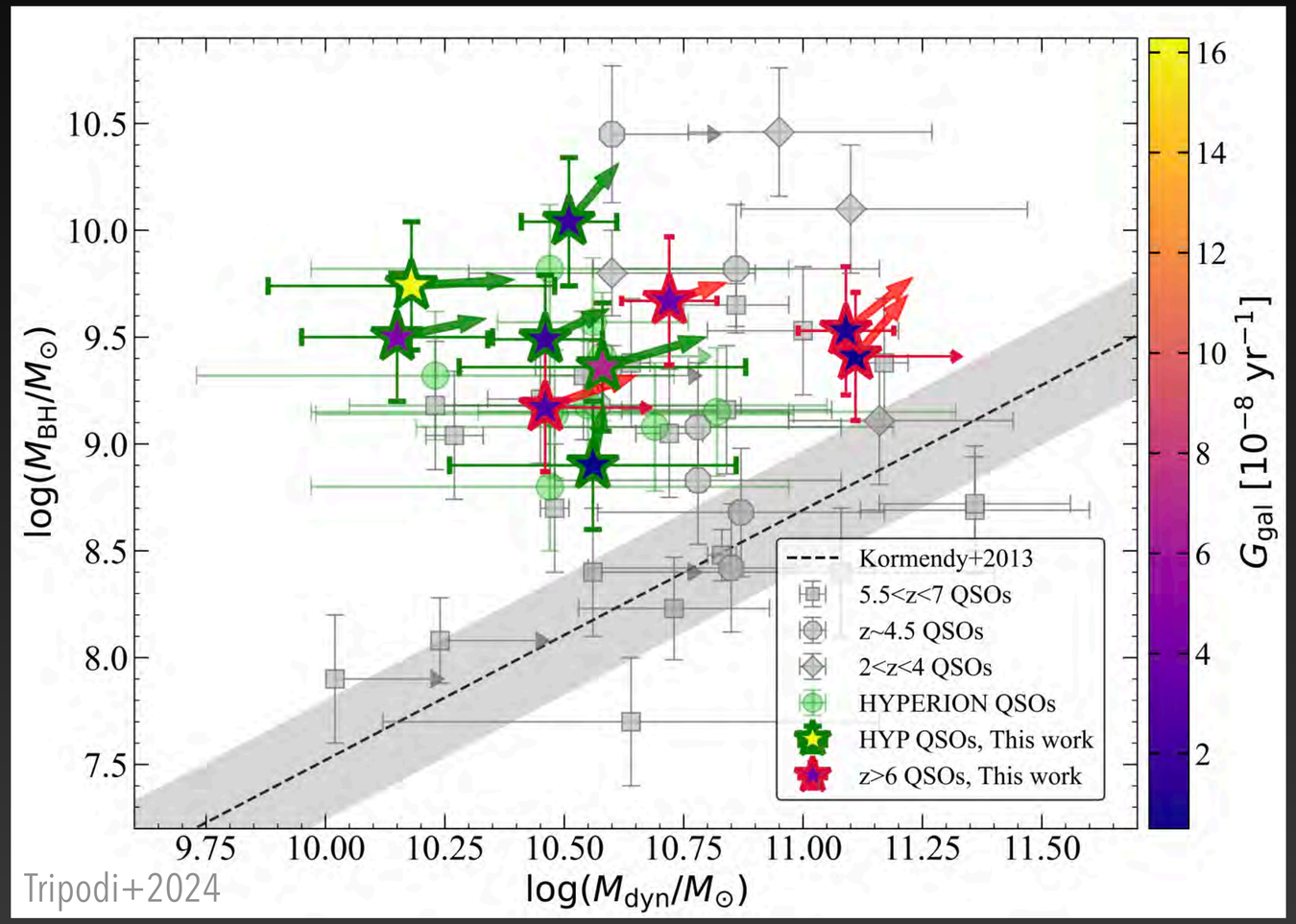
Tripodi+2024



Article: “HYPERION: Coevolution of supermassive black holes and galaxies at z > 6 and the build-up of massive galaxies” Tripodi et al 2024, *A&A*

HYPERION: Coevolution of SMBHs and galaxies at z >6

THE CHICKEN OR THE EGG?



-HYPERION QSOs marked by intense SMBH growth

-above the local M_{BH}-M_{dyn} plane: QSOs at $z \gtrsim 6$ undergo rapid galaxy growth - possibly regulated by strong outflows

-pathway: intense black hole growth ***followed*** by substantial galaxy growth, in contrast with symbiotic growth scenario

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A BIT CLOSER:
STARS, PLANETS, EXOCOMETS

Parallel disks and jets erupting from a pair of young stars

High-resolution (~25 au) ALMA Band 4 and Band 6 continuum + CO(2-1) and JWST MIRI-MRS images of multiple system WL20

©U.S. NSF/ NSF NRAO/B. Saxton.; NASA/JPL-Caltech/Harvard-Smithsonian CfA

-star system WL20, in ρ-Ophiuchi molecular cloud complex

-ALMA resolved twin, edge-on disks of ~100 AU in WL20S in continuum and CO(2-1)

-MIRI found the parallel jets ([ArII], [FeII], [NiII], [NeII]), and a wide-angled disk wind in H2 surrounding the ionized jets

-outflow evolutionary scenario: mol. gas dominates in the young; fast, ionized jets dominate in the oldest

Article: “Resolving Twin Jets and Twin Disks with JWST and ALMA: The Young WL 20 Multiple System” Barsony et al 2024

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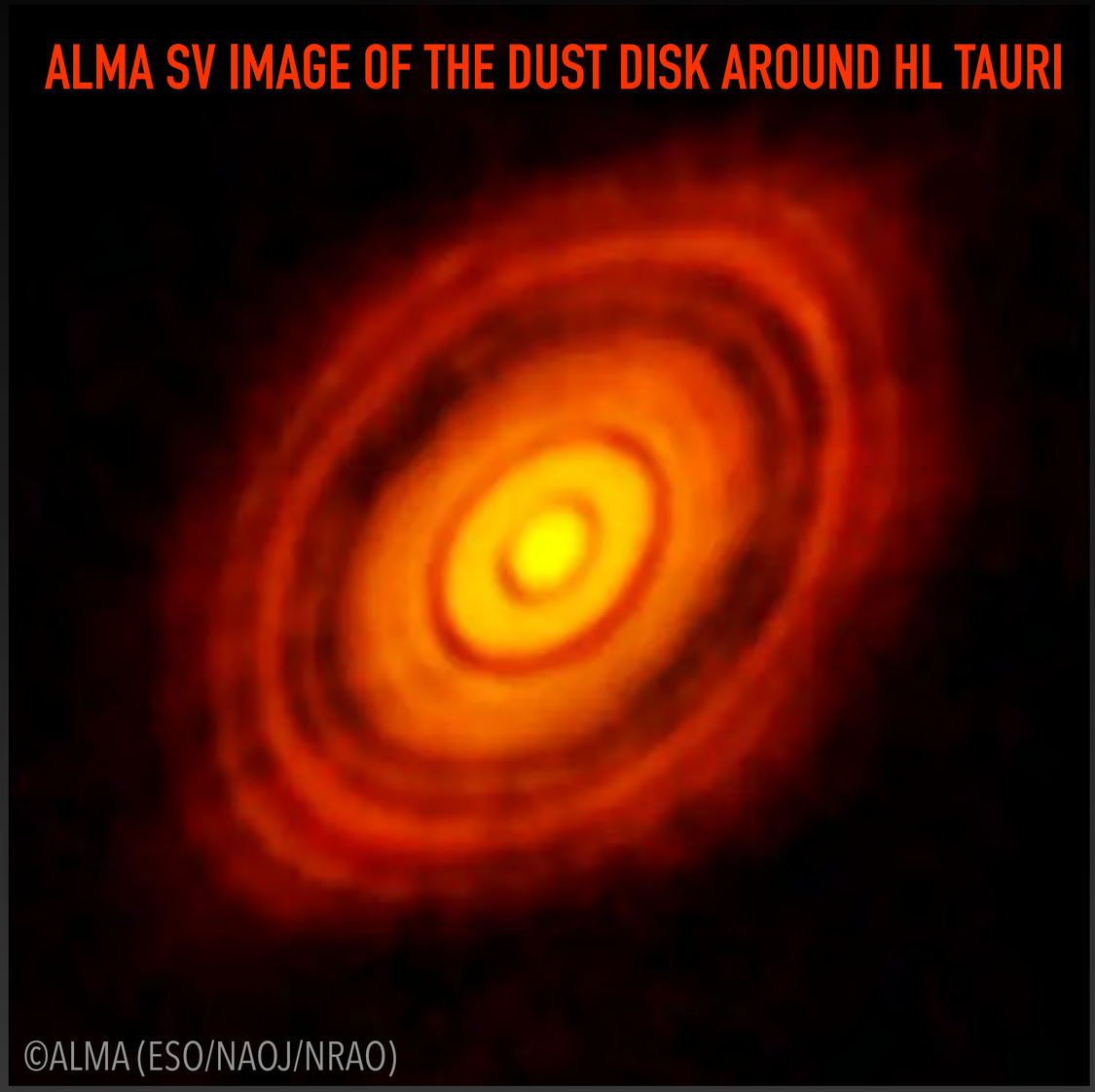
Footprints of baby planets in a gaseous disk

New data analysis techniques of ALMA Science Verification observations uncover gaps in the gas disk at ~10 au resolution around protostar HL Tau

-performed azimuthal averaging on HCO+ image: locations HCO+ disk gaps match the gaps in the dust found in the ALMA SV high resolution image taken in 2014.

-gaps in the dust are caused by the gravity of (sub-)Jovian mass forming planets

-planets form in short timescales: needs of alternative planet formation scenarios



Article: “Gas Gaps in the Protoplanetary Disk around the Young Protostar HL Tau” Yen et al 2016, *ApJ Letters*

Footprints of baby planets in a gaseous disk

New data analysis techniques of ALMA Science Verification observations uncover gaps in the gas disk at ~10 au resolution around protostar HL Tau

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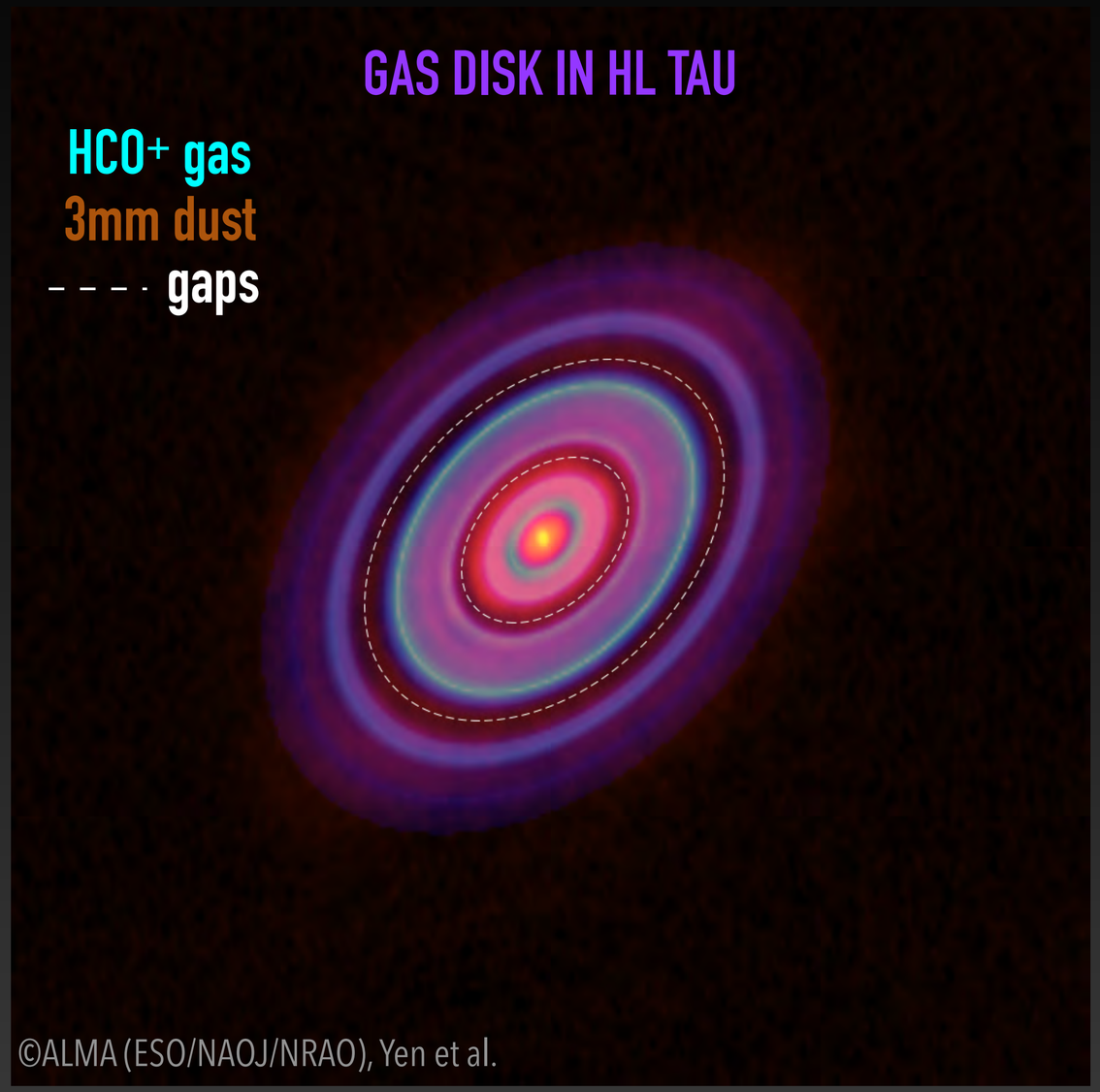

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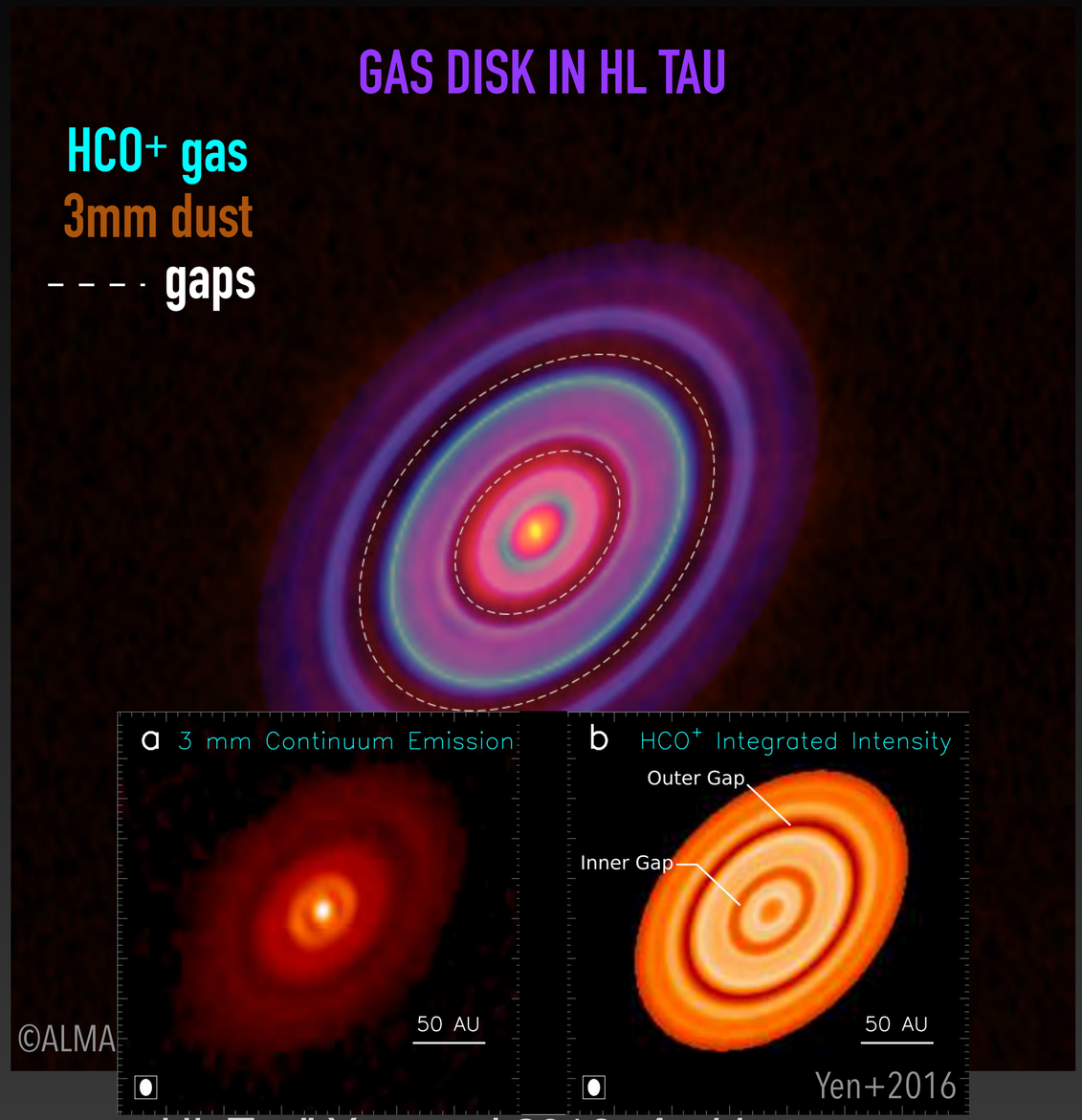

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How does planet formation begin?

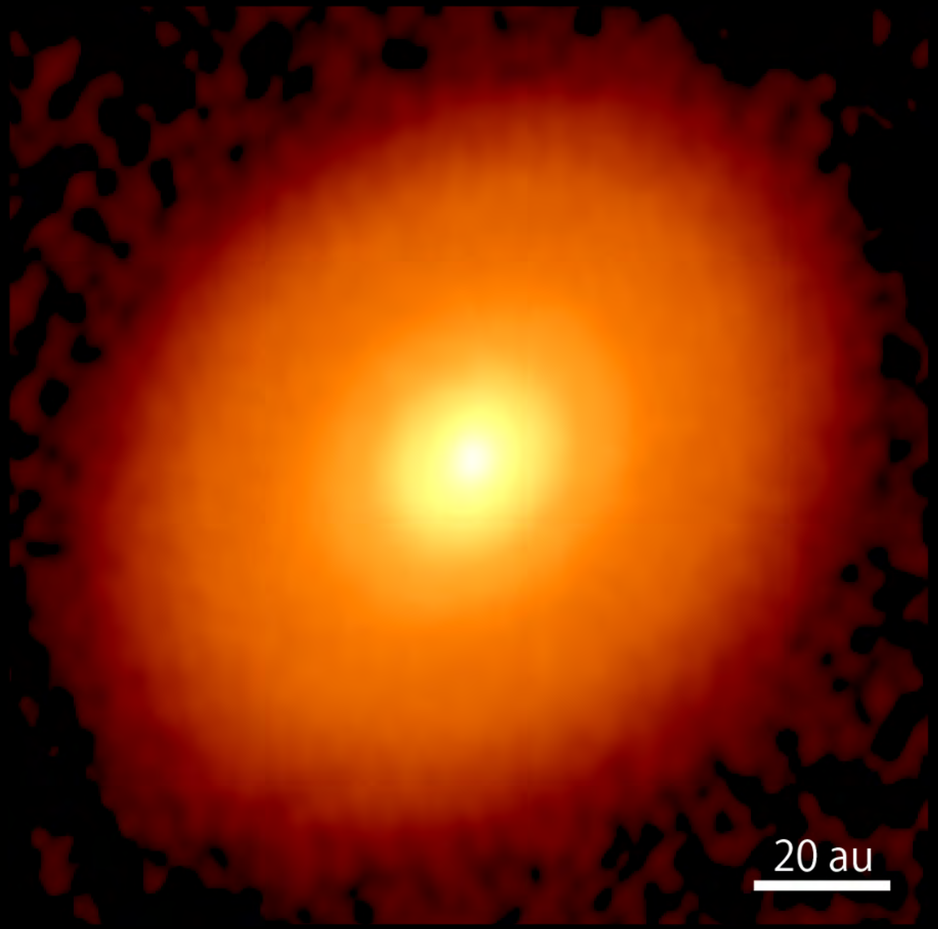
<u>High-resolution (≈5 au) 1.3 mm dust continuum observations of young protoplanetary disk around DG Tau reveal thin and smooth disk without substantial substructures</u>

-ALMA archive data @0.87 and 3.1 mm dust analyzed the distributions of dust surface density, temperature, and grain size

-“pristine” disk retains the initial conditions of planet formation

-SED + radiative transfer model: disk’s outer regions as the potential starting point for planet formation, challenging current view

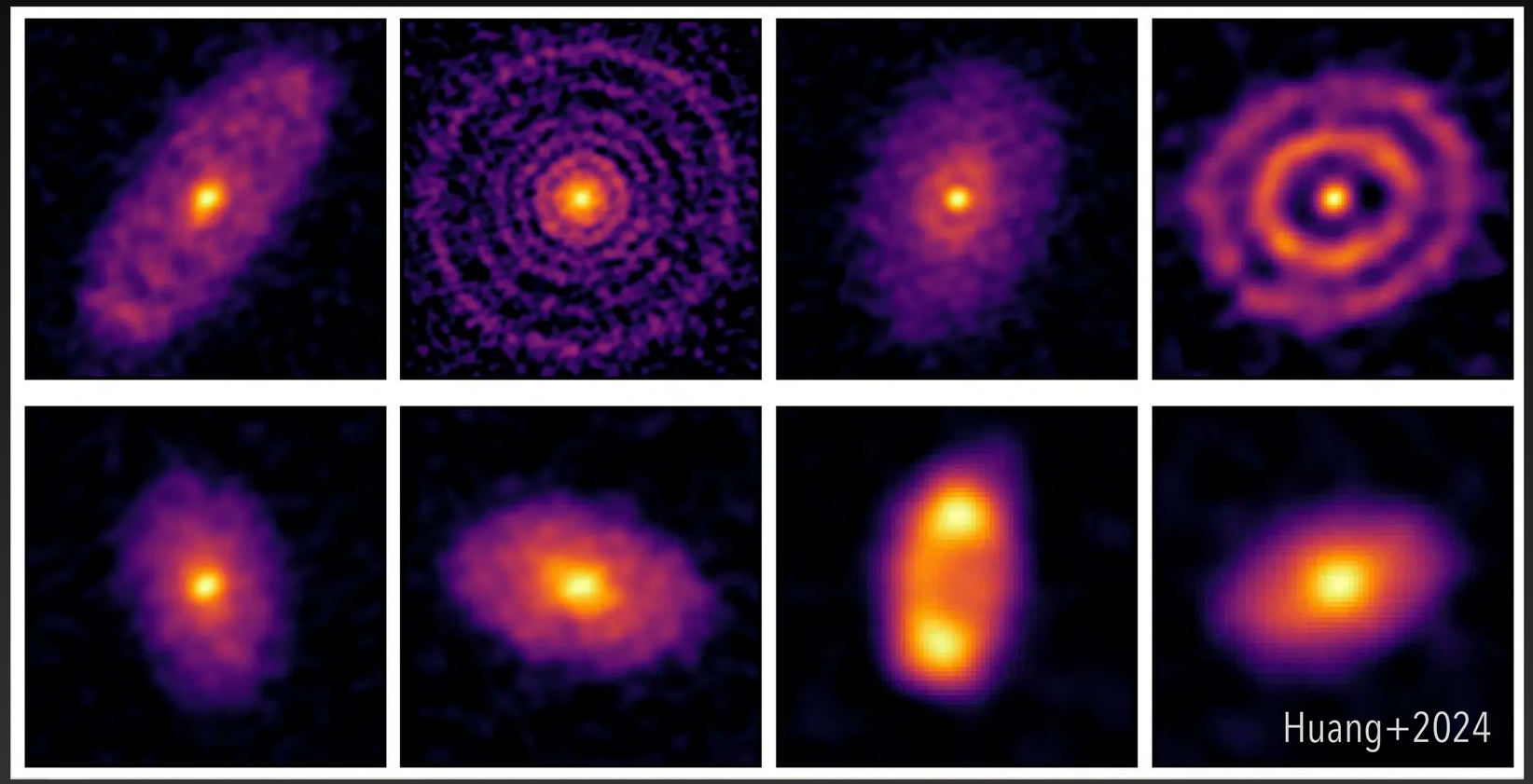
SMOOTH YOUNG PROTOPLANETARY DISK AROUND DG TAU



Article: “Dust Enrichment and Grain Growth in a Smooth Disk around the DG Tau Protostar Revealed by ALMA Triple Bands Frequency Observations” Ohashi et al 2023, *ApJ*

Planets can form under harsh radiation

High-resolution (~8 au) ALMA 1.3 mm continuum images images of 8 protoplanetary disks in the σ-Orionis cluster



-intense radiation from massive star

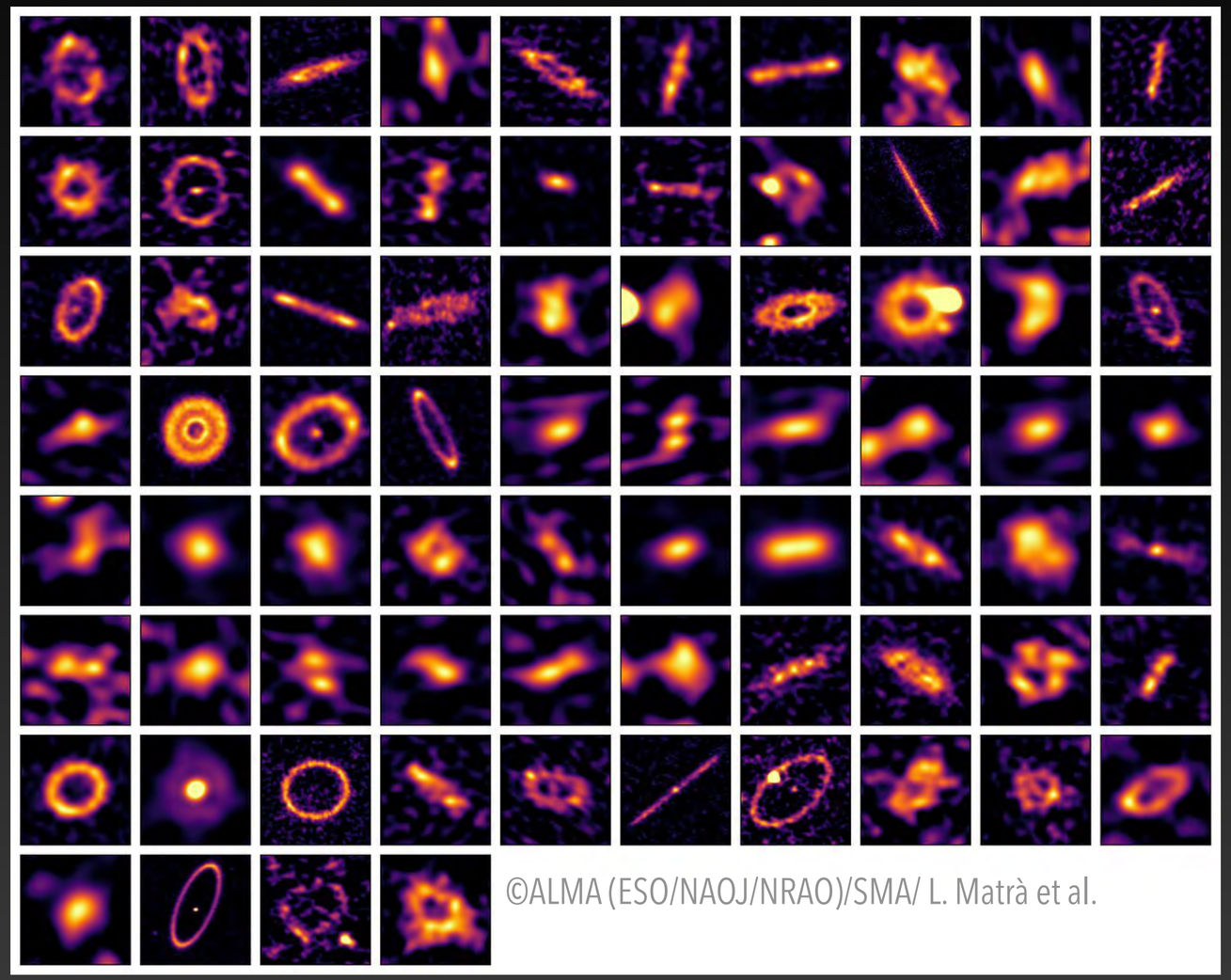
-gaps and rings in most of the disks: structures associated with formation of giant planets

-challenge in planet formation: survival of planets in intermediate levels of UV radiation

Article: “High-resolution ALMA Observations of Richly Structured Protoplanetary Disks in σ Orionis” Huang et al 2024

Exocomet belts in all shapes, sizes and ages

Resolved ALMA and SMA Observations of Nearby Stars (REASONS): largest survey of exocomet belts



-Exocomets: boulders of rock and ice >1km size, smash together in belts (found ~20% planetary systems)

-resolved dust observations of 74 planetary systems (25 ALMA+SMA survey + 49 archive)

-diversity in structure: narrow rings, or ‘belt’ like our Kuiper belt, but many are wide, better described as “disks”

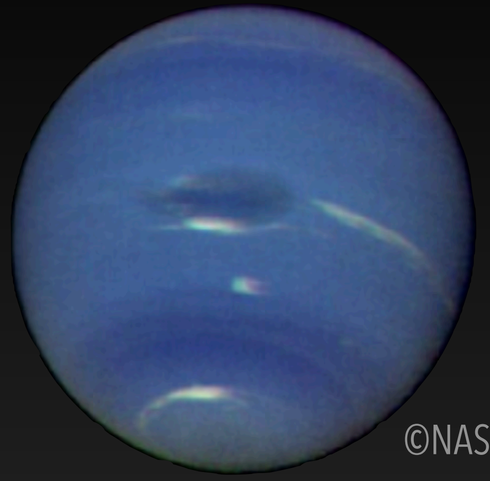
-dust depleted faster in smaller belt

-history of our Solar System and Earth

Article: “REASONS: A population of 74 resolved planetesimal belts at millimetre wavelengths” Matrà et al 2024, *A&A*

Belt-like distribution of hydrogen cyanide on Neptune's equator

NEPTUNE BY VOYAGER 2 IN 1989



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-HCN(4-3) detected at Neptun's stratosphere (high altitudes)

-0.4" beam, enough to resolve Neptune's 2.24" diameter disk.

-band-like HCN enhancement at the equator: high HCN abundances at the equator, almost depleted at 60° south

-**atmospheric dynamics**: large atmospheric flows to HCN rich region, air is transported upward ~60° south and then downward at both the equator and south pole

Iino+2020

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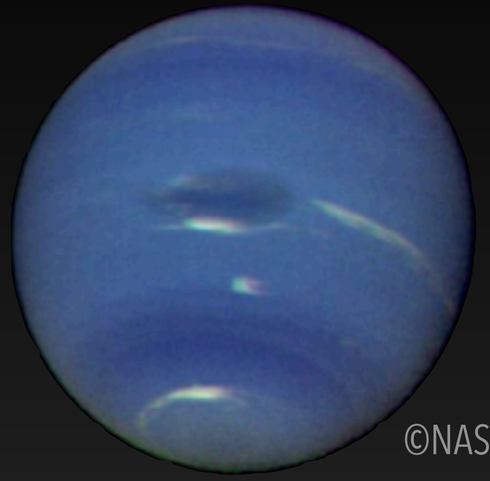

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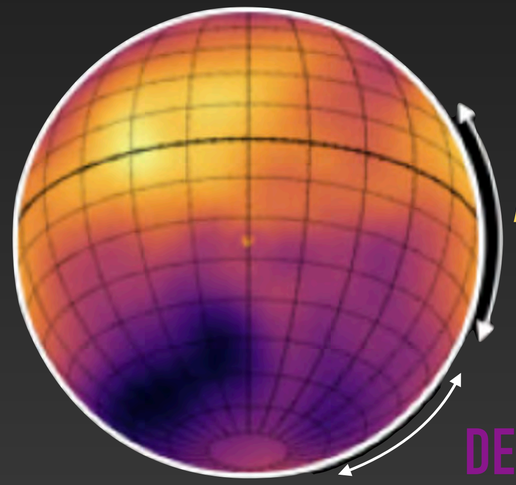
HCN RATIO BY ALMA IN 2016



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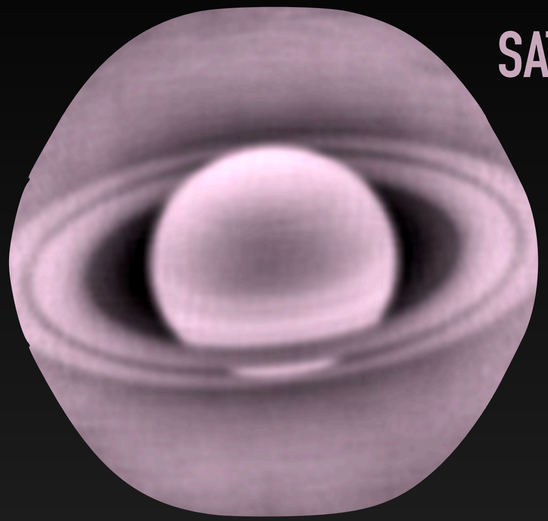
HCN rings in Saturn's atmosphere



SATURN @350GHZ CONTINNUM

Manna+2024

<u>HCN is an important nitrogen molecule: plays key role in formation of several biomolecules via chain reactions</u>

-only archival observations: HCN in eastern and western limbs, up to 475 km in the stratosphere of Saturn

-possible formation mechanism of HCN: photochemical reactions in a mixture of H_2, methane (CH_4) and ammonia (NH_3) under ultraviolet light

Article: "ALMA detection of hydrogen cyanide (HCN) in the atmosphere of Saturn" Manna et al 2024, *JApA*

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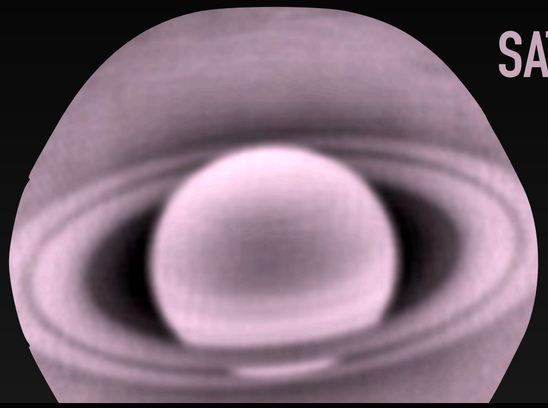

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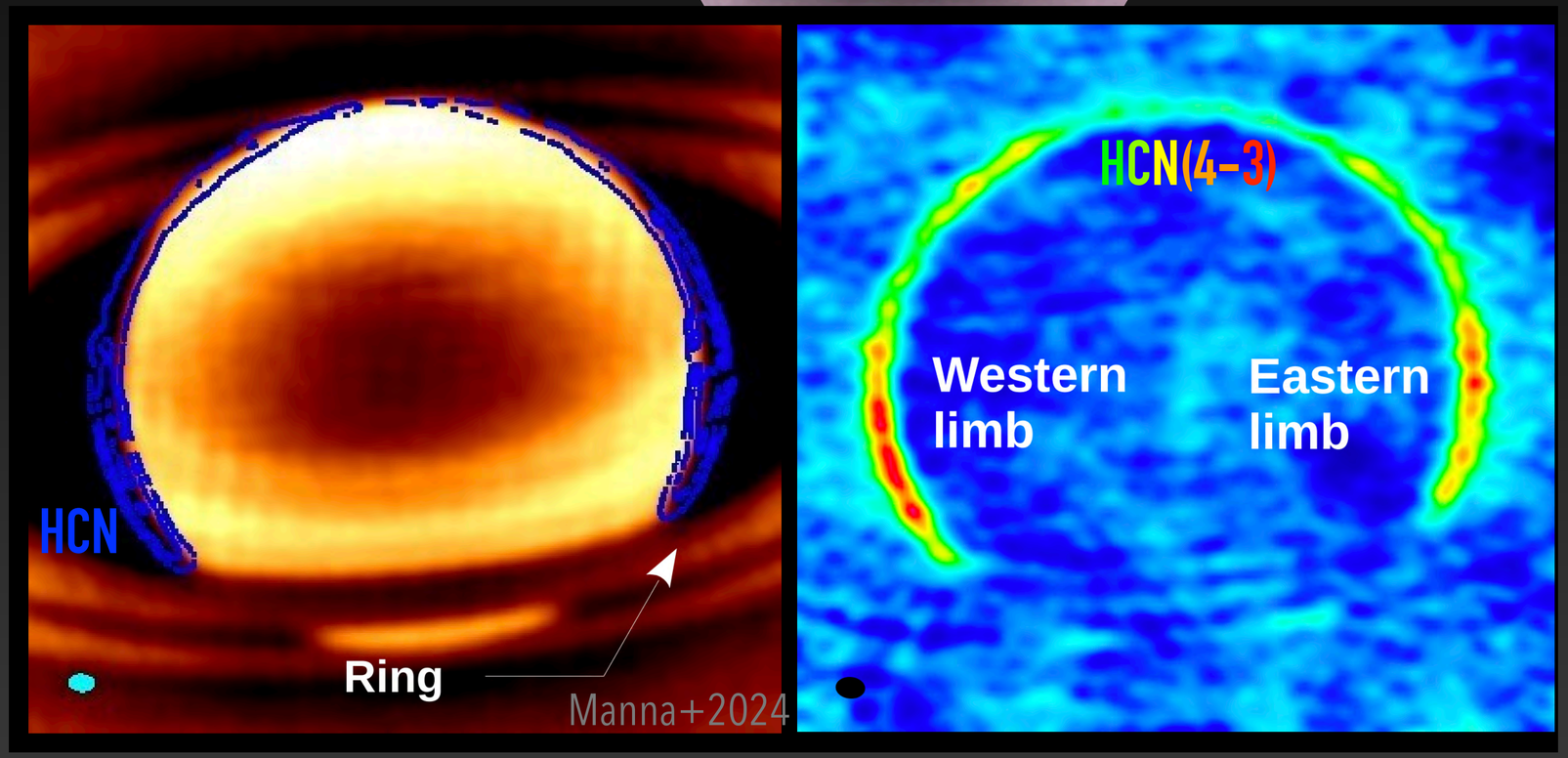

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