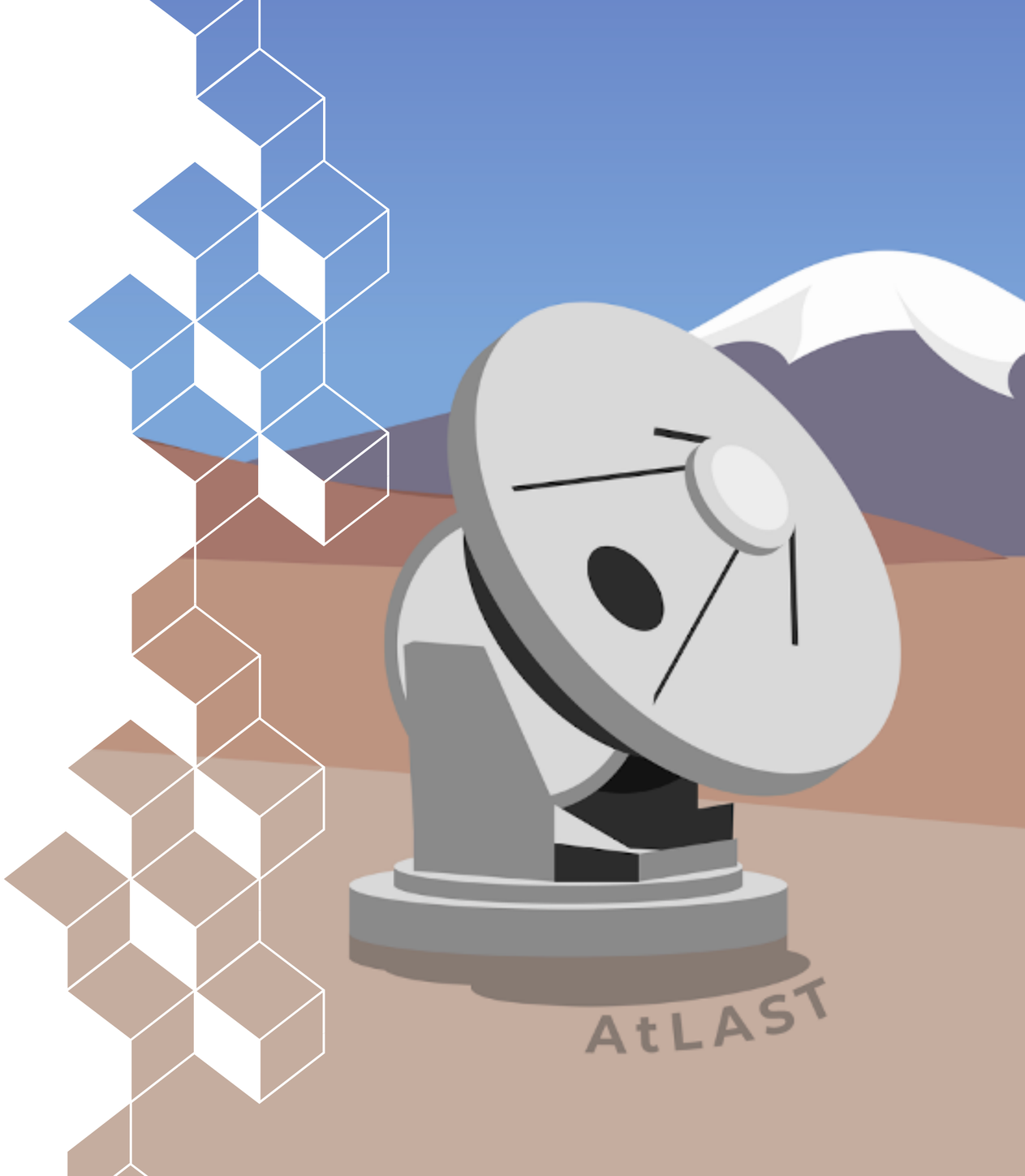
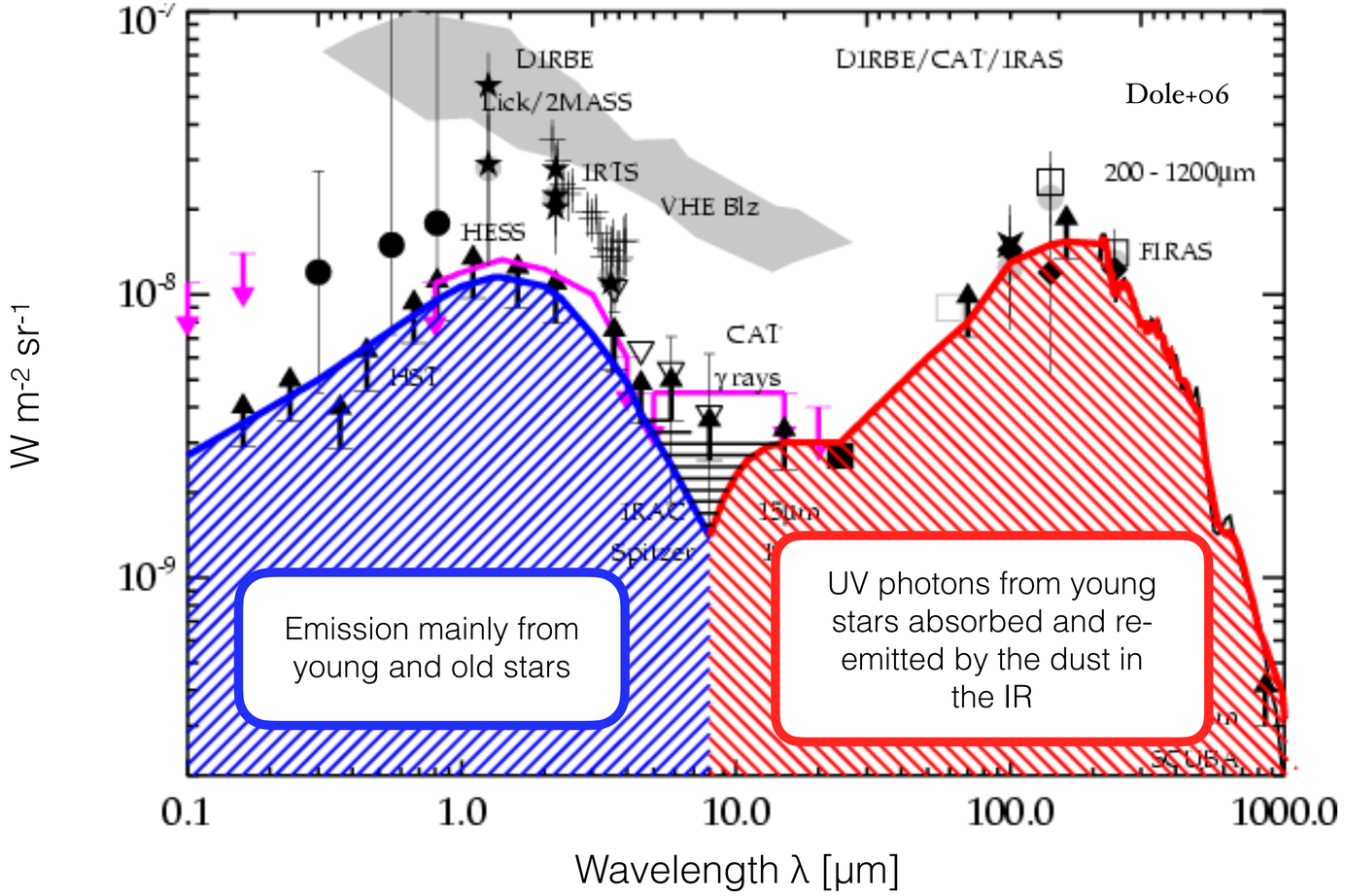
Cosmic evolution of galaxies : Resolving the cosmic infrared background with AtLAST

Benjamin Magnelli,
Eelco van Kampen and the AtLAST team



The Cosmic Infrared Background (CIB)

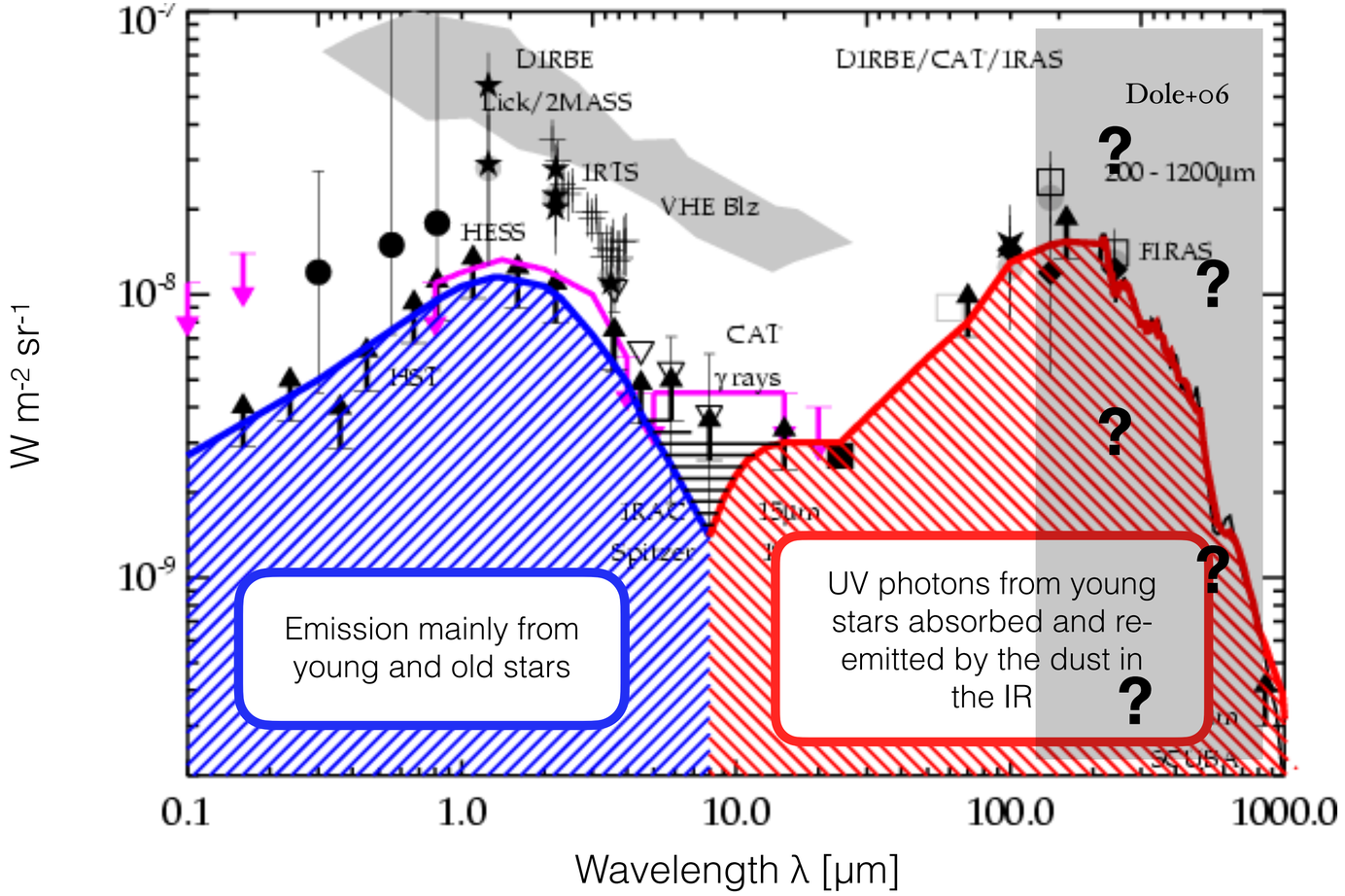


The cosmic infrared background includes about half of the energy radiated by all galaxies at all wavelengths across cosmic time (e.g., Dole+06)

at z~0, L_{IR} ~1/3 L_{opt}

Strong evolution of the IR galaxy population with redshift

The Cosmic Infrared Background (CIB)



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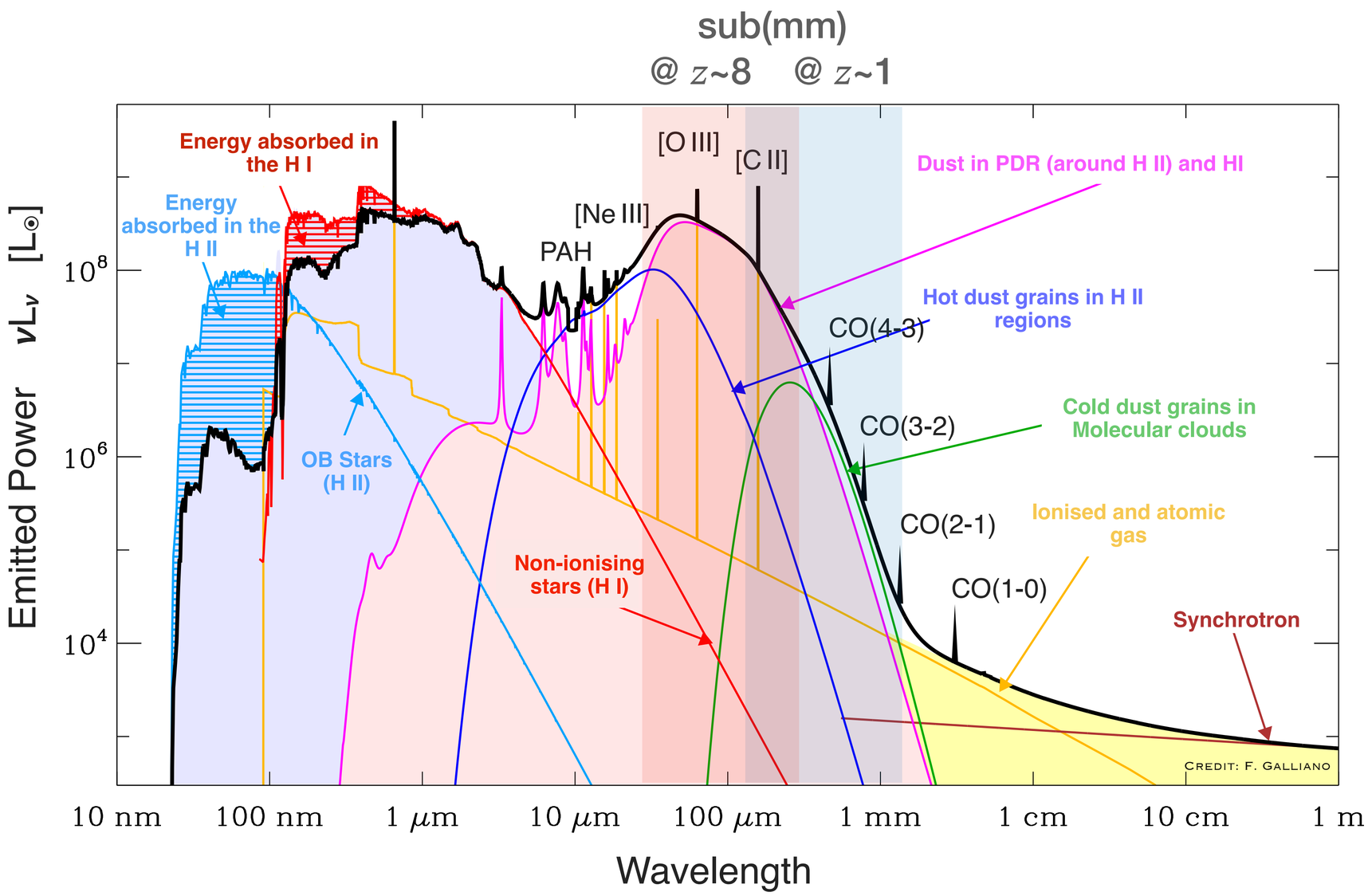
At λ > 250um, only ~10% of the CIB has been resolved into individual sources !!

At ~100um, only 50% of the CIB has been resolved

Nature of the FIR/(Sub)Mm Emission of Galaxies



Short-wavelength bands (350-500um) are excellent proxies of the IR-luminosity of high-z galaxies

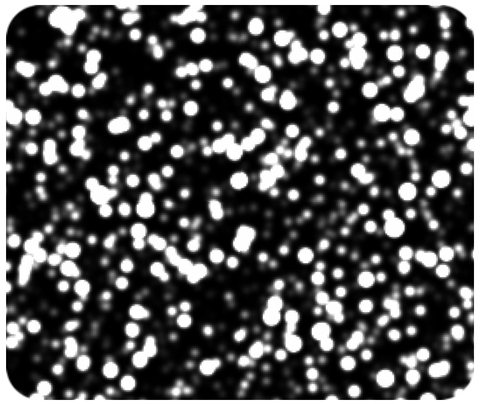
Long-wavelength bands (>500um) are excellent proxies of the dust mass of high-z galaxies

The (sub)mm spectroscopic provides excellent proxies about the ISM conditions in high-z galaxies

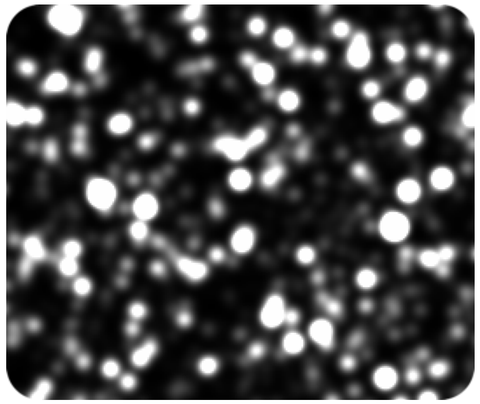
Resolving the CIB: Current Limitations

Why have *Herschel* or other single-dish facilities resolved only a small fraction of the CIB at λ>250 μm?

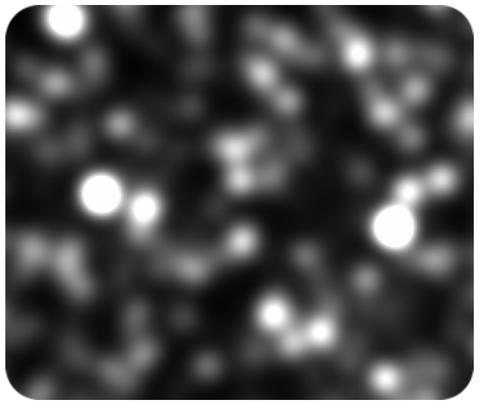
CONFUSION limit



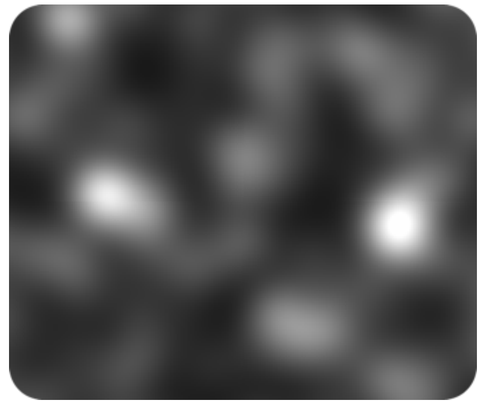
FWHM = x



FWHM = $2x$



FWHM = $4x$



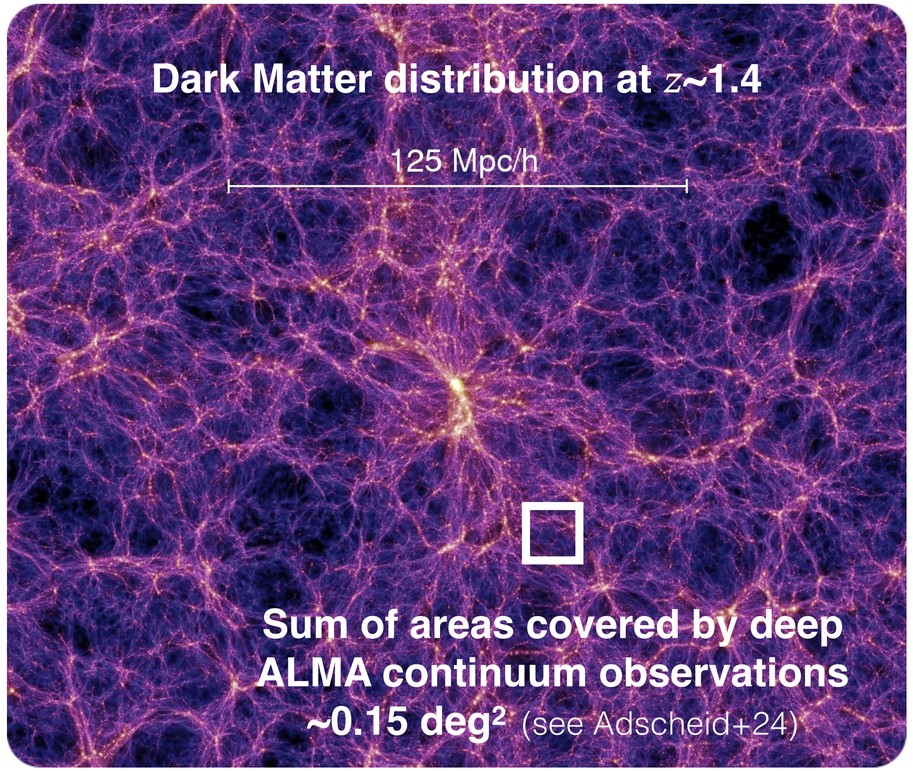
FWHM = $8x$

CONFUSION ≡ NUMBER COUNT ⊗ FWHM
and
FWHM ∝ λ / D

Resolving the CIB: Current Limitations

Why hasn't ALMA resolved **accurately** the CIB at λ>250 μm?

SMALL FIELD-of-VIEW



ALMA can readily detected the continuum, CO, CII, or other FLS lines in high-z SFGs…

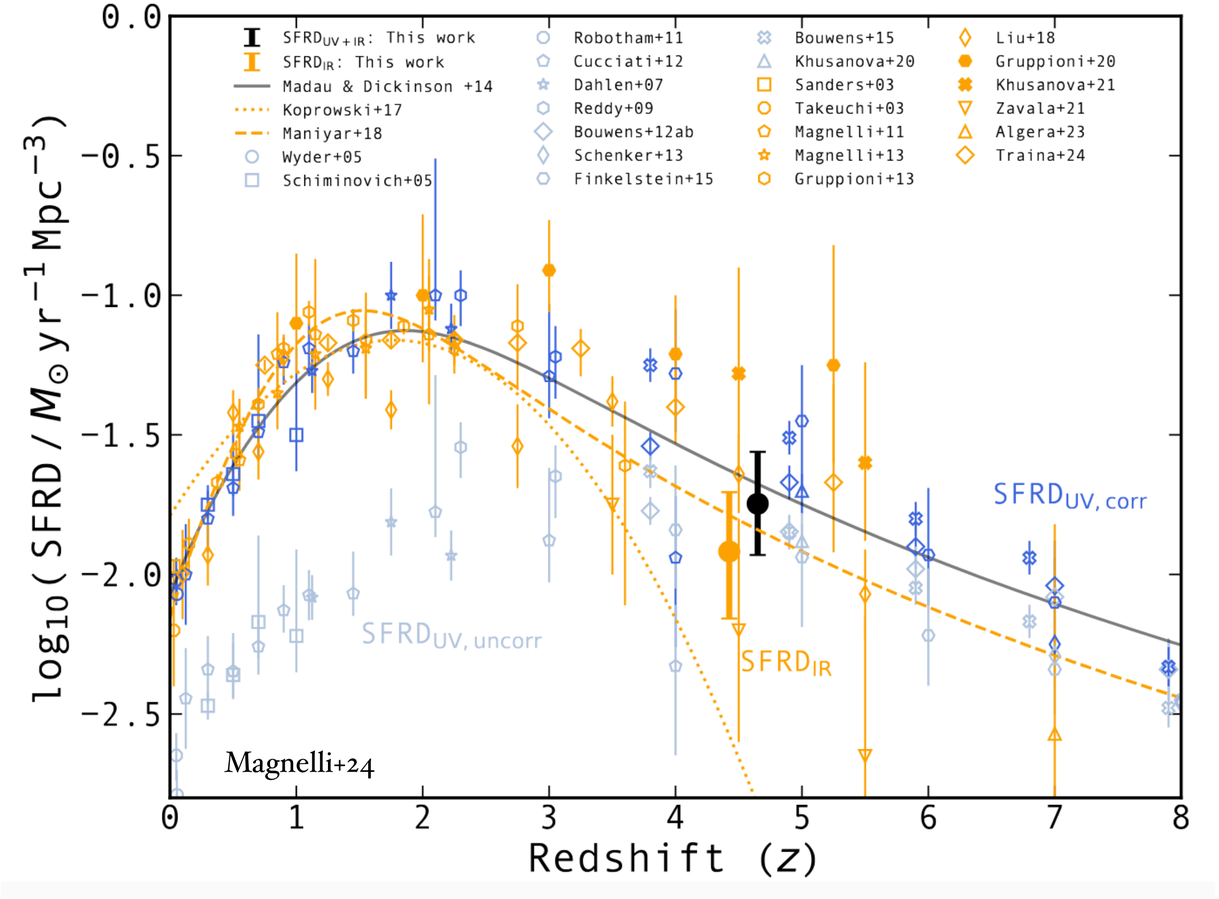
…but it still takes several minutes (continuum, CII) to hours (CO and FLS) per galaxy…

… and only one galaxy can be observed at the time…

…so only few hundreds high-z SFGs with ALMA continuum and line observations so far!

Key Unresolved Issues Due to Current Limitations

- The cosmic SFRD at $z > 3$ is still unknown within a factor 5 – 10



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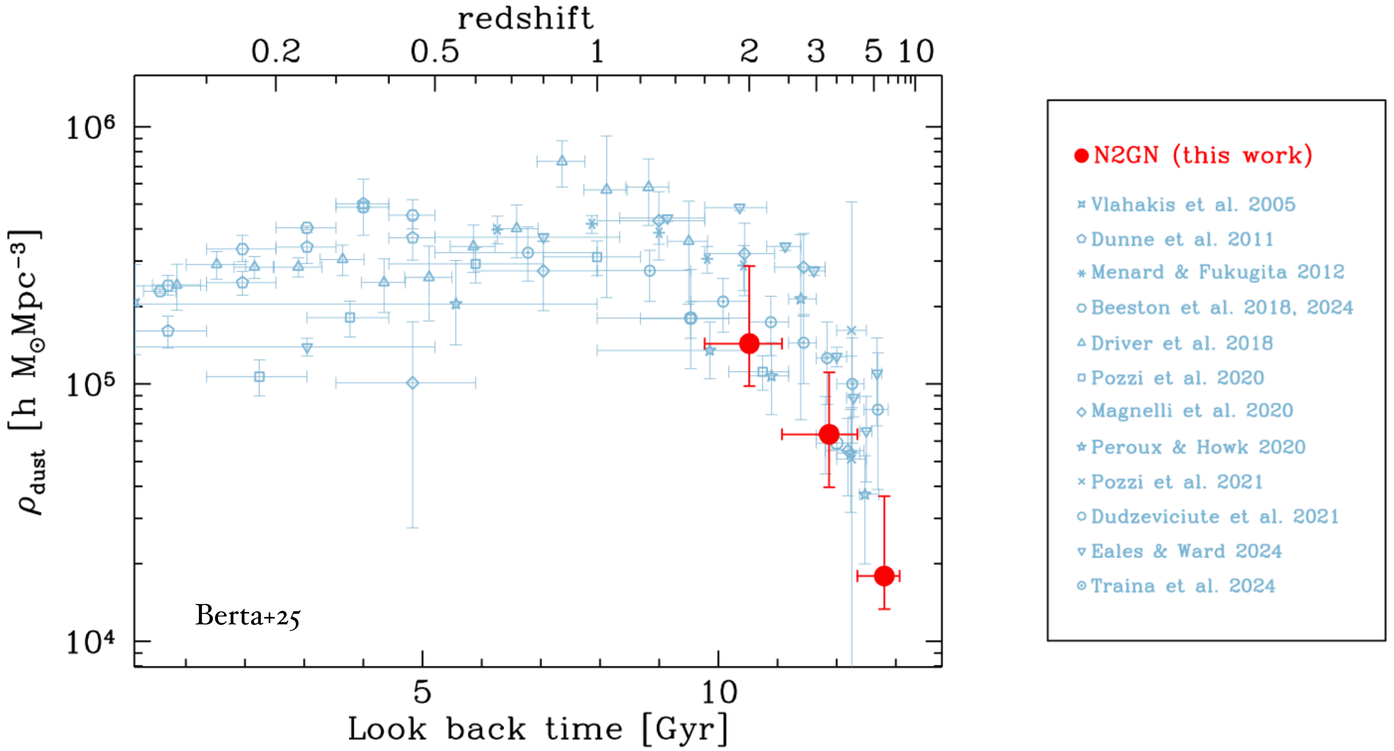

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- The role of environment on the SF and cold ISM content of high-z galaxies is virtually un-explored although suspected to be fundamental (gas accretion from the cosmic web, ram pressure,…etc.)

An AtLAST Galaxy Evolution Survey

AtLAST in a nutshell

- ✓ 50-m aperture submillimeter (submm) telescope
- ✓ Exceptional location at 5000-m
- ✓ Large field of view of 1deg^2
- ✓ Bolometer —> simultaneous observations in 8 bands from 350 μm to 3mm over a ~1° FoV
- ✓ Spectrometer —> R ~ 1000, 8 bands from 350 μm to 3mm with 500 horns each

An AtLAST Galaxy Evolution survey

“Studying galaxy evolution with the deepest and widest submillimeter to date”

- ✓ 1000hr continuum survey (~4 years) —> ~ 1000 deg^2 down to the confusion limit
- ✓ 3000hr spectroscopic survey (~4 years) —> ~ 1 deg^2 - 120 000 high-z with multiple line detections

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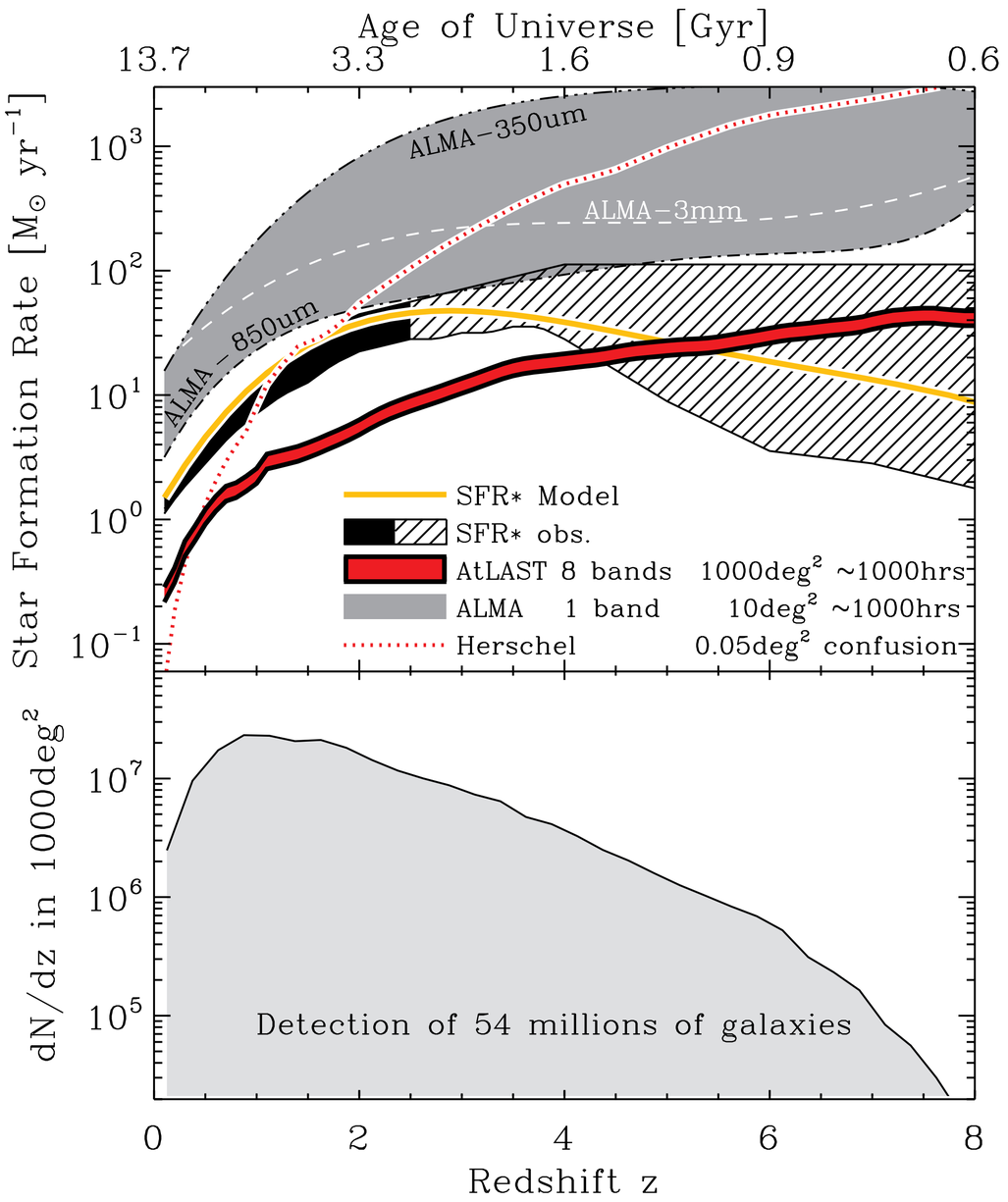
An AtLAST Galaxy Evolution Survey — Continuum Survey



AtLAST will be able to detect galaxies well below SFR★ up to z~5…

…1000 hrs single-Band ALMA survey over only 10deg² is ×10-100 less sensitive (!!) …

… 54 millions of galaxies detected…

van Kampen+24 using SIDES model (Gkogkou+23)

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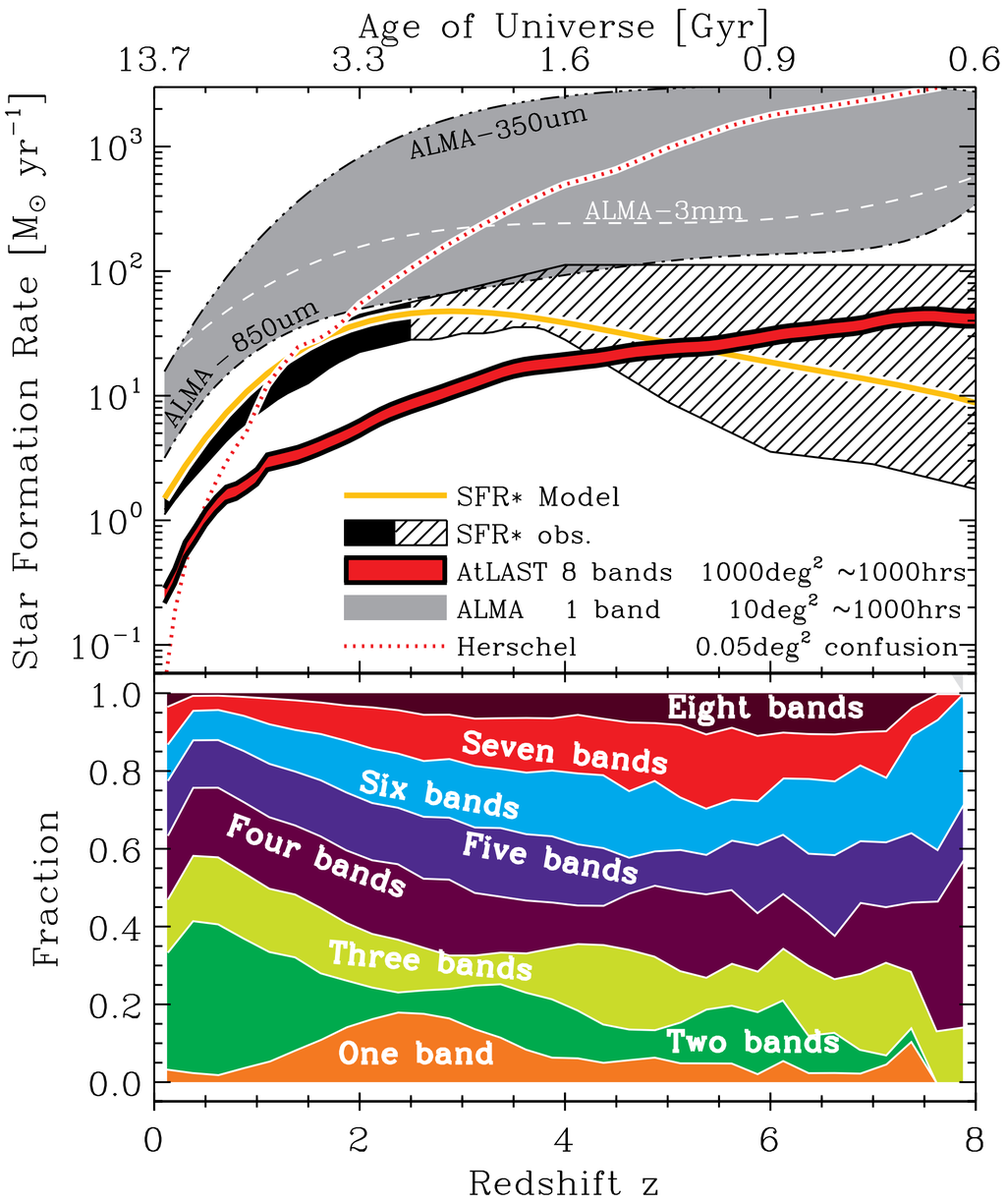

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…most over multiple bands…

…yielding very accurate (< 0.2dex error) L_{IR}, T_{dust}, M_{dust} measurements at all redshifts…

… resolving ~80% of the CIB at 350-750 μm

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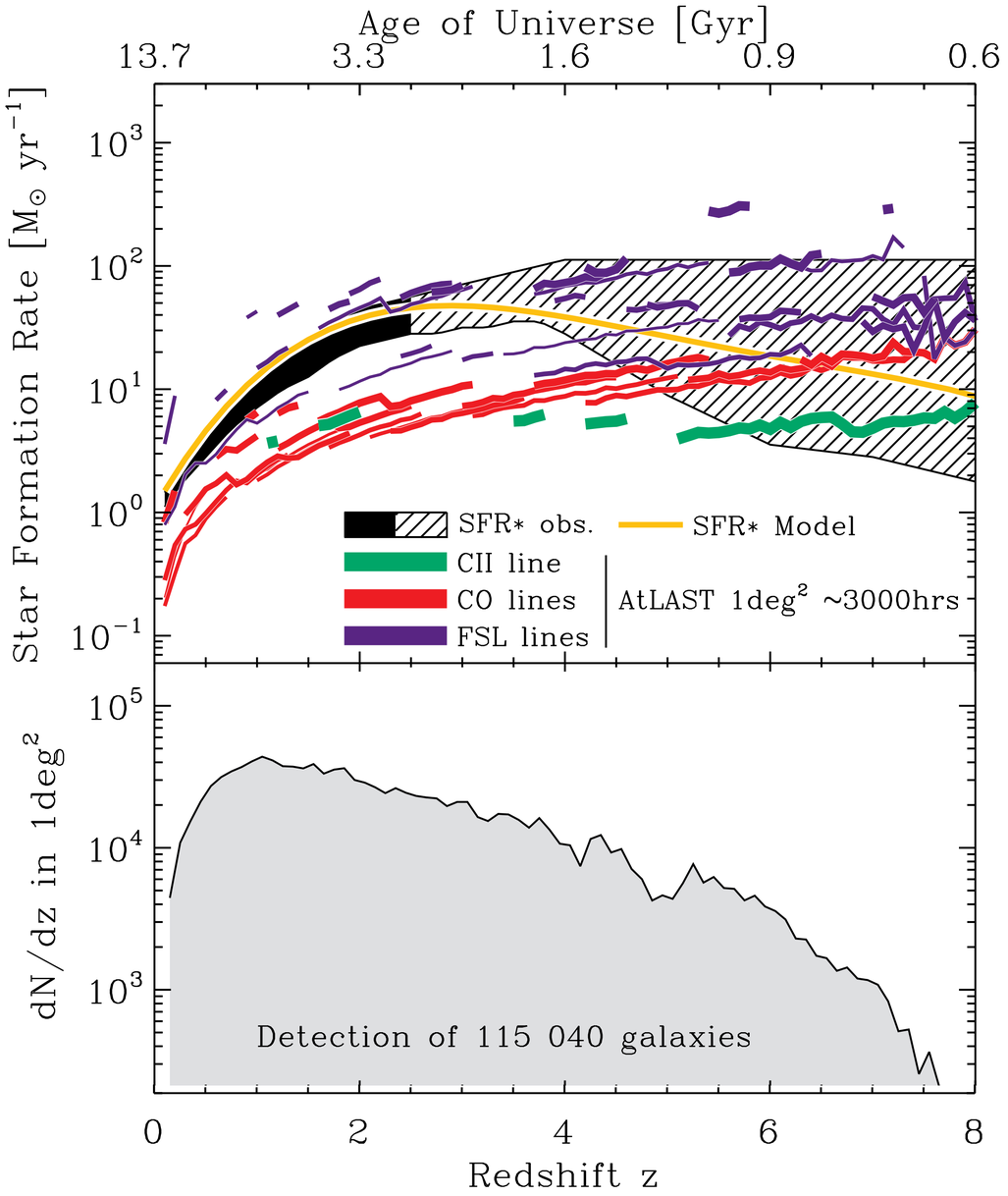
An AtLAST Galaxy Evolution Survey — Spectroscopic Survey



AtLAST will be able to detect line in galaxies well below SFR★ up to z~7…

…conducting such survey ALMA will be ×50 less sensitive (!!) …

… 115 thousands of galaxies detected…

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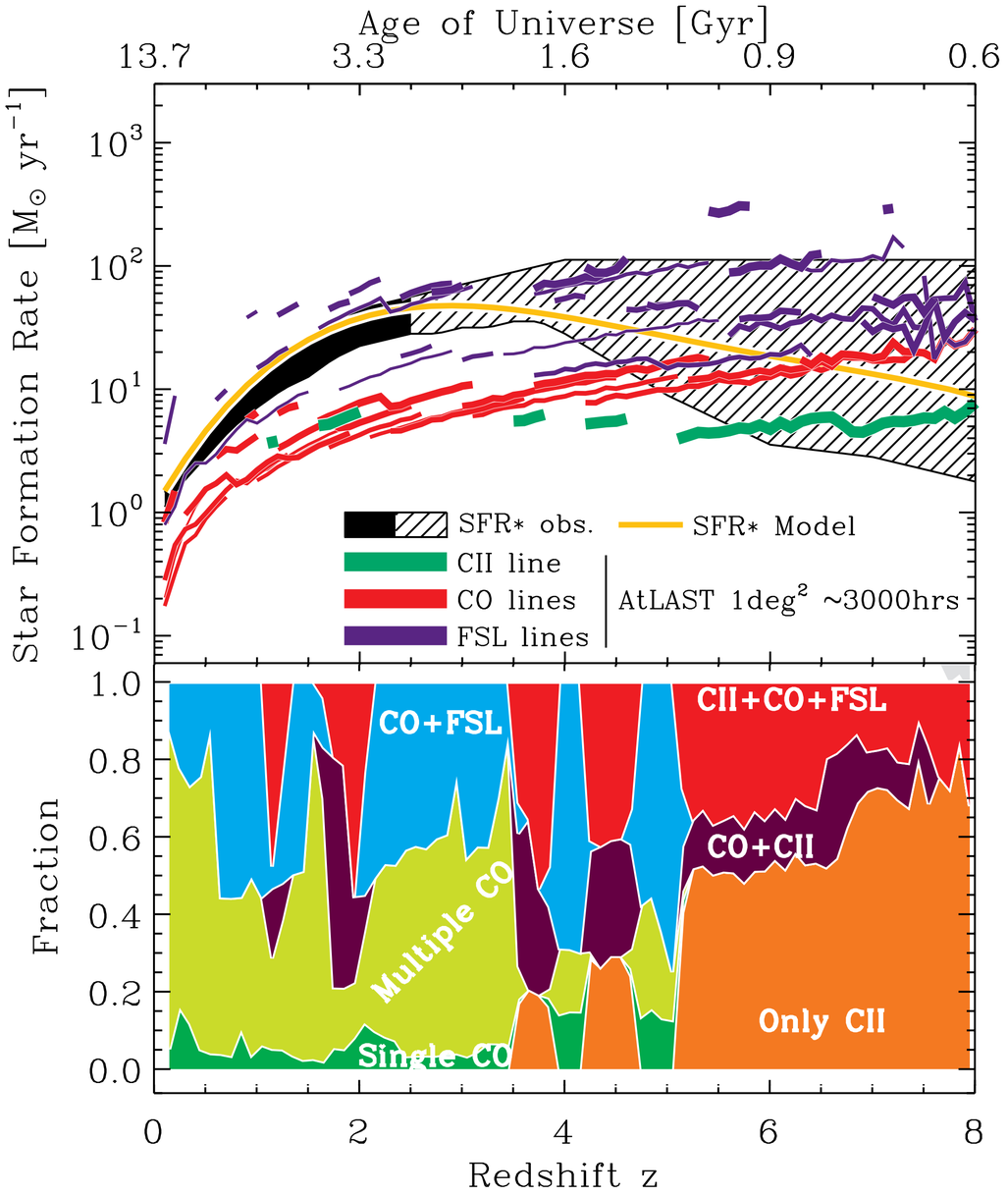

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… 115 thousands of galaxies detected…

… with 90% and 50% of them at z<5 and z>5, respectively, having multiple lines …

…combined with multiple band continuum detection, this characterises the redshift, gas content, cooling budget, SFR, $M_{\rm dust}$ and $T_{\rm dust}$ for all galaxies down to SFR★ and up to z~7!

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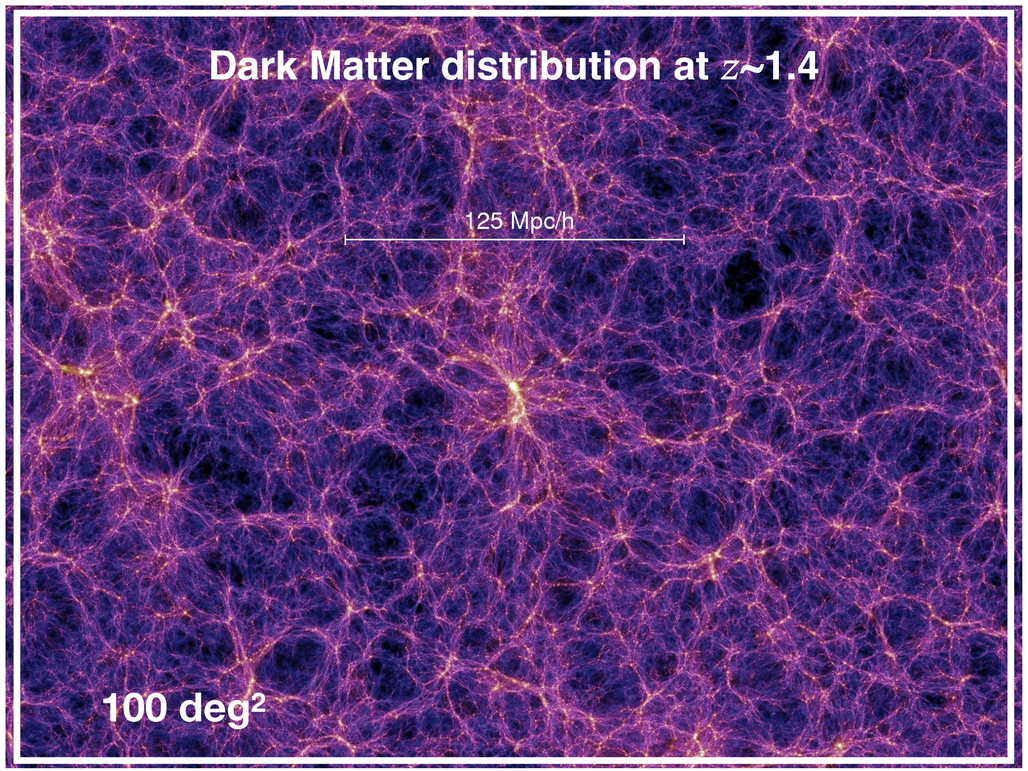
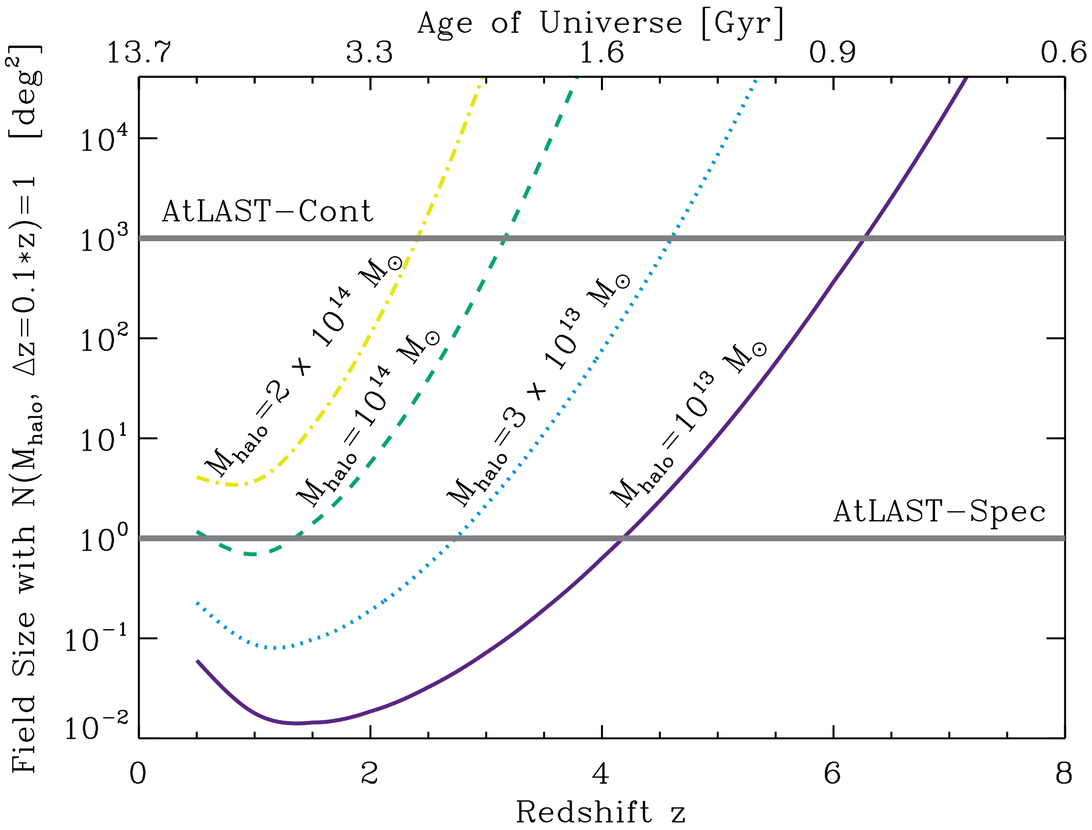
An AtLAST Galaxy Evolution Survey — Role of Environment

AtLAST will study the critical role of the environment in shaping the cold ISM of galaxies from the epoch of reionisation to z~0

(e.g., gas accretion from the cosmic web, environmental quenching)





Large AtLAST surveys will contain many Virgo/Coma-like structures up to z~2, and group/poor clusters up to z~6.

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An AtLAST Galaxy Evolution Survey — Synergies

Entering this era of <u>deep</u> and <u>large</u> extragalactic surveys

UV | **Optical** | **Infrared** | **Submillimeter** | **Radio**

Euclid*, LSST, *Roman

Accurate measurement of the redshift, stellar mass and stellar distribution of galaxies

Accurate measurement of the unobscured SFR of galaxies

AtLAST

Accurate measurement of dust-obscured SFR of galaxies

Accurate measurement of the dust and molecular gas content of galaxies

SKA (ngVLA ?)

Accurate measurement of star-formation and AGN activity of galaxies

Accurate measurement of the atomic gas content of galaxies

Summary

- ✓ An AtLAST Galaxy Evolution survey would be the deepest and widest submillimeter survey to-date, resolving ~80% of the submillimeter CIB into individual sources
- ✓ It would provide us with large (>100 thousands) and comprehensive (down to SFR★) samples of SFGs at $0 < z < 7$ with multiple (sub)millimeter continuum and line detections
- ✓ This would characterise the redshift, gas content, cooling budget, SFR, $M_{\rm dust}$ and $T_{\rm dust}$ for all galaxies down to SFR★ and up to z~7
- ✓ In synergy with *Euclid*, *Roman*, LSST, and SKA, it would enable us to constrain the cosmic (dust-obscured) star formation history from the EoR to z~0, to witness the rise of dust in the early Universe, to reveal the ISM conditions for SF, and to elucidate the critical role of the environment on galaxy evolution