High-redshift galaxy surveys with CCAT-p

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-
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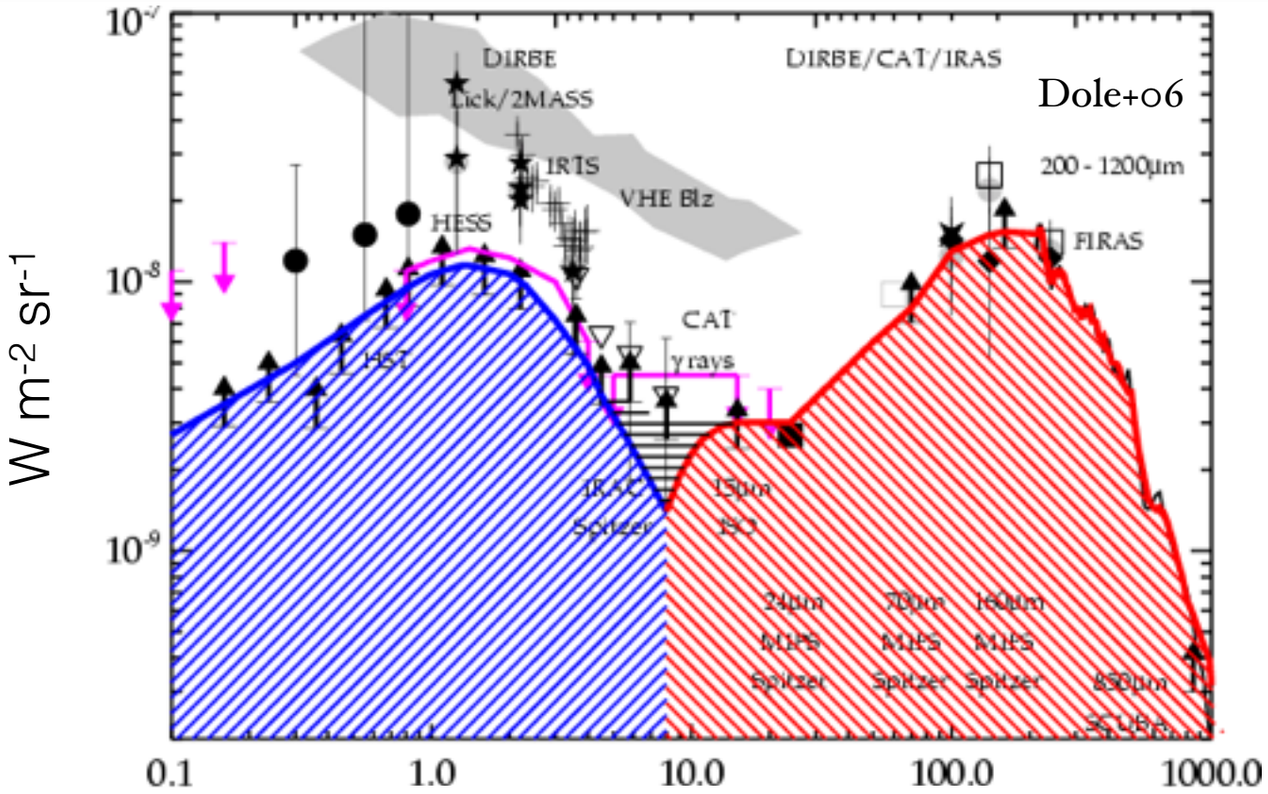
The Cosmic Infrared Background (CIB)



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, $L_{IR} \sim 1/3\ L_{opt}$

→ Strong evolution of the IR galaxy population with redshift

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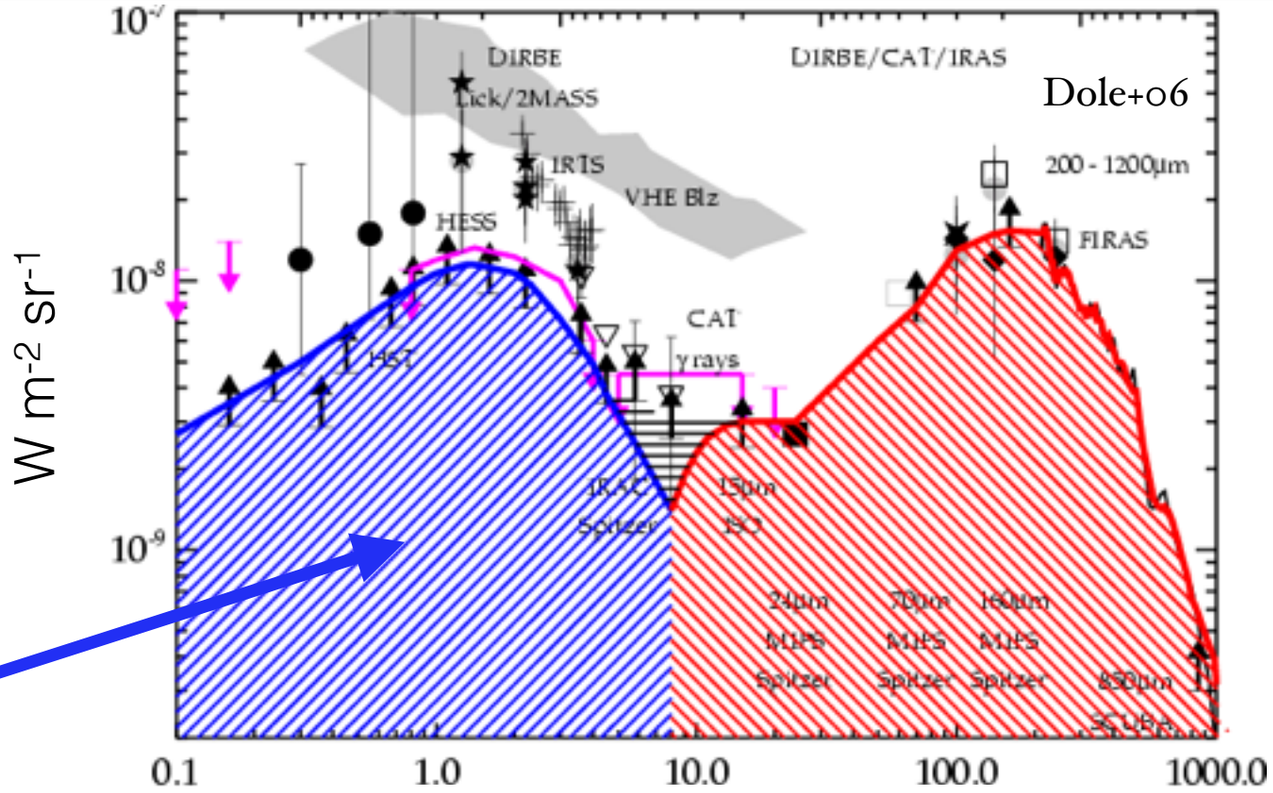

Emission mainly from young and old stars

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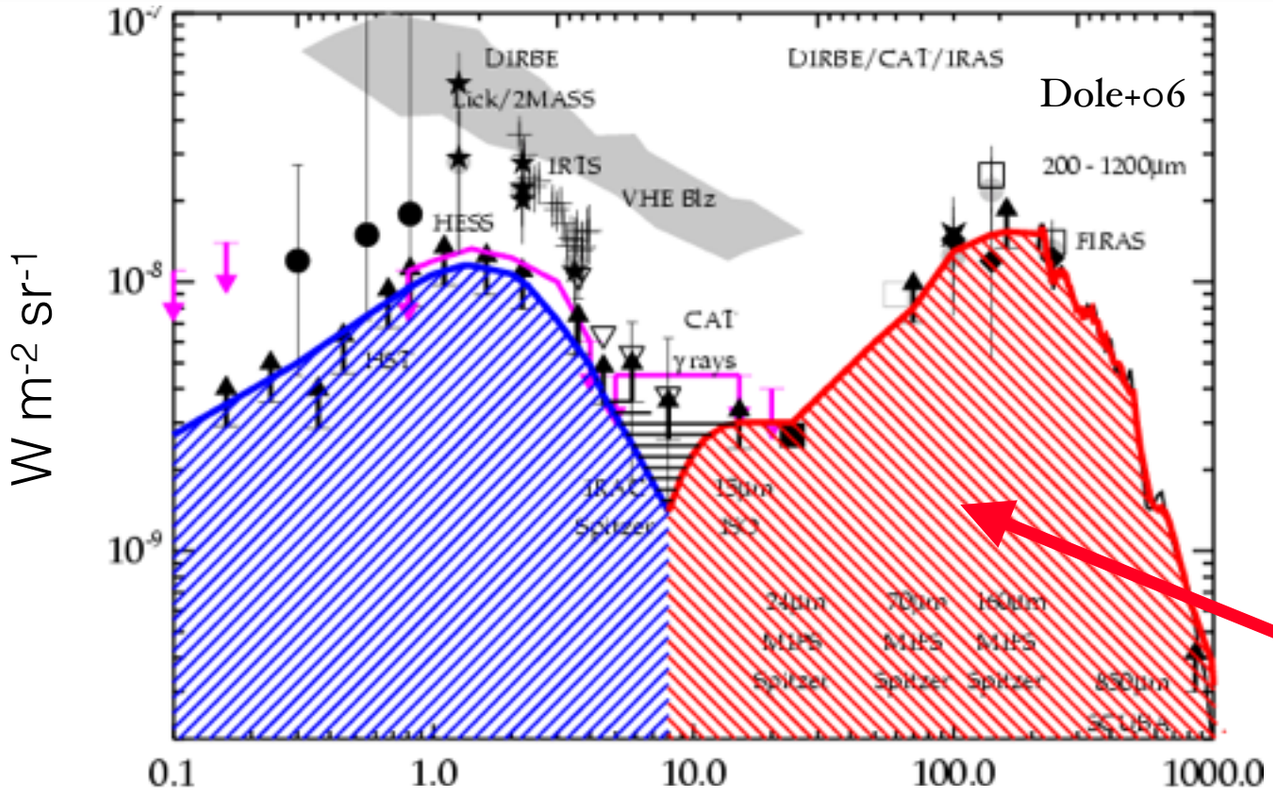

Dust thermal emission :

UV photons from young stars absorbed and re-emitted by the dust

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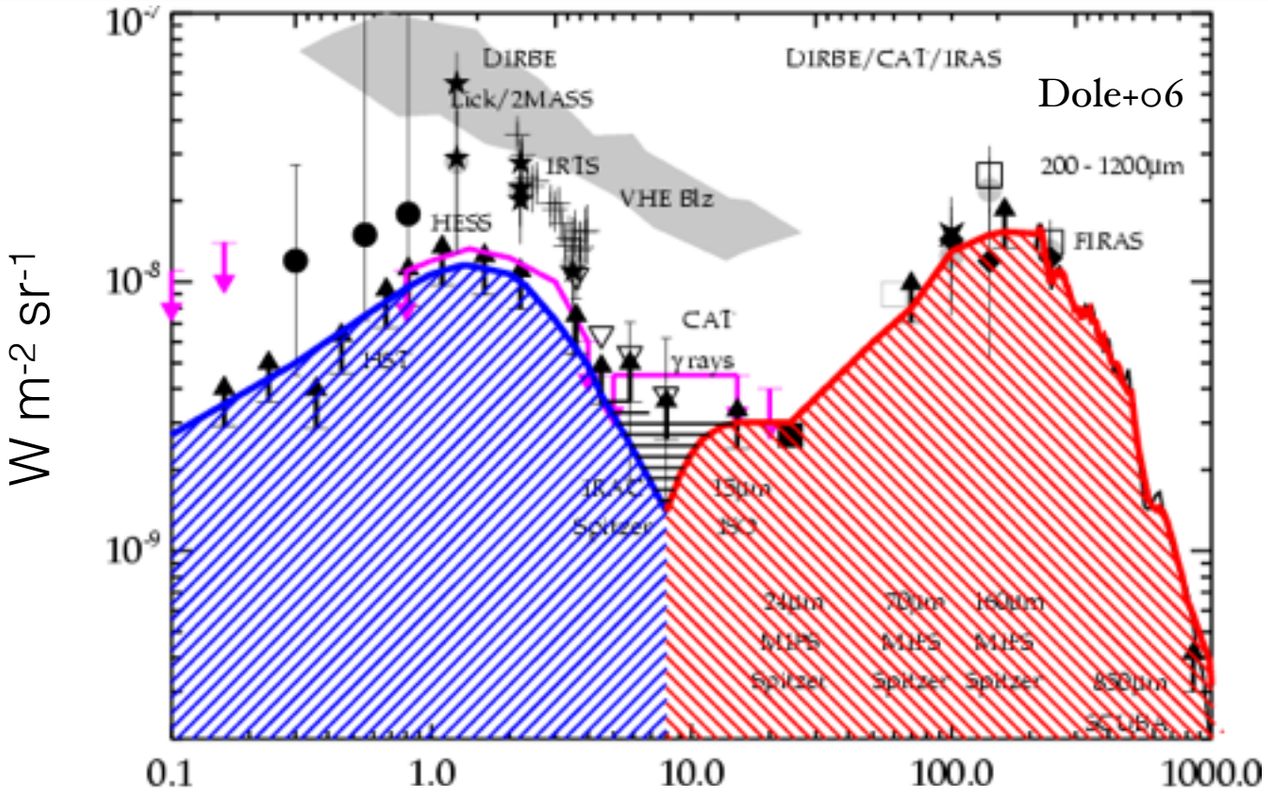

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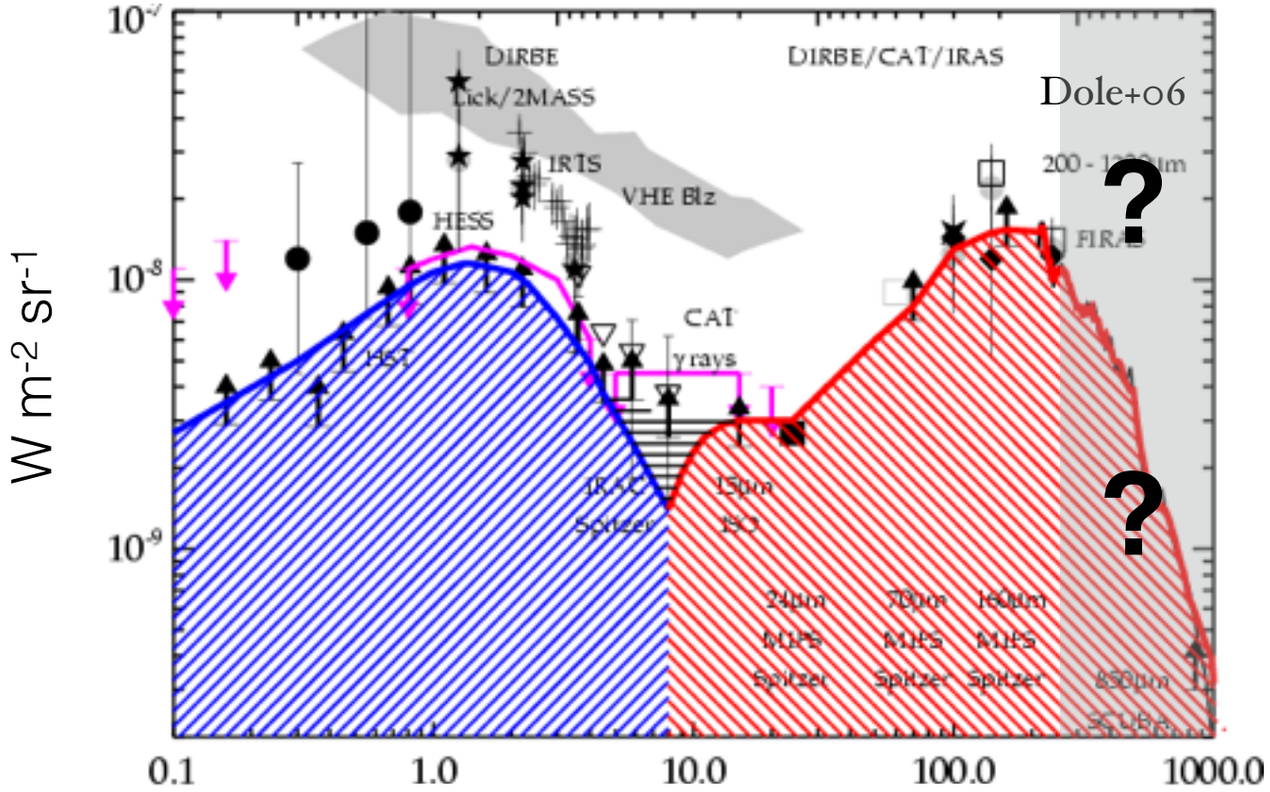

At λ > 250um, only ~15% of the CIB has been resolved into individual sources !!

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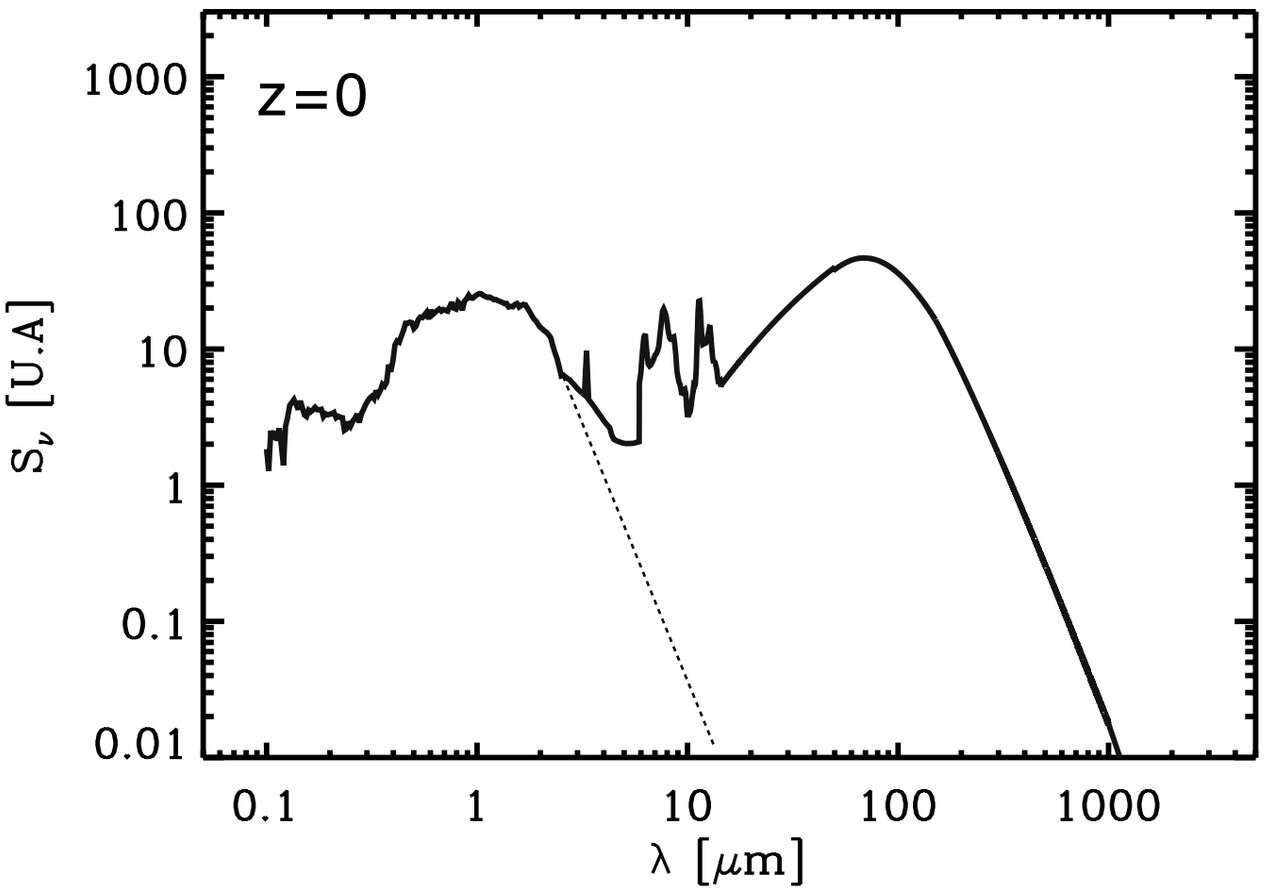
Nature of the FIR/(sub)mm emission of galaxies



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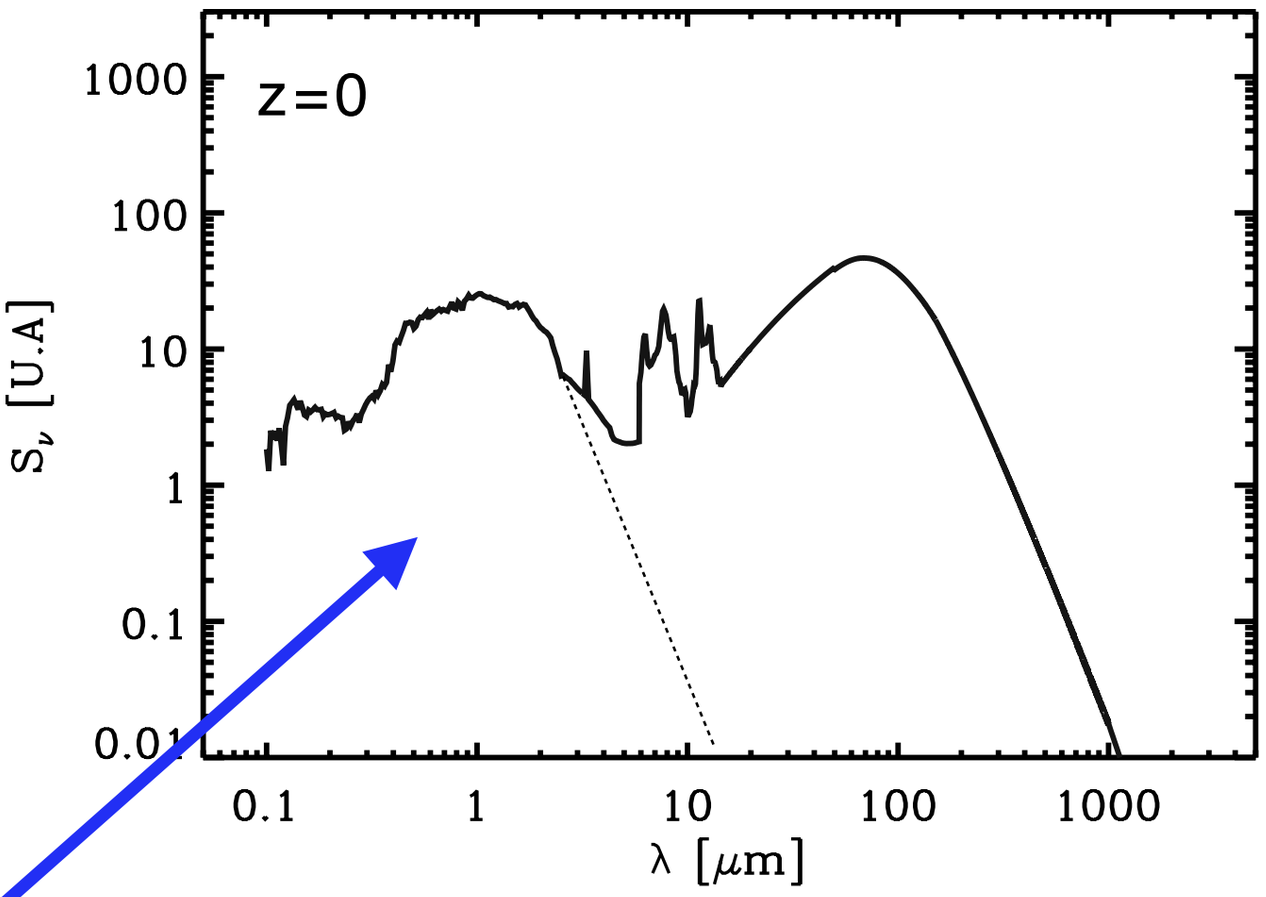

Emission from young and old stars

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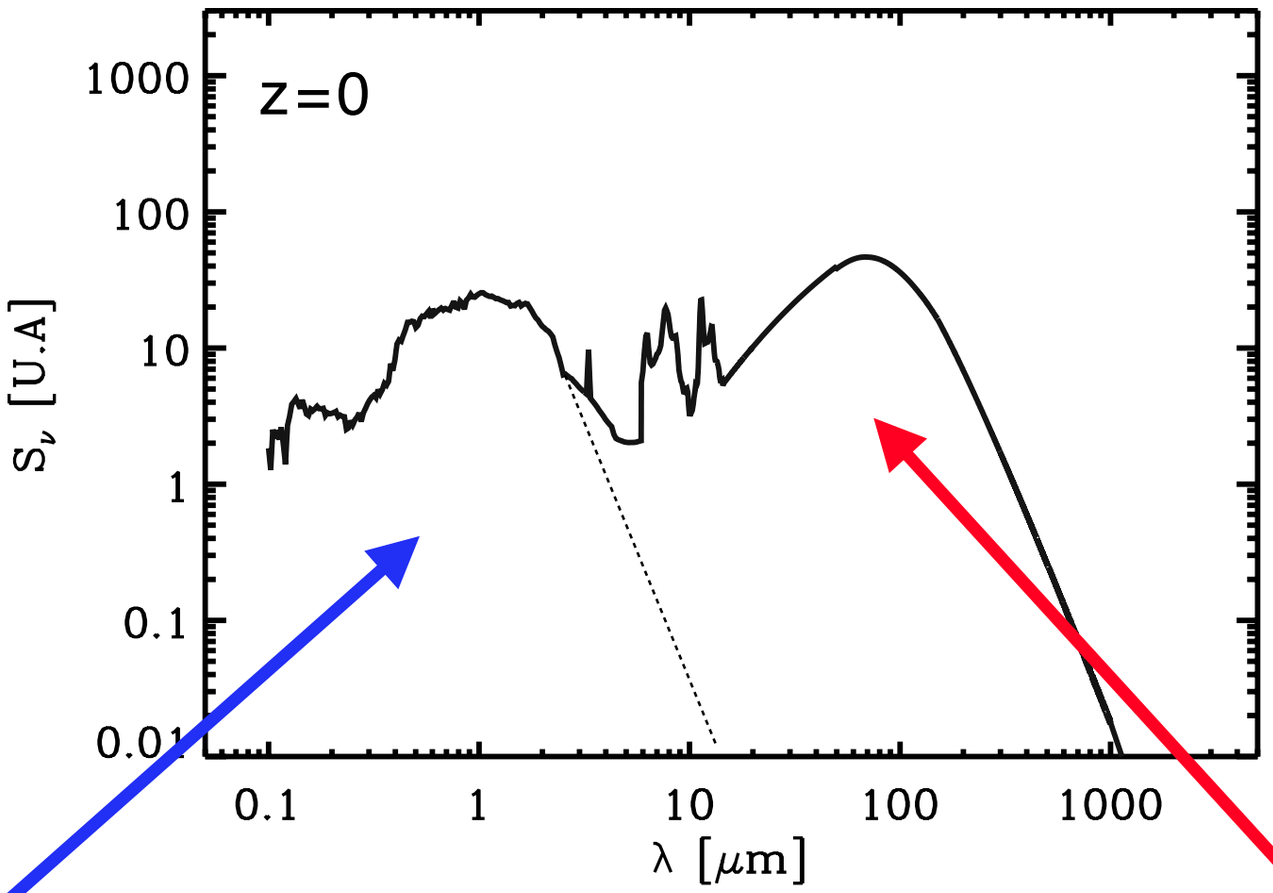

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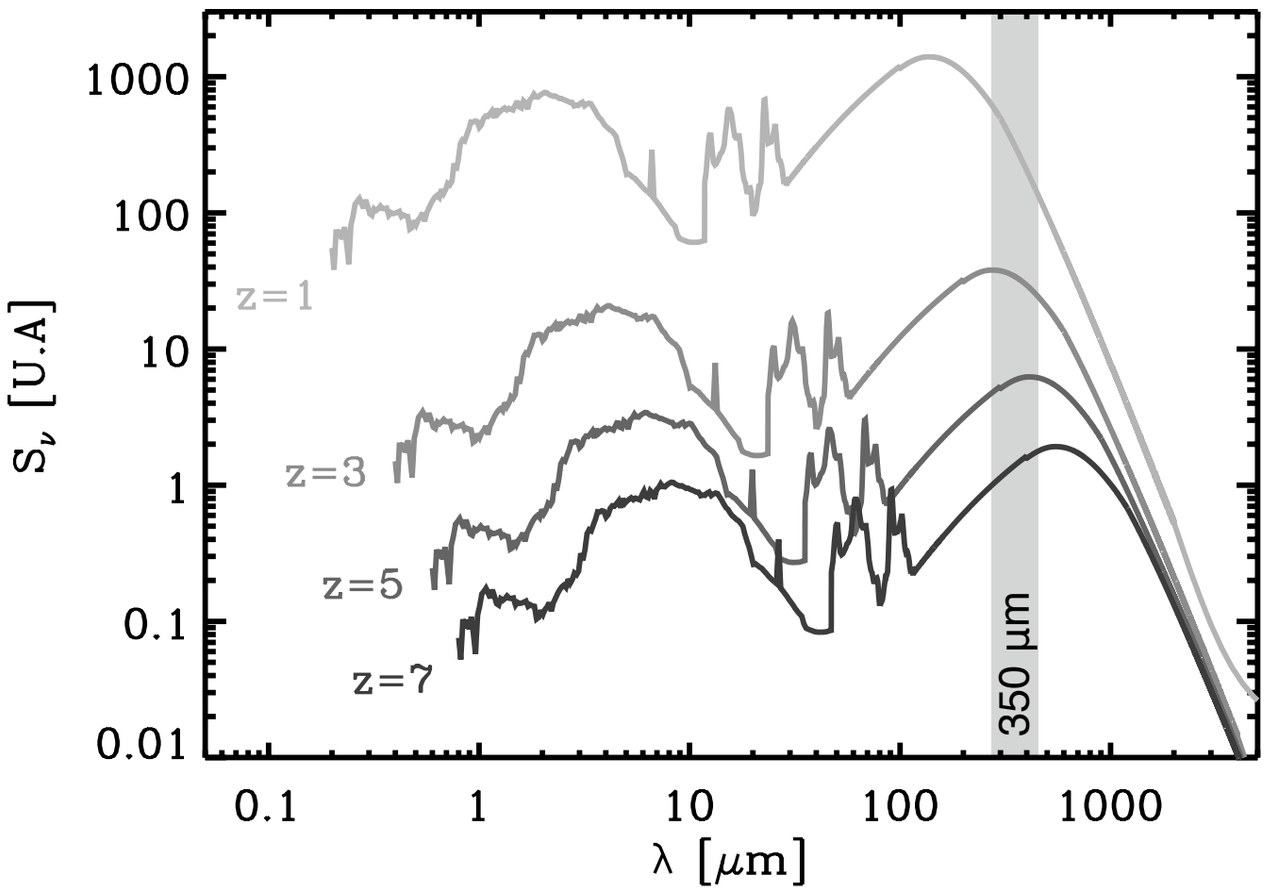
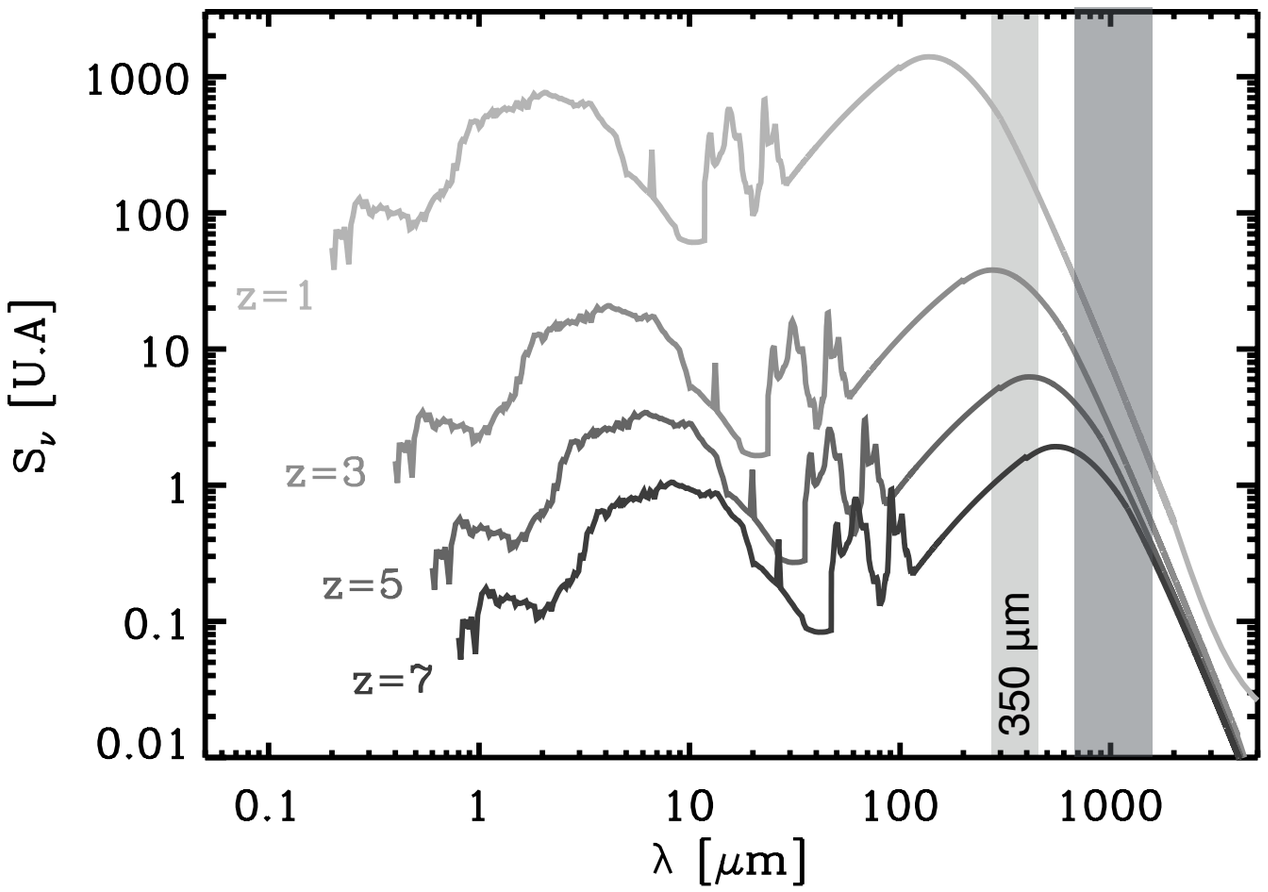


At 1 < z < 7, the 350μm band probes the peak of the IR emission of galaxies

350μm fluxes are thus excellent proxies of the IR-luminosity and SFR_{IR} of high-z galaxies

Nature of the FIR/(sub)mm emission of galaxies



On the contrary, the ≳850μm bands probe the IR peak of galaxies only at z ≳ 5

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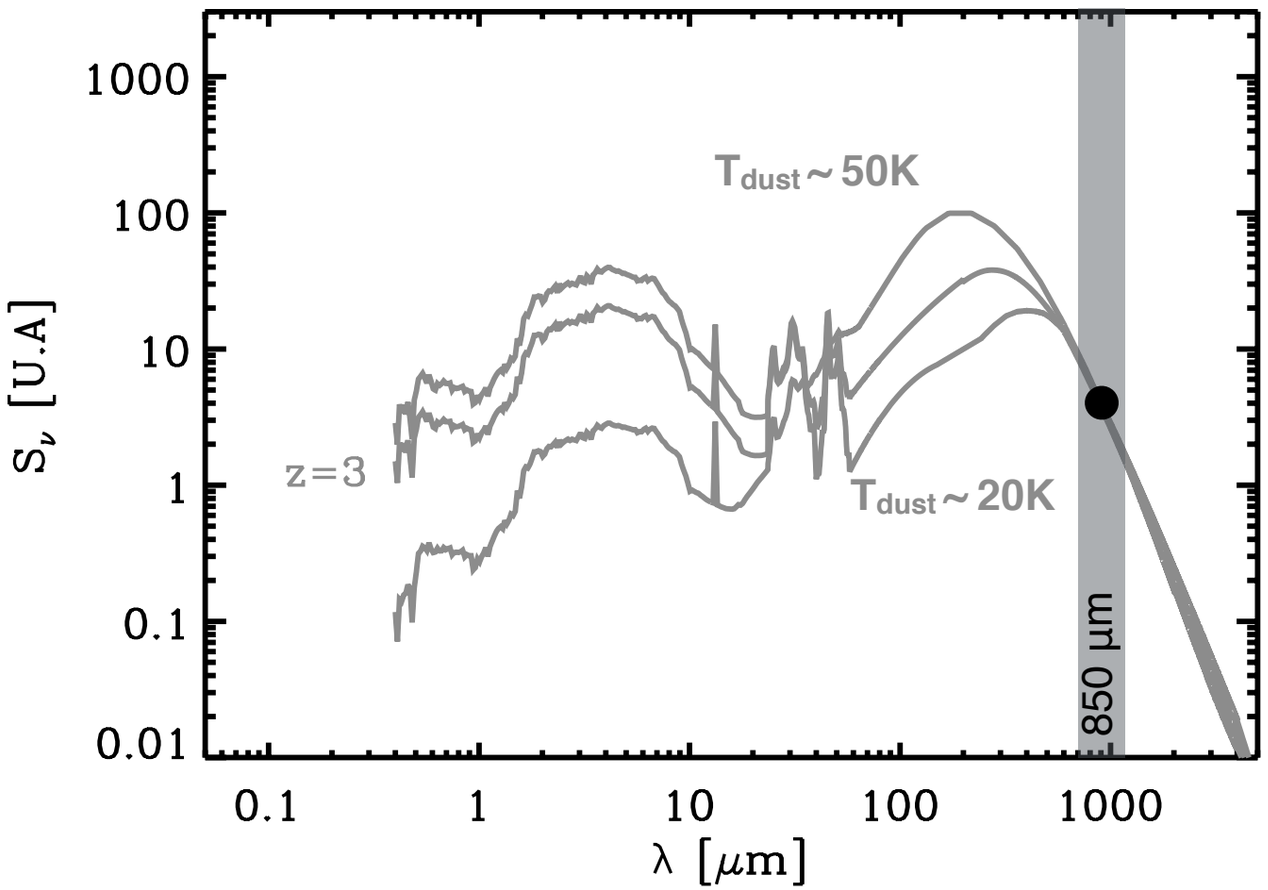


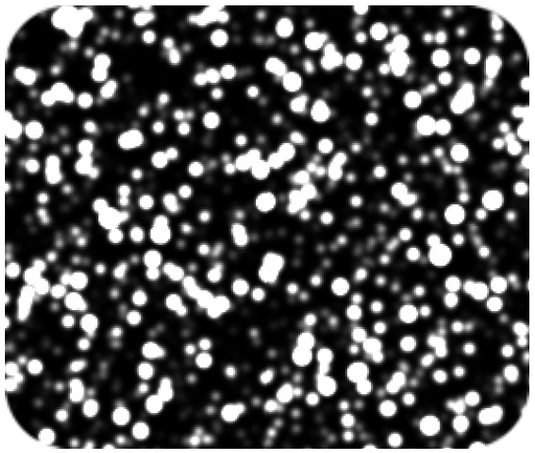
On the contrary, the ≳ 850μm bands probe the IR peak of galaxies only at z ≳ 5

→ ≳ 850μm fluxes provide robust SFR_{IR} estimates only at z ≳ 5

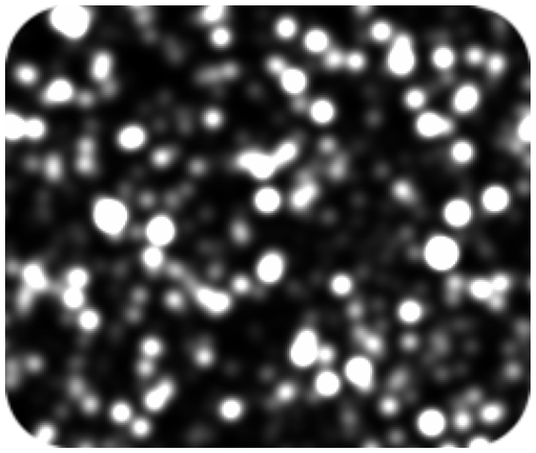
Resolving the CIB: current limitations

Why did Herschel resolve only a small fraction of the CIB at 250μm< λ <500μm ?

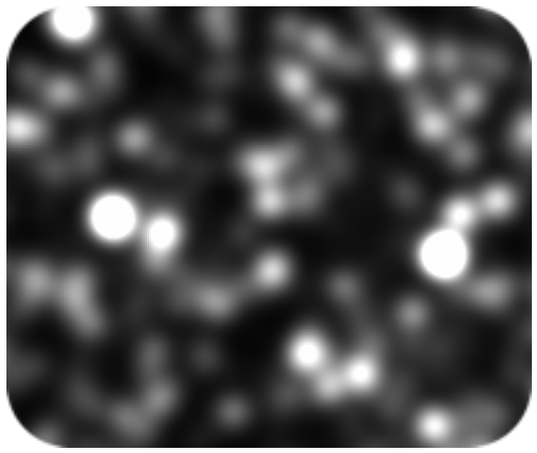
CONFUSION limit



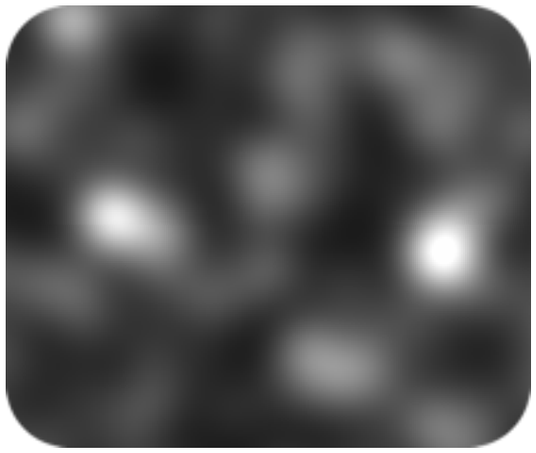
FWHM = x



FWHM = 2x



FWHM = 4x



FWHM = 8x

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

—> increase D … difficulty to put large aperture telescope in space and difficulty to observe from the ground at these wavelengths because of the atmosphere

CCAT-p and the GEvo survey

CCAT-p in a nutshell

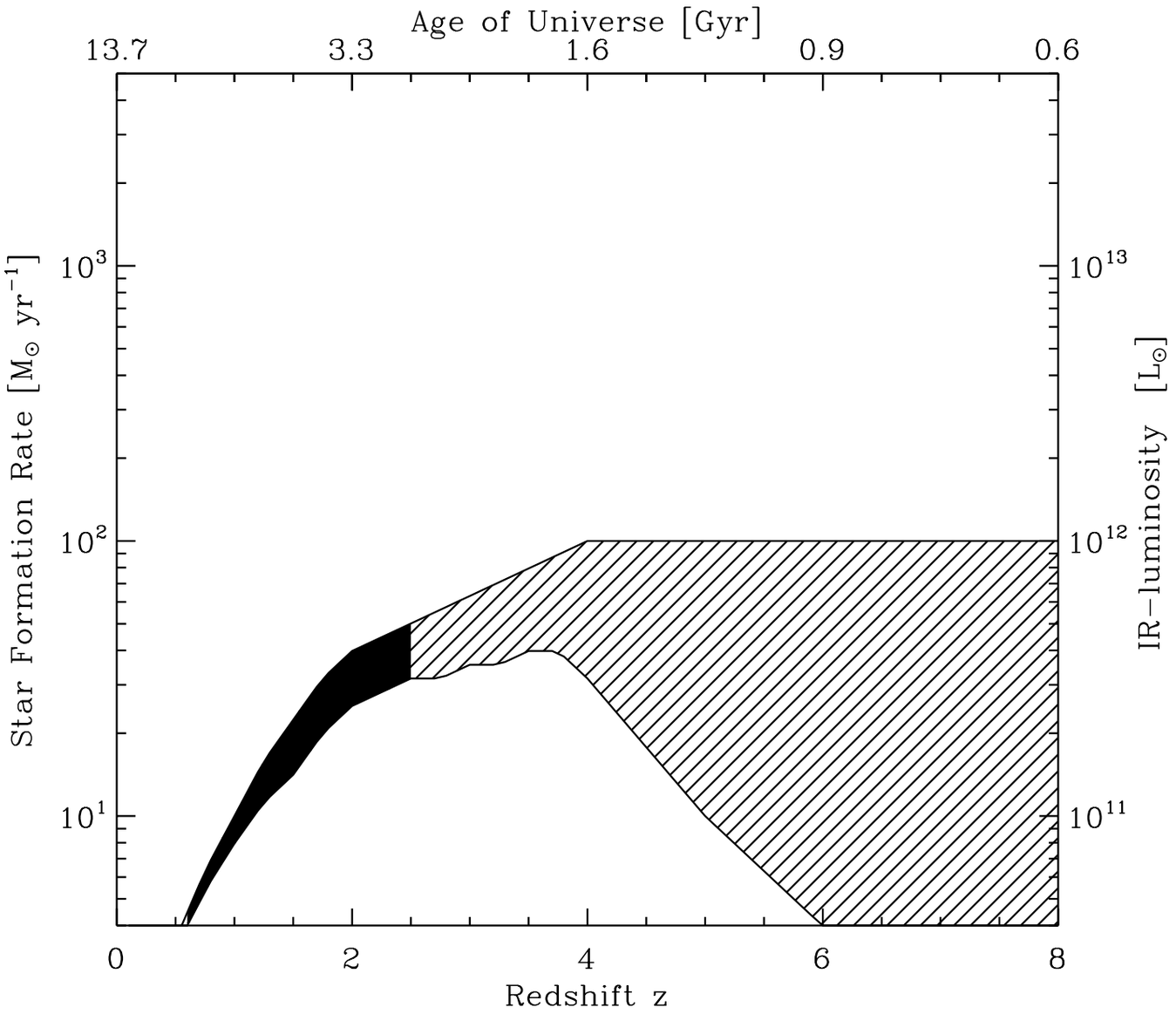
- ✓ 6-m aperture submillimeter (submm) telescope
- ✓ Exceptional location at 5600-m on Cerro Chajnantor
- ✓ 11 μm rms surface accuracy allowing efficient operation at 350 μm
- ✓ P-Cam —> simultaneous observations at 350, 740, 860μm, 2 and 3mm with each a ~1° FoV
- ✓ P-Cam + Fabry-Perot interferometer —> low (sub)millimeter spectrometer in all these bands

GEvo
(The CCAT-p Galaxies Evolution survey)

"Studies of dusty star-forming galaxies with a survey going deeper and over a wider area than those carried by the Herschel Space Observatory"

- ✓ 1st year - "science demonstration survey" —> ~ 50 deg^2 down to the confusion limit
- ✓ 4 years - "full survey" —> ~ 200 deg^2 down to the confusion limit

GEvo: tracing the evolution of dusty SF galaxies over cosmic time



Typical SFR of galaxies

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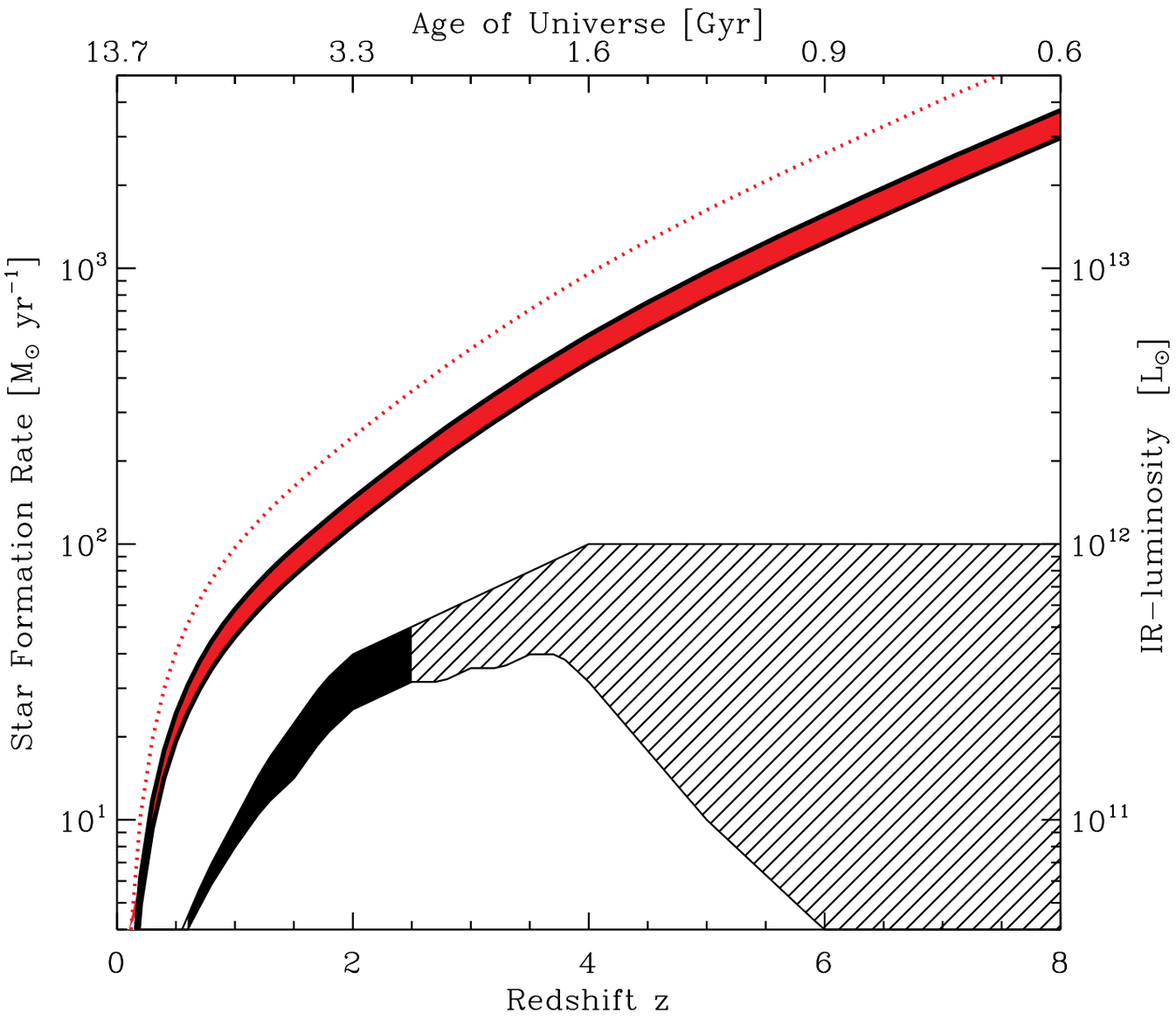

GEvo 350μm

SPIRE 350μm

Typical SFR of galaxies

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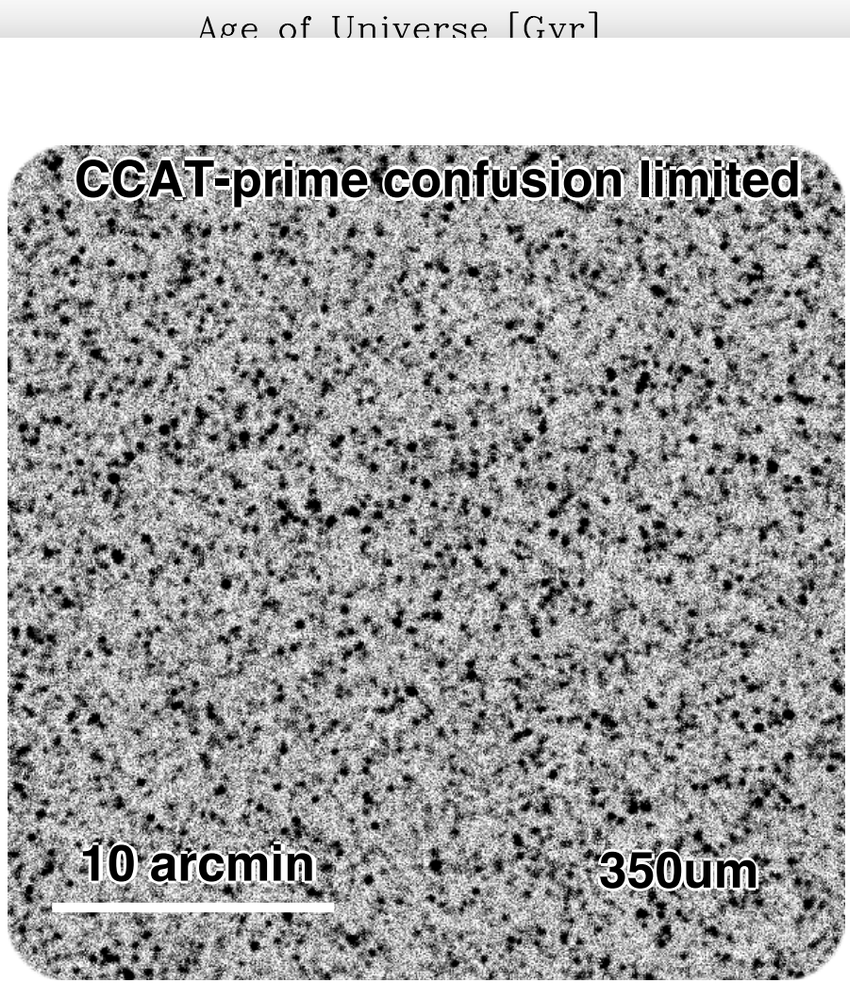

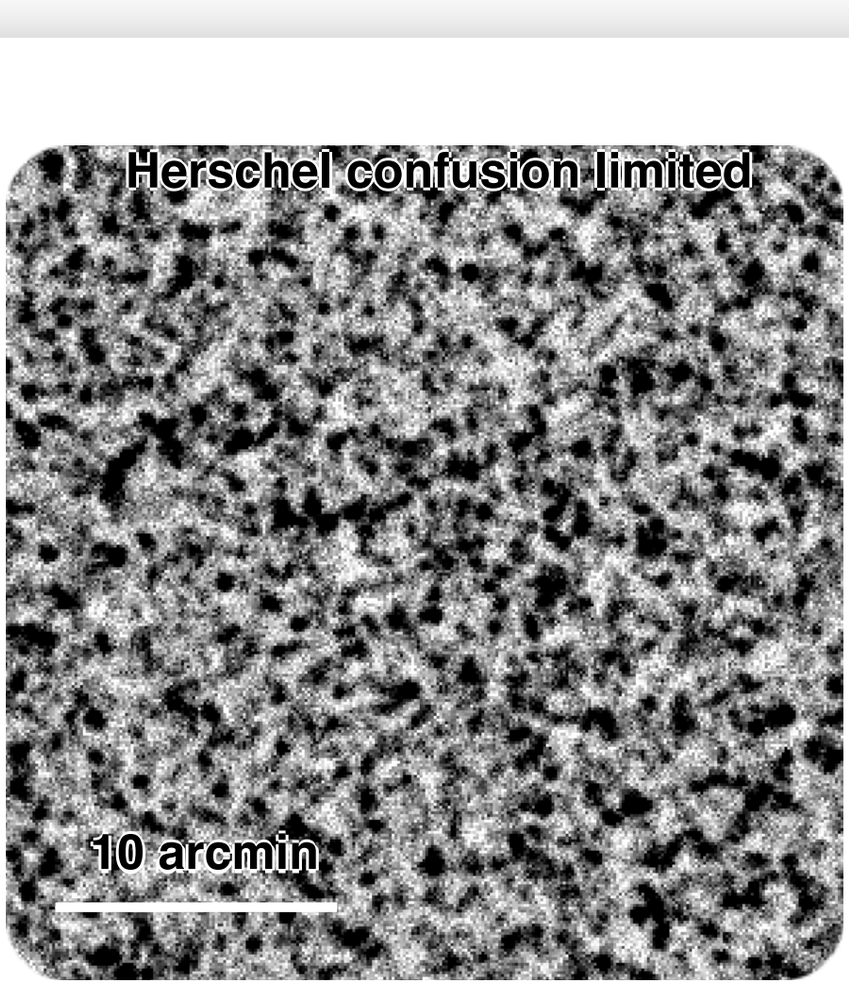

Age of Universe [Gyr]

Star Formation Rate [$M_\odot$ yr^{-1}]

Redshift z

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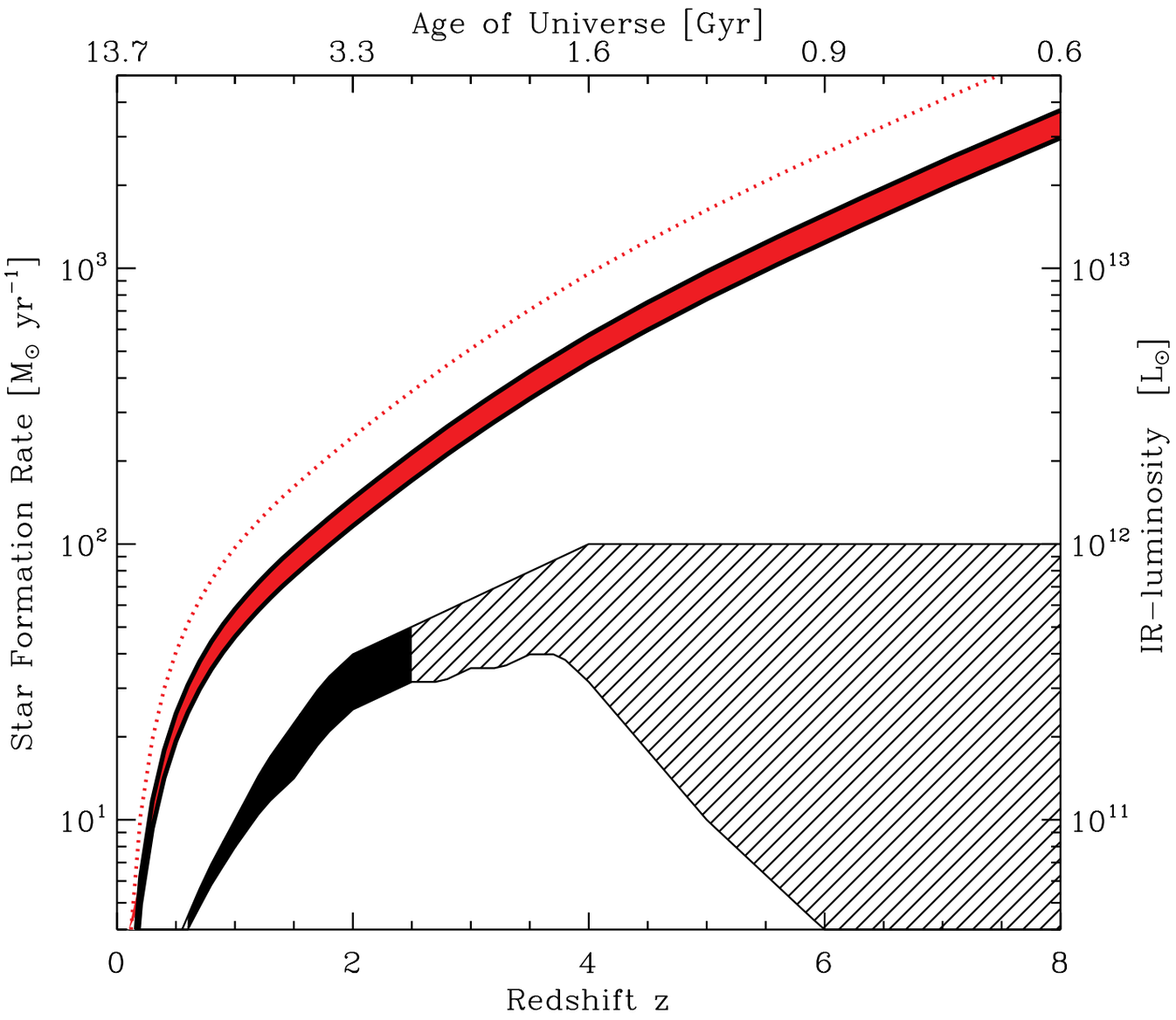

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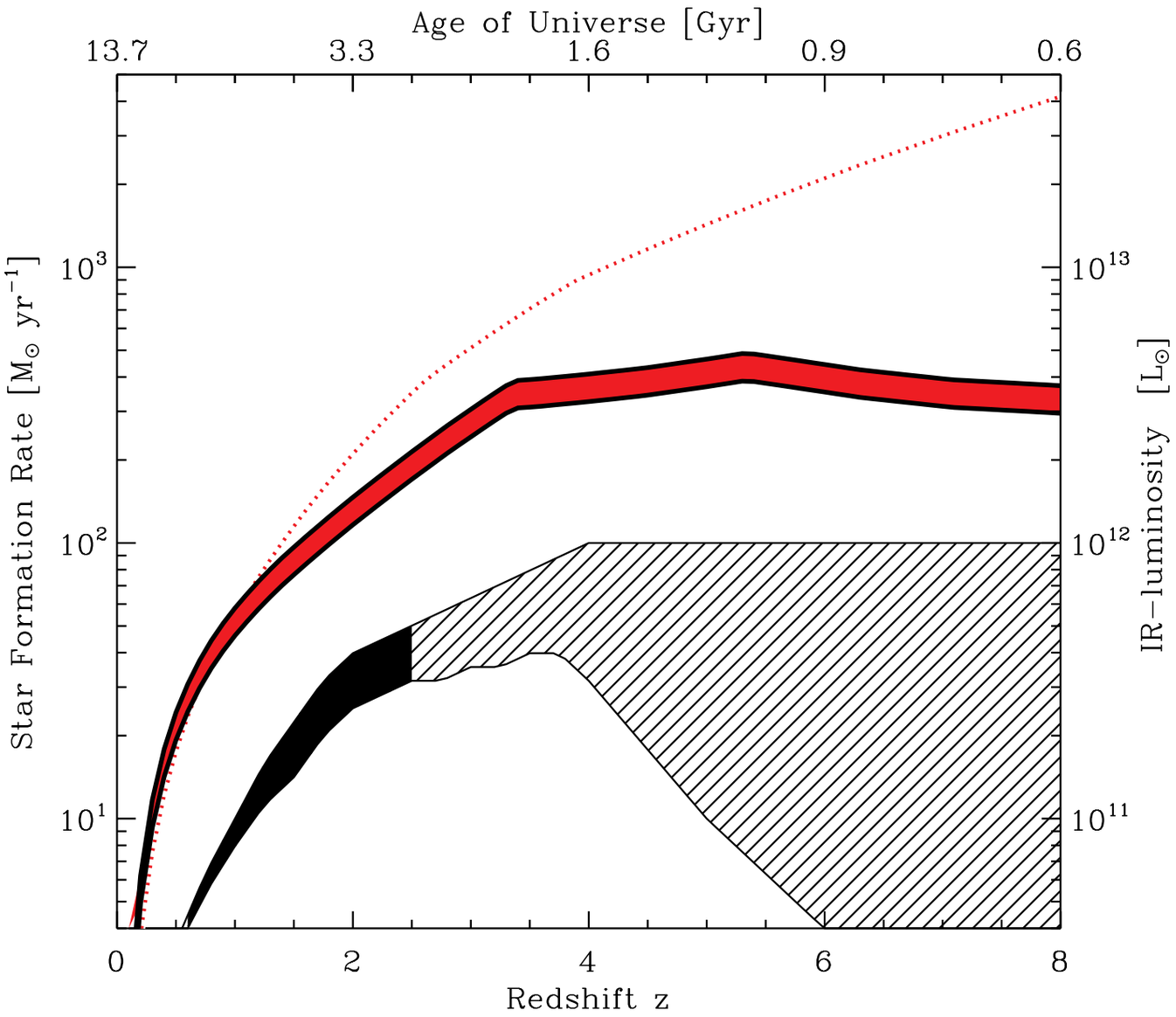

GEvo all bands (350-2000μm)

SPIRE all bands (350-500μm)

Typical SFR of galaxies

GEvo: tracing the evolution of dusty SF galaxies over cosmic time

Age of Universe [Gyr]

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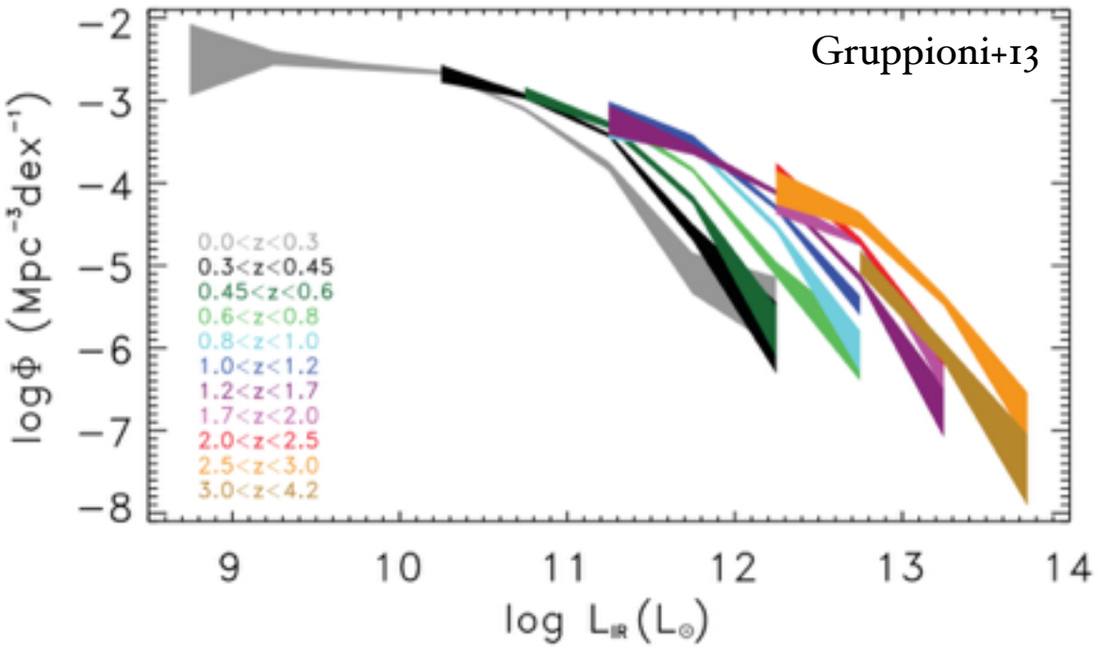
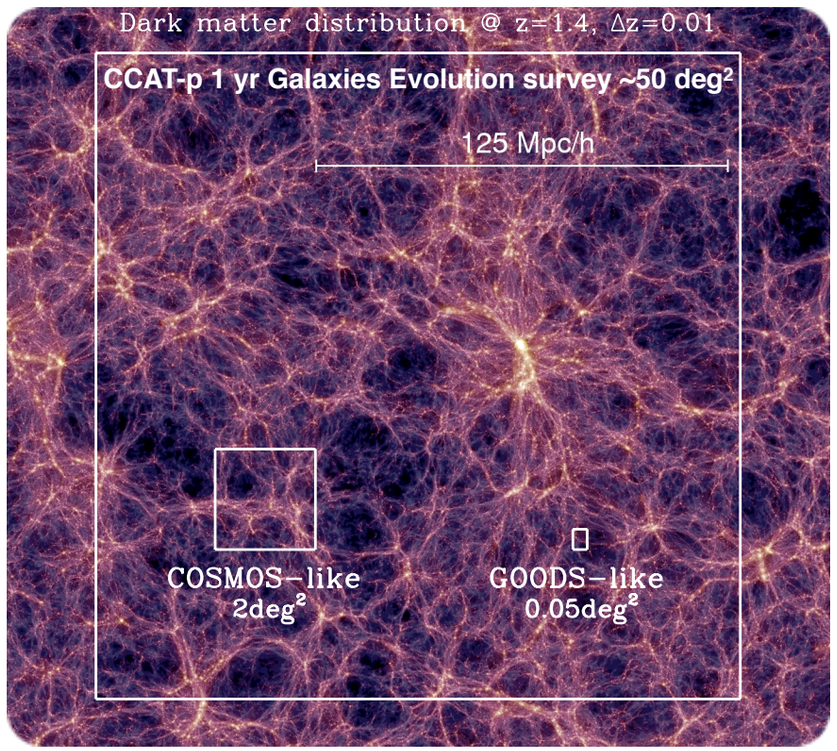
Redshift z

The area of the survey matters also a lot …



… to **accurately** probe the high-end of the LF



… to probe the impact of environment

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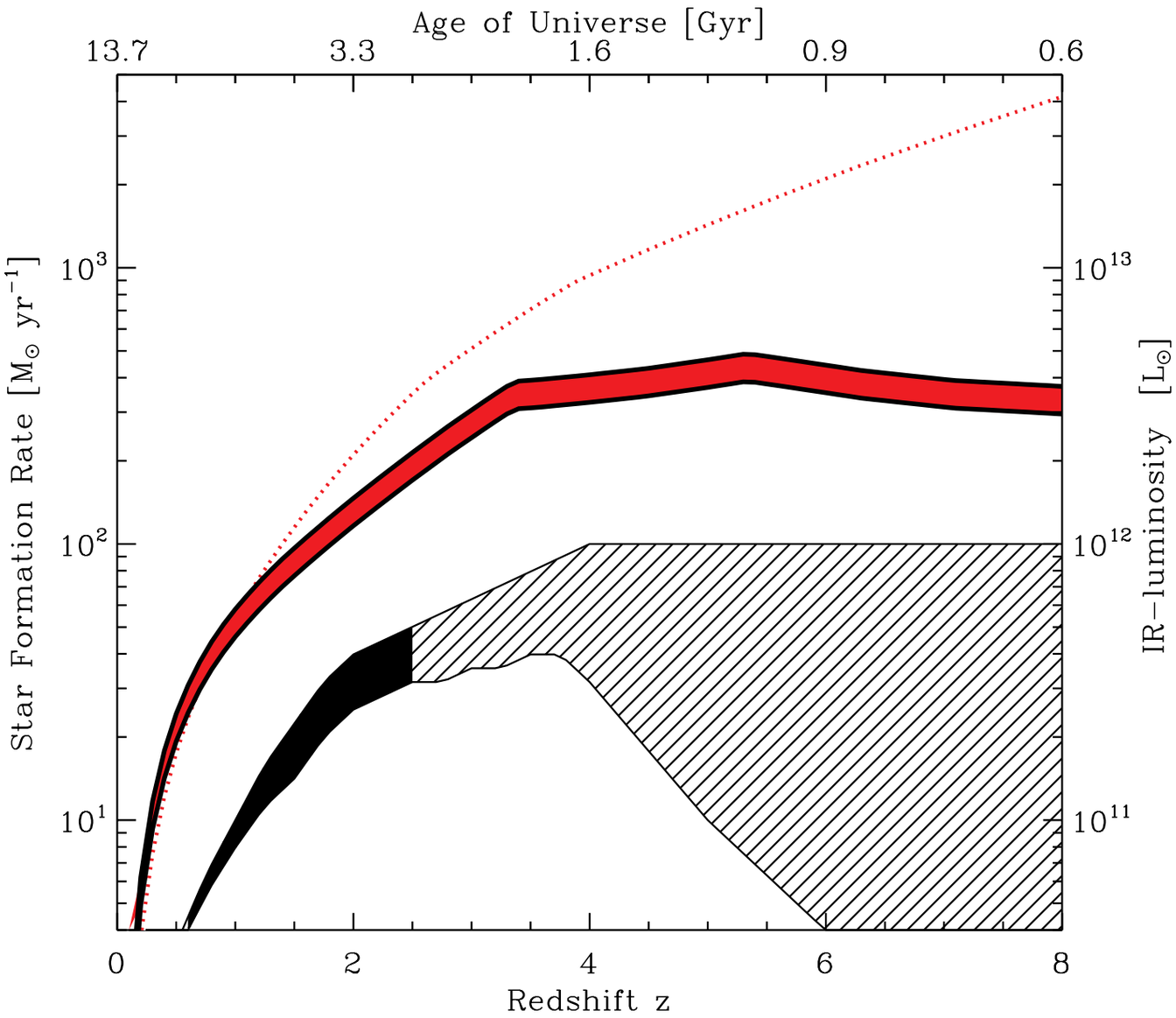

GEvo all bands (350-3000μm)

SPIRE all bands (350-500μm)

Typical SFR of galaxies

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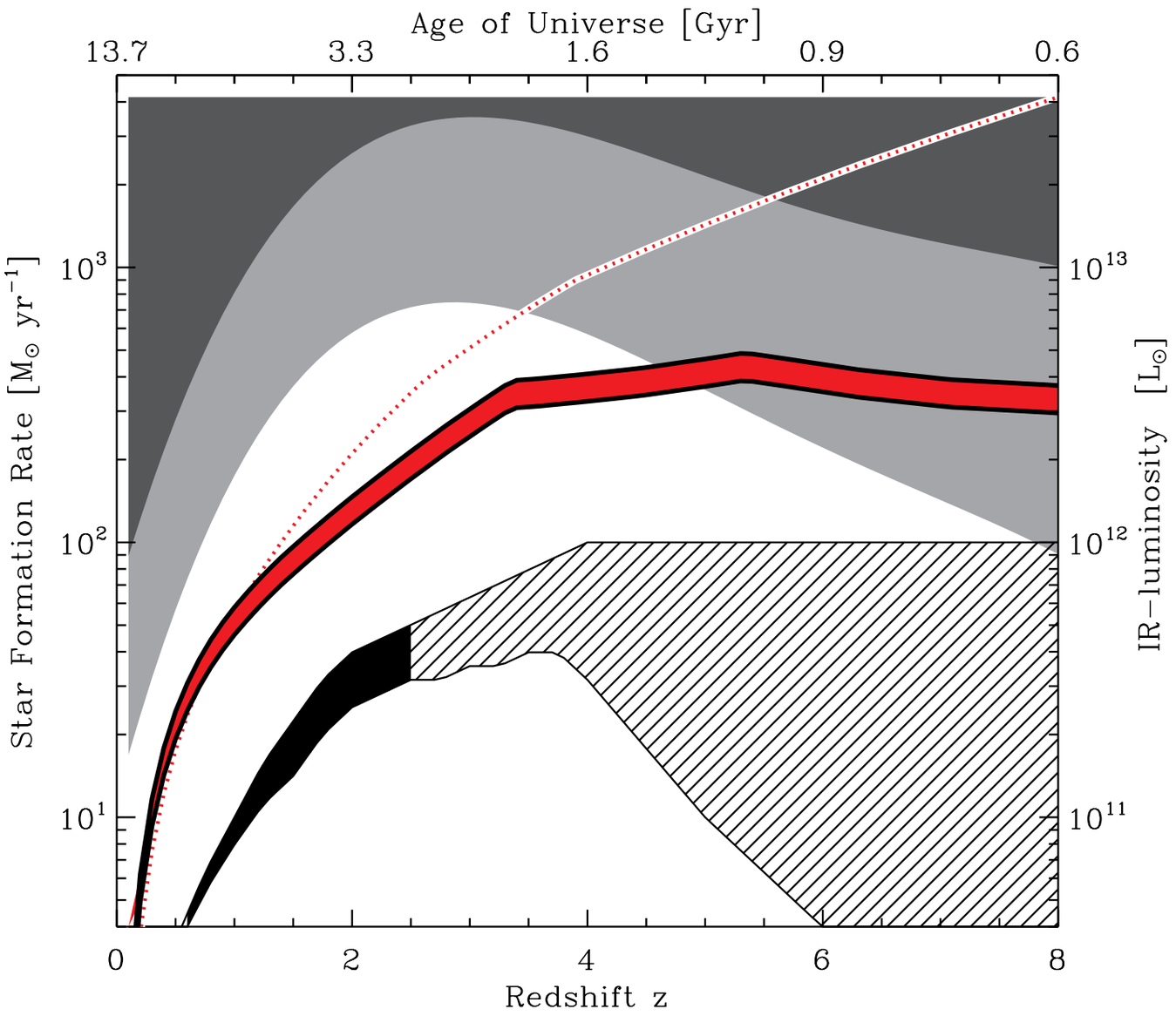

GEvo all bands (350-3000μm; 200deg²)

SPIRE all bands (350-500μm; ~30deg²)

Not accessible by < 200 deg² surveys

Not accessible by < 2 deg² surveys

Typical SFR of galaxies

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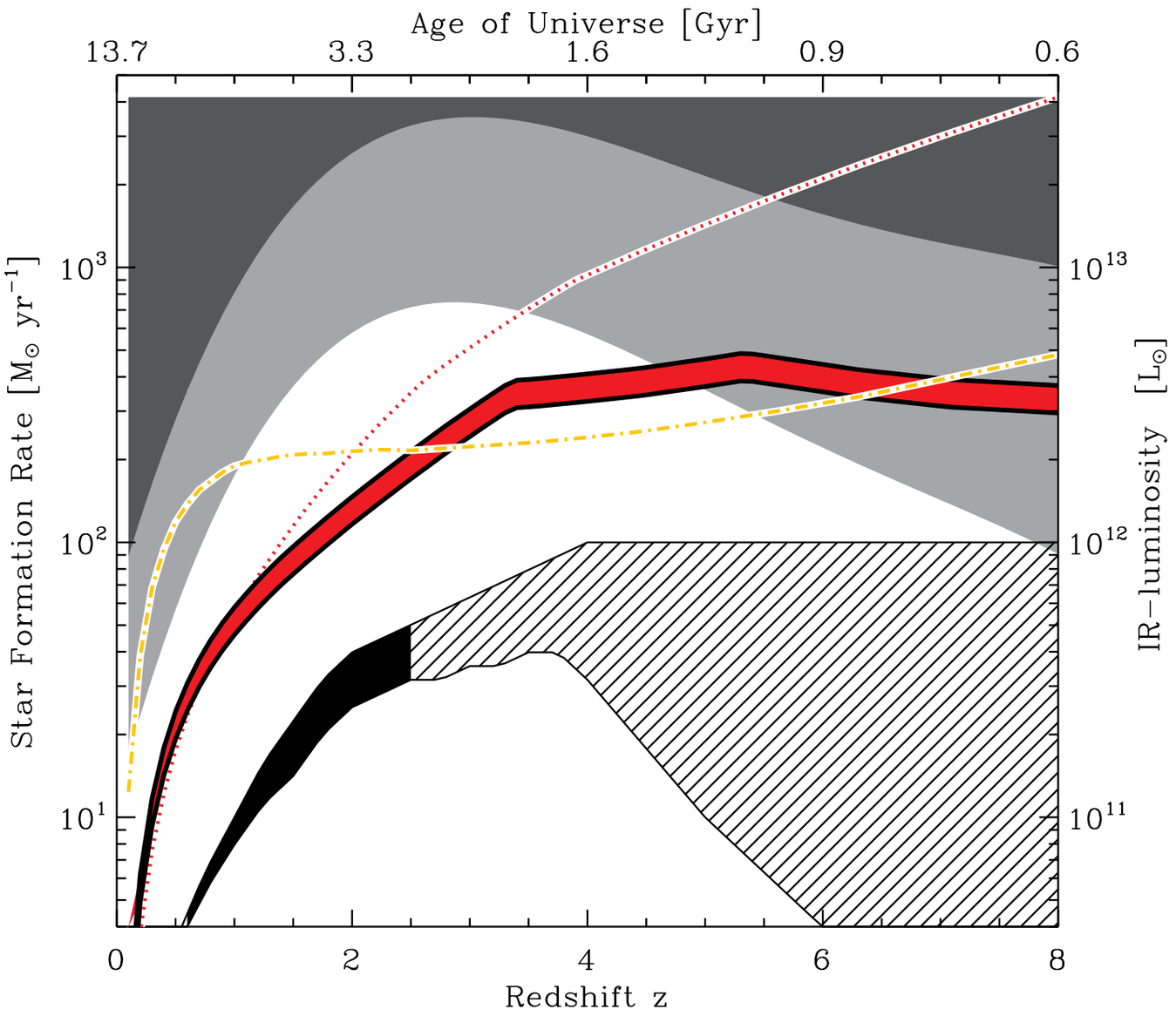

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SCUBA 850μm — ~5 deg²

Typical SFR of galaxies

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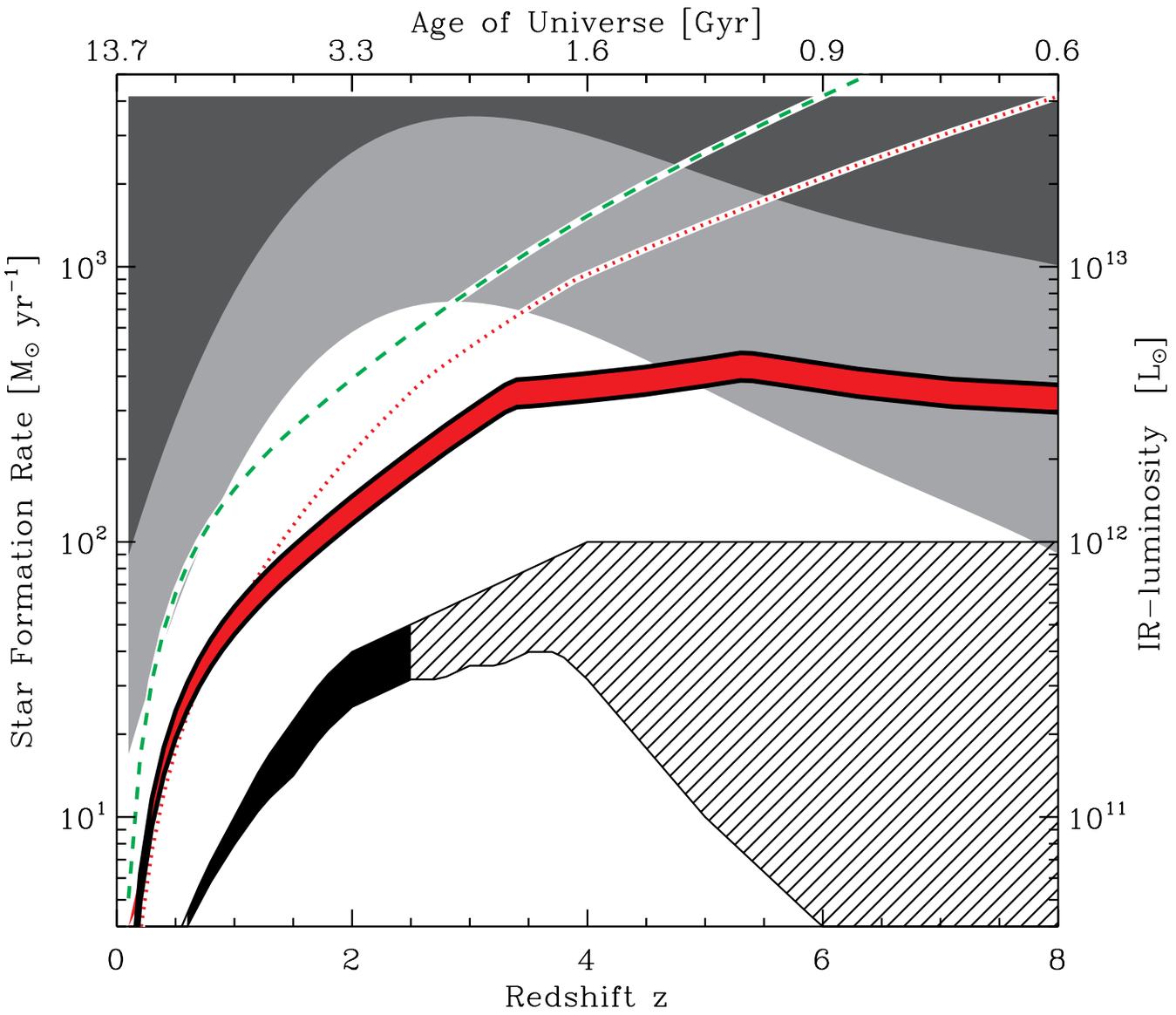

GEvo all bands (350-3000μm; 200deg²)

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Not accessible by < 200 deg² surveys

Not accessible by < 2 deg² surveys

ALMA 350μm — 2 deg² — ~2000hrs

Typical SFR of galaxies

GEvo: tracing the evolution of dusty SF galaxies over cosmic time

In brief, the CCAT-p GEvo survey will provide us with …

- A submm map deeper (≳ x 2) and over a wider area (≳ x 5) than those obtained by the *Herschel Space Observatory*

  —> Resolving up to ~40% of the CIB at 350μm

- A large and comprehensive sample of dusty SF galaxies (≳ 20,000) :

  —> Robust constraints of the bright-end of the LF

  —> Role of dusty SF galaxies in the global galaxy evolution scenario

  —> Impact of environment

  —> Study of “exotic” galaxies

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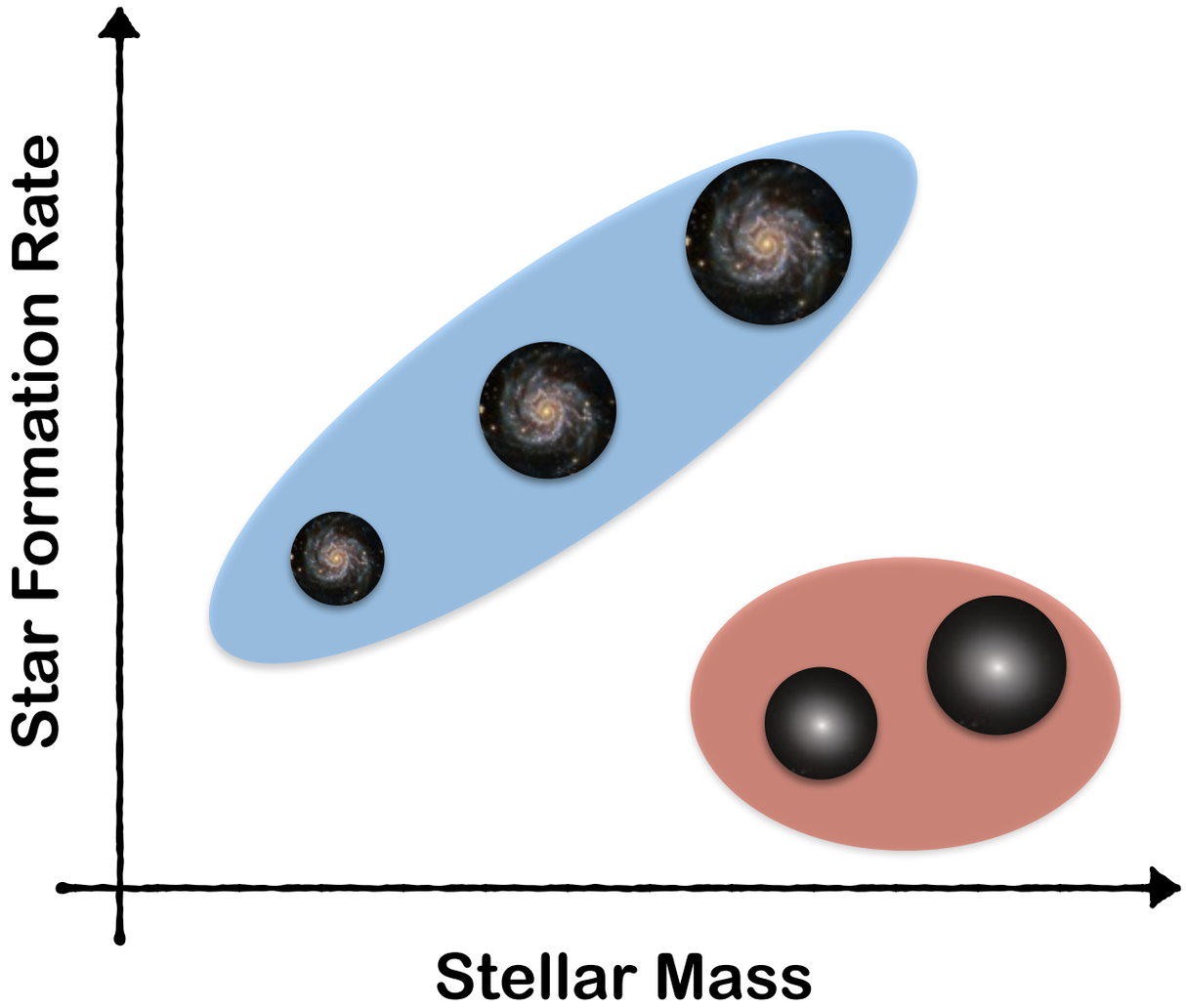
The redshift of these galaxies will be obtained using :

- Multi-λ observations from P-CAM (FIR photometric redshift)
- [CII] and CO line detections from the P-Cam + Fabry-Perot interferometers
- ALMA follow-up

Dusty SF galaxies, the missing link between blue and red galaxies ?

Why do we care about having a good statistic on this population of dusty highly star-forming galaxies ?



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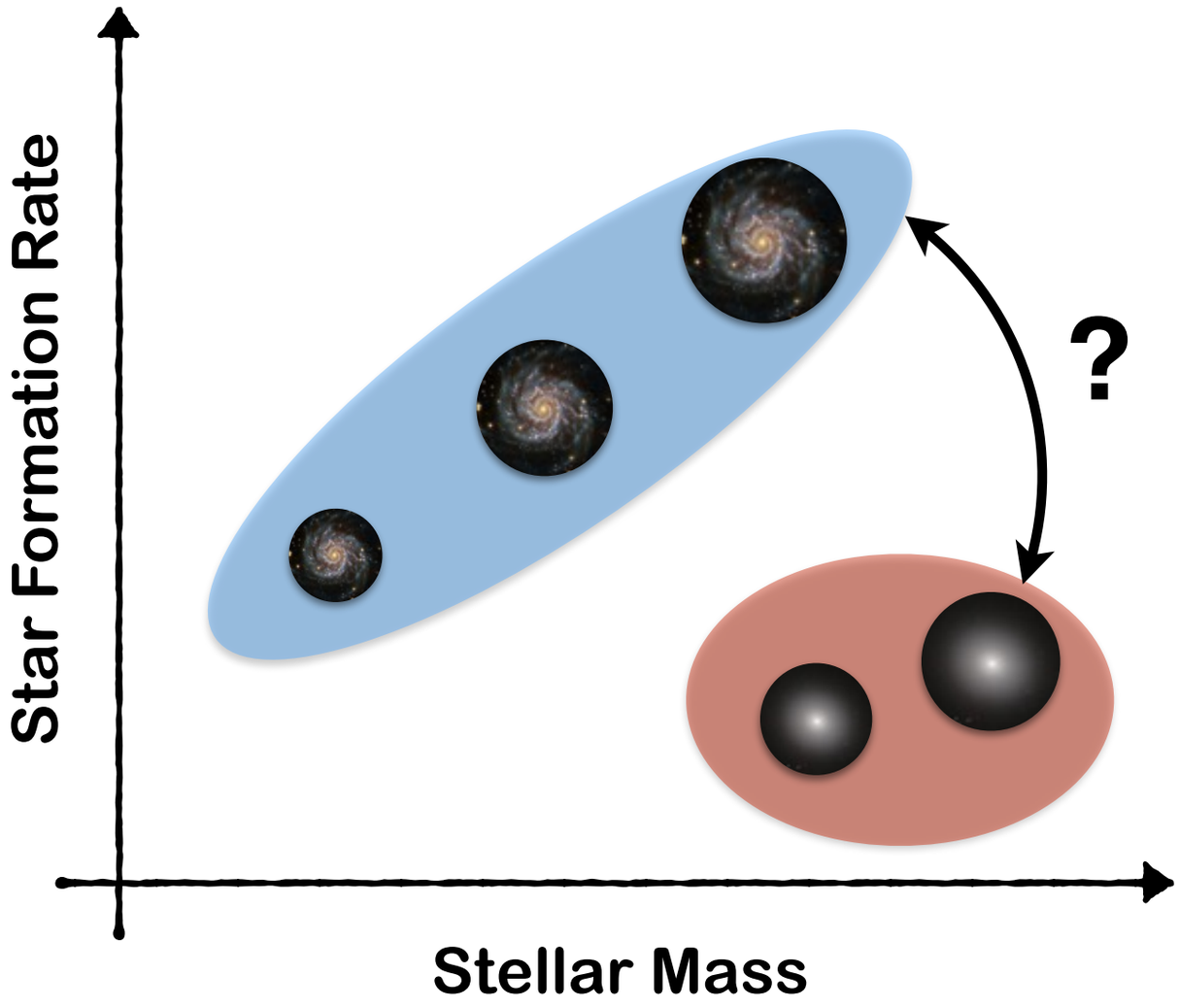

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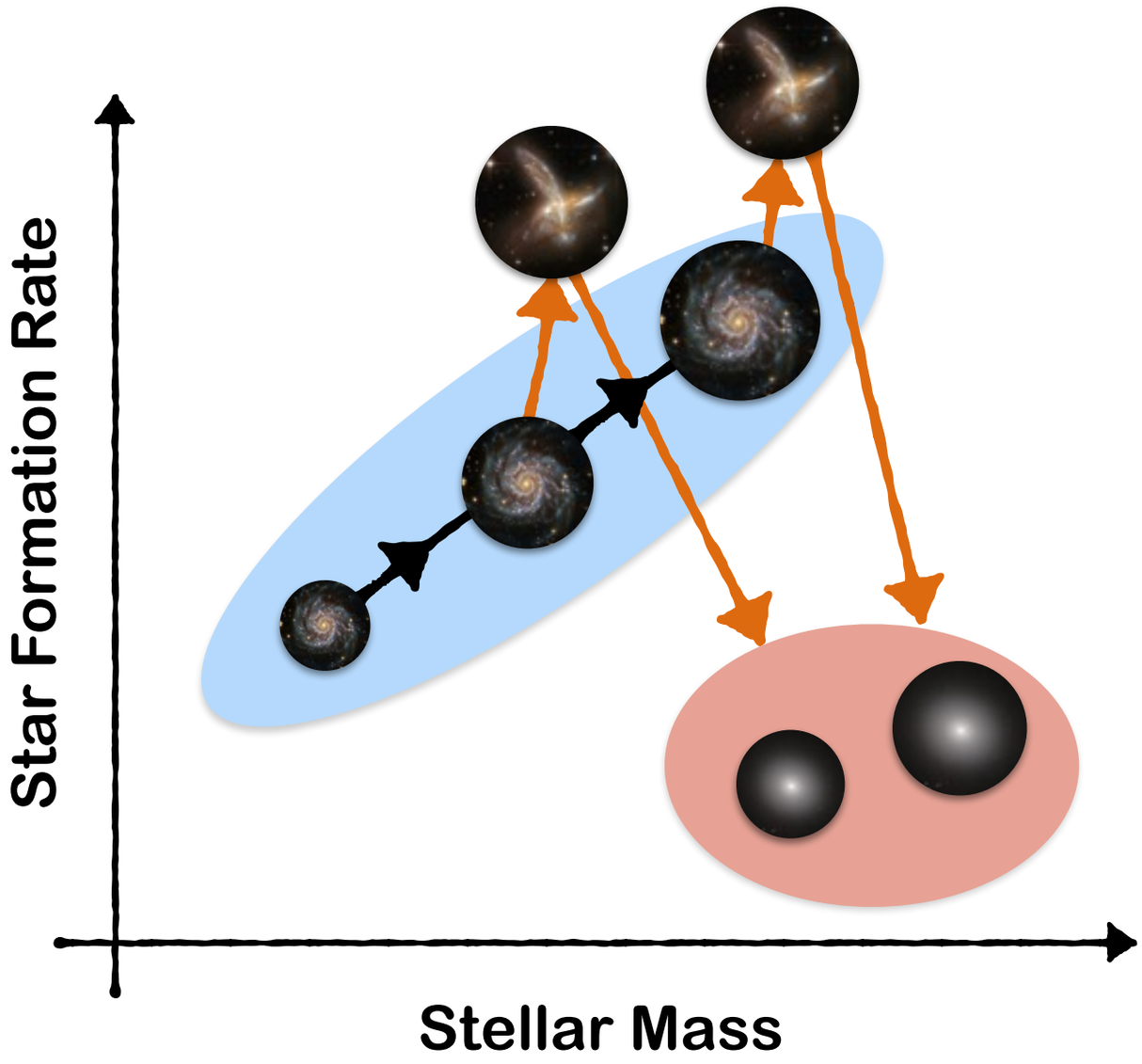

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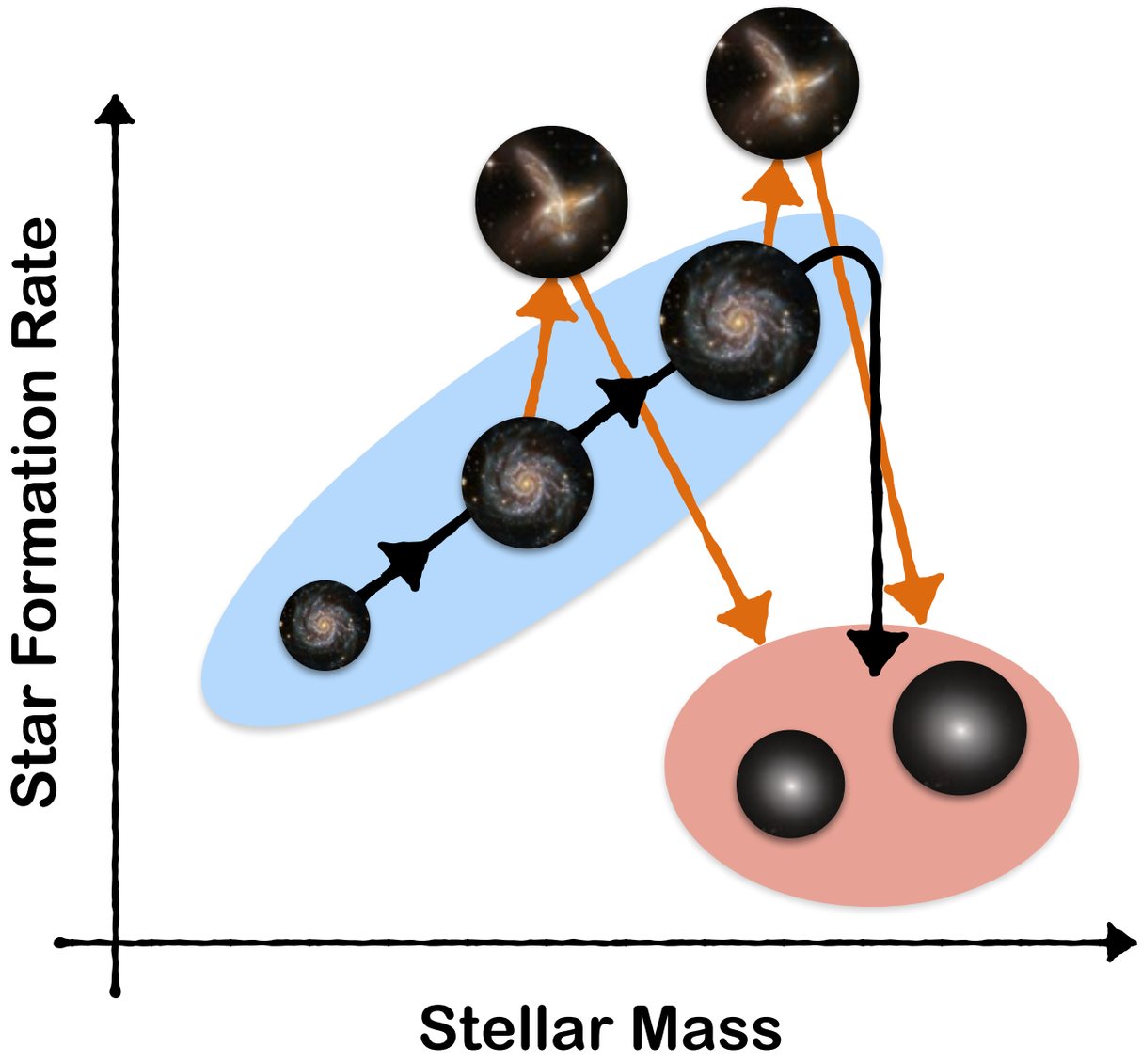

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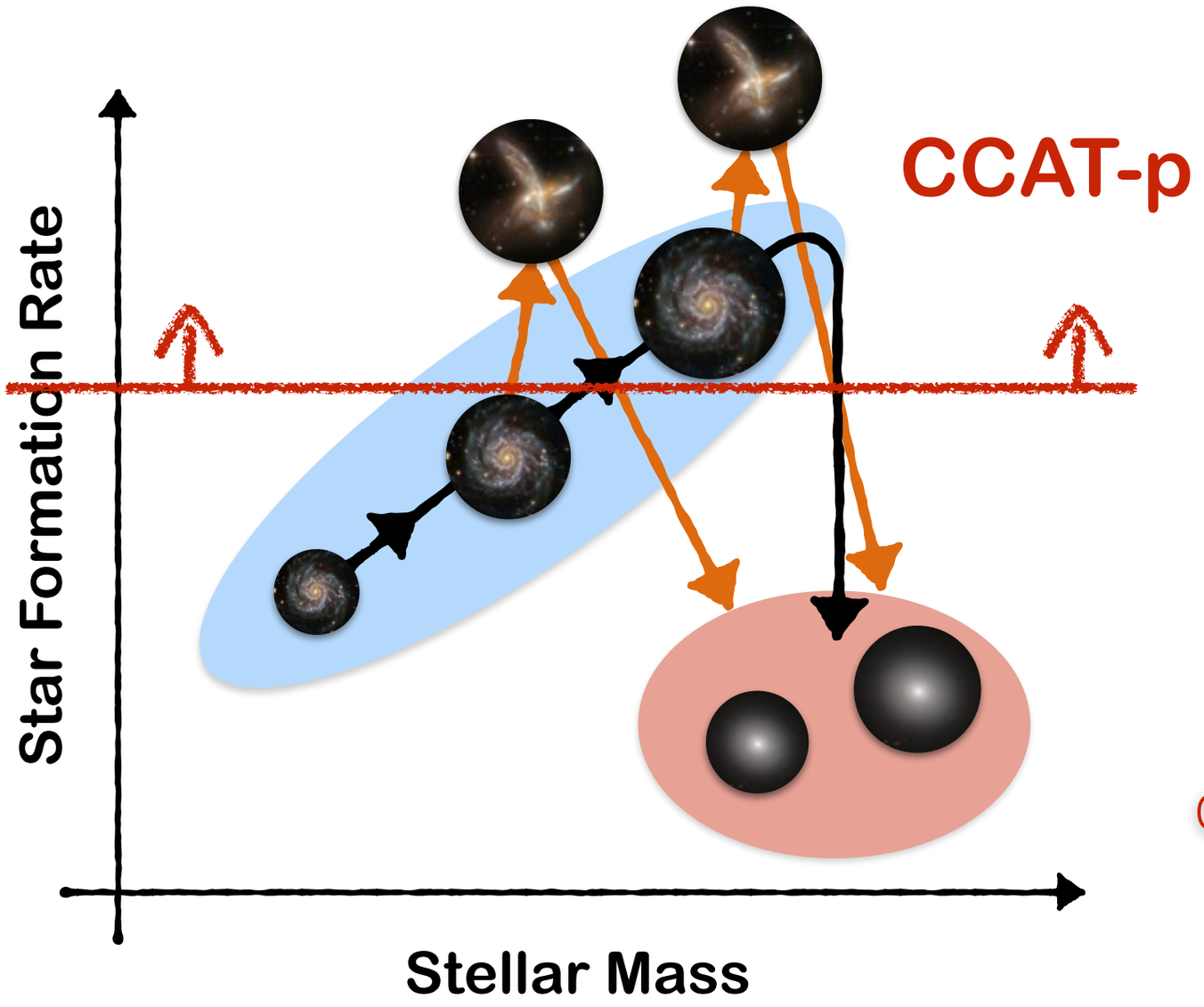

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CCAT-p will detect large samples of such galaxies, allowing us to understand the formation of local ellipticals

Conclusions

- ✓ The CCAT-p GEvo survey will be deeper and wider than those carried by the *Herschel Space Observatory,* resolving up to ~40% at > 250 μm
- ✓ For the first time, it will provide us with very large and comprehensive samples of dusty SF galaxies over cosmic time
- ✓ These samples will allow the study of the bright end of the LF and the impact of environment on the SF activity of galaxies
- ✓ These samples might provide us with the missing link between blue and red galaxies

Resolving the CIB with the next generation of (sub)mm antenna