Quenching of star formation from a lack of inflowing gas to galaxies

Whitaker et.al 2021

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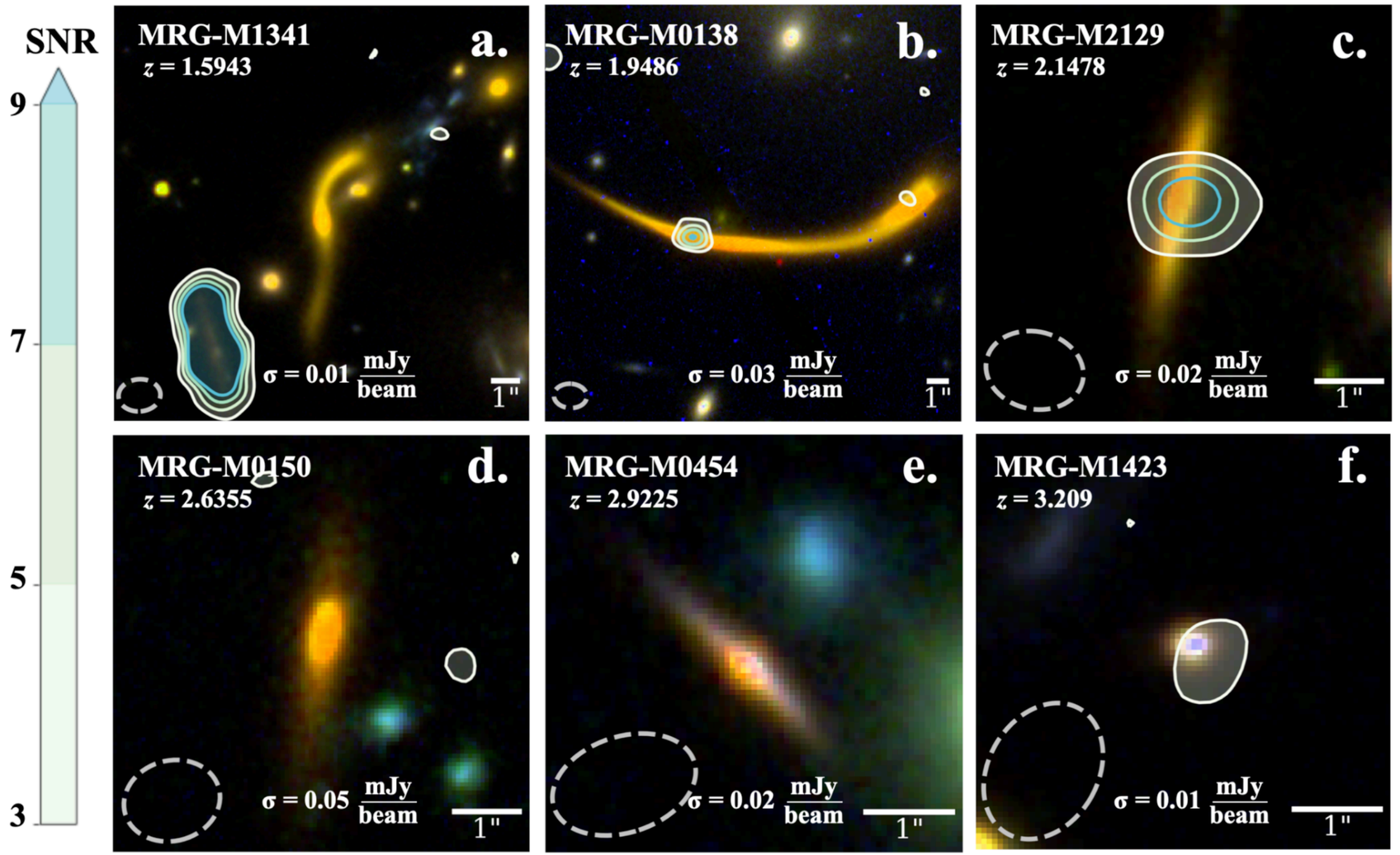
2021.12.10

Take home message

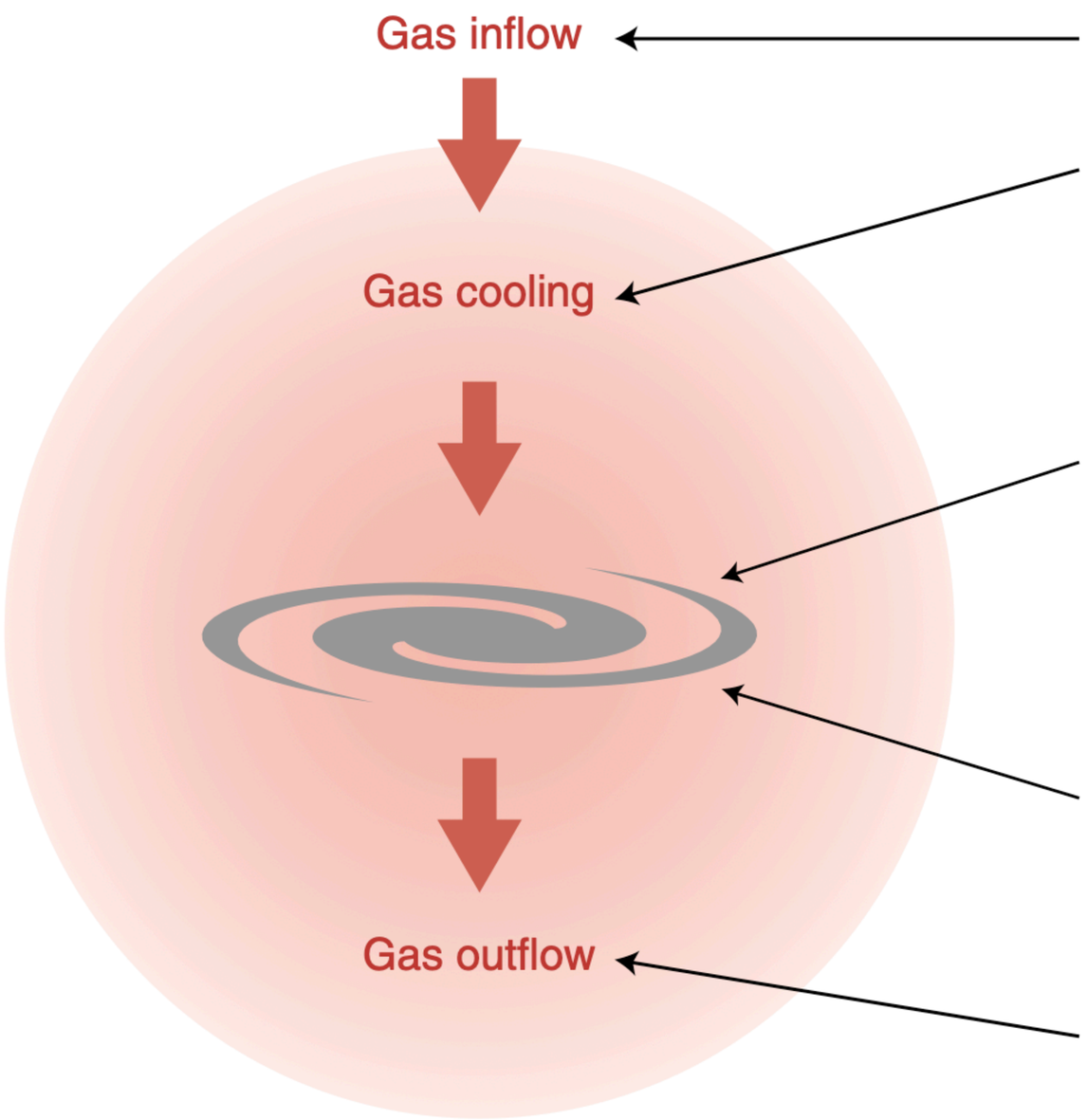
Whitaker et.al 2021



Quenched galaxy: the galaxy doesn't have star formation.

Six strongly lensed and **quenched** galaxies have **two orders** of magnitude **less molecular gas** than that seen in typical galaxies at similar **high redshifts.**

What causes quenching in massive galaxies?



(i) **Gas does not accrete**
- Cosmological starvation

Man et.al 2018

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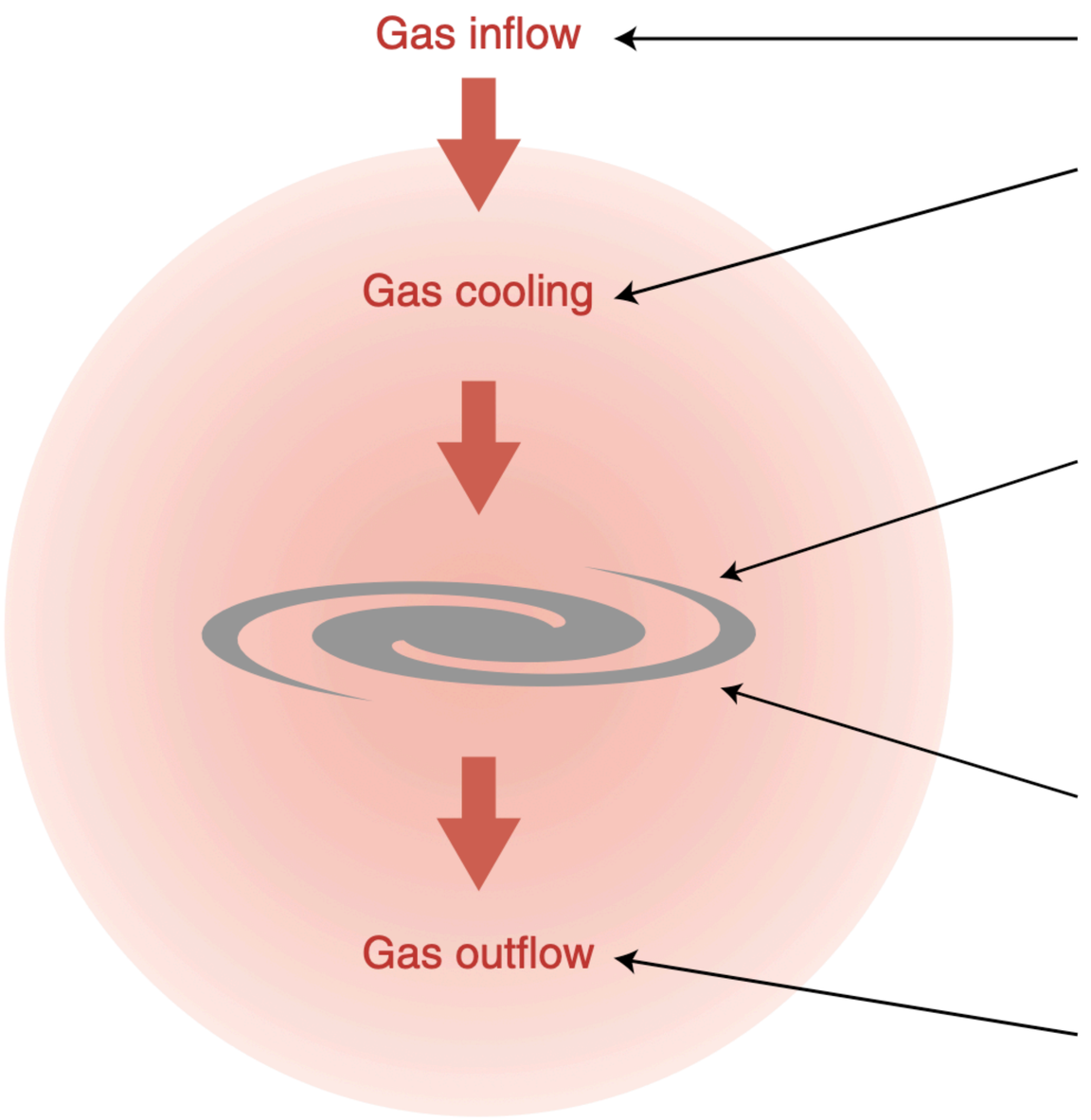

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(ii) **Gas does not cool**
- Virial shock heating
- AGN feedback
- Gravitational heating
- Stellar feedback

Man et.al 2018

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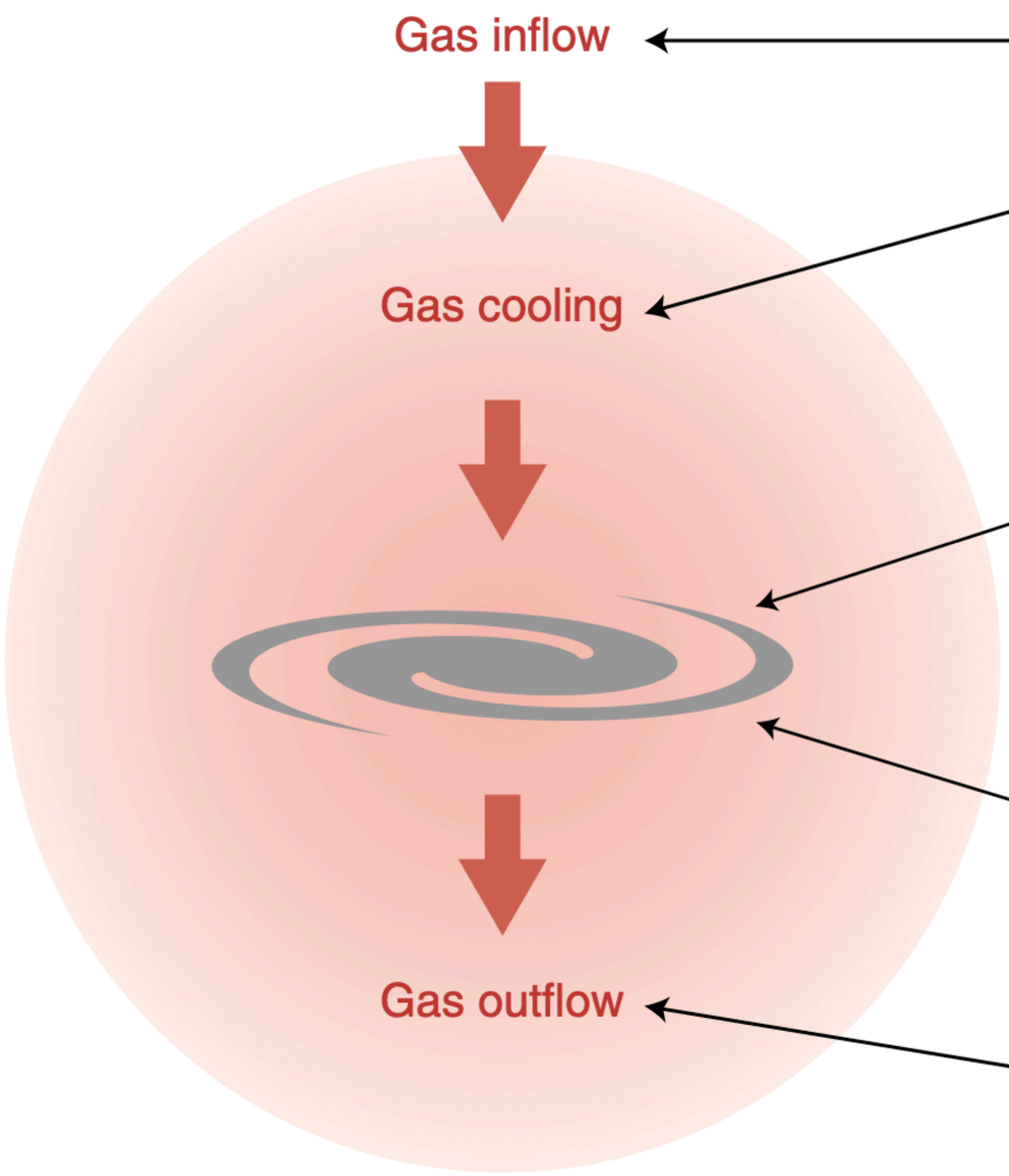

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(iii) **Cold gas does not form stars**
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- Bar quenching
- AGN feedback
- Magnetic fields

Man et.al 2018

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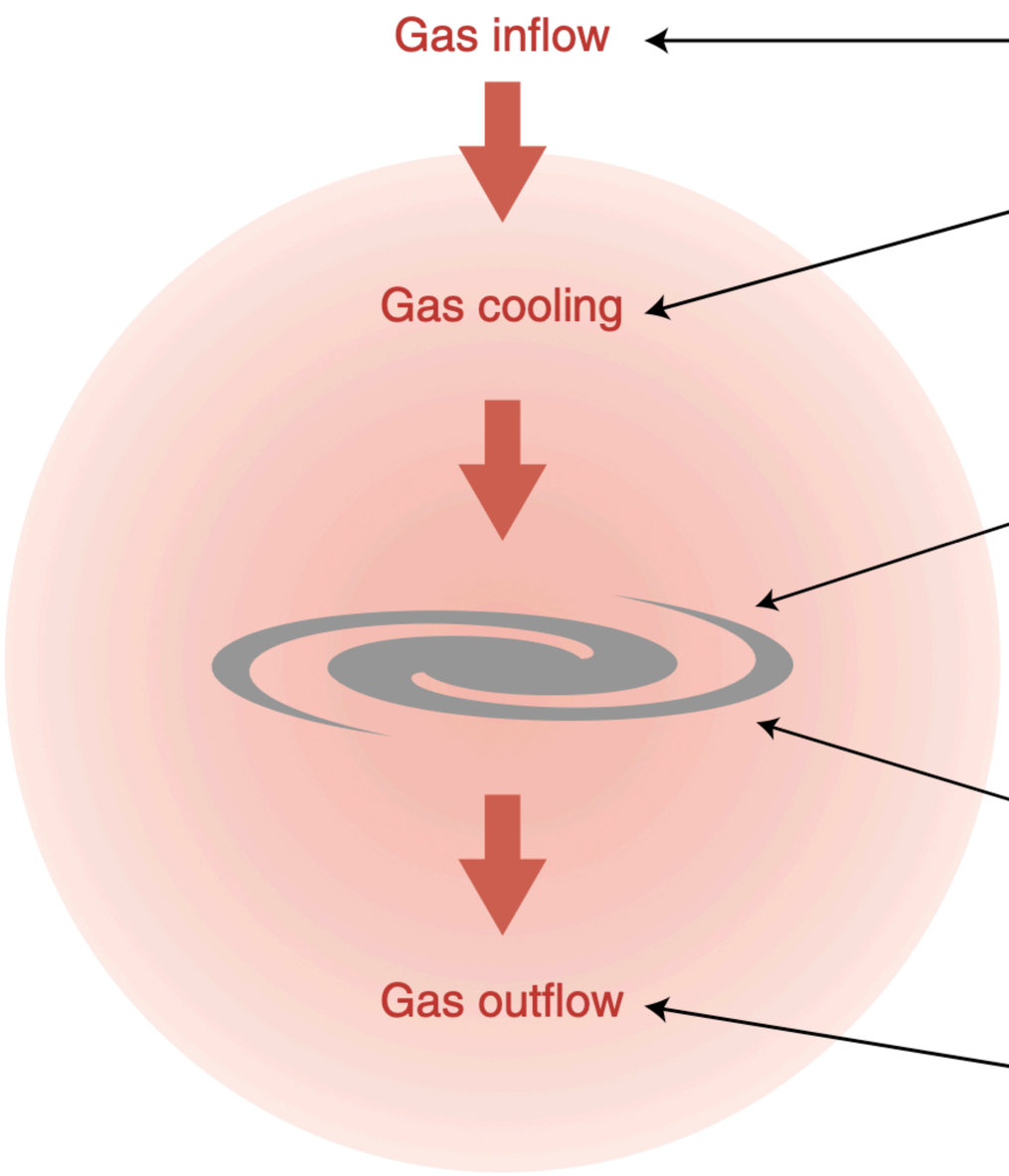

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(iv) **Cold gas is rapidly consumed**
- Mergers
- Disk instabilities
- Positive AGN feedback

Man et.al 2018

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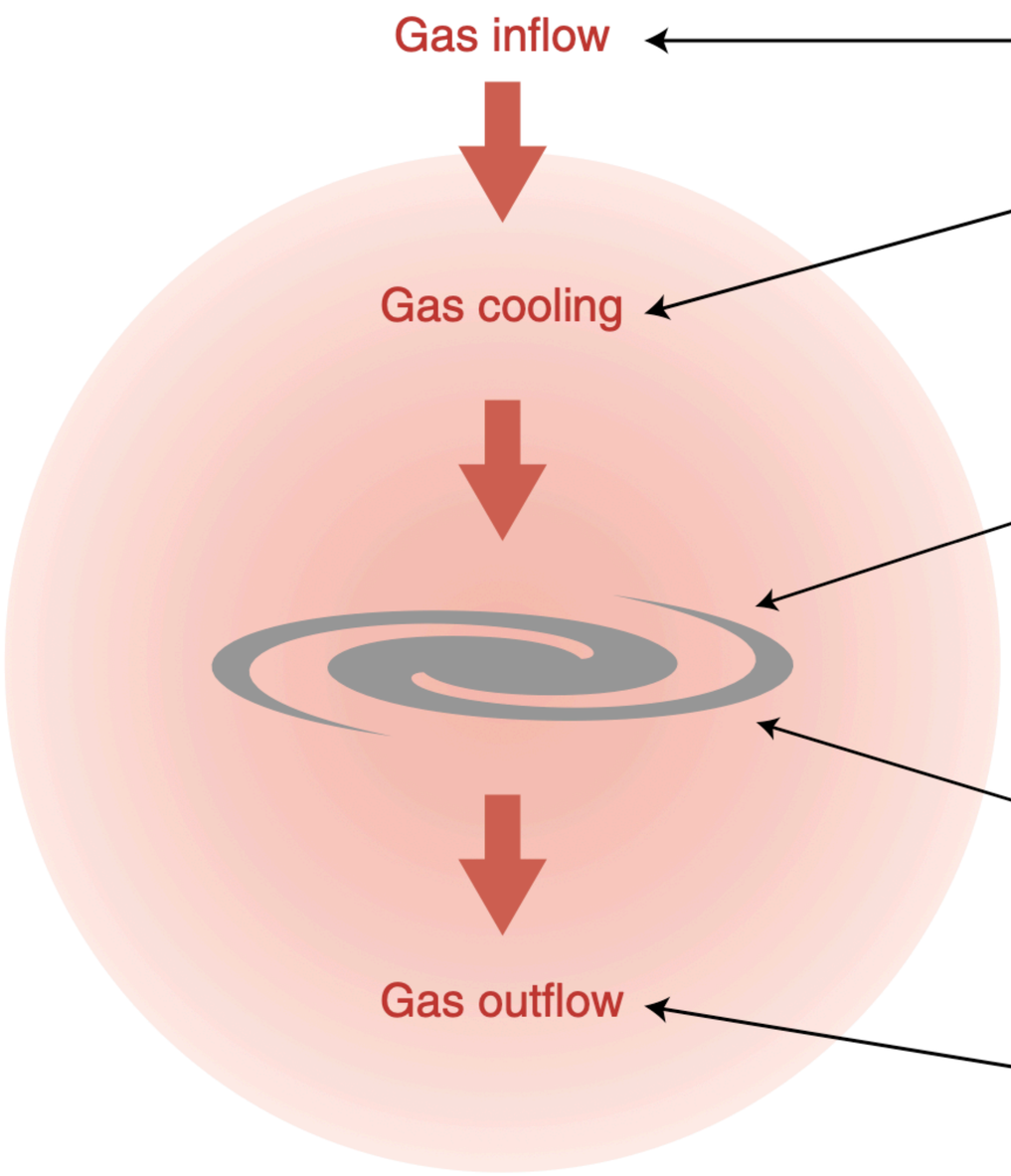

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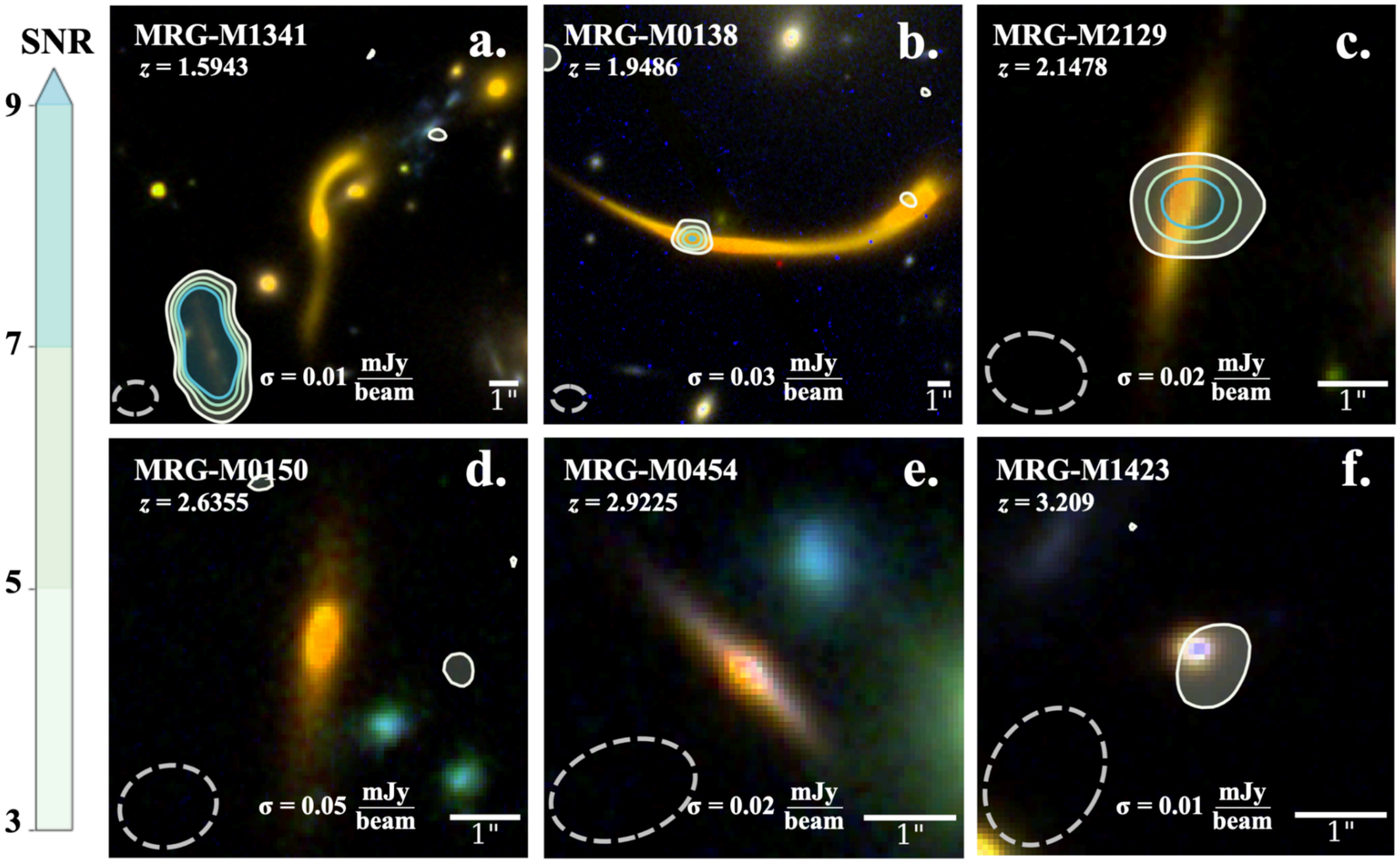
(v) **Gas is removed**
- AGN feedback

Man et.al 2018

REsolving **QUIE**scent **M**agnified (**REQUIEM**) galaxy survey



The photometry & spectroscopy

Hubble Space Telescope(HST)

Spitzer Space Telescope

The 1.3mm observations (dust):

Atacama Large Millimeter / submillimeter Array (ALMA)

Four of the six galaxies are **undetected** in dust emission.

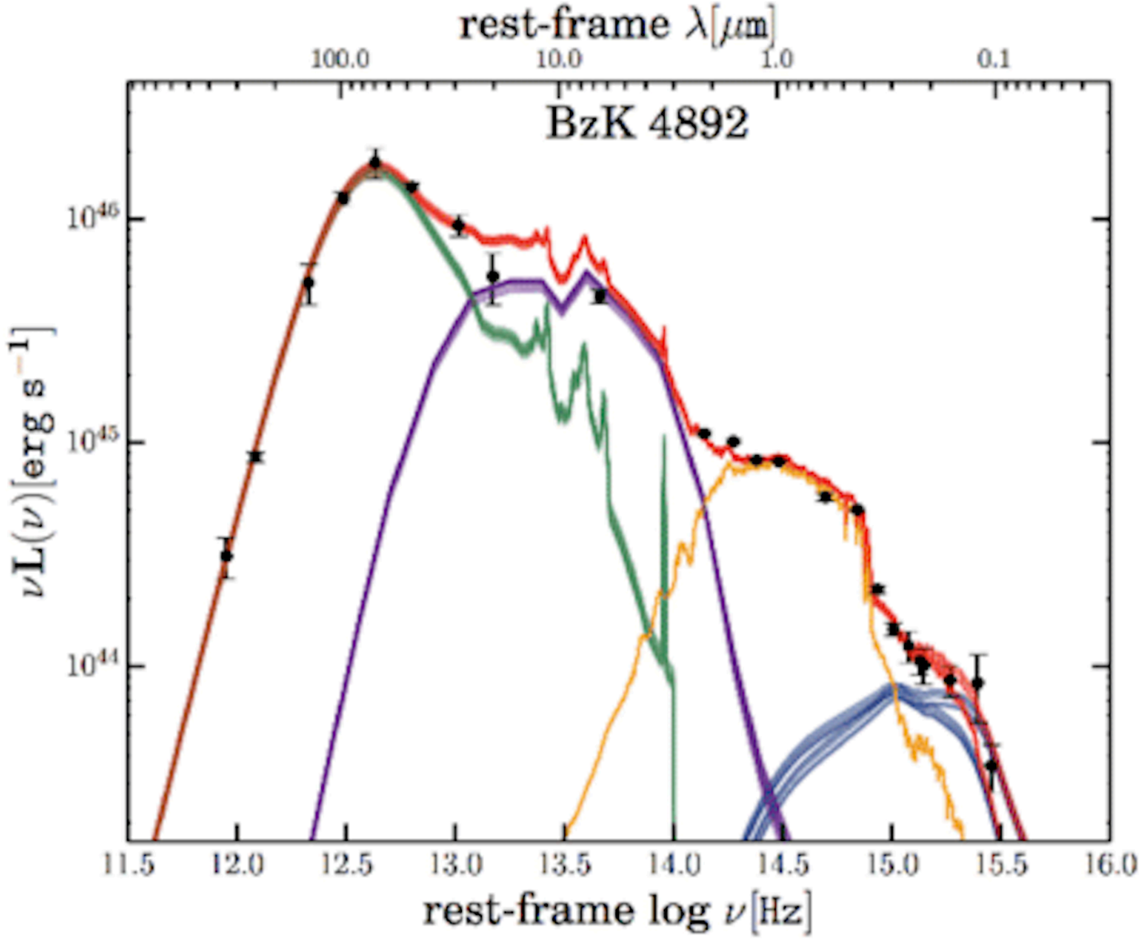
Methods — **SED fitting**

5 *HST* filters

2 *Spitzer Infrared Array Camera* filters

λ covers [1000Å ,1]

Spectral energy distribution (SED)

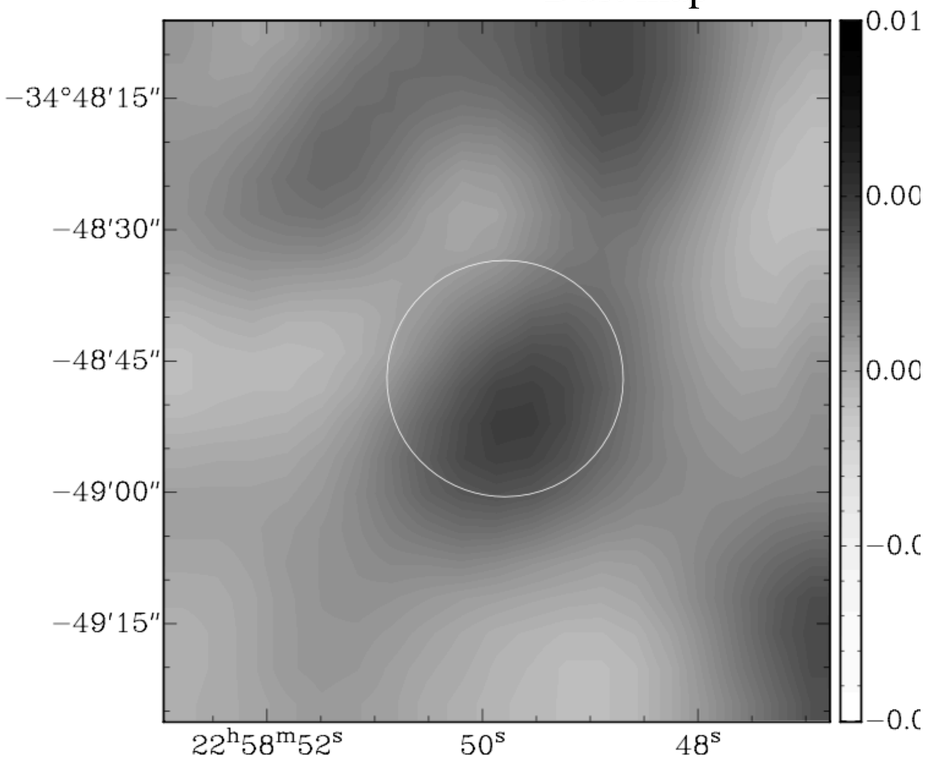


Perna et.al 2018

M_* & Star-formation rate

Methods — **molecular gas fraction**

Dust map



Johansson et.al 2018

detected galaxy

undetected galaxy:

magnification rms

(SNR) weighted stack

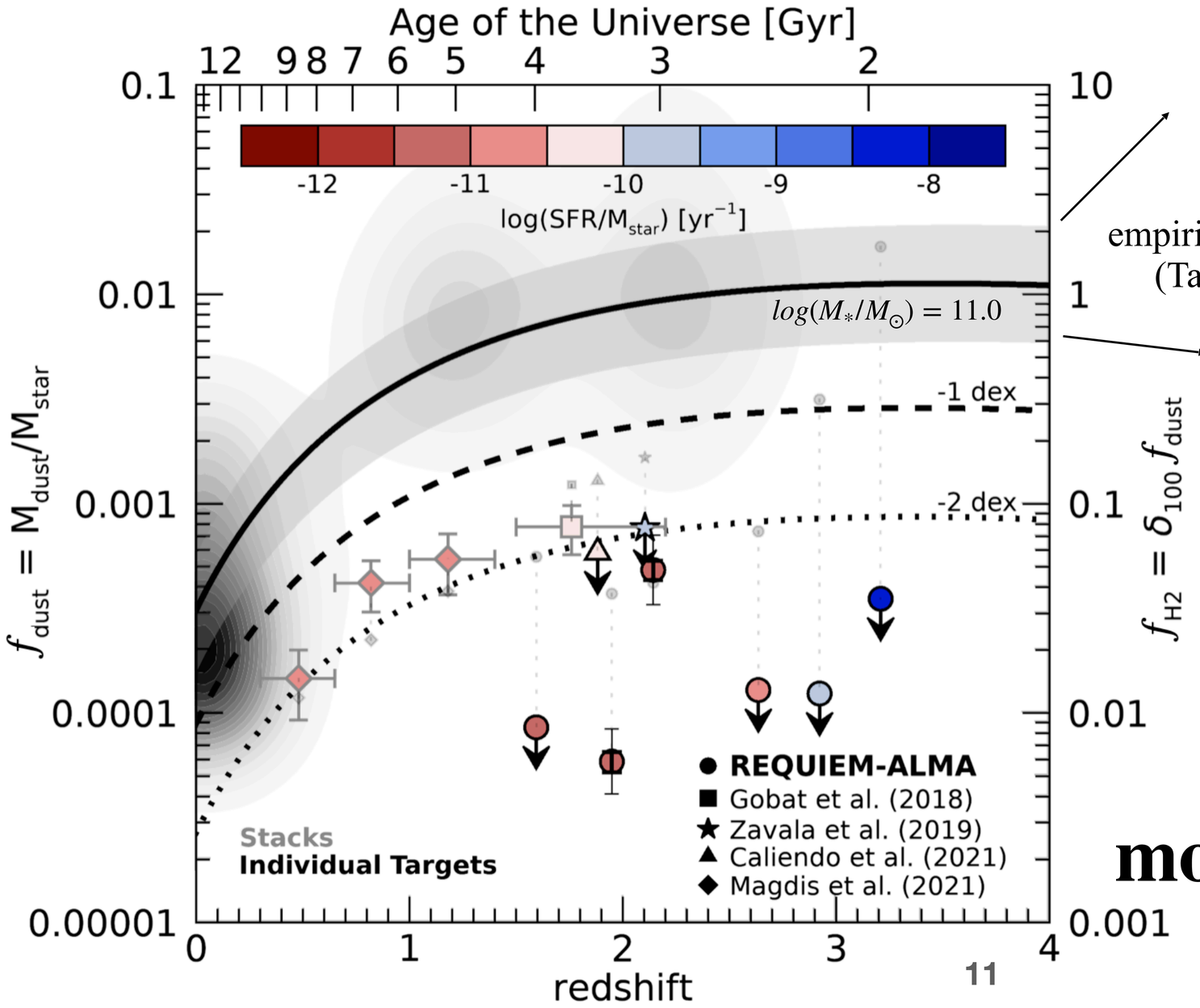
Blackbody fit

M_{dust}

Gas to dust ratio

M_{H_2}

Result — **low gas fraction**



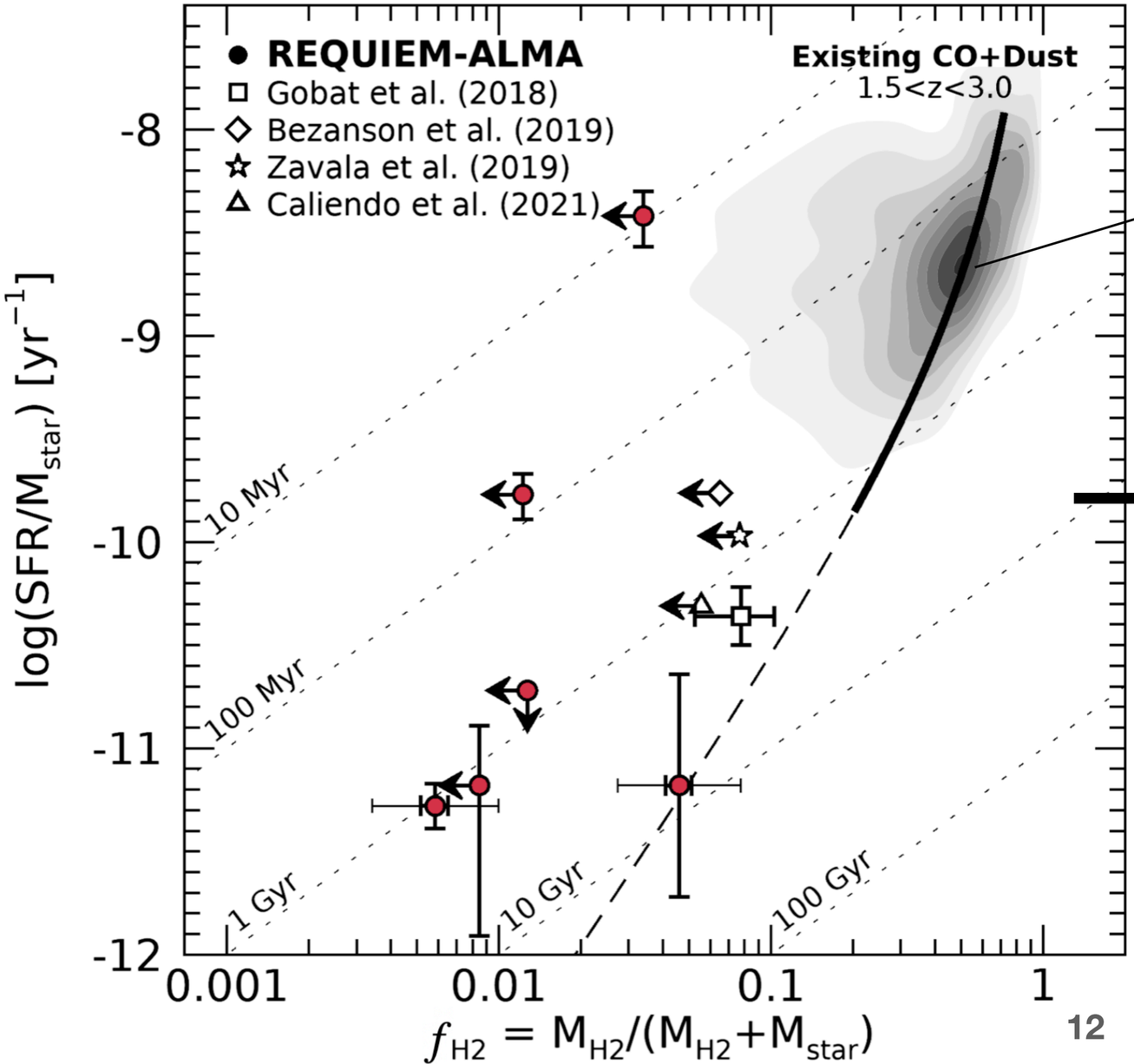
$log(M_*/M_\odot) = 10.1$

empirical scaling relations
(Tacconi et.al 2017)

$log(M_*/M_\odot) = 11.7$

It puts constraints on models of galaxy evolution.

Result — **low gas fraction**



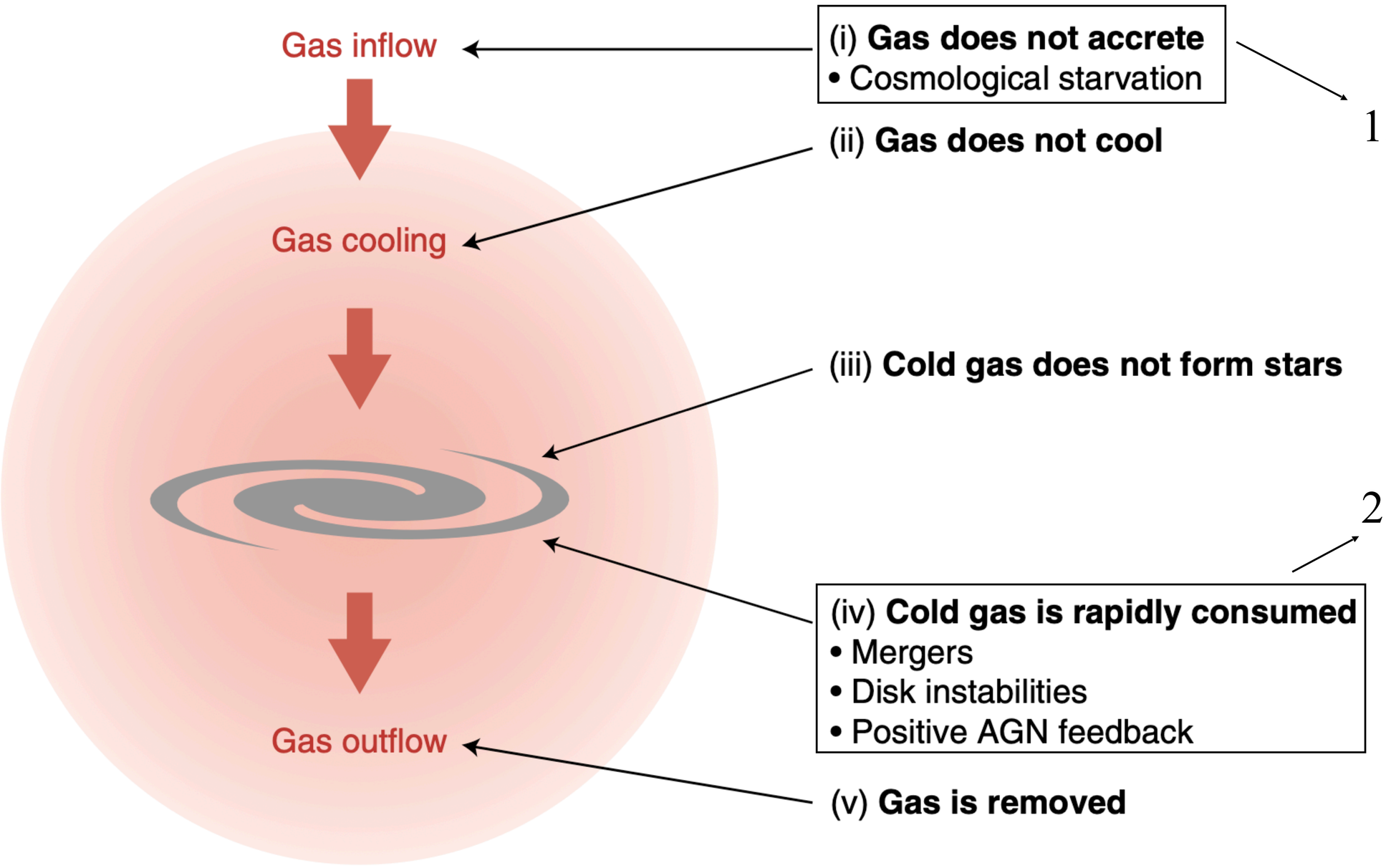
Star formation galaxies

Gas depletion time = $\frac{M_{gas}}{SFR}$

gas depletion time ~ 1Gyr

—rapid gas depletion

Physical possible explanations



1. The cold interstellar medium was already **rapidly depleted** at high redshift in at least some galaxies, not slowly consumed until the present day.
2. The process which effectively **blocks** the **replenishment** of the cold gas reservoirs also occurs at the high redshift.

Conclusion

1. Six strongly lensed and **quenched** galaxies have **two orders** of magnitude **less molecular gas** than that seen in typical galaxies at similar **high redshifts.**
2. It puts **constraints** on models of galaxy evolution.

Physical possible explanations:

3. The cold interstellar medium was already **rapidly depleted** at high redshift in at least some galaxies, not slowly consumed until the present day.
4. The process which effectively **blocks** the **replenishment** of the cold gas reservoirs also occurs at the high redshift.

Comments

1. These samples are too small. It is difficult to give effective constraints for galaxy evolution model.

2. The feasibility of using dust as a proxy for the interstellar medium in massive galaxies with star-formation rates must be further investigated.

3. Model parameters for low redshift may not be applicable at high redshift, such as gas-to-dust ratio, dust temperature and so on.

Questions

- Which quenching mechanism is most important at low redshift, or at high redshift?
- Why didn't they directly measure the gas fraction by CO emission?
- Which process effectively blocks the replenishment?
- How did they find quenched galaxies at high redshift with so little gas?
- Why do they use the strongly lensed galaxy?