How does the ISM* evolve in passive galaxies?

Krzysztof Lisiecki under supervision of Darko Donevski

*ISM – interstellar medium, matter between the stars

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Plan

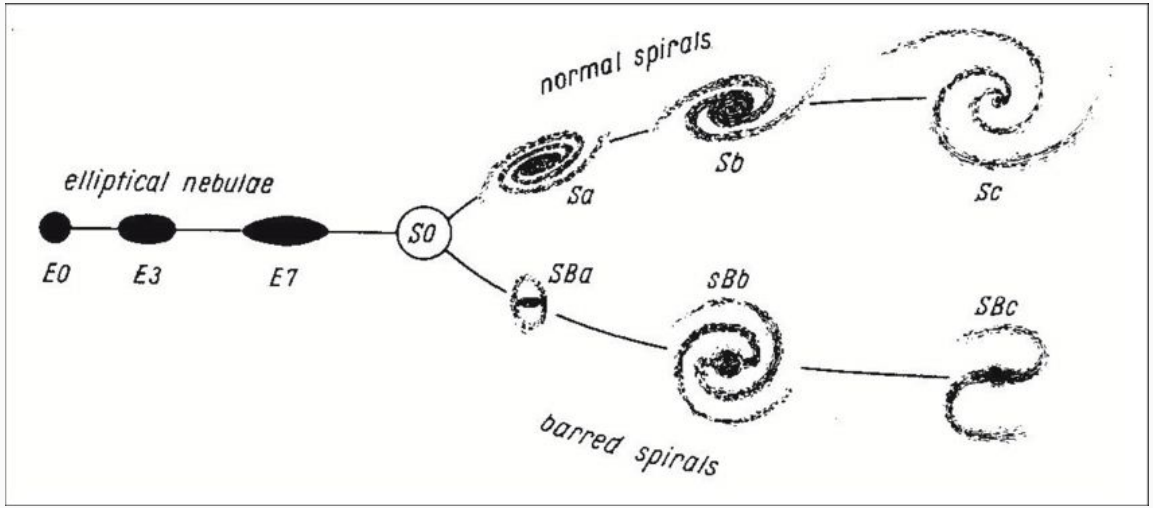
- Introduction
  - How do we see galaxies?
  - What do we know about them?
- Scientific problem
  - Which galaxy properties do we miss?
  - What can we improve?
- Our attempt to the problem
  - Theoretical framework – cosmological simulation
  - Observation with space telescopes
- Summary
  - Results so far
  - Future goals

How do we see galaxies?

History of galaxies

In 1926 Hubble published his diagram of galaxy types called Hubble sequence or tuning-fork diagram.

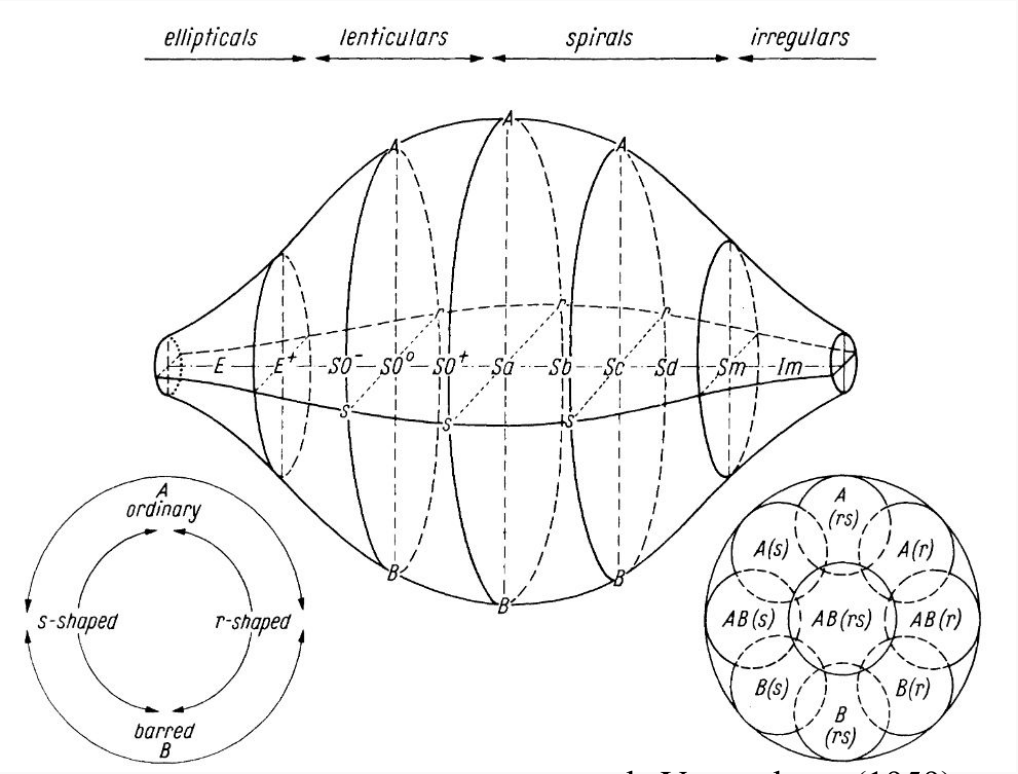
It was only a few years after we realized that galaxies are not part of Milky Way!



www.researchgate.net

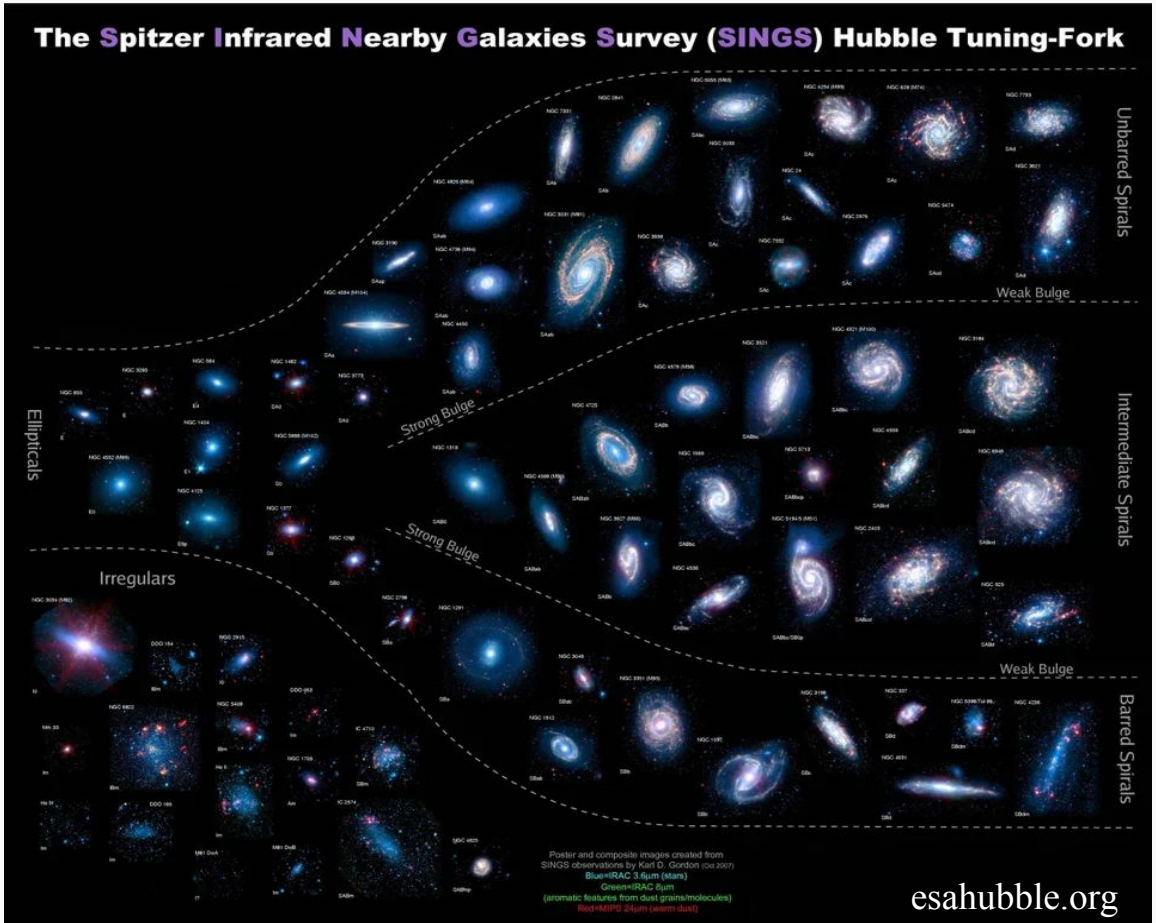
Not only Hubble's fork

Since then, we know that the Universe is a bit more complicated than Hubble's picture. In 1959 De Vaucoulers published his lemon-shape model…



de Vaucouleurs (1959)

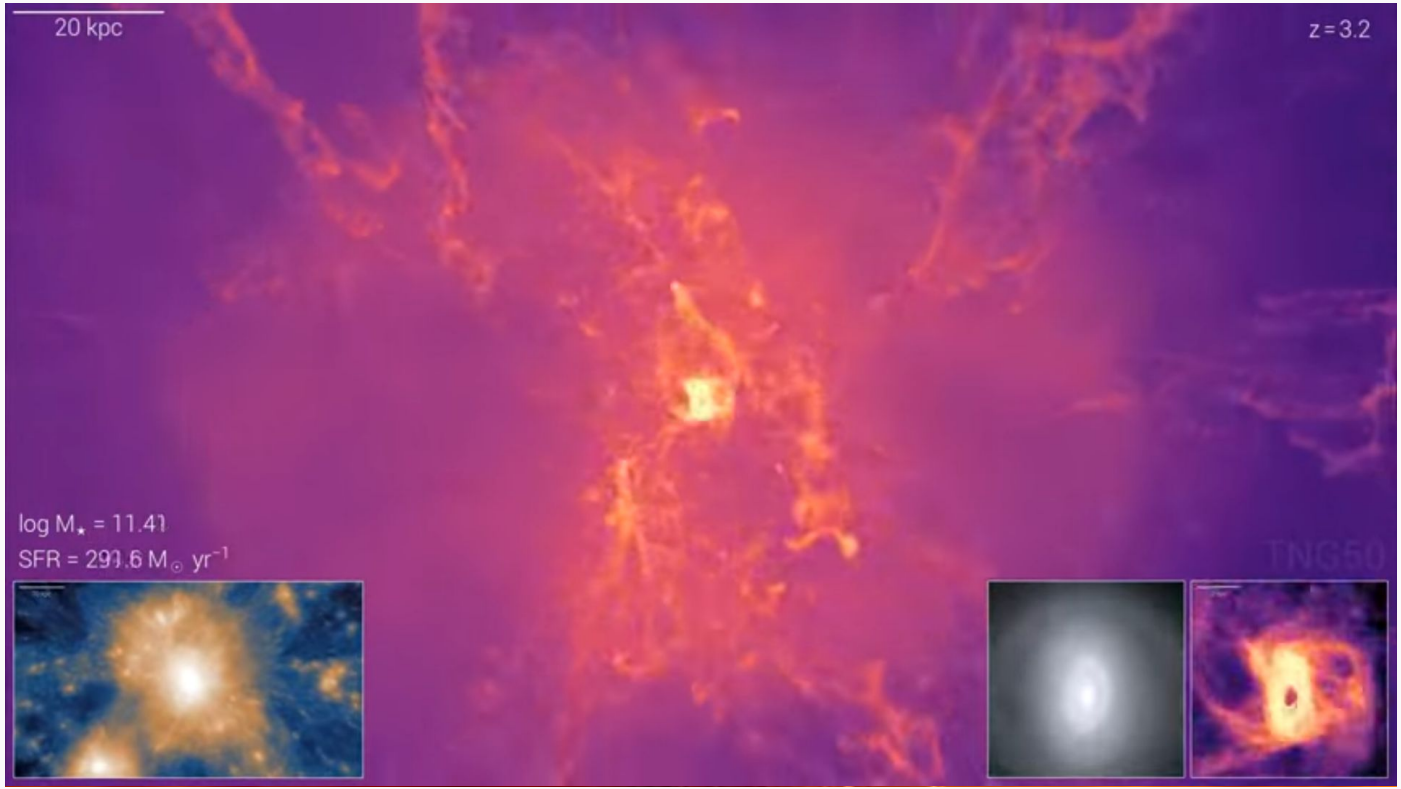
But mostly Hubble's fork…



Color bimodality

What's important, the shape of the galaxy is often correlated with other observational and physical properties!

Early-type galaxies tend to be more red and rather passive, quiescent!



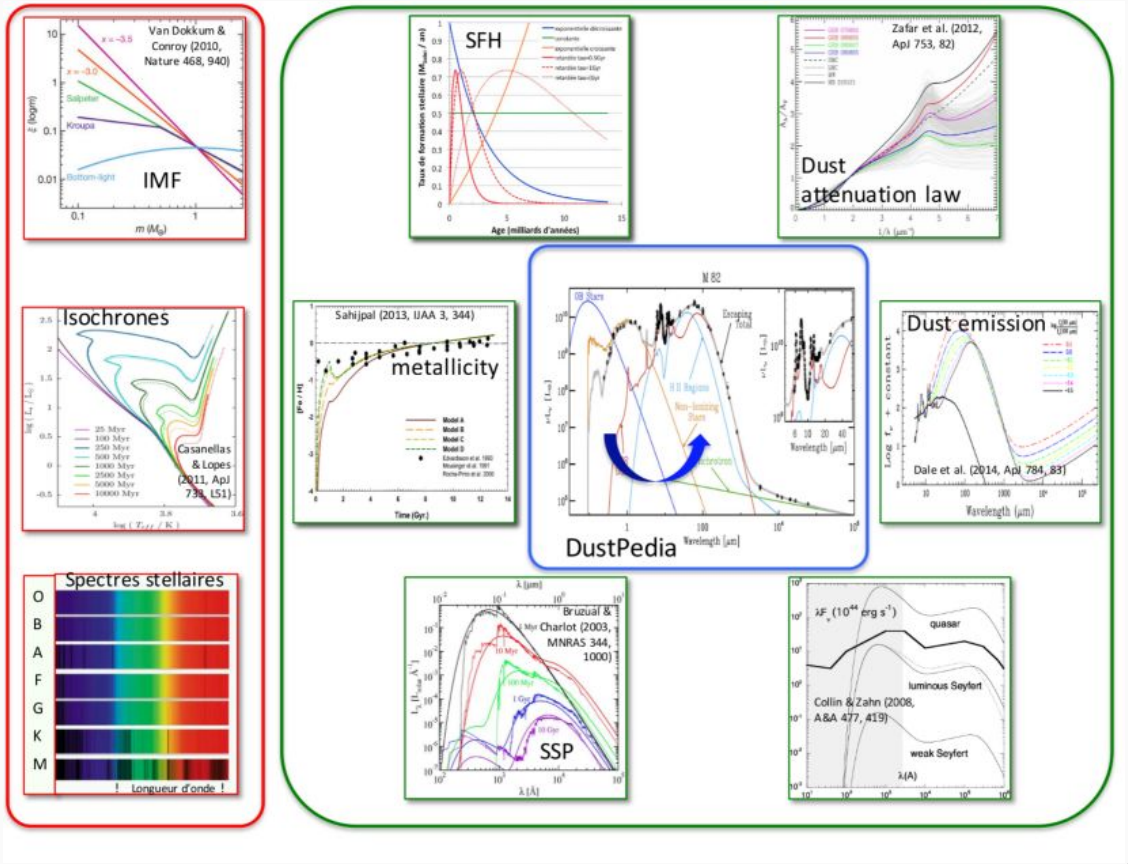
www.tng-project.org/media/

What do we know about galaxies?

Galaxy properties in a nutshell

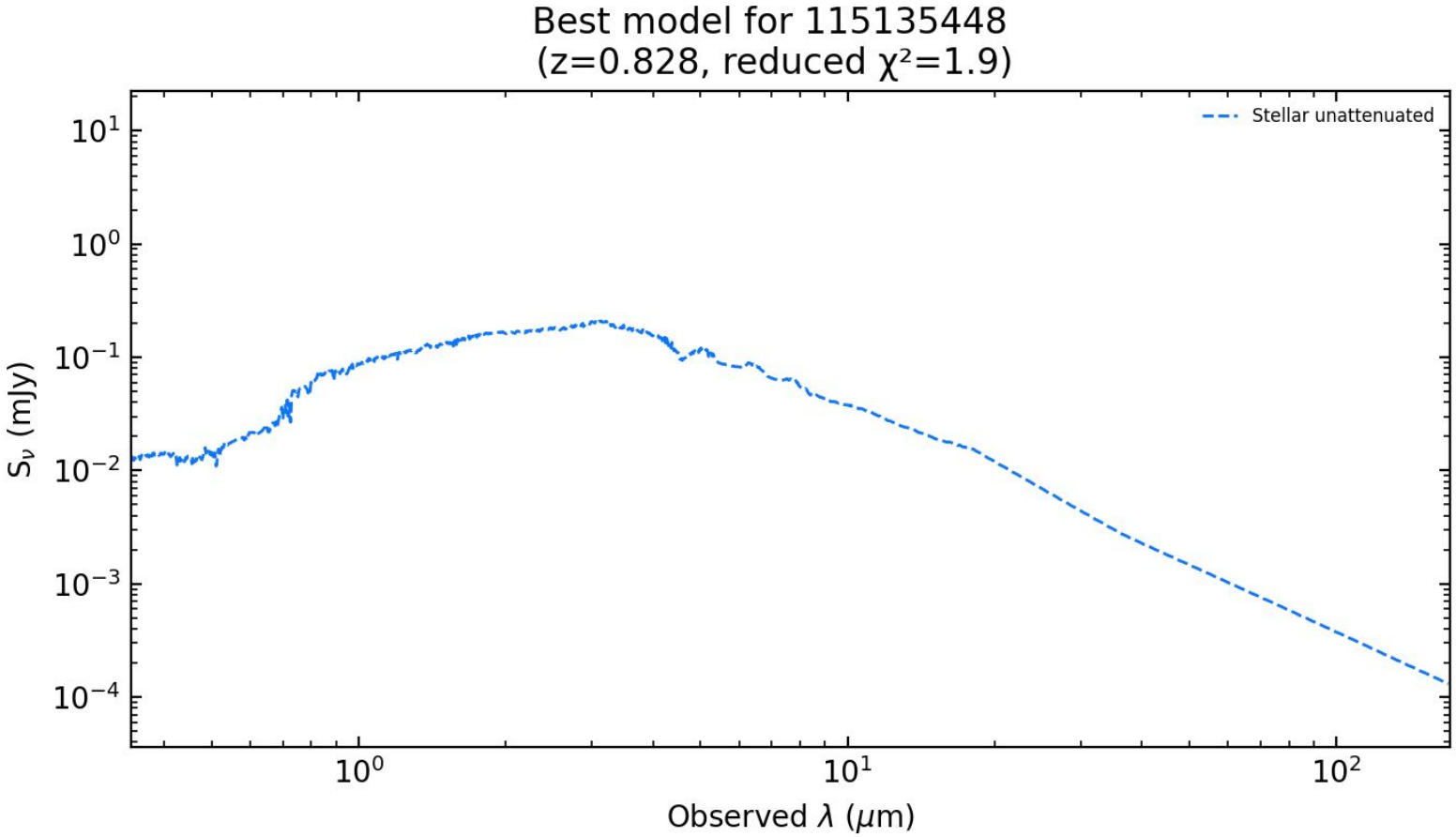
Galaxies are complex, dynamically changing system, driven by various processes.

All of the components are heavily studied and modeled, and all of them influence the final look of the galaxy!

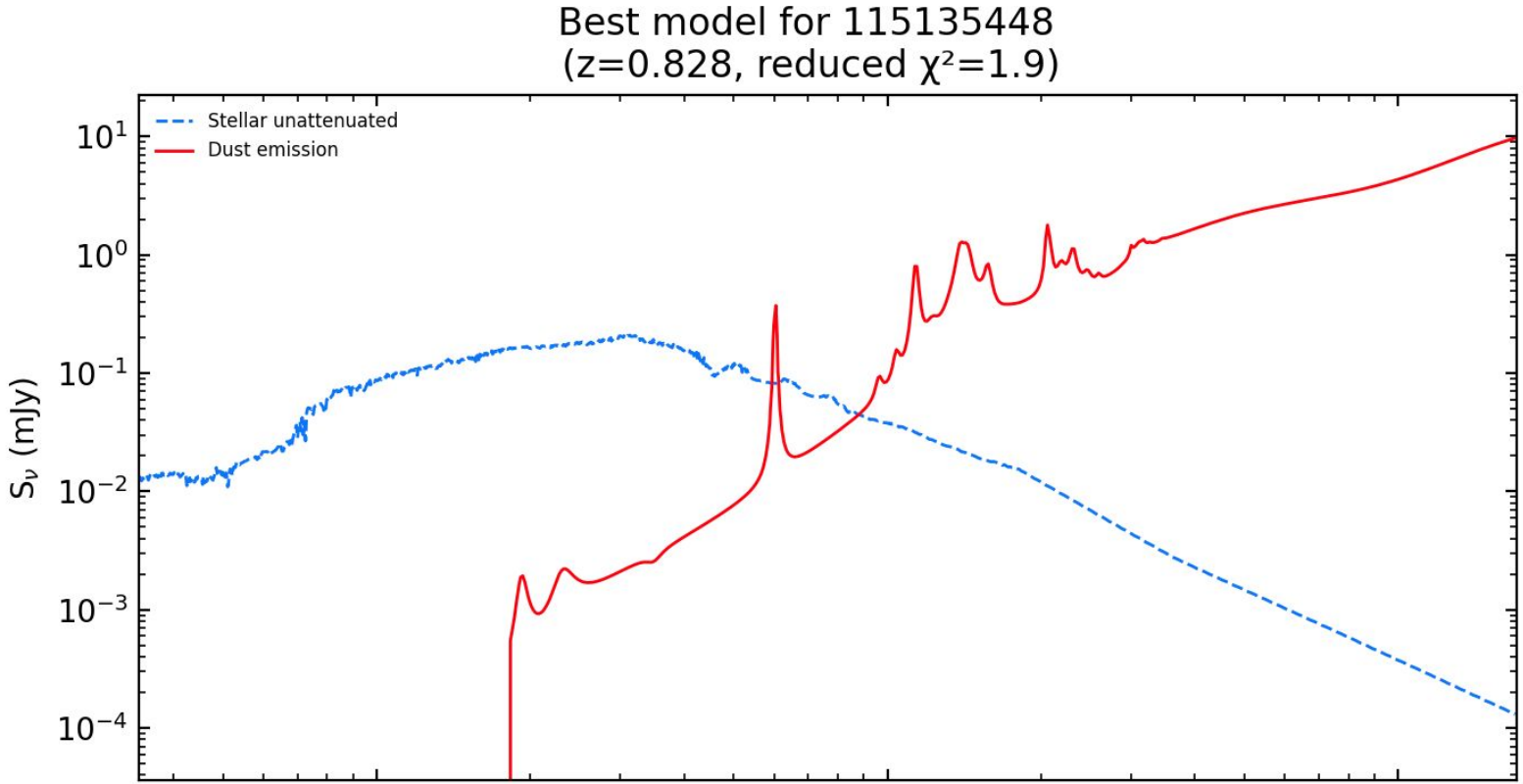


Boquien et al. 2019

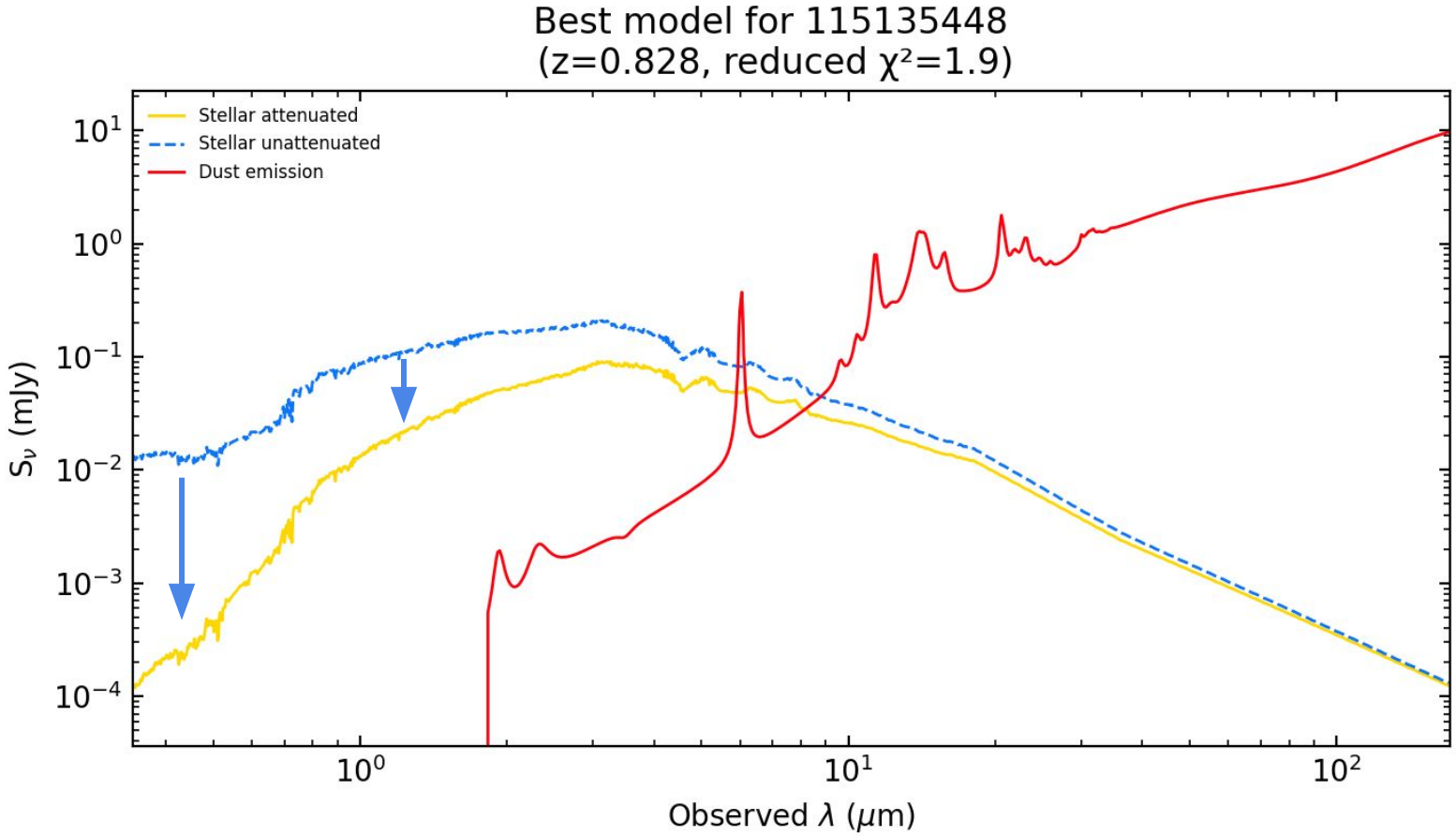
Let’s build a galaxy! Stars



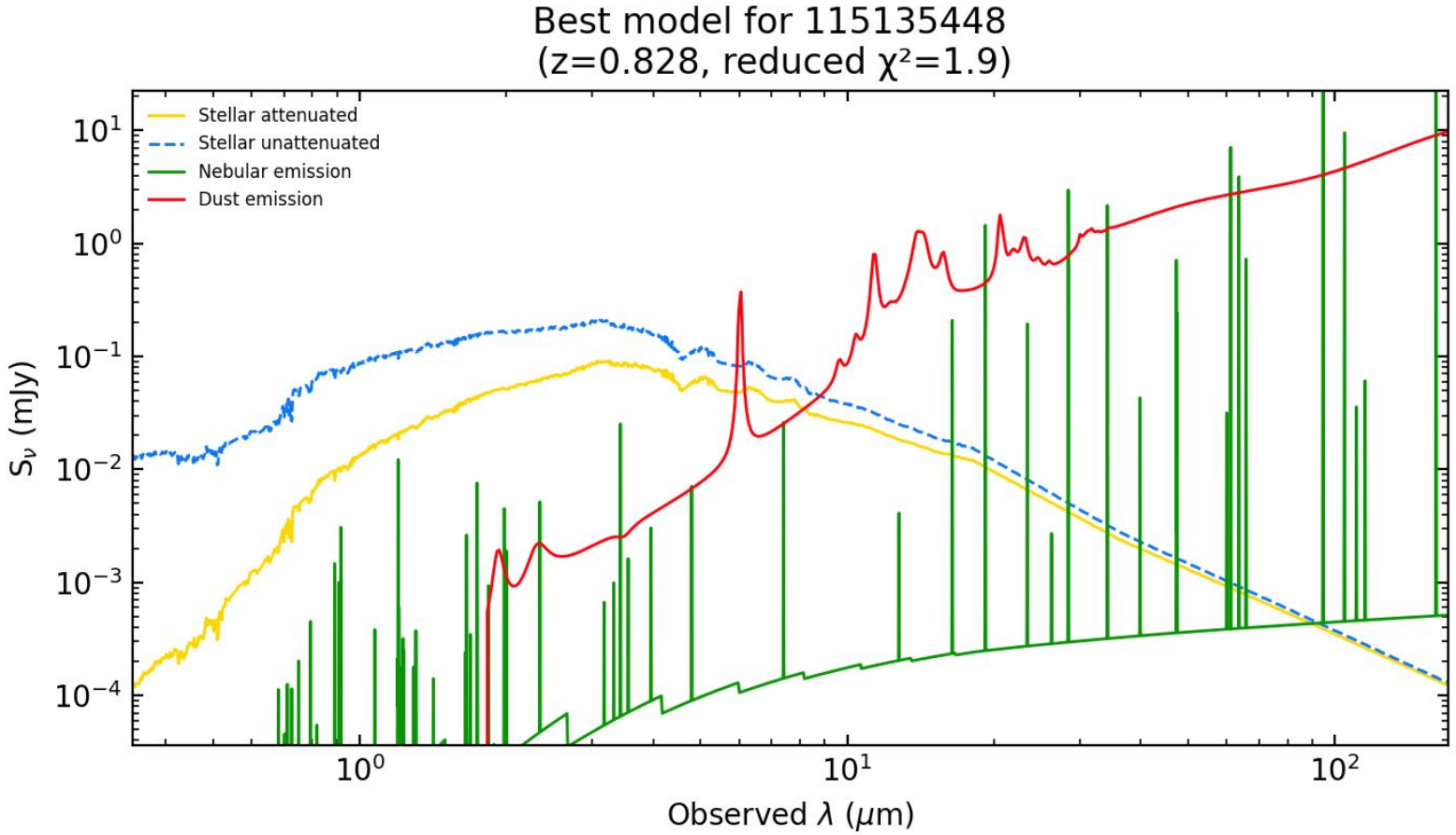
Let’s build a galaxy! Dust



Let’s build a galaxy! Dust – light interraction



Let's build a galaxy! Other components



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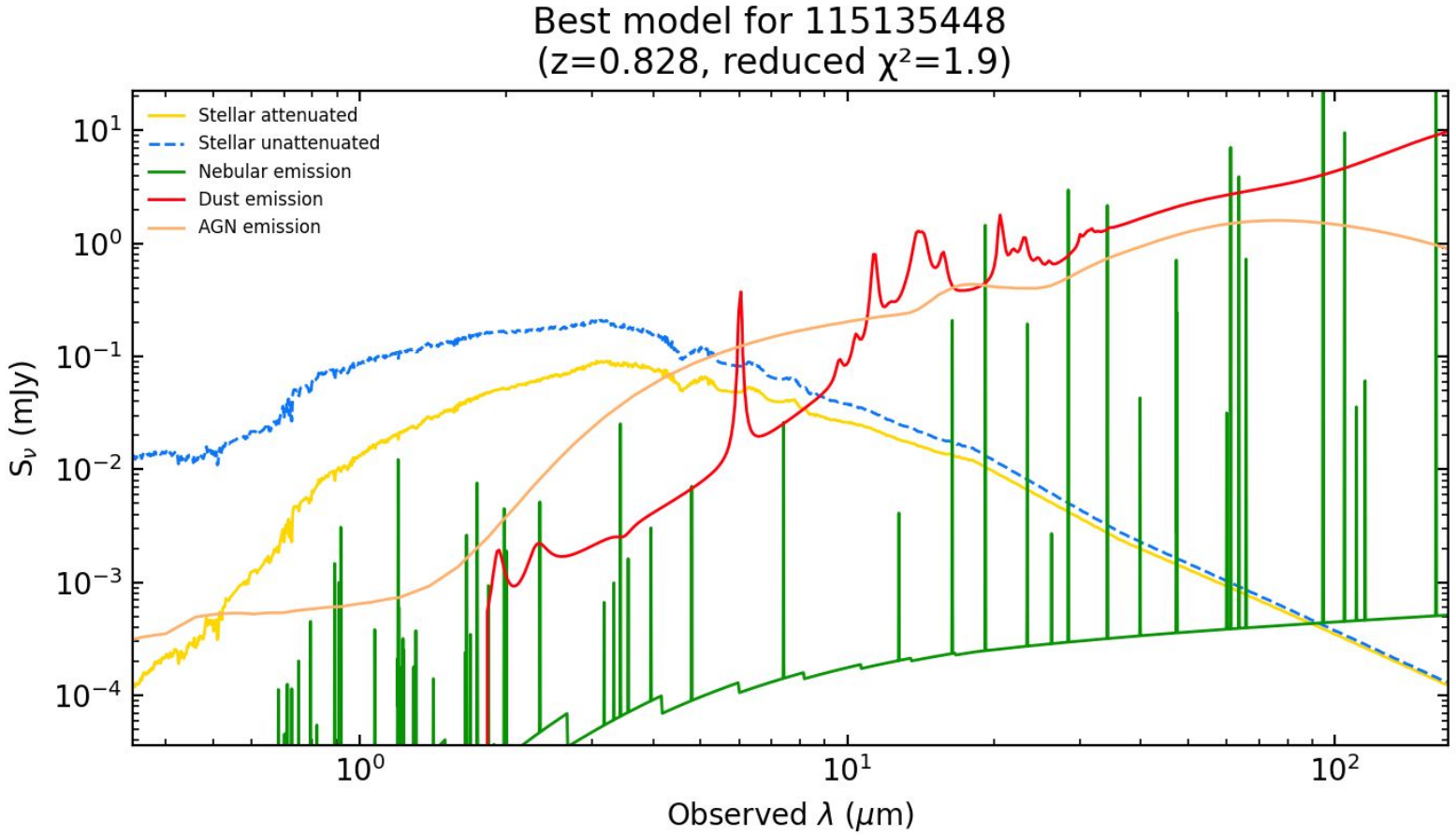
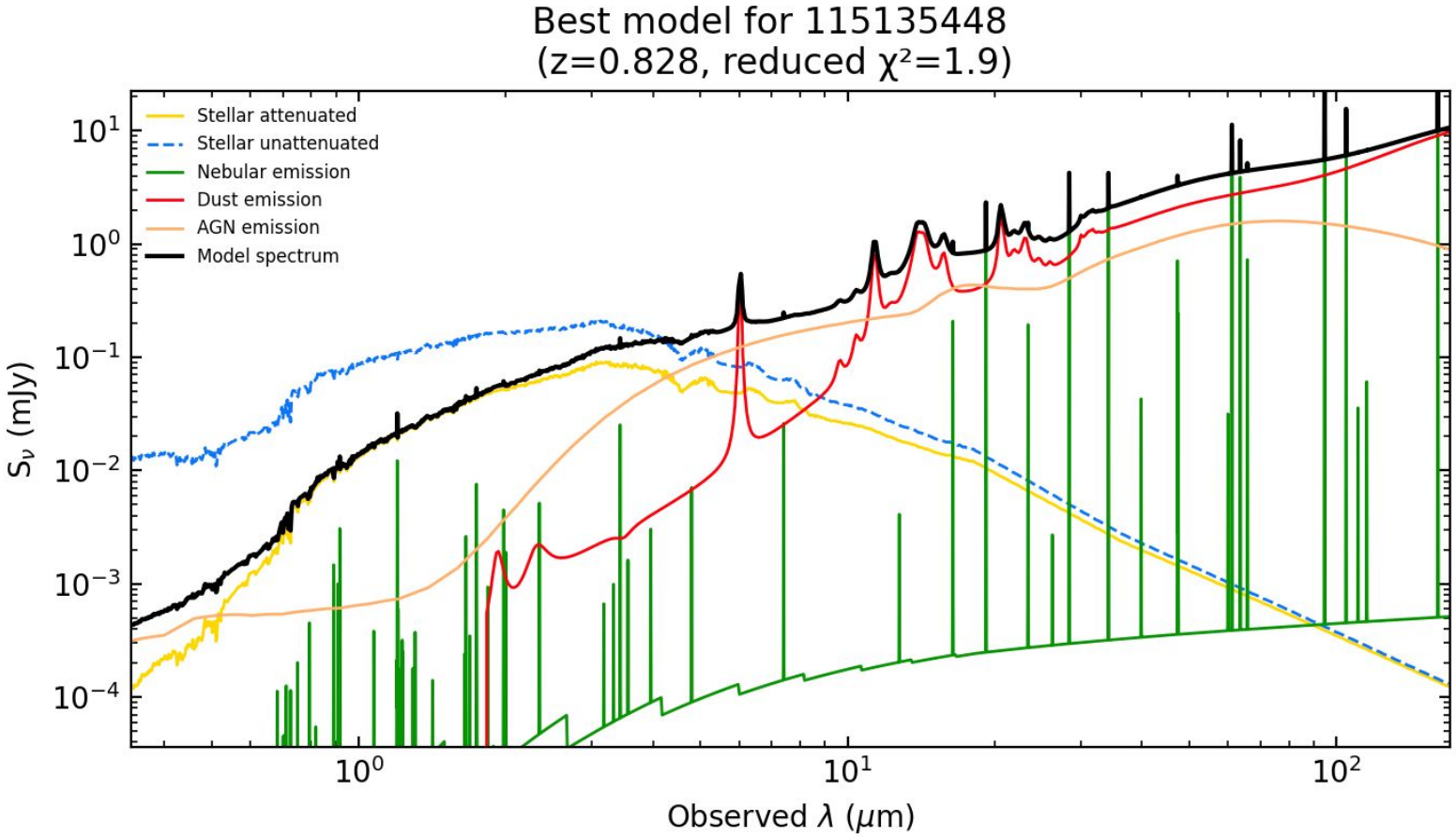
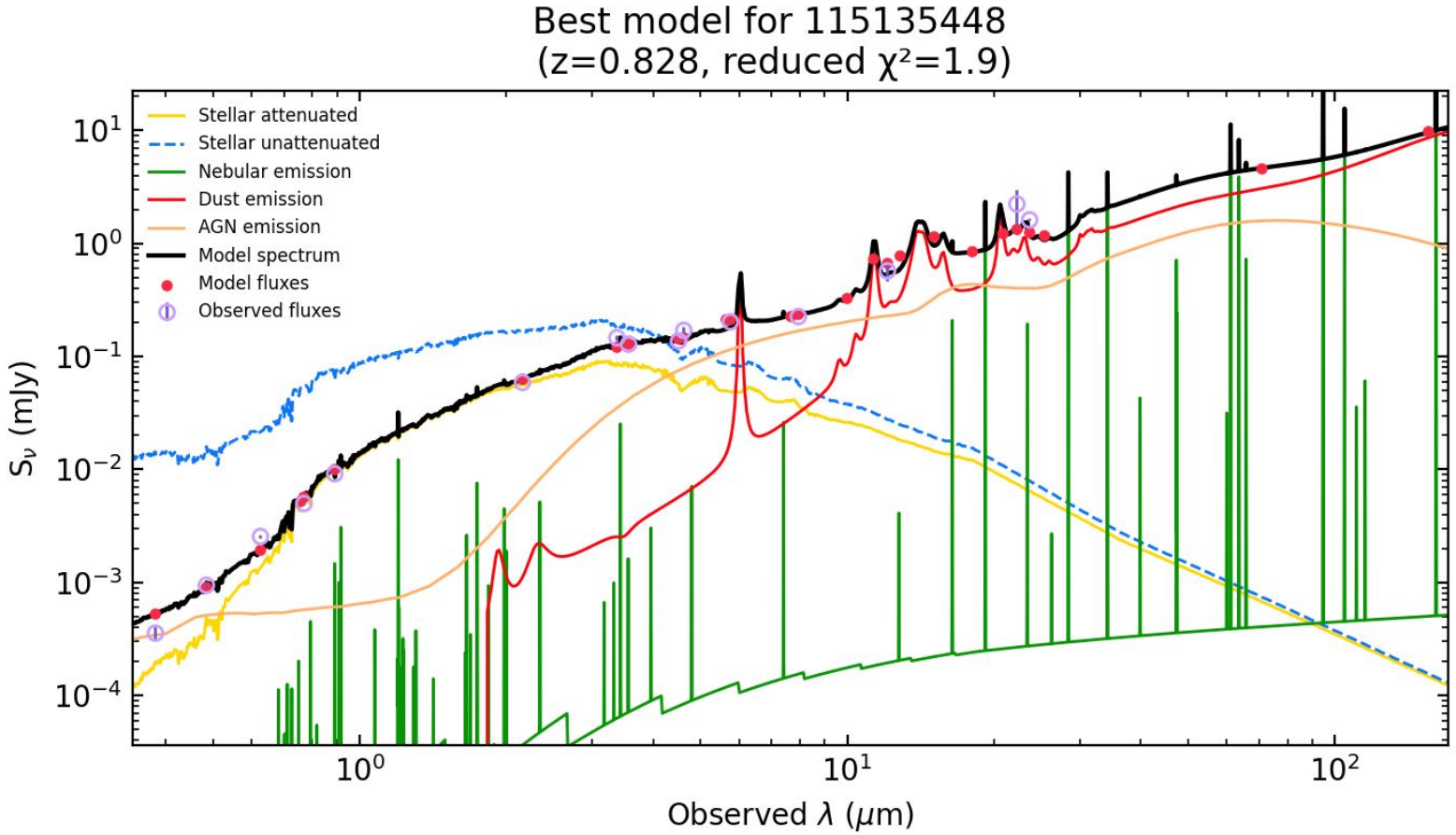


Let's build a galaxy! Full model

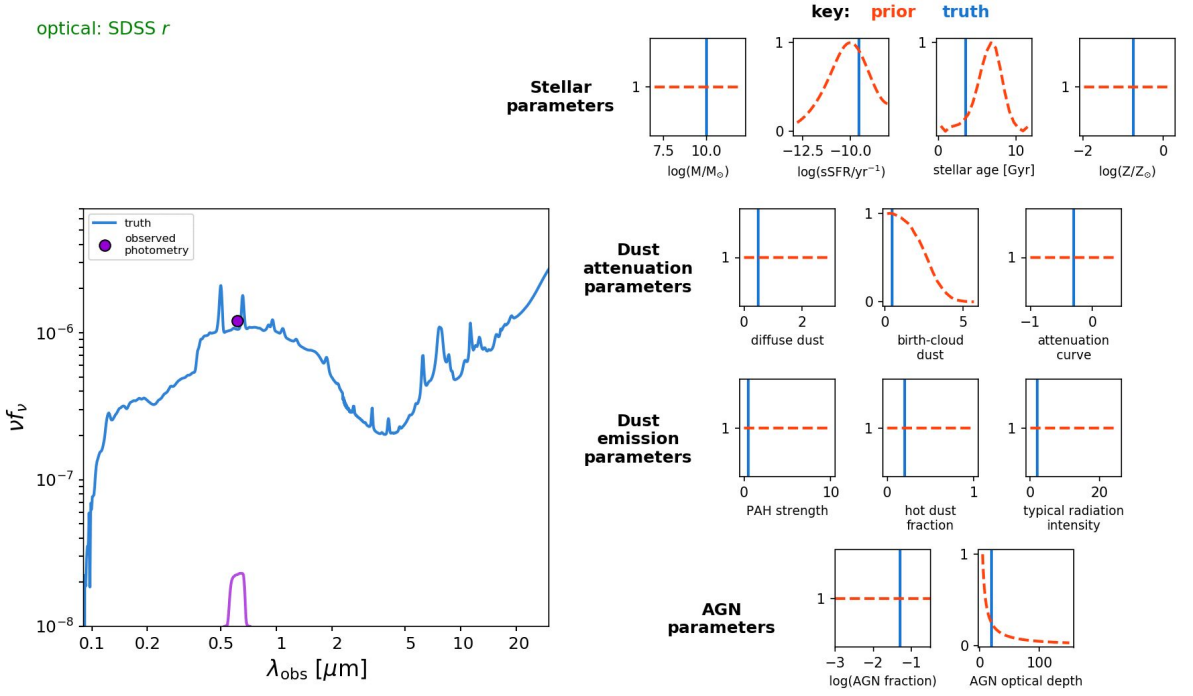


Let's build a galaxy! Compare with observations



Spectral energy distribution

To obtain all physical properties of a galaxy, we need to combine many observations and fit the best model!



github.com/bd-j/prospector

Star-formation rate and main sequence

Years of studies led to a conclusion that there is a relation between stellar mass of a galaxy and its star-formation rate.

astrobites.org

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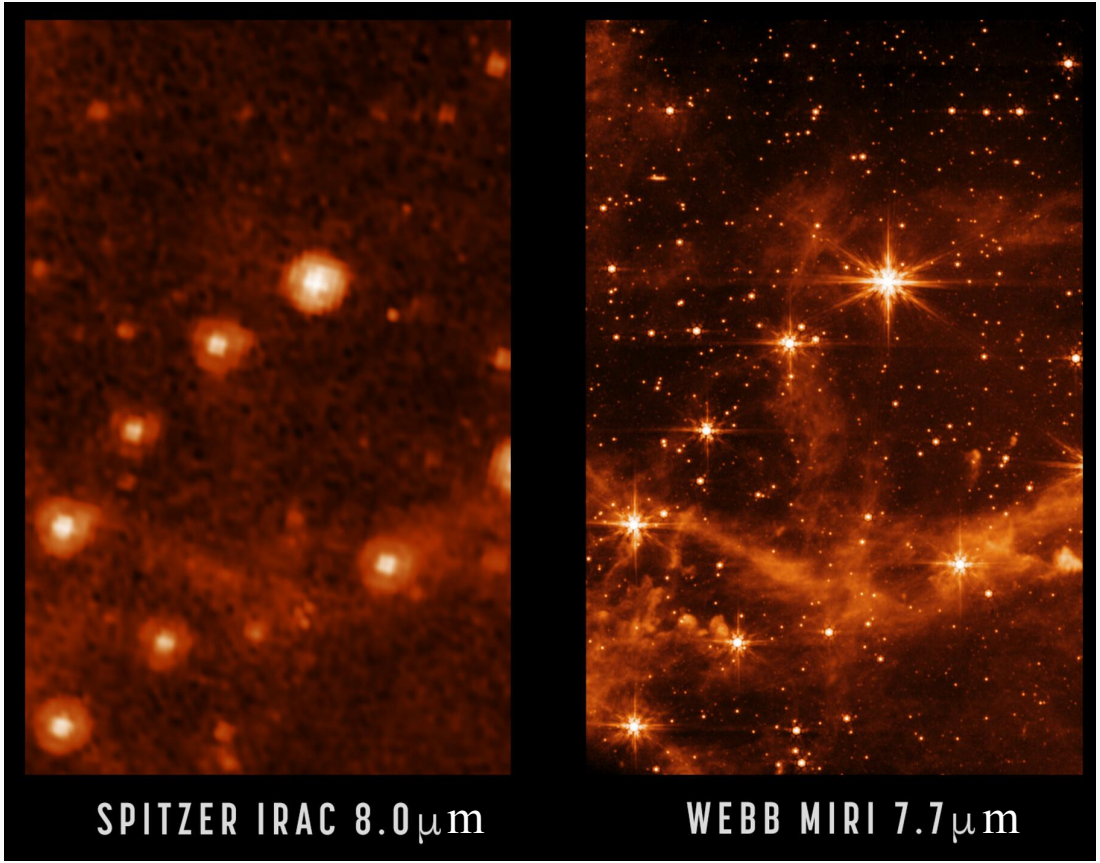
astrobites.org

Main problem

How does the ISM of quiescent galaxies evolves over cosmic time?

Source of the problem

Dust, cold gas and metallicity are extremely difficult to observe and measure, even with Hubble Space Telescope (HST), Atacama Large Millimeter Array (ALMA), or any other modern facility (Whitaker et al. 2021, Lee et al. 2023, Donevski et al. 2023).

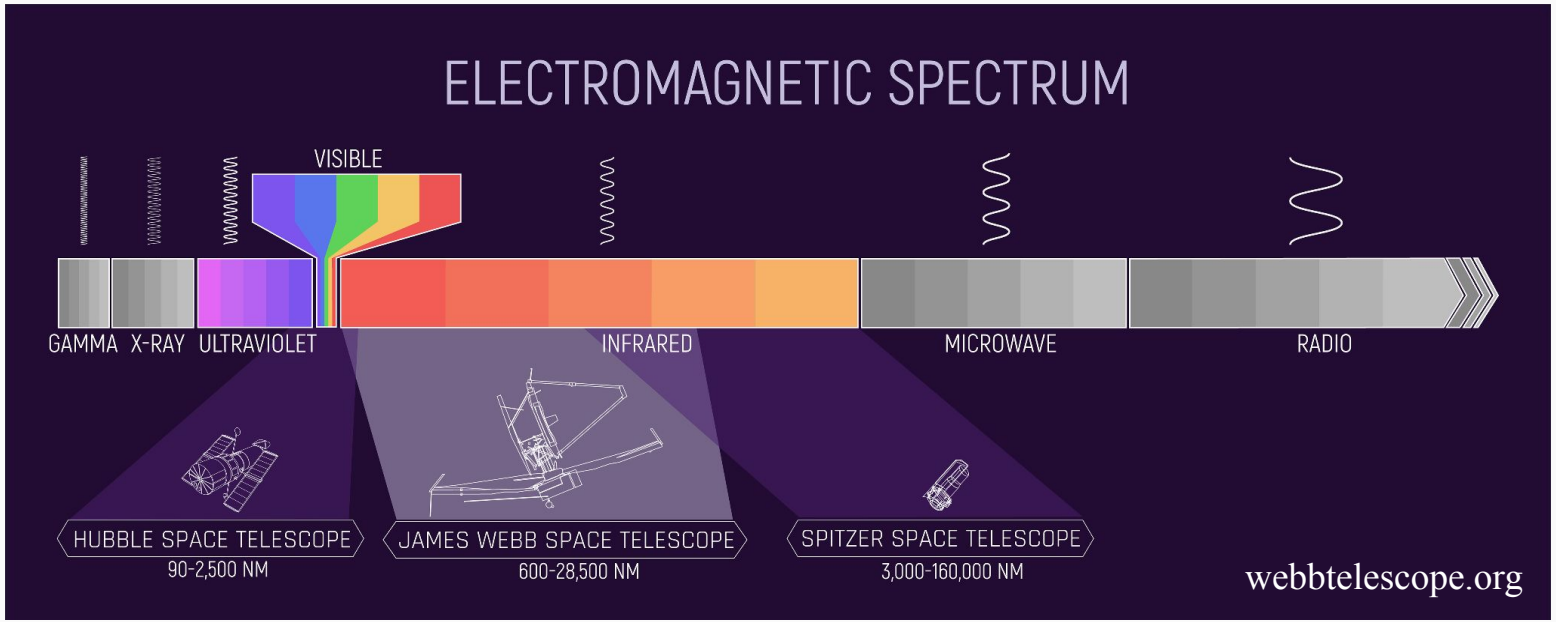


esawebb.org

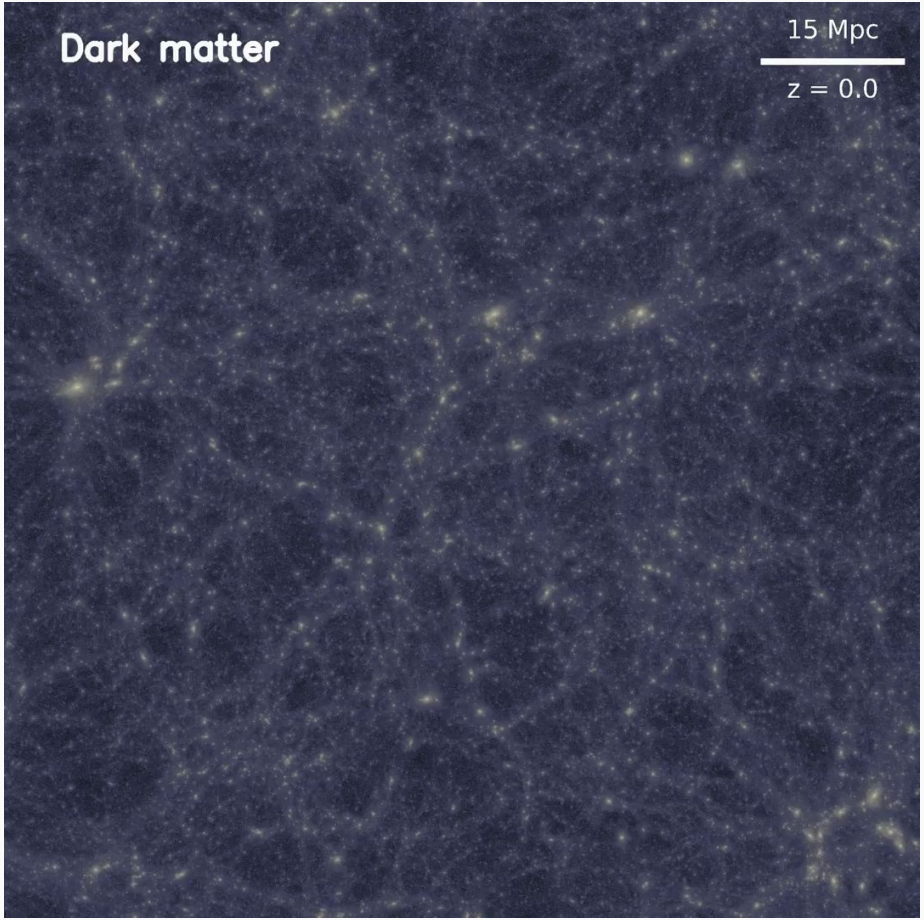
What can we improve? Observations!

Our current knowledge of this topic is limited due to the observed resolution. So far, late stages of evolution of quiescent galaxies has been determined from stellar mass-size properties.

Now we can study them directly!



What can we improve? Simulations!

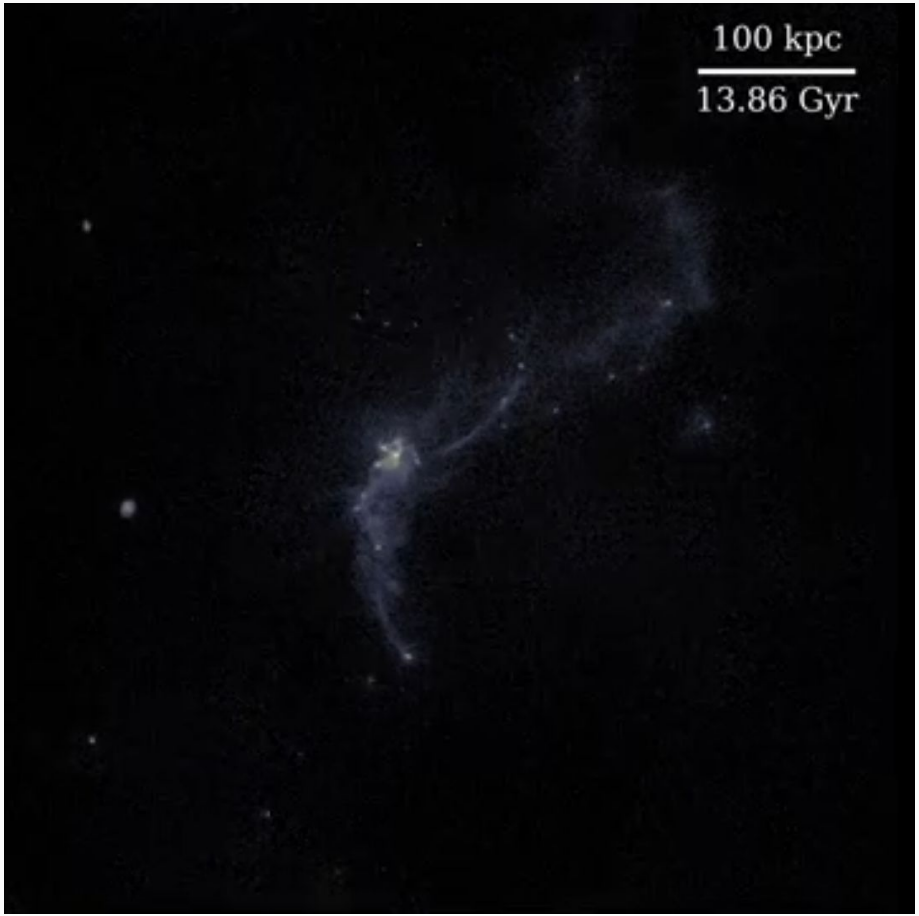


Credits: me

Developing theoretical framework

Best suited simulation for this problem!

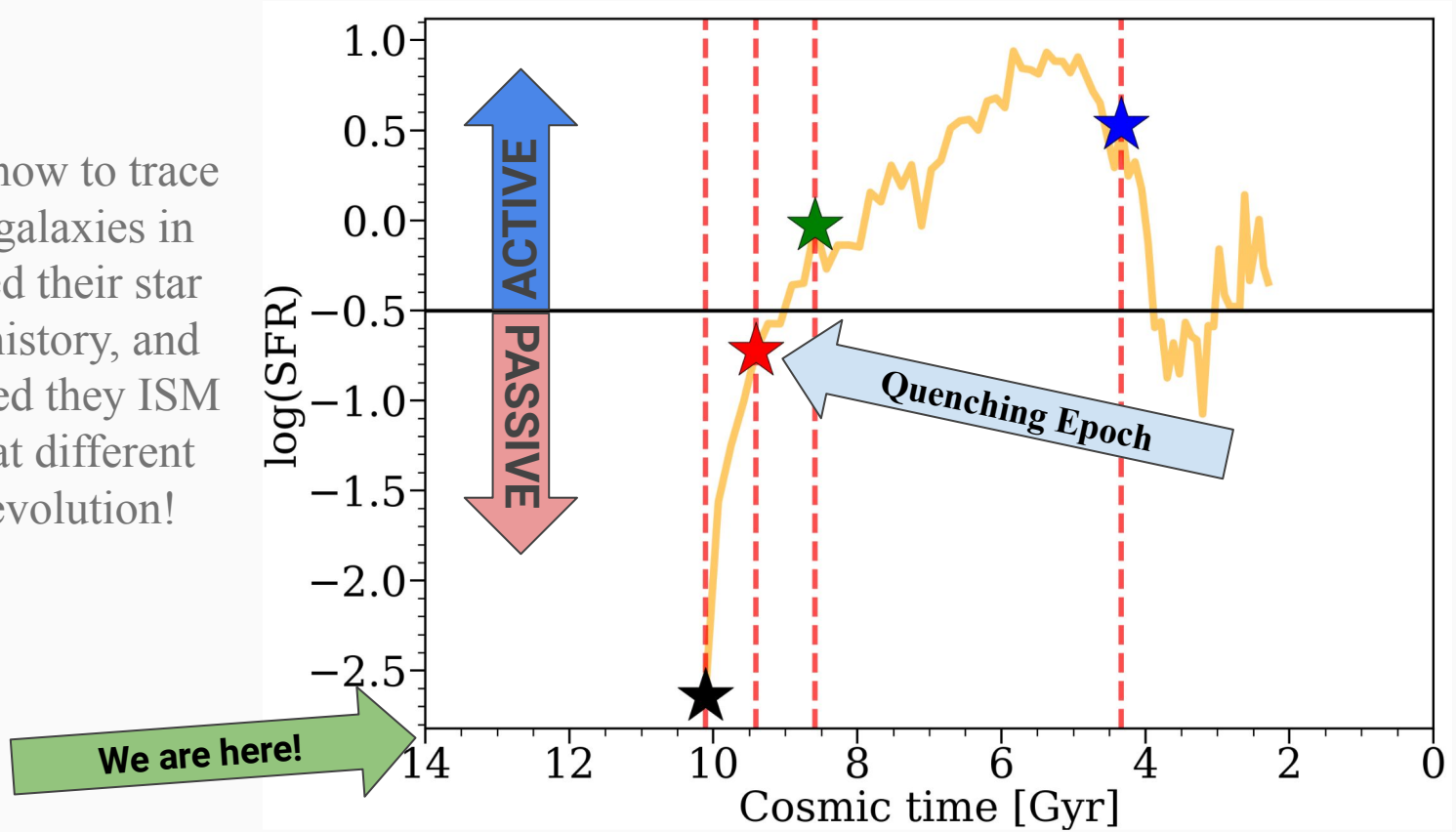
SIMBA is a large-scale (100 Mpc^3/h) cosmological simulation. It is one of the few simulations that focuses on dust production, destruction through the calculations!



Credits: me

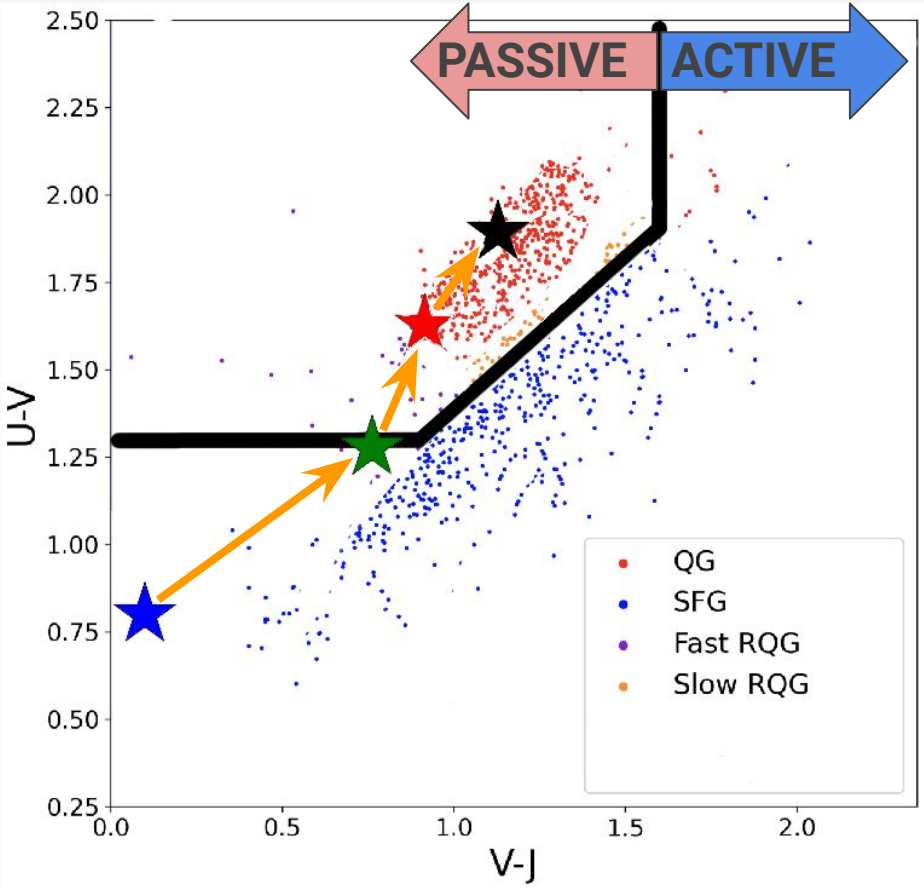
Dive into SIMBA

We learned how to trace individual galaxies in time, studied their star formation history, and finally studied they ISM properties at different stages of evolution!



Simulation to observation

Using those point we can prepare predictions for the observational study, for example study how bright would those galaxies be in the state-of-the-art observatories like JWST!

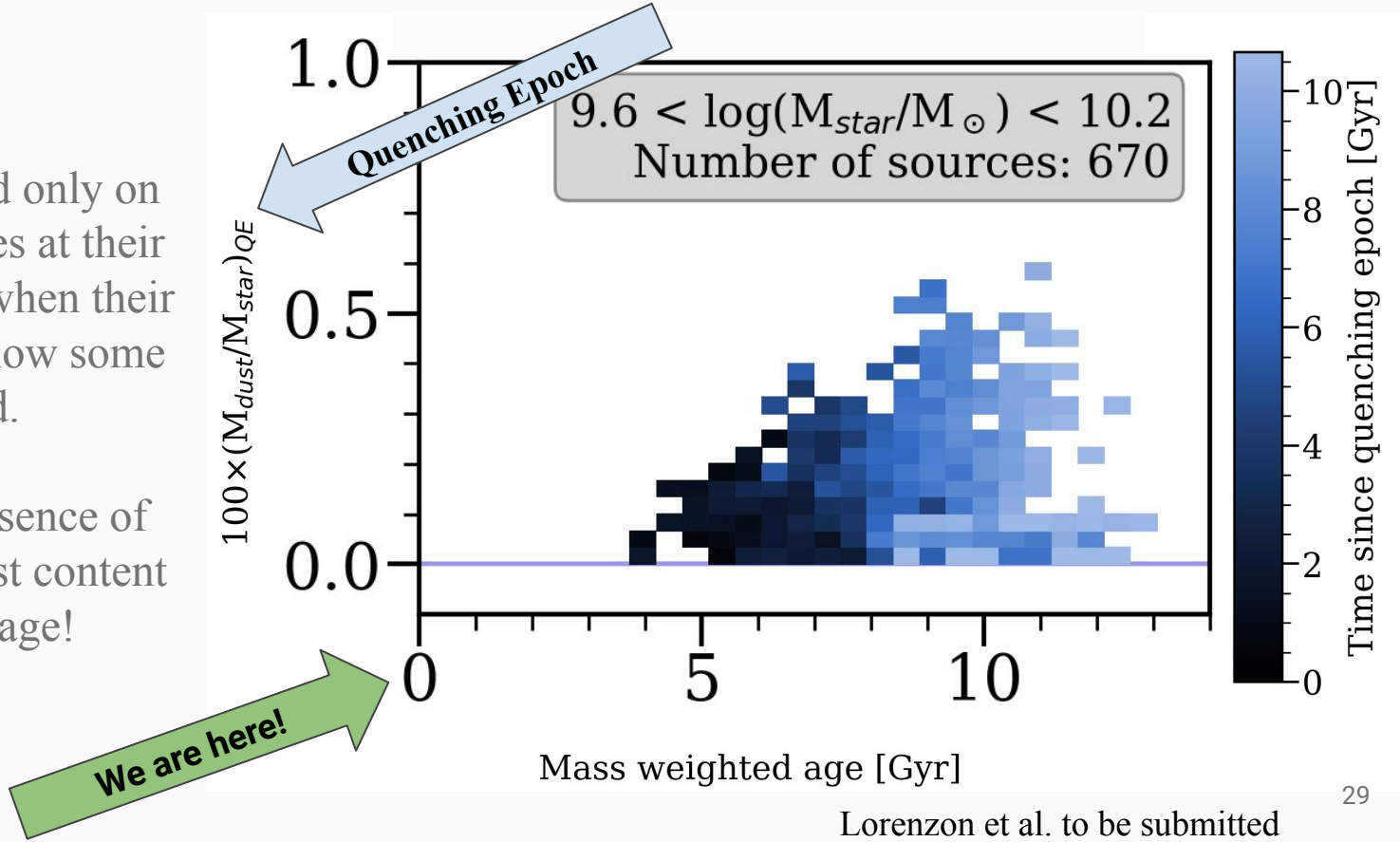


Donevski et al. in prep. including Lisiecki

First results!

First, we focused only on quiescent galaxies at their turnover epoch, when their SFR dropped below some threshold.

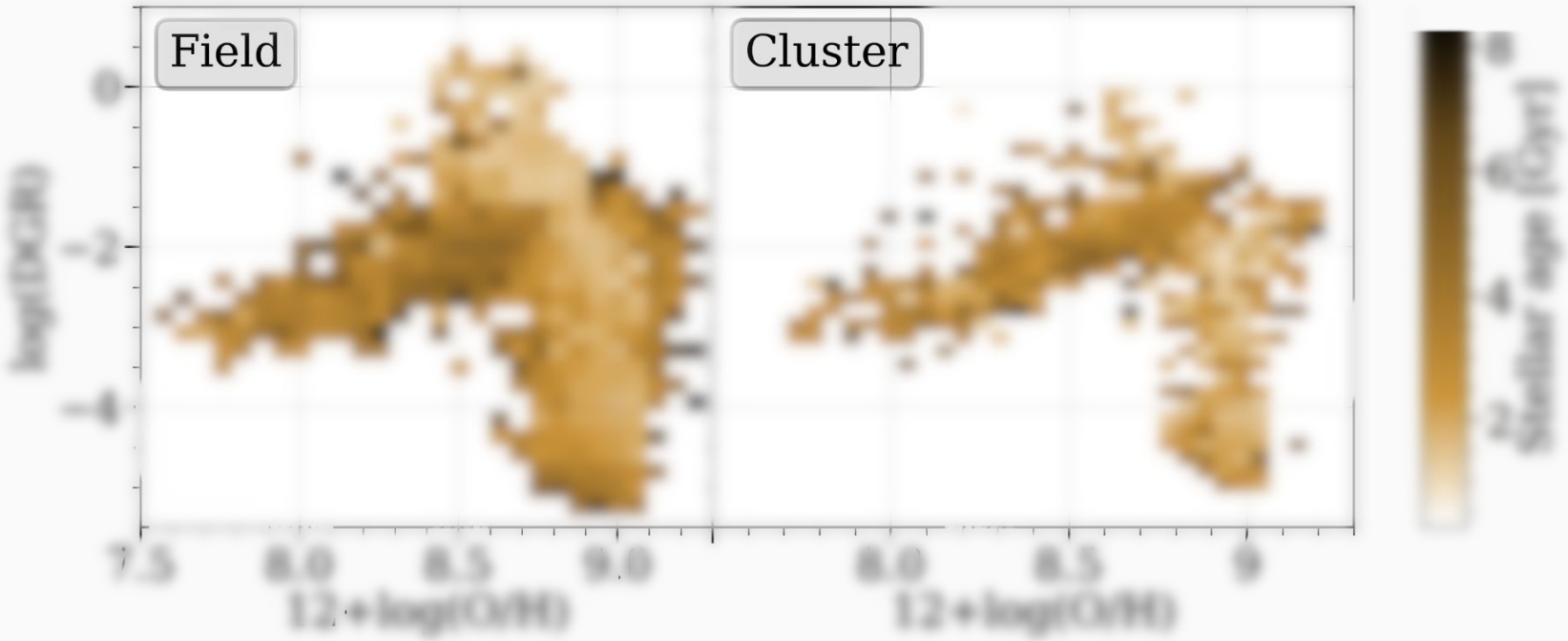
We found an absence of clear trend of dust content with stellar age!



Lorenzon et al. to be submitted

It’s gonna be epic!

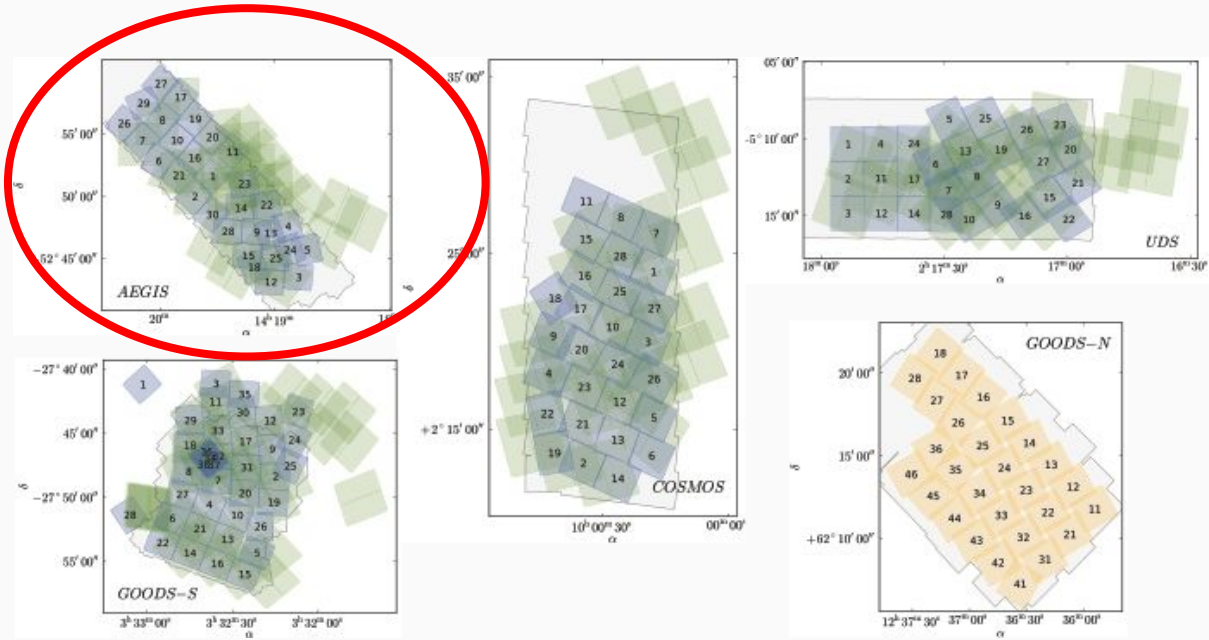
We have much more results studying environmental impact, internal mechanisms, timescales and much more! But you will have to wait until 29.02.2024 to listen Giulianos talk about it or for his paper Lorenzon et al. (including Lisiecki) to be submitted!



Multiwavelength analysis of JWST detected galaxies

Multiwavelength and spectroscopic survey – 3D HST

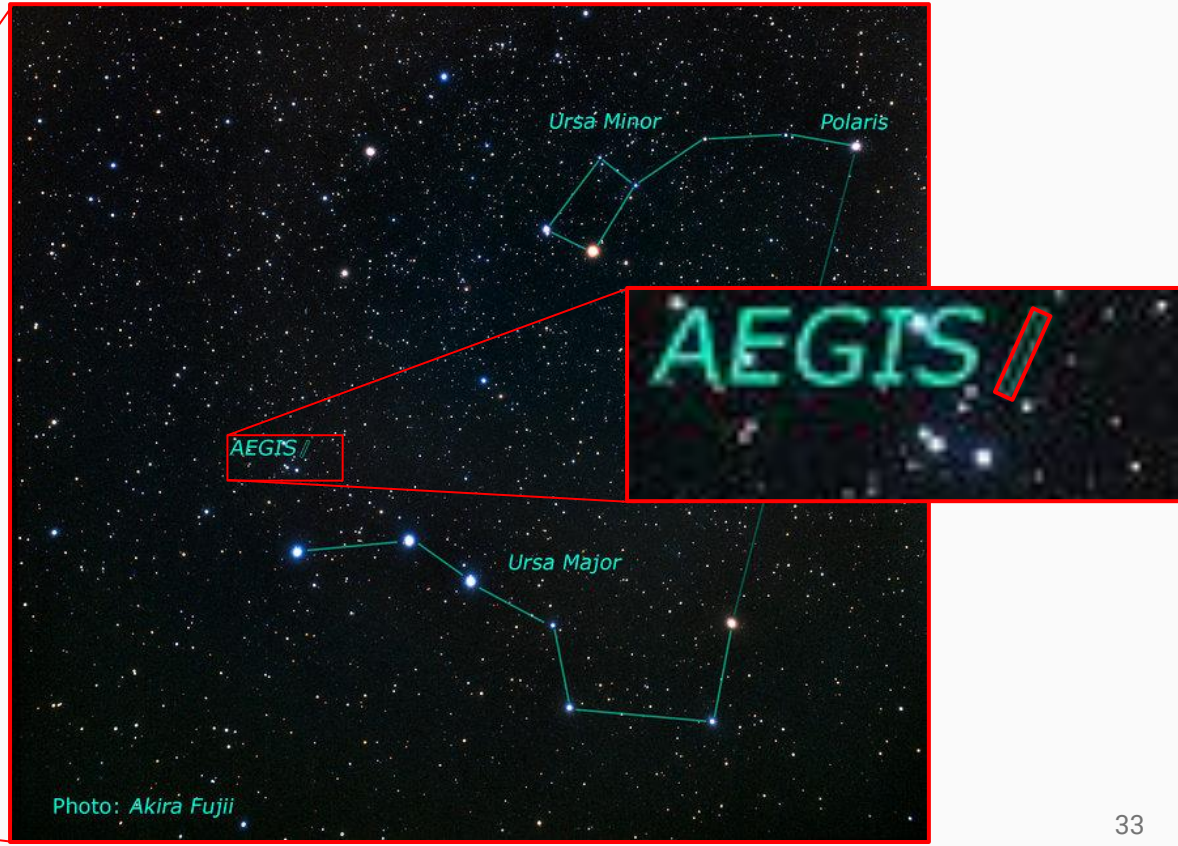
3D-HST is a spectroscopic survey focused on galaxy evolution studies in the distant Universe. It utilizes the previously observed sky areas.



Brammer et al. 2012

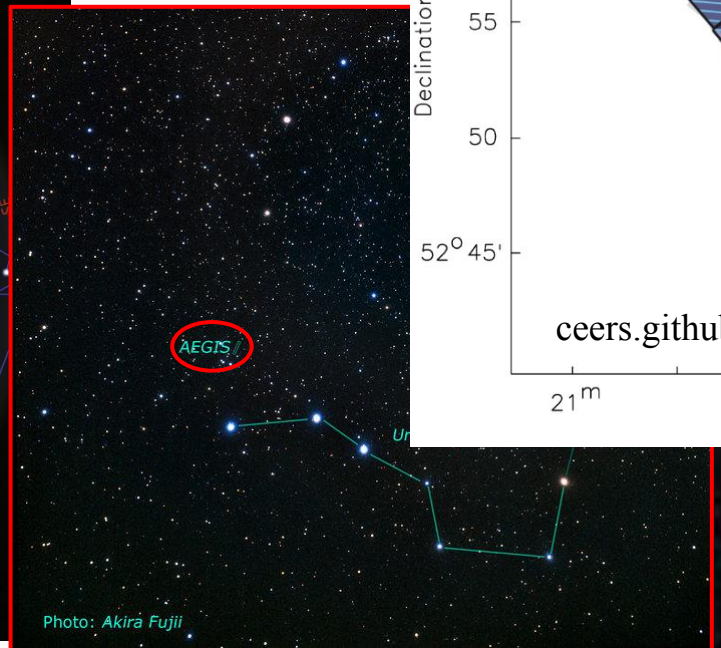
A bit more about AEGIS

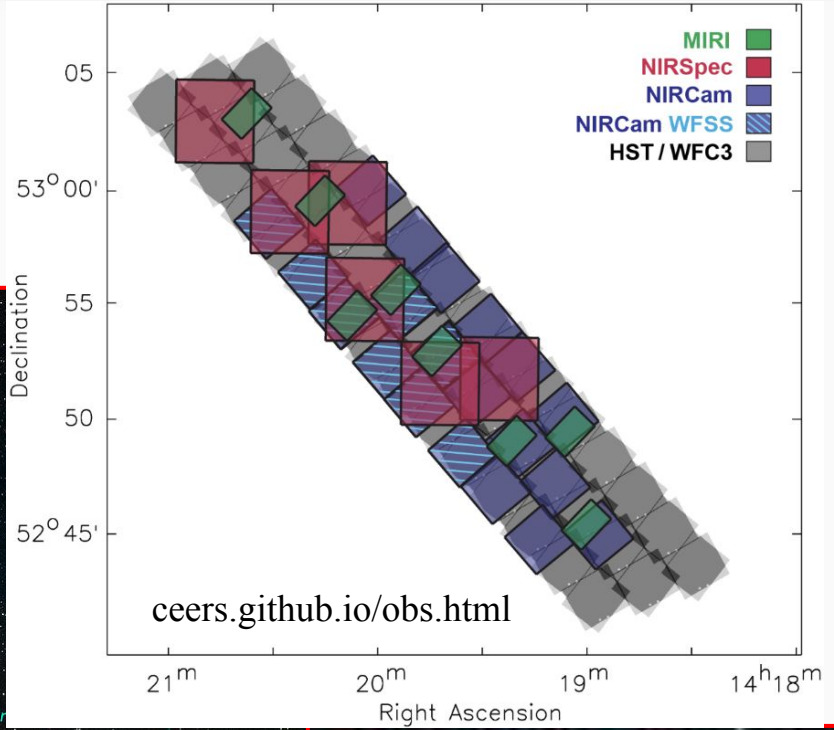
CEERS is a project focused on observing AEGIS field with JWST.

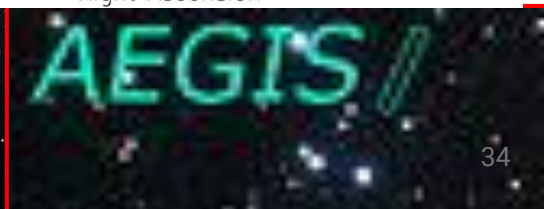


Current science focus – CEERS project

Thousands of high-redshift galaxies observed in plenty different wavelengths, now with great coverage in infrared!



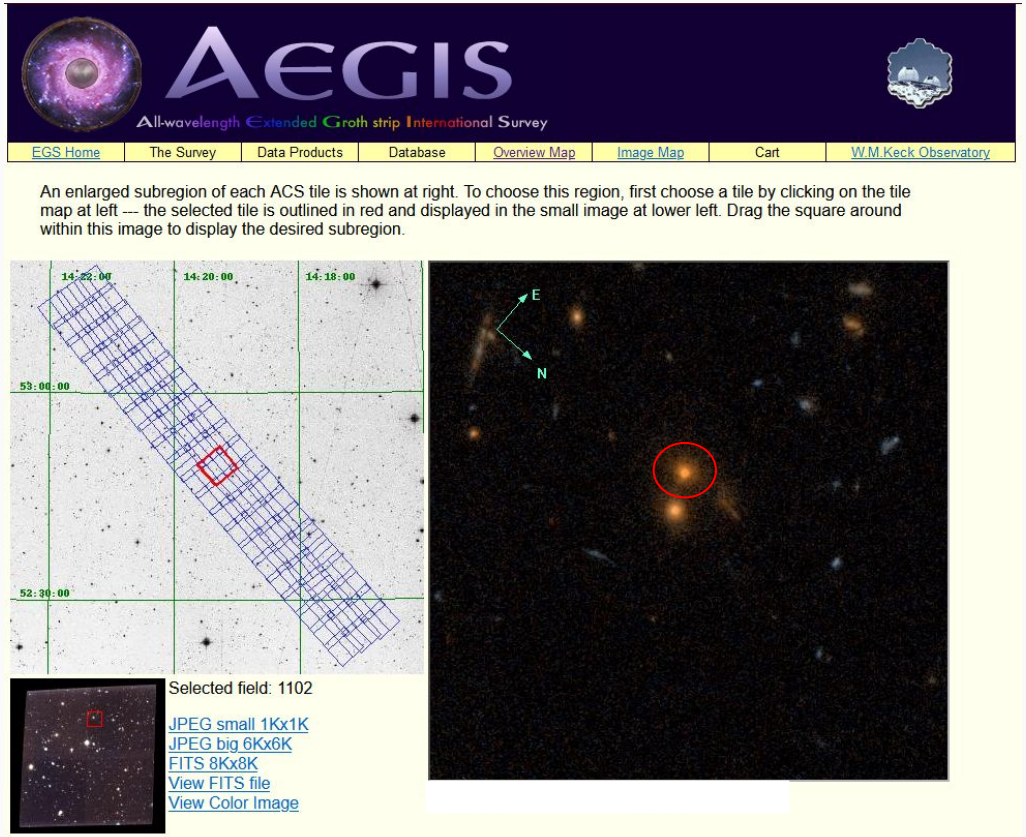




CEERS sample selection

Out of those thousands of galaxies, we focused only on a specific group:

Sample	Sources
AEGIS	41 200



tkserver.keck.hawaii.edu/egs/overviewMap/

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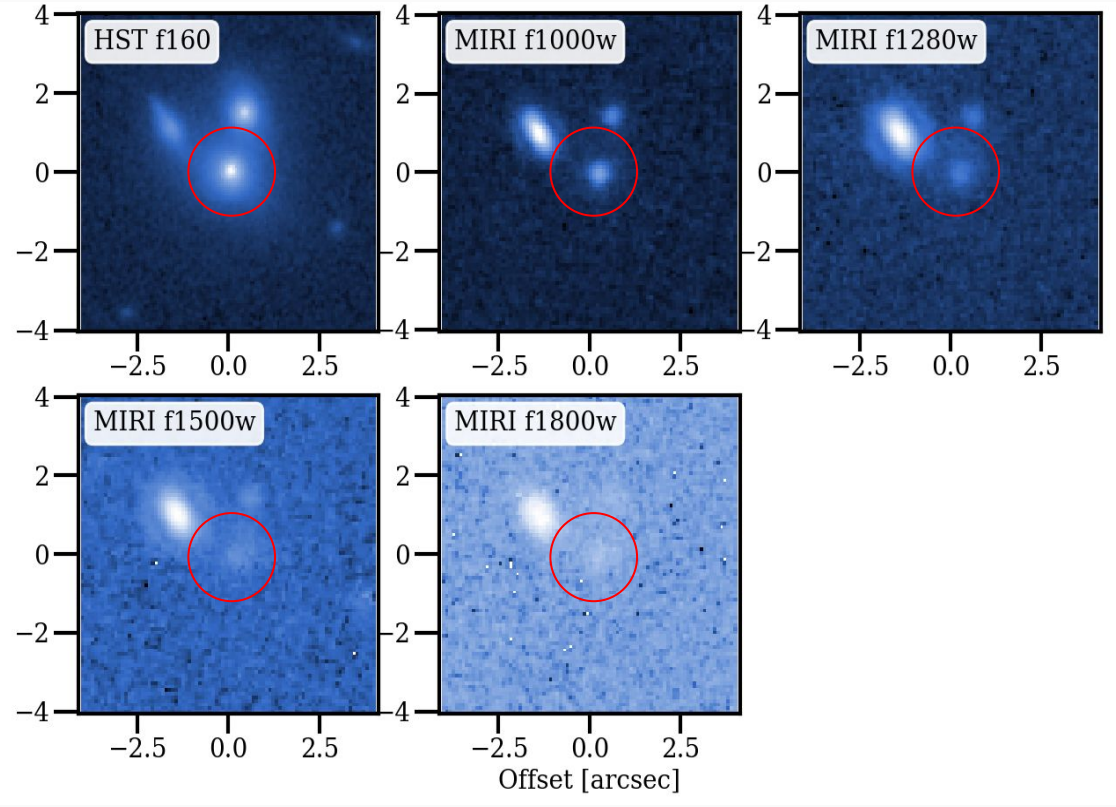

Exemplary galaxy, Lisiecki et al. in prep

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AEGIS	41 200
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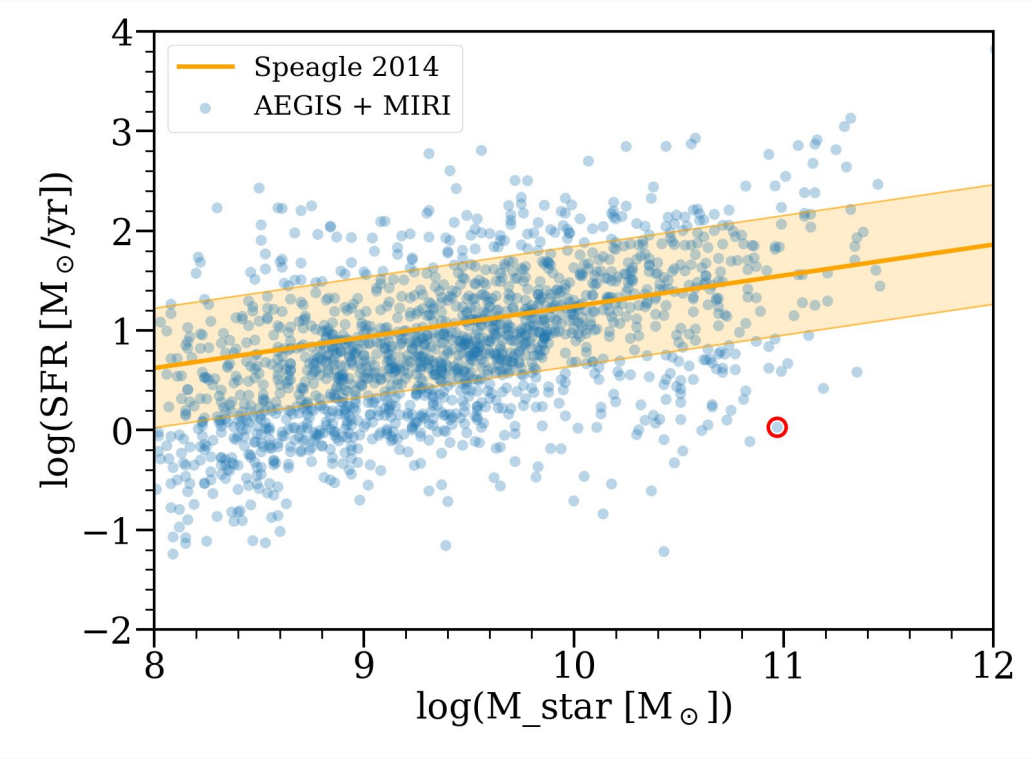
Below Main Sequence	194



Lisiecki et al. in prep

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Sample	Sources
AEGIS	41 200
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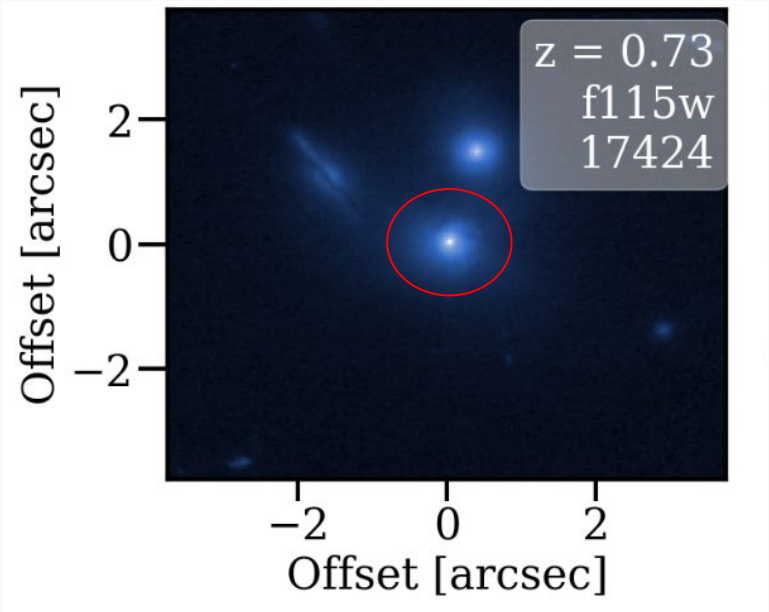
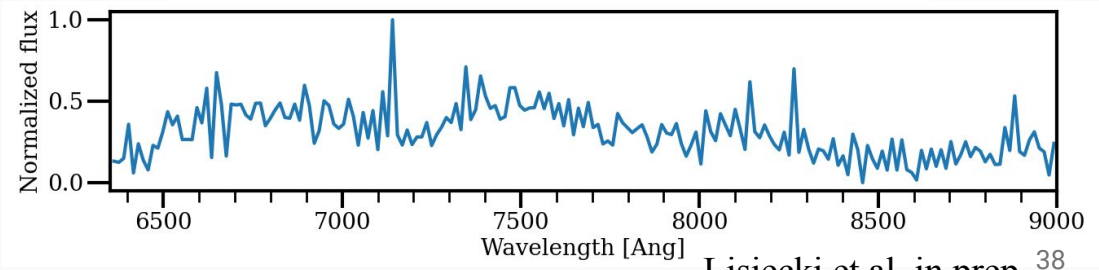
Below Main Sequence	194
HST spectra + NIRCam	21



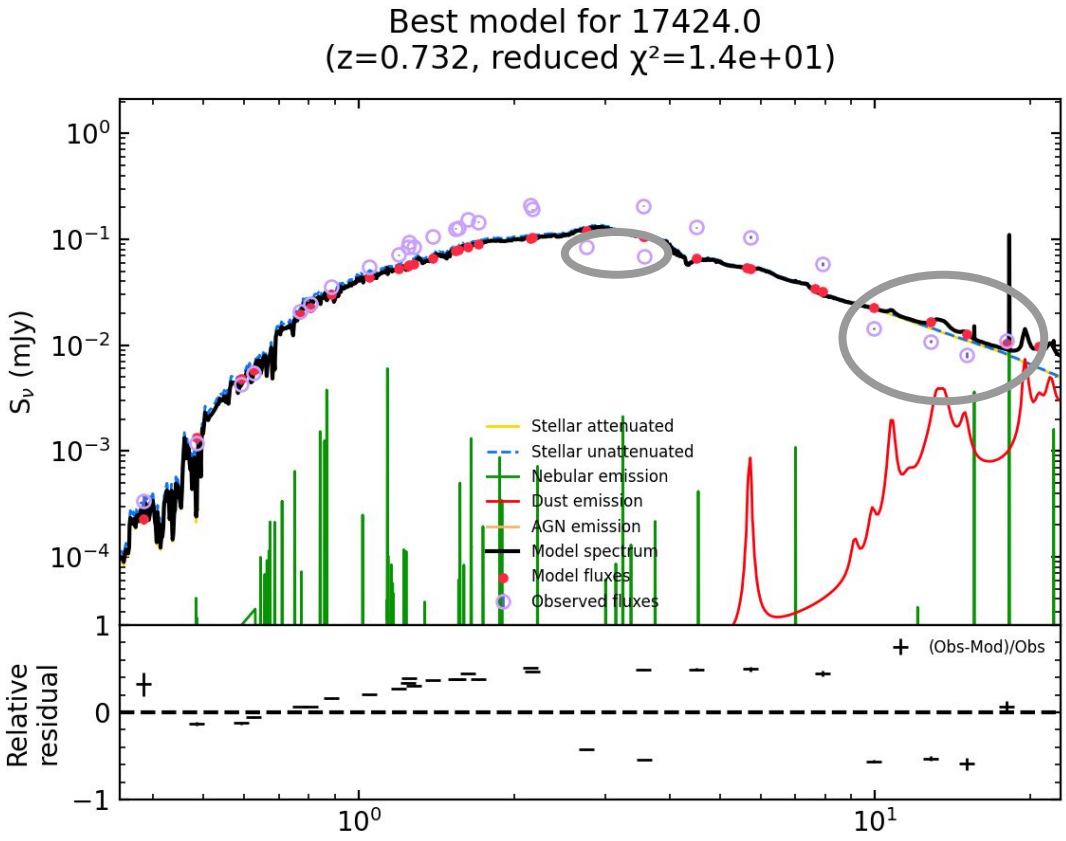


Lisiecki et al. in prep

CEERS SED modelling

The next step, we are currently doing, is to model the galaxy, its physical properties according to the observations but…

We found JWST measurements (marked with grey circles) are in disagreement with archival observations!



Lisiecki et al. in prep

Summary

Results so far

- Developing the first theoretical framework for interpreting ISM in quiescent galaxies from SIMBA
- Photometric and multiwavelength analysis of selected quiescent galaxies in CEERS field
- JWST proposal of quiescent galaxies in COSMOS field

Future goals

- Inspect the JWST data of dusty quiescent galaxies in the other GOODS fields, finally extend the analysis on the largest COSMOS field

- Develop the new analysis approach based on spectra-photometric analysis of near-infrared and mid-infrared data collected with NIRCam, NIRSpec and MIRI

- Unveiling how the movement of high-z quiescent galaxies in size-mass plane, correlates with their age-ISM characteristics

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Thank you for attention!