Spectral Energy Distribution of Galaxies:

a tool to probe the Star Formation History of Galaxies

Laure CIESLA

2009-2012

PhD with A. Boselli

The physical properties of galaxies probed with *Herschel*

2013-2015

Postdoc with V. Charmandaris

Physical properties of AGN host galaxies

2006

Internship with S. Charnoz

Study of Saturn's rings with *Cassini*

2008

Internship with S. Corbel

Accretion-Ejection rcoupling in RXTE-J1550-564

2015-2017

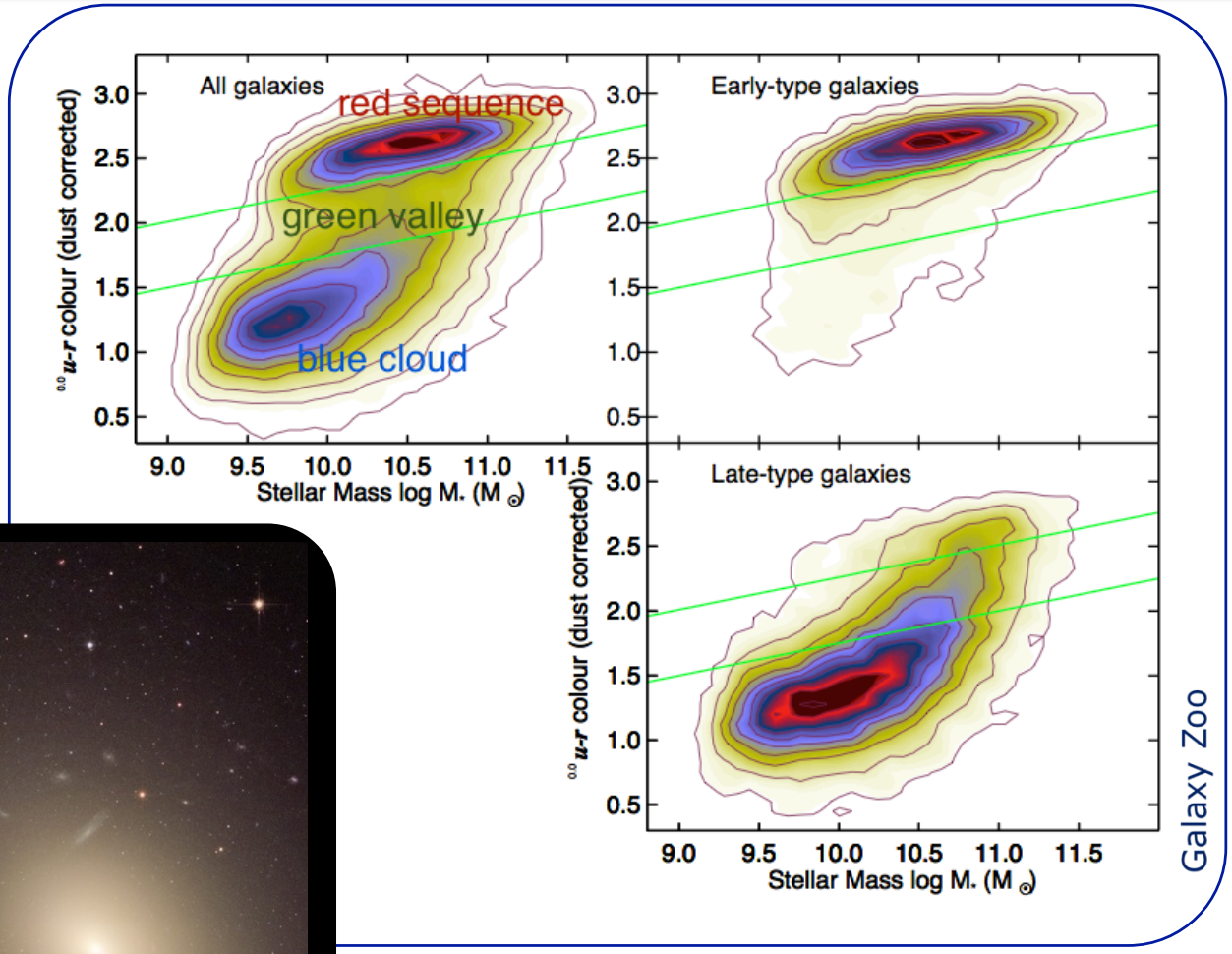
Postdoc with D. Elbaz

Evolution of physical properties of galaxies with cosmic time

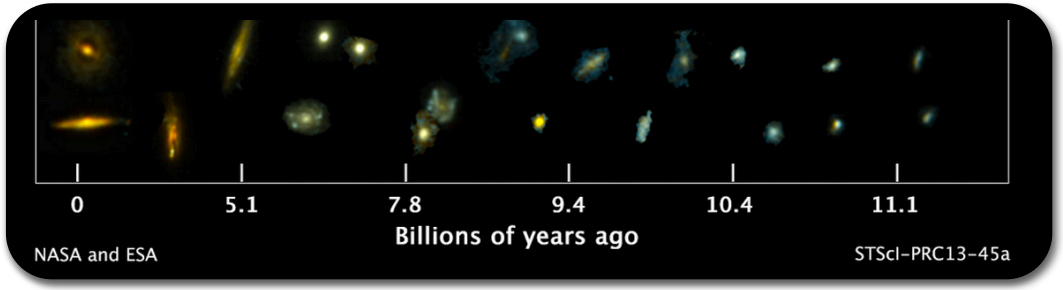
Bimodality of galaxies

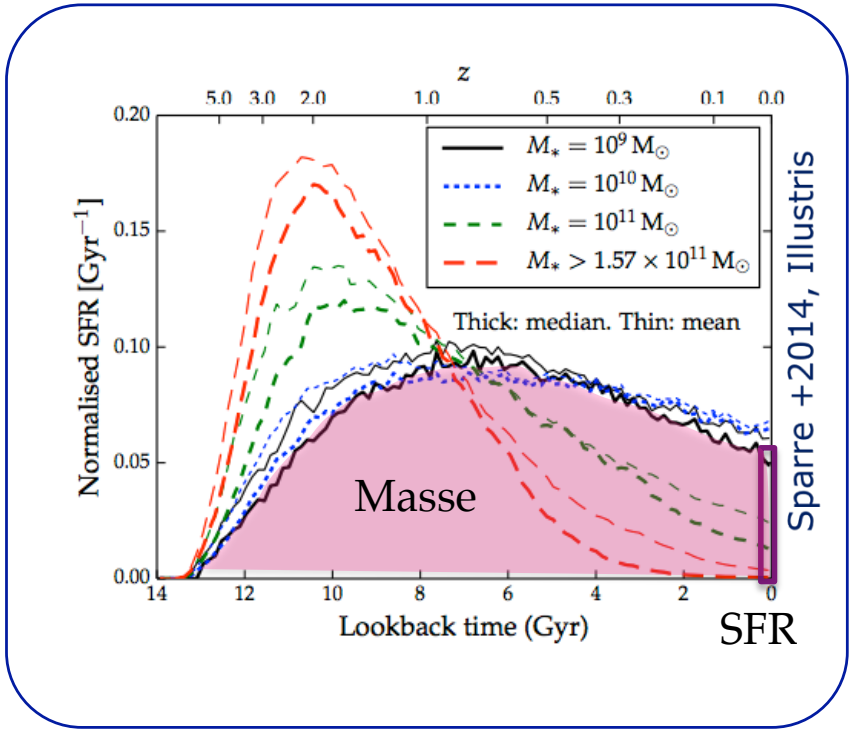
What are the mechanisms responsible for the transformation of galaxies from active to passive?

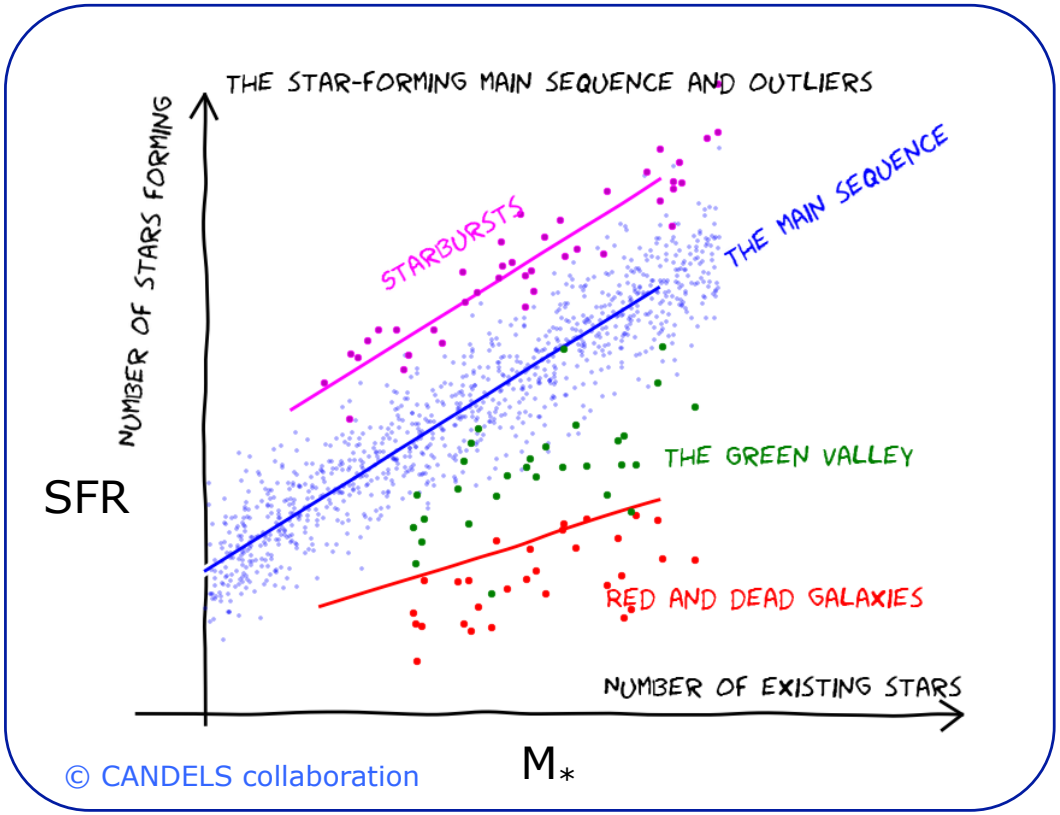
How galaxies die?



Focussing on green valley galaxies

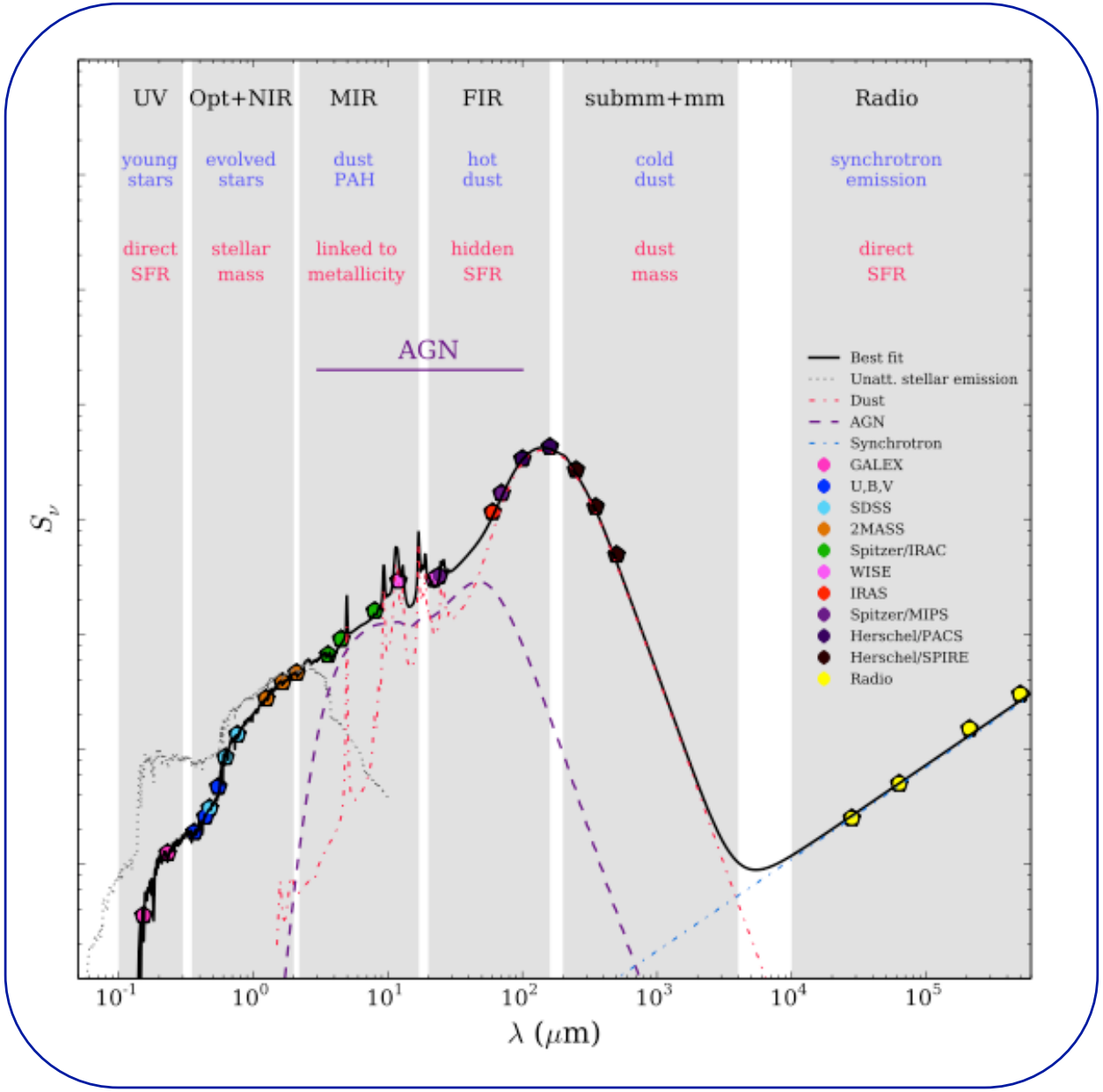






Noeske+07
Elbaz+11
Rodighiero+11
Etc …

The Spectral Energy Distribution of Galaxies



Modeling galaxies SED

SFH:
Analytical (exp-dec, delayed, …)
Complex (SAM, etc…)

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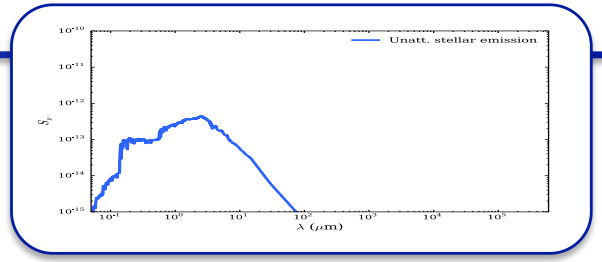
Stellar Populations:
Bruzual&Charlot 03
Maraston+05

→

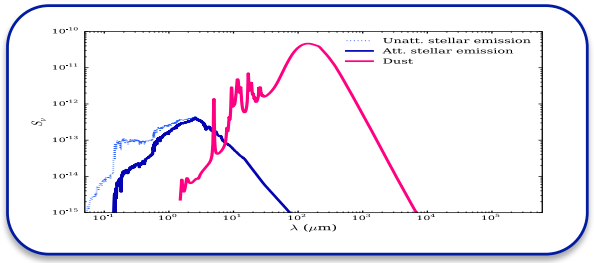


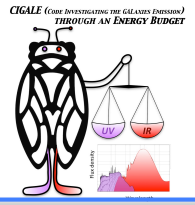
Attenuation:
Calzetti law, power law

↷

Dust emission:
Dale+14,
Draine&Li 07 + updates
Casey+12

→





Analysis:
χ^2 computation + probability distribution function analysis

Nebular emission:
Inoué models

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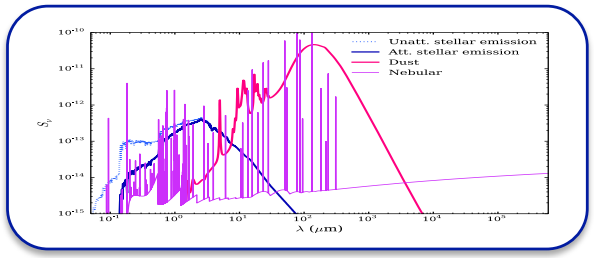

Synchrotron from SF:
FIR-radio correlation

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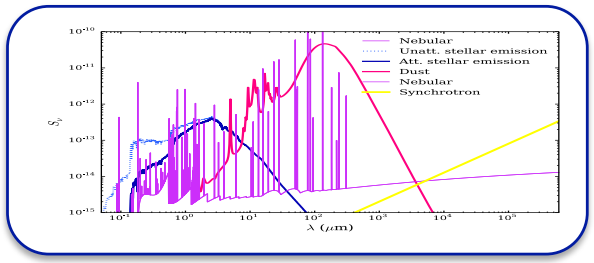
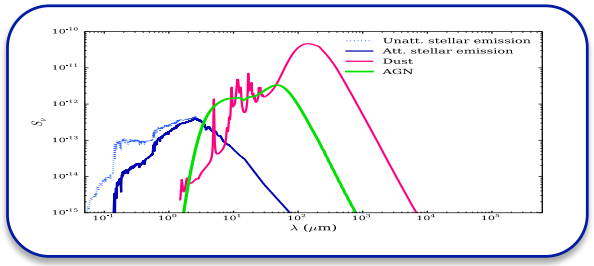


Boquien +, in prep
Burgarella+, in prep
Ciesla+15 (AGN)

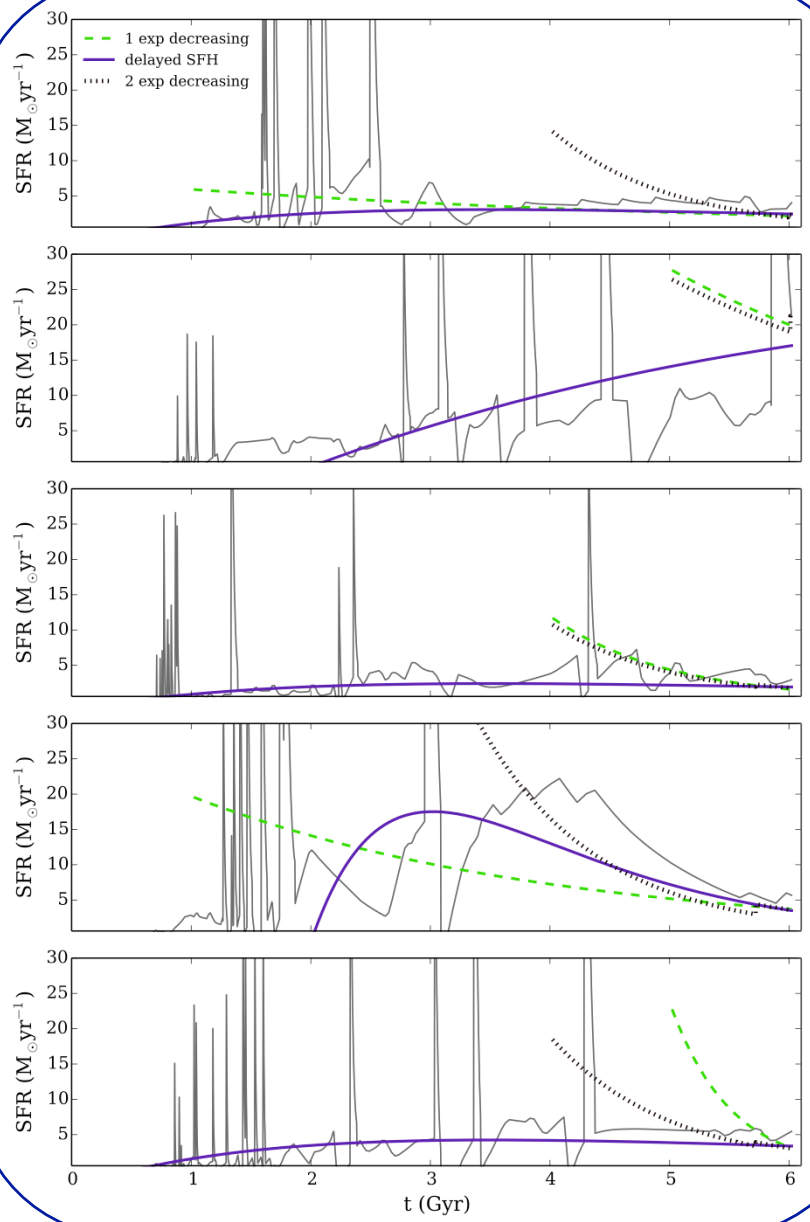
AGN:
Fritz+06

→



Usual SFH assumptions

Ciesla+15



SFH model	M*	SFR
1-tau-dec	-10.0 %	-11.4%
2-tau-dec	-5.2 %	-6.6%
delayed	-6.5%	-9.1%

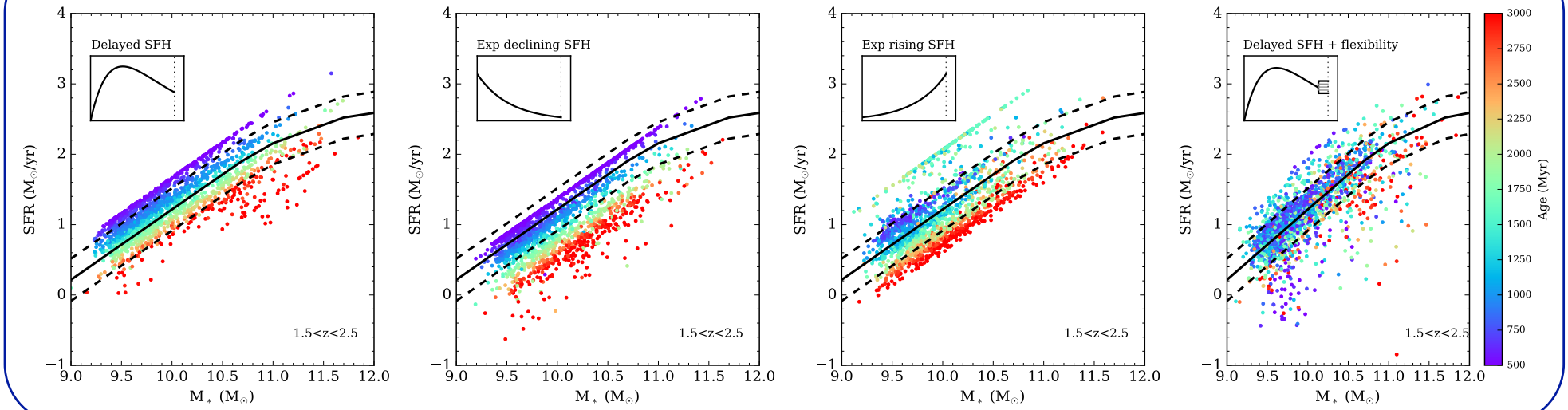
In the litterature: SFH for normal star forming galaxies, for starbursting galaxies, for quiescent…

What about rapidly quenched galaxies?

- Ram pressure stripping from cluster
- Galaxies in compact groups
- Quenching from AGN?

Beware of the biases

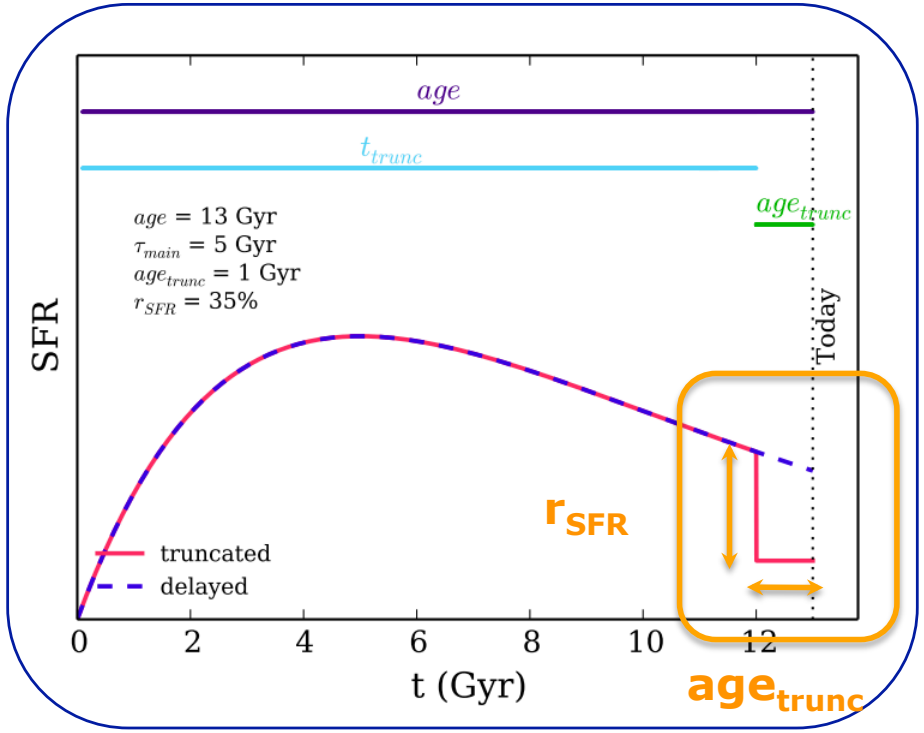
Ciesla+17a, to be sub.

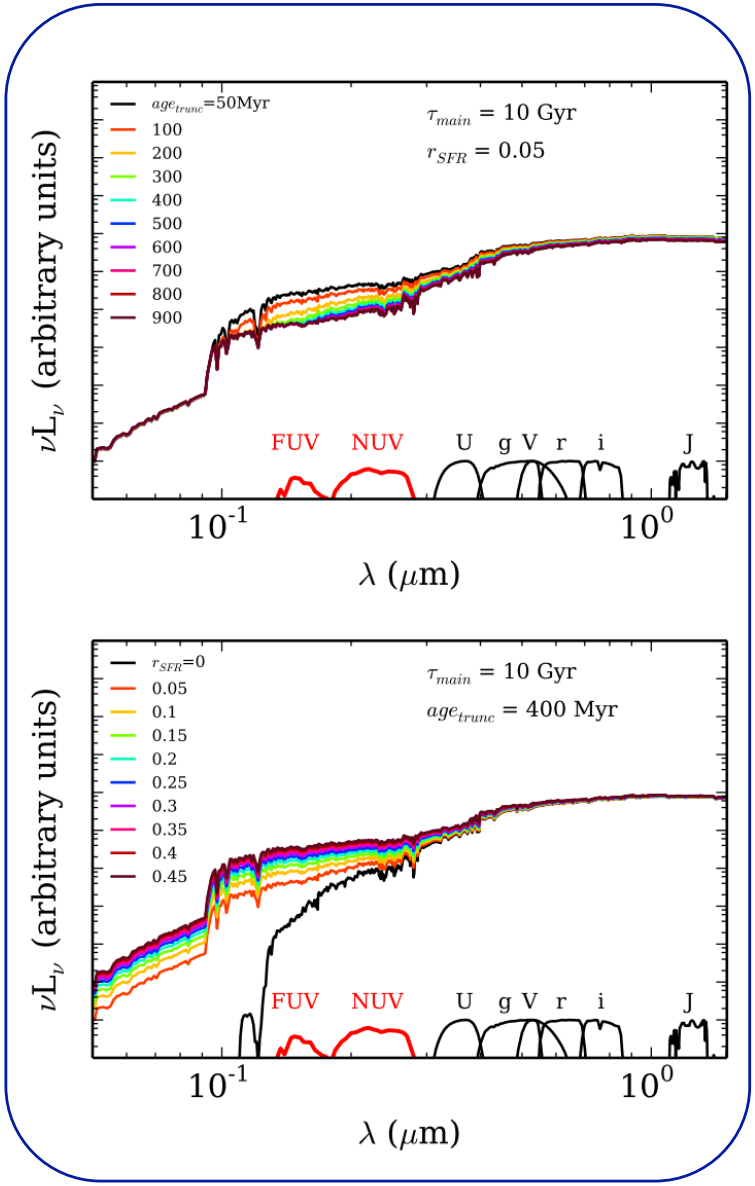


A quenched delayed Star Formation History

$$SFR(t) \propto \begin{cases} t \times exp(-t/\tau_{main}), & \text{when } t <= t_{trunc} \\ r_{SFR} \times SFR(t = t_{trunc}), & \text{when } t > t_{trunc} \end{cases}$$

$$r_{SFR} = \frac{SFR(t > t_{trunc})}{SFR(t_{trunc})}.$$



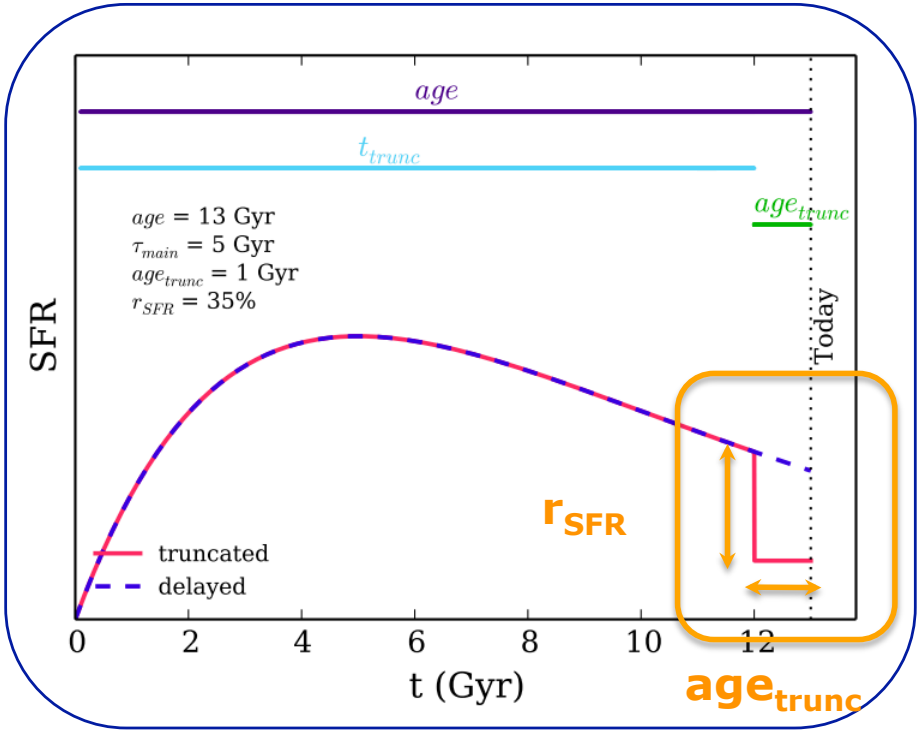


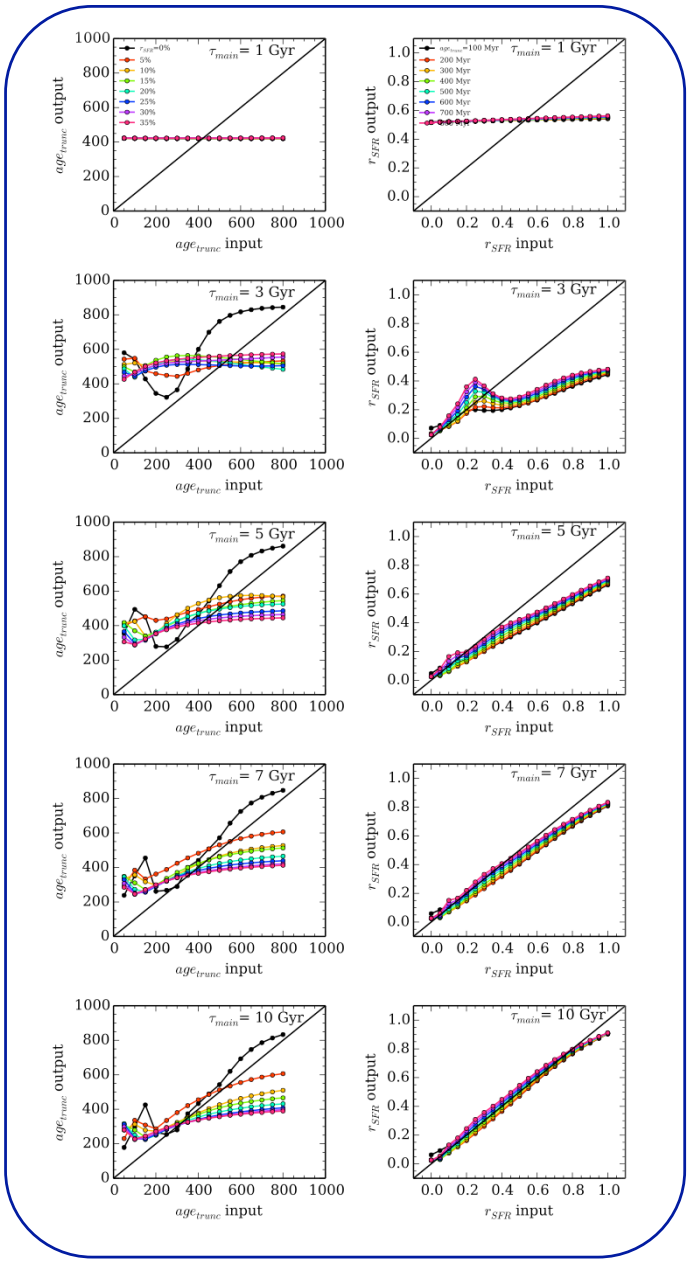
Can we constrain these parameters from broad band SED fitting?

Ciesla+16

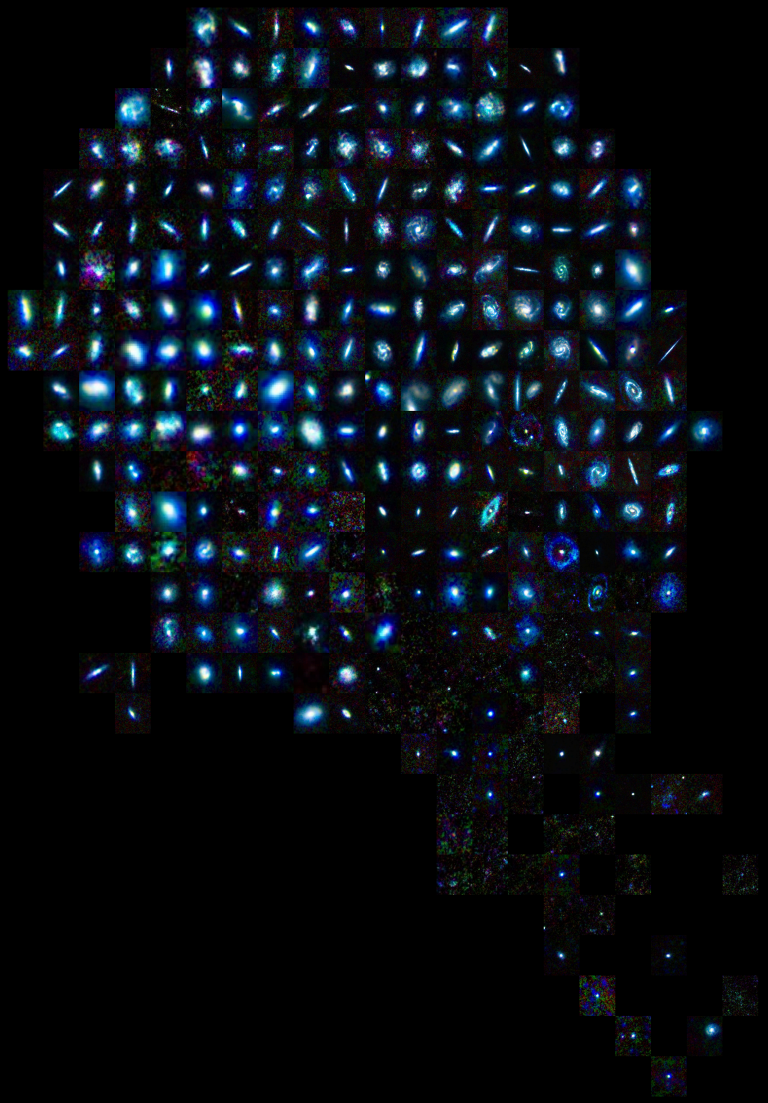
$$SFR(t) \propto \begin{cases} t \times exp(-t/\tau_{main}), & \text{when } t <= t_{trunc} \\ r_{SFR} \times SFR(t = t_{trunc}), & \text{when } t > t_{trunc} \end{cases}$$

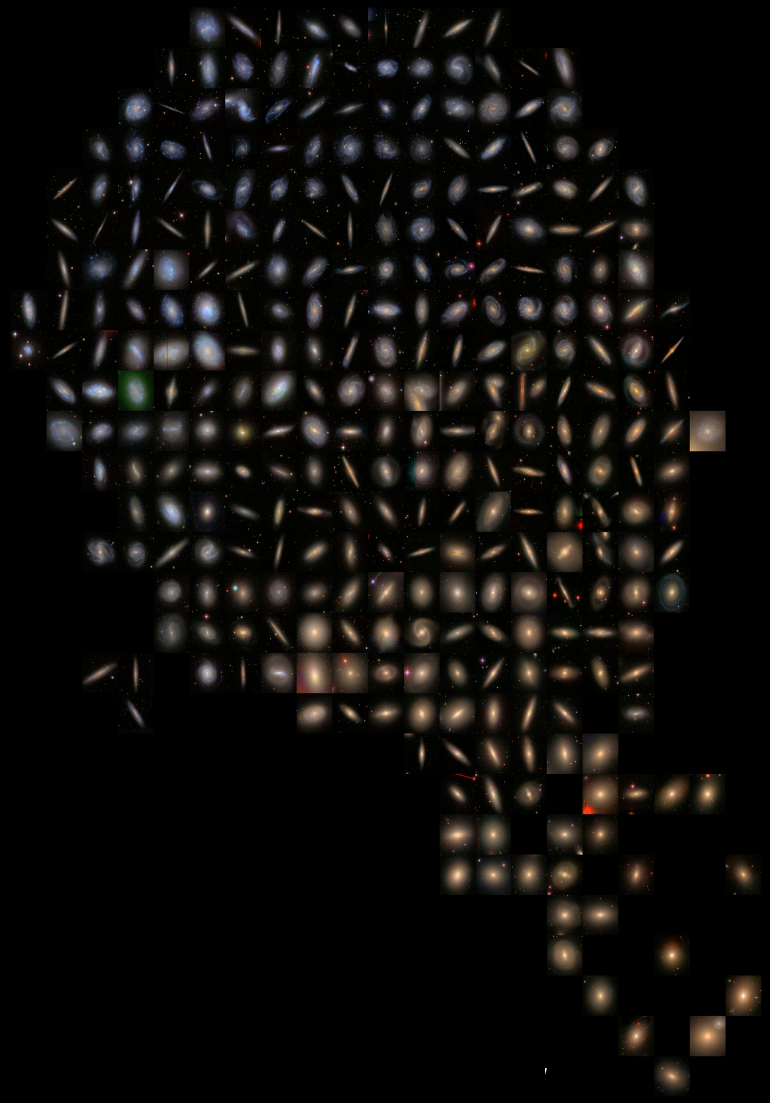
$$r_{SFR} = \frac{SFR(t > t_{trunc})}{SFR(t_{trunc})}.$$





Test on local galaxies

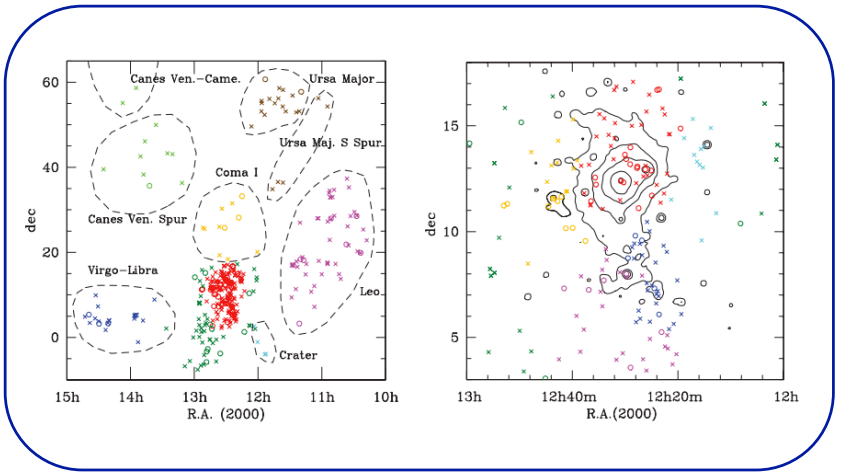




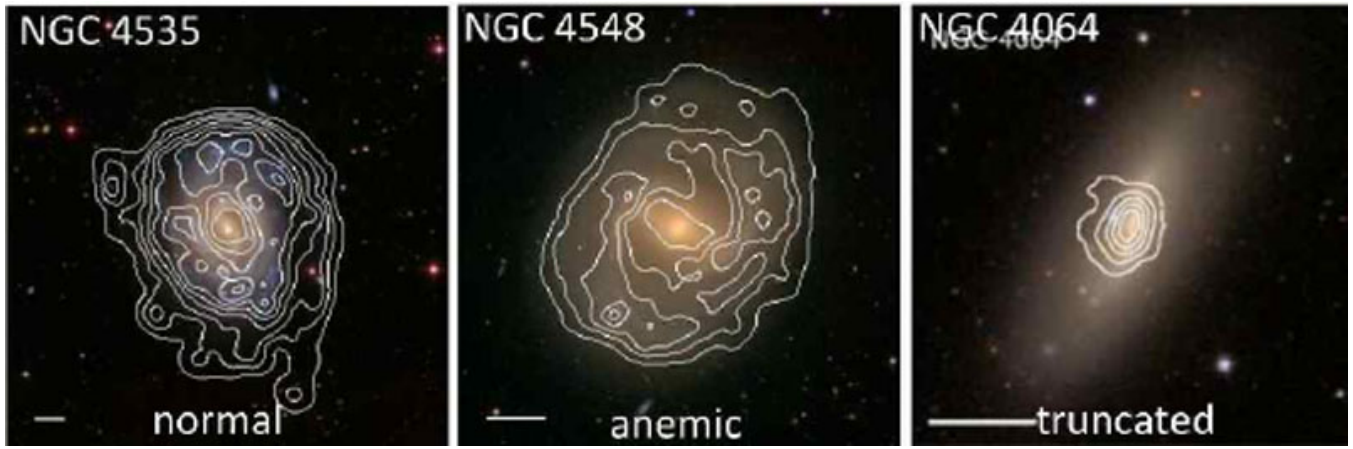
A test sample: the *Herschel* Reference Survey

PI: S. Eales, Boselli+10a

- 322 local galaxies:
  Volume limited
  K-band selected (Mass selected)
- all morphological types
- wealth of ancillary data
- broad range of environment density:
  from field galaxies to the core of
  the Virgo cluster



Quantifying the effect of environment: the HI-deficiency



Chung+09

Quenching from ram pressure stripping
(e.g. Gunn&Gott+72, Tonnesen&Bryan+09)

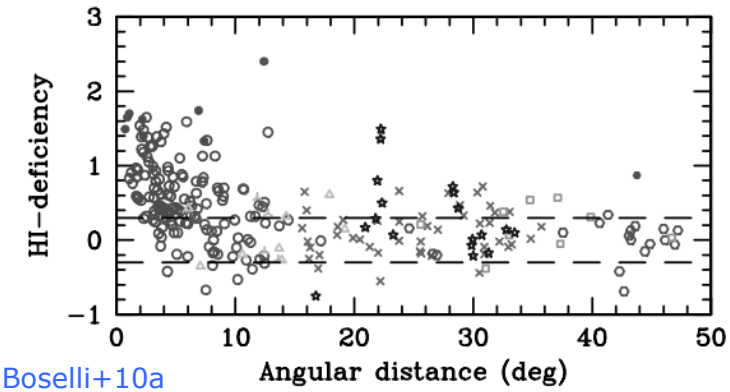
Several hundreds Myr to produce typical gas-deficient cluster galaxy
About 1.5Gyr to completely remove the gas
(e.g. Vollmer+04,08,12, Boselli+06, Pappalardo10)

By definition:

logarithmic difference between the average HI mass of a reference sample of isolated galaxies of similar type and linear dimension anf the HI mass actually oberved

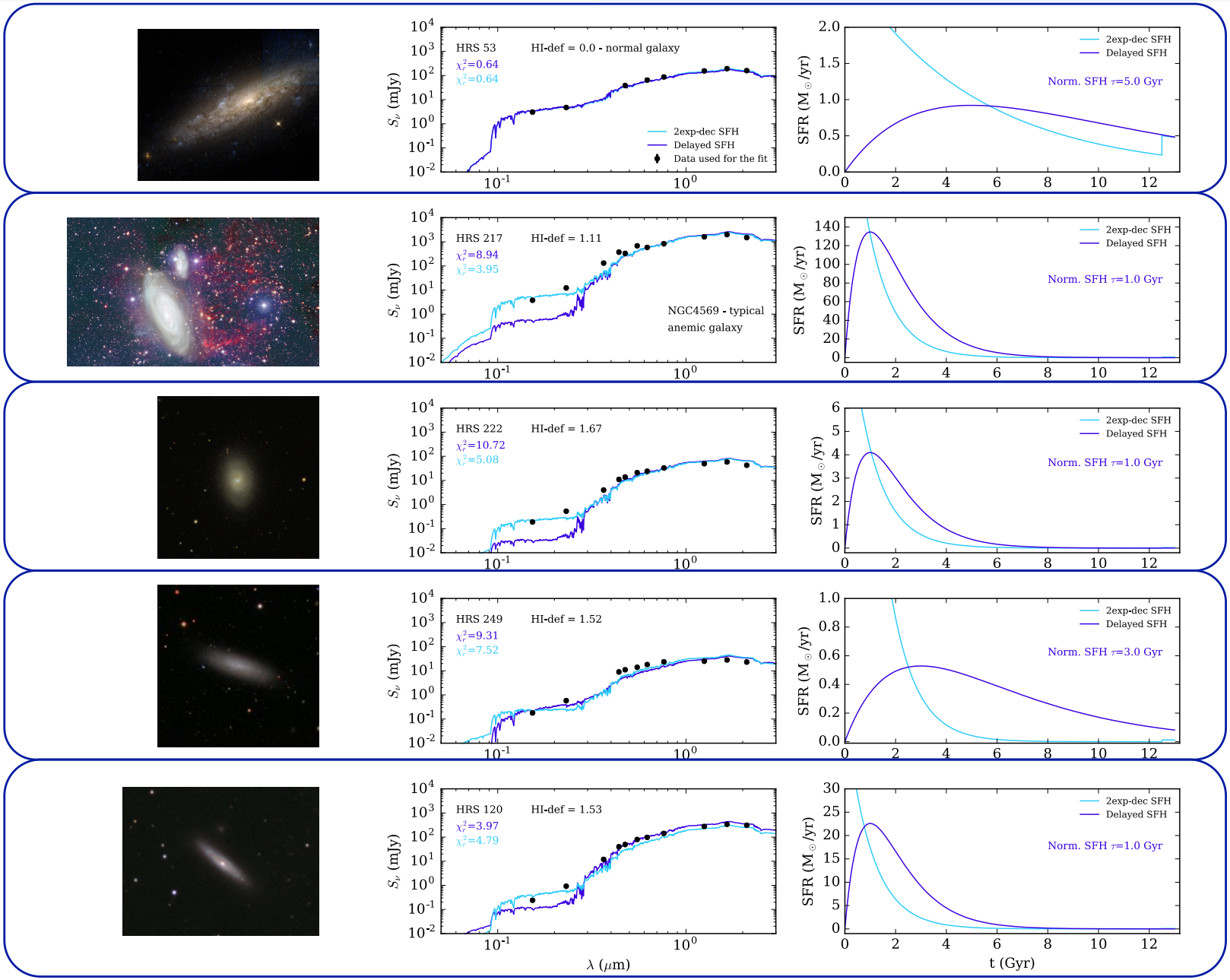
HI-def = log MHI_{ref} – log MHI_{obs}

e.g., Haynes+84, Gavazzi+05

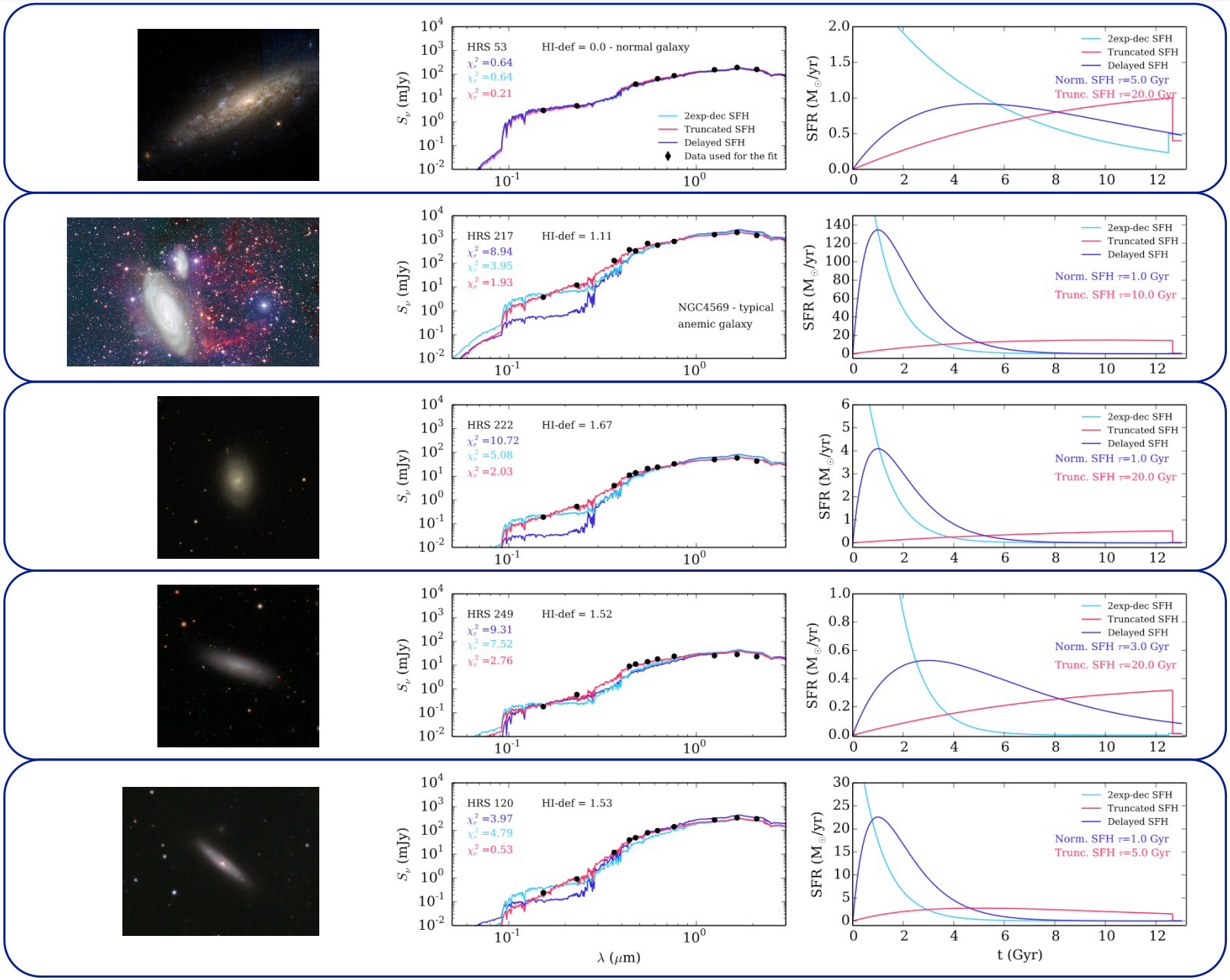


Boselli+10a

Using normal SFHs to model HI-deficient galaxies SED



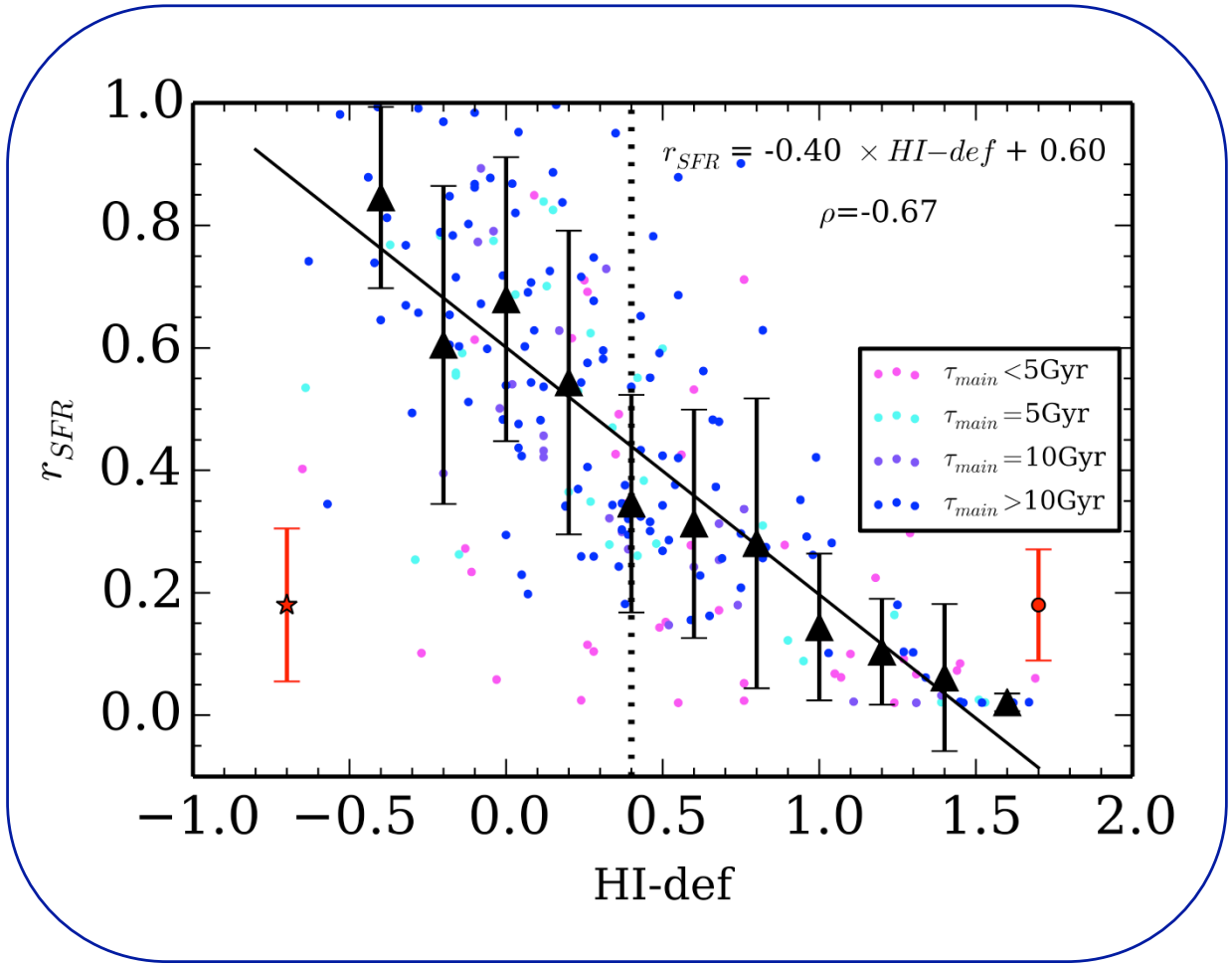
Using the truncated SFH



Output of the SED fitting versus observations

normal

quenched

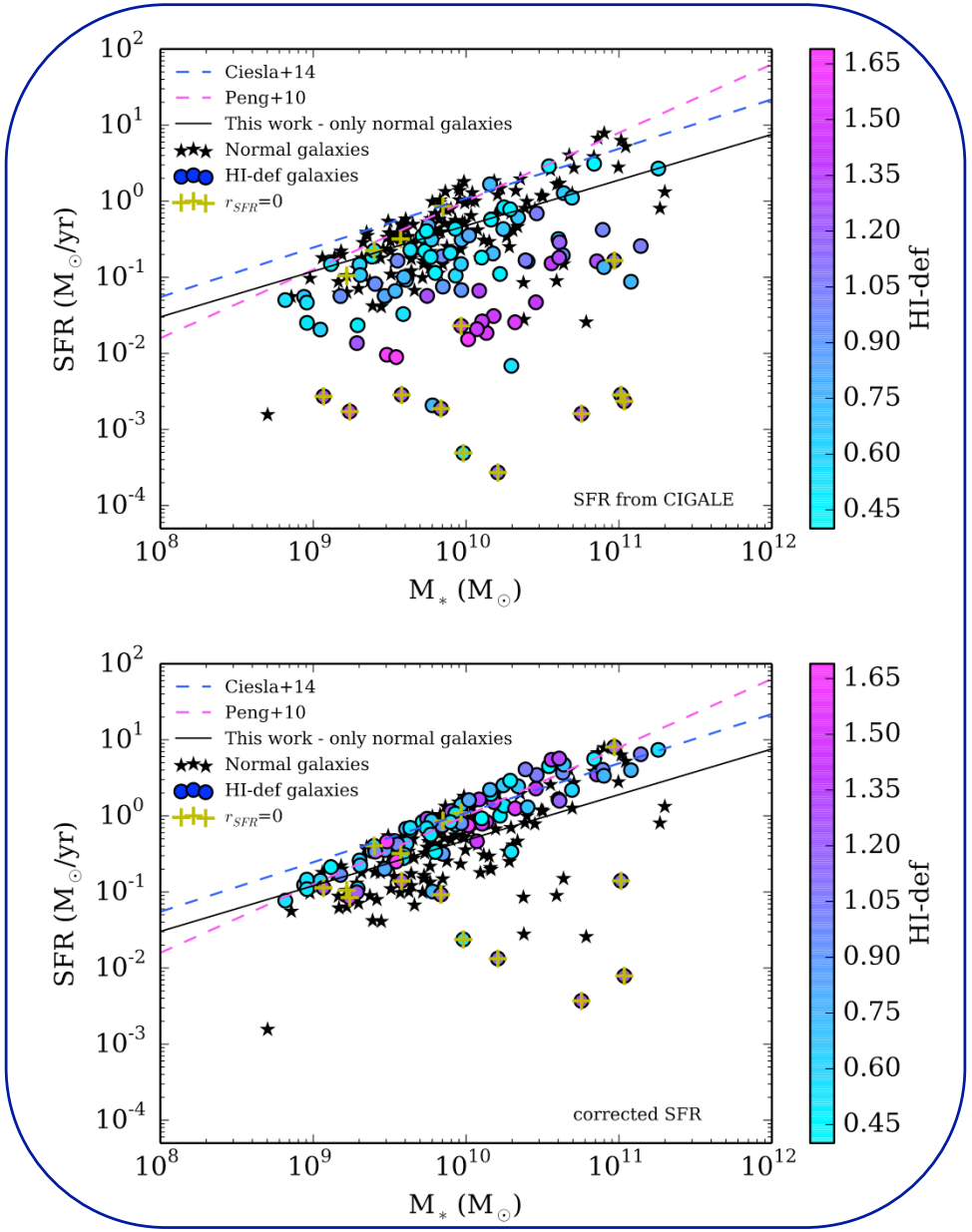


normal

highly deficient

Falling back on the Main Sequence

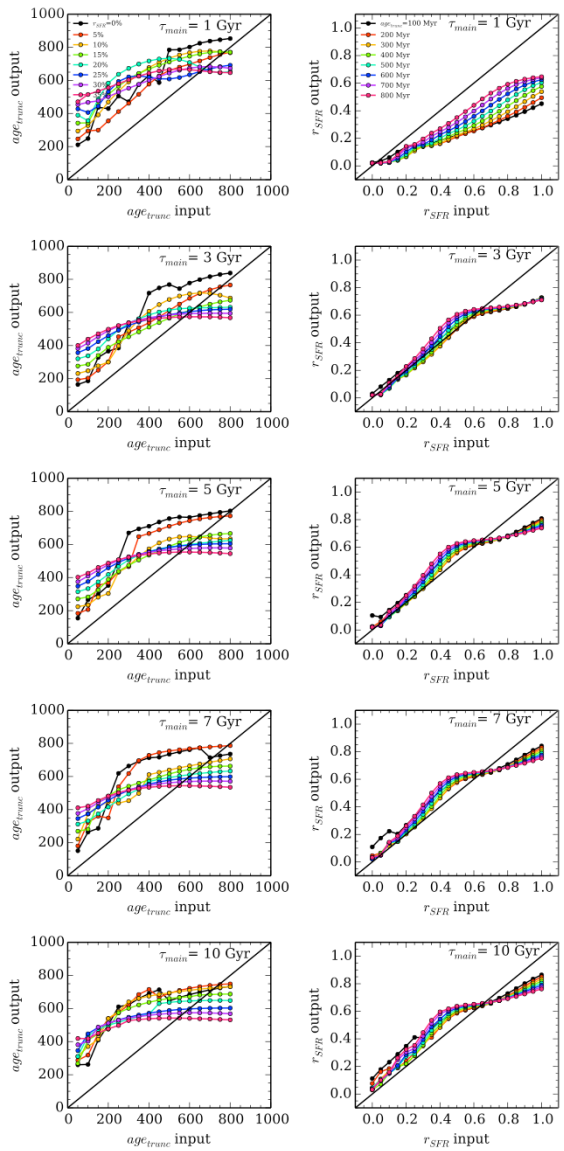
Recovering the SFR:
$SFR_{before} = SFR_{today} / r_{SFR}$



What about high-z sources?

Work in progress, Ciesla+17b, in prep

What about high-*z* galaxies?



Built mock catalogues of *z*=2 galaxies with A_{FUV}=4mag (Buat+15)

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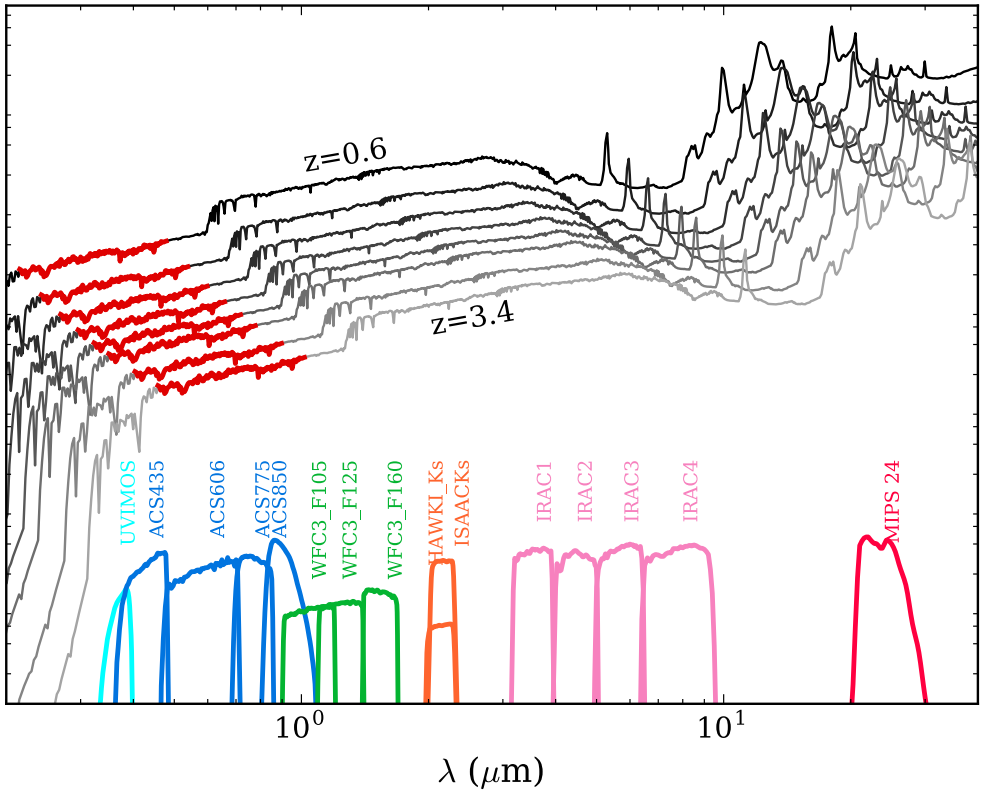
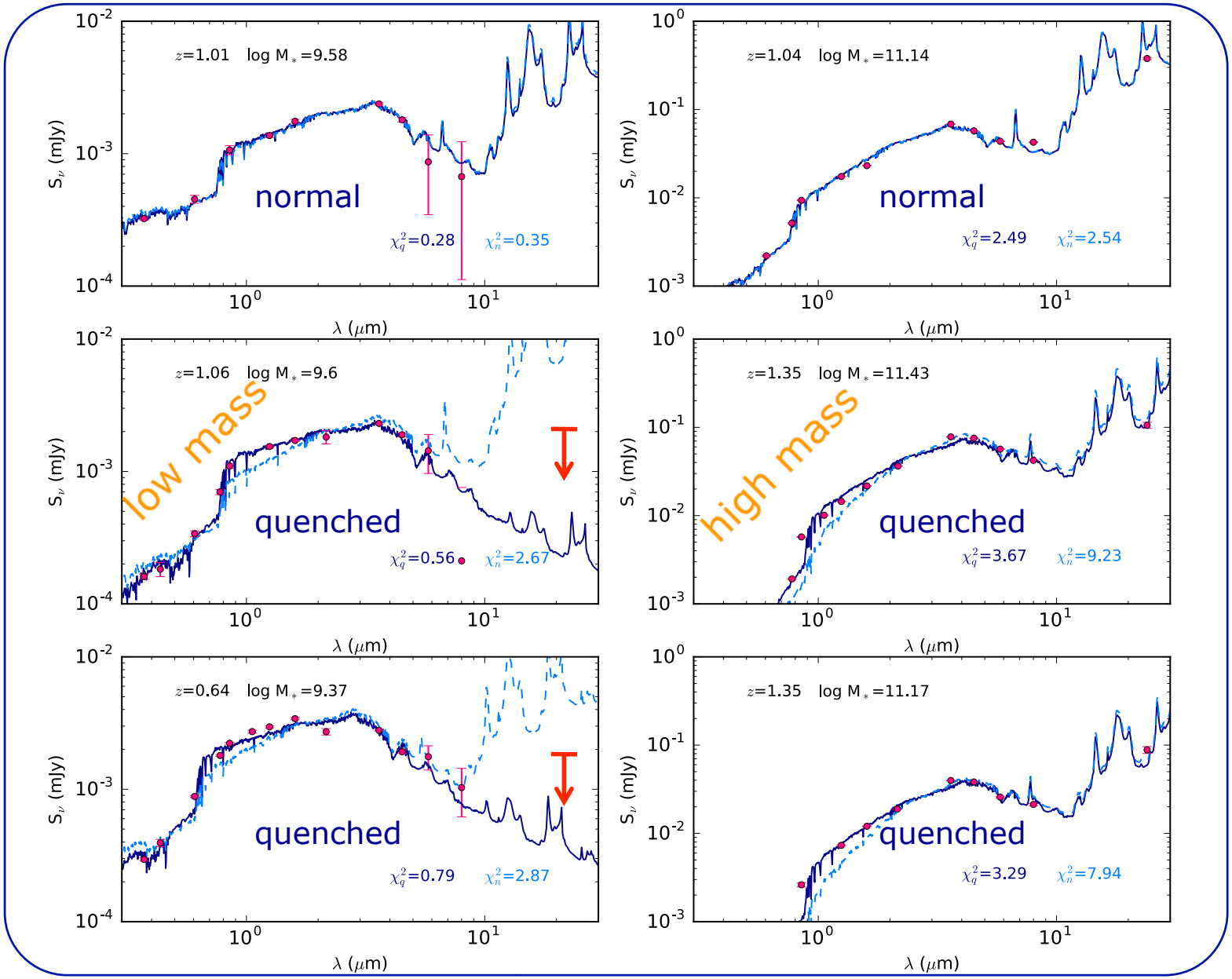
Results similar to those obtained for local sources: r_{SFR} possible to constrain



High-z galaxies: examples of SED

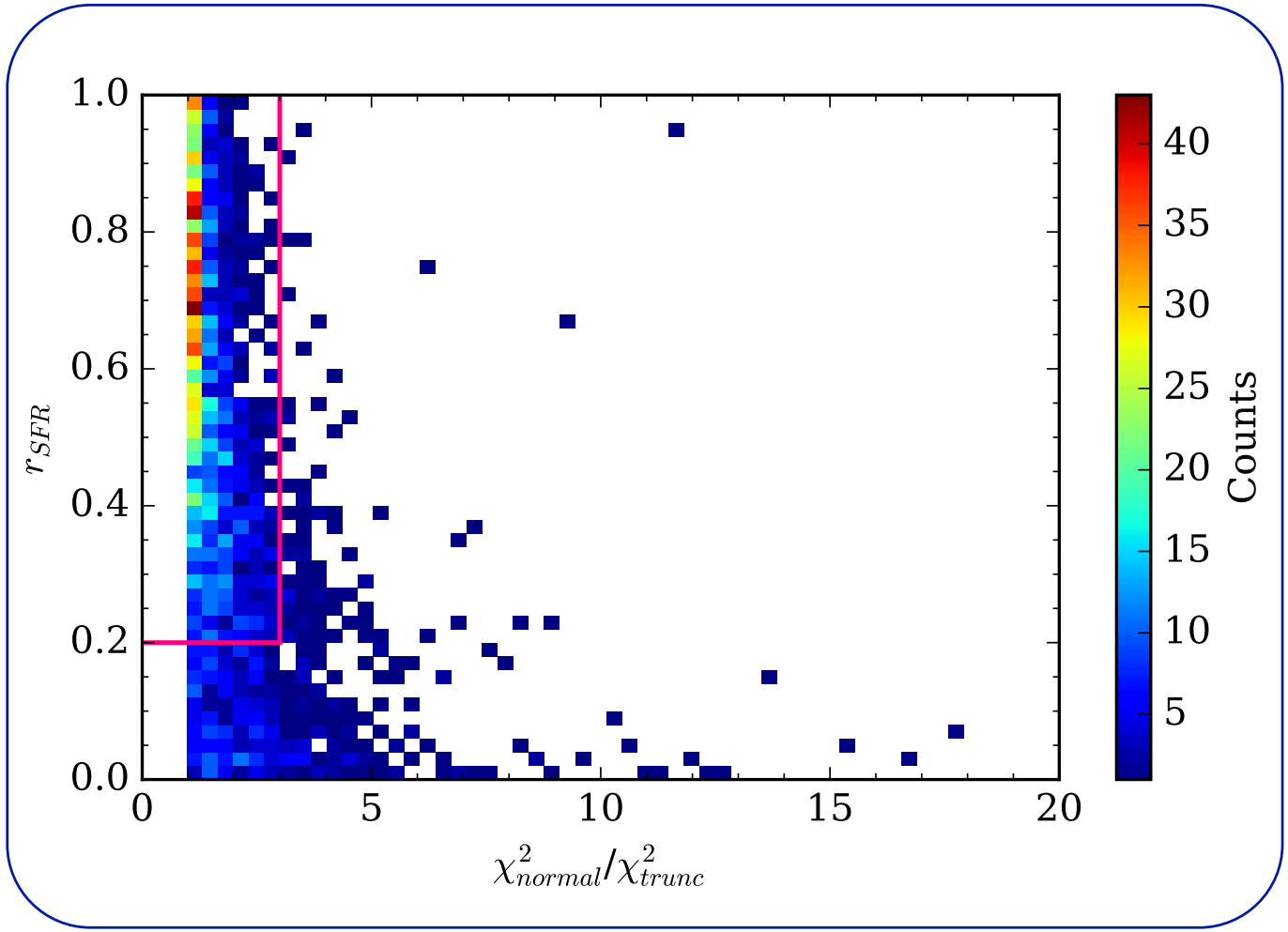


High-z galaxies: selecting a sample

Ciesla+17, in prep

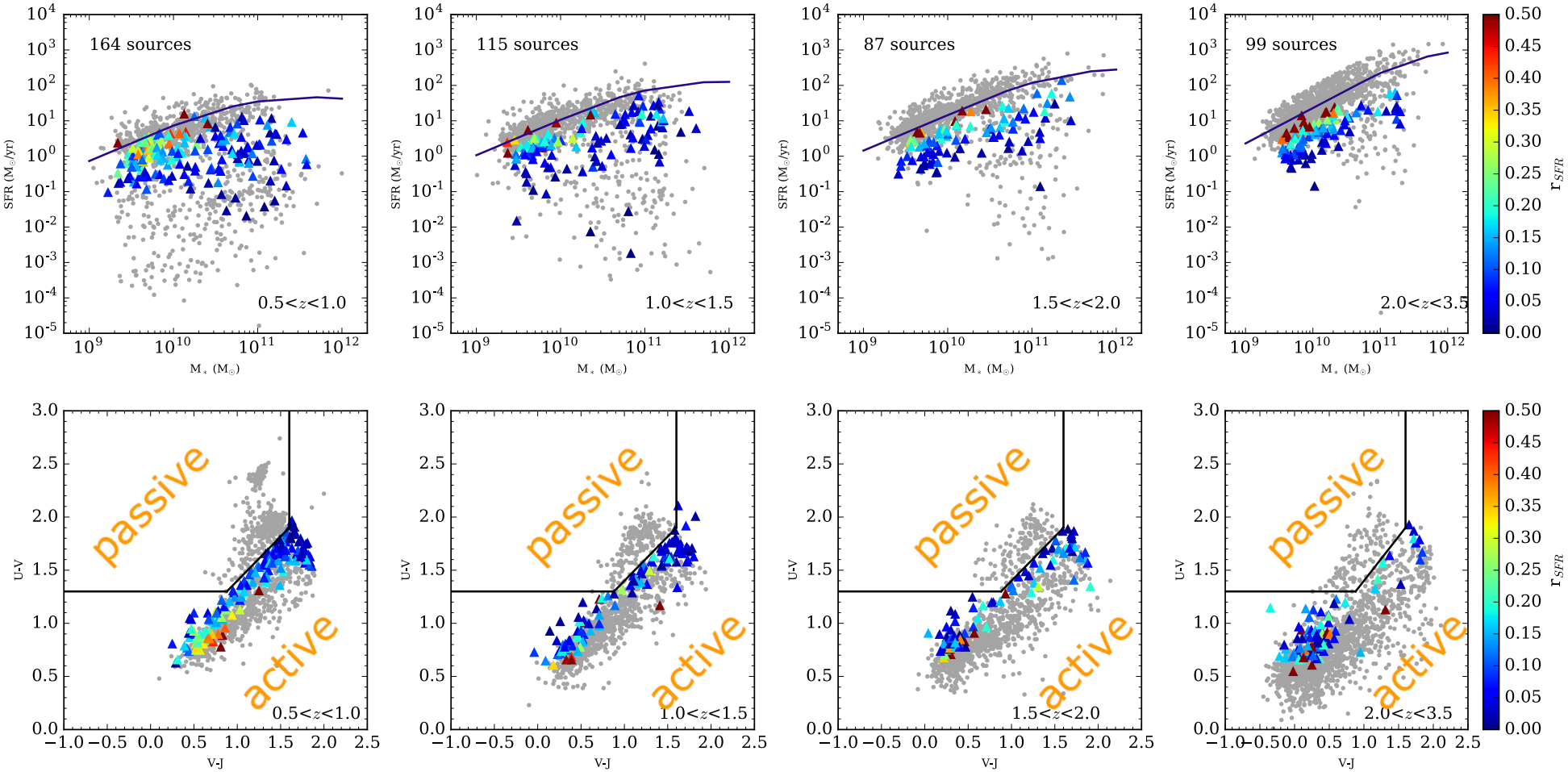
normal

quenched

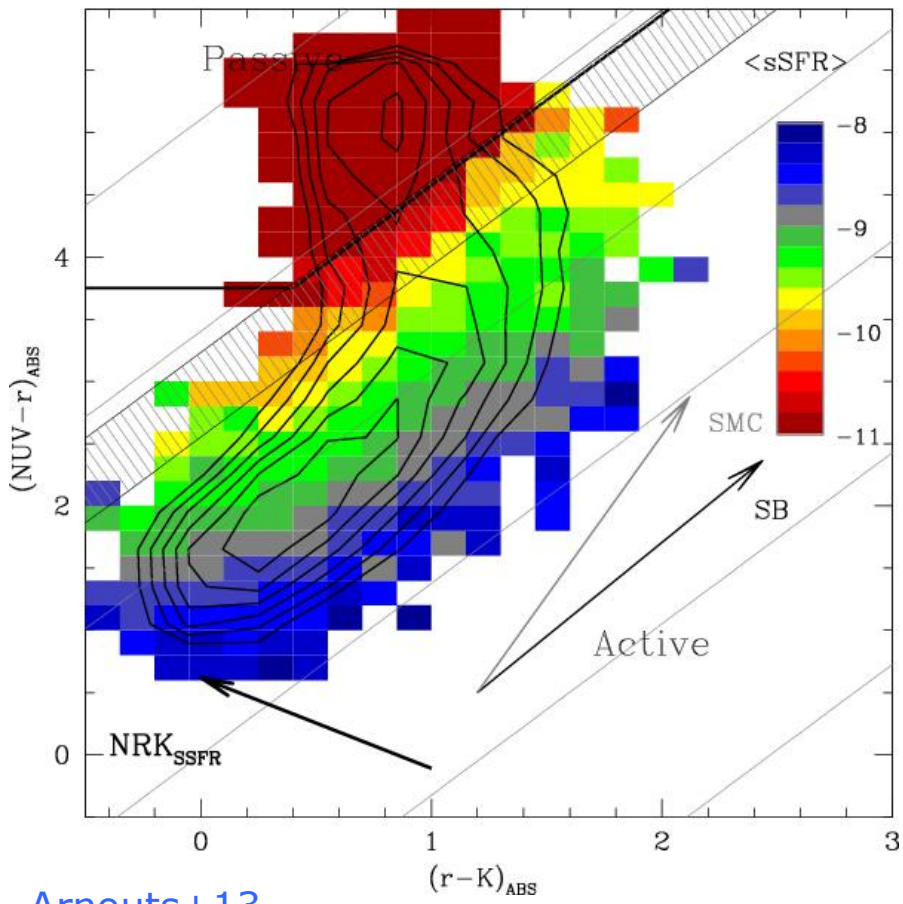


differences in the quality of the fits

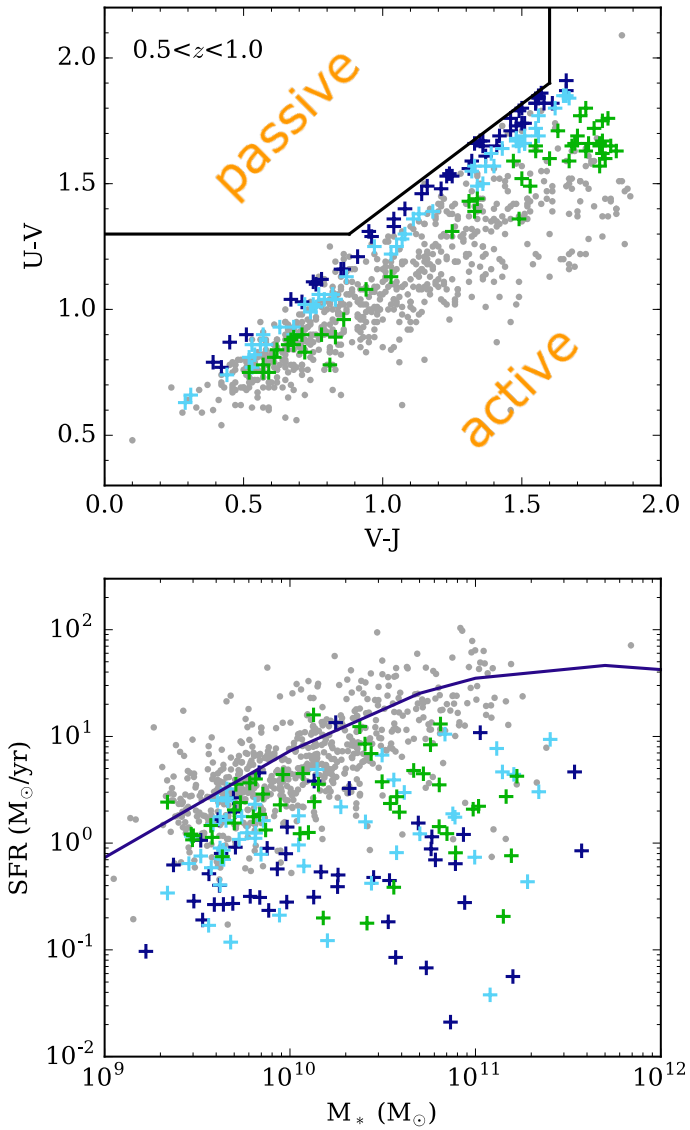
High-z galaxies: location on UVJ and Main Sequence diagrams



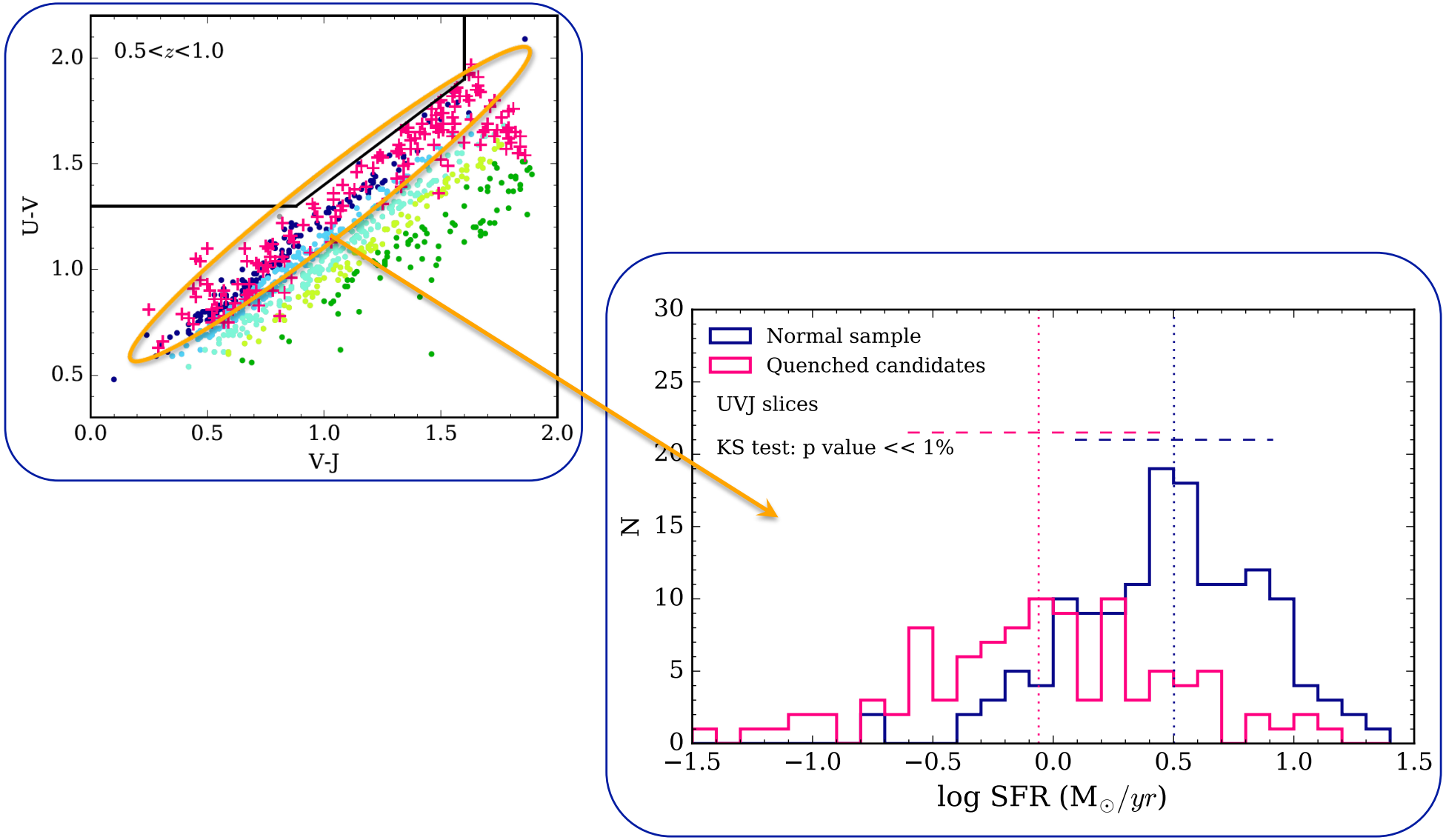
High-z galaxies: location on UVJ and Main Sequence diagrams



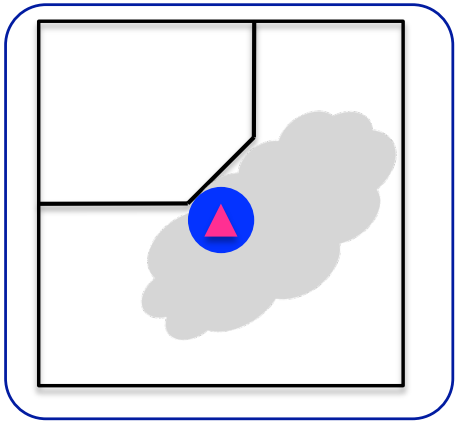
Arnouts+13

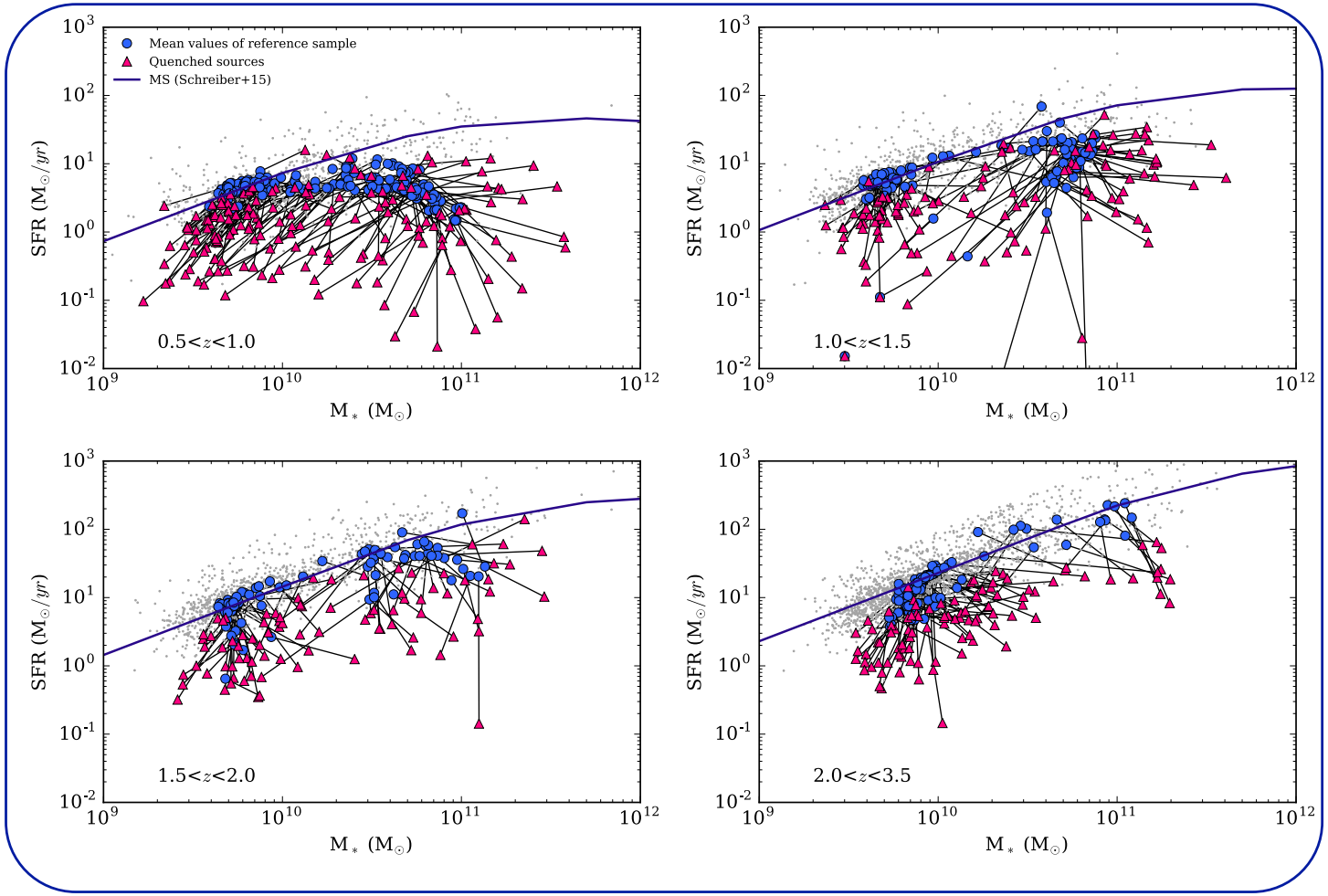


High-z galaxies: location on UVJ and Main Sequence diagrams



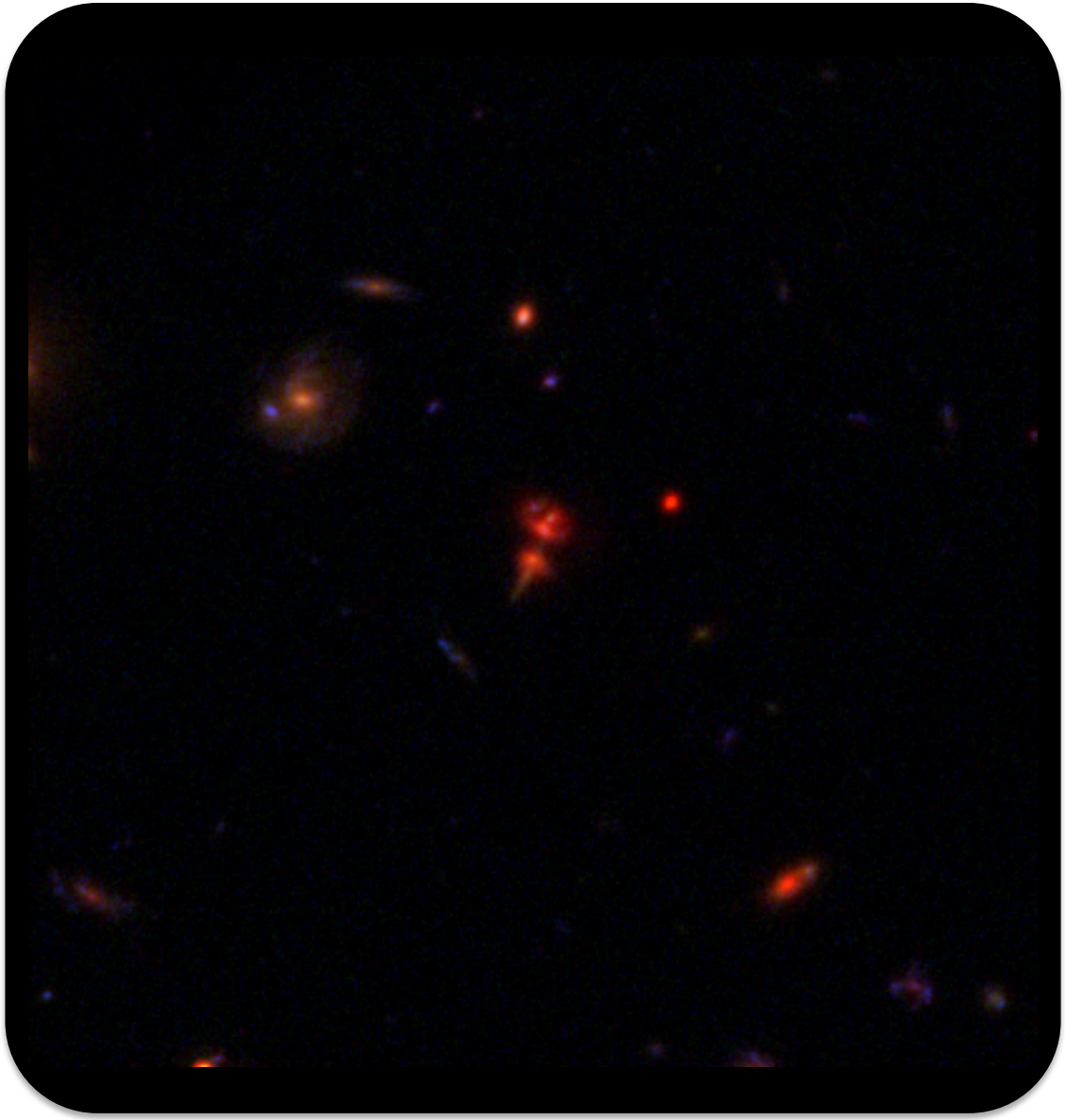
High-z galaxies: location on UVJ and Main Sequence diagrams





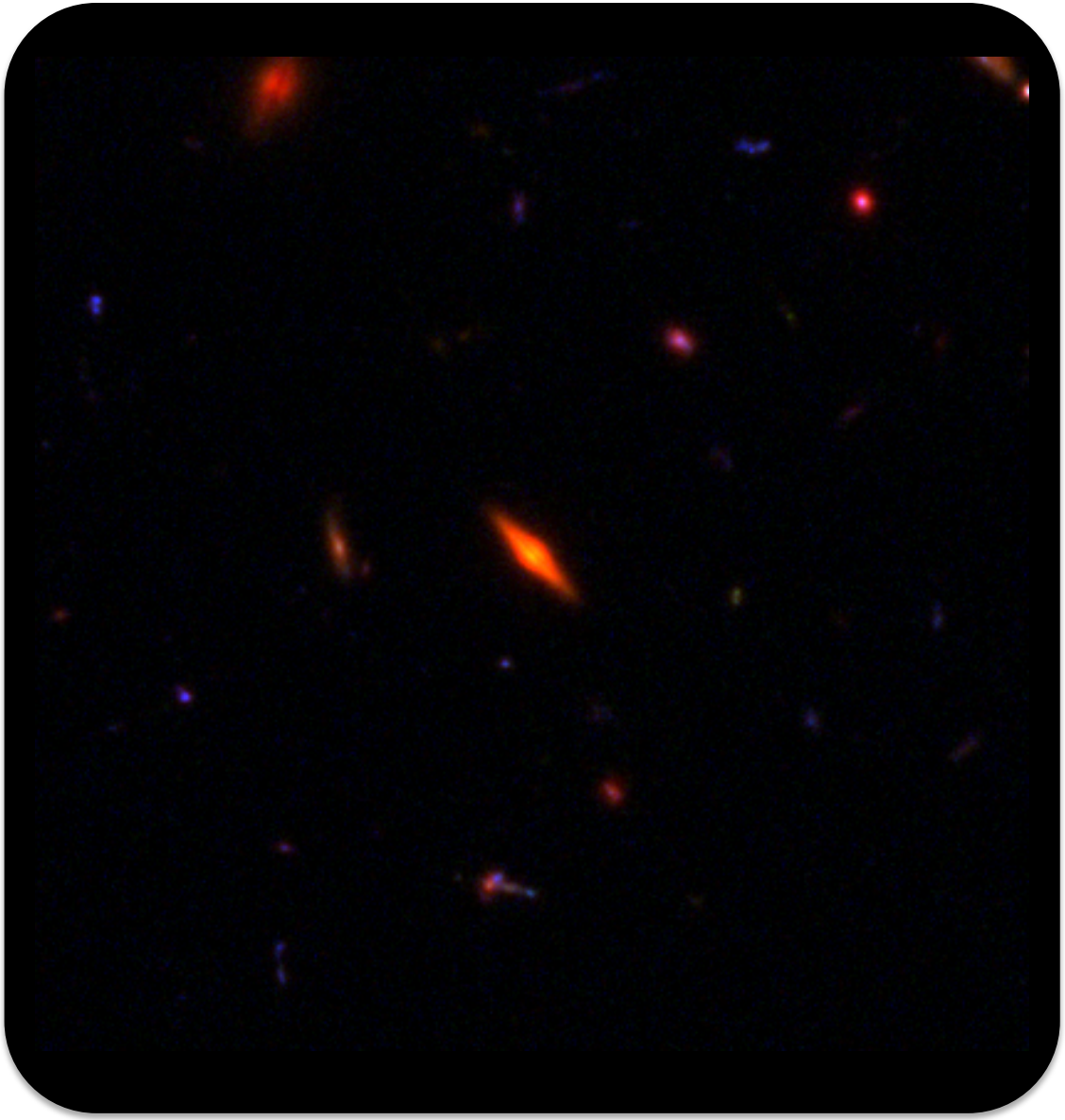
High-z galaxies: how do they look like?

z= 1.46
log M* = 10.4
SFR = 0.98 Msol/yr
r_SFR = 0.02



High-z galaxies: how do they look like?

z= 0.9
log M* = 11.2
SFR = 0.06 Msol/yr
r_SFR = 0.01



High-z galaxies: how do they look like

z= 0.99
log M* = 11.5
SFR = 0.29 Msol/yr
r_SFR = 0.01

Next steps and Conclusions

Next steps are:

Looking at potential role of AGNs

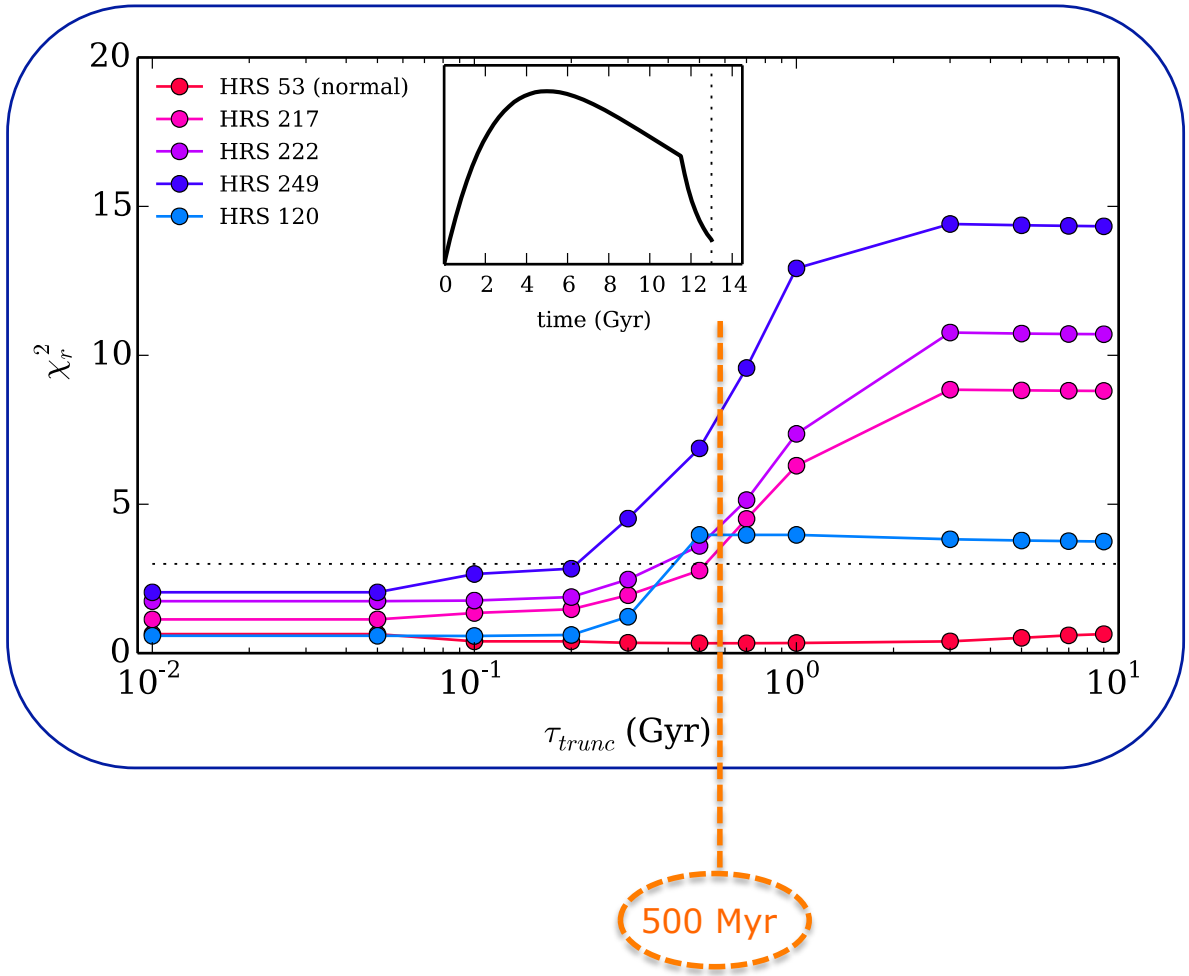
Looking at environment

Studying the gas content of these sources

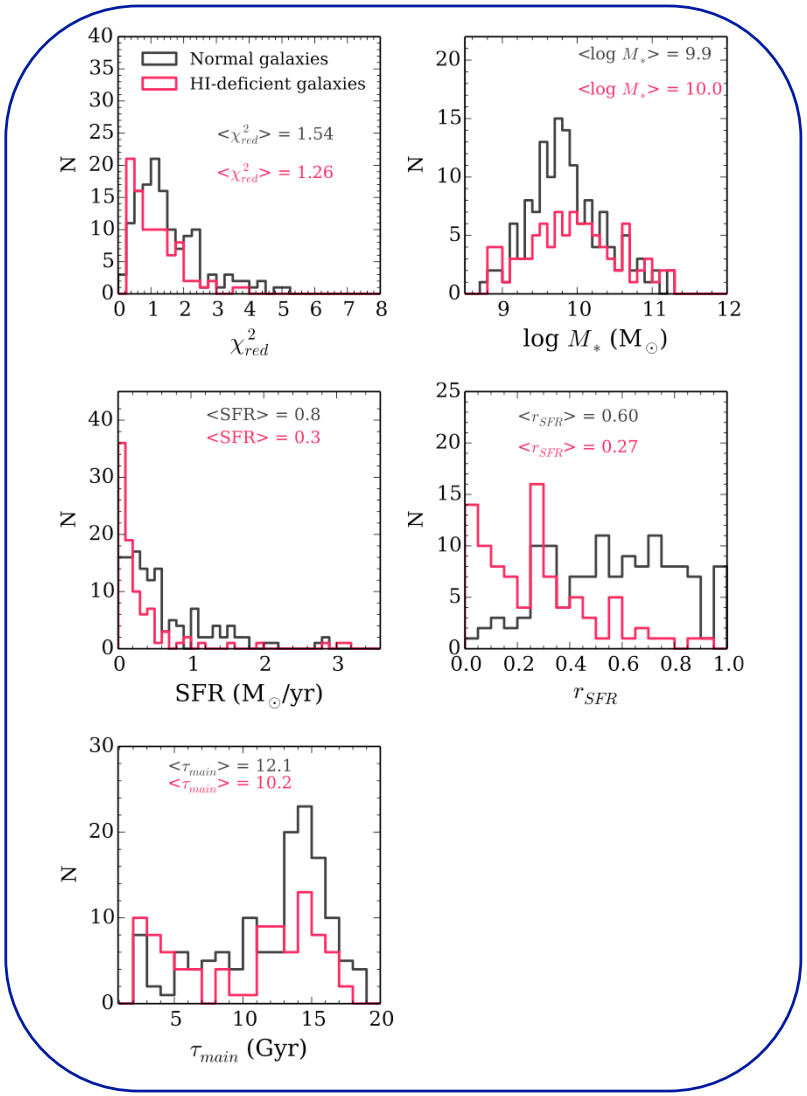
→ Identify the cause(s) of the rapid quenching of these galaxies

- We implemented a new SFH modeling a rapid quenching of the SF.
- The ratio between the SFR after and before the quenching can be constrained as long as UV rest frame data are present. The time when the quenching happened cannot be constrained from broad band SED fitting.
- This SFH was tested on the HRS sample that includes galaxies from the Virgo cluster undergoing ram pressure stripping.
- We showed that these galaxies were lying on the Main Sequence before their SF got quenched by the cluster environment.
- We applied this method on high-z galaxies to identify a sample of quenched sources.

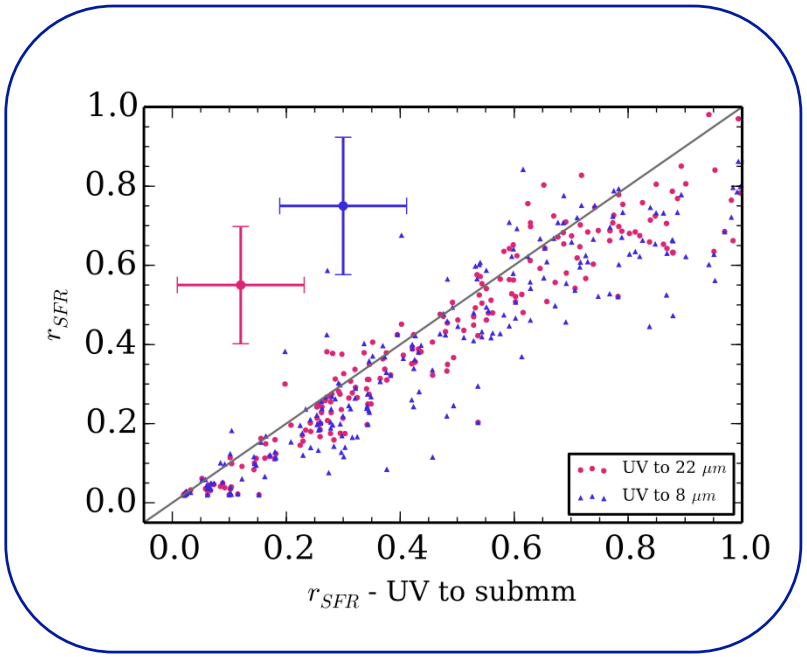
Is an instantaneous quenching a too strong assumption?



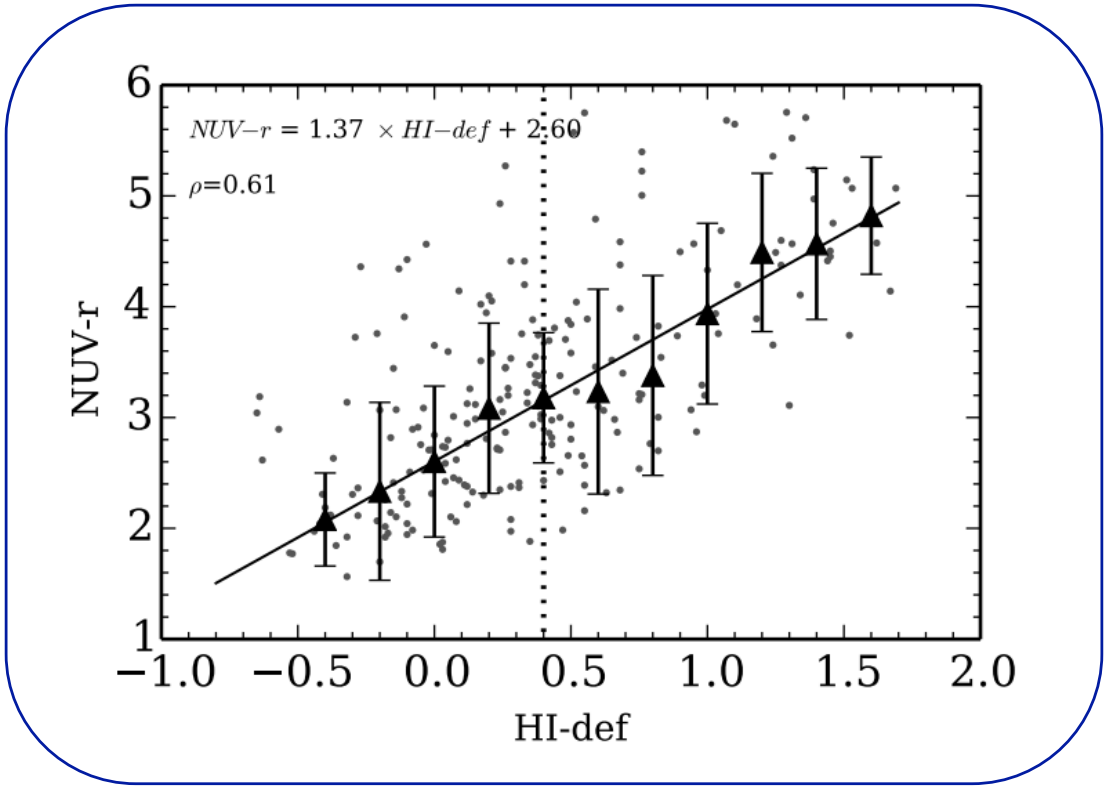
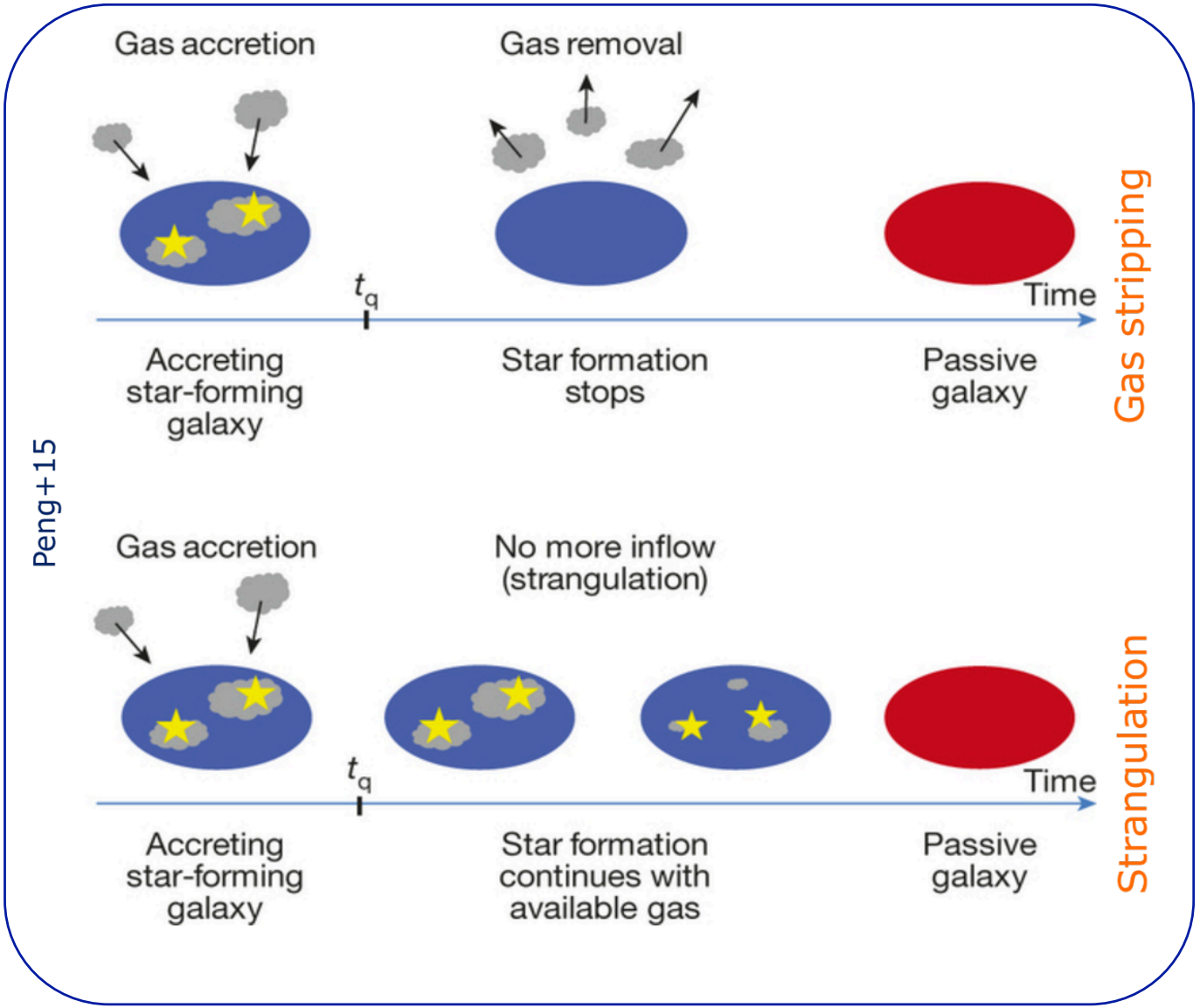
Results of the SED fitting



If no IR data available?



NUV-r vs HI-def



Possible quenching mechanisms