Galaxy components, Star-Formation and Quenching at z~1.7

Chiara Mancini

Dipartimento di Fisica e Astronomia,
Università di Padova, Italy

Co-authors: A. Renzini (Padova observatory, Italy), E. Daddi (CEA, Saclay, France), G. Rodighiero (University of Padova, Italy), S. Berta (MPE, Garching, Germany), N. Grogin (STScI, Baltimore, USA), D. Kocevski (University of Kentucky, USA), A. Koekemoer (STScI, Baltimore, USA)

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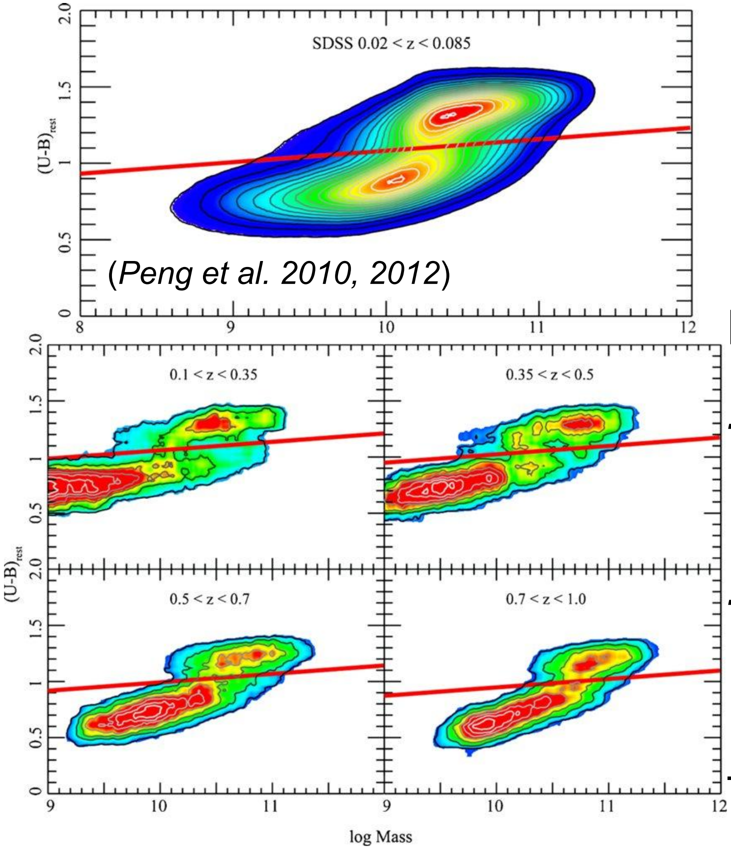
GETTING A GRIP ON GALACTIC GIRTHS

What drives the *quenching* of star-formation?



(*Peng et al. 2010, 2012*)

- *Environment Quenching*
  (more important at z<1)

- *Mass Quenching*
  (Efficient since high-z in the most-massive gal.)

Proposed mechanisms for *Mass-Quenching* :

- ***AGN feedback*** :
  expulsion of the gas or suppression of gas accretion (e.g., *Granato+04*)

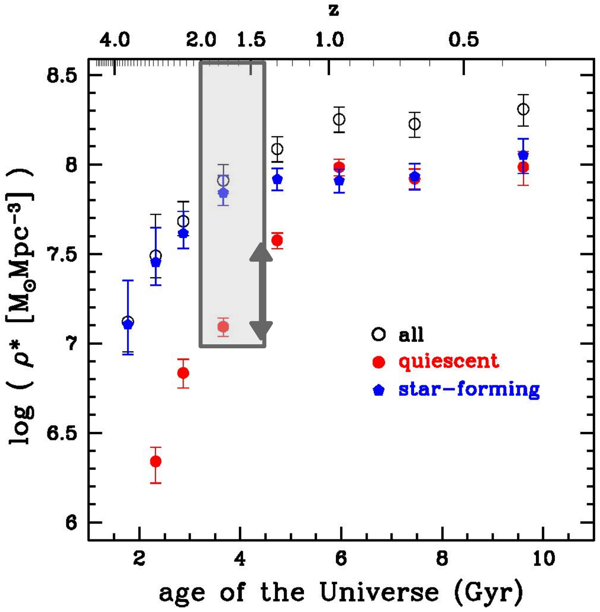
- ***Halo Quenching*** :
  circumgalactic gas is shock-heated to high temperatures above a critical $\mathbf{M_H}$(~$10^{12}M_\odot$,*Birinboim & Dekel+03*)

- ***Morphological/Gravitational Quenching***:
  growth of a central bulge stabilize the disc against fragmentation and preventing formation of clumps (*Martig+09*)

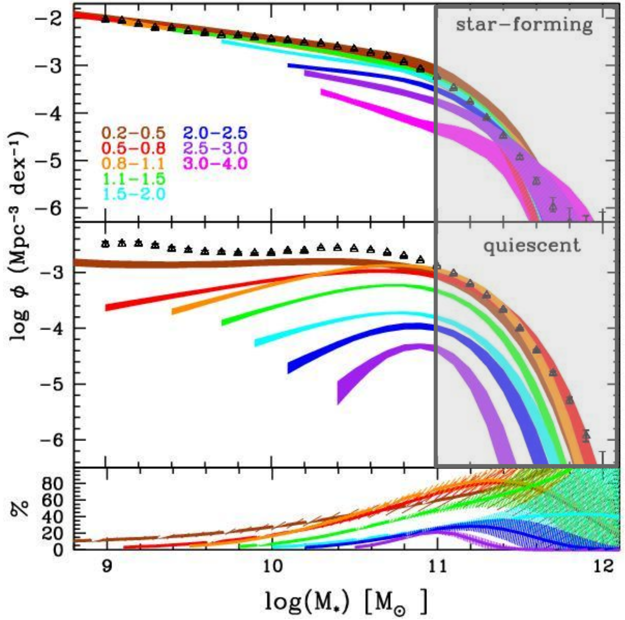
Investigating cause & effect of Mass-Quenching

sample: 56 galaxies in GOODS-South

Redshift range in which Mass-Quenching started to be very efficient ($1.4<z<2$) and the Environment-Quenching should be still “negligible”



The high-mass end of the mass function ($M^* \geq 10^{11}{}_{\odot}$ Salpeter IMF)



Ilbert et al. (2013)

Main goals

- Unambiguously distinguish between ***galaxies forming stars at a MS rate***, ***quenched***, or with a ***lower sSFR*** w.r.t. normal MS galaxies

- Search for objects ***in a transient phase*** from star-forming to quenched

- Study the ***morphology*** (size $R_{e,circ}$, Sèrsic n, galaxy components, B/T ratio), ***stellar population***, and ***AGN activity,*** and their interconnection among them and with the ***quenching of star-formation***

OUTLINE

- Data - Sample selection
- Sub-classes based on colors and sSFR
- Morphology: SB fitting (single-Sèrsic(+PSF), B+D(+PSF)
- Morphology for AGNs
- Conclusions

DATA (GOODS-South)

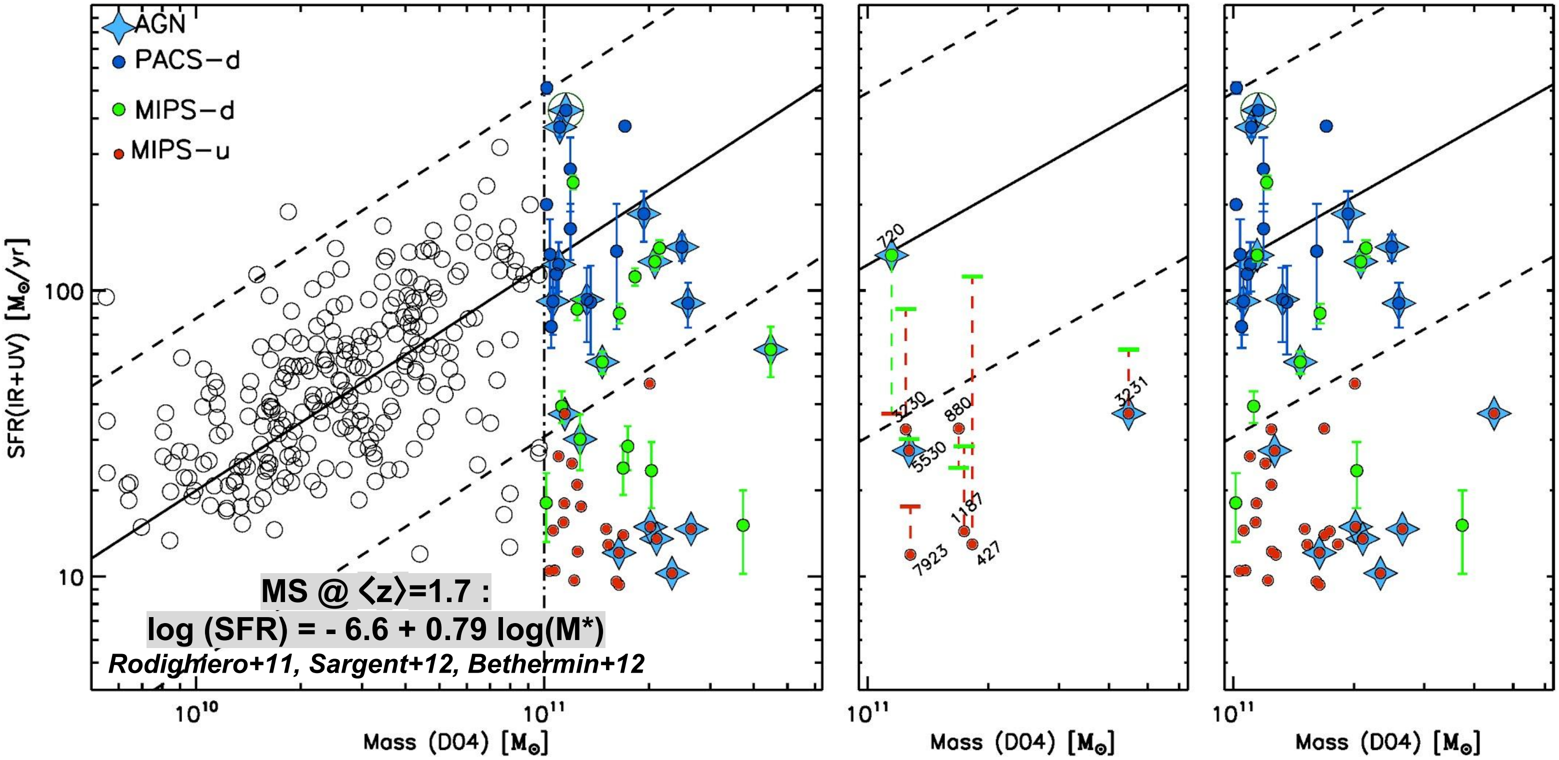
- K-selected (K_{Vega}< 22) multi-band catalog (*Daddi+07b*)
- CANDELS WFC3/HST F160W image mosaic (*Grogin+11*, *Koekemoer+11*)
- MIPS/24μm image (*Rieke+04*) and catalog (*Daddi et al. in prep.*)
- H-GOODS/HerMES, *Herschel* PACS, SPIRE catalogs (*Elbaz+11*,*Oliver+10*)
- *Chandra* Deep Field South (CDF-S) 4Ms catalog (*Xue+11*)
- complementary data from *the GOODS Treasury Program* (*Giavalisco+04*)
- GOODS-MUSIC photo-z catalog ($\Delta z/(1+z) \approx 0.03$ at $z < 2$; *Grazian+06, +07*)
- GOODS, GMASS spec-z (*Vanzella+05, Cimatti+08, Popesso+09, Kurk+13*)

Sample selection: 56 galaxies (30 zspec)

$M^* \gtrsim 10^{11} M_\odot$ (Salpeter IMF) , $1.4 \lesssim z_{(phot/spec)} \lesssim 2$

M*-SFR relation

MIPS-deblending ➞spurious star-forming galaxies below the MS



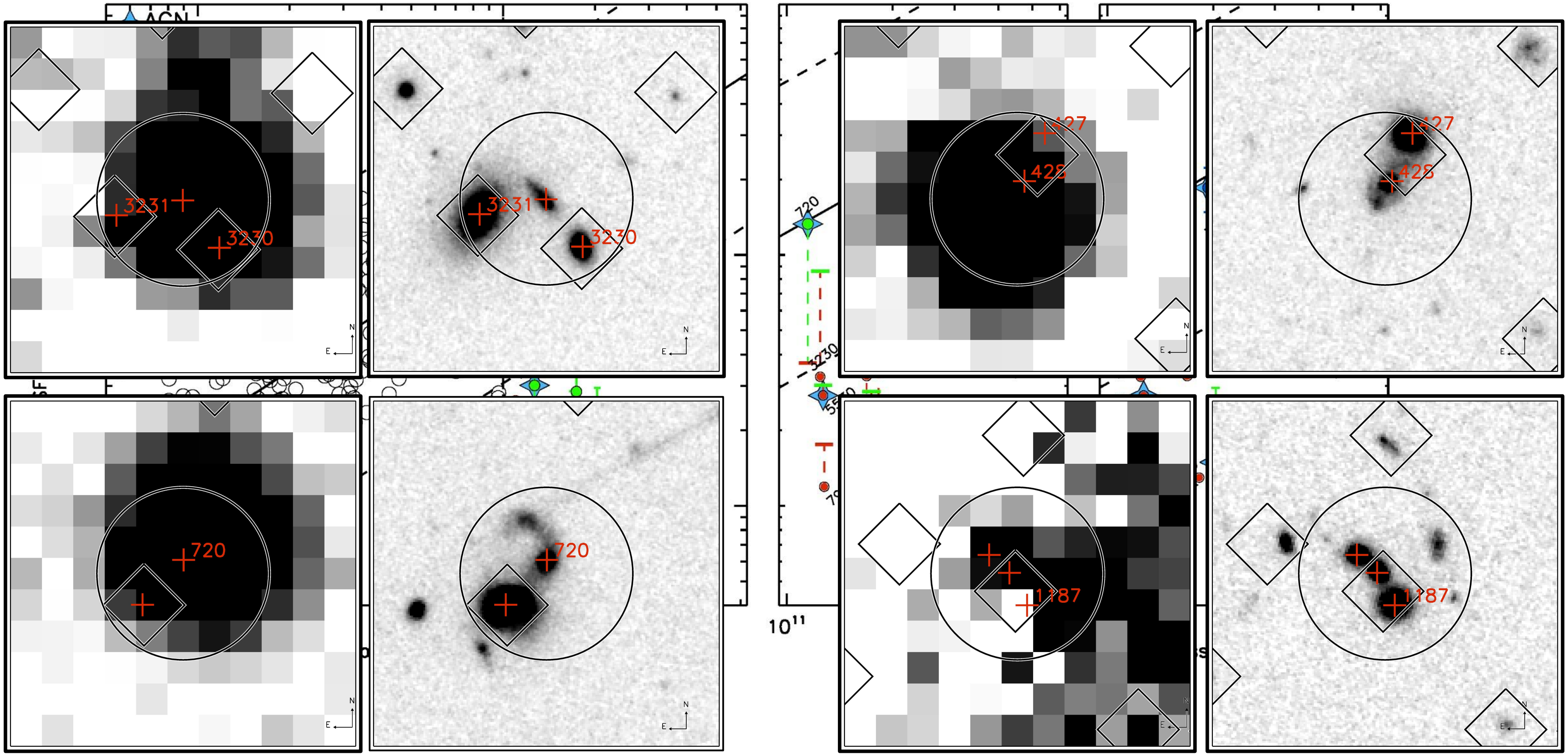
M* (Stellar Mass) *Daddi+04 K-Mass relation*

SFR =SFR(IR)+SFR(UV) *Kennicutt+98* : {SFR(UV)-> L1500 rest-frame
SFR(IR) ->total LIR derived from IR SEDs

(*Mancini et al. 2015, subm.*)

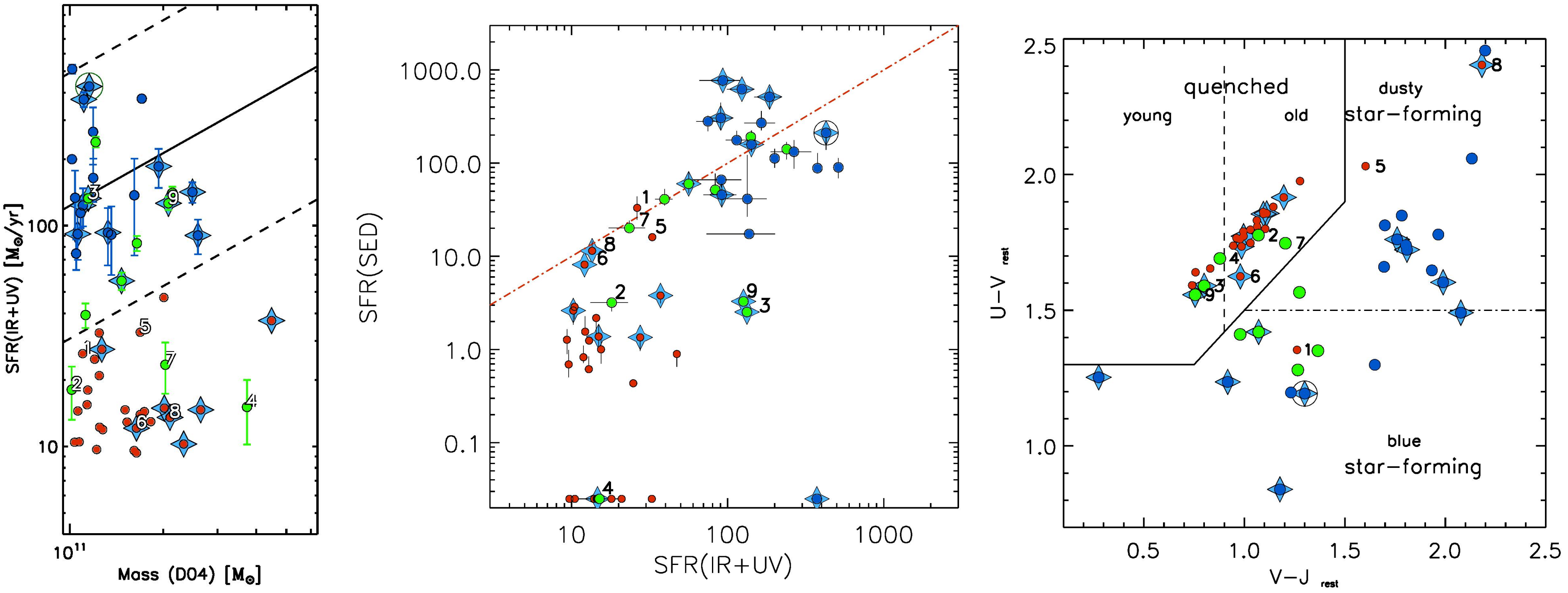
M*-SFR relation

MIPS-deblending ➝spurious star-forming galaxies below the MS



SED fitting and two-color diagrams

Constraining SFR for galaxies below the MS (i.e., MIPS/24μm-undetected or S/N≈3)



Summary: source classification

$\log(sSFR / sSFR_{MS})$ = dist. from the MS @ ⟨z⟩= 1.7

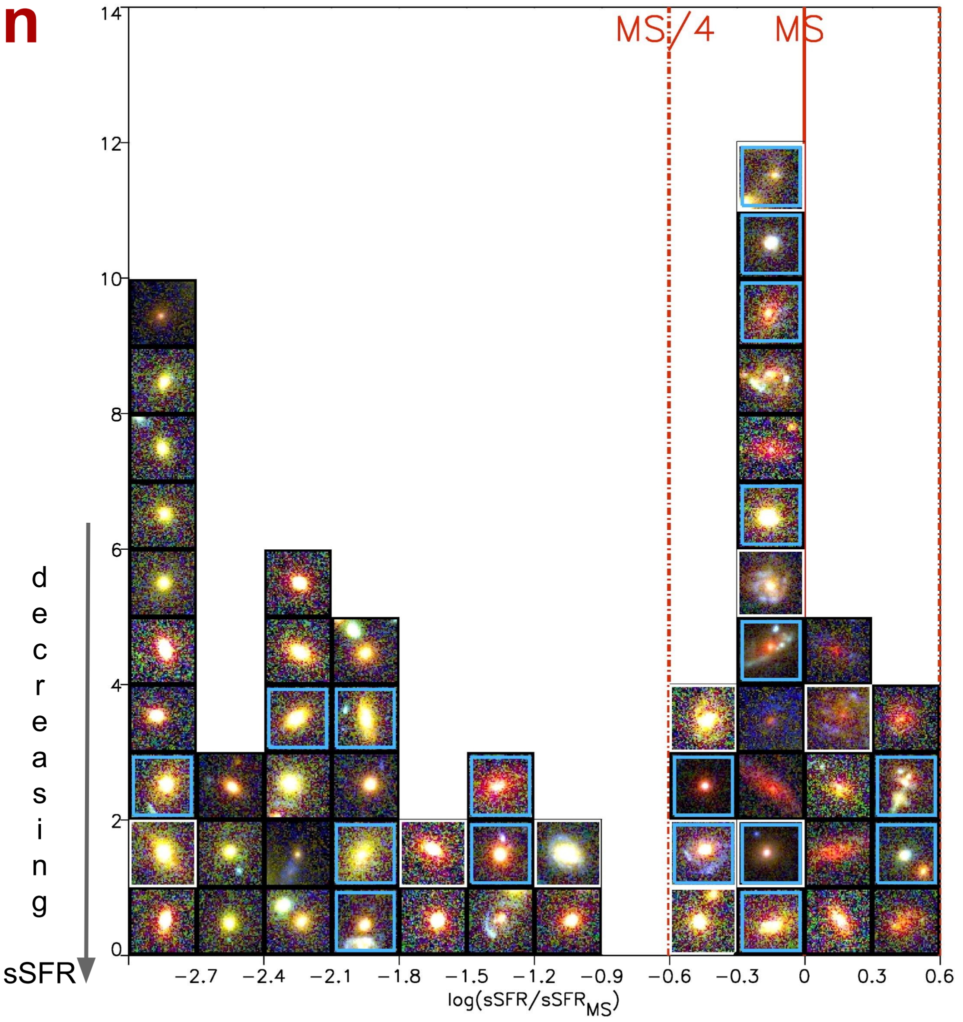
$sSFR_{MS} = 1.24 \times (M^*/10^{11} M_\odot)^{-0.21}\ Gyr^{-1}$
(*Bethermin+12*)

- *Transient quenching* objects ?
  Not a well defined class in our sample:
  SFGs below the MS are already quenched

- 31/56 (~55%) quenched galaxies
  $sSFR < 10^{-10}\ yr^{-1}$ <10 x the MS avg. value
  for ⟨M*⟩ =1.5 x$10^{11}\ M_\odot$ $M_{doubl\text{-}time}$ >9 Gyr

- 25/56 (~45%) MS galaxies
  $10^{-9.5}\ yr^{-1} < sSFR < 10^{-8.3}\ yr^{-1}$
  for ⟨M*⟩=1.5x$10^{11} M_\odot$ 0.2 Gyr < $M_{doubl\text{-}time}$ < 3.5 Gyr

- 18/56 (~32%) X-ray detected AGN:
  (cyan frames: 11 in MS, 7 in quenched galaxies)



Single-Sèrsic models (*n* free-parameter)

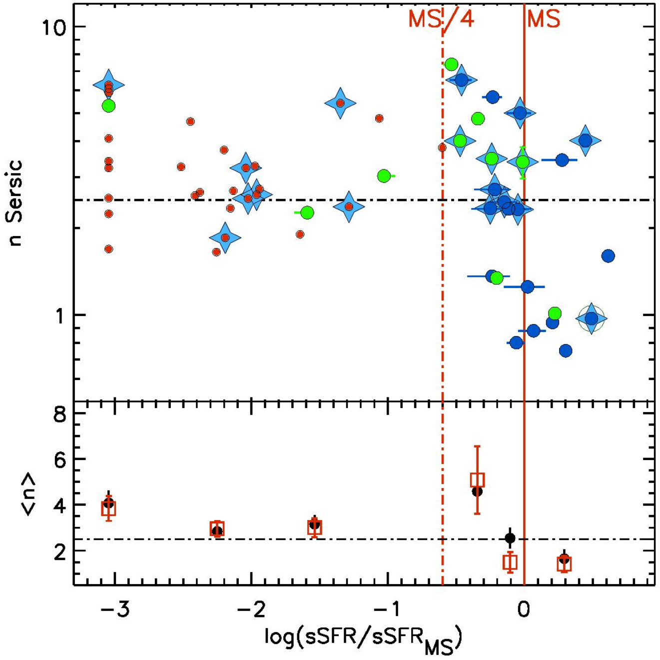
(Galfit v.3.0, *C. Peng+10*)

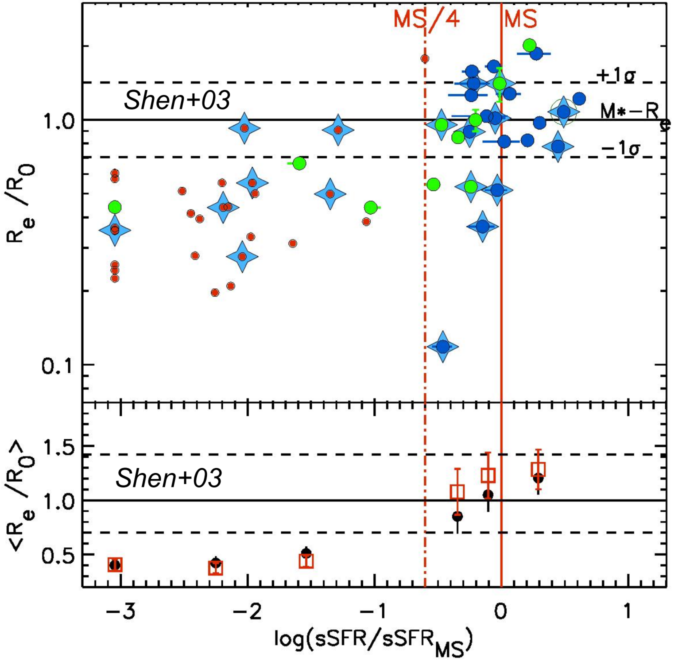
MS:

- n≳2.5 ~45% (7/11 AGN)
- n<2.5 ~55% (3(+1?)/14 AGN)
- R_e/R_0<0.7 : 20% (4/5 AGN)

sub-MS:

- n≳2.5 ~75% (5/21 AGN)
- n<2.5 ~25% (2/8 AGN)
- R_e/R_0<0.7~90%(5/28 AGN)





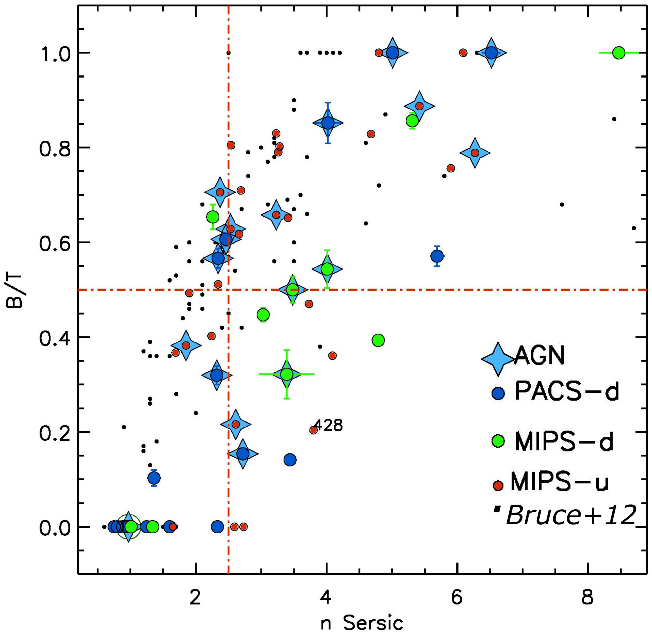
***n* index**: quenched galaxies → “Early-Type morphology”(n>2.5) , MS→ 2 groups, AGN host→ n>2.5
Size : quenched galaxies→compact , but **only 5/25 MS “blue-nuggets”**

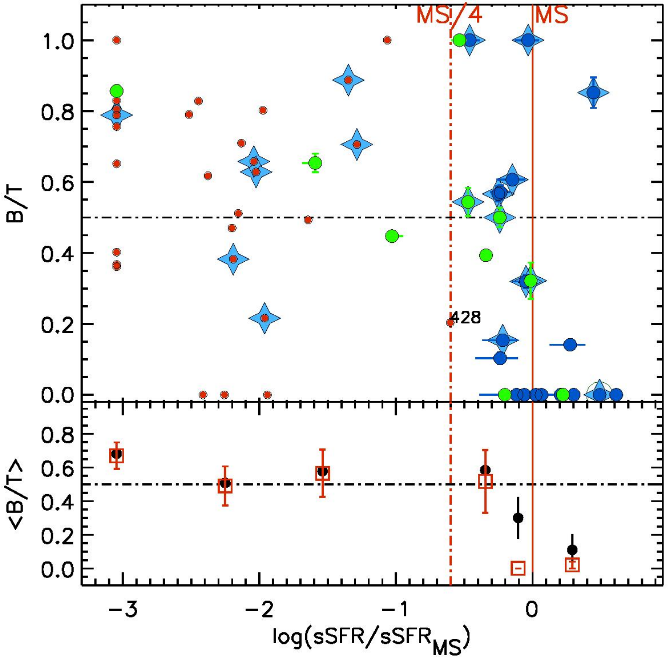
2 component models: Bulge(n=4) + Disc(n=1)

B/T *vs* n:
- B/T<0.5 & n>2.5: point-source
- B/T>0.5 & n<2.5 : 2<n<2.5 only

MS:
- B/T>0.5 ~36% (7/9 AGN)
- 0.3<B/T<0.5 ~12% (2/3 AGN)
- B/T<0.3 ~52% (1(+1?)/13 AGN)

sub-MS:
- B/T>0.5 ~61% (5/19 AGN)
- 0.3<B/T<0.5 ~16%(1/7 AGN)
- B/T<0.3 ~23% (1/5 AGN)





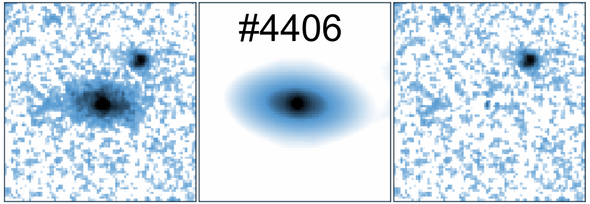
Note*:* unreliable components : R_e>4",R_e<0.03",b/a<0.1 ⇨contribution <10%
- 15/56 simple discs + 3 irregular ⇨ B/T=0
- 5/56 simple bulge ⇨ B/T=1

Summary: Morphology

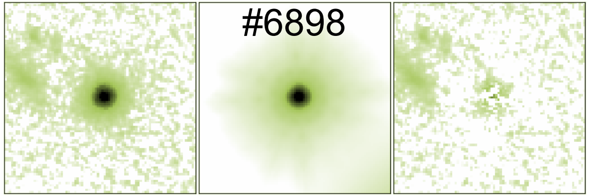
MS

B/T<0.3 DISC-DOMINATED

40 %



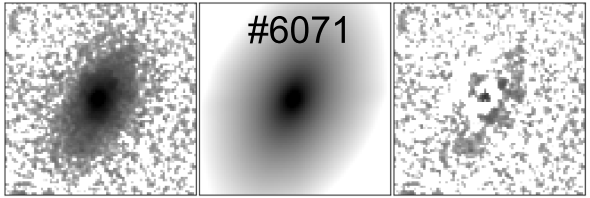
B/T>0.5 BULGE-DOMINATED



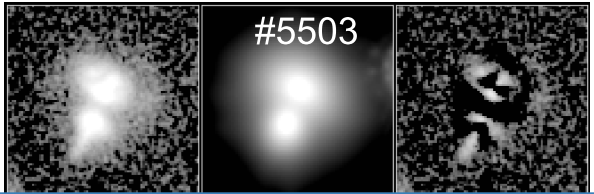
36 %

0.3<B/T<0.5 BULGE + DISC

12 %



GAL. IRREGULAR (mergers)

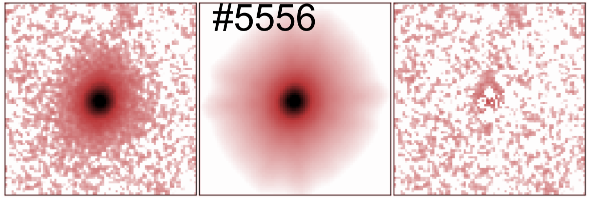


12 %

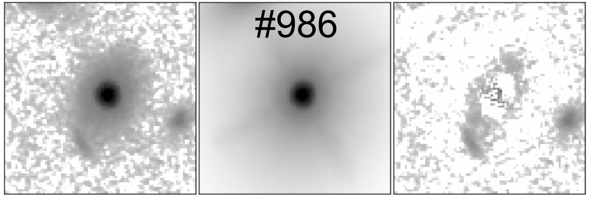
sub-MS

SUB-MS B/T>0.5 BULGE-DOMINATED

61 %



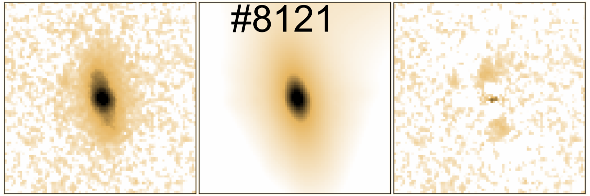
SUB-MS 0.3<B/T<0.5 BULGE + DISC

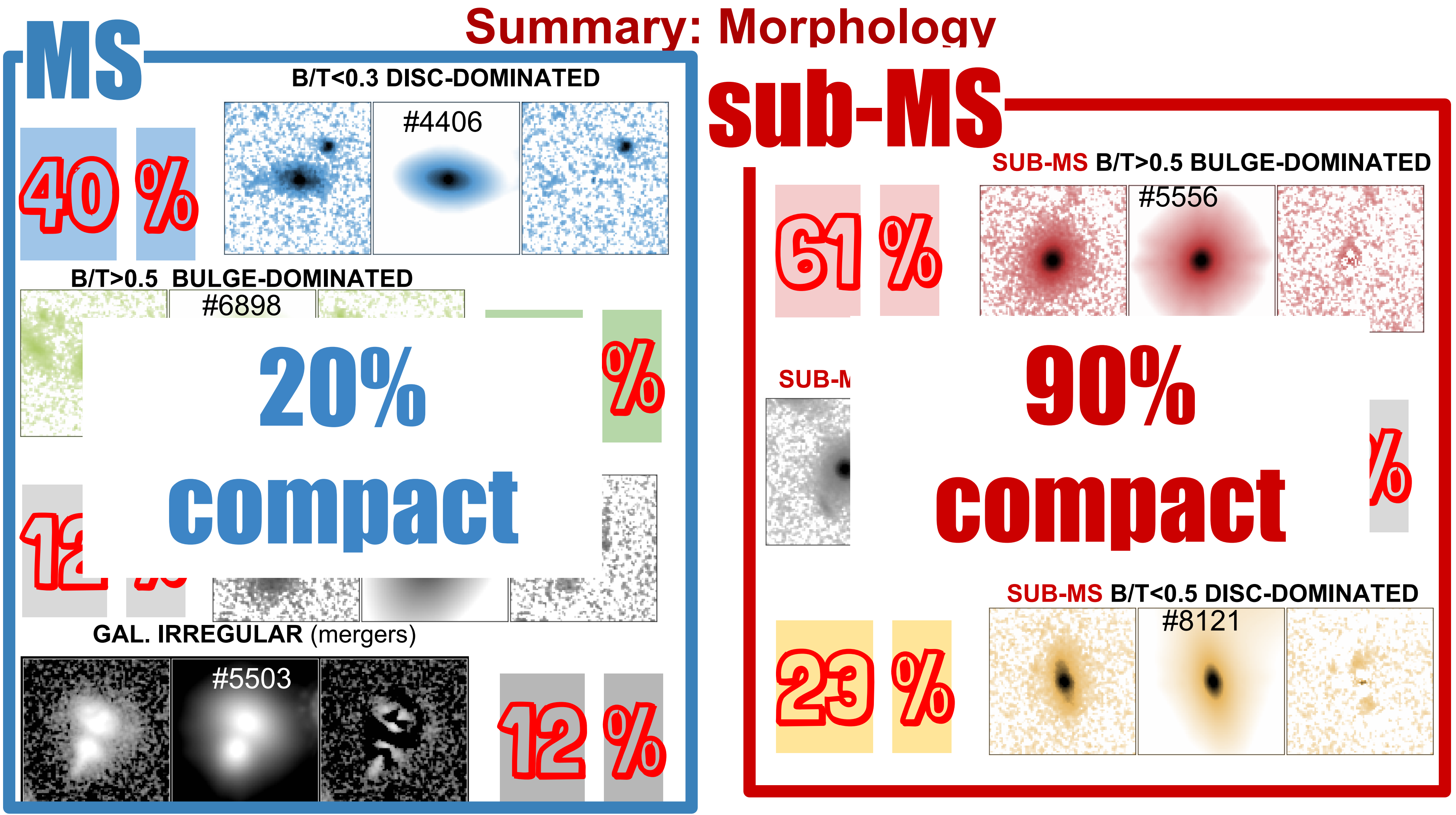


16 %

SUB-MS B/T<0.5 DISC-DOMINATED

23 %




Summary: Morphology
MS
B/T<0.3 DISC-DOMINATED
40 %
#4406
B/T>0.5 BULGE-DOMINATED
#6898
20%
compact
%
GAL. IRREGULAR (mergers)
#5503
12 %
sub-MS
SUB-MS B/T>0.5 BULGE-DOMINATED
61 %
#5556
90%
compact
SUB-MS B/T<0.5 DISC-DOMINATED
23 %
#8121

Morphology of AGN host galaxies

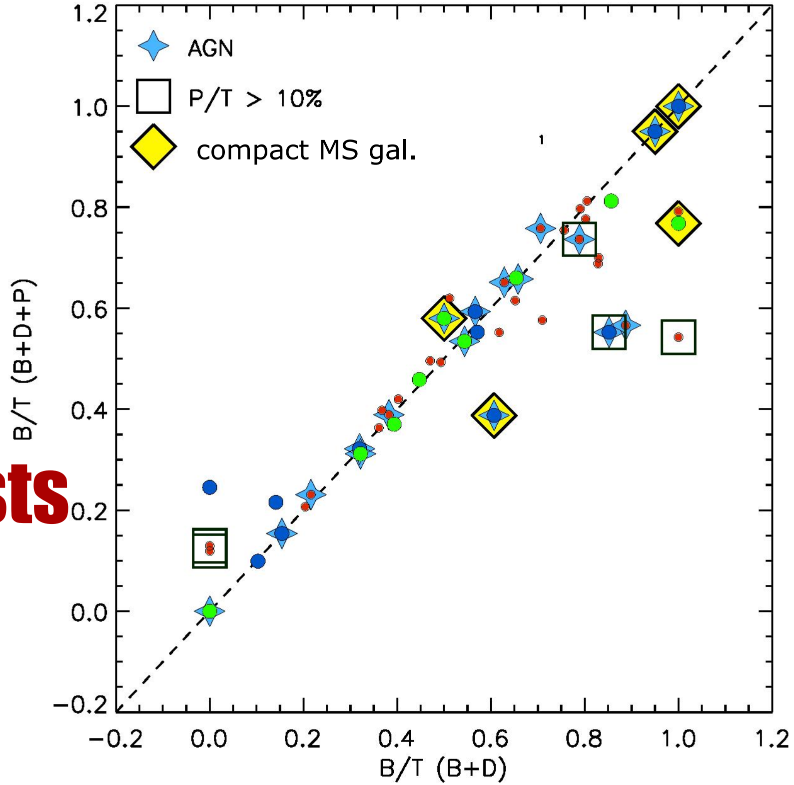
Does the AGN affect the results of SB fitting ?

~80% of the AGN (MS+sub-MS)→ B/T≳0.3

10(+1?) MS-AGN : { 9 B/T>0.3, 1(+1) B/T<0.3
4 compact, 7 normal-size

7 Quenched AGN host : { 6 B/T>0.3, 1 B/T<0.3
5 compact, 2 normal-size

Bulge to total ratio:
B/T(B+D+P) *vs* B/T(B+D)



Real Bulge component in AGN hosts

cf. also
Barro+12,+14 : ~47% of cSFGs host an AGN
Rosario+15: AGN at z~2 → red central light enhancement

Summary and Conclusions

- Sample of **56 $M^* > 10^{11}{}_{\odot}$ @ z~1.7** in GOODS-S: (25) **~45%** on **MS**, (31) **~55% Quenched** (sSFR<10^{-10} yr^{-1})
- **Deconfusion in mid-IR** using HST prior position **crucial to identify "*quenching*" galaxies** (i.e., frac. MIPS-blended sources ~12% but 100% of the *quenching* candidates)
- No star-forming galaxies below the MS ⇢ Fast (<1 Gyr) quenching process for $M^* > 10^{11}{}_{\odot}$ galaxies?
- **MS galaxies** morphology:
  ~20% compact and ~80% normal-size (average R_e comparable with local ETGs)
  ~50% with a relevant bulge (B/T >0.3) ⇢ **inside-out quenching mechanism** (cf., *Tacchella+14, in press, Lang+14*)
- **Quenched galaxies** morphology:
  ~ 90% compact (R$_e$ on average 2.5x smaller than local ETGs)
  ~ 80% with a relevant bulge (B/T >0.3) and **~20% disc-dominated**
- **~32% of AGN in the sample**, both in **MS (~20%)** and in **quenched galaxies (~12%)**
  of which 80% show B/T >0.3 ⇢ co-evolution, towards the local M_{Bulge}- M_{BH} relation (*Magorrian+98*)
  ⇢ **connection between AGN, Bulge growth, and Quenching**

(Ref. : *Mancini et al. 2015, submitted to MNRAS*)

Thanks!
ありがとう!

OPEN QUESTIONS

- **Quenching and progenitors of high-z compact ETGs:**
  - What drives the quenching of star-formation?
  - Do high-z compact galaxies born compact? or are cSFGs an intermediate phase between large SFGs and compact ETGs (*Dekel & Bukert+14, Barro+14*)?
  - If the "*mass-quenching*" of star-formation at high-z is linked to the bulge growth (cf., this work, Tacchella+14, Lang+14, Barro+14), what about the high-z quiescent compact discs?
  - Which is the quenching timescale? Is it related to the galaxy size (compactness)?

- **Evolution of the M*-size relation of ETGs :** evolution of single galaxies + addition of larger newly quenched galaxies ? Can we establish the relative contribution of these two factors ?