Investigating galaxy evolution with a multi-wavelength approach

An UV view of galaxies in nearby groups

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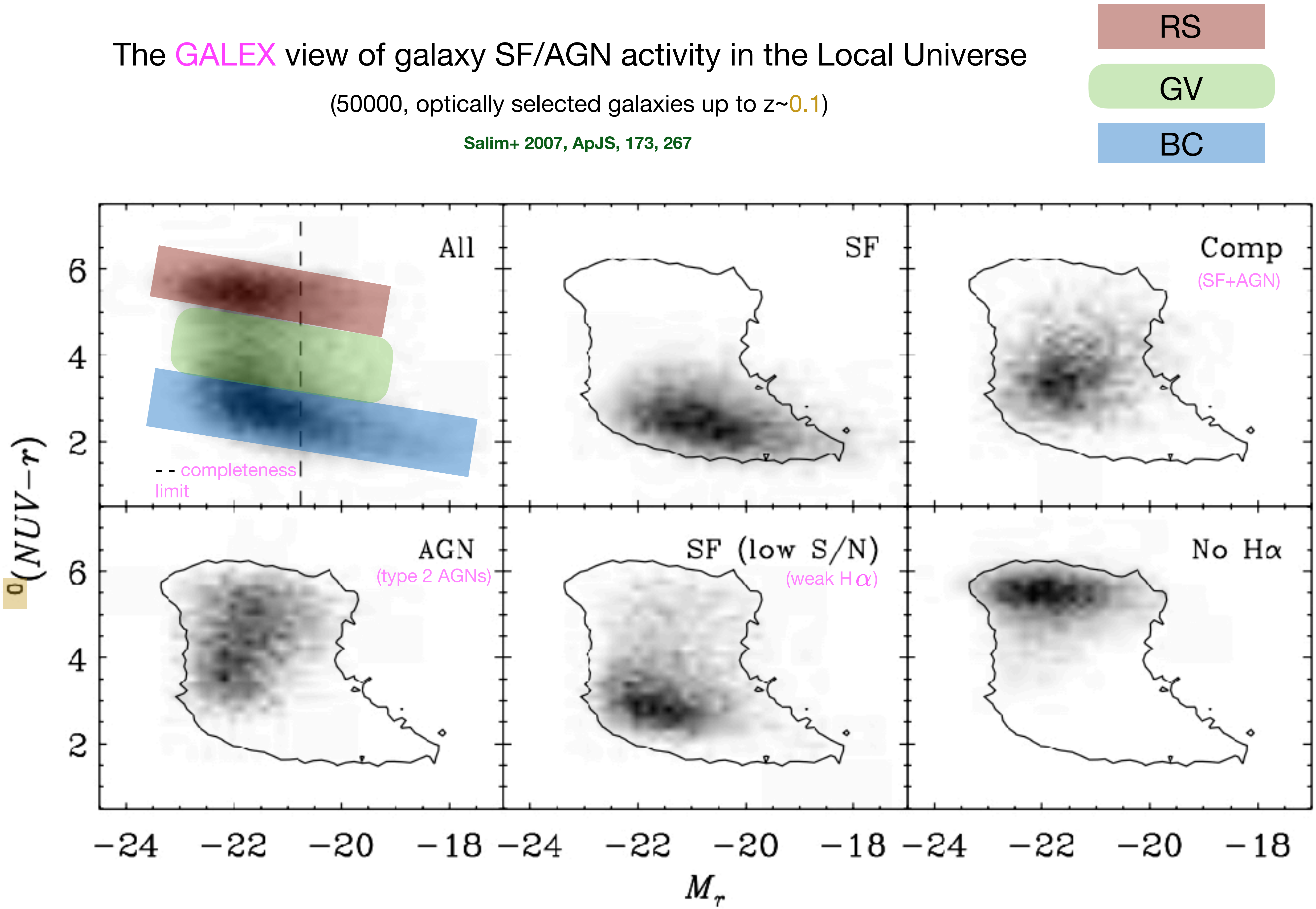
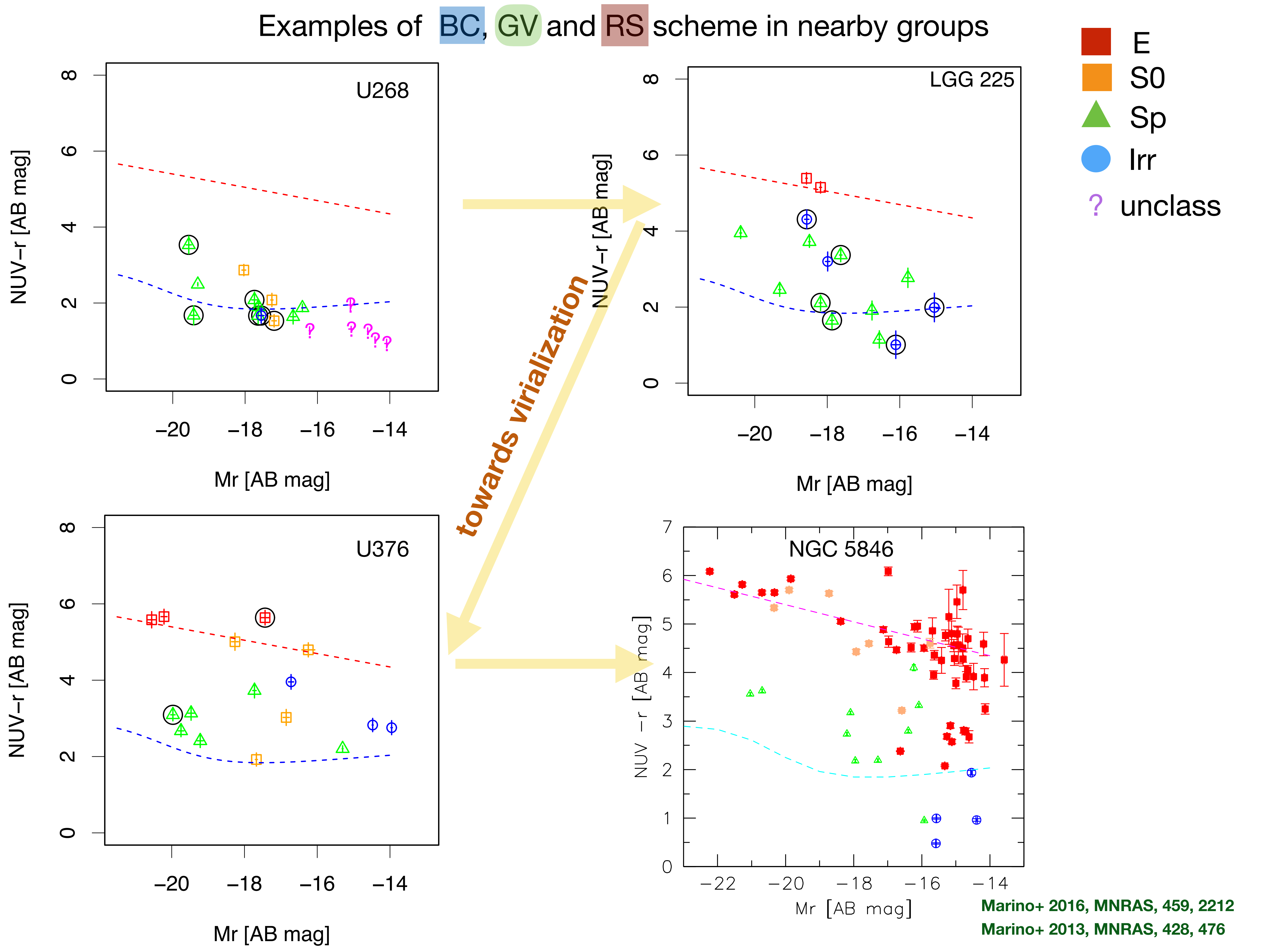
GEE-5
Galaxy evolution and environment: observations meet simulations and theory
Arcetri November 15, 2017

The GALEX view of galaxy SF/AGN activity in the Local Universe

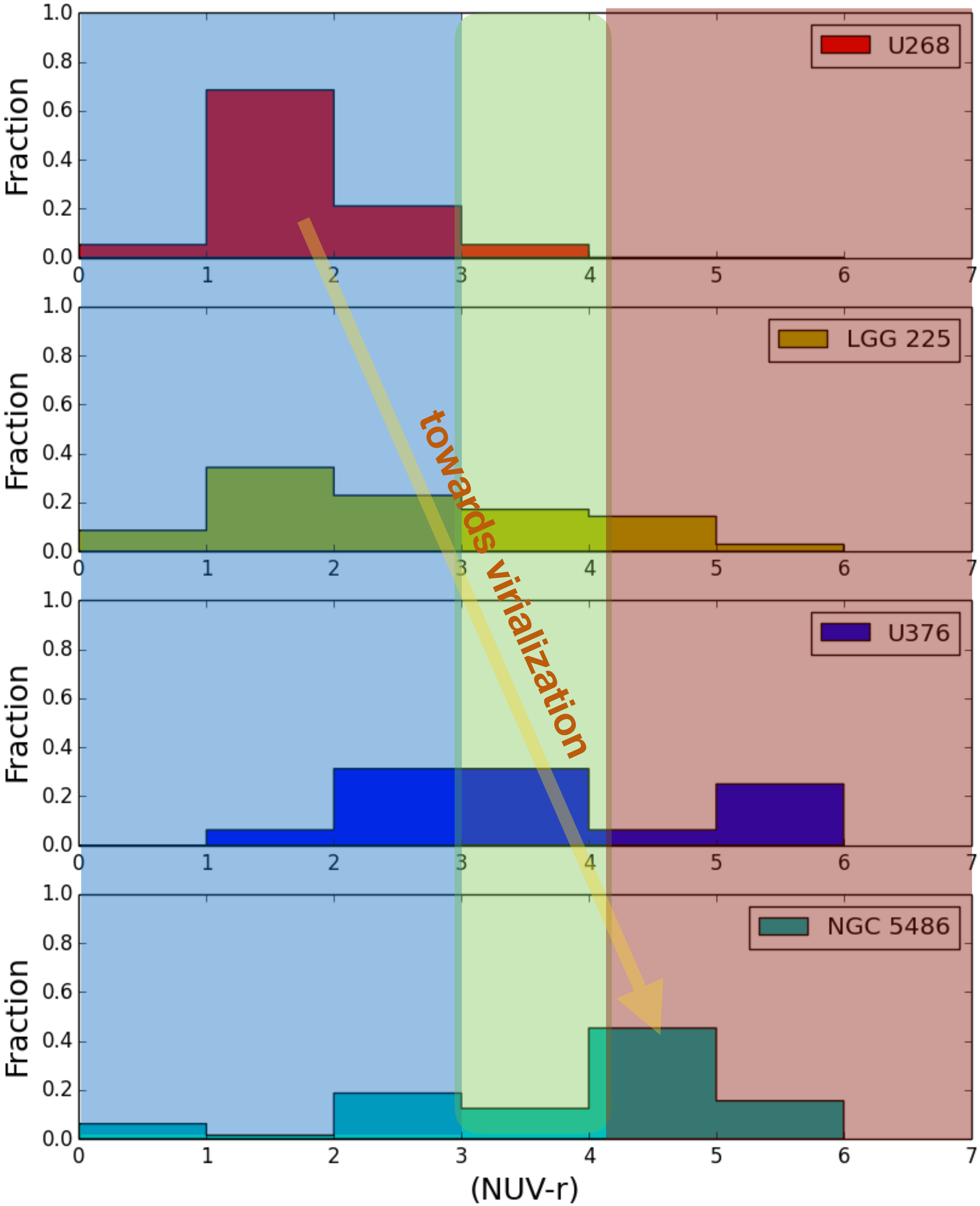
(50000, optically selected galaxies up to z~0.1)

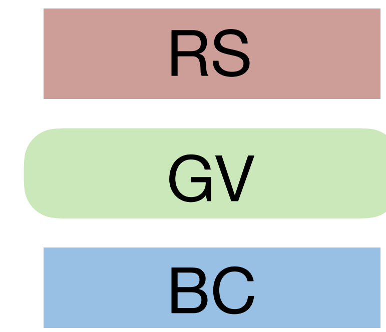
Salim+ 2007, ApJS, 173, 267





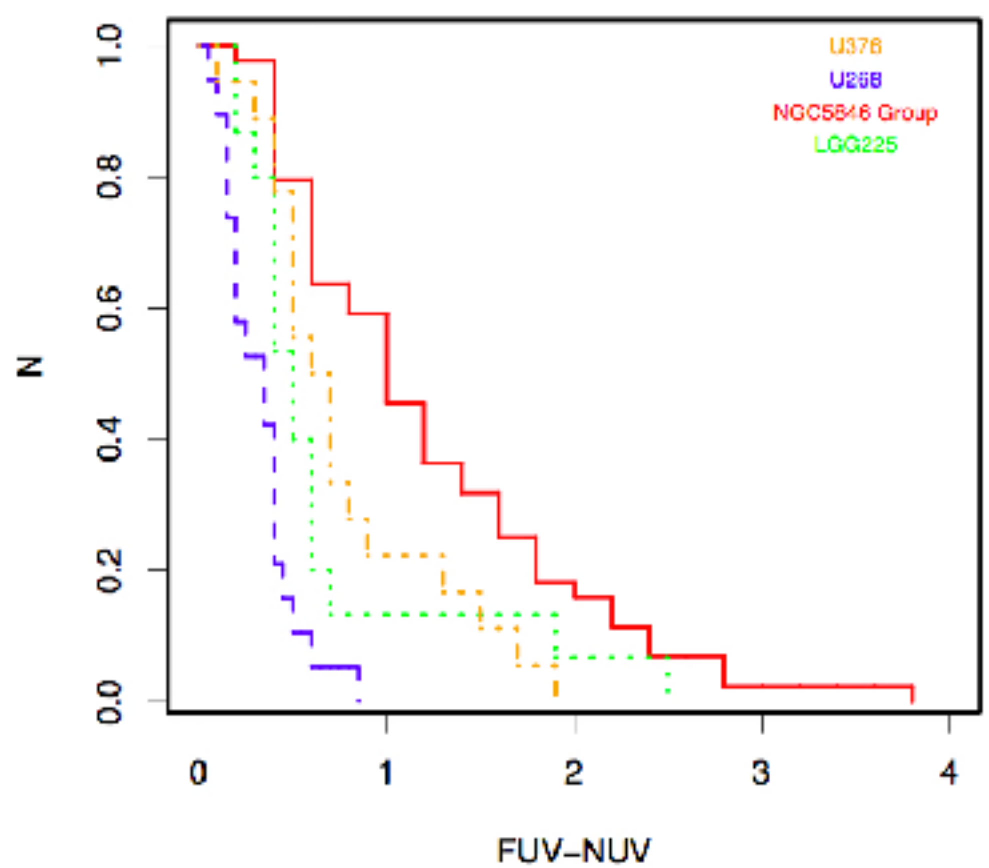
Examples of BC, GV and RS scheme in nearby groups
E
S0
Sp
Irr
? unclass
U268
LGG 225
U376
NGC 5846
towards virialization
NUV−r [AB mag]
Mr [AB mag]
Marino+ 2016, MNRAS, 459, 2212
Marino+ 2013, MNRAS, 428, 476





observation highligth the different richness of BC vs. GV or RS:

1) is this marking a different group evolutionary phase ?
2) at what extent are ETGs in the RS “red & dead” ?



Marino+ 2016, MNRAS, 459, 2212

An UV view of galaxies in nearby groups

1. Observations: the UV vs. optical morphological structures of ETGs
2. Simulations: understanding the eventful life of ETGs in LDE via SPH-CPI

   2.a following a mixed merger: NGC 454 an E+S pair

   gas rich + gas poor

   2.b NGC 3447/3447A: an odd pair

Table 1. Global properties of sampled ETGs

Mazzei+ 2017, in prep.

Galaxy Ident.	D_{25} [arcmin]	D [Mpc]	scale [kpc arcmin^{-1}]	m-M [mag]	M_B [mag]	M_{HI} [10^9 $M_\odot$]	L_X(gas) [10^{40} erg s^{-1}]
NGC 1366	2.1	21.1±2.1	6.1	31.62±0.50	-18.88±0.54	<1.0	<0.03
NGC 1415	3.7	22.7±2.5	6.5	31.78±0.55	-19.23±0.59	1.2[a]	0.1
NGC 1426	2.9	24.1±2.4	7.0	31.91±0.50	-19.70±0.52	....	<0.03
NGC 1533	3.2	21.4±2.1	6.2	31.65±0.50	-19.86±0.52	7.4[b]	<0.11
NGC 1543	3.6	20.0±2.0	5.8	31.50±0.50	-20.11±0.53	0.8	<0.16
NGC 2685	4.4	16.0±1.6	4.8	31.02±0.50	-19.09±0.51	3.0[c]	< 0.04
NGC 2974	3.5	21.5±2.0	6.2	31.66±0.46	-20.01±0.48	0.7[d]	0.2
NGC 3818	2.4	36.3±3.6	10.4	32.80±0.50	-20.22±0.58	...	0.55
NGC 3962	4.2	35.3±3.5	10.2	32.74±0.50	-21.29±0.53	2.8[e]	0.33
NGC 7192	2.4	37.8±3.8	10.7	32.89±0.50	-20.81±0.51	0.7[e]	1.0
IC 2006	2.3	20.2±2.0	5.9	31.53±0.50	-19.34±0.51	0.3	0.08

no gas

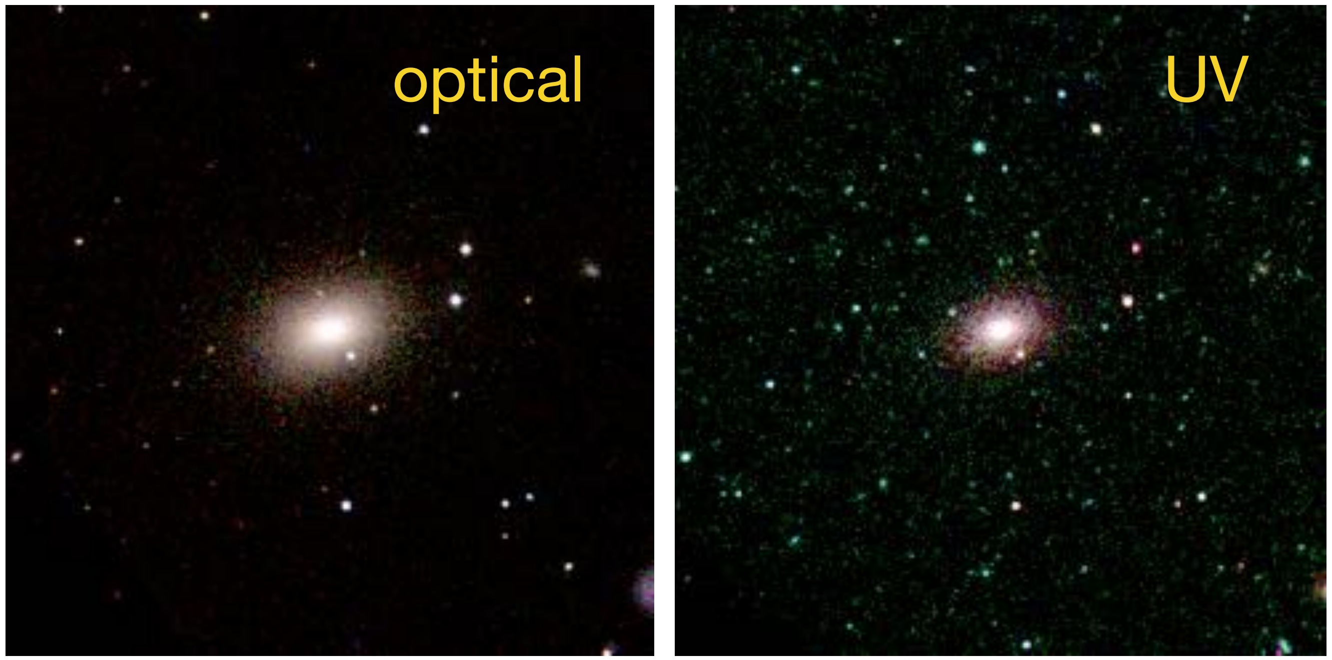
gas rich

The apparent diameters (col. 2) and the adopted distances (col. 3) are derived from the Extragalactic Distance Database (EDD: http://edd.ifa.hawaii.edu), as in Papers 1 and II. Absolute total magnitudes in col. 6 are derived from col. 5 using B-band observed total magnitudes and extinction corrections from `Hyperleda` (Makarov et al. 2014) catalogue. The HI masses (col. 7) are obtained using the distance in col. 3 and fluxes from `NED` and from the following references: [a] Courtois et al. (2015); [b] Ryan-Weber, Webster & Starvely-Smith (2003); [c] Józsa et al. (2009); [d] Kim et al. (1988); [e] Serra & Oosterloo (2010). X-ray gas luminosity (col. 8) is from Table 7 of Trinchieri et al. (2015).

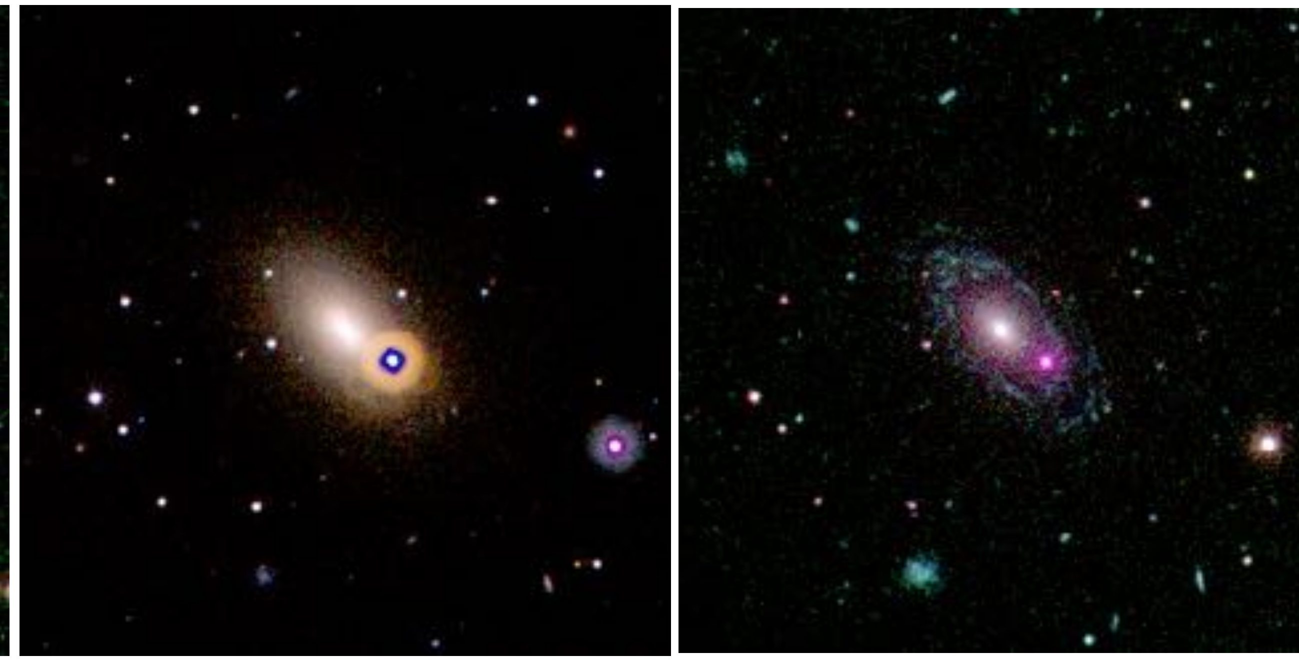
2. UV (Swift) vs. optical structures

Rampazzo+ 2017, A&A, 602, A97

NGC 1426

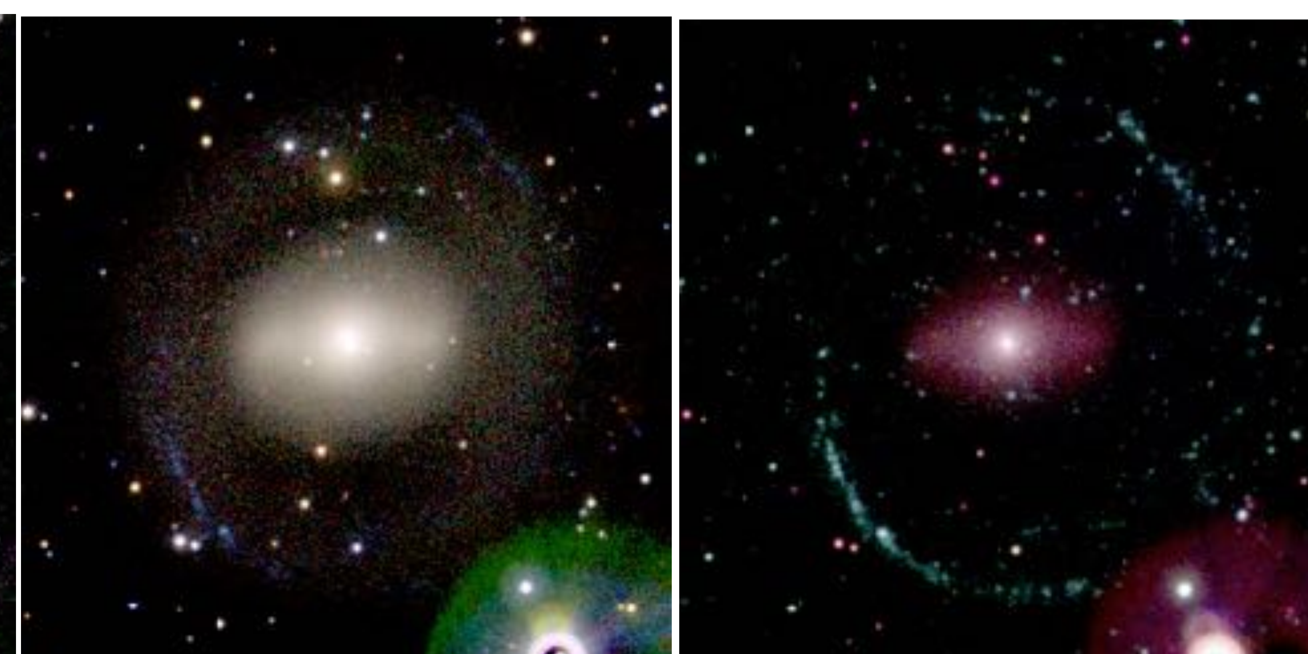


NGC 2974



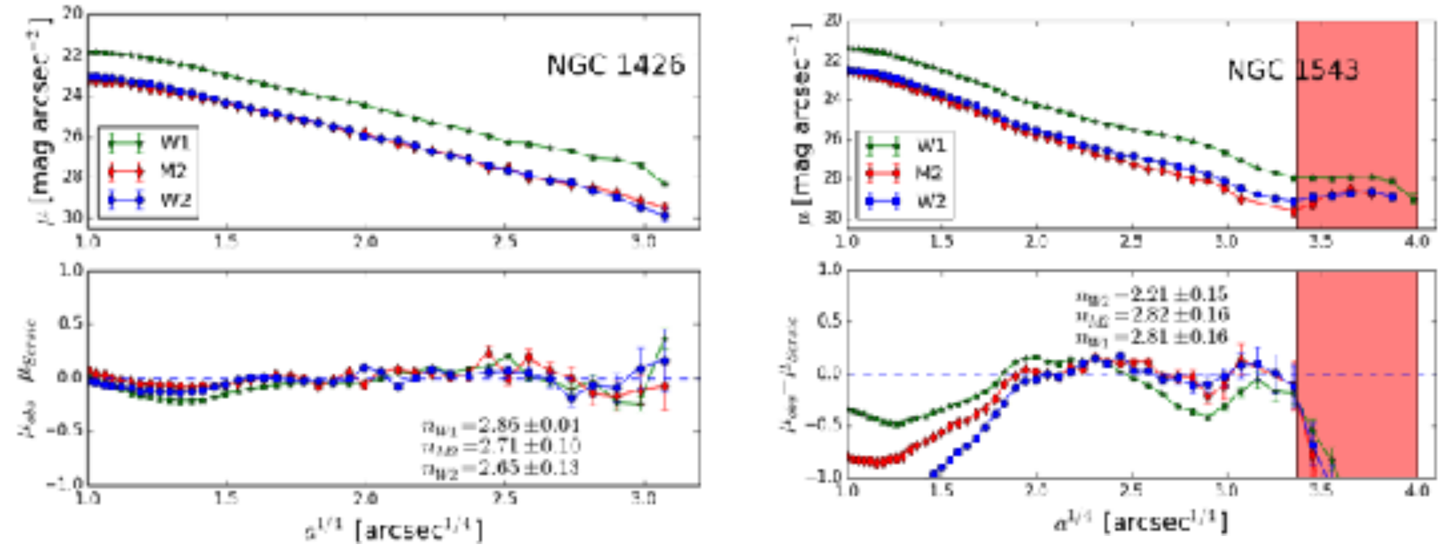
IC 2006

NGC 1543



UV vs. optical structure.

Rampazzo+ 2017, A&A, 602, A97



luminosity profile best fit

Sersic law + PSF

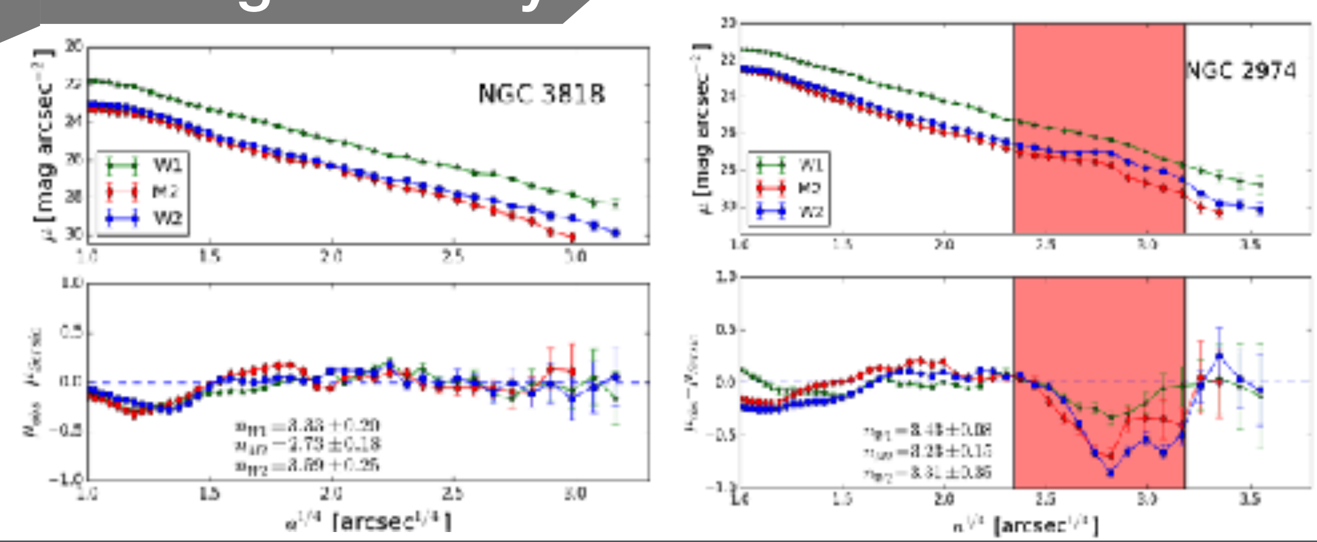
rule

range: UV -> NIR

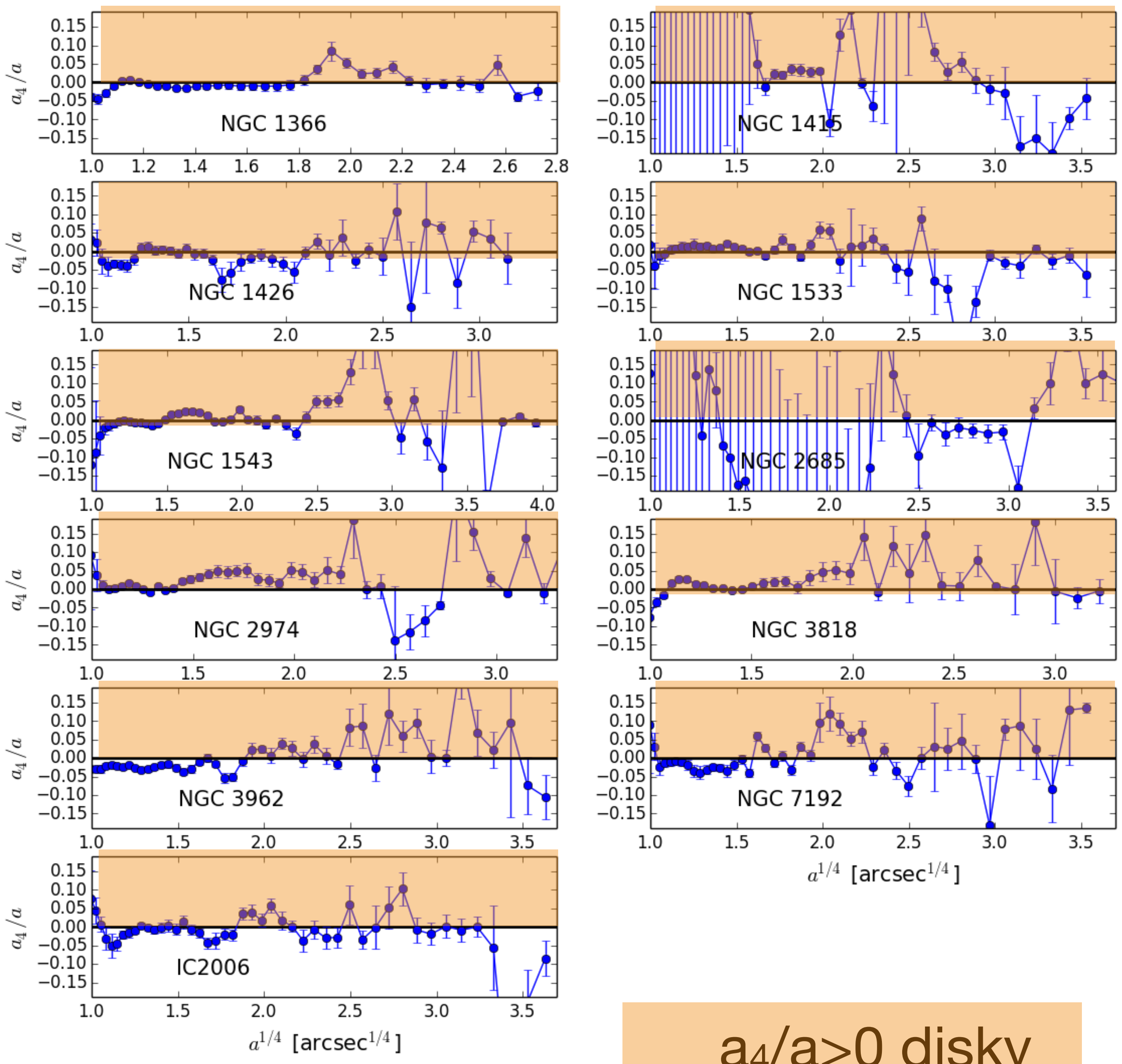
Carnegie-Survey

optical vs. NIR comparison

Ho+ 2011, ApJS, 197, 21

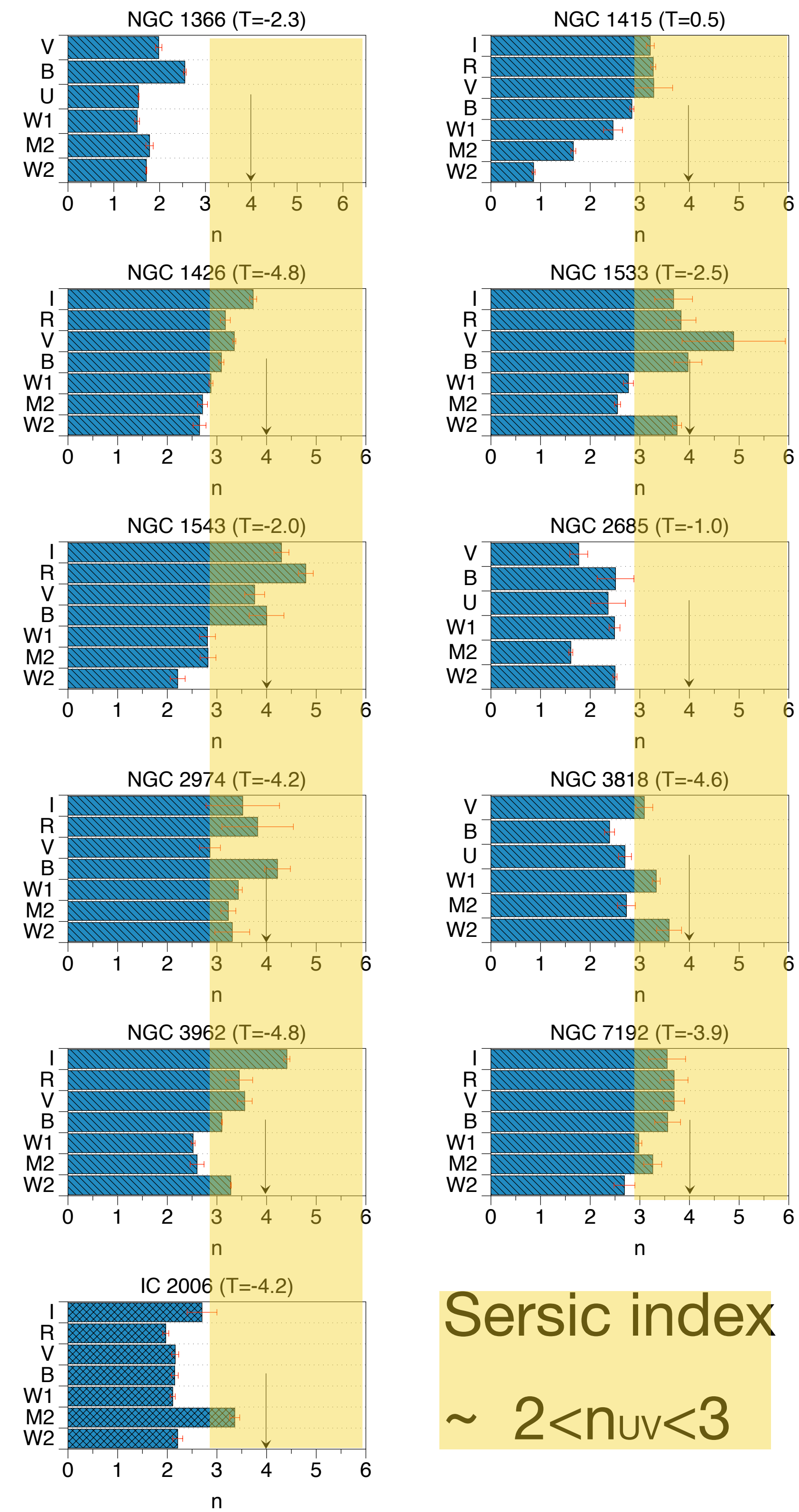


UV vs. optical synoptic view of the Swift data set



$a_4/a>0$ disky

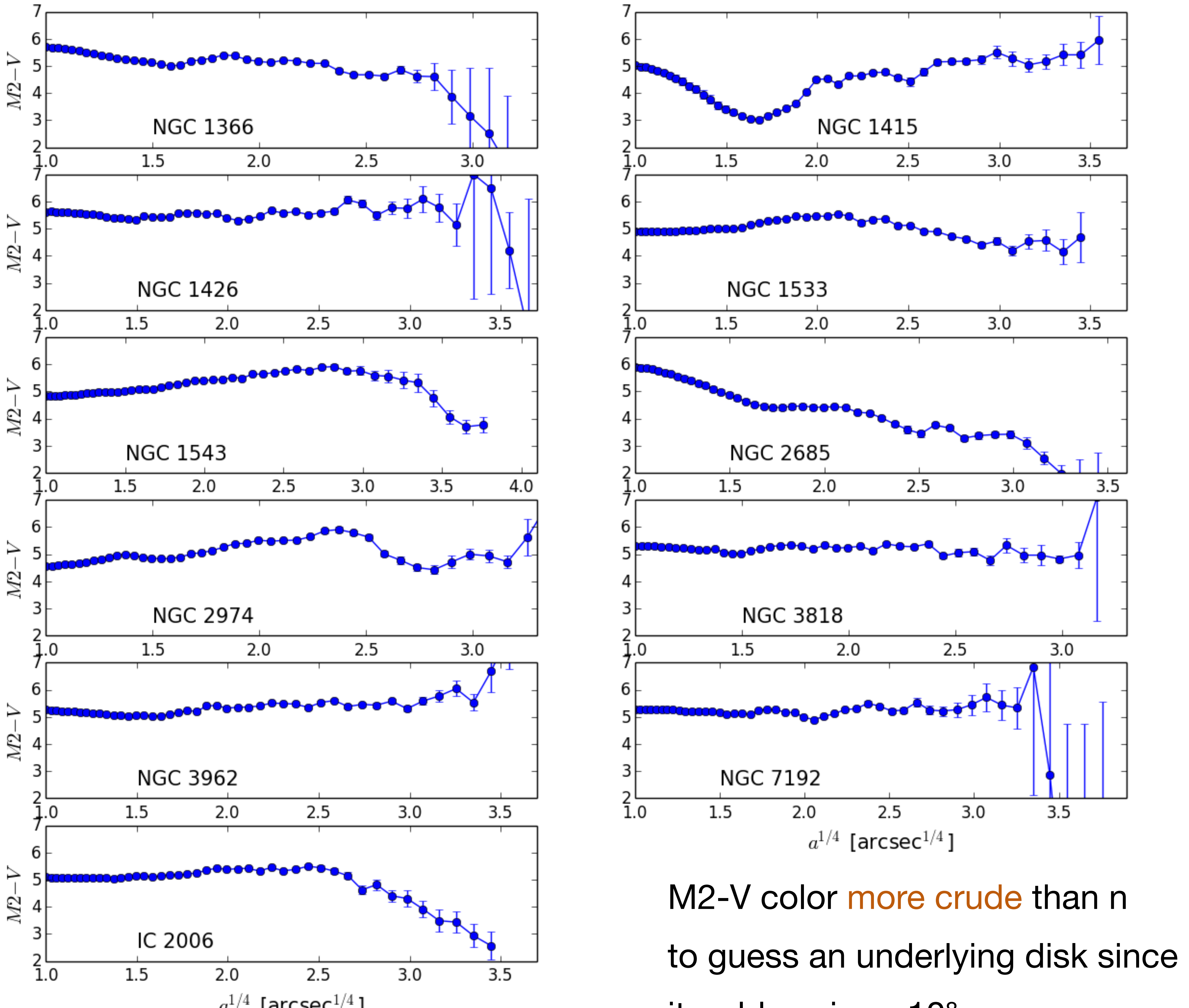
$a_4/a<0$ boxy



Sersic index

~ $2<n_{UV}<3$

Rampazzo+ 2017, A&A, 602, A97



M2-V color more crude than n

to guess an underlying disk since

it reddens in <~10^8 year

Summarizing from UV observations ….

- ✓ Bright ETGs in the RS can still host active SF often in their outskirts
- ✓ UV Sersic index are lower (n<~ 2-3) than optical ones (n >~3-4)
  —> presence of an underlying disk
- ✓ disky isophotes … colors are less sensitive indicators than n since their fast variation with time
- ✓ if disks are present —> dissipative mechanism —> gas i.e no dry mergers
- ✓ dissipation cannot be neglected not only in the first phases of formation
  but along all the galaxy evolution leading to our ETGs

3. Understanding the eventful life of ETGs in LDE:

SPH simulations with Chemo Photometric Implementation

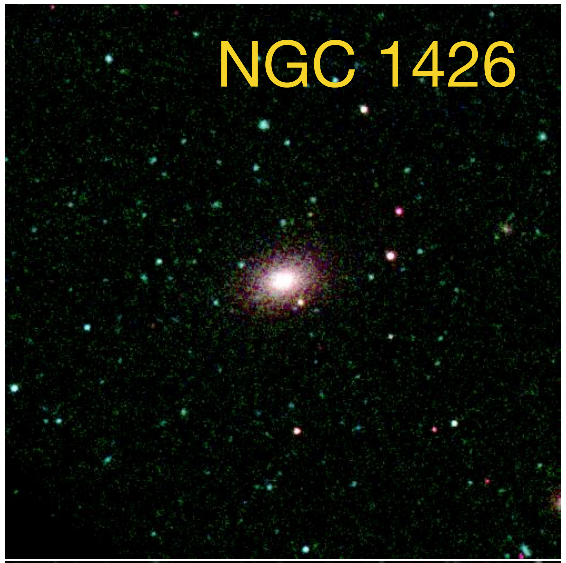
1. Triaxial ($\mathcal{T}$ = 0.84) halos initially of DM+gas with the same average density, spin and virial ratio (0.1)

2. SF on - feedback from type II SNae and stellar winds (mass loss in evolved stars)

3. IMF- Salpeter from 0.01$M_\odot$ to 100 $M_\odot$

4. CPI based on Padova EPS models including six stellar populations: Z=0.0004, 0.001, 0.004, 0.008, 0.02, 0.05

5. Providing the SED from 0.05 micron to 1mm at each snapshot, i.e. accounting for dust effects (extinction and re-emission) in a self-consistent way

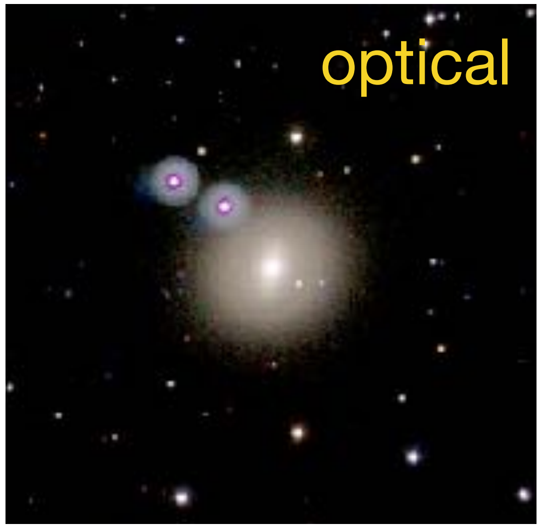


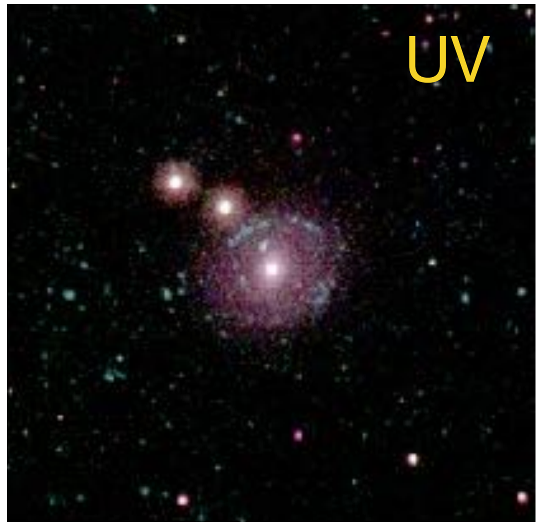
Mazzei & Curir 2003, ApJ, 591, 784

Mazzei+ 2014a AdSpR, 93, 950

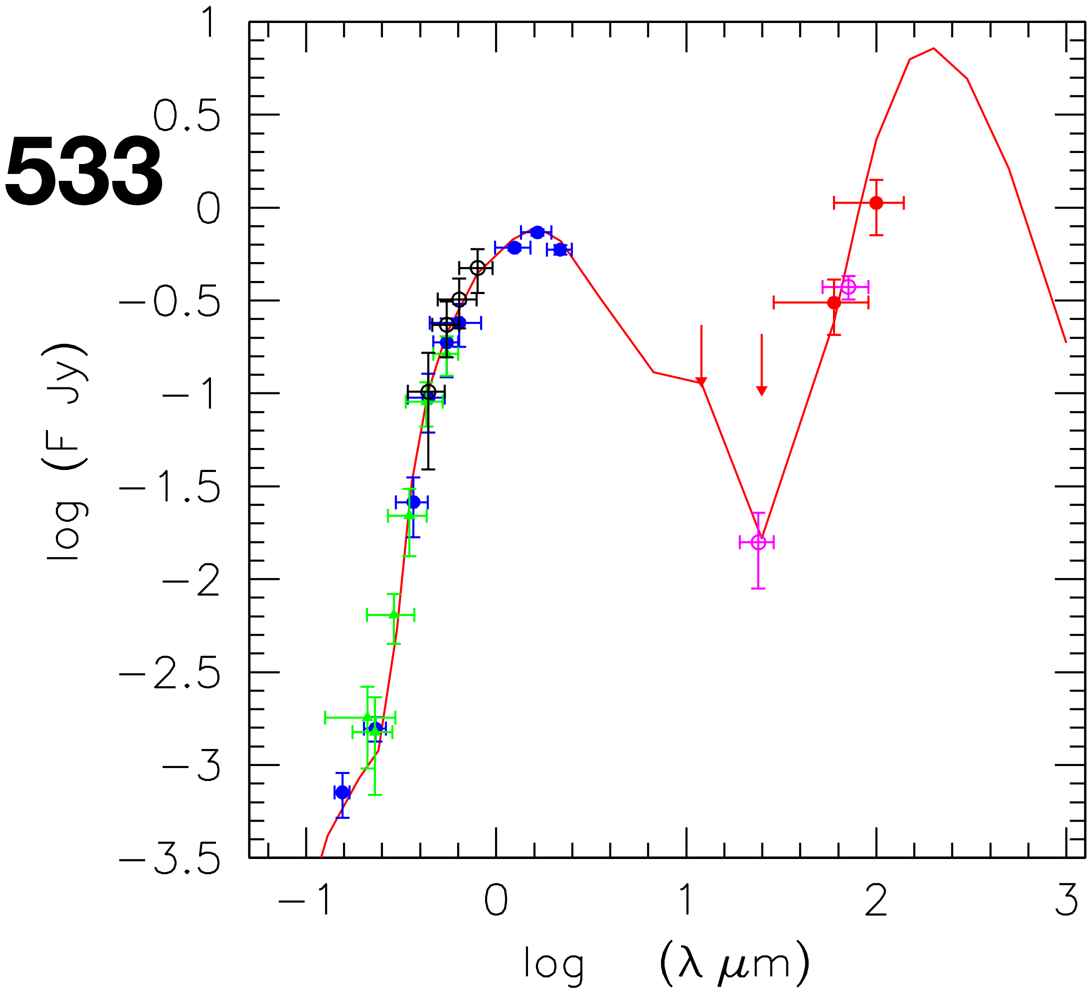
Mazzei+ 2014b, ApJ, 782, 53

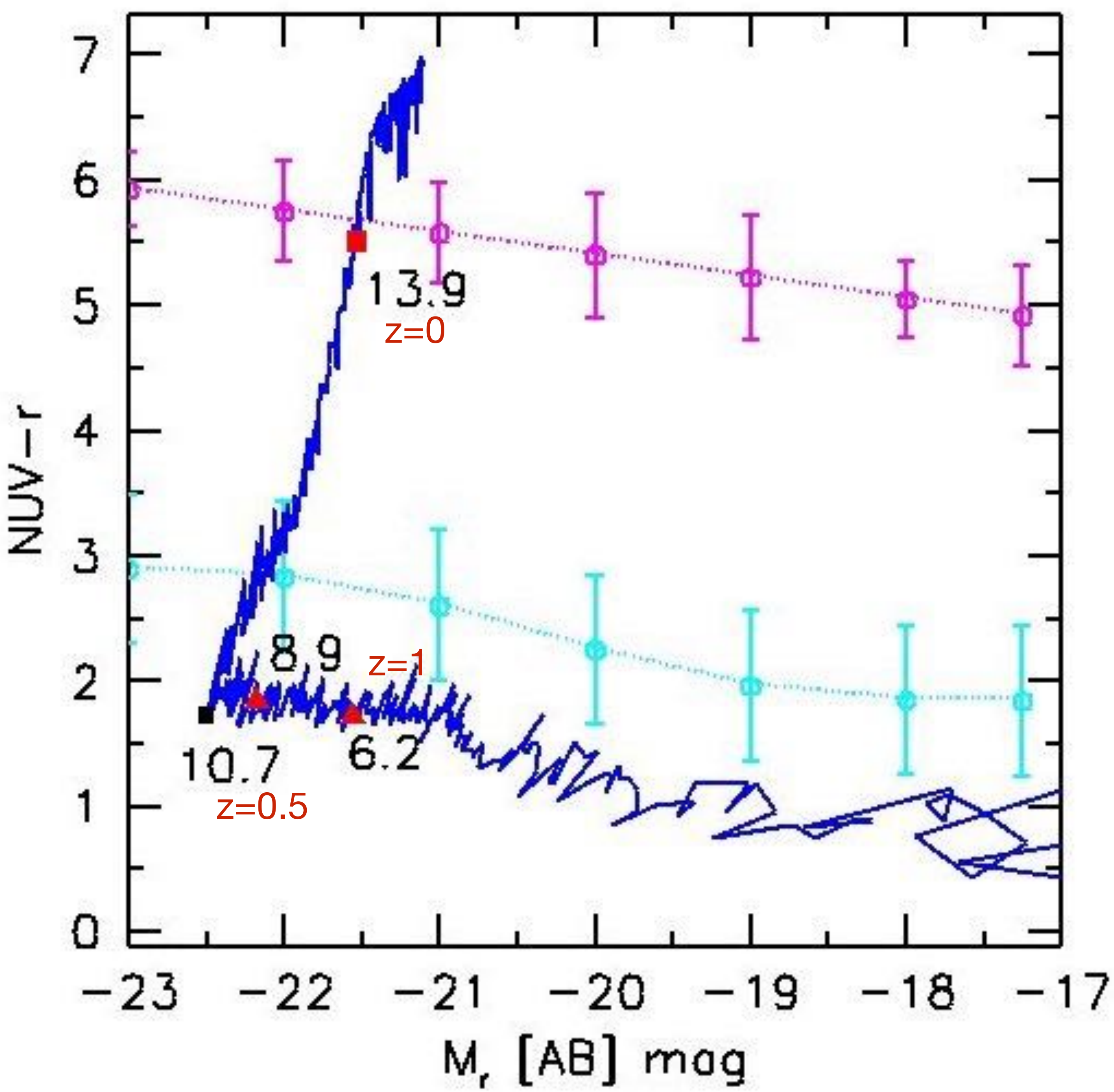
Mazzei+ 2017, in preparation

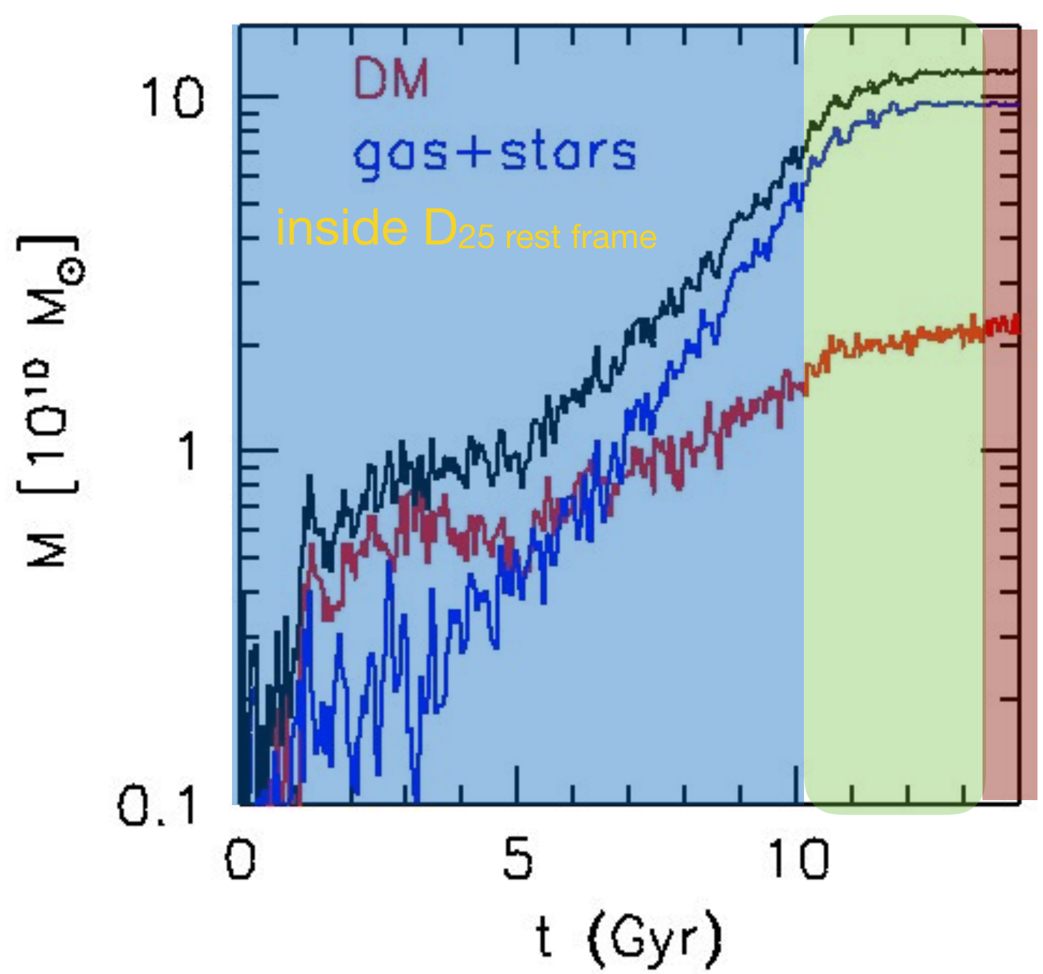

optical


UV

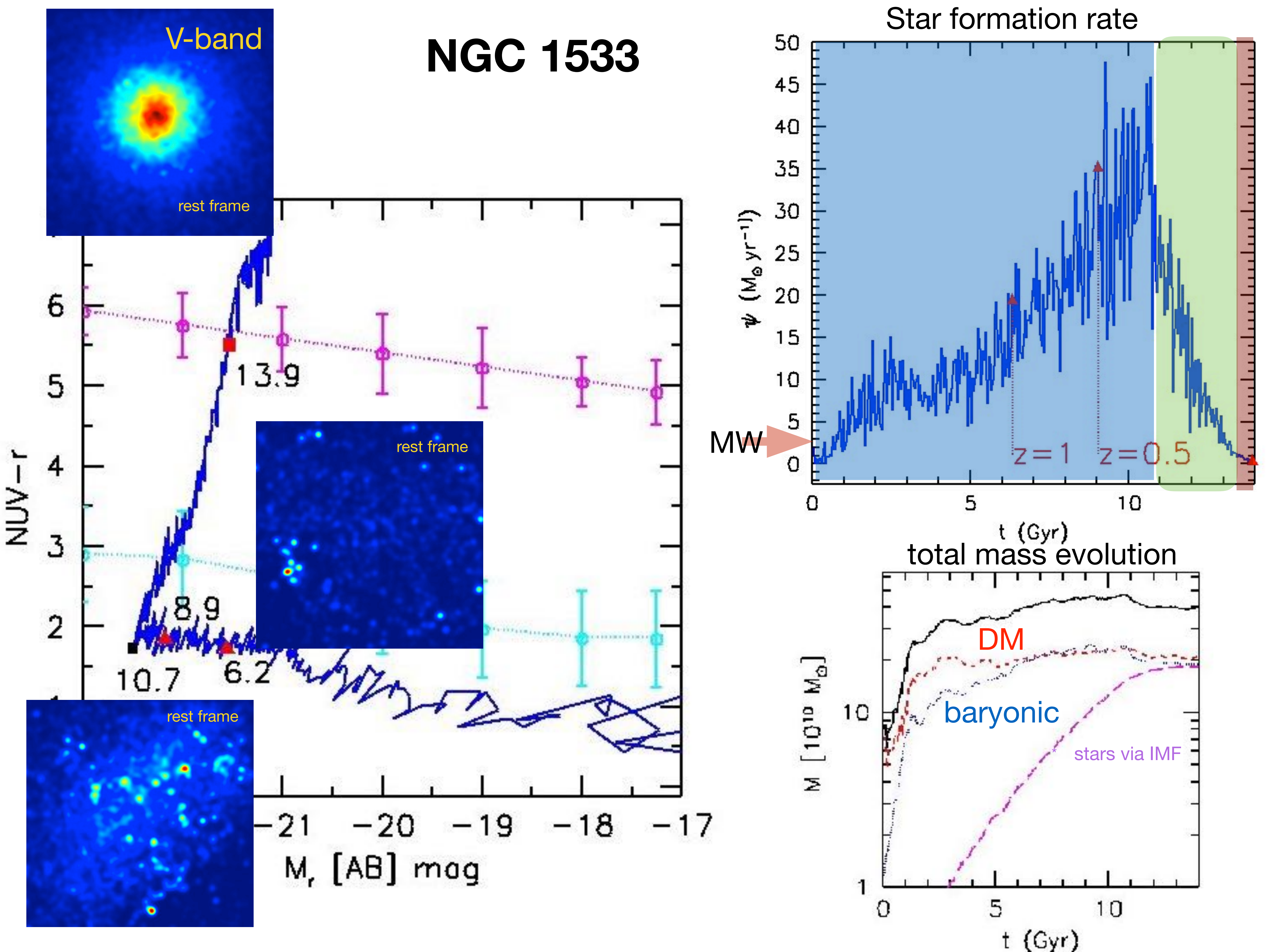
NGC 1533


log (F Jy)
log (λ μm)
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
−3
−3.5
−1
0
1
2
3

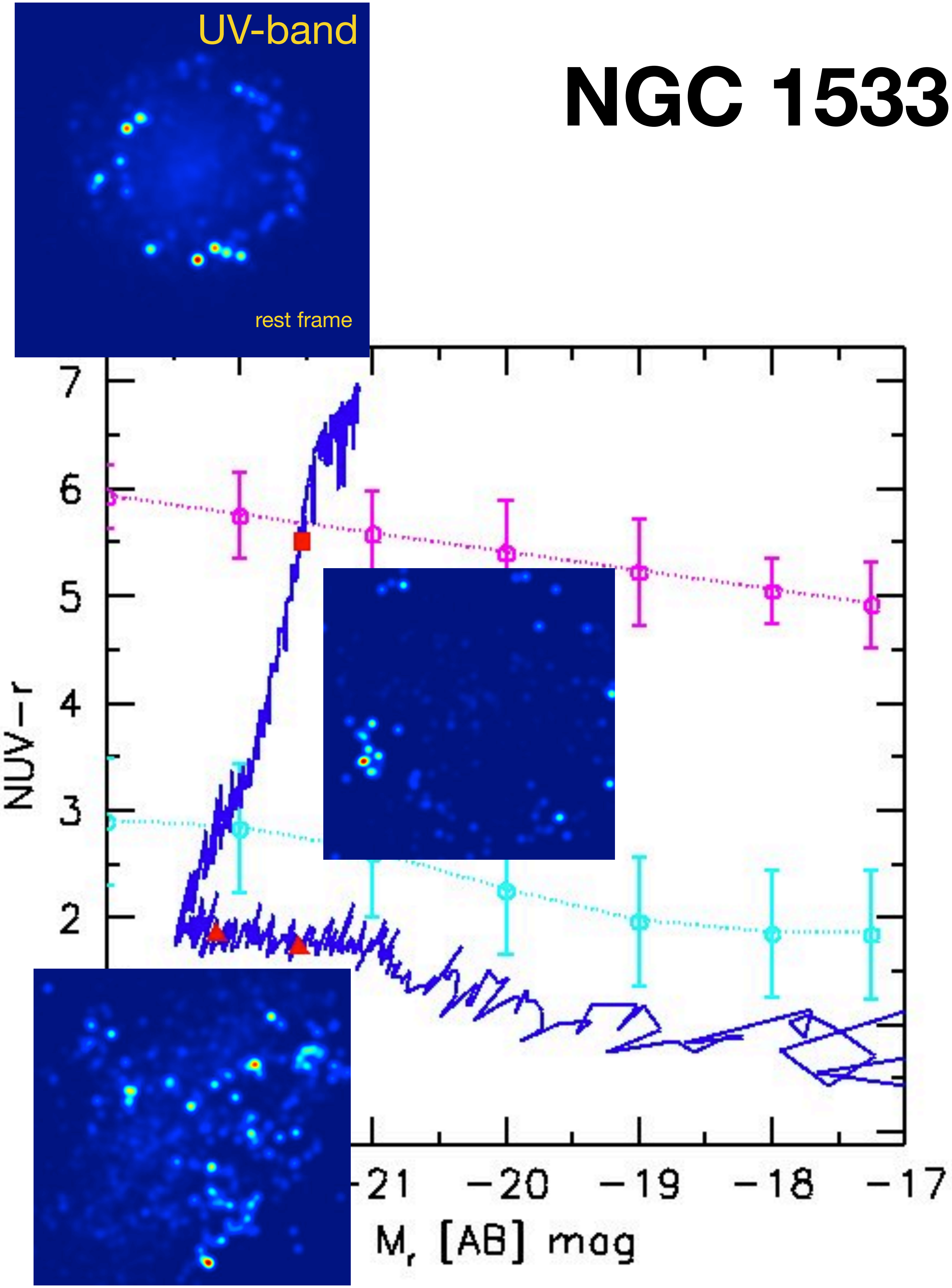

NUV−r
M_r [AB] mag
13.9
z=0
8.9
z=1
10.7
z=0.5
6.2
7
6
5
4
3
2
1
0
−23
−22
−21
−20
−19
−18
−17

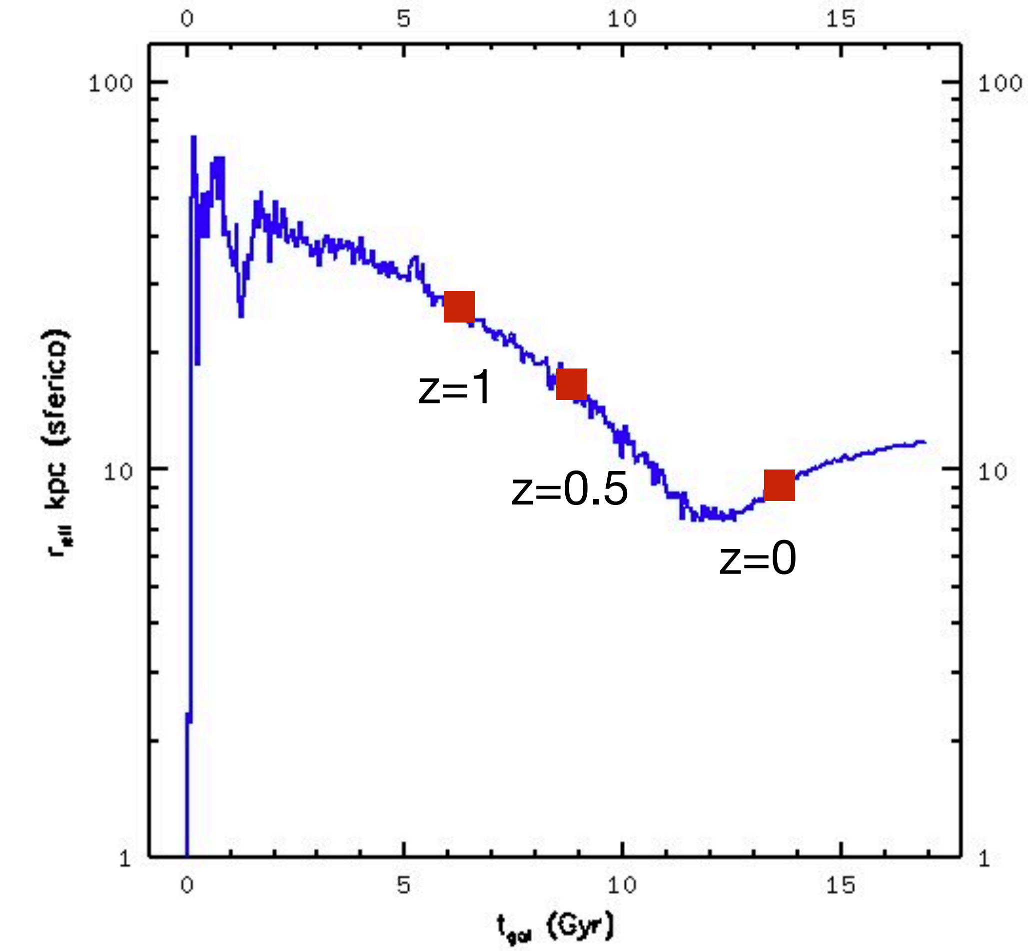

DM
gas+stars
inside D25 rest frame
M [10^10 M⊙]
t (Gyr)
10
1
0.1
0
5
10

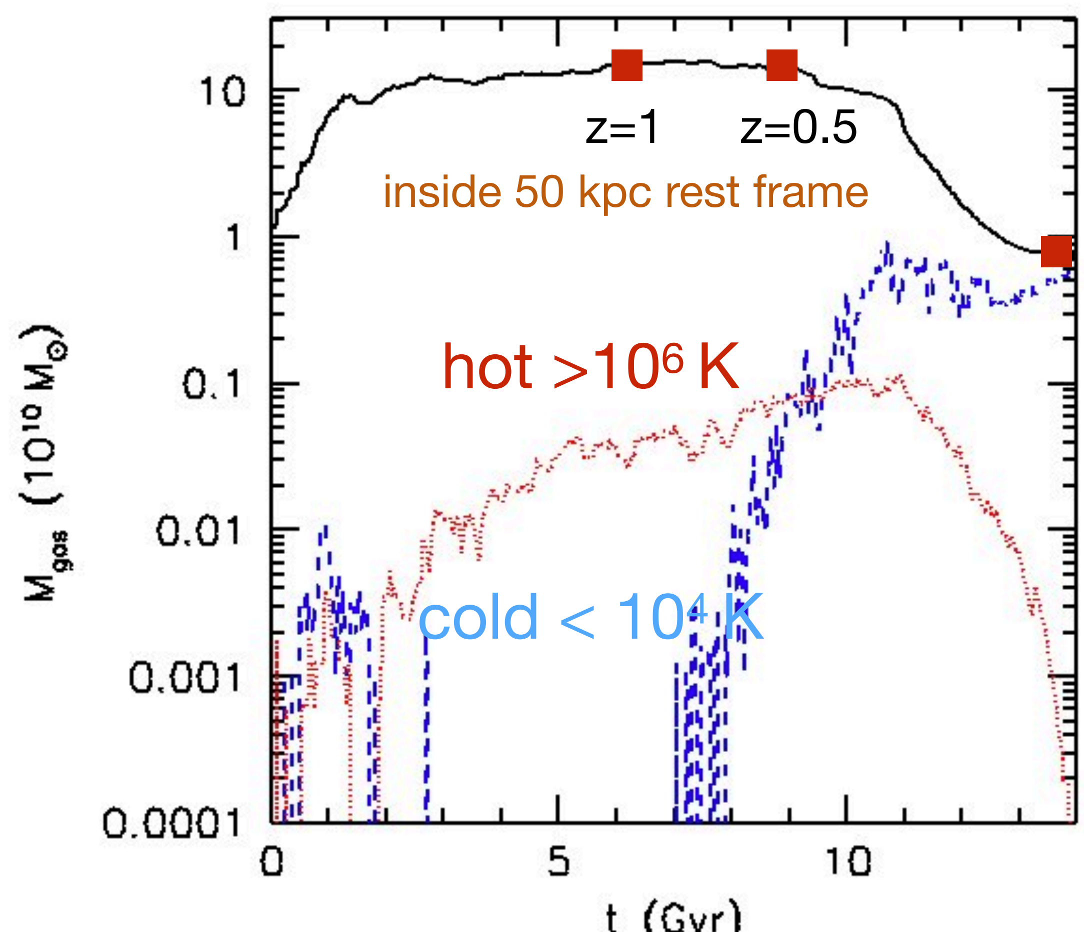
NGC 1533


V-band
rest frame
rest frame
rest frame
NUV−r
M_r [AB] mag
13.9
8.9
10.7
6.2
Star formation rate
ψ (M_⊙ yr⁻¹)
t (Gyr)
MW
z=1
z=0.5
total mass evolution
M [10¹⁰ M_⊙]
DM
baryonic
stars via IMF
t (Gyr)

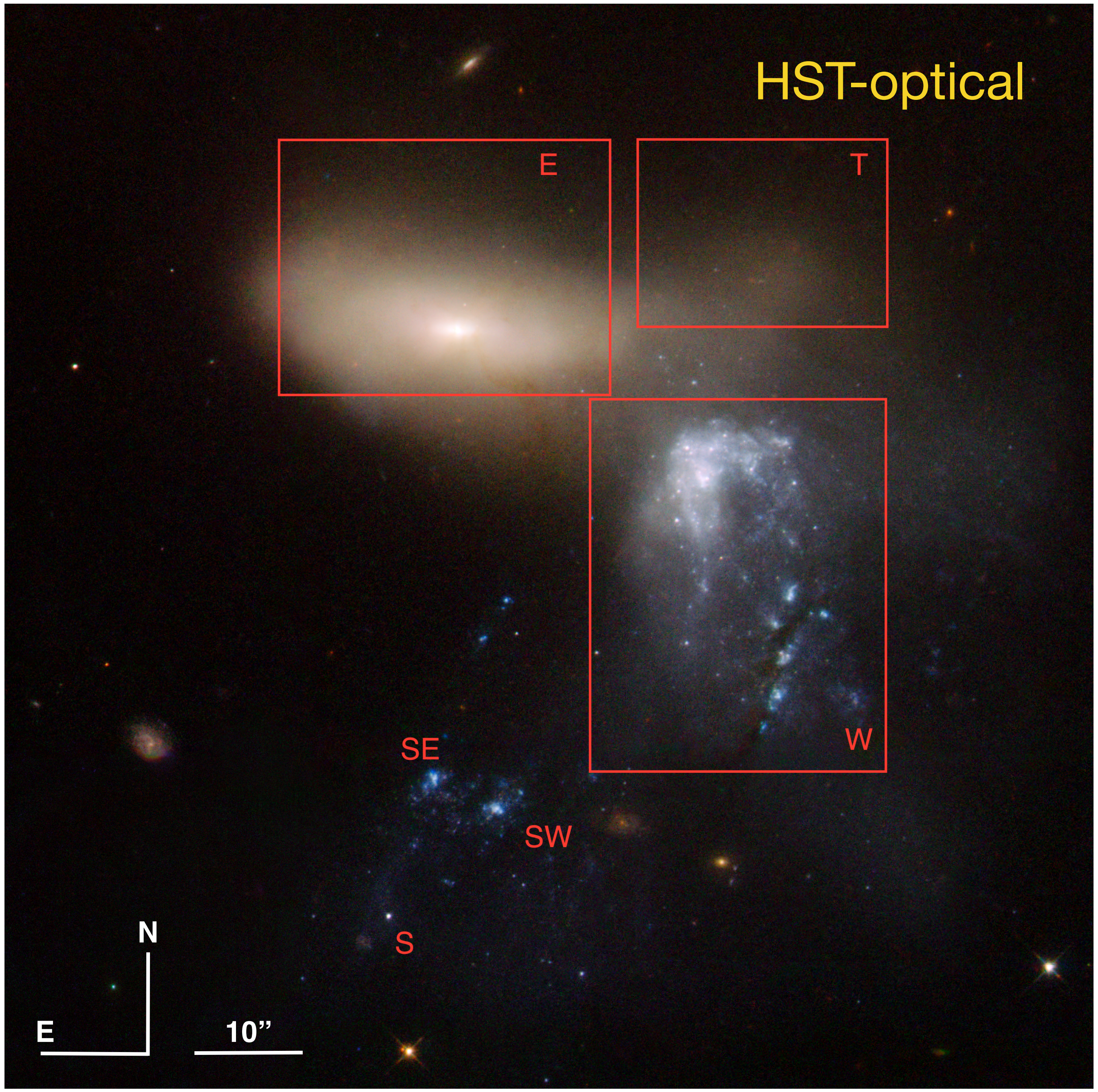
NGC 1533

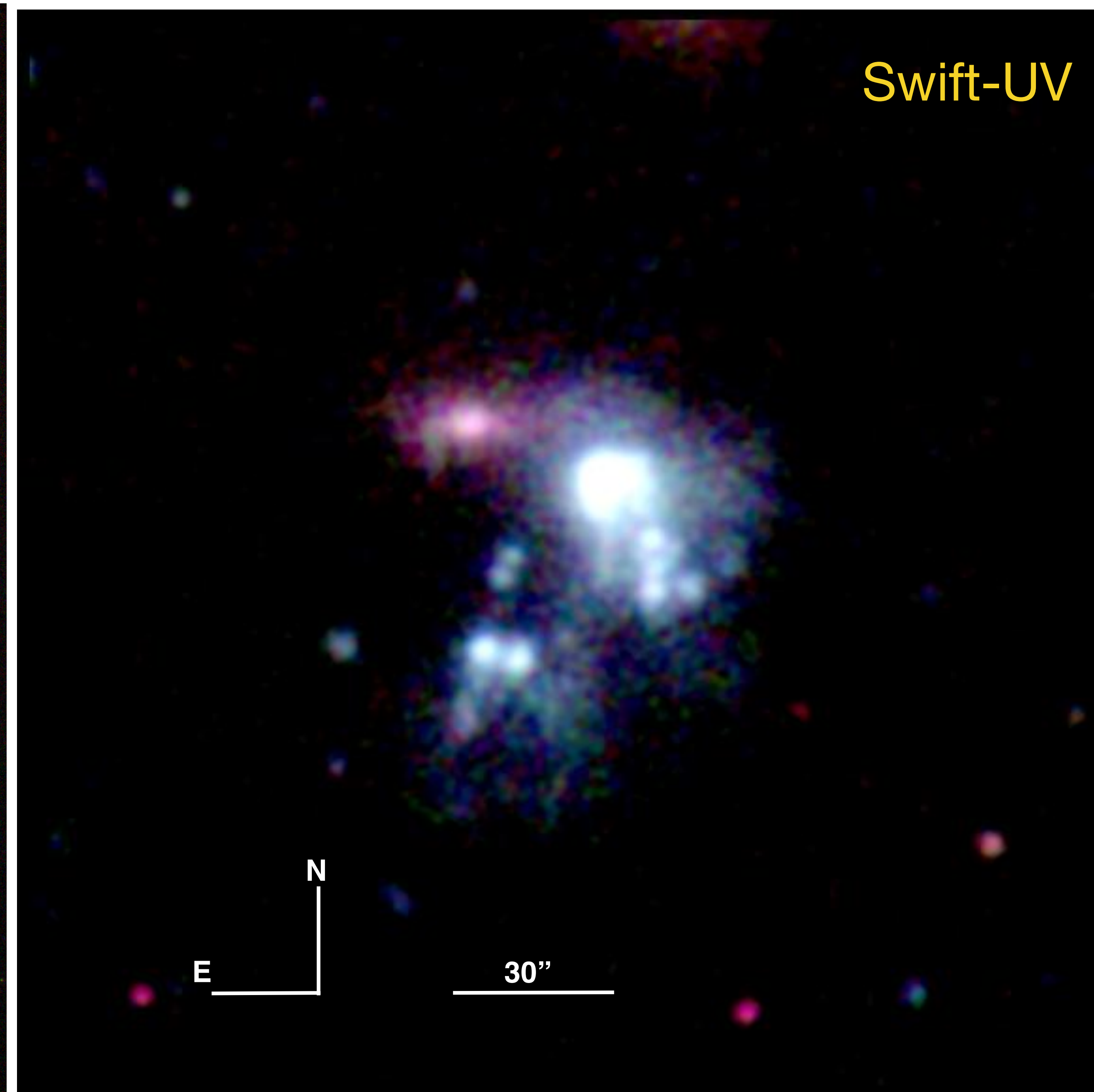

UV-band
rest frame
NUV−r
M_r [AB] mag
7
6
5
4
3
2
−21
−20
−19
−18
−17


r_eff kpc (sferico)
t_gal (Gyr)
z=1
z=0.5
z=0
0
5
10
15
100
10
1

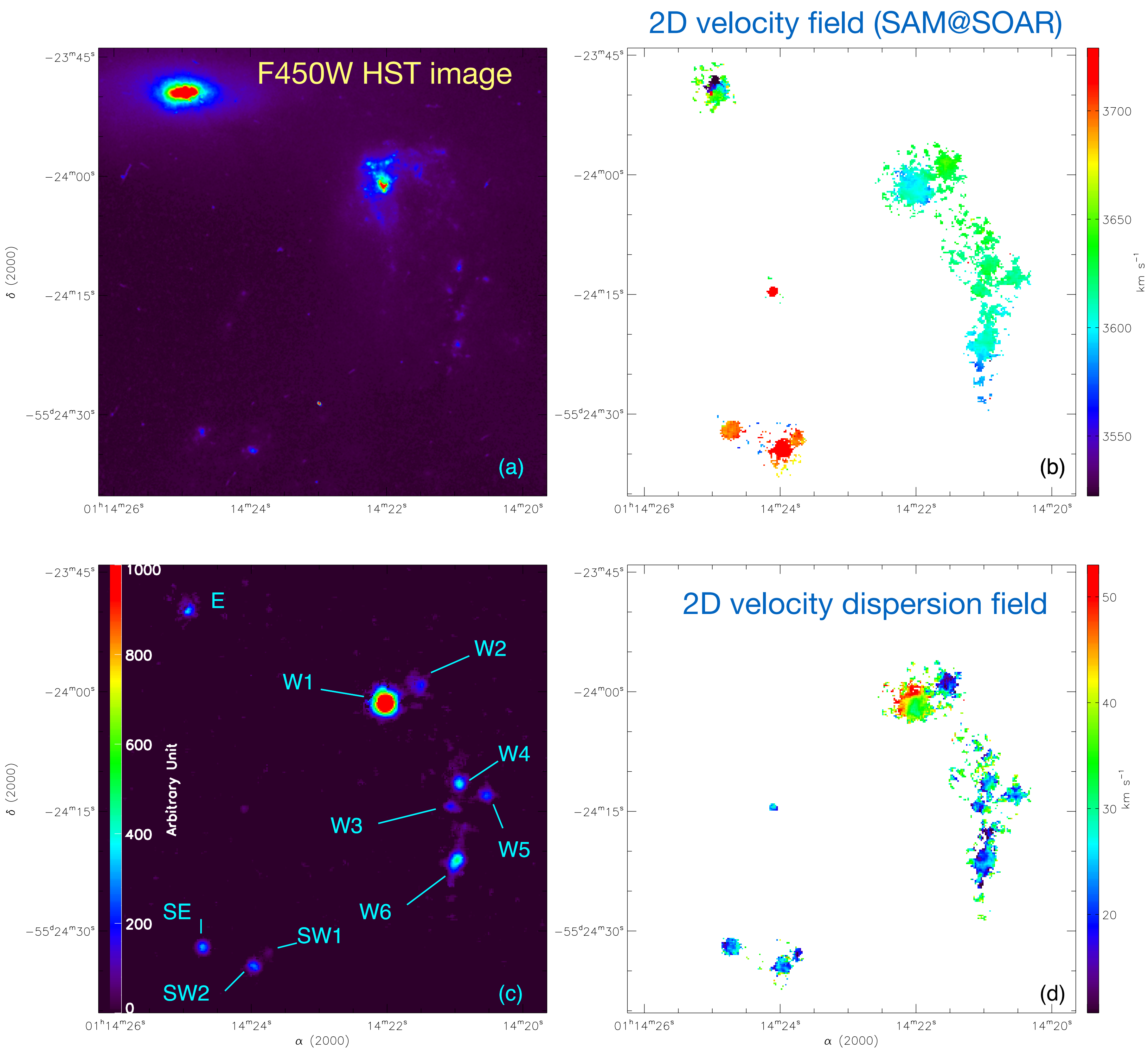

M_gas (10^10 M_⊙)
t (Gyr)
z=1
z=0.5
inside 50 kpc rest frame
hot >10^6 K
cold < 10^4 K
10
1
0.1
0.01
0.001
0.0001
0
5
10

4. Following a mixed merger in LDE: the case of NGC 454





Plana+ 2017, A&A, submitted

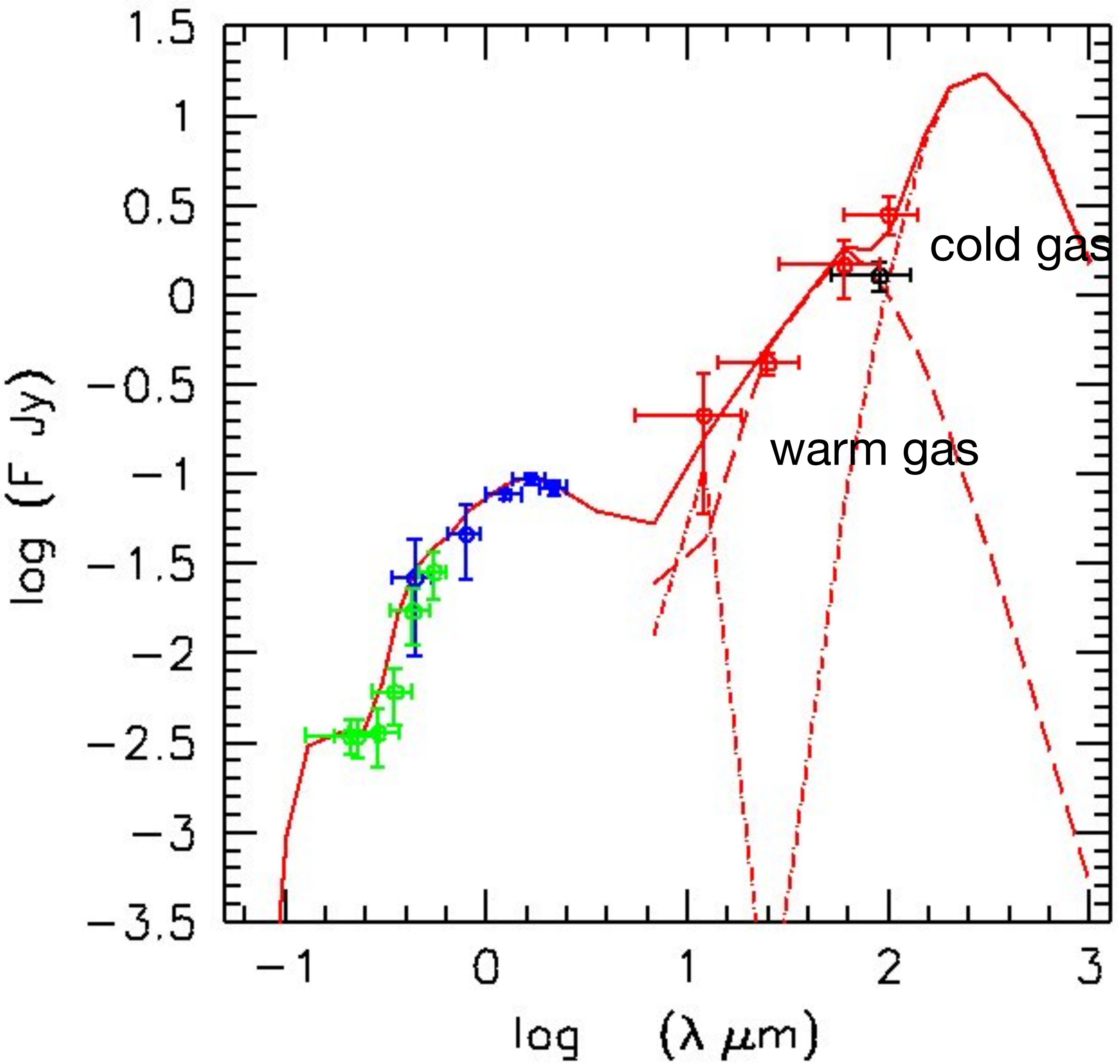


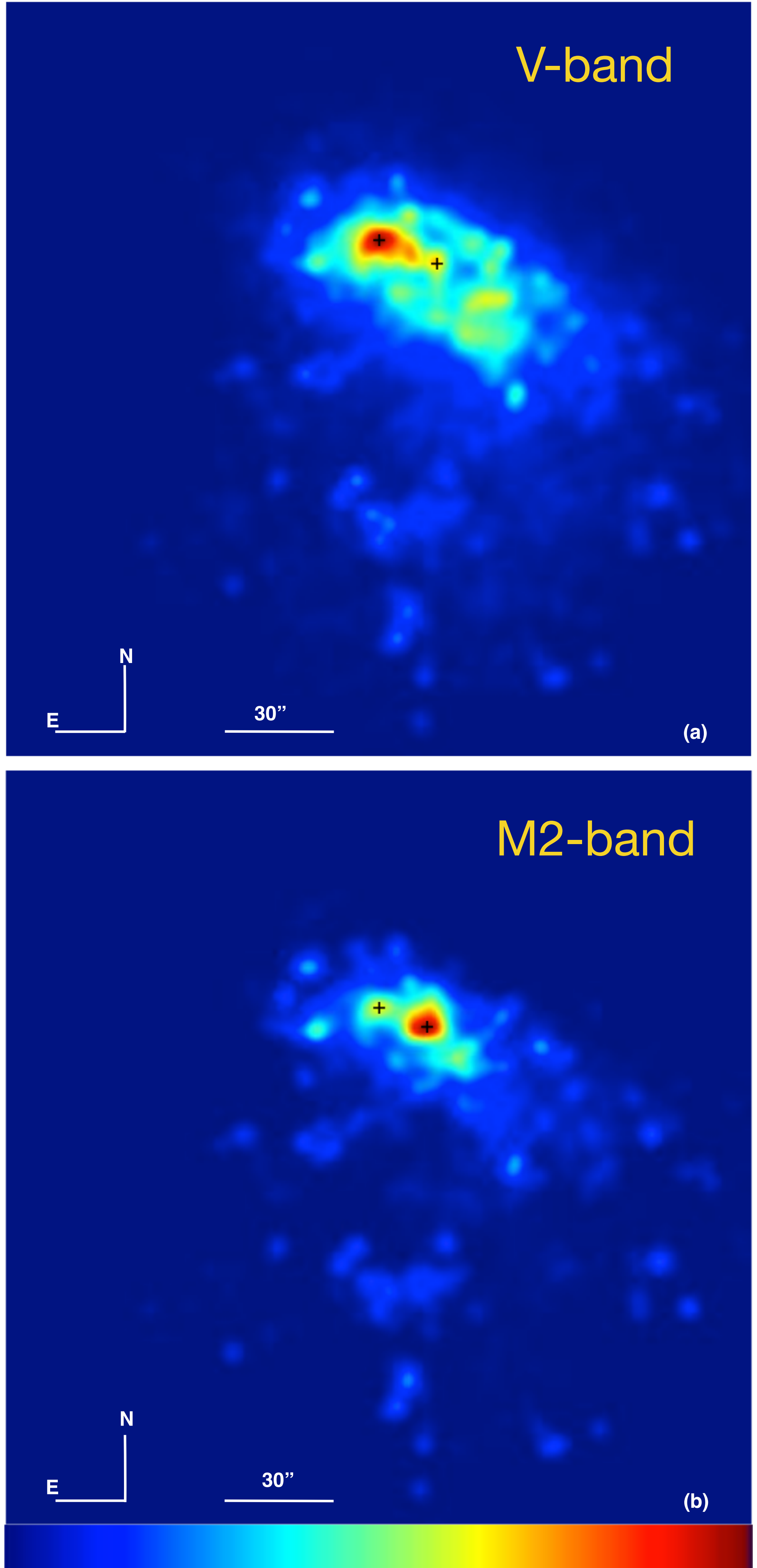
F450W HST image
(a)
2D velocity field (SAM@SOAR)
(b)
km s⁻¹
(c)
E
W1
W2
W3
W4
W5
W6
SE
SW1
SW2
Arbitrary Unit
2D velocity dispersion field
(d)
α (2000)
δ (2000)

a) SPH+CPI simulations suggest 1:1 merger with strong dust obscuration in UV -> FIR emission is 2.5 times that in NUV-near range.

b) galaxies will merge in less than 0.2 Gyr.

c) system age 12.4 Gyr

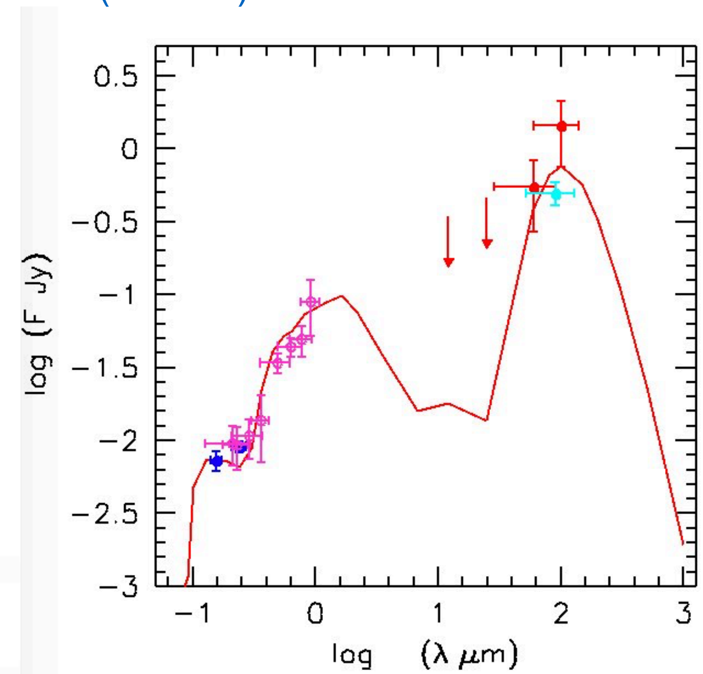


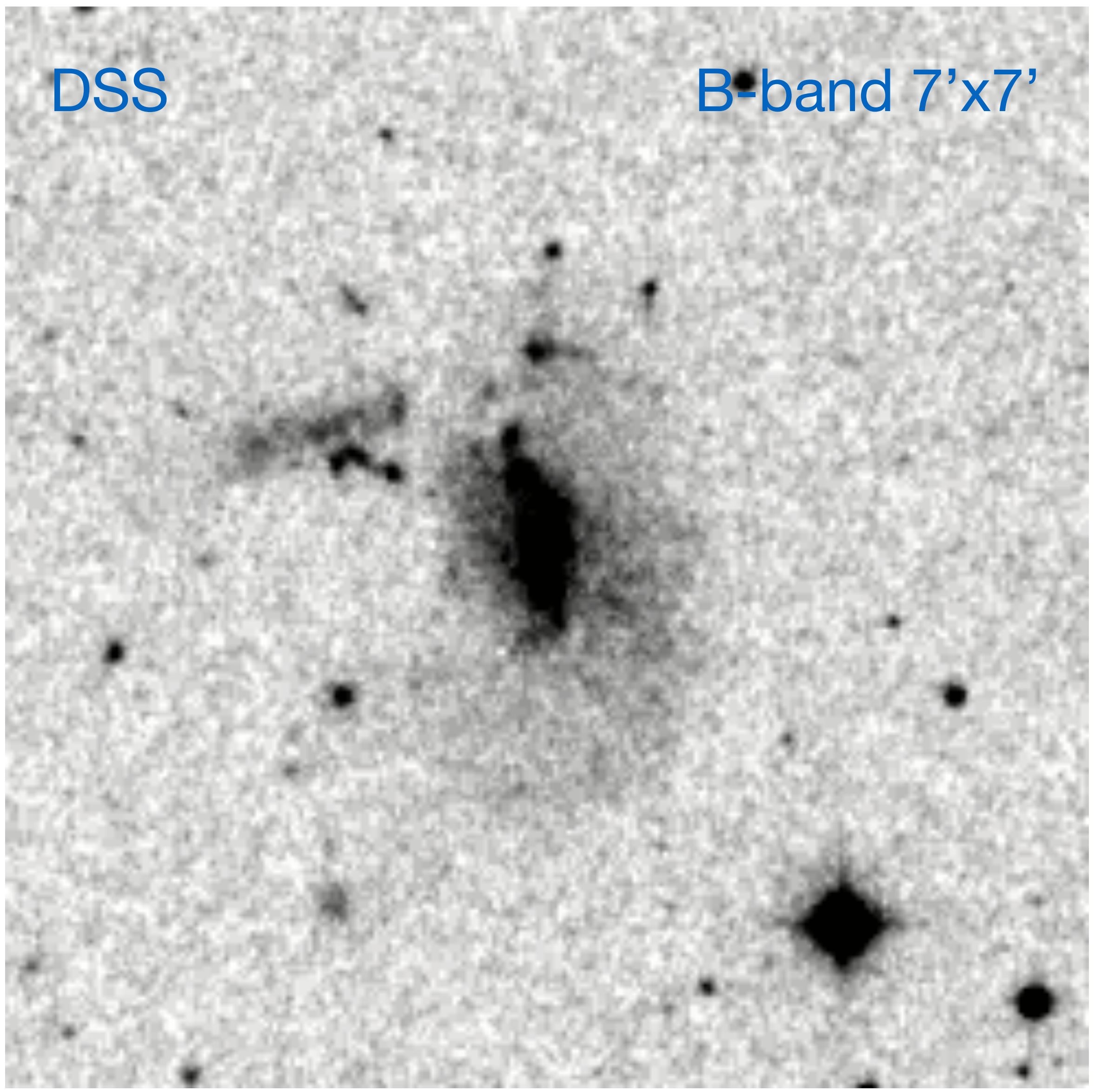


5. NGC 3447/ 3447A: an odd pair

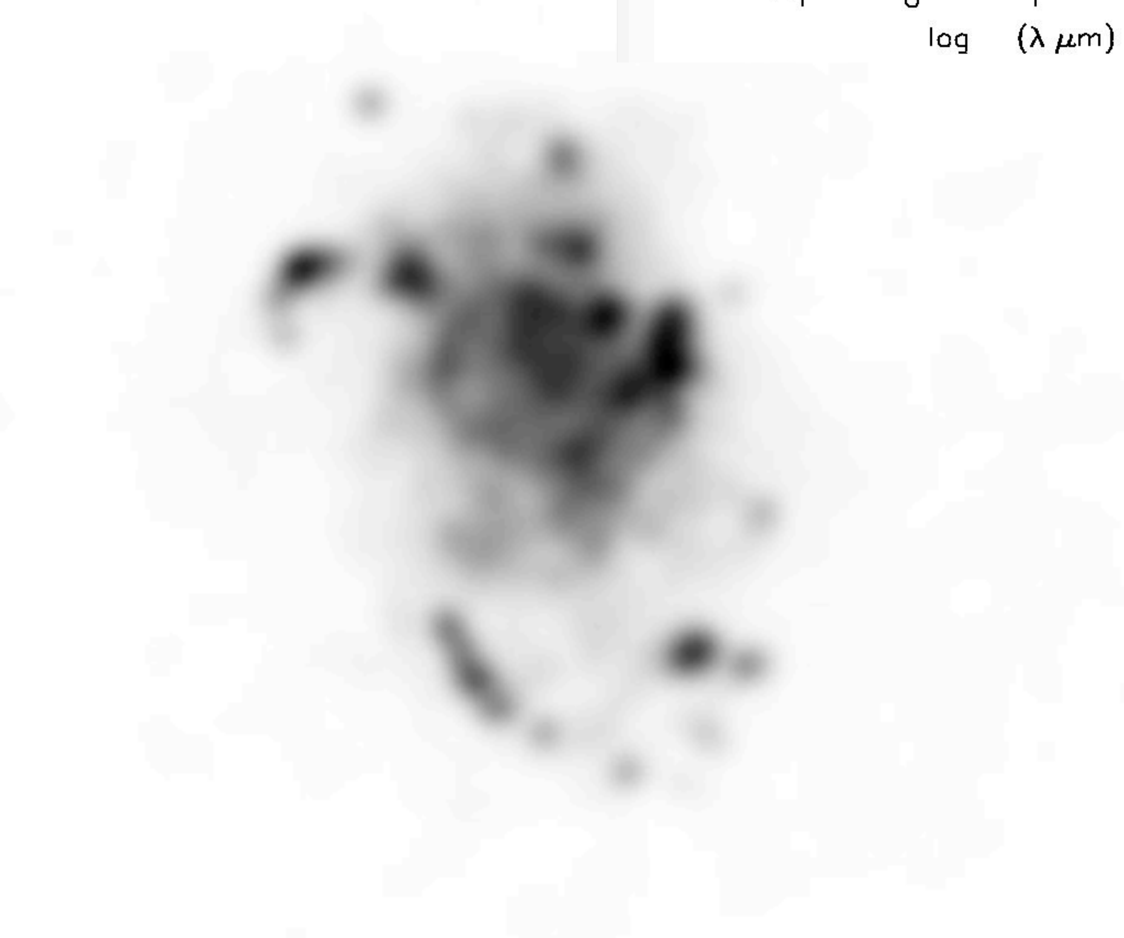
SED and best representation

(red line) of the SED of NGC 3447



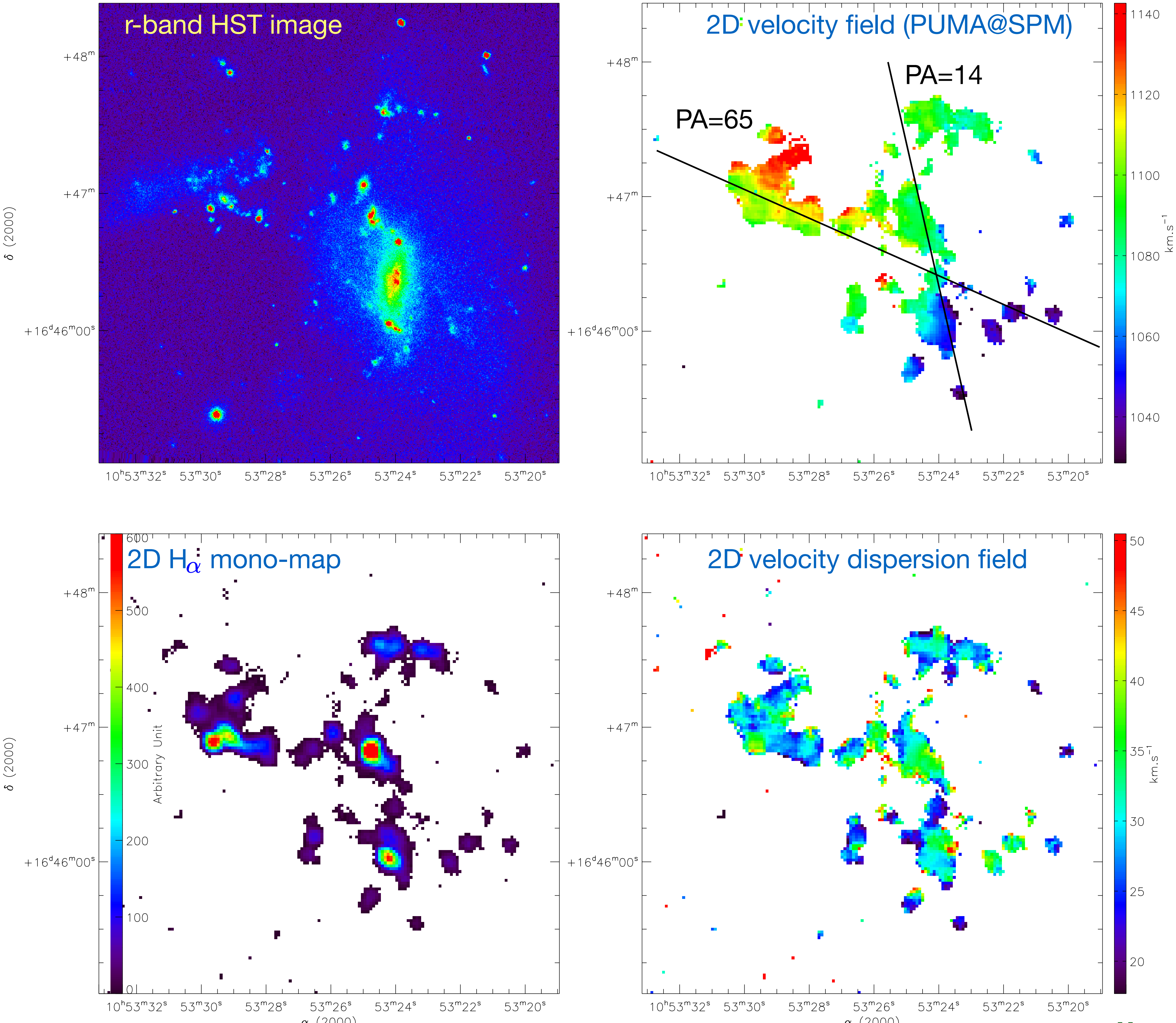


Simulation



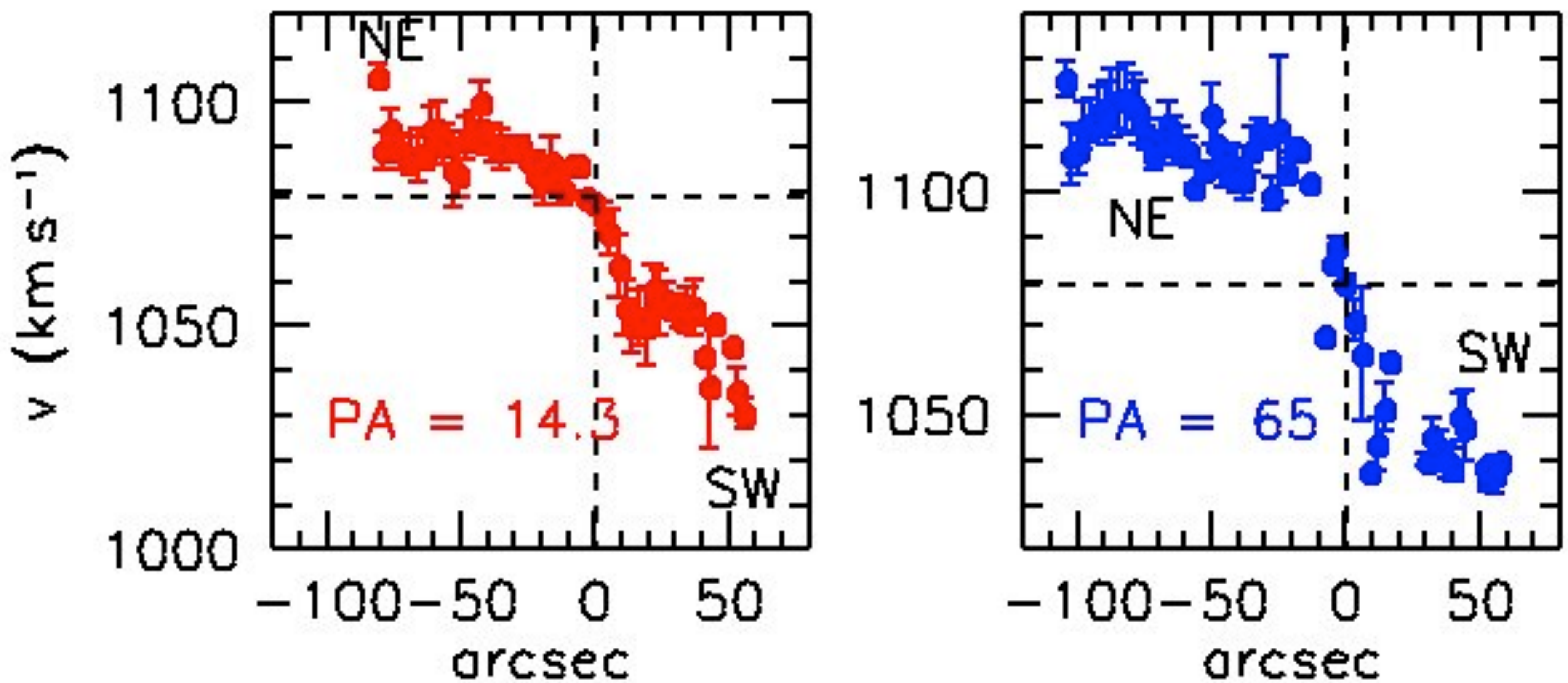
galaxy age = 12 Gyr best fit

Mazzei+ 2017b, A&A, in press

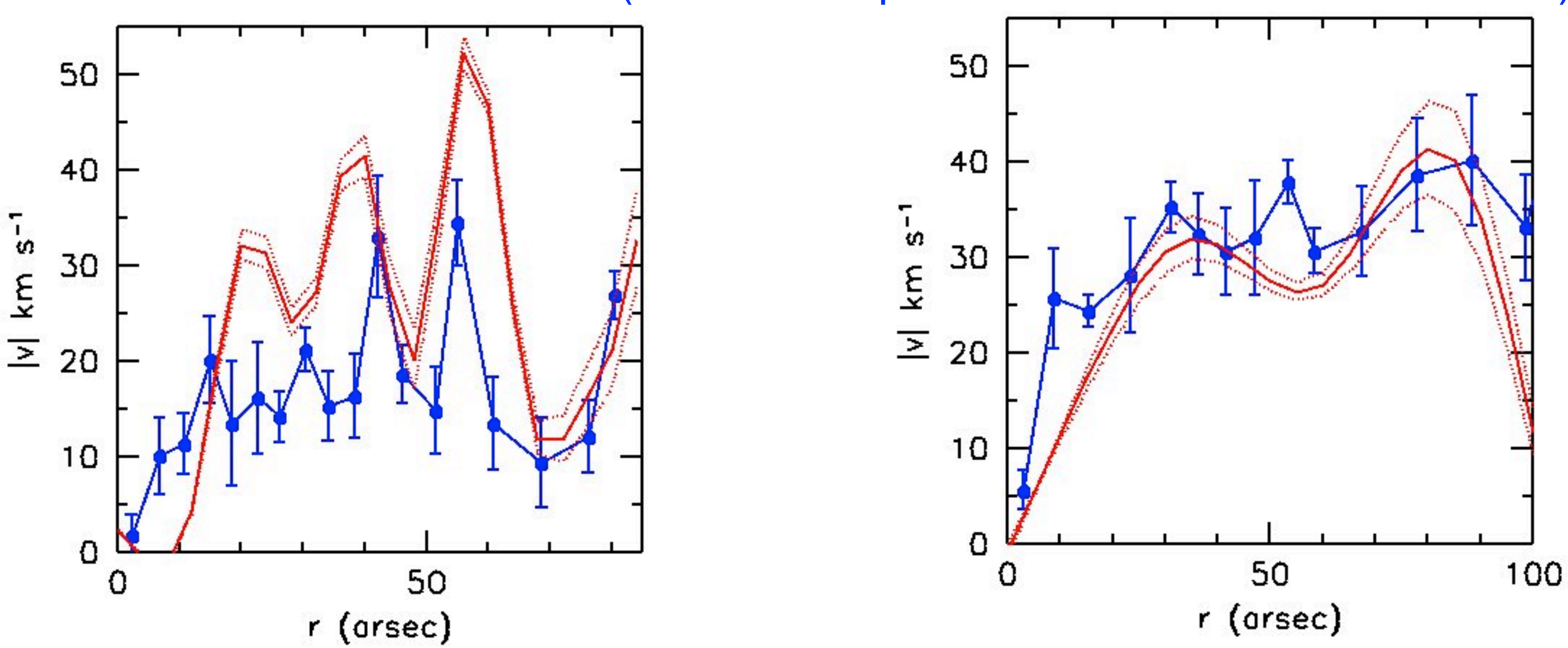


Mazzei+ 2017b, A&A, in press

Observations PA=14 and PA=65



Red lines are simulations (V observed profiles PA=14 and PA=65 folded)

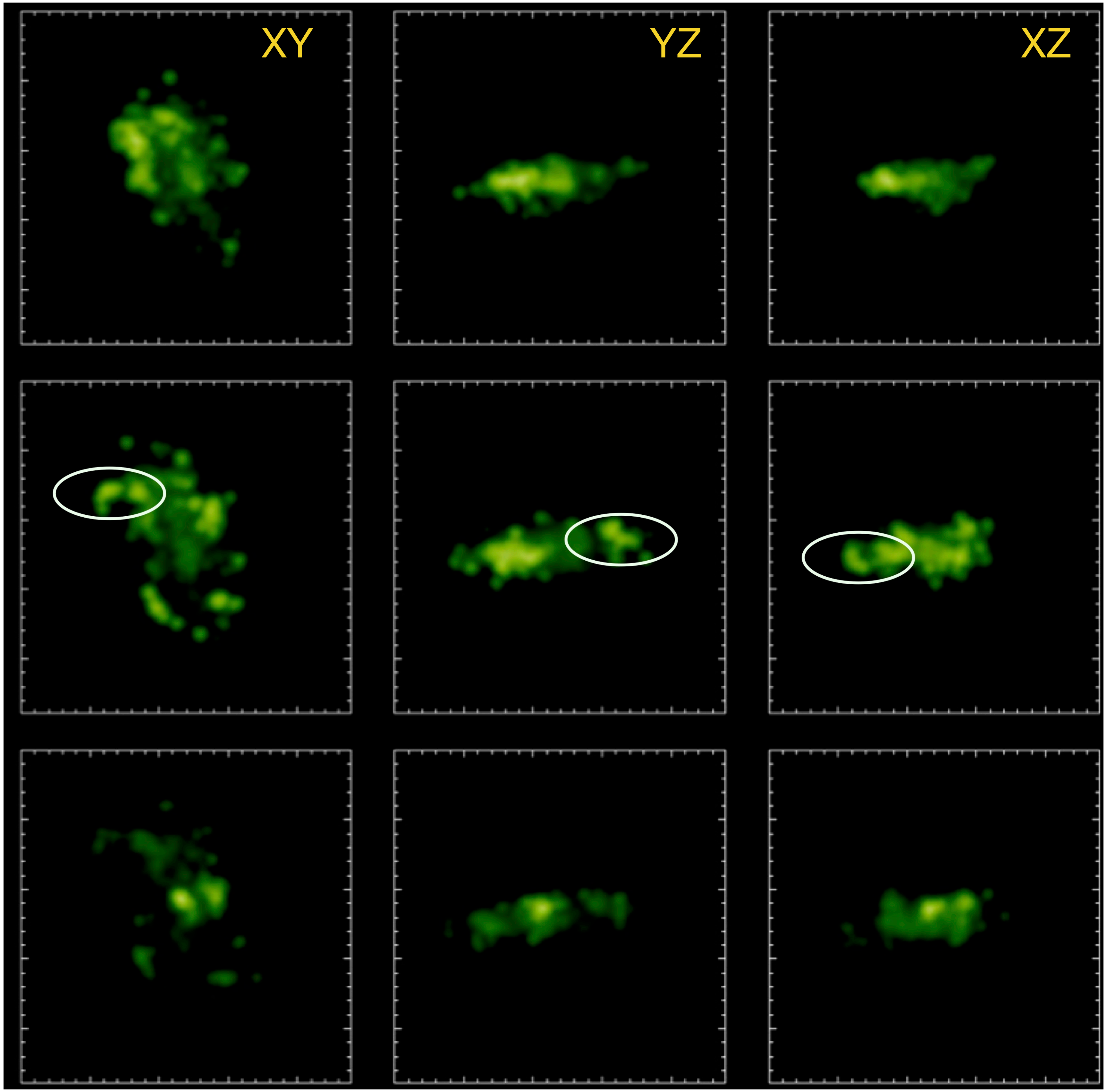


Projected luminosity - density map:

a disk instability rather than a companion

time step

37×10^6



best fit snapshot

Summarizing ….

Mazzei+ 2014, ApJ, 782, 53

- ✓ Bright ETGs spend less time (up to 3~5 Gyr) in the GV than fainter ones

  in LDE the predominance of barionic/dark matter within D_{25} in ETGs starts at z~1

- ✓ up to 30% of the stellar mass is assembled in the GV of LDE

  SF quenching is intrinsic and, in LDE, independent from the environment richness

  Mazzei+ 2017, in prep.

- ✓ Odd pairs in loose groups: E+S pairs (~10 -25% in pair catalogues) can be understood

  in term of mergers—> 1:1 on-going merger in the case of NGC 454

  Plana+ 2017, MNRAS,

- ✓ Odd pairs and disk instabilities: NGC 3447/NGC 34447A is a false pair!

  how many in galaxy surveys?

  Mazzei+ 2017b, A&A, in press

- ✓ Thanks a lot for the patience !