

Tema 8:

Galaxias a distancias cosmológicas: formación y evolución de galaxias

Consultar: "Extragalactic Astronomy and Cosmology", Schneider, 2006, Springer, Tema 9.

"Galaxy Formation and Evolution", Mo, van den Bosch, White, 2010, Cambridge, Tema 2.

NASA Extragalactic Database (NED) Level 5: <http://ned.ipac.caltech.edu>.



Objetivos del tema

- **Describir los aspectos fundamentales sobre las exploraciones de galaxias distantes y qué sabemos sobre esas galaxias.**
 - ◆ **¿Cuáles son las propiedades físicas esenciales de las galaxias a distintas distancias?**
 - ◆ **¿Cómo se miden?**
 - ◆ **¿Qué nos revelan estos estudios de galaxias distantes sobre la evolución del Universo?**



8.1.Exploraciones de galaxias

Las exploraciones de galaxias distantes son nuestro experimento para estudiar el Universo en distintas épocas de su existencia e intentar entender su evolución y los procesos de formación de galaxias y la LSS.

Algunos números para cosmología ($H_0, \Omega_M, \Omega_\Lambda$)=(70,0.3,0.7):

$t_H=14.0$ Gyr

Edad=13.5 Gyr

z	L_d (Mpc)	lbt (Gyr)	DM (mag)	1" to kpc
0.0452	200.3	0.6	36.5	0.9
0.1	460.3	1.3	38.3	1.8
0.5	2833	5.0	42.3	6.1
1	6608	7.7	44.1	8.0
2	15540	10.2	46.0	8.4
4	35852	12.0	47.8	7.0
7	69021	12.7	49.2	5.2
10	103843	13.0	50.1	4.2
1000	13.7×10^6	13.47	60.7	0.07



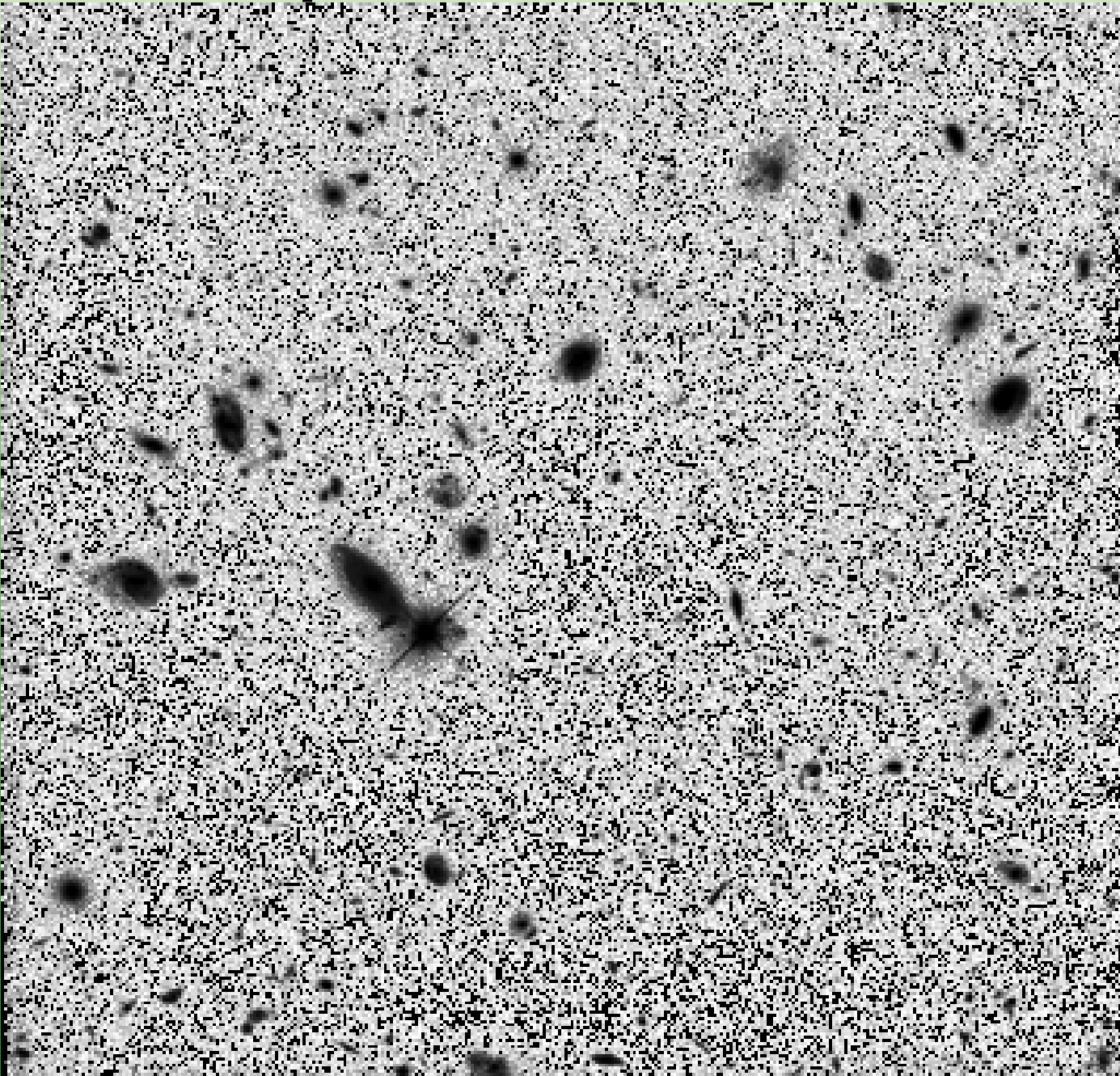
8.1.Exploraciones: fotométricas



<http://www.ifa.hawaii.edu/~cowie/tts/tts.html>



8.1.Exploraciones: fotométricas



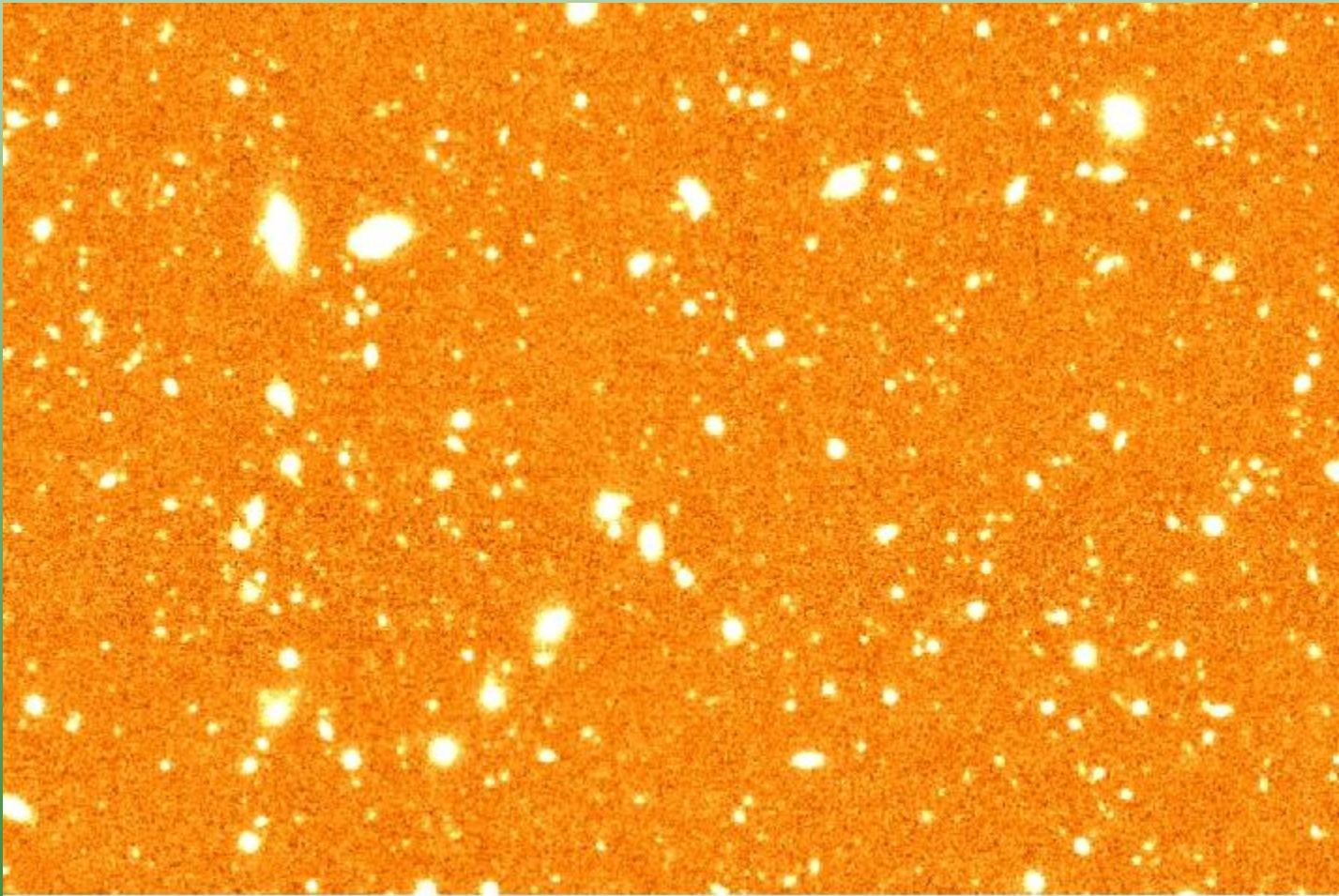
<http://www.stsci.edu/stsci/meetings/sfst2/williamsr.html>



8.1.Exploraciones: fotométricas



NB816 (Subaru)



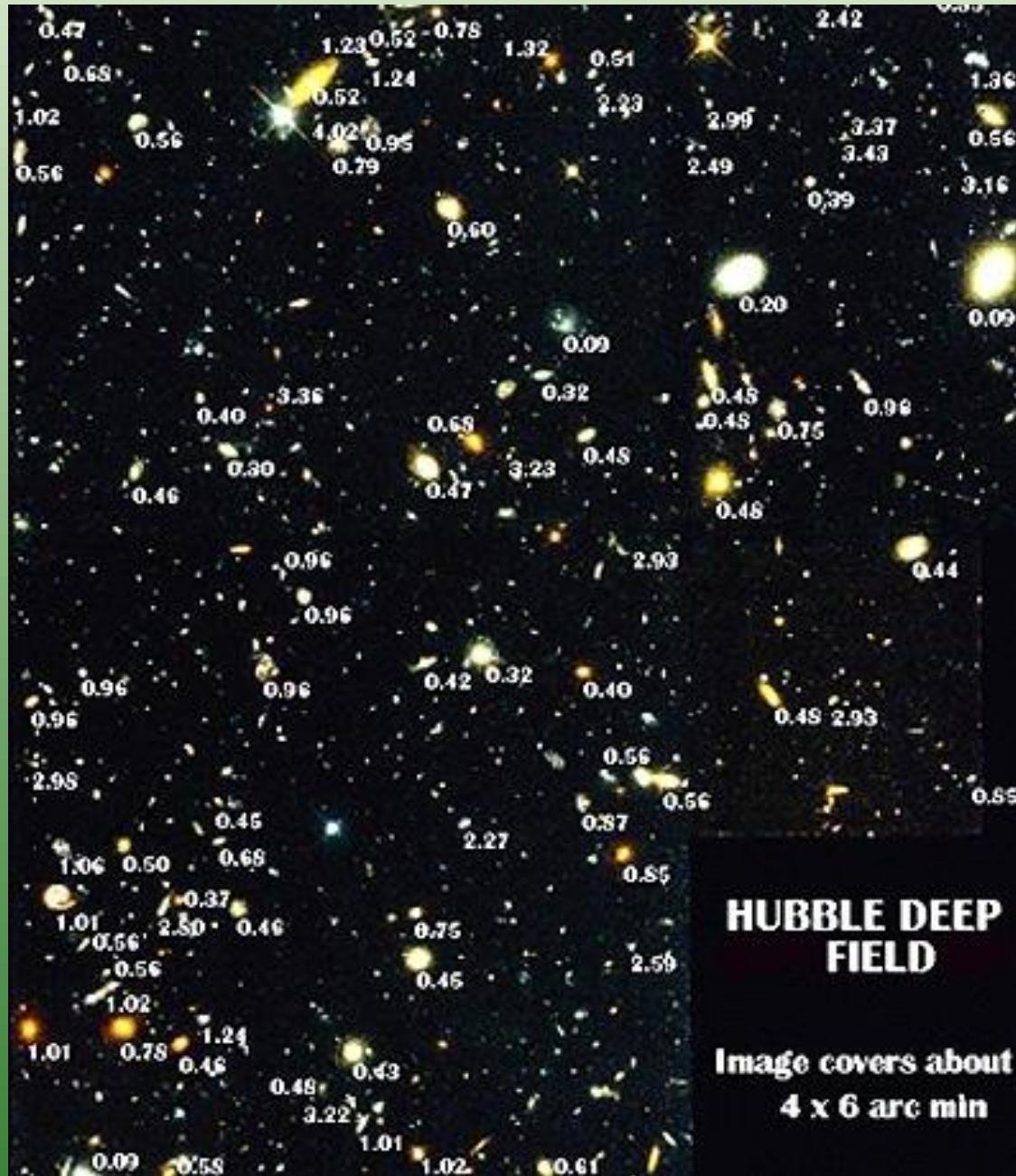
8.1.Exploraciones: fotométricas



<http://acs.pha.jhu.edu/~coe/UDF/segm/>



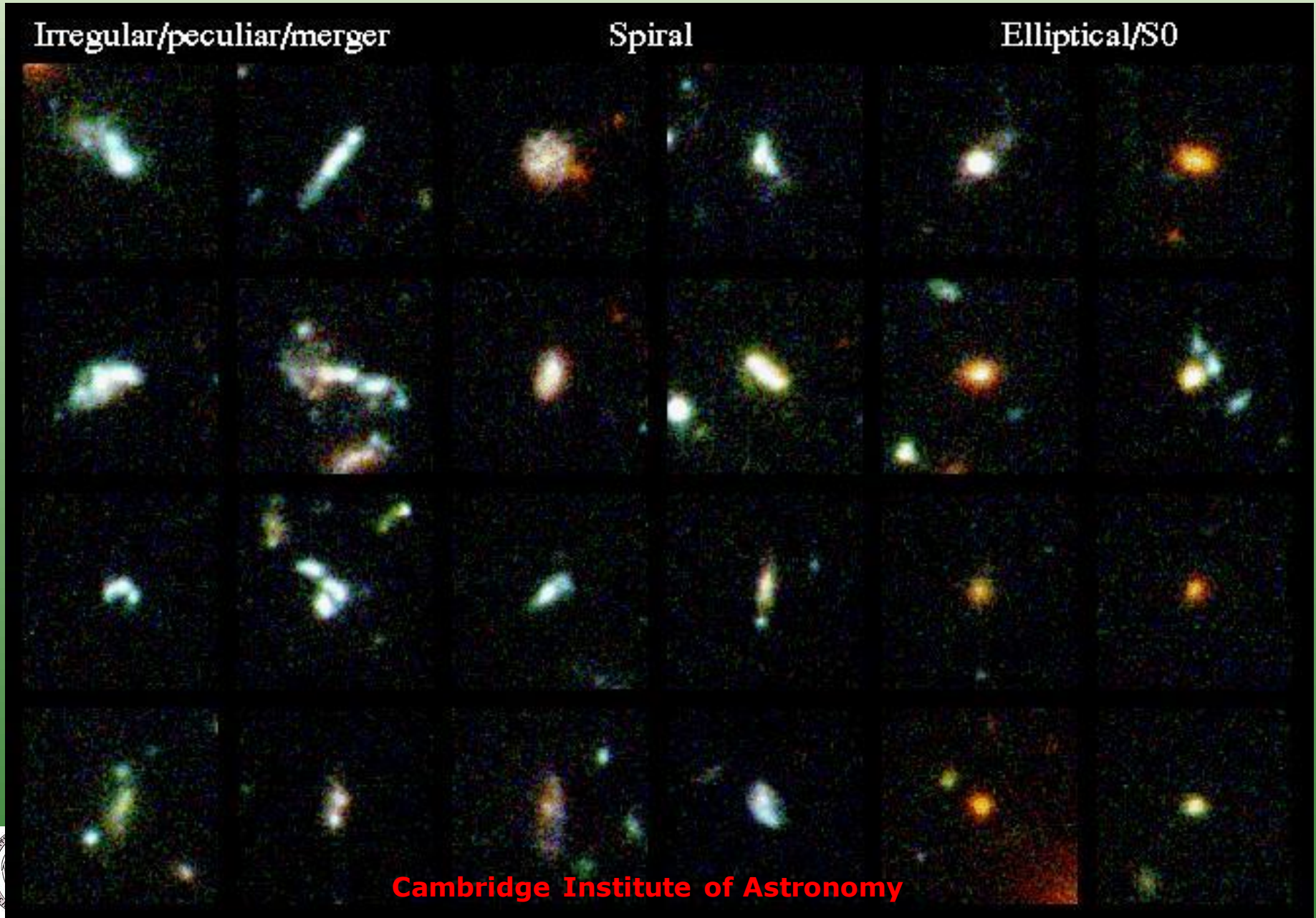
8.1.Exploraciones: fotométricas



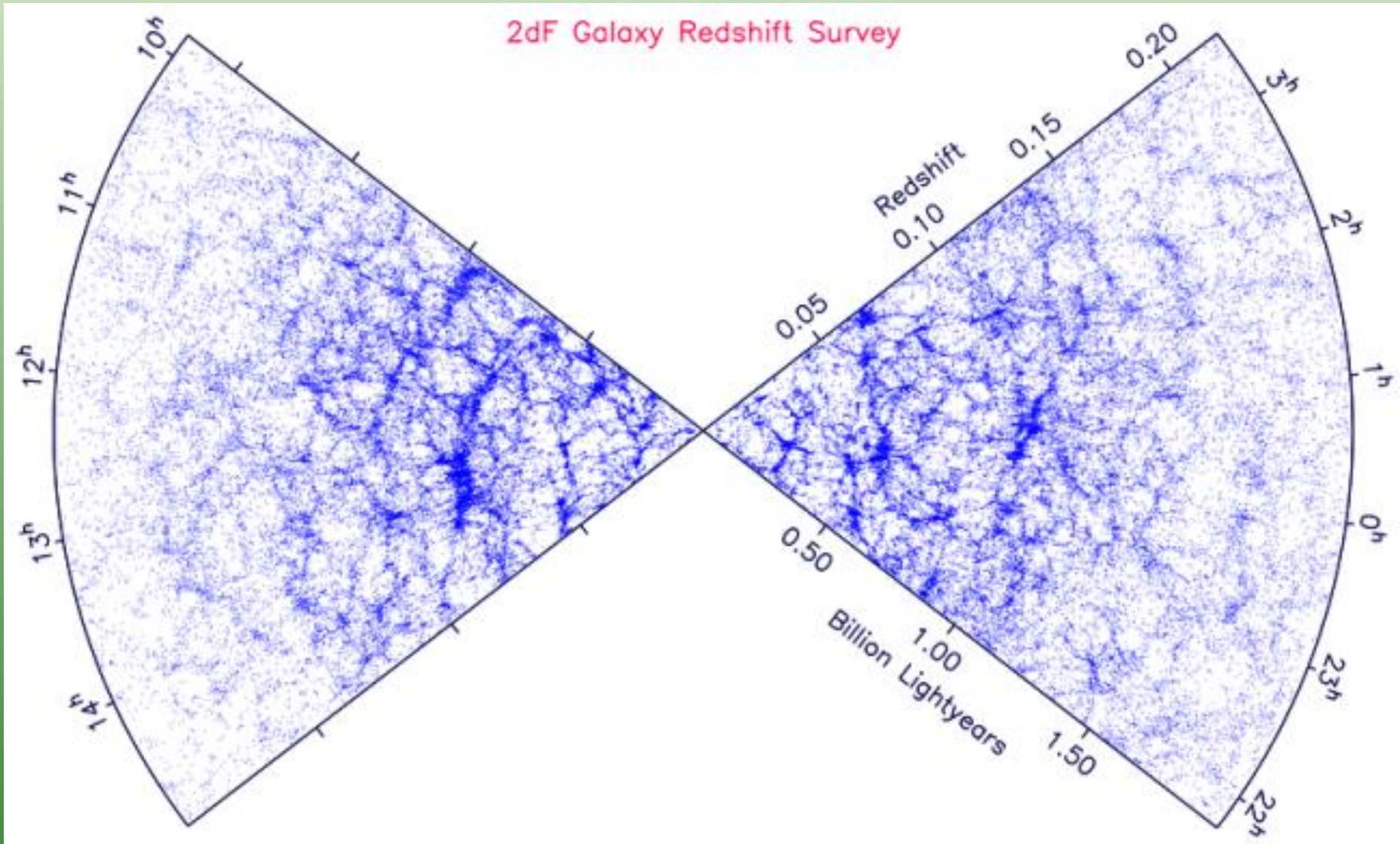
<http://rst.gsfc.nasa.gov/Sect20/A2a.html>



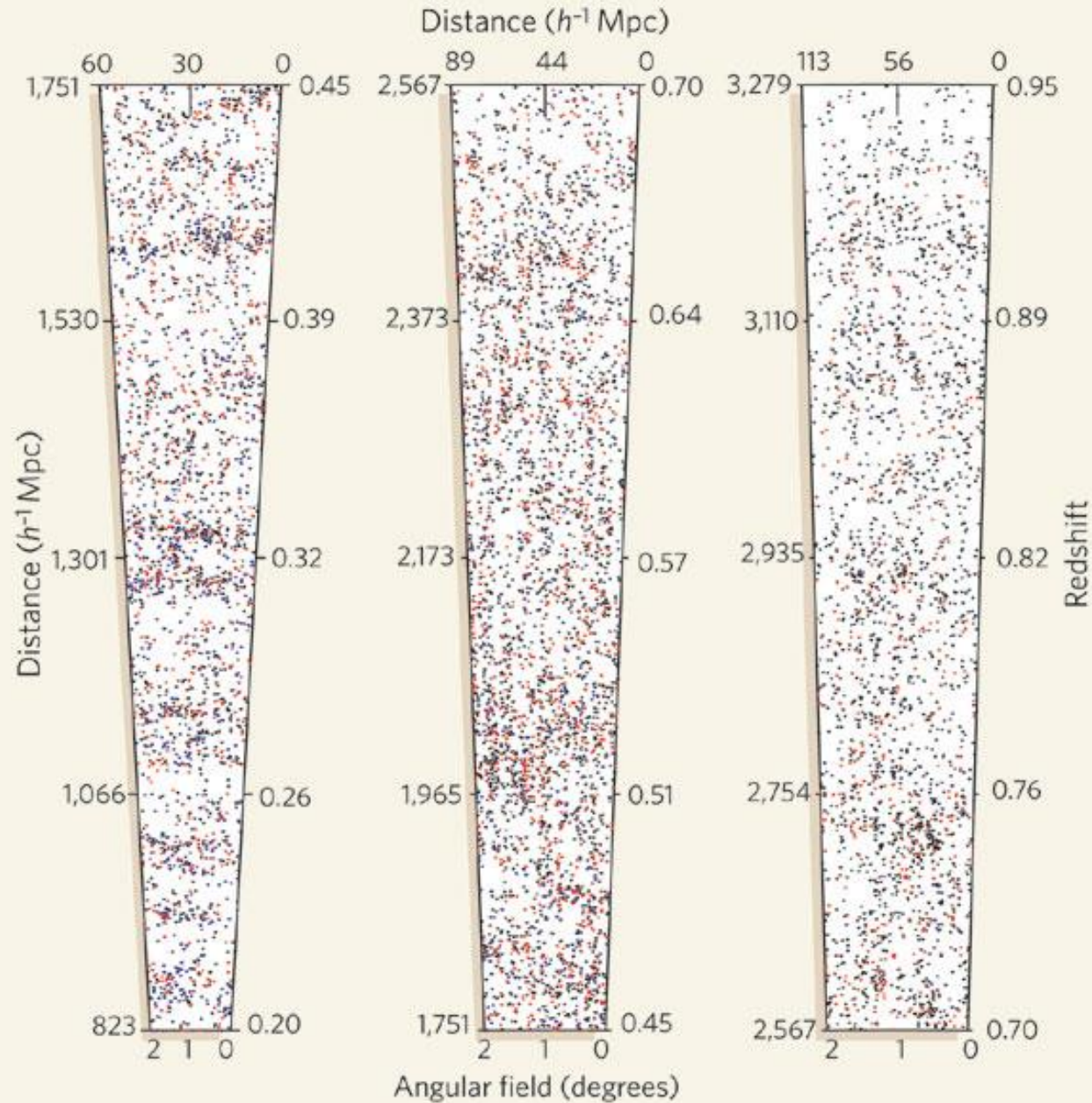
8.1.Exploraciones: fotométricas



8.1.Exploraciones: espectroscópicas



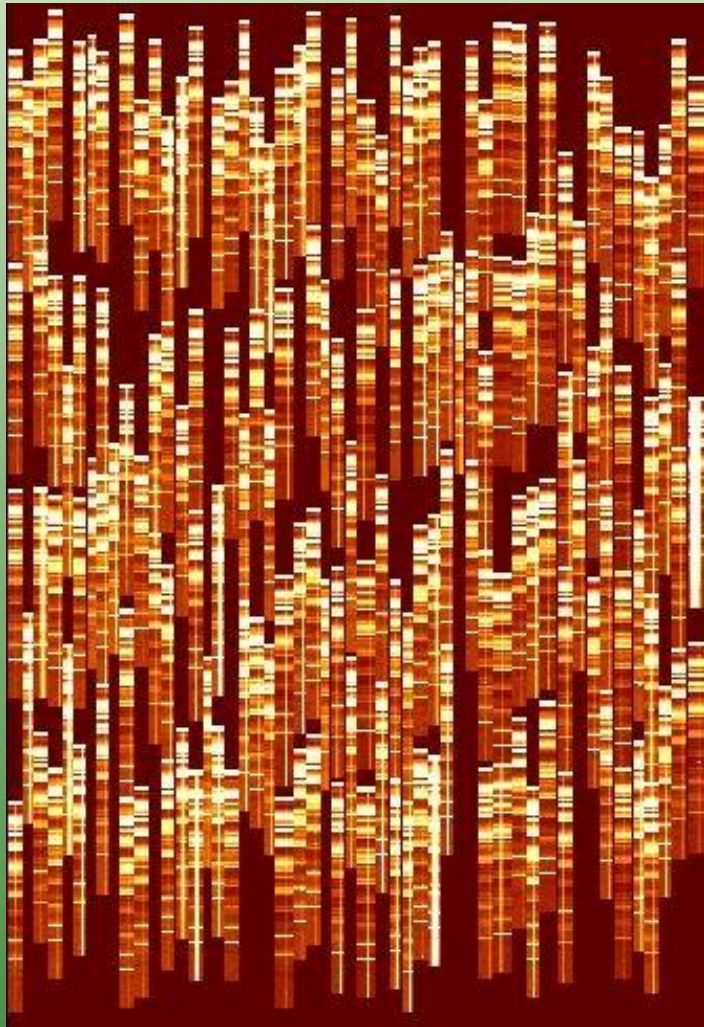
8.1.Exploraciones: espectroscópicas



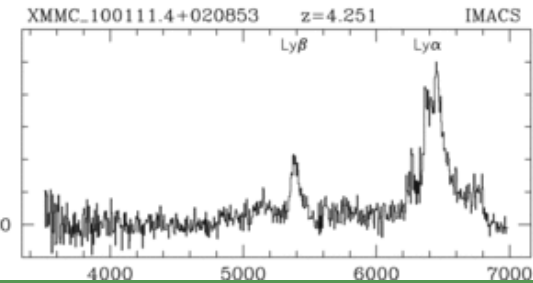
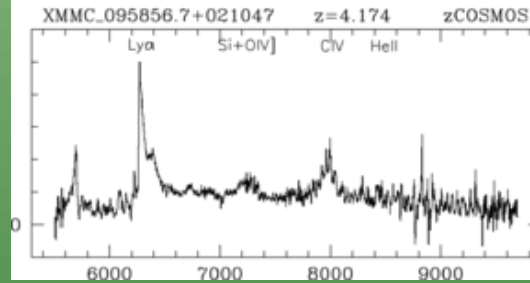
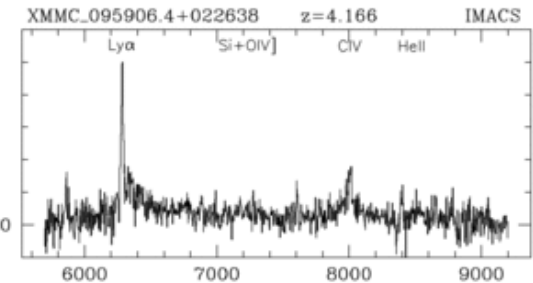
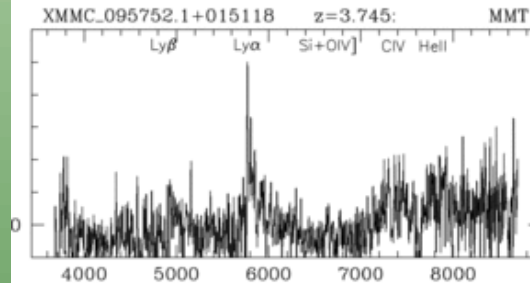
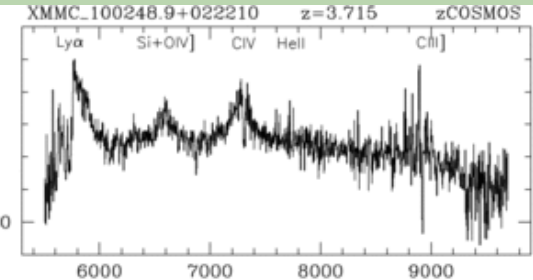
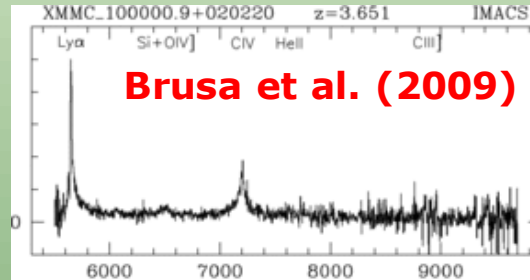
Marinoni et al. (2008)



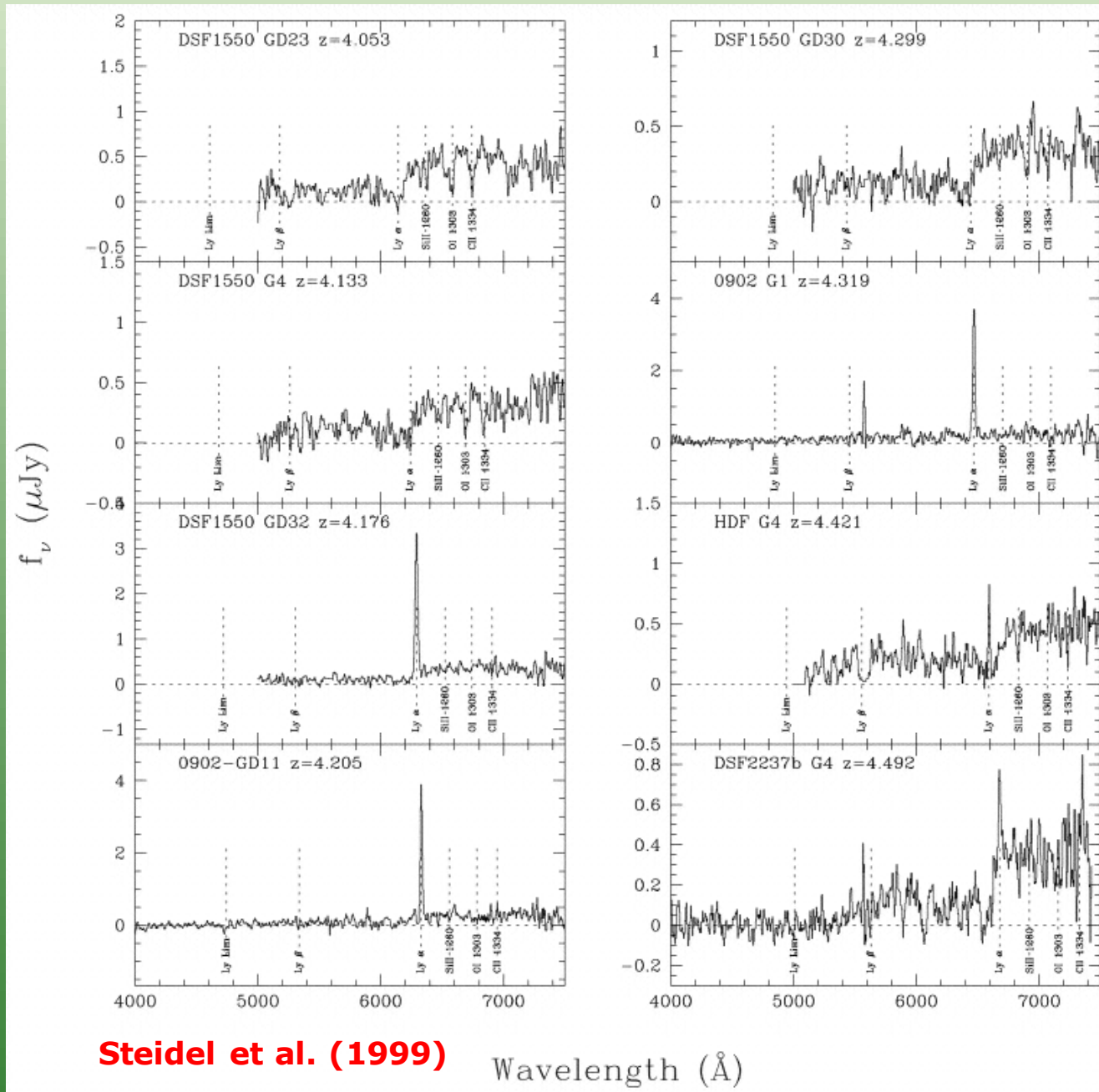
8.1.Exploraciones: espectroscópicas



VVDS



8.1.Exploraciones: espectroscópicas

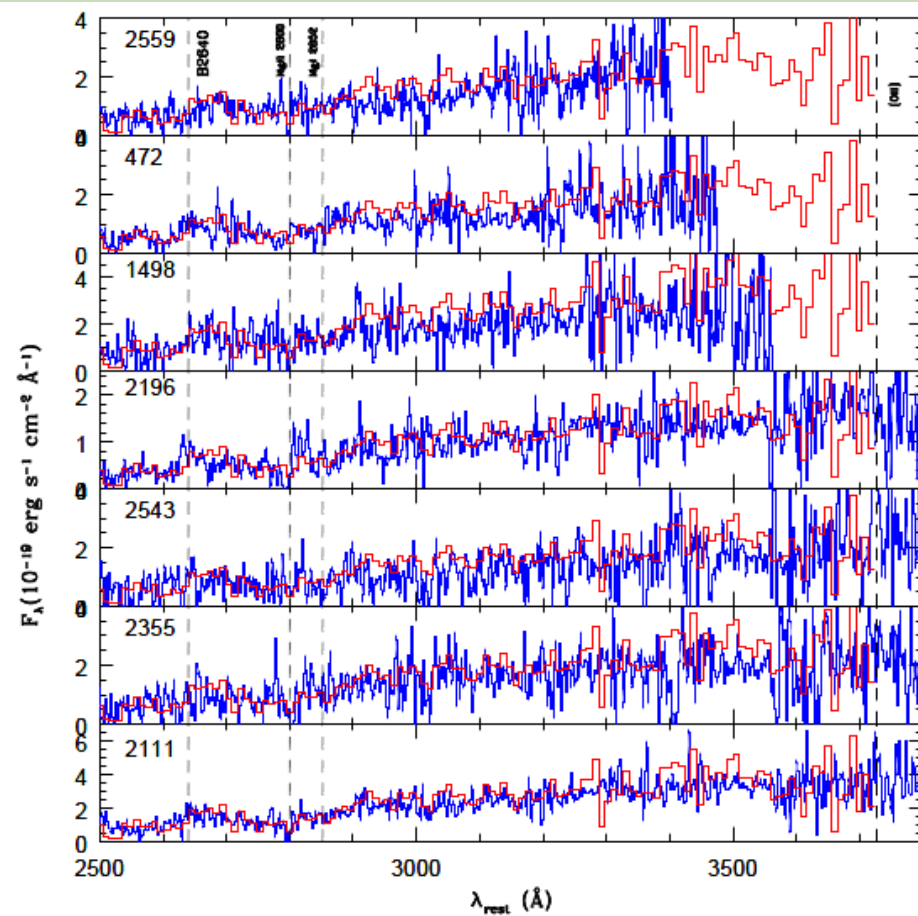
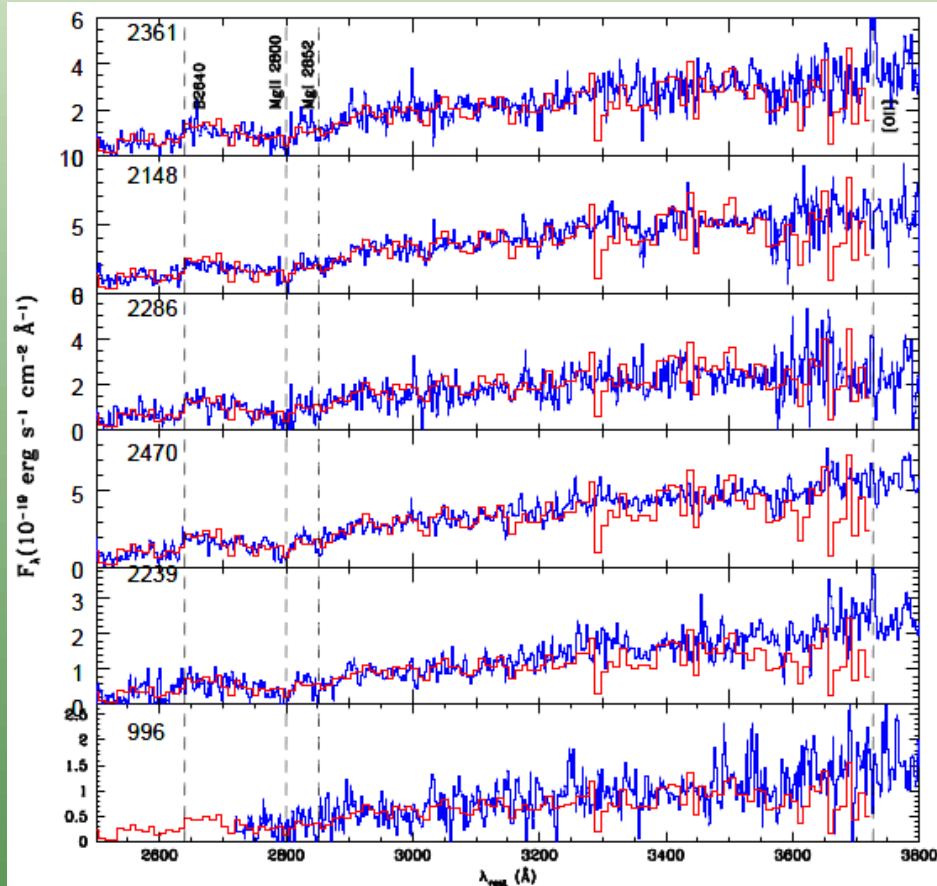


Steidel et al. (1999)

Wavelength (\AA)



8.1.Exploraciones: espectroscópicas

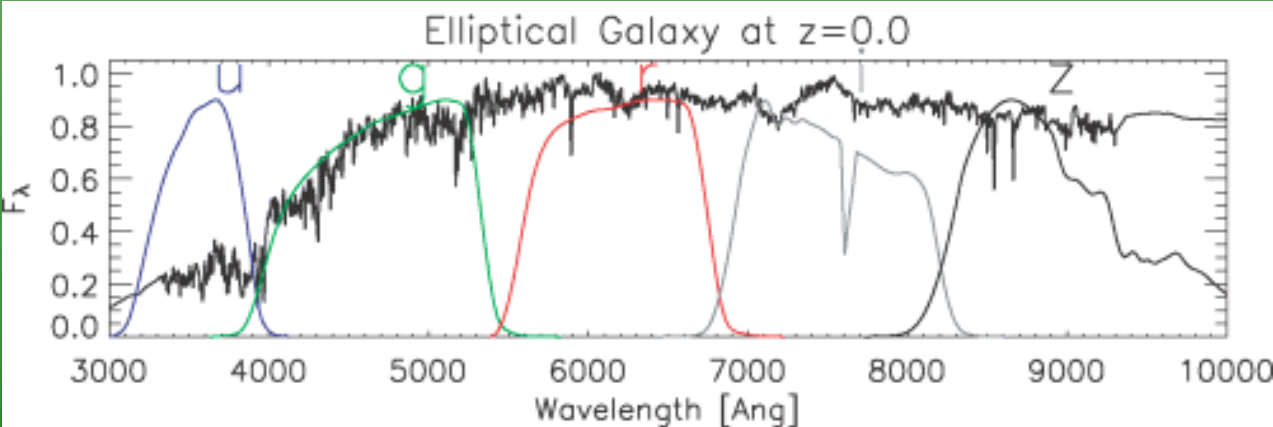


**"Dead" galaxies in
Cimatti et al. (2008)**

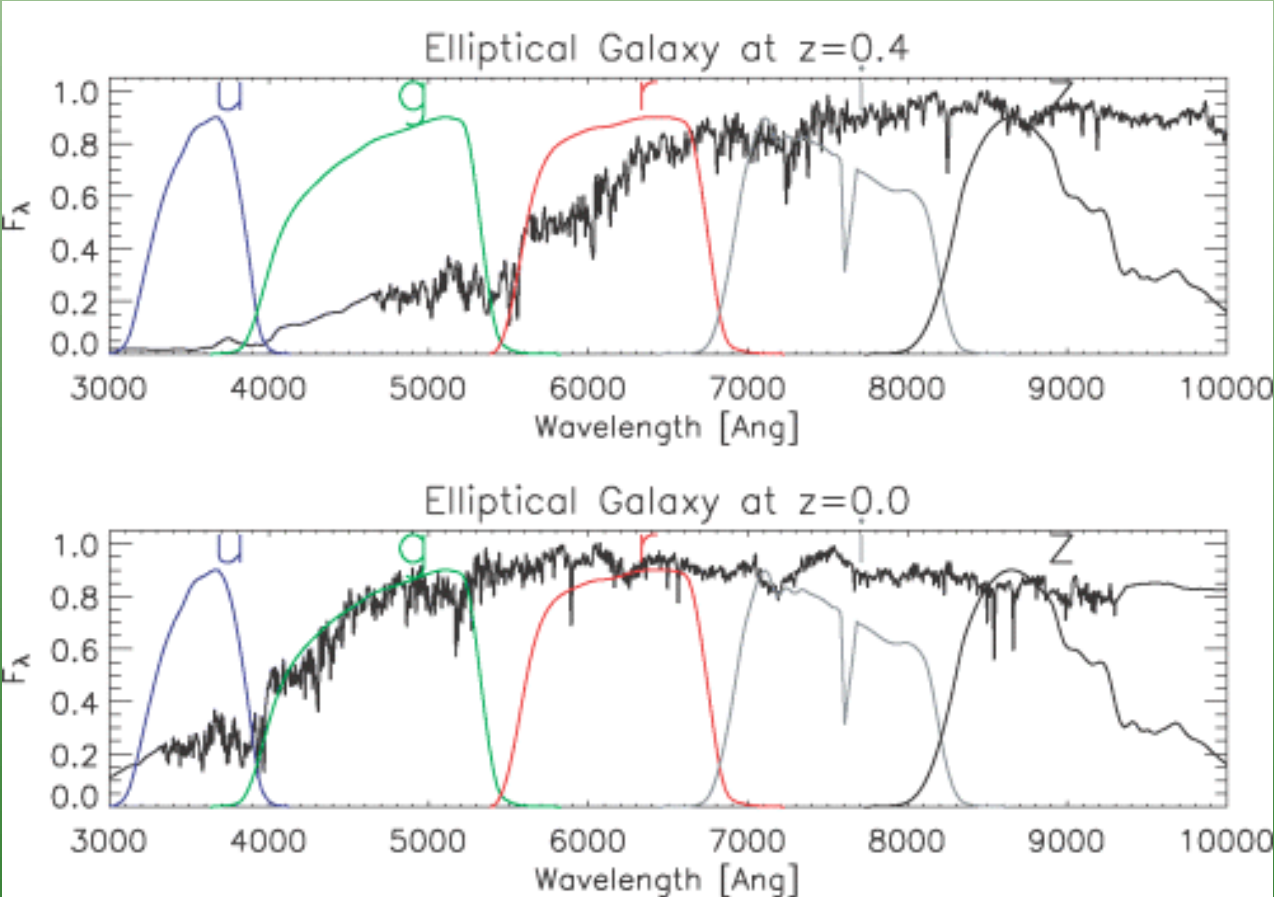


8.2. Selección de galaxias a $z > 0$: efecto del redshift

Padmanabhan et al. (2007)



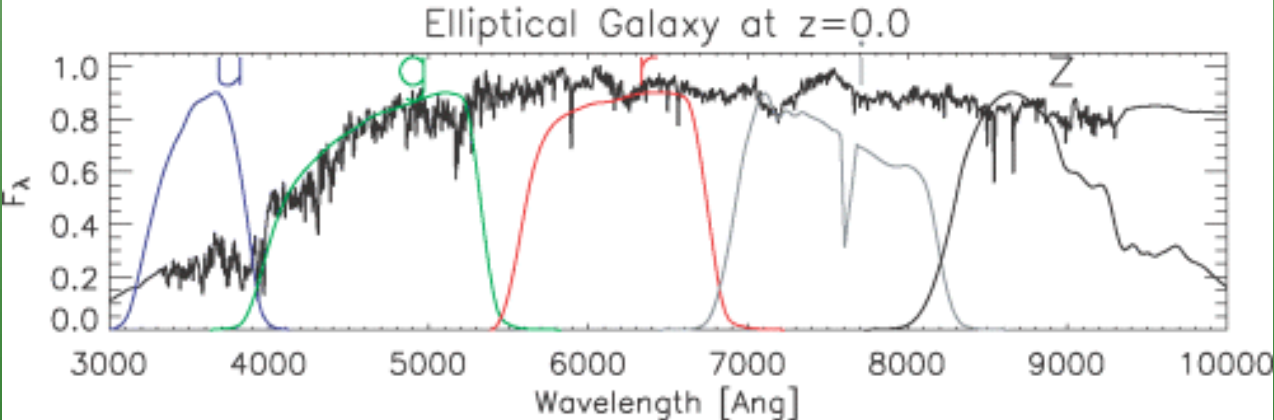
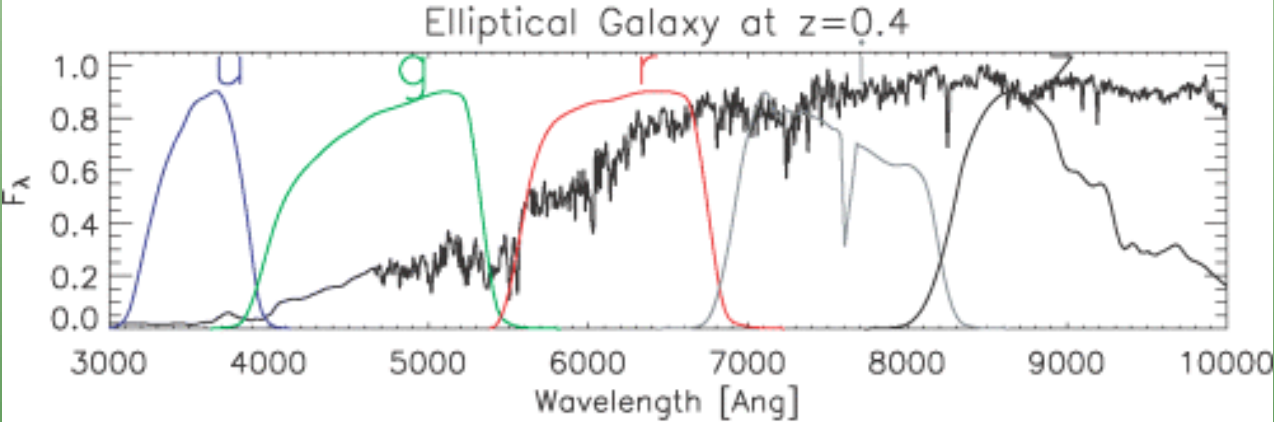
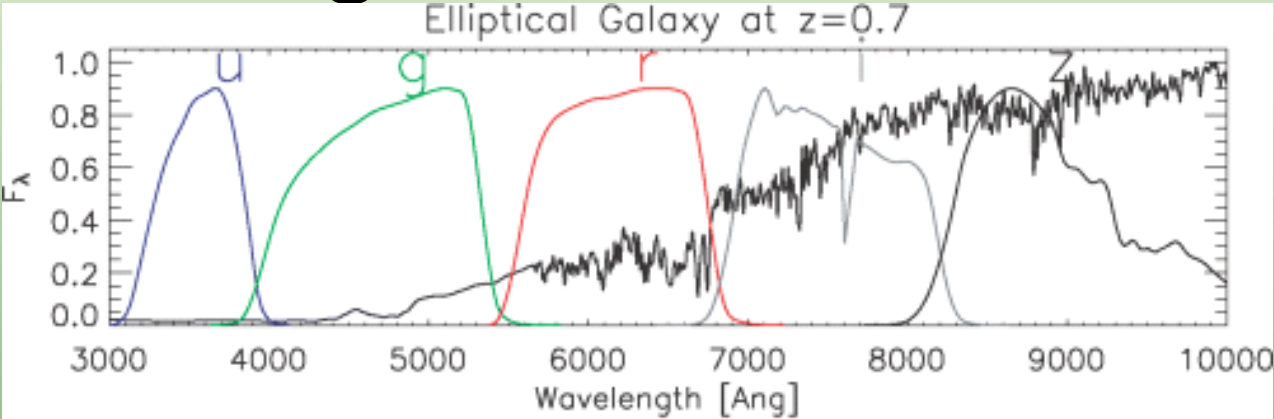
8.2. Selección de galaxias a $z > 0$: efecto del redshift



Padmanabhan et al. (2007)



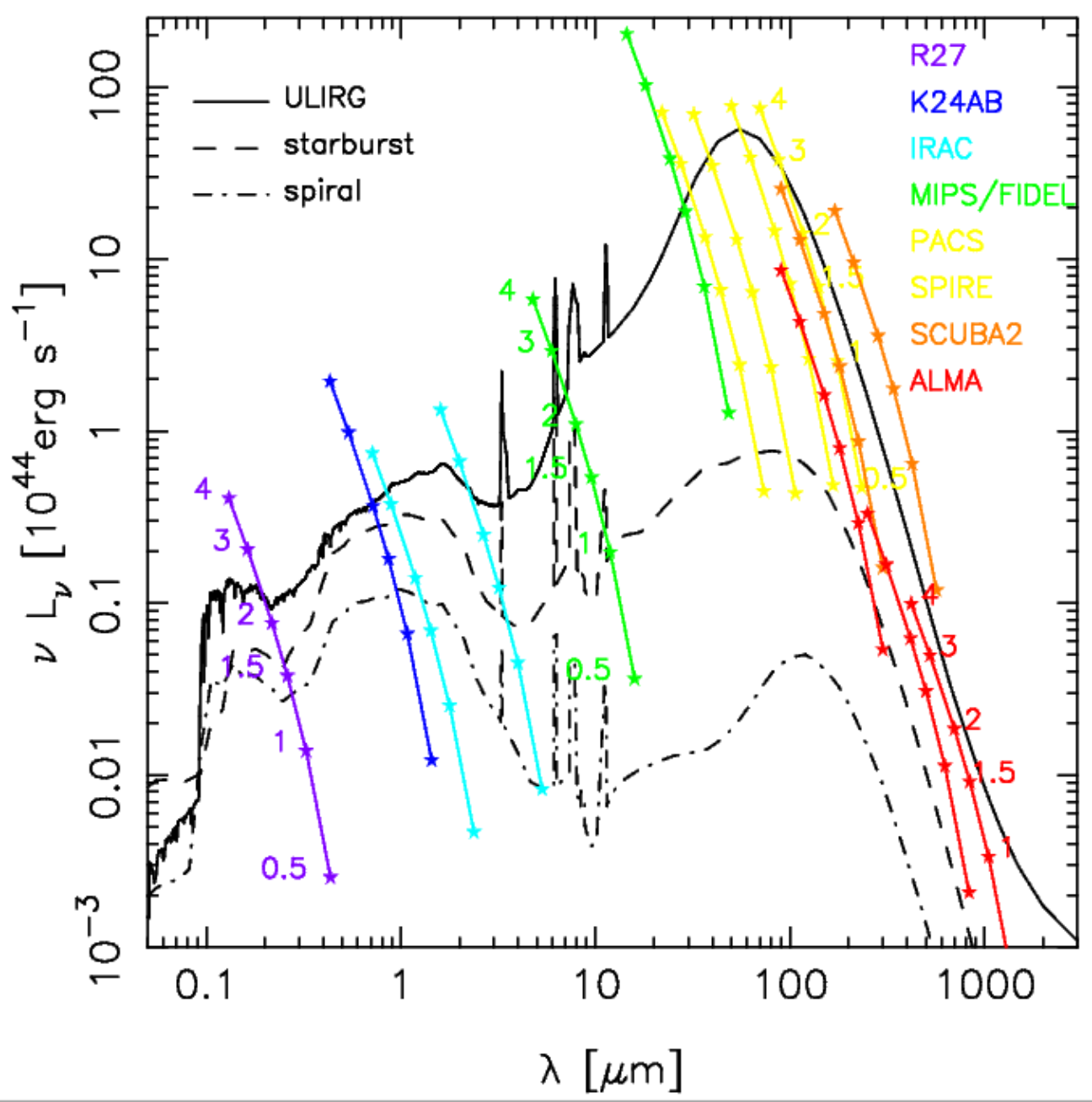
8.2. Selección de galaxias a $z > 0$: efecto del redshift



Padmanabhan et al. (2007)



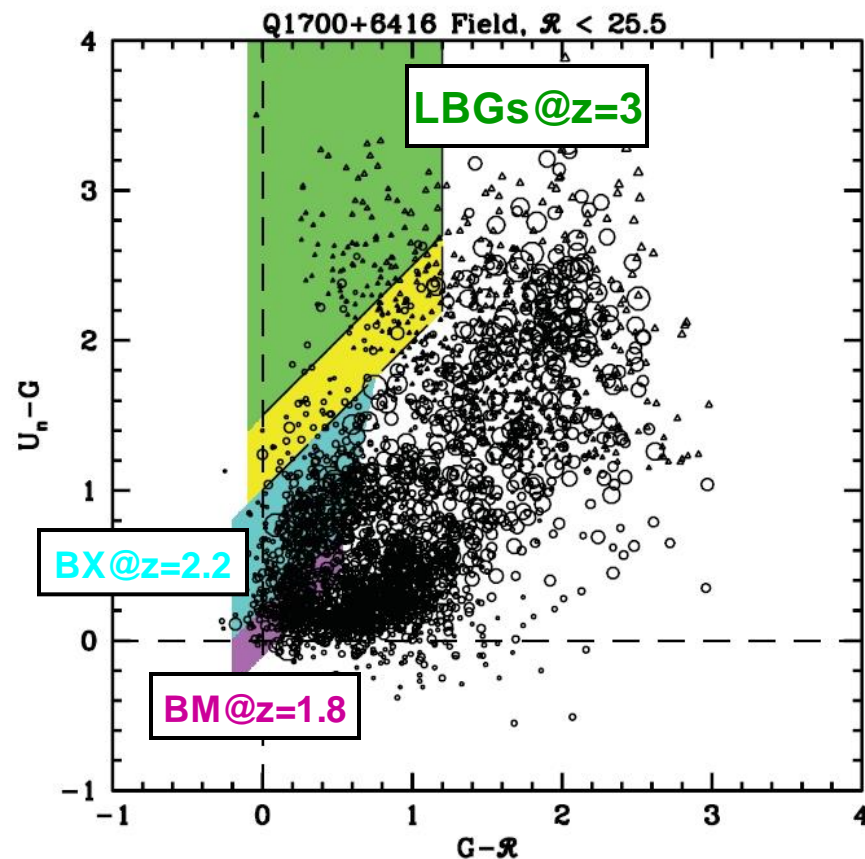
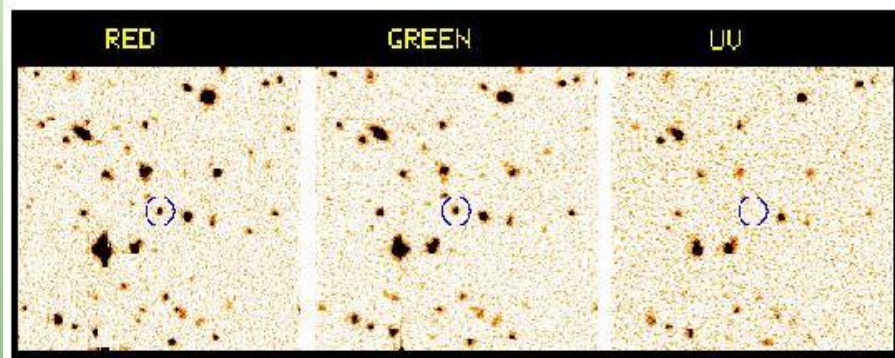
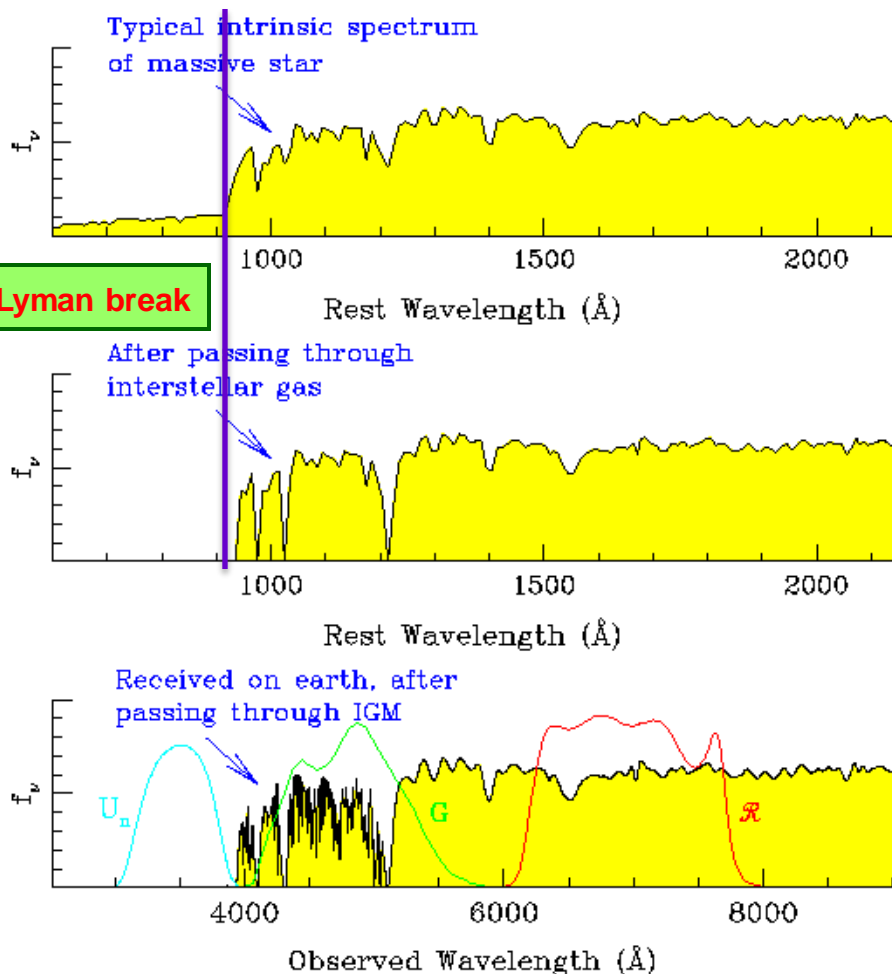
8.2. Selección de galaxias a $z > 0$: efecto del redshift



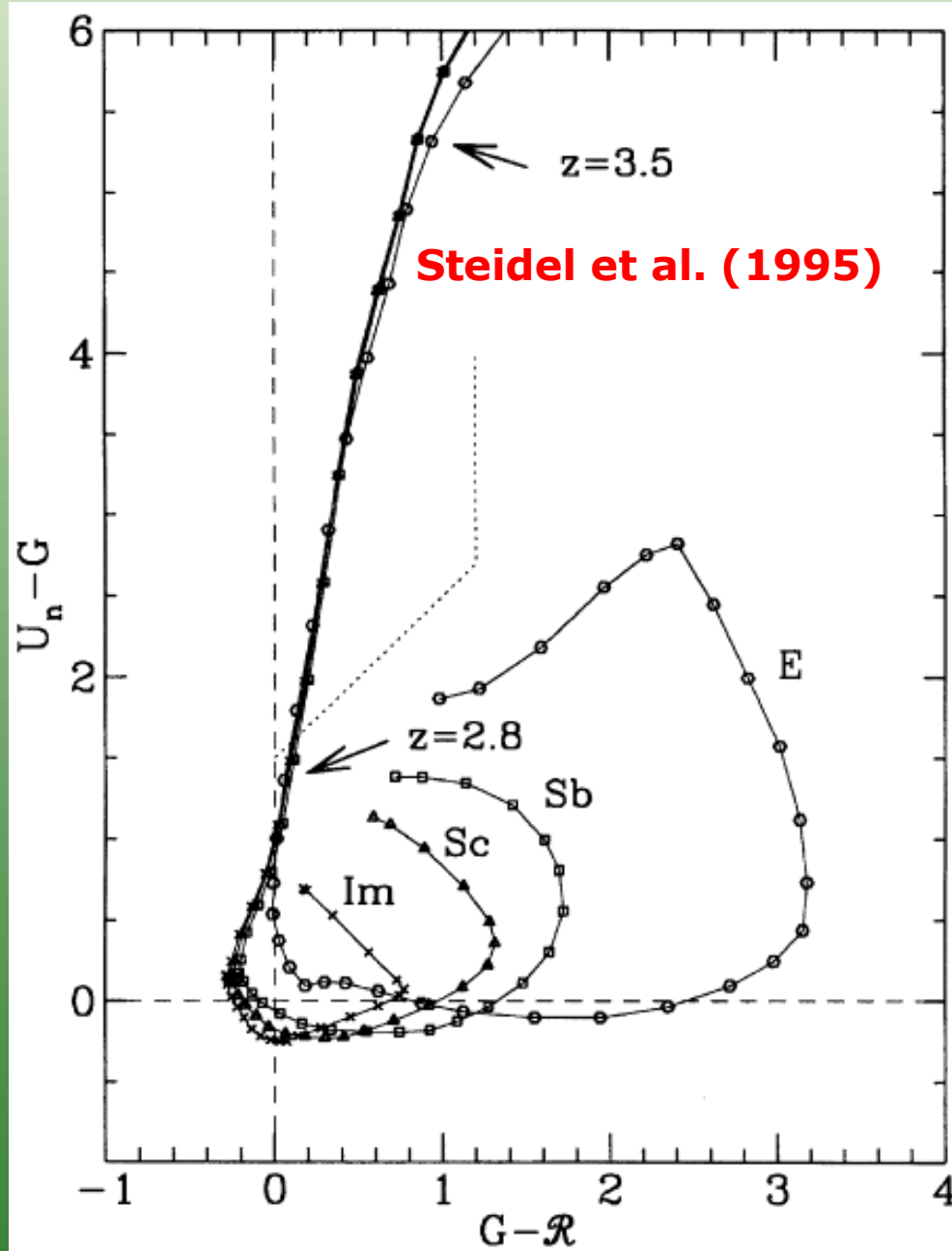
8.2. Selección de galaxias a $z > 1$: LBGs

Dropout or color selection technique

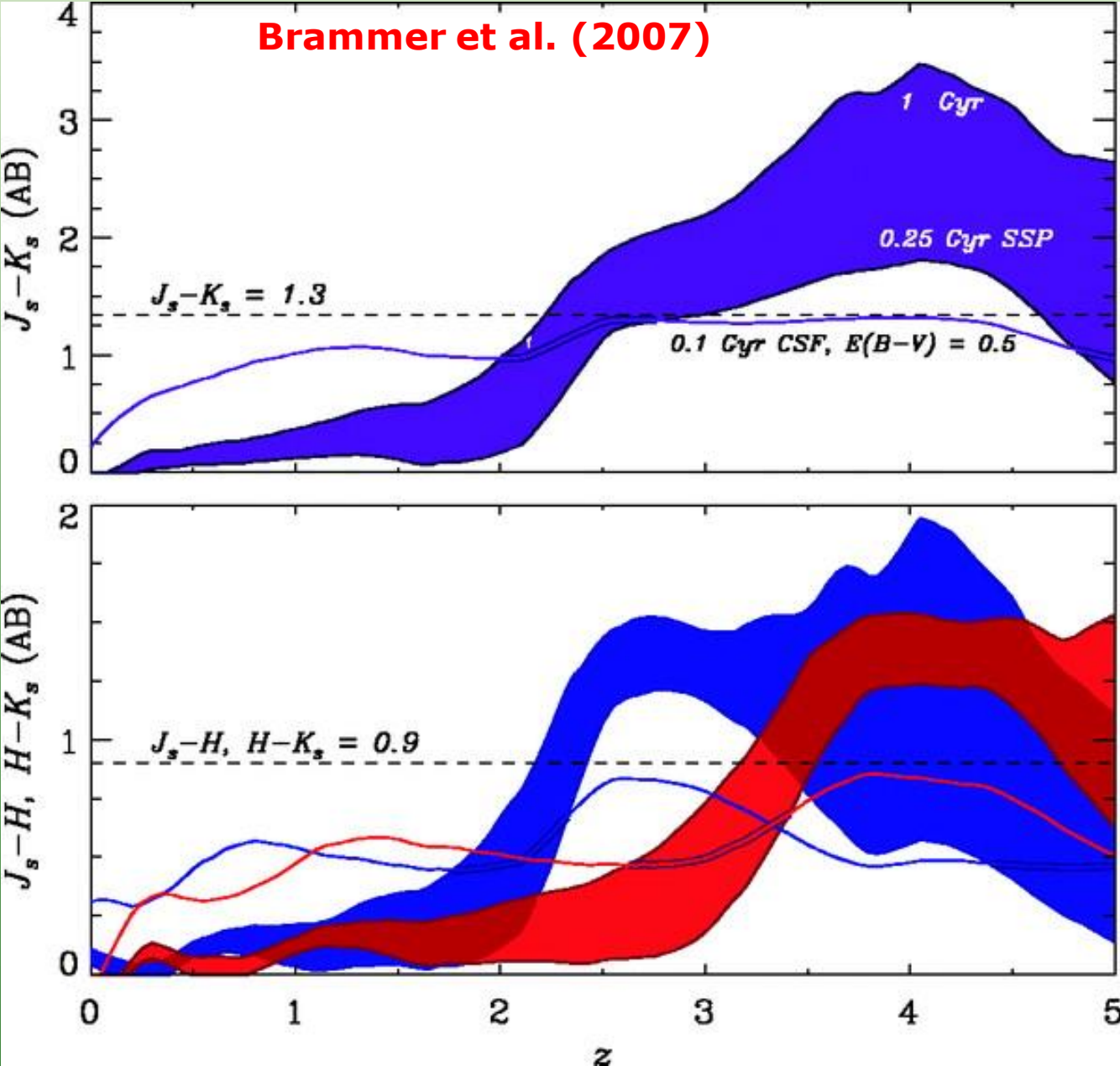
Steidel et al. (1996, 1999, 2004)



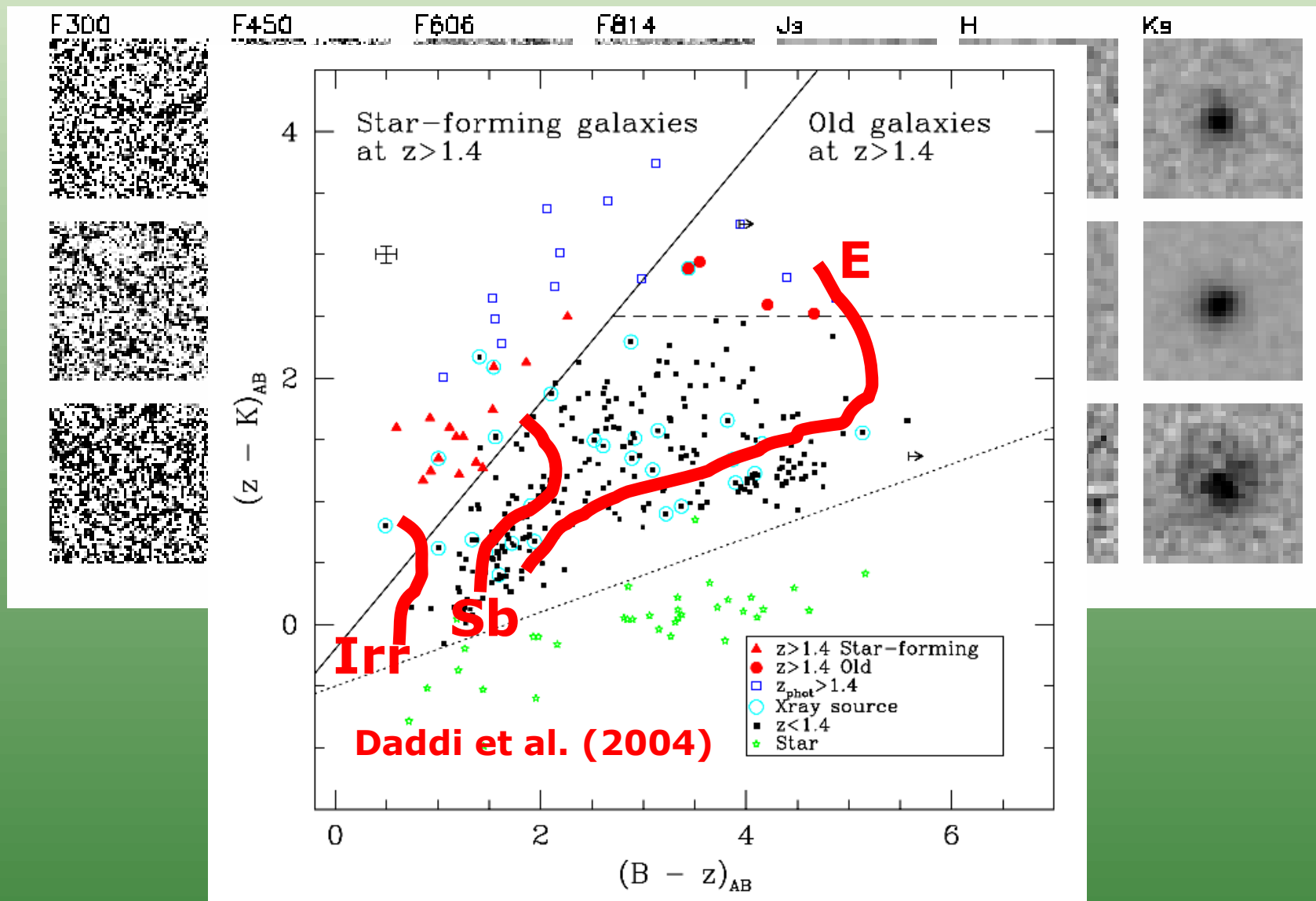
8.2. Selección de galaxias a $z > 1$ con colores: LBGs



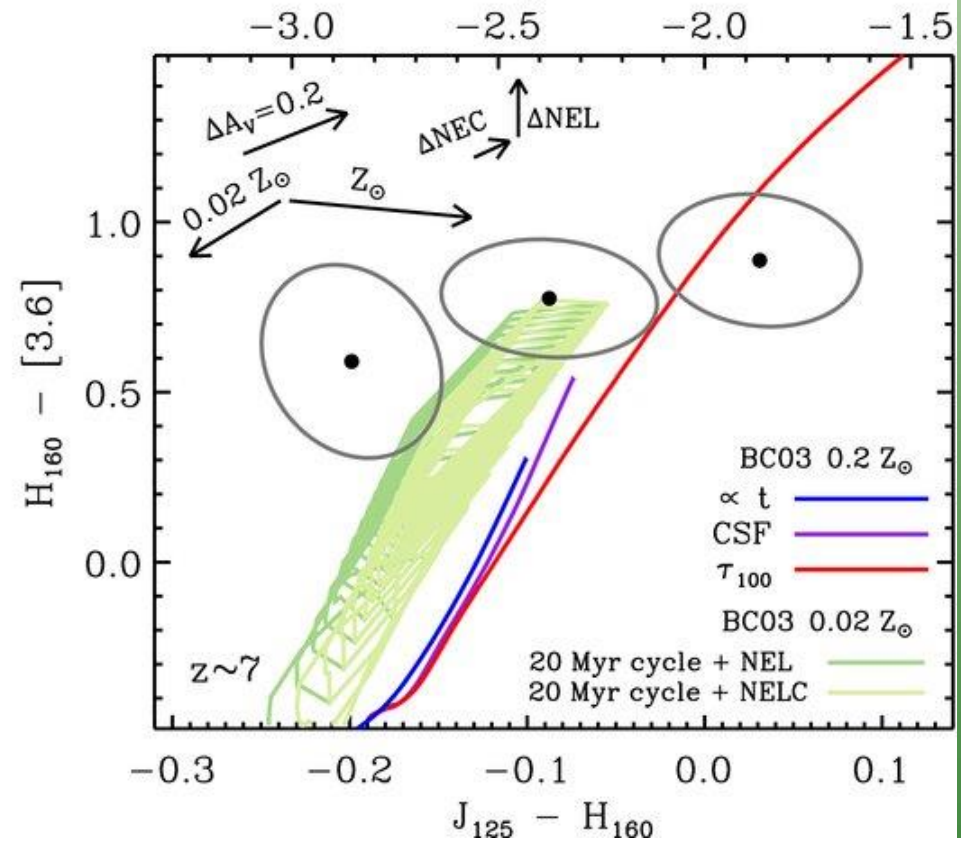
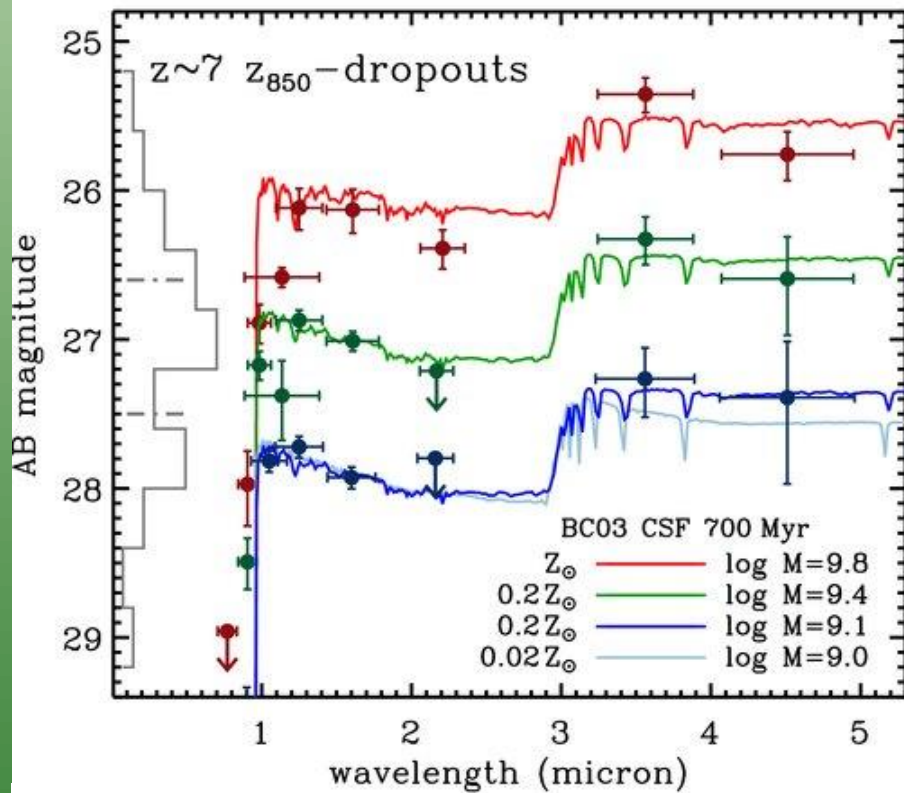
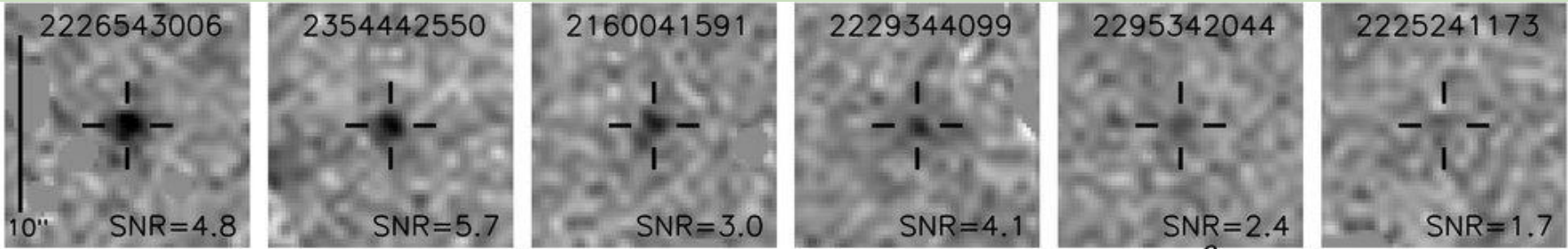
8.2. Selección de galaxias a $z > 1$ con 1 color (DRGs)



8.2. Selección de galaxias a $z > 1$ en el NIR: BzK

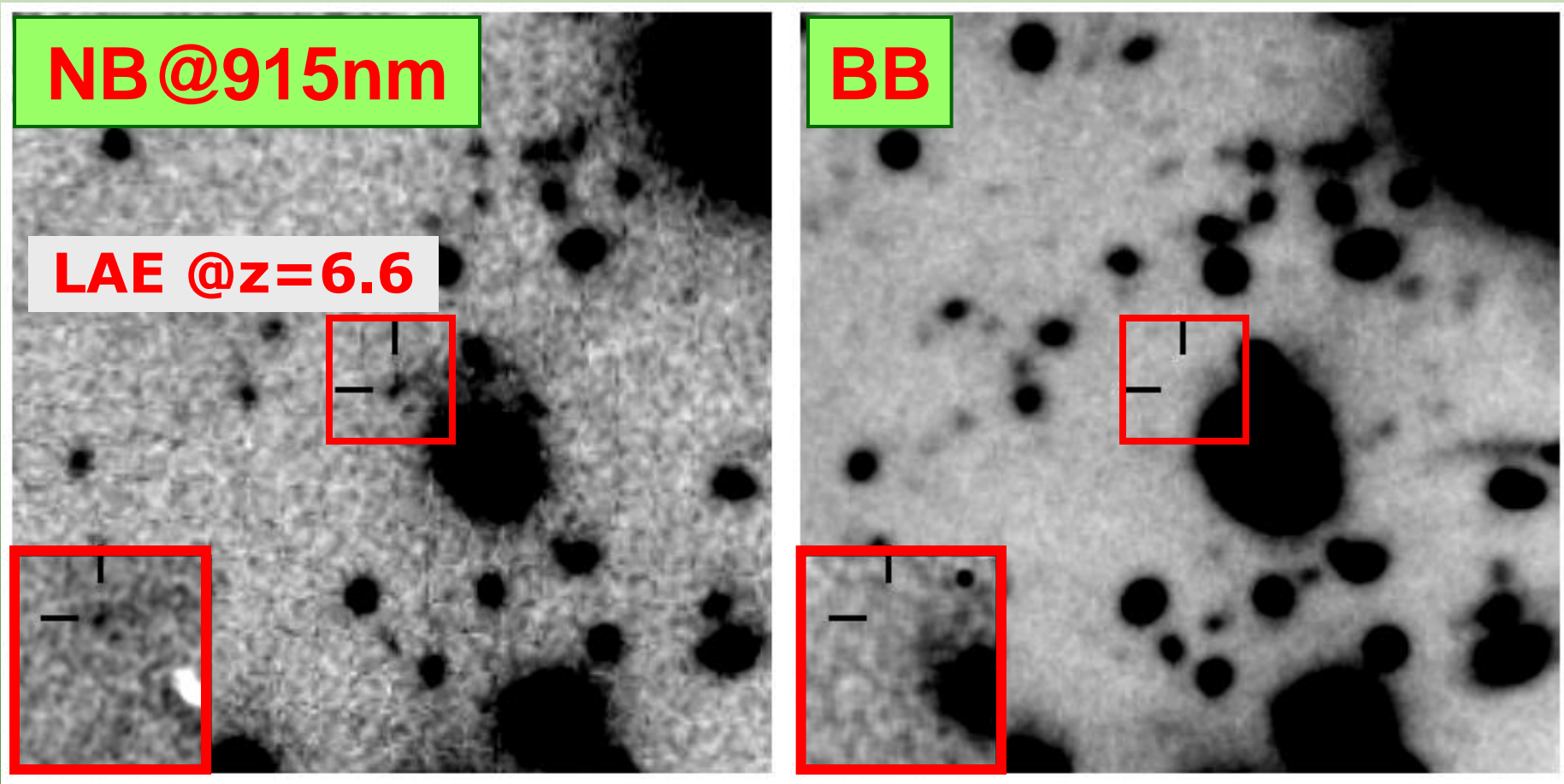


8.2. Selección de galaxias a $z \gg 1$: dropouts



Labbé+ (2006, 2010ab), Bouwens+ (2010ab), Bunker+ (2010), Finkelstein+ (2010), Oesch+ (2010ab), Ouchi+ (2009), SEDS, CANDELS, SHARDS

8.2. Selección de galaxias a $z \gg 1$: NB

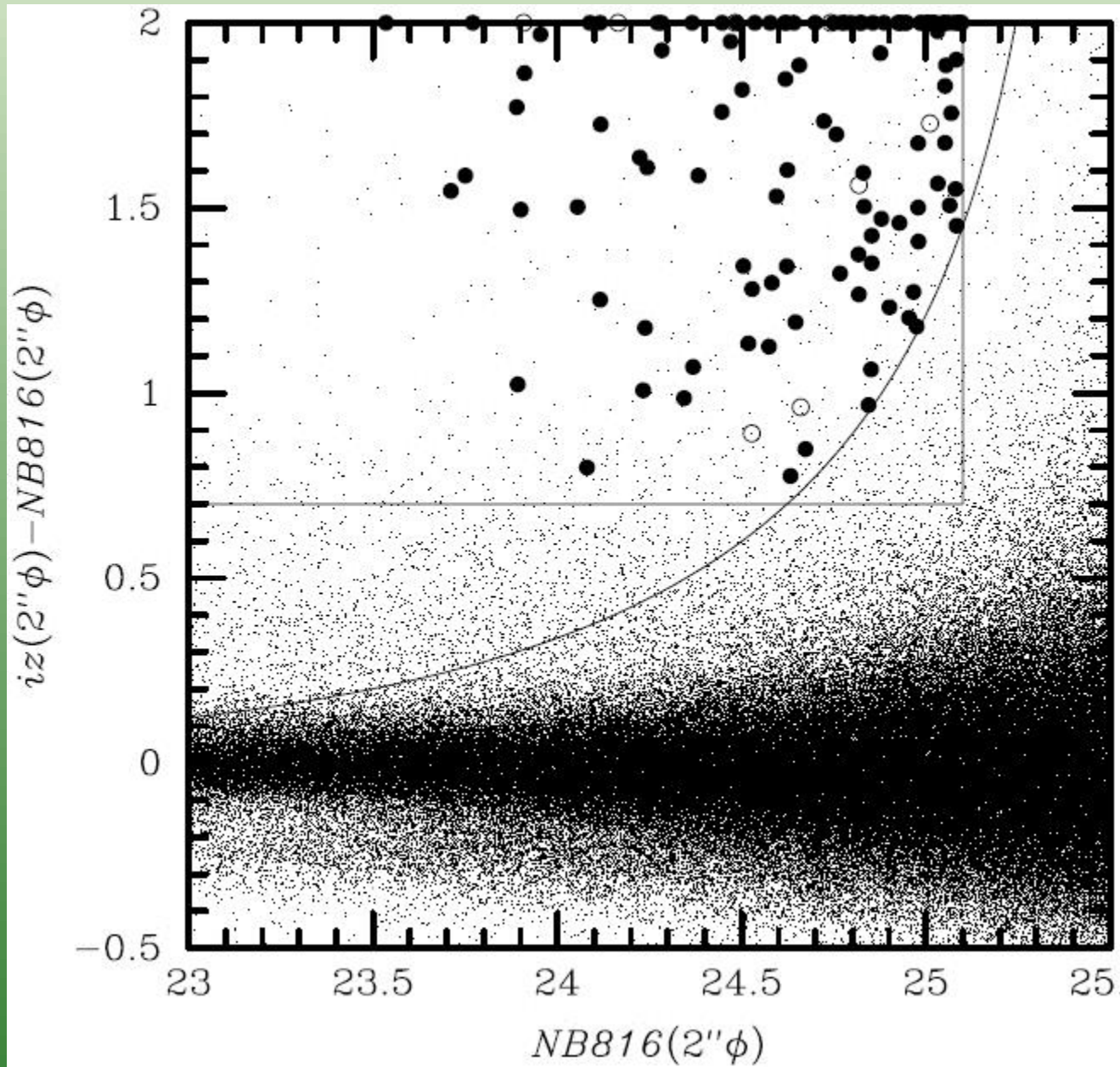


Narrow band technique:
LAEs-Hu et al. (2004)
see also Pascual et al. (2007)



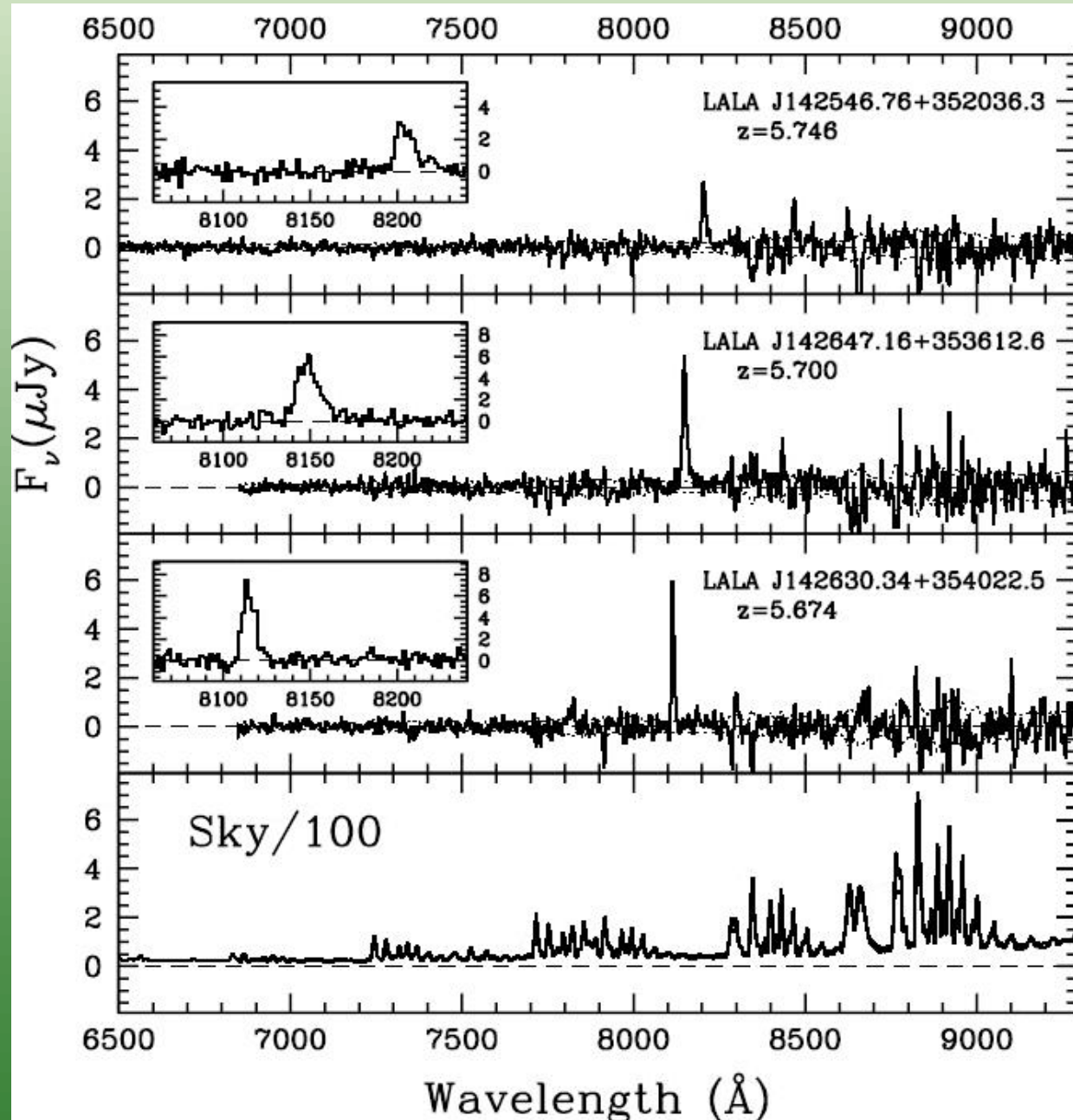
8.2. Selección de galaxias a $z \gg 1$: NB

Murayama et al. (2007)

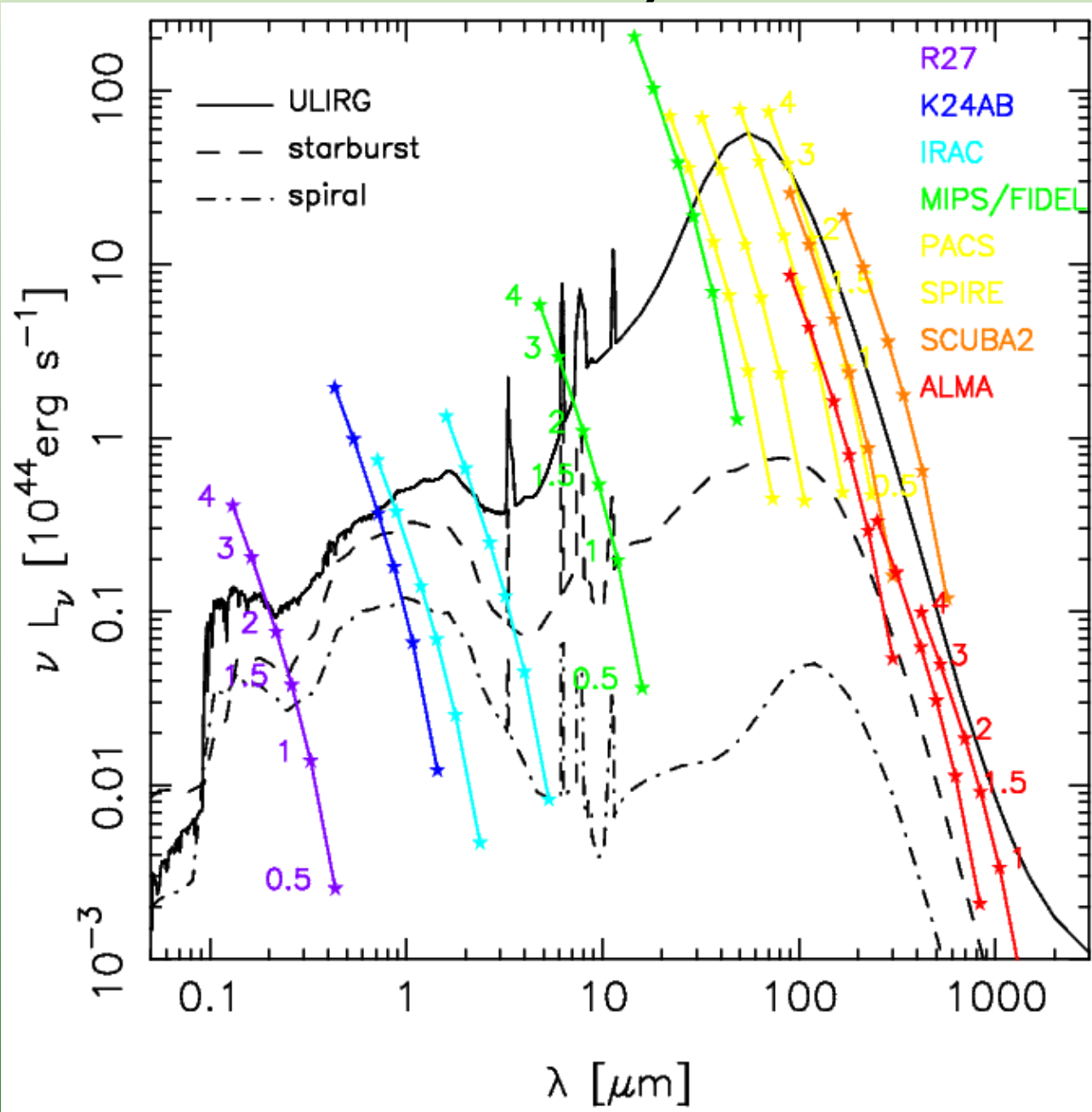


8.2. Selección de galaxias a $z \gg 1$: follow-up

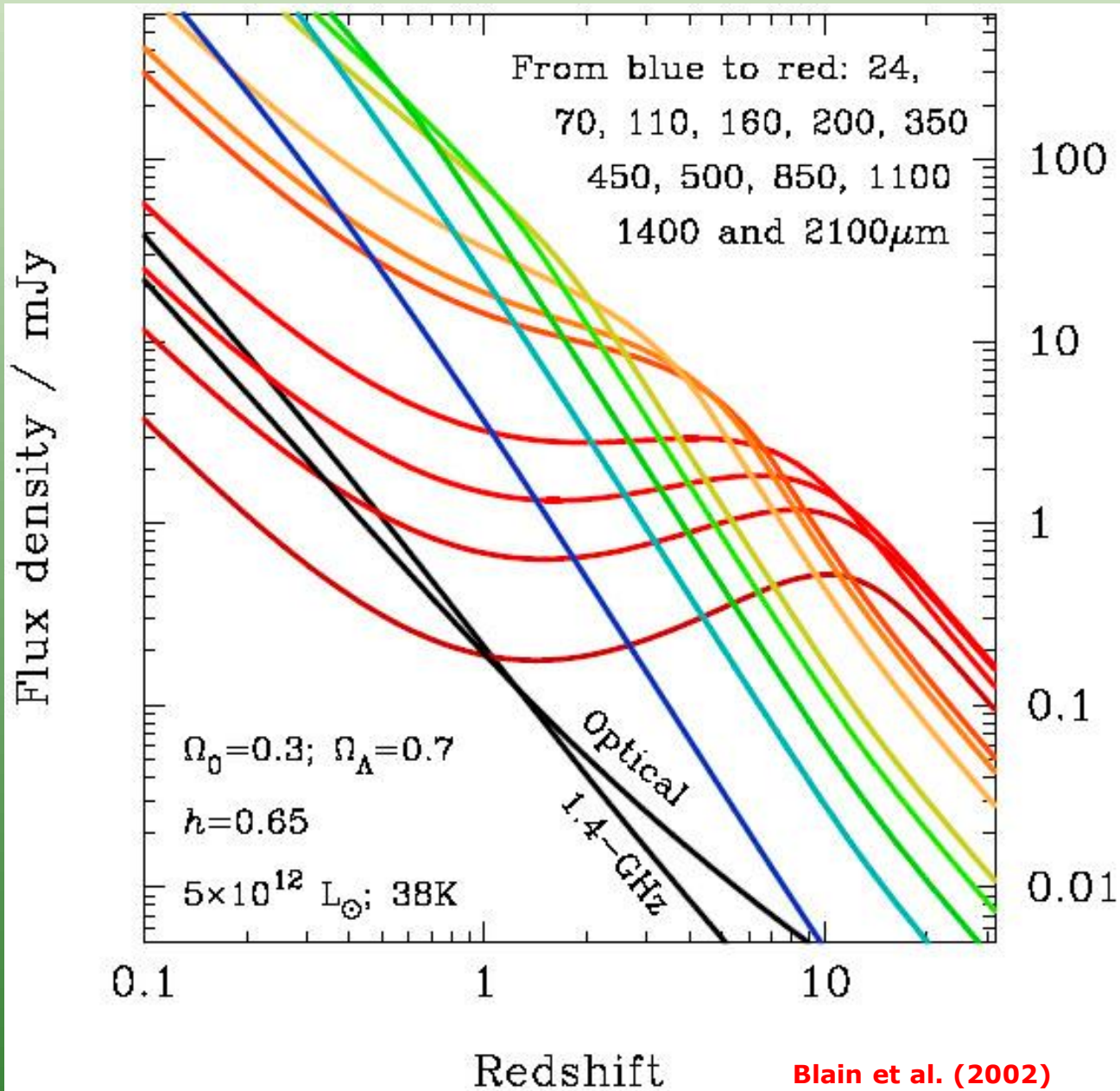
Rhoads et al. (2003)



8.2. Galaxies IR/sub-mm

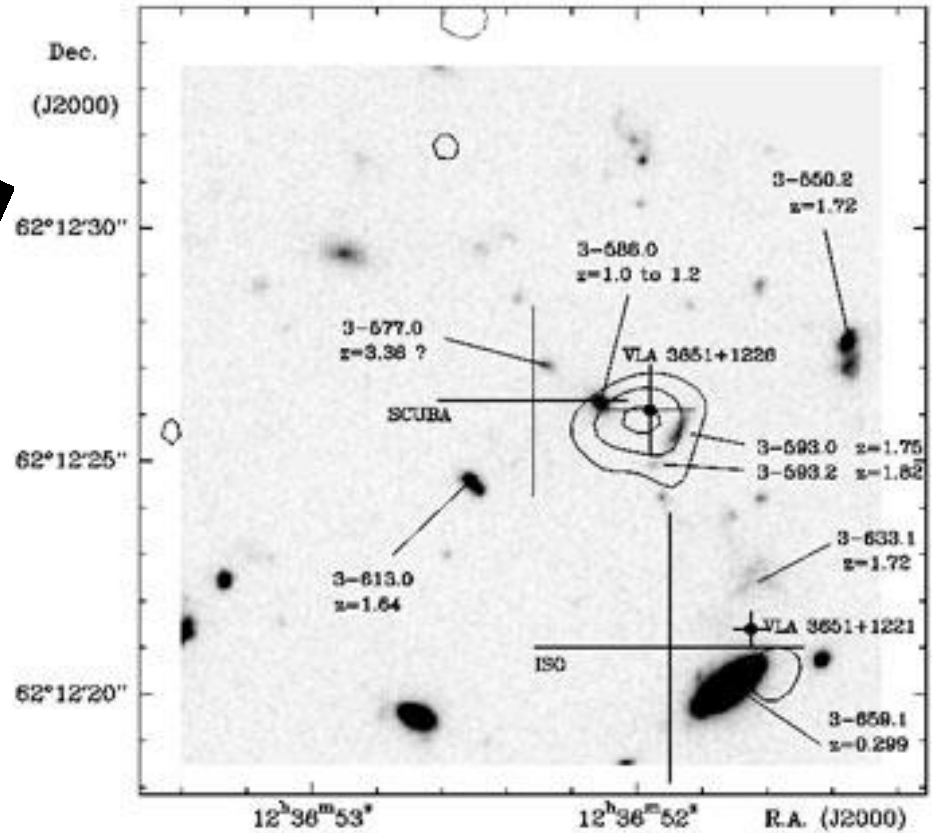
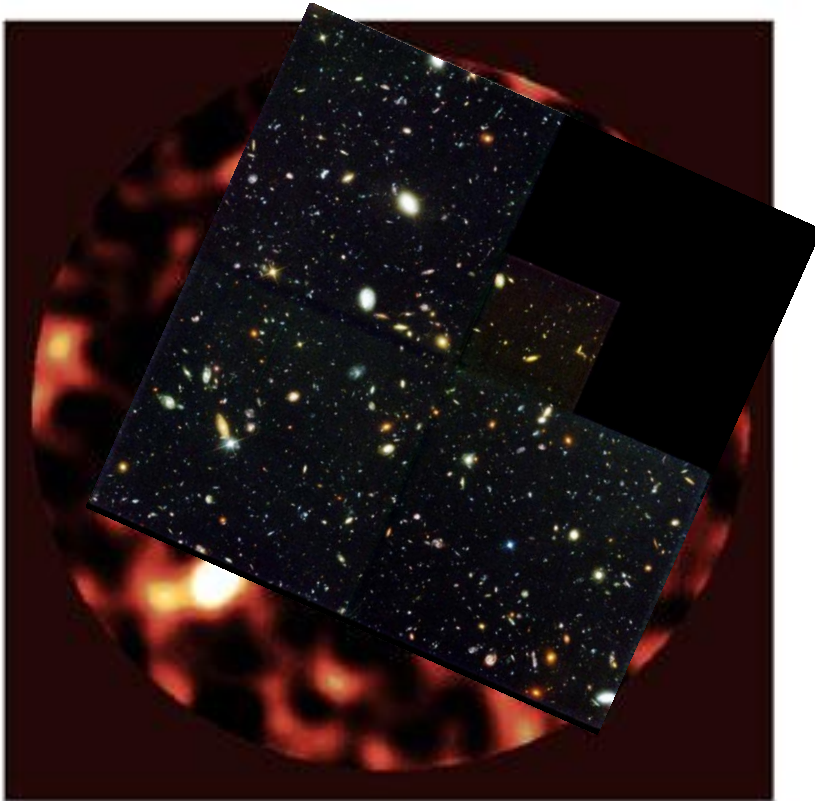


8.2. Galaxies IR/sub-mm

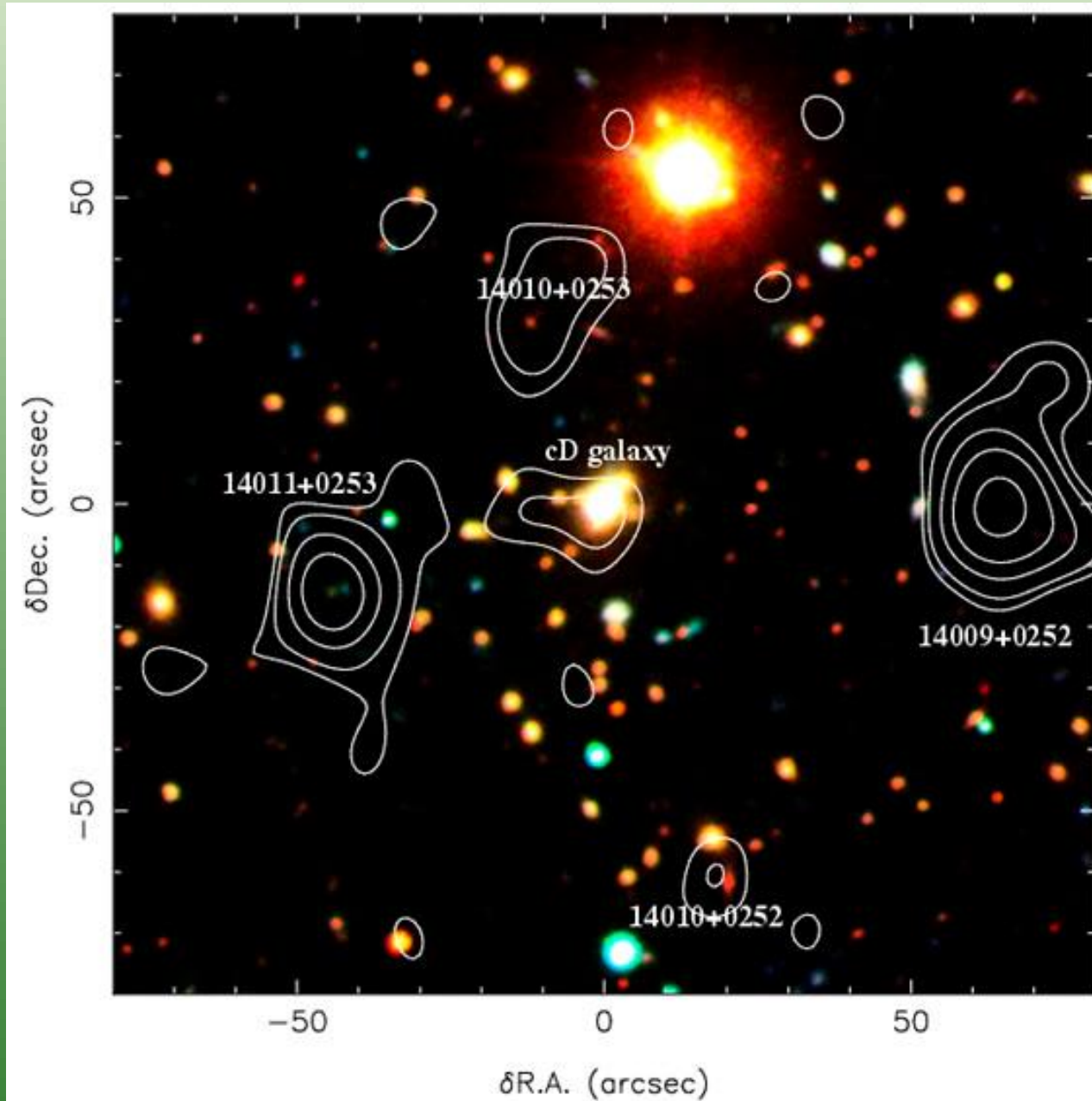


8.2. Galaxias IR/sub-mm

Hughes et al. (1998)



8.2. Galaxias IR/sub-mm

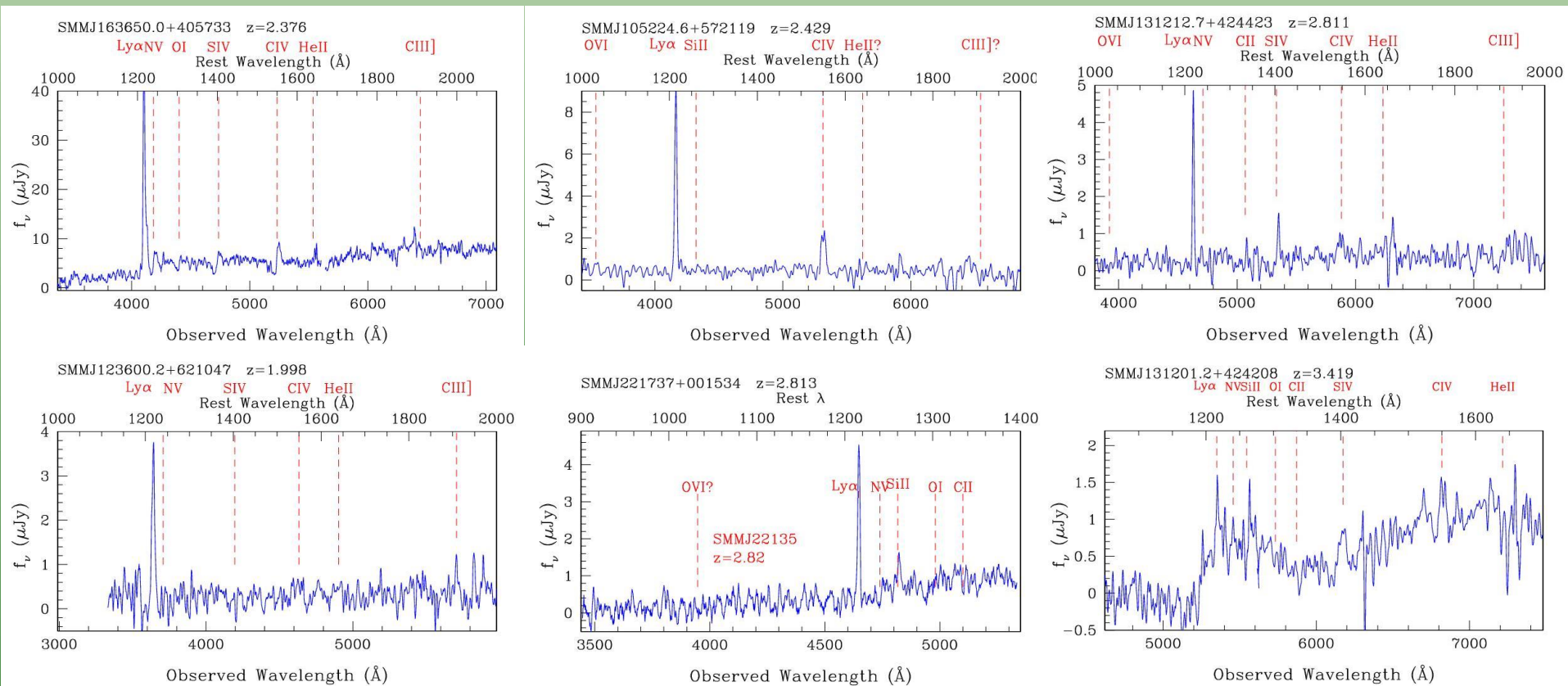


Blain et al. (2002)

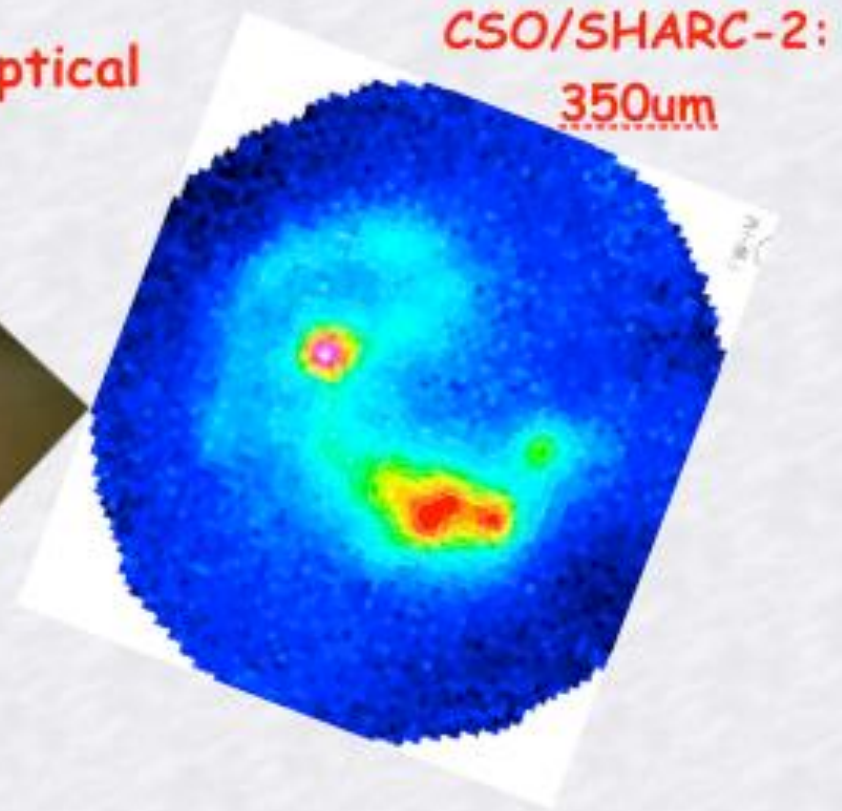
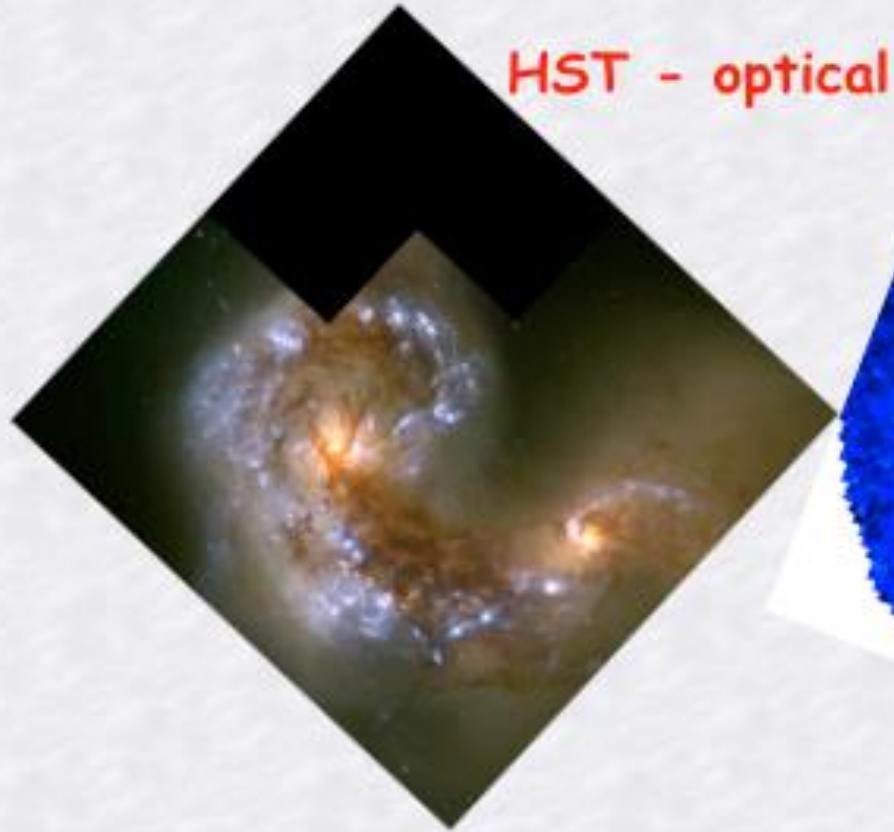


8.2. Galaxias IR/sub-mm

Chapman et al. (2003,2005)



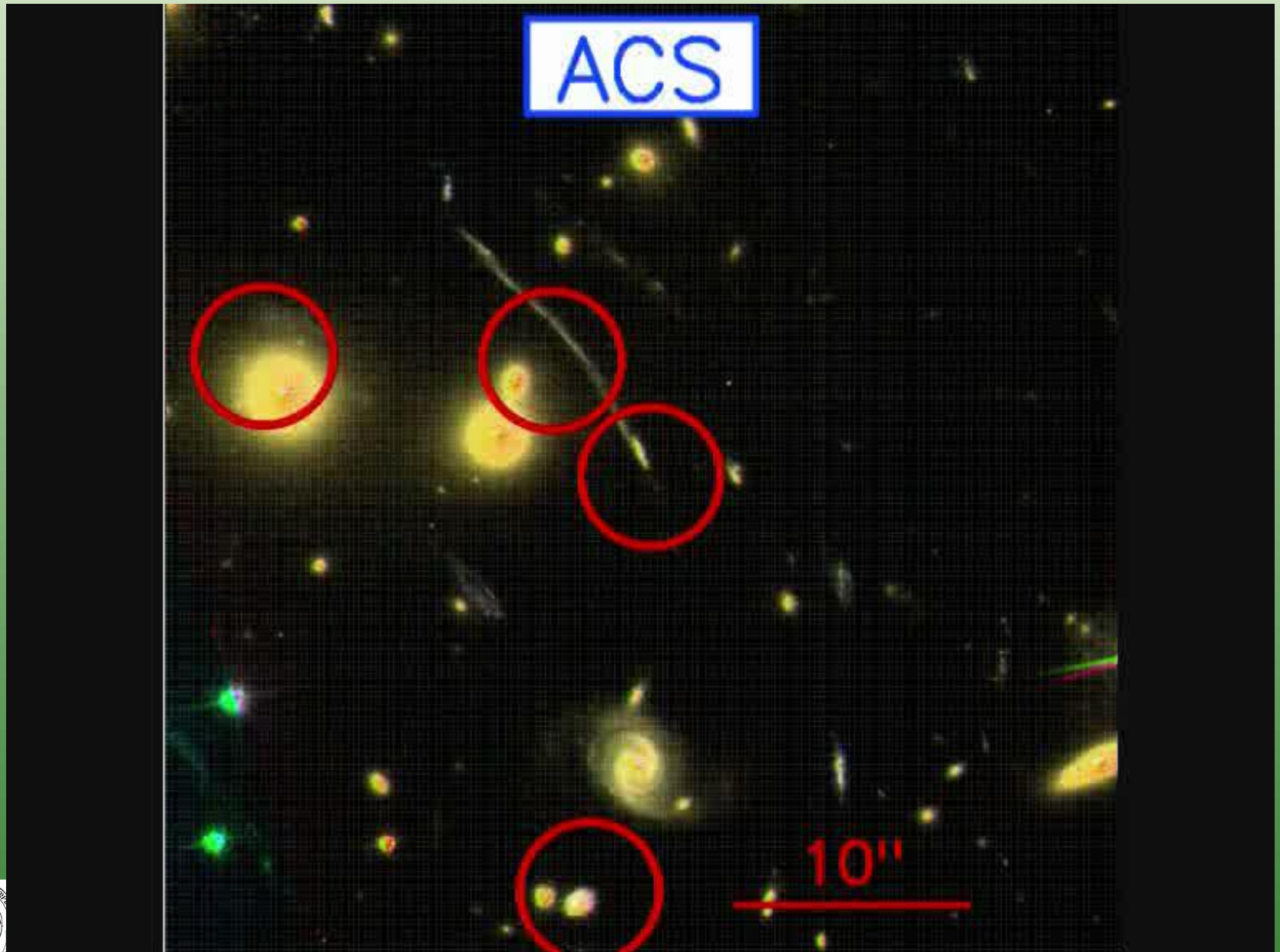
8.2. Galaxias IR/sub-mm



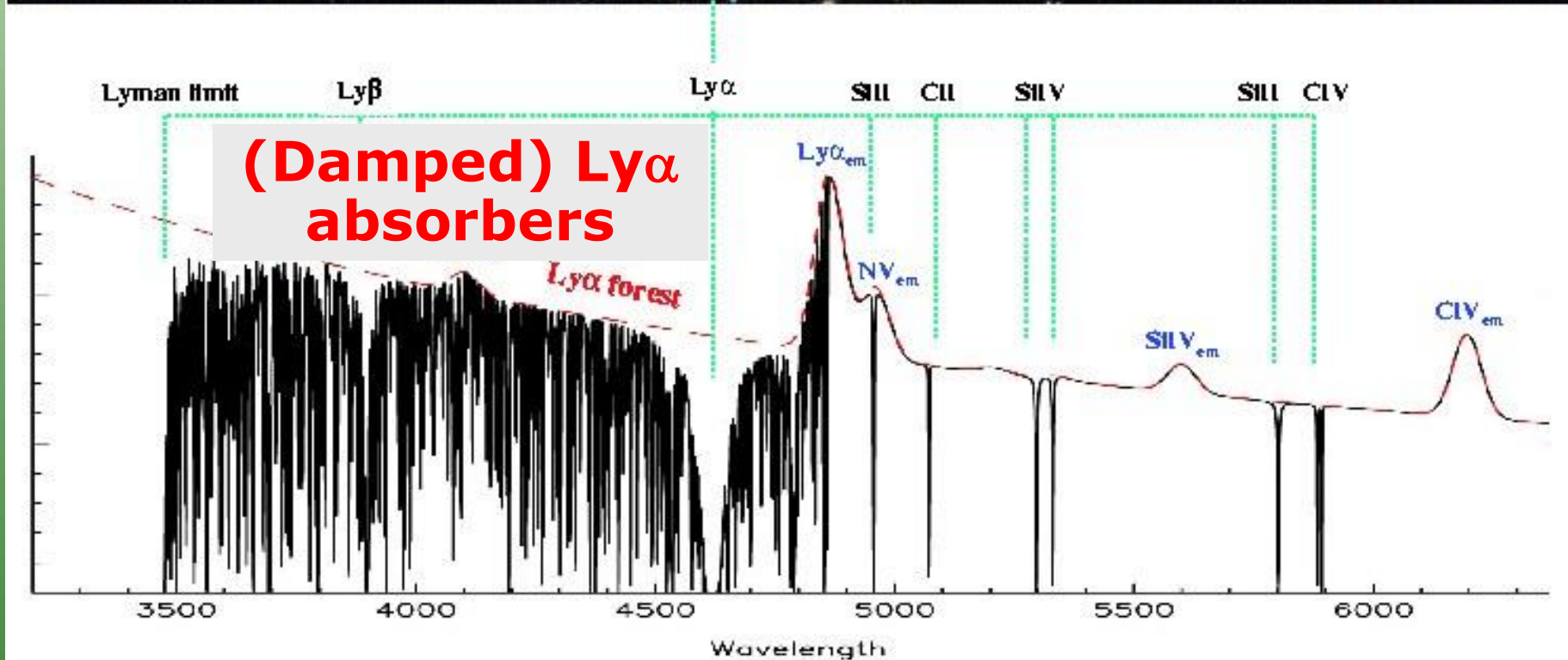
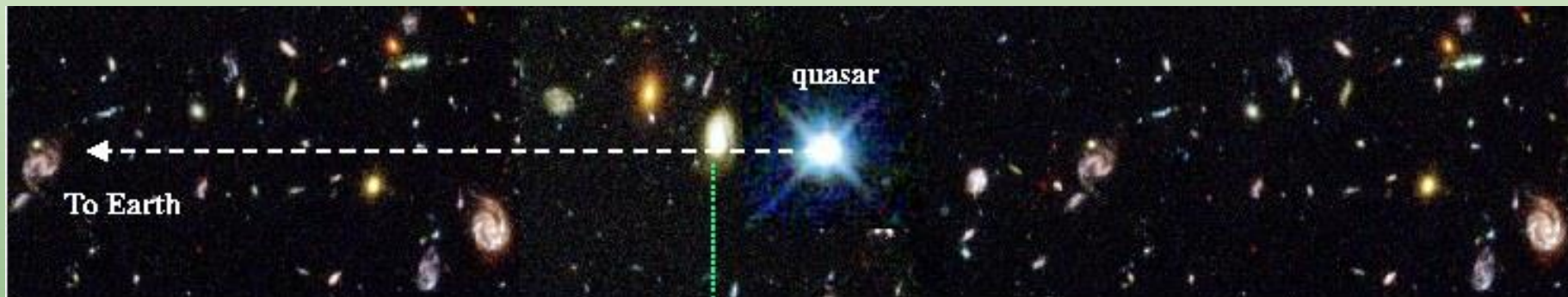
<http://astro.dur.ac.uk/~ams/>



8.2. Galaxias IR/sub-mm



8.2. Selección de galaxias a $z \gg 1$: DLAs

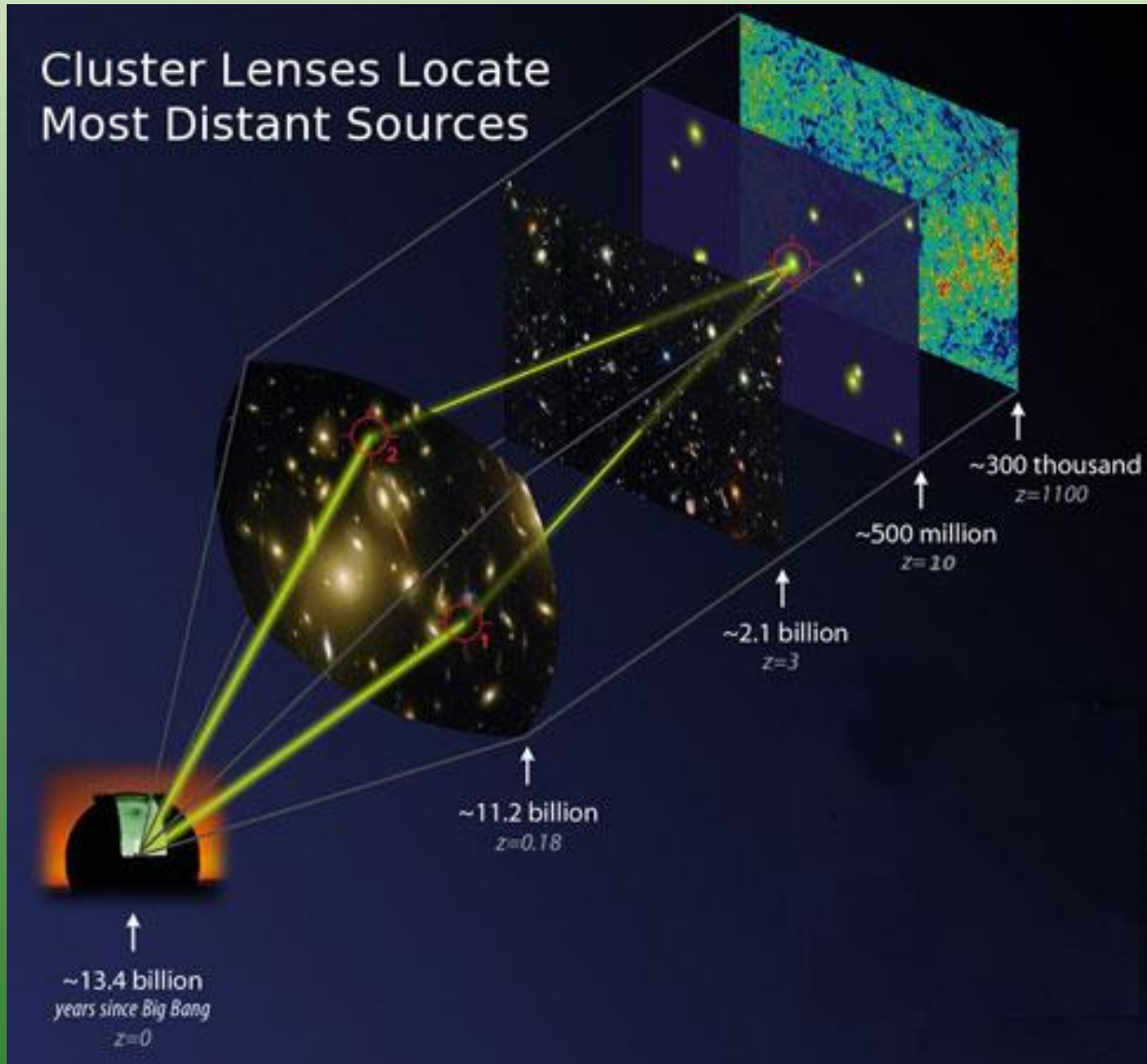


DLAs:

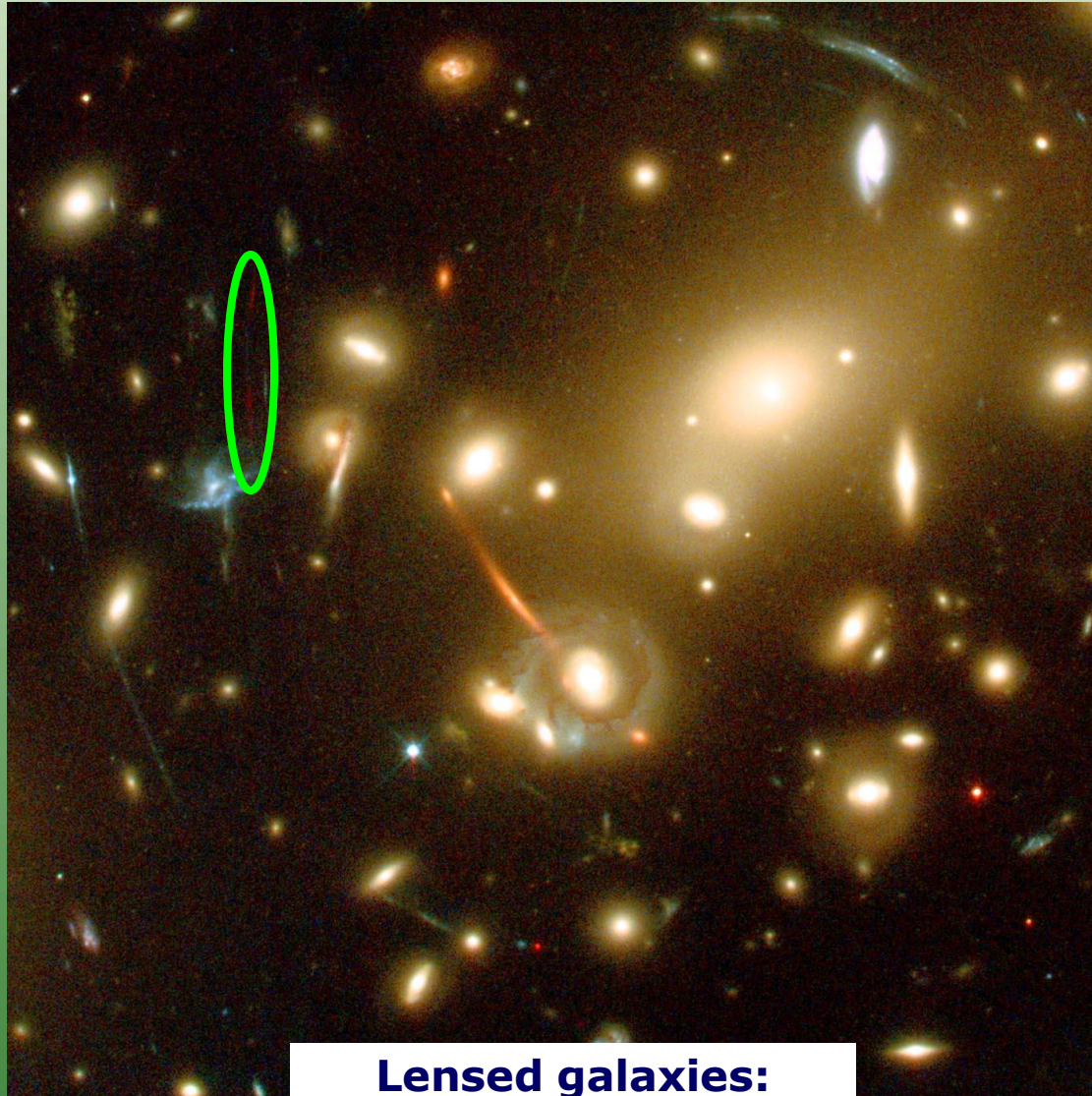
Lu et al. (1996)



8.2. Selección de galaxias a $z \gg 1$: lentes



8.2. Selección de galaxias a $z \gg 1$: lentes

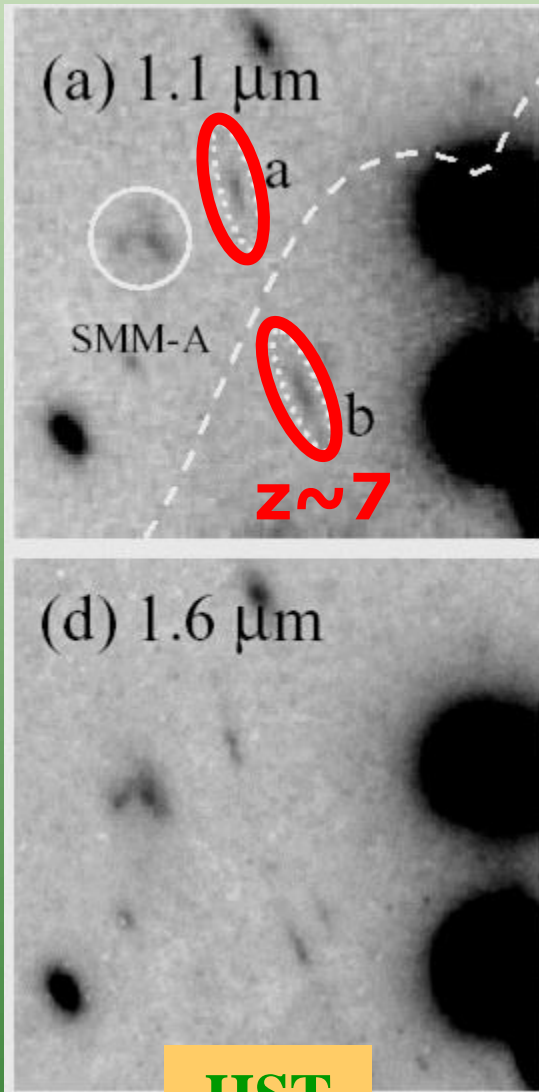


**Lensed galaxies:
Kneib et al. (2004)**

Astrofísica Extragaláctica



8.2. Selección de galaxias a $z \gg 1$: lentes

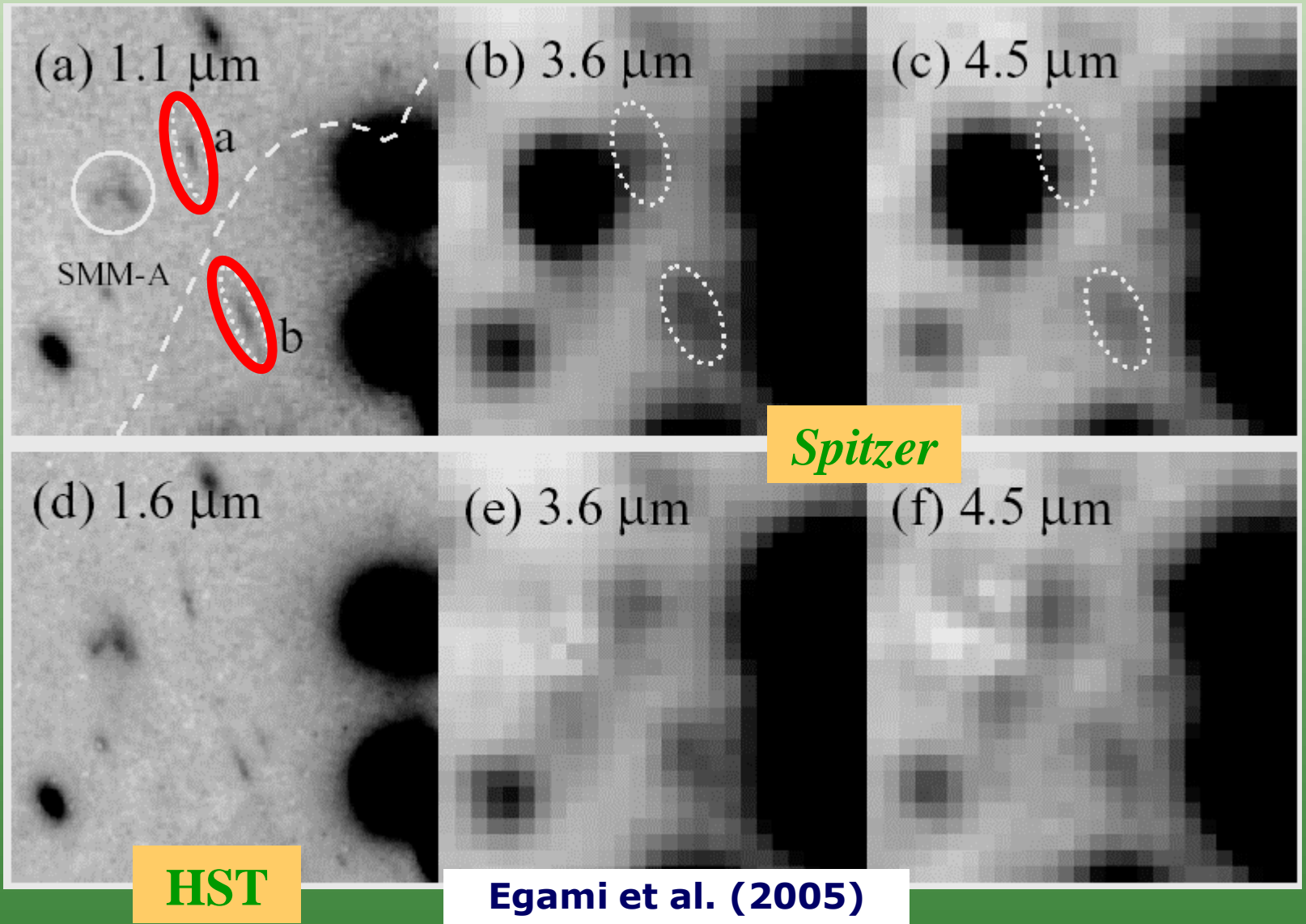


HST

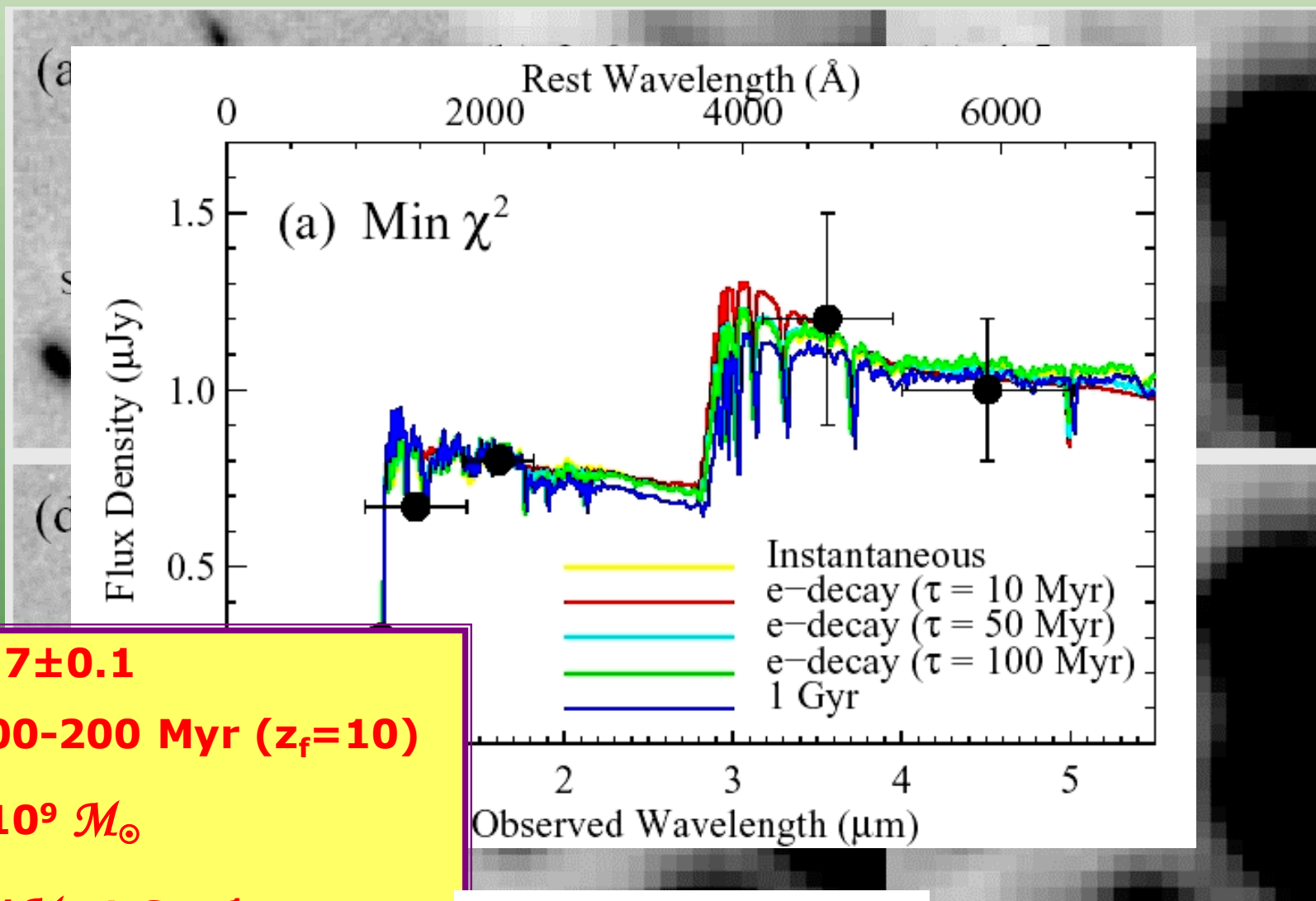
Kneib et al. (2004)



8.2. Selección de galaxias a $z \gg 1$: lentes



8.2. Selección de galaxias a $z \gg 1$: lentes



• $z = 6.7 \pm 0.1$

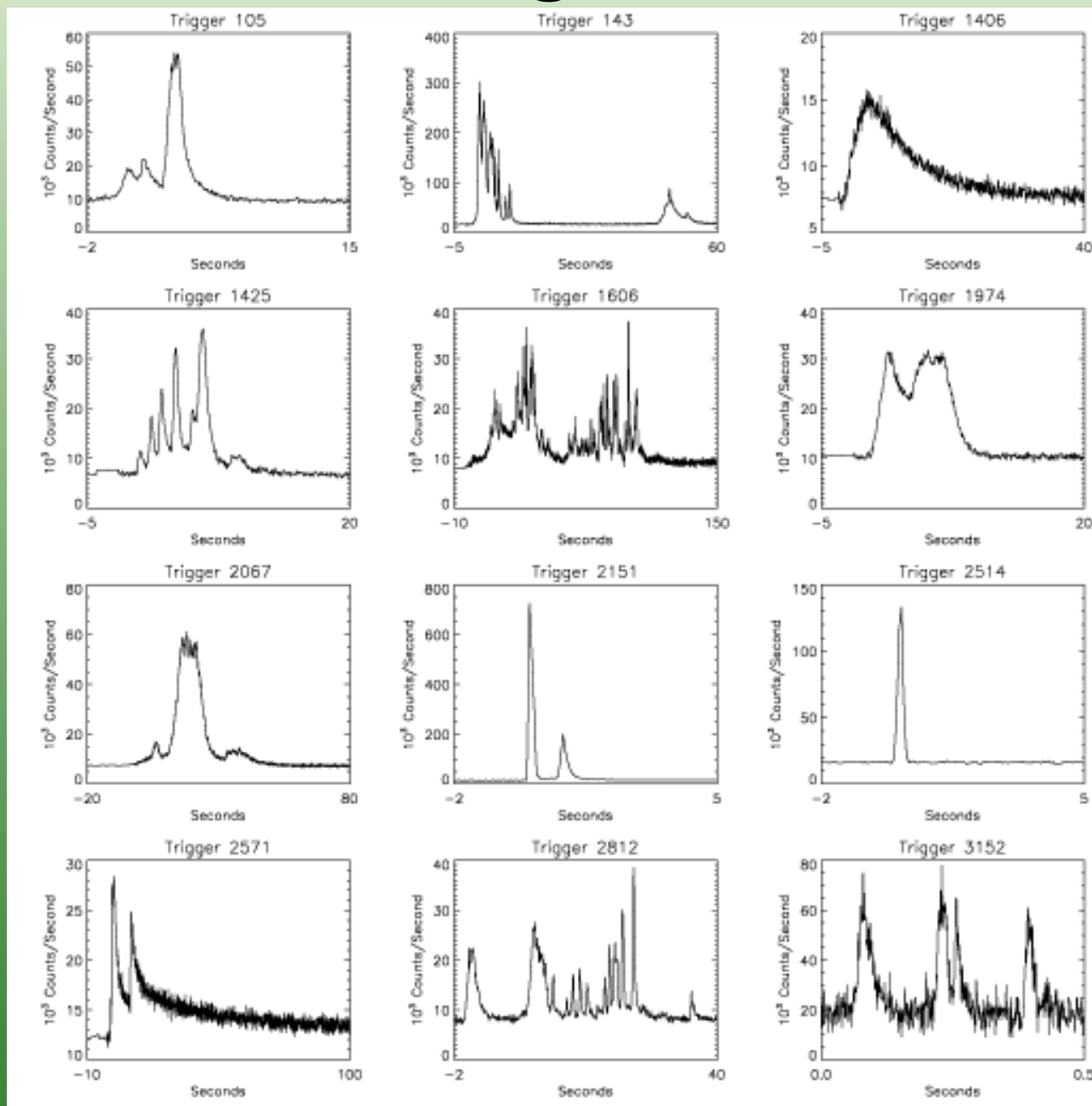
• $t = 100\text{-}200 \text{ Myr}$ ($z_f = 10$)

• $M = 10^9 M_\odot$

• $\text{SFR}/M = 1 \text{ Gyr}^{-1}$

Egami et al. (2005)

8.2. Selección de galaxias a $z > 0$: GRBs

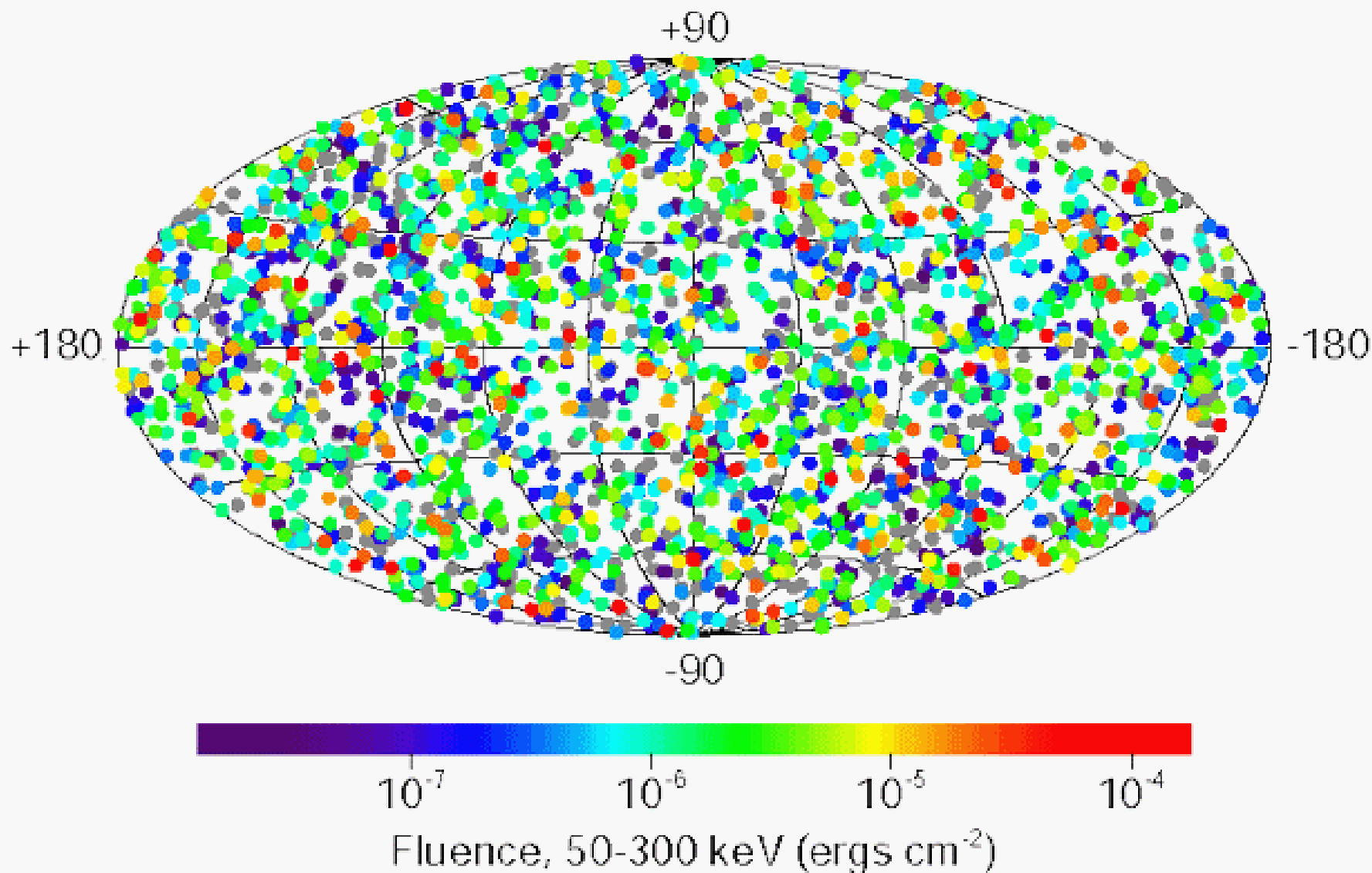


<http://www oulu.fi/astrophysics/>



8.2. Selección de galaxias a $z > 0$: GRBs

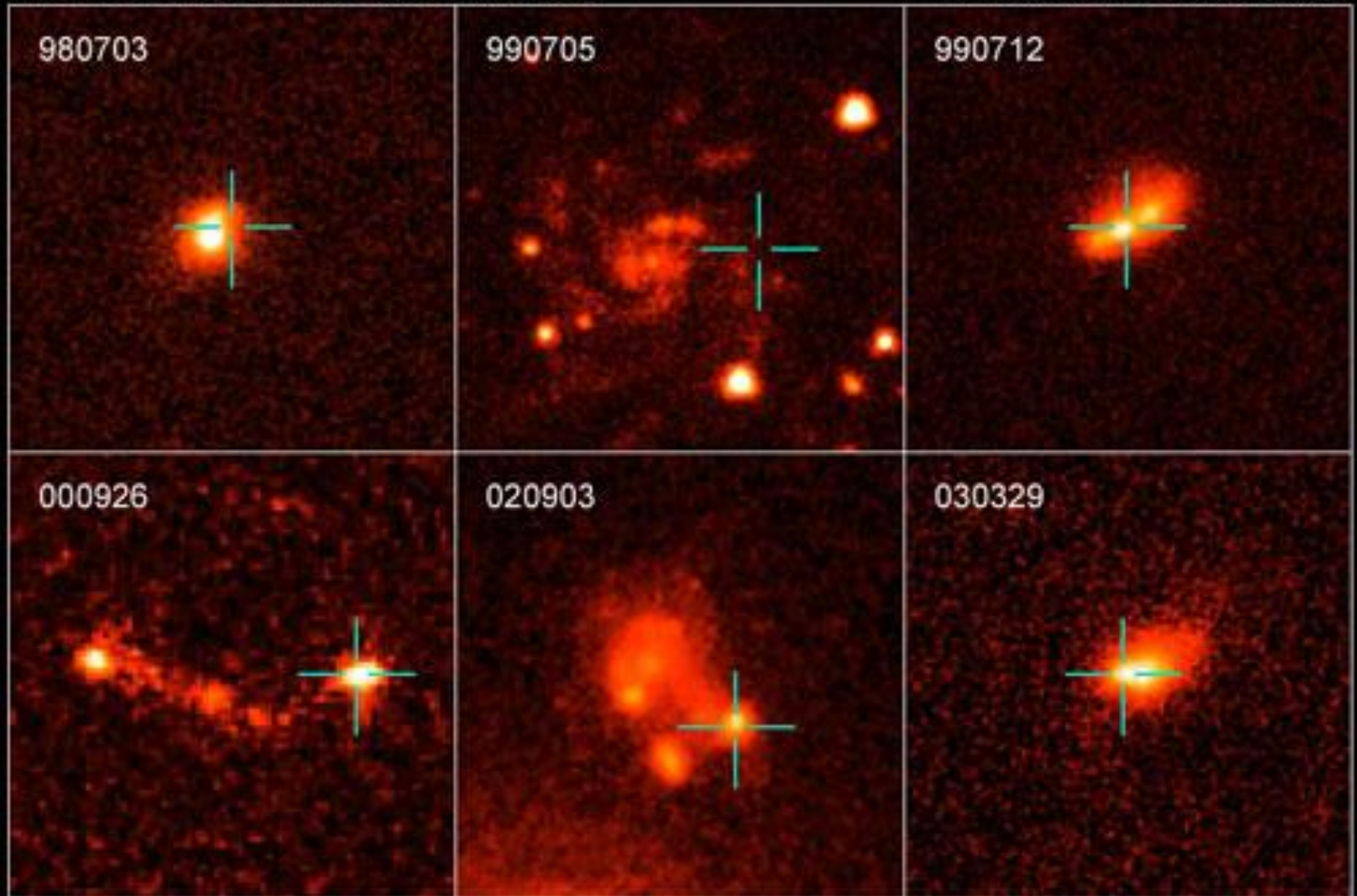
2704 BATSE Gamma-Ray Bursts



8.2. Selección de galaxias a $z > 0$: GRBs

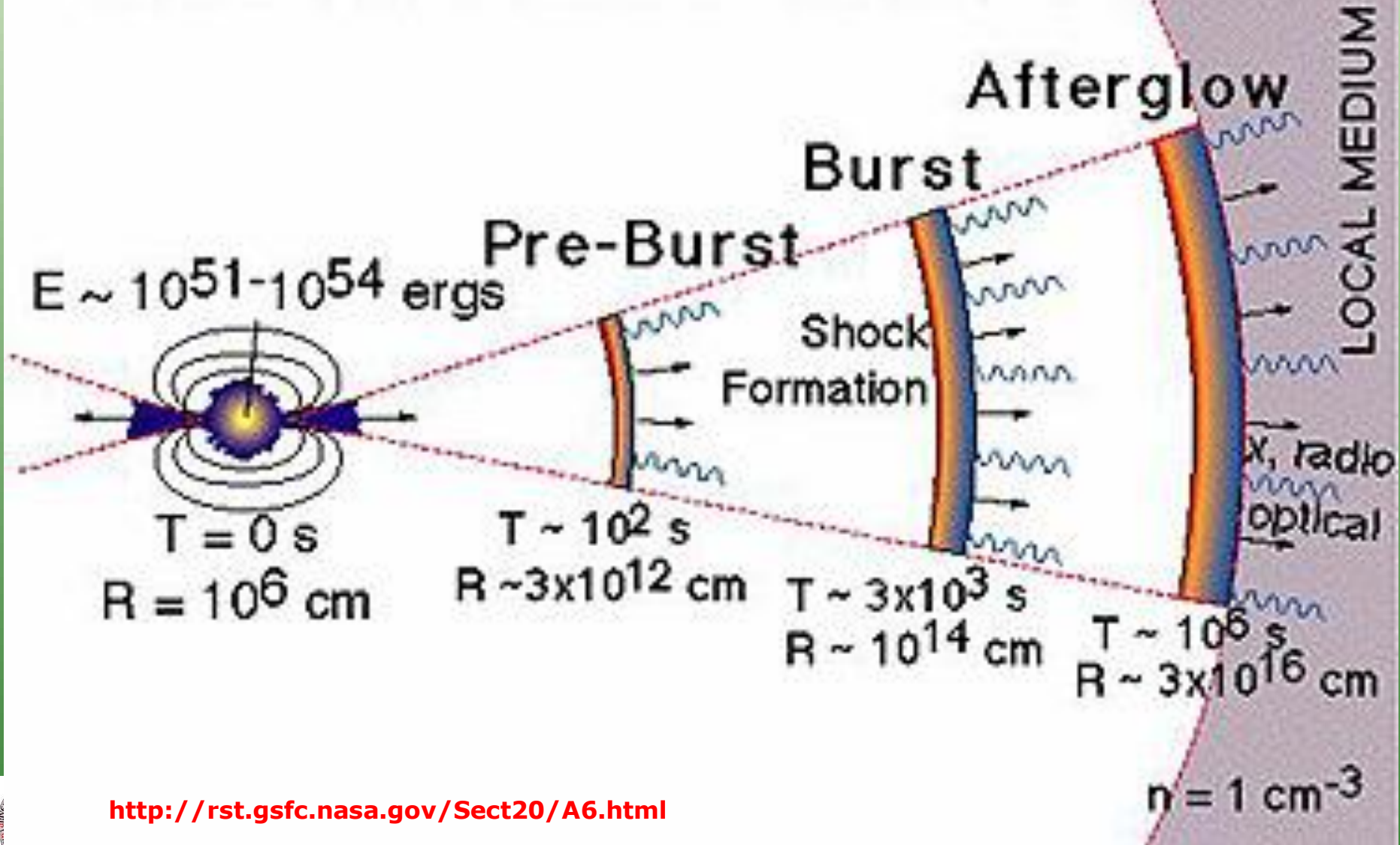
Gamma-Ray Burst Host Galaxies

Hubble Space Telescope



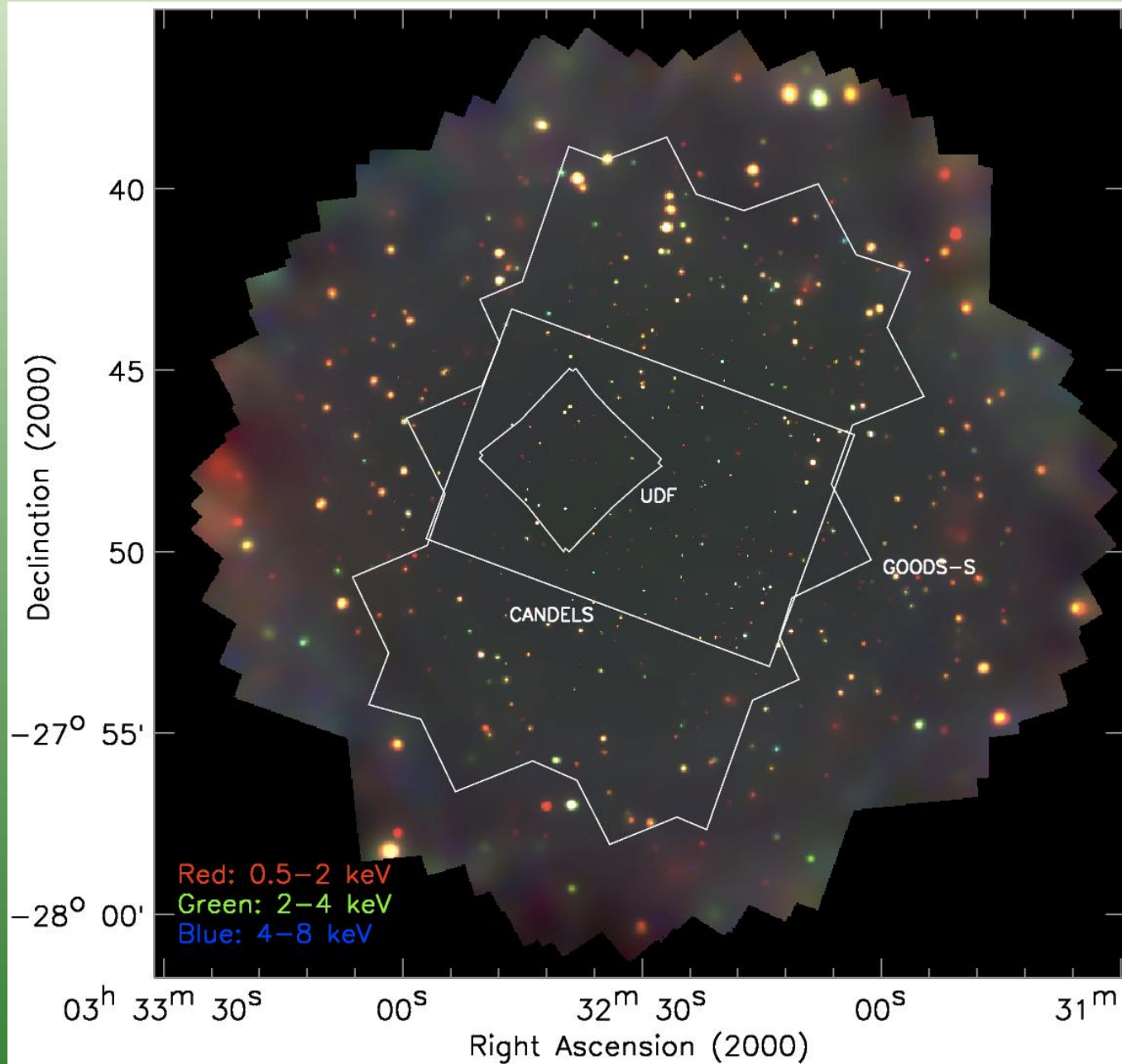
8.2. Selección de galaxias a $z > 0$: GRBs

GRB FIREBALL MODEL



<http://rst.gsfc.nasa.gov/Sect20/A6.html>

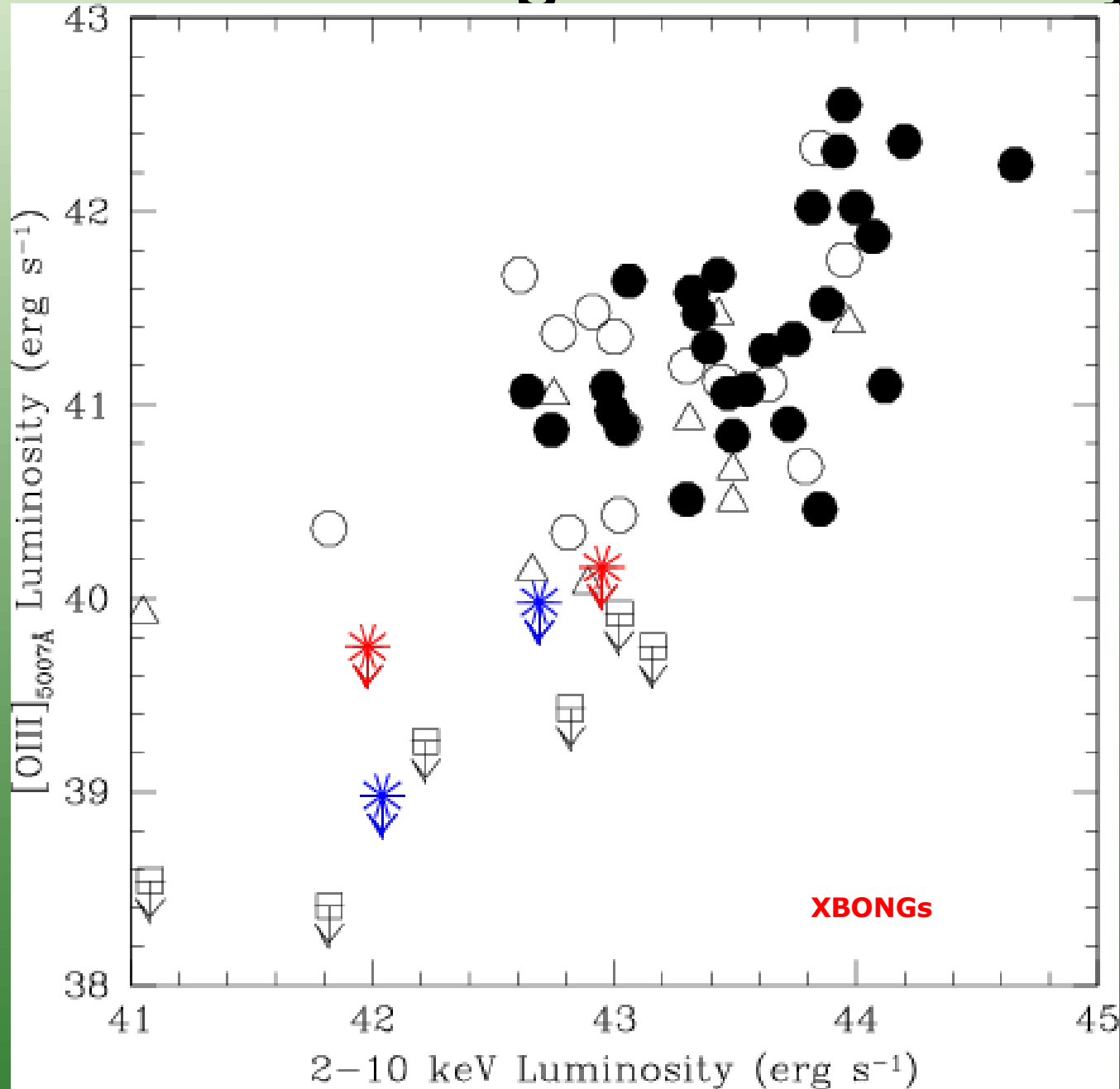
8.2. Selección de galaxias a $z > 0$: x-ray



<http://www.2.astro.psu.edu/users/niel/cdfs/cdfs-4Ms-pic-large.jpg>



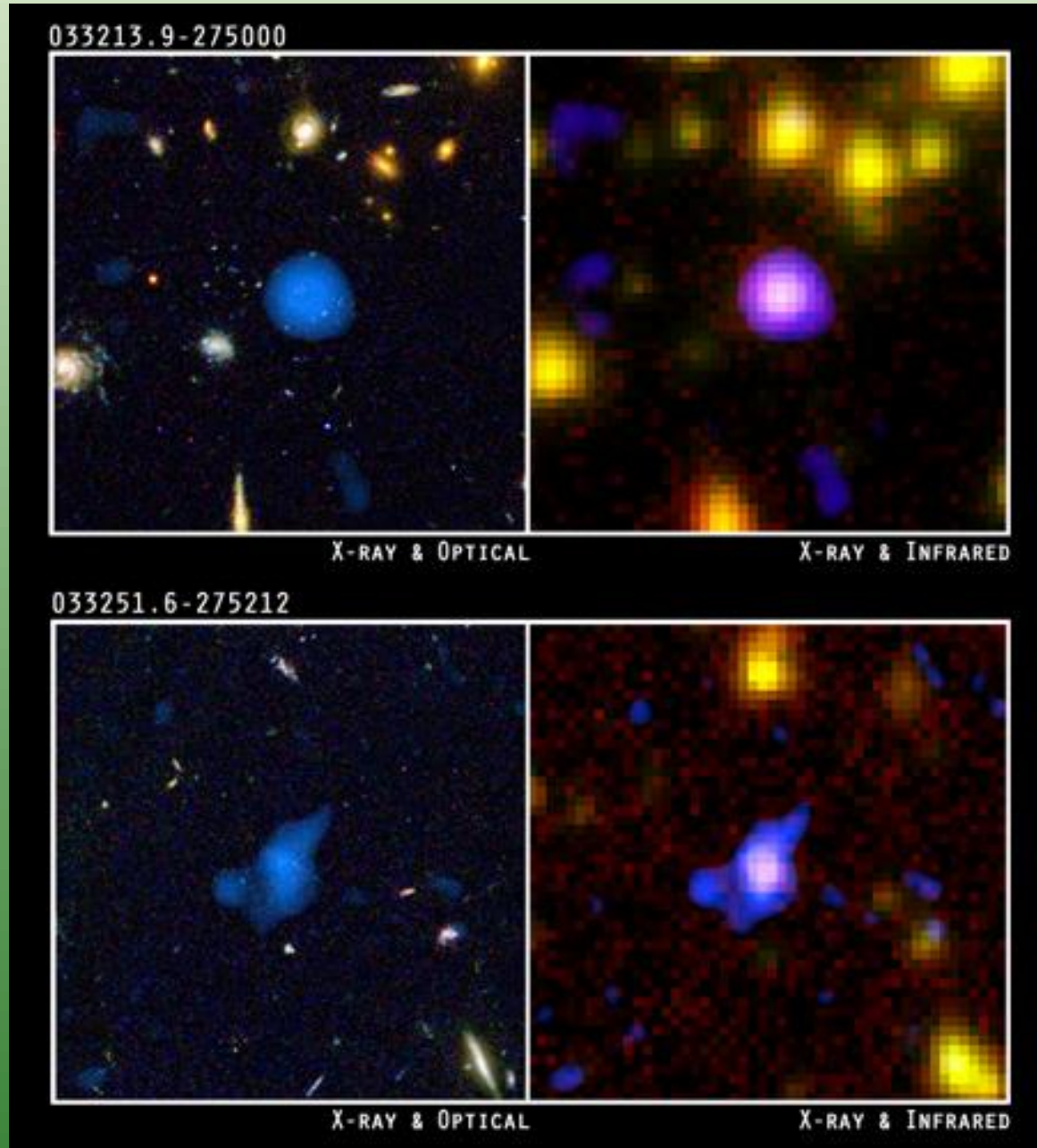
8.2. Selección de galaxias a $z > 0$: x-ray



Civano et al. (2007)



8.2. Selección de galaxias a $z > 0$: x-ray



http://chandra.harvard.edu/photo/2004/goodsbh/goodsbh_hand.html



8.2. Selección de galaxias a $z > 0$: x-ray

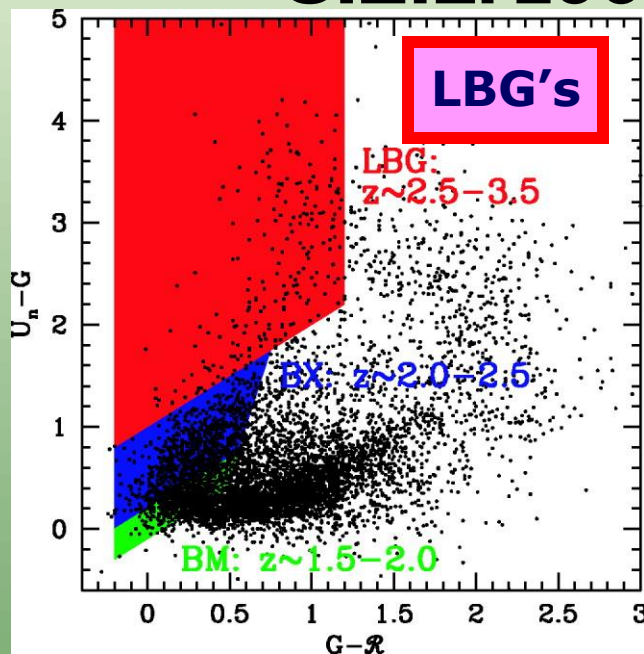


<http://chandra.harvard.edu/blog/node/288>



8.2.El zoo de galaxias a $z > 0$

Reddy et al. 2006



PEG's

UVLG's

GRBH's

LAE's

ERO's

BM/BX

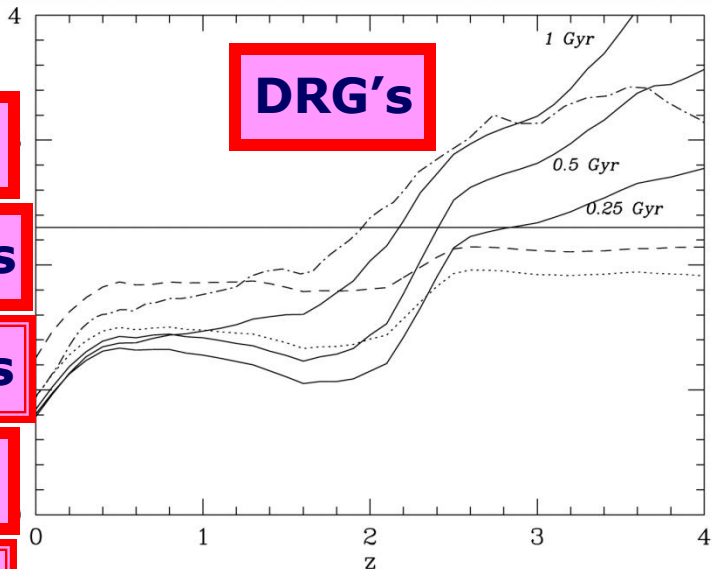
XBONGs

SMG's

ERO's

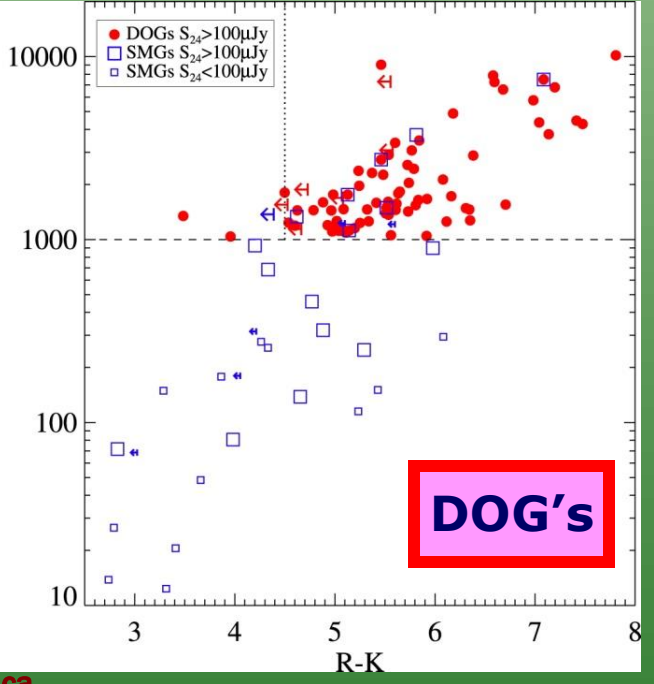
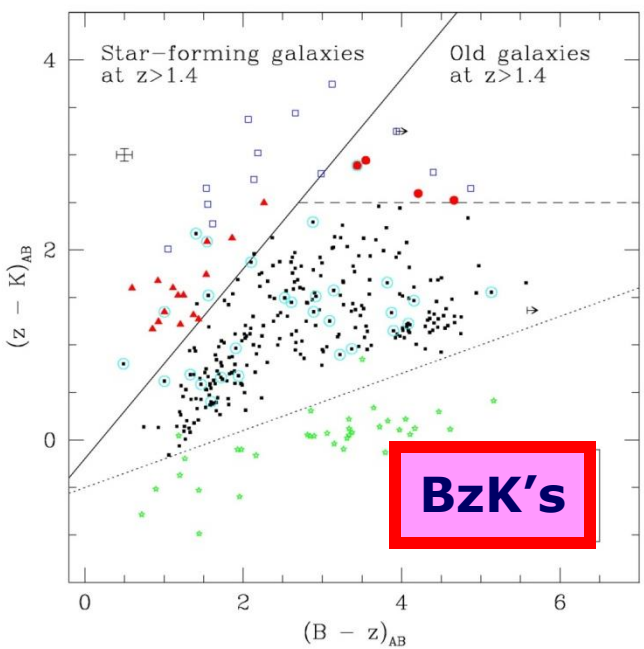
PLG's

DRG's



Franx et al. 2003

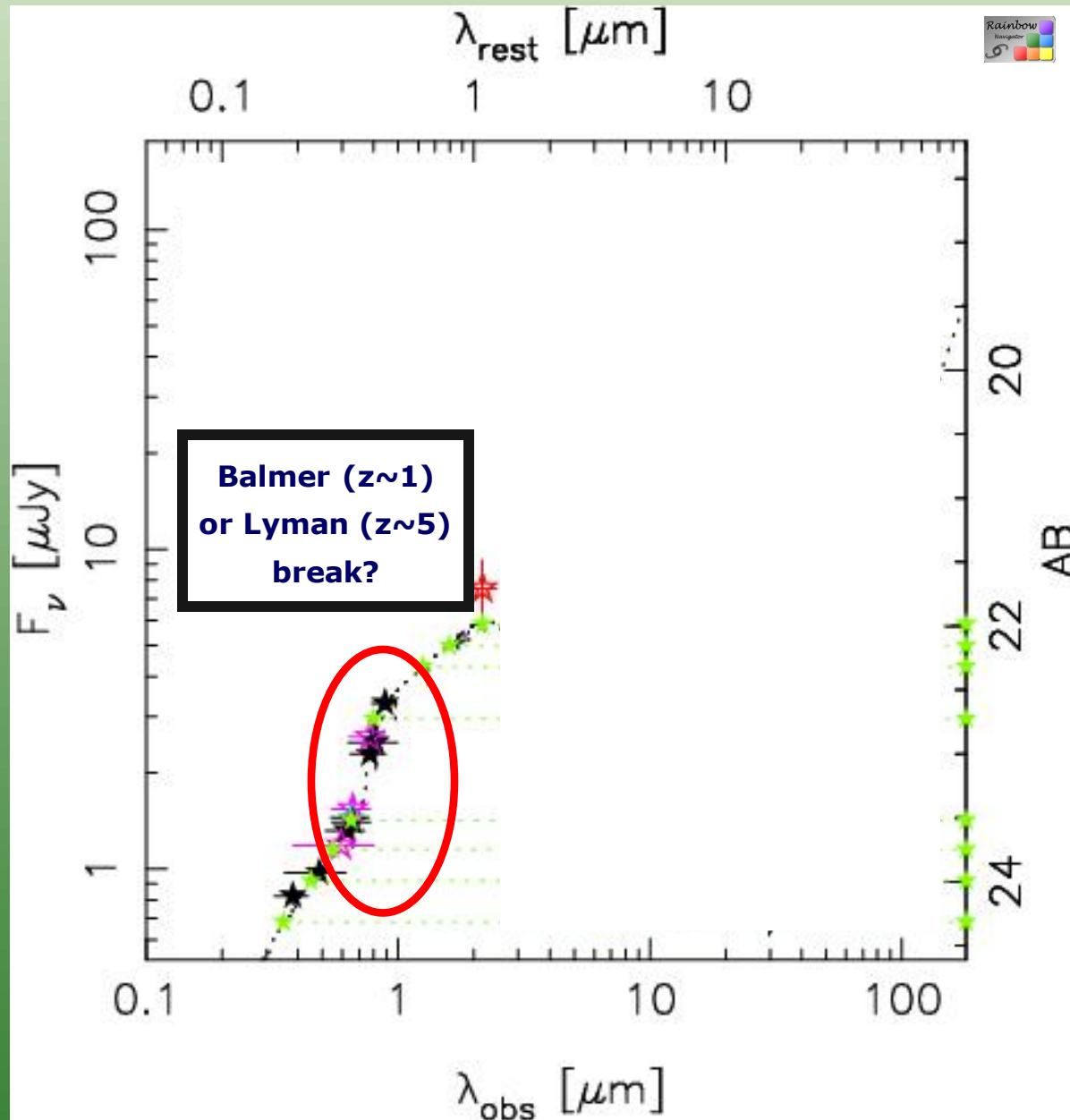
Daddi et al. 2004



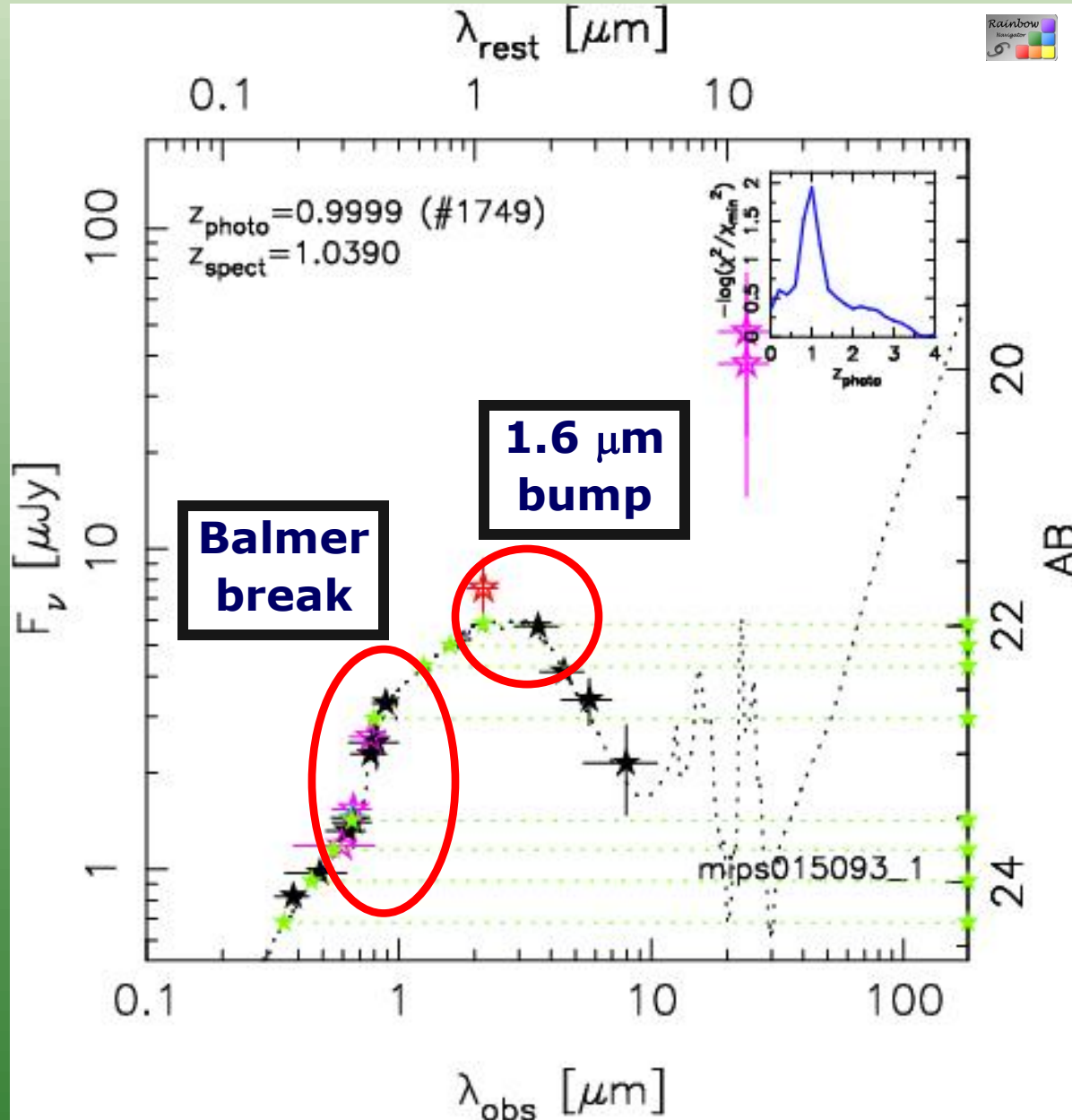
Pope et al. 2008



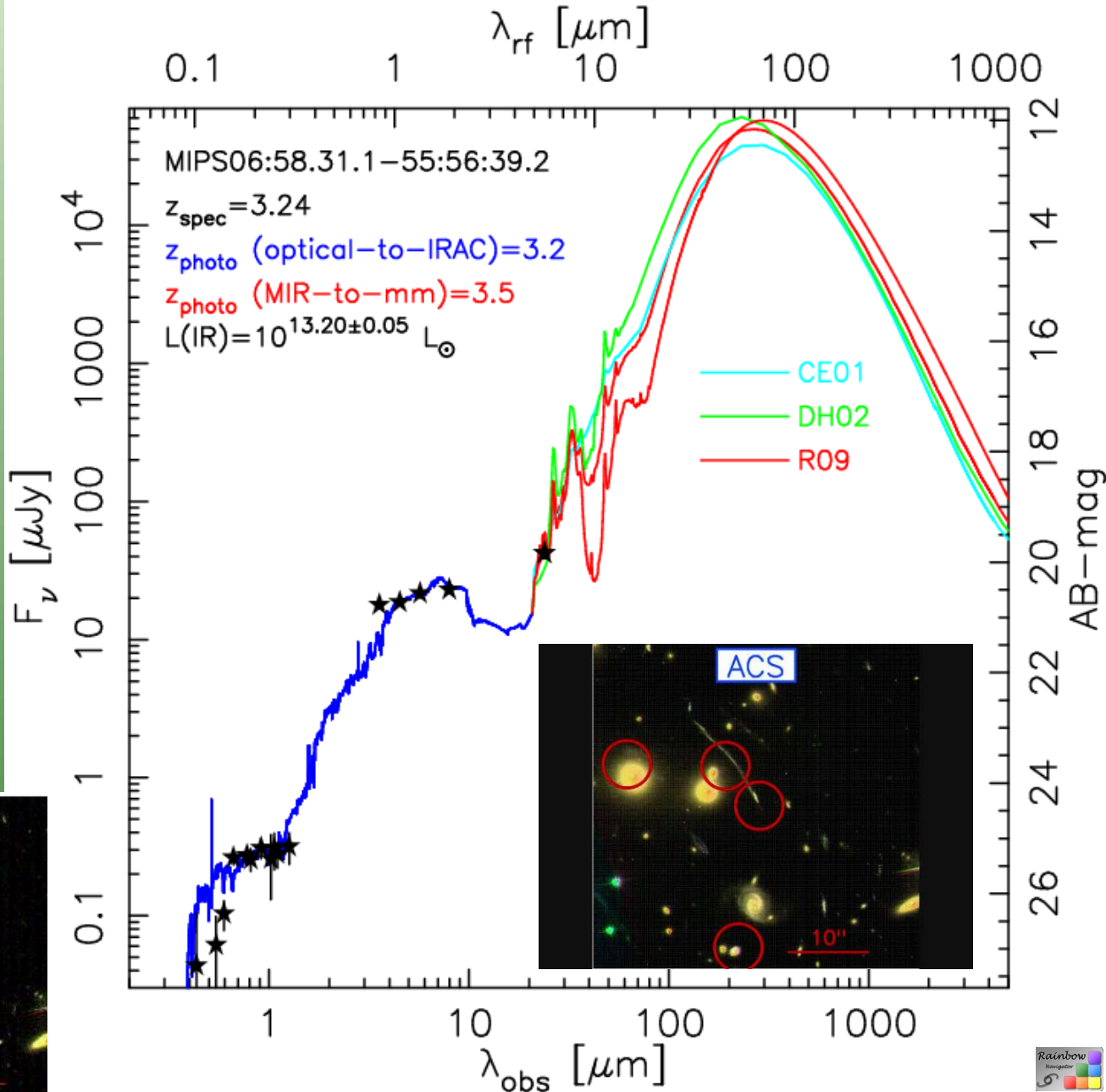
8.2.Redshifts fotométricos



8.2.Redshifts fotométricos

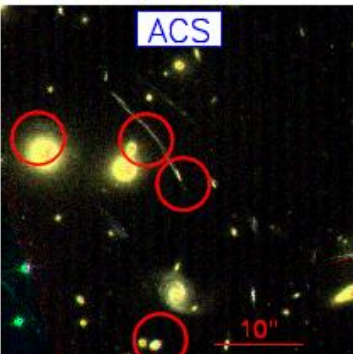
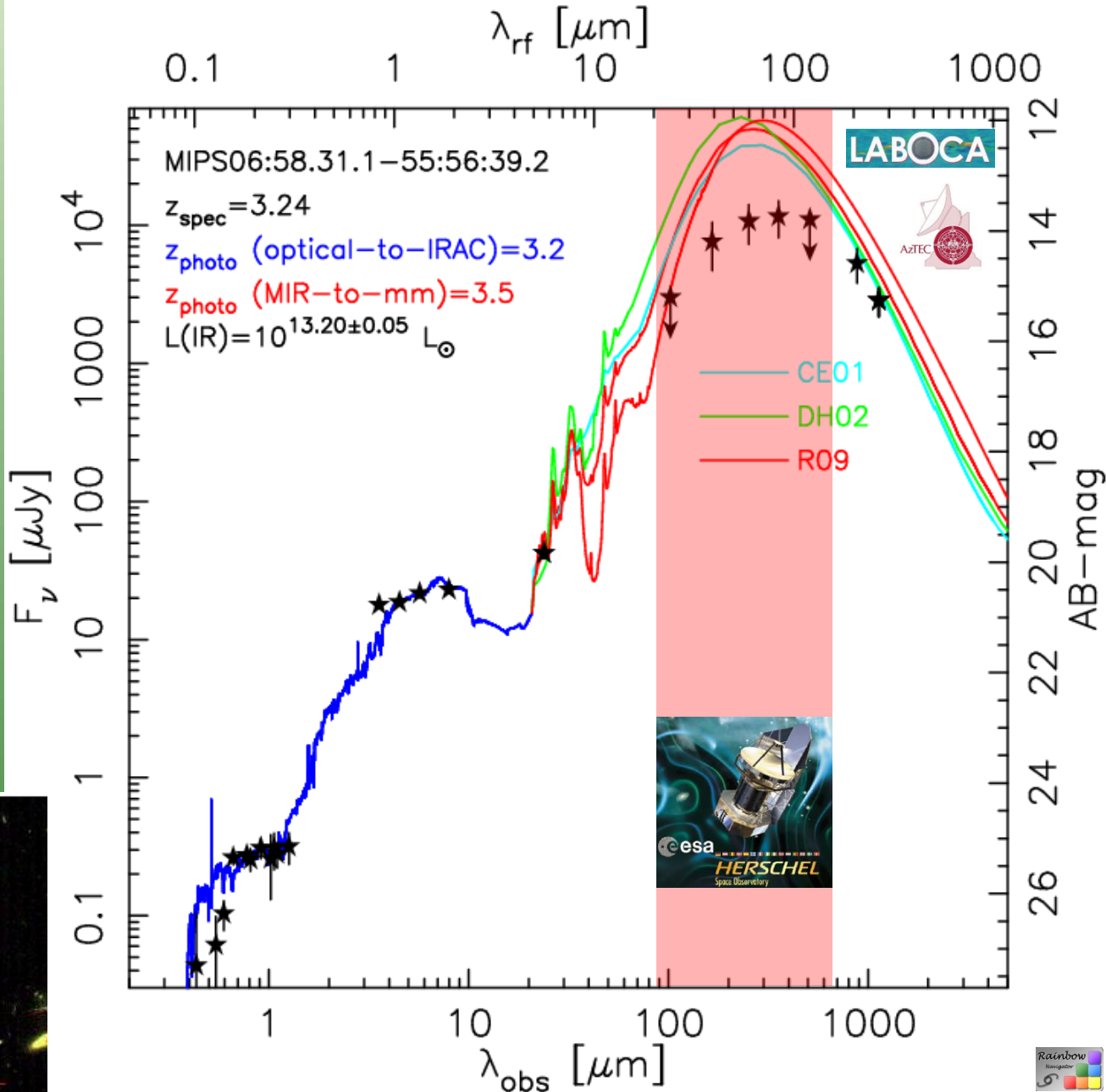


8.2.Redshifts fotométricos



Adapted from
Pérez-González et al. (2010)

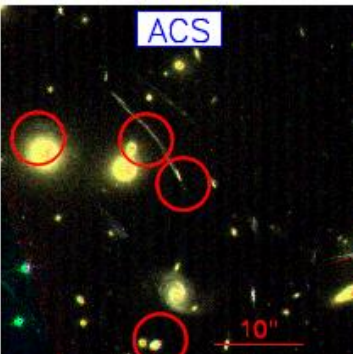
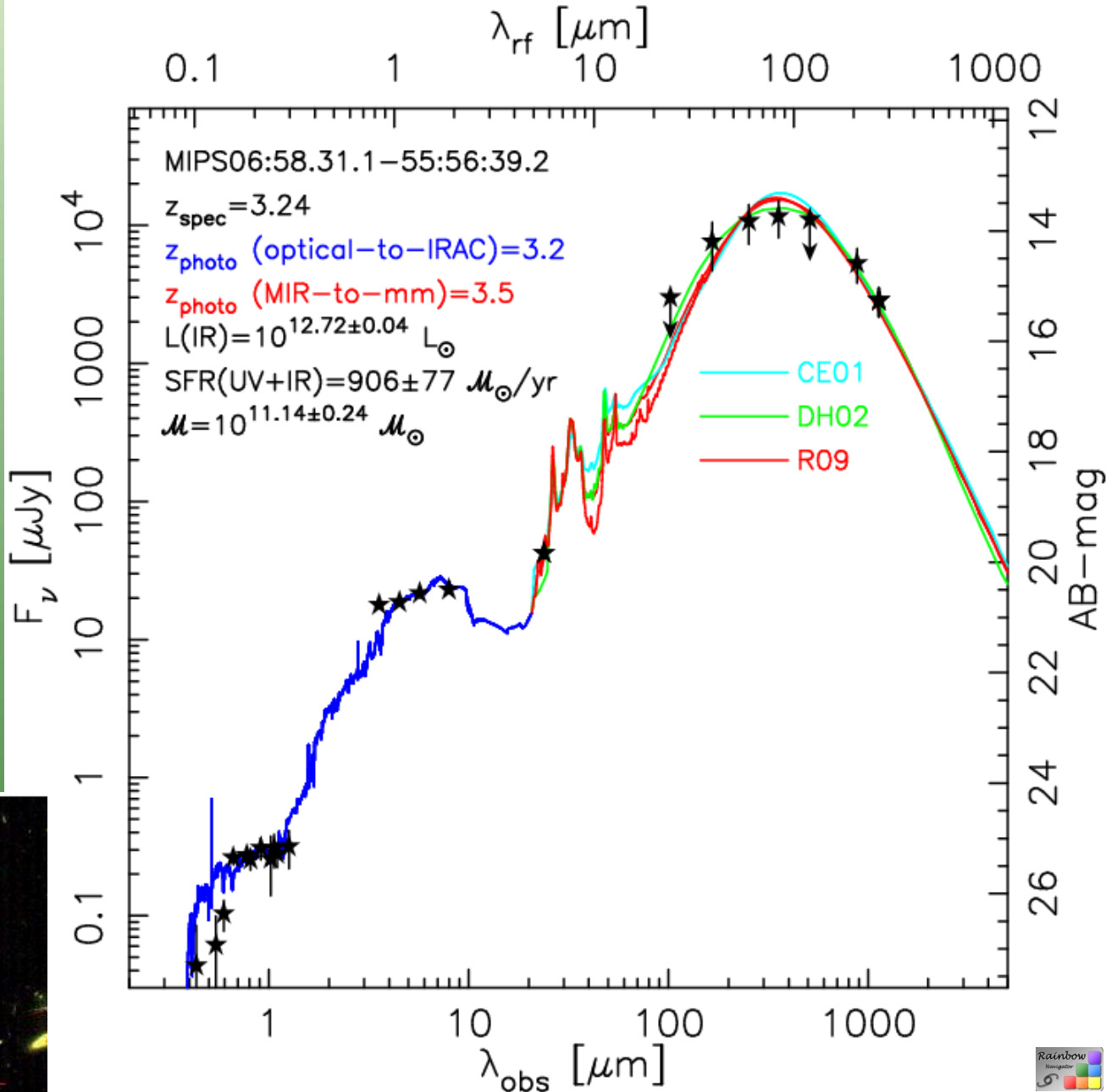
8.2.Redshifts fotométricos



Adapted from
 Pérez-González et al. (2010)



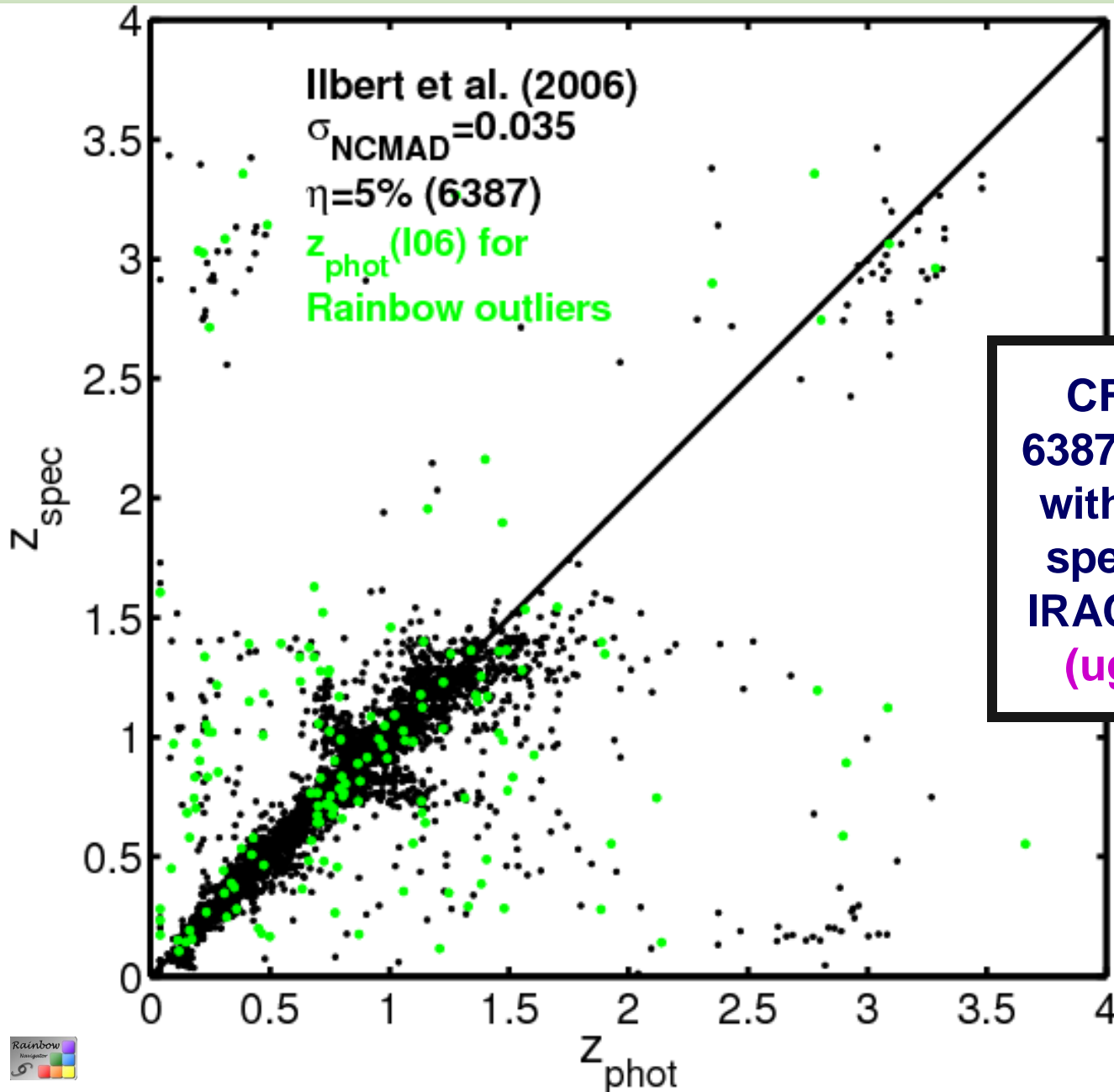
8.2.Redshifts fotométricos



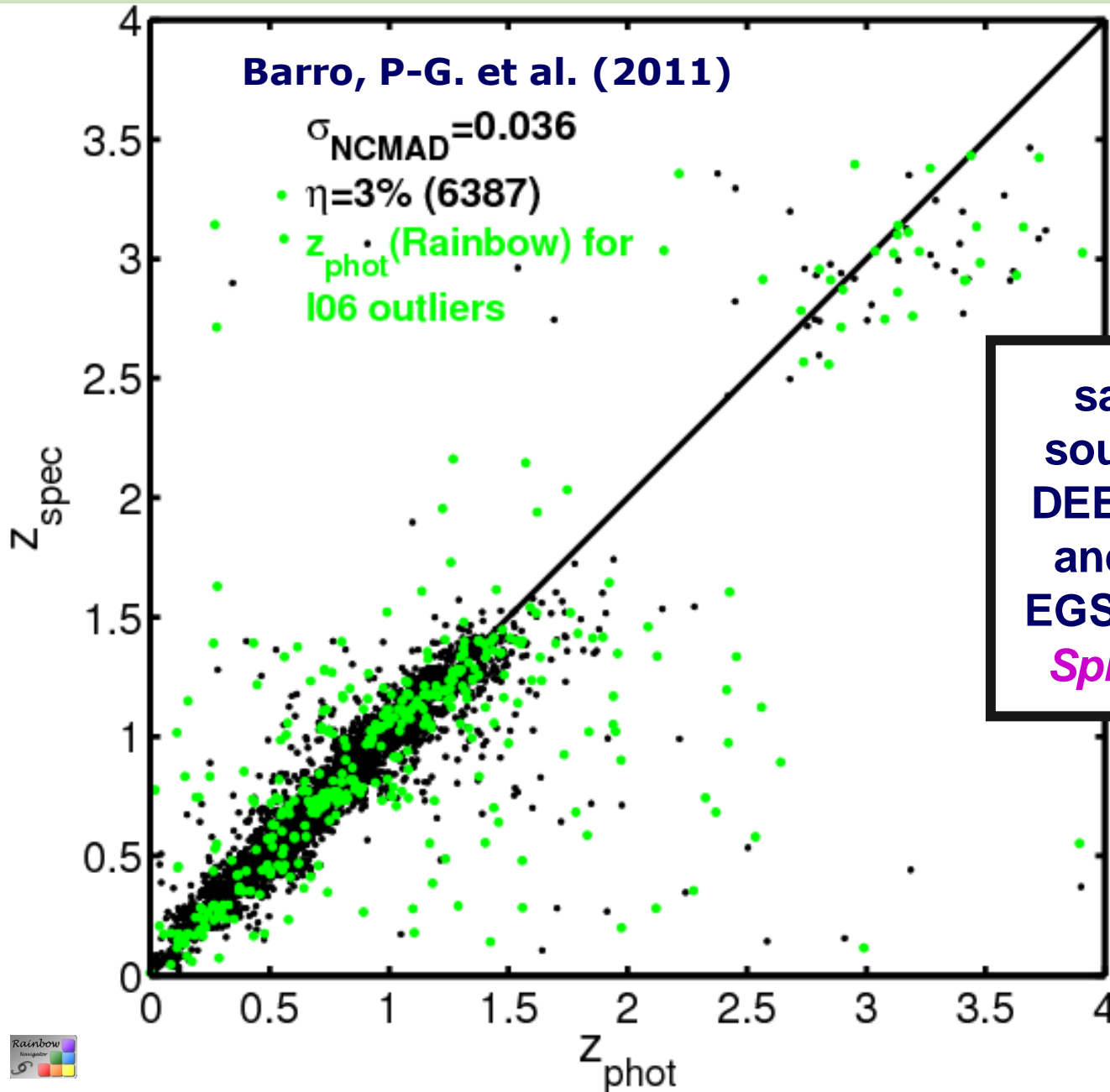
Adapted from
Pérez-González et al. (2010)



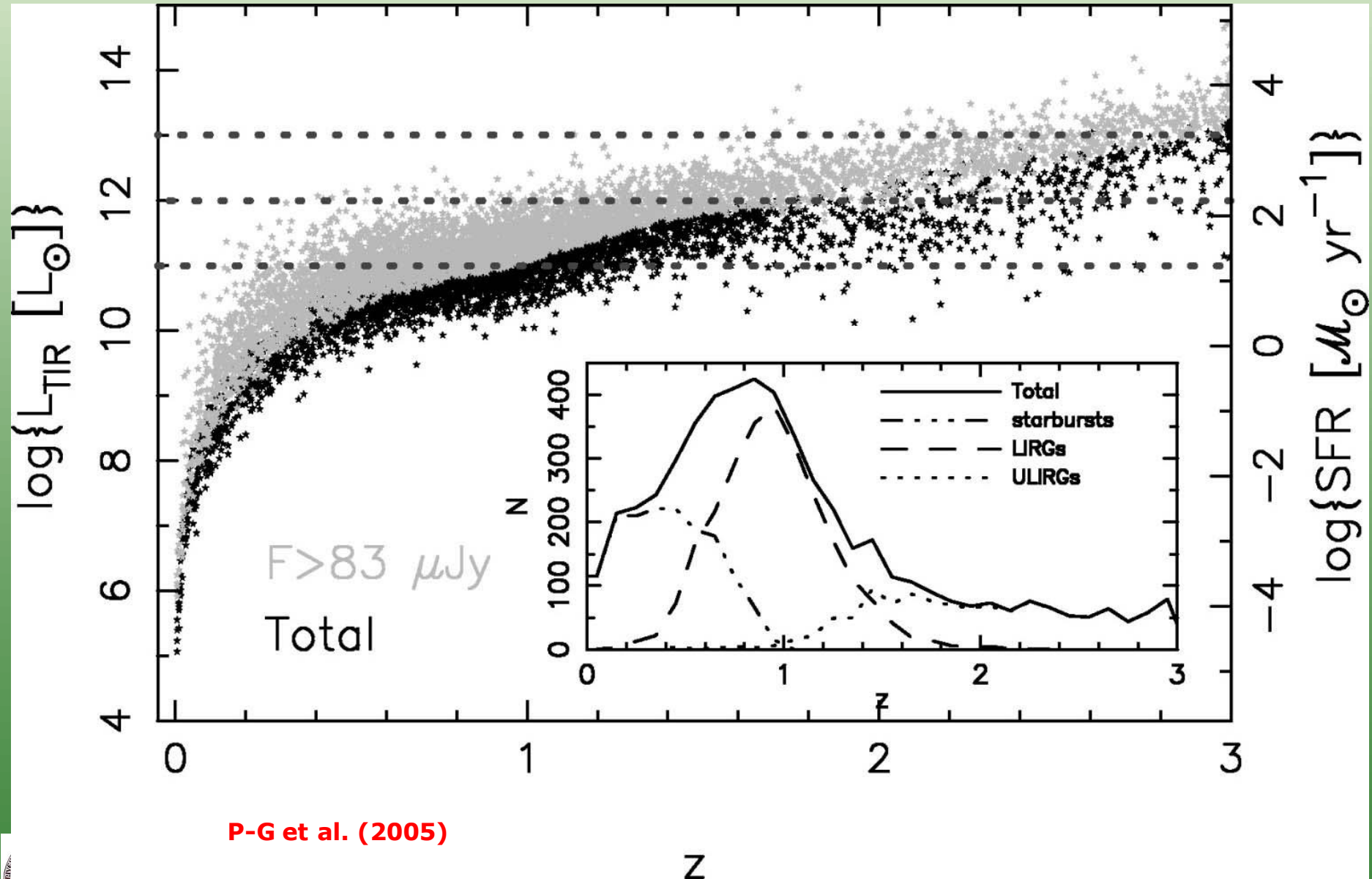
8.2.Redshifts fotométricos



8.2.Redshifts fotométricos

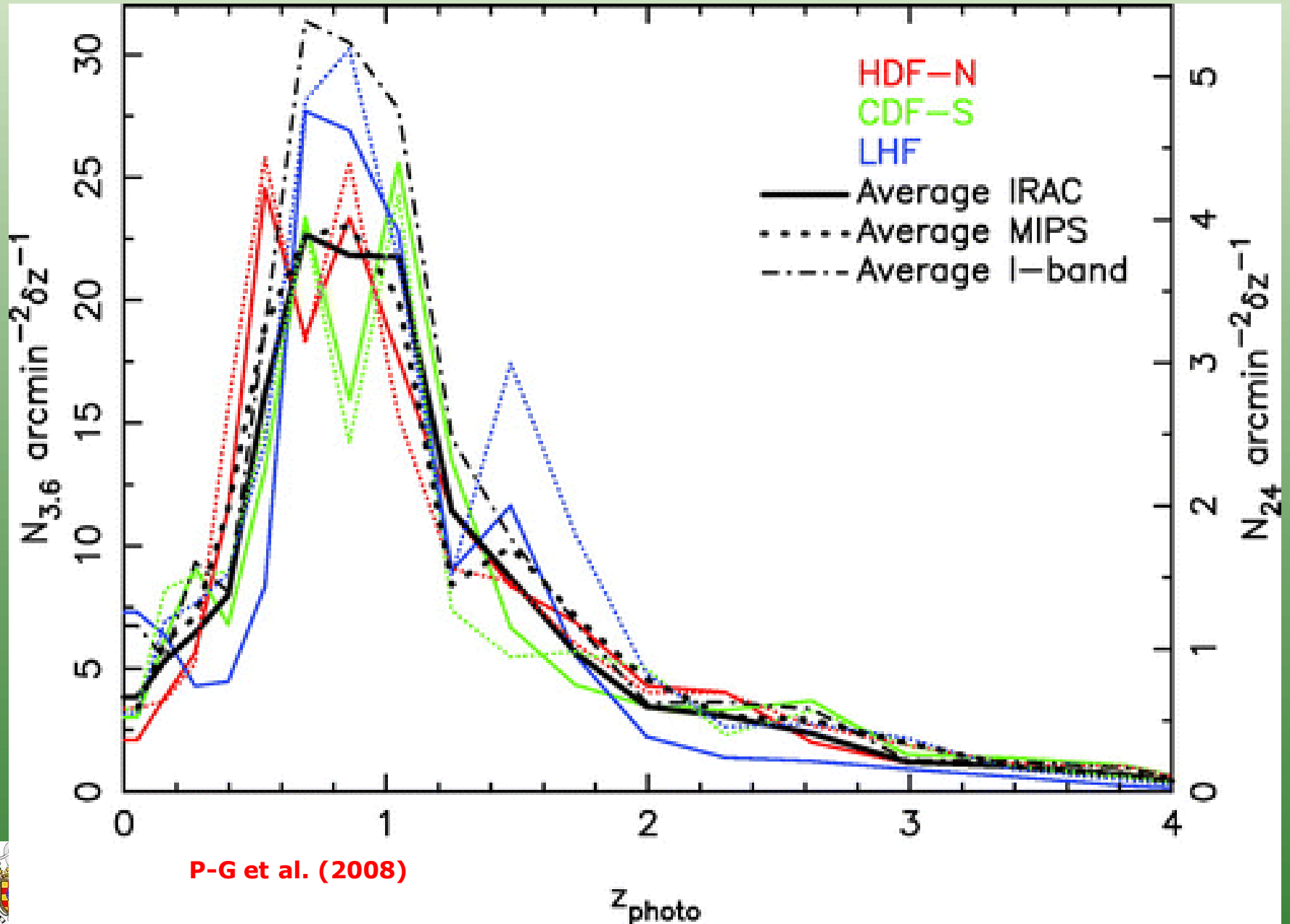


8.2. Distribuciones de redshifts: sesgos

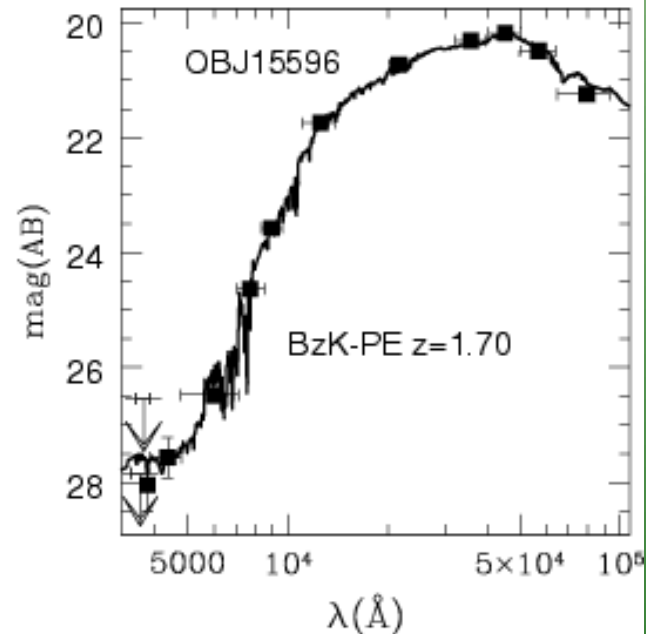
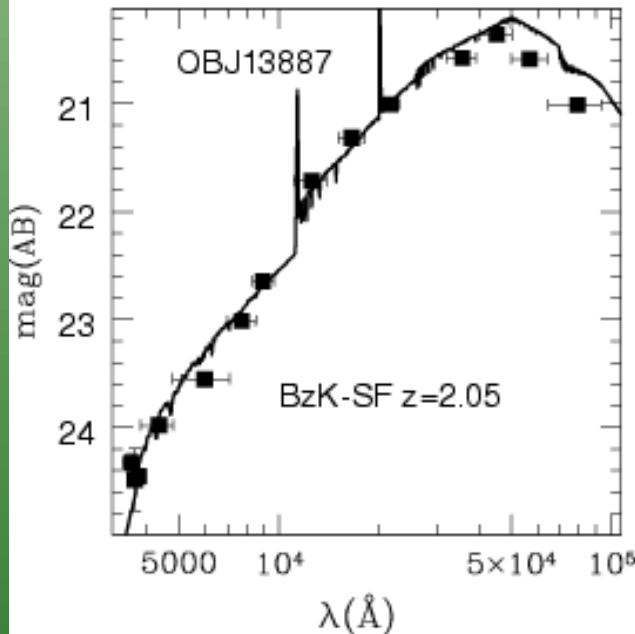
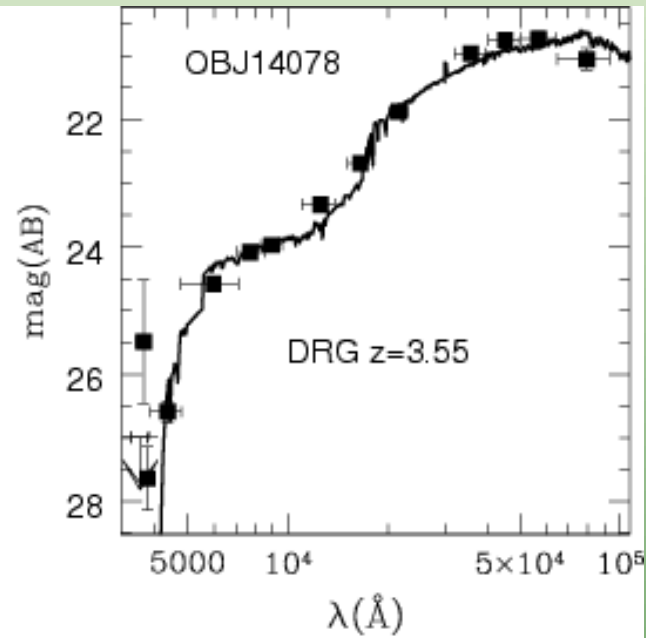
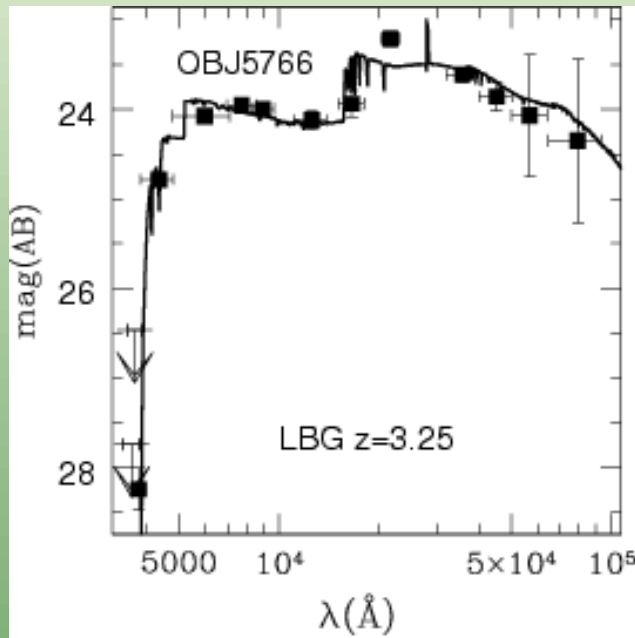


P-G et al. (2005)

8.2. Distribuciones de redshifts: sesgos



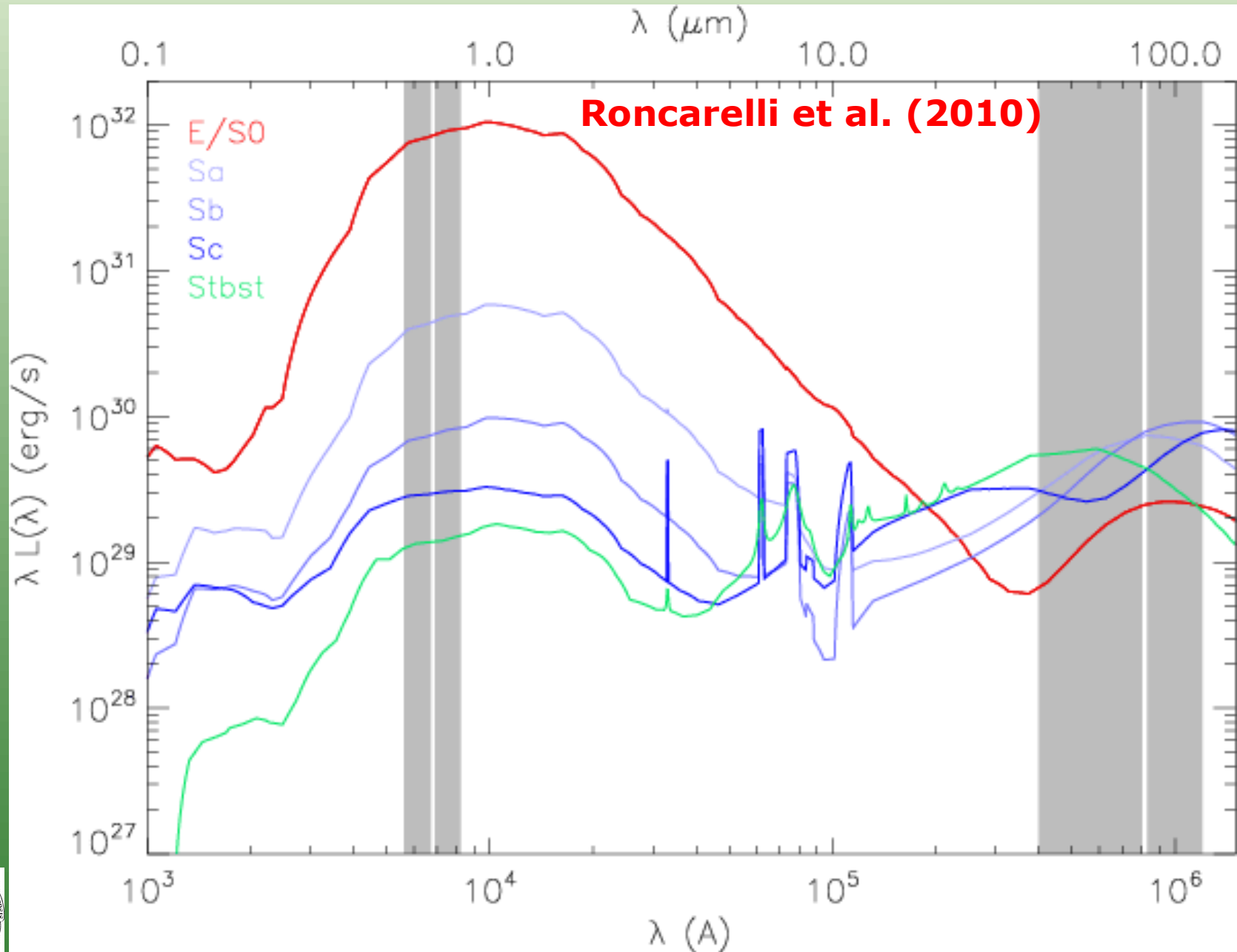
8.2. Selección de galaxias: sesgos (en color/tipo)



Grazian et al. (2007)



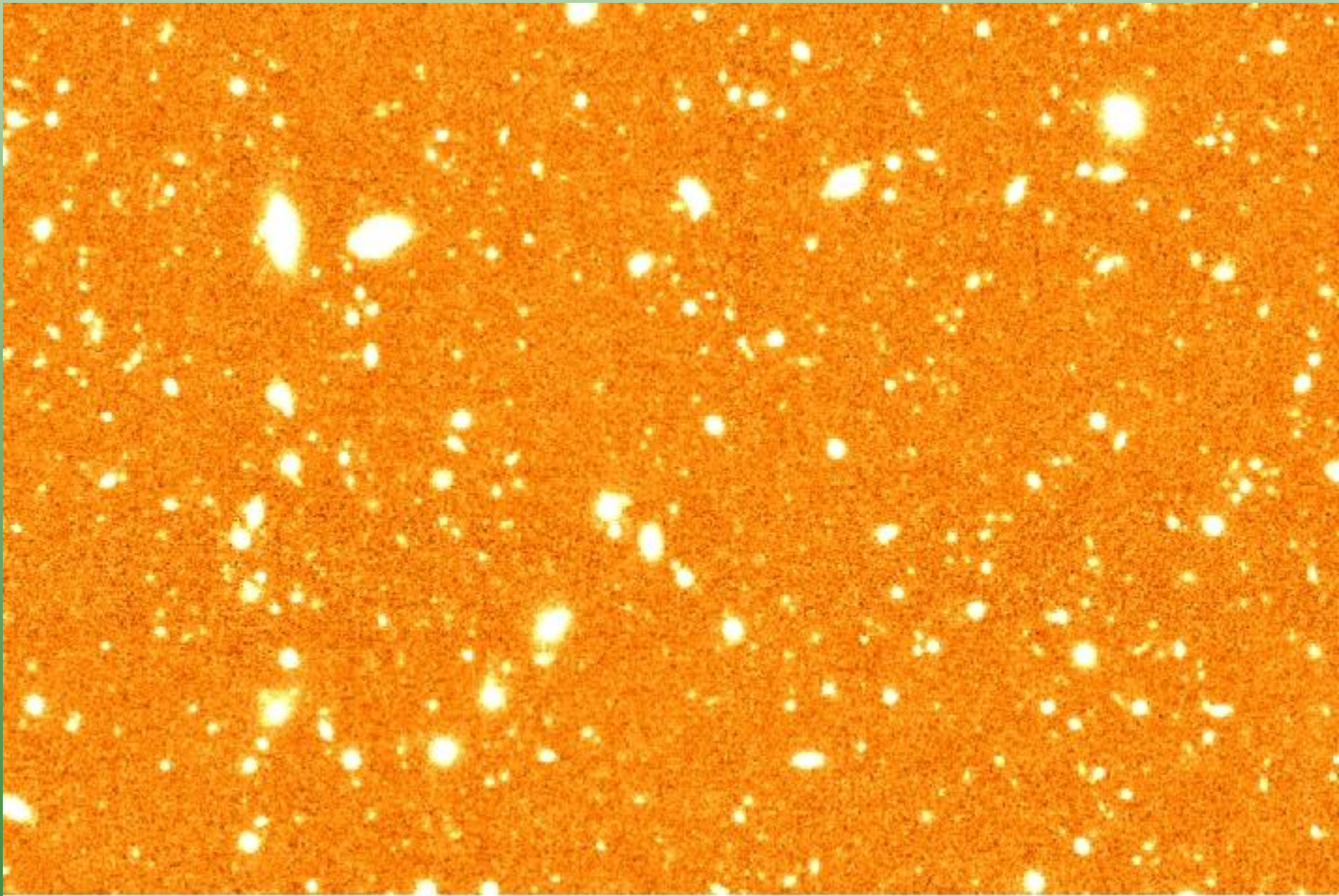
8.2. Selección de galaxias: sesgos (en masa/lum.)



8.2.Datos multi-longitud de onda



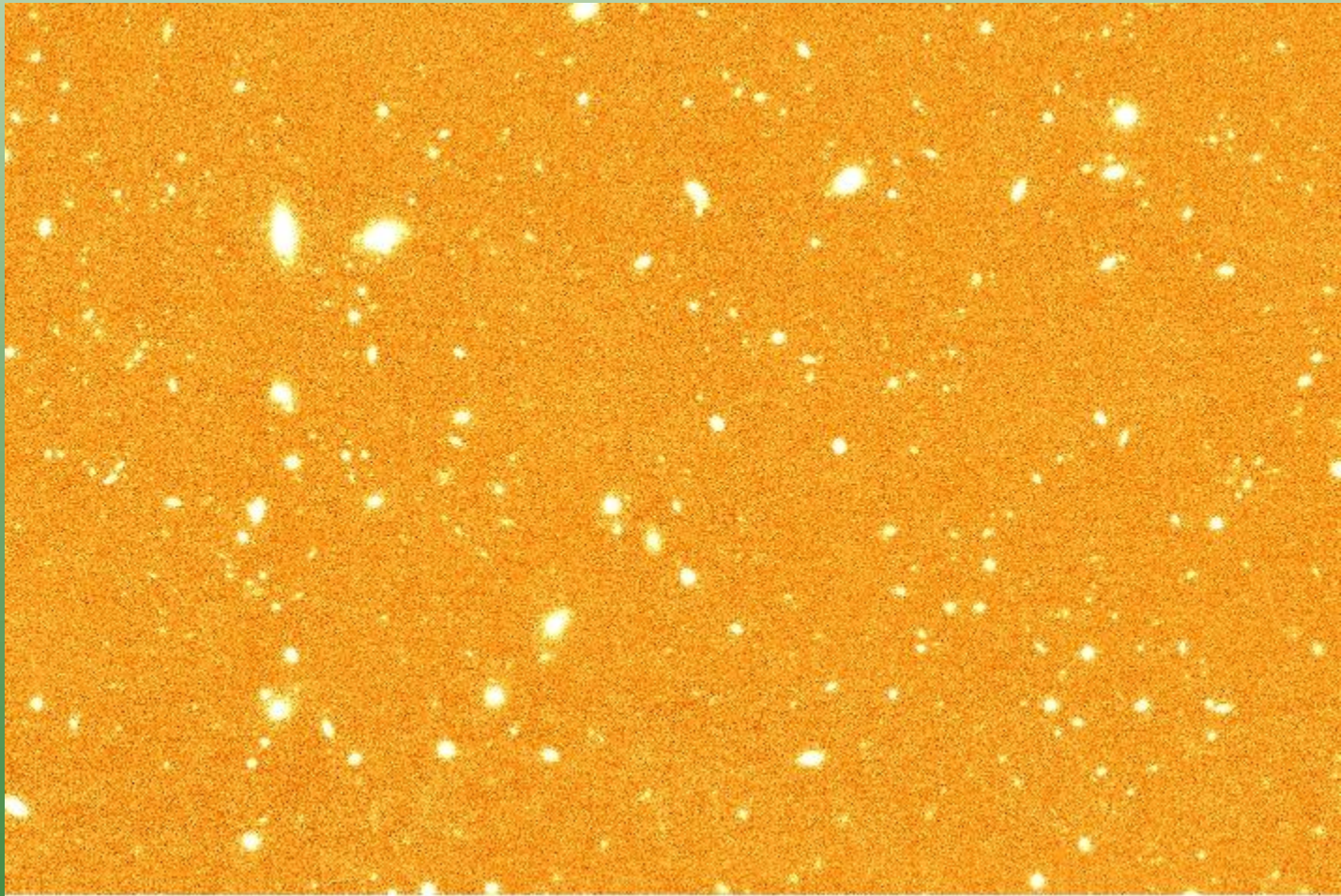
NB816 (Subaru)



8.2.Datos multi-longitud de onda



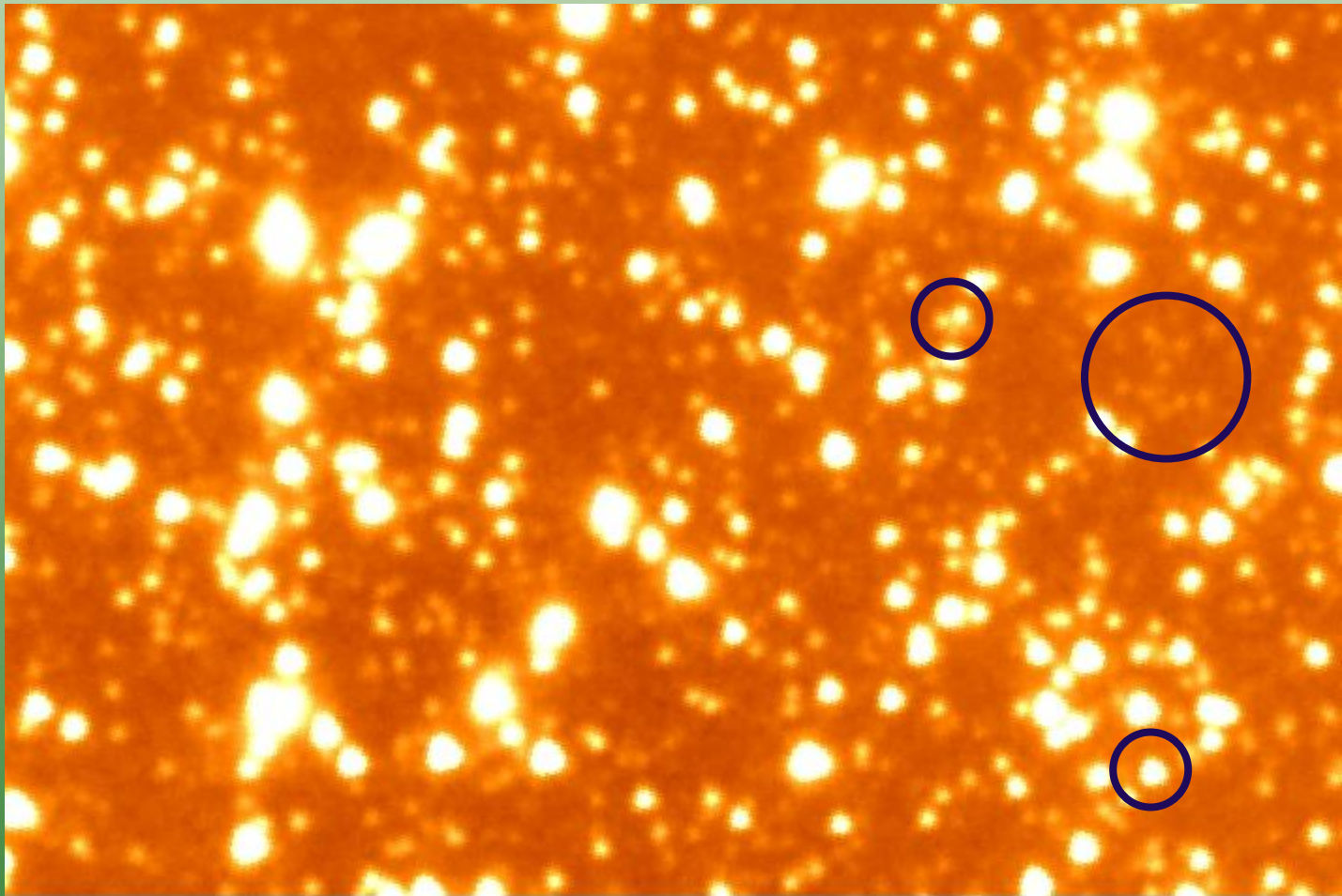
K (ISAAC 400 ks)



8.2.Datos multi-longitud de onda



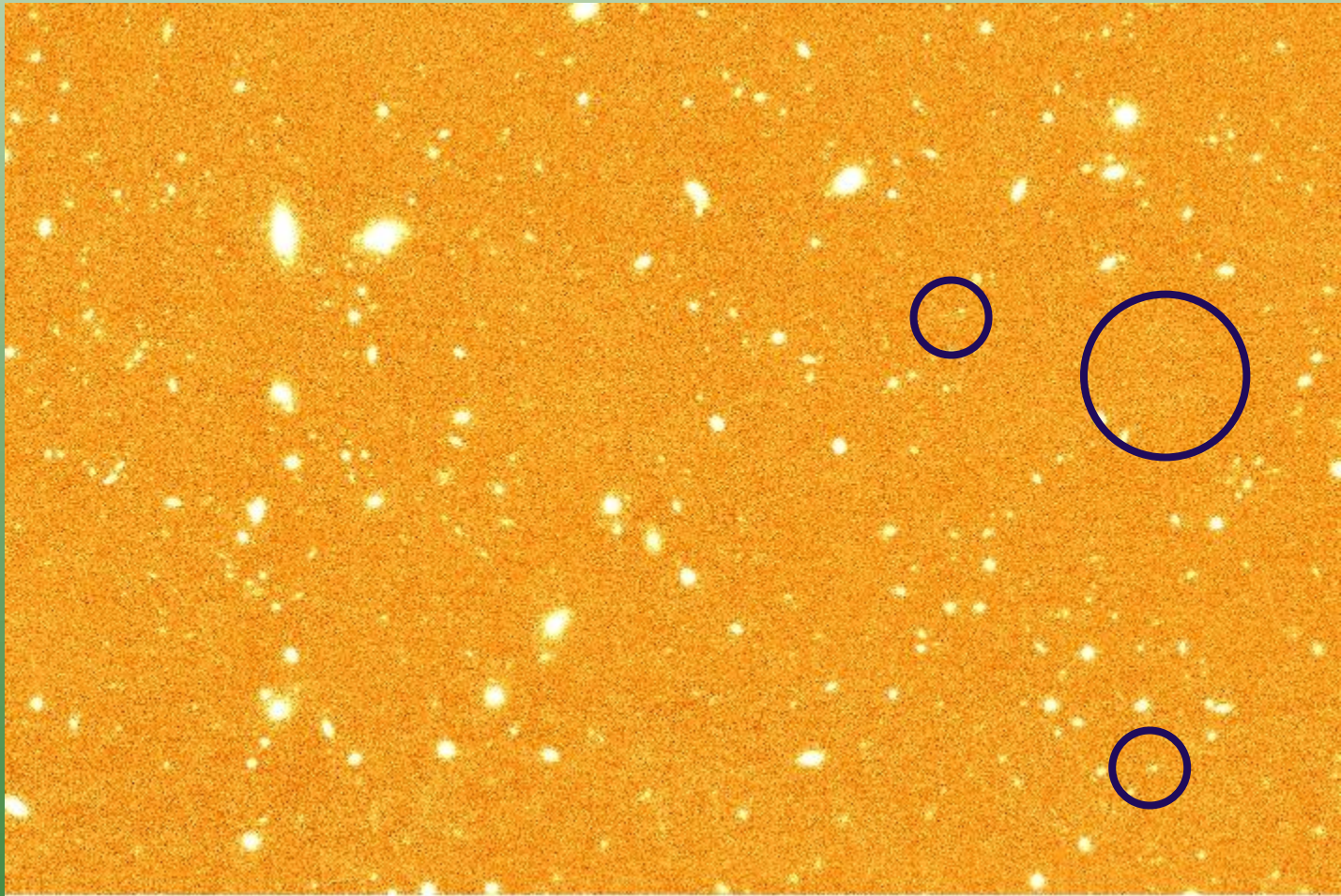
IRAC (3.6 μm 76 ks)



8.2.Datos multi-longitud de onda



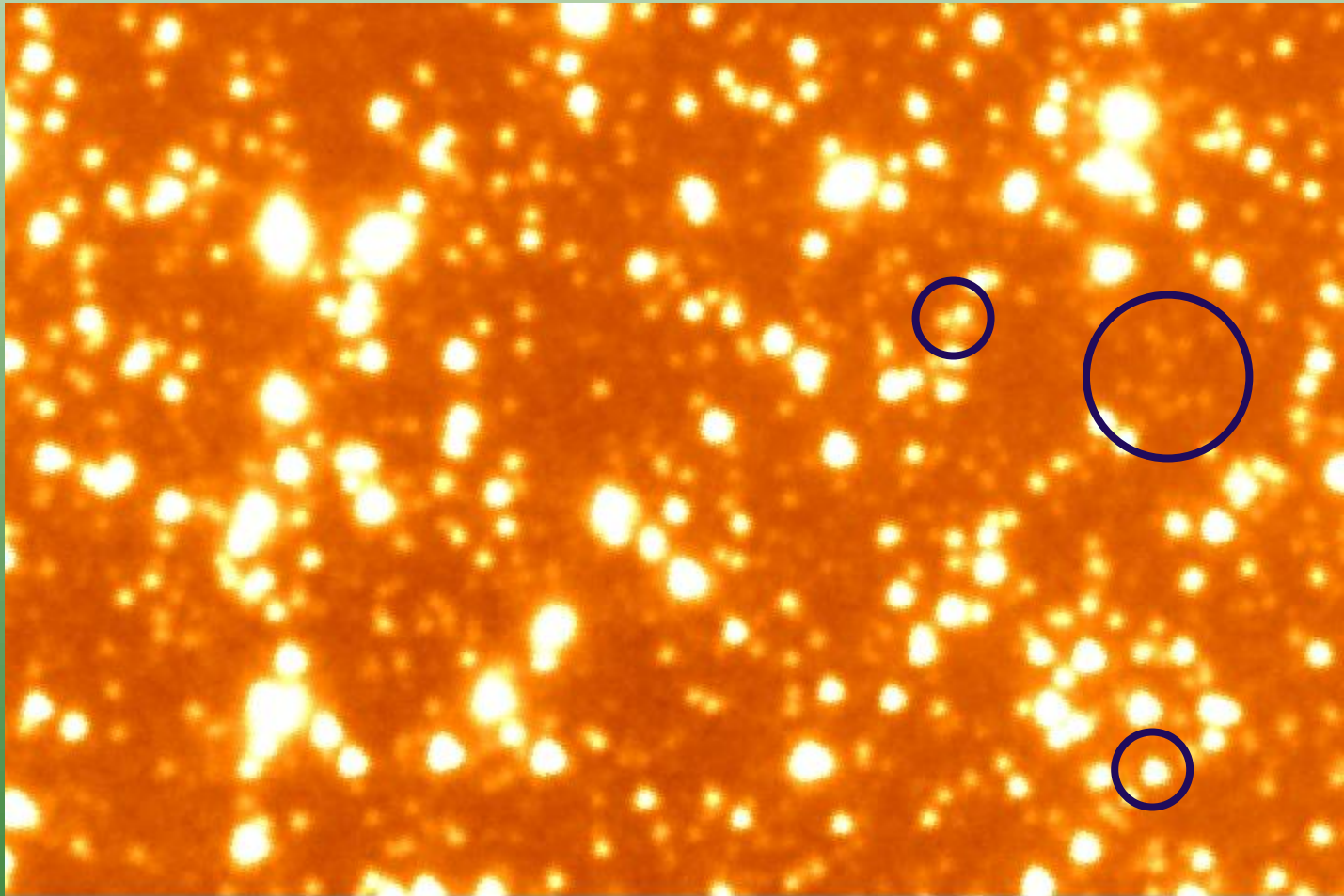
K (ISAAC 400 ks)



8.2.Datos multi-longitud de onda



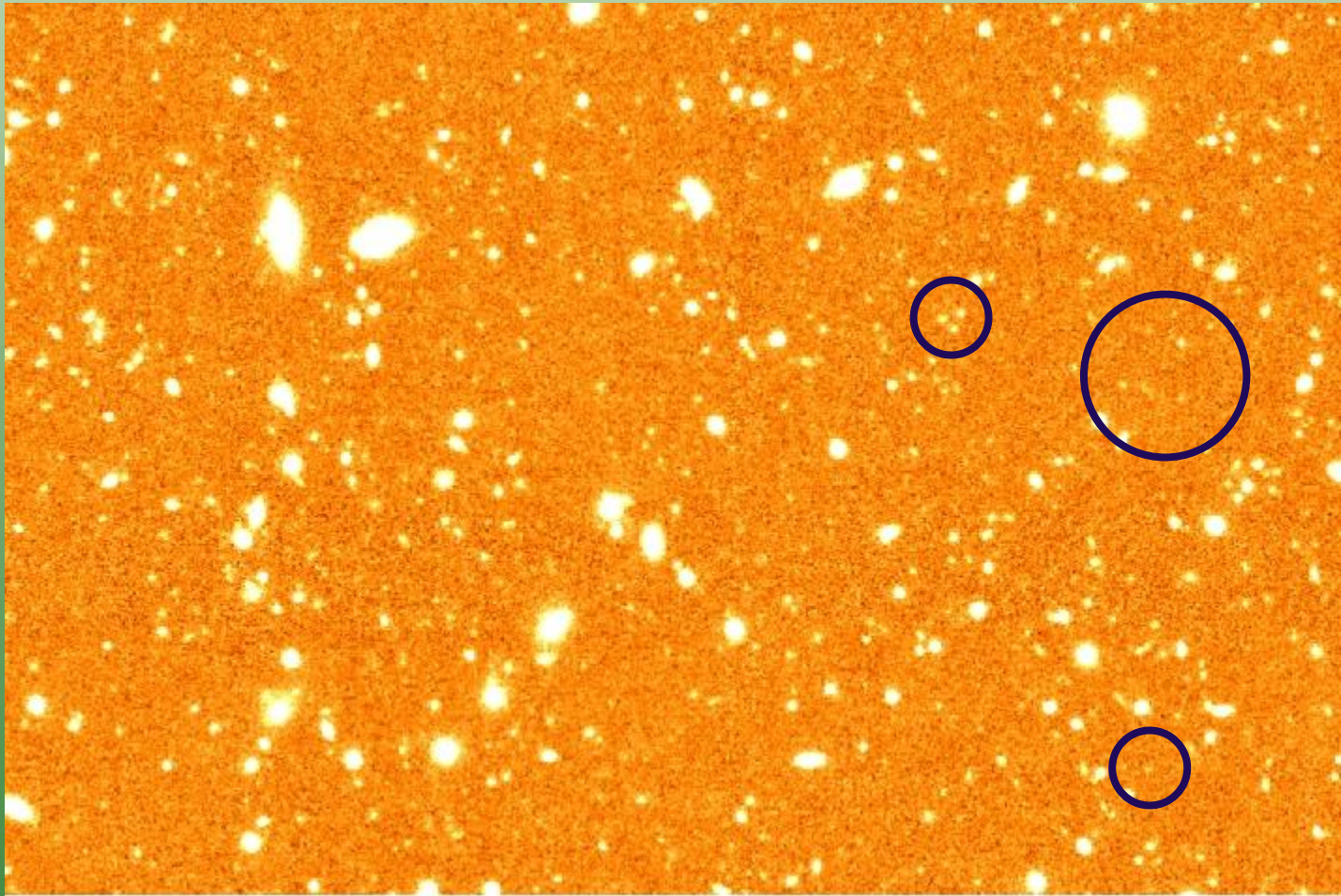
IRAC (3.6 μm 76 ks)



8.2.Datos multi-longitud de onda



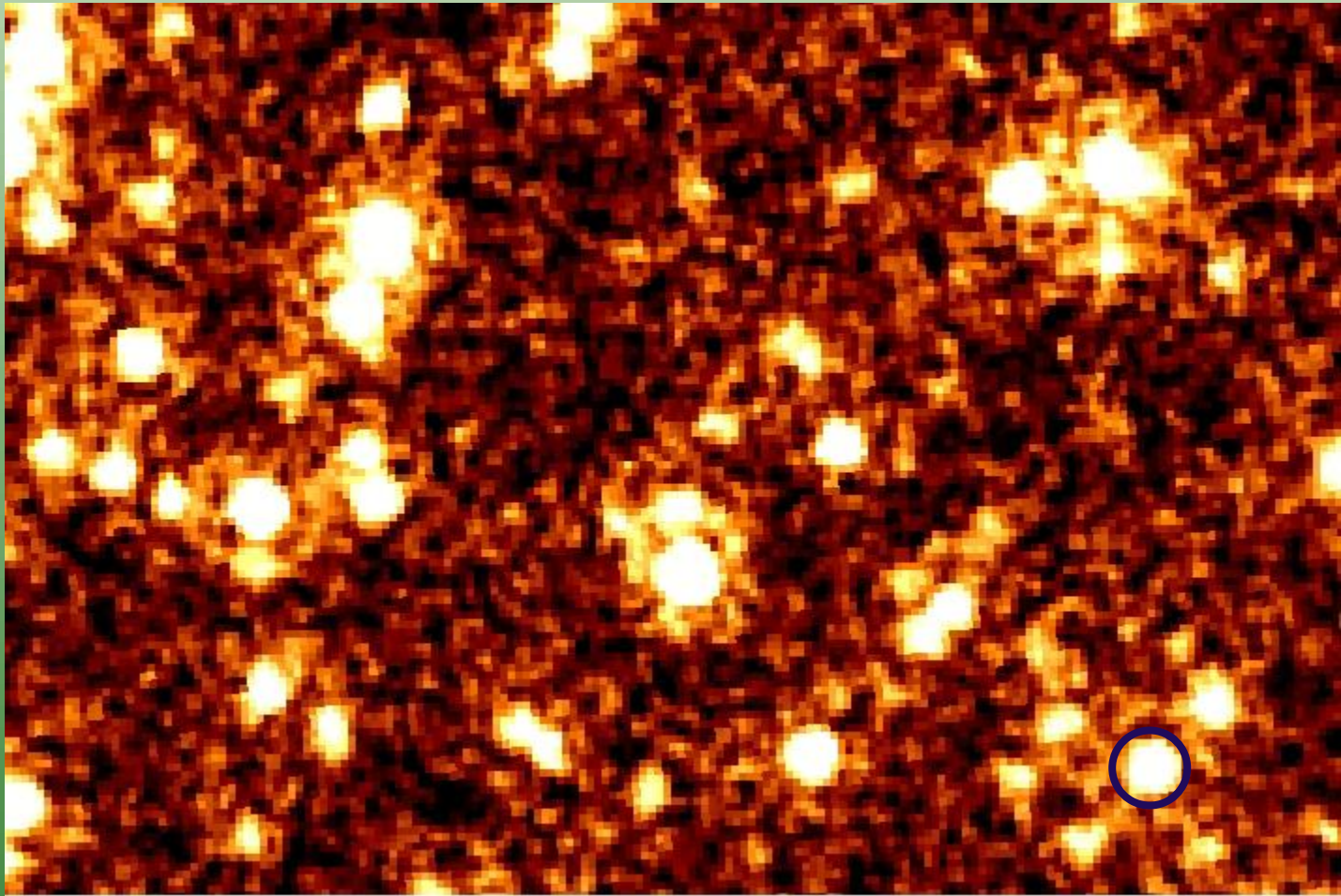
NB816 (Subaru)



8.2.Datos multi-longitud de onda

1'

MIPS



8.3.Historia del Universo

¡¡Al final del curso!!

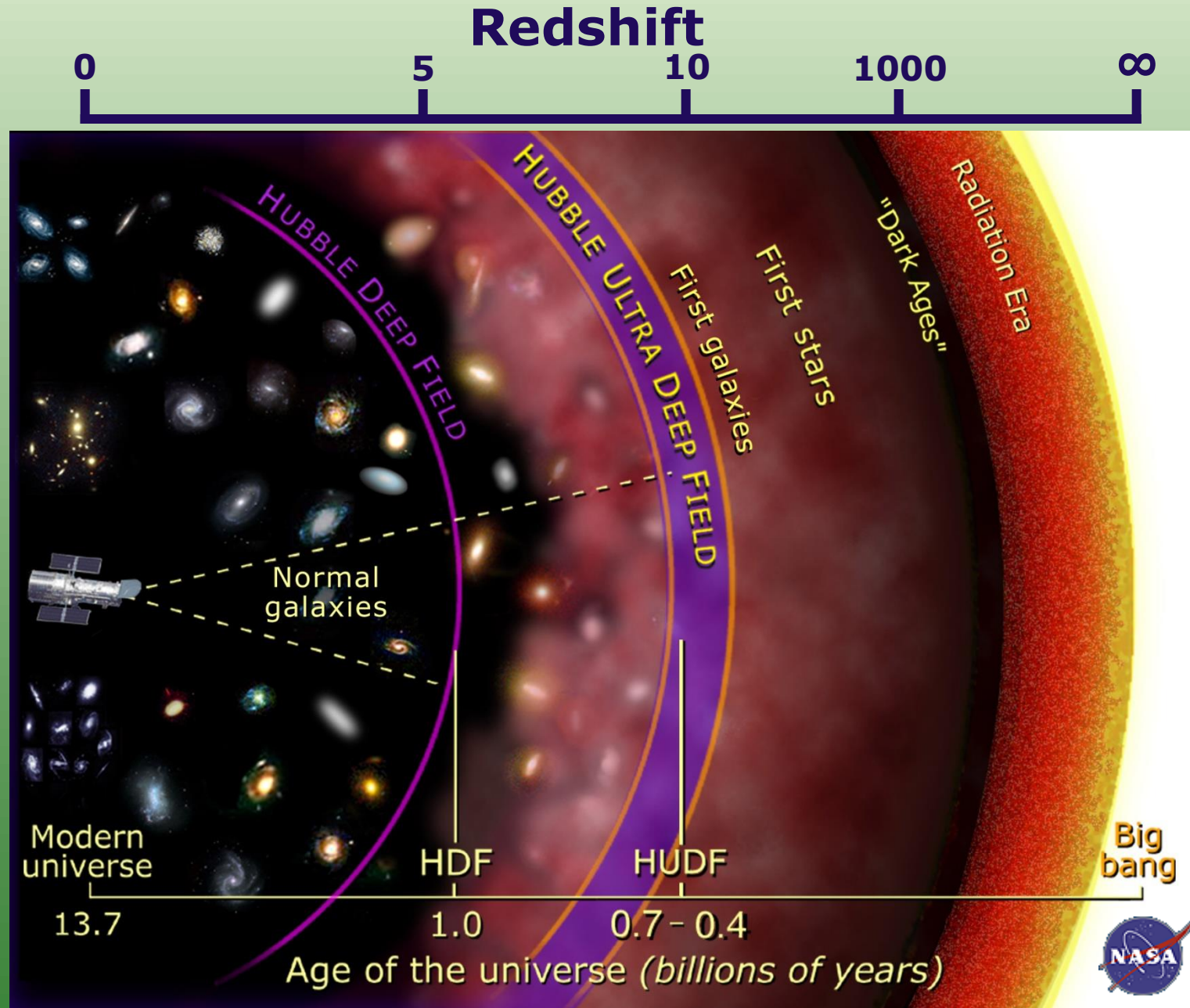


Resumen

- **Exploraciones fotométricas y espectroscópicas.**
- **¿Cómo se seleccionan y estudian galaxias a $z > 0$?**
- **Principales tipos de galaxias (según selección, longitud de onda, etc...).**
- **Efectos de selección.**



8.3.Historia del Universo



8.3.Fondo cósmico de microondas

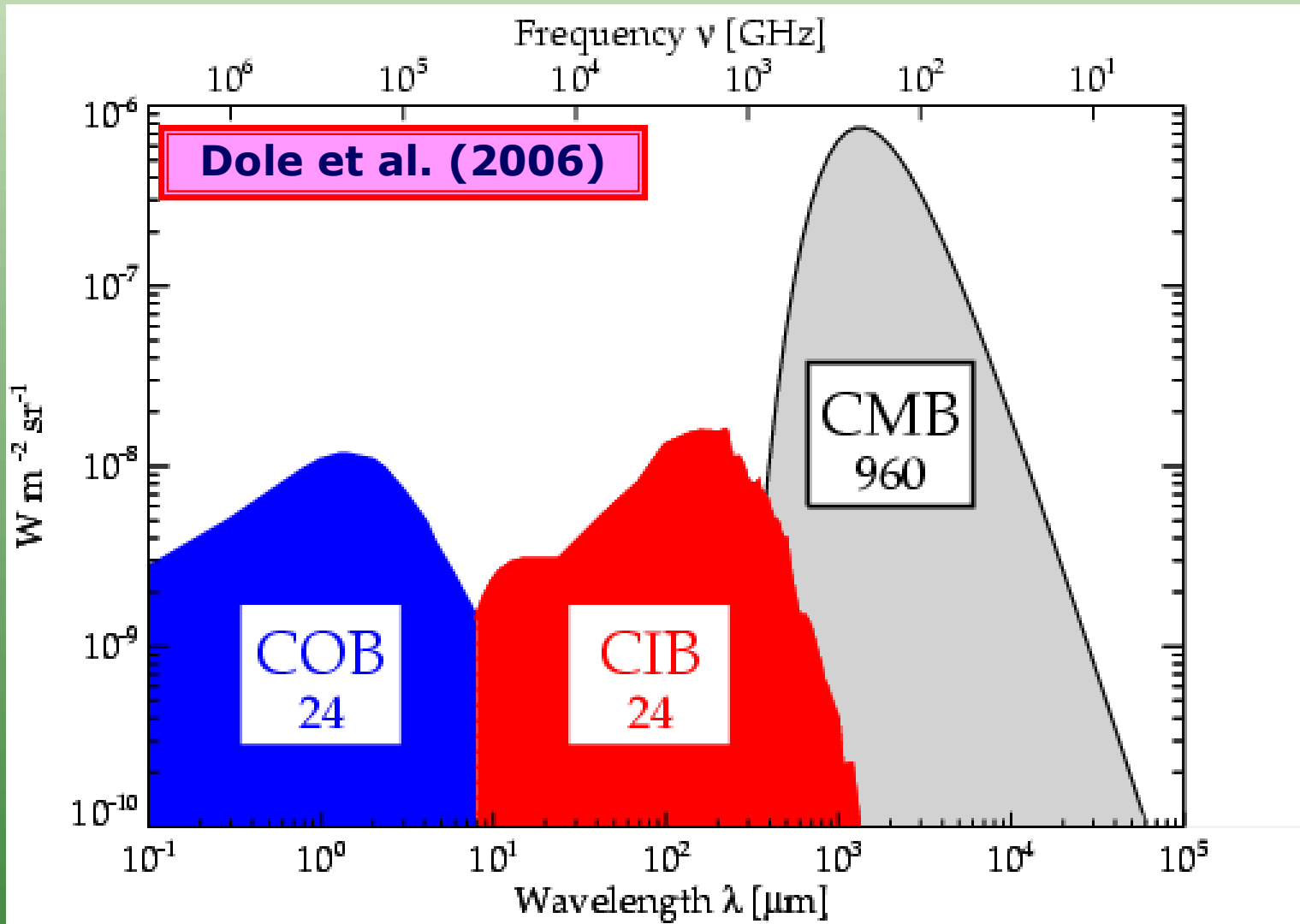
WMAP 2006

$\langle T \rangle = 2.73 \text{ K}$
 $\Delta T = 10^{-6} \text{ K}$

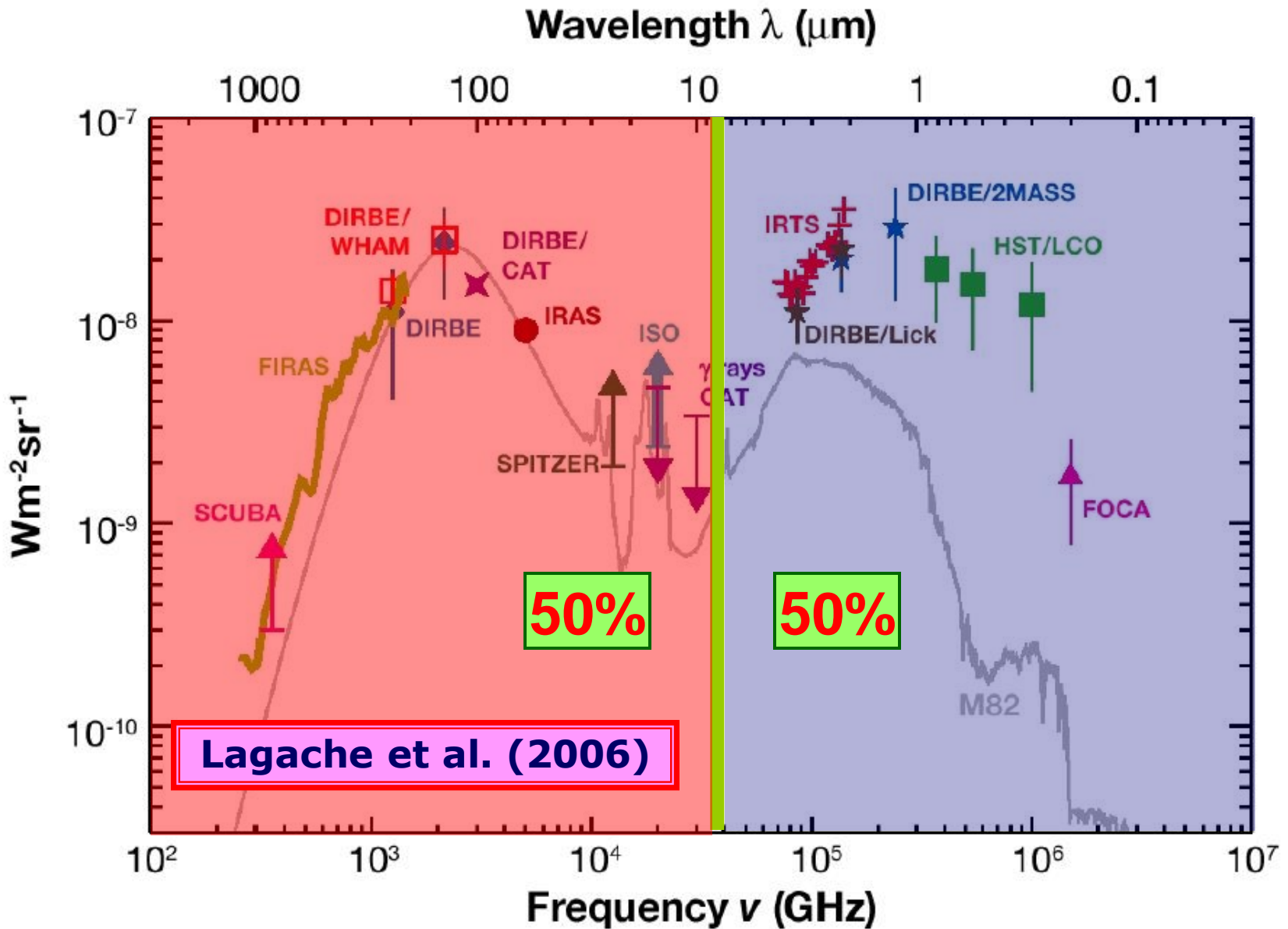
- $H_0 = 73.2 \pm 3.2 \text{ km/s/Mpc}$
- $\Omega_m = 0.241 \pm 0.034$
- $\Omega_\Lambda = 0.759 \pm 0.034$
- **Universe Age = 13.7 Gyr**



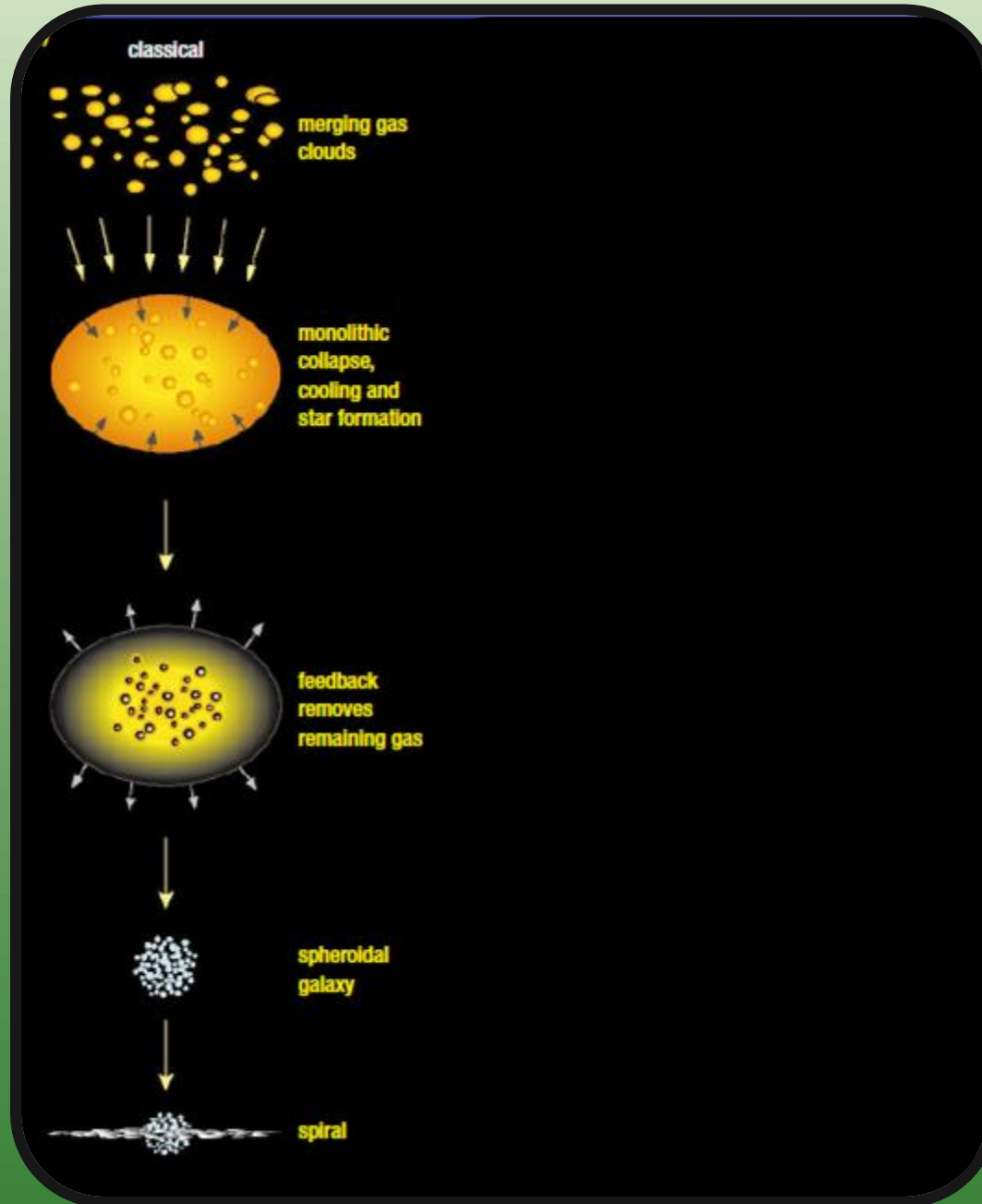
8.3.Fondo cósmico



8.3.Fondo cósmico



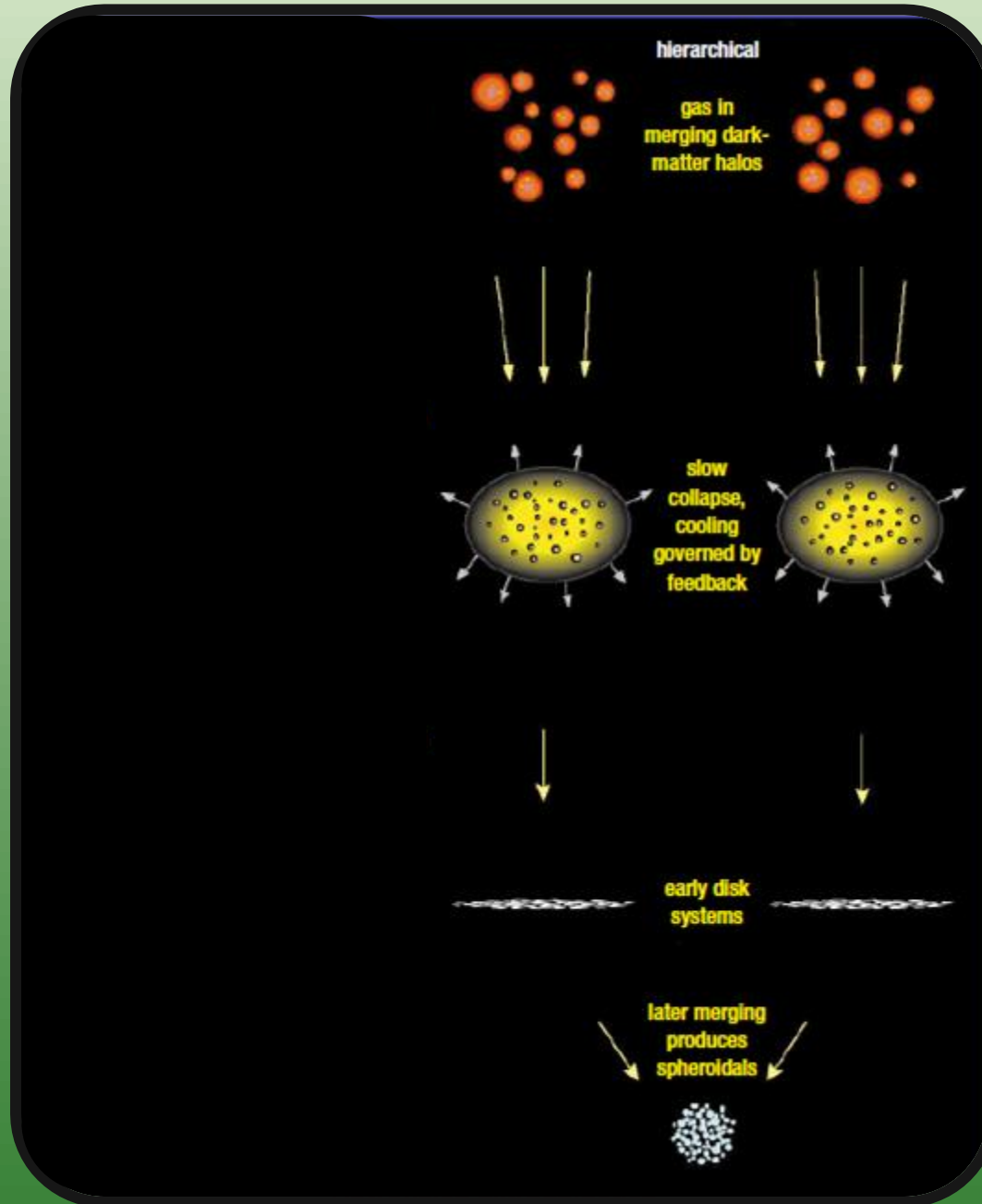
8.3.El paradigma actual



Ellis et al. (2000)



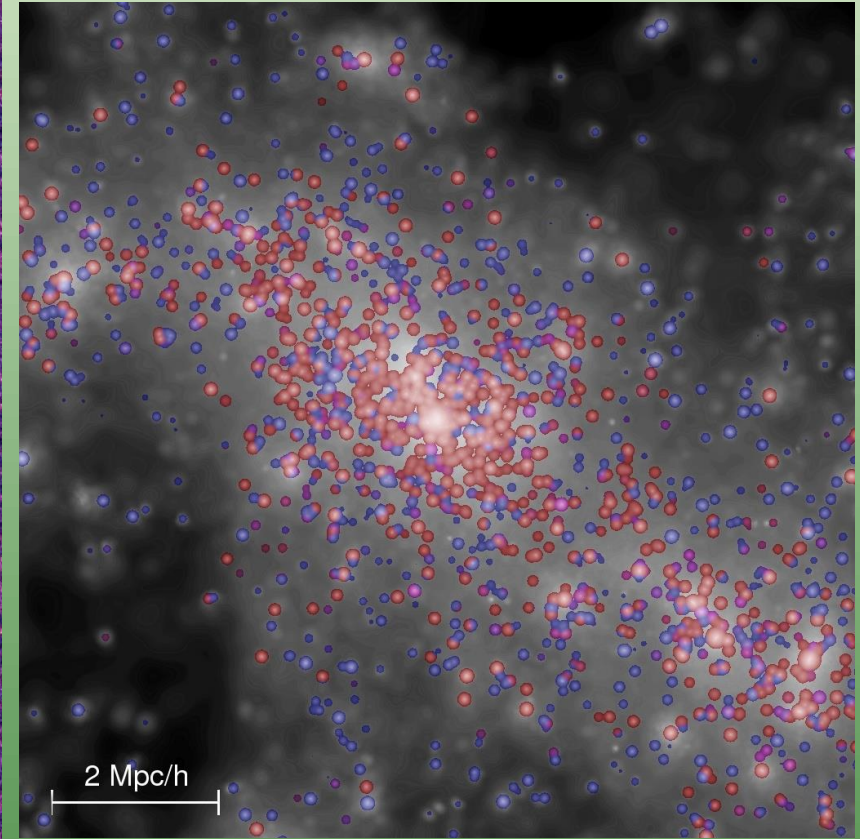
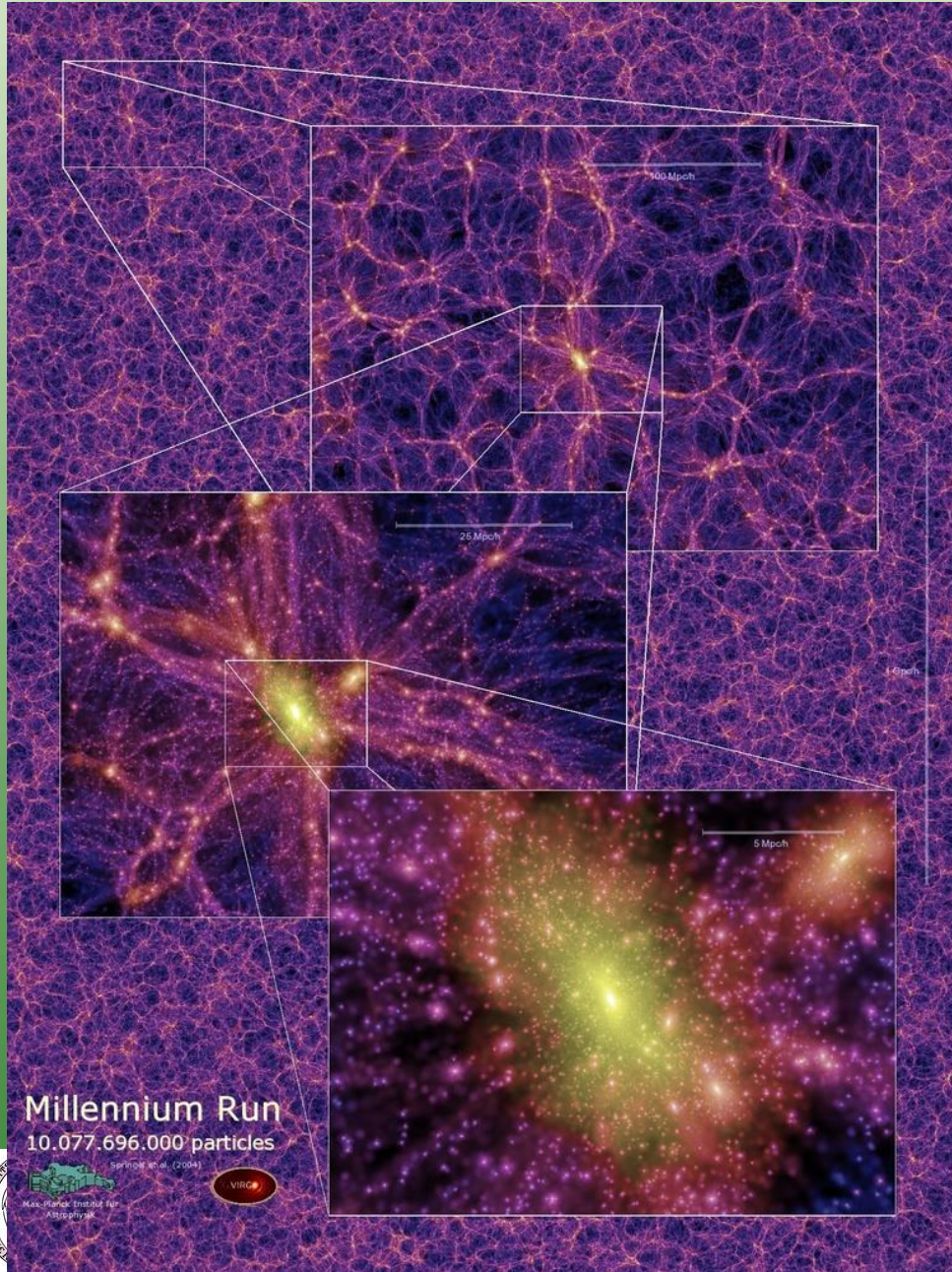
8.3.El paradigma actual



Ellis et al. (2000)

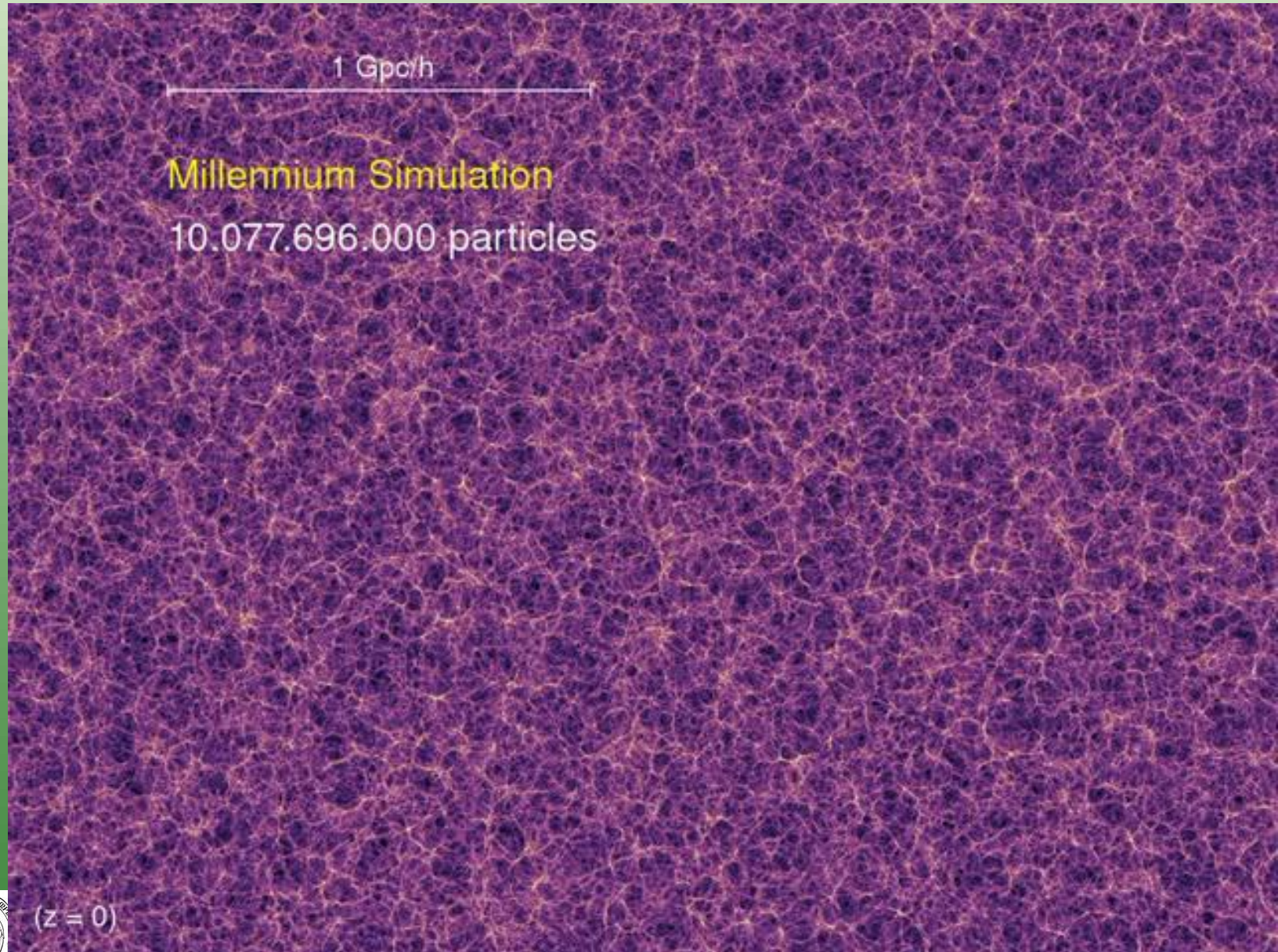


8.3.El paradigma actual



Springel et al. (2005)

8.3.El paradigma actual



8.3.El paradigma actual

$z = 20.0$

50 Mpc/h



Springel et al. (2005)



8.3.El paradigma actual

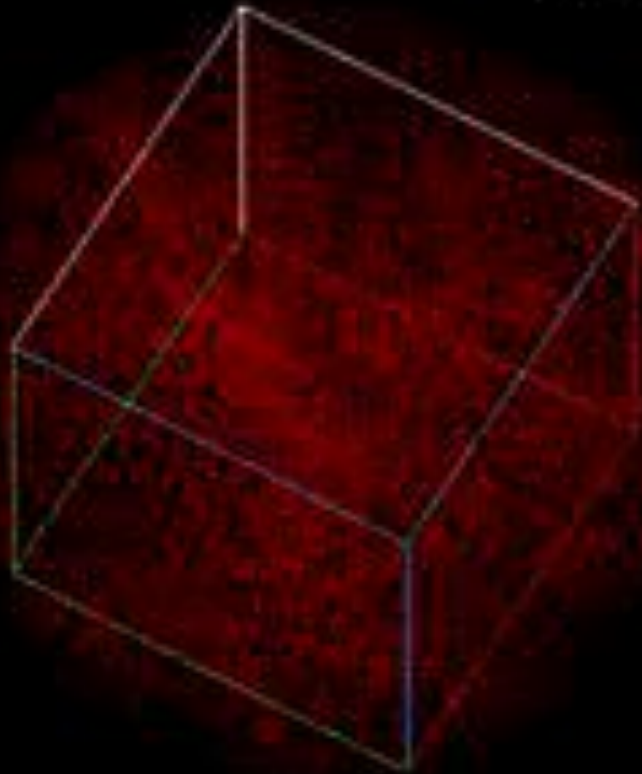
Springel et al. (2005)



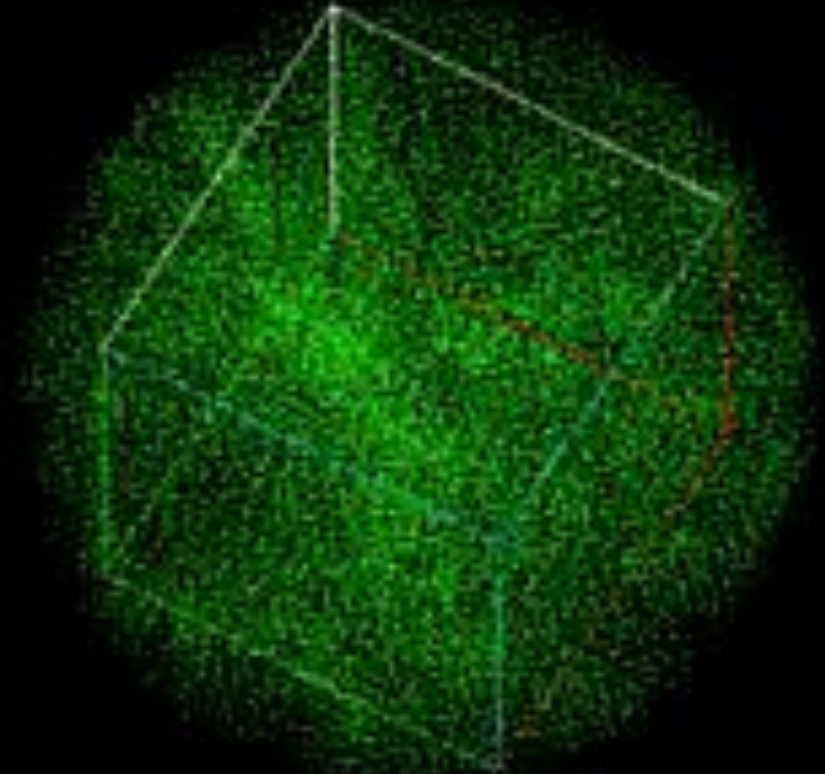
8.3.El paradigma actual

Springel et al. (2005)

$z: 20.7$



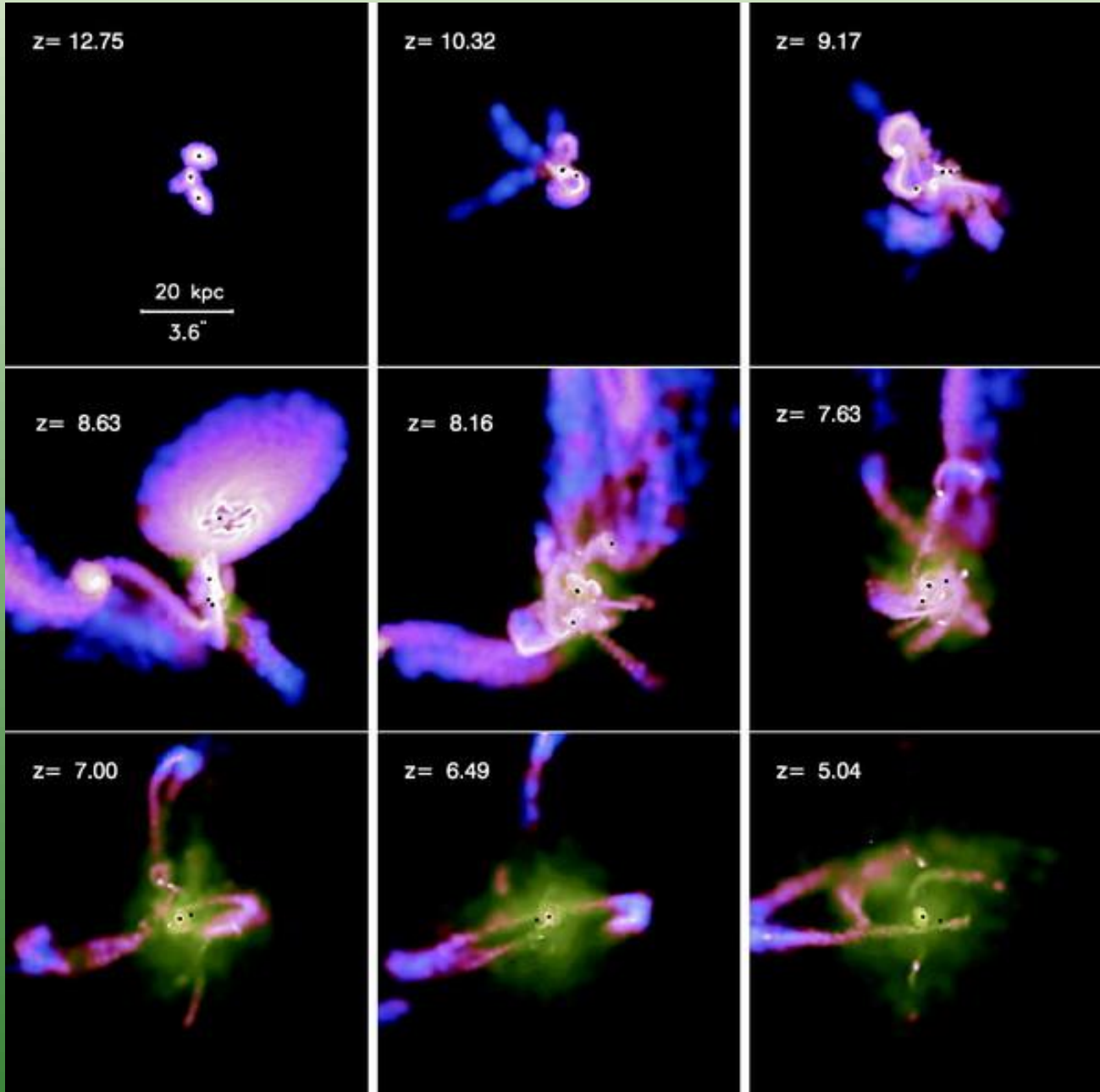
Gas



Dark Matter



8.3.El paradigma actual

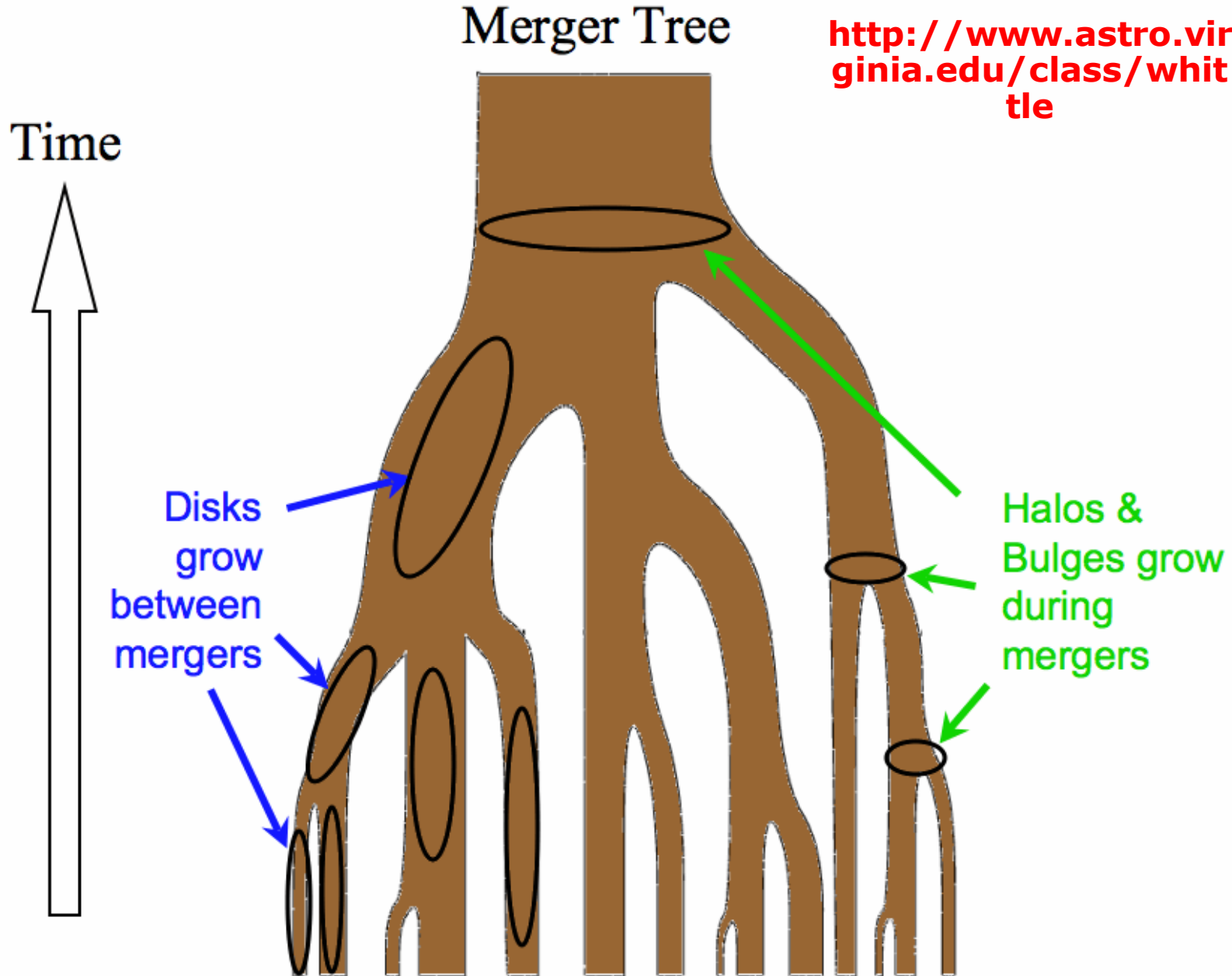


Li et al. (2008)

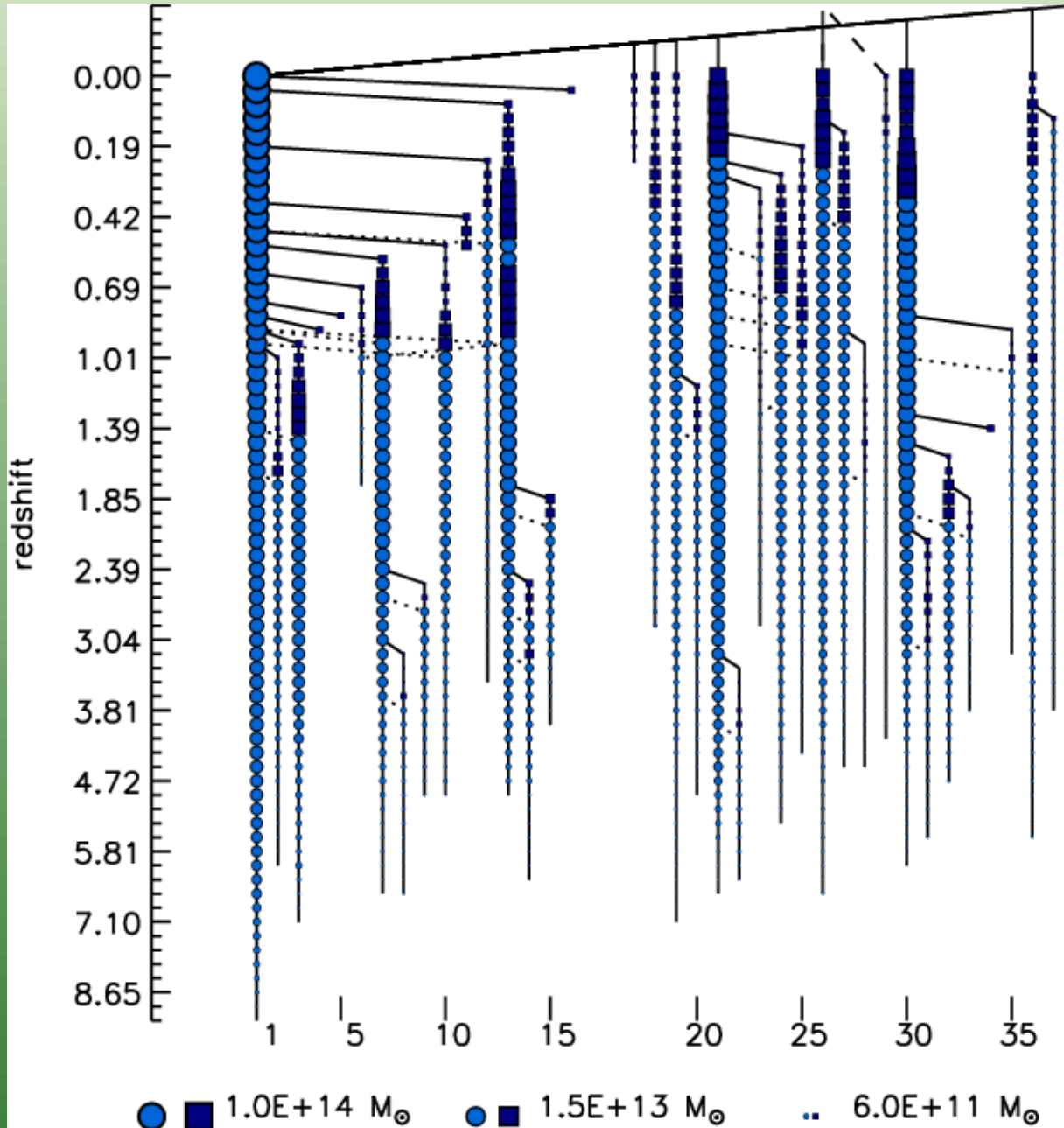


8.3.El paradigma actual

<http://www.astro.virginia.edu/class/whittle>



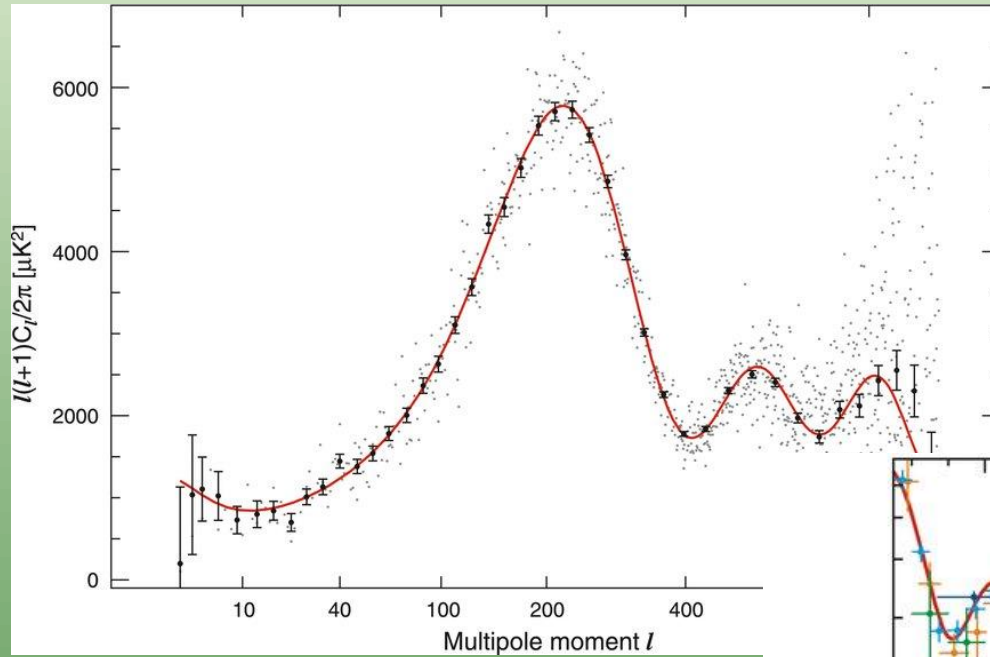
8.3.El paradigma actual



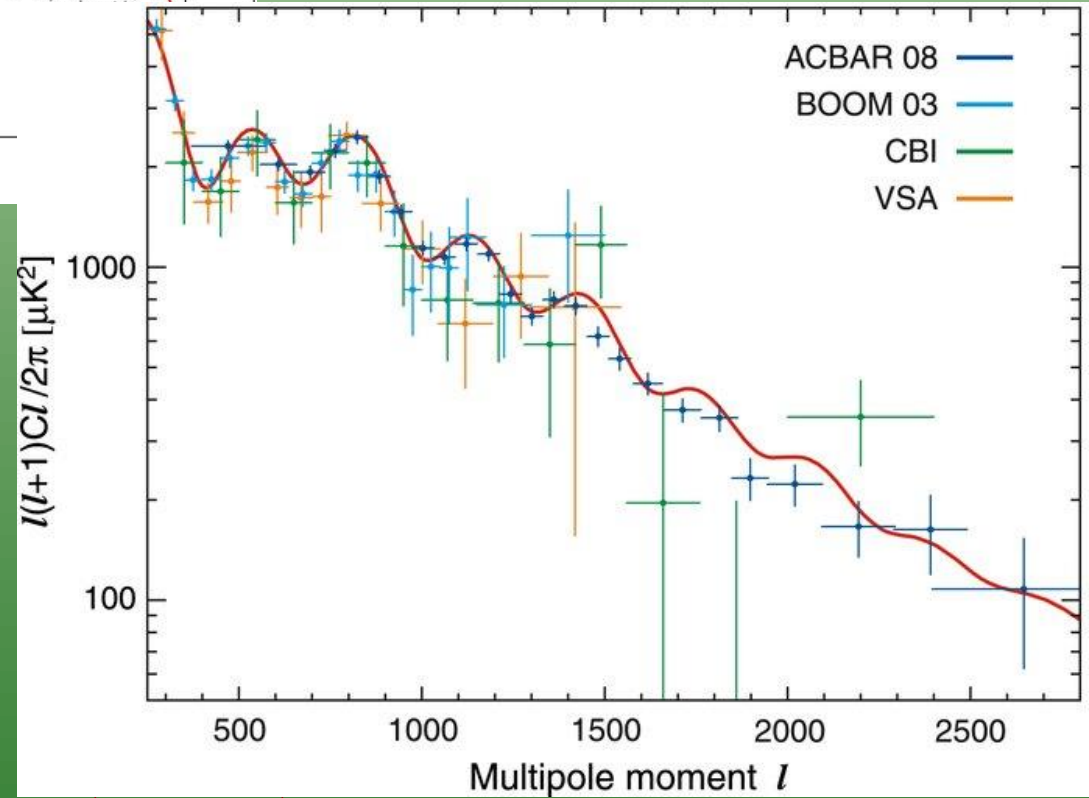
Tweed et al. (2009)



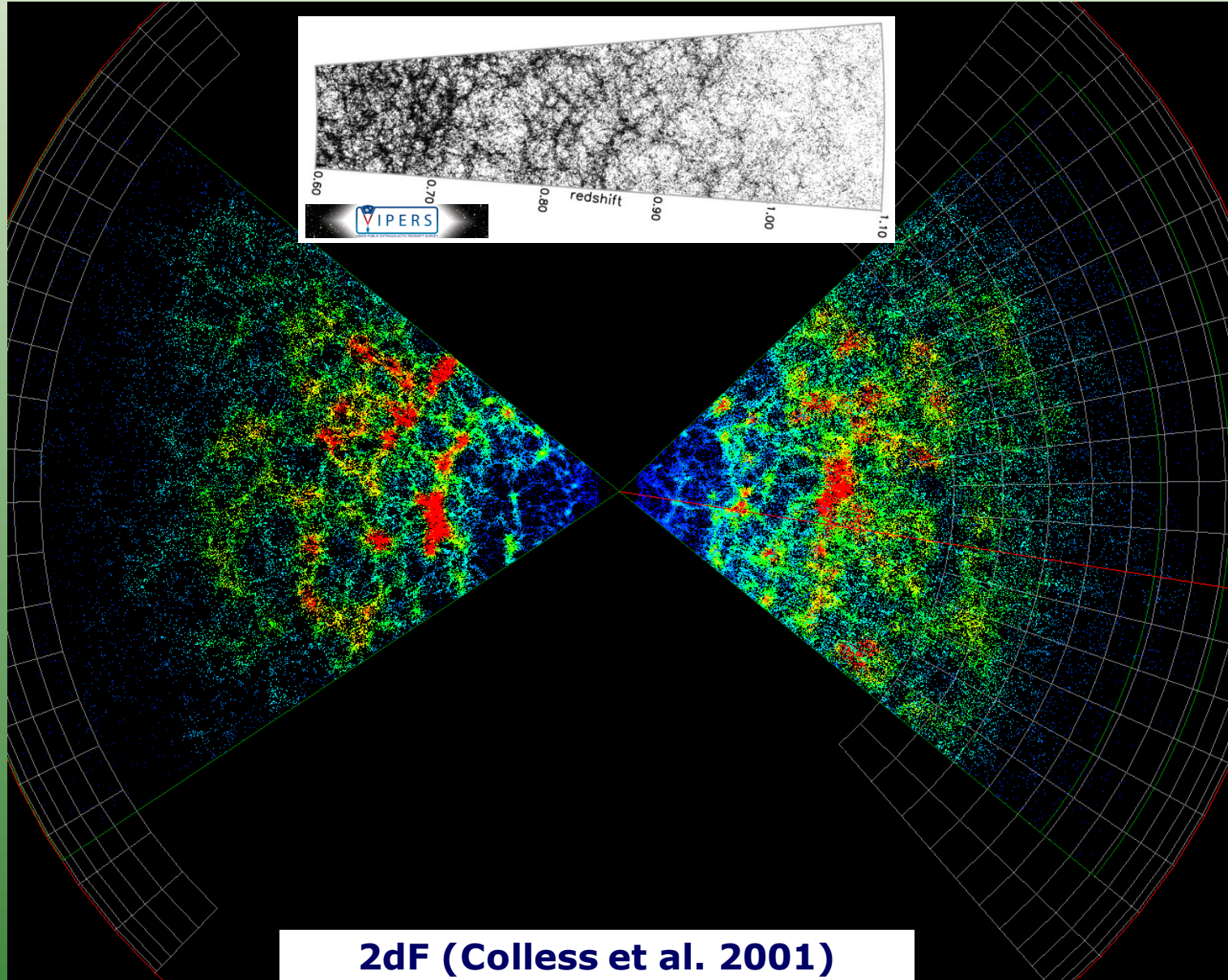
8.3.El paradigma actual



Dunkley et al. (2009)
Spergel et al. (2004, 2006)



8.3.El paradigma actual

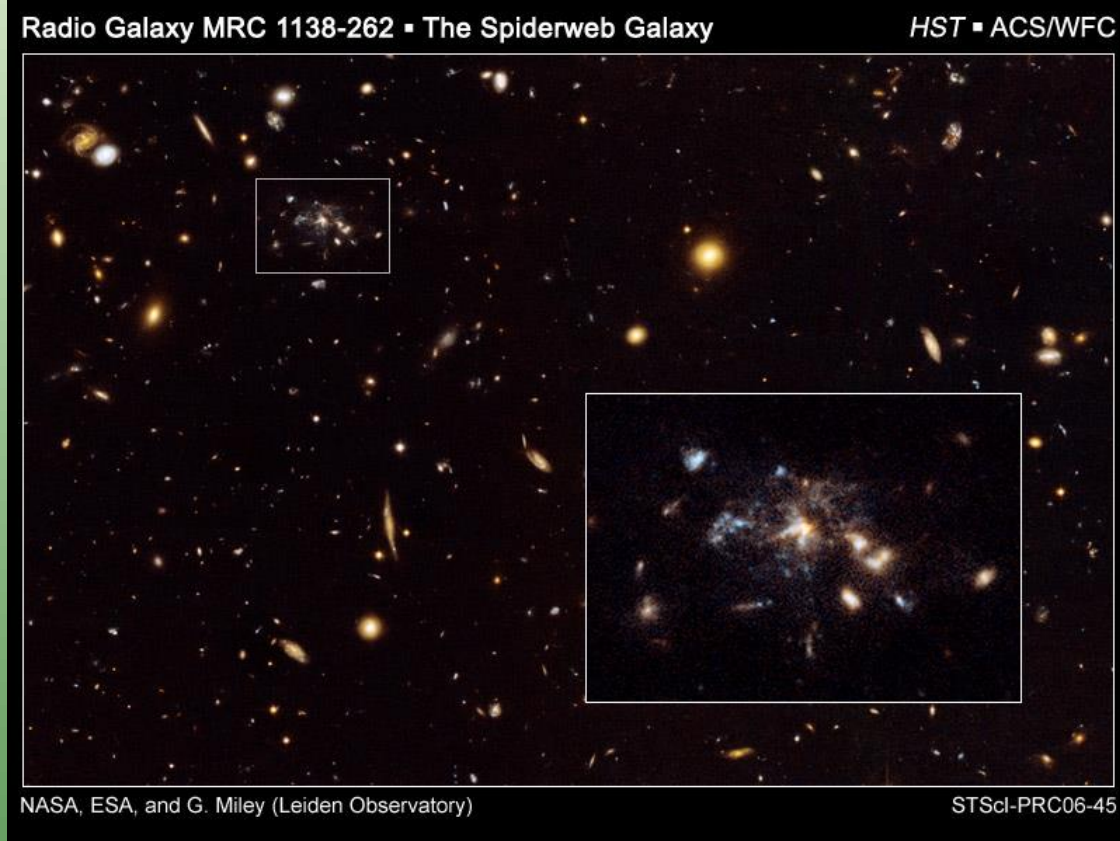
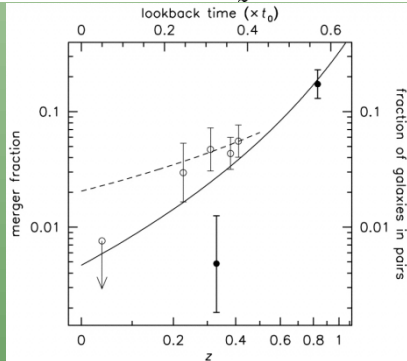
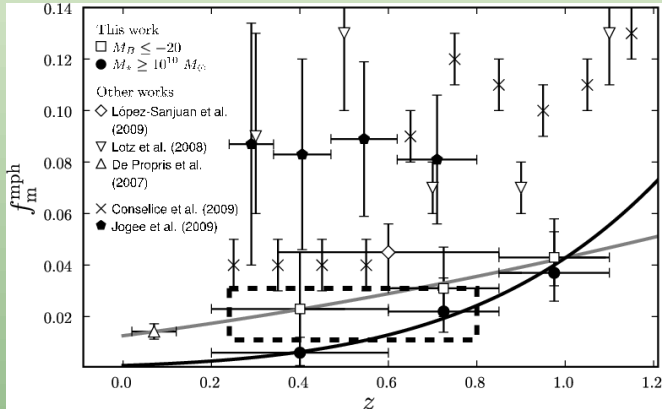


2dF (Colless et al. 2001)

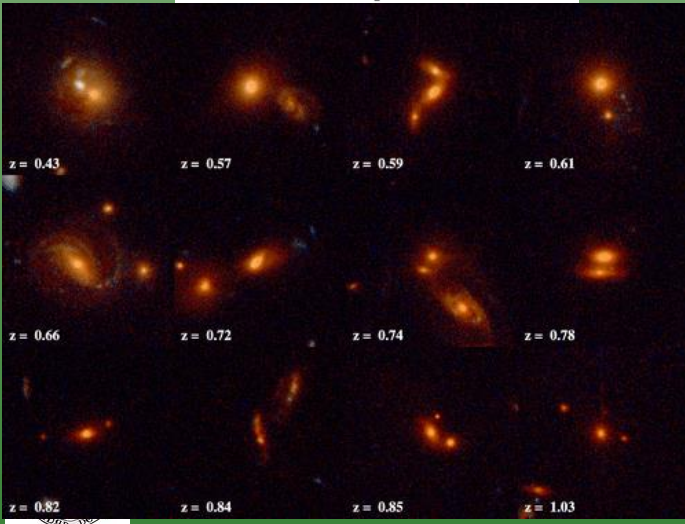
Sim by VIPERS project



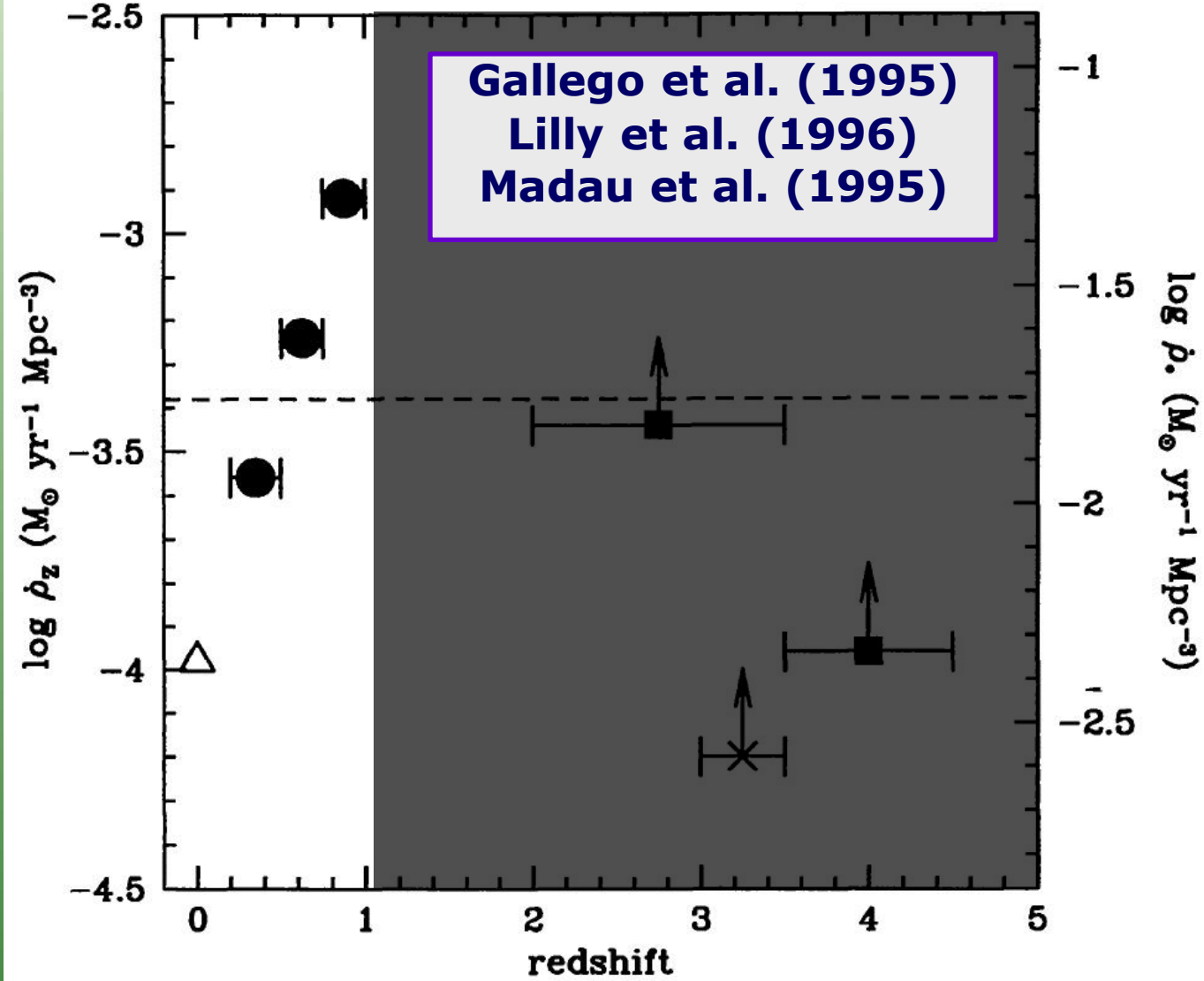
8.3.EI paradigma actual



van Dokkum et al. (1999), Le Fevre et al. (2000), Conselice et al. (2003), Bell et al. (2006), Miley et al. (2006), Lotz et al. (2008), López-Sanjuan et al. (200*)

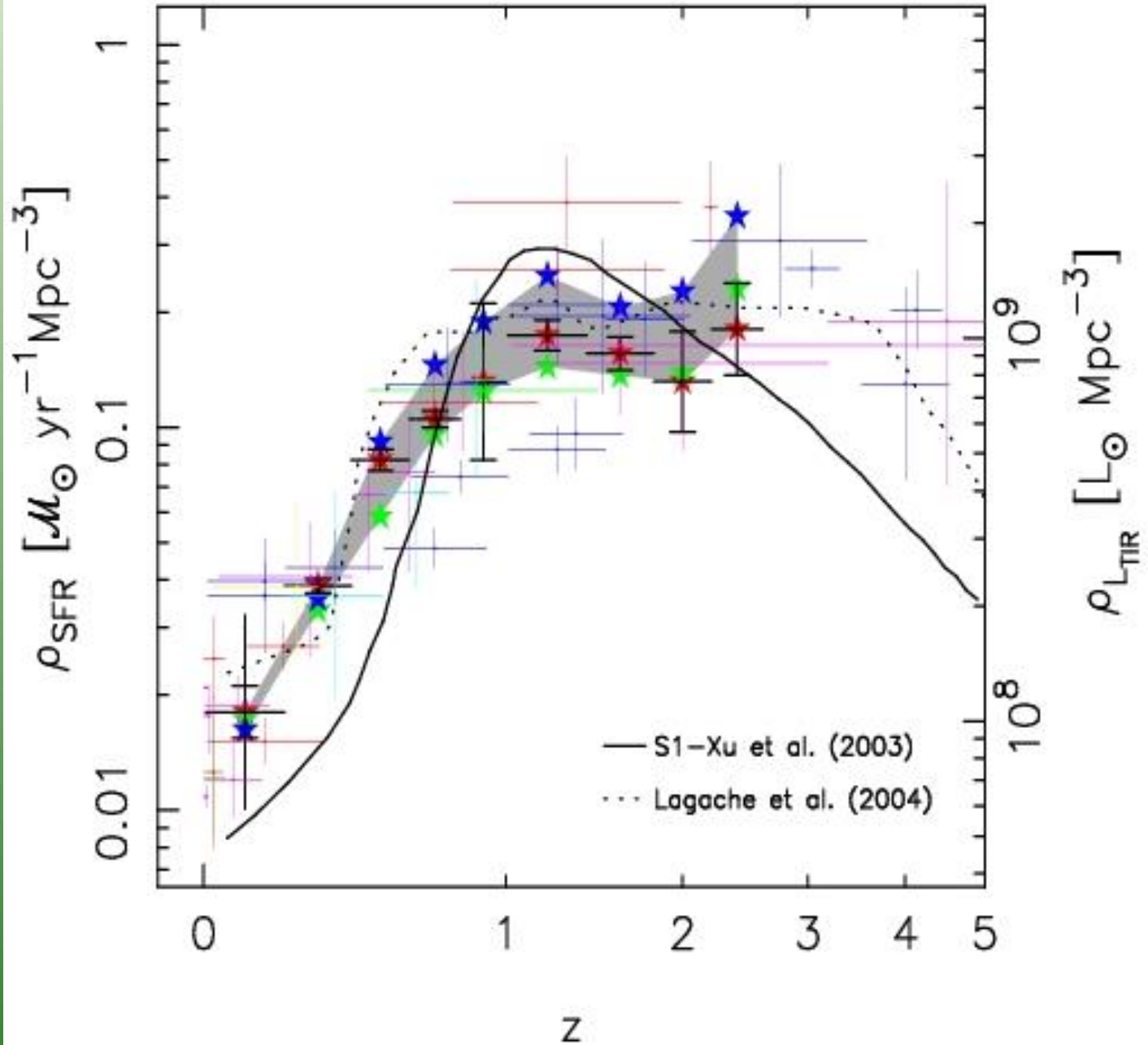


8.3. Evolución de galaxias



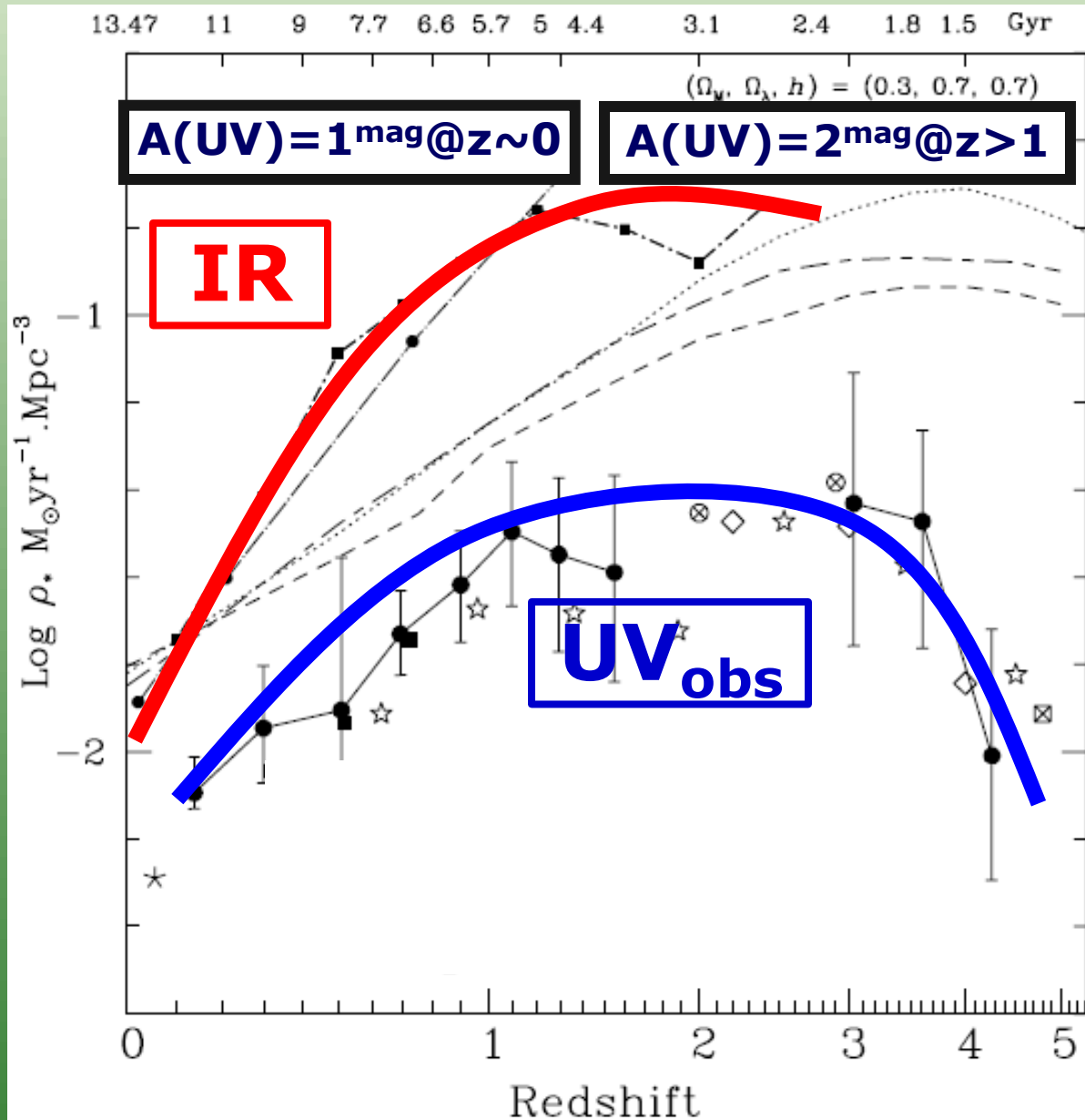
8.3. Evolución de galaxias

Pérez-González et al. (2005)

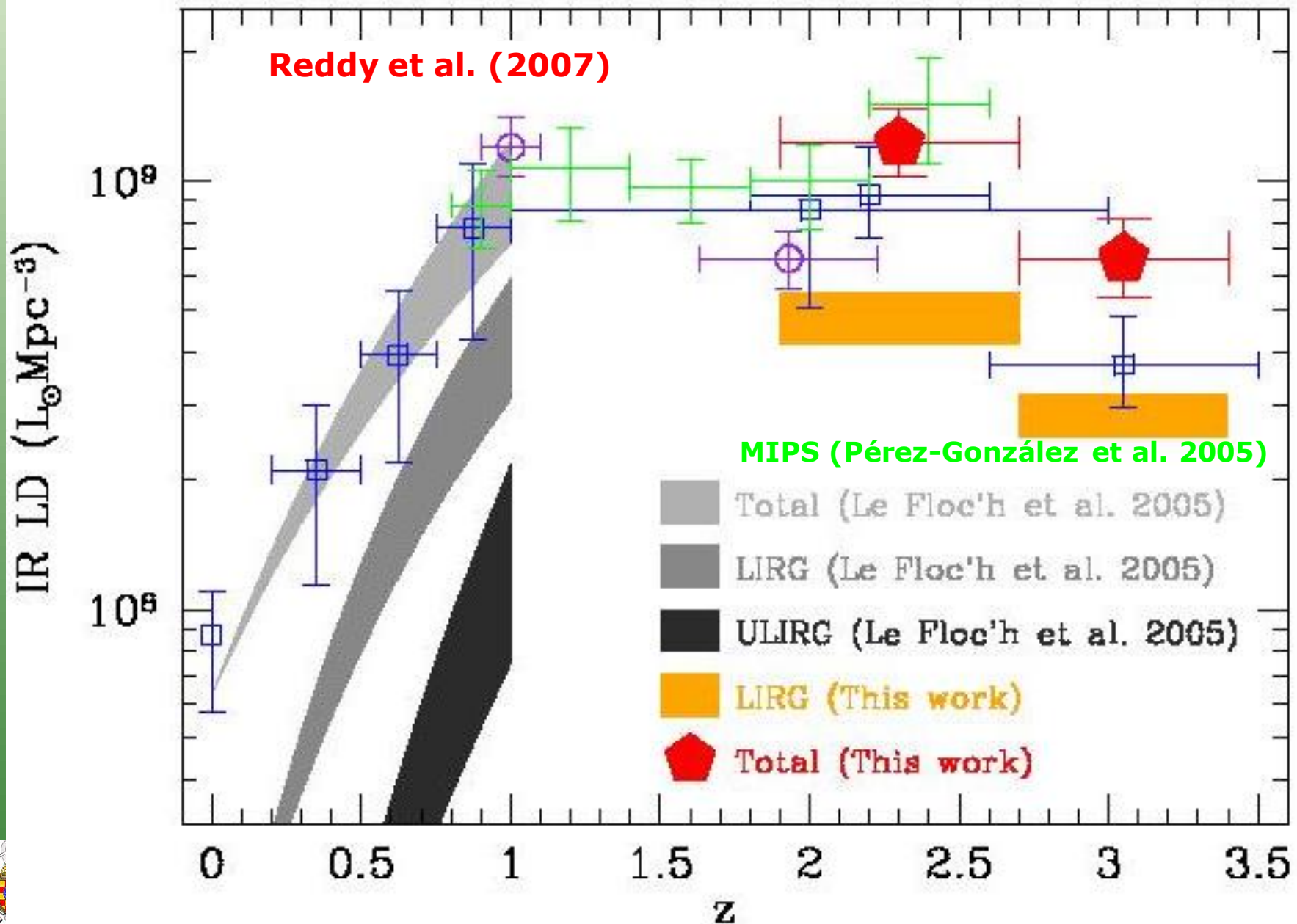


8.3. Evolución de galaxias

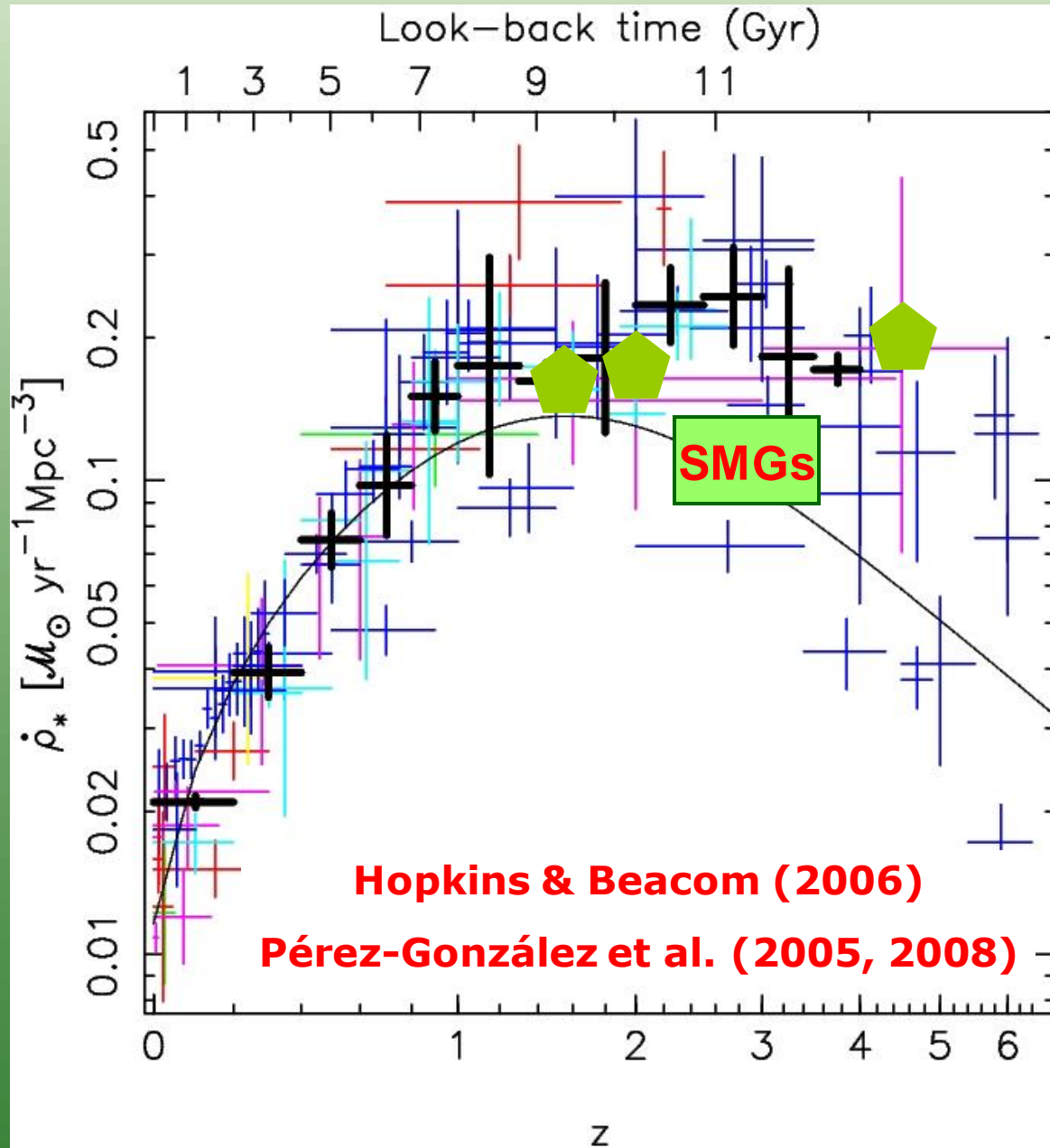
Tresse et al. (2007)



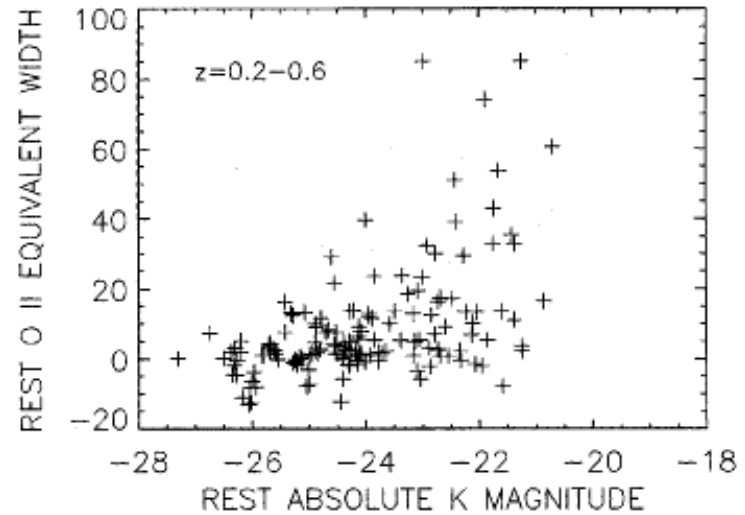
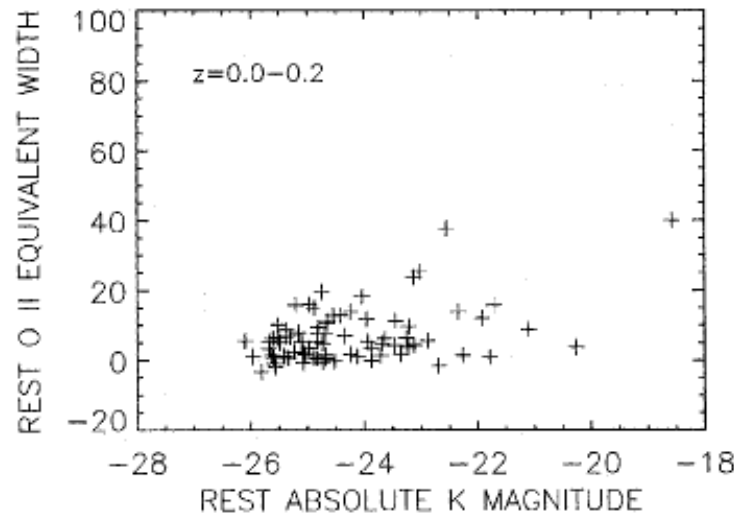
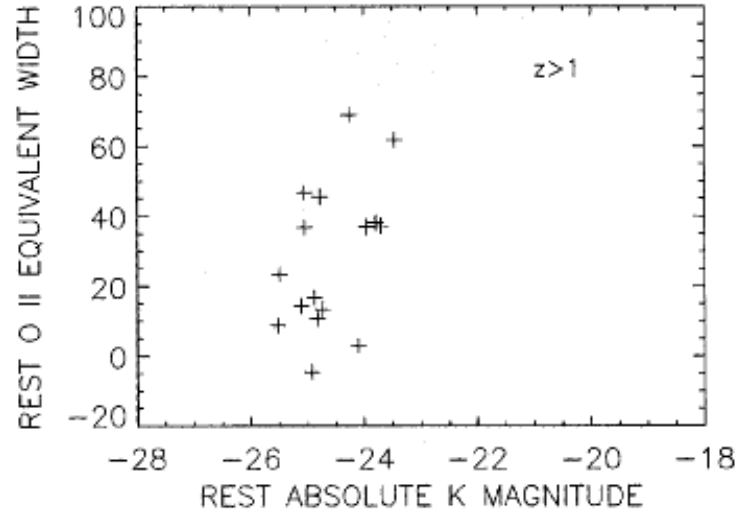
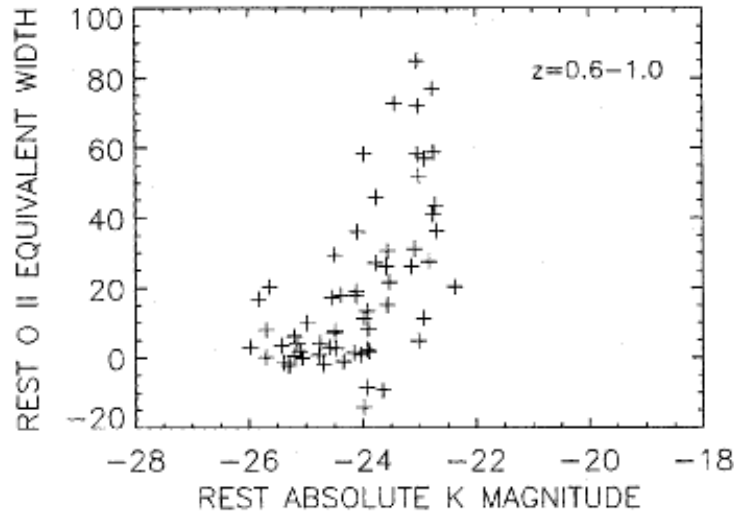
8.3. Evolución de galaxias



8.3. Evolución de galaxias



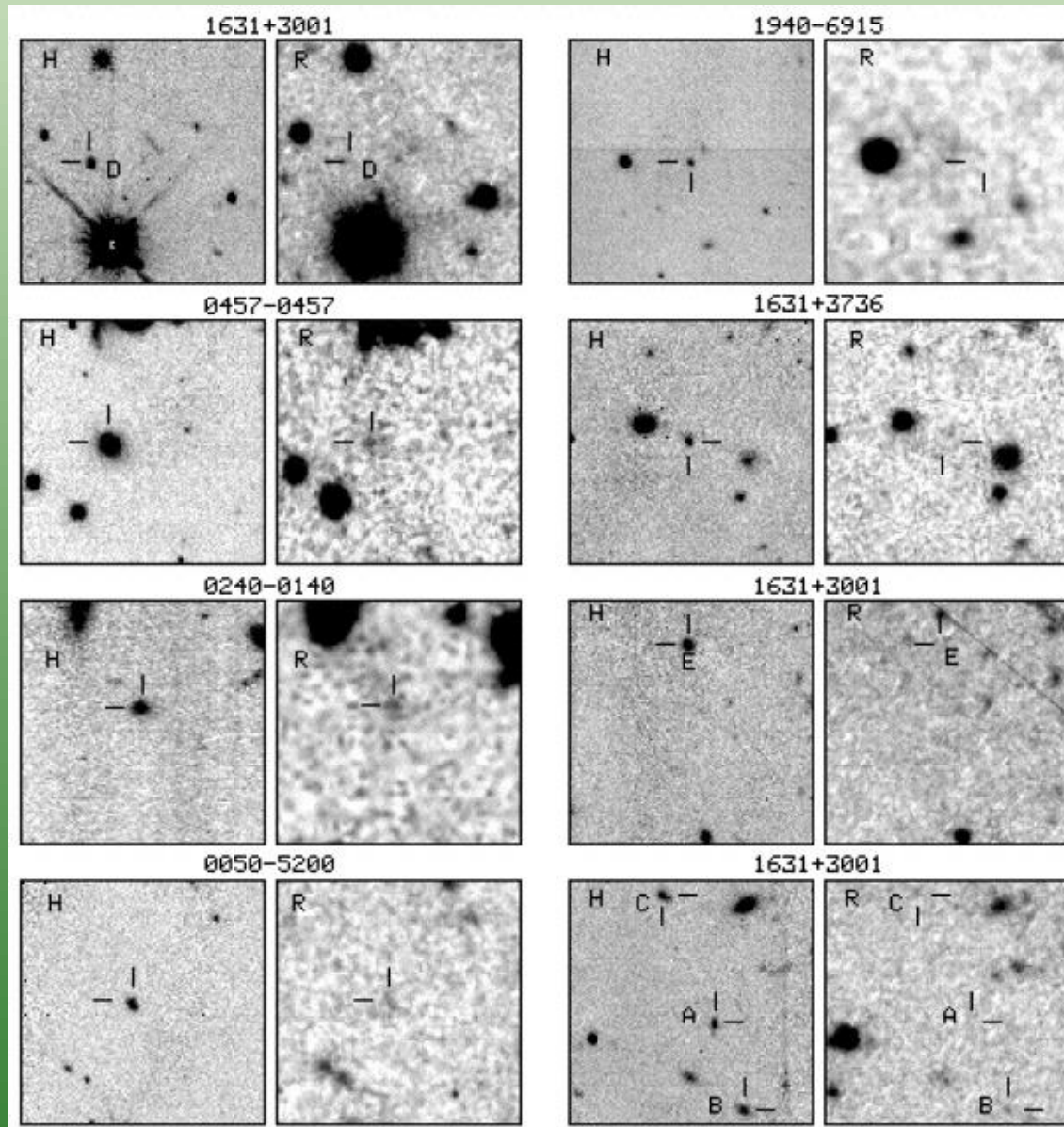
8.3. Evolución de galaxias



Cowie et al. (1996)



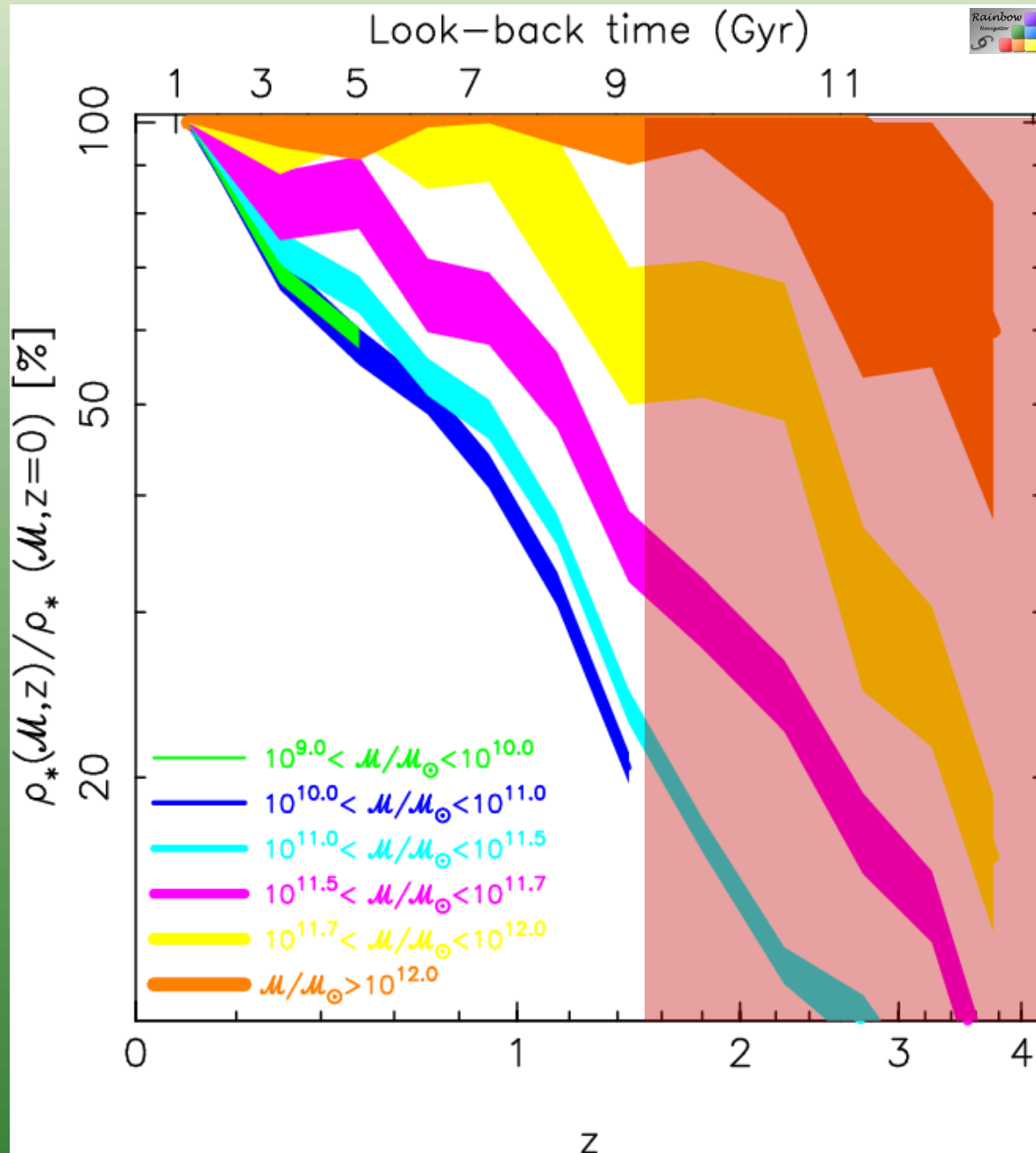
8.3. Evolución de galaxias



Yan et al. (2000)
Franx et al. (2003)
Daddi et al. (2004)



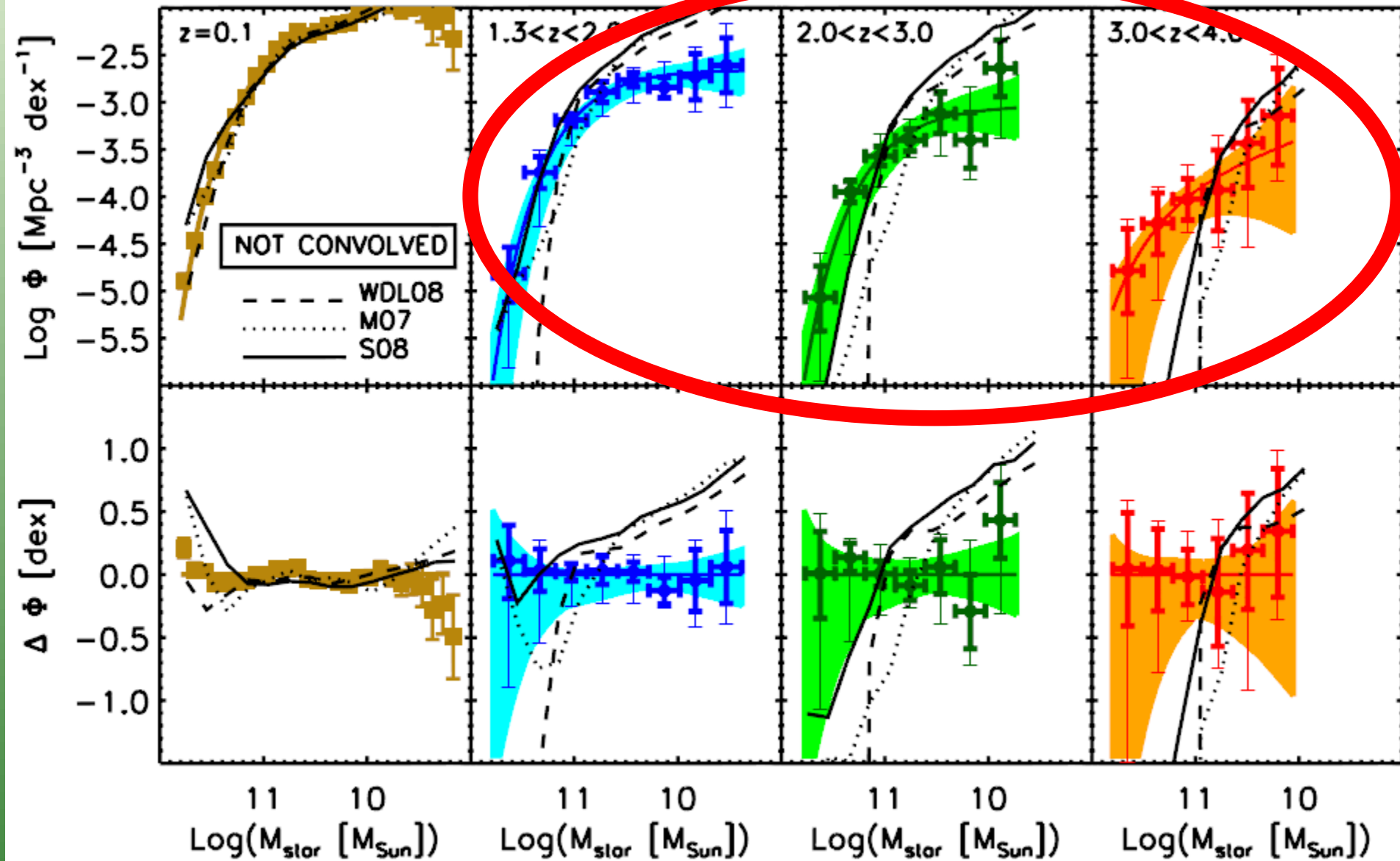
8.3. Evolución de galaxias



Adapted from
Pérez-González et al. (2008a)



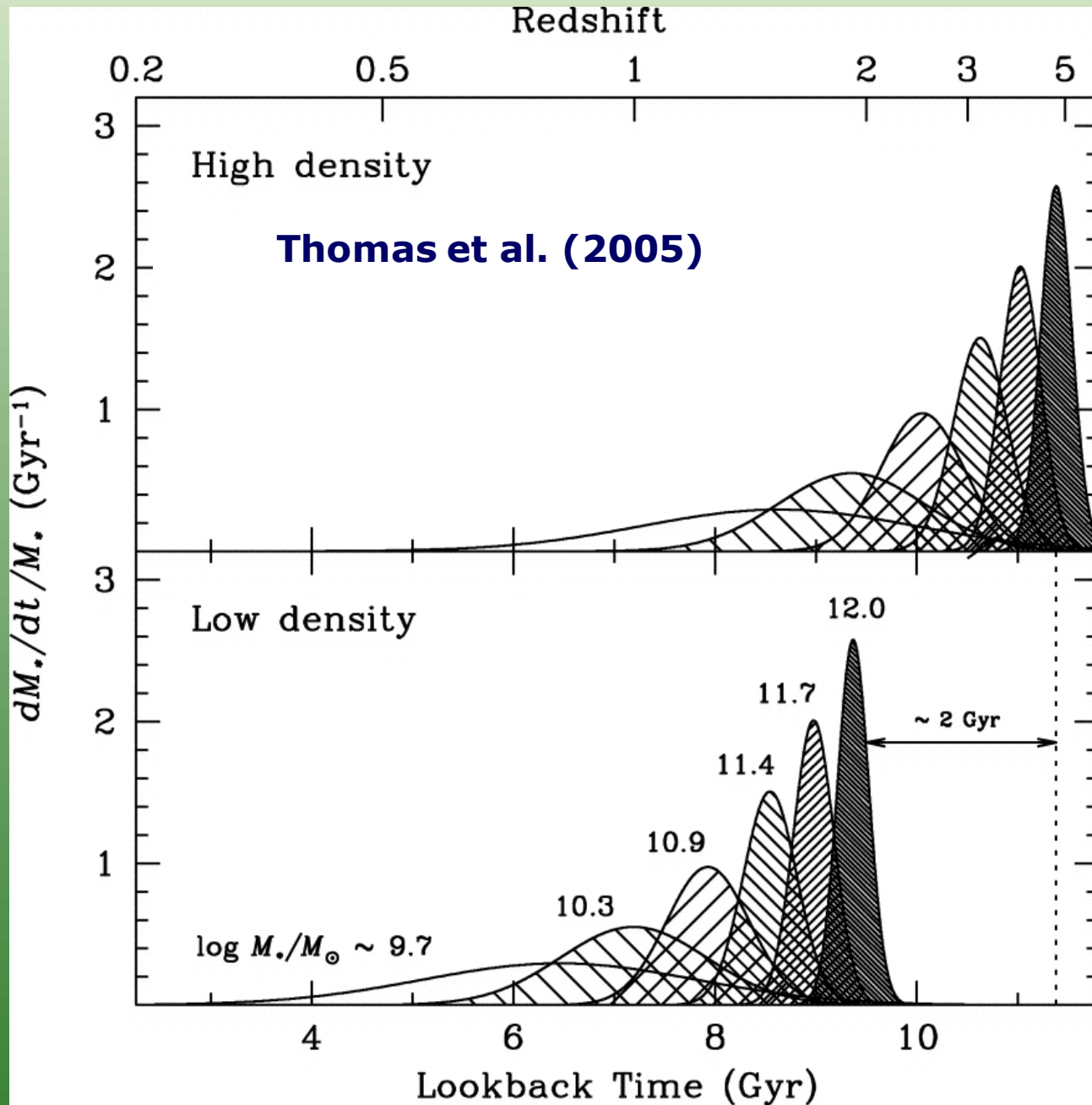
8.3. Evolución de galaxias



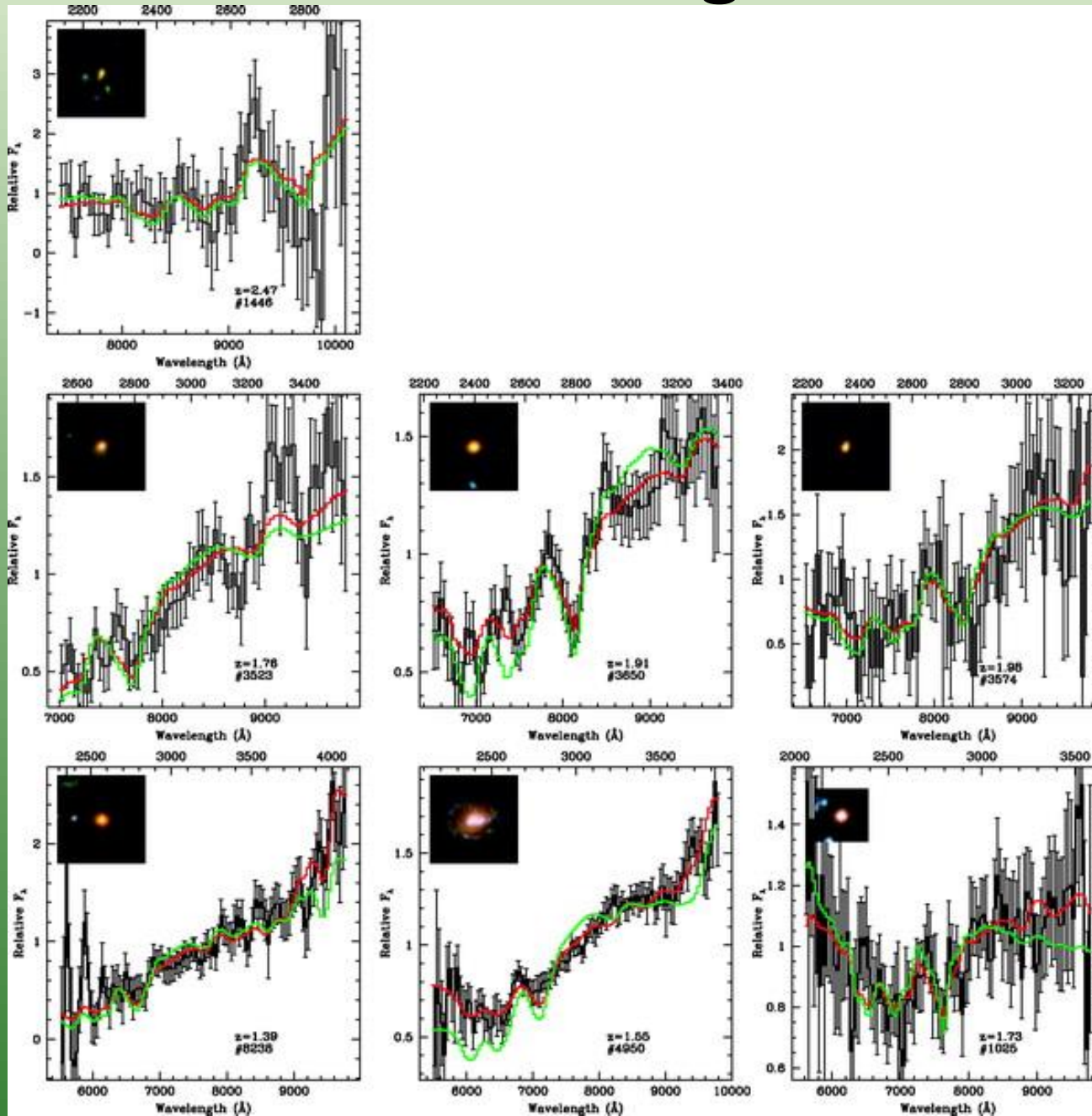
Marchesini et al. (2009)



8.3. Evolución de galaxias



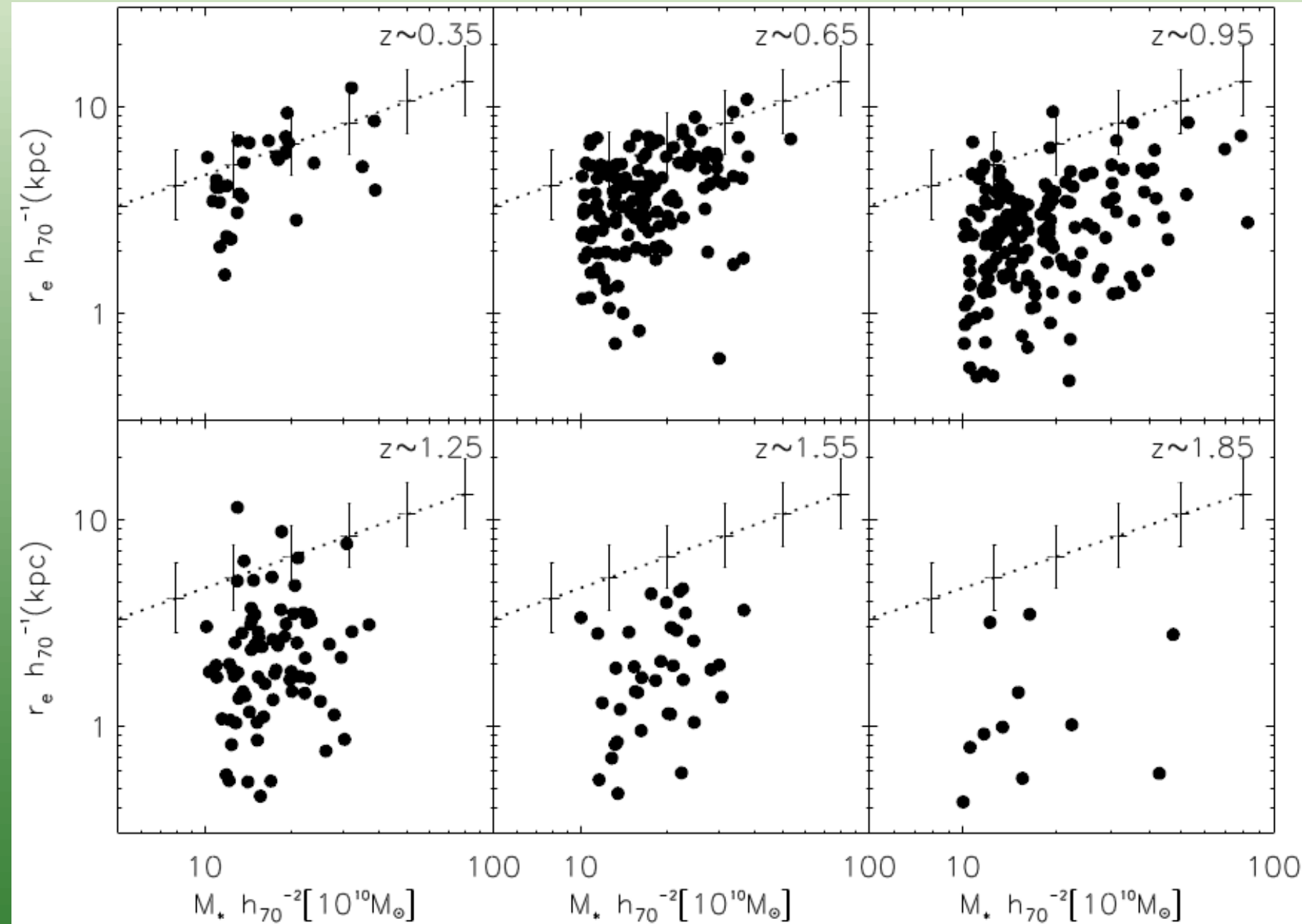
8.3. Evolución de galaxias



Daddi et al. (2005)



8.3. Evolución de galaxias



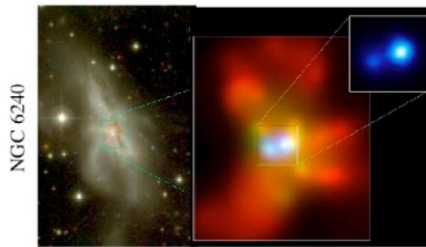
8.3. Evolución de galaxias

(c) Interaction/“Merger”



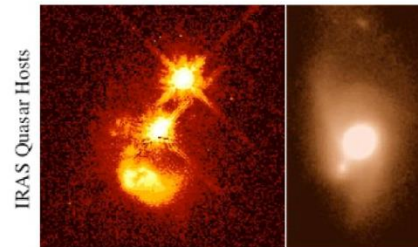
- now within one halo, galaxies interact & lose angular momentum
- SFR starts to increase
- stellar winds dominate feedback
- rarely excite QSOs (only special orbits)

(d) Coalescence/(U)LIRG



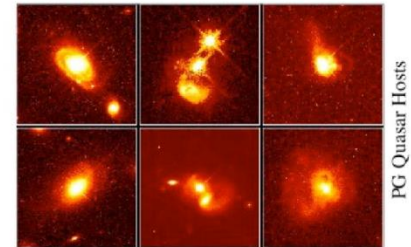
- galaxies coalesce: violent relaxation in core
- gas inflows to center: starburst & buried (X-ray) AGN
- starburst dominates luminosity/feedback, but, total stellar mass formed is small

(e) “Blowout”



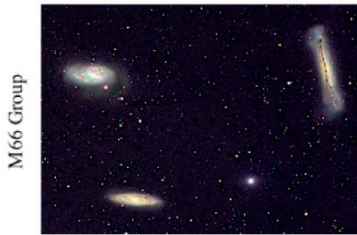
- BH grows rapidly: briefly dominates luminosity/feedback
- remaining dust/gas expelled
- get reddened (but not Type II) QSO: recent/ongoing SF in host
- high Eddington ratios
- merger signatures still visible

(f) Quasar



- dust removed: now a “traditional” QSO
- host morphology difficult to observe: tidal features fade rapidly
- characteristically blue/young spheroid

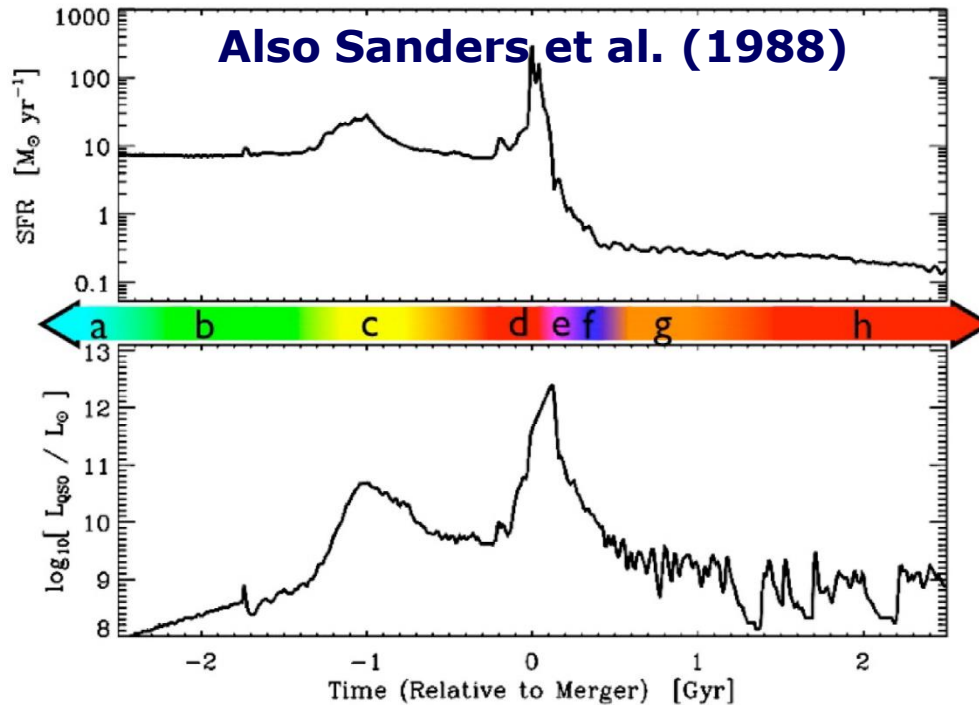
(b) “Small Group”



- halo accretes similar-mass companion(s)
- can occur over a wide mass range
- M_{halo} still similar to before: dynamical friction merges the subhalos efficiently

Hopkins et al. (2008)

Also Sanders et al. (1988)



(g) Decay/K+A



- QSO luminosity fades rapidly
- tidal features visible only with very deep observations
- remnant reddens rapidly (E+A/K+A)
- “hot halo” from feedback
- sets up quasi-static cooling

(a) Isolated Disk



- halo & disk grow, most stars formed
- secular growth builds bars & pseudobulges
- “Seyfert” fueling (AGN with $M_{\text{B}} > -23$)
- cannot redden to the red sequence

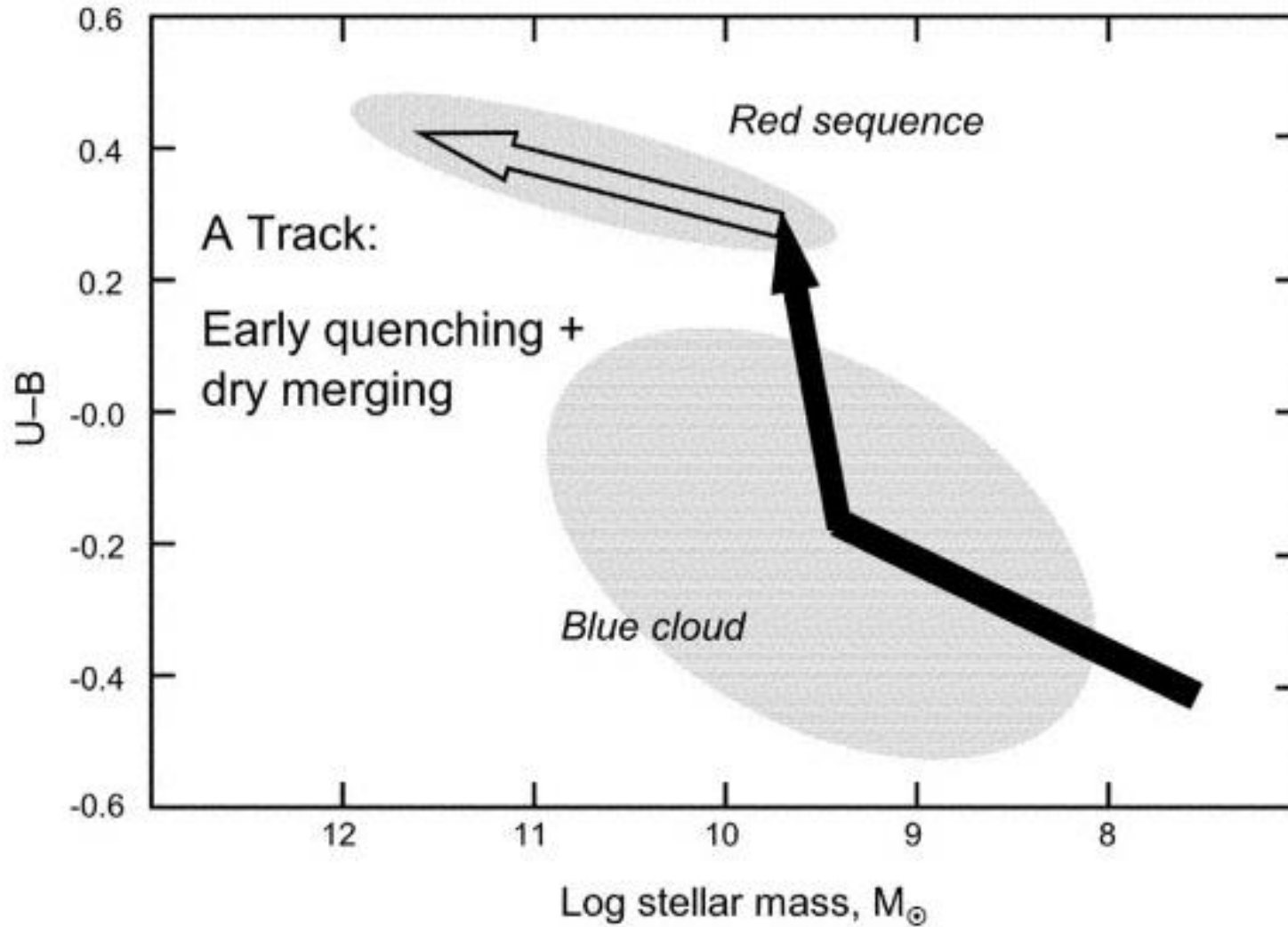
(h) “Dead” Elliptical



- star formation terminated
- large BH/spheroid - efficient feedback
- halo grows to “large group” scales: mergers become inefficient
- growth by “dry” mergers



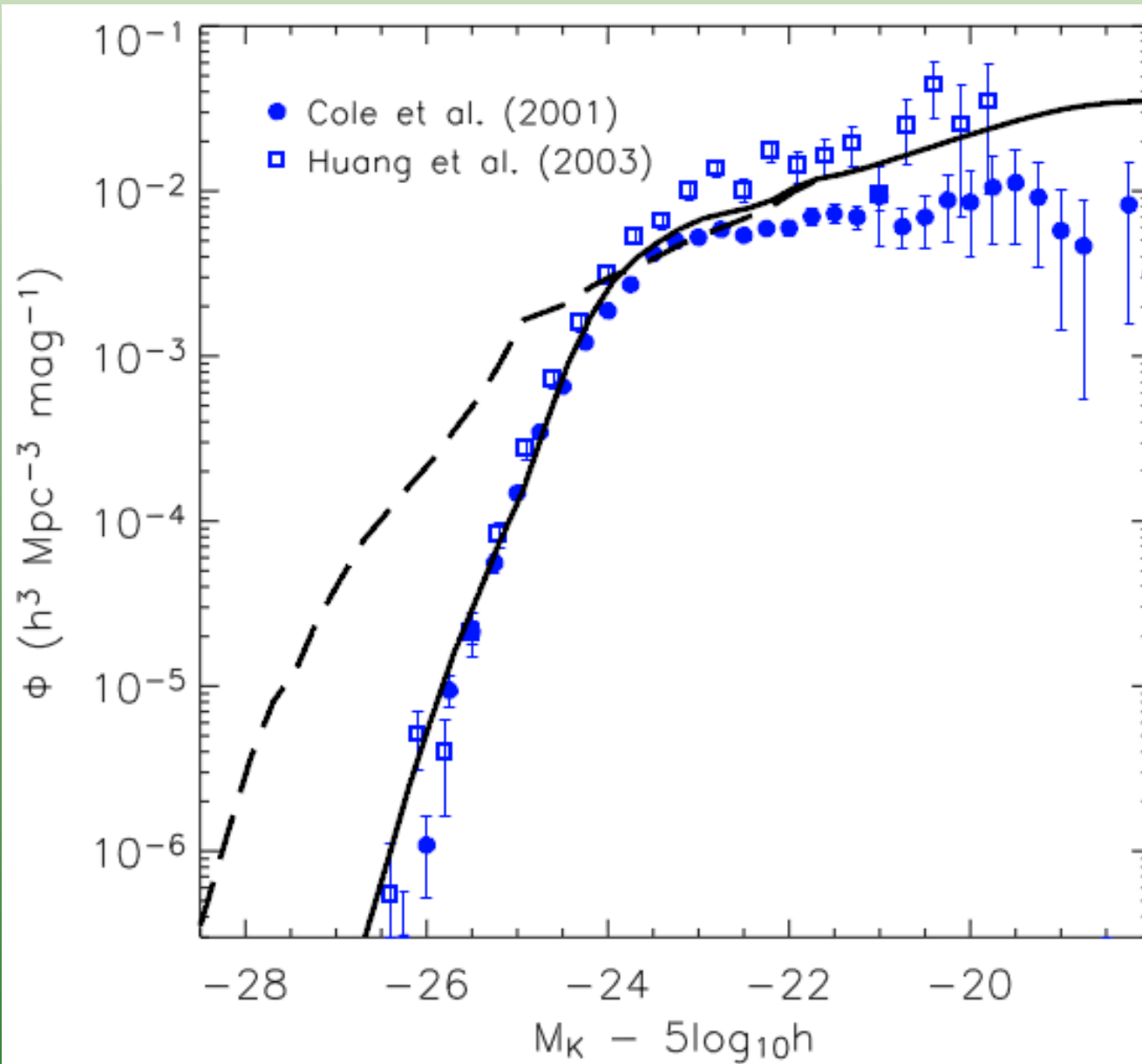
8.3. Evolución de galaxias



Faber et al. (2007)



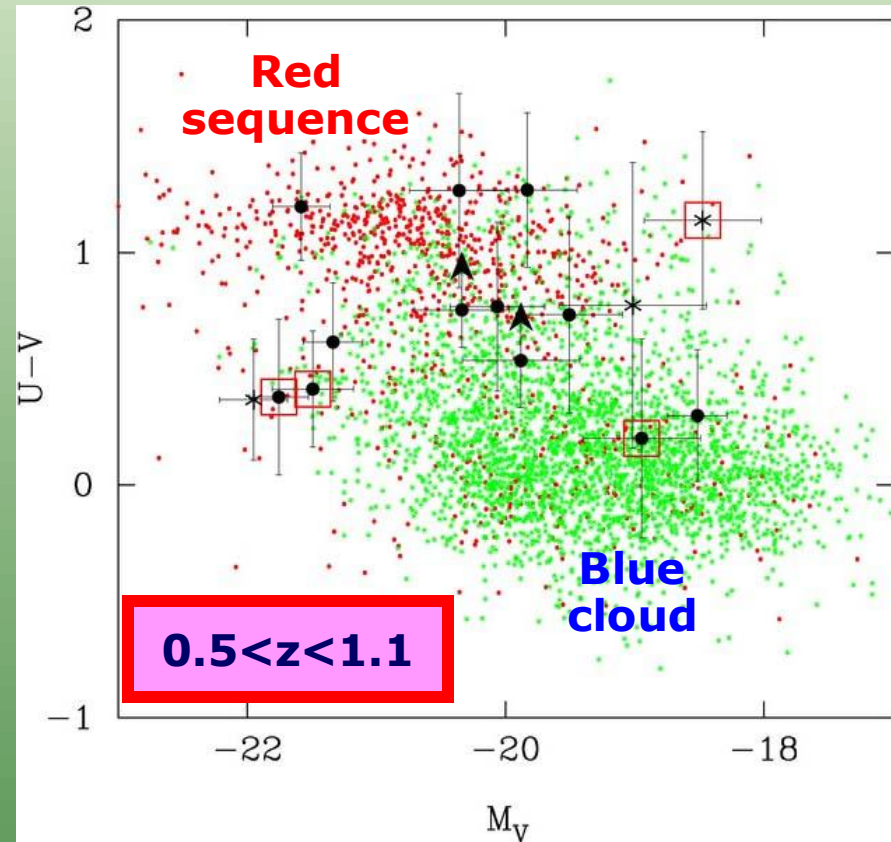
8.3. Evolución de galaxias



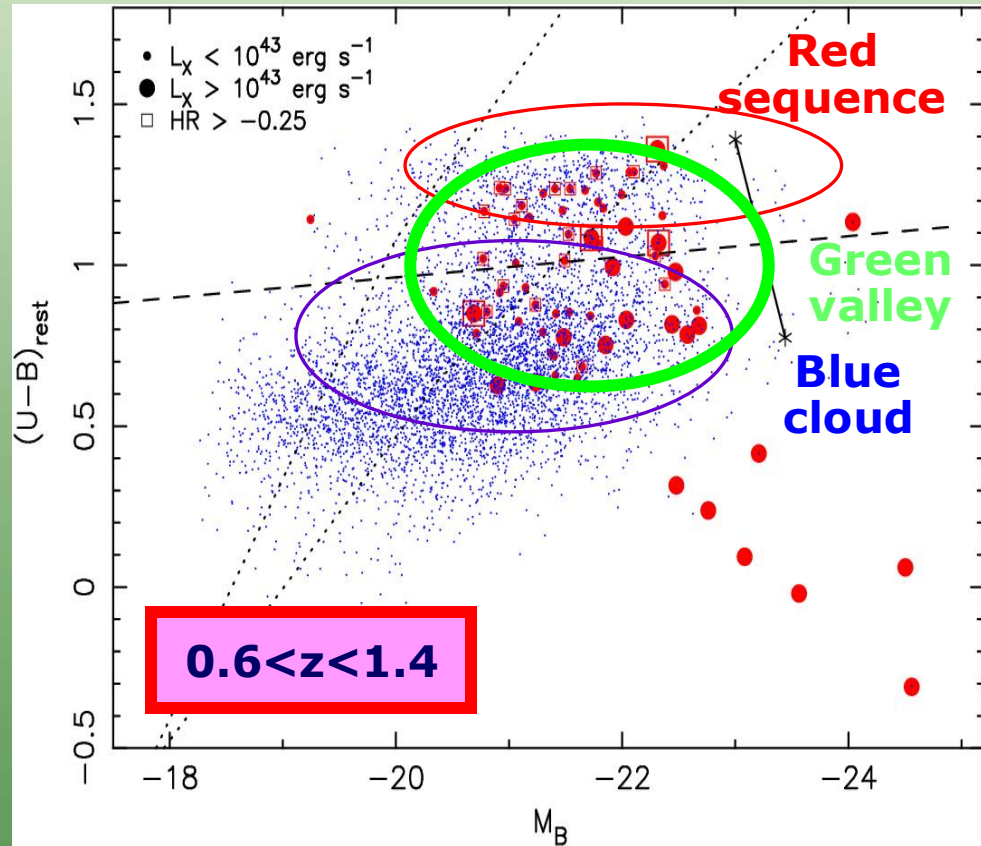
Croton et al. (2006)



8.3. Evolución de galaxias



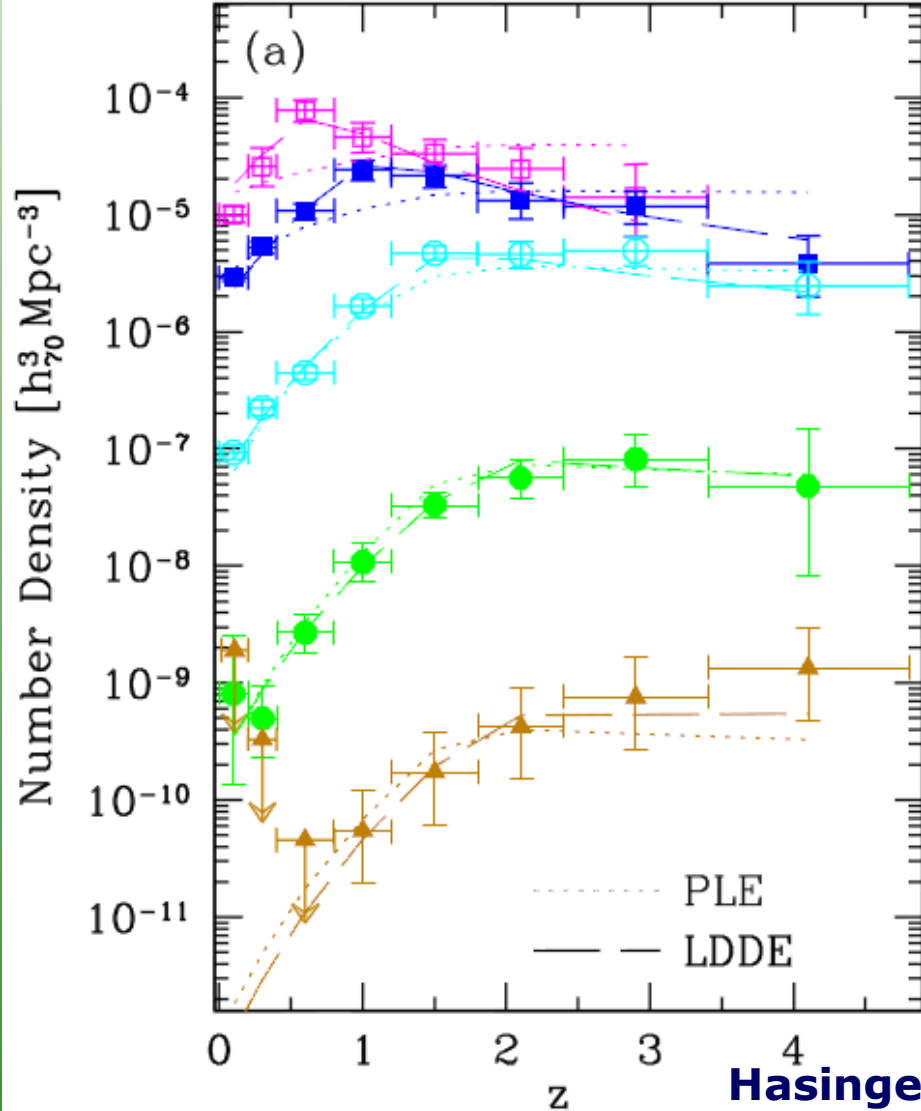
Sánchez et al. (2004)



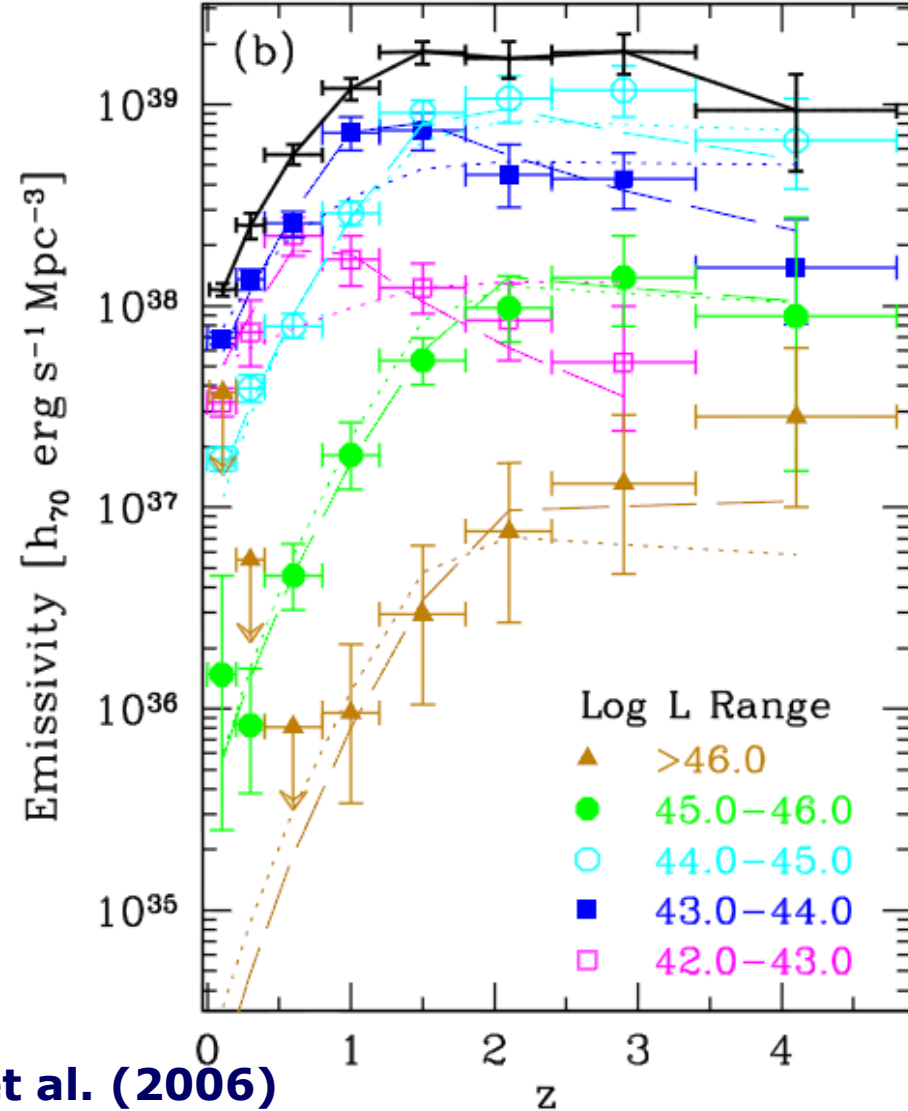
Nandra et al. (2007)



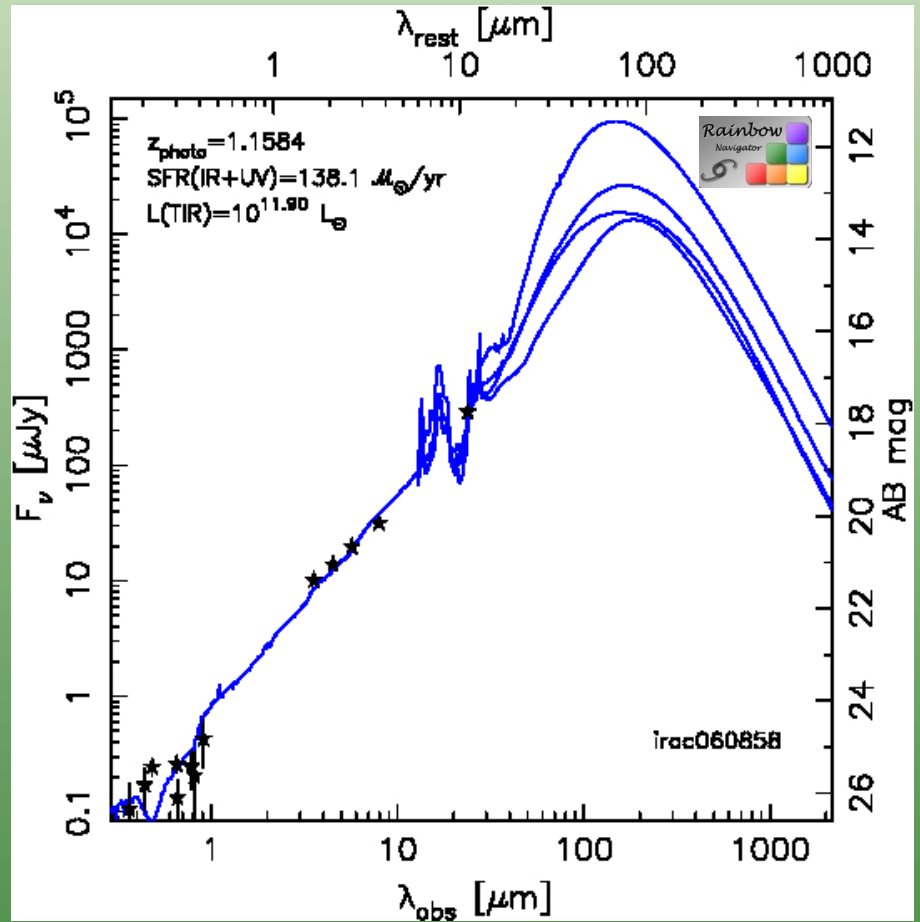
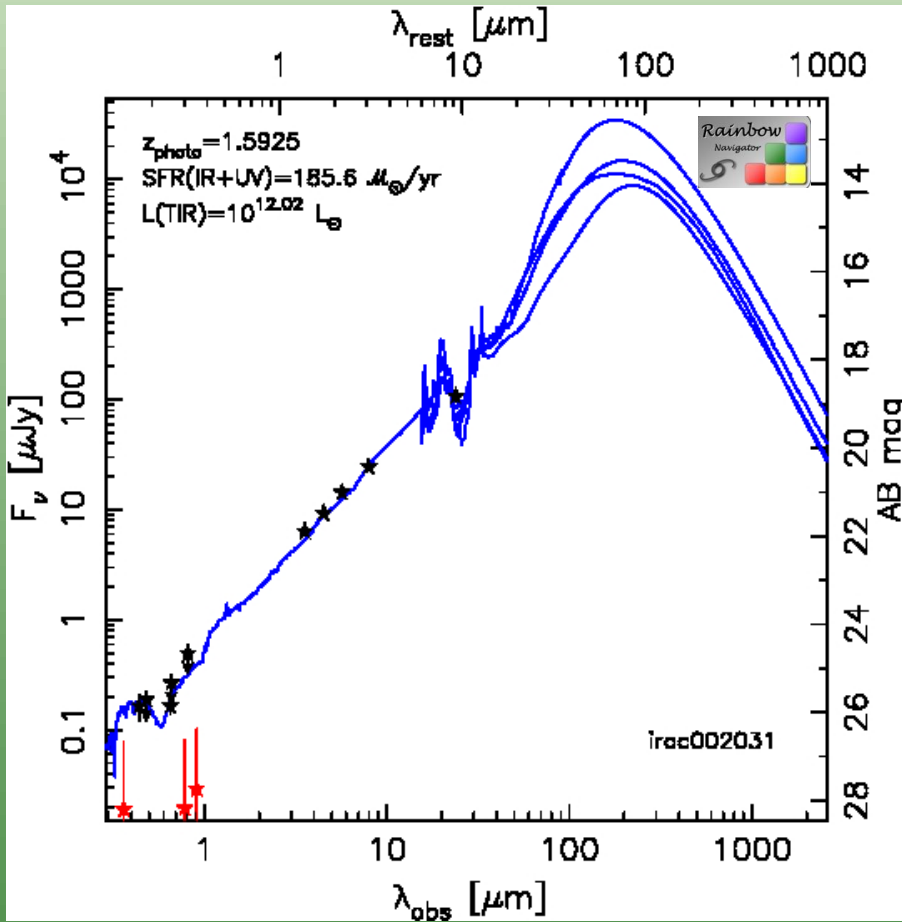
8.3. Evolución de galaxias



Hasinger et al. (2006)



8.3. Evolución de galaxias

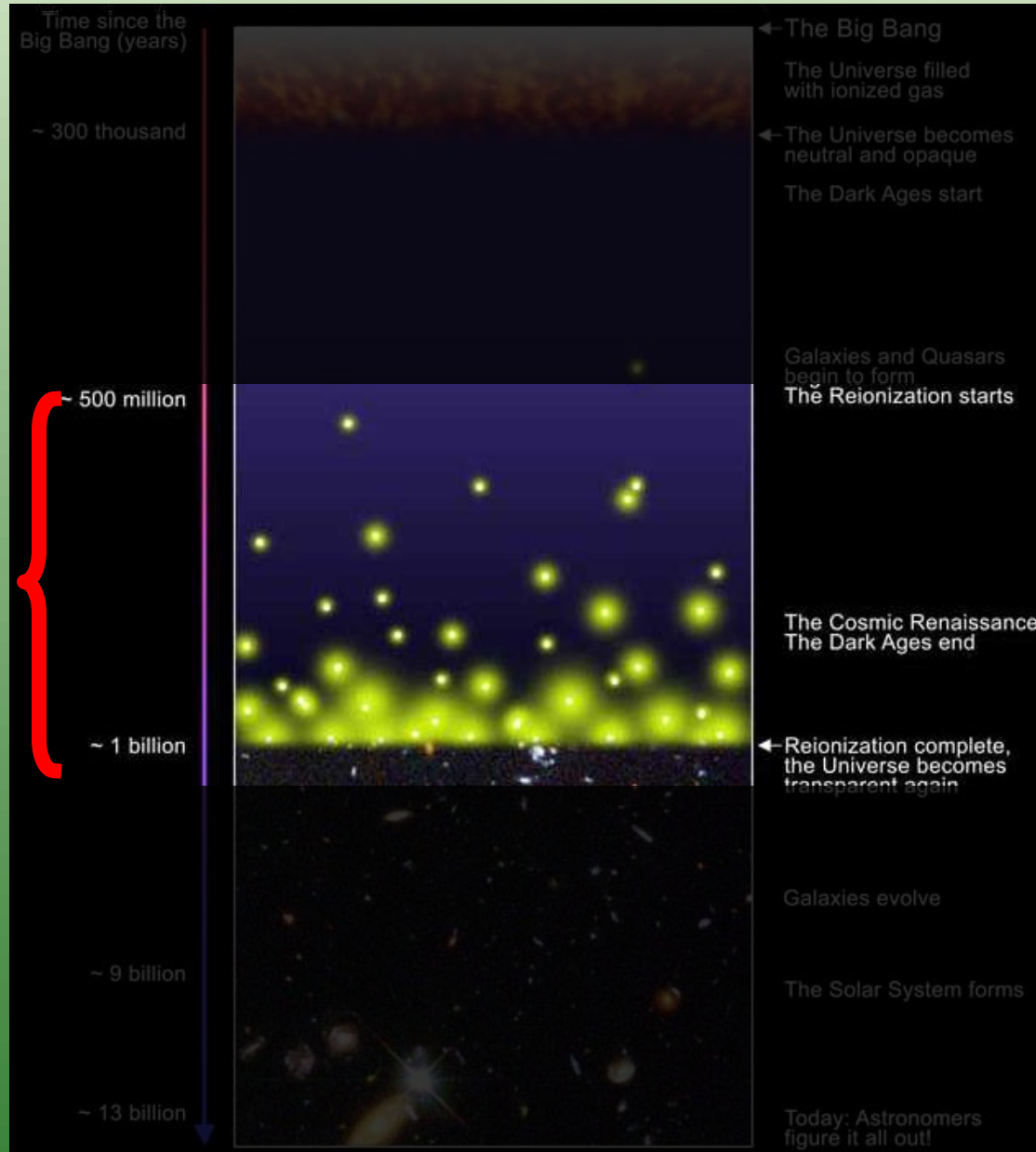


PLGs: Alonso-Herrero et al. (2006)

Donley et al. (200*)



8.3.Evolución de galaxias

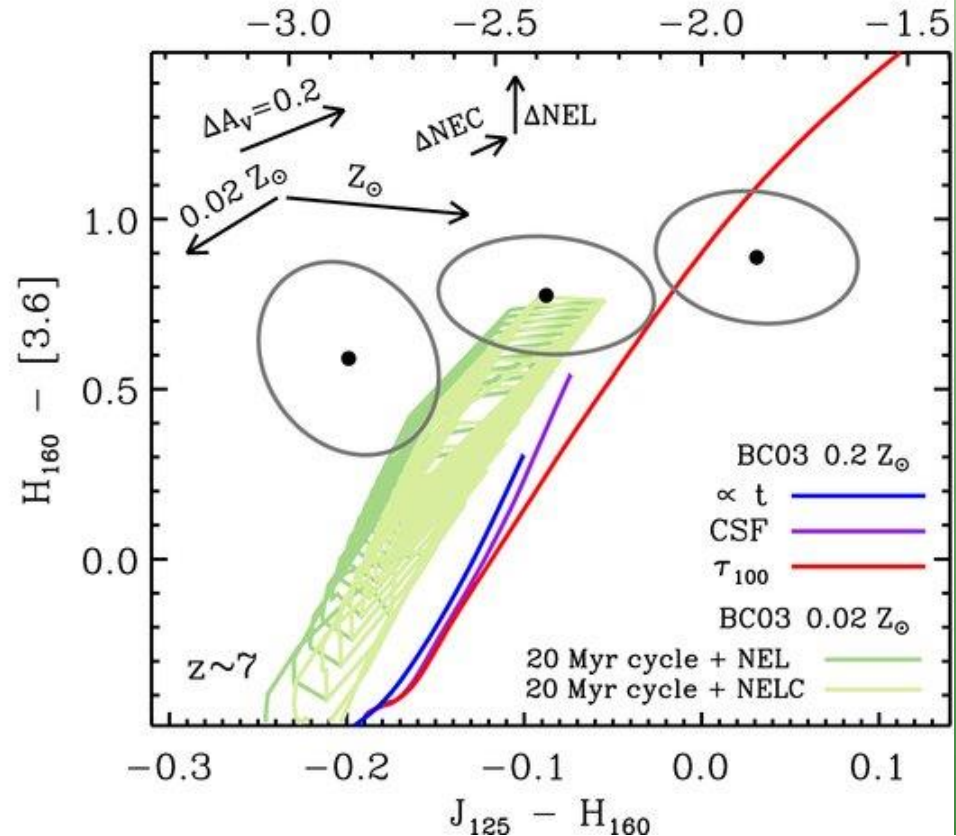
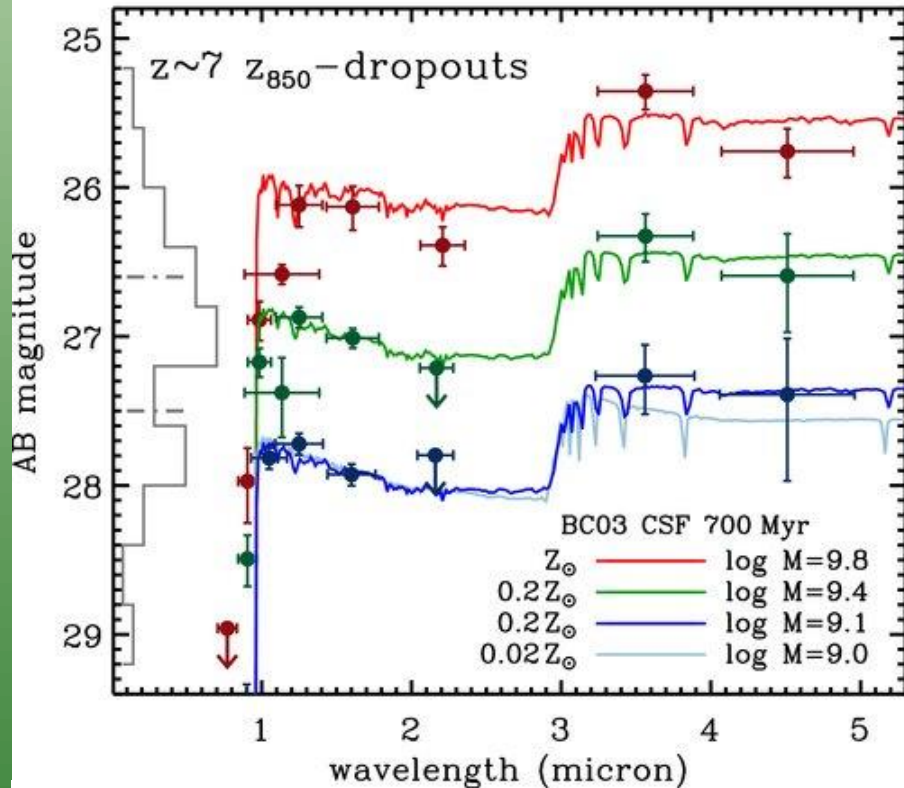
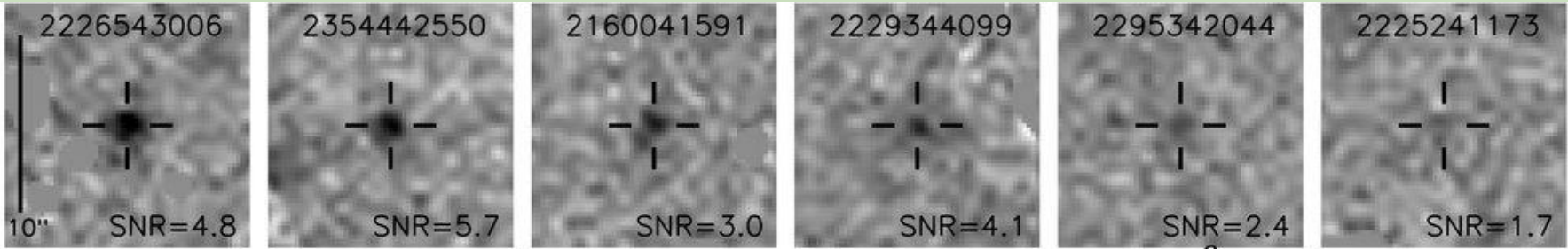


$z < ?$

$z > 5$

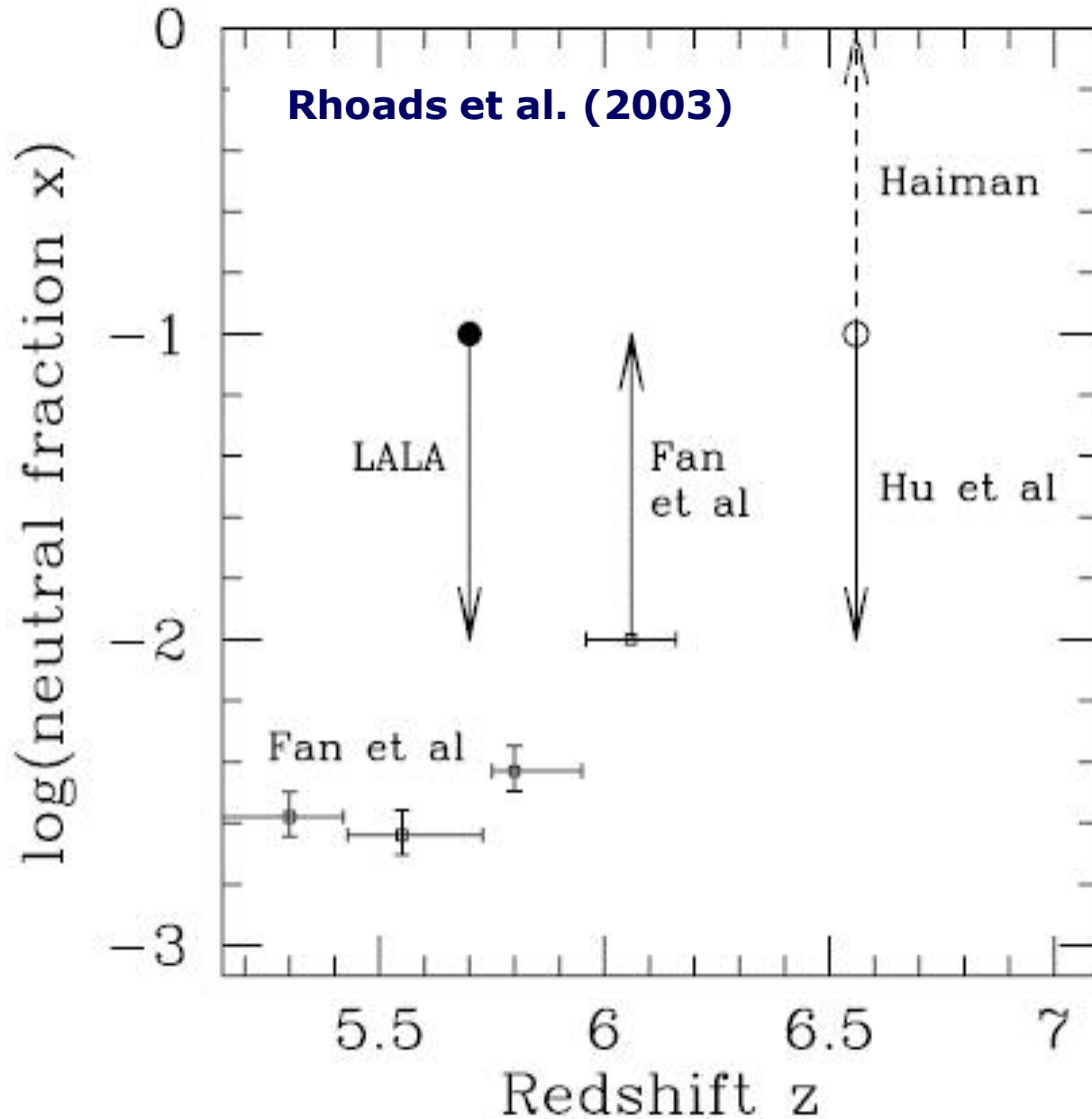


8.3. Evolución de galaxias



Labbé+ (2006, 2010ab), Bouwens+ (2010ab), Bunker+ (2010), Finkelstein+ (2010), Oesch+ (2010ab), Ouchi+ (2009), SEDS, CANDELS, SHARDS

8.3. Evolución de galaxias



Resumen

- **¿Cómo se seleccionan y estudian galaxias a $z > 0$? Principales tipos de galaxias (según selección). Efectos de selección.**
- **Modelos jerárquicos.**
- **Evolución de parámetros cósmicos de la formación de galaxias.**
- **Problemas del paradigma actual: downsizing.**
- **Importancia de los AGN y relación entre actividad AGN y SF.**
- **Universo a muy alto z . Reionización.**
- **Otros temas: BAOs, red & dead galaxies a alto- z , rango de bajas luminosidades en LF,...**

