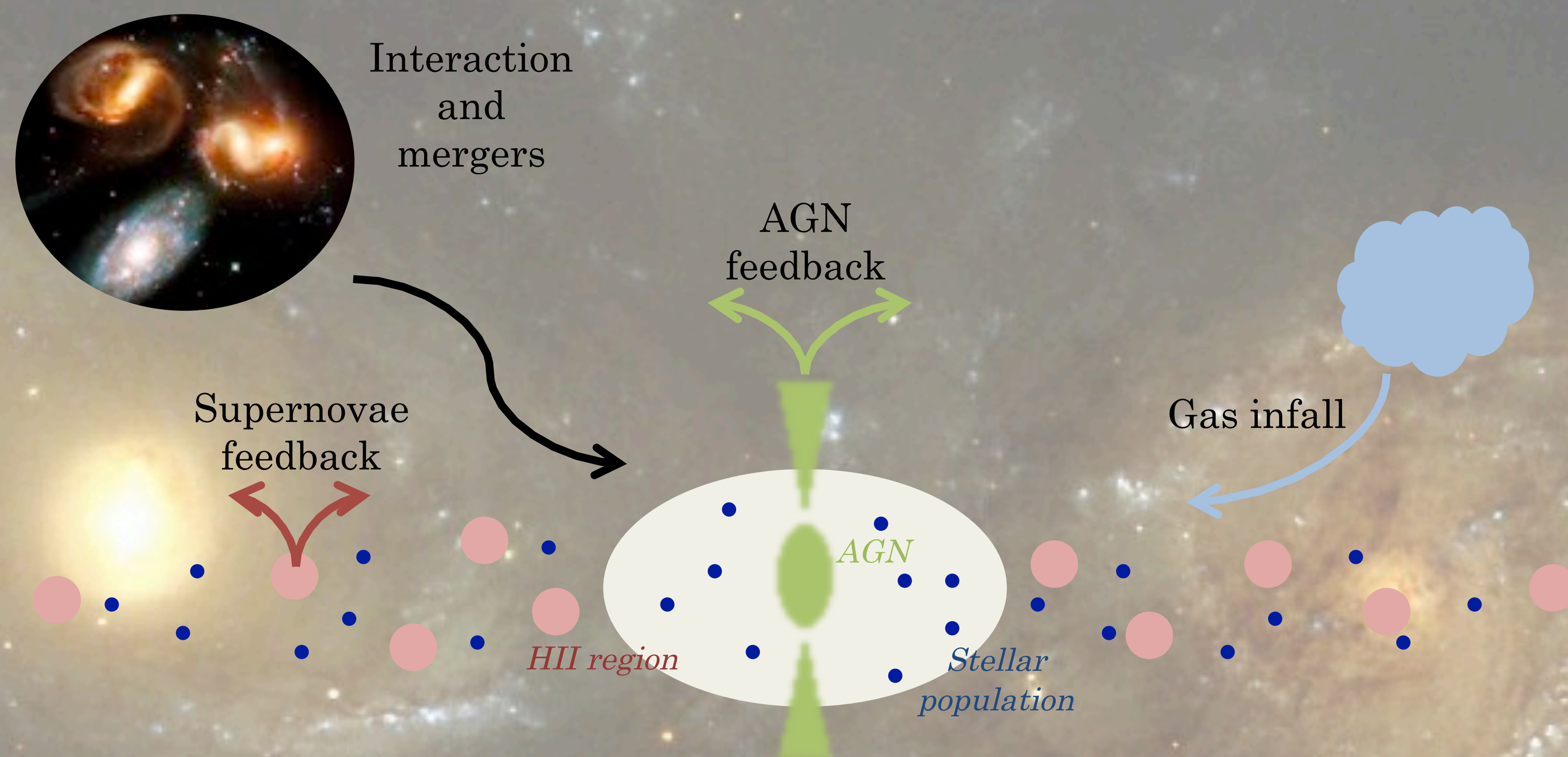
Evolution of the intermediate mass galaxies ISM



Observable quantities of the gas

Velocity field	Velocity dispersion	Radius	Density	SFR	Metallicity

M. Rodrigues,
F. Hammer, M. Puech, H. Flores, B. Rothberg

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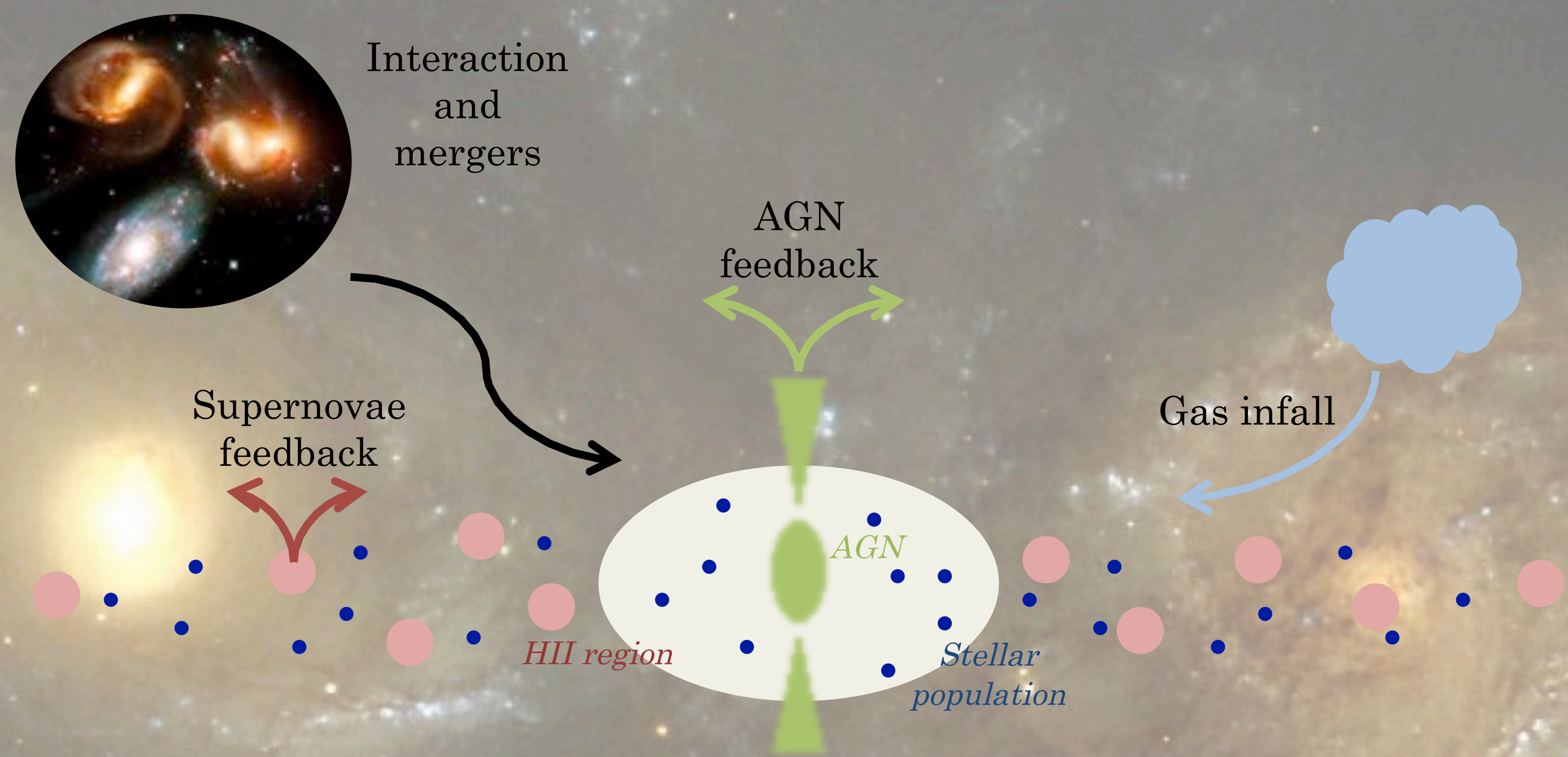

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Chemical evolution of the gas

Closed-box model

No interaction with the environment

- Constant total mass
- Metals enrichment of the gas
- Increase of the stellar mass

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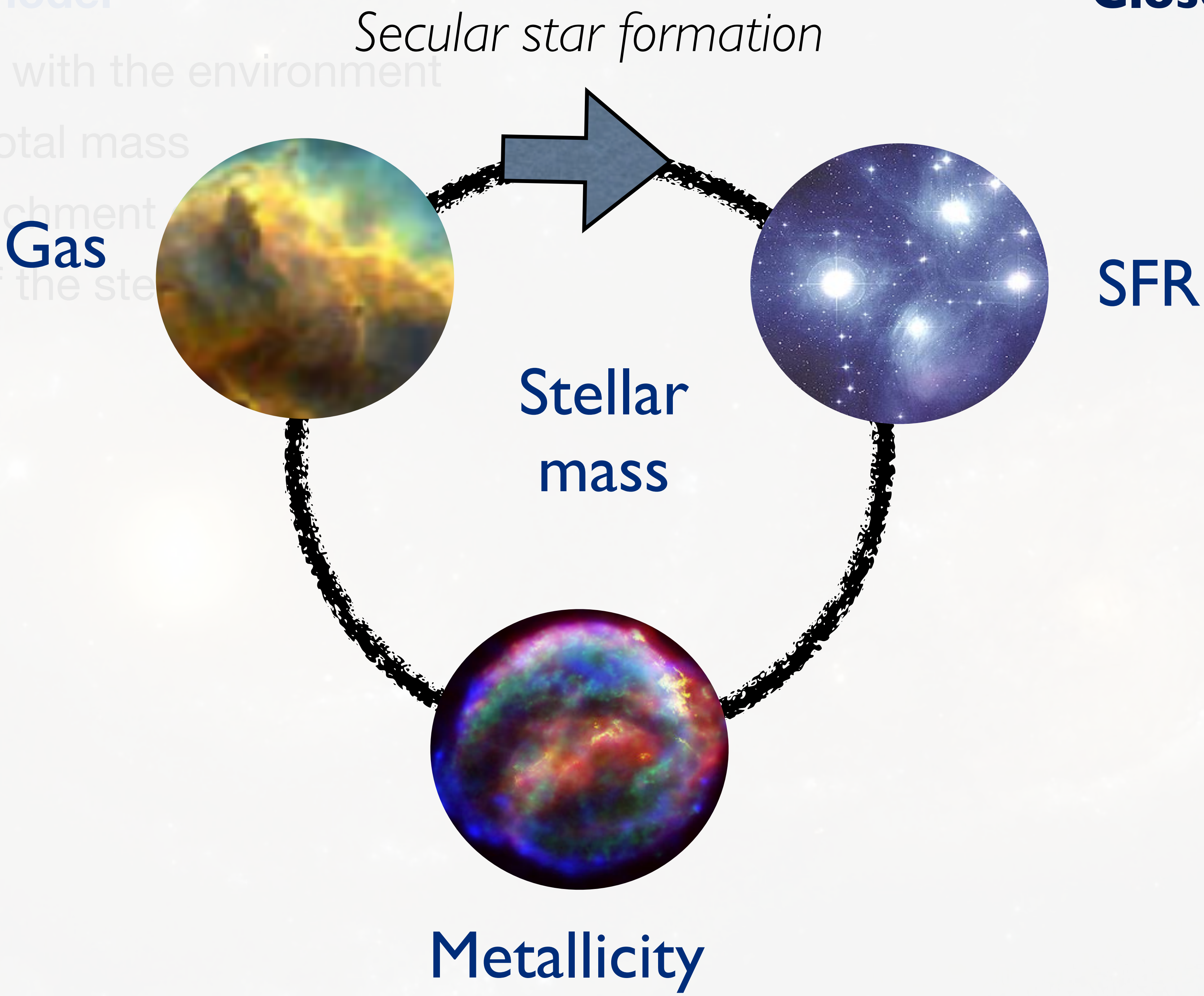

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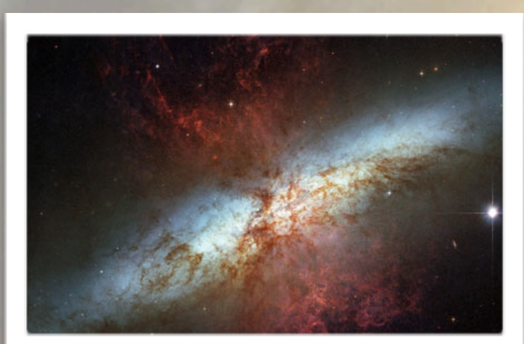
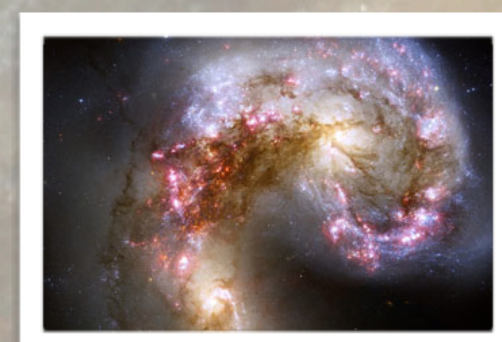
Opened-box model



Ejection of gas and metals

Ejection of gas by stellar winds

- Decrease the metal content
- Possible for low mass galaxies (Dacalton et al. 2007)



Infall of gas

Primordial gas or from mergers and interactions

- Increase of the mass
- Metals dilution if the gas is metal-poor

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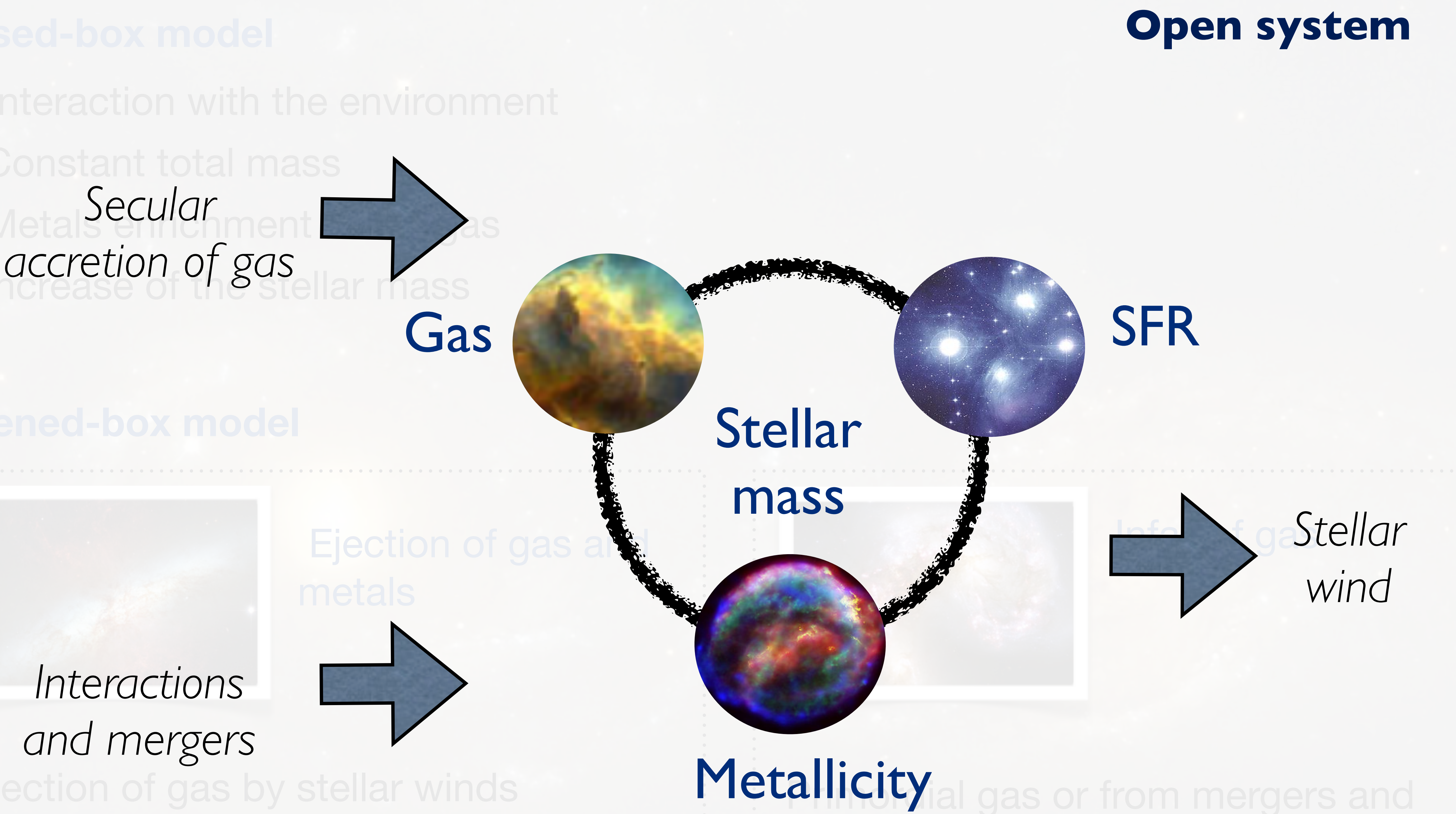

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Formation of local disks :

Quasi-adiabatic process VS Violent process

The main driver of their formation is still unknown

Star formation

Gas accretion

Major mergers

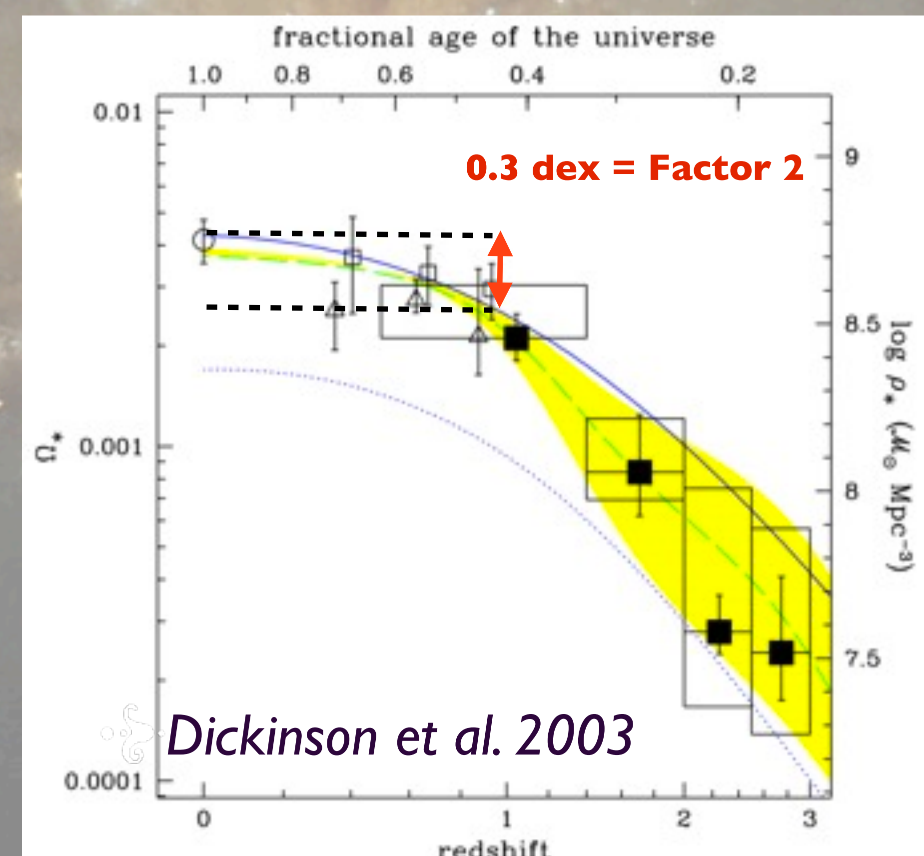
Feedback

Minor mergers

Intermediate mass galaxies at z~0.7

- Stellar mass double since z=1
  (Dickinson et al. 2003; Drory et al. 2004)
- Evolution associated to the intermediate mass galaxies $10<\log M_{stellaire}<11$
  (Hammer et al. 2005, Bell et al. 2005)

progenitor of local spirals



Large survey IMAGES

Intermediate MAss Galaxy Evolution Sequence

Sample selection
$M_J < -20.3$ & $0.4 < z < 0.9$
Chandra Deep Field South

→

Intermediate mass galaxies
$M_{stellar} > 1.5\ 10^{10} M$

Large survey IMAGES

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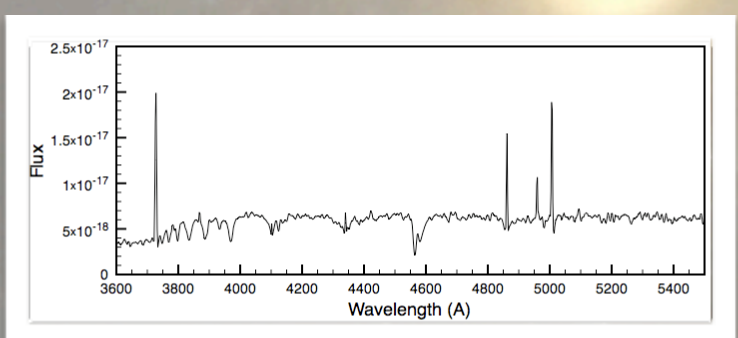
FORS2 (600RI+600z)
Spitzer
Galex



- SFR
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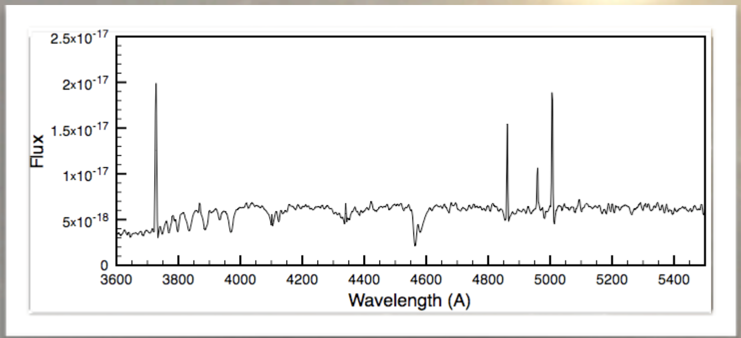

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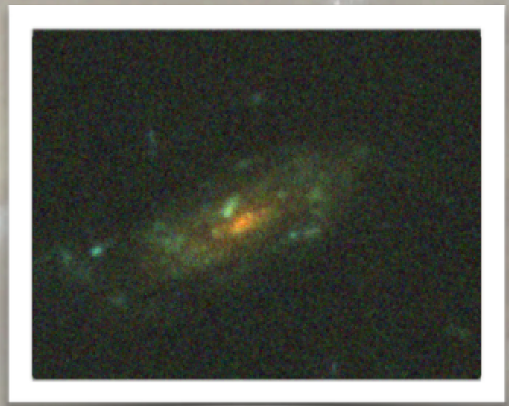
ACS/HST



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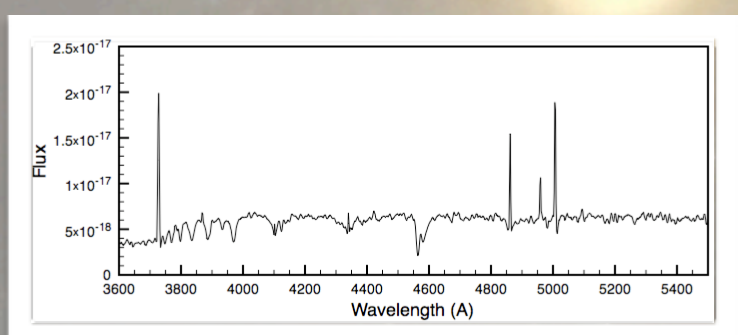

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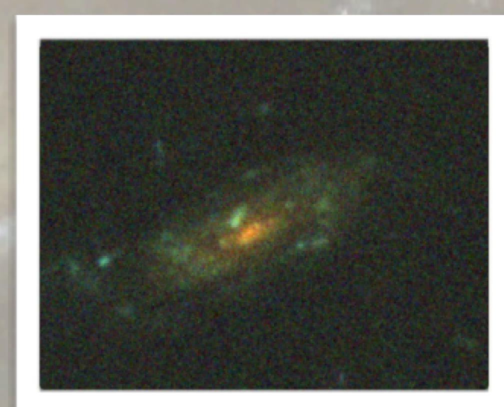

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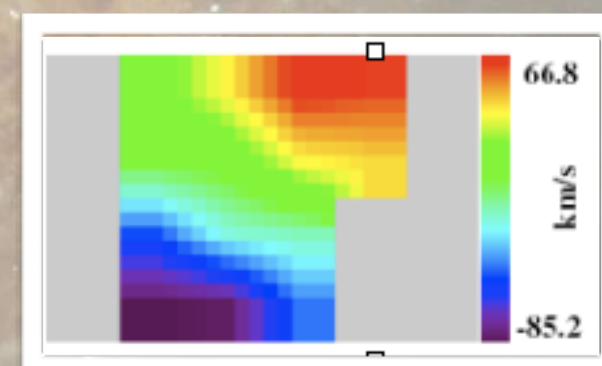
3D Spectroscopy

VLT/FLAMES-GIRAFFE



- Kinematics
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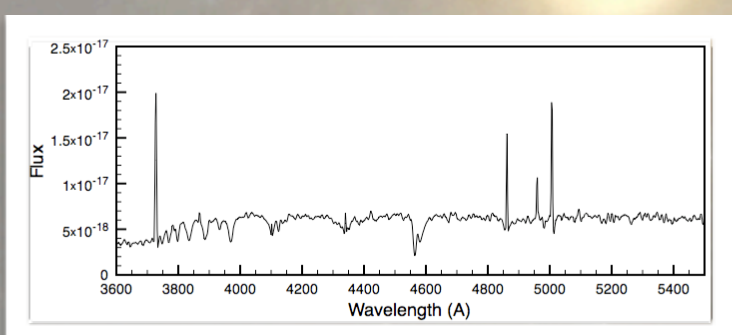

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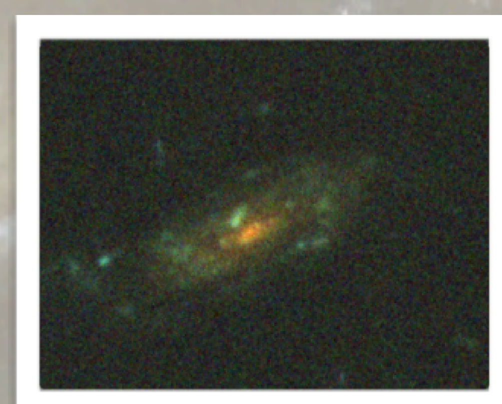

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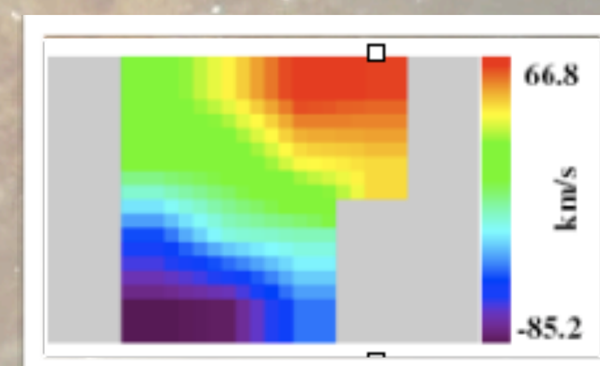

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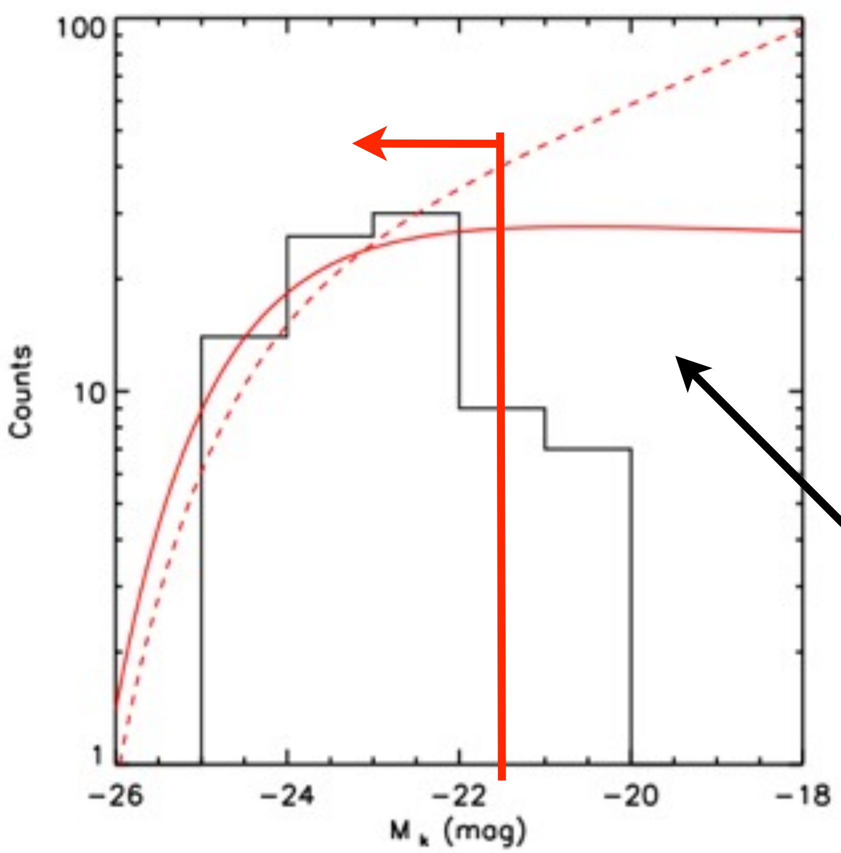

Principal sample of 63 galaxies:

- From the IMAGES/FORS2 sample
- Galaxies with star formation EW[OII]>15Å[OII]
- Emission lines [OII], Hb, [OIII]
- <z>~0.7 and <S/N>~11.5

Comparison with the luminosity function of Pozzetti et al. 2003

Complete sample for $M_{stellaire} > 10^{10}\ M_{\odot}$

- Metallicity
- SED

Measuring metals, gas fraction and SFR

Metallicity

- Subtraction of the stellar component

Fit by STARLIGHT (Cid fernandes et al. 2005) + 15 stellar templates *(Jacobi et al. 1984)*

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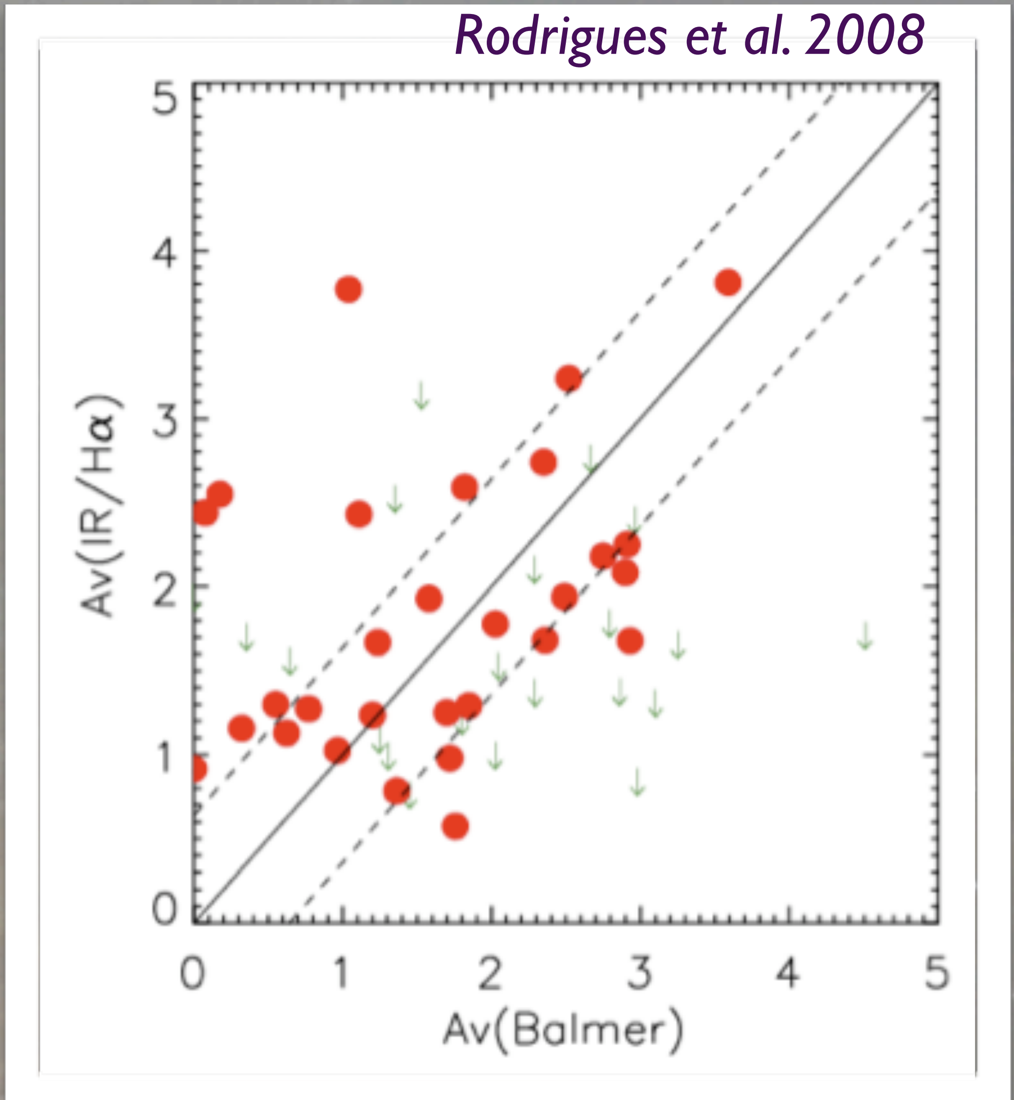

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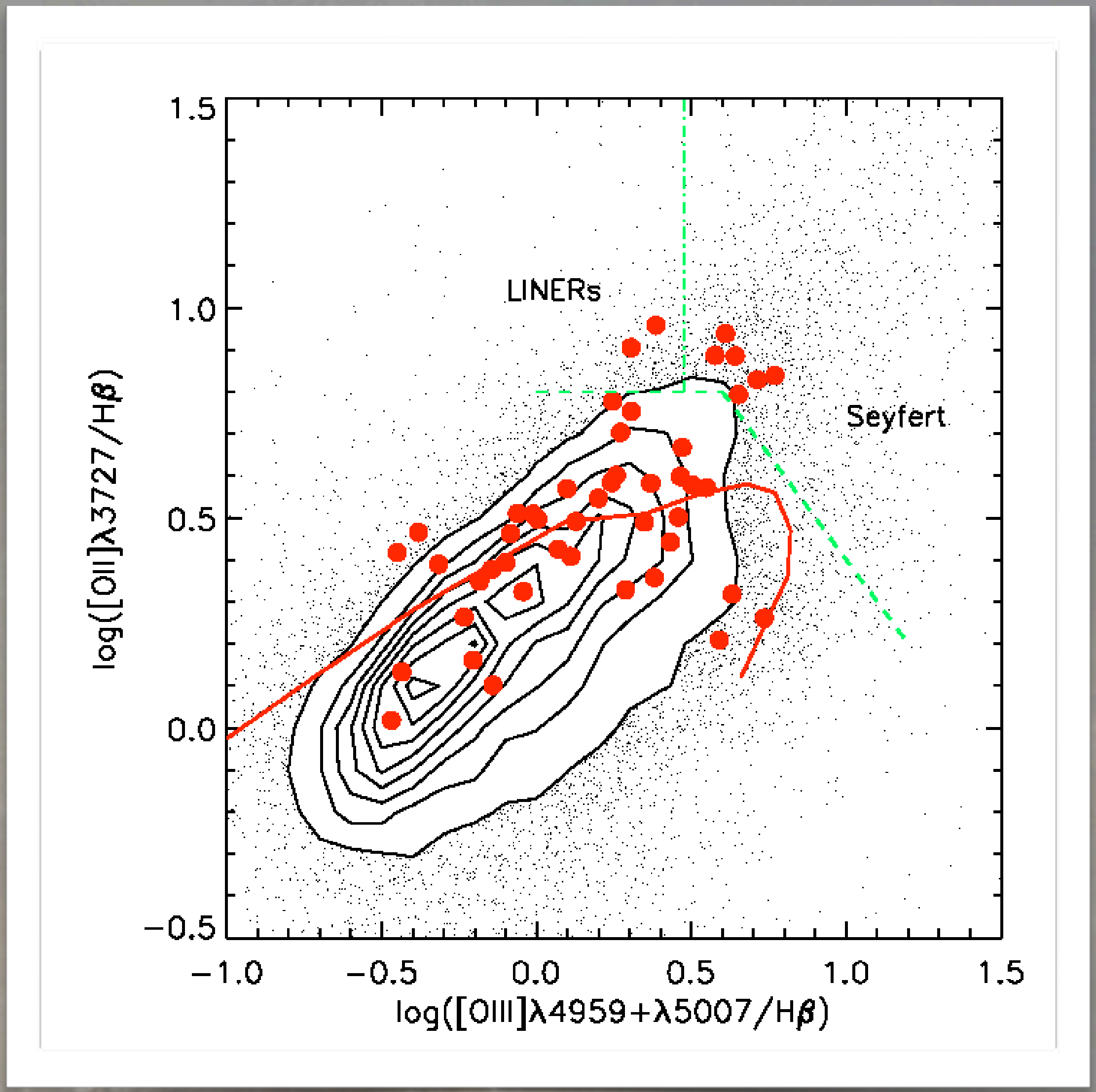

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SFR Star formation

- Calibration *Kennicutt 1998* + IMF of *Salpeter 1955*

Integrated SFR in past 100 Myr

- SFRUV from SED fitting
- SFRIR from 24μm flux *Chary & Elbaz 2001*
- SFRTotal = SFRUV + SFRIR

Instantaneous SFR (10 Myr)

- SFR Hα

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Gas fraction

- Inversion of the Schmidt-Kennicutt
- Assume that the K-S law doesn't evolve with z
- Already apply to distant galaxies *z~2 Erb et al. 2006, z~3 Mannucci et al. 2009, z=0.6 Puech*

Measuring metals, gas fraction and SFR

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  Fit by STARL
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alpeter

2001

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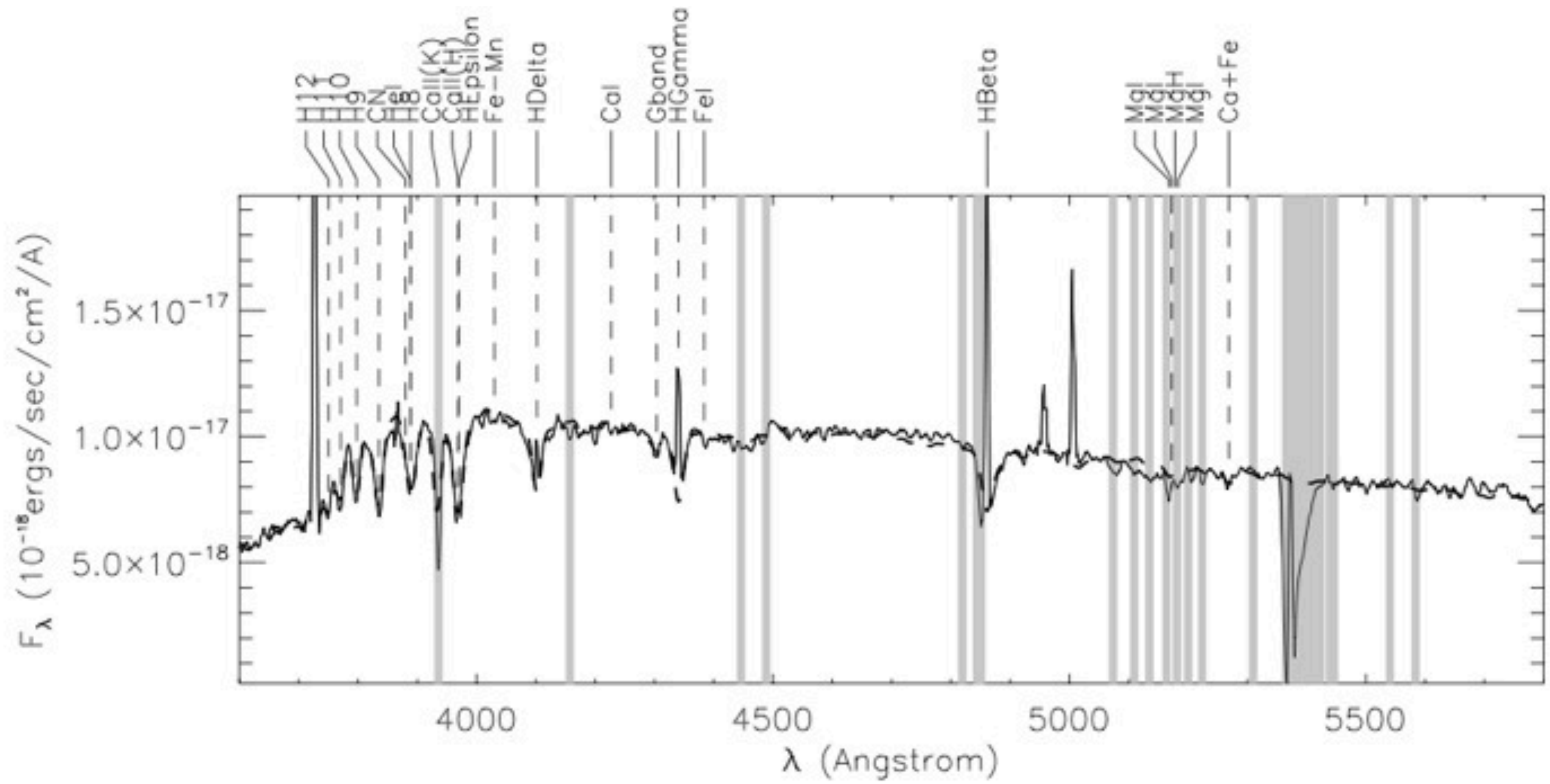
Methodology and data quality similar to those of the SDSS sample

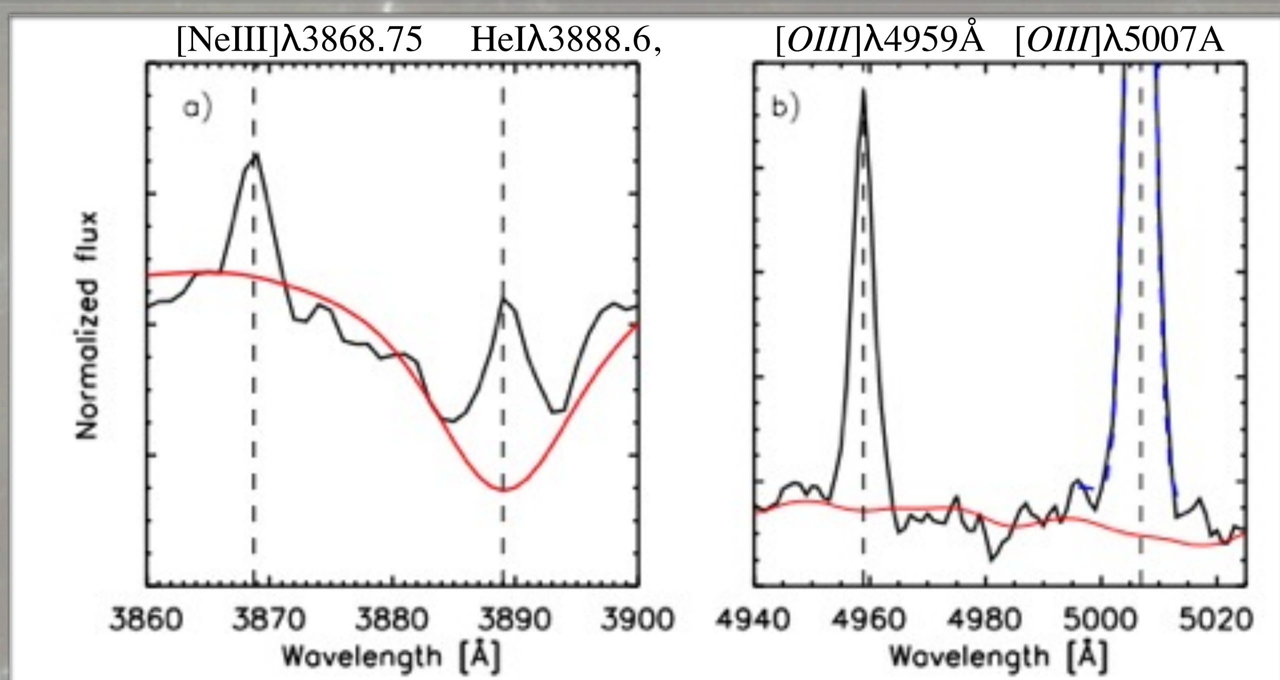


Monday, September 12, 2011

No evidence of large scale outflows

SFR

Powerful large-scale winds(~ 200 – 2000km/s) detected at z ~ 0.7
luminous post-starburst (*Tremonti et al. 2007*), MgII absorbers (*Nestor et al. 2011*)
star forming galaxies at *z* ~ 1.4 (*Weiner et al. 2009*).



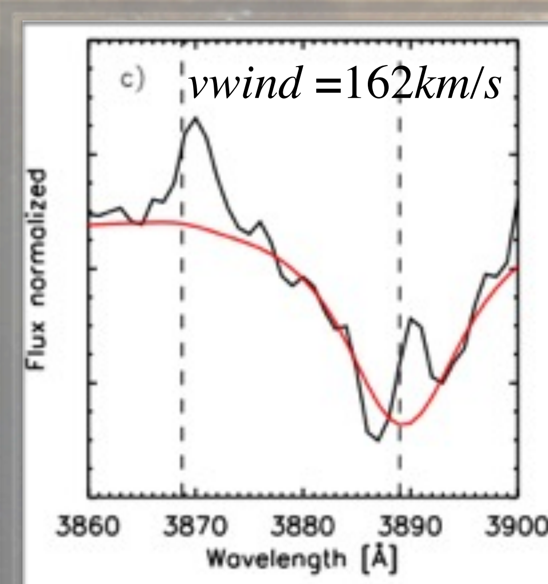
Stacked spectra (40 galaxies)

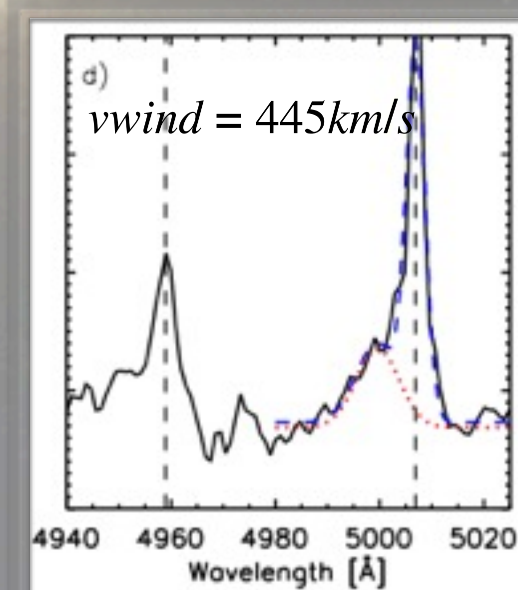
- Δv=0 km/s
- Emission lines have gaussian profiles
- No evidence of large scale outflows v_{wind}>150km/s

Synthetic spectrum
Gaussian fit

High S/N spectra (20 galaxies)

- 4 galaxies have Δv~200 km/s
- 1 galaxy have a [OIII] line profile compatible with a outflow ($v_{wind=445km/s}$)

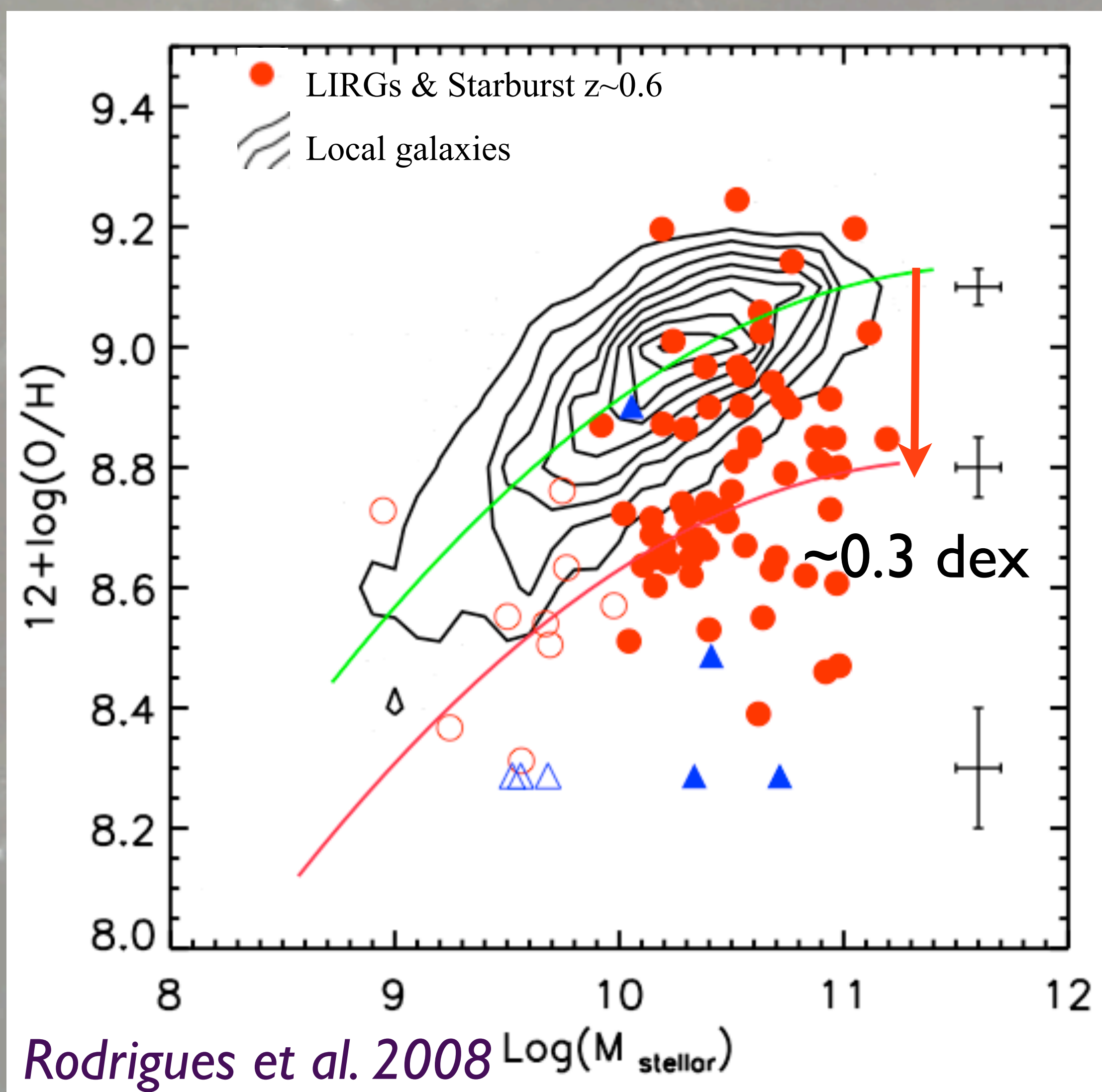




Mass-metallicity relation

Stellar mass : quantity of baryons locked in stars

Metallicity : Reflect the gas reprocess by stars and any gas exchange between the galaxy and its environment



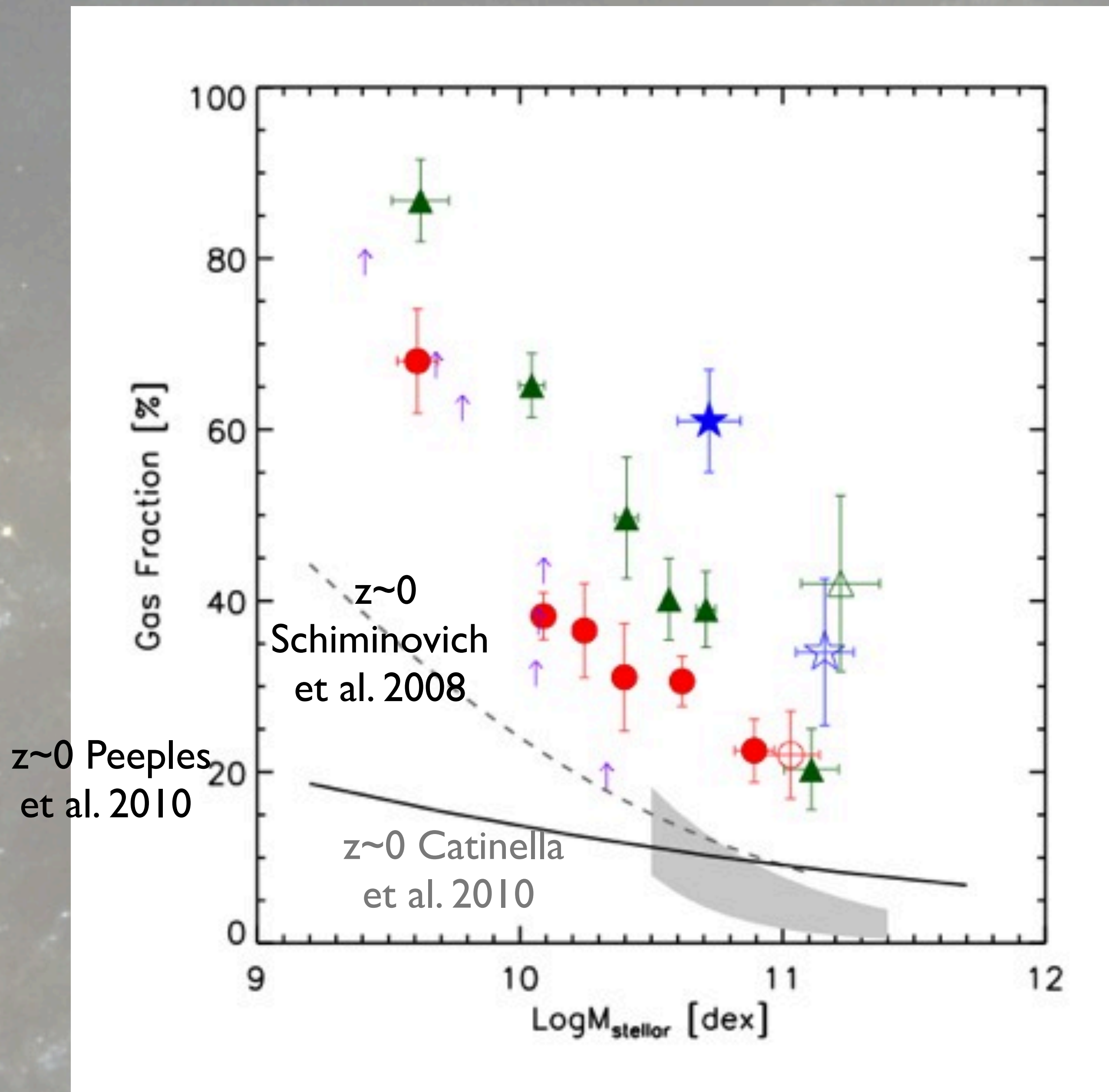
Comparison with the local sample of Tremonti et al. 2004

Strong evolution of the metal content in past 6 Gyrs

Intrinsic dispersion higher of the M-Z à z~0.6 relation than at z=0

Gas fraction

Gas



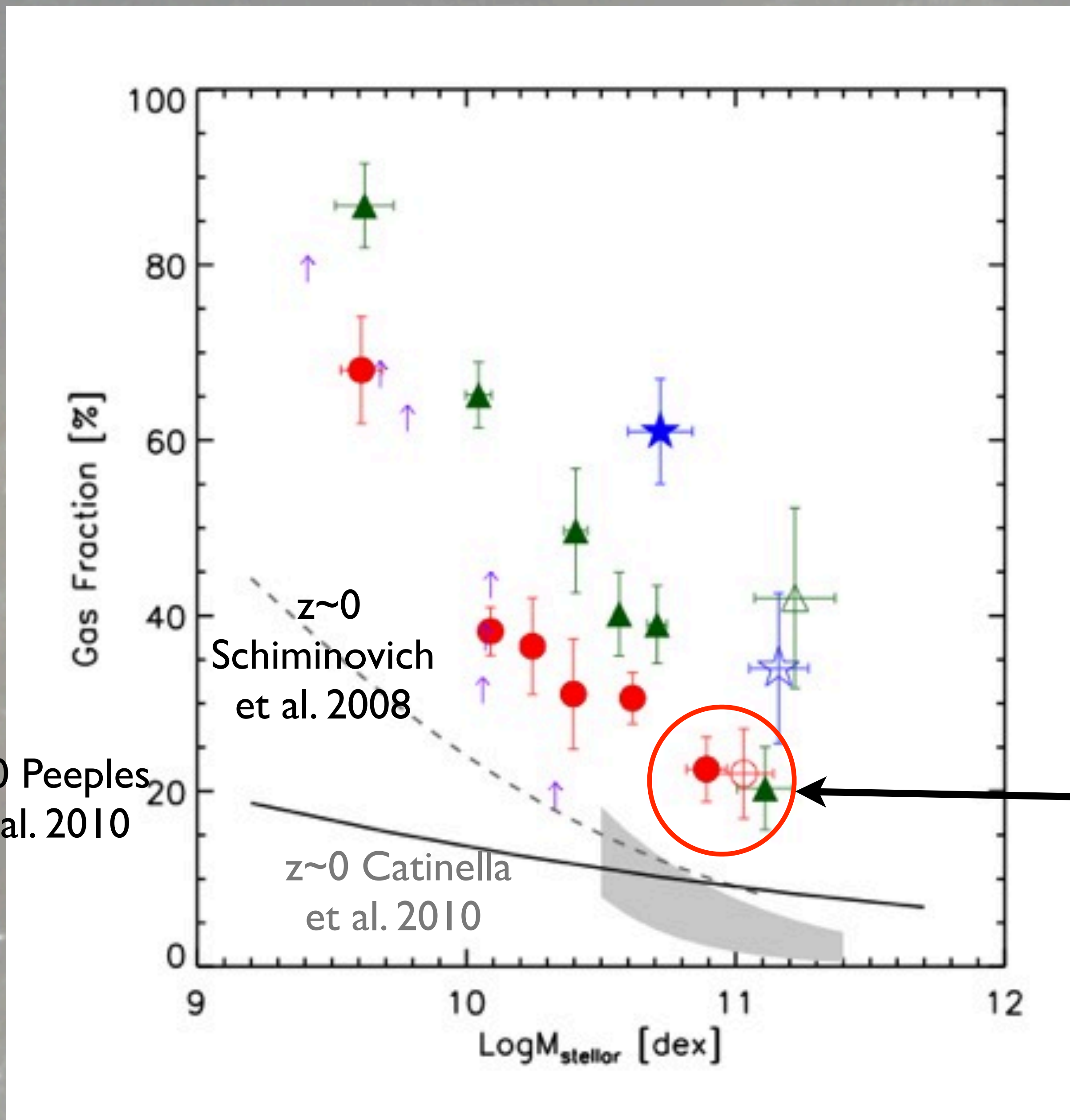
	Fill symbols	*Open symbols*
z~0.6	IMAGES	Geach et al. 2010
z~1.5	Daddi et al. 2010	Tacconi et al. 2010
z~2.2	Erb et al. 2006	Tacconi et al. 2010

Strong correlation between gas fraction and stellar mass

$$\ln \mu = 12.49 - 0.867 \times (\log M_* / \log M_\Theta)$$

The gas fraction has doubled from z=0 to z=0.6

Gas fraction



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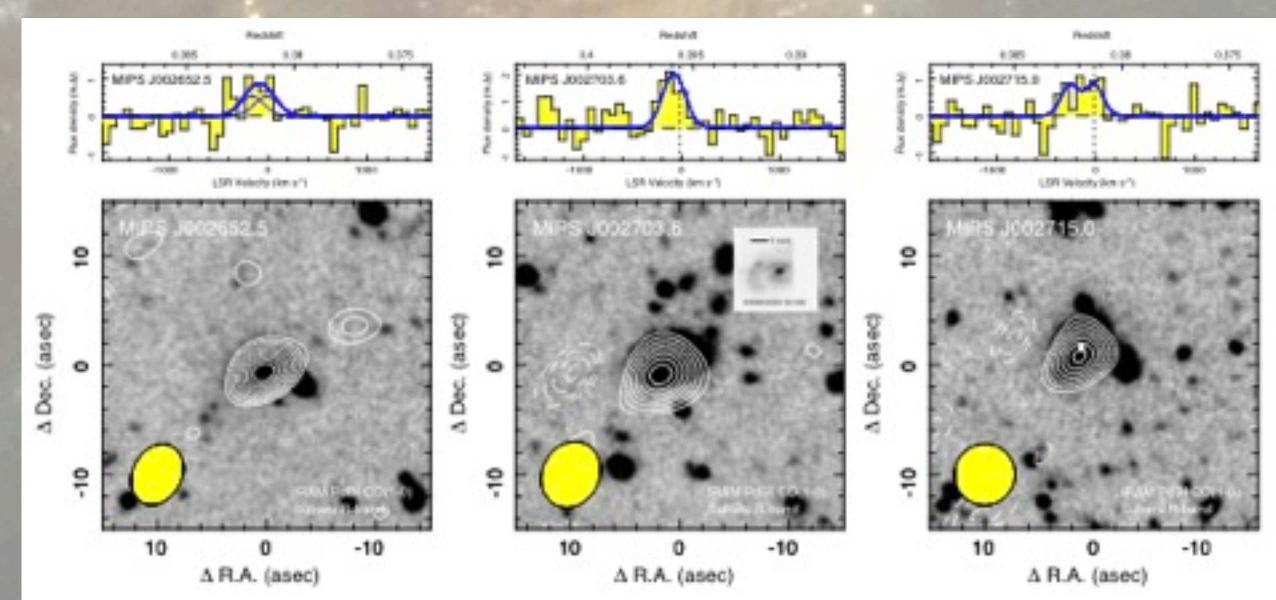
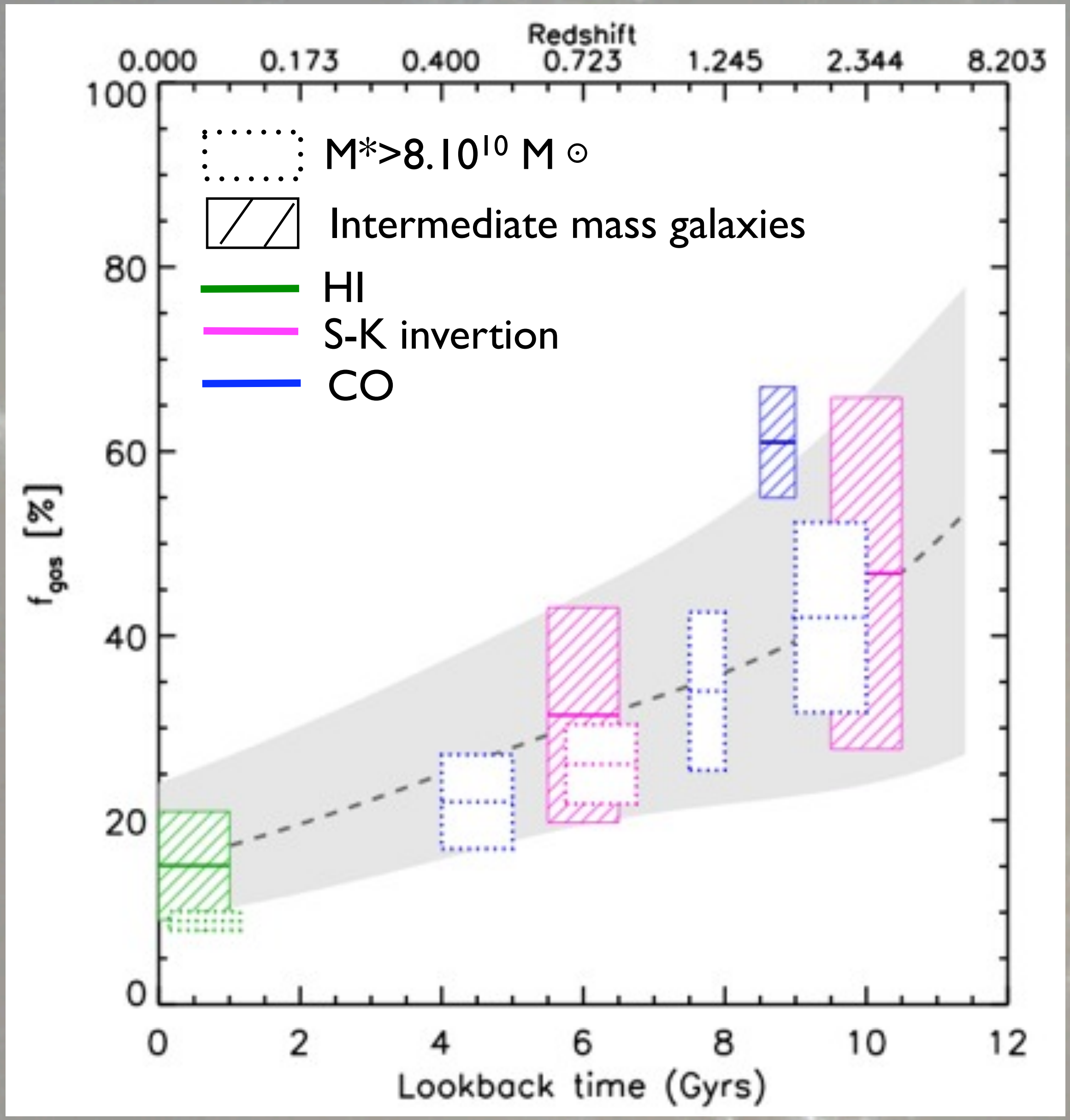
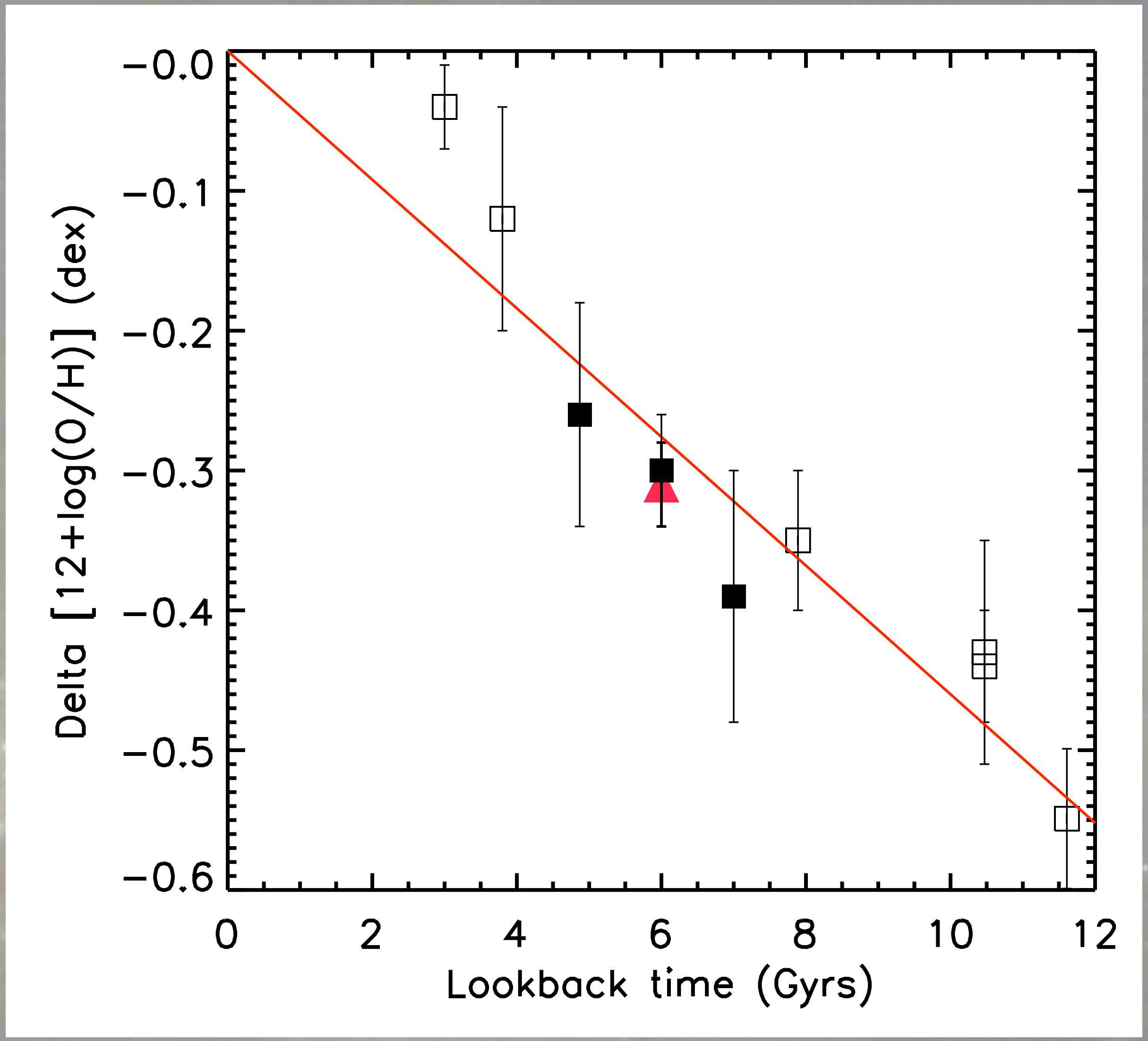
The K-S estimation and CO measurements are in good agreement



Co-evolution of gas and metals





Rodrigues et al. 2008

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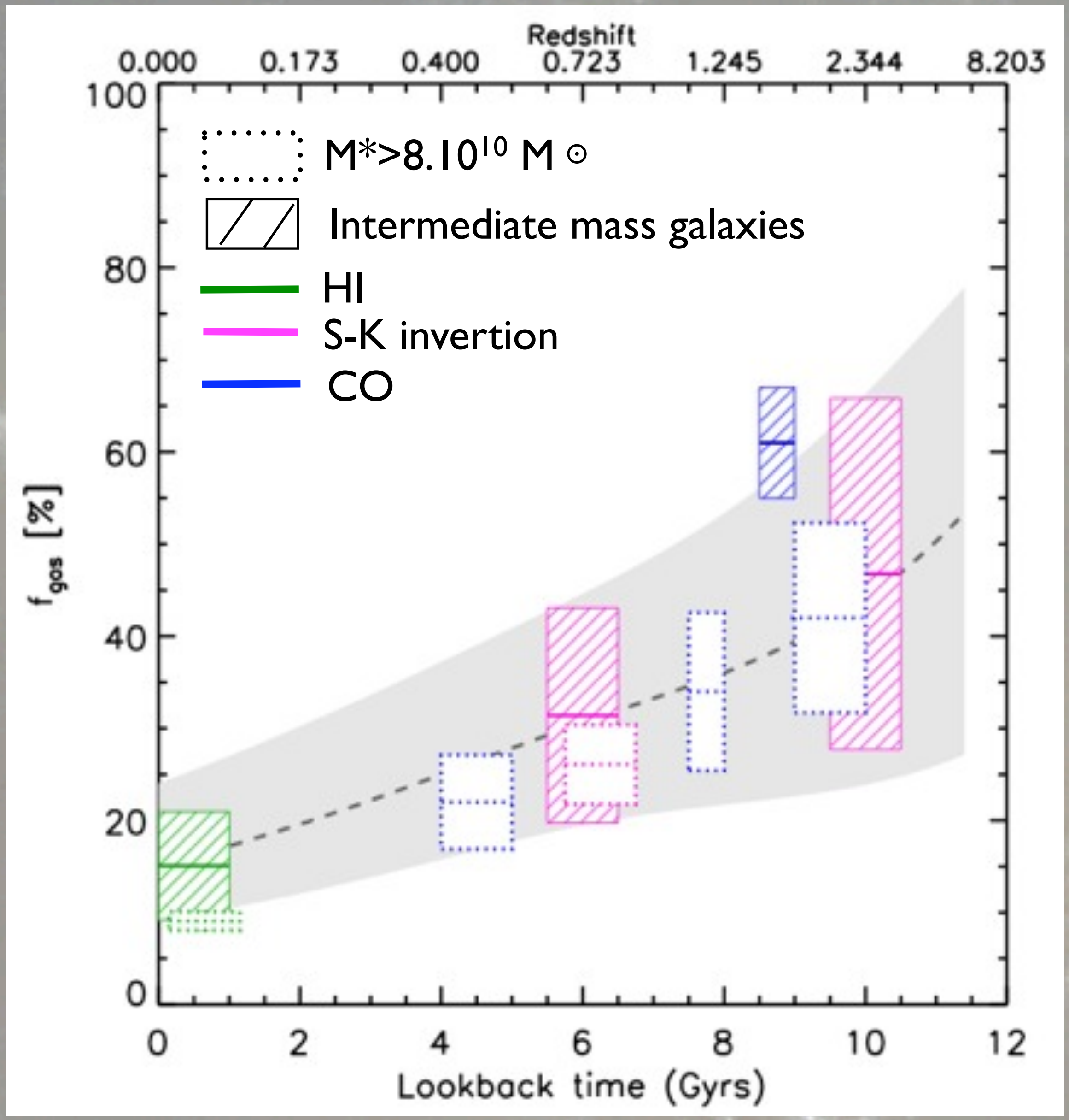
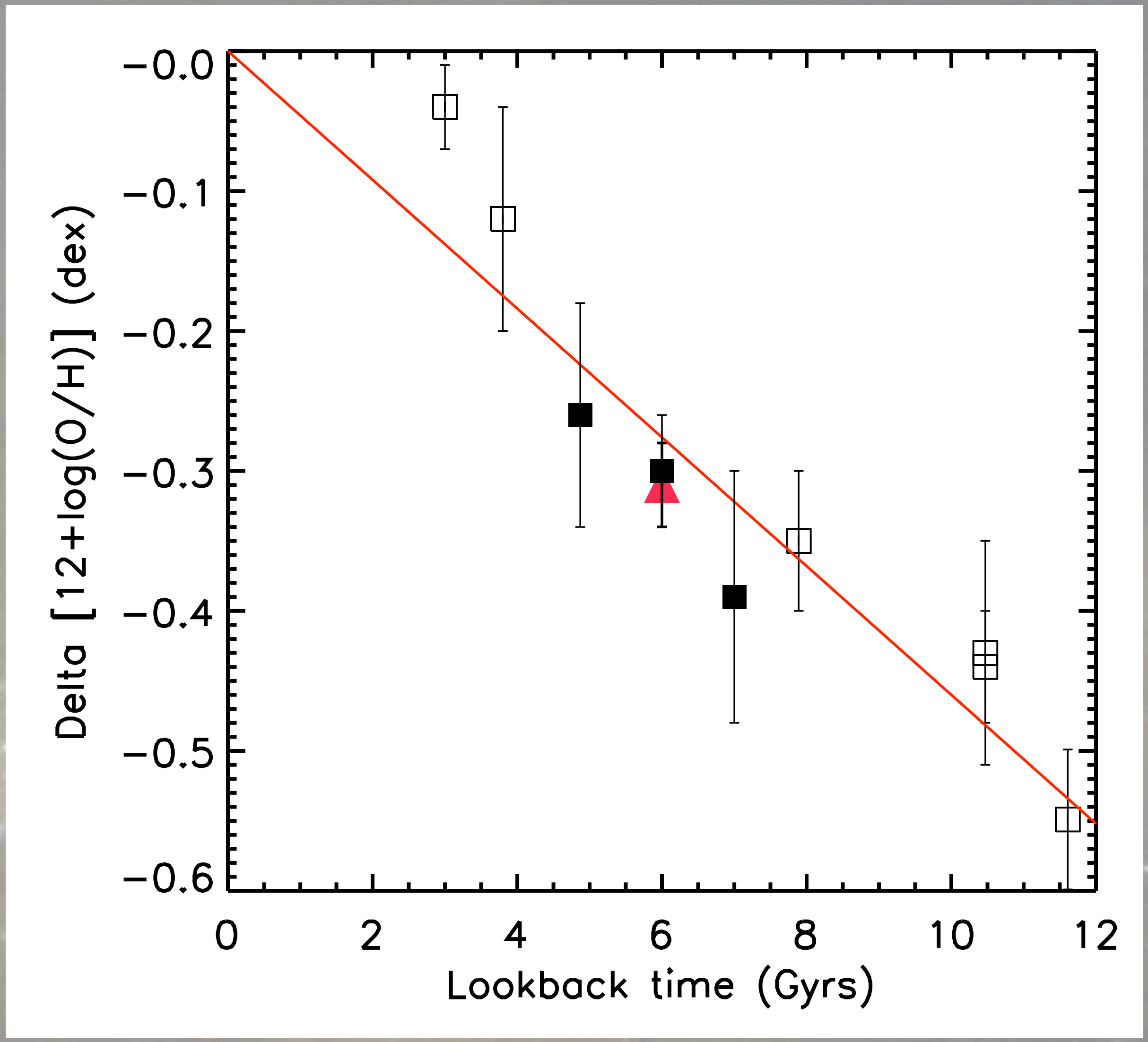




Rodrigues et al. 2008

Is the chemical evolution only due to the conversion of the gas into stars?

Testing the closed-box model

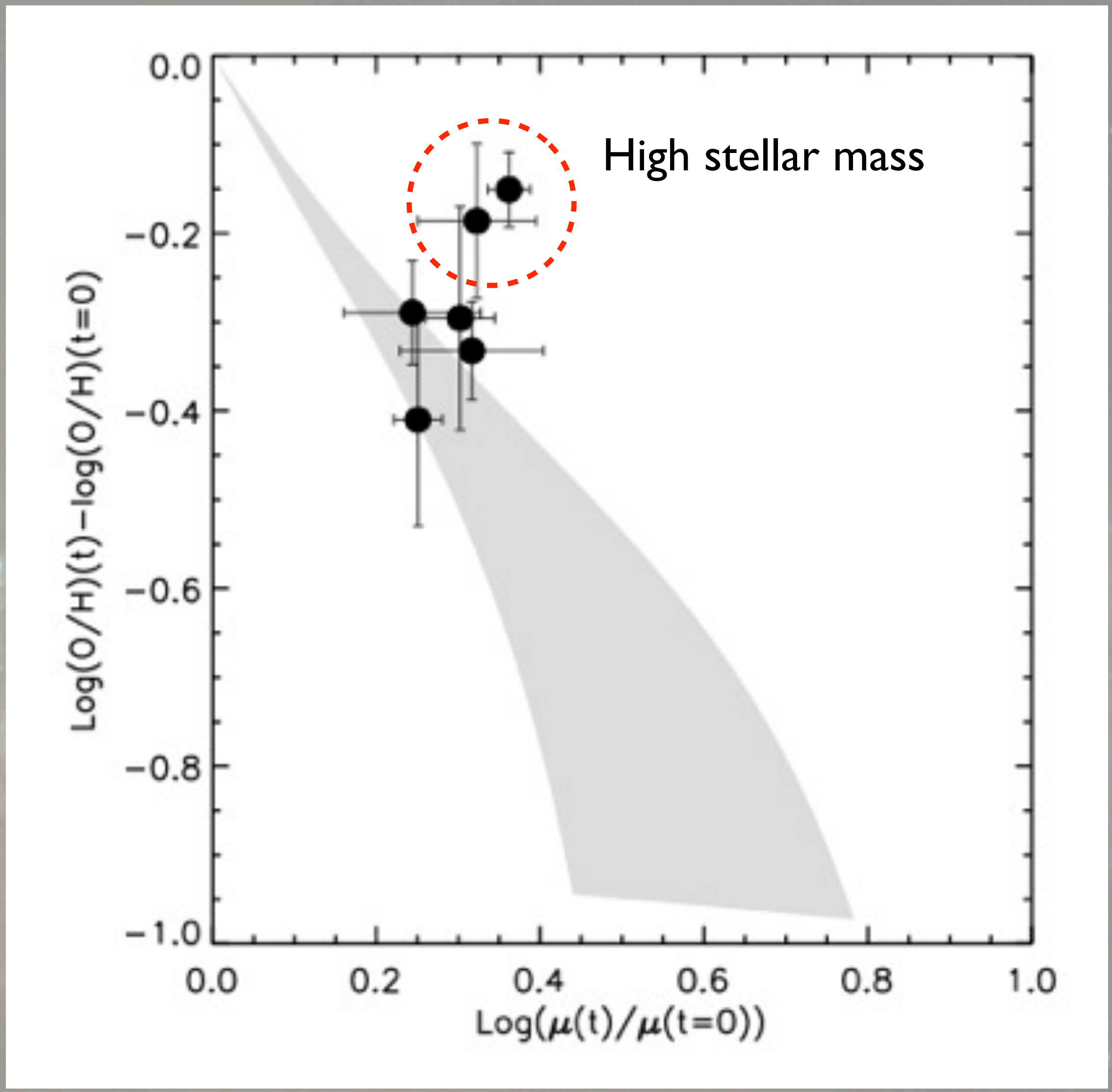
From observations :

- Local M-Z Tremonti et al. 2004
- Observed local gas fraction
  Schiminovitch et al. 2008

+

Analytical model of chemical evolution for a closed-box system Kobulnicky et al.

$$\frac{d(\log Z)}{d\mu} = \frac{0.434}{\mu \ln \mu}$$



10-30% too gas-rich for the given metallicity in the high stellar mass bin

metal rich gas infall at z~0.7 ?

The yield

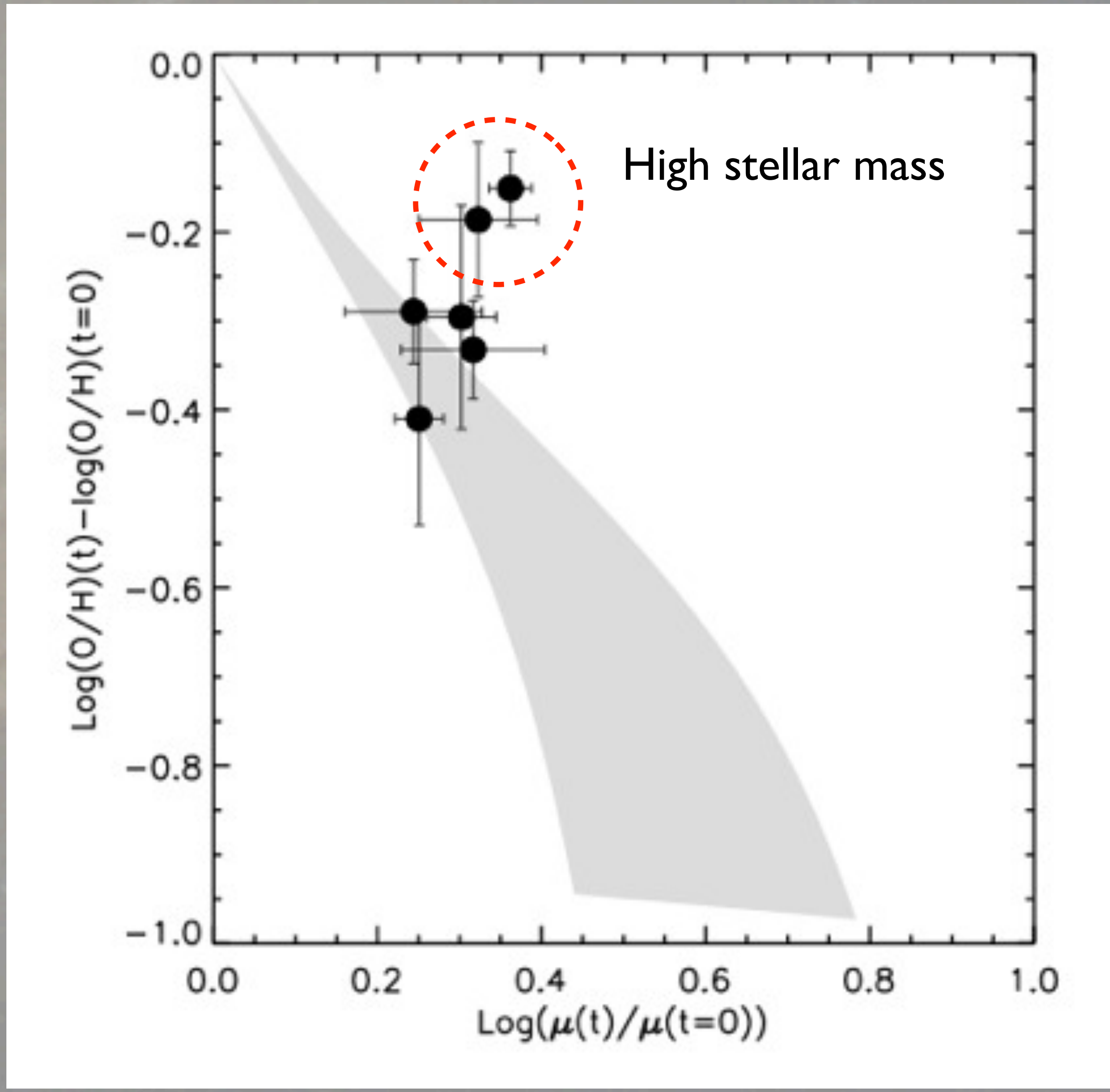
Gas Z

In a closed-box model, the chemical evolution follows : $$Z = y_{true} \ln \frac{1}{\mu}$$

Where y_{true} is the nucleosynthesis yield - The mass of newly produced metals locked into long-life stars

$$y_{eff} = \frac{Z}{\ln(1/\mu)}$$

$y_{eff} = y_{stellar}$



Exchanges of gas with the environment decrease y_{eff}
(Edmunds et al. 1990, Dalcanton 2007)

Gas poor and high SF efficiency regime
The Yeff is poorly sensitive to infall

Testing now models with enrich infall

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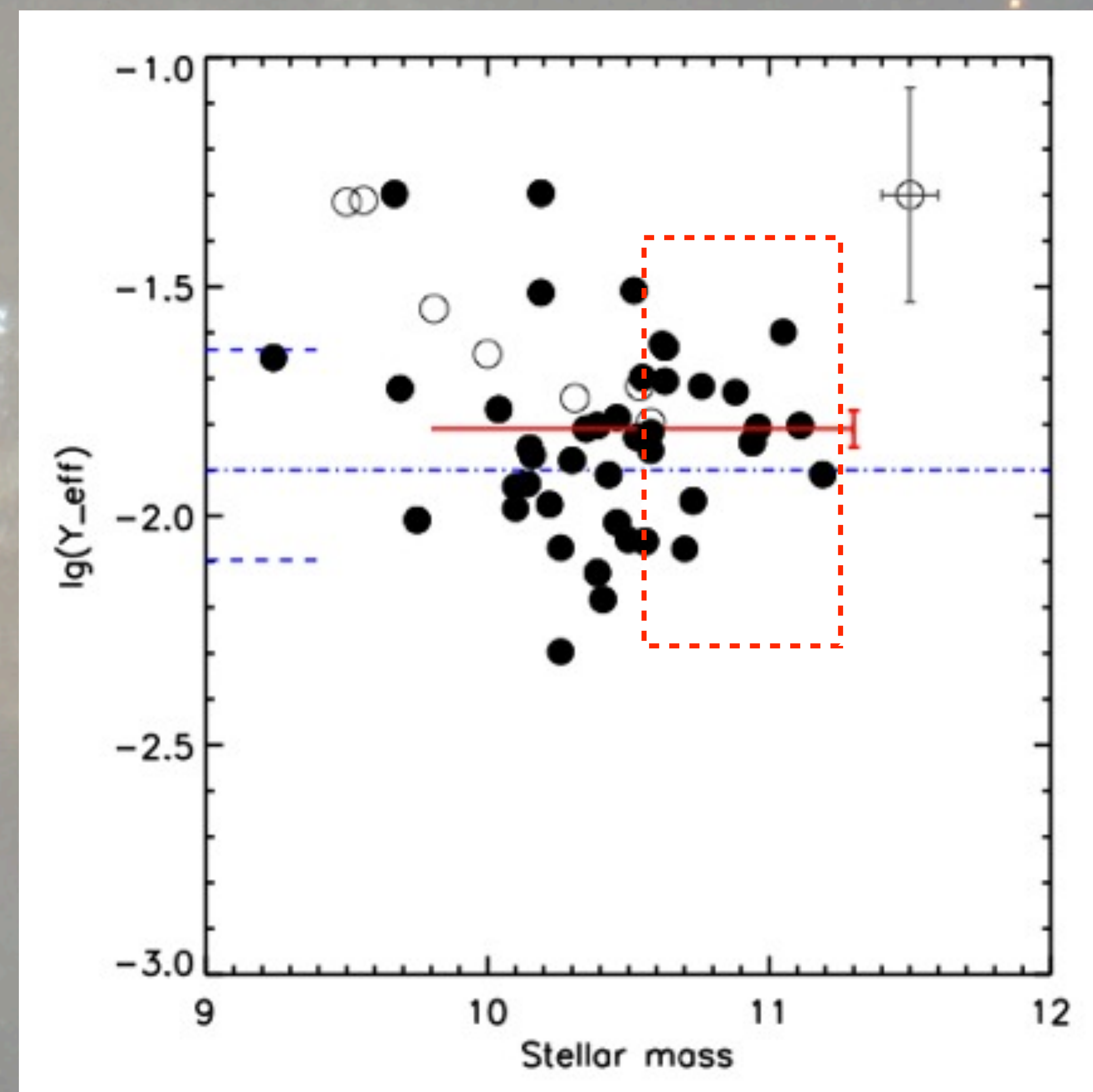

Chemical evolution scenario

At z~0.6

- There is no evidence of important contribution of outflow

The observations show that during the last 6 Gyrs

- The metallicity content have strongly increased
- The gas fraction have decrease by half
- The gas and metallicity have evolved closely as closed-system
- 10-30% of the gas fraction in local galaxies may come from infall of gas during the last 6 Gyrs

Low stellar mass range evolves as a closed-system from z=0.6 to nowadays

The observed co-evolution of fgas and Z of the higher stellar mass range may require the infall of enriched gas

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- The gas an closed system
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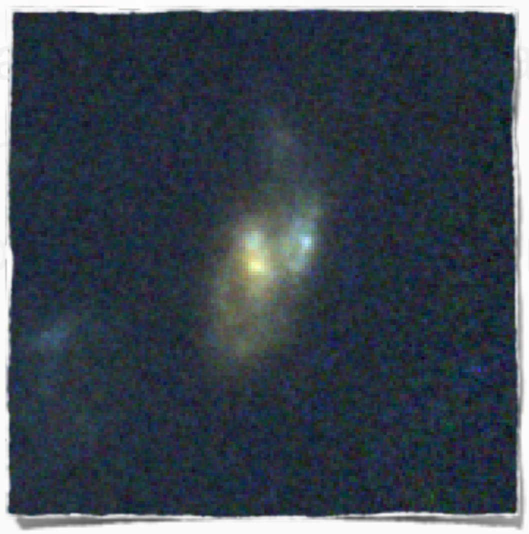
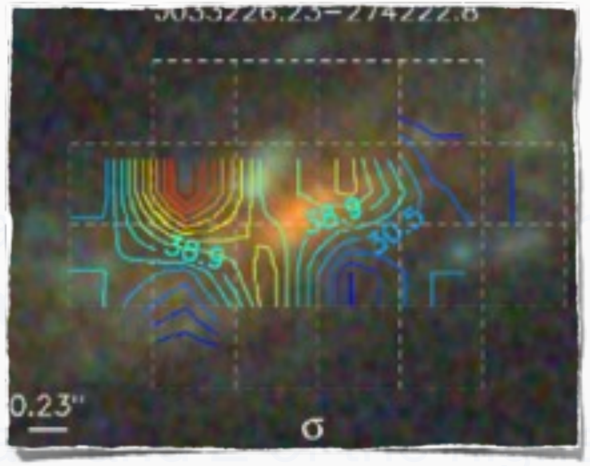
At z~0.6, galaxies show evidences of mergers and interactions !



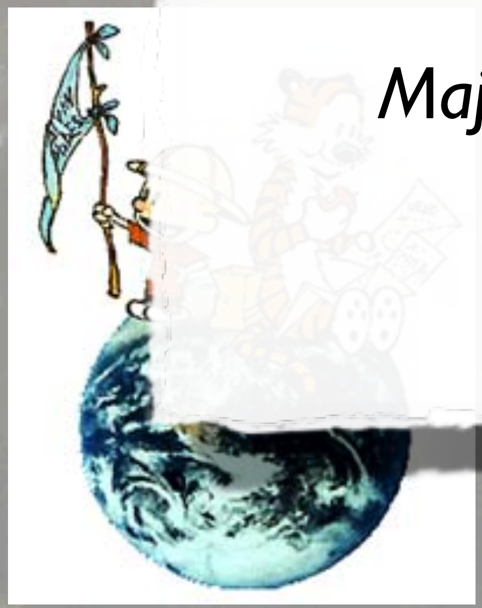
at z~0.6, 46% of galaxies are experimenting a major merger

Hammer et al. 2010

Minor merger



Major mergers



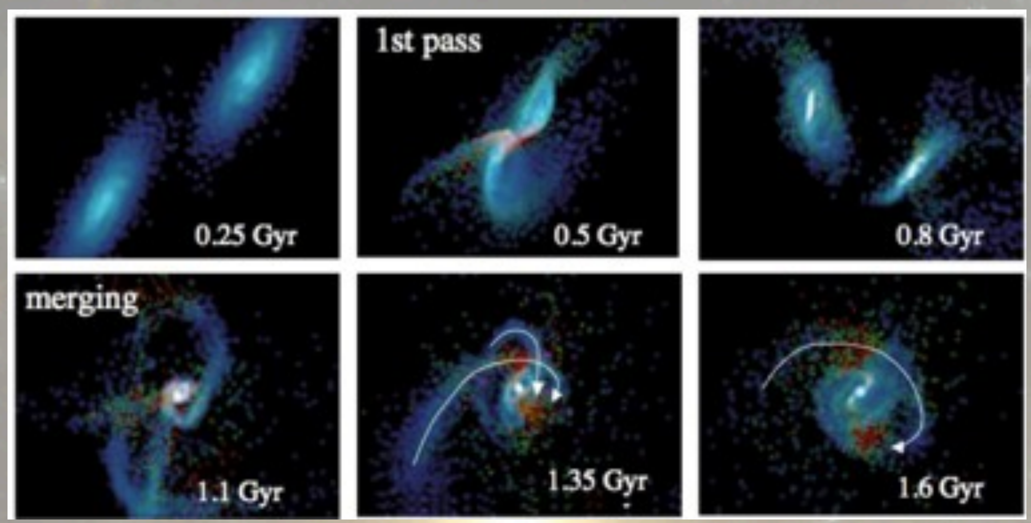
The ob ution of fga
stellar mass range may require the infall of enriched gas

Effect of mergers

In local Universe

mergers and interactions are responsable of the dispersion in the M-Z relation

Kewley et al. 2006 , Rupke et al. 2008, Michel-Dansac et al. 2008, Ellison et al. 2008



Adapted from Barnes

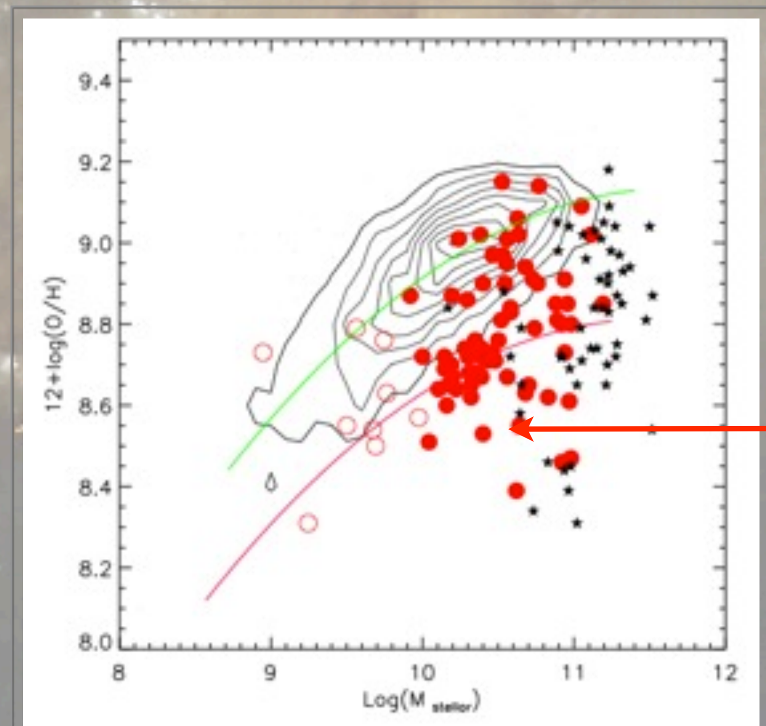
The gas situated in the outskirts falls in the center of the merger and dilutes the metals

Rupke et al. 2010, Montuori et al. 2010

At intermediate redshift

Increase the dispersion of the M-Z relation

The 2 galaxies more metal-poor are in first phase of merger



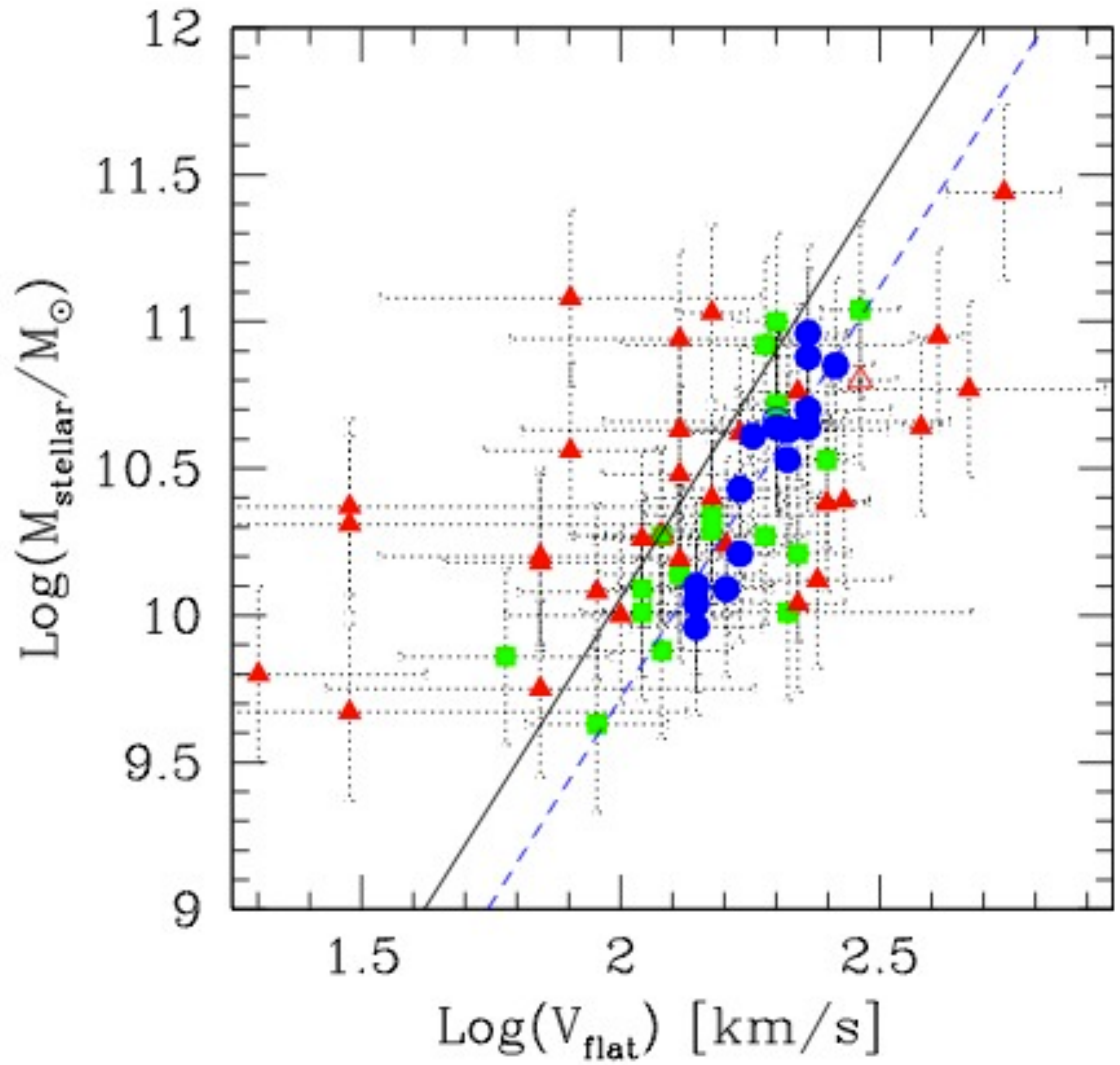
The diversity of formation histories in the framework of a hierarchical formation scenario can explain the dispersion

Effect of mergers

Effect of mergers on the Tully-Fisher relation at z~0.6

Flores et al. 2006,
Puech et al. 2010

- ▲ Complex kinematics
- ■ Perturbed rotation
- ● Rotation disc



The diversity of formation histories in the framework of a hierarchical formation scenario can explain the dispersion

Conclusion

- The evolution of the gas fraction and those of the metal content in the past 6 Gyrs is compatible with a scenario in which the intermediate mass galaxy population has small exchanges with the intergalactic medium (minor contribution of cold flows and outflow)

- The dispersions of the fundamental relations of the ISM at z~0.6 are probably induce by merger events

More ..

- Stellar population analysis combining the spectra and SED
- Morphological study
- Effect of merger on the metallicity. Infividual modeling of galaxies
- Chemical models with infall of none pristine gas