

GAS INFLOWS AND METALLICITY EVOLUTION IN INTERACTING PAIRS

Paola Di Matteo (Obs de Paris)

Marco Montuori (CNR, Rome),
M. Lehnert, F. Combes, B. Semelin (Obs de Paris)

OUTLINE

- ➔ Interactions and star formation
- ➔ Nuclear gas metallicities as a tracer of gas inflows
 - ✓ Observations
 - ✓ Simulations
- ➔ Conclusions

INTERACTIONS AND STAR FORMATION

In the local Universe, the most luminous galaxies are associated to gas-rich interactions and mergers

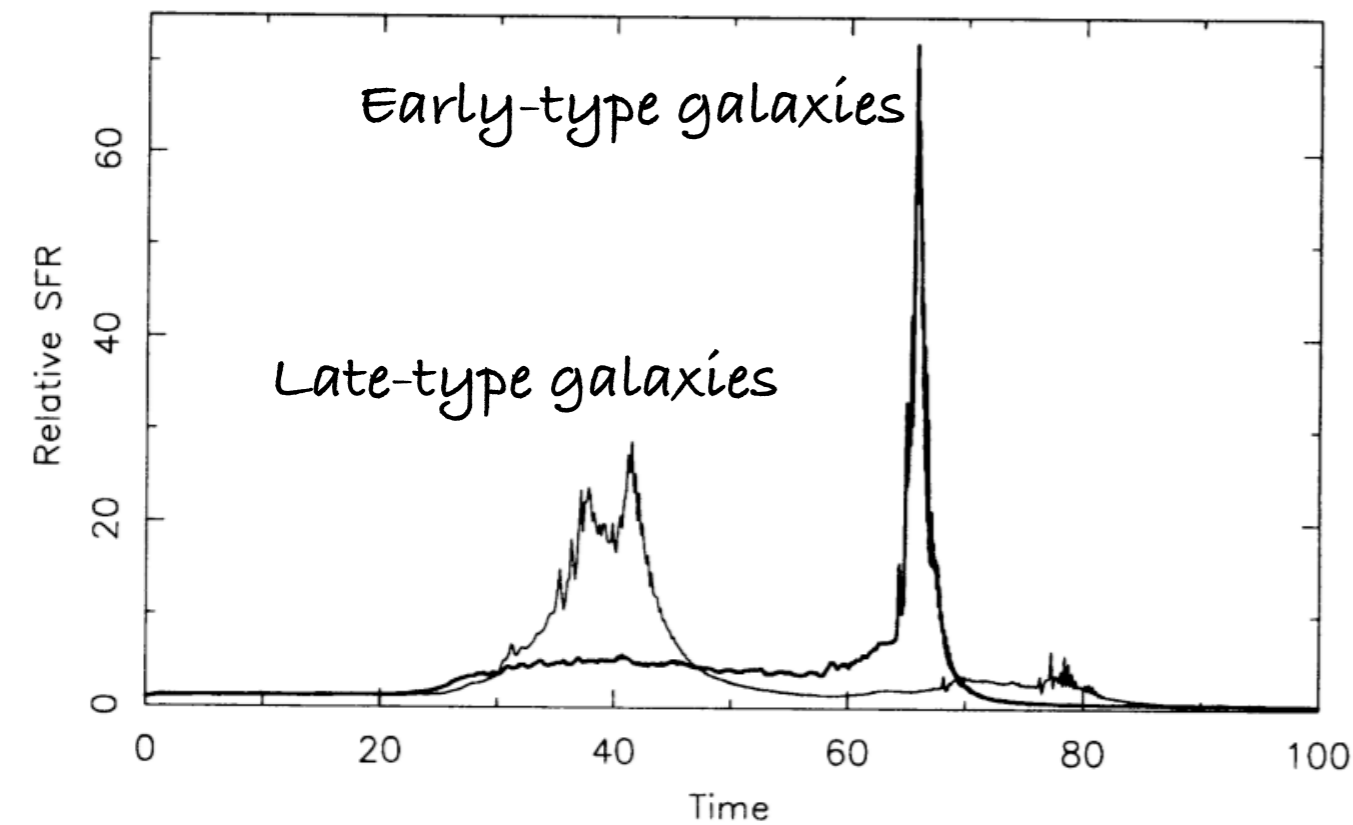
(Sanders & Mirabel 1996), **but this is not reciprocal**

Galaxy interactions and mergers are not a sufficient conditions to drive strong starbursts

- ▶ at low redshift (Bergvall et al. 2003, Knapen & James 2009, Sara Ellison's talk)
- ▶ at intermediate redshifts (Jogee et al. 2009, Robaina et al. 2009)
- ▶ in simulations (Di Matteo et al. 2007, 2008)

The amplitude of the SF burst depends on a number of parameters: morphology, gas content, strength of the tidal effects, mass ratio...

INTERACTIONS AND STAR FORMATION



➔ The timing of the SF burst depends on the morphology of the interacting galaxies (Mihos & Hernquist 1994)

Mihos & Hernquist, 1994, ApJL, 431, 9

➔ **Dependence** on orbital parameters and **on the strength of the interaction**

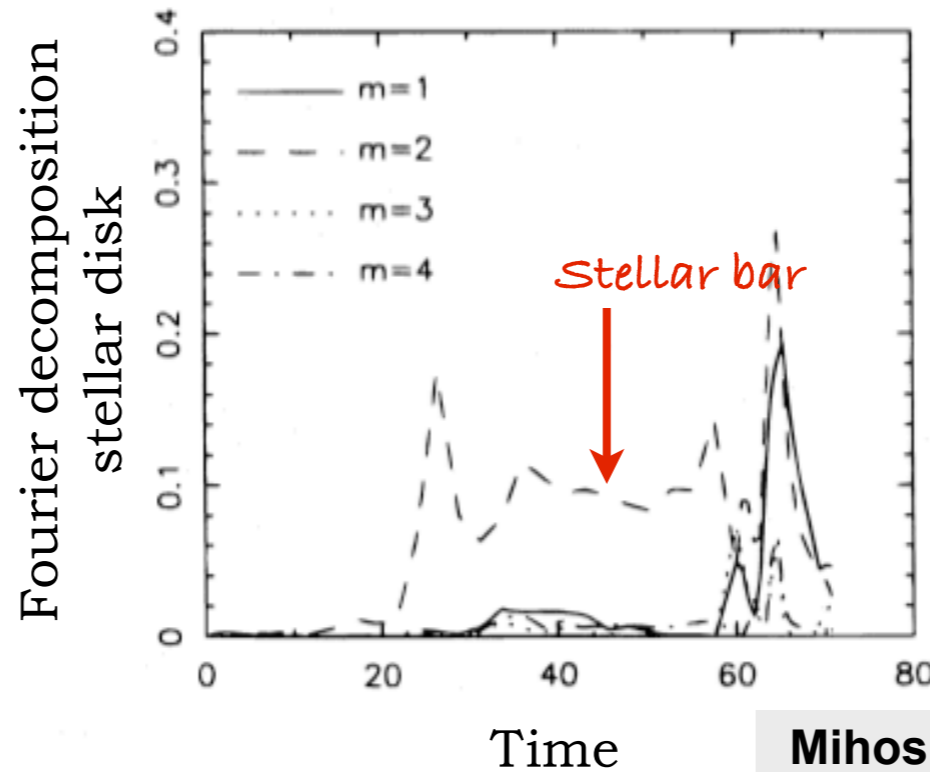
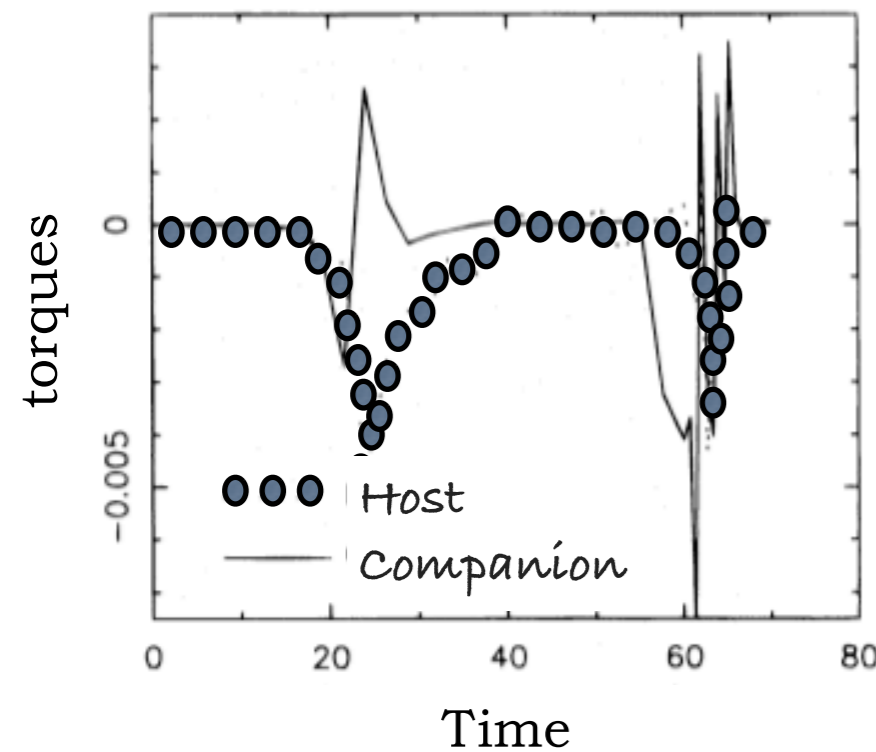
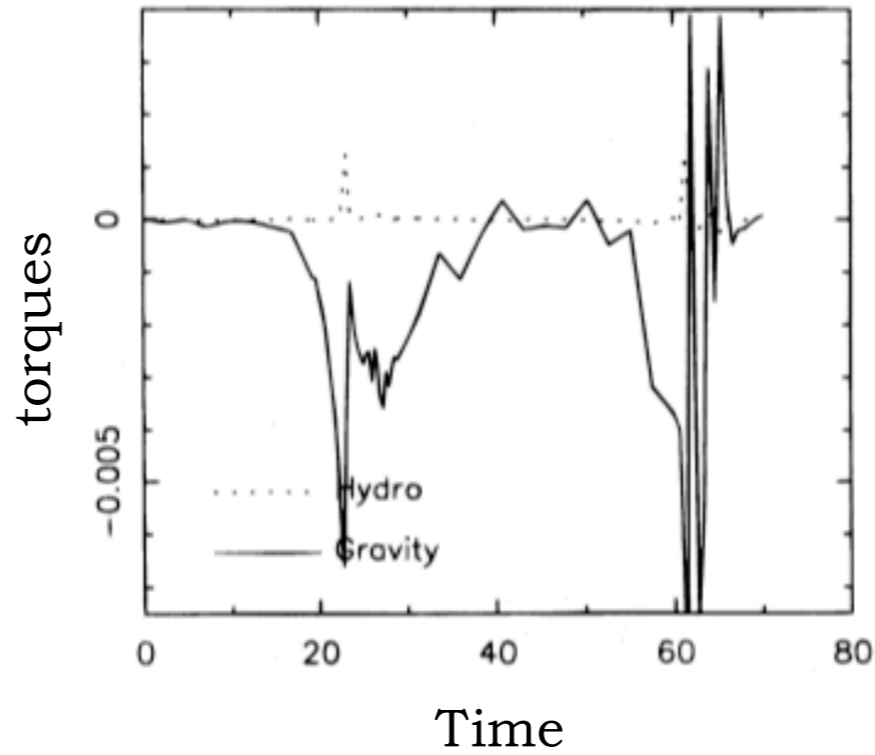
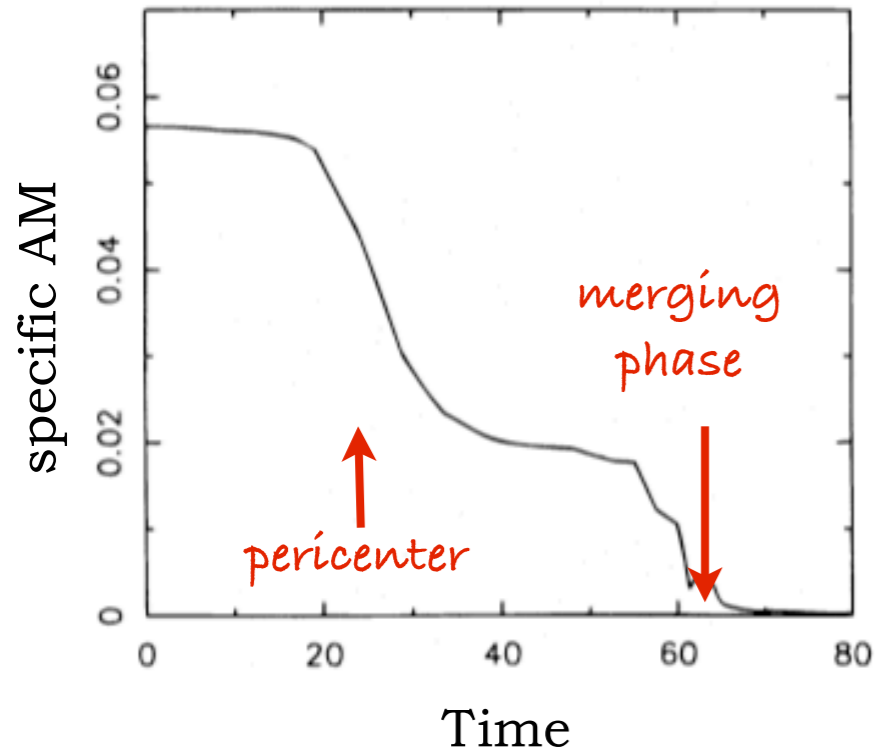
(Dí Matteo et al. 2007, 2008)

➔ The SF efficiency decreases with the mass ratio (Cox et al. 2008)

➔ **Dependence on the SF prescription:** more extended SF if the local rate of energy dissipation in shocks is included (Barnes 2004)

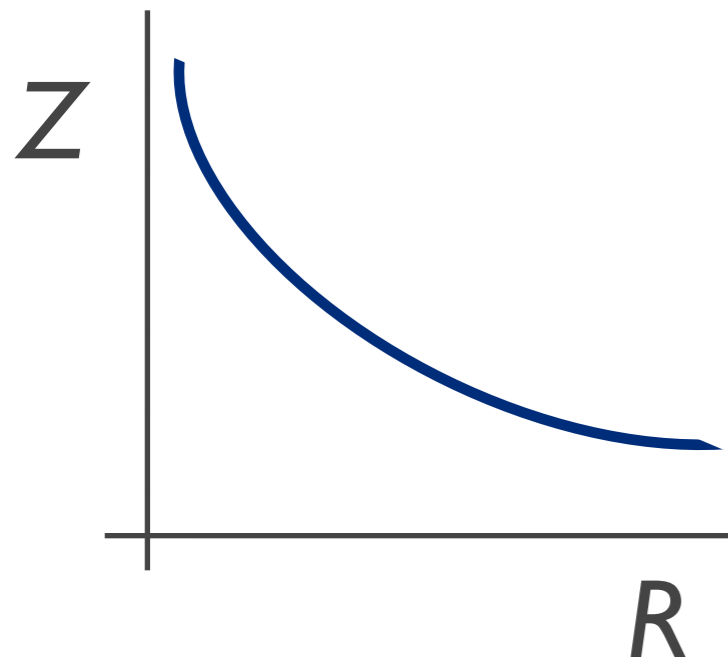
➔ **Dependence on the spatial numerical resolution adopted** (Teyssier et al. 2010)

INTERACTIONS AND GAS DYNAMICS



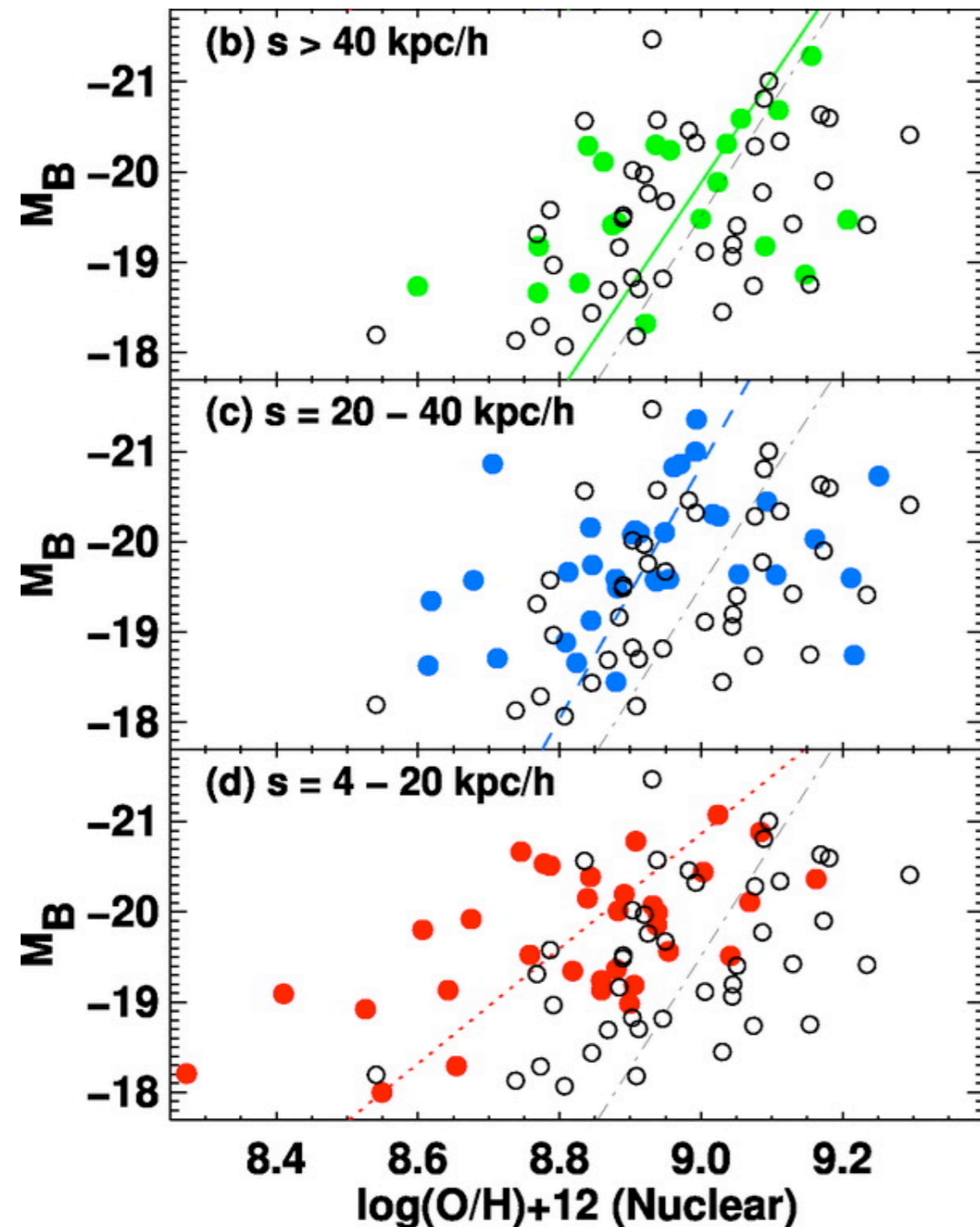
Gas inflows generated by the gravitational torques exerted by stars of the host galaxy

TRACING THE GAS INFLOWS



If the progenitor disks have metallicity gradients, interaction-induced gas inflows will drive **low metallicity gas from the outer disk into the central regions**, thus lowering the central (1-2 kpc) gas metallicity, **until SF will increase it again**

GAS METALLICITY IN INTERACTING PAIRS: OBSERVATIONS



Kewley et al., 2006:

➔ Galaxy pairs with close projected separations $s < 20$ kpc have systematically lower metallicities than either the field galaxies or the widely separated pairs

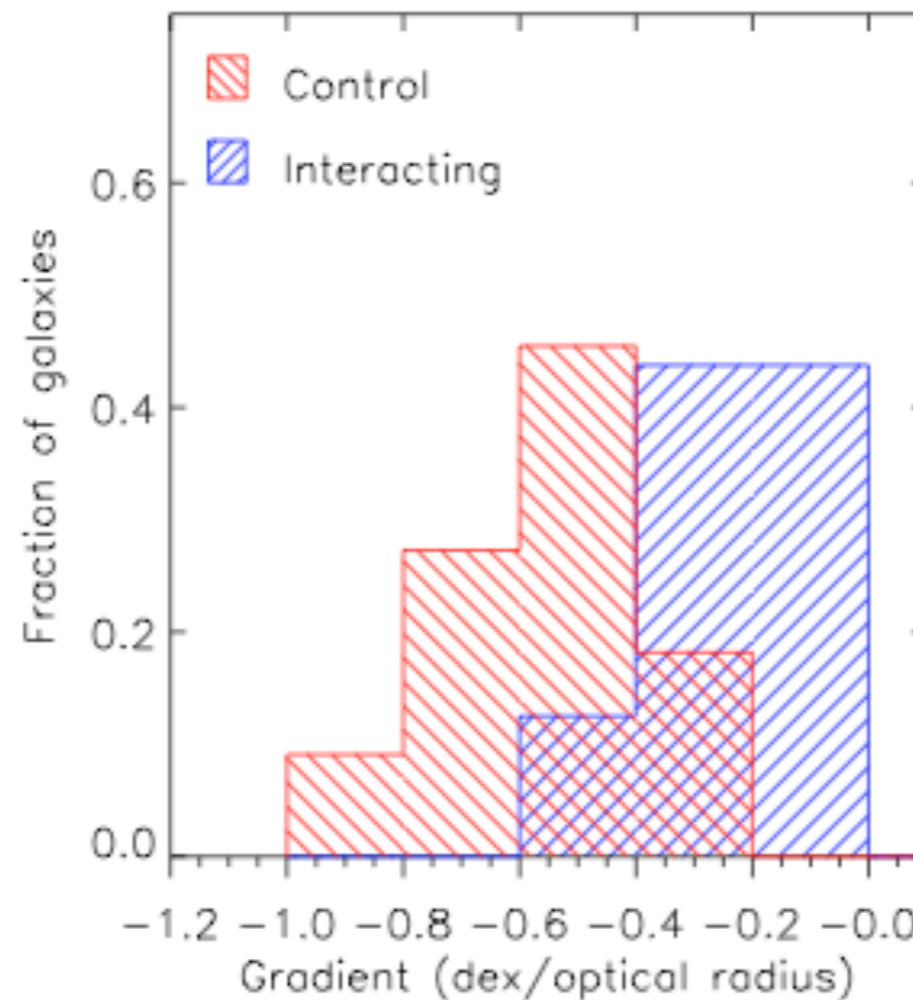
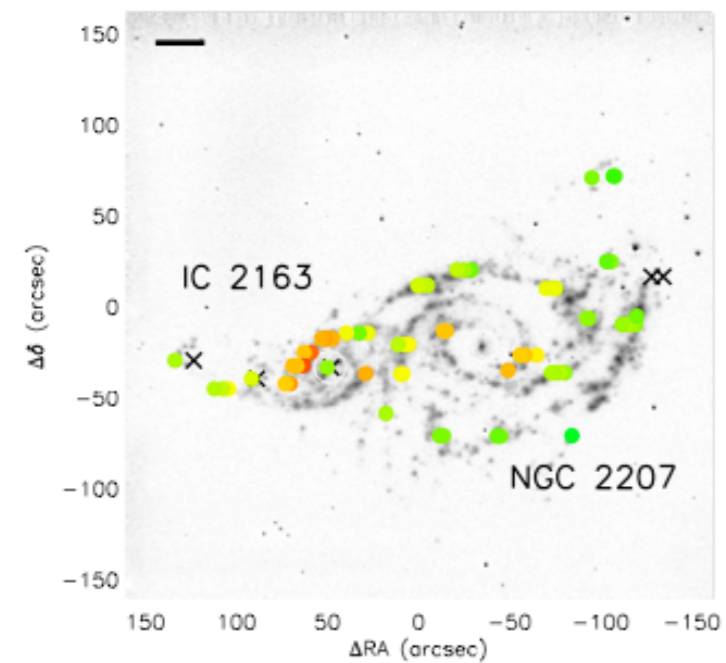
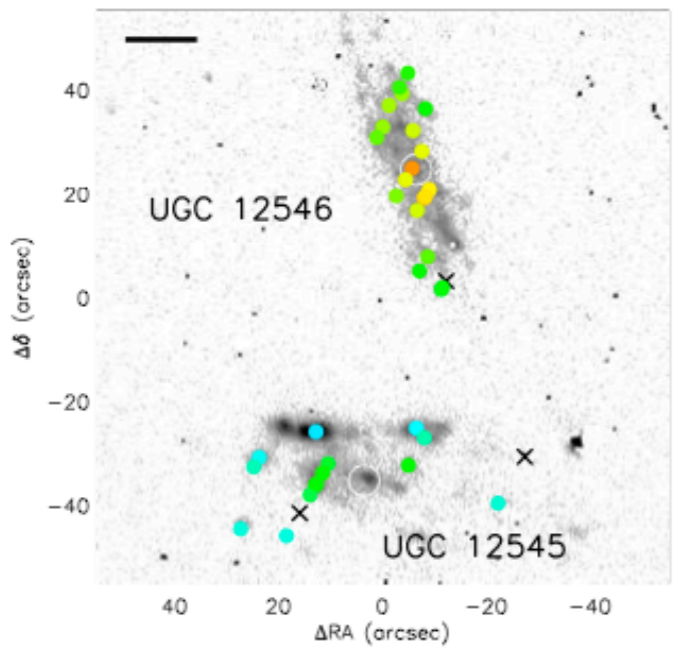
➔ Anticorrelation between nuclear metallicity and central burst strength in the galaxy pairs: **lower metallicity pairs have greater central burst strengths**

GAS METALLICITY IN INTERACTING PAIRS: OBSERVATIONS

Rupke et al., 2010:

Metallicities of over 300 H II regions in a sample of 16 spirals members of strongly interacting galaxy pairs with mass ratio ~ 1 .

Abundance Map



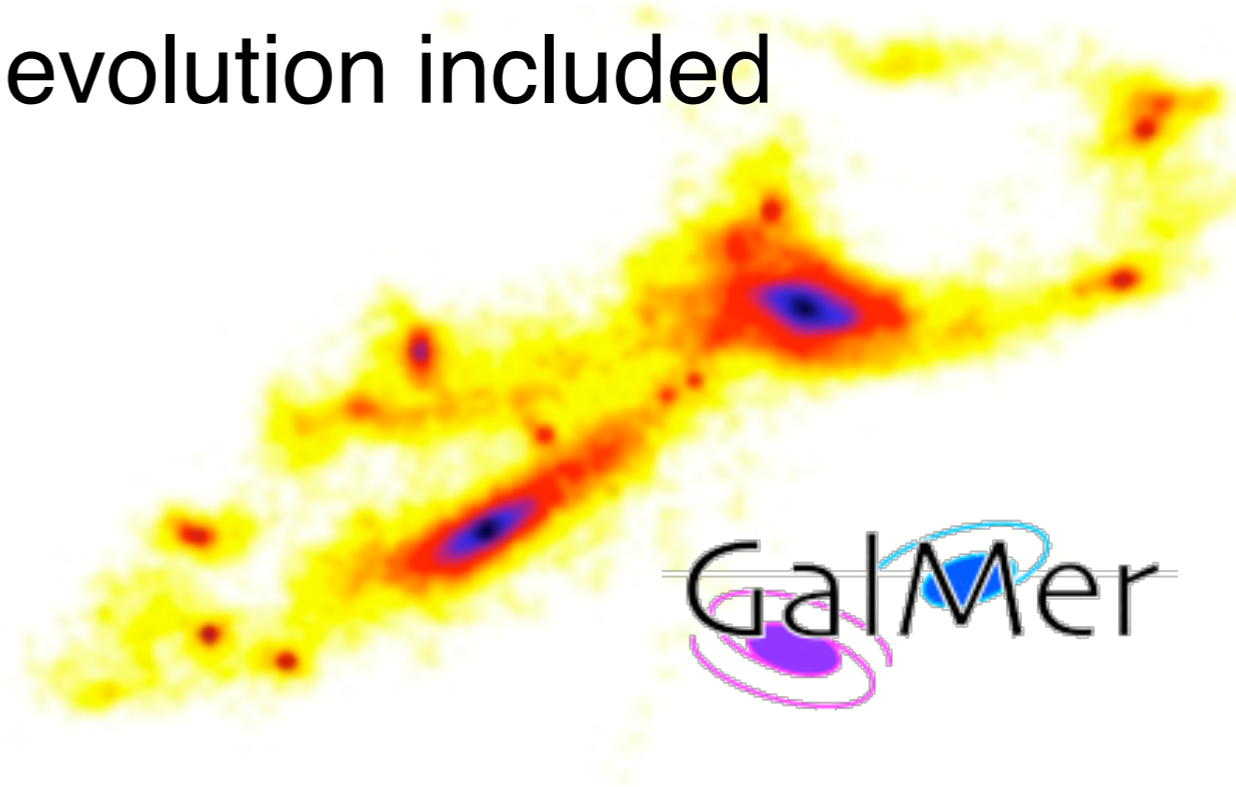
→ The inflow flattens the radial metallicity gradients in strongly interacting galaxies

SOME QUESTIONS

- ➔ What is the **timing** and the **duration** of this dilution?
- ➔ **How** and **when** does the SF induced by the gas inflow enrich the circum-nuclear gas with re-processed material?
- ➔ Is there **any correlation** between the timing and strength of the **dilution** and the timing and intensity of the **star formation**?

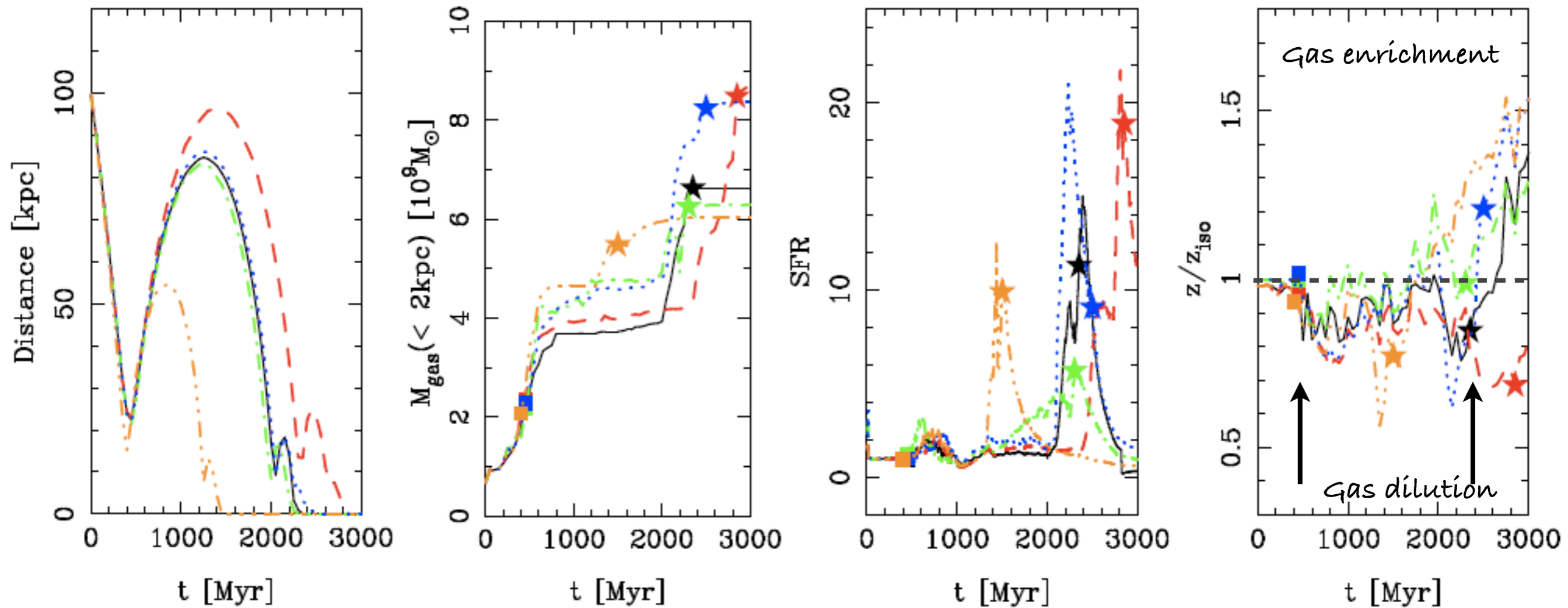
THE SIMULATIONS

- ➔ We analyse a sample of ~ 100 simulations of interacting galaxies with mass ratio 1:1
- ➔ Both mergers and flybys included
- ➔ Spatial resolution of ~ 200 pc
- ➔ Tree-SPH code (*Semelin & Combes 2002*)
- ➔ Star formation and metallicity evolution included



GAS FLOWS: WHERE AND WHEN?

for some mergers....

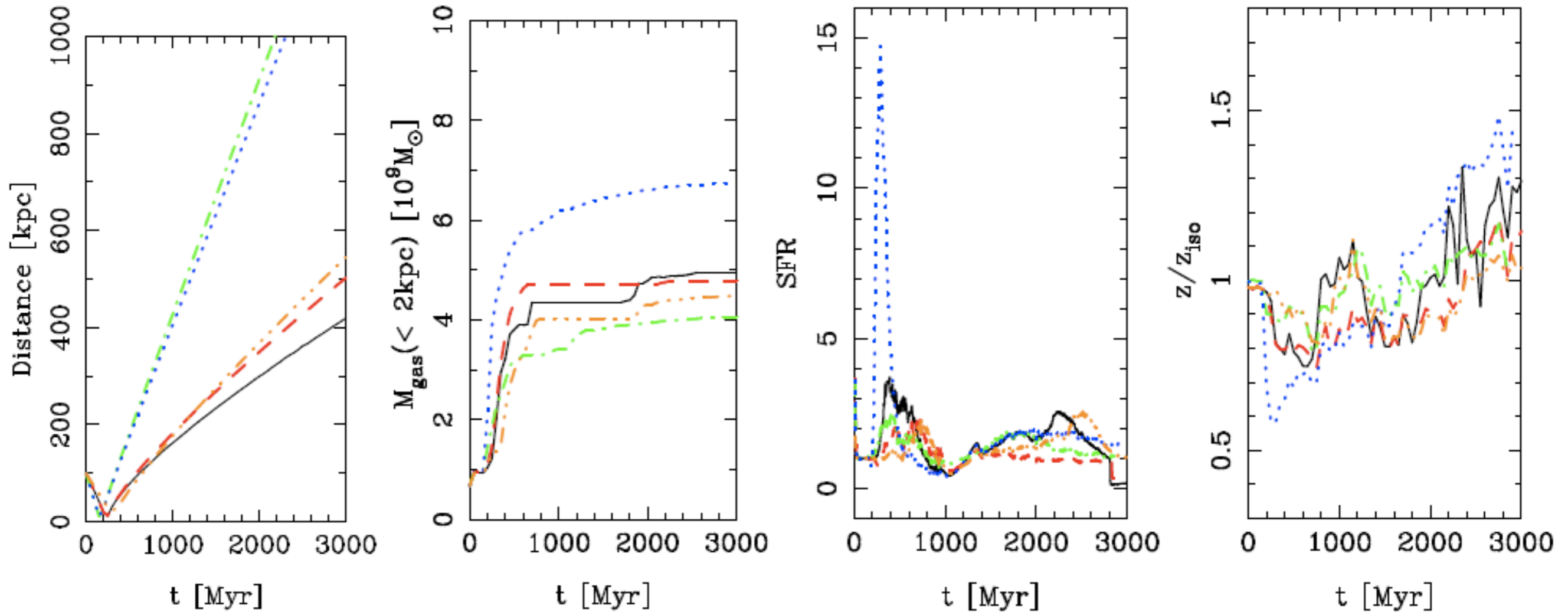


Montuori et al, 2010, A&A,518, 56

The dilution phase is very rapid, less than 5×10^8 ys, and it is followed by the enrichment of the ISM, due to the interaction-driven enhanced SF

GAS FLOWS: WHERE AND WHEN?

... and fly-bys

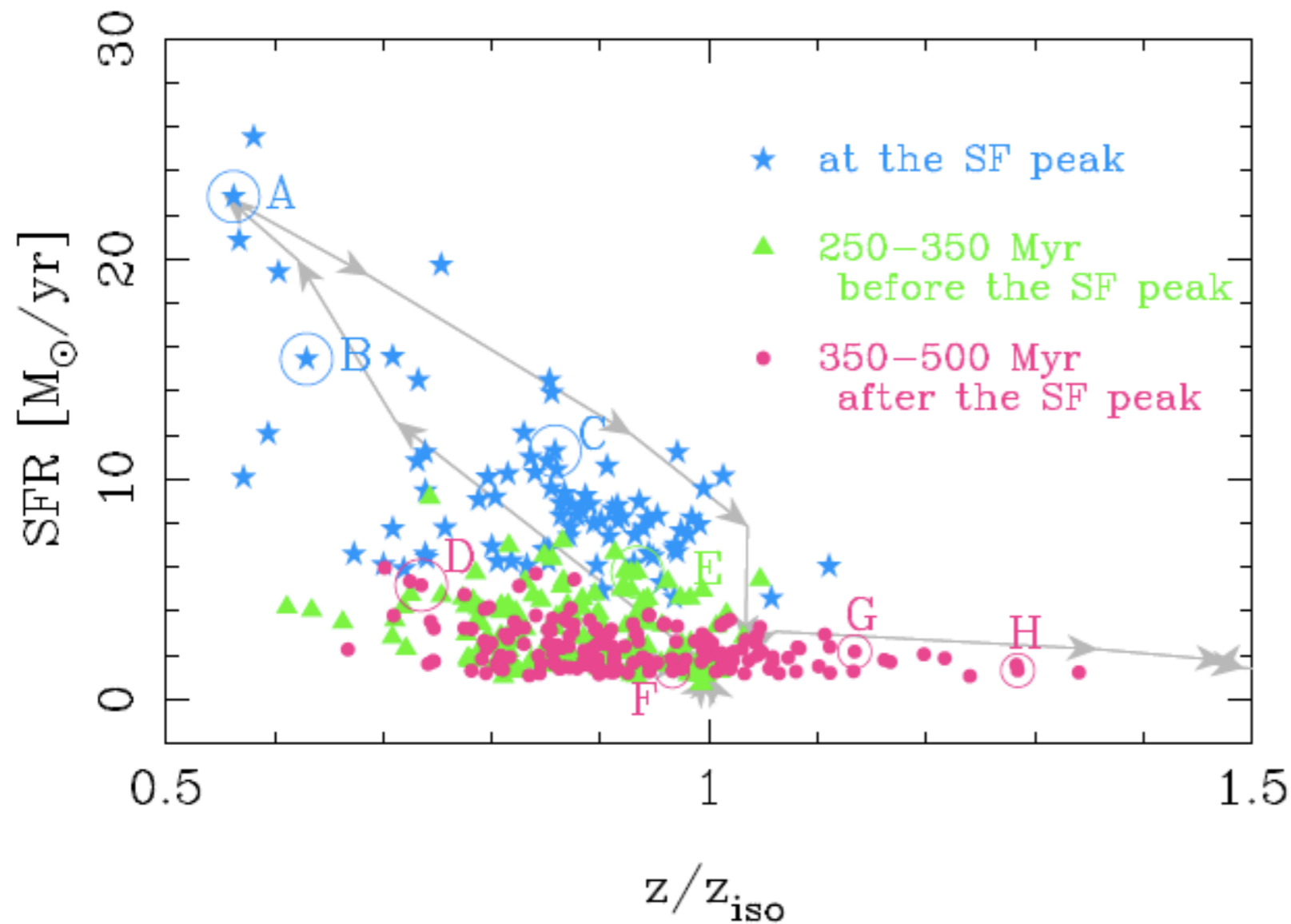


Montuori et al, 2010, A&A,518, 56

Strong dilution can be found also in fly-bys.

The highest dilution in interactions with the strongest star formation

STAR FORMATION AND METALLICITY DILUTION



Montuorí et al., 2010:

Before the SFR peak:

Galaxies tend to populate a region of low to moderate SFRs and dilutions

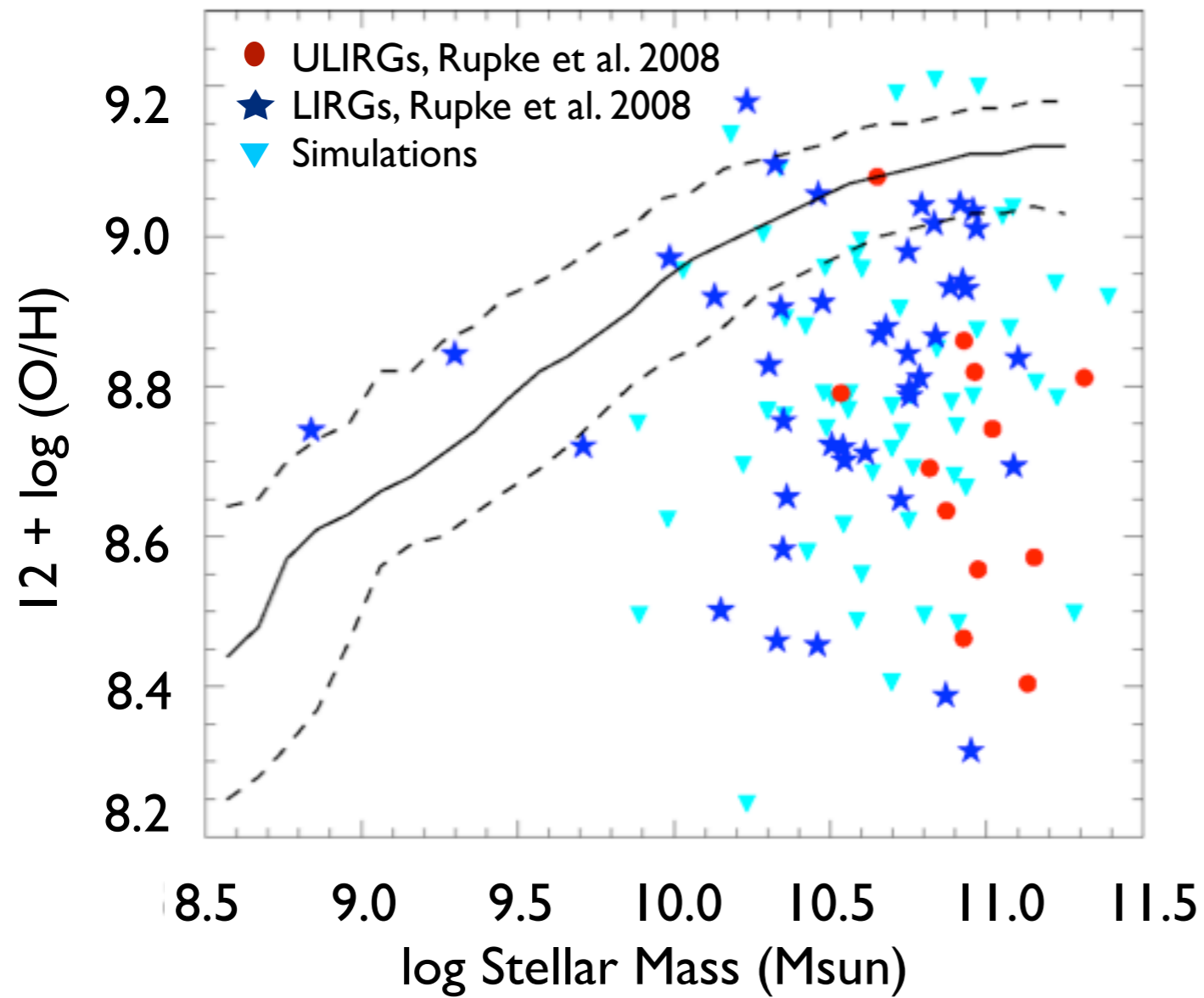
At the SF peak:

The highest SFRs are associated to strongest dilution

After the SF peak:

Galaxies move towards lower SFRs and higher metallicities

MODELS VERSUS OBSERVATIONS



Models can explain the full range of circumnuclear metallicities observed in more violent mergers in the local Universe (Rupke et al. 2008)

CONCLUSIONS

- ➔ The more intense the central burst of star formation, the more the gas is diluted
- ➔ This trend comes from **strong inflows of relatively metal-poor gas from the outer regions of both disks, which fuels the intense star formation and lowers the overall metallicity**
- ➔ The strong inflows happen on timescales of about 10^8 years, and **the most intense star formation and lowest gas phase metallicities are seen generally after the first pericentre passage**
- ➔ **As the star formation proceeds and the merger advances, the dilution reduces and enrichment becomes dominant** - ultimately increasing the metallicity of the circumnuclear gas to a level higher than the initial metallicities of the merging galaxies
- ➔ The "fly-bys" - pairs that interact but do not merge - also cause some dilution



What conditions are needed to reproduce the positive gradients at high z ?