“Semi-analytic galaxies (SAG) model: results on BH and galaxy population”

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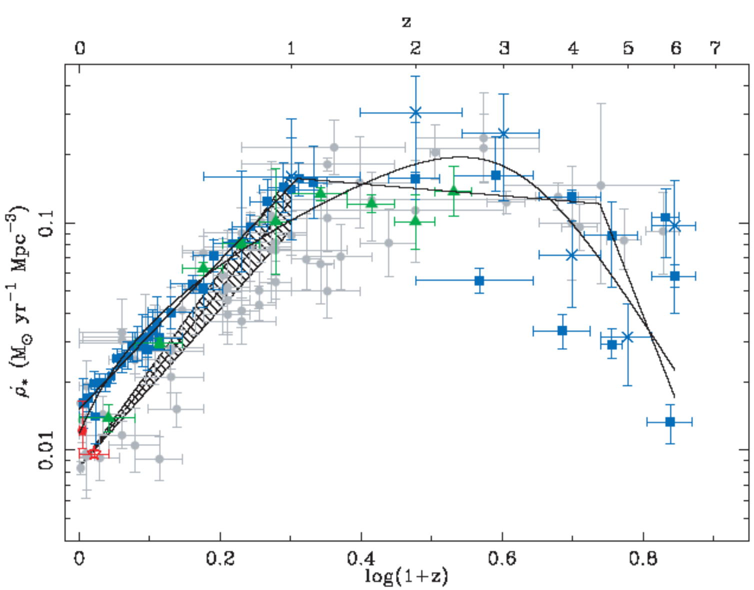
Motivation

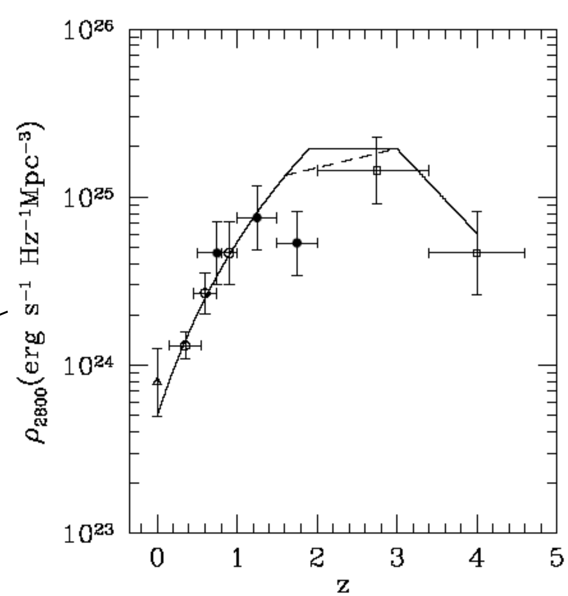
Study AGNs and galaxy population simultaneously

→ Include a BH growth / AGN feedback model based upon the model Cora (2006)

- Starburst activity suggests quasar activity associated (Sanders & Mirabel 1993).
- Global SFR correlated with QSO density (Boyle et al. 1998).

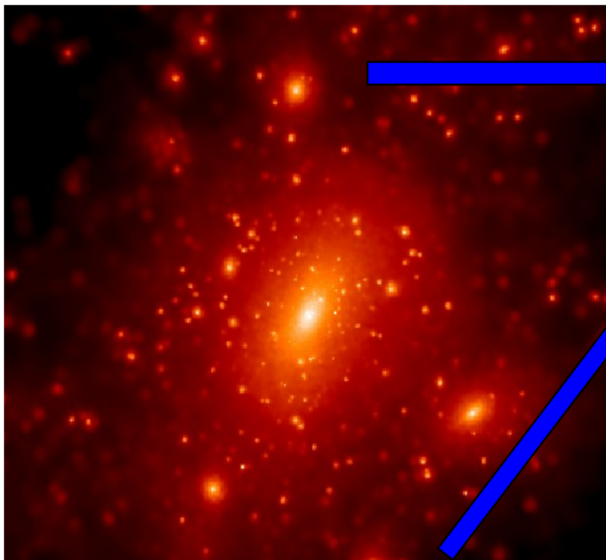


QSO density



The SAG model

AGN introduction over the **semi-analitic model SAG1** (Sofía Cora 2006).
Using latest prescriptions (Croton et al. 2006, Bower et al. 2006, Malbon et al. 2007)



Hot Gas

Cold Gas

$$\dot{M}_{\rm BH} = \kappa_{\rm AGN} \frac{M_{\rm BH}}{10^8 M_\odot} \times \frac{f_{\rm hot}}{0.1} \times \left(\frac{V_{\rm vir}}{200\,{\rm km\,s^{-1}}} \right)^3$$

$$L_{\rm BH} = \eta \dot{M}_{\rm BH} c^2$$

$$\dot{m}'_{\rm cool} = \dot{m}_{\rm cool} - \frac{L_{\rm BH}}{V_{\rm vir}^2/2}$$

AGN feedback

Eddington Limit

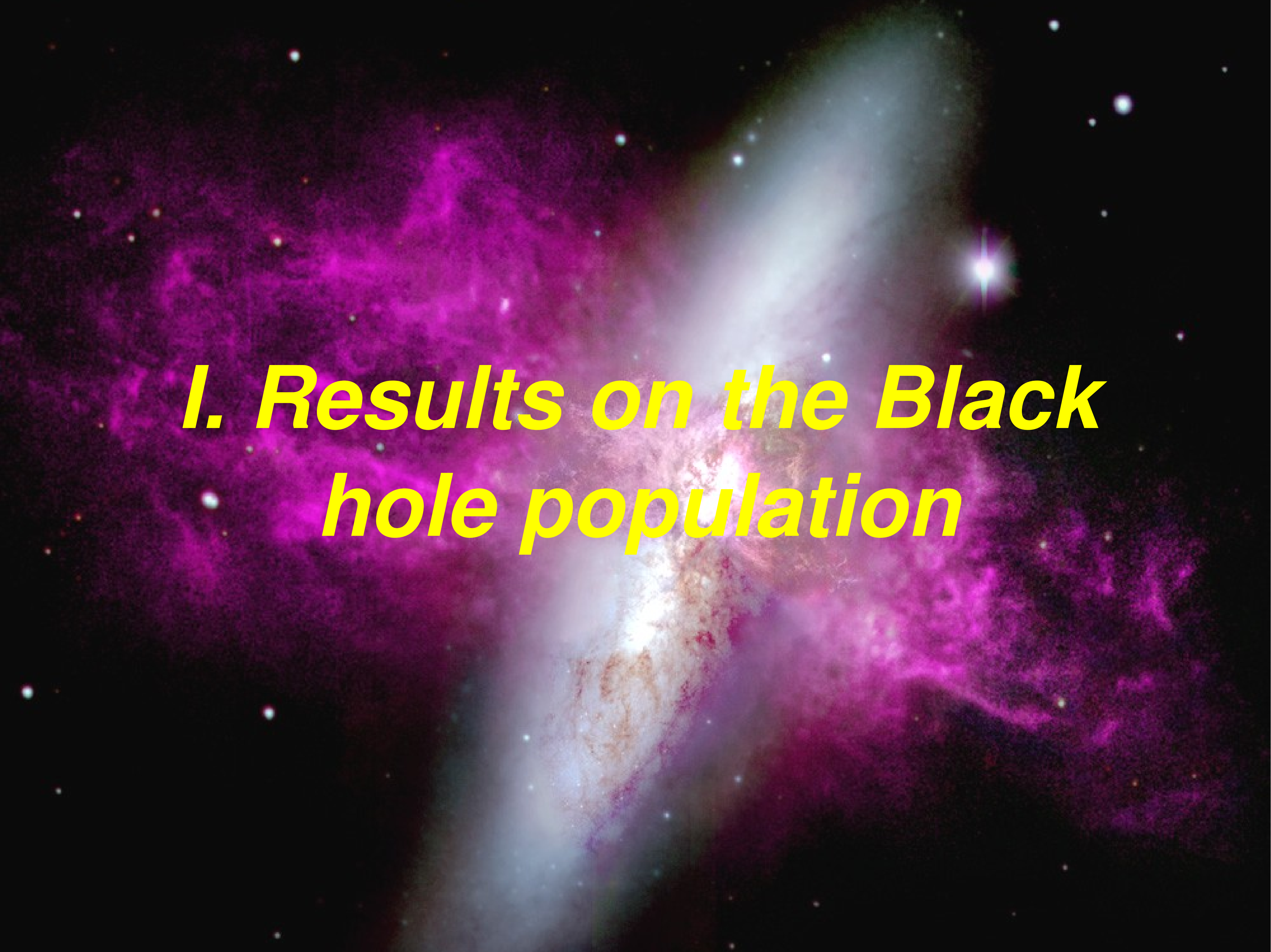
Stars

SNs CC

SNs Ia

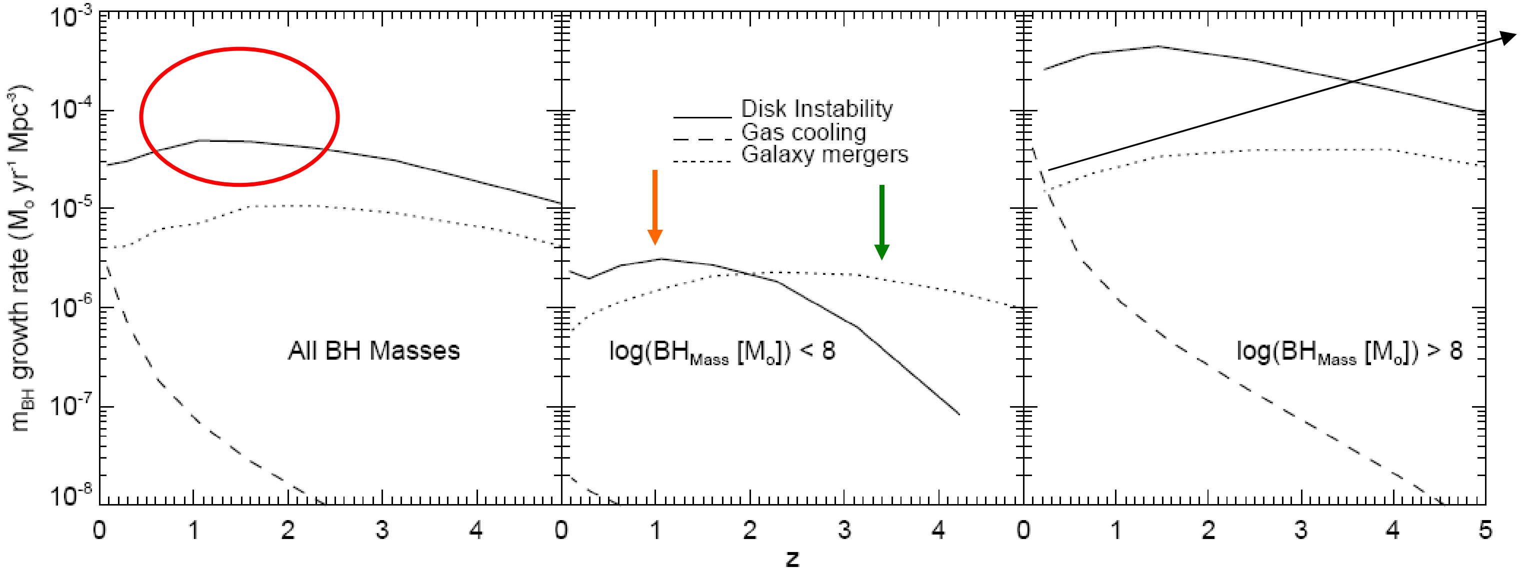
Low- mass

Disc Instabilities (Bower et al. 2006) + **Minor mergers** (Malbon et al. 2007)

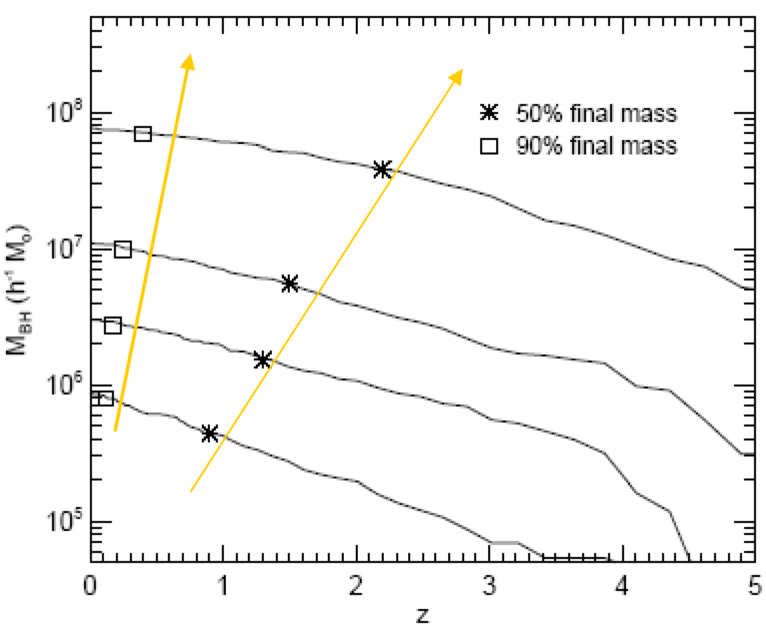

I. Results on the Black hole population

Results: BH growth in SAG2

Lagos, Cora & Padilla (2008, MNRAS, tmp, 736)



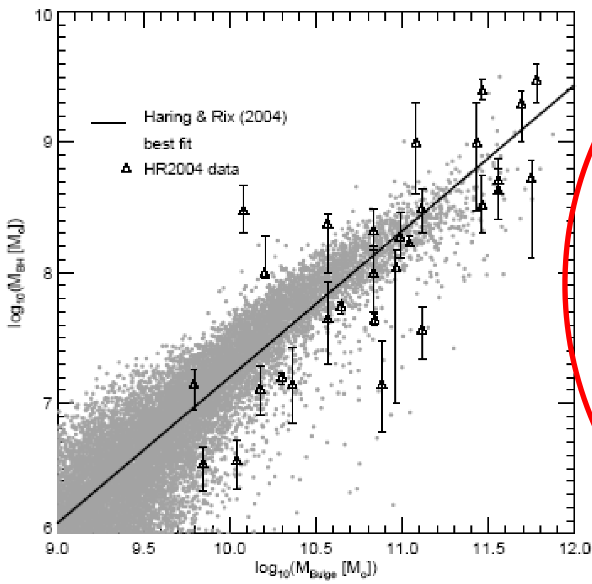
Accretion driven by **gas cooling is always lower but increase at low z**

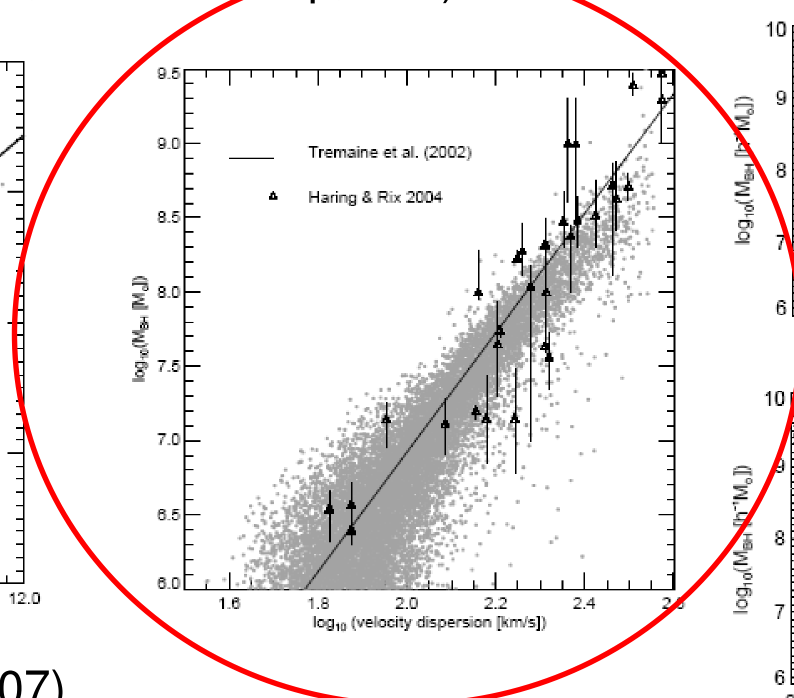


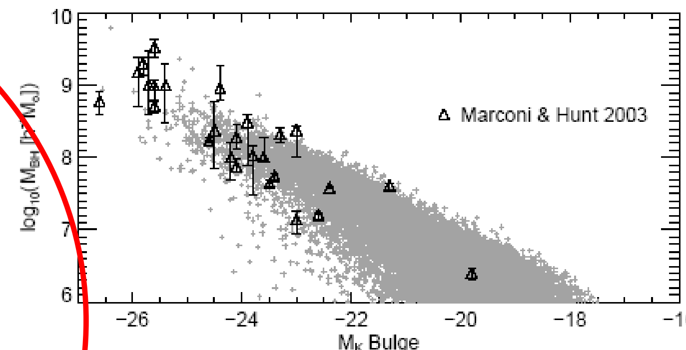
Anti-hierarchical BH growth

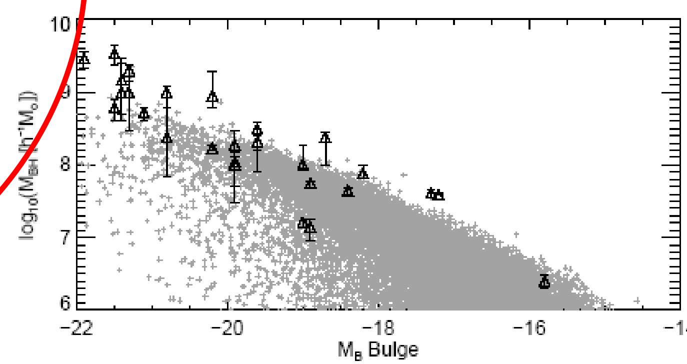
Comparing with observations:
The BH population

Lagos, Cora & Padilla (2008, MNRAS, tmp, 736)

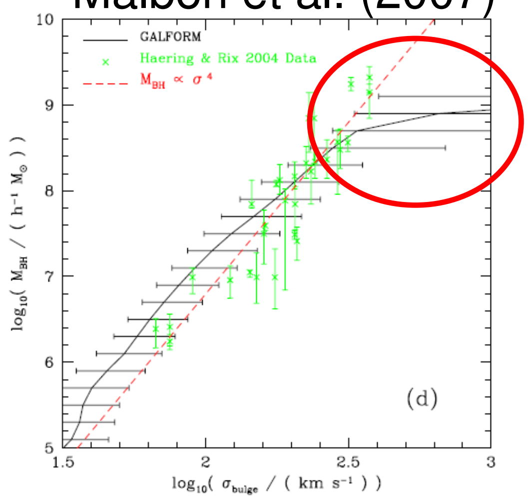




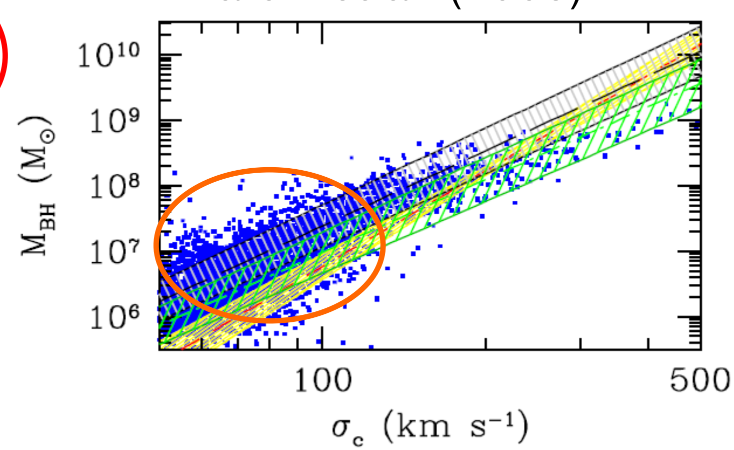




Malbon et al. (2007)



Marulli et al. (2008)



The QSO Luminosity function

Accretion rate → BH luminosity

$$L_{\rm BH} = \eta\, \dot{M}_{\rm BH} c^2$$

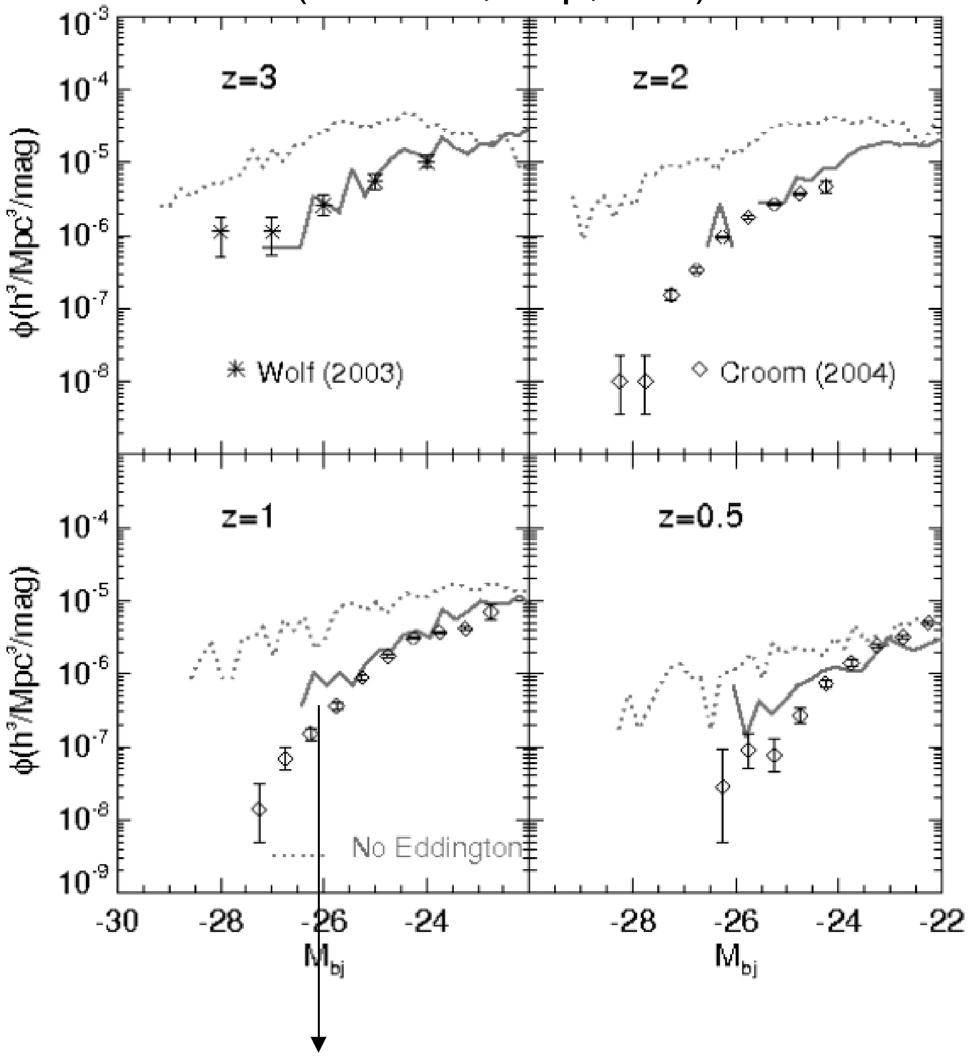
Croom et al. (2005)

$$M_{\rm bJ} = -2.66 \log_{10}(L^{\rm QSO}_{\rm Bolom}) + 79.42$$

Obscured fraction of QSOs = 0.8

(Lacy et al. 2007)

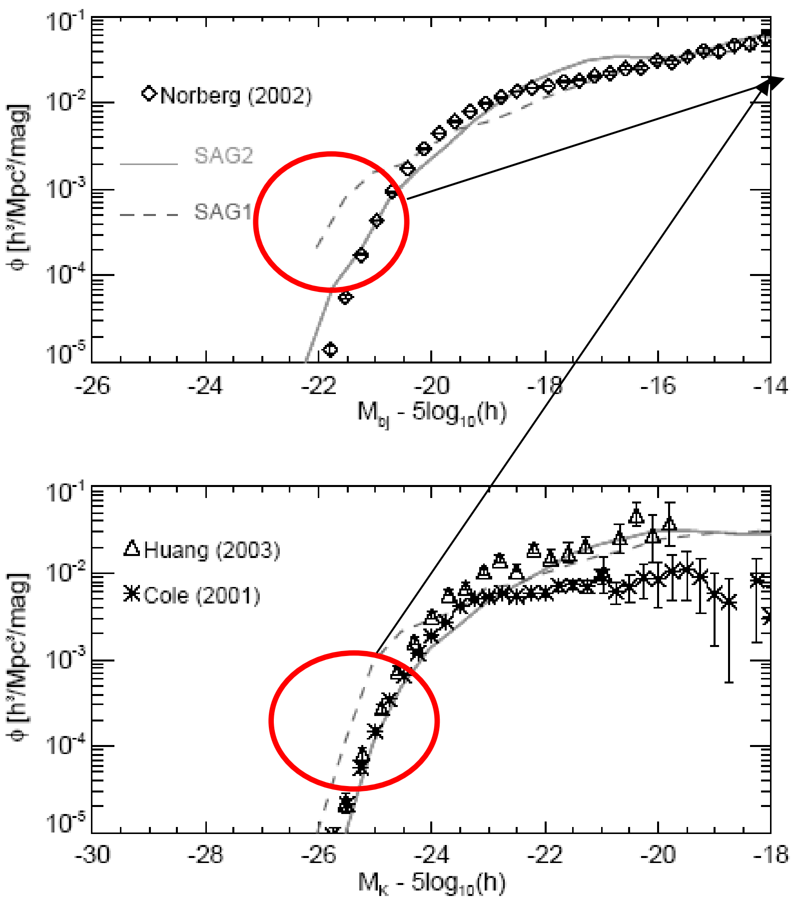
(MNRAS, tmp, 736)



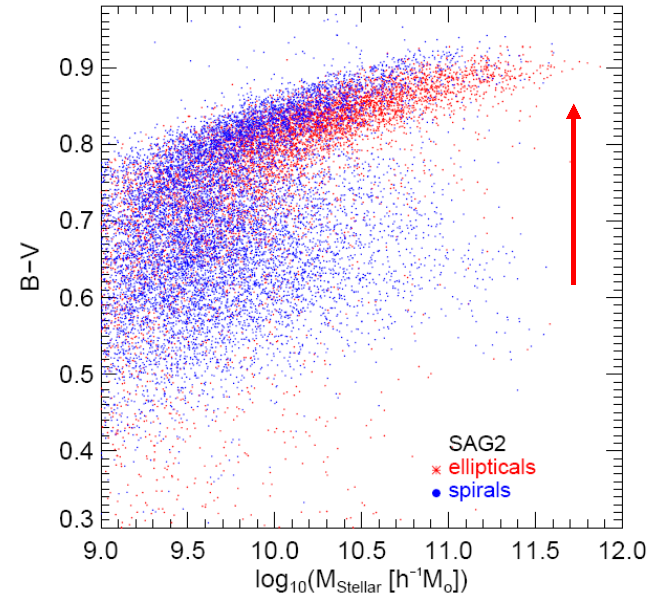
Obscured fraction: Possible dependence on z (Ghandi & Fabian 2003)

II. Results on the Galaxy population

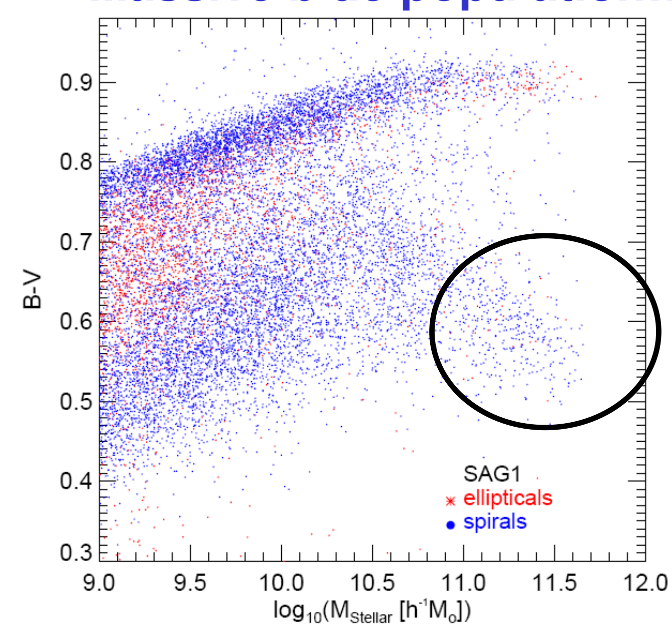
Results: **The galaxy population**



It solves the problem



Massive blue population!!



Lagos, Cora & Padilla (2008, MNRAS, tmp, 736)

Galaxy morphologies

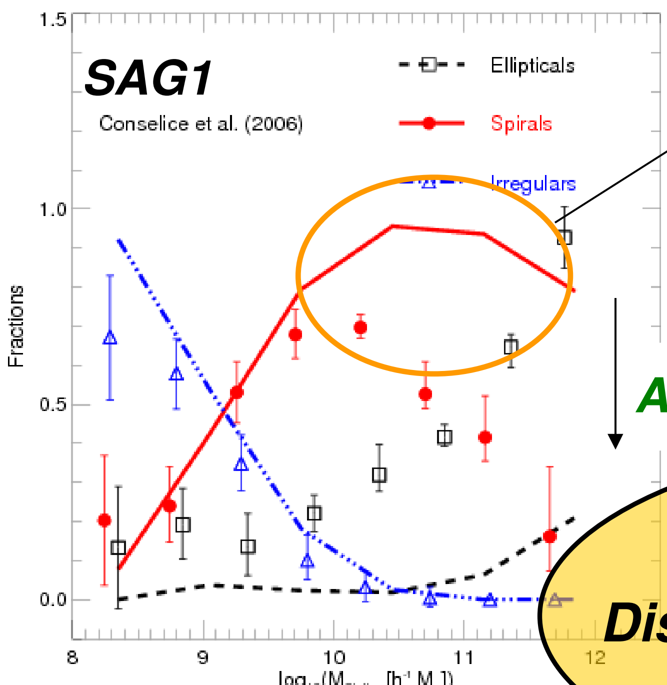
$r = M_{\rm Bulge}/M_{\star}$ Bertone et al. (2007)

→ Greater values of r defines early type galaxies

0.95 < r : ellipticals

0 < r < 0.95: spirals

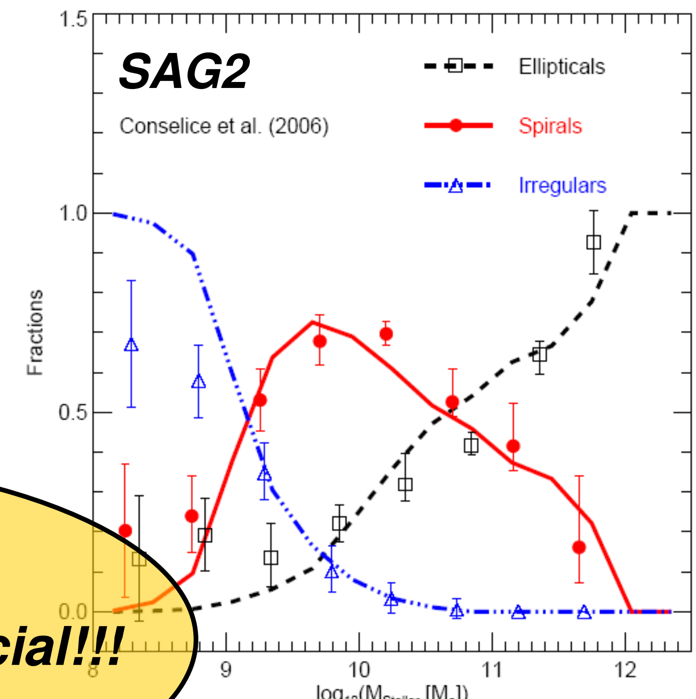
r=0 : Irregulars



SAG1: Excees of spiral galaxies

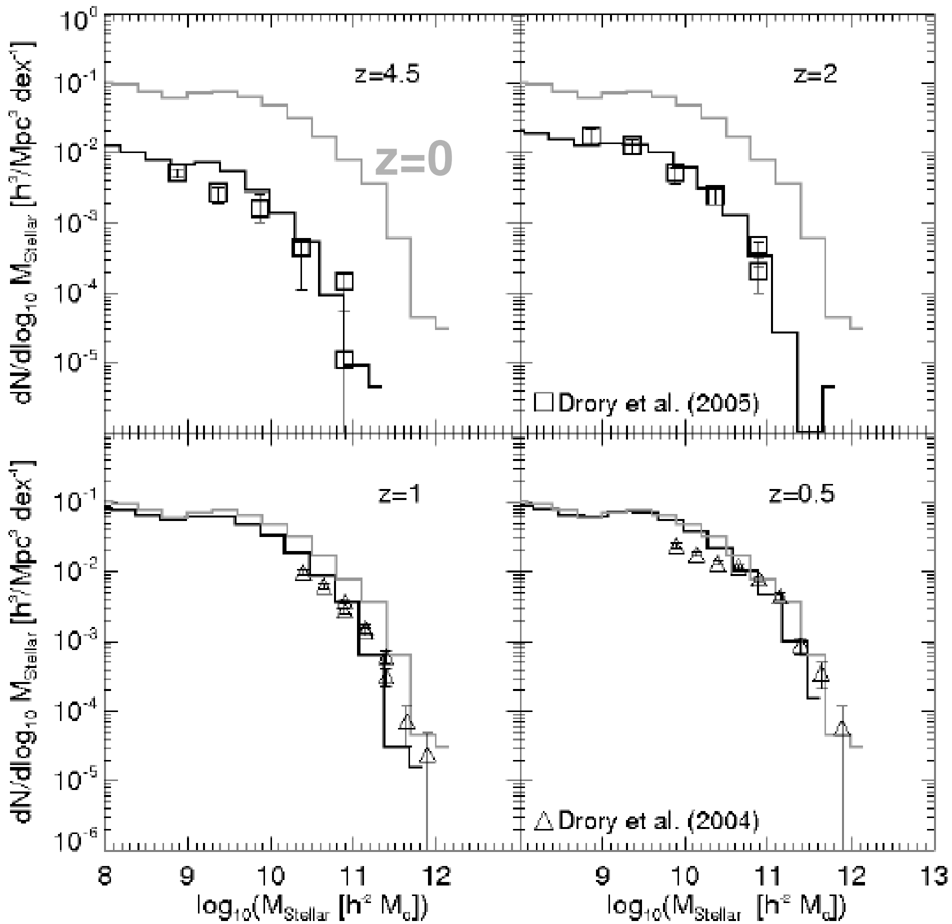
AGN feedback

Disc instabilities are crucial!!!

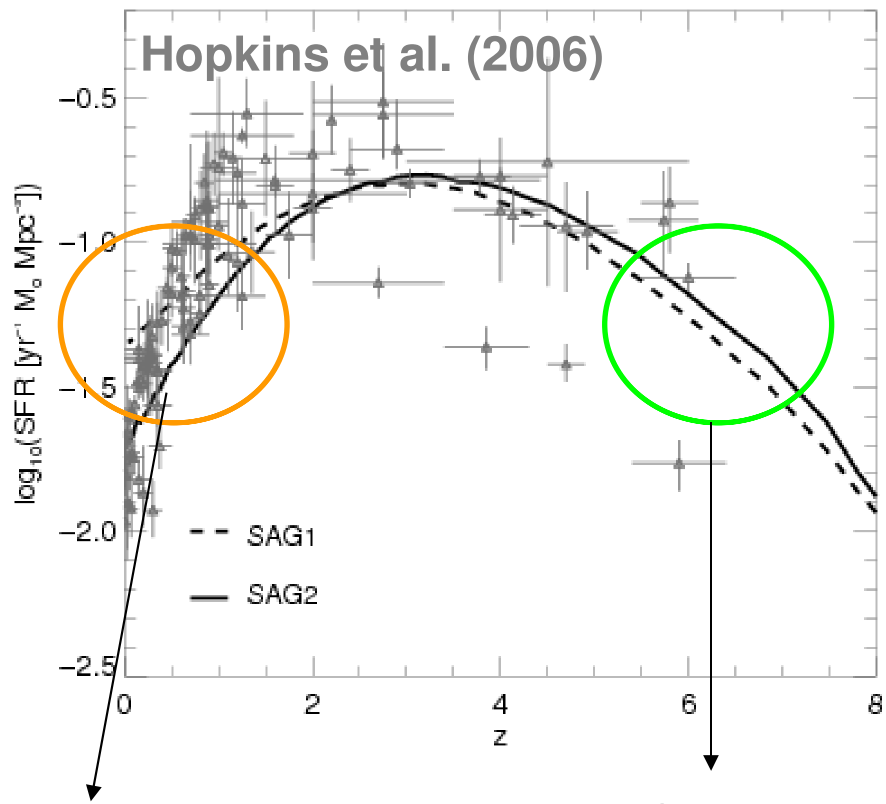


(MNRAS, tmp, 736)

Galaxies at high redshifts



→ **Good agreement at all z!**



AGN feedback

Higher SFR due to SBs in **minor mergers and disc instabilities**

Conclusions and Summary

→ **SUMMARY:** we obtain good agreement with observation in

- **BH behaviours:** → *Anti-hierarchical growth, BH-Bulge relations, QSO LF*
- **Effects on galaxy population:** → *galaxy LF, color bimodality, morphology distribution, Stellar mass function, cosmic SFR*

→ The treatment on disc instabilities is crucial to obtain good agreement with observations

→ *Dynamical range of K_{AGN} is importantly reduced* when we consider a set of observational constraints

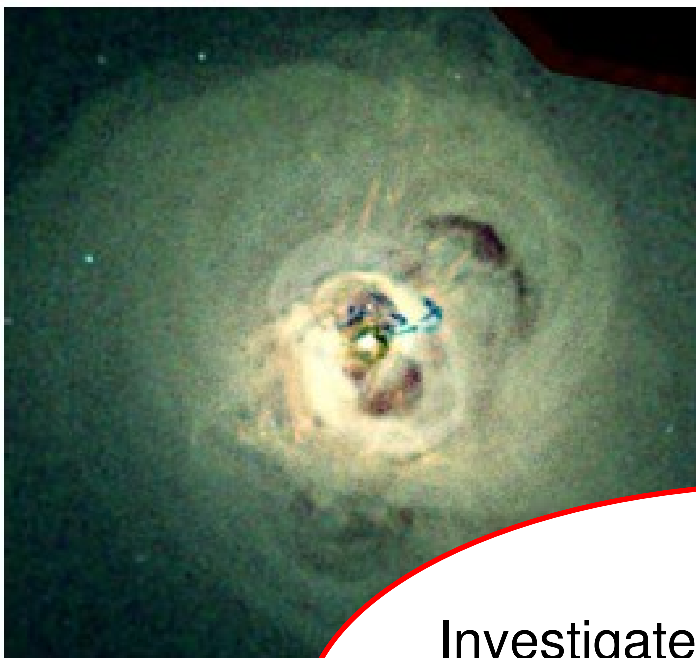
People working in the *SAG* model

- *“The BH Spin paradigm in the SAG model: defining the radio-loudness”* Claudia Lagos, Nelson Padilla, Sofia Cora.
- *“Solving LCDM inconsistences”* Claudia Lagos, Nelson Padilla, Sofía Cora.
- *“QSO properties in the SAG model and the SDSS”* Basilio Solis (PhD, PUC), Nelson Padilla.
- *“Chemical enrichment of the ICM”* Sofía Cora (UNLP), Paolo Tozzi.
- *“The effects of RAM pressure on the galaxy population”* Tomas Tecce (PhD IAFE, Argentina), Sofía Cora.
- *“Star formation rate in the universe”* Roberto González (PhD, PUC).
- *“Comparing SAG and MUSYC galaxies”* Ignacio Araya (undergraduate, PUC), Nelson Padilla.

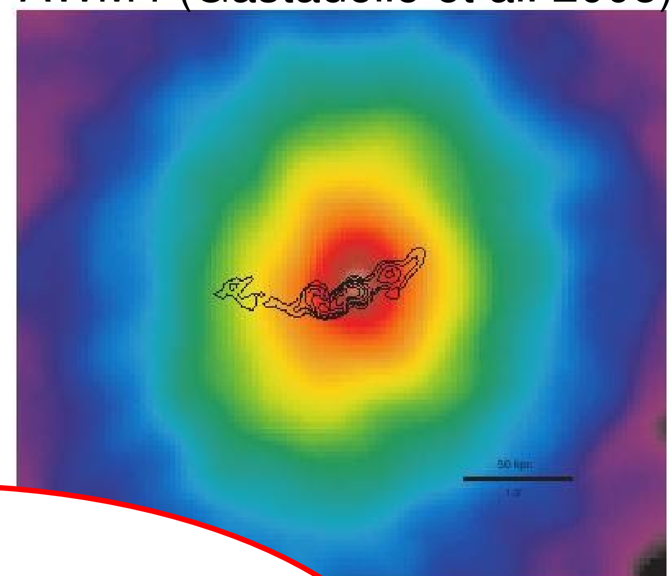
AGN feedback on *QSO mode*

Why to consider that BH low accretion rates are only achieve during gas cooling?

Chandra image of Perseus



AWM4 (Gastadello et al. 2008)



No T gradients

→ No gas cooling

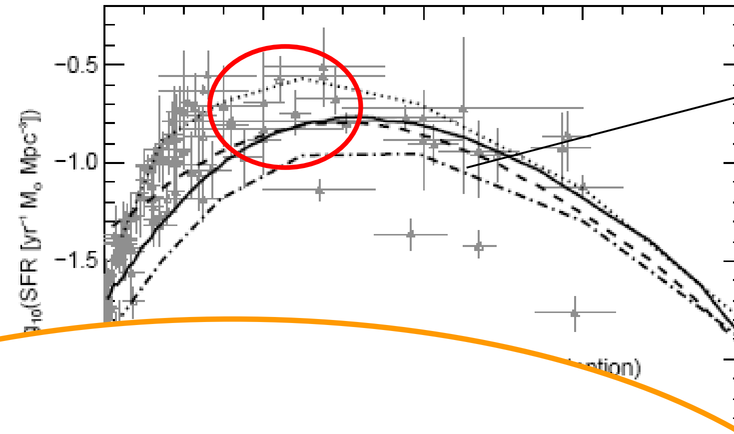
Investigate other possibilities of AGN feedback in galaxy merger or disc instabilities

Results: AGN feedback in QSO mode

$$L_{\rm BH} = \eta\, \dot{M}_{\rm BH} c^2$$

$$\frac{L_{\rm BH}}{V_{\rm vir}^2/2}$$

Retained by the hot gas



Ejection mode: underpredicts

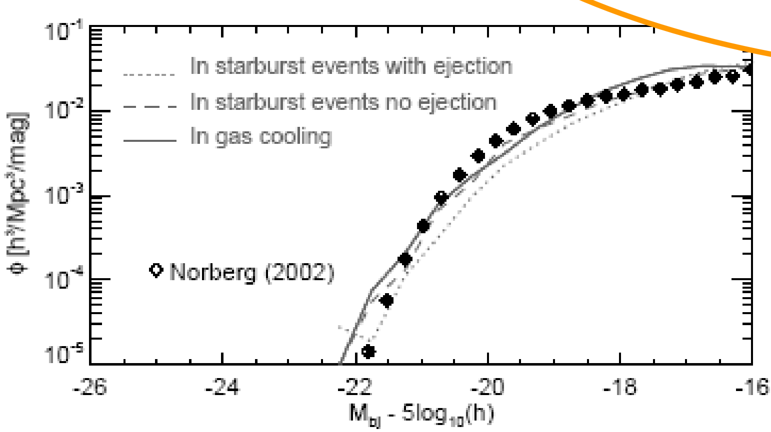
Retention mode

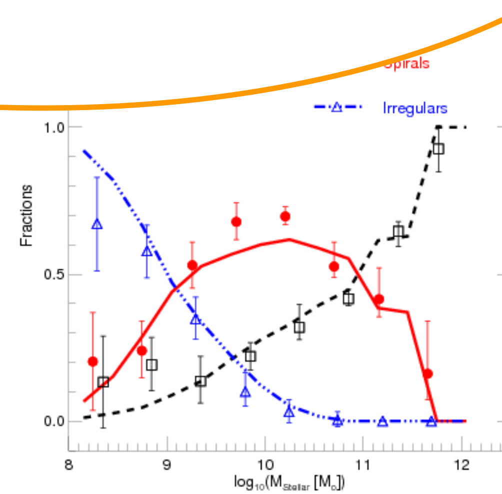
…oduces an "excess"

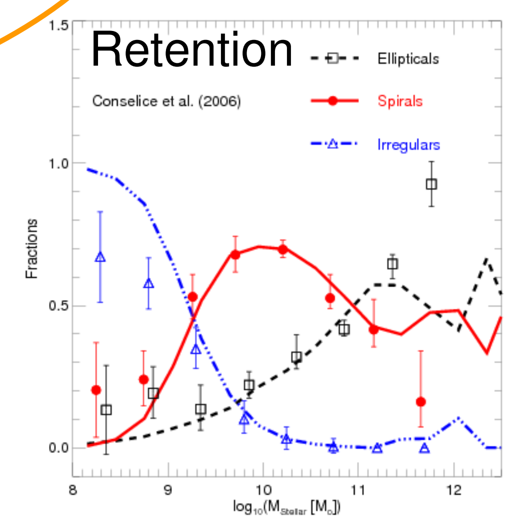
…t gas

Higher K_{AGN}

AGN feedback in the QSO mode must act ejecting all the heated material outside the host halo







The SAG model: *Starburst Processes*

- **Enough massive disk** Disk component is unstable

$$\epsilon = \frac{V_{\rm Max}}{(GM_{\rm Disk}/r_{\rm Disk})^{1/2}} < \epsilon_{\rm DI} \approx 1$$

Disk: Stars + Cold Gas → **New stars** / **BH**

$$\Delta M_{\rm BH,mer} = f_{\rm BH} \frac{M^{\rm sat}}{M^{\rm central}} \times \frac{M_{\rm ColdGas}}{1 + (200\,{\rm km\,s^{-1}}/V_{\rm vir})^2}$$

- **Galaxy fusion**

$$T_{\rm friction} = \frac{1}{2}\frac{f(\epsilon)}{C}\frac{V_{\rm c} r_{\rm c}^2}{G m_{\rm sat} \ln \Lambda}$$

$$\frac{M^{Satellite}}{M^{Central}}$$

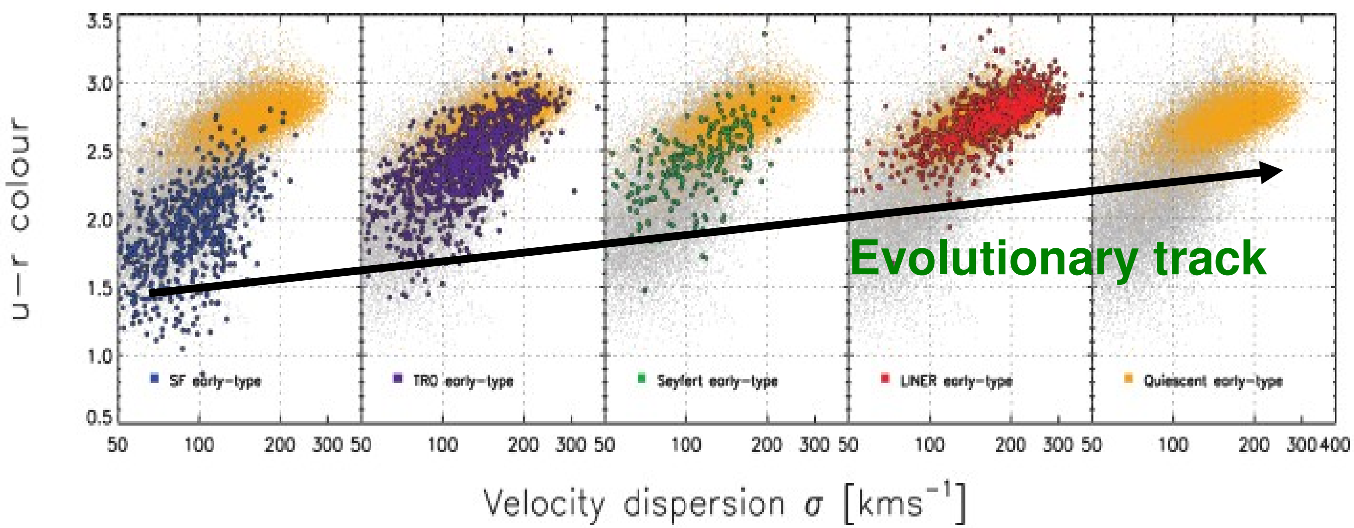
Major Merger: both galaxies → **Disk: Stars + Cold Gas** → **New stars** / **BH**

Minor Merger: **Satellite Stars**

Both galaxies: Cold Gas → **New stars** / **BH**

Statistical study of galaxy population

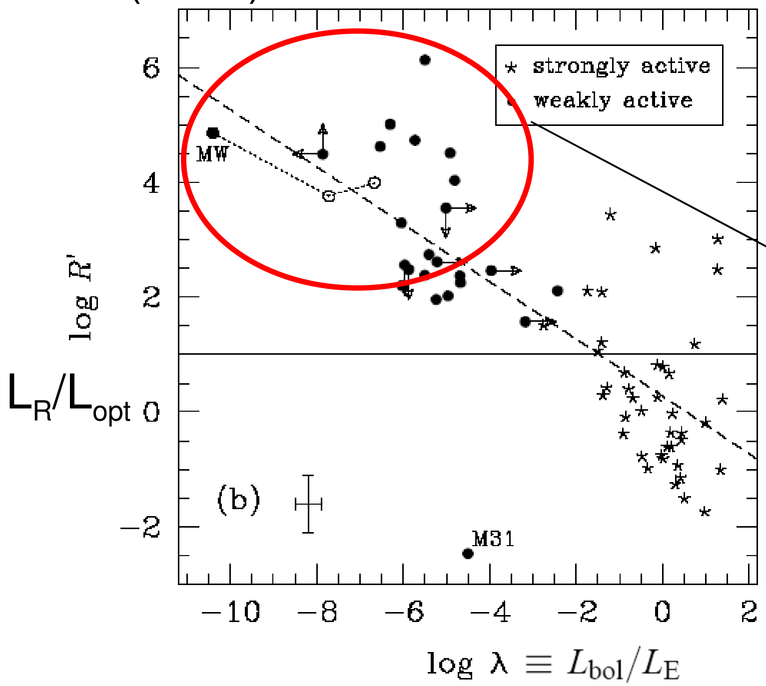
Schawinski et al. (2007): early type SDSS population



Extended SF regions take low time
to decay → AGN feedback

Accretion rate during gas cooling

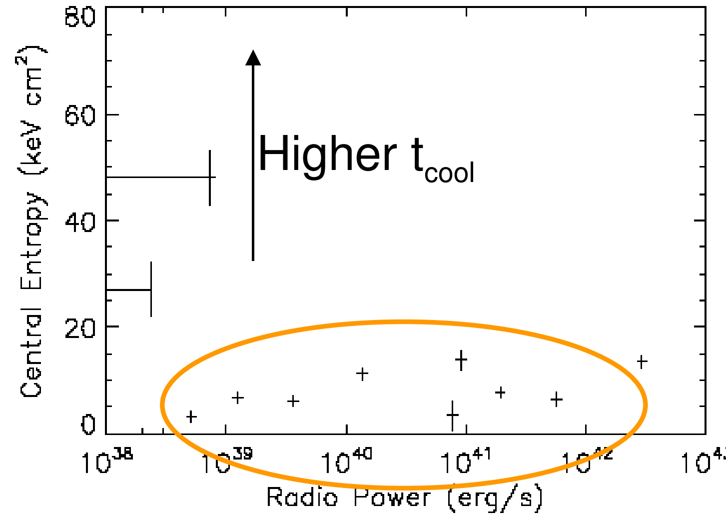
Ho (2002)



Radio-loud systems

→ ***Low accretion rates***

Donahue et al. (2005)



$$\dot{M}_{\rm BH} = \kappa_{\rm AGN} \frac{M_{\rm BH}}{10^8 M_\odot} \times \frac{f_{\rm hot}}{0.1} \times \left(\frac{V_{\rm vir}}{200\,{\rm km\,s^{-1}}} \right)^3 \longrightarrow L_{\rm BH} = \eta \dot{M}_{\rm BH} c^2$$

Gravitational atraction

The gas reservoir

environment

EDDINGTON LIMIT

The Dark Matter Simulation

→ In concordance with the LCDM cosmology

- Ran by Roberto González (PUC). GADGET-2
- Box size 60 Mpc/h
- Resolution 1 x 10^9 M_o/h and M_{max} 6 X 10^{14} M_o
- Postprocessing code by V. Springel (MPA)