Massive relic galaxies challenge the co-evolution of SMBHs and their host galaxies

by

Anna Ferré-Mateu,

Subaru Telescope

And

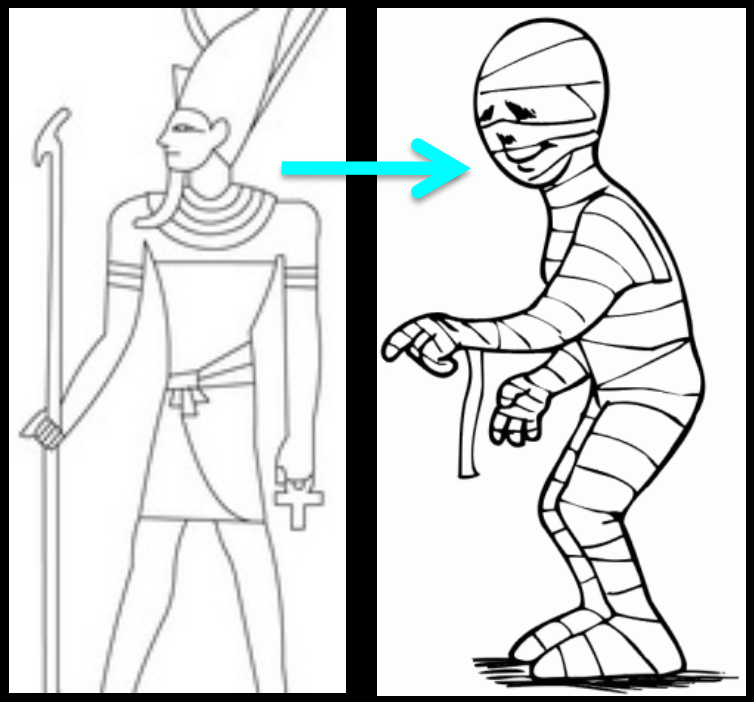
I. Trujillo (IAC), M. Mezcua (CfA), M. Balcells (ING)

& R. van den Bosch (MPIA)

EWASS, S3, Monday 22nd June 2015

What is a relic galaxy?

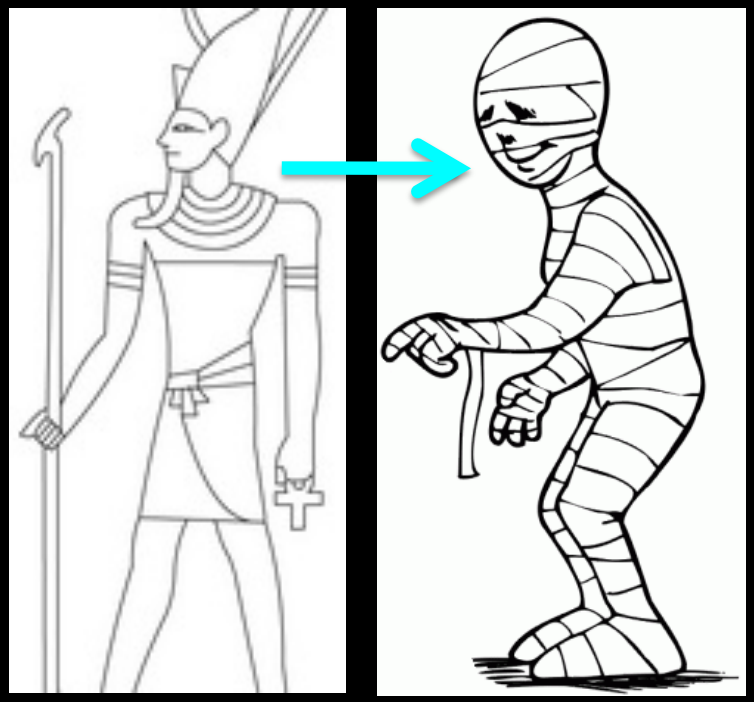
We consider a galaxy in the nearby Universe is a *relic* if…



…has not been altered at ALL
after its formation at high-z
= frozen over cosmic time

WHAT IS A RELIC GALAXY?

We consider a galaxy in the nearby Universe is a *relic* if…



…has not been altered at ALL after its formation at high-z = frozen over cosmic time

SAME properties than those galaxies we see in the early Universe (z>2):

1. *Massive*:
   $M^* > 10^{11}$ Msun

2. *Compact*:
   $R_e < 2$ kpc

3. *Old at all radii*:
   Age > 10 Gyr

Finding a relic galaxy hasn't been easy…

See e.g.
Trujillo+09, Taylor+10, Valentinuzzi+10, Ferré-Mateu+12, Trujillo +12, Damjanov+13, Poggianti+13, Damjanov+15,…

and Trujillo's & Damjanov's Talks

NGC1277

NGC1277

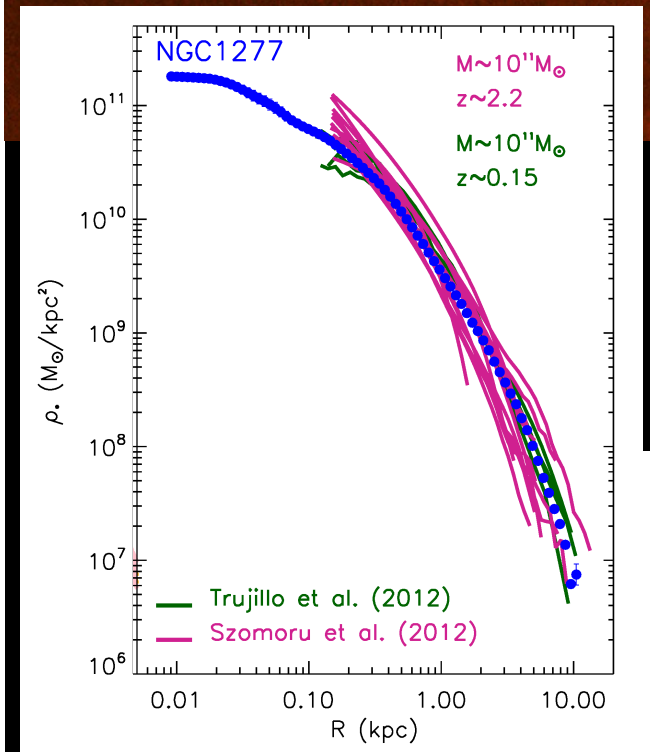
$M_* = 1.2 \times 10^{11} M_{sun}$

$R_e = 1.2$ kpc

$\sigma > 330$ km/s

$V_{rot} > 300$ km/s

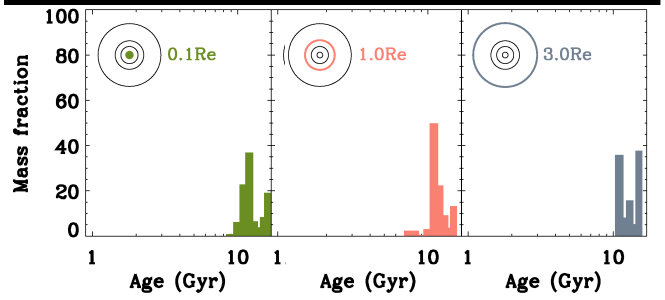
Age > 10 Gyr out to 3Re

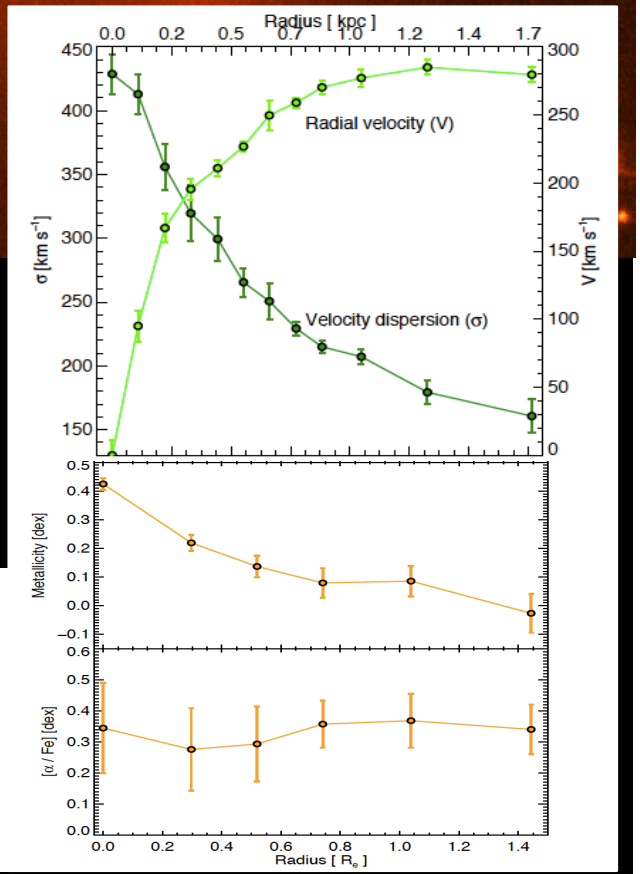


van den Bosch +12

Trujillo +14

Martin-Navarro +15





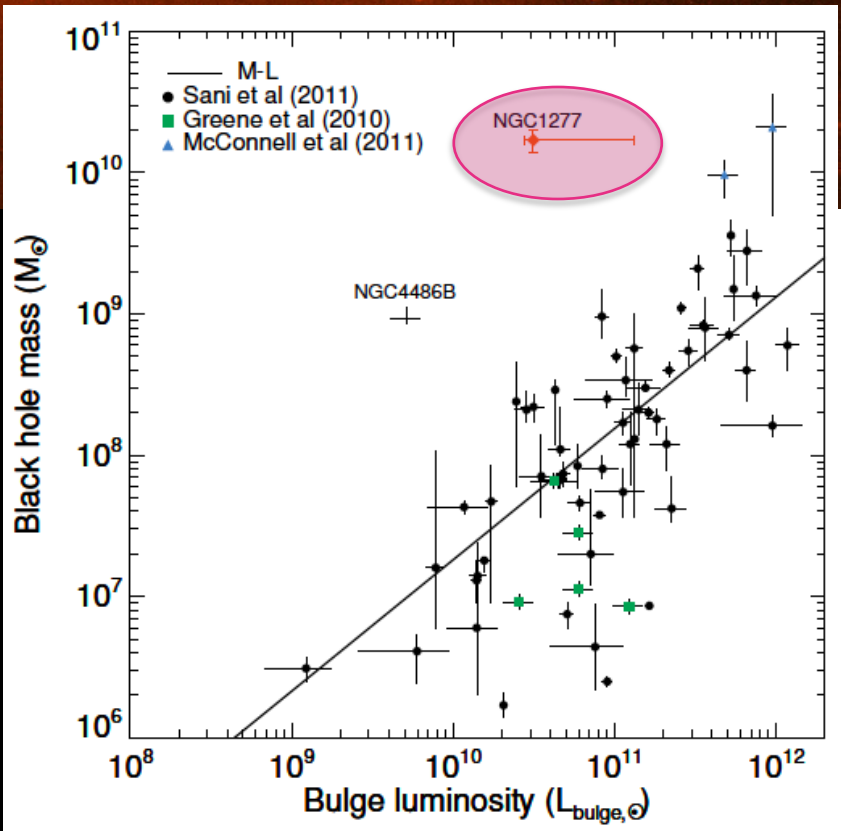
NGC1277

$M_\bullet = 1.7 \times 10^{10}\ M_{sun}$

$\rightarrow M_\bullet / M^* \sim 0.02$

x 4 more massive!

van den Bosch +12



NGC1277

$M_\bullet = 1.7 \times 10^{10}\ M_{sun}$
→ $M_\bullet / M^* \sim 0.02$

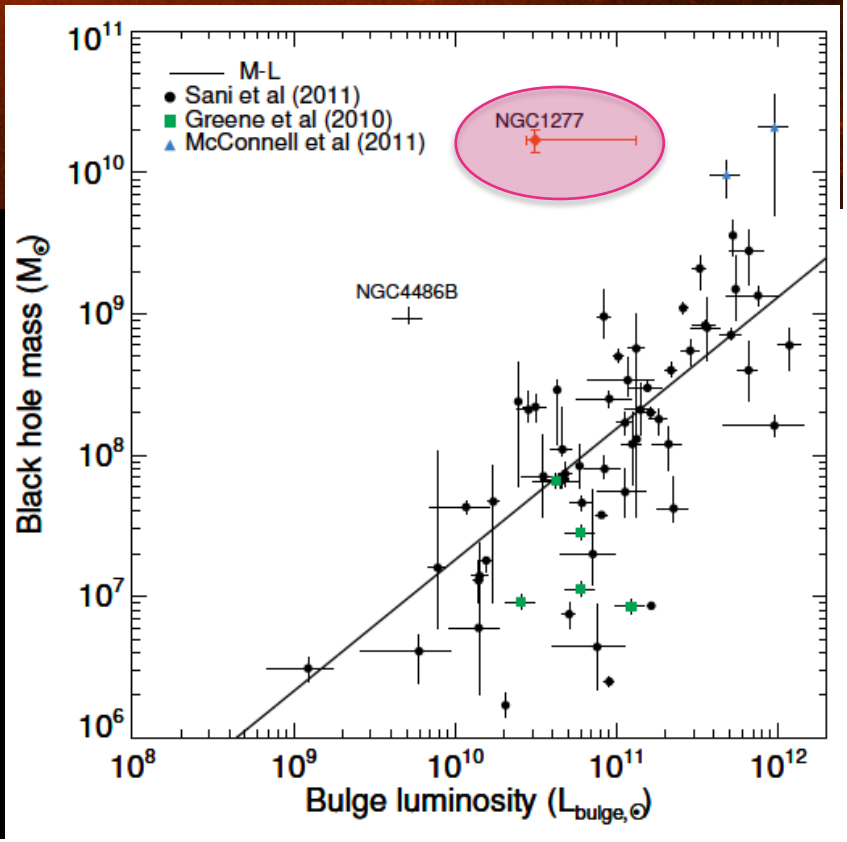
x 4 more massive!

van den Bosch +12

What is wrong with this extreme SMBH?

(Läsker+13, Emsellem+13, Yildirim+15)

1) Effect of the **IMF** → negligible (Martin-Navarro+15)
2) **Upper limit** from the Virial → with dynamical models $M_\bullet = 12 \times 10^9\ M_{sun}$ (Yildirim+15)



Relic galaxies and SMBHs:
Co-evolution or not?

Massive relic galaxies are outliers in the SMBH scaling relations because they follow a different evolutionary path

Ferré-Mateu et al. 2015 (ApJ, accepted, arxiv: 150602663)

THE SAMPLE

Galaxies from the HETMG Survey (van den Bosch+15) that are good candidates to host a SMBH:

- To have $M_{vir} > 4 \times 10^9 M_{sun}$
- To be nearby enough to resolve the BH
- To lay far beyond the 3σ deviation
- To have SDSS spectra

Ferré-Mateu +15

THE SAMPLE

Galaxies from the HETMG Survey (van den Bosch+15) that are good candidates to host a SMBH:

- To have $M_{vir} > 4 \times 10^9 M_{sun}$
- To be nearby enough to resolve the BH

→ 174 galaxies (Re~4kpc)

- To lay far beyond the 3σ deviation
- To have SDSS spectra

Ferré-Mateu +15

THE SAMPLE

Galaxies from the HETMG Survey (van den Bosch+15) that are good candidates to host a SMBH:

- To have $M_{vir} > 4 \times 10^9 M_{sun}$
- To be nearby enough to resolve the BH

→ 174 galaxies (Re~4kpc)

- To lay far beyond the 3σ deviation

→ 30 galaxies (Re~2kpc)

- To have SDSS spectra

Ferré-Mateu +15

THE SAMPLE

Galaxies from the HETMG Survey (van den Bosch+15) that are good candidates to host a SMBH:

- To have $M_{vir} > 4 \times 10^9 M_{sun}$
- To be nearby enough to resolve the BH

→ 174 galaxies (Re~4kpc)

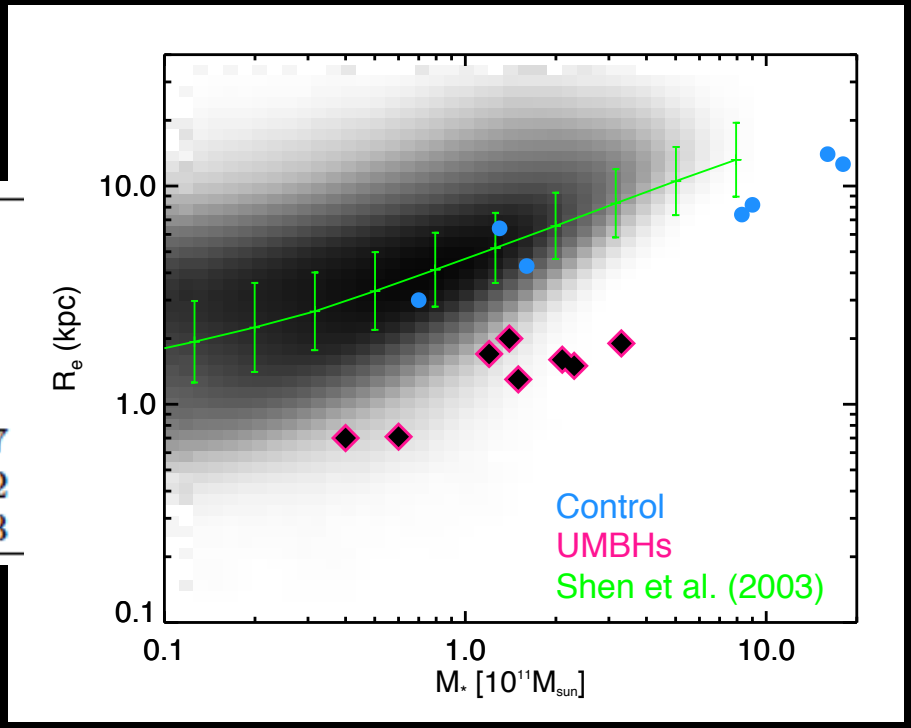
- To lay far beyond the 3σ deviation

→ 30 galaxies (Re~2kpc)

- To have SDSS spectra

→ 8 ÜMBH candidates

NGC1270
NGC1271
NGC1277
NGC1281
NGC2767
PGC012557
PGC012562
PGC032873



Ferré-Mateu +15

THE SAMPLE

Galaxies from the HETMG Survey (van den Bosch+15) that are good candidates to host a SMBH:

- To have $M_{vir} > 4 \times 10^9 M_{sun}$
- To be nearby enough to resolve the BH

→ 174 galaxies (Re~4kpc)

- To lay far beyond the 3σ deviation

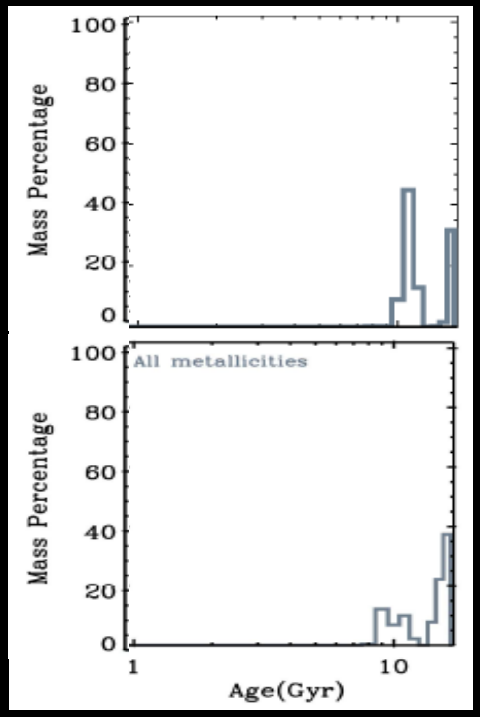
→ 30 galaxies (Re~2kpc)

- To have SDSS spectra

→ 8 ÜMBH candidates

✓ SFH → compatible with being relic galaxies

✓ Lower limit of SMBH formation at ~ 10 Gyr



Ferré-Mateu +15

THE SAMPLE

Galaxies from the HETMG Survey (van den Bosch+15) that are good candidates to host a SMBH:

- To have $M_{vir} > 4 \times 10^9 M_{sun}$
- To be nearby enough to resolve the BH

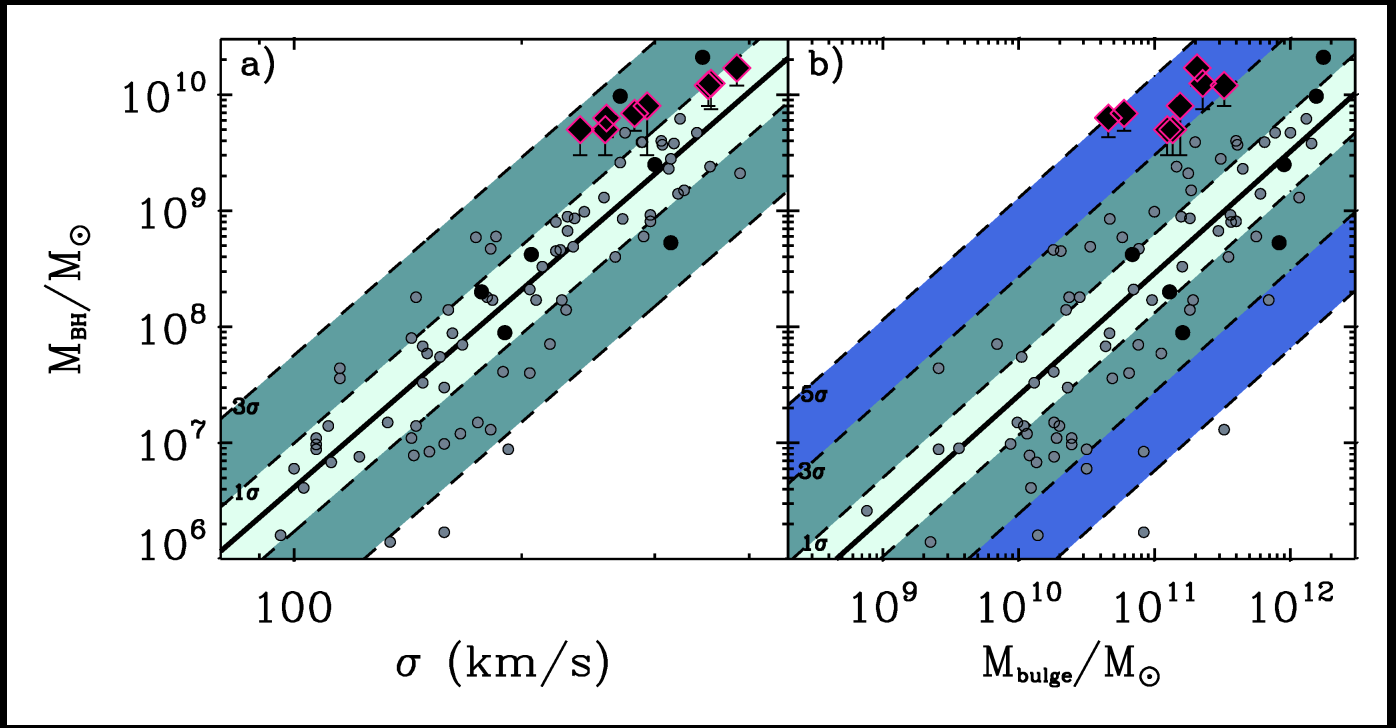
→ 174 galaxies (Re~4kpc)

- To lay far beyond the 3σ deviation

→ 30 galaxies (Re~2kpc)

- To have SDSS spectra

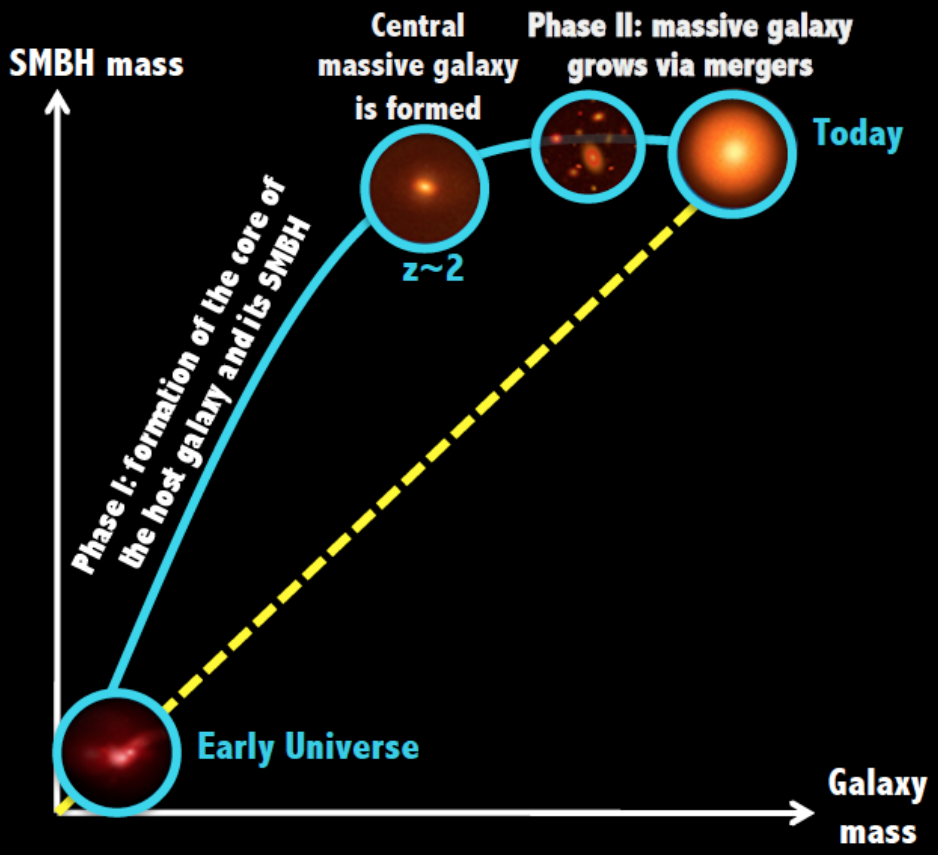
→ 8 ÜMBH candidates



Ferré-Mateu +15

Massive relic galaxies are outliers in the SMBH scaling relations because they follow a different evolutionary path

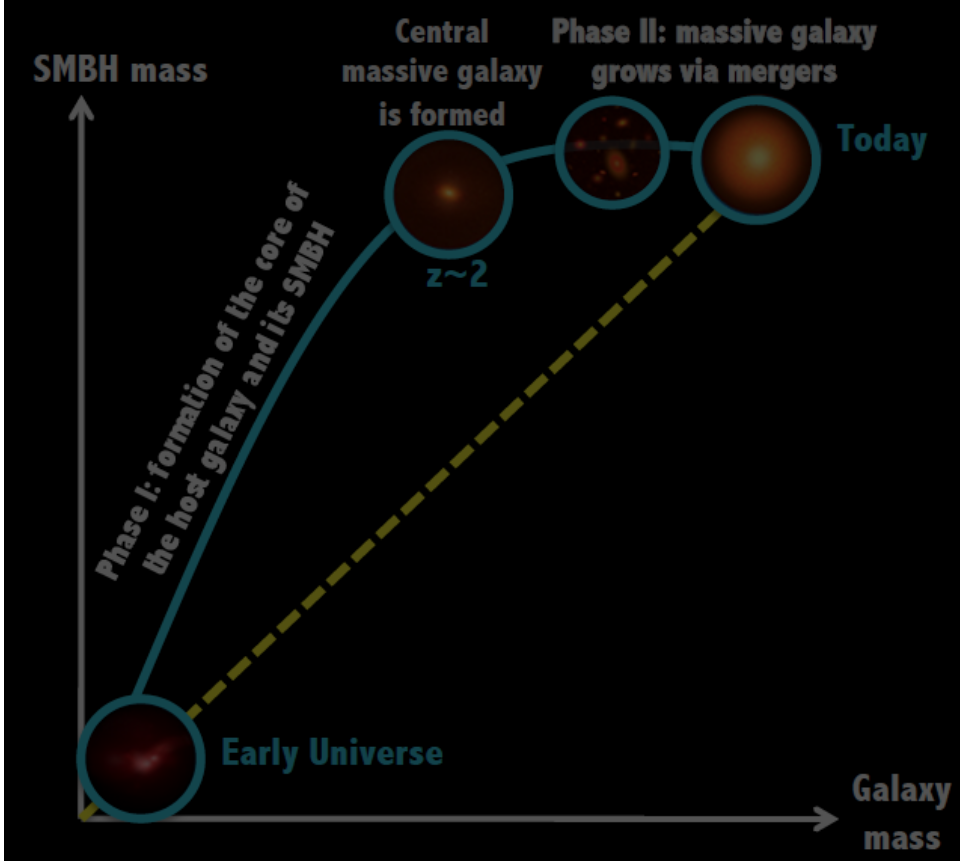
Ferré-Mateu et al. 2015



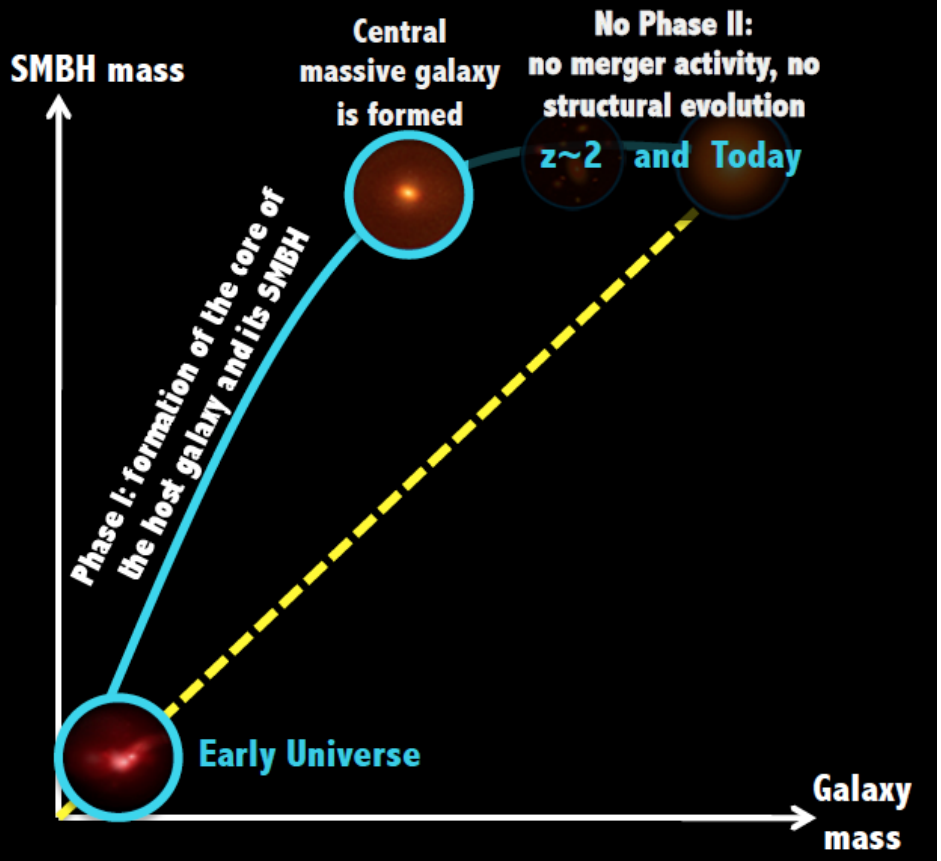
Massive galaxy evolutionary track

Massive relic galaxies are outliers in the SMBH scaling relations because they follow a different evolutionary path

Ferré-Mateu et al. 2015



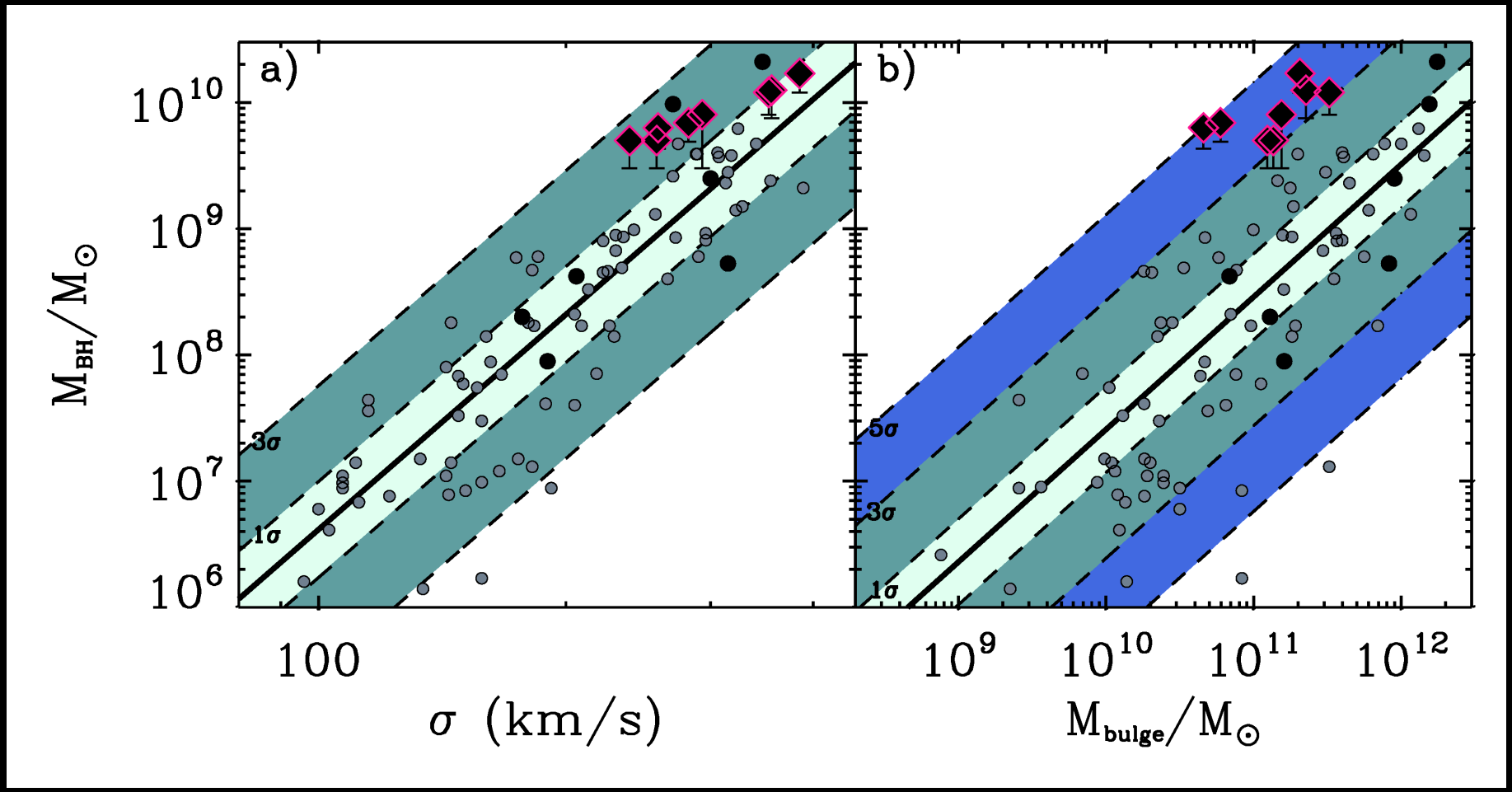
Massive galaxy evolutionary track



Relic galaxy evolutionary track

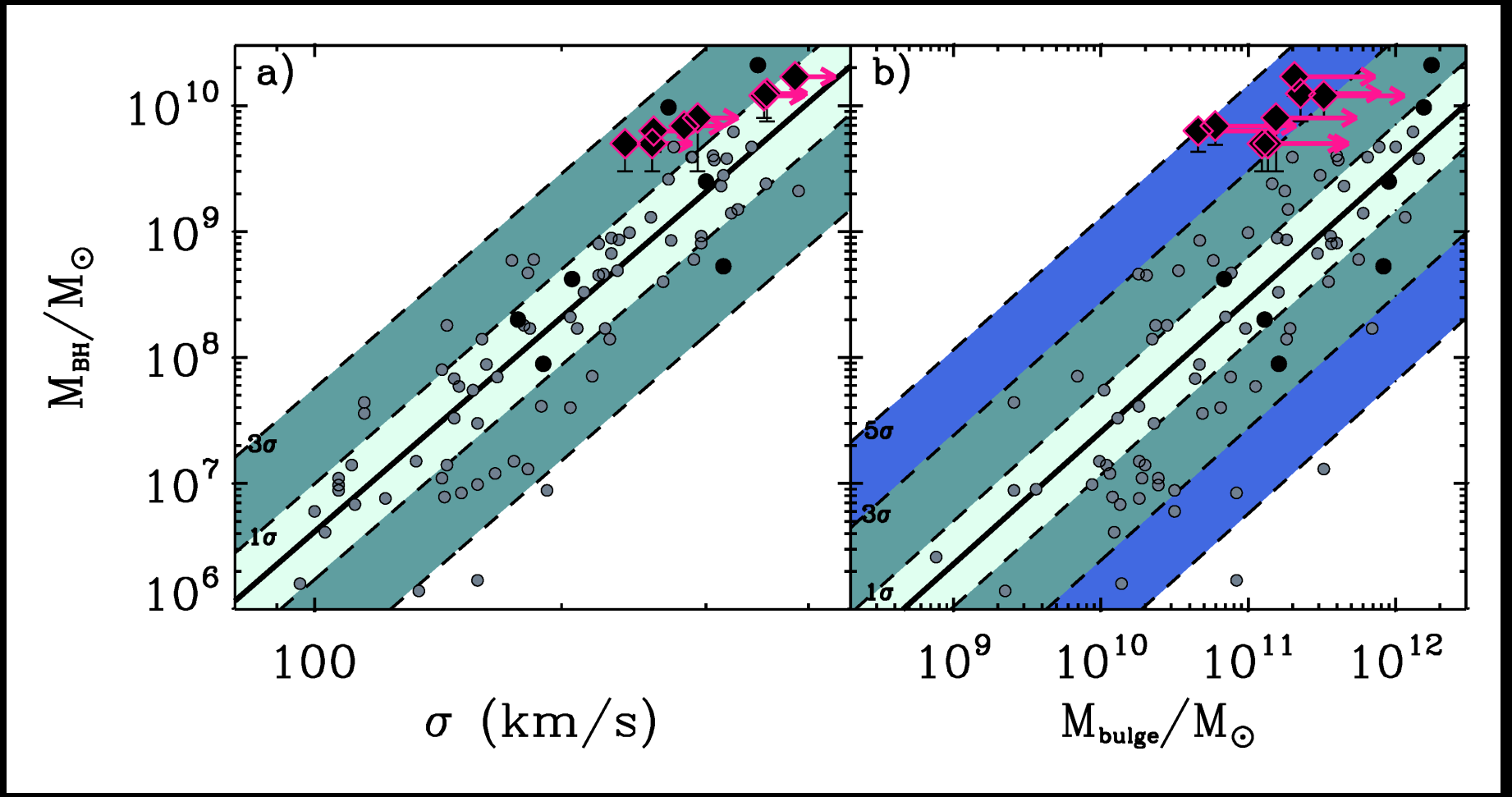
Relic galaxies are outliers in the SMBH scaling relations because they follow a different evolutionary path

Ferré-Mateu et al. 2015



Relic galaxies are outliers in the SMBH scaling relations because they follow a different evolutionary path

Ferré-Mateu et al. 2015



Size x 7

- Velocity dispersion x1.1 (Oogi&Habe+13, Wellons+15, Tapia+15)
- Stellar masses x5 (Oser+10+12,Trujillo+11,Hilz+12)

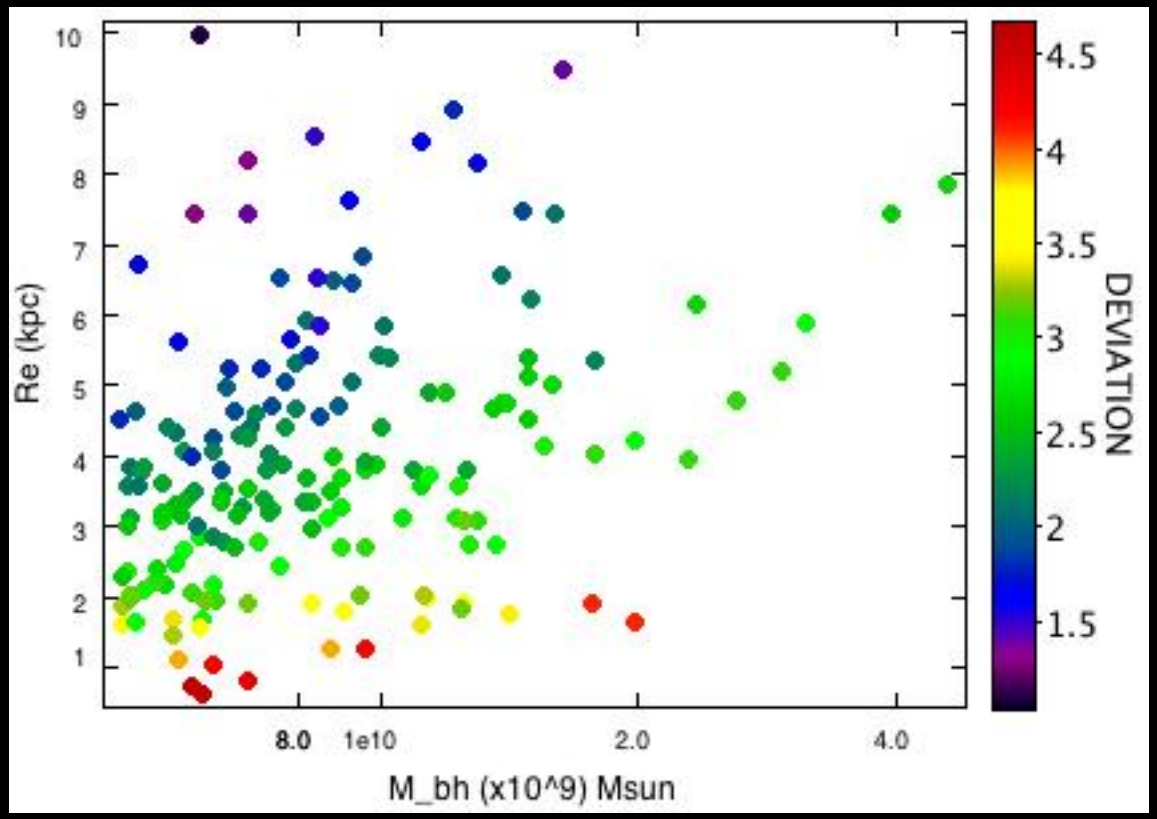
SUMMARY

1) Massive relic galaxies are extreme outliers in the SMBHs scaling relations because they follow another evolutionary path than large massive ellipticals

2) Limit for SMBH formation at ~10Gyr

3) Possible way to detect the elusive relic galaxies

4) The SMBH and the host galaxy should not co-evolve


Re (kpc)
10
9
8
7
6
5
4
3
2
1
8.0
1e10
2.0
4.0
M_bh (x10^9) Msun
DEVIATION
4.5
4
3.5
3
2.5
2
1.5