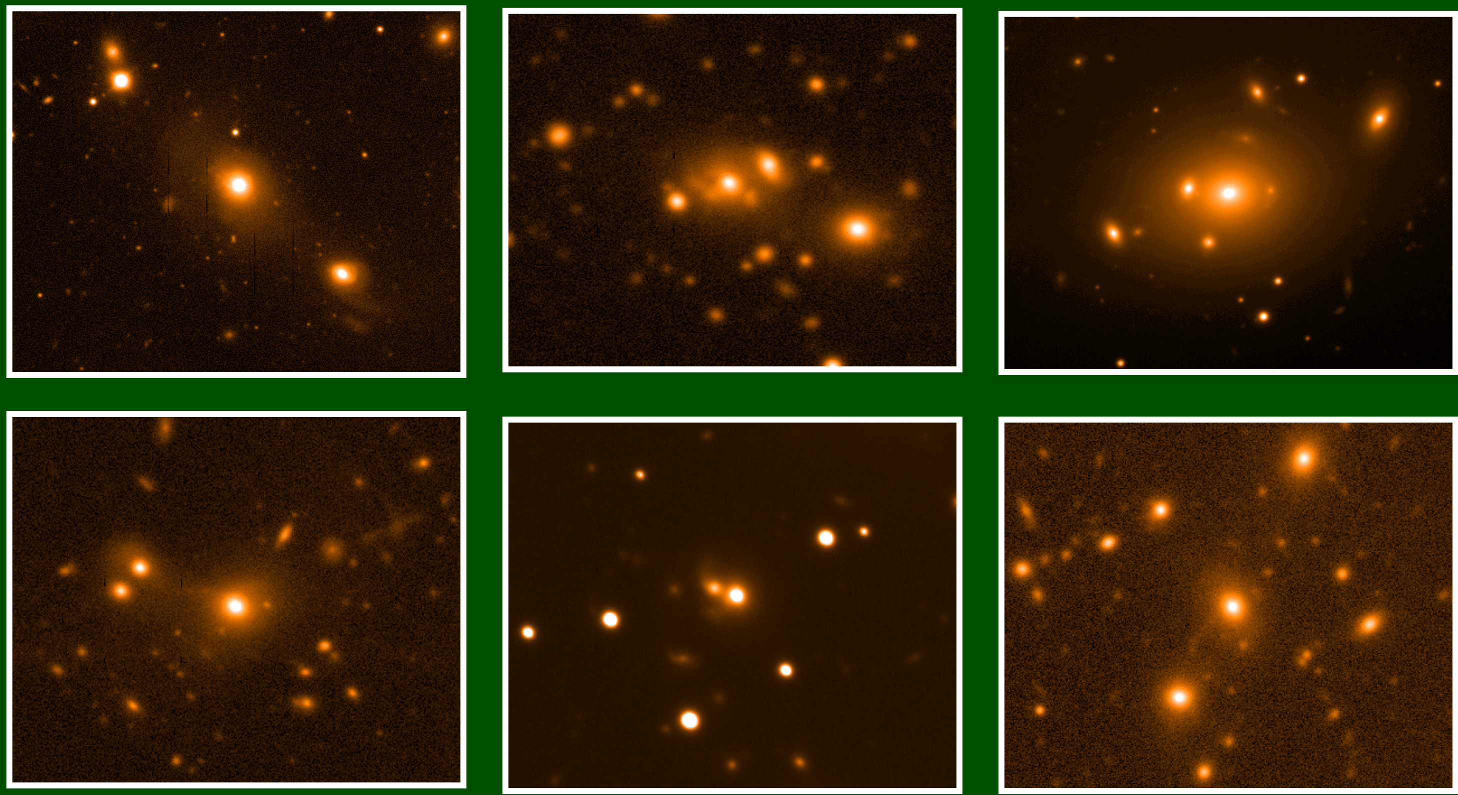
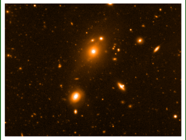
The environments of radio-loud and radio-quiet quasars



Cristina Ramos Almeida – Marie Curie Fellow @ IAC

Clive Tadhunter, Patricia Bessiere, K. Inskip, R. Morganti,

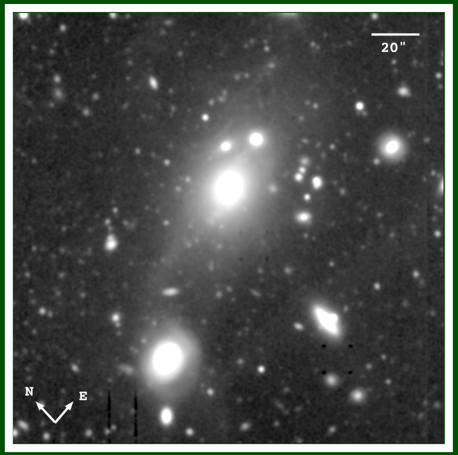
D. Dicken, I. González Serrano and J. Holt

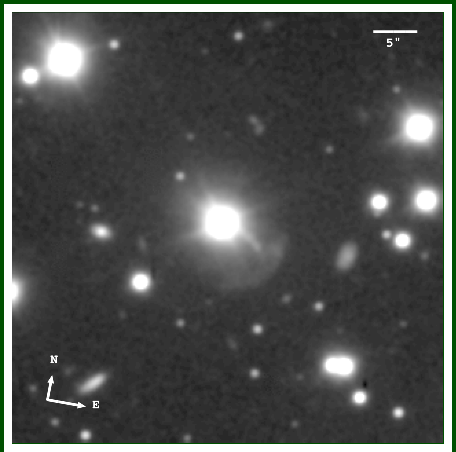


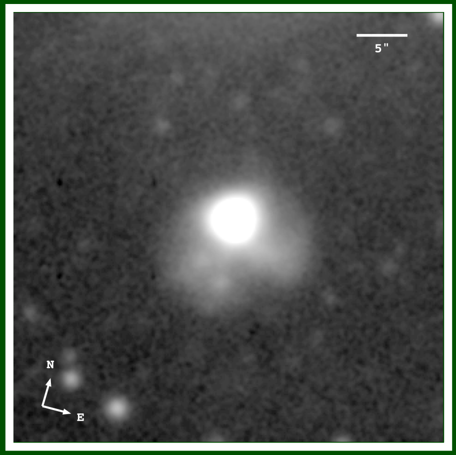
Outline

The triggering mechanisms for Active Galactic Nuclei

- Galaxy interactions as the triggers for radio-quiet and radio-loud nuclear activity.
- Galaxy interactions in active and quiescent galaxy samples.
- The environments of radio-quiet and radio-loud activity.



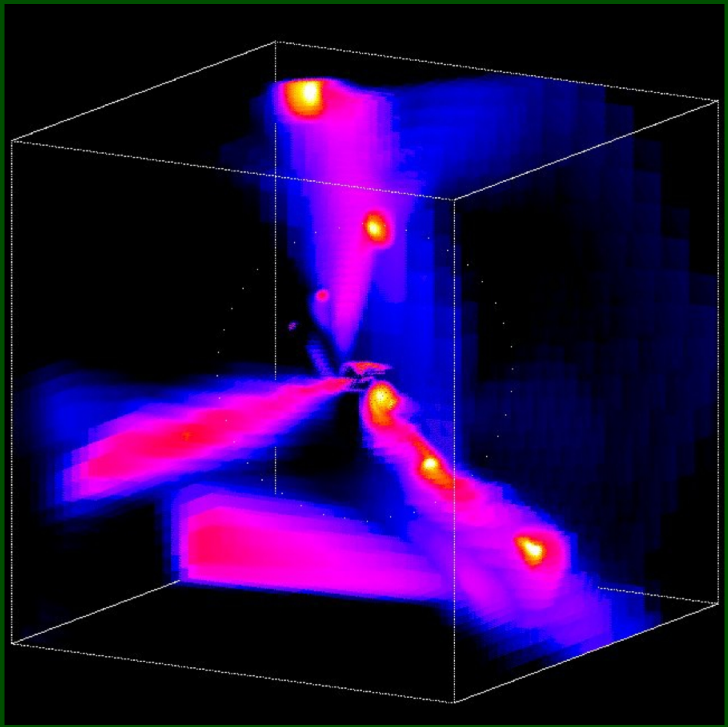




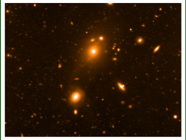
Introduction

The triggering mechanisms for Active Galactic Nuclei

- Gas supply required to trigger/feed the SMBH
  - Cold flows from large-scale filamentary structures (Keres 2005, Dekel et al. 2009)



Mare Nostrum simulations.
Cold streams feeding a massive galaxy @high redshift (Dekel et al. 2009)



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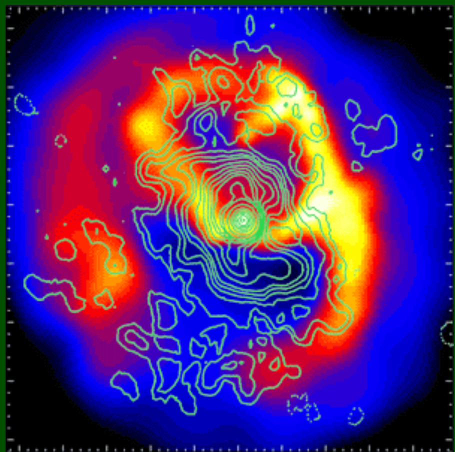
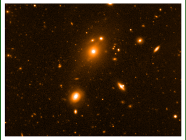


Chandra observation of the cooling flow Cluster Abell 2052 with radio contours overlaid (Blanton et al. 2009)



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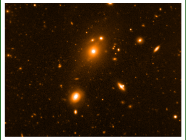
  - Galaxy mergers and interactions (Heckman et al. 1986, Smith & Heckman 1989)



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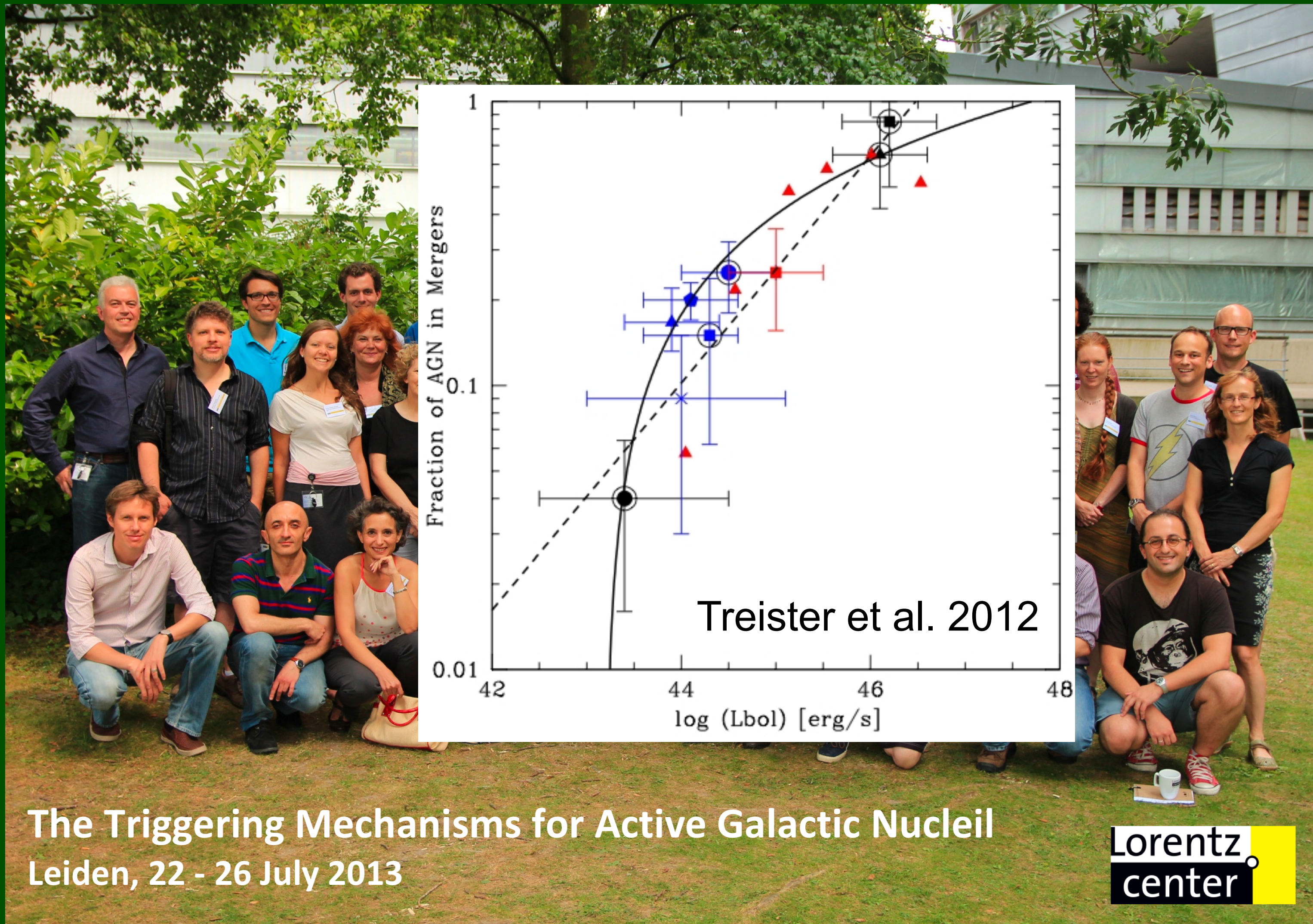
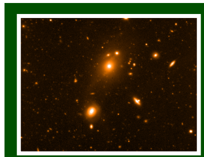
Are all AGN triggered in the same way?

Introduction

The triggering mechanisms for Active Galactic Nuclei





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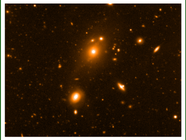
  - **Galaxy mergers and interactions** (Heckman et al. 1986, Smith & Heckman 1989)

Radio galaxies and QSOs = associated with ealy-type hosts → cleaner searches for signs of morphological disturbance.



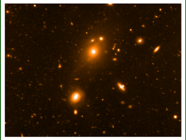
Observations

The 2Jy and the QSO-2 sample

- Try to shed some light about importance of mergers/interactions in the triggering of radio-loud and radio-quiet activity by solving previous problems: completeness, environment & control samples.

- Deep GMOS-S / Gemini optical broad-band observations of complete samples of PRGs and type-2 QSOs.

Complete samples	Wide range of redshift	Deep observations	Big sky area covered
46 PRG 20 QSO-2s	$0.05 < z < 0.7$ $0.3 < z < 0.41$	$21 \leq \mu_V \leq 26$ mag/arcsec^2	~0.8□



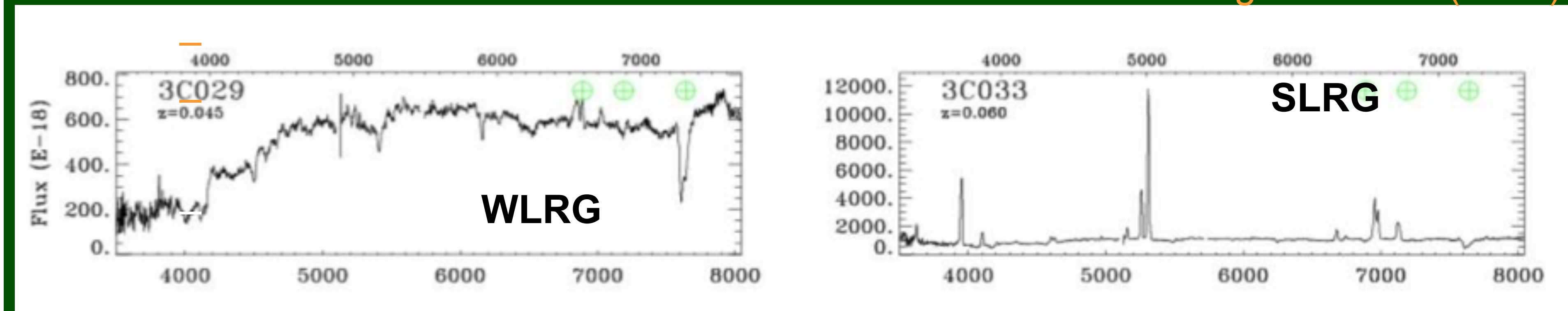
Observations

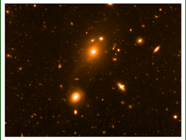
The 2Jy sample of radio galaxies

- 46 PRG ($S_{2.7\ GHz}$ > 2Jy) with 0.05 < z < 0.7 from the complete sample of Tadhunter et al. (1993).

- Sample divided in (according to optical spectroscopy):
  - Strong-line radio galaxies (SLRGs; 78%)
  - Weak-line radio galaxies (WLRGs; 22%).

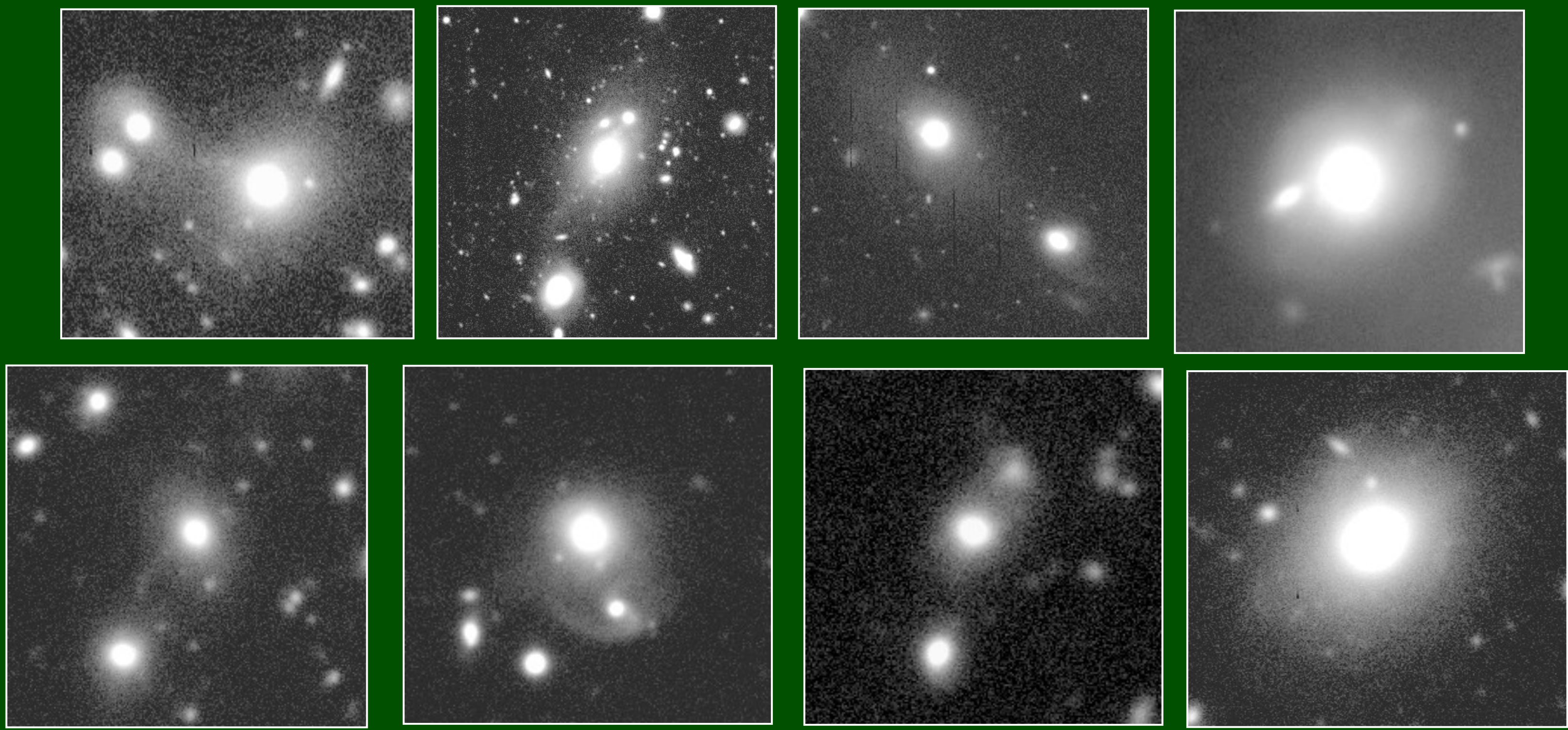
Buttiglione et al. (2010)



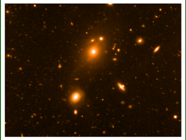


Results

Evidence for galaxy interactions in PRGs



• 85% of the 2Jy sample (95% of SLRGs) show signs of morphological disturbance (Ramos Almeida, Tadhunter, et al. 2011).

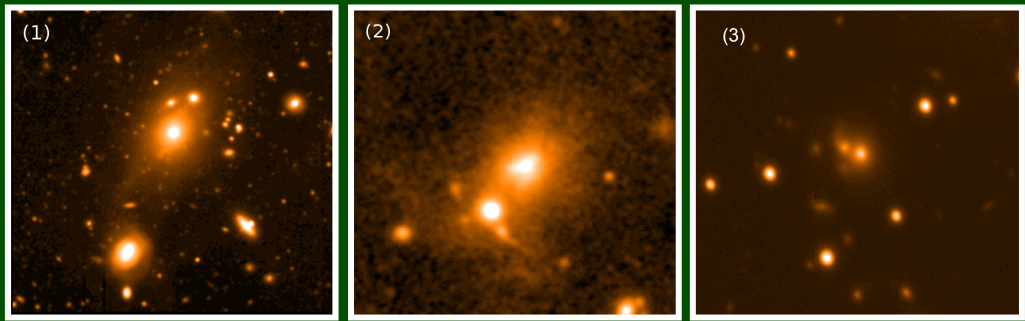


Results

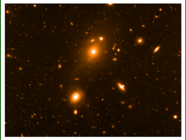
Evidence for galaxy interactions in PRGs

35% included in 1 & 2: observed after the first peri-center passage but before the final coalescence of the merging nuclei.

Close pairs & gas-rich mergers = 0.5-1.5 Gyr (e.g., Conselice et al. 2003)
PRG activity = 0.1 Gyr (Leahy et al. 1989)



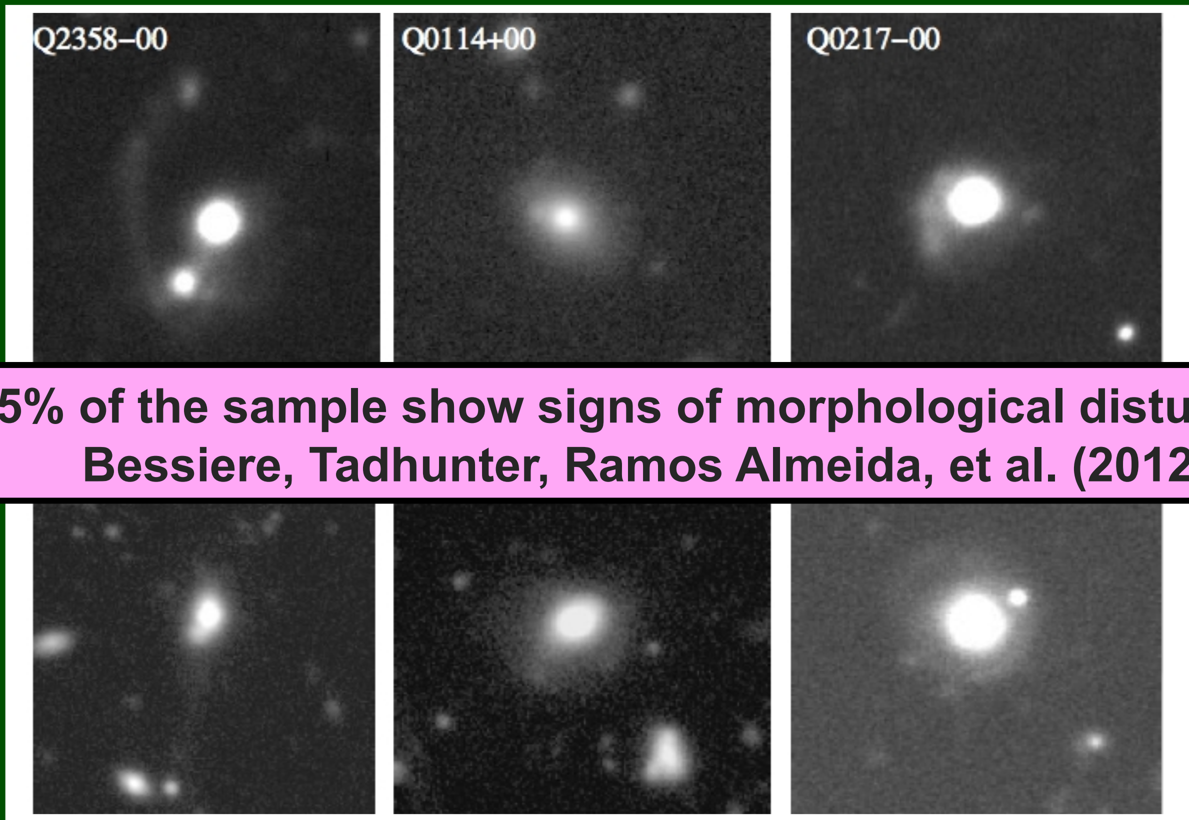
If interactions play a role in the triggering of PRG, that can happen at different stages of the interaction.



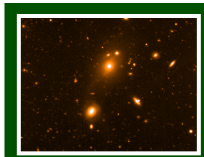
Results

Evidence for galaxy interactions in Type-2 QSOs

- RA-limited sample of 20 SDSS-selected QSO-2s.
    - z = [0.3 - 0.4] → subsample of Zakamska et al. (2003)

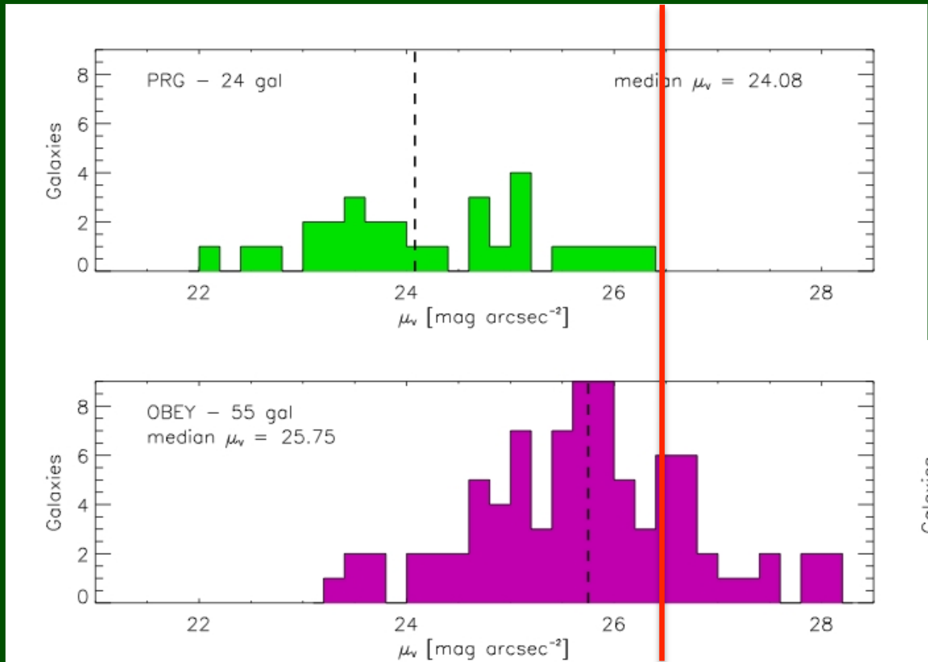


~75% of the sample show signs of morphological disturbance
Bessiere, Tadhunter, Ramos Almeida, et al. (2012)



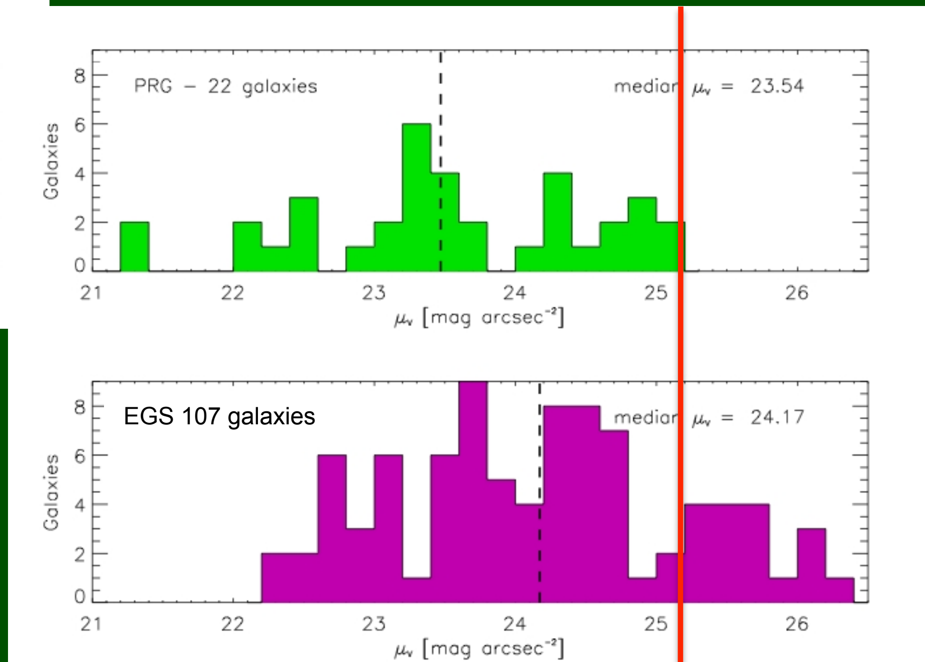
Control sample

Evidence for galaxy interactions in quiescent galaxies



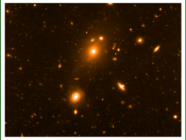
Development of control samples of quiescent early-type galaxies

0.2 < z < 0.7 – EGS sample



z < 0.2 – OBEY survey

Features in PRGs up to 2 mag brighter than those in quiescent elliptical galaxies.



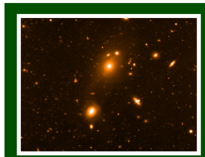
Control sample

Evidence for galaxy interactions in quiescent galaxies

- Fewer disturbed morphologies in quiescent population than in PRGs and QSO-2s when same surface brightness limits considered.
  - Quiescent = 53% vs active = 93% at $z<0.2$ (OBEY survey)
  - Quiescent = 48% vs active = 95% at $z>0.2$ (EGS sample)

- PRGs likely represent a fleeting active phase of the subset of elliptical galaxies that have recently undergone a merger/interaction.

- Ramos Almeida, Bessiere, Tadhunter, et al. (2012)



Results

The environments of radio-loud and radio-quiet quasars

- Study of the environment of PRGs, type-2 quasars and control sample galaxies to determine influence in triggering.

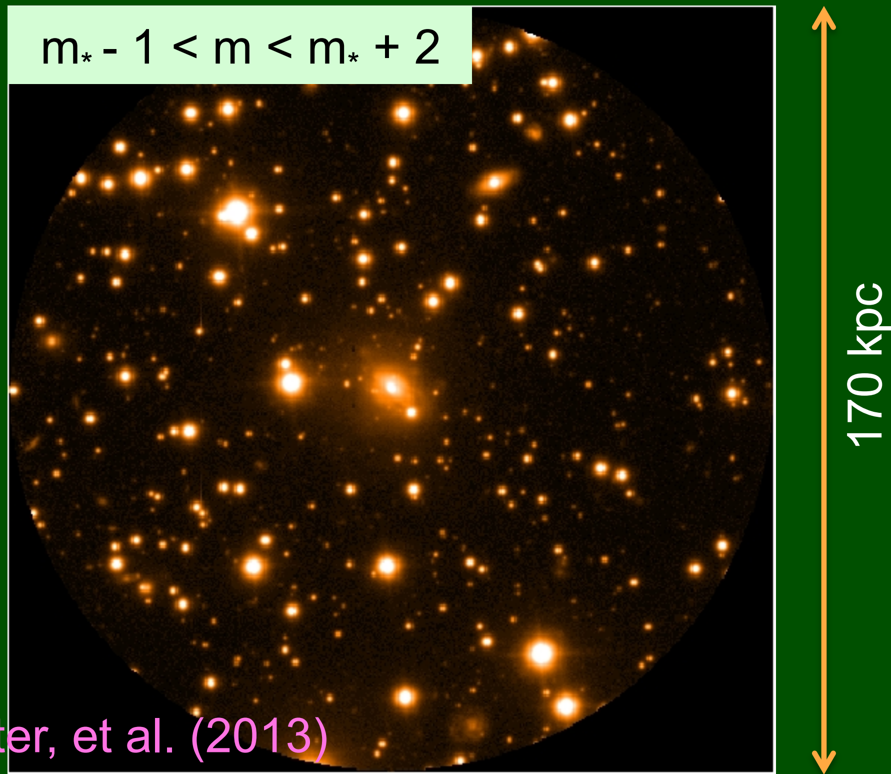
Spatial clustering amplitude

(Longair & Seldner 1979)

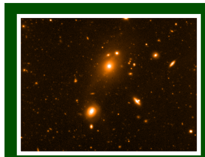
$$B_{gq} = \frac{A_{gq} N_g}{I_\gamma \phi(z)} \left[\frac{D}{1+z}\right]^{\gamma-3}$$

Agq = excess of galaxies around the target as compared with the number of background galaxies per unit area.

Ng = average surface density of galaxies.



Ramos Almeida, Bessiere, Tadhunter, et al. (2013)



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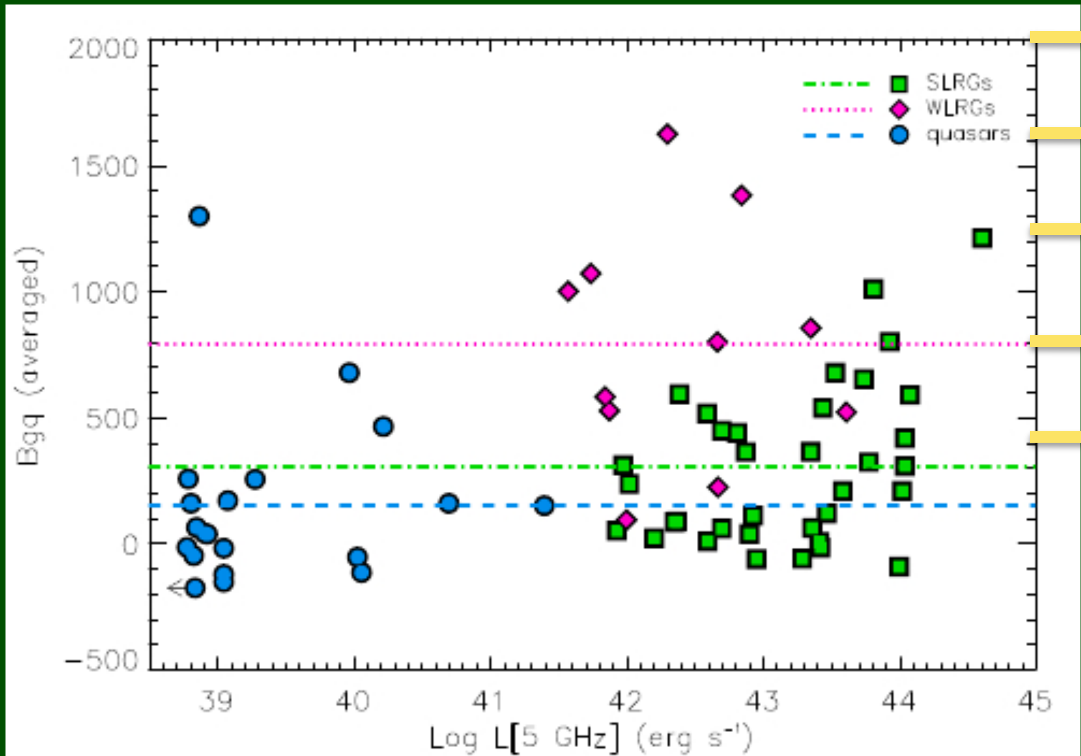


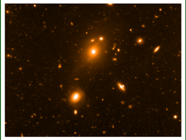
Abell class 4

Abell class 3

Abell class 2

Abell class 1

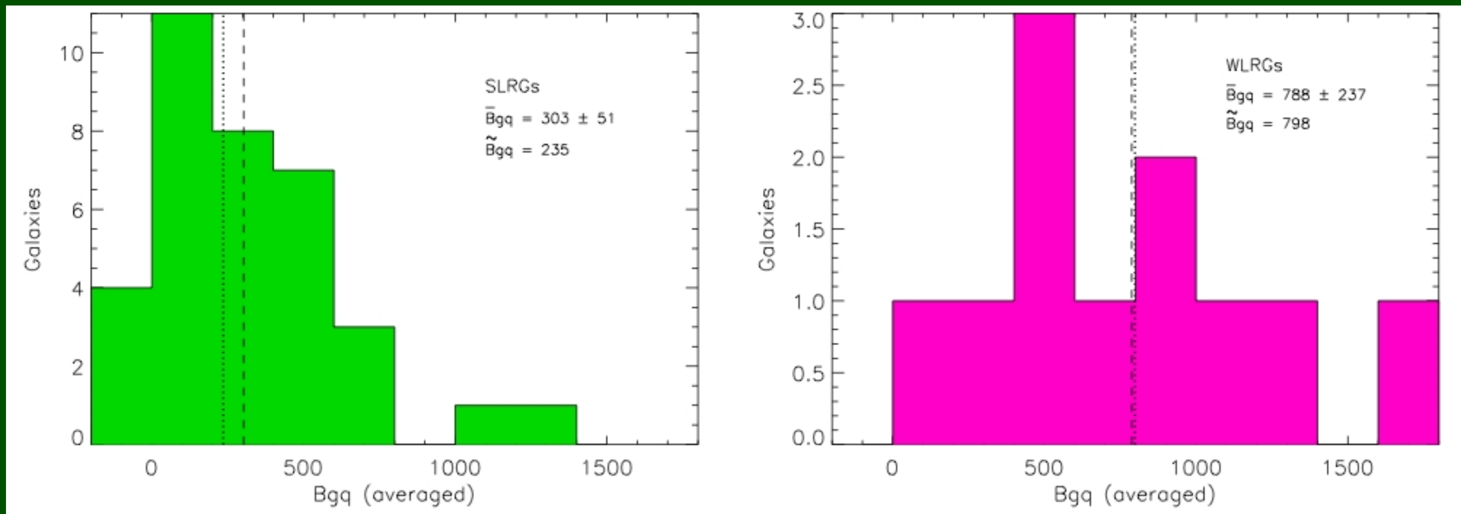
Abell class 0

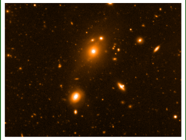


Results

The environments of radio-loud and radio-quiet quasars

- WLRGs (~FRIs) are in denser environments (Abell classes 0 – 1) than SLRGs (~FRIIs) - 3 sigma result.





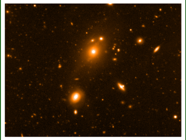
Results

The environments of radio-loud and radio-quiet quasars

- WLRGs in denser environments (Abell classes 0 – 1) than SLRGs (3 sigma result).
- Evidence for galaxy interactions in only 27% of WLRGs (Ramos Almeida et al. 2011).

Possible scenarios:

- WLRGs triggered/fuelled by Bondi accretion of hot ISM in galaxy clusters (e.g. Best et al. 2005, Hardcastle et al. 2007).
- …but, presence of star formation in circumnuclear regions of some WLRGs → evidence of cold accretion –cooling flows?
- Denser environments washing out features because of tidal disruption?

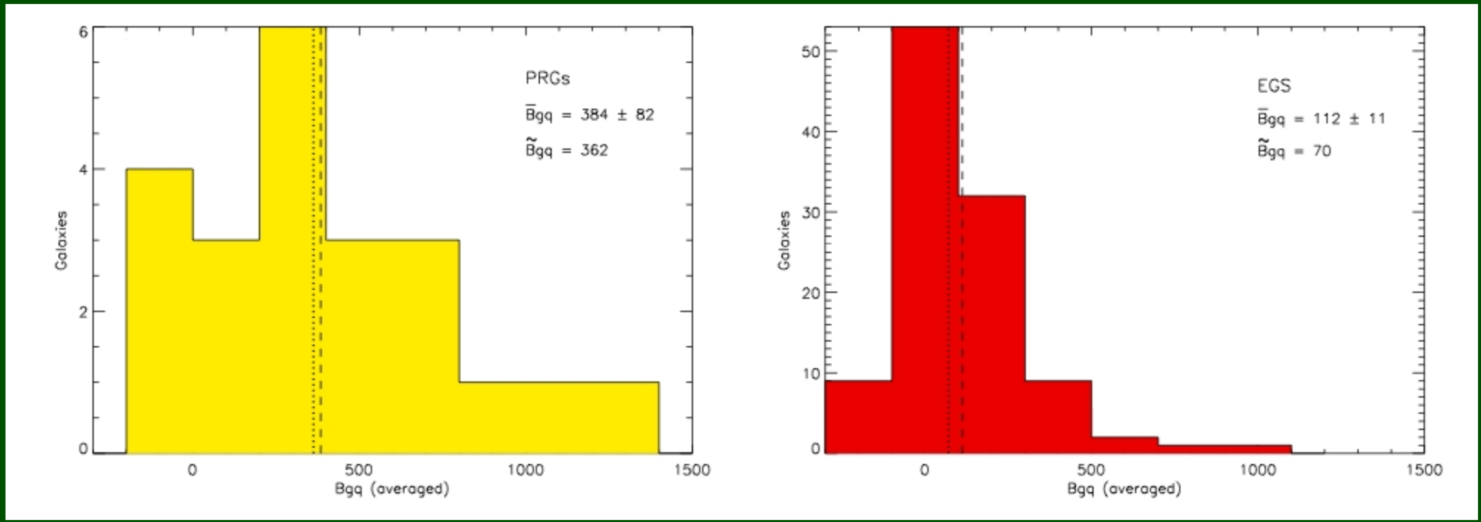


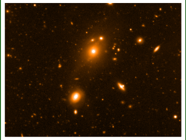
Results

The environments of radio-loud and radio-quiet quasars

Comparison between environments of PRGs and control sample galaxies.

- PRGs (and SLRGs) in denser environments than their quiescent counterparts (3 sigma result).



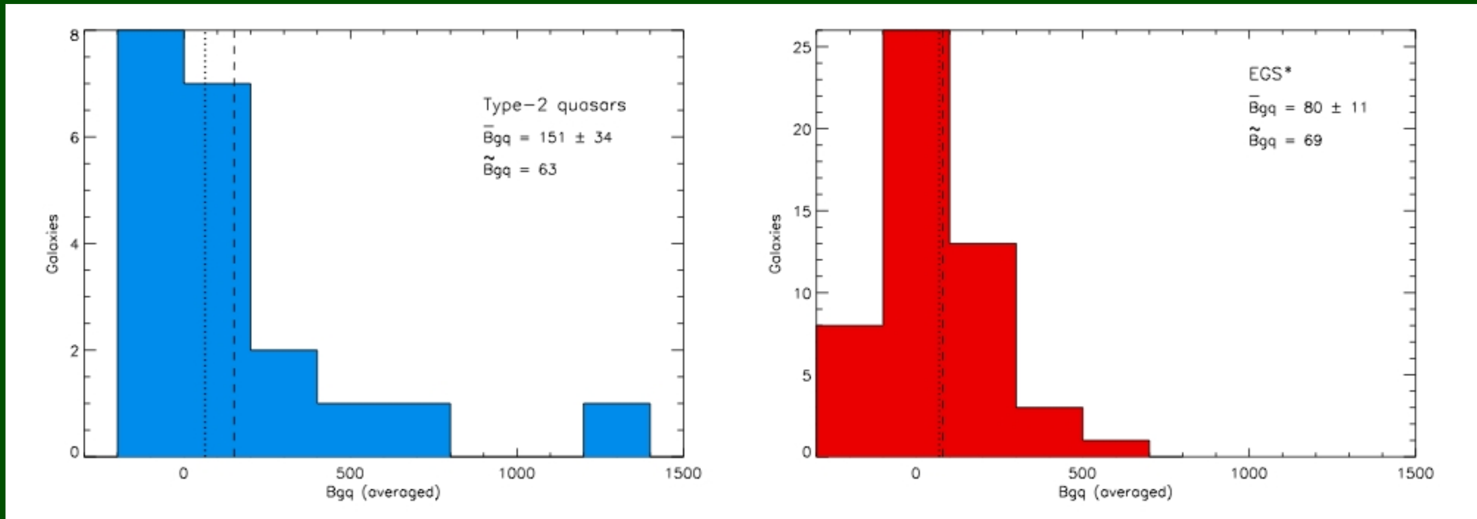


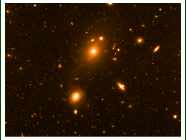
Results

The environments of radio-loud and radio-quiet quasars

Comparison between environments of PRGs and control sample galaxies.

- Type-2 quasar environments do not differ from quiescent galaxies.

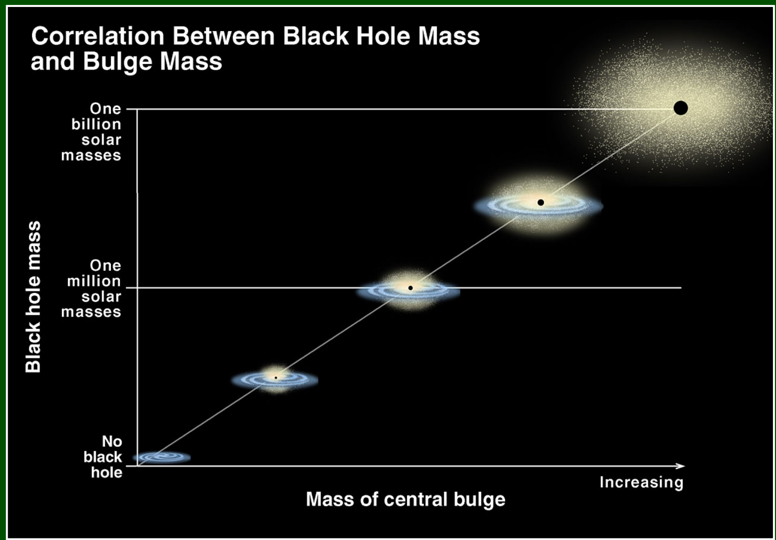




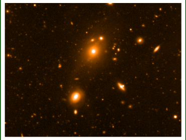
Results

The environments of radio-loud and radio-quiet quasars

- Periods of black hole growth coupled with host galaxy growth → we expect no differences between environment of QSO-2s and quiescent early-type galaxies of same M and z.



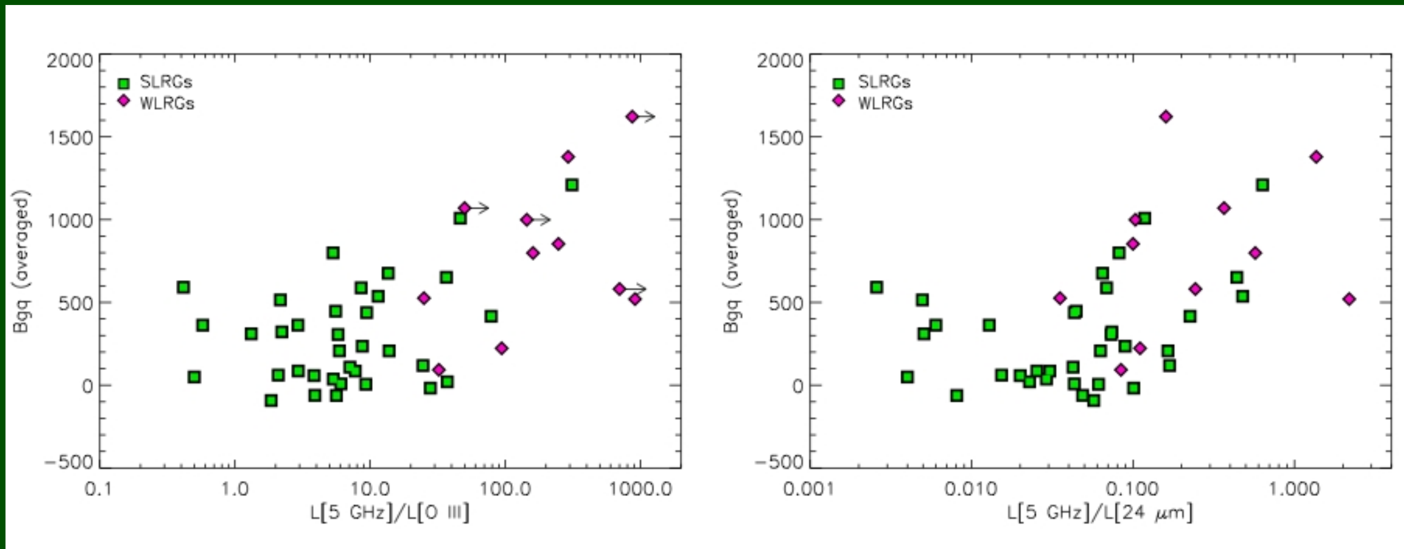
- Environment won´t change significantly during a single AGN period.

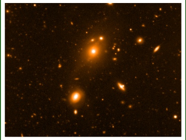


Results

The environments of radio-loud and radio-quiet quasars

In contrast, only some quiescent early-type galaxies have been/may be radio-loud AGN at some point. High density hot gas environments could be favouring transformation of AGN power into radio luminosity. Alternatively, SMBHs properties could be influenced by environment.



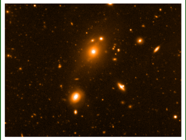


Conclusions

The environments of radio-loud and radio-quiet quasars

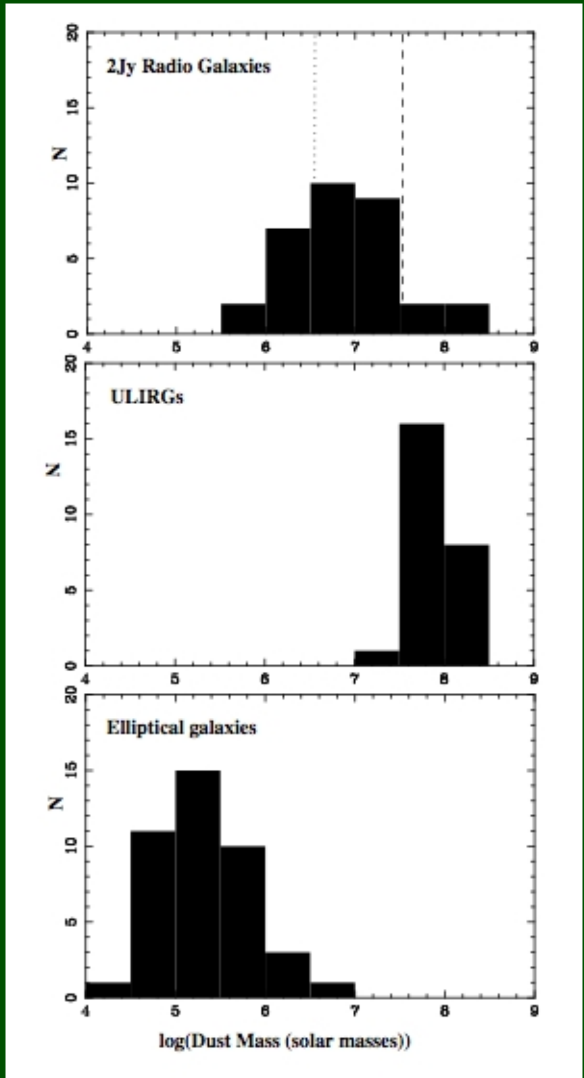
- WLRGs are in denser environments than SLRGs (3 sigma result).
- PRGs are in denser environments than their quiescent counterparts (3 sigma result).
- Type-2 quasar environments do not differ from quiescent galaxies.
- The environment seems to have an influence in the radio loudness, but it would not determine the presence of nuclear activity.
- Results against cycling radio-loud activity: not all AGN go through a radio-loud phase.

- Ramos Almeida, Bessiere, Tadhunter, et al. (2013)



Ongoing work

Herschel Space Observatory



- Quantifying the cool ISM contents of powerful 2Jy radio galaxies with Herschel.

- Radio galaxies show intermediate masses between those of ULIRGs and quiescent elliptical galaxies.

Tadhunter et al. 2014, MNRAS, submitted

Thanks!

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