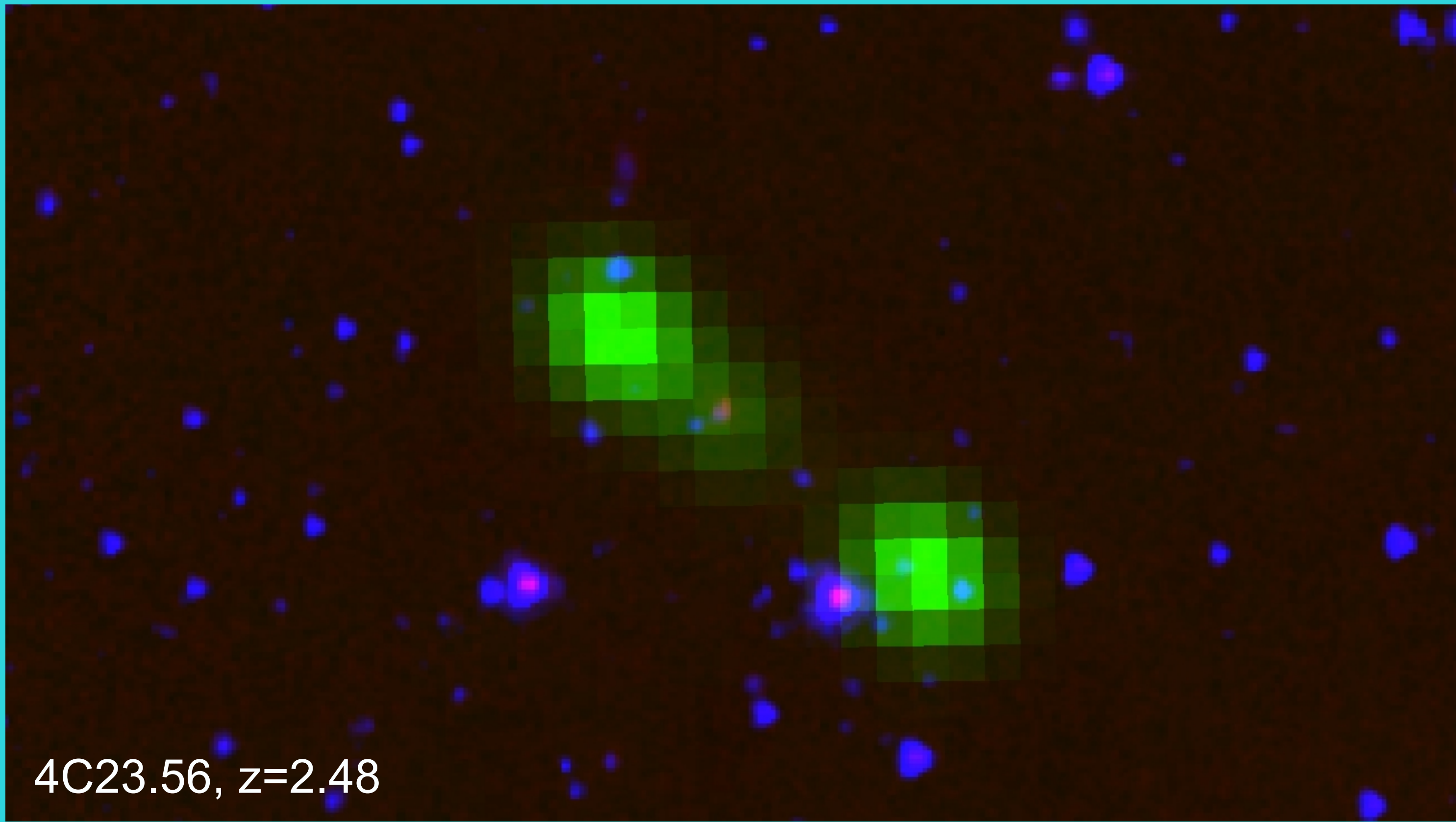


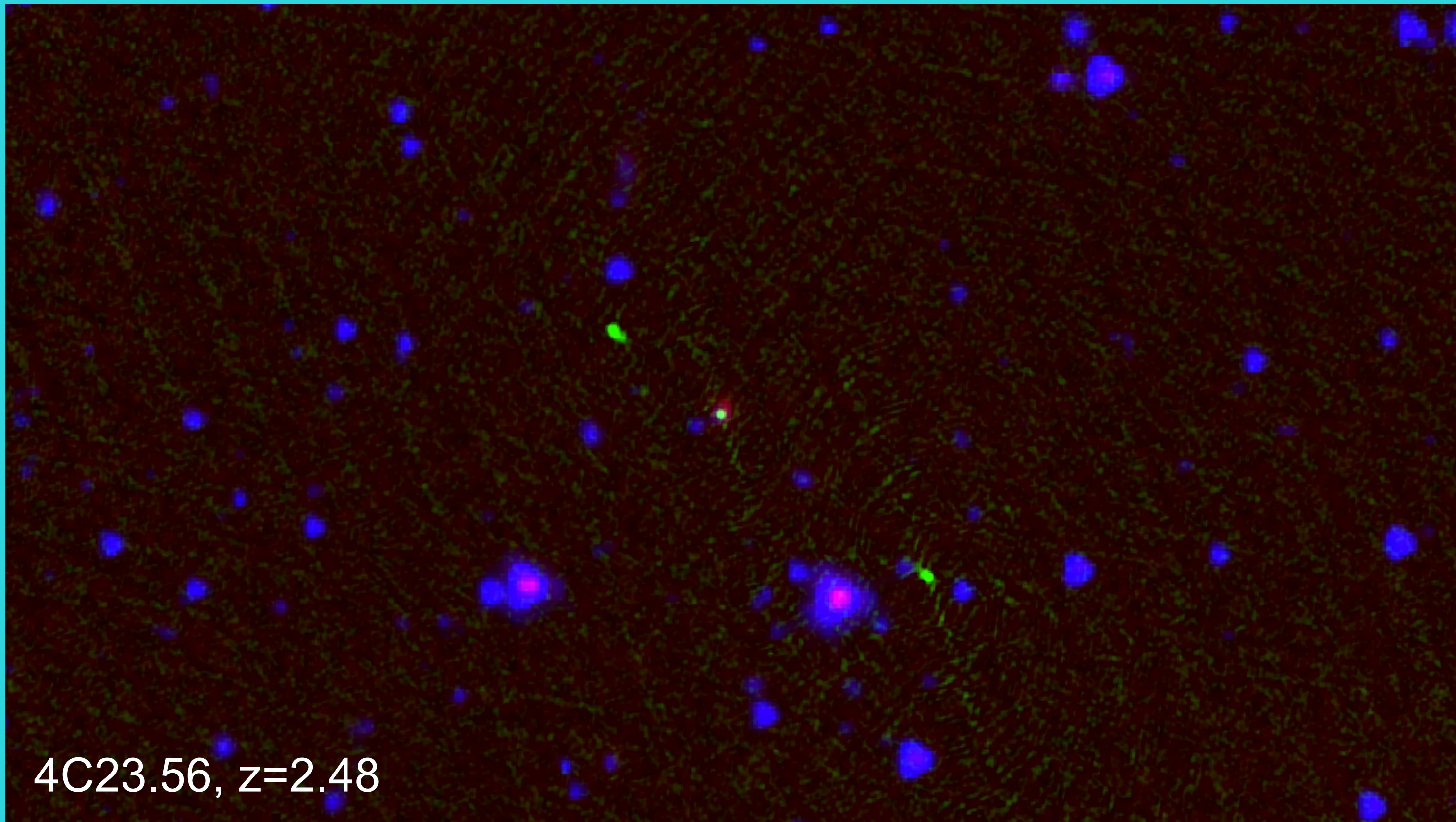
The Impact of High Redshift Radio Galaxies on Their Environments

Nick Seymour (CASS) and the HeRGÉ Collaboration[1]

12 September 2012

CSIRO ASTRONOMY & SPACE SCIENCE
www.csiro.au

[1] Presented by Daniel Stern (JPL/Caltech) due to late time travel issues for NS.



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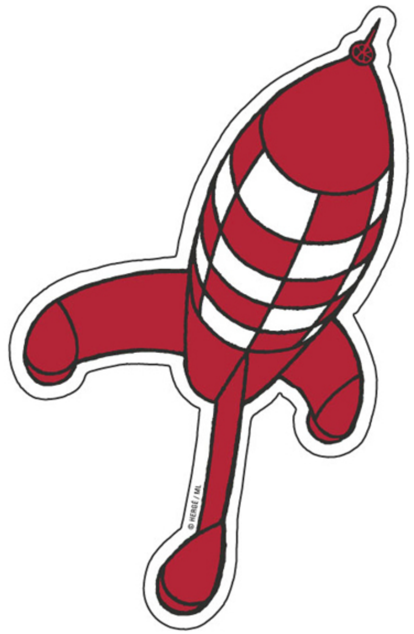
Projet HeRGÉ (Herschel Radio Galaxy Evolution Project)

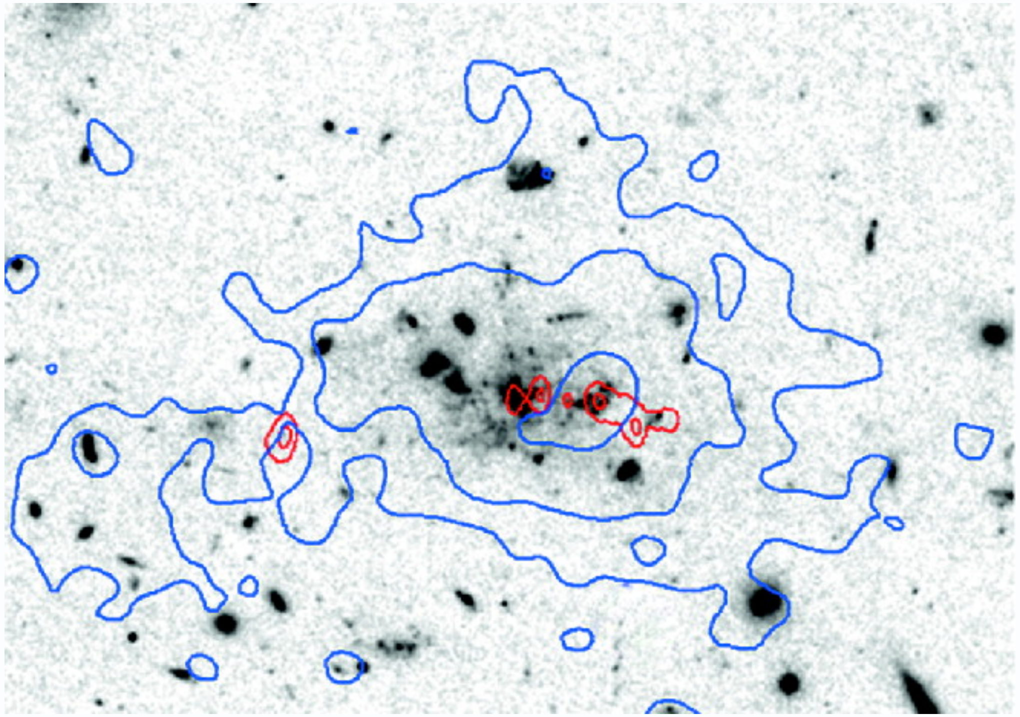
Carlos De Breuck (ESO)
Joel Vernet (ESO)
Guillaume Drouart (ESO)
Dominika Wylezalek (ESO)
Daniel Stern (JPL/Caltech)
Jason Rawlings (MSSL)
Thomas Greve (UCL)
Sabine Koenig (Dark Cosmology Center)
Bjorn Emonts (CASS/CSIRO)
Edo Ibar (UKATC/ROE)
Rob Ivison (UKATC/ROE)
Jack Mayo (UKATC/ROE)
Audrey Galametz (Rome)
Peter Barthel (Groningen)
Martin Haas (Bochum)
Nina Hatch (Nottingham)
Matt Jarvis (Hertfordshire/UWC)
Jason Stevens (Hertfordshire)
Attila Kovacs (Minnesota)

Matt Lehnert (Observatoire de Paris)
Nicole Nesvadba (IAS, Orsay)
Alessandro Rettura (JPL/Caltech)
Huub Rottgering (Leiden)
Brigitte Rocca-Volmerange (IAP)
Arjun Dey (NOAO)
Mark Dickinson (NOAO)
Bruno Altieri (ESA)
George Miley (Leiden)



High Redshift Radio Galaxies

PKS1138-262 at z=2.156
`The Spiderweb Galaxy'
(Miley et al. 2006; Hatch et al. 2008)



- Probably Massive
- (Proto-)cluster environment (see talks by J. Vernet and D. Wylezalek)
- Evidence of high SFR
- Most radio luminous sources in the Universe

High Redshift Radio Galaxies

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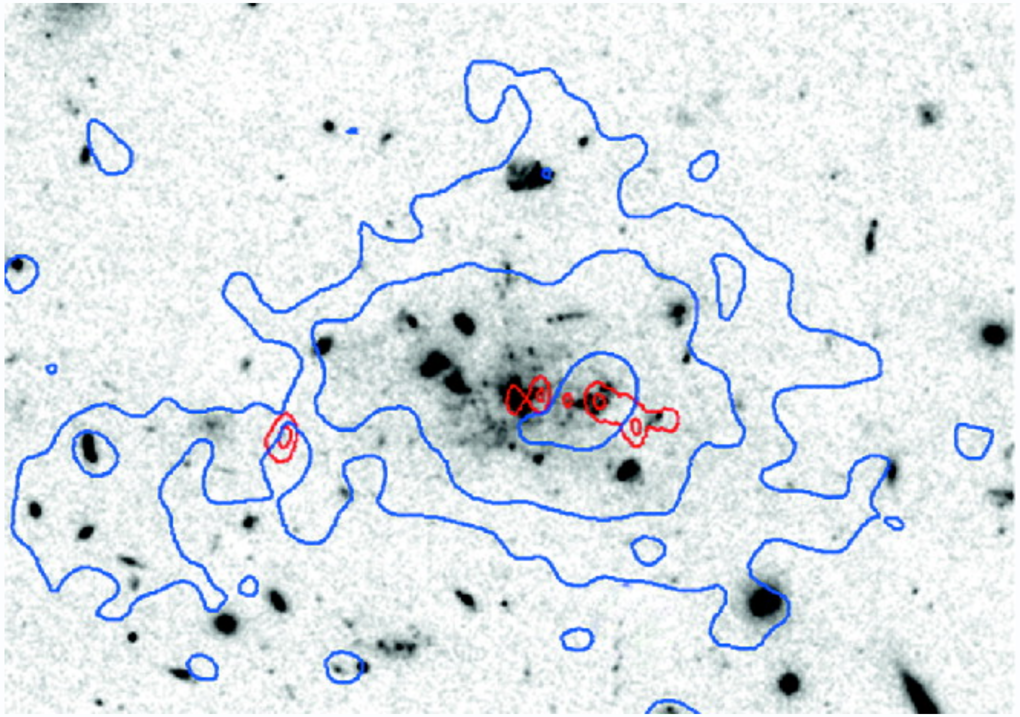
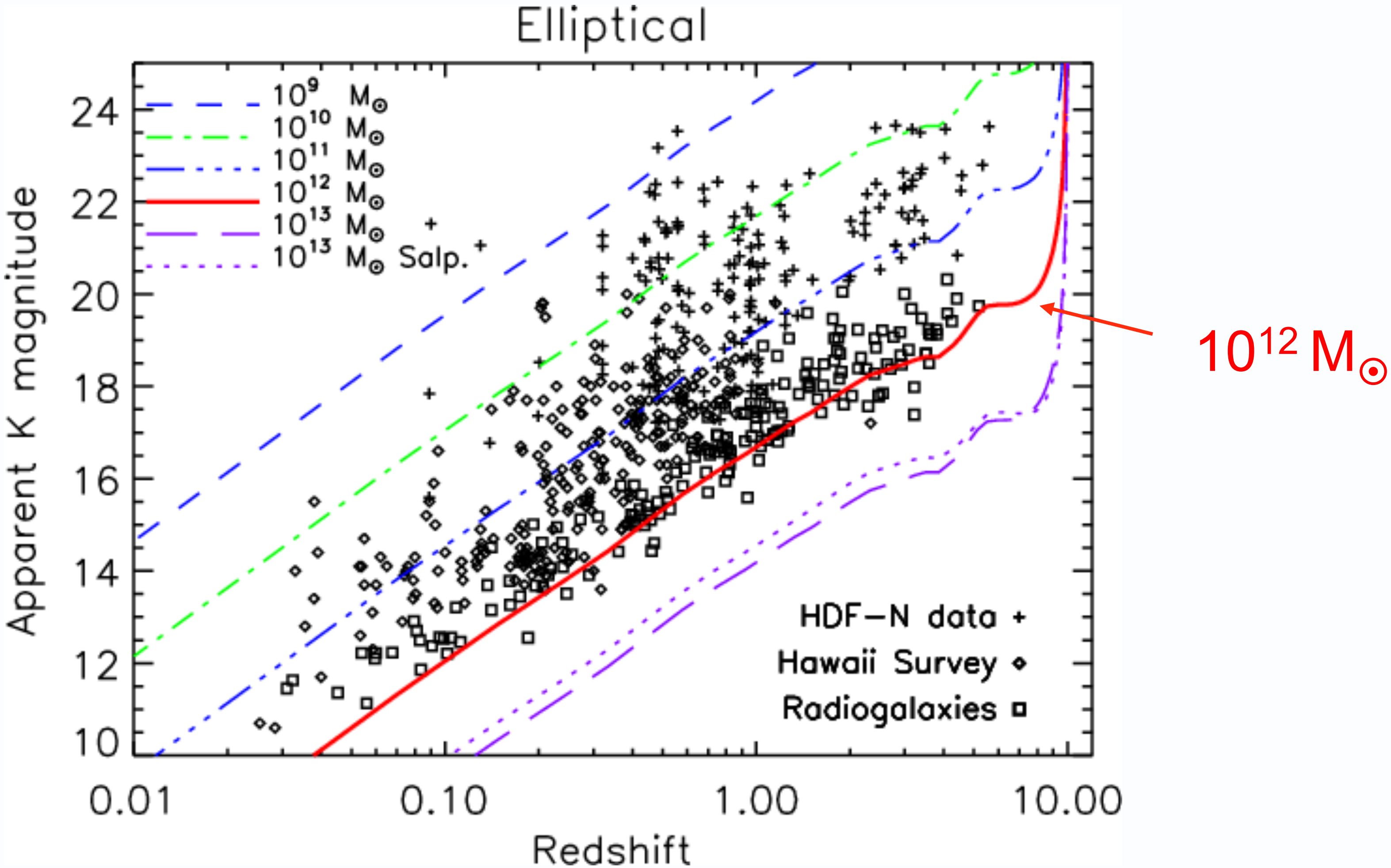


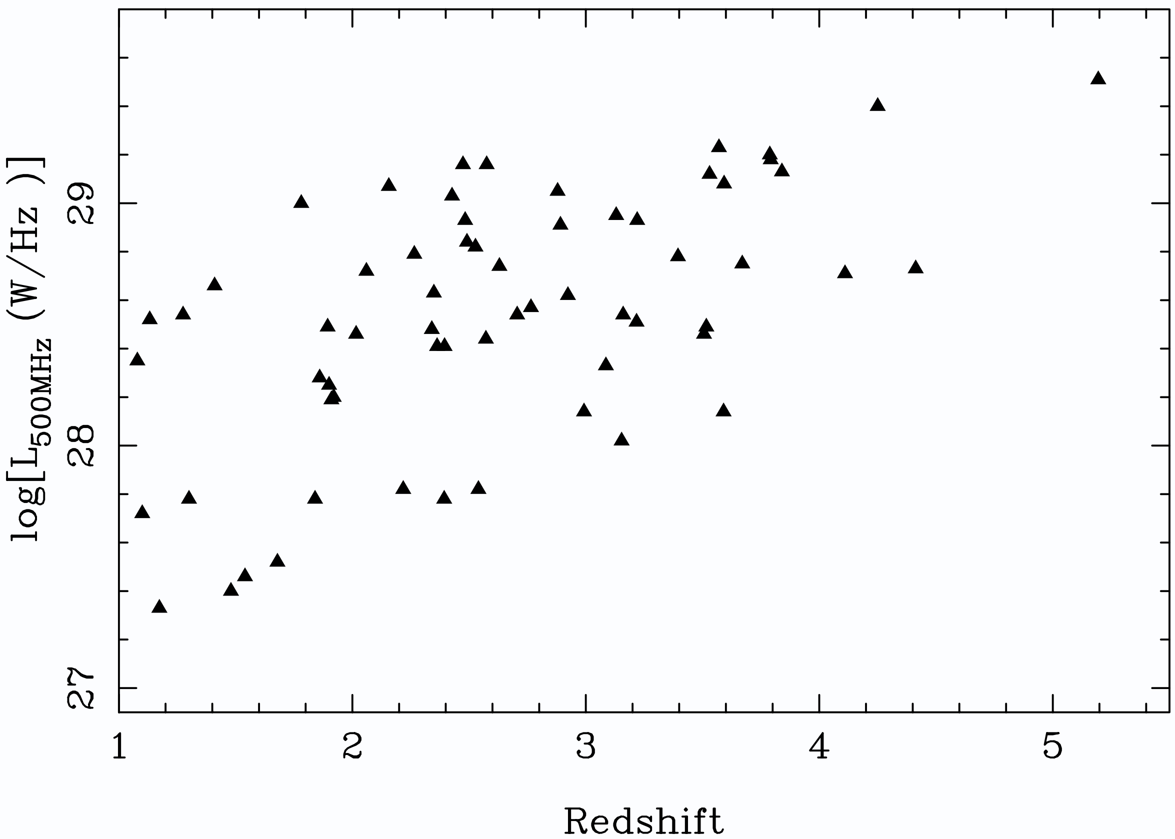
- Probably Massive
- (Proto-)cluster environment (see talks by J. Vernet and D. Wylezalek)
- Evidence of high SFR
- Most radio luminous sources in the Universe
- Archetypal obscured type 2 AGN

K-z or Hubble diagram for radio galaxies



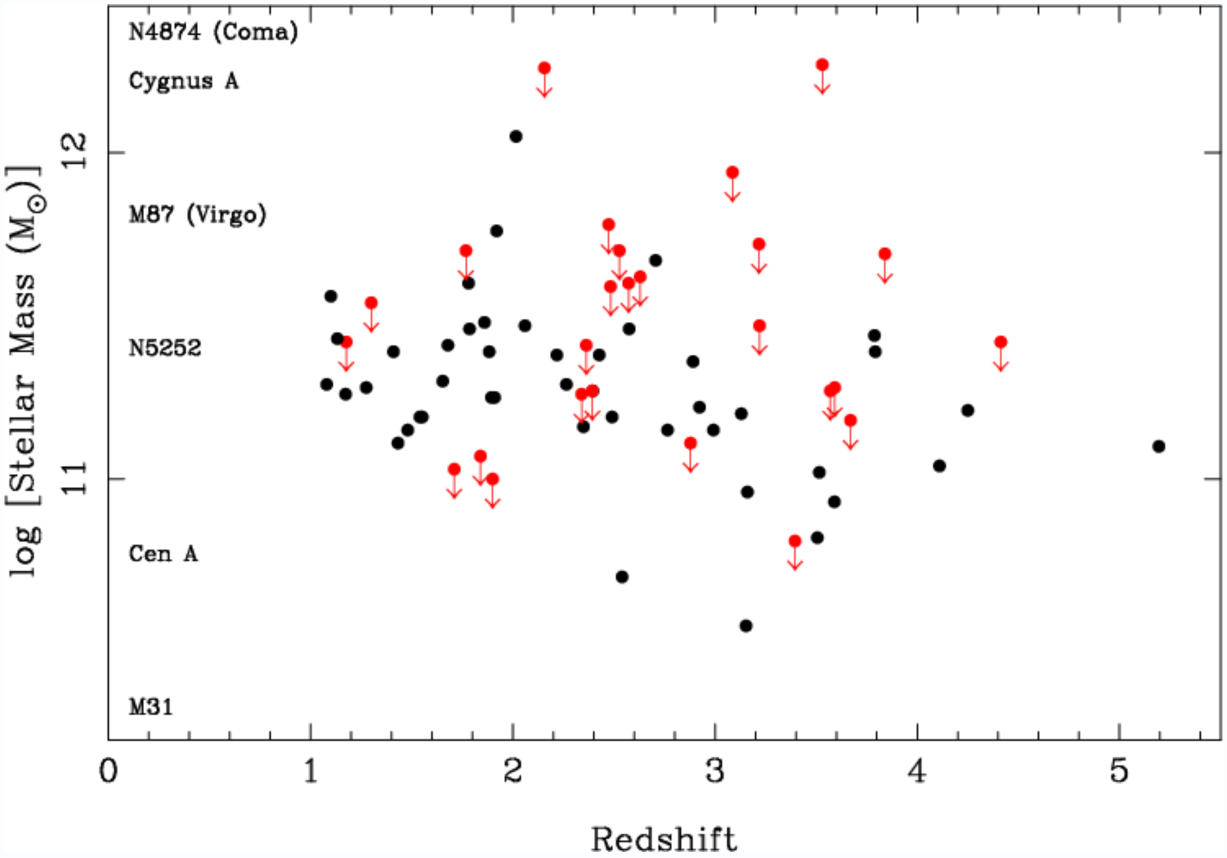
Rocca-Volmerange et al. (2004)

Spitzer High-z Radio Galaxy survey (SHzRG survey)



- 8 band imaging survey of 71 high-z radio galaxies (HzRGs: 1<z<5.2 and $L_{3GHz} > 10^{26}$ WHz^{-1})
- Goal to obtain stellar masses (via rest-frame near-IR luminosities) and deconvolve the AGN component
- Later supplemented with IRS spectroscopy of a z~2 subset

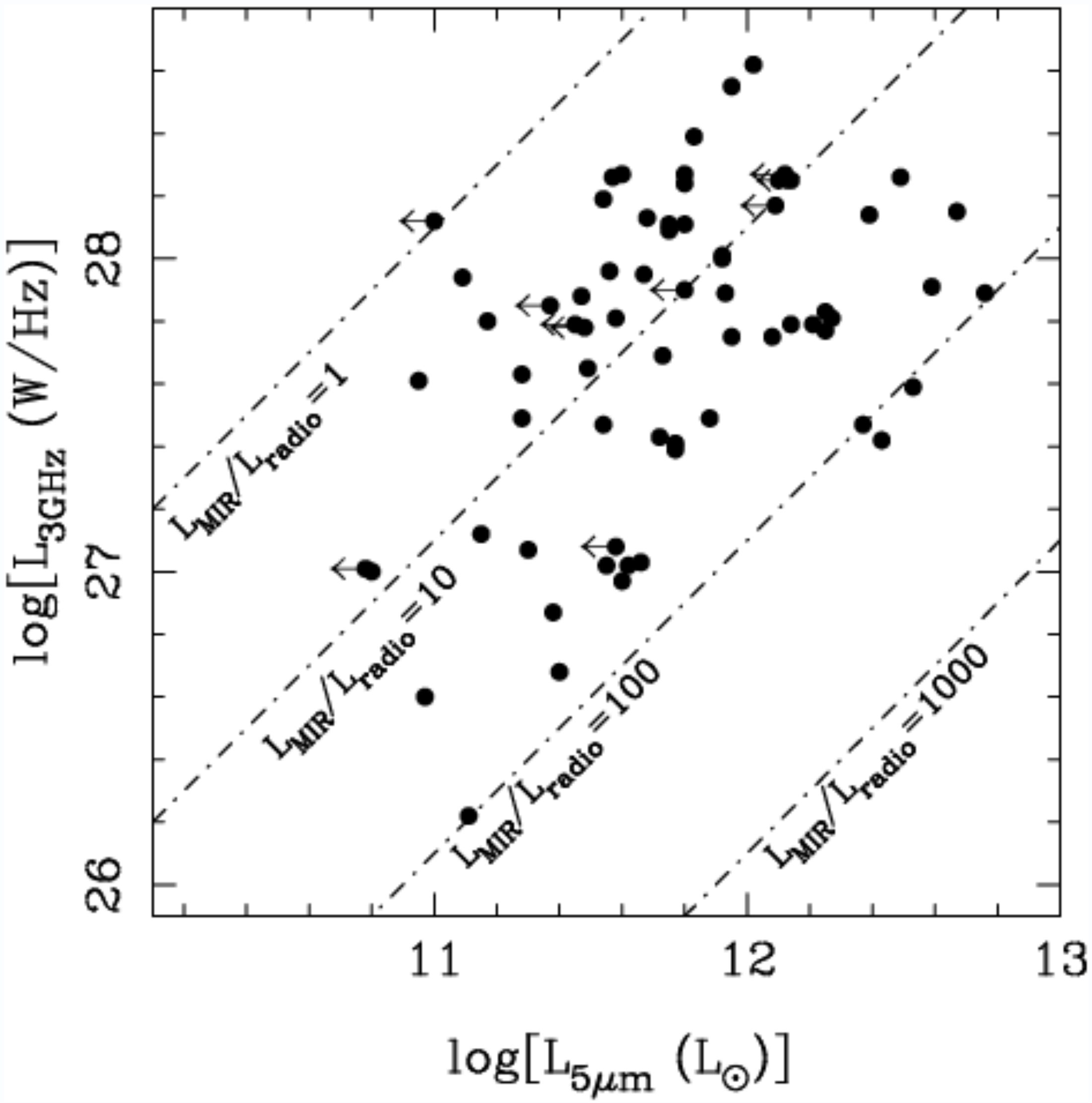
Stellar Masses of HzRGs



<log(M/M$_{\odot}$)> ~ 11.3, but still time to grow a bit more

(Seymour et al. 2007; De Breuck et al. 2010)

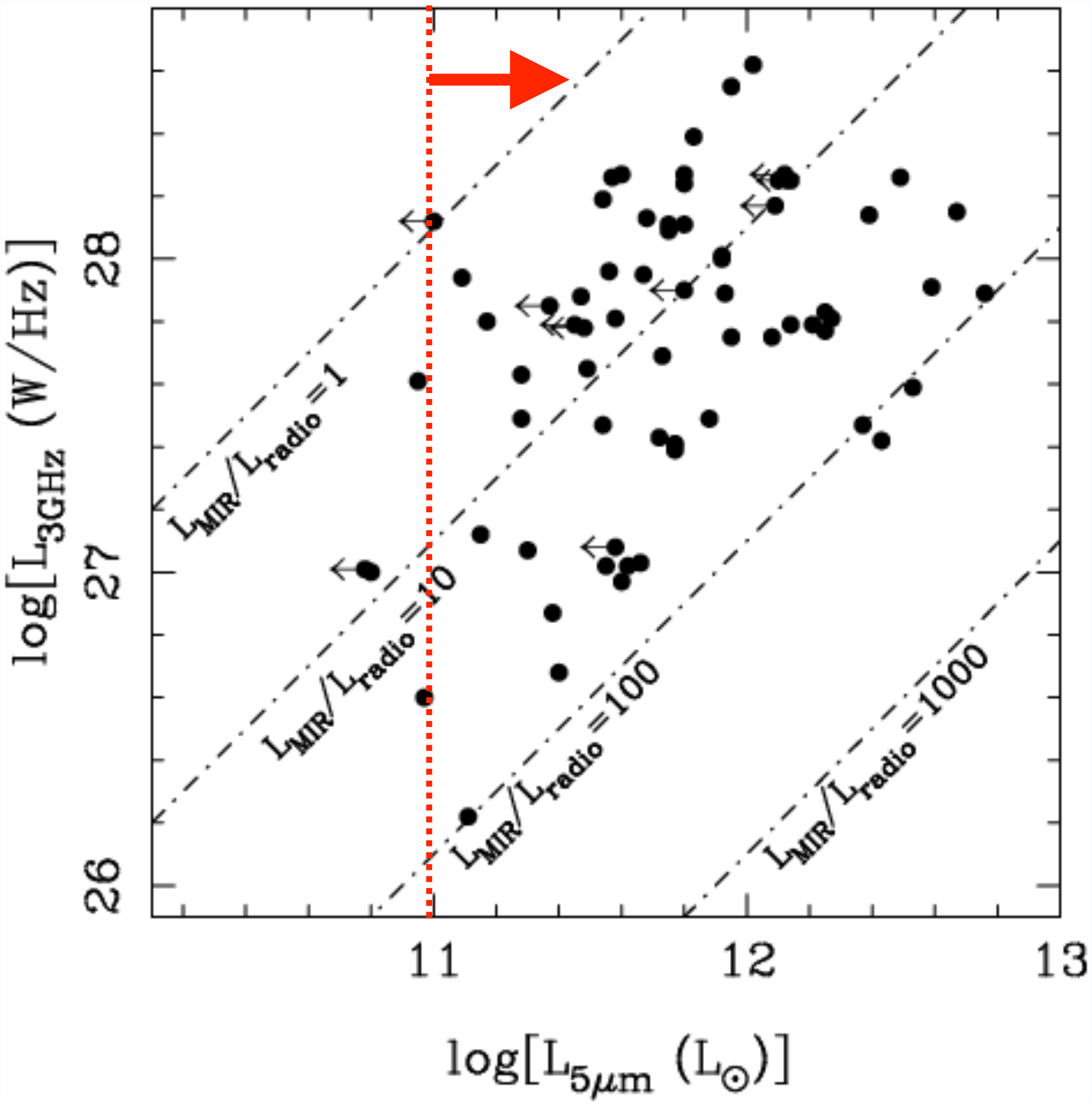
AGN Mid-IR Power



Seymour et al. (2007)
De Breuck et al. (2010)

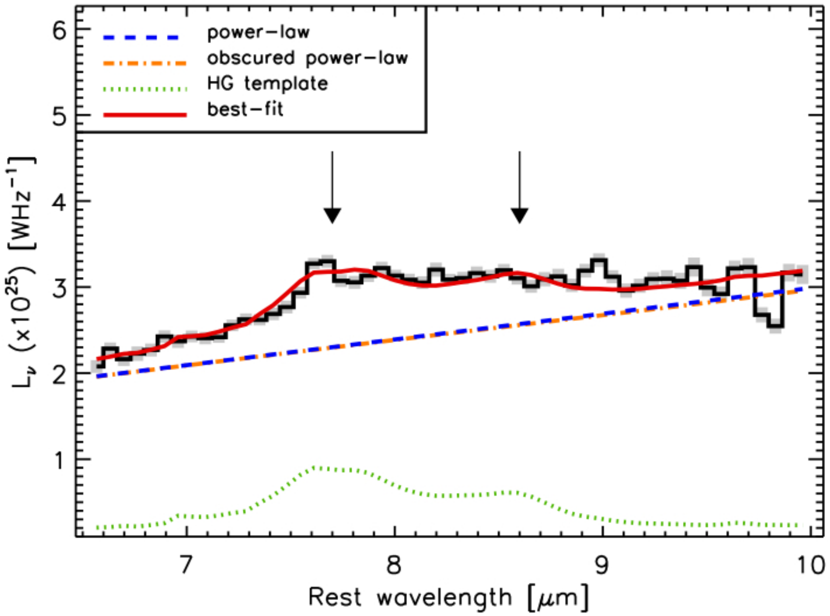
AGN Mid-IR Power

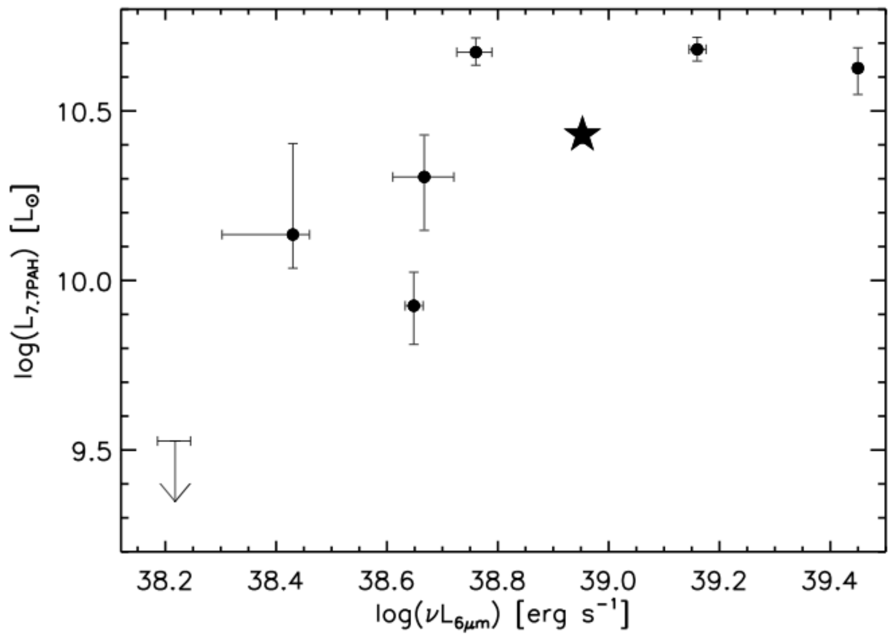
mid-IR strong for quasars
(Ogle et al. 2006)



Seymour et al. (2007)
De Breuck et al. (2010)

Mid-IR Spectroscopy



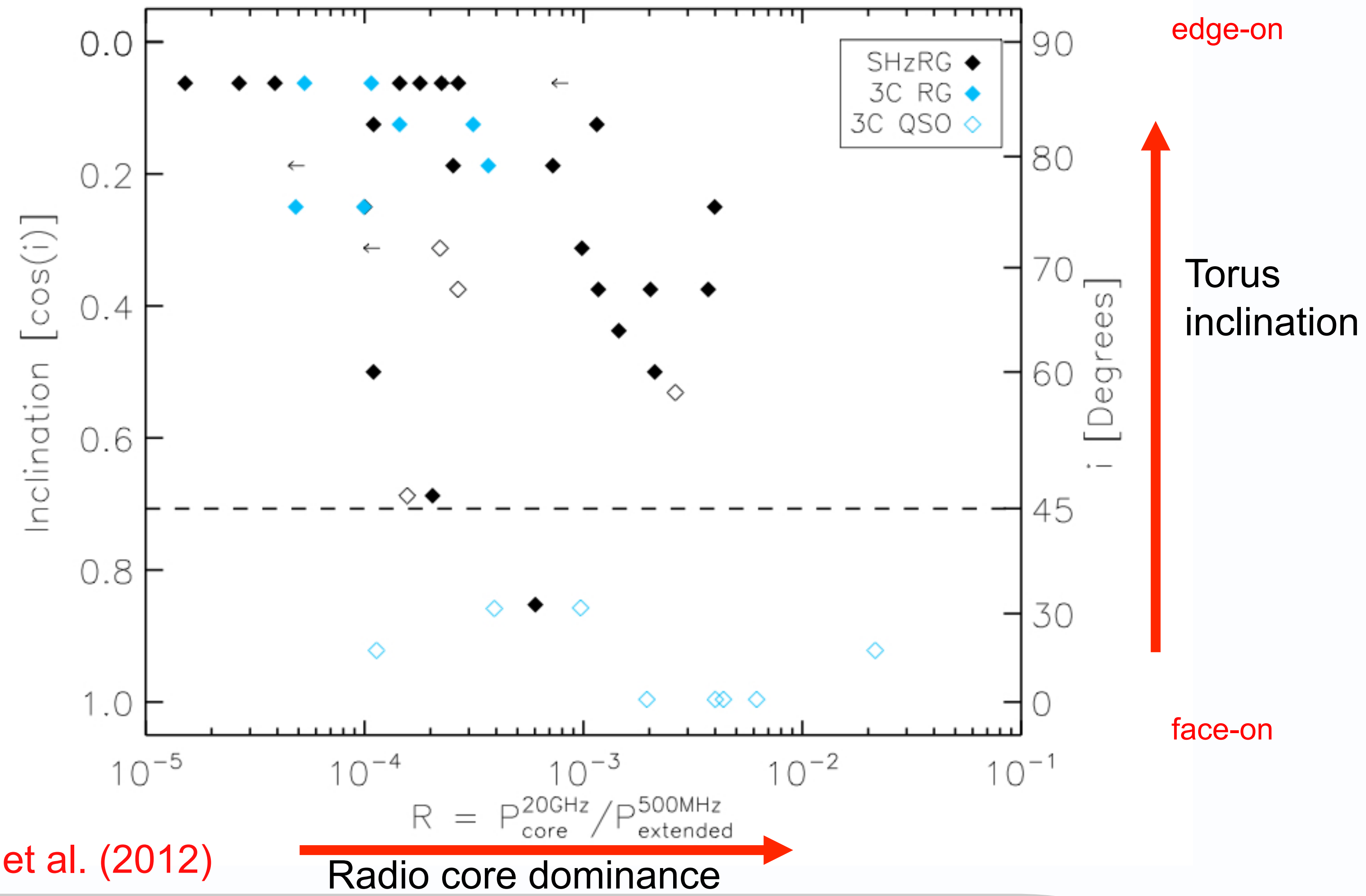


Measure SFR and accretion from mid-IR spectra

No correlation between AGN and SF power although both are high

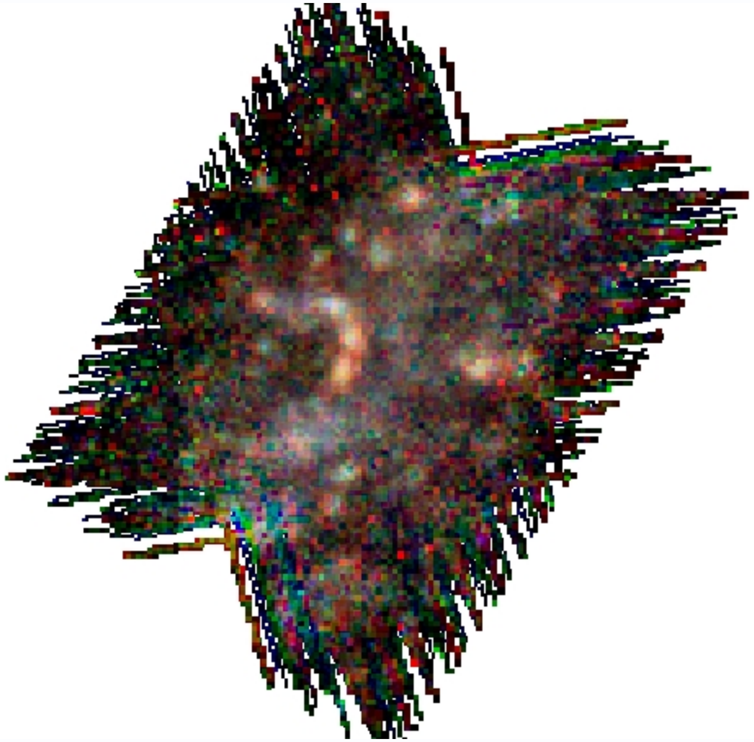
Rawlings et al. (2012)

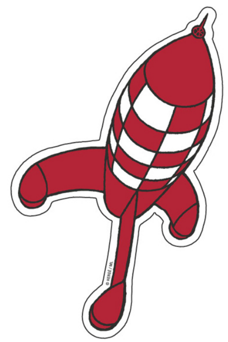
Torus and jet alignment



Drouart et al. (2012)

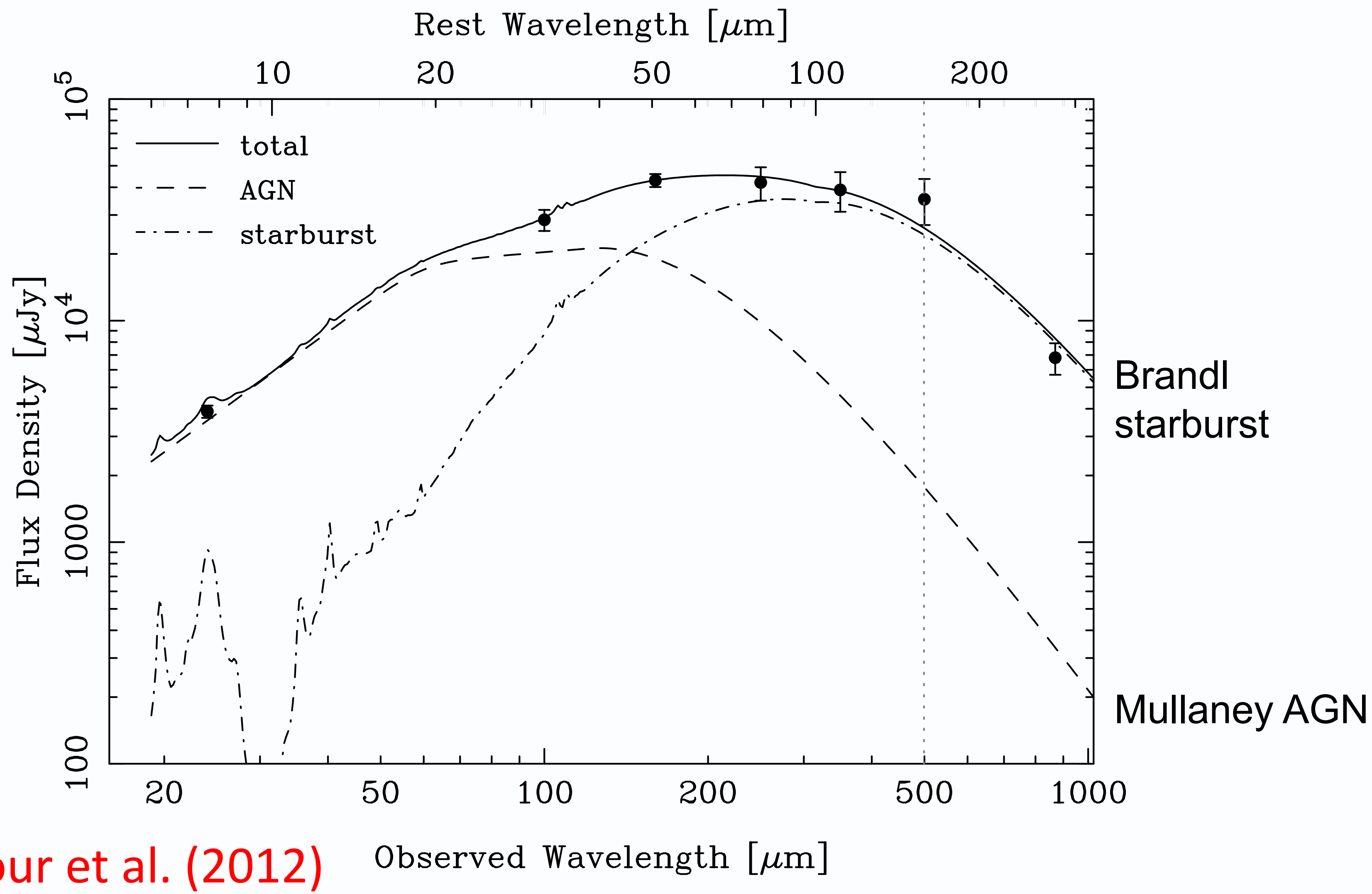
Projet HeRGÉ (Herschel Radio Galaxy Evolution Project)





- Five-band Cycle 1 *Herschel* photometry of all 71 SHzRGs (PI Seymour)
- Data 100% observed
- Students working hard
- Two papers accepted
- Two papers submitted
- Several more in prep.

PKS1138-262 z=2.156 – The Hungry Spider!



Seymour et al. (2012)

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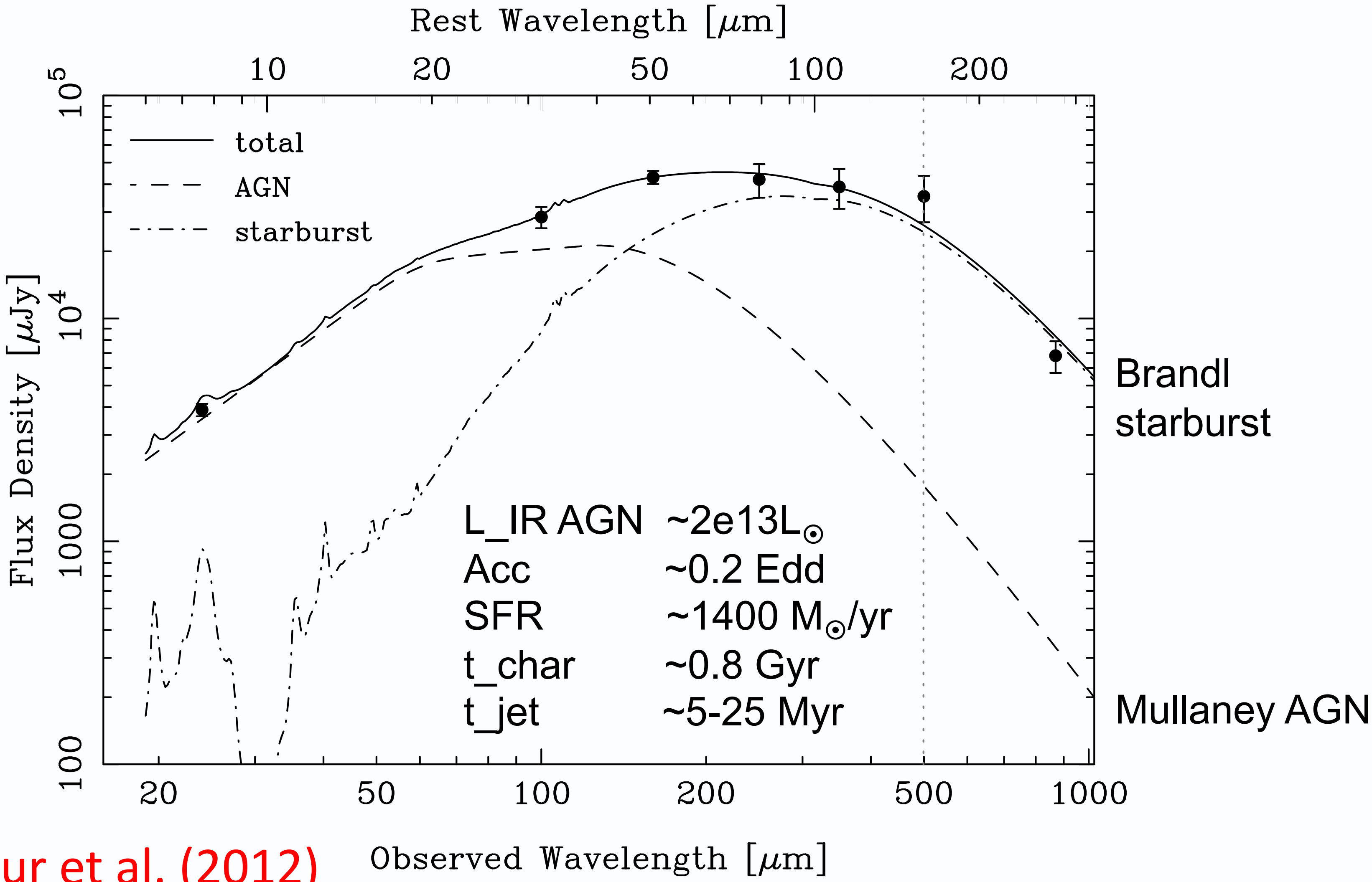
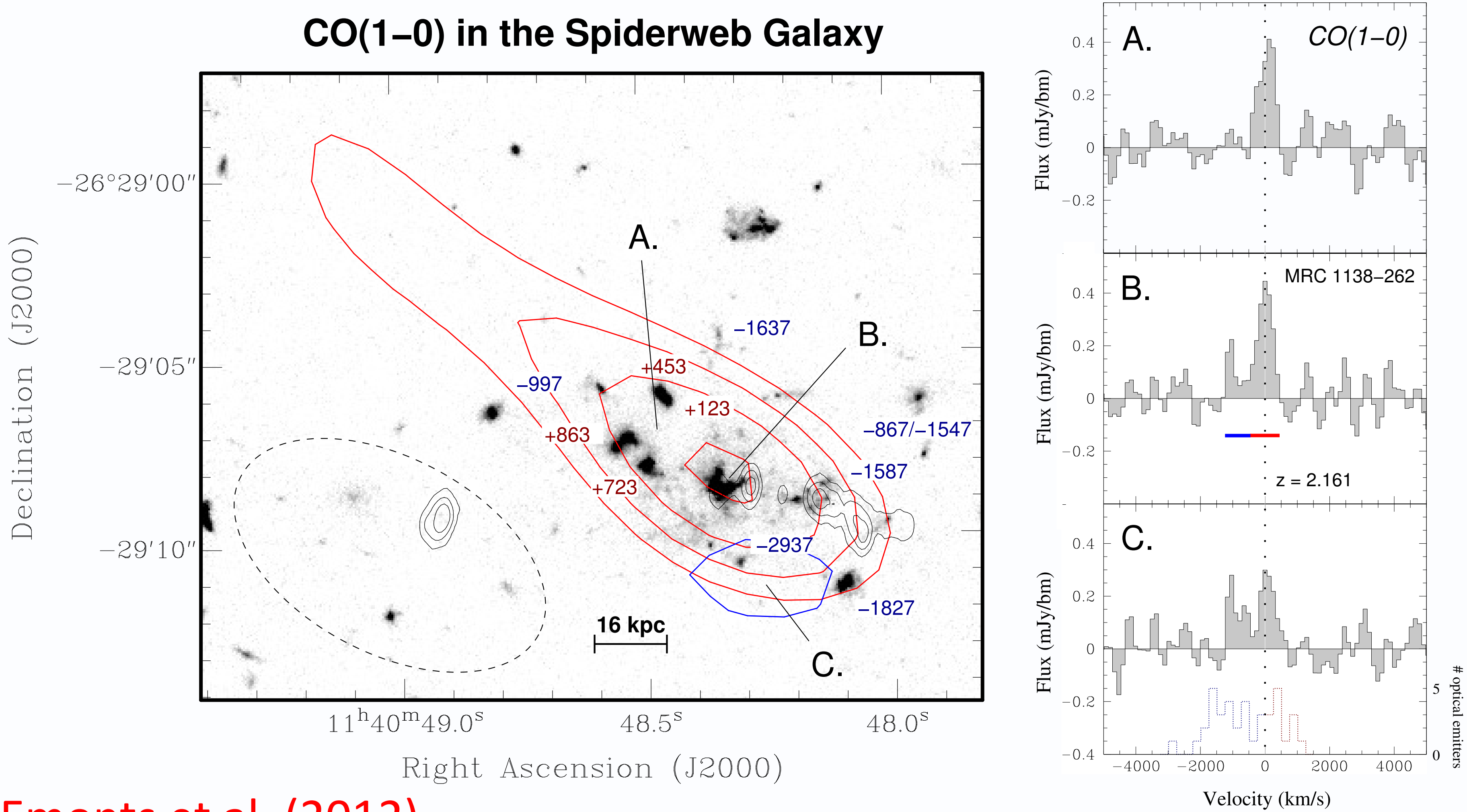


Seymour et al. (2012)

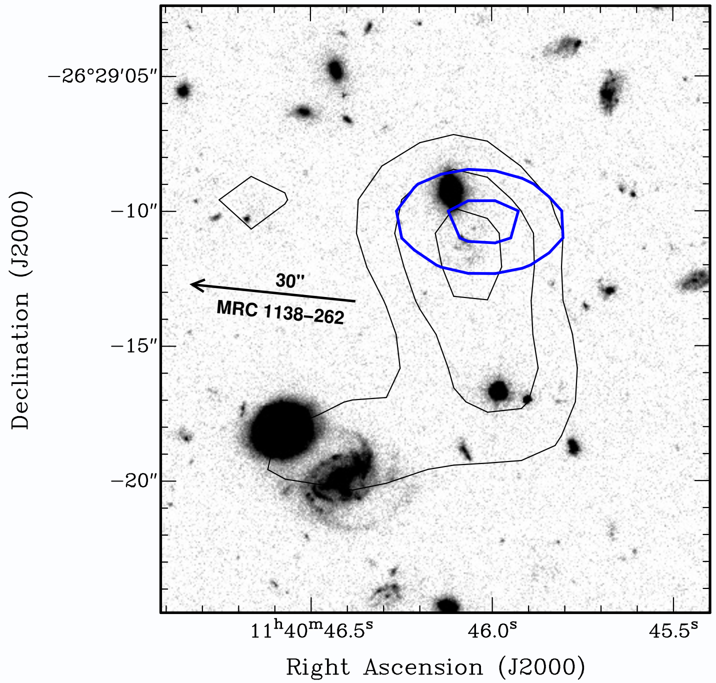
PKS1138-262 z=2.156 – The Gas-rich Spider!

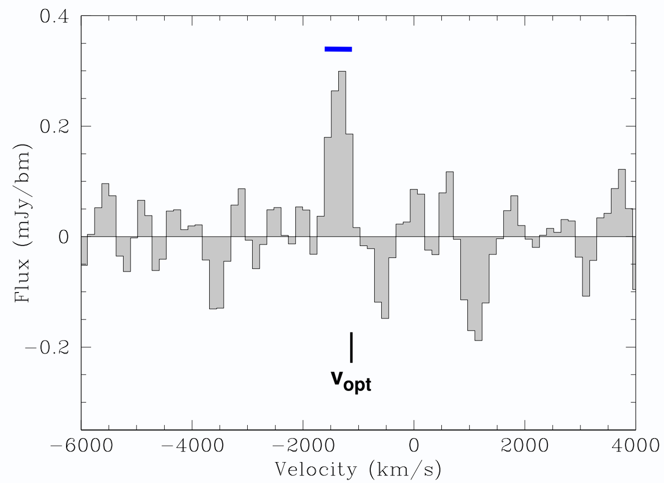


Emonts et al. (2012)

PKS1138-262 z=2.156 – Gas-rich companion

- HAE229 lies ~250 kpc away
- HST image with CO contours (blue)
- black contours = 3.6μm
- CO spectrum seen in (lower left)
- group of 4 galaxies, 2 confirmed as proto-cluster members
- strong PAH emission (Ogle et al. 2012)





Emonts et al. (2012)

Mergers and feedback amongst starbursting radio galaxies

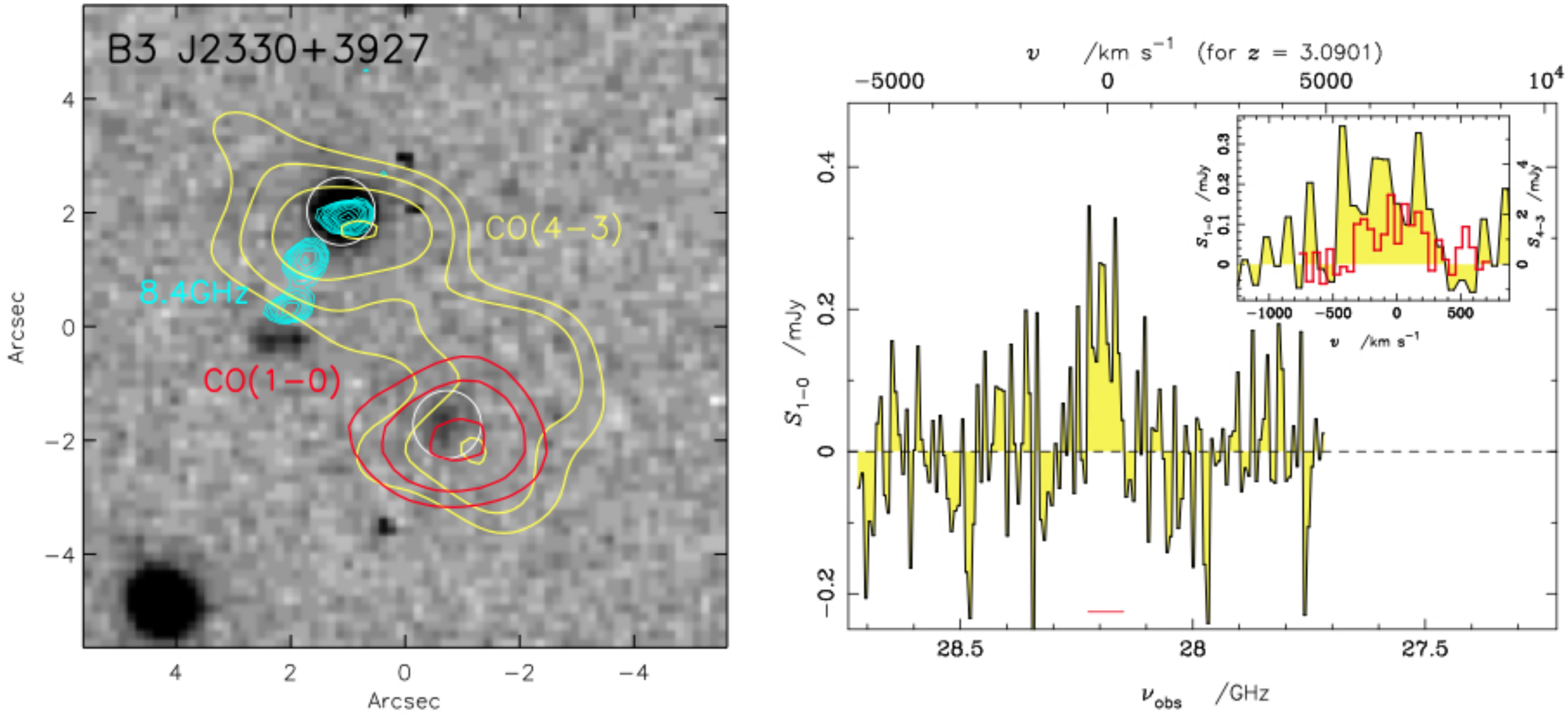
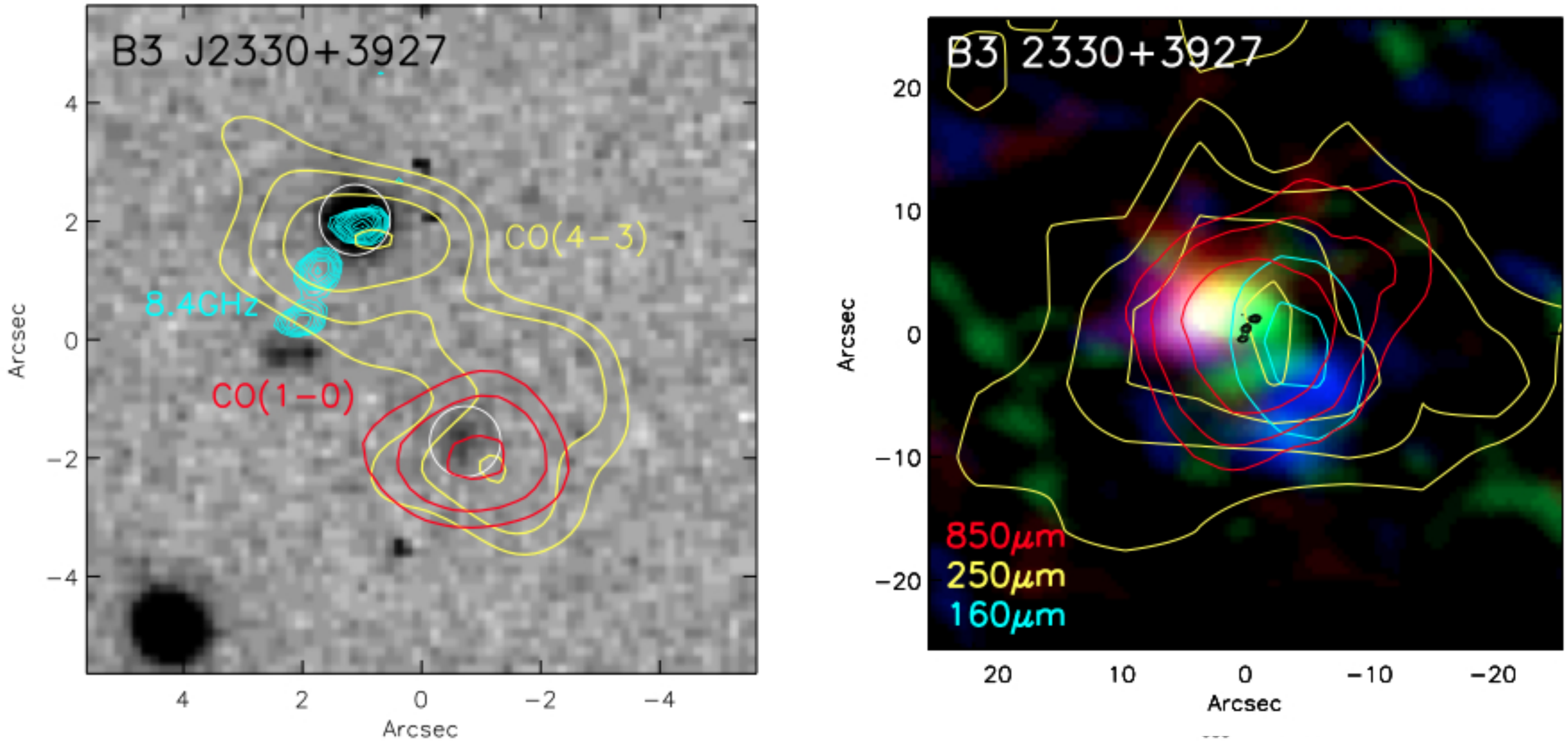


Figure 2. *Left:* Greyscale K' image of the B3 J2330+3927 field (DB03) with isophotal contours of the ^{12}CO $J=1-0$ emission in red ($-3, 3, 3\sqrt{2}, 6... \times$ local noise level). N is up; E is left. The ^{12}CO $J=1-0$ is associated with component c (circled, lower right), rather than the core of the AGN host galaxy (also circled, betrayed by its powerful synchrotron emission – cyan contours – Pérez-Torres & De Breuck 2005). ^{12}CO $J=4-3$ emission is shown in yellow – a radically different morphology from that presented by DB03. The brightest component is centred on the AGN while a fainter clump lies to the south-west, coincident with component c. The astrometric uncertainties here are $\lesssim$0.5 arcsec. *Right:* ^{12}CO $J=1-0$ spectrum of JVLA 233024.69+392708.6 (component c), near B3 J2330+3927. Inset: zoomed in on the line, with the IRAM PdBI ^{12}CO $J=4-3$ spectrum of the same galaxy (§2.2) shown in red, binned to 53 km s^{-1} and scaled by $16^{-1}\times$ to be on the same Rayleigh-Jeans T_b scale as the ^{12}CO $J=1-0$ spectrum. The red horizontal line shows the spectral region summed to create the ^{12}CO $J=1-0$ image shown alongside, and to determine I_{CO}.

Ivison et al. (2012)

Mergers and feedback amongst starbursting radio galaxies



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Ivison et al. (2012)

Environment of 4C41.17

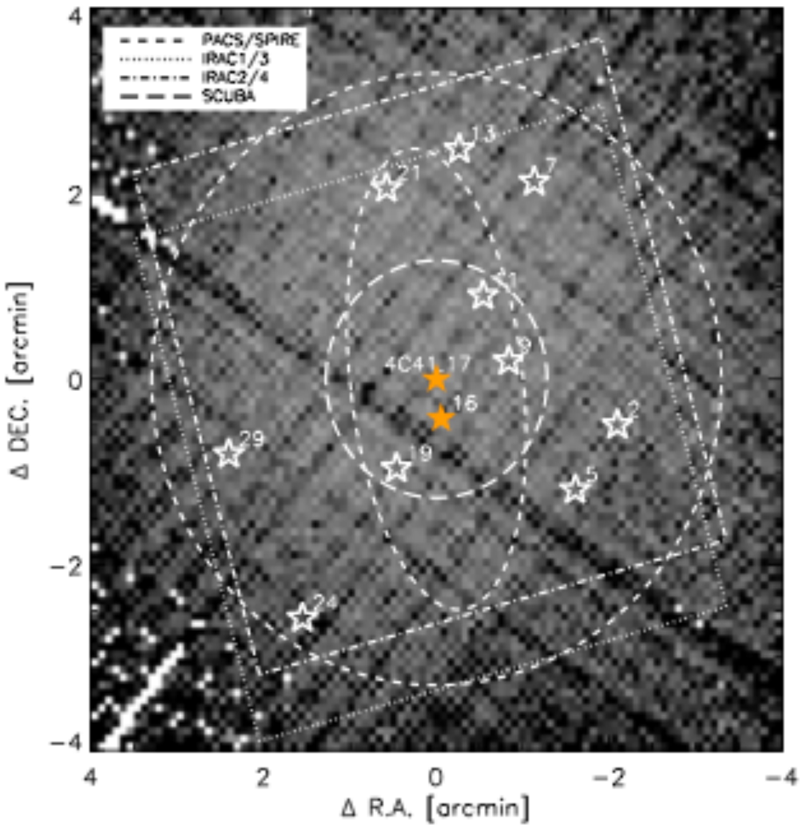

Figure 2. Coverage map and spatial distribution of sources with derived photometric redshifts, centered on 4C+41.17. Dark pixels indicate regions with low coverage. White, open stars indicate sources that have $z_{phot} < 3$, orange, filled stars show sources with $z_{phot} > 3$. 4C+41.17 and source 16 are very likely to be at the same redshift. The dashed circle ($r = 3.3'$)/ellipse ($a = 2.5'$, $b =$

Wylezalek et al. (2012)

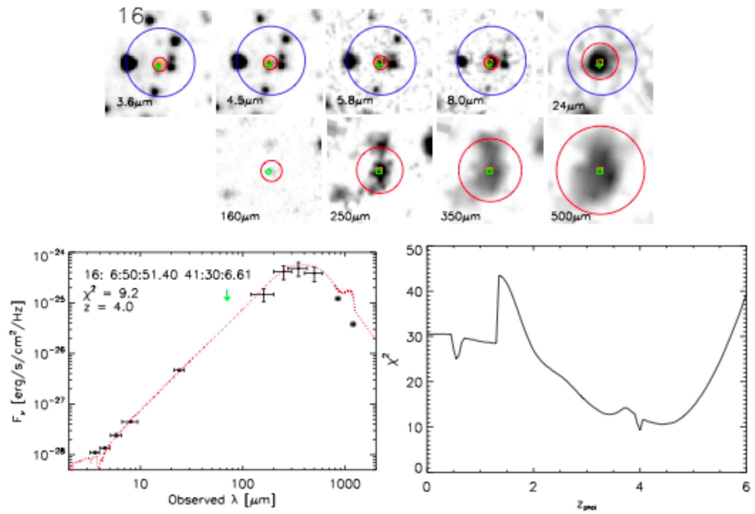

Figure A7. This source is nicely fit by an AGN dominated template, similar to the SED of 4C+41.17. The χ^2 distribution shows a clear and prominent dip at the redshift of the radio galaxy. This source is therefore our most likely candidate to be associated with the radio galaxy.

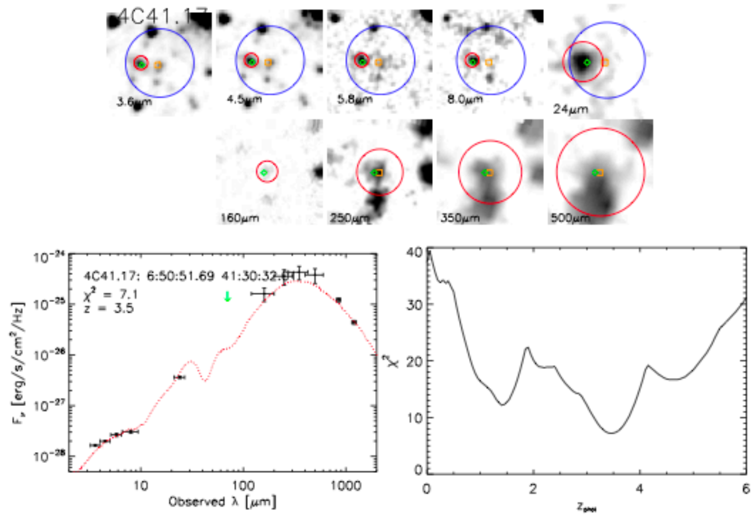

Figure A8. The redshift of the radio galaxy is well constrained by the photometric redshift fitting using a composite AGN+starburst template (I19254). A single significant dip appears at a redshift of ~ 3.5 in the χ^2 distribution which is consistent with the spectroscopic redshift of 3.792. Note that this source is not fit by its own template as the stellar to dust peak ratio in those templates is not as optimal as in template 2.

Conclusions

(1) HzRGs are unique laboratories to study the formation of massive galaxies and clusters

(2) HzRGs are massive, radio-loud, highly accreting starbursts probably triggered by gas rich major mergers

(3) Projet HeRGÉ will provide a complete measure of their evolutionary state, and will test theories of how radio-loud phase of AGN relates to galaxy formation

Thank you

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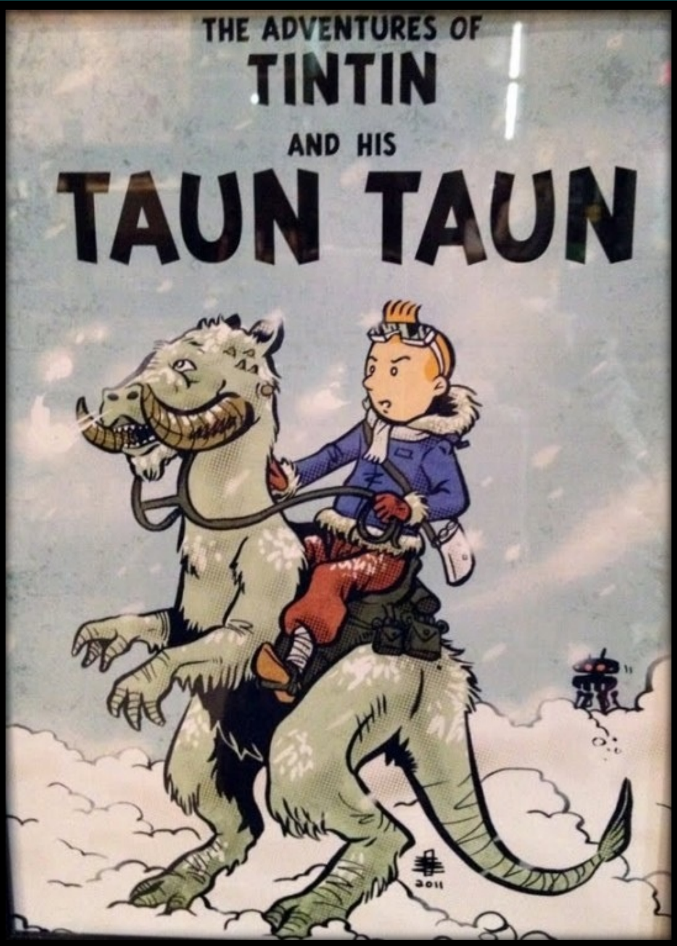


Star Formation Rates of HzRGs

SFRs from SCUBA observations

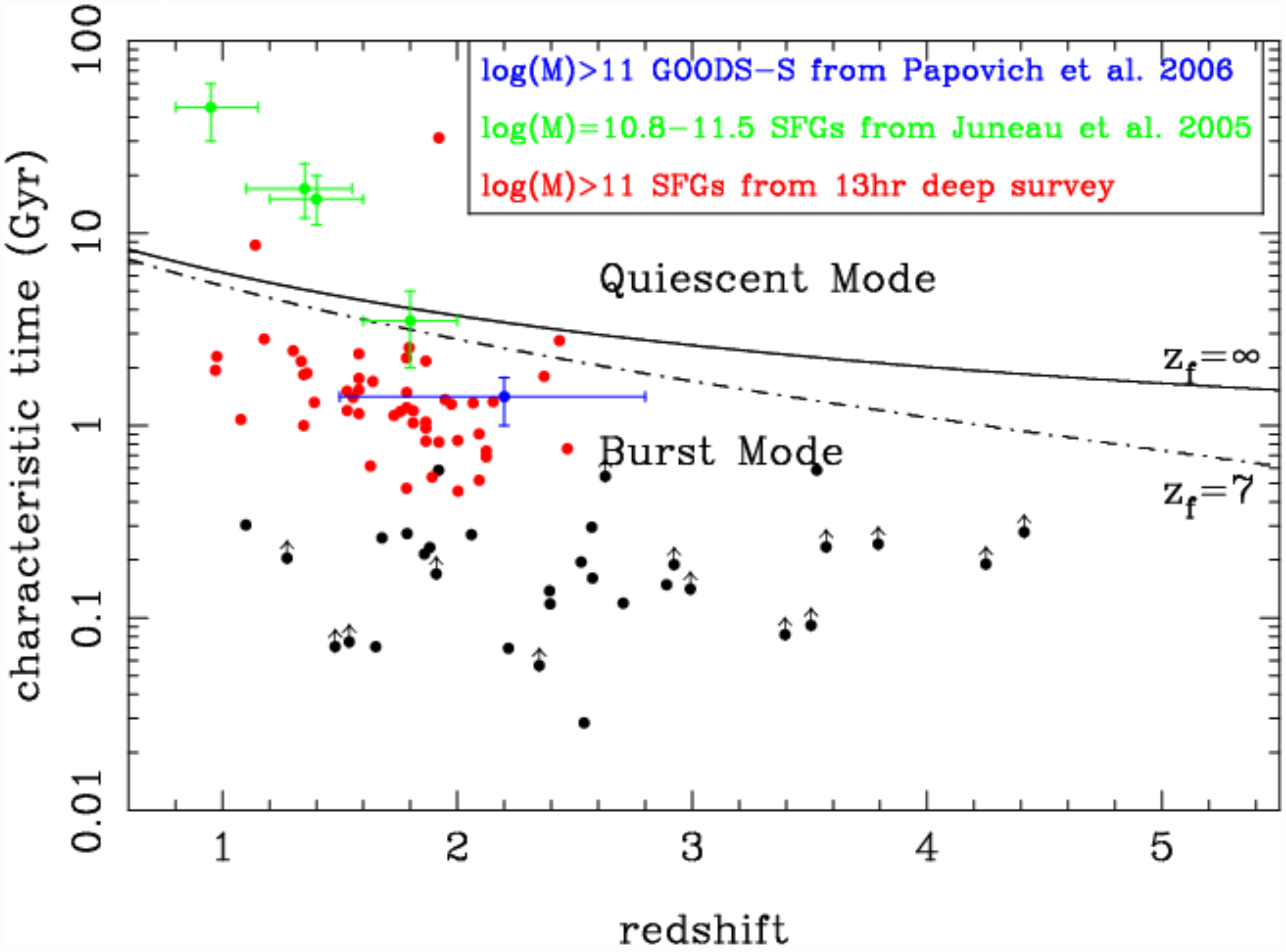
specific Star Formation Rate (sSFR) = SFR/$M_{\odot}$ (Gy^{-1})

= measurement of the current SFR relative to past SFR needed to build up the stellar mass of the galaxy (Gy^{-1})

Characteristic time = inverse of sSFR (in units of time)

= time to double mass at given SFR

Specific Star Formation Rates/Characteristic Time



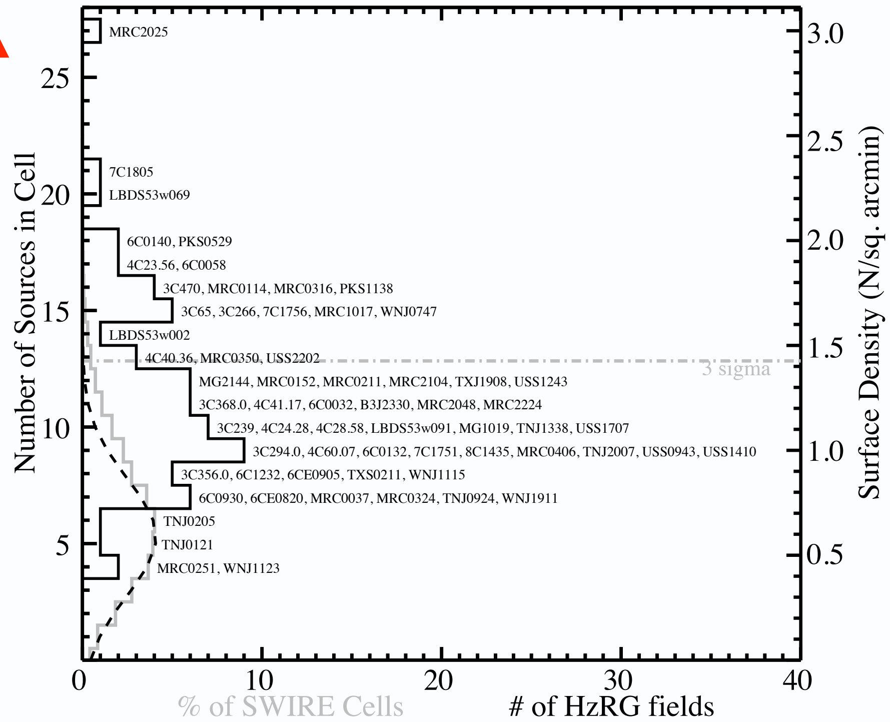
Seymour et al, 2007

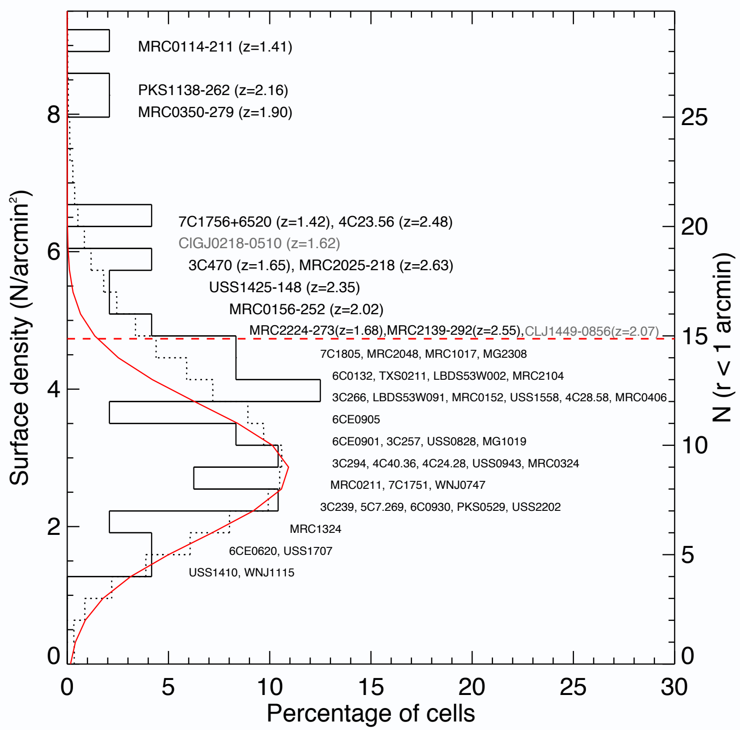
Environments of HzRGs

24um selected sources
(Mayo et al. 2012)

Red IRAC selected sources
(Galametz et al. 2012)

Number galaxies within 1'





Number of HzRGs