The Massive Hosts of Radio Galaxies Across Cosmic Time

Nick Seymour (*Spitzer* Science Center/JPL)

"Obscured AGN Across Cosmic Time"

Seeon, June 7th 2007


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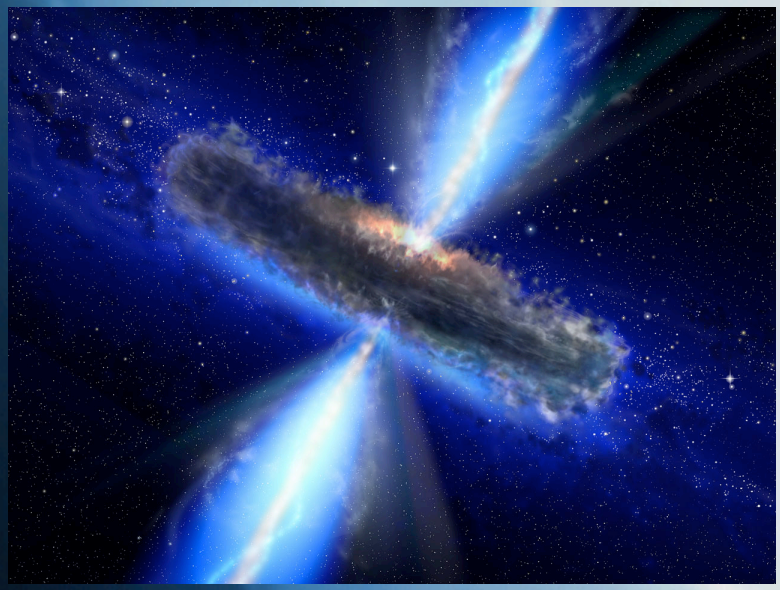
Structure of Talk

- Introduction to the SHzRG project.
- Results from the *Spitzer* Data on the host galaxy
- Results using *Spitzer* and other data looking at the relationship between the host galaxy and AGN activity

Unification of Active Galactic Nuclei (AGN) by Orientation



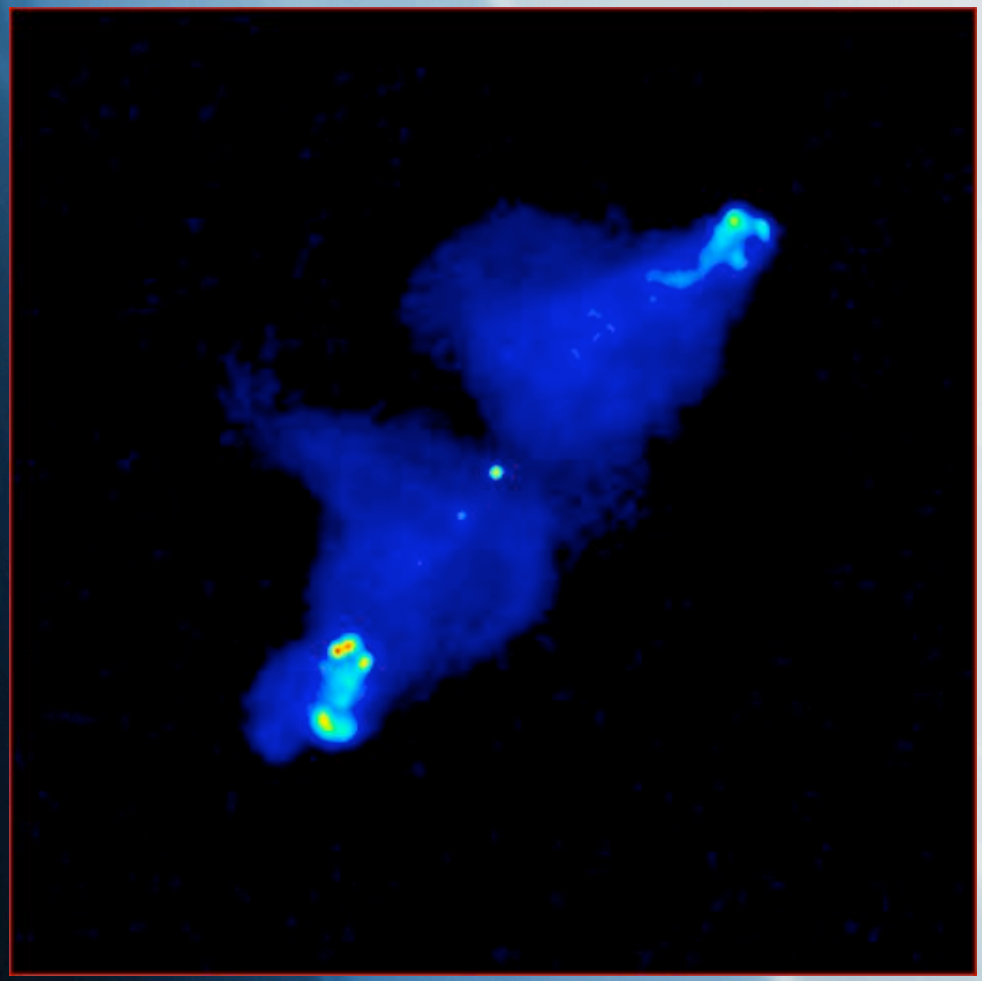
ESA/NASA, the AVO project and Paolo Padovani

	Un-obscured AGN (broad-lined)	Obscured AGN (narrow-lined)
Low luminosity	Type 1 Seyfert Galaxies	Type 2 Seyfert Galaxies
High luminosity	QSOs (Quasi-Stellar Objects)	Type 2 QSOs

All these can be radio-loud or radio-quiet (i.e. have a radio jet or not)

Why are radio galaxies interesting?

Archetypical (radio-loud) type II AGN!

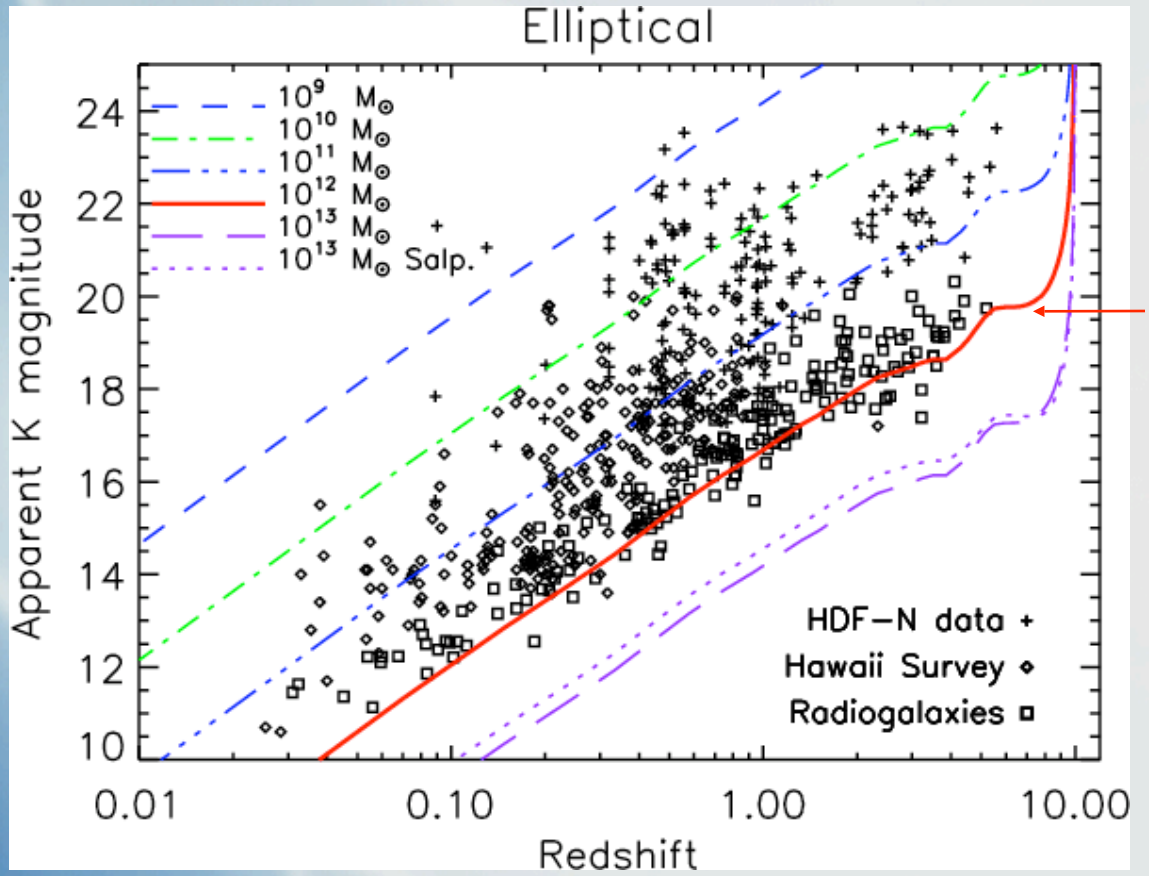


4C14.11 (Leahy & Perley 1991)

- Locally hosted by gE and cD galaxies (Matthews *et al.* 1964; Zirm, Dickinson & Dey 2003)
- Reside in moderately rich (proto) cluster environments (Stern *et al.* 2003)
- Sometimes surrounded by Ly -alpha haloes (Reuland *et al.* 2003)
- Often luminous at sub-mm wavelengths (Archibald *et al.* 2001)

K-*z* or Hubble diagram for radio galaxies

Apparent *K* magnitude



$10^{12}M_\odot$

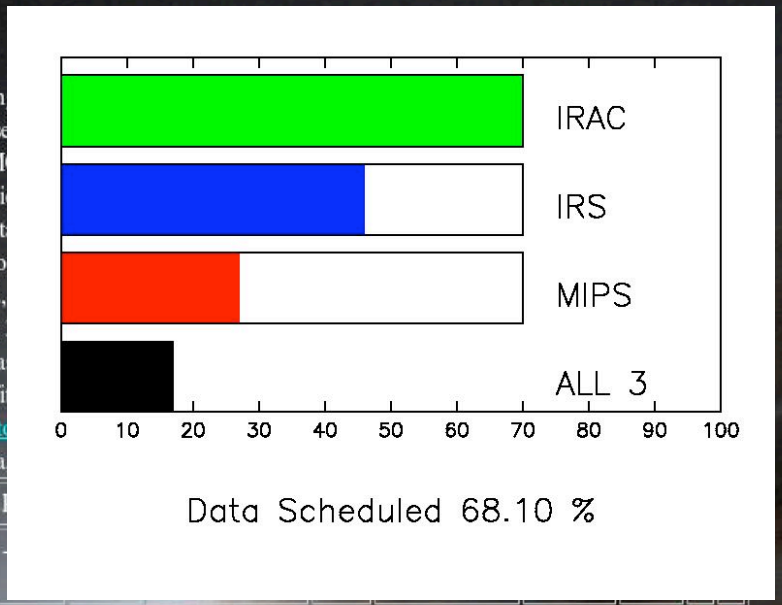
Redshift

Rocca-Volmerange *et al.* 2004

A Comprehensive *Spitzer* Survey of HzRGs: The Most Massive Galaxies at Every Epoch

- 28.3 hr of *Spitzer* Cycle 1 GO observations
- 70 HzRGs at $1<z<5.2$
- 3 camera imaging, to measure the SEDs of stellar populations and the dust properties
- Data taken from Nov. 2004 to Nov. 2006
- Now 20 more hours of data from a GTO Cycle 4 proposal (to complete 16 and 24μm imaging)!
- And bonus IRS spectrum of 4C23.45 (to be observed in two weeks)

Welcome to the SHzRGS status page

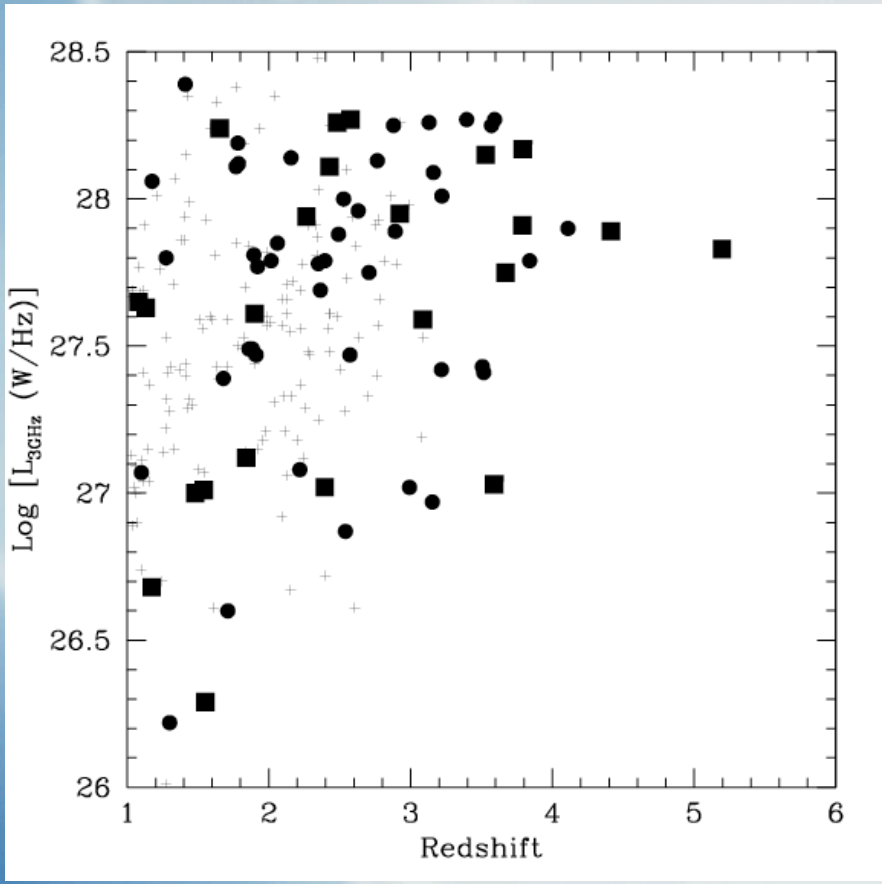


1) Sources order in increasin
2) Name is a link to NED (2amin s
3) HST: W=WFPC2, WI=WFPC2IMPOL, A=ACS, N=NICM
(*)=some data with PI outside collaborati
4) X (X-ray): C=Chandra data has been t
5) a magnitude with a link leads to
6) Scuba data added: A01 = Archibald 2002,
7) logL = log restframe luminosity at
8) ROC + date = publicly relea
9) RED - reduced and link to fi
10) notes have details of phot
11) POL: *=proposed to be observed, ^=got data

Name	RA	dec	z	X	Optical	HST	Spectra								
6C 0032+412	08.7212076 00:34:53.09	41.52541730 +41:31:31.50	3.670	-	z'	-	-								
MRC 0037-258	09.985036 00:39:56.41	-25.575281 -25:34:31.01	1.100	-	R	-	-	Im	K	RED	-	-	-	27.09	D	N
6C*0058+495	15.328557 01:01:18.85	49.8367480 +49:50:12.29	1.173	P	-	-	-	-	K	RED	-	RED	-	26.68	D	N
MRC 0114-211	19.2143510 01:16:51.44	-20.8685314 -20:52:6.71	1.410	-	-	W*	-	-	K	RED	-	-	-	28.32	D	N
TN J0121+1320	20.4280417 01:21:42.73	13.3494444 +13:20:58.00	3.516	-	R	-	-	Sp	JK	RED	RED	-	SCUBA	27.17	D	N
6C*0132+330	23.876644 01:35:30.39	33.283560 +33:17:0.82	1.710	-	z'	-	-	-	K	RED	-	-	-	26.57	D	N
6C 0140+326	25.9325829	32.89702990	4.413	-	-	W(*) N	-	-	K	ROC Dan	RED	ROC	SCUBA	27.26	D	N

Luminosity-redshift distribution

$Log(L_{3GHz})$ [W/Hz]

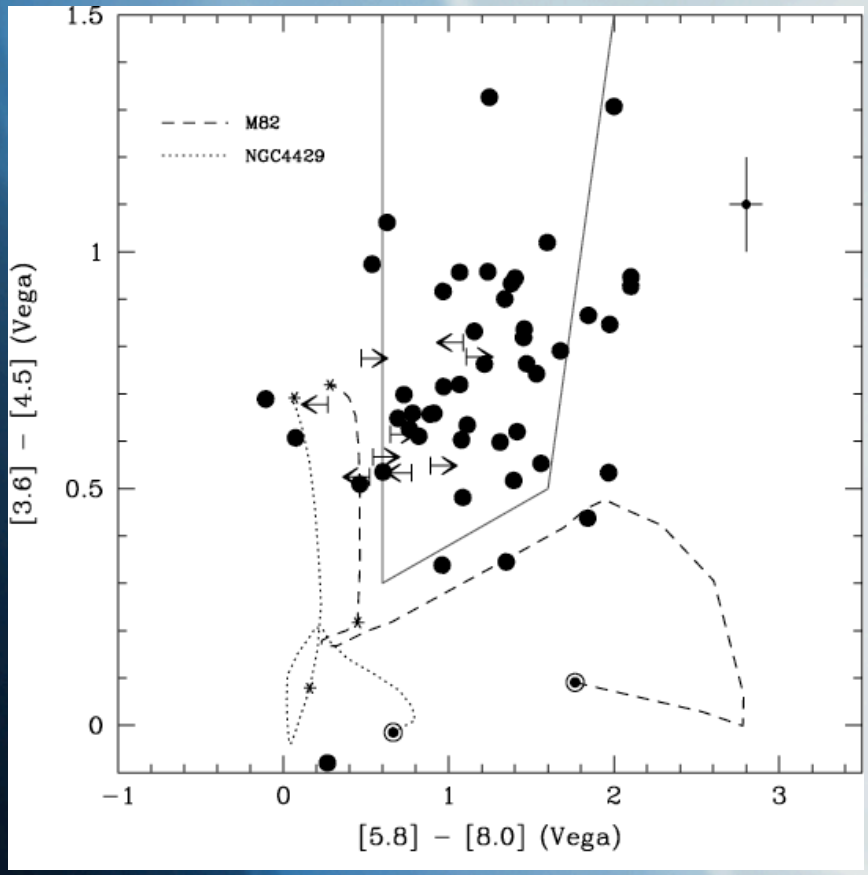


Circles - HzRGs in our *Spitzer* sample with IRAC/IRS imaging

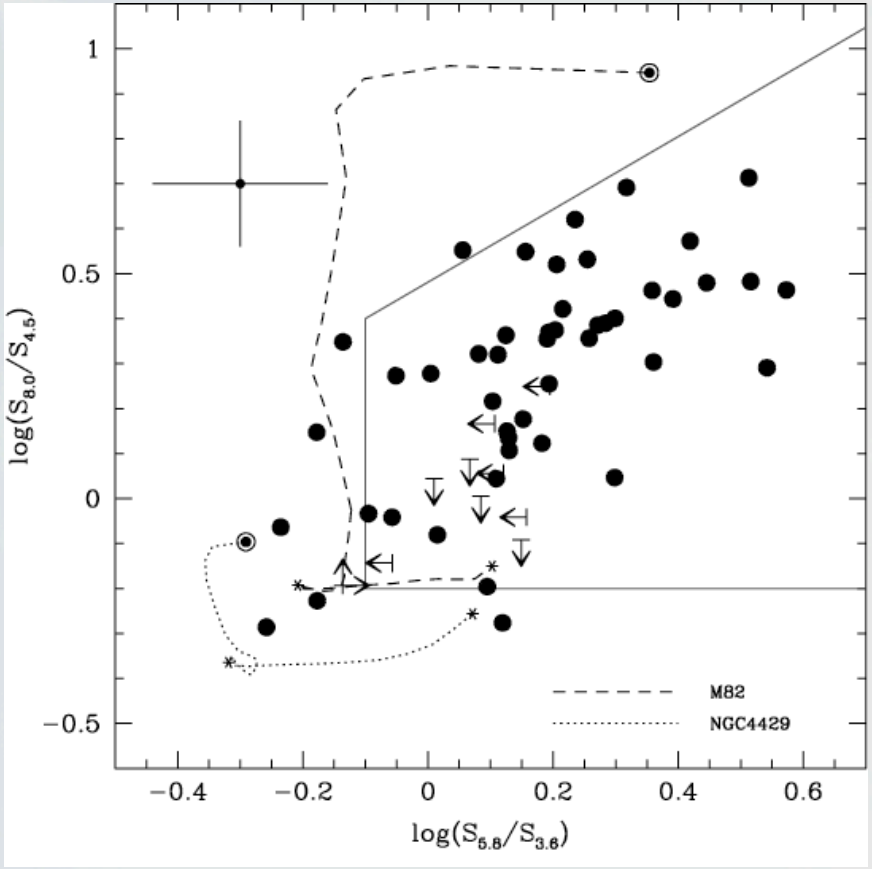
Squares - MIPS observations as well, i.e. low galactic background

Plusses - parent sample of 225 HzRGs from which our sample of 70 was drawn

The IRAC colours



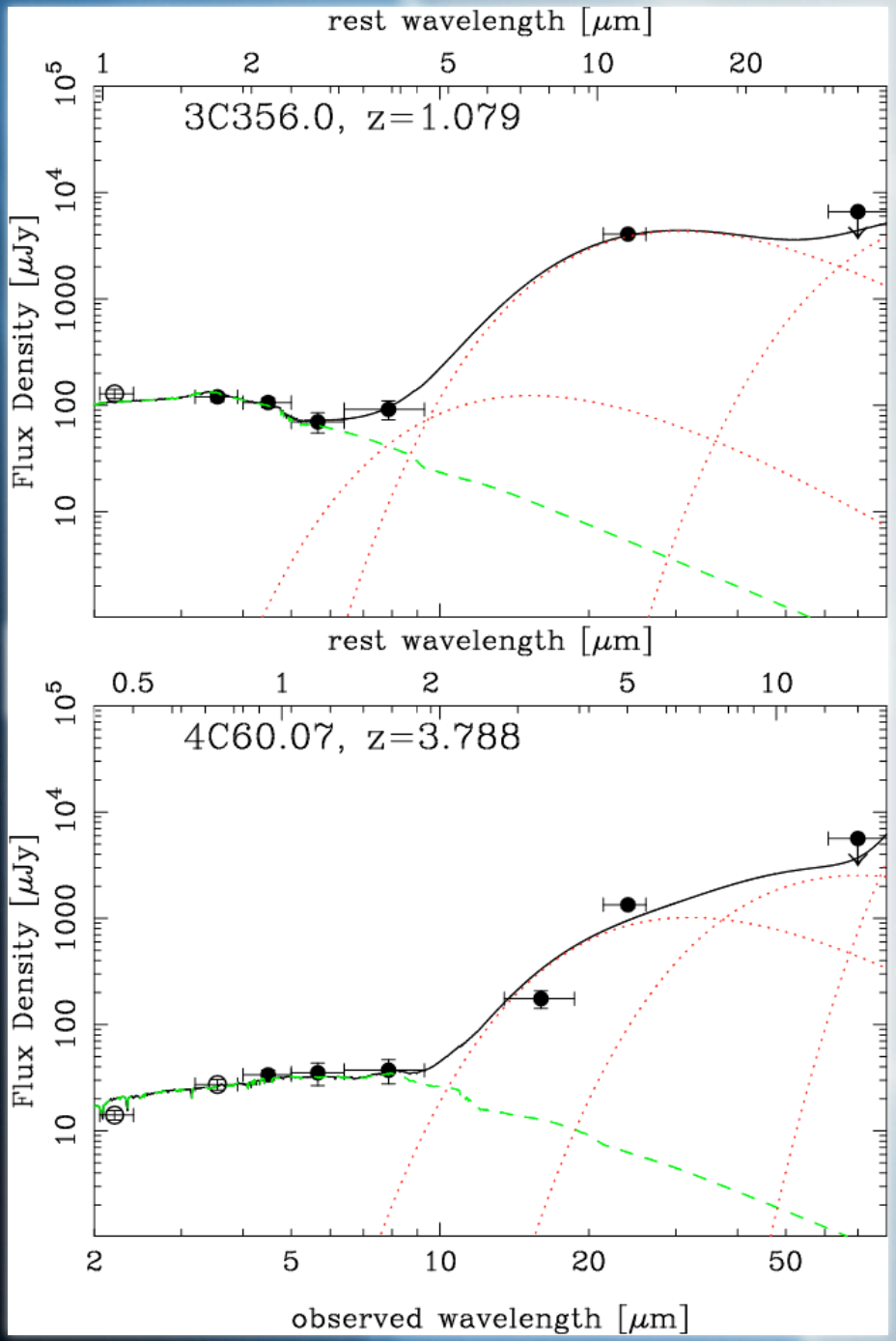
Stern et al. 2005

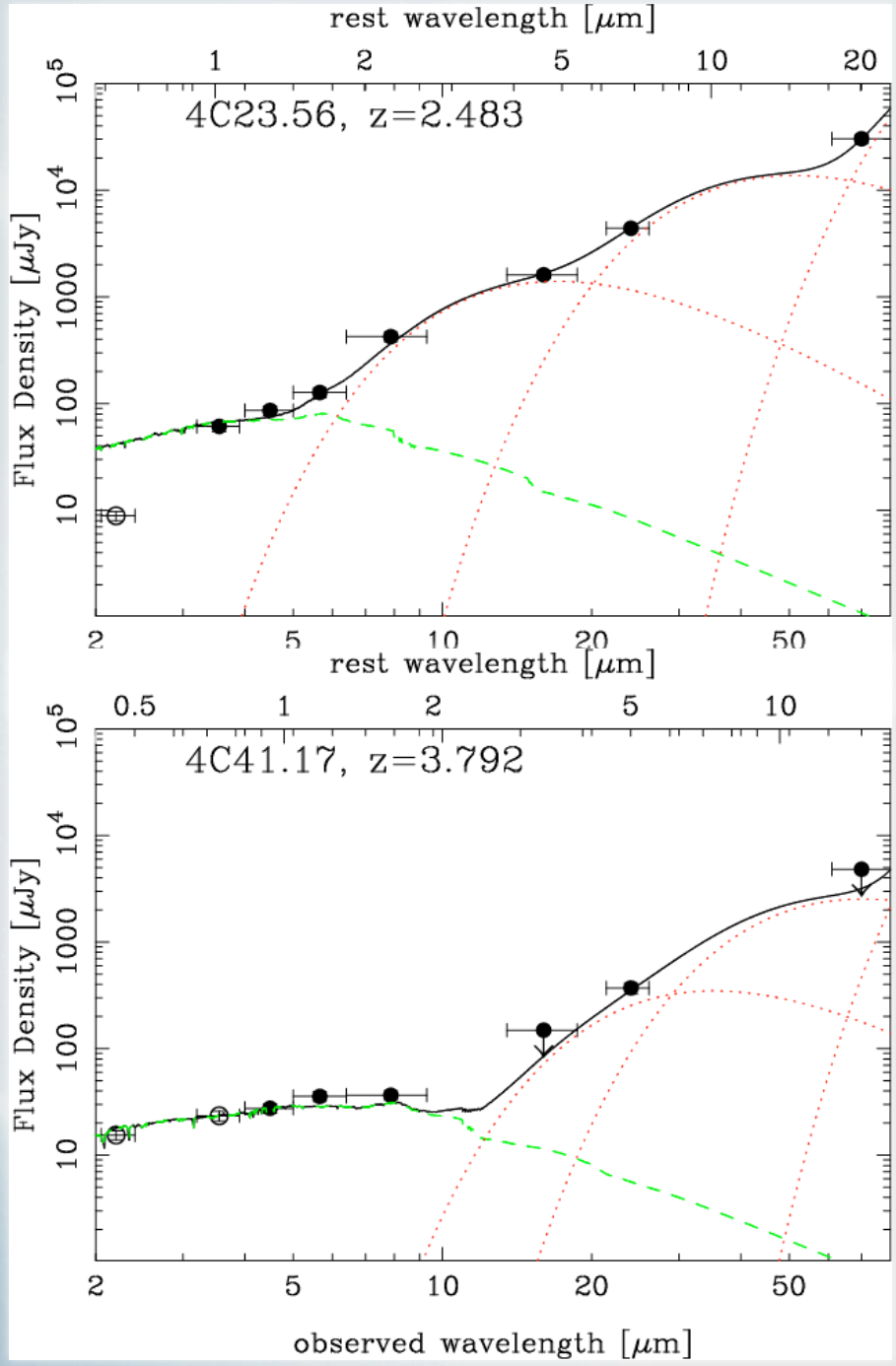


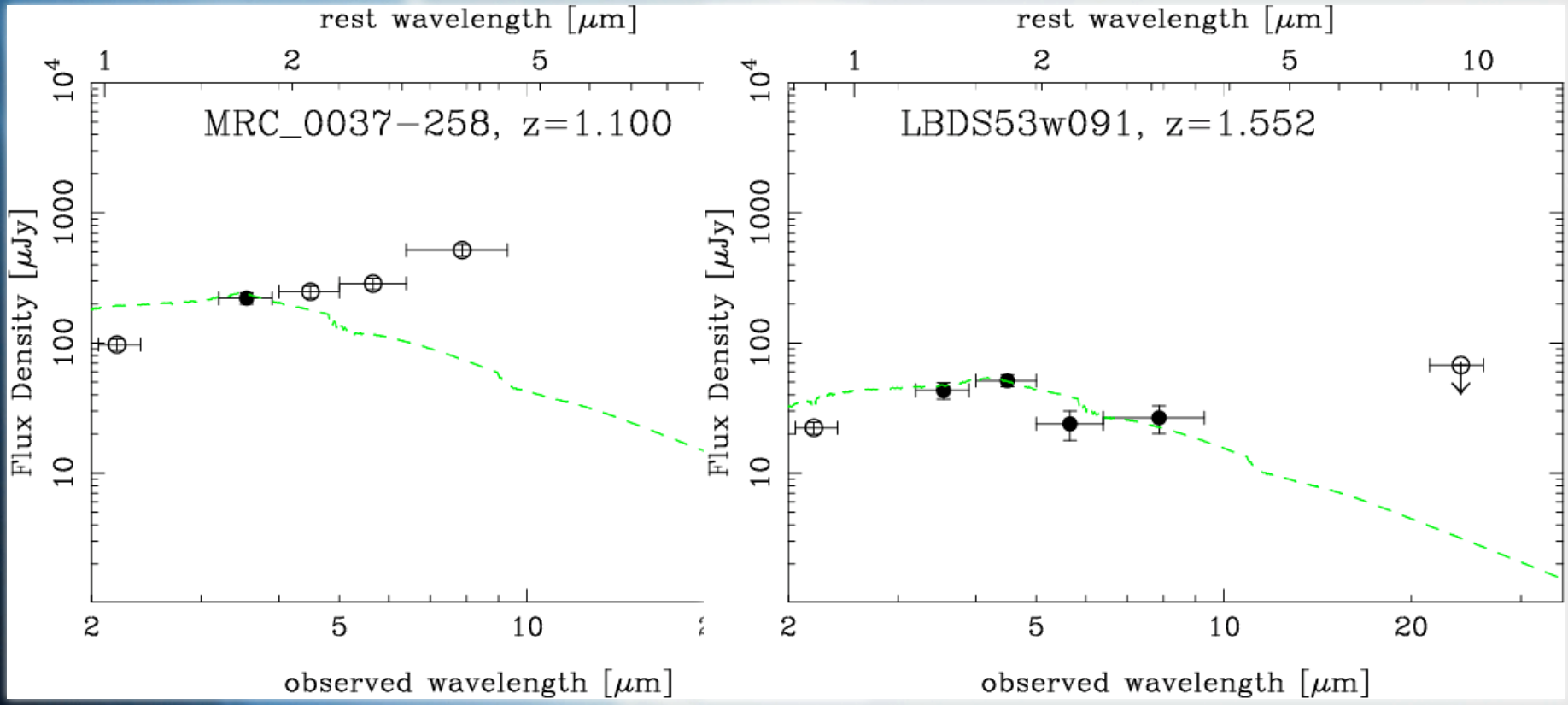
Lacy et al. 2004

Stellar *H*-band Luminosities:
Modeling the rest-frame near-IR SEDs

- Using only IRAC bands + 16μm + 24μm
- Fit elliptical templates of varying age from PEGASE 2 (assuming z_{form}=10).
- Use 3 black-body components of dust at different temperatures: 60K and 250K, both fixed, and 600-1500K hot AGN heated dust
- Use formal χ^2 fitting for results


rest wavelength [μm]
1
2
5
10
20
3C356.0, z=1.079
Flux Density [μJy]
10
100
1000
10^4
10^5
rest wavelength [μm]
0.5
1
2
5
10
4C60.07, z=3.788
Flux Density [μJy]
observed wavelength [μm]
2
5
10
20
50

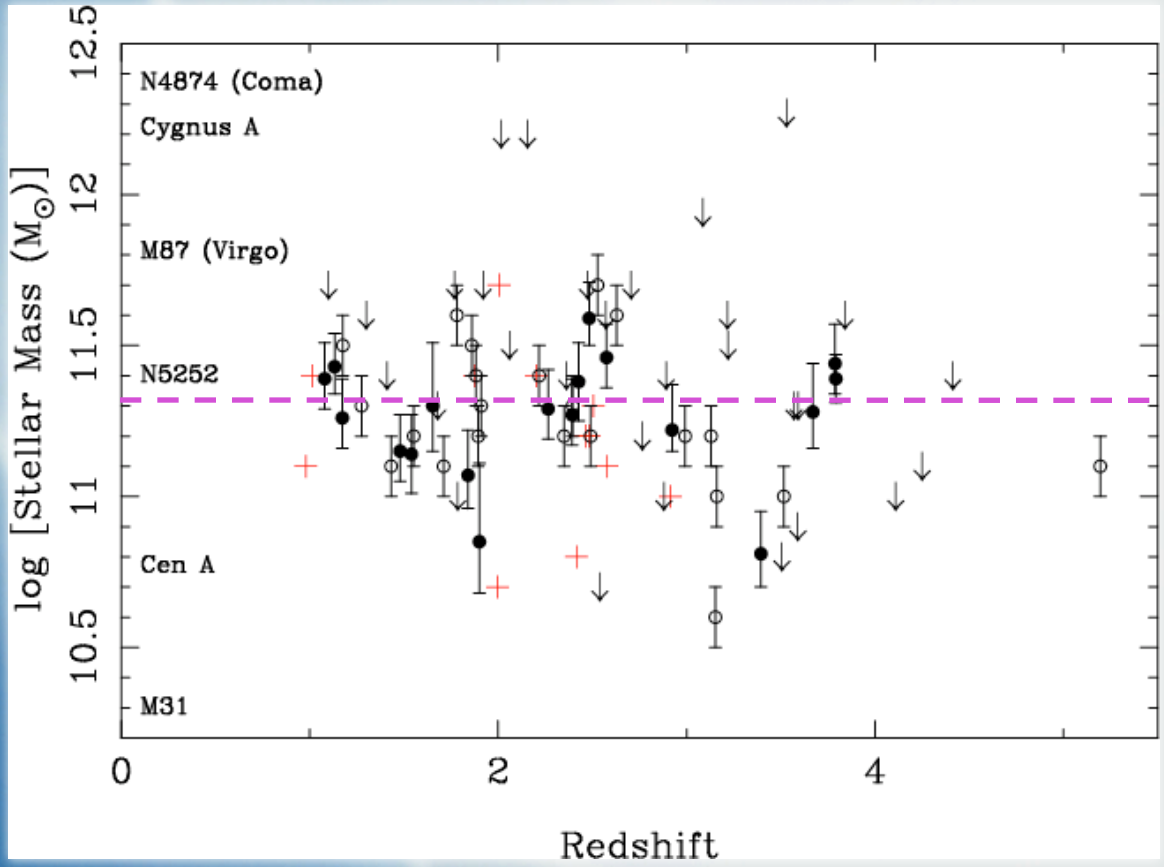

rest wavelength [μm]
1
2
5
10
20
4C23.56, z=2.483
Flux Density [μJy]
10
100
1000
10^4
10^5
rest wavelength [μm]
0.5
1
2
5
10
4C41.17, z=3.792
Flux Density [μJy]
observed wavelength [μm]
2
5
10
20
50



HzRGs without 24μm observations or detections

Stellar masses of HzRGs

Stellar Mass Log(M)



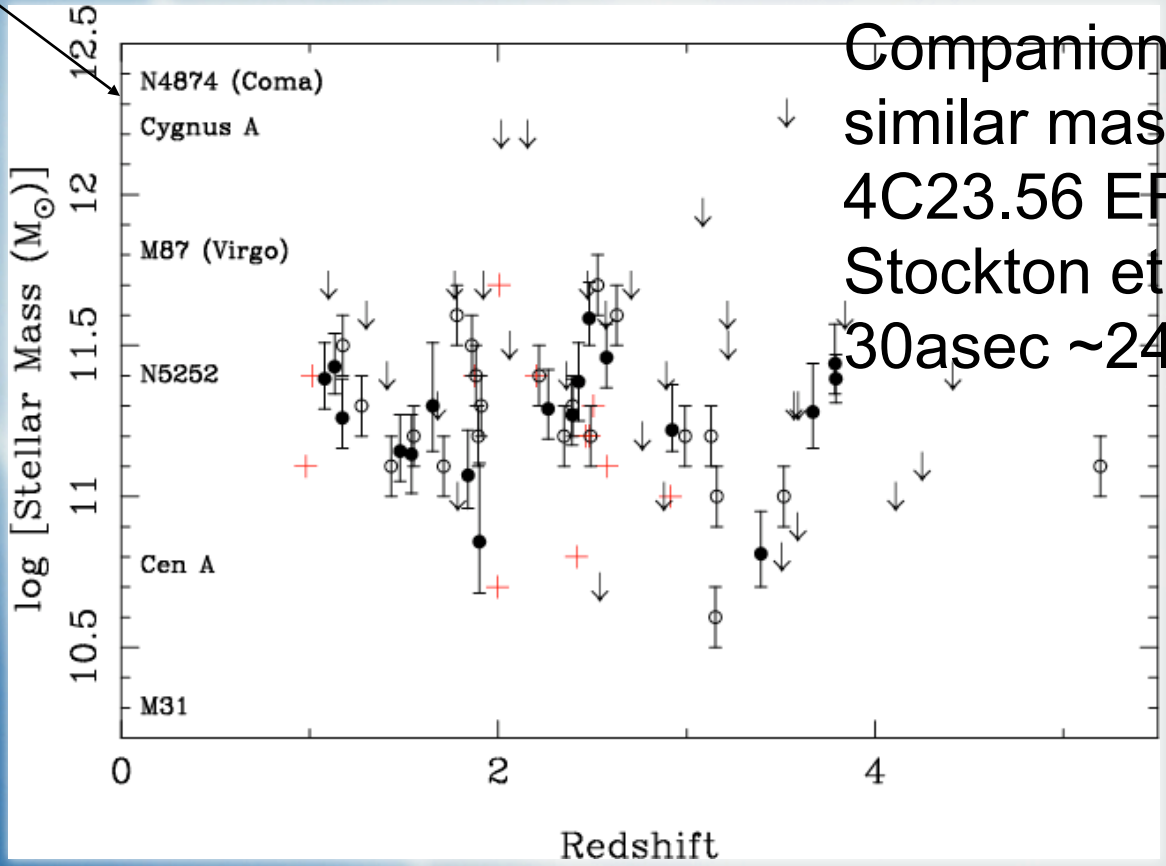
Sub-mm galaxies

Redshift

Stellar masses of HzRGs (photometric)

Dynamical masses

Stellar Mass Log(M)

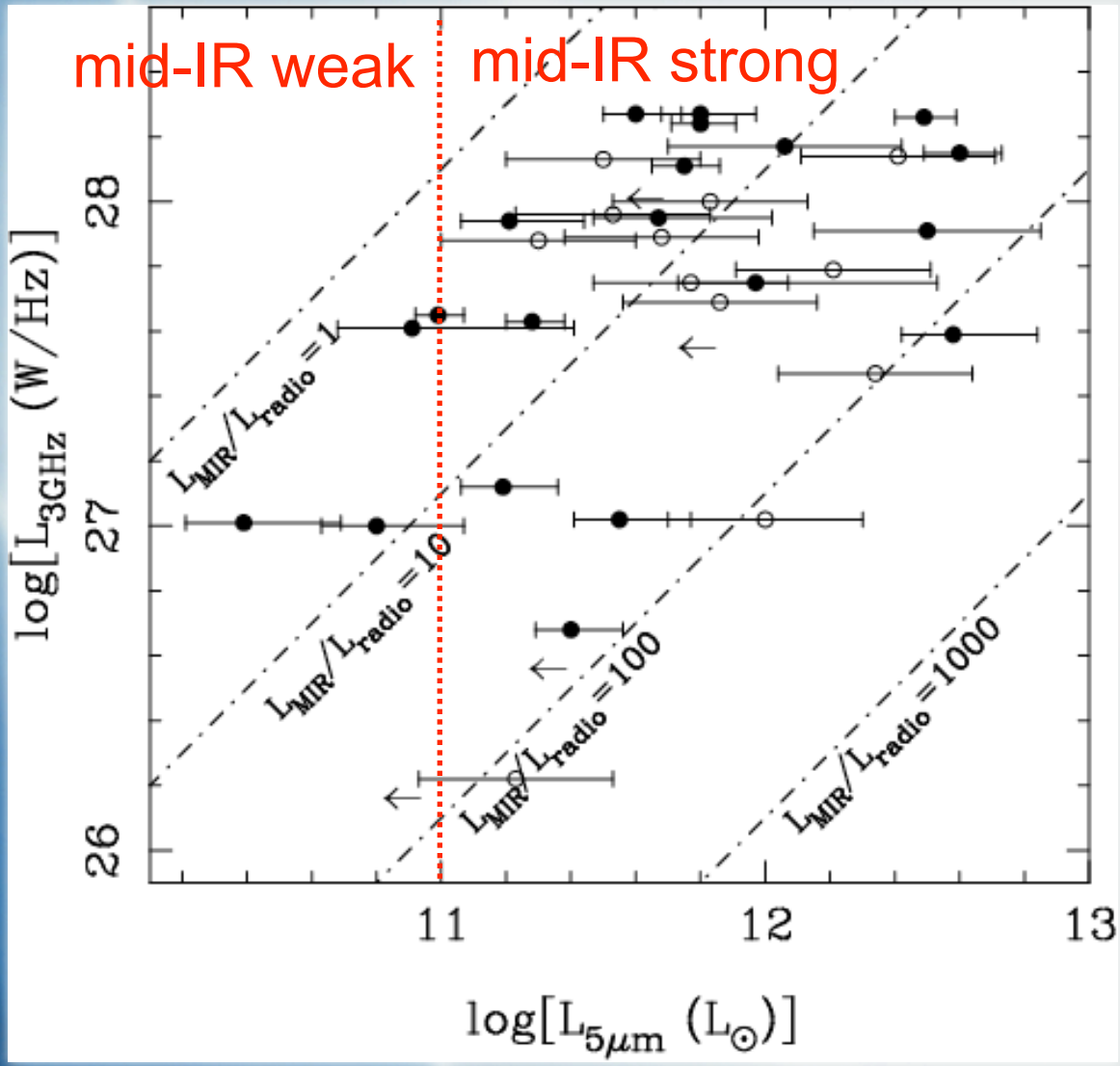


Companion galaxy with similar mass, e.g 4C23.56 ER1 (A. Stockton et al., 2004) at 30asec ~240kpc

Redshift

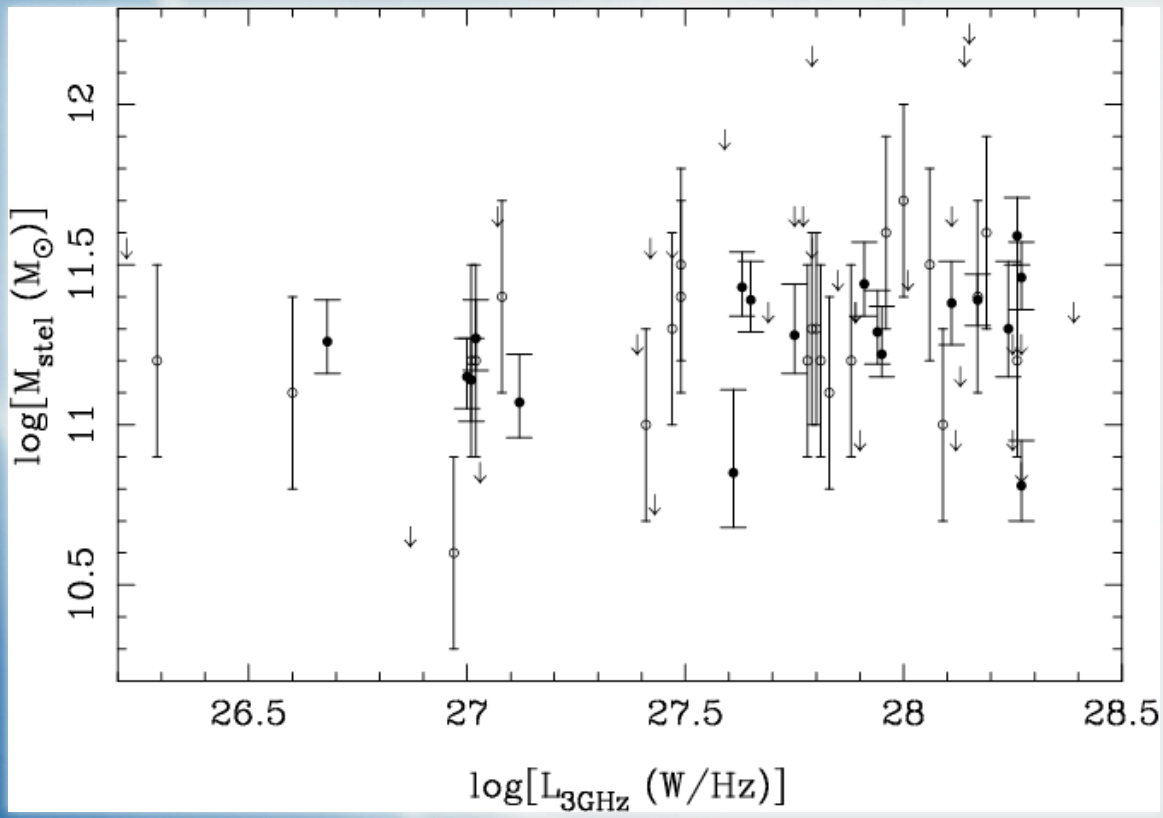
To appear in ApJS (astroph/0703224)

Radio/mid-IR Luminosity Ratio



Ogle et al. 2006

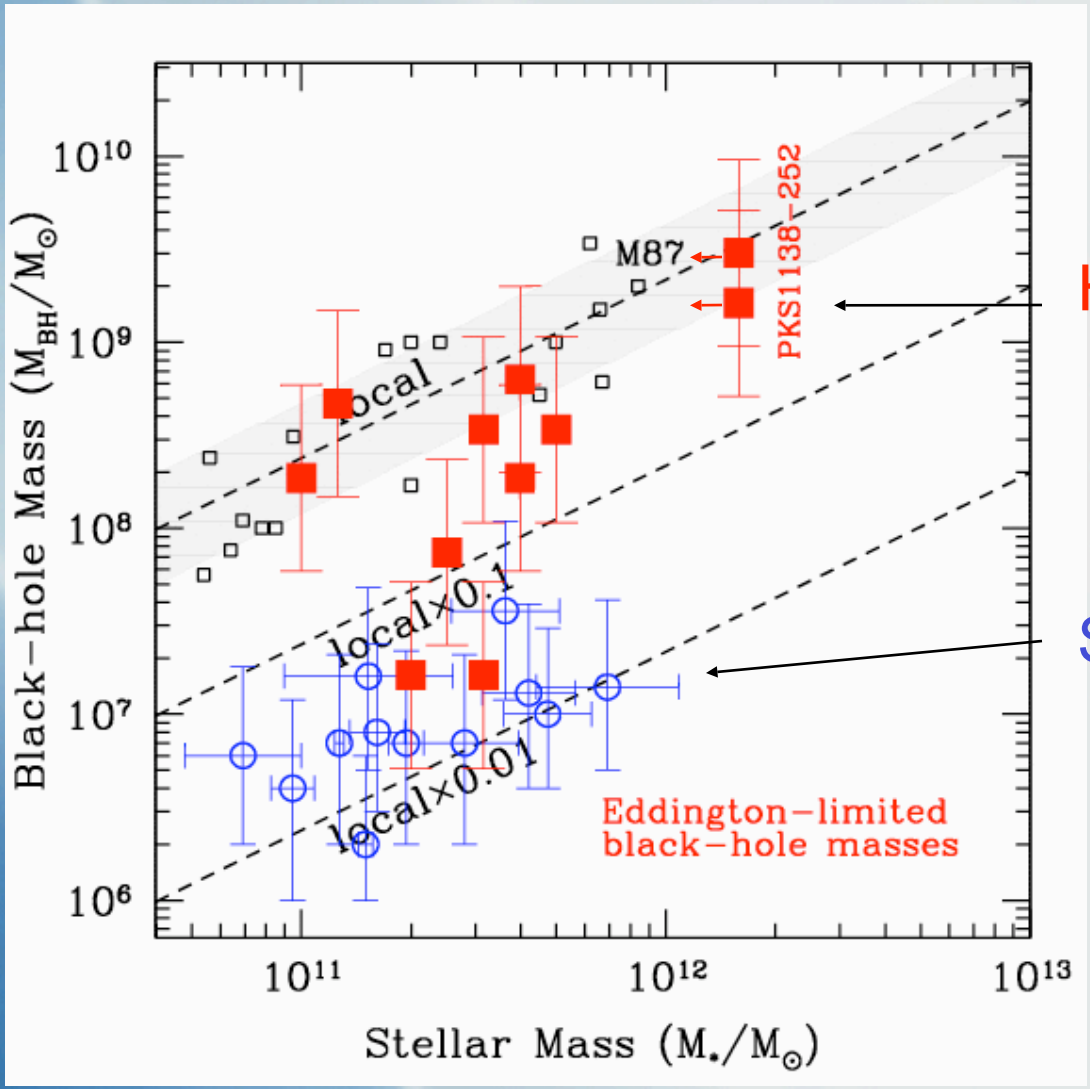
Stellar Mass/Radio Luminosity Correlation



Comparison with Other Data

- *Chandra* and *XMM-Newton*
- High resolution, high frequency radio observations
- Sub-mm observations, mainly with SCUBA

Black-hole mass v stellar mass



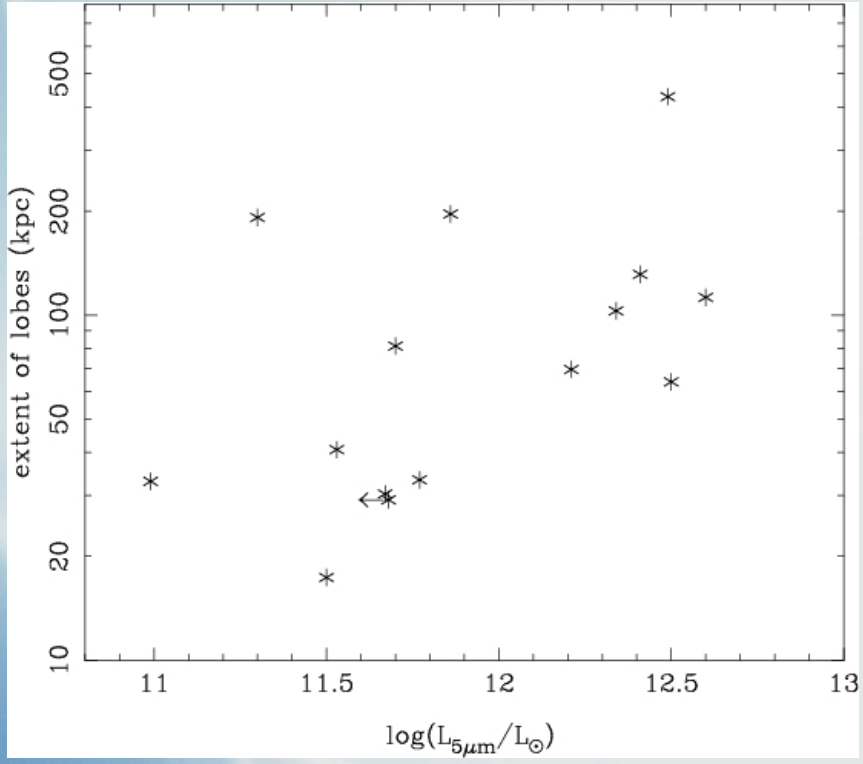
HzRGs

SMGs

D. Alexander et al. in prep.

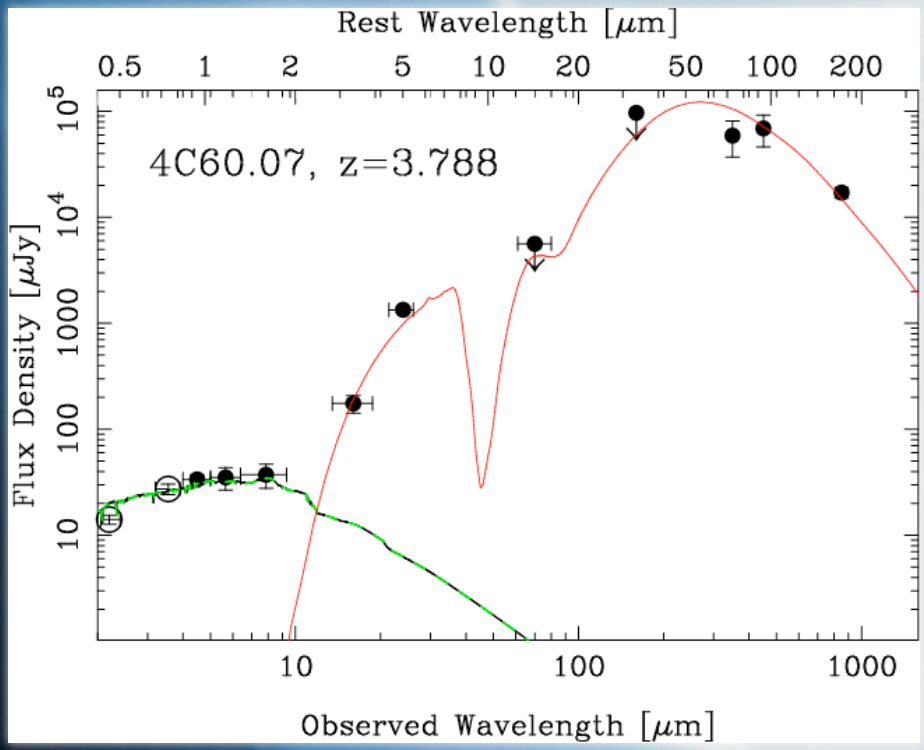
Other AGN measures

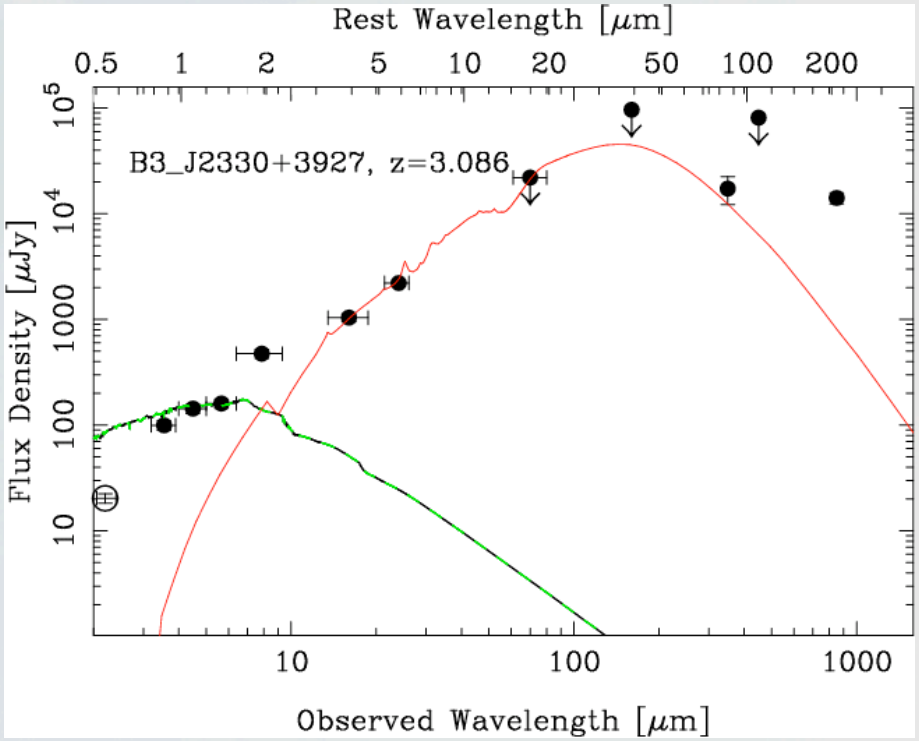
Projected extent of lobes (kpc)



5μm luminosity

IR to Sub-mm SED
Using MIPS, SCUBA and CSO data

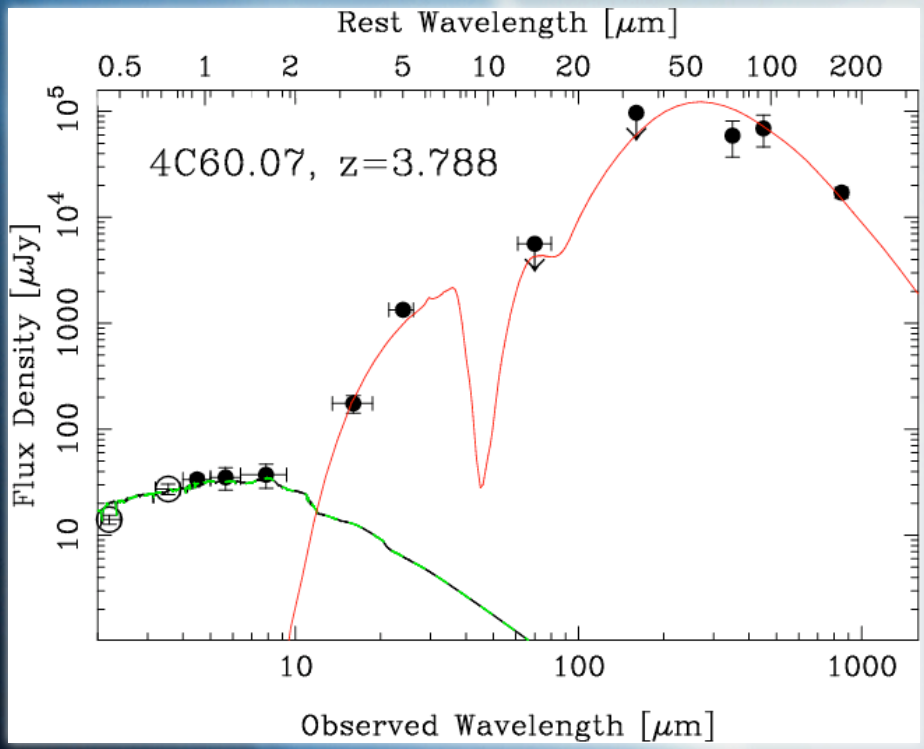


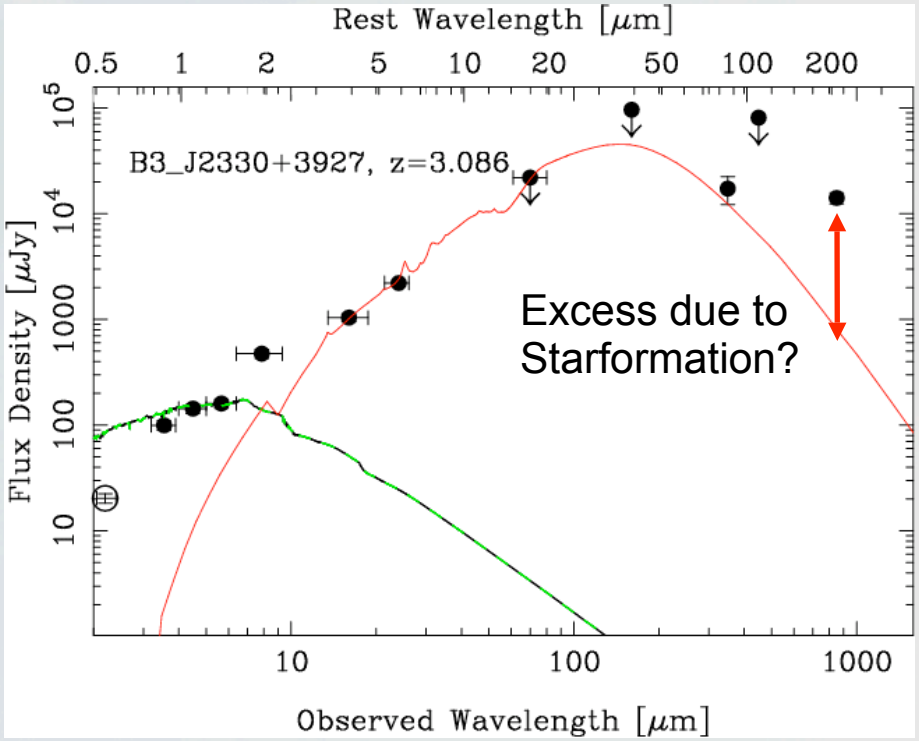


Siebenmorgen AGN SEDs

- visual extinction
- outer radius of dust clouds
- total luminosity

IR to Sub-mm SED
Using MIPS, SCUBA and CSO data





R_{dust}=8000pc, L_{bol} =$10^{14.5}$ $L_\odot$, A_v=128

R_{dust}=4000pc, L_{bol} =$10^{14.25}$ $L_\odot$, A_v=128

Siebenmorgen AGN SEDs

- visual extinction
- outer radius of dust clouds
- total luminosity

Conclusions: the Spitzer HzRG sample

- At high-z IRAC colours find type 2 as well as type 1 AGN.
- Radio Galaxies are hosted by massive ($10^{11\text{-}12}$ $M_{\odot}$) galaxies across $1<z<5.2$.
- Most high-z radio galaxies have strong mid-IR luminosities similar to QSOs implying high accretion rates.
- very weak trend of decreasing stellar mass with decreasing radio luminosity.
- HzRGs have a close to M_{BH}-σ relationship.
- HzRGs may have very high star formation rates and hence low specific star formation rates.

Future work: the Spitzer HzRG sample

- 4 publications already
- How do the AGN properties (IR luminosity, radio lobes) relate to the properties of the host galaxy, e.g. SFR and specific SFR?
- Herschel/Alma observations are desired.
- Environments of HzRGs: Zirm et al. (tomorrow), Galametz et al. (yesterday), Kodama, Kurk et al. (yesterday)
- Happy to share our data with anyone interested!
- webpage: spider.ipac.caltech.edu/staff/seymour/SHzRGs.html
- ``The Massive Hosts of Radio Galaxies Across Cosmic Time'' Seymour et al. 2007 ApJS August volume (astroph/0703224)

Future work: the Spitzer HzRG sample

- 4 publications already, 5 babies
- How do the AGN properties (IR luminosity, radio lobes) relate to the properties of the host galaxy, e.g. SFR and specific SFR?
- Herschel, APEX, SCUB2 and ALMA observations are needed.
- Environments of HzRGs: Zirm et al. (tomorrow), Galametz et al. (yesterday), Kodama, Kurk et al. (yesterday)
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Conclusions: the Spitzer HzRG sample

3c65	6c0140+326	MRC 0037-258	TN J0924-2201
3c239	6c0930+389	MRC 0114-211	TN J1338-1942
3c257	6c1232+389	MRC 0152-209	TN J2007-1316
3c266	6ce0820+3642	MRC 0156-252	
3c294	6ce0905+3955	MRC 0211-256	TX J1908+7220
3c356		MRC 0251-273	
3c368	7c1751+6809	MRC 0316-257	USS 0828+193
3c470	7c1756+6520	MRC 0324-228	USS 0943-242
	7c1805+6332	MRC 0350-279	USS 1243+036
4c23.56		MRC 0406-244	USS 1410-001
4c24.48	8c1435+635	MRC 1017-220	USS 1558-003
4c28.58		MRC 2025-218	USS 1707+105
4c40.36	B2 0902+34	MRC 2048-272	USS 2202+128
4c41.17	B3 J2330+3927	MRC 2104-242	
4c60.07		MRC 2224-273	WN J0617+5012
	LBDS 53W002		WN J0747+3654
5c7.269	LBDS 53W069	PKS 0529-549	WN J1115+5016
	LBDS 53W091	PKS 1138-262	WN J1123+3141
6c0032+412			WN J1911+6342
6c0058+495	MG 1019+0534	TN J0121-1320	
6c0132+330	MG 2144+1928	TN J0205+2242	

http://spider.ipac.caltech.edu/staff/seymour/SHzRGs.html