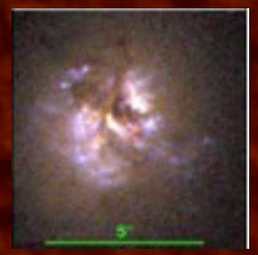


Localising the star formation in high redshift radio galaxies

Collaborators: C. De Breuck (ESO), J. Vernet (ESO), N. Seymour (Curtin Uni.), M. Lehnert (IAP), B. Rocca-Volmerange (IAP), D. Stern (JPL), B. Emonts (CSIC-INTA), B. Gullberg (ESO) + HeRGE team

G. Drouart (OSO, Chalmers), Sintra, 18 March 2015

Spitzer Observations of High Redshift Radio Galaxies

Nick Seymour (SSC)

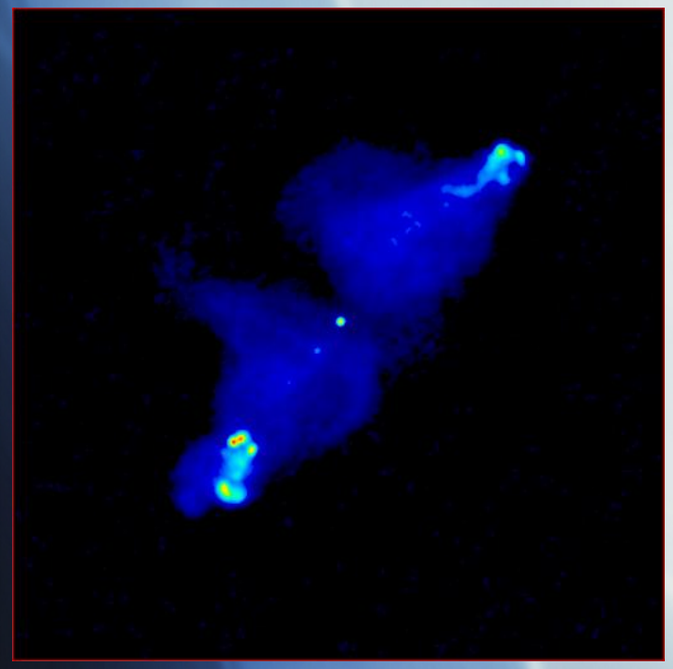
"At the Edge of the Universe" October 12th 2006

Co-conspirators:

Daniel Stern (JPL), Carlos De Breuck, Joel Vernet, Alessandro Rettura, Robert Fosbury (ESO), Andrew Zirm (STSCI), Brigitte Rocca-Volmerange (IAP), Mark Lacy, Harry Teplitz (SSC), Arjun Dey, Mark Dickinson (NOAO), Wil van Breugel, Adam Stanford (UC/LLNL), George Miley, Huub Rottgering (Leiden), Peter Eisenhardt (JPL), Patrick McCarthy (OCIW)

Why are radio galaxies interesting?

Archetypical (radio-loud) type II AGN!

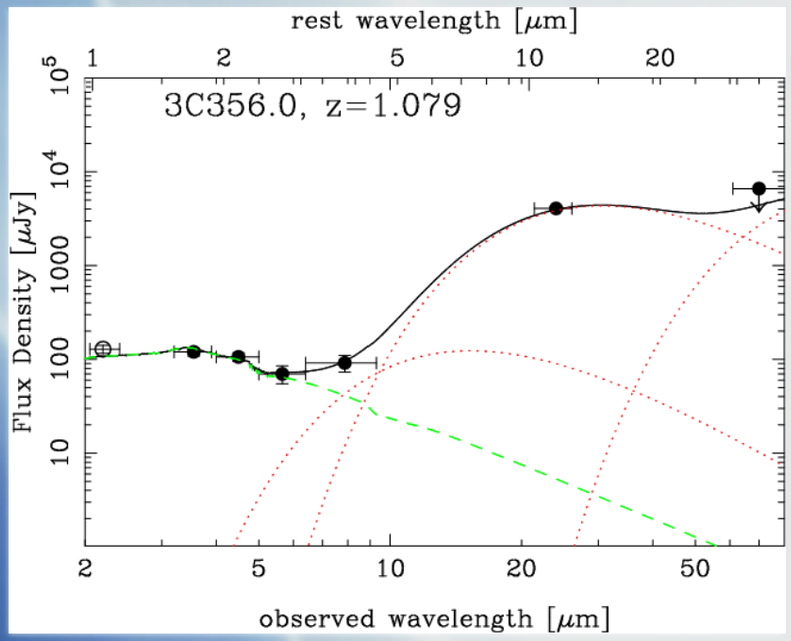


4C14.11 (Leahy & Perley 1991)

- 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)
- Lie on a tight correlation in *K-z* space (Rocca-Volmerange *et al.* 2004)

Rest wavelength (μm)

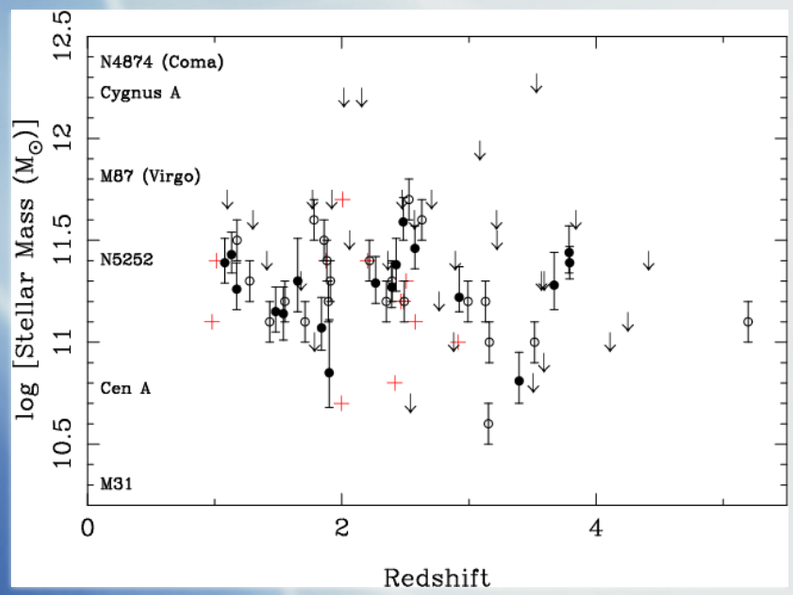
Flux density (μJy)



Observed wavelength (μm)

Stellar masses

Stellar Mass Log(M)

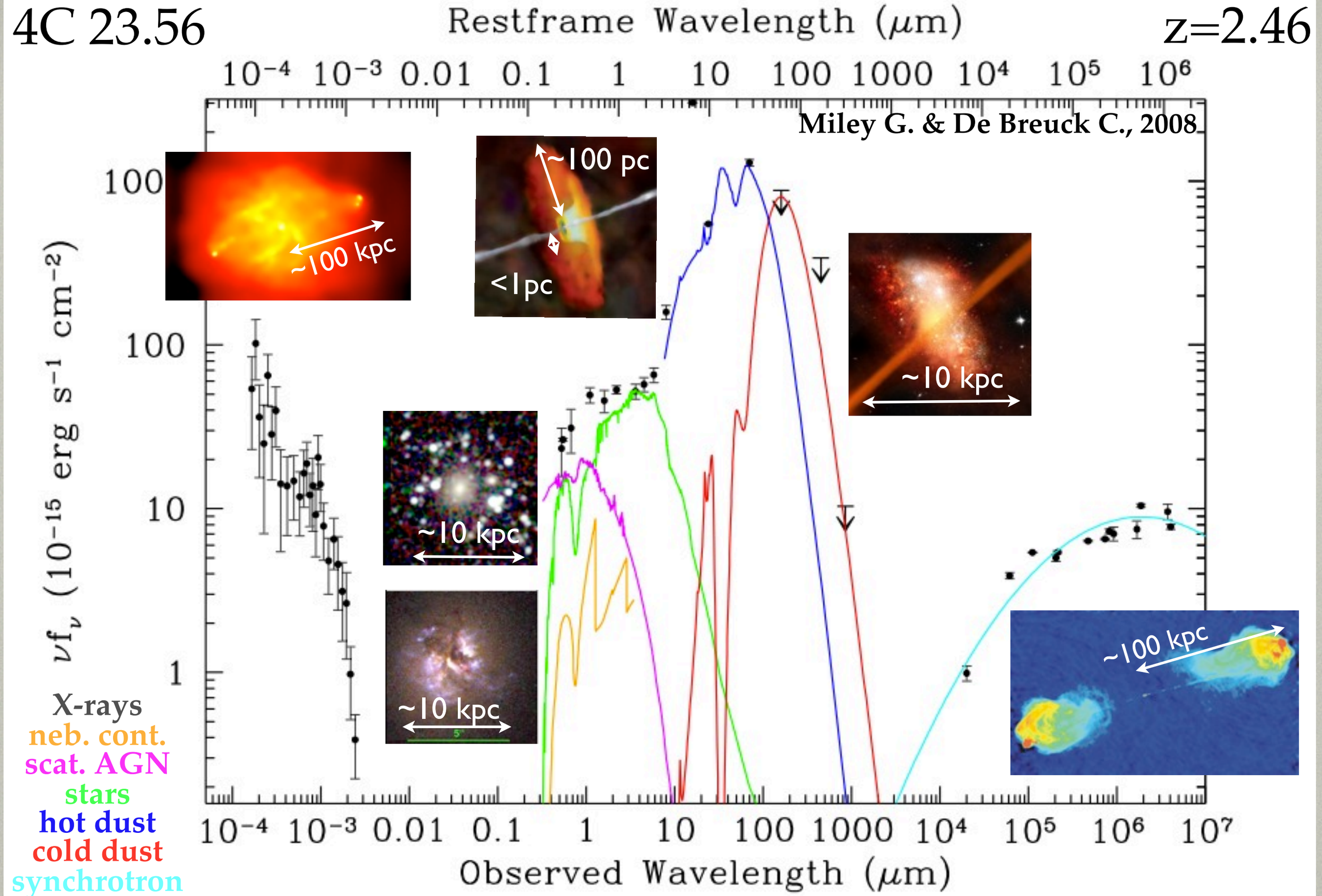


Redshift

Sub-mm galaxies

4C 23.56

z=2.46


Restframe Wavelength (μm)
10^{-4} 10^{-3} 0.01 0.1 1 10 100 1000 10^4 10^5 10^6
Miley G. & De Breuck C., 2008
100
100
10
1
νf_ν (10^{-15} erg s^{-1} cm^{-2})
~100 kpc
~100 pc
<1pc
~10 kpc
~10 kpc
~10 kpc
~100 kpc
X-rays
neb. cont.
scat. AGN
stars
hot dust
cold dust
synchrotron
10^{-4} 10^{-3} 0.01 0.1 1 10 100 1000 10^4 10^5 10^6 10^7
Observed Wavelength (μm)

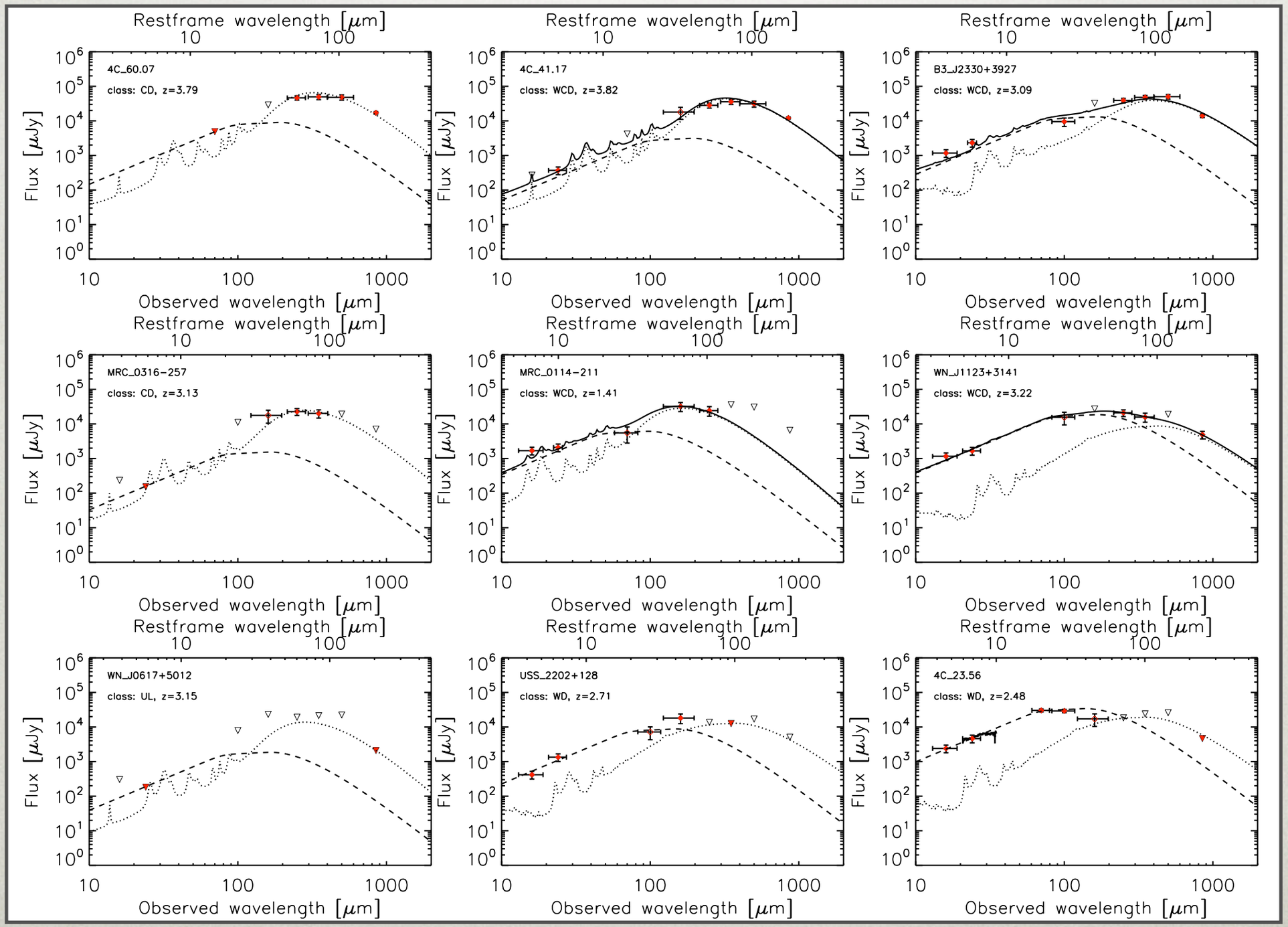
Projet HeRGé

Herschel Radio Galaxy Evolution project
International team (~25 members)

- 70 powerful radio galaxies at 1 < z < 5.2: Ultra Steep Spectrum (USS) radio source selected at 3GHz restframe, parent sample >200 objects
- Supporting data: *HST*, VLT, Keck, ***Spitzer***, ***Herschel***, SCUBA, LABOCA, VLA, ATCA, **ALMA**
- SED coverage from UV to radio (>12 broad bands)

Some publications: Seymour et al., 2007, De Breuck 2010, Galametz et al. 2012, Mayo et al. 2012, Seymour et al. 2012, Ivison et al. 2012, Wylezalek et al. 2013, Rocca et al. 2013, Drouart et al. 2014, Emonts et al. 2015, Gullberg et al. in prep

Examples of AGN-SB decomposition



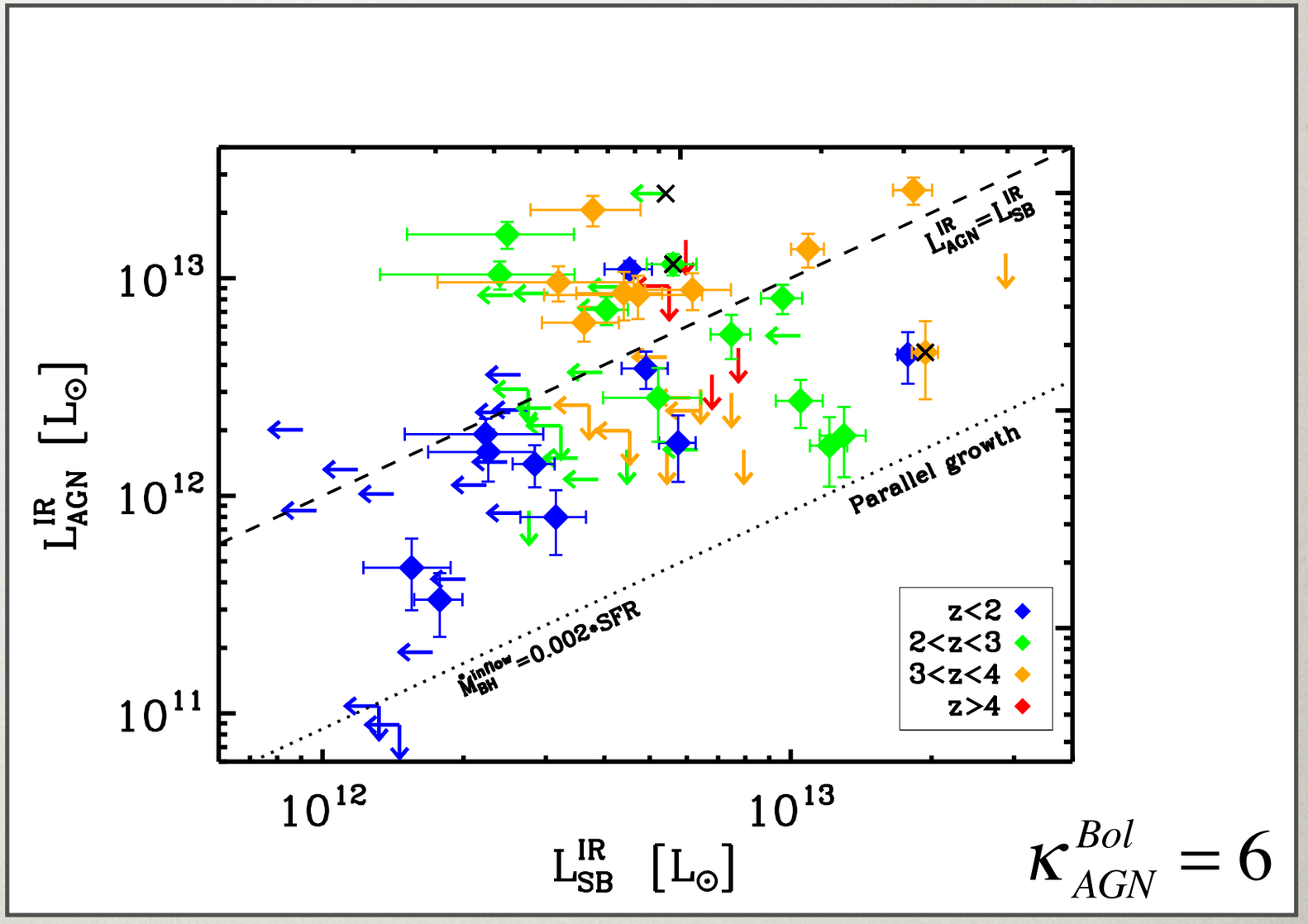
L_{SB}^{IR}

L_{AGN}^{IR}

$\dot{M}_{BH}$-SFR: AGN-SB connection ?

(no) evidence for AGN-SB connection ?

Netzer, 2009; Hatziminaoglou et al., 2010; Asmus et al., 2011; Dicken et al., 2012; Bongiorno et al., 2012; Harrison et al., 2012; Rosario et al., 2012, 2013; Feltre et al., 2013; Videla et al., 2013; Esquej et al., 2014; Leipski et al., 2014...



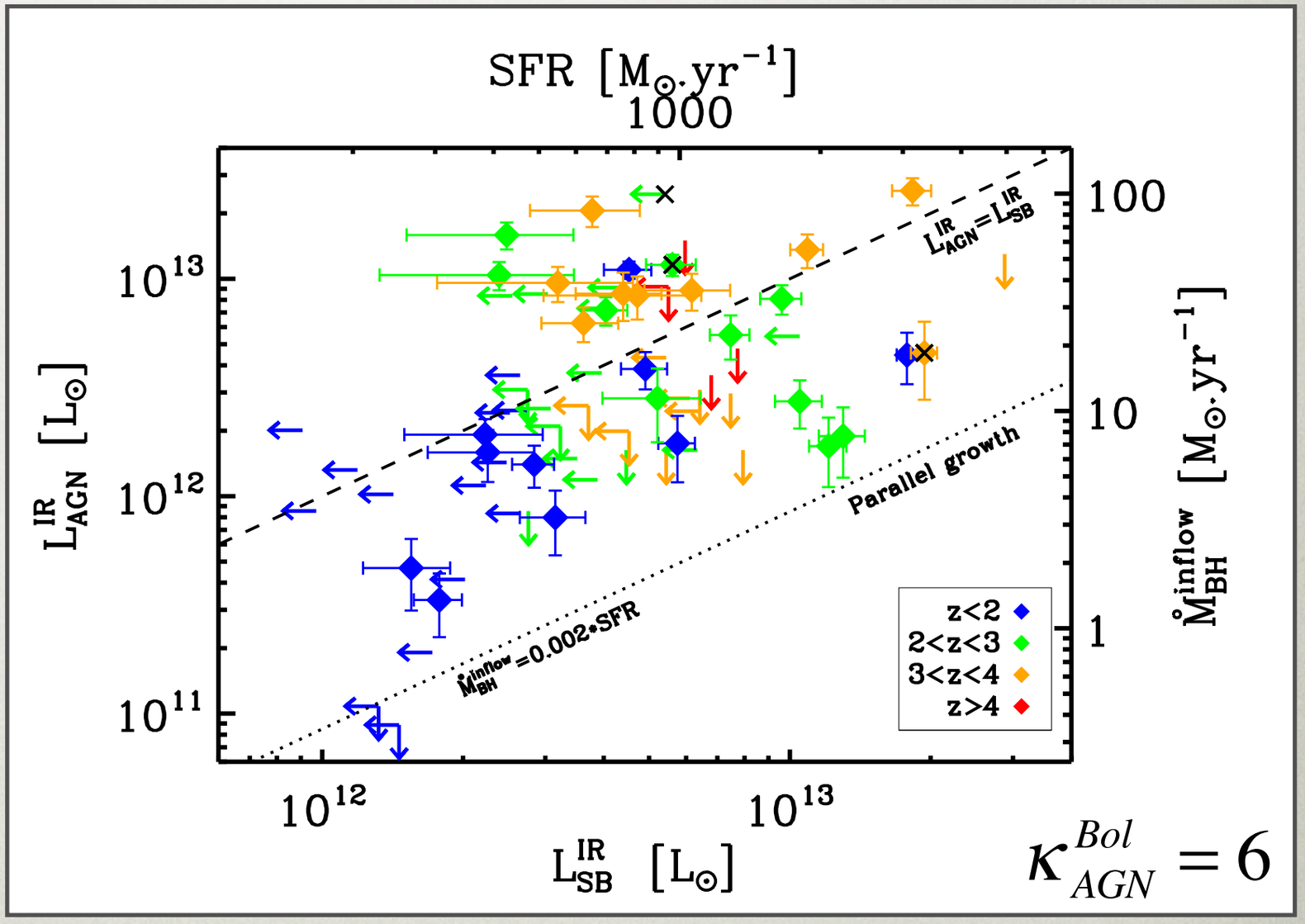
Drouart et al. 2014

$\dot{M}_{BH}$-SFR: AGN-SB connection ?

$$\kappa_{AGN}^{Bol} L_{AGN}^{IR} = \varepsilon \dot{M}_{BH}^{inflow} c^2$$

$$SFR = 1.72\ 10^{-10}\ L_{SB}^{IR}$$

Kennicutt et al., 1998



Drouart et al. 2014

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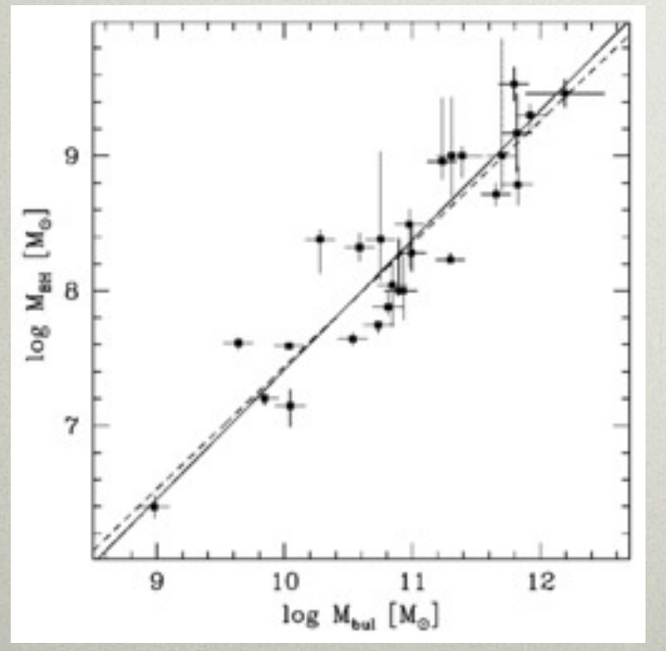
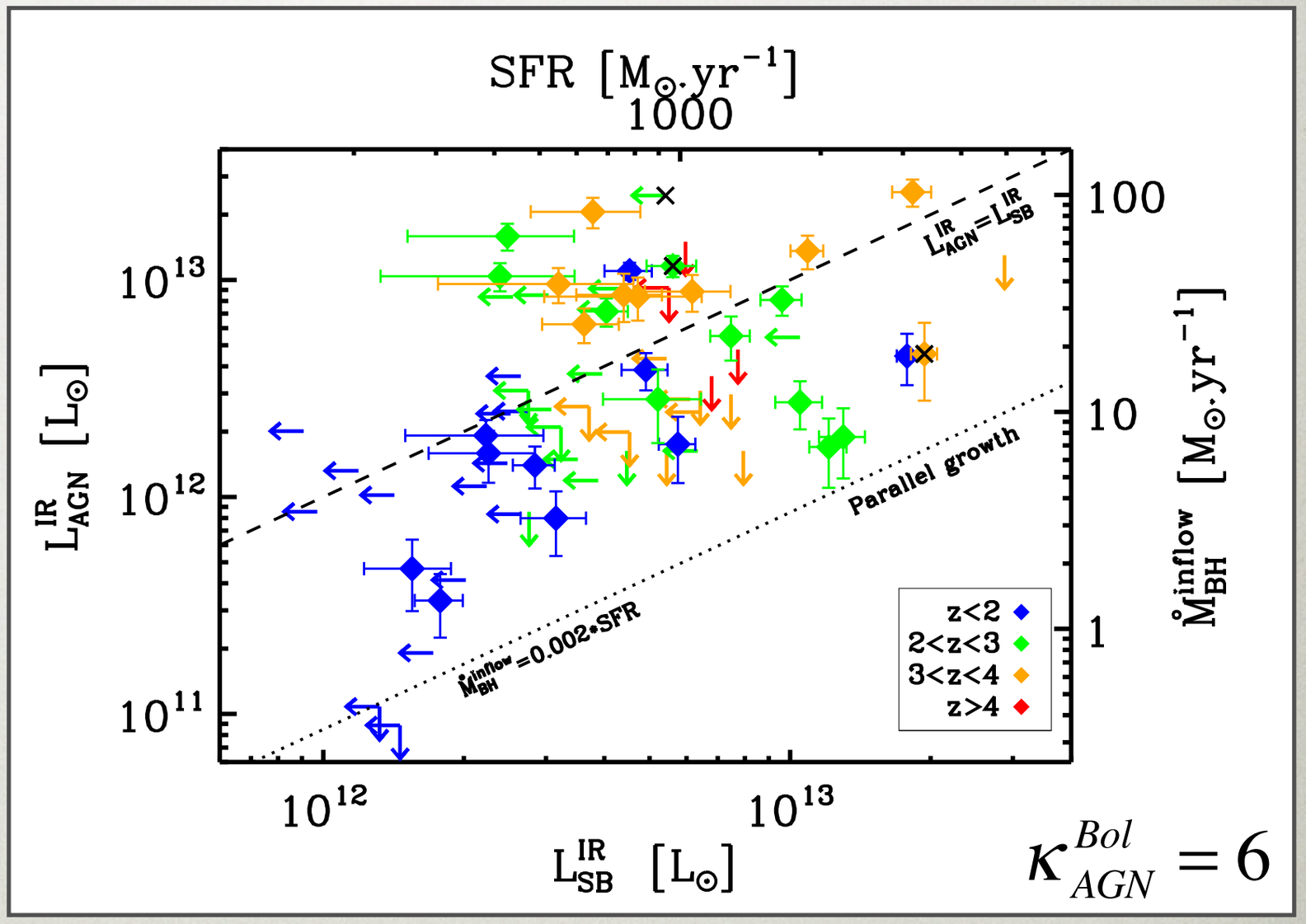
Kennicutt et al., 1998

local M_{BH}-M_{gal} relation (Marconi & Hunt, 2003)





Drouart et al. 2014

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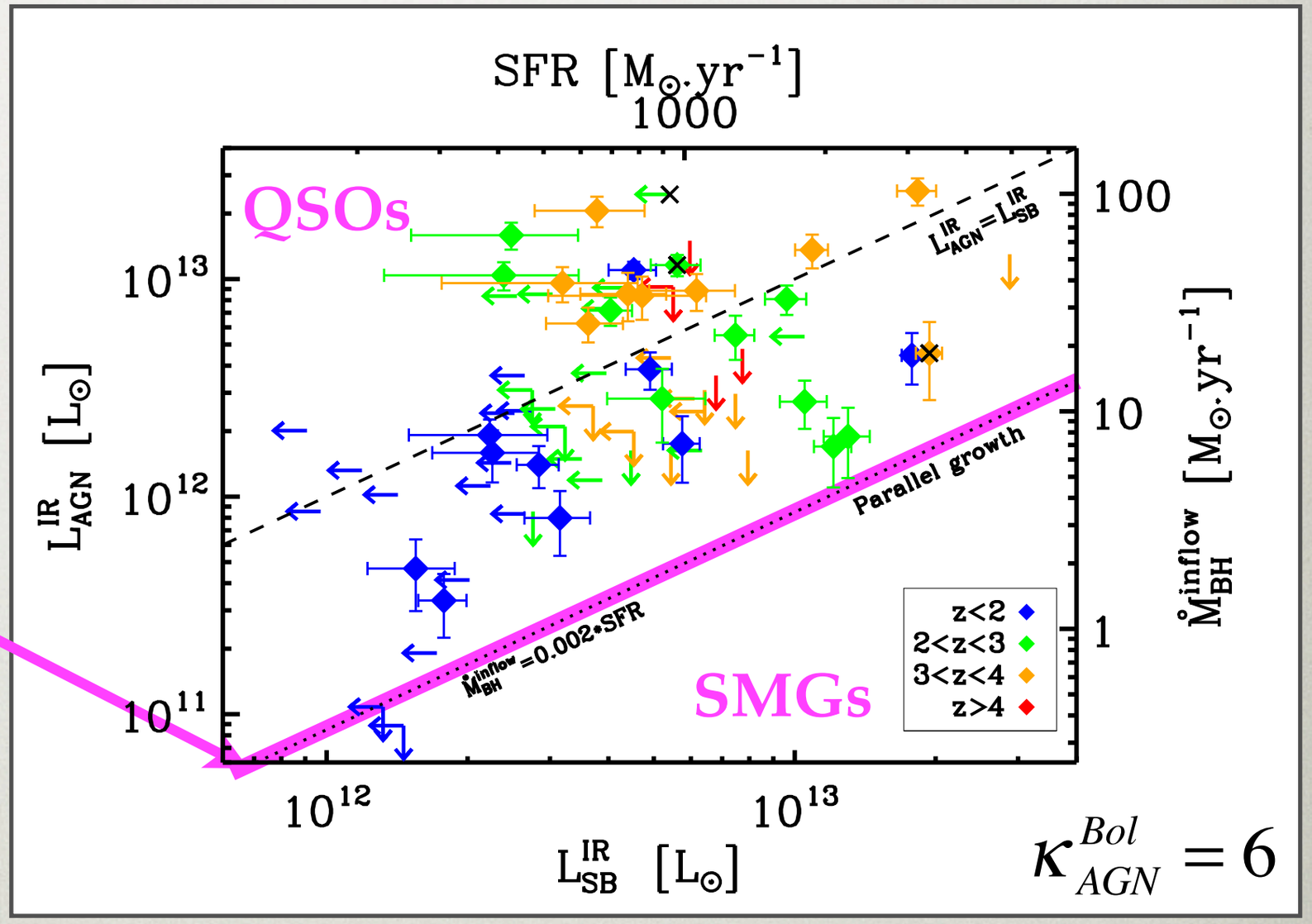
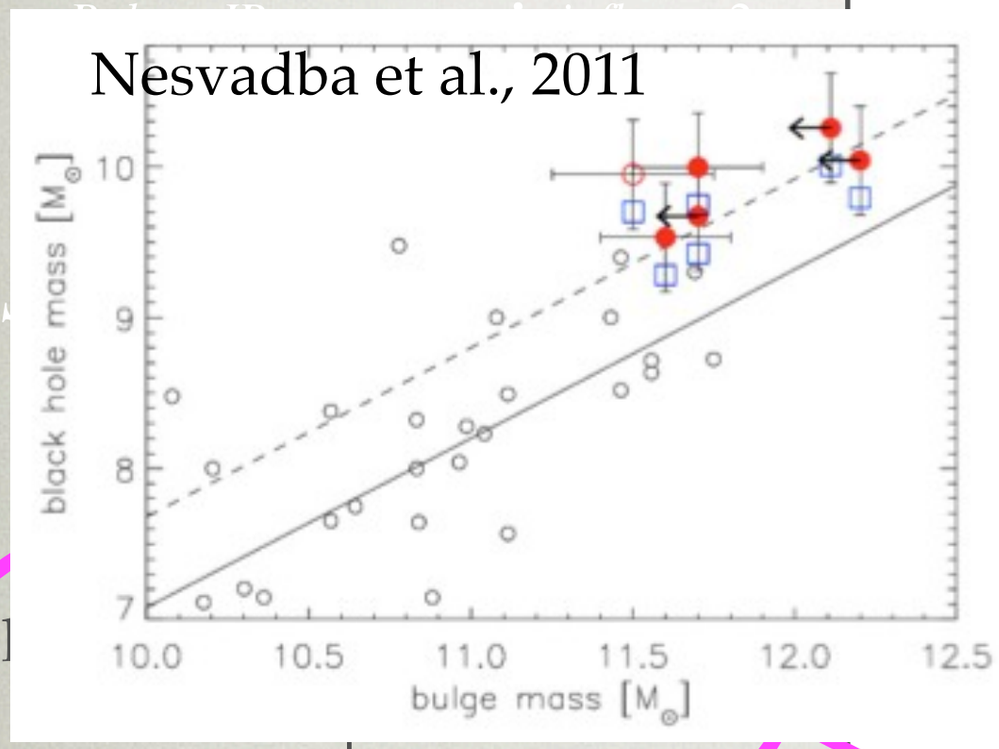
+

parallel growth

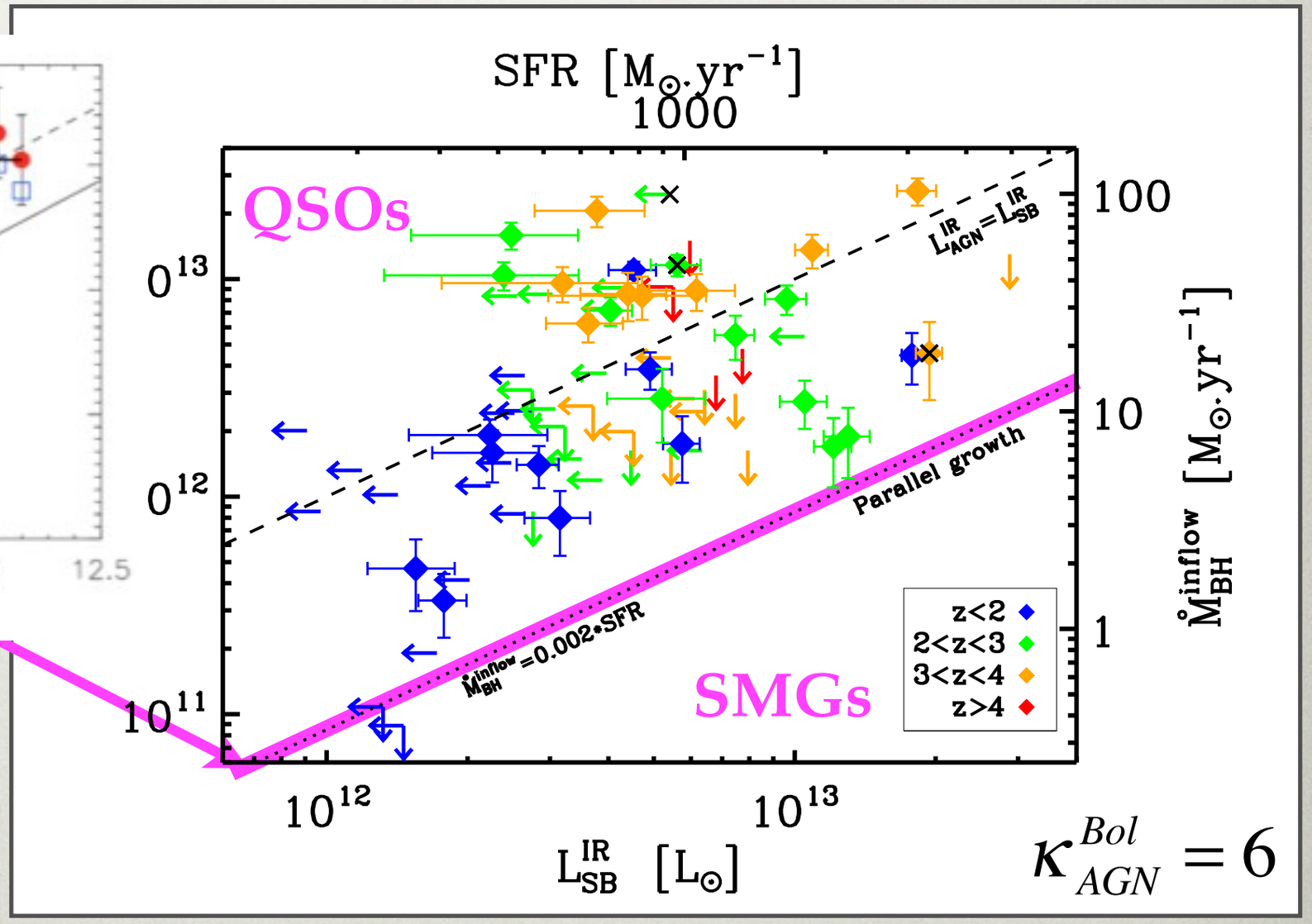


Drouart et al. 2014

$\dot{M}_{BH}$-SFR: AGN-SB connection ?

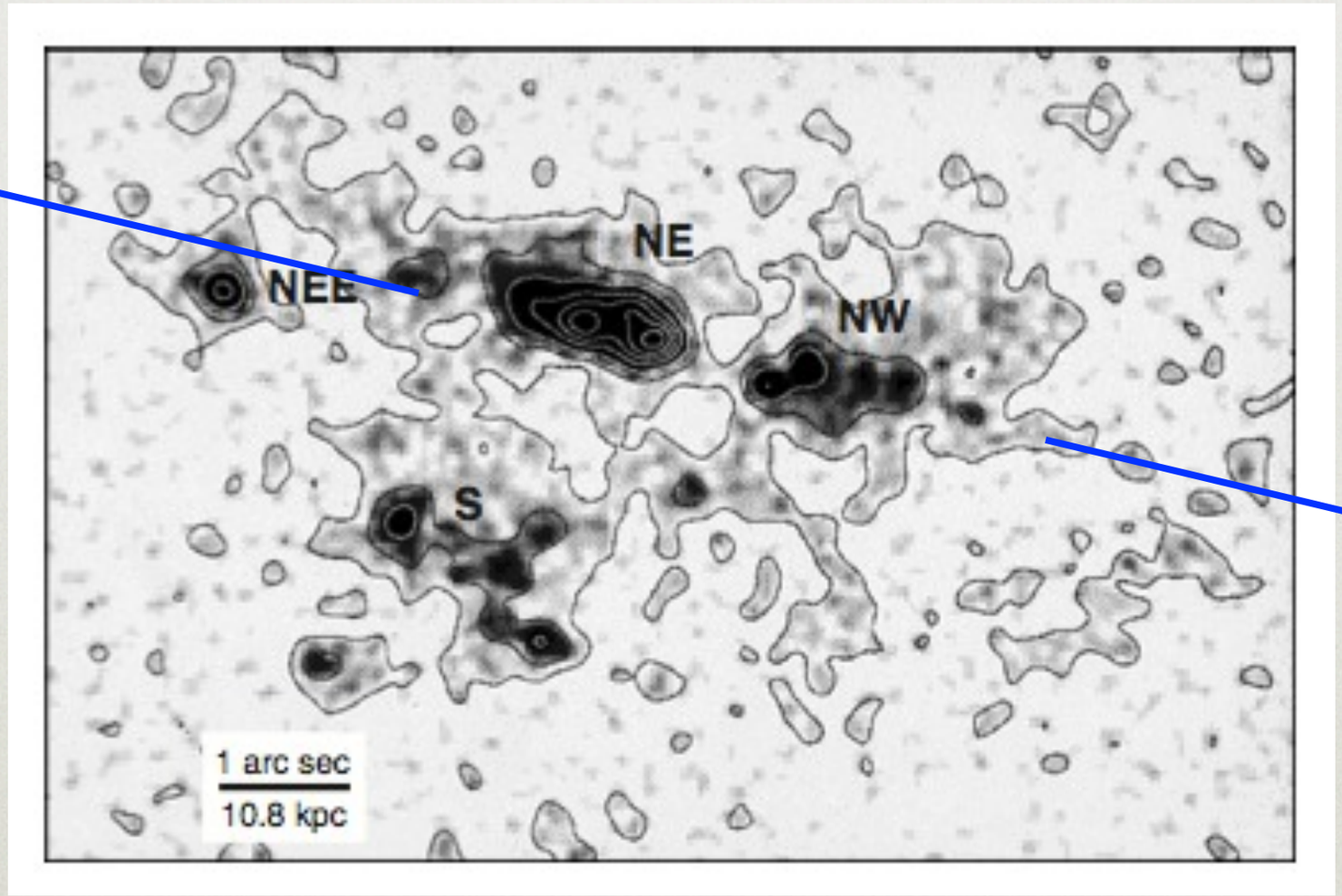


parallel growth



Drouart et al. 2014

Pb! Resolution at long wavelength



Miley et al. 1992

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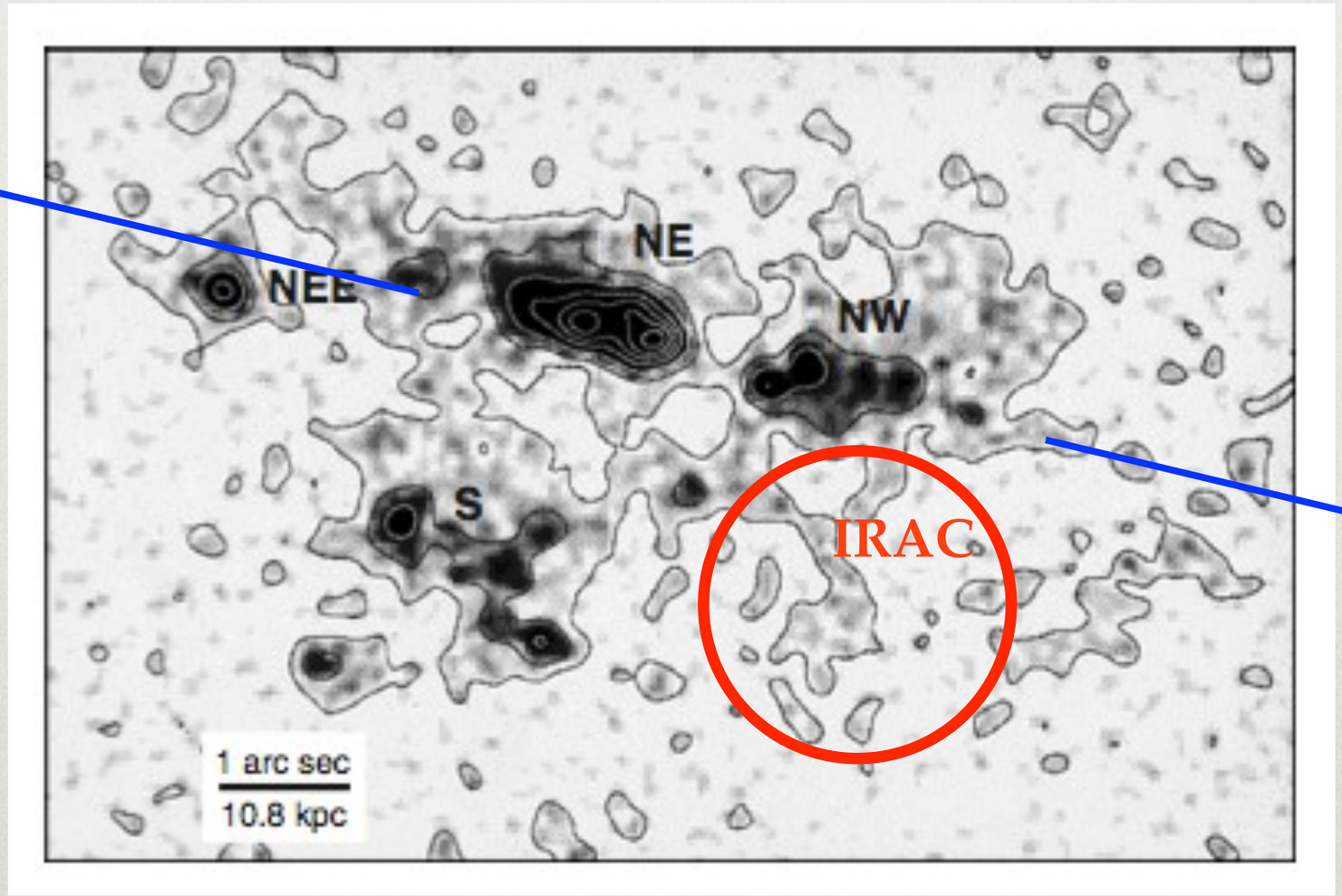

Miley et al. 1992

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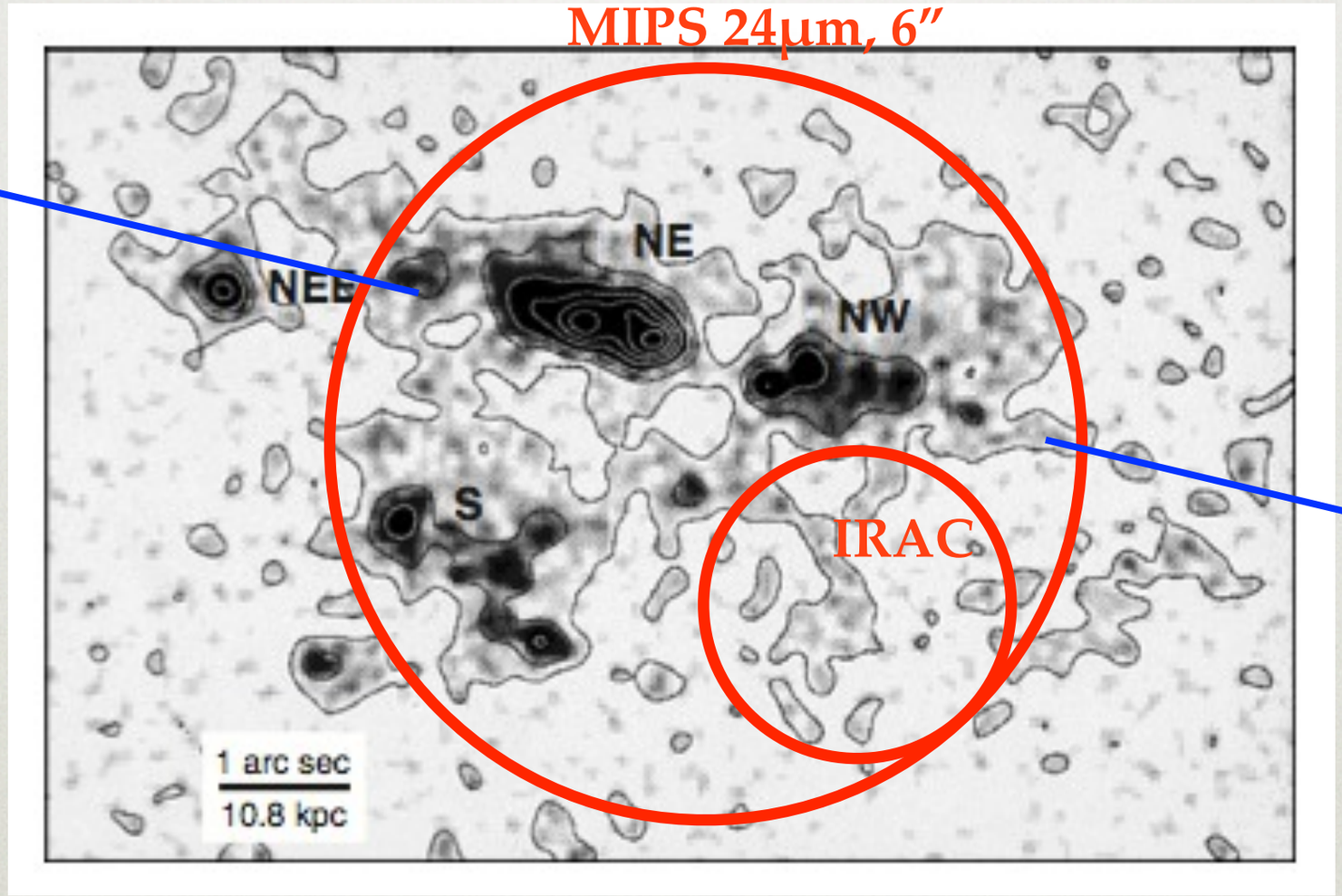
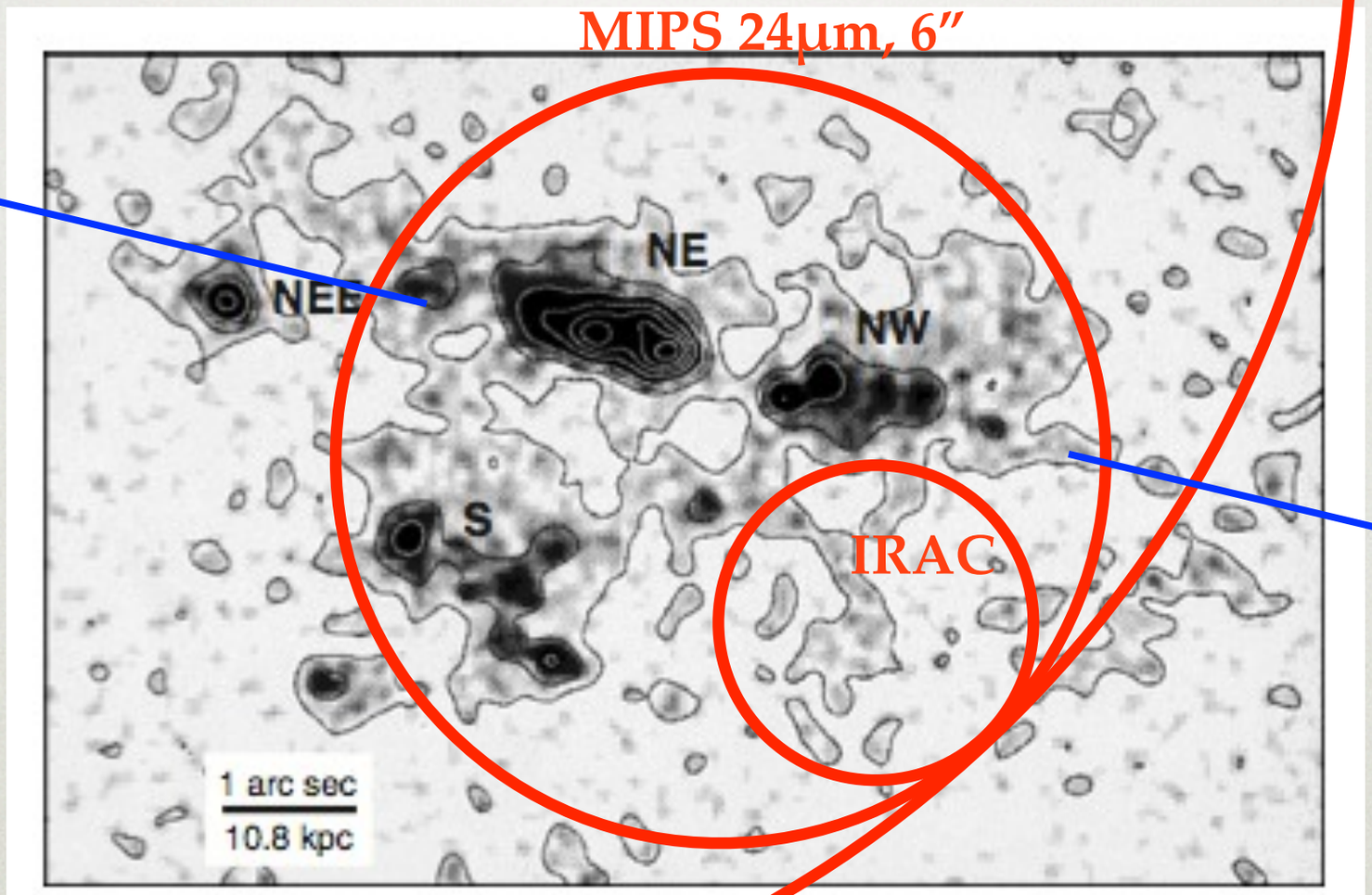


Miley et al. 1992

Pb! Resolution at long wavelength

SPIRE 250μm, 18″

MIPS 24μm, 6″



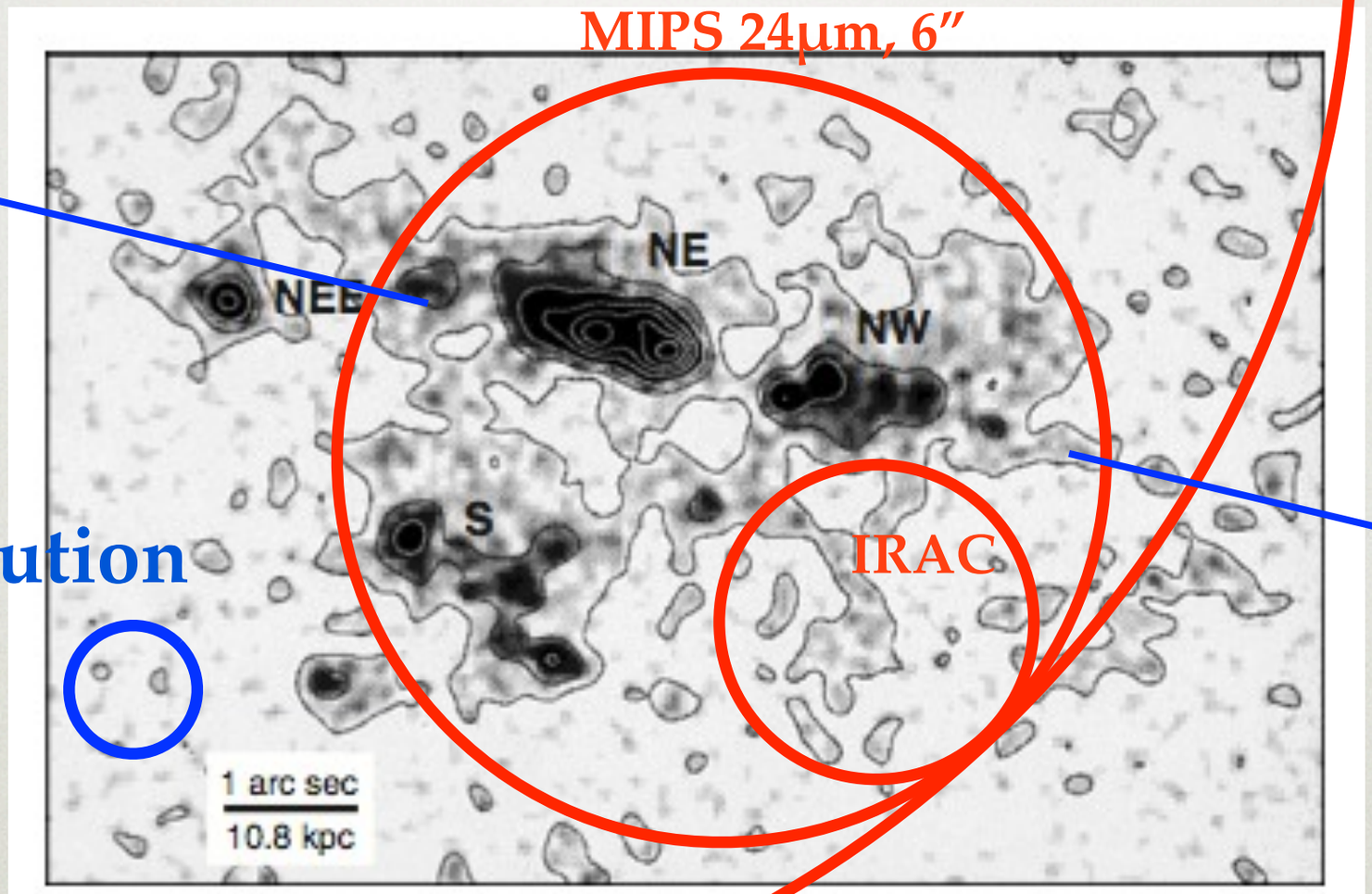
radio jet axis

Miley et al. 1992

PB! Resolution at long wavelength

SPIRE 250μm, 18″

MIPS 24μm, 6″



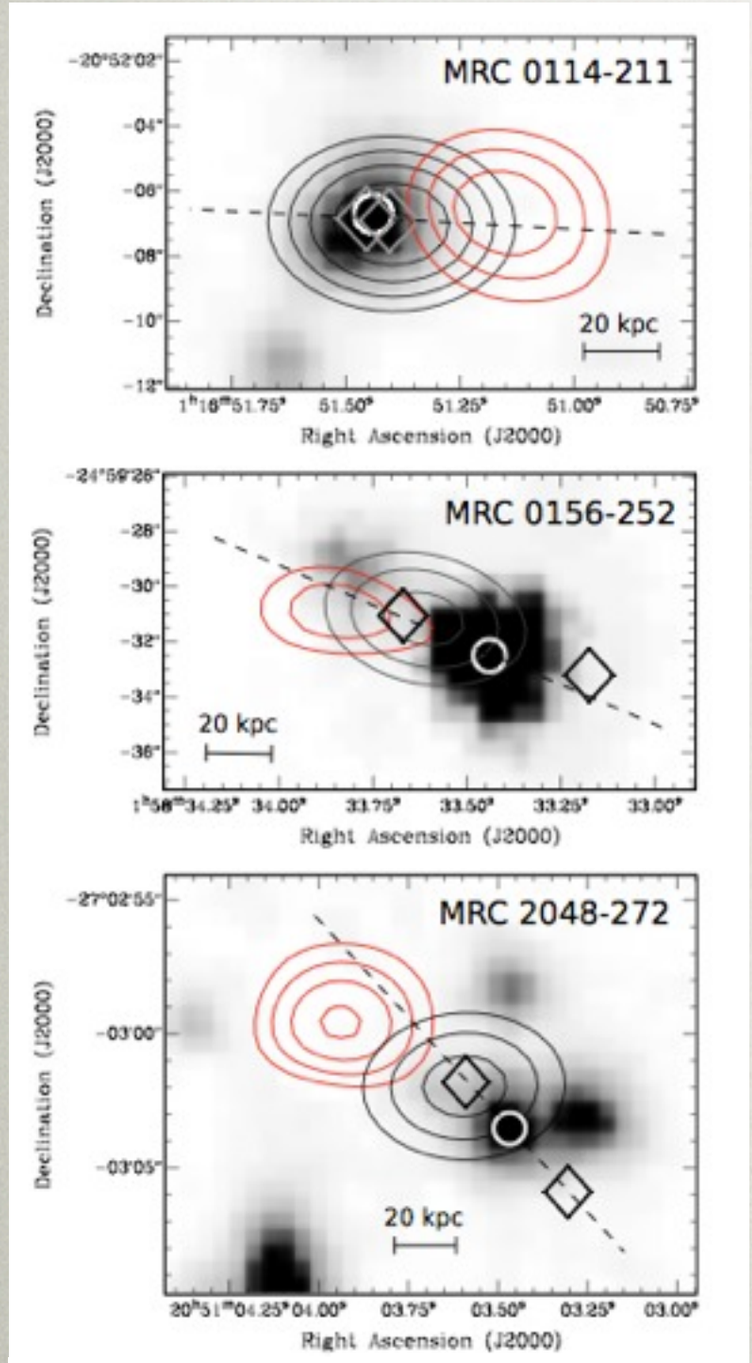
ALMA resolution

radio jet axis

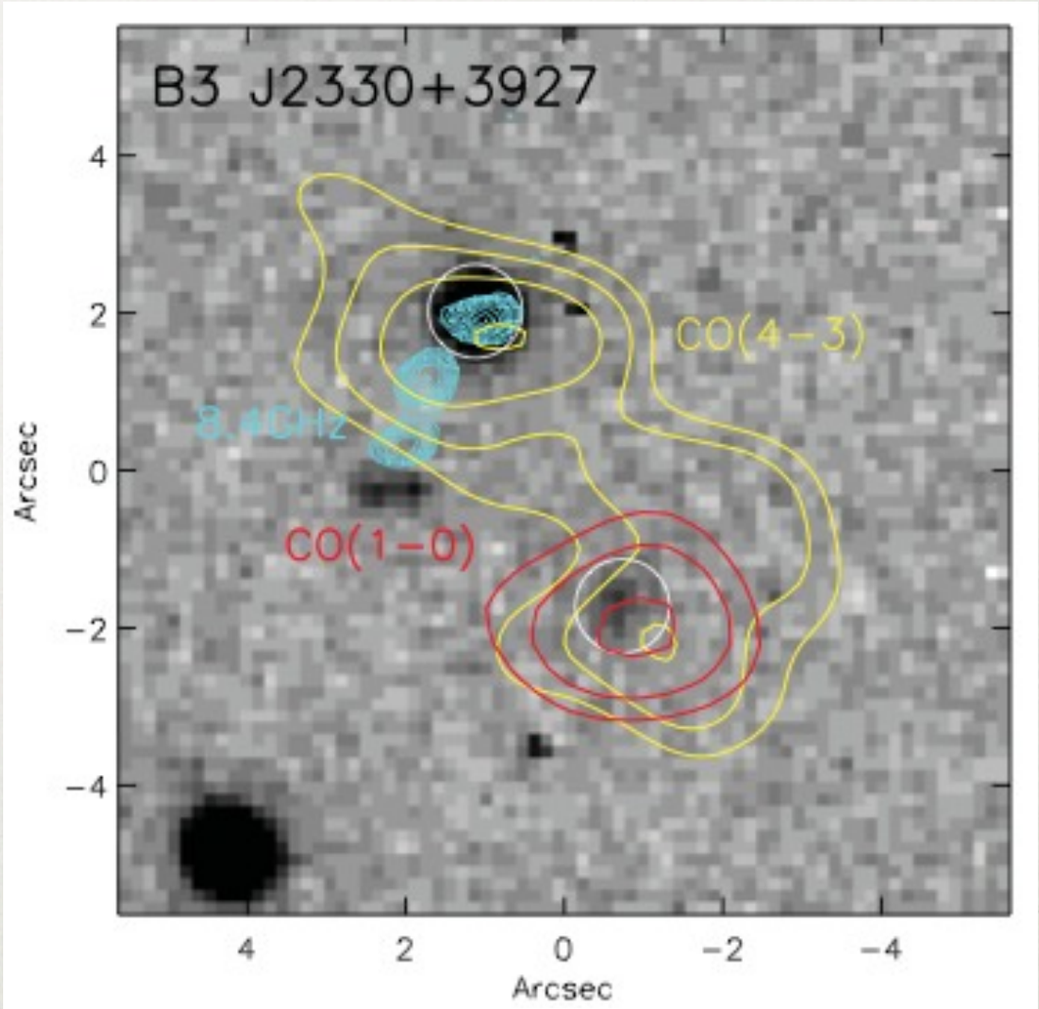
Cycle 1/2 ALMA program at ~1″ resolution (Gullberg et al., in prep)

Where does star formation take place ?

Molecular gas as a tracer for star formation



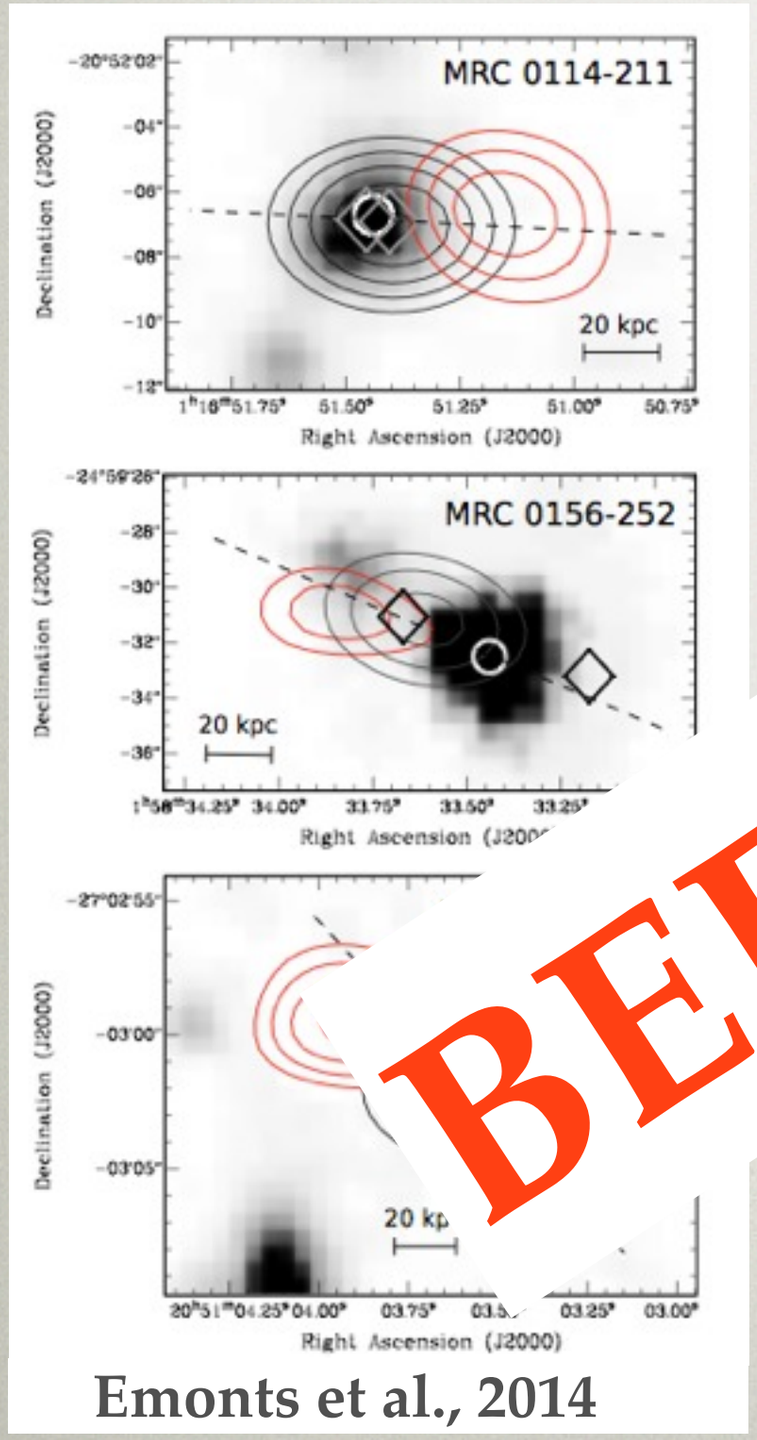
Emonts et al., 2014



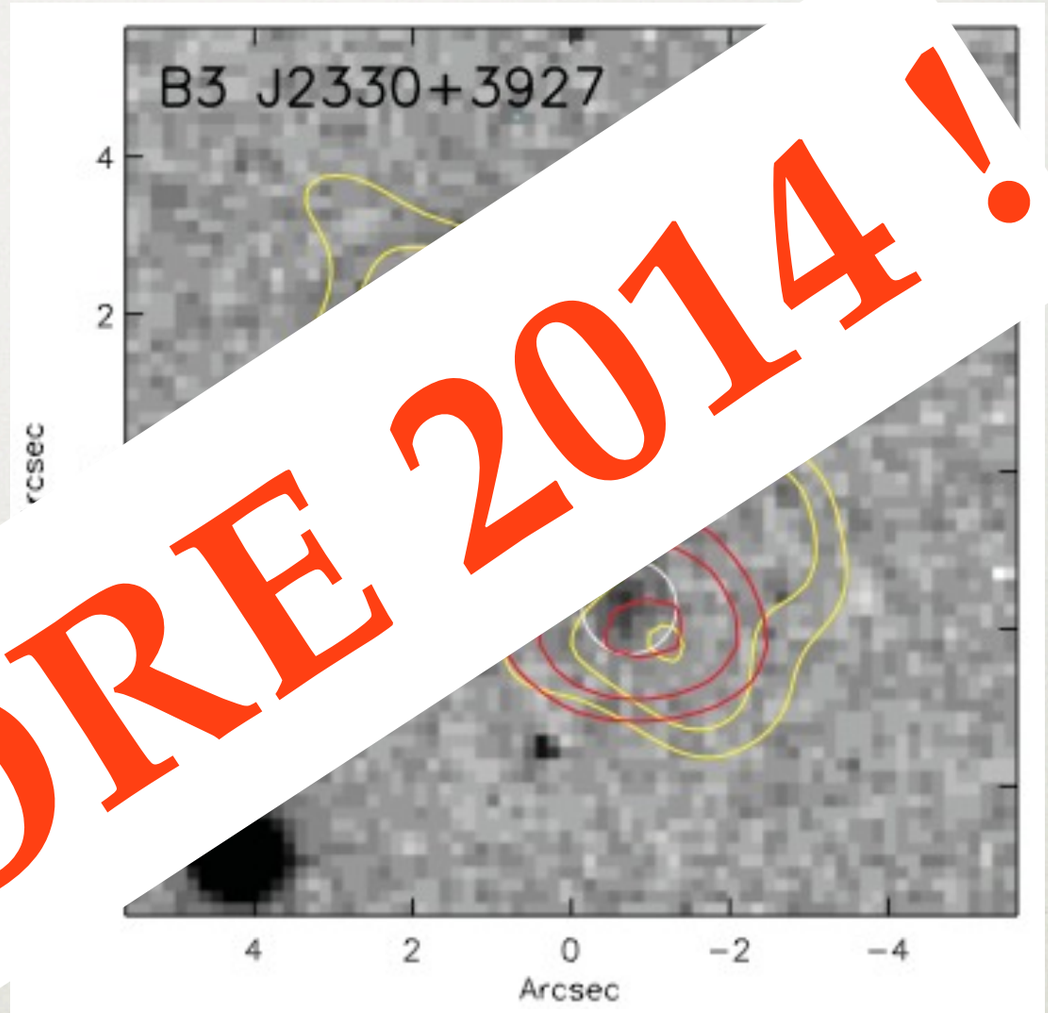
Ivison et al., 2012

Molecular gas not centered on the source ! possible (very) obscured star forming companion !

Molecular gas as a tracer for star formation



Emonts et al., 2014



Ivison et al., 2012

BEFORE 2014 !

Molecular gas not centered on the source ! possible (very) obscured star forming companion !

MRC 0943-242,z~2.9 or a "Glimpse of Valhalla"

MUSE+*Spitzer*+*Herschel*+ALMA B6

Gullberg et al. in prep

The dragonfly galaxy
Massive SF at z~2

Emonts et al., sub.

Conclusion

- Star formation properties similar to SMGs; AGN properties similar to QSOs
- Triggering mechanism for star formation still not clear
- ALMA "helping" a lot to understand where star formation takes place
- Lots of molecular gas present to form new generations of stars

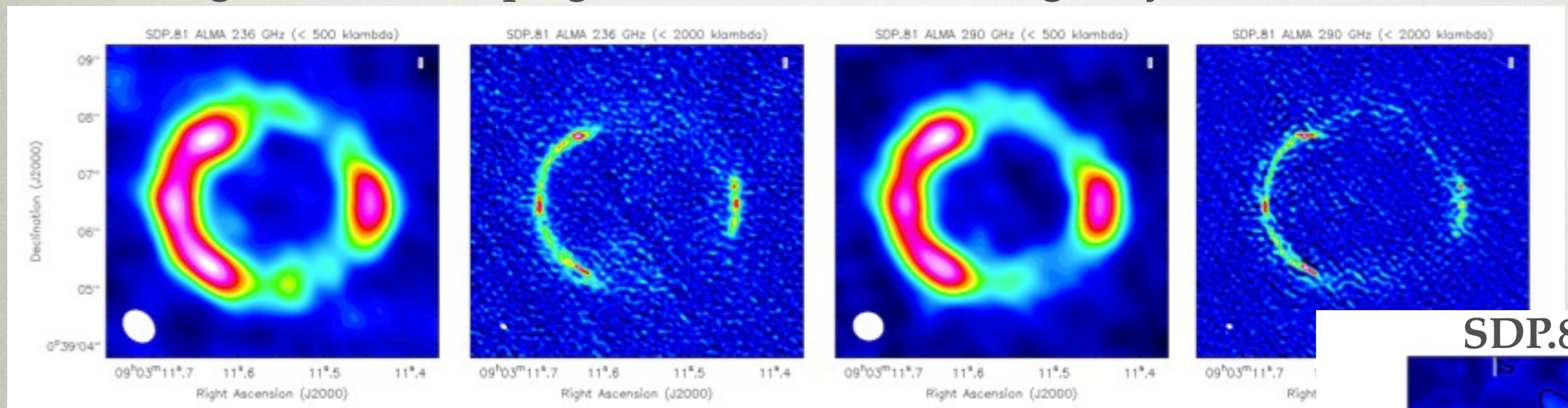
What's next?

Here and back... again, the tale of an astronomer at the edge of the Universe

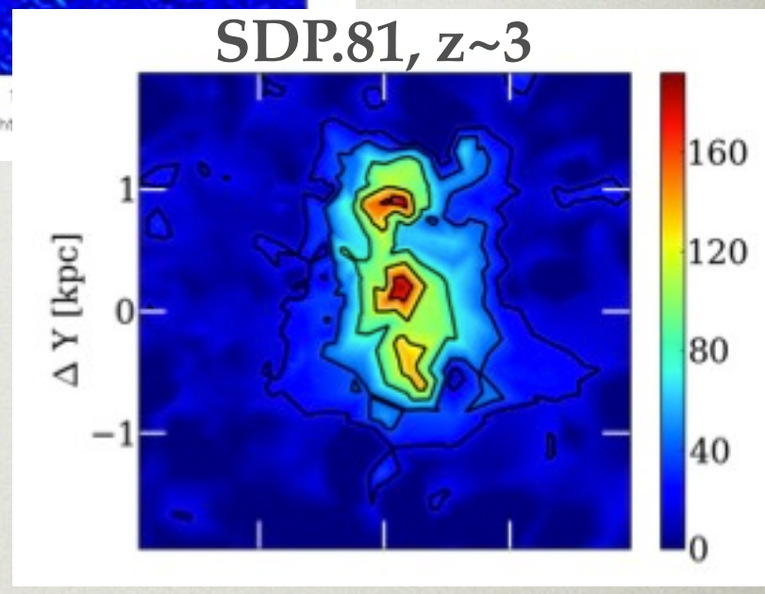
J. Afonso

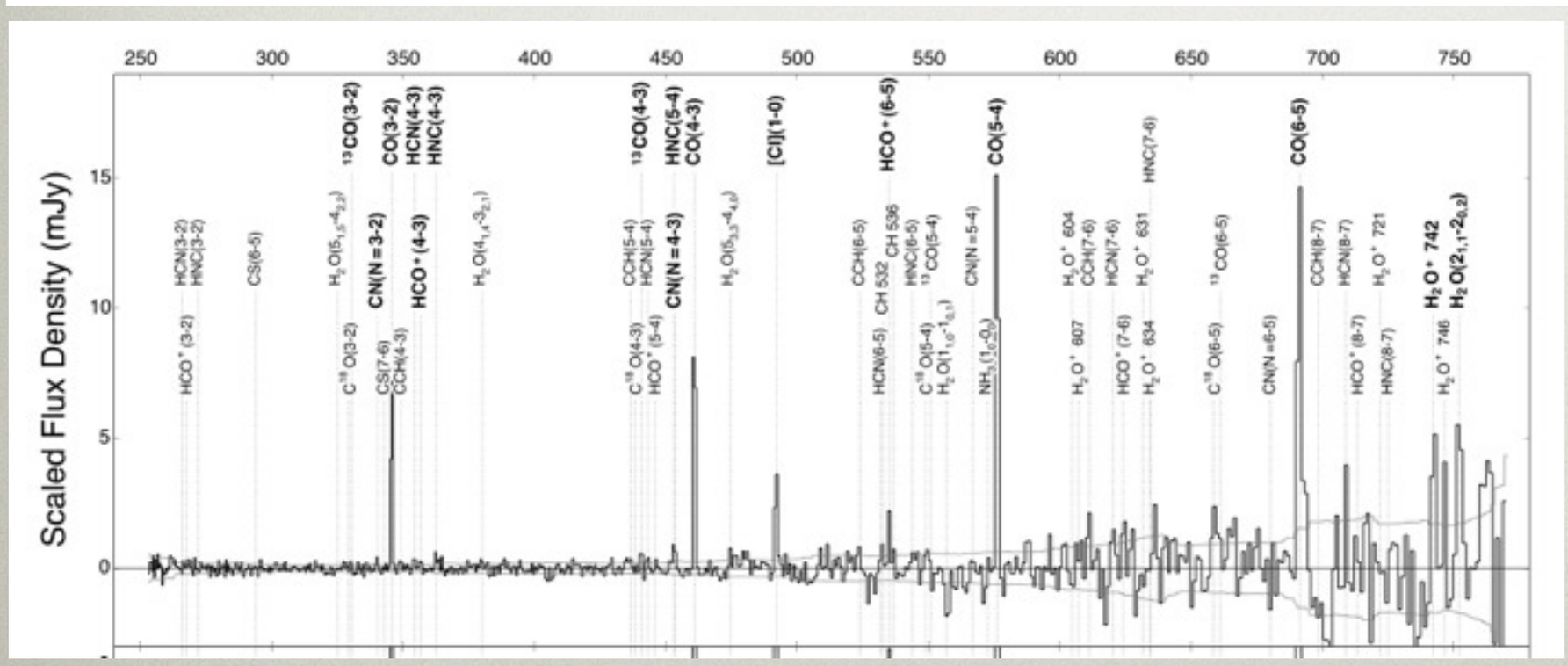
What's next?

Long baseline campaign B4,B6,B7 of a lensed galaxy at z~3, ~5h observation



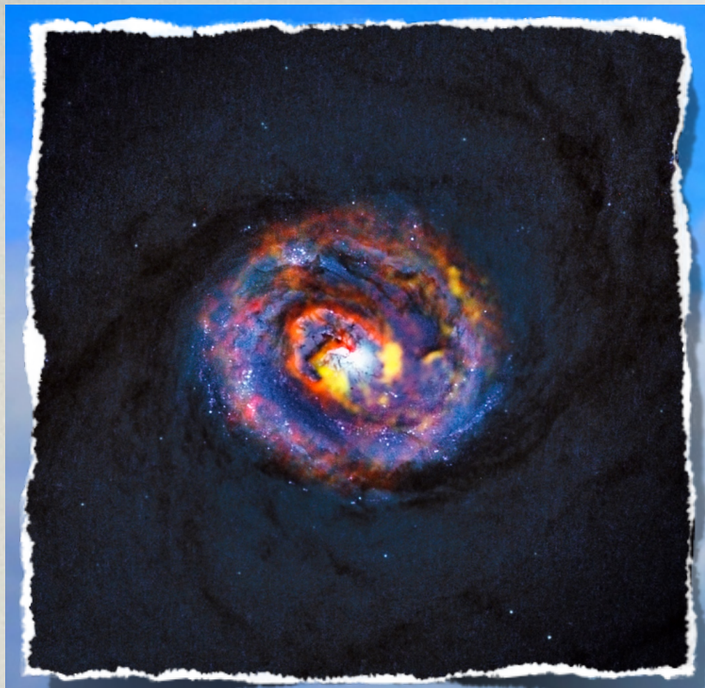
Rybak et al. arxiv





Spilker et al., arxiv

Spectral line survey, SPT sources, ALMA cycle 0/1, ~10min on source



LOC	SOC
G. Drouart	F. Costagliola
F. Costagliola	G. Drouart
N. Falstad	S. Aalto
L. Lindroos	K. Knudsen
	N. Scoville
	D. Sanders
	J. Gallagher

Galaxies of many colours: Star formation across cosmic time

1-5 June 2015, Marstrand, Sweden

http://www.chalmers.se/en/conference/Galaxies-of-Many-Colours/Pages/default.aspx