

Hot Dust Obscured Galaxies

The Most Luminous Obscured Quasars in WISE

Roberto J. Assef

Universidad Diego Portales

In collaboration with Tanio Diaz-Santos, Jorge Gonzalez, Manuel Aravena Claudio Ricci (UDP), Daniel Stern, Peter Eisenhardt (JPL), Jingwen Wu (NAOC), Chao-Wei Tsai (UCLA), Andrew Blain (Leicester), Hyunsung Jun (KIAS), Franz Bauer (PUC), Dominic Walton (Cambridge) and Murray Brightman (Caltech)

Hot DOGs and the Search for the Most Luminous Galaxies

- One of WISE main goals was to identify the most luminous IR galaxies in the Universe.
- AllWISE catalog has >700M sources, so very stringent selection is needed
 - We know we are looking for very red objects
- Solution: Require no detection in W1*, and very red W2-W3 or W2-W4 colors.
 - Exact selection in Eisenhardt et al. (2012)
- Total: 30 per sq. degree
 - 1000 over the whole extragalactic sky

Hot DOGs are Hyper-Luminous and at High-z

Almost all have $L_{\text{Bol}} > 10^{13} L_{\odot}$

Since IR dominates, almost all qualify as **HyLIRGs**

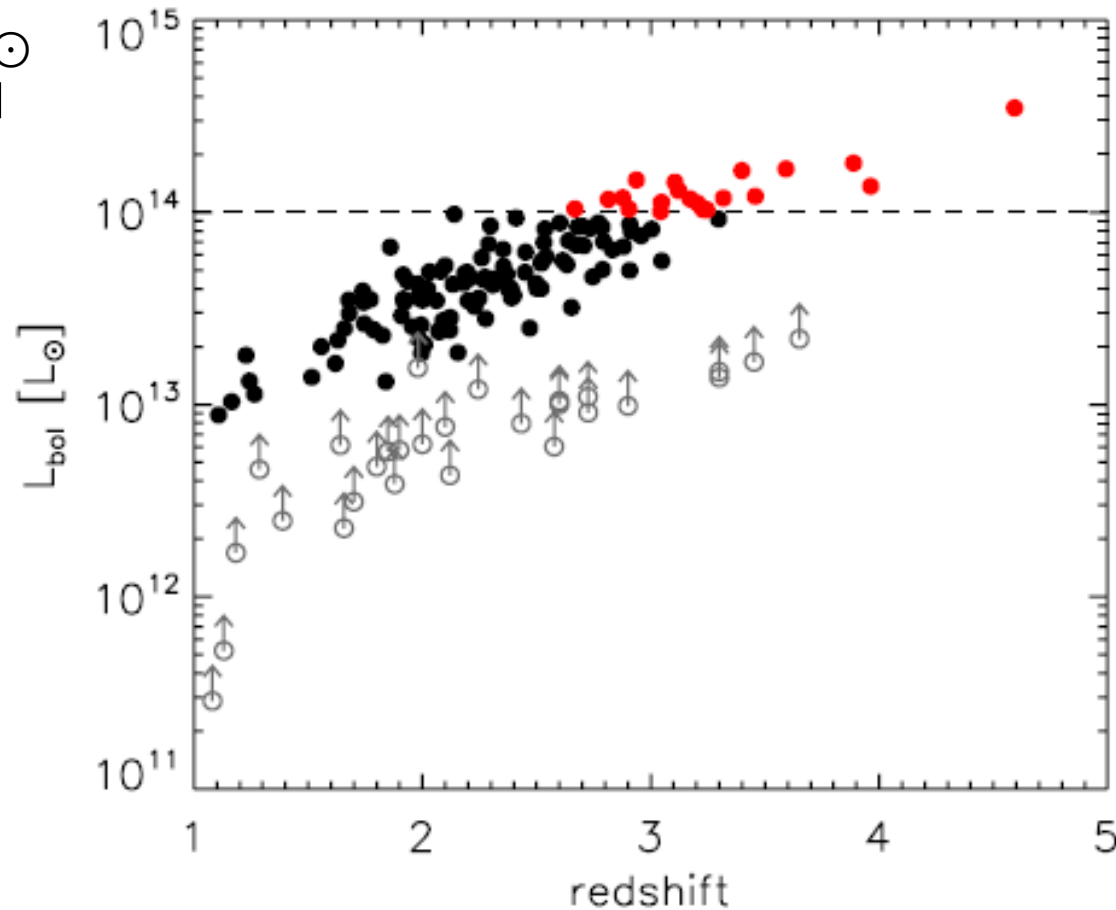
10% have $L_{\text{Bol}} > 10^{14} L_{\odot}$

Nicknamed **ELIRGs** by Tsai et al. (2015)

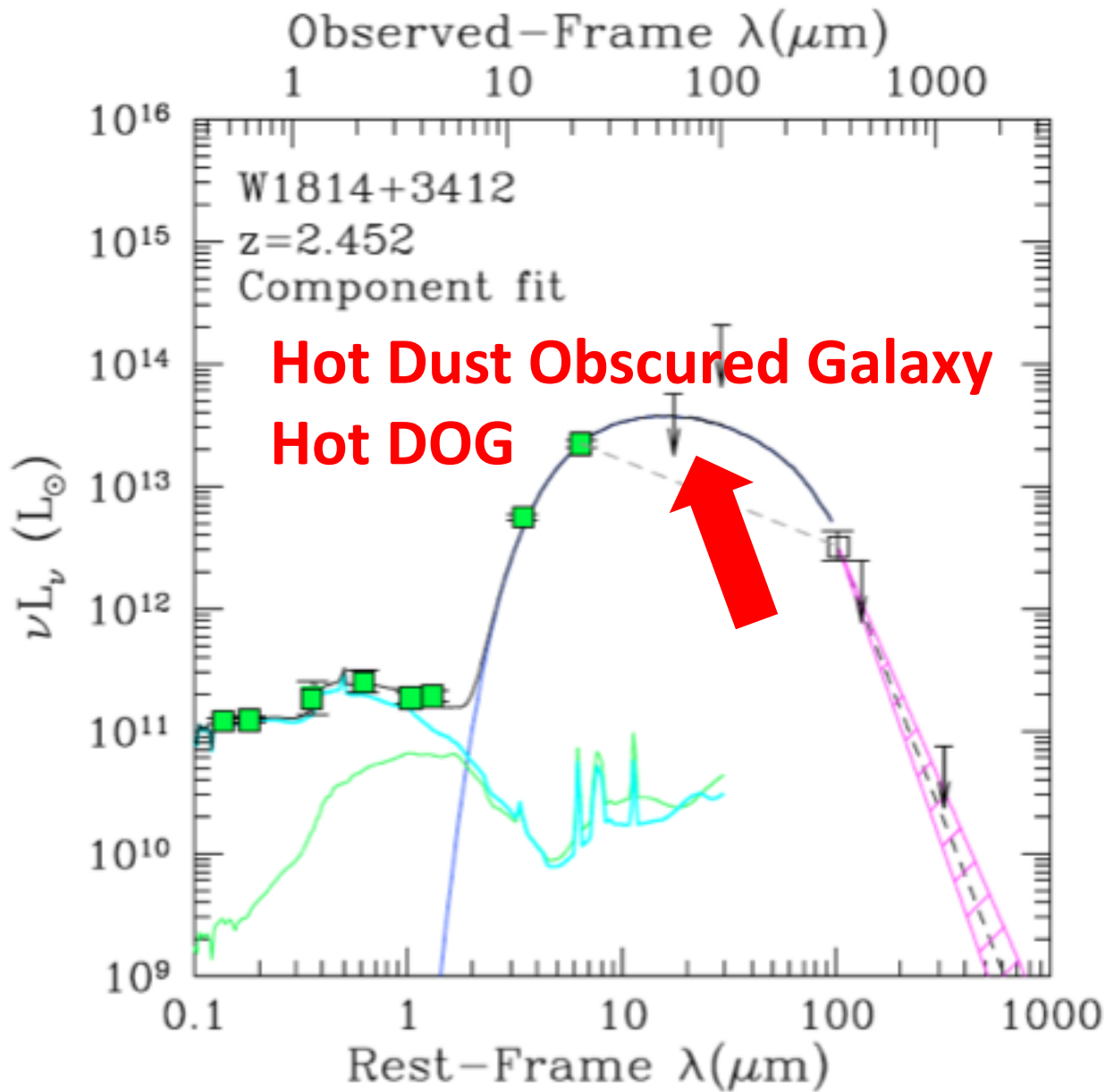
No lensing

All measurements have Herschel follow-up

All lower bounds lack far-IR follow-up



Tsai et al. (2015, ApJ, 805, 90)

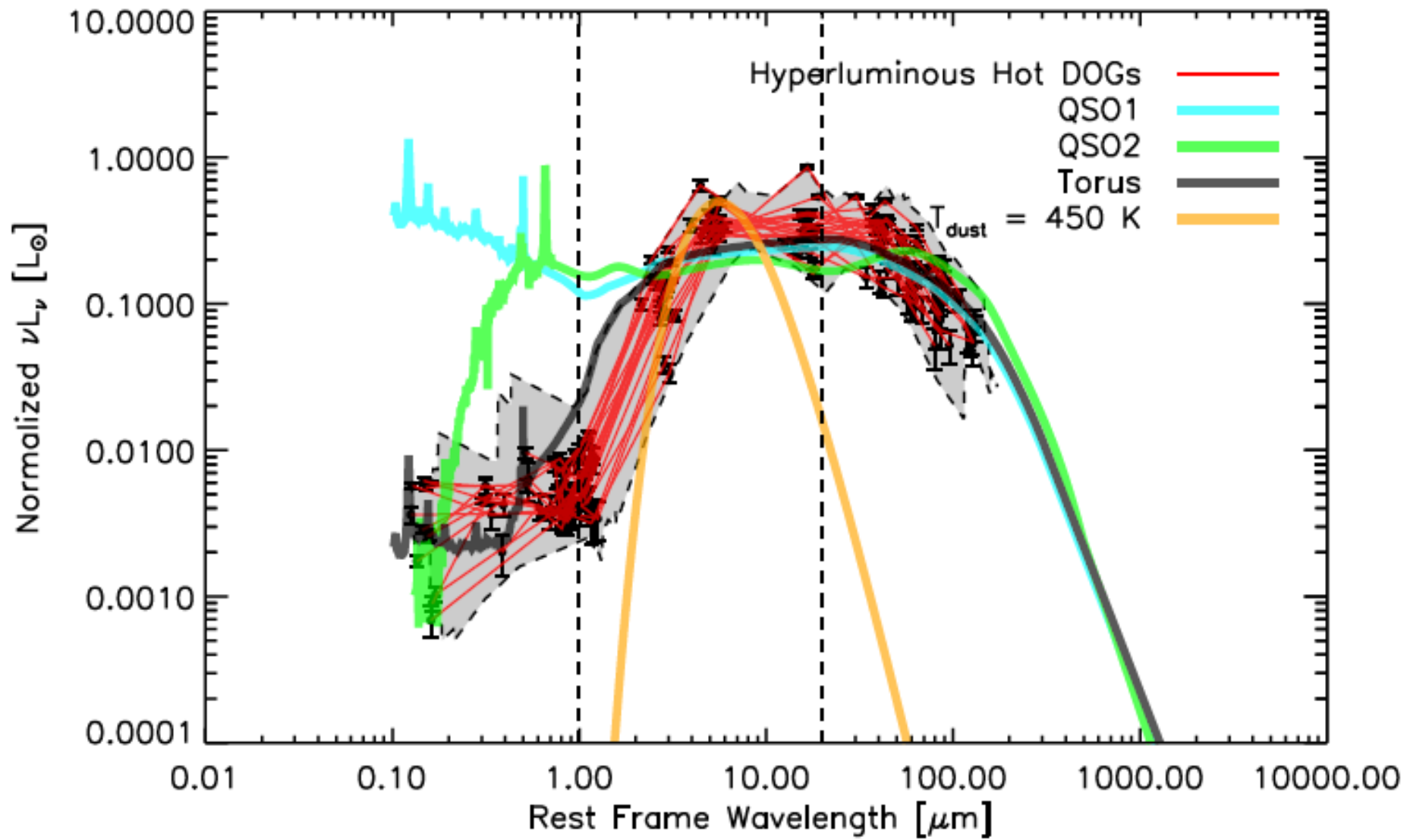


First object studied in detail (*Eisenhardt et al. 2012, 755, 173*)

Best fit SED model has

- AGN with $A_V \sim 50$ mag
- Starburst with $\sim 300 M_{\text{sun}}/\text{yr}$ SFR
- $L_{\text{Bol}} = 9 \times 10^{13} L_\odot$

Adapted from Eisenhardt et al.(2012)

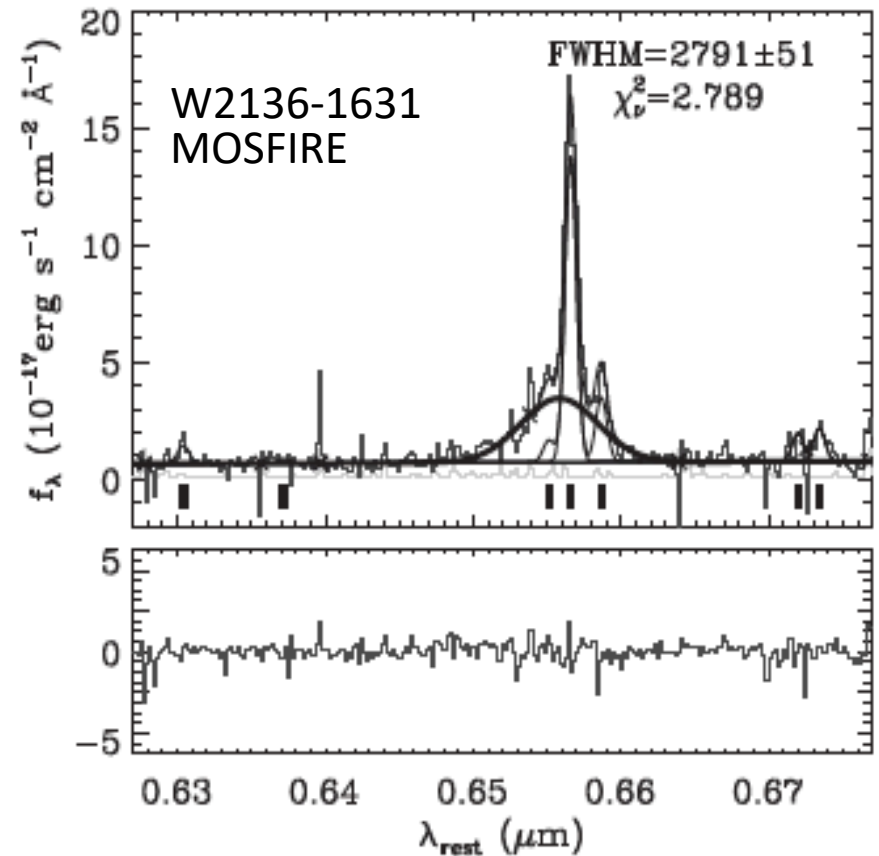
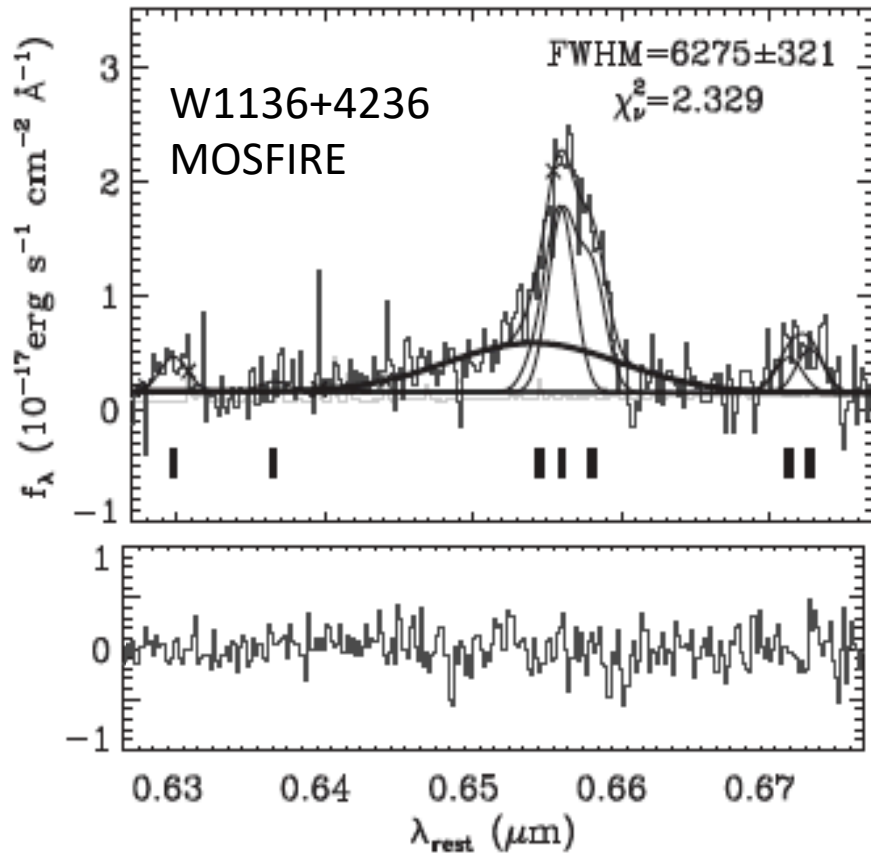


Tsai et al. (2015, ApJ, 805, 90)

Hot DOGs and Host Galaxies

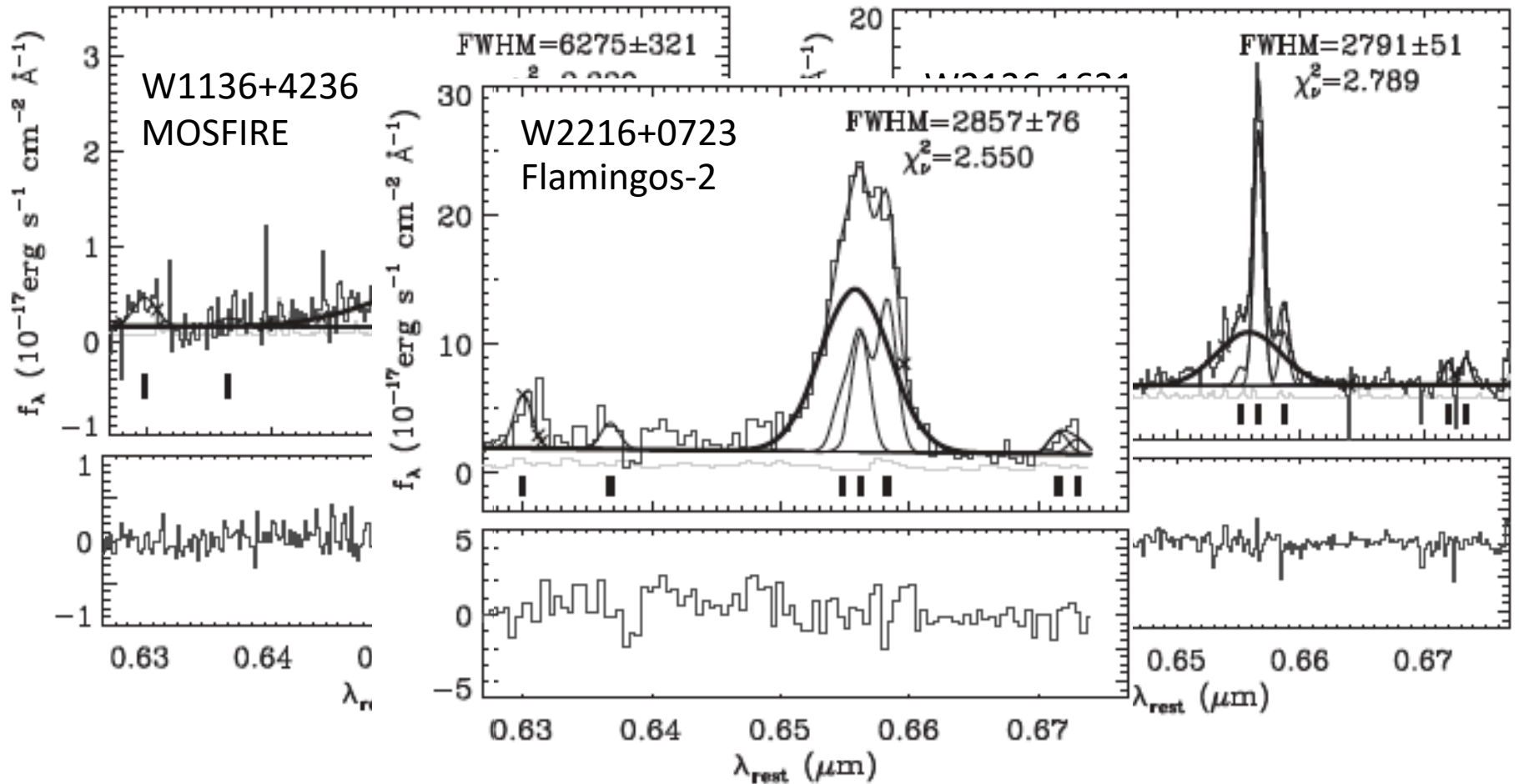
- Very luminous AGN, in “not so” massive galaxies
- Somewhere between two limits (*Assef et al. 2015*)
 - a) Very massive SMBHs for their hosts
 - b) Very high Eddington ratios
- Regardless of which, these objects may be great places on which to observe feedback in progress

Broad H α profiles – Black Hole Masses?

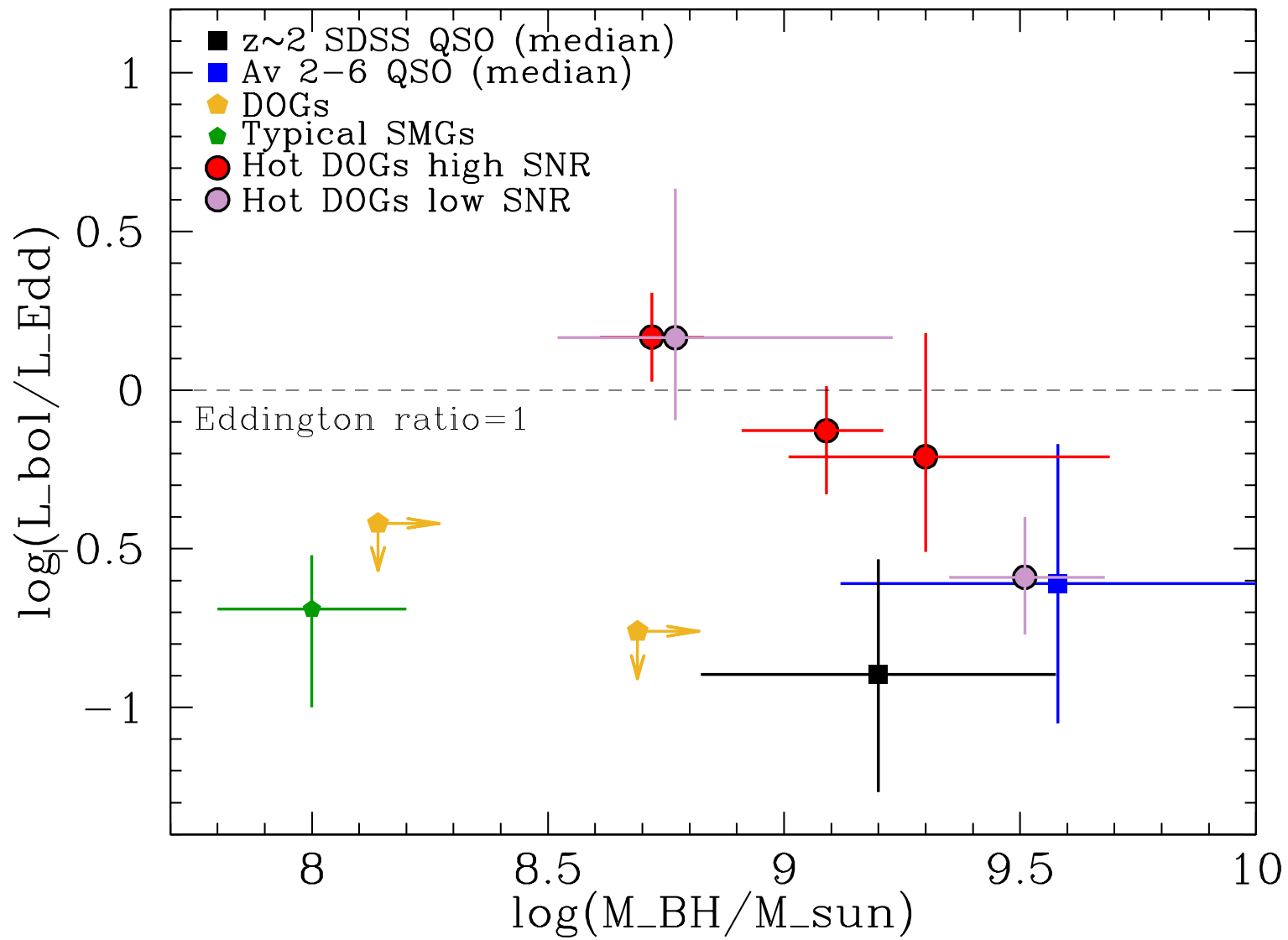


Wu et al. (2018, ApJ, 852, 96)

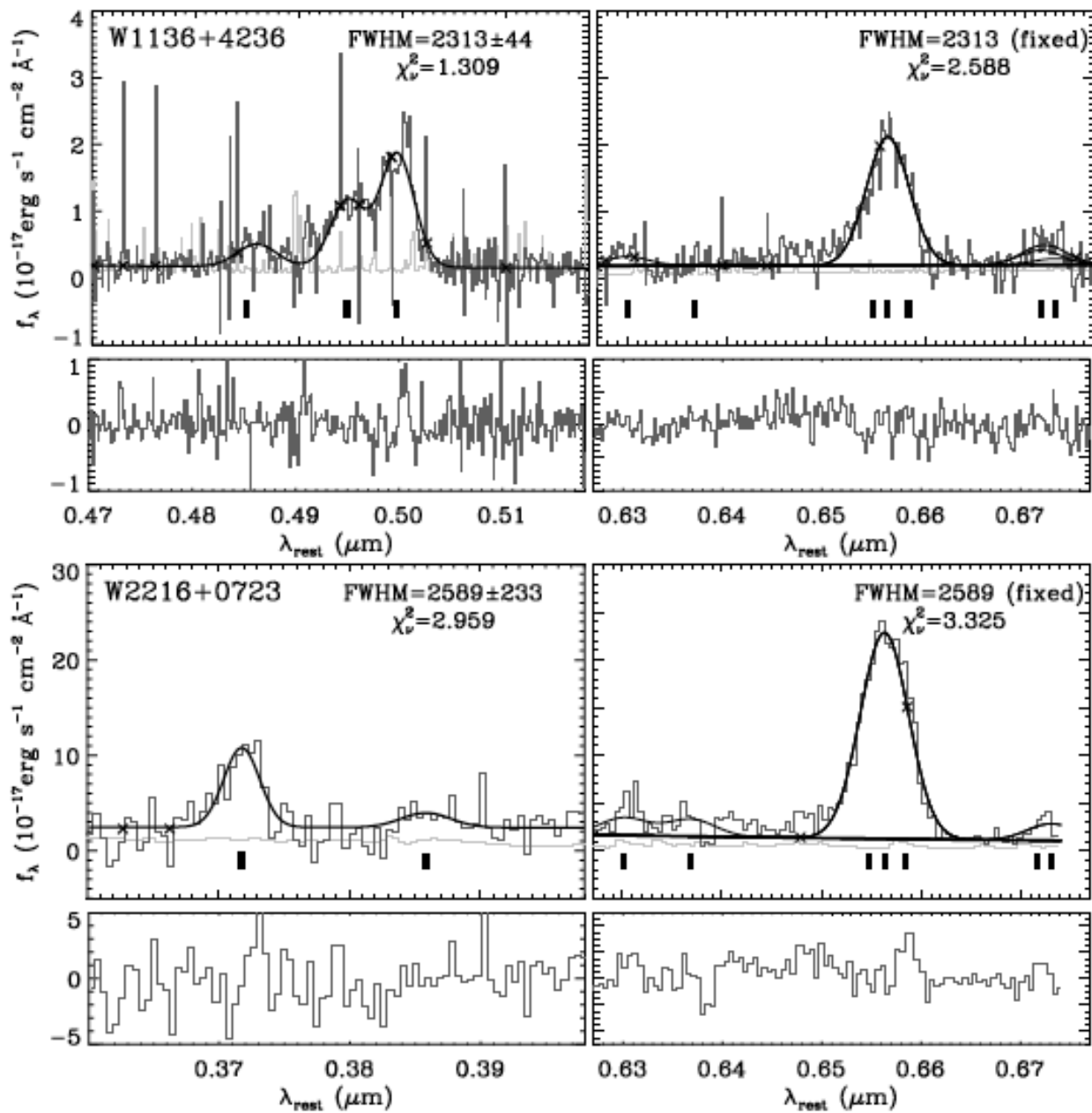
Broad H α profiles – Black Hole Masses?



Wu et al. (2018, ApJ, 852, 96)



Wu et al. (2018, ApJ, 852, 96)

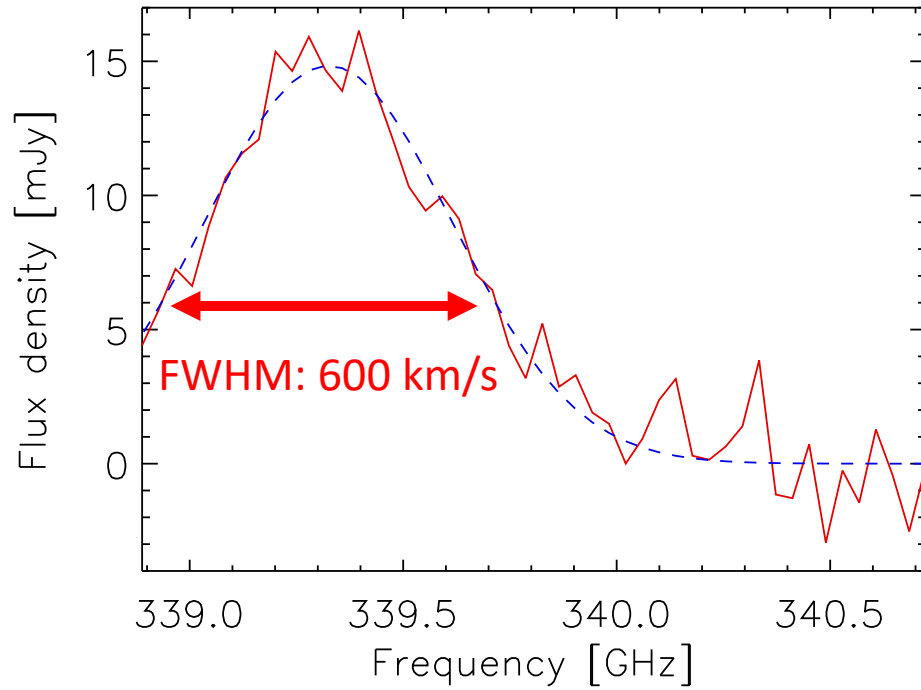


Wu et al. (2018, ApJ, 852, 96)

W2246-0526

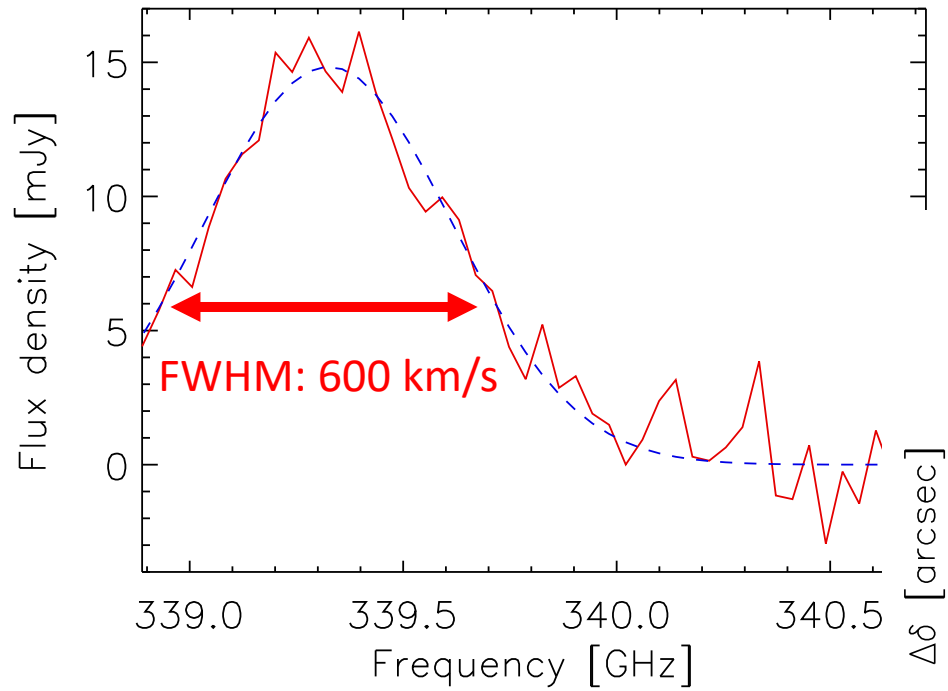
$z=4.601$, $L_{\text{IR}}=2 \times 10^{14}$ Lsun

Diaz-Santos et al. (2016, ApJL, 816, 6)



Tanio Diaz-Santos
Postdoc @ UDP

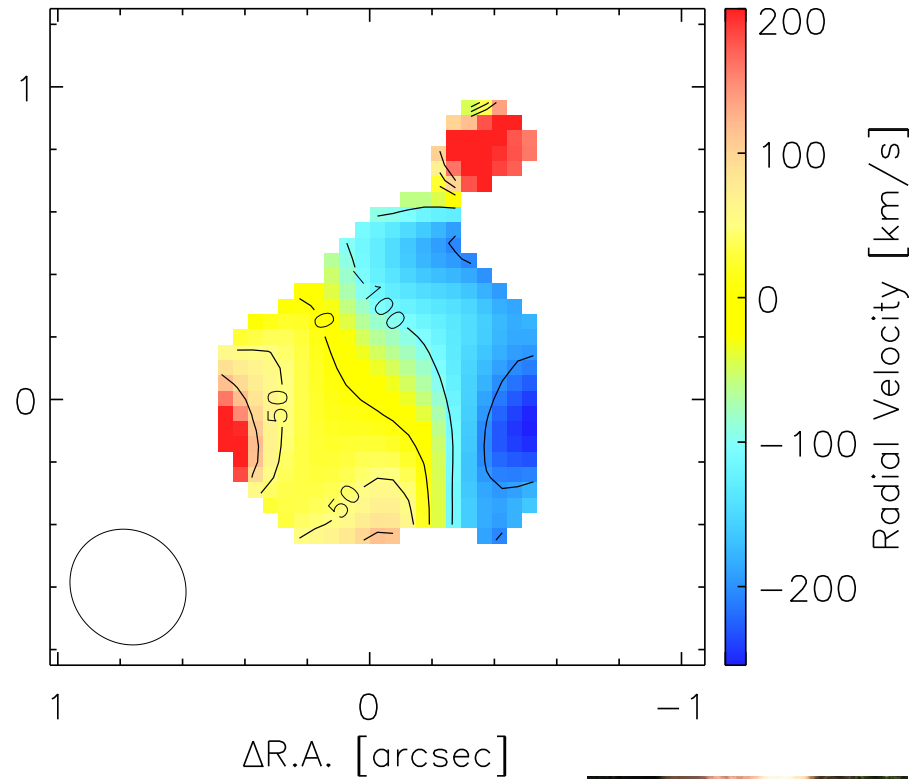




W2246-0526

$z=4.601$, $L_{\text{IR}}=2 \times 10^{14}$ Lsun

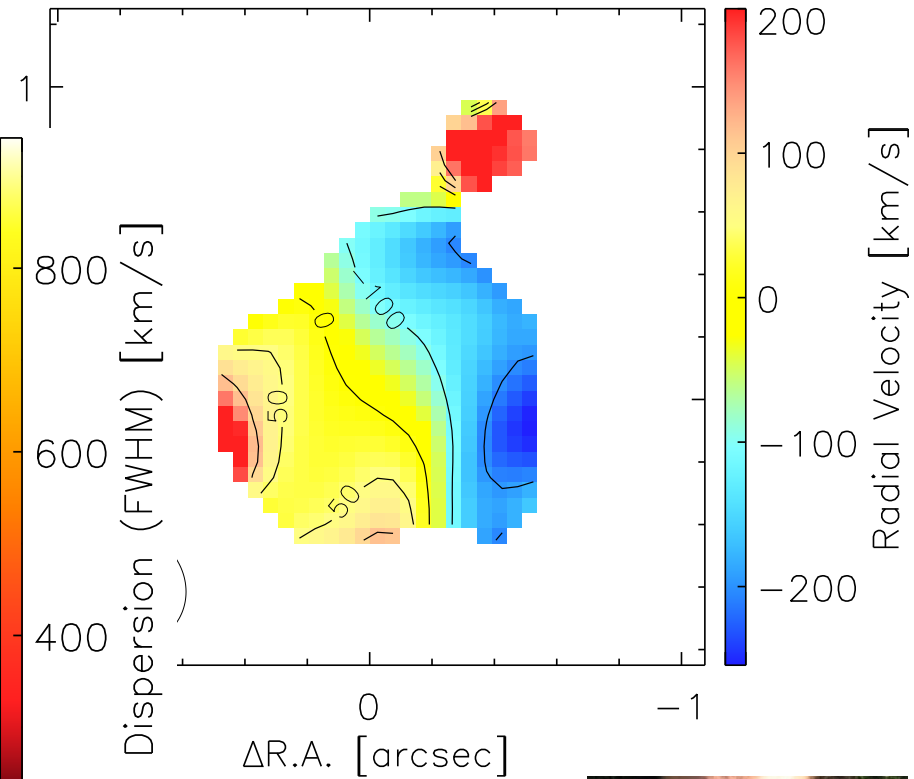
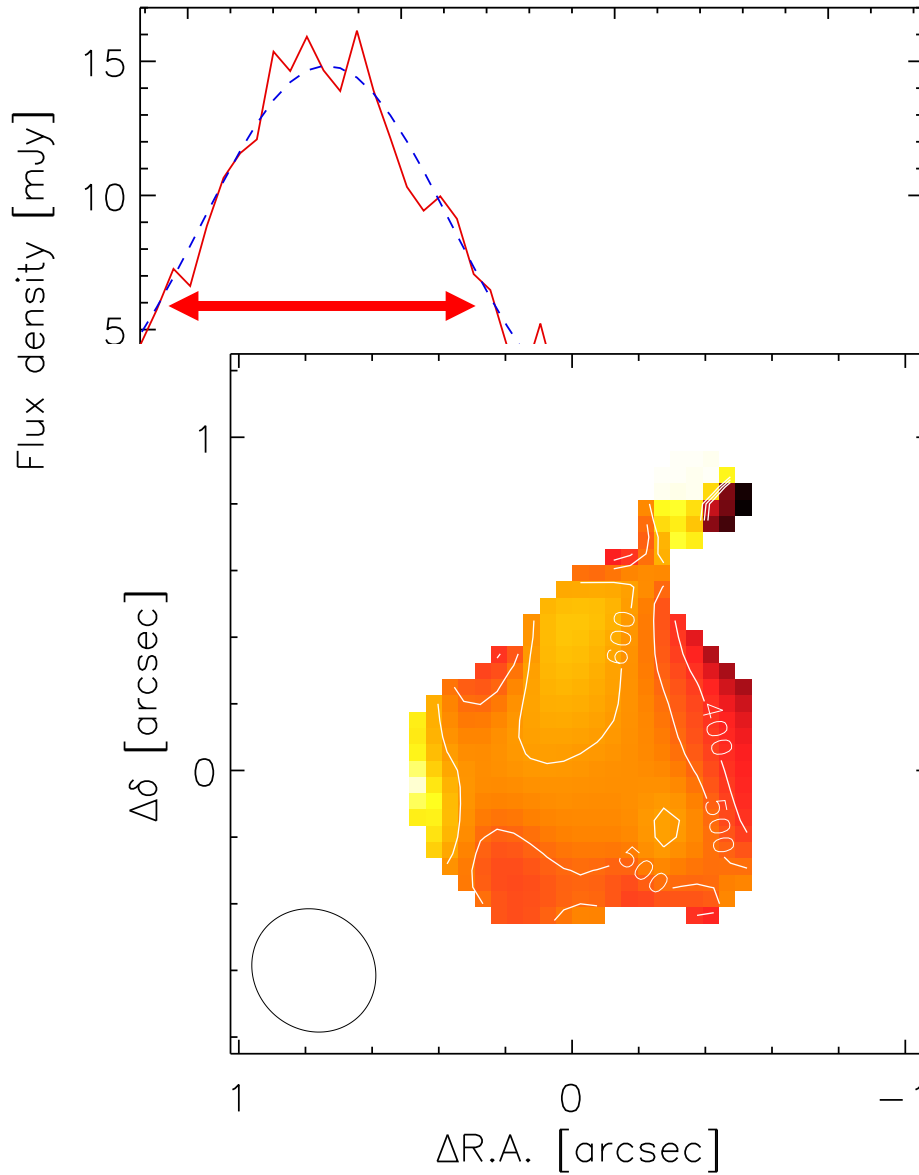
Diaz-Santos et al. (2016, ApJL, 816, 6)



W2246-0526

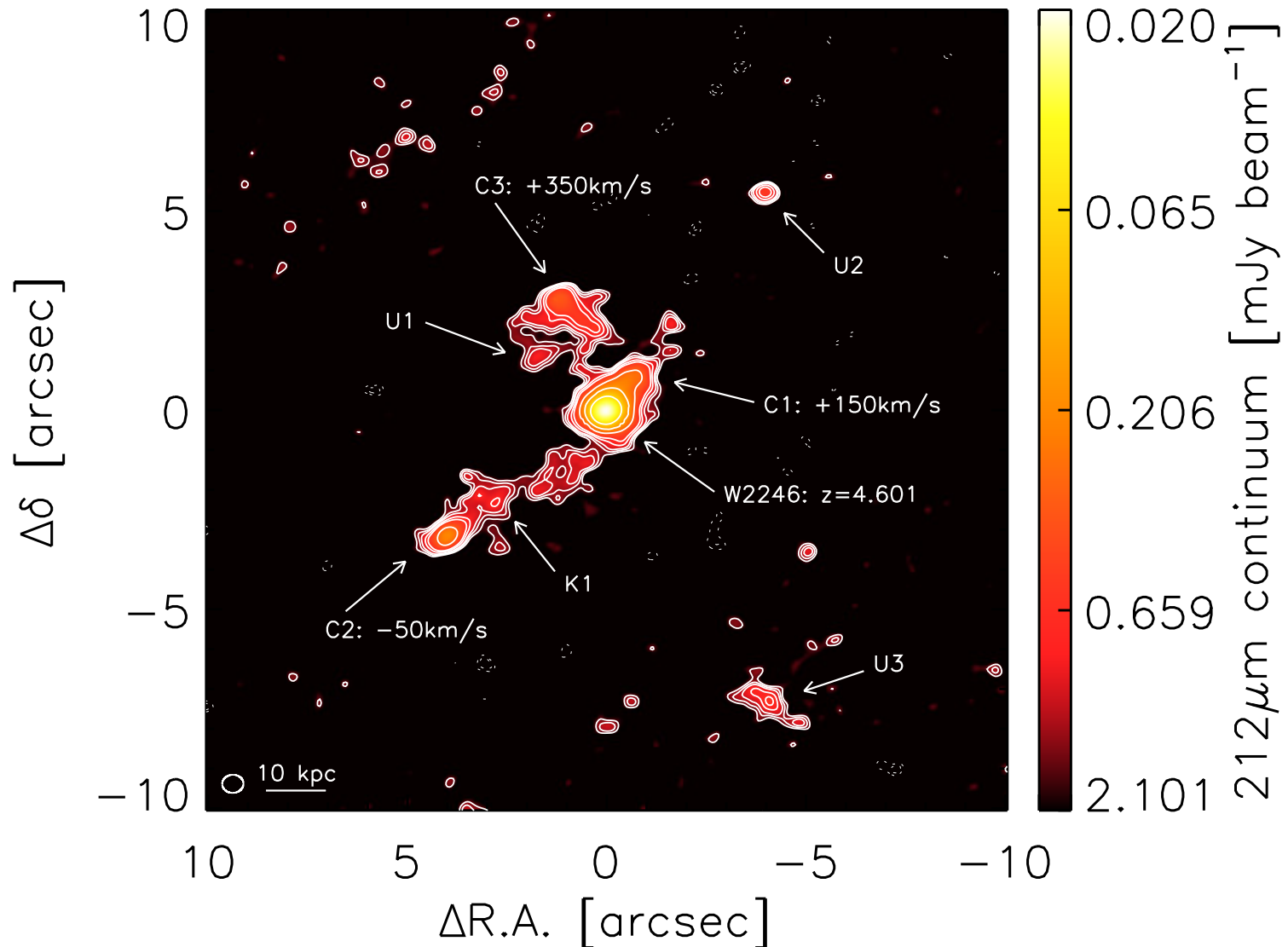
$z=4.601$, $L_{\text{IR}}=2 \times 10^{14}$ Lsun

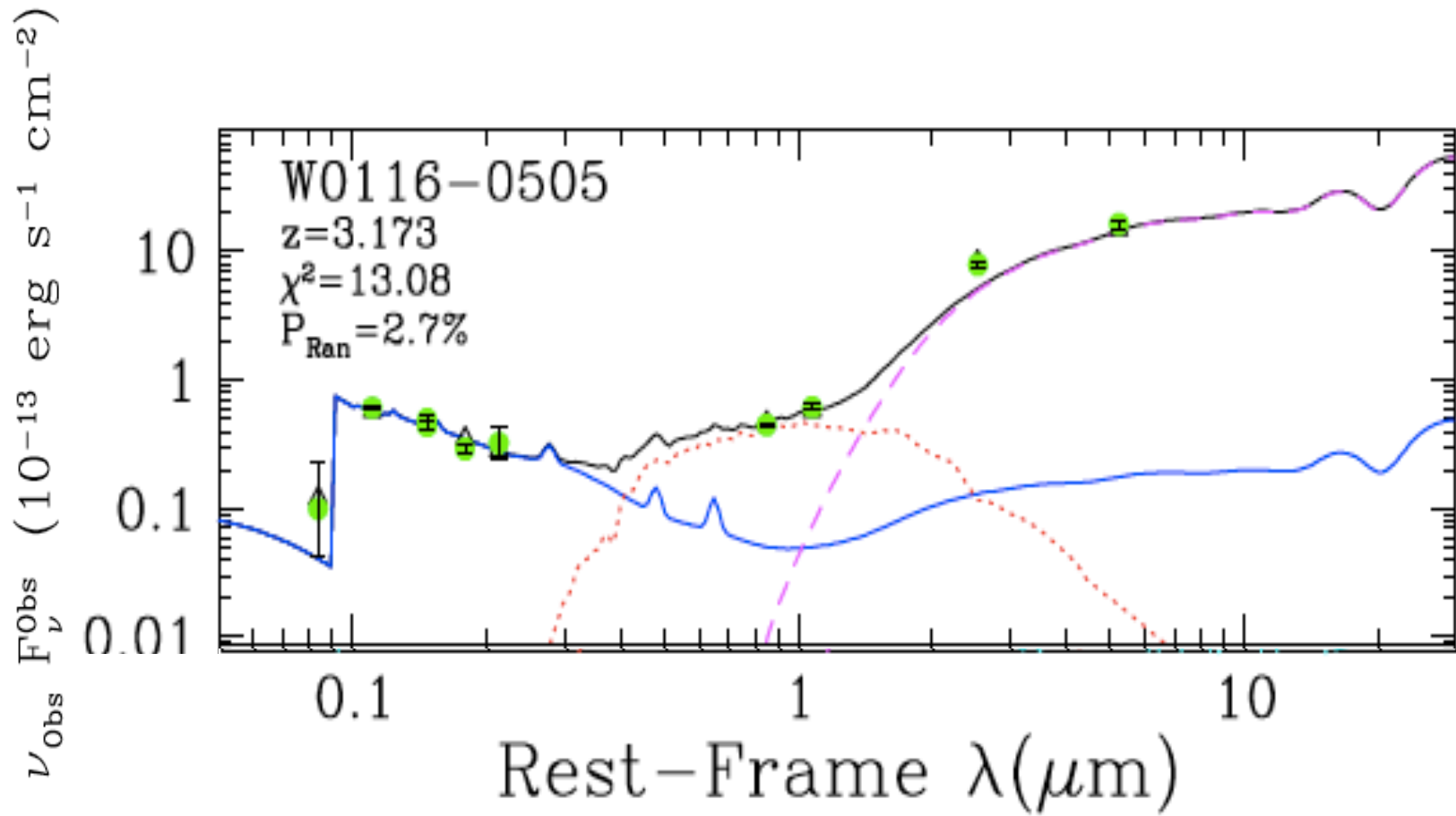
Diaz-Santos et al. (2016, ApJL, 816, 6)



W2246 Dust Continuum

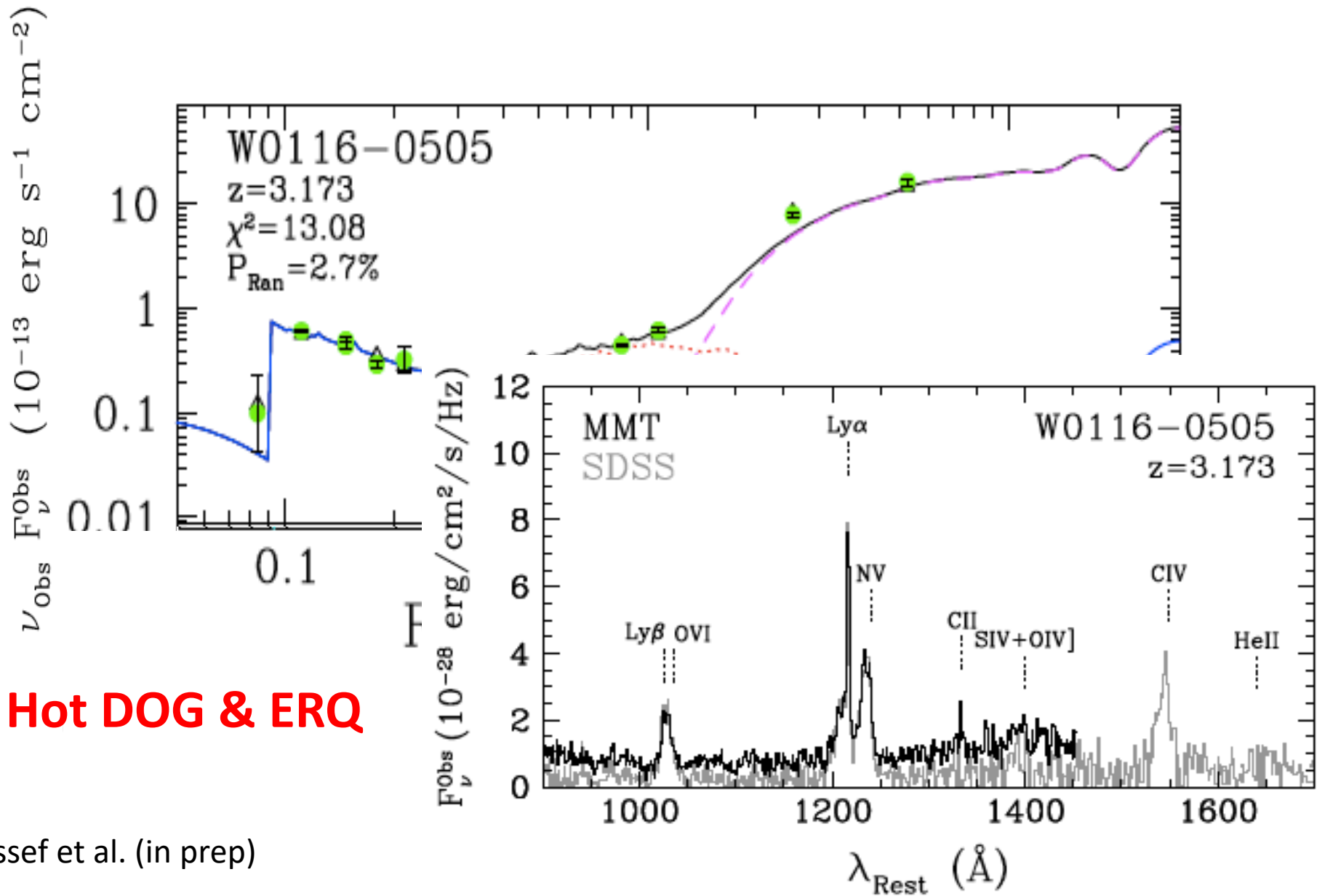
Diaz-Santos et al. (2018, submitted)



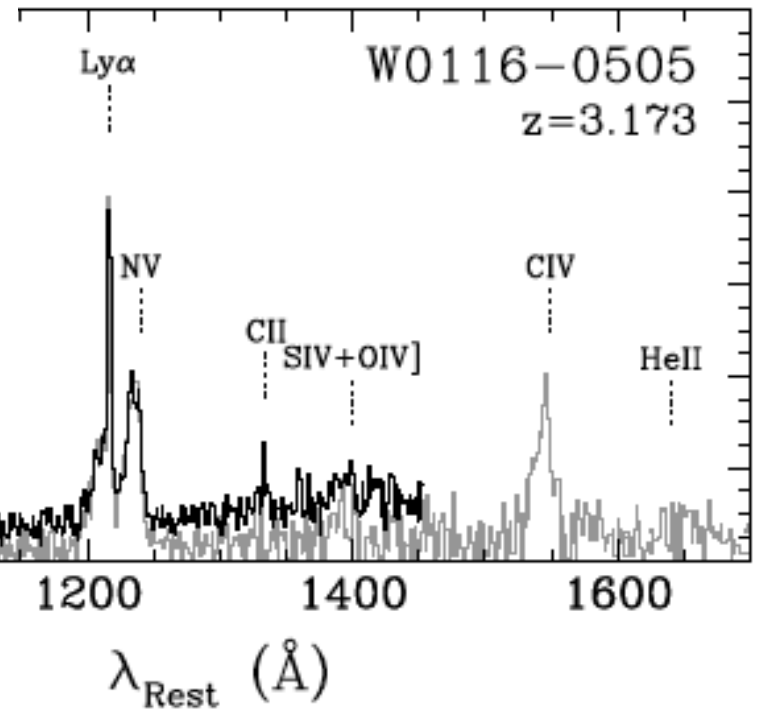
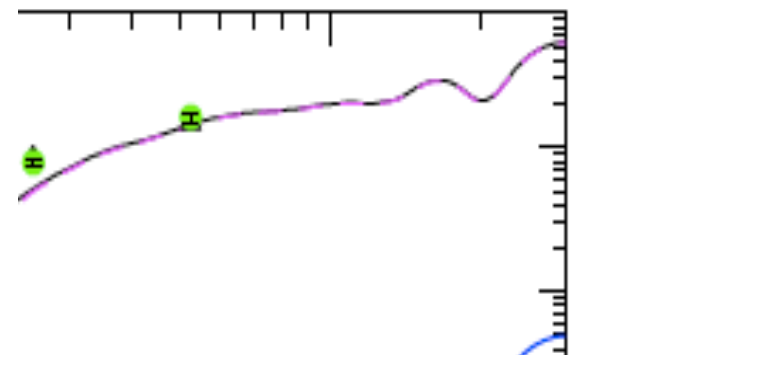
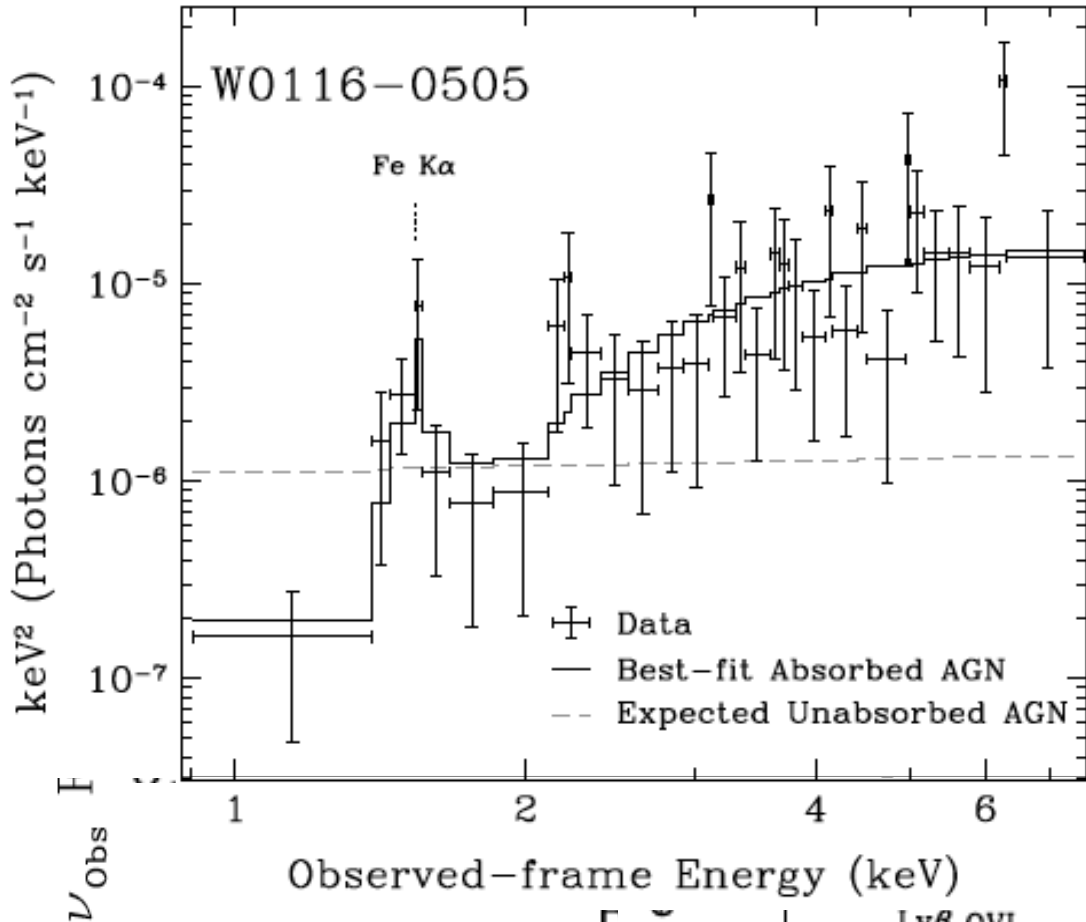


Hot DOG & ERQ

Assef et al. (in prep)

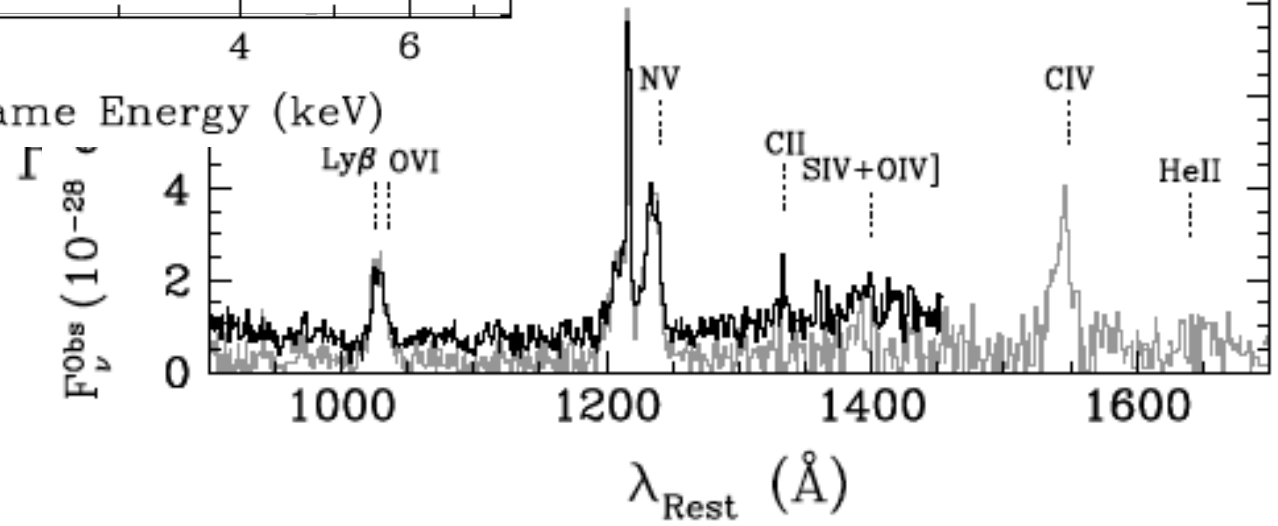
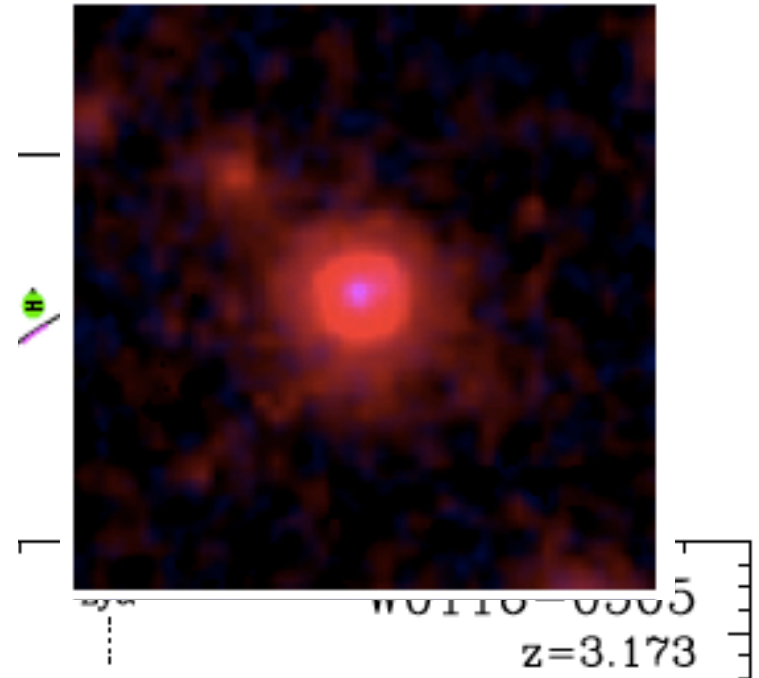
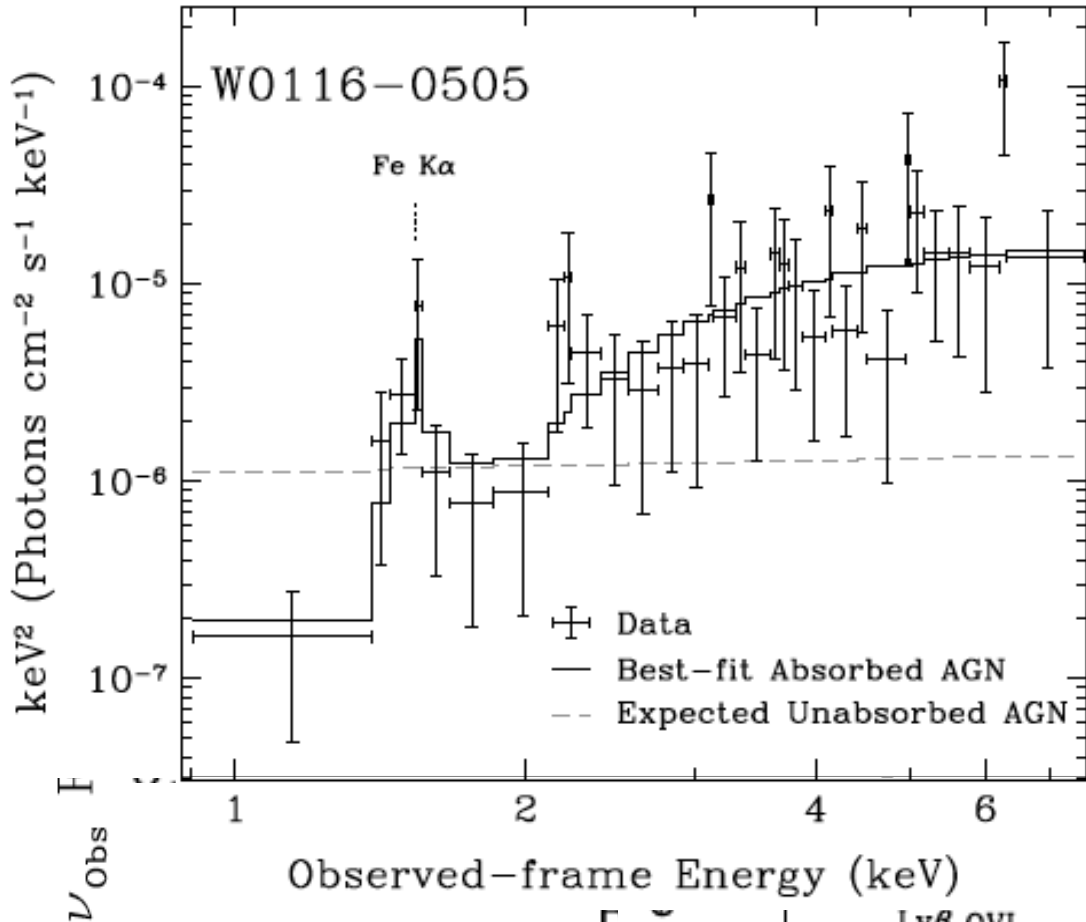


Assef et al. (in prep)



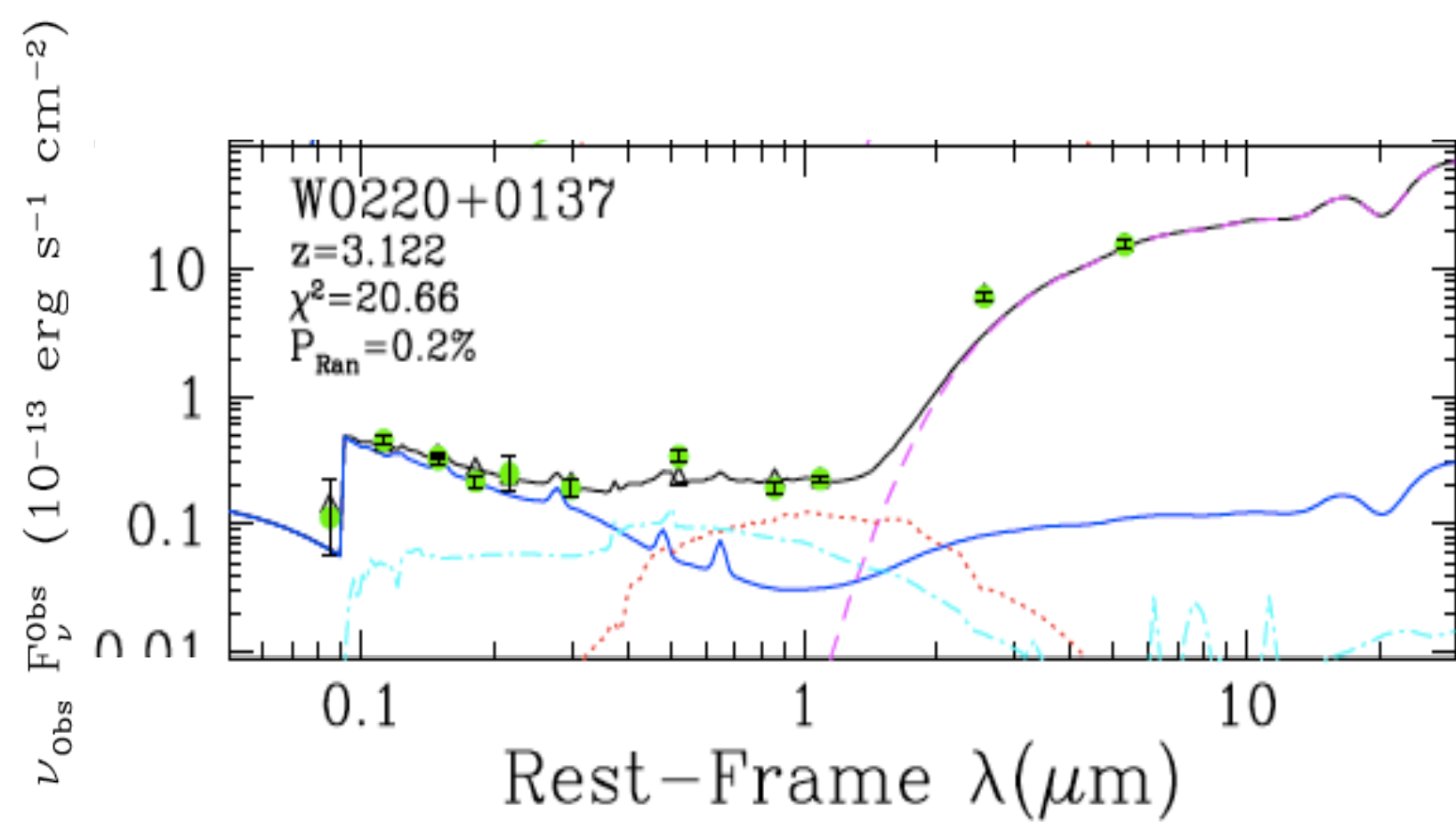
Hot DOG & ERQ

Assef et al. (in prep)



Hot DOG & ERQ

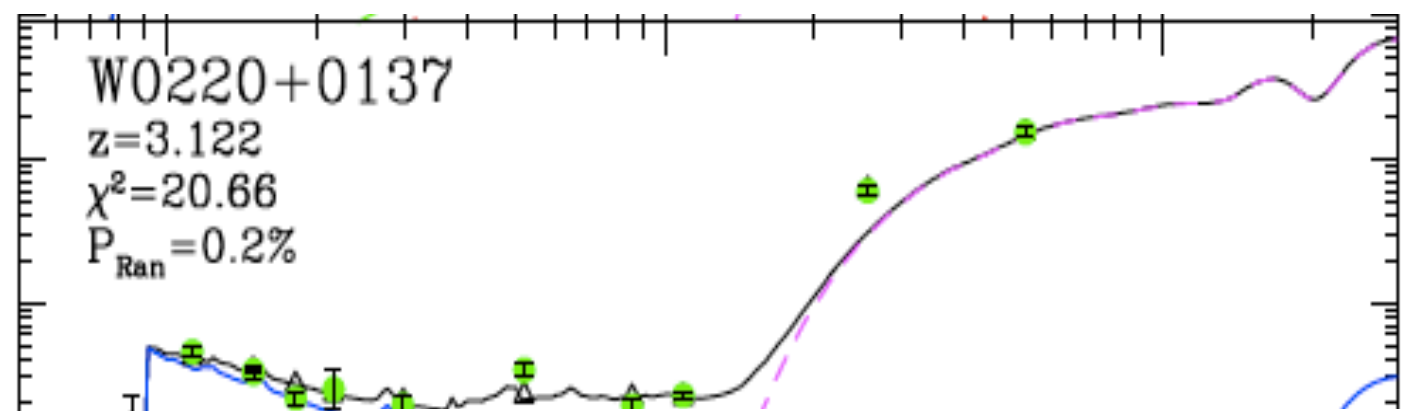
Assef et al. (in prep)



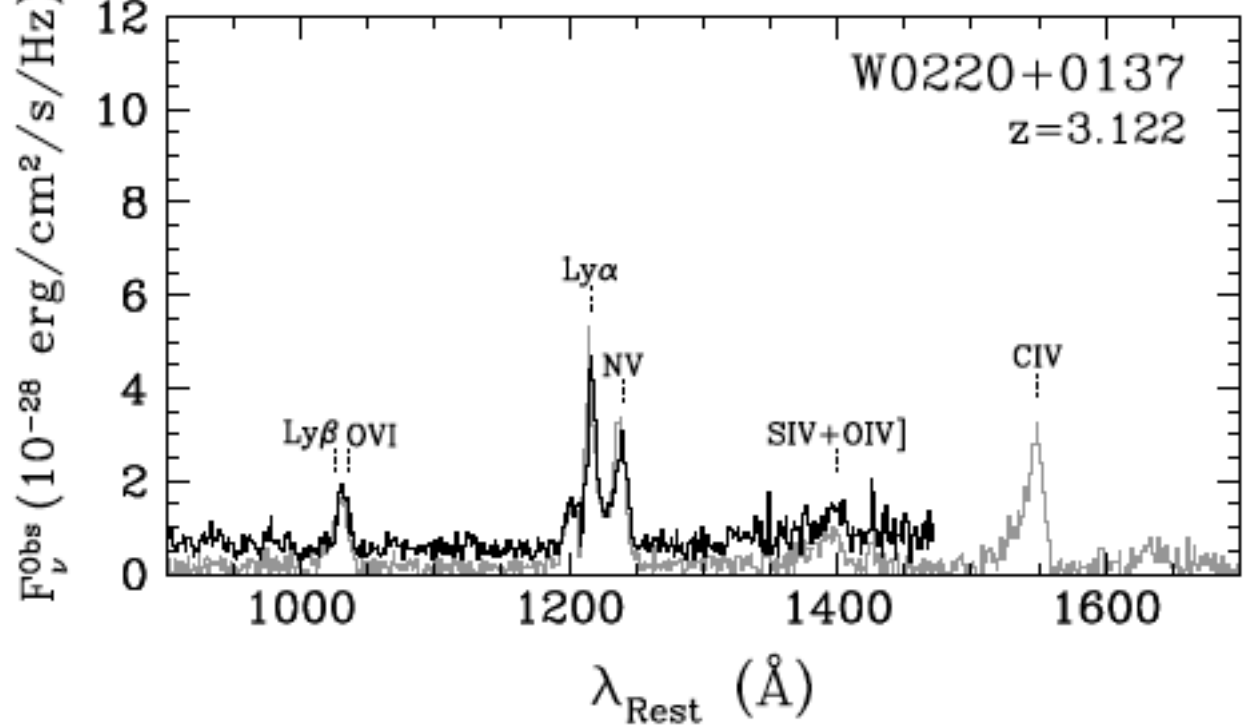
Hot DOG & ERQ

Assef et al. (in prep)

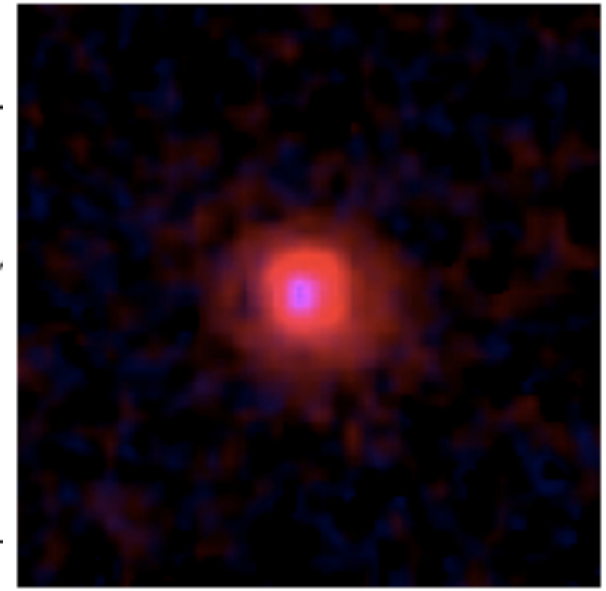
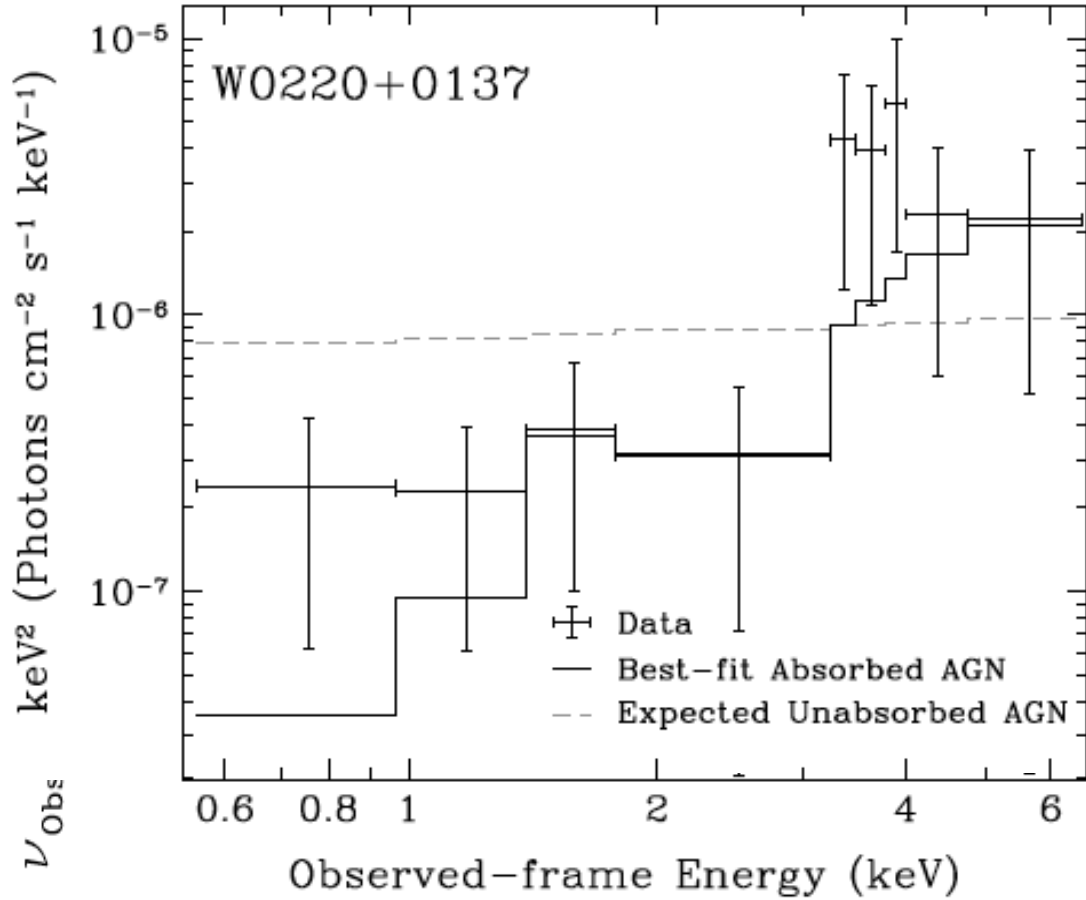
$\nu_{\text{obs}} F_{\nu}^{\text{obs}} (10^{-13} \text{ erg s}^{-1} \text{ cm}^{-2})$



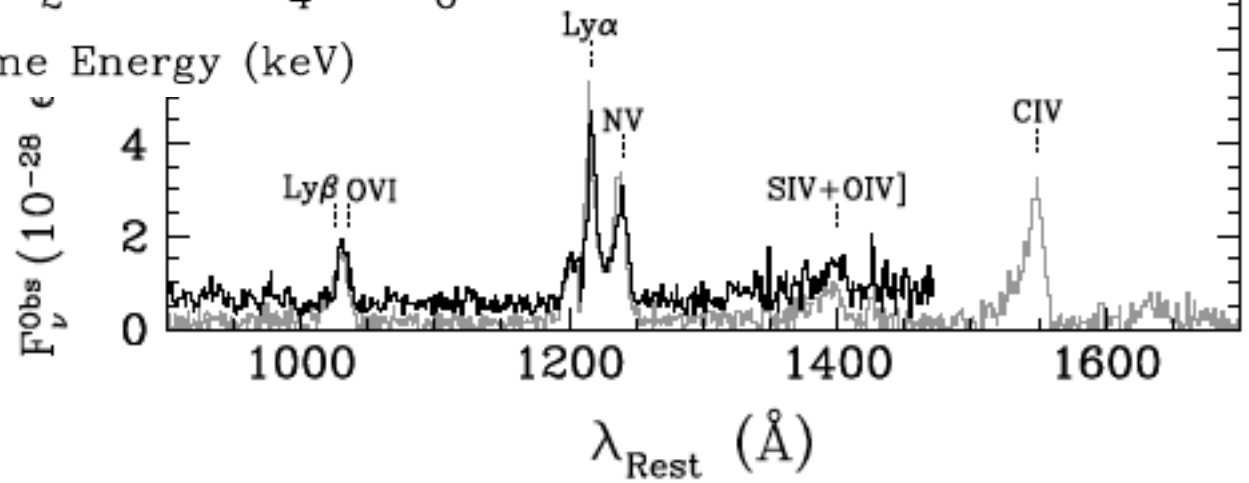
Hot DOG & ERQ



Assef et al. (in prep)

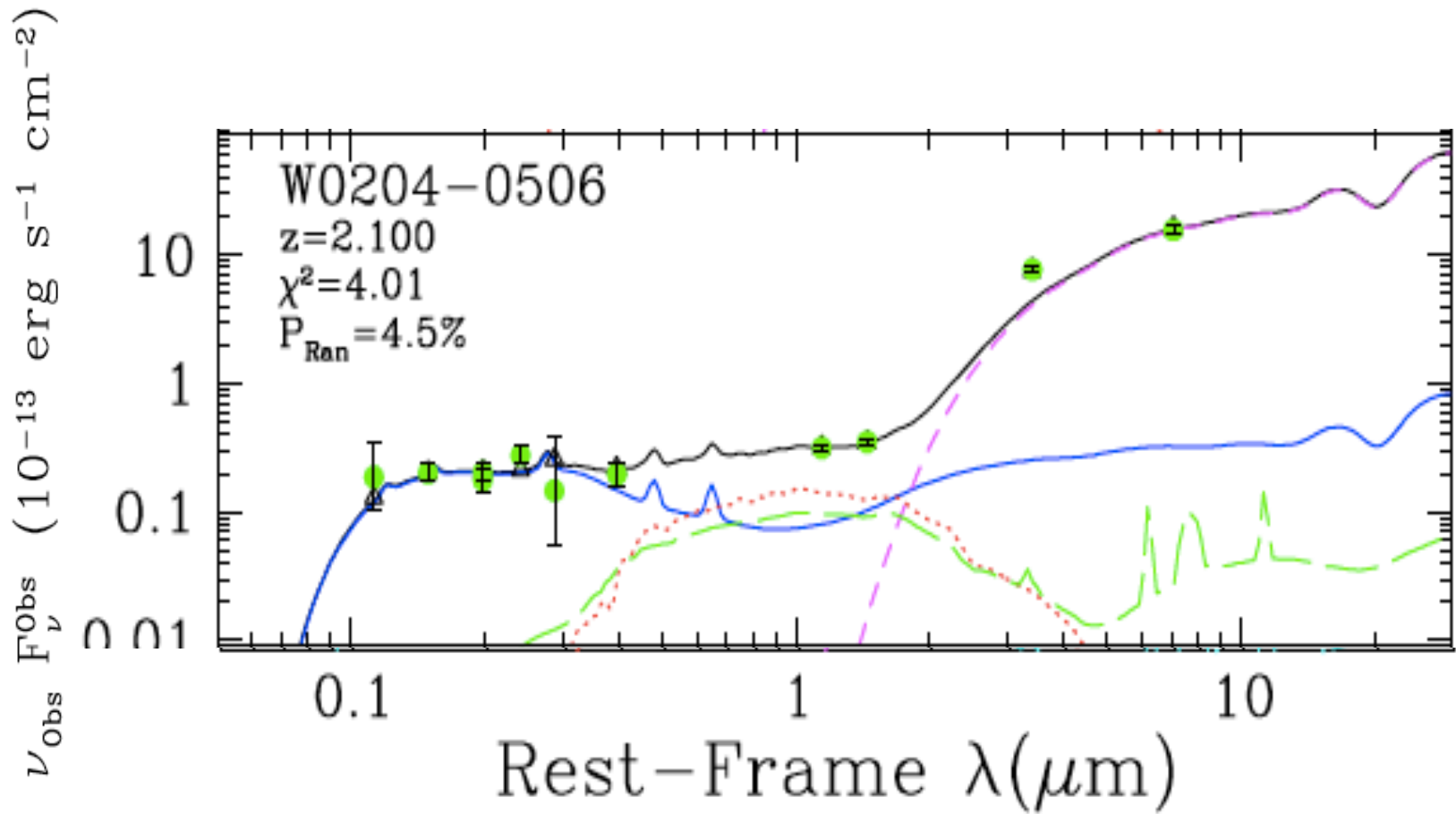


W0220+0137
z=3.122



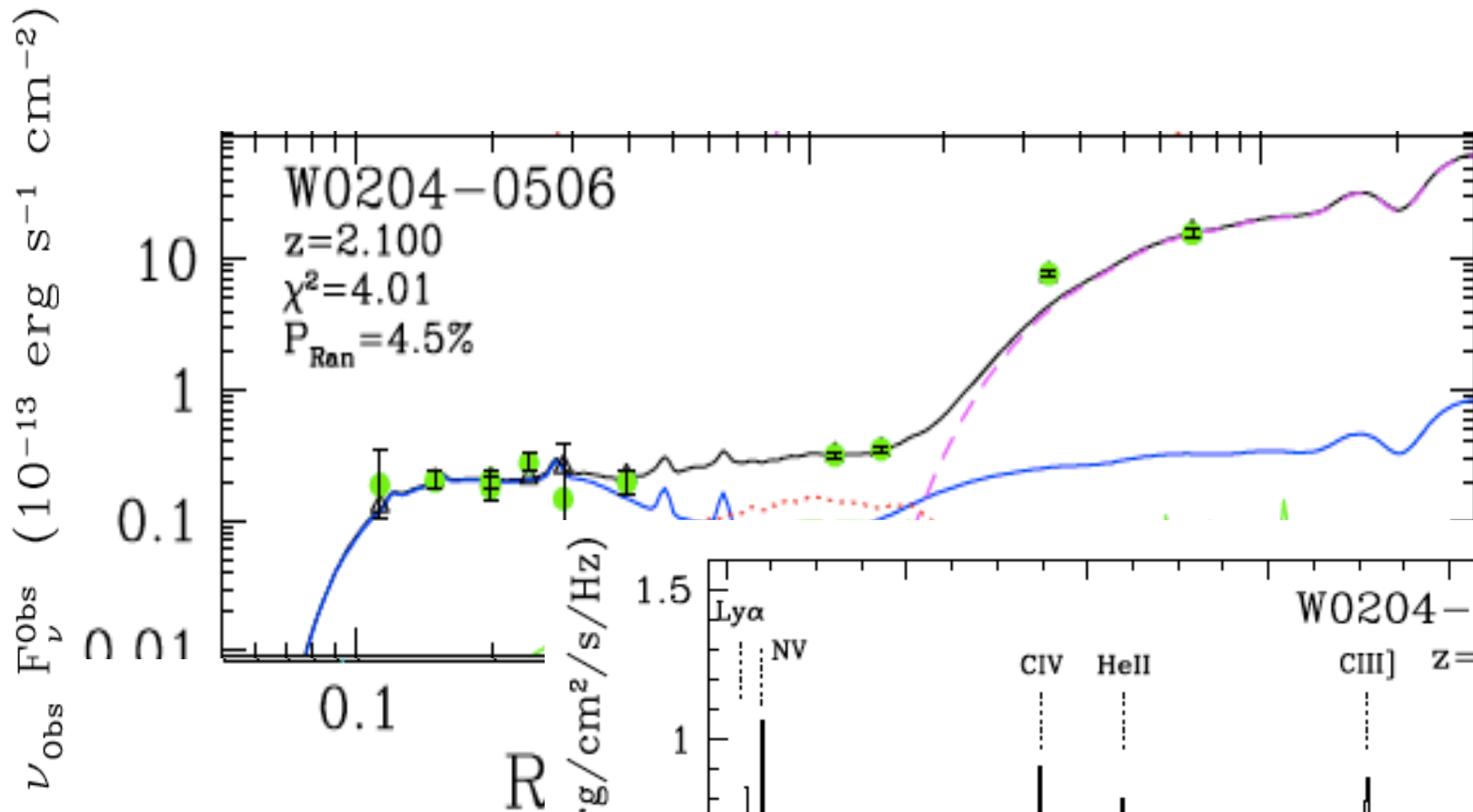
Hot DOG & ERQ

Assef et al. (in prep)

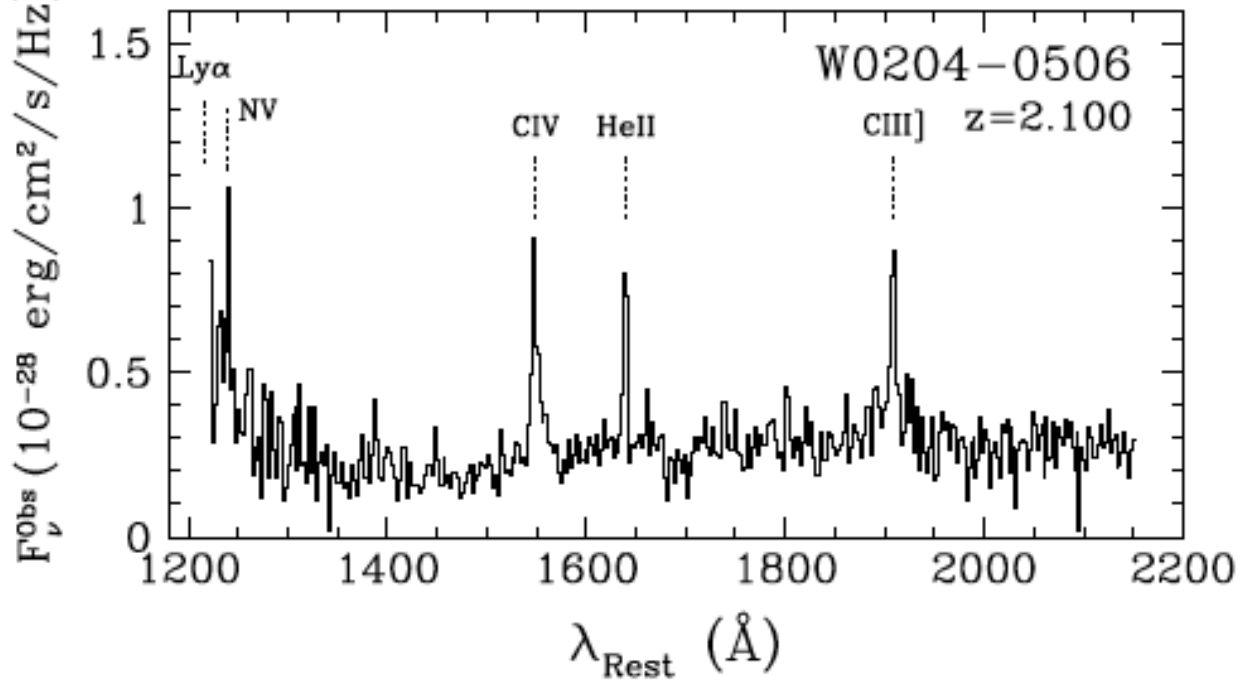


Hot DOG only

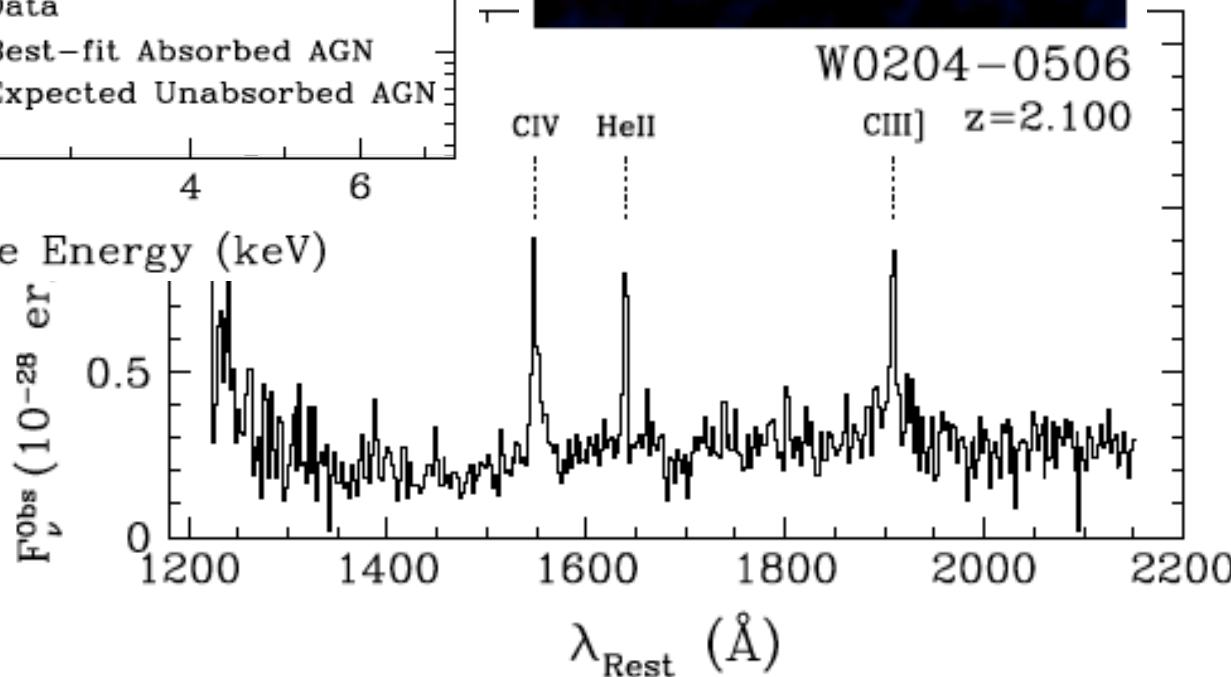
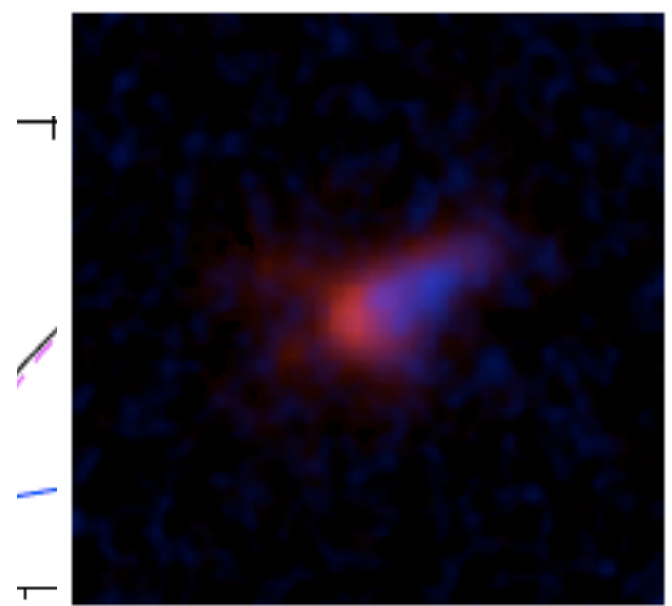
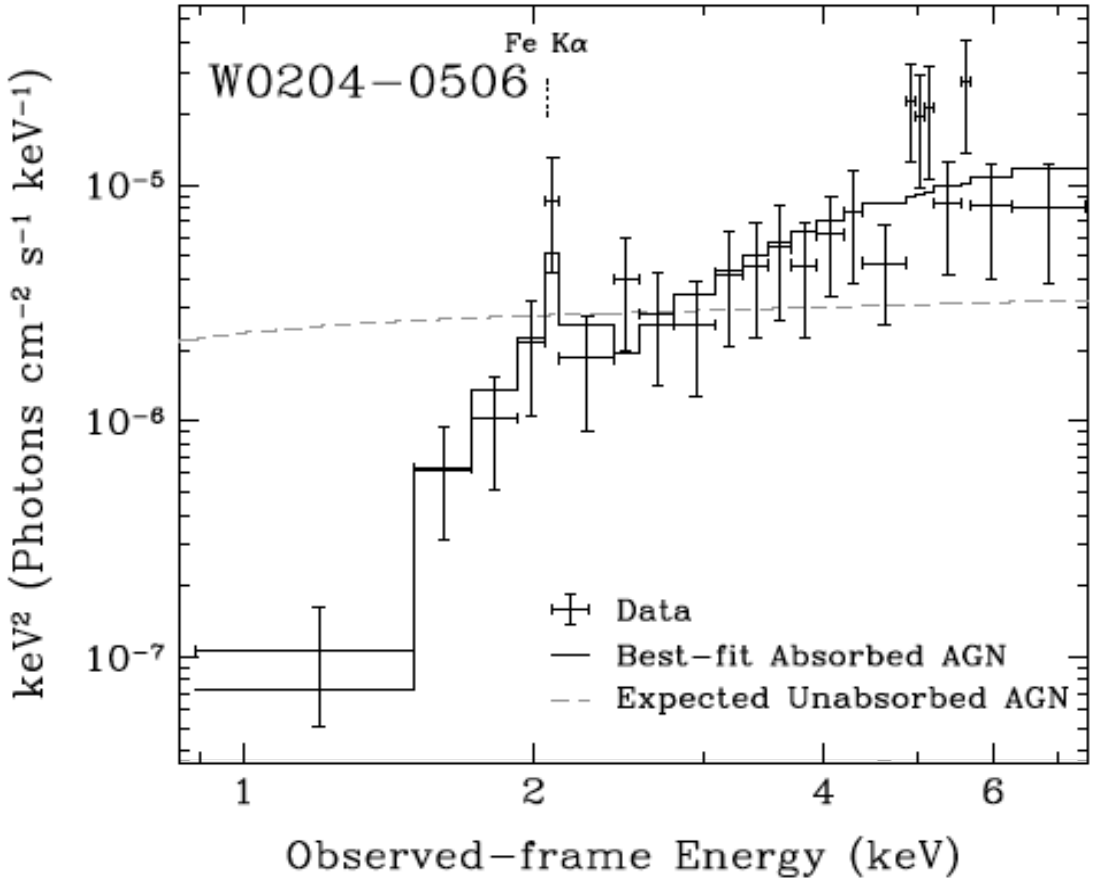
Assef et al. (in prep),
 Assef et al. (2016)



Hot DOG only



Assef et al. (in prep),
 Assef et al. (2016)



Hot DOG only

Assef et al. (in prep),
Assef et al. (2016)

Are Hot DOGs Special?

- They are rare, but not that much
 - As common as type 1 QSOs of the same luminosity (*Assef et al. 2015*)
 - As common as red quasars at the same luminosity (*Banerji et al. 2015*)
- They seem to be affecting the galaxy around them
 - Outflows observed
- Some of them display merger signs
 - Although maybe only visible in the IR?
 - *Farrah et al. (2017)* found in the optical they do not have a higher than expected merger fraction. Although see *Fan et al. (2016)*
- Hot DOGs and ERQs may be related populations
 - Maybe different stages of a same event?