

Using R-W1 to Uncover Obscured AGN in X-ray surveys

ApJ 818, 88 2016

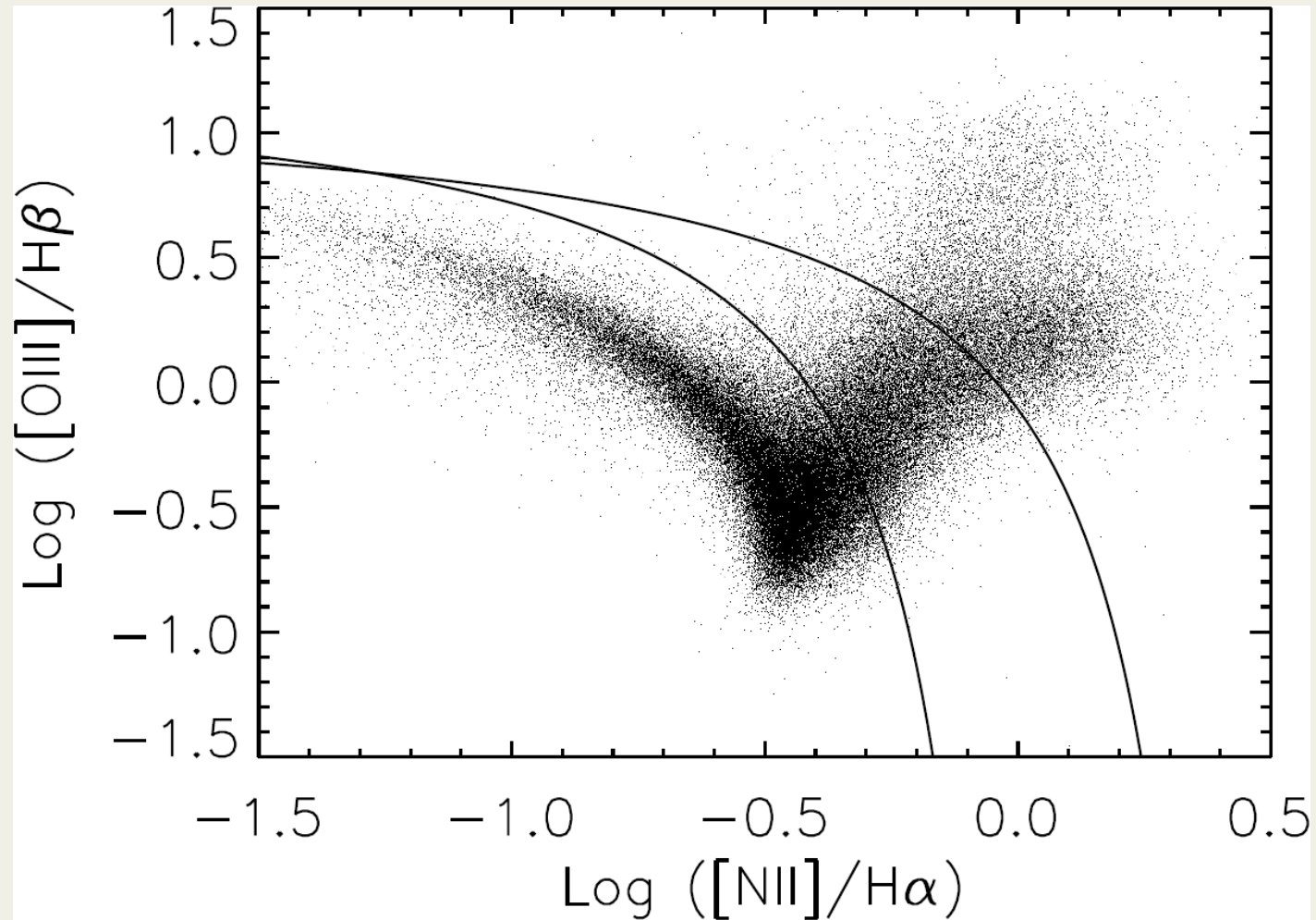
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+ Stripe 82X Collaboration

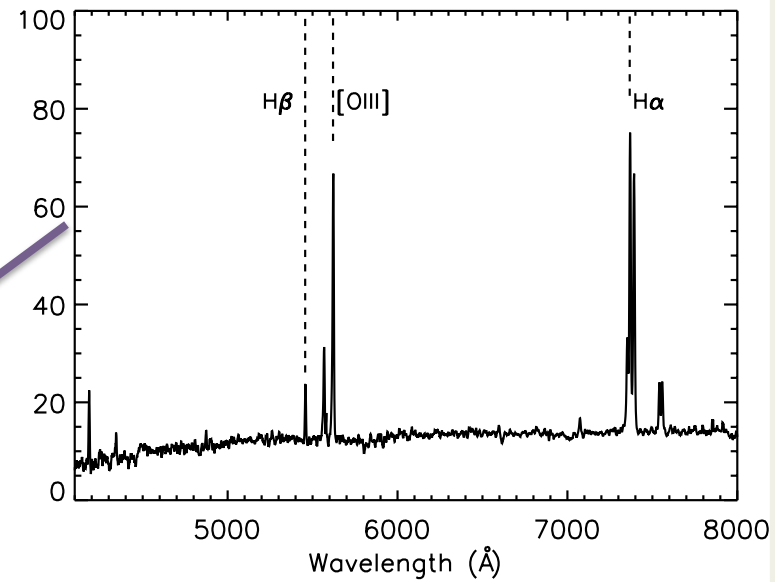
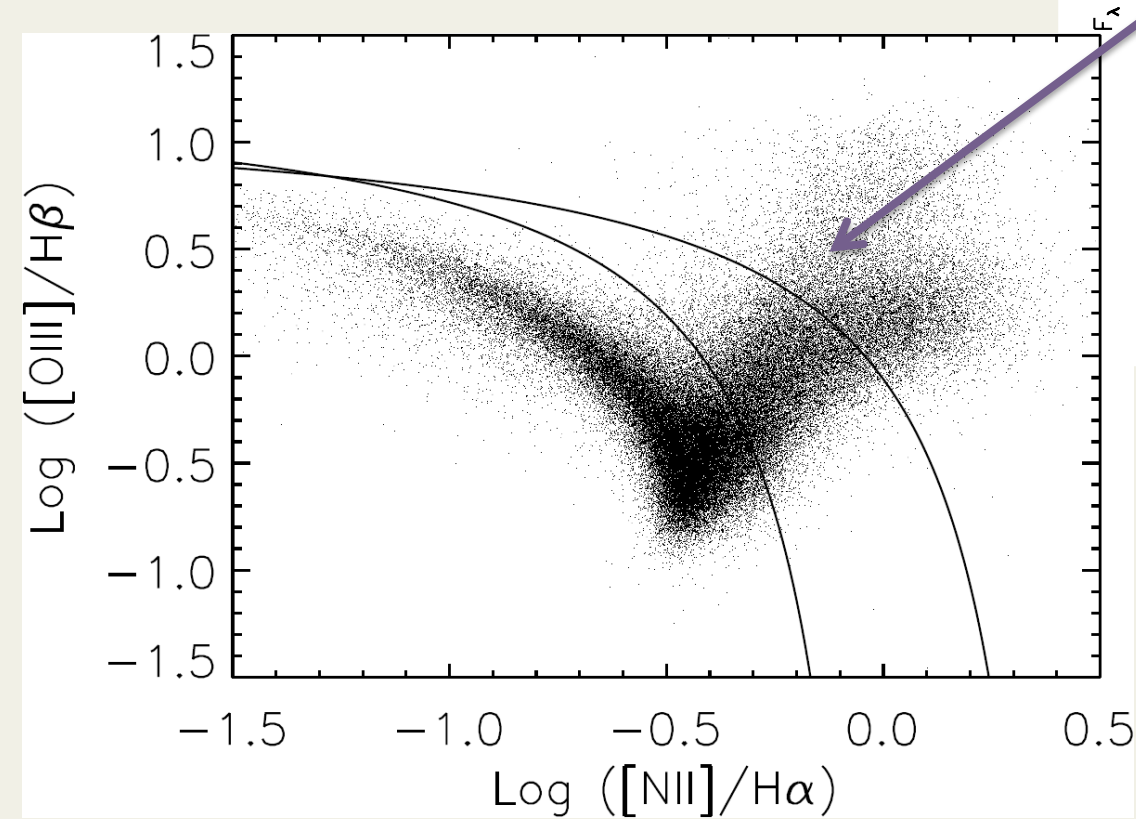
Obscured AGN are Important

- Majority of local AGN population *Comastri 2004, Treister+ 2004*

Obscured AGN

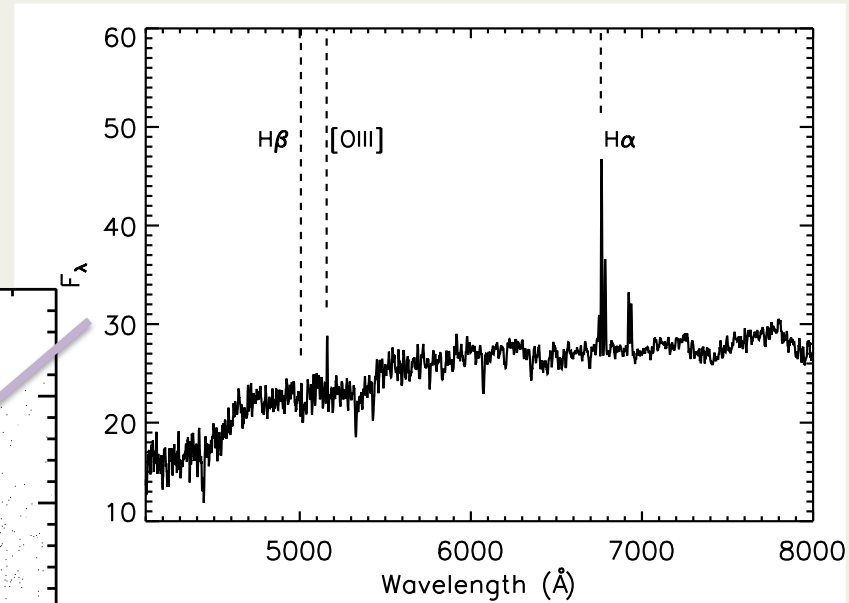
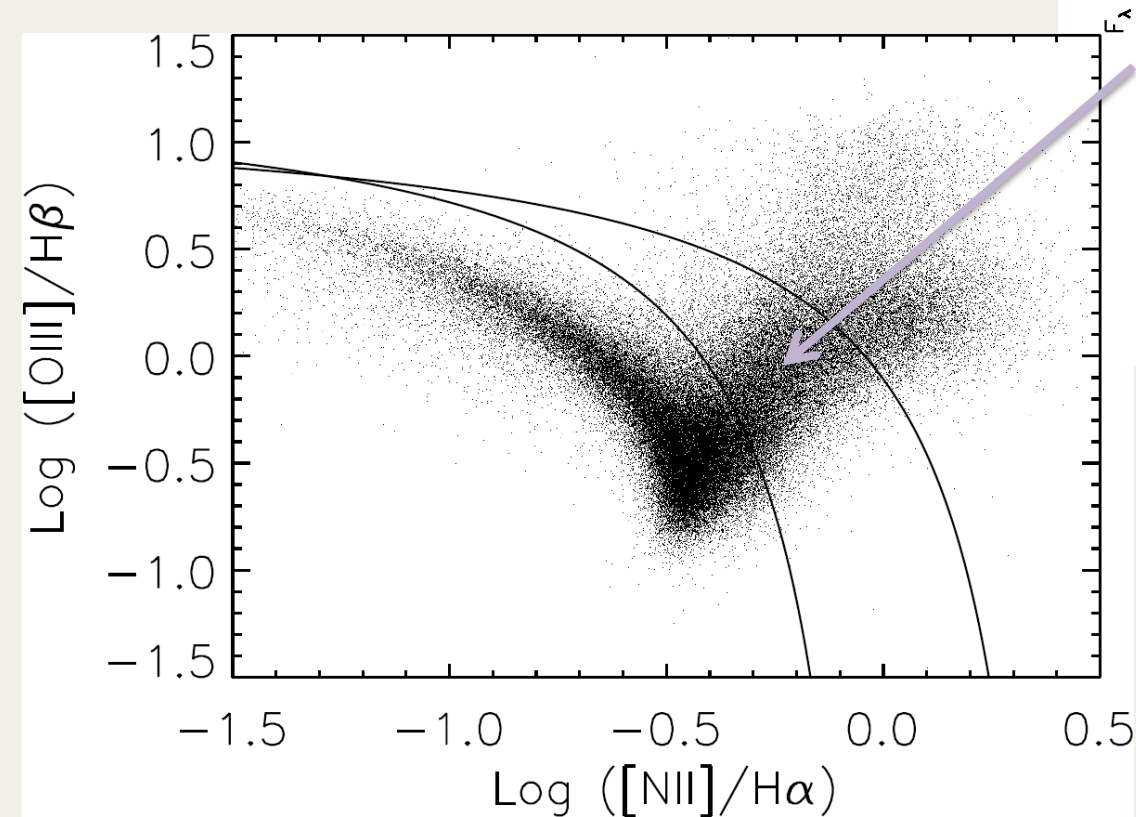


Obscured AGN: Type 2 AGN



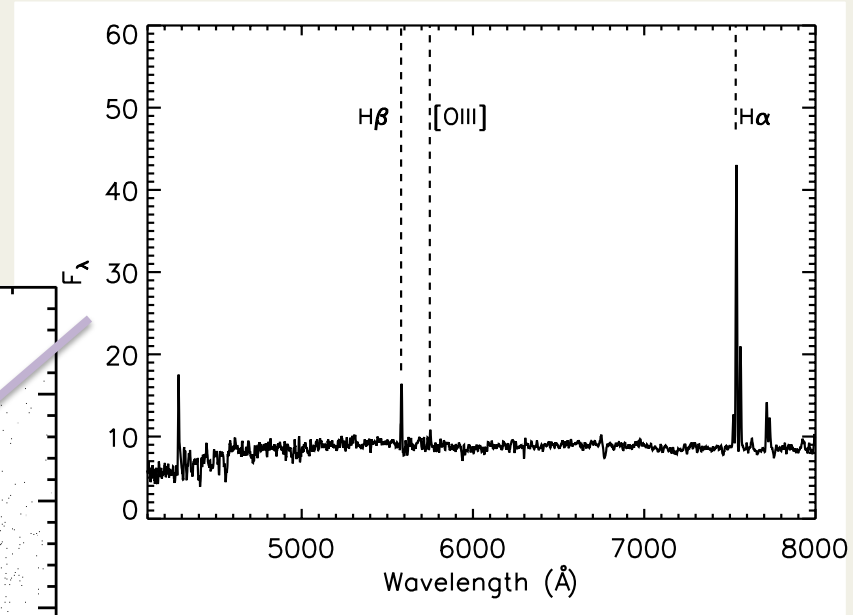
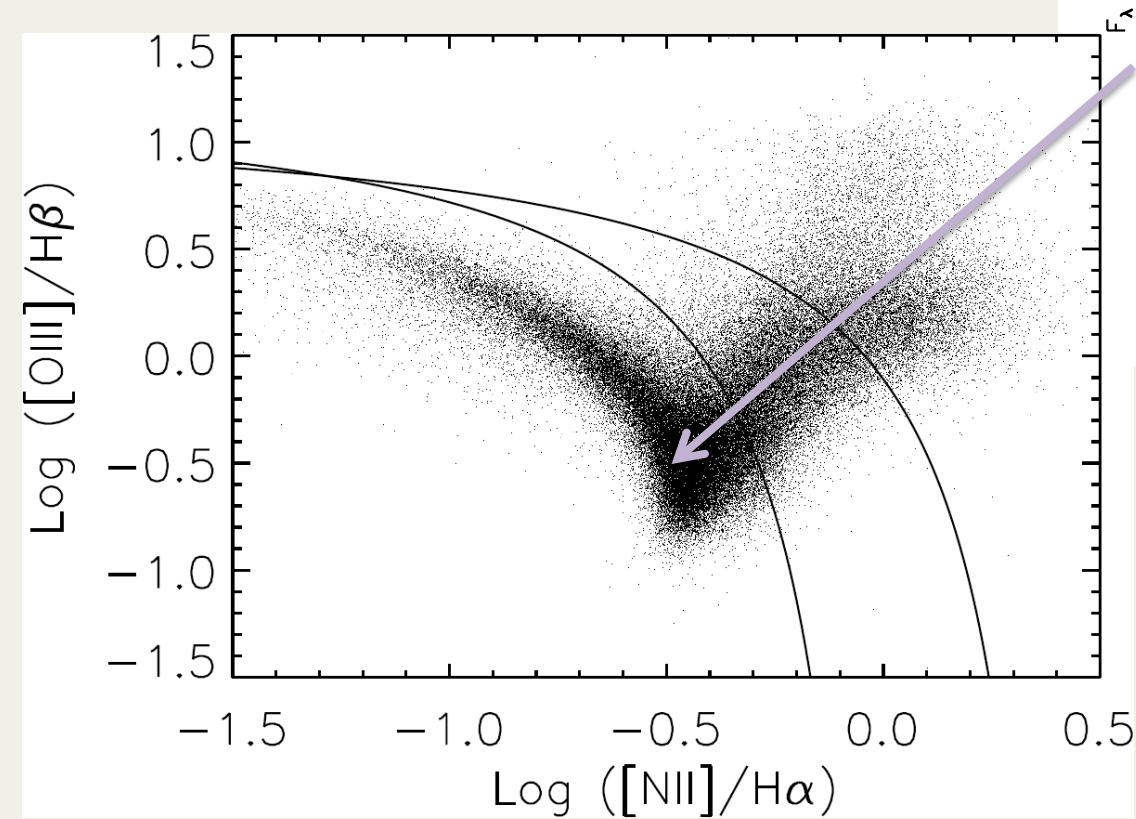
Baldwin, Philips, & Terlevich 81;
Kewley+ 2001

Obscured AGN: Composite

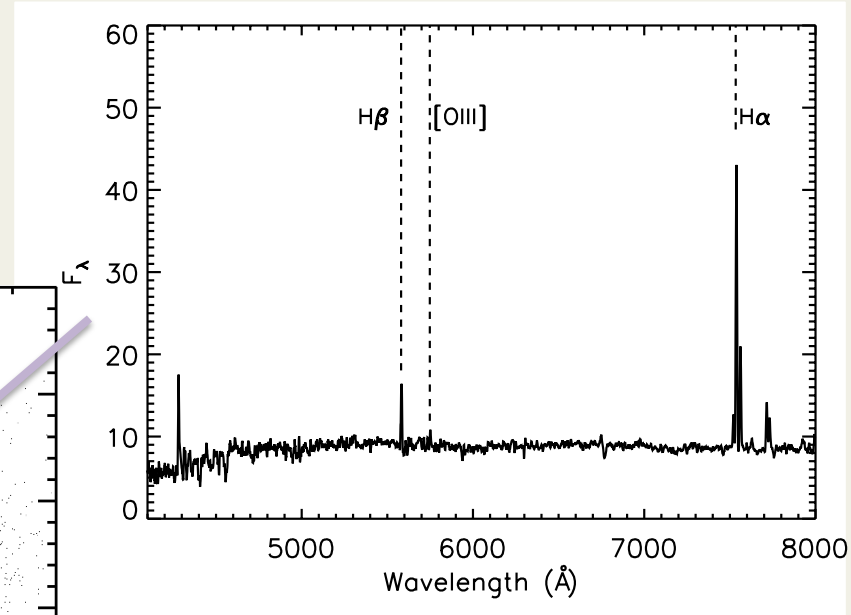
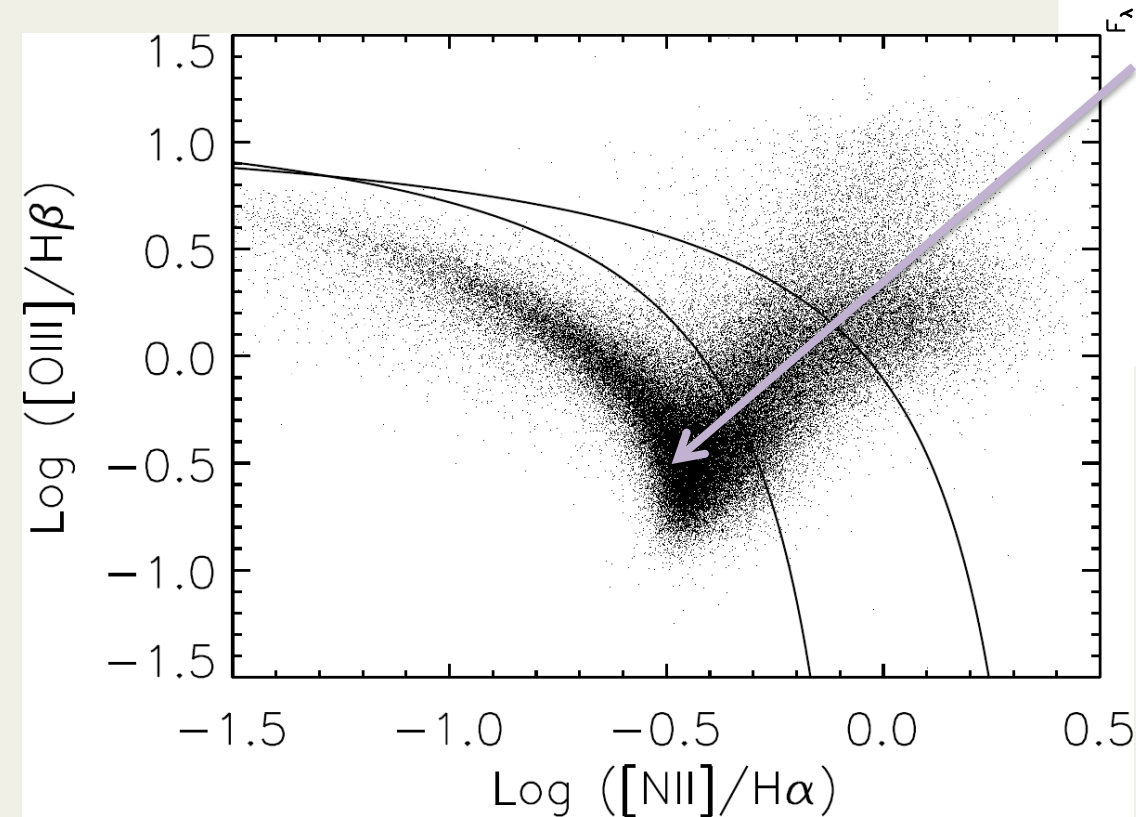


Kauffmann+ 2003

Star-Forming Galaxies



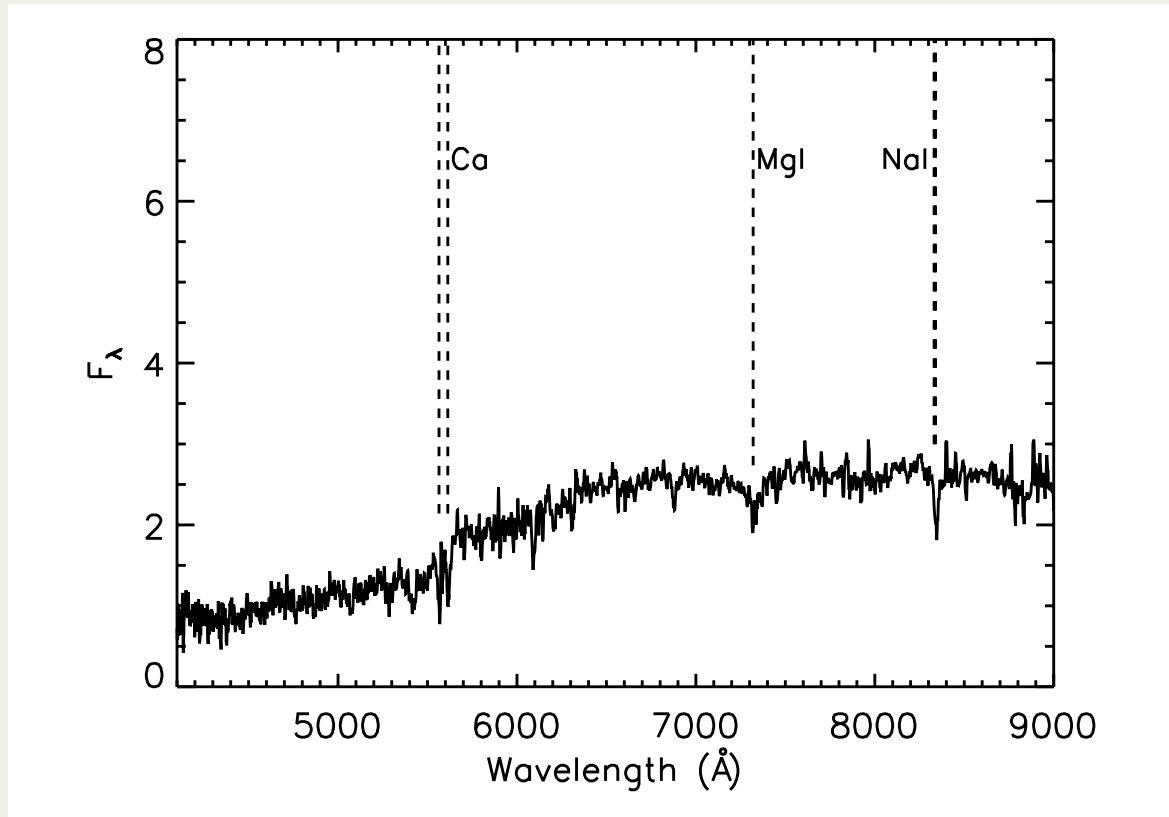
Obscured AGN: Optically Elusive AGN



$$L_x > 10^{42} \text{ erg s}^{-1}$$

e.g., Moran+ 2002, Maiolino+ 2003

Obscured AGN: X-ray Bright Optically Normal Galaxies (XBONGs)



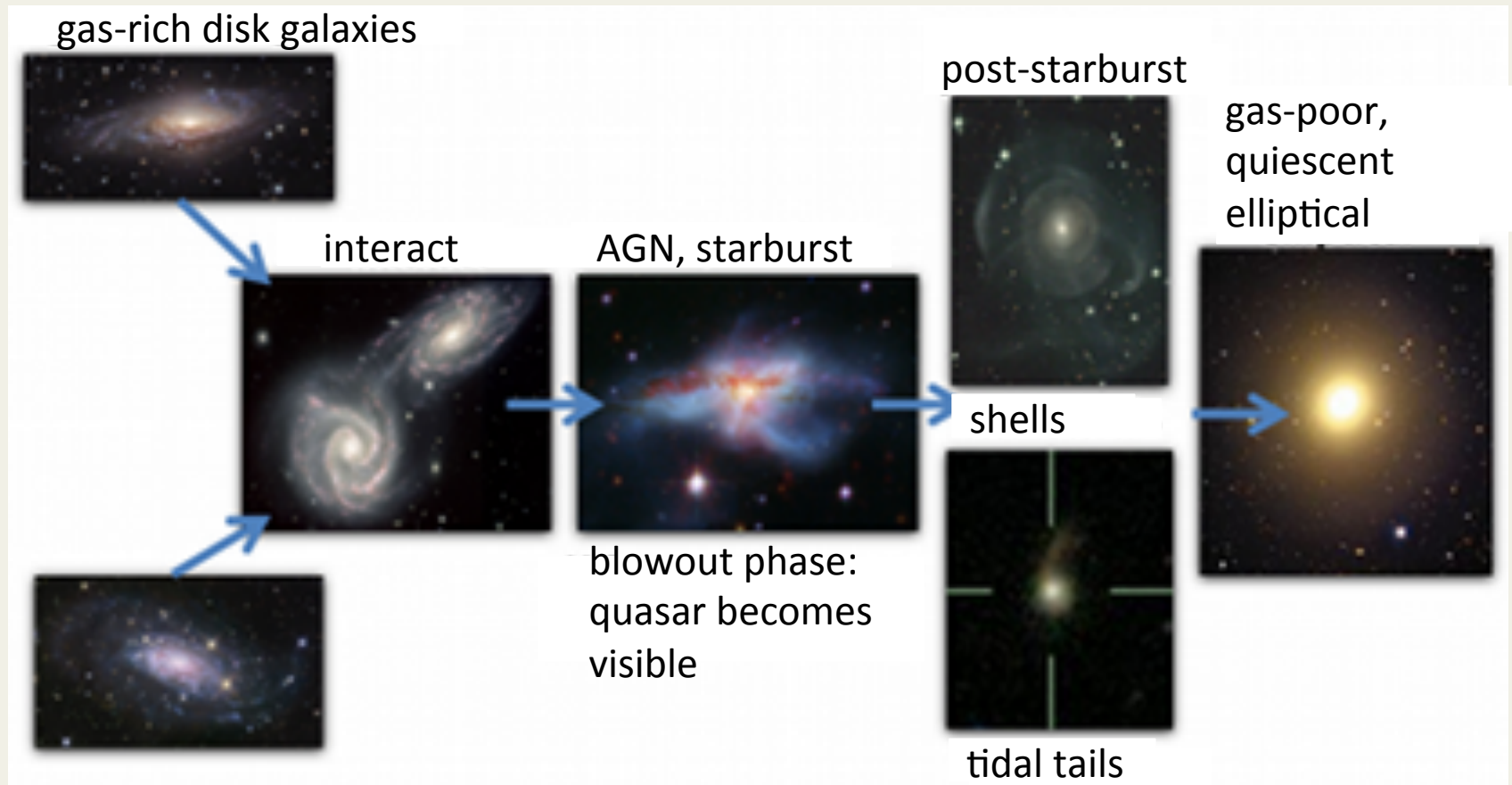
$$L_x > 10^{42} \text{ erg s}^{-1}$$

e.g., Fiore+ 2000, Comastri+ 2002, Cocchia+ 2007

Obscured AGN are Important

- Majority of local AGN population *Comastri 2004, Treister+ 2004*
- Transitional link in merger-induced SMBH/galaxy evolution paradigm

Major Mergers: A Mechanism for SMBH Growth



Sanders+ 1988, Hopkins+ 2008

image credit: E. Hooper (U Wisc.)

Some Red Quasars Are Transitional Link

- Intrinsically luminous [Glikman+ 2012](#), [Banerji+ 2015](#), [Assef+ 2015](#)
- Merger morphologies [Urrutia+ 2008](#), [Glikman+ 2015](#)
- Outflows [Brusa+2015](#), [Perna+ 2015](#)

Some Red Quasars Are Transitional Link

- FIRST-2MASS “red quasars”: $(R-K)_{AB} > 4$, $(J-K)_{AB} > 1.7$ *Glikman+ 2004, 2007, 2012, 2013*
- IR red quasars: $(J-K)_{\text{vega}} > 2.5$ *Banerji+ 2012, 2013, 2015*
- WISE Hot DOGs: $W3, W4$ cf w_{1, w_2} *Stern+ 2014, Assef+ 2015*
- X-ray-IR-optical reddened AGN: $(R-K)_{\text{vega}} > 5$, $X/O > 1$ *Brusa+ 2005, 2010, 2015, Perna+ 2015*

see also *Georgakakis+ 2009, Farrah+ 2012*

Obscured AGN Demography

- Non-broad-line AGN
 - Type 2 AGN
 - Composites
 - Optically elusive AGN
 - XBONGs
- Reddened quasars
 - includes broad-line AGN

Era of Wide-Area X-ray surveys

- Stripe 82X: 31 deg² *LaMassa+ 13b,c,16a*
- *XMM-XXL*: 50 deg² *Pierre+ 15*; see also *Menzel+ 15*
- *XMM-Serendipitous*: 877 deg² *Rosen+ 2015*
- *eROSITA*: all sky *Predehl+ 2014*
also ChaMP, XBoötes, *XMM-HATLAS*

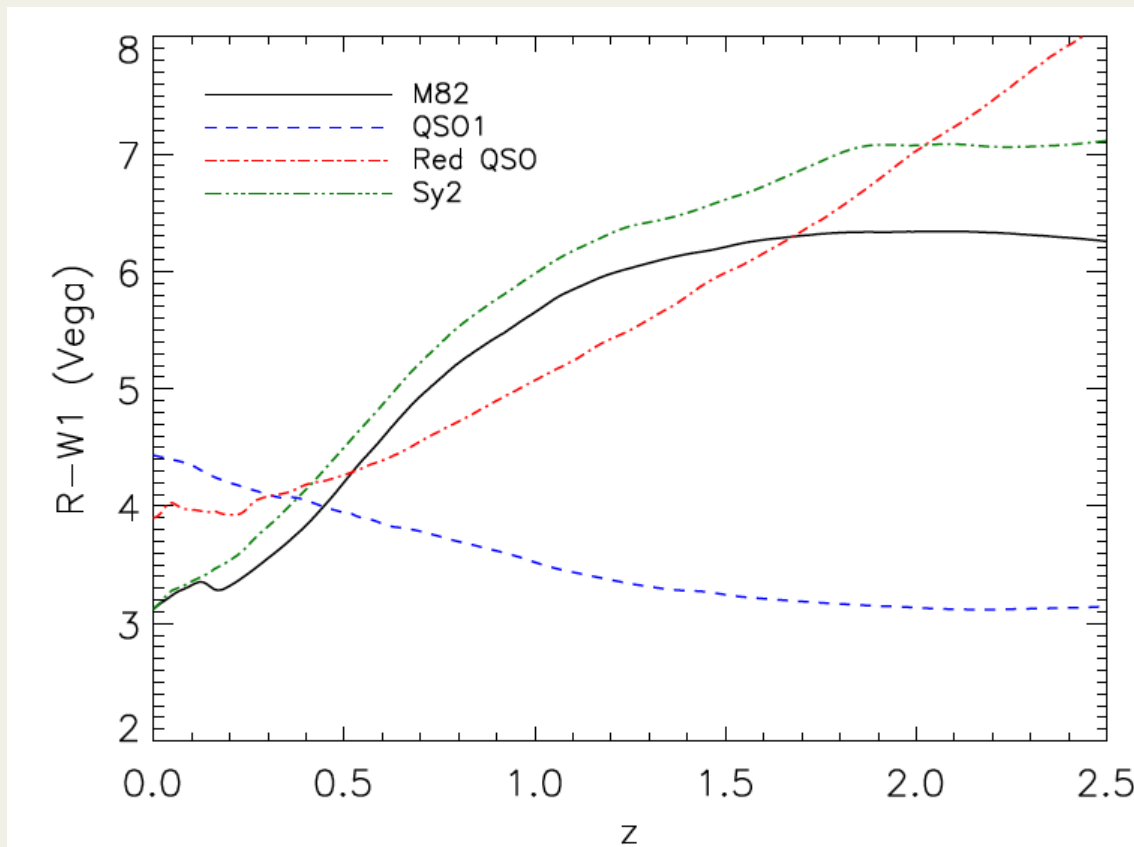
combine $\lambda\lambda\lambda$ info to discover obscured black hole growth?

R-W1 as Obscured AGN Diagnostic

- Available over most of the sky (SDSS, Pan-STARRS, *WISE*)

$R-W1$ as Obscured AGN Diagnostic

- $R-W1$ differentiates obscured v. non-obscured AGN at $z > 0.5$



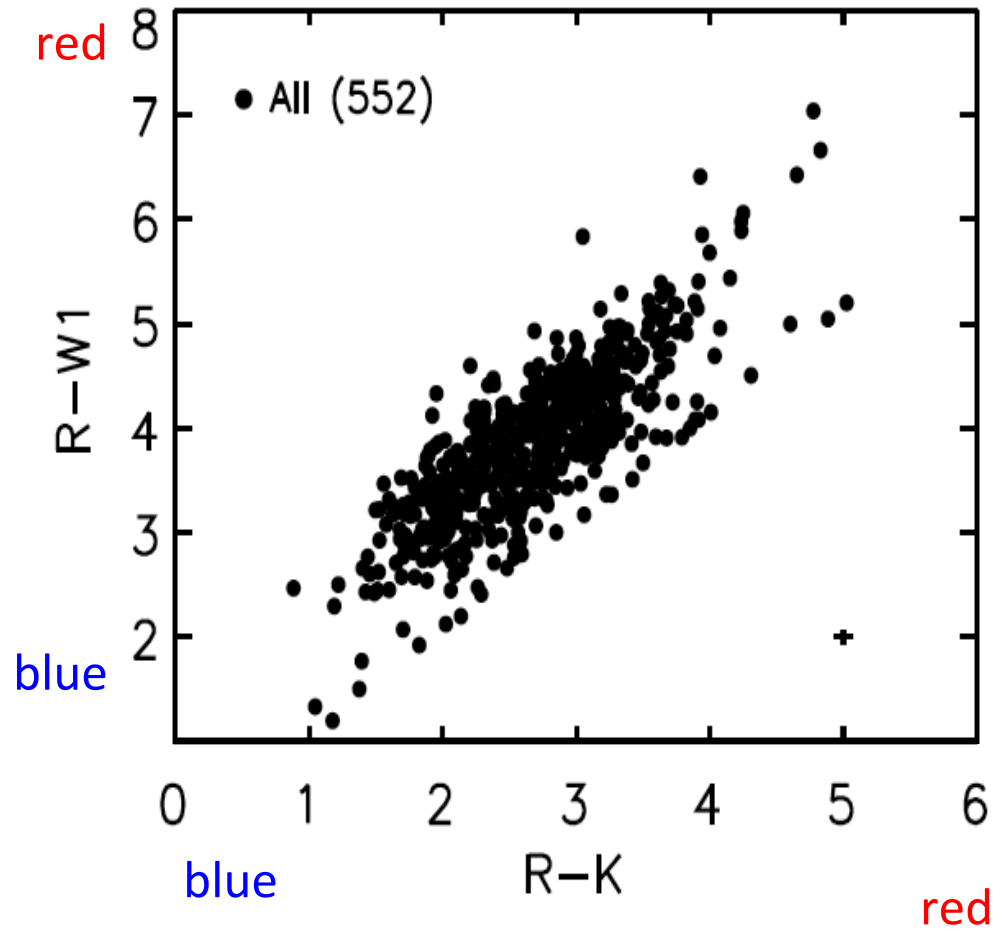
Templates f/
Polletta+ 07

R-W1 Calibrated on S82X Sample

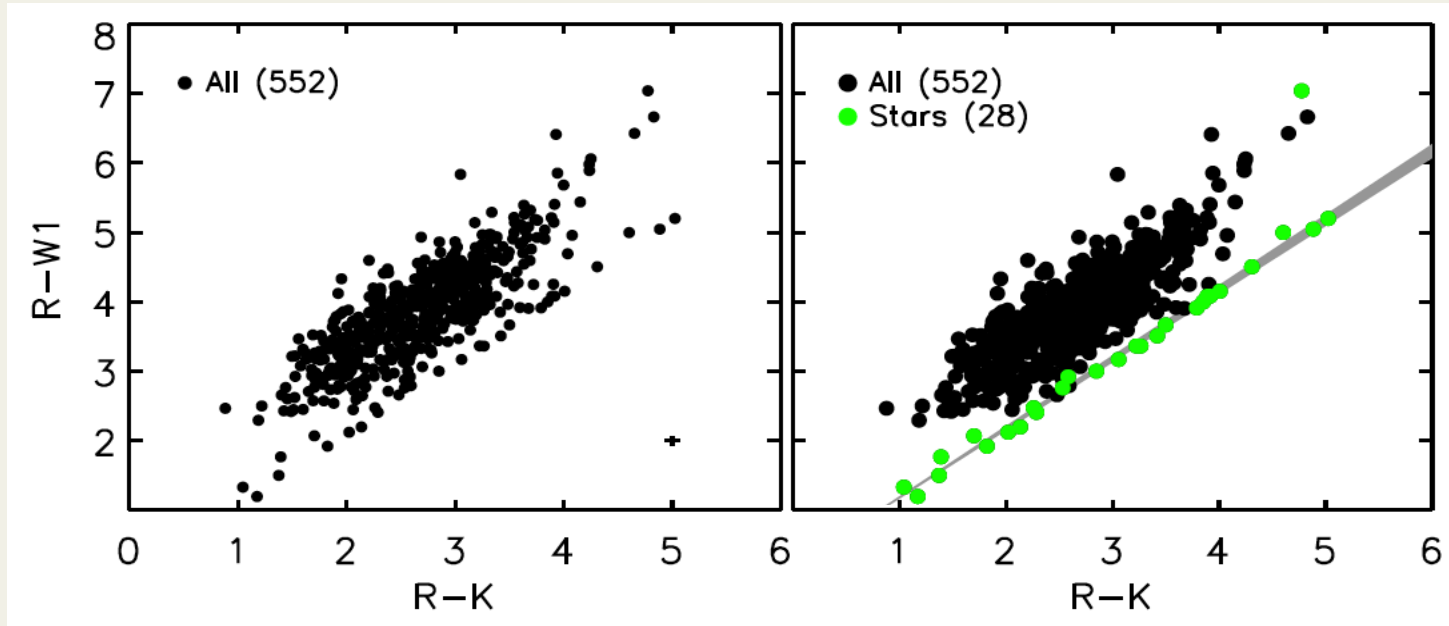
LaMassa+ 16b

- 16.5 deg² release of S82X catalog; 3362 sources *LaMassa+ 13c*
- 661 sources
 - spec-z 30% of parent sample
 - SDSS counterpart
 - W1 SNR > 5
- Terminology
 - “Obscured AGN” – no broad-lines in optical spectra; $L_x > 10^{42}$ erg/s
 - “Galaxy” – no broad-lines in optical spectra; $L_x < 10^{42}$ erg/s

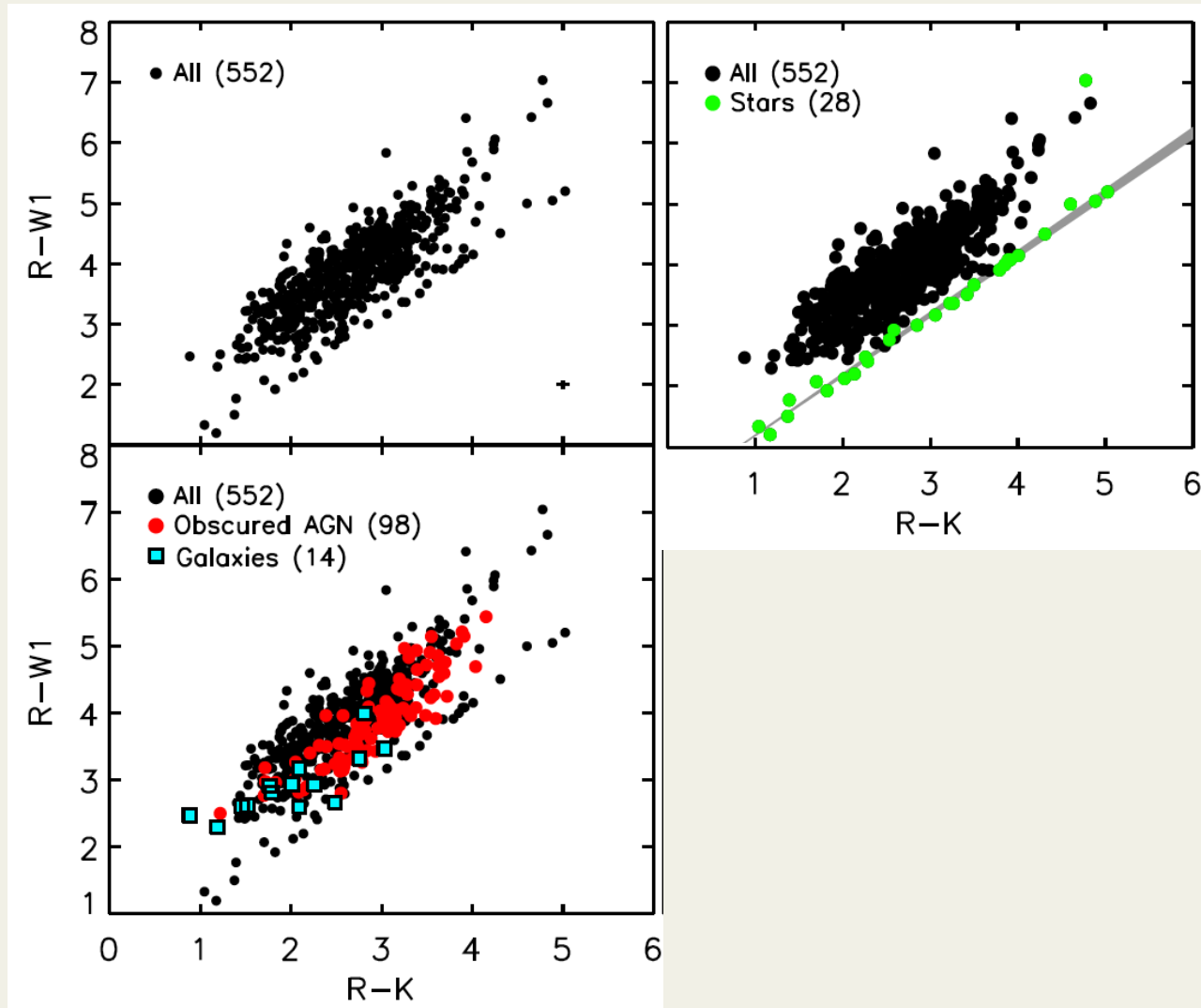
Comparison with $R-K$



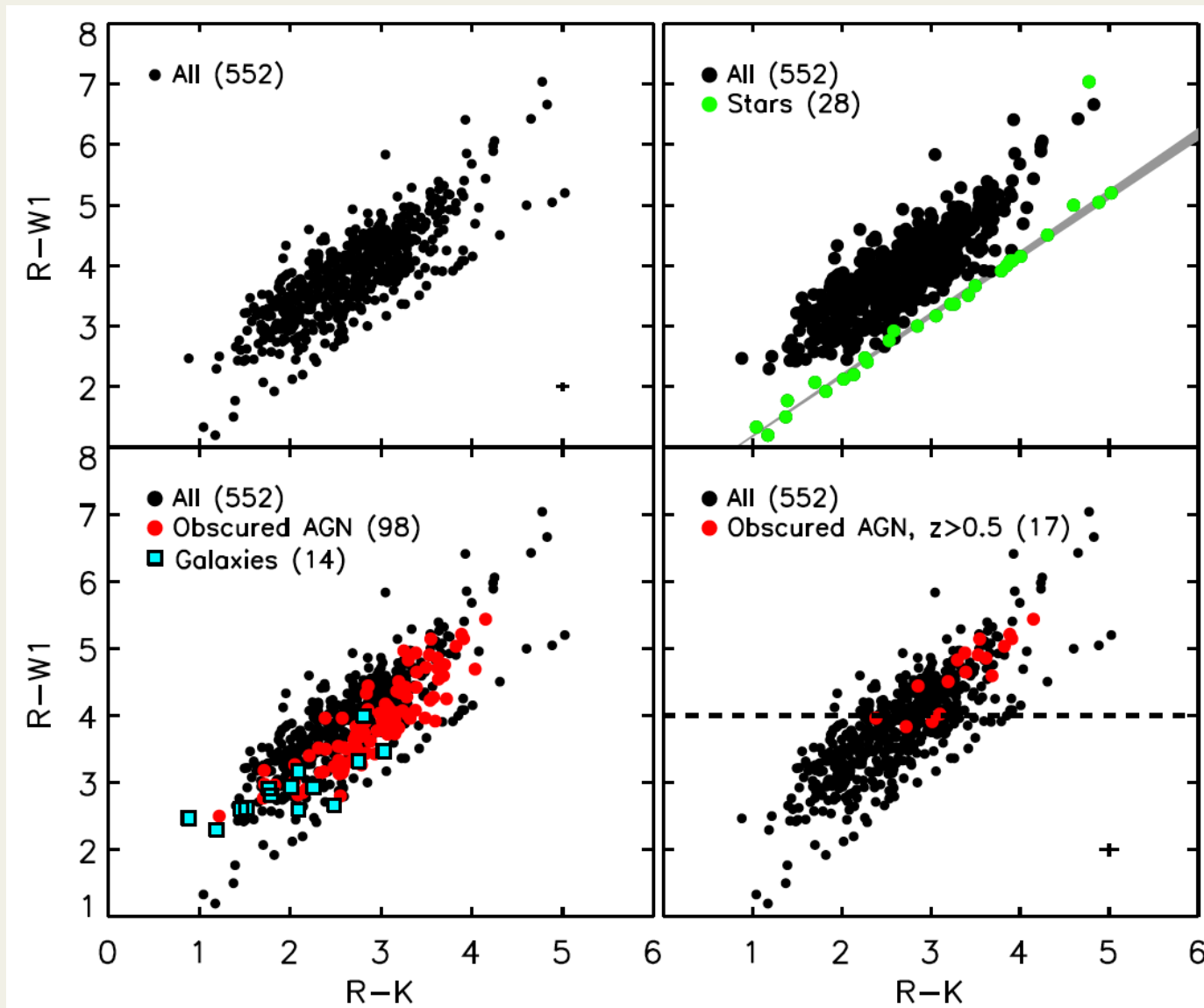
Comparison with $R-K$: Stellar Locus

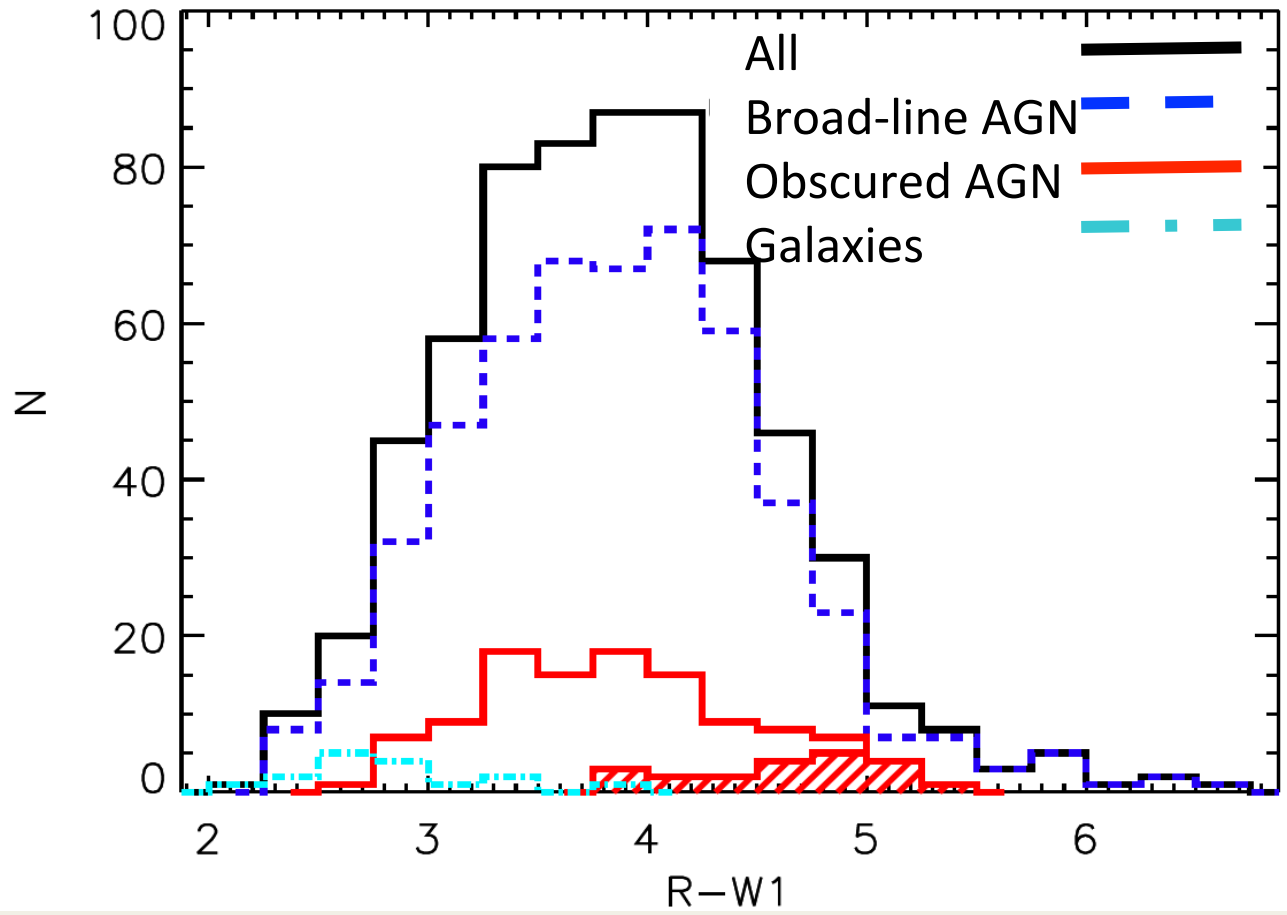


Comparison with $R-K$: Galaxies Bluer



Comparison with $R-K$: Obscured AGN @ $z > 0.5$ redder





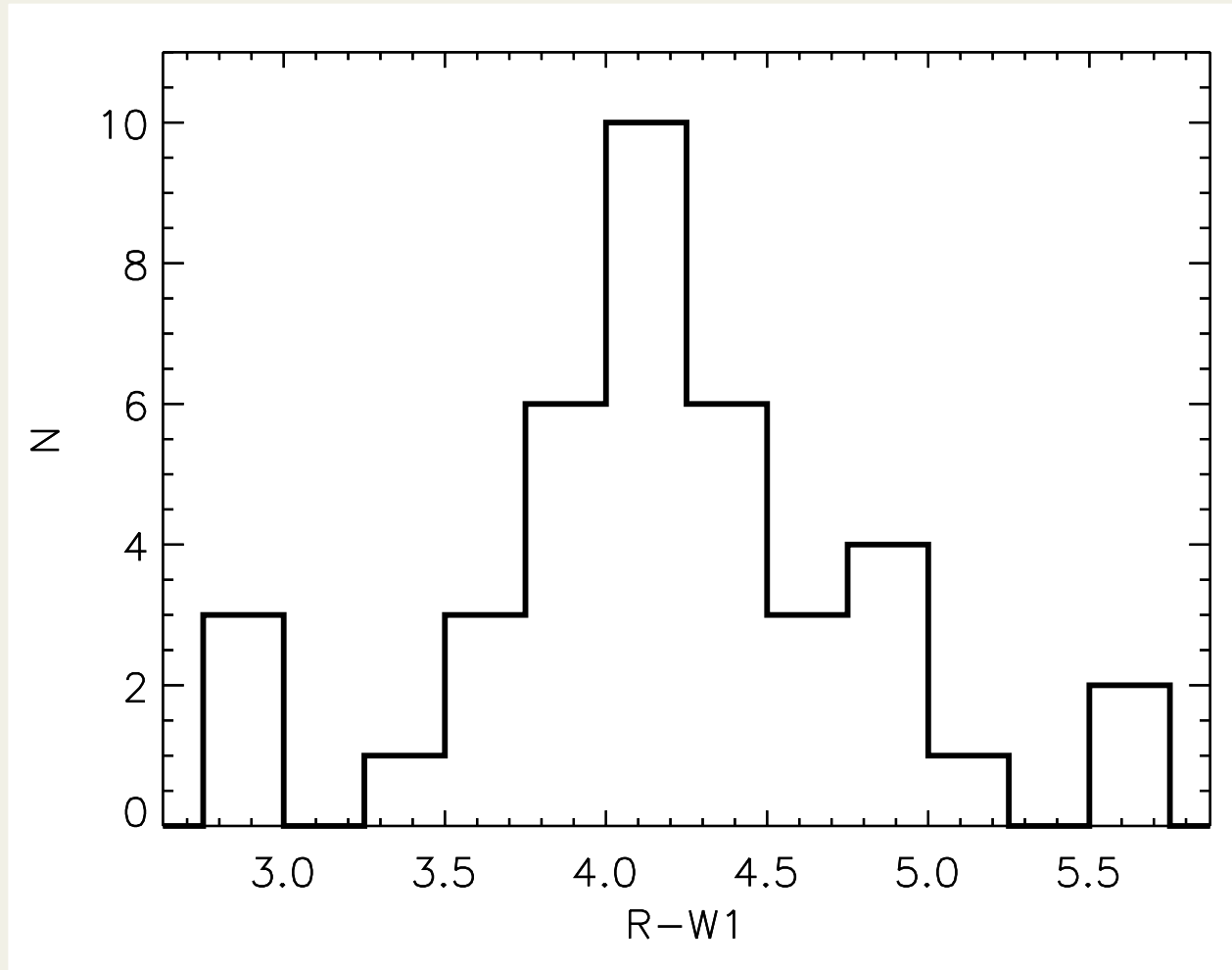
Galaxies: $(R-W1)_{Vega} < 4$

Obscured AGN at $z > 0.5$:
 $(R-W1)_{Vega} > 4$

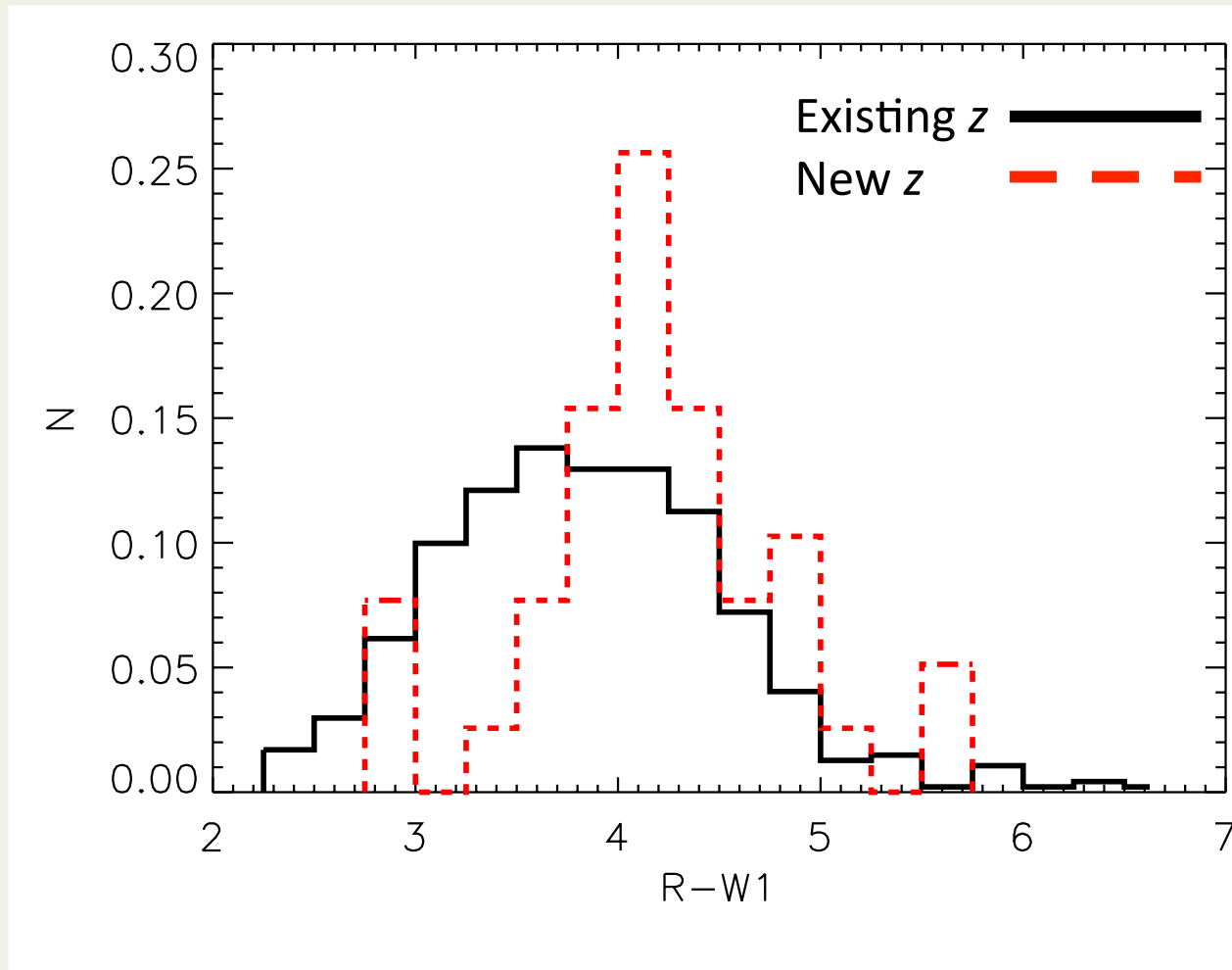
Many reddened broad-line AGN

LaMassa+ 16b

Follow-up Recovering Red QSOs?



Follow-up Recovering Red QSOs?



Caveats

- X-ray surveys
 - don't apply to IR/optical parent samples
 - color trends (e.g., stellar locus) might not hold for objects not emitting X-rays
- Respect the flux limits
 - deep X-ray surveys detect red galaxies at higher- z
 - not tested on deep optical & IR photometry



Summary

ApJ 818, 88 2016

- $(R-W1)_{\text{Vega}} > 4$ in *X-ray surveys* recovers obscured SMBH growth at $z > 0.5$
- $R-W1$ v $R-K$ hone target selection
- new Stripe 82X catalog out: ApJ 817, 172, 2016
 - 31 deg²
 - 6181 X-ray sources; 88% with $\lambda\lambda\lambda$ counterparts
- See Tonima Annana's poster on S82X photo-zs! G2

