

# Uncovering the Signatures of Obscured AGN in Mergers

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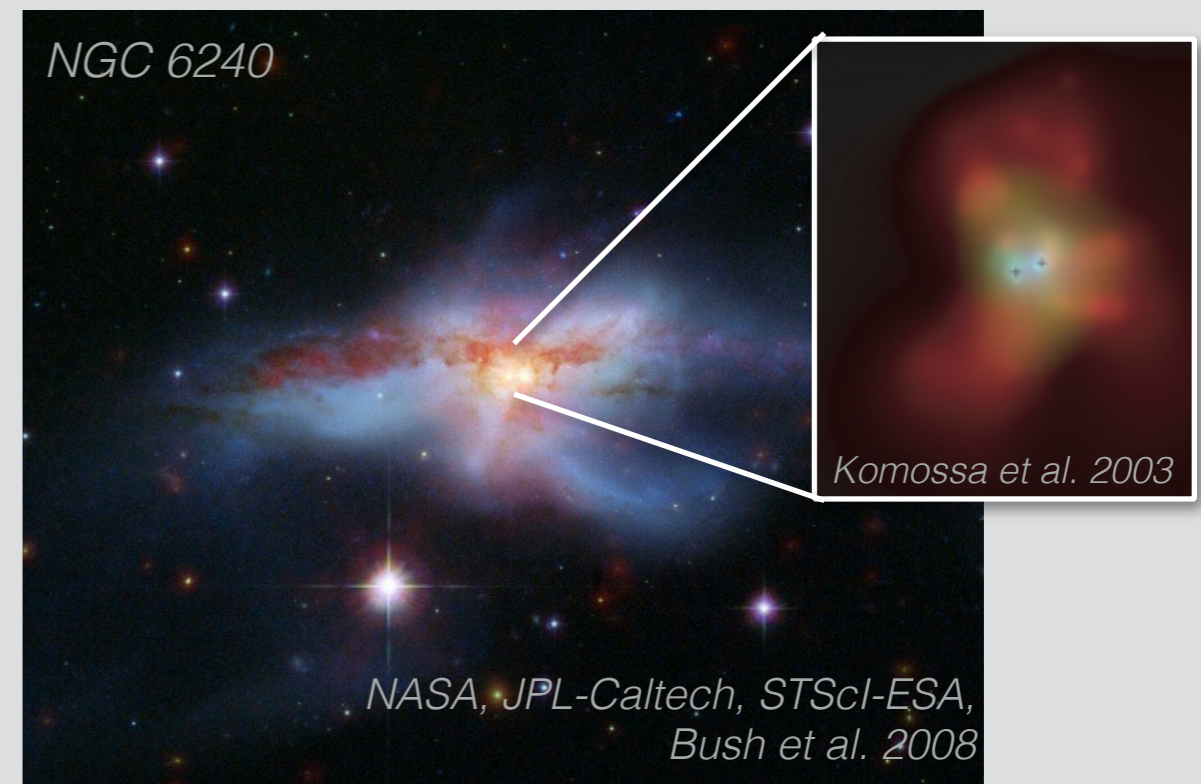
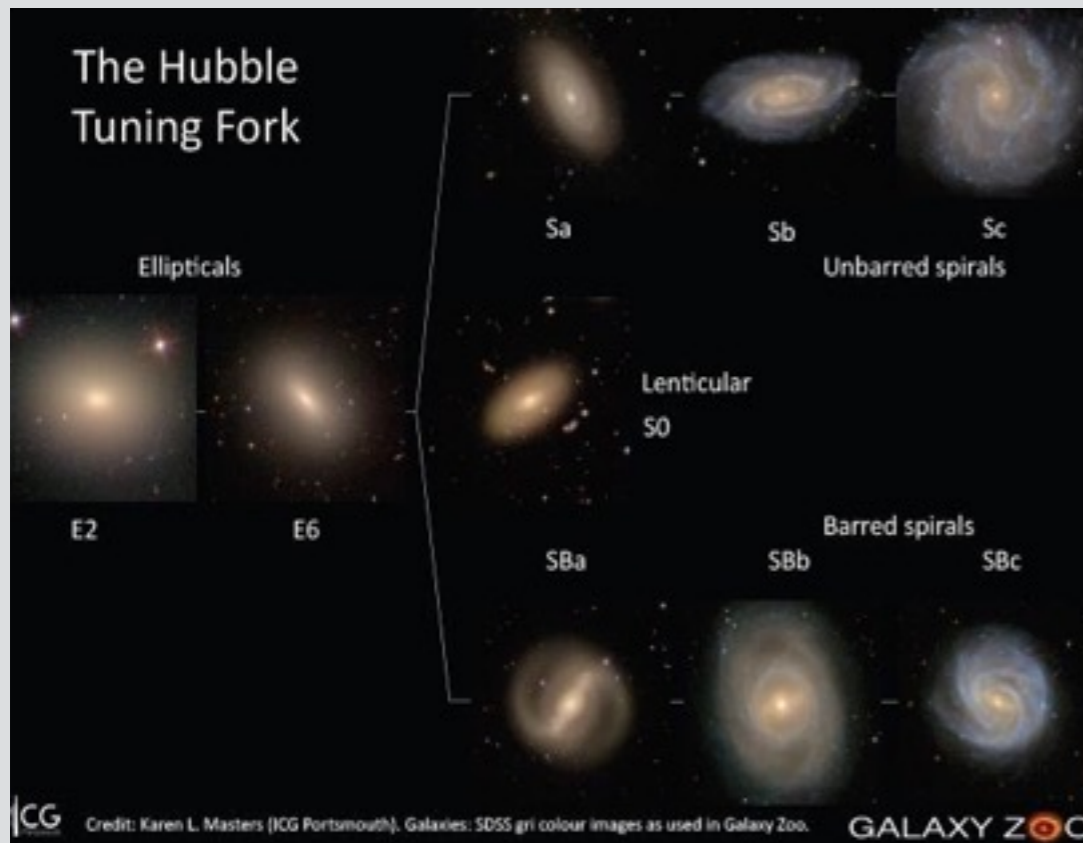
In collaboration with Shobita Satyapal (GMU), Sara Ellison  
(UVic), & Greg Snyder (STScI)

Breaking the Limits:

Super-Eddington Accretion on Compact Objects

Arbatax, Italy, Sept 19-23, 2016

# BH-galaxy co-evolution: the merger-driven paradigm



- Simultaneous growth of SMBHs and galaxy bulges
- Galaxy evolution along the Hubble sequence
- (Self-)regulation of growth via stellar and AGN feedback

# The elusive merger/AGN connection

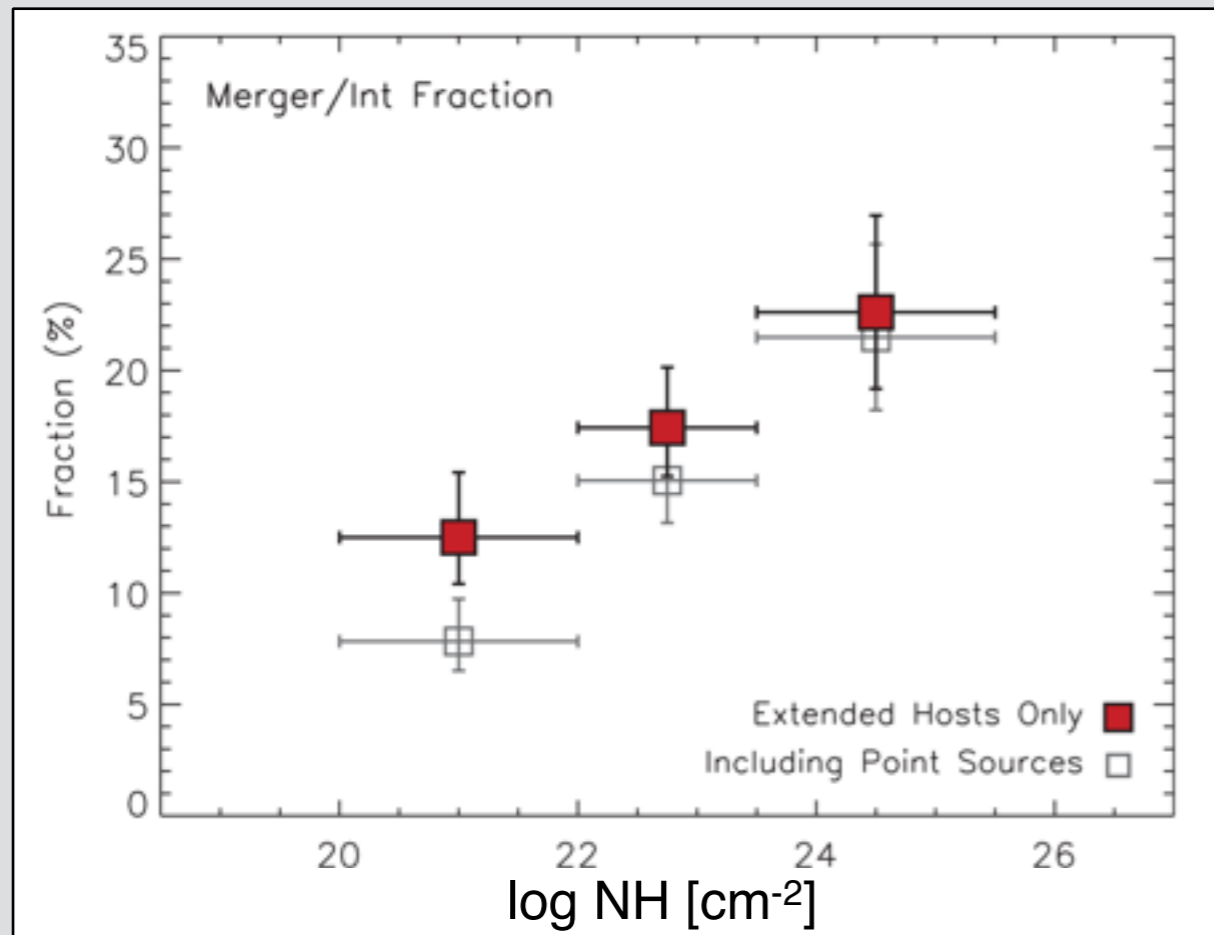


*(Liu et al. 2011)*

- A small minority of SDSS AGN are hosted in apparent mergers
- Most optically & (soft) X-ray selected AGN hosts show no signs of merger activity  
(e.g., Cisternas et al. 2011, Kocevski et al. 2012, Villforth et al. 2014)
- No evidence for a connection between mergers & AGN fueling?
- **Selection effects: nuclear obscuration, AGN luminosity, merger stage**

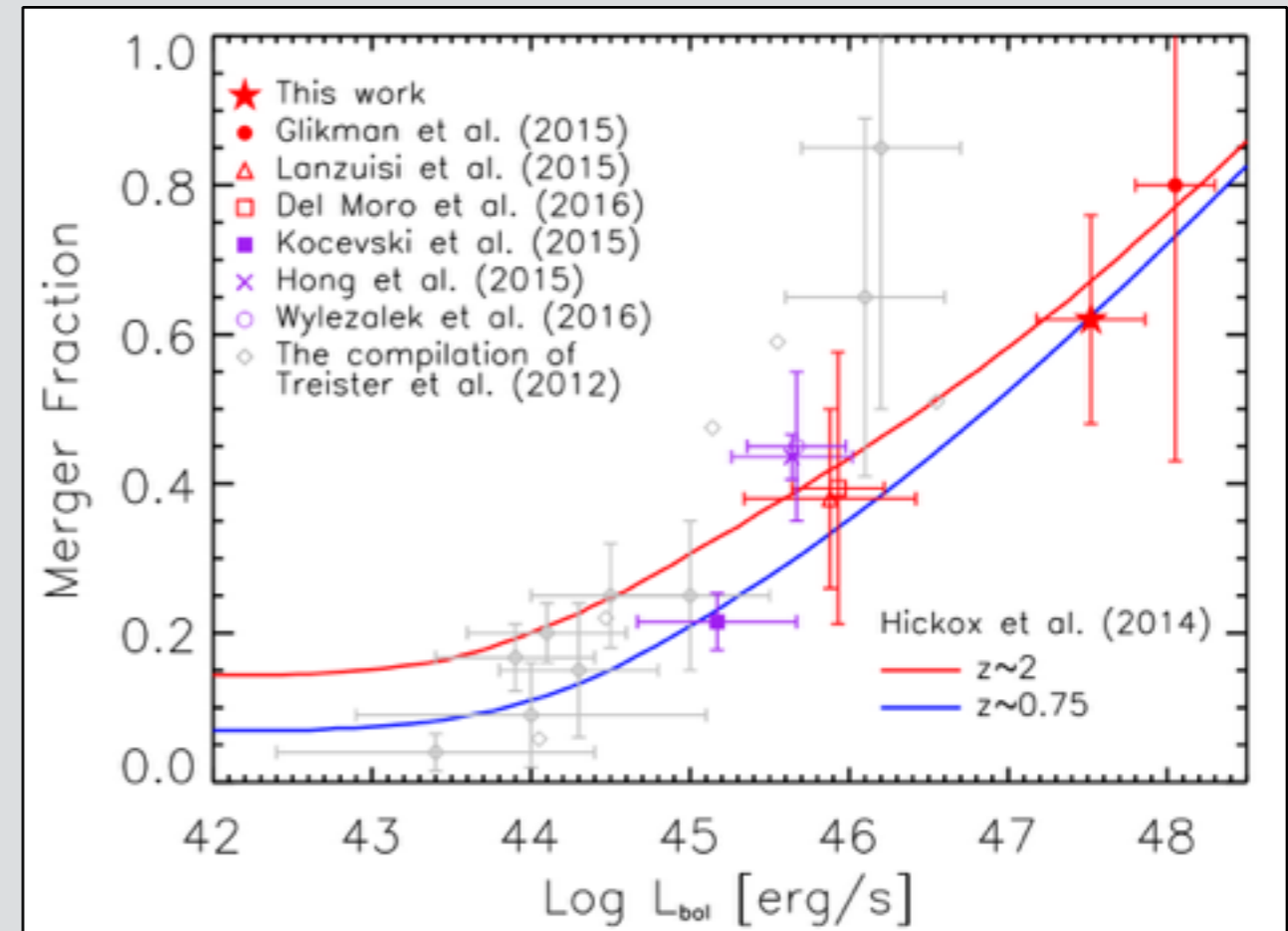
# Mergers trigger *obscured, luminous* AGN

High merger fraction for hosts of obscured AGN:



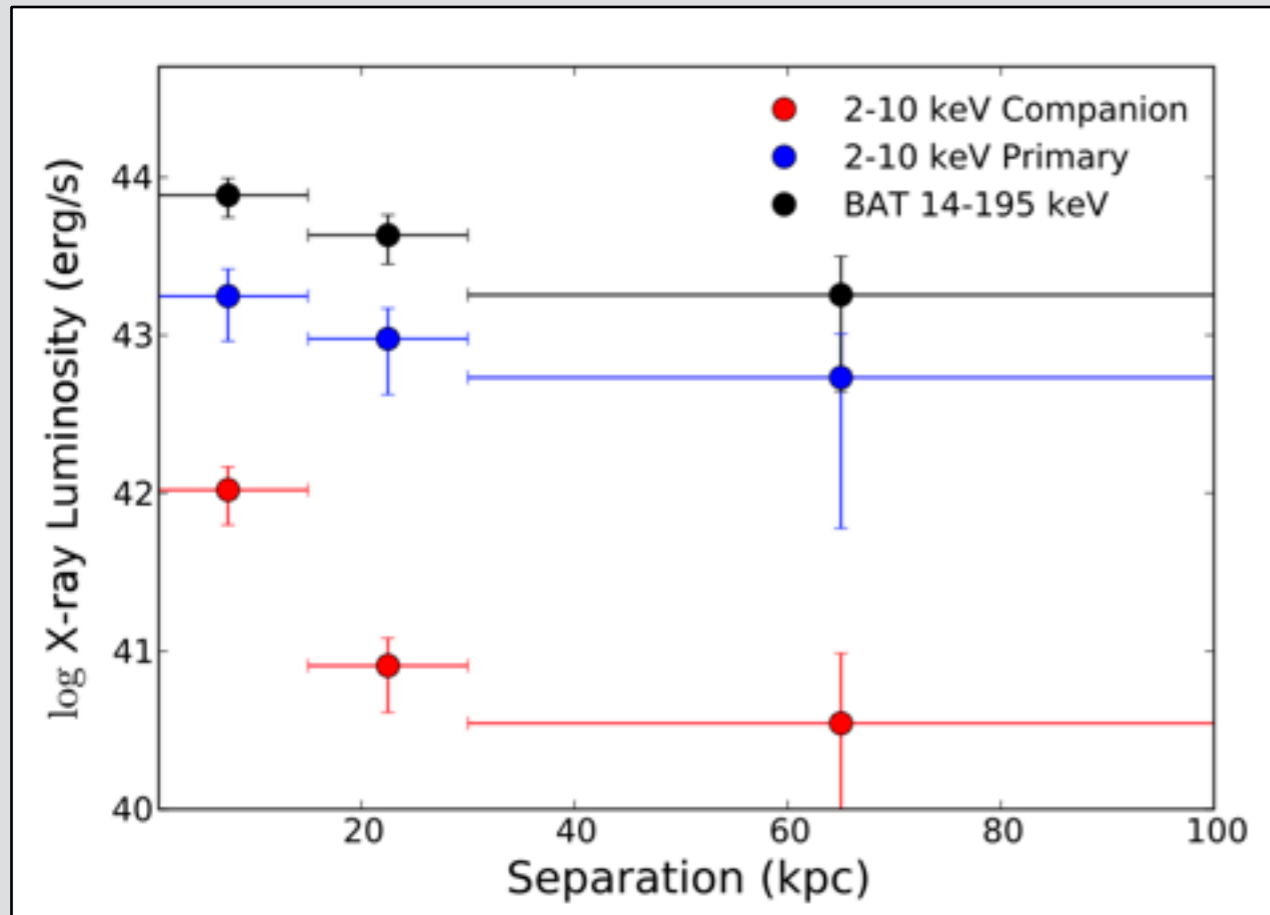
Kocevski et al. 2015

High merger fraction for hosts of the most luminous AGN:



Fan et al. 2016

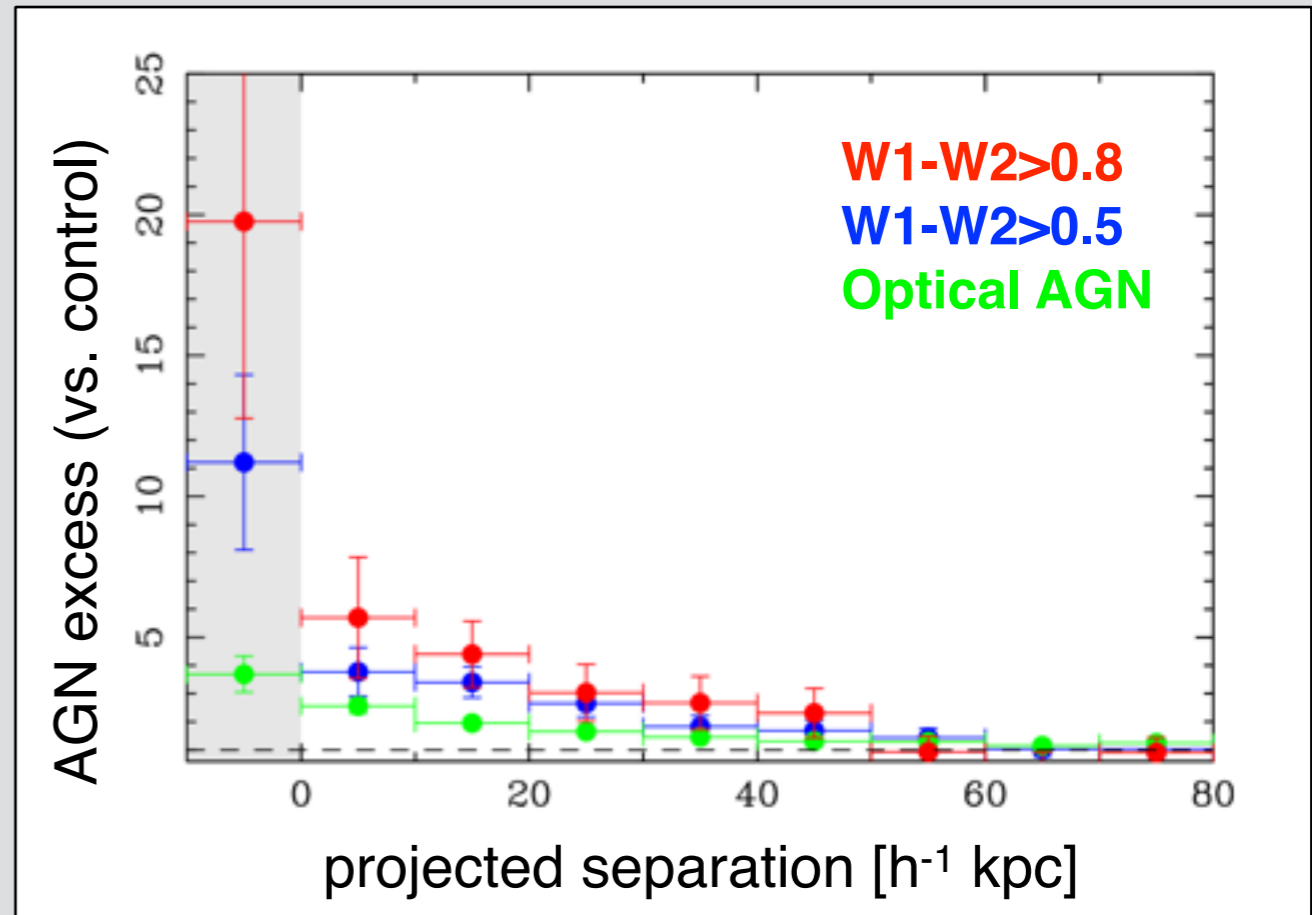
# Mergers trigger *obscured, luminous* AGN



*Koss et al. 2012*

## Hard X-ray AGN selection:

- Robust & insensitive to dust obscuration
- But only shallow surveys possible

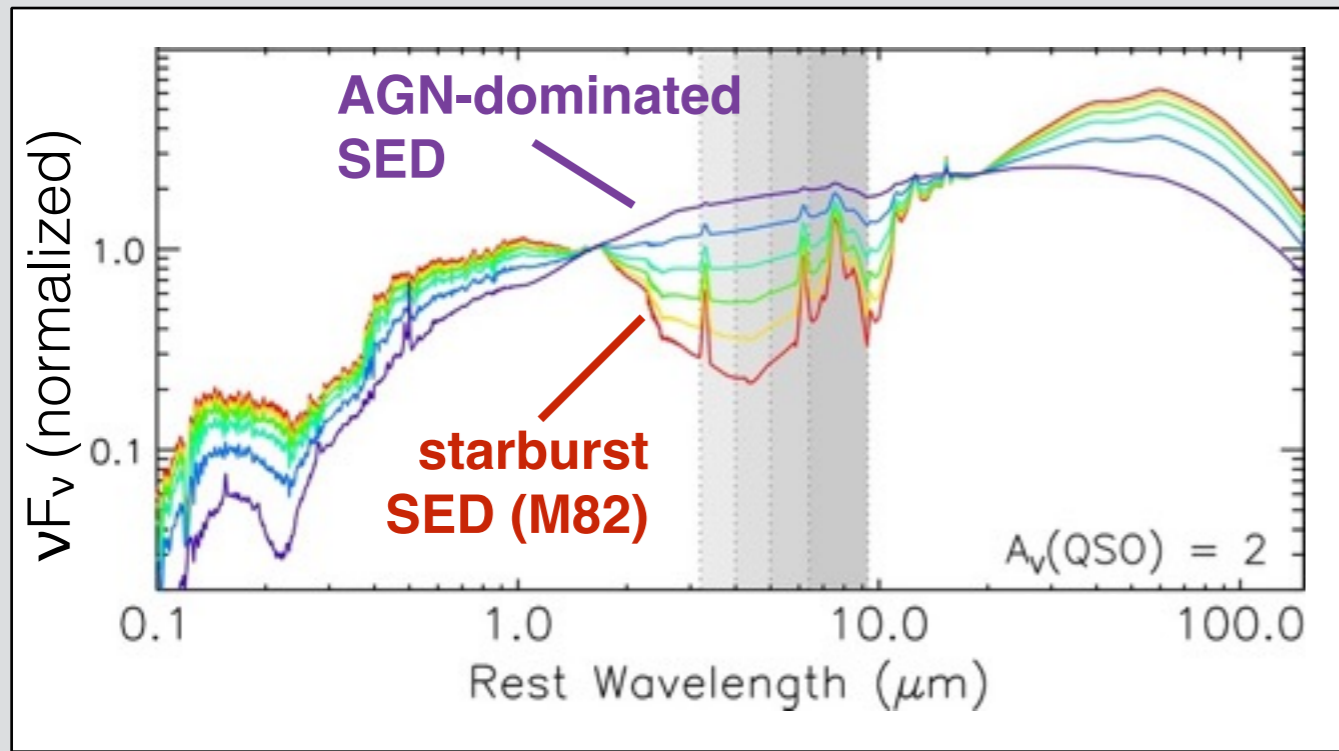


*Satyapal et al. 2014*

## Mid-IR color selection:

- Much larger surveys possible
- But sensitive only to most luminous AGN (& contaminated by galaxies at high  $z$ )
- How do mid-IR colors (& completeness) evolve throughout the merger?
- When are they associated with dual AGN?

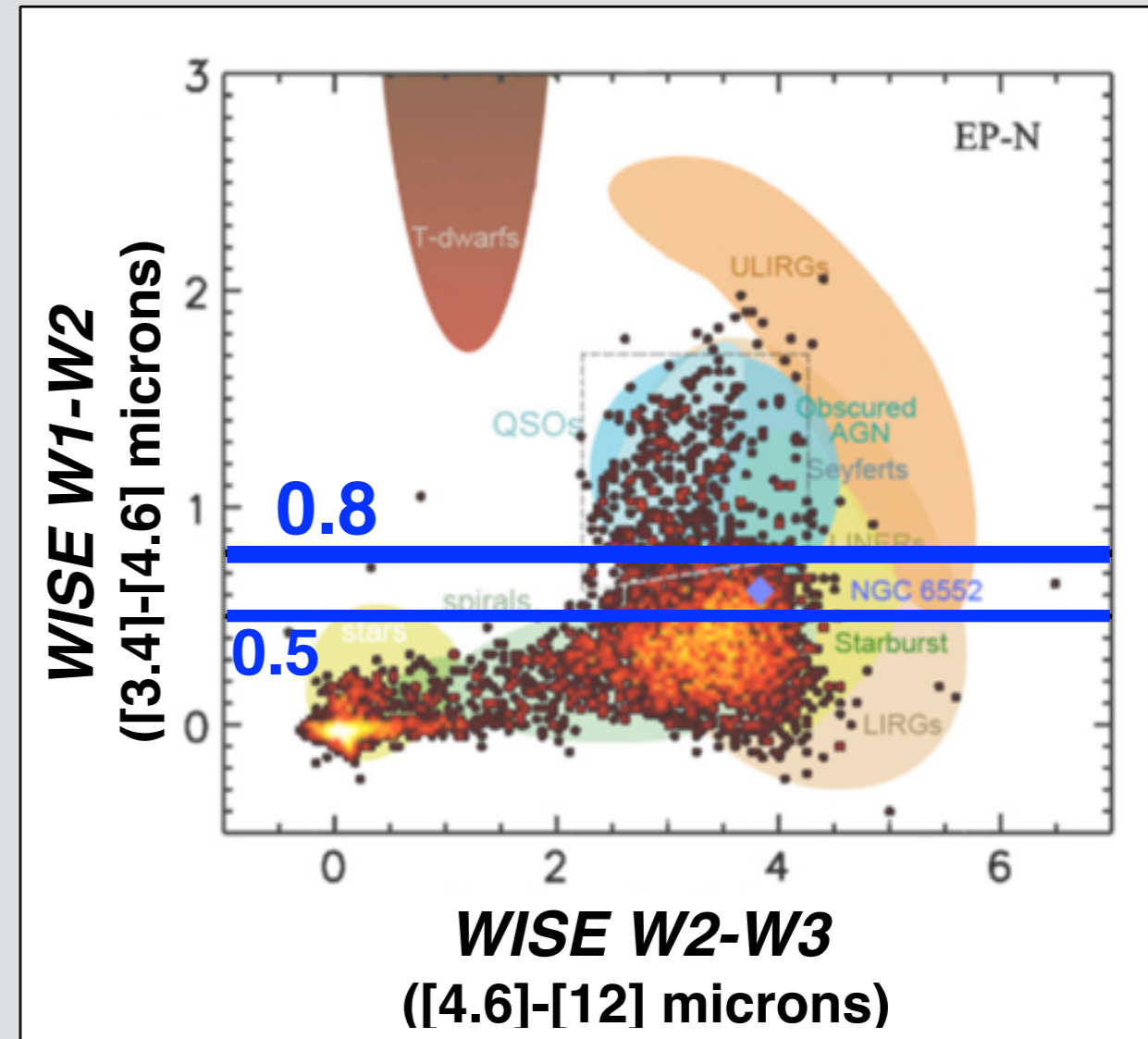
# Infrared selection of obscured, luminous AGN



*Donley et al. 2012*

## Mid-IR color selection:

- Much larger surveys possible
- But sensitive only to most luminous AGN (& contaminated by galaxies at high  $z$ )
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*Jarrett et al 2011,  
see also Stern et al 2012*

# Simulations of AGN in merging galaxies

Hydrodynamic simulations  
with GADGET-3\*:

*\*(Springel & Hernquist 2003, Springel 2005)*

- 7 major merger simulations
- init. gas fraction: 10 - 30 %
- init. bulge-to-total ratio: 0 - 0.2
- SMBHs with accretion & feedback

3-D dust radiative transfer with  
SUNRISE\*:

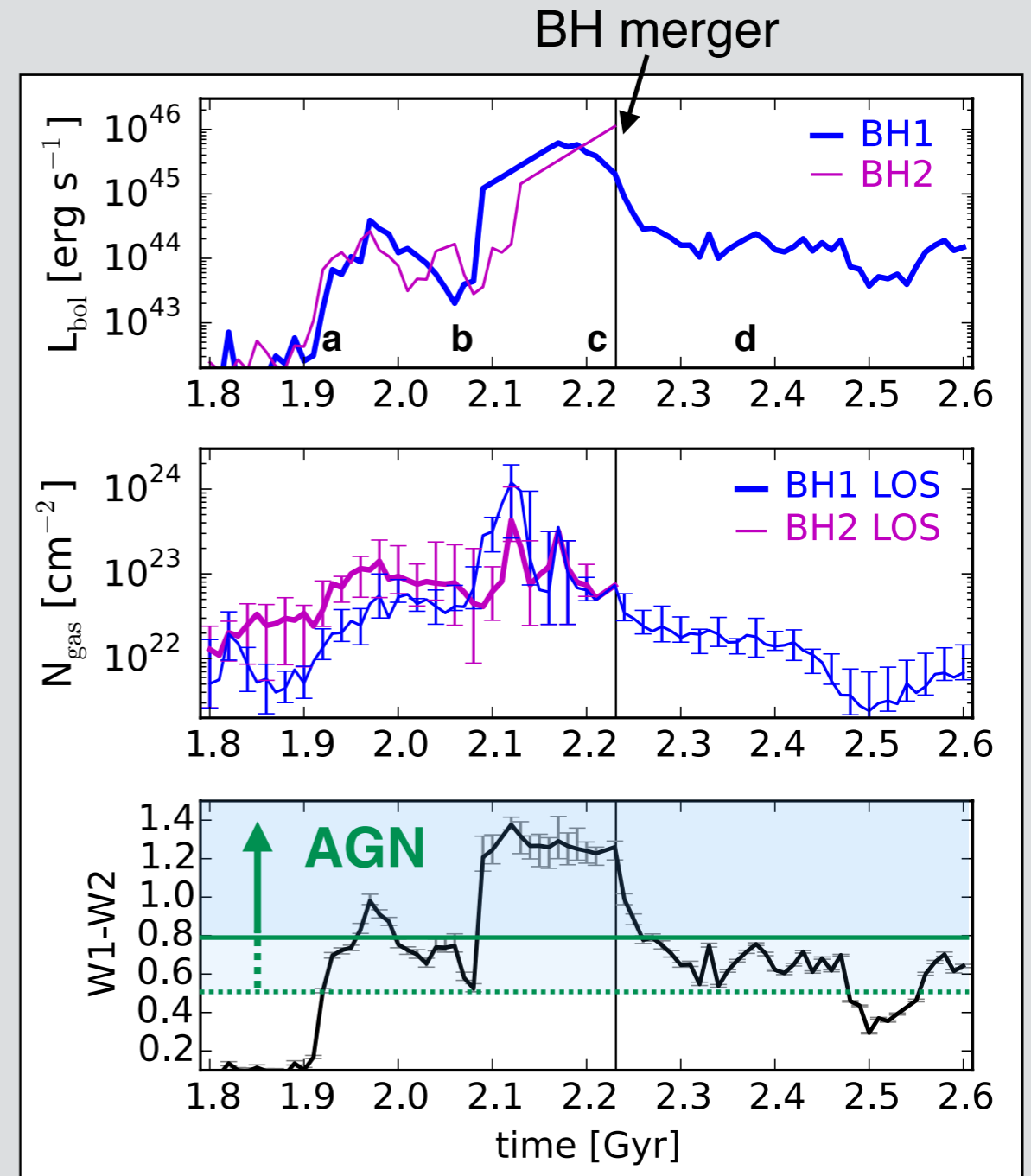
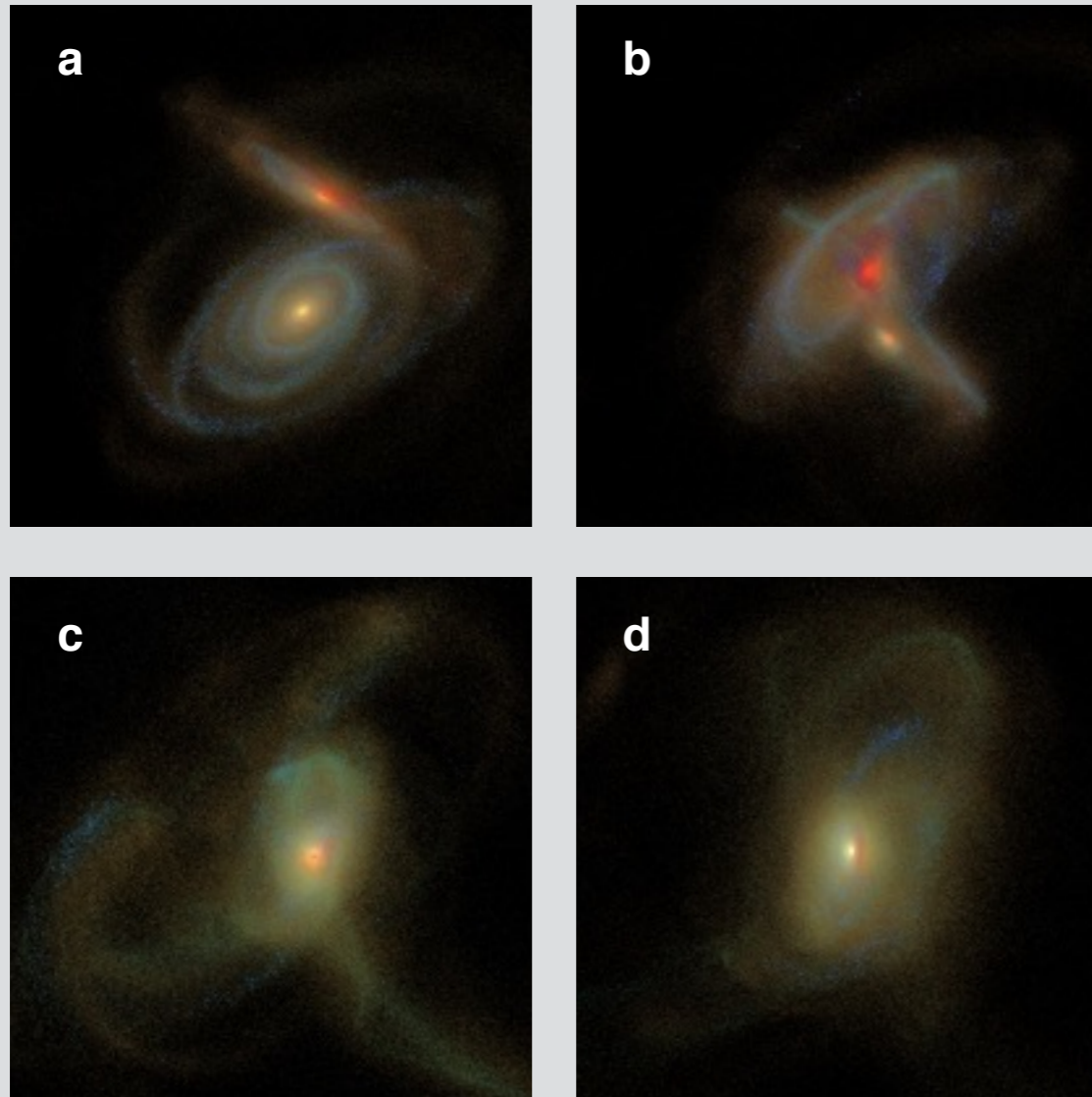
*\*(Jonsson 06, Jonsson+ 10)*

- Use luminosity-dependent AGN SED template
- 7 viewing angles for each simulation
- Calculate resolved UV-IR spectra of galaxies at each timestep, incl. dust absorption/re-emission



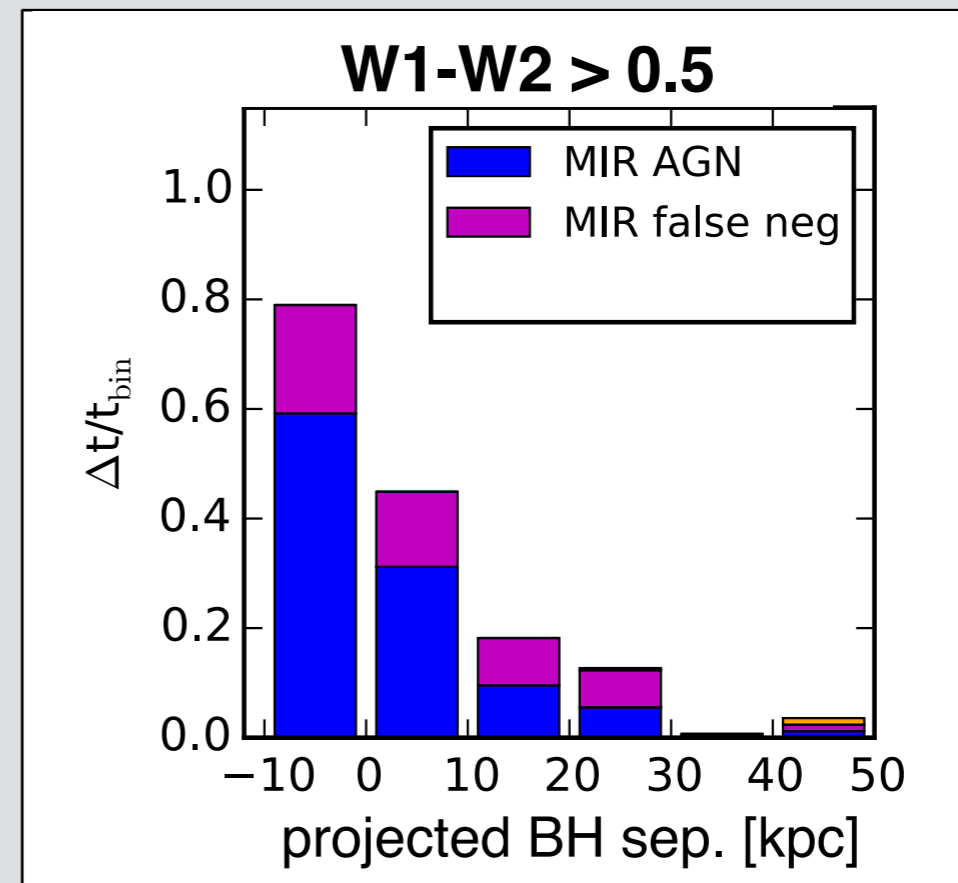
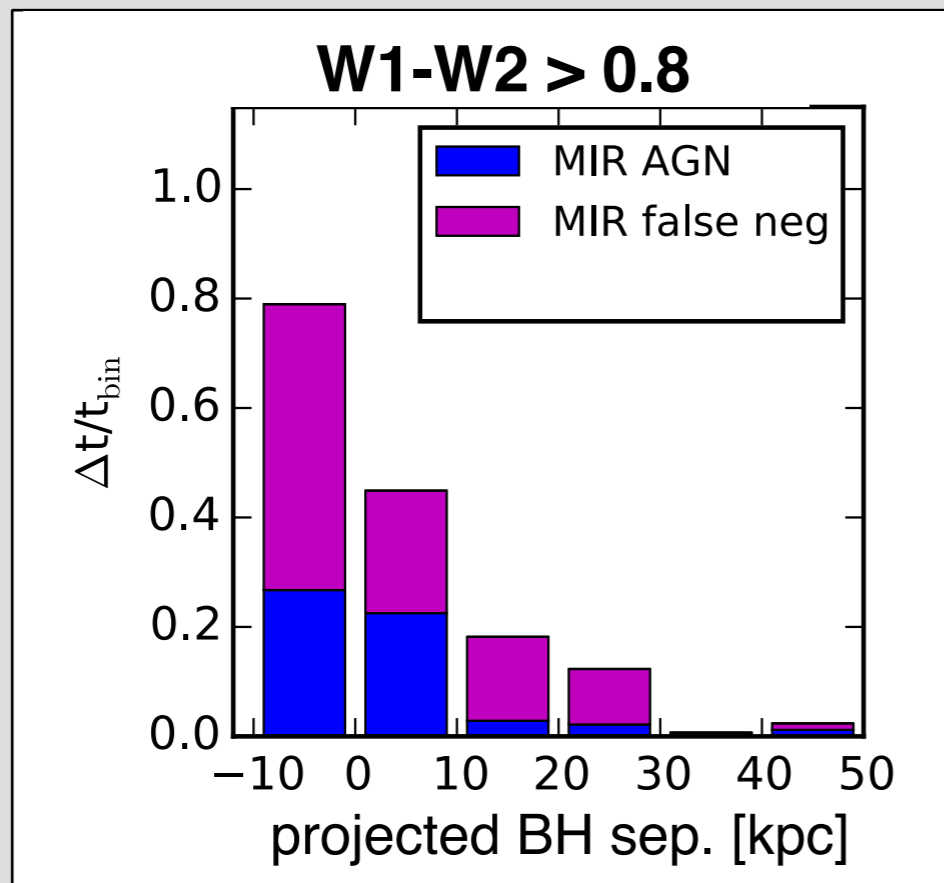
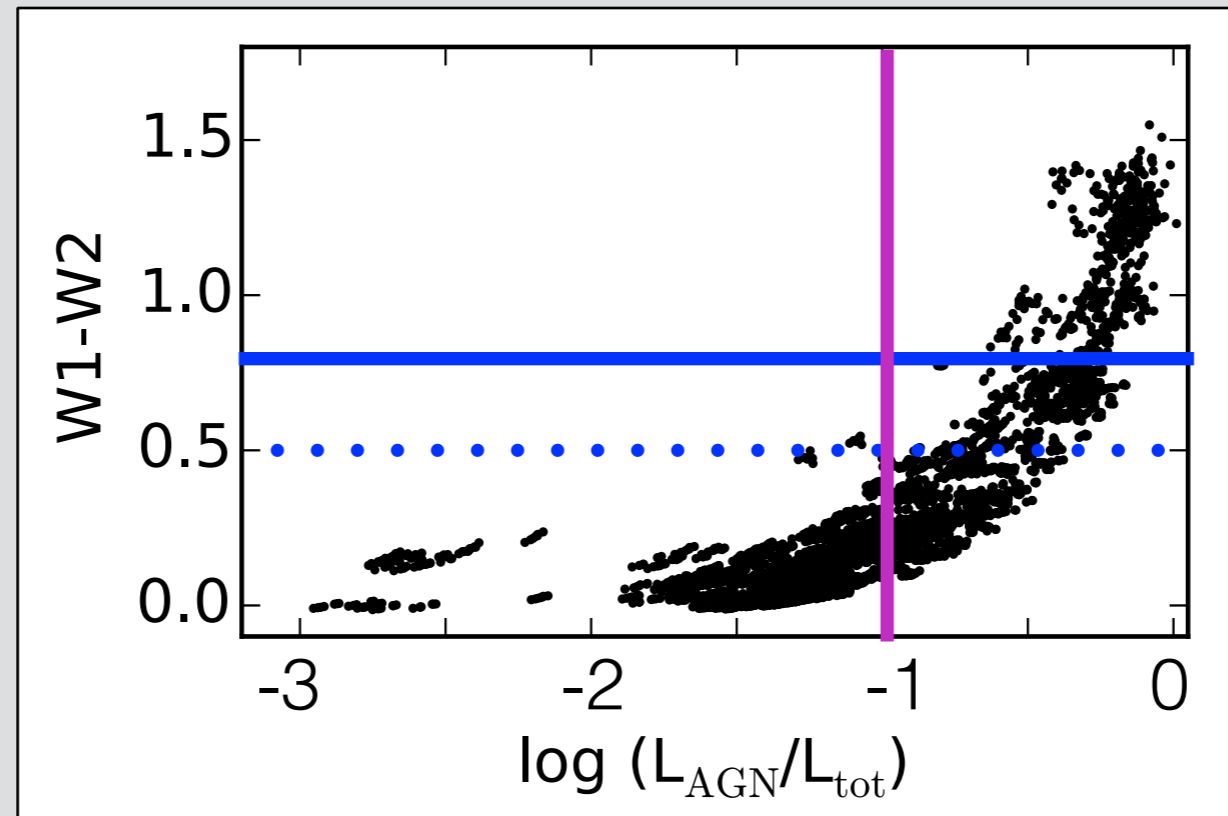
*credit: P. Jonsson*

# Infrared (IR) selection of obscured AGN

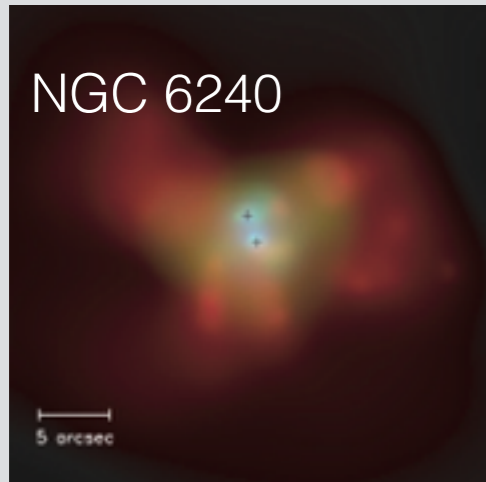




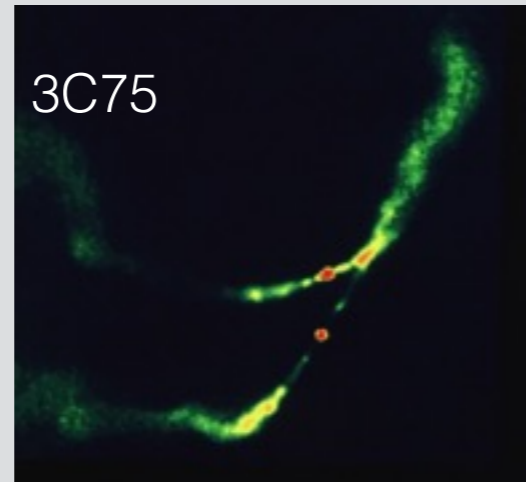
# WISE colors vs. AGN fraction



# Dual AGN: unique probes of merger-triggered growth



NGC 6240  
*Komossa et al. 2003*



3C75  
*NRAO/AUI/F.N.Owen et al.*

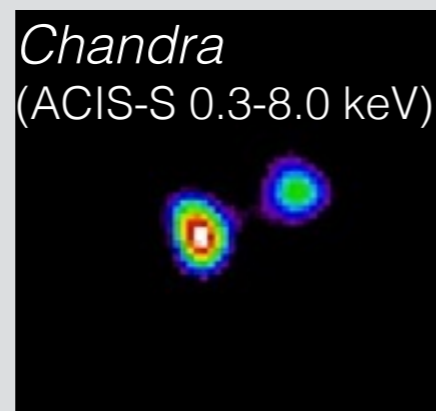


*Koss et al. 2012*

*Satyapal et al. in prep*

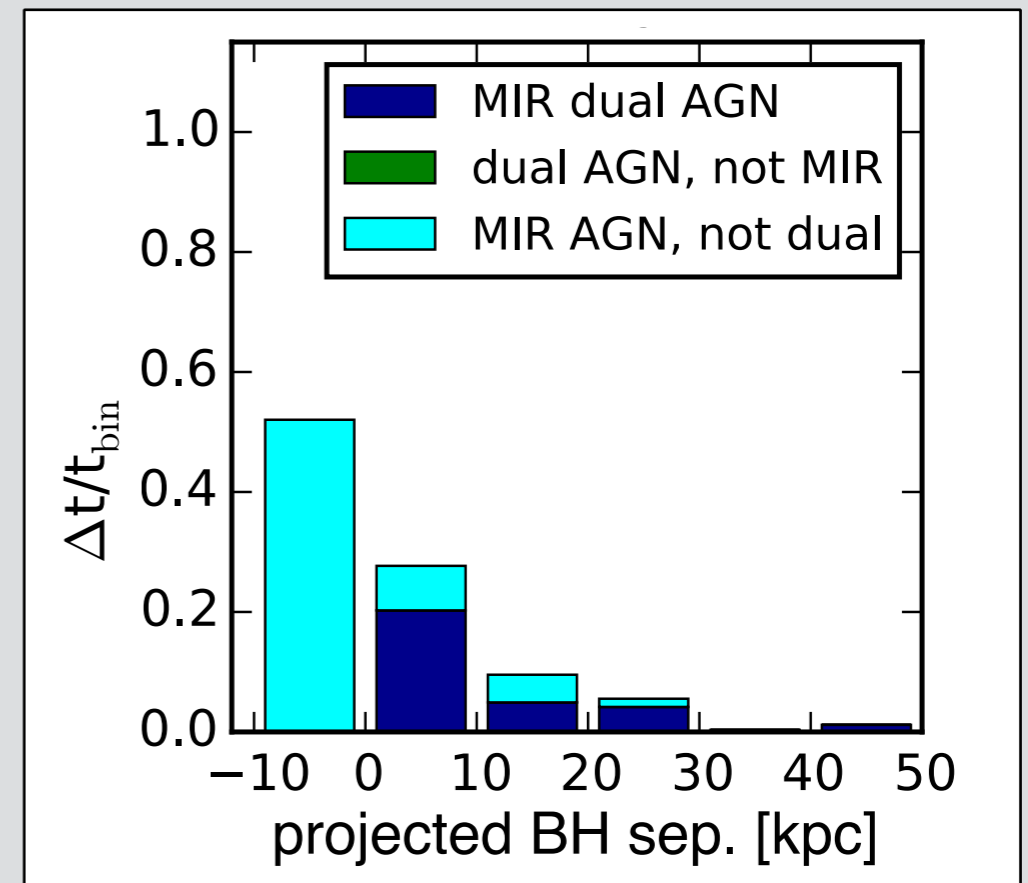


SDSS



Chandra  
(ACIS-S 0.3-8.0 keV)

## Simulated WISE- selected dual AGN:



- Highest luminosities at smallest separations (< 3 kpc)
- Many are likely still unresolved
- Prime targets for *JWST*

# Summary

- Observed merger/AGN connection depends strongly on selection effects: *most rapid accretion in late stage mergers, coincident with highest obscuration*
- Mid-IR color selection identifies luminous ( $L_{\text{AGN}}/L_{\text{tot}} > 30 - 50\%$ ) merger-triggered AGN, but most lower-lum AGN are missed with common selection criteria
- Less-stringent ( $WISE\ W1-W2 > 0.5$ ) cut selects merger-triggered AGN with high accuracy (at low  $z$ ) & completeness
- Effective means of identifying *dual AGN* at  $< 10$  kpc; *many are yet unresolved* ( $< 3$  kpc), with *highest luminosities at smallest separations*
- Mid-IR selected AGN are *promising targets for JWST*; could uncover a population of obscured, sub-kpc dual AGN in mergers.