AGN wind scaling relations

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Summary

Open problems

AGN wind scaling relations

AGN feedback in a cosmological context

(A few) open problems

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Do wind properties correlate with AGN and host galaxy properties?

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If yes, is there a cooling sequence?

If not, do molecular winds dissolve out into lower density atomic winds? Which is the fate of the winds?

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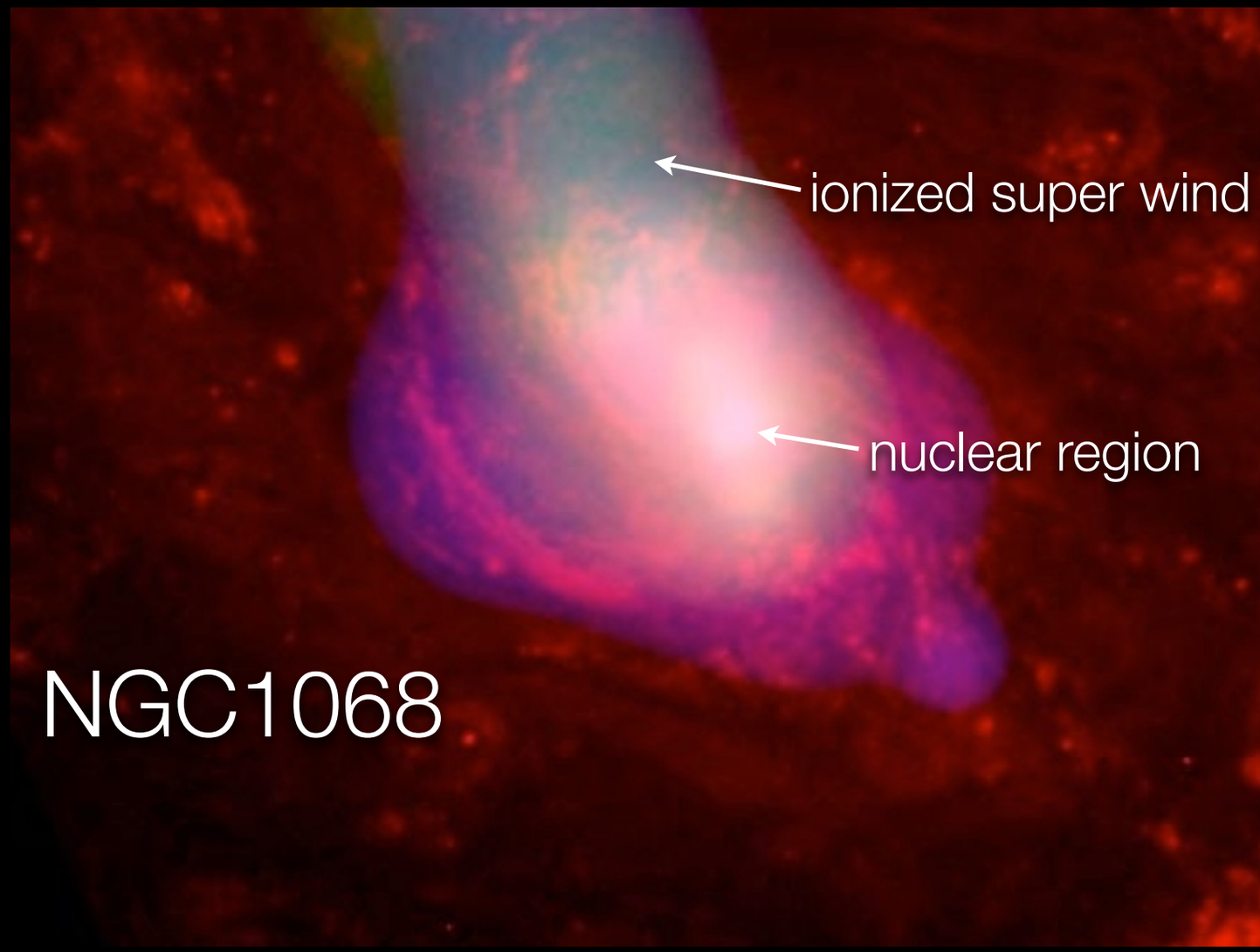
If yes, is there a cooling sequence?
If not, do molecular winds dissolve out into lower density atomic winds? Which is the fate of the winds?

Are AGN winds short episodes in rare systems?
or do the affect the bulk of galaxy population?

AGN winds are ubiquitous



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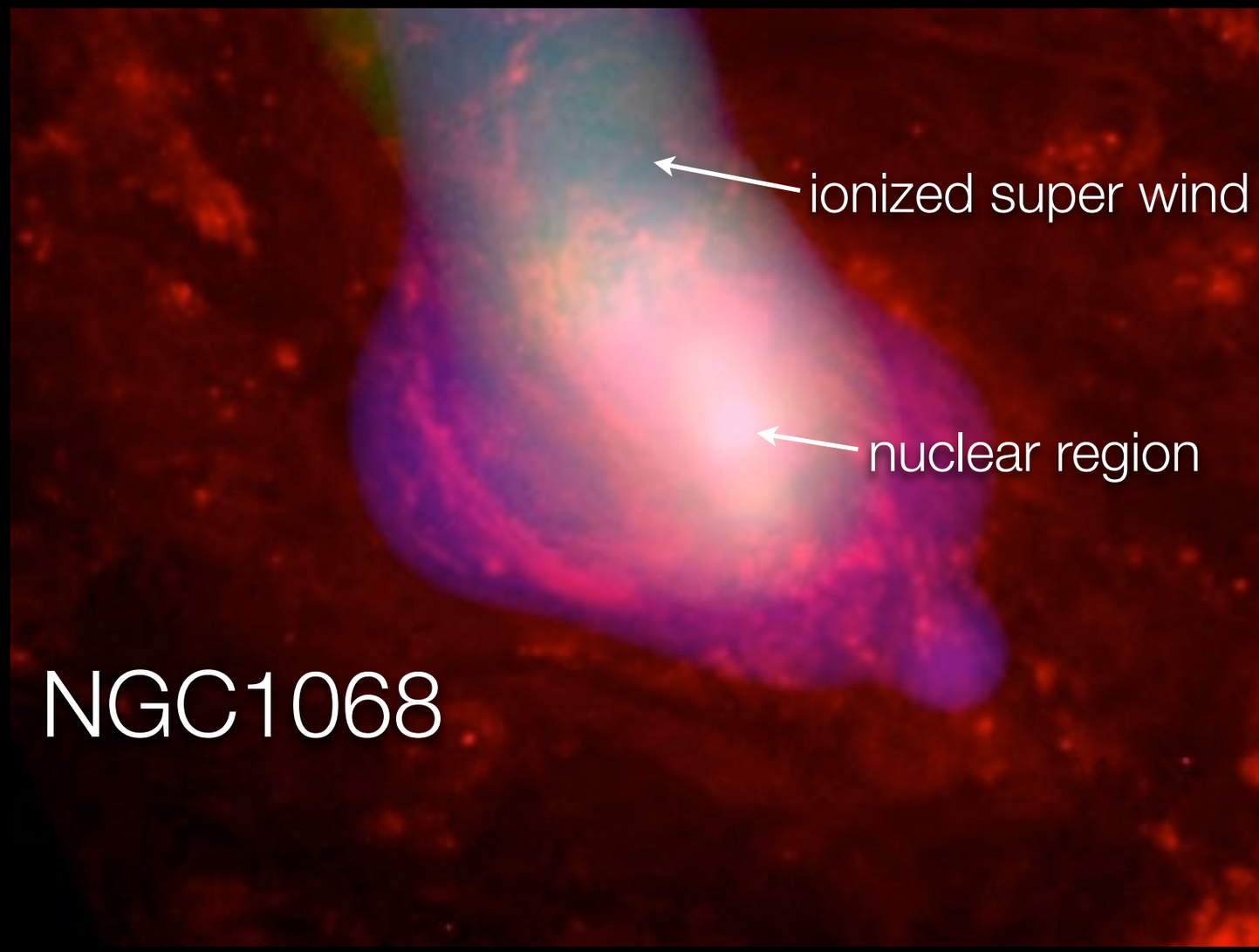
Radio jets, relativistic



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X-ray winds,
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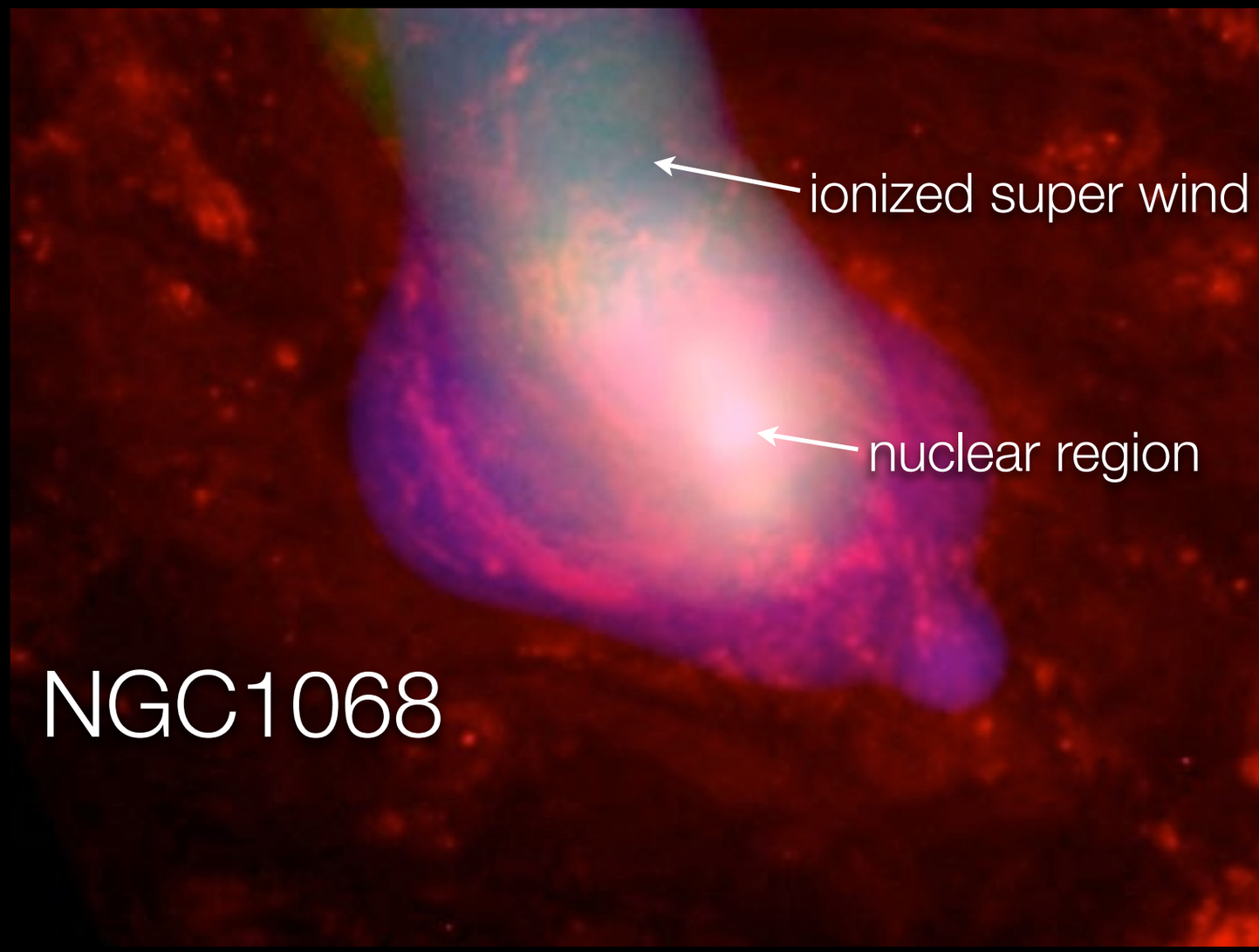

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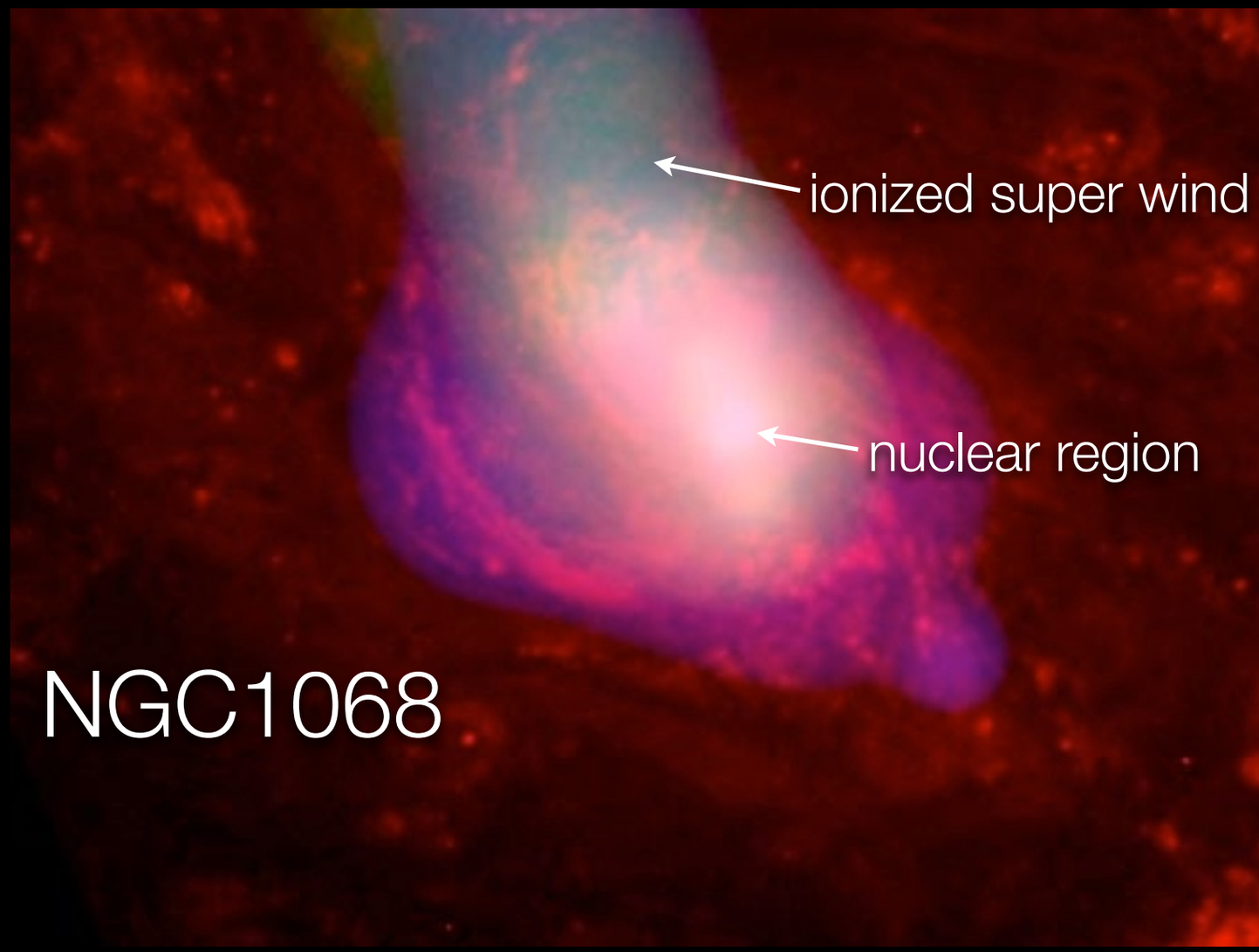
v~500-3000 km/s



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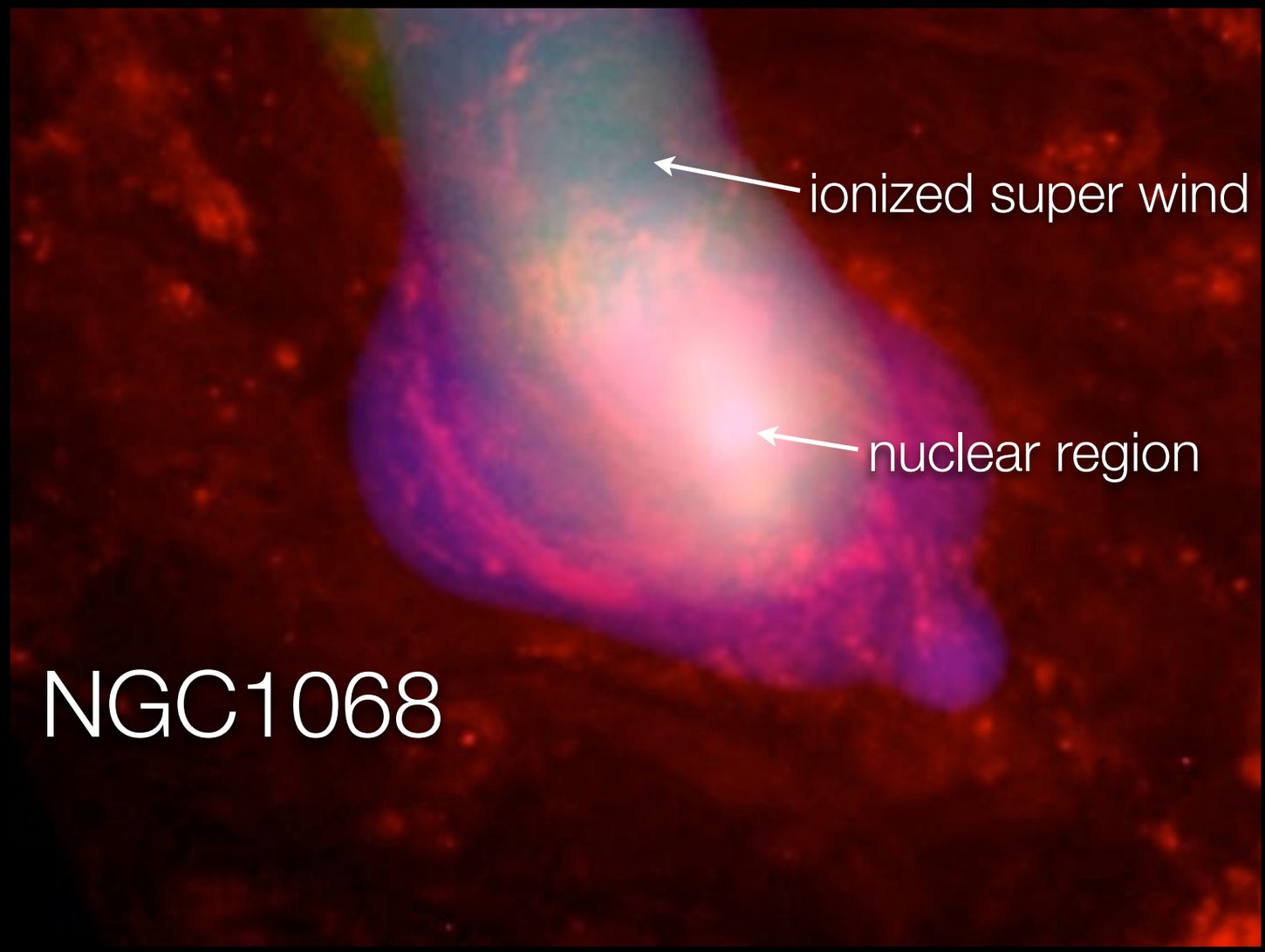

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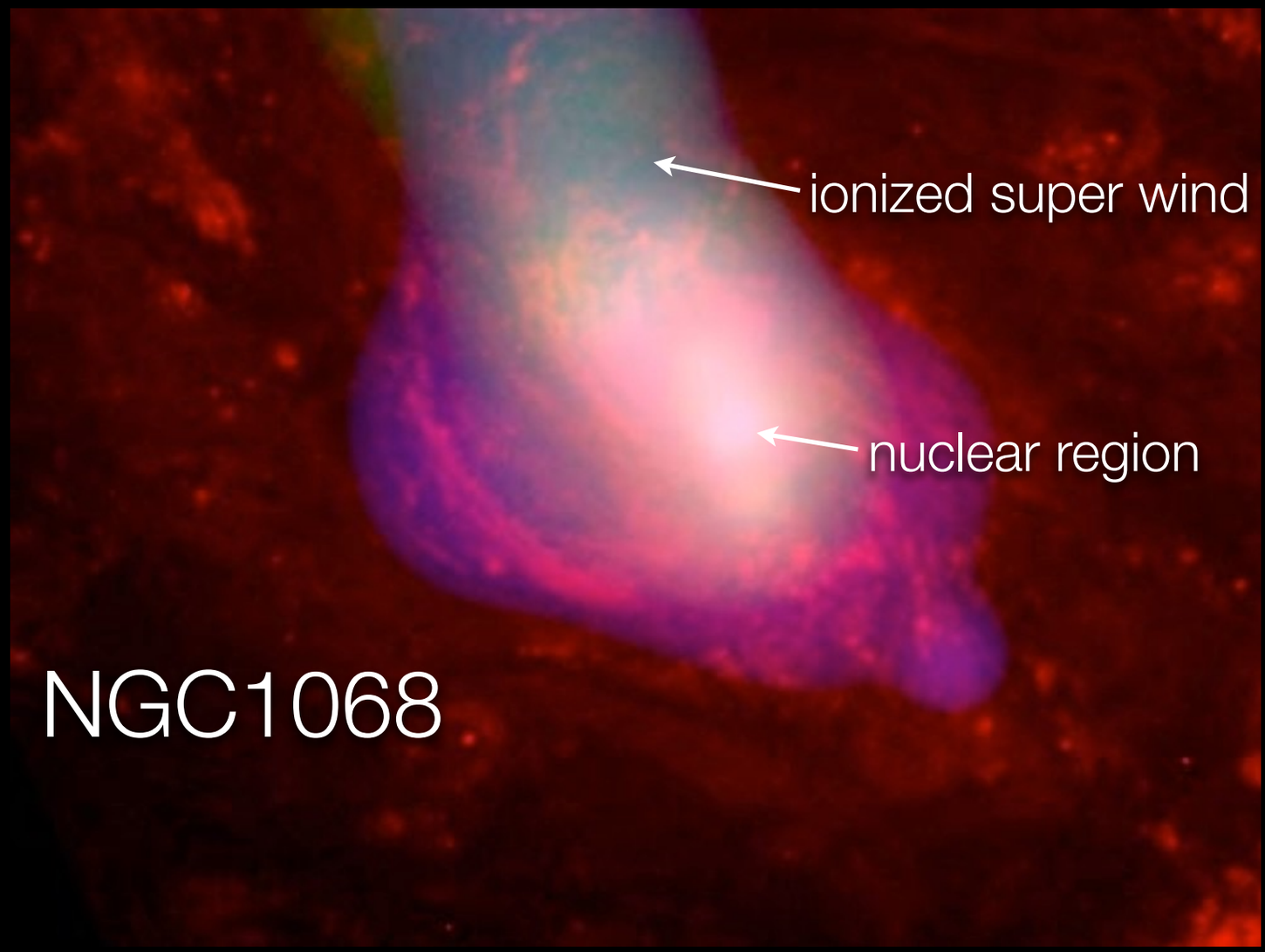
Molecular winds
v~100-2000 km/s



AGN winds are ubiquitous

Radio jets, relativistic

X-ray winds,
semirelativistic

All carry significant amount of AGN L_{bol} ie~a few%

Atomic gas winds
v~100-1000 km/s

Molecular winds
v~100-2000 km/s

AGN winds are ubiquitous

Feedback observations are difficult

Radio-mode *feedback* observed frequently, joining X-ray and radio observations

Quasar-mode *feedback* observations are rare. Systematic investigation of super winds impact on galaxy evolution still missing

Systematic studies

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Biased and heterogeneous samples

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Next generation surveys ***must target blind samples***
(SUPER, WISSH, PHIBBS2, CARS, IBISCO, etc.)

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In the meantime… collections of ***all winds in AGN***

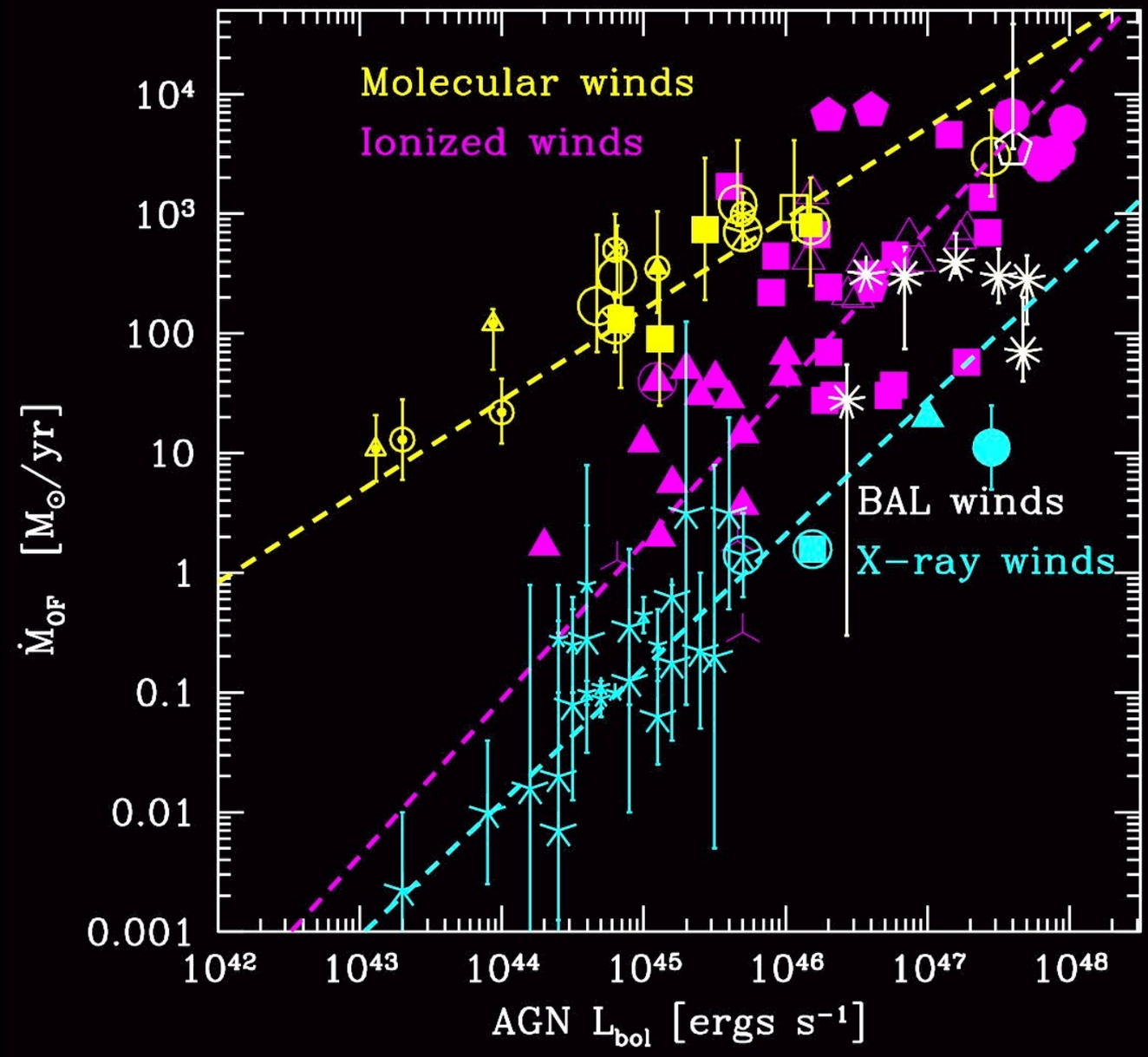
19 molecular winds

40 ionized gas winds: SDSS type 2 AGN, z~2 QSOs, radio galaxies, z~3 hyper-luminous QSOs, WISSH sample:

6 BAL (with spatial info)

31 X-ray winds

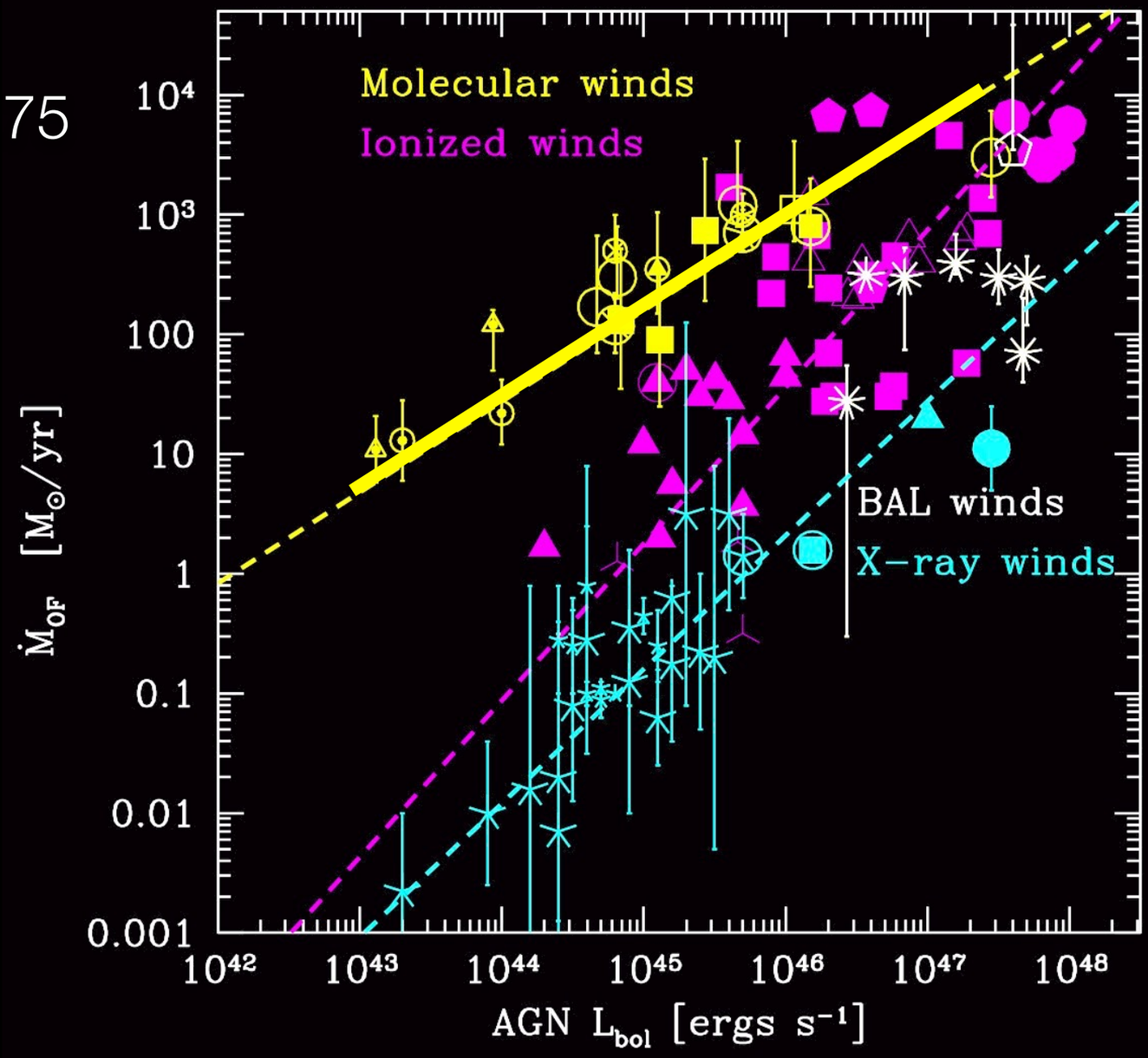
Statistics of Super Winds



Molecular small=nucl. large=gal. **Ionized - WISSH** **BAL** **X-ray**

Statistics of Super Winds

Molecular $dM_{OF}/dt \sim L_{bol}^{0.75}$



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Statistics of Super Winds

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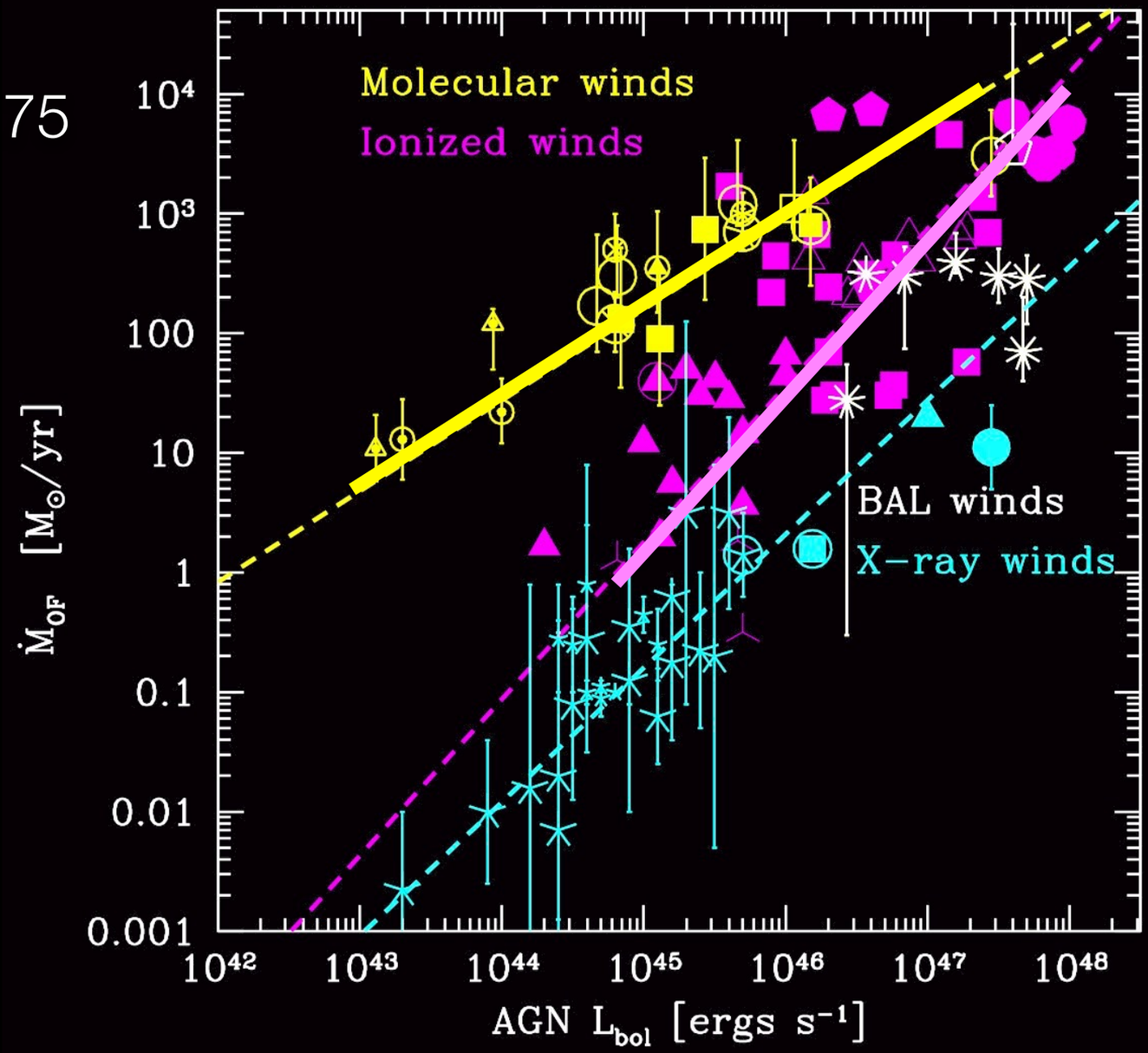
Ionized $dM_{OF}/dt \sim L_{bol}^{1.3}$



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Wind Mass outflow rate

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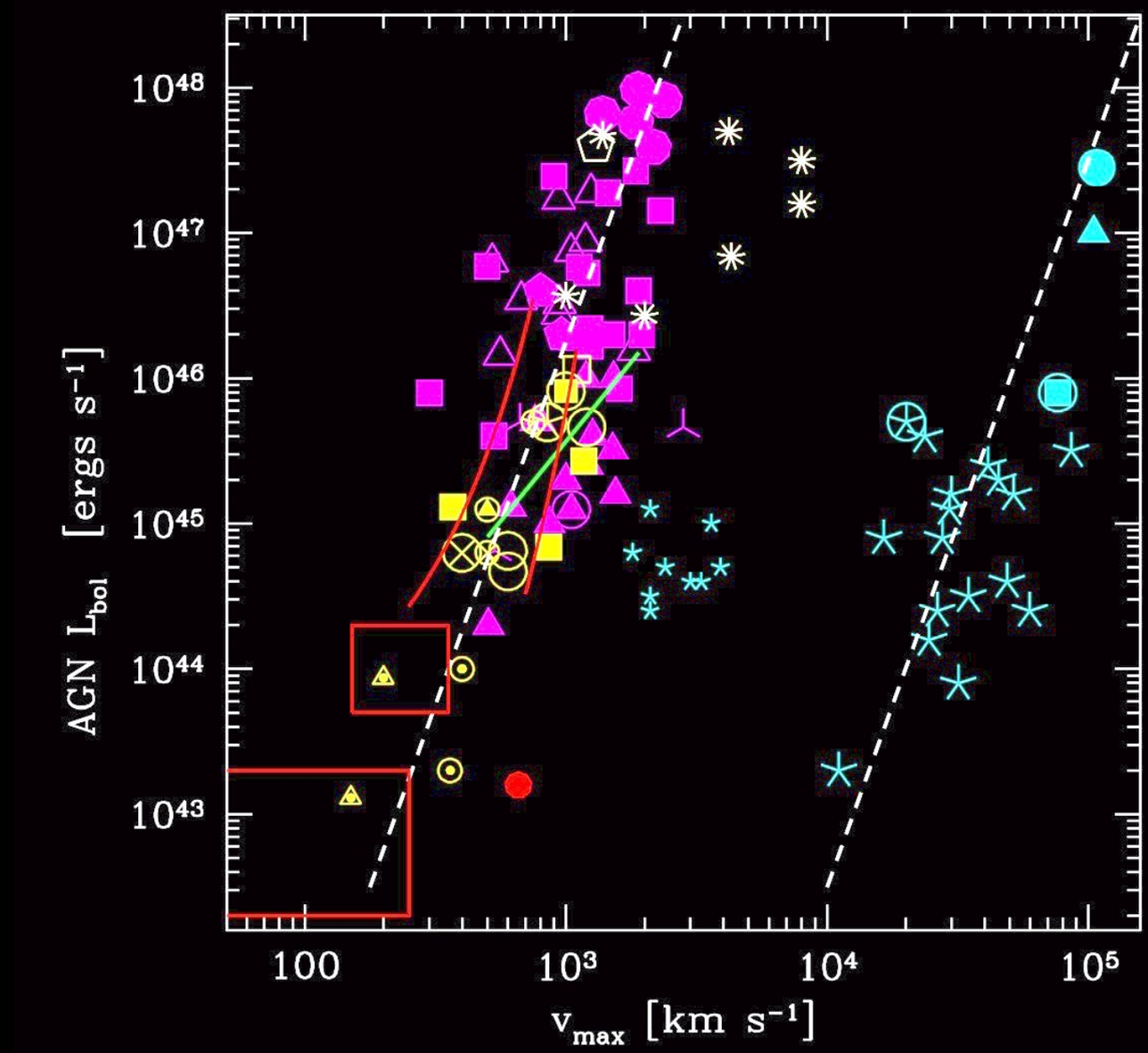
Which is the scaling of v_{max}, M_{OF} and R_{OF} with L_{bol}?

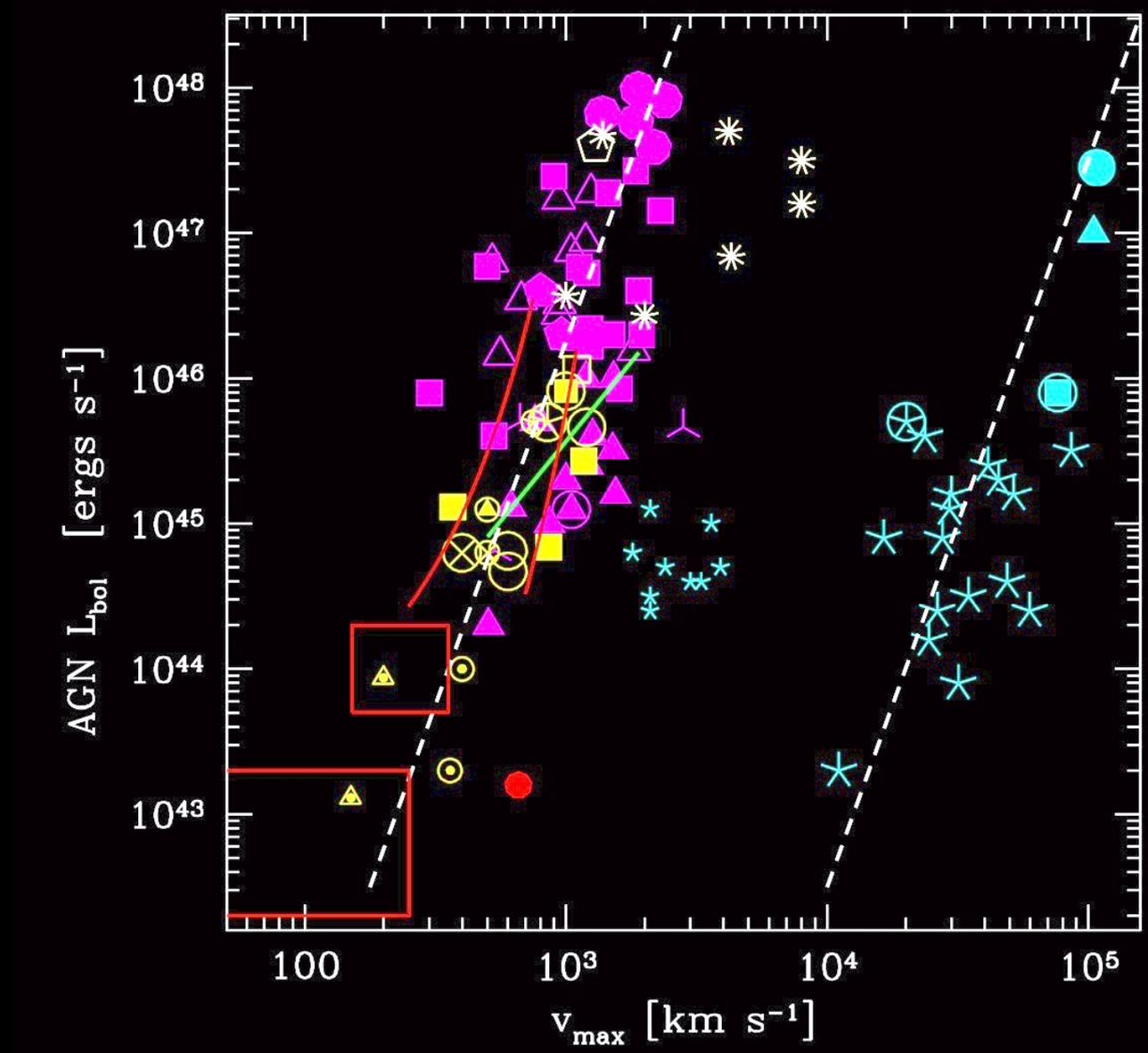
Wind scaling with L_{bol}



Molecular small=nucl. large=gal. **Ionized - WISSH** **BAL** **X-ray**

Wind scaling with L_{bol}

$L_{bol} \sim v_{max}^{4\text{-}5}$
similar to $M_{BH} \sim \sigma^{4\text{-}5}$



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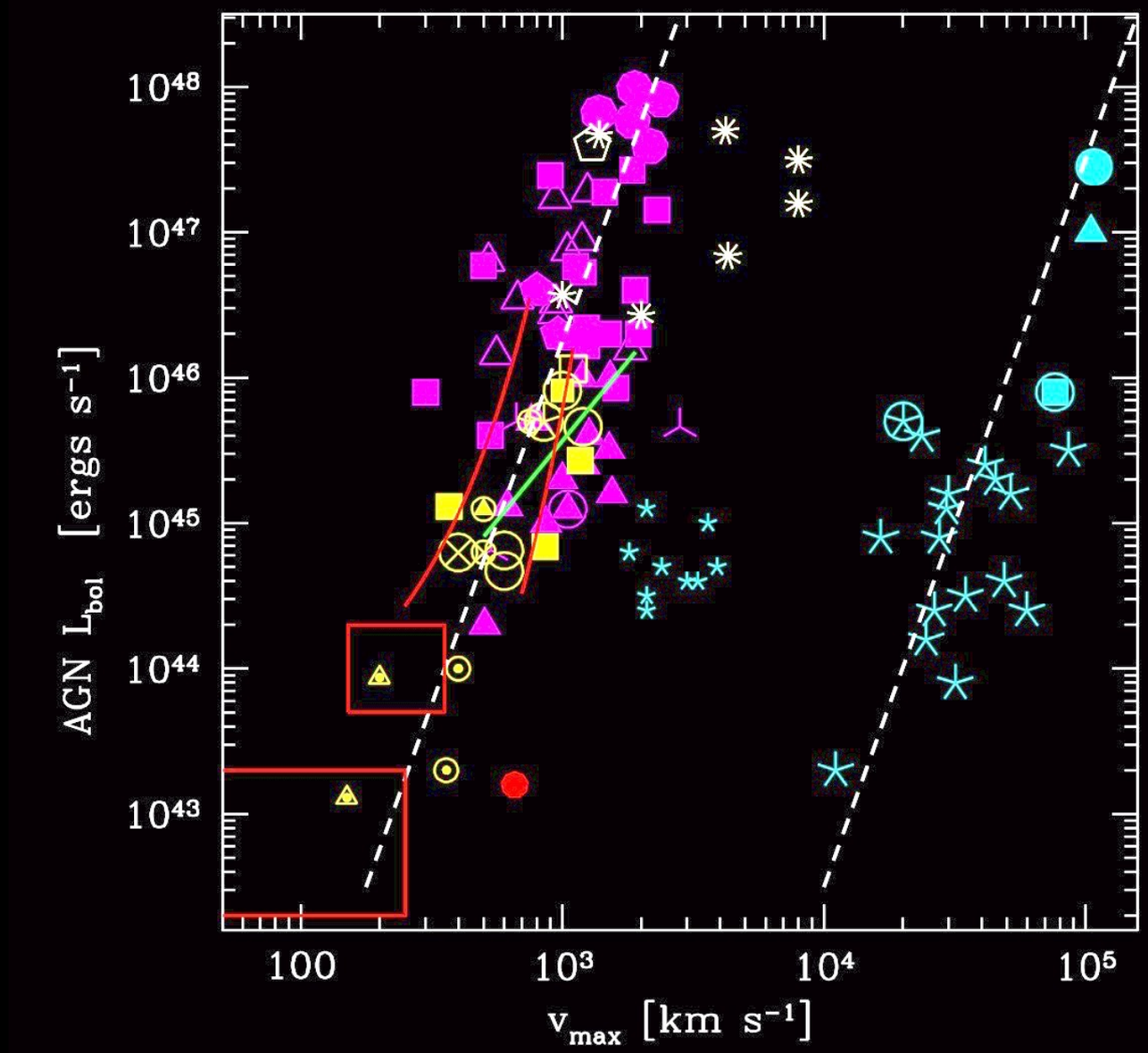
$M_{mol} \sim M_{ion} \sim 2000\ M_{UFO}$



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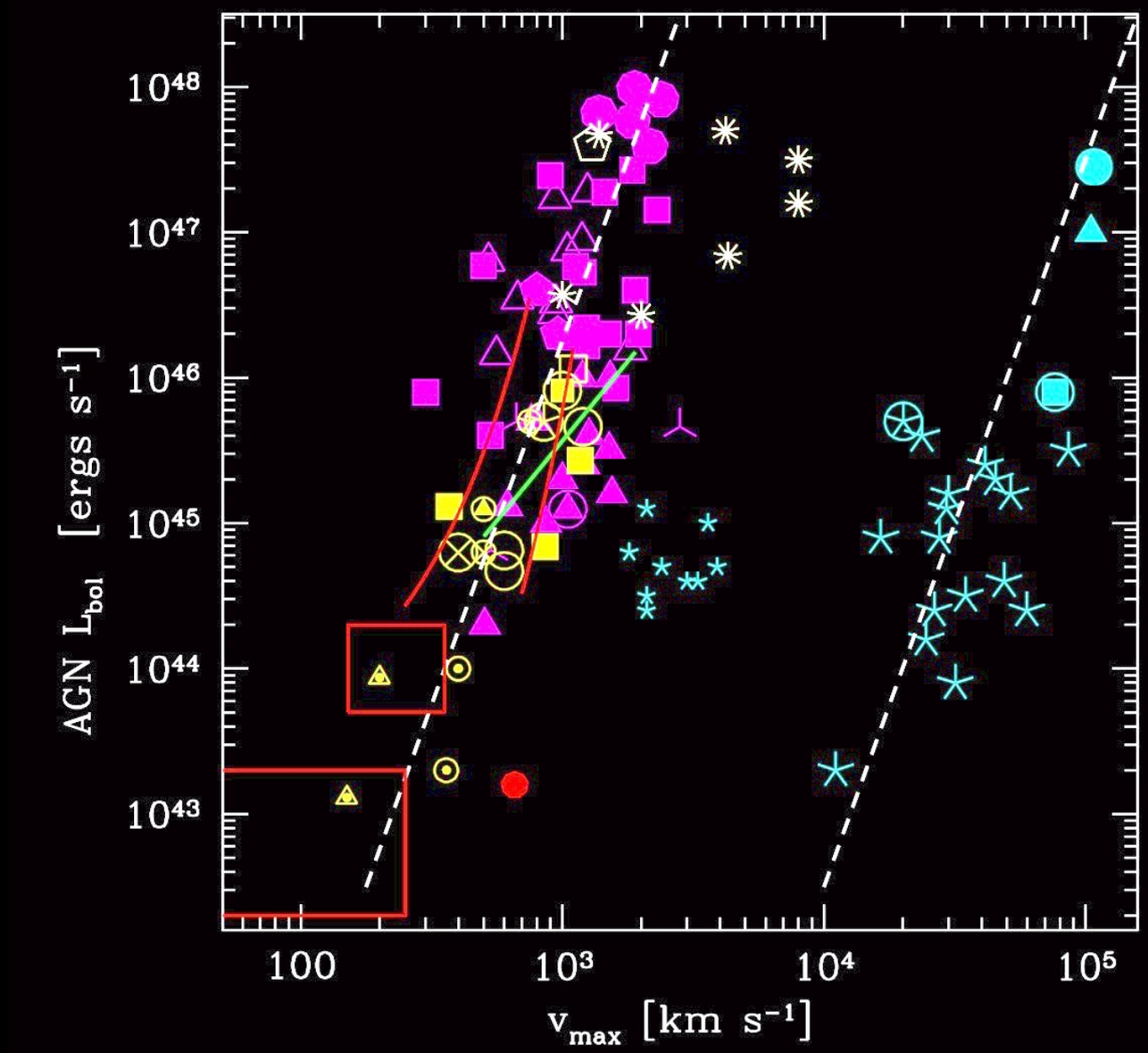
$v_{UFO} \sim 10 v_{BAL} \sim v_{WA}$



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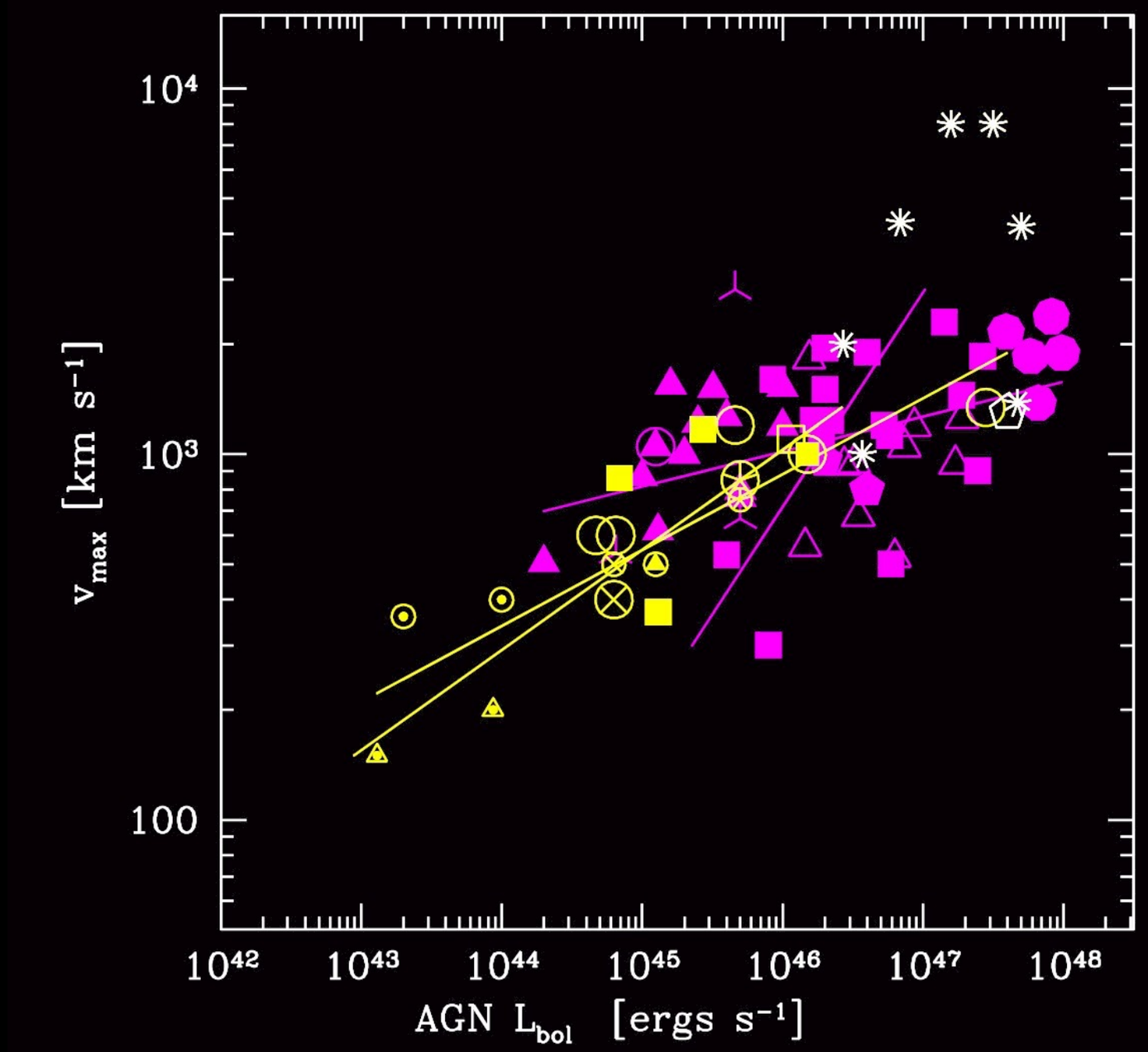
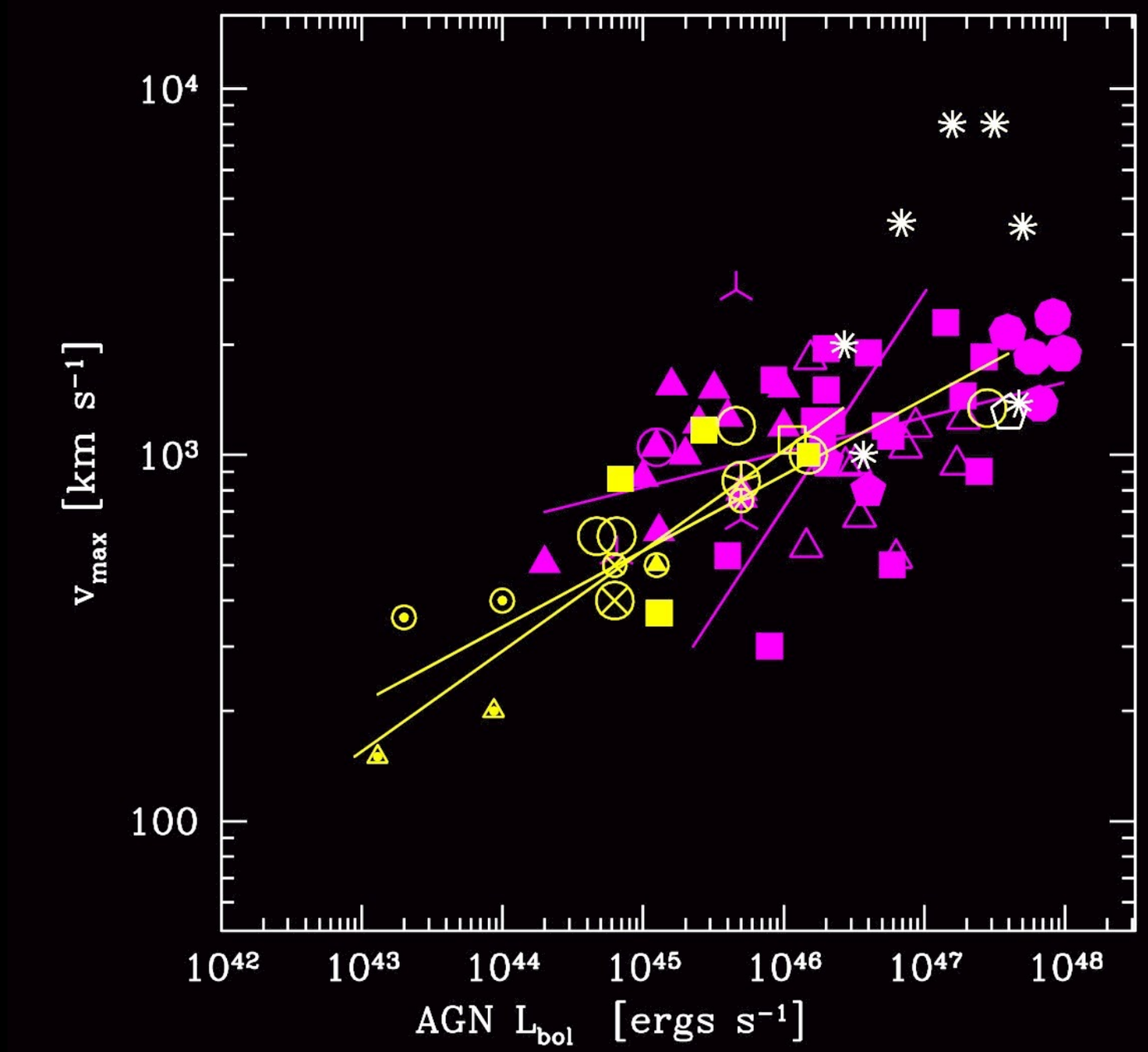


Molecular small=nucl. large=gal. **Ionized - WISSH** **BAL**

Wind scaling with L_{bol}

$v_{max} \sim L_{bol}^{0.2\text{-}0.25}$

for both molecular and ionized winds



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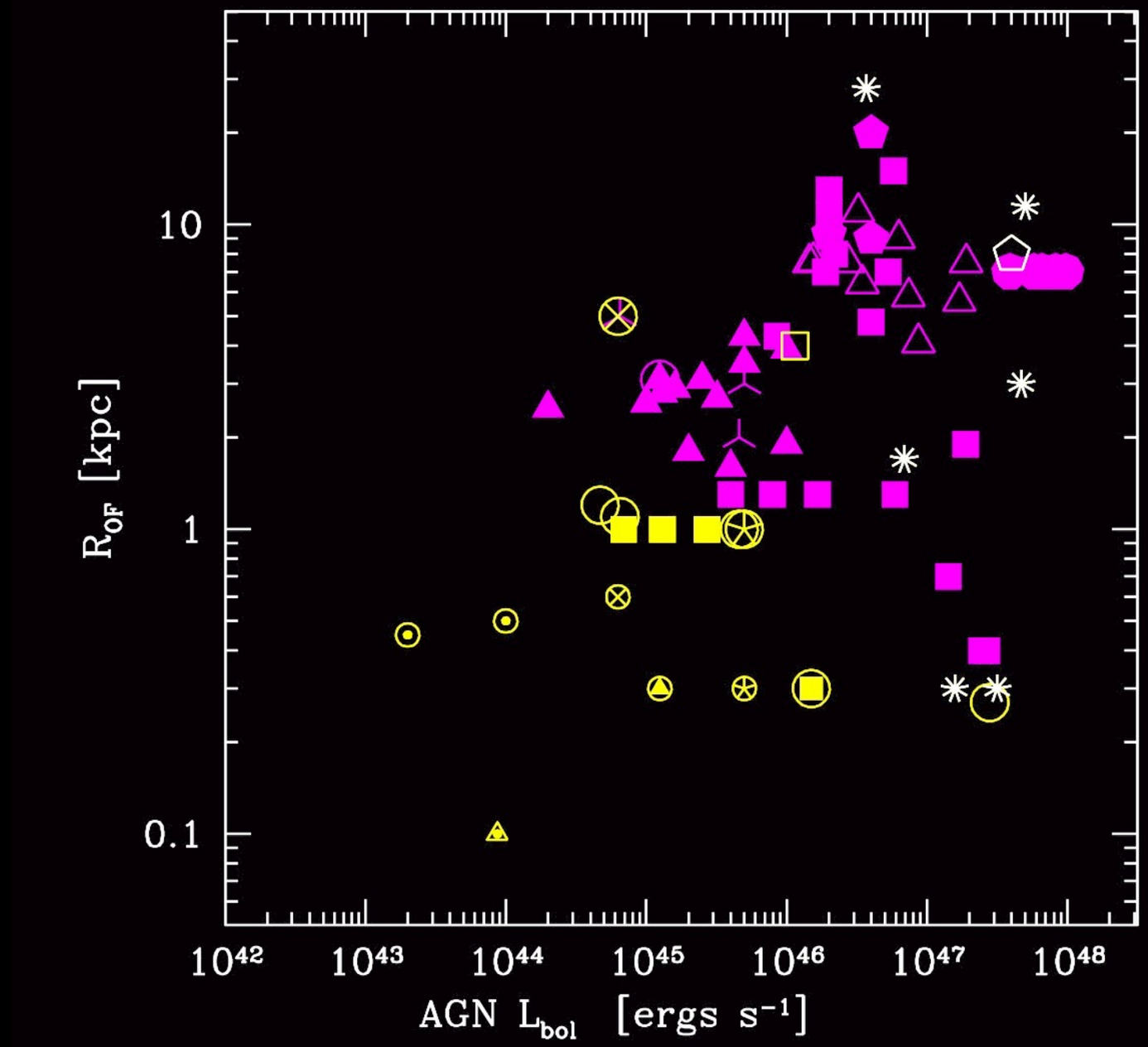

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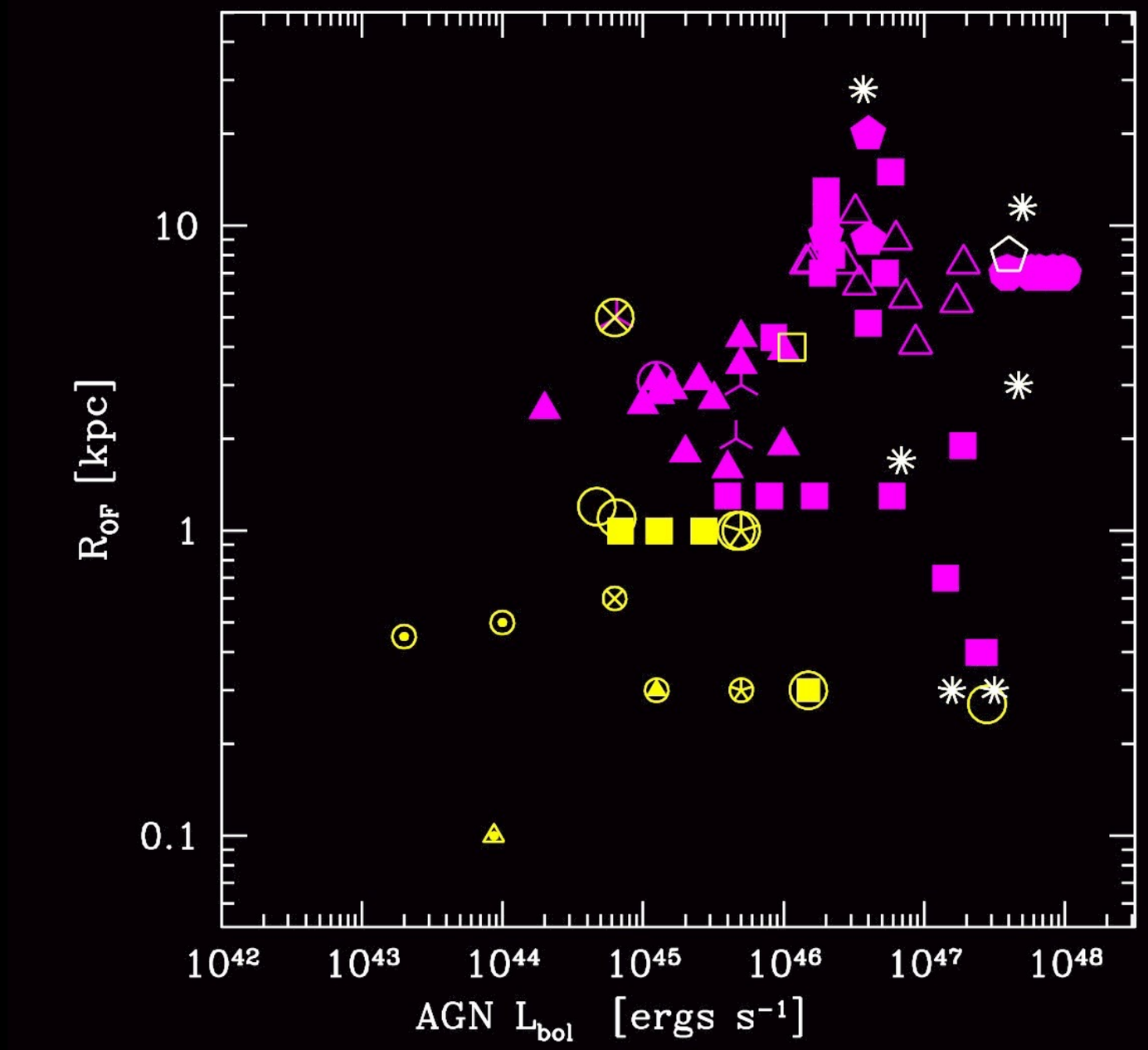
Wind scaling with L_{bol}

No significant scaling of R_{OF} with L_{bol} for both molecular and ionized winds



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Wind scaling with L_{bol}

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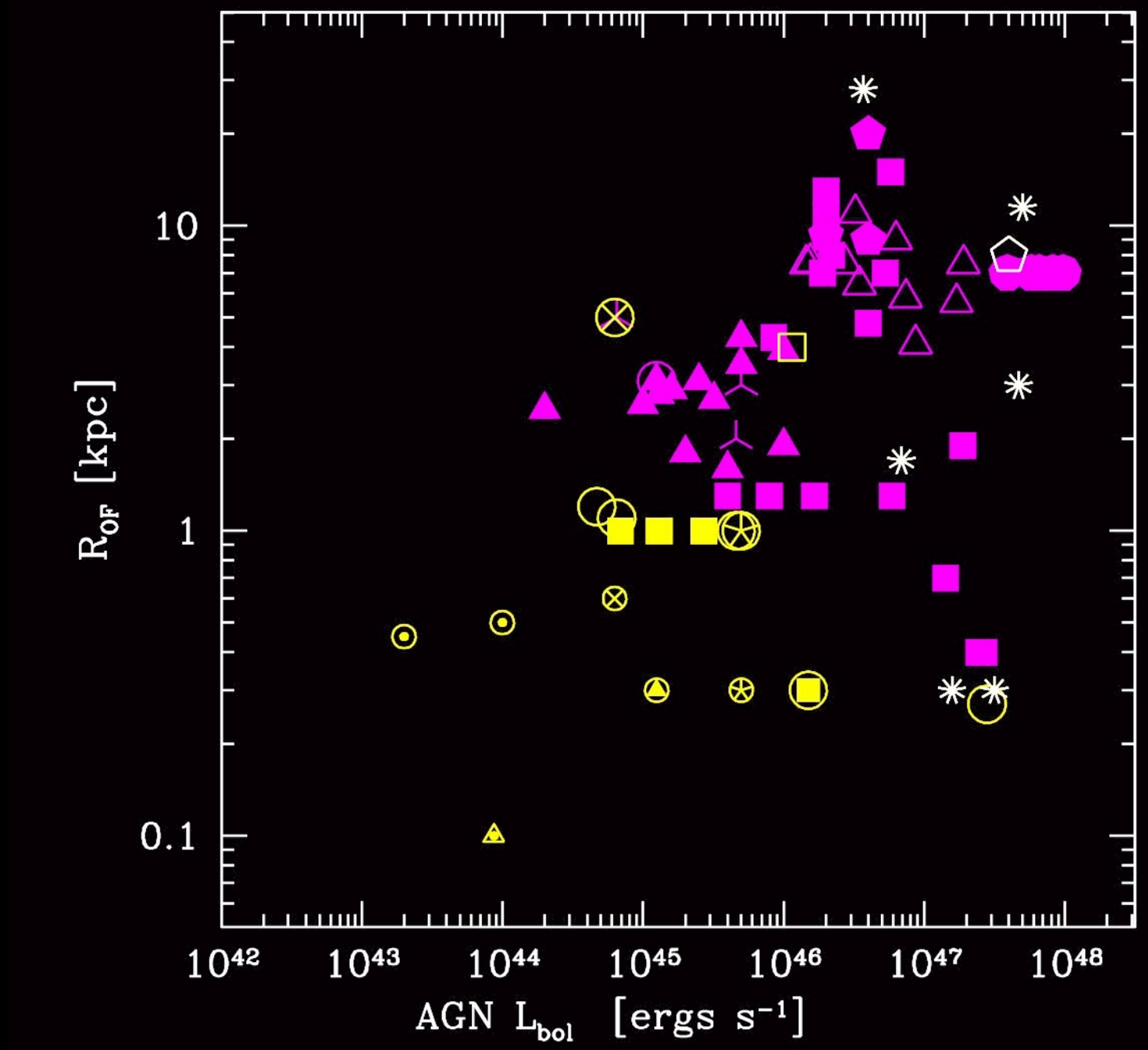
Molecular winds are more compact than ionized winds



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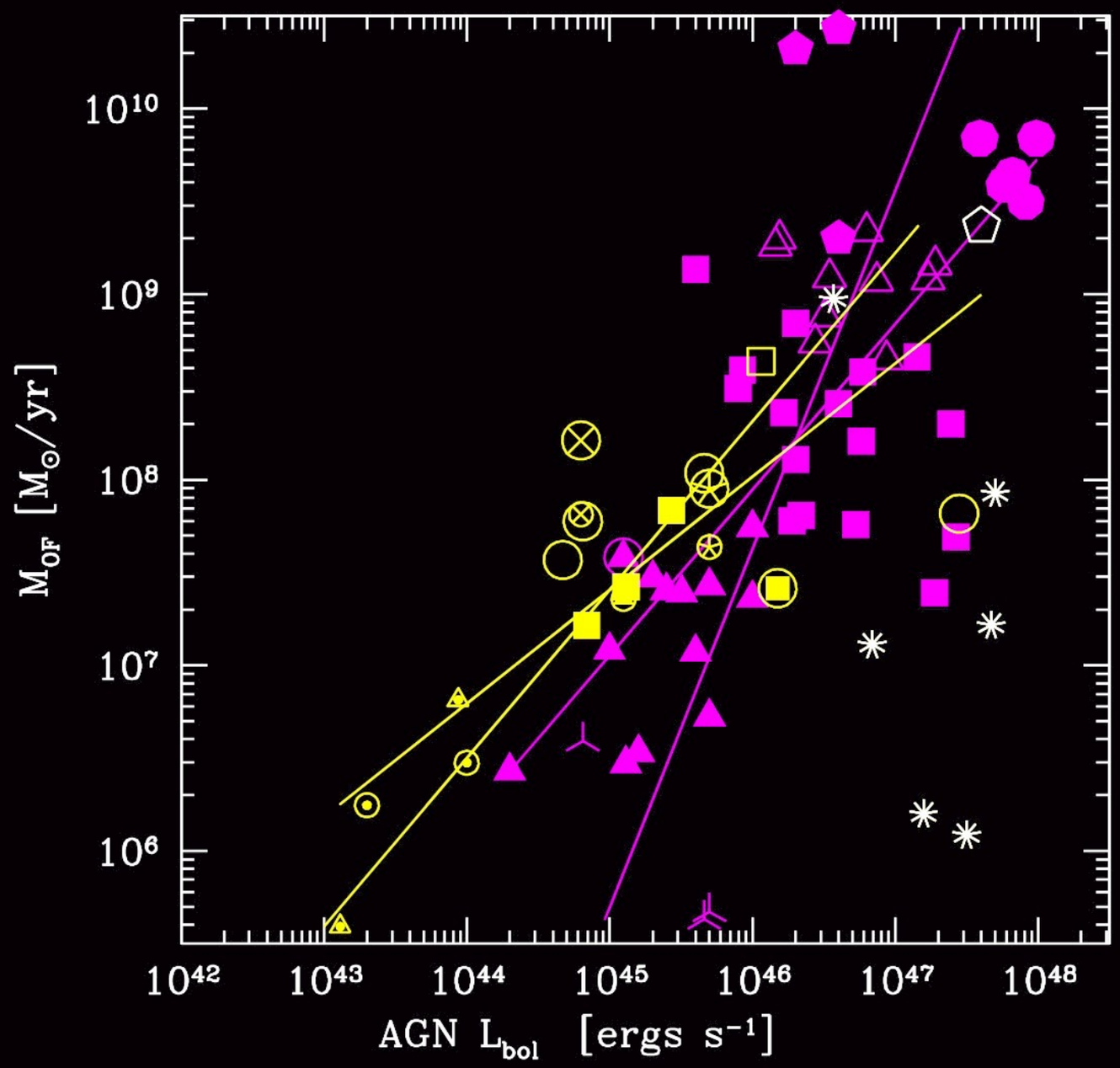
Wind scaling with L_{bol}



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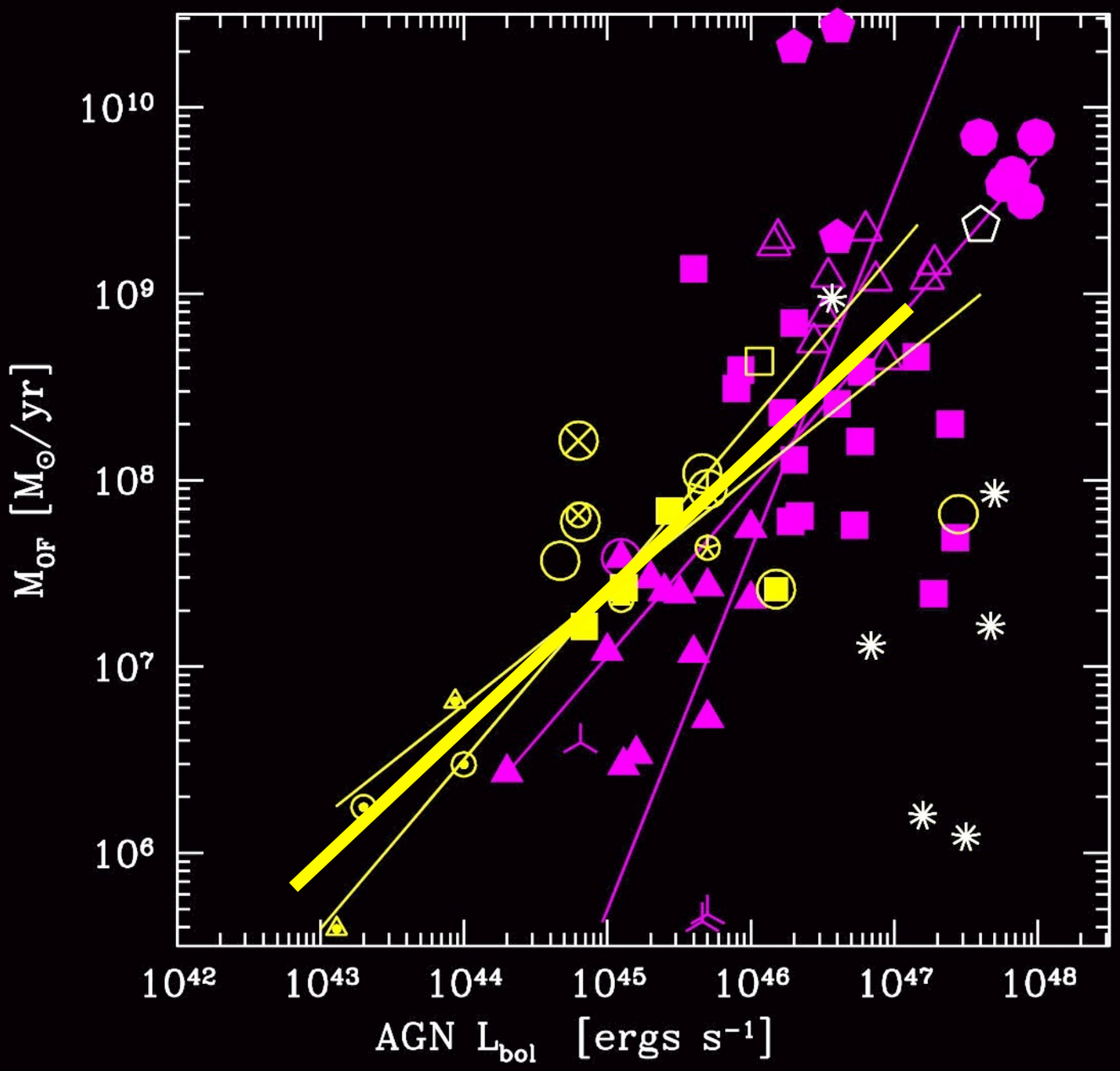
Wind scaling with L_{bol}

Molecular $M_{OF} \sim L_{bol}^{0.8}$



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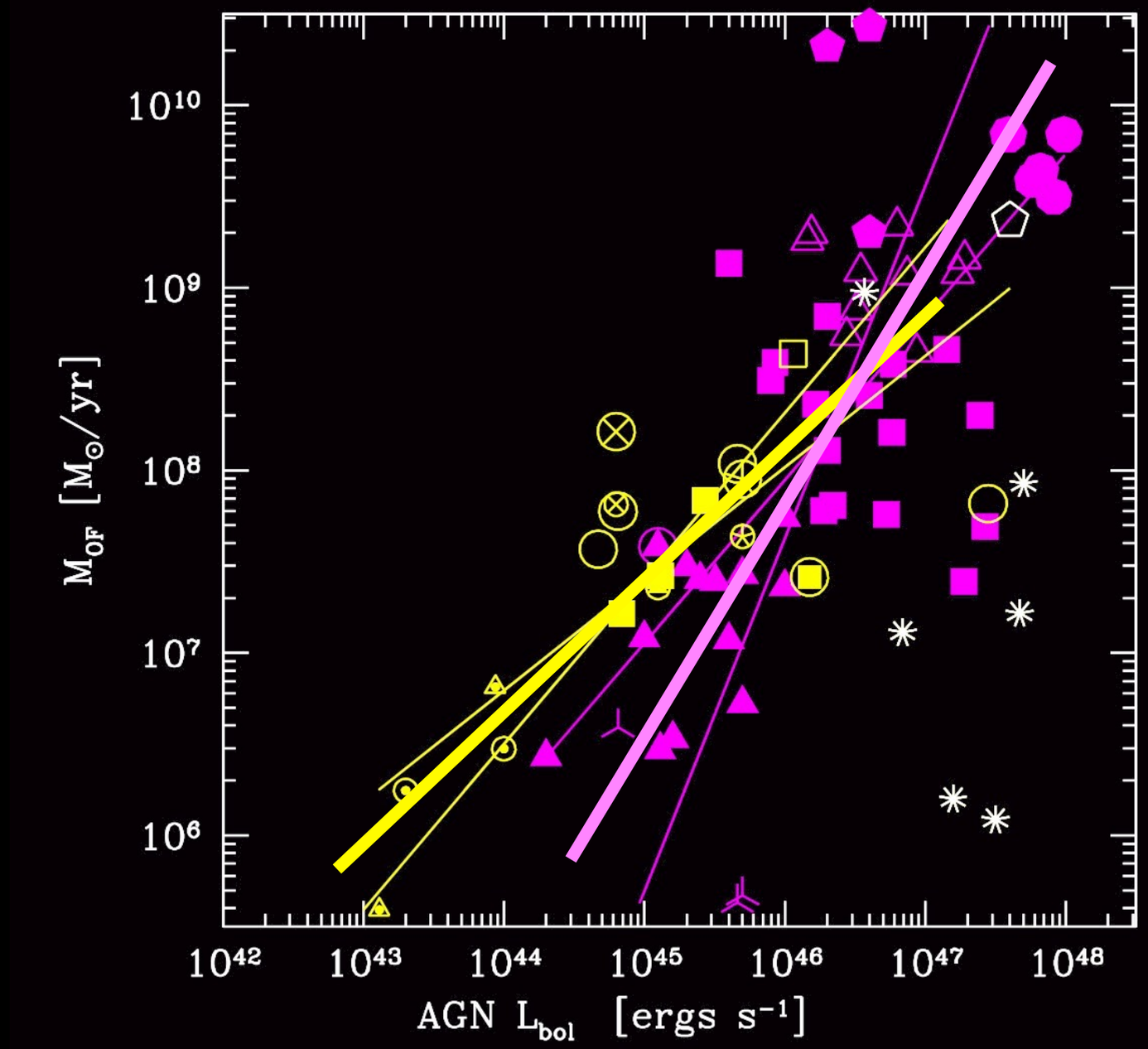
Wind scaling with L_{bol}

Molecular $M_{OF} \sim L_{bol}^{0.8}$

Ionized $M_{OF} \sim L_{bol}^{1.4}$



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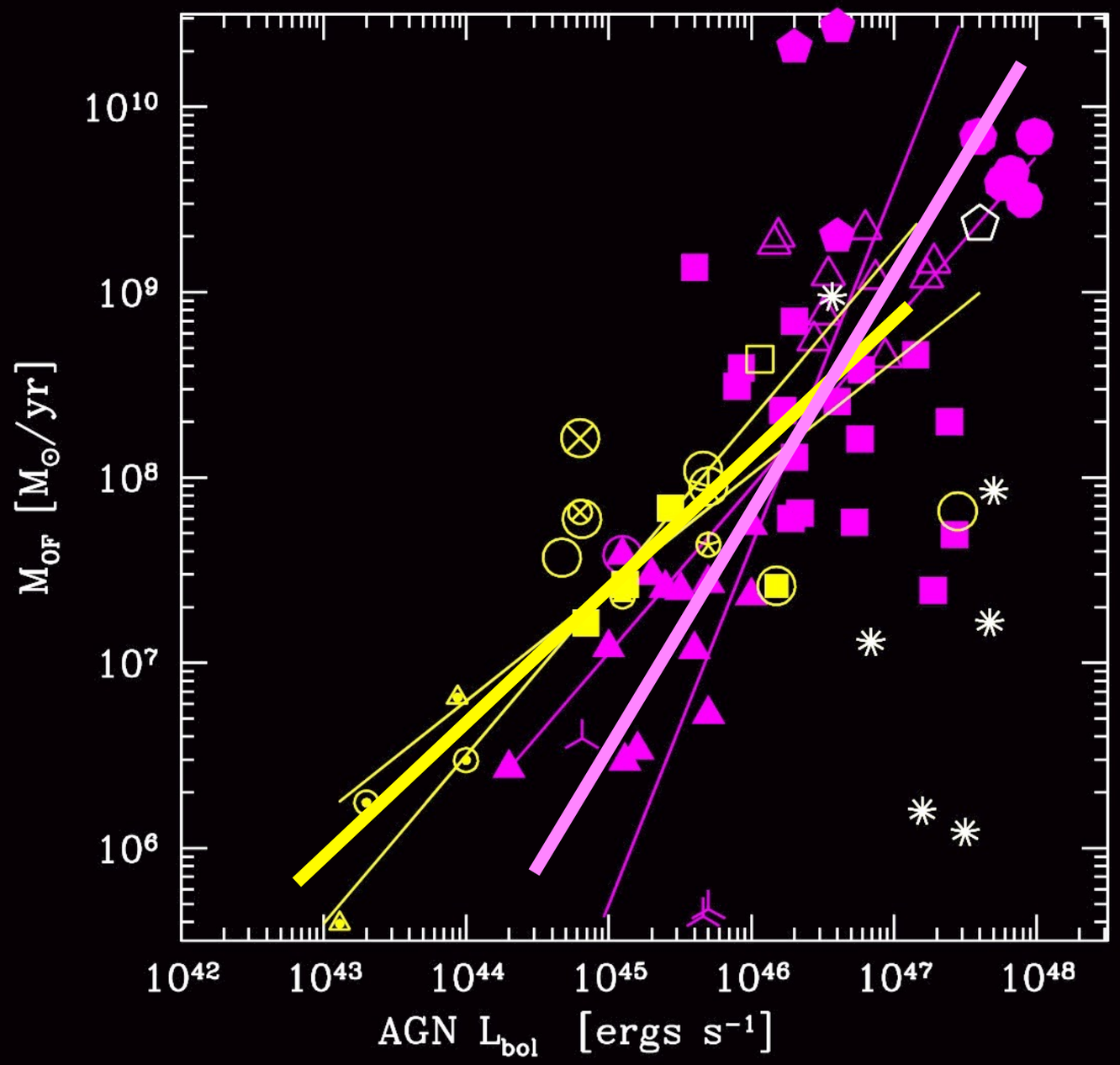
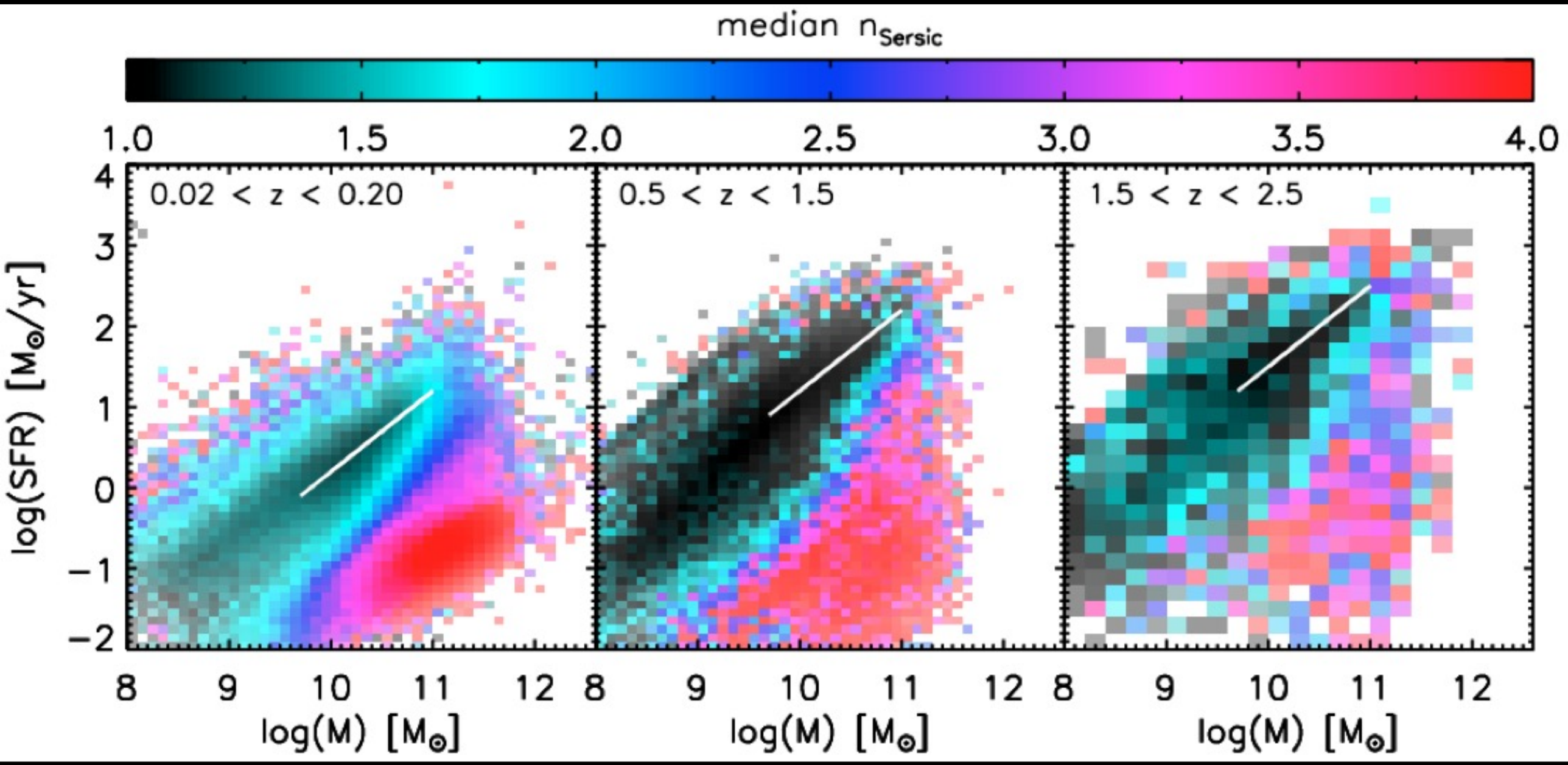
The molecular/ionized wind mass reduces at high L_{bol}



Molecular small=nucl. large=gal. Ionized - WISSH BAL

AGN winds scaling relations: Galaxy main sequence



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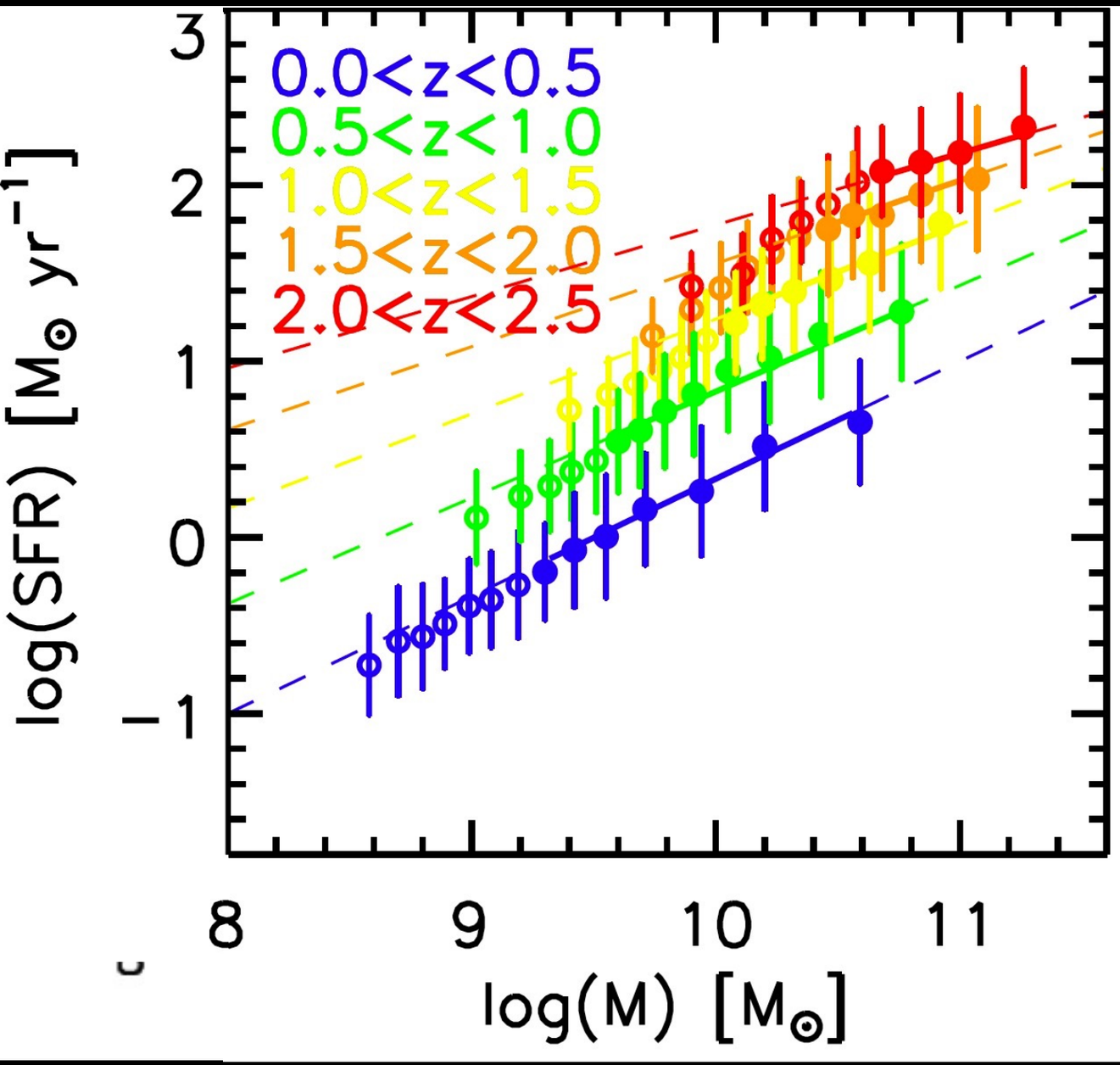

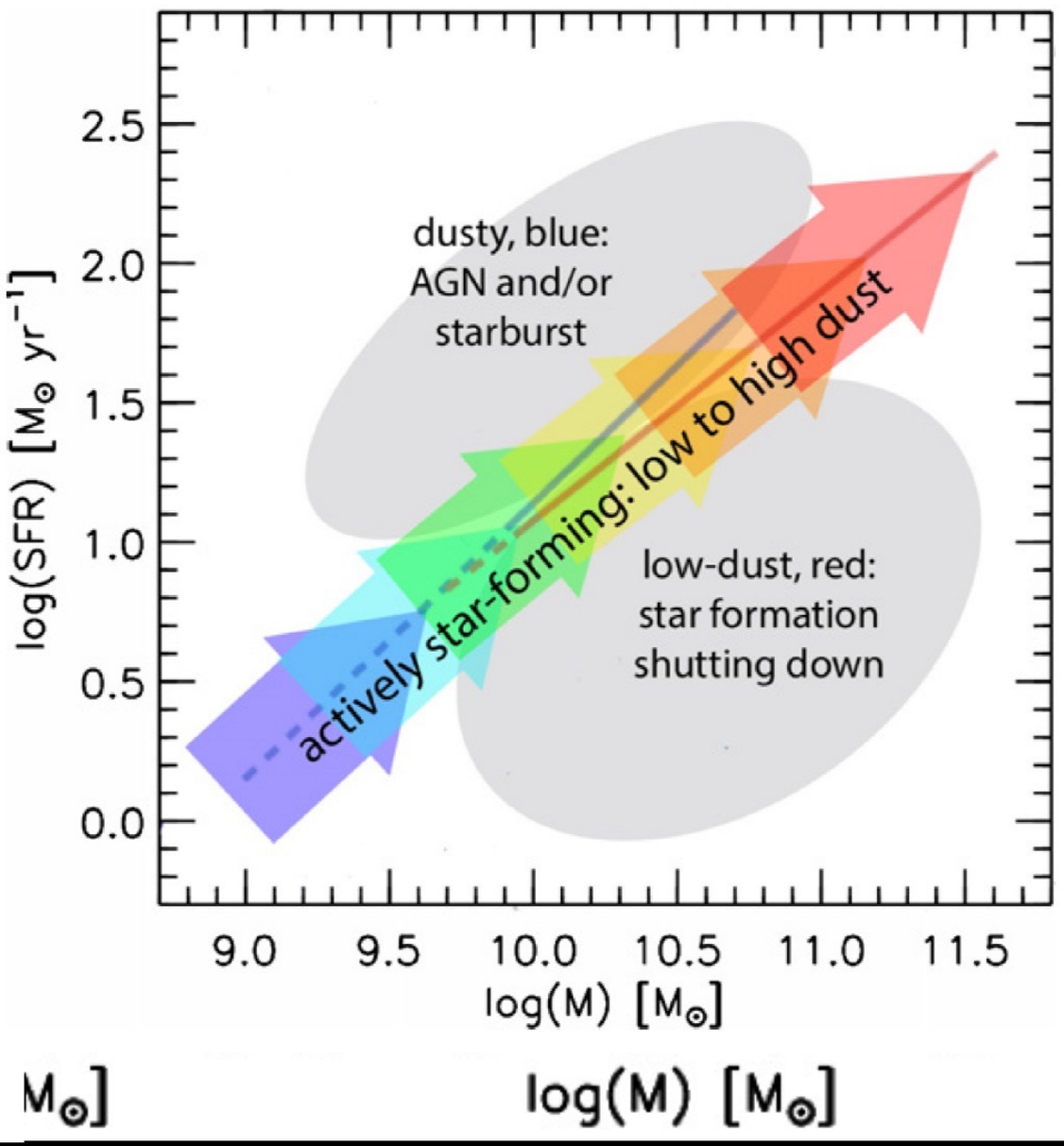

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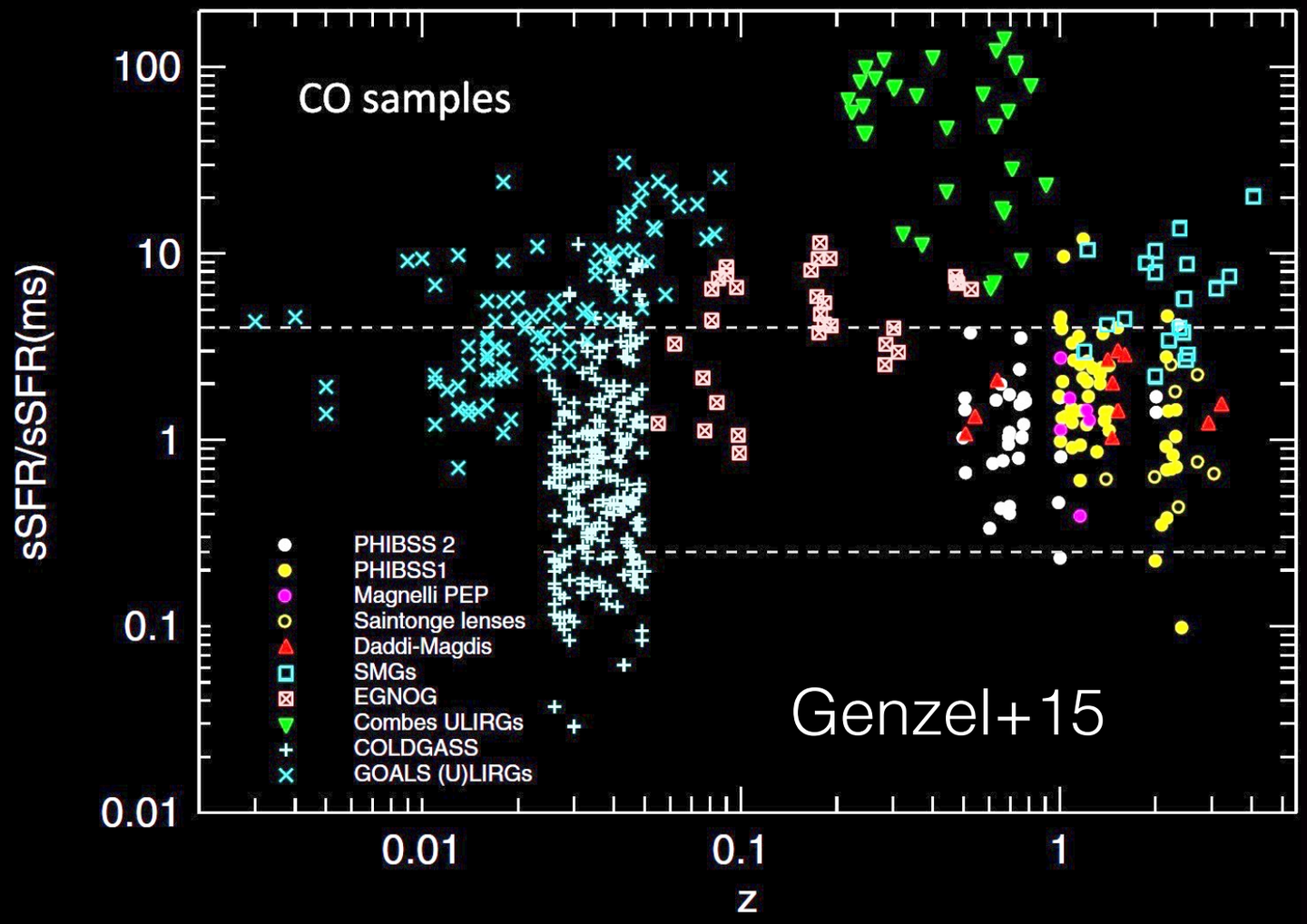
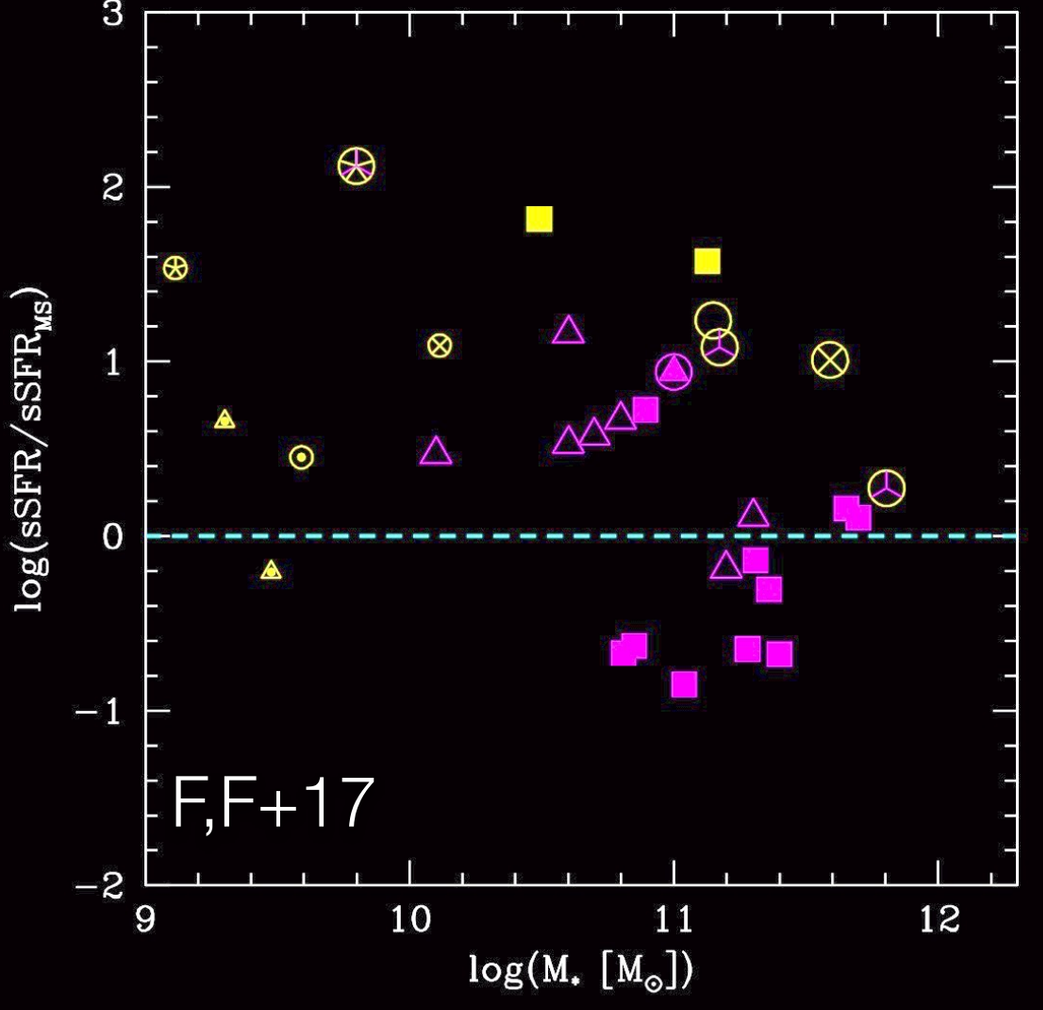


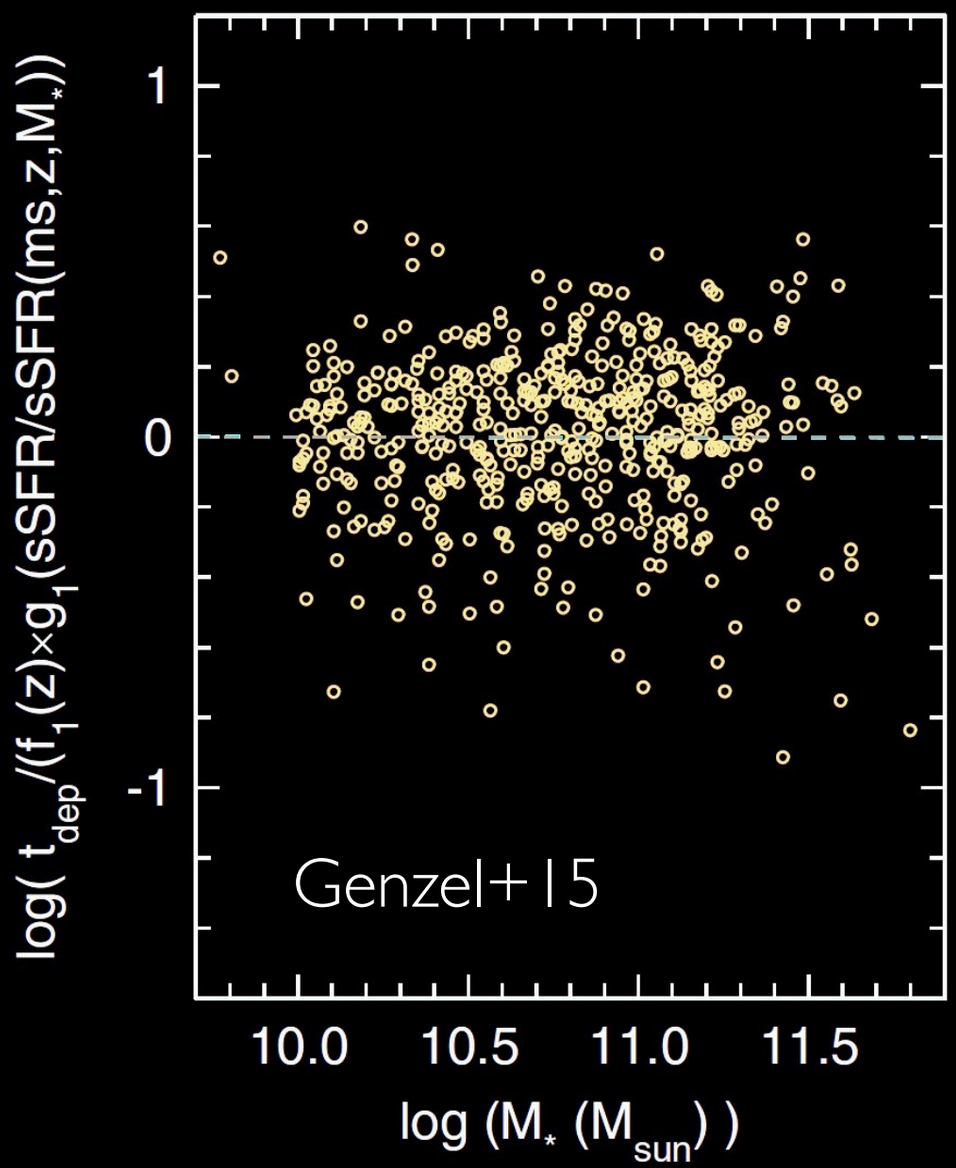


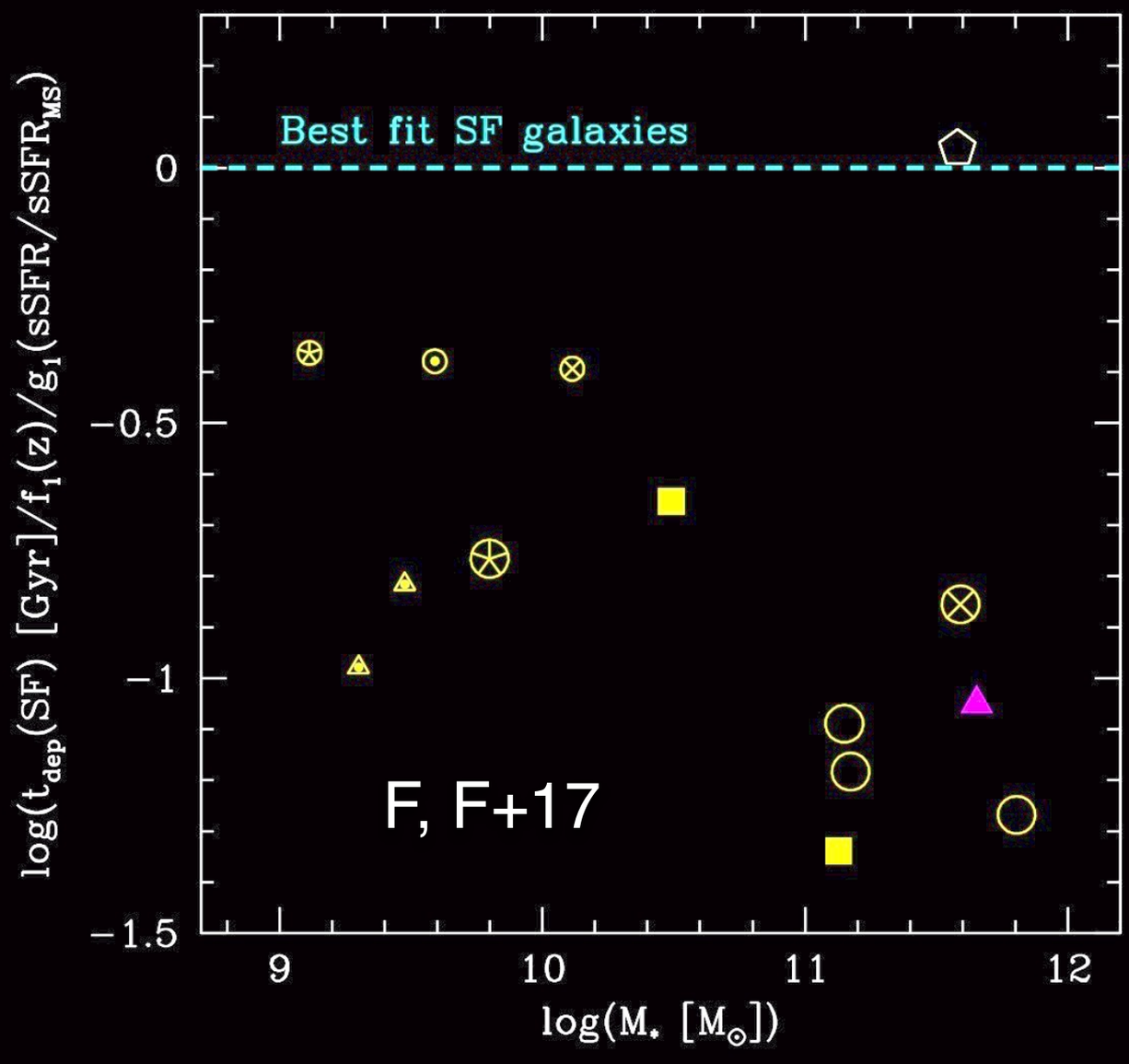
Heterogeneous sample:

Molecular winds in local (U)LIRGs and nearby Seyfert galaxies.

Most ionized winds in z~2 AGN

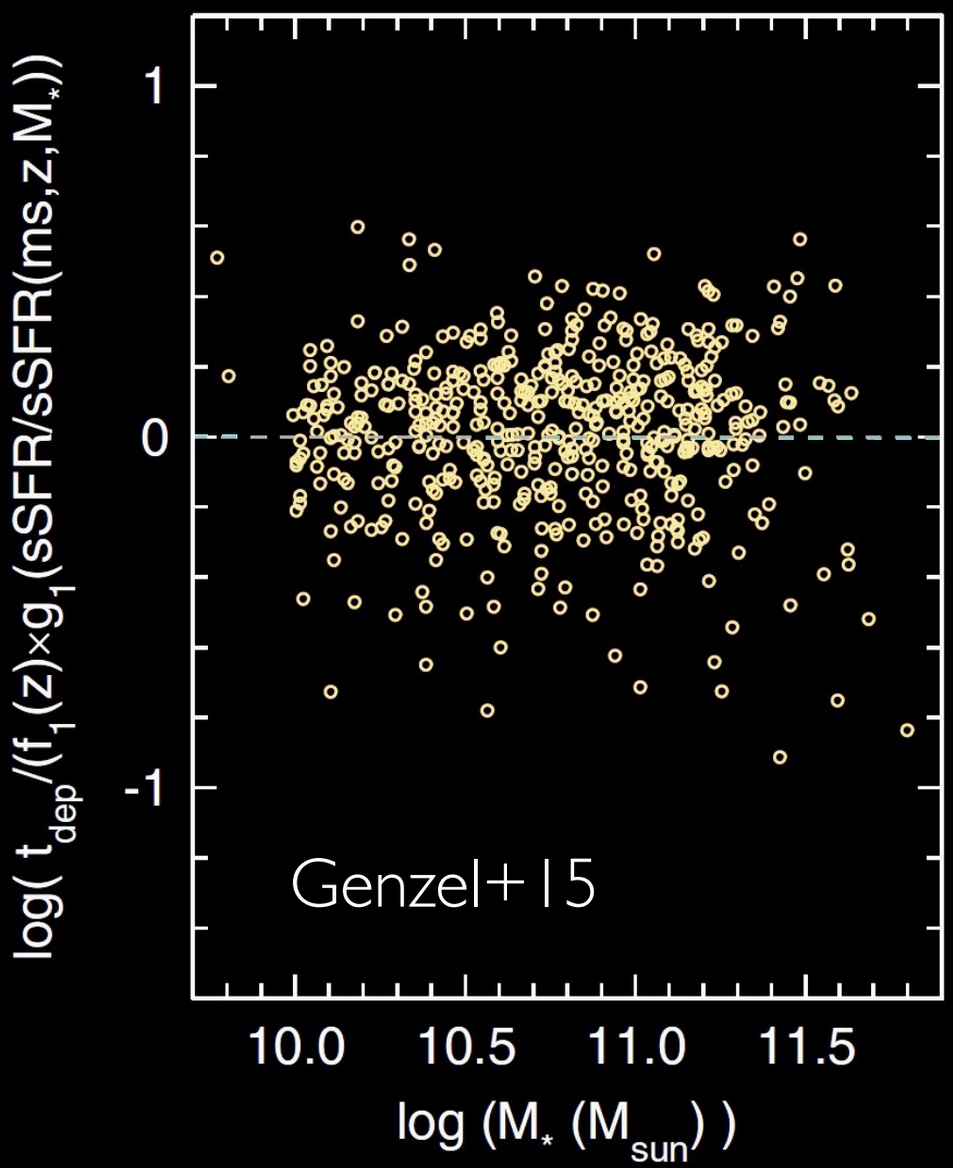
AGN wind scaling relations

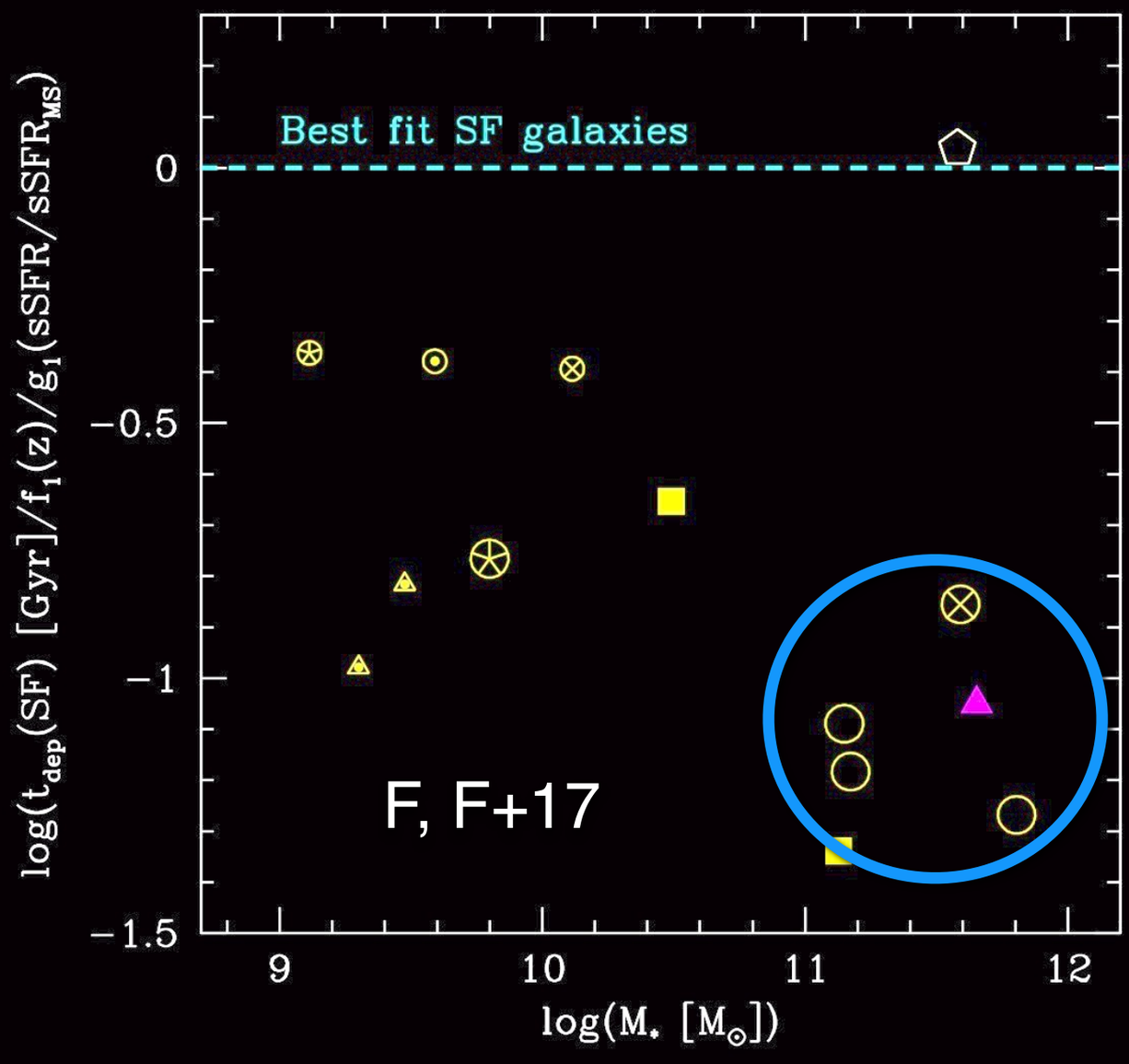




Gas depletion timescale (M_{gas}/SFR) normalised for trends with z and offset from galaxy main sequence

AGN wind scaling relations

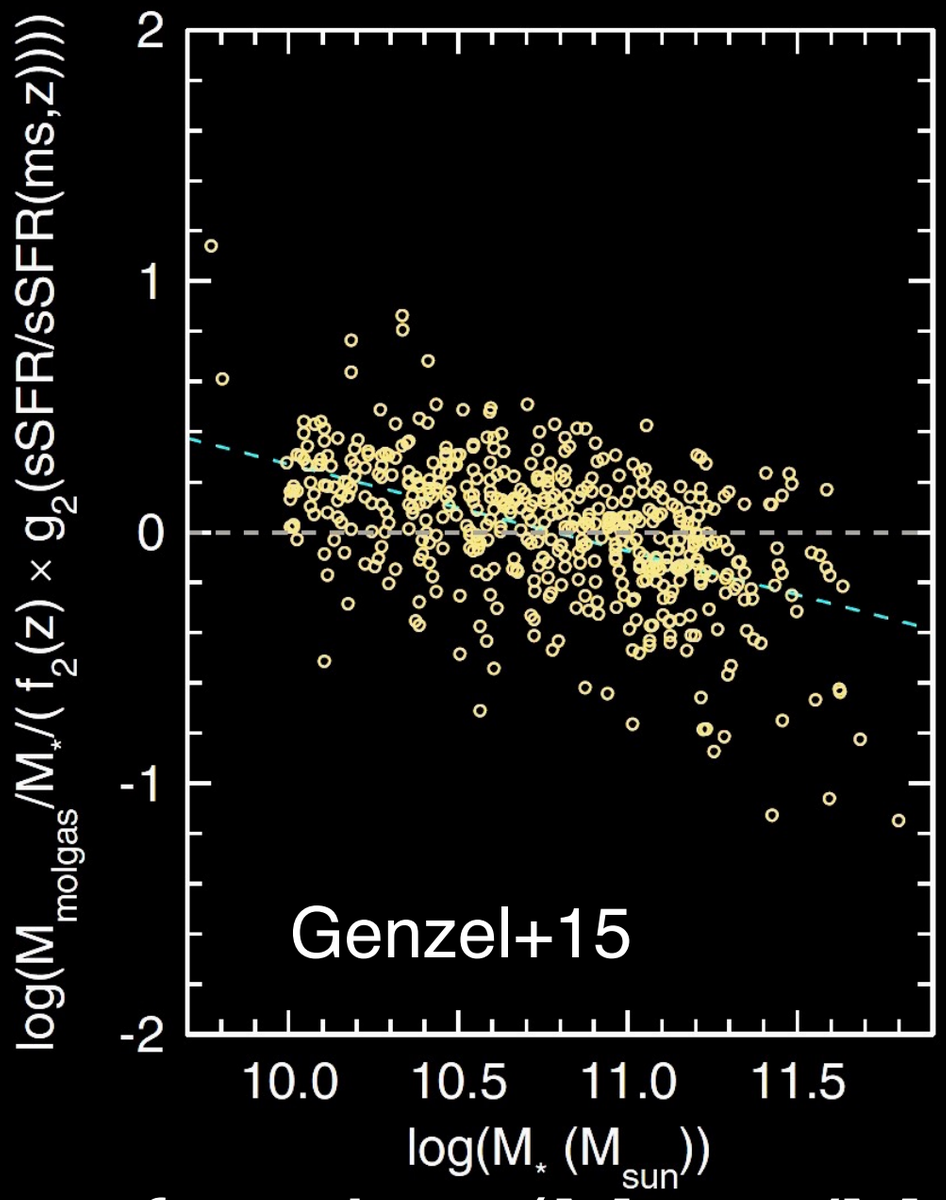


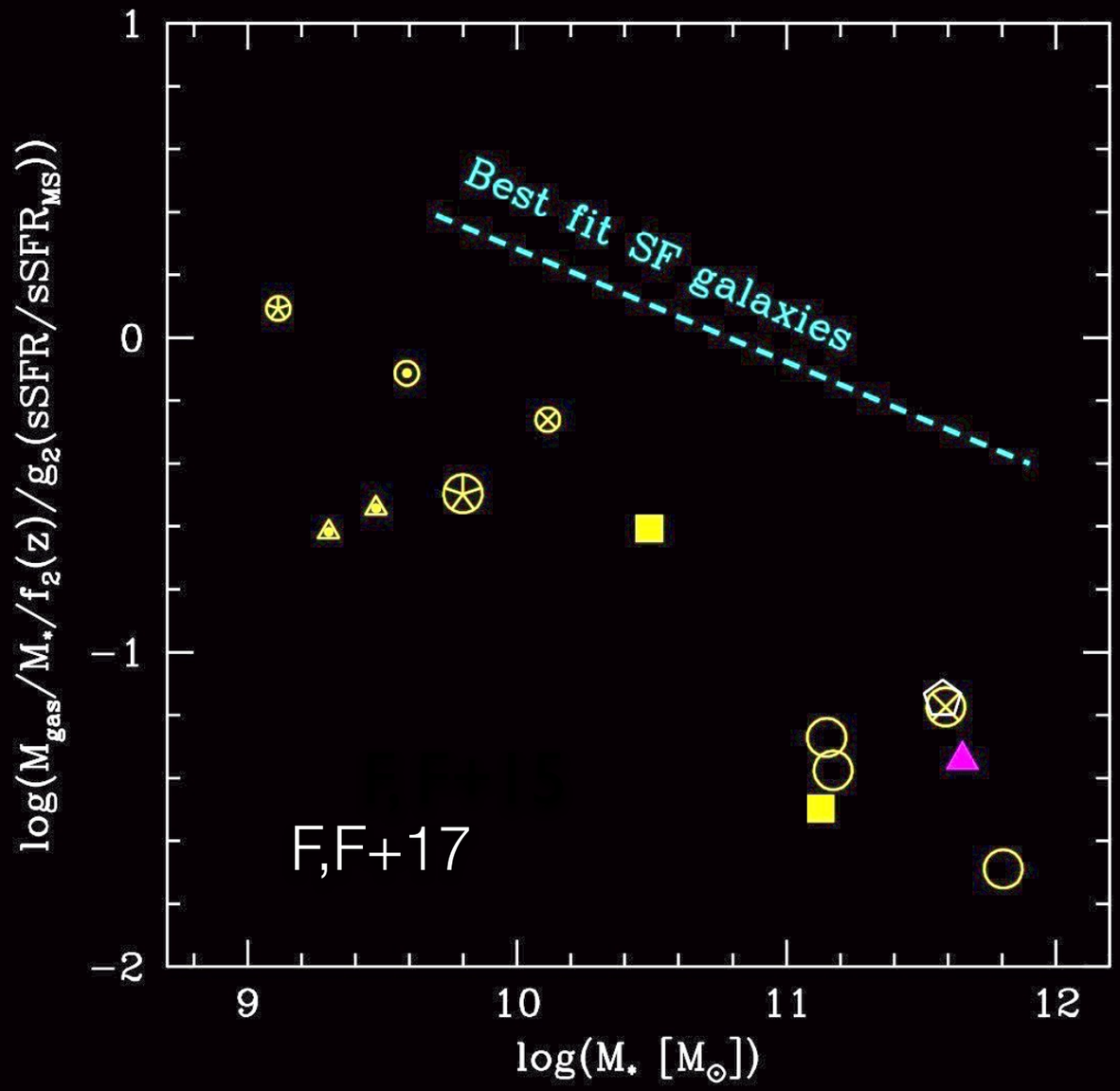


Gas depletion timescale (M_{gas}/SFR) normalised for trends with z and offset from galaxy main sequence

t_{dep} ~3-30 times shorter than average at high M_*

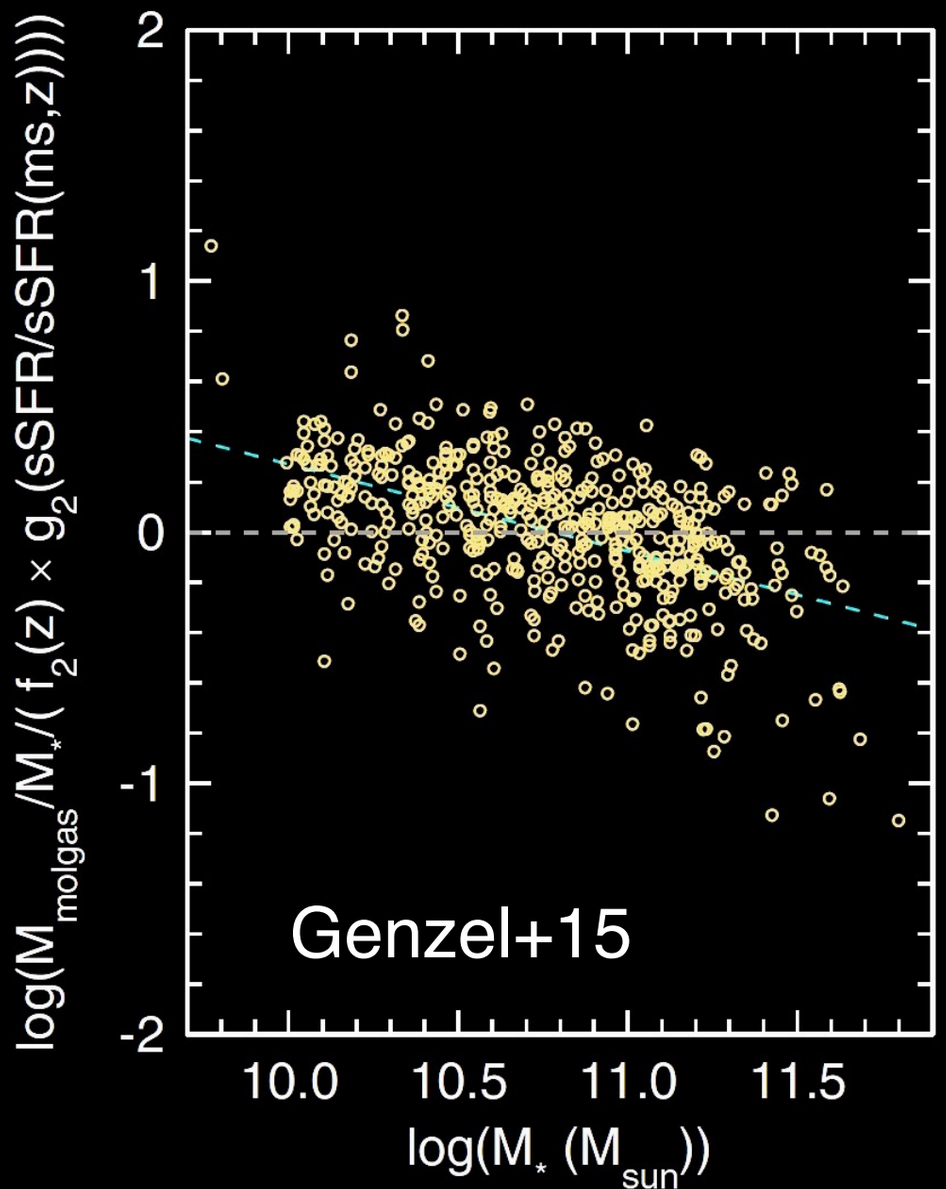
AGN wind scaling relations

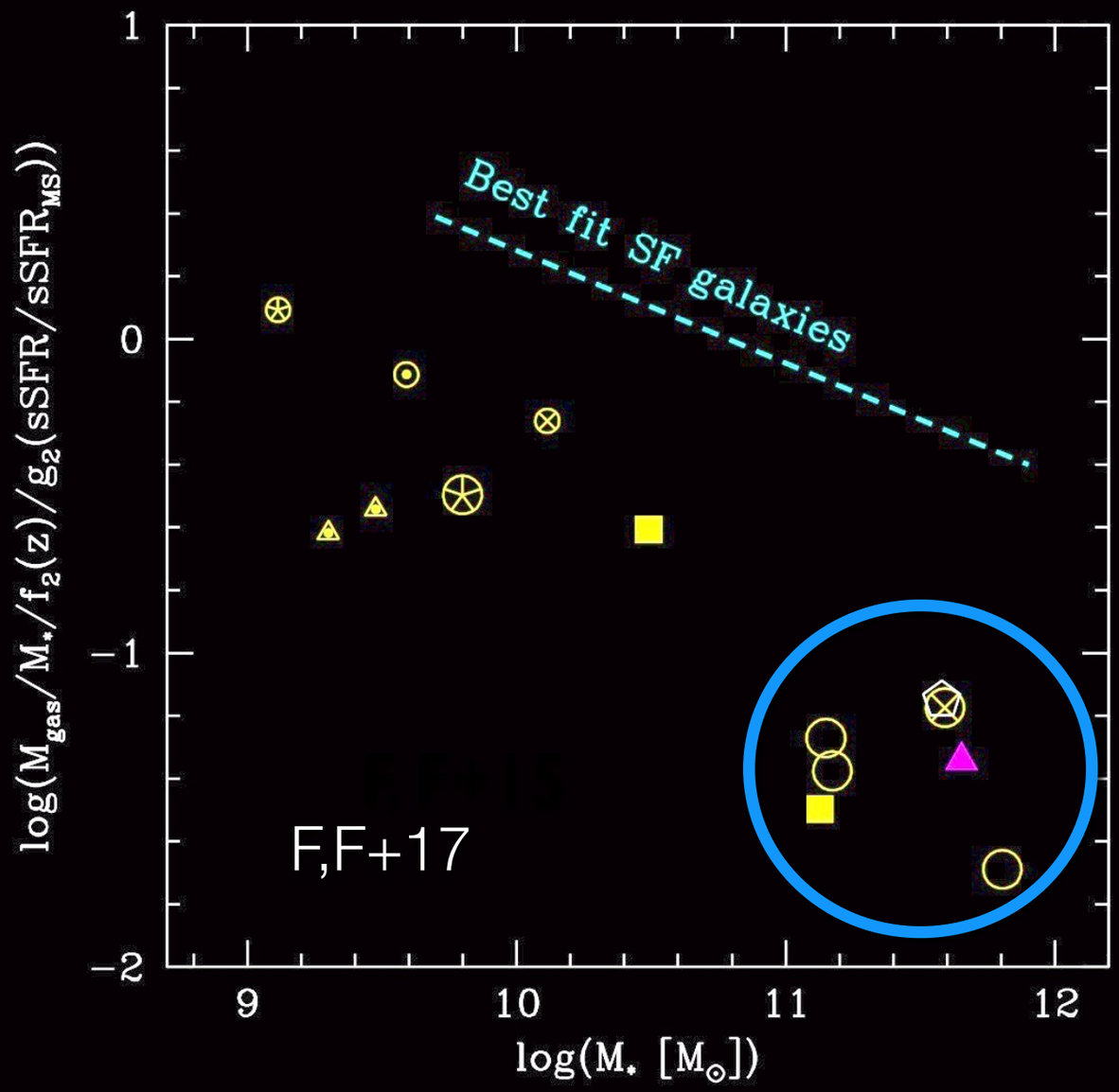




Gas fraction (M_{gas}/M_*) normalised for trends with z and offset from galaxy main sequence

AGN wind scaling relations



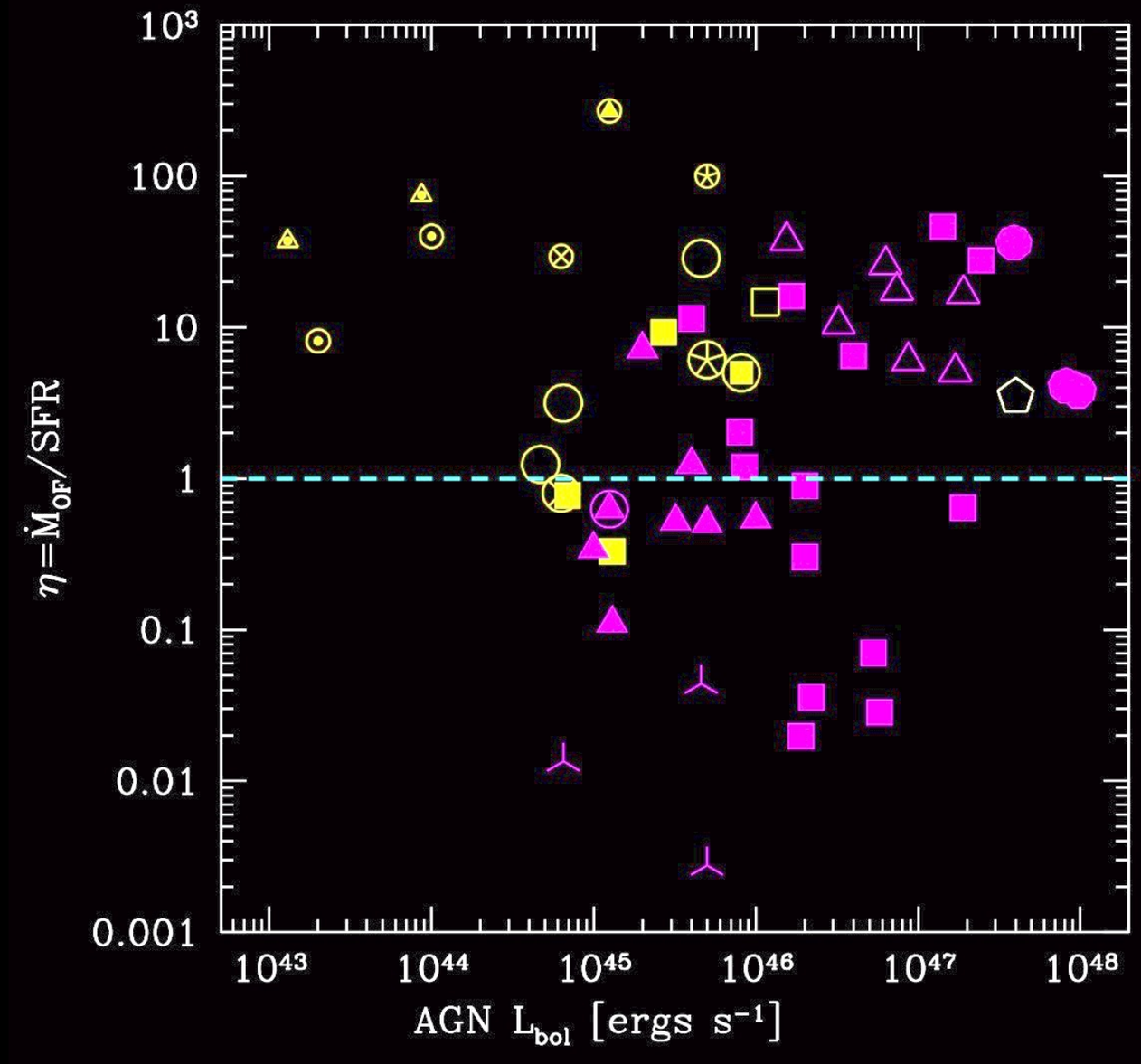


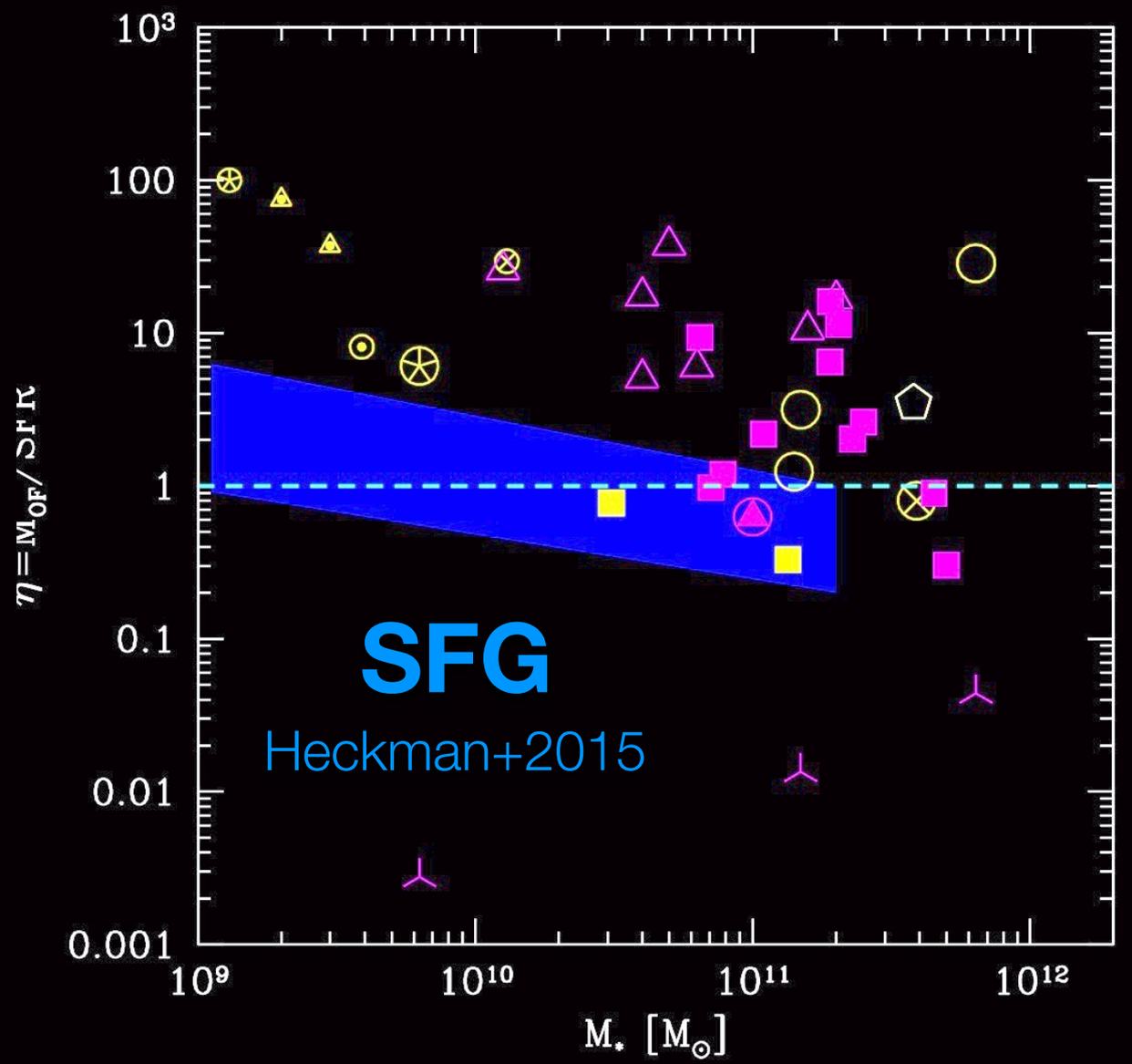
Gas fraction (Mgas/M*) normalised for trends with z and offset from galaxy main sequence

Gas fraction 3-20 times smaller than average at high M*

AGN wind loading factor

$\eta = dM_{OF}/dt/SFR$



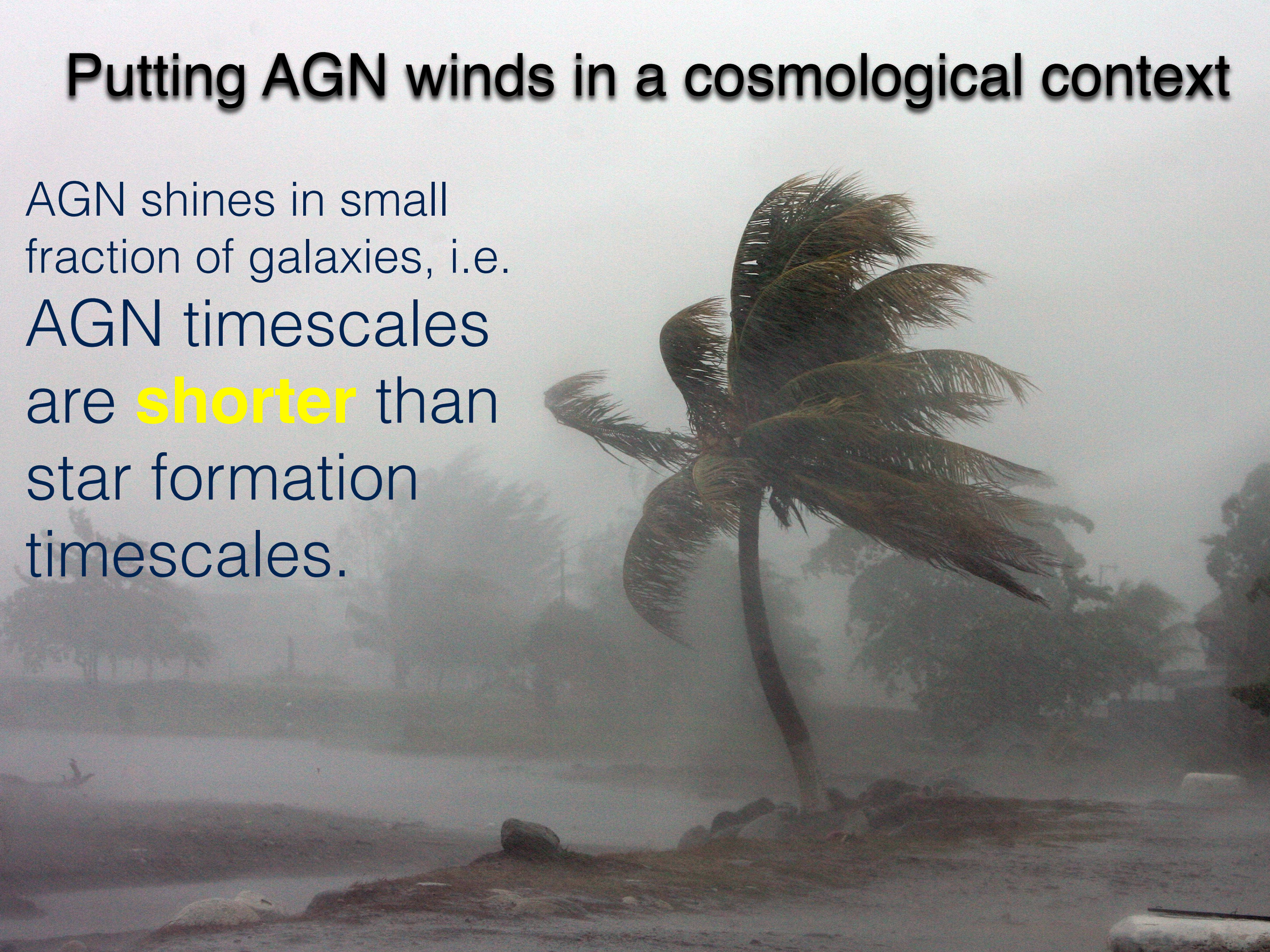


Putting AGN winds in a cosmological context

Putting AGN winds in a cosmological context

AGN shines in small fraction of galaxies, i.e.

AGN timescales are **shorter** than star formation timescales.



Putting AGN winds in a cosmological context

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July 17, 2001


August 31, 2005

Putting AGN wind in a cosmological context

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Weight AGN loading factor $\eta = dM_{OF}/dt/SFR$
for the AGN duty cycle:

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Difficult. dM_{OF}/dt and SFR in single objects

Putting AGN wind in a cosmological context

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for the AGN duty cycle:

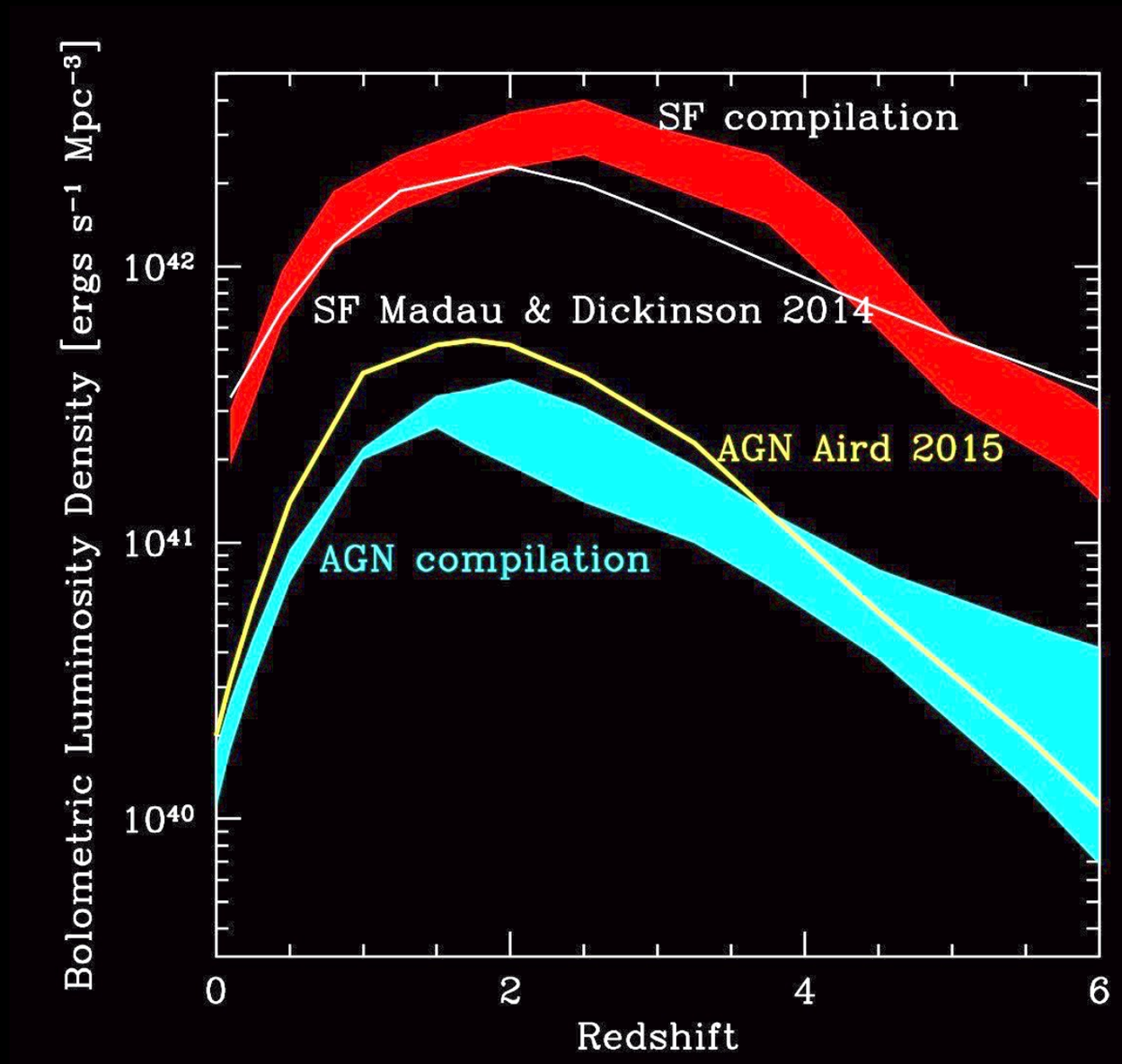
$\langle\eta\rangle = \langle dM_{OF}/dt/SFR\rangle$

Difficult. dM_{OF}/dt and SFR in single objects

$\langle\eta\rangle \sim \langle dM_{OF}/dt\rangle / \langle SFRD\rangle$
assuming AGN wind scaling relations

Putting AGN wind in a cosmological context

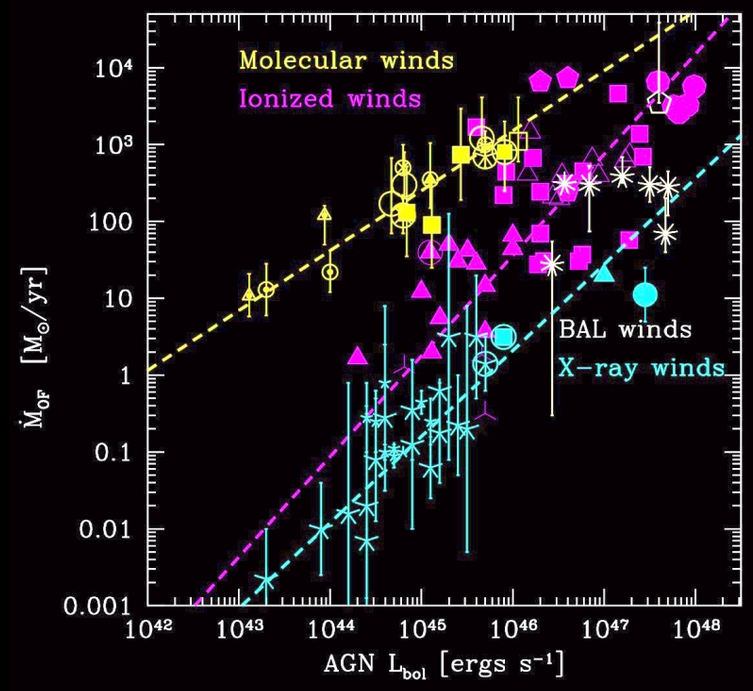
AGN & galaxy luminosity densities



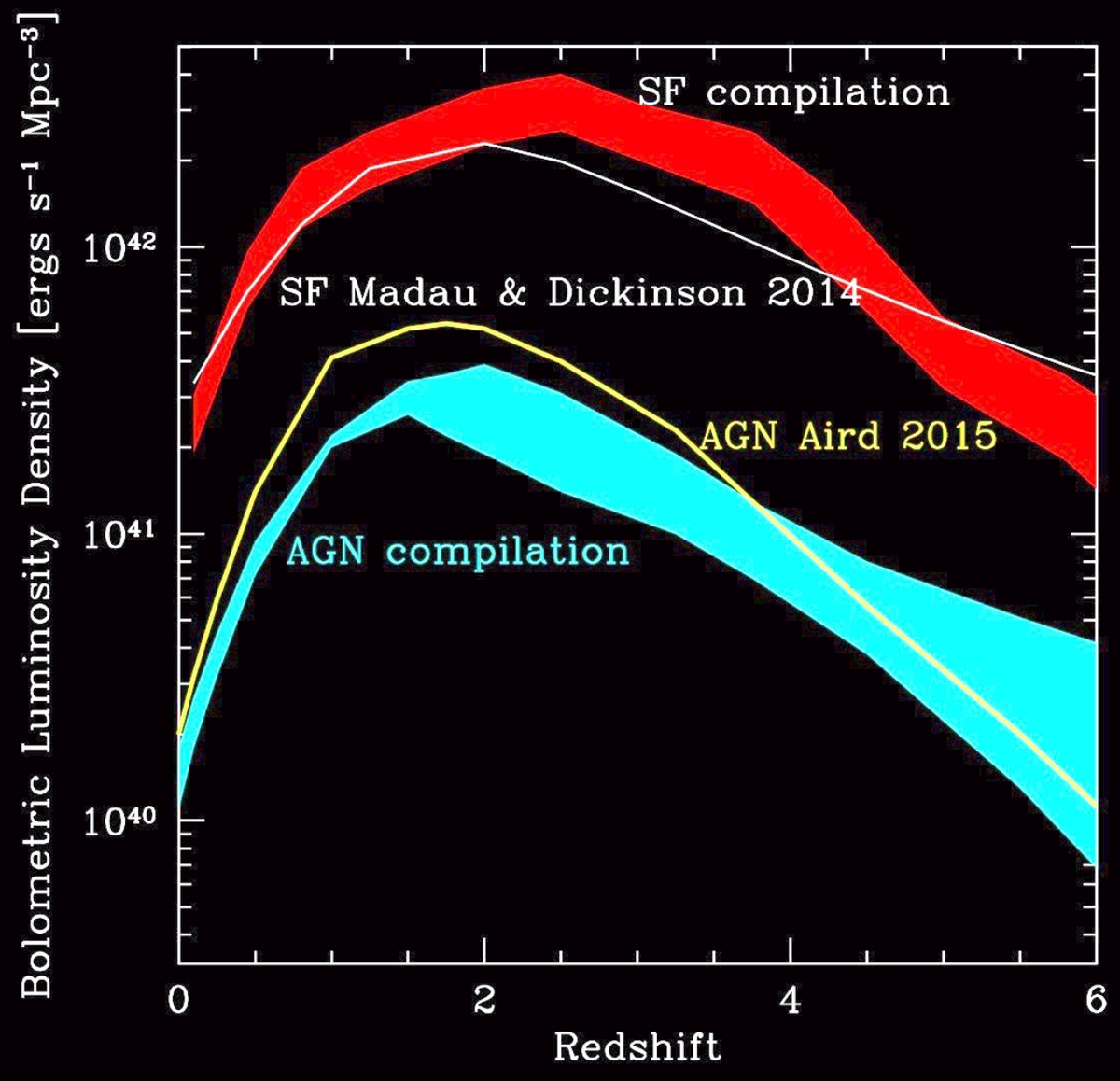
Putting AGN wind in a cosmological context

AGN & galaxy luminosity densities

Fold AGN mass outflow rate



with AGN luminosity density, divide by SFR density



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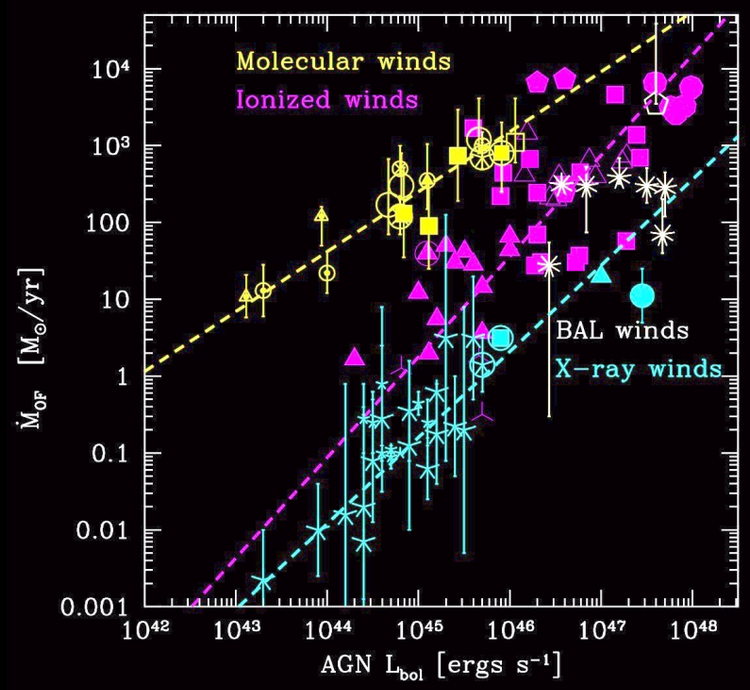
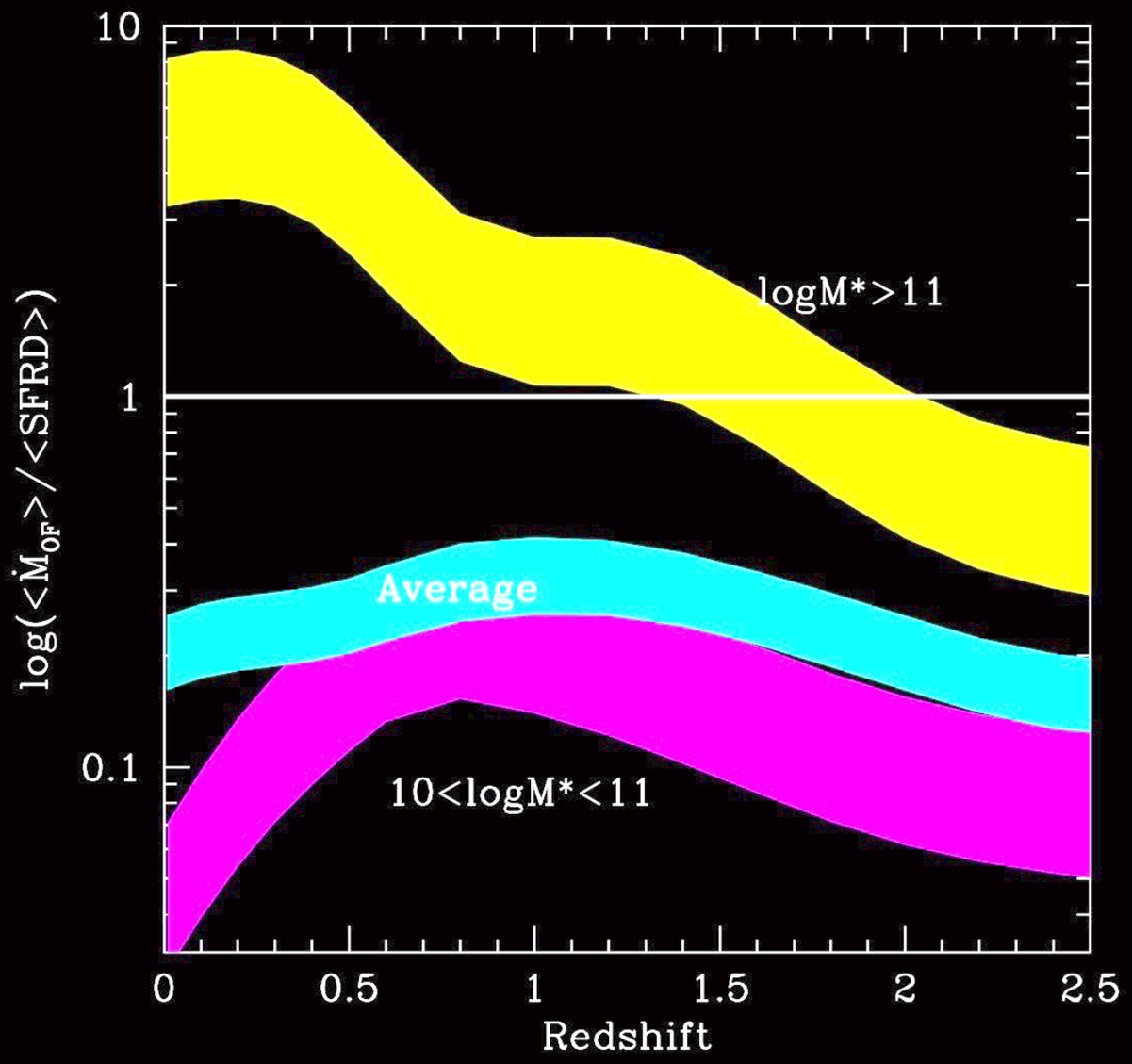
AGN & galaxy luminosity densities

Fold AGN mass outflow rate



with AGN luminosity density, divide by SFR density



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Speculation: 1+2 increasing fraction of ionised/molecular gas in winds: molecule in massive galaxies hosting powerful AGN are gradually destroyed in the wind

Summary 2

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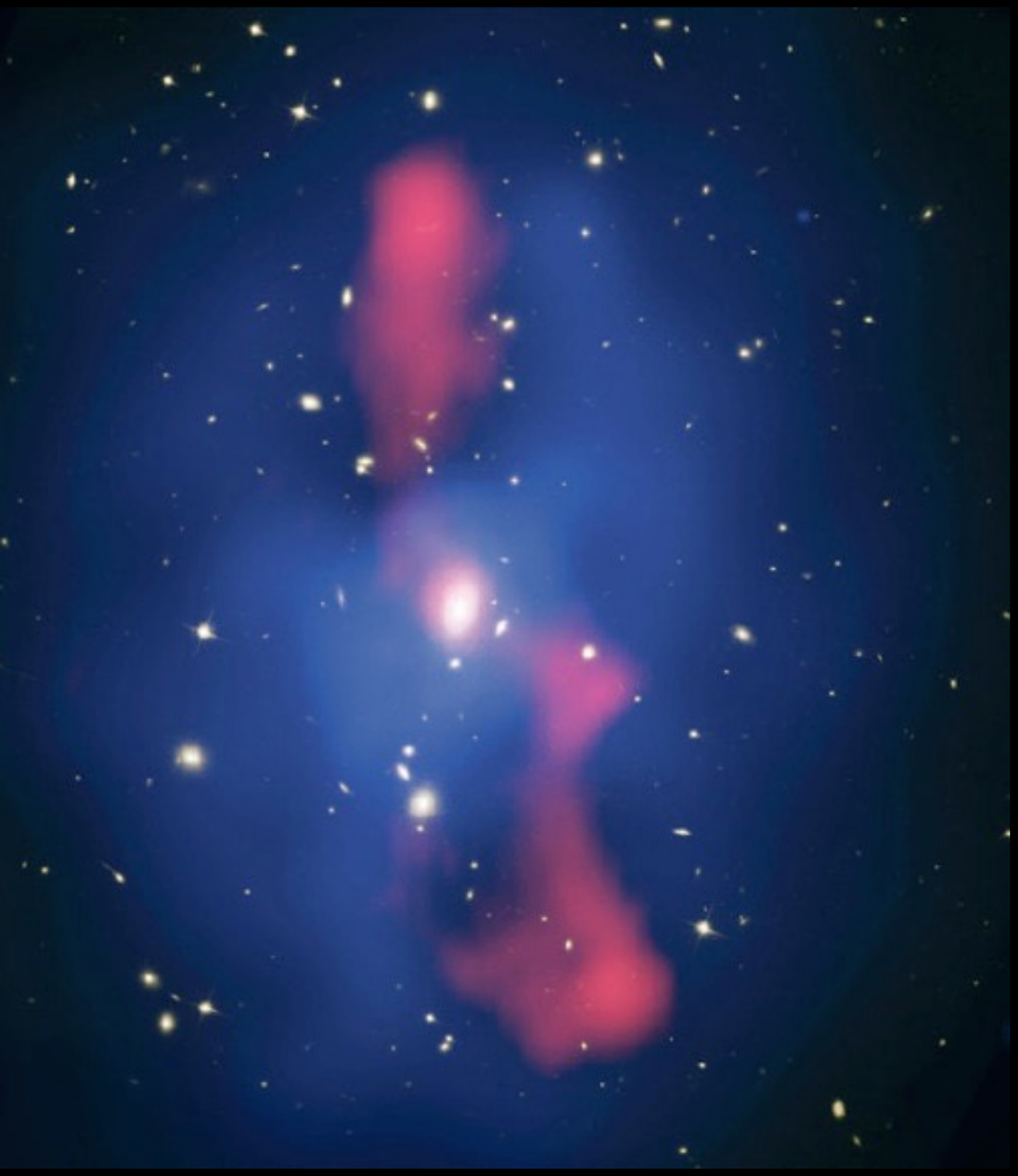
Feedback: galaxy ***growth hormone***
"regulates and modulates galaxy and BH growth"

Radio-mode feedback



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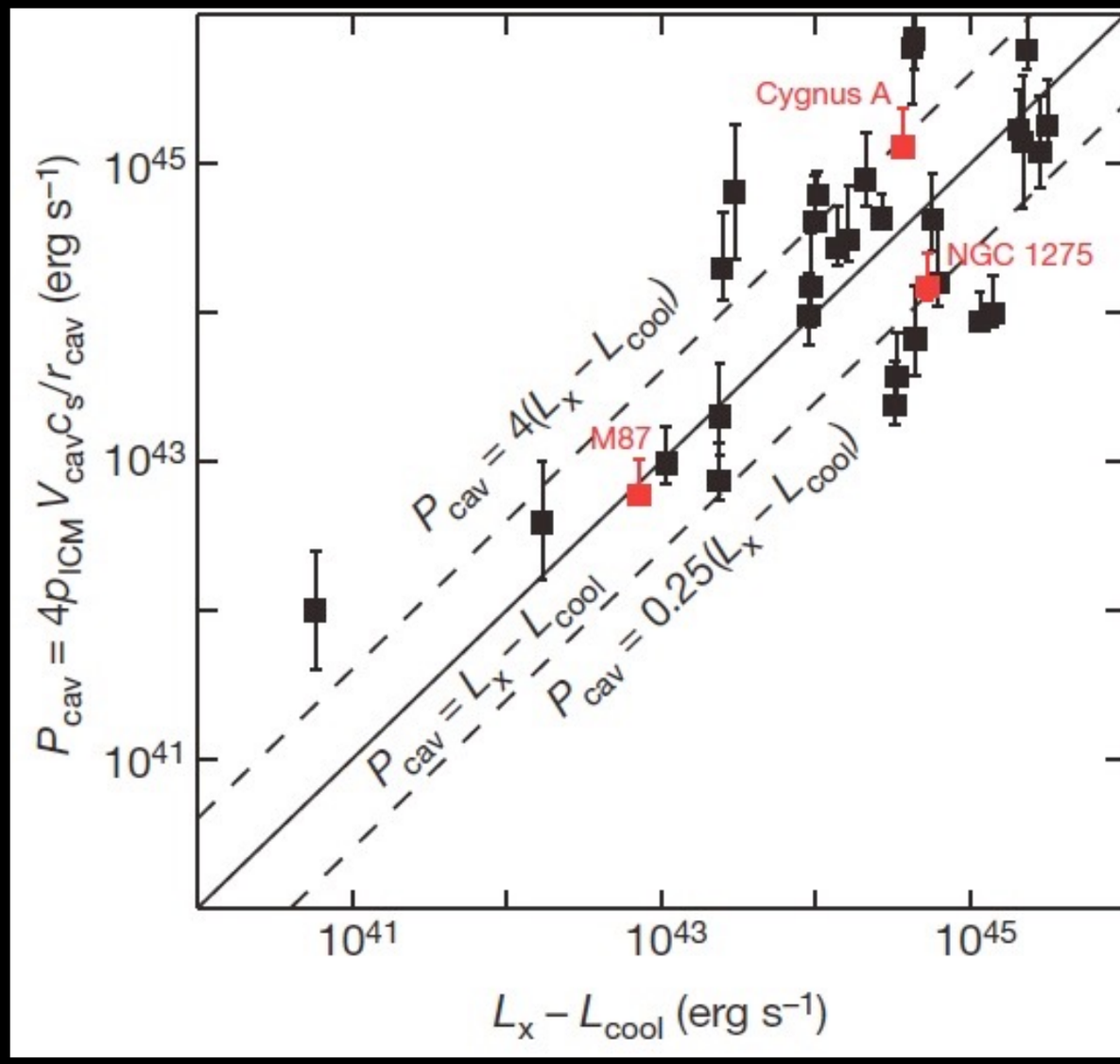

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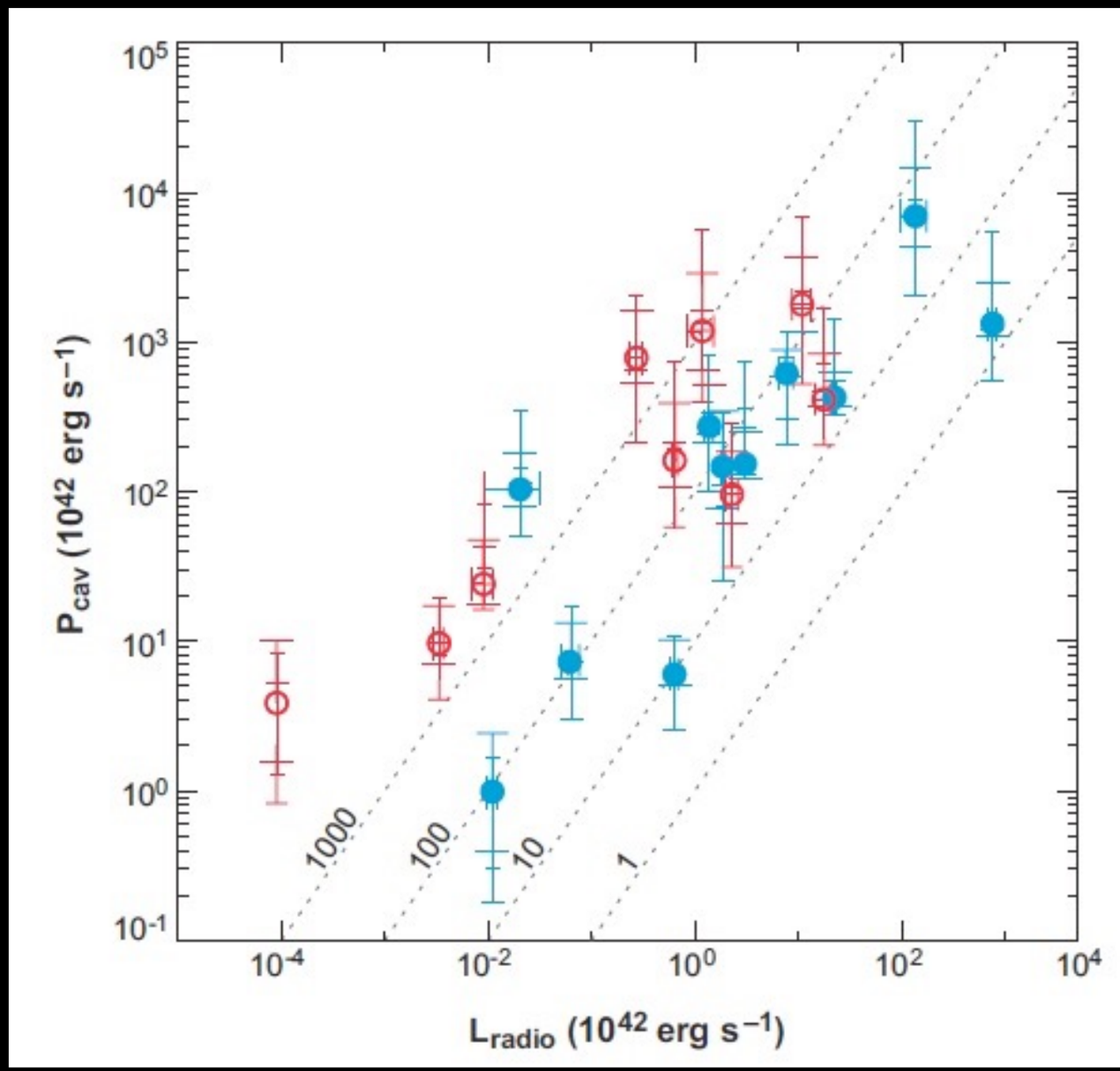
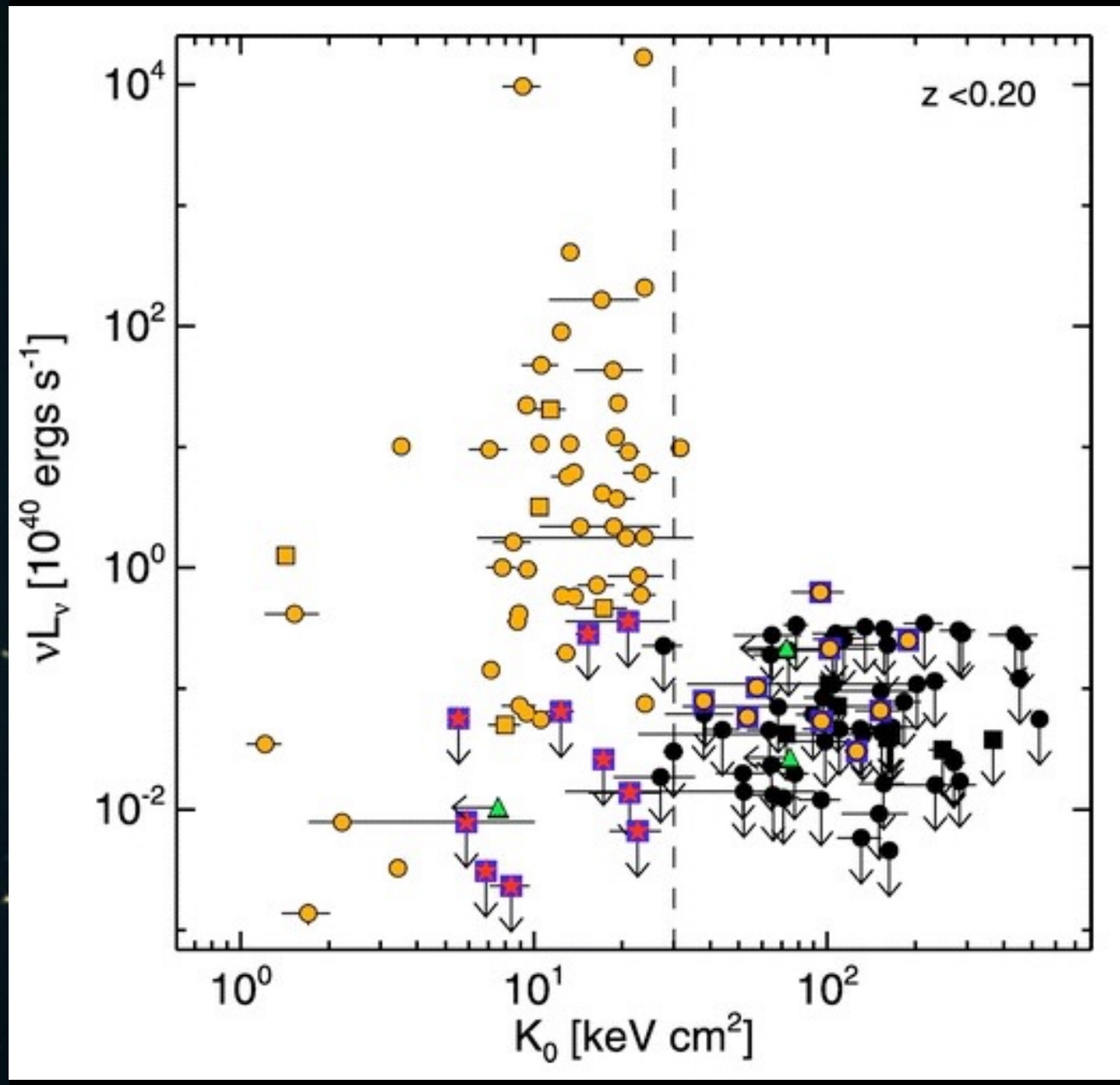


Radio-mode feedback

Power to excavate cavities ∝ L_X

Power in cavities ∝ L_R

AGN only in BCGs with *low inner entropy:* **cold accretion**



Radio-mode feedback

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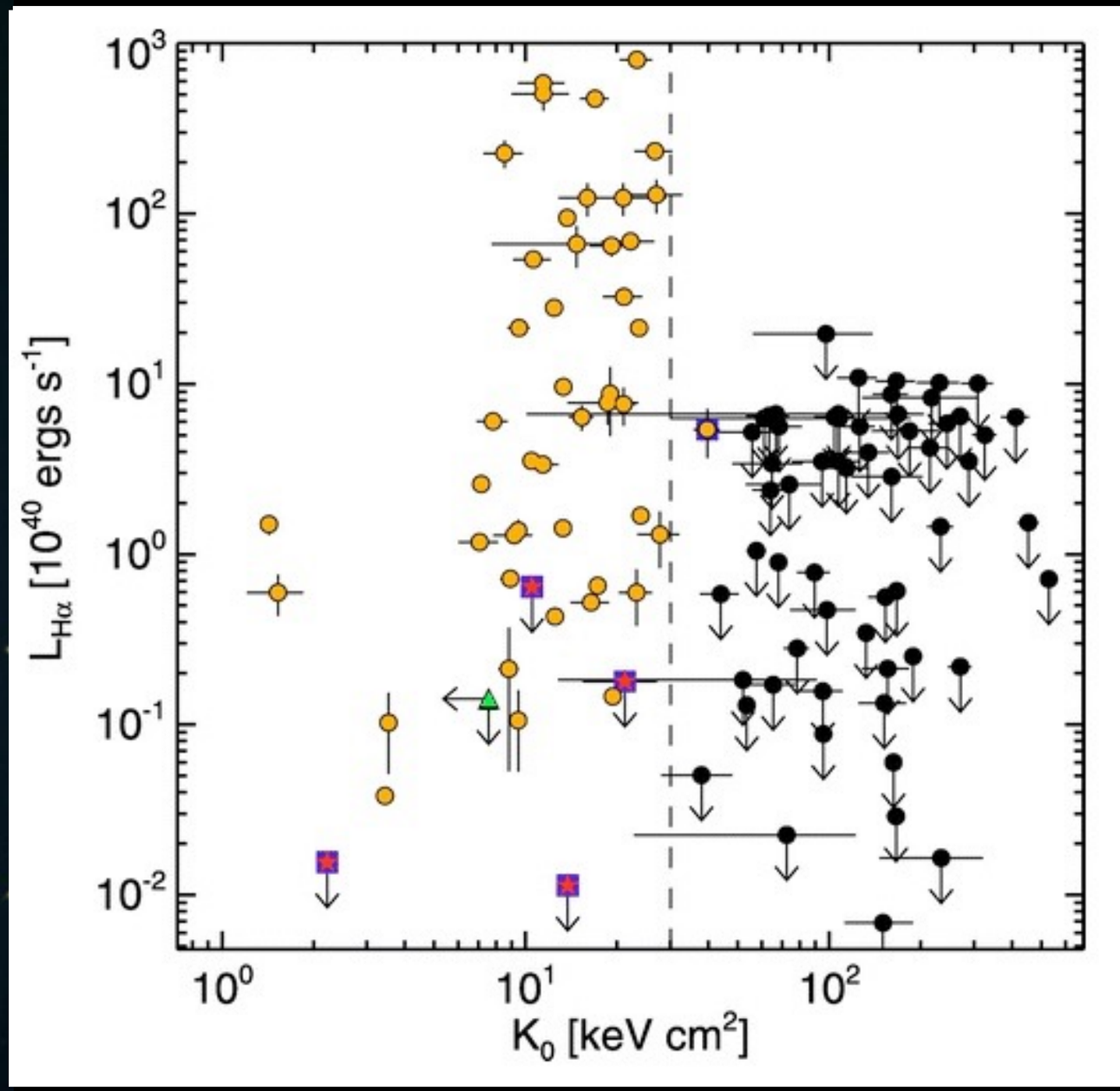
BCGs with low inner entropy & AGN are **forming stars**

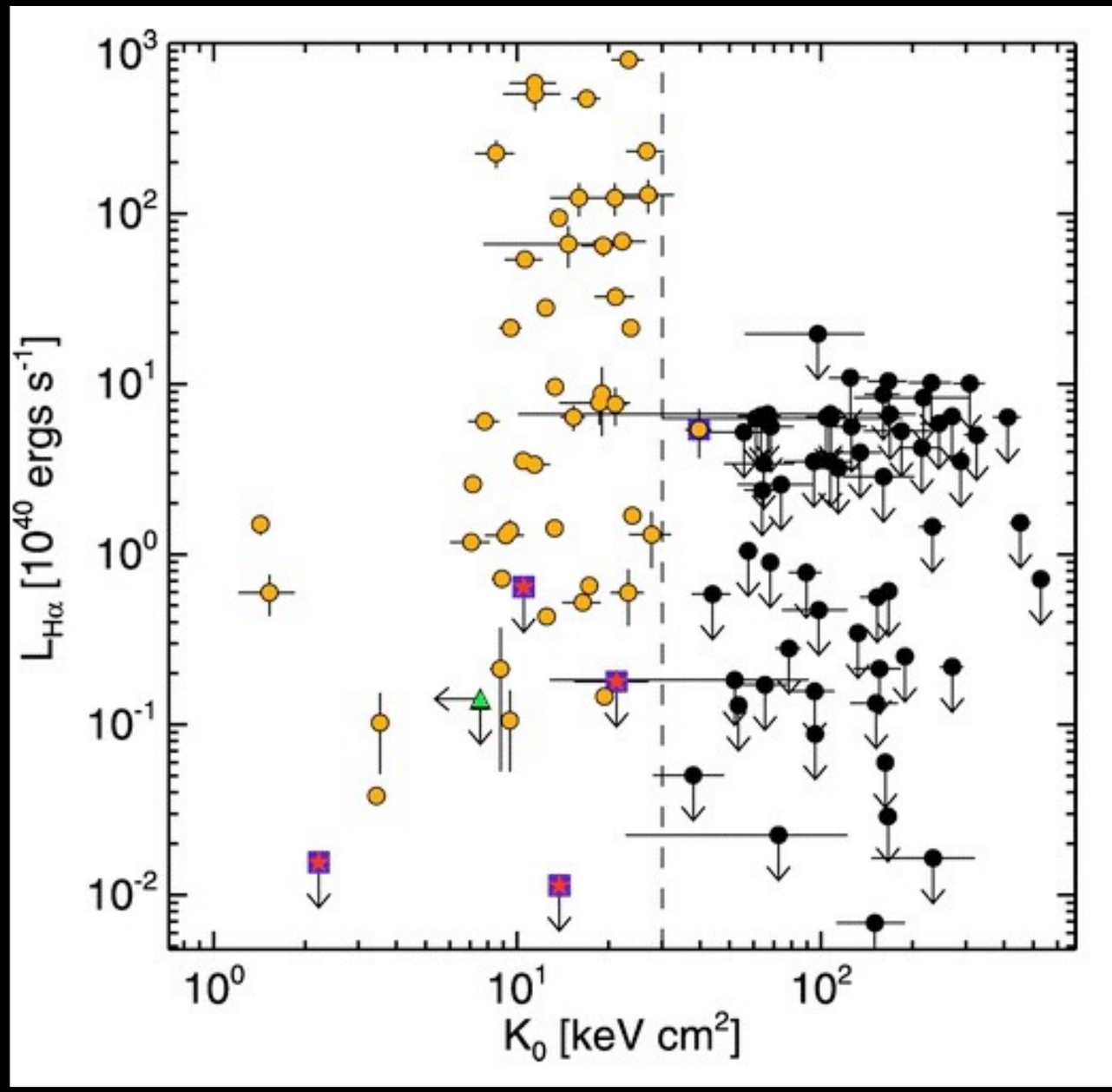


Radio-mode feedback

A delicate feedback mechanism:

"*AGN input energy regulates the gas entropy and, in turn, further gas accretion and SF (stars can form from low entropy, cold and dense gas only).*"

Voit & Donahue 2014



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we need to test them on blind/unbiased samples:
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Thanks..!