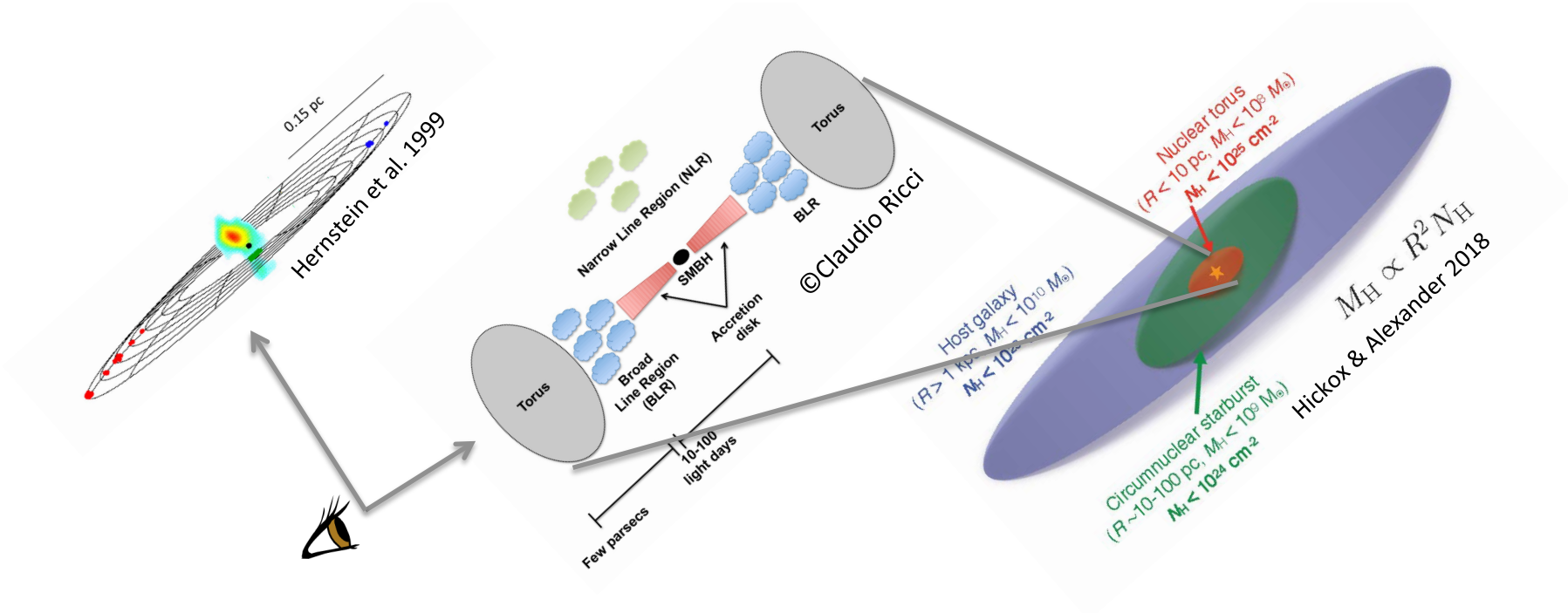

Probing the Nature of the Obscuring Torus via Megamaser Activity

Anca Constantin

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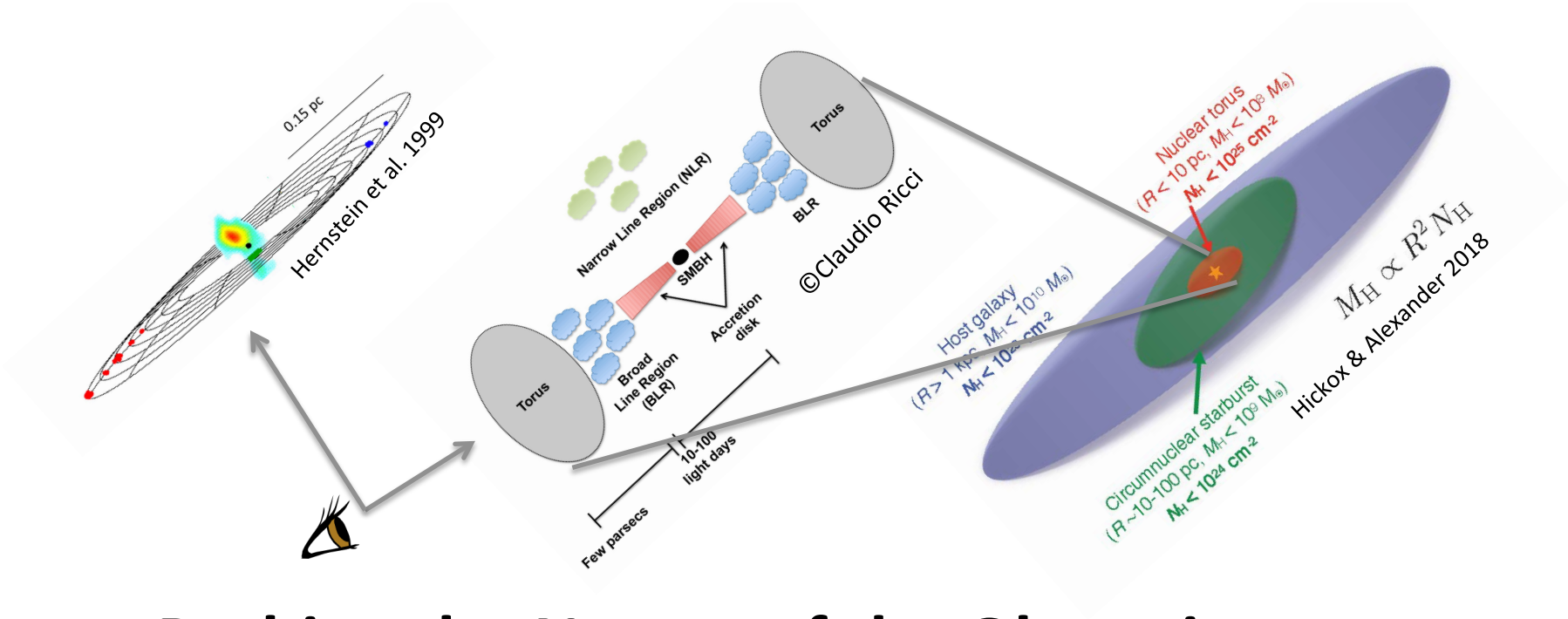
Chengyu Kuo (Sun Yat-Sen Univ.), Jim Braatz (NRAO), C. A. Witherspoon (JMU/UWisconsin), D. Pesce (UVa/NRAO) , Violette Impellizzeri (NRAO), and MCP



Probing the Nature of the Obscuring Torus via Megamaser Activity

- Can we identify host galaxy traits that betray the megamaser emission?
  - => Increase the megamaser detection rate.
  - => learn about peculiar conditions conducive to maser-disk emission:
    - Are megamaser disks always related to obscured AGNs?

Megamaser disks: amazing tools but scarce

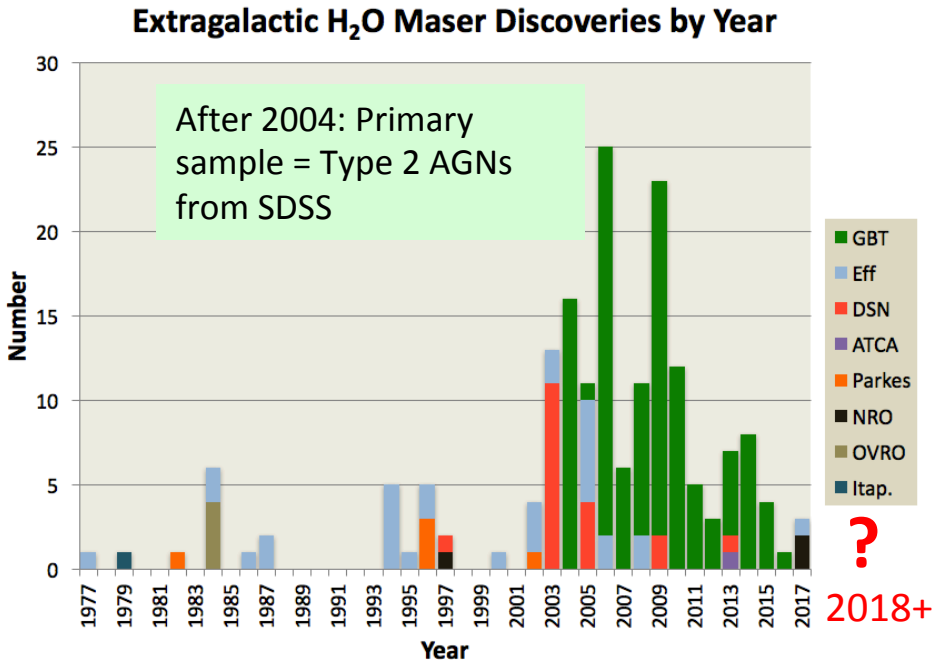
- Direct (geometric) extragalactic distances
  - Does not rely on external calibrations or a distance ladder
  - constrain H_0 & nature of Dark Energy
- Gold standard for SMBH masses
  - $\delta M_{BH} < 10\%$ (dominated by uncertainty in host distance)
  - Constrain BH occupation fraction.
- Direct probe of the sub-pc environments of AGNs.
  - T, density, pressure, accretion efficiency, properties of obscuring torus, etc.

Megamaser Cosmology Project (MCP):

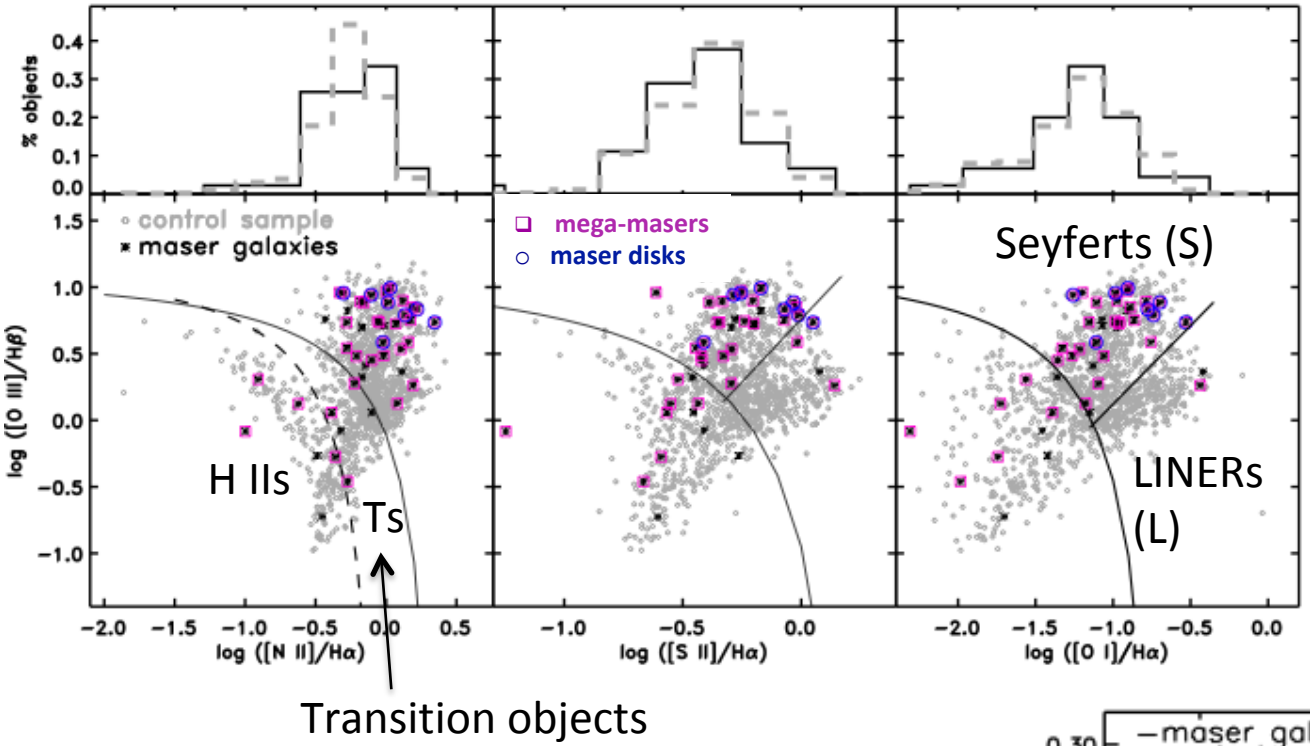
~180 water maser galaxies (~3% of all surveyed)

➢ 20% in disk-like configuration

(< 1% of all surveyed)



Optical Spectral type comparison

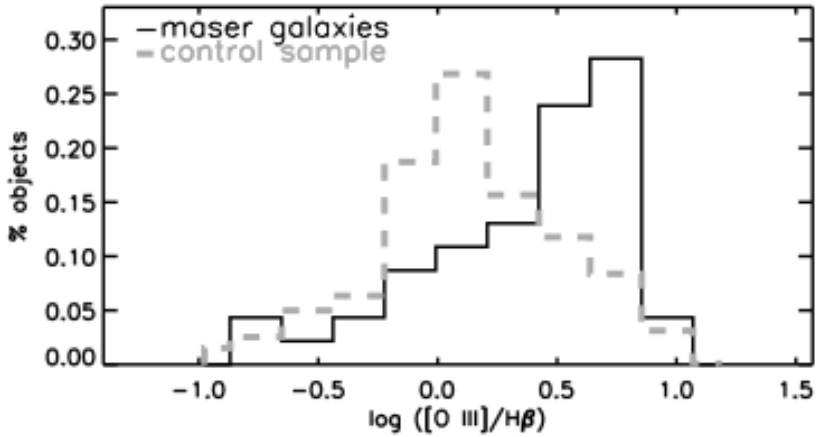


Transition objects

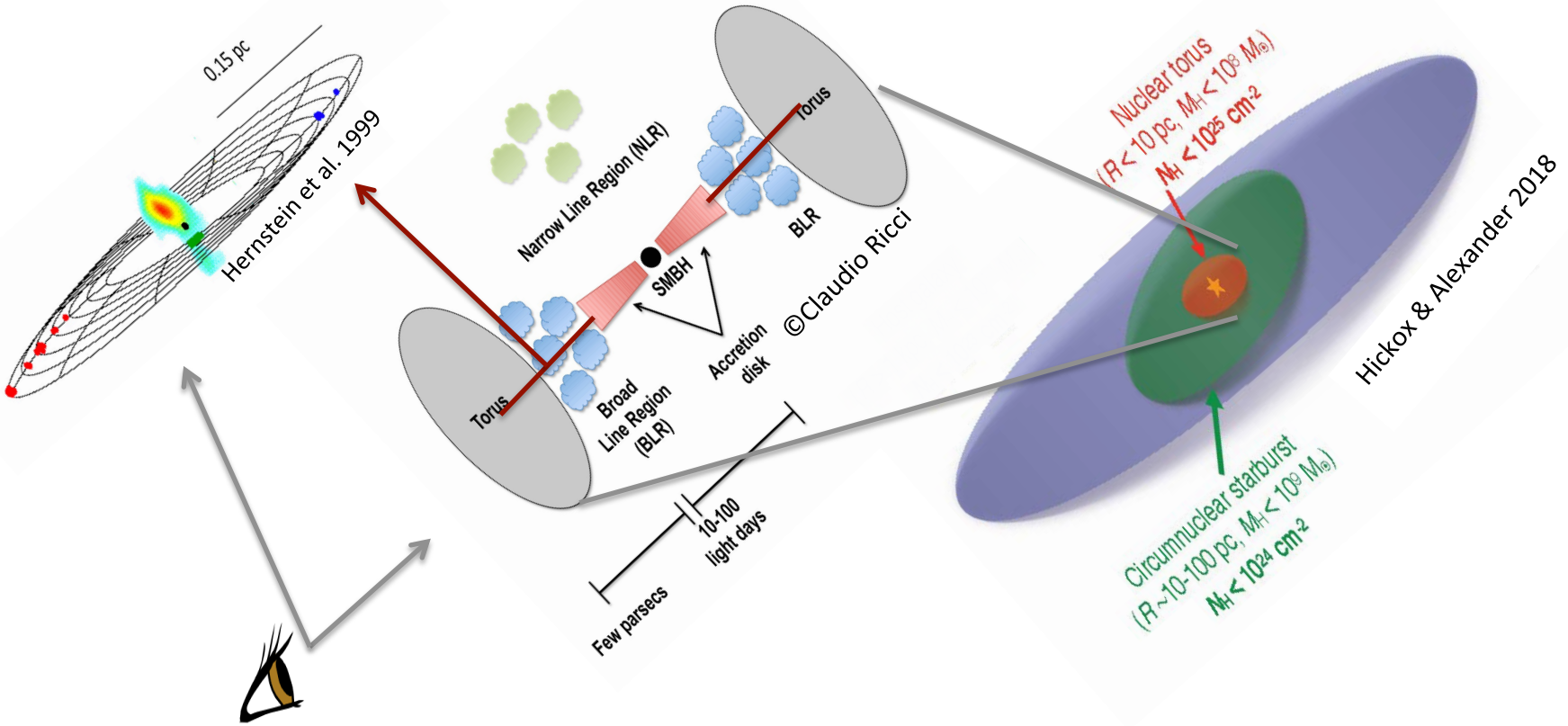
- Very similar line-diagnostic diagrams for the **maser** and **control** samples.

Mega-maser: $L_{H2O} > 10L_{\odot}$

- [O III]/Hβ is higher in maser galaxies.
  -- Explained by the sheer fraction of Seyfert galaxies, which is the result of survey selection.



Maser disk activity: dependent on geometry and intrinsic properties of the molecular gas.



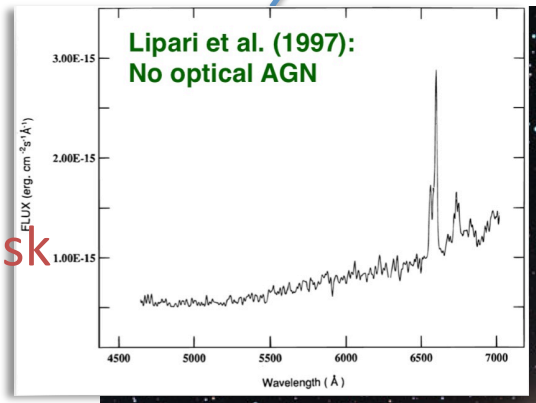
Lack of optical AGN signatures ~~=~~=> no obscured AGN

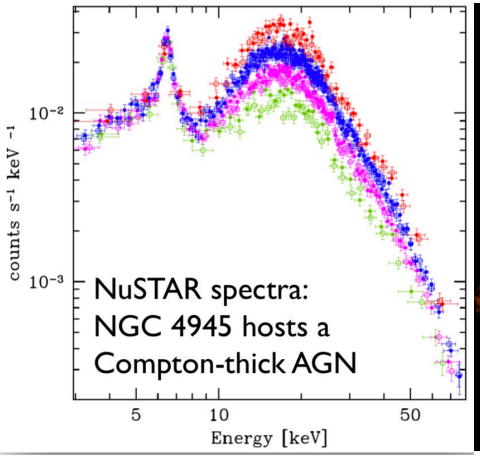
Lack of optical AGN signatures ==> no obscured AGN

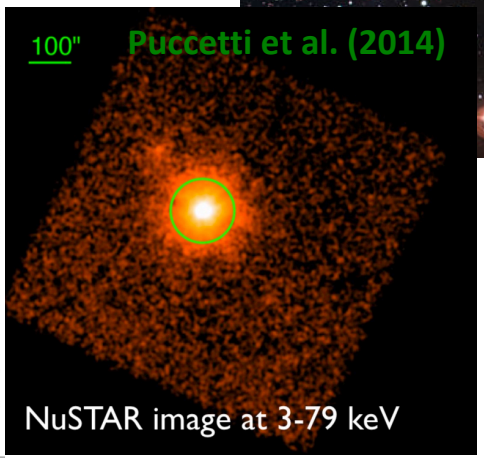
E.g., NCG 4945:

(an Scd galaxy at ~4 Mpc)

- A luminous H_2O maser disk
- Not a clear optical AGN (HII/Sy2)
- mid-IR spectrum of a starburst
- The brightest 100 keV emission in the sky!

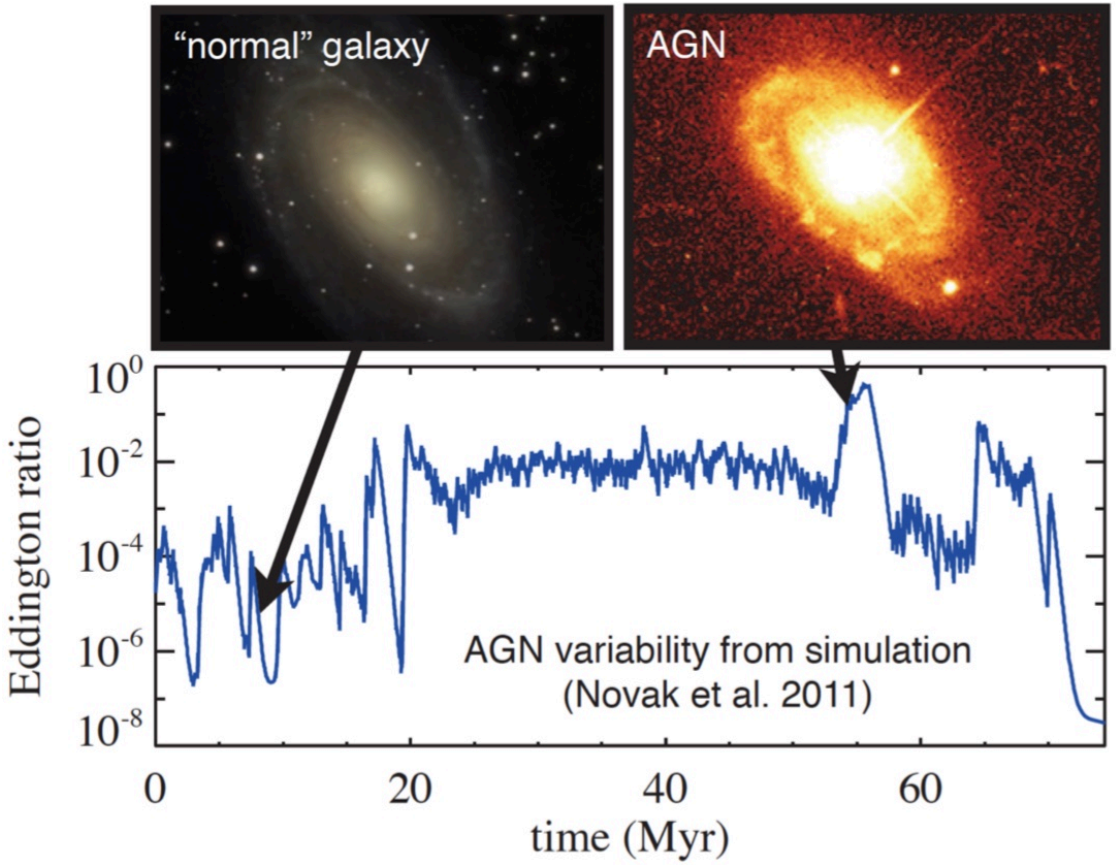






(Obscured) AGN Identification = a multi-scale, multi-component, multi-wavelength CHALLENGE

1. Variability: AGN signatures can disappear/appear



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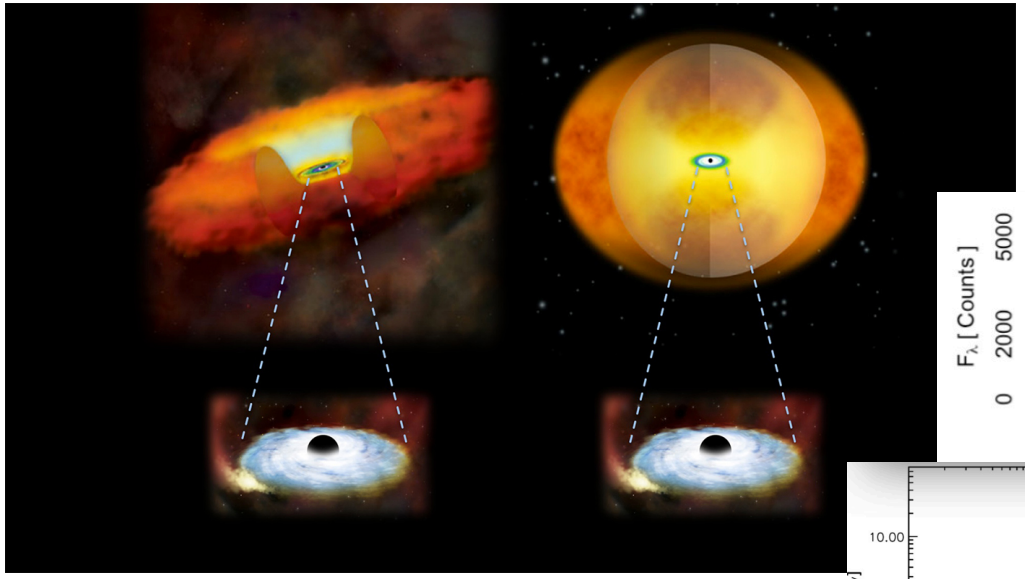
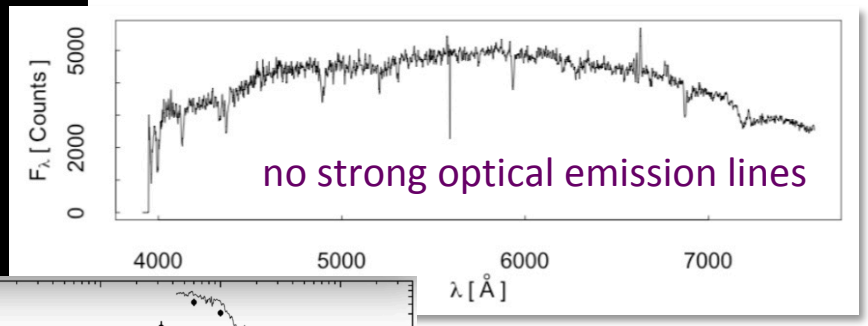
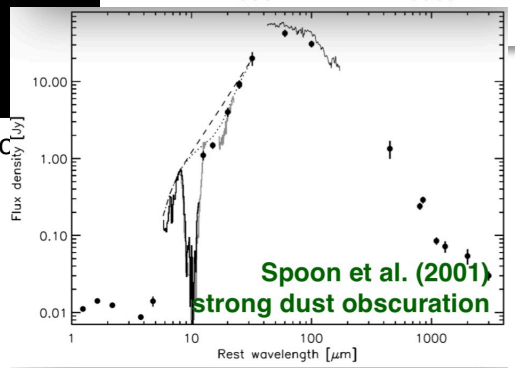


NASA/CXC/M.Weiss/National Astronomical Observatory C

NGC 4418: spherical obscuration example?





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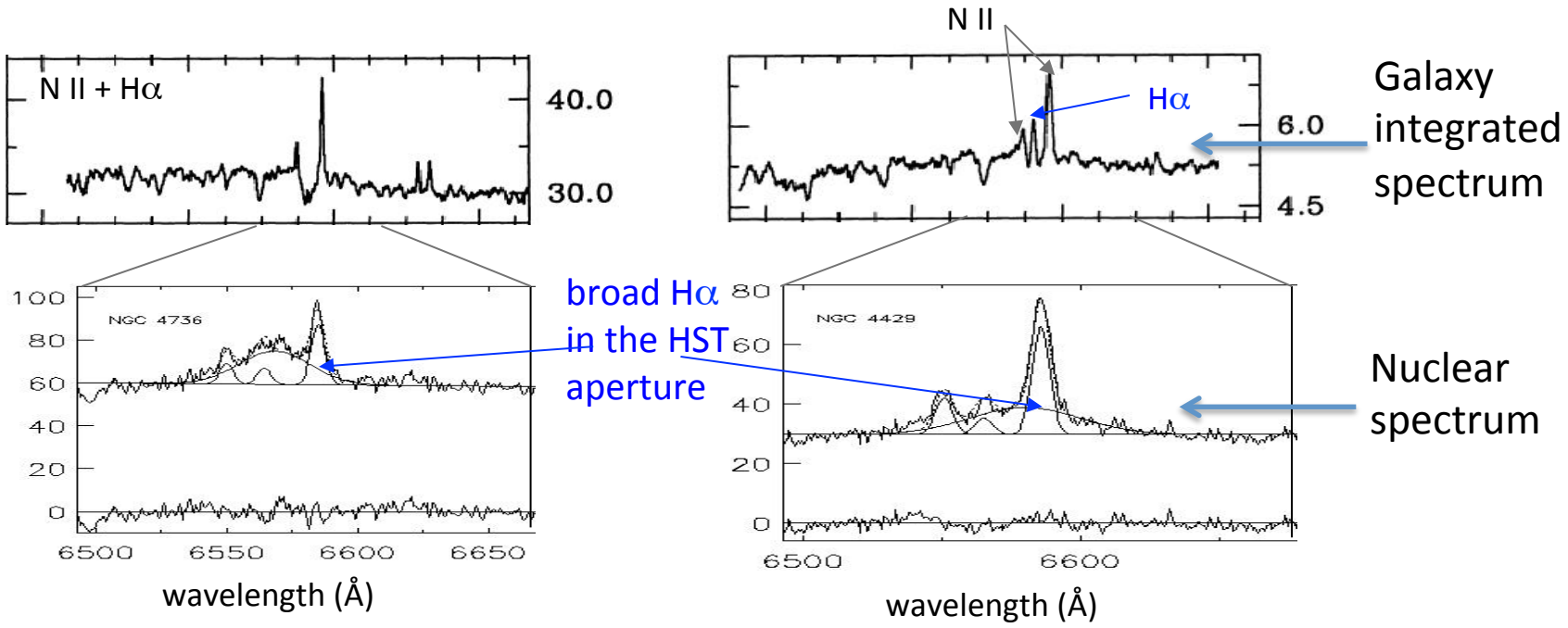

e.g., Constantin et al. (2015)

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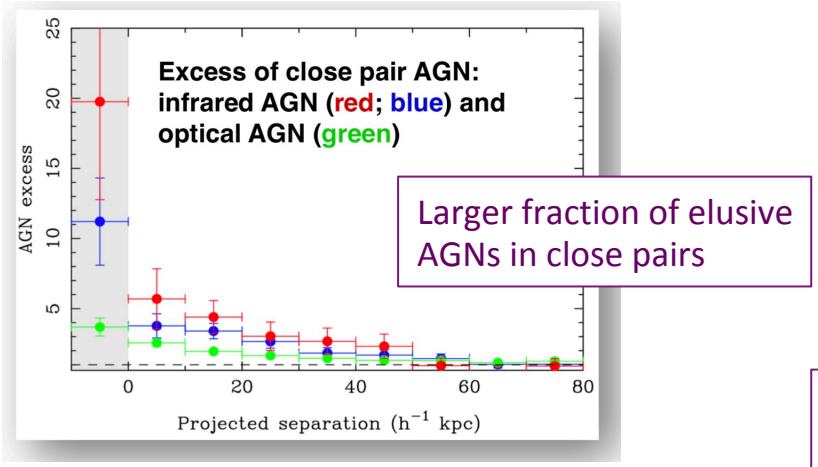
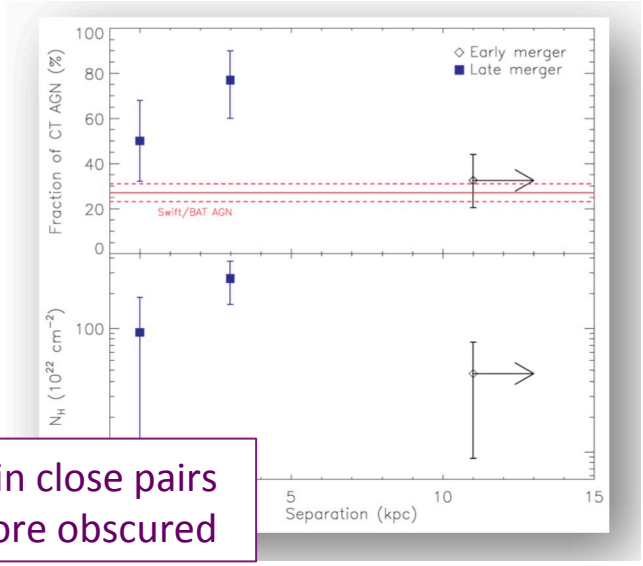
4. Different environments -> more elusive among major mergers & rapid growth phases



Larger fraction of elusive AGNs in close pairs

Satyapal et al. (2014); Ellison et al. (2013)



AGNs in close pairs are more obscured

Ricci et al. (2017)

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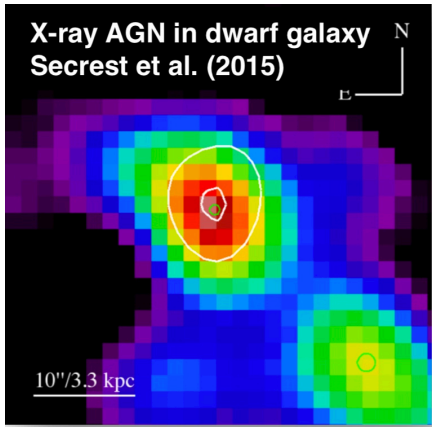
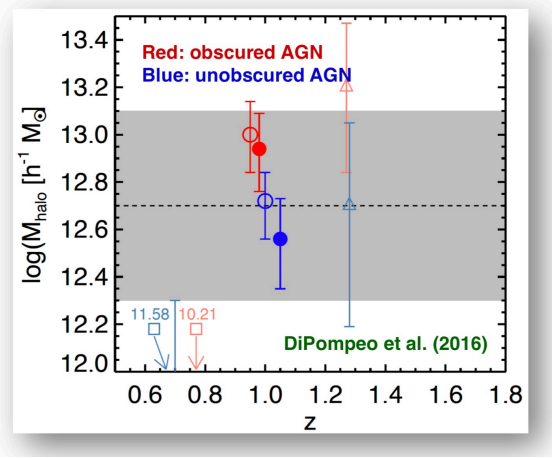
5. Simply lowest accretion rates (e.g., dwarf hosts, more massive DM haloes)





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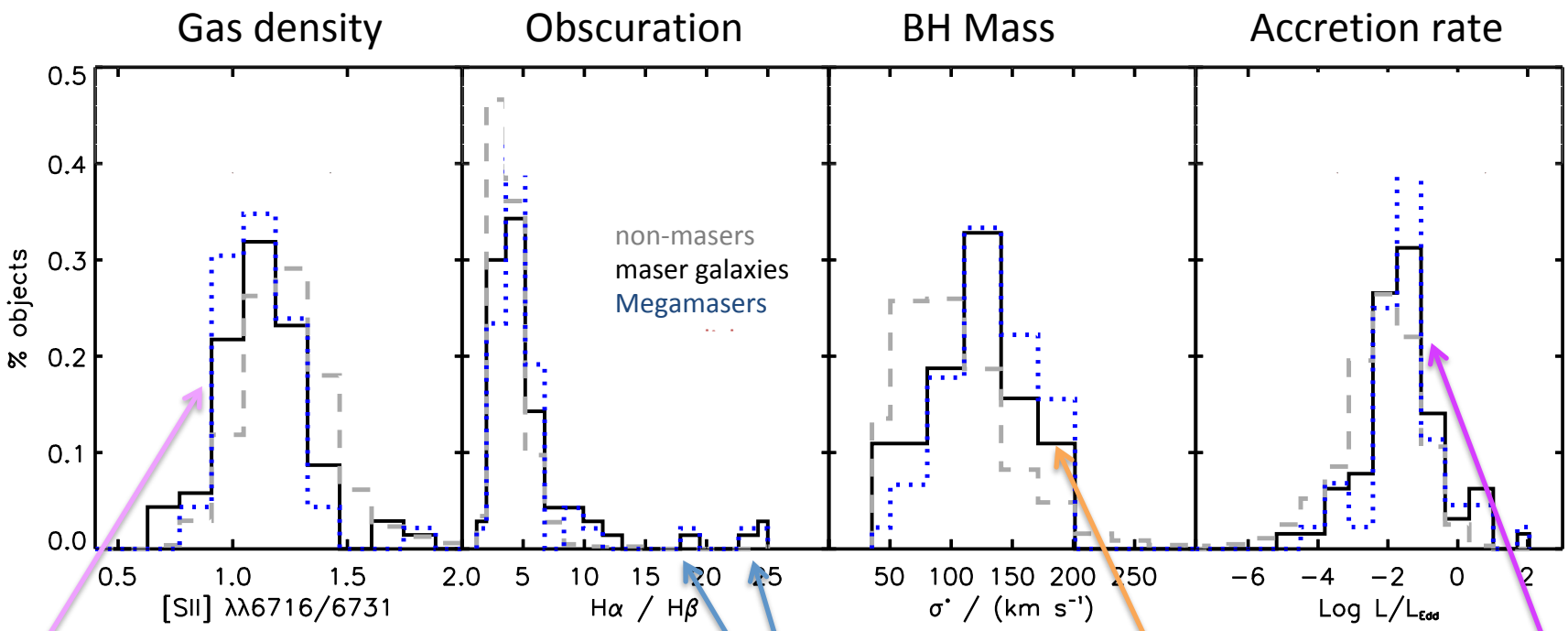
How do these factors connect with the masing activity?

Masers vs. non-masers: host properties



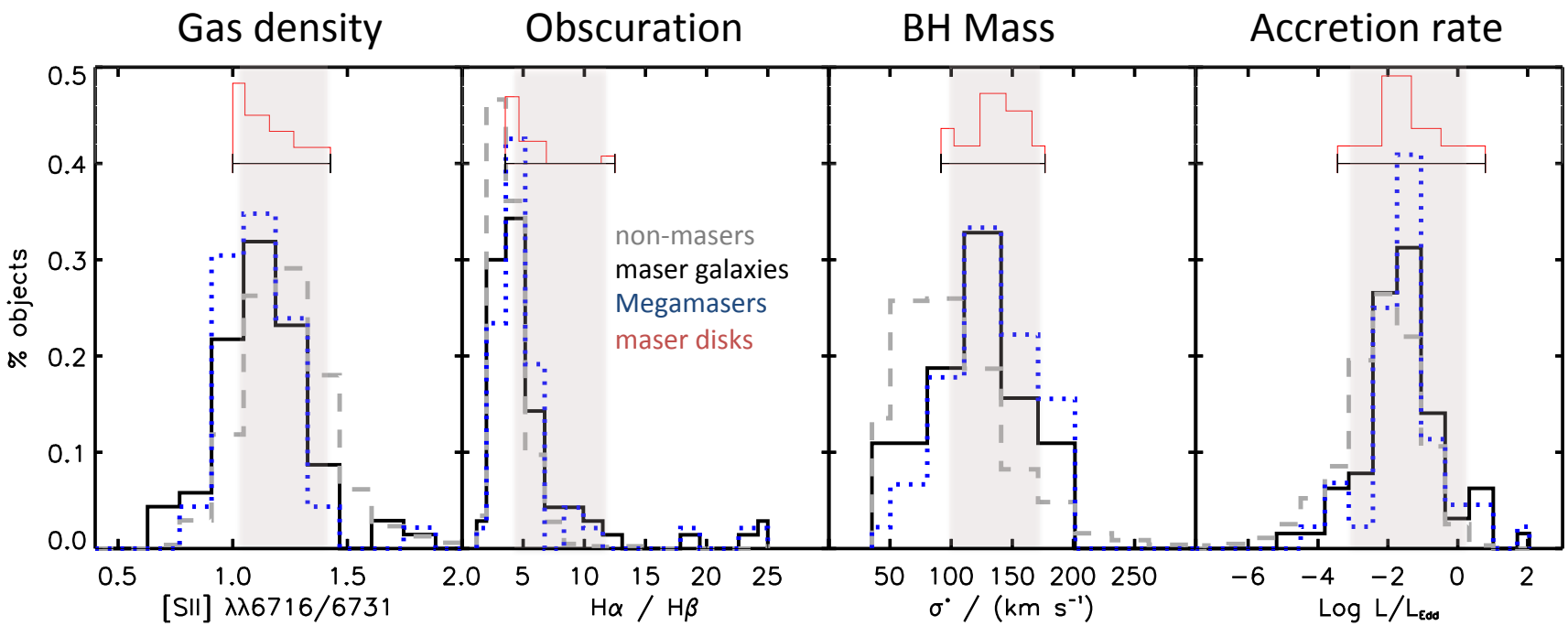
Slightly higher n_e in megamaser galaxies

Megamaser galaxies are the only ones showing huge levels of obscuration.

More massive BHs in megamaser galaxies

Slightly higher L/Ledd in megamaser galaxies

Maser disks vs. non-masers: host properties



⇒ A possible "goldilocks" range:

- n_e ~ few 100's cm-3
- M_{BH} ~ $10^7 M_\odot$
- **log L/L_{edd} ~ -2**

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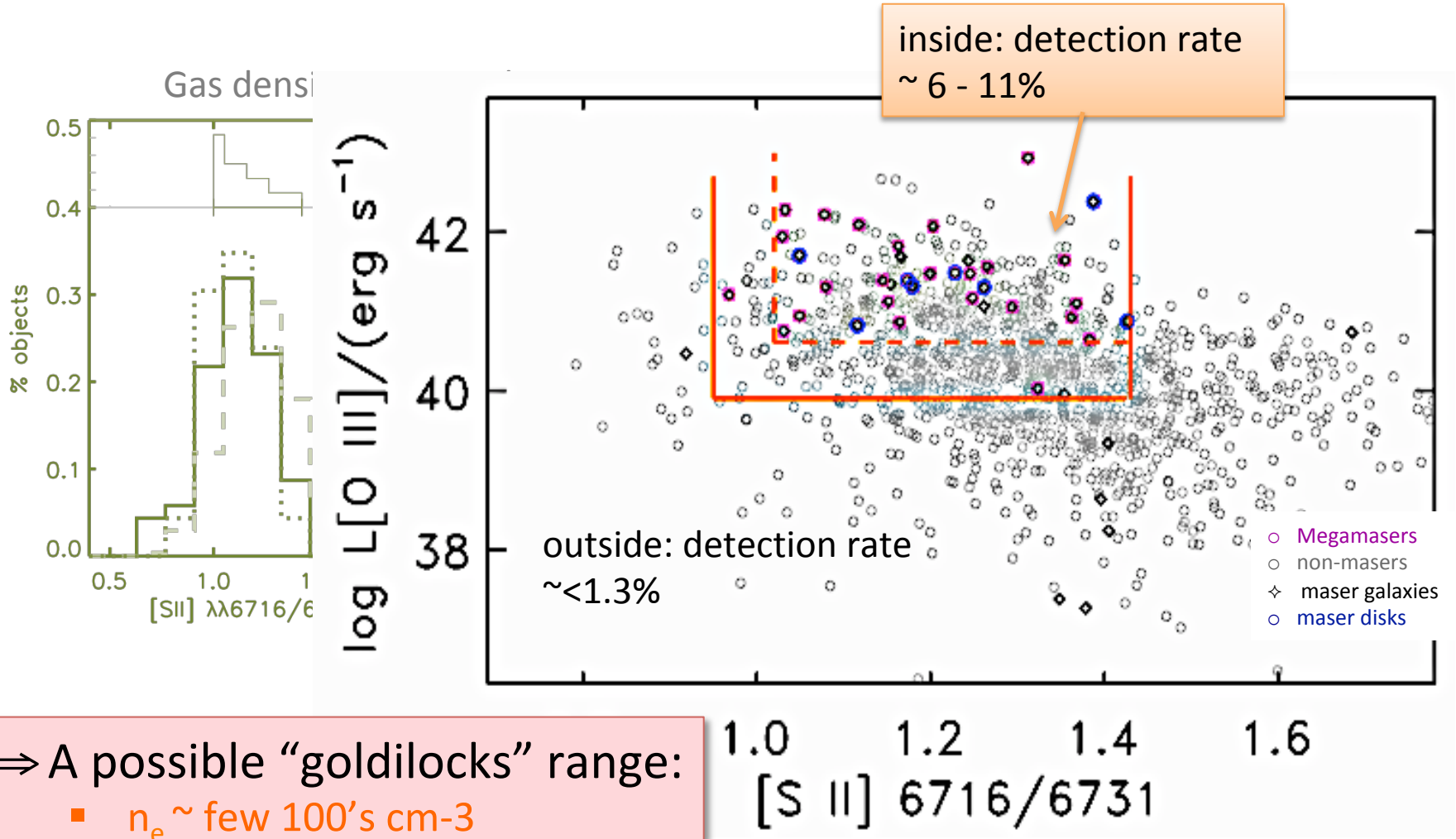

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- n_e ~ few 100's cm-3
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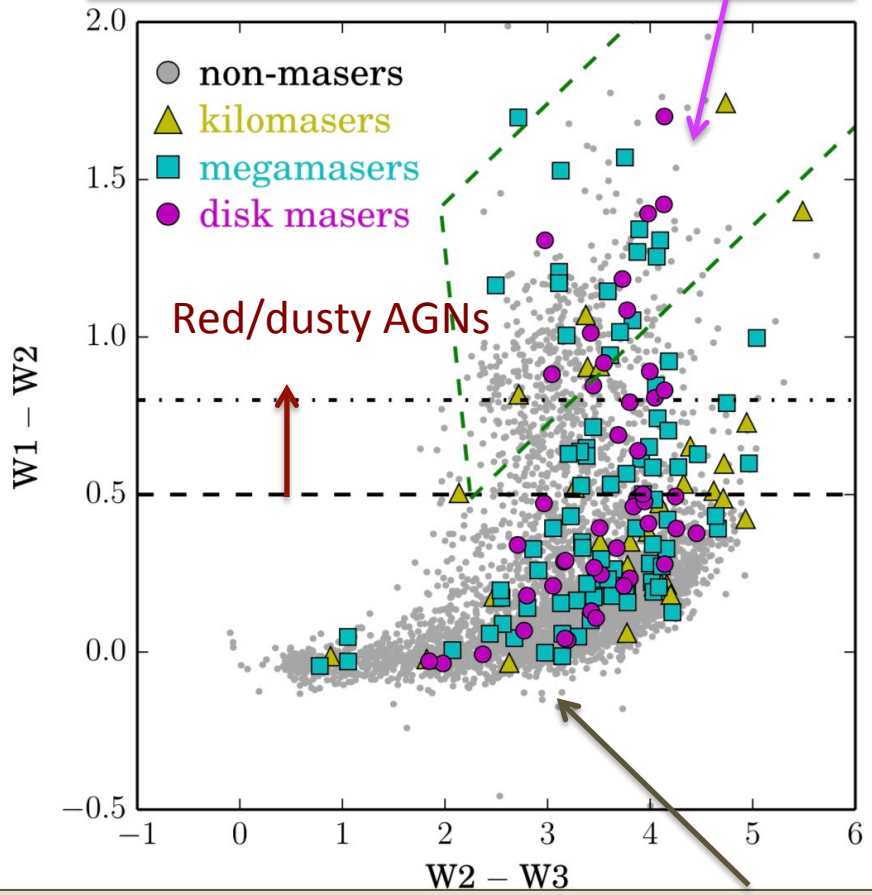
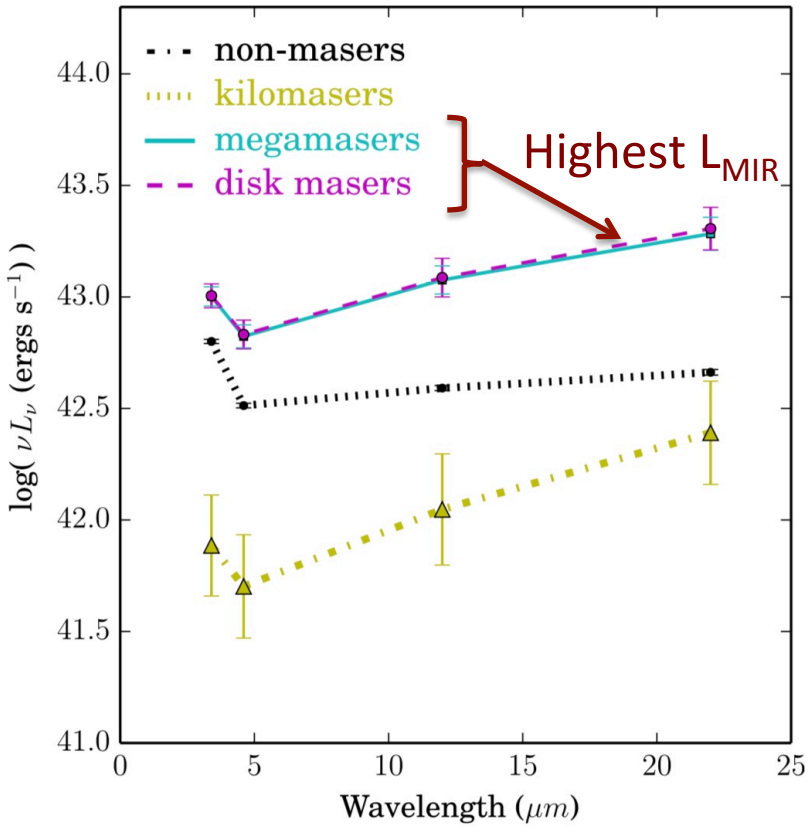
- **log L/L_{edd} ~ -2**

Insights from WISE: *red* AGN colors?

- detection rate ~ 7 - 9%

But only 1/3 of megamaser disks



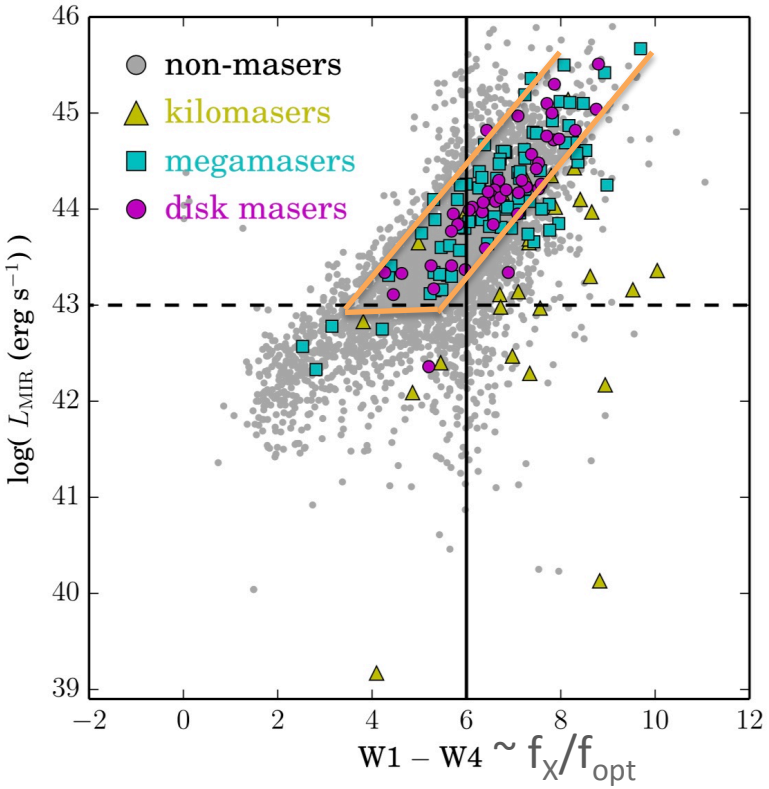


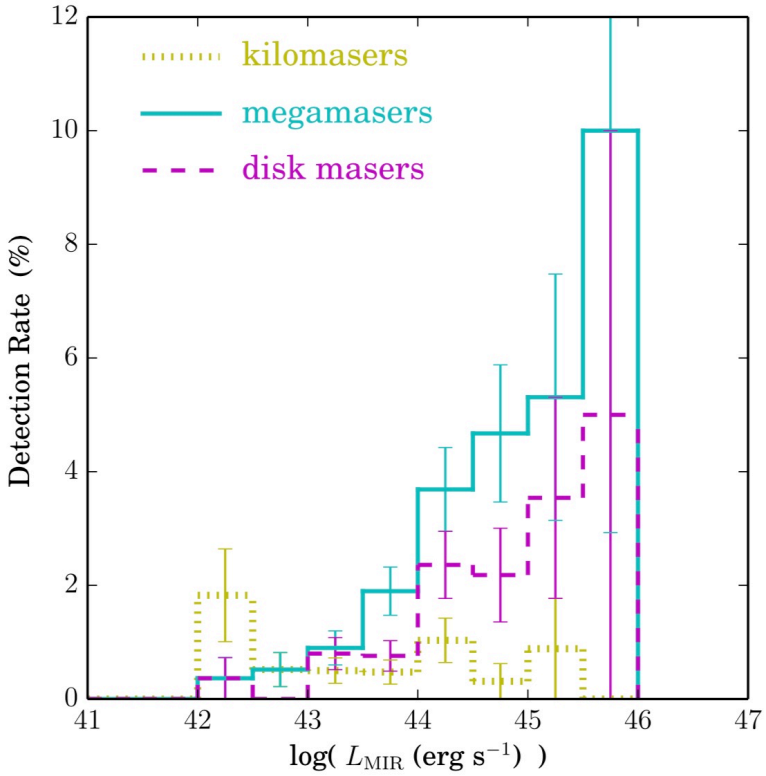
- detection rate ~ 2-3%

2/3 of maser disks among non-WISE-AGNs

Kuo, Constantin, et al. 2018

Insights from WISE: colors + Integrated L_{MIR}



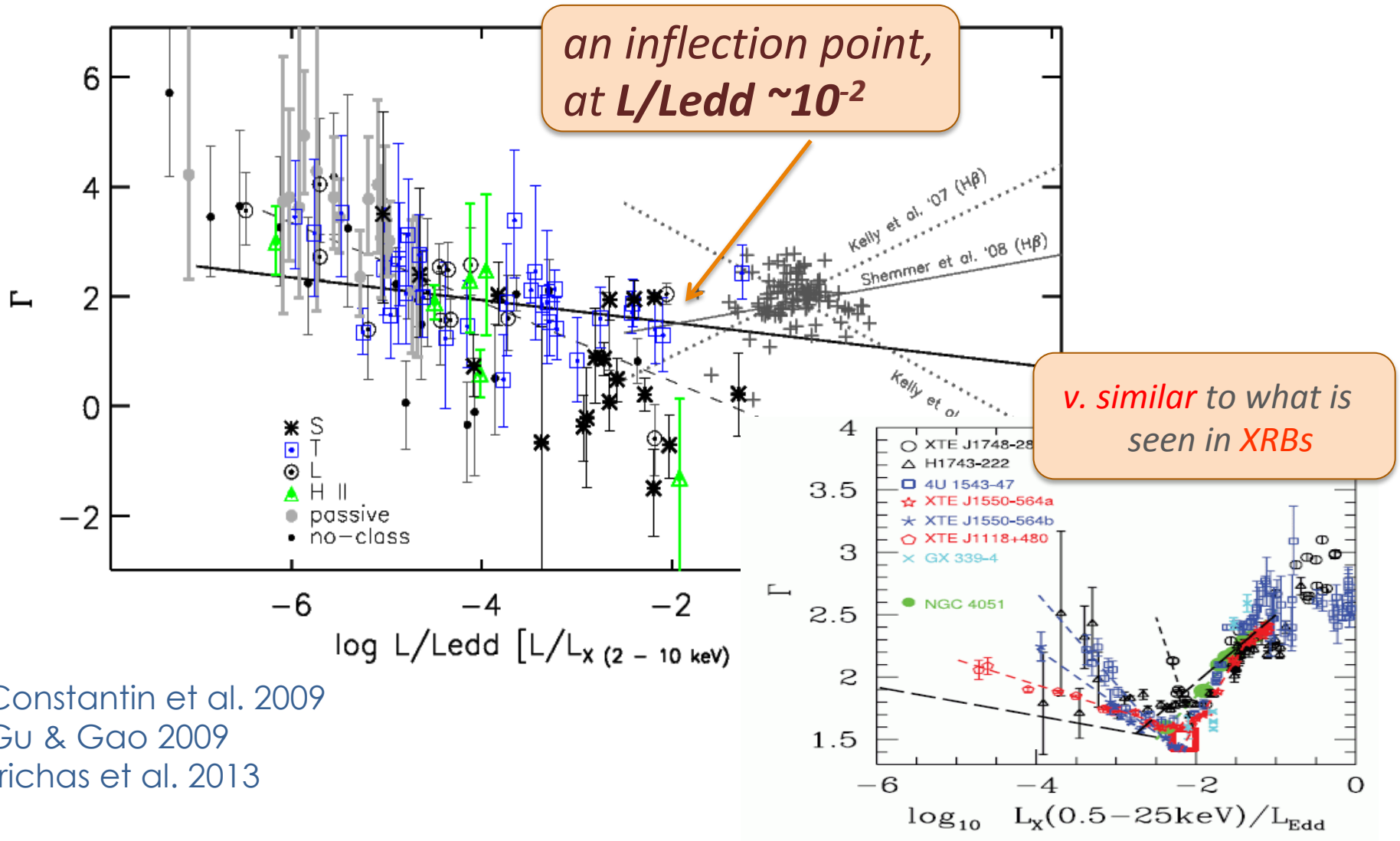


→ "relative" obscuration

- again, a narrow ("goldilocks") locus in their mid-IR properties: total L_{MIR}, and *W1-W4* => *8-14% maser detection rates*

Kuo, Constantin, et al. 2018

→ An interesting correlation: Γ_X – L/L_{edd}

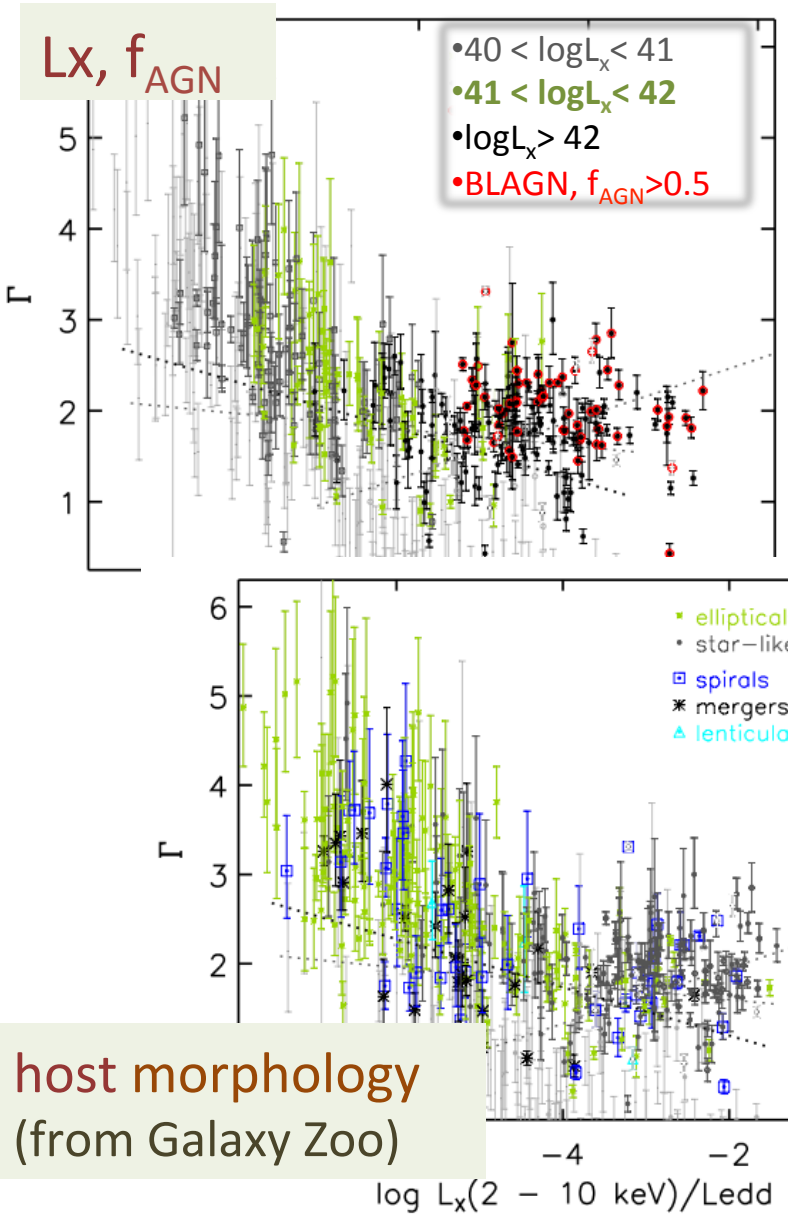


Constantin et al. 2009
Gu & Gao 2009
Trichas et al. 2013

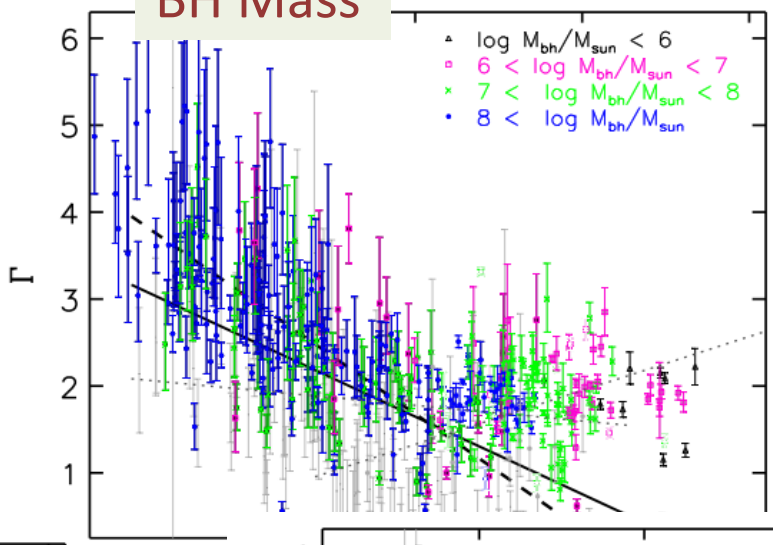
Wu & Gu 2008

Γ – L/L_{edd}: same inflection point for wide ranges of:

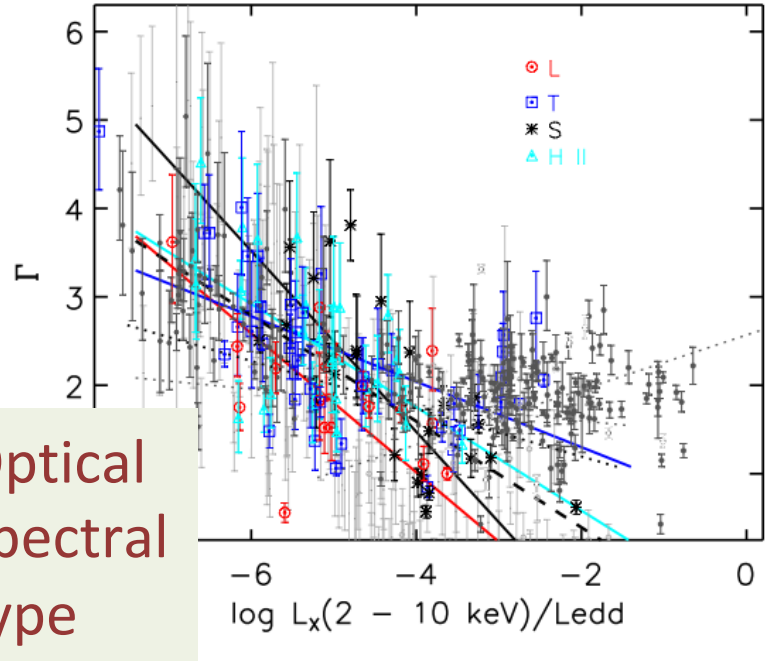
Lx, f_{AGN}



BH Mass



host morphology
(from Galaxy Zoo)



Optical spectral type

An inflection point in Γ – L/L_{edd}: what could it mean?

1. Intrinsic absorption is blown away for higher accretion rates
   --> Explanation for the dearth of obscured (type II) QSOs

2. A transition in the accretion mode:
   RIAF(ADAF) --> Shakura-Sunyaev standard accretion disk/corona
(e.g., Esin, McClintock & Narayan 1997, Lu & Yu 1999, Noda & Done 2018)

Increase in L/L_{edd}
--> increase in
Compton-*y* parameter
--> harder spectrum.

Further increase in L/L_{edd}
--> increase energy release --> decrease in T
--> weaken corona, lower optical depth
--> reduction in *y*-parameter --> softer spectra.

An inflection point in Γ – L/L_{edd}: what could it mean?

1. Intrinsic absorption is blown away for higher accretion rates
   --> Explanation for the dearth of obscured (type II) QSOs

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(e.g., Esin, McClintock & Narayan 1997, Lu & Yu 1999, Noda & Done 2018)

Also at the inflection log L/L_{edd} ~ -2:

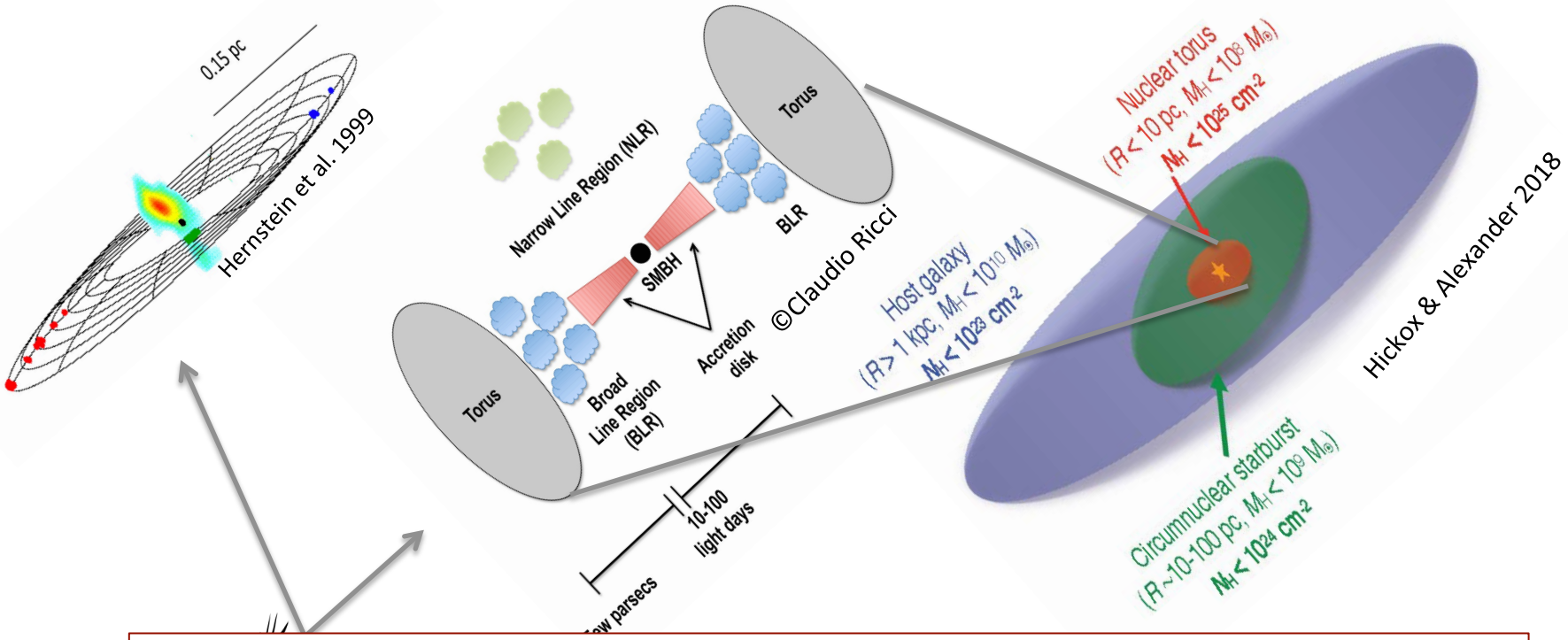
i. "changing-look" AGNs, e.g., from type 1 to type 1.8 (2?) Seyfert
(e.g., Noda & Done 2018)

ii. A sharp transition in column density N_H
(e.g., Ricci et al. 2017)

iii. Megamaser disk emission is more prevalent

SUMMARY (i.e., homework for both observers and theorists)

Maser disk activity: not only dependent on geometry and intrinsic properties of the molecular gas.



Maser disk activity: associated with a particular (short) episode in a galaxy's life → a "goldilocks" parameter space