A Census of the Most Obscured Galaxy Nuclei over Cosmic Time to be revealed by PRIMA

Fergus R. Donnan

Dimitra Rigopoulou, Ismael Garcia-Bernete, Laura Bisigello, Susanne Aalto

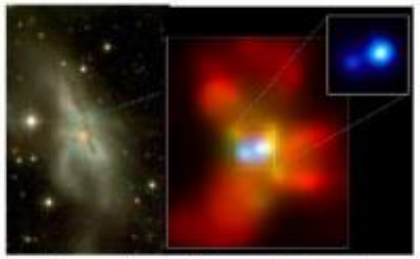
fergus.donnan@physics.ox.ac.uk

UNIVERSITY OF OXFORD

(c) Interaction/"Merger"

- now within one halo, galaxies interact & lose angular momentum
- SFR starts to increase
- stellar winds dominate feedback
- rarely excite QSOs (only special orbits)

(d) Coalescence/(U)LIRG

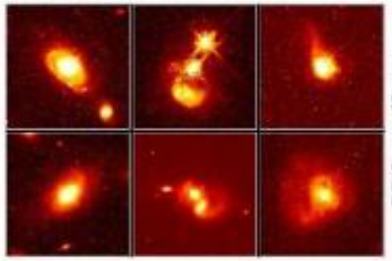


- galaxies coalesce: violent relaxation in core
- gas inflows to center: starburst & buried (X-ray) AGN
- starburst dominates luminosity/feedback, but, total stellar mass formed is small

(e) "Blowout"

- BH grows rapidly: briefly dominates luminosity/feedback
- remaining dust/gas expelled
- get reddened (but not Type II) QSO: recent/ongoing SF in host high Eddington ratios merger signatures still visible

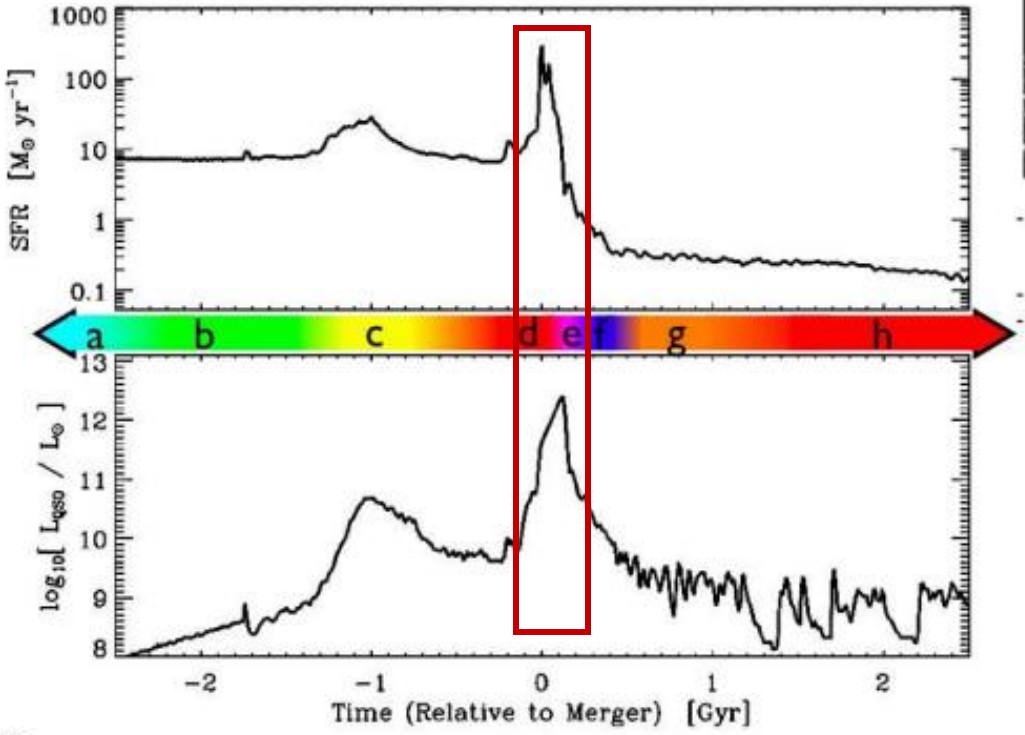
(f) Quasar



- dust removed: now a "traditional" QSO
- host morphology difficult to observe: tidal features fade rapidly
- characteristically blue/young spheroid

(b) "Small Group"

- halo accretes similar-mass companion(s)
- can occur over a wide mass range
- M_{halo} still similar to before: dynamical friction merges the subhalos efficiently



(g) Decay/K+A

- QSO luminosity fades rapidly
  - tidal features visible only with very deep observations
- remnant reddens rapidly (E+A/K+A)
- "hot halo" from feedback
  - sets up quasi-static cooling

(a) Isolated Disk

- halo & disk grow, most stars formed
- secular growth builds bars & pseudobulges
- "Seyfert" fueling (AGN with M_B>-23)
- cannot redden to the red sequence

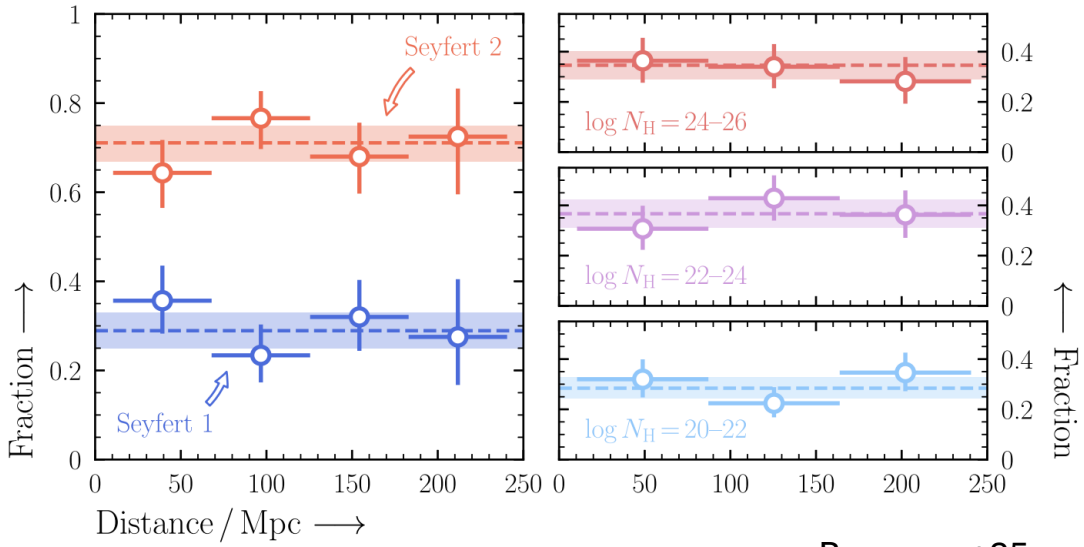
(h) "Dead" Elliptical

- star formation terminated
- large BH/spheroid - efficient feedback
- halo grows to "large group" scales: mergers become inefficient
- growth by "dry" mergers

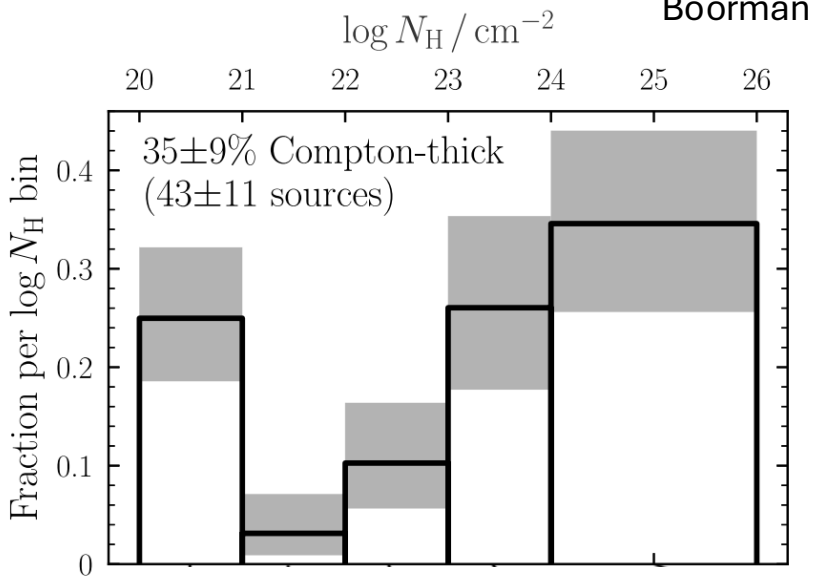
Hopkins+07

Population of Obscured AGN: X-ray view

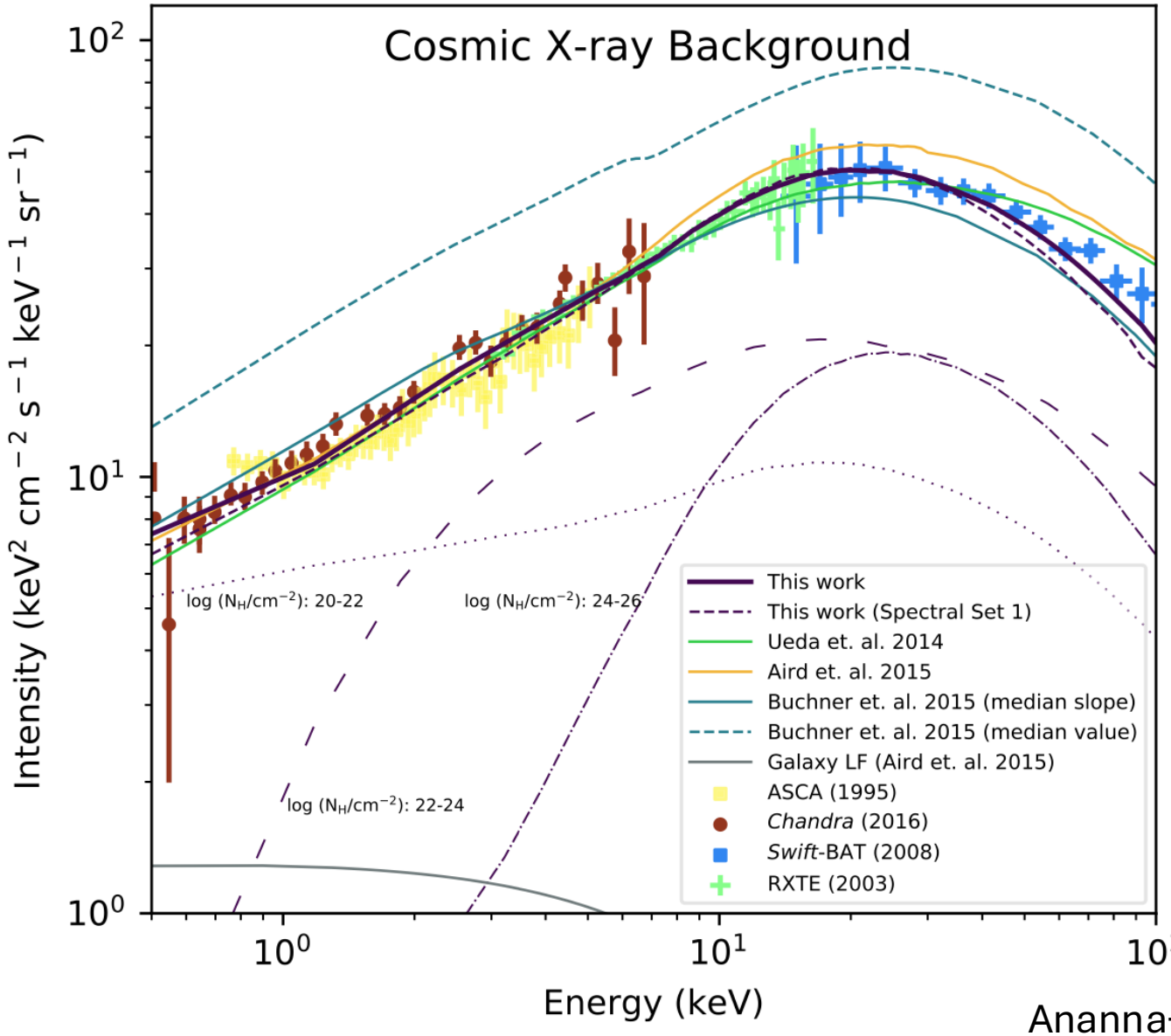
- Most AGN are Obscured!
- ~ 70% of AGN with $N_H > 10^{22}$ cm^{-2}
- ~ 35% of AGN are Compton Thick with $N_H > 10^{24}$ cm^{-2}
- Lack of sensitivity to detect photons behind $N_H \sim 10^{26}$ cm^{-2} (Ricci+21)



Boorman+25



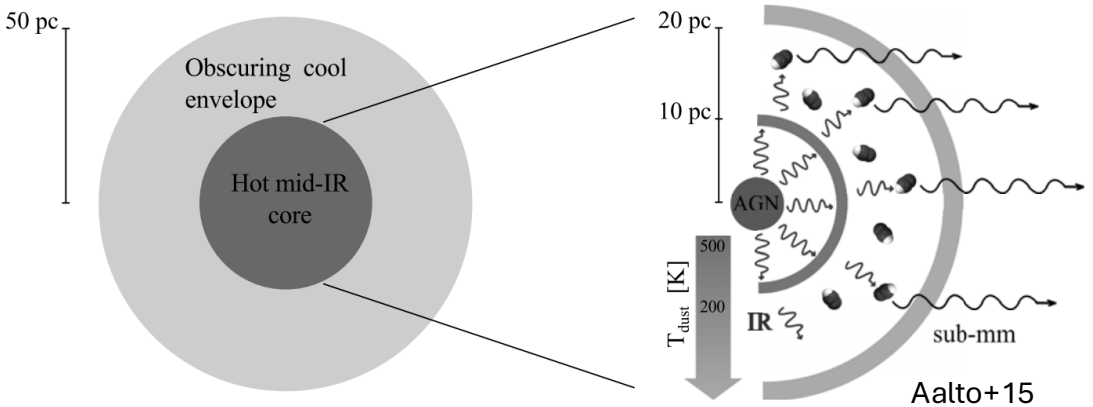
Cosmic X-ray Background



Ananna+19

Compact Obscured Nuclei (CONs)

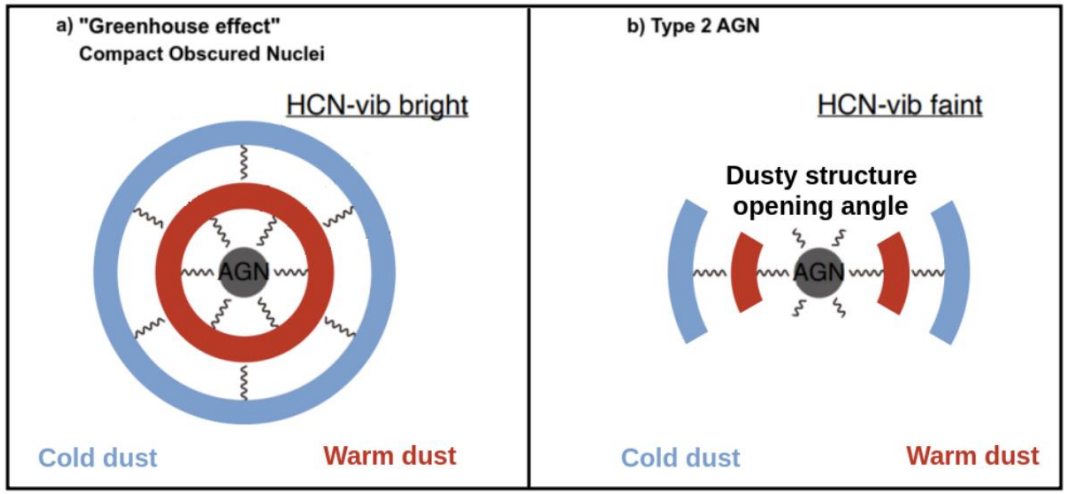
- Power Source (likely AGN) completely obscured by gas/dust (N_H>10^{25})



Aalto+15

- Detected via dense gas tracers in mm (HCN-vib) (e.g. Aalto+15,19)
  - Very faint – even with ALMA

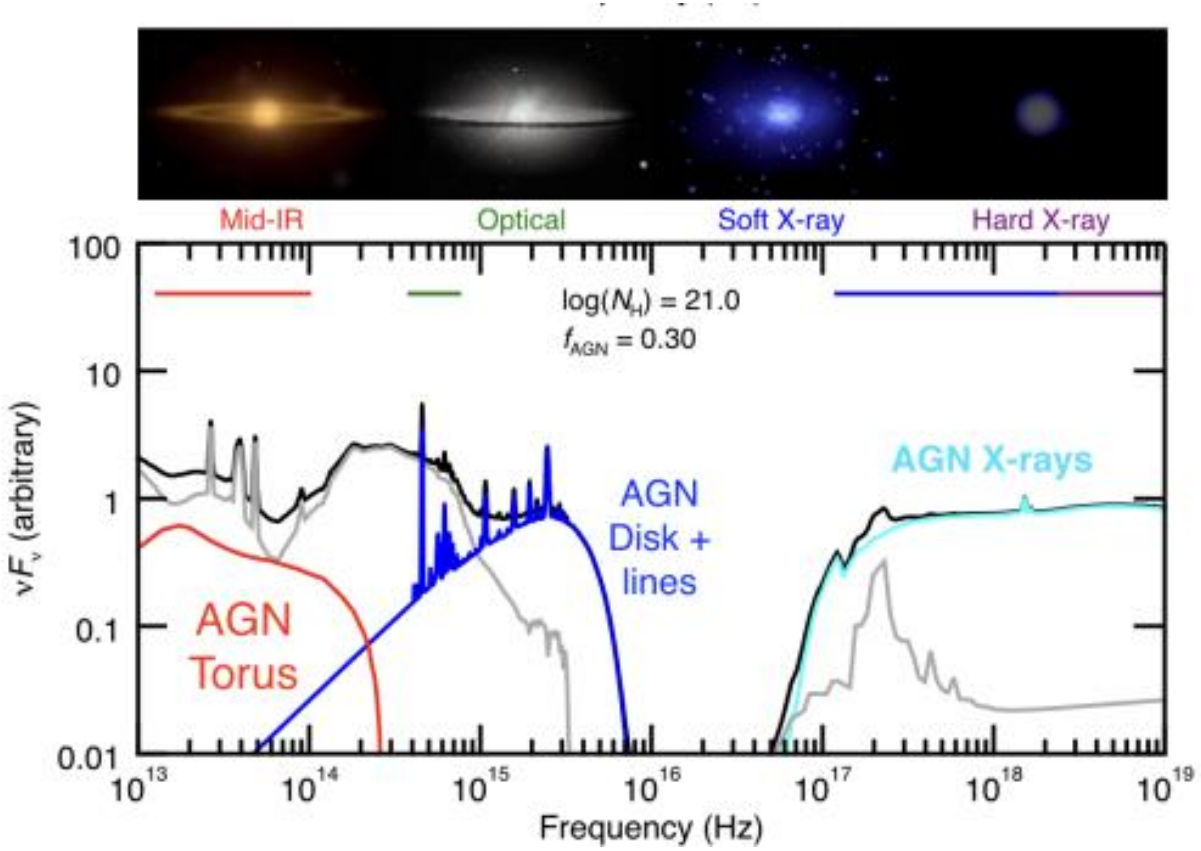
- 40% of local ULIRGs
  - Often major mergers



Garcia-Bernete adapted from Baba+22

What do Obscured AGN look like?

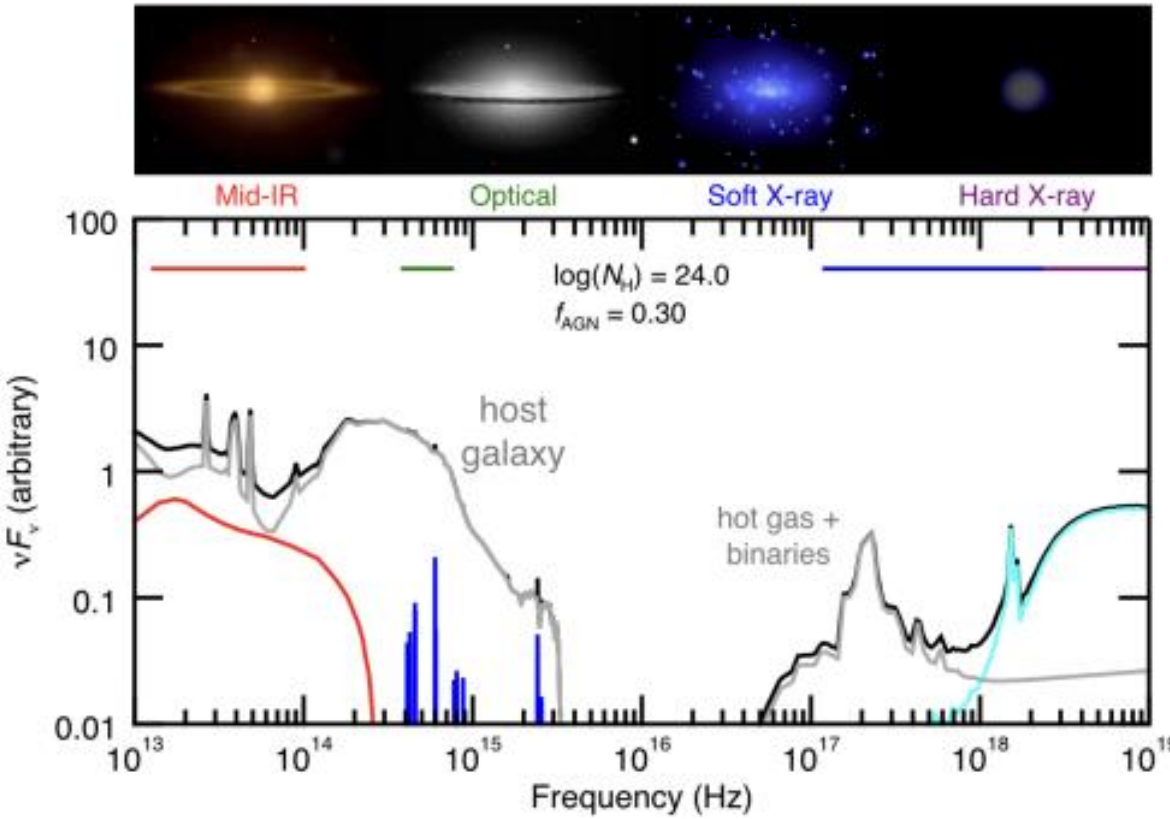
Unobscured



- Soft X-rays
- High Ionisation potential lines -> BPT diagram
- Broad HI lines -> BH Mass
- UV/Optical accretion disk continuum -> Accretion rate

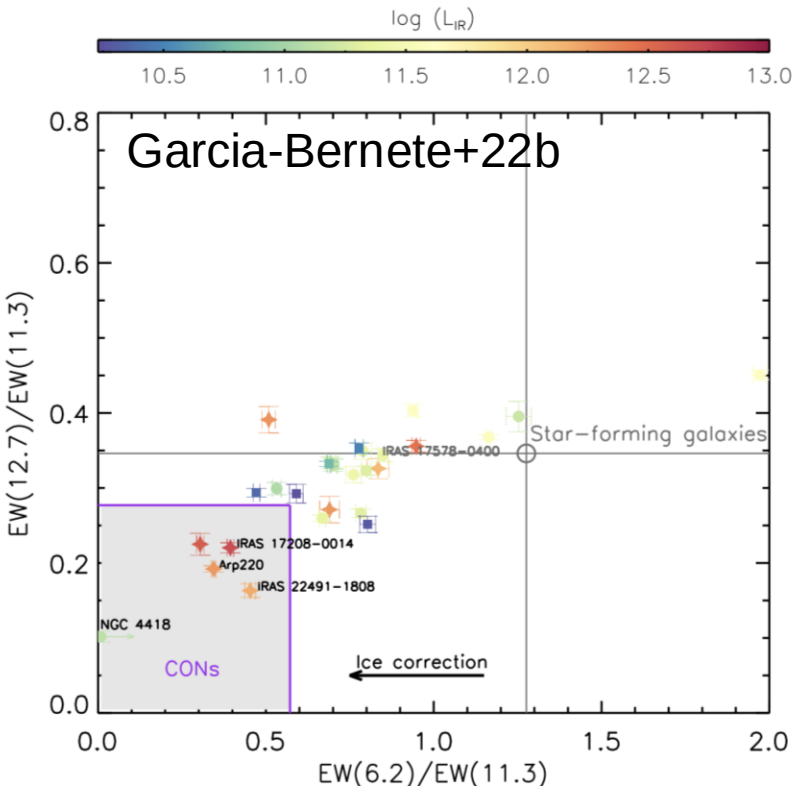
Obscured

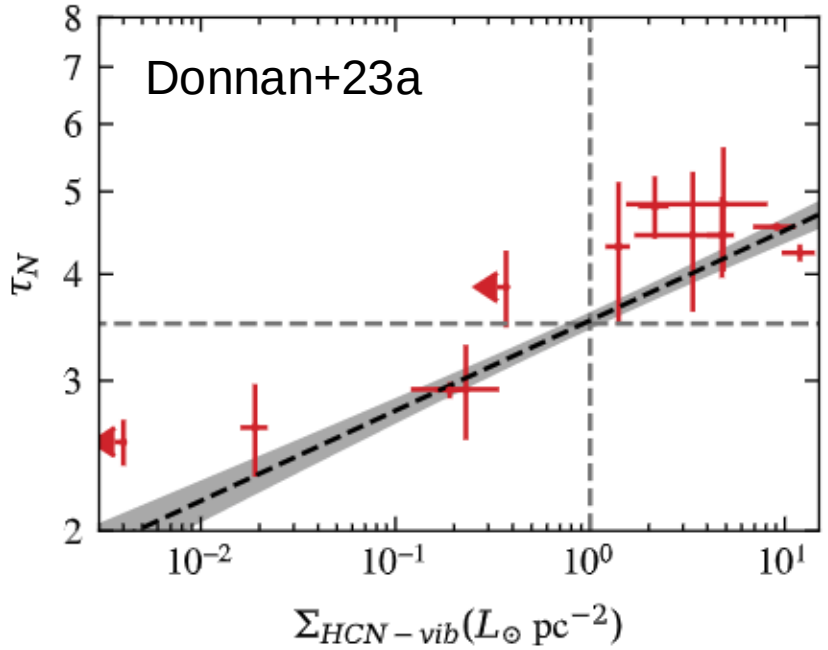
Hickox & Alexander

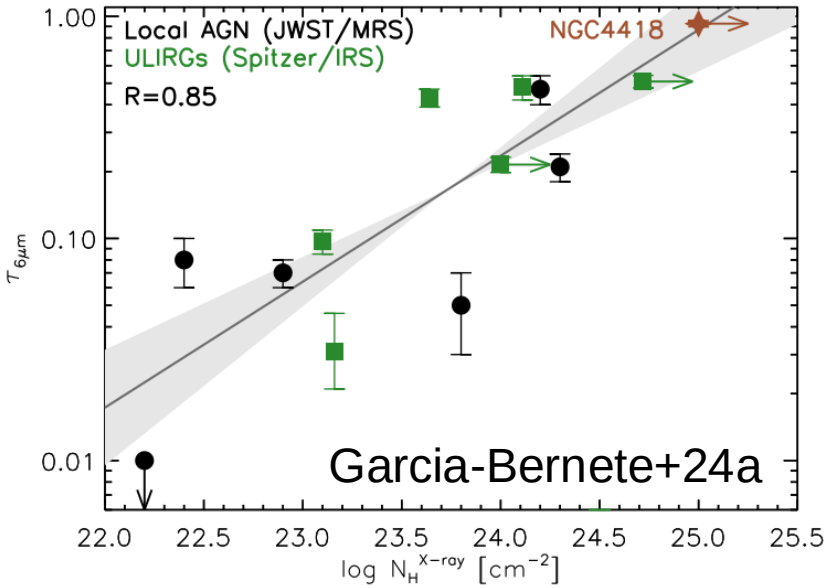


- No photons escape – no high-IP lines
- Only mid-IR continuum

Mid-IR as a probe of obscured activity

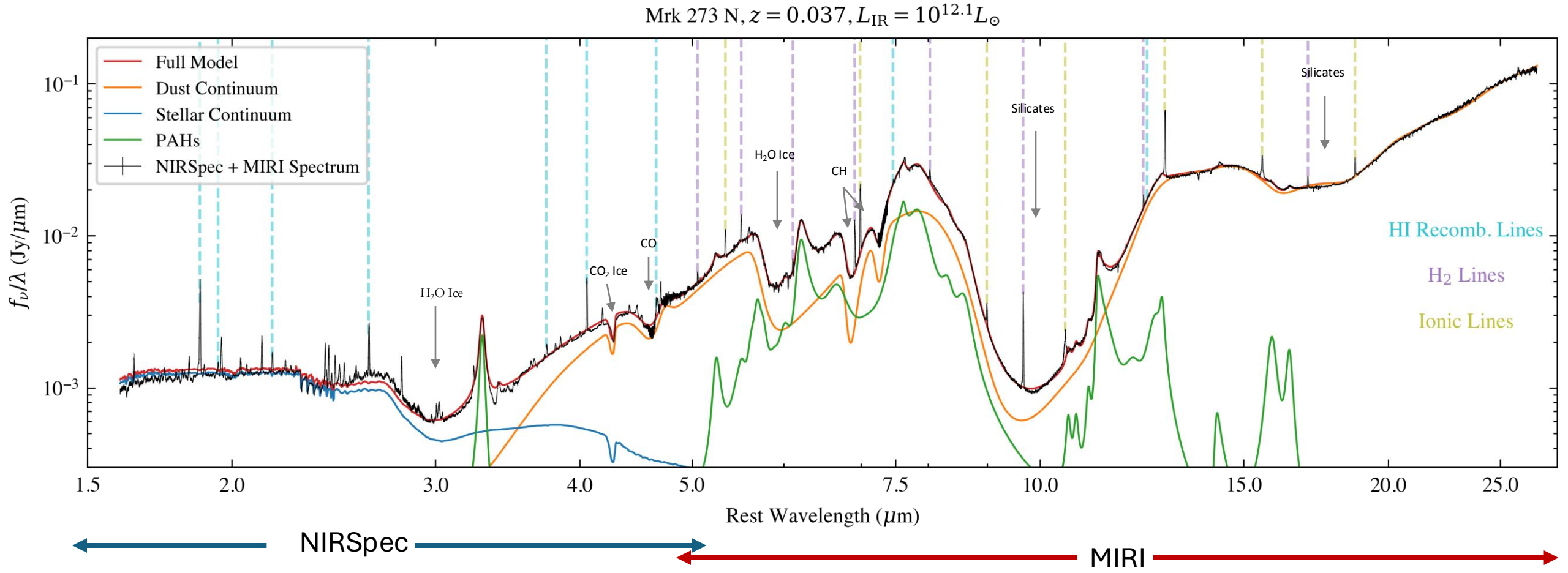






- Select Highly Obscured Nuclei via PAH EW ratios
- Silicate depth traces HCN-vib surface brightness after accounting for SF dilution.
- H_2O Ice traces obscuration sequence from AGN to ULIRGs

JWST View

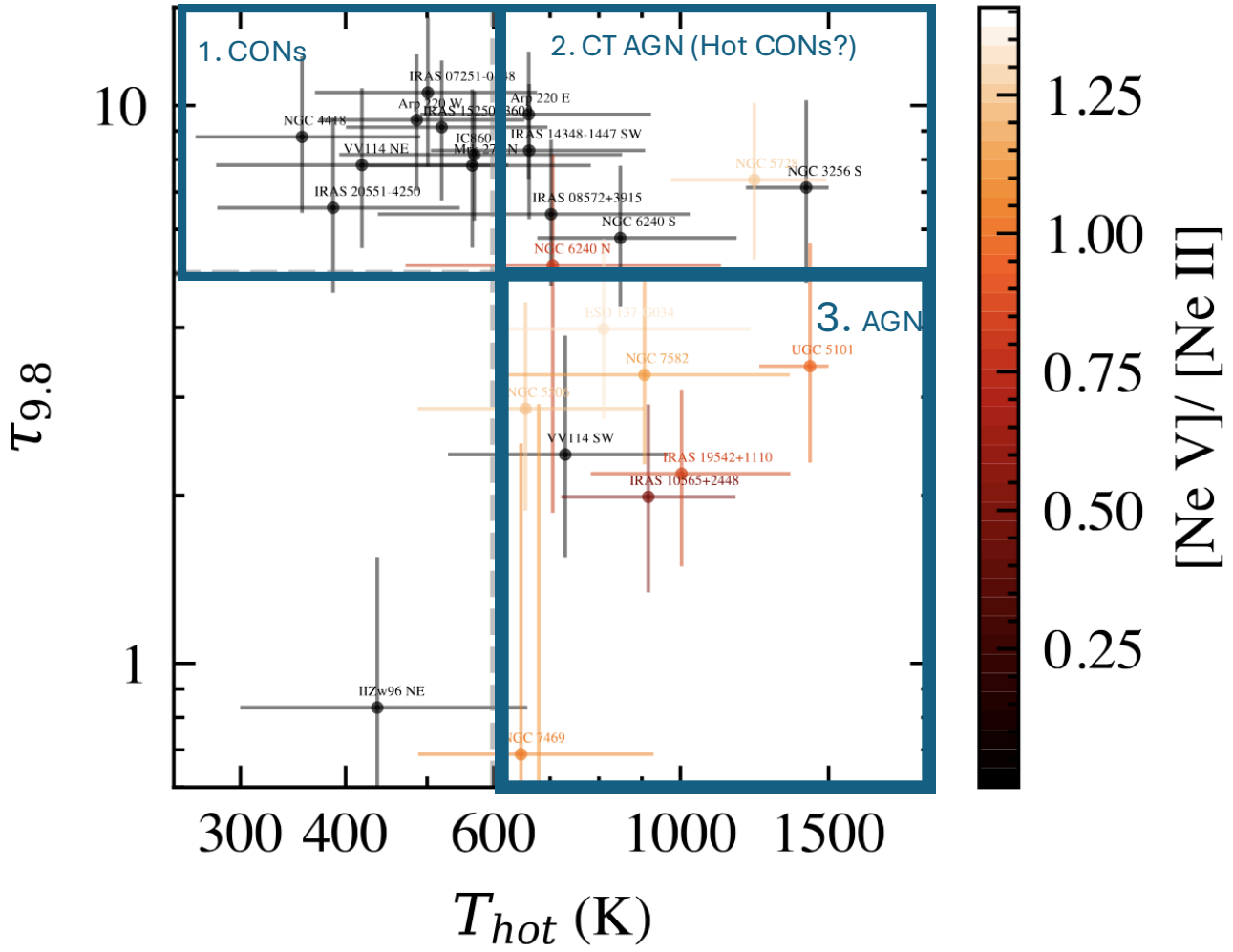


NIRSpec

MIRI

JWST View

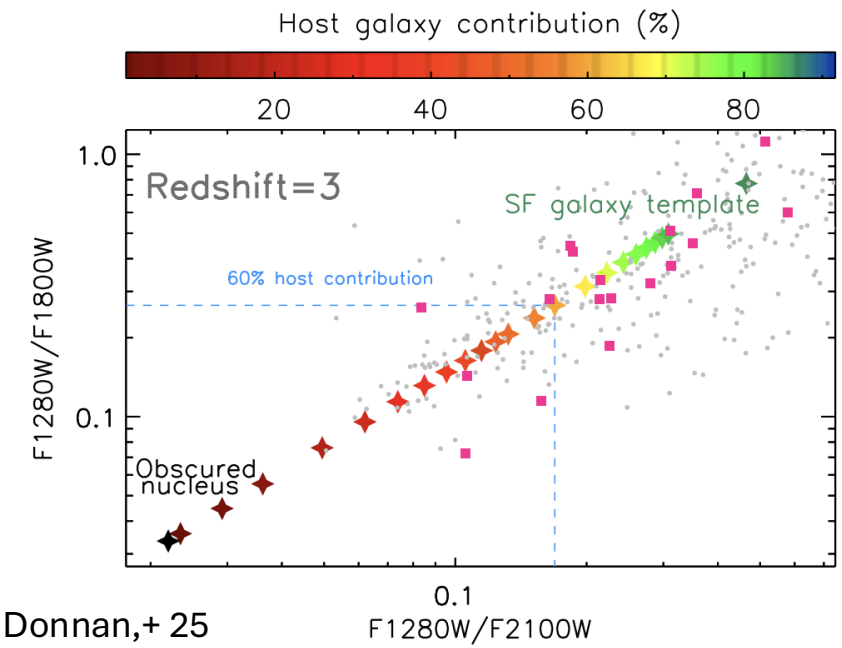
- Cool dust continuum & deep silicates
- No high-IP lines
- No X-ray detections (Ricci+21)
- See also Donnan+23b, 24a



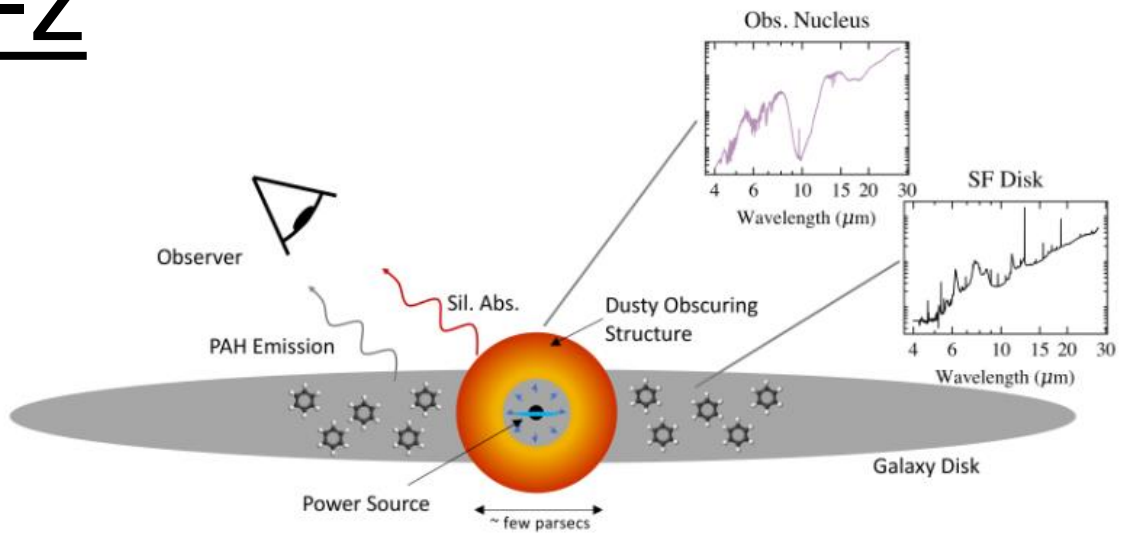
Donnan+ in prep.

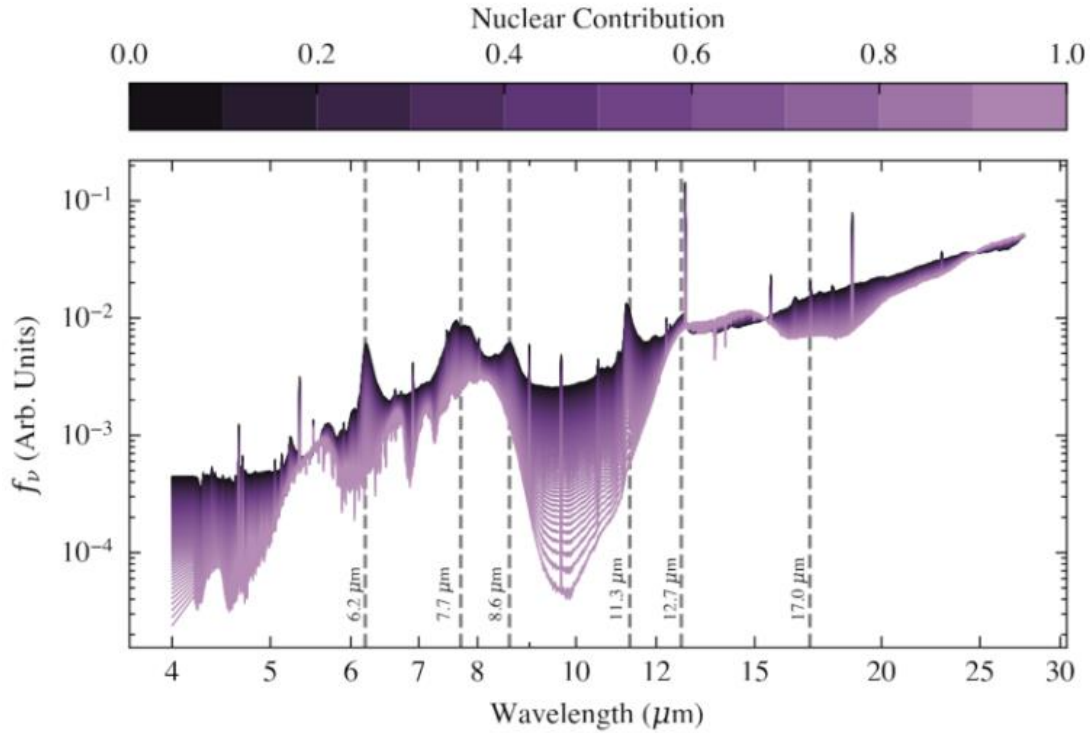
Obscured nuclei at high-z

- Detect deep silicate with imaging
- JWST MIRI: z~0-3
- PRIMA: z~2-7



Garcia-Bernete, Donnan,+ 25

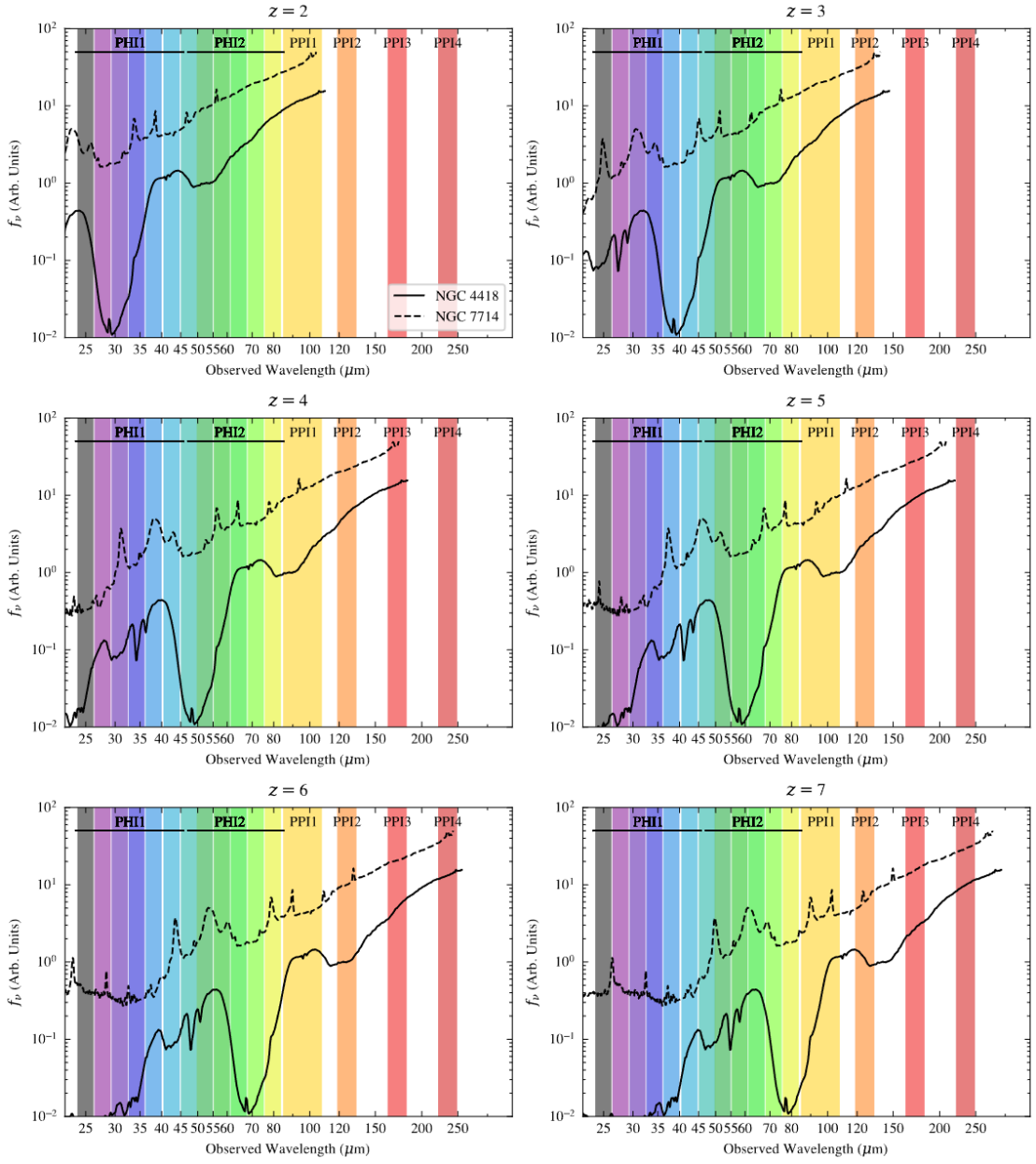




Obscured nuclei with PRIMA

- Select candidates via imaging surveys
- Obtain accurate phot-z using PAHs/silicate features
- Color selection and/or SED fitting to select candidates

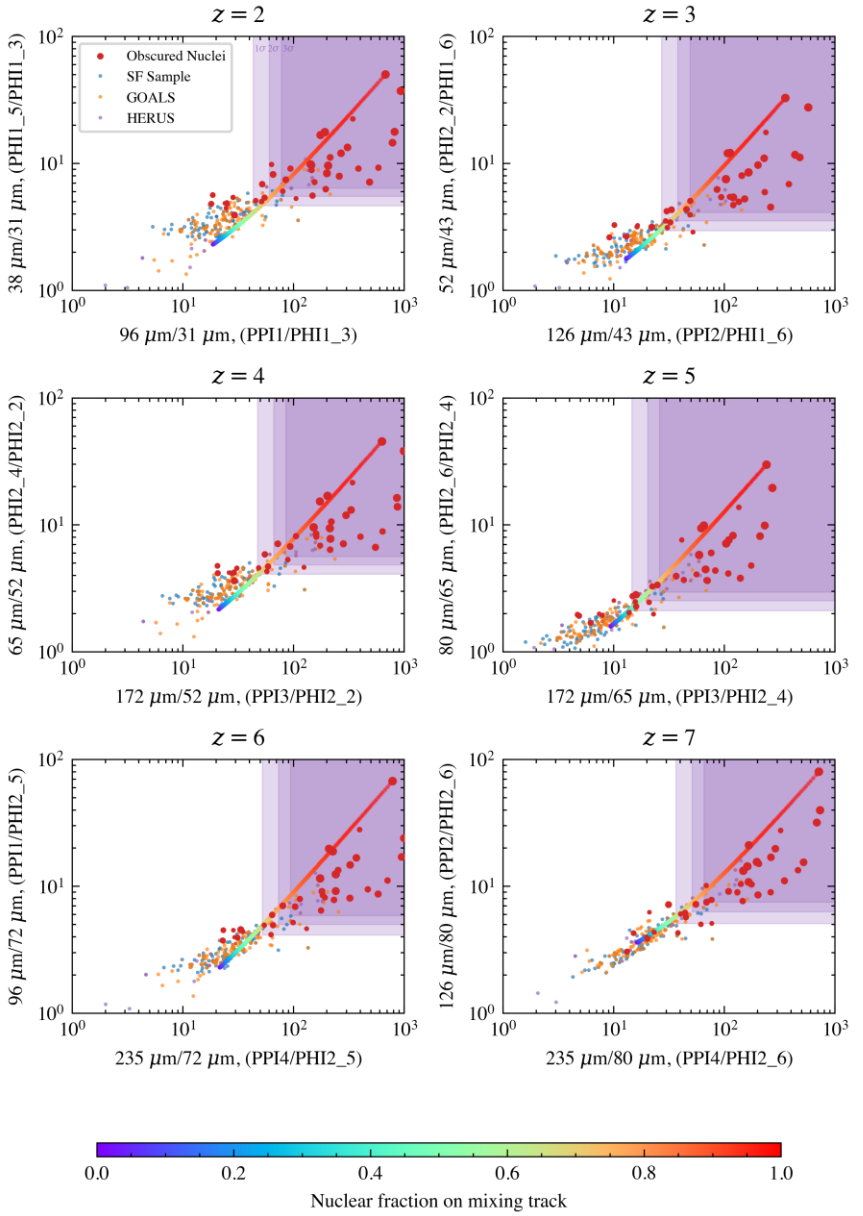
Donnan+25 (JATIS)



Obscured nuclei with PRIMA

Donnan+25 (JATIS)

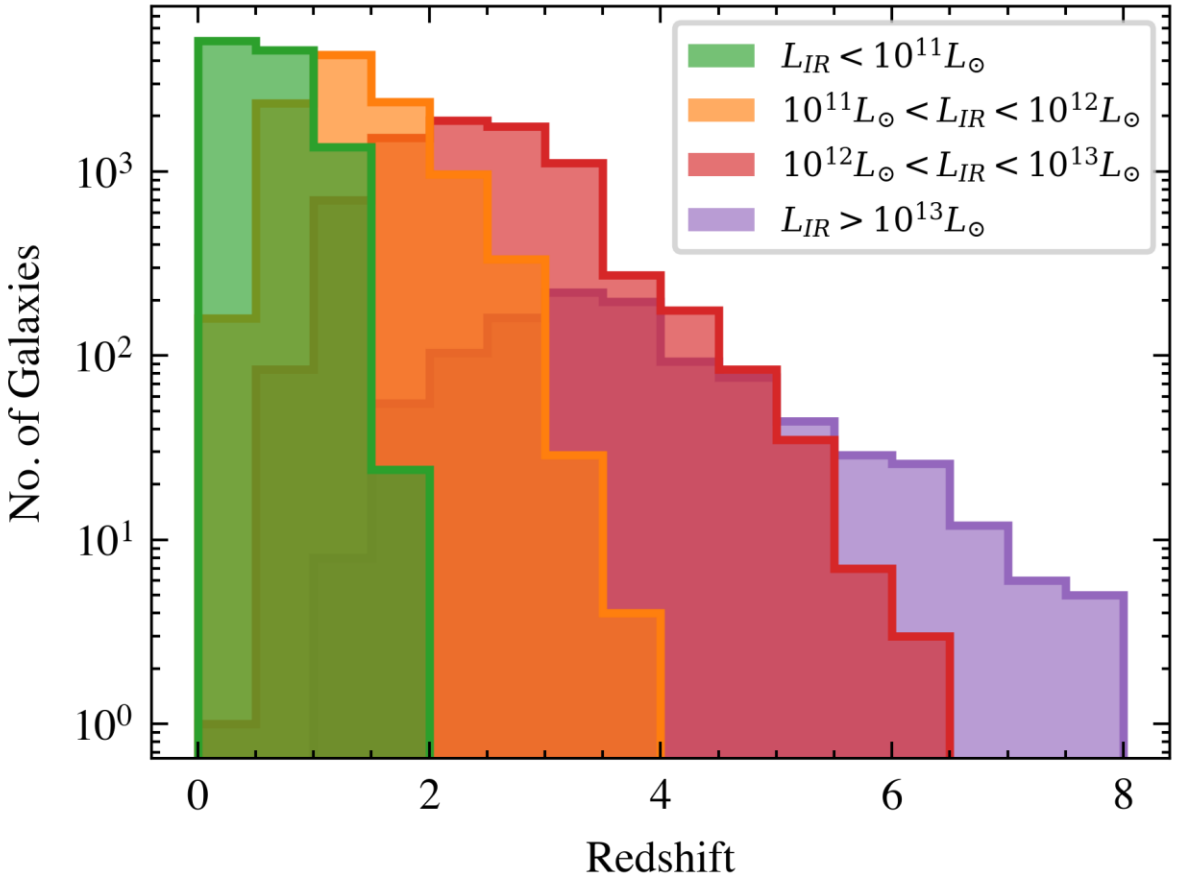
- Select candidates via imaging surveys
- Obtain accurate phot-z using PAHs/silicate features
- Color selection and/or SED fitting to select candidates



How many targets will PRIMAger identify?

- 1500h/deg^2 survey using confusion mitigation techniques (Donnellan+24, talk later)

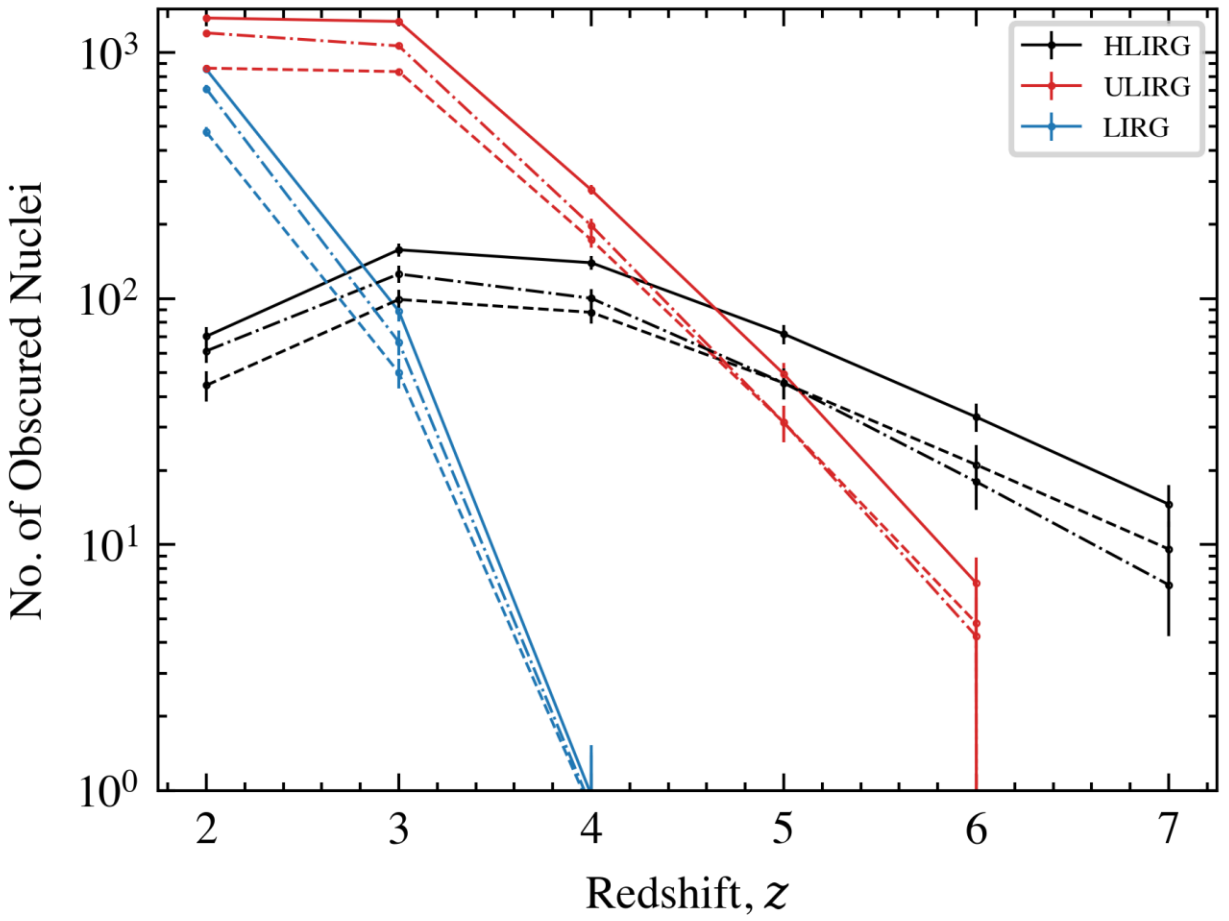
- SPRITZ simulation: generate galaxy catalogue from IR luminosity functions (Bisigello+21, 24)



Donnan+25 (JATIS)

How many targets will PRIMAger identify?

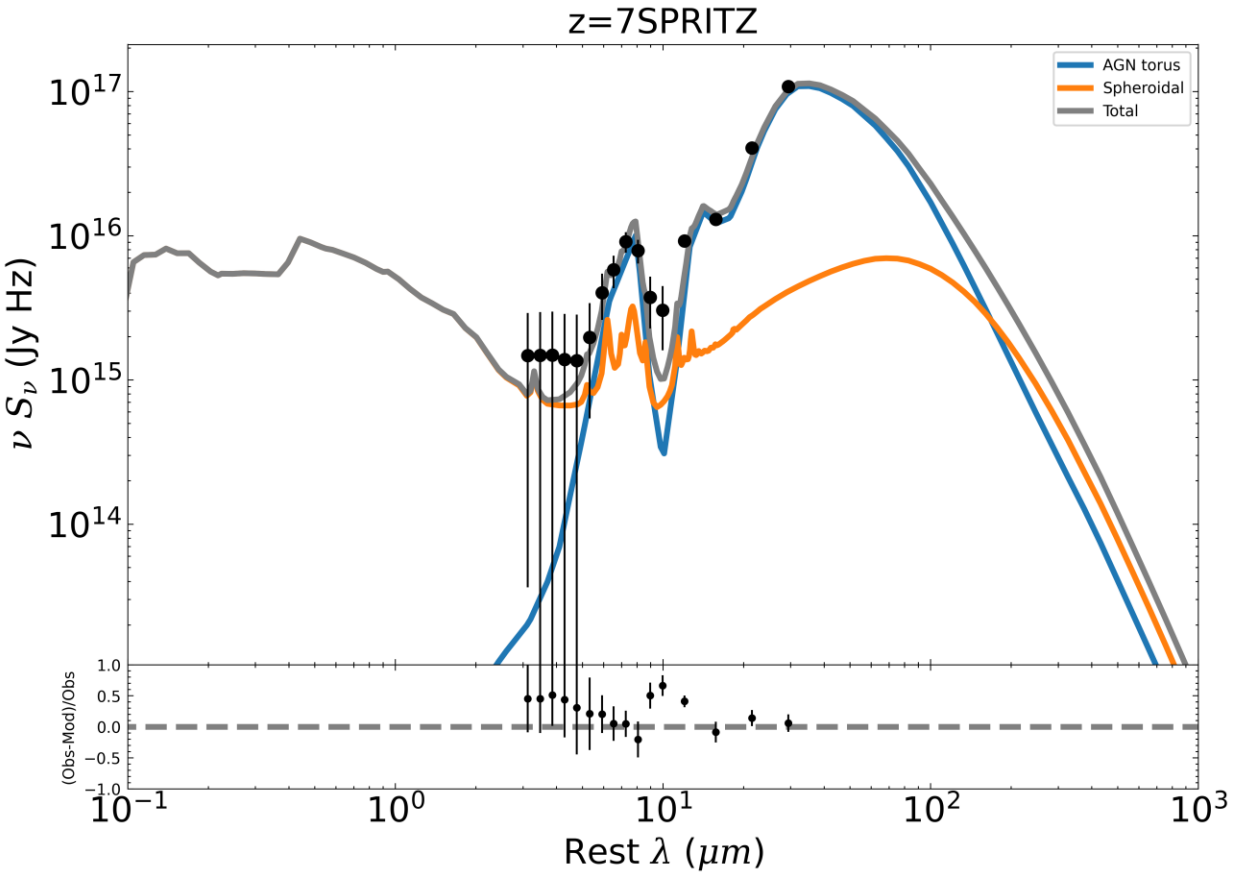
- 1500h/deg^2 survey using confusion mitigation techniques (Donnellan+24, talk later)
- SPRITZ simulation: generate galaxy catalogue from IR luminosity functions (Bisigello+21, 24)



Donnan+25 (JATIS)

PRIMAger

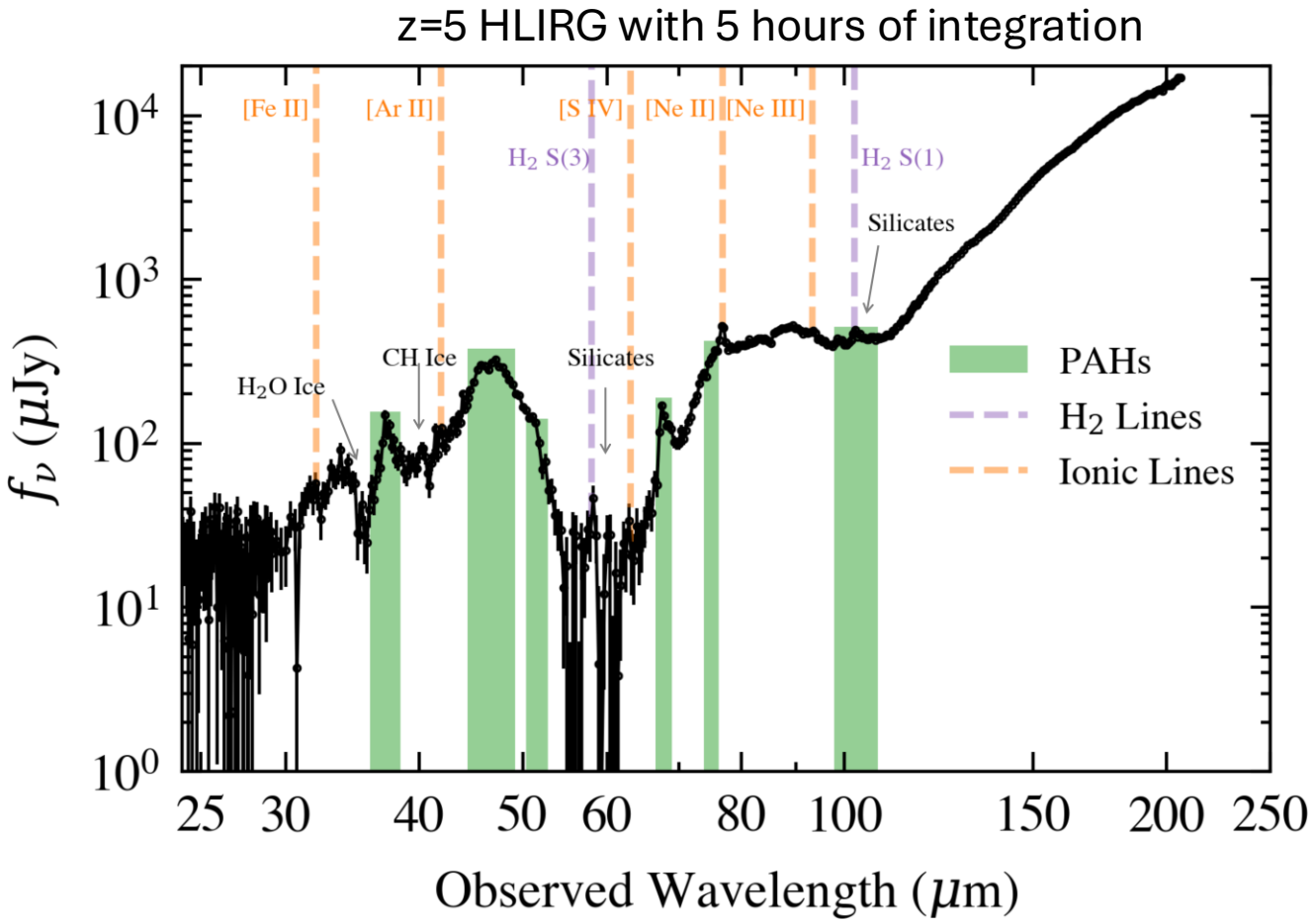
- High quality SEDs up to z~7
- Constrain AGN torus models from SED fitting
- SMART SED Code (Varnava & Efstathiou+24)



Donnan+25 (JATIS)

FIRESS Spectroscopy

- Follow-up spectroscopy of photometric candidates
- Identify ices, silicates, PAHs, ionic lines, molecular lines



Donnan+25 (JATIS)

Summary

- Identify Obscured Nuclei over cosmic time via mid-IR silicate absorption.
- PRIMAger: 1000s-10s of obscured nuclei between z~2-7
- FIRESS: high quality spectral follow-up with modest time investment