

The mid-/near-IR interferometry of AGNs :
key results and their implications

Makoto Kishimoto

Kyoto Sangyo University

IR interferometers

- Keck & VLT interferometers



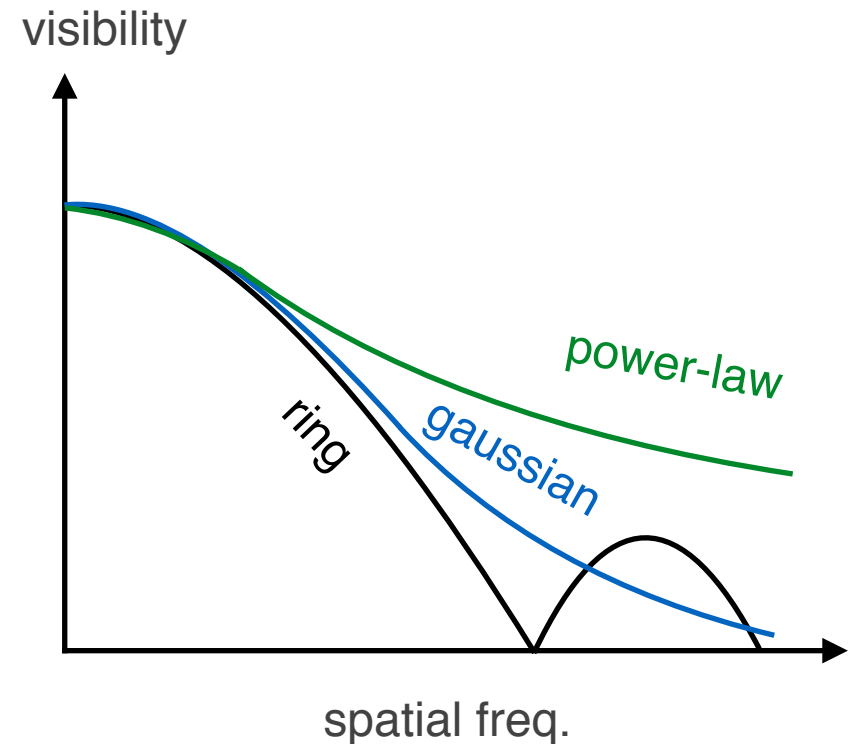
near-IR
max 85m
2 telescopes



near-IR / mid-IR
max 130m
4 telescopes

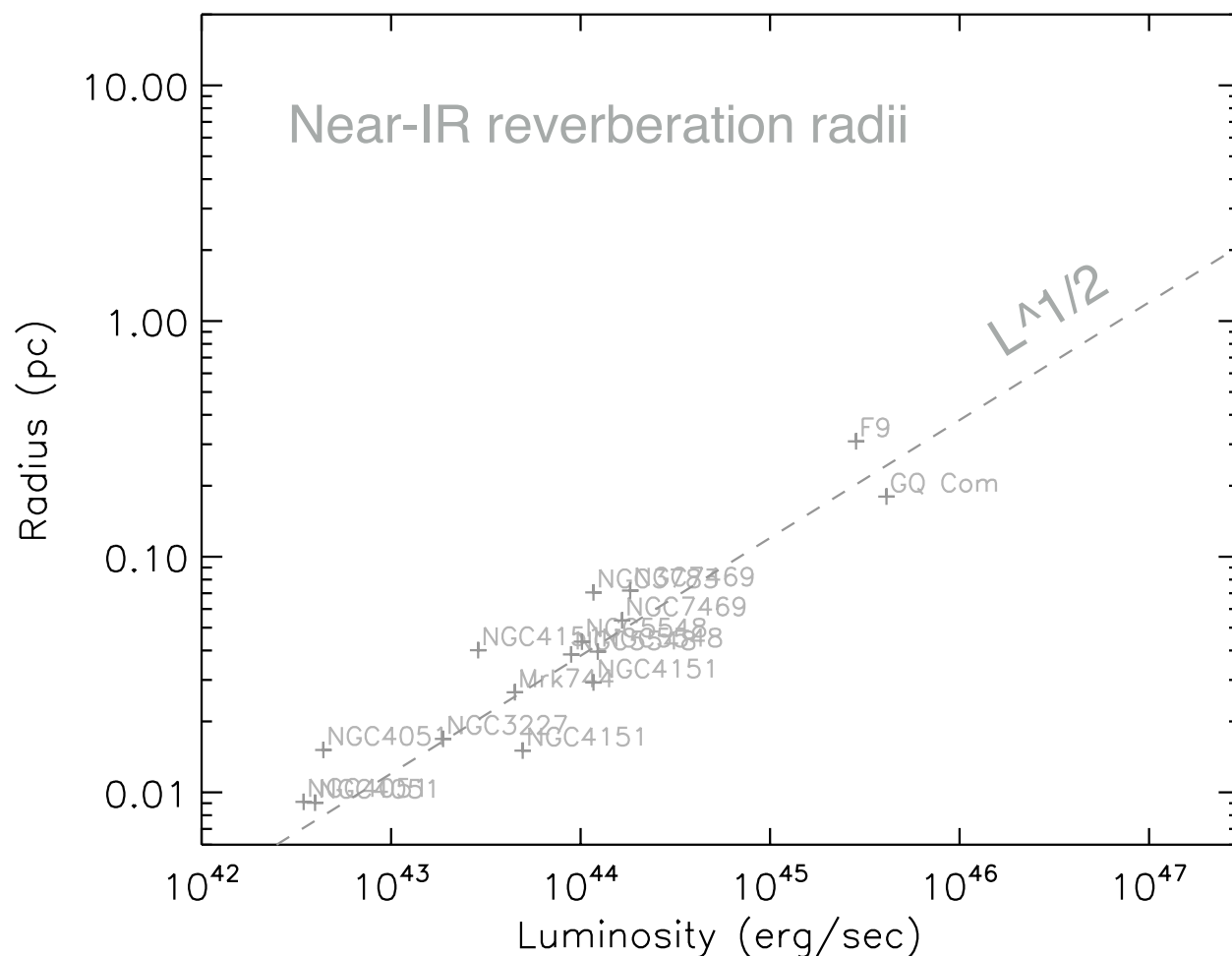
What we can do now with IR interf. on AGN:

- Spatially resolve the dust distribution,
 - dealing often only with the "first lobe"
- Almost no phase info
 - two beams, or
 - zero closure phase at low spatial freq.
- We can still measure:
 - overall size
 - radial profile in mid-IR
 - PA & L dependency



A thing to keep in mind for centrally-heated dust

- Opt. / near-IR variability time-lag :
 - innermost 'boundary' radius of dust dist. ($\equiv R_{\text{sub}}$)
 - prop to $L^{1/2}$



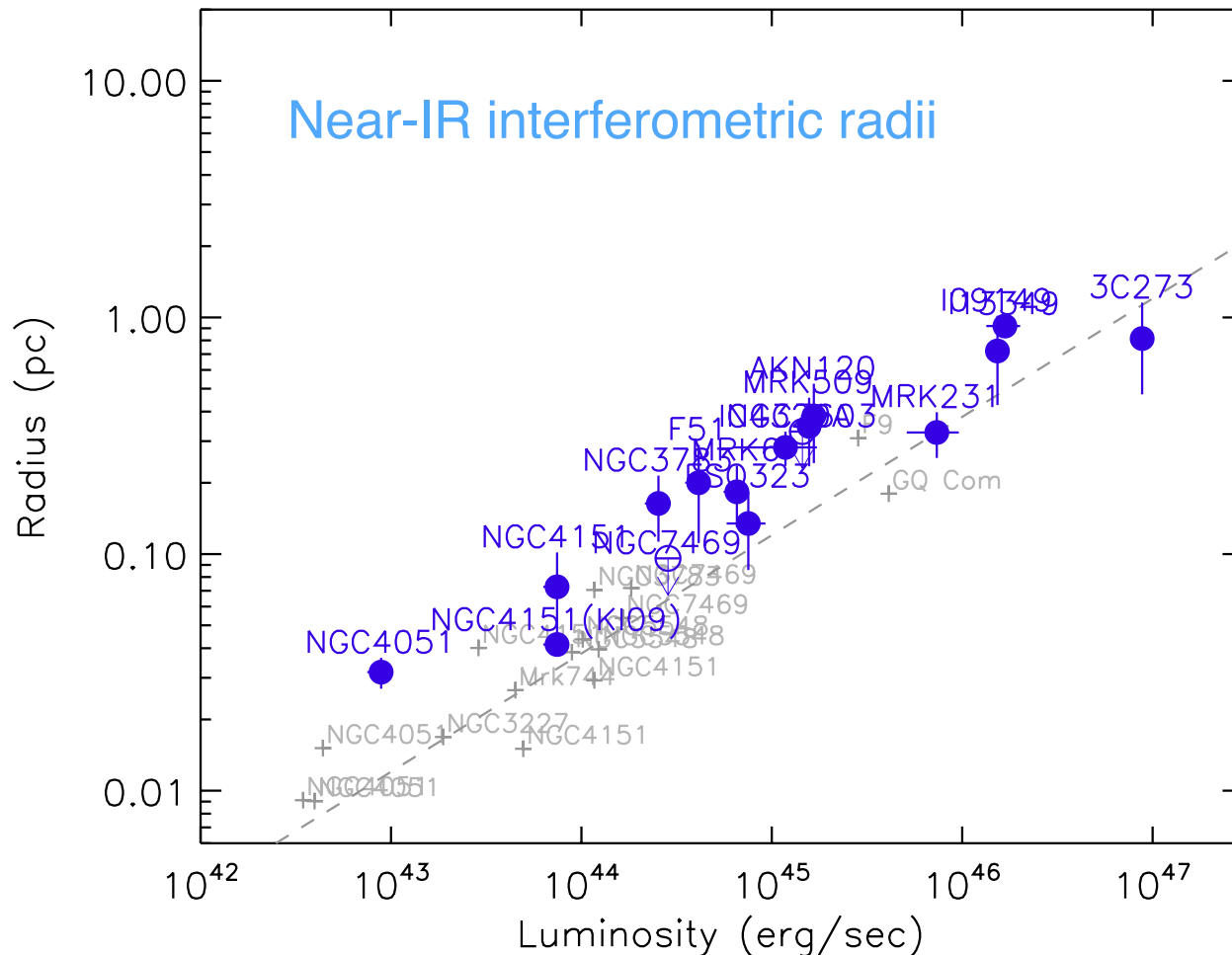
Oknyanskij+01

Suganuma+06

Koshida+14

Near-IR interferometry

- Many Type 1s, marginally resolved
 - brightness radius up to a few R_{sub}



Kishimoto+09,11,13

Pott+10

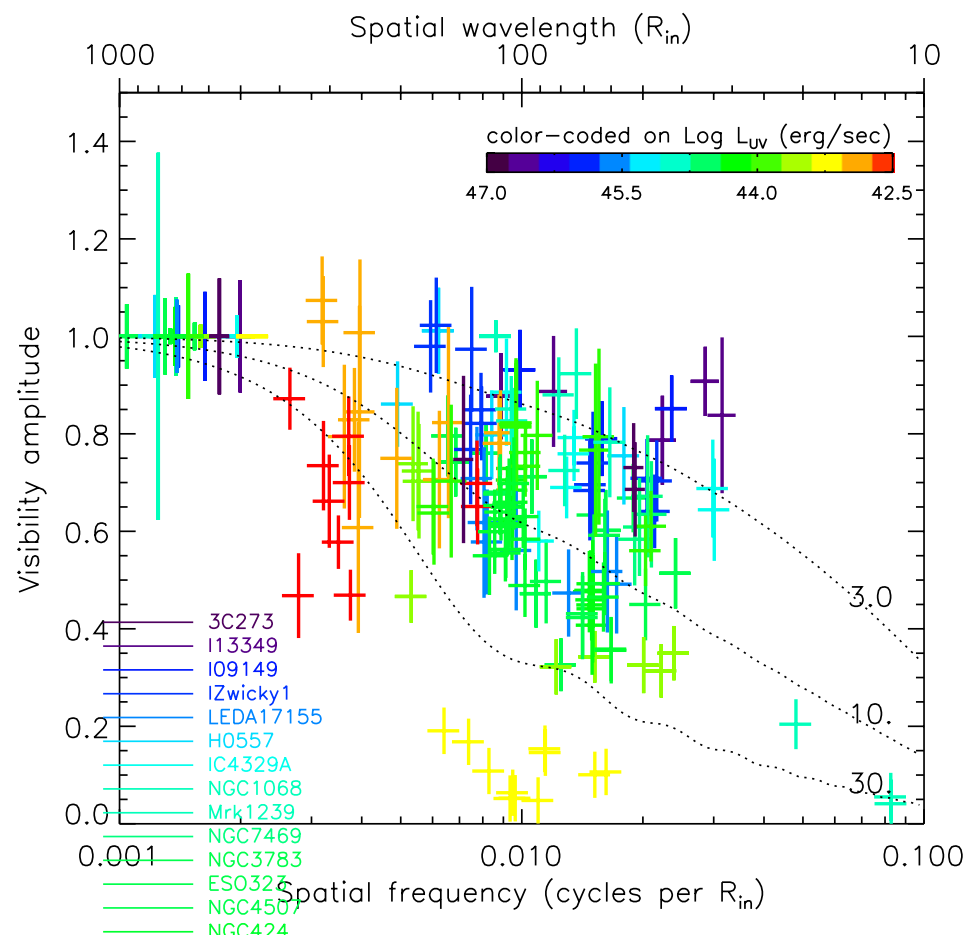
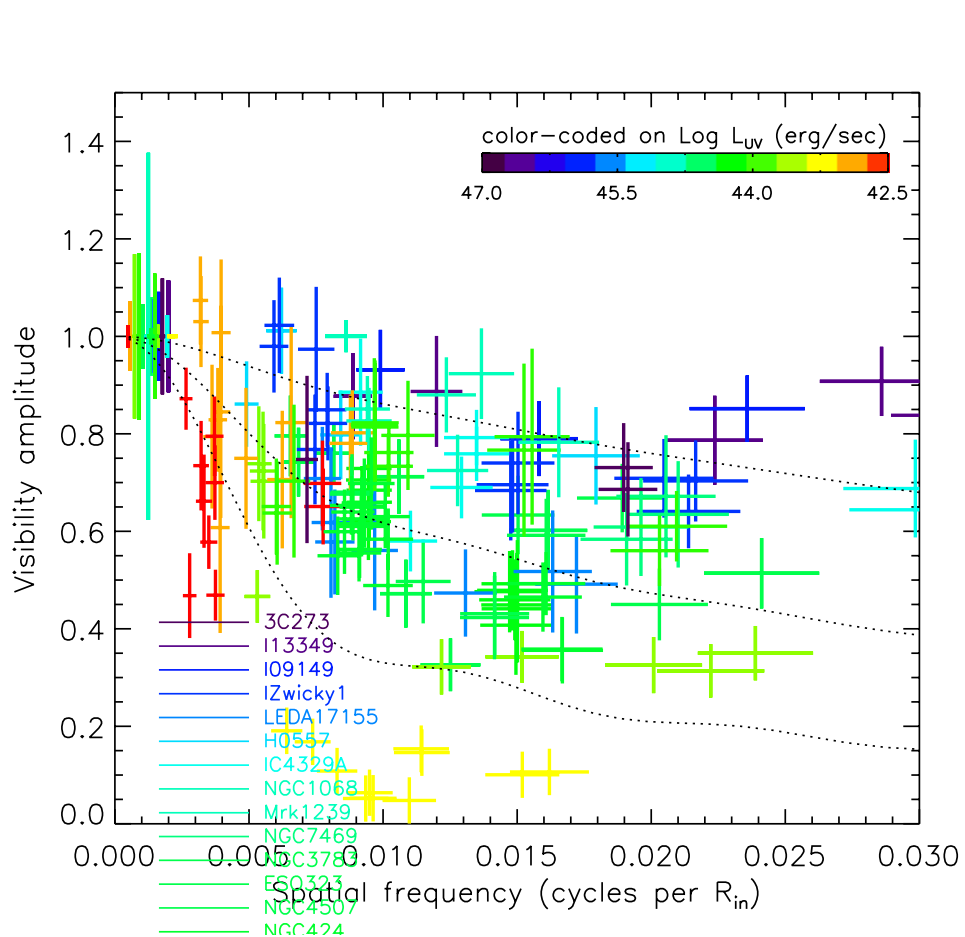
Weigelt+12

Mid-IR interferometry

- Starting from NGC1068, Circinus, Cen A (Jaffe+04, Tristram+07, Meisenheimer+07; Tristram+14, Lopez-Gonzaga+14)
 - people have observed many fainter targets.
- ESO Large Program gathered 20+ targets (Burtscher+13).
 - Data look a bit complicated.
- A key to disentangle the vast data:
 - use $R_{\text{sub}} (\equiv R_{\text{reverb}})$ to normalize the probed scales to get rid of the simple $L^{1/2}$ dependency and distance scaling.

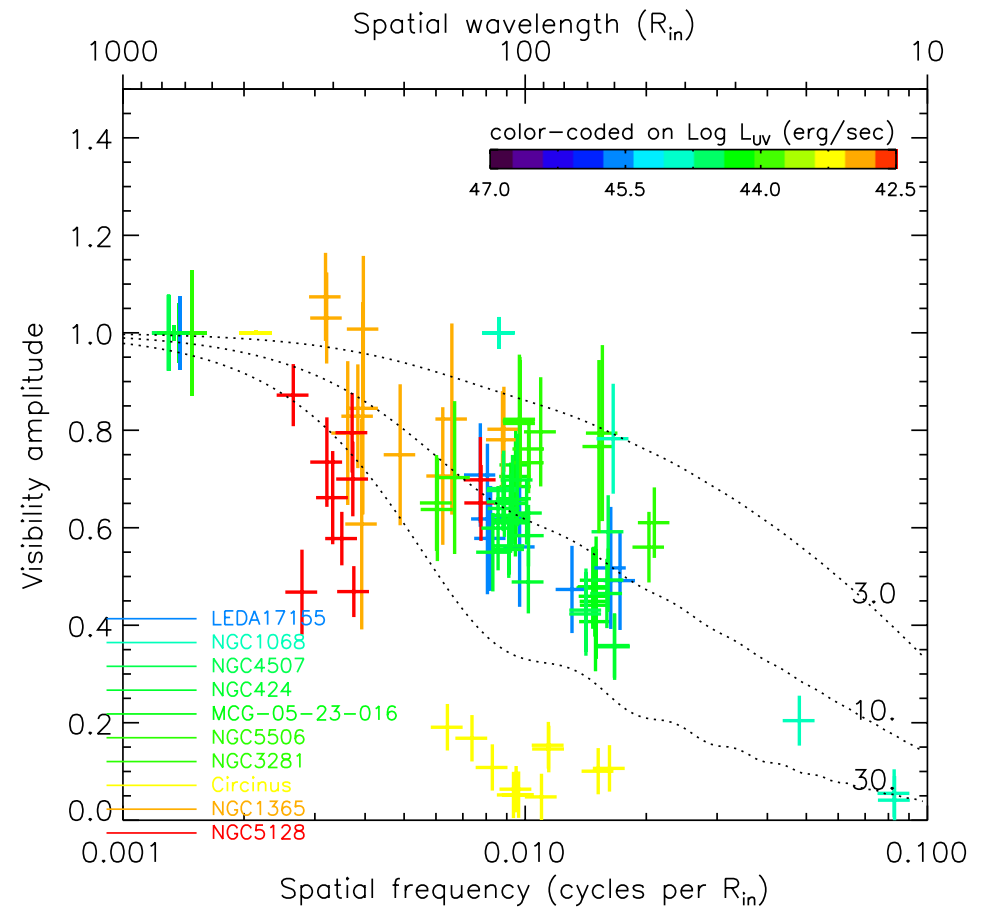
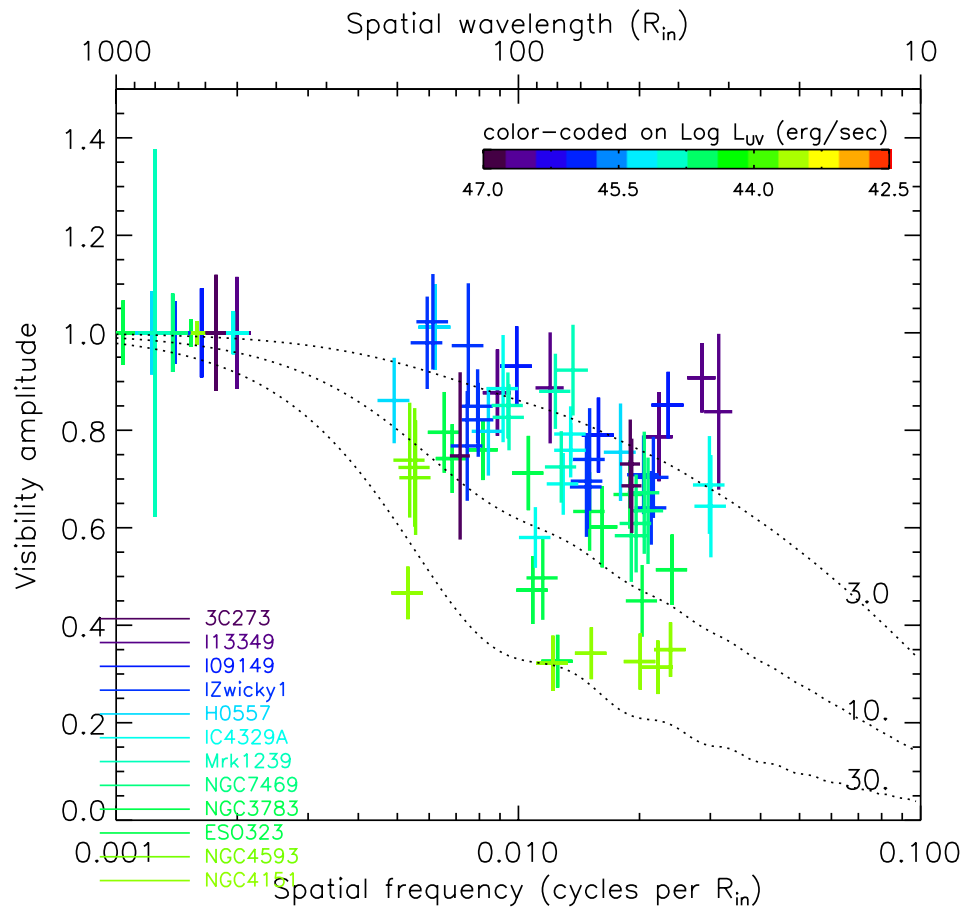
Visibilities as a function of spatial scales in R_{sub}

- Quite systematic behaviour
 - mid-IR radial profile suggesting power-law-like dist
 - Overall size can be parameterized by $R_{1/2}$



Visibilities as a function of spatial scales in R_{sub}

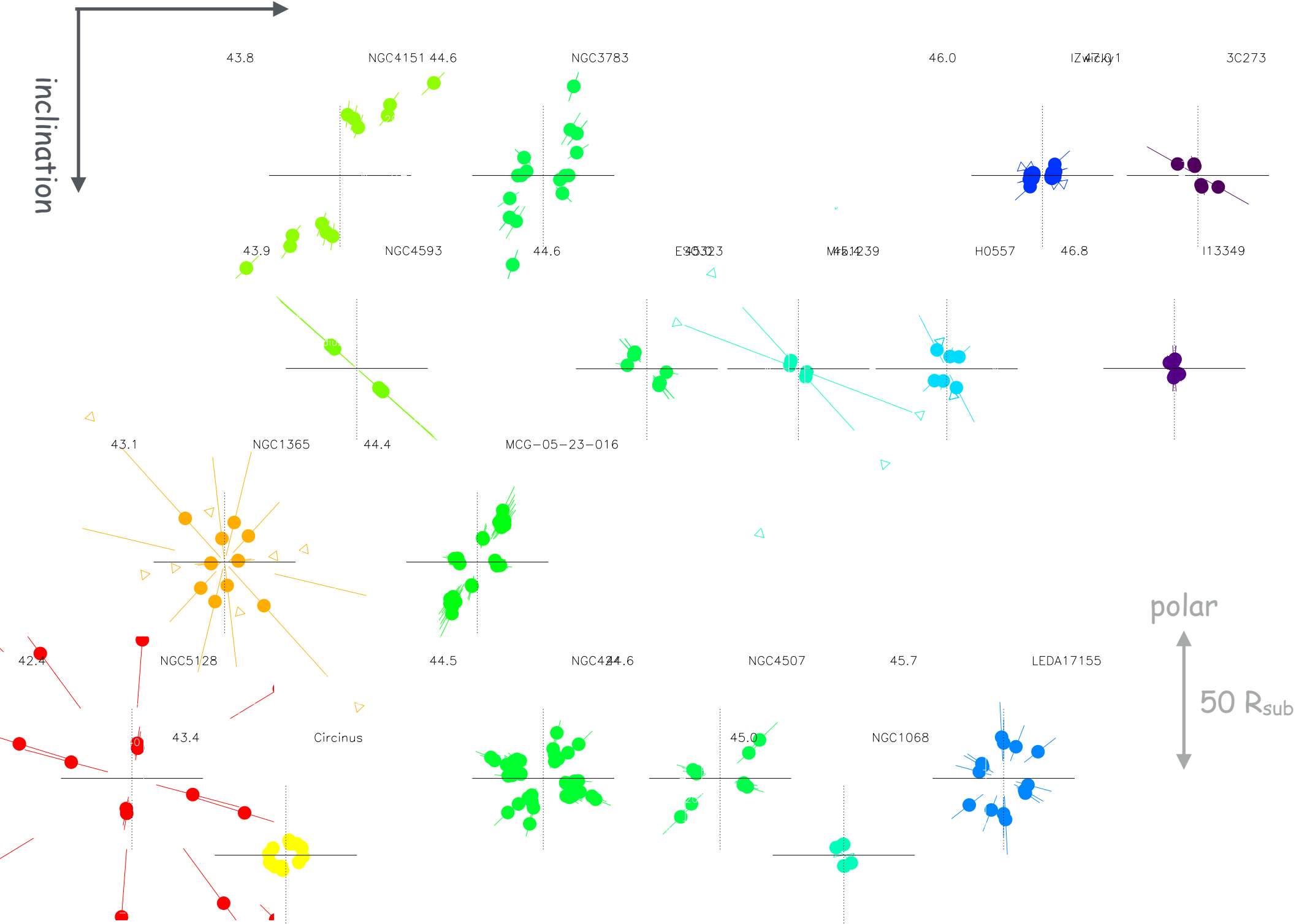
- Type 1 vs Type 2
- L dependence is quite clear



Luminosity

Half-light radius

inclination



$R_{1/2}$ in units of R_{sub}

- At higher L ,
 - $R_{1/2}$ smaller
 - radial surface density profile steeper
 - much less illuminated material in outer radii
- Polar elongation at 10s of R_{sub} ; Eq. elong. at $\sim 5 R_{\text{sub}}$
 - dusty polar wind? (Hoenig+12,13)
 - Circinus (Tristram+12,14), NGC1068 (Lopez-Gonzaga+14)
 - might be more prominent in lower L objects

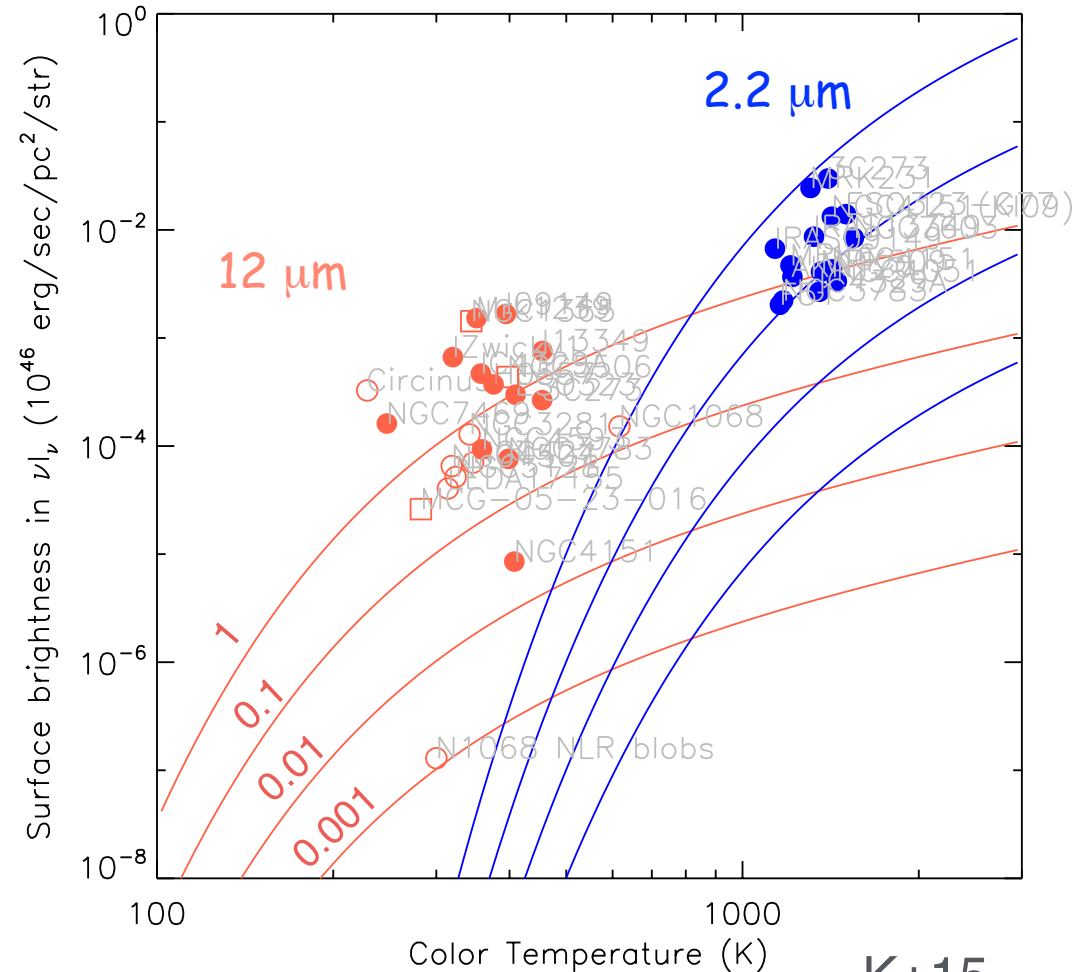
Polar stuff also participates in obscuration

- Surf. brightness gives emissivity of unity to sub-unity

- consistent with directly-illuminated UV-opt-thick surface

- participating in obscuring the nucleus

- very different from resolved NLR clouds

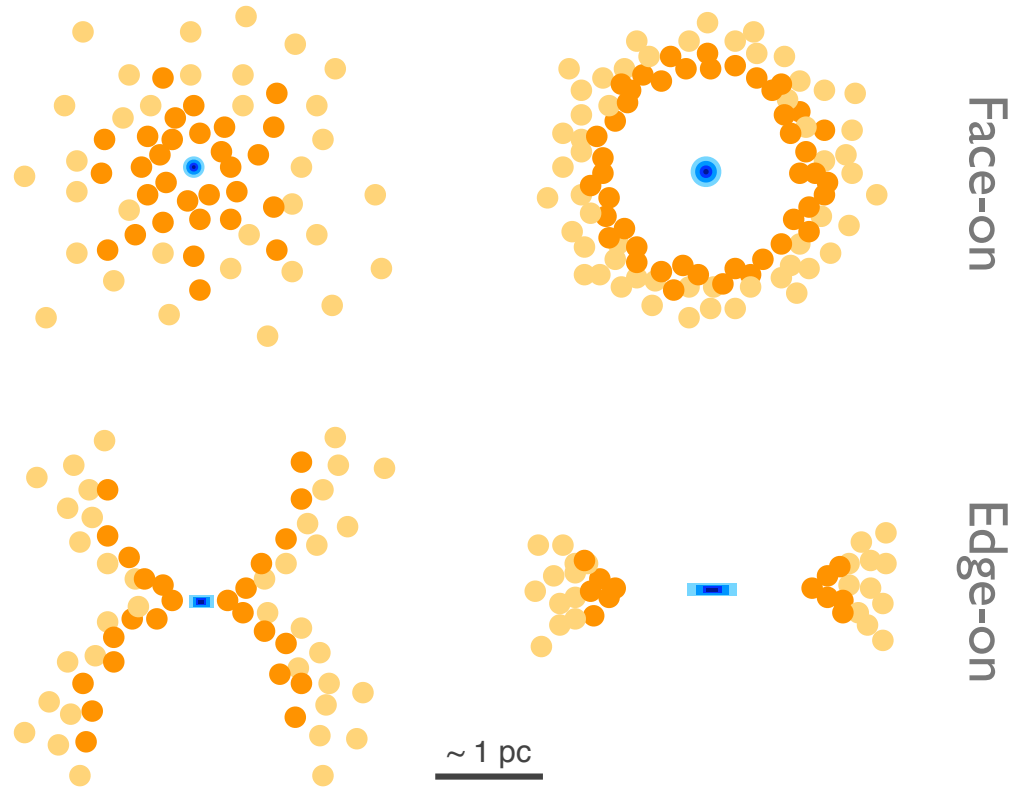


Interpretations

- Polar stuff in
 - hollow, valley shape to avoid Type-1 obsc.
- At higher acc.rate:
 - polar, outer stuff gone
 - eff. wider opening
- radiation pressure on dust grains (e.g. Semenov+03)
 - eff. L/L_{Edd} potentially > 1
- possible anisotropic illumination
 - anisotropy of acc. disk (Netzer+85; Kawaguchi+11)

Lower L or L/L_{Edd}

Higher L or L/L_{Edd}



Summary

- At higher L , IR stuff looks smaller in units of R_{sub}
- Polar elongation at 10s of R_{sub}
- Polar stuff participates obscuration
 - 'hollow-cone' shape is required
- Perhaps "polar clearing" at higher L :
 - leaving the $\sim 5 R_{\text{sub}}$ equatorial core
 - effectively leading to wider opening angle