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

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IR interferometers

- Keck & VLT interferometers

near-IR
max 85m
2 telescopes

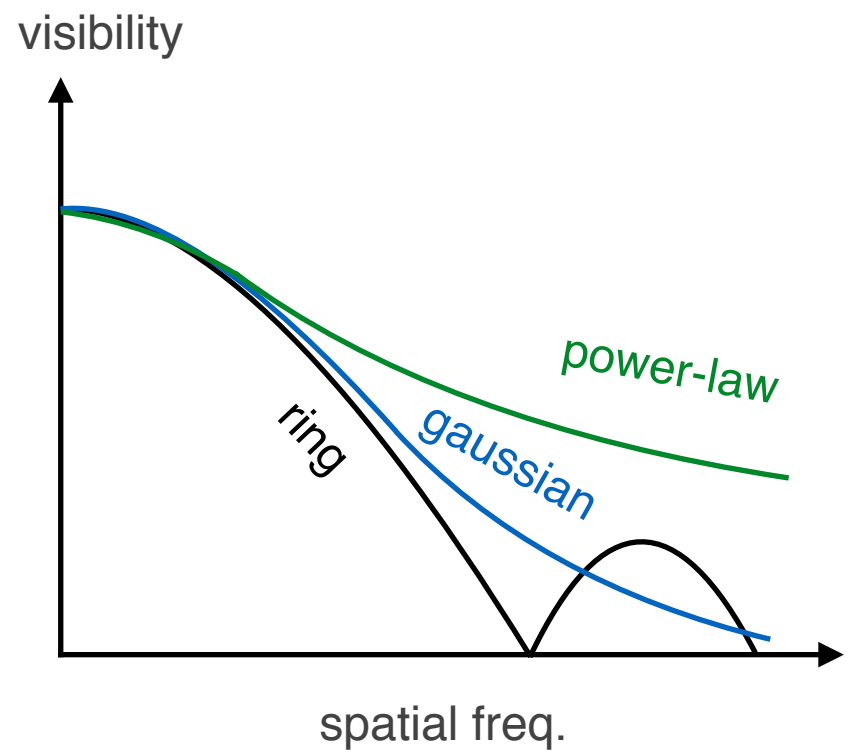
near-IR / mid-IR
max 130m
4 telescopes

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

- Spatially resolve the dust distribution,
  - dealing often only with the "first lobe"

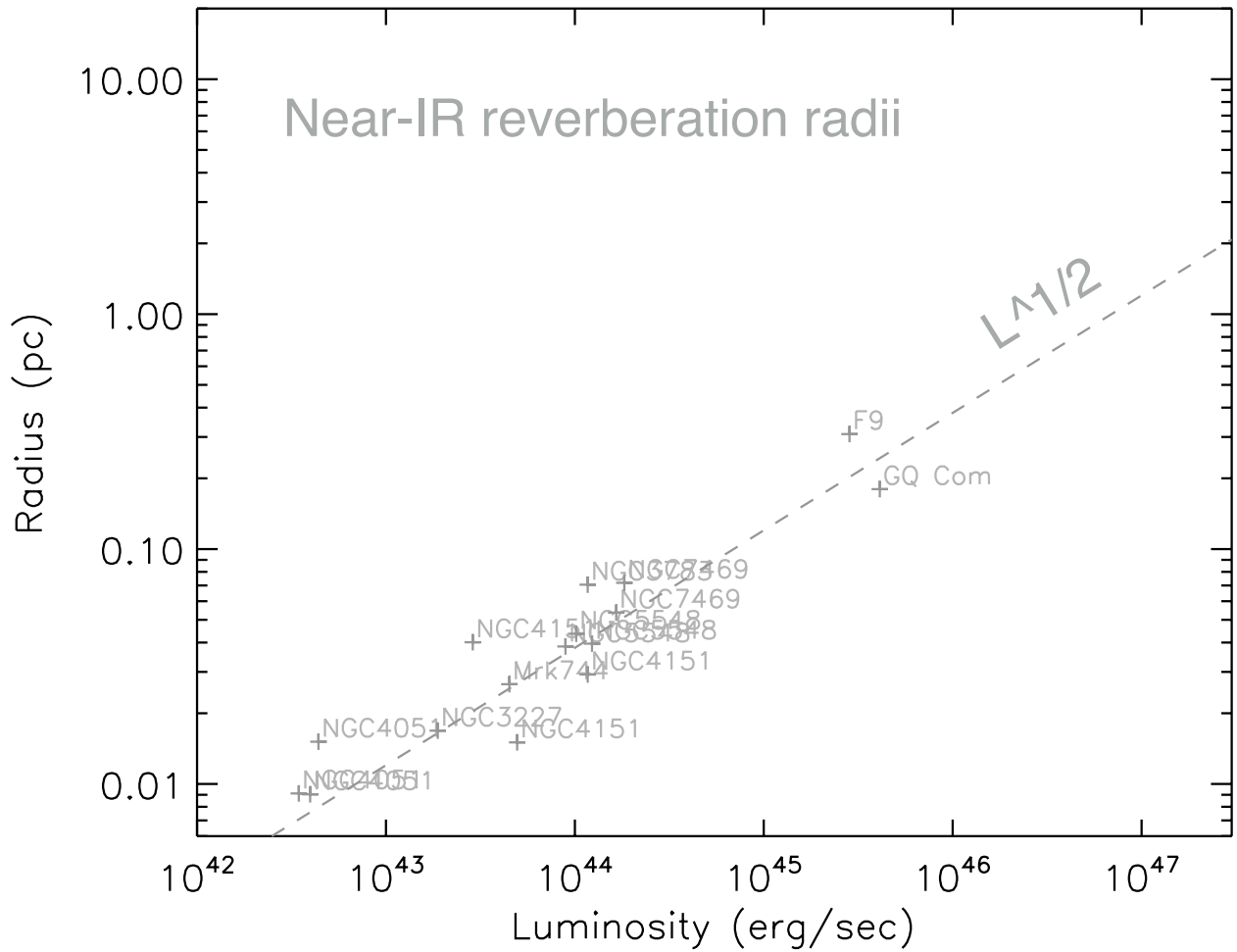
- Almost no phase info
  - two beams, or
  - zero closure phase at low spatial freq.

- 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. (≡ R_{sub})
  - prop to L^1/2



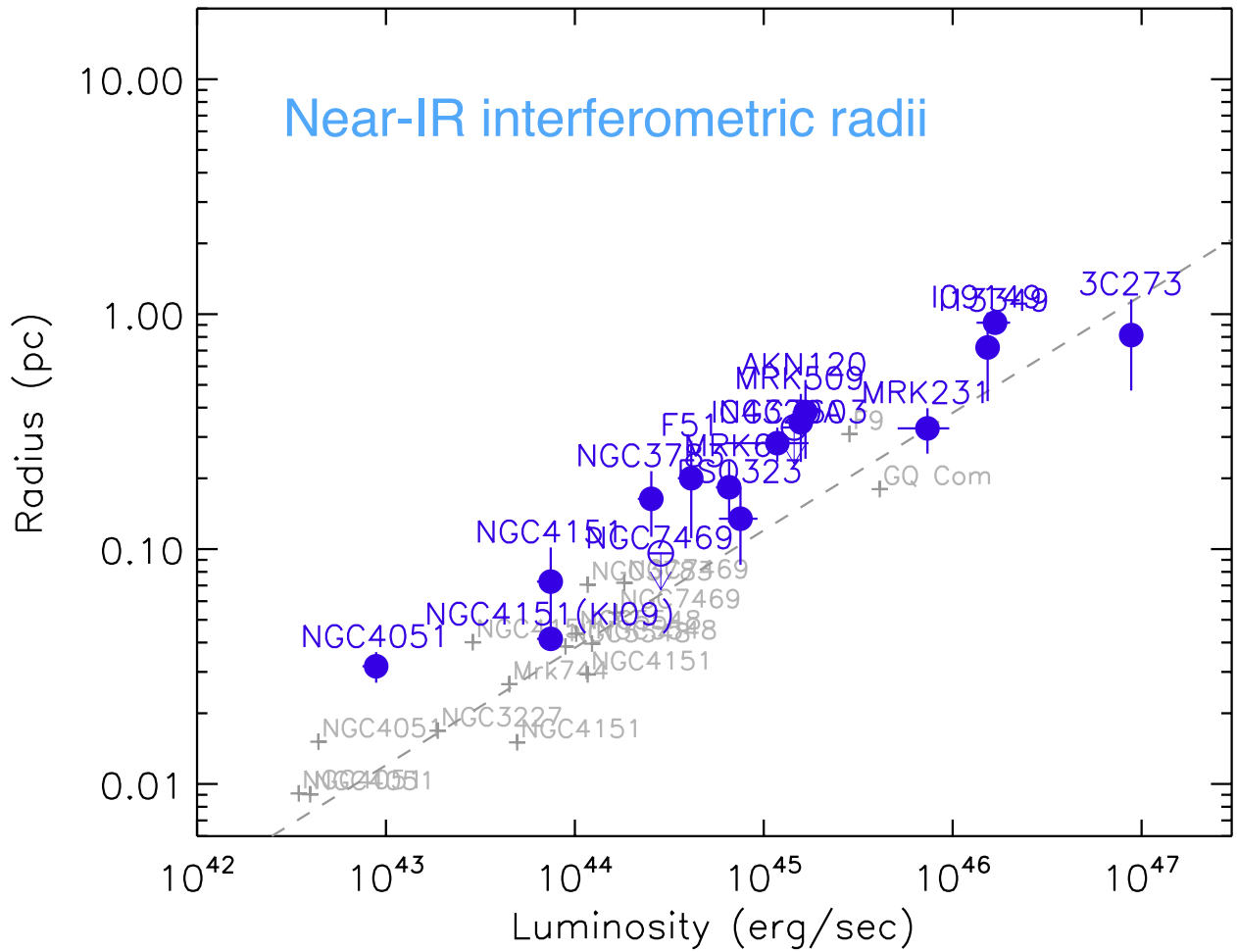
Oknyanskij+01

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

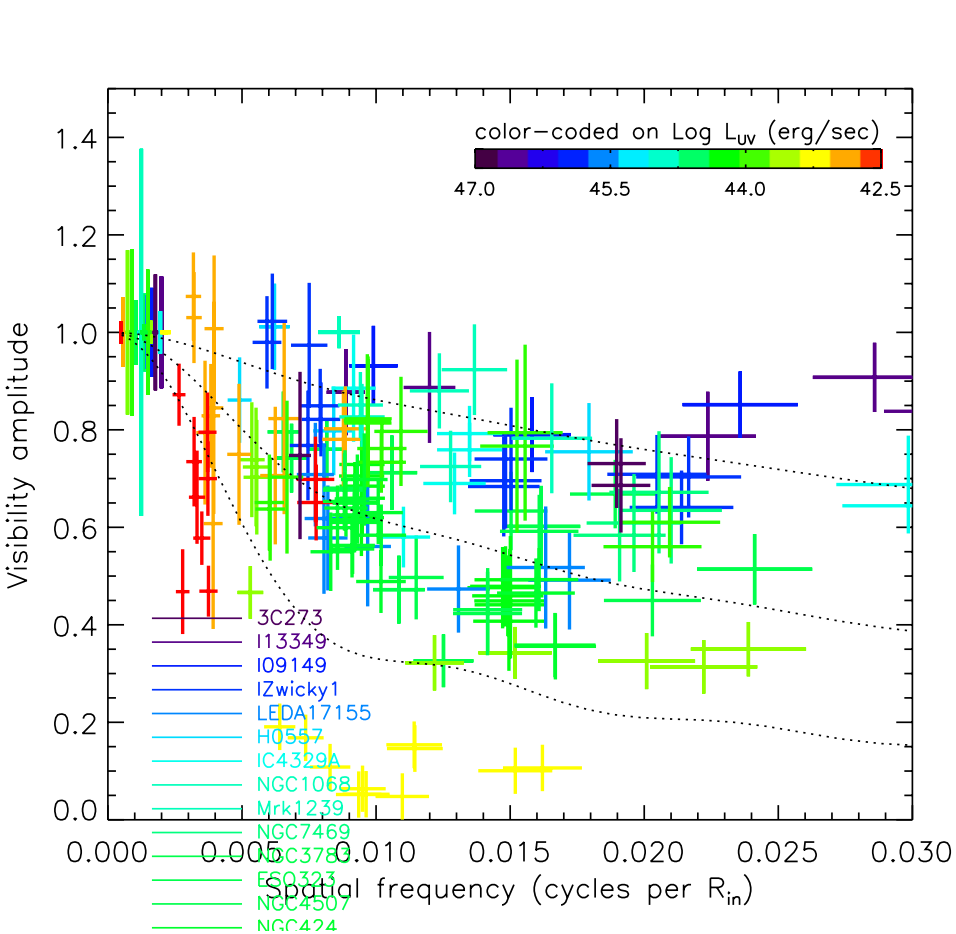
- Starting from NGC1068, Circinus, Cen A (Jaffe+04, Tristram+07, Meisenheimer+07; Tristram+14, Lopez-Gonzaga+14)
  - people have observed many fainter targets.

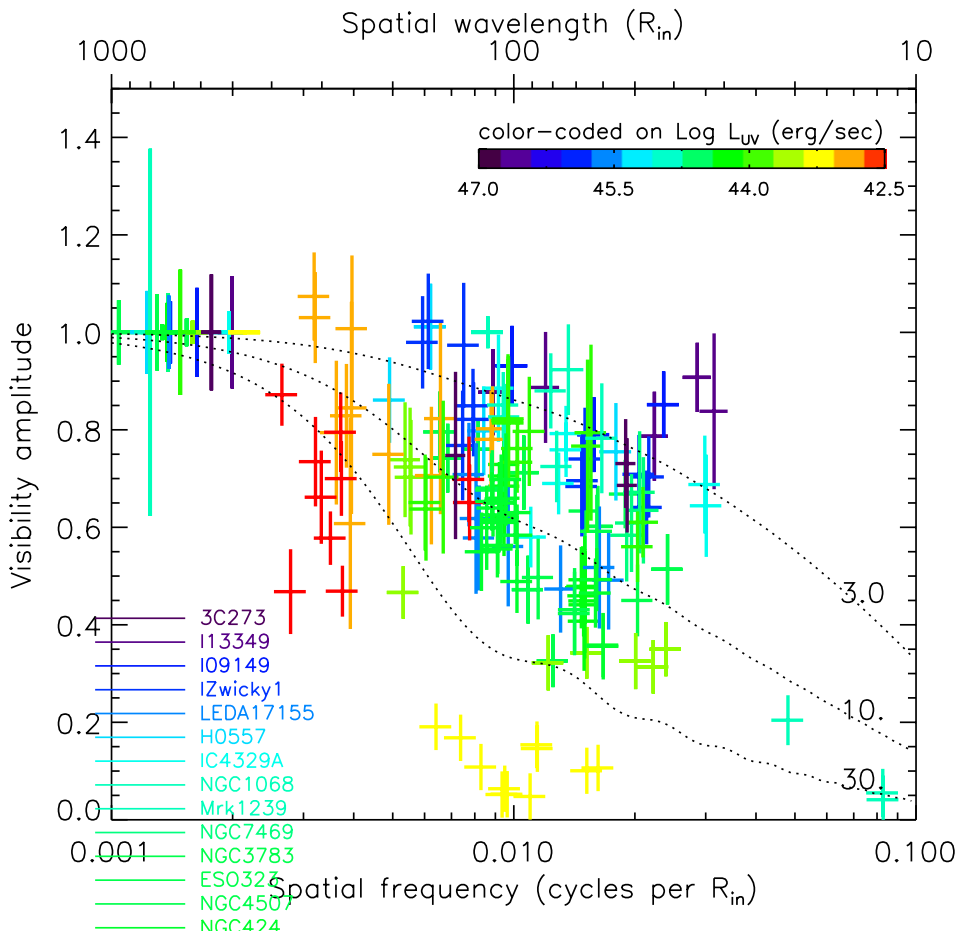
- ESO Large Program gathered 20+ targets (Burtscher+13).
  - Data look a bit complicated.

- A key to disentangle the vast data:
  - use R_{sub} ($\equiv R_{reverb}$) 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 $R_{1/2}$

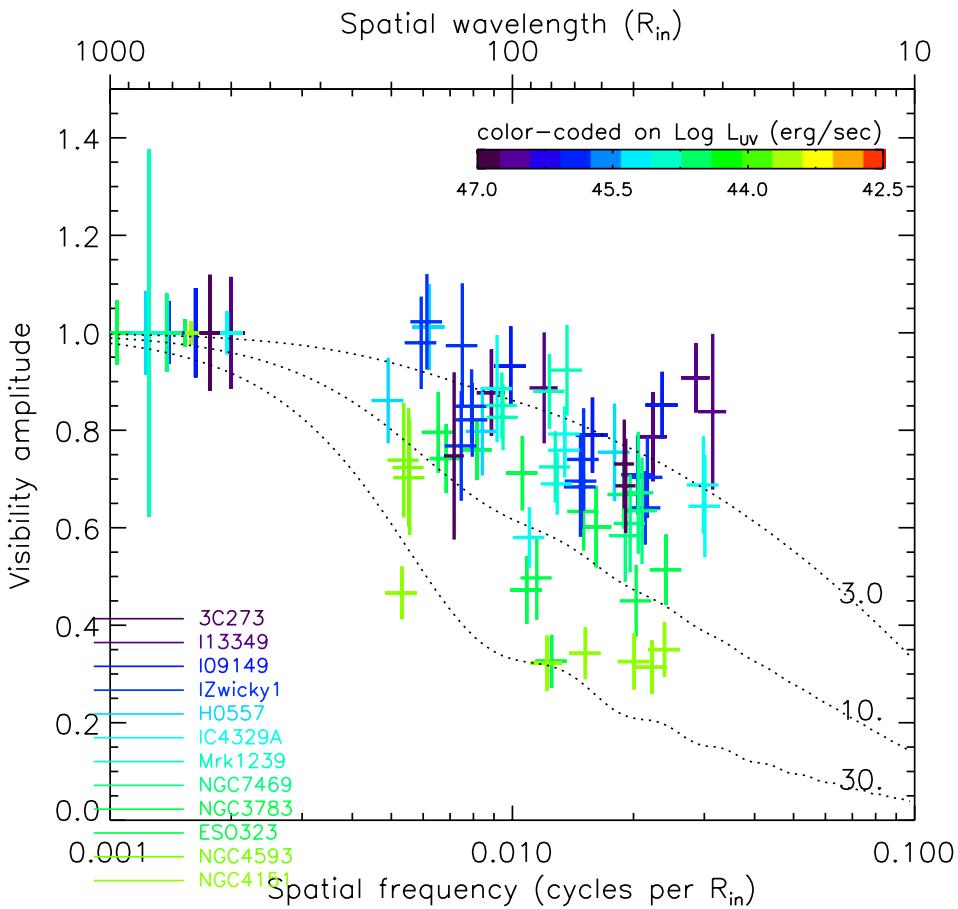


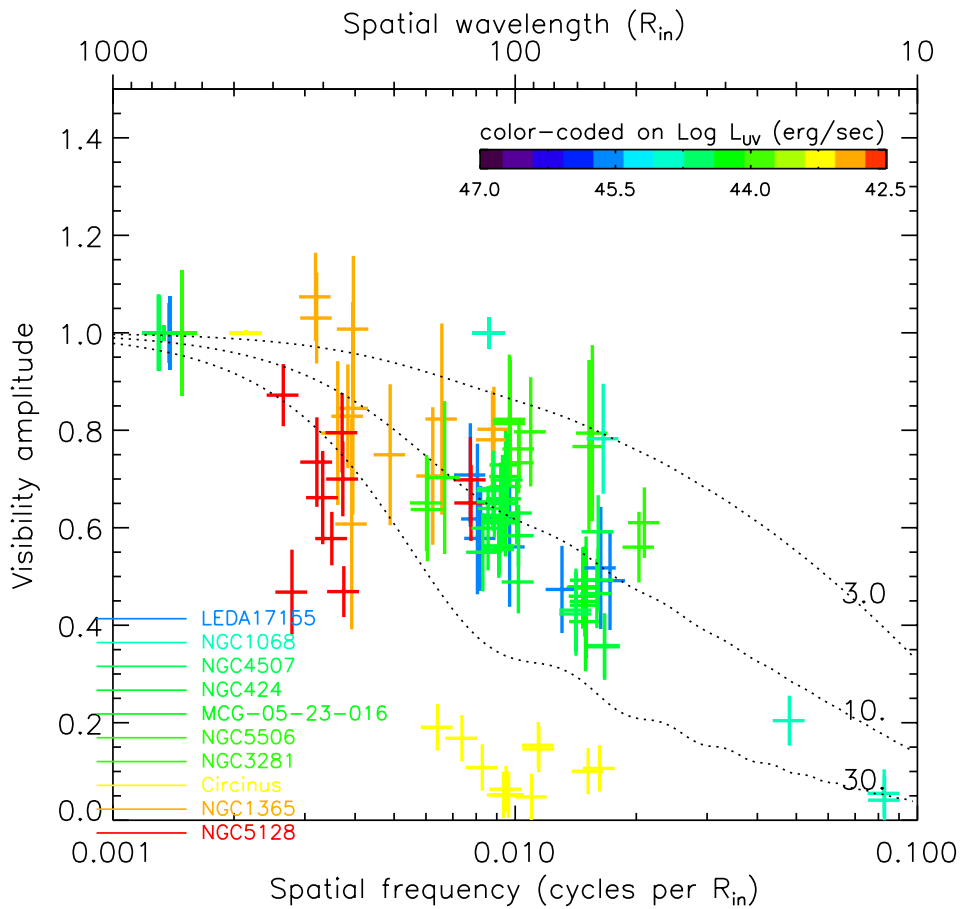


K+15

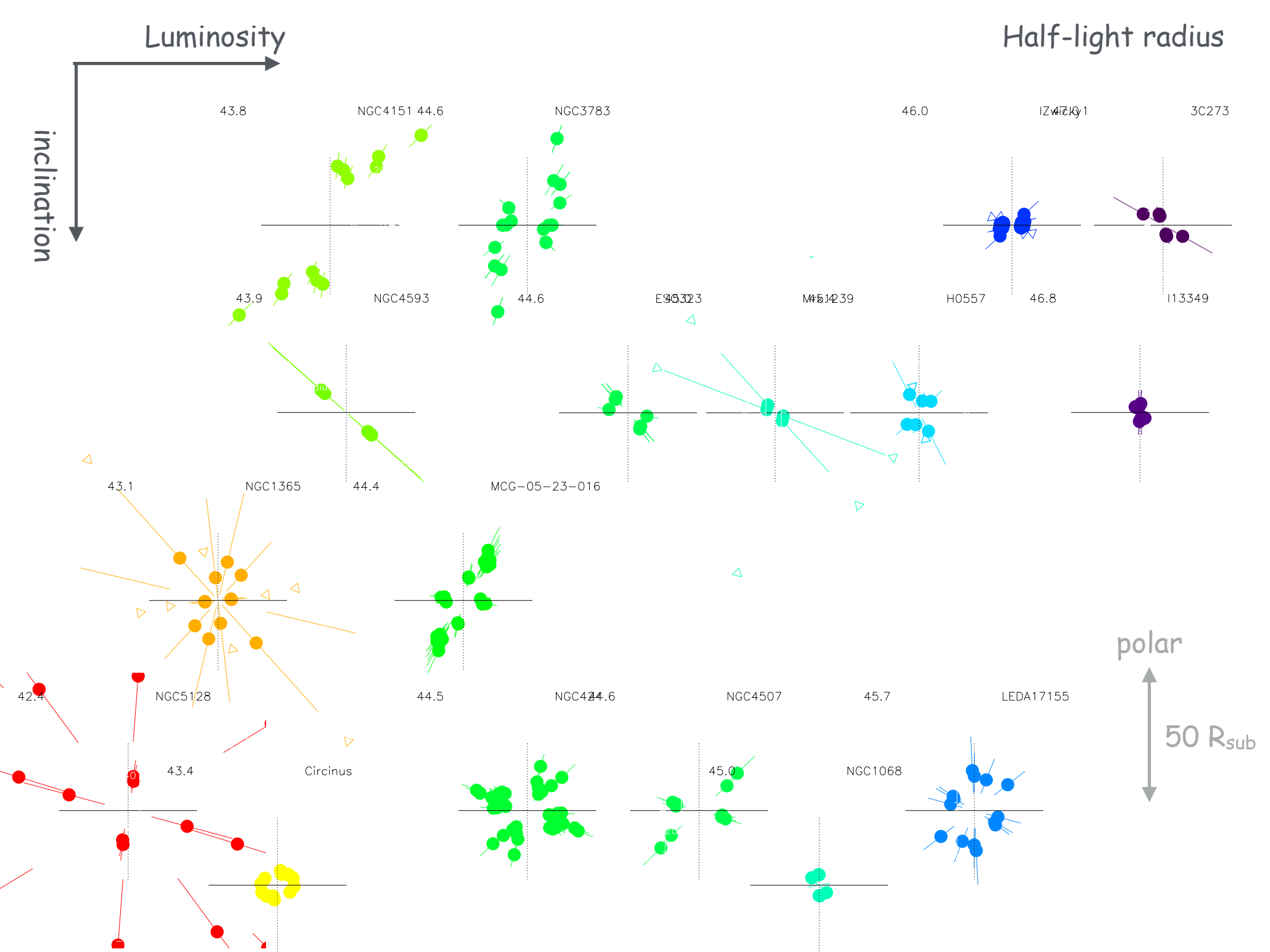
Visibilities as a function of spatial scales in R_{sub}

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





K+15


Luminosity
Half-light radius
inclination
43.8
NGC4151
44.6
NGC3783
46.0
IZw1
3C273
43.9
NGC4593
44.6
H0557
46.8
I13349
43.1
NGC1365
44.4
MCG−05−23−016
polar
50 Rsub
42.4
NGC5128
44.5
NGC4507
45.7
LEDA17155
43.4
Circinus
45.0
NGC1068

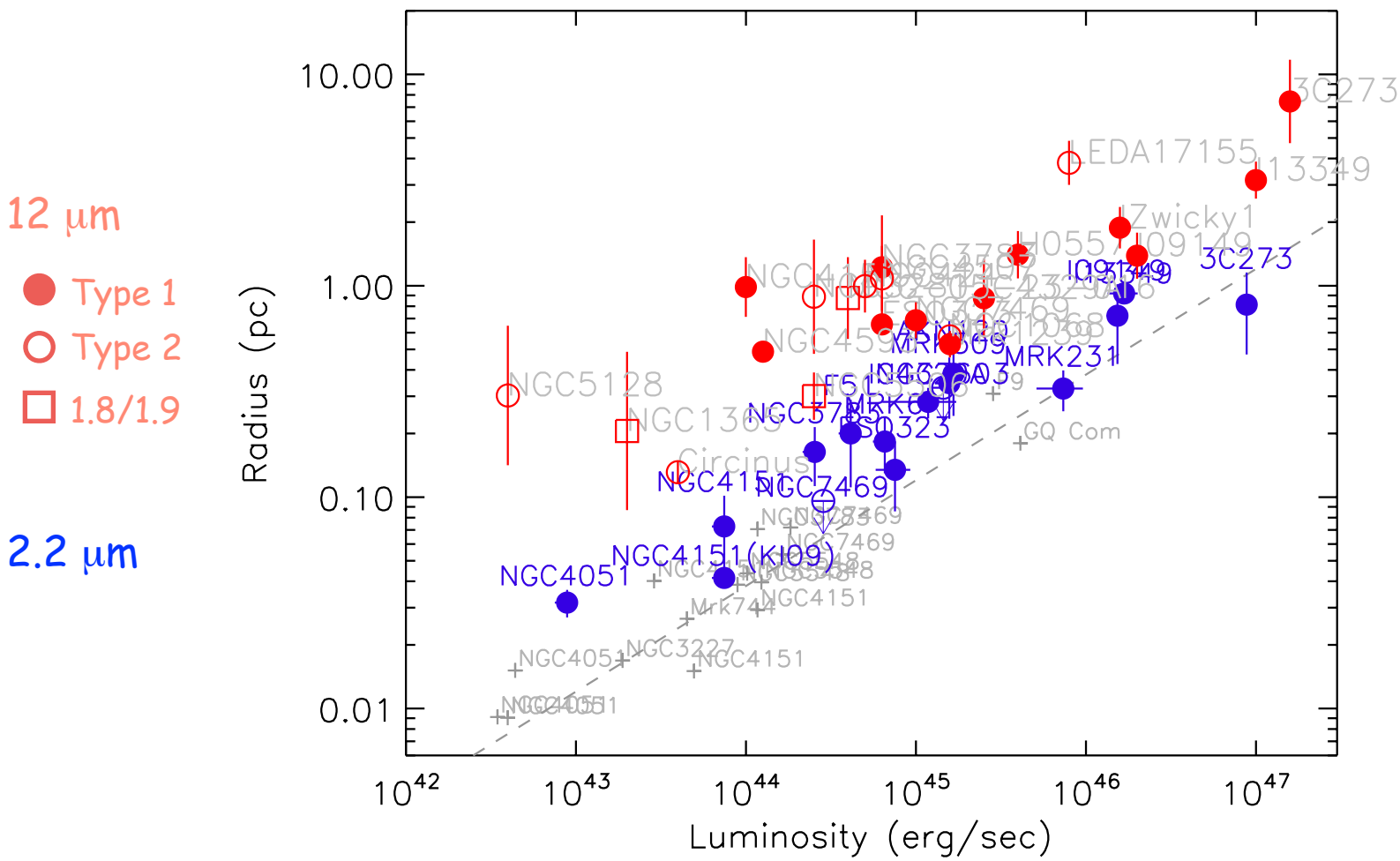
$R_{1/2}$ in units of R_{sub}

- 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 ~5 R_{sub}
  - dusty polar wind? (Hoenig+12,13)
  - Circinus (Tristram+12,14), NGC1068 (Lopez-Gonzaga+14)
  - might be more prominent in lower L objects

$R_{1/2}$ in physical units, pc

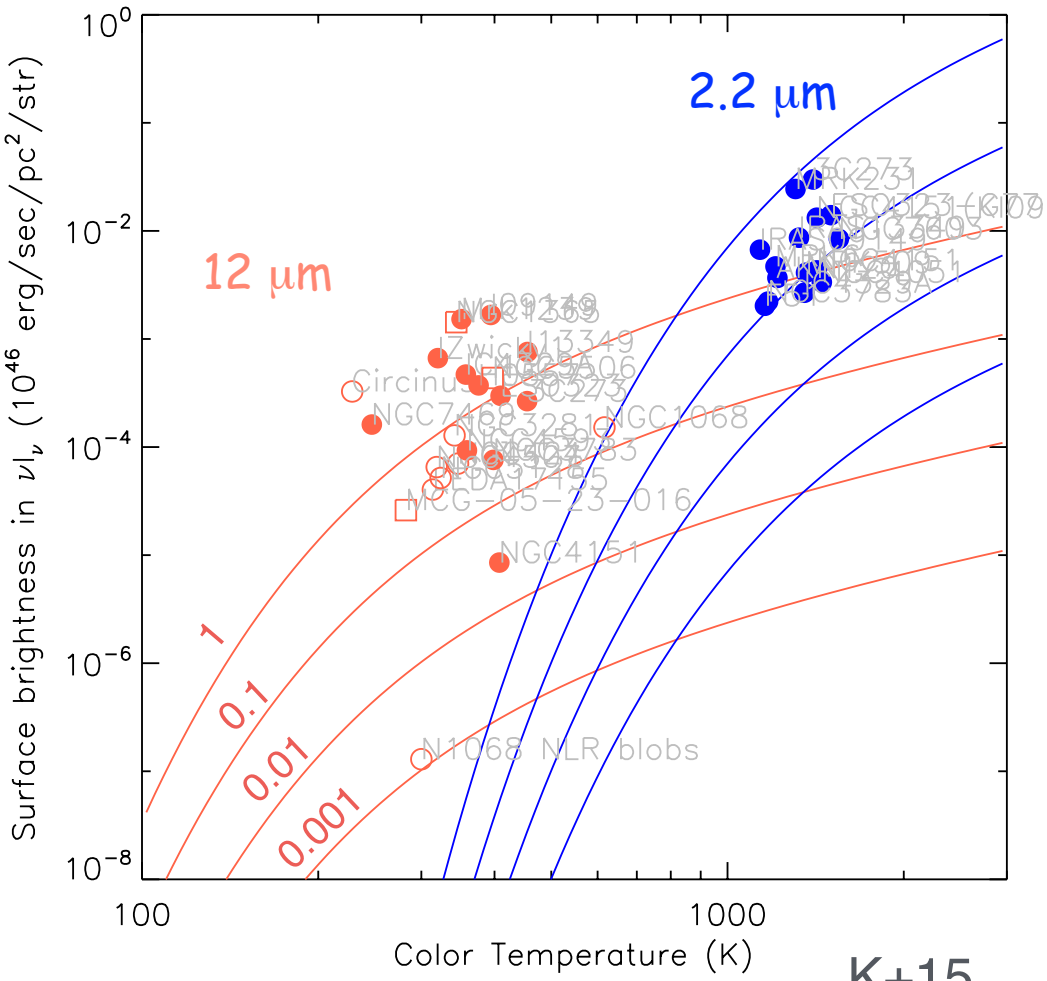
- mid-IR $R_{1/2}$ has a shallower L dep.
- 1s and 2s similar L dep., though 2s more scatter?
  - 'eq core' of 2s similar in size to high-L 1s



K+15

Polar stuff also participates in obscuration

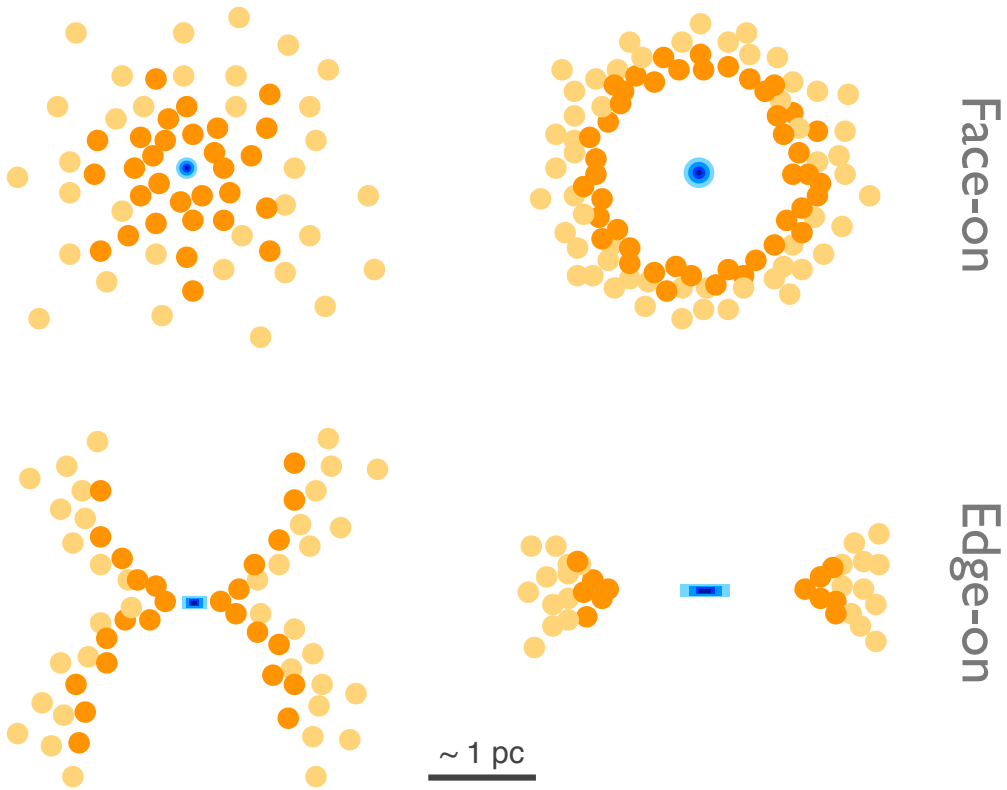
- Surf. brightness gives emissivity of unity to sub-unity
  - consistent with directly-illuminated UV-opt-thick surface
  - participating in obscuring the nucleus
  - very different from resolved NLR clouds



K+15

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/Ledd potentially > 1
- possible anisotropic illumination
  - anisotropy of acc. disk (Netzer+85; Kawaguchi+11)

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 ~5 R_{sub} equatorial core
  - effectively leading to wider opening angle