Infrared nuclei of active galaxies as probed by interferometers: a review

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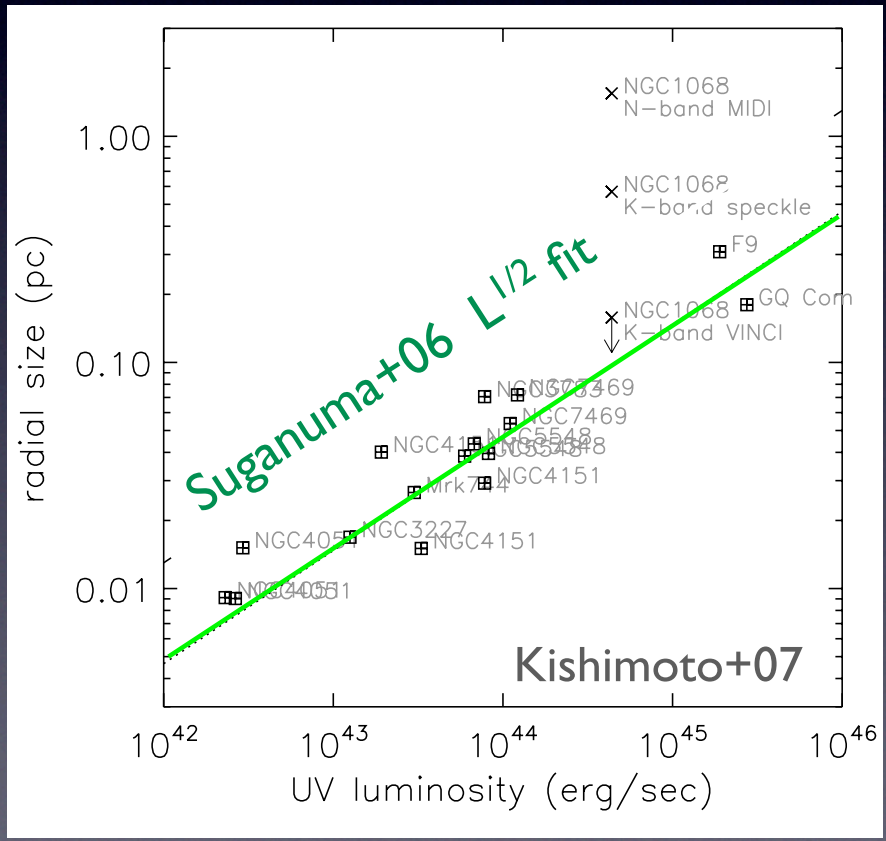
Two prerequisites for AGN tori

- Type 1 vs 2 : face-on vs edge-on, un- vs obscured
- Empirical dust sublimation radius

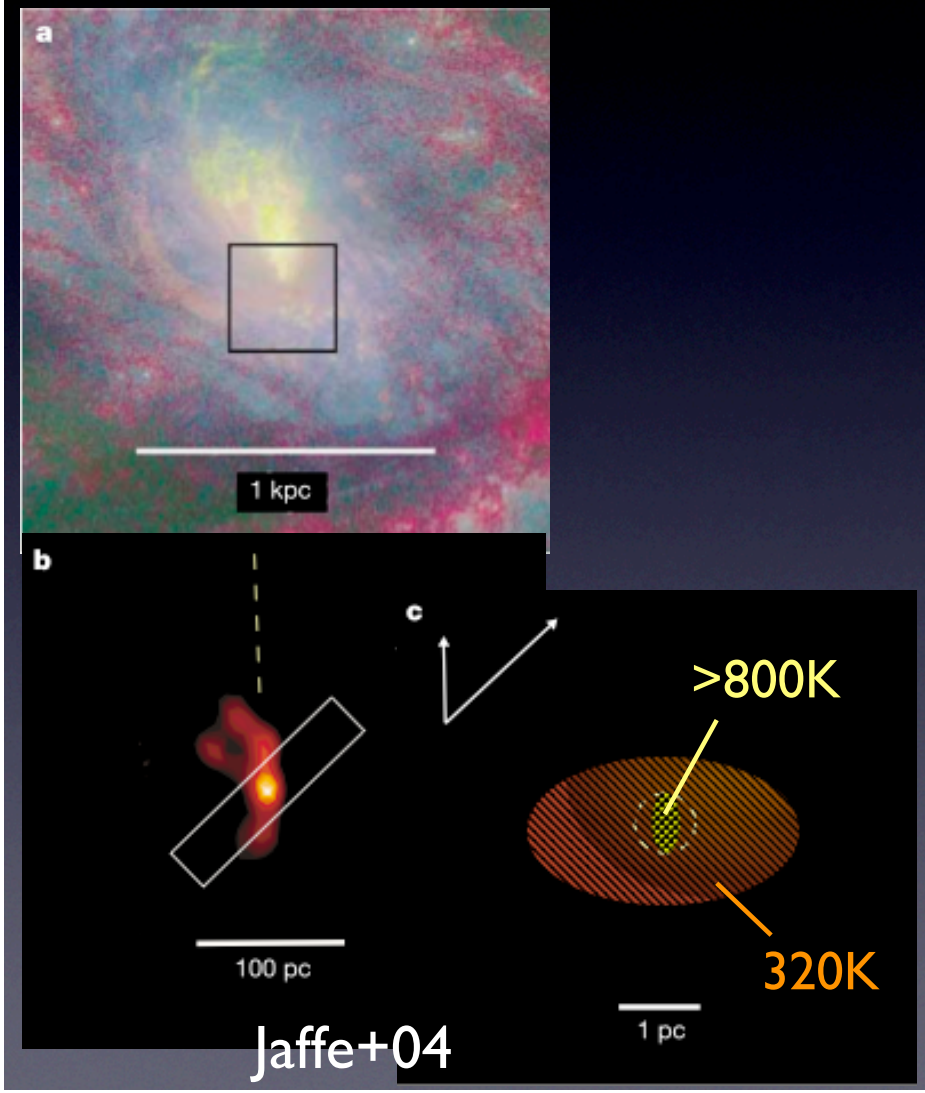
  - time-lag between UV/opt and near-IR (reverberation)
  - normalization of radial extent



Early studies, mainly on Type 2s

NGC1068

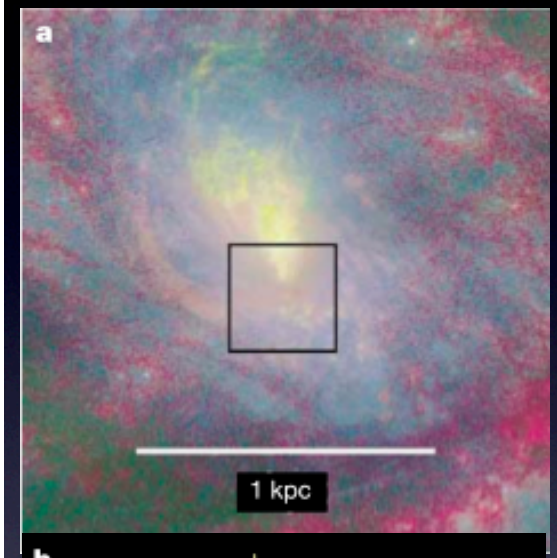
- mid-IR

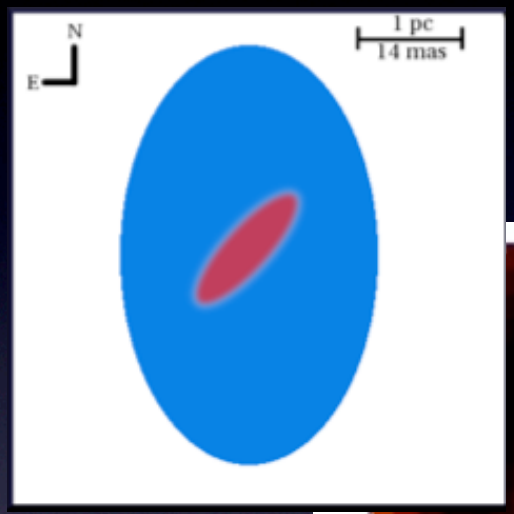


Jaffe+04

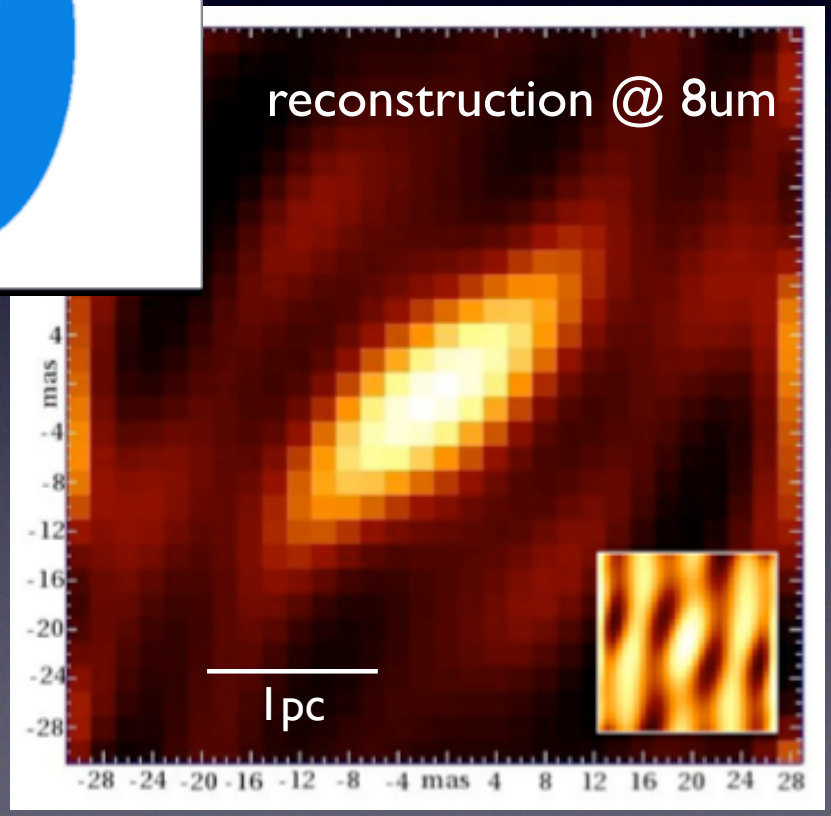
NGC1068

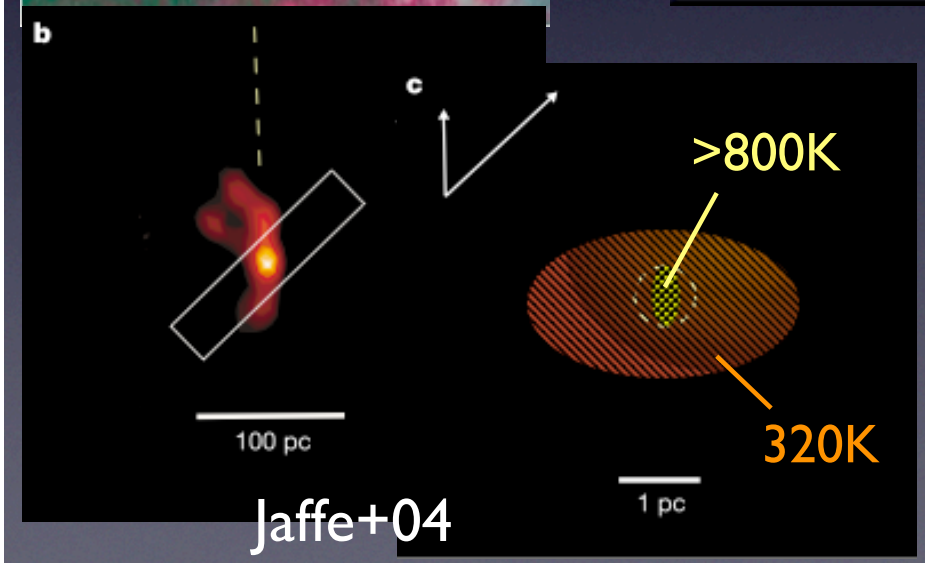
- mid-IR, detailed follow-up





Raban+09





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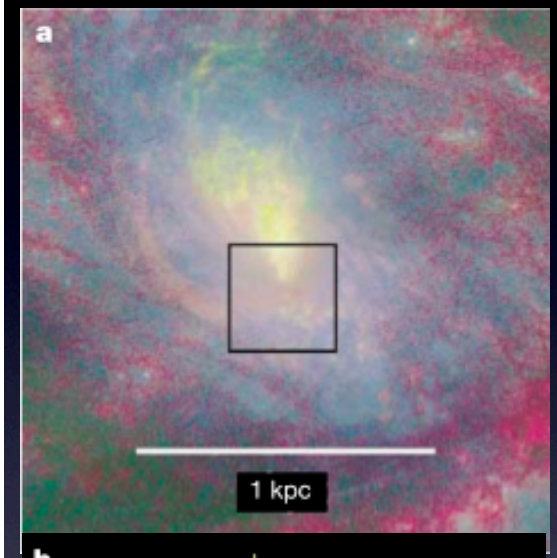
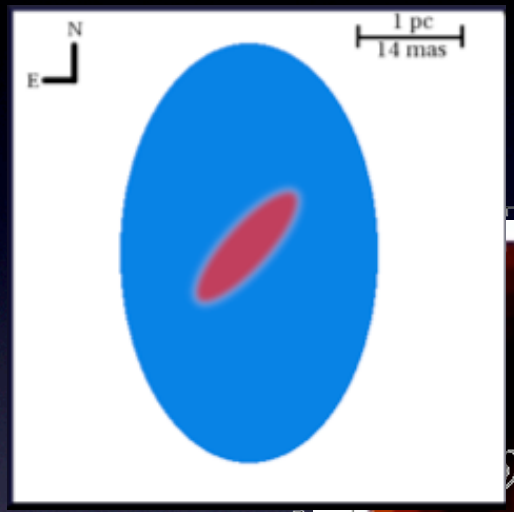
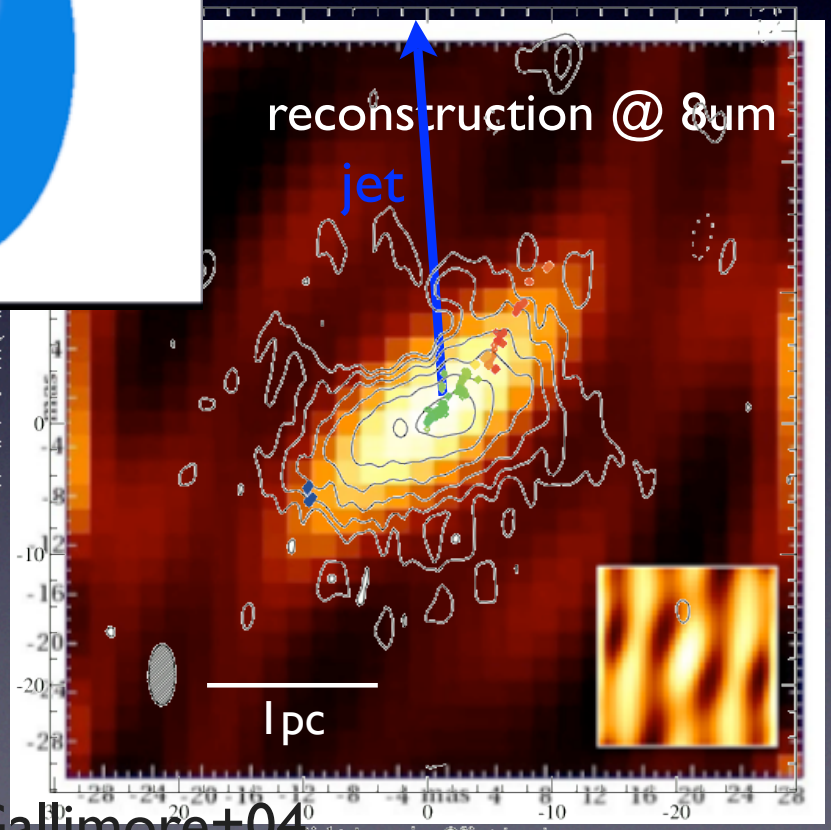
NGC1068

- mid-IR, detailed follow-up

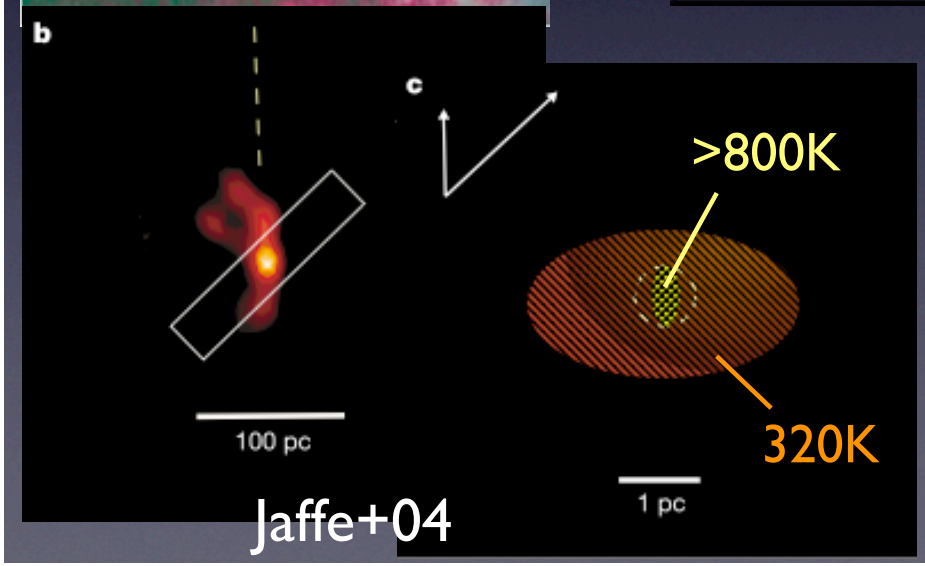




Raban+09



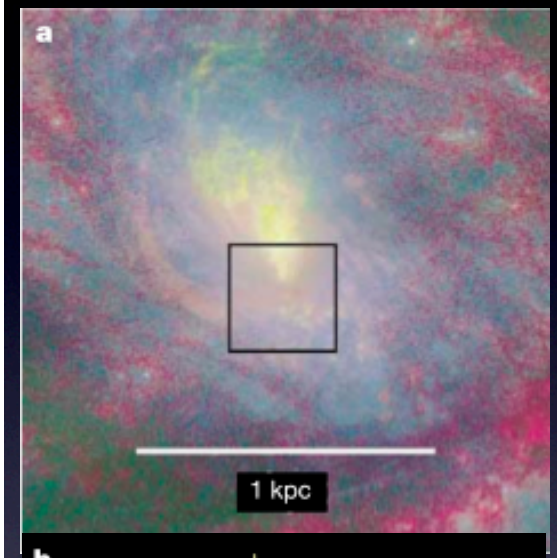
Gallimore+04

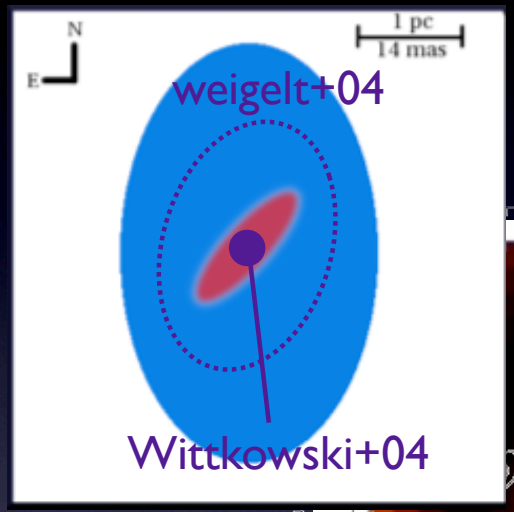


Jaffe+04

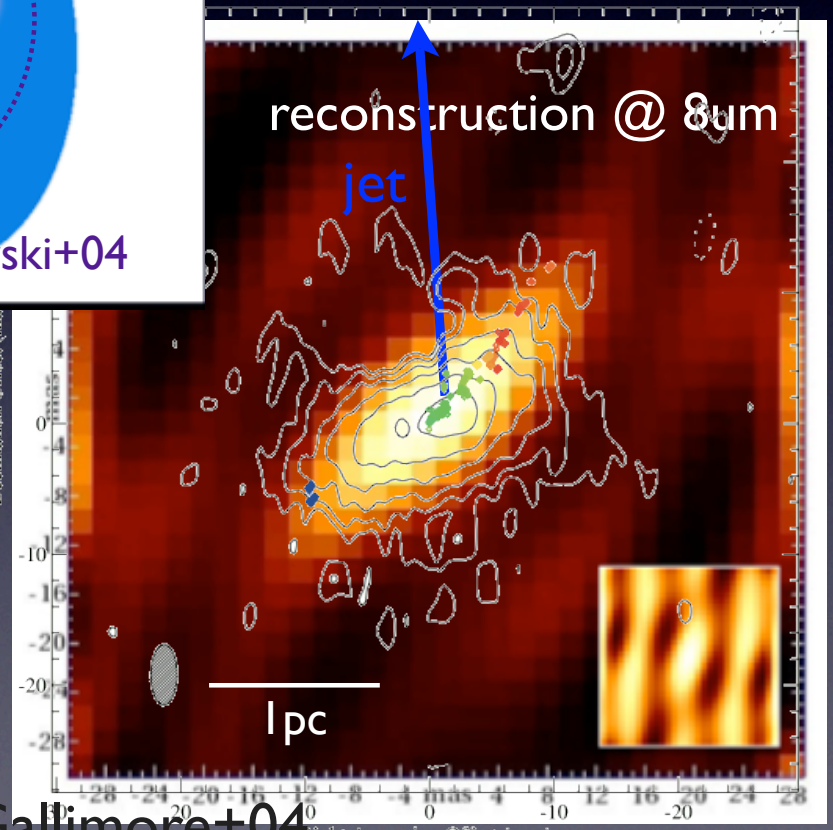
NGC1068

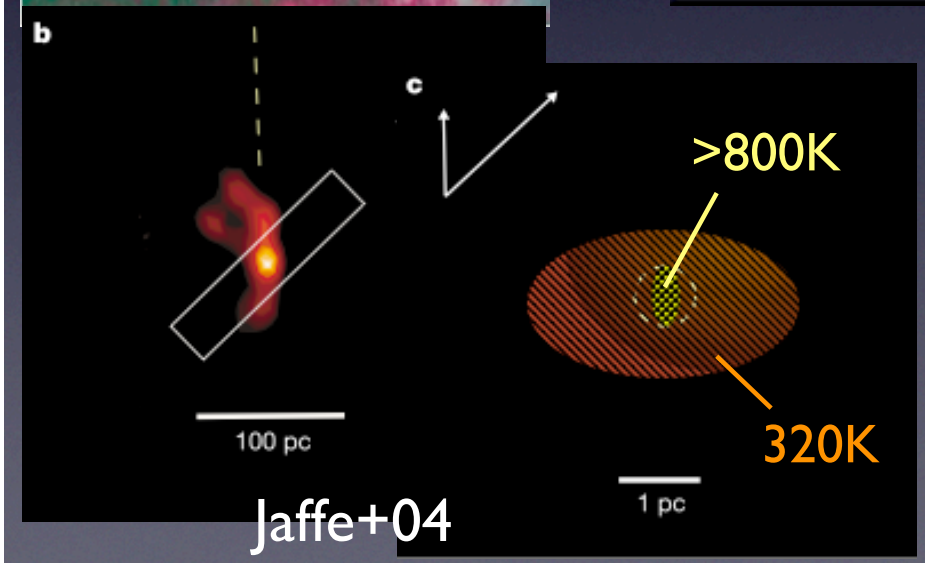
- mid-IR, detailed follow-up & near-IR (VINCI)





Raban+09



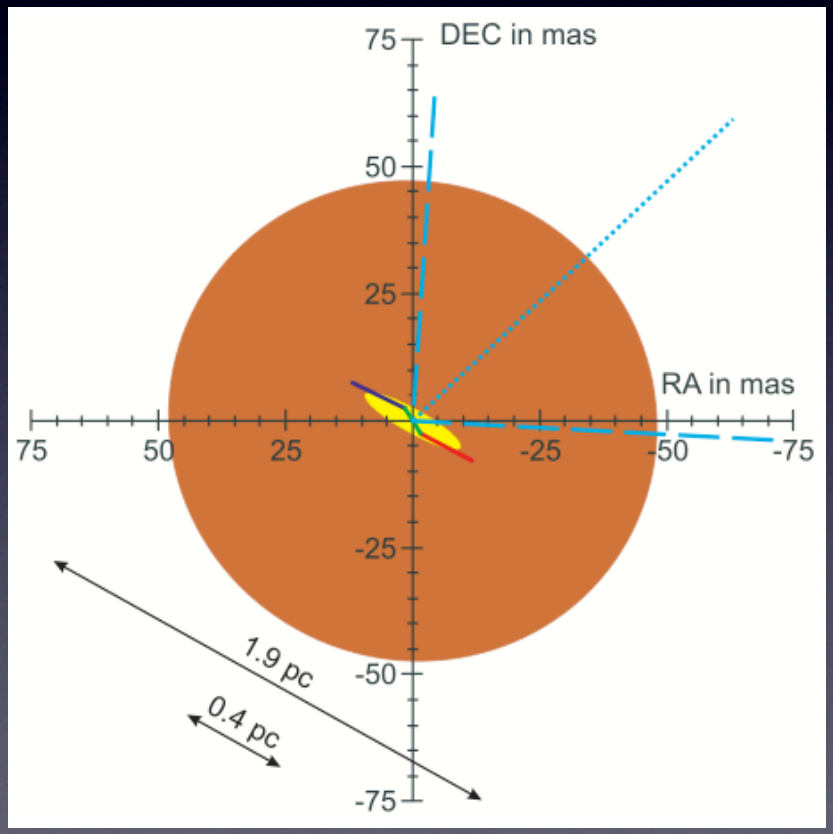


Jaffe+04

Gallimore+04

Circinus

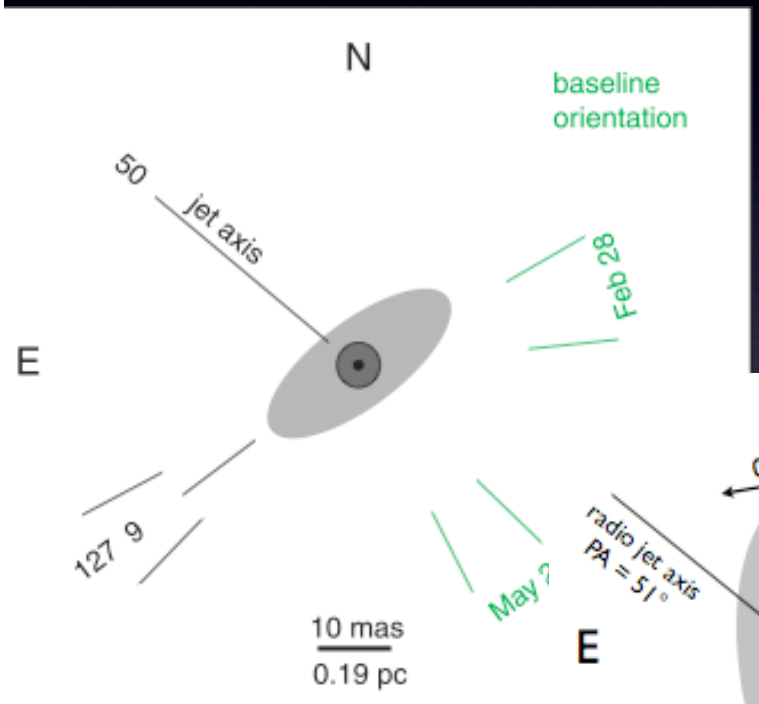
- Detailed investigations with MIDI (Tristram+07)
  - suitable pos for VLTI: many many uv points



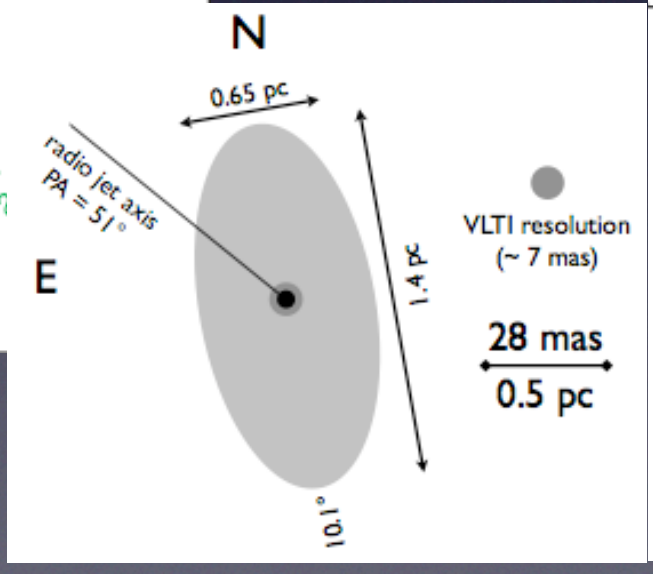
see next talk
by Konrad Tristram

Centaurus A

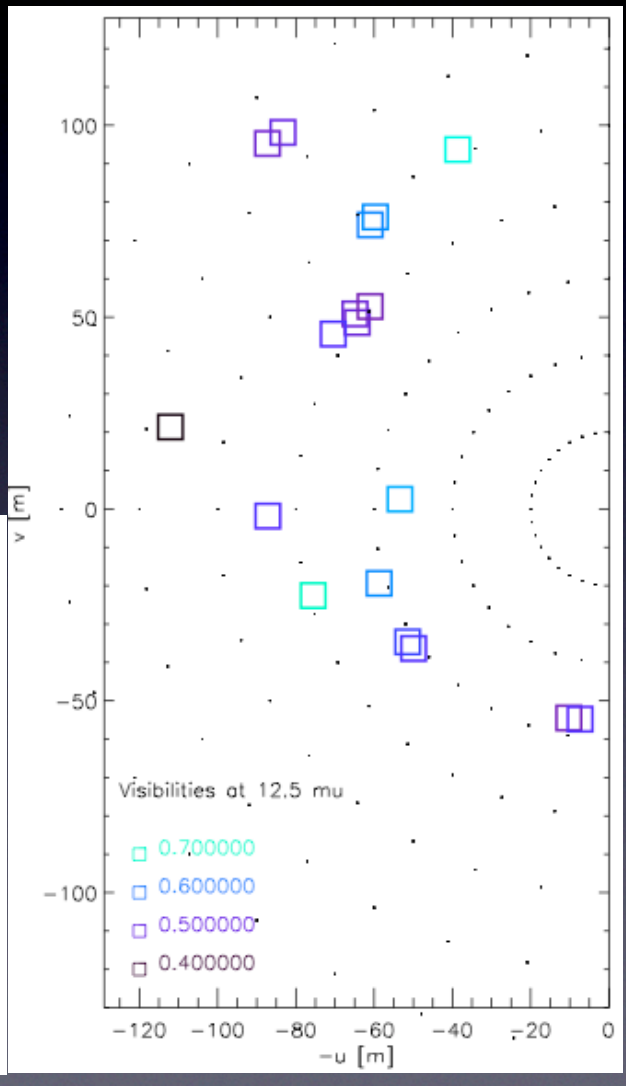
- First radio-loud Type 2 AGN
  - ~50% mid-IR - synch. core



Burtscher+10

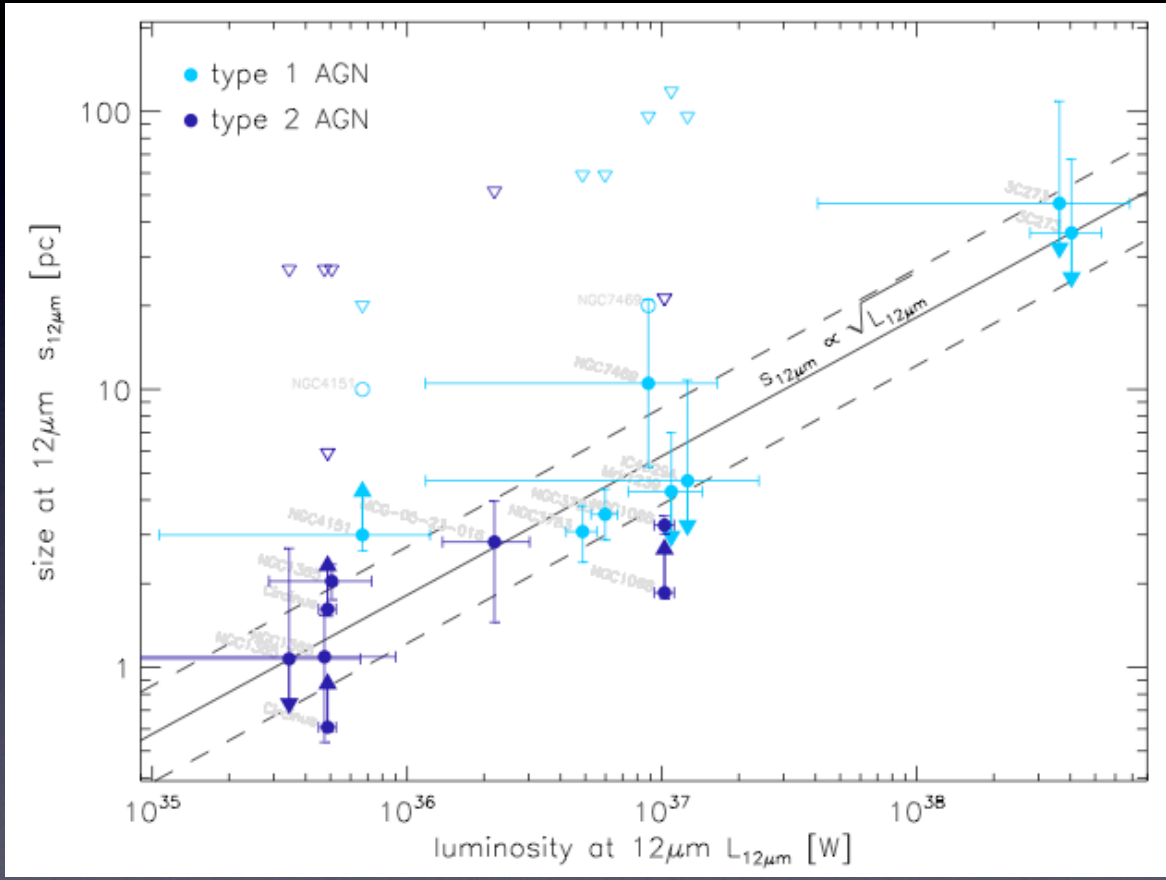


Meisenheimer+07



MIDI 'snap-shot' survey

- mid-IR emission size vs luminosity



Tristram+09,11

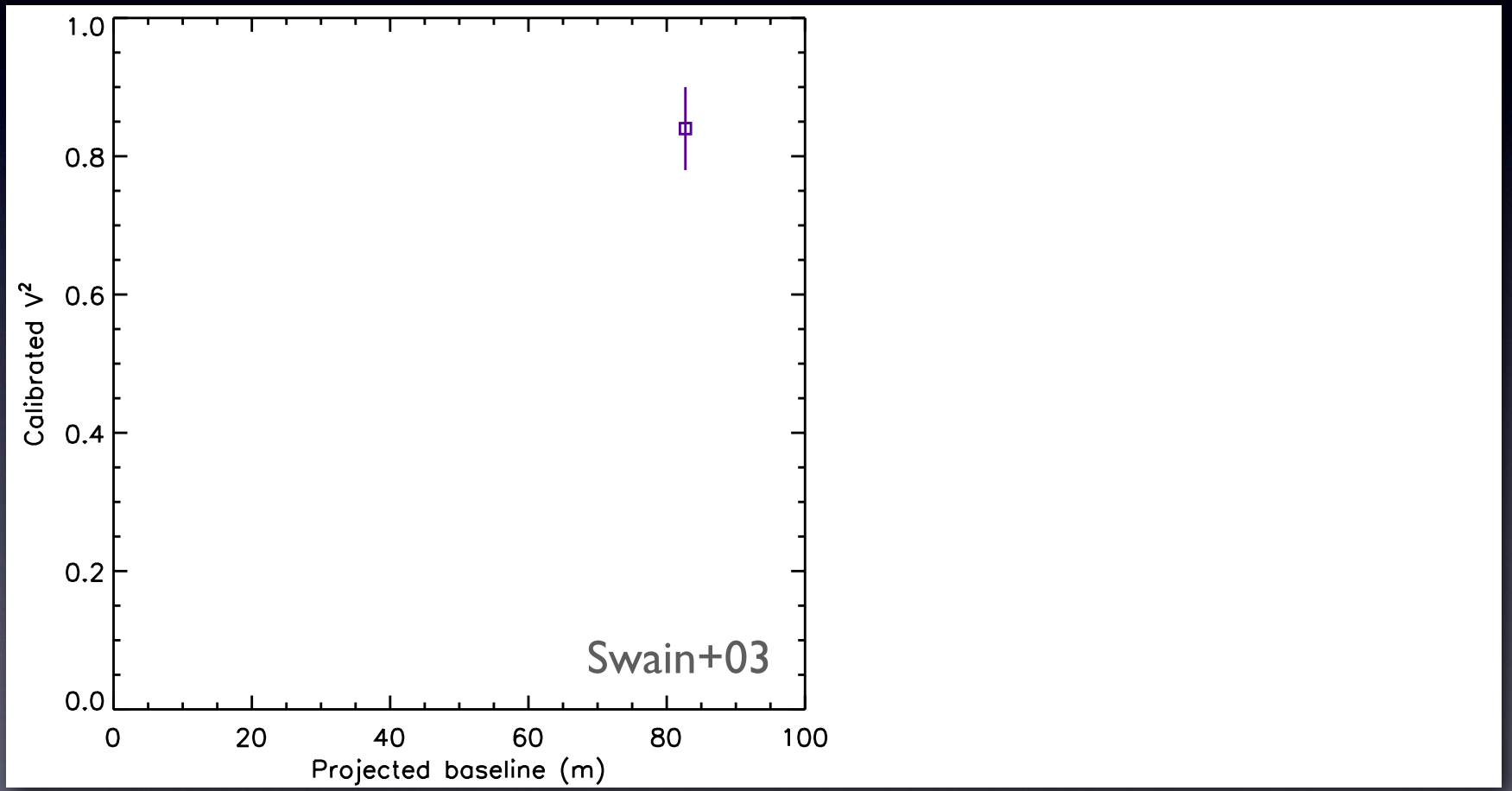
mid-IR size
propto L^1/2 ?

Type 2 vs Type 1 study

- A few brightest sources happen to be Type 2s
  - detailed exploration done, or underway
- A hard aspect ... disentangle RT / inc. effects
- Type 1s ... directly see inner, intrinsic structure
  - radial distribution vs central engine's properties

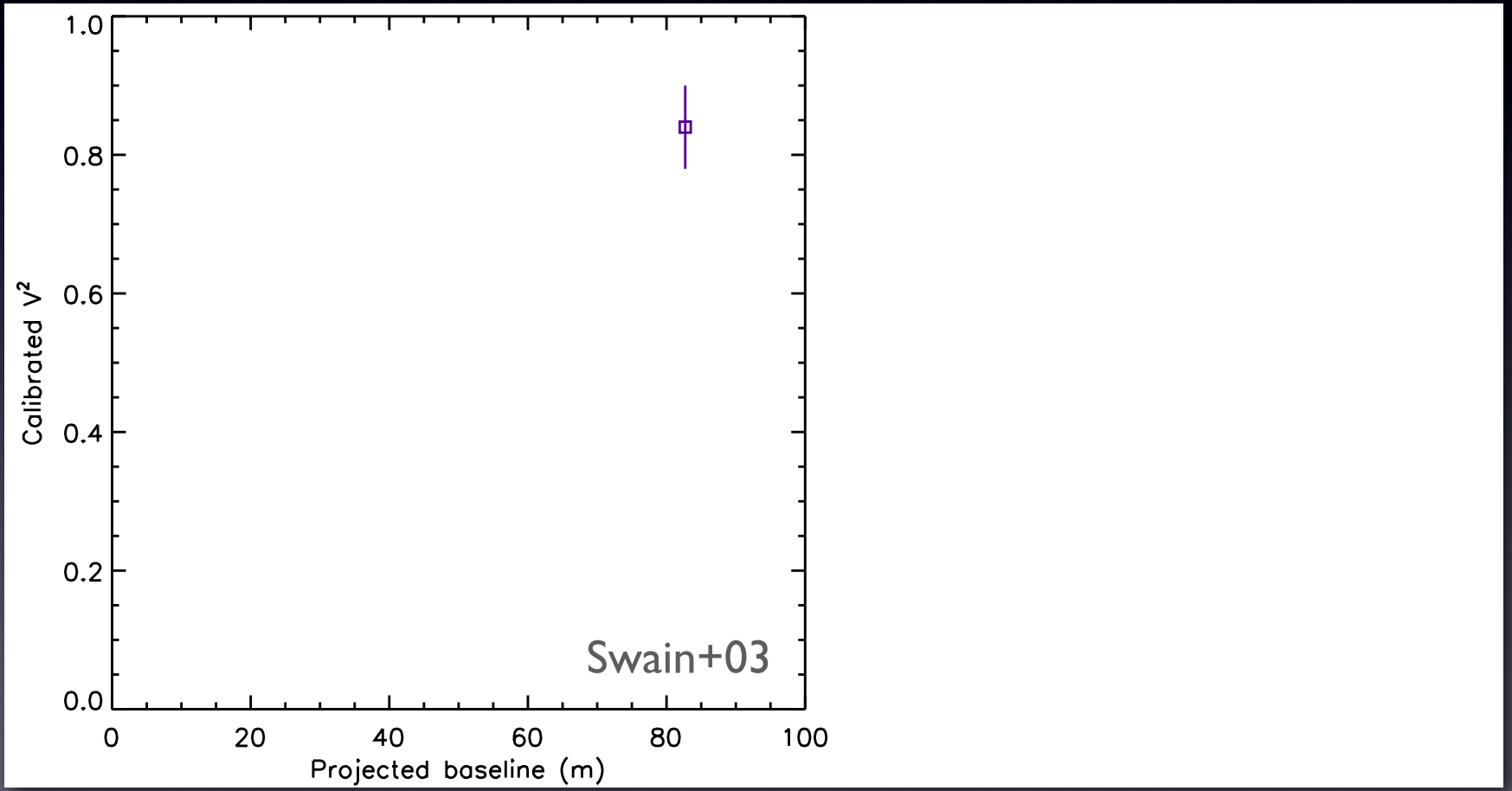
Type 1 study in the near-IR

KI results : the brightest Type 1 NGC4151



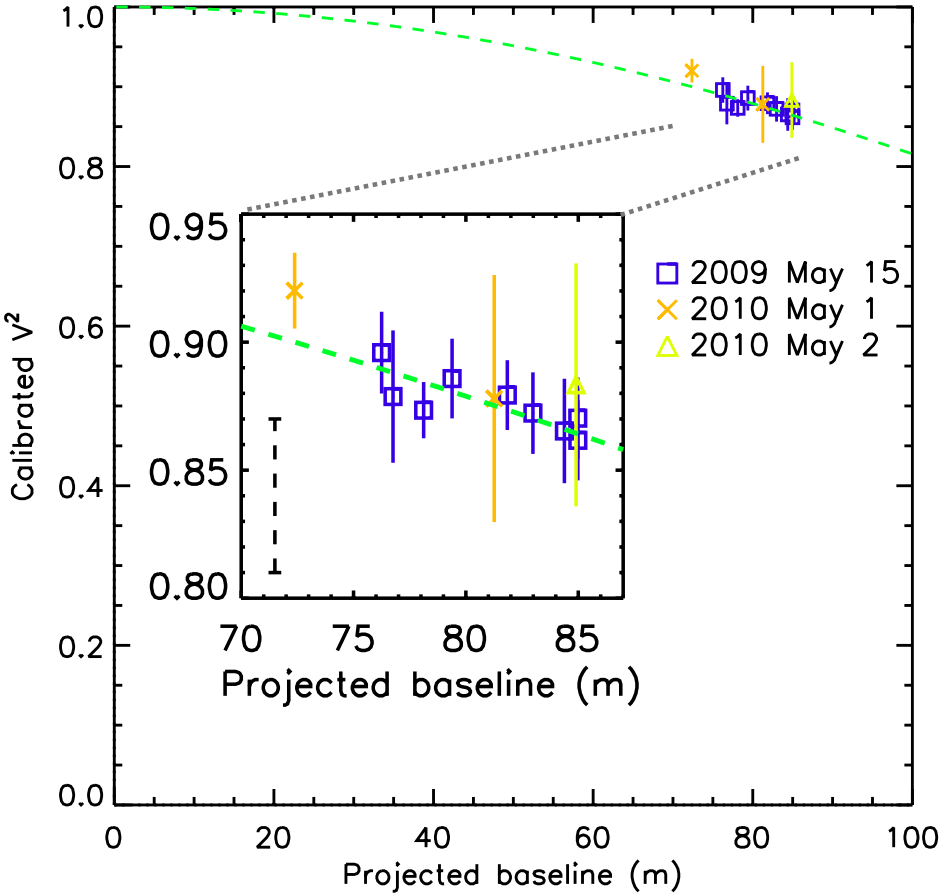
KI results : the brightest Type 1 NGC4151

- Confirm Swain+03 obs (Kishimoto+09; Pott+10)

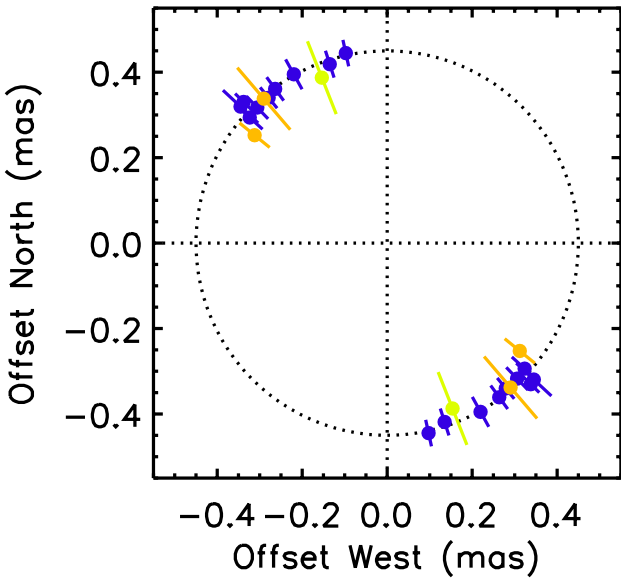


KI results : the brightest Type 1 NGC4151

- Confirm Swain+03 obs (Kishimoto+09; Pott+10)
- Visibility 'curve', no app. PA dep. (Kishimoto+09,11)



Ring radius ~0.45 mas, 0.04 pc

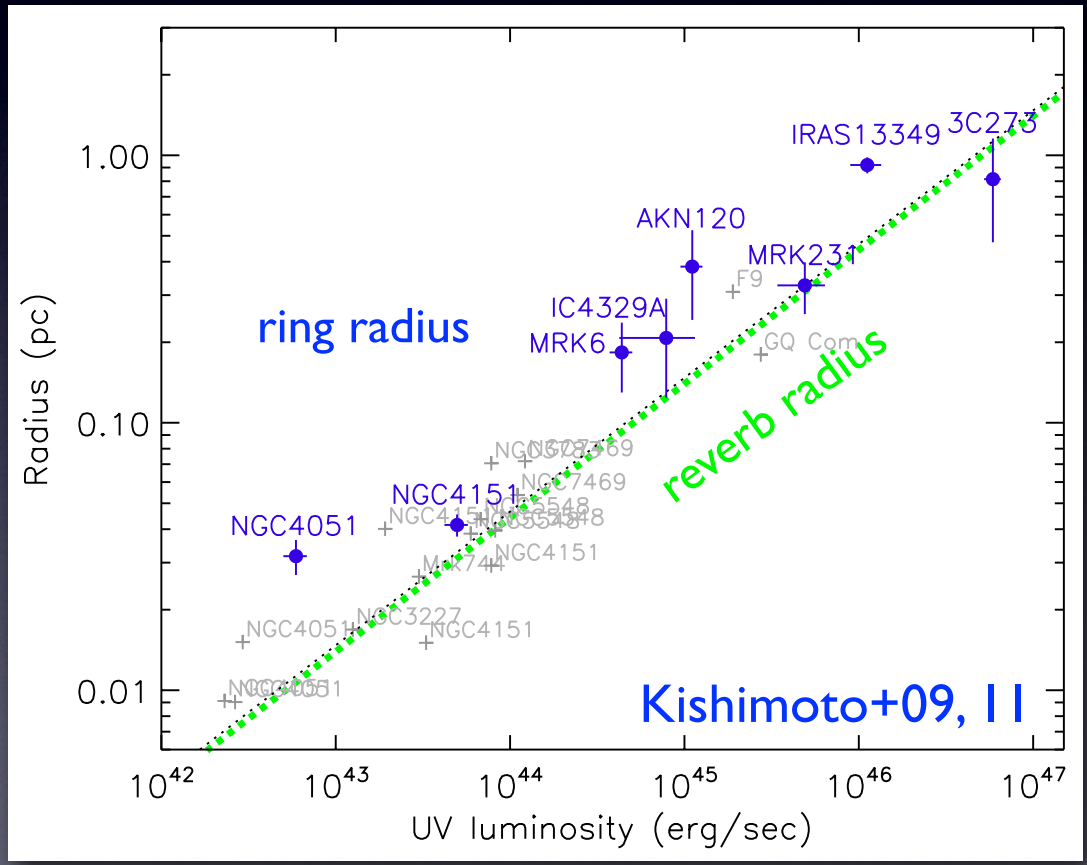


Kishimoto+09, 11

KI results : over a sample of 8 Type 1s

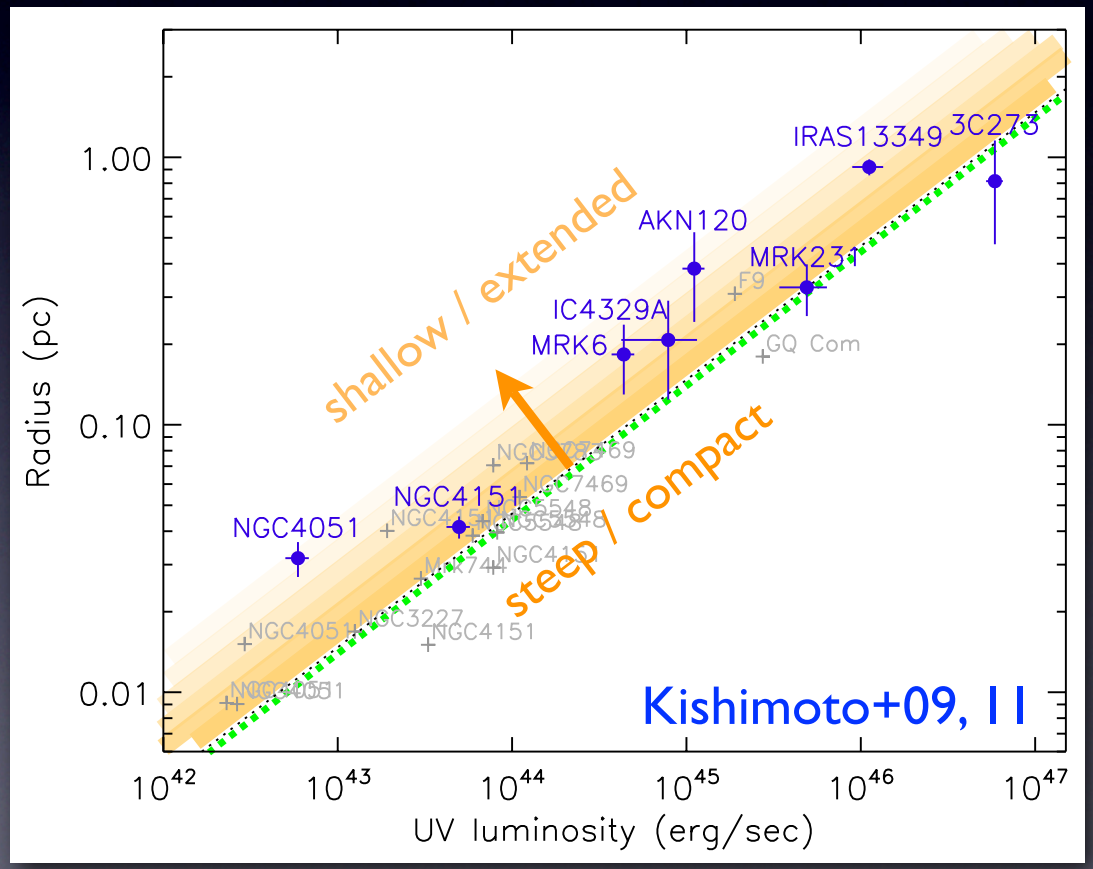
- ~4 orders of mag in luminosity
  - including 2 QSOs at z~0.11 and 0.16

- Resolving dust sublimation region
  - approx. prop.to L^1/2
  - approx. match nIR reverb. radii



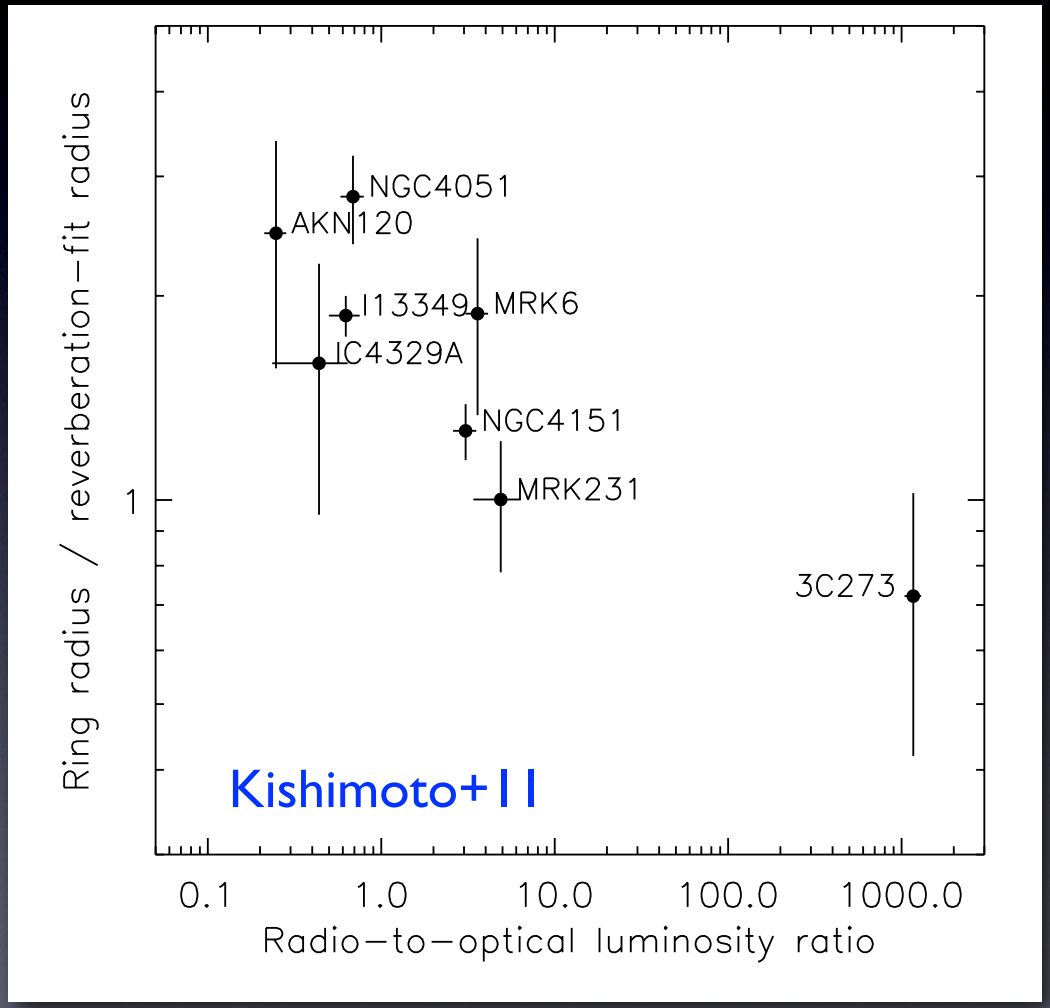
Near-IR R_{ring} / R_{in}

- can approx. probe inner radial structure.



Near-IR R_{ring} / R_{in}

- can approx. probe inner radial structure.
- Intriguing, possible relation with radio-loudness



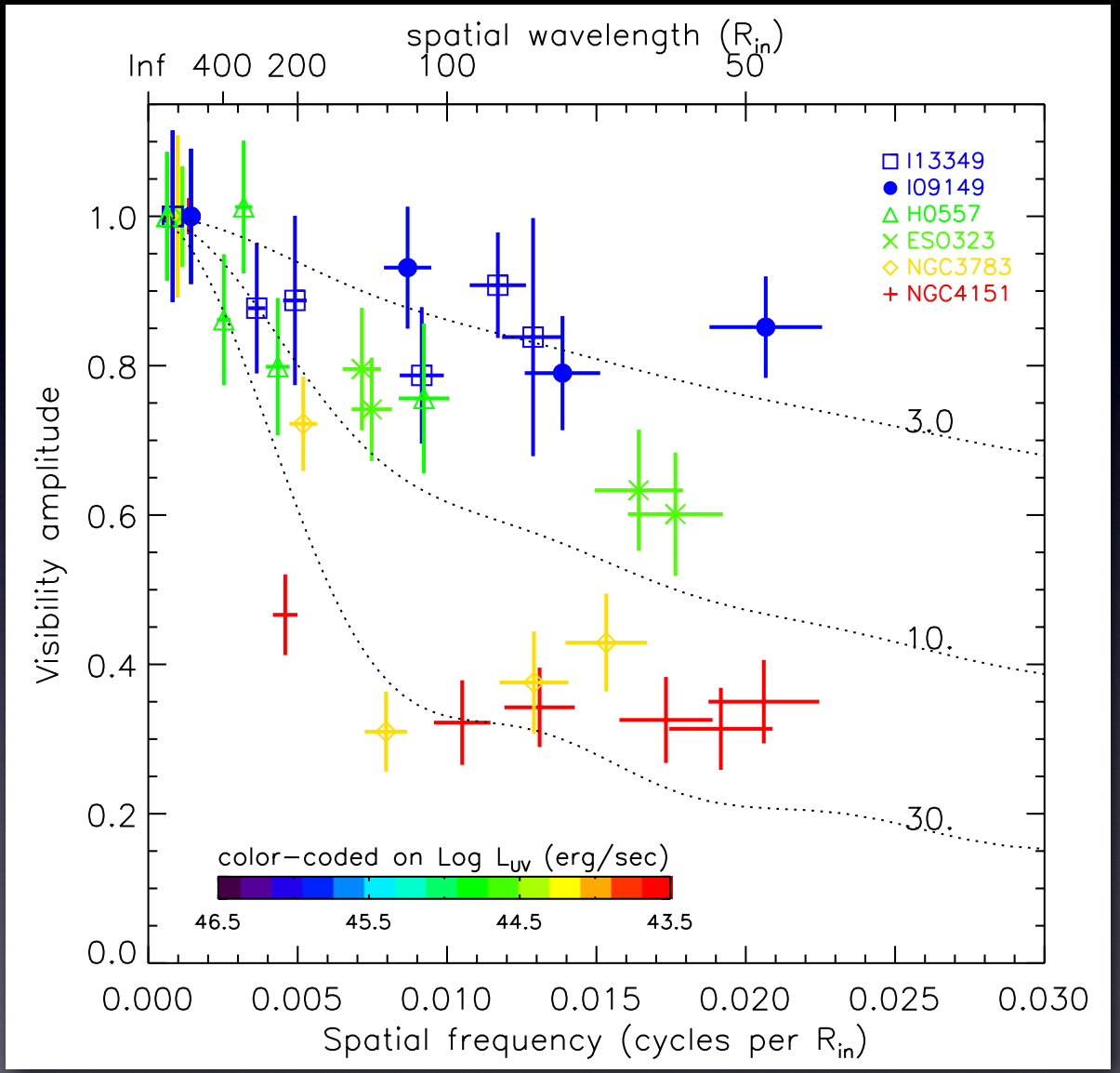
Type 1 study in the mid-IR

Recent studies

- Bright Type 1s NGC3783/NGC4151 (Beckert+08, Kishimoto+09, Burtscher+09), snap-shot survey (Tristram+09,11)

- A first systematic study for Type 1s (Kishimoto+11)
  - sub-Jy sources - bias had to be removed

6 Type 1s at 11 micron

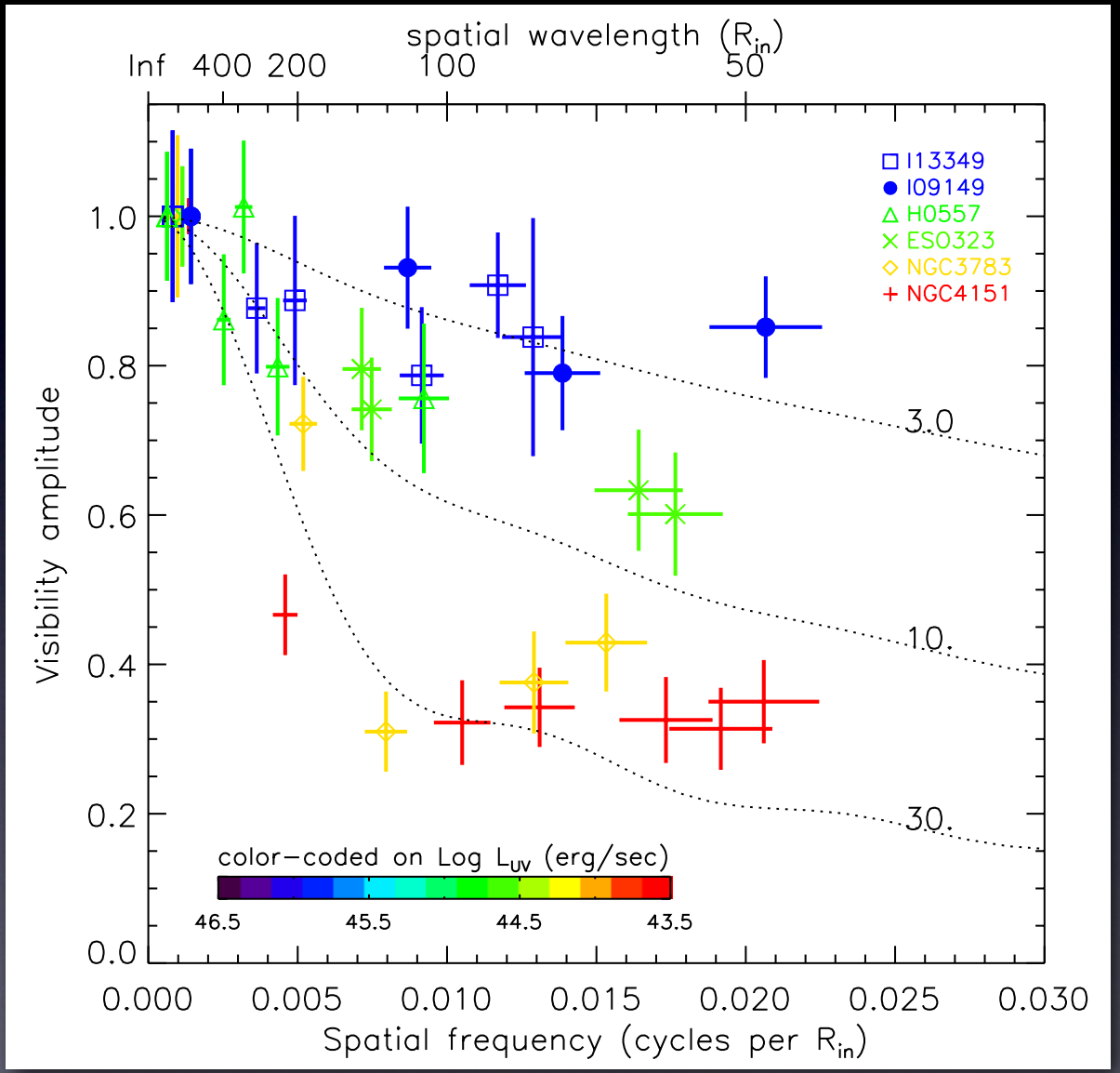


Kishimoto +11b

Plot for radial structure

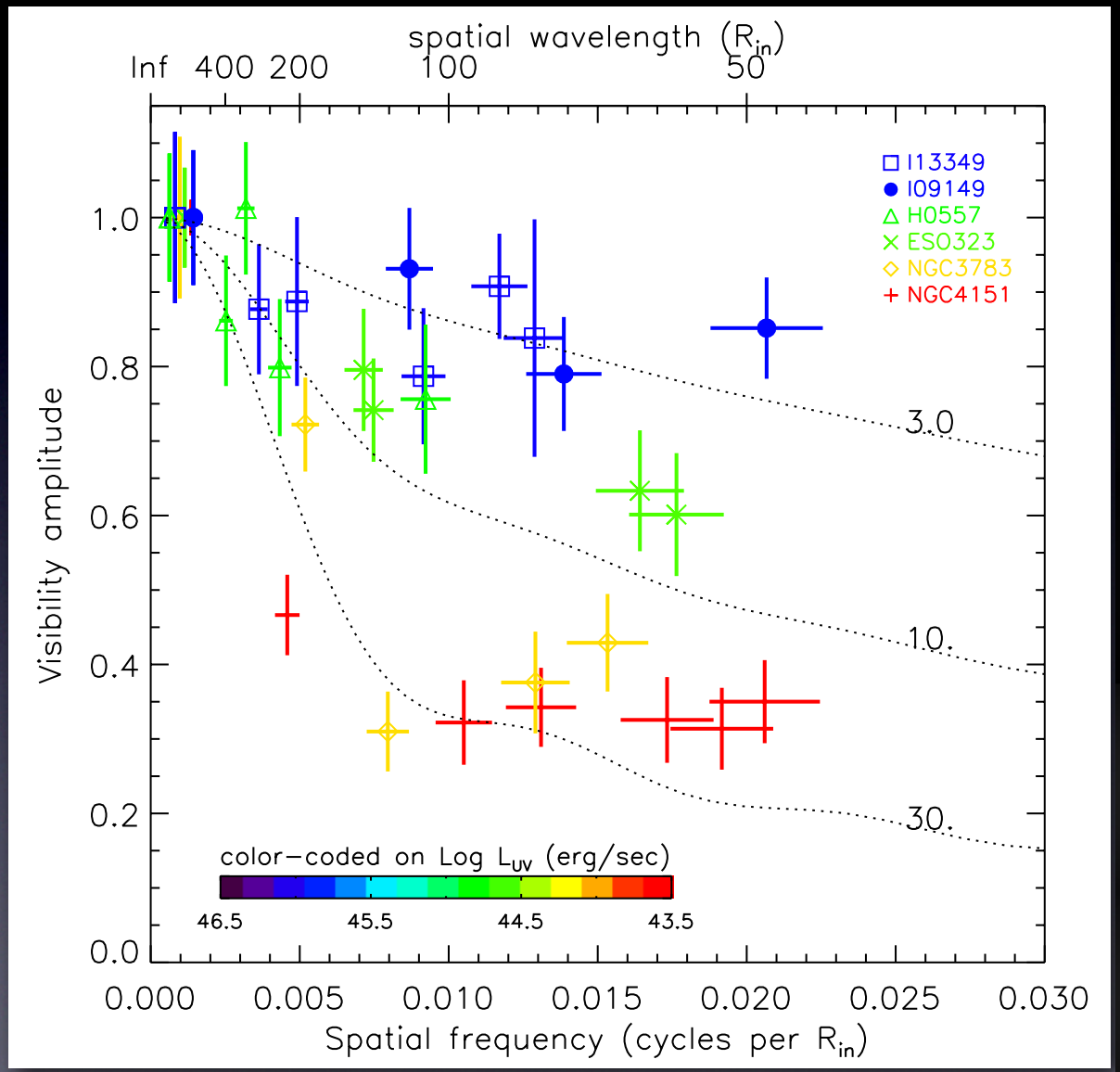
- Normalize by R_{in}, remove L^1/2 and distance dependency.
  - spatial freq. in cycles per R_{in}
  - spatial wavelength in R_{in}
  - uniformly compare different objects
- power-law brightness seems adequate
  - half-light radius useful
- Luminosity dependence - beyond L^1/2 scaling

6 Type 1s at 11 micron



Kishimoto +11b

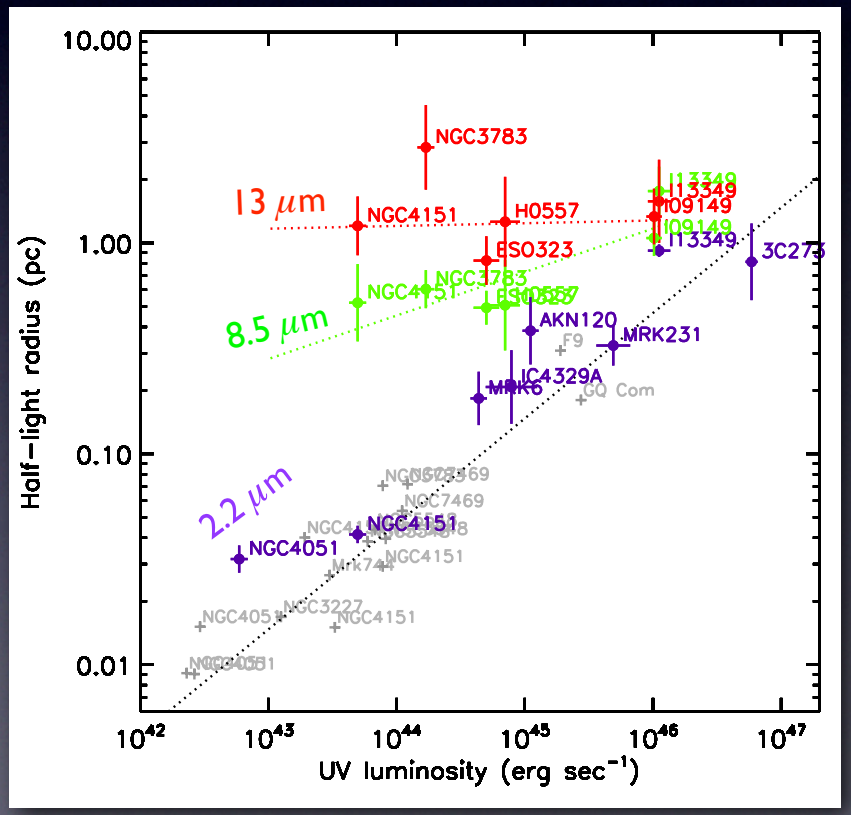
6 Type 1s at 11 micron



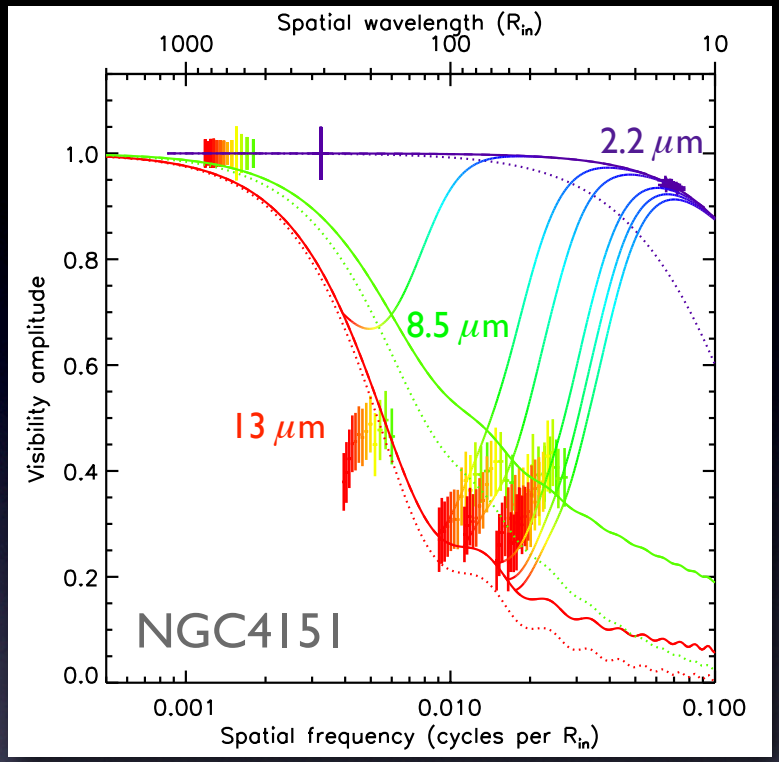
to

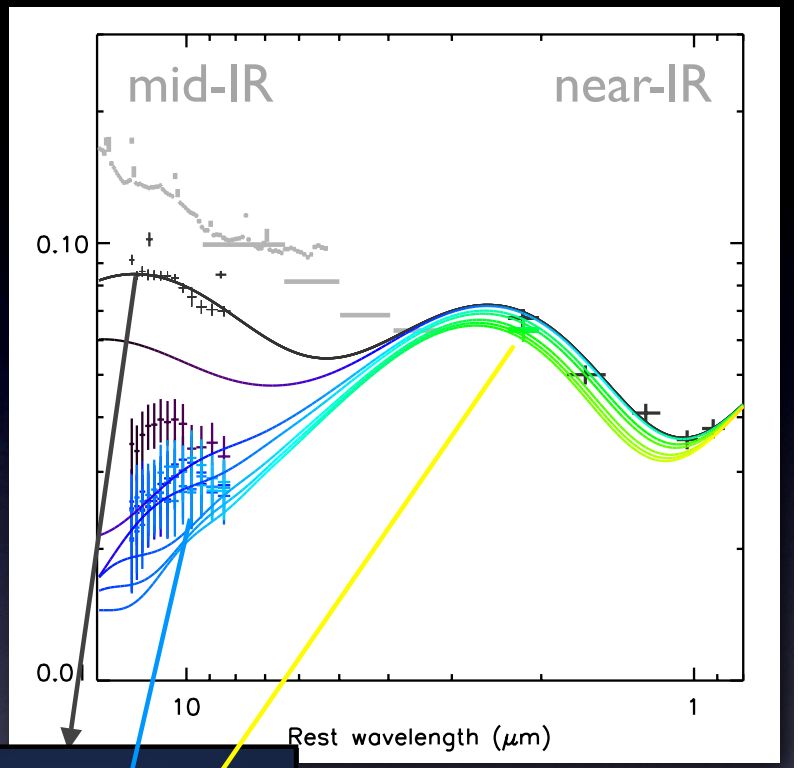
Direct consequences ...

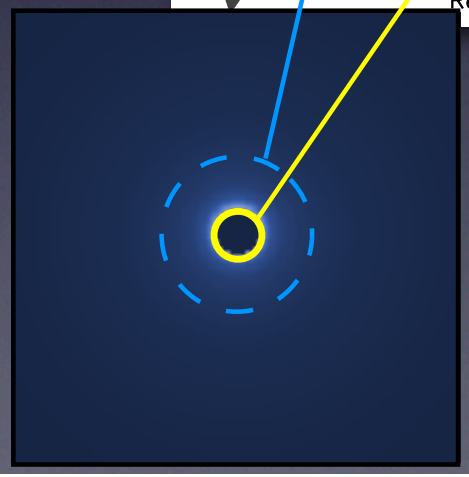
- mid-IR size in pc increases much slower than L^1/2
- surface density distribution gets steeper with higher L



Combining all the info...





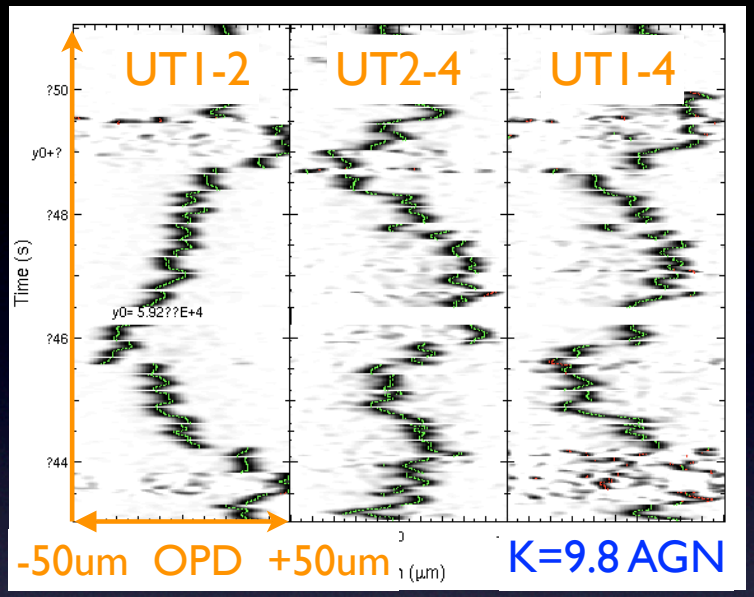


- near-IR hot bright 'rim'
- low-T_{in} core & hot rim co-exists at ~R_{in}

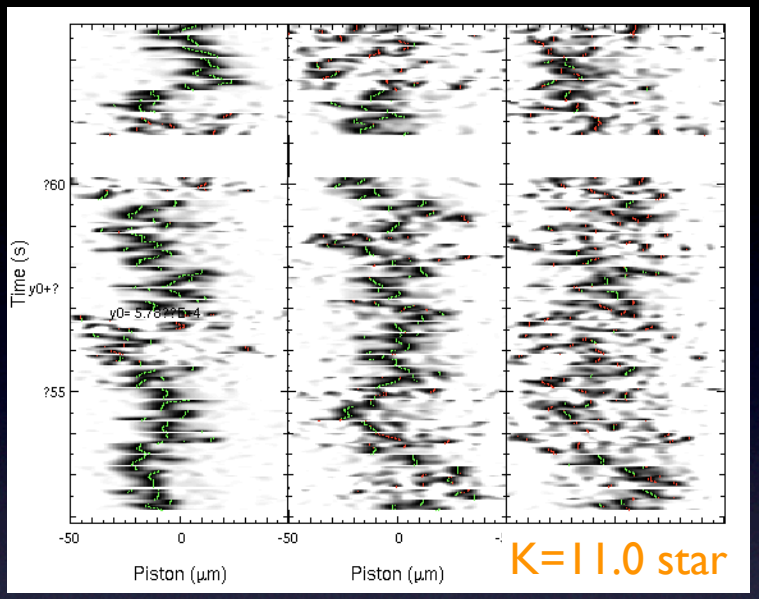
Most recent AGN observations at VLTI

AMBER at full limit

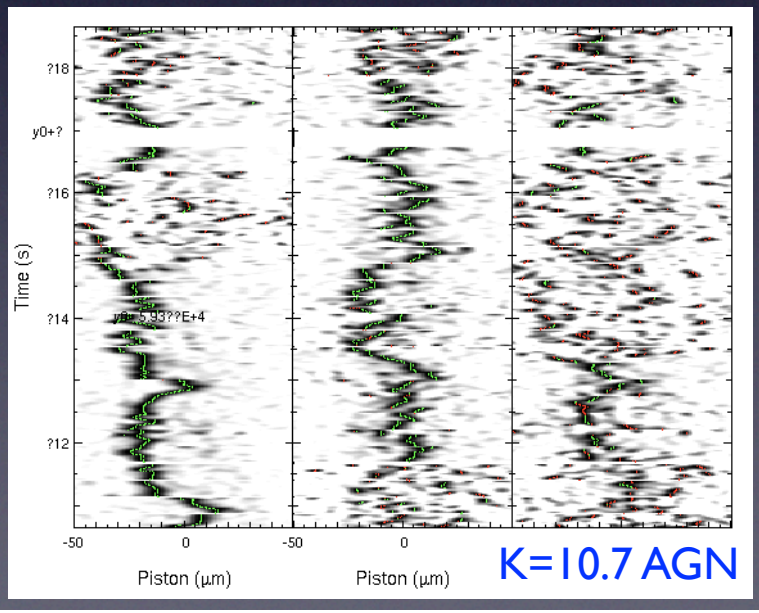
Time



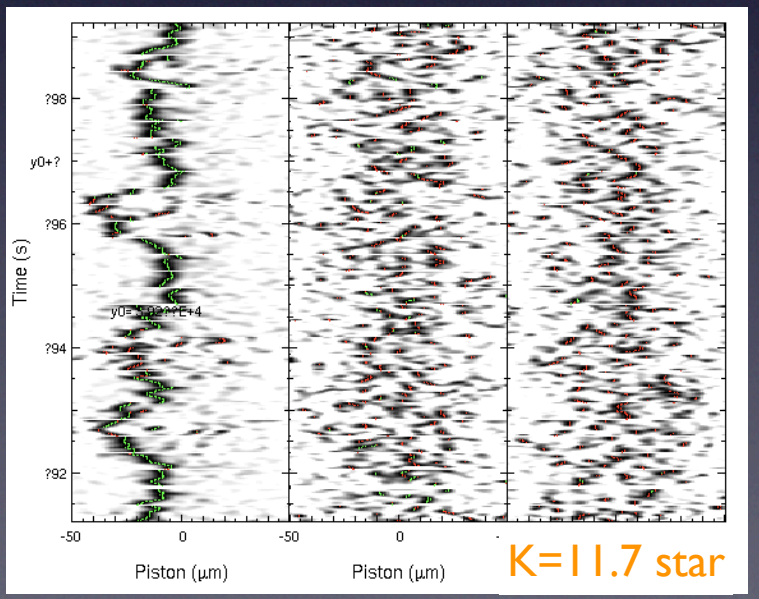
K=9.8 AGN



K=11.0 star



K=10.7 AGN



K=11.7 star

AMBER at full limit

AMBER at full limit

Two-telescope measurements, up to Bp~90m, GTO (Weigelt+)
Three-telescope on several AGNs, Bp~130m (Kishimoto+ in prep)
Technical paper (Millour+ in prep)
plan to collect more data ...

Summary

- Long-baseline IR interferometry is now dealing with a sample of 10-20 AGNs, both in the near-IR and mid-IR.
- Using Type 1 sample, radial distribution of AGN tori is now being mapped.
- There seems to be the near-IR hot rim and mid-IR warm power-law-like structure, with L-dependency.
- Inner dist. correlated with radio-loudness?
- With AMBER, we are now exploring AGNs down to K~11 (stars down to K~12).