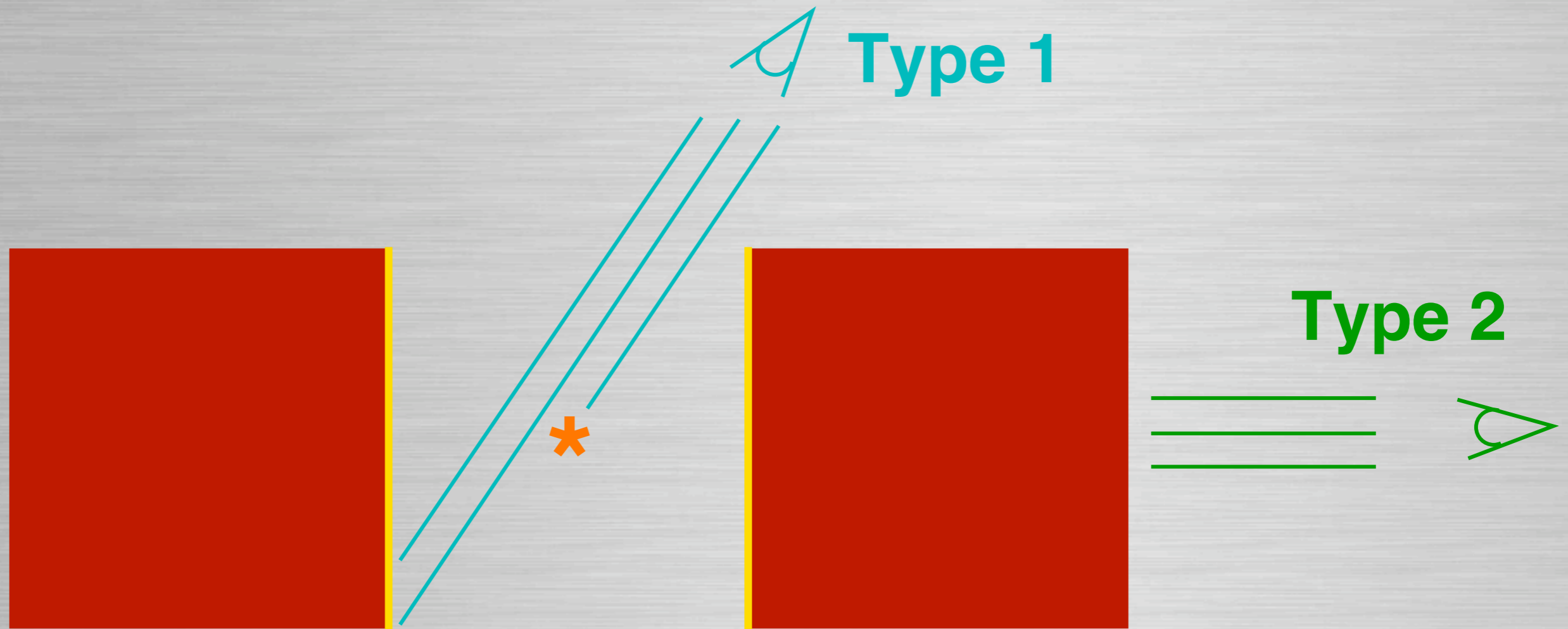


Isotropic Mid-Infrared Emission from Active Galactic Nuclei

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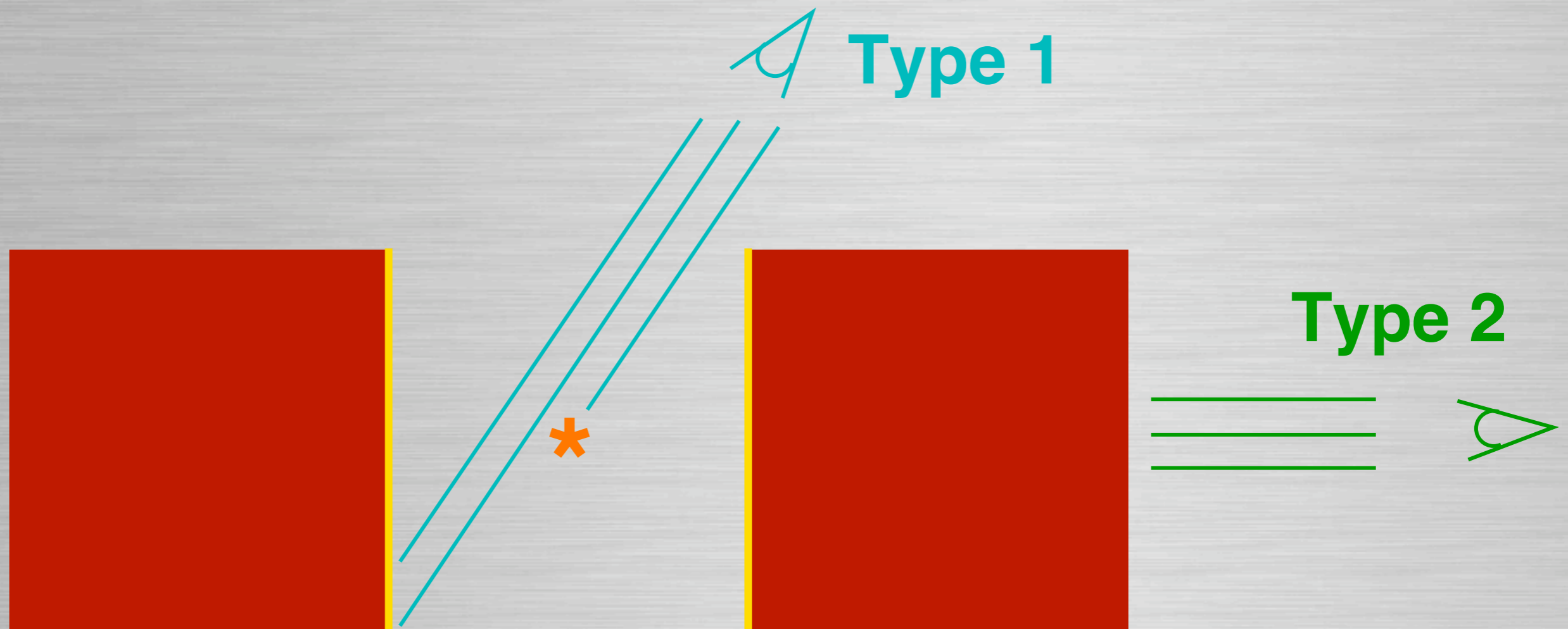
AGN unification



Optically and geometrically thick dusty torus reprocesses intrinsic AGN continuum to emerge in the infrared

Infrared luminosity depends on intrinsic AGN luminosity

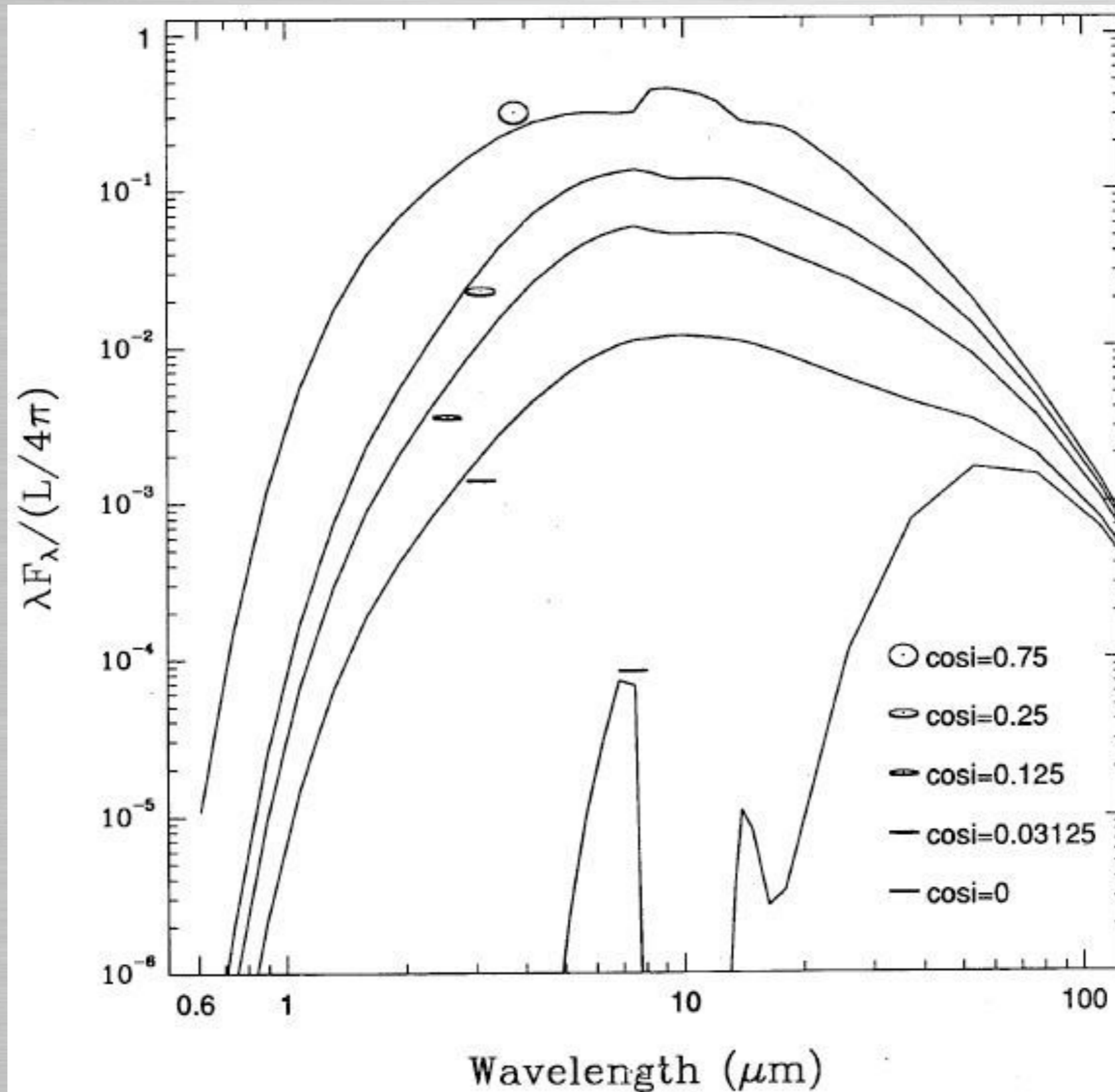
AGN unification -- smooth torus



Consequences for homogeneous torus:

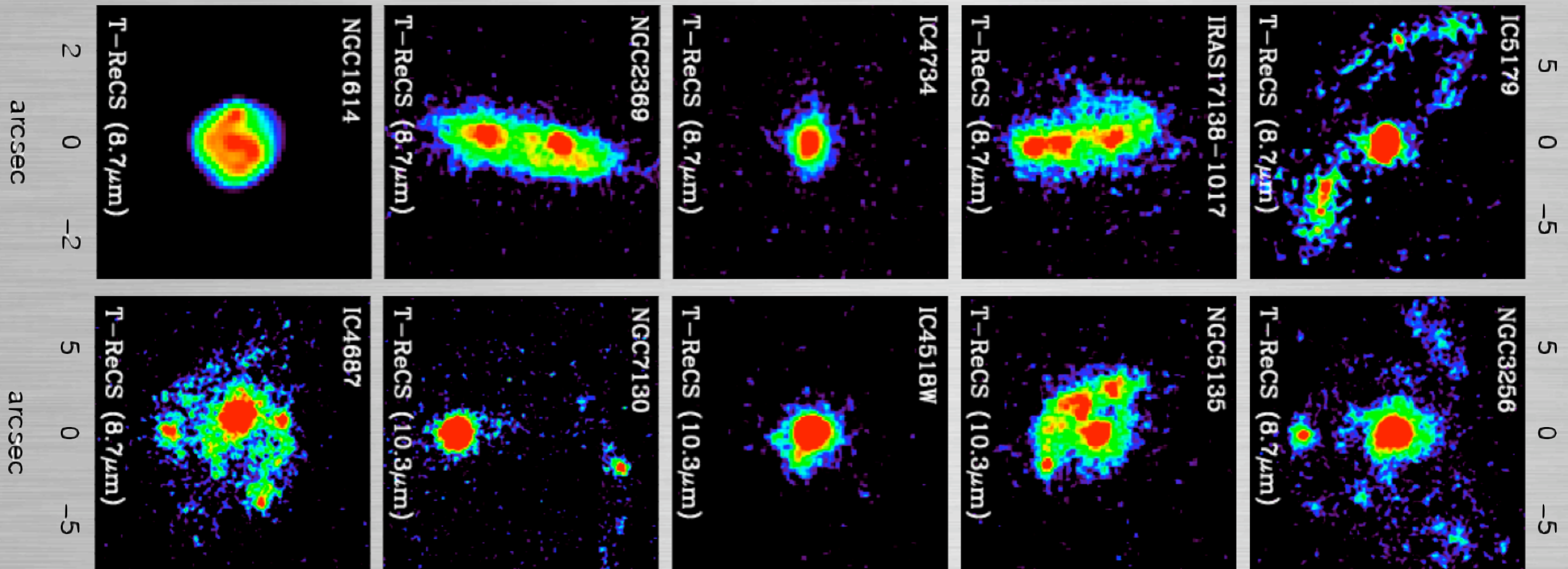
- Anisotropic MIR emission
- Type 1 strong silicate emission; Type 2 deep silicate absorption

AGN unification -- smooth torus models



(Pier & Krolik 1992)

Small torus

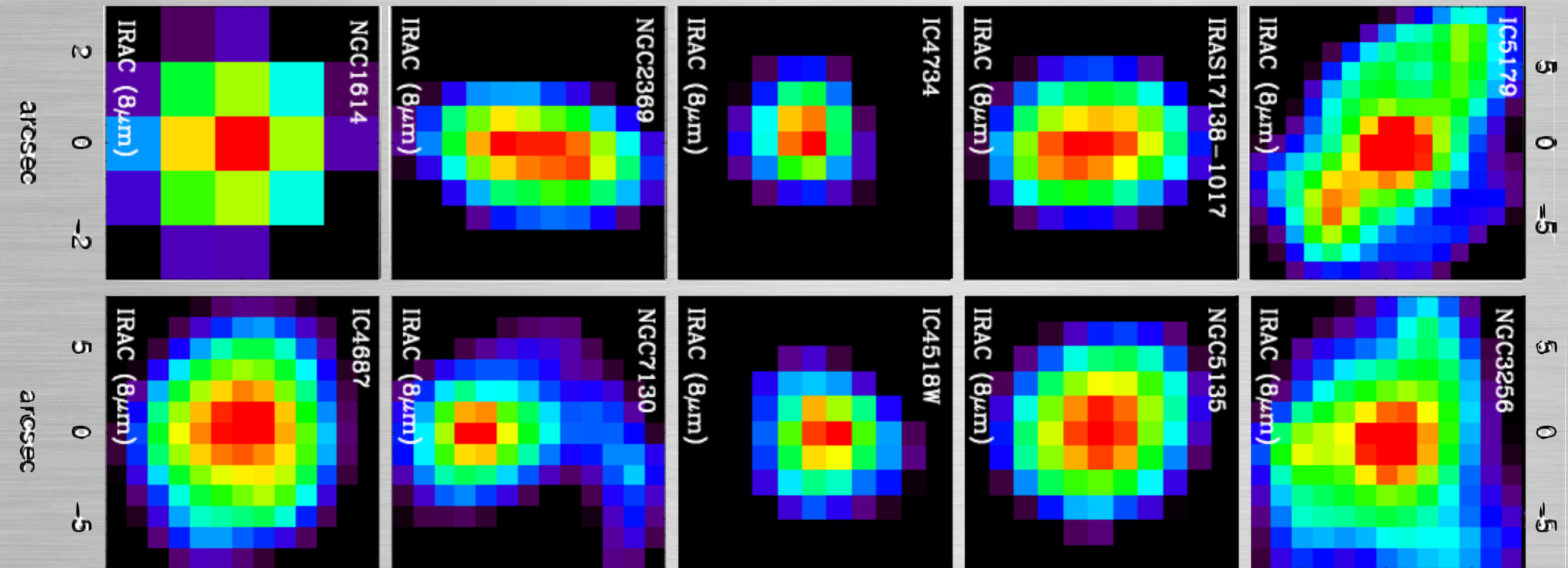


T-ReCS

(Díaz-Santos et al. 2008)

- Small scale measurements are essential!
torus size < 5 pc
star formation can contribute significantly on large scales
- diffraction-limited observations with Gemini
 $R_{8\mu\text{m}} \sim 0.3''$ (50pc at 30Mpc)

Small torus

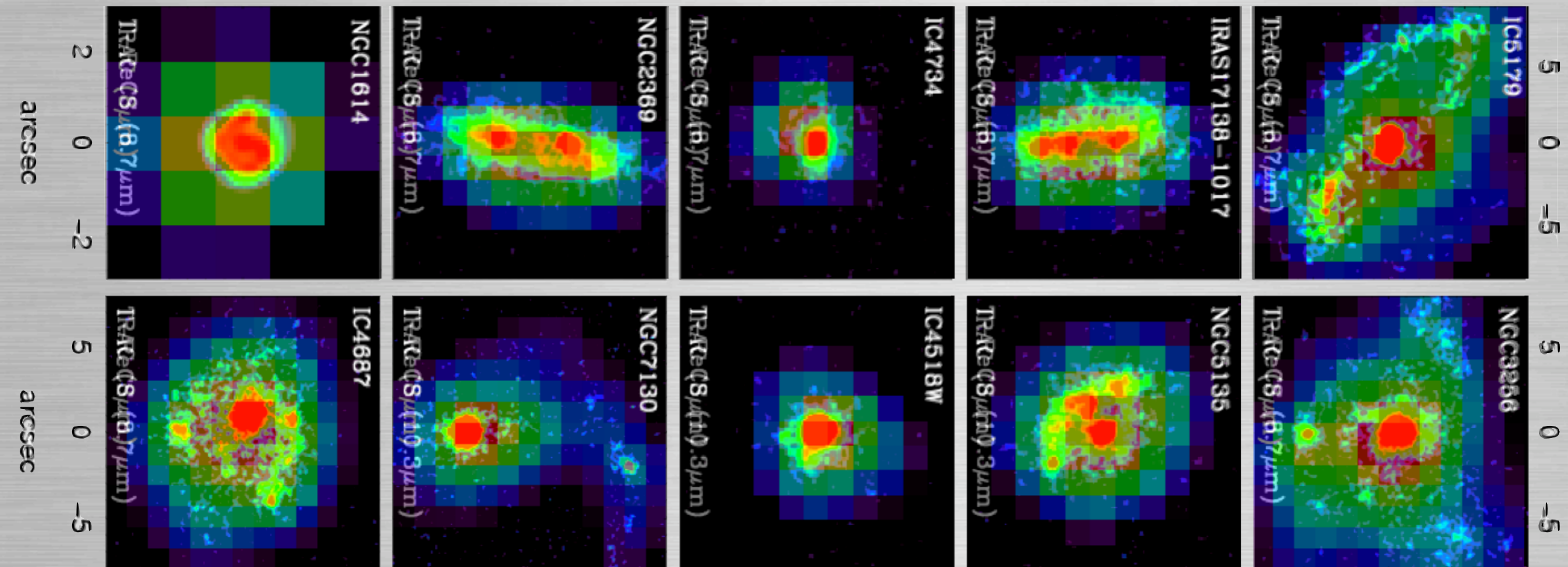


Spitzer

(Díaz-Santos et al. 2008)

- Small scale measurements are essential!
torus size $< 5\text{pc}$
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 $R_{8\mu\text{m}} \sim 0.3''$ (50pc at 30Mpc)

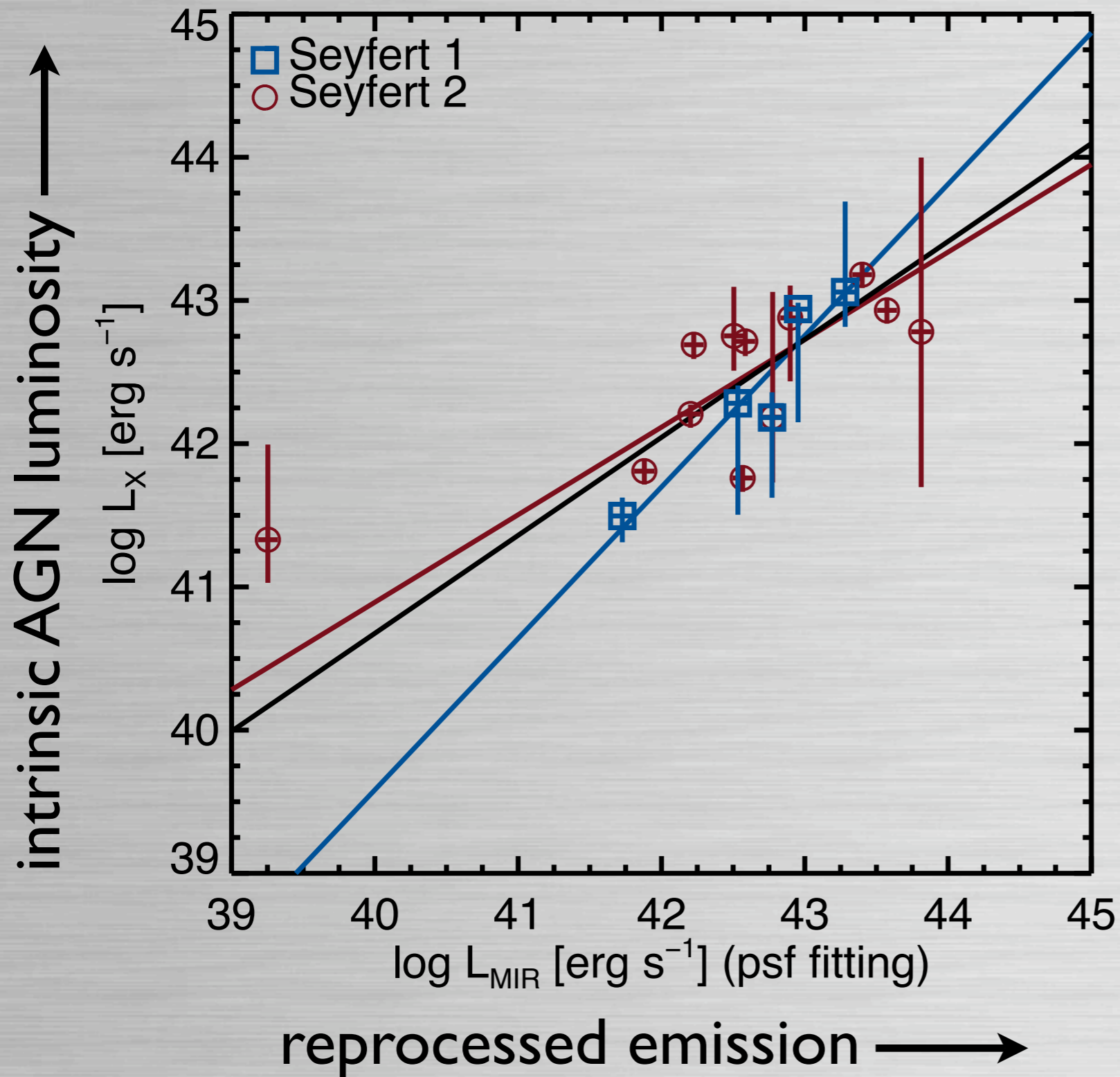
Small torus



(Díaz-Santos et al. 2008)

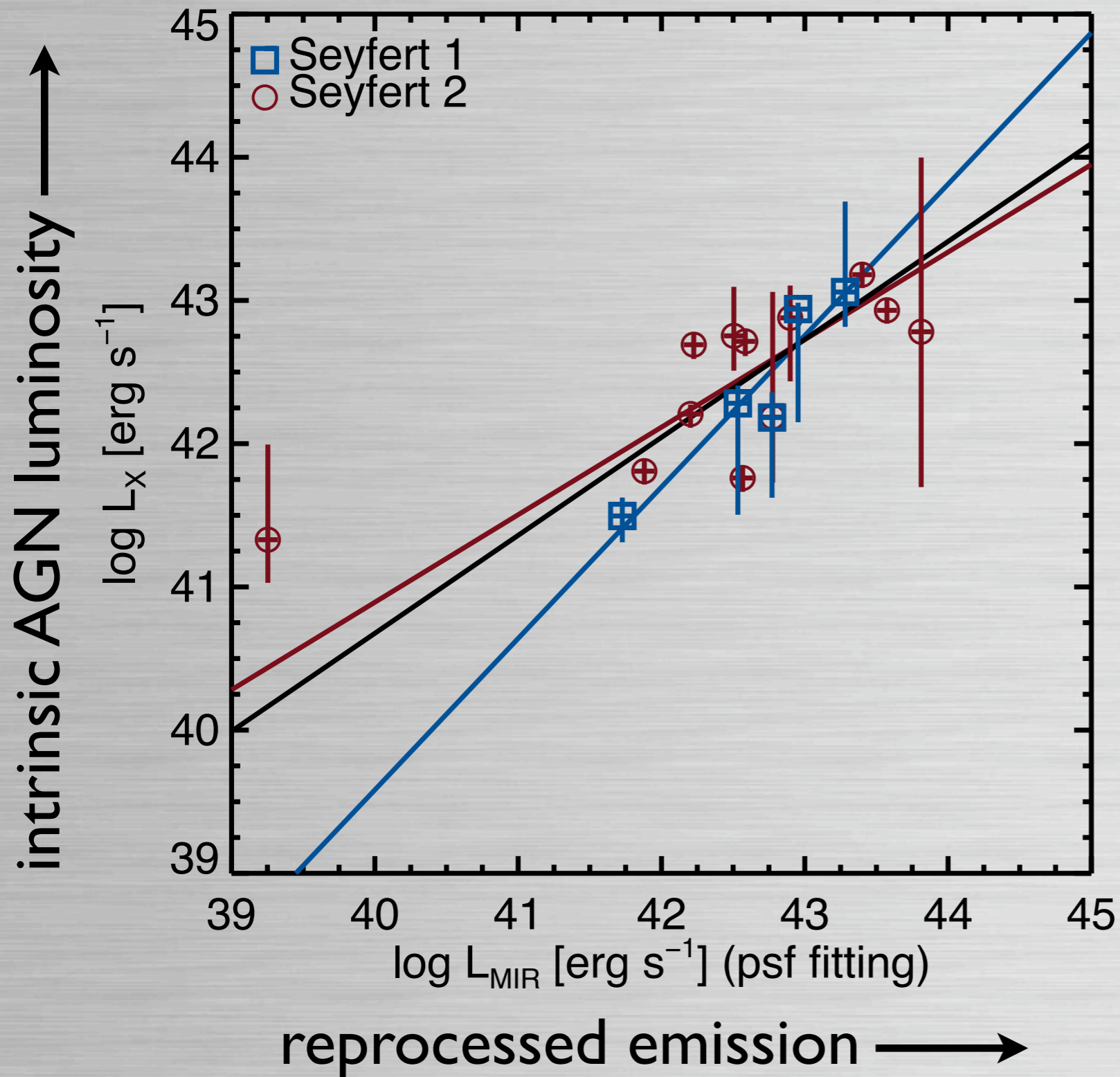
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Mid-infrared/X-ray correlations



- distance-limited sample
D < 50 Mpc
- normal Seyfert galaxies
- fit PSF to MIR (to isolate unresolved AGN)
- absorption-corrected L_X is a proxy for L_{AGN}
- X-ray variability → type I uncertainty

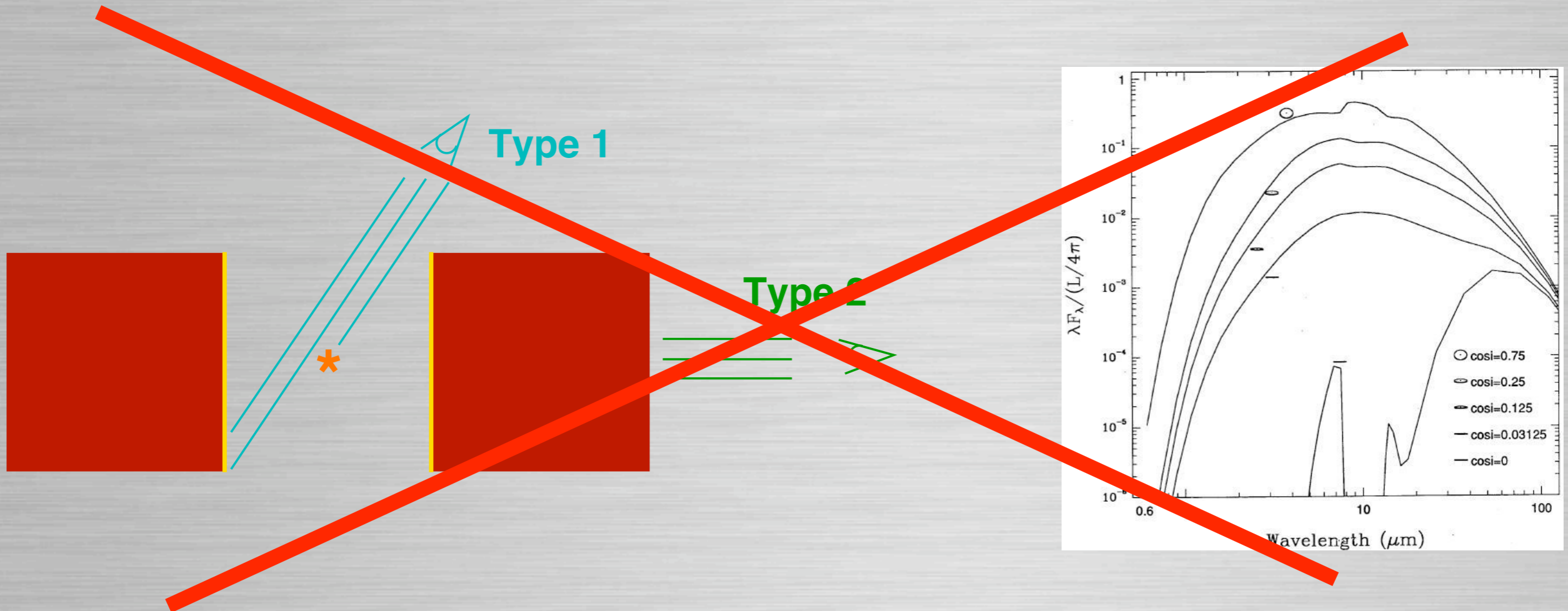
Mid-infrared/X-ray correlations



- MIR and X-ray are strongly correlated
- no significant differences between types 1 and 2
→ isotropic MIR emission
- in agreement with previous work
e.g., Horst+ 2008, Gandhi+ 2009

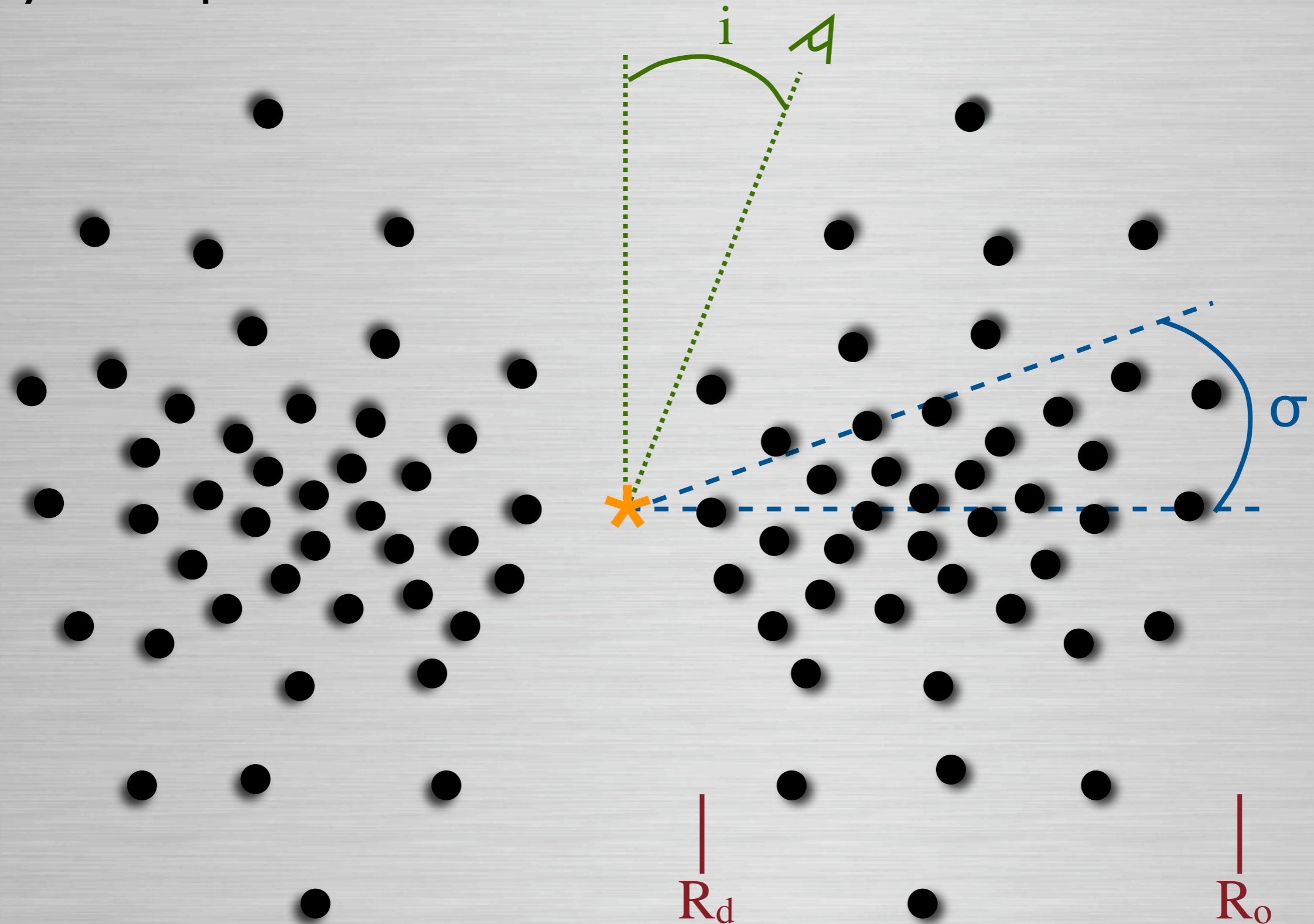
Mid-infrared/X-ray correlations

- type 1 and type 2 are not significantly different
→ isotropy of MIR emission



Inhomogeneous (clumpy) torus

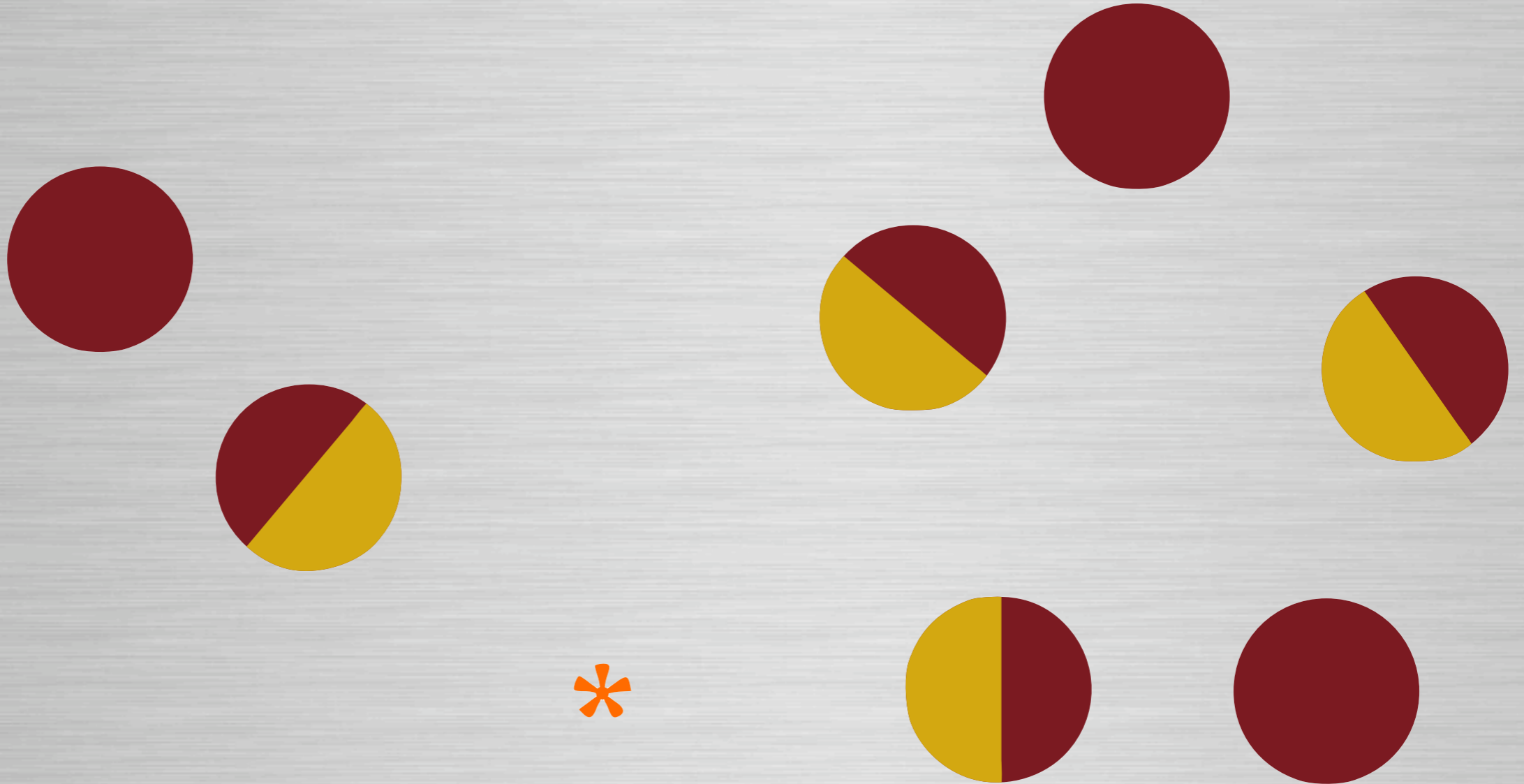
- Nearly isotropic MIR emission with weak silicate features



$$N(R, \beta) = N_0 \exp(-\beta^2/\sigma^2) (R/R_d)^{-q}$$

(Nenkova et al. 2008)

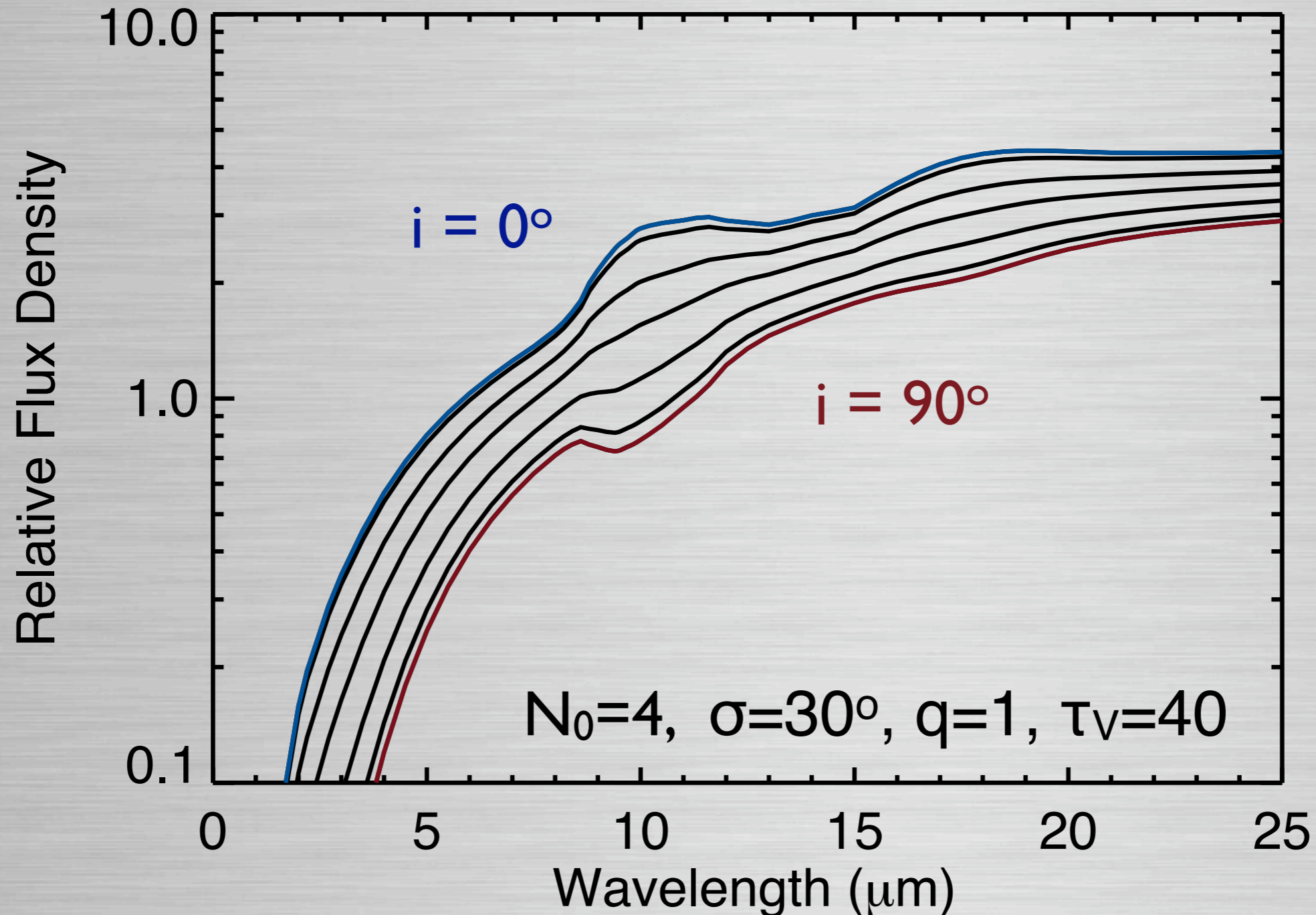
Inhomogeneous (clumpy) torus



- individual clouds are optically thick ($\tau_V \geq 20$)
- AGN directly heats some clouds
- radiative transfer within dusty clouds
- illuminated and dark sides may be observed from both type 1 and 2

Inhomogeneous (clumpy) torus

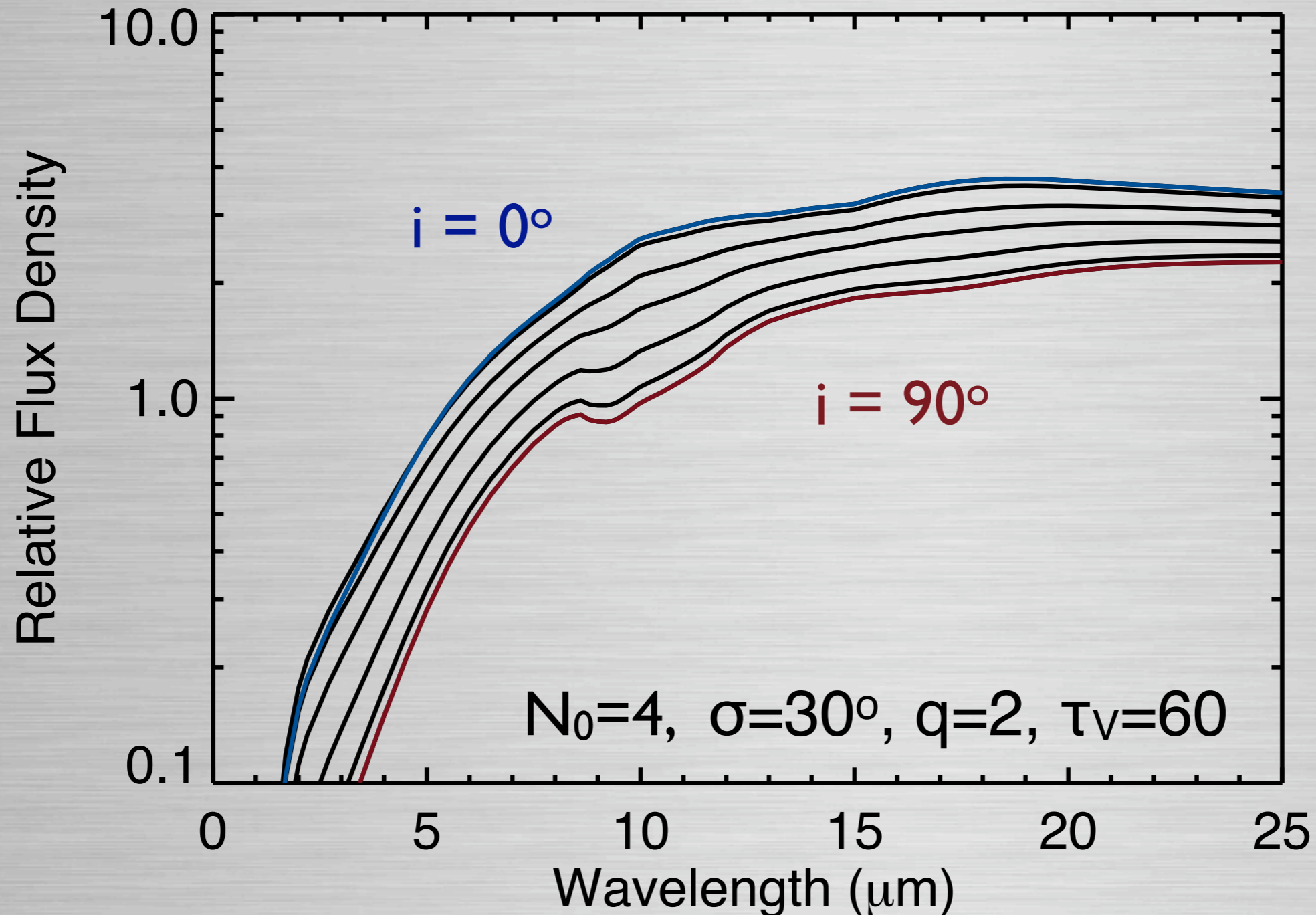
- clumpy torus models produce nearly isotropic MIR emission
- isotropy increases toward longer wavelengths
- isotropy increases with a more compact torus



(Levenson et al., in preparation)

Inhomogeneous (clumpy) torus

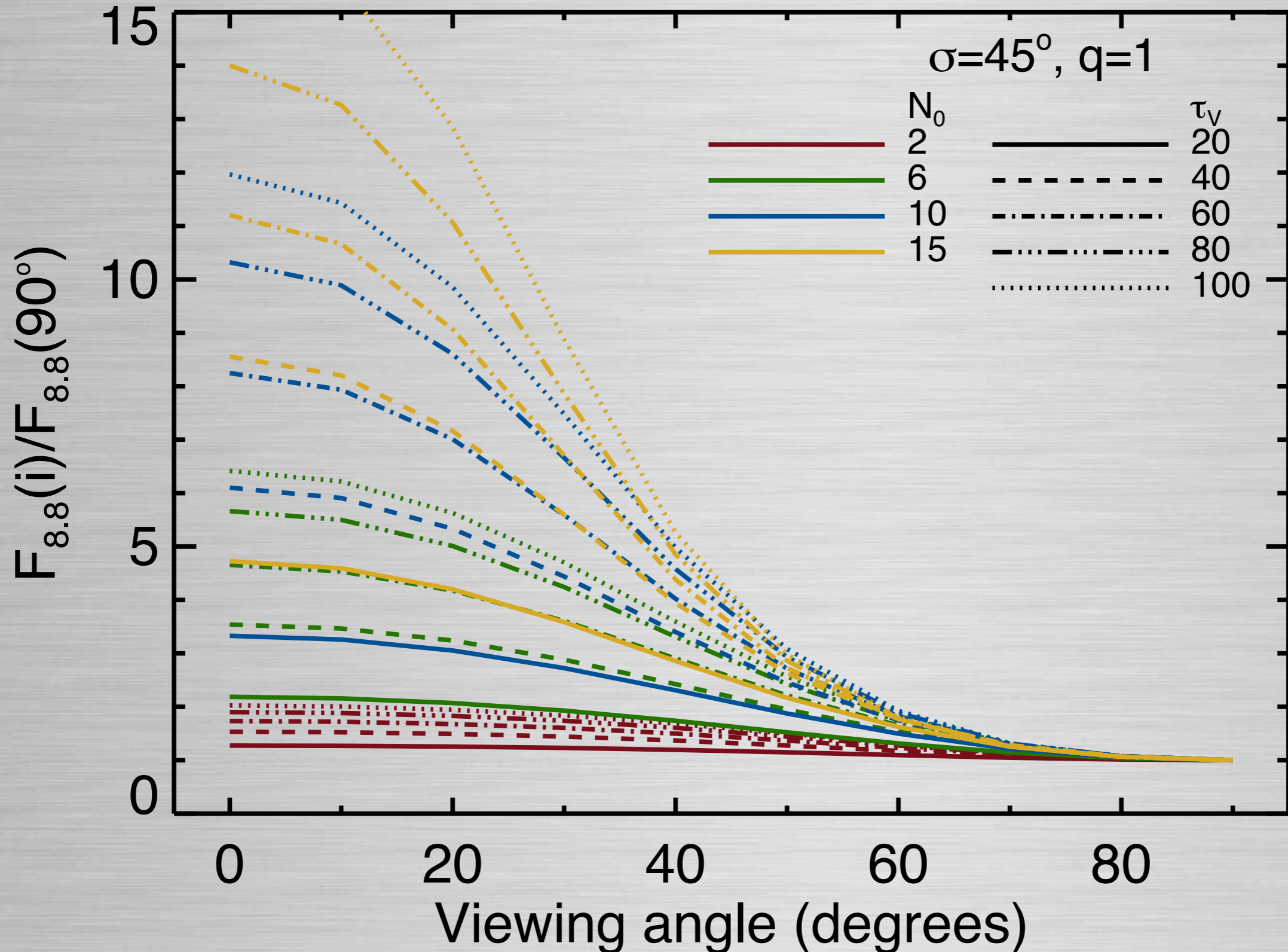
- for a given model, MIR flux typically varies by less than 5x
- considering all parameter combinations, absolute MIR luminosity varies by less than 600x



(Levenson et al., in preparation)

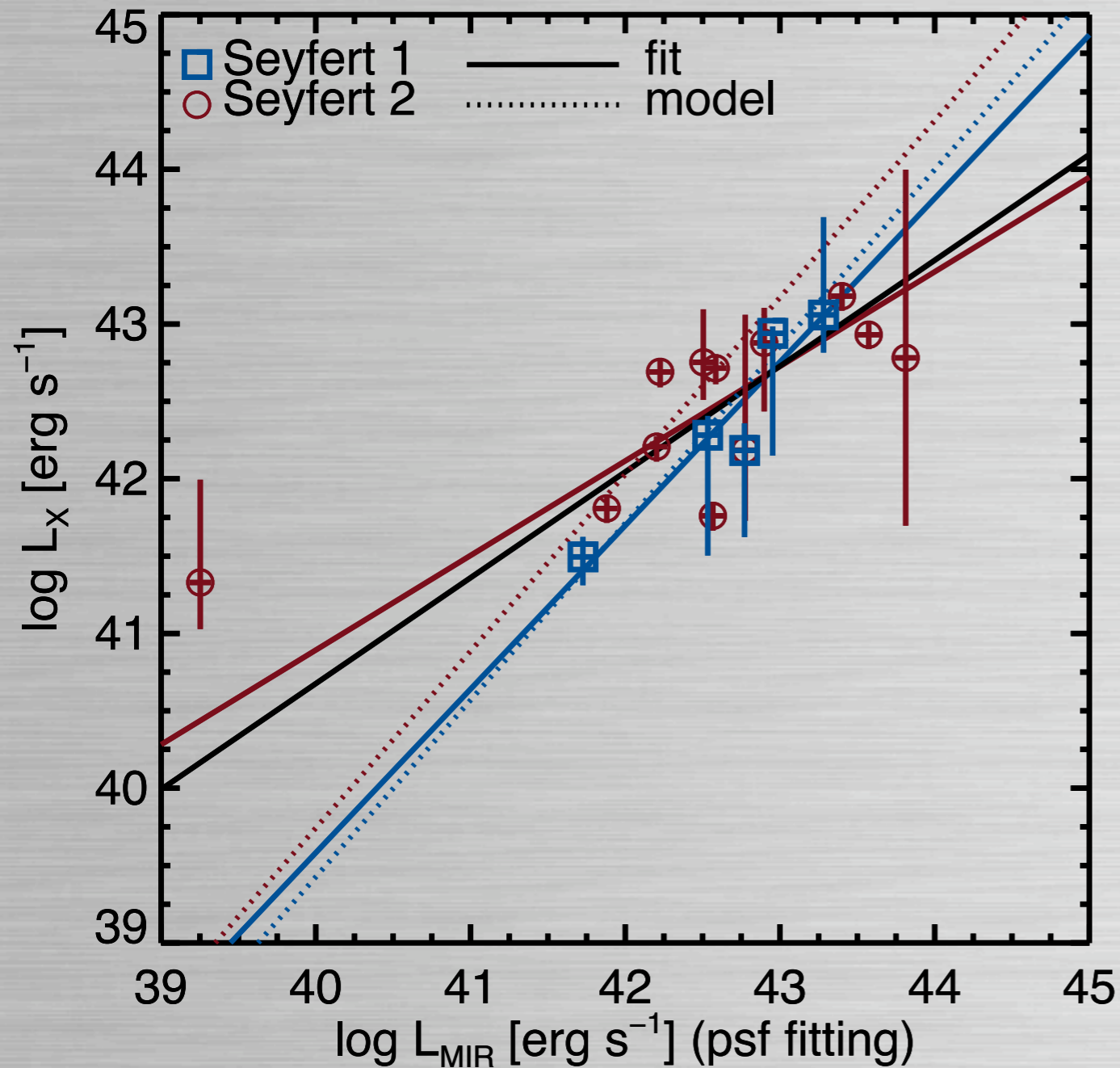
Inhomogeneous (clumpy) torus

8.8 μm flux as a function of viewing angle:



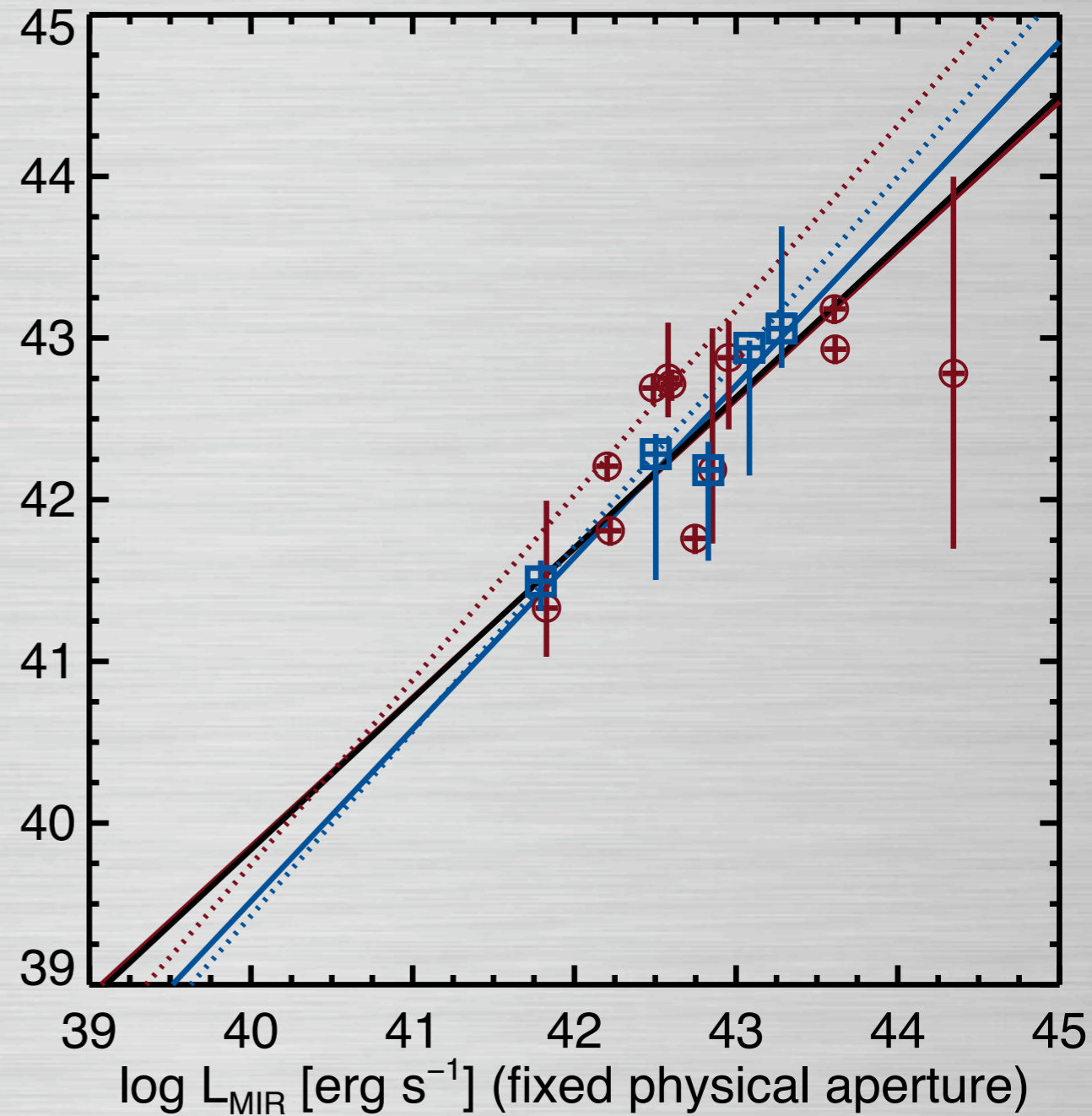
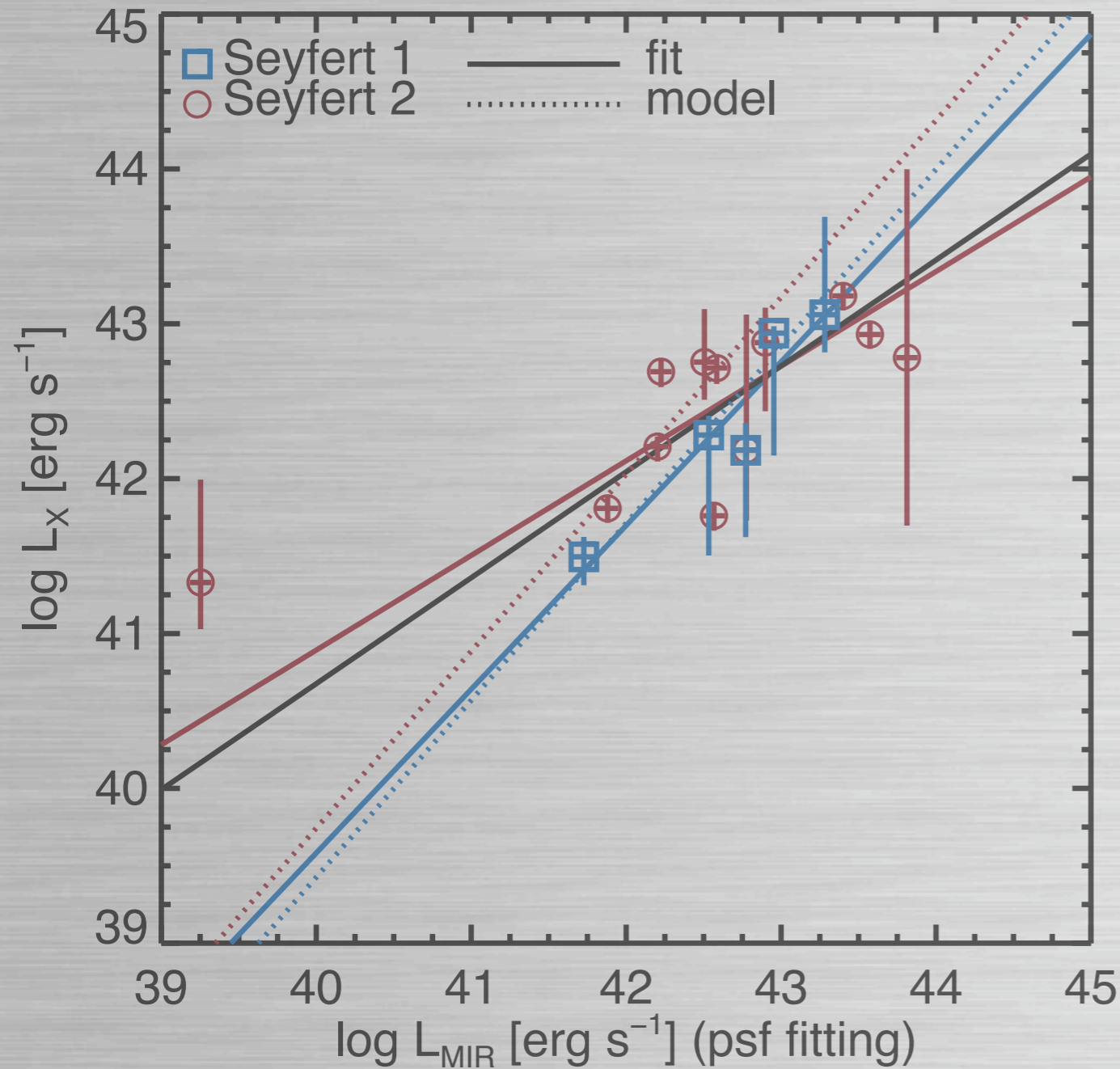
(Levenson et al., in preparation)

Mid-infrared/X-ray correlations



- general agreement with theoretical predictions
- luminosity dependence here reduced L_X with stronger MIR
- sources in addition to AGN contribute to MIR
 - nuclear star formation, in variable amounts

Mid-infrared/X-ray correlations



- fixed 100 pc aperture:
no luminosity dependence
- comparable star formation on these scales

(Levenson et al., in preparation)

Conclusions

- MIR and intrinsic (X-ray) luminosity are strongly correlated
- MIR emission is effectively isotropic
- account for these results with a clumpy AGN torus
 - more isotropic with longer wavelength
 - more isotropic with smaller torus
 - weak silicate features in emission and absorption
- some luminosity dependence on MIR/X-ray correlation
 - understand as contamination by nuclear star-heated dust
 - not apparent on 100 pc scales

