# Isotropic Mid-Infrared Emission from Active Galactic Nuclei

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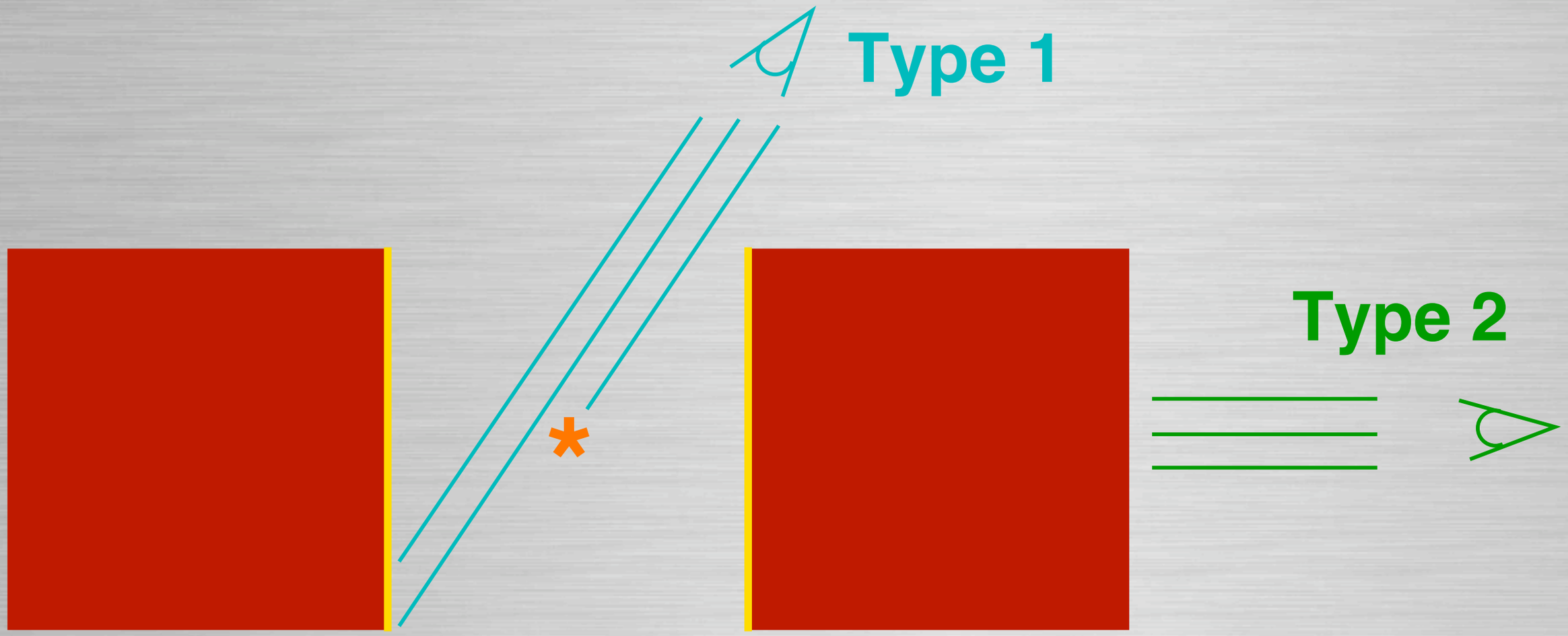
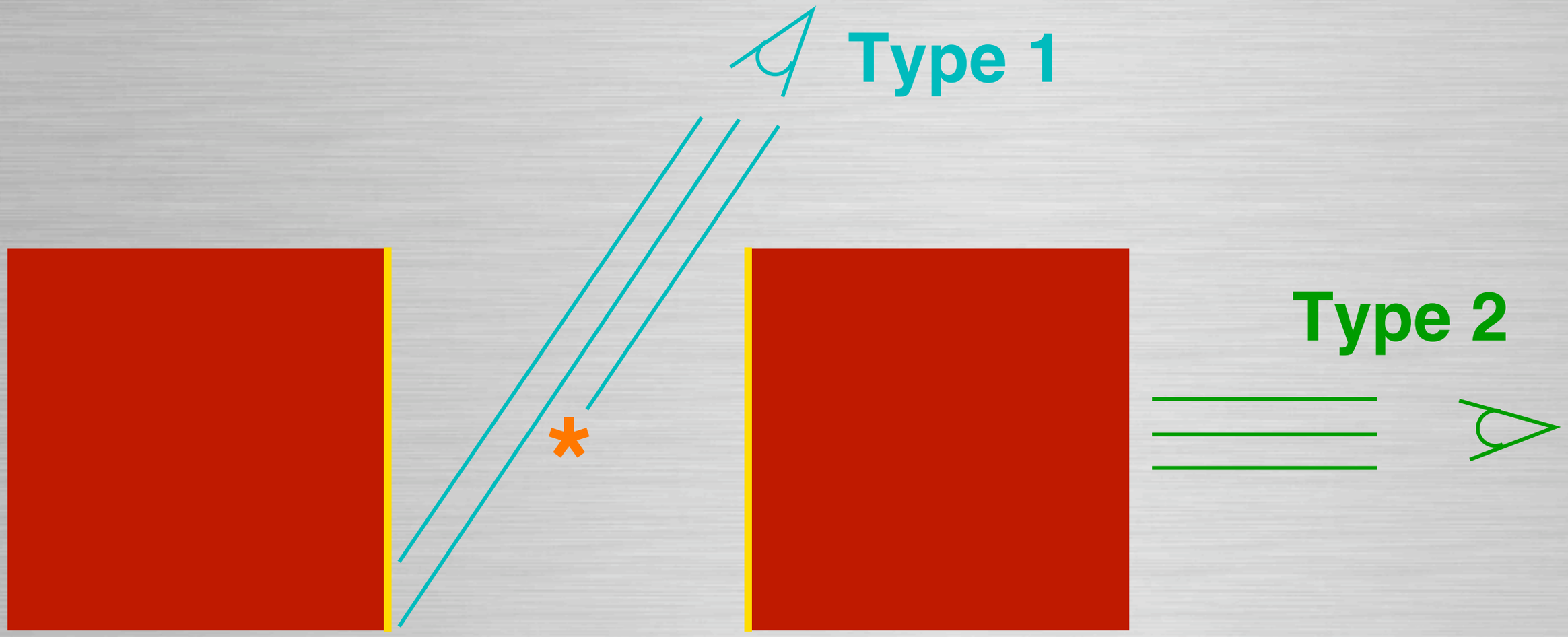
# AGN unification




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

Infrared luminosity depends on intrinsic AGN luminosity

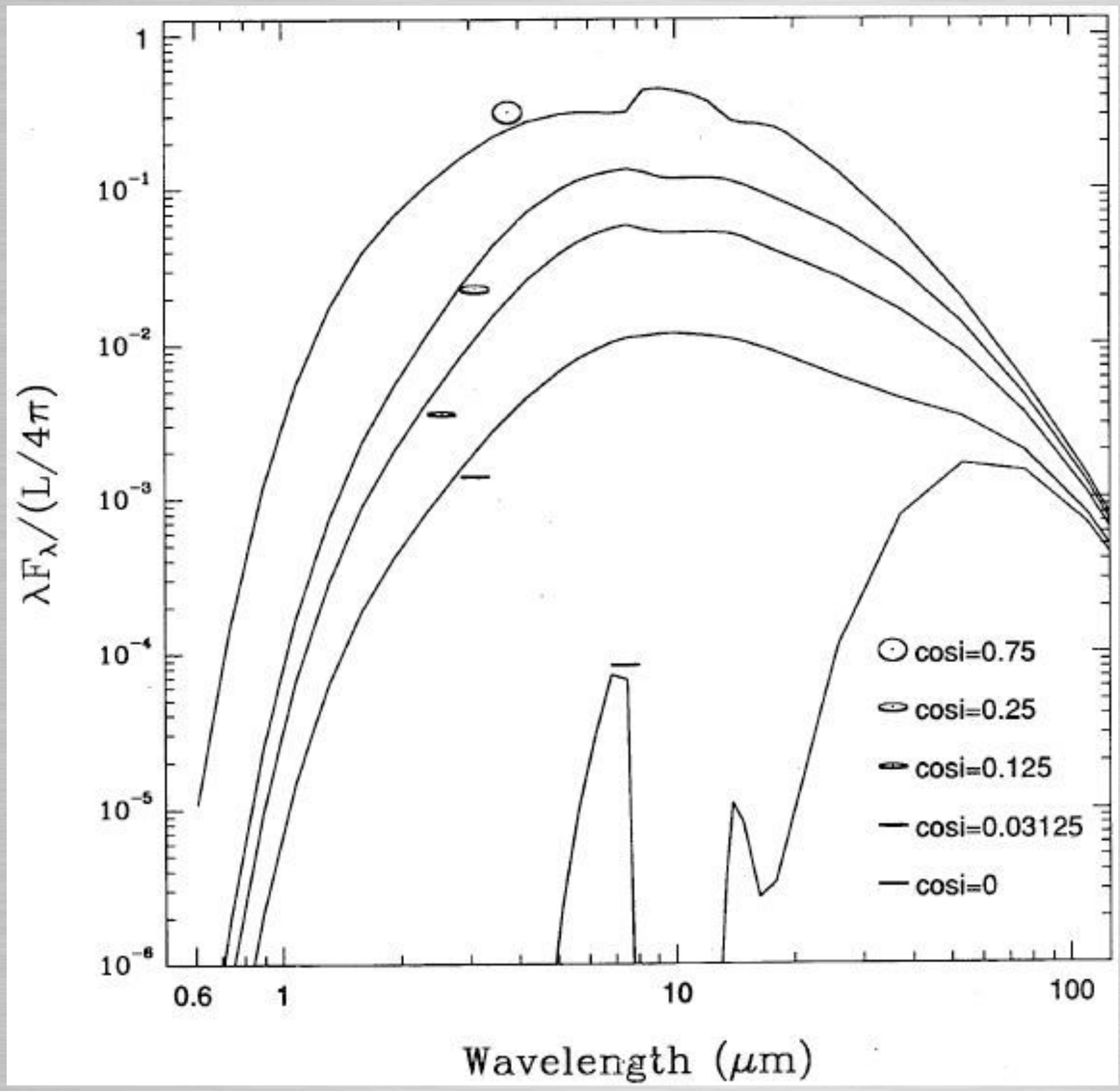
# AGN unification -- smooth torus




Consequences for homogeneous torus:

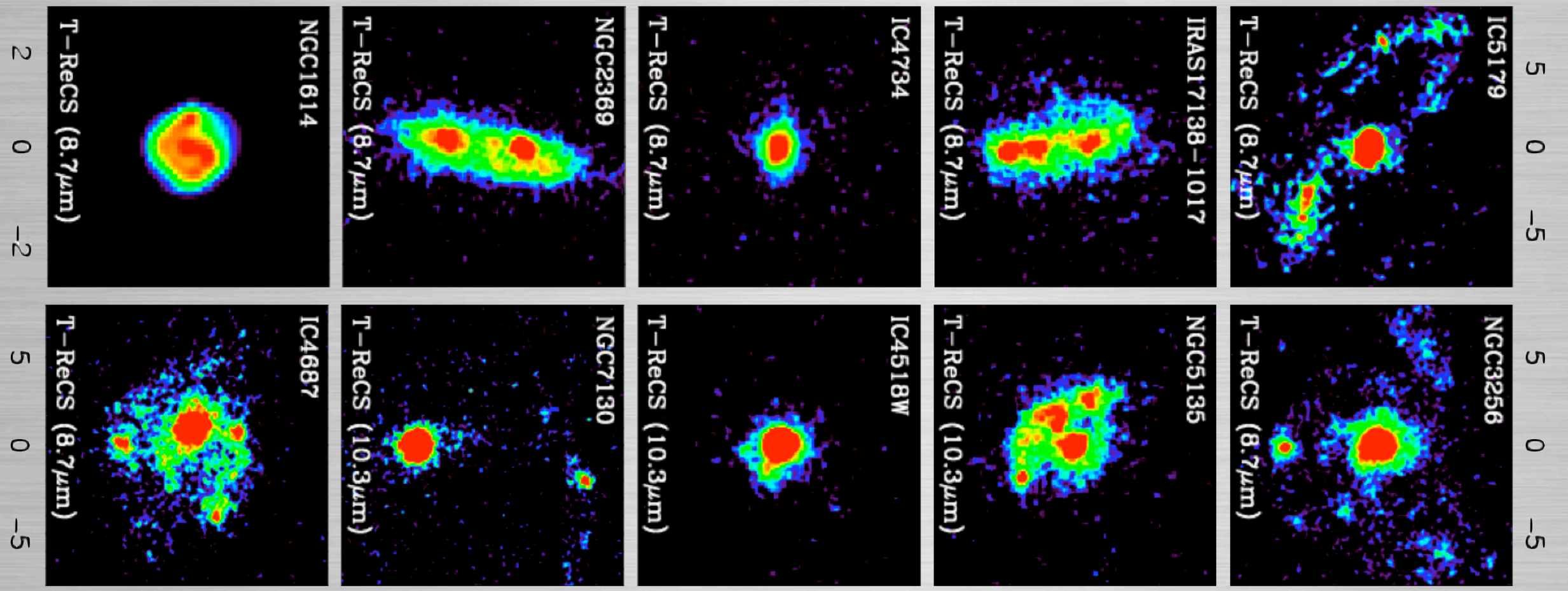
- Anisotropic MIR emission
- Type 1 strong silicate emission; Type 2 deep silicate absorption

# AGN unification -- smooth torus models




(Pier & Krolik 1992)

# Small torus




T-ReCS (Díaz-Santos et al. 2008)

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

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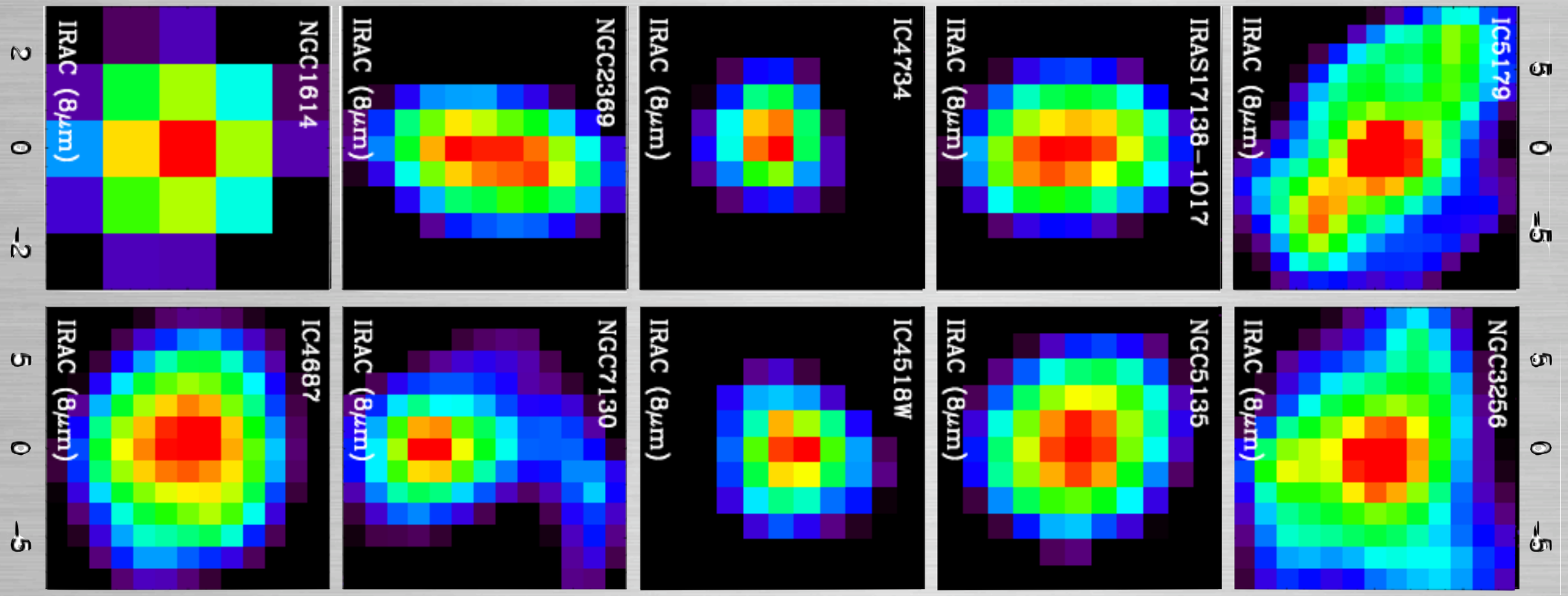


Spitzer (Díaz-Santos et al. 2008)

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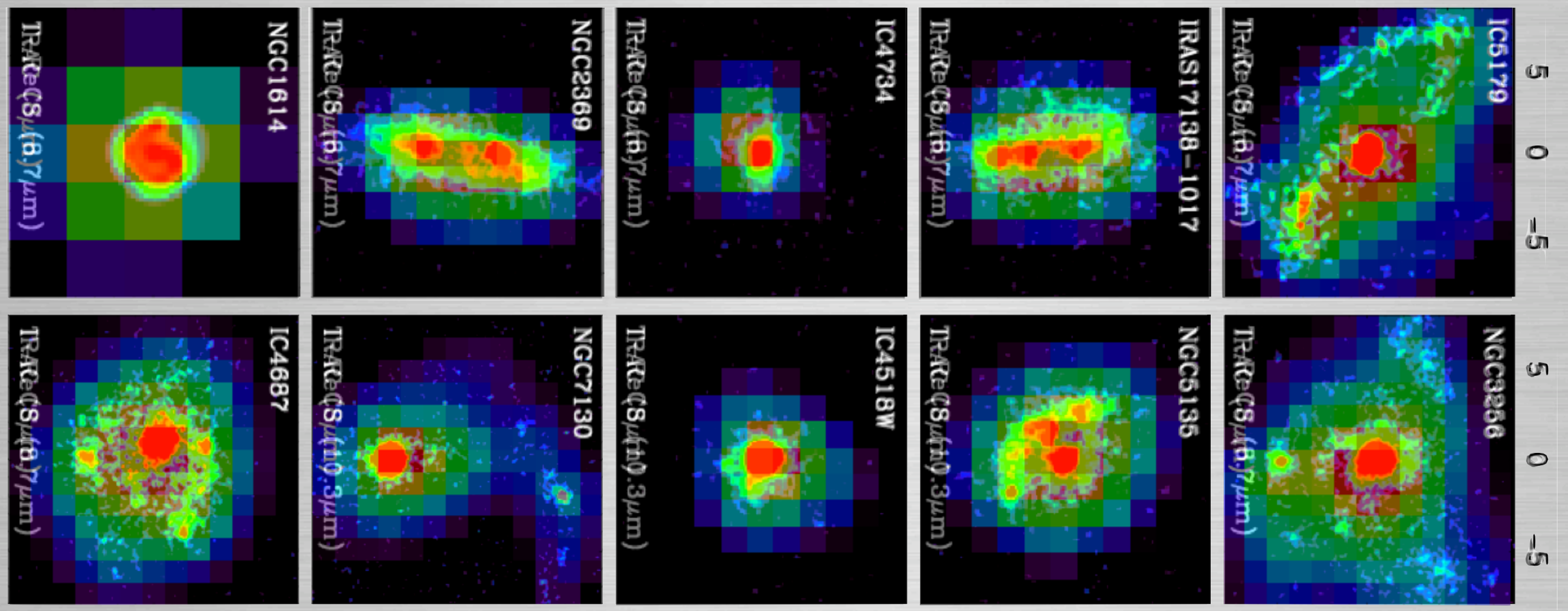


(Díaz-Santos et al. 2008)

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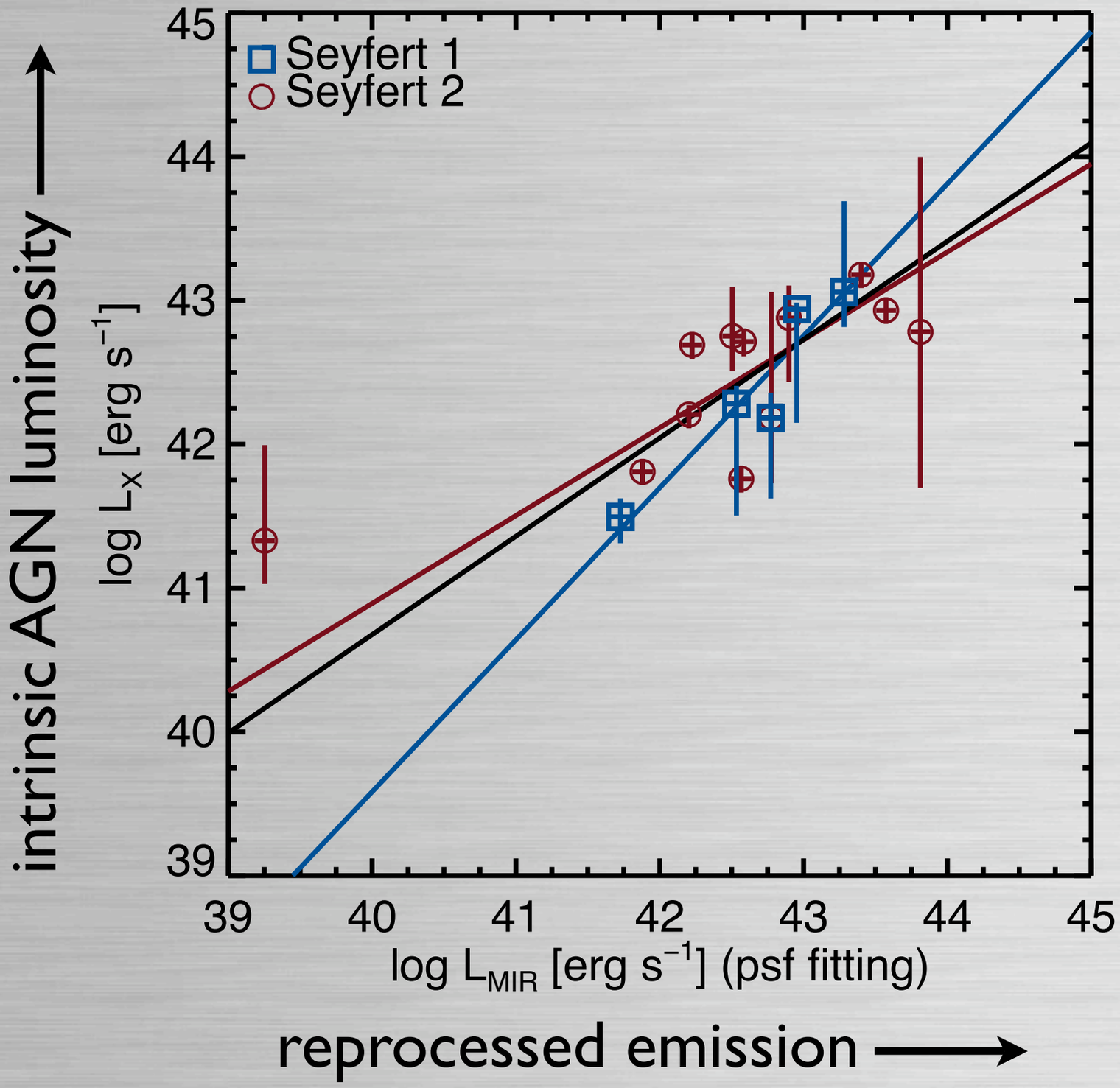
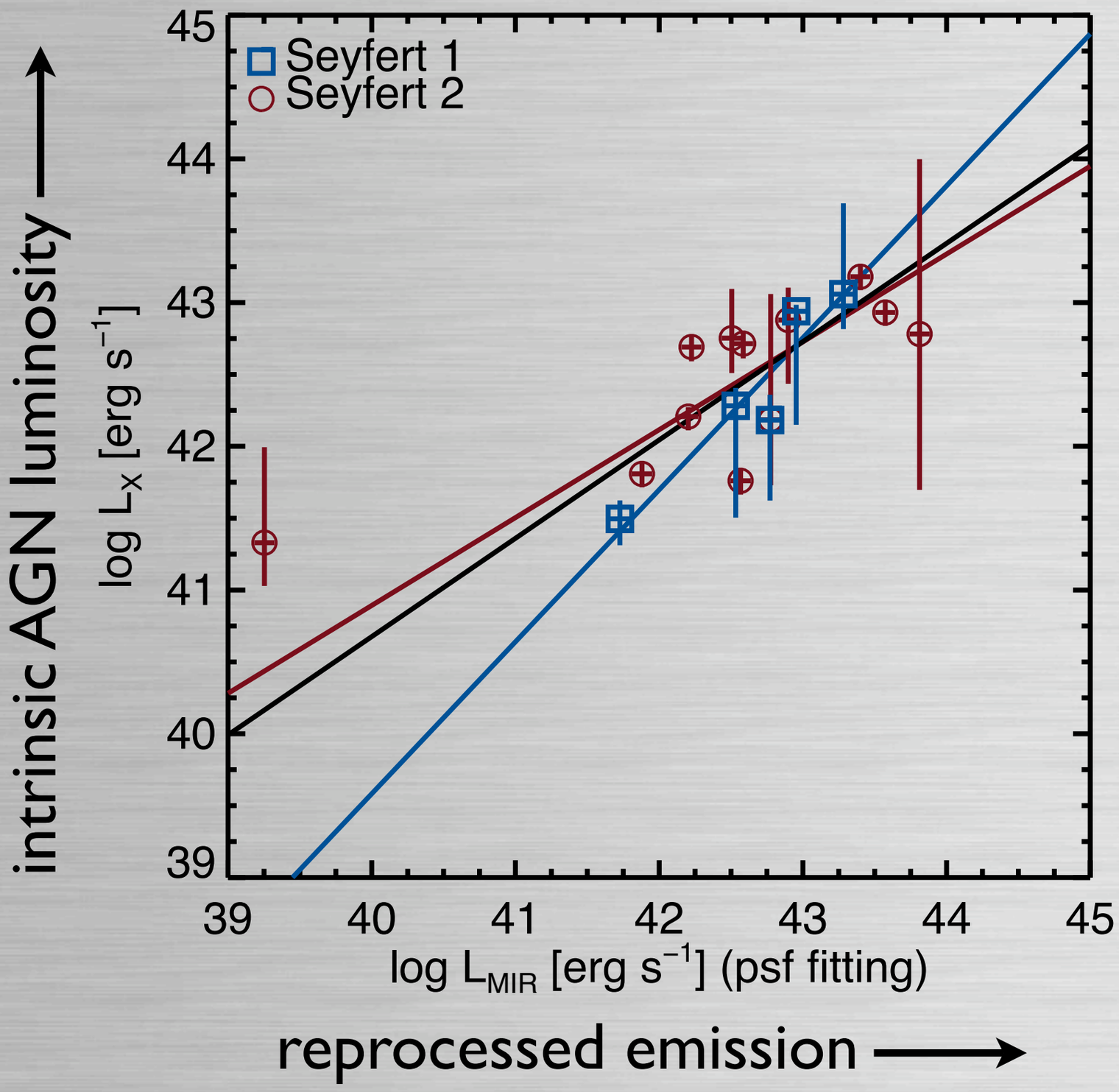
# Mid-infrared/X-ray correlations




- 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

(Levenson et al., in preparation)

# Mid-infrared/X-ray correlations

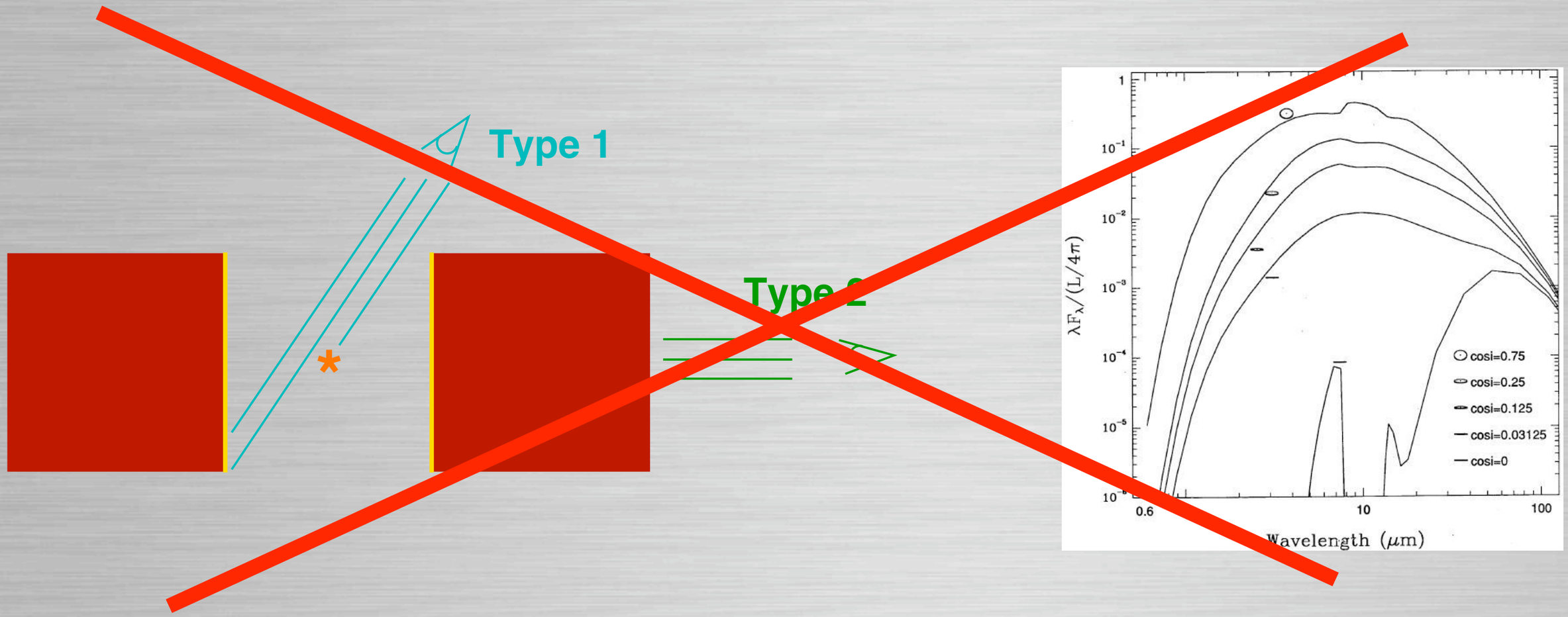



- MIR and X-ray are strongly correlated
- no significant differences between types 1 and 2
  → isotropic MIR emission
- in agreement with previous work
  e.g., Horst+ 2008, Gandhi+ 2009

(Levenson et al., in preparation)

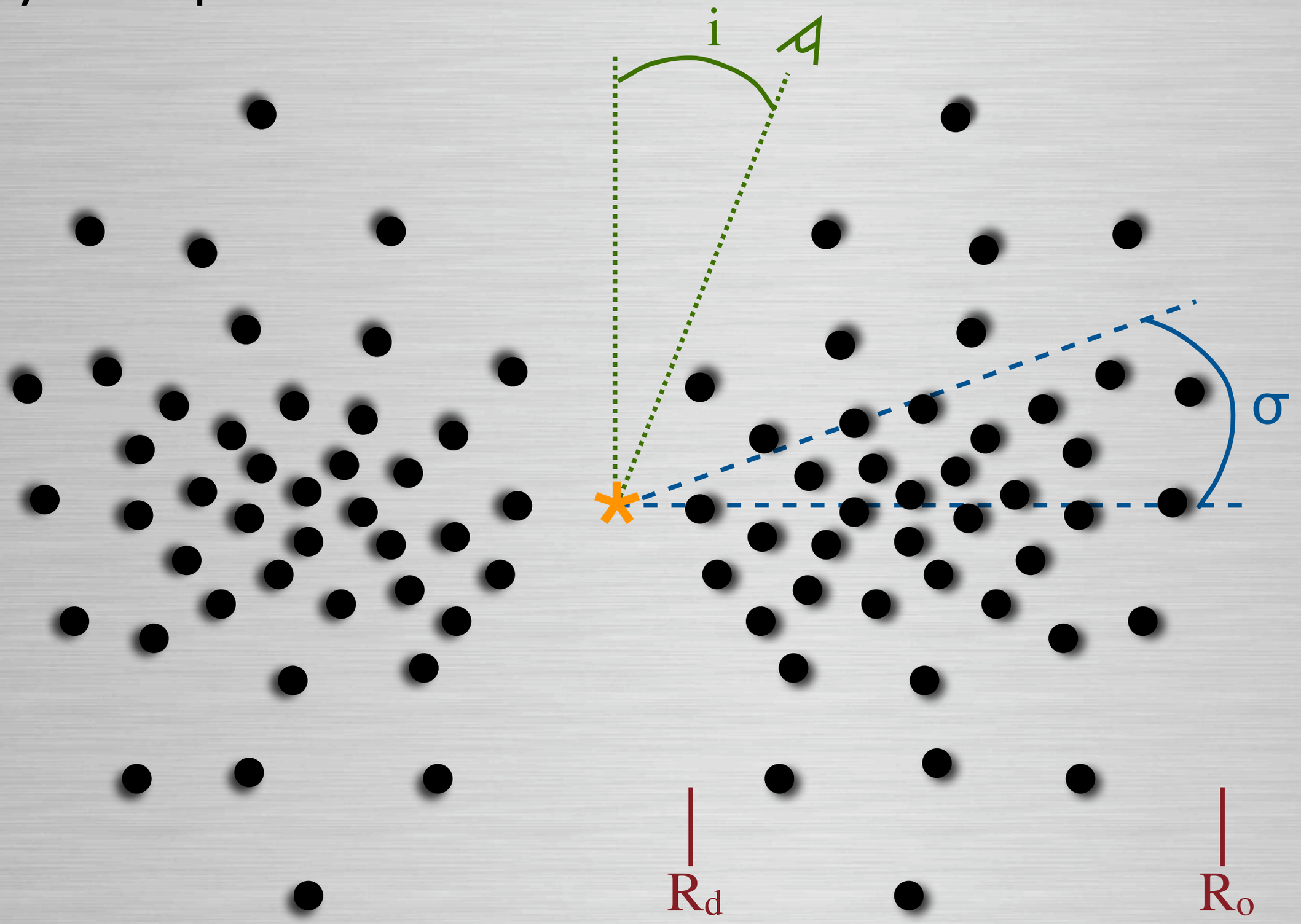
# Mid-infrared/X-ray correlations

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



# Inhomogeneous (clumpy) torus

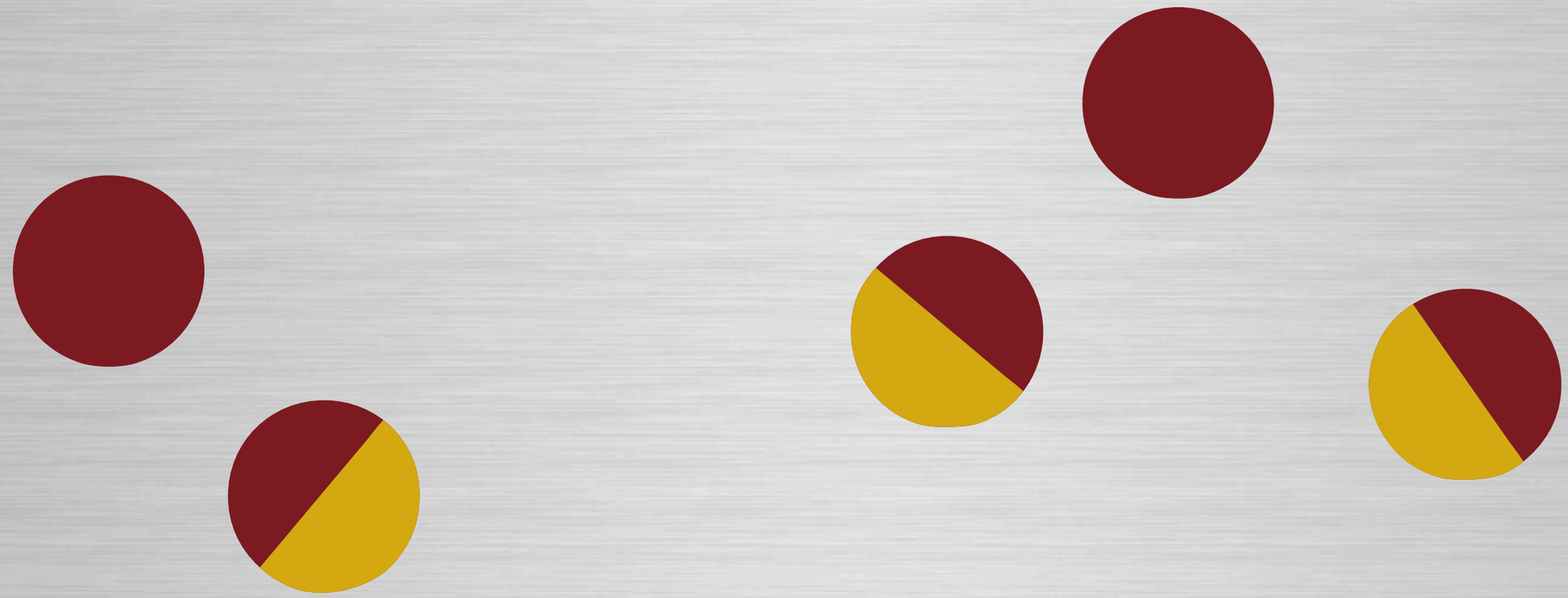
- Nearly isotropic MIR emission with weak silicate features

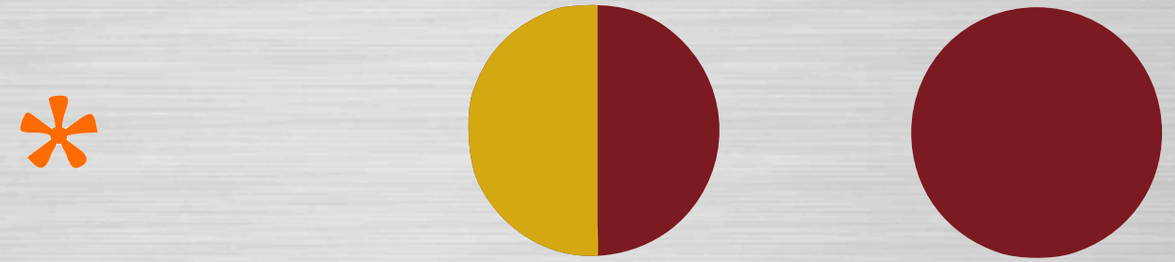



$$N(R,\beta) = N_0 \exp(-\beta^2/\sigma^2)(R/R_d)^{-q}$$

(Nenkova et al. 2008)

# Inhomogeneous (clumpy) torus

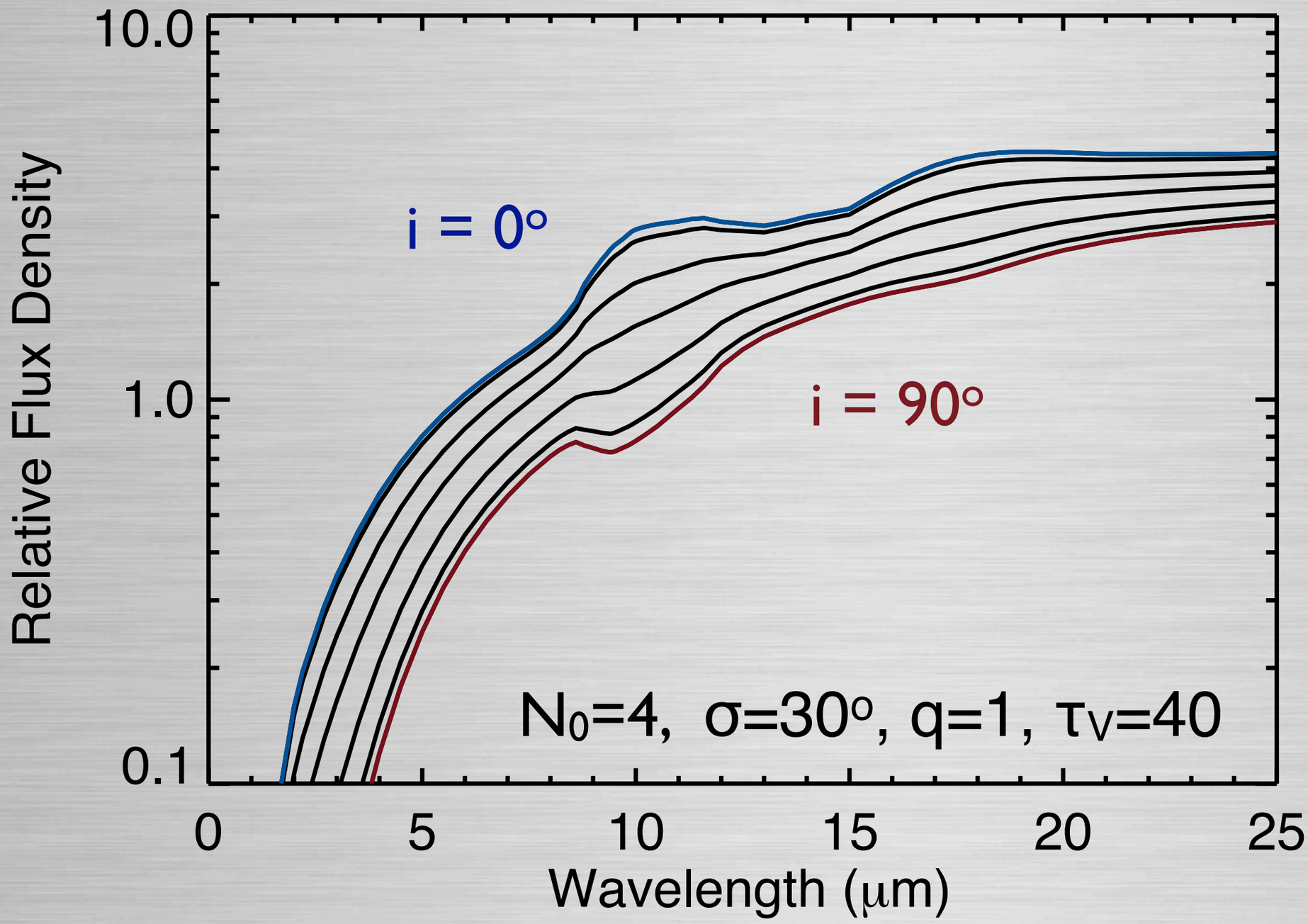




- individual clouds are optically thick ($\tau_V \geq 20$)
- AGN directly heats some clouds
- radiative transfer within dusty clouds
- illuminated and dark sides may observed from both type 1 and 2

# Inhomogeneous (clumpy) torus

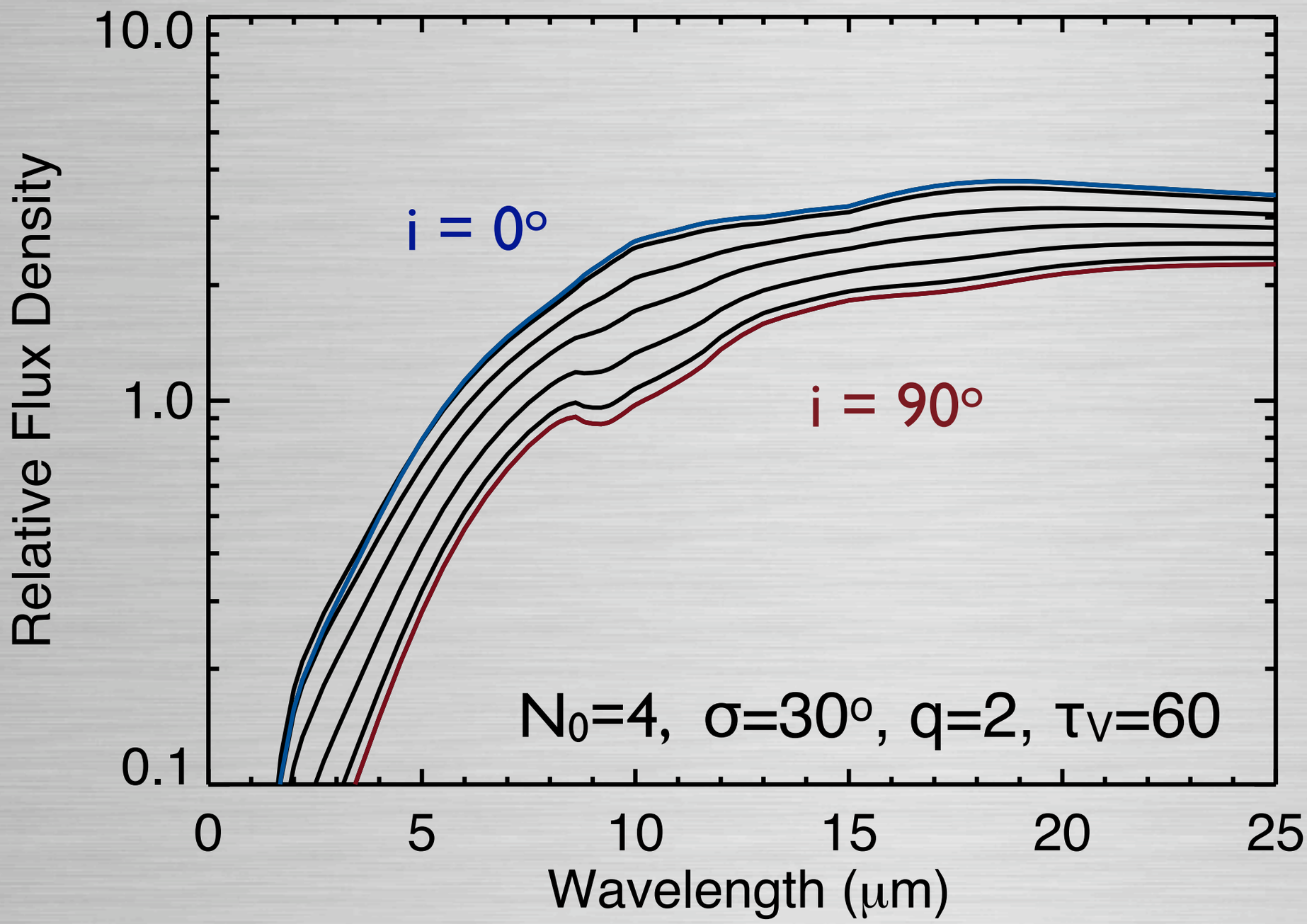
- clumpy torus models produce nearly isotropic MIR emission
- isotropy increases toward longer wavelengths
- isotropy increases with a more compact torus




(Levenson et al., in preparation)

# Inhomogeneous (clumpy) torus

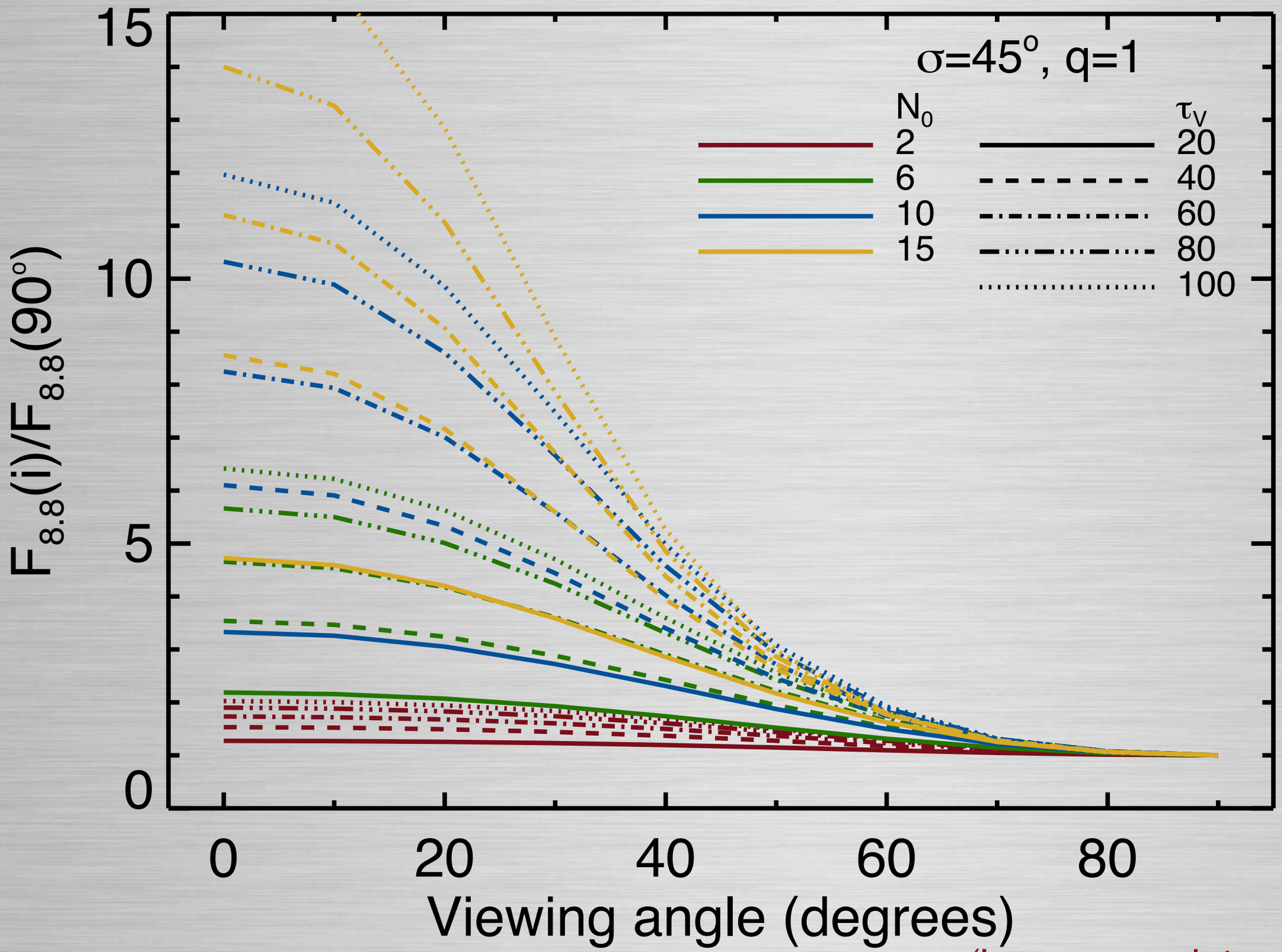
- for a given model, MIR flux typically varies by less than 5x
- considering all parameter combinations, absolute MIR luminosity varies by less than 600x




(Levenson et al., in preparation)

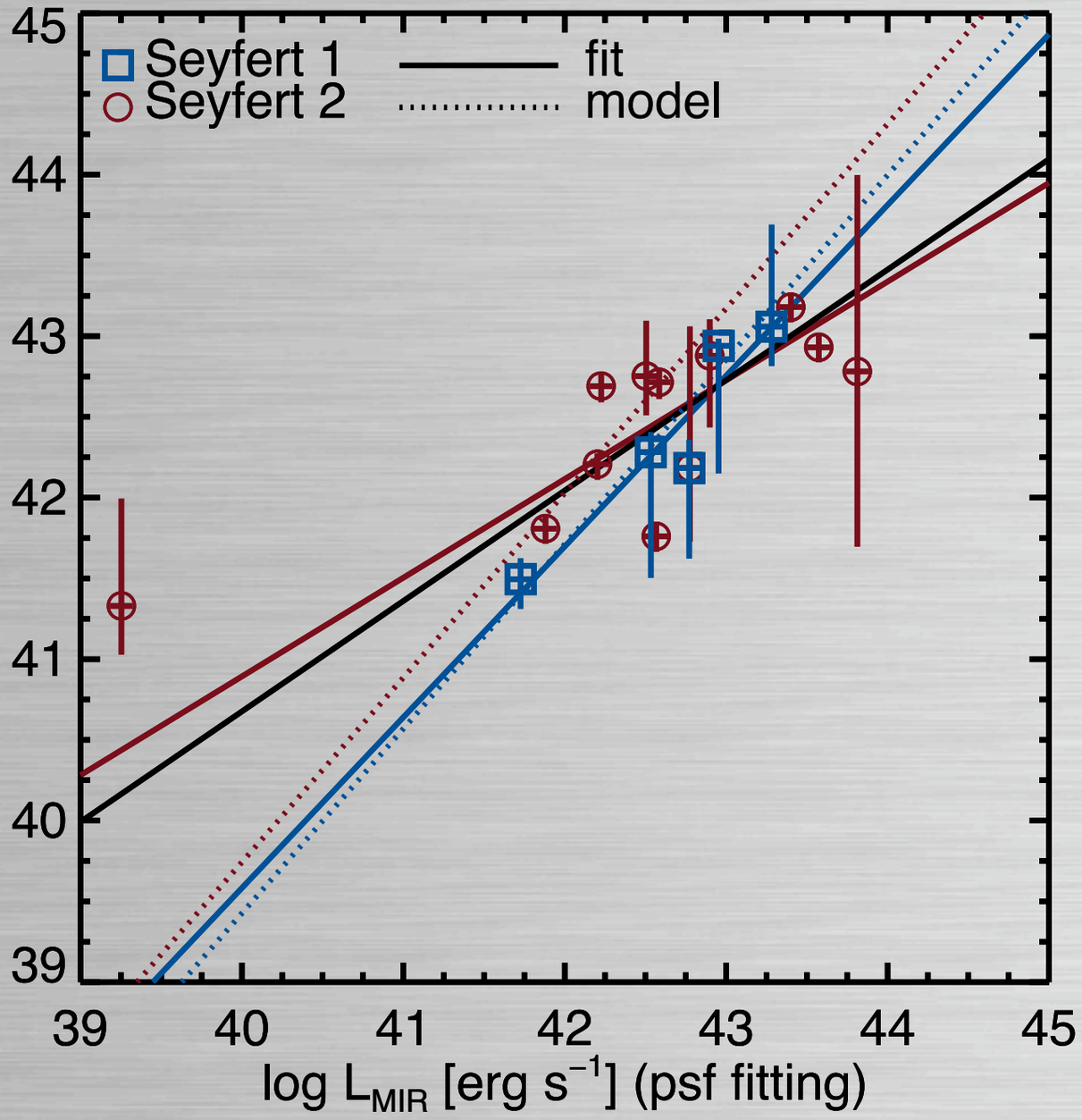
# Inhomogeneous (clumpy) torus

8.8 μm flux as a function of viewing angle:




(Levenson et al., in preparation)

# Mid-infrared/X-ray correlations

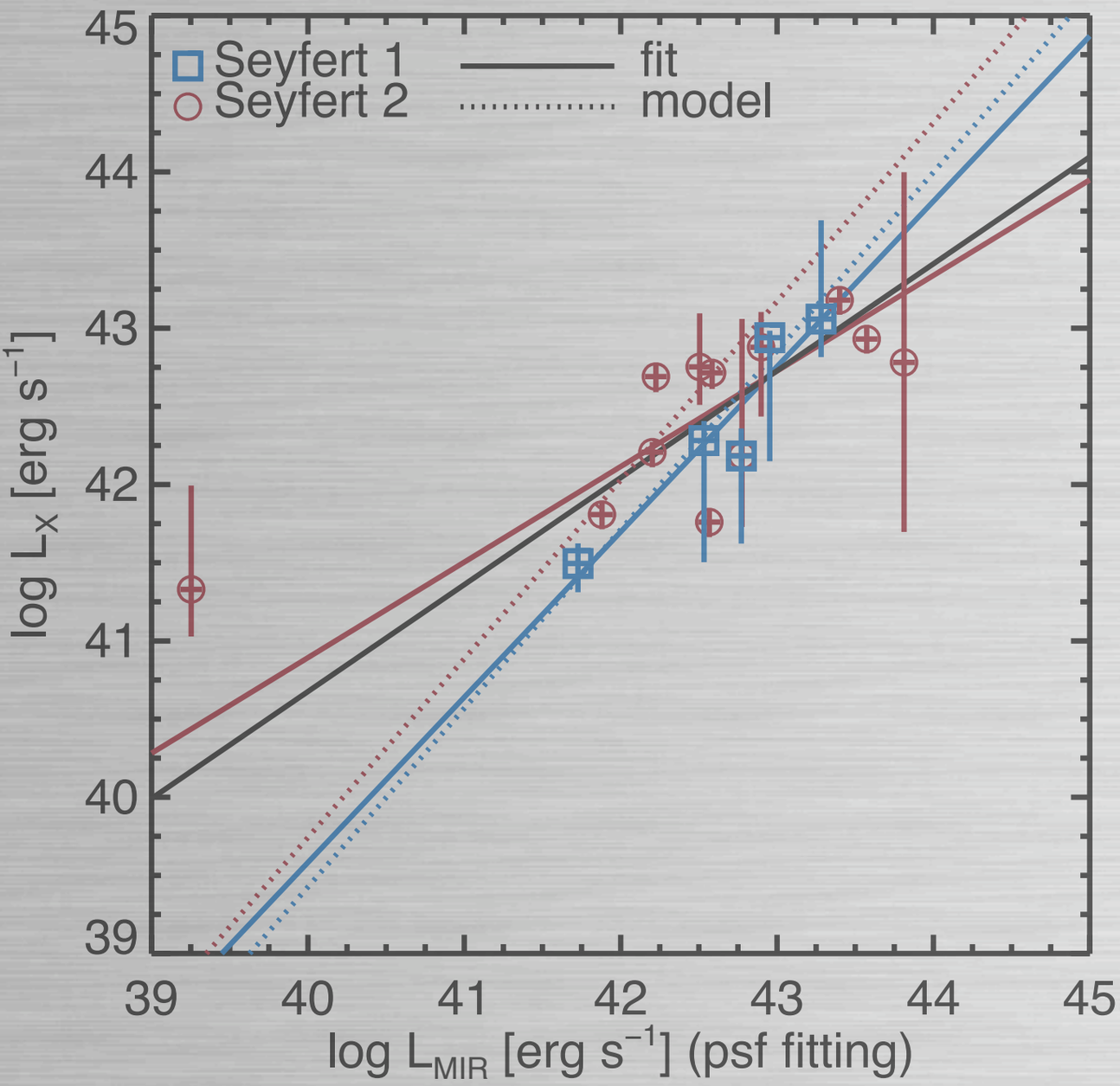


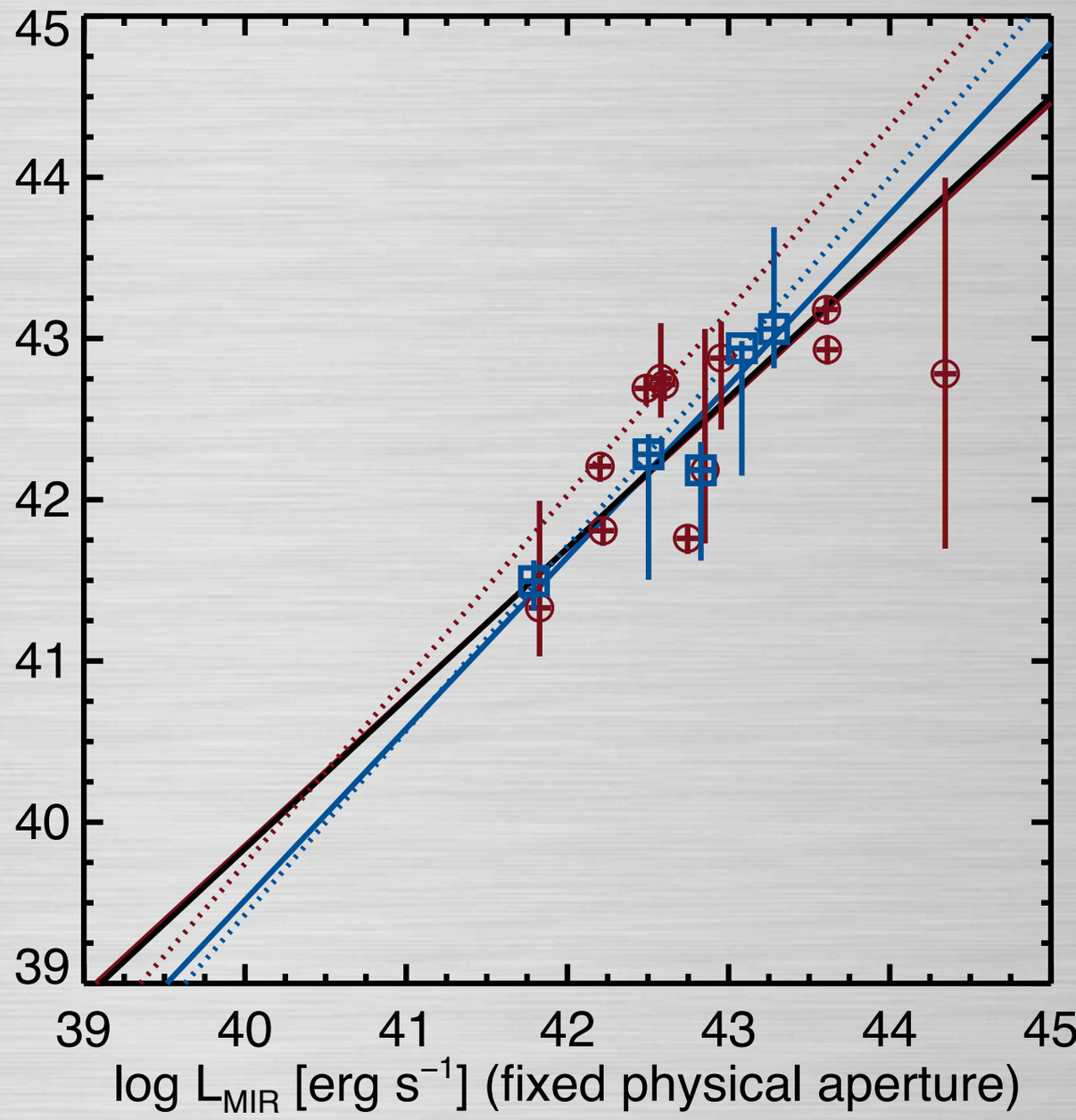

- general agreement with theoretical predictions
- luminosity dependence here reduced $L_X$ with stronger MIR
- sources in addition to AGN contribute to MIR

  nuclear star formation, in variable amounts

(Levenson et al., in preparation)

# 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