Observational Constraints on Spatial Variations of Grain Growth in Circumstellar Disks

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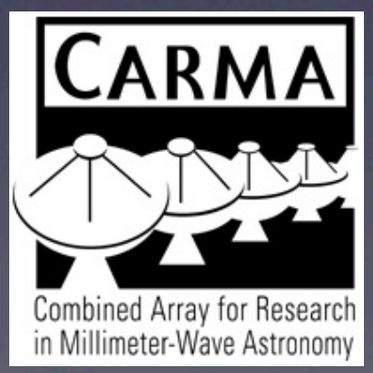
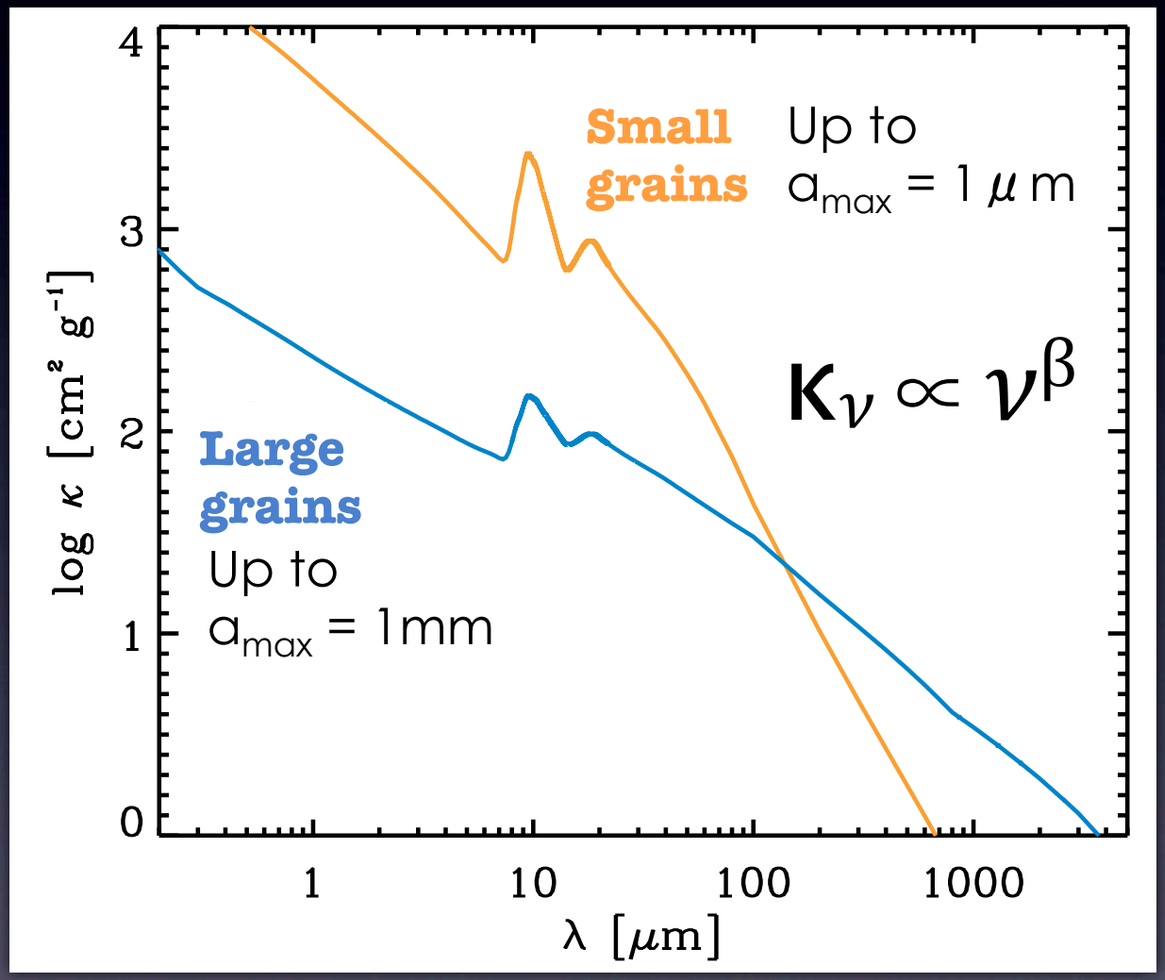
Disks@EVLA collaboration

*** PhD thesis work

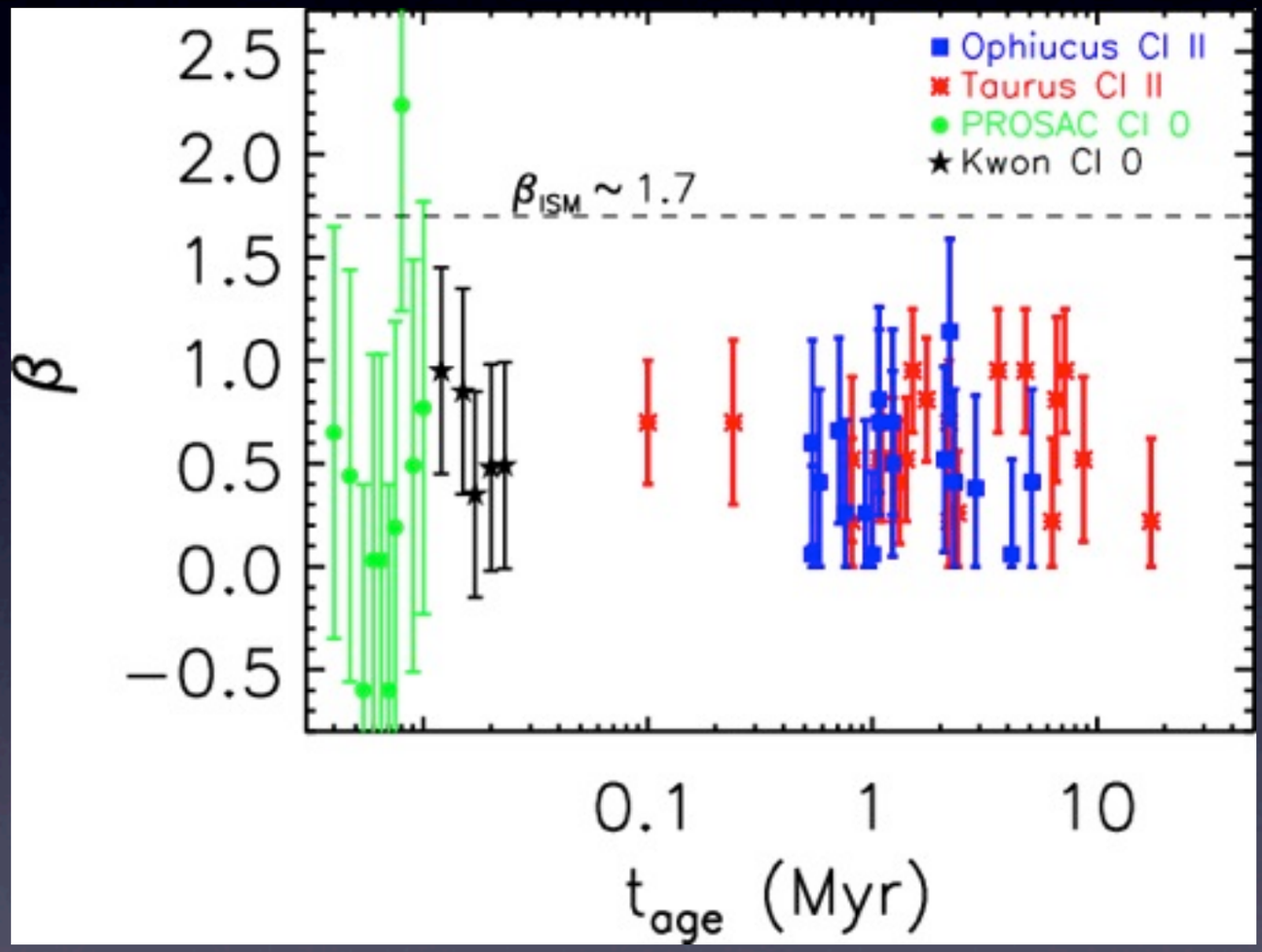


Diagnostics of grain sizes in disks

Submillimeter slope

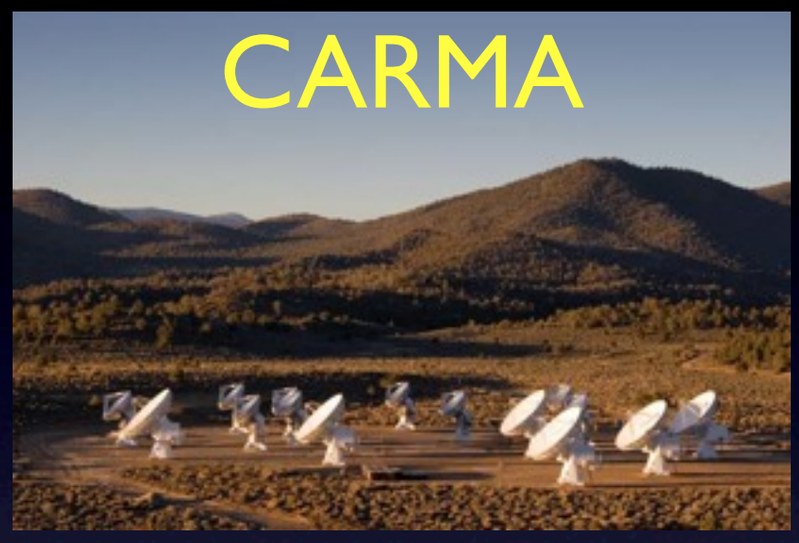


Andrews et al. (2011)



Ricci et al. (2010)

Observations

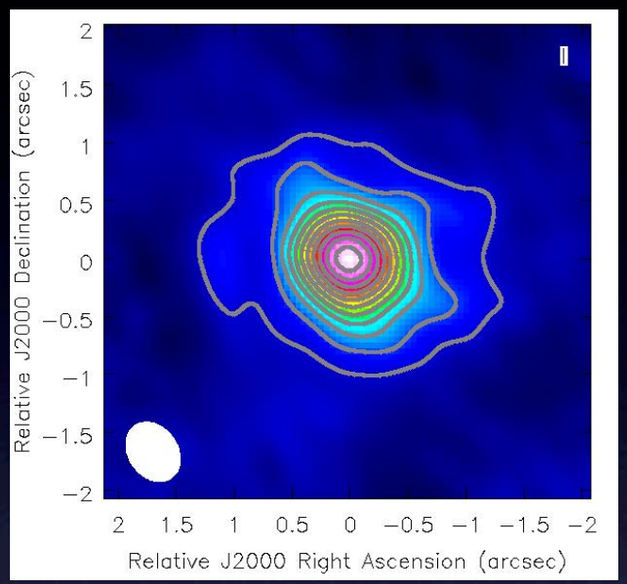


λ 0.88 & 1.3mm λ 1.3 & 3 mm λ 1 & 6 cm

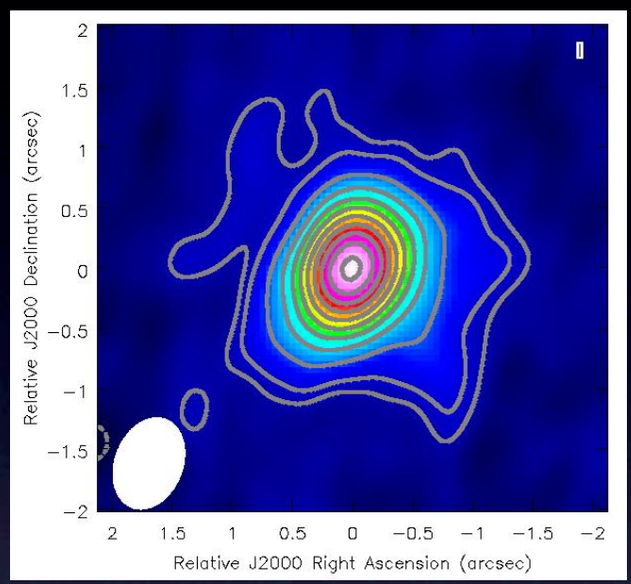
- Sub-arcsecond images ⇒ resolve disks
- Large wavelength coverage ⇒ measure β(R)

First results: AS 209

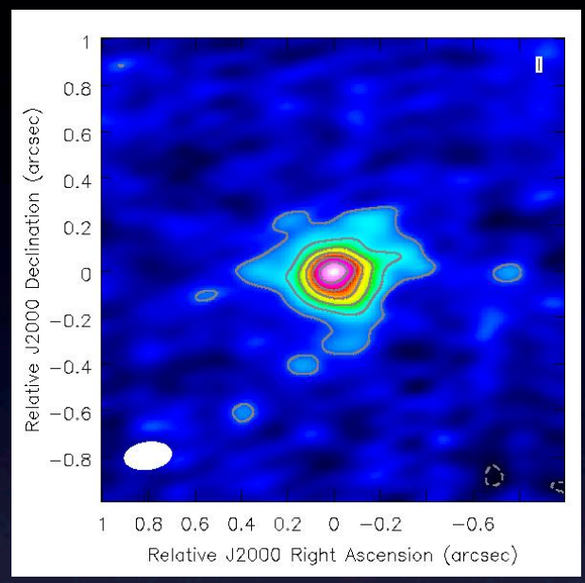
SMA - 0.88 mm



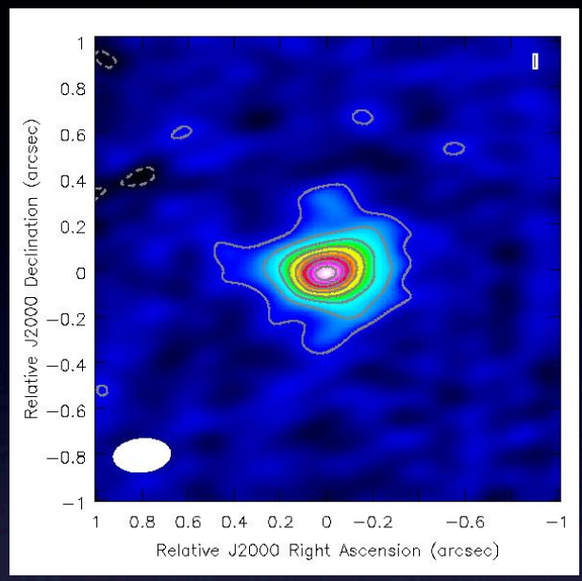
CARMA - 2.7 mm



VLA - 8 mm



VLA - 10 mm



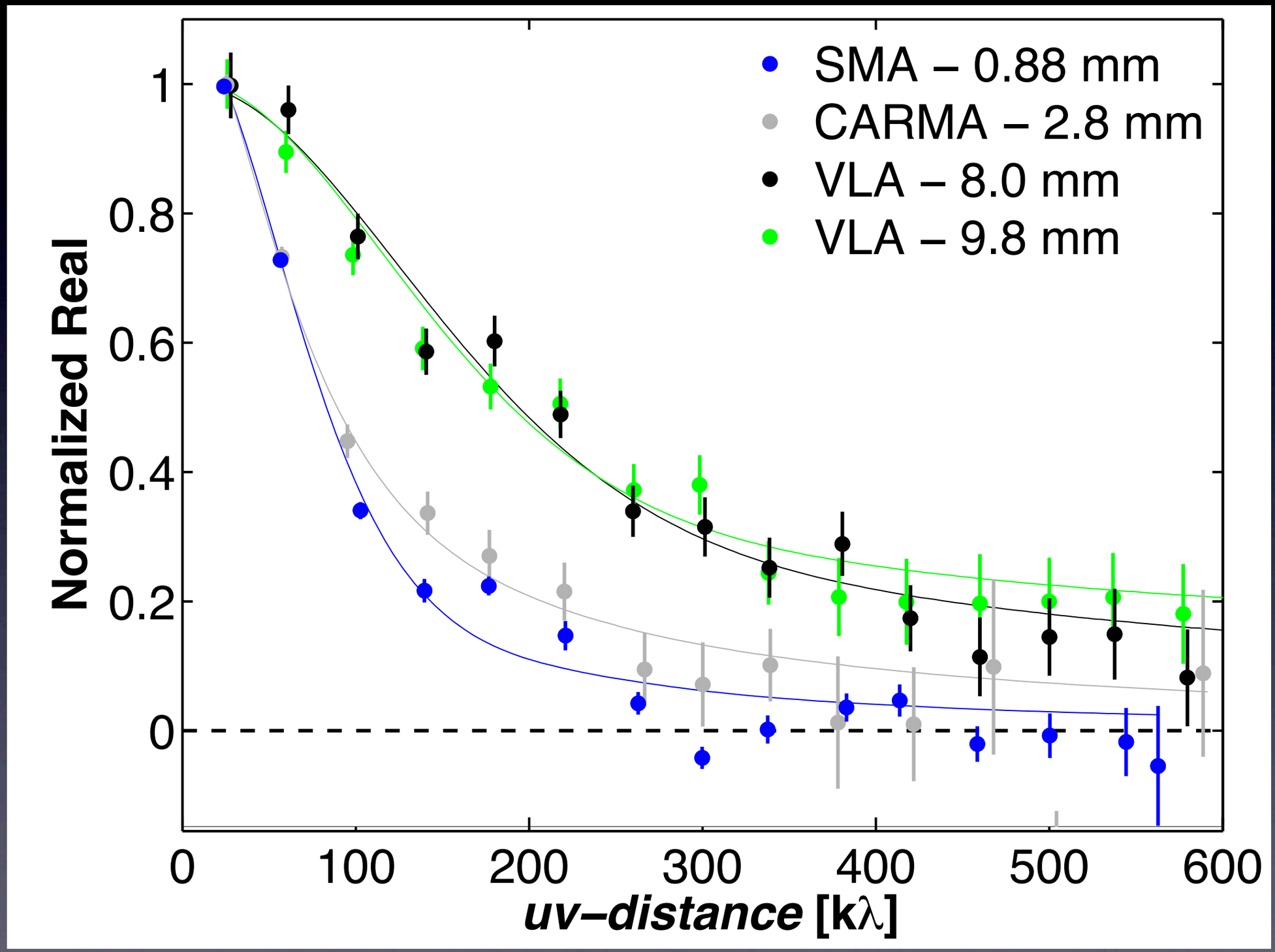
Andrews et al. 2009

Pérez et al., in submitted

AS 209:

- K5 star in ρ Oph
- distance: 125 pc
- 0.9 Msun
- 1.6 Myr

Wavelength dependent structure

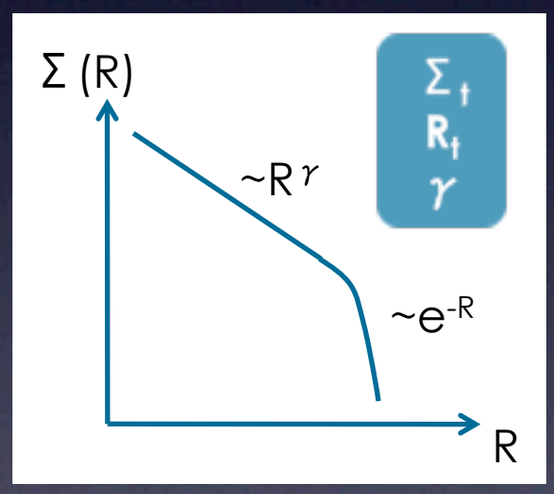


Disk models

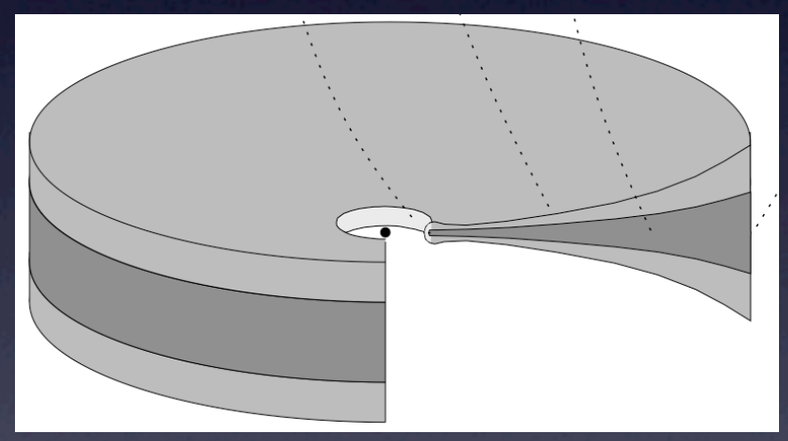
$$S_\nu(R) \propto \kappa_\nu(R)\Sigma(R)B_\nu(T_d(R))$$

Dust opacity Surface density Dust temperature

- composition
- a_{min}
- a_{max}
- n(a)



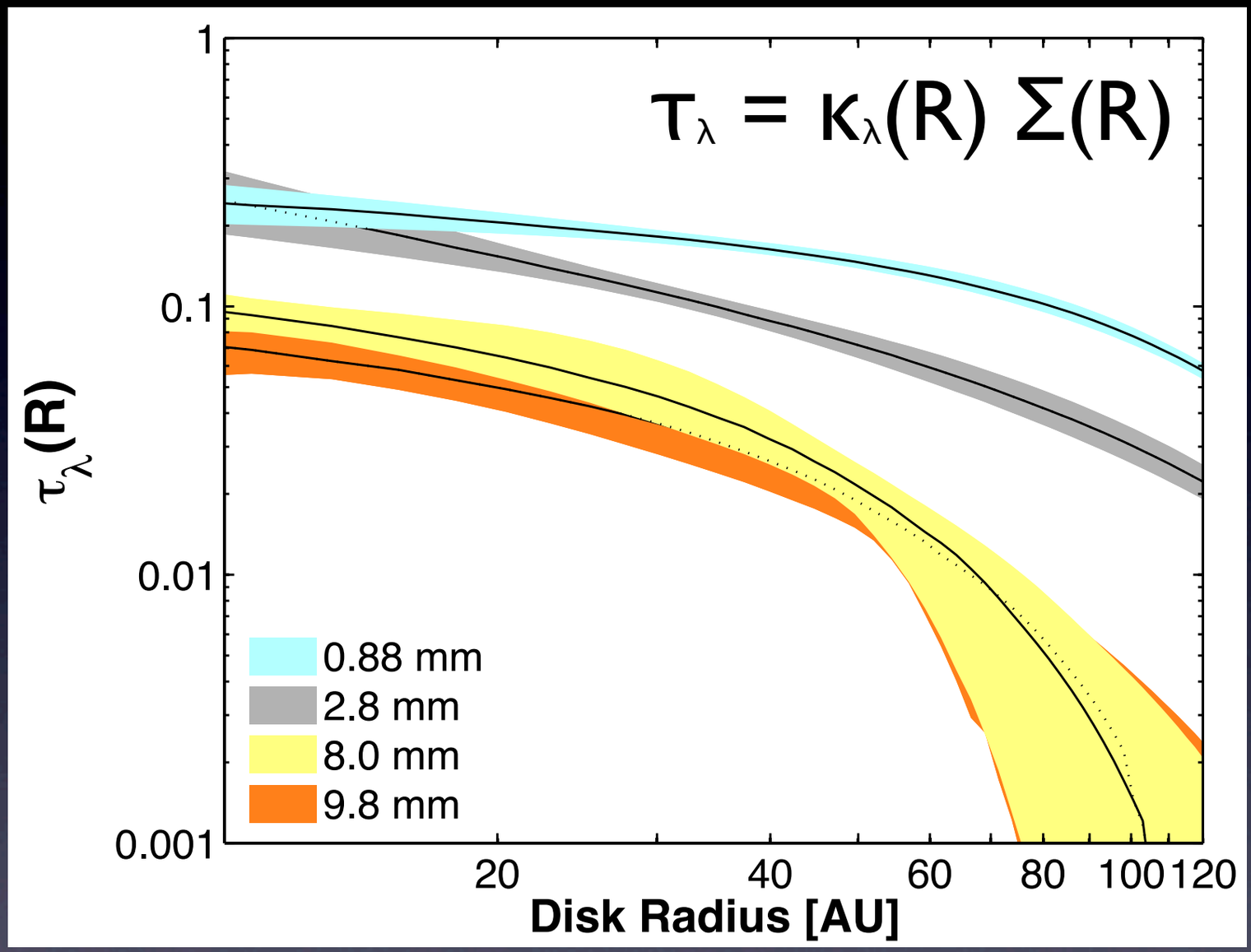
Lynden-Bell & Pringle (1974)



"Two-layer" model

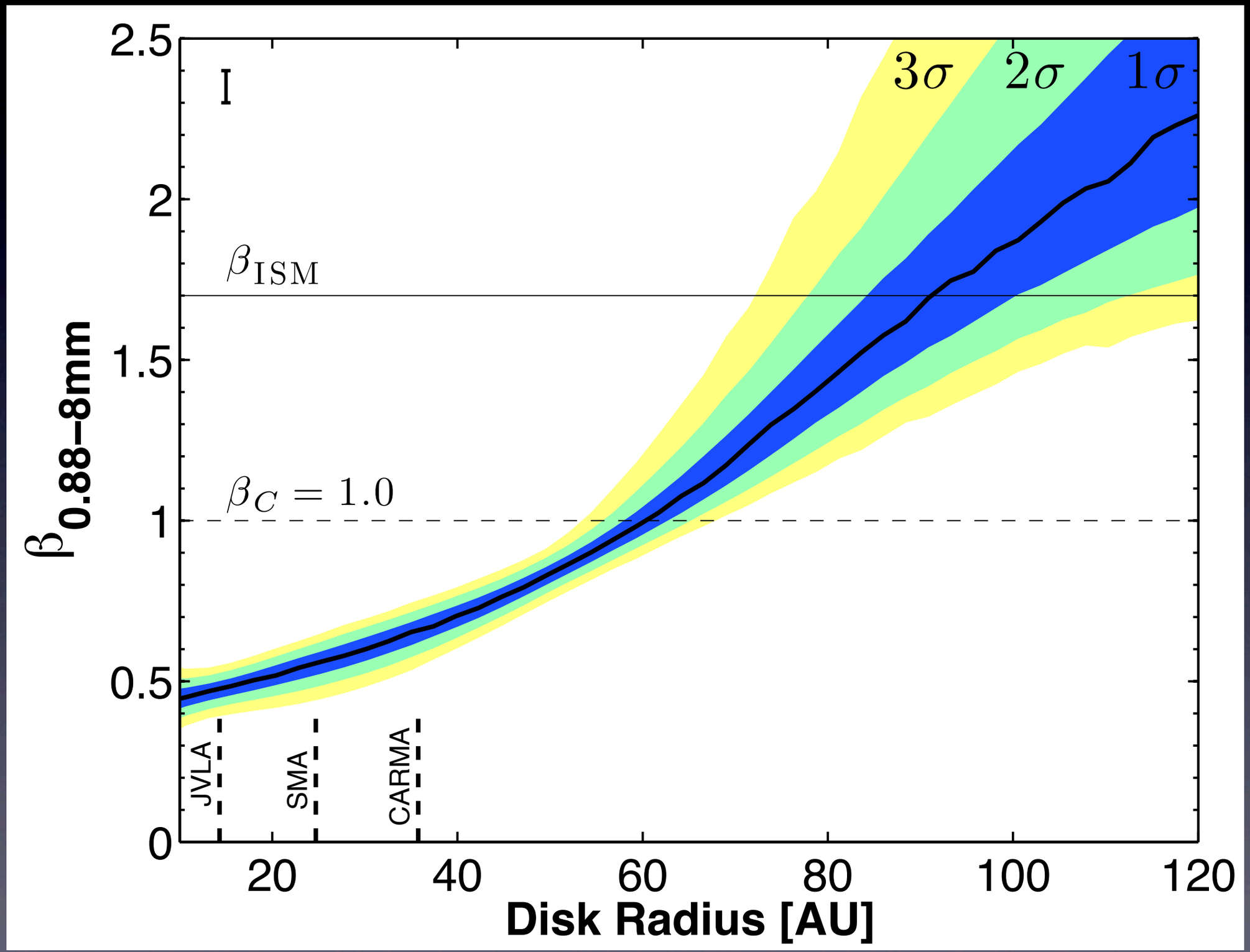
Chiang & Goldreich 1977

Analysis

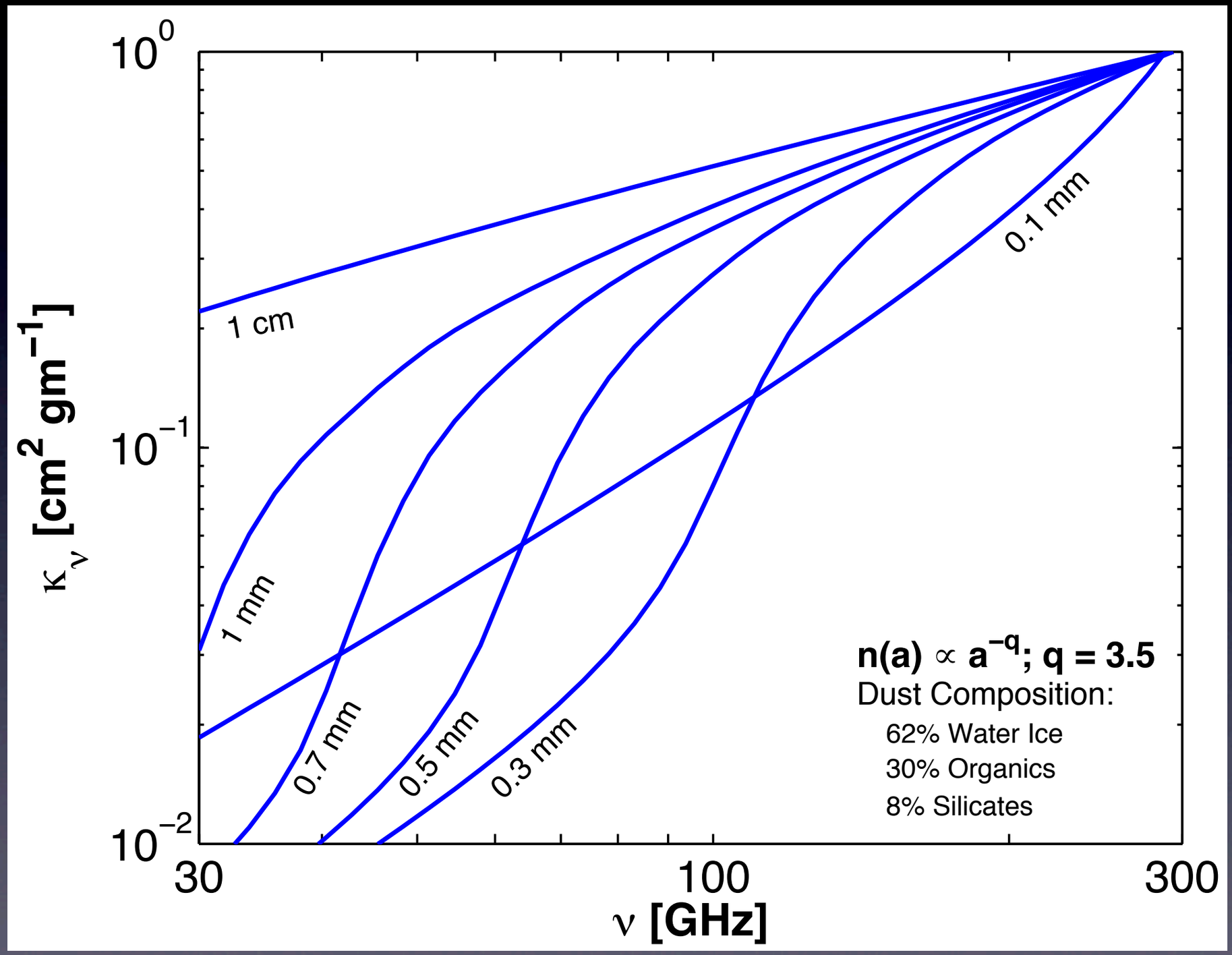


- $\tau(R)$ derived assuming constant κ_λ
- $\Sigma(R)$ must be the same for each wavelength
- Differences in *inferred* $\Sigma(R)$ reflect $\kappa_\lambda(R)$

Results: β(R)

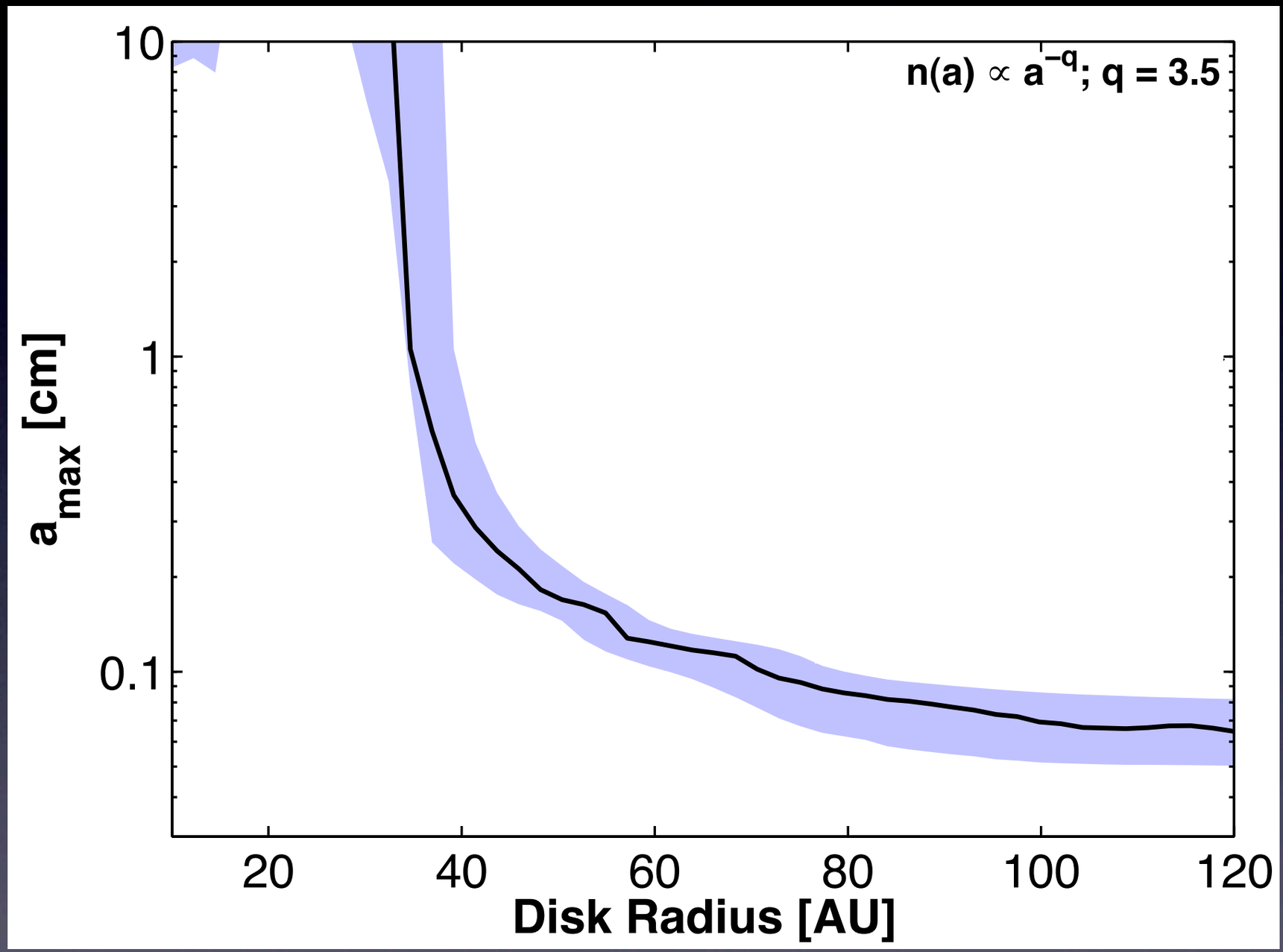

2.5
2
1.5
1
0.5
0
I
3σ
2σ
1σ
$\beta_{\rm ISM}$
$\beta_C = 1.0$
JVLA
SMA
CARMA
$\beta_{0.88-8mm}$
20
40
60
80
100
120
Disk Radius [AU]

Results: Maximum grain size

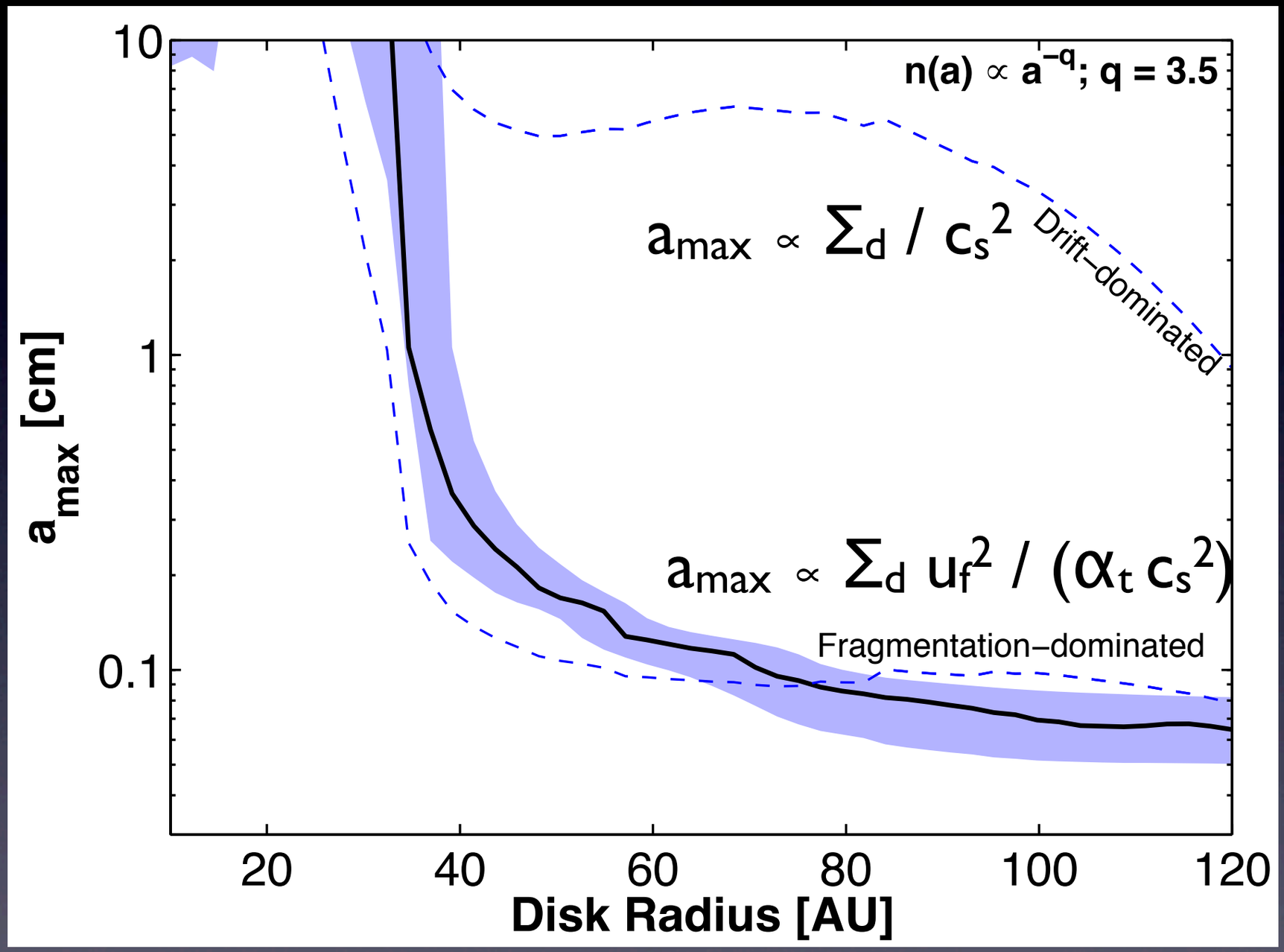


see Draine (2006)

Results: Maximum grain size



Results: Maximum grain size



Birnstiel et al (2012) model

Summary

- Evidence for radial variations in grain properties
- 5 additional disks with high resolution images from CARMA, SMA, and VLA will be analyzed soon!