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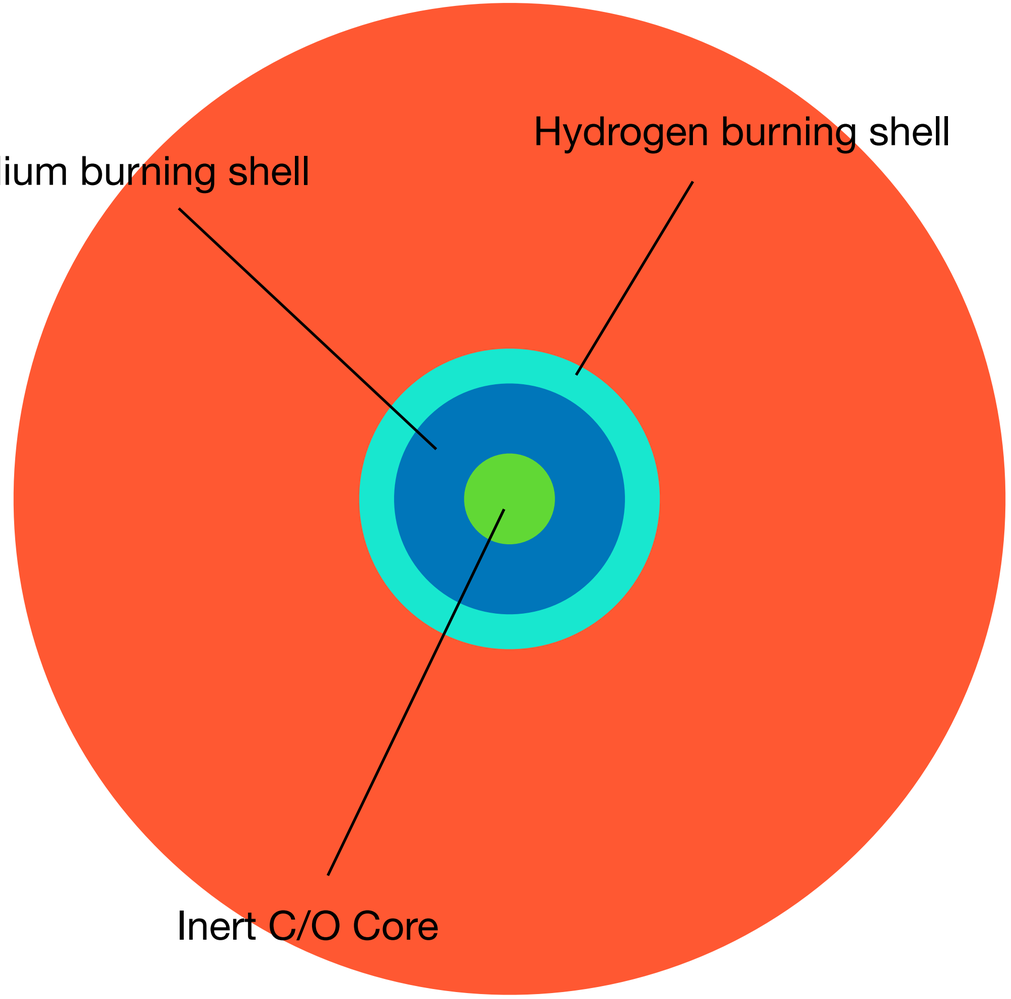
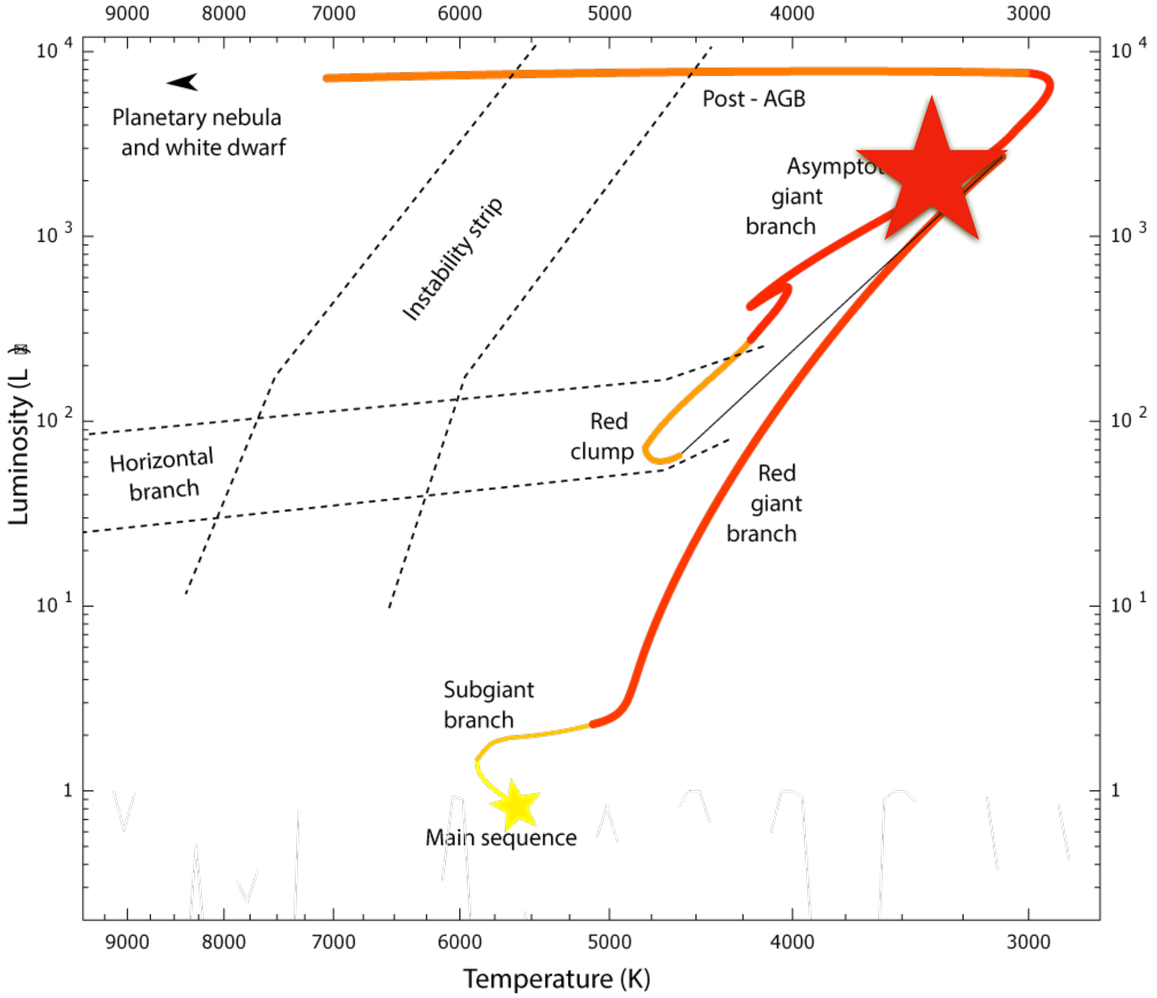
Spatially resolving the extended atmospheres of evolved stars with the SKA

Behzad Bojnordi Arbab — Chalmers University of Technology
Wouter Vlemmings — Chalmers University of Technology
Theo Khouri — Chalmers University of Technology
Susanne Höfner — Uppsala University

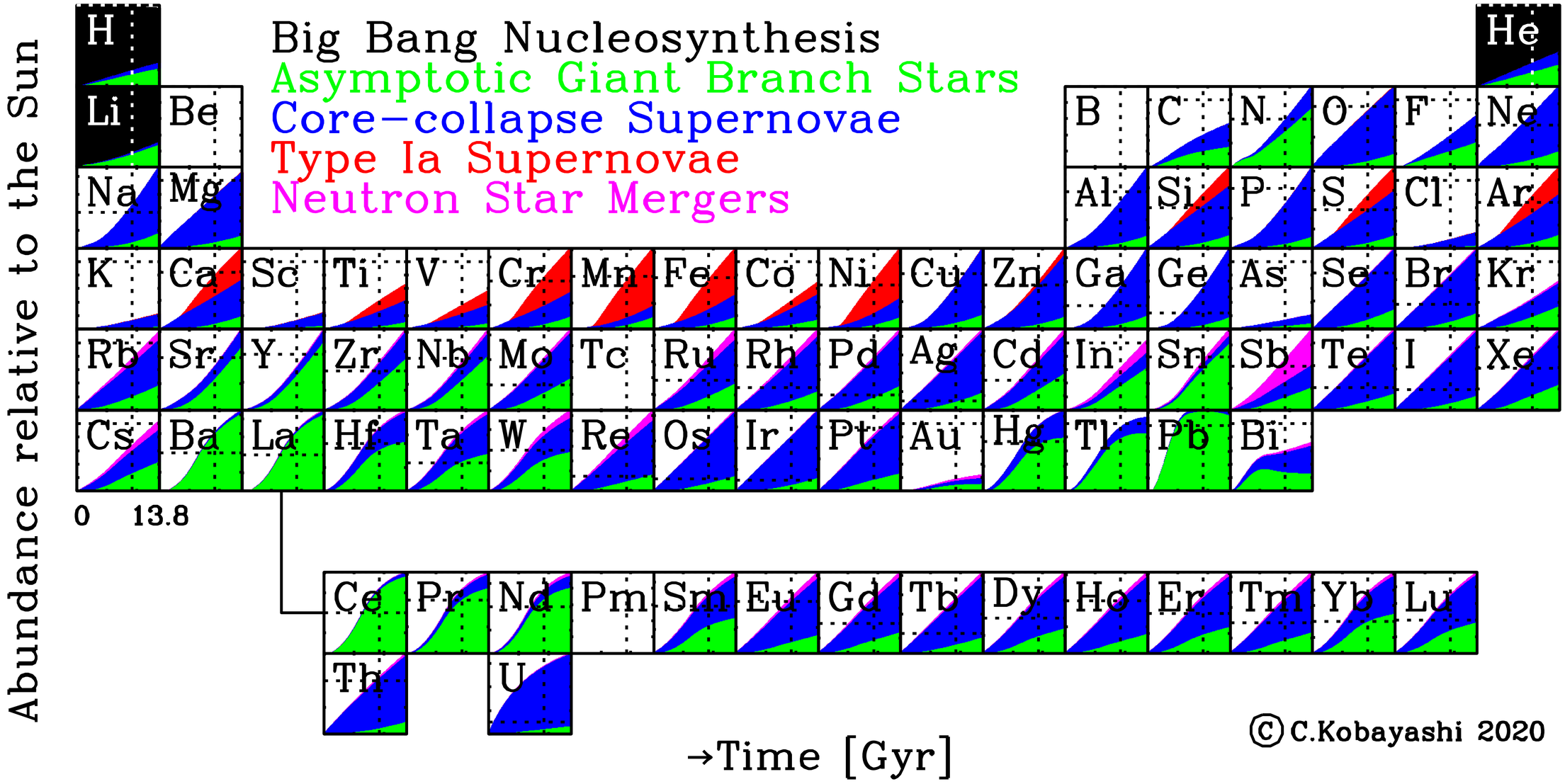
Asymptotic Giant Branch (AGB) stars



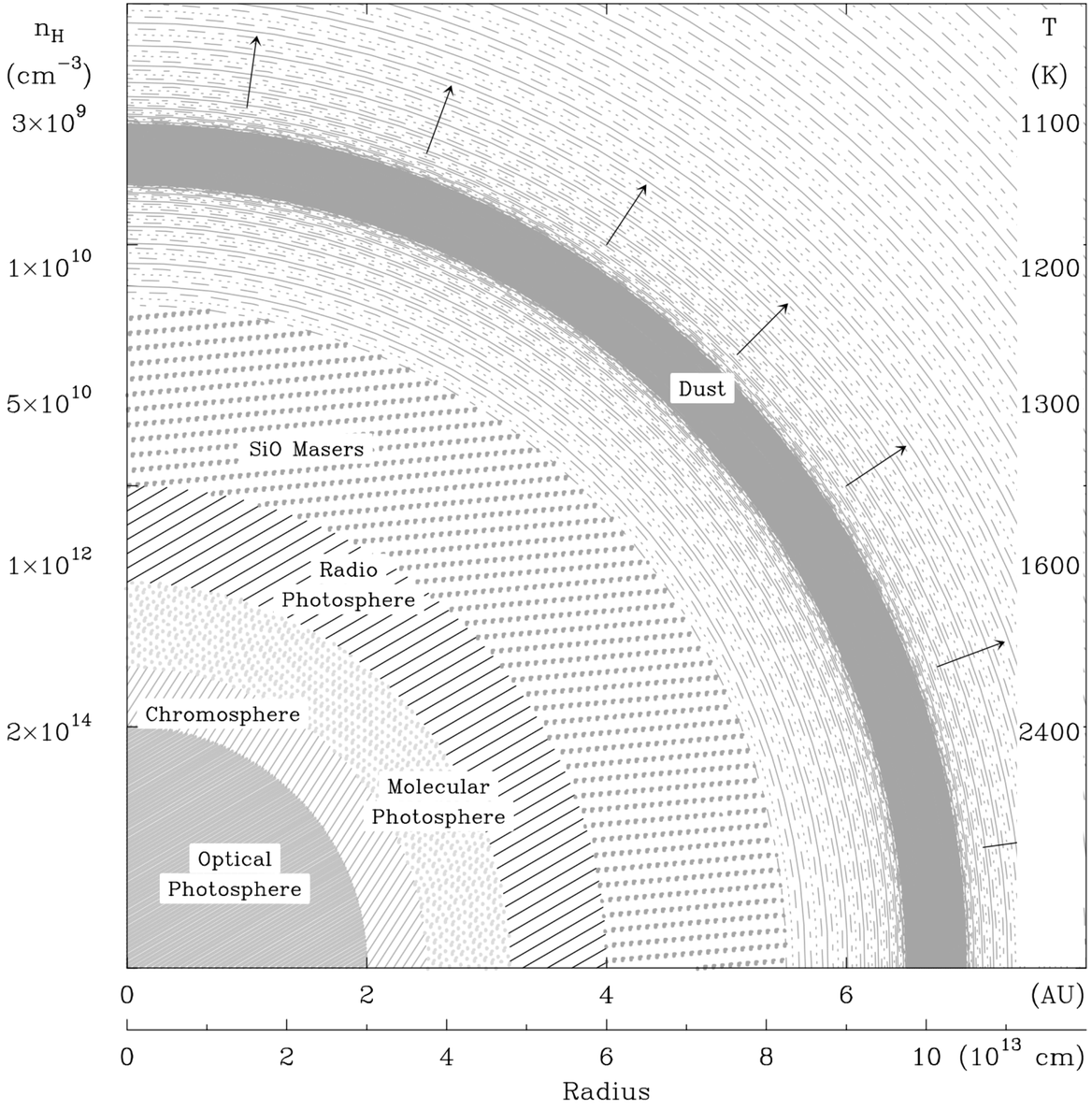
$$\approx 200R_{\odot} - 500R_{\odot}$$

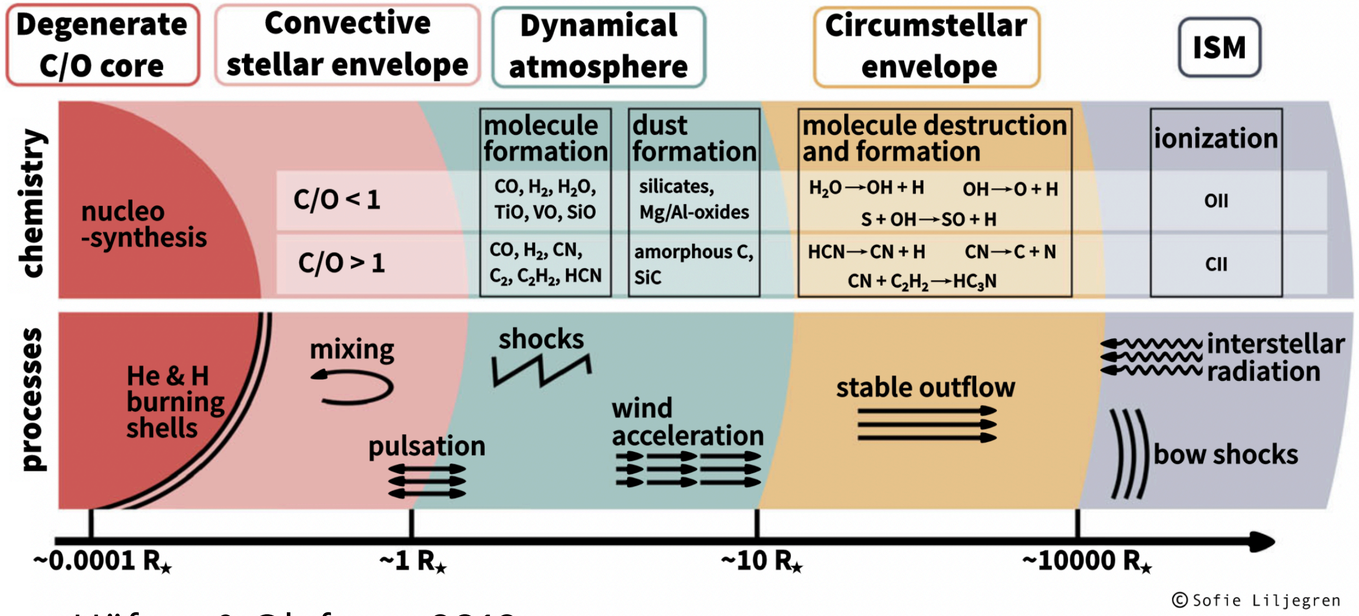


Why are AGB stars important?



Structure of AGB stars





Höfner & Olofsson 2018

Reid & Menten 1997

State of the art models

- Star-in-a-box models
- Solve the equations of hydrodynamics
- Radiative and convective energy transfer, with energy balance

- With assumptions of dust properties, it can produce mass loss and the steady outflow
- Show variations for short-term (pulsations) and long-term changes in profiles

DARWIN

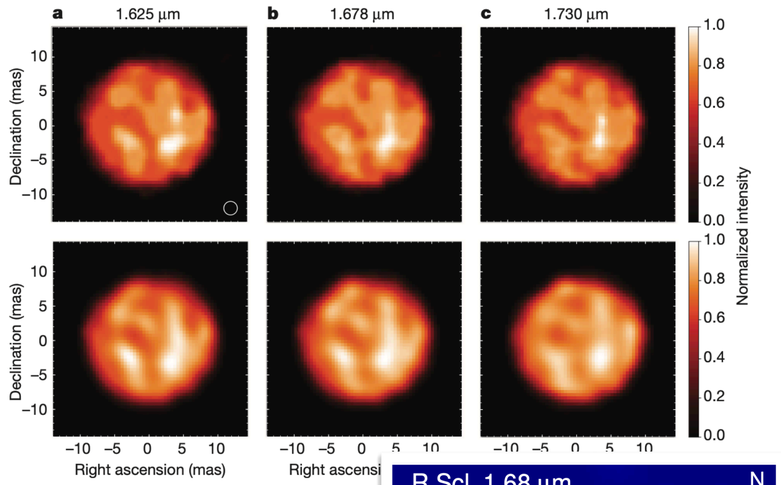
- Dimensions = 1
- Radial variations
- Higher number of models
- Goes to much larger radii

CO5BOLD

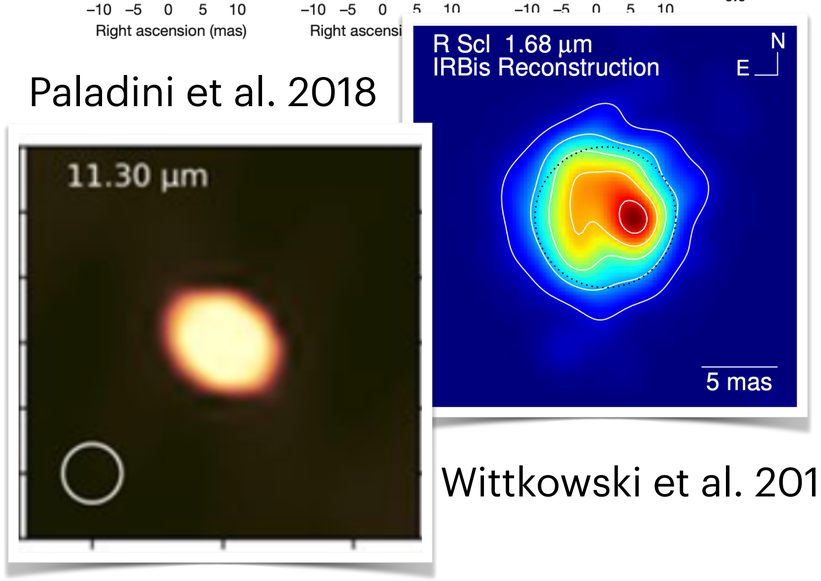
- Dimensions = 3
- Asymmetries and shape changes

Recent observations

VLTI



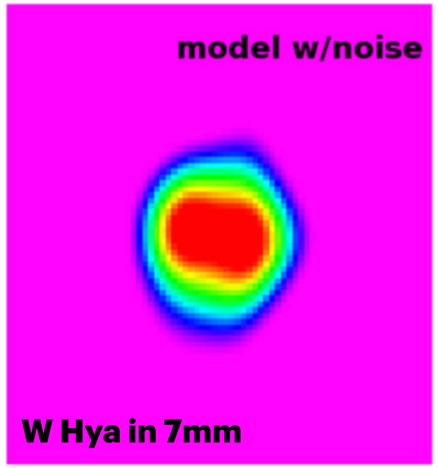
Paladini et al. 2018



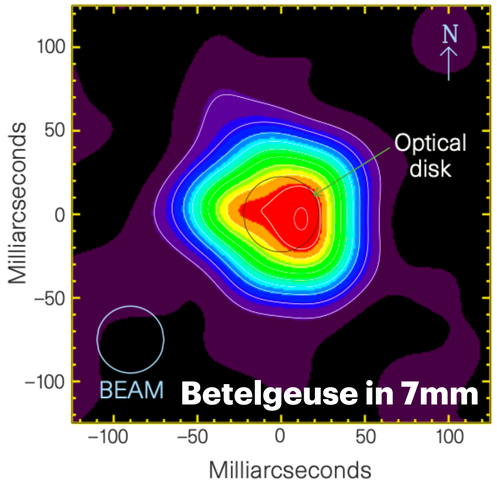
Wittkowski et al. 2017

Drevon et al. 2022

VLA

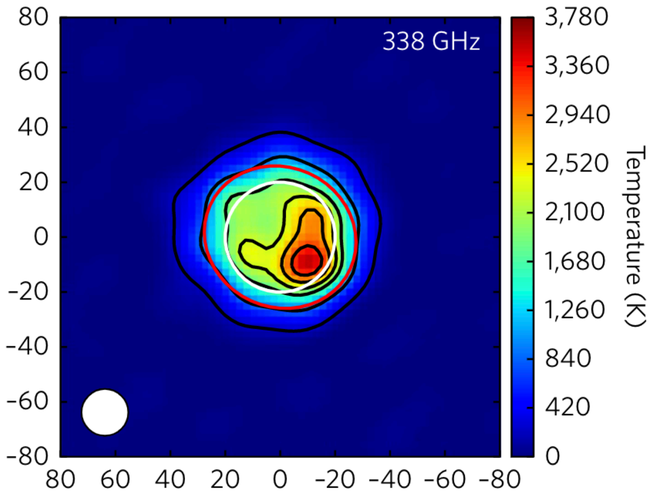


From Matthews et al 2018

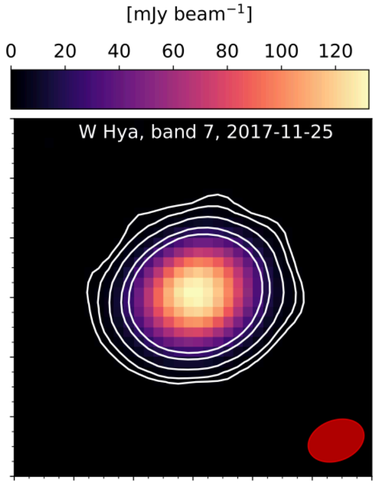


Lim et al. 1998

ALMA

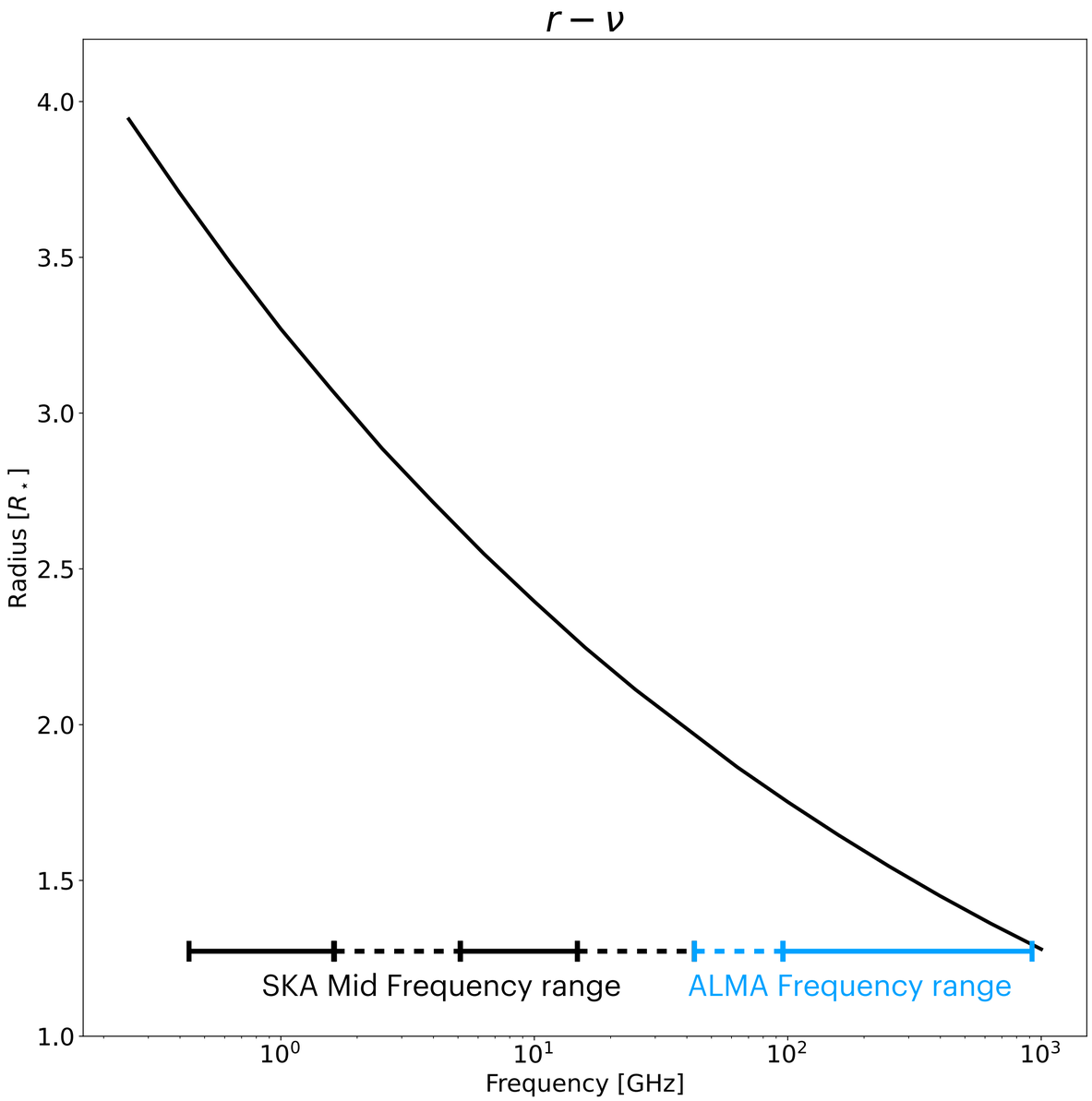


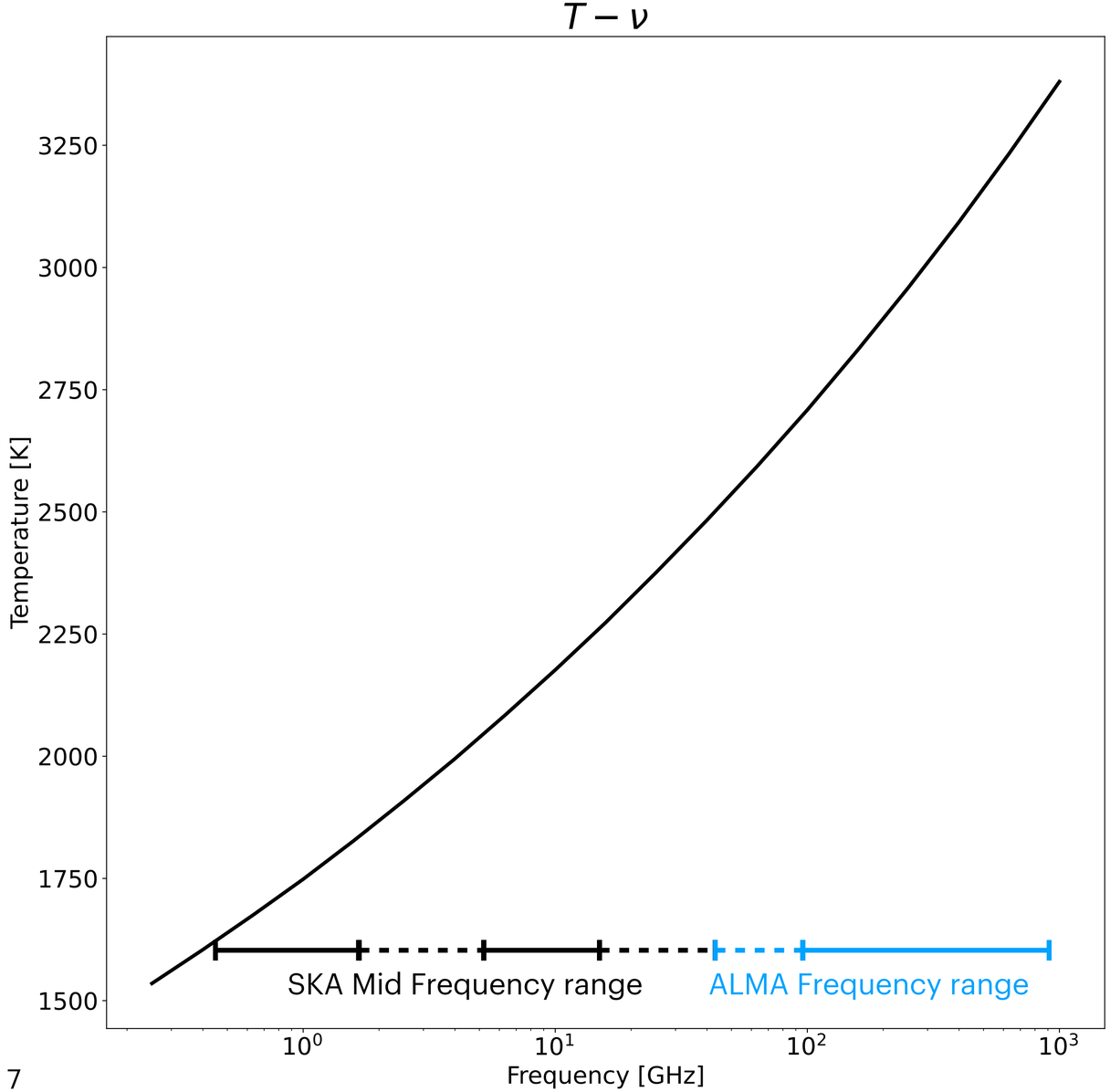
Vlemmings et al. 2017



Vlemmings et al 2019

Why SKA: Lower Frequencies (Compared to ALMA)





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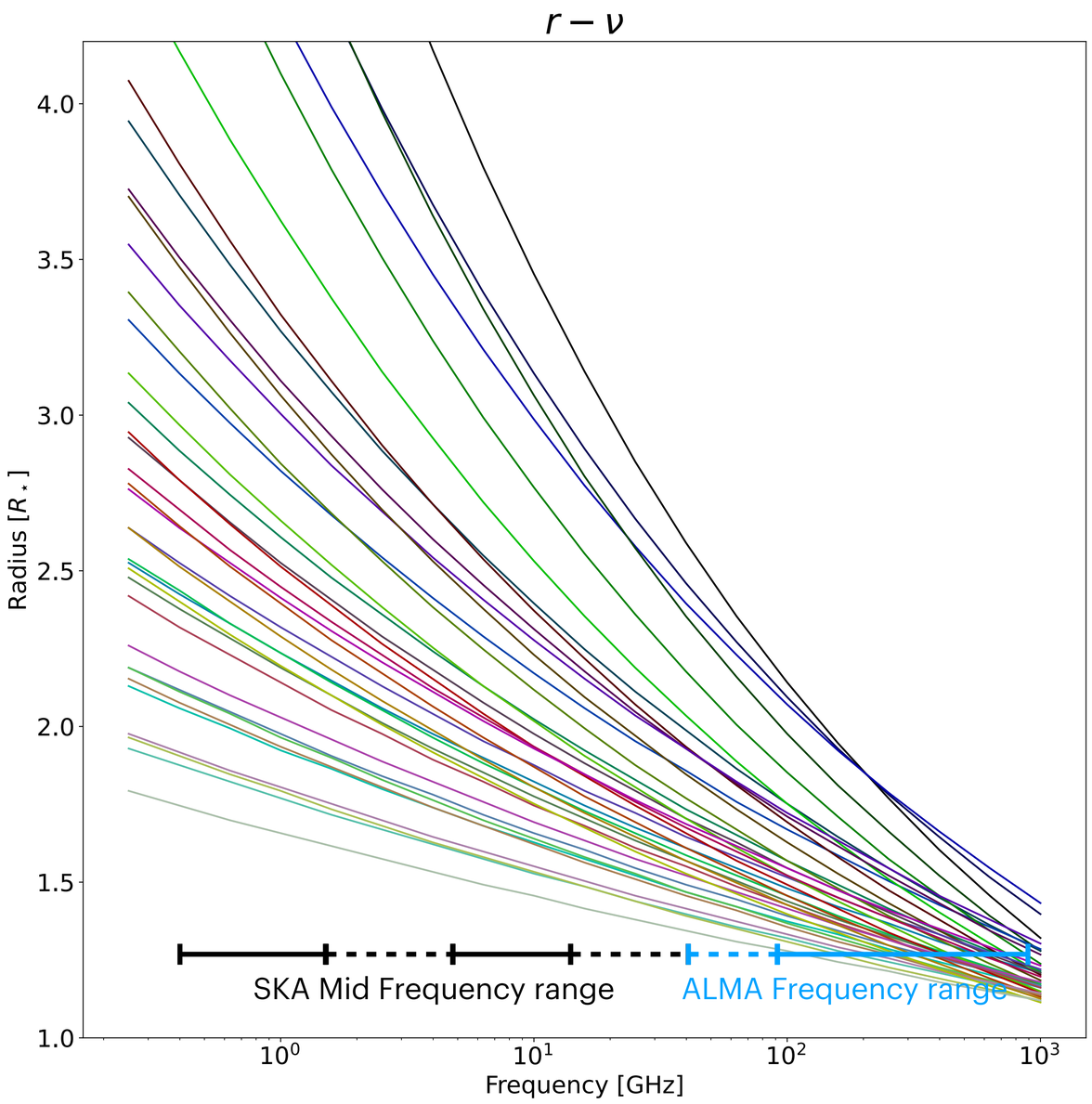
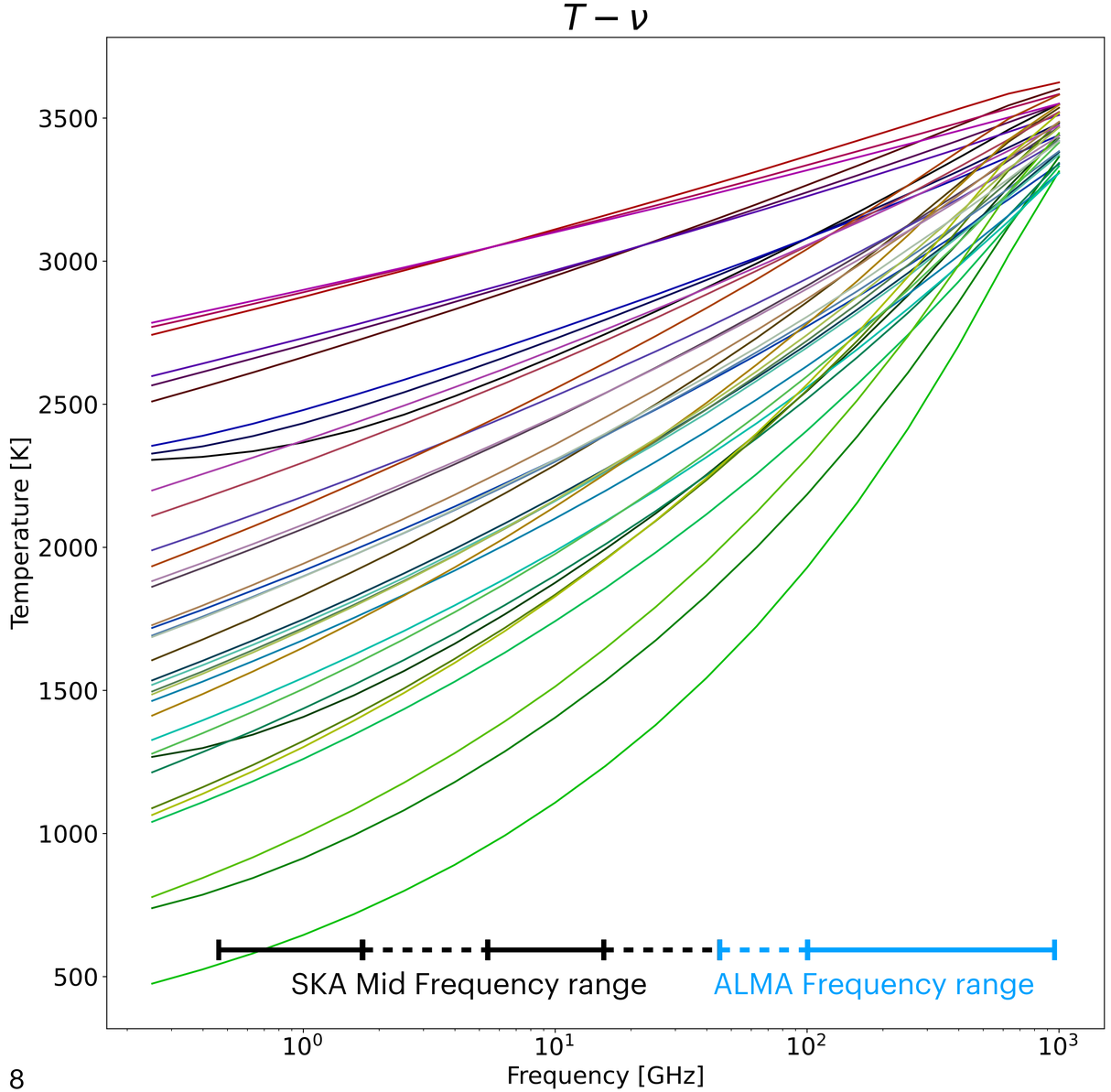
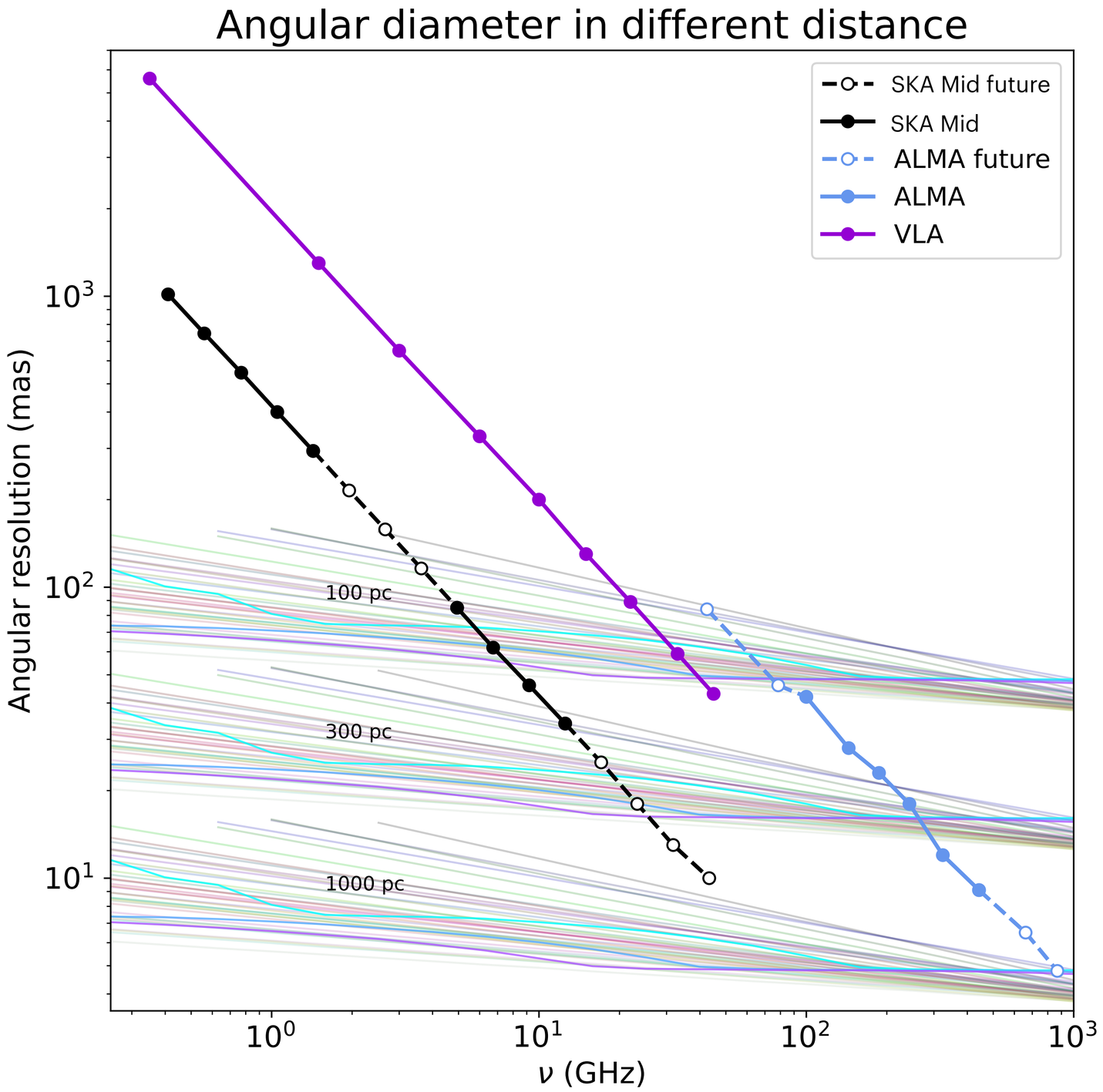




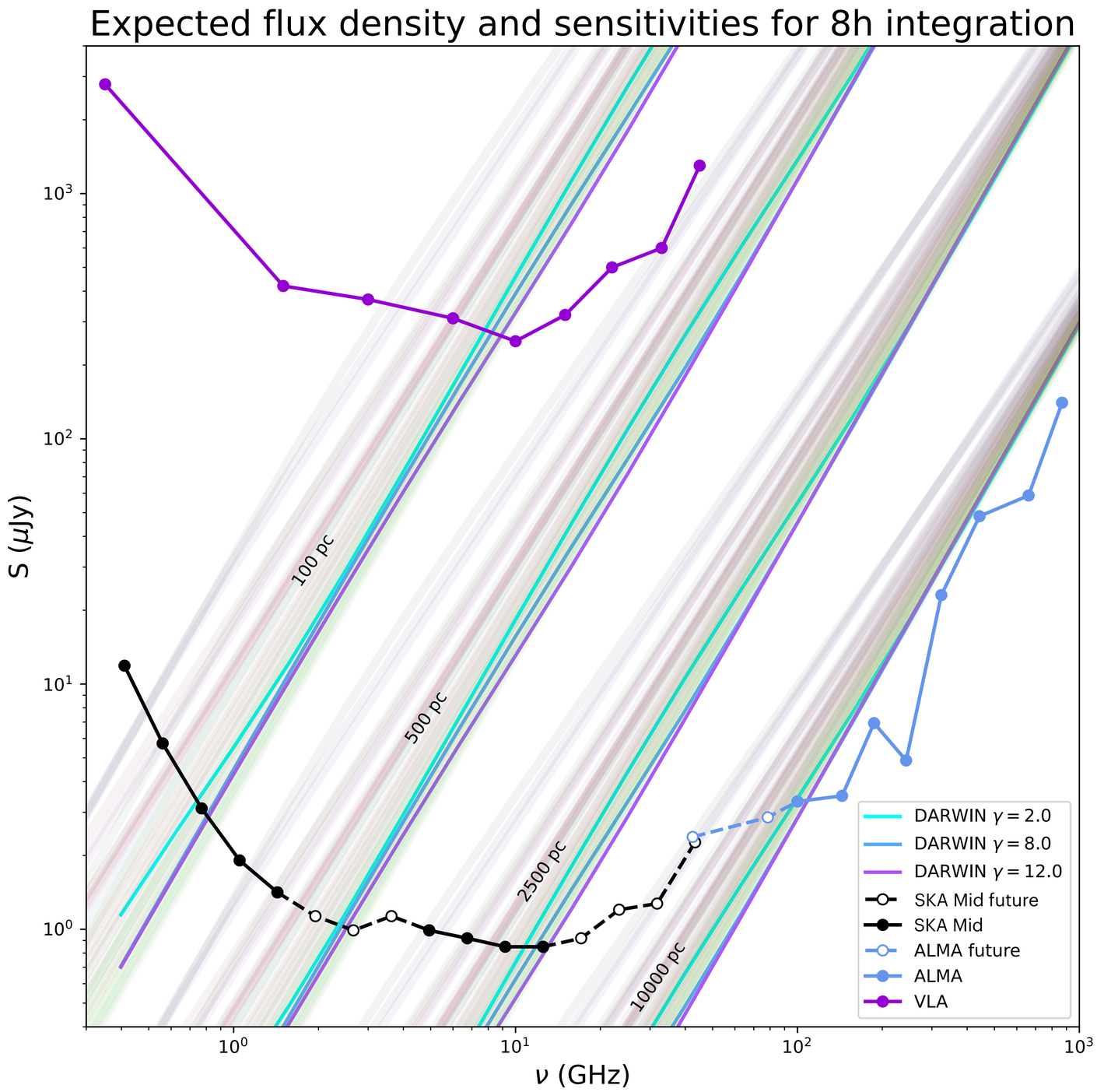
Why SKA: Higher resolutions (Compared to VLA)

- Resolving structure for further sources
- Constraining the radial density and temperature profile
- Finding asymmetries
- Resolving for different models up to <~200 pc



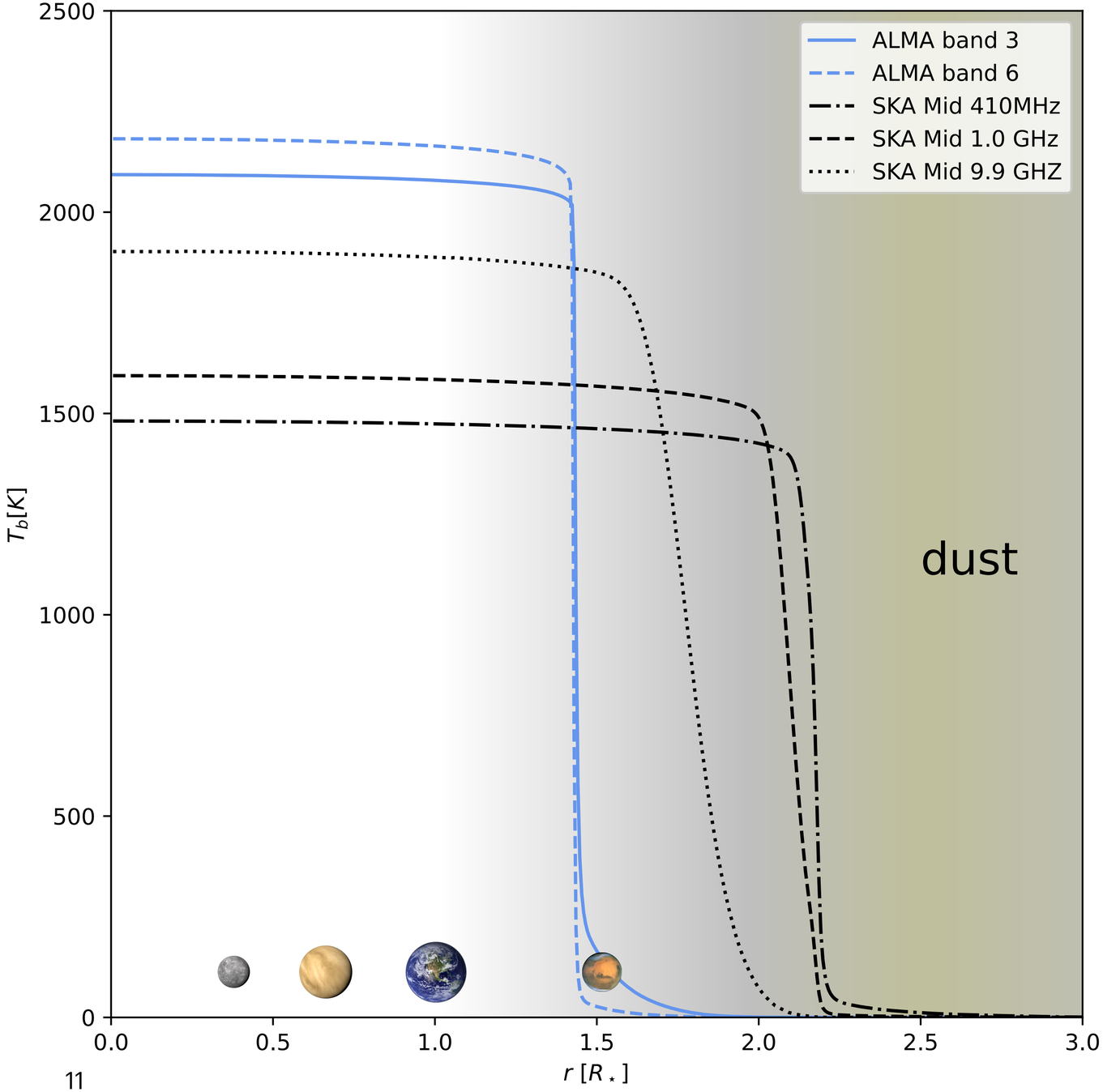
Why SKA: Better sensitivity

- Flux density profile for stars at d<~2000pc
- Higher S/N



Testing models in low-frequency

- Shocks
- Dust-forming region
- Observing extended atmospheres in various sizes
- Differences in central temperatures



Why SKA: Targeted observation

- As a result of SKA's high sensitivity, high S/N can be obtained much faster than VLA
- As a result of the comparable sensitivity of SKA mid and ALMA, we can use simultaneous observations in frequencies from 400MHz to 800GHz!
- To constrain theoretical models and test atmospheric dynamics (e.g. Shocks), we require high-sensitivity observations on the nearest AGB stars
- SKA targeted-observations will be invaluable for understanding the mass-loss mechanism and atmospheric structure of AGB stars

Why SKA: Surveys!

- AGB phase is comparably short in the evolutionary path of stars
  → Low number density of AGB stars
  → Large areas in the sky required for an AGB population large enough for statistical analysis
- Studying the variability of the AGB stars is pivotal in understanding their dynamics
  → Measuring the variability periods requires multiple observations for periods of ~ 1 year
- Wide field recurring surveys with enough S/N are required for studying large populations of AGB stars
- Good news: SKA is capable of such surveys!

Conclusion

Why AGB stars?

One of the main sources of heavy elements

The mass-loss mechanism is mainly happening in the extended atmosphers

Why SKA?

SKA is in the right frequencies for studying dust-forming regions

SKA mid has sufficient resolving power and sensitivity to observe the dynamics and structures of this region

SKA + ALMA = observing extended atmospheres layer-by-layer