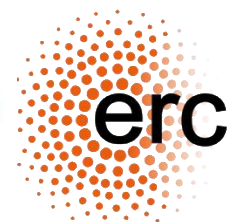


# From dust to pebbles and planets: dust evolution during star and planet formation

Leonardo Testi

Alma Mater Studiorum - University of Bologna





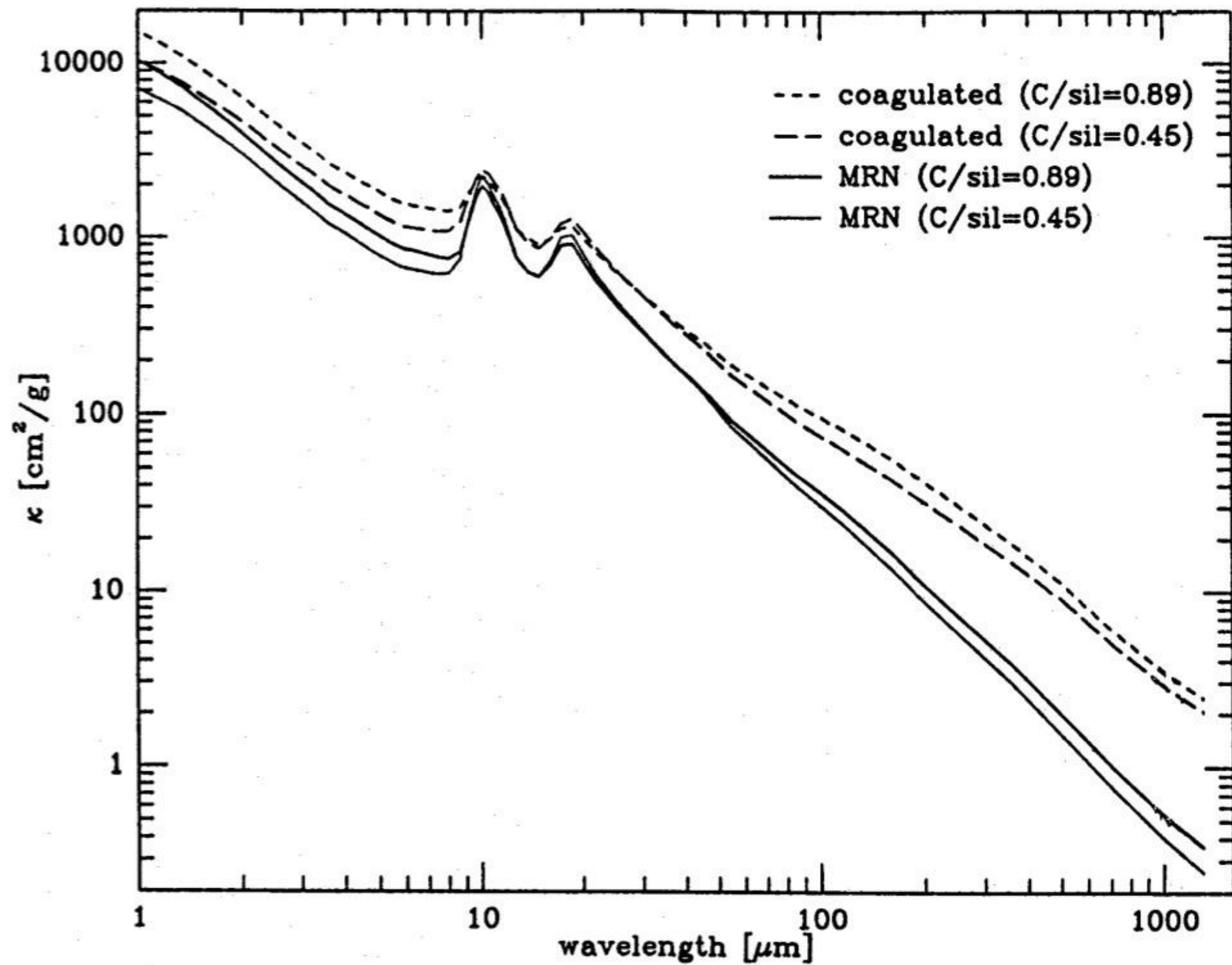
# ESO and ALMA



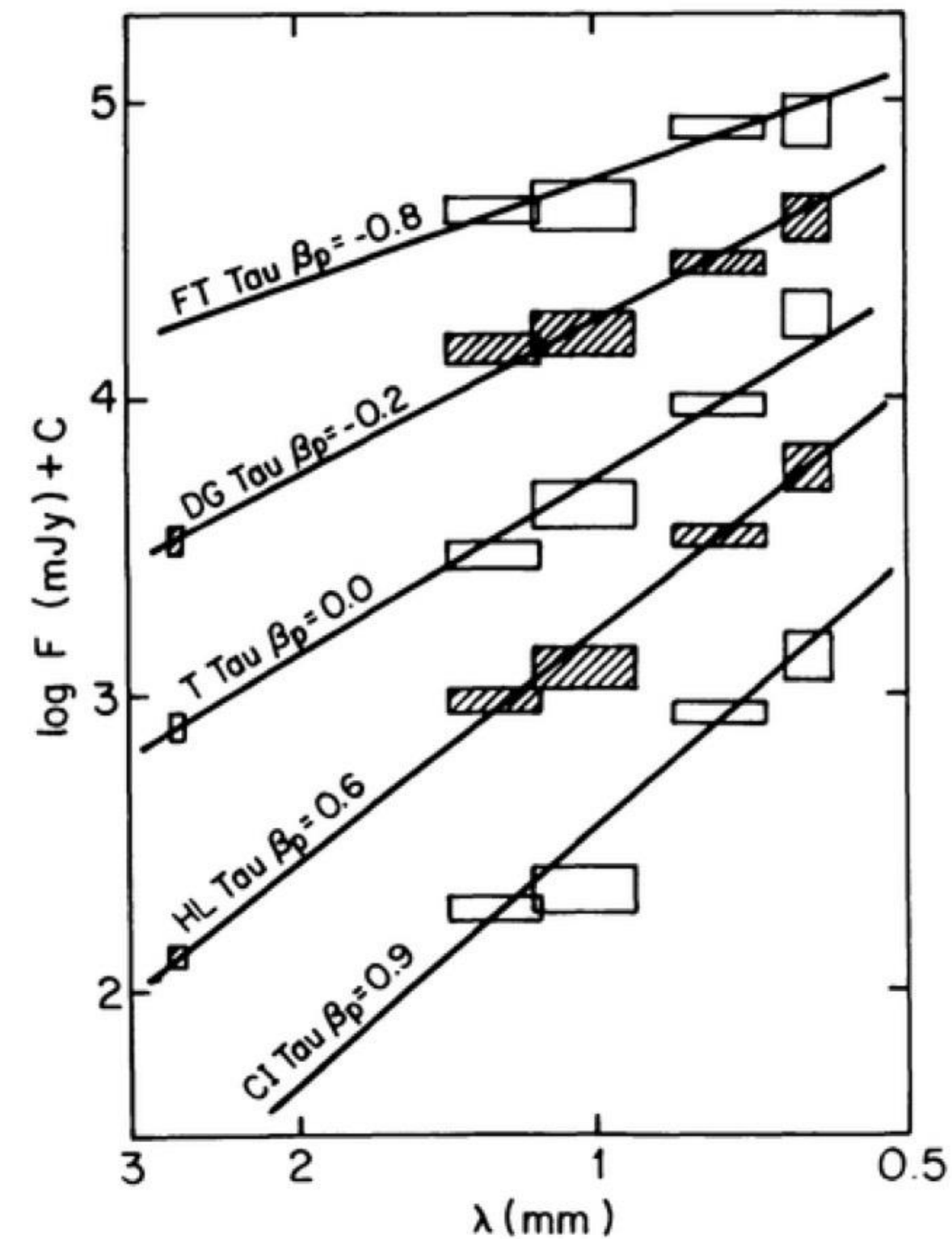
ESO Council & ALMA Visiting Committee



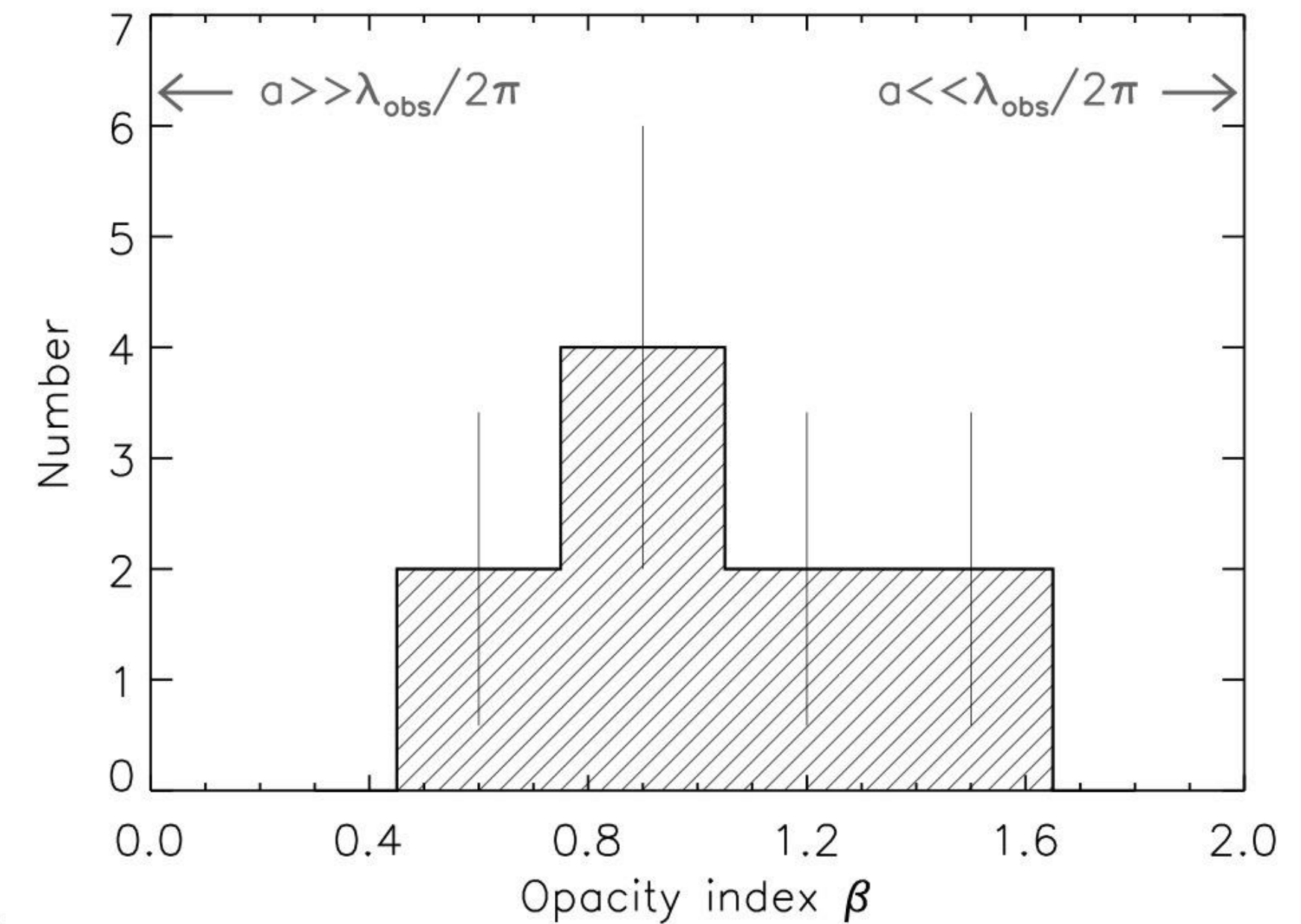
# Seminal work on dust evolution



Ossenkopf & Henning 1994



Beckwith & Sargent 1991



Rodmann, ThH+ 2006

Dust coagulation in cores

Grain growth in disks

# Pre-ALMA work

## Dust in Proto-Planetary Disks: Properties and Evolution

**Antonella Natta and Leonardo Testi**  
Osservatorio Astrofisico di Arcetri

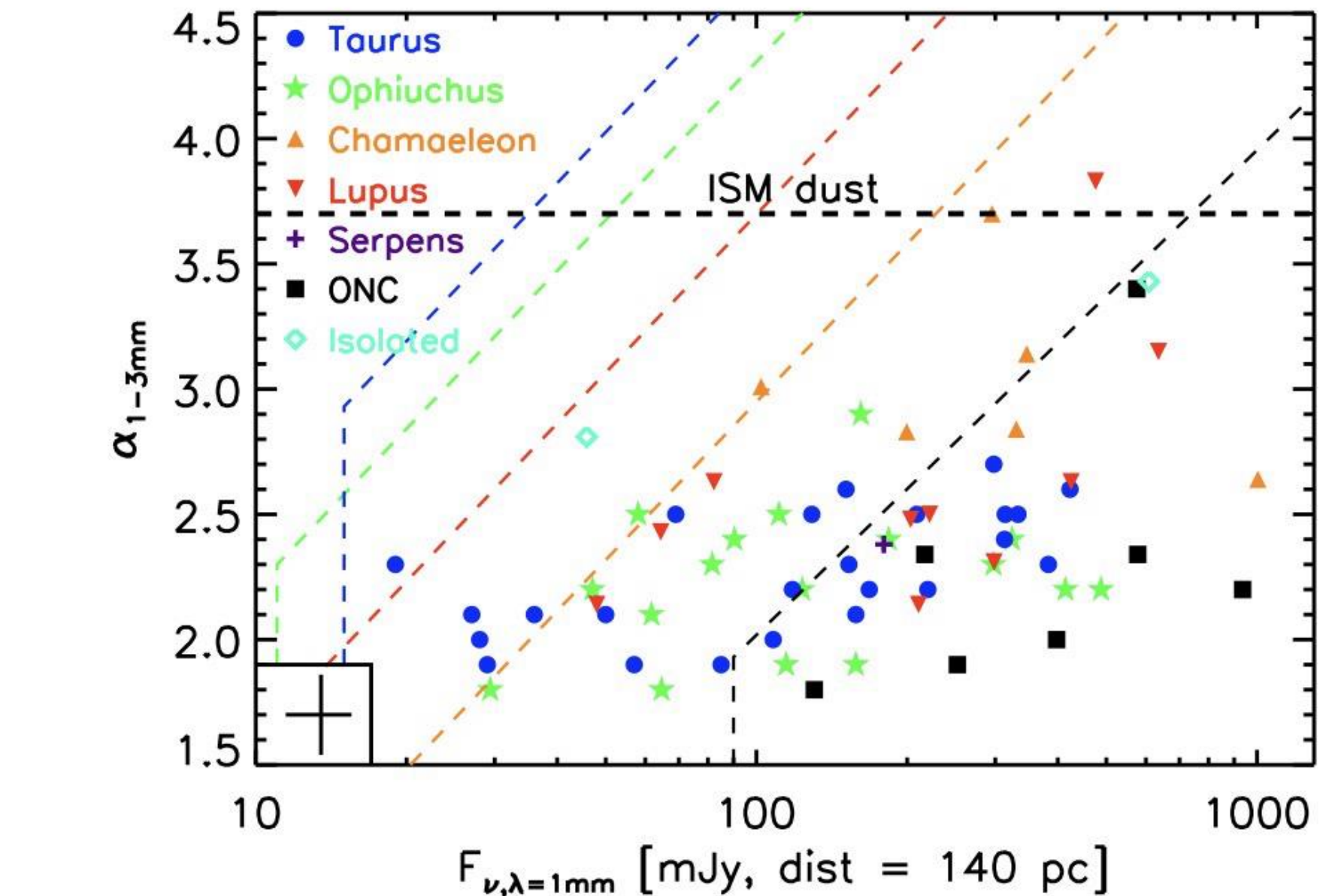
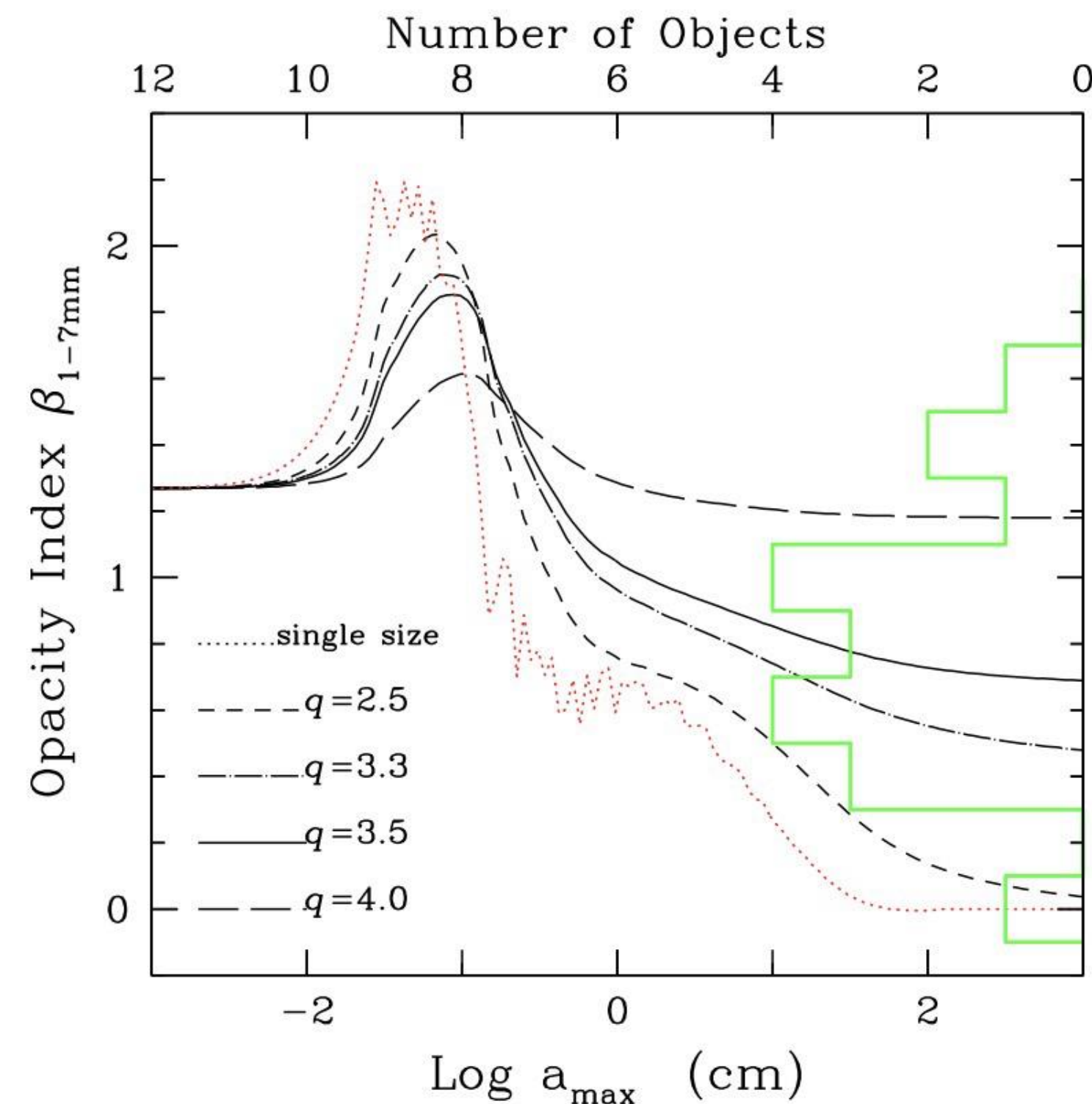
**Nuria Calvet**  
University of Michigan

**Thomas Henning**  
Max Planck Institute for Astronomy, Heidelberg

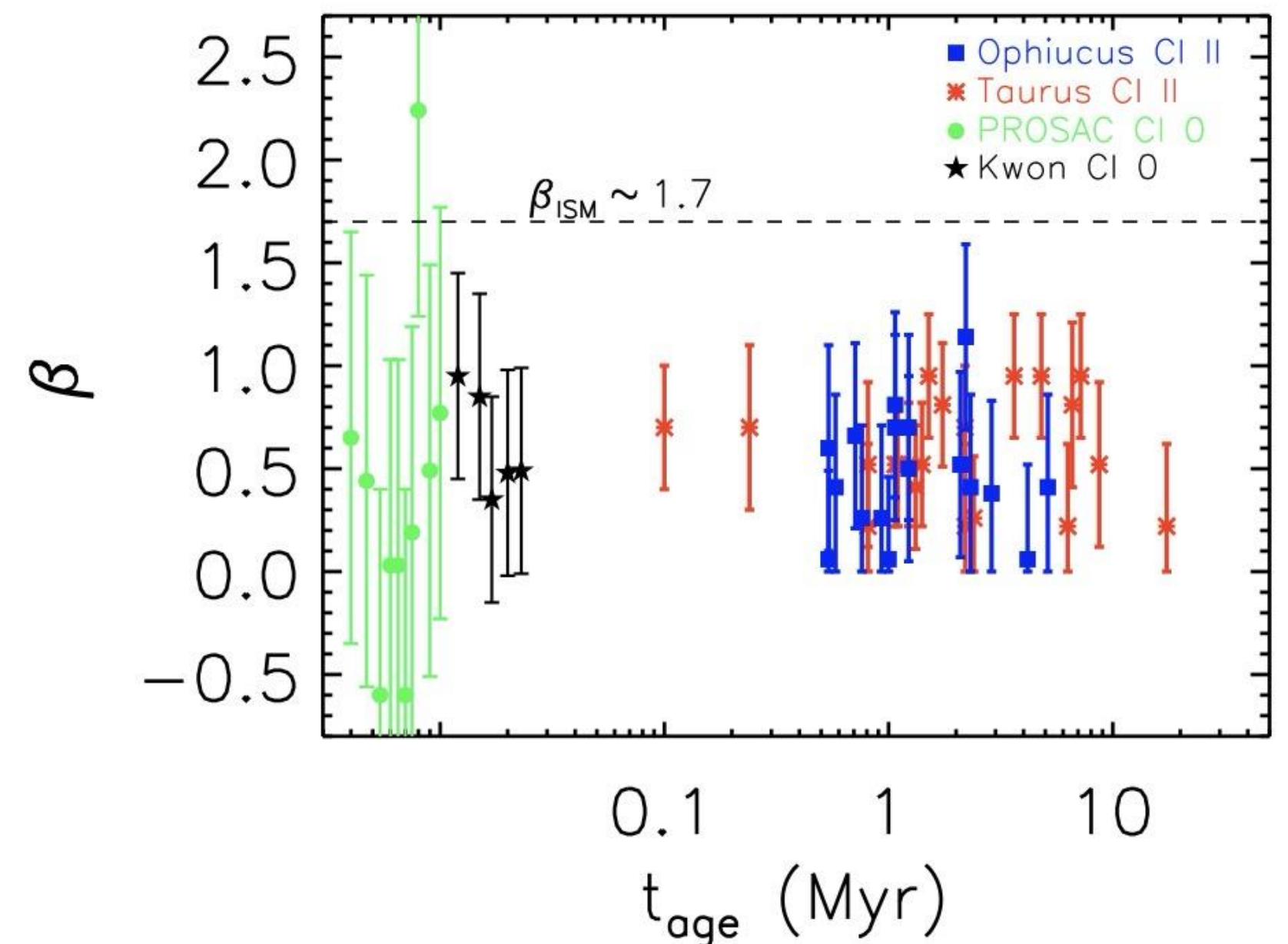
**Rens Waters**  
University of Amsterdam and Catholic University of Leuven

**David Wilner**  
Harvard-Smithsonian Center for Astrophysics

PPV - 2007



PPVI – Testi+2014



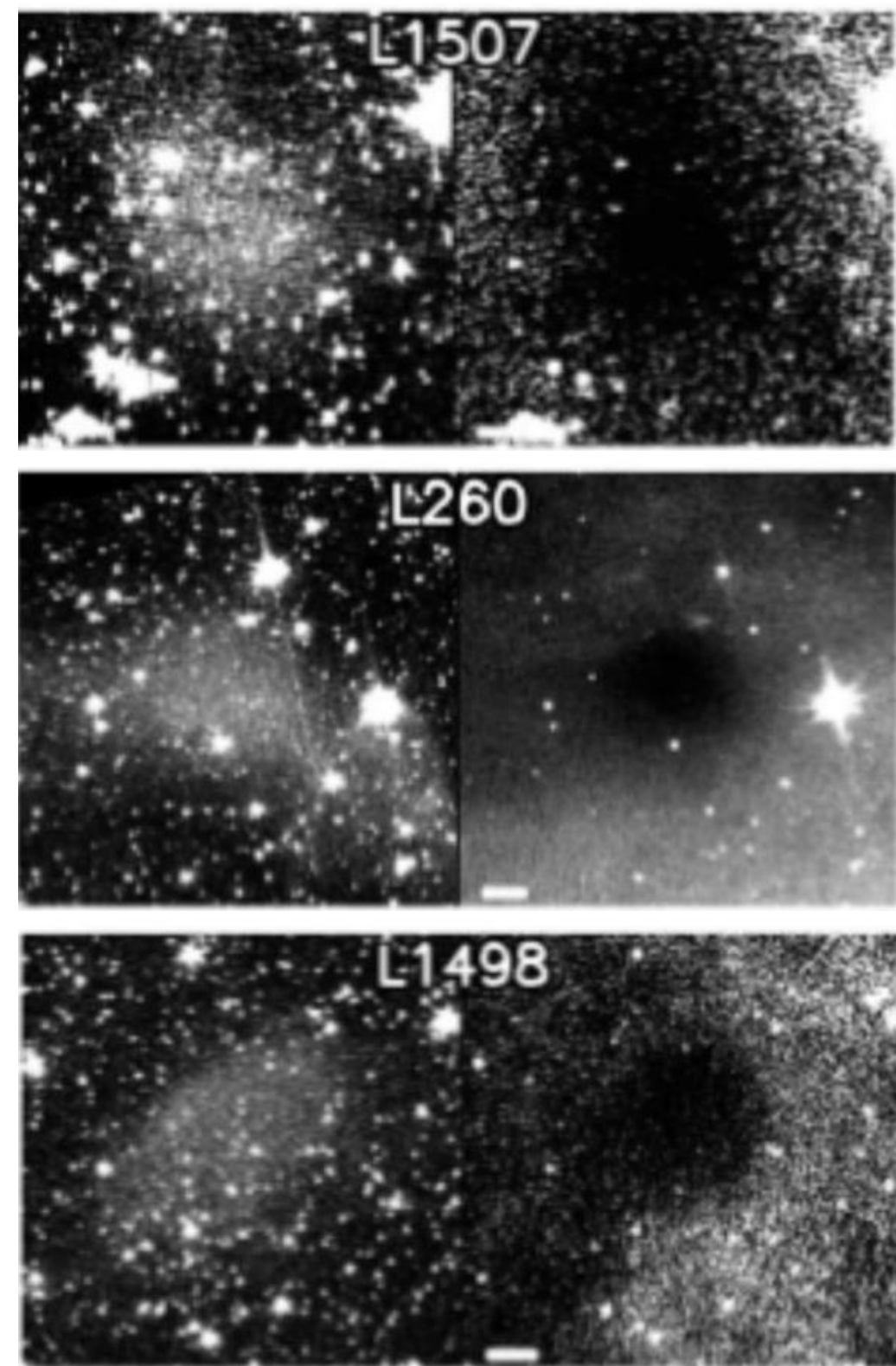
Ricci+2010



# Two paths to progress

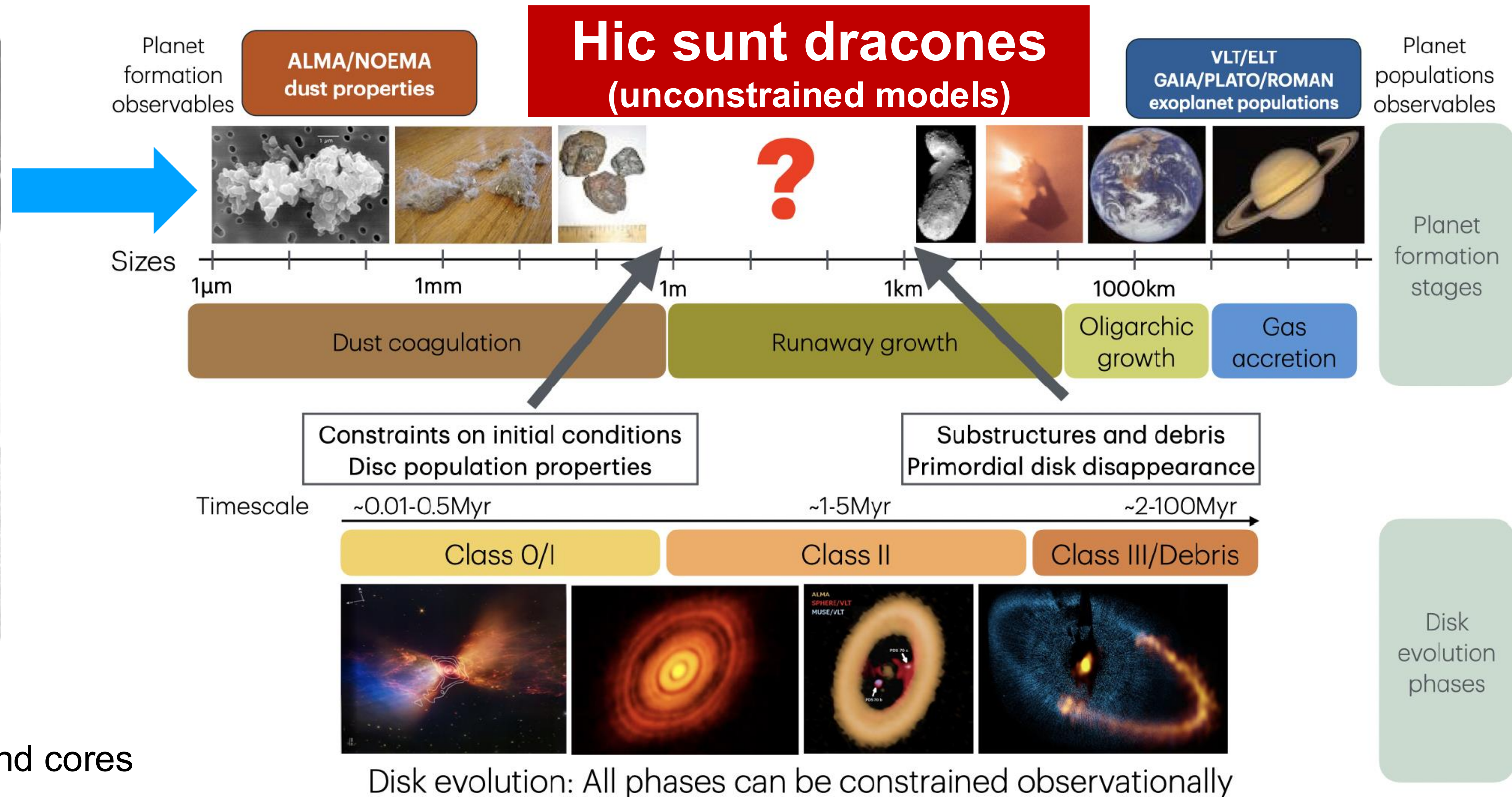
Origin

Fate



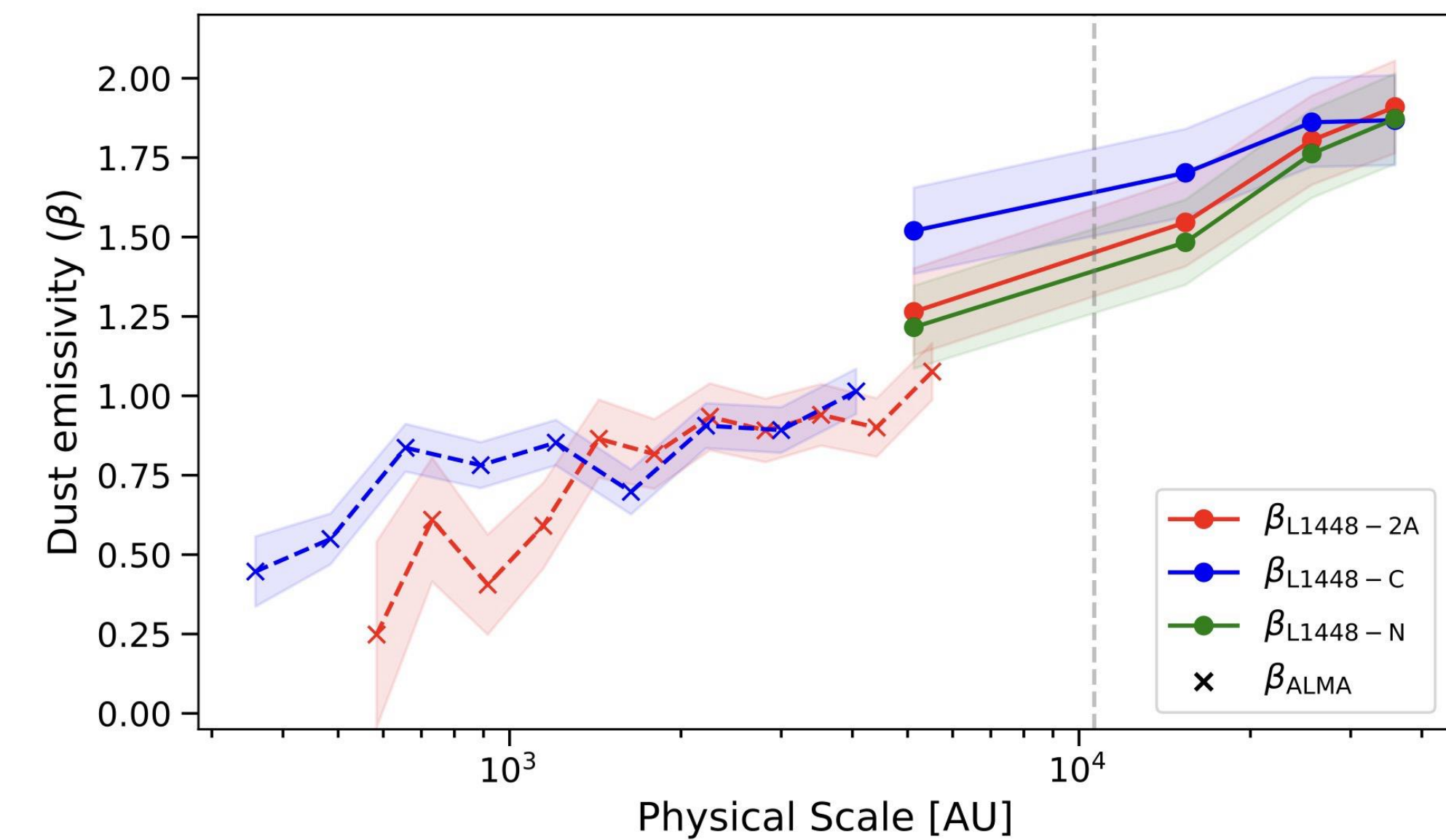
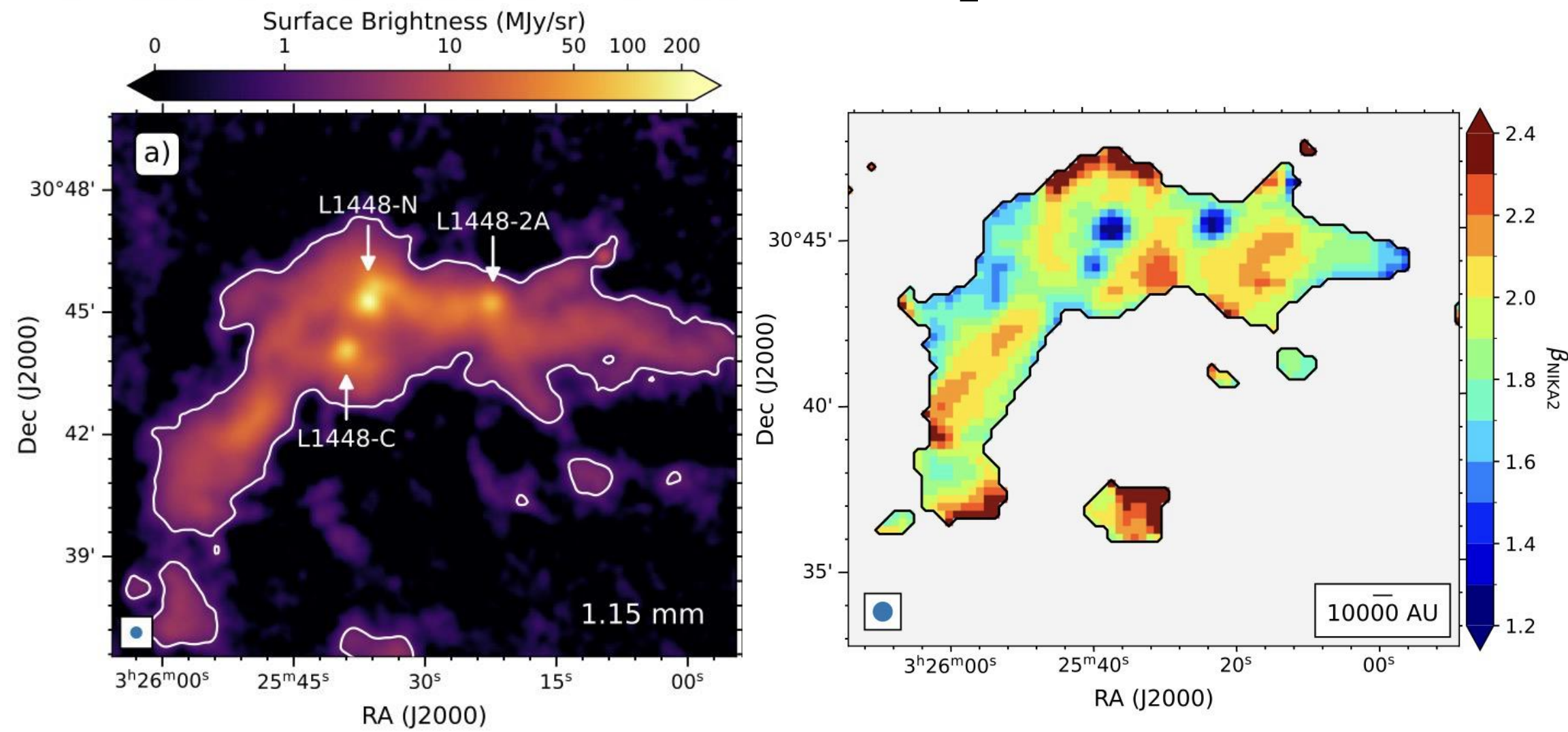
Pagani+(incl. ThH) 2010

Dust growth in clouds and cores

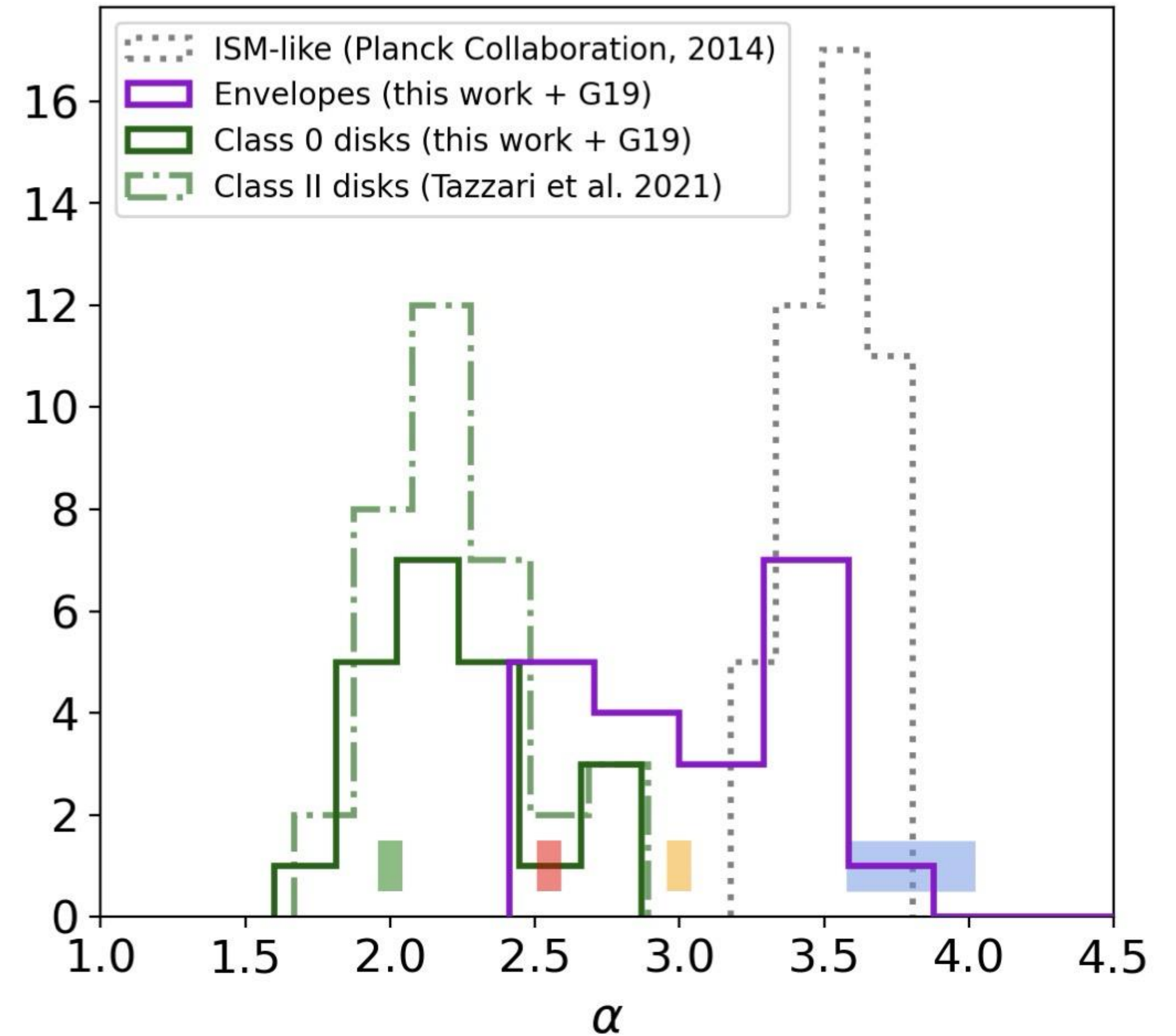




# Dust properties from cloud to disks



Zuleta+2026



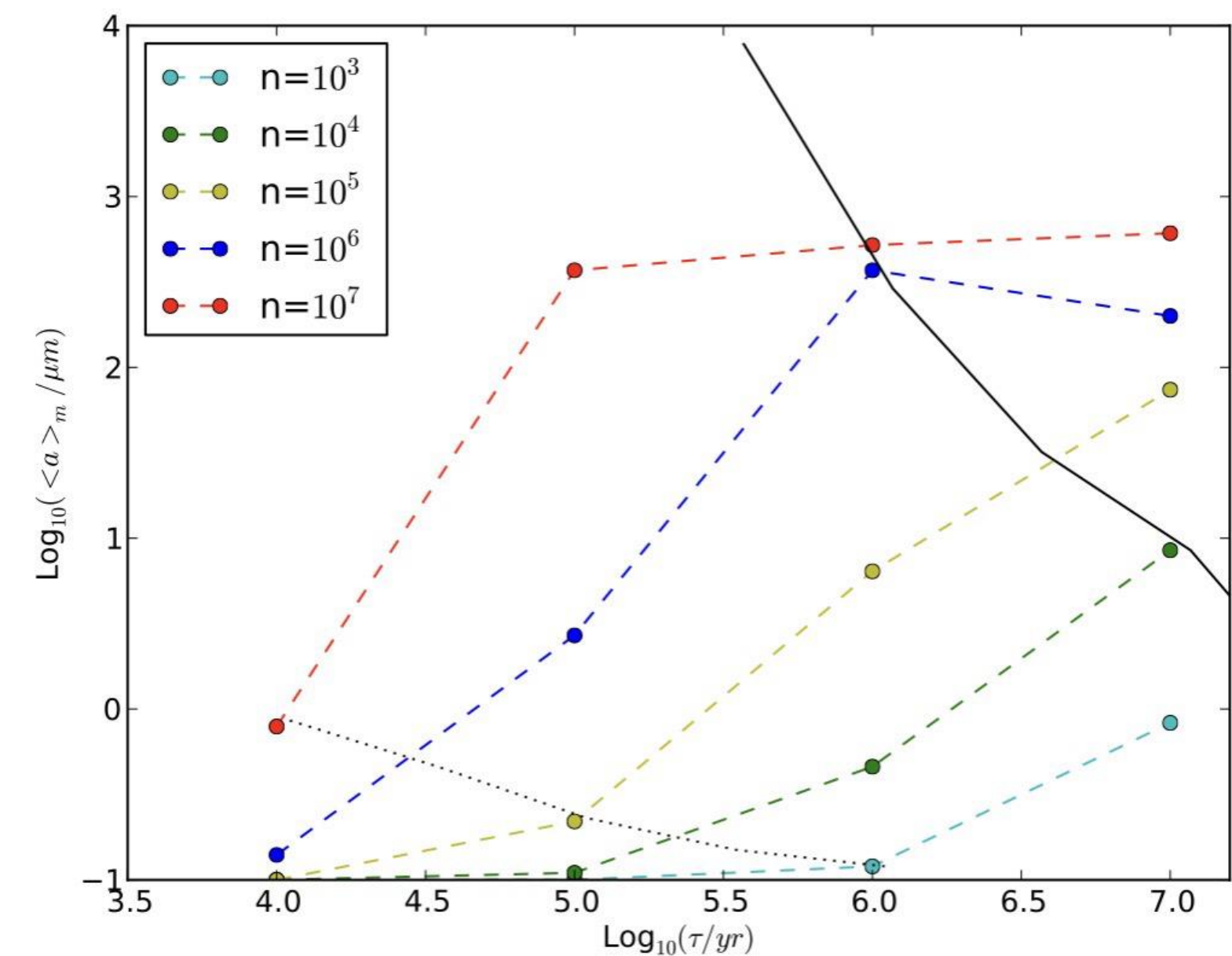
FAUST ALMA LP  
Cacciapuoti+2025



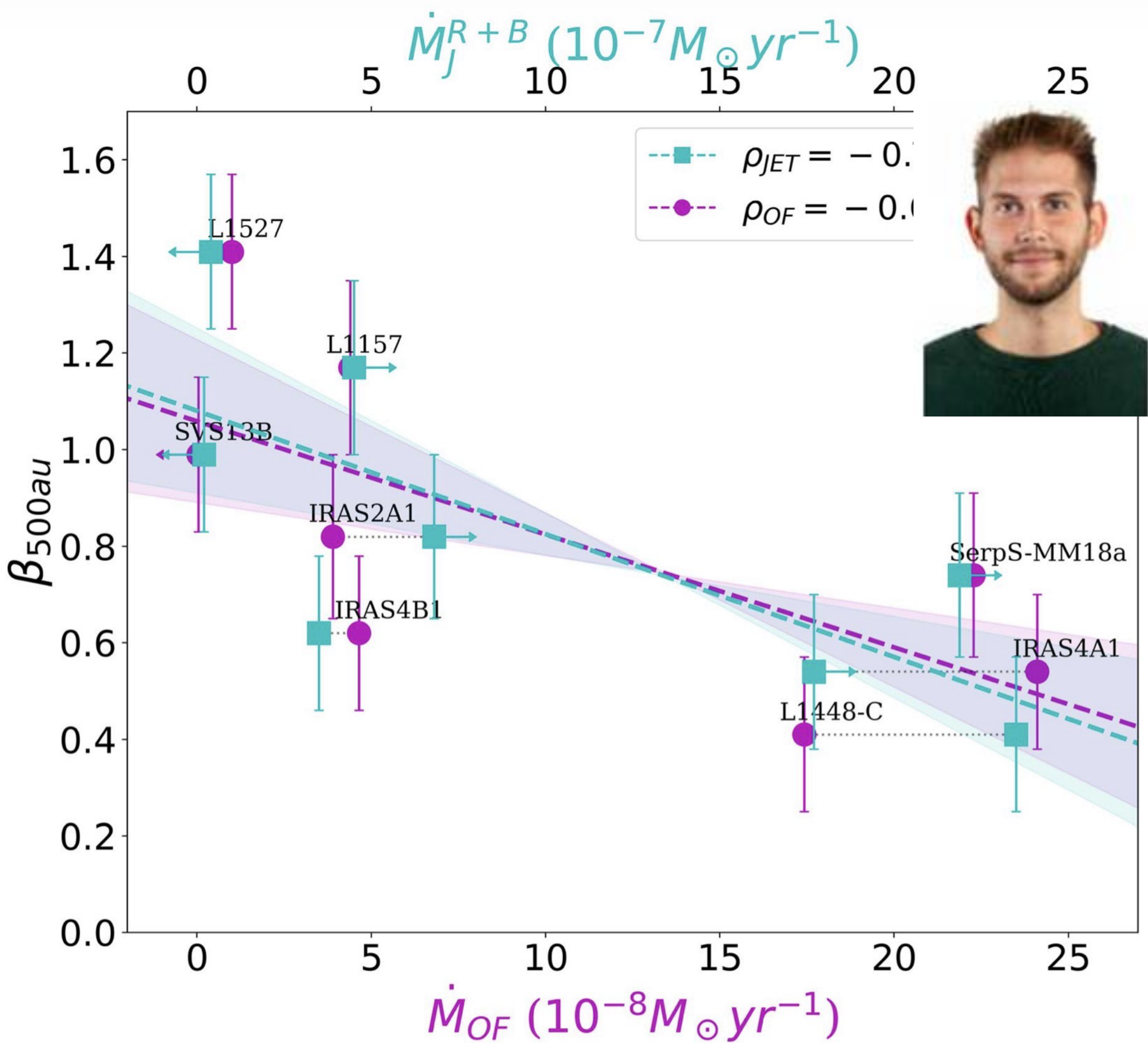
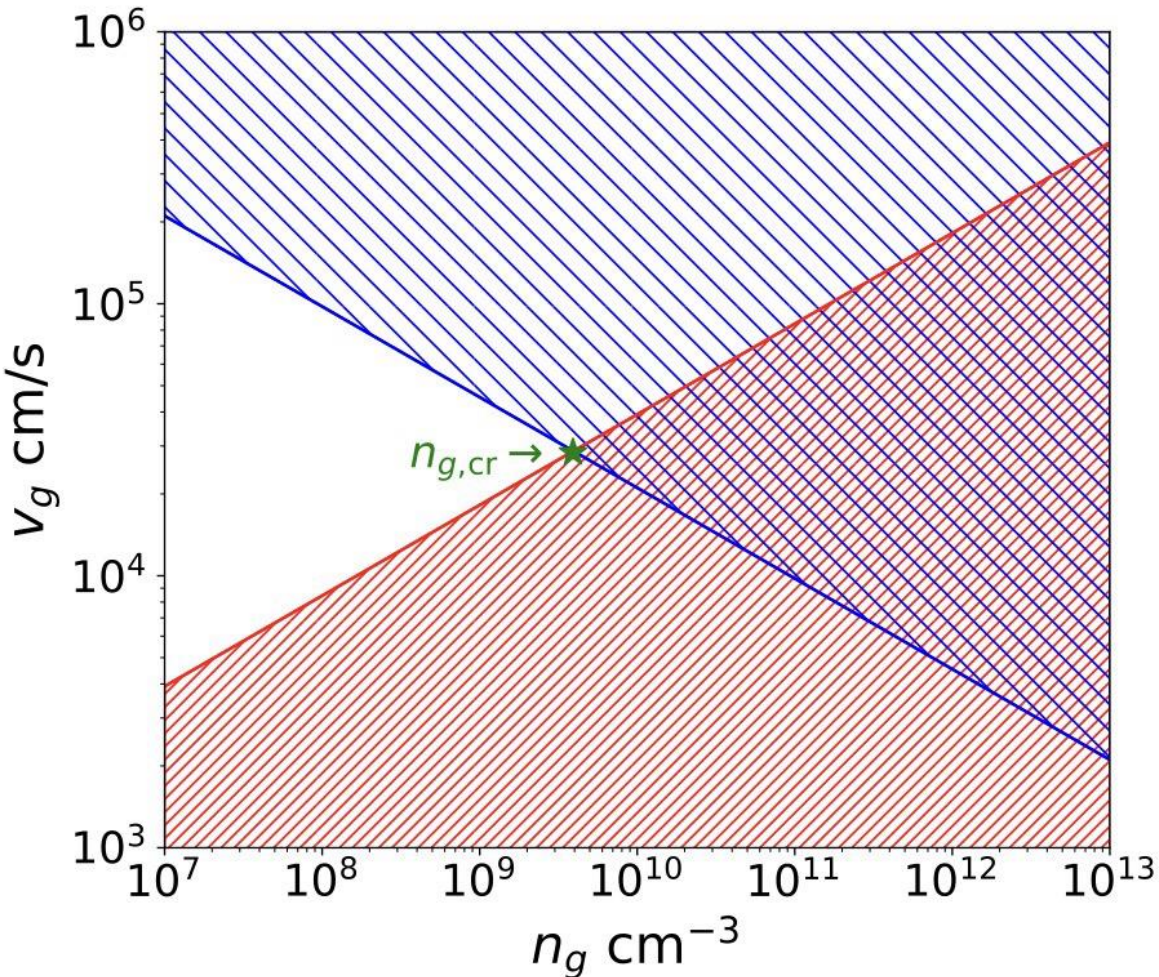


# Dust properties from cloud to disks

Ossenkopf & Henning 1994;  
Ormel+2009; Silsbee+2022...



$v_{\text{coll}} < 10\text{m/s}$      $\tau_{\text{coag}} < 10^5 \text{ years}$

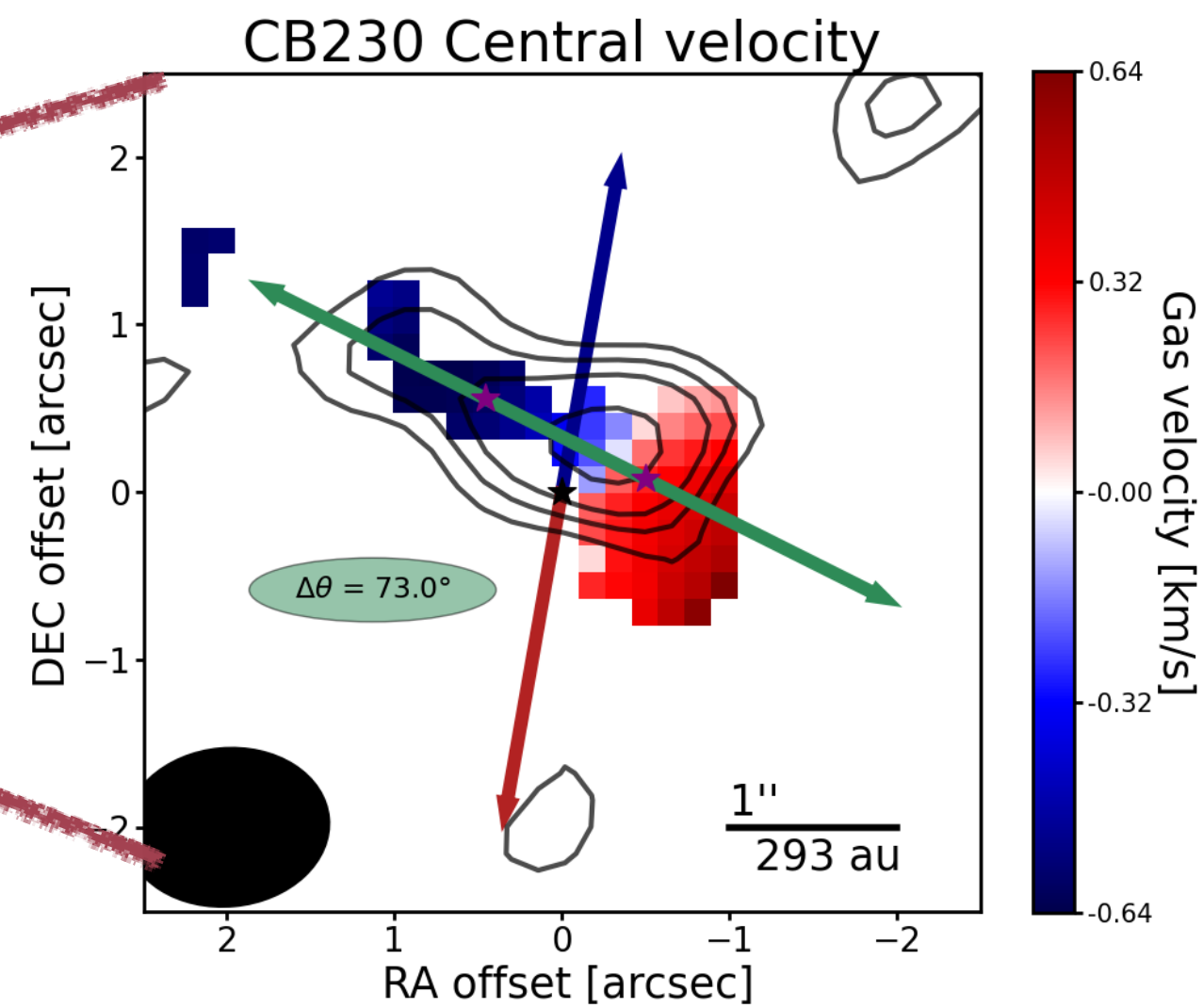
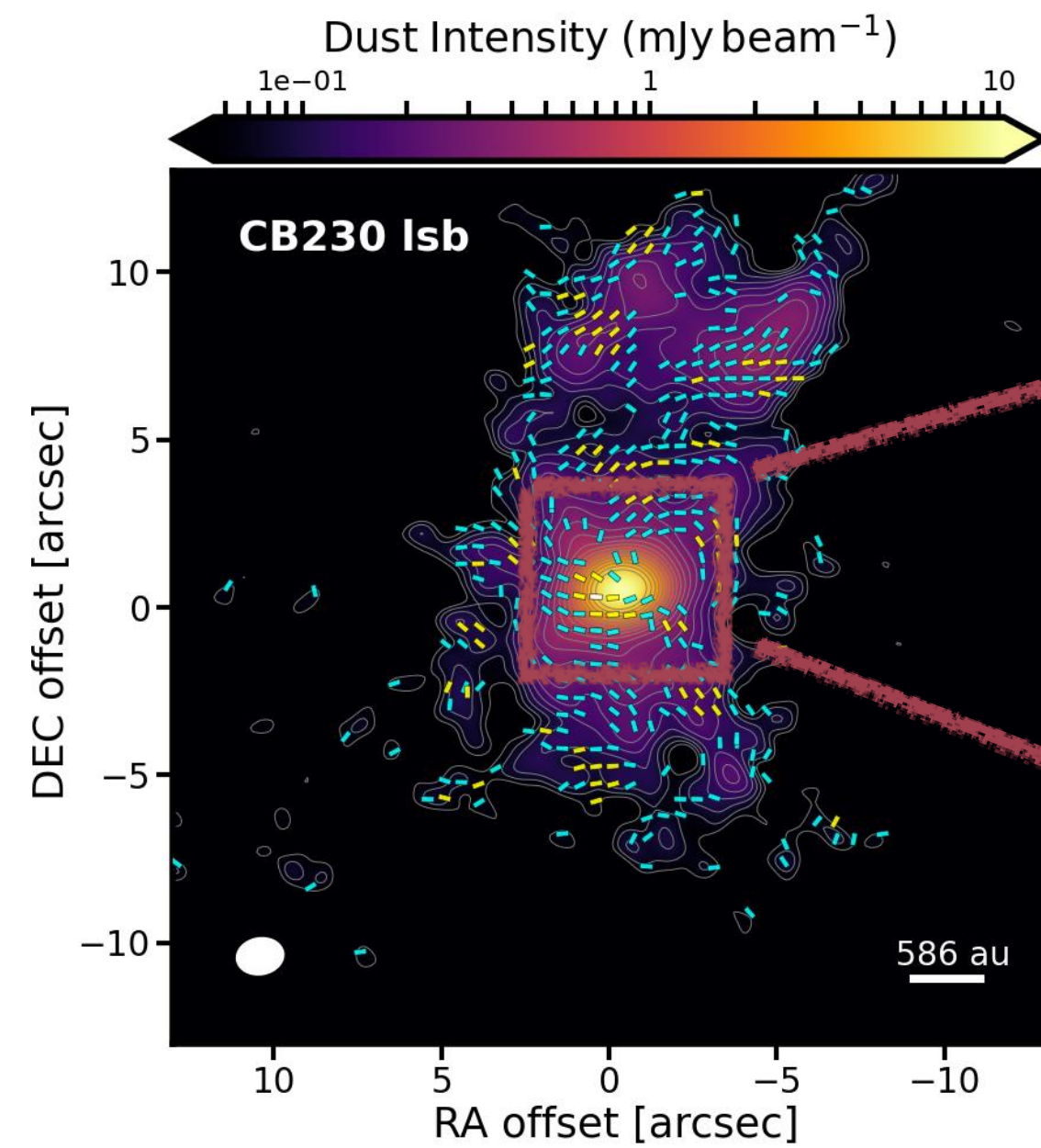


Cacciapuoti+2024





# Dust polarization, magnetic braking and disk formation



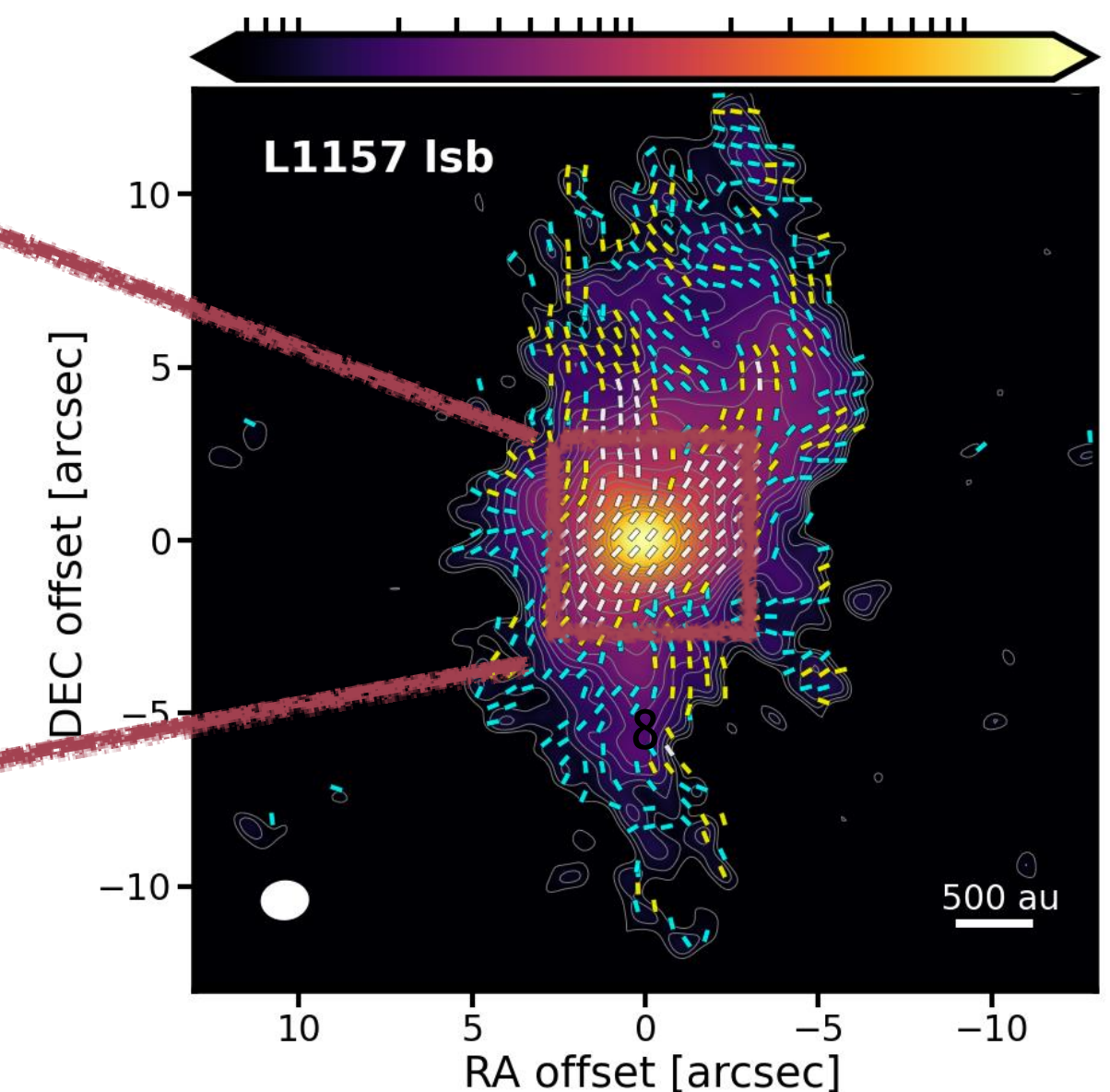
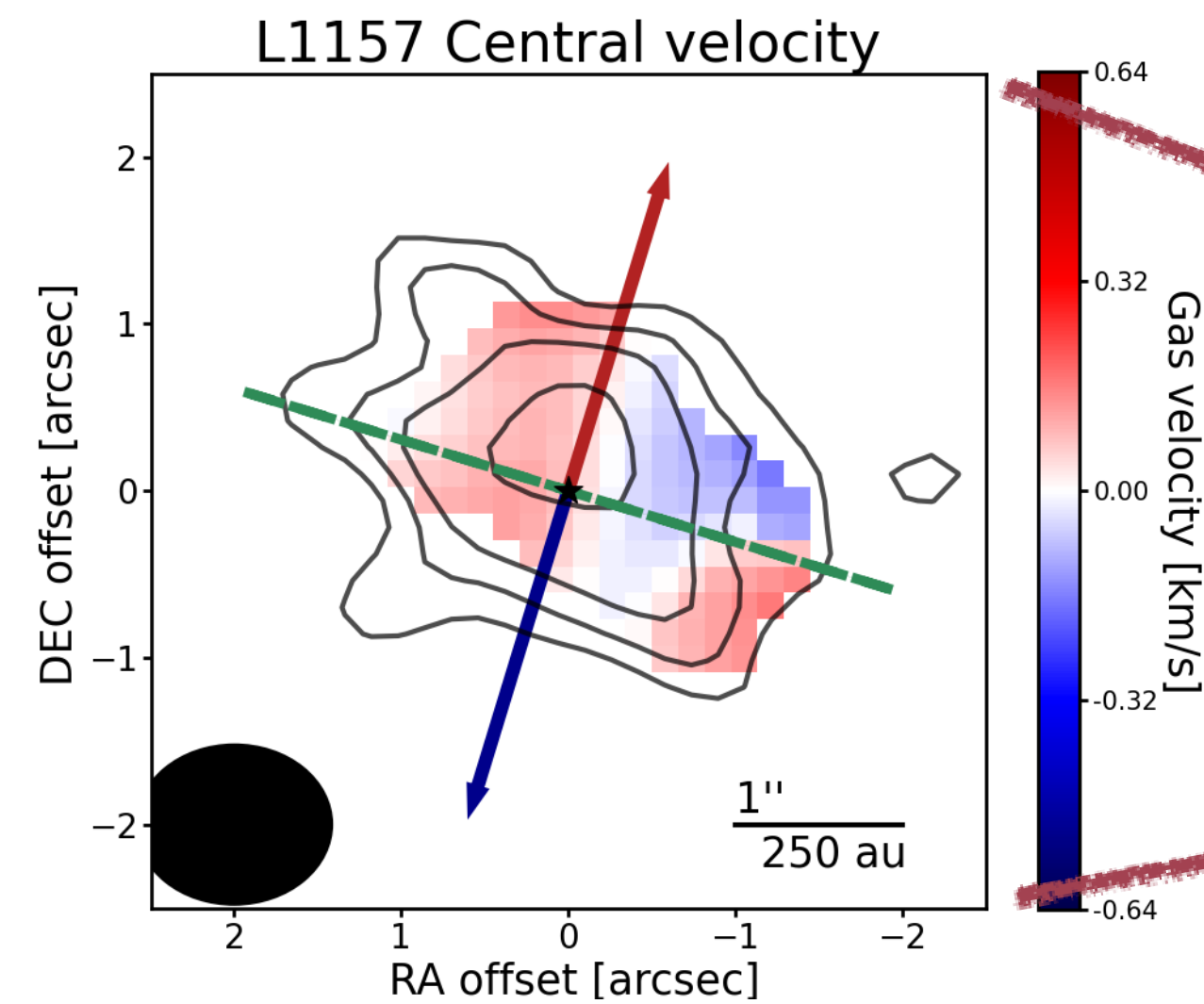
**CB230**

Disordered B field ->  
weaker magnetic  
braking ->  
Higher (rotational)  
velocity gradient



**L1157**

Pinched magnetic  
field lines -> stronger  
magnetic braking ->  
small (rotational)  
velocity gradient



Soave+2026

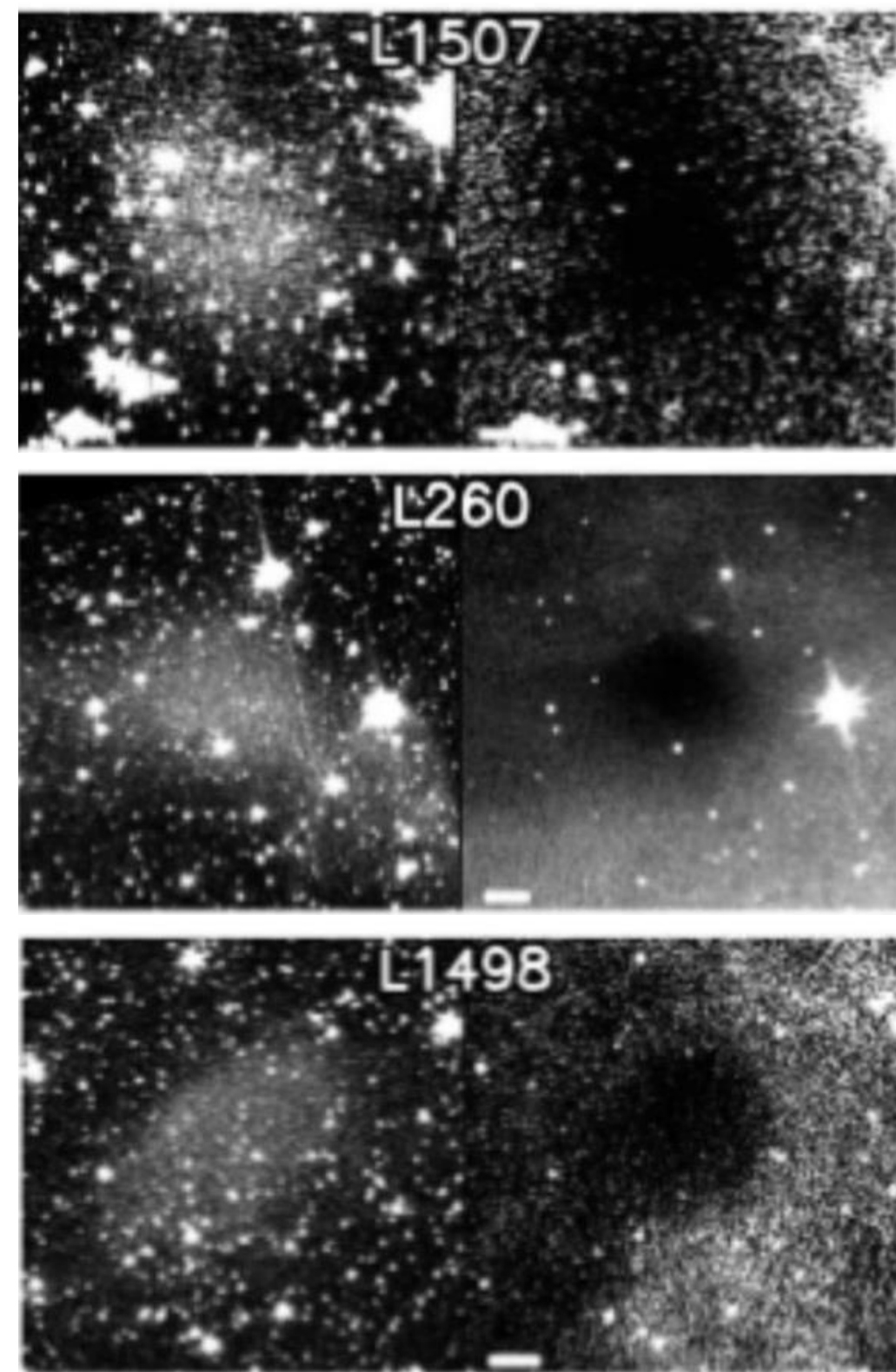




# Two paths to progress

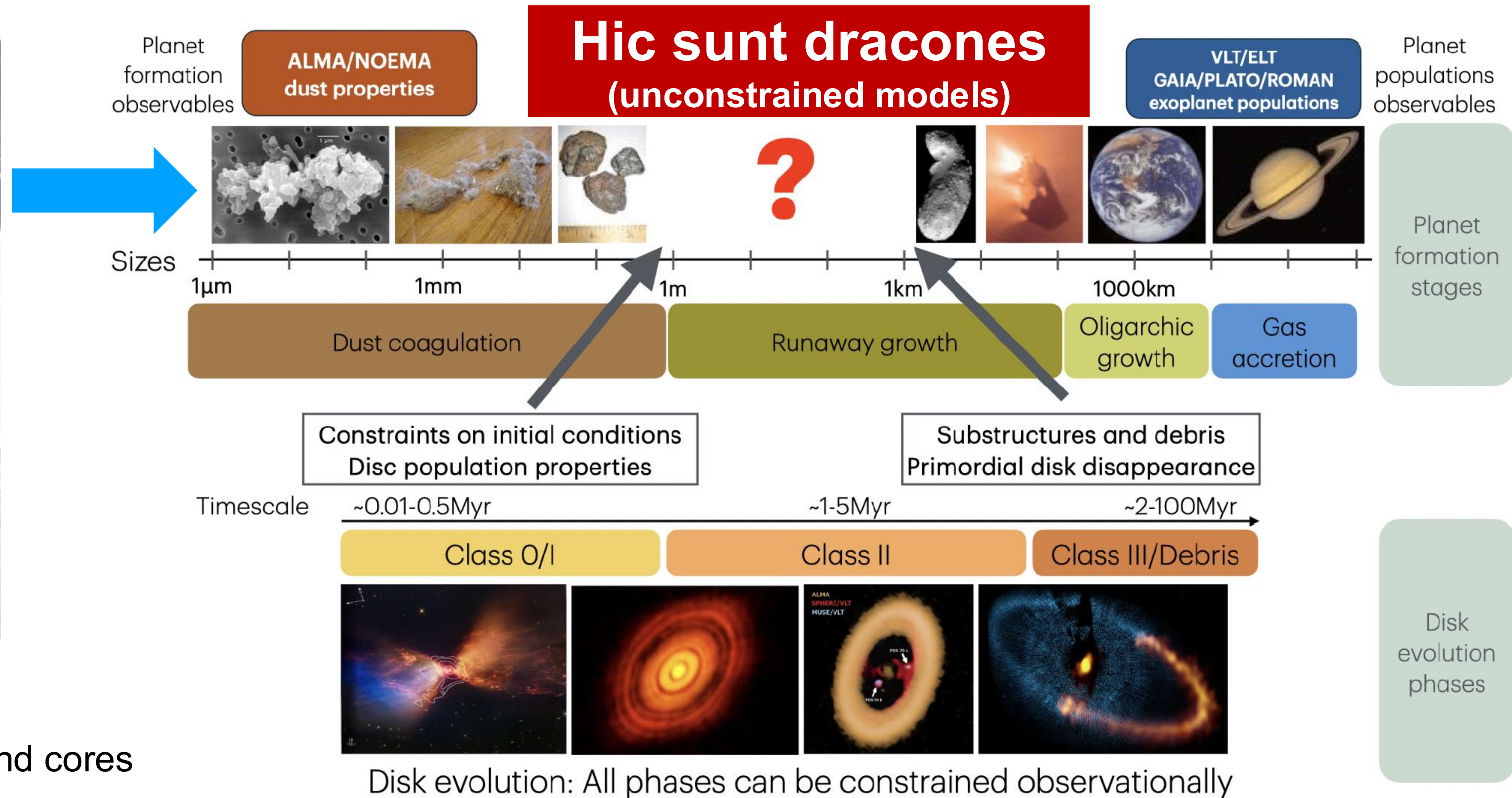
Origin

Fate



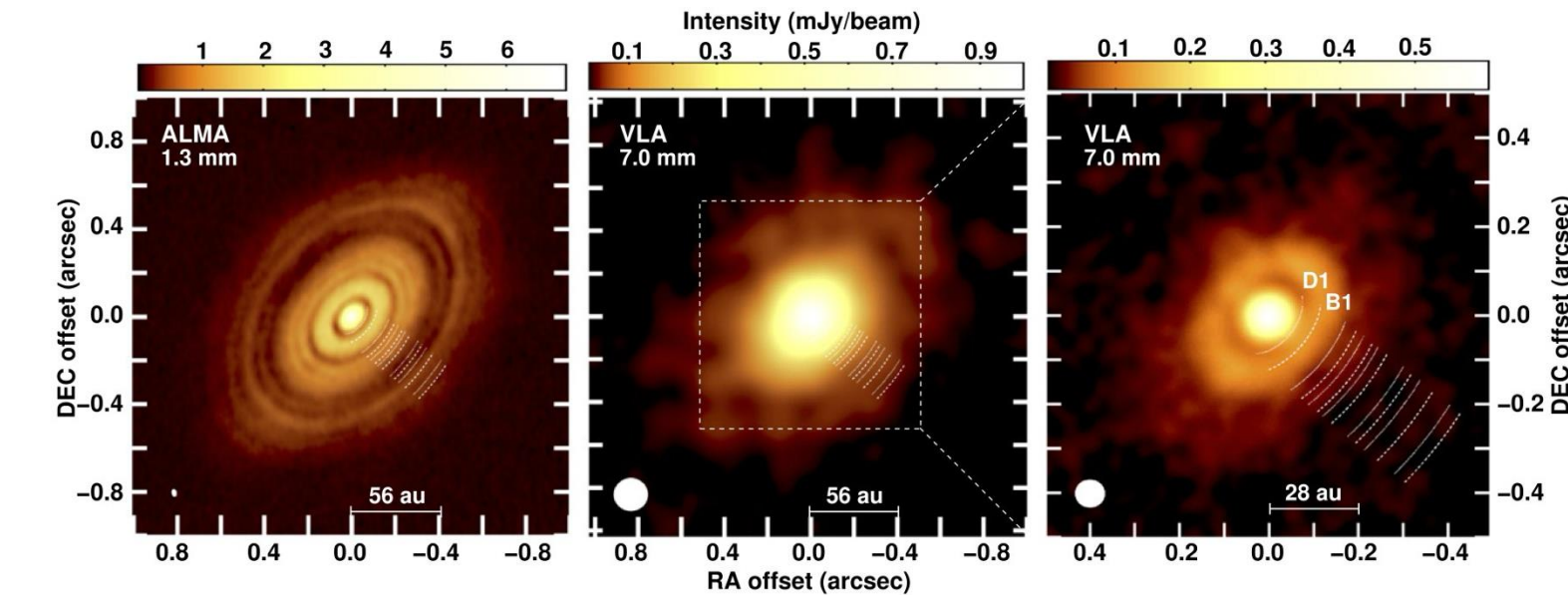
Pagani+(incl. ThH) 2010

Dust growth in clouds and cores

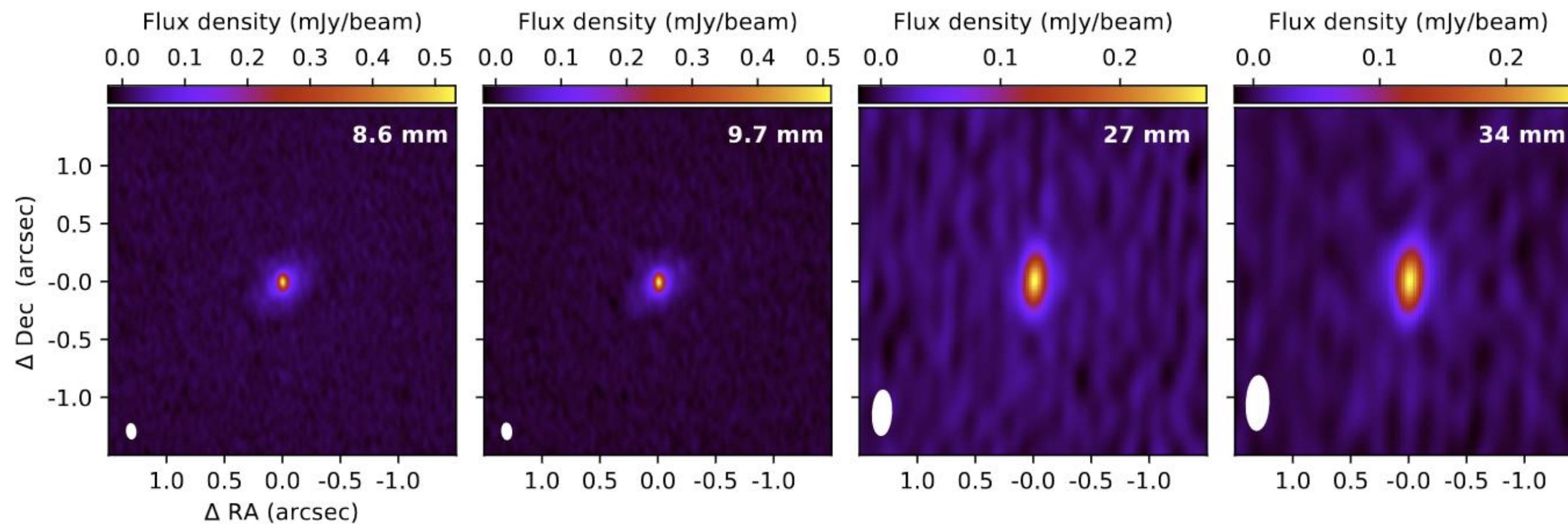
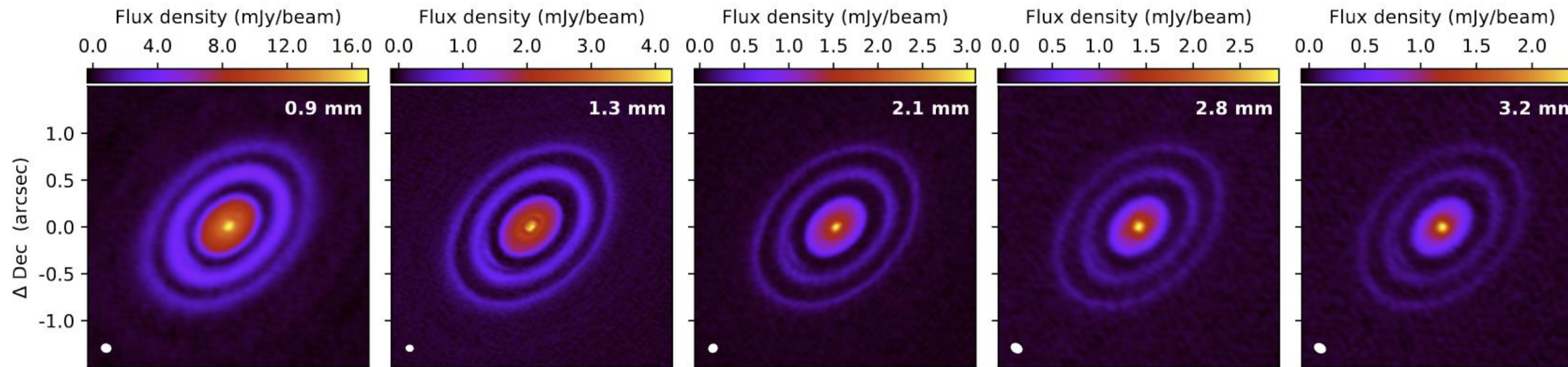




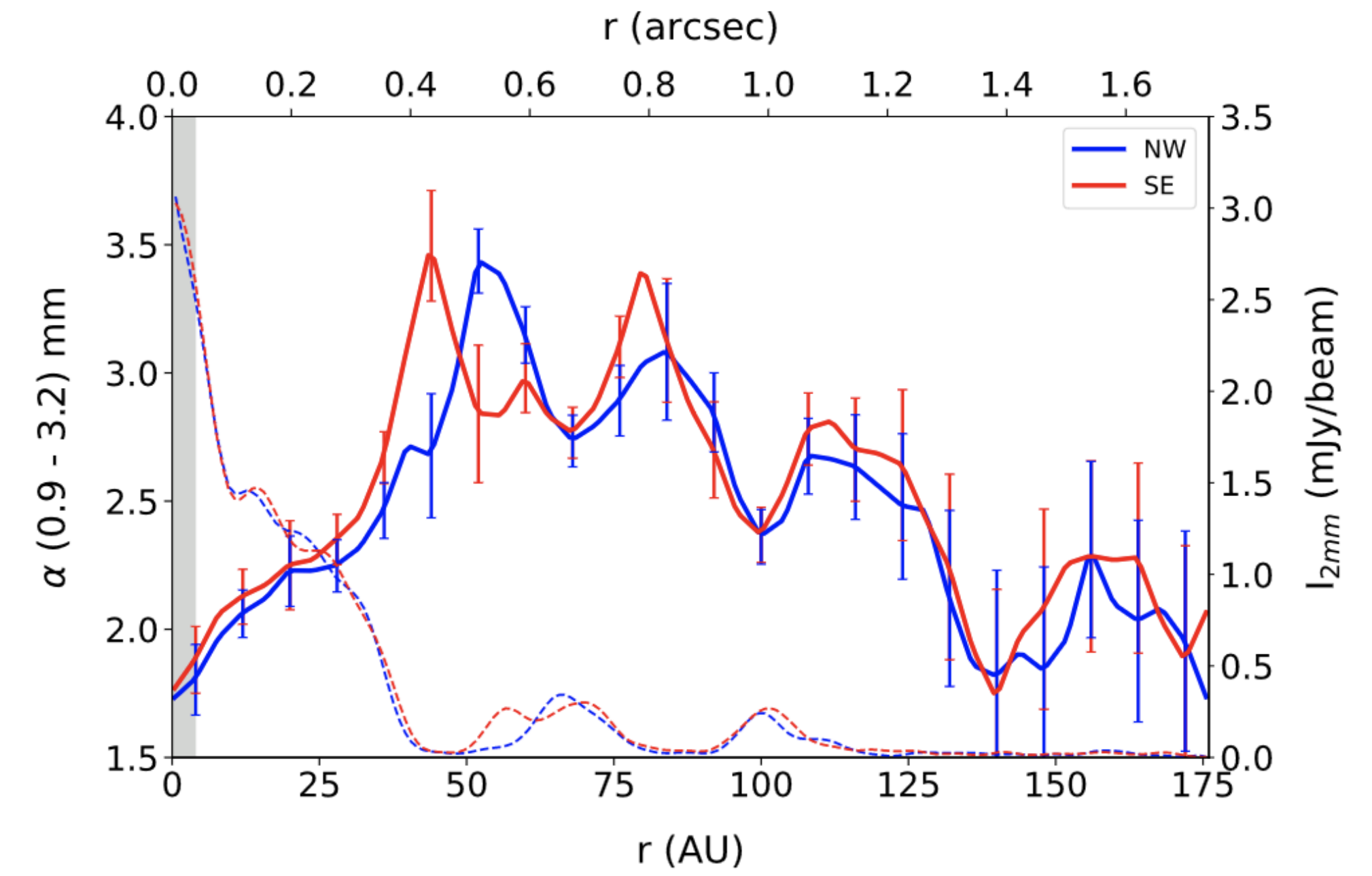
# From dust to planets (in which direction?)



Carrasco Gonzalez, Henning+ 2016



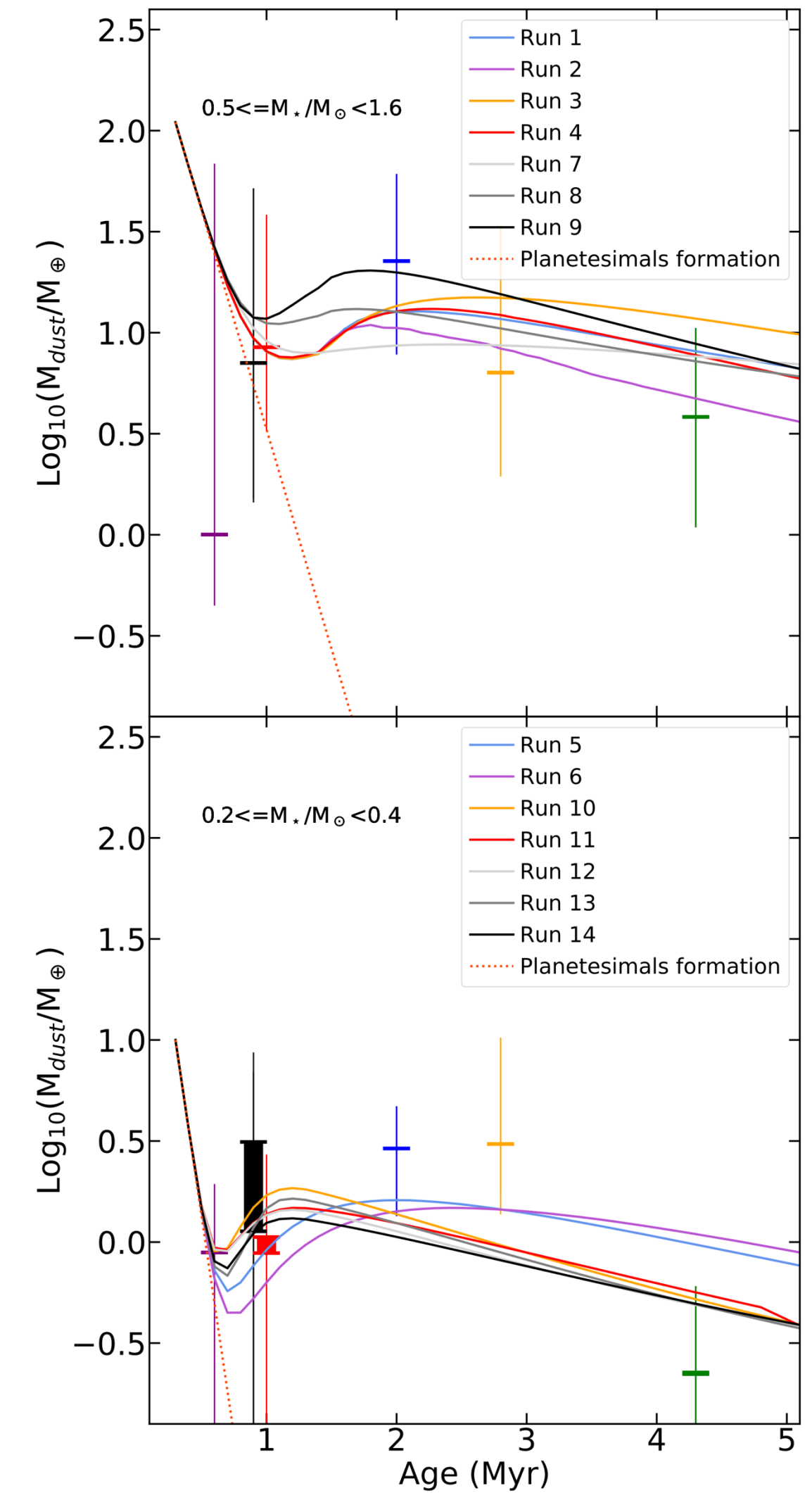
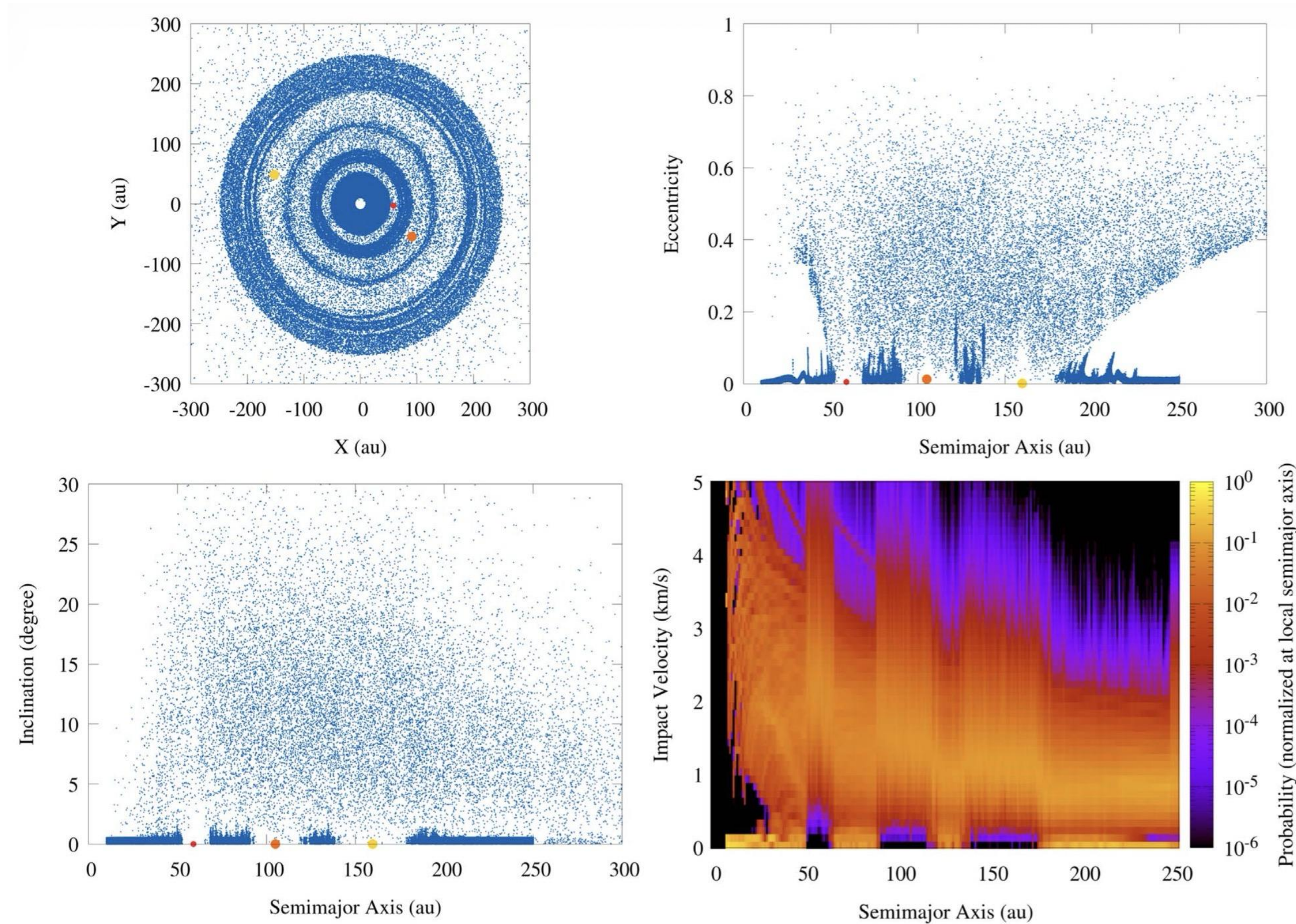
Guidi+2022





# From dust to planets

## (in which direction?)





# Summary & Perspectives

- The combination of densities and timescales is such that dust growth appears always to be too slow (envelopes) or too fast (disks) to fit with out simple minded evolutionary progression
- Observations are better explained by feedback loops of the star and planet formation process, these need to be included more consistently in the models
- Constraints from polarization (scattering, RAT) and absorption (JWST) will improve our constraints on dust properties in envelopes
- Both outflow feedback and planets-planetesimals interaction may be efficient mechanisms for mixing solids in disks of different ages