The Ophiuchus DIsc Survey Employing ALMA (ODISEA)–III: the evolution of substructures in massive discs at 3-5 au resolution (submitted to MNRAS)

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ABSTRACT: We present 1.3 mm continuum ALMA long-baseline observations at 3-5 au resolution of 10 of the brightest discs from the ODISEA project. We identify a total of 26 narrow rings and gaps distributed in 8 sources and 3 discs with small dust cavities (r < 10 au). We find that two discs around embedded protostars lack the clear gaps and rings that are ubiquitous in more evolved sources with Class II SEDs. Our sample includes 5 objects with previously known large dust cavities (r >20 au). Our long-baseline observations resulted in the largest sample of discs observed at 3-5 au resolution in any given star-forming region (15 objects when combined with Ophiuchus objects in the DSHARP Large Program) and allow for a demographic study of the brightest 5% of the discs in Ophiuchus (i.e. the most likely formation sites of giant planets in the cloud). We use this unique sample to propose an evolutionary sequence and discuss a scenario in which the substructures observed in massive protoplanetary discs are mainly the result of planet formation and dust evolution. If this scenario is correct, the detailed study of disc substructures might provide a window to investigate a population of planets that remains mostly undetectable by other techniques.

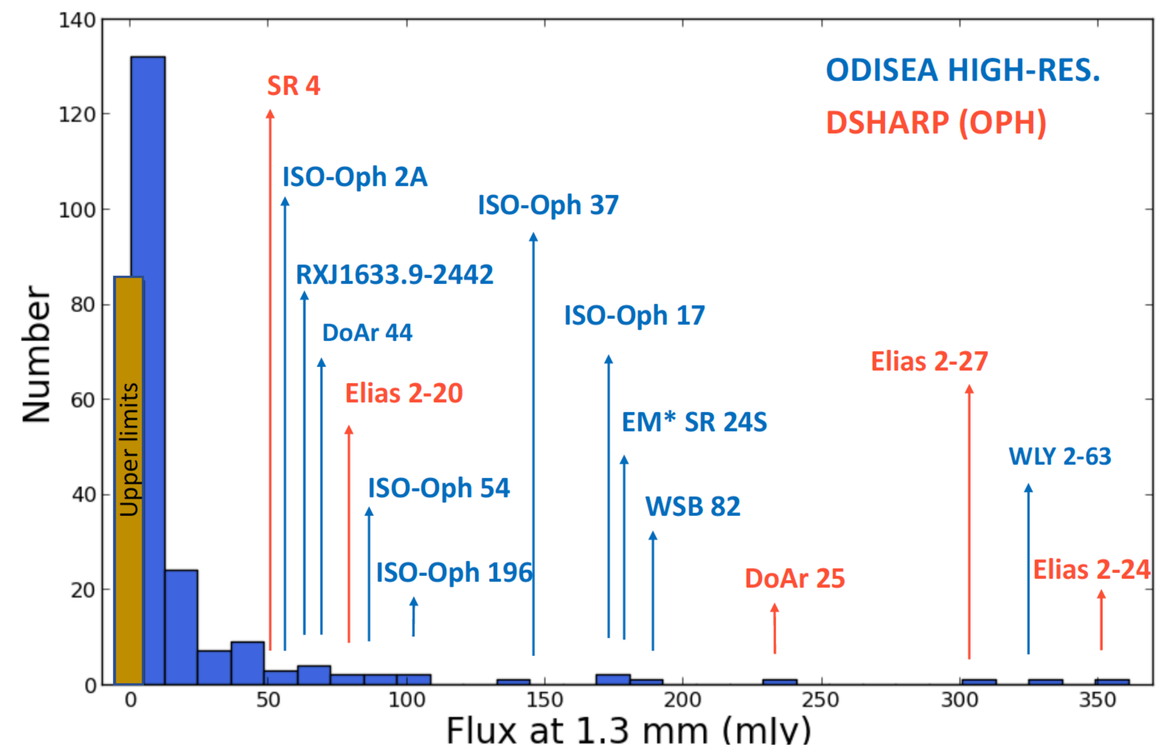

Figure 1. Histogram of 1.3mm fluxes of the 289 objects in the full ODISEA sample (Cieza et al. 2019;Williams et al. 2019), which corresponds to all YSO candidates identified by Spitzer in the Ophiuchus molecular cloud (Evans et al. 2009). The 10 "ODISEA long-baseline targets" observed at 0.02" (3 au) to 0.035" (5 au) resolution are at the upper end of the flux distribution. We combine our long-baseline sample with the 5 Ophiuchus objects brighter than 70 mJy that were observed by DSHARP at 5 au resolution (Andrews et al. 2018) to create a flux-limited sample containing the 5% brightest discs in the cloud.

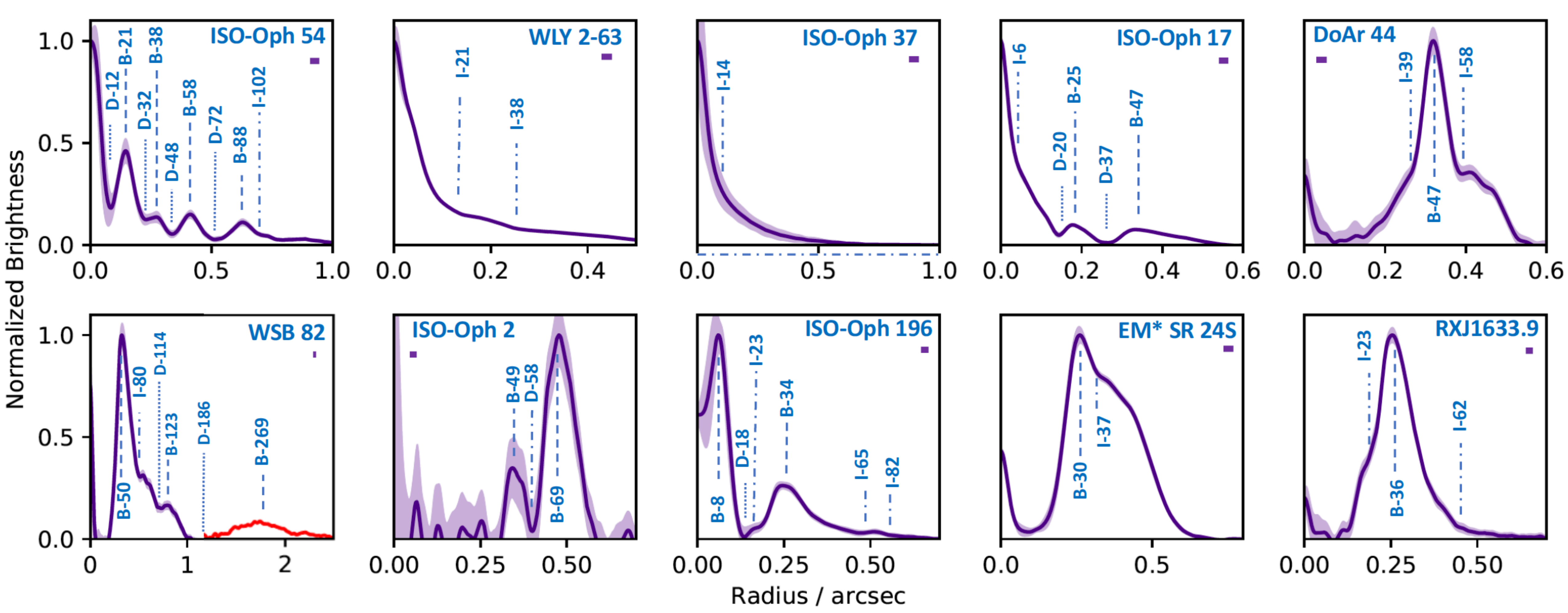

Figure 2. Deprojected radial profiles of the "ODISEA long-baseline sample" normalized to the peak flux. The small bar below the name of each source indicates the size of the beam. Substructures are labeled with a prefix ("D" for gaps, "B" for rings, and "I" for inflection points), and a number indicating their location in au. The blue profile corresponds to the long-baseline data alone, while the red profile in WSB 82 includes observations at 0.2" resolution. The shaded regions indicate the 3- error around the mean of the profiles.

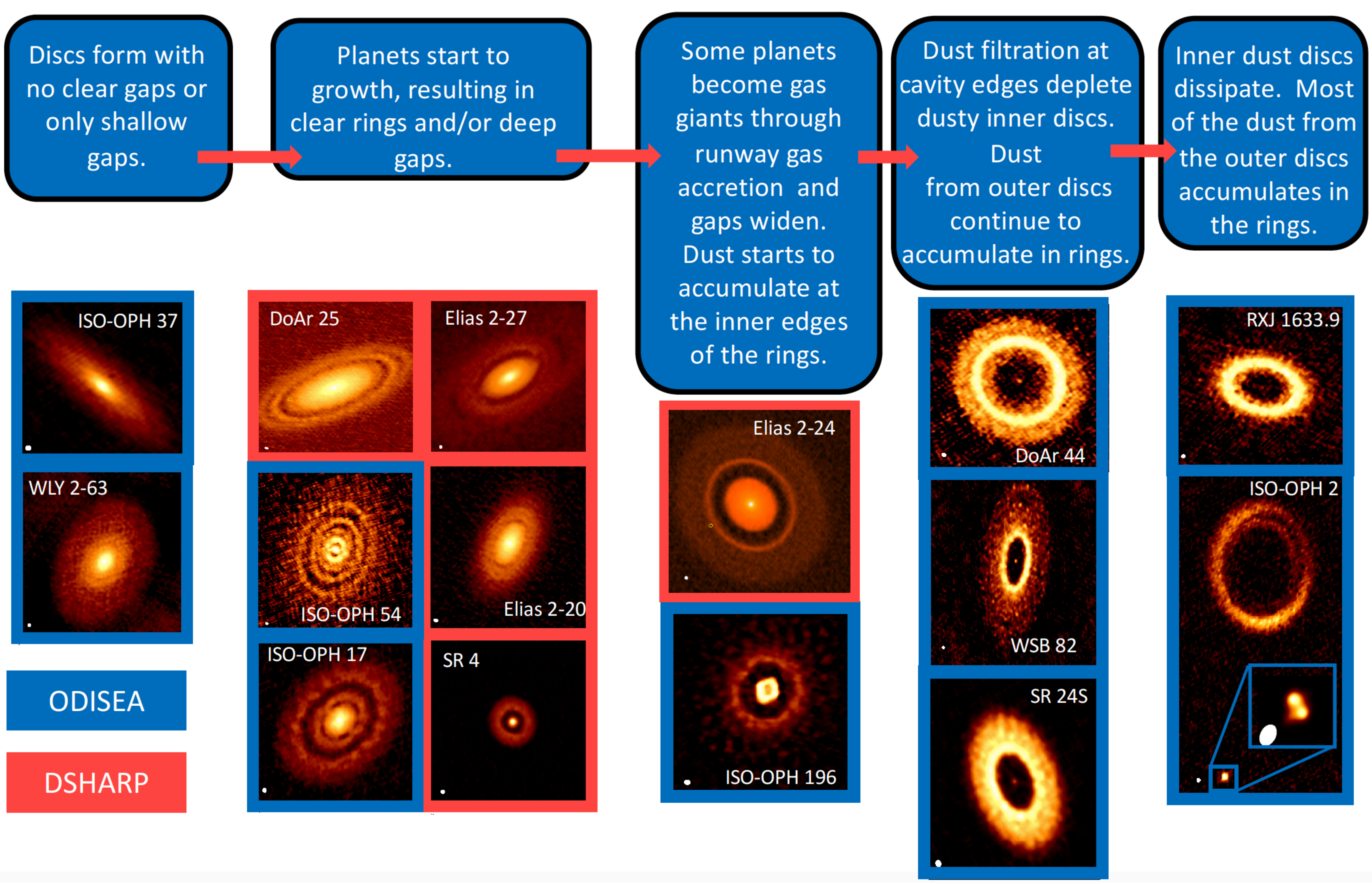

Figure 3. Schematic figure of the possible evolution of substructures in massive discs (M_{DUST} > 40 M_{JUP}) using the objects in the Ophiuchus long-baseline sample to illustrate different stages. In the proposed scenario, the progression of the features observed in 1.3 mm continuum at 3-5 au resolution is driven the formation of giant planets though core accretion and dust evolution. By construction, the scenario only applies to systems massive enough to form giant planets.