# The masses of Herbig disks


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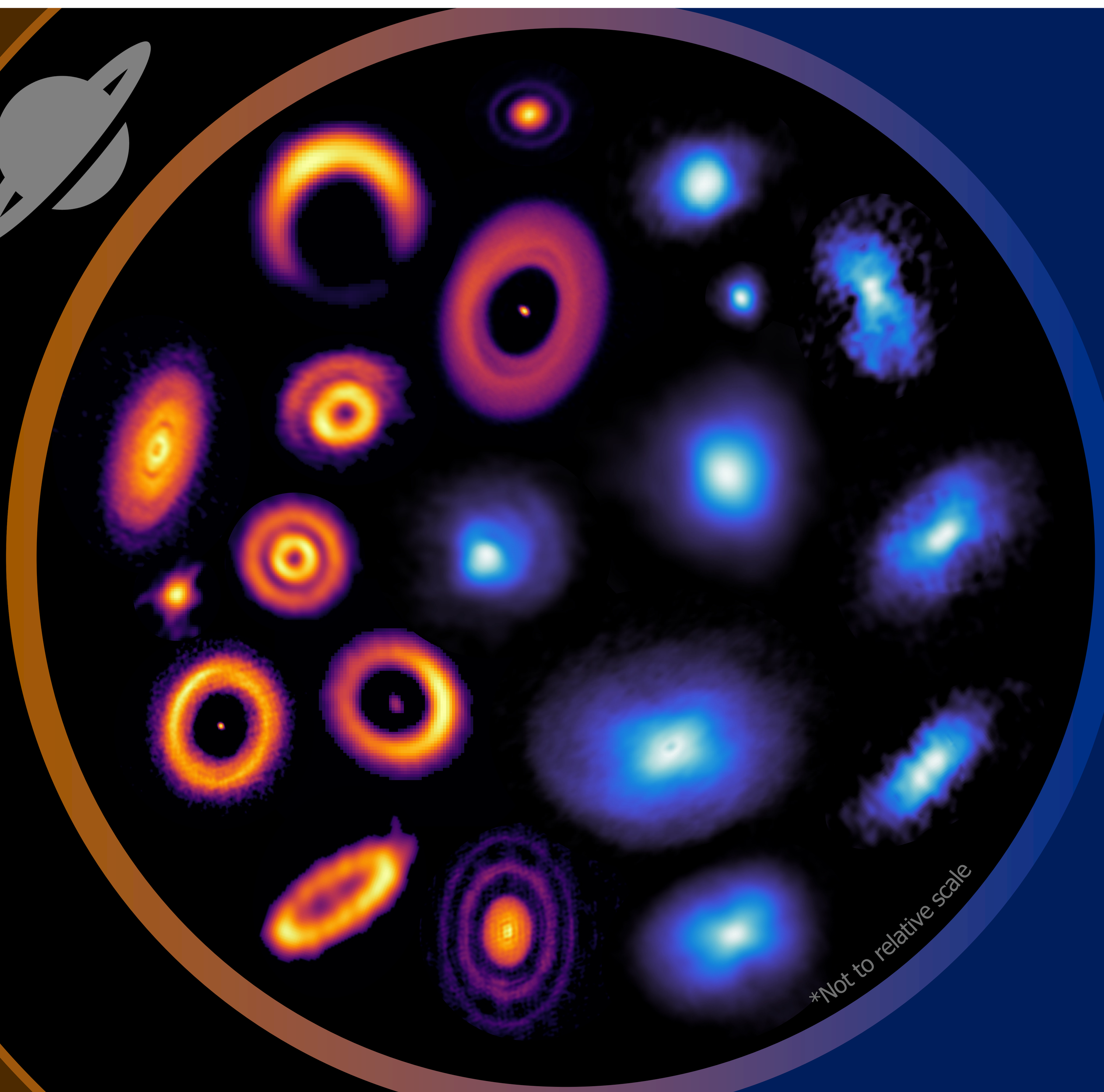
## Dust

Stapper et al. 2022[1]

For 36 Herbig disks[4][5] in the ALMA archive we obtain the dust masses and compare these to T Tauri disks. We find that Herbig disks are significantly more massive and larger than T Tauri disks. This might be linked to the increase in prevalence of giant planets with host star mass[6][7].




## Gas

Stapper et al. in prep[2]
Stapper et al. 2023[3]

Using DALI models[8][9], we obtain estimates on the gas masses of 35 Herbig disks with ALMA and NOEMA data. We find that Herbig disks are consistent with a gas-to-dust ratio of at least 100 and that one can underestimate the disk mass by orders of magnitude using $C^{18}O$ flux alone due to optical depth.

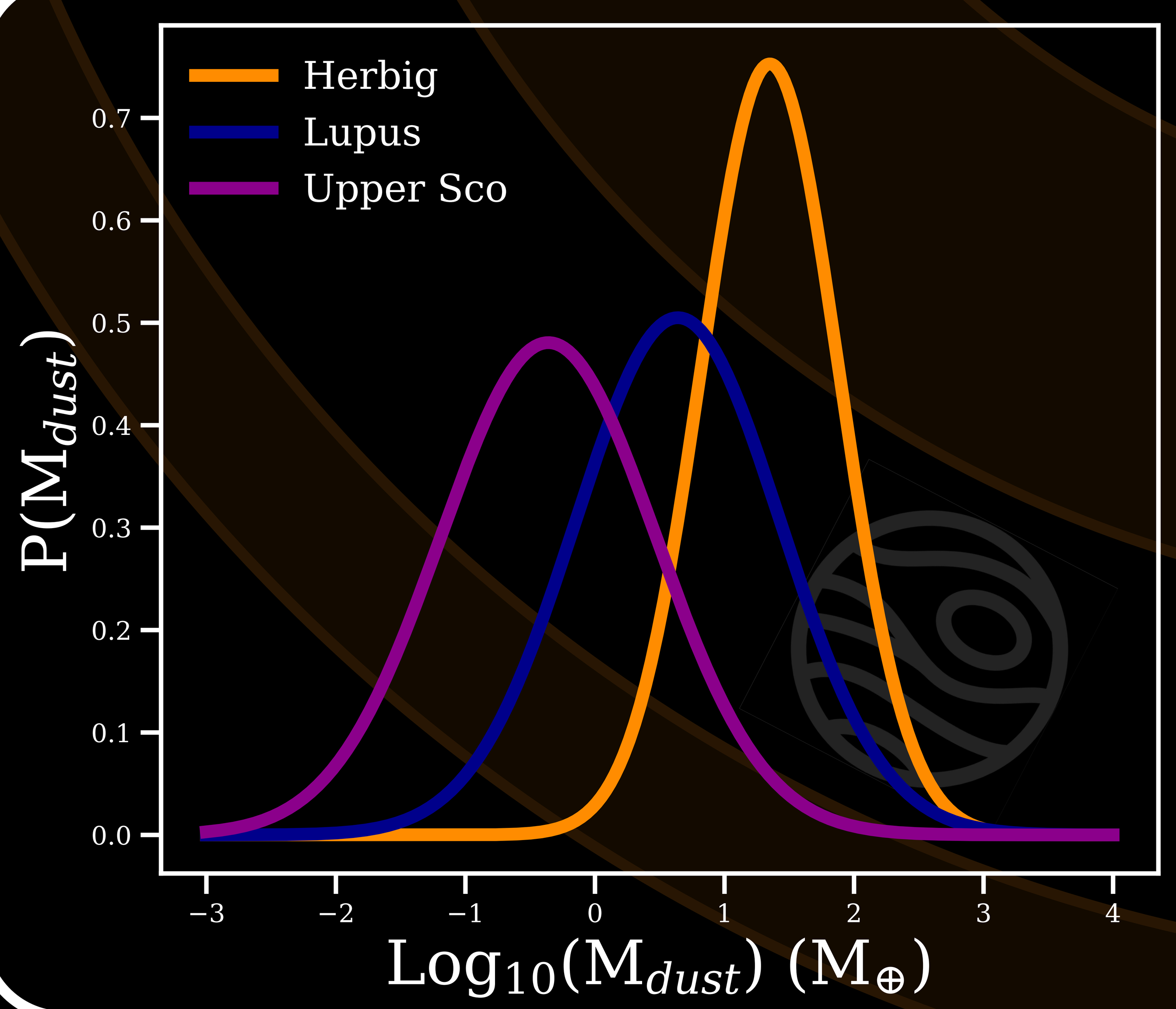



**Fig.1** Probability distributions obtained by fitting through dust mass cumulative distributions. The **Herbig** disks are a factor 3 and 7 more massive than the disks in Lupus[10] and **Upper Sco**[11]

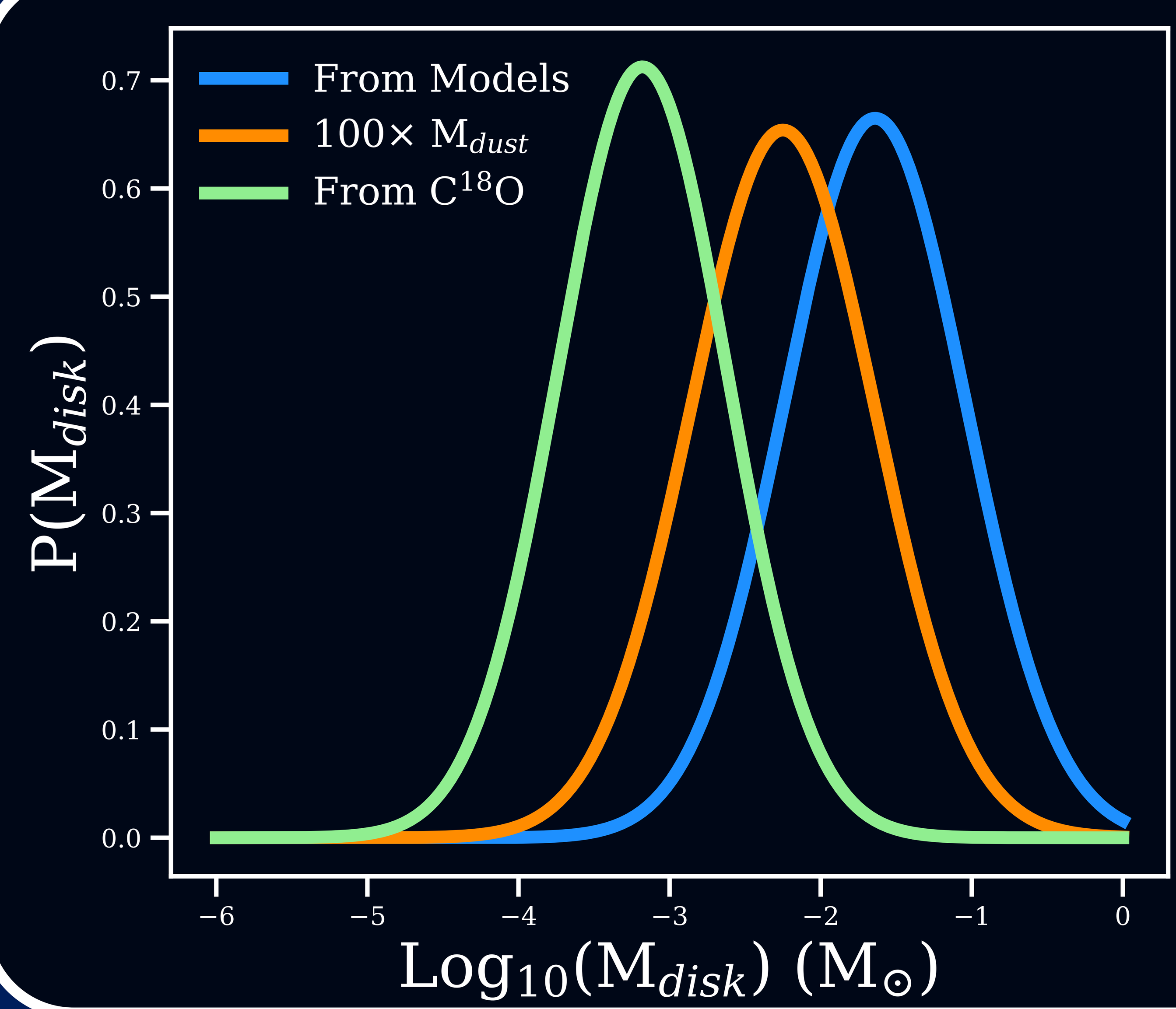



**Fig.2** Same as Fig. 1, but now for gas masses. The masses from the **DALI models** are higher than **100x$M_{dust}$** while the masses from the **$C^{18}O$ fluxes** are underestimating the total mass by multiple orders of magnitude.

**Fig.3** Combining the dust masses from Fig.1 and the gas masses from Fig.2 gas-to-dust ratios can be obtained. Comparing the these to those obtained from **Lupus**[10][12] and **Chamaeleon I**[13][14], we see a stark difference with Herbig disks. Over multiple orders of magnitude in dust the **Herbig disks** are consistently above the ISM value, while the T Tauri disks lie below it.

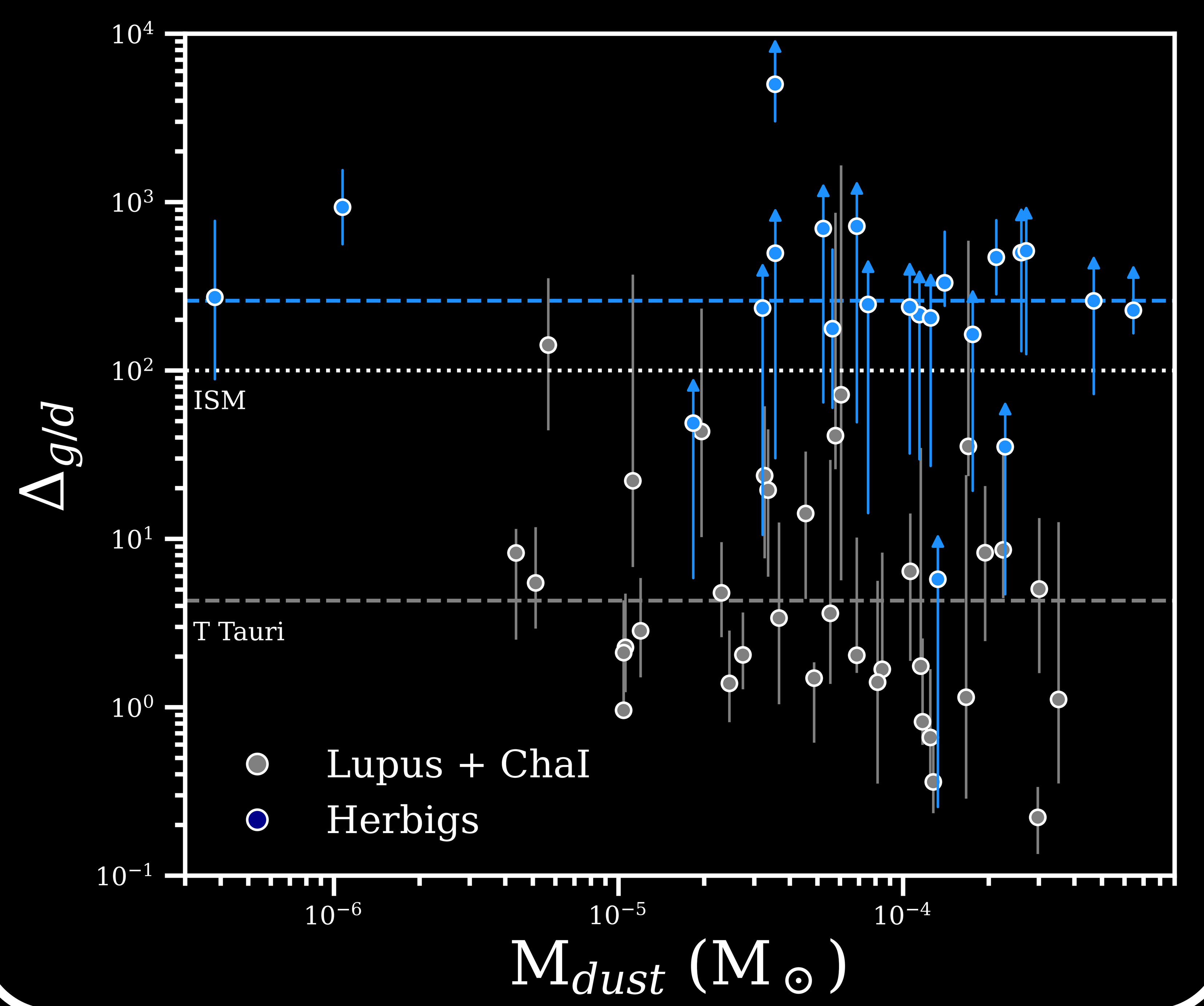
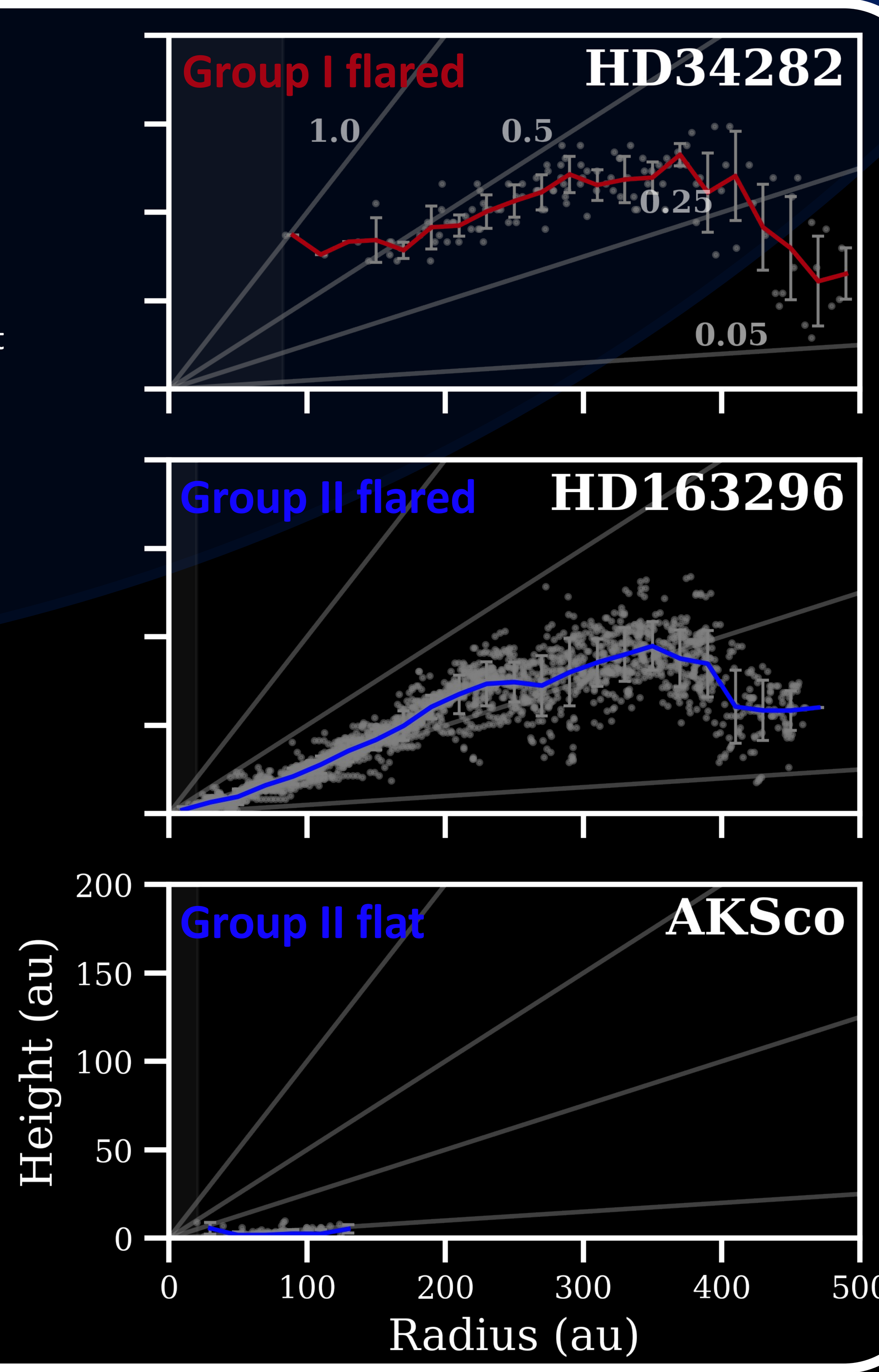



**Fig.4**

Using the gas observations, we[3] can obtain emission height profiles[15] as well for Herbig disks from different groups[16] and find that **group I** Herbigs are all vertically extended disks, while **group II** disks can either be vertically extended or compact flat disks. This coincides well with work done in scattered light[17].




Lastly, HD 163296 has been found to have a disk wind[18][19]. However, a search for disk winds in the other Herbig disks with $^{12}CO$ observations has not yielded any results.


**References:** [1] Stapper, Hogerheijde, van Dishoeck, Mentel 2022, A&A, 658, A112; [2] Stapper, Hogerheijde, van Dishoeck, Grant, Leemker, Lin, in prep; [3] Stapper, Hogerheijde, van Dishoeck, Paneque-Carreño 2023, A&A, 669, A158; [4] Guzmán-Díaz et al. 2021, A&A,650, A182; [5] Brittain et al. 2023, Space Sci. Rev., 219, 7; [6] van der Marel & Mulders 2021, AJ, 162, 28; [7] Fulton et al. 2021, ApJS, 255, 14; [8] Bruderer 2013, A&A, 559, A46; [9] Bruderer et al. 2012, A&A, 541, A91; [10] Ansdell et al. 2016, ApJ, 828, 46; [11] Barenfeld et al. 2016, ApJ, 827, 142; [12] Miotello et al. 2017, A&A, 599, A113; [13] Pascucci et al. 2016, ApJ, 831, 125; [14] Long et al. 2017, ApJ, 844, 99; [15] Paneque-Carreño et al. 2022, A&A, 669, A126; [16] Meeus et al. 2001, A&A, 365, 476; [17] Garufi et al. 2017, A&A, 603, A21; [18] Klaassen et al. 2013, A&A, 555, A73; [19] Booth et al. 2021, ApJS, 257, 16;