JWST probes the role of stellar mass and morphology in obscuring galaxies

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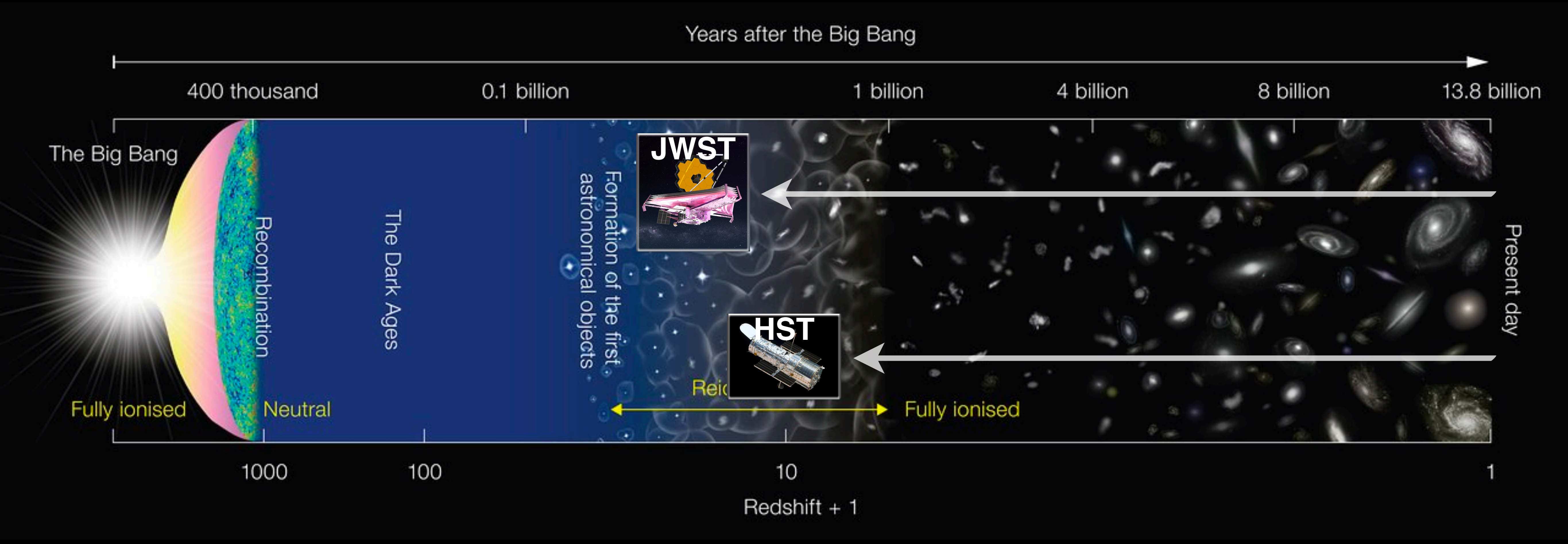
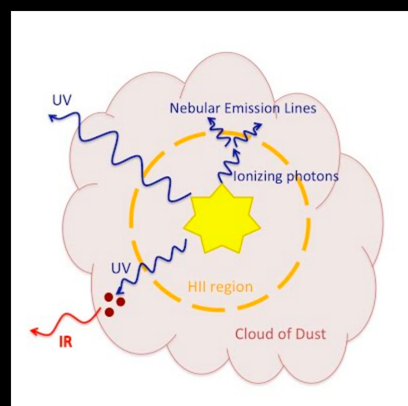
Schematic History of the Universe

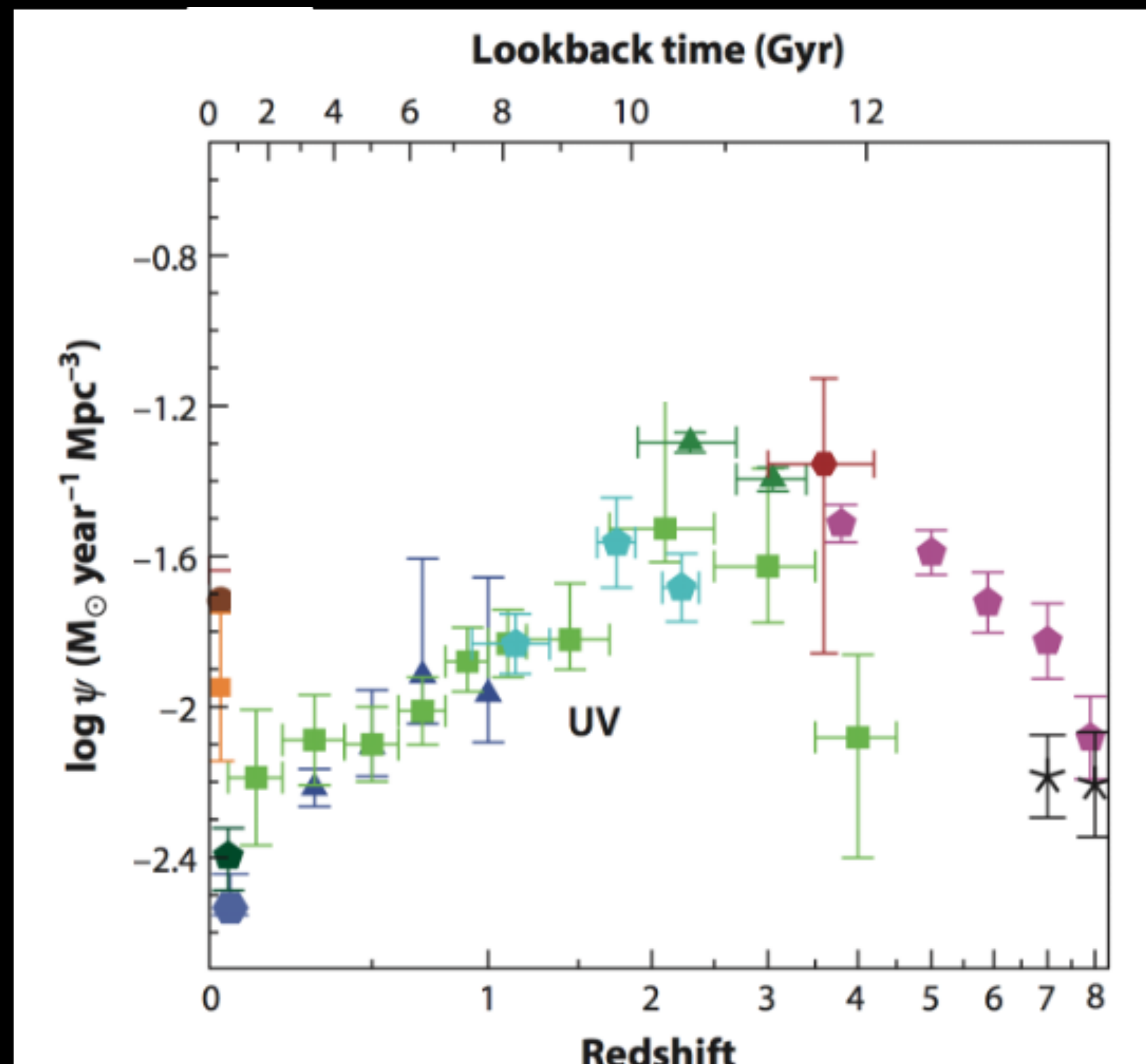


Credit: NAOJ

Cosmic Star Formation History

- Star formation rate density peaks at z ~ 2

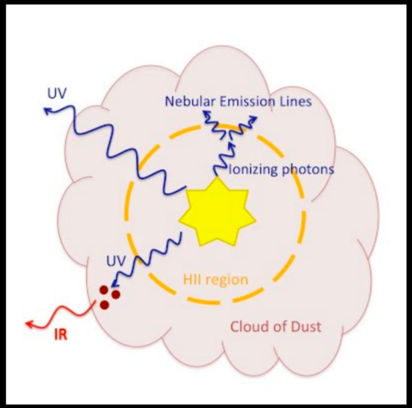


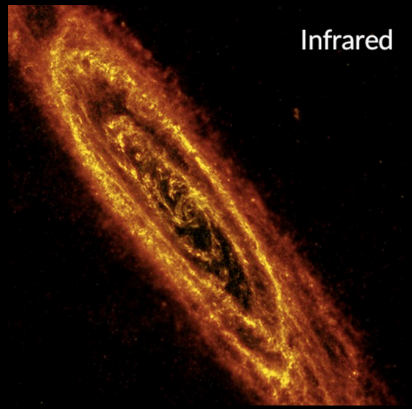


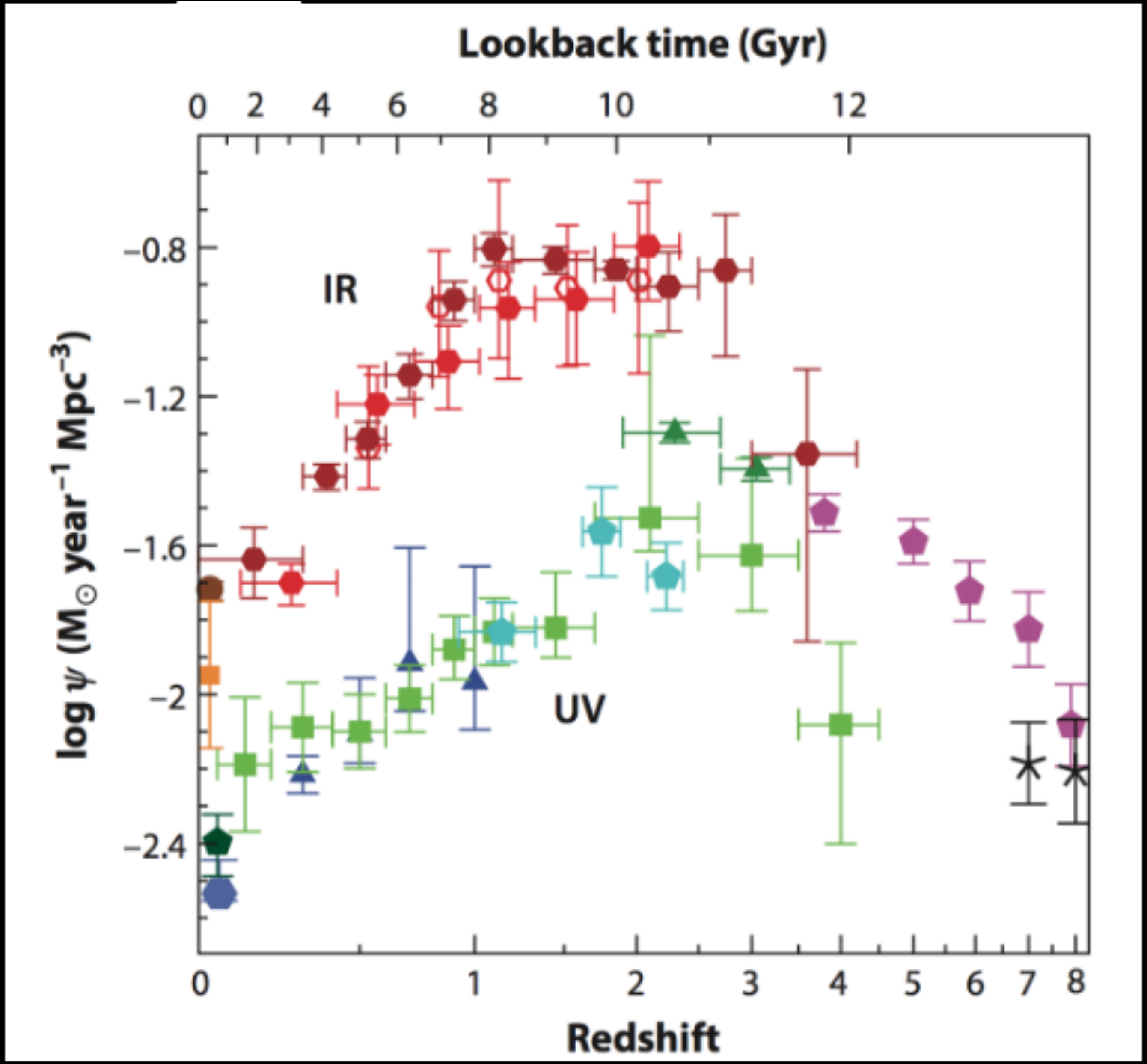
Madau & Dickinson 2014

Cosmic Star Formation History

- Star formation rate density peaks at z ~ 2
- ~80% of star formation is dust-enshrouded at z < 3







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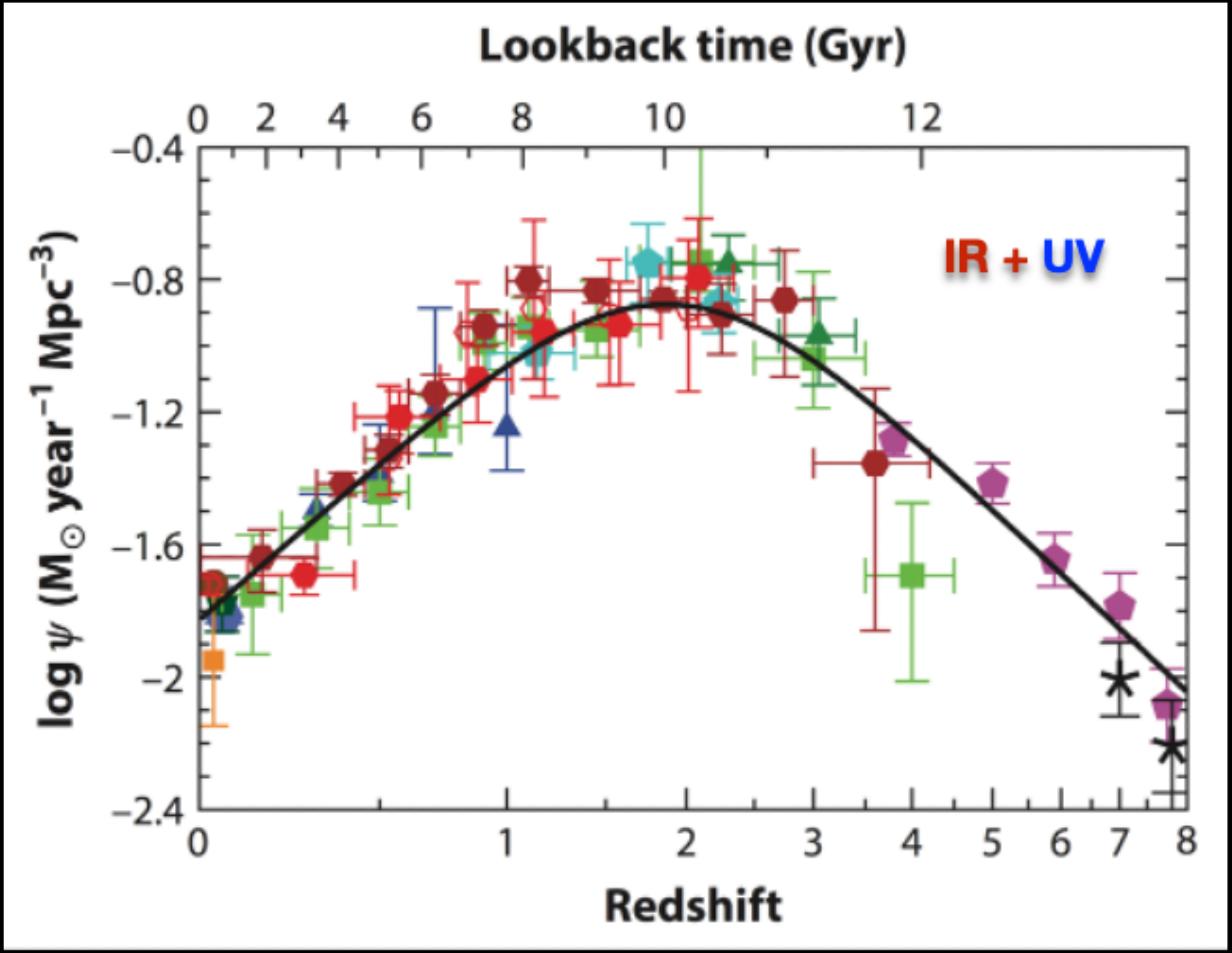

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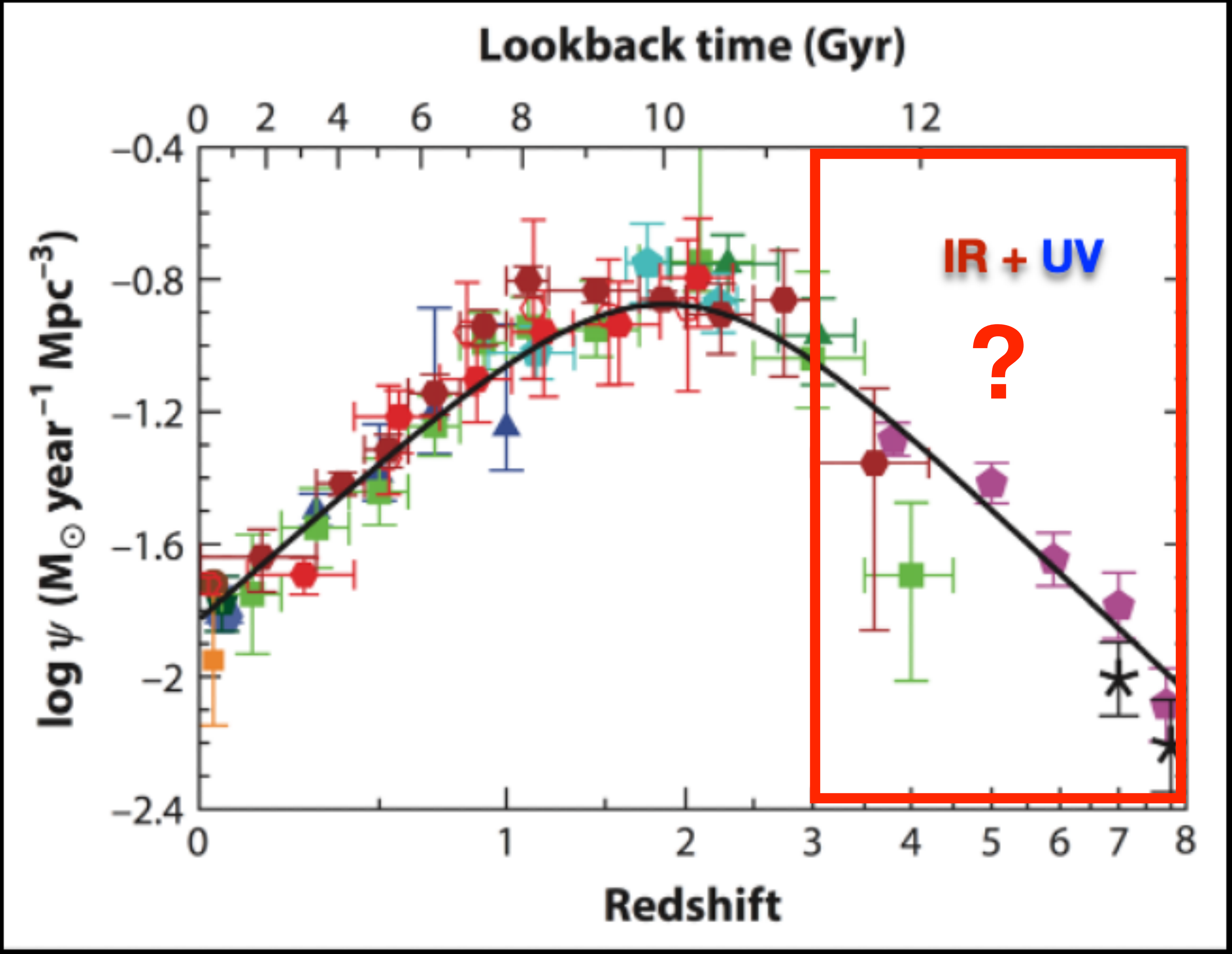
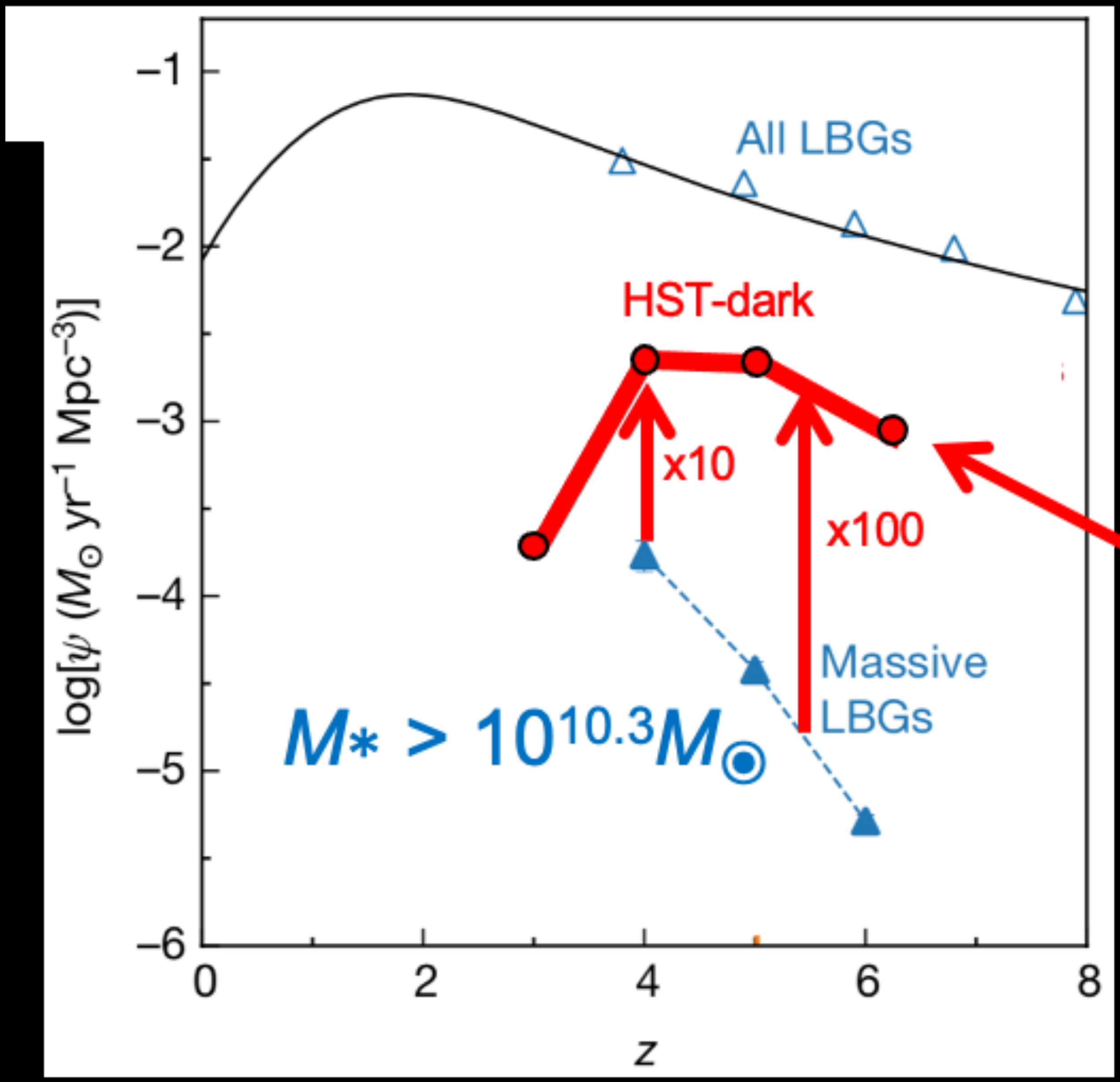
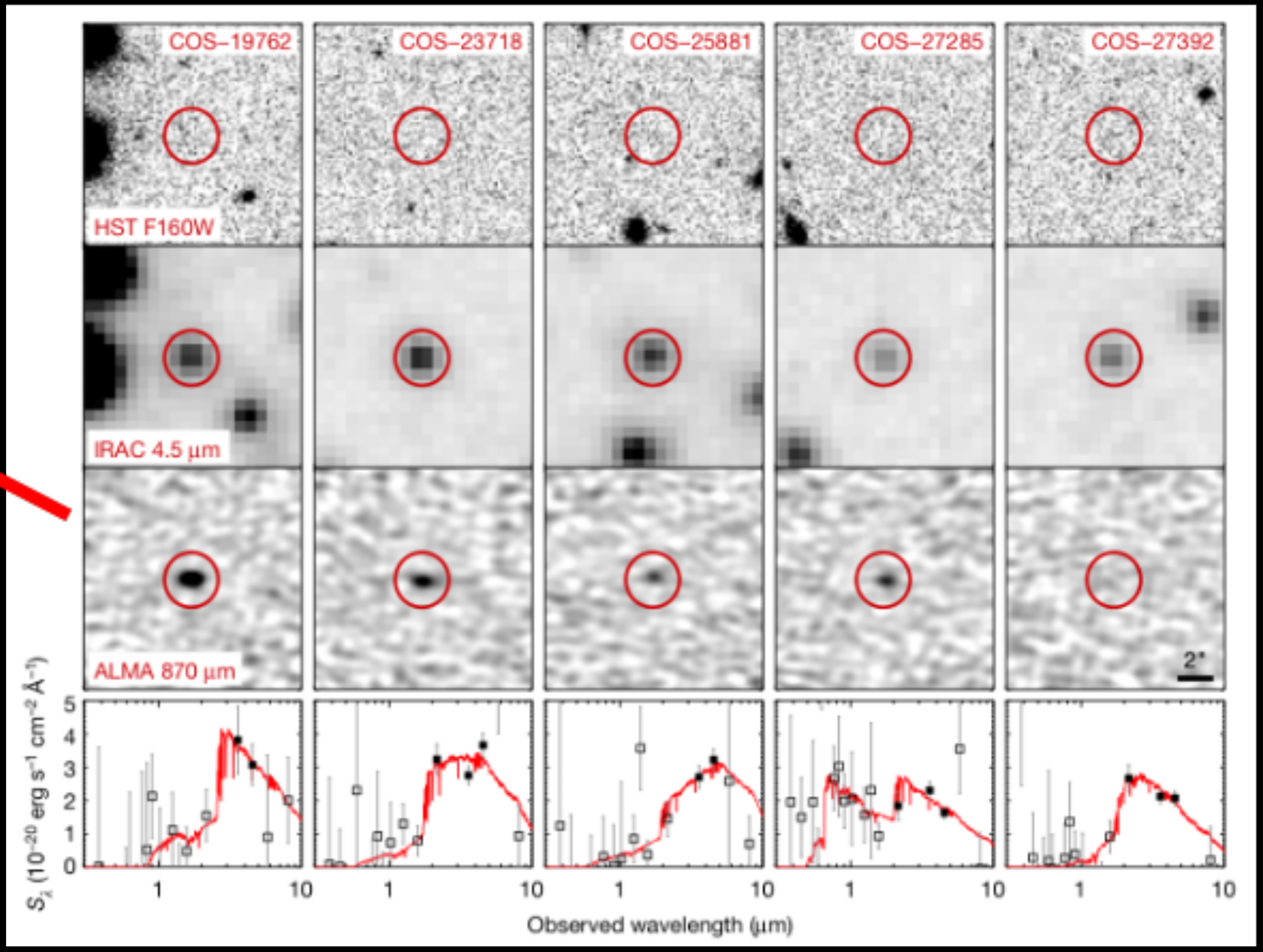


Madau & Dickinson 2014

Optically Dark Galaxies

- Invisible in deep optical/near-IR surveys, but bright at longer far-IR/mm wavelengths
- z > 3, massive, dusty SFGs, with typical main sequence SFR
- Abundant and important contributors of massive galaxies to the cosmic SFRD at z > 3



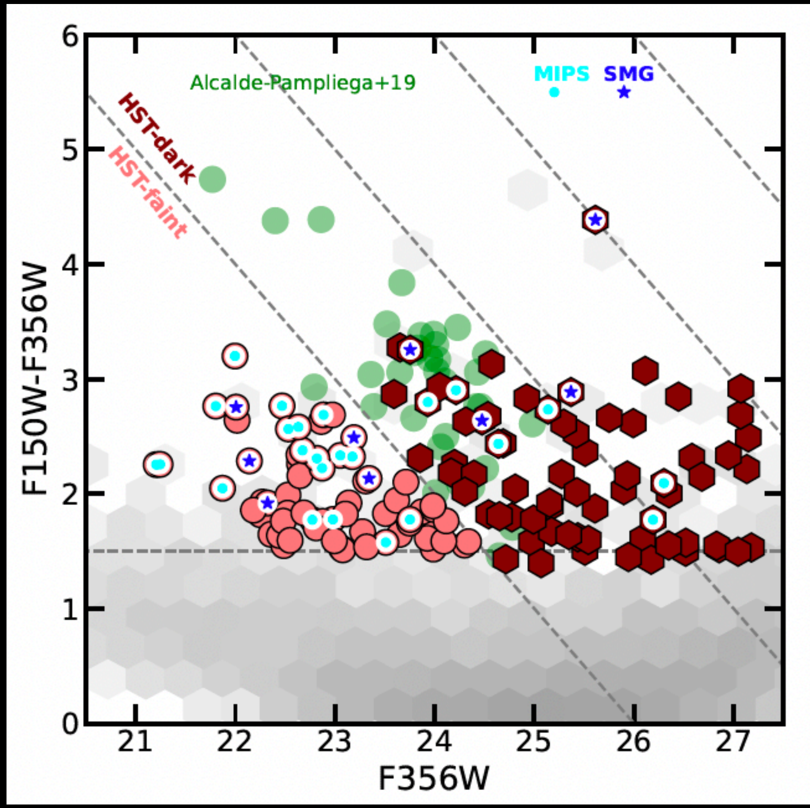


Wang et al. 2019

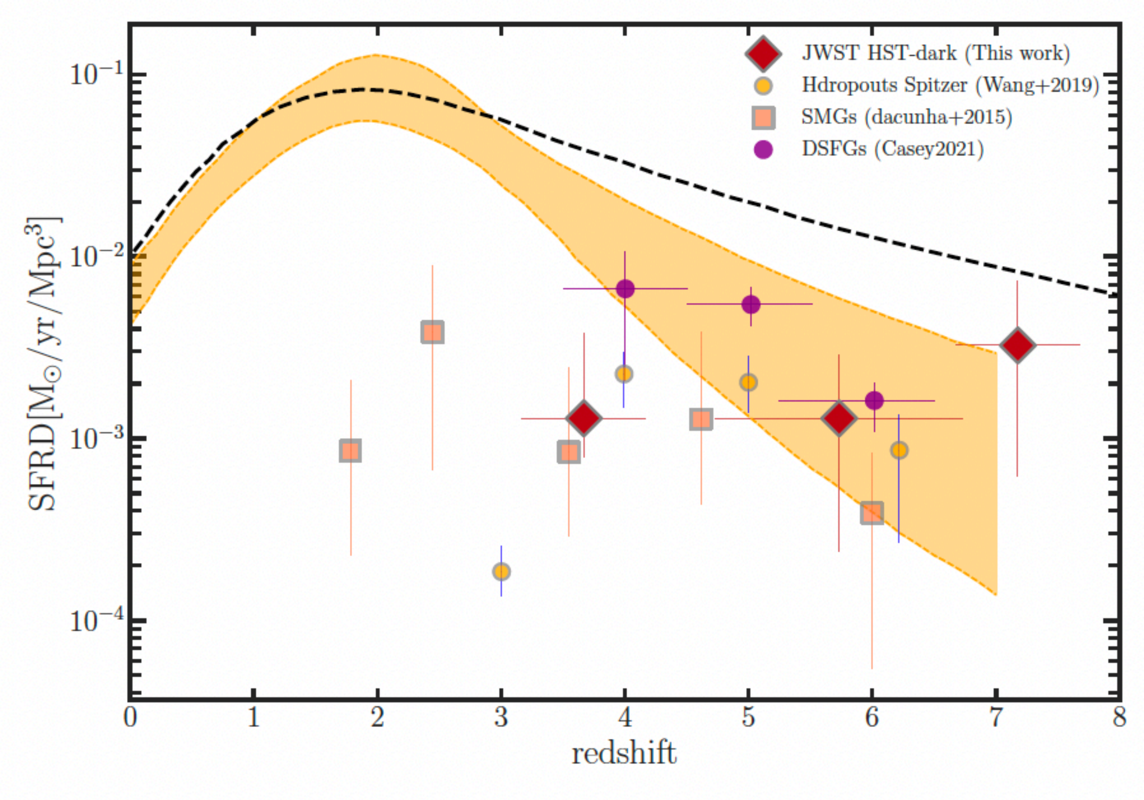
Pre-JWST: see e.g., Simpson+14; Wang+16,19; Franco+18; Alcalde Pampliega+19; Yamaguchi+19; Williams+19; Romano+20; Toba+20; Umehata+20; Zhou+20; Gruppioni+20; Talia+21; Smail+21; Fudamoto+21; Manning+22; **Gómez-Guijarro+22**; Shu+22; Enia+22; Xiao+23

JWST era: Optically Dark Galaxies

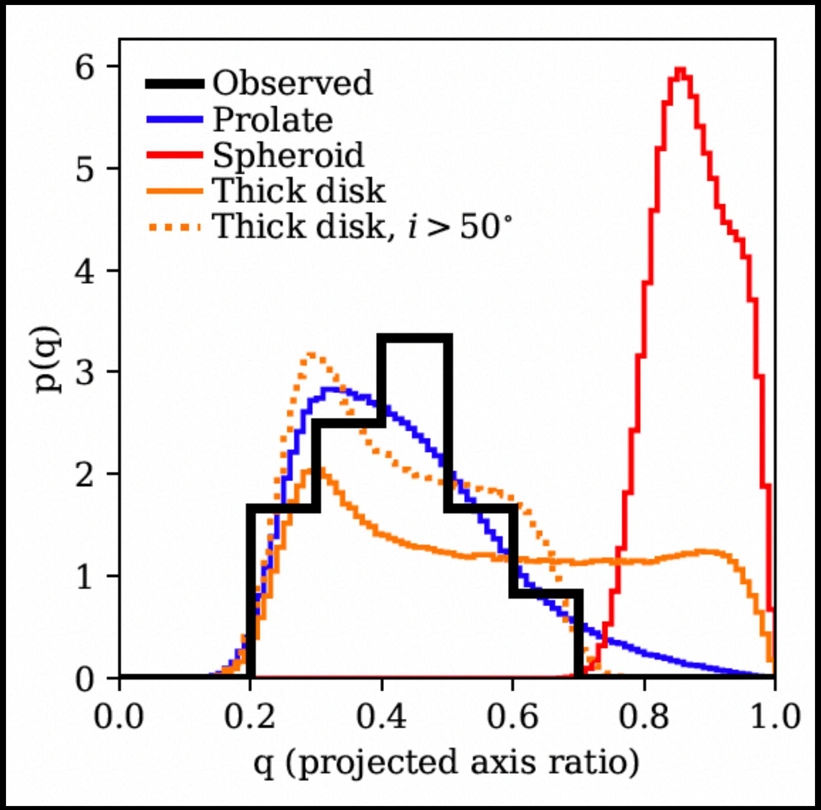
- Unknown nature:
  - Redshift, stellar mass, cosmic relevance
  - Why are they so faint at optical/near-IR wavelengths?



Pérez-González et al. 2023



Barrufet et al. 2023



Nelson et al. 2023

JWST era: Optically Dark Galaxies

Gómez-Guijarro et al. 2023

- **What are the drivers of dust attenuation in the JWST-era?**
  - **Role of stellar mass, size, and orientation in obscuring star-forming galaxies at $3 < z < 7.5$**

see also e.g., Barrufet+23; Nelson+23; Pérez-González+23; Rodighiero+23; Kokorev+23

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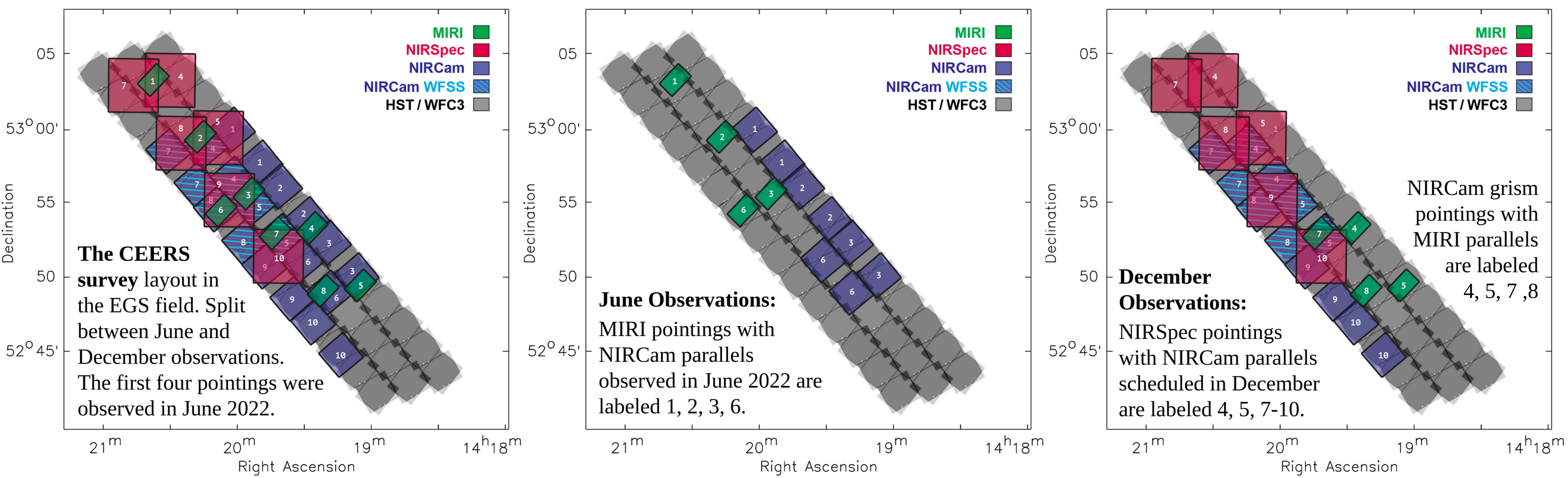
CEERS

- *JWST* CEERS (Finkelstein et al. 2022) - Full dataset (EGS: ~ 100 arcmin²)
- NIRCam: F115W, F150W, F200W, F277W, F356W, F410M, and F444W
- *HST* ACS/WFC F606W, F814W; WFC3/IR F105W, F125W, F140W, and F160W



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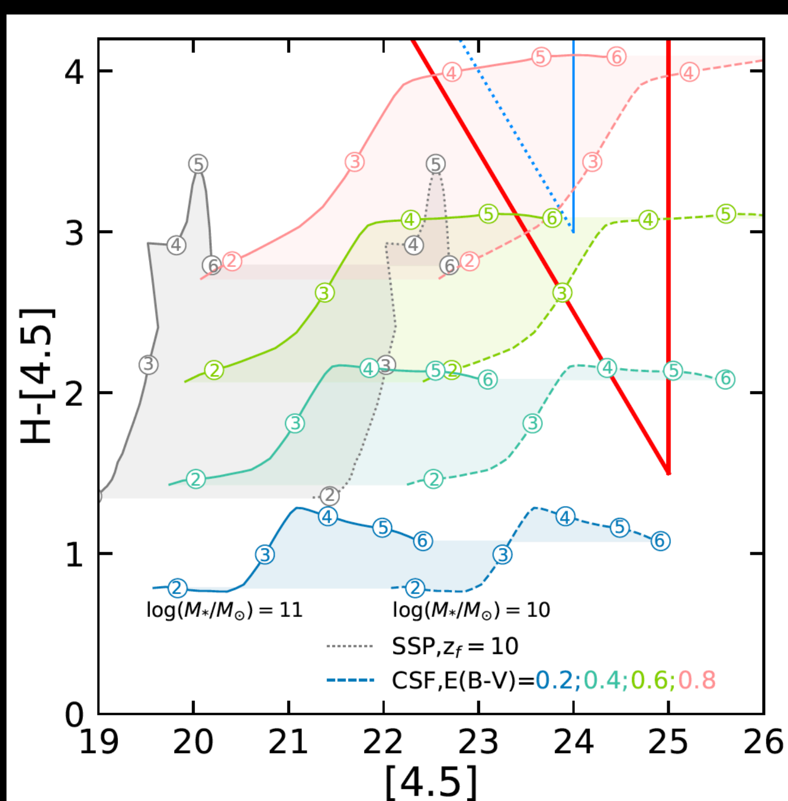
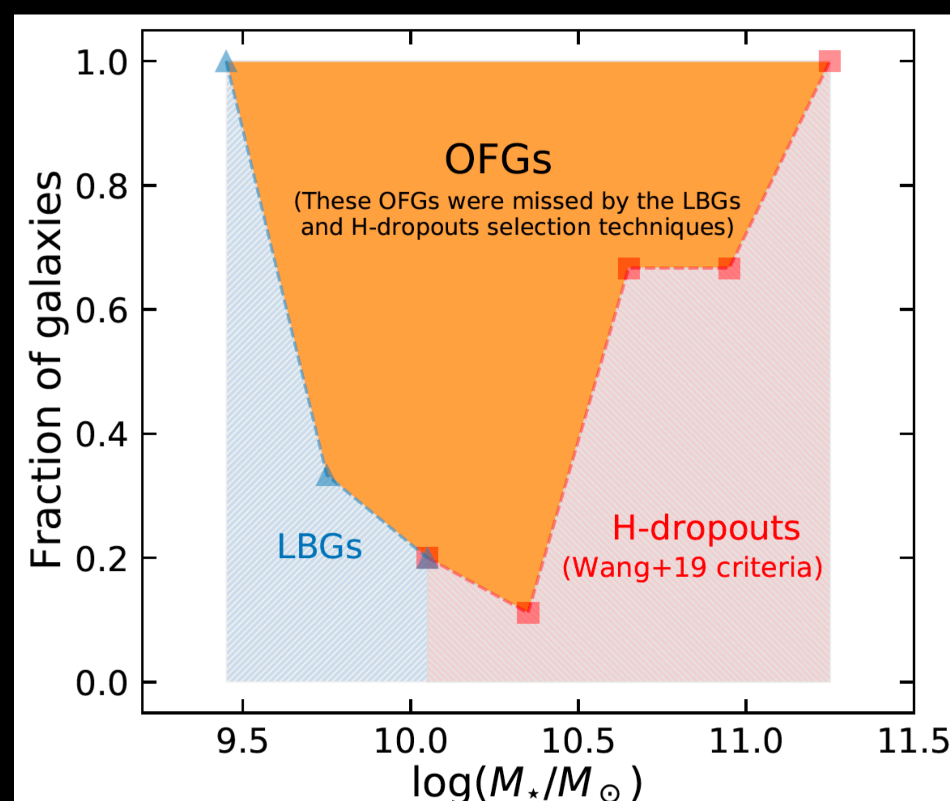
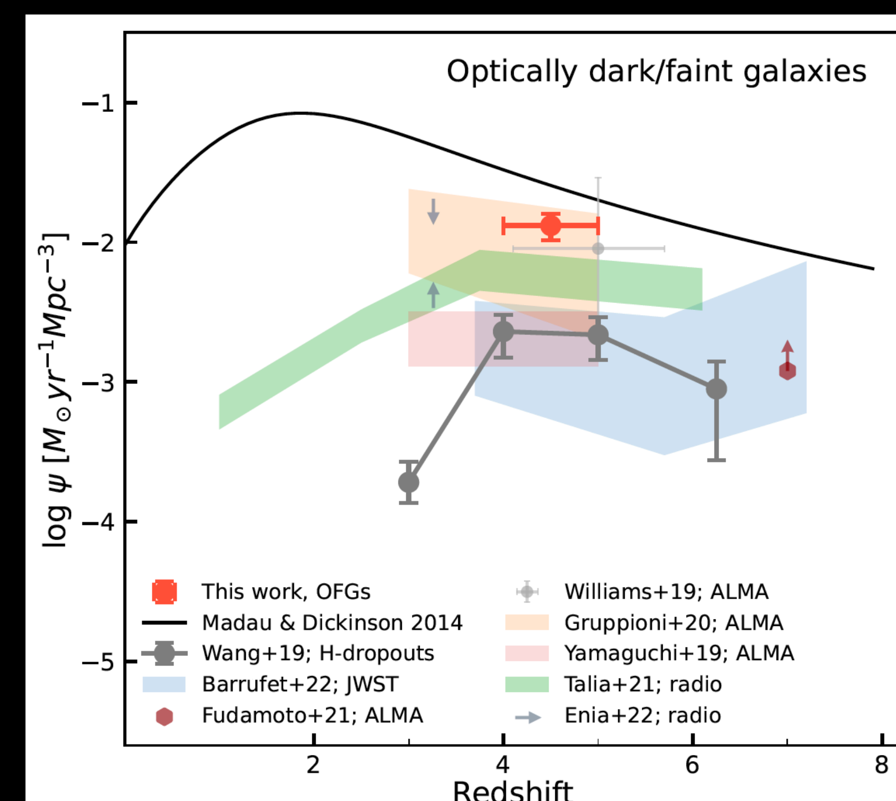
Gómez-Guijarro et al. 2023

- **What are the drivers of dust attenuation in the JWST-era?**
  - Role of stellar mass, size, and orientation in obscuring star-forming galaxies at $3 < z < 7.5$
  - Parent SFGs: UVJ-classified SFGs
  - Blue SFGs: Lyman break galaxies (LBGs)
  - Red SFGs: Optically dark/faint galaxies (OFGs)







Xiao, Elbaz, Gómez-Guijarro et al. 2023

see also e.g., Barrufet+23; Nelson+23; Pérez-González+23; Rodighiero+23; Kokorev+23

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Gómez-Guijarro et al. 2023

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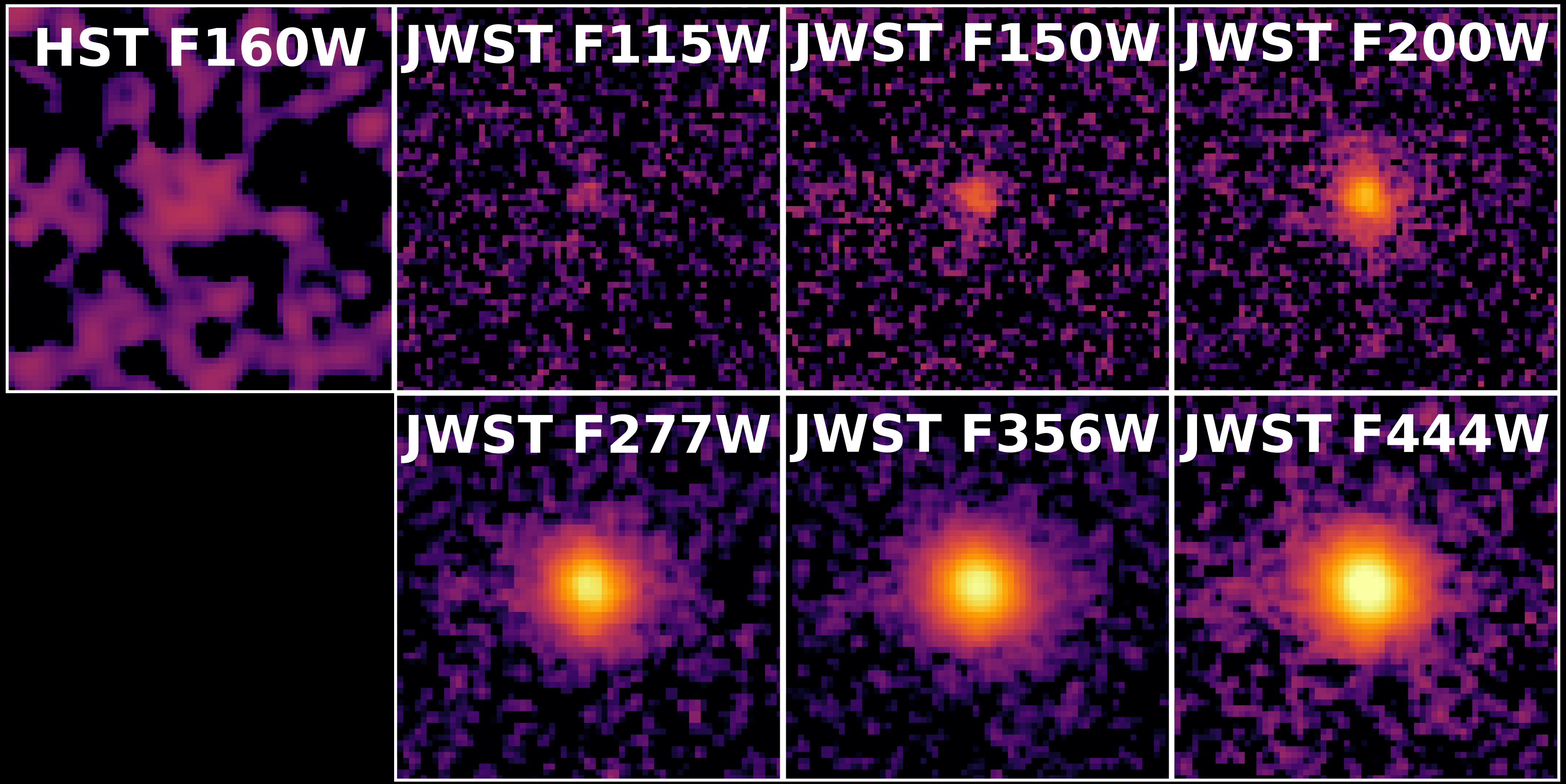
$z = 3.52$; $\log(M_*/M_\odot) = 10.39$



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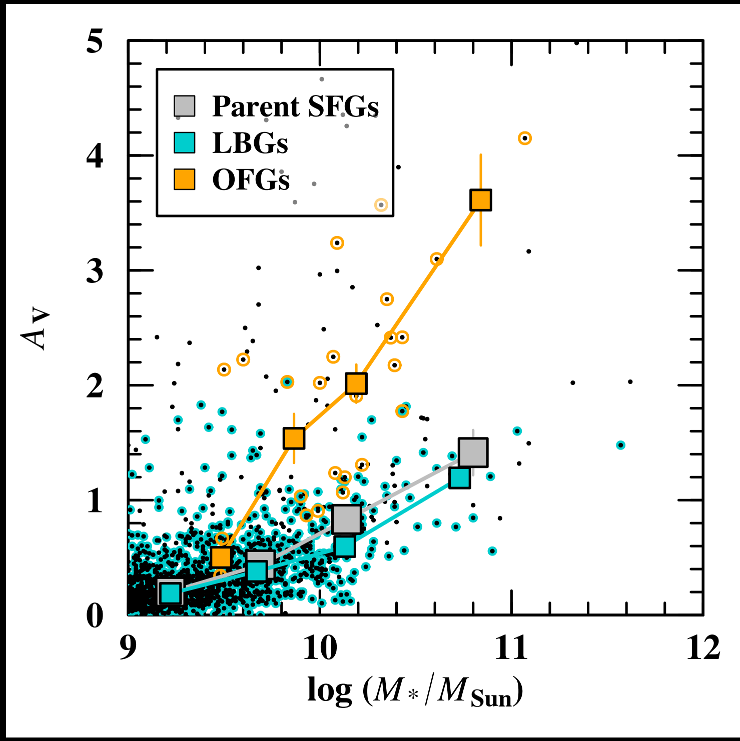
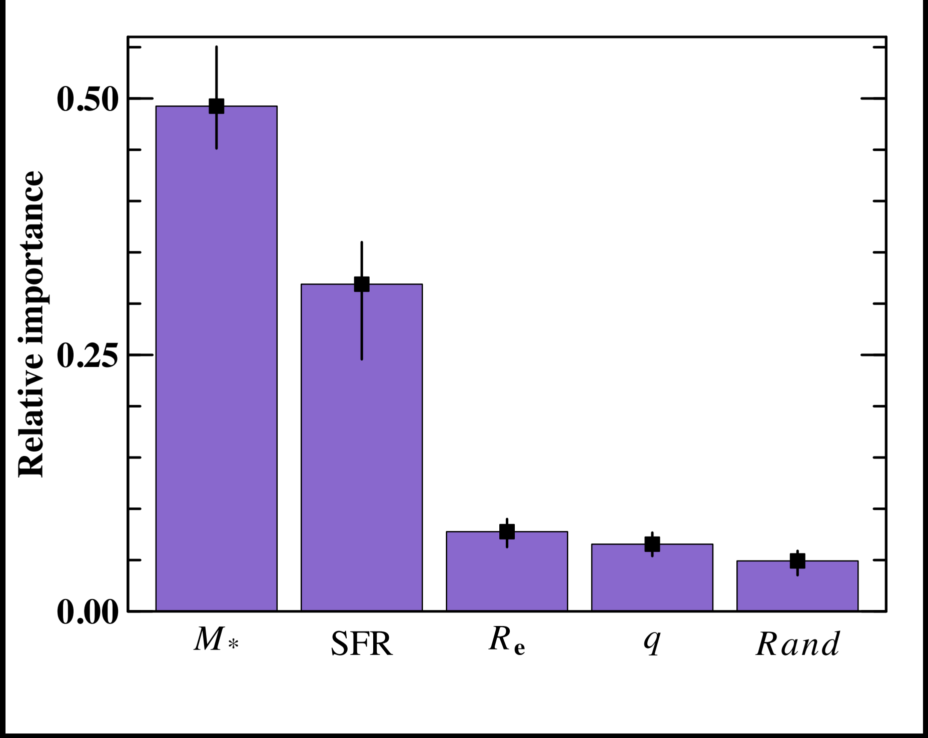
Drivers of Dust Attenuation

- Stellar mass is the primary proxy of dust attenuation among those studied



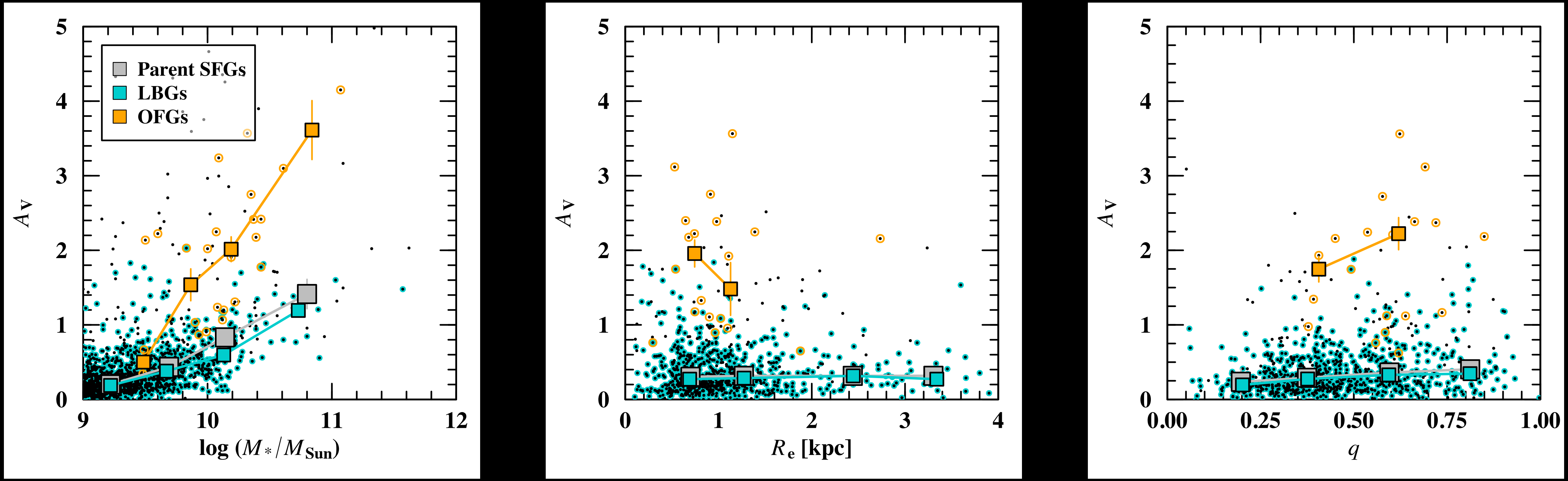


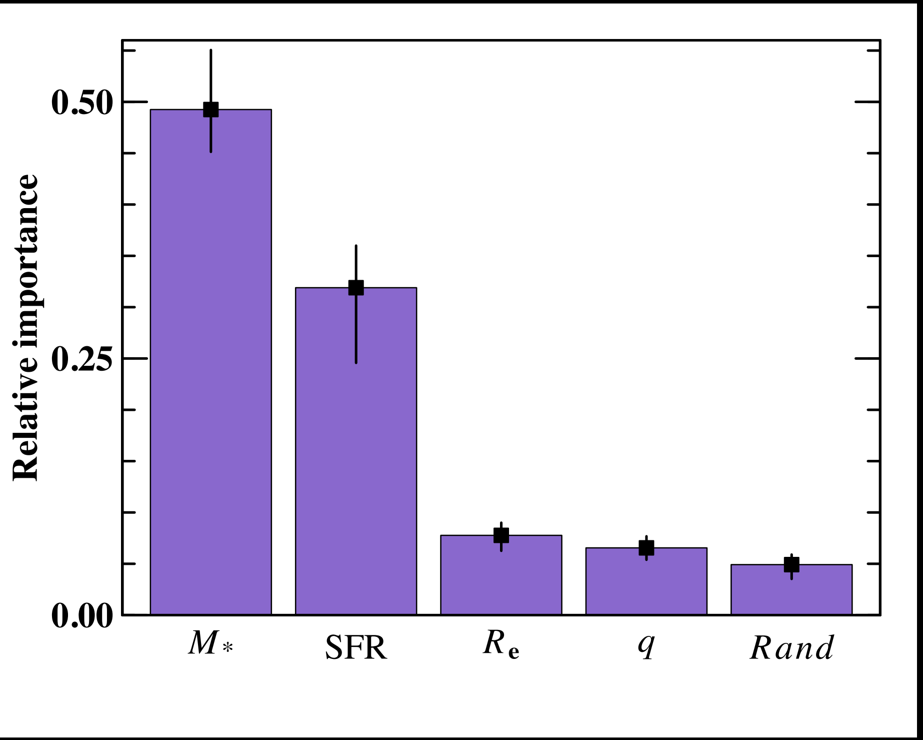
Gómez-Guijarro et al. 2023

see also e.g., Garn & Best 2010; Zahid+13; Heinis+14; Pannella+15; Álvarez-Márquez+16; Yung+19; Fudamoto+20; Bogdanoska & Burgarella 2020; Shapley+23

Drivers of Dust Attenuation

- Stellar mass is the primary proxy of dust attenuation among those studied
- Effective radius and axis ratio do not show a clear link with dust attenuation
- Orientation close to random





Gómez-Guijarro et al. 2023

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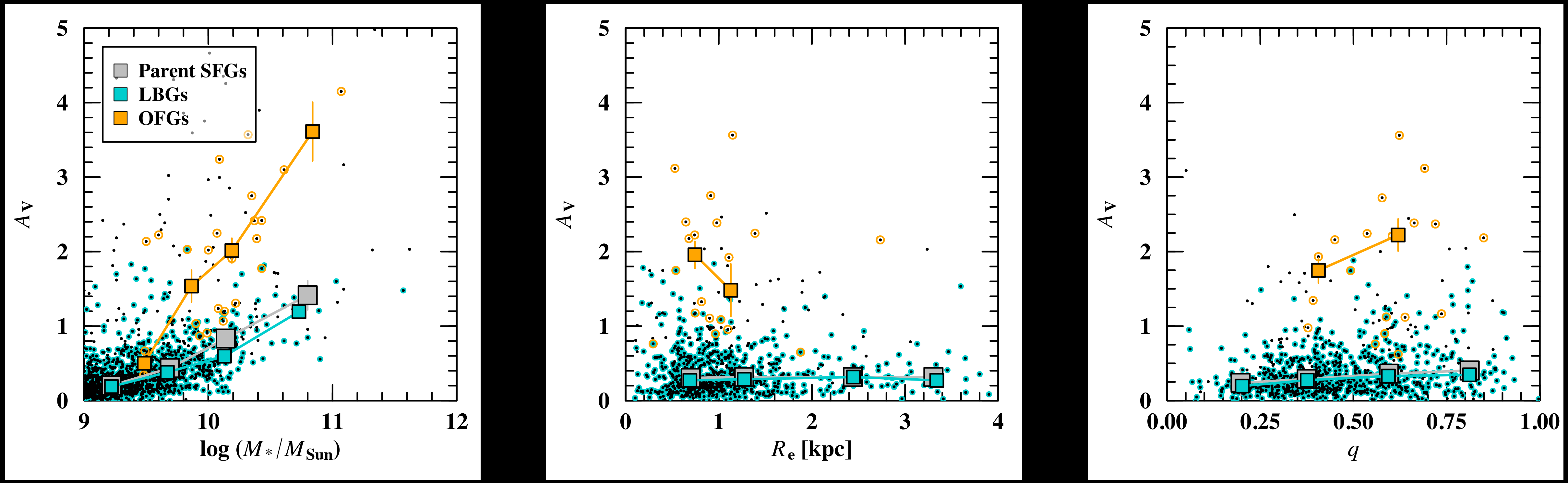

- **Still:** Subset of optical/near-IR faint galaxies highly dust attenuated (Av > 1)
- **Why are they so faint at optical/near-IR wavelengths?**

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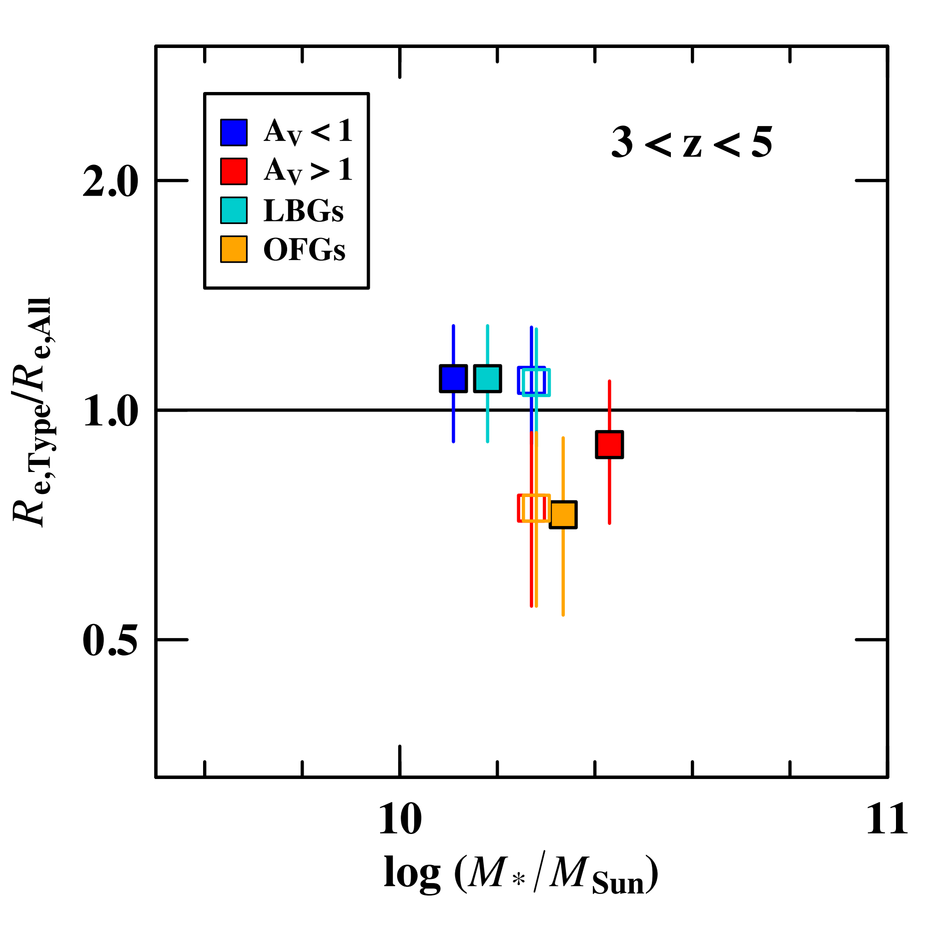
Drivers of Dust Attenuation

- OFGs: Why are they so faint at optical/near-IR wavelengths?
- Key distinctive feature is their compact size
- 30% smaller effective radius than the average SFGs at fixed stellar mass and redshift
- No preference for low axis ratios, e.g., edge-on disks (Nelson+23)



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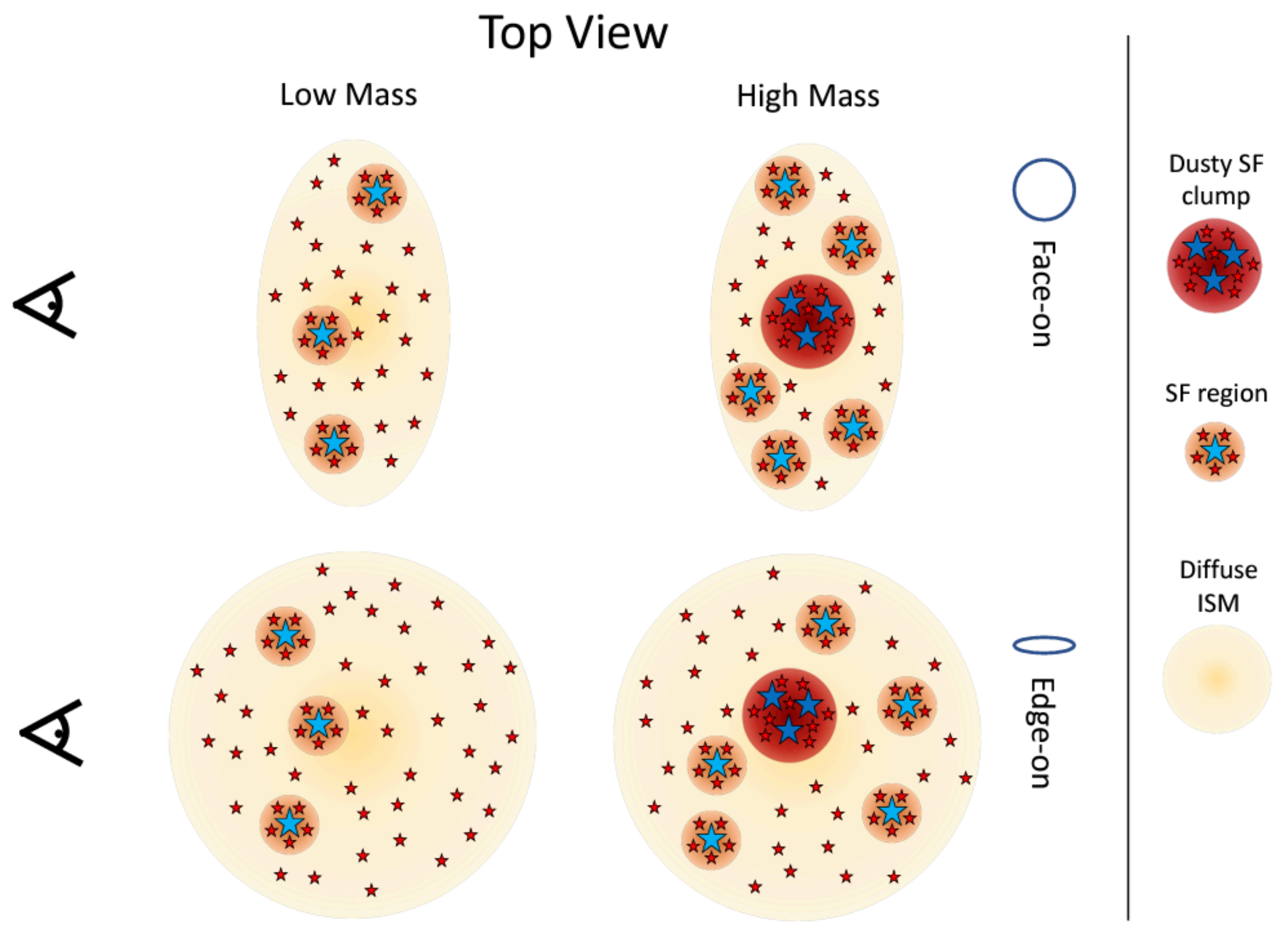

Figure 9. One low-mass galaxy (left) and one high-mass galaxy (right) viewed by an observer as a face-on (top) and edge-on (bottom) system. The observer is represented by an eye, and the reader is viewing the picture from above. The yellow background represents dust in the diffuse ISM, the orange represents dust in typical-size star-forming regions, and the red represents dust in the large 1kpc-scale star-forming clumps. Both of the star-forming structures are populated with young stars, but there is a higher fraction of young stars in the clumps. In all cases, since the ISM is not contributing much to attenuation, the observer sees similar attenuation in both face-on and edge-on orientations. Also, at higher masses (right), larger attenuation is observed due to the longer average path-length of light through the larger clumps. Finally, the excess attenuation ($A_{\rm Balmer} - A_V$) is larger for the high mass (high SFR) galaxies, due to the extra Balmer light originating in the massive clumps.

Lorenz+23

- **Keck/MOSFIRE MOSDEF survey**
- **Dust attenuation dependence on viewing angle for 308 SFGs at 1.3 < z < 2.6**
- ***"None of the dust properties (Balmer decrement, A_V, β) vary with axis ratio"***

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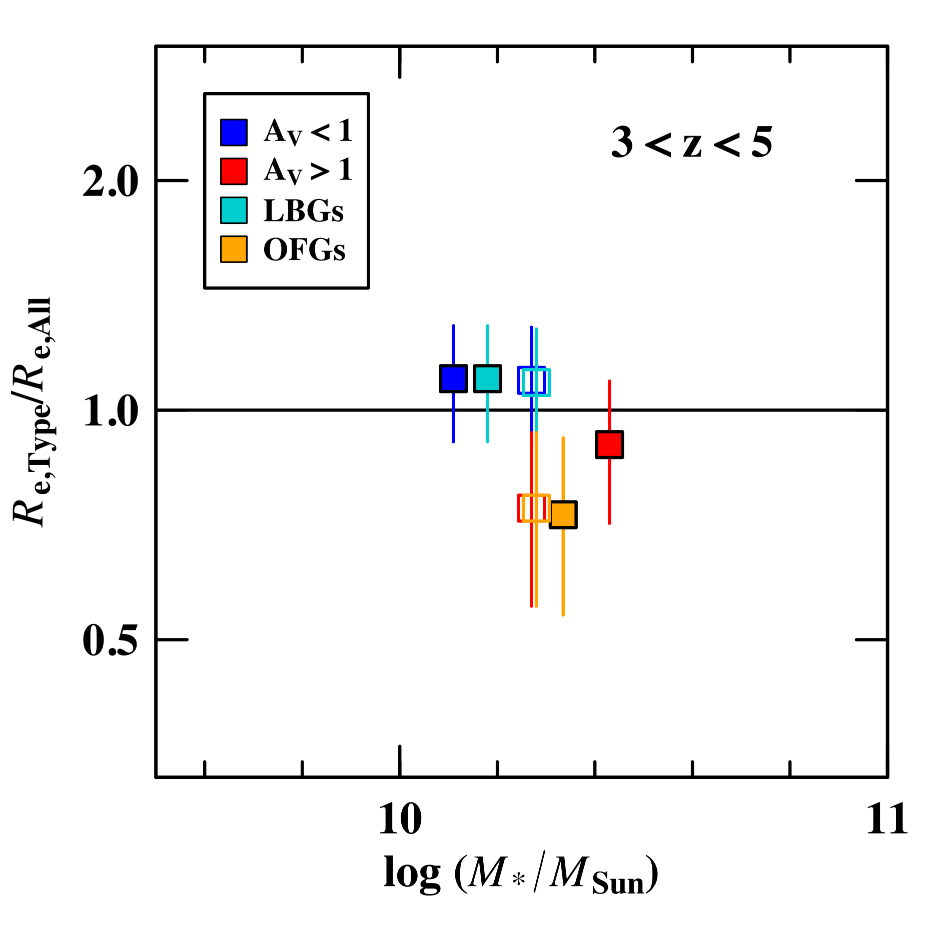

- Stellar mass as a primary proxy of dust attenuation
- Compact stellar light profiles behind thick dust columns obscuring typical massive SFGs

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