DUST IN GALAXIES AT INTERMEDIATE Z: WHAT CAN WE LEARN FROM CANDELS DATA?

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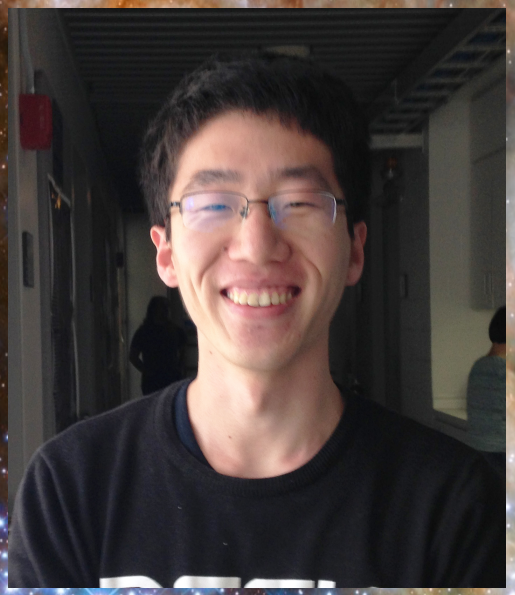


Weichen Wang

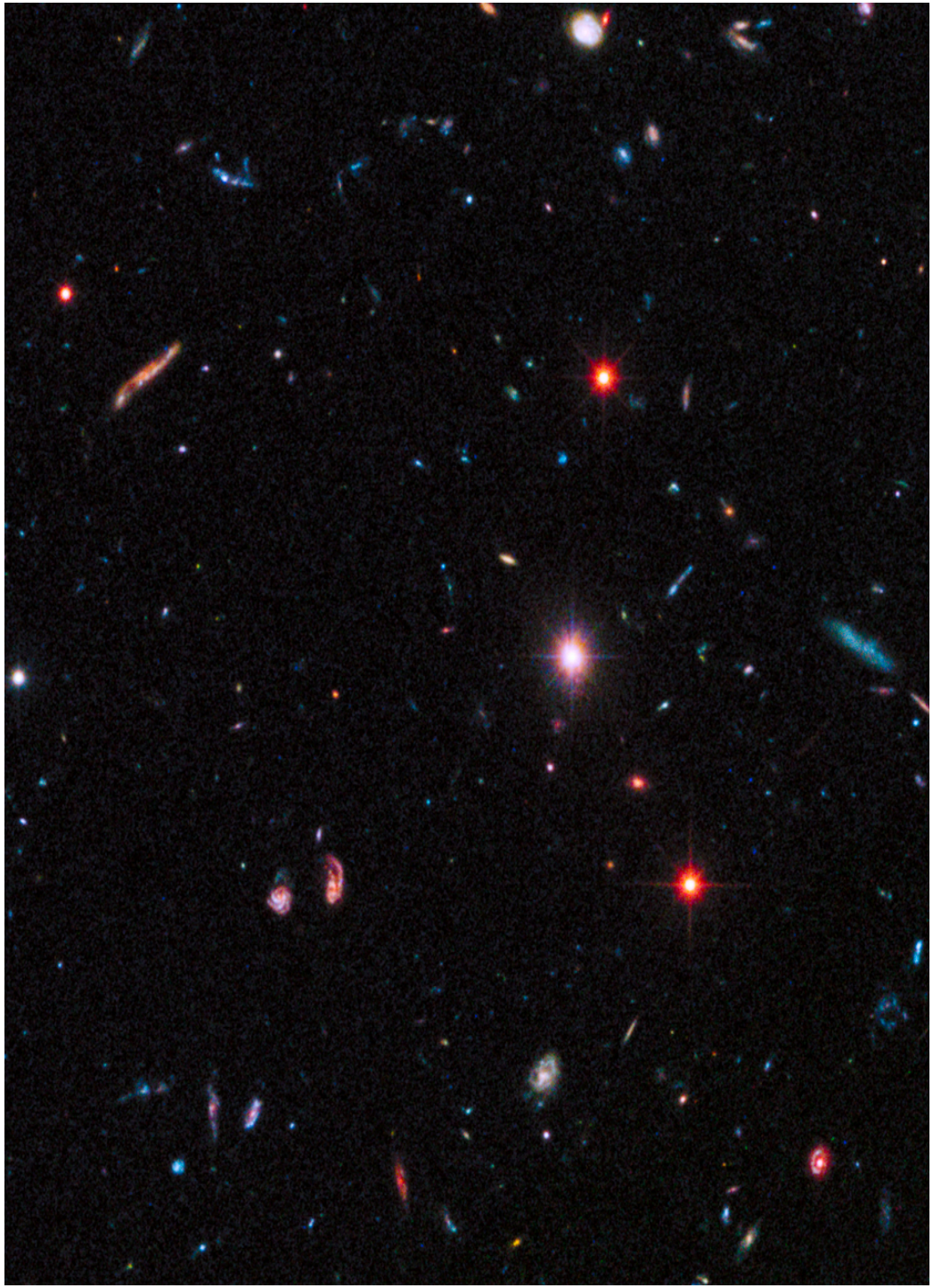
First Year Graduate Student at Johns Hopkins Universty

At Cosmic Noon, galaxies are affected by dust, especially in the UV/optical

1. How does this affect our measurements of SFR when only the UV/optical is used?

2. What does this tell us about interpreting SFR measurements at high z?

3. What can we learn about the dust/star geometry at this epoch?



Measuring SFR from UV observations

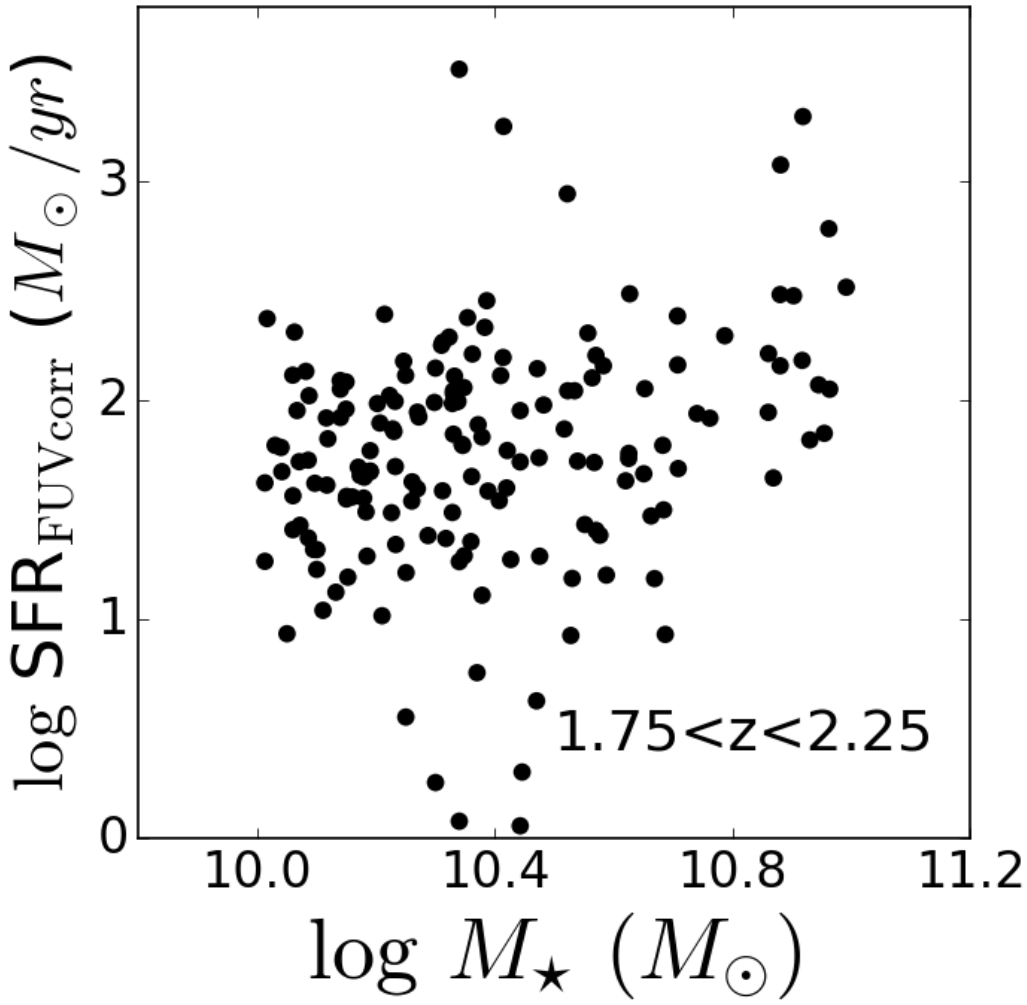
$A_{FUV} = 1.99\,\beta + 4.48$
Meurer et al. 1999

- Measure attenuation A_{FUV}
  - Far UV photometry or spectra -> β (UV slope) -> A_{FUV}
- Correct Flux in the FUV by A_{FUV}
- SFR_{FUV} using Daddi et al. 2007

NGC 4388; credit: HST

Star-Formation Main Sequence using SFR_{FUV}

UV (rest-1600Å) corrected for dust using Meurer+99



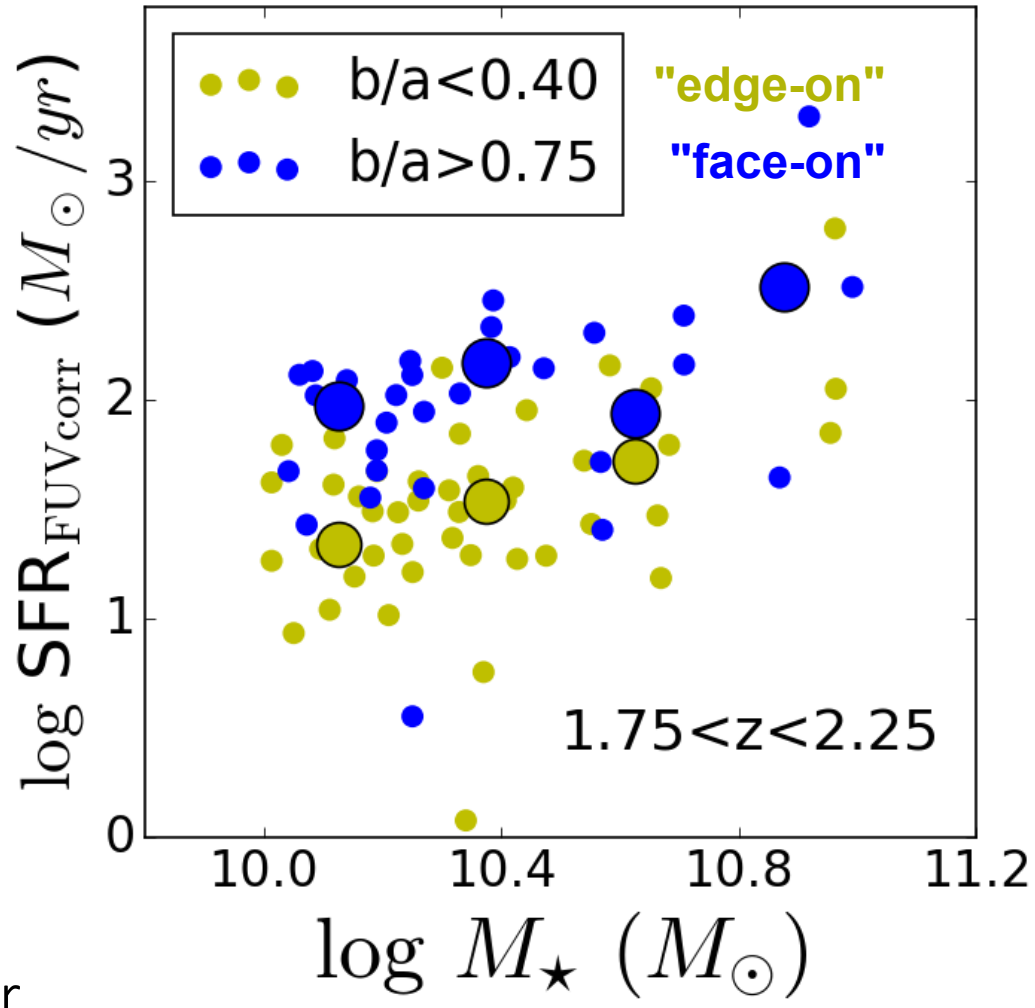
Wang, Kassin et al. in prep

SFR_{UV} Depends on Galaxy Inclination

offset is ~0.5dex

UV corrected for dust using Meurer+99

b/a = galaxy major-to-minor axis ratio in WFC3/F160W (van der Wel et al. 2012)



Wang, Kassin et al. in prep

Measuring SFR from UV observations

Need to take inclination into account

Offset is on order 0.5dex for galaxies of different inclination.

$A_{FUV} = 1.99\,\beta + 4.48$
Meurer et al. 1999

Far UV photometry or spectra -> β (UV slope) -> Attenuation A_{FUV}

NGC 4388; credit: HST

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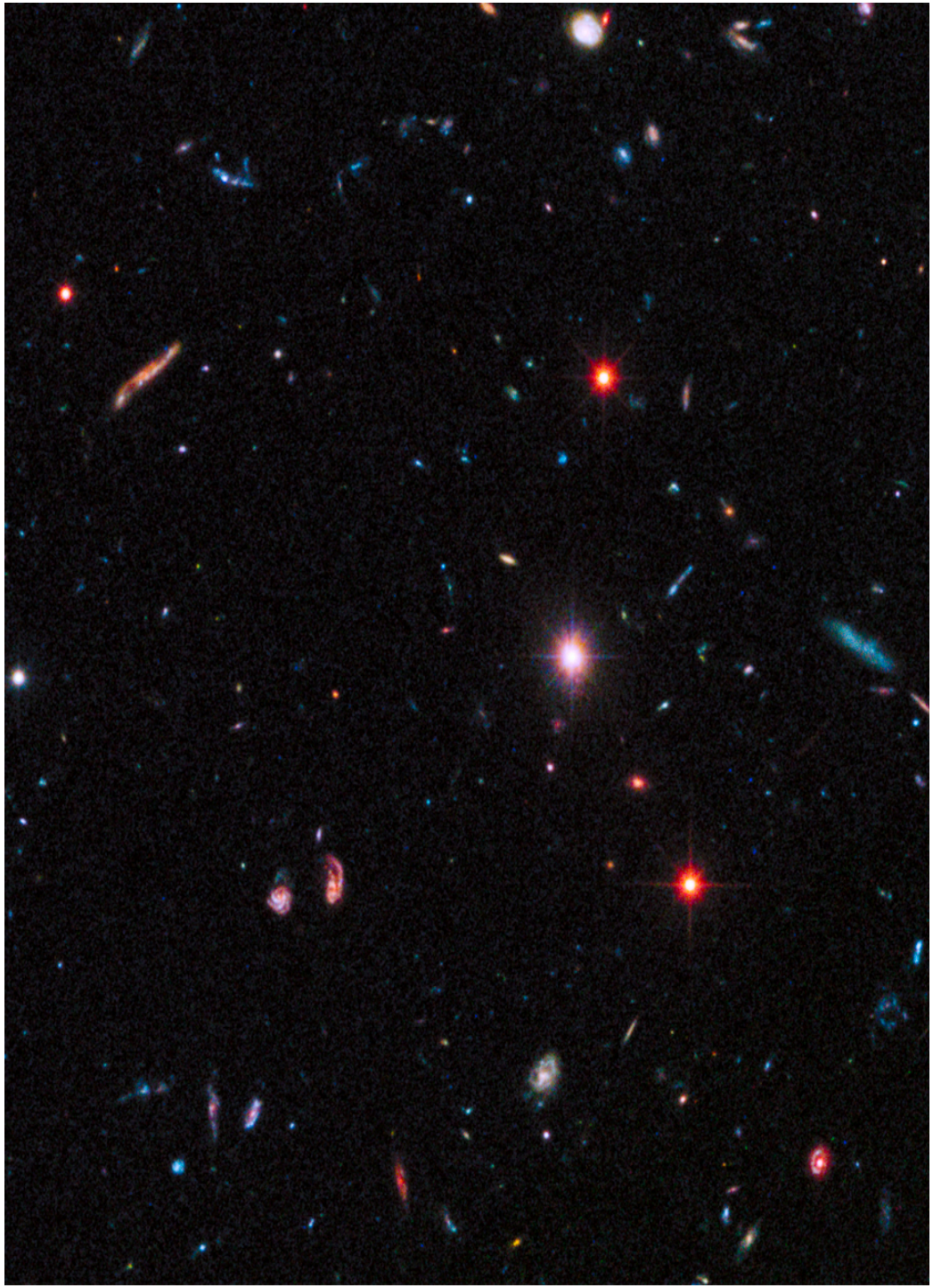
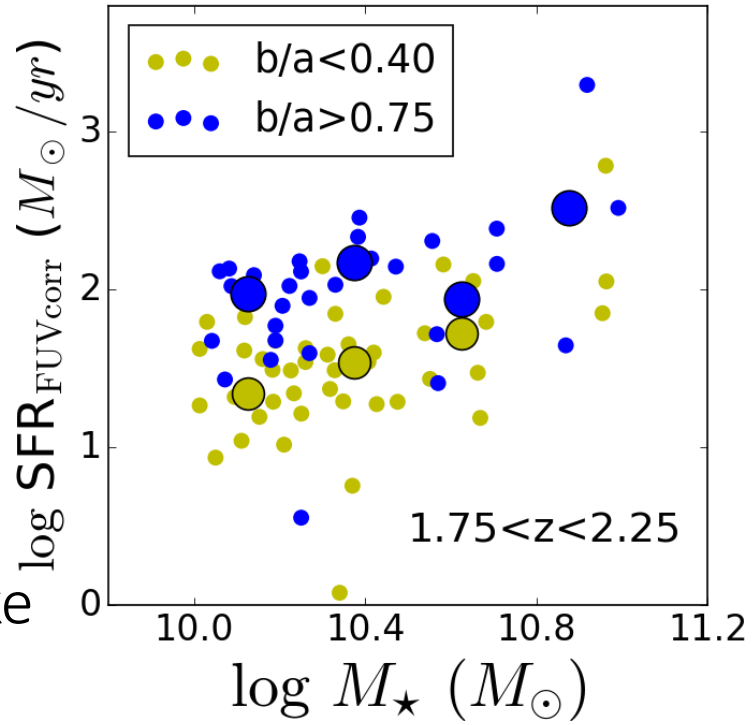


How do we interpret the inclination dependence of the extinction correction (e.g., Meurer et al. 99)?

One possibility:
-Axial ratio is telling you about inclination (i.e., they're mostly disk-like and not all mergers/prolate/chains).
-Edge-on galaxies are opaque enough that a good amount of the UV flux is not getting through.

UV-derived SFRs need to take into account galaxy inclinations.



SFR_{UV} Depends on Galaxy Inclination

Wang, Kassin et al. in prep

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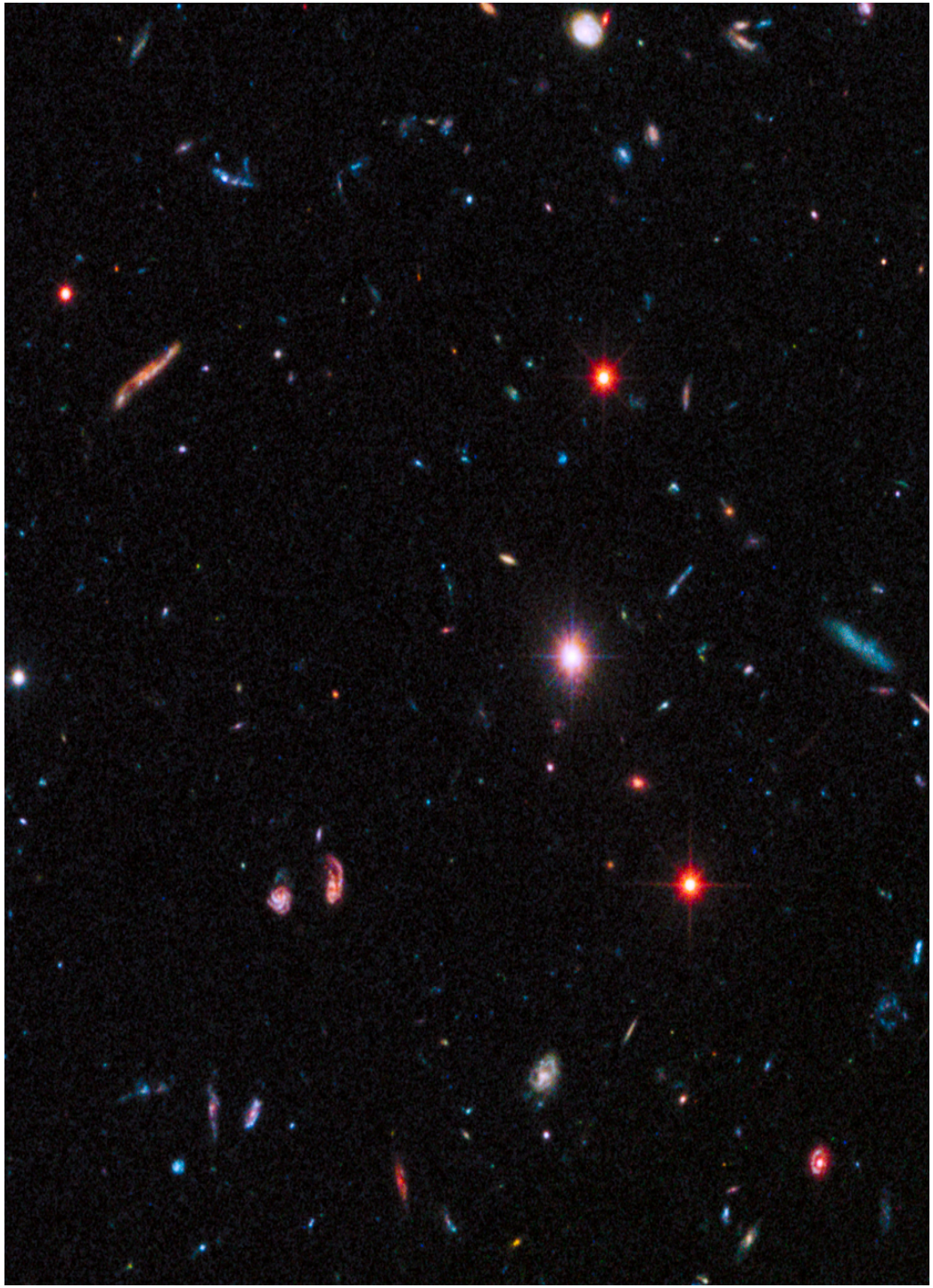
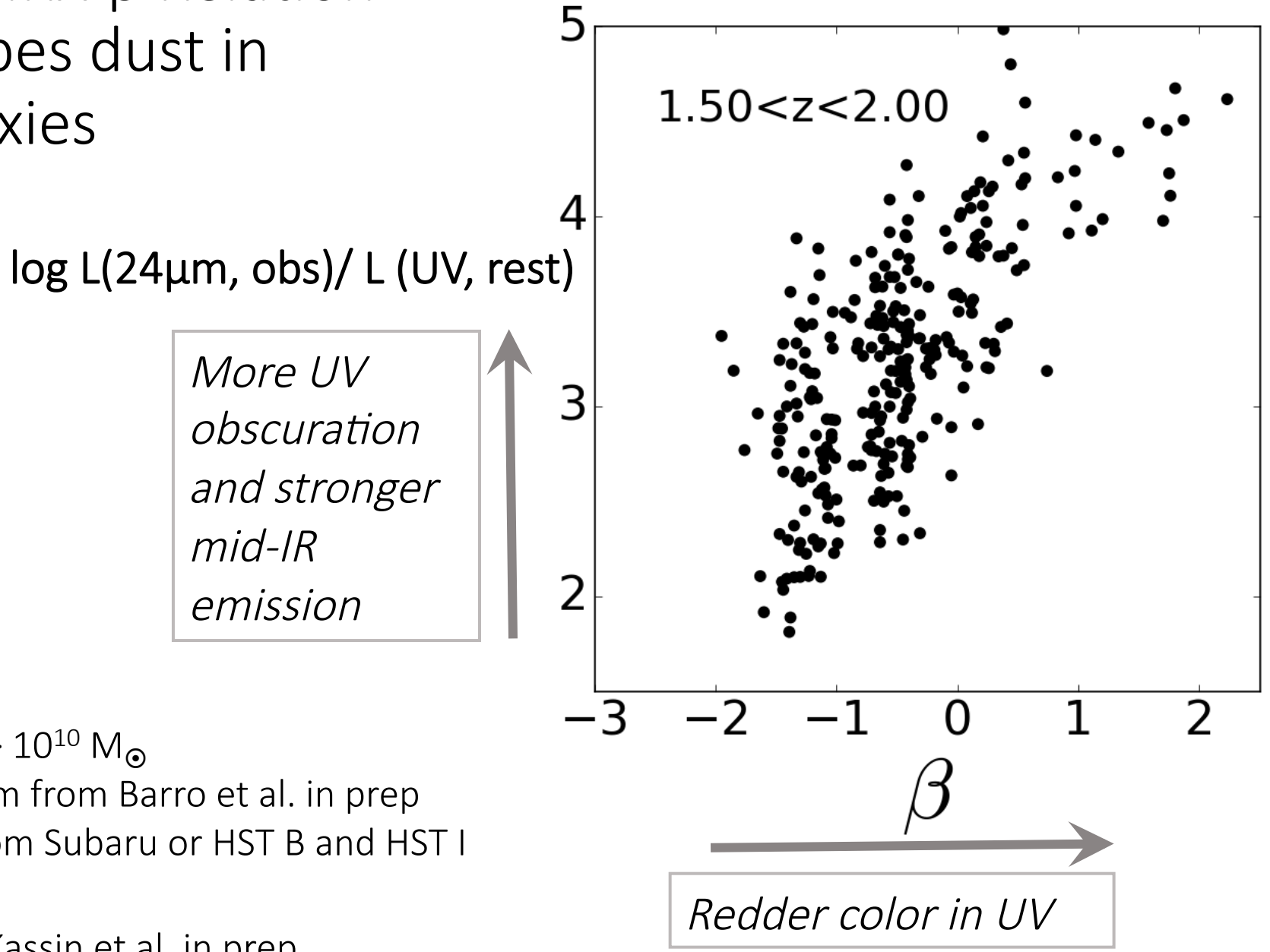


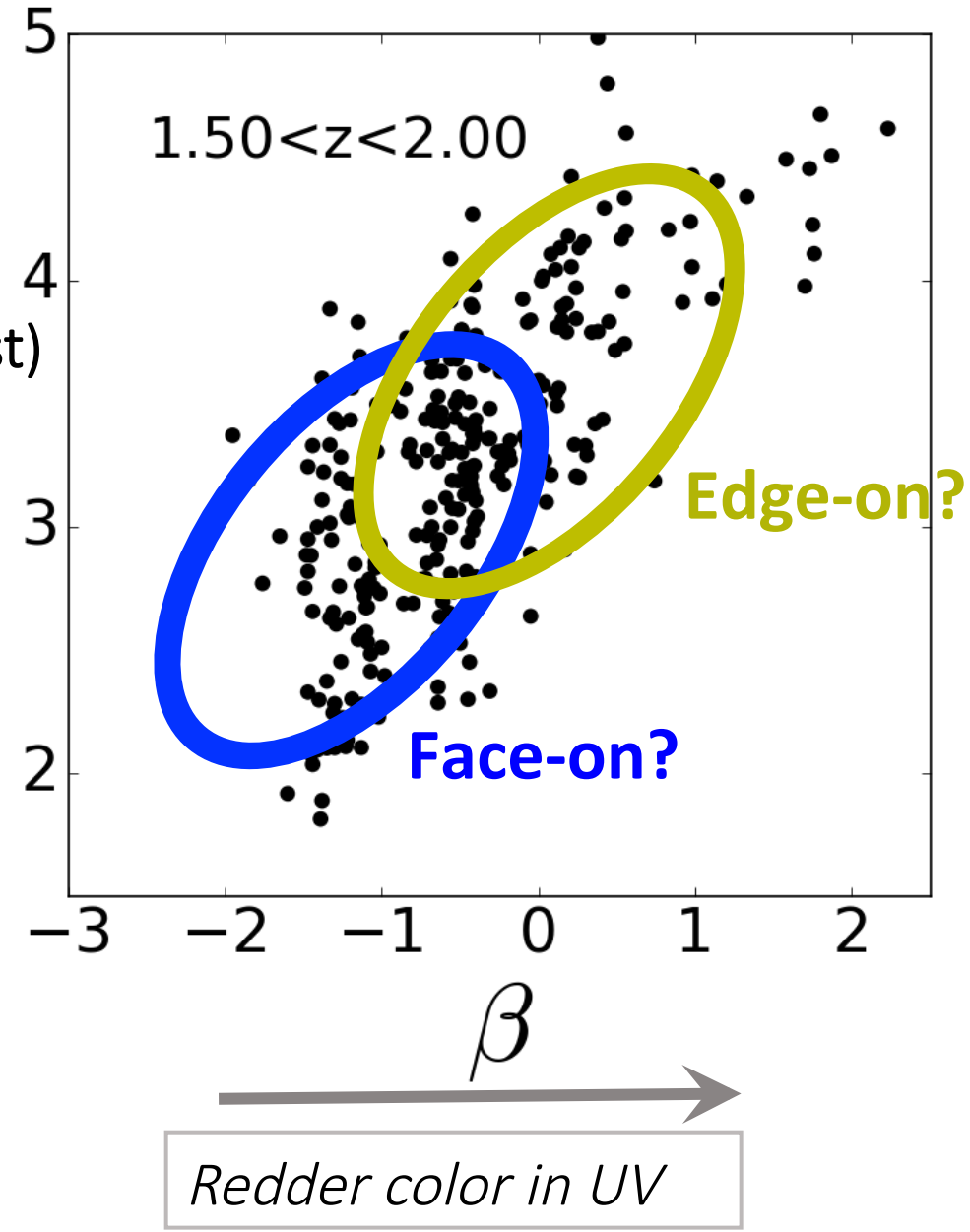
The IRX-β Relation probes dust in galaxies



- $M_* > 10^{10} M_\odot$
- 24μm from Barro et al. in prep
- β from Subaru or HST B and HST I

Wang, Kassin et al. in prep

Where do you think edge-on galaxies lie on IRX-β? Face-on galaxies?



log L(24μm, obs)/ L (UV, rest)

More UV obscuration and stronger mid-IR emission

Redder color in UV

- $M_* > 10^{10}\ M_\odot$
- 24μm from Barro et al. in prep
- β from Subaru or HST B and HST I

Wang, Kassin et al. in prep

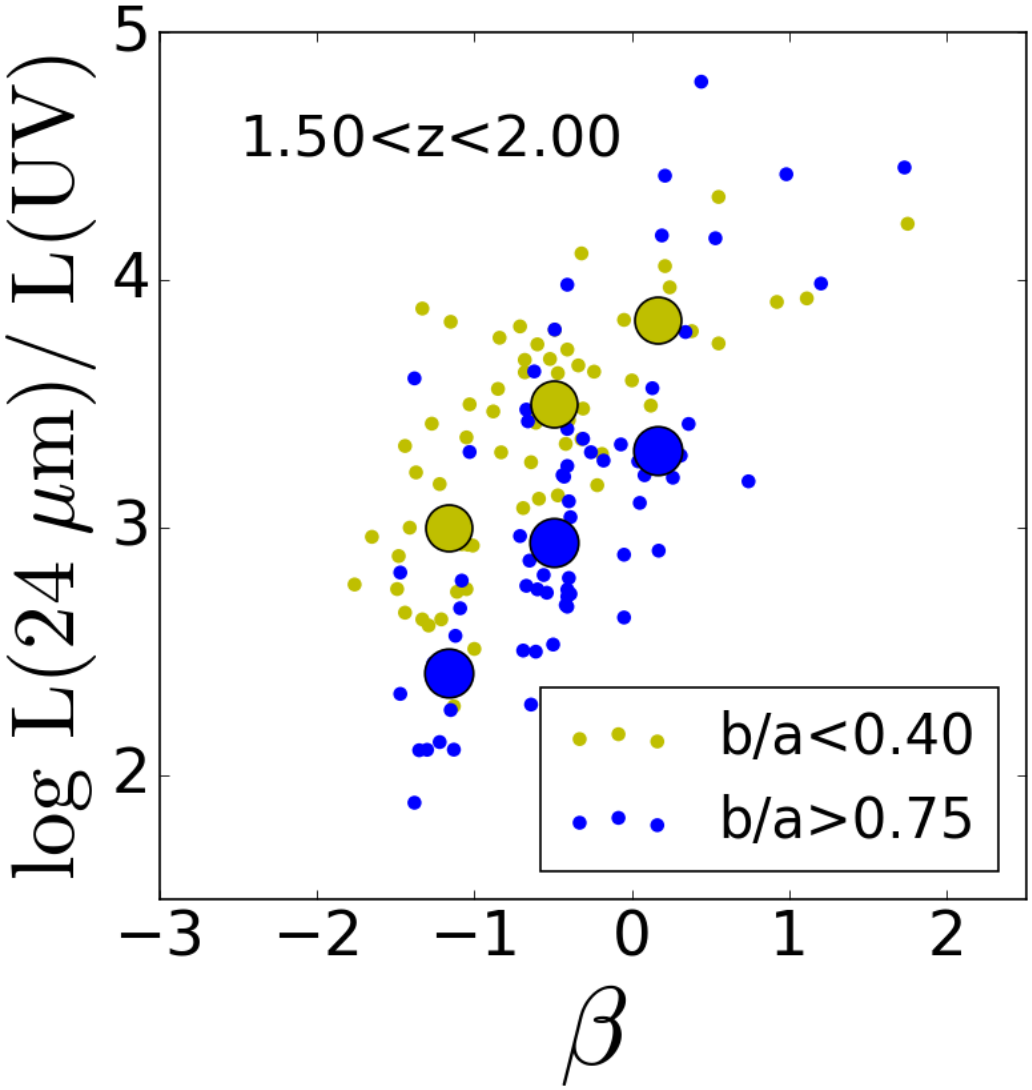
The inclination depen across the relation

(preliminary)

Blue: Face-on galaxies

Yellow: Edge-on galaxies

Inclined galaxies have a large IR/UV for a given β. Inclination moves them *across* the relation, instead of along the relation.

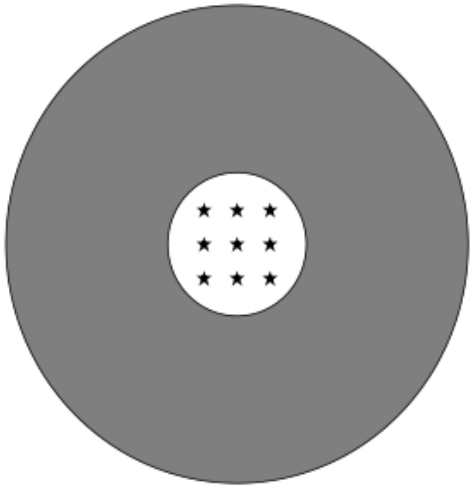


b/a = galaxy major-to-minor axis ratio in WFC3/F160W (van der Wel et al. 2012)

Wang, Kassin et al. in prep

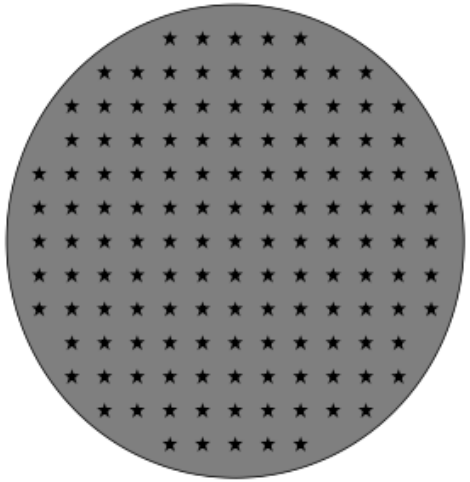
DIRTYGRID: Radiative Transfer modeling (DustI Radiative Transfer, Yeah!)

Shell Model



Geometry 1:
Stars in the center of a dust shell

Dusty Model



Geometry 2:
Stars and dust mixed with each other

Witt & Gordon 2000; Law, Gordon & Misselt in prep.

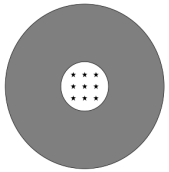
DIRTYGRID model parameters

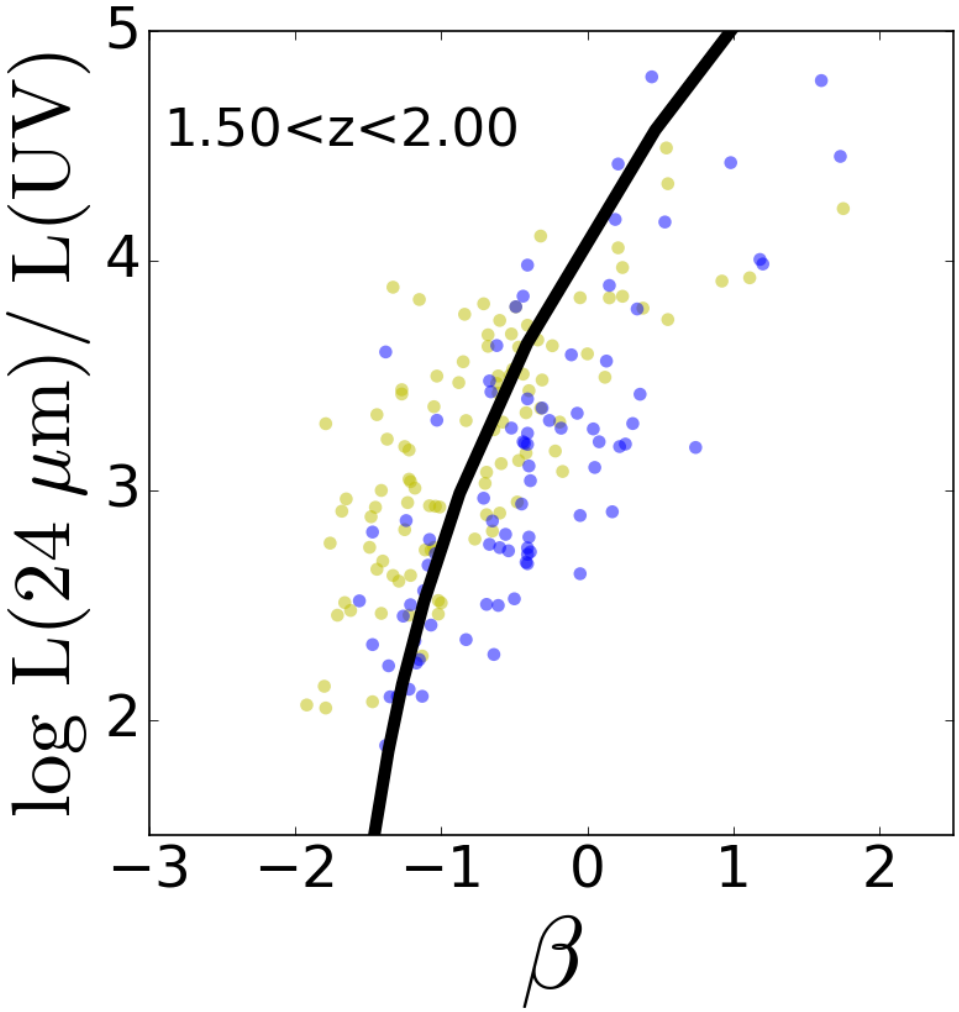
Parameters	Range
Dust geometry	Shell, Dusty, Cloudy
Dust type	Milky Way, SMC, LMC
Star formation history	Single burst, Constant
Stellar age	1 Myr-13 Gyr
Star formation rate density	—
Metallicity of stars	0.005-5.0 Solar Abundance

DIRTIGRID for Shell geometry

Fiducial model:

- Shell geometry
- Milky Way dust
- 100 Myrs
- solar metallicity
- single burst
- $M_* = 10^{10}\ M_\odot$



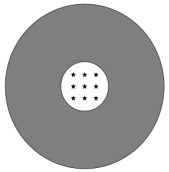


Wang, Kassin et al. in prep

DIRTIGRID shell geometry with varying stellar population ages

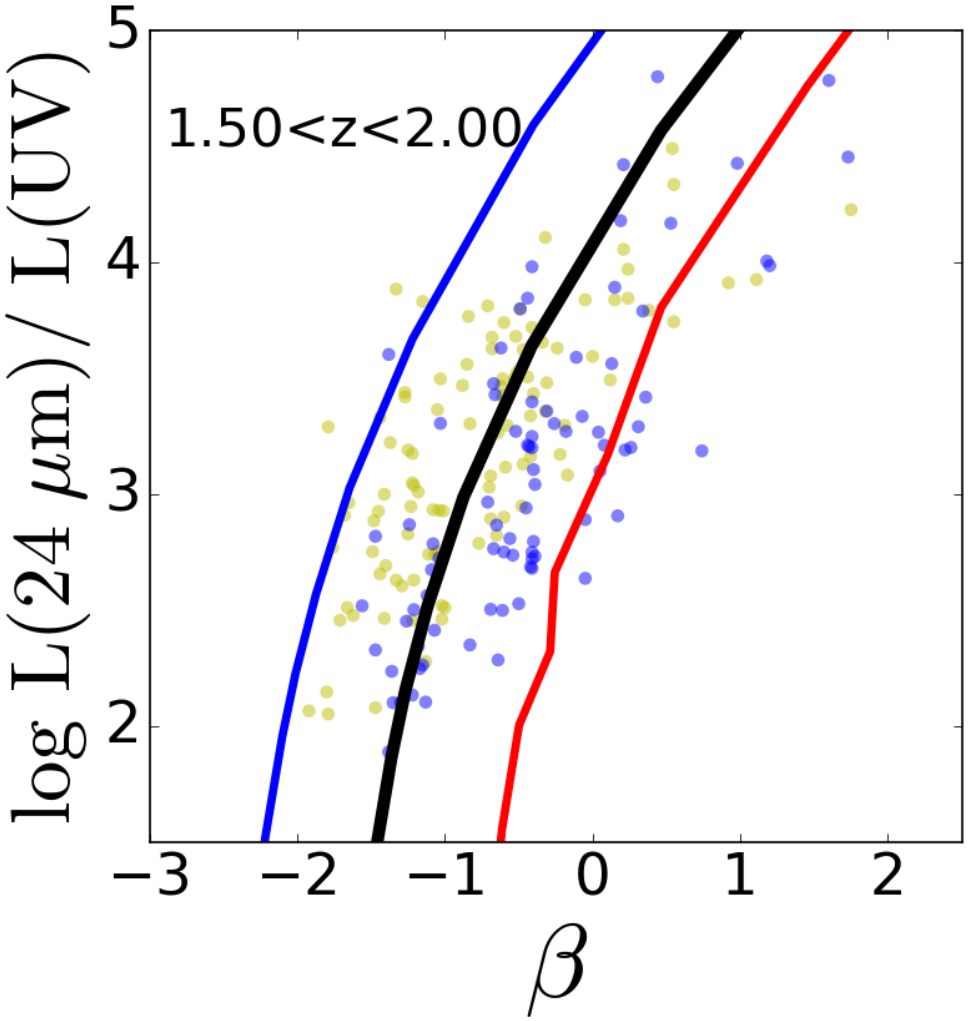
Fiducial model:

- Shell geometry
- Milky Way dust
- 100 Myrs
- solar metallicity
- single burst
- $M_* = 10^{10}\ M_\odot$



10 Myrs Young stellar pop

250 Myrs Old stellar pop



Wang, Kassin et al. in prep

DIRTIGRID shell geometry with varying stellar pop ages, Z, SFR density

Fiducial model:

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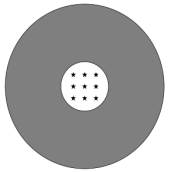
- Milky Way dust
- 100 Myrs
- solar metallicity
- single burst
- $M_* = 10^{10}\ M_\odot$

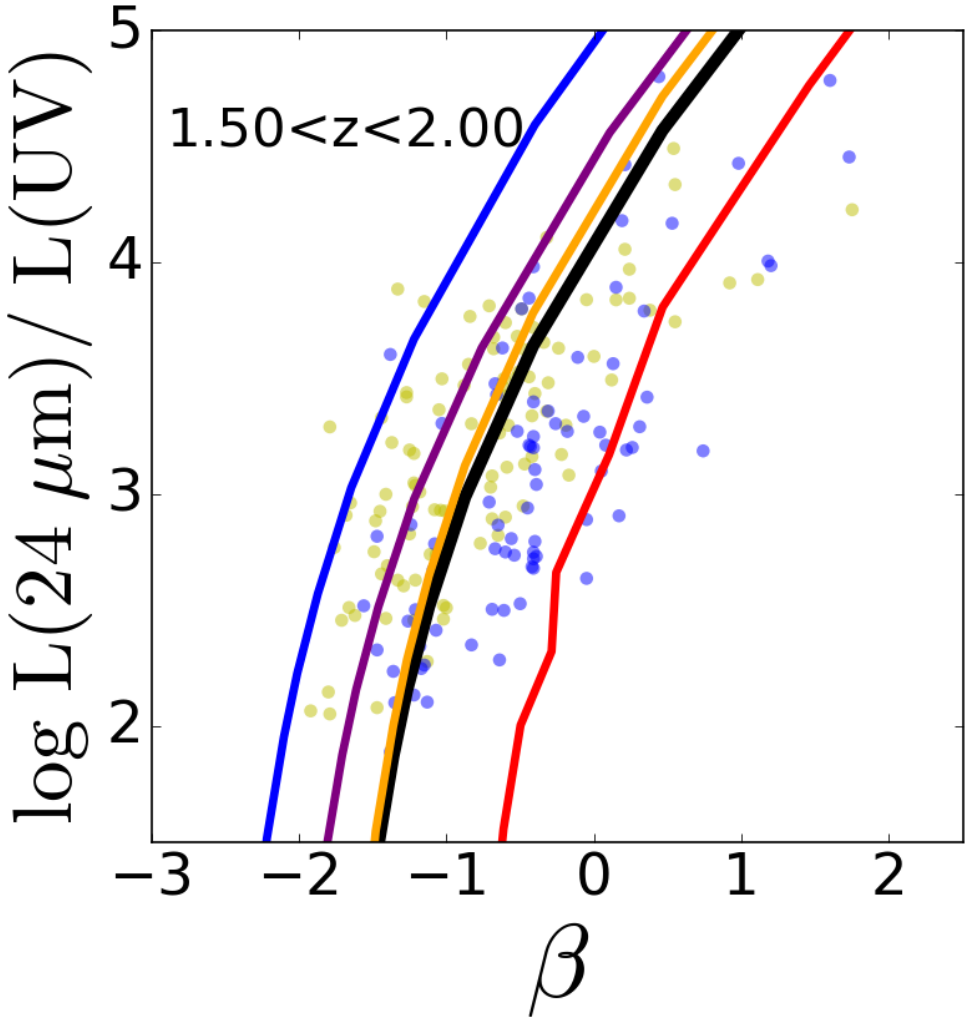


10 Myrs Young stellar pop

250 Myrs Old stellar pop

0.2 x solar metallicity

higher SFR density by x 10



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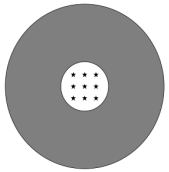
Can dust geometry explain the inclination dependence?

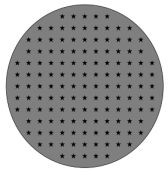
Fiducial model:

- Shell geometry
- Milky Way dust
- 100 Myrs
- solar metallicity
- single burst
- $M_* = 10^{10}\ M_\odot$

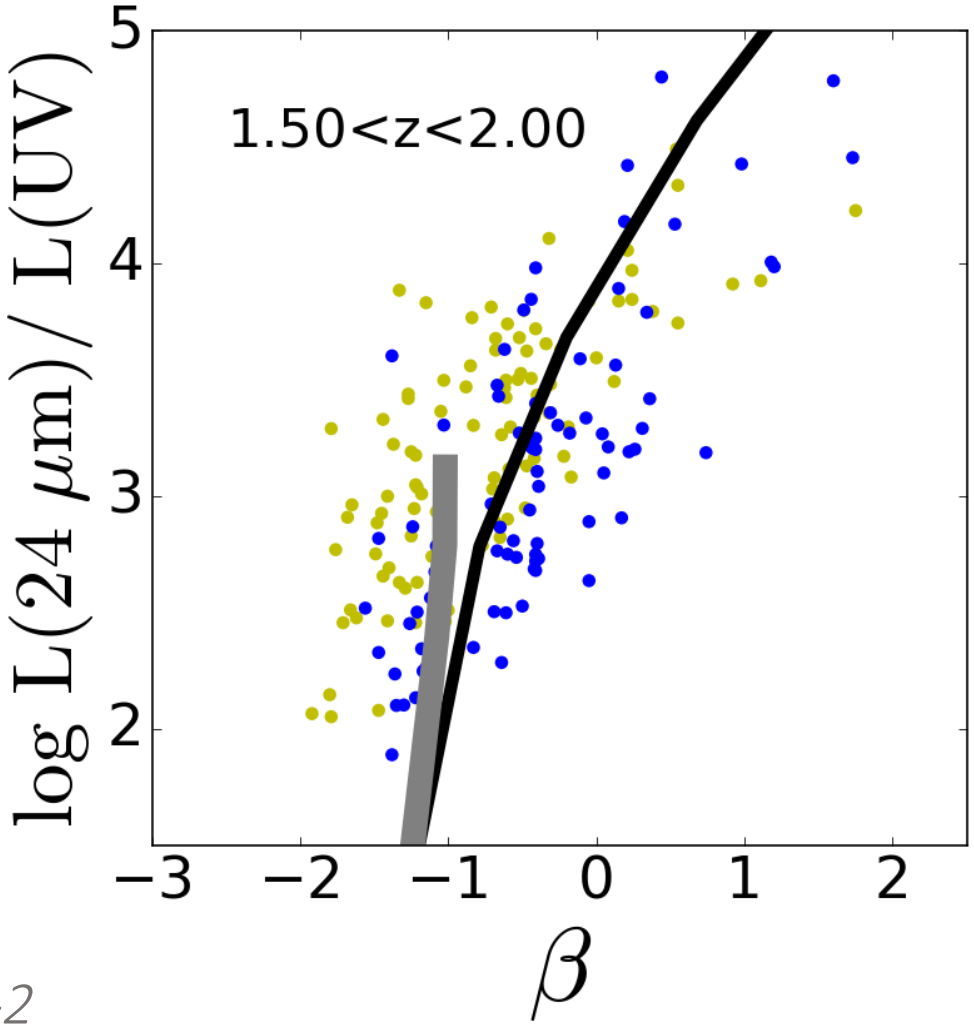


As you increase dust content to very high τ, get to a point where UV is invisible…

Dusty geometry



Always see some UV: see into ~1-2 optical depths and then stop…



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Open Questions

What implications does this have for measuring SFRs?

What should we do to understand this further?