A cloud-scale view of dust-obscured star formation in nearby galaxies with JWST

Francesco Belfiore

INAF – Arcetri Astrophysical Observatory

Florence, Italy

PHANGS Colloquium, 5 June 2024

INAF

Outline

1. SFR rate measurements:
   timescales, spatial scales and tracers

2. JWST + MUSE SFR on 100 pc scales (FB+23b)

3. Limitations of the approach,
   stochastic sampling, IR cirrus

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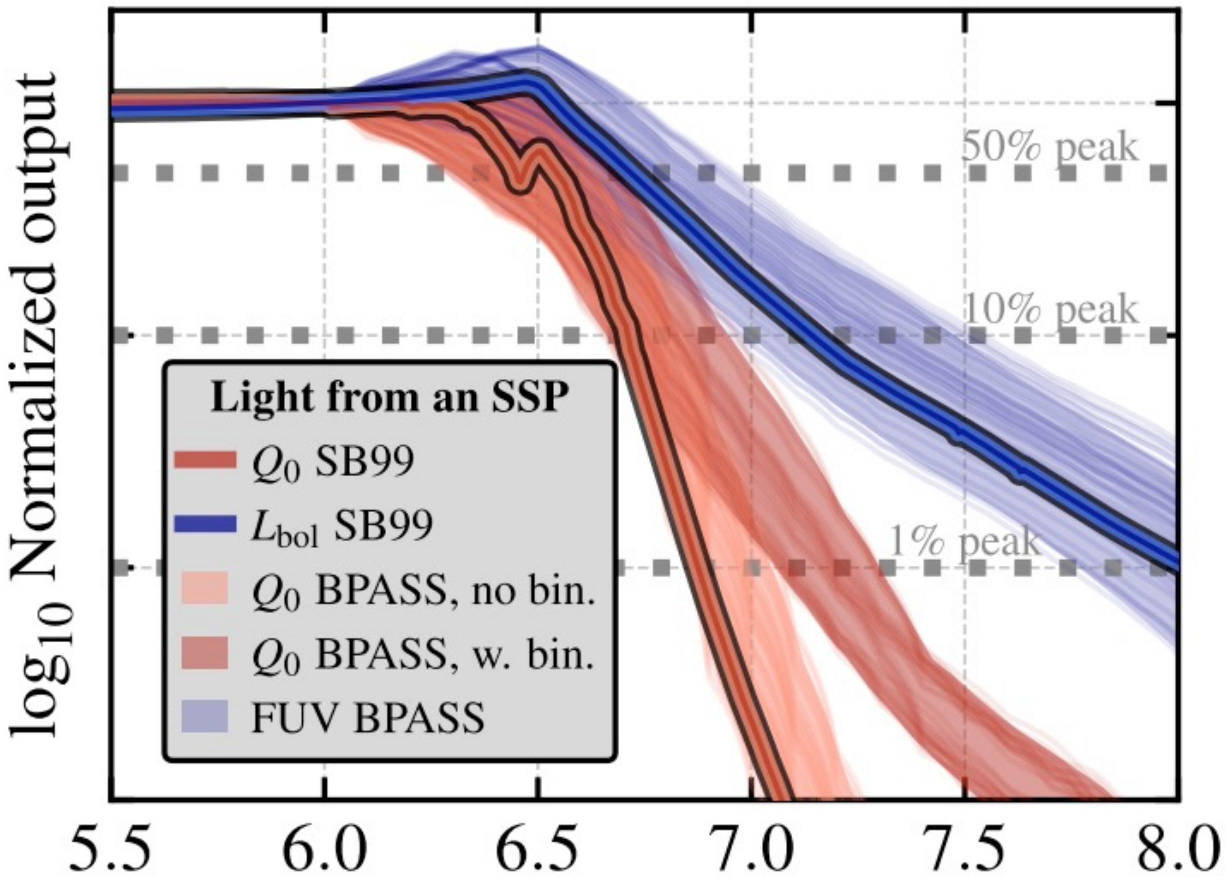
Tracing star formation with multi-wavelength data

Timescales

- Ionizing photon production (Hα) ~ 4 Myr
- Bolometric luminosity (~dust), ~ 100 Myr



Log (Age)

Schinnerer & Leroy 24

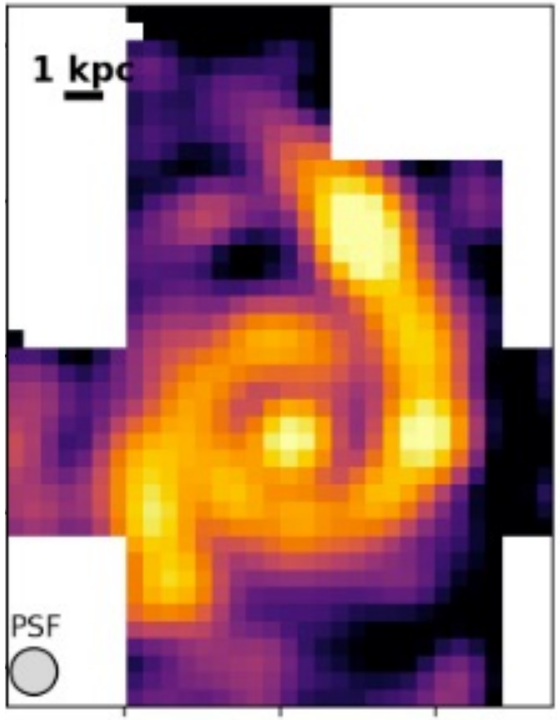
Tracing star formation with multi-wavelength data

Timescales

Spatial Scales

- On larger (kpc) scales tend to include more older stellar populations (**IR cirrus**)
- On very small scales, low-mass cluster suffer from **stochastic sampling** of the IMF.

Kpc resolution



JWST 100 pc @ 21μm

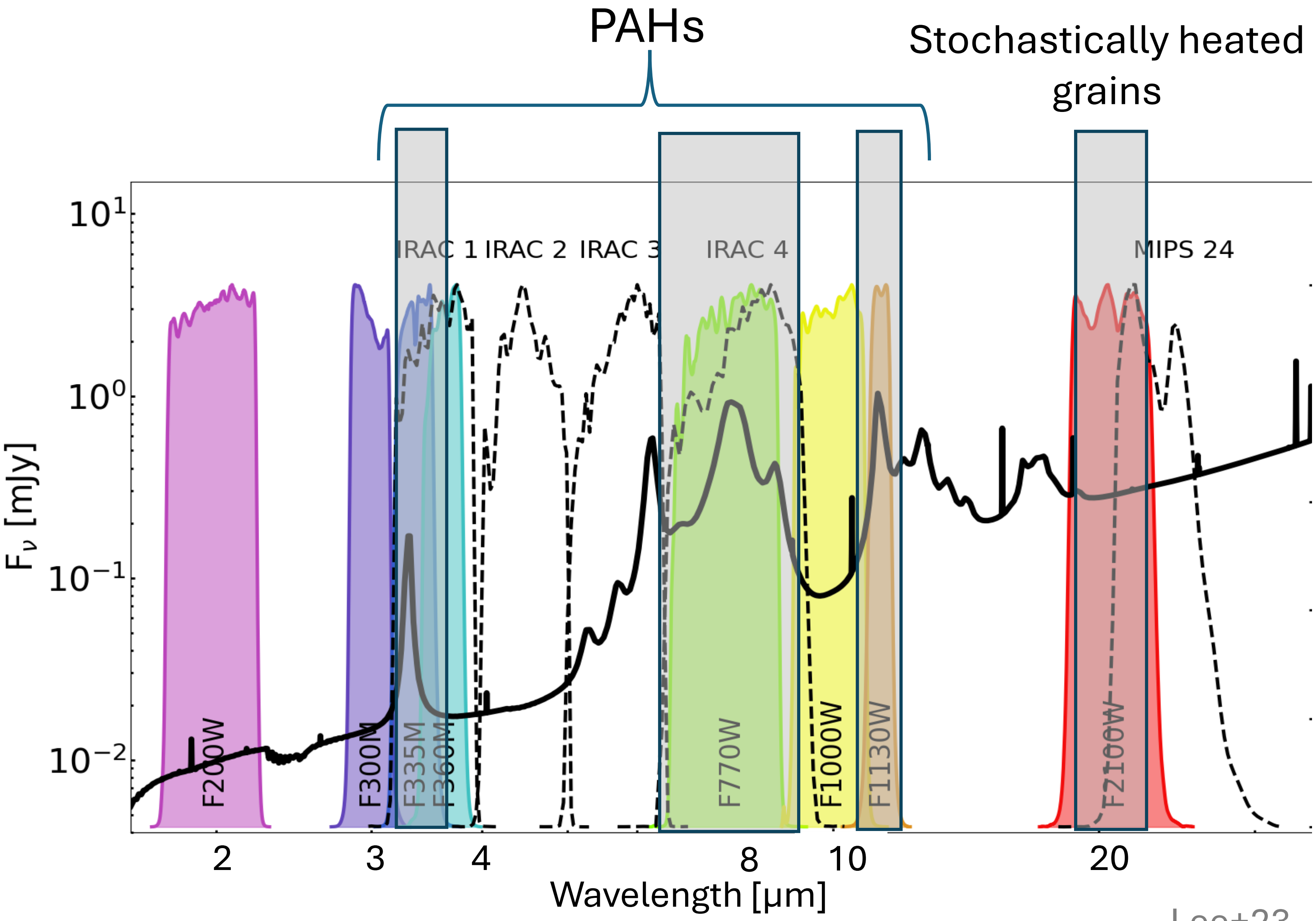
Tracing star formation with multi-wavelength data

Timescales

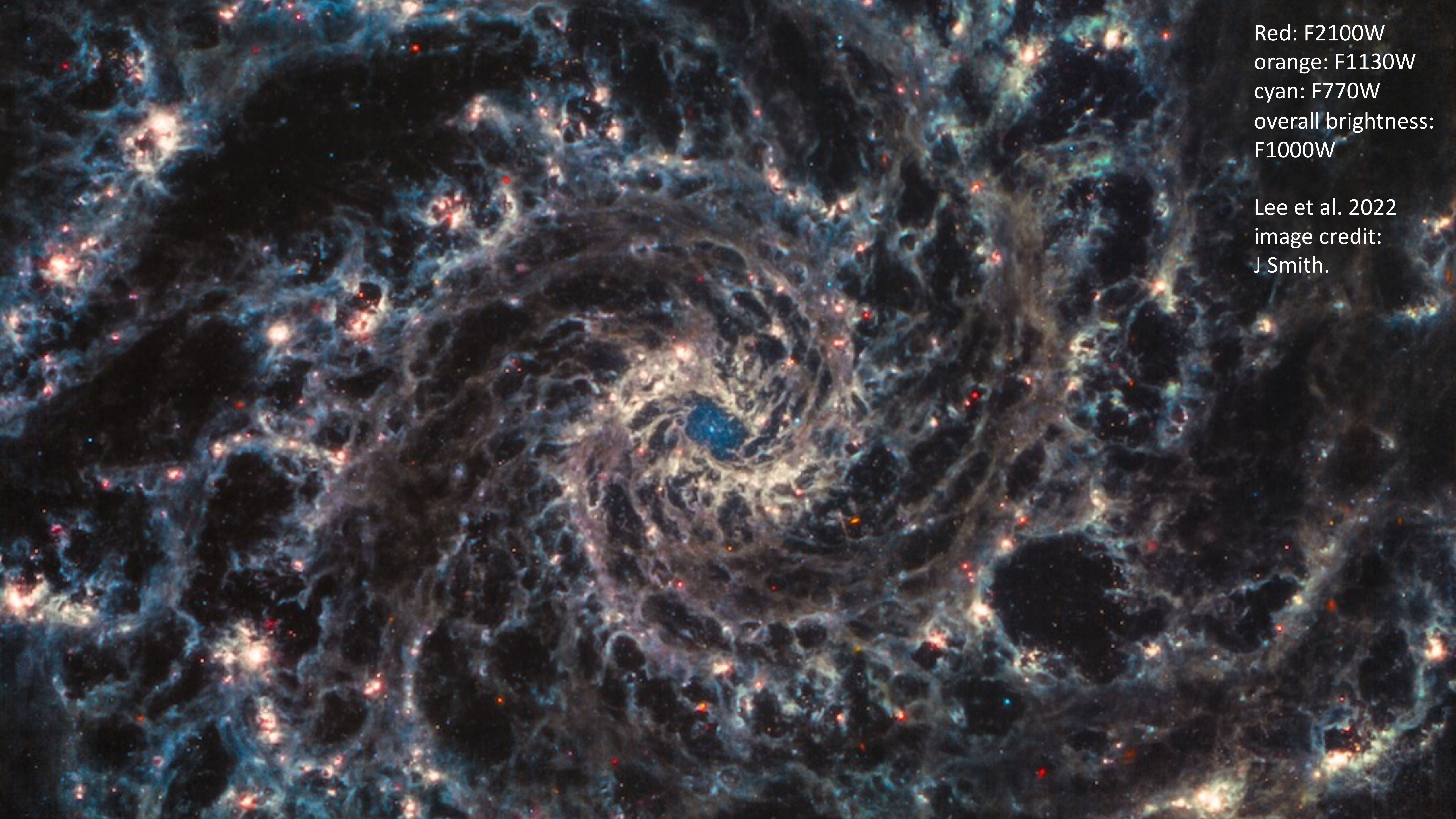
Spatial Scales

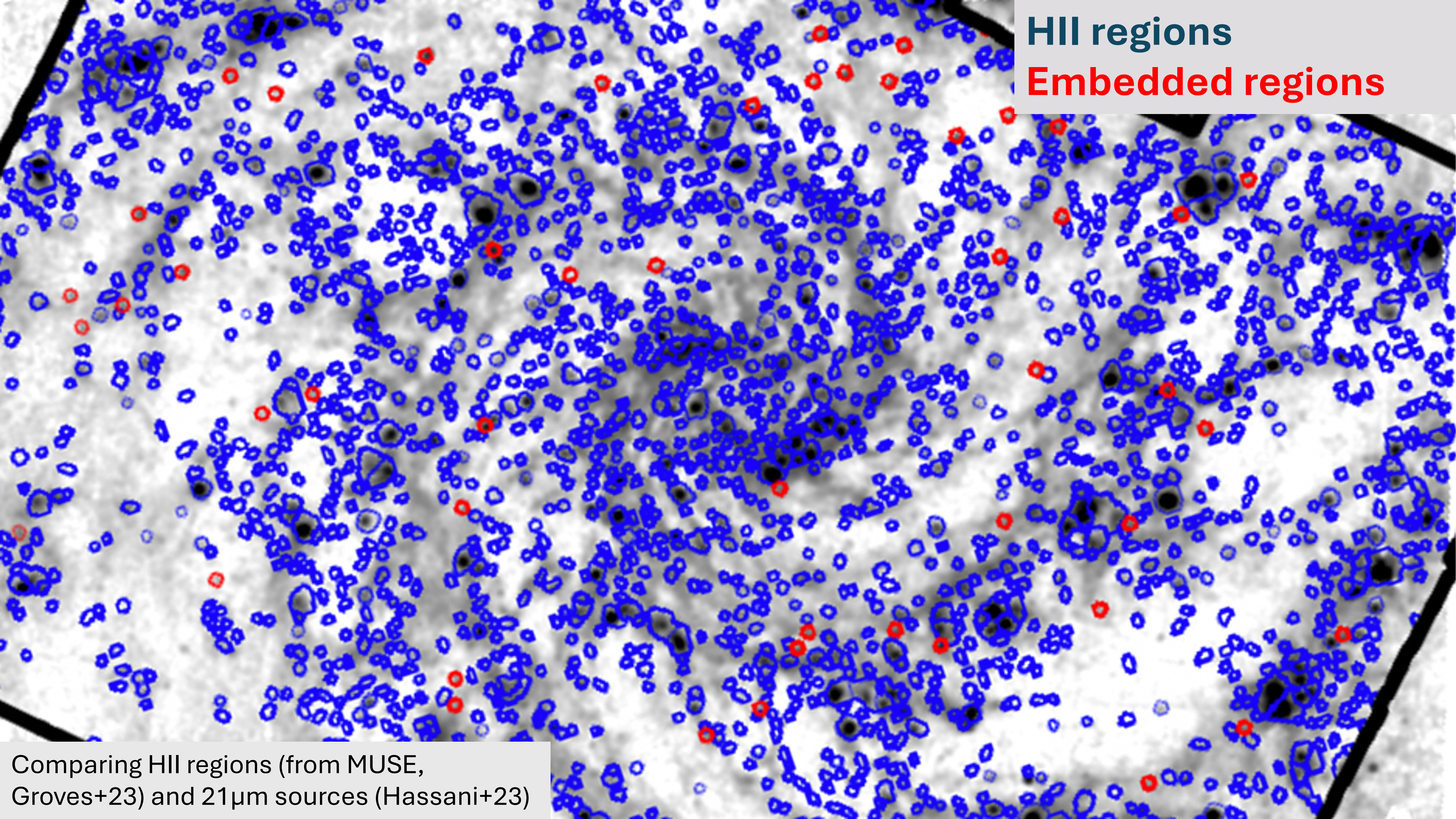
Tracers

- **Un-extincted** (Hα, UV)
- **Extincted**: 21 (24) μm correlates with L_{bol}
- PAH bands: extra physics (see next talk!)



Lee+23

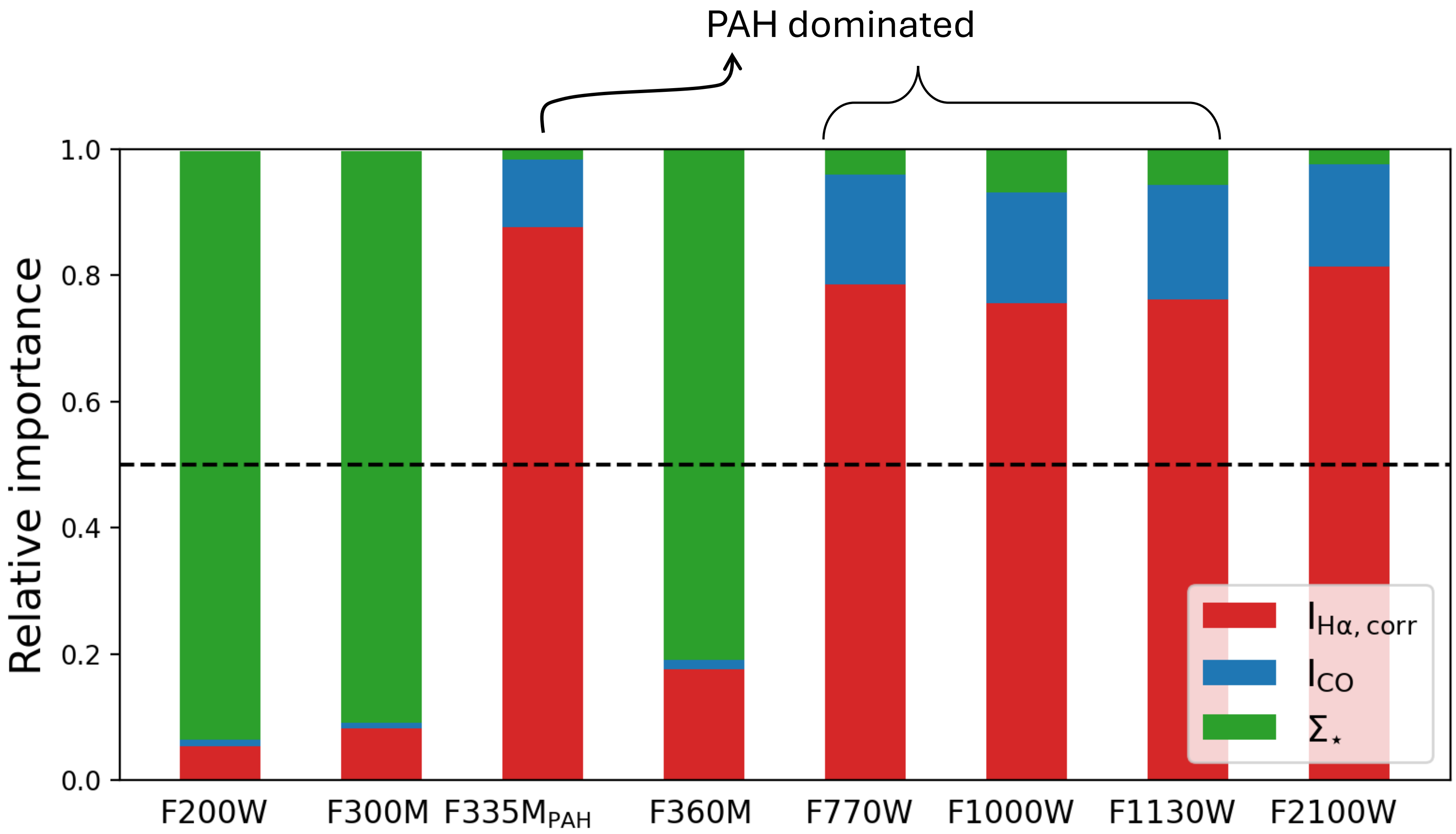

Red: F2100W
orange: F1130W
cyan: F770W
overall brightness: F1000W
Lee et al. 2022
image credit:
J Smith.



Comparing HII regions (from MUSE, Groves+23) and 21µm sources (Hassani+23)

Tracing SFR with JWST

Does **stellar mass**, **Hα** or **CO** drive the emission in the JWST bands in **HII regions**?



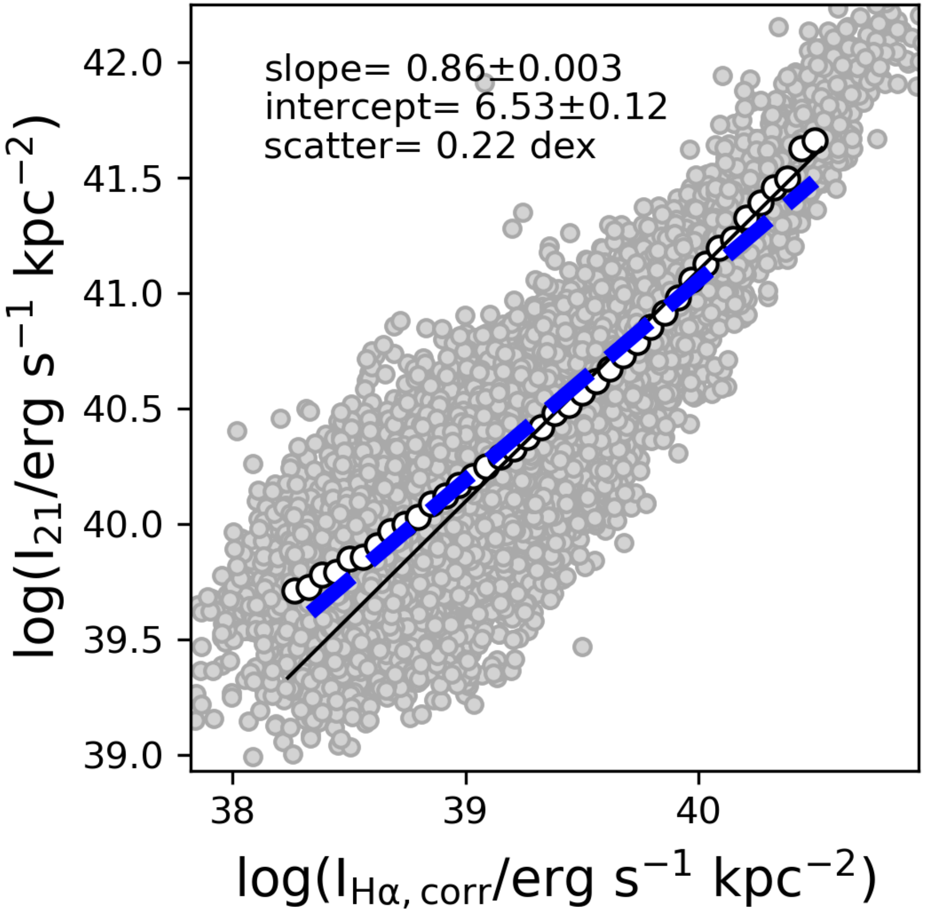
Relative feature importance determined via a Random Forest analysis

FB+2023b

Tracing SFR with JWST

Individual HII regions

$H\alpha_{corr}$ vs 21μm



FB+2023b

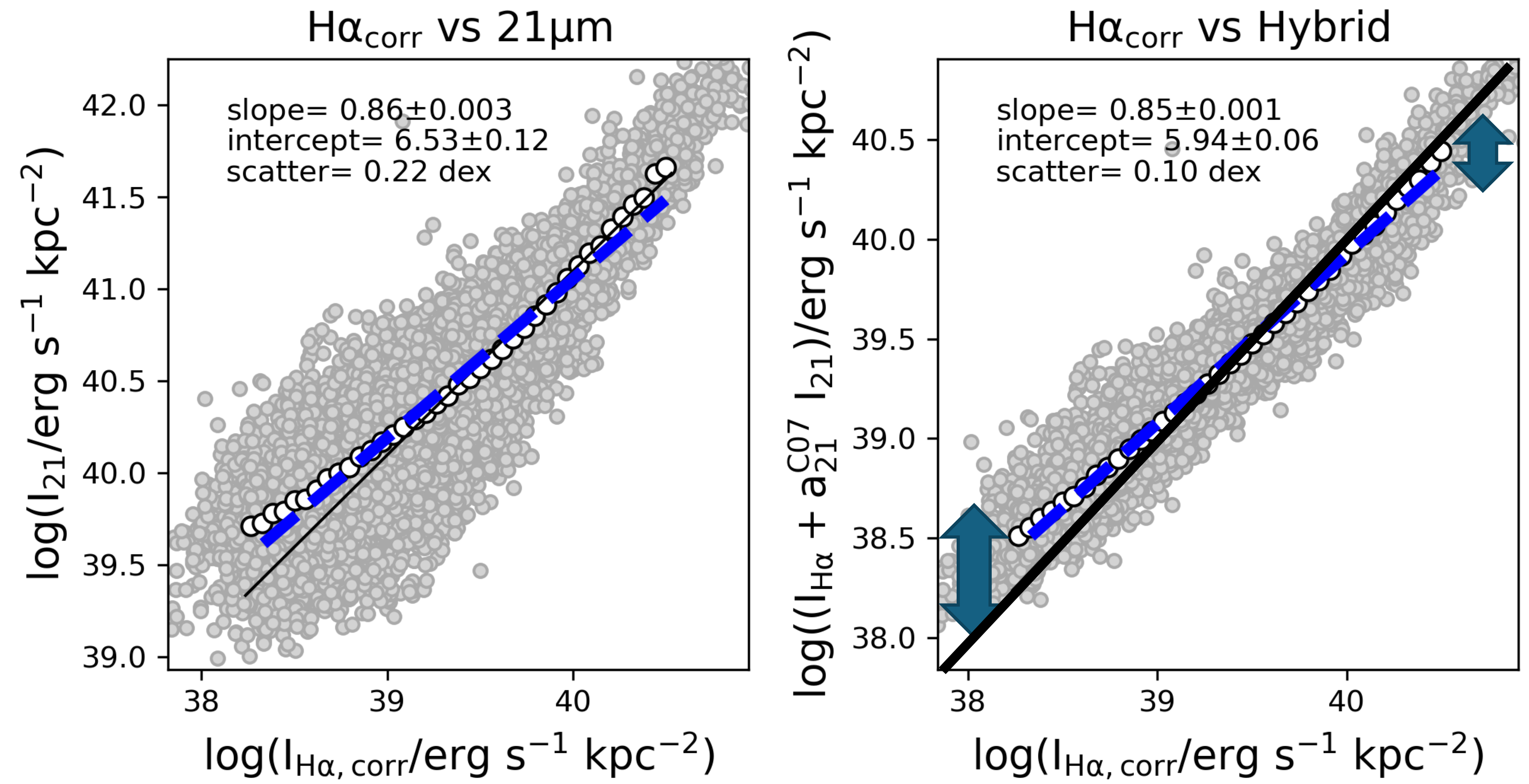
Hybrid SFR tracers

$$I_{H\alpha,\,corr} = I_{H\alpha} + a_{IR} I_{IR}$$

Using Balmer Decrement

Unextincted, MUSE

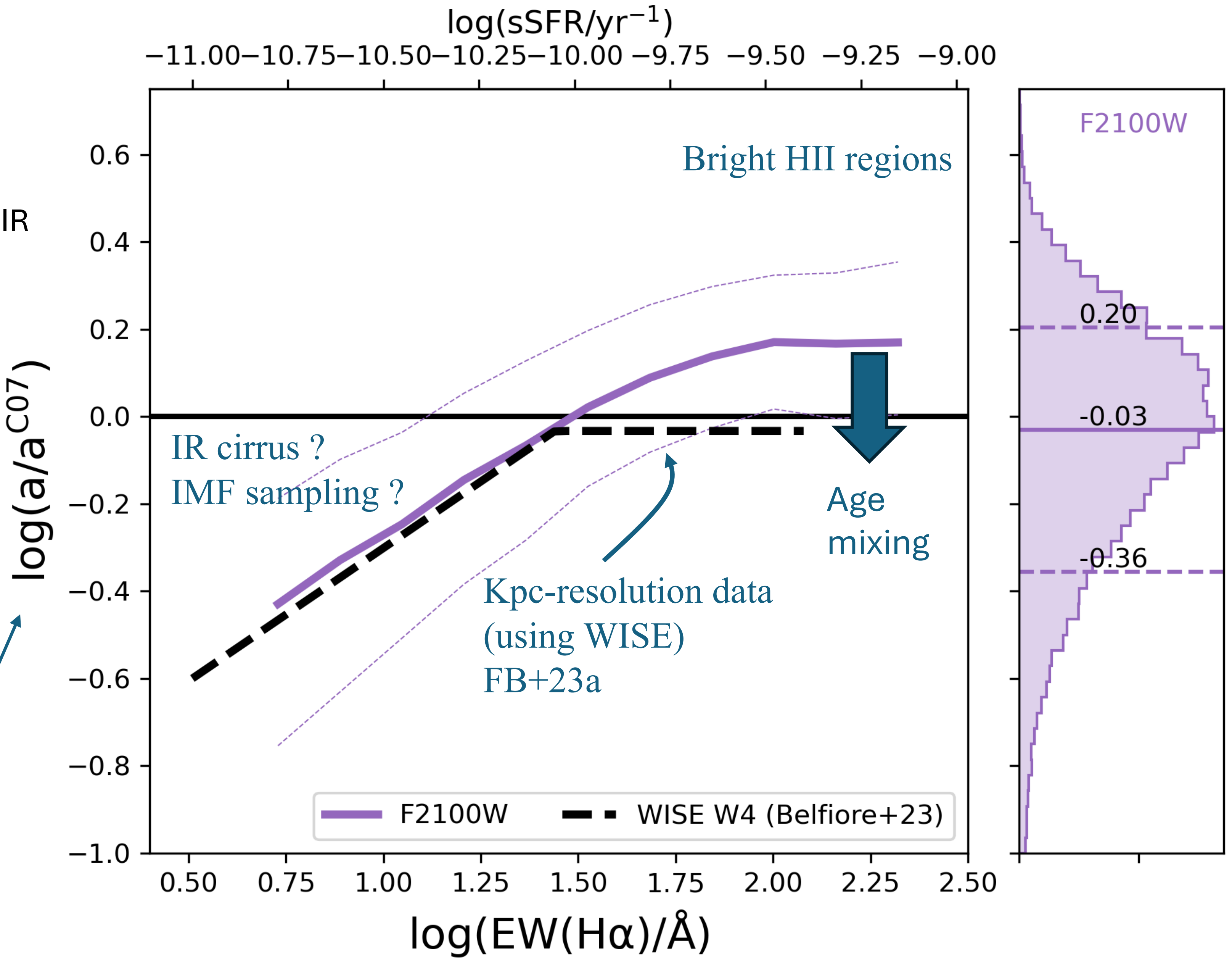
dust-extincted, JWST



FB+2023b

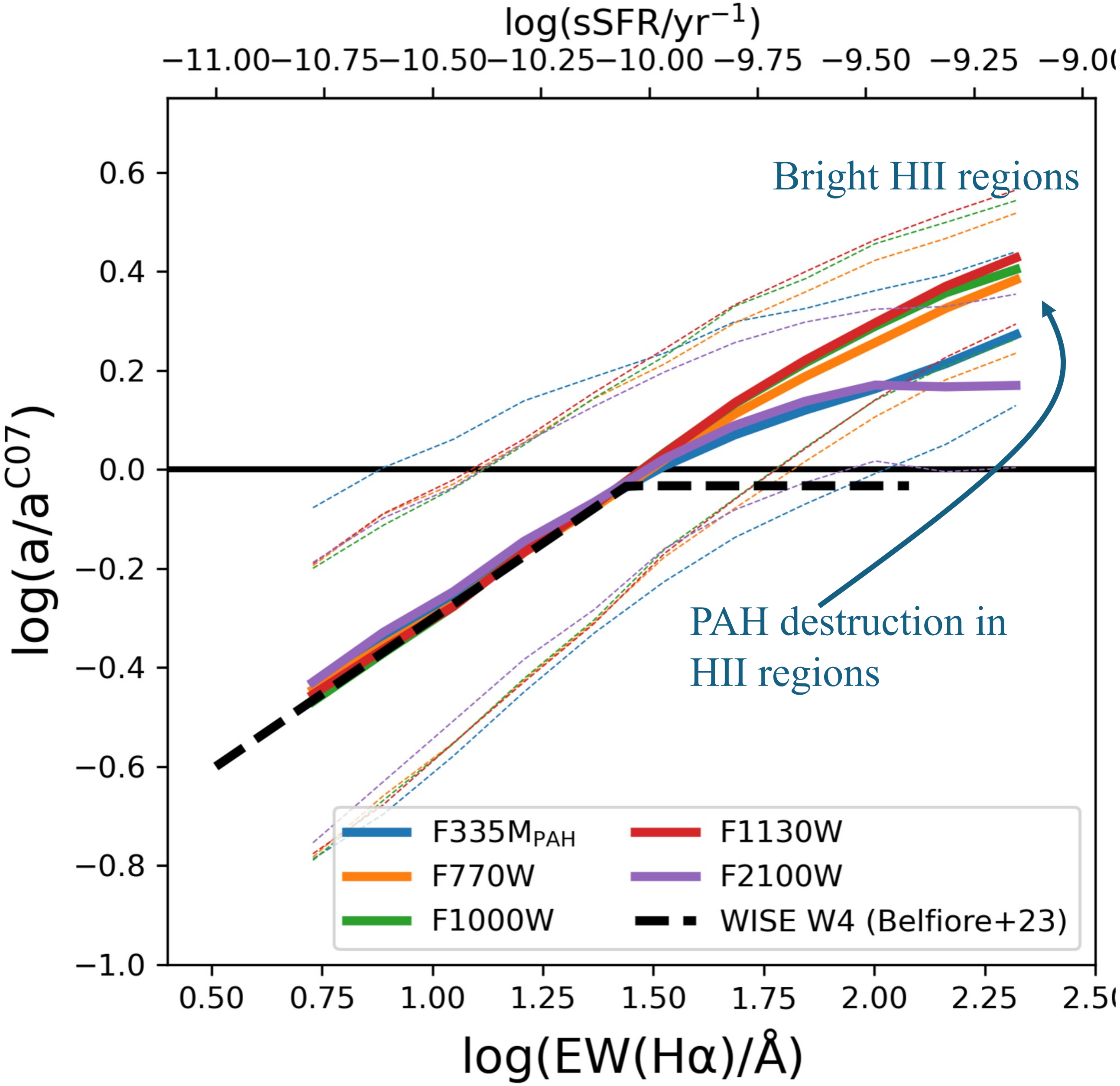
$$I_{H\alpha,\,corr} = I_{H\alpha} + a_{IR} I_{IR}$$
$$a_{IR} = (I_{H\alpha,\,corr} - I_{H\alpha}) / I_{IR}$$

IR conversion coefficient, normalised to a canonical value from the literature (Calzetti+2007)



The average across our sample agrees well with the Calzetti+07 value for the 21μm band

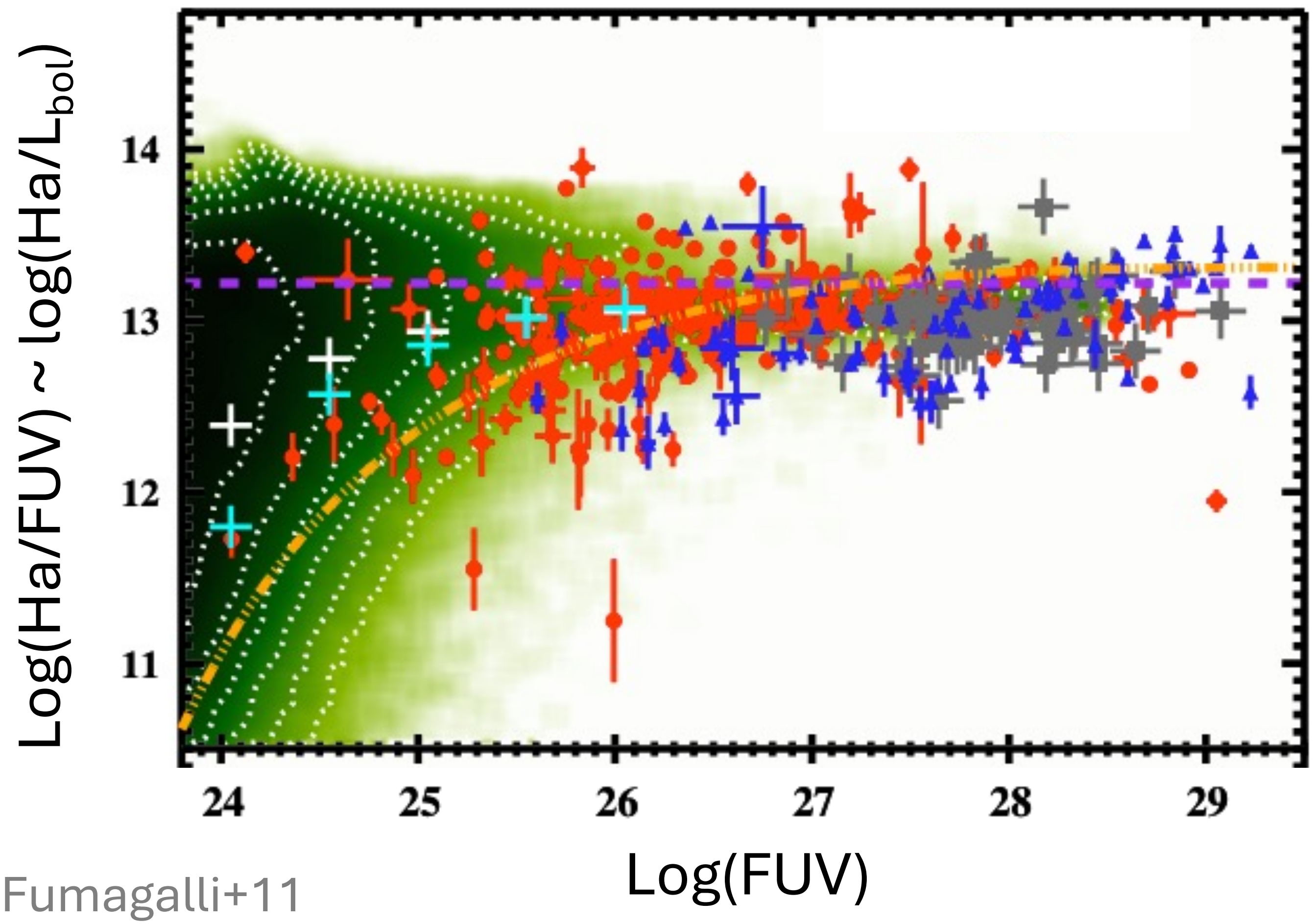
FB+2023b



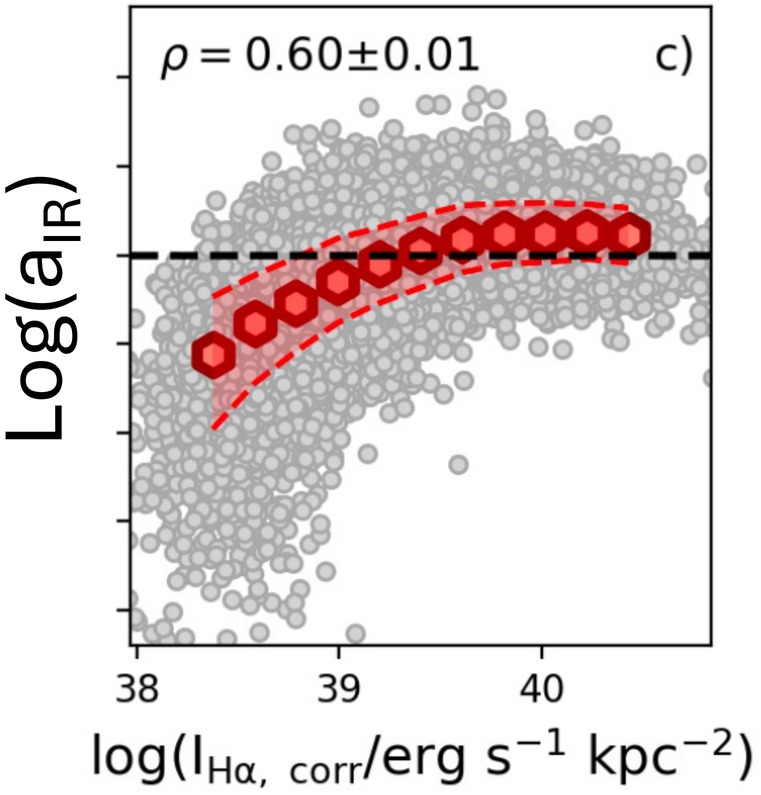
- PAH are destroyed in bright HII regions (a_{IR} higher)
- The 3.3μm feature being the least affected (PAHs get smaller?)

The effect of stochastic IMF sampling

Stochastic sampling models with SLUG

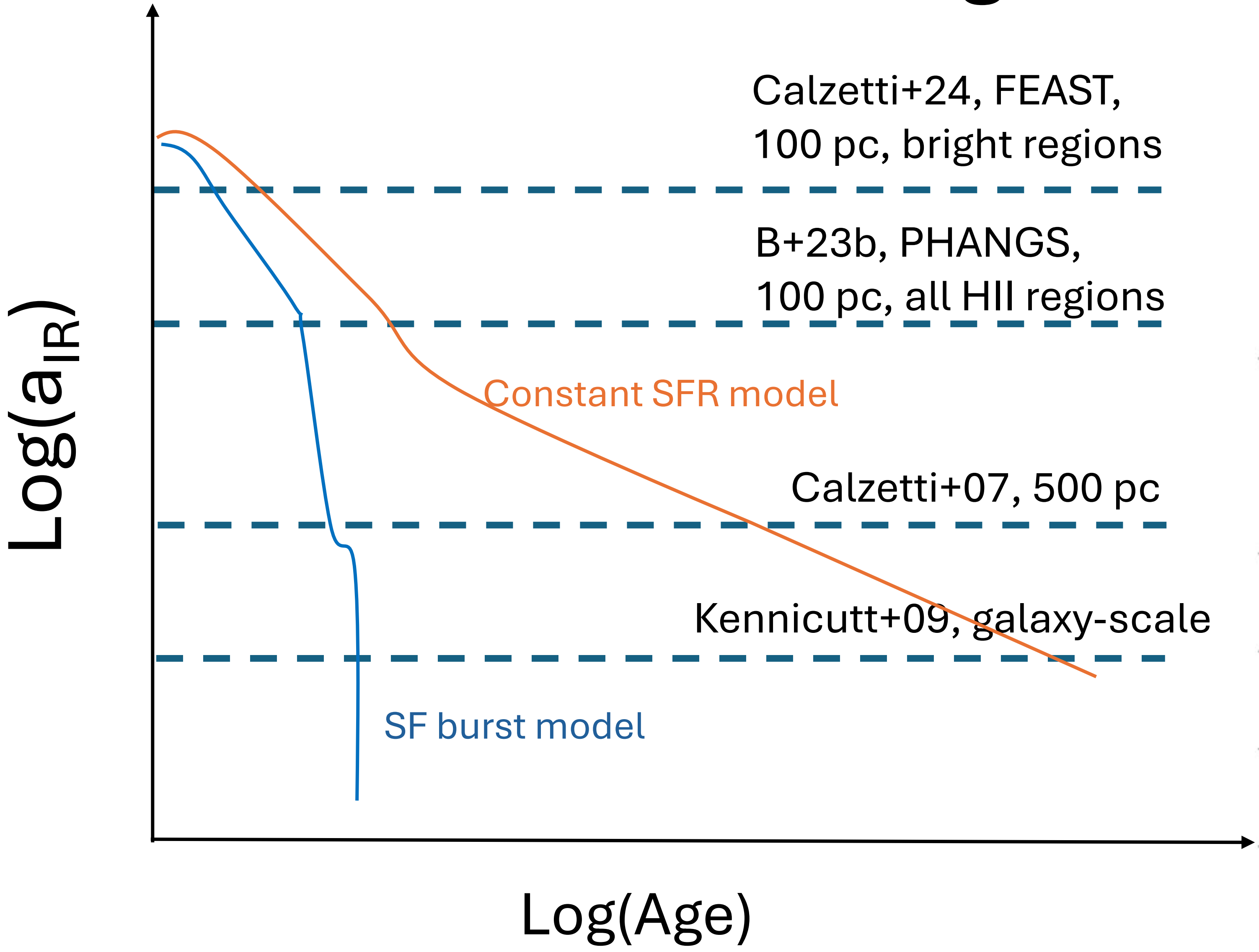


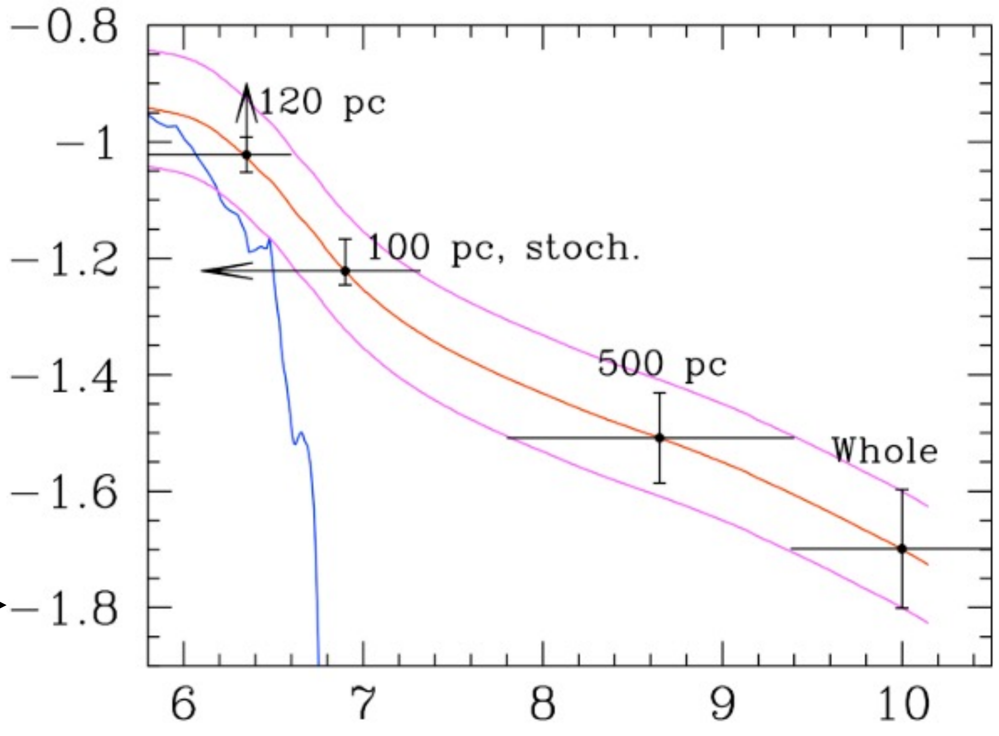
Fumagalli+11



$a_{IR} = (I_{H\alpha, corr} - I_{H\alpha}) / I_{IR} \sim I_{H\alpha} / I_{IR}$

The effect of scale an age mixing





Calzetti+24 today

Summary

- MUSE + JWST trace SFR on scales of 100 pc in PHANGS galaxies
- Average SFR calibrations agree well with previous literature estimates
- IR cirrus (age mix) introduces a scale-dependent term
- IMF stochastic sampling may be responsible for deviations seen at low luminosities.

Next Steps

1. **Cycle II Paα data + MUSE extended + HST Hα**
2. **Modelling of stochastic sampling**