JWSTで探るz>10銀河の統計的・物理的性質

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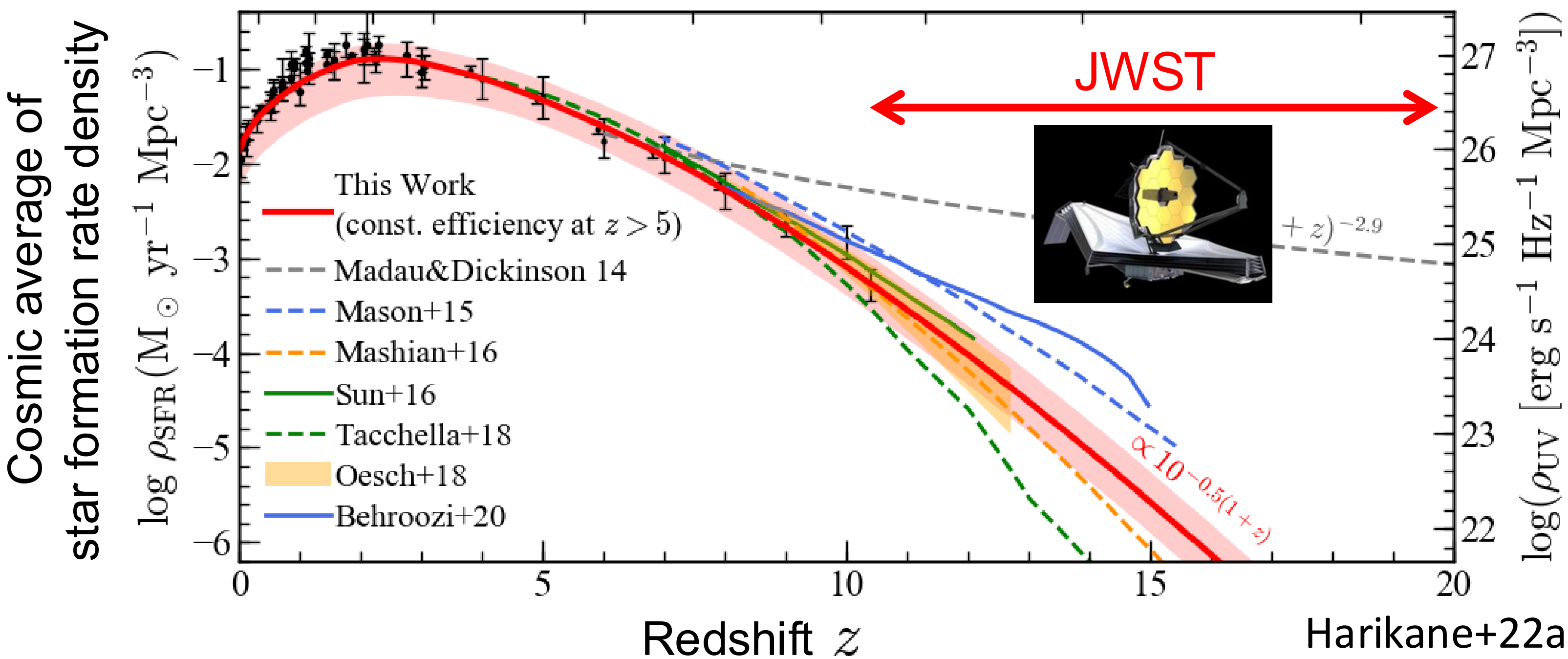
Results/Predictions Before JWST

- Cosmic star formation rate density at z~0-10
  - Results from Hubble Space Telescope
- Constant star formation efficiency (SFR/(dM_h/dt)) model
  - Reproducing evolution at z=0-10, $10^{-0.5(1+z)}$ at z>10



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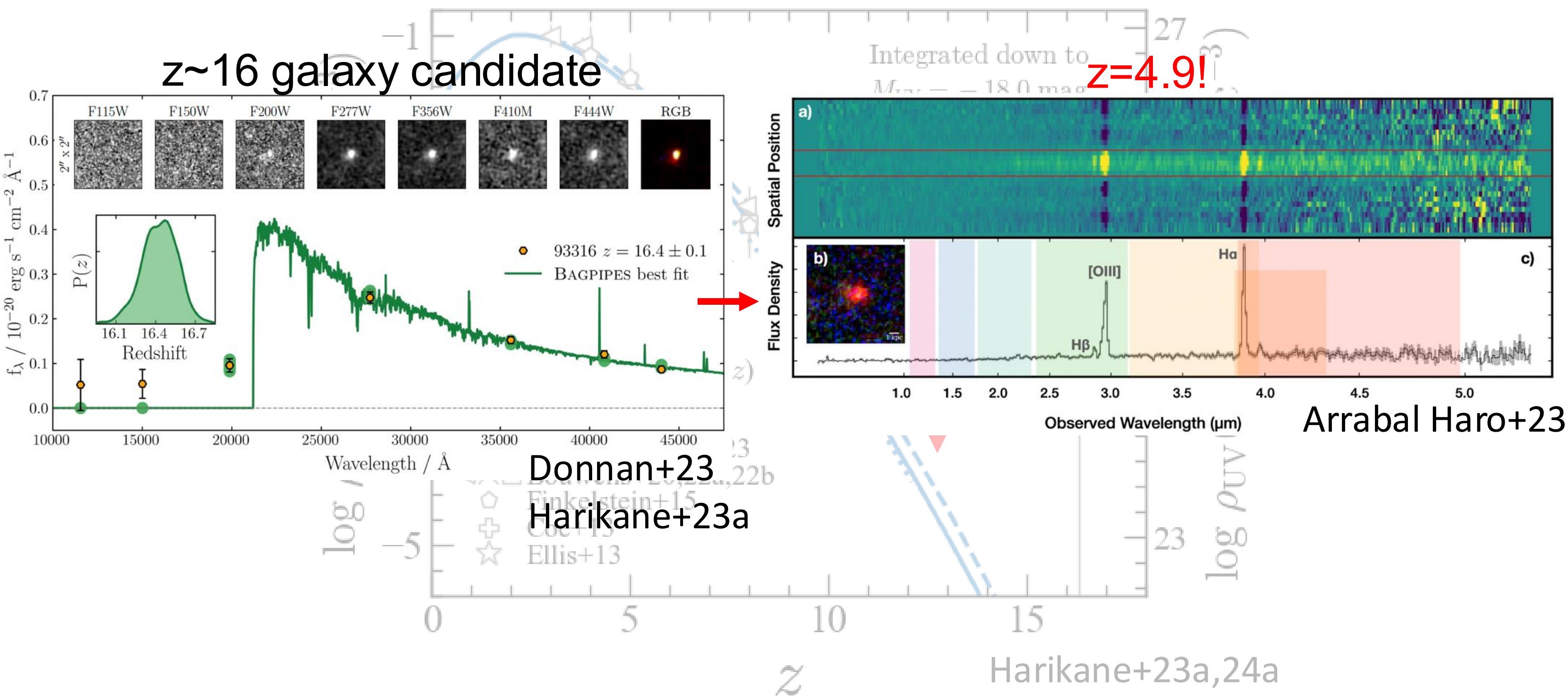
See e.g., Bouché+10,Madau+14,Bouwens+15,Finkelstein+15,Mason+15,Tacchella+18,Oesch+18,Tacconi+20…

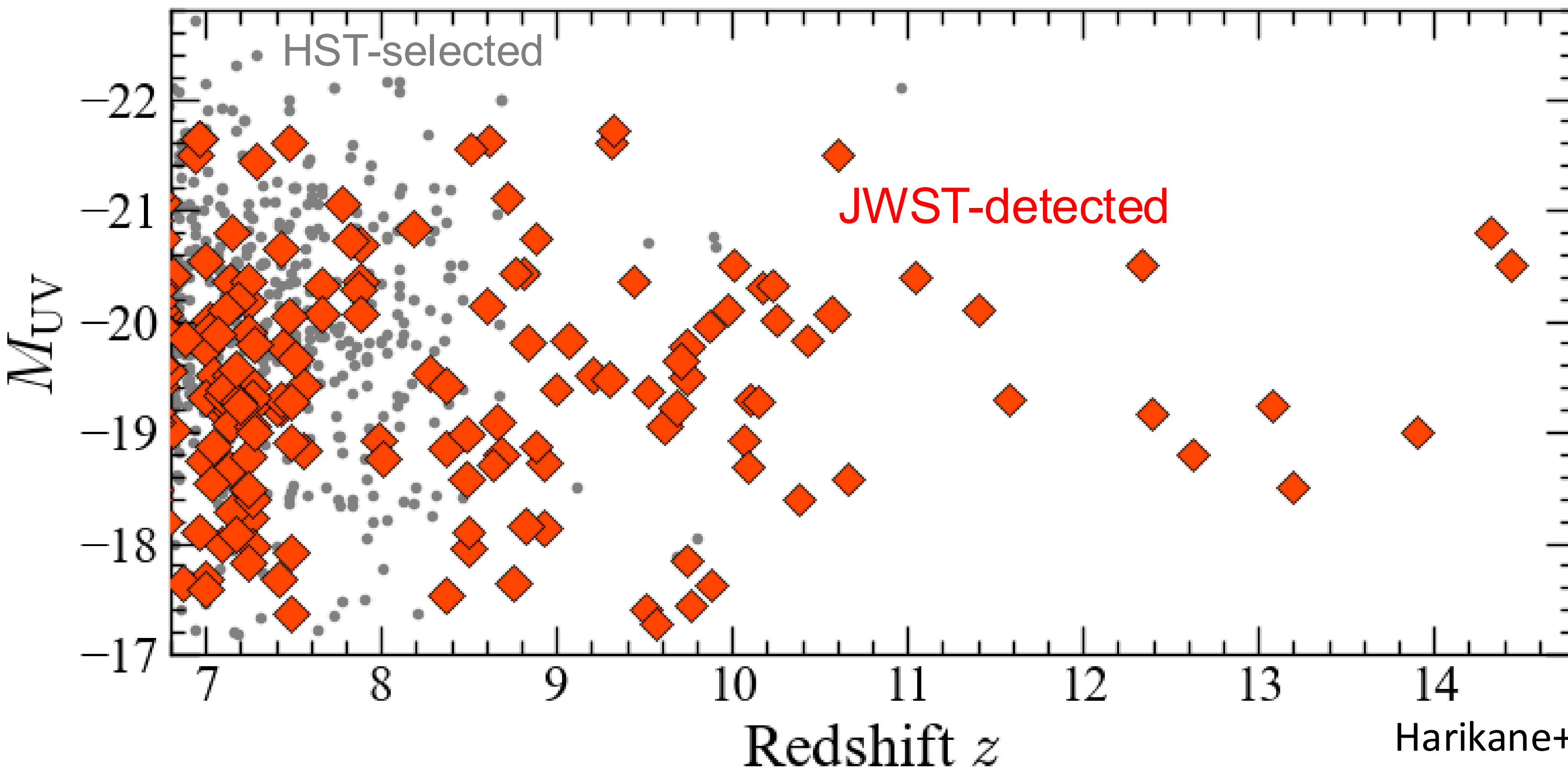
JWST Observations

- Higher SFR density at z>10 based on photo-z
- Contamination? e.g., z~16 candidate → z=4.9



JWST Spec-z Sample

- ~25 galaxies at z_{spec}>10 confirmed w/ NIRSpec



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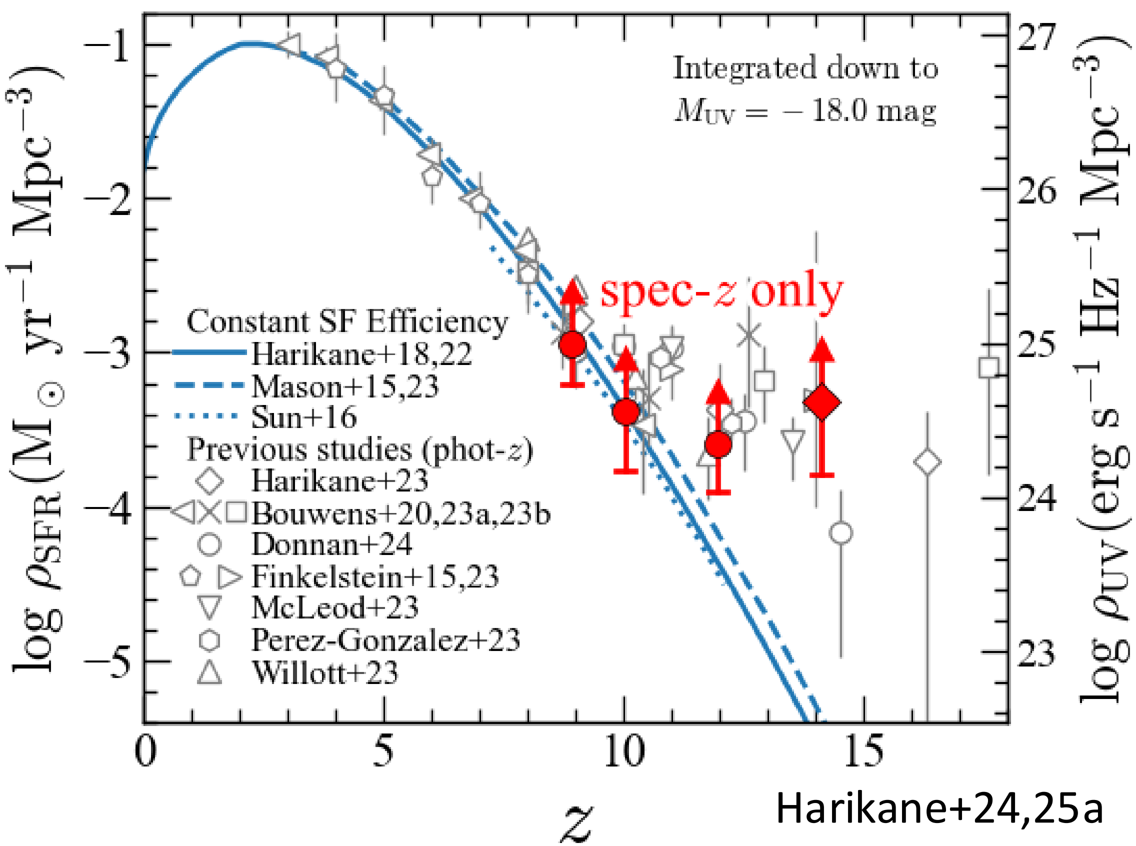
See also, Arrabal Haro+23ab, Curtis-Lake+23, Castellano+24, Carniani+24, Pérez-González+25, Naidu+25…

Spec-z Cosmic SFR Density at z=9-14

- UV→SFR: $SFR(M_\odot\ \mathrm{yr}^{-1}) = \mathcal{K}_{\mathrm{UV}} L_{\mathrm{UV}}(\mathrm{erg\ s^{-1}\ Hz^{-1}})$

$$\mathcal{K}_{\mathrm{UV}} = 1.15 \times 10^{-28}\ M_\odot\,\mathrm{yr}^{-1}/(\mathrm{erg\,s^{-1}Hz^{-1}})$$

- Tension with constant efficiency models at z>10



Harikane+24,25a

Physical Interpretations

Why are we finding more galaxies at z>10 than models?

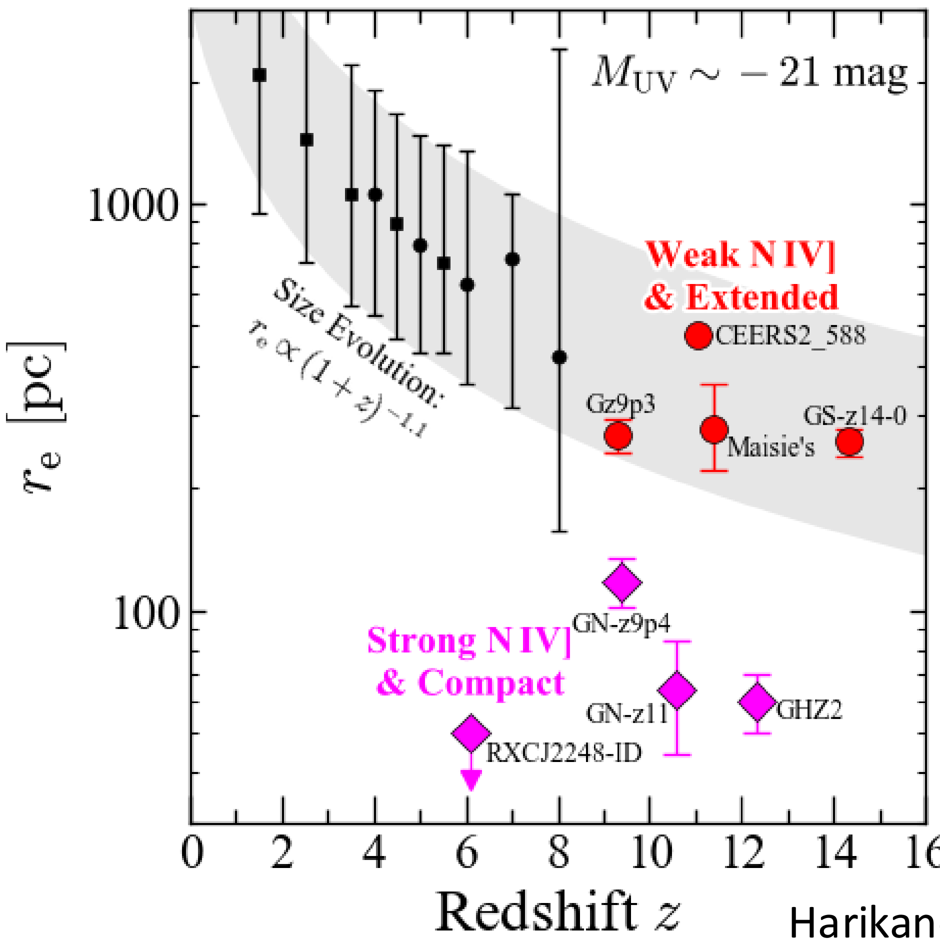
Models: calibrated at z=0-10. Different galaxy formation physics at z>10?

1. **High star formation efficiency**, e.g., by feedback free starburst (Dekel+23), compact SF (Fukushima+22, Ono+23)
2. **Top-heavy initial mass function (IMF)** (e.g., Chon+22, Cameron+23, see also Rasmussen Cueto+23)
3. **Radiation driven outflow** (Ferrara+22,23)
4. **Bursty star formation** (e.g., Mason+23, Shen+23, Sun+23ab, Donnan+25, see also Pallottini+23) **See Asada-san's talk**
5. **Cosmology** (e.g., Menci+23, Parashari+23, Hirano+23, Shen+24)
6. **AGN activity** (e.g., Hedge+24)

See discussions in Harikane+23a,24,25a

Galaxies at z>10: Compact or Extended

- Two types of bright (M_{UV}<-20 mag) galaxies at z>10
  - Extend
  - Compa



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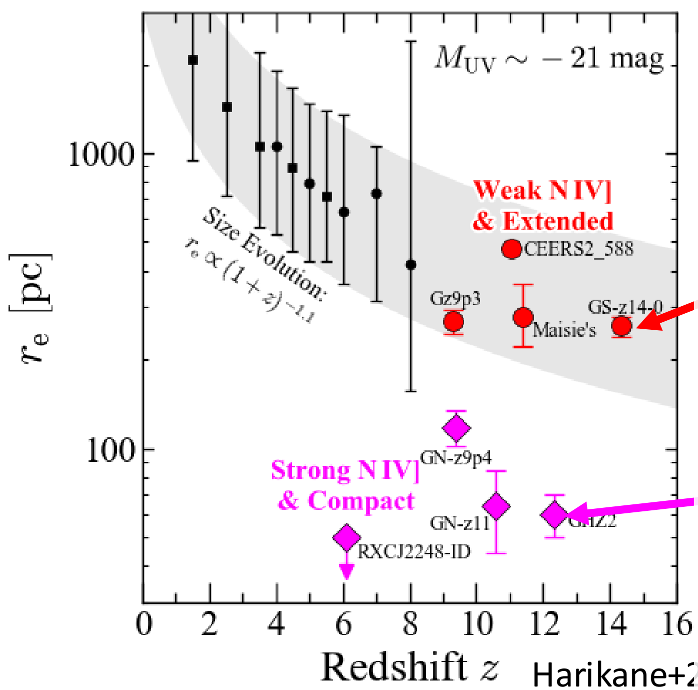
Galaxies at z>10: Compact or Extended

- Two types of bright (M_{UV}<-20 mag) galaxies at z>10
  - Extended galaxies wo/ strong emission lines
    → high star formation efficiency?
  - Compact galaxies w/ high ionization emission lines
    → compact starburst (enhancing N production) or AGN?



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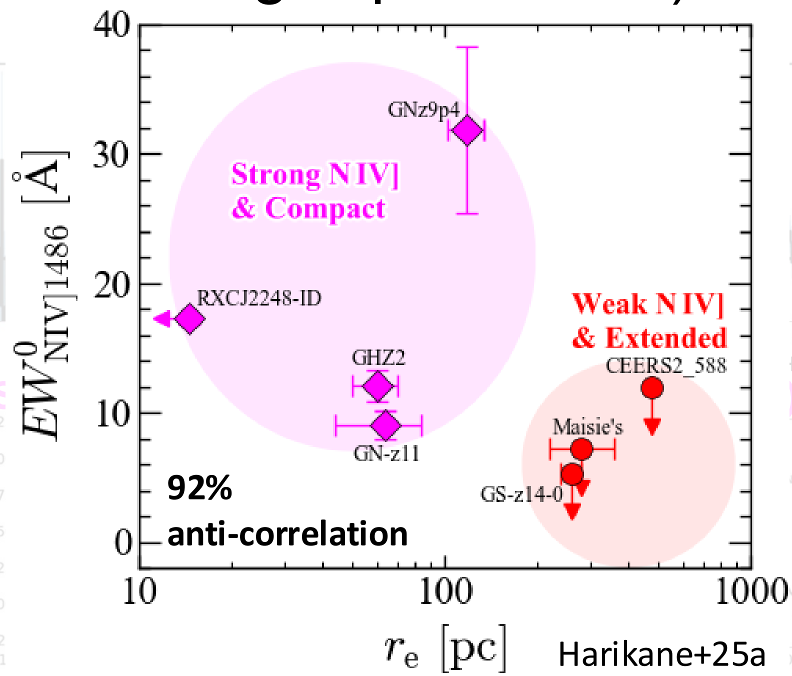

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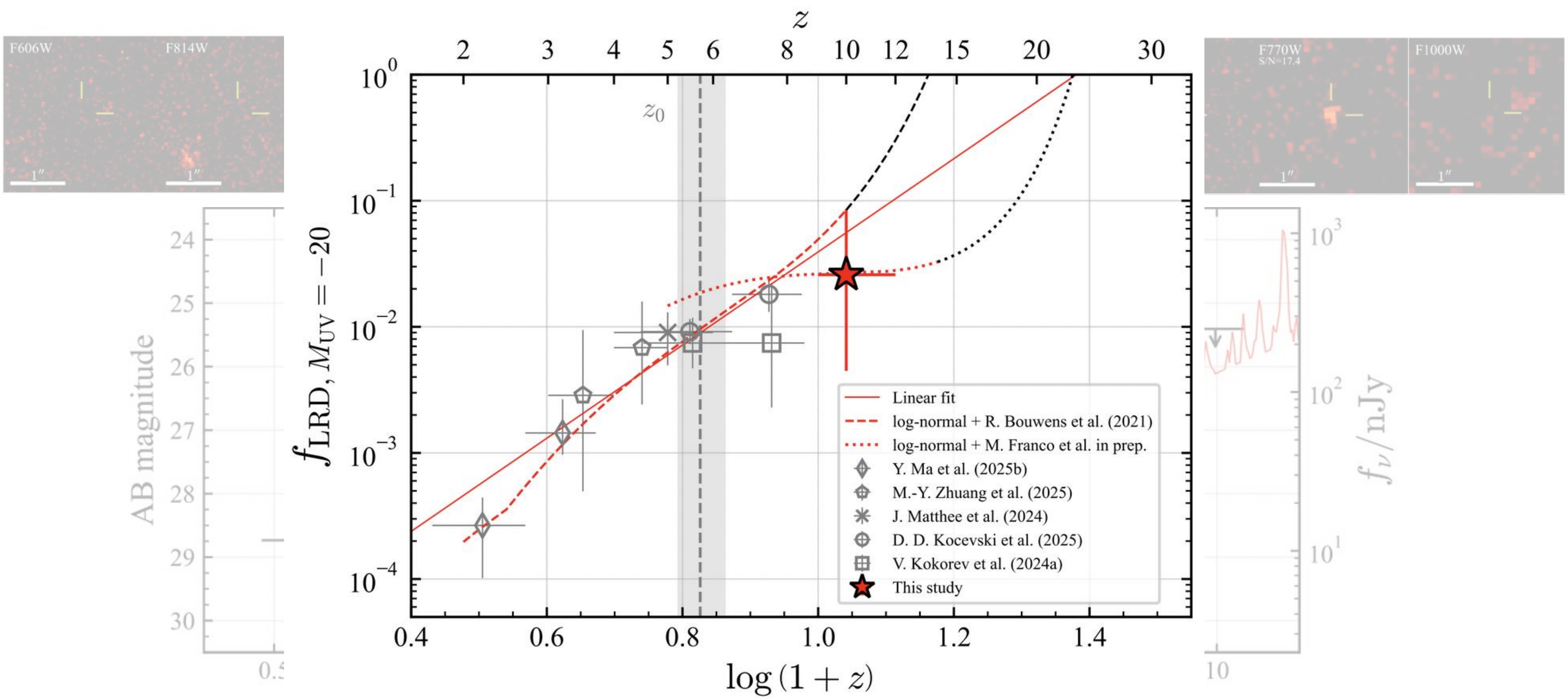
Little Red Dot (LRD) at z>10

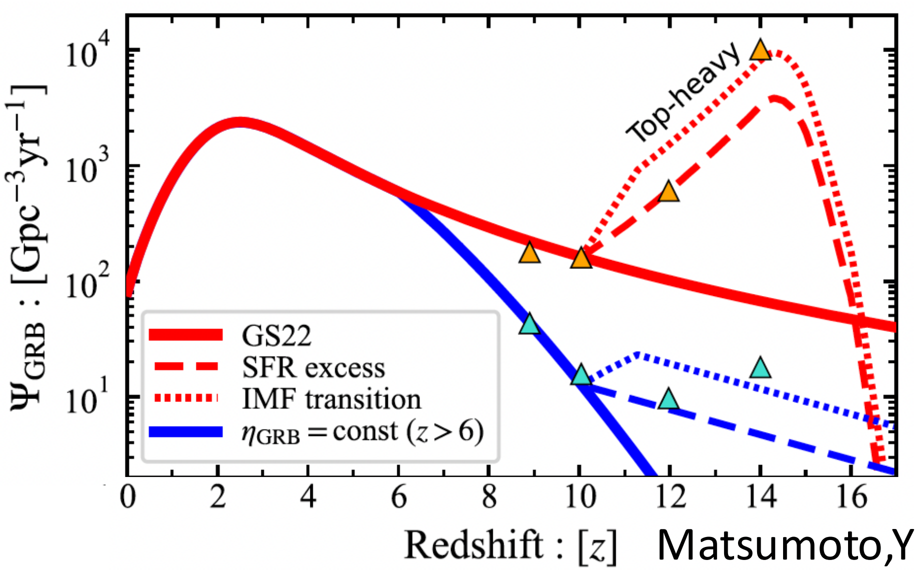
- A robust z~10.5 LRD candidate from NIRCAM+MIRI
  - LRD fraction in the entire galaxy: f_{LRD}~3% at z=10
  - Higher than f_{LRD} at z<10, increasing f_{LRD} to higher-z



Tanaka,Akins,YH+25 (arXiv this Monday!)

Massive Star Contribution Probed from GRBs

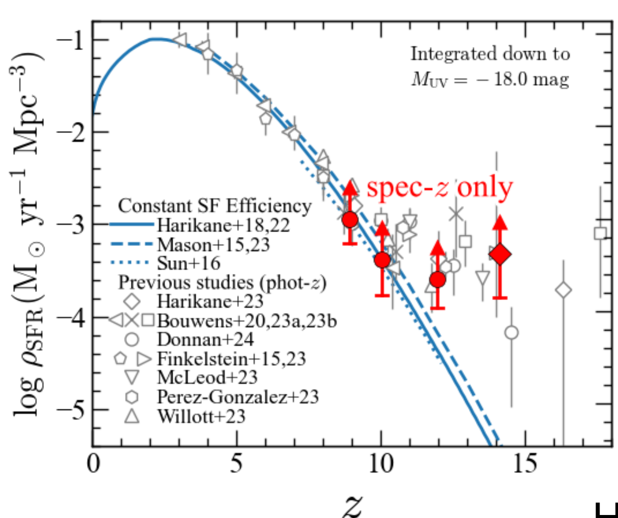
- GRB: Explosion of massive stars
  - Kinugawa&Asano17: ~5-50 M_{sun}, Chrimes+20: 11-60 M_{sun}
- Comparing w/ JWST rest-UV densities (~3-7 M_{sun}), we can constrain the IMF slope at high-z
  - Understanding massive star contributions to the JWST overabundance problem

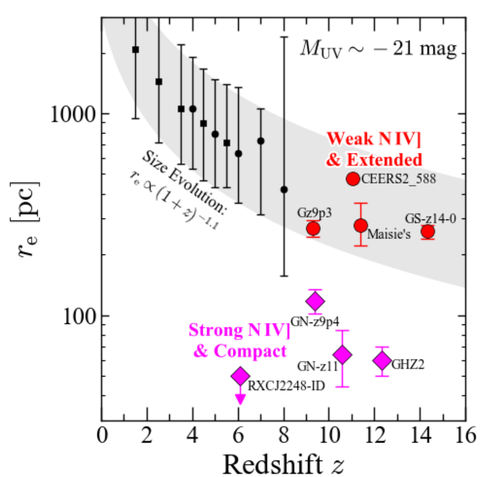


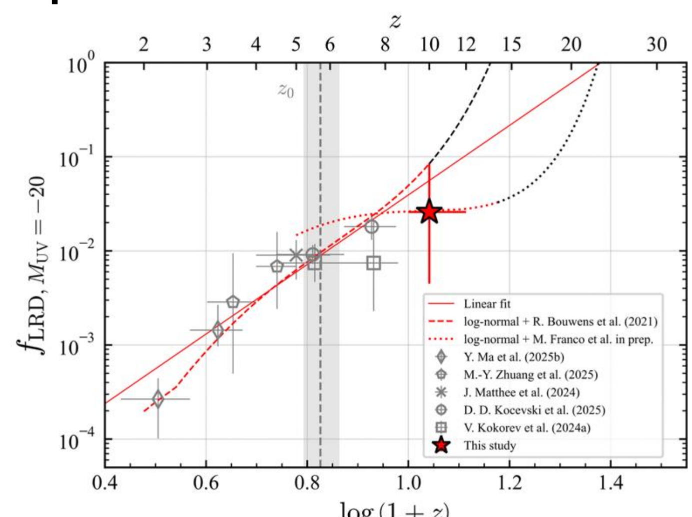
Matsumoto,YH+24

Summary

- JWST studies on high-z galaxies
  - Large number of z>10 galaxies, tension with models.
  - Two types of bright galaxies at z>10 (compact, extended) with different emission line properties (incl. NIV]1486)
  - LRD candidate at z~10. Higher LRD fraction at higher-z
  - High-z GRB is a useful probe for contributions of massive star to the JWST overabundance problem at z>10







Harikane+25a, ApJ 980, 136 Tanaka,Akins,Harikane+25, arXiv