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Robust estimates of the high-redshift GSMF with BUFFALO

BUFFALO High-redshift galaxy catalogs and Completeness simulations

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BUFFALO Collaboration meeting — July 12, 2021

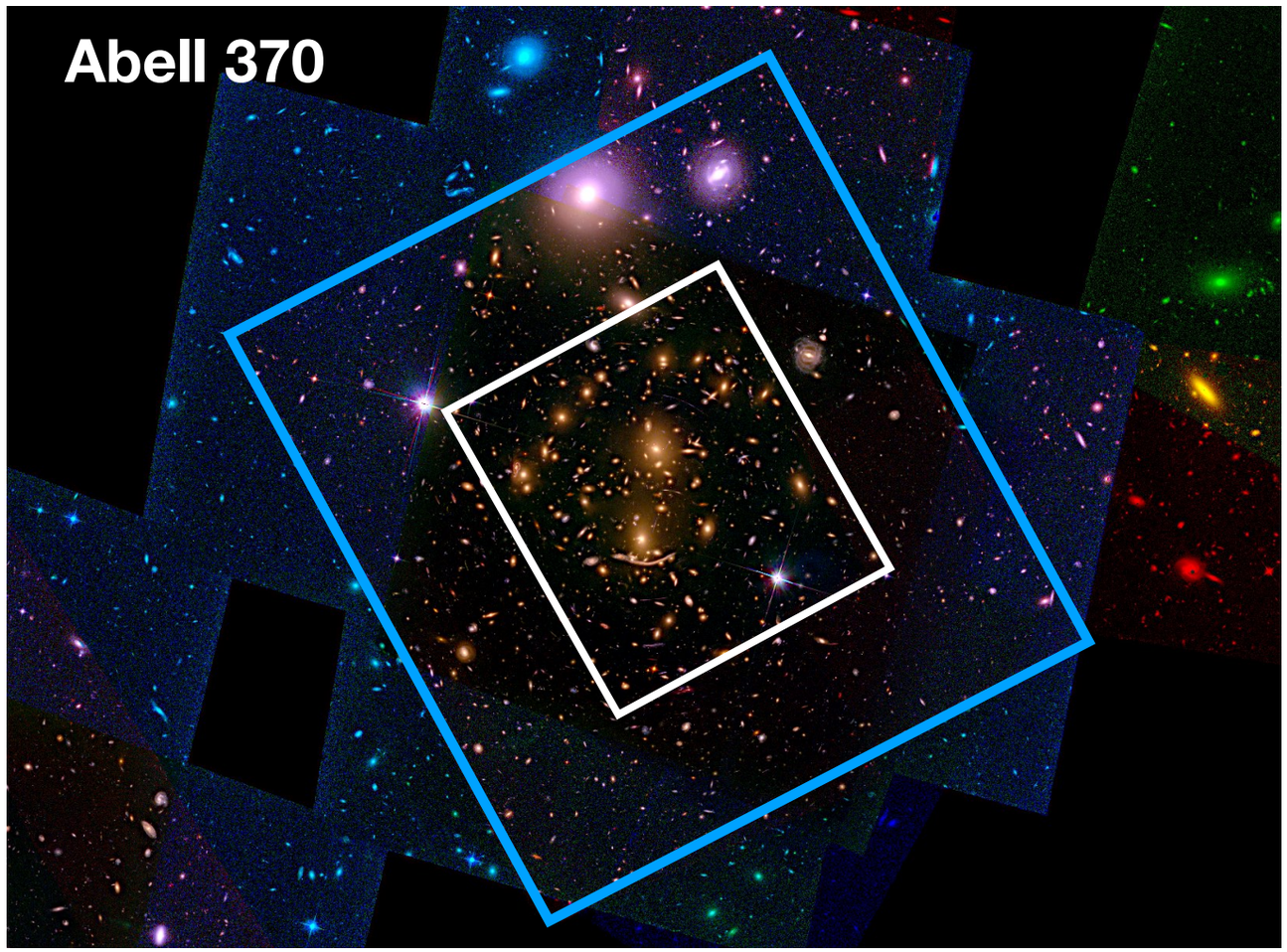
Overview

- BUFFALO A370 high-redshift galaxy catalog

- $M_\star$ Completeness simulations

- Stellar mass model dependence

- Lensing — BUFFALO source planes

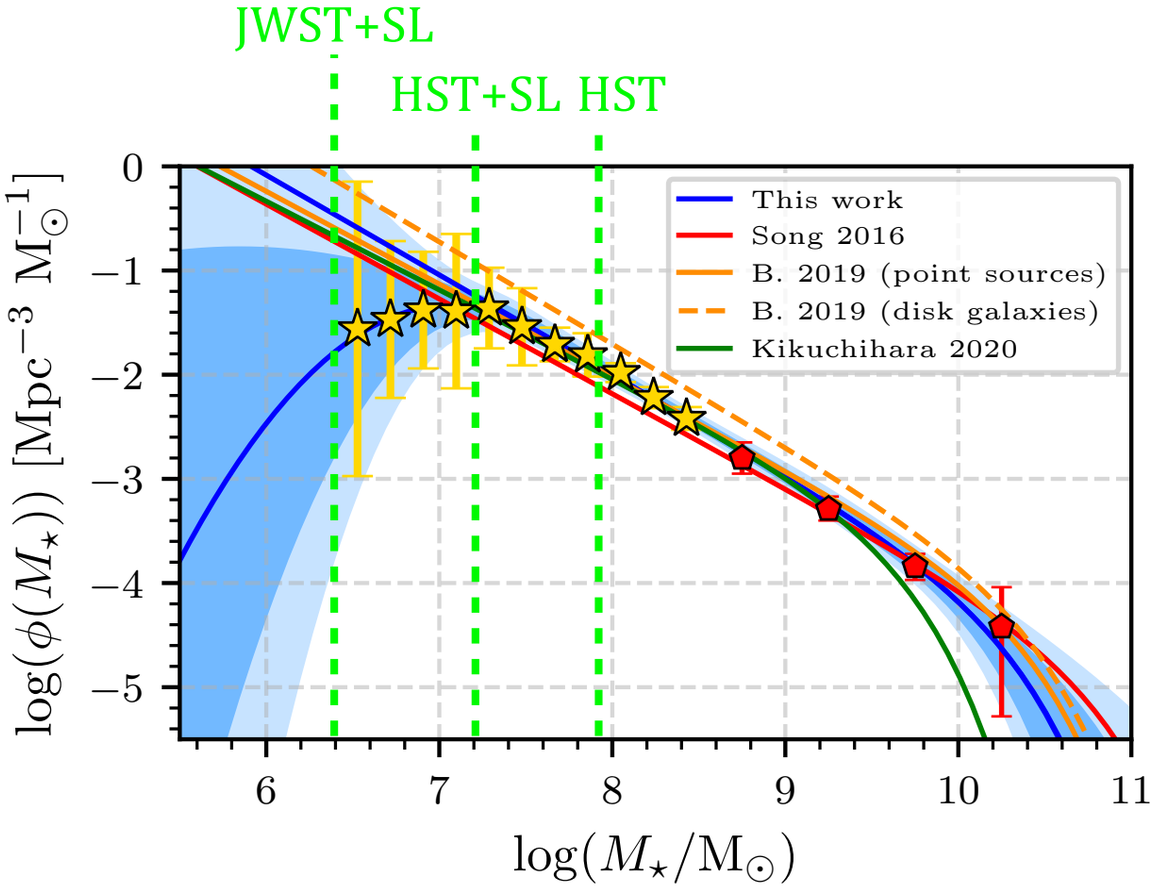


The high-redshift stellar mass function

- Provides **crucial** observational constraints on galaxy formation and evolution models and simulations

$$\phi(M_\star)\mathrm{d}M_\star = \frac{N}{V(M_\star)}$$

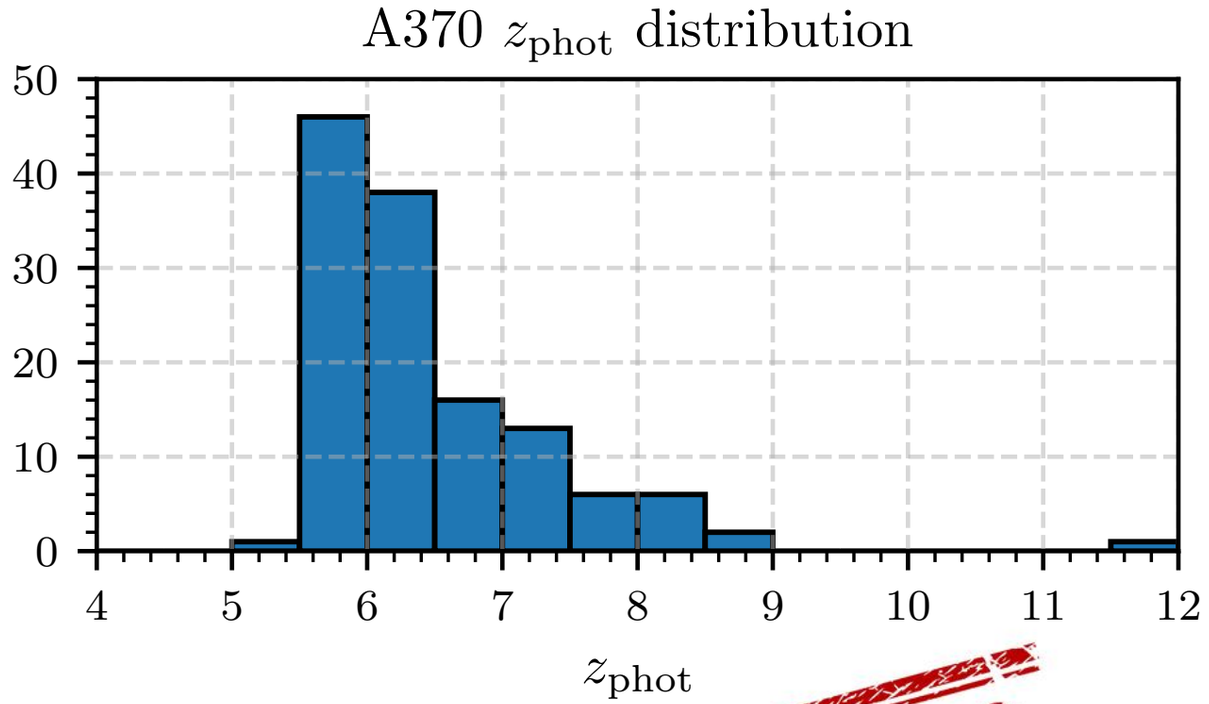
- The $z \sim 6-7$ stellar mass function measured down to $\sim 10^{7.5}\,\mathrm{M}_\odot$ in **blank fields** (*Song et al. 2016*, *Stefanon et al. 2021*)
  - down to $\sim 10^{6}\,\mathrm{M}_\odot$ with HFF (*Bhatawdekar et al. 2019*, *Kikuchihara et al. 2020*, *Furtak et al. 2021*)
  - Tentative down-ward turnover at $M_T \sim 10^{7}\,\mathrm{M}_\odot$ (*Furtak et al. 2021*)
- $M_\star$ **is model dependent** —> Depends on physical galaxy parameters!



Furtak et al. 2021

BUFFALO A370 High-redshift catalog

- v1.0 for A370 online on the BUFFALO data page! —> Cluster + parallel field
  - 114 $z \sim 6 - 7$ candidates
  - 14 $z \sim 8 - 9$ candidates
  - HST, IRAC and Ks photometry + photometric redshifts with BEAGLE
- To do for v2.0:
  - **Flag IRAC photometry for blending**
  - Physical parameters with BEAGLE —> $M_\star$
  - Gravitational magnification factors



Furtak et al. (in prep.)

WORK IN PROGRESS

Measuring Stellar Mass — SED-fitting

- BayEsian Analysis of GaLaxy sEds tool (BEAGLE, *Chevallard et al. 2016*)

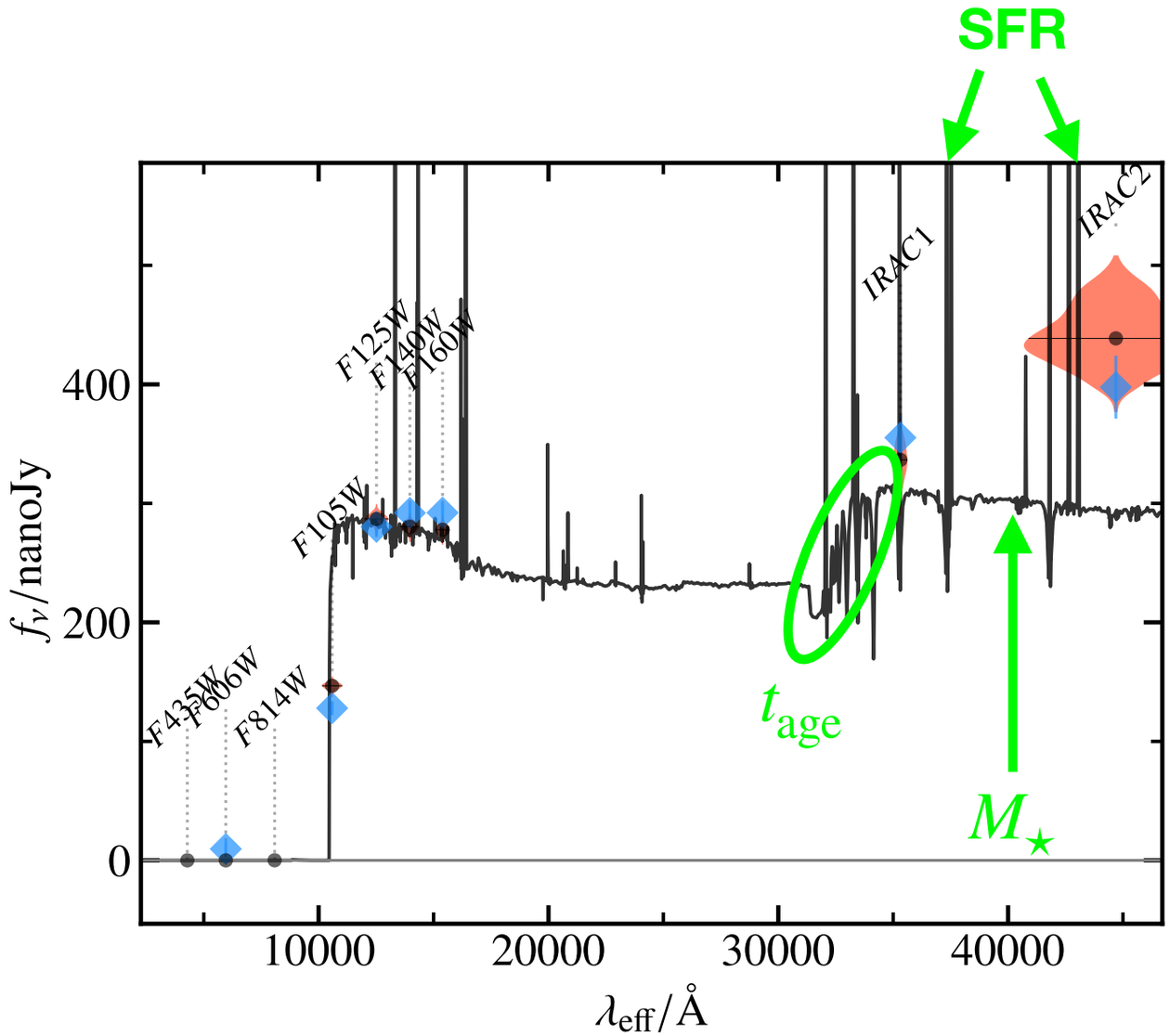
- $M_\star$ is **heavily degenerate** with physical parameters:

  - Nebular emission lines —> SFR and SFH

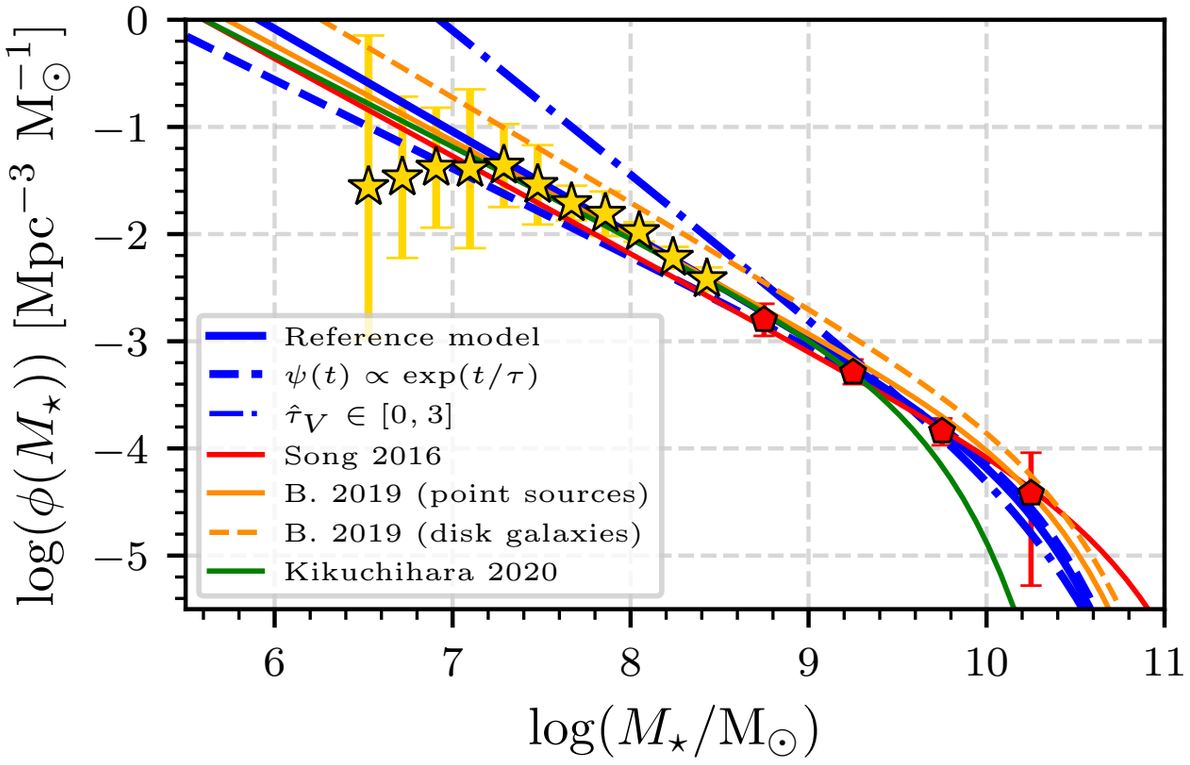
  - Balmer break —> Stellar age

  - Dust extinction

- Low-mass end sensible to shifts of $\gtrsim 0.1\,\mathrm{dex}$ in $M_\star$ and $M_\star - M_{\mathrm{UV}}$ -relation (*Furtak et al. 2021*)!

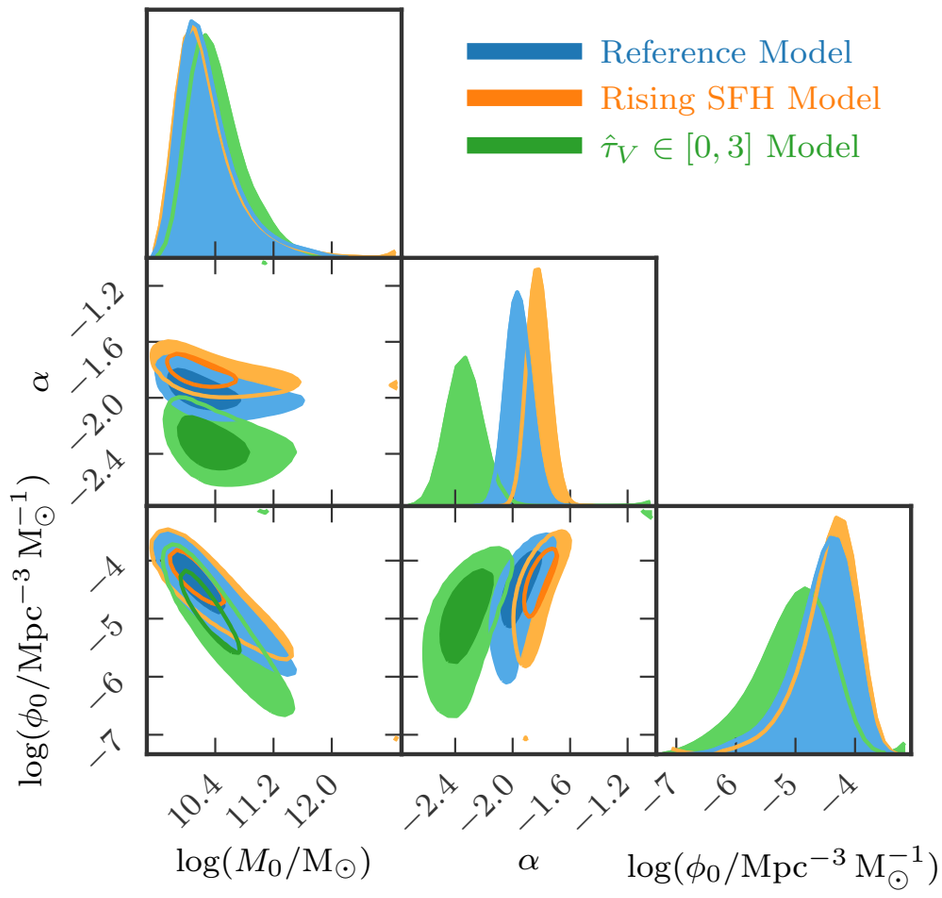


Impact of SED-fitting assumptions



Furtak et al. 2021

- Most notable impacts from **SFH** and **dust attenuation**
  - Span **low-mass end slopes** from $\alpha \simeq -2.2$ to -1.7



Furtak et al. 2021

- Higher dust attenuation makes GSMF ***steeper***:
  - Lack of accurate ***Spitzer*/IRAC photometry** on the low-mass end
- Exponentially rising SFH makes GSMF ***shallower***:
  - Degeneracy with **nebular emission lines**

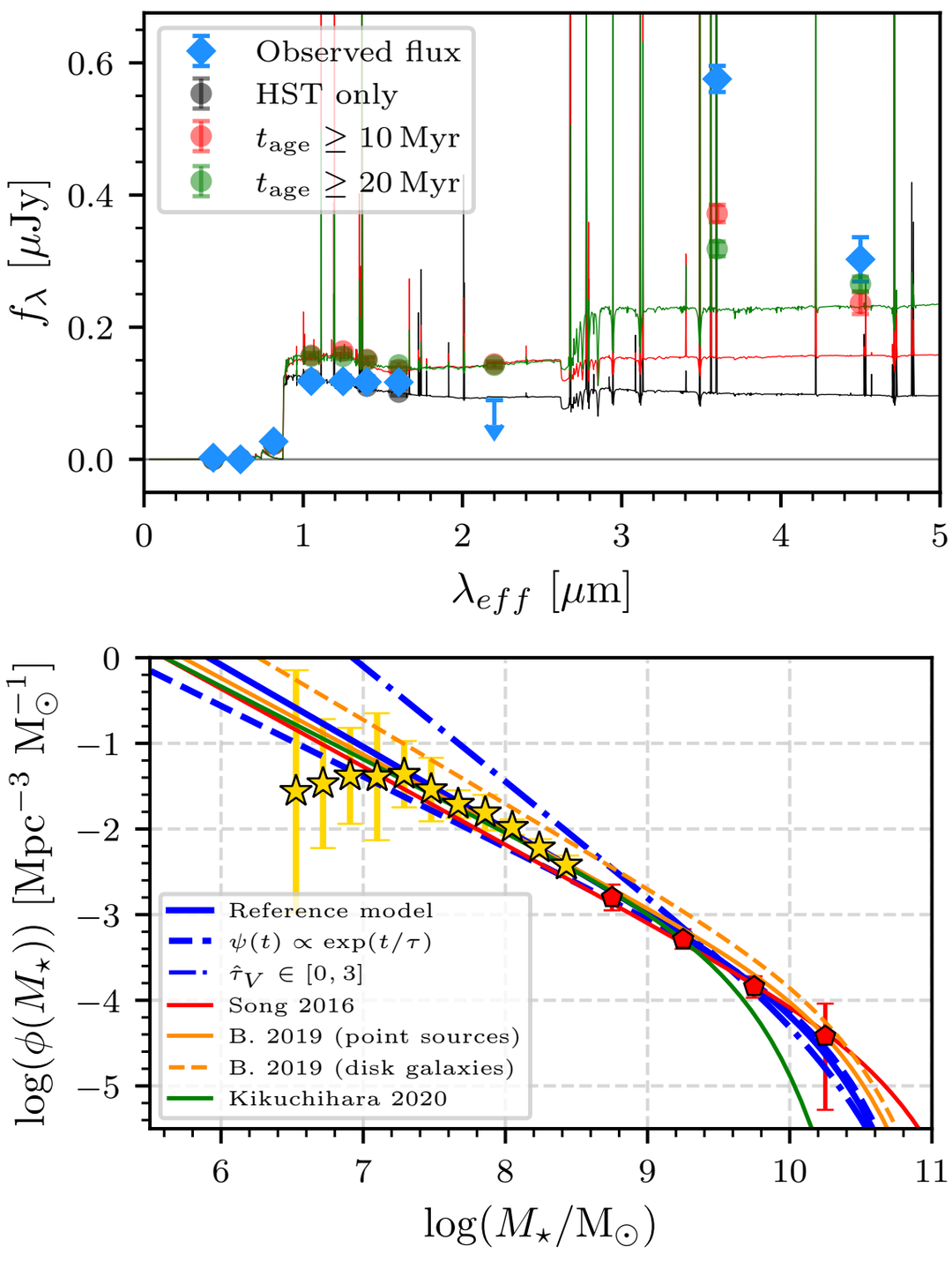
The way forward — $M_\star$-completeness simulations

- **Usually**: Convert UV luminosity completeness to $M_\star$ —> But that is not necessarily the same!

- Need to **incorporate** the model dependence of $M_\star$ into the survey volume!

- Fully understand our **selection function** $f(z, M_\star, \mu)$

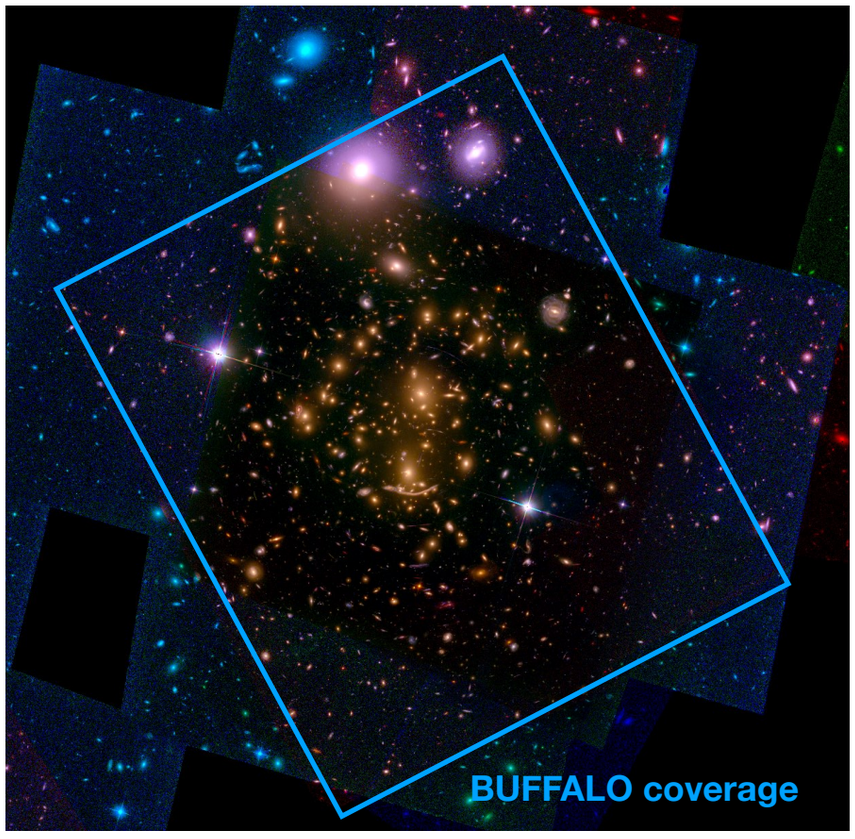
- Robust **uncertainties** on BUFFALO high-redshift stellar mass functions



Furtak et al. 2021

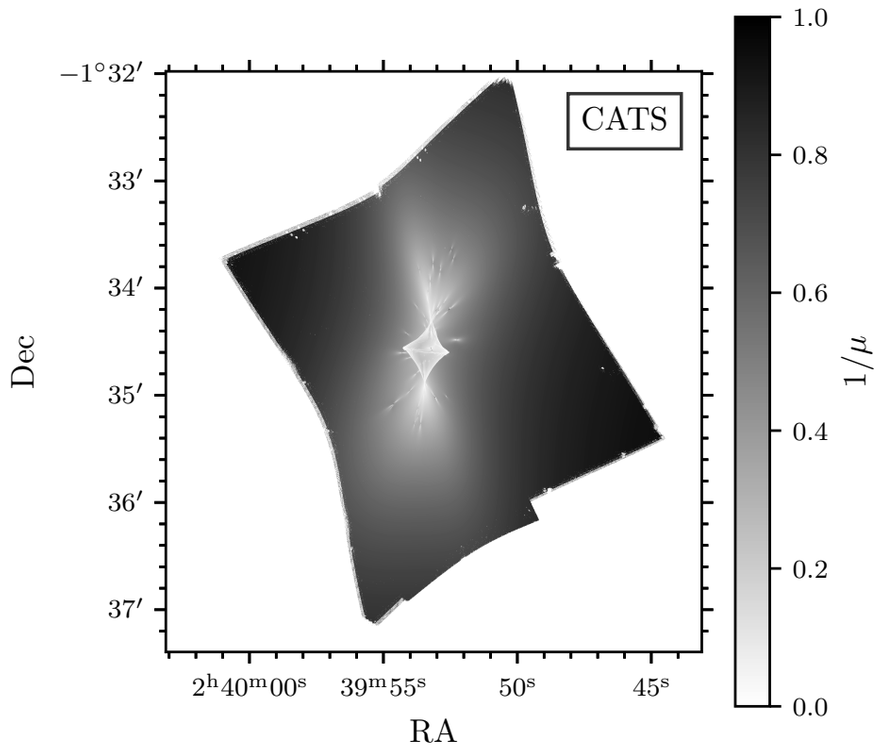
Forward modeling approach

- Simulate **galaxy SEDs** with BEAGLE —> Integrate for broad-band photometry
- Create mock **galaxy images** with galsim —> inject in source plane
- Run lenstool to incorporate SL effects

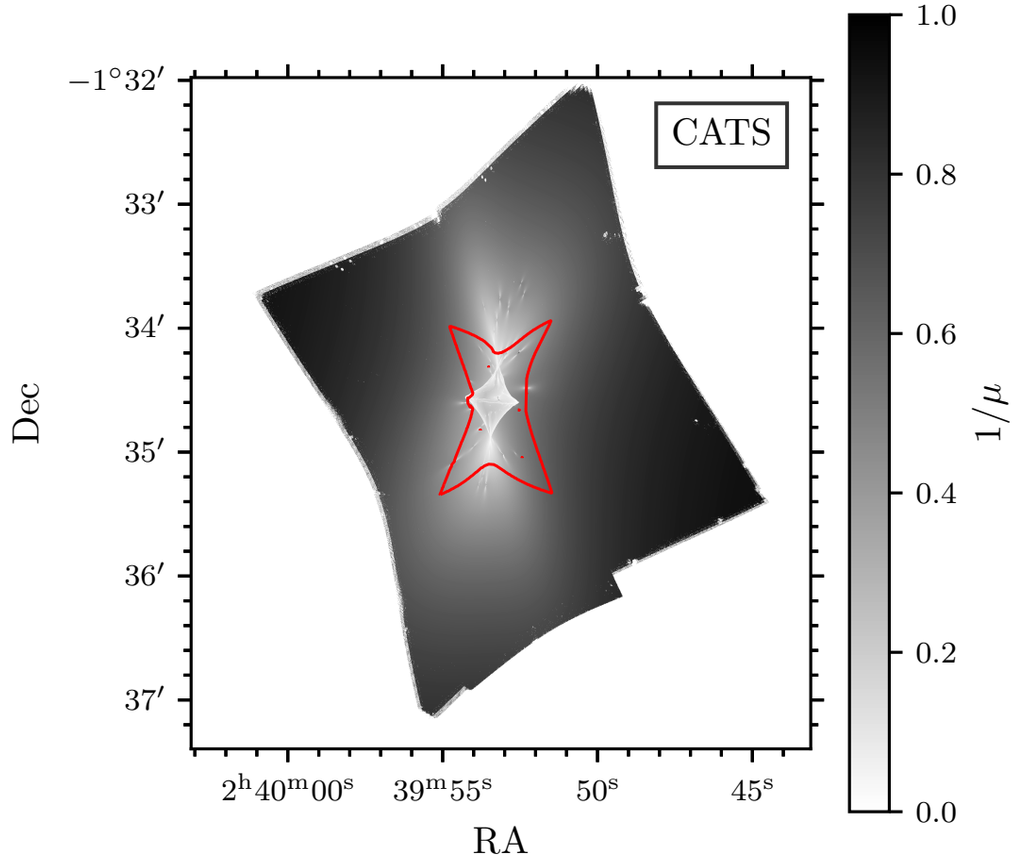


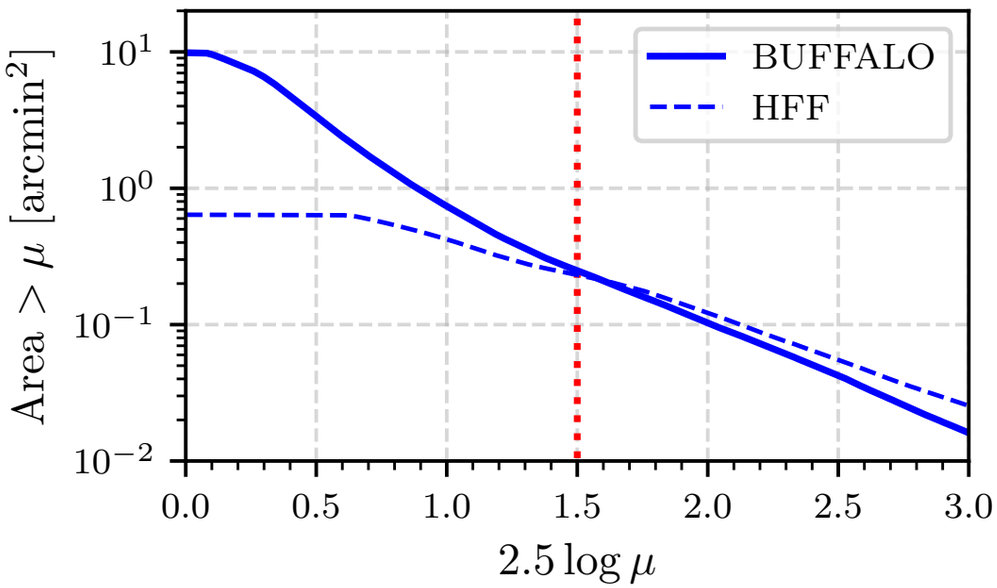
Lensing

$$\vec{\beta} = \vec{\theta} - \vec{\alpha}(\vec{\theta})$$



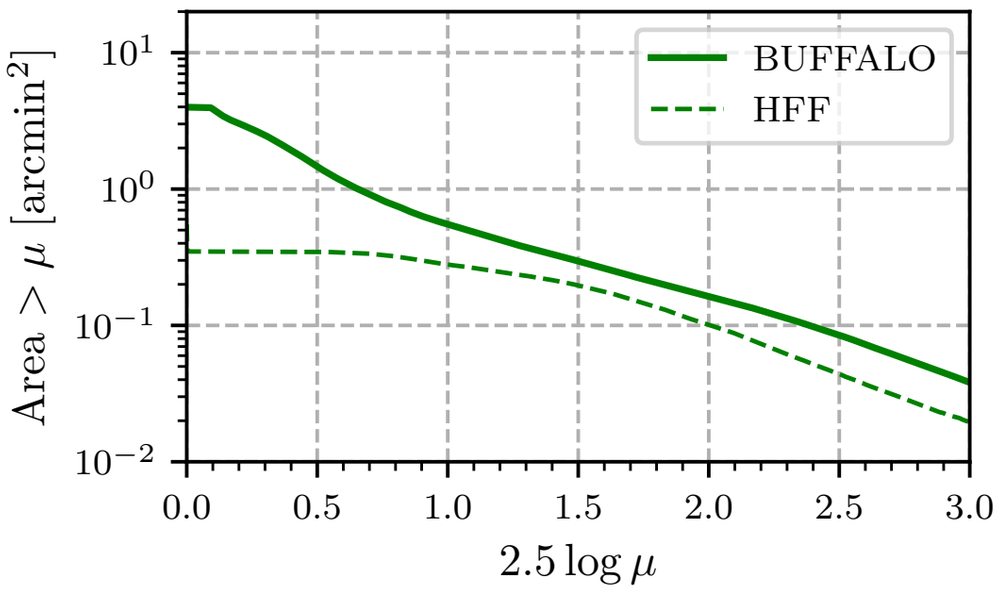
The BUFFALO source plane





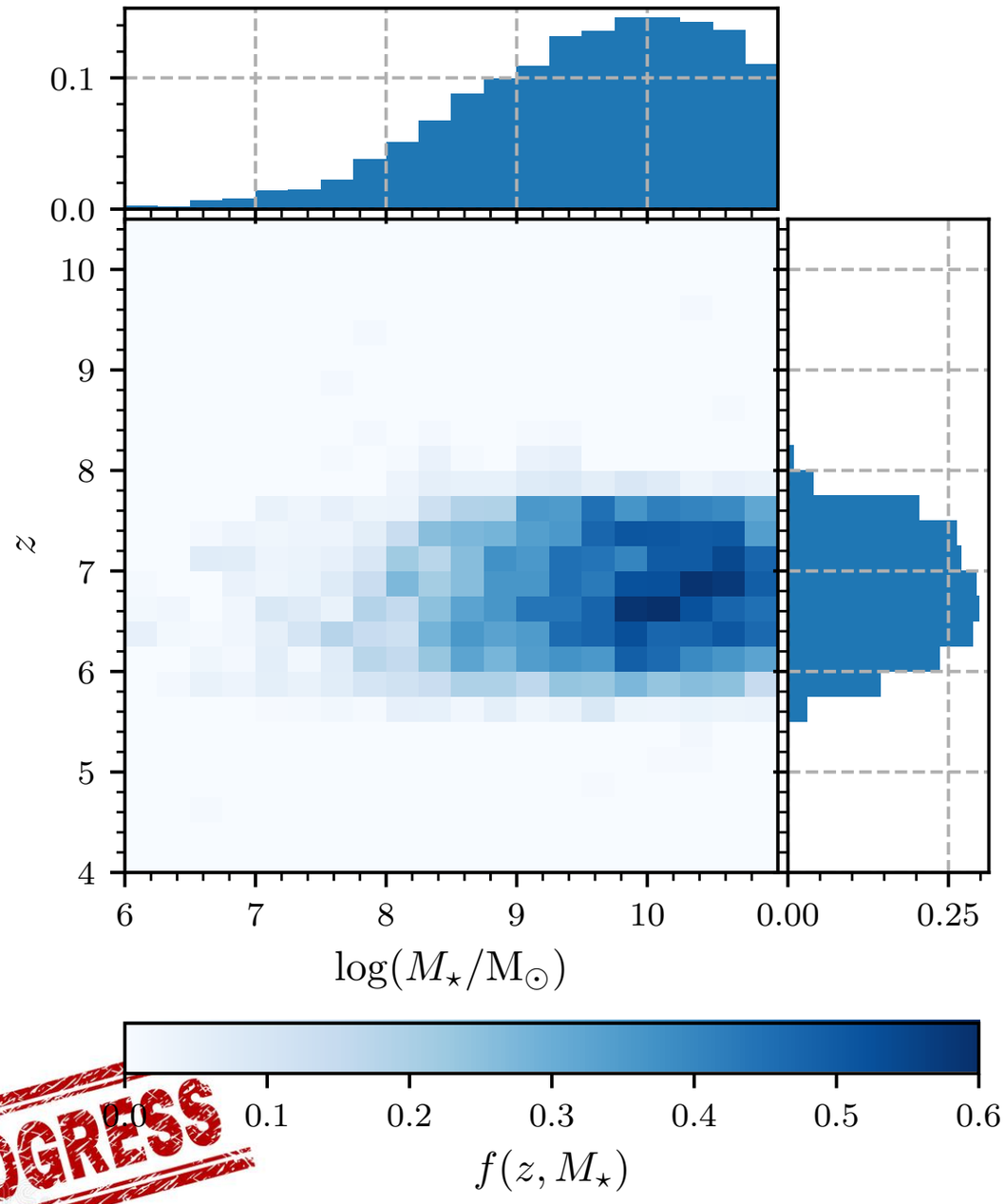
Furtak et al. (in prep.)

- Gain a factor $\times 15$ in source plane area vs. HFF!
- Mostly $\mu \lesssim 4$… (assuming CATS model)
- **But:** *Ghosh et al. 2021* model show new **high-magnification** areas!



Selection function

- Run SExtractor + high-redshift candidate selection on **mock images**
- Compare input/recovered galaxies
  - $M_\star$ selection function
- <u>Combine survey volume **uncertainties** from:</u>
  - **Galaxy parameter degeneracies**
  - Lensing systematics (—> 3 different SL models)
  - Source-size distribution

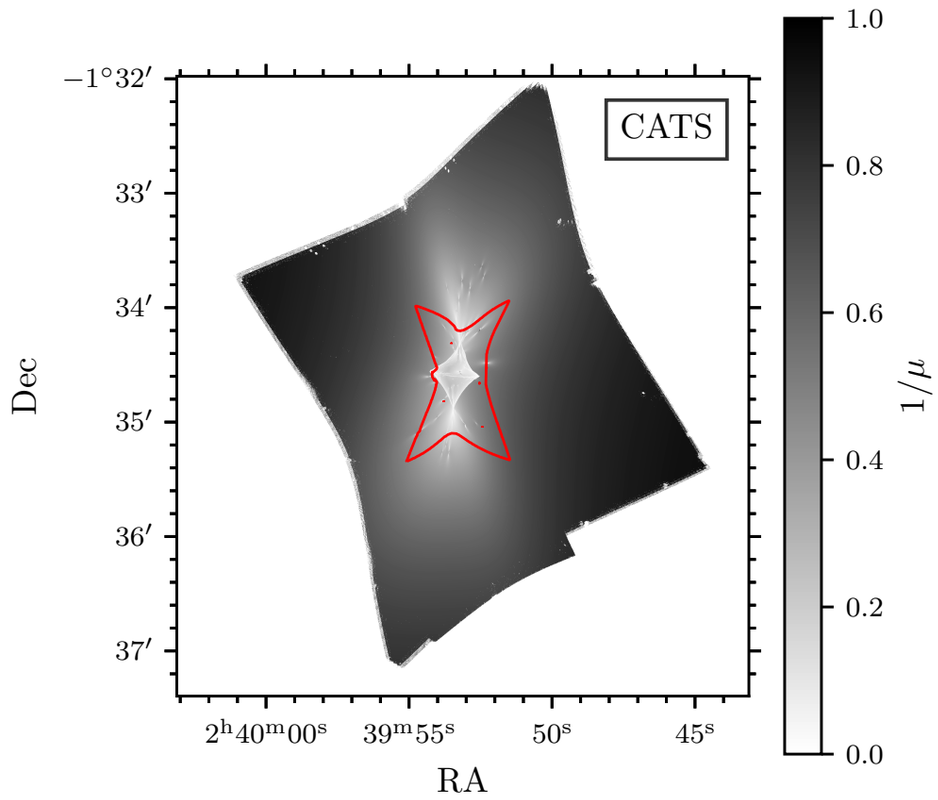


Furtak et al. (in prep.)

WORK IN PROGRESS

Summary and Conclusion

- Observe the **130 high-redshift candidates** in A370 with BUFFALO —> v1.0 catalog online!
- Different can **SED-fitting prescriptions** span GSMF low-mass end slopes from $\alpha \simeq -2.2$ to -1.7…
    - Low-mass end sensible to shifts of $\gtrsim 0.1\,\mathrm{dex}$ in $M_\star$ and $M_\star - M_{\mathrm{UV}}$-relation from **parameter degeneracies** in the rest-frame optical range
- Work to incorporate this **model dependence** of $M_\star$ into the GSMF **uncertainties** with new $M_\star$ **completeness simulations**
- <u>Ongoing work</u>
    - v2.0 of A370 high-redshift catalogs in prep.
    - $M_\star$ completeness simulations using all available lensing models —> **Contact me if you have a lensing model that I can use!**
    - Once this works, other clusters coming soon!



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