michelle.denny@ontariotechu.net

COUNTING MASSIVE GALAXIES IN THE EARLY UNIVERSE WITH JWST

MICHELLE DENNY [1,2,3], JACQUELINE ANTWI-DANSO [1,2], SAMANTHA BEREK [1,2,4] JOSHUA SPEAGLE [1,2,4,5]

BACKGROUND

Massive galaxies in the early universe tend to be difficult to study; many low-mass galaxies masquerade as massive galaxies due to observational limitations. The **Stellar Mass Function (SMF), Φ(M,z),** tells us how many galaxies of a given mass exist at a particular redshift and can help us understand galaxy evolution.

As we get to higher redshifts and masses, the number density of galaxies **drastically decreases**, with increasing uncertainty.

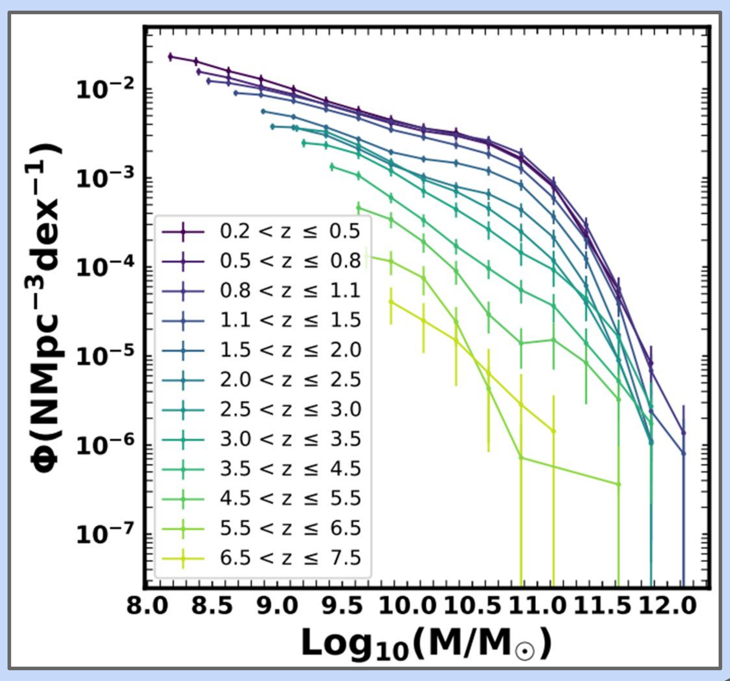

Fig 1: SMF of Galaxies

DATA

COSMOS2020 covers ground and space-based photometry from 0.3-8 μm. **COSMOS-Web** contains near-infrared photometry from **JWST** at wavelengths inaccessible from the ground. Massive galaxies have unique spectral features embedded in their spectra, such as **Balmer Breaks**, that help to classify them.

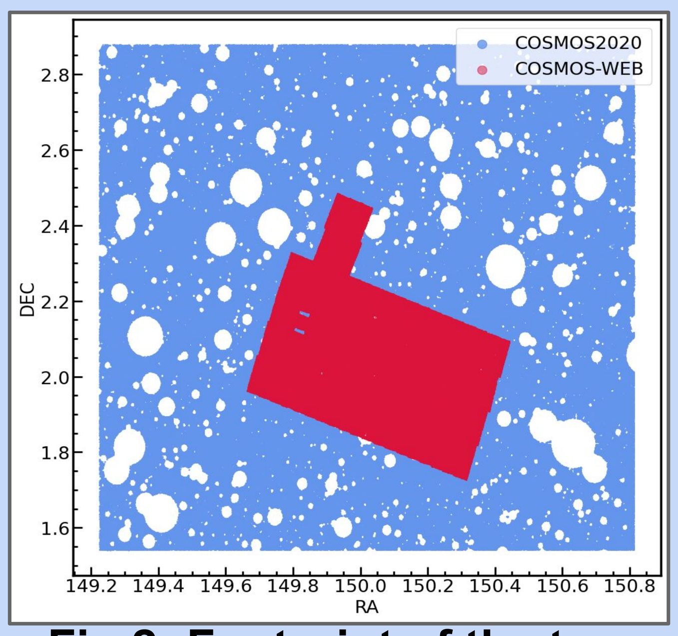

Fig 2: Footprint of the two catalogs

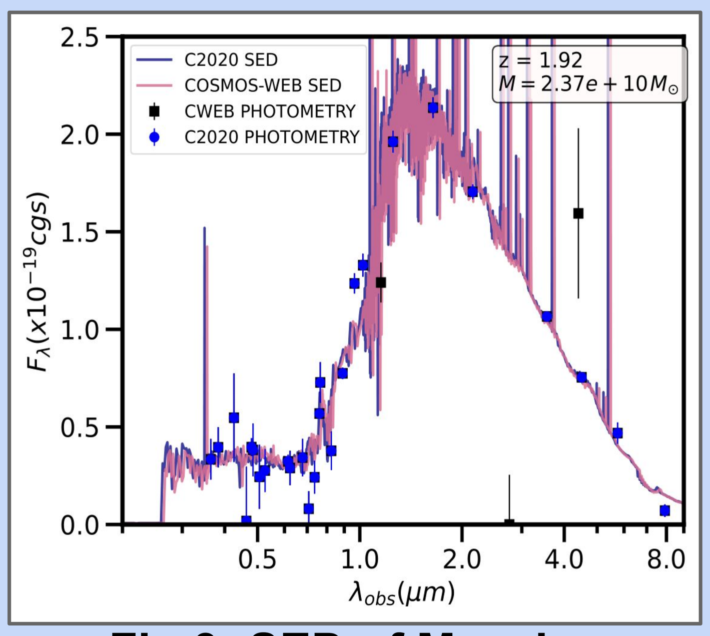

Fig 3: SED of Massive Quiescent Galaxy

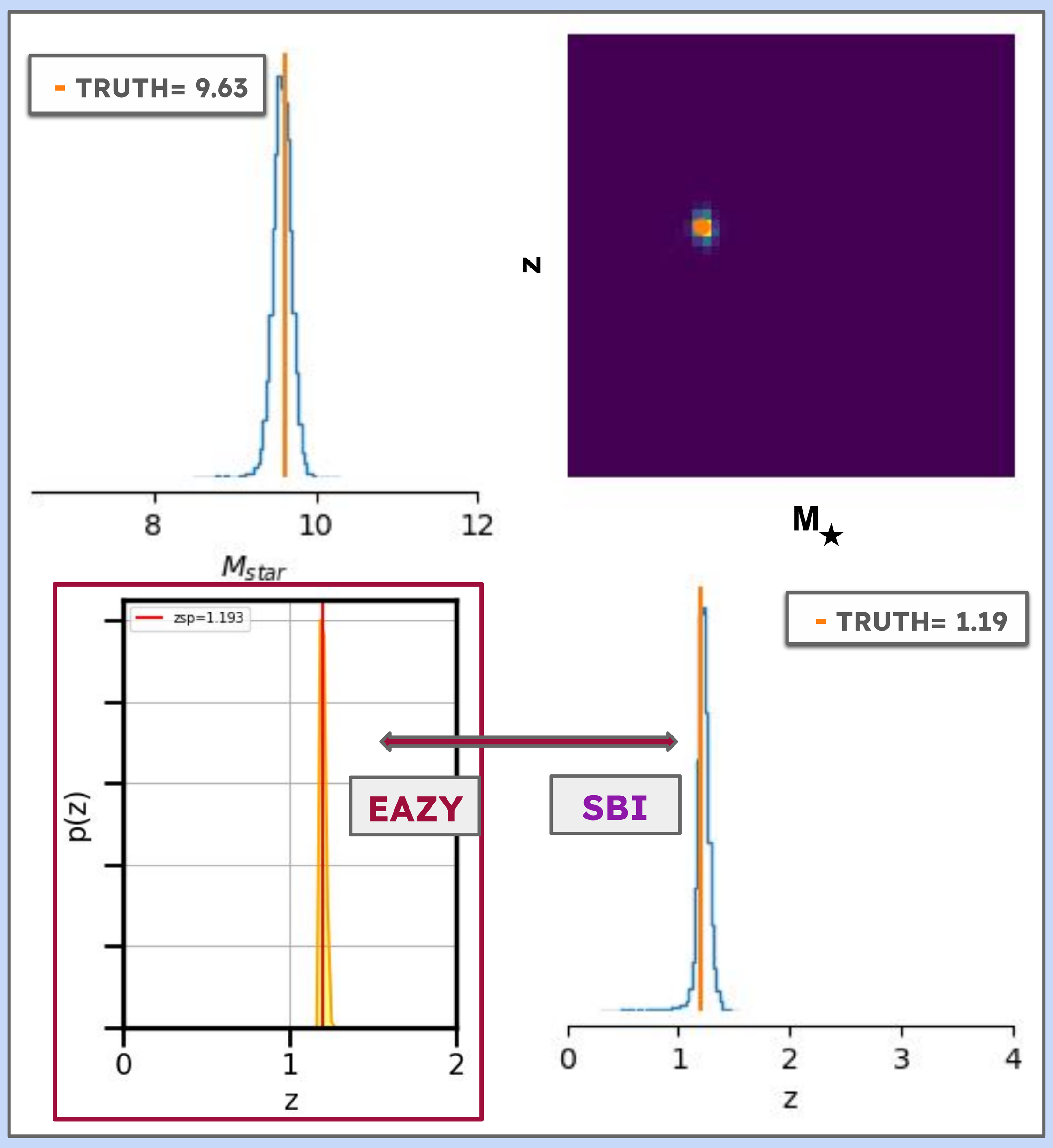

Fig 4: Comparison between SBI and EAZY

SIMULATION-BASED INFERENCE (SBI)

- **EAZY**, a photometric redshift fitting software predicts **redshift (z), stellar masses ($M_\bigstar$)** and other parameters by fitting a **linear combination of templates** photometry of a galaxy
- SBI is a **likelihood free method** that generates **posterior probabilities** by comparing **observed data to simulations (ground truth)**
- By training the simulator on a **subset** of galaxies in COSMOS2020 which **have JWST data**, we can use it to predict the **$M_\bigstar$ and z** of the full C2020 sample
- Training the SBI model was approximately **three times faster** than running the same catalog through EAZY to fit z, and SBI can be **extended to a larger dataset** almost instantaneously

MISCLASSIFICATION RATE

Next we calculate the **scatter (σ_z)** of the COSMOS2020 redshifts with respect to COSMOS-Web; galaxies with a photometric redshift scatter **greater than 15%** are considered **misclassified**. The **misclassification rate, η** can then be calculated as follows:

$$\sigma_z = \frac{|z_{catalog,C2020} - z_{eazy,C2020+JWST}|}{1 + z_{eazy,C2020+JWST}}$$

$$\eta = \frac{no.\ of\ \ \sigma_z > 0.15}{\text{total no. of samples}}$$

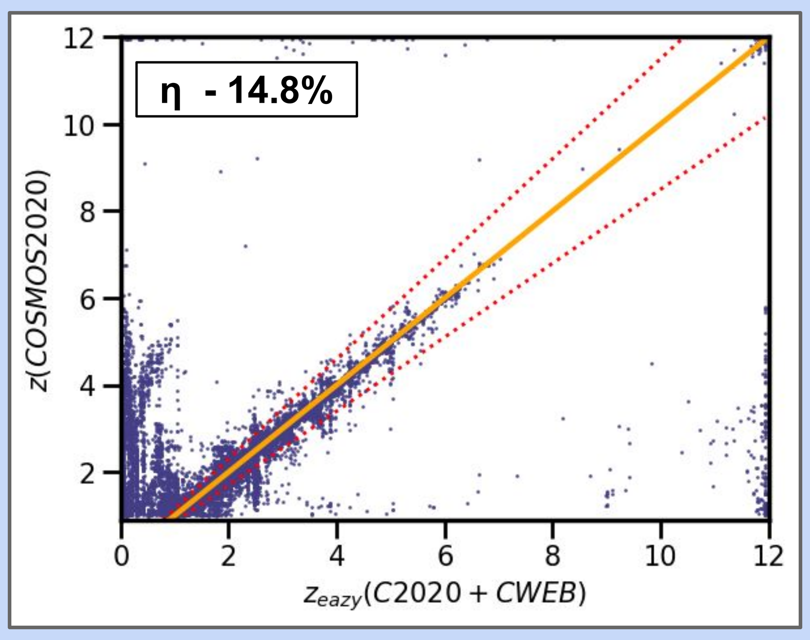

Fig 5: Photo-z scatter between catalog and Eazy redshifts

FUTURE WORK

- Estimating **η** for SBI and training it with **NaN values**
- Incorporating **photometry errors** while training SBI to weight the **$M_\bigstar$** and **z** with respect to the photometry data
- Observe **stellar mass distributions** predicted by SBI

CONCLUSION

SBI is a valuable method to use for **accelerated prediction of fitted parameters** of galaxies like **$M_\bigstar$** and **z.** This in turn could help **reduce the misclassification rate** of massive galaxies leading to more accurate studies of our early universe.

1. **David A. Dunlap Department of Astronomy & Astrophysics,** University of Toronto
2. **Dunlap Institute for Astronomy and Astrophysics**
3. **Department of Physics,** Ontario Tech University
4. **Data Sciences Institute**, University of Toronto
5. **Department of Statistical Sciences**, University of Toronto

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