JWST Early Release Science Program TEMPLATES:

Targeting Extremely Magnified Panchromatic Lensed Arcs and Their Extended Star formation

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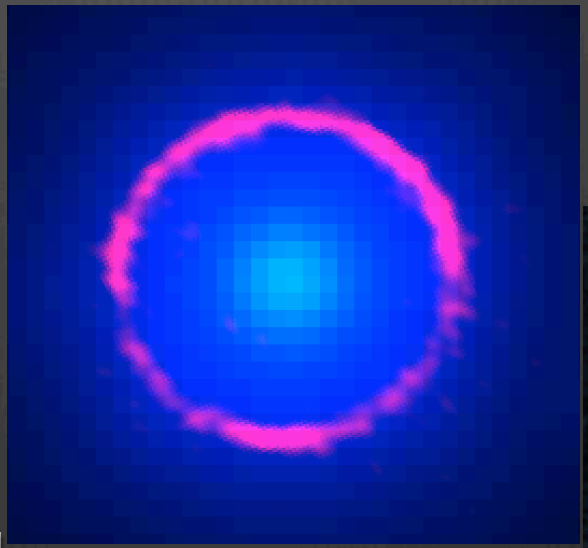
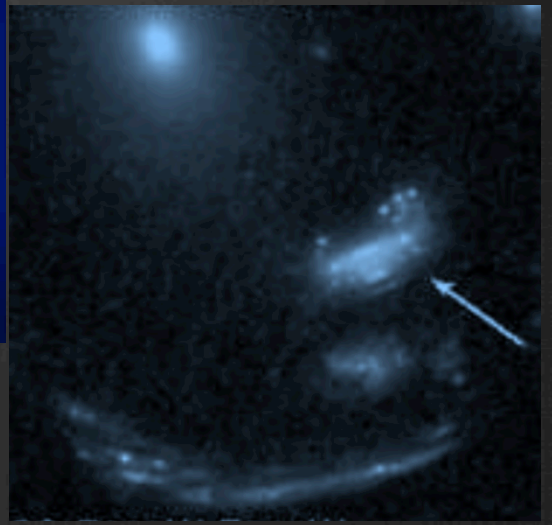




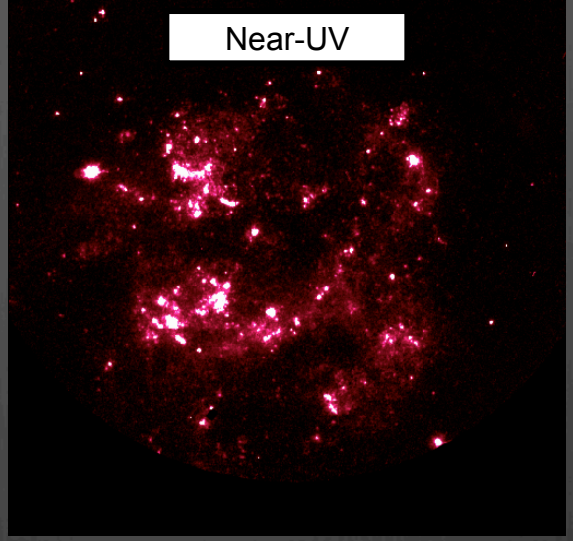
TEMPLATES Motivating Questions

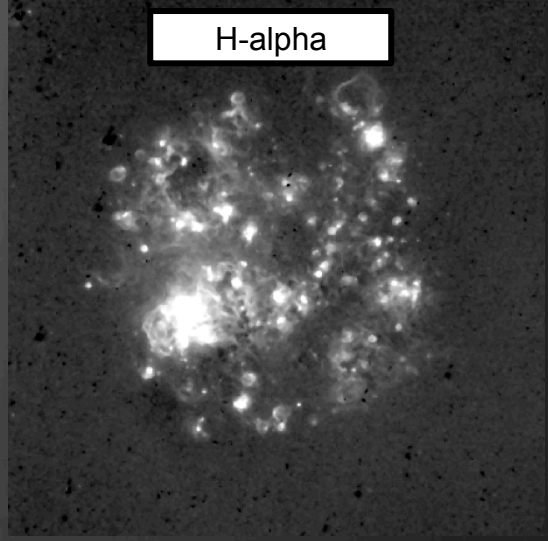
- Where do stars form in galaxies? How are the mass profiles assembled?
- What is the typical size scale for star formation? How clumpy is star formation?
- How well (or not) do various tracers of star formation agree? How do spatial differences in galaxy properties (e.g., extinction) affect inferred quantities?

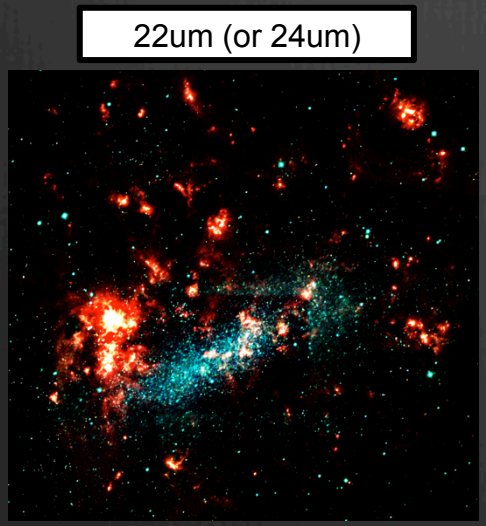
IFU observations are key!

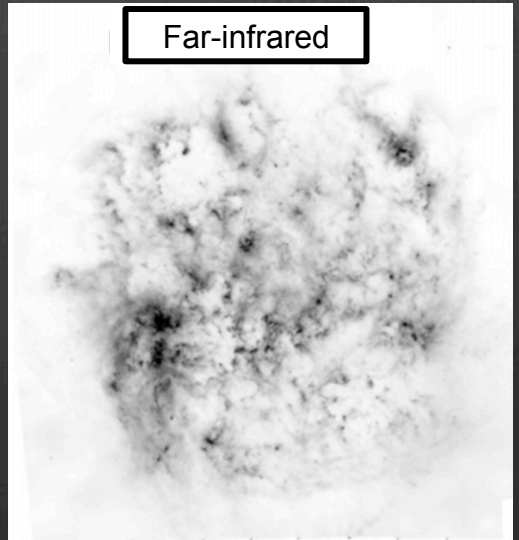
How well do we understand star formation and mass growth in galaxies?

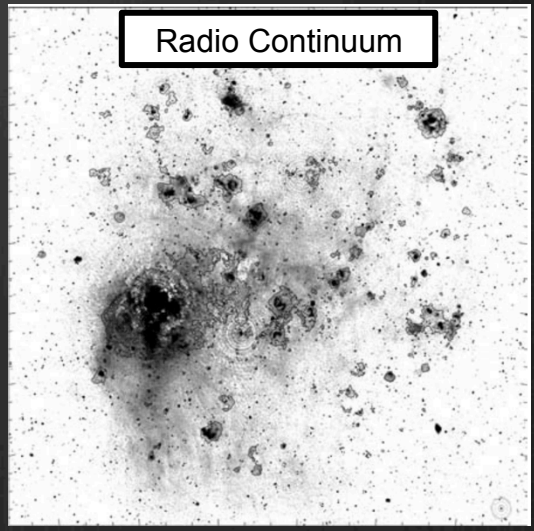
Five views of the “star formation rate” in the Large Magellanic Cloud







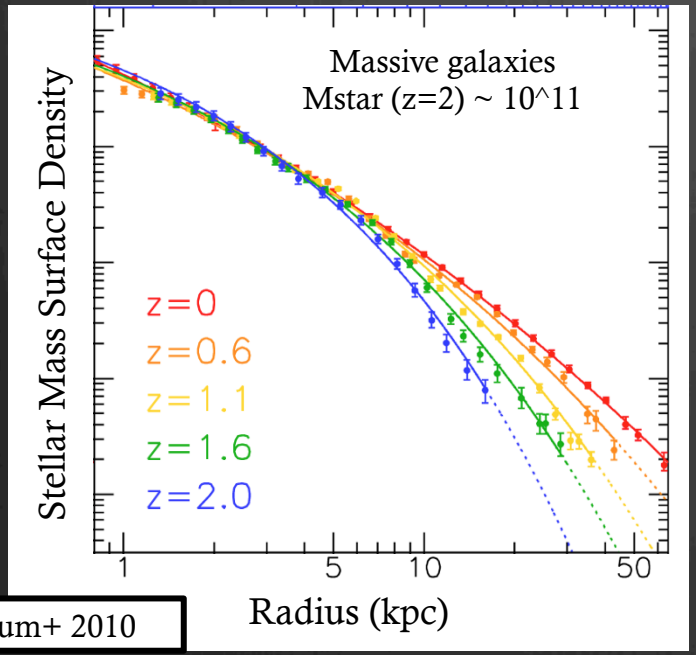




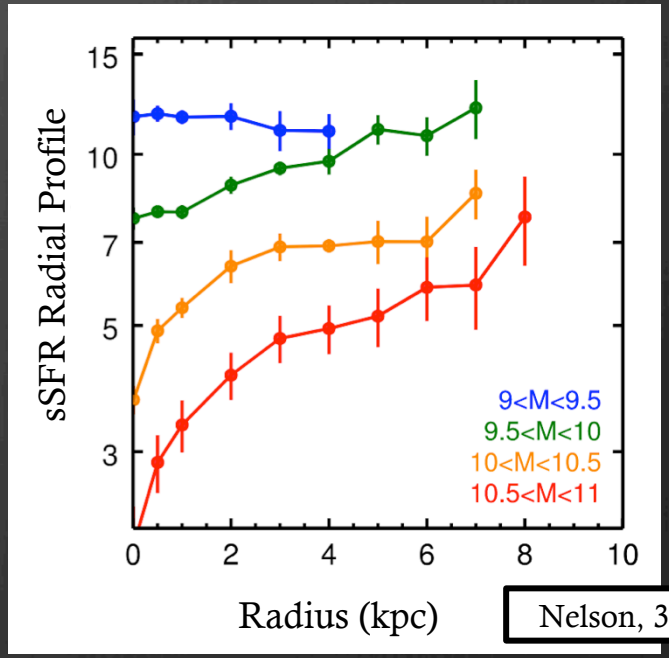
Where do stars form in galaxies? How are the mass profiles assembled?

Inside-out growth: current SF is more extended than the existing stellar mass, rising sSFR profiles with radius. Most ongoing growth in the outskirts.

Observational bias: Much easier to get a trend like this with UV (or Halpha) than the converse



van Dokkum+ 2010

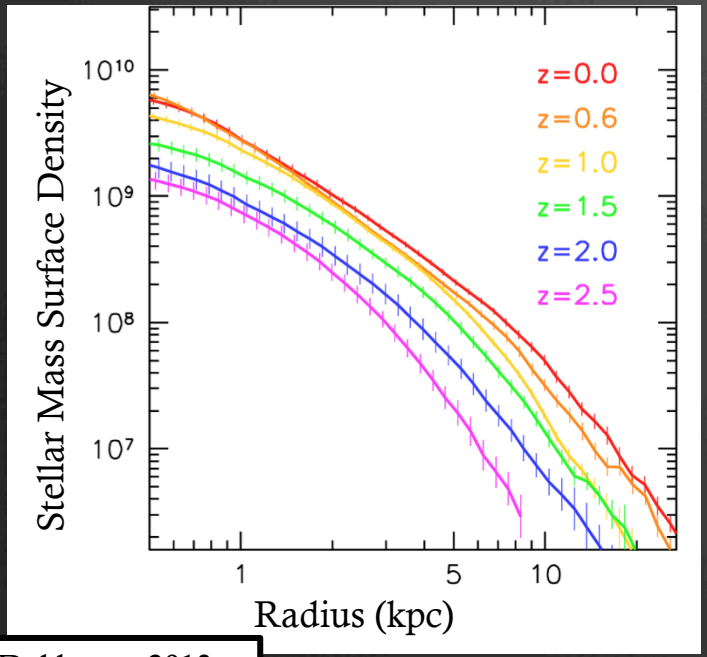


Nelson, 3D-HST 2016

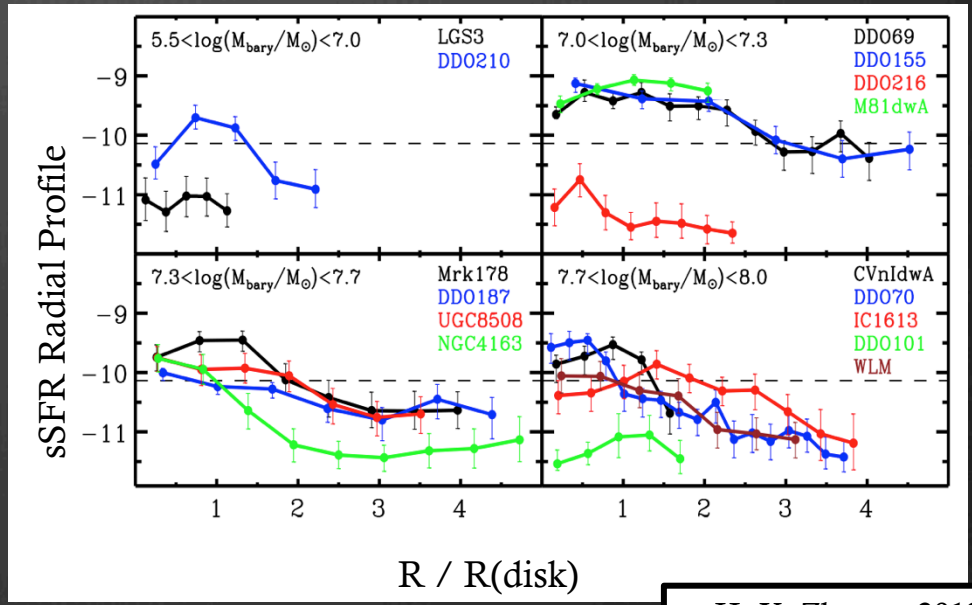
Where do stars form in galaxies? How are the mass profiles assembled?

Outside-in growth: Current SF is more compact than existing stellar mass.

Most relevant for low masses at z=0. Related to bulge formation at higher redshift?



van Dokkum+ 2013



H.-X. Zhang+ 2012

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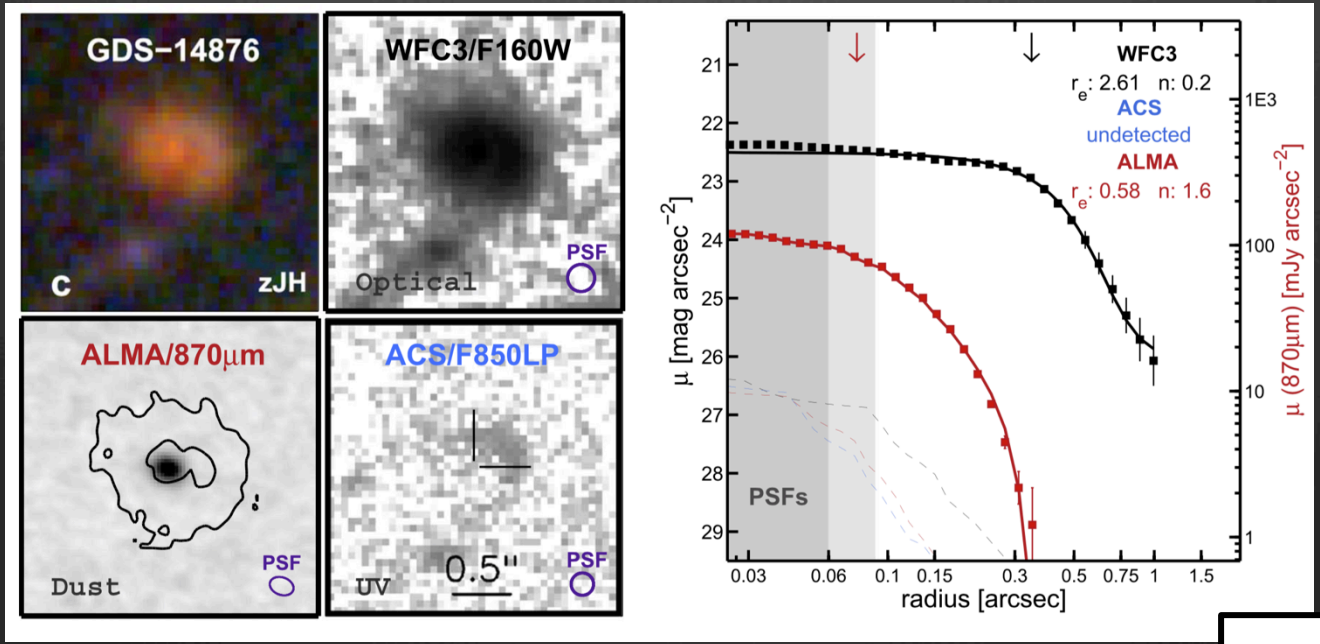
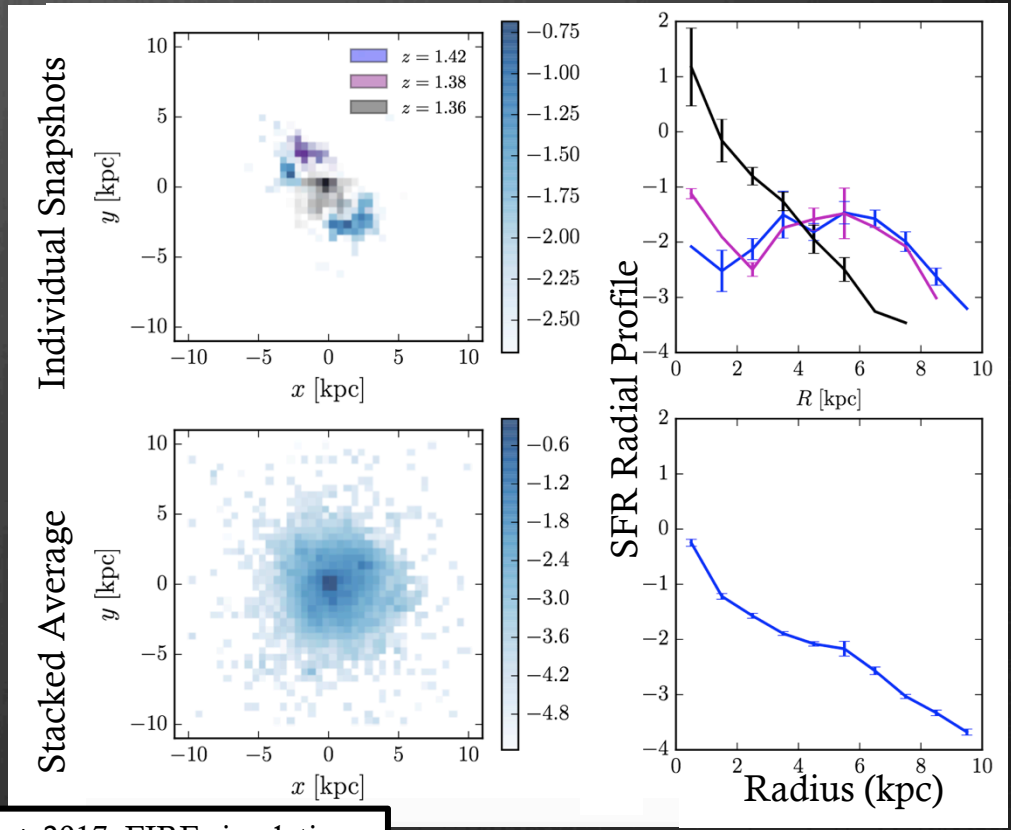


Barro+ 2016

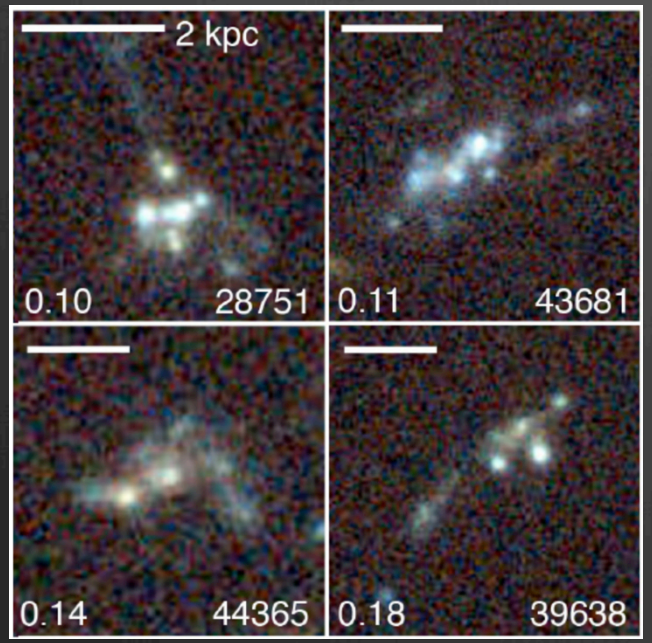
What is the typical size scale for star formation? How clumpy or bursty is star formation?

The smooth profiles above are probably misleading – stacking washes out clumpy structures.

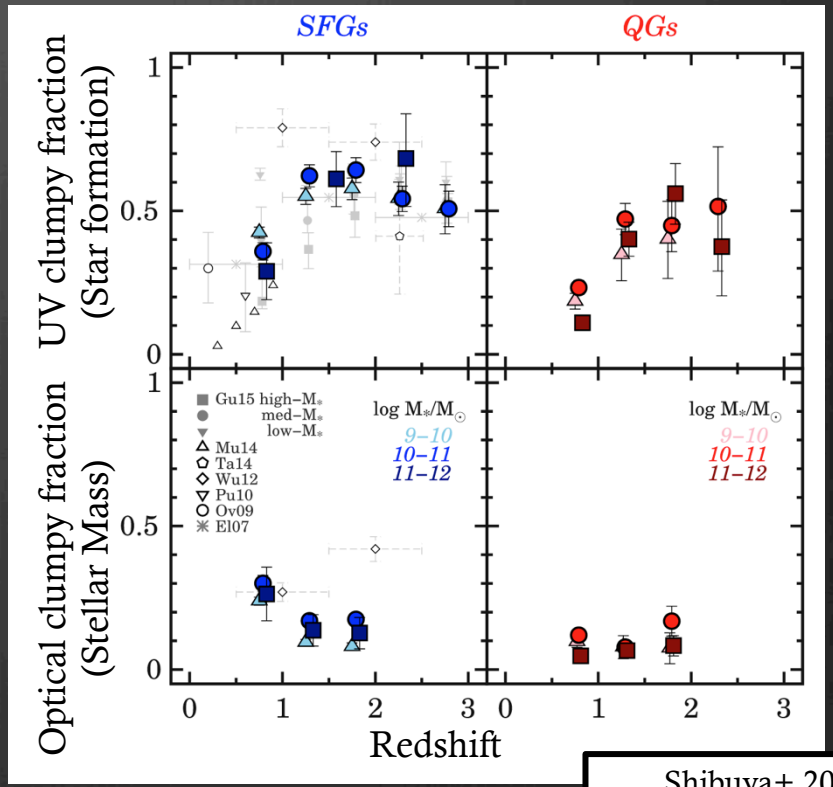


Orr+ 2017, FIRE simulations

What is the typical size scale for star formation?
How clumpy or bursty is star formation?



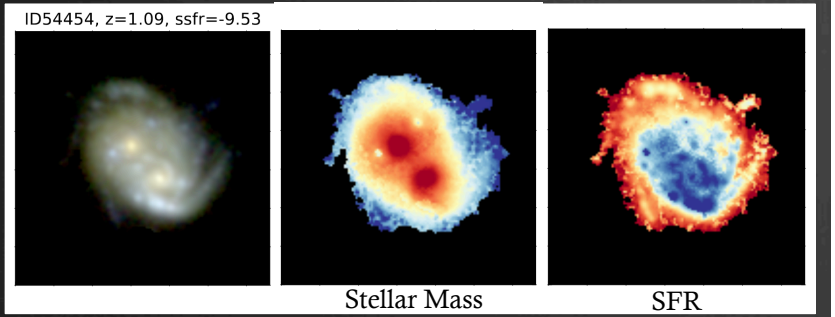
Elmegreen+ 2005, 2007, 2009



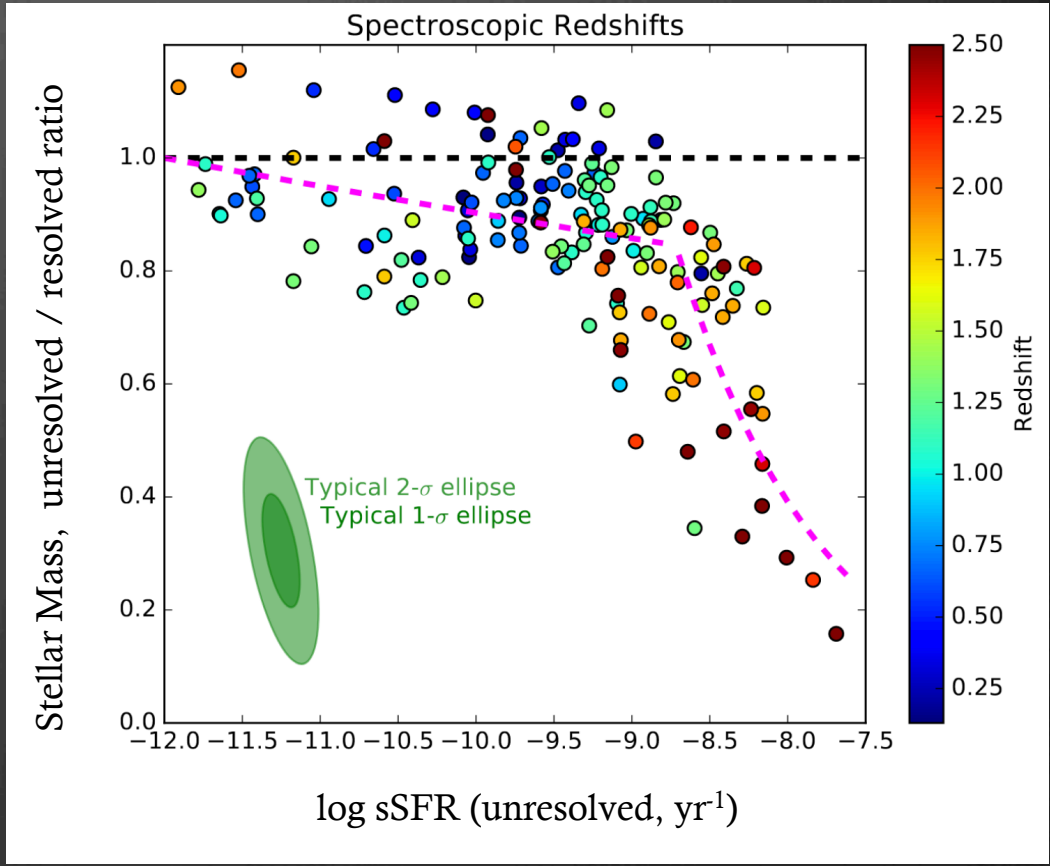
Shibuya+ 2016

How do spatial variations affect inferred quantities?

Spatial variations within galaxies (e.g., non-uniform extinction, star formation histories, etc.) may cause a bias in measured quantities (e.g., stellar mass, SFR, etc.)



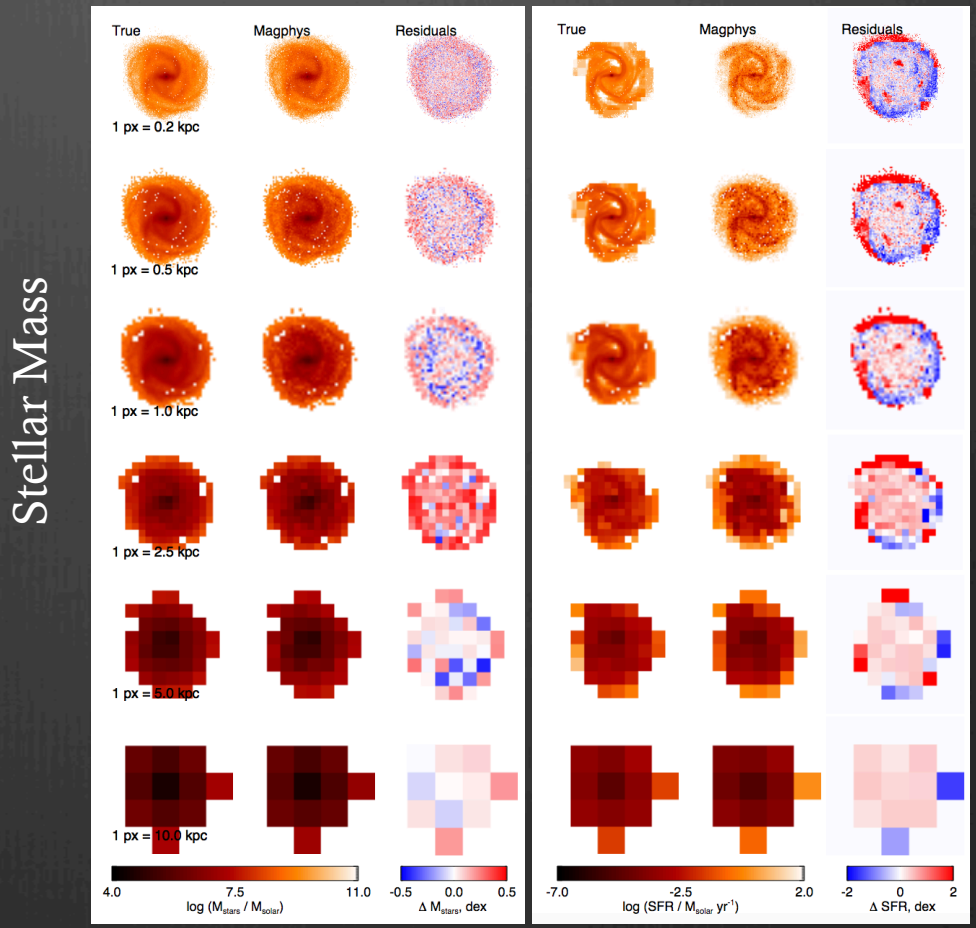
Sorba & Sawicki 2018



How do spatial variations affect inferred quantities?

How well can galaxy properties be recovered, even in “ideal cases”?

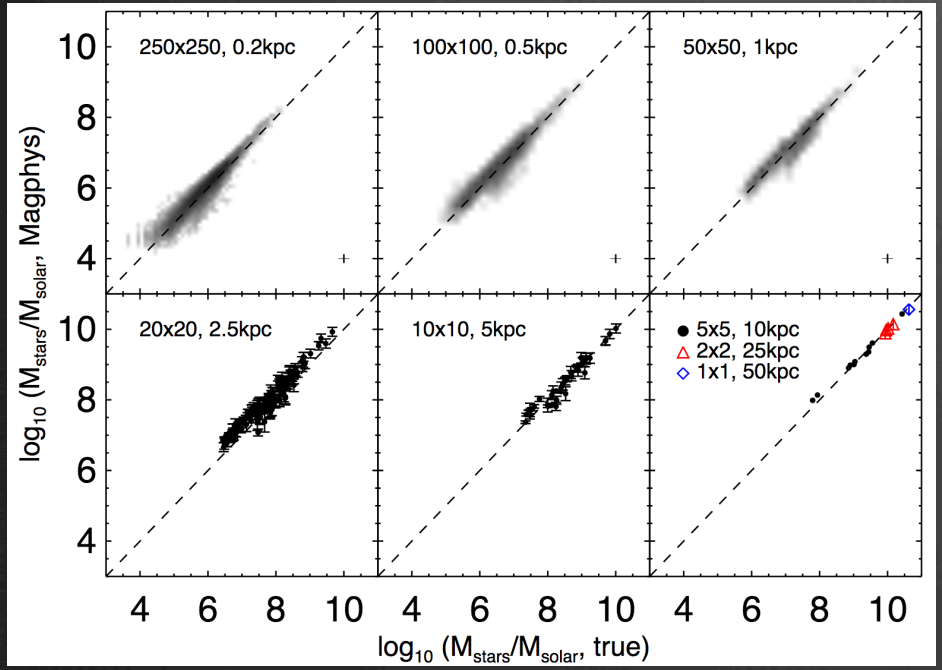
Fit to SEDs from hydro simulation + radiative transfer at different resolutions



Smith & Hayward 2018

How do spatial variations affect inferred quantities?

Stellar Mass



Smith & Hayward 2018

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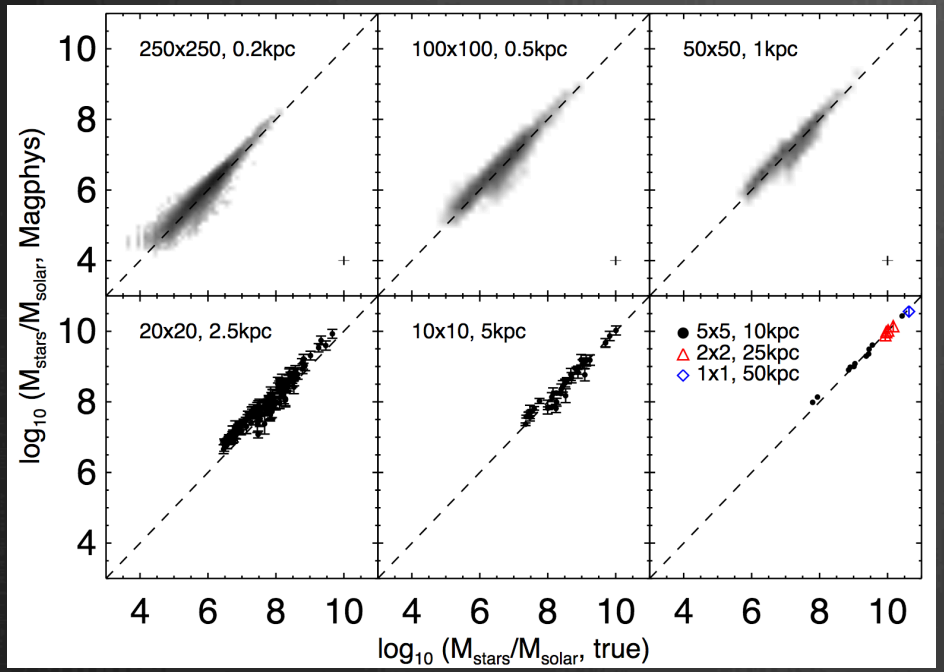
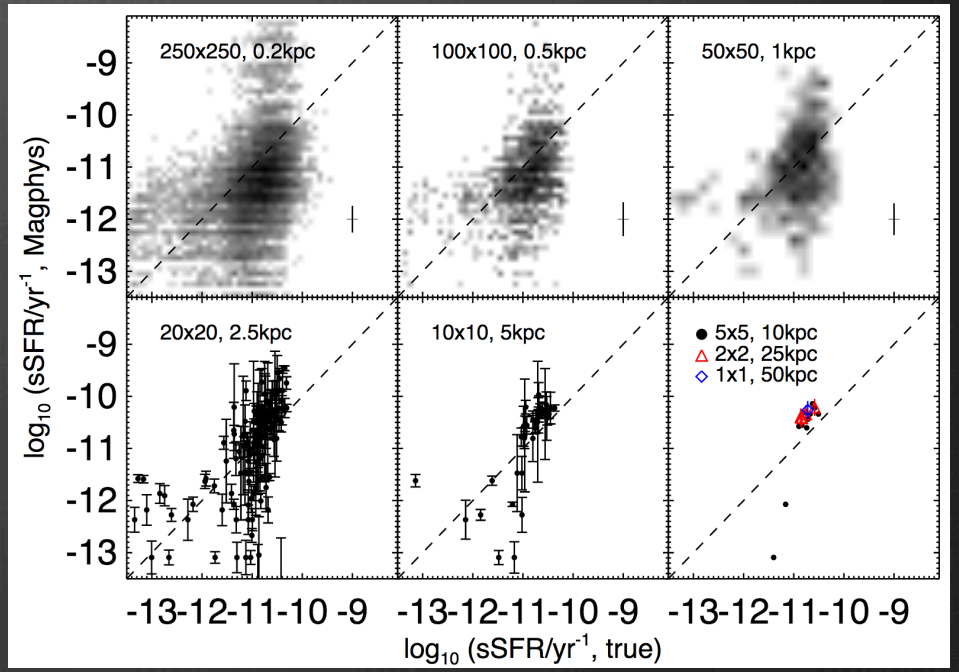


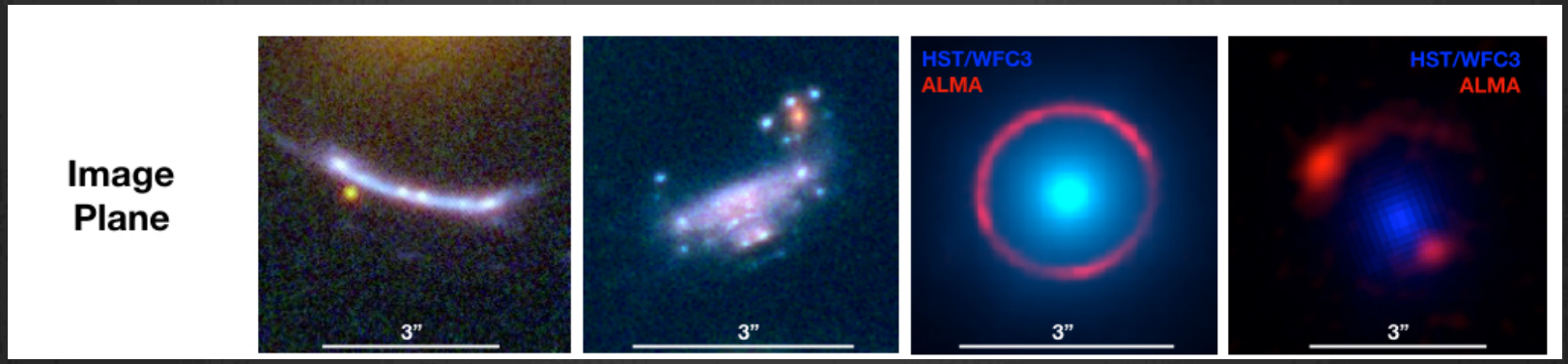
(specific) SFR



Smith & Hayward 2018

TEMPLATES

- Comprehensively study four lensed z ~ 1 – 4 galaxies
  - NIRCam & MIRI 13-band imaging
  - NIRSpec & MIRI IFU – Halpha, Hbeta, Pa-alpha, PAH 3.3um
  - Four sources, ~55 hours, magnified by 7 – 40x



TEMPLATES

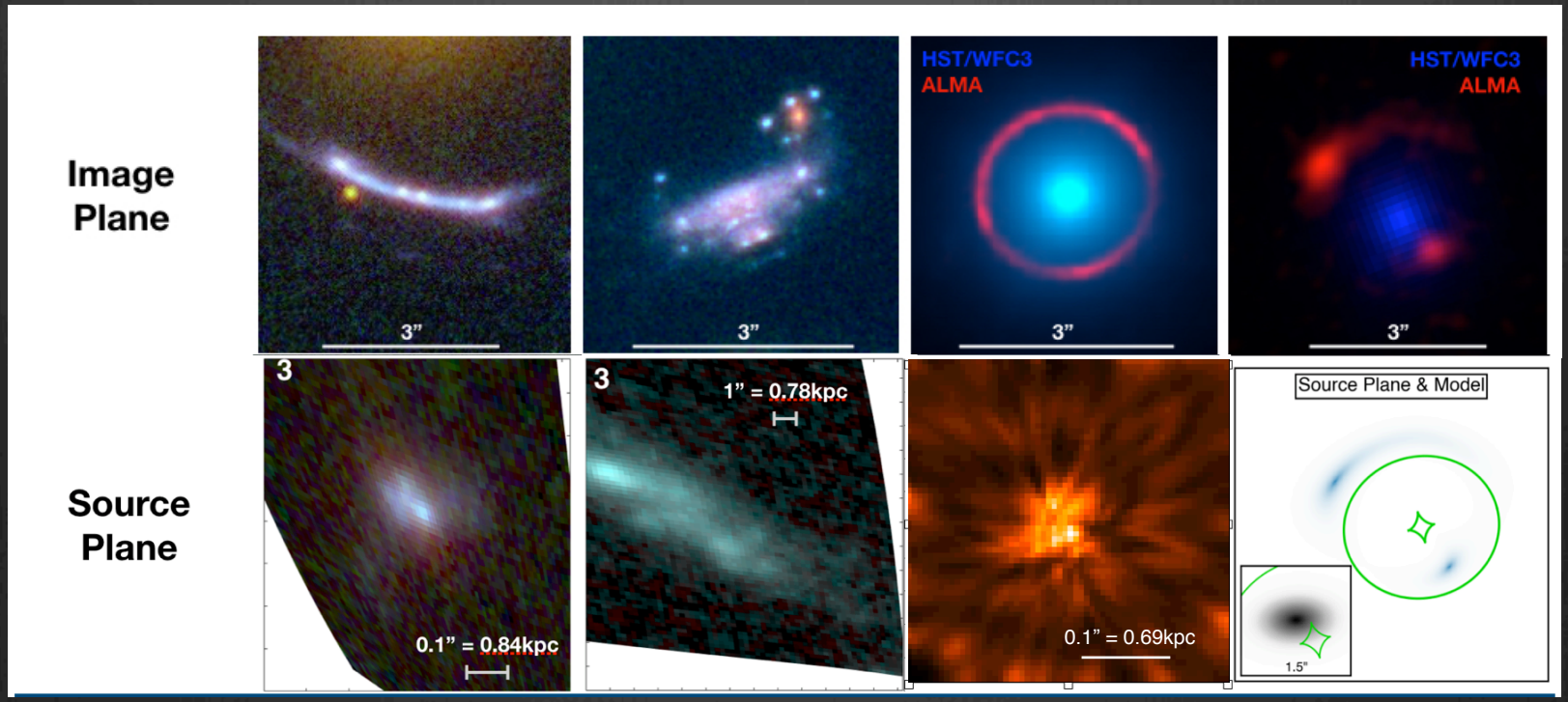
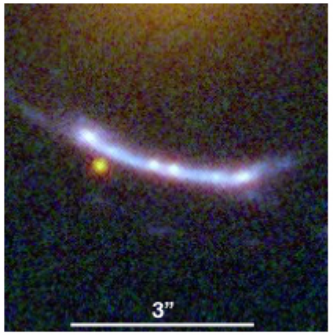
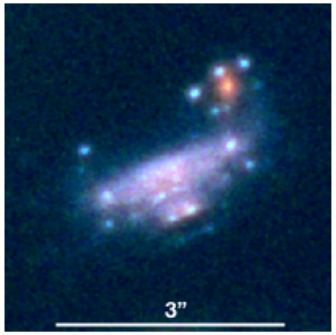


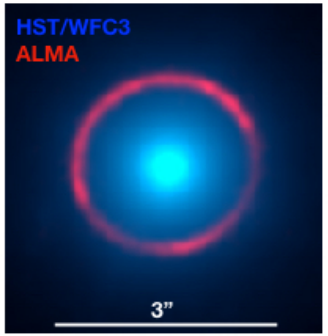
Image Plane
Source Plane
3"
3"
HST/WFC3
ALMA
3"
HST/WFC3
ALMA
3"
3
0.1" = 0.84kpc
3
1" = 0.78kpc
0.1" = 0.69kpc
Source Plane & Model
1.5"

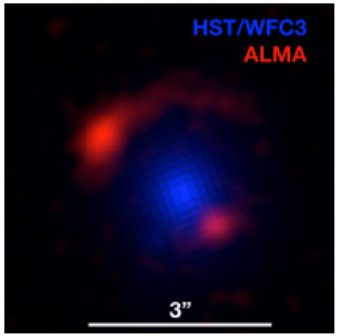
TEMPLATES

Image Plane



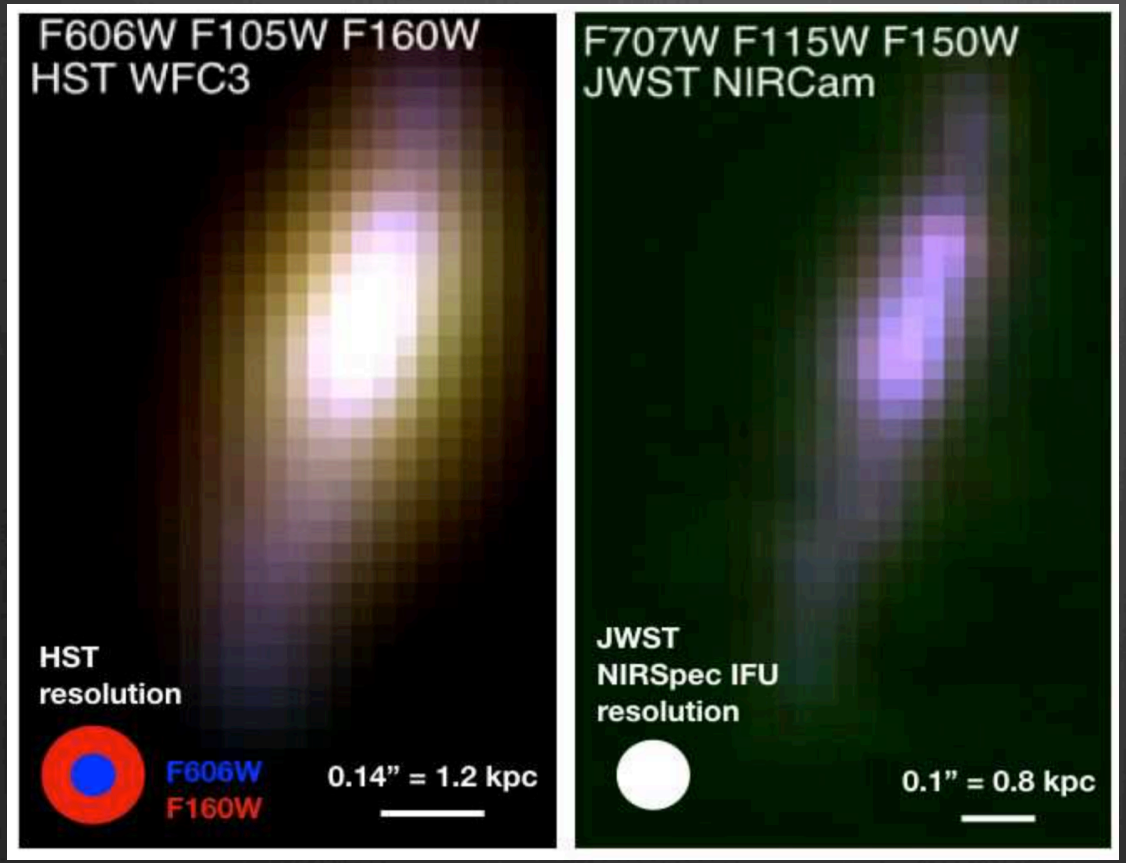




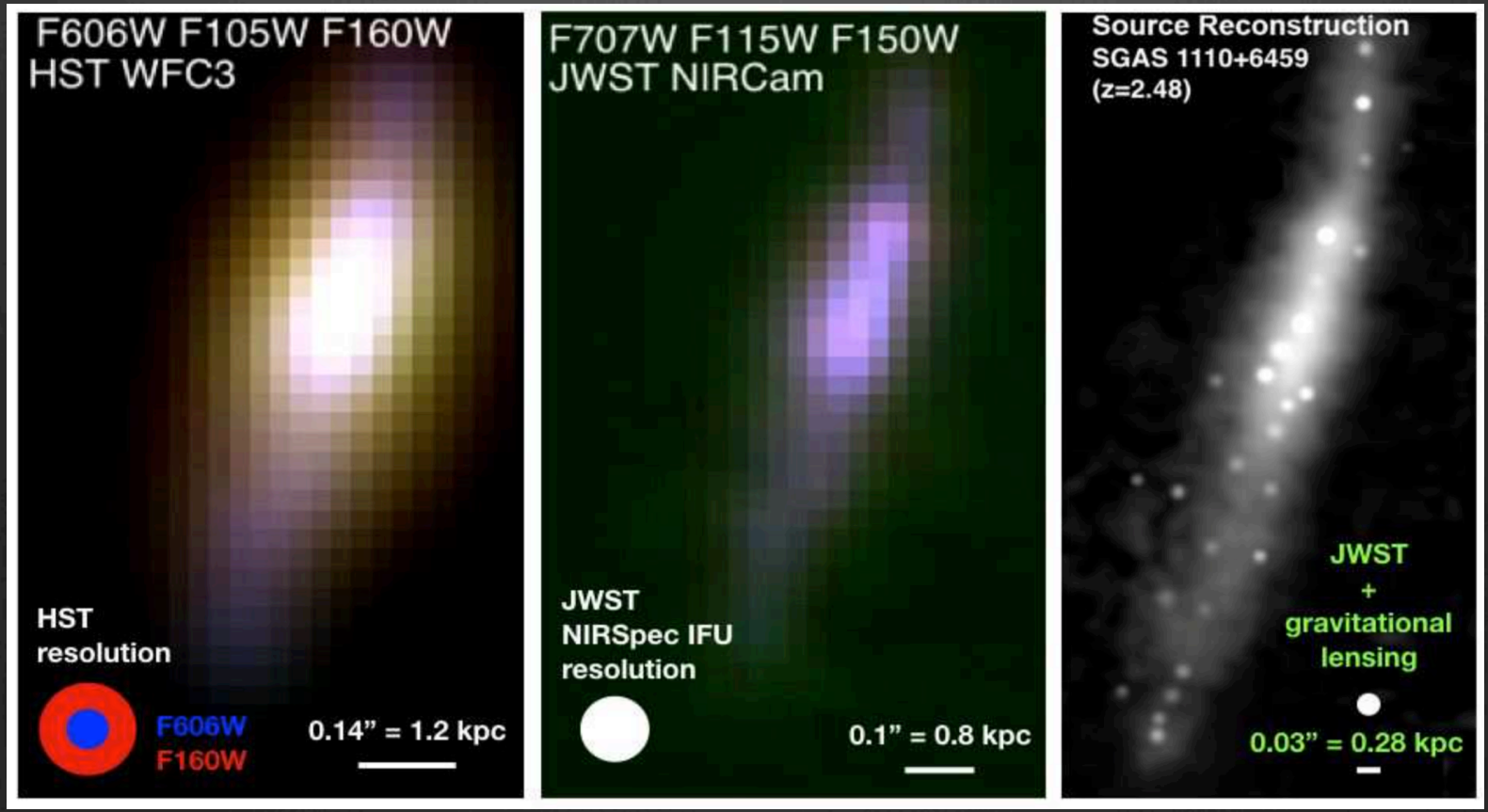


Source	SDSS1723+34	SDSS1226+21	SPT0418-47	SPT2147-50
redshift	1.32	2.92	4.22	3.76
magnification	20	40	32	6.6
r_E [arcsec]	4.7	9	1.2	1.2
$M_\star$ [$M_\odot$]	$<3\times10^{10}$	5×10^{9}	4.4×10^{10}	2.0×10^{10}
SFR [$M_\odot$/yr]	8	40	230	1290
sSFR [Gyr^{-1}]	>3	8	5.3	64
A_V	0.64—1.0	0.2—1	6	6

TEMPLATES


F606W F105W F160W
HST WFC3
HST
resolution
F606W
F160W
0.14” = 1.2 kpc
F707W F115W F150W
JWST NIRCam
JWST
NIRSpec IFU
resolution
0.1” = 0.8 kpc

TEMPLATES


F606W F105W F160W
HST WFC3
HST
resolution
F606W
F160W
0.14” = 1.2 kpc
F707W F115W F150W
JWST NIRCam
JWST
NIRSpec IFU
resolution
0.1” = 0.8 kpc
Source Reconstruction
SGAS 1110+6459
(z=2.48)
JWST
+
gravitational
lensing
0.03” = 0.28 kpc

Planned Observations

Science goals:

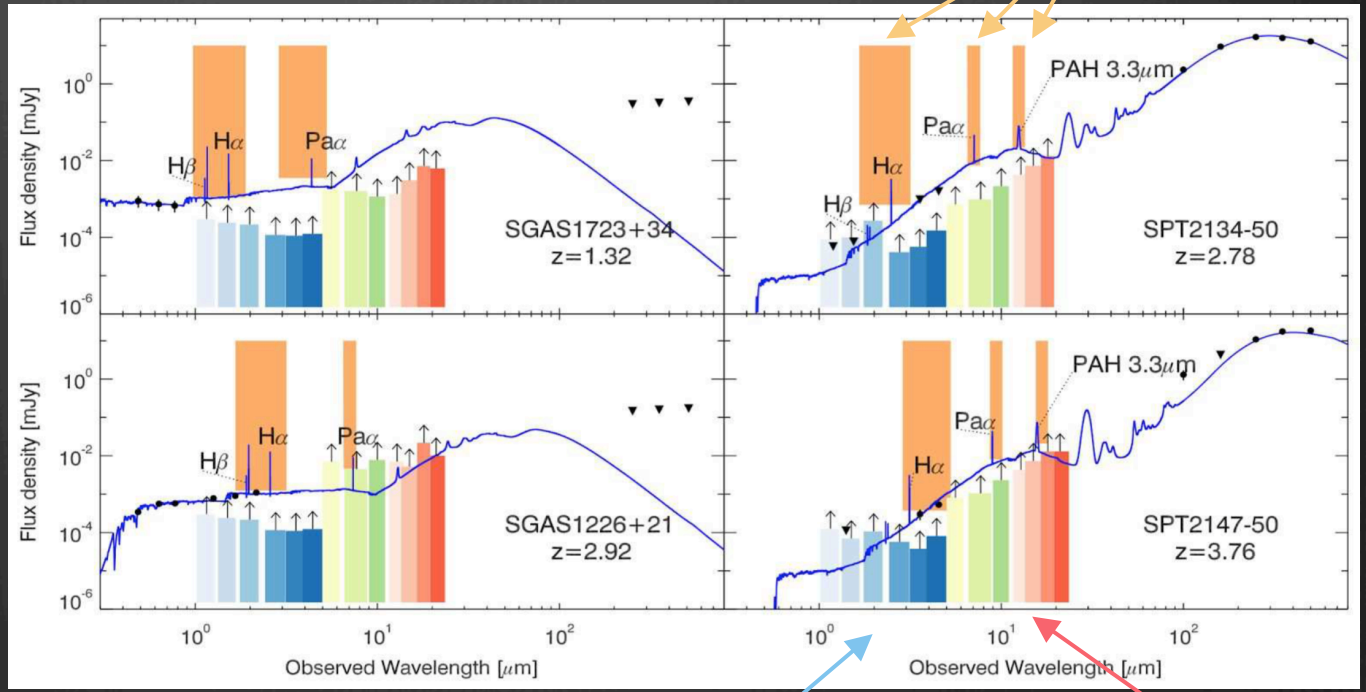
Demonstrate extinction-robust star formation rate diagnostics for distant galaxies.

Determine the physical scales of star formation in distant galaxies, in an extinction-robust way.

Measure specific star formation rates and compare the spatial distribution of the young and old stars.

Measure the physical conditions of star formation and their spatial variation.

NIRspec & MIRI IFUs



NIRcam

MIRI

Planned Data Releases

- Around launch time:
  - All existing imaging & spectra, lens model products, model line ratios
- Launch + 10 months
  - “Level 3” (science-ready) imaging and data cubes, updated lens models
  - Cookbooks on planning & executing IFU observations, calibration strategies
- Launch + 13 months (or prior to Cycle 2 deadline)
  - Main data release. Maps of H-alpha, H-beta, Pa-alpha, stellar mass, extinction
  - PSF-matched images and data cubes
  - Source reconstructions of stellar mass, all available SFR tracers

Questions?