Welcome! Goals of the meeting

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Goals of the meeting

- JWST has been doing science for 1.5 years
- How does what we learned affect the science drivers for ELTs?
- How do we use the lessons learned from JWST to optimize instrumentation and operations for ELTs?
- One example: the high redshift universe

A bit of history: HST ground based synergy

TYPE Ia SUPERNOVA DISCOVERIES AT $z > 1$ FROM THE *HUBBLE SPACE TELESCOPE*: EVIDENCE FOR PAST DECELERATION AND CONSTRAINTS ON DARK ENERGY EVOLUTION[1]

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Spectroscopic Data

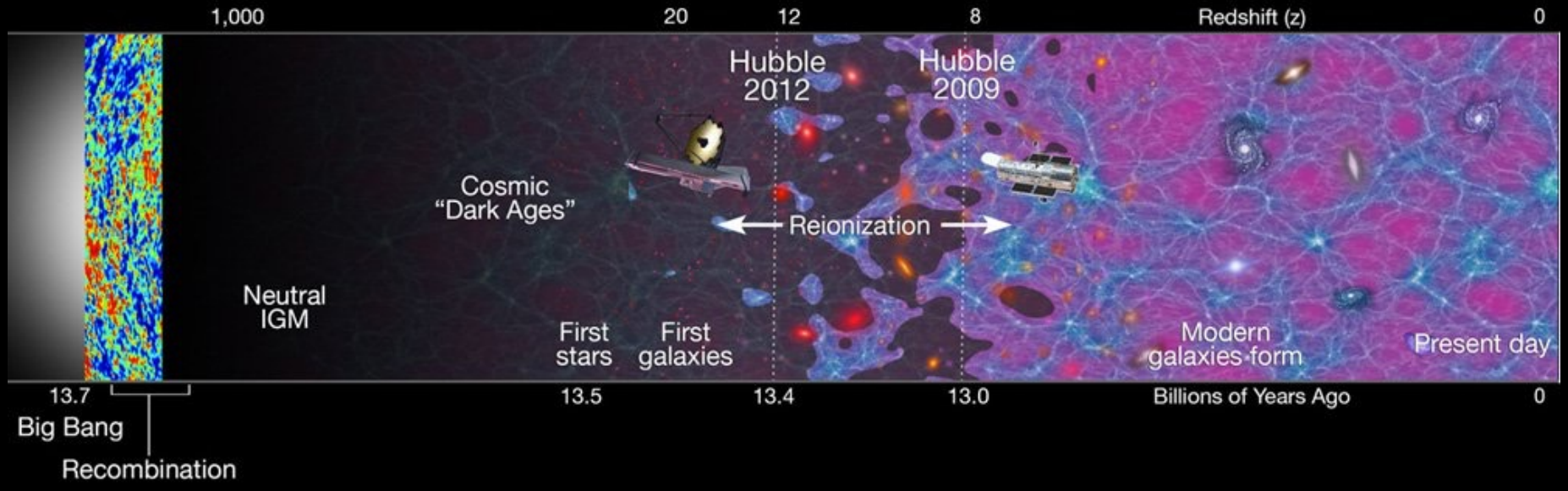
SN	UT Date	Instrument	Exposure (s)	z
2002fw	2002 Sep 31	*HST* ACS	15000	1.30[a,b]
2002fx	2003 Sep 14	Keck II NIRSPEC	2000	1.40[c,d]
2002hp	2002 Nov 7	Keck I LRIS	7800	1.305[c,e]
	2002 Nov 7	VLT FORS	14000	1.305[c,e]
2002hr	2002 Nov 8	Keck I LRIS	7800	0.526[b,f]
2002kc	2003 Jan 7	Keck I LRIS	1500	0.216[b,f]
2002kd	2003 Jan 1	Magellan LDSS	7200	0.735[b,f]
2002ki	2003 Jan 7	Keck I LRIS	2700	1.141[b,f]
2003aj	2003 Oct 1–3	VLT FORS2	16800	1.307[c,g]
2003ak	2003 Sep 11	Keck II NIRSPEC, VLT FORS2	14000	1.551[c,d]
2003az	2003 Mar 3	*HST* ACS	6500	1.27[a,b]
2003bd	2003 Feb 27/28	Keck I LRIS	16500	0.67[a,b]
2003be	2003 Feb 28	Keck I LRIS	5400	0.64[b,f]
2003dy	2003 Apr 16	*HST* ACS	15000	1.34[b,h]
2003XX	2003 Apr 16	*HST* ACS	15000	0.935[c,h]
2003eb	2003 Apr 16	*HST* ACS	15000	0.899[b,h]
2003eq	2003 Jun 2	*HST* ACS	6000	0.839[a,b]
2003es	2003 Jun 2	*HST* ACS	6000	0.954[b,h]

Complementarity of JWST and ELTs

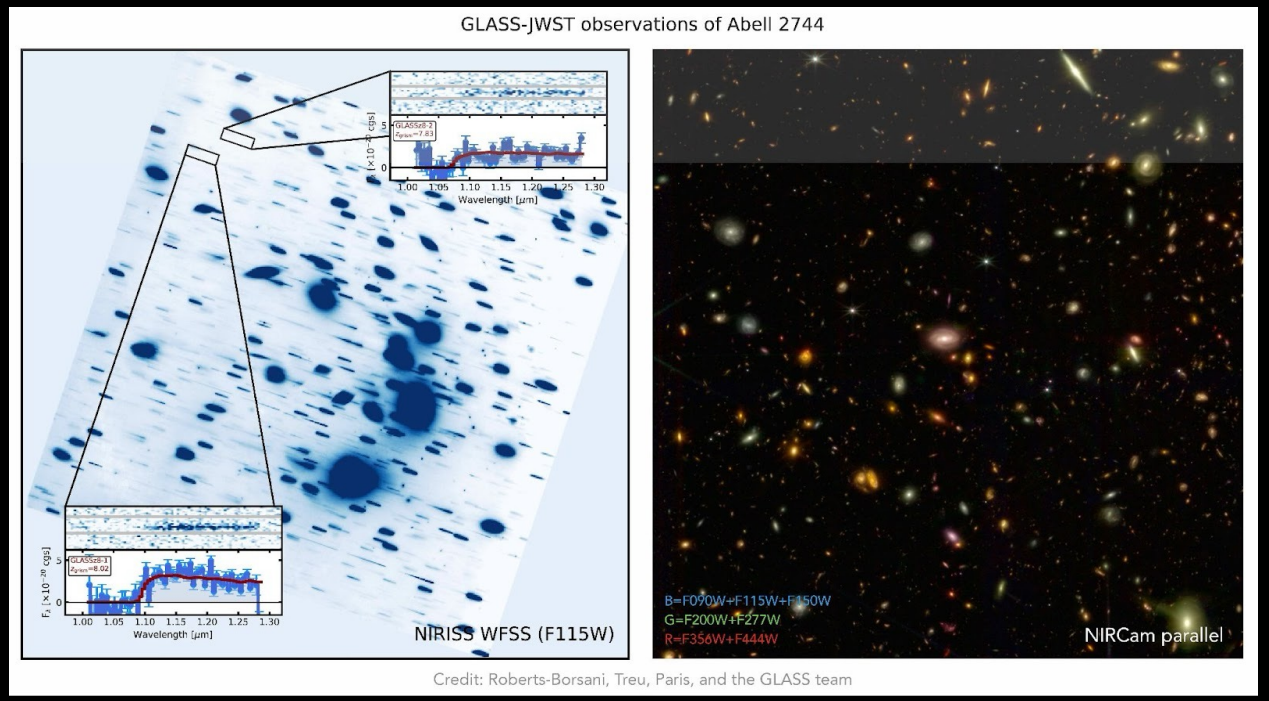
- **JWST**
  - Access to full wavelength range (no atmospheric opacity, turbolence)
  - Low thermal background (30K) and no sky emission lines
- **ELTs**
  - Higher angular resolution with adaptive optics (factors 3.5-6)
  - Larger collecting area (factors 12-36)
  - New instruments can be built, answering new scientific questions and taking advantage of new technology
  - Lifespan can be extended (Palomar 5m is still in operation, after amost 75 years)

The high redshift universe

First light and reionization

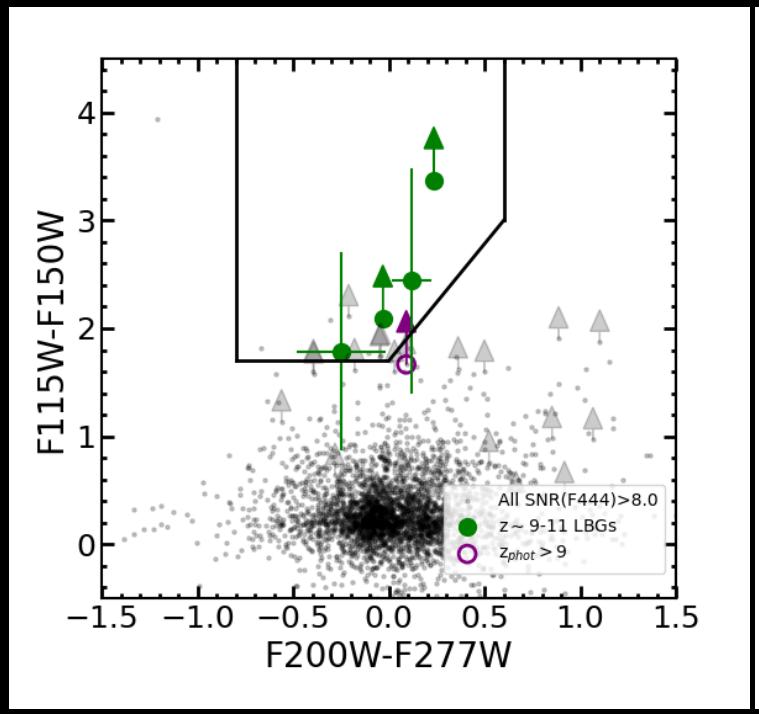


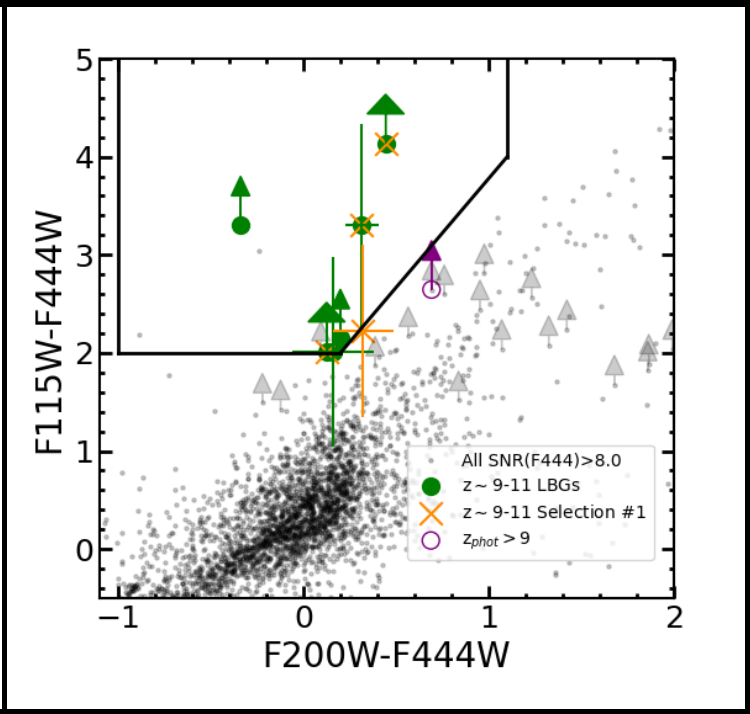
July 14 2022: first data arrive!



Roberts-Borsani et al. 2022; Merlin et al. 2022

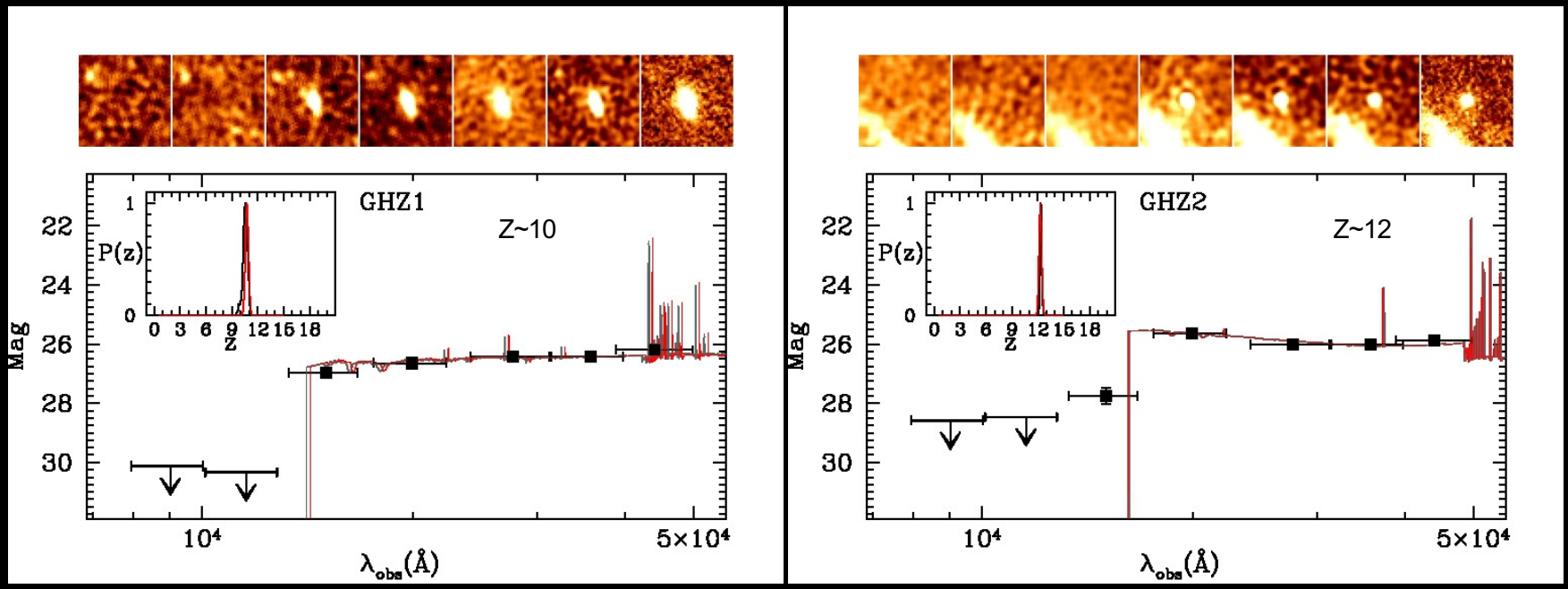
July 19 2022: lots of bright galaxies at z>10!





Castellano et al. 2022; see also Naidu et al. 2022, Donnan et al. 2022

July 19 2022: bright galaxies at z>10



We expected 0.1!

Castellano et al. 2022; see also Naidu et al. 2022, Donnan et al. 2022

Galaxies form earlier and faster than we thought!

On the stunning abundance of super-early, massive galaxies revealed by JWST

ANDREA FERRARA [1], ANDREA PALLOTTINI [1] AND PRATIKA DAYAL [2]

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The brightest galaxies at Cosmic Dawn

Charlotte A. Mason[1,2]★, Michele Trenti[3,4] and Tommaso Treu[5]
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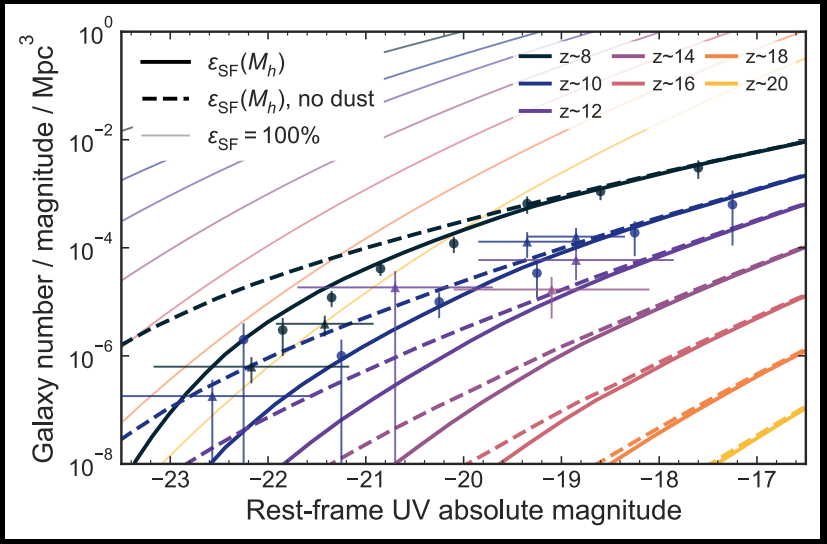
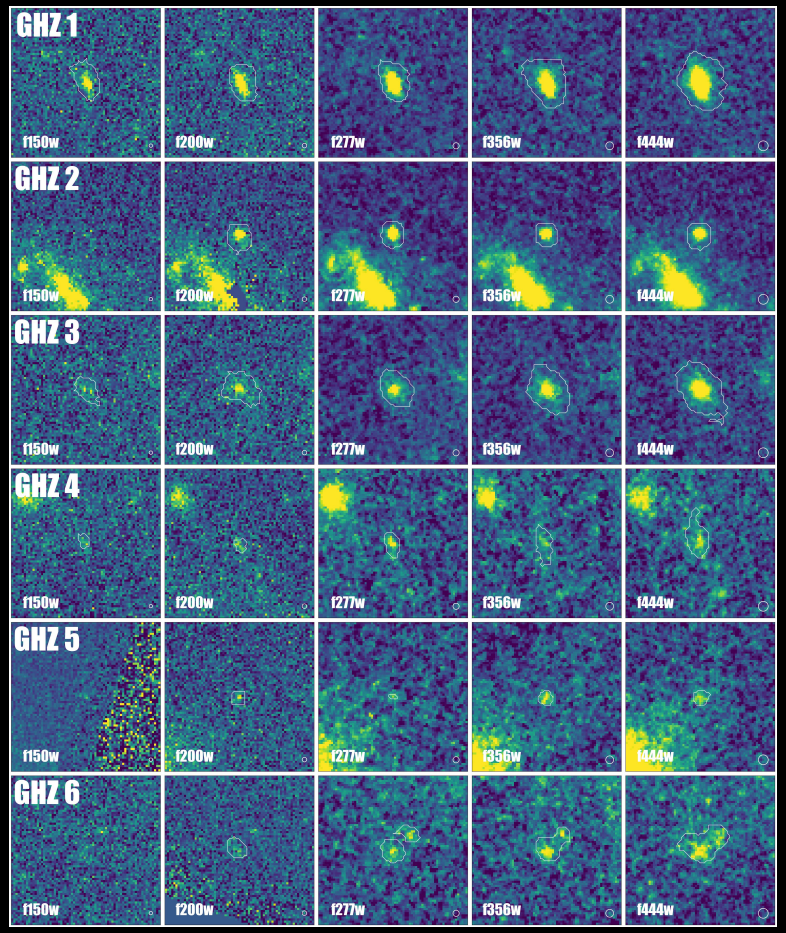
[4] *ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions (ASTRO 3D), Australia*
[5] *Department of Physics and Astronomy, University of California, Los Angeles, 430 Portola Plaza, Los Angeles, CA 90095, USA*

What are the implication for the formation of supermassive black holes? Does it mean they have more time as well?



Mason, Trenti & Treu 2022; see also Ferrara et al. 2022

High-z Galaxies are extremely compact out to optical rest frame

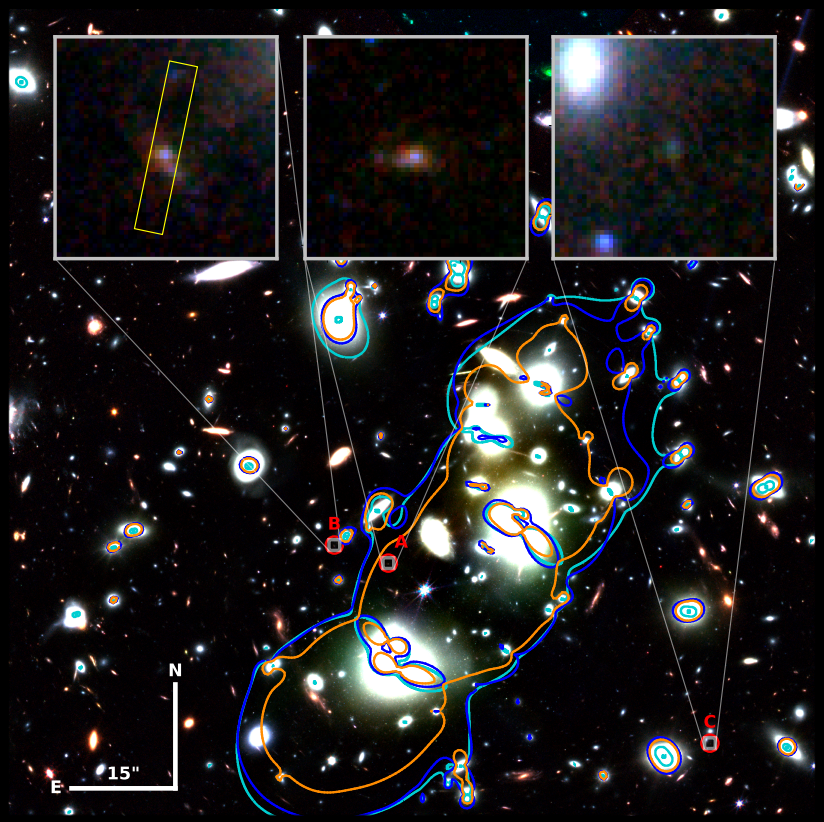


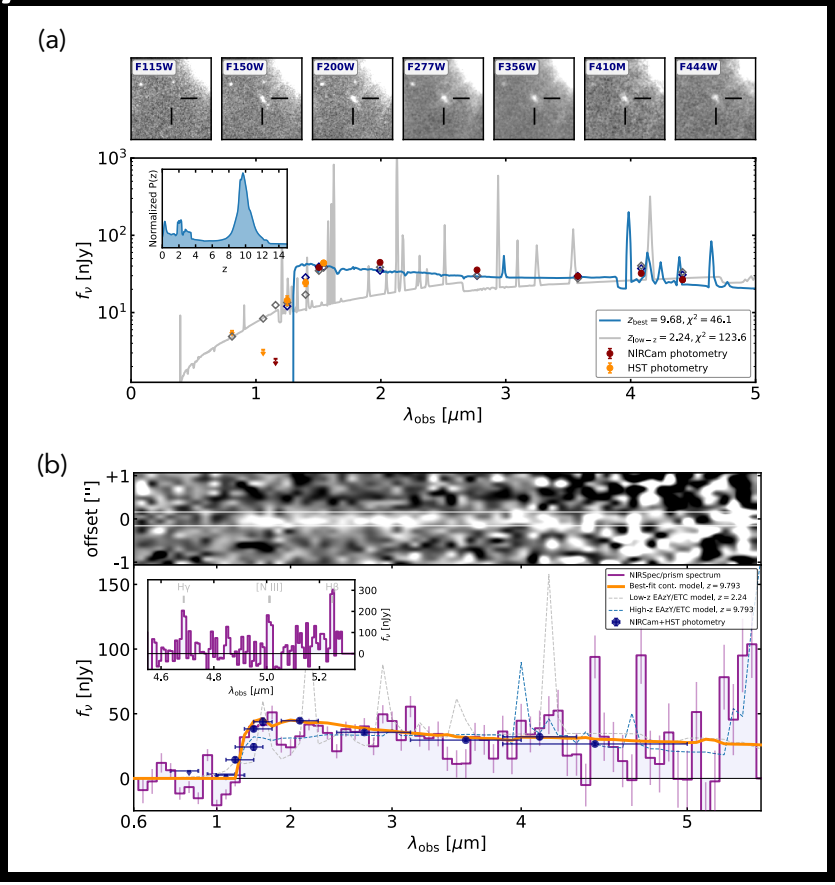
Galaxies at z>7 are galaxy scale starbursts
Run Run Run as Fast as you Can!

Treu et al. 2023; Yang et al. 2022b

Roberts-Borsani et al. 2023

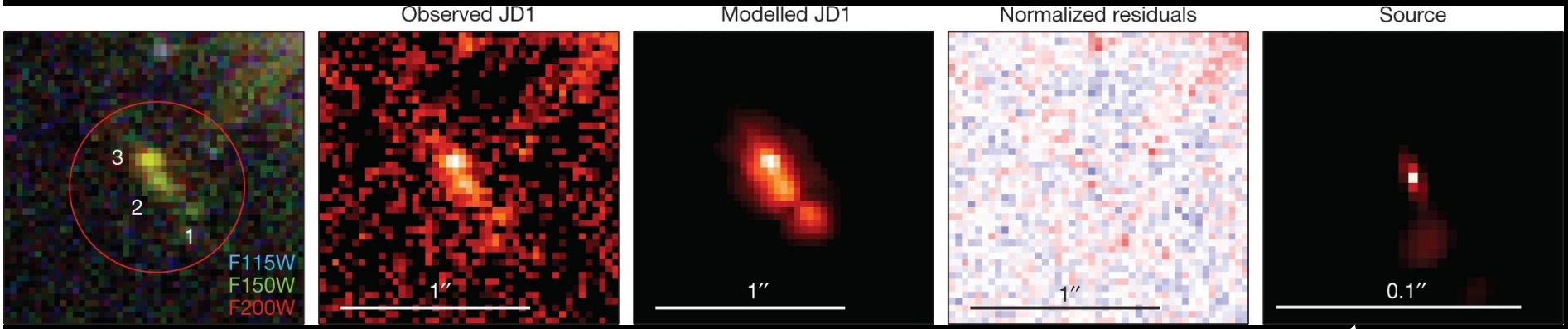
A sub-L* galaxy at Z=9.79





Roberts-Borsani et al. 2023

A sub-L* galaxy at Z=9.79



Magnified by a factor of 13

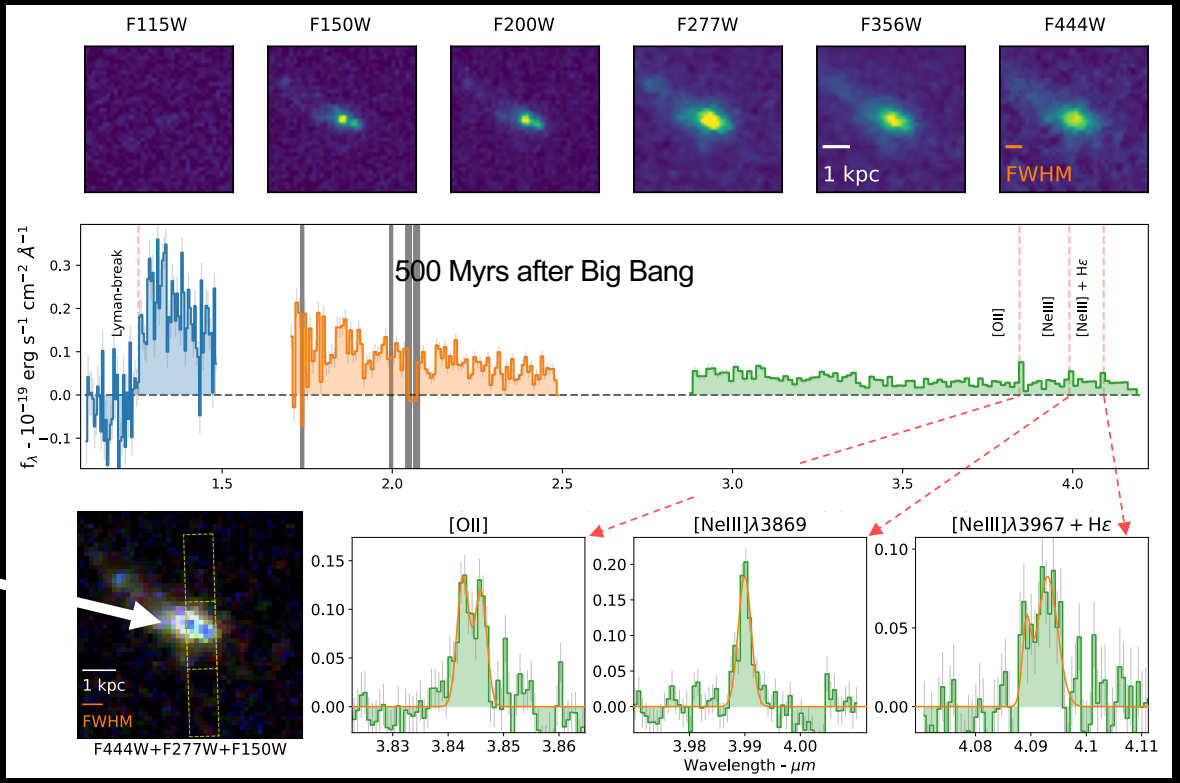
1 NIRSPEC-IFU pixel
FWHM of TMT @ 2μm = 16mas
IRIS pixels 4-50mas

Boyett et al. 2023

A bright and massive galaxy at z=9.3 (10^9 M_{sun})

Magnification ~1.5

NIRSPEC MSA slit



Summary

- **The synergy between HST and 8-10m telescopes from the ground has been tremendously productive in the past 30 years**
- **JWST discoveries highlight the need for extremely large telescope to complement it and follow it-up**
  - **Larger collecting area**
  - **Higher angular resolution (with adaptive optics)**
  - **ELT can have multiple generations of instruments, taking advantage of technological and scientific developments**
  - **Background is higher than in space, so in some configurations JWST will remain unsurpassed**
- **For example: JWST discovered that galaxies form earlier and faster than we previously thought. Plenty of galaxies just a few 100Myrs after the Big Bang at z>10. These galaxies are extremely compact with typical sizes of order 10-100pc, often smaller than a single NIRSpec spaxel. ELTs AO-fed integral field spectrographs will be needed to study their internal composition and kinematics.**

The end