Two Years of Galaxies

with the

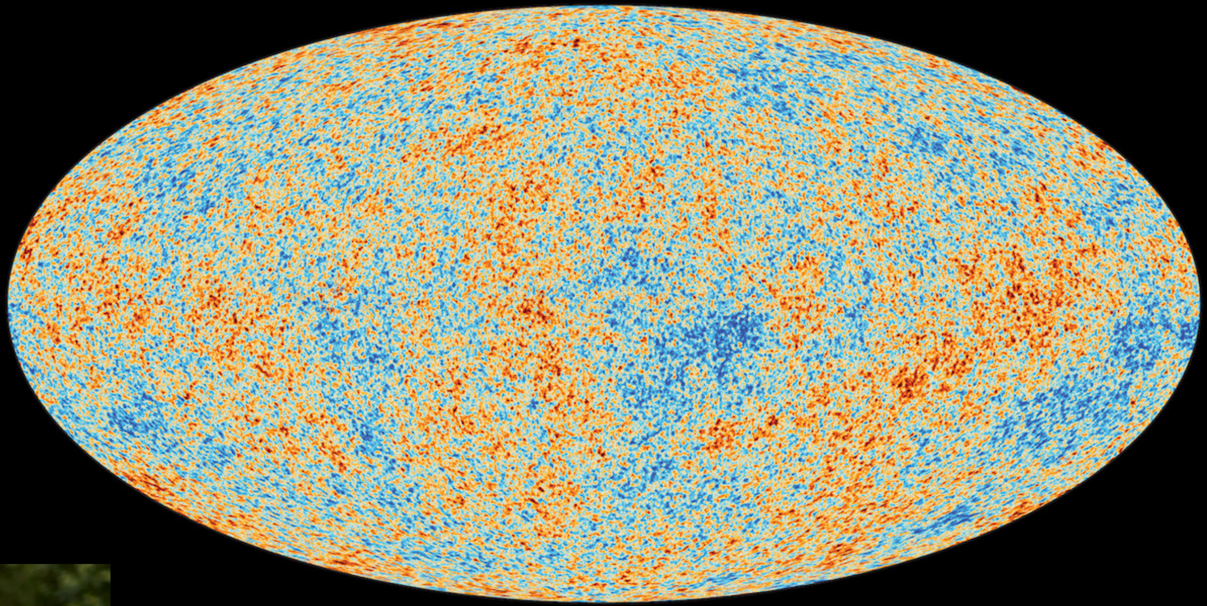
WEBB SPACE TELESCOPE

December, 2023 – June, 2024

STScI | SPACE TELESCOPE SCIENCE INSTITUTE

The Story of Us

- How do we get from this:

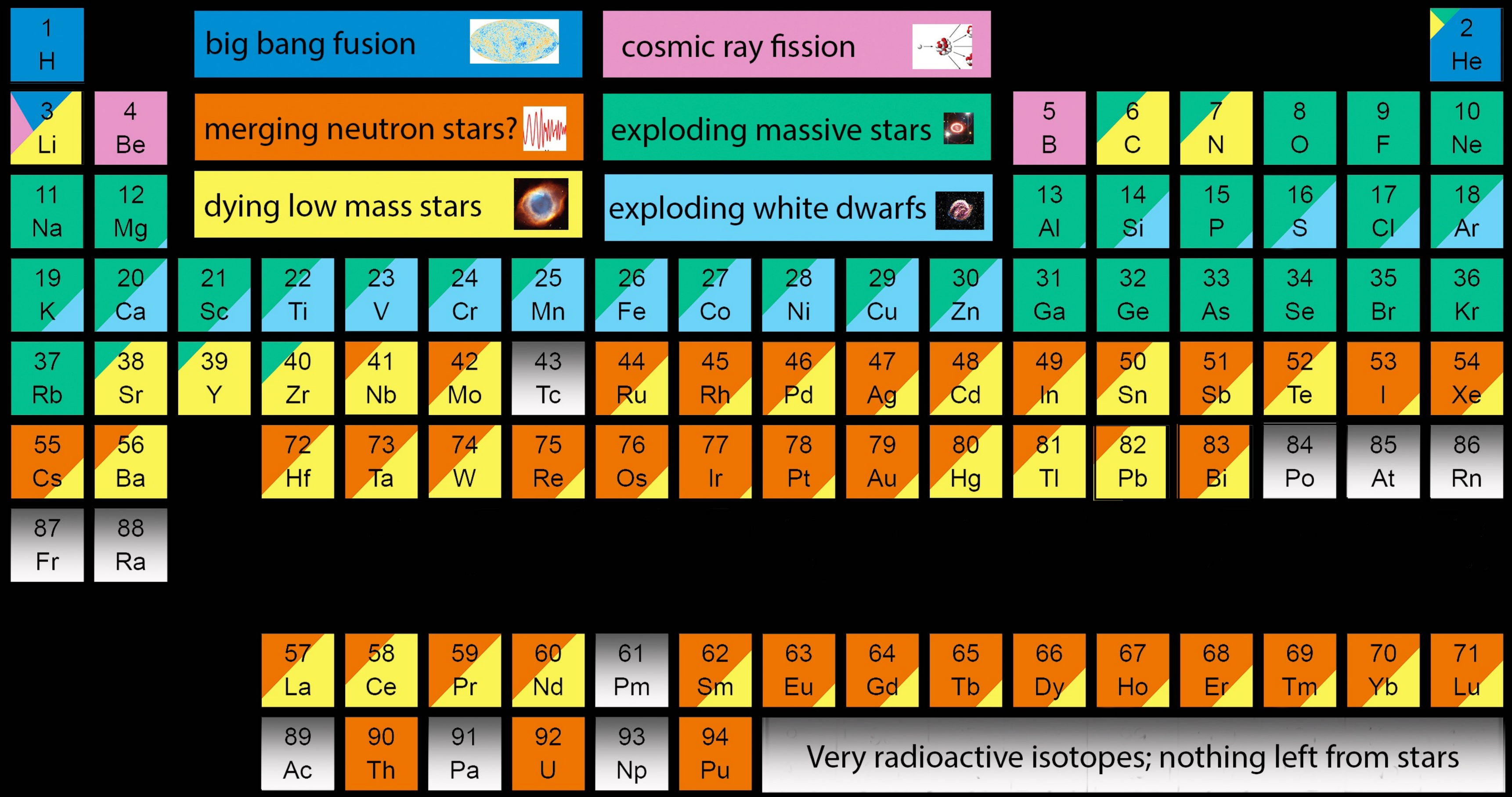


Hydrogen & Helium

- To this?

Carbon, Oxygen, Nitrogen, Calcium, Iron…
All arranged in complex molecules

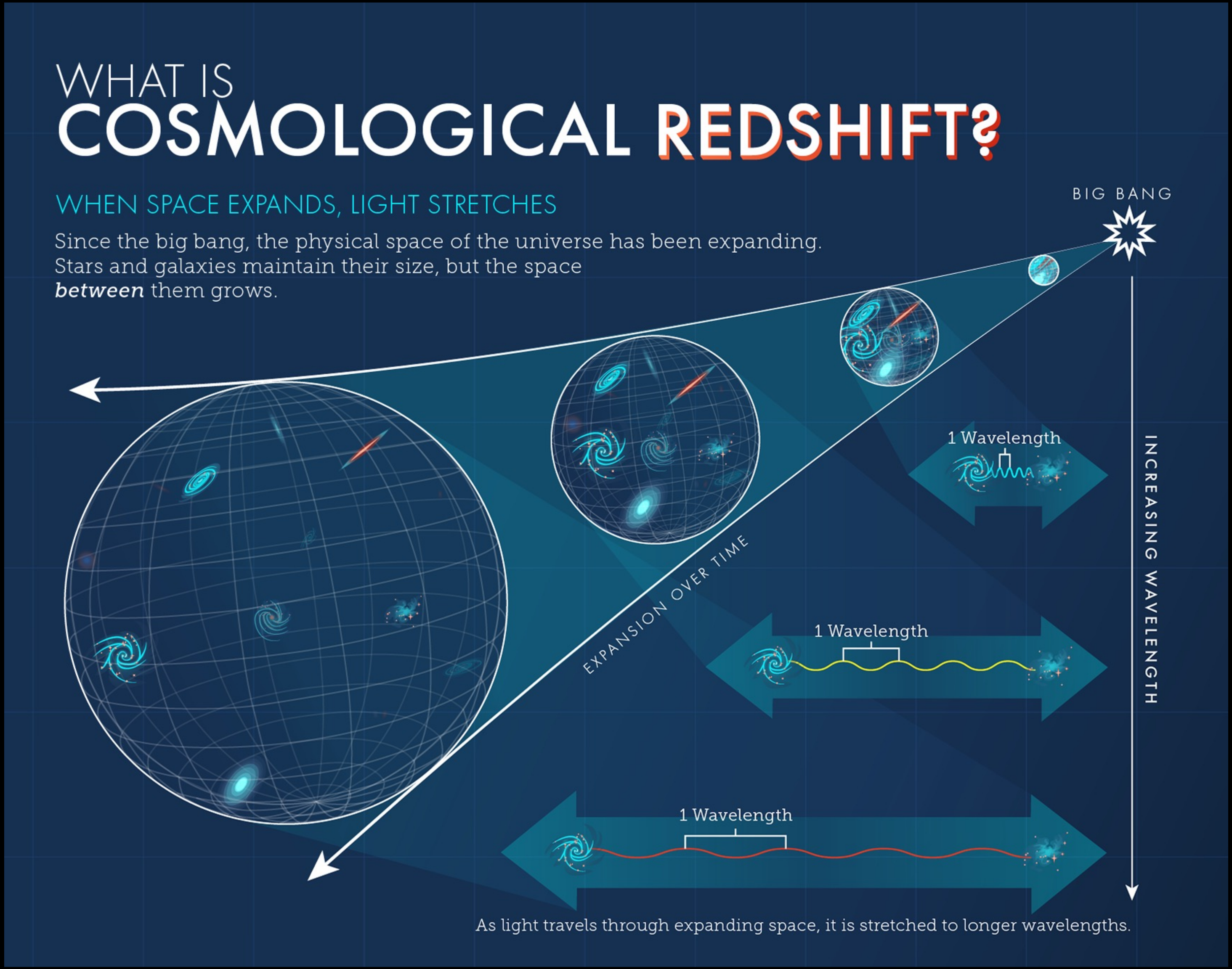
The Origin of elements



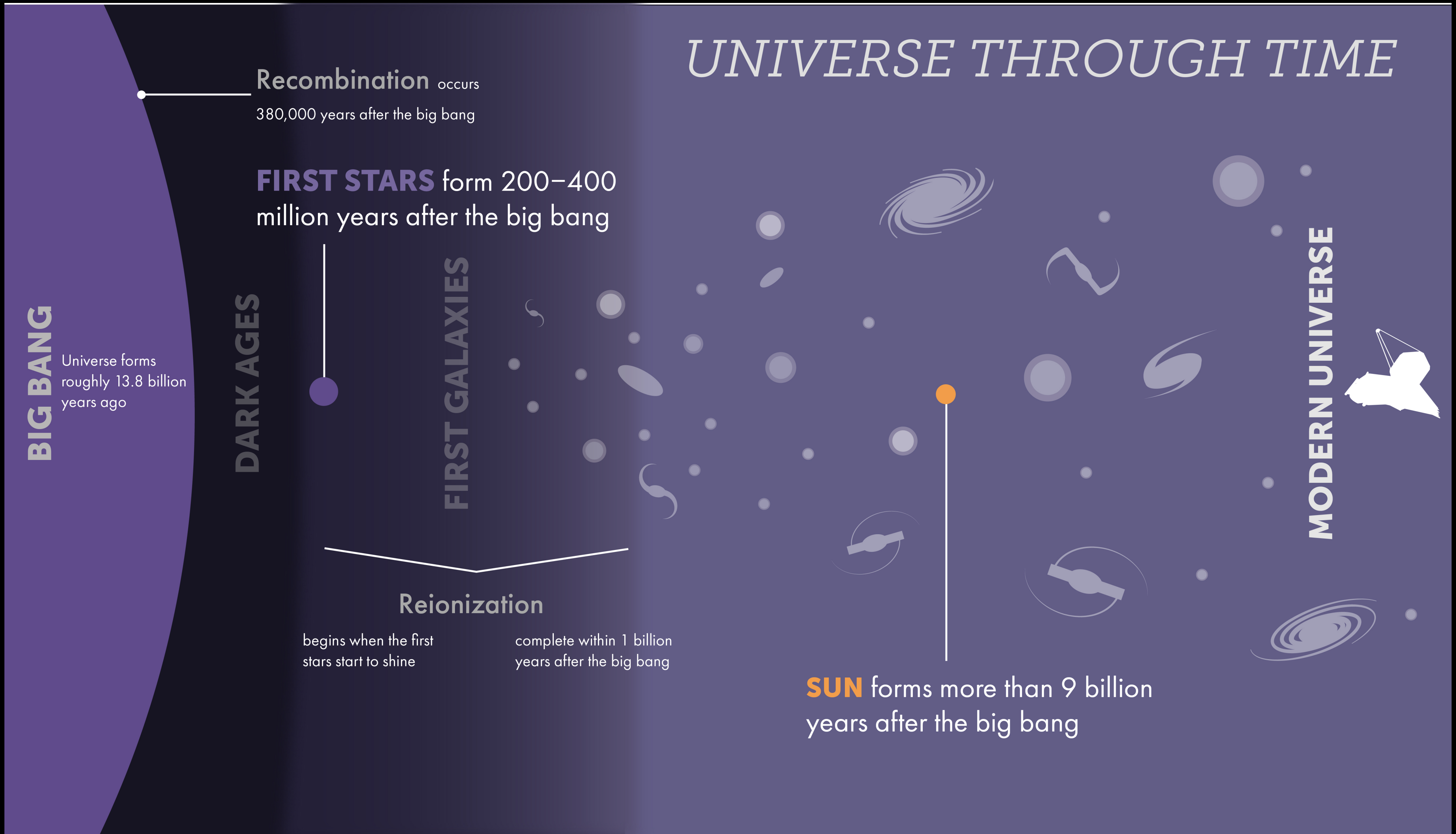
Graphic created by Jennifer Johnson
http://www.astronomy.ohio-state.edu/~jaj/nucleo/

Astronomical Image Credits:
ESA/NASA/AASNova

Telescopes are time machines

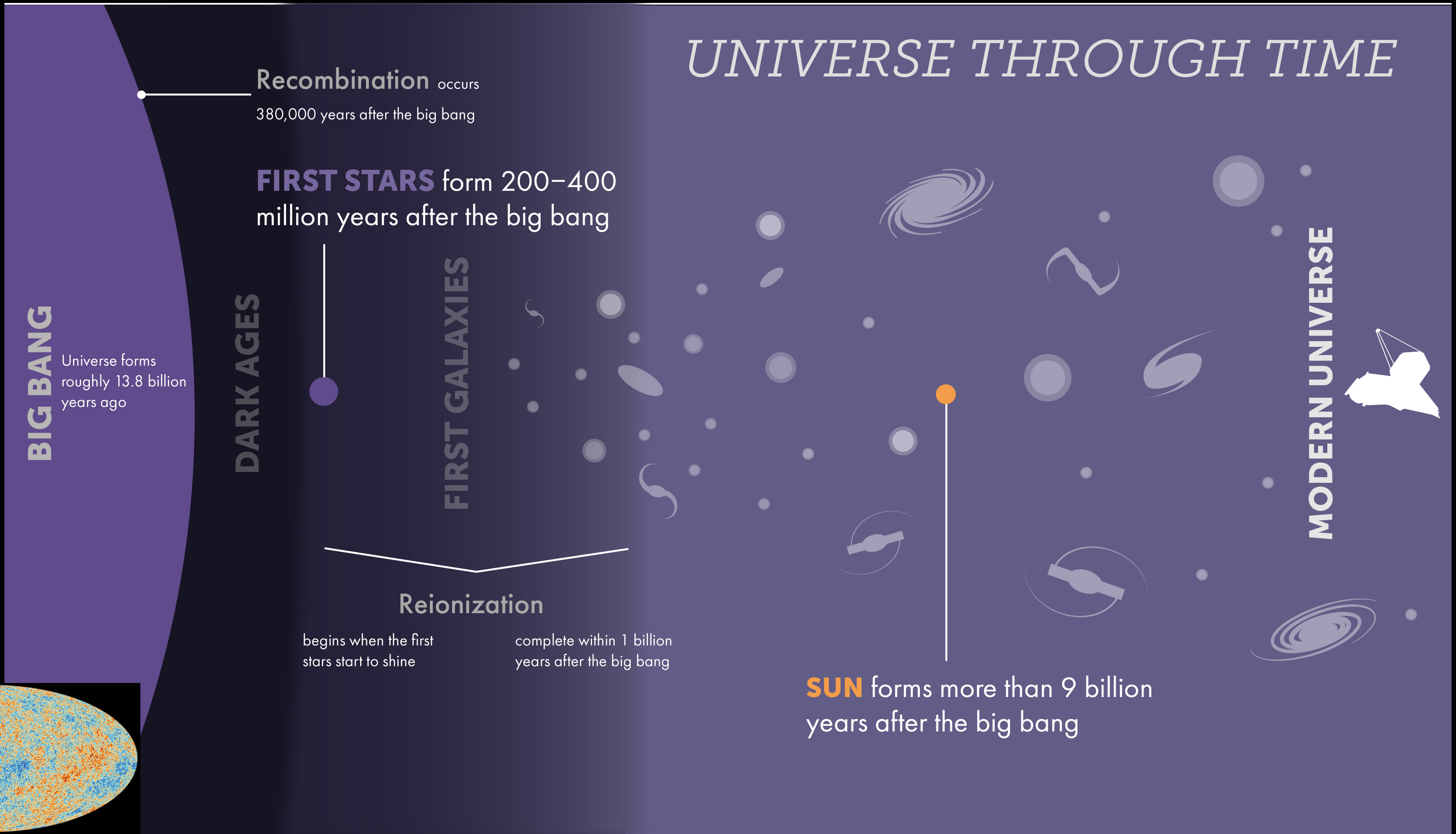


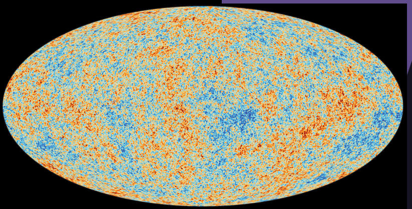
How did we get here?



STScI | SPACE TELESCOPE SCIENCE INSTITUTE

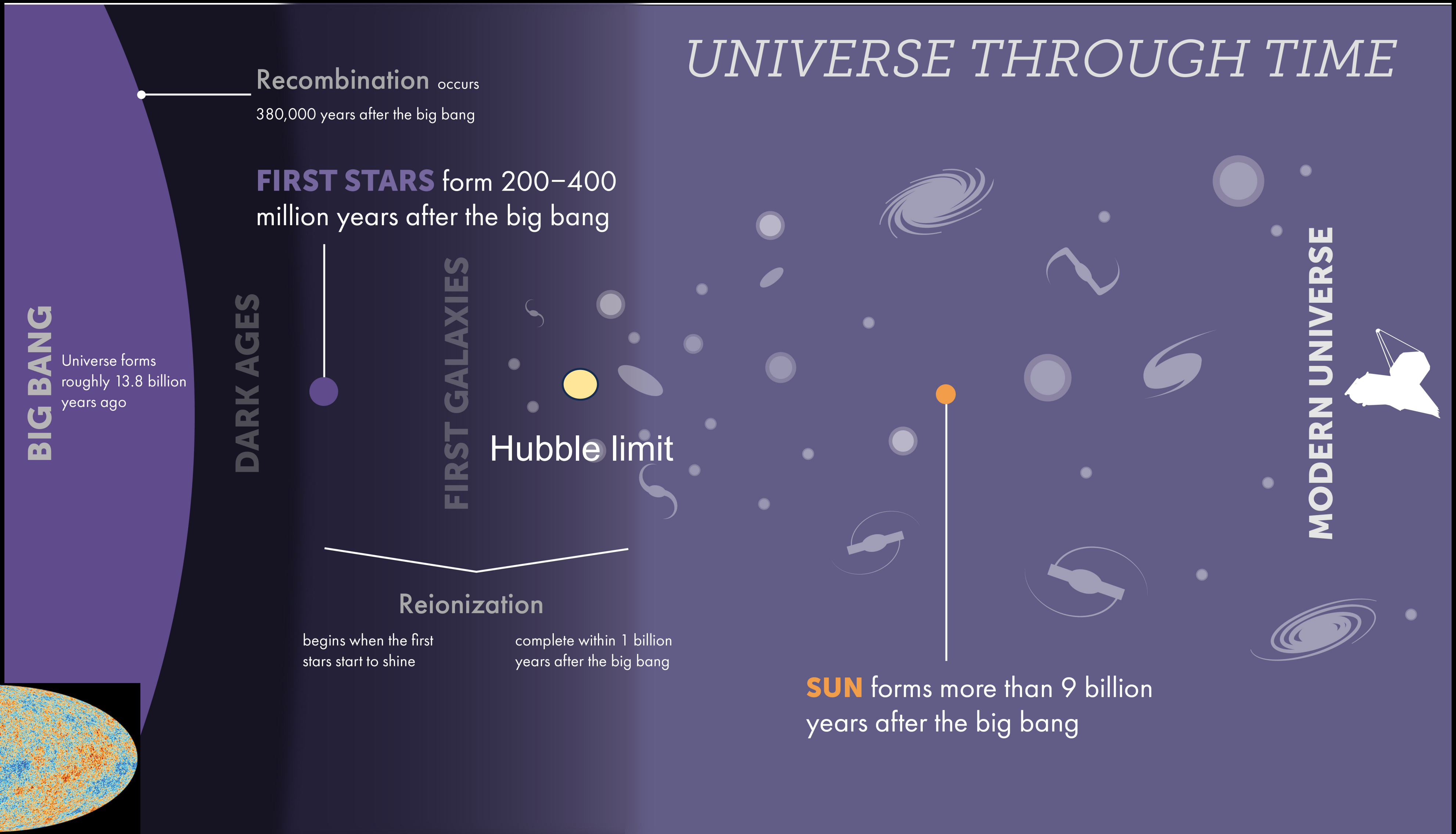
How did we get here?

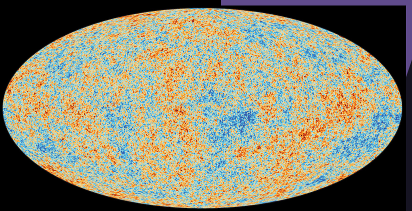




WEBB SPACE TELESCOPE

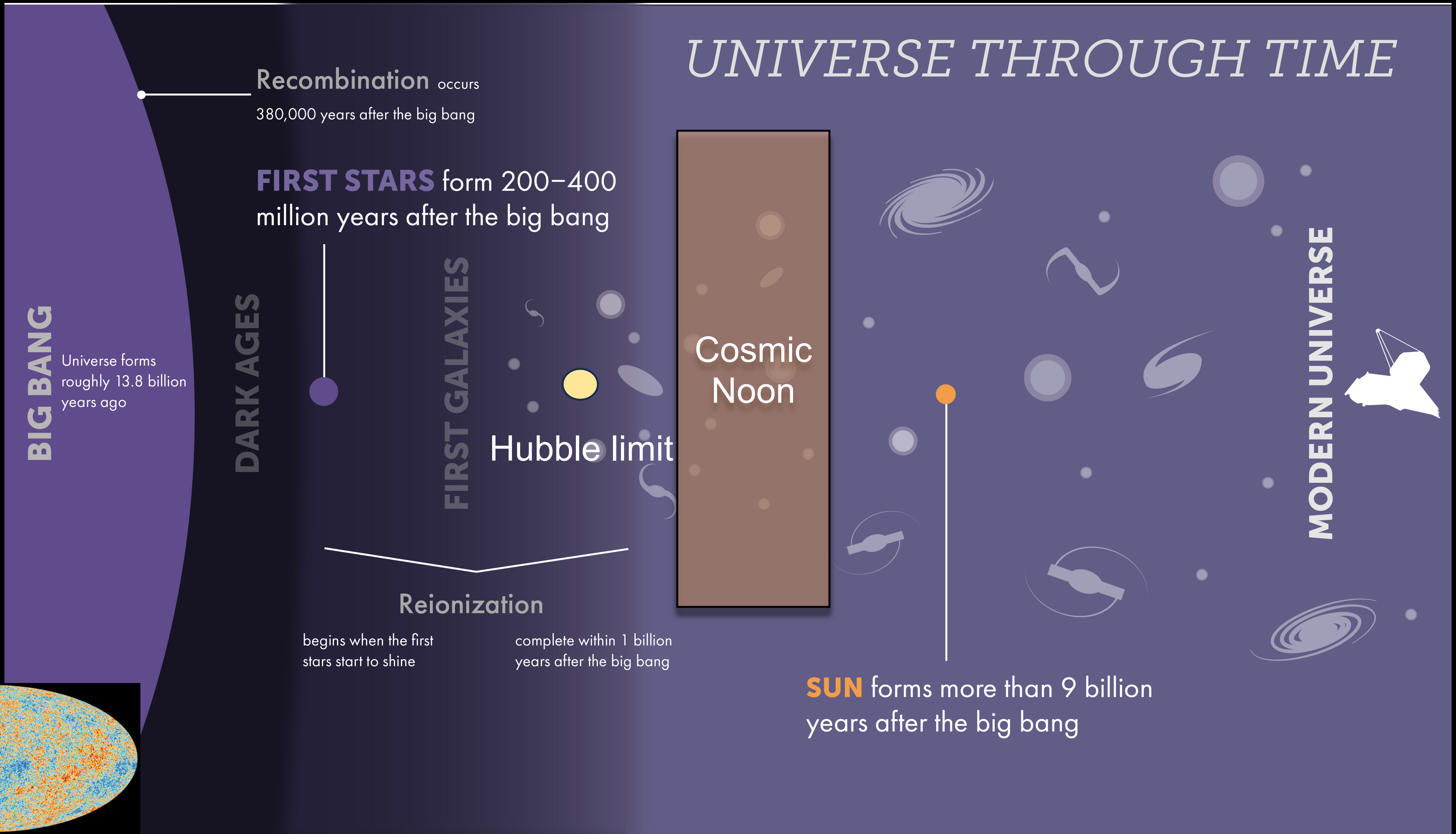
How did we get here?

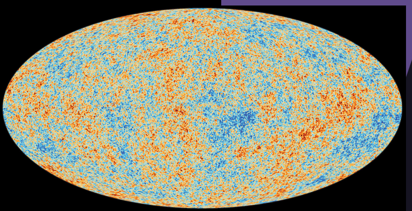




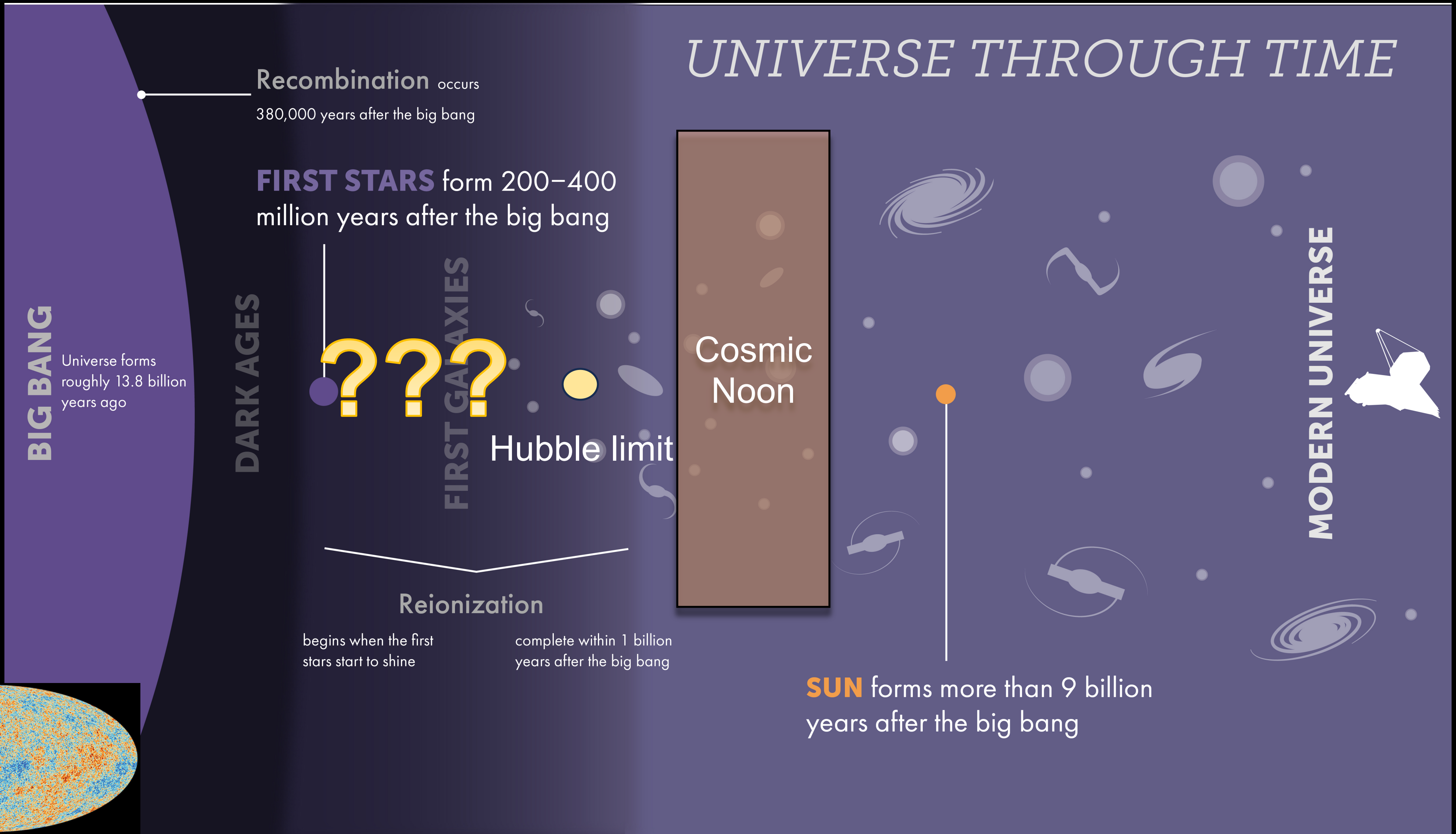
STScI | SPACE TELESCOPE SCIENCE INSTITUTE

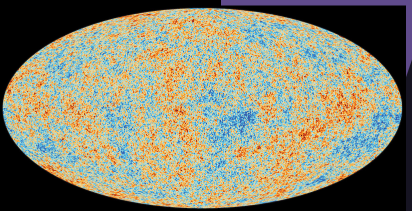
How did we get here?





Lingering questions





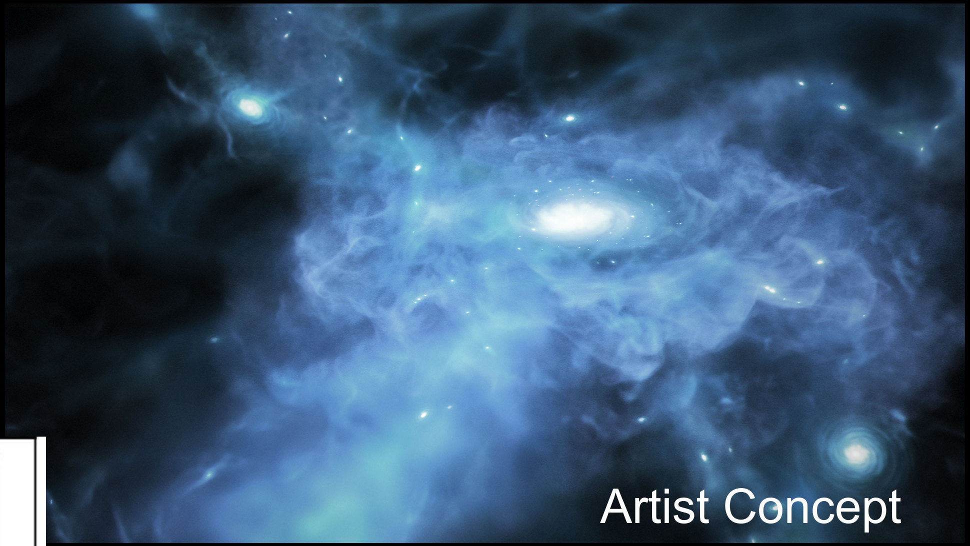
Galaxy assembly simulations

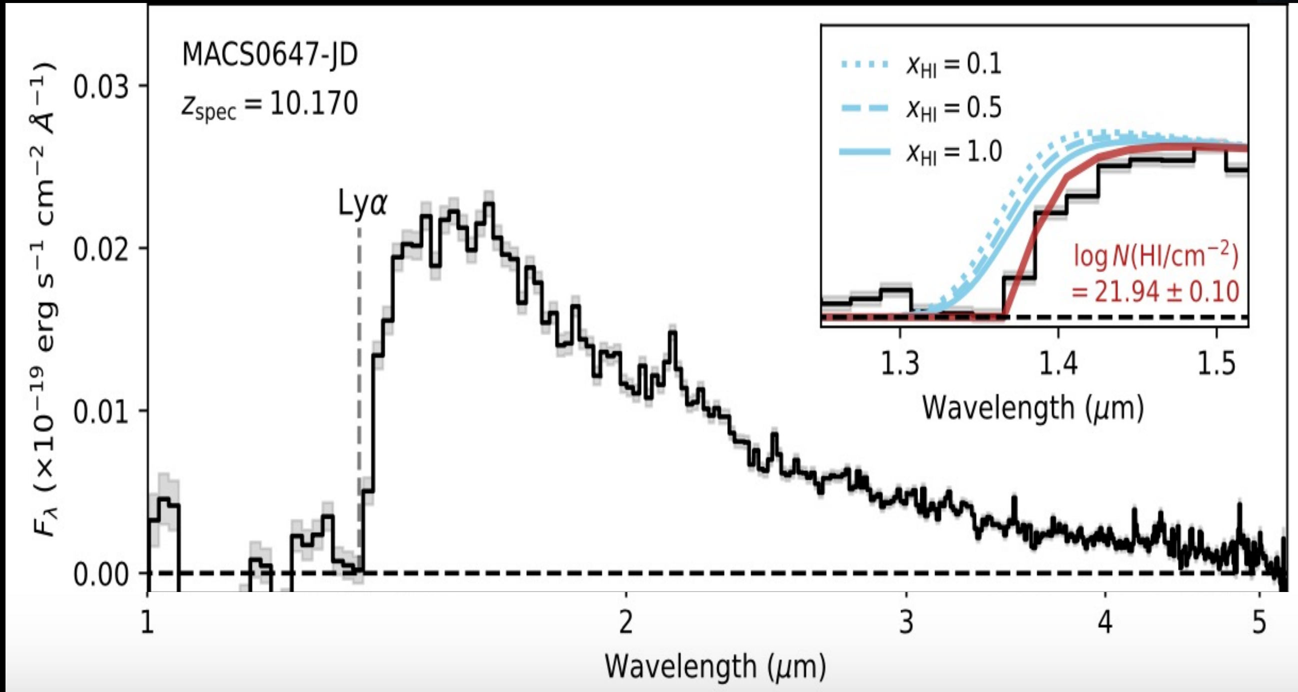
- Dark matter's gravity forms the deep "wells" that material follows onto nascent galaxies

STScI | SPACE TELESCOPE SCIENCE INSTITUTE

Webb is showing this earlier epoch

- For the first time, we have seen direct evidence of galaxies pulling in primordial, neutral H





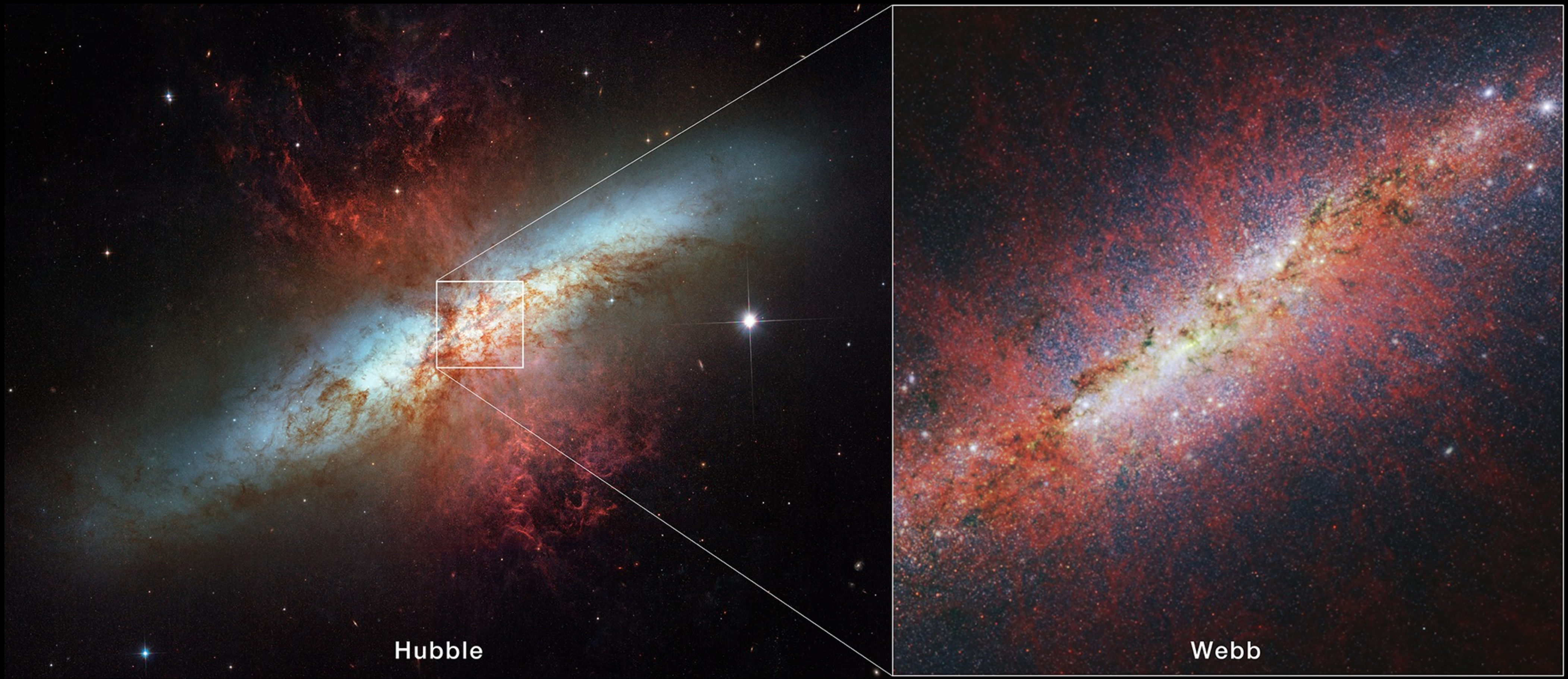
What are the biggest surprises?

- Webb is seeing more bright galaxies than expected.
- There could be many reasons for this:
  - Dust cleared out of smaller galaxies by intense star formation?

We can see something similar happening locally after all…

M82: Example of nearby dust clearing

- Burst of star formation blows gas out of the galaxy



What are the biggest surprises?

- Webb is seeing more bright galaxies than expected.
- There could be many reasons for this:
  - Dust cleared out of smaller galaxies by intense star formation?
  - Star formation happens in brief, bright bursts?
  - Easier to form massive stars with fewer heavy elements?
  - Webb happened to look so far at a sight line along a dense strand of the cosmic web?
  - “Extra light” from growing black holes throwing off models that assume starlight?
  - Dark matter has a somewhat different nature than we thought?
  - And more!

More surprises: the most distant galaxy known so far

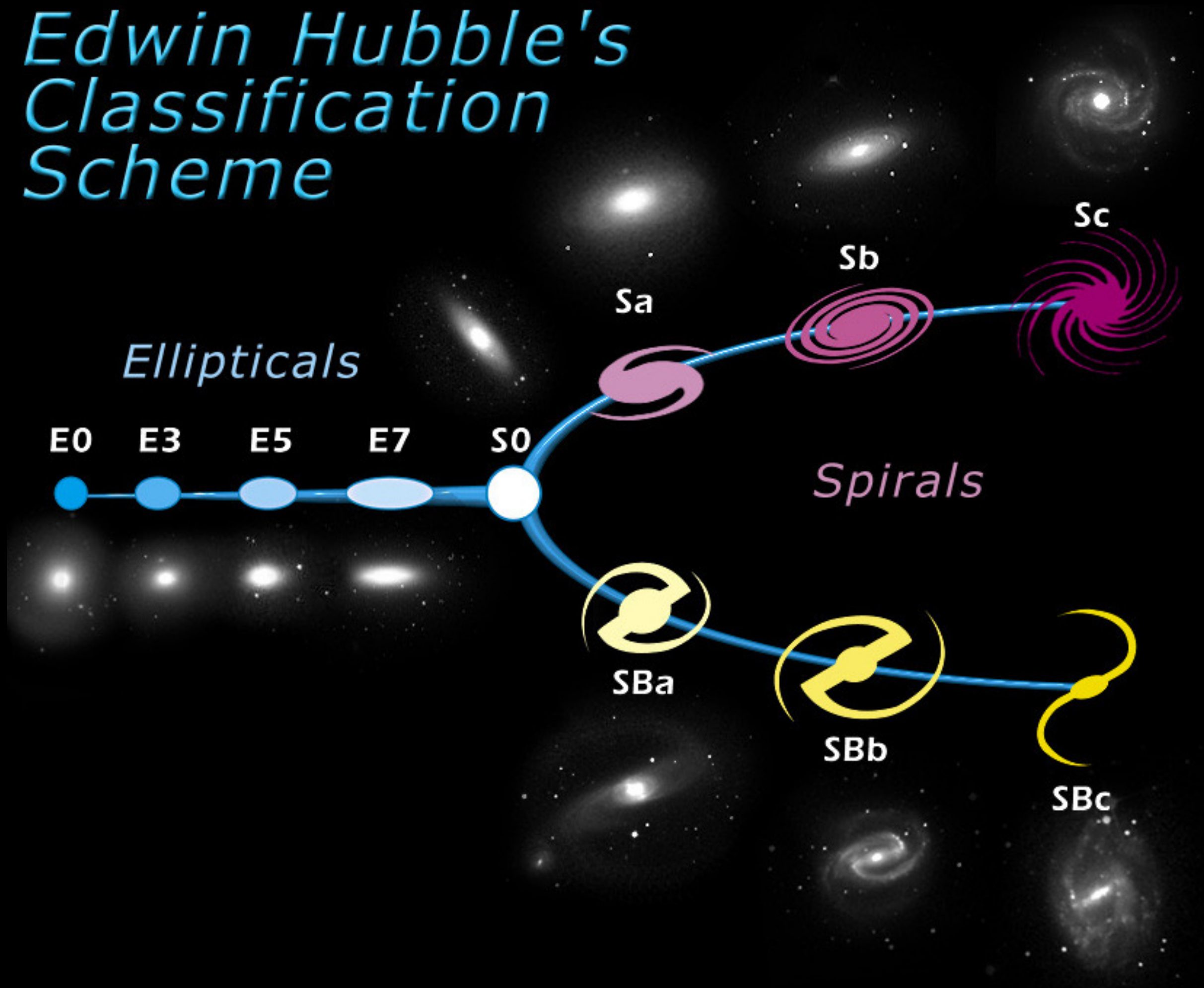
- Seeing some relatively enriched galaxies at very early times
- <300 million years after the Big Bang, ~3% as many heavy elements as the Sun
- Already reddened by dust!

SPACE TELESCOPE SCIENCE INSTITUTE

Surprises in galaxy evolution

Modern galaxies follow a "tuning fork"

No dust
Few stars forming
Redder

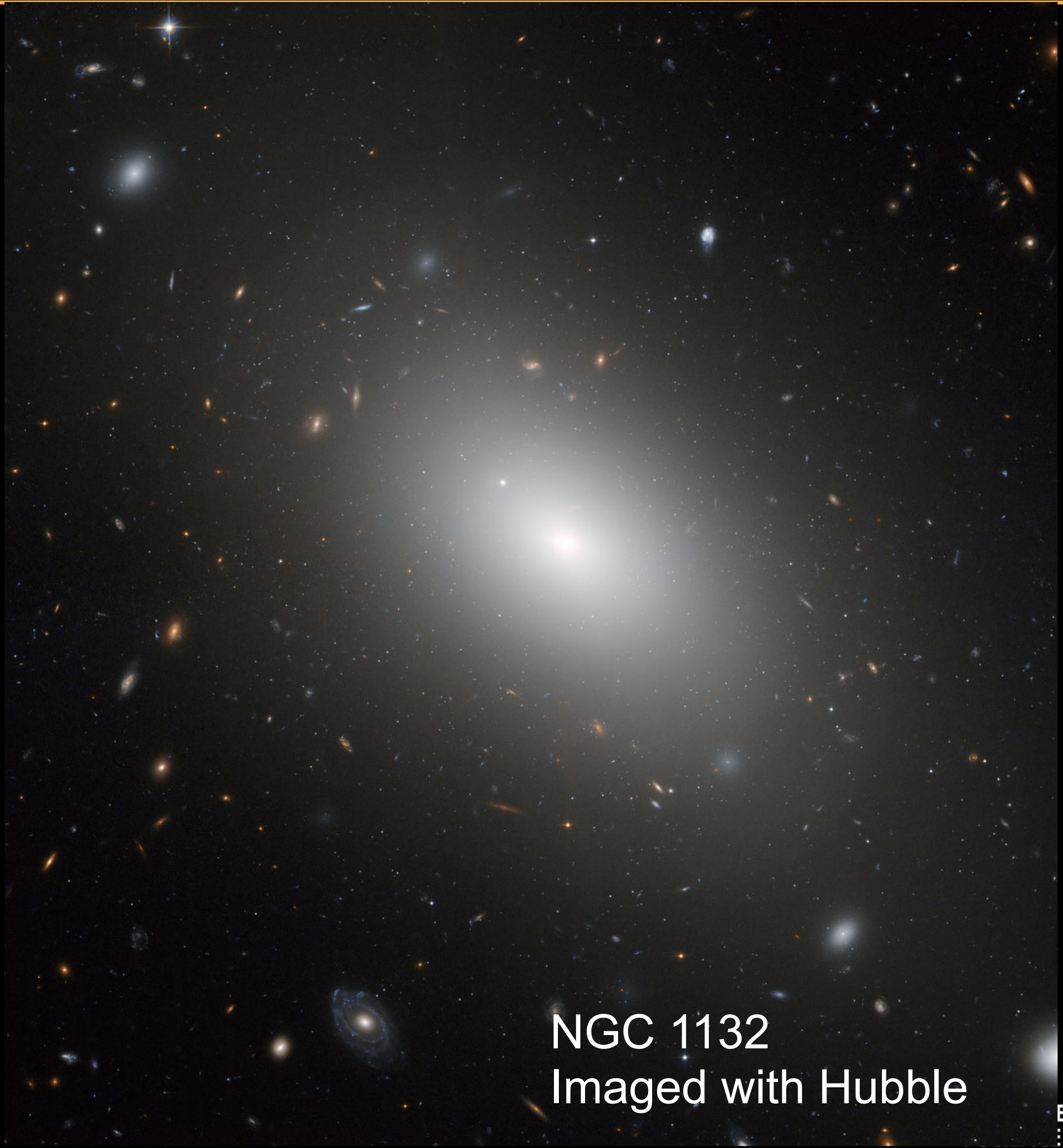


Lots of dust
Many stars forming
Bluer

Surprises in galaxy evolution

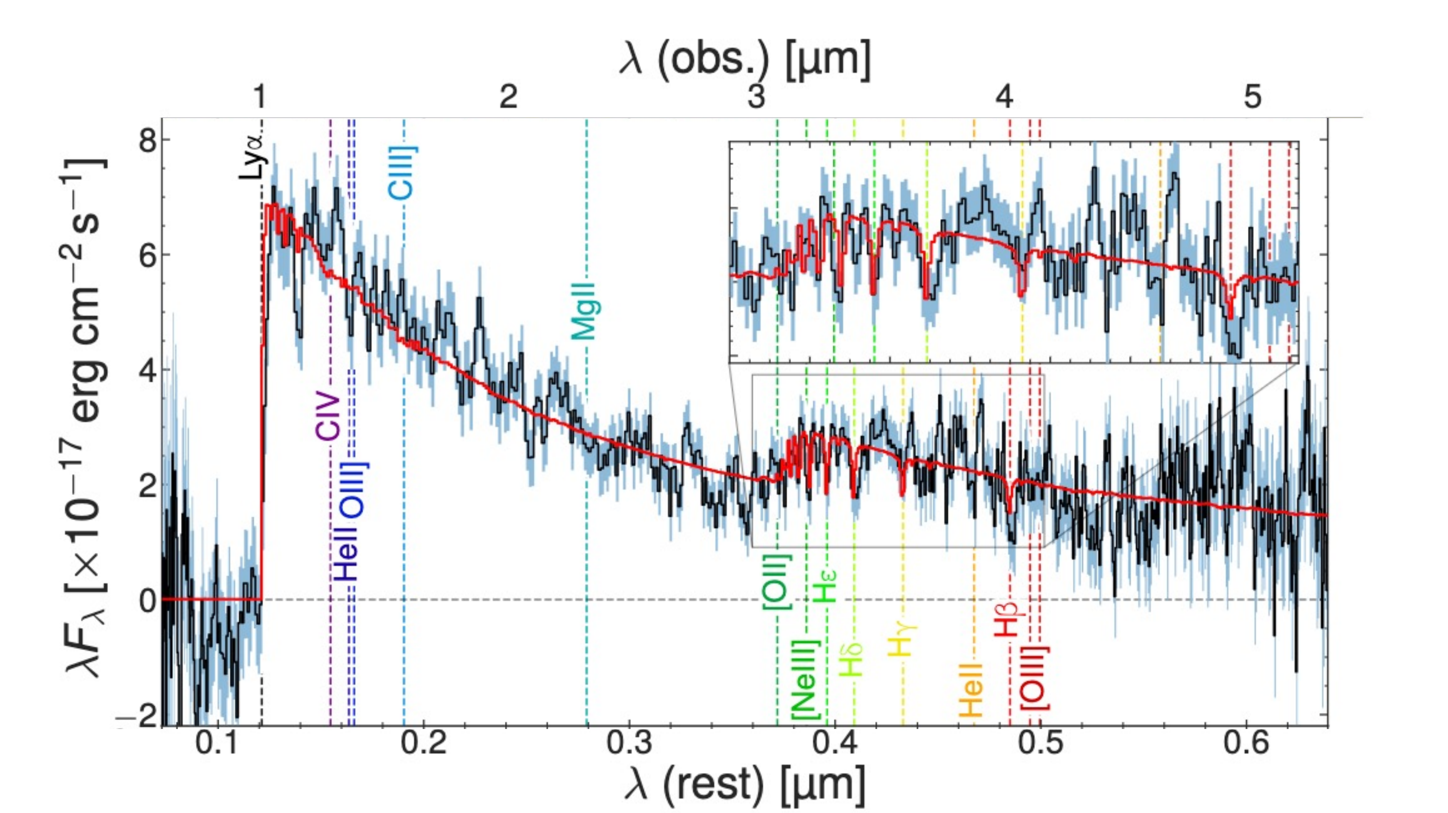
NGC 3147
Imaged with Hubble

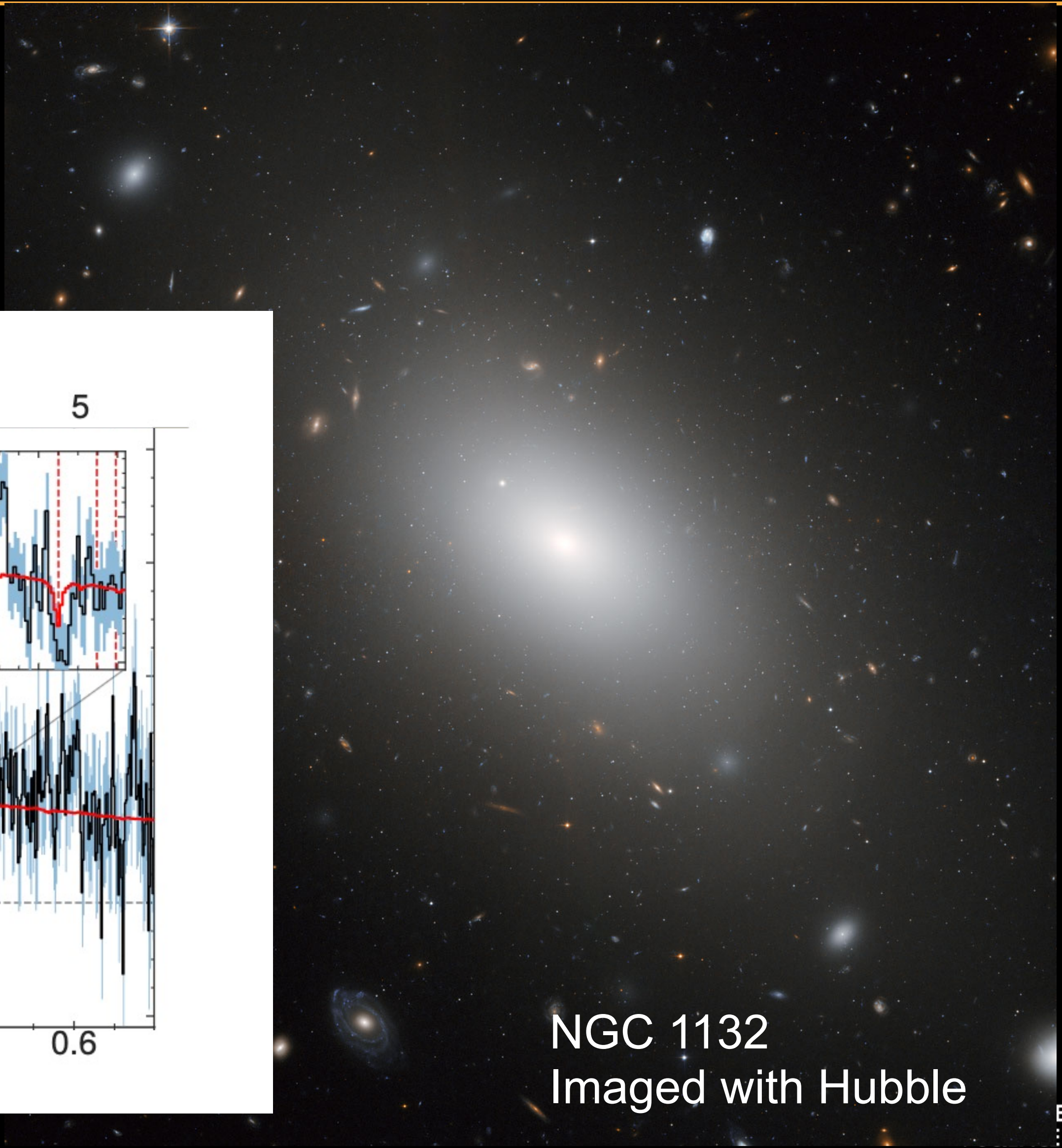
VS



NGC 1132
Imaged with Hubble

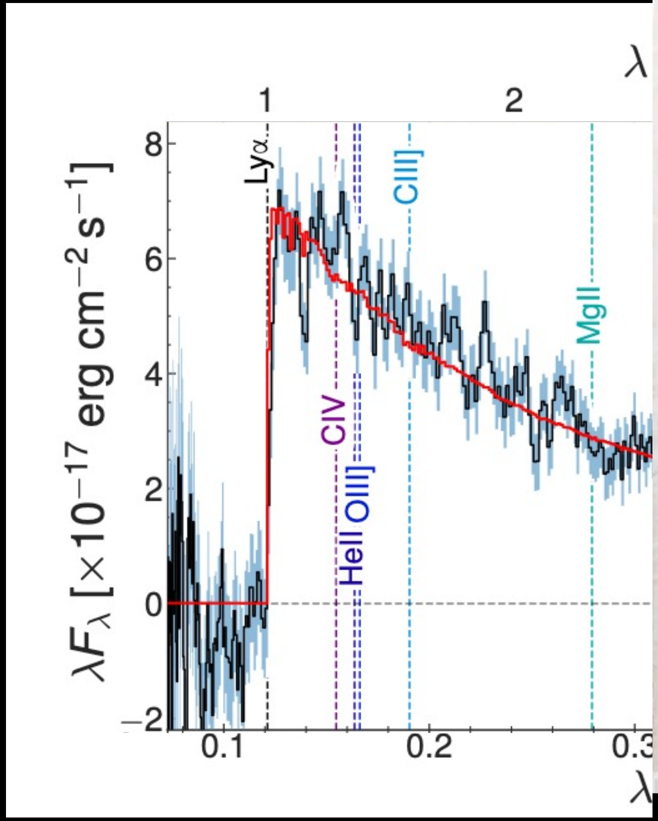
More surprises: Red & Dead early galaxies

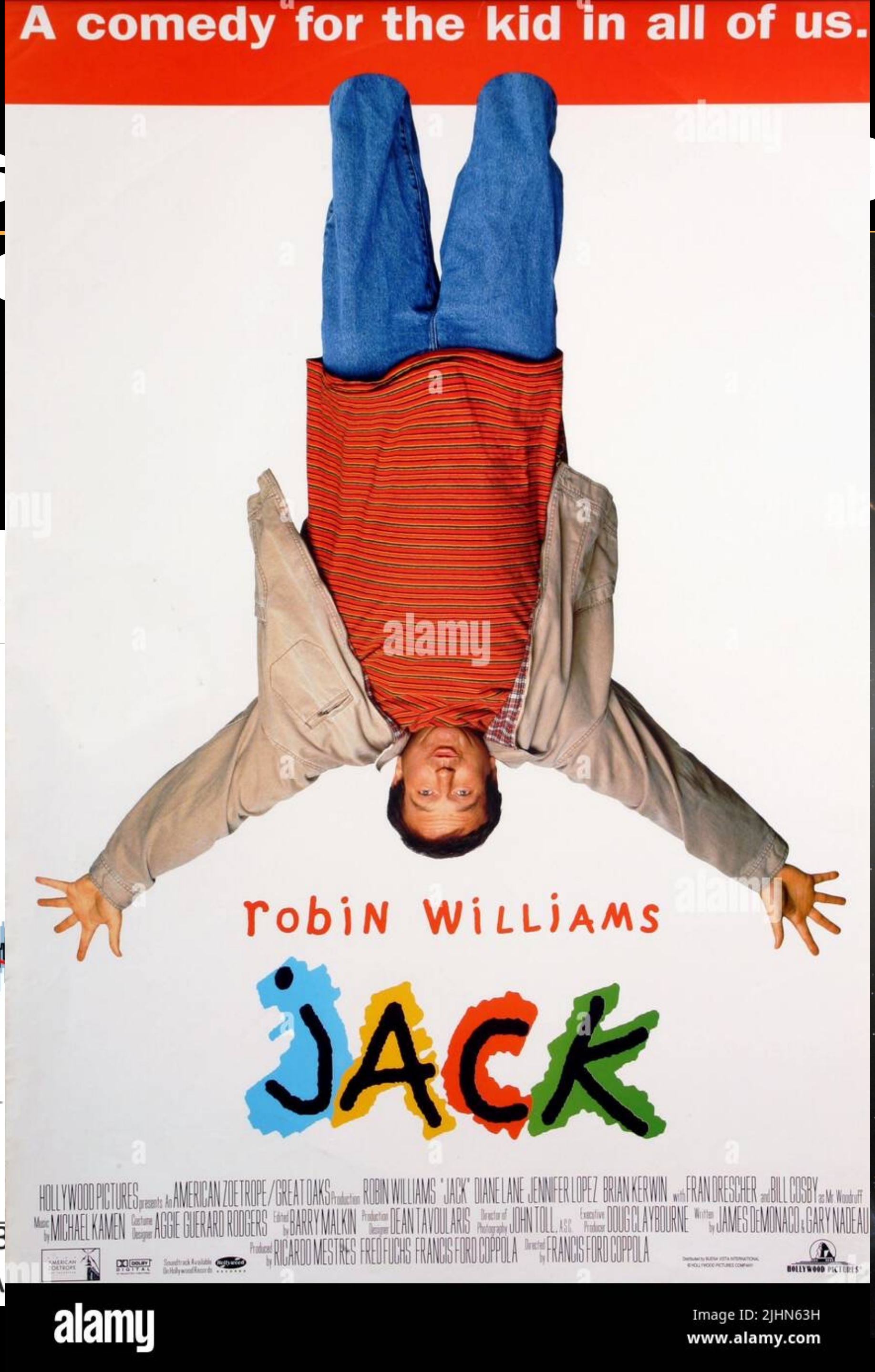


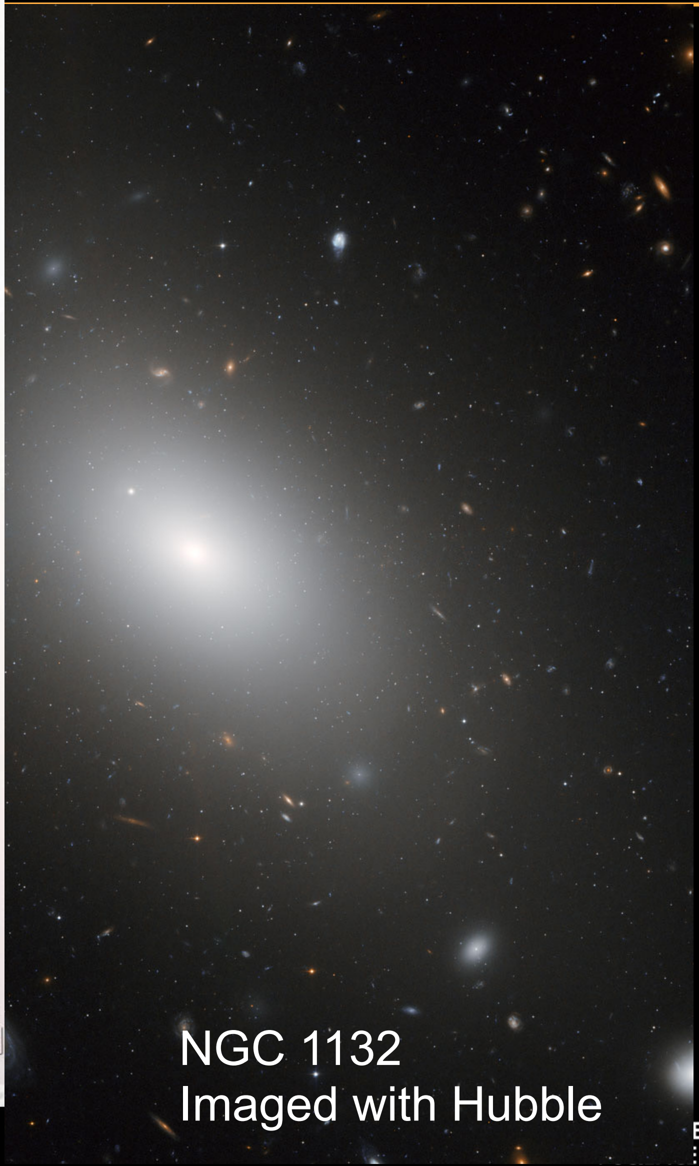


ELESCOPE
INSTITUTE

More s… ead early galaxi…

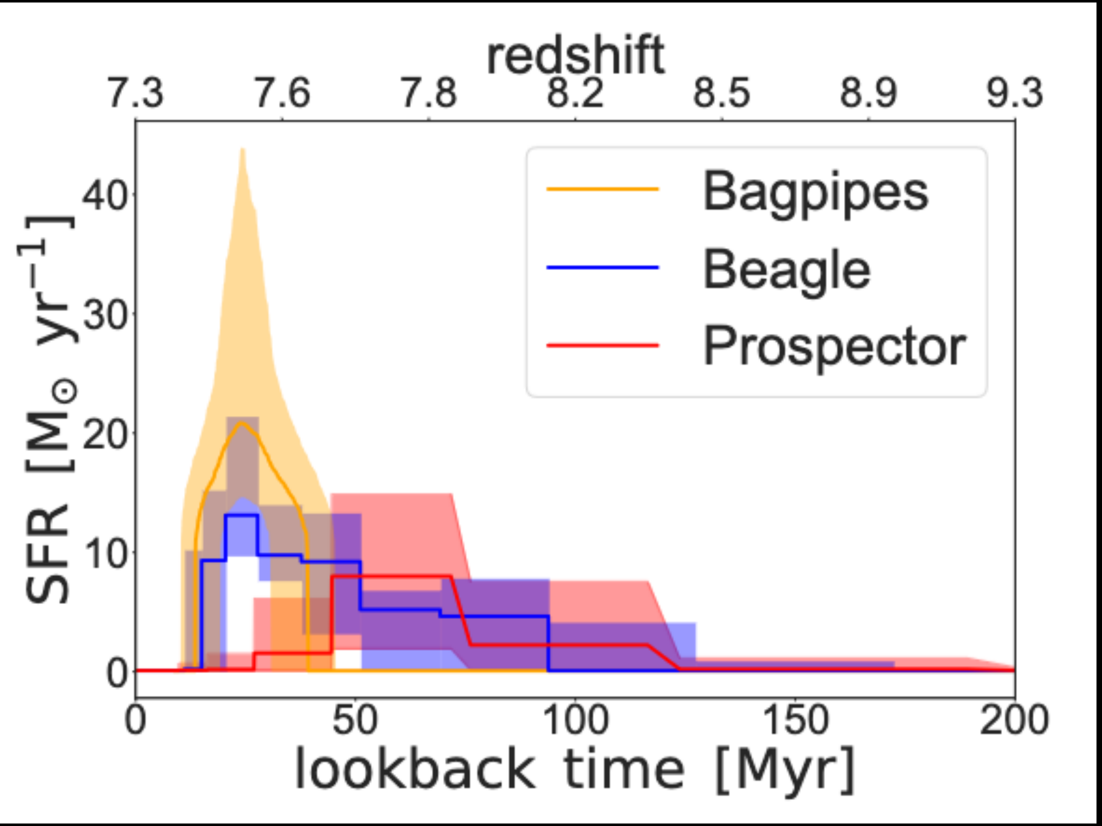


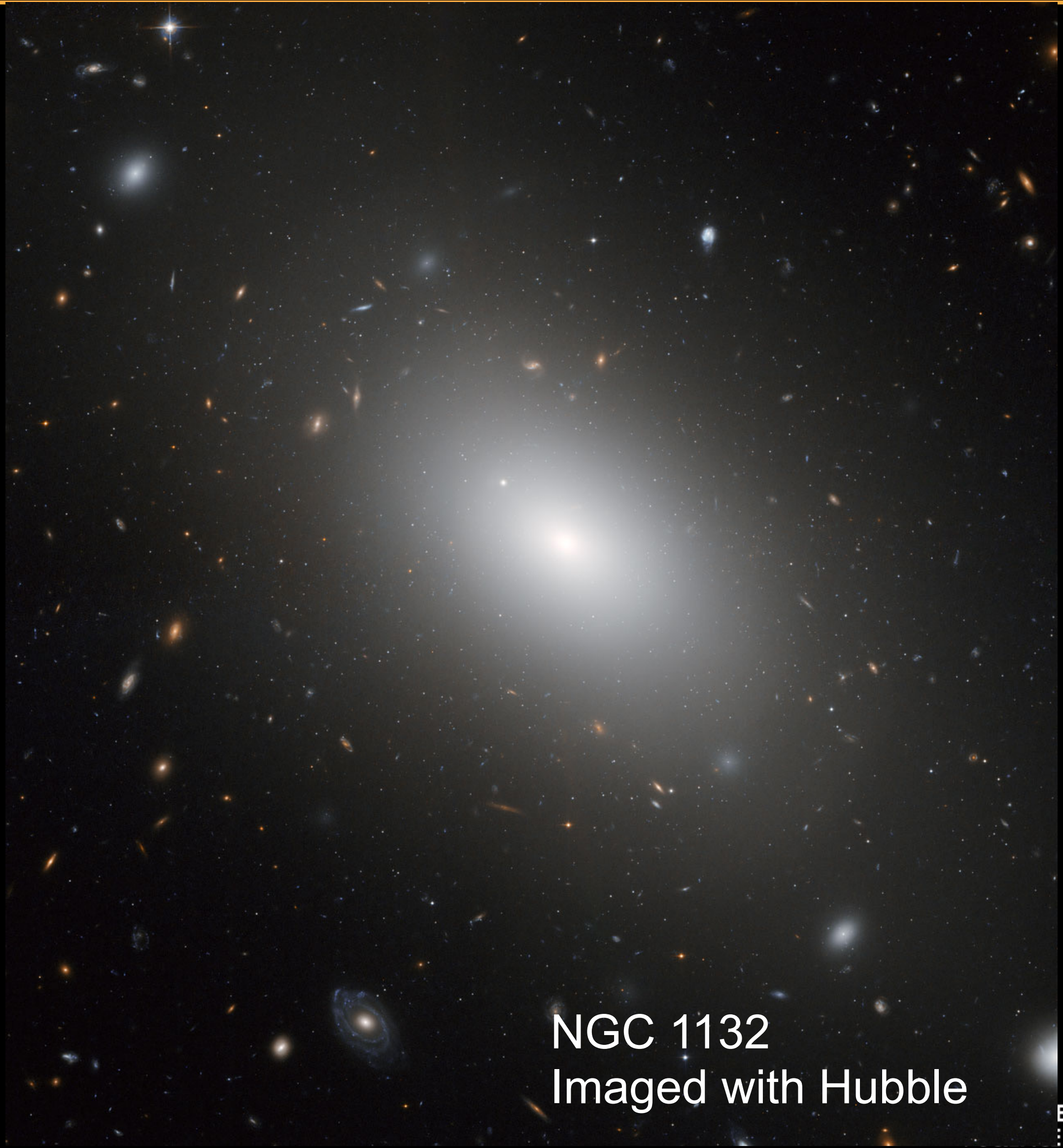




ELESCOPE
INSTITUTE

More surprises: Red & Dead early galaxies



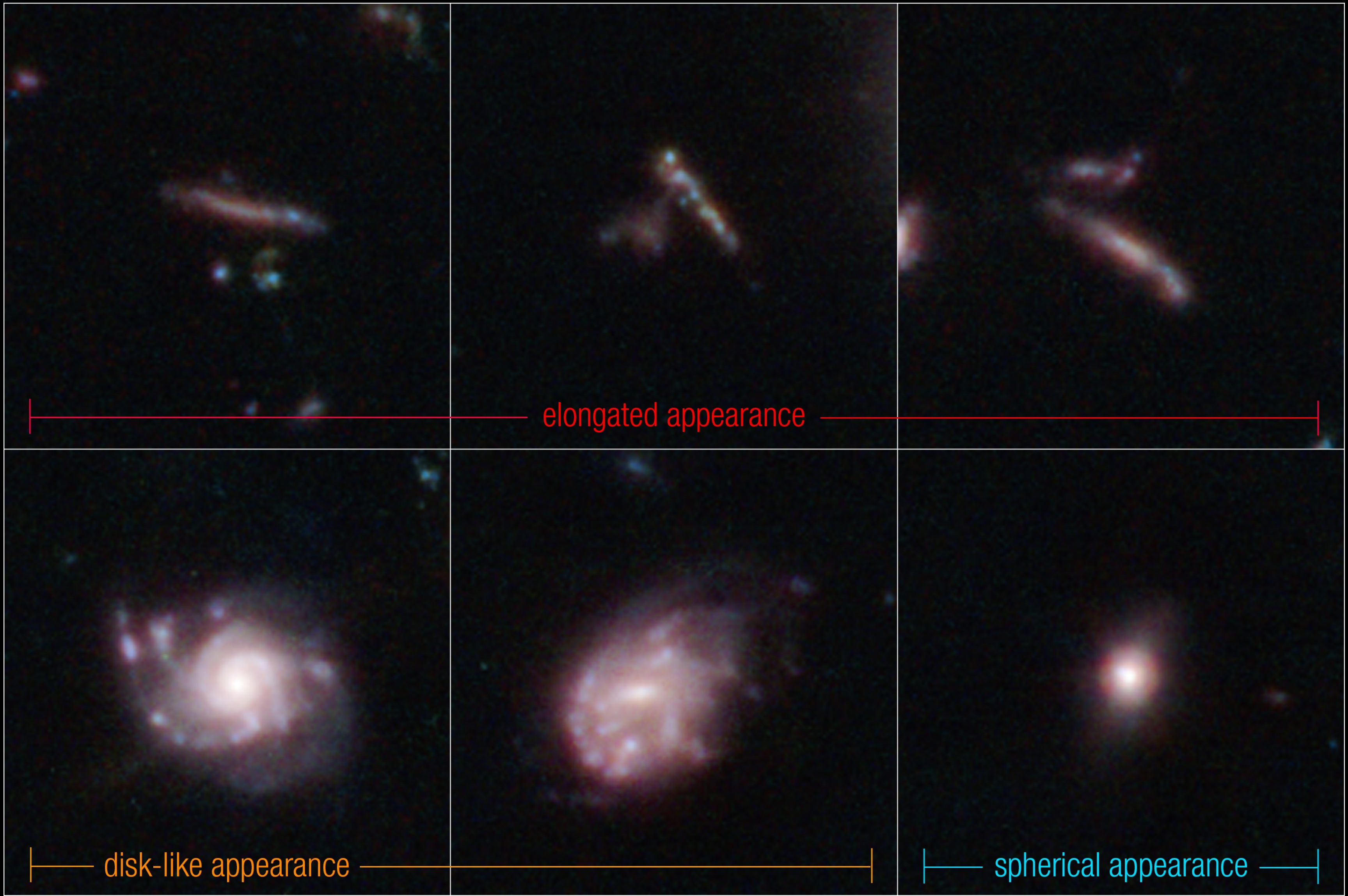


ELESCOPE
INSTITUTE

WEBB SPACE TELESCOPE

More surprises: Disks and Noodles

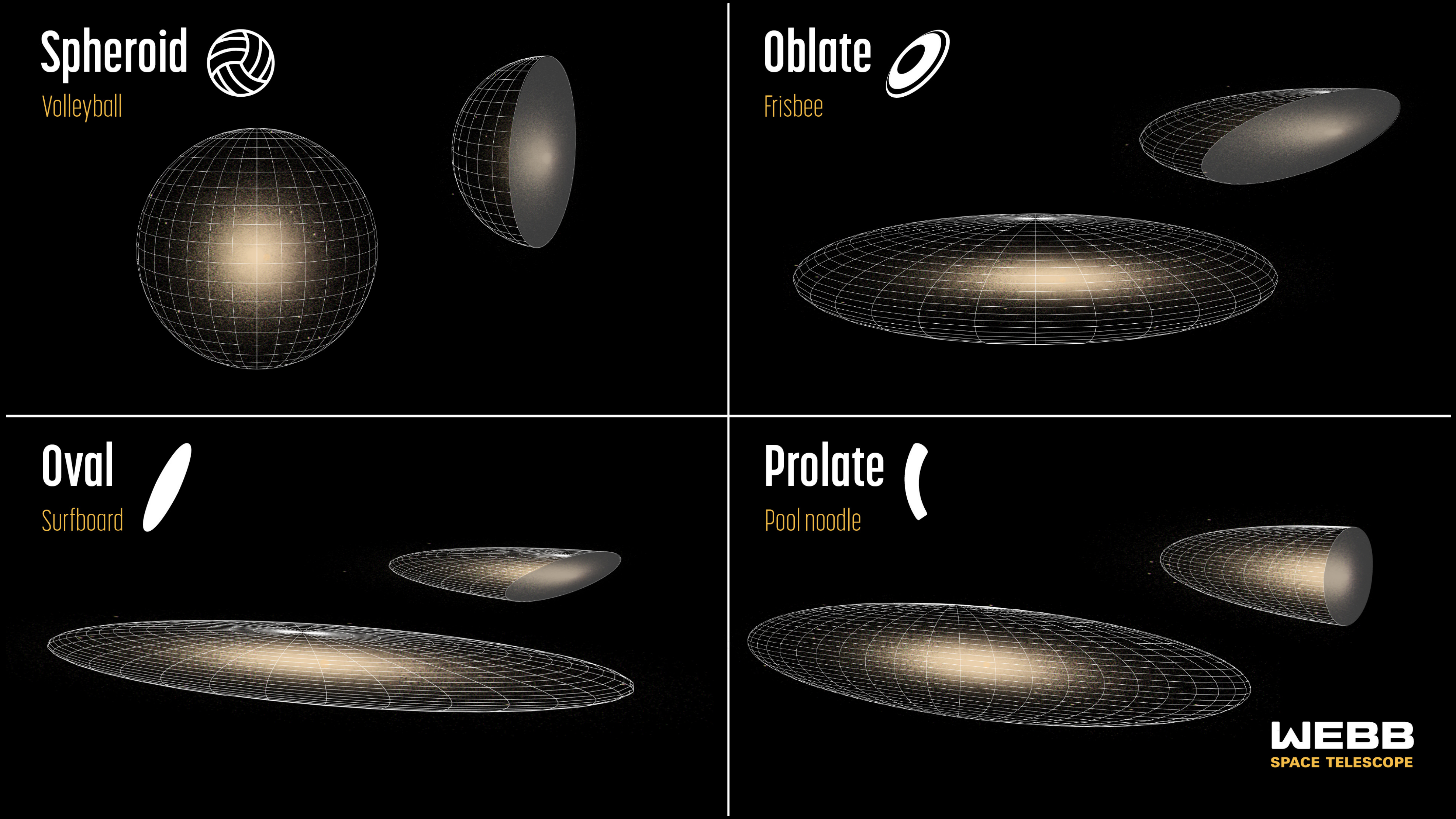
More surprises: Disks and Noodles



STScI | SPACE TELESCOPE SCIENCE INSTITUTE

WEBB
SPACE TELESCOPE

More surprises: Disks and Noodles

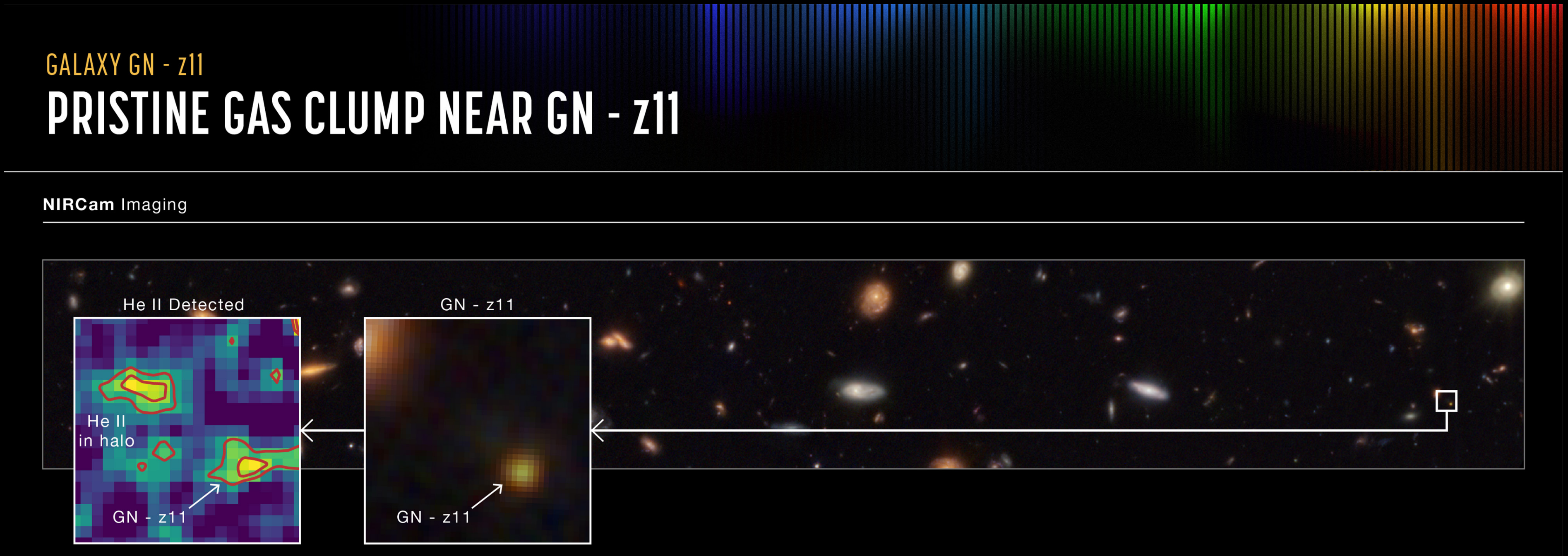


WEBB
SPACE TELESCOPE

STScI | SPACE TELESCOPE SCIENCE INSTITUTE

More surprises: Hints of the first stars?

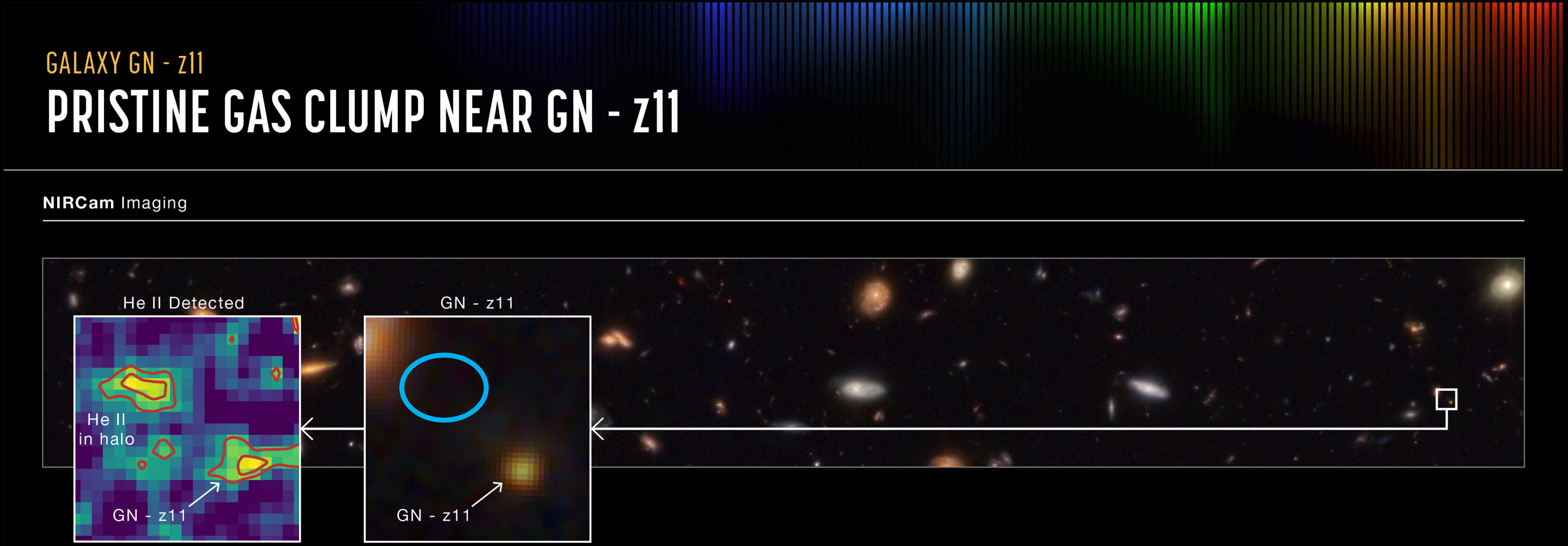
More surprises: Hints of the first stars?



Wavelength specific to ionized helium

All observed wavelengths

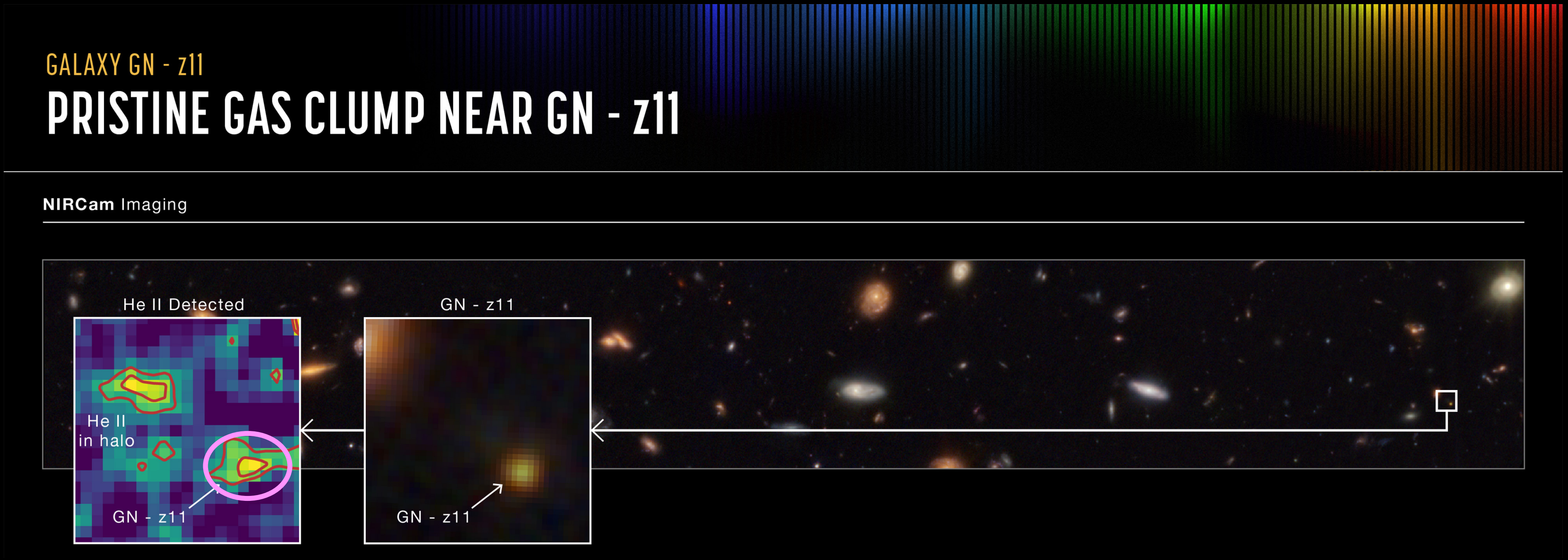
More surprises: Hints of the first stars?



Wavelength specific to ionized helium

All observed wavelengths

More surprises: Hints of the first stars?

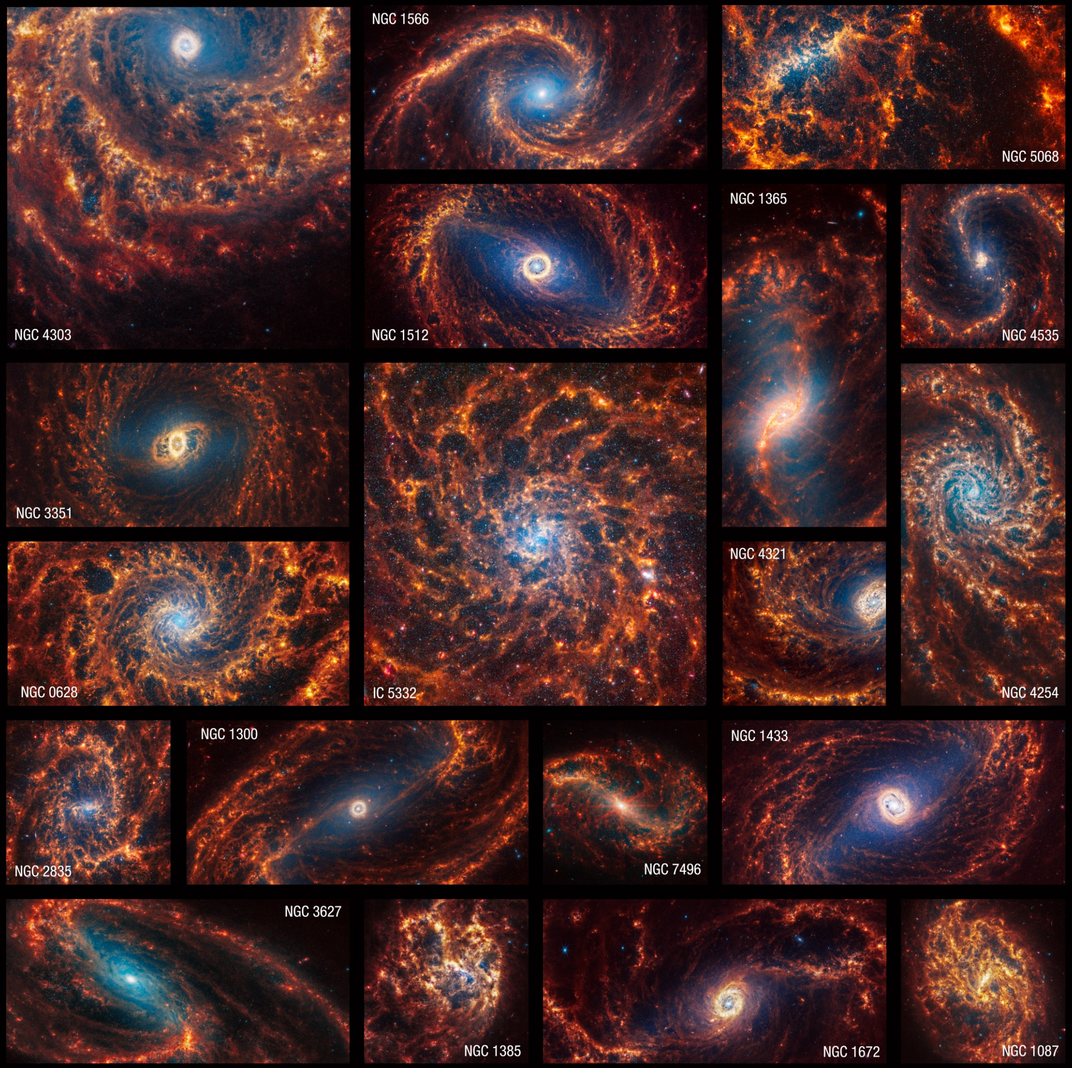


Wavelength specific to ionized helium

All observed wavelengths

A close look at how star formation shapes a galaxy

- PHANGS survey – many high resolution images



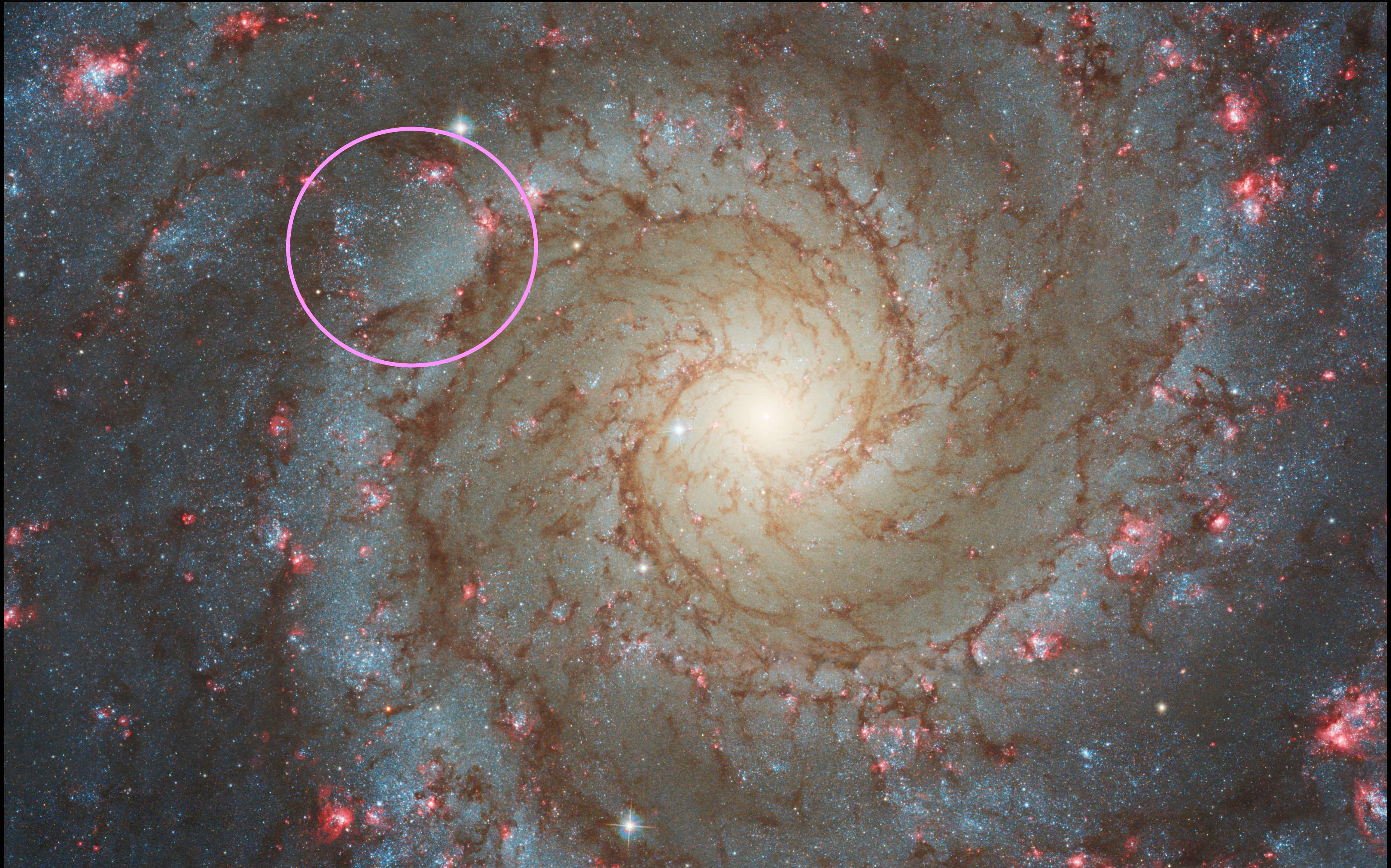
WEBB SPACE TELESCOPE

The “Phantom Galaxy”, M74

STScI | SPACE TELESCOPE SCIENCE INSTITUTE

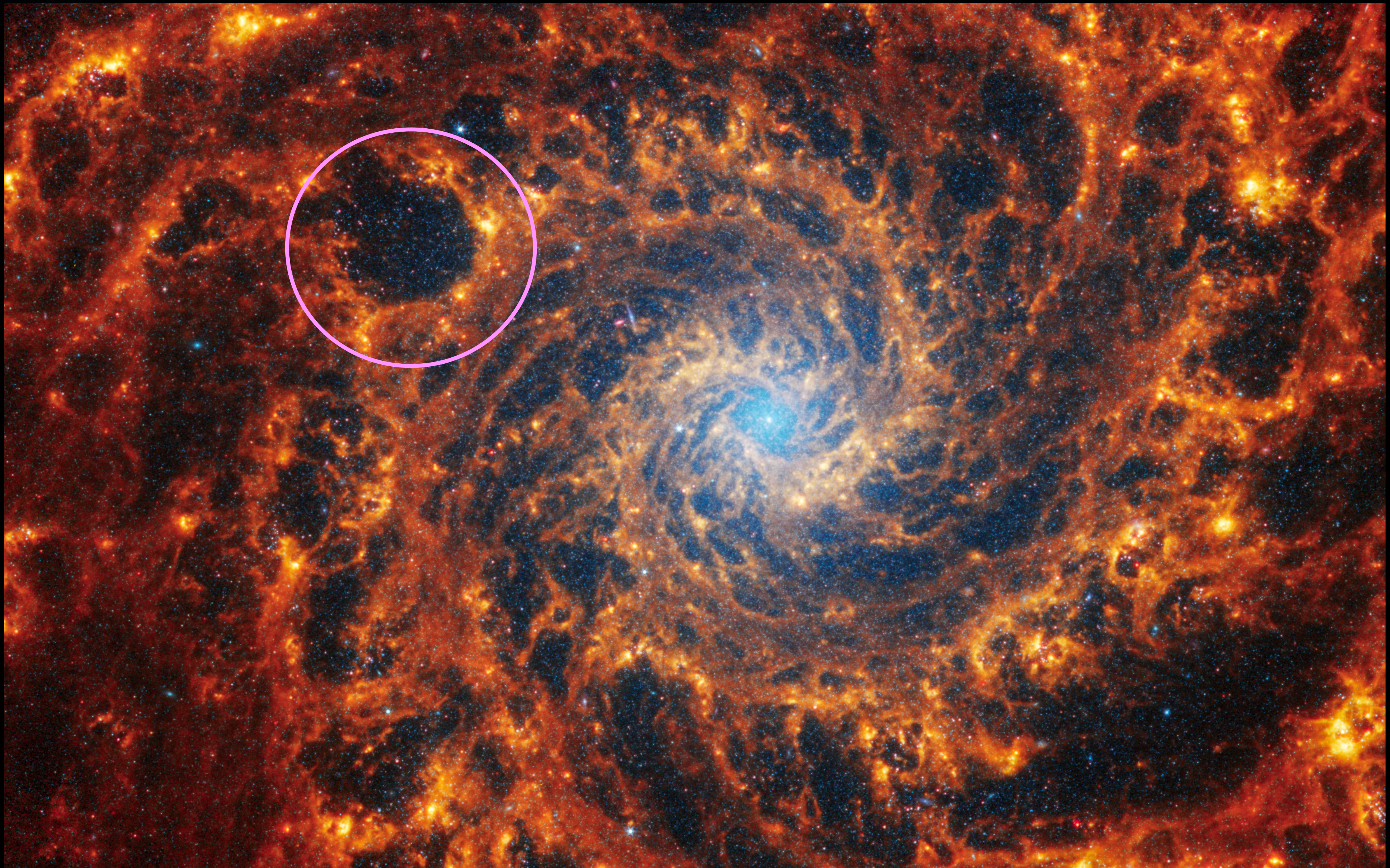
The "Phantom Galaxy", M74

The “Phantom Galaxy”, M74



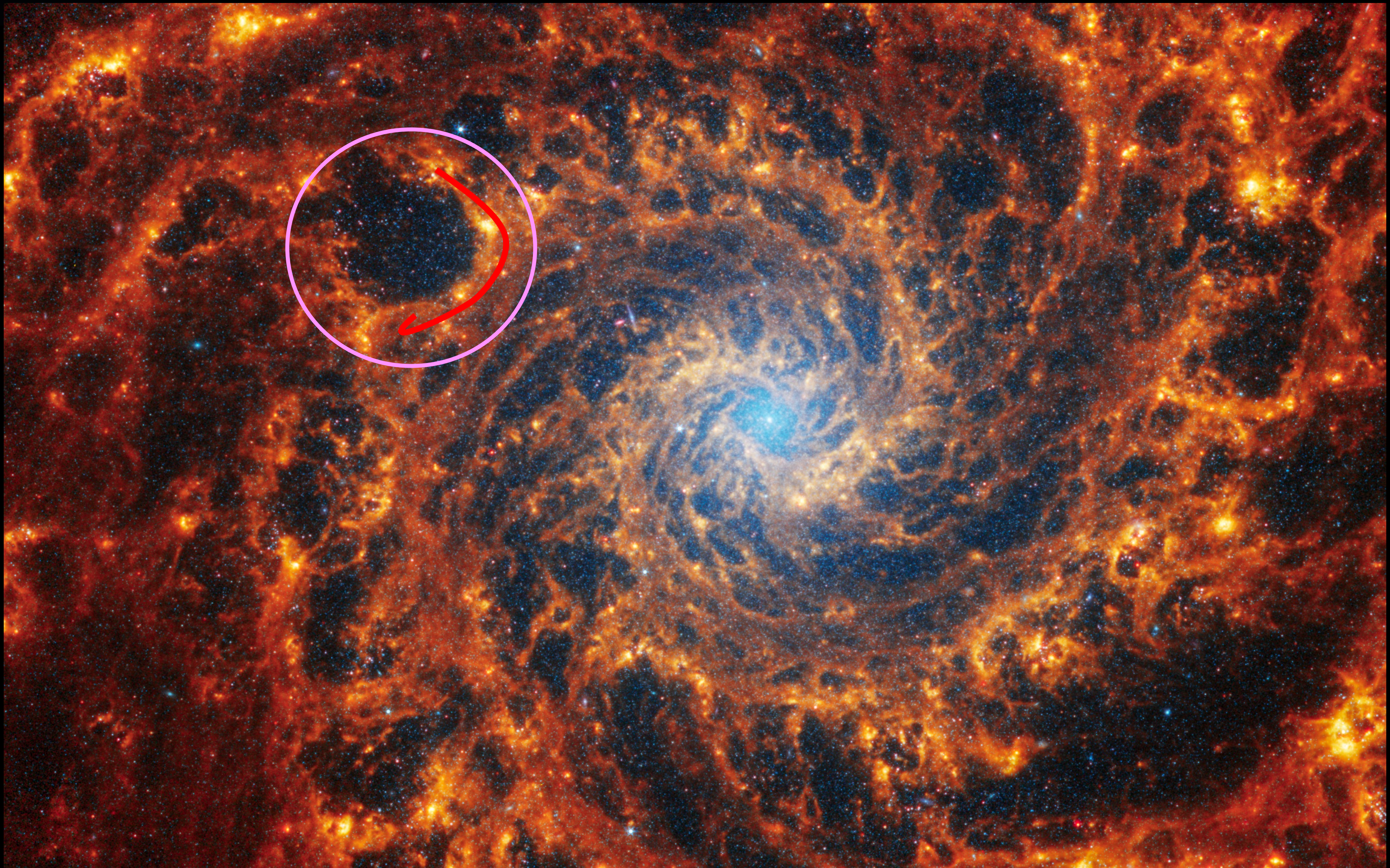
WEBB SPACE TELESCOPE

The "Phantom Galaxy", M74



STScI | SPACE TELESCOPE SCIENCE INSTITUTE

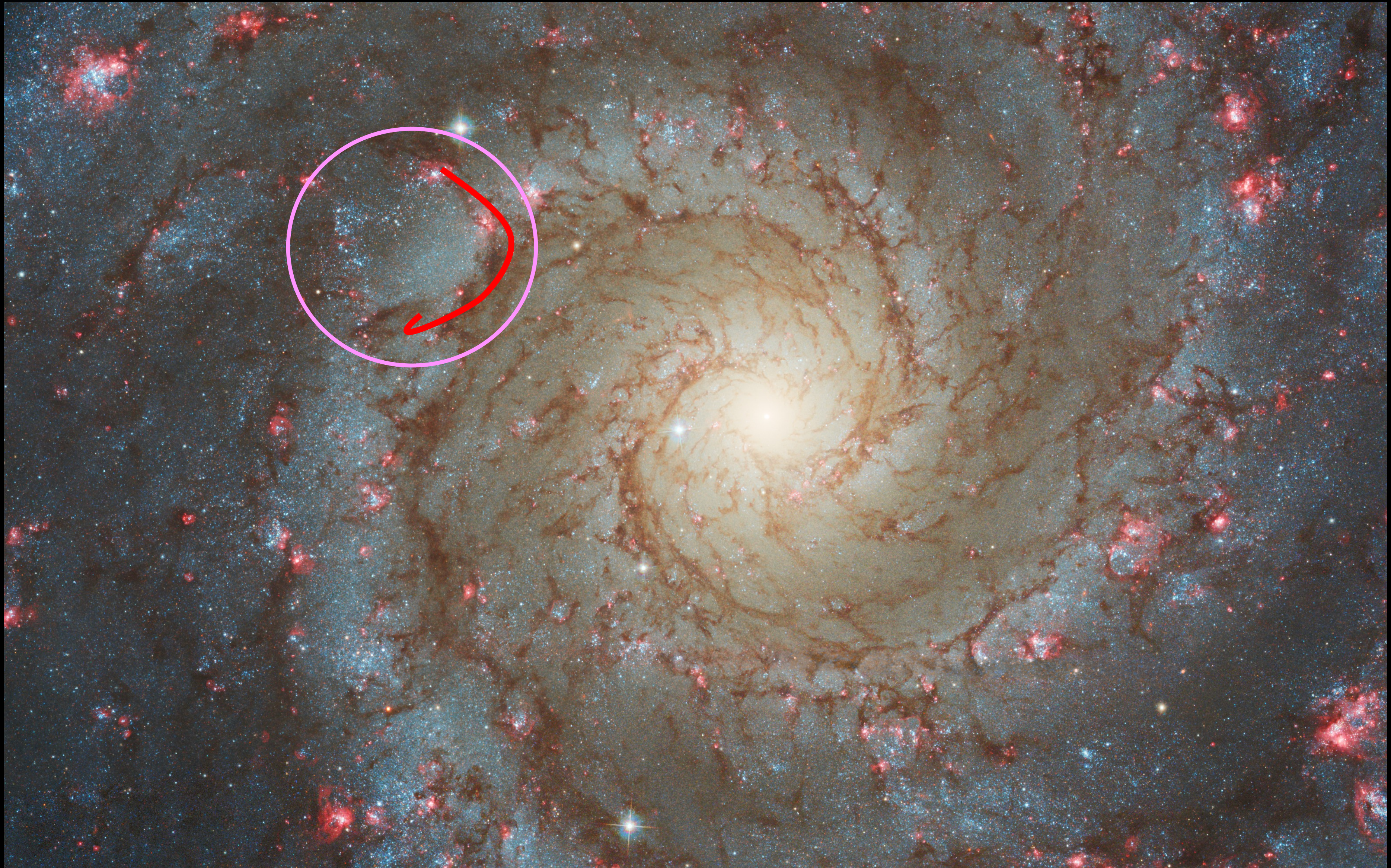
The "Phantom Galaxy", M74



SPACE TELESCOPE SCIENCE INSTITUTE

WEBB SPACE TELESCOPE

The “Phantom Galaxy”, M74



STScI | SPACE TELESCOPE SCIENCE INSTITUTE

The “Phantom Galaxy”, M74

The "Phantom Galaxy", M74

NGC 7496

- Face-on barred spiral
- Is the center a bit bright?

NGC 7496

- Face-on barred spiral
- Is the center a bit bright?
  - Yes! There’s an active black hole in the center

STScI | SPACE TELESCOPE SCIENCE INSTITUTE

NGC 1512

SPACE TELESCOPE SCIENCE INSTITUTE

NGC 1512

SPACE TELESCOPE
SCIENCE INSTITUTE

The Changing Universe

Can you spot the differences?

The Changing Universe

Can you spot the differences?

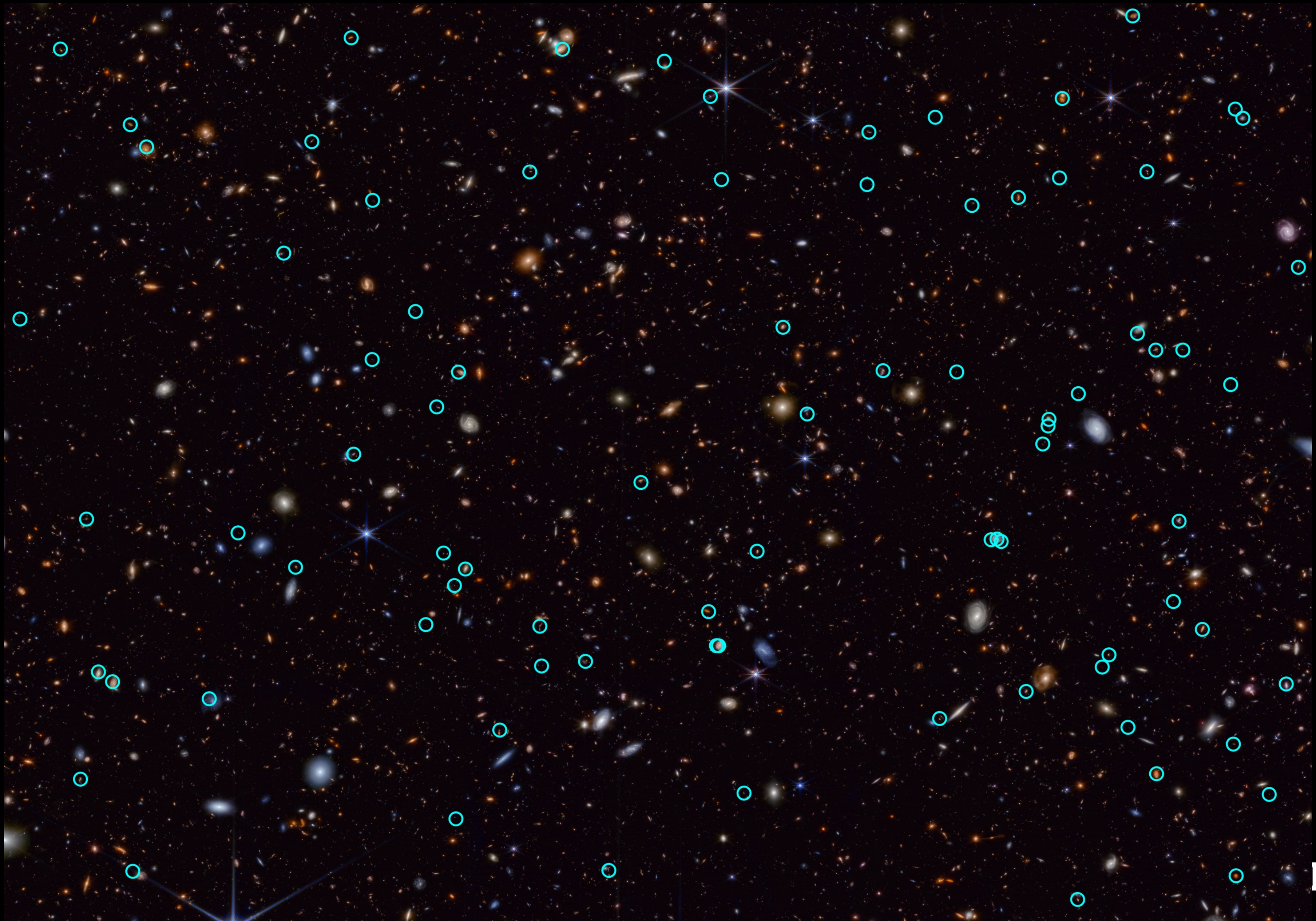
2022

2023

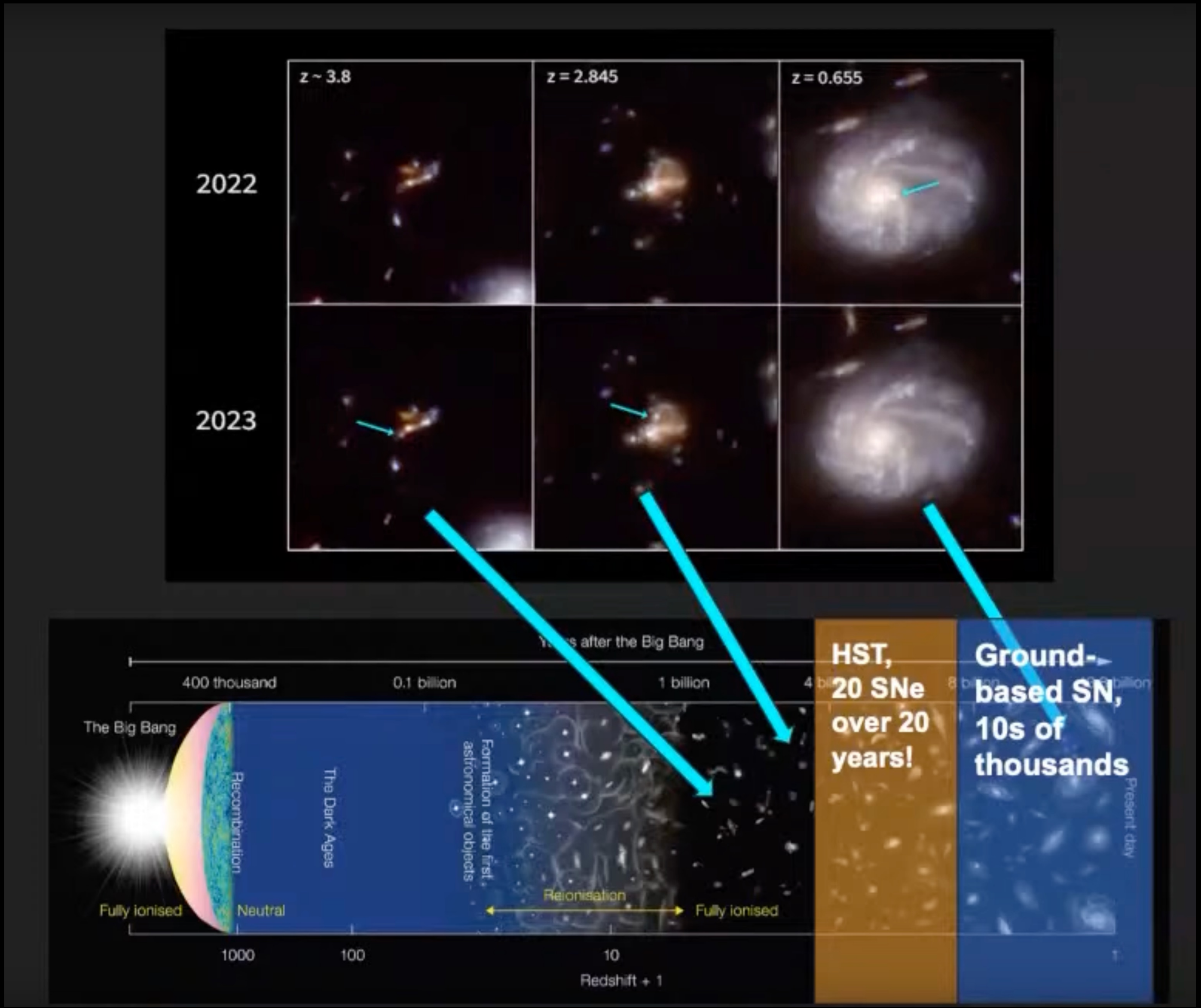
The Changing Universe

Webb found over **80** supernovae in this field

~40 per year

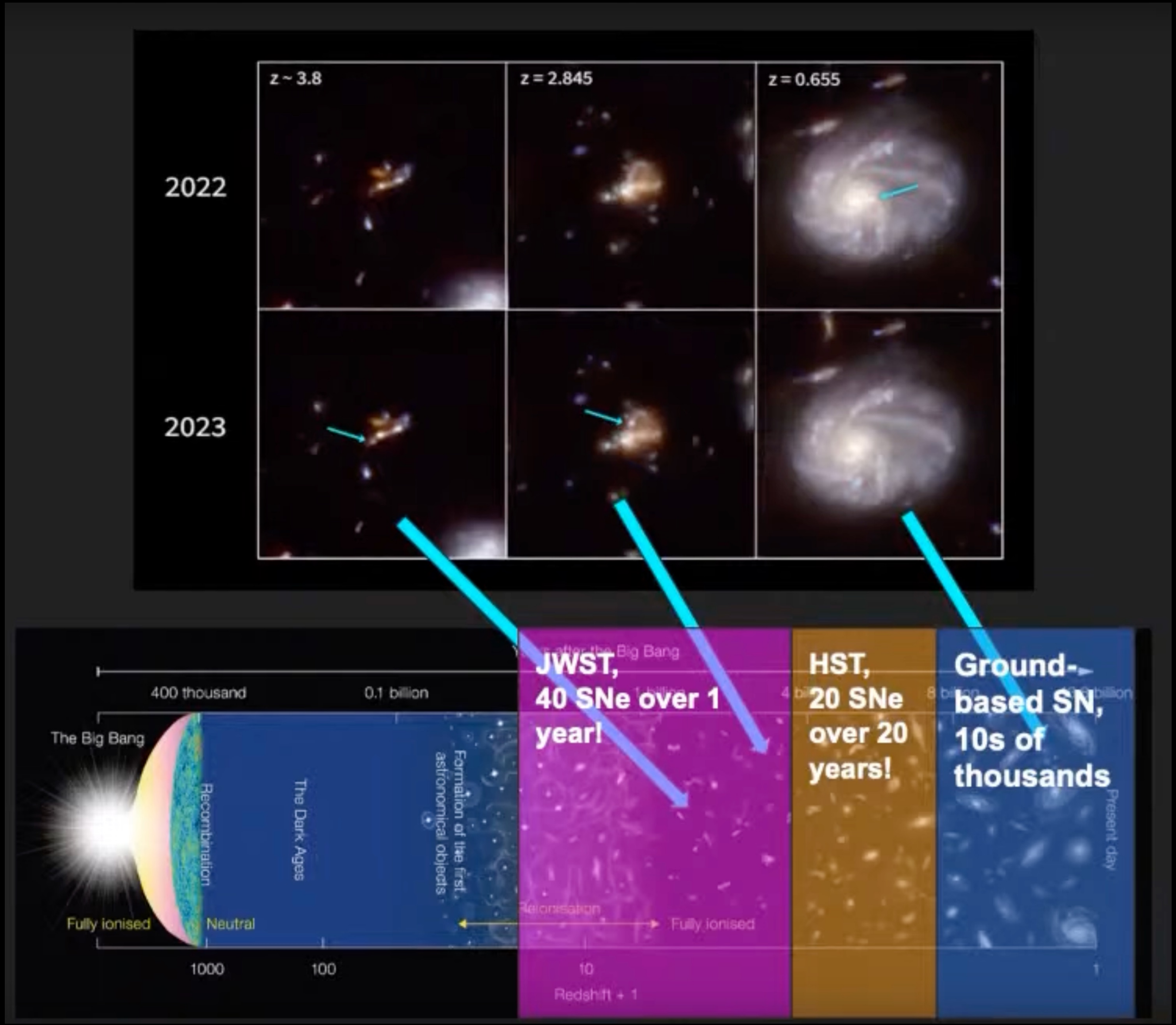


The Changing Universe



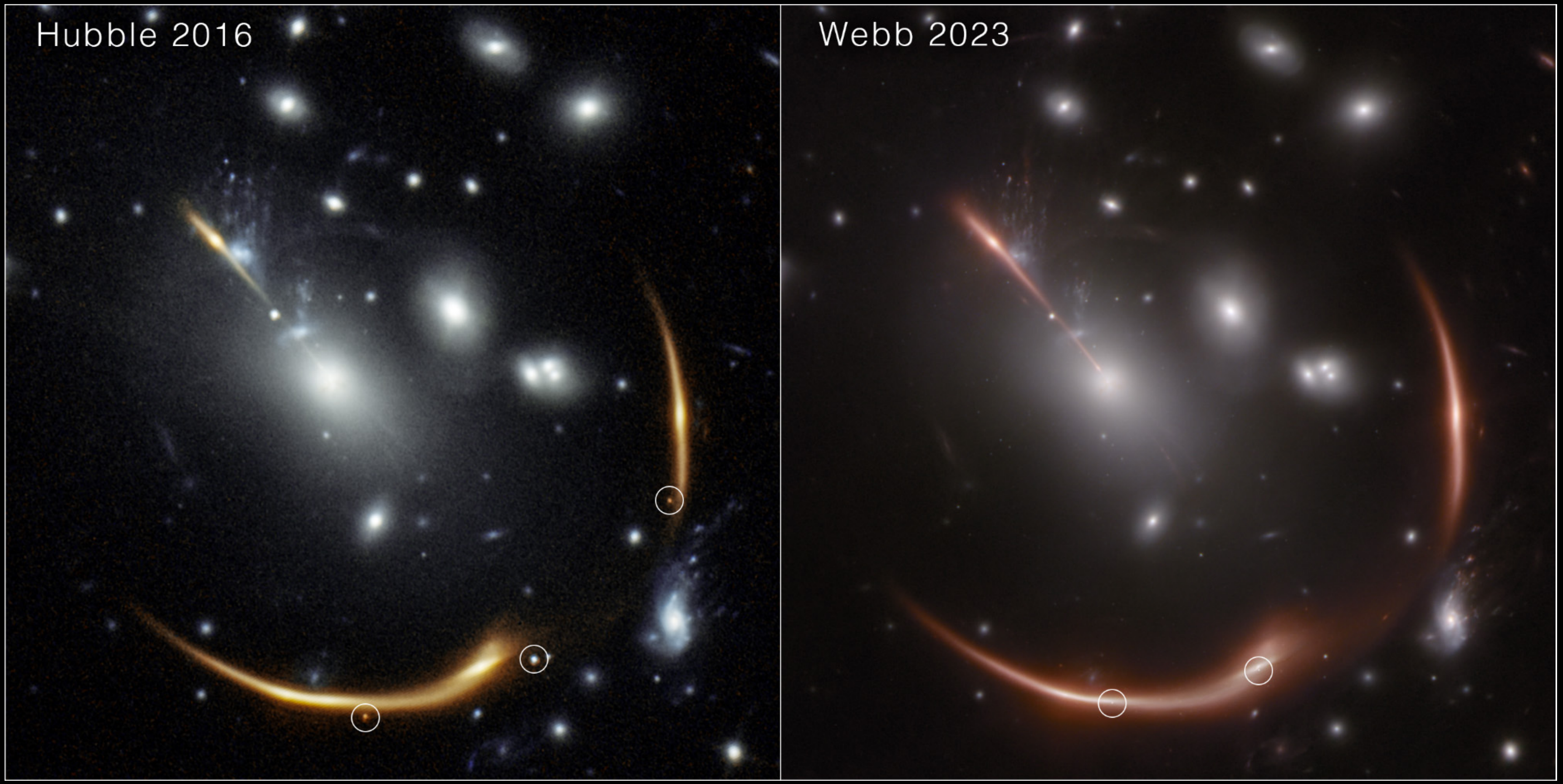
STScI | SPACE TELESCOPE SCIENCE INSTITUTE

The Changing Universe



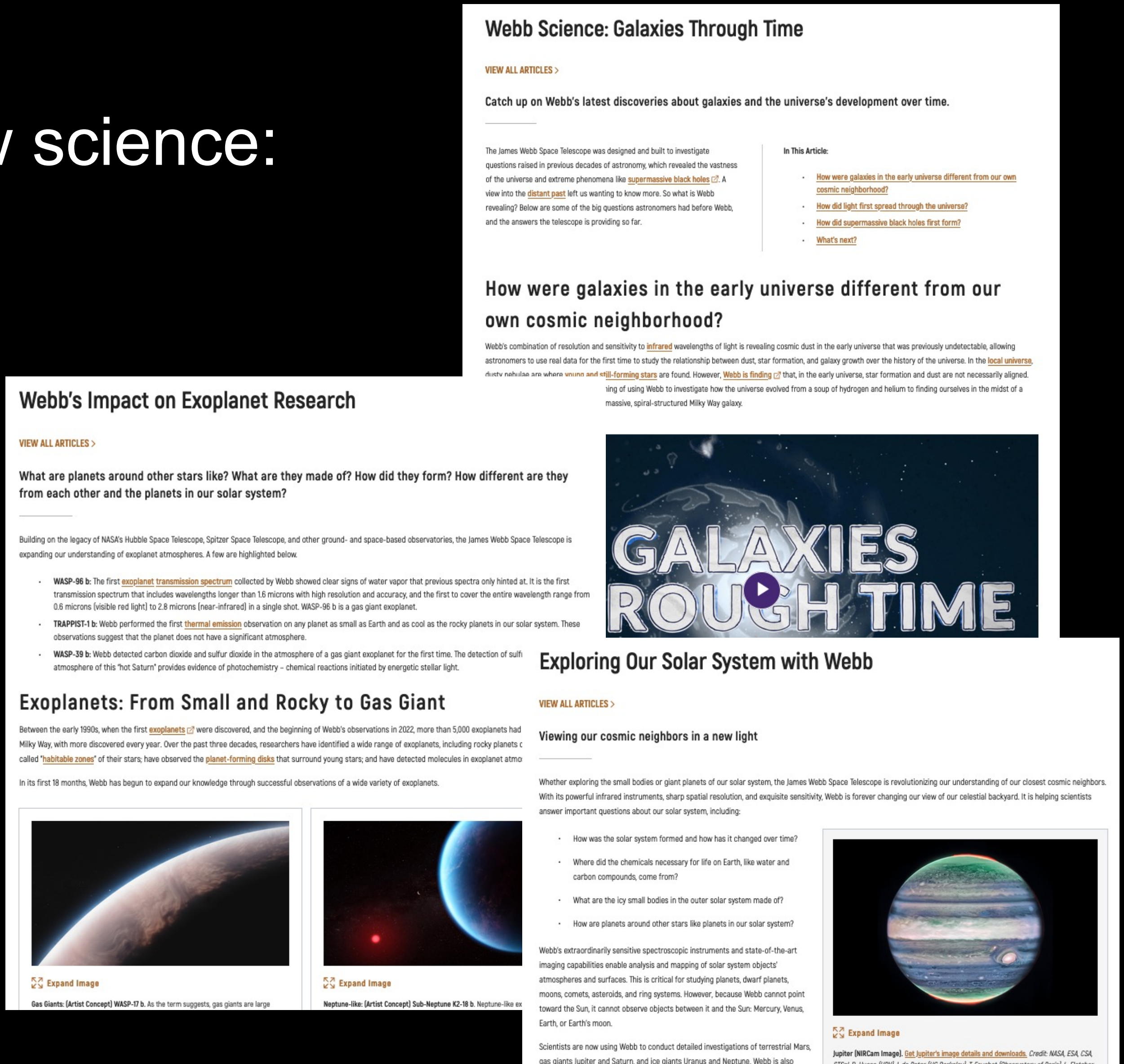
SN Requiem and Encore

- Multiple images of same SN
- A second SN happened in the same galaxy!



New resources

- Articles broadly summarizing new science:
  - Galaxies through time
  - Exoplanets
  - Solar System Science
- More articles and videos coming soon!




WEBB
2023 YEAR IN HEADLINES

Questions?