John M. O’Meara, W. M. Keck Observatory, HWO START Co-Chair

THE BARYON CYCLE IN THE HWO ERA
(AND ALONG THE WAY)

The cosmic landscape – big questions

What does clustering on galactic scales reveal about the nature of dark matter?

How do galaxies and their gas co-evolve?

How do galaxies quench and stay that way?

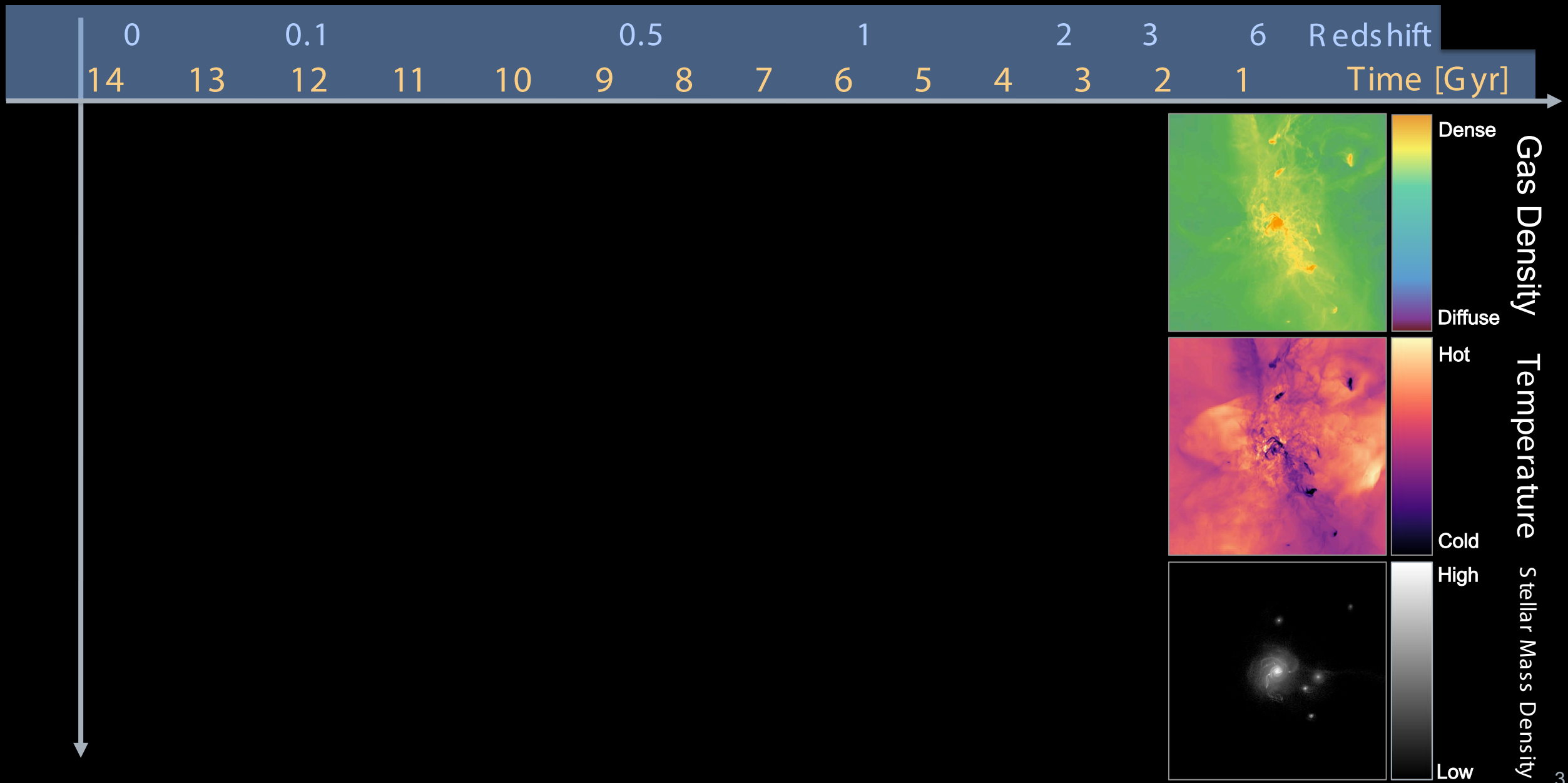
How are the chemical elements produced and distributed?

How do stars evolve and end their lives?

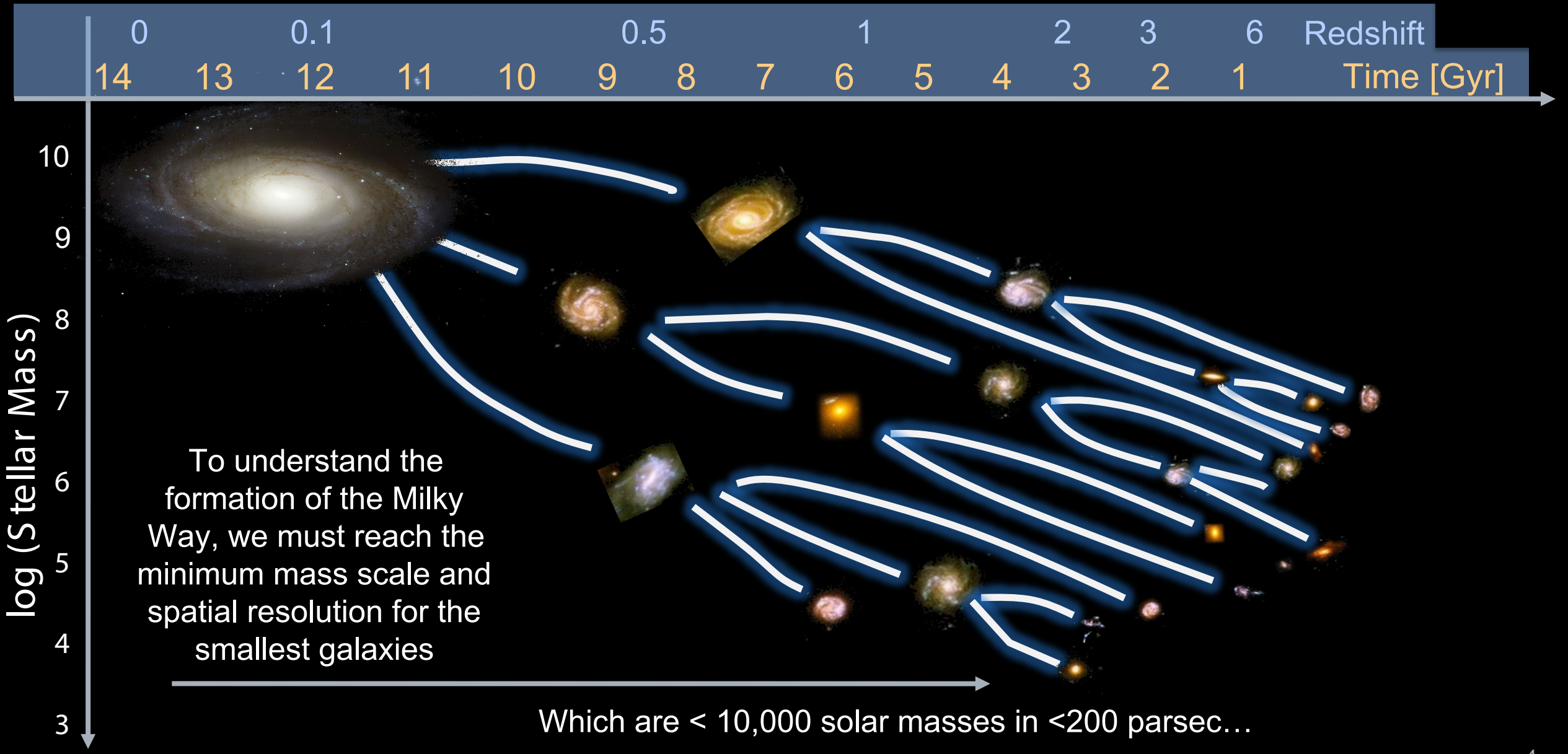
What are the stellar and galactic environments of the transient zoo?

HWO will address these big questions with **unprecedented sensitivity, resolution, and multiplexing** to push back the ultra-faint and ultra-small frontiers

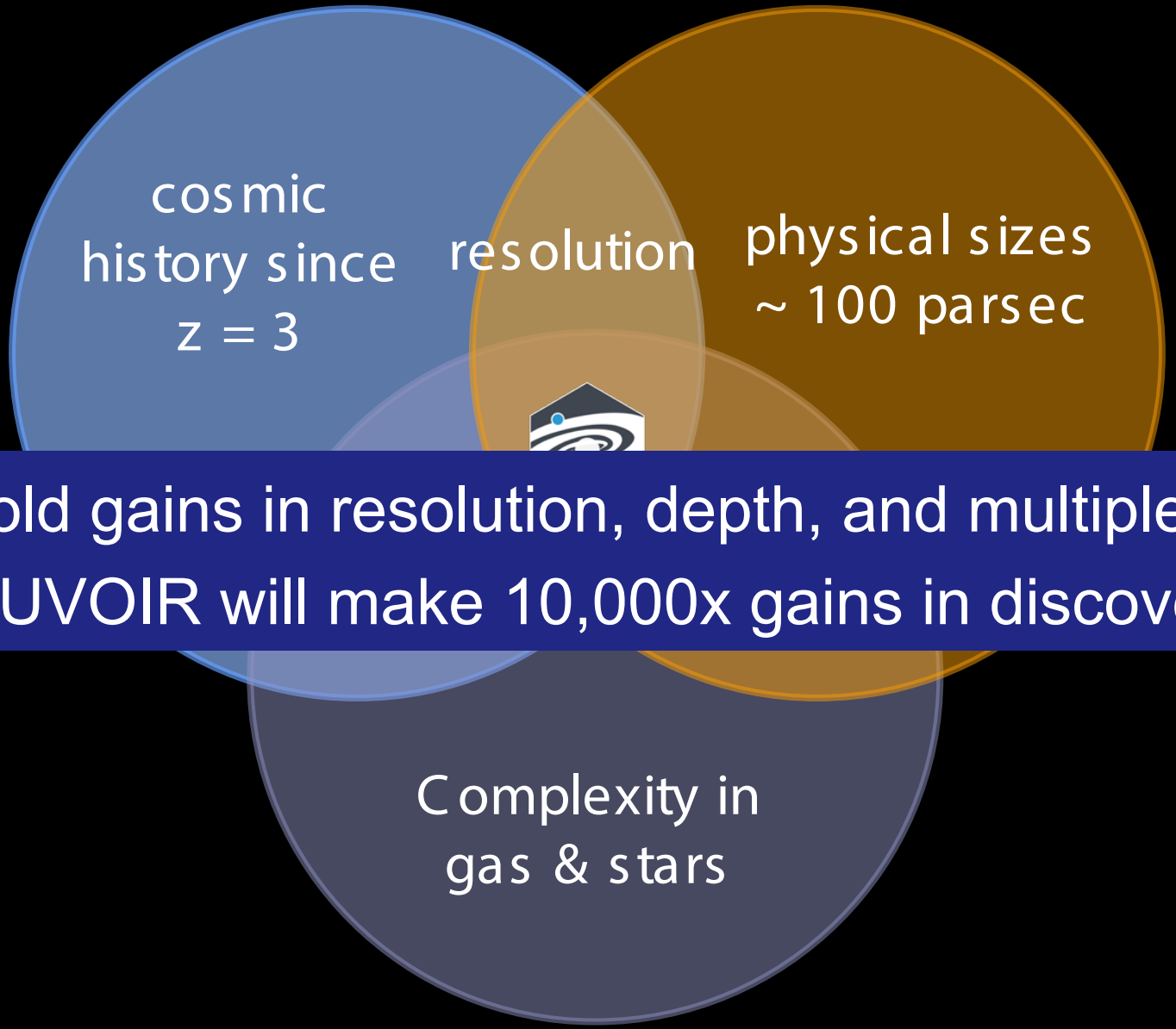
The cosmic landscape – galaxy formation



The cosmic landscape – Milky Way assembly

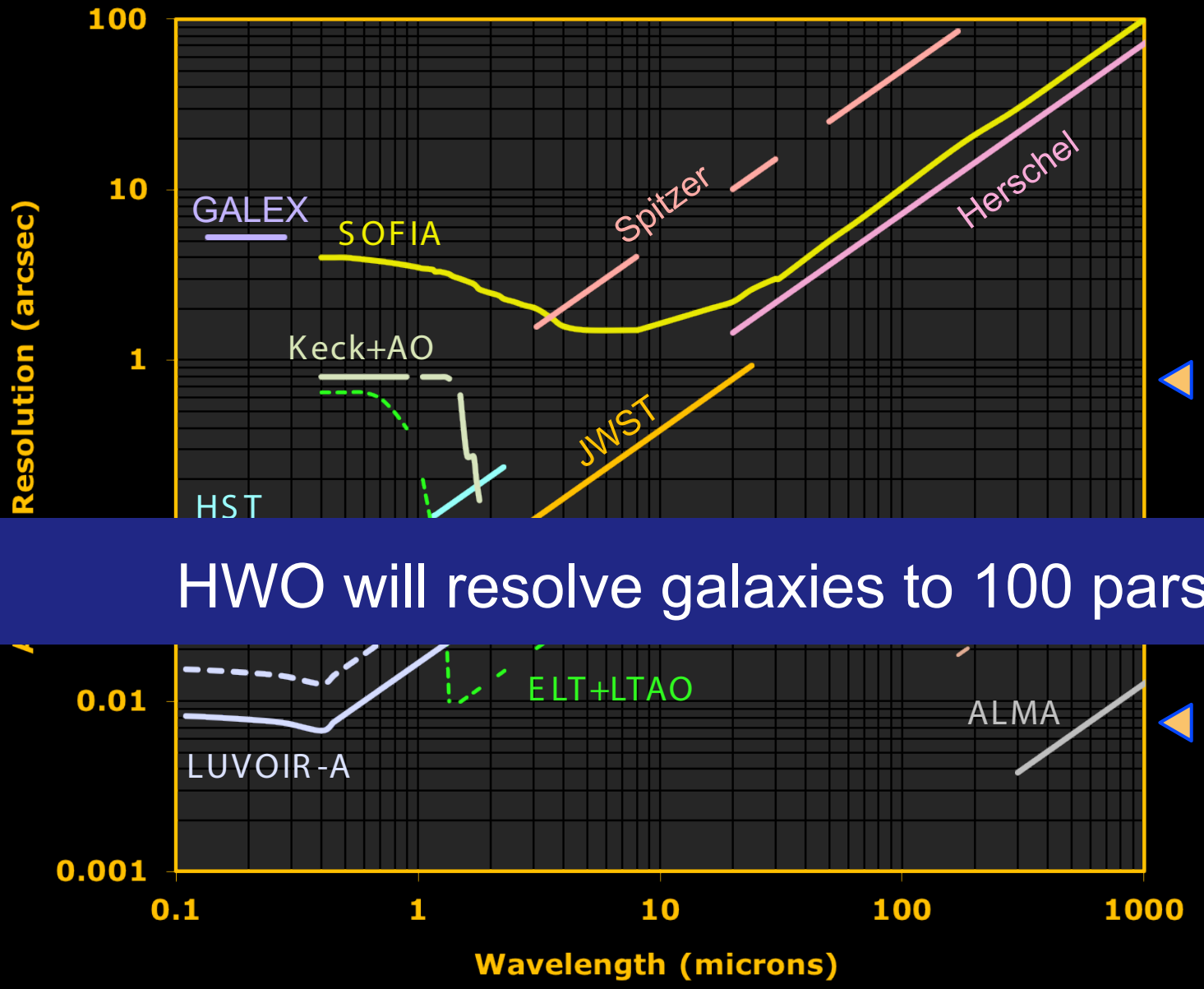


The essentials – resolution, depth, and wavelength



With 10 to 100-fold gains in resolution, depth, and multiplexing across the UVOIR, LUVOIR will make 10,000x gains in discovery space

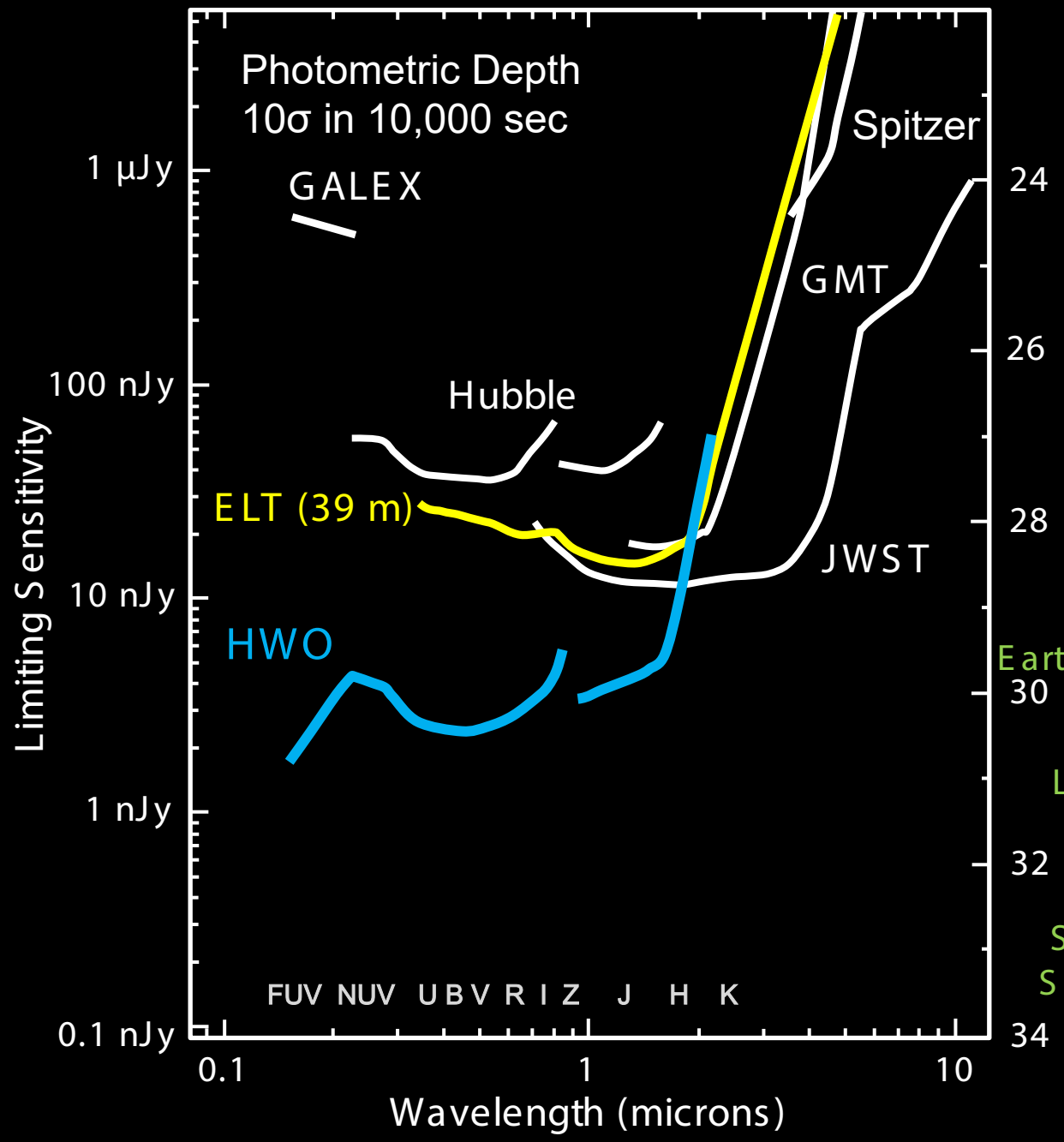
THE ESSENTIAL RESOLUTION

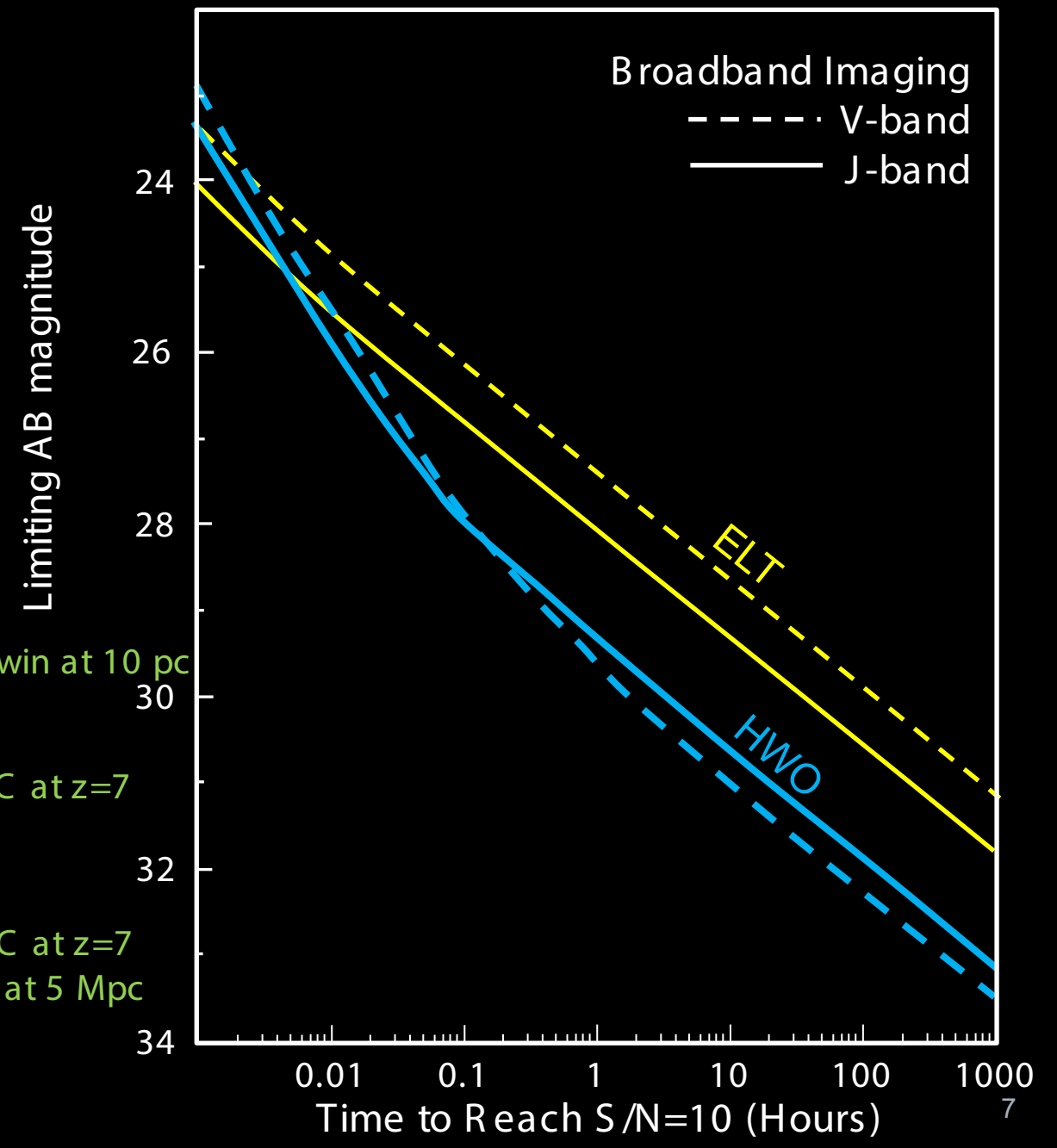


Spatial Resolution at z = 2	Spatial Resolution at 5 Mpc	Spatial Resolution at 50 pc
8.5 kpc	20 pc	35 AU
850 pc	2 pc	3.5 AU
85 pc	0.2 pc	0.35 AU

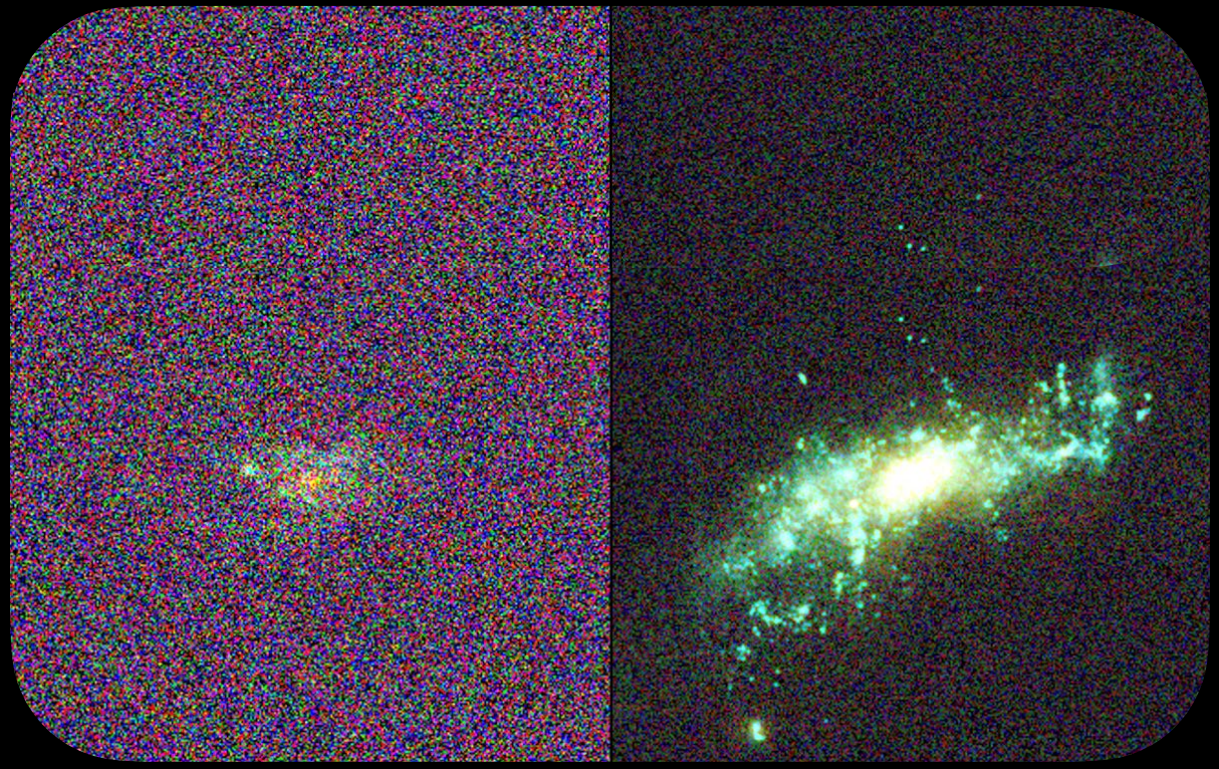
HWO will resolve galaxies to 100 parsec scales <u>at any redshift</u>

THE ESSENTIAL DEPTH





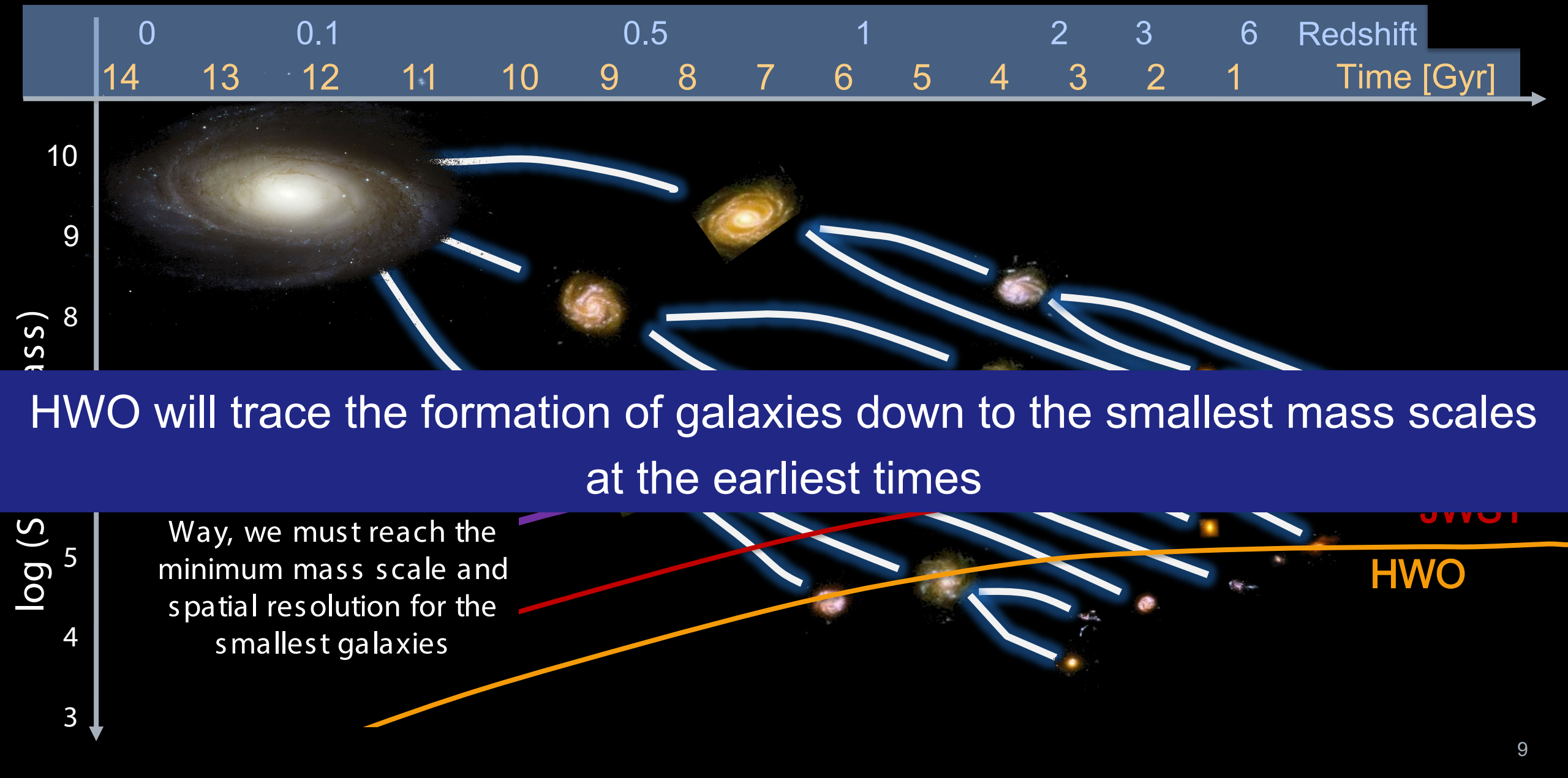
SEEKING THE BUILDING BLOCKS OF GALAXIES



HST HWO

HWO can see ultra-faint (100,000 solar mass) systems out to z=5!

The cosmic landscape – Milky Way assembly



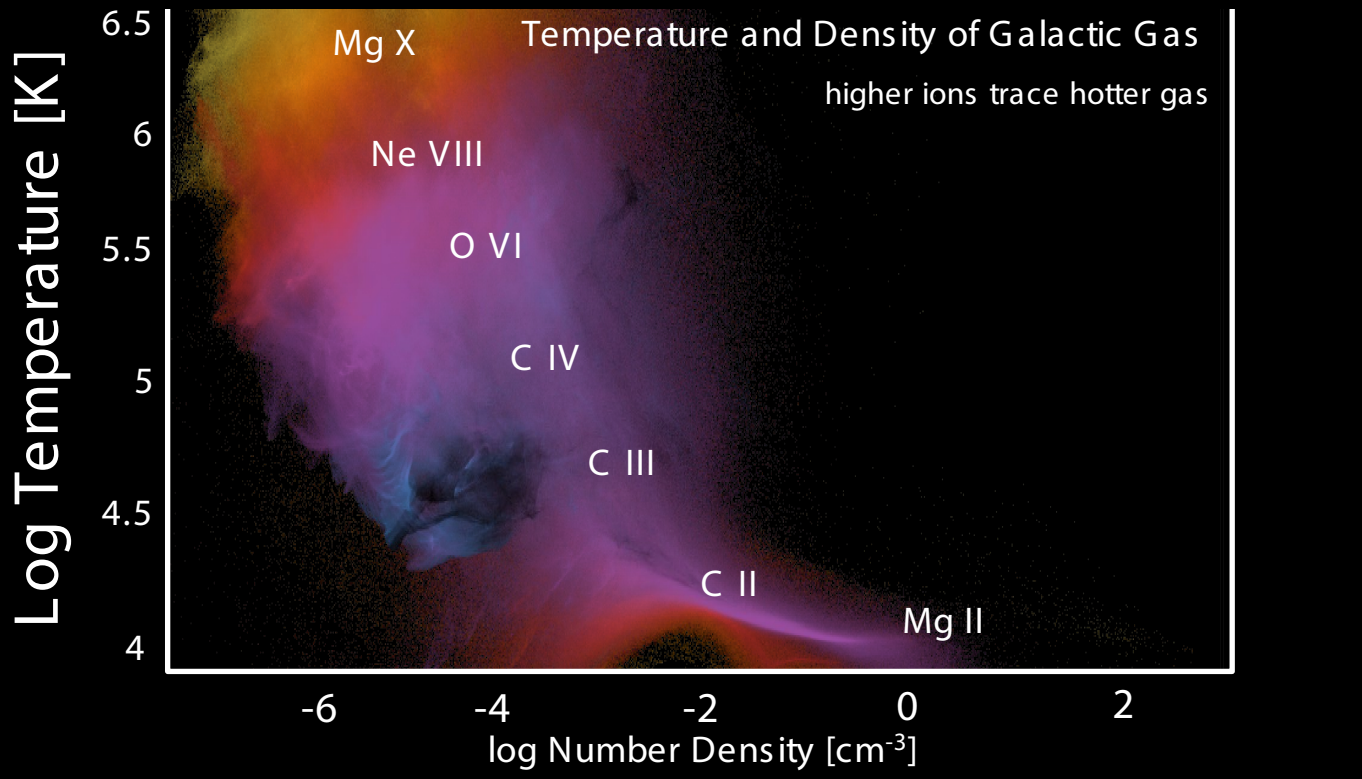
HWO will trace the formation of galaxies down to the smallest mass scales at the earliest times

THE BARYON CYCLE AND THE ESSENTIAL ULTRAVIOLET

LUMOS

LUVOIR

Cold — Gas Temperature — Hot

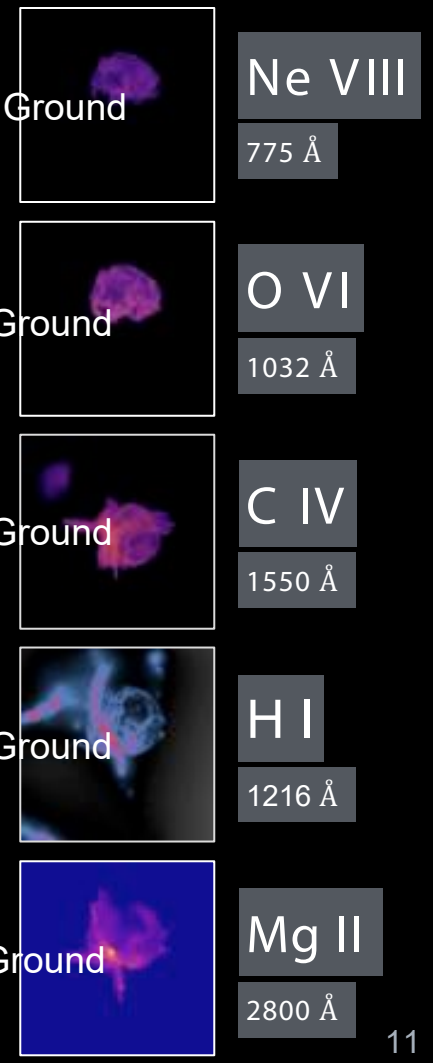


THE BARYON CYCLE AND THE ESSENTIAL ULTRAVIOLET

LUMOS

LUVOIR

With ground-based OIR we can probe the cold gas down almost to z = 0, but lack access to the warm/hot gas over most of cosmic time



THE BARYON CYCLE AND THE ESSENTIAL ULTRAVIOLET

LUMOS

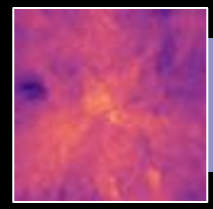
LUVOIR

Hot

Gas Temperature

Cold

With ground-based OIR we can probe the cold gas down almost to z = 0, but lack access to the warm/hot gas over most of cosmic time



Ground

Ne VIII

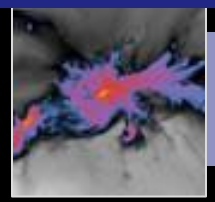
775 Å

Ground

O VI

1032 Å

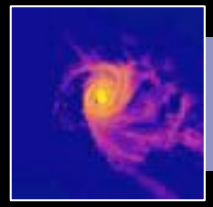
With access to 1000-3000 Å, HWO can map all phases of diffuse galactic gas over 80+ percent of cosmic time



Ground

H I

1216 Å



Ground

Mg II

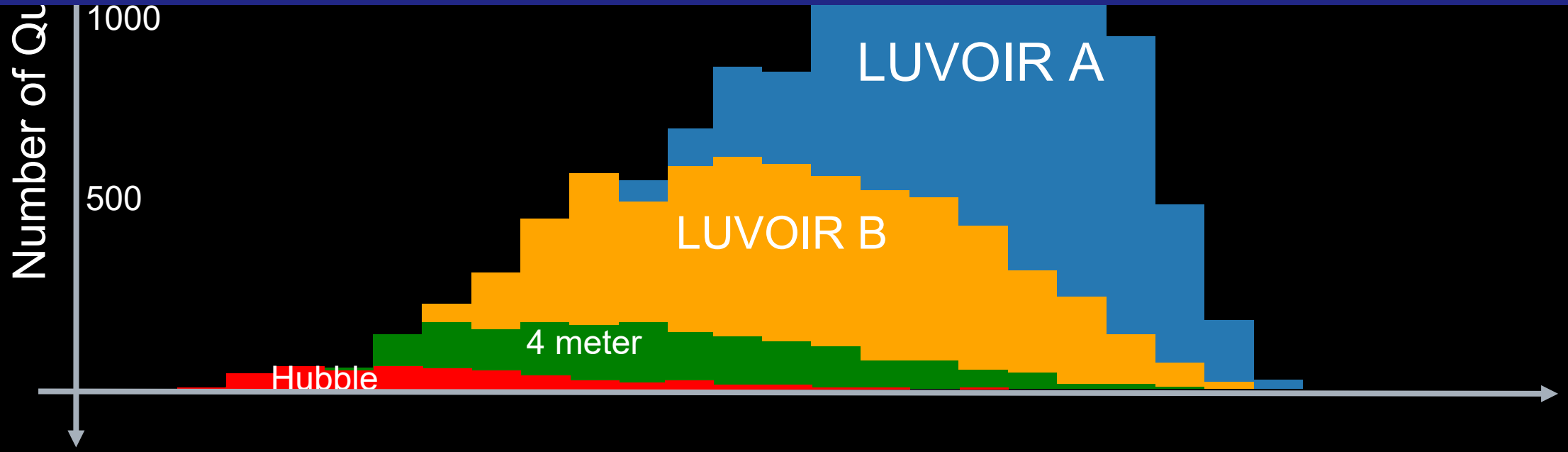
2800 Å

THE BARYON CYCLE AND THE ESSENTIAL ULTRAVIOLET

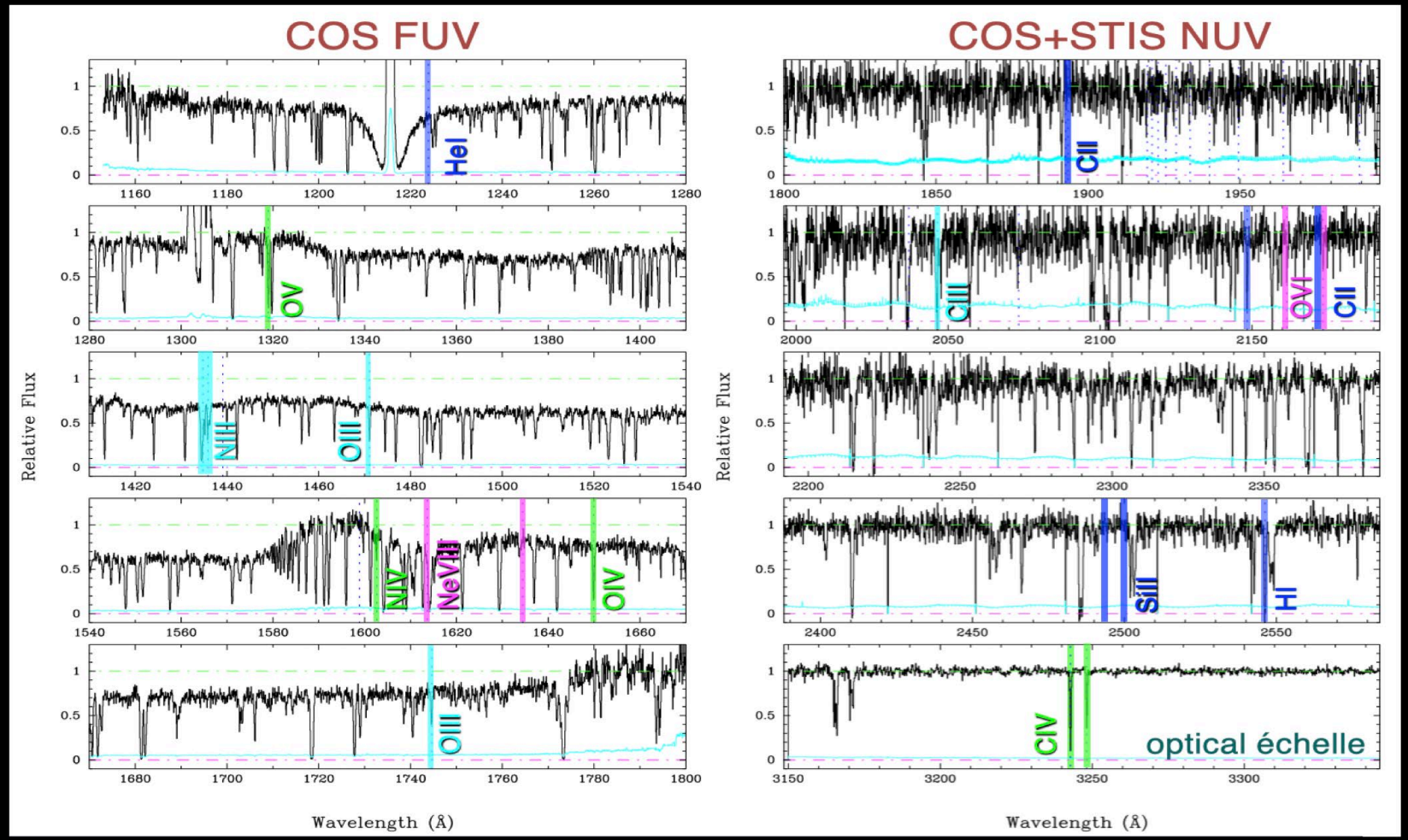
LUMOS

LUVOIR

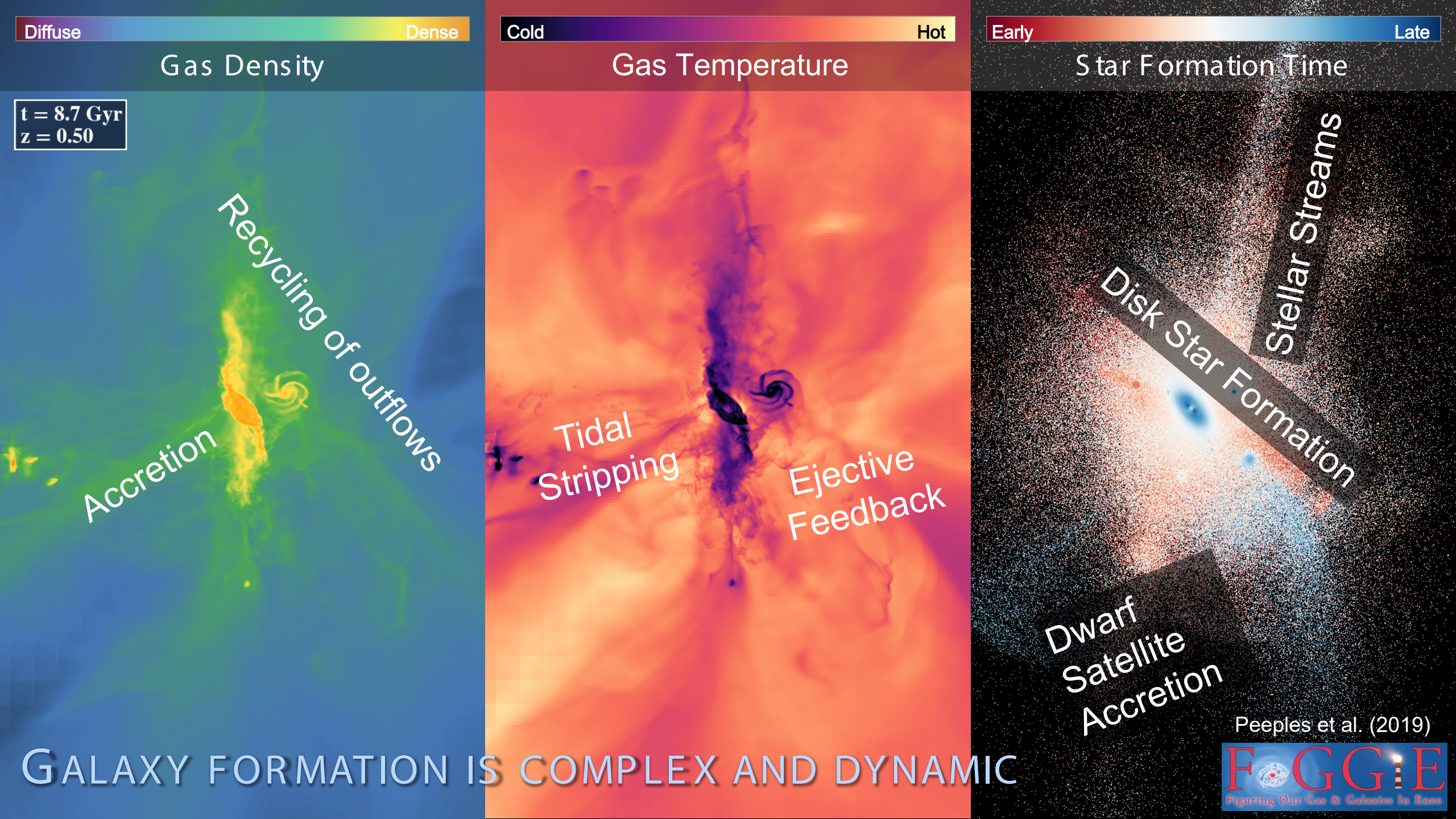
HWO provides the UV sensitivity to reach faint background sources (QSOs and galaxies) at z > 1-2, allowing a full accounting of galaxies and their gas reservoirs over the last 80% of cosmic time



WHY WE NEED SO MANY



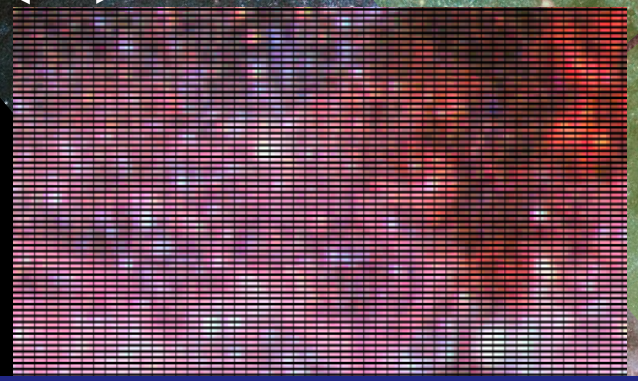
Courtesy Hsiao-Wen Chen

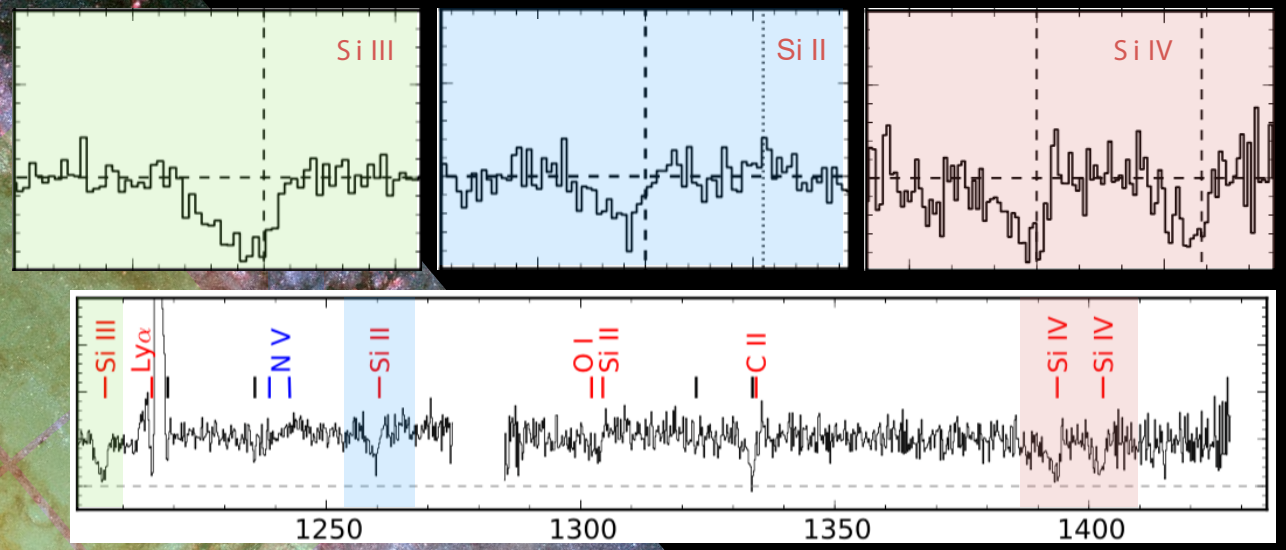

Diffuse
Dense
Gas Density
t = 8.7 Gyr
z = 0.50
Recycling of outflows
Accretion
Cold
Hot
Gas Temperature
Tidal Stripping
Ejective Feedback
Early
Late
Star Formation Time
Stellar Streams
Disk Star Formation
Dwarf Satellite Accretion
Peeples et al. (2019)
GALAXY FORMATION IS COMPLEX AND DYNAMIC
FIRE
Figuring Our Gas & Galaxies In Enzo

Resolving gas flows to probe galaxy evolution

LUMOS

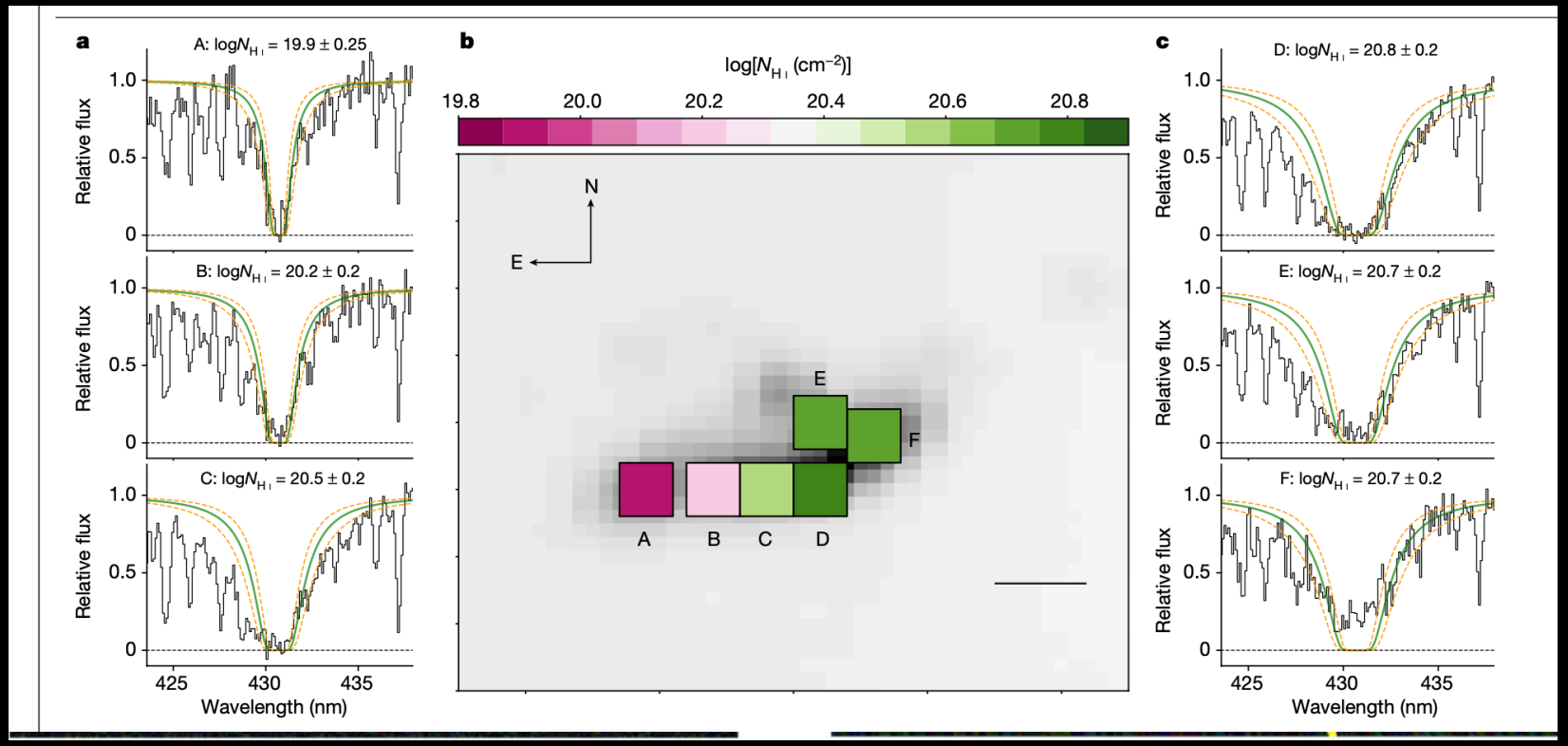
LUVOIR





HWO will map the stars, gas, and dust that drive galaxy formation at <10 pc scales using UV spectroscopy hundreds of times faster than Hubble

Leveraging lensing to probe the cycle at all scales at most times



Bordoloi+ 2022

The promise of HWO and the work ahead

- HWO with revolutionize the study of the baryon cycle with massive gains in aperture, multiplexing, and wavelength coverage
- But only if you fight for it
- So fight for it
- And along the way, there are great things to be done with lensing
- And we must find the sources