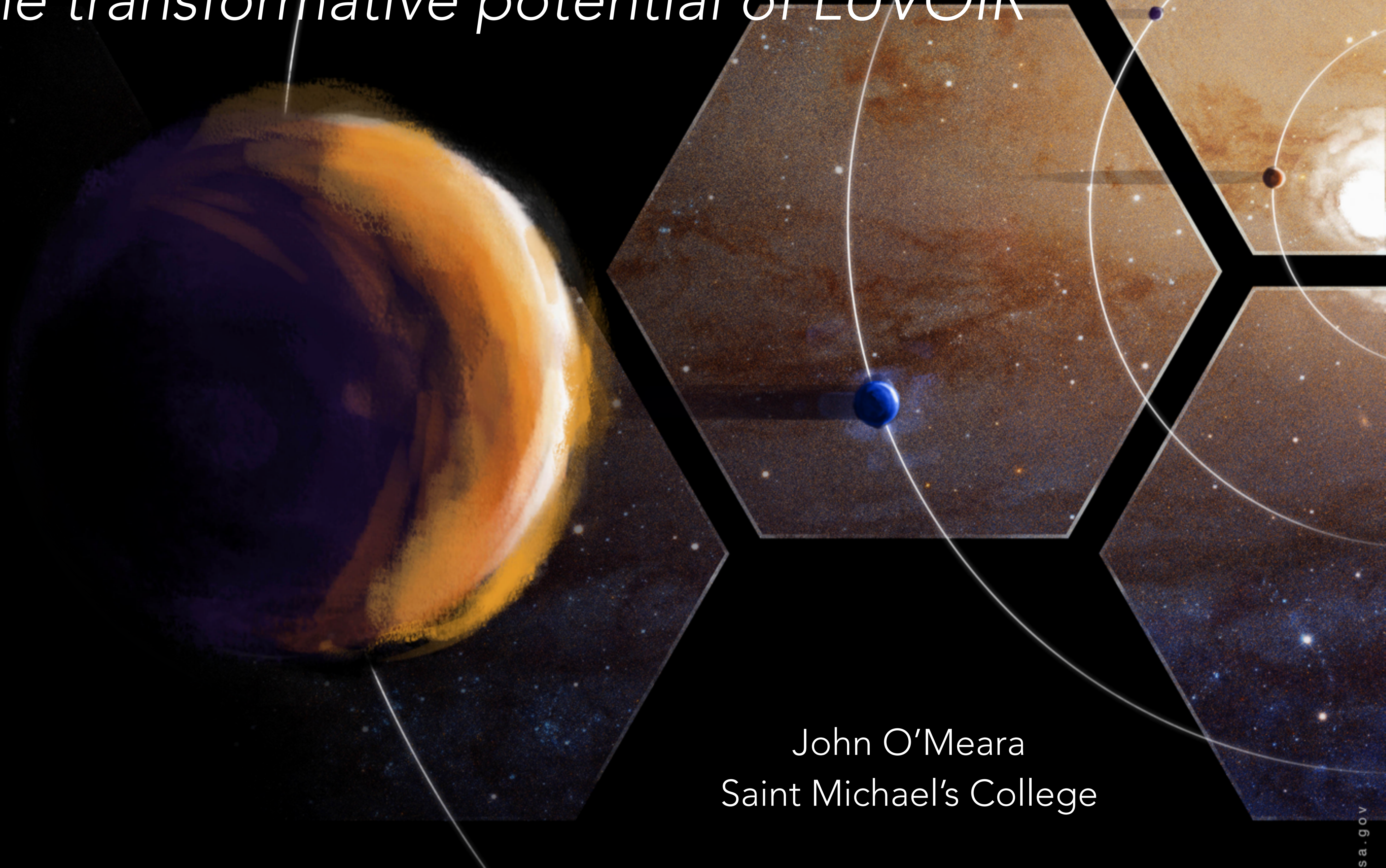
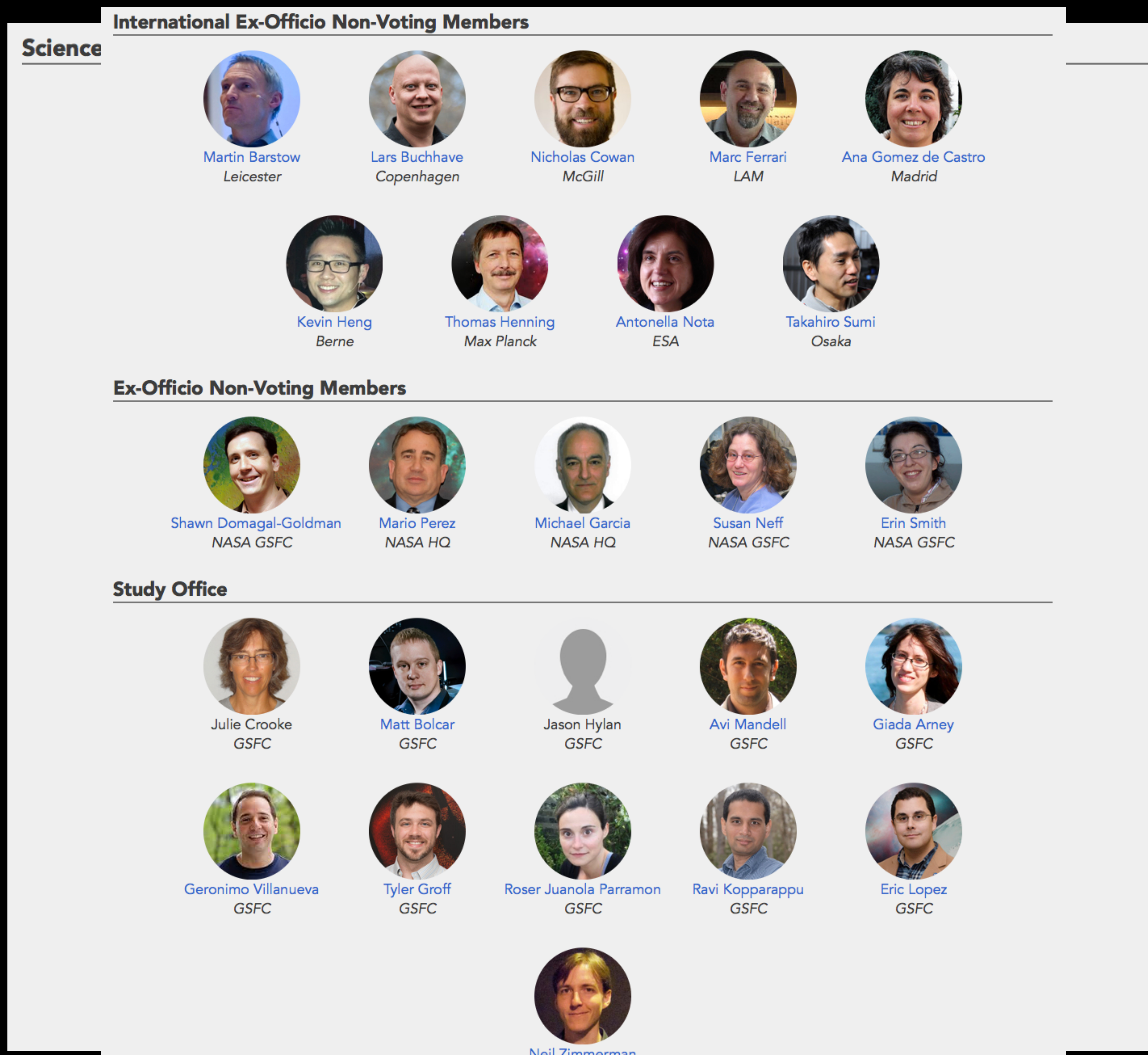
The lifecycle of galaxies from inside, outside, and in between: the transformative potential of LUVOIR



John O'Meara
Saint Michael's College

THE BOOK THAT LAUNCHED A THOUSAND WHITE PAPERS

THE LUVOIR TEAM



Science

International Ex-Officio Non-Voting Members

Martin Barstow
Leicester

Lars Buchhave
Copenhagen

Nicholas Cowan
McGill

Marc Ferrari
LAM

Ana Gomez de Castro
Madrid

Kevin Heng
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Thomas Henning
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NASA GSFC

Mario Perez
NASA HQ

Michael Garcia
NASA HQ

Susan Neff
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Erin Smith
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Study Office

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Matt Bolcar
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Jason Hylan
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Avi Mandell
GSFC

Giada Arney
GSFC

Geronimo Villanueva
GSFC

Tyler Groff
GSFC

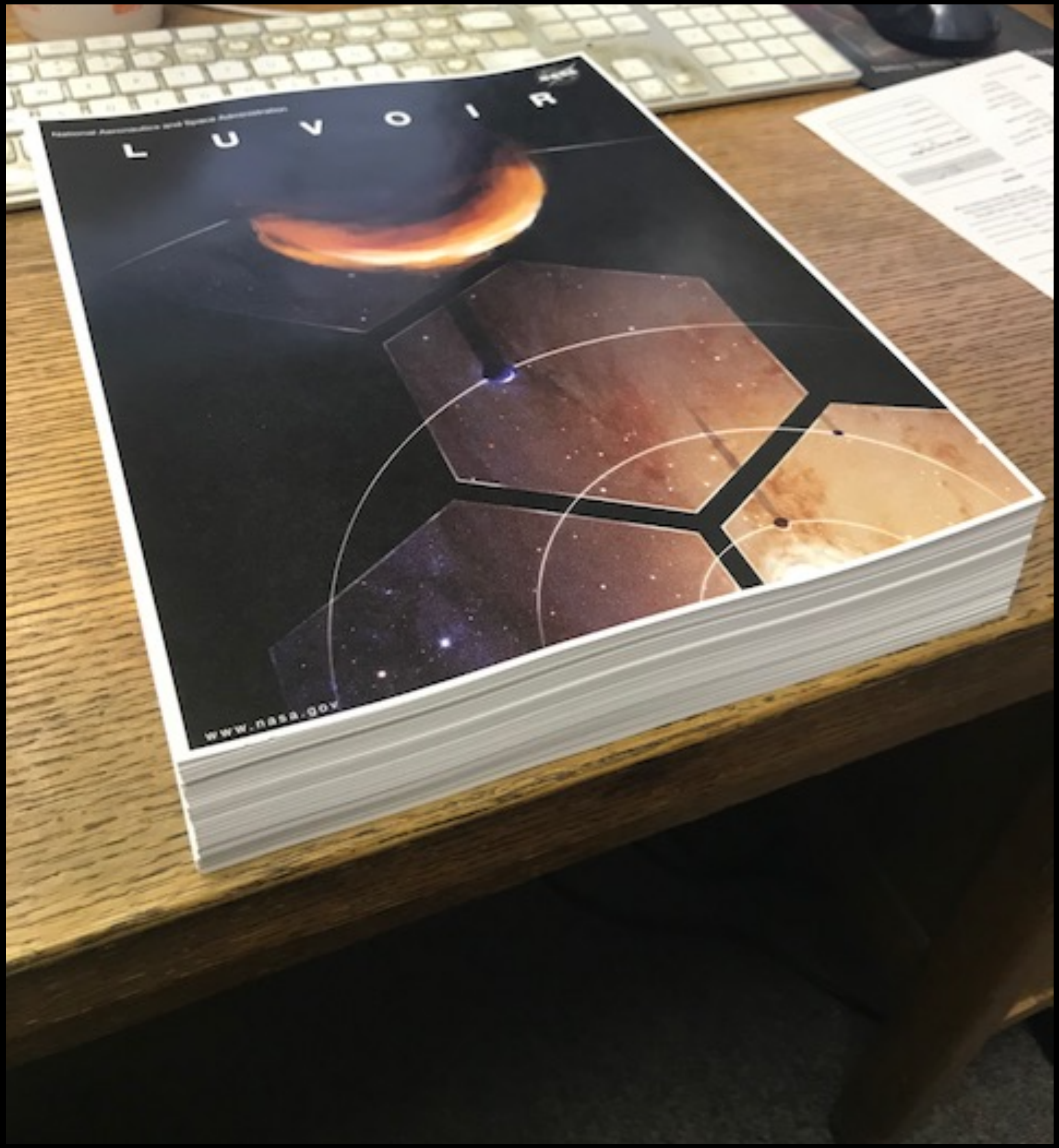
Roser Juanola Parramon
GSFC

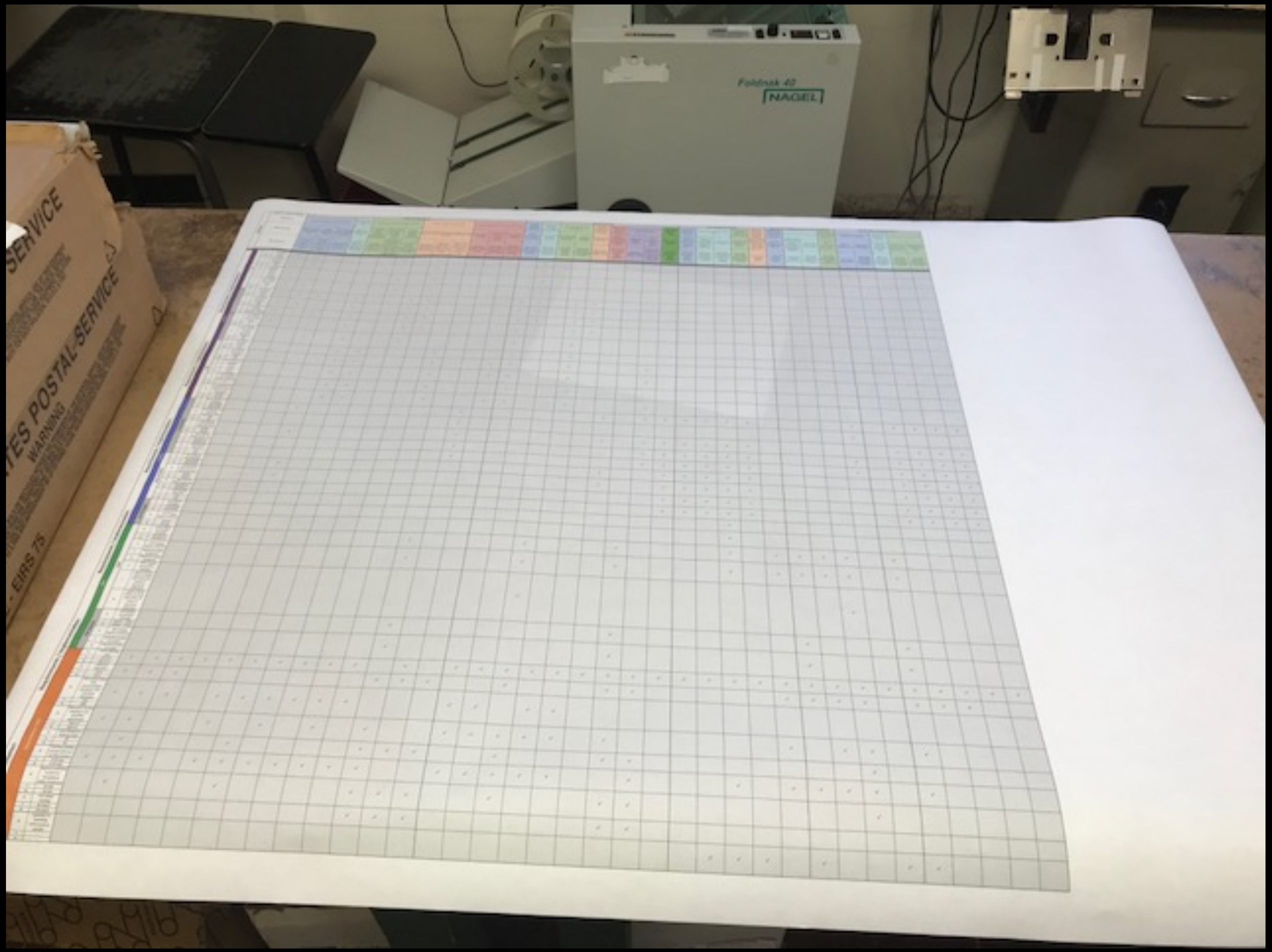
Ravi Kopparappu
GSFC

Eric Lopez
GSFC

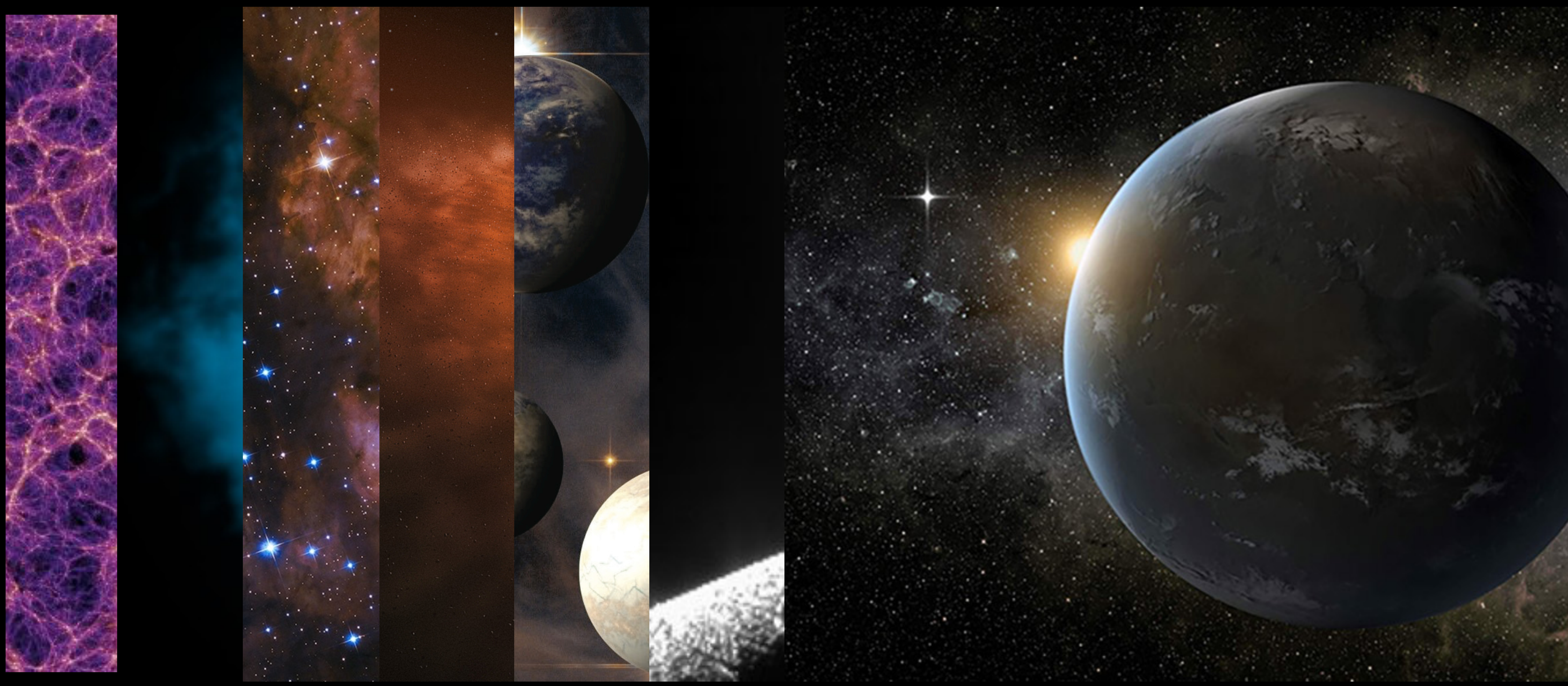
Neil Zimmerman

WE'RE HALFWAY DONE





THE STORY OF LIFE IN THE UNIVERSE



LUVOIR

The most effective way to do it,
is to do it.

-AMELIA EARHART

LUVOIR

LUVOIR

- It’s Large.
- It’s Powerful.
- It’s Serviceable.
- It’s Open.

LUVOIR

- It’s Large.
- It’s Powerful.
- It’s Serviceable.
- It’s Open.

HISTORICAL POINT

NO MATTER WHAT YOU COME UP WITH, LYMAN SPITZER ALREADY THOUGHT OF IT

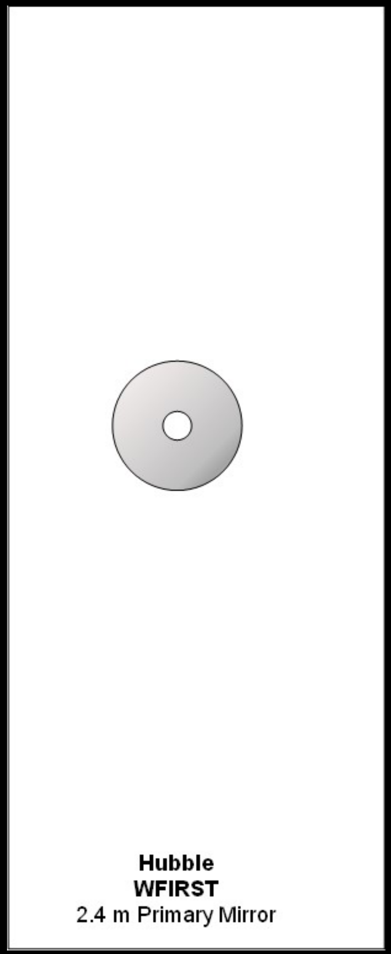
III. Astronomical Research with a Large Reflecting Telescope

The ultimate objective in the instrumentation of an astronomical satellite would be the provision of a large reflecting telescope, equipped with the various measuring devices necessary for different phases of astronomical research. Telescopes on earth have already reached the limit imposed by the irregular fluctuations in atmospheric refraction, giving rise to "bad seeing". It is doubtful whether a telescope larger than 200 inches would offer any appreciable advantage over the 200 inch instrument. Moreover, problems of flexure become very serious in mounting so large an instrument. Both of these limitations disappear in a satellite observatory, and the only limitations on size seem to be the practical ones associated with sending the equipment aloft.

While a large reflecting satellite telescope (possibly 200 to 600 inches in diameter) is some years in the future, it is of interest to explore the possibilities of such an instrument. It would in the first place always have the same resolving power, undisturbed by the terrestrial atmosphere. If the figuring of the mirror could be sufficiently accurate, its resolving power would be enormous, and would make it possible to separate two objects only .01" of arc apart (for a mirror 450 inches in diameter); an object on Mars a mile in radius could be clearly recorded at closest opposition while on the moon an object 50 feet across could be detected with visible radiation. This is at least ten times better than the typical performance of the best terrestrial telescopes. Moreover, in ultra-violet light the theoretical resolving power would of course be considerably greater; ideally an object 10 feet across could be distinguished on the moon

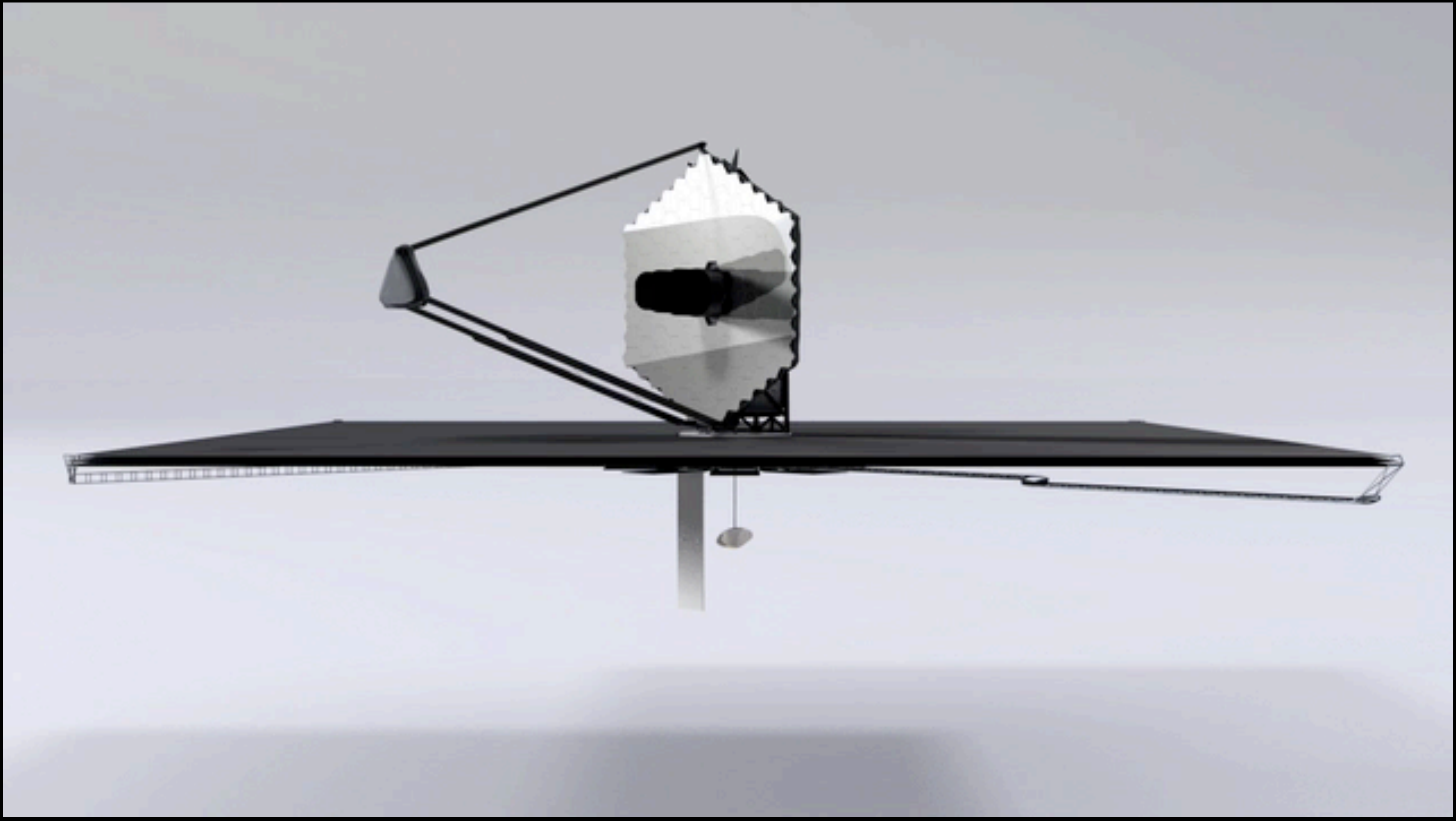
Spitzer, 1946

IT'S LARGE

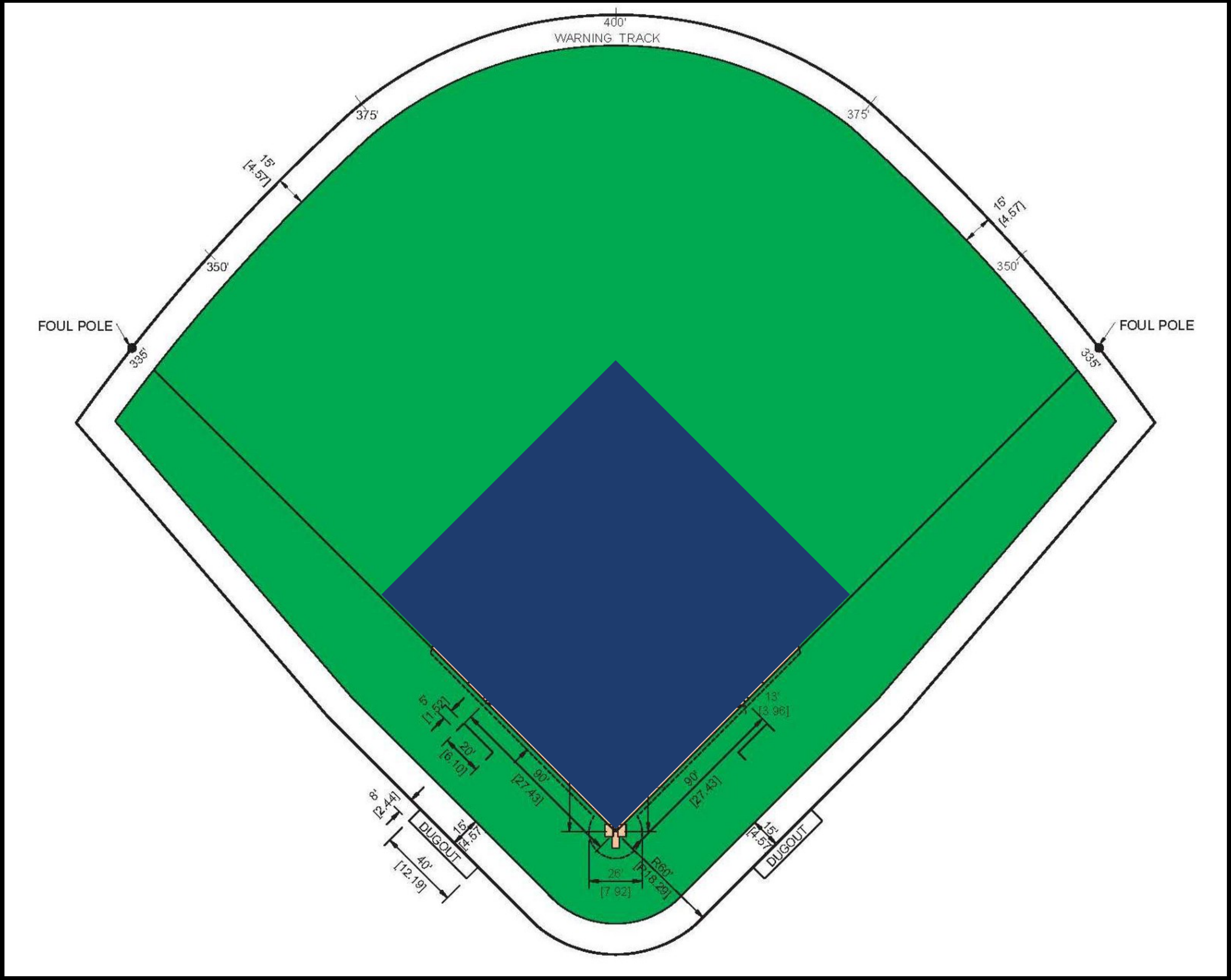


LUVOIR-A

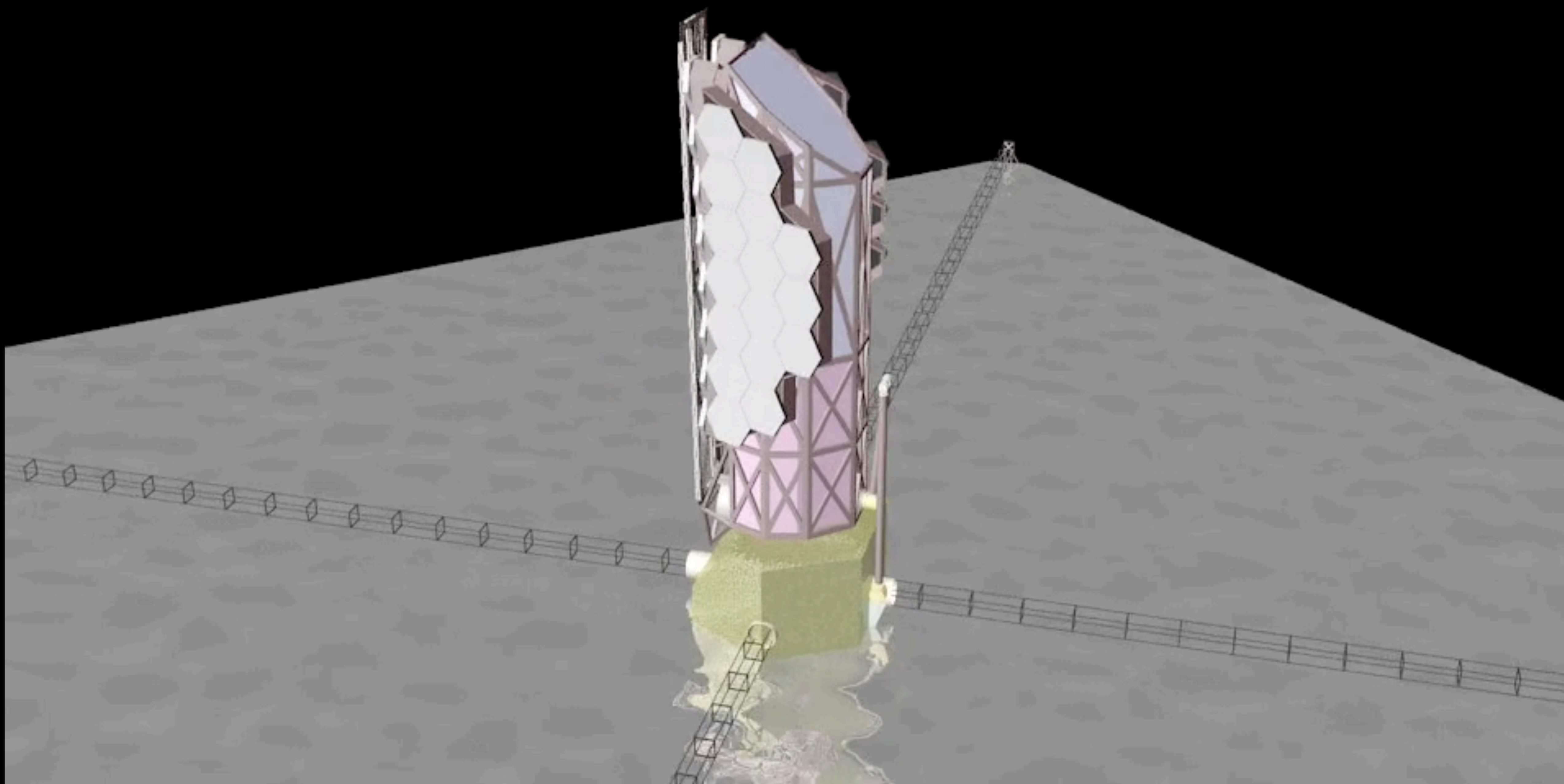
NO, REALLY. IT'S LARGE



THAT'S A BIG SUNSHIELD



LUVOIR-B ~8 METER OFF-AXIS



LUVOIR

LUVOIR IN A NUTSHELL

- It’s Large.
- It’s Powerful.
- It’s Serviceable.
- It’s Open.

LUVOIR

IT'S POWERFUL

- 4 instruments being studied for architecture A (15m)
  - ECLIPS: High contrast (10^{-10}) NUV/VIS/NIR coronagraph with imaging and integral field spectroscopy
  - HDI: ~3 Gigapixel, Nyquist sampled simultaneous dual-channel (NUV/VIS, NIR) 2'x3' imager reaching V=31 (10σ) in 1 hour. 2.75 mas/pix UV, 8.25 mas/pix NIR)
  - LUMOS: FUV/NUV FUV imager able to observe hundreds of objects simultaneously, reaching FUV mag=21 (10σ) in <1 hour at R=30,000 and λ=1300Å
  - POLLUX: (European Instrument Study): High resolution (R~120,000) UV spectropolarimiter

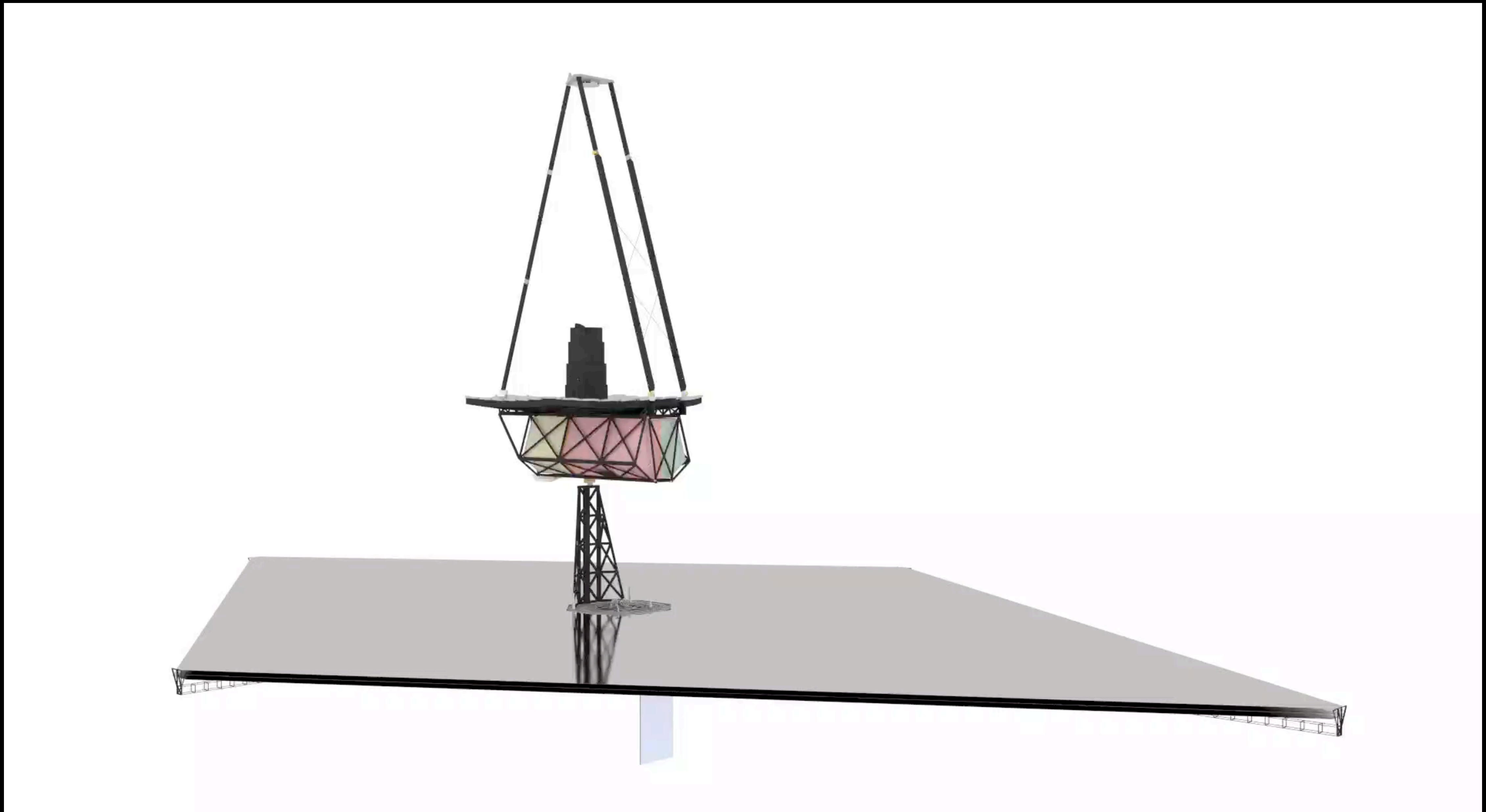
LUVOIR

LUVOIR IN A NUTSHELL

- It's Large.
- It's Powerful.
- It's Serviceable.
- It's Open.

IT'S SERVICEABLE

- Observatory designed from the beginning to have swappable instruments and some telescope components



LUVOIR

LUVOIR IN A NUTSHELL

- It's Large.
- It's Powerful.
- It's Serviceable.
- It's Open.

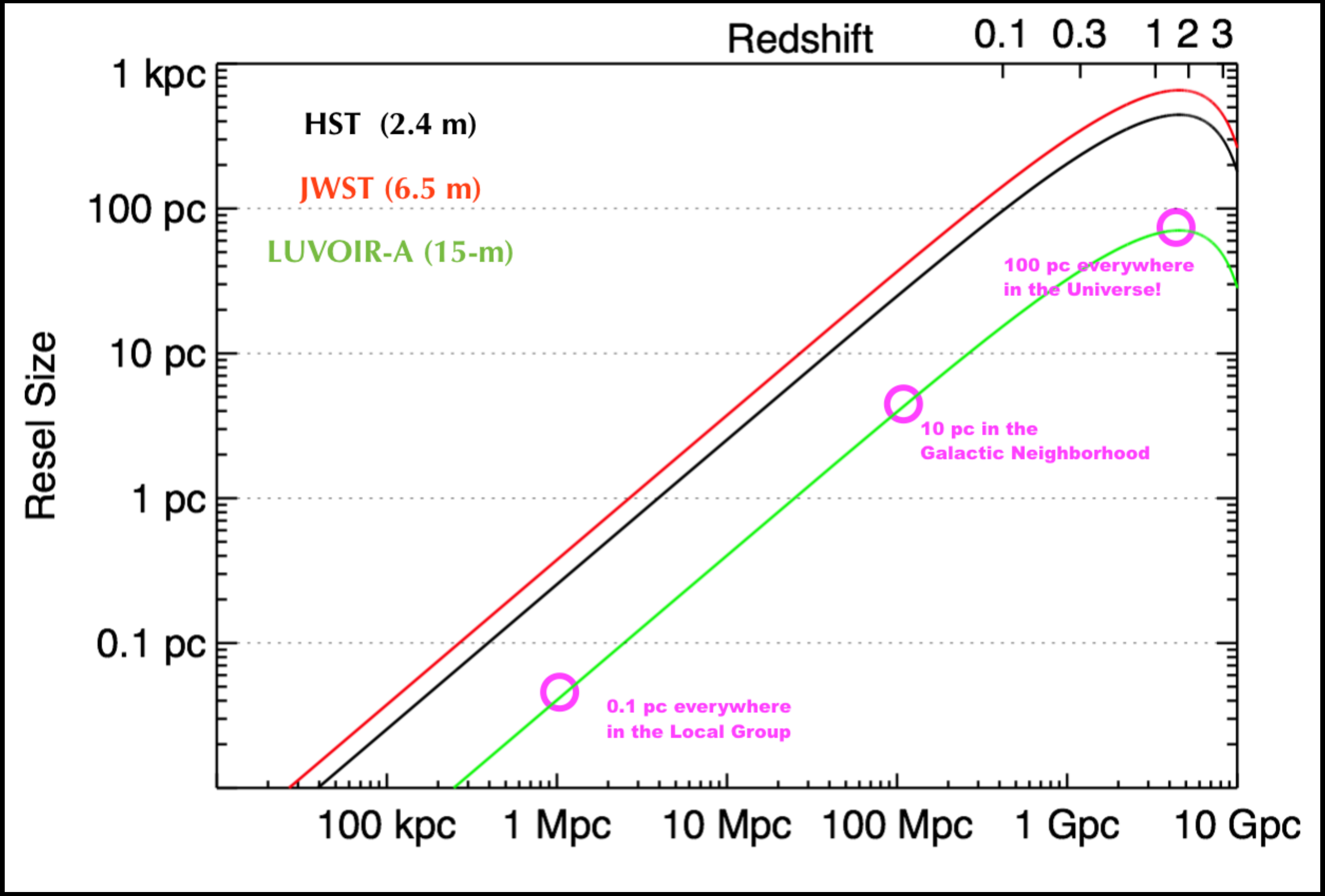
LUVOIR

IT'S OPEN

- LUVOIR will be a Guest Observer driven facility analogous to NASA's Great Observatories

L U V O I R

BUT WHY?



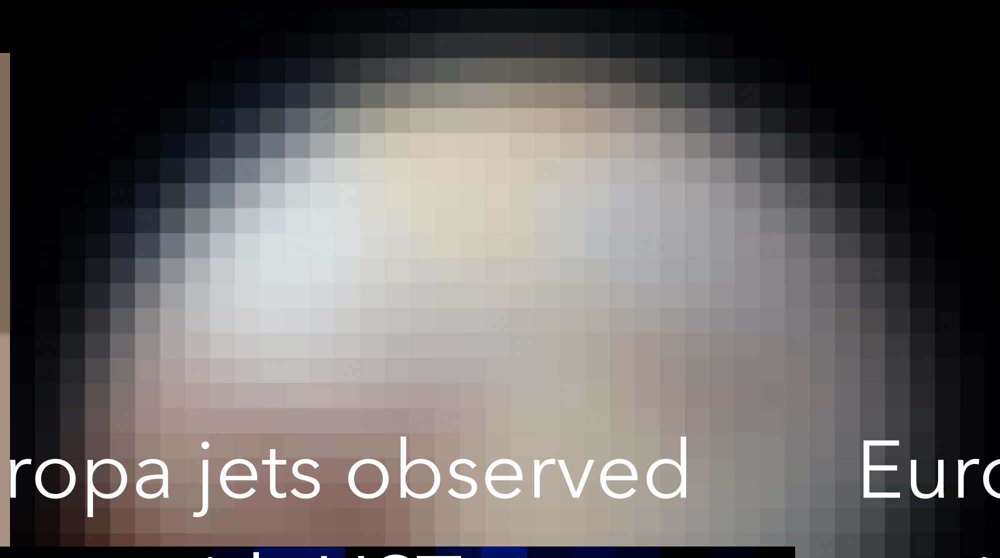
LUVOIR

SIGNATURE SCIENCE

THE SOLAR SYSTEM

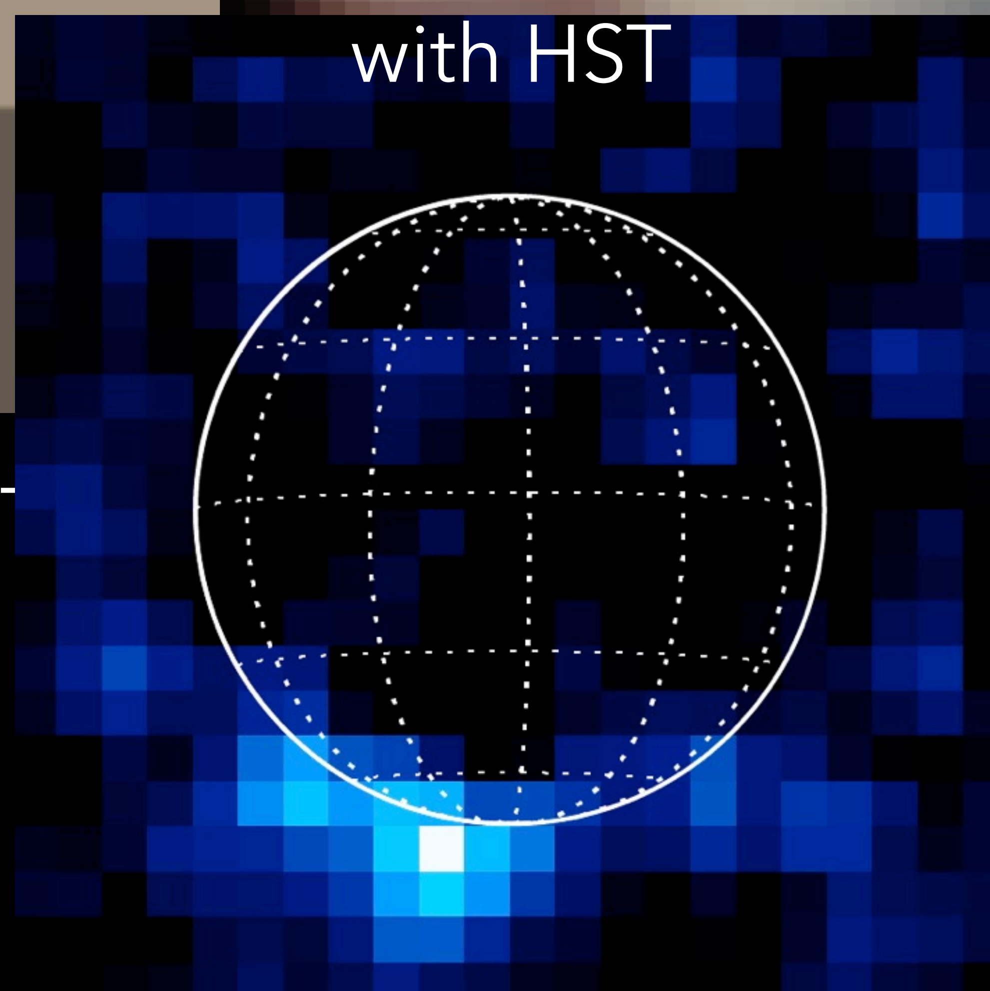
LUVOIR

REMOTE SENSING IN OUR BACK YARD



Pluto with HS

Europa jets observed with HST

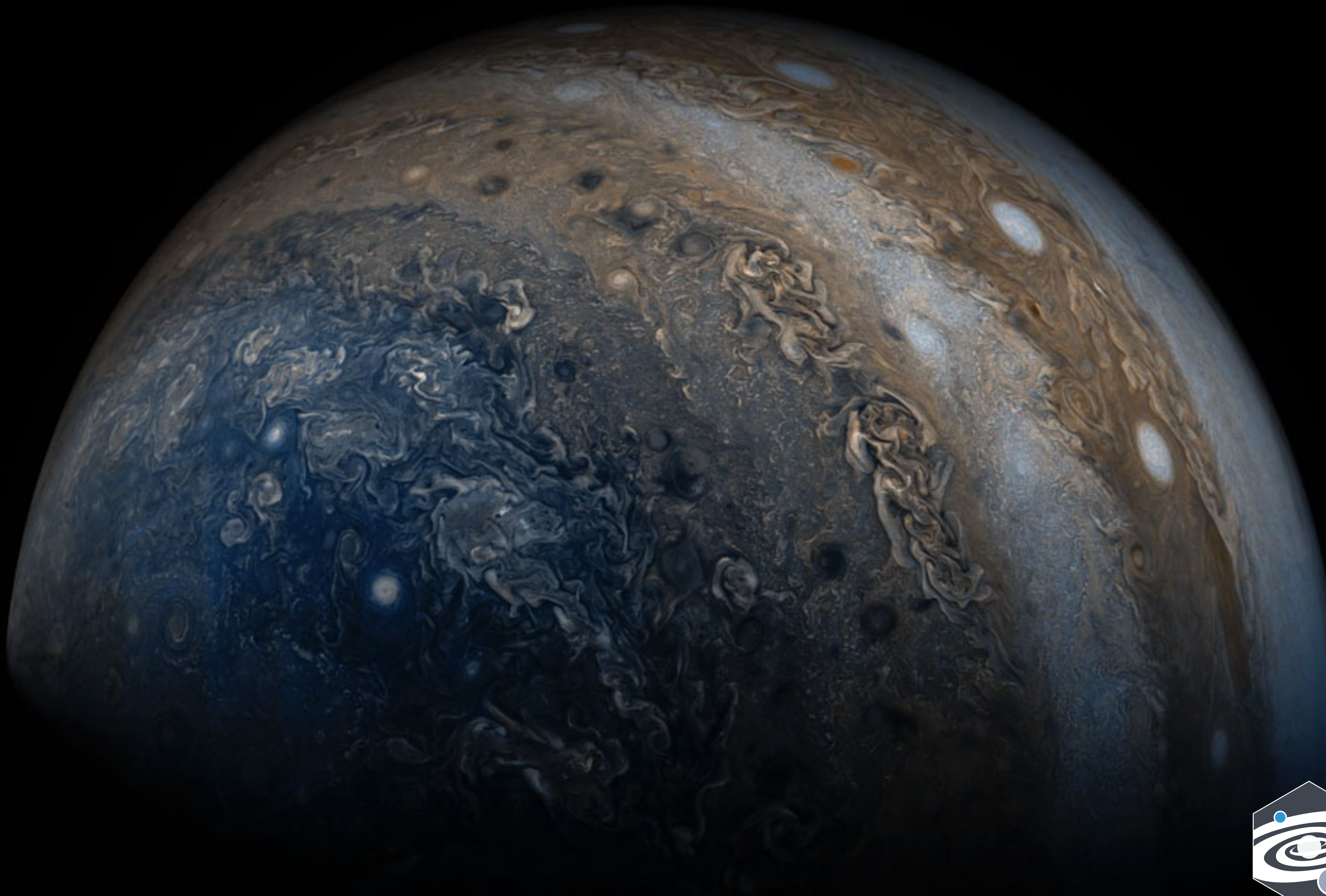


Roth et al. (2014)

Europa jets observed with 15-m LUVOIR

Credit: G. Ballester (LPL)

REMOTE SENSING IN OUR BACK YARD



LUVOIR

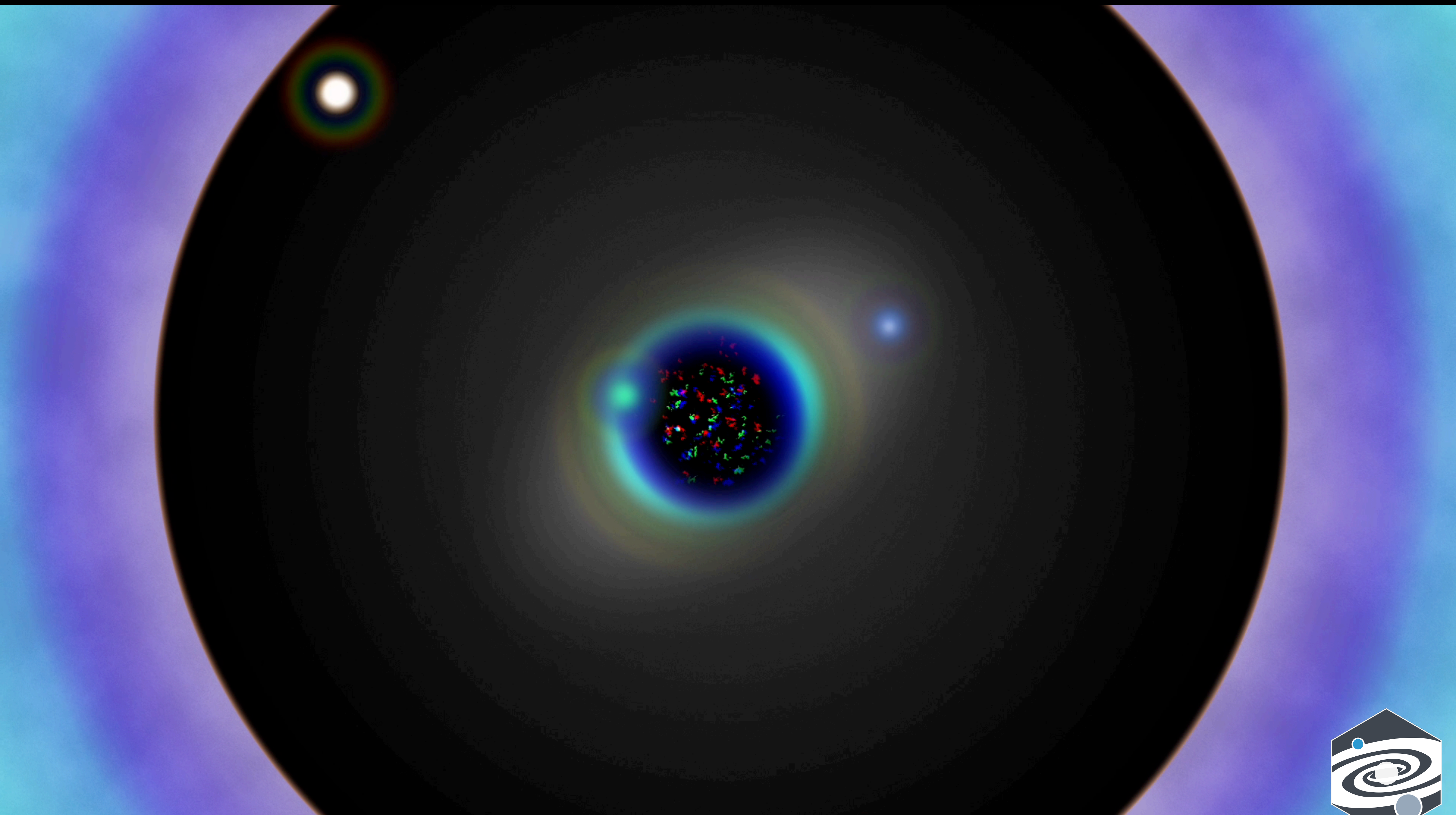
EXTRASOLAR PLANETS

LUVOIR

EXPECT THE UNEXPECTED

LUVOIR

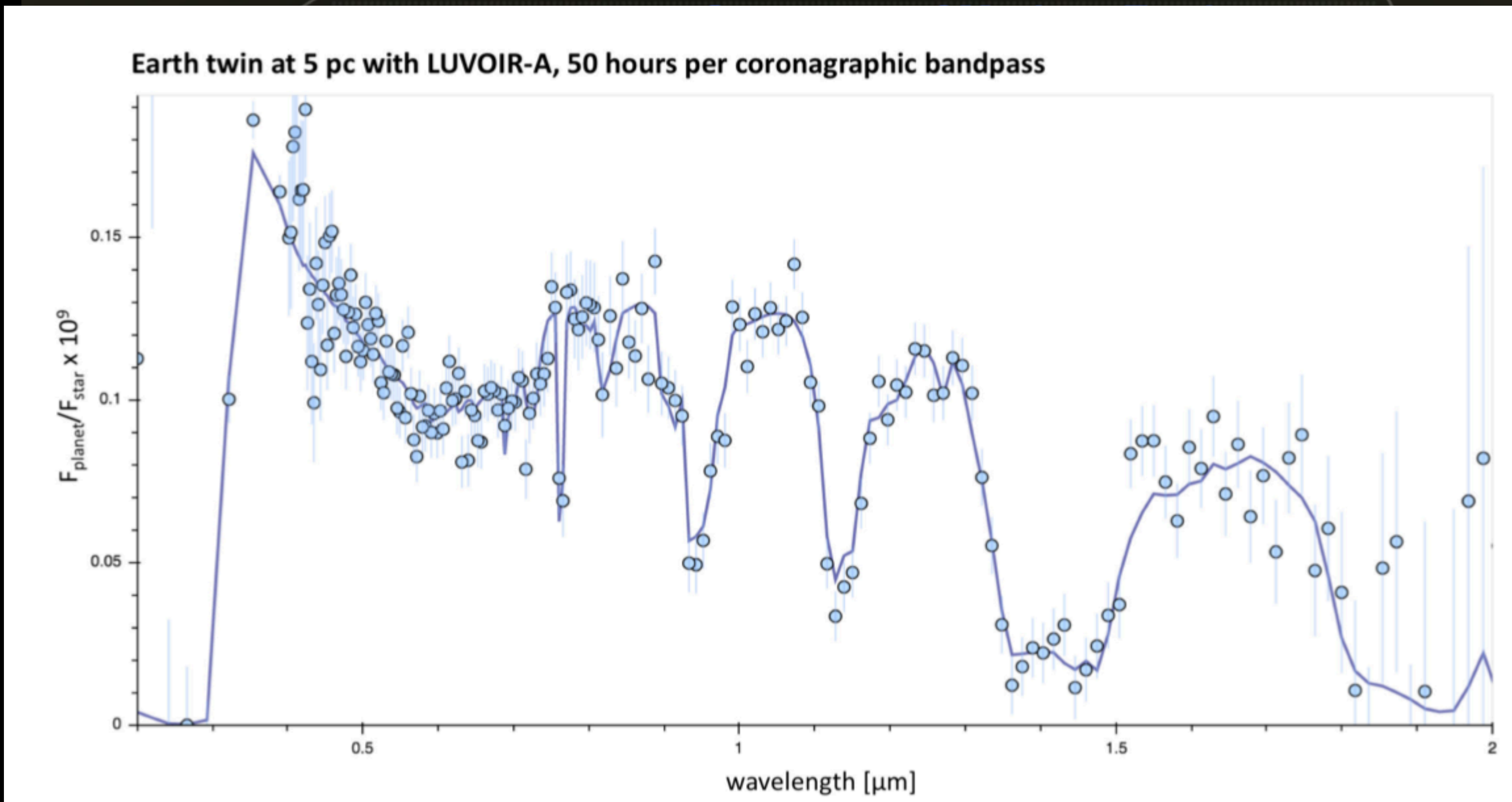
THE PALE BLUE DOT



LUVOIR

THE LIVING *AND CHANGING* BLUE DOT

Rayleigh scattering

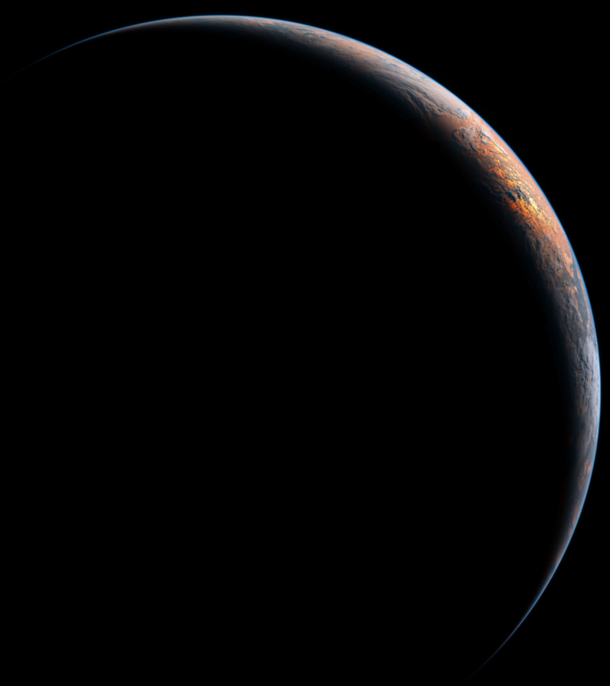


0.4 microns

2.4 microns

LUVOIR

TWO EXTREMES

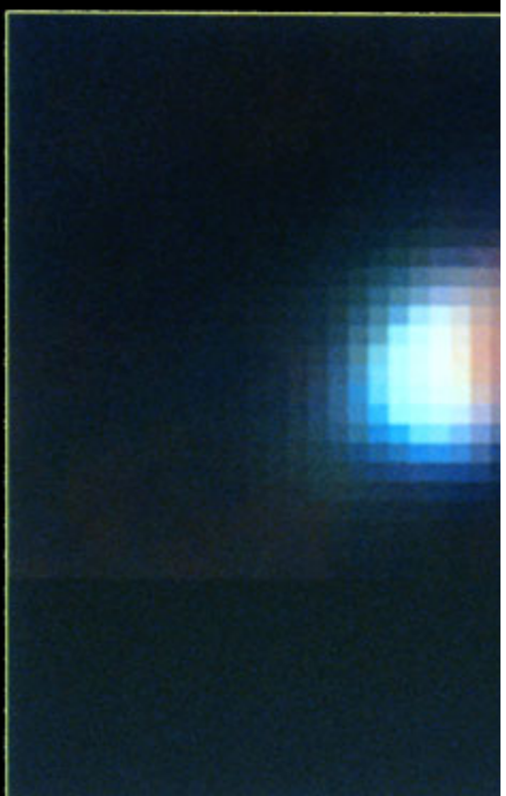


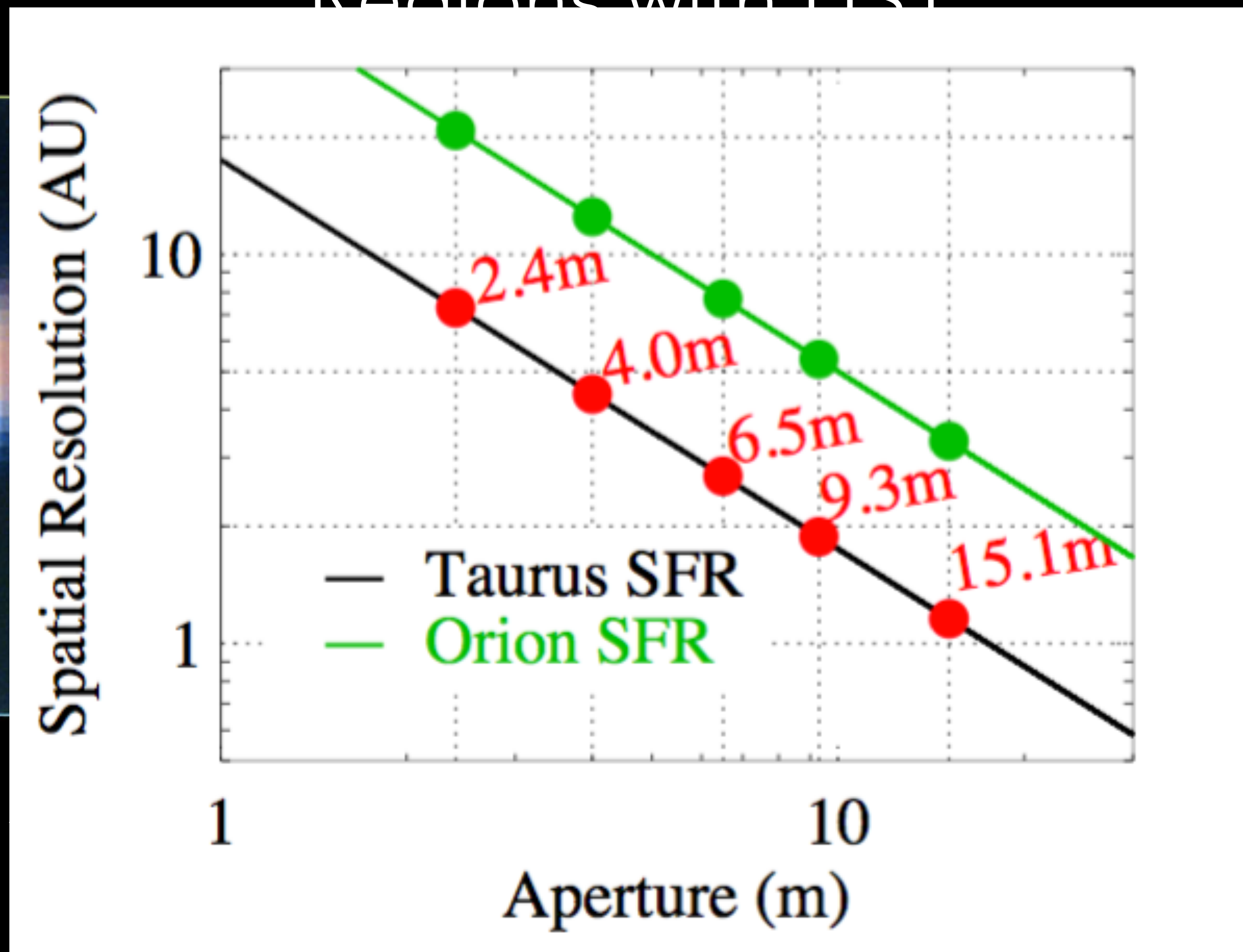
Either case demands a large survey

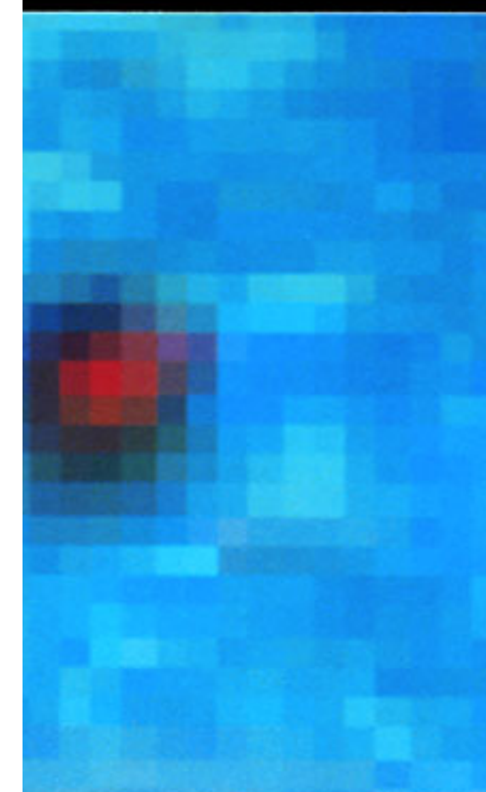
STARS & STAR FORMATION

FROM NURSERIES TO CRADLES

Proto-Planetary Disks in the nearest Star Forming Regions with HST







A … ere

in the Milky Way

GALAXIES, THEIR ENVIRONMENTS, AND THEIR EVOLUTION

REDEFINING "DEEP" FIELDS

HUDF
400 orbits
11.3 days (~1 Million sec)
4 filters
m_{AB} ~ 29

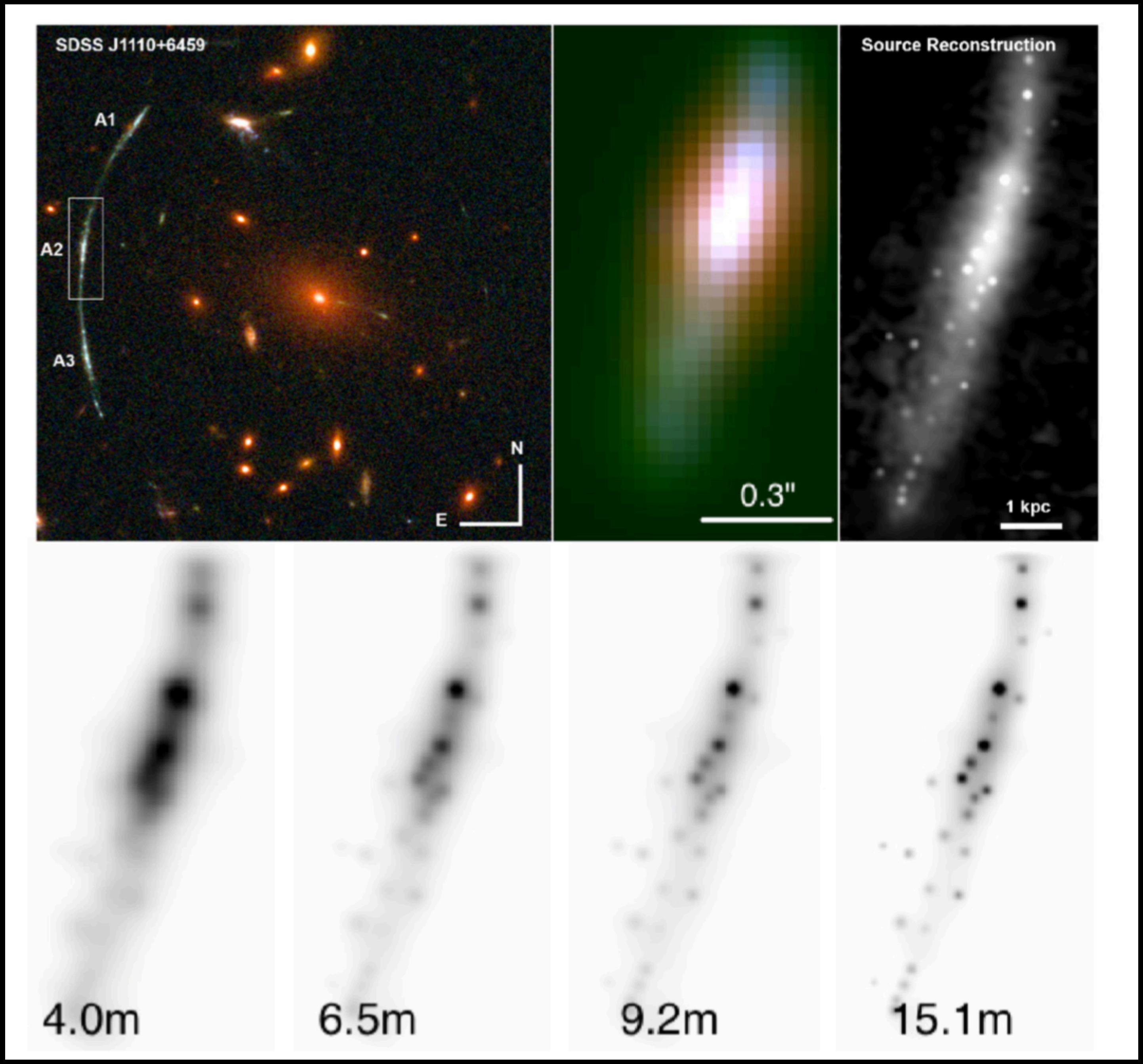
	Photometric bands, Limits are 5σ for point or point like sources in 100,000 seconds limits for 200,000 seconds are 0.4 mag deeper									
	F225W	F275W	F336W	F475W	F606W	F775W	F850W	F125W	F160W	F220W
15m	32.9	33.0	33.4	33.6	33.4	33.1	32.6	33.5	33.2	30.2
9m	31.8	32.0	32.4	32.5	32.4	32.2	31.6	32.4	32.2	29.2

GALAXIES IN HIGH DEFINITION

2.4 m

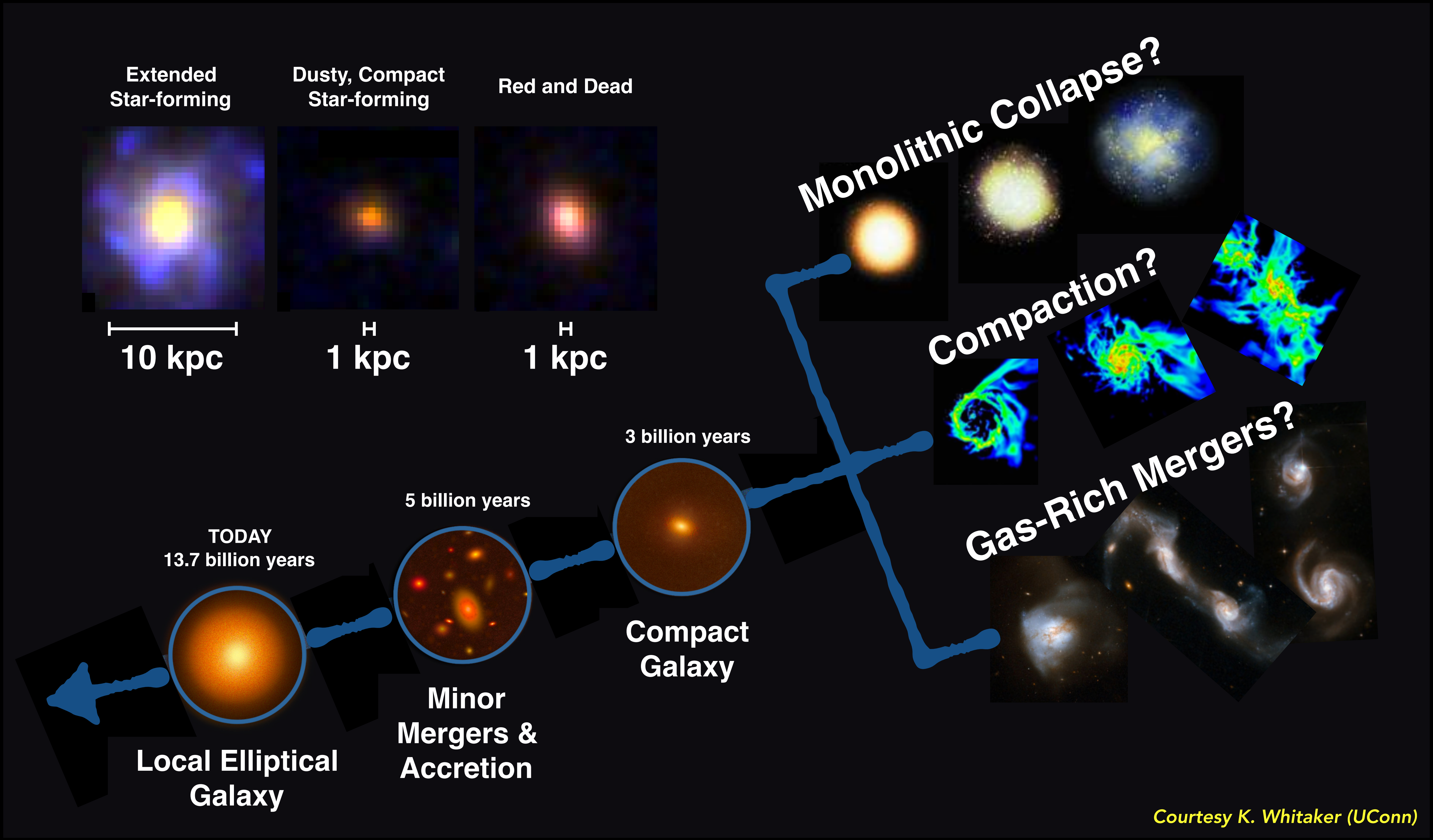
15.1 m: LUVOIR-A

REDEFINING "SUBSTRUCTURE"



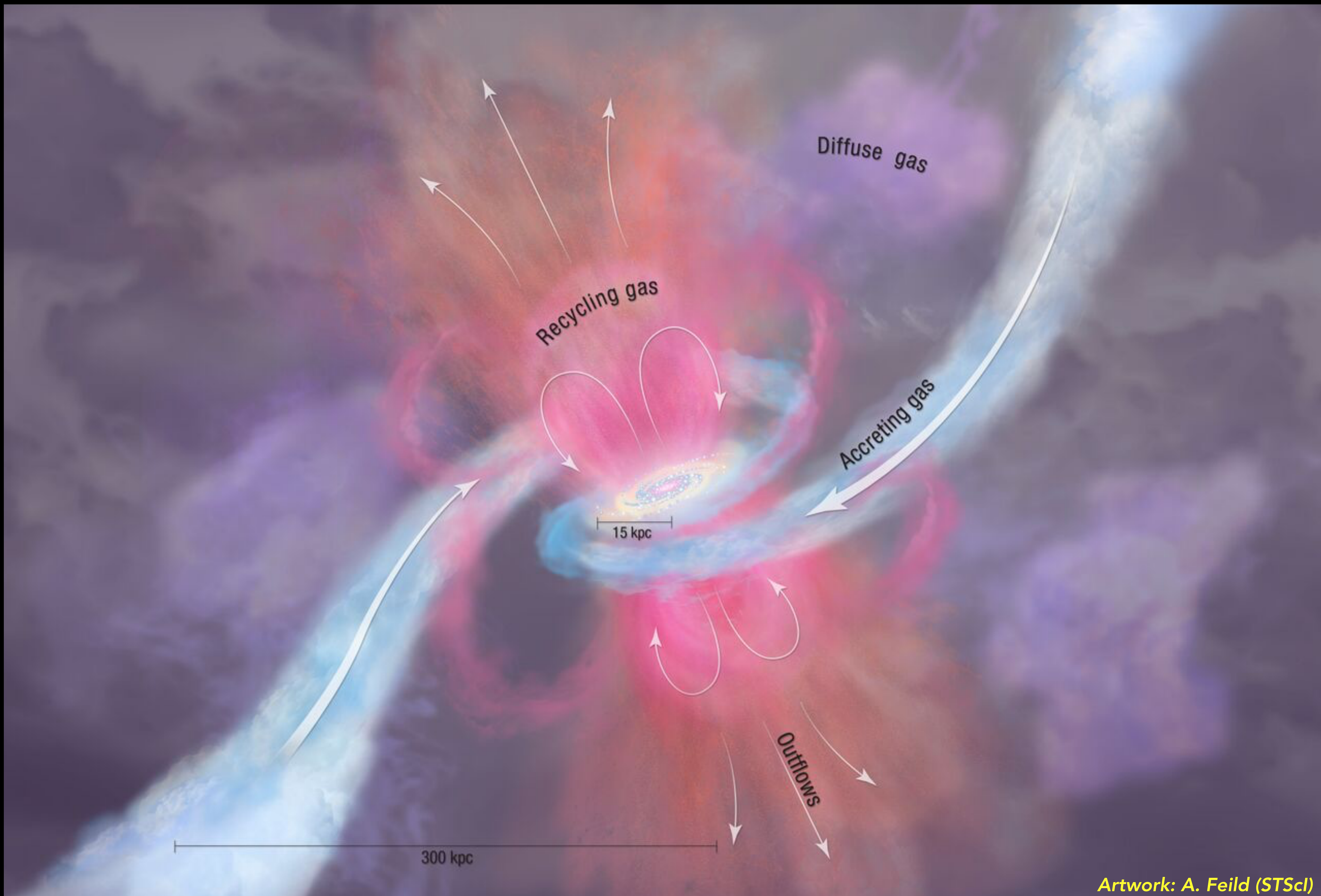
<u>Every</u> distant galaxy with LUVOIR will probe the small spatial scales that are only available with lensing today.

RED AND DEAD AT Z~2

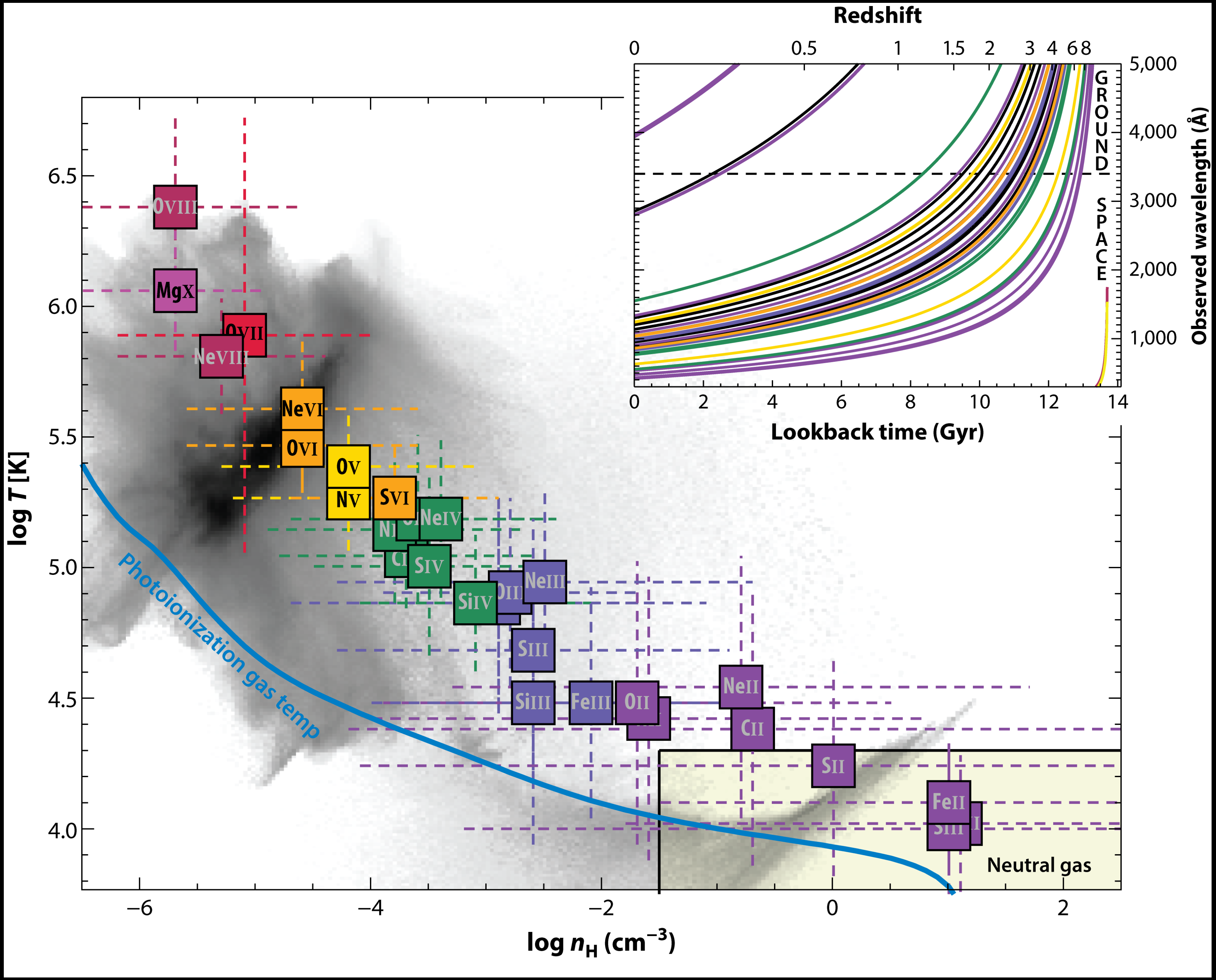


13 billion years of gas history

THE CIRCUMGALACTIC MEDIUM

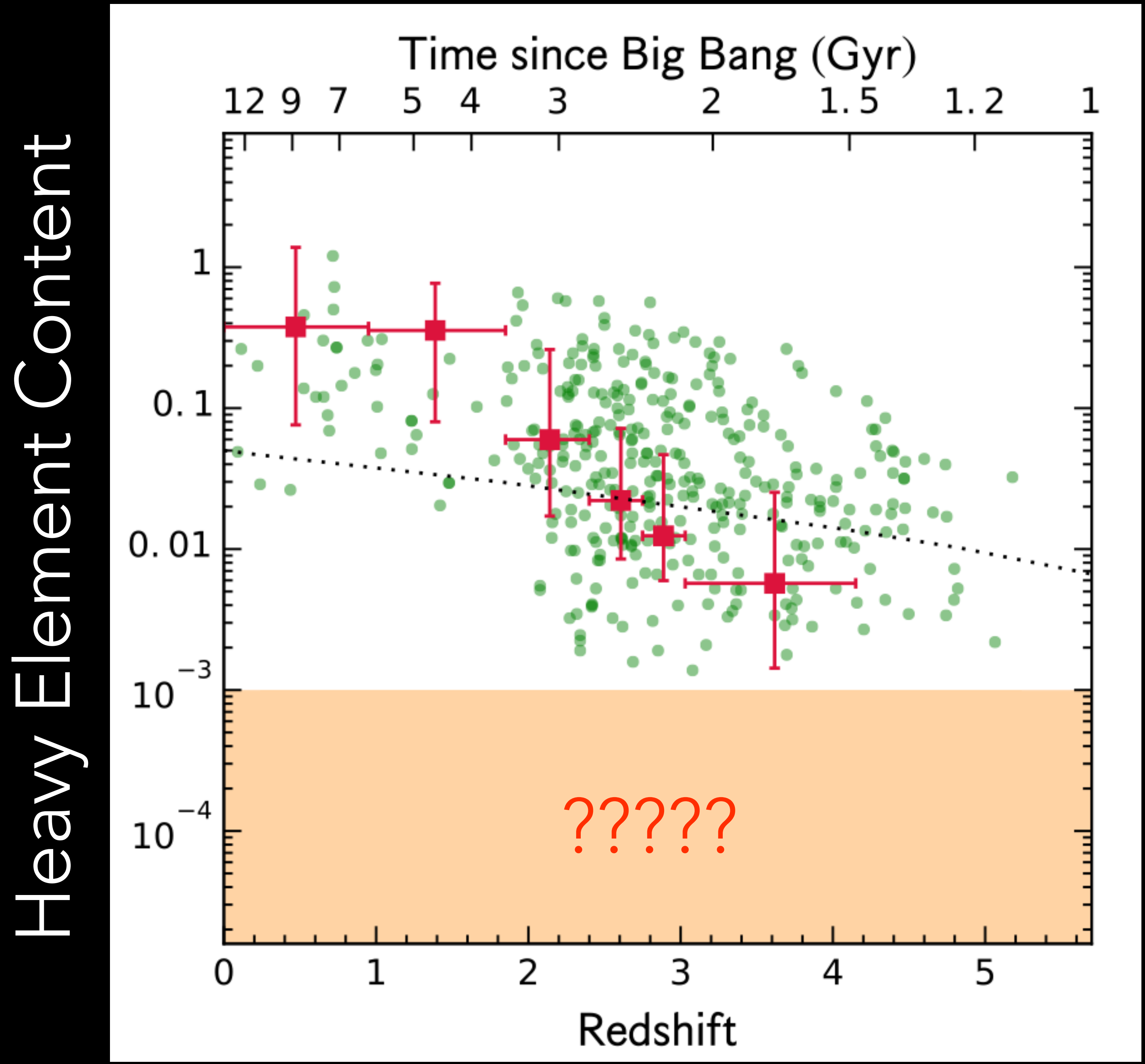


COSMIC ATOMIC HISTORY: A UV STORY

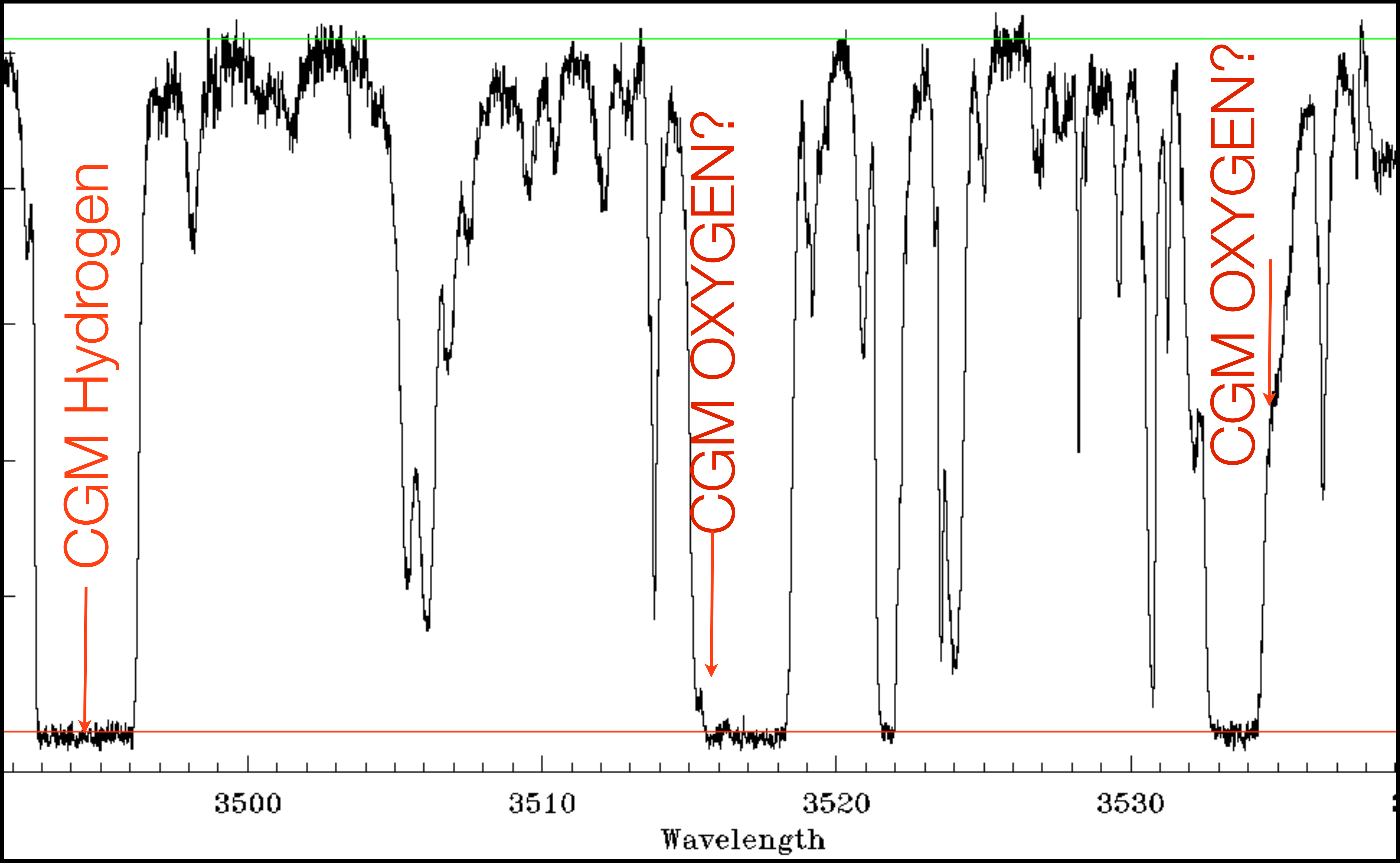


<u>All</u> of these temperatures are accessible in the UV

THE COSMIC WEB (AND WHERE IT OVERLAPS) IS ENRICHED!



AN INCONVENIENT TRUTH



to measure gas in the universe you must avoid gas in the universe

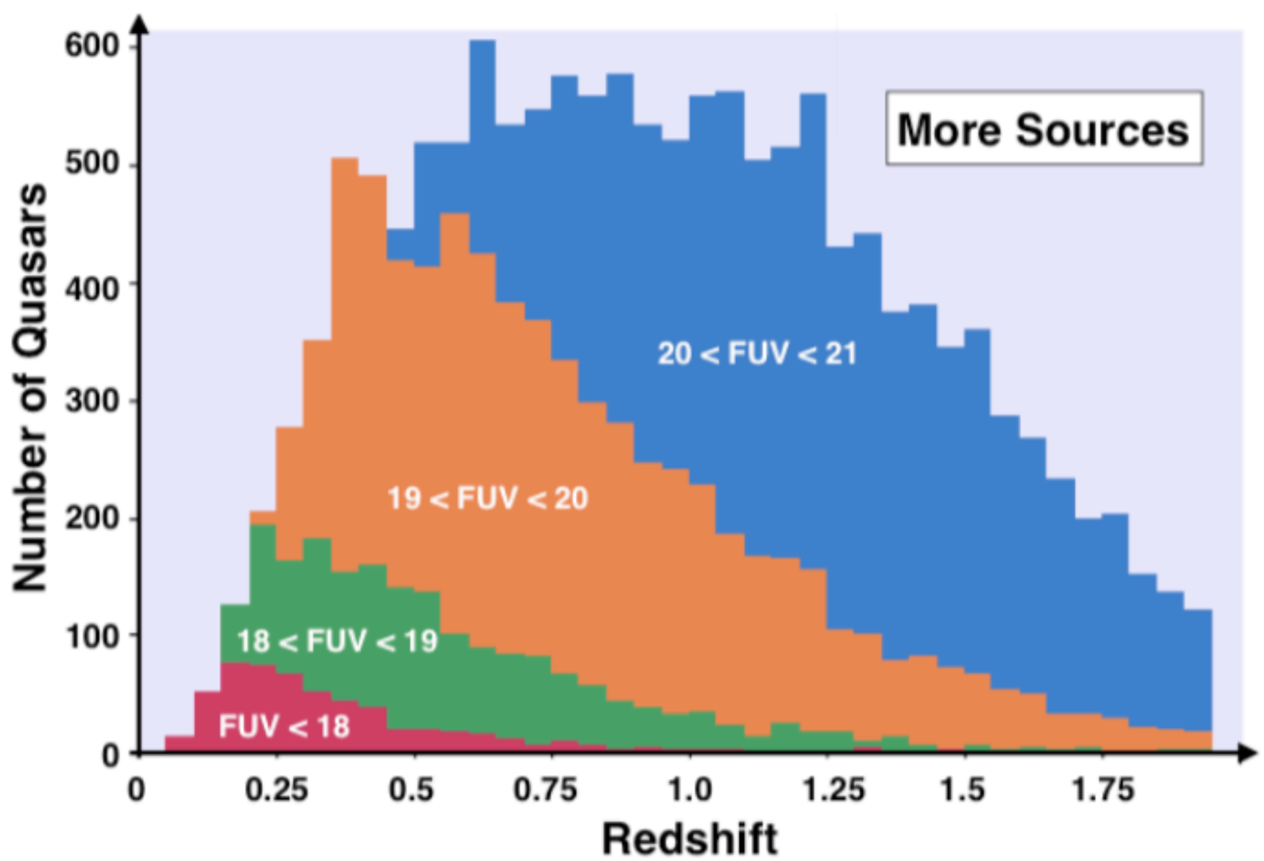
A CONVENIENT TRUTH: ARCHIVES!

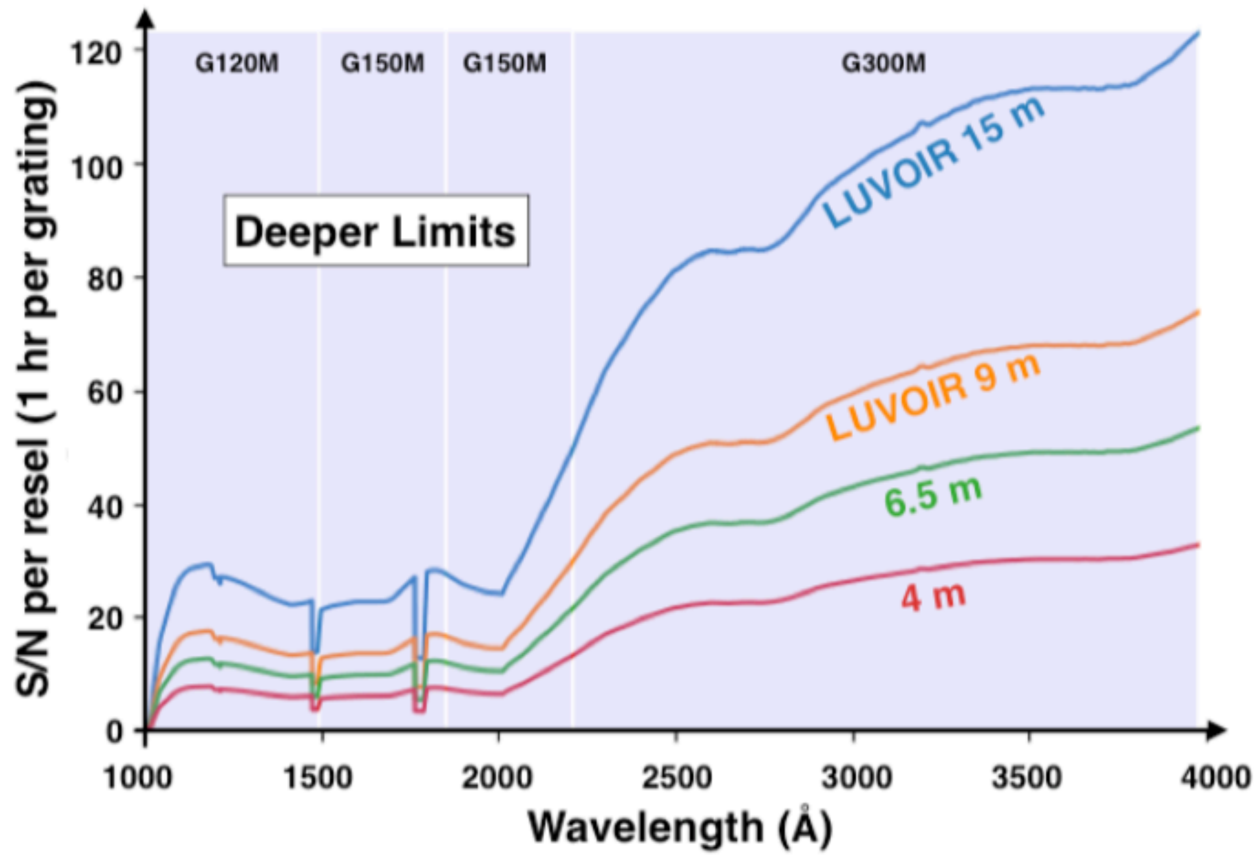
KODIAQ

THE KODIAQ PROJECT

- All HIRES quasar observations since 1994
- >500 unique objects
- DR1,2 (O'Meara+ 2015, 2017) now publicly available with 300 quasars

THINK LOCALLY, ACT GLOBALLY

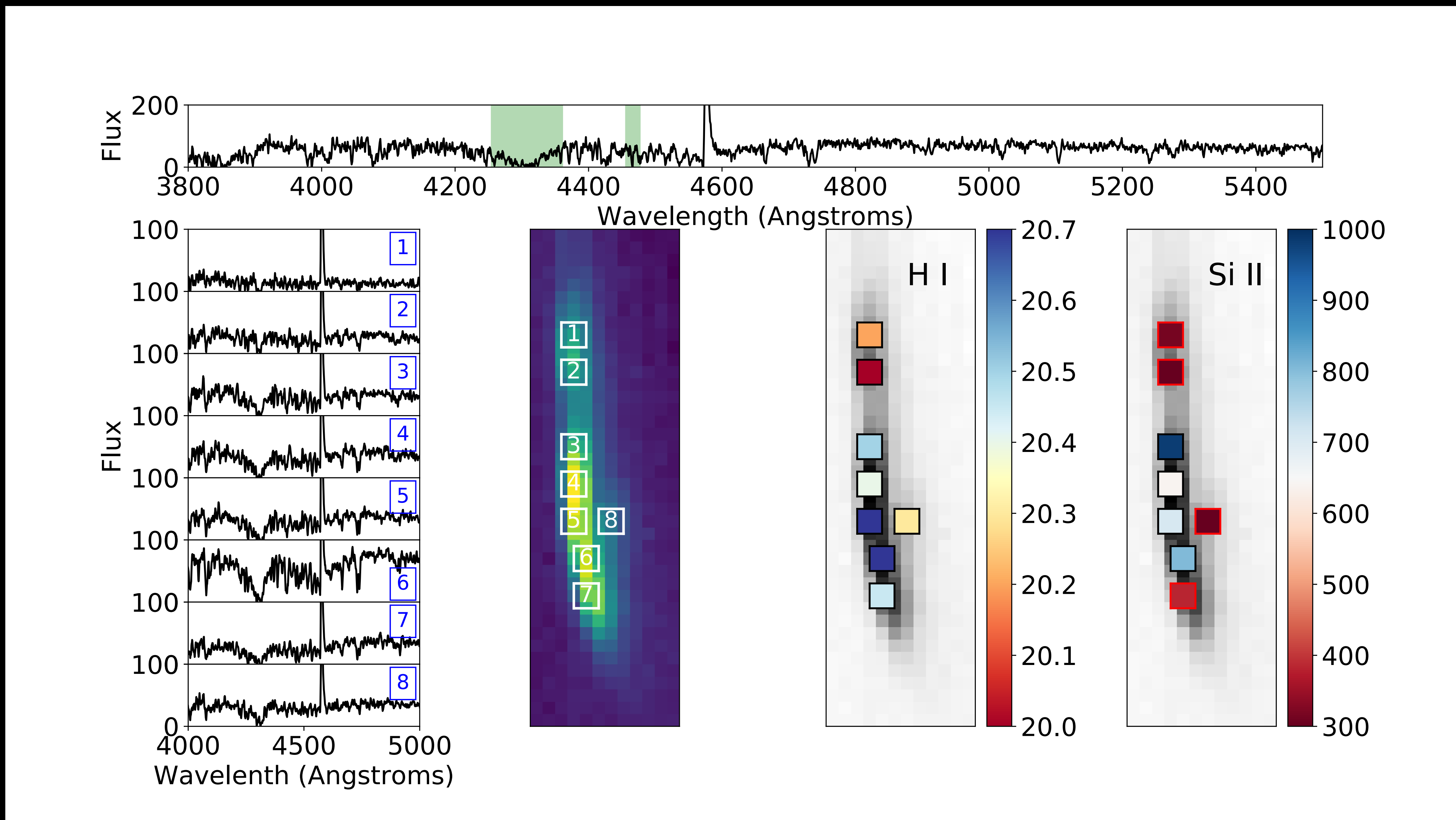




4m 6m 9m 15m

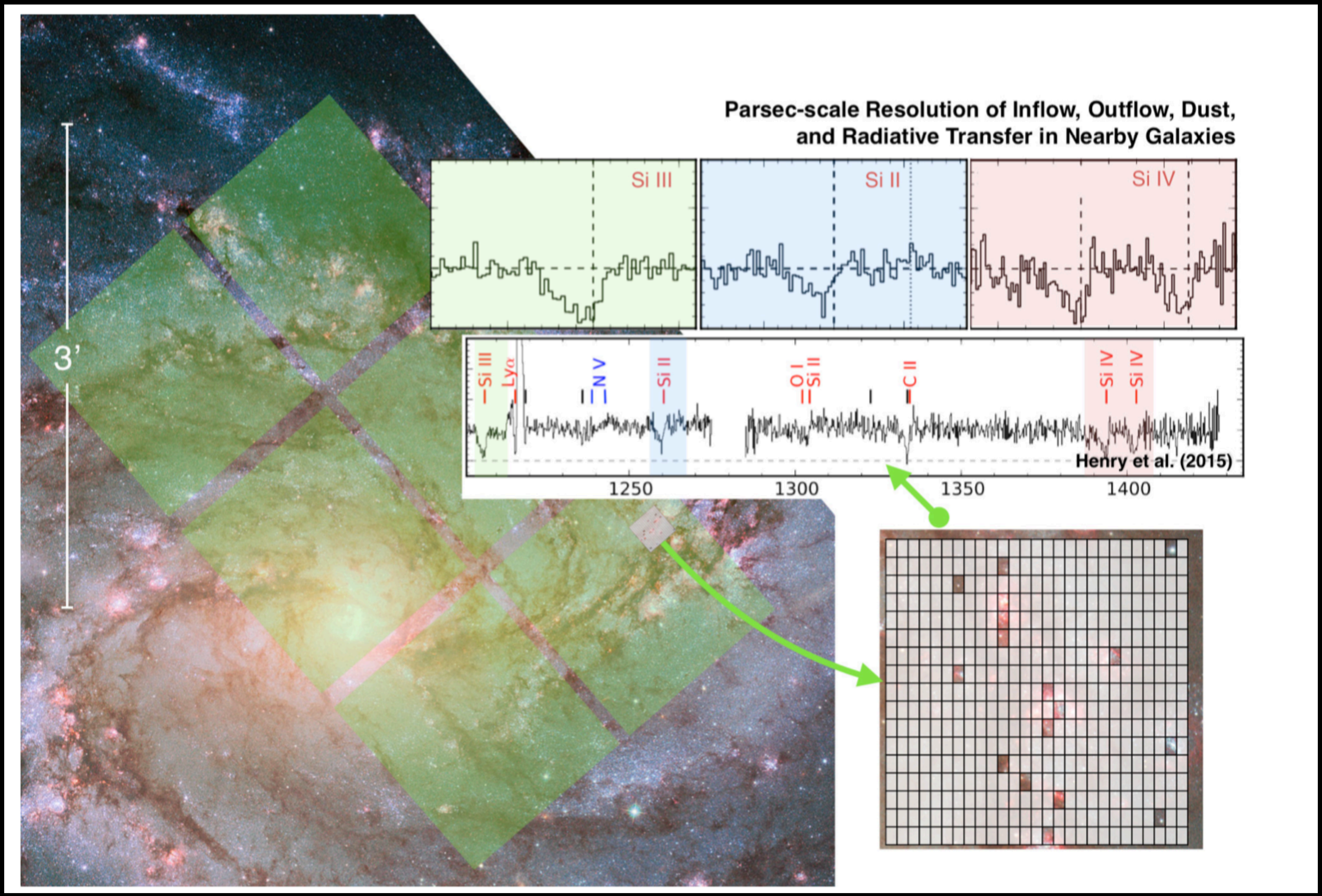
LUVOIR

SPATIALLY RESOLVED GAS EXPLORATION

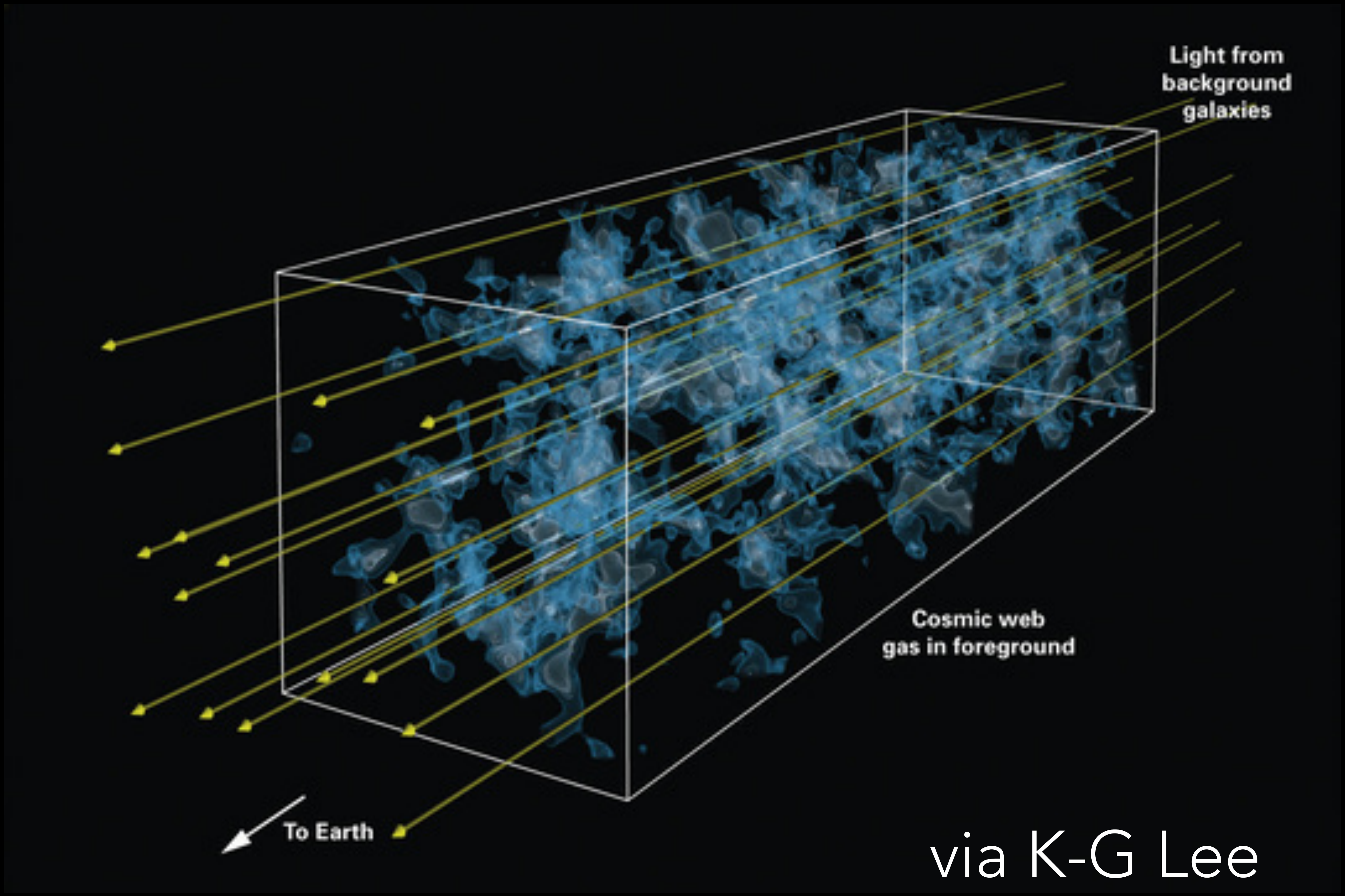


O’Meara+ 2018

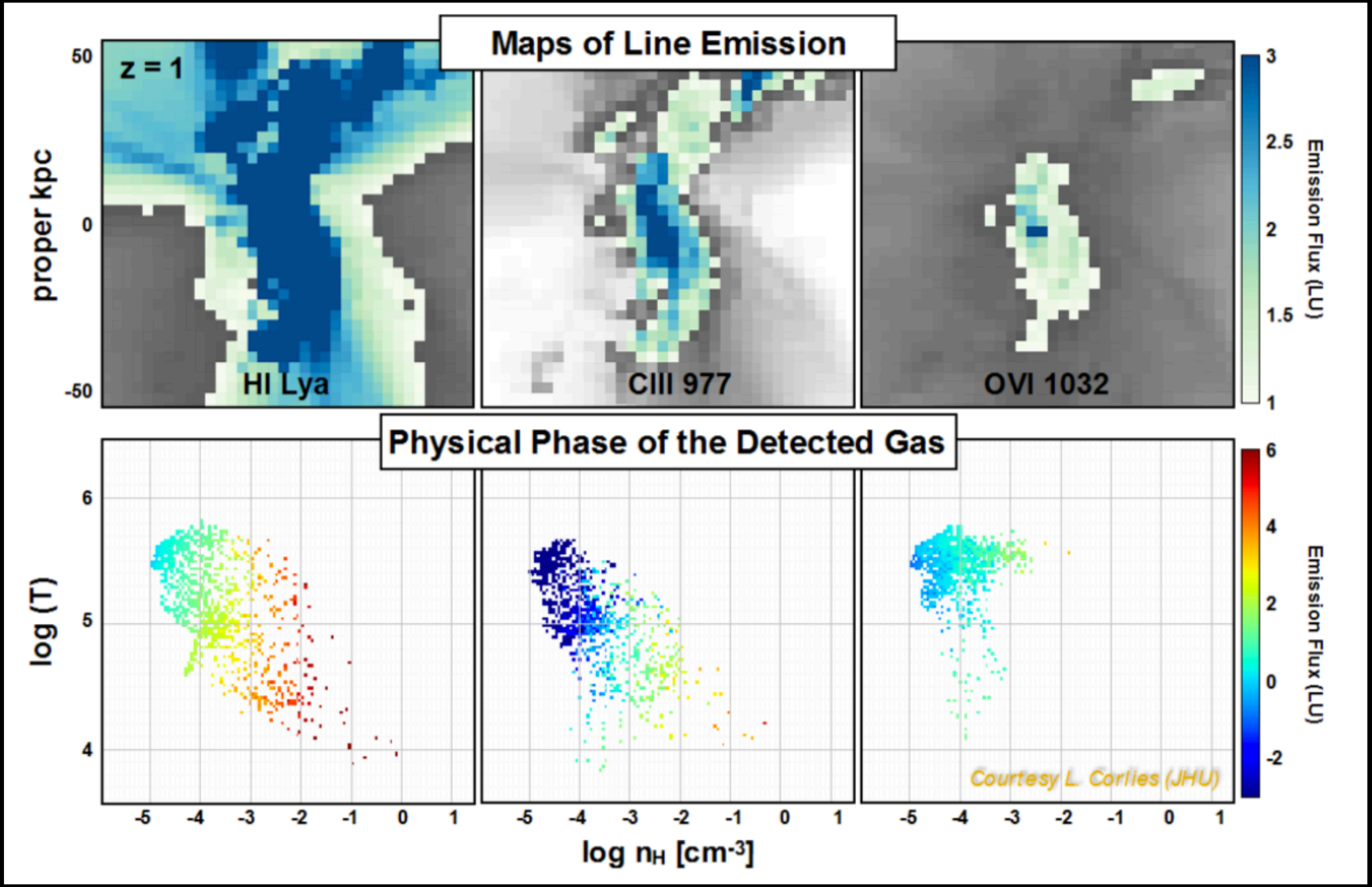
NOT JUST FOR QUASARS!



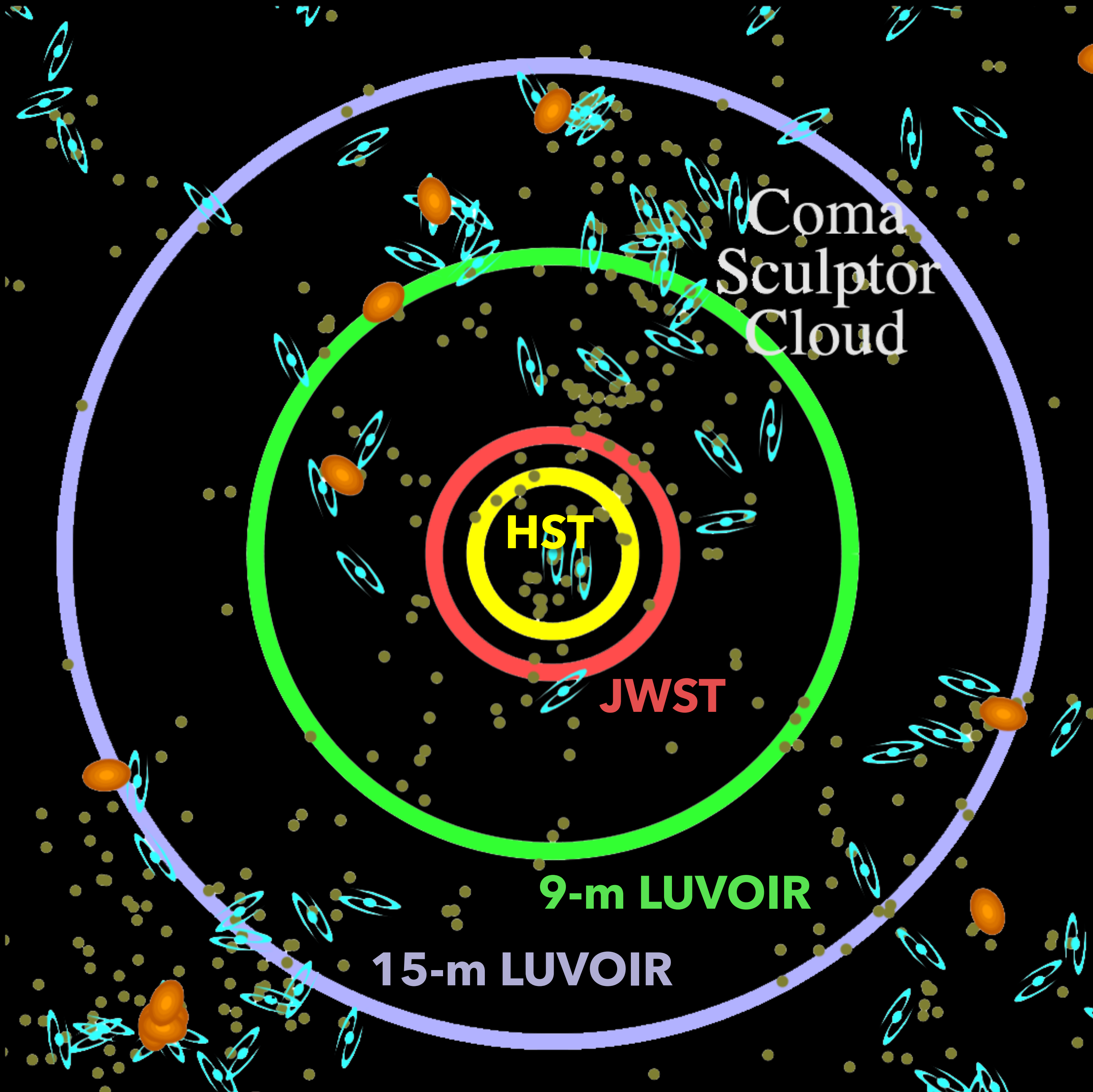
NOT JUST FOR QUASARS II: REVENGE OF THE IGM



IMAGING THE CGM



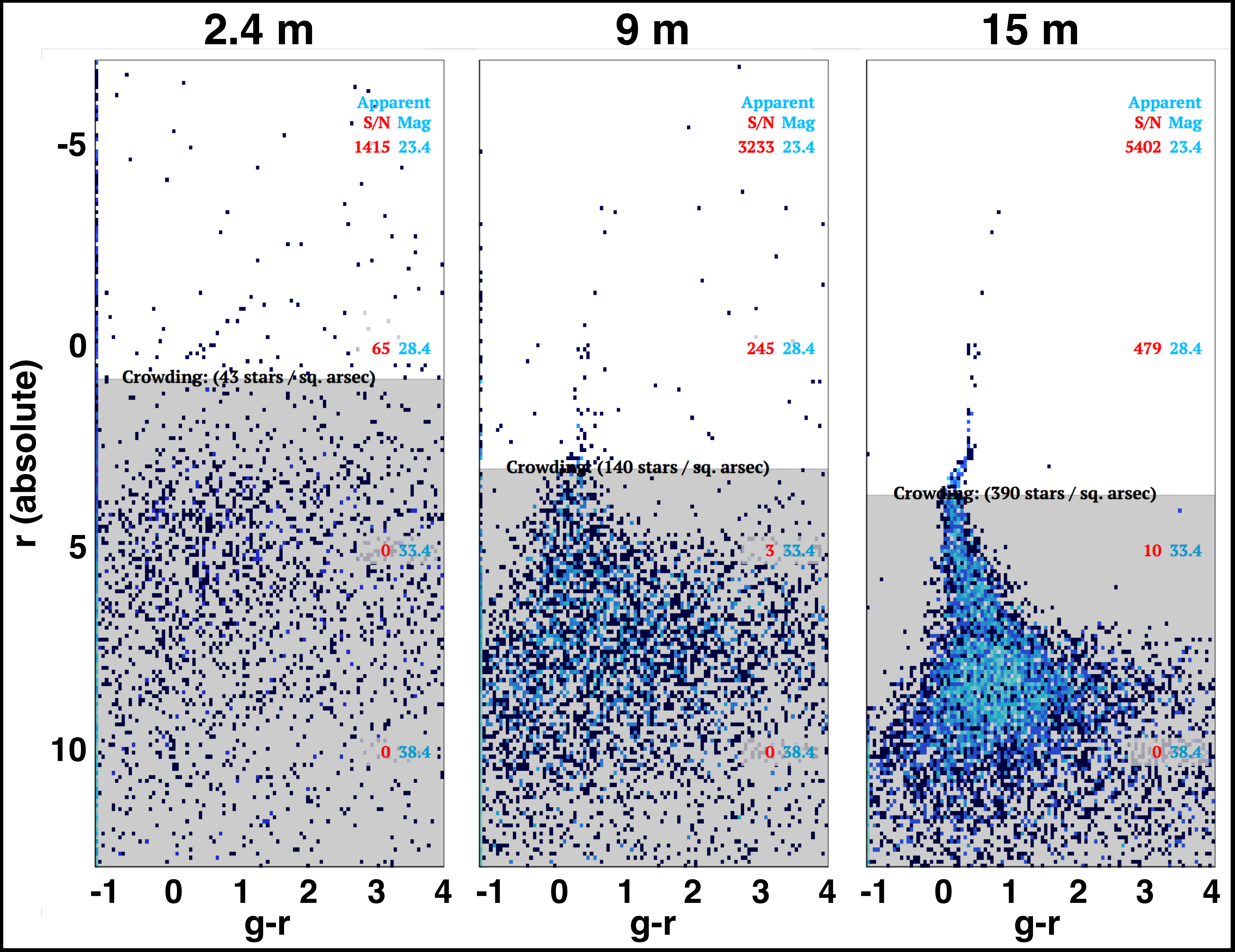
STEPPING OUT OF THE NEIGHBORHOOD



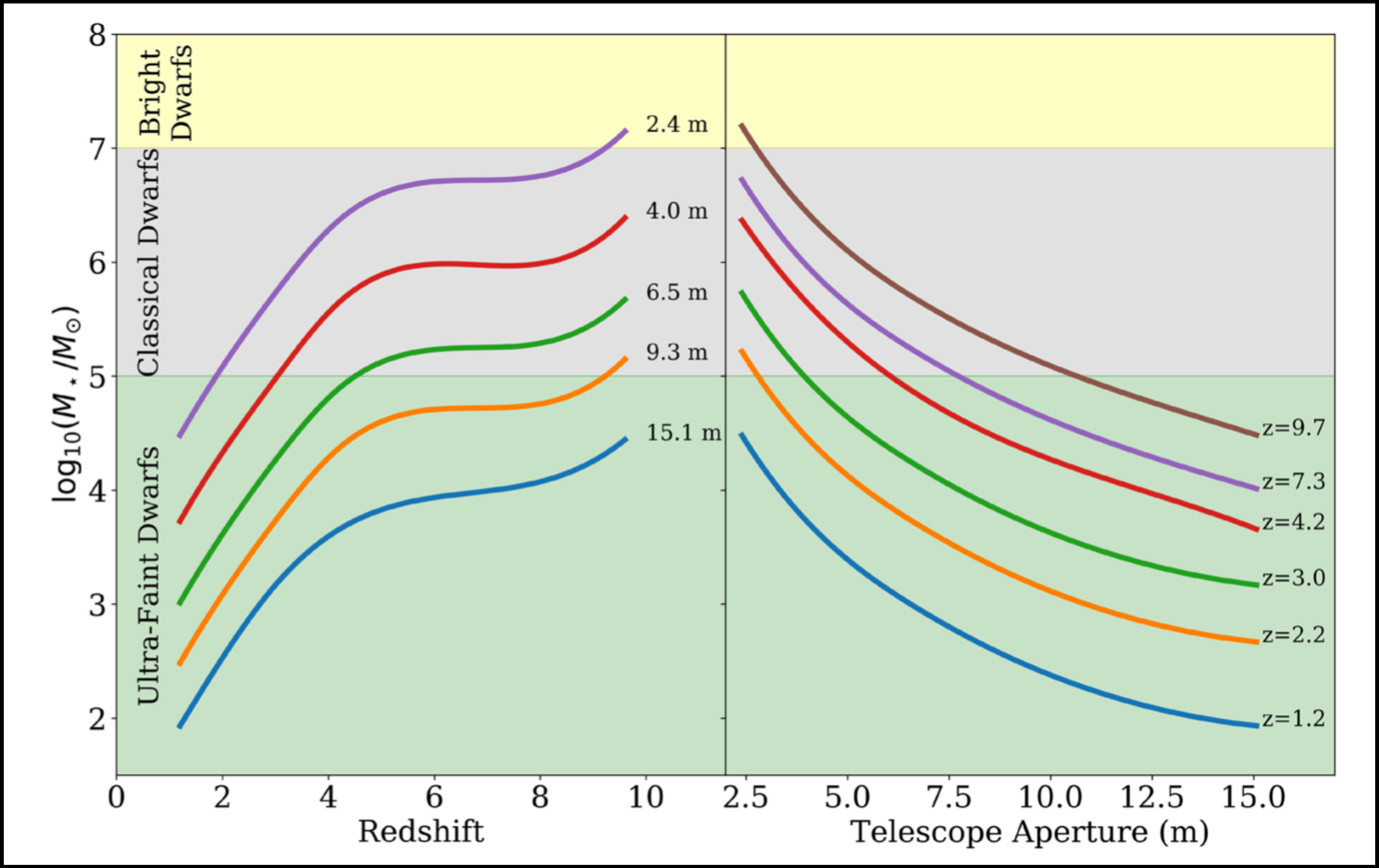
Map of Galaxies within 12 Mpc of Our Galaxy

Main Sequence turnoff chronometers in every environment

THE CMD AT 5 MPC

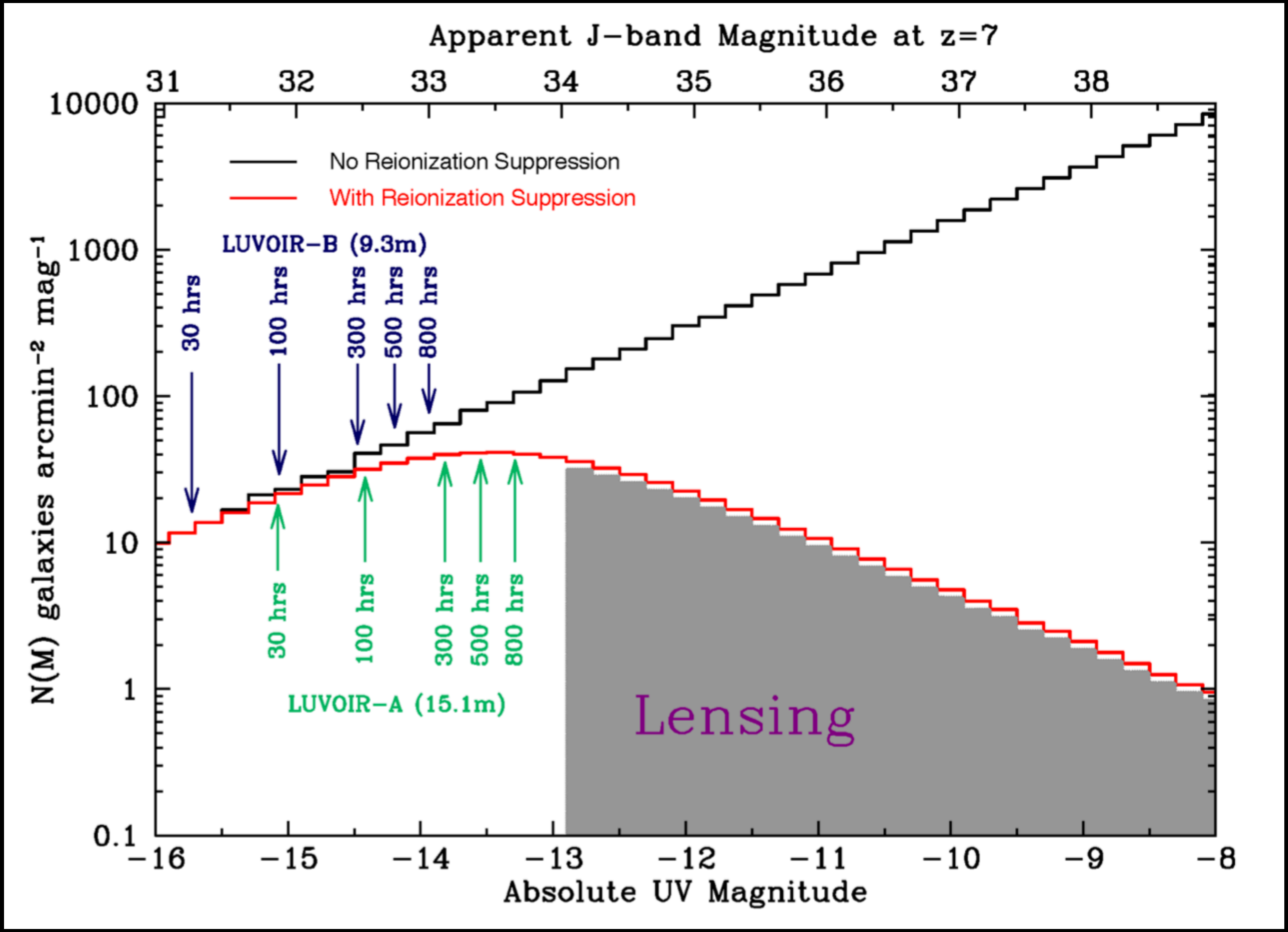


DWARFS ACROSS COSMIC TIME

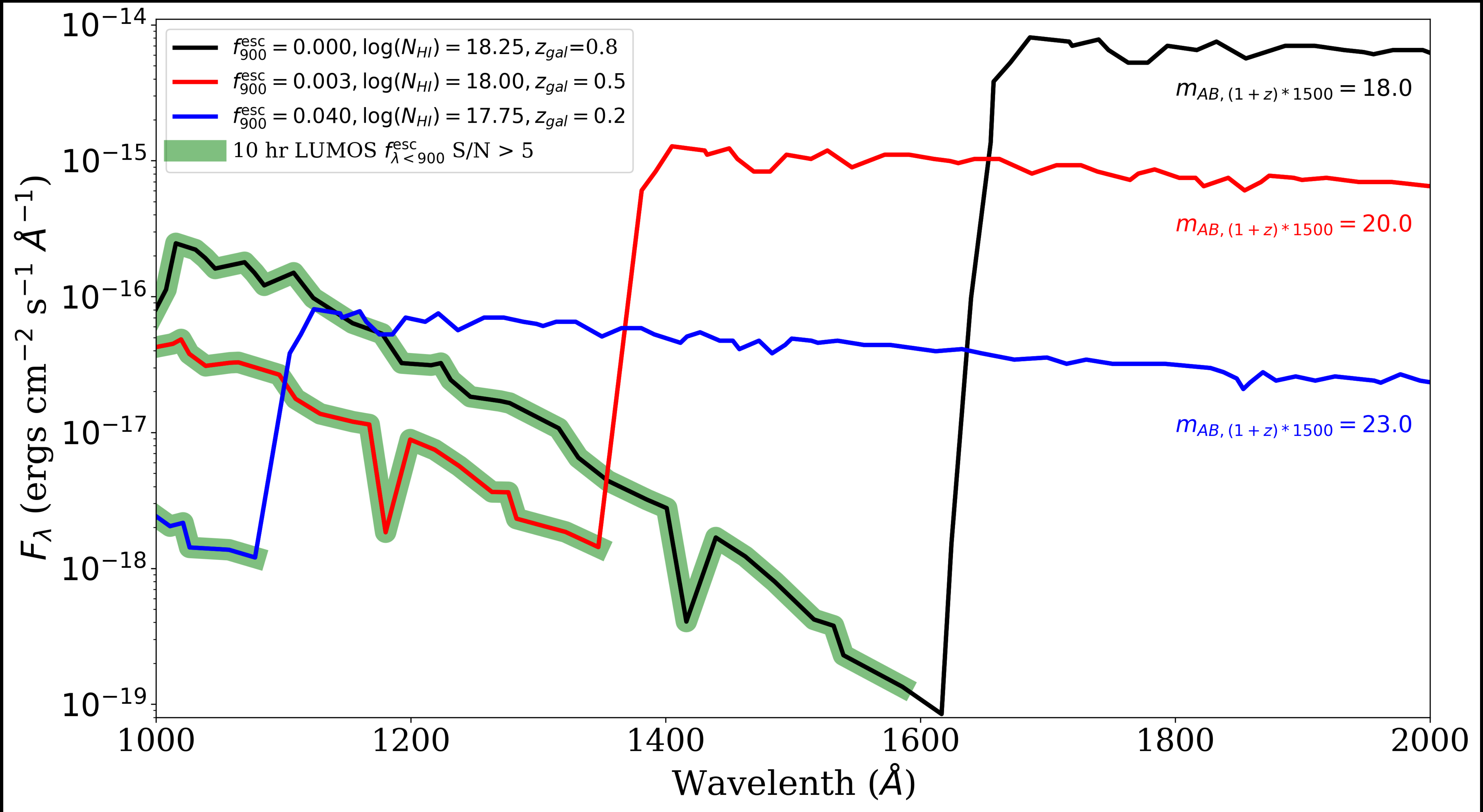


Sensitivity from 500 ksec observation

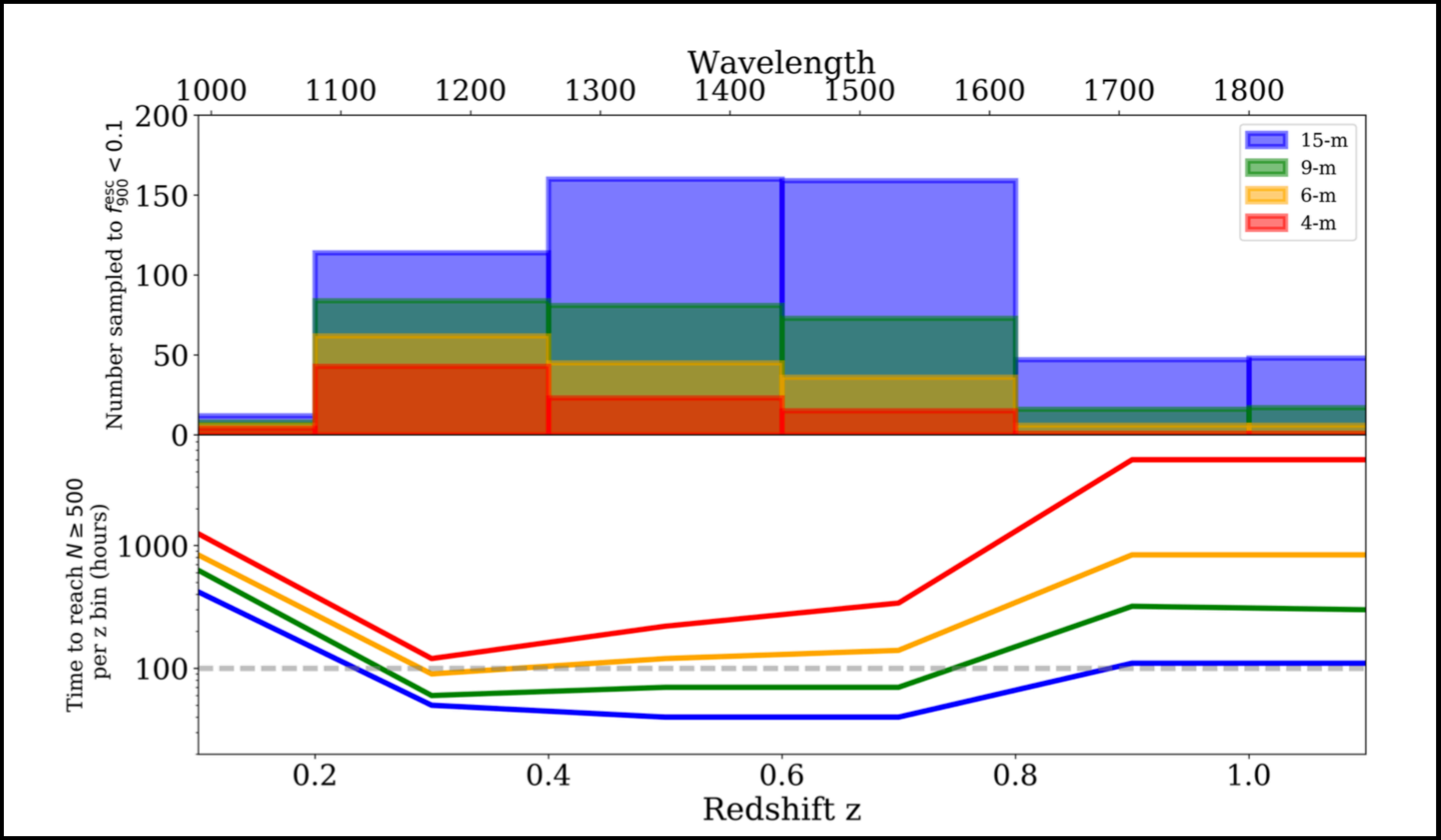
REIONIZATION REVEALED



REIONIZATION REVEALED



LET THERE BE (LEAKING) LIGHT



10hr single LUMOS pointing

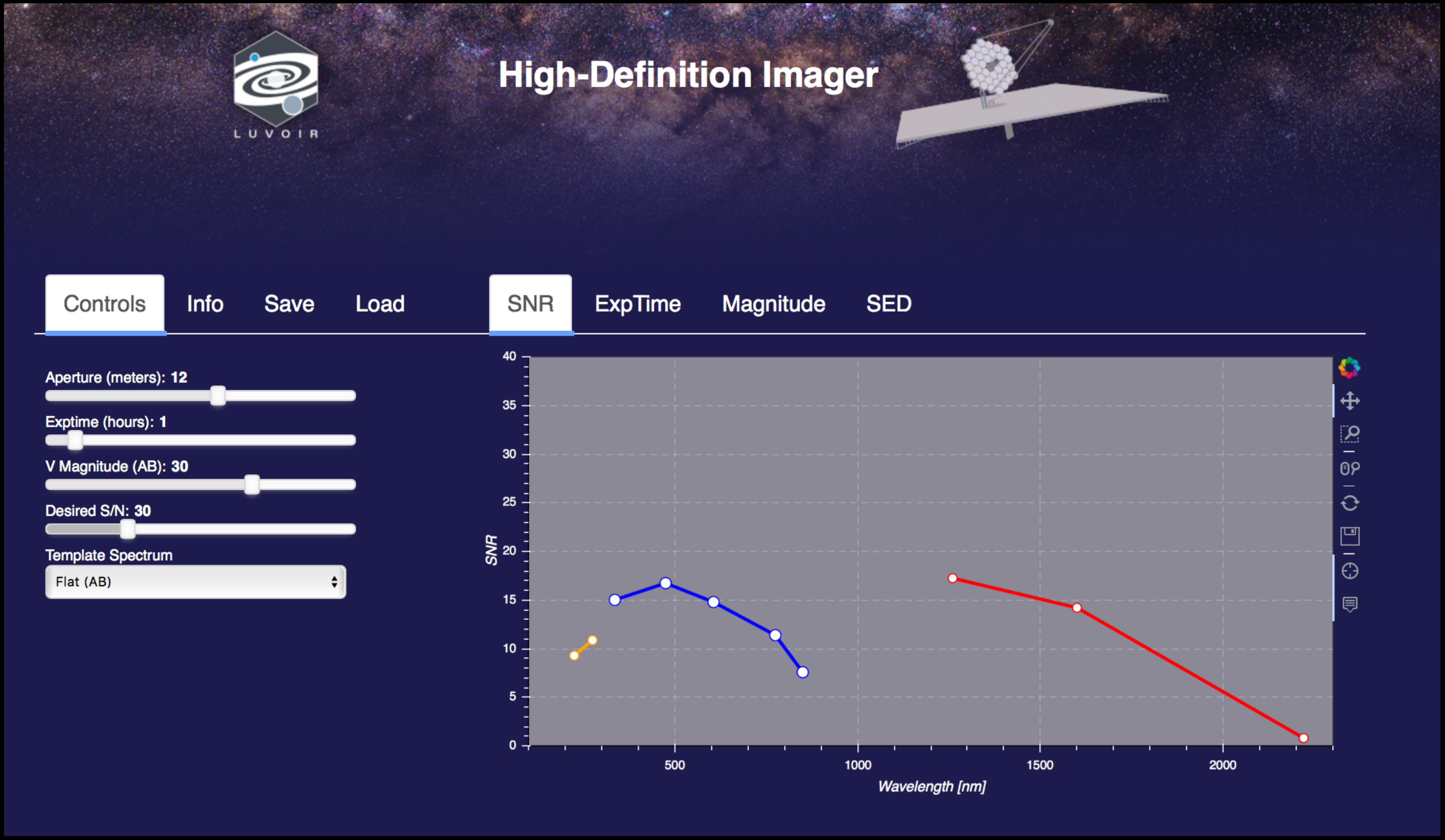
Time to reach 500 per bin

WHAT'S NEXT?

WHAT'S NEXT? YOU!

USE OUR TOOLS!

http://luvoir.stsci.edu



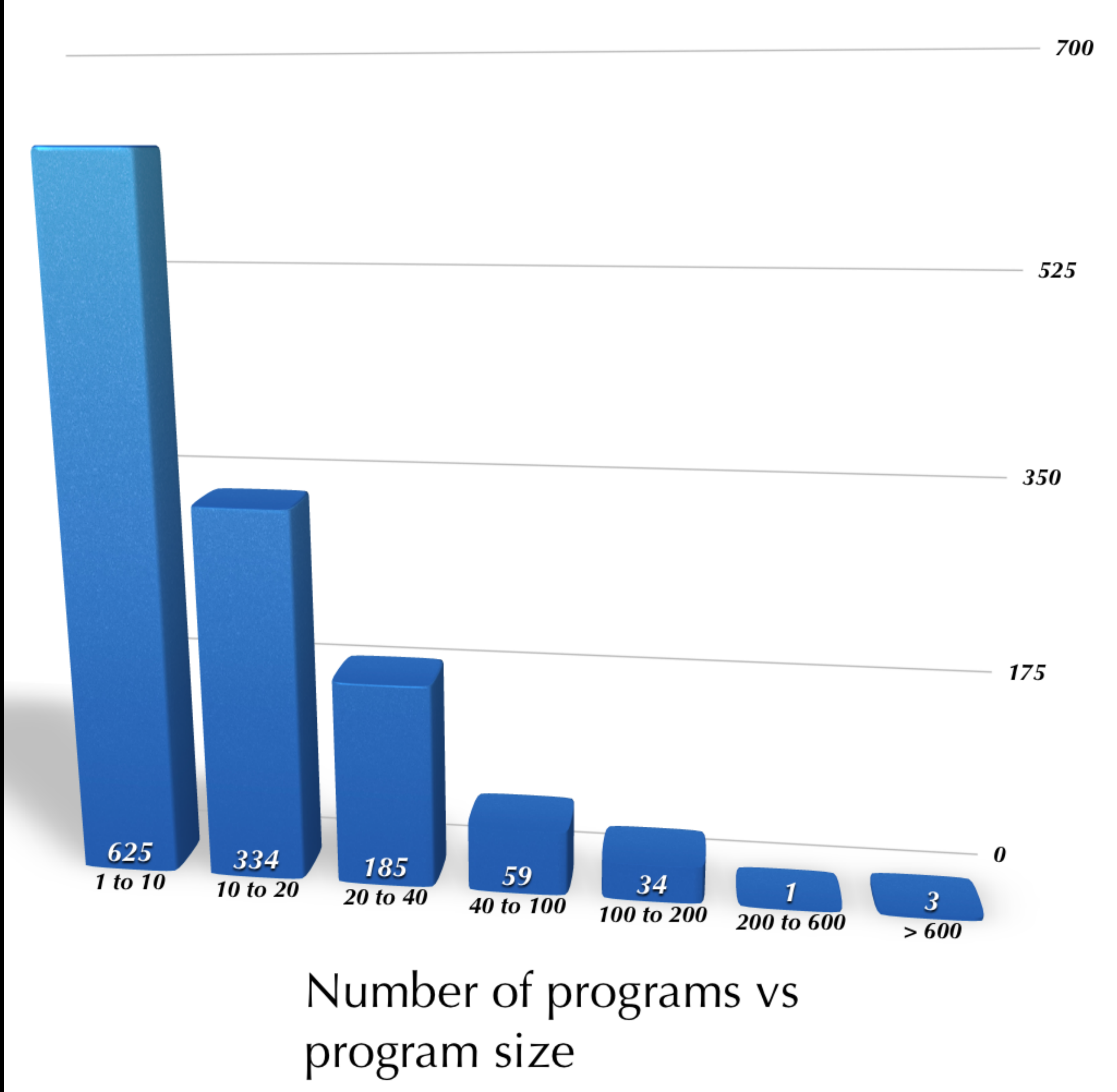
THANKS

LUVOIR

POINT #1

JUST BECAUSE YOU CAN, DOESN'T MEAN YOU WILL

do the "impossible" both ways



HST Cycles 17-23

POINT #2

WE HAVE ALWAYS HAD LARGER TELESCOPES ON THE GROUND. THAT'S OK

but what will the community landscape be in 2035?

POINT #3

THE LUVOIR STDT MAY NOT KNOW WHAT THE MOST IMPORTANT SCIENCE OF 2035, 2045, AND 2055 IS

Scientific Uses of the Large Space Telescope

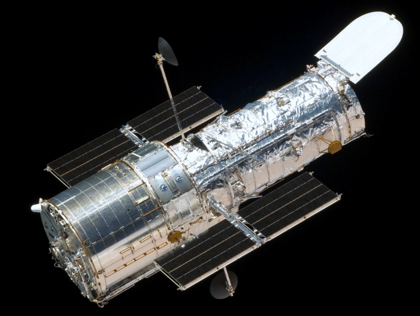
AD HOC COMMITTEE ON THE LARGE SPACE TELESCOPE
SPACE SCIENCE BOARD
NATIONAL ACADEMY OF SCIENCES–NATIONAL RESEARCH COUNCIL

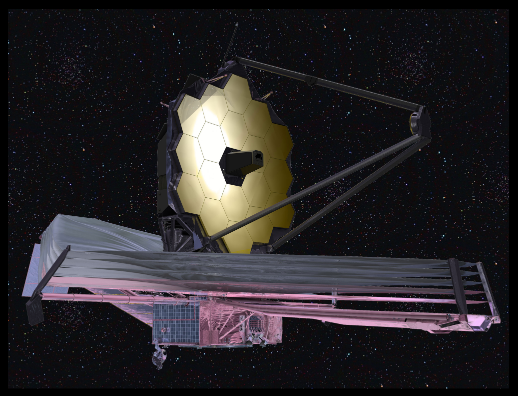
NATIONAL ACADEMY OF SCIENCES
WASHINGTON, D.C.
1969

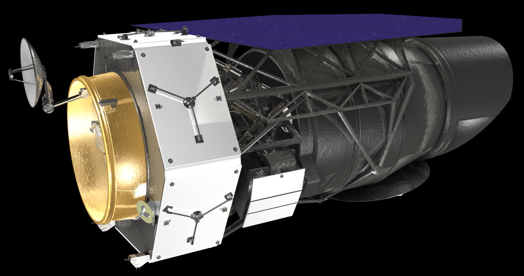
we must build powerful and flexible

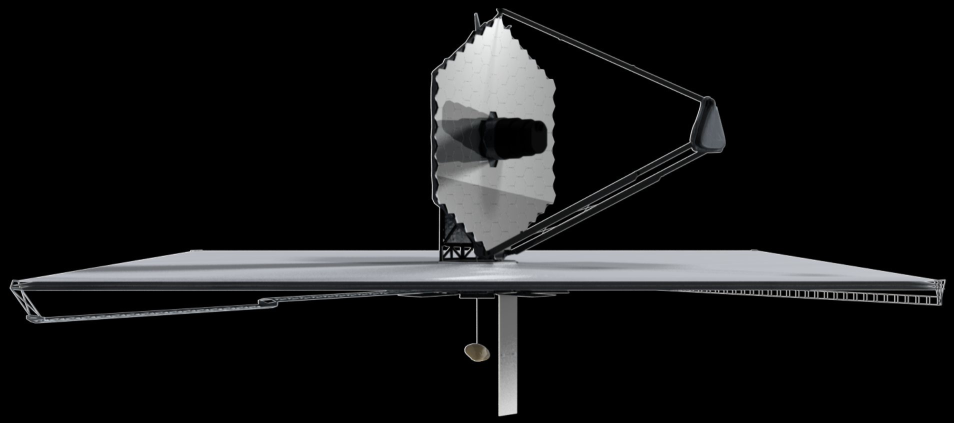
POINT #4

WE CAN STAND ON THE SHOULDERS OF GIANTS



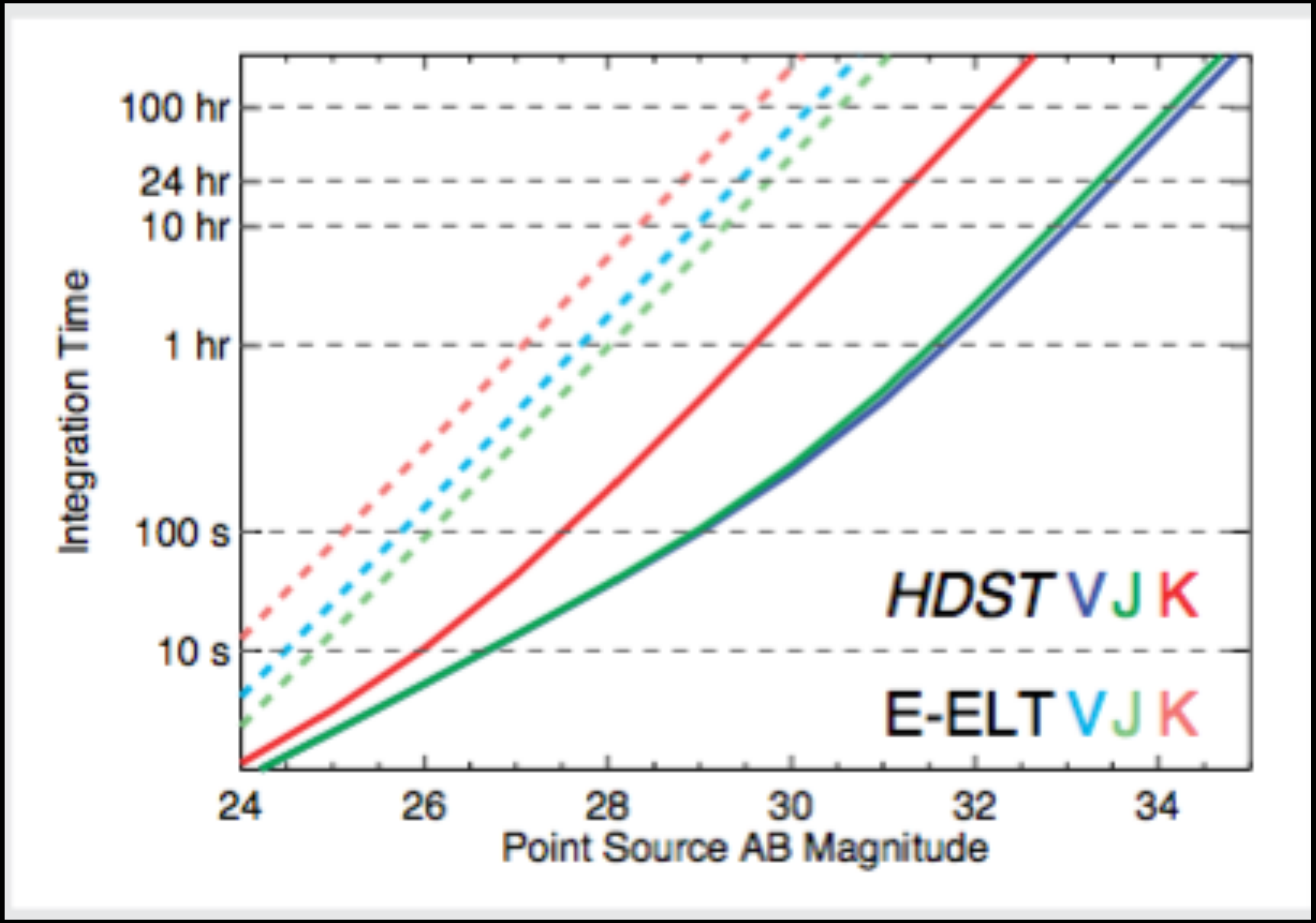




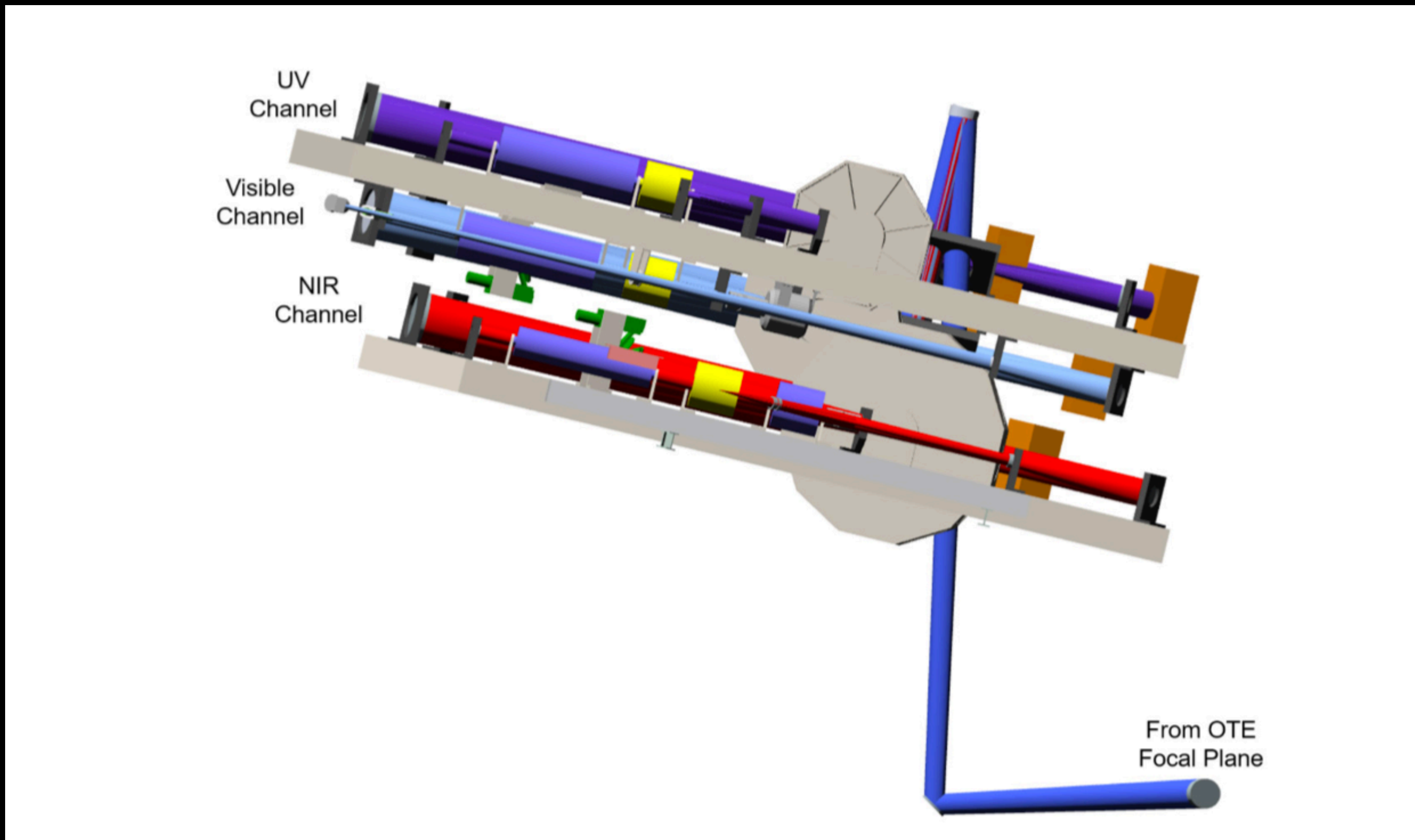


we have significant heritage to leverage

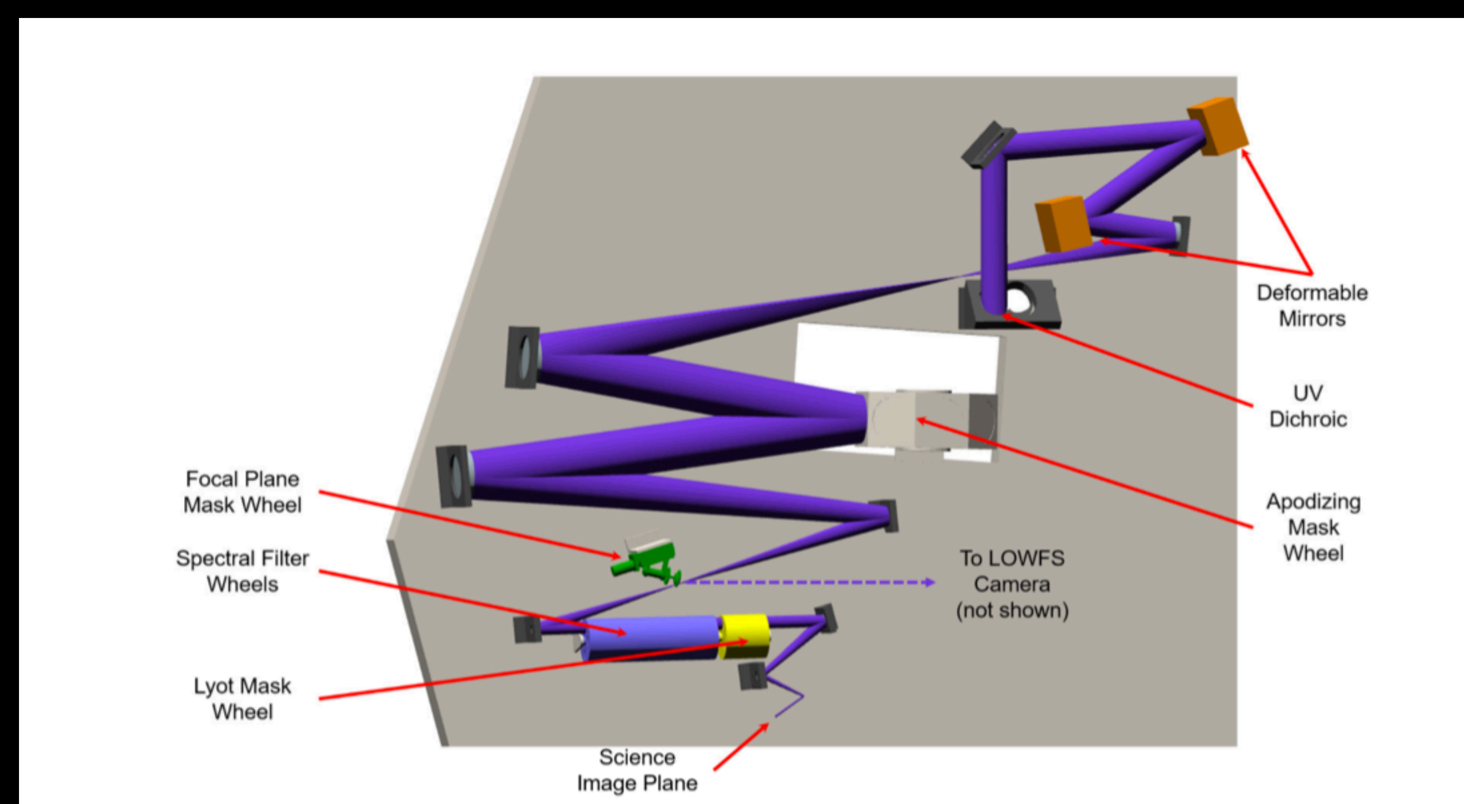
YEAH, BUT THE 30-METERS WILL DO THIS ALL



from the HDST report

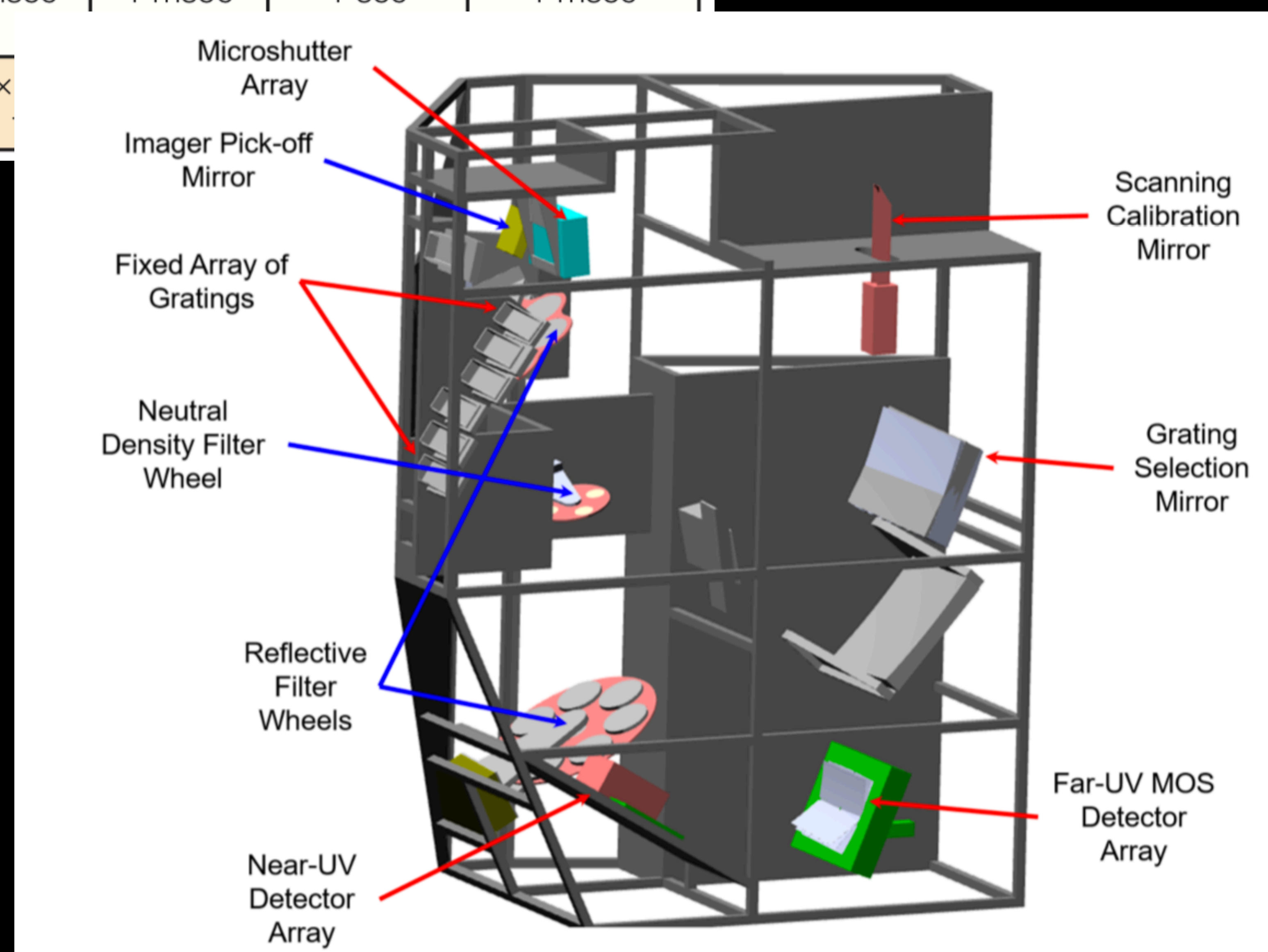

UV
Channel
Visible
Channel
NIR
Channel
From OTE
Focal Plane

ECLIPS

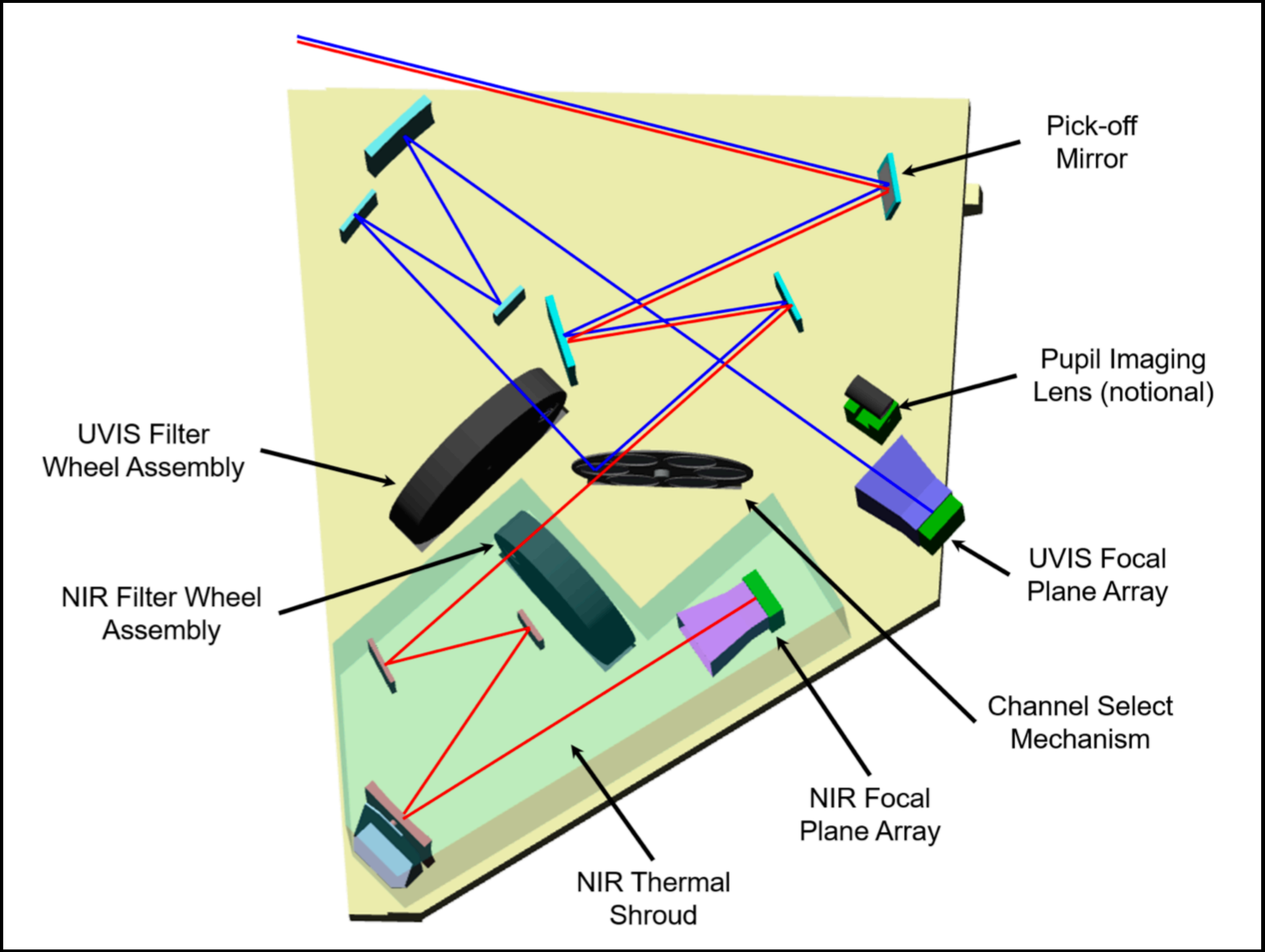

Deformable
Mirrors
UV
Dichroic
Apodizing
Mask
Wheel
Focal Plane
Mask Wheel
Spectral Filter
Wheels
To LOWFS
Camera
(not shown)
Lyot Mask
Wheel
Science
Image Plane

Instrument Parameter	G120M	G150M	G180M	G155L	G145LL	G300M	FUV Imaging
Spectral Resolving Power	30,000 (42,000) (30,300)	30,000 (54,500) (37,750))	30,000 (63,200) (40,750)	8,000 (16,000) (11,550)	500 (500)	30,000 (40,600) (28,000)	N/A
Optimized Spectral Bandpass	100-140 nm (92.5-147.4 nm)	130-170 nm (123.4 -176.6 nm)	160-200 nm (153.4-206.6 nm)	100-200 nm (92.0-208.2 nm)	100-200 nm	200-400 nm	100-200 nm
Angular Resolution	50 mas (11 mas) (17 mas)	50 mas (15 mas) (19.5 mas)	50 mas (17 mas) (24 mas)	50 mas (15 mas) (27.5 mas)	100 mas (32 mas)	50 mas (8 mas) (26 mas)	25 mas (12.6 mas) (12.6 mas)
Temporal Resolution	1 msec	1 msec	1 msec	1 msec	1 msec	1 sec	1 msec
Field-of-View	2’ × 2’ (3’ × 1.6’)	2’ × 2’ (3’ × 1.6’)	2’ × 2’ (3’ × 1.6’)	2’ × (3’ ×			

LUMOS



HDI


Pick-off
Mirror
Pupil Imaging
Lens (notional)
UVIS Filter
Wheel Assembly
UVIS Focal
Plane Array
NIR Filter Wheel
Assembly
Channel Select
Mechanism
NIR Focal
Plane Array
NIR Thermal
Shroud