

PLANETS NEAR AND FAR WITH LUVOIR

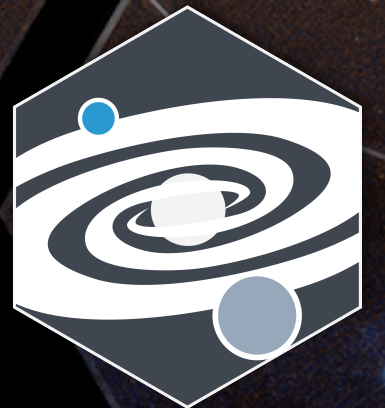
AKI ROBERGE

NASA GODDARD SPACE FLIGHT CENTER

GIANT PLANET SYSTEMS PANEL

PLANETARY SCIENCE AND ASTROBIOLOGY DECADAL SURVEY

APRIL 16, 2021

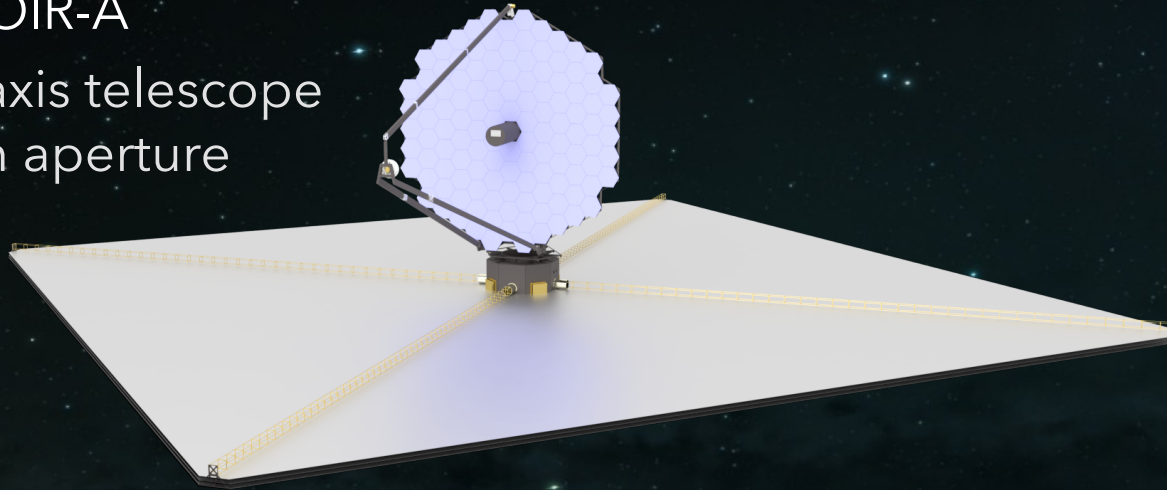


LUVOIR

THE LARGE UV / OPTICAL / INFRARED SURVEYOR

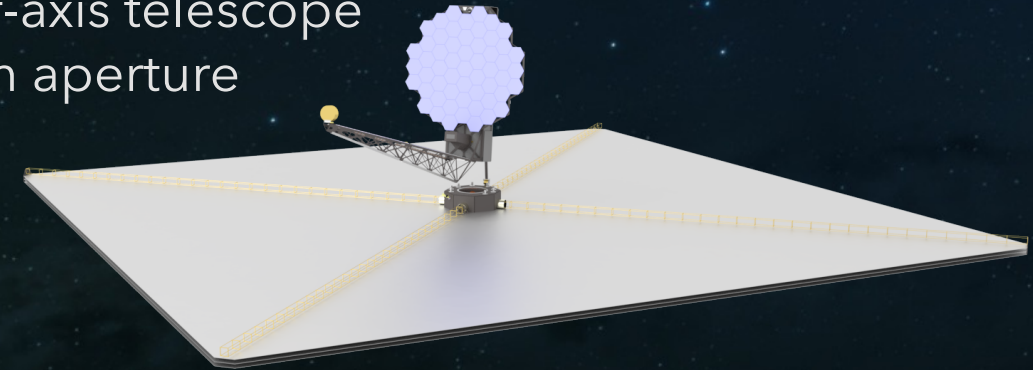
LUVOIR-A

On-axis telescope
15 m aperture



LUVOIR-B

Off-axis telescope
8 m aperture



Space telescope concept with broad science capabilities
Exoplanets, Solar System, Astrophysics

Candidate Instruments

Far-UV to near-IR total bandpass

ECLIPS

Extreme Coronagraph for
Living Planetary Systems

HDI

High-Definition Imager

LUMOS

LUVOIR Ultraviolet Multi-
Object Spectrograph

POLLUX

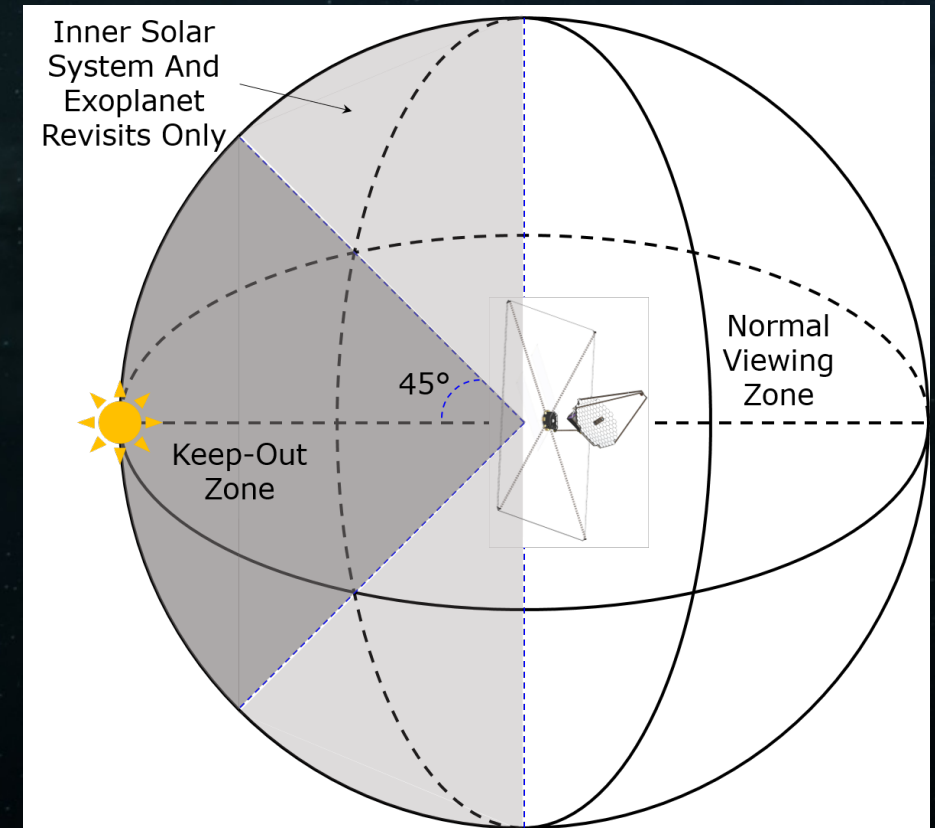
UV spectropolarimeter
(on LUVOIR-A only)

KEY FEATURES FOR SOLAR SYSTEM OBSERVATIONS

Can point to Venus at max elongation and planets at opposition

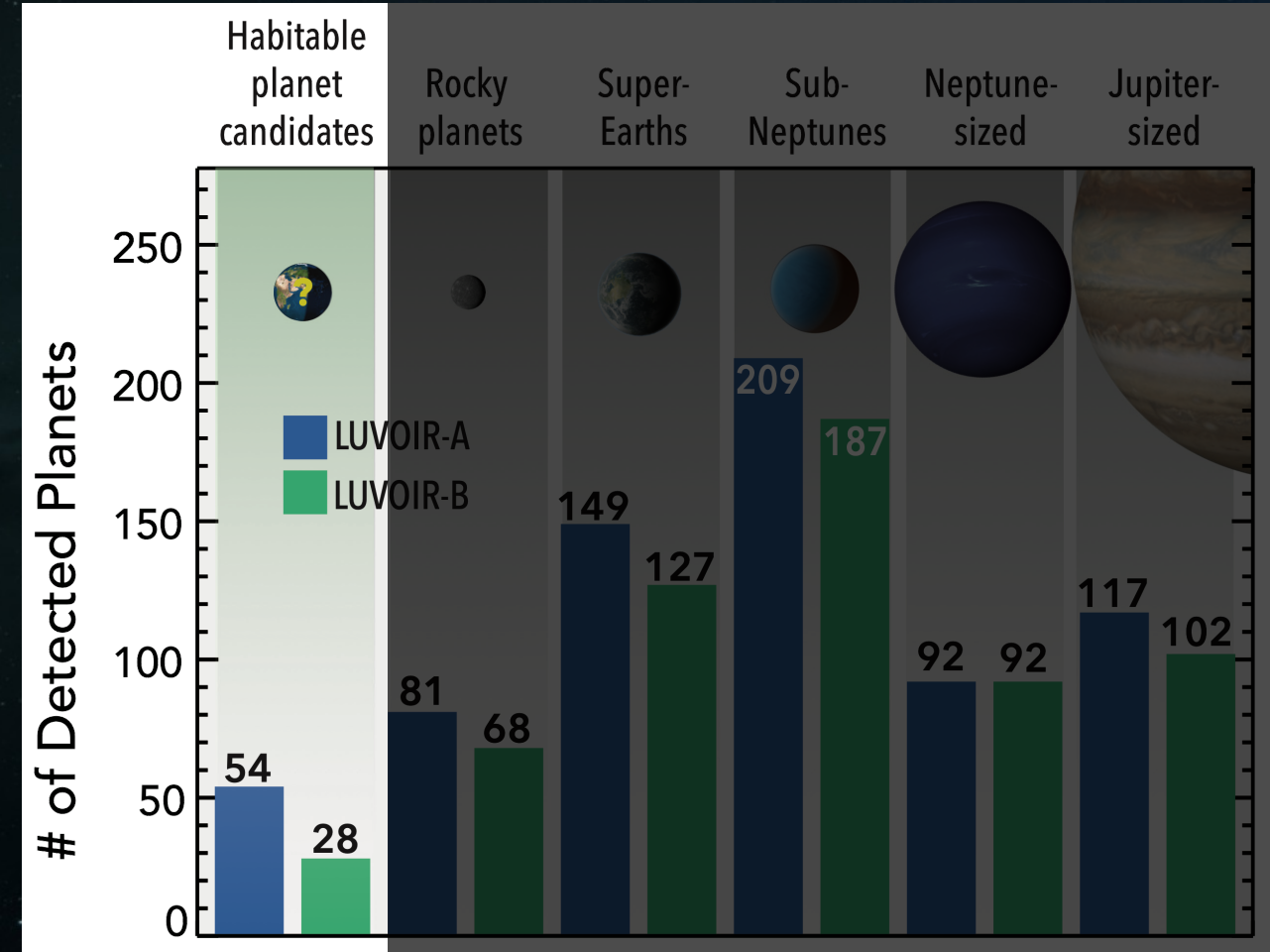
Table 1: Summary of the LUVOIR space telescope concepts

	LUVOIR-A	LUVOIR-B
Telescope diameter	15-m	8-m
Location	Earth-Sun Lagrange 2	
Telescope properties	Diffraction limited at 500 nm; 270 K telescope operating temperature	
Lifetimes & launch date	5-year prime mission; 10 years of consumables; 25-year lifetime goal for non-serviceable components; proposed launch date in late 2030s	
Instantaneous field of regard	Sun-Telescope-Target angles $\geq 45^\circ$	
Moving target tracking speed	≤ 60 milliarcsec/second (2x speed of JWST)	
Total wavelength range of candidate instrument suite	100 nm – 2500 nm	
Current candidate instrument capabilities	High-contrast near-UV/optical/ NIR imaging & low-resolution spatially resolved spectroscopy	
	Wide-field near-UV/optical/NIR imaging	
	UV/optical multi-resolution, multi-object spectroscopy	
	UV spectropolarimetry	...
Max spatial resolution at 1 μm		
Venus, Jupiter, Saturn	15 km, 50 km, 102 km	28 km, 94 km, 193 km
Uranus, Neptune, 40 AU	217 km, 346 km, 464 km	409 km, 653 km, 875 km



KEY GOALS FOR LUVOIR INCLUDE ...

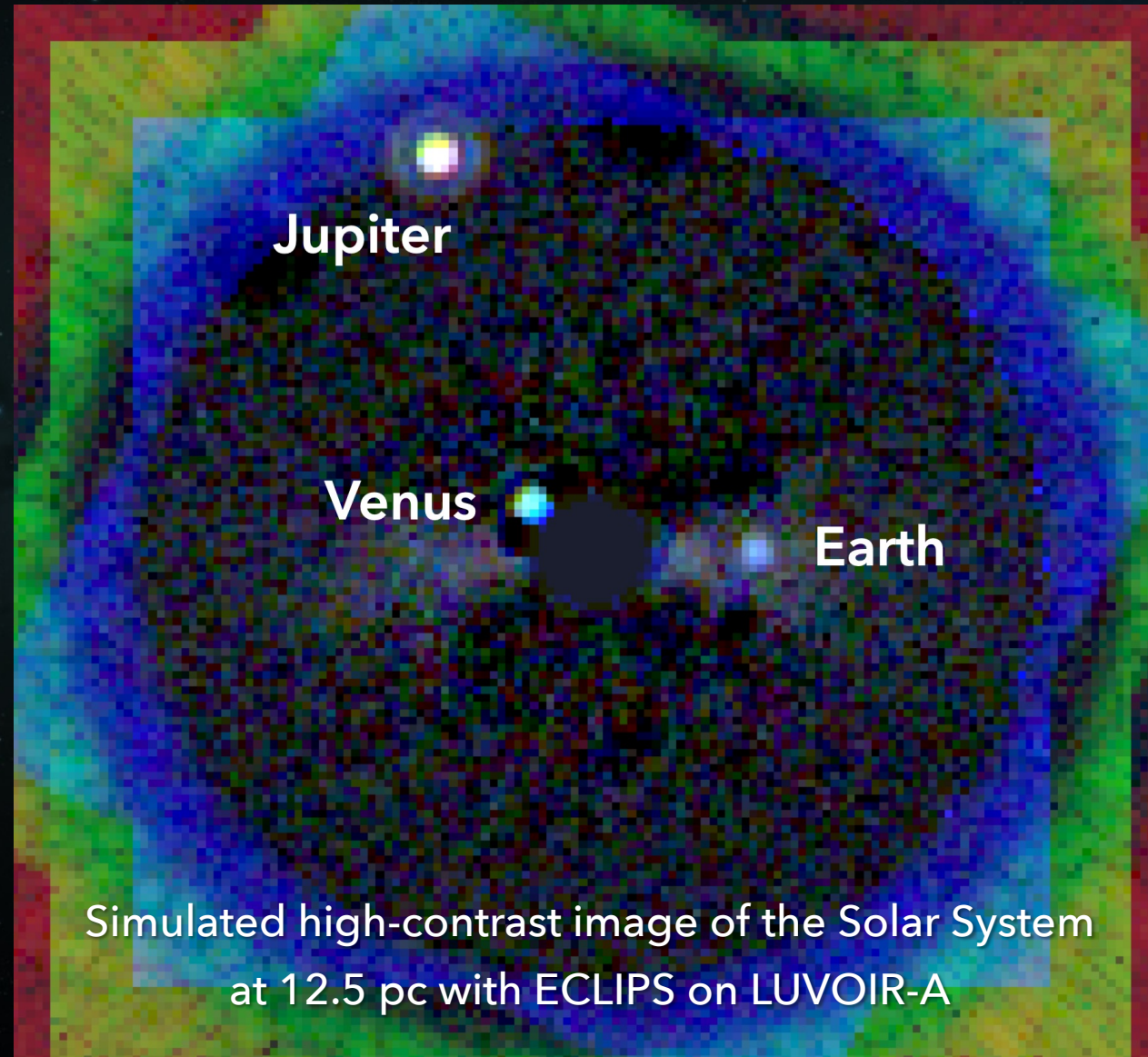
1. Find dozens of potentially habitable exoplanets and search them for signs of life



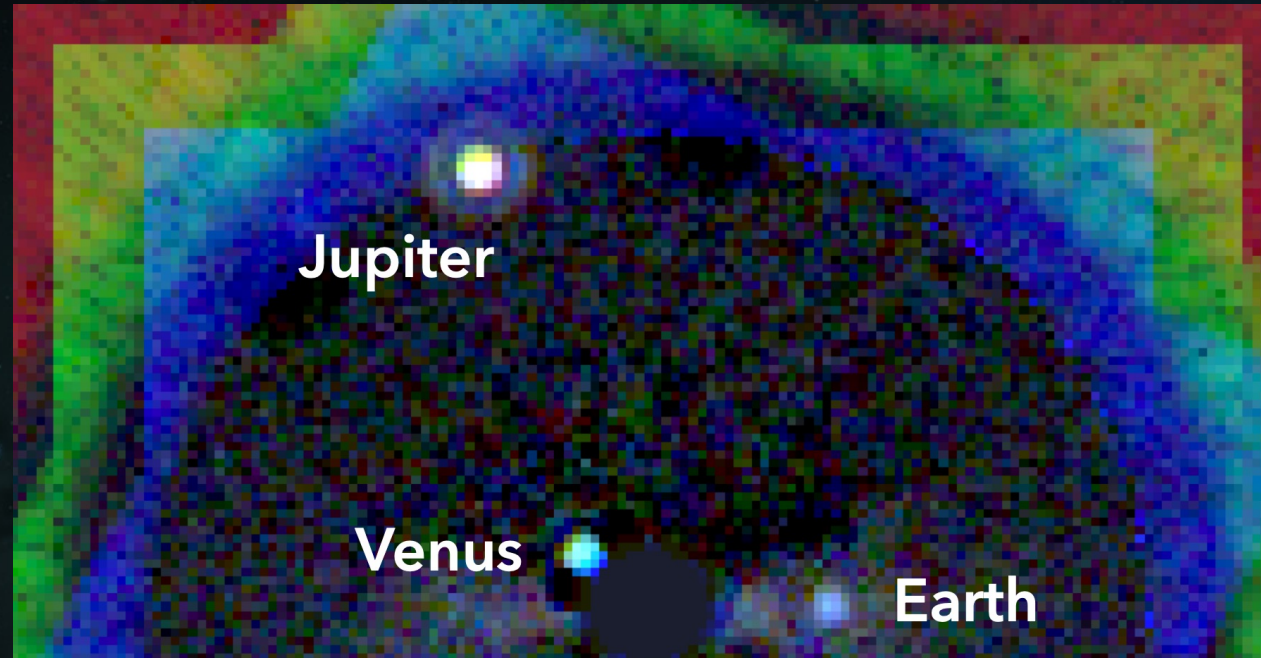
Expected yields of directly imaged exoplanets

LUVOIR Final Report, Figure 1-6

THE HABITABLE PLANET SURVEY OBSERVATIONS



THE HABITABLE PLANET SURVEY OBSERVATIONS



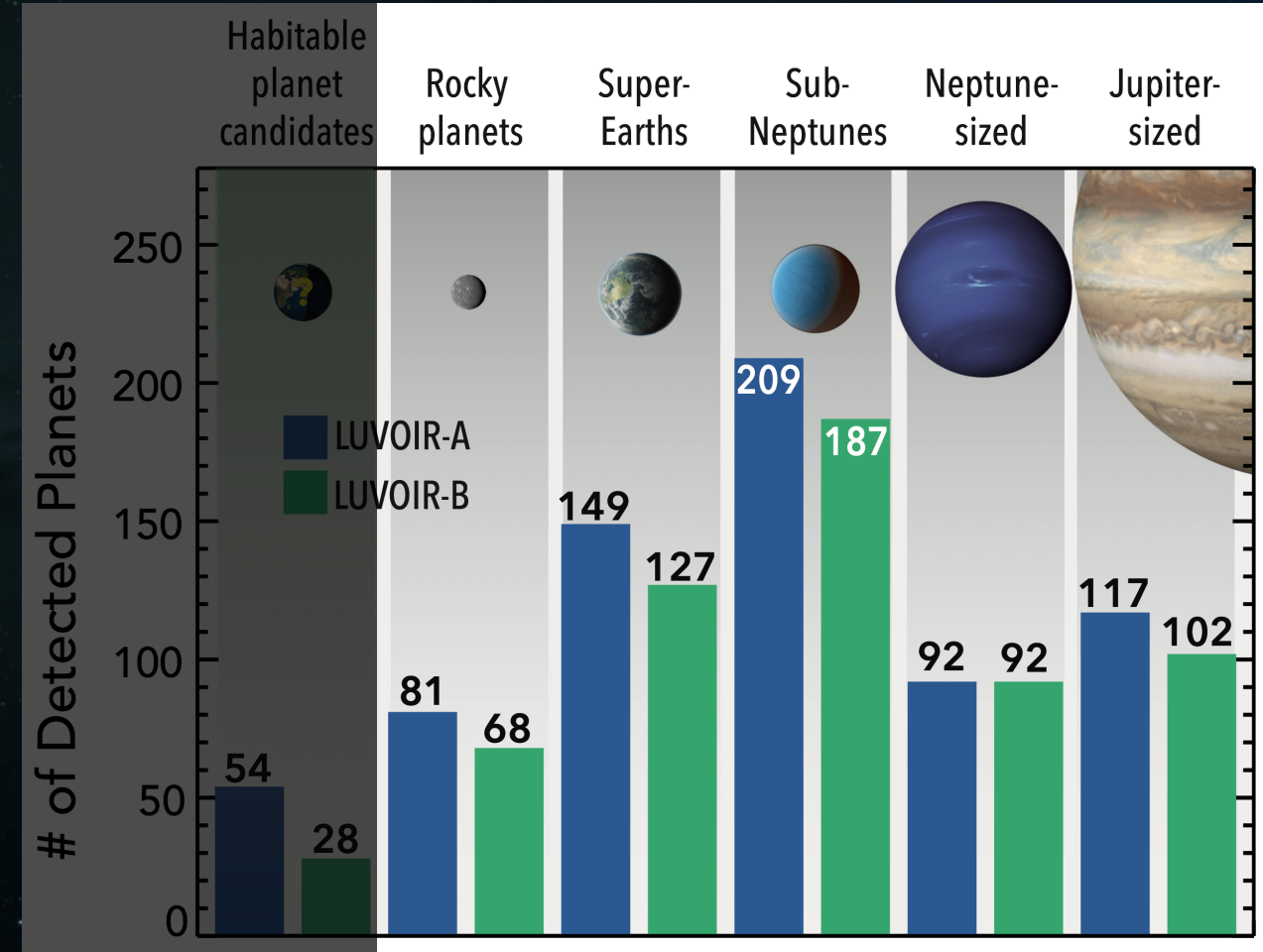
High-contrast direct imaging of hundreds of nearby stars

Preliminary characterization for every habitable planet candidate

Detailed follow-up of promising candidates

KEY GOALS FOR LUVOIR INCLUDE ...

1. Find dozens of potentially habitable exoplanets and search them for signs of life
2. Observe a wide range of exotic exoplanets to place the Solar System in context



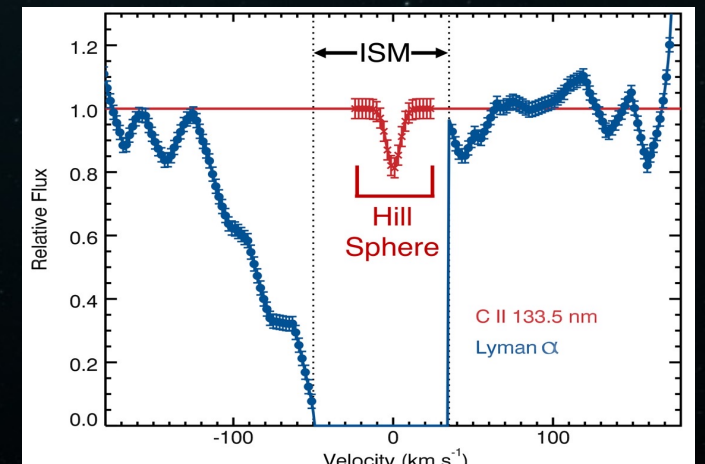
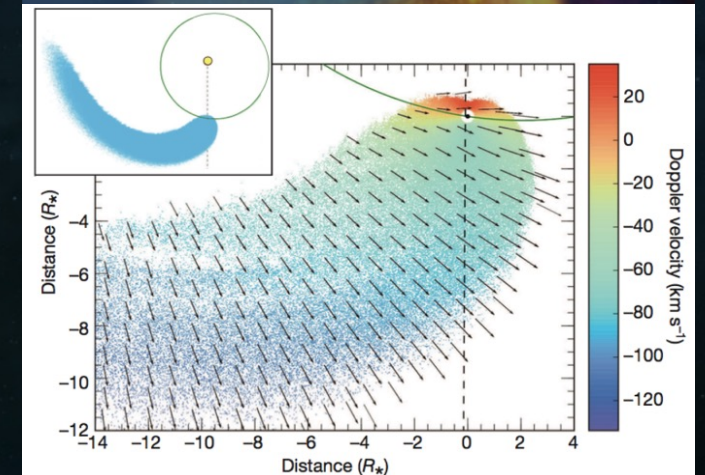
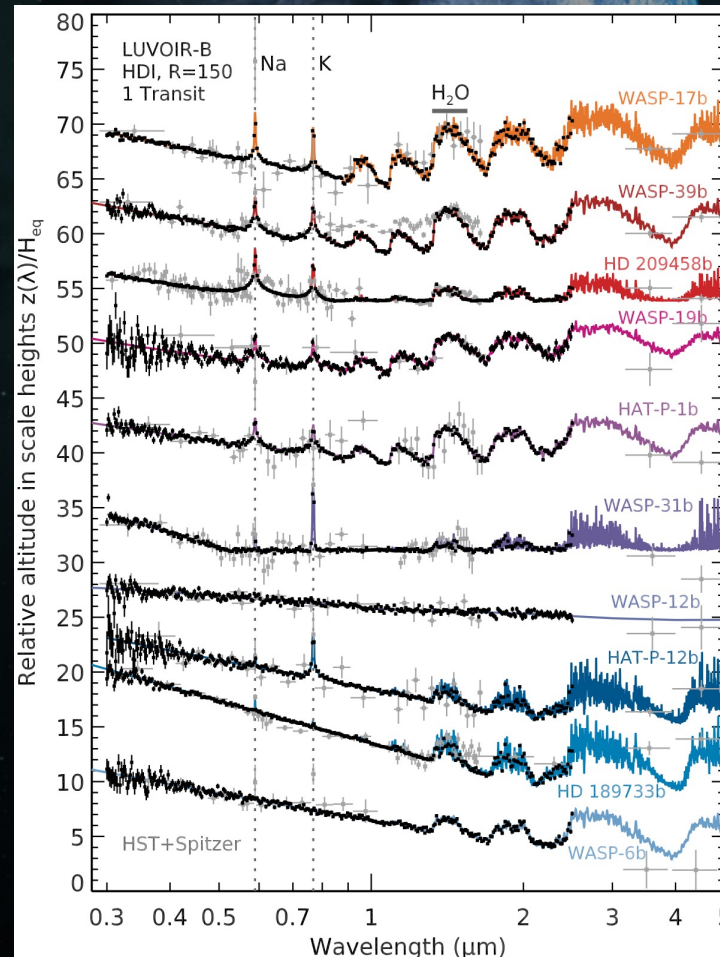
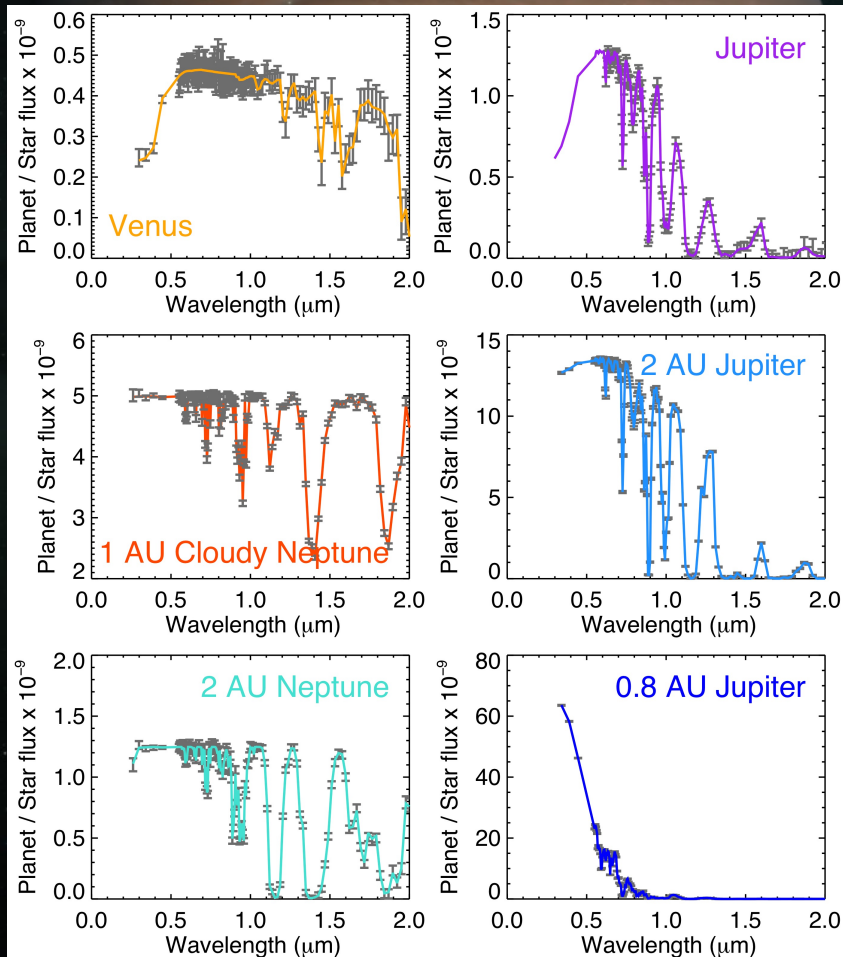
Expected yields of directly imaged exoplanets
LUVOIR Final Report, Figure 1-6

COMPARATIVE EXOPLANETOLOGY

Cold to warm planets
NUV / optical / NIR direct spectroscopy

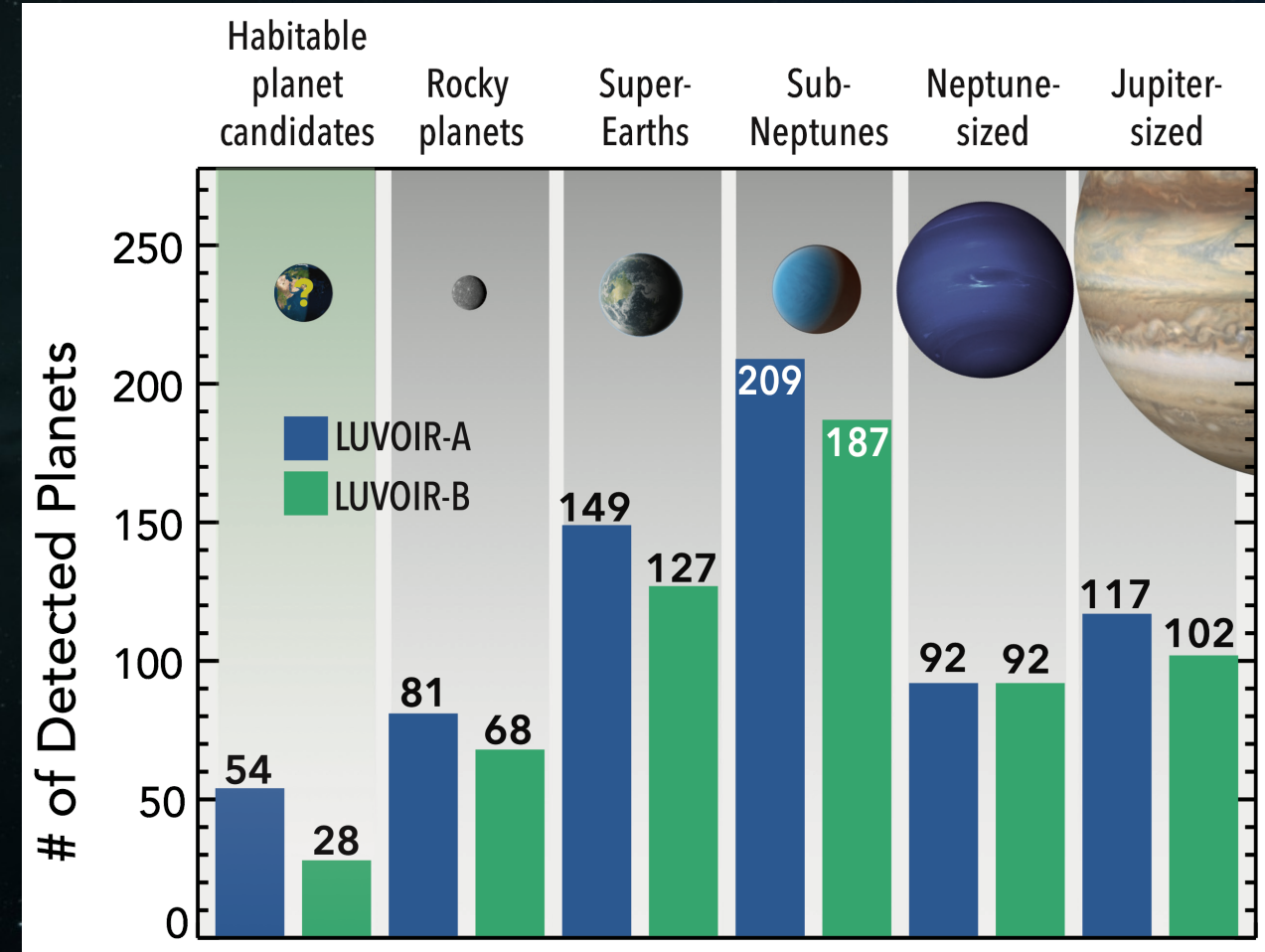
Warm to hot planets
Optical / NIR transit spectroscopy

Atmospheric escape
FUV transit spectroscopy



KEY GOALS FOR LUVOIR INCLUDE ...

1. Find dozens of potentially habitable exoplanets and search them for signs of life
2. Observe a wide range of exotic exoplanets to place the Solar System in context
3. Study the Solar System in detail to better understand what we'll see far more coarsely in exoplanet systems

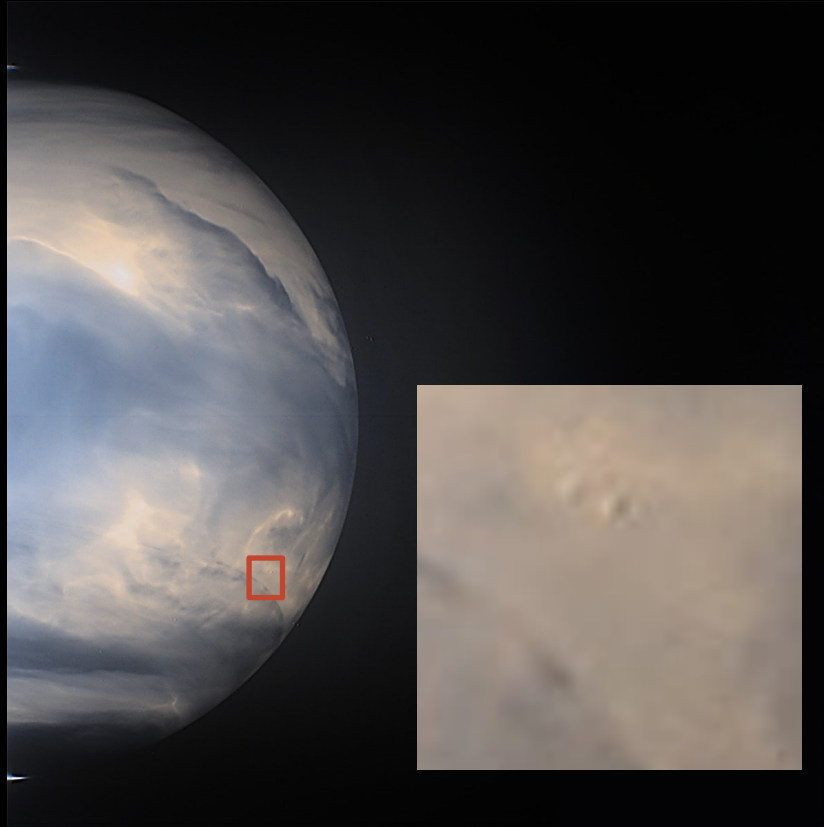


Expected yields of directly imaged exoplanets
LUVOIR Final Report, Figure 1-6

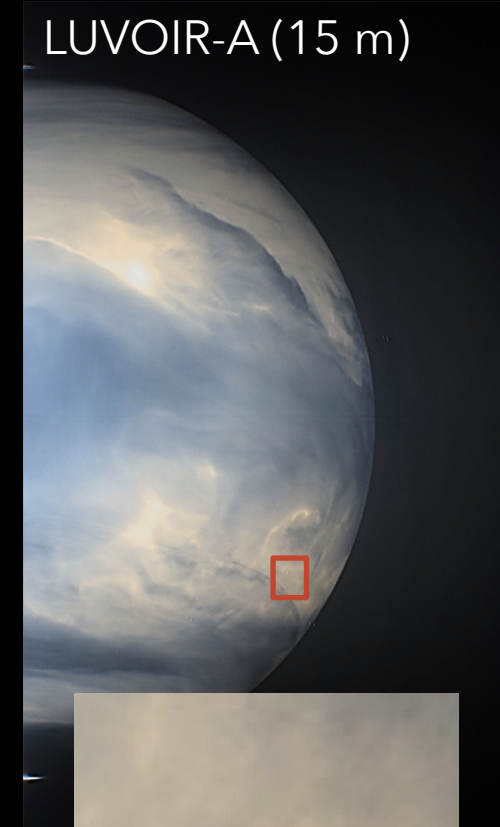
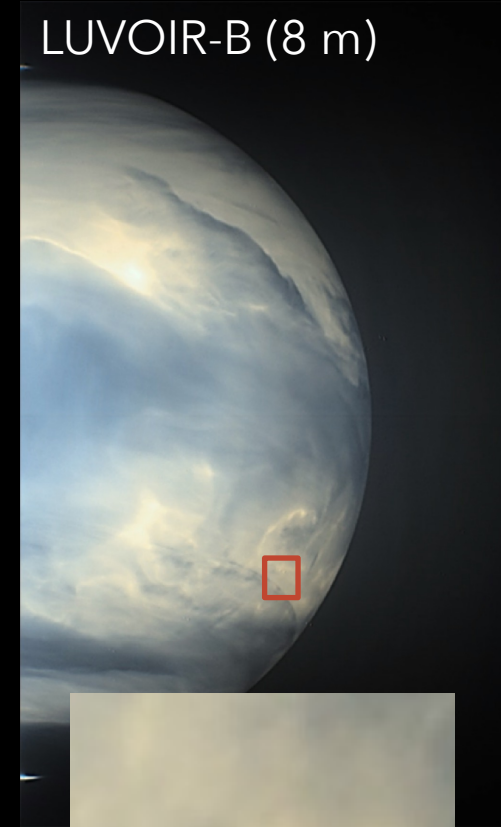
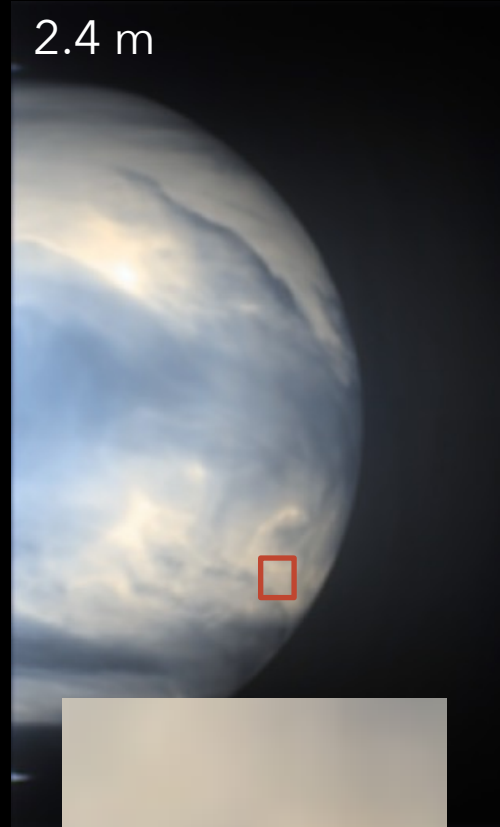
VENUS



Evolution of habitable conditions

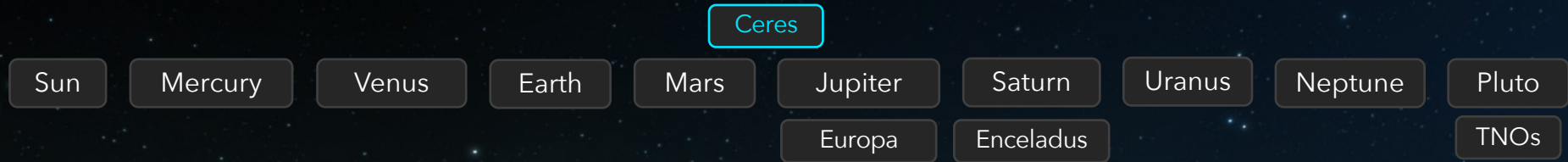


Akatsuki probe, IR2 camera
Wavelengths: 1.735 μm ; 2.26 μm ; 2.32 μm
JAXA/ISAS/DARTS/Damia Bouic



CERES

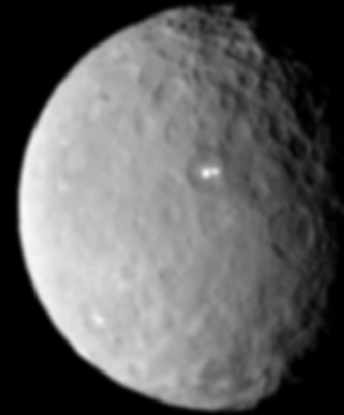
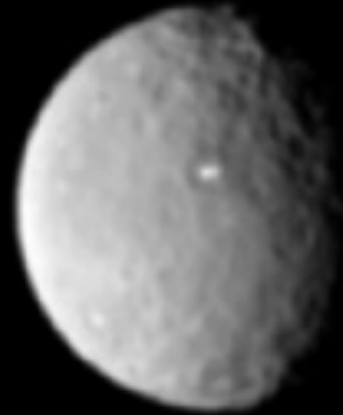
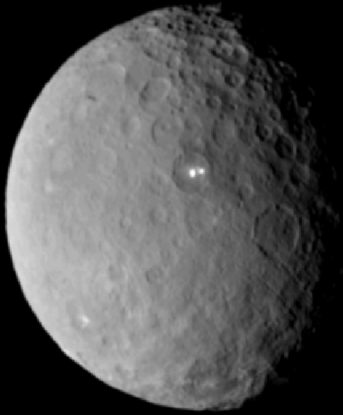
Volatiles in the asteroid belt



2.4 m

LUVOIR-B (8 m)

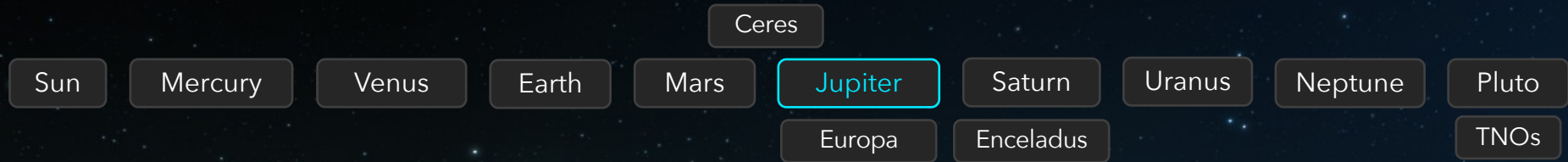
LUVOIR-A (15 m)



Dawn mission (Feb 2015)
Distance: 46000 km
Resolution 4 km/pixel
Wavelength: 550 nm
NASA/JPL-Caltech/UCLA



JUPITER



LUVOR's wide-field optical imaging resolution is near-flyby quality

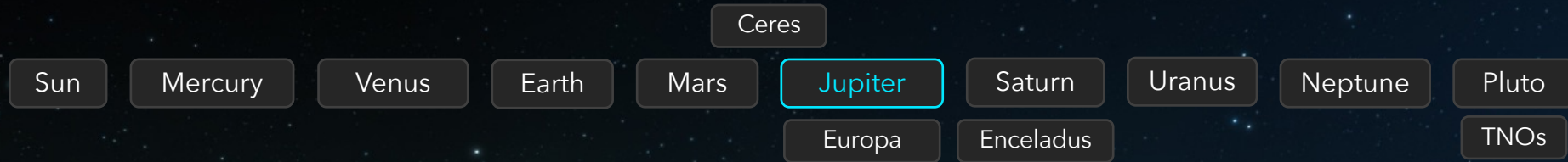
JunoCAM image: 30 km/pixel

LUVOR (15 m): 24 km resolution

NASA, Juno, SwRI, MSSS, Gerald Eichstädt & Seán Doran

JUPITER

Planetary magnetic fields



UV imaging and spatially resolved spectroscopy

Hubble provided first detailed imaging of the Jovian UV aurora

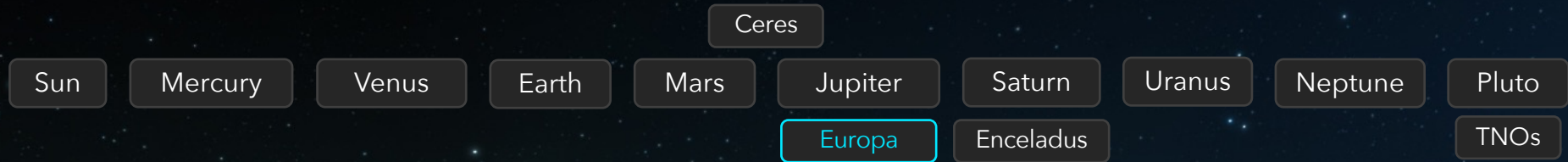
LUVOIR can monitor magnetospheric interactions at higher resolution



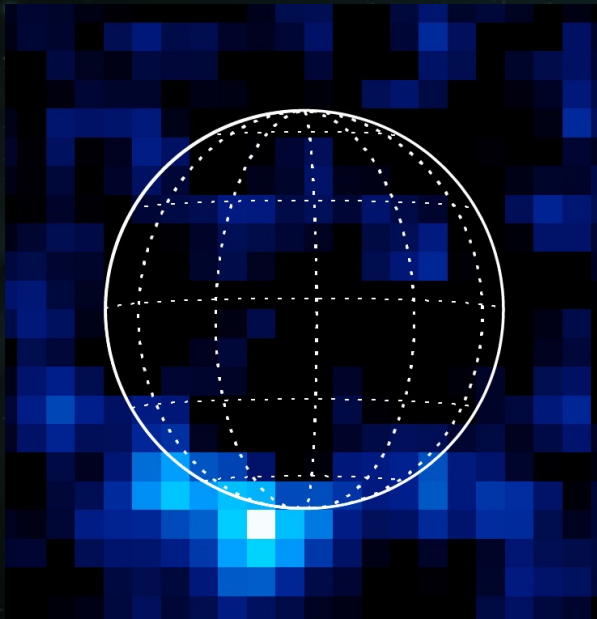
A. Mura-JIRAM / IAPS / NASA

EUROPA

Other habitable environments?



Hubble (2.4 m)



LUVOIR-B (8 m)



LUVOIR-A (15 m)

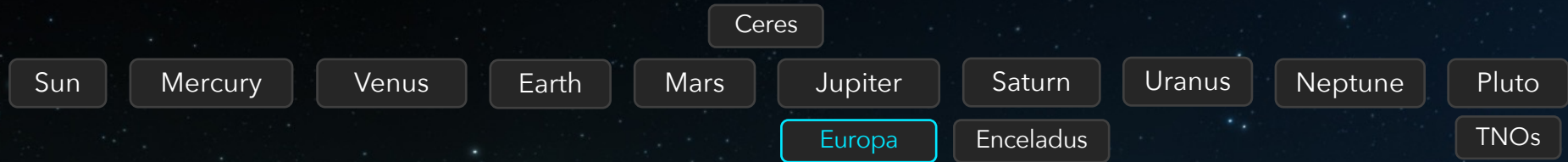


UV hydrogen Lyman- α emission from HST
Roth et al. (2014)

G. Ballester (LPL) / R. Juanola-Parramon (GSFC)
LUVOIR Lyman- α images assume 16-exposure dither pattern

EUROPA

Other habitable environments?



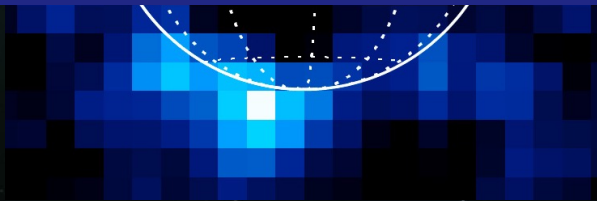
Hubble (2.4 m)

LUVOIR-B (8 m)

LUVOIR-A (15 m)

LUVOIR Signature Science Case #3

Far-UV monitoring of Europa, plus multi-epoch optical/near-IR imaging of 6 ocean moons



UV hydrogen Lyman- α emission from HST
Roth et al. (2014)



G. Ballester (LPL) / R. Juanola-Parramon (GSFC)
LUVOIR Lyman- α images assume 16-exposure dither pattern

ENCELADUS

Sun

Mercury

Venus

Earth

Mars

Jupiter

Saturn

Uranus

Neptune

Pluto

Ceres

Europa

Enceladus

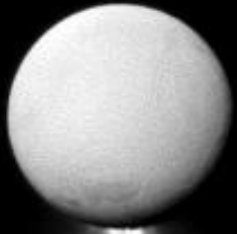
TNOs

Other habitable environments?

2.4 m

LUVOIR-B (8 m)

LUVOIR-A (15 m)



Cassini (April 2013)

ISS - Narrow angle camera

Blue filter

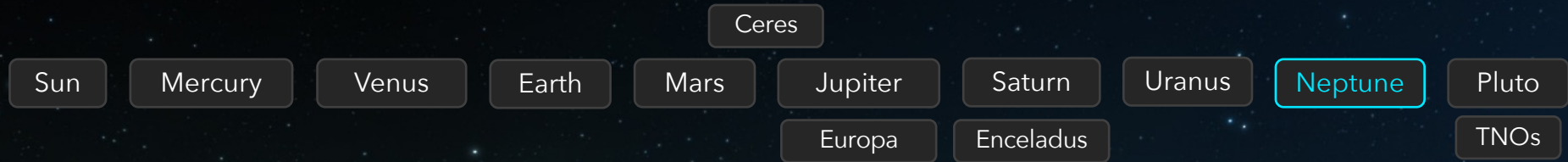
Distance: 832000 km

Resolution: 5 km/pixel

NASA/JPL-Caltech/Space Science Institute

NEPTUNE

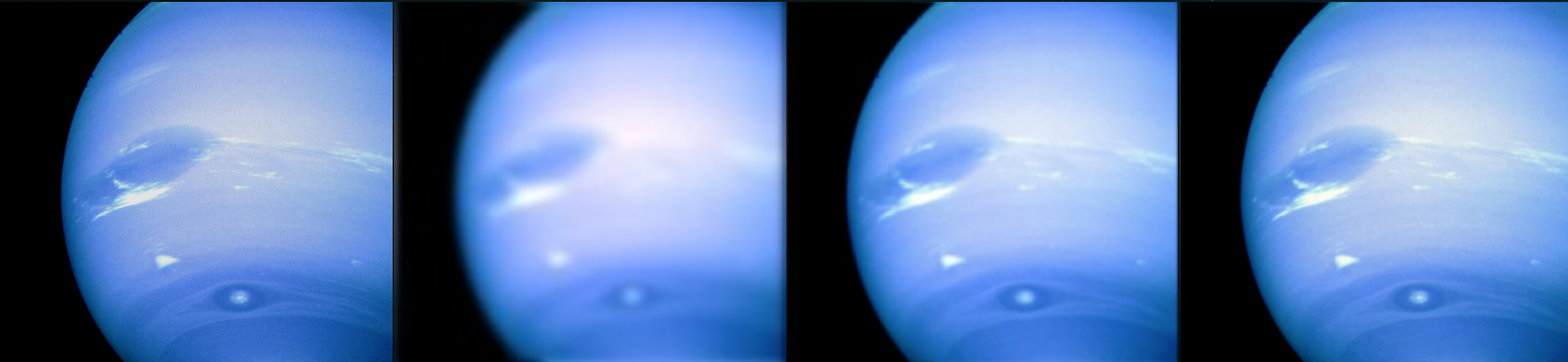
Illuminate a common class of exoplanets



2.4 m

LUVOIR-B (8 m)

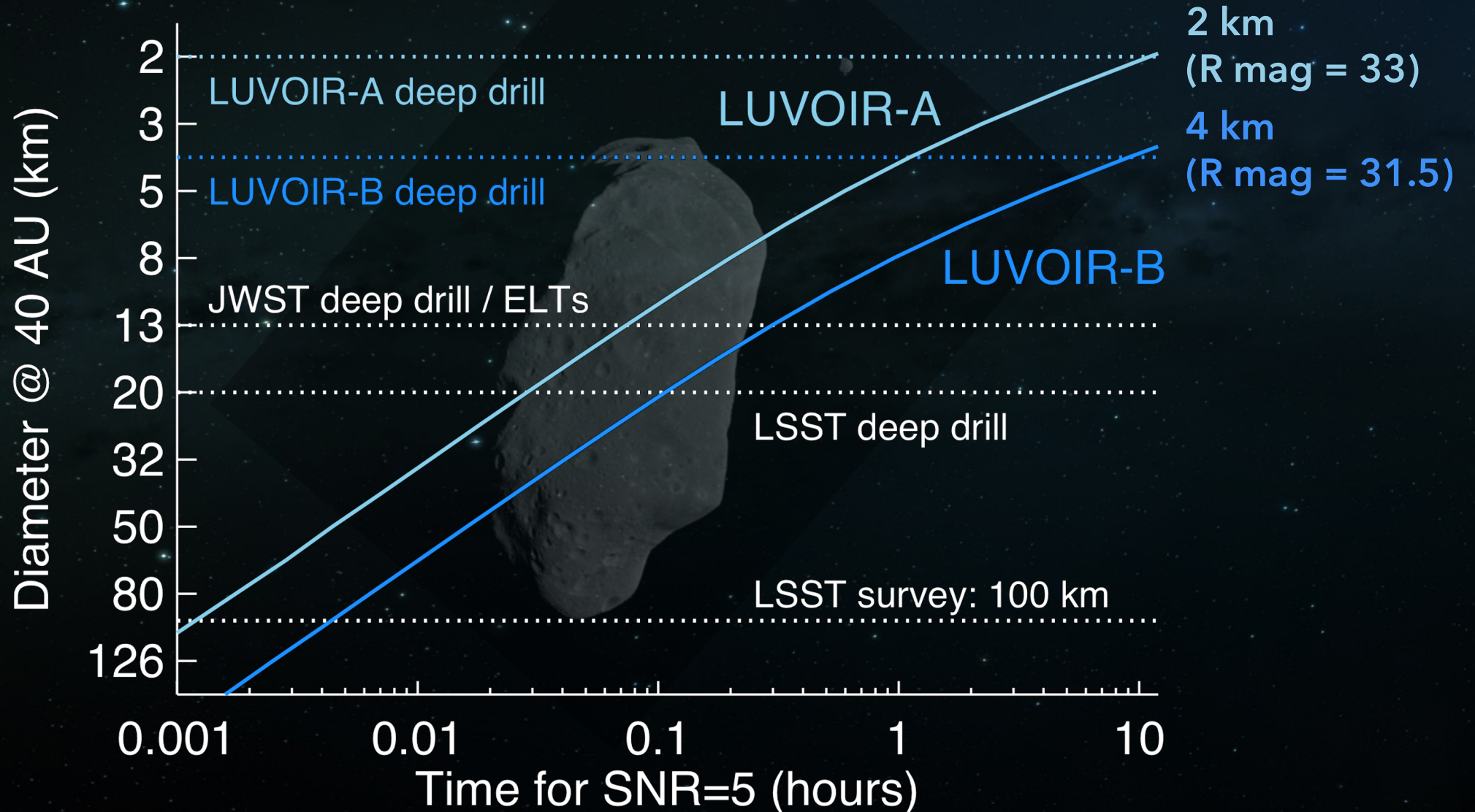
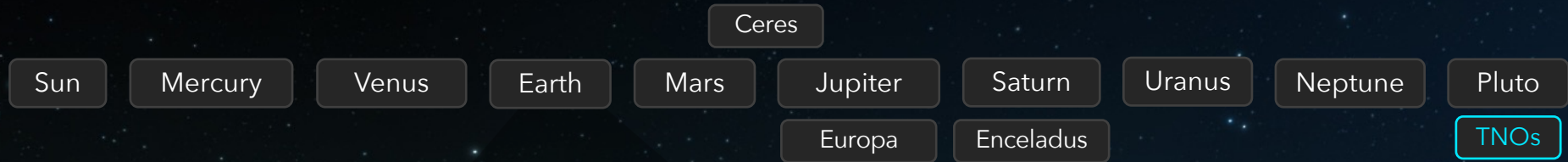
LUVOIR-A (15 m)



Voyager 2 (1989)
ISS - Narrow angle camera
Green (530-640 nm) and clear (280-640 nm) filters
NASA/JPL

TNOs

Initial stages of planet formation



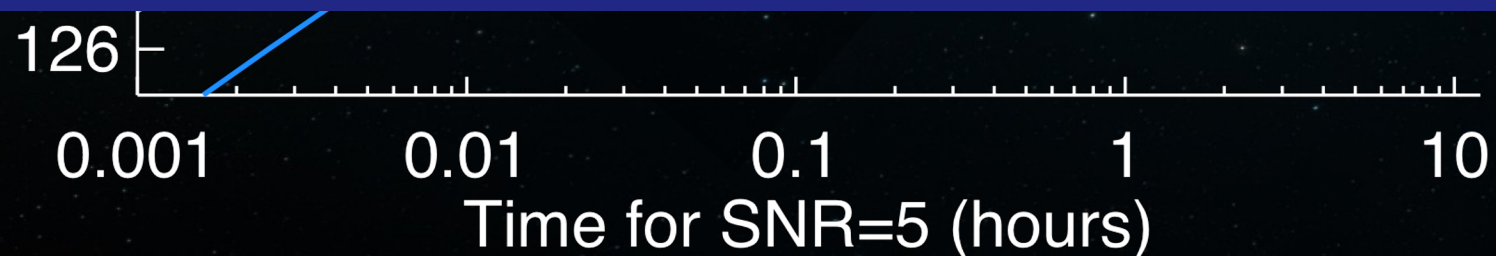
TNOs

Initial stages of planet formation



LUVVOIR Signature Science Case #6

Deep imaging survey for very small trans-Neptunian objects to constrain models of planetesimal formation and debris disk evolution



SUMMARY



The LUVOIR mission concept was studied in detail for 3.5 years and built upon extensive earlier work on similar concepts

LUVOIR can deliver observations with very high spatial resolution throughout much of the Solar System

LUVOIR's sensitivity makes currently daunting projects routine and impossible ones feasible

The combination of LUVOIR's exoplanets and Solar System science will enable deeper understanding of both areas

<https://www.luvoirtelescope.org>



Backup

PLUTO

Sun

Mercury

Venus

Earth

Mars

Jupiter

Saturn

Uranus

Neptune

Pluto

TNOs

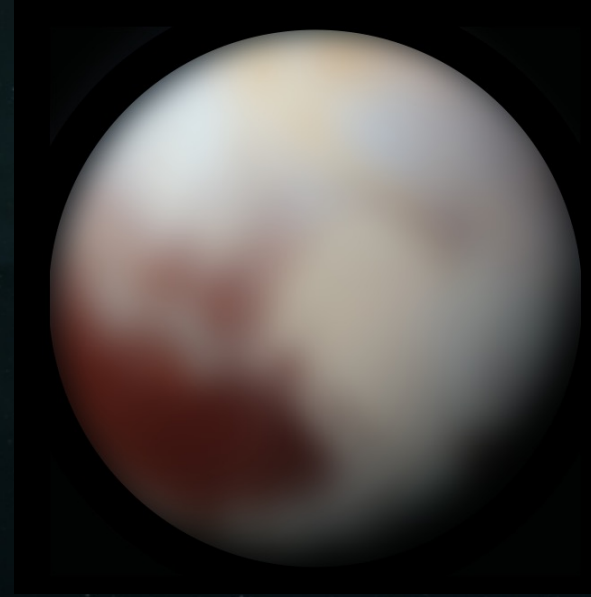
Europa

Enceladus

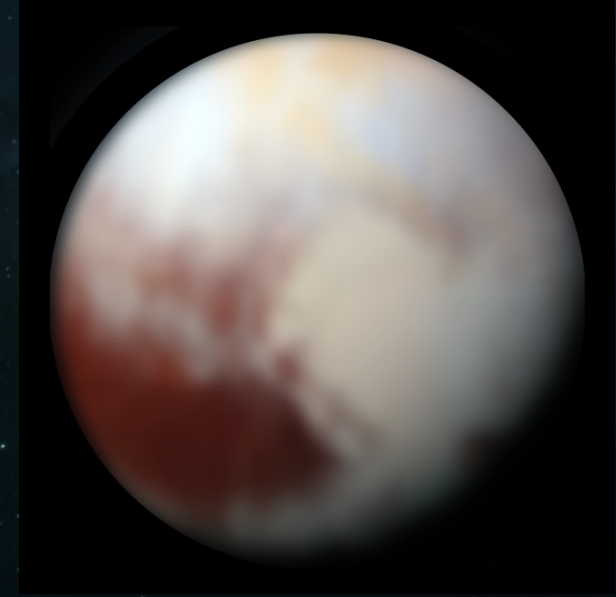
Hubble
Buie et al (2010)



LUVOIR-B (8 m)



LUVOIR-A (15 m)



New Horizons (July 2015)

MVIC camera:

400 - 550 nm (blue)

540 - 700 nm (red)

780 - 975 nm (NIR)

Resolution 1.3 km/pixel

NASA/JHUAPL

LUVOIR-A deployment and pointing sequence



Watch video at <https://www.luvoirtelescope.org/design>