BIG BANG TO BIOSIGNATURES: THE LUVOIR MISSION CONCEPT

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LUVOIR study scientist

Science with the HST and JWST Telescopes 5

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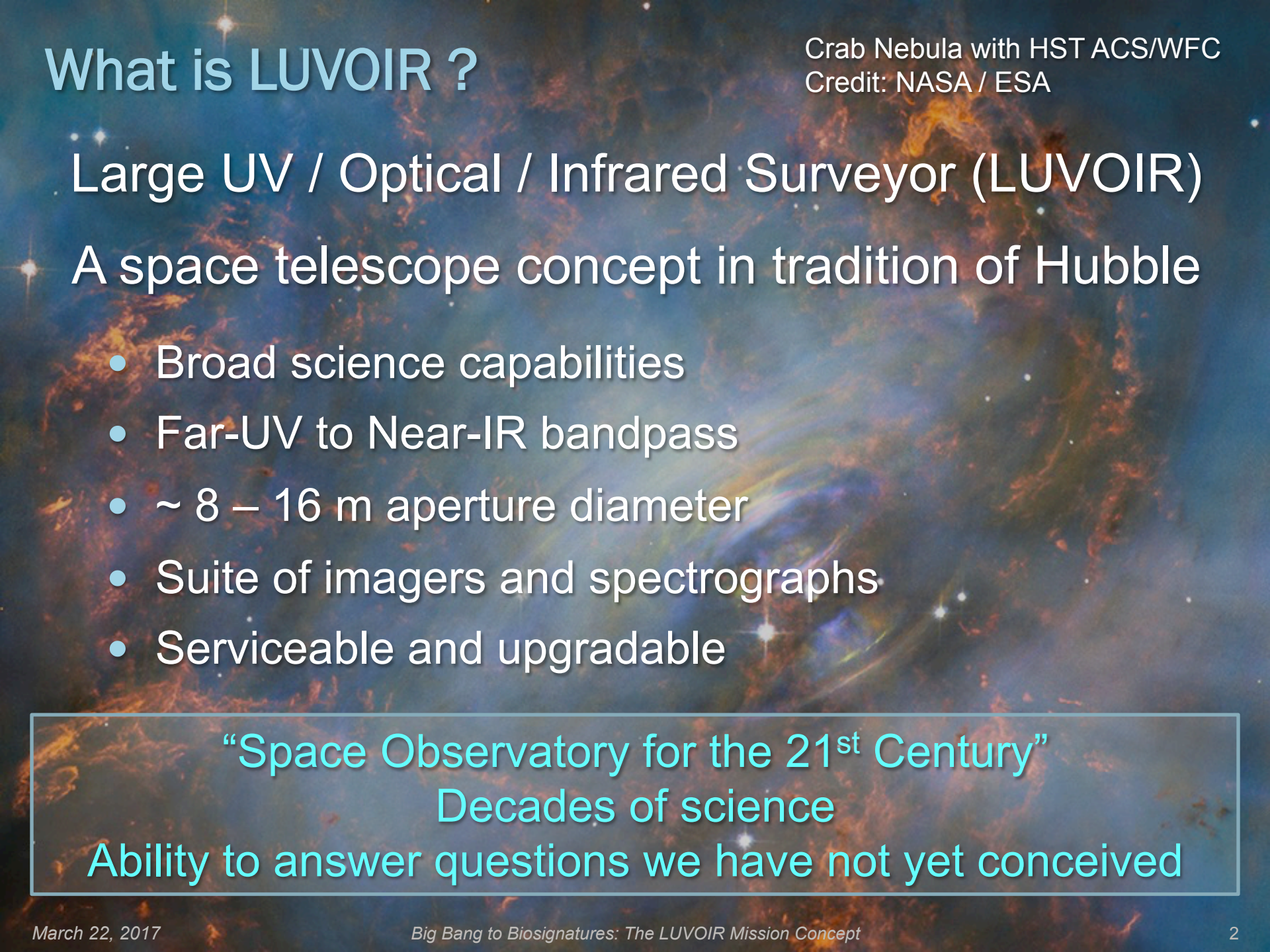
March 22, 2017

What is LUVOIR ?


Crab Nebula with HST ACS/WFC
Credit: NASA / ESA

Large UV / Optical / Infrared Surveyor (LUVOIR)

A space telescope concept in tradition of Hubble

- Broad science capabilities
- Far-UV to Near-IR bandpass
- ~ 8 – 16 m aperture diameter
- Suite of imagers and spectrographs
- Serviceable and upgradable

"Space Observatory for the 21st Century"
Decades of science
Ability to answer questions we have not yet conceived

Imagine astronomy without Hubble …

Eagle Nebula
(high resolution over wide field)

Hubble Ultra Deep Field
(ultra-deep imaging)

Jupiter's aurora
(UV, global monitoring)

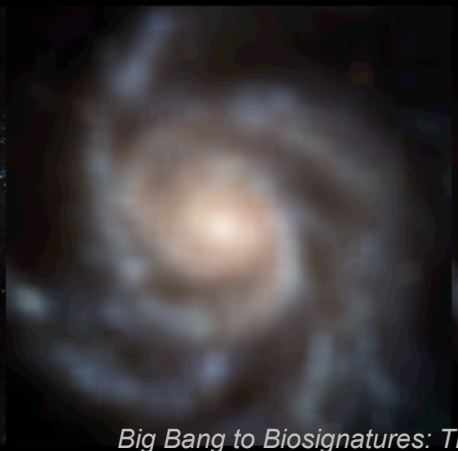
Imagine astronomy with LUVOIR …

Hypothetical planet "Nine"
Located at ~1000 AU
Diameter of 40,000 km

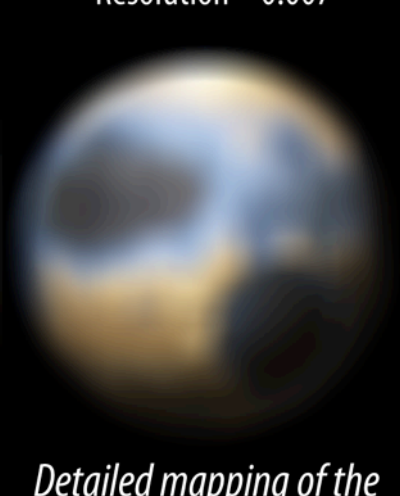
Hubble Space Telescope (HST)
Best optical resolution (2016)
2.5m diameter (0.05")

LUVOIR
6m diameter
Resolution ~0.02"

Clear Identification of local differences



LUVOIR
18m diameter
Resolution ~0.007"



Detailed mapping of the surface morphologies and composition anisotropies

How we're doing the study

NASA started four large mission concept studies in Jan 2016 to prepare for Astro2020 Decadal Survey

- LUVOIR
- Habitable Exoplanet Imaging Mission (HabEx)
- Origins Space Telescope (aka. Far-IR Surveyor)
- X-Ray Surveyor

Two LUVOIR mission architectures to be studied

- Aperture sizes chosen Nov 2016: 15-m and ~ 9-m

Study office and engineering team at GSFC

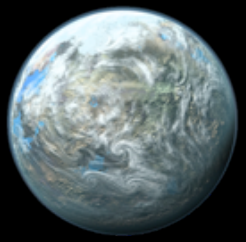
How we're doing the study

Science and Technology Definition Team

- 24 voting members from community
- 8 non-voting reps. of international space agencies

Six Community Working Groups

- Exoplanets
- Cosmic Origins
- Solar System
- Simulations
- Communications
- Technology



Four Instrument Teams

STDT voting members


Debra Fischer
(Yale)


Brad Peterson
(Ohio State / STScI)


Jacob Bean
(Chicago)


Daniela Calzetti
(U Mass)


Rebekah Dawson
(Penn State)


Courtney Dressing
(Caltech)


Lee Feinberg
(NASA GSFC)


Kevin France
(Colorado)


Olivier Guyon
(Arizona)


Walter Harris
(Arizona / LPL)


Mark Marley
(NASA Ames)


Leonidas Moustakas
(JPL)


John O'Meara
(St. Michael's)


Vikki Meadows
(Washington)


Ilaria Pascucci
(Arizona)


Marc Postman
(STScI)


Laurent Pueyo
(STScI)


David Redding
(JPL)


Jane Rigby
(NASA GSFC)


Aki Roberge
(NASA GSFC)


David Schiminovich
(Columbia)


Britney Schmidt
(Georgia Tech)


Karl Stapelfeldt
(JPL)


Jason Tumlinson
(STScI)

The LUVOIR instruments

Observational challenge

Faint planets next to bright stars

Solution

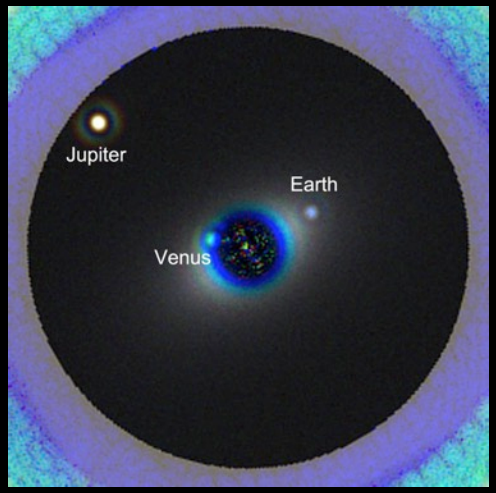
Optical / Near-IR Coronagraph

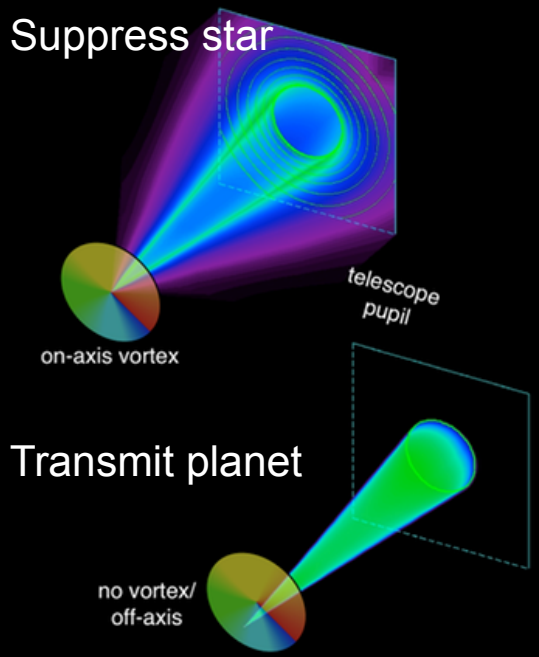
Contrast < 10^{-10} to observe exoEarths

Low resolution spectroscopy (R > 150)

Bandpass: 0.2 μm to 2.4 μm

Tech development via WFIRST coronagraph





Vector vortex coronagraph
(Credit: D. Mawet)

The LUVOIR instruments

Observational challenge

No UV through Earth's atmosphere

Solution

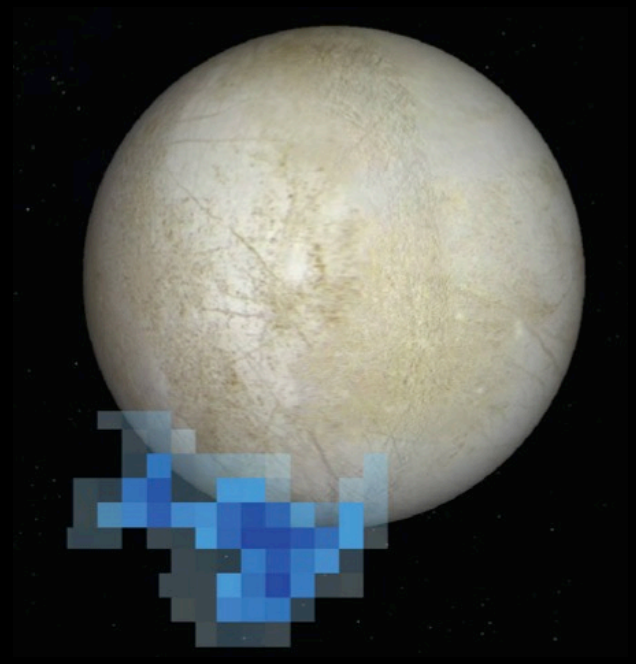
LUMOS

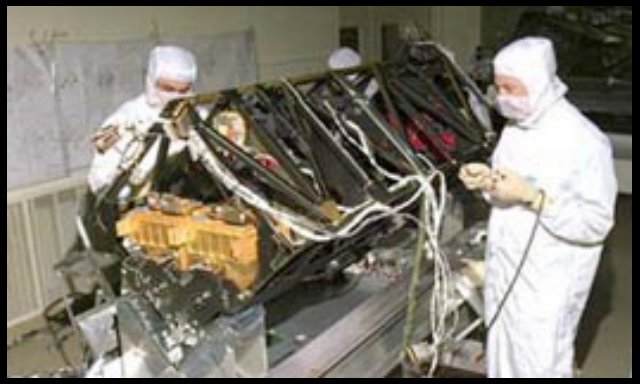
Far-UV to near-UV spectroscopy

Multi-object capability

Near-UV imaging

Major upgrade of HST STIS





HST STIS UV instrument

The LUVOIR instruments

Observational challenge

Imaging deep fields at high resolution

Solution

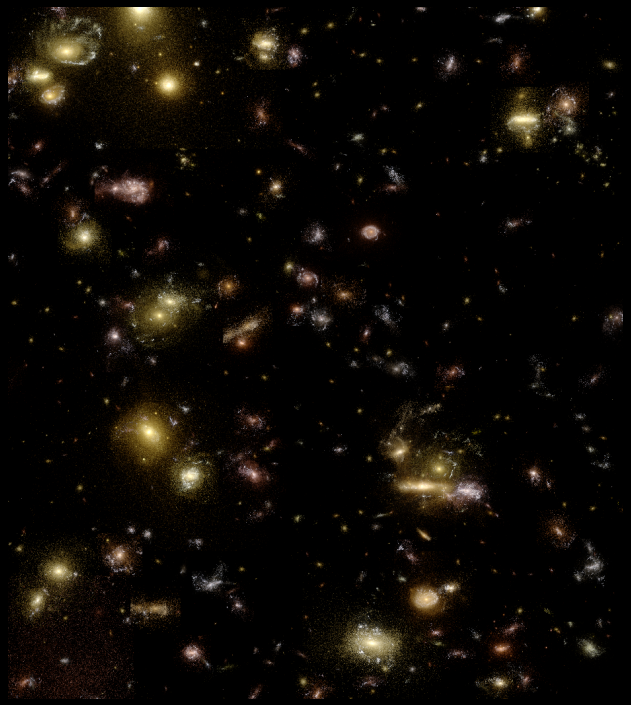
High-Definition Imager

2 x 3 arcmin field-of-view

Optical to near-IR bandpass

High precision astrometry mode

Major upgrade of HST WFC3



HST Wide Field Camera 3

The LUVOIR instruments

Observational challenge

Measuring warm molecules present in Earth's atmosphere

Solution

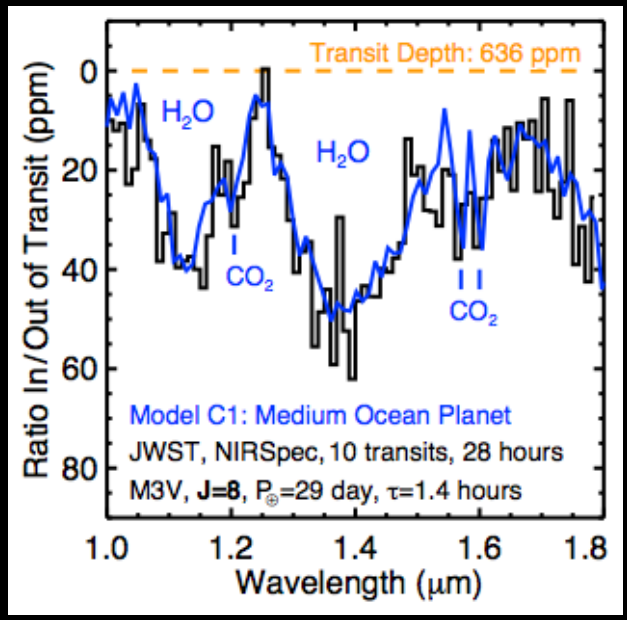
Optical / Near-IR Spectrograph

Multiple resolutions up to R ~ 10^5

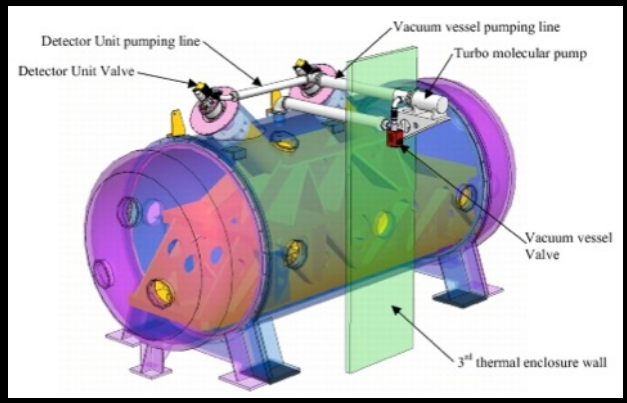
High photometric precision for transits

Possibly high precision RV to measure planet masses

Ground-based analogs in development



Credit: Natasha Batalha



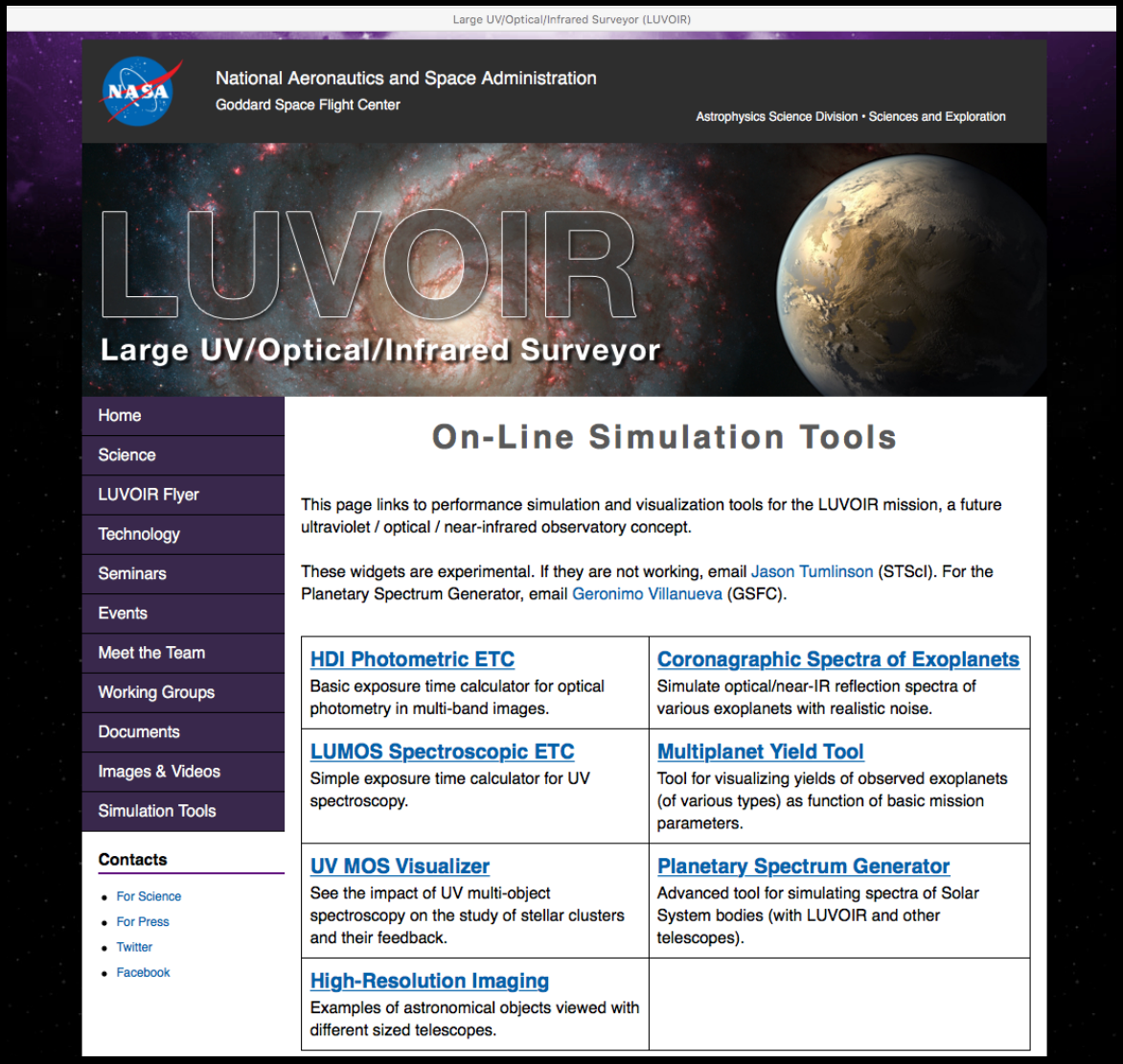
ESPRESSO spectrograph for VLT (Credit: ESO)

POLLUX: a European contribution to the LUVOIR mission study

- POLLUX is a concept for a UV spectro-polarimeter with high resolution point-source capability (R ~ 10^5)
- Complimentary to the LUMOS instrument
- To be defined & designed by a consortium of 10 European institutions, with leadership/support from CNES
  - Instrument leads: Coralie Neiner & Jean-Claude Bouret
- The conceptual study conducted by CNES could serve as a support for a future ESA contribution

LUVOIR online simulation tools in development

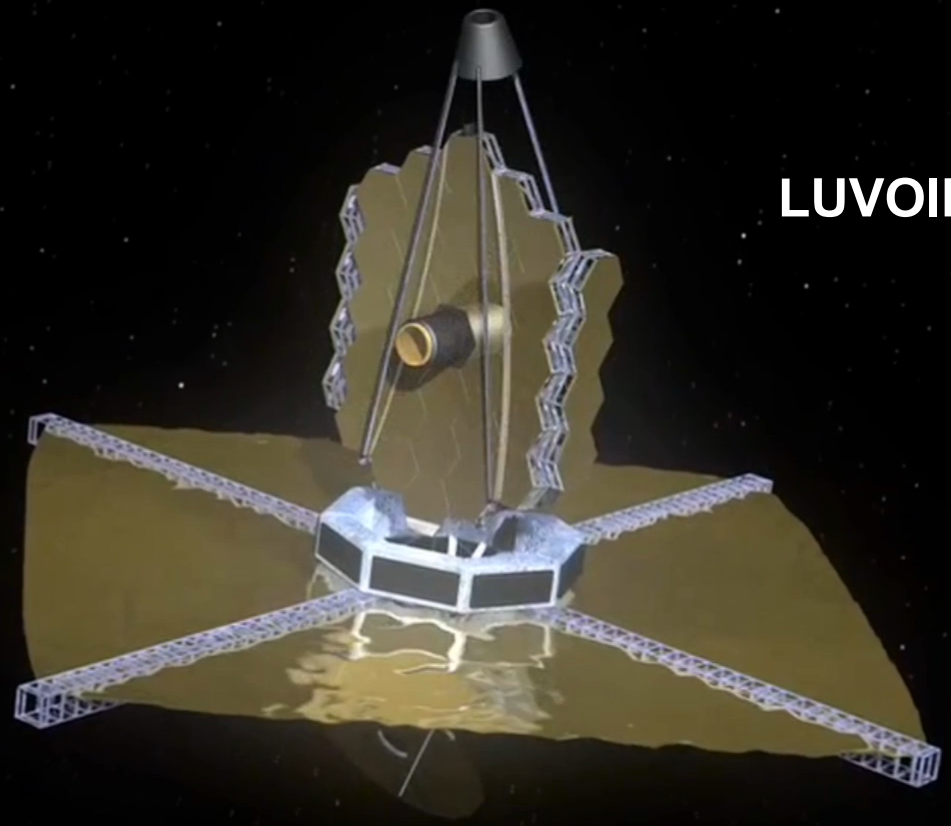
http://asd.gsfc.nasa.gov/luvoir/tools/



Technological challenges

Deployment of large segmented telescope

To be demonstrated by JWST



LUVOIR deployment

Technological challenges

Need heavy lift launch vehicle with large fairing

Suitable vehicles (SLS and commercial) in development

Compatibility of UV and coronagraphy

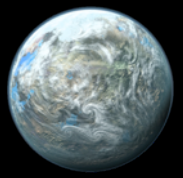
New lab work shows UV reflective mirrors are just fine for coronagraphy

Ultra-high contrast observations with a segmented telescope

Coronagraphs can be designed for segmented telescopes. Working hard to demonstrate needed system stability

Series of short, readable “LUVOIR Tech Notes” available at
http://asd.gsfc.nasa.gov/luvoir/tech/

Difference between LUVOIR and HabEx ?



Both LUVOIR and HabEx have two primary science goals

- Habitable exoplanets & biosignatures
- Broad range of general astrophysics

The two architectures will be driven by difference in focus

- For LUVOIR, both goals are on equal footing. LUVOIR will be a general purpose "great observatory", a successor to HST and JWST in the ~ 8 – 16 m class
- HabEx will be optimized for exoplanet imaging, but also enable a range of general astrophysics. It is a more focused mission in the ~ 4 – 8 m class

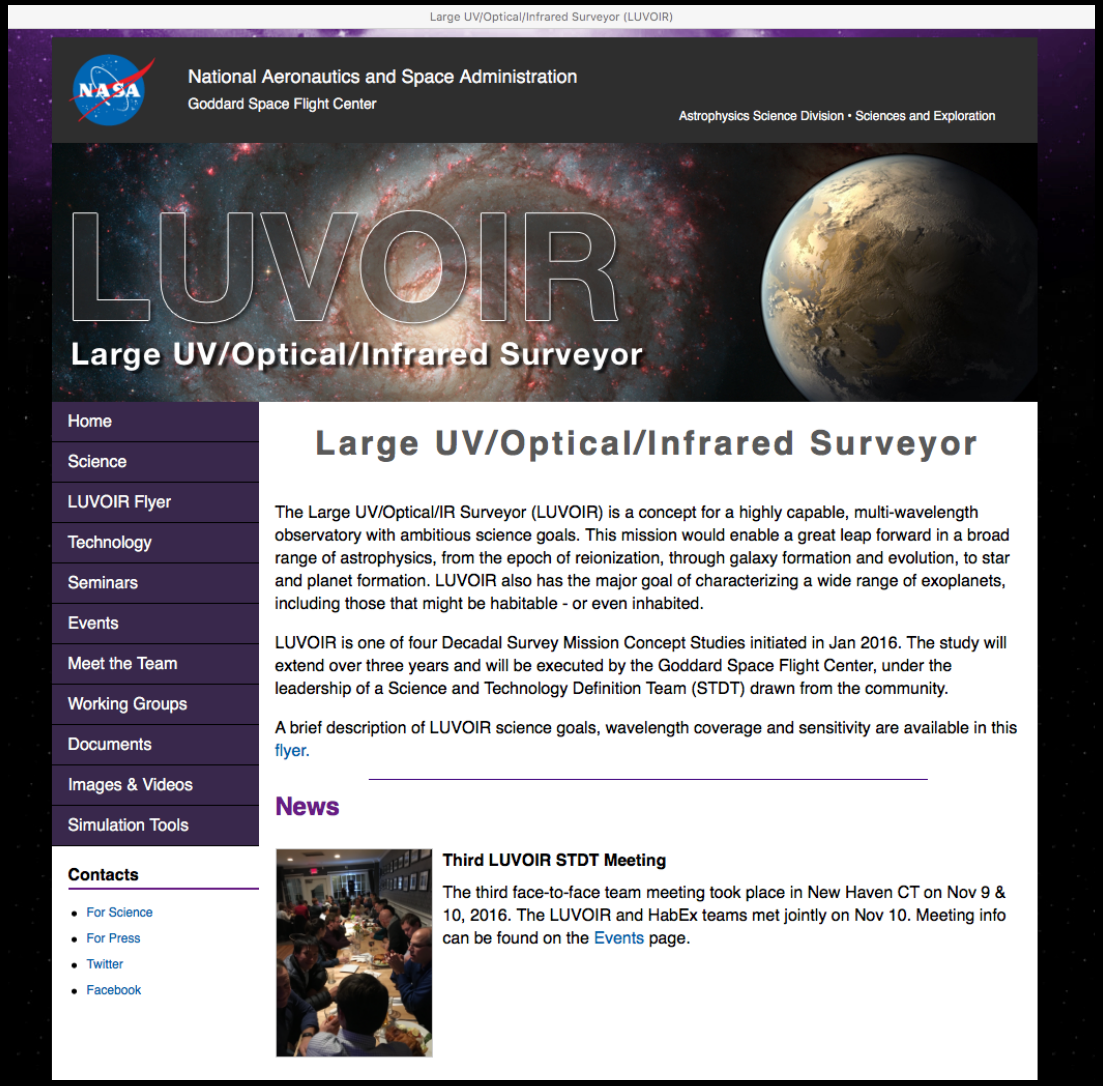
Similar exoplanet goals, differing in quantitative levels of ambition

- HabEx will *explore* the nearest stars to "search for" signs of habitability & biosignatures via direct detection of reflected light
- LUVOIR will *survey* more stars to "constrain the frequency" of habitability & biosignatures and produce a statistically meaningful sample of exoEarths

The two studies will provide a continuum of options for a range of futures

Get involved with LUVOIR

http://asd.gsfc.nasa.gov/luvoir/



4th meeting Apr 17 – 18, 2017 at JPL

Observers welcome at all LUVOIR meetings & telecons

Interim Report: Dec 2017

Final Report: Jan 2019