Science Drivers for LUVOIR

Mapping the Emergence of Complexity

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

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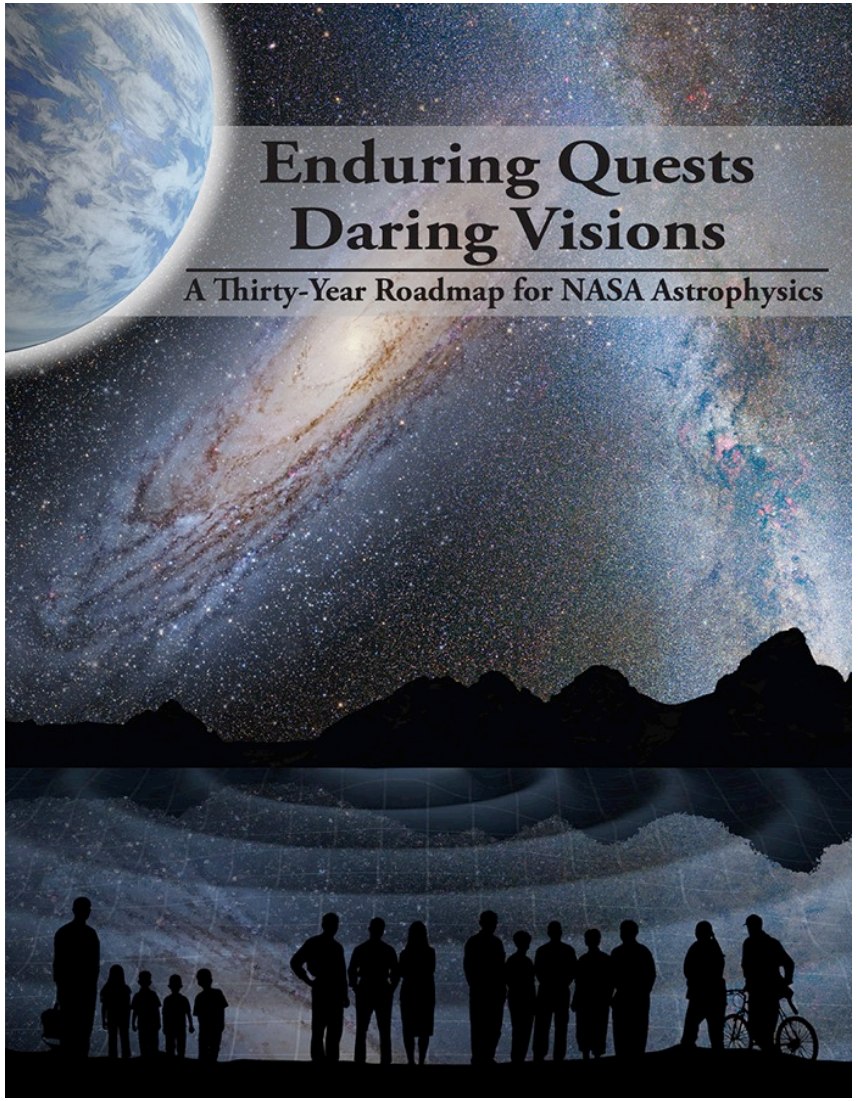
Science & Technology Definition Team (STDT)

Large Ultraviolet Optical Infrared (LUVOIR) 2020 Flagship Study

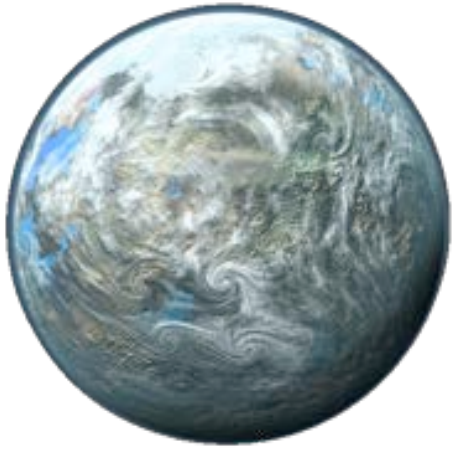
From the early universe to habitable worlds

- The Observatory
  - General purpose, multi-wavelength observatory with expansive capabilities for Cosmic Origins and Exoplanetary Science.
- The scientific motivation
  - Firmly rooted in previous Decadals' goals.
- The "LUVOIR" conceptualization
  - Comes from the **2013** NASA Astrophysics 30-year Visionary Roadmap. This is worth reading!



NASA PAGs' Vision of LUVOIR (**2015**)

- Primary Science Goals
  - Definitive Cosmic Origins science capability
  - Direct imaging of Earth analogs, including bio-signature characterization
- General Capabilities
  - **FUV to (Near) IR wavelength sensitivity**
  - **High-contrast imaging capability (~ 10^{-10})**
  - **Aperture diameter of order 8 – 16 m**
  - Suite of imagers and spectrographs, both slit and integral field
- Earlier concepts including ATLAST and HDST give insight into science motivation framework



LUVOIR Capabilities for Cosmic Origins

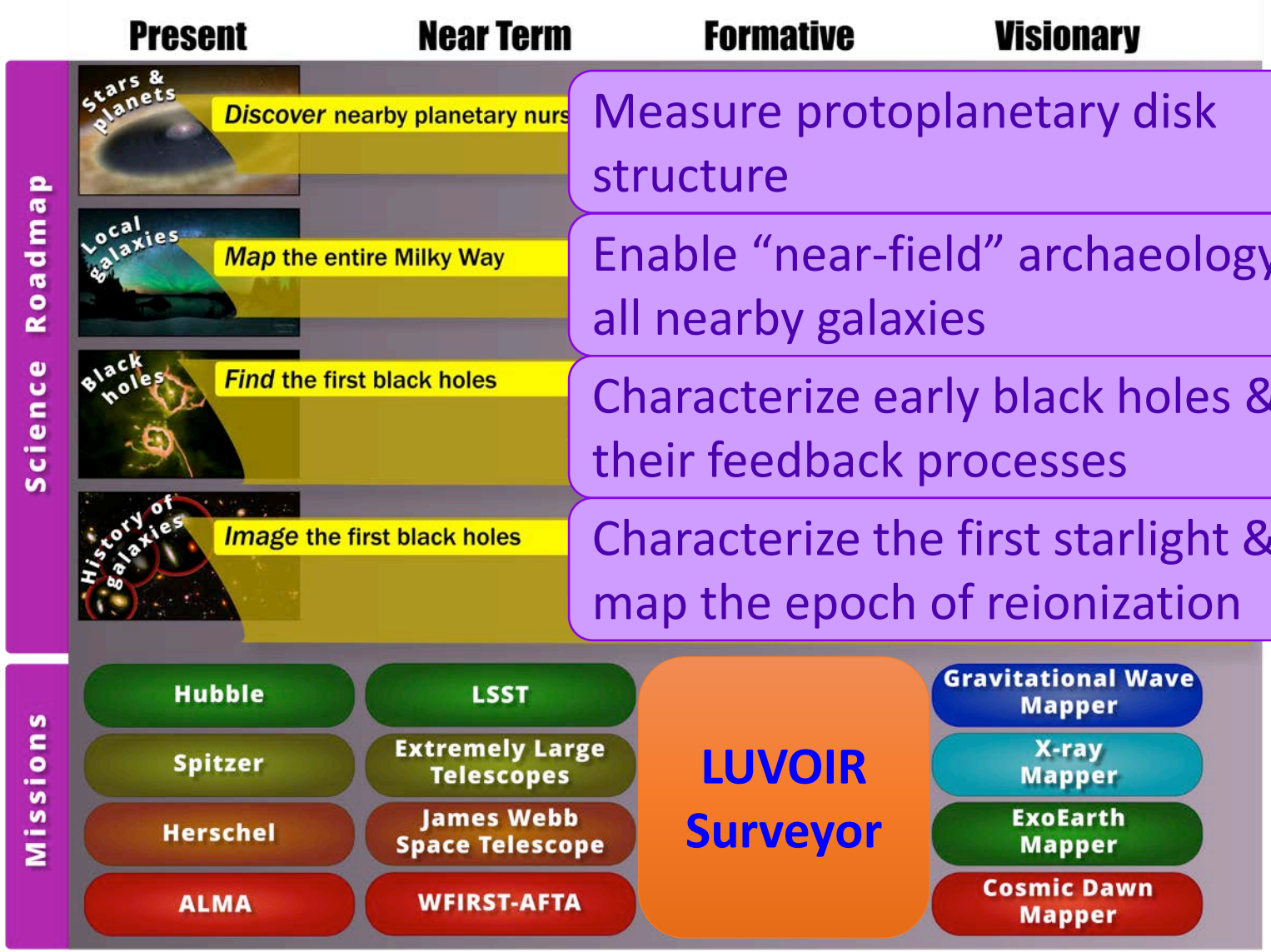
- Capability Drivers
  - High imaging resolution
  - Spectroscopic integral field multiplexing
  - Spectroscopic resolution for emission line mapping and tomography
  - Wavelength reach giving high sensitivity in the ultraviolet
  - Sensitivity to allow 100-1000-fold improvement in speed for large samples
- LUVOIR's Properties & Complement
  - Large ~8-16 meter aperture
  - ~0.1-2 um wavelength range
  - Non-cryogenic to optimize ultraviolet performance
  - Stability with appropriate sensing and control
  - Broad instrument complement

Cosmic Origins Science Goals

How, when, and where does “complexity” emerge in the universe?

- ❖ Structure Emergence, and interplay with radiation
- ❖ Chemical Emergence, from elements to complex molecules
- ❖ Life Emergence, across the Galaxy

Cosmic Origins Science Goals



Measure protoplanetary disk structure

Enable “near-field” archaeology of all nearby galaxies

Characterize early black holes & their feedback processes

Characterize the first starlight & map the epoch of reionization

A Baryonic Story…

The Circum-Galactic Medium

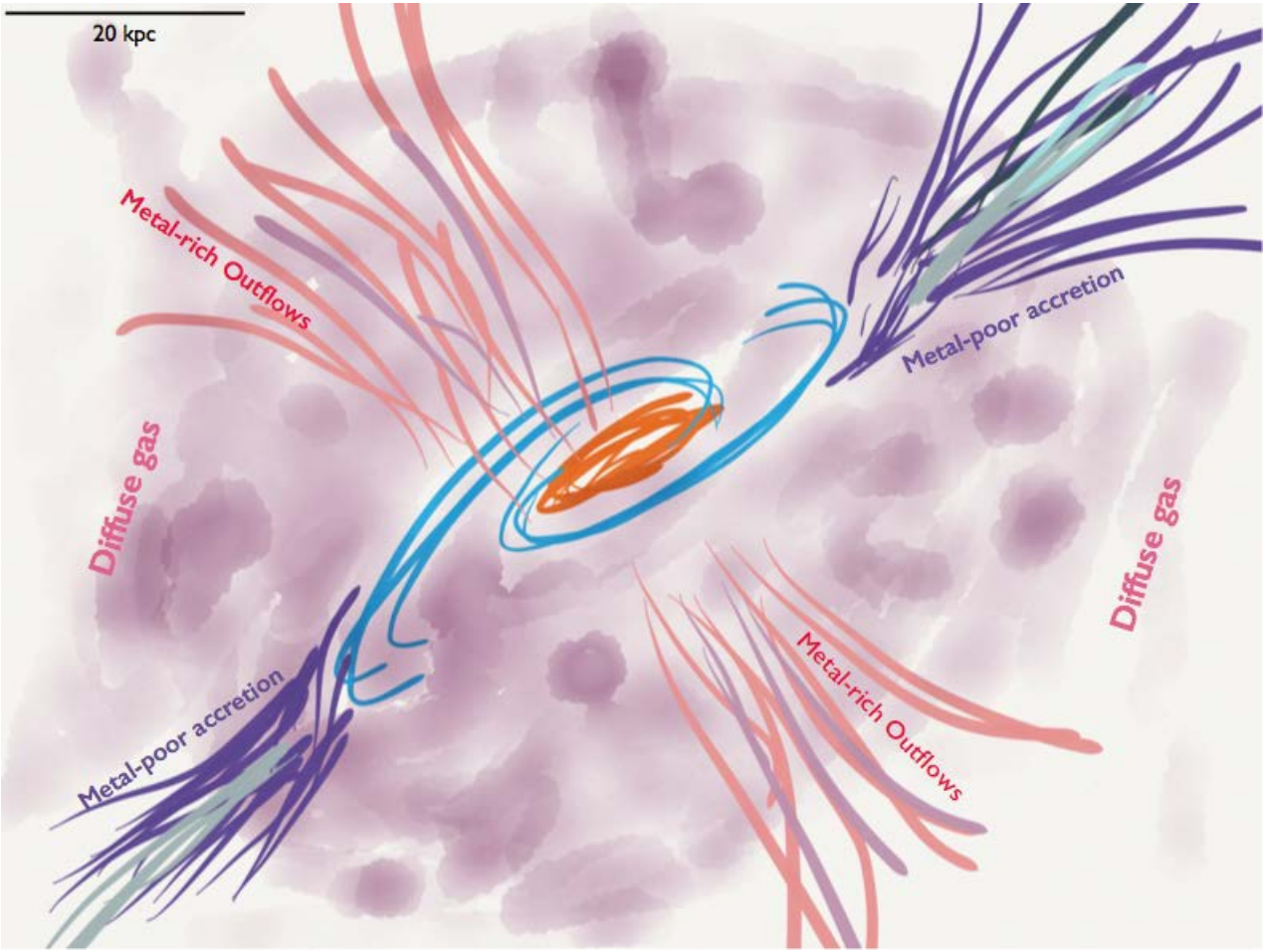
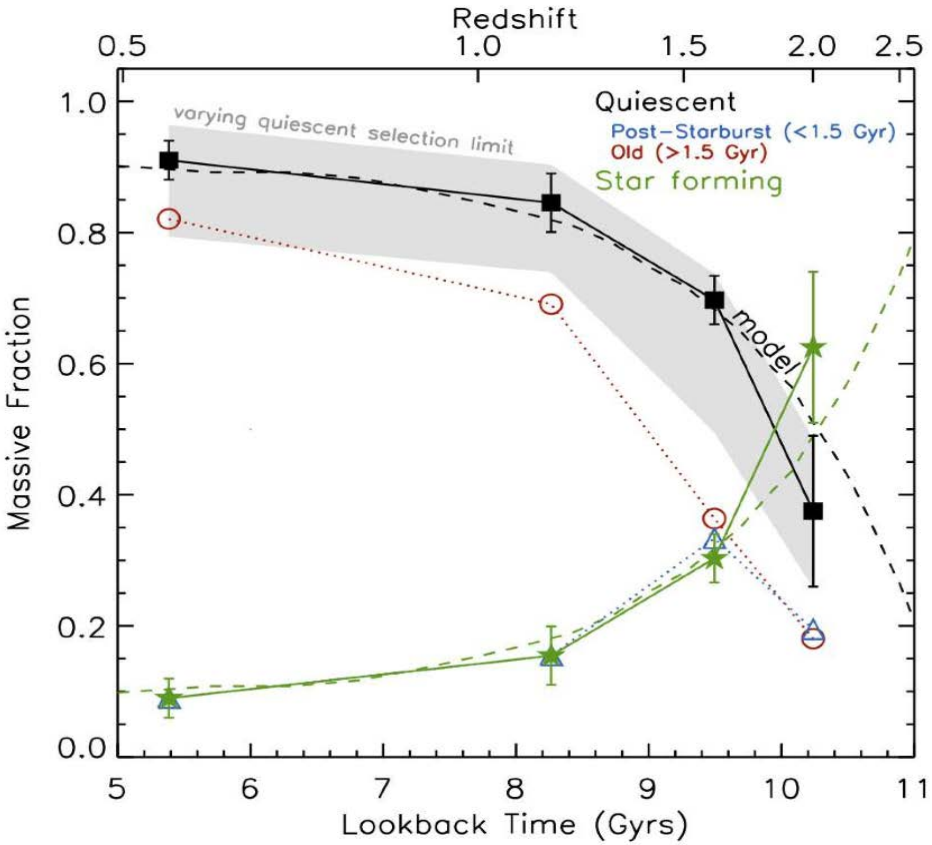


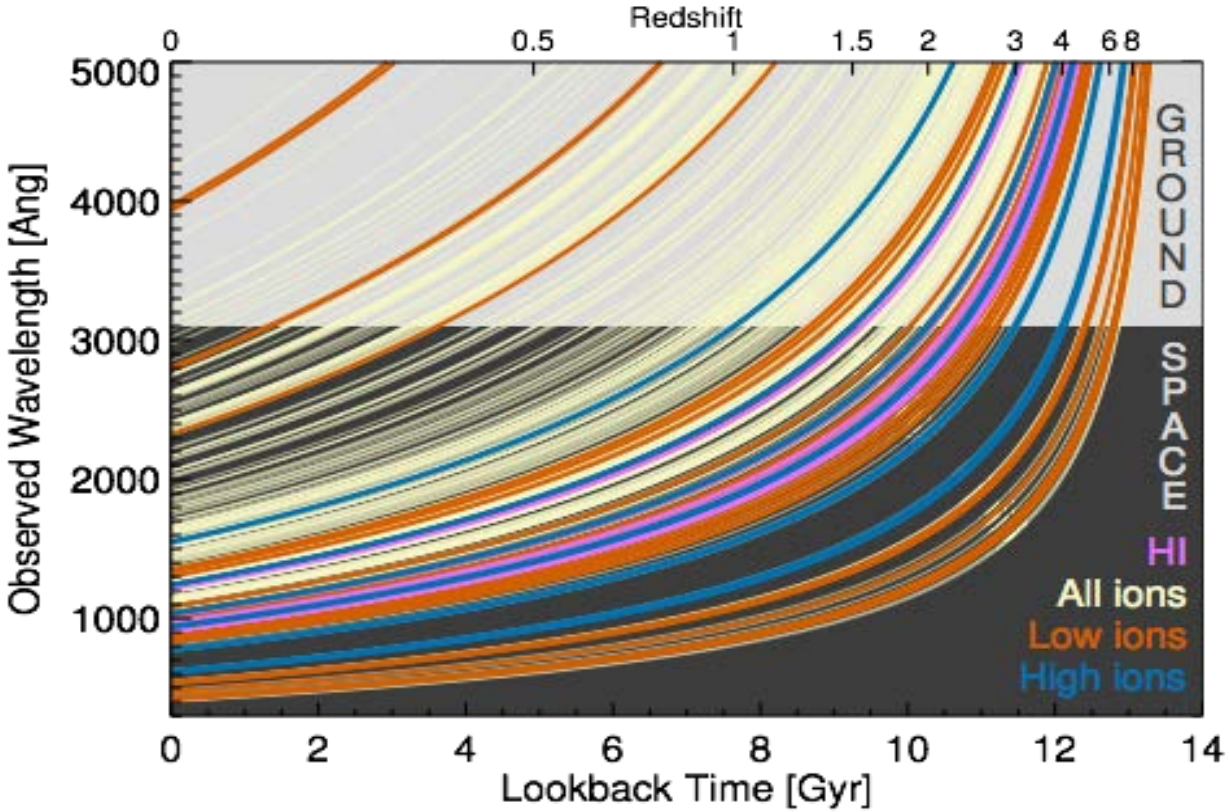
image courtesy J.C. Howk

Ultraviolet access is key

Massive galaxies transition from star-forming to quenched at 0.5<z<1.5

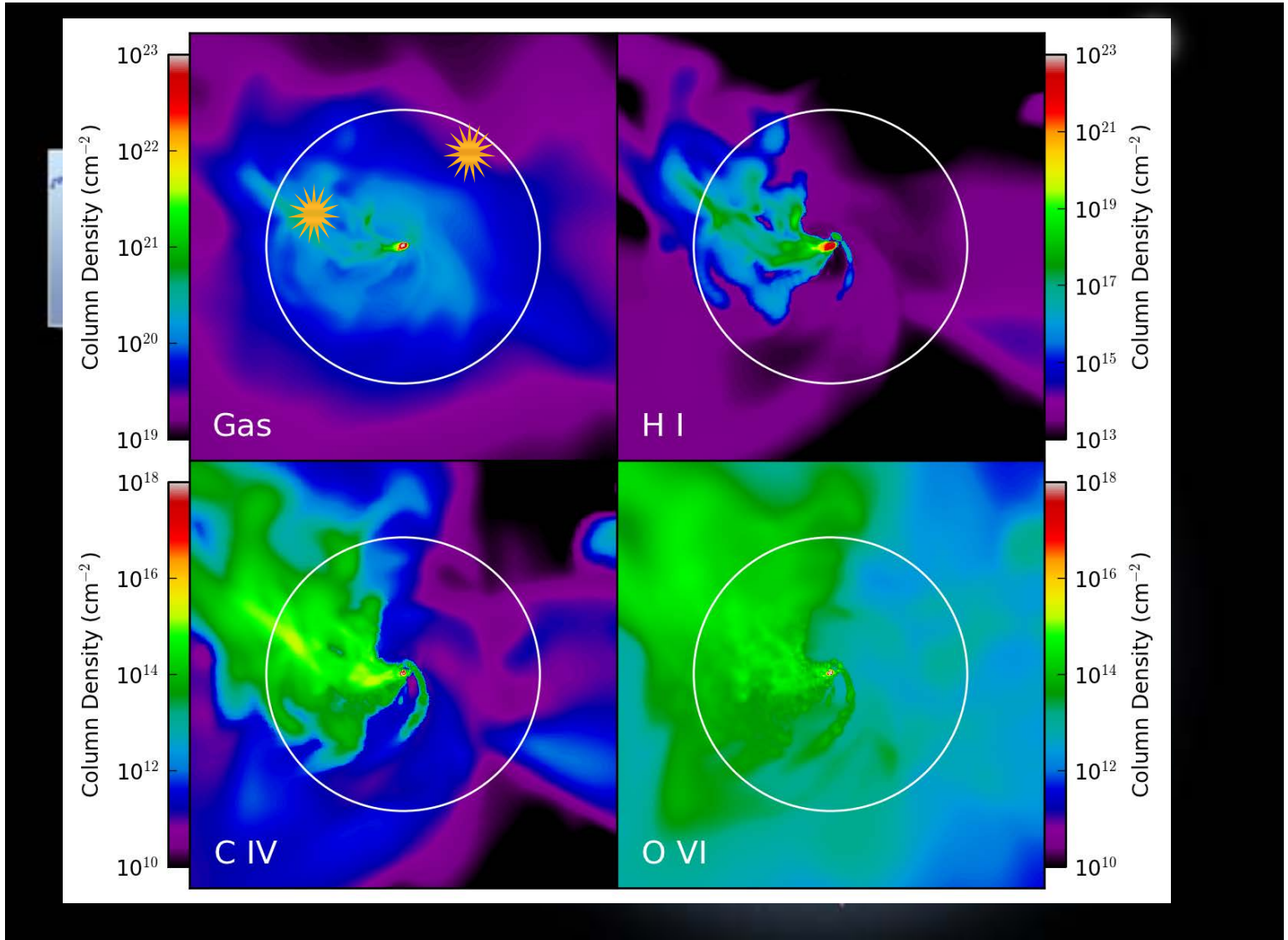


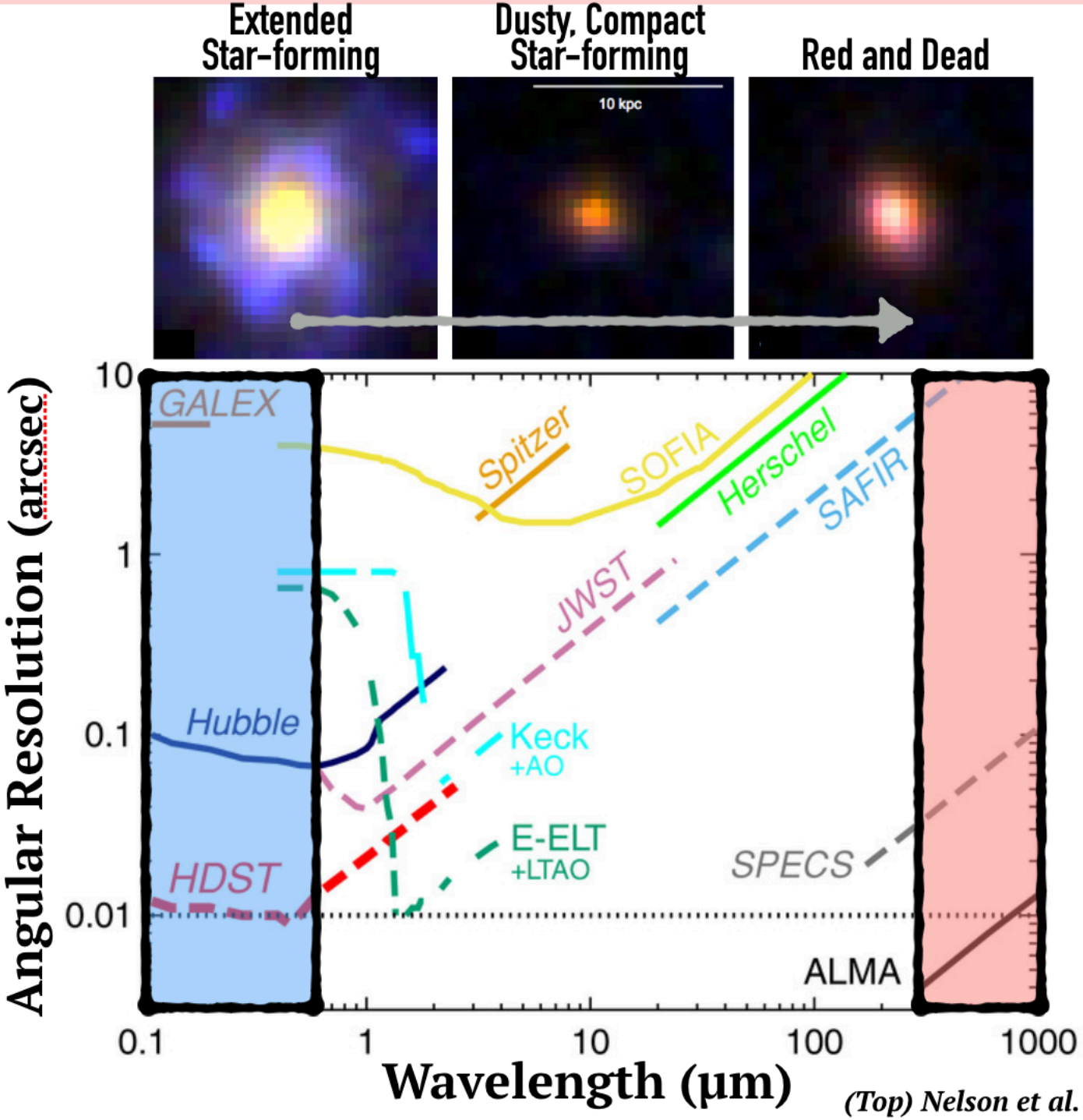
Most of the powerful line diagnostics are in the UV



Whitaker et al. 2010

High Spatial Sampling is Necessary





1. Resolution
2. Area
3. UV coverage

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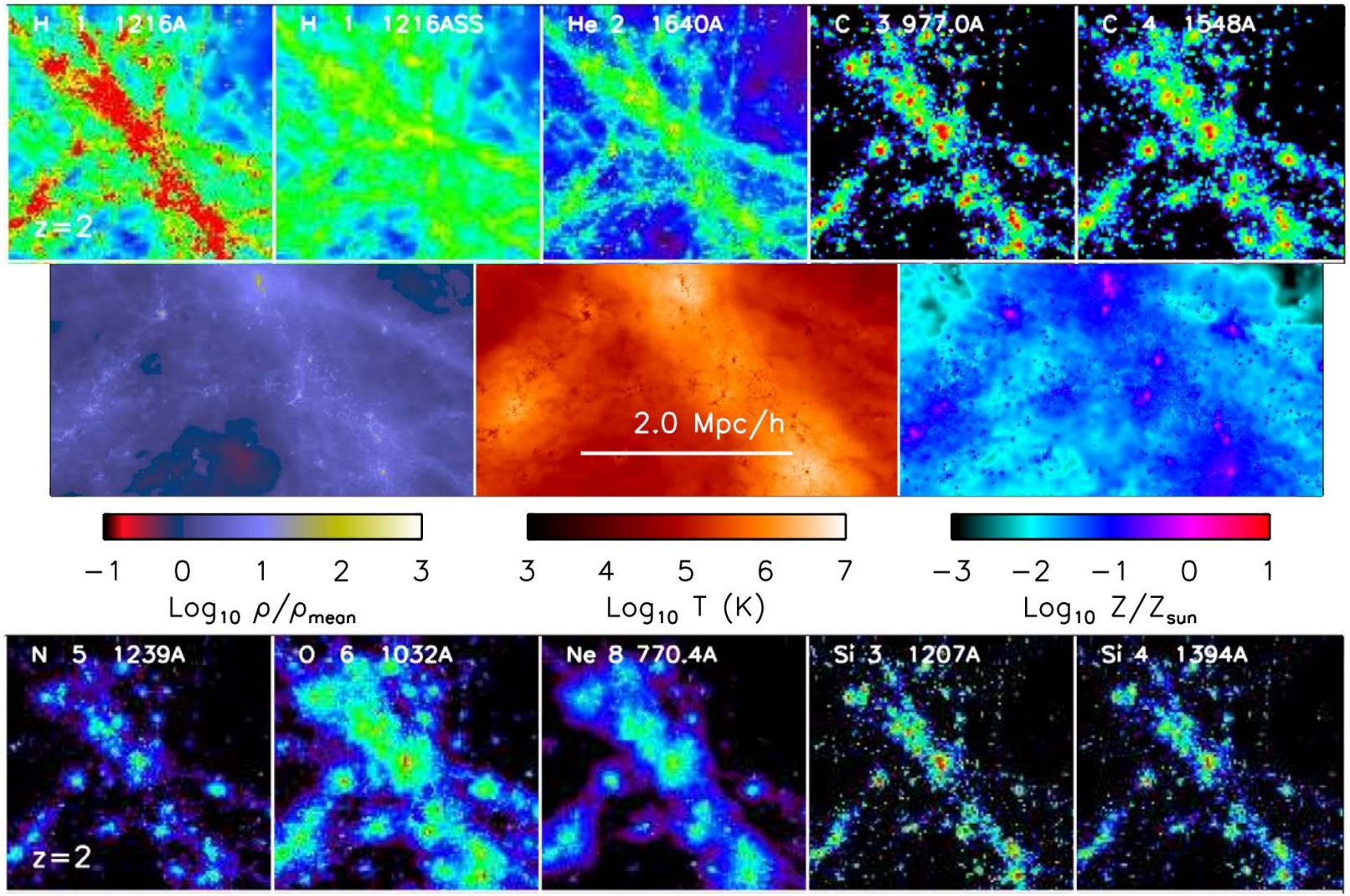
(Top) Nelson et al. 2014, (Bottom) AURA Report

The Universe in Three Dimensions



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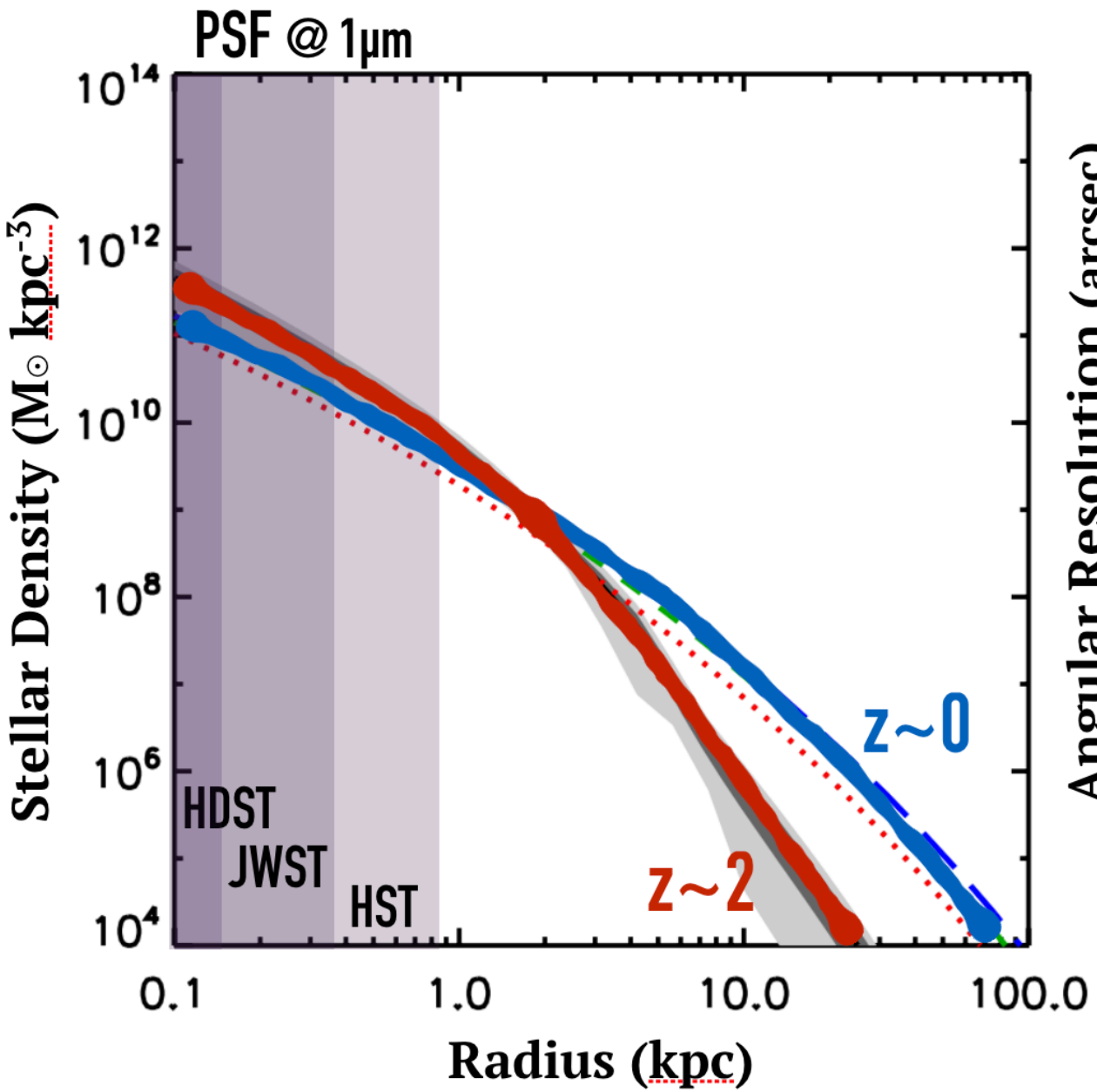

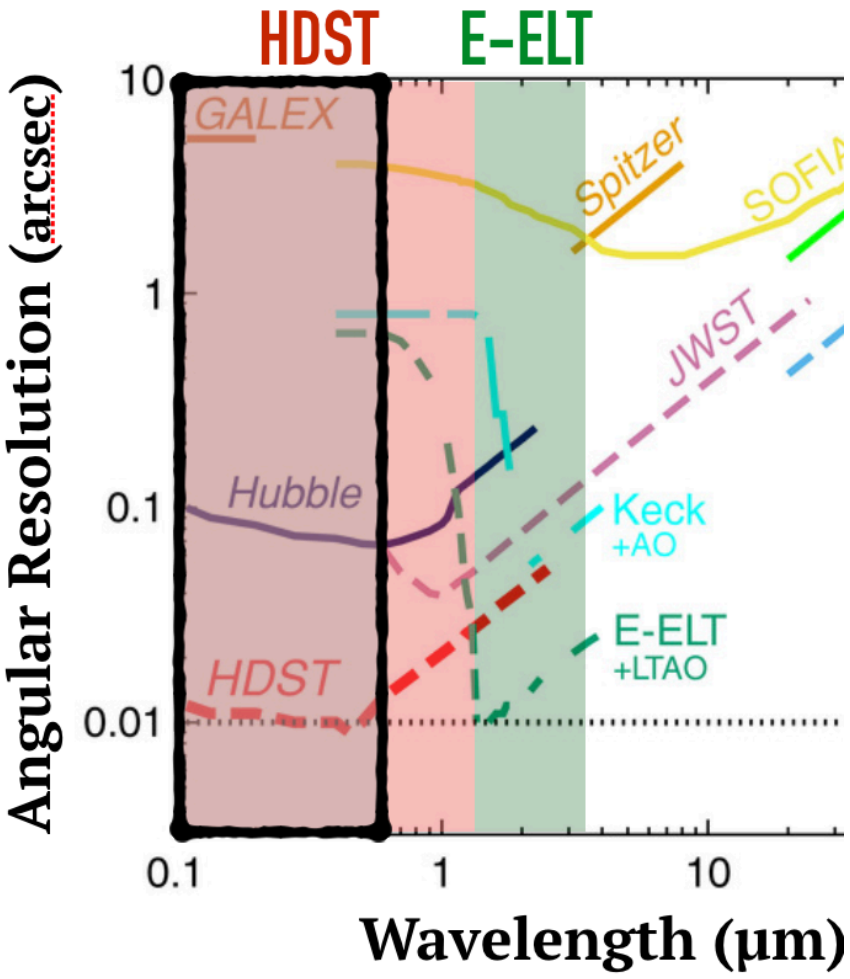

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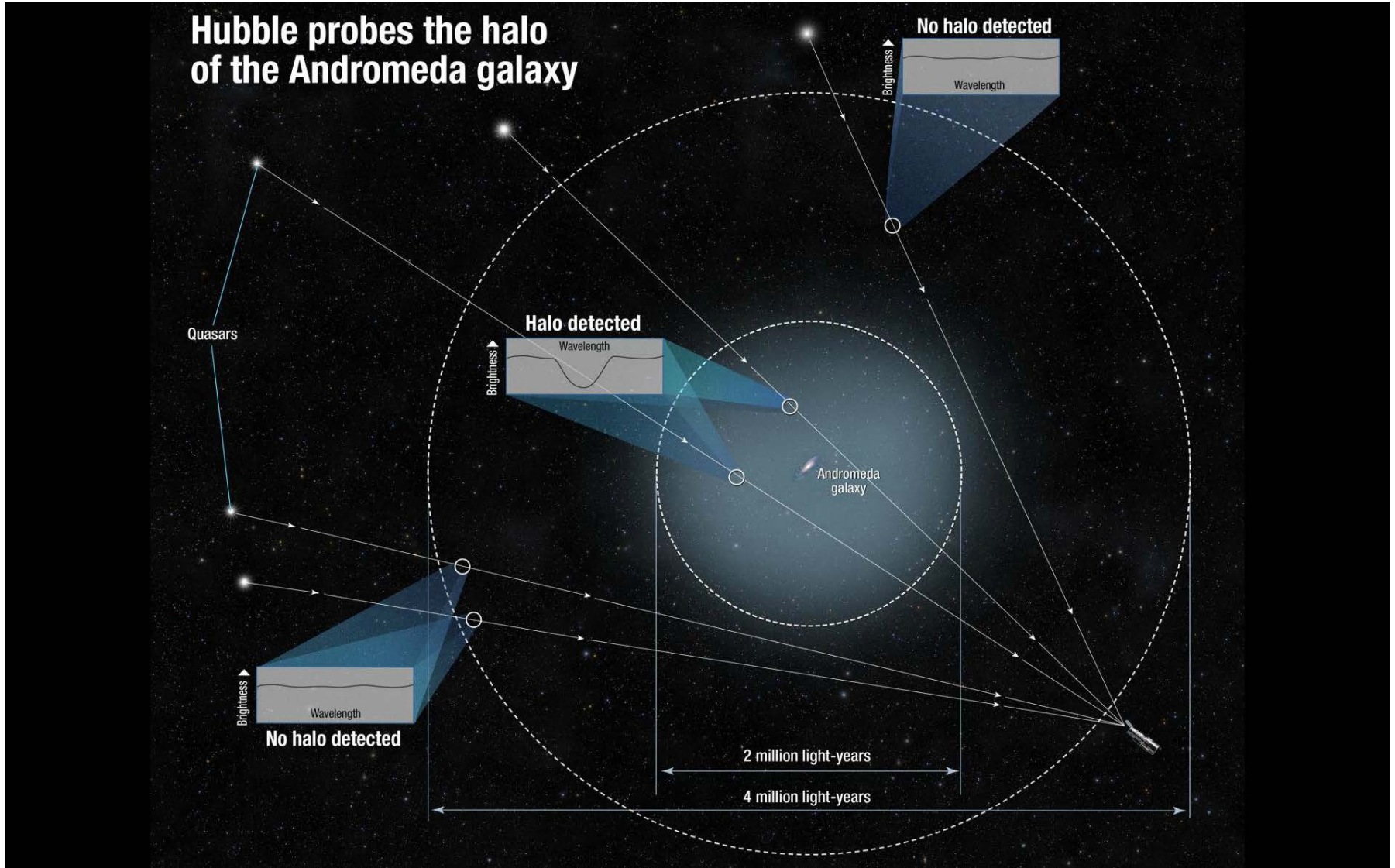
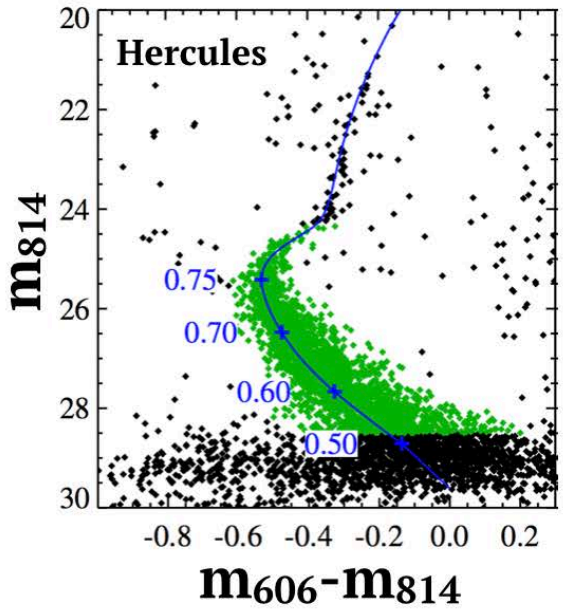
(Left) Bezanson et al. 2009, (Right) AURA Report

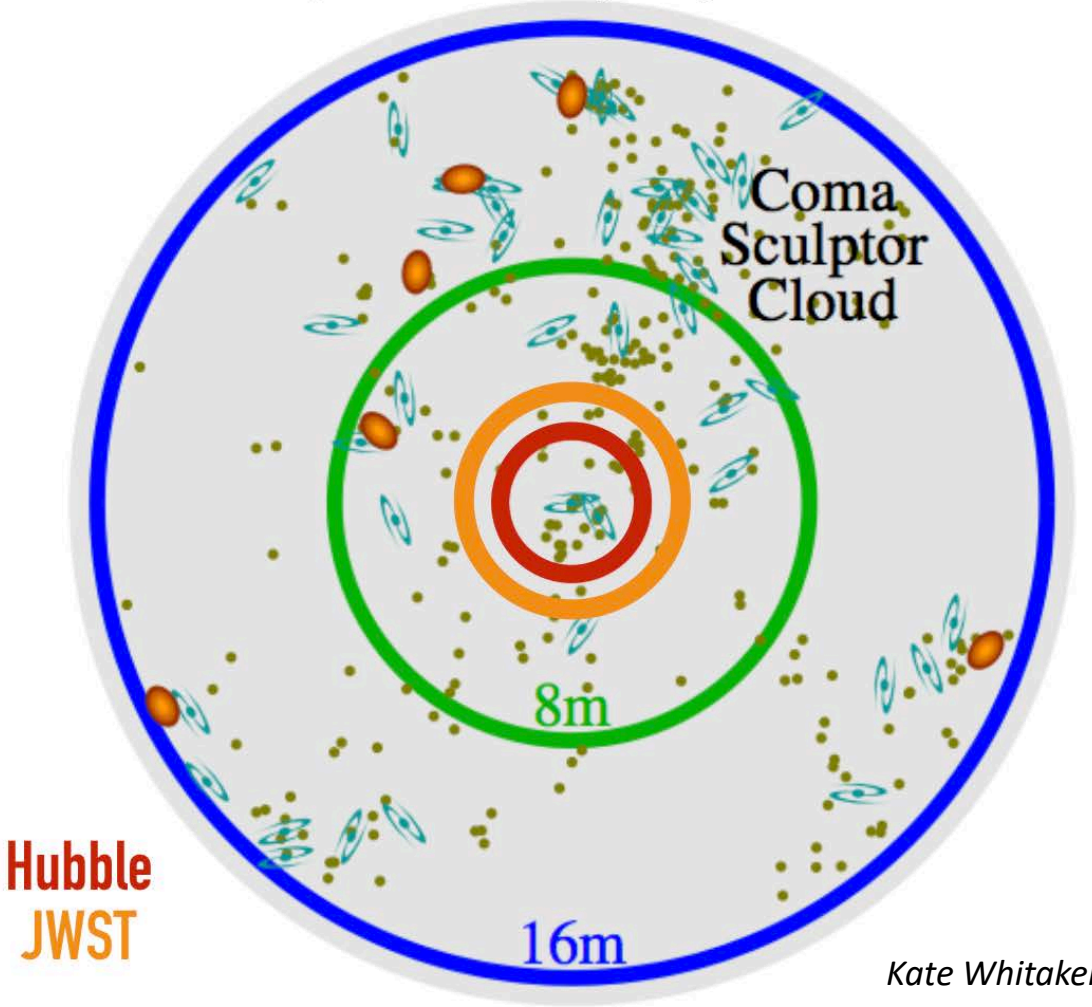
Unveiling the Local Group – via spec probes…



… and Through Direct Characterization

Map all Galaxies within 12 Mpc of the Milky Way





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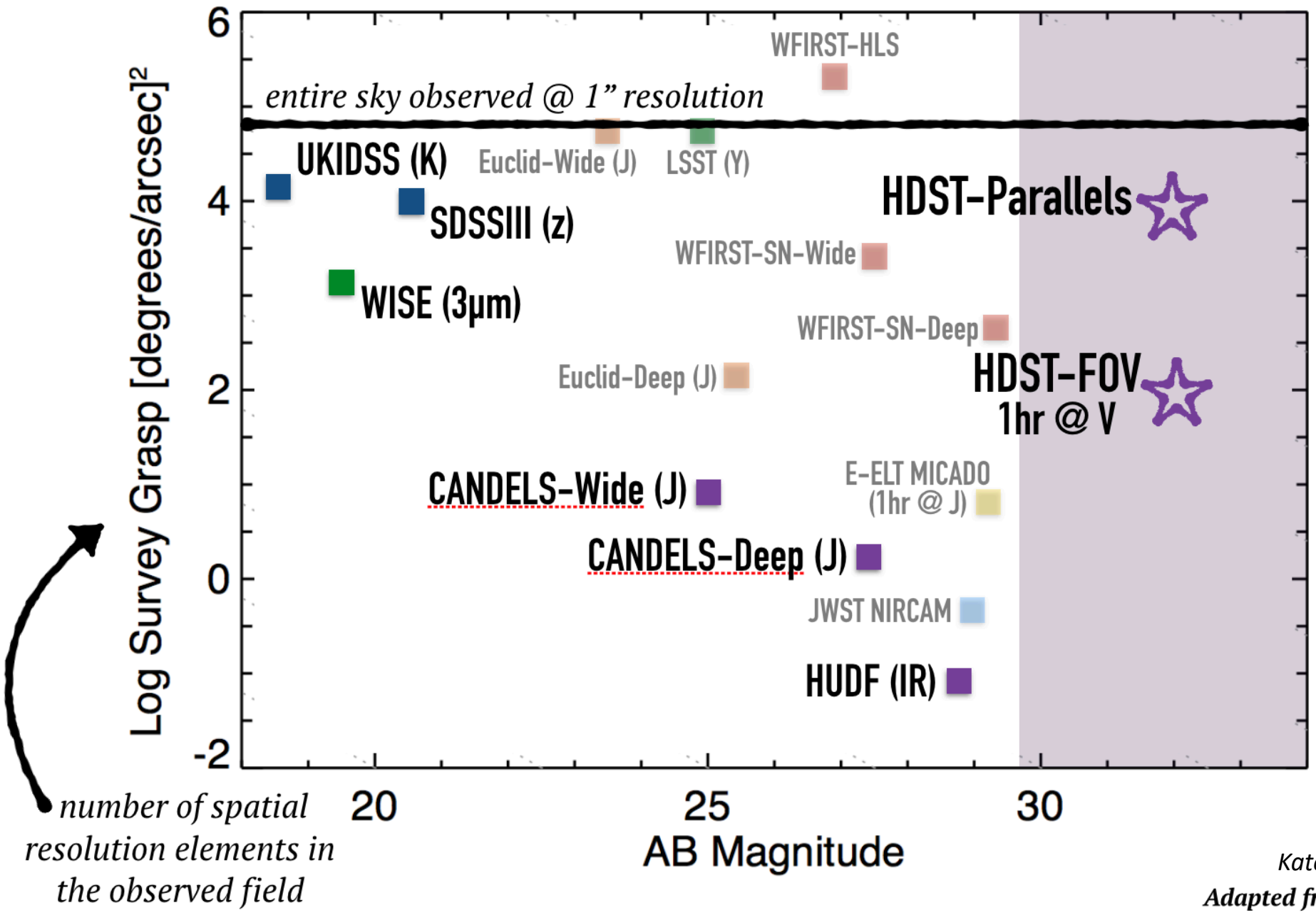
(Left) Geha et al. 2013, (Right) Tom Brown for ATLAST



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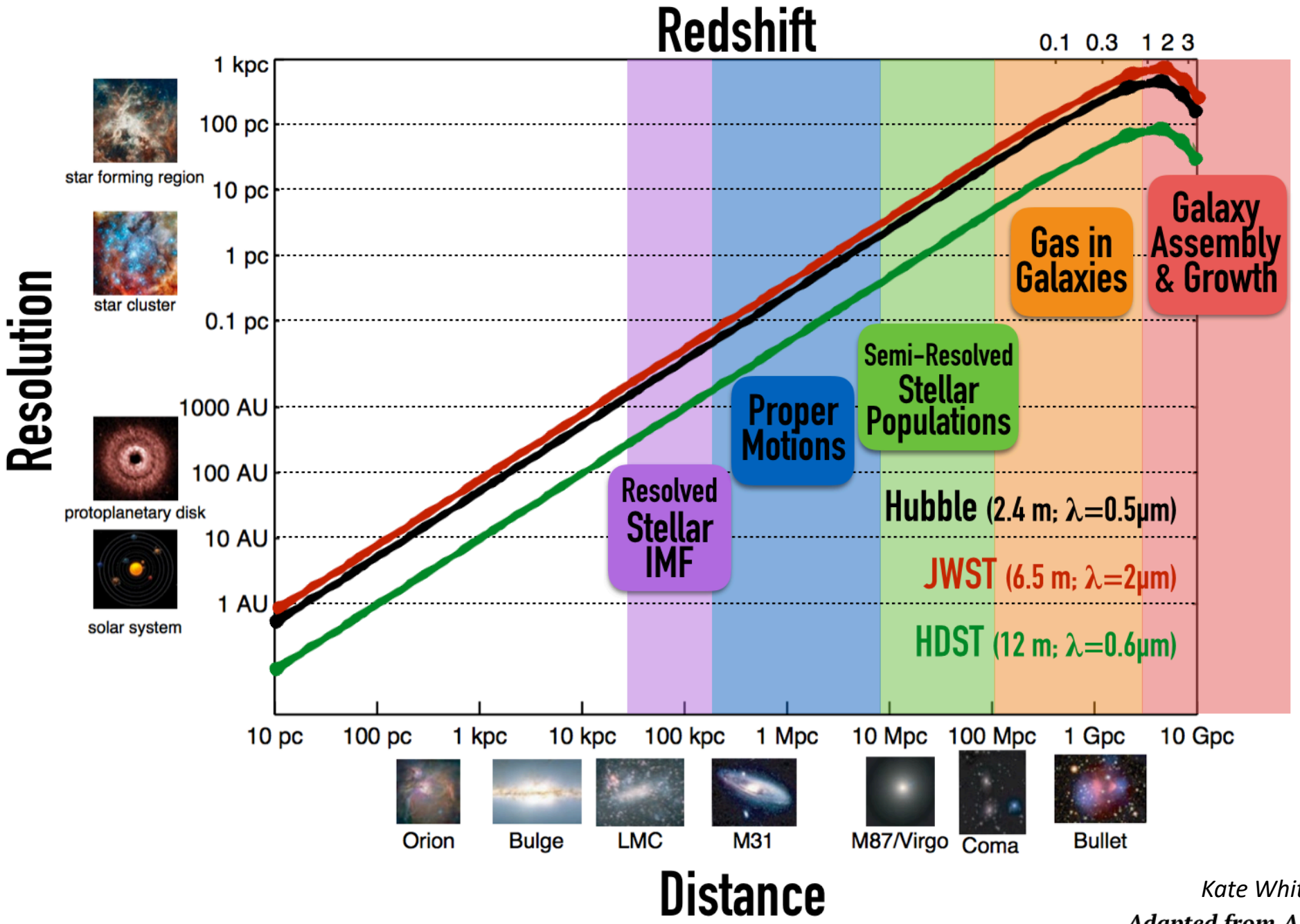
Adapted from AURA Report



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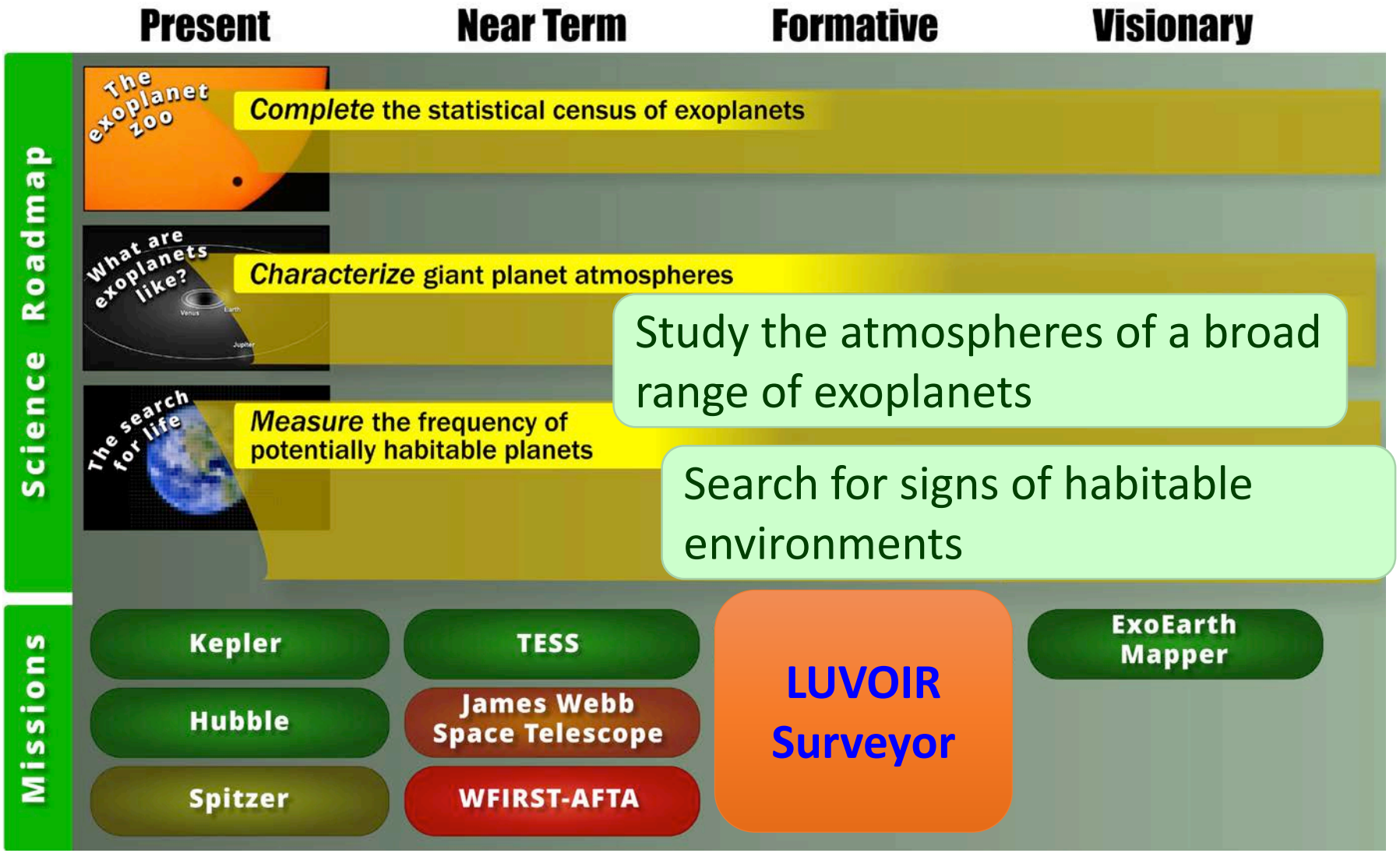
Exoplanet Science Goals



Study the atmospheres of a broad range of exoplanets

Search for signs of habitable environments

LUVOIR Exoplanet Science Goals

- LUVOIR should “constrain the frequency of” habitability and bio-signatures, and
- Deliver a statistically meaningful survey of exo-Earths

LUVOIR Exoplanet Science Goals

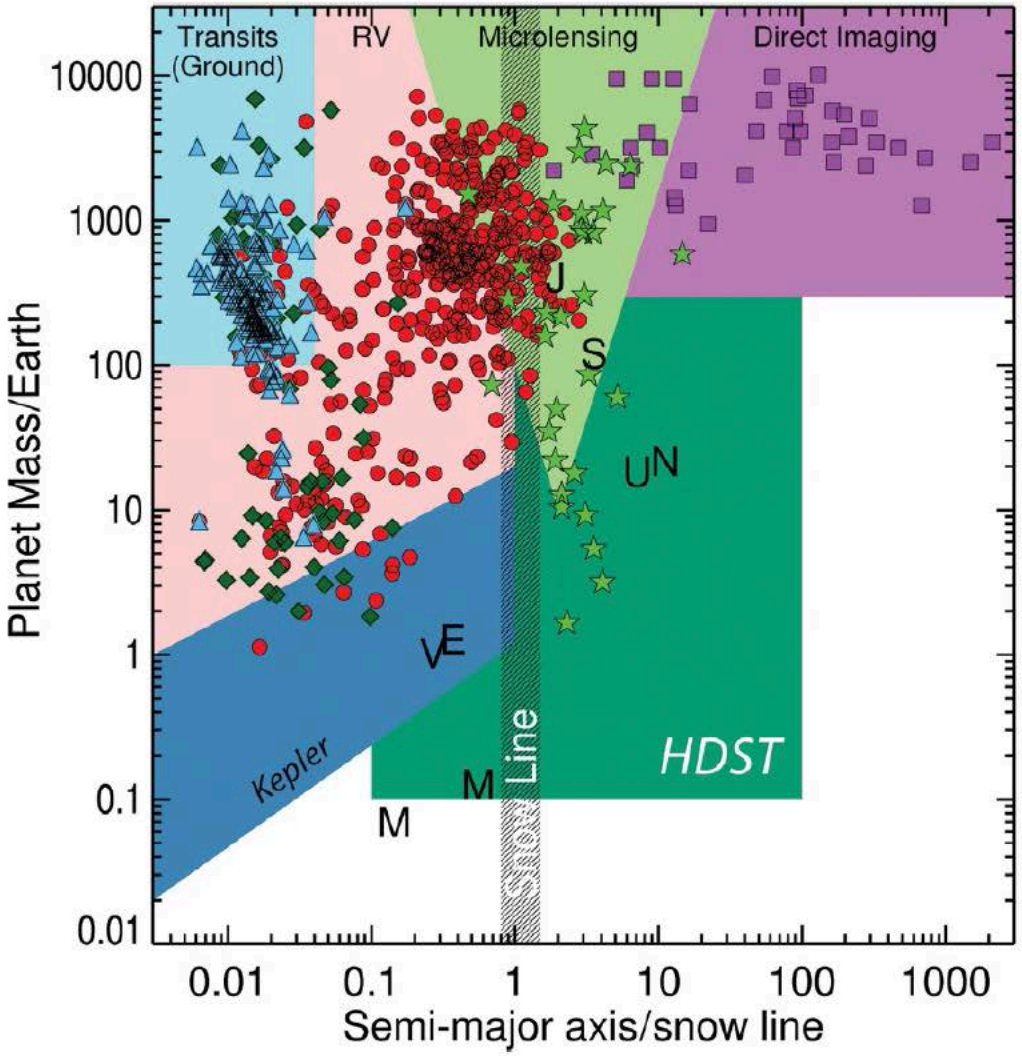


Figure 3-5: The variety of exoplanets as illustrated by their masses and orbital semi-major axes. Different exoplanet-finding techniques' discovery spaces and discovered planets are indicated by colors. Many more exoplanets are known that do not have measured masses (see Figure 3-3). The anticipated parameter space accessible with *HDST* is shown in dark green. Figure adapted from Gaudi and Henderson (private communication) and Wright and Gaudi (2013).

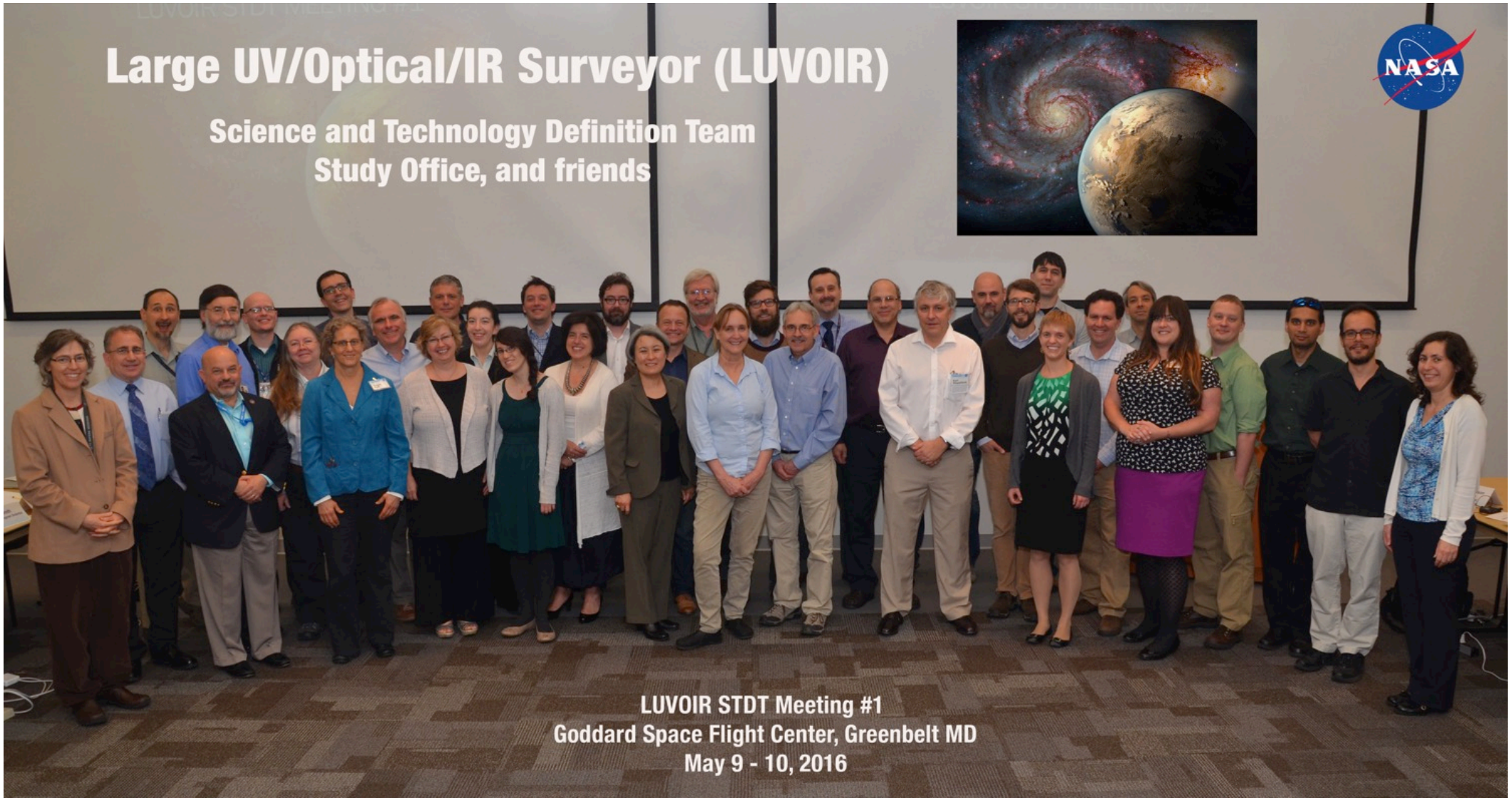
From AURA HDST Report

Technology Gap Areas

- LUVOIR Decadal Mission Concept Study "O1" Deliverable: Technology Gap Assessment for the 2016 Program Office Technology Cycle

Technology Area	Difficulty	Urgency
High-Contrast Segmented-Aperture Coronagraphy	CRITICAL	CRITICAL
Ultra-Stable Opto-mechanical Systems (includes Sensing, Control, Mirrors, and Structures)	CRITICAL	CRITICAL
Large Format, High Sensitivity, High-Dynamic Range UV Detectors	HIGH	HIGH
Vis/NIR Exoplanet Detectors	HIGH	MED
Starshade	HIGH	MED
Mirror Coatings	MED	MED
MIR (3–5 μm) Detectors	LOW	LOW

Science & Technology Definition Team



2016 - 2019

1st meeting 5/9-10
2nd meeting 8/18-19

LUVOIR Community Working Groups

- Exoplanets
  - Leads: Mark Marley, Avi Mandell
- Cosmic Origins
  - Leads: John O'Meara, Jane Rigby
- Solar System
  - Leads: Walt Harris, Geronimo Villanueva
- Simulations
  - Leads: Jason Tumlinson, Aki Roberge
- Technology
  - Leads: David Redding, Matt Bolcar

Current LUVOIR work status

- Initial technology gap assessment submitted
- Each STDT member currently writing up at least one science case
  - High-level science question, desired measurements, preliminary observation requirements
- Community members solicited for additional science cases.
  - **All Community Input Encouraged and Welcome!**
- ExoPAG SAG15 input coming from D. Apai
- STDT recommendations on instrument capabilities coming this Fall

LUVOIR STDT Voting Members

Roughly equal proportions of COR and EXO scientists, ~ 10% each of Solar System and Technology.

Debra Fischer (Chair)	**Yale**	**Bradley Peterson (Chair)**	**Ohio State**
Jacob Bean	Chicago	Leonidas Moustakas	JPL
Daniela Calzetti	U Mass	John O'Meara	St. Michael's
Rebekah Dawson	Penn State	Victoria Meadows	Washington
Courtney Dressing	Caltech	Ilaria Pascucci	Arizona (LPL)
Lee Feinberg	NASA GSFC	Marc Postman	STScI
Kevin France	Colorado	Laurent Pueyo	STScI
Jay Gallagher	Wisconsin	David Redding	JPL
Olivier Guyon	Arizona	Jane Rigby	NASA GSFC
Walter Harris	Arizona (LPL)	Aki Roberge	NASA GSFC
David Schiminovich	Columbia	Britney Schmidt	Georgia Tech
Mark Marley	NASA Ames	Karl Stapelfeldt	JPL

International Ex-Officio Non-Voting Members

8 representatives of international space agencies

Martin Barstow	Leicester	UK Space Agency representative
Lars Buchhave	Copenhagen	Danish Space Agency representative
Nicholas Cowan	McGill	CSA representative
Marc Ferrari	LAM	CNES representative
Ana Gomez de Castro	Madrid	SNPRDI representative
Thomas Henning	Max Planck	DLR representative
Antonella Nota	ESA	ESA representative
Takahiro Sumi	Osaka	JAXA representative

LUVOIR Study Office Members & al

Aki Roberge	NASA GSFC	Study scientist
Shawn Domagal-Goldman	NASA GSFC	Deputy study scientist
Julie Crooke	NASA GSFC	Study manager
Norman Rioux	NASA GSFC	Chief engineer
Matt Bolcar	NASA GSFC	Chief technologist
Avi Mandell	NASA GSFC	Science support analysis team lead
Mario Perez	NASA HQ	Program scientist
Erin Smith	NASA HQ	Program scientist
Susan Neff	NASA GSFC	COR program chief scientist
Deborah Padgett	NASA GSFC	COR program chief scientist