

The James Webb Space Telescope

... your space telescope after *Hubble*



Dr. Rolf Jansen (Arizona State University, SESE)

Challenger Space Center of Arizona — Sep 24, 2011

Background: HST's Astronomical Revolution

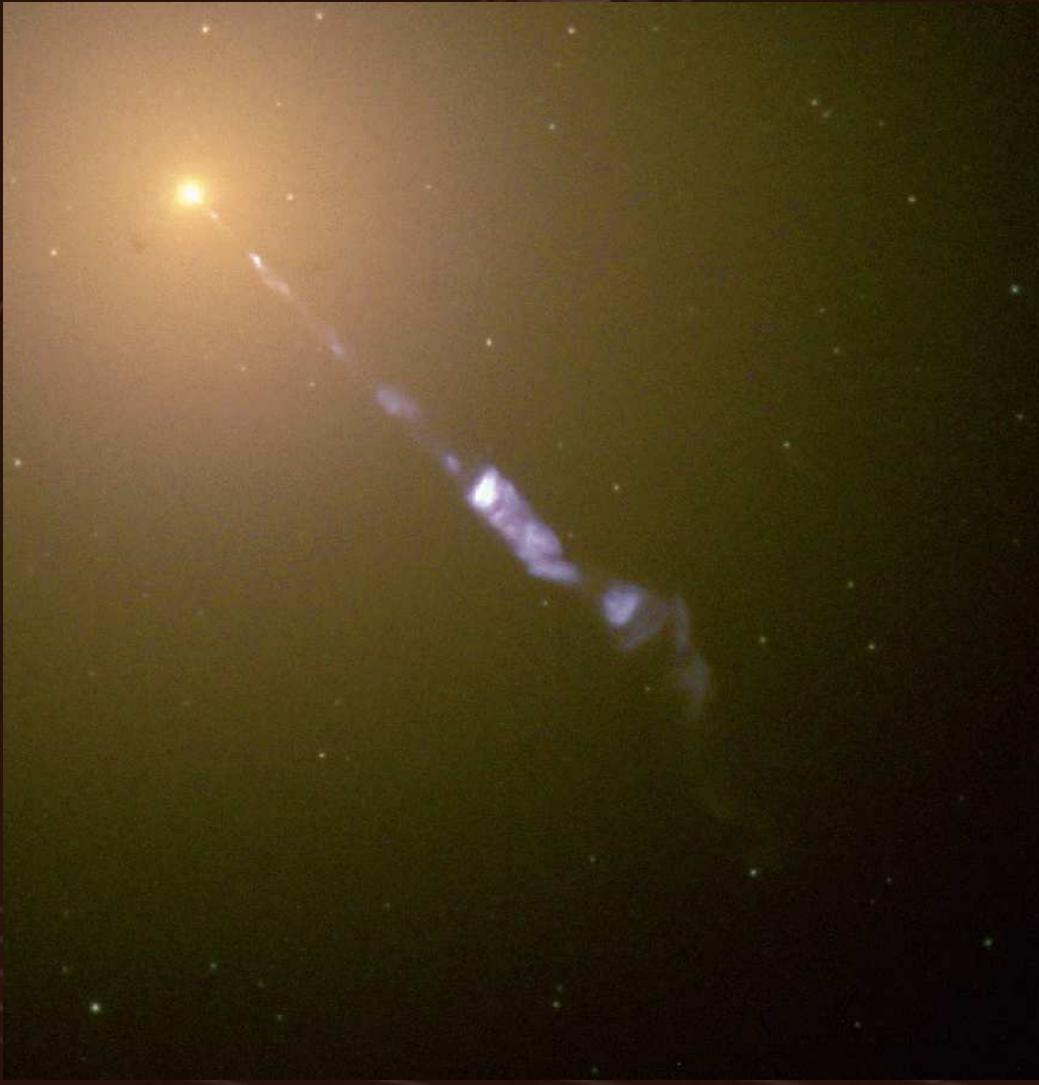


Ground: N.A. Sharp, AURA, NOAO, NSF

HST: NASA, ESA, Hubble SM4 ERO Team

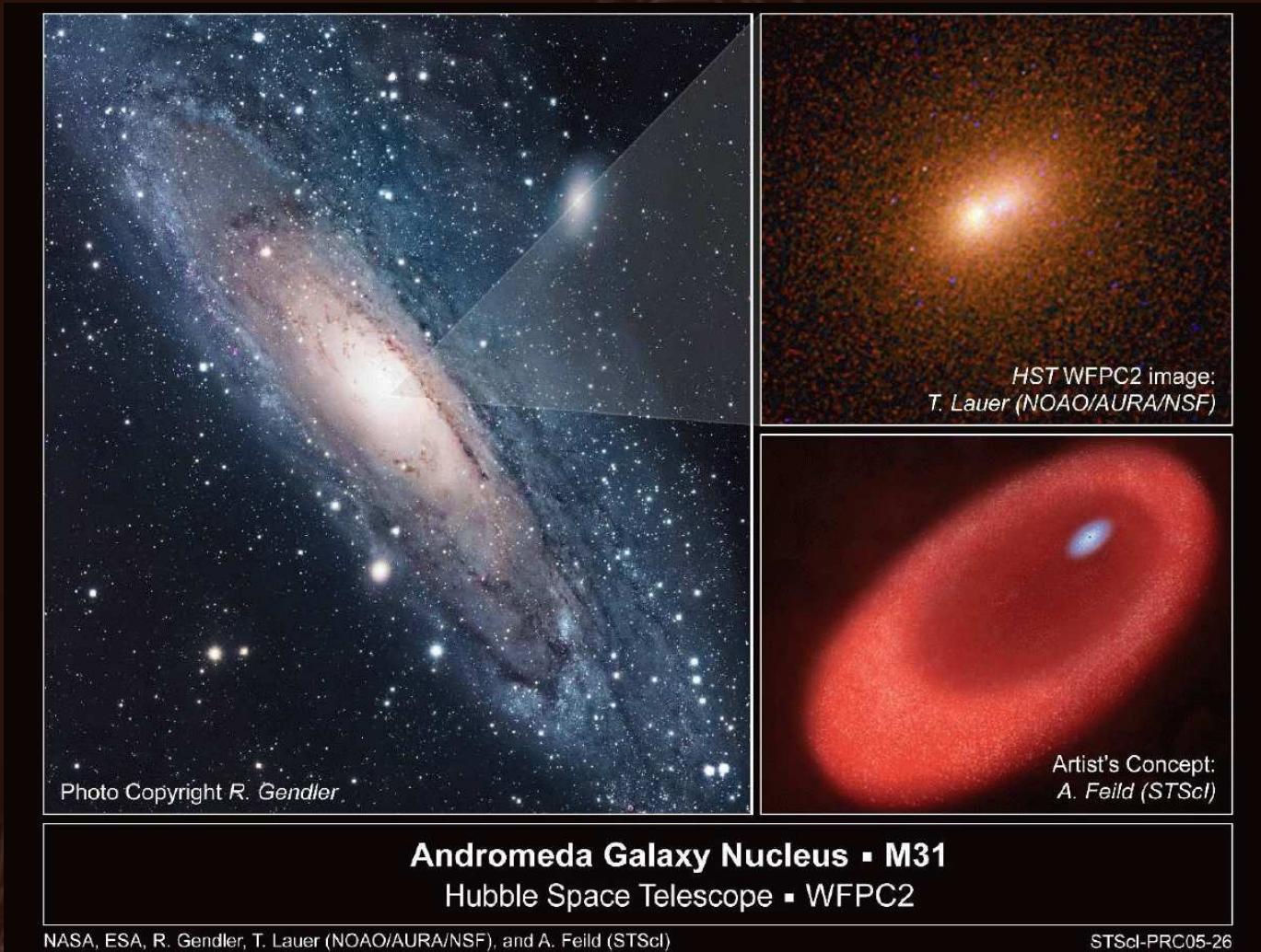
- *Hubble Space Telescope* provides darker sky background, higher resolution, and access to wavelengths inaccessible from the ground (absorbed by Earth's atmosphere)

Background: HST's Astronomical Revolution



- *HST* discovered that ***all*** large galaxies have a supermassive black hole at their center...

Background: *HST*'s Astronomical Revolution



... even our own Milky Way Galaxy and our nearest big neighbor, M 31, the Andromeda Galaxy

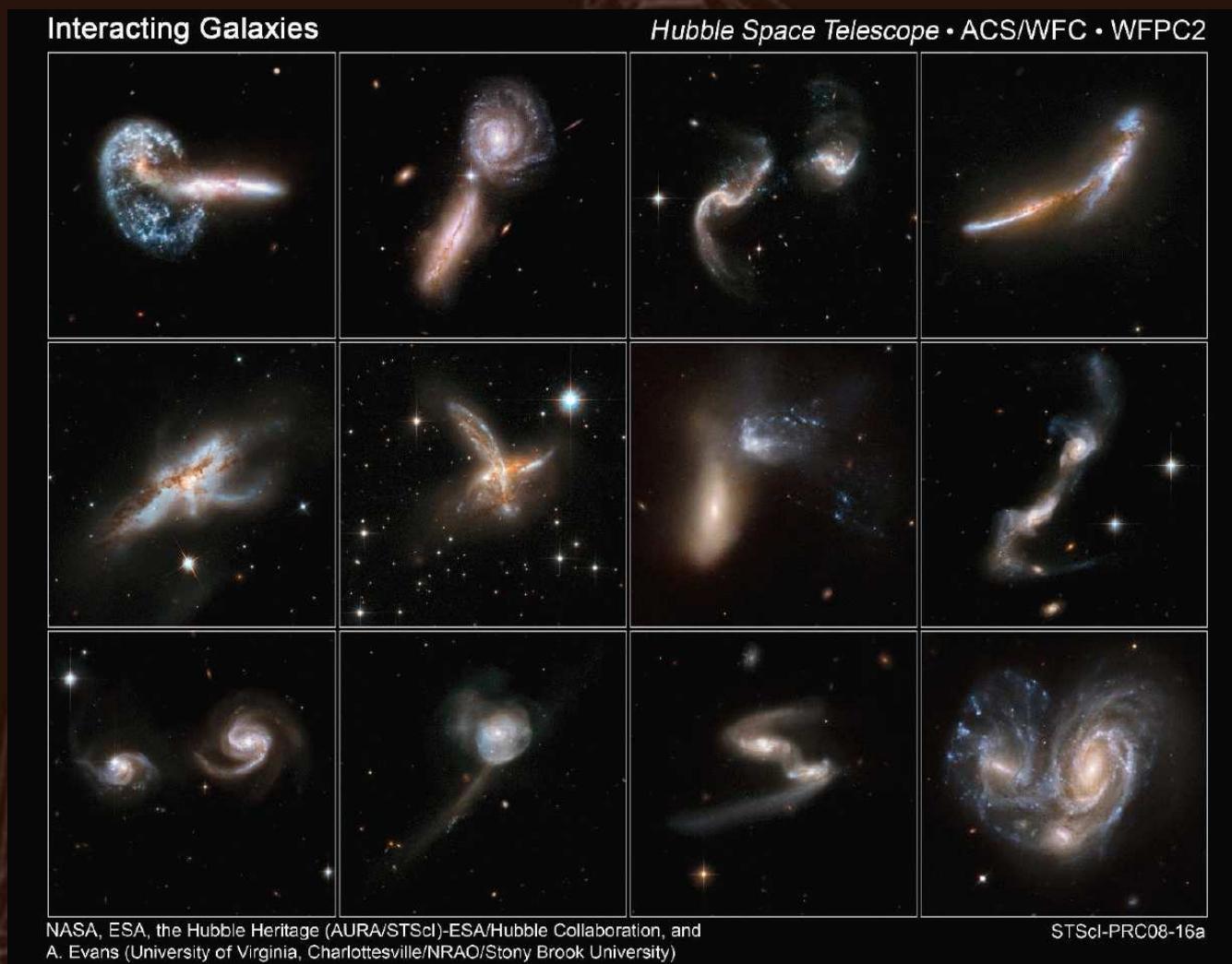
Background: HST's Astronomical Revolution



NASA, ESA, Hubble Heritage Team (STScI/AURA)-ESA/Hubble Collab.; B. Whitmore & J. Long

- HST gave us sharp views of star bursting galaxies, interacting galaxies, ...

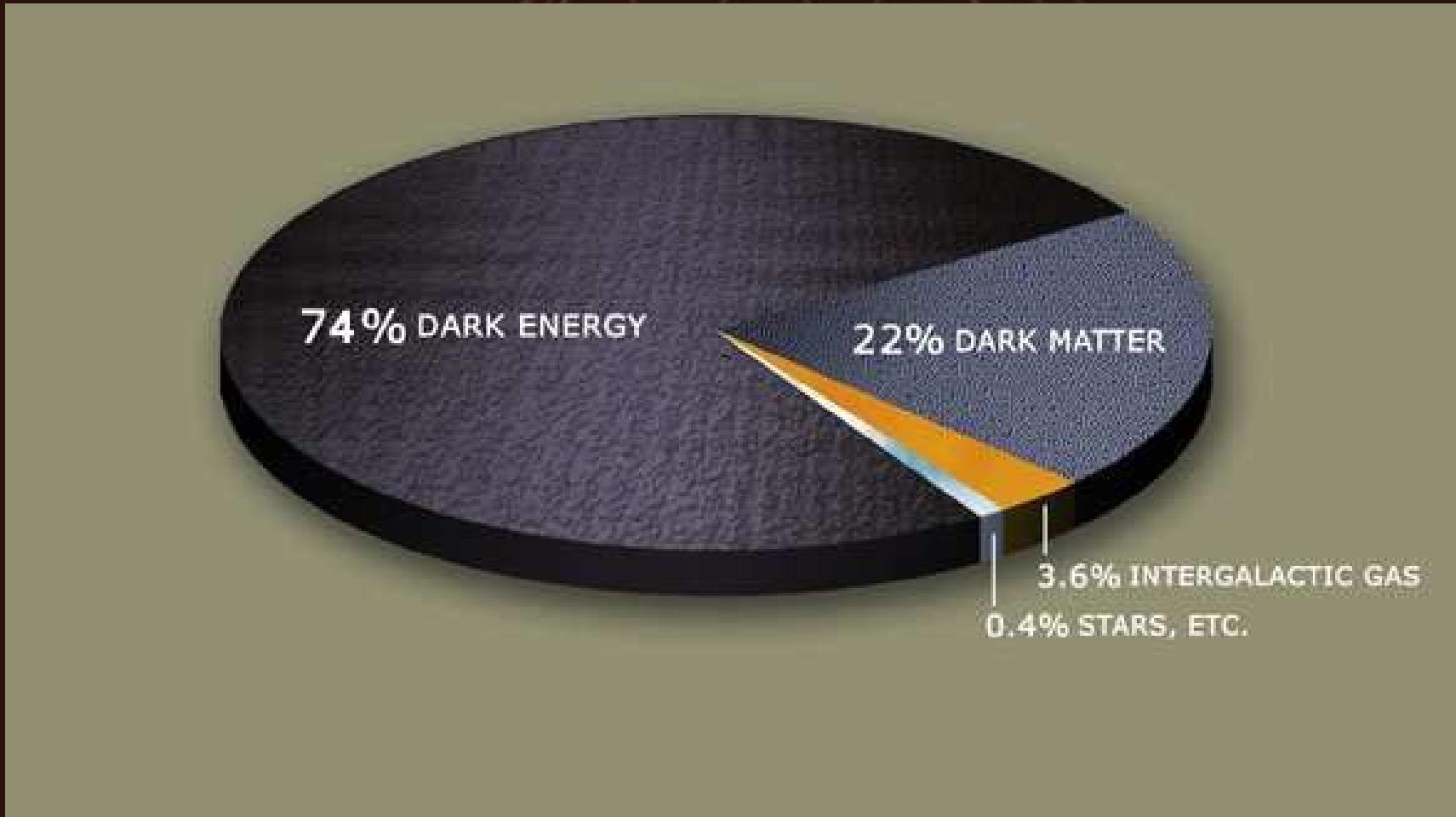
Background: *HST*'s Astronomical Revolution



... and allowed us to trace galaxy assembly and subsequent evolution over the past 12 billion years

Background: HST's Astronomical Revolution

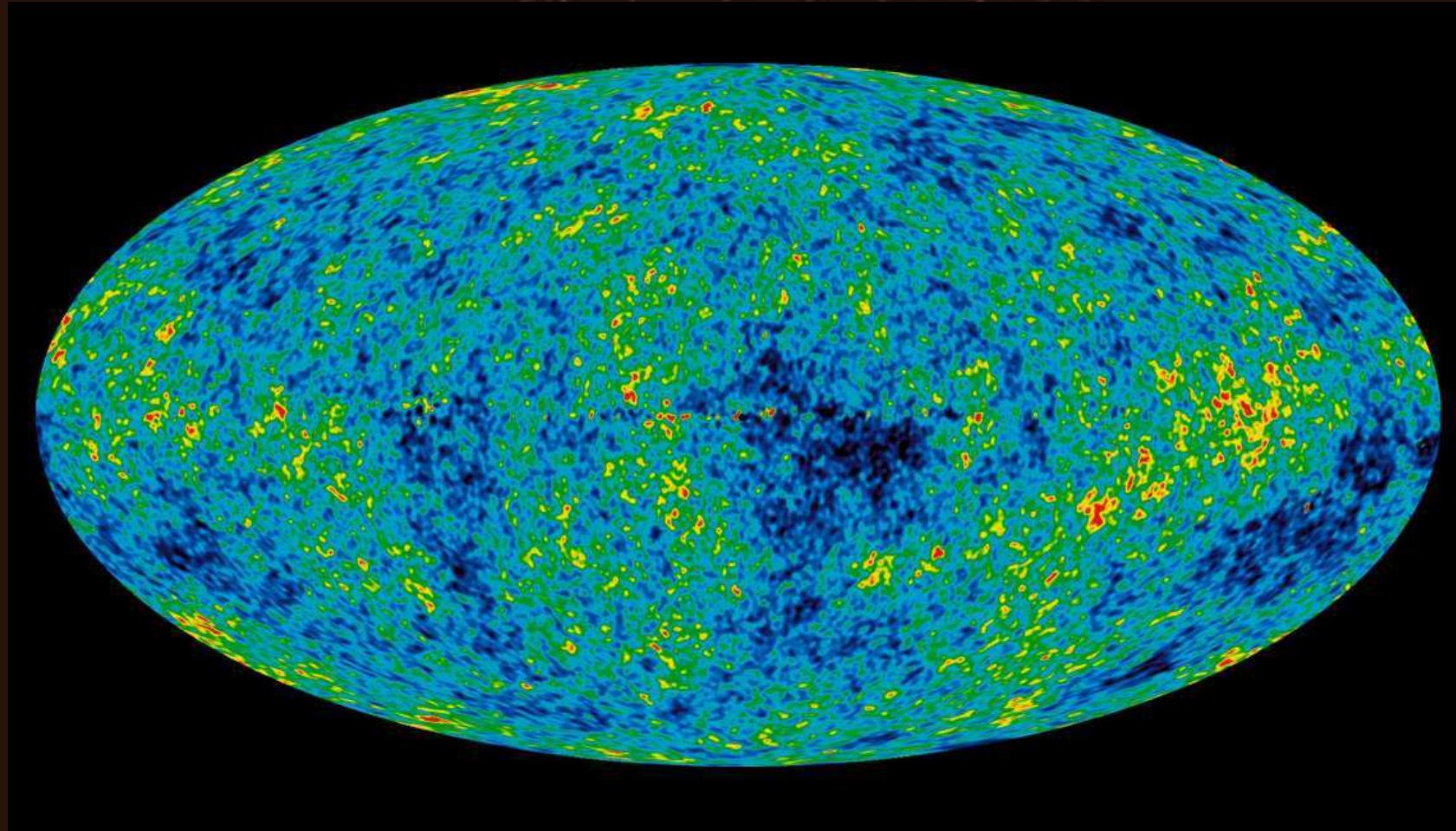
- Recipe for a Universe ... *Dark Energy???*



NASA

HST (and *WMAP*)'s Astronomical Revolution

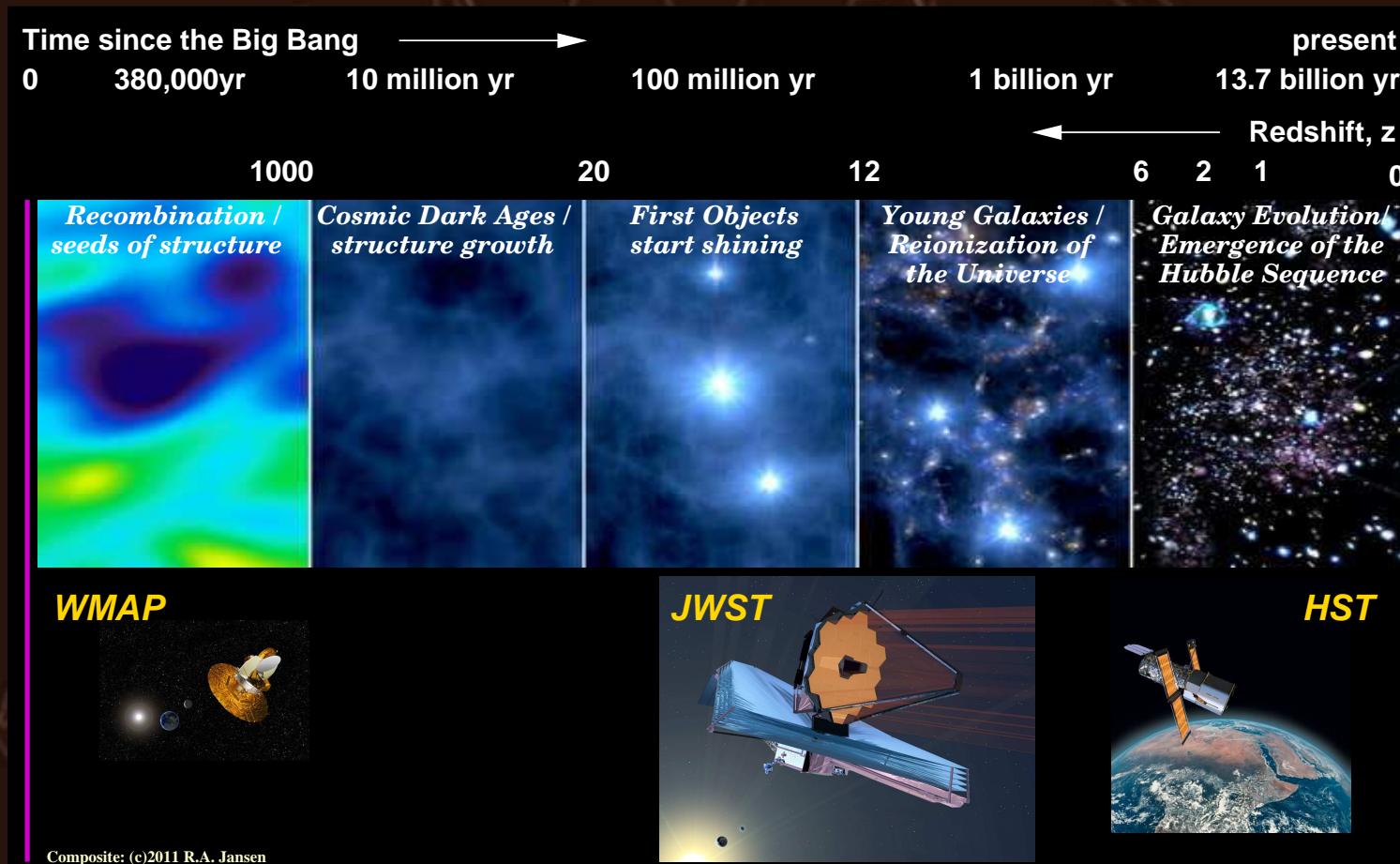
- Start with a Big Bang, inflate, let simmer until transparent



NASA / WMAP Science Team

HST (and *WMAP*)'s Astronomical Revolution

- Let rise and cool through the Dark Ages until stars and quasars ignite, the IGM gets reionized



NASA / WMAP Science Team / R.A. Jansen

Background: *HST*'s Astronomical Revolution

- 12 billion years of cosmic history in one picture



NASA, ESA, R. Windhorst (ASU), P. McCarthy (CIW), & R. O'Connell (UVa)

Background: HST's Astronomical Revolution



NASA, ESA, N. Smith (UCBerkeley), Hubble Heritage Team (STScI/AURA)

- HST gave new insights into the star formation process within the Milky Way...

Background: HST's Astronomical Revolution

HST/WFC3 ‘Mystic Mountain’



NASA, ESA, M. Livio and the Hubble 20th Anniversary Team (STScI)

Background: HST's Astronomical Revolution



Composite: (c)2007 R.A. Jansen

NGC 602; NASA, ESA, STScI, Hubble Heritage Team (APOD Jan 10, 2007)

... and in nearby galaxies like the Small Magellanic Cloud (and beyond)

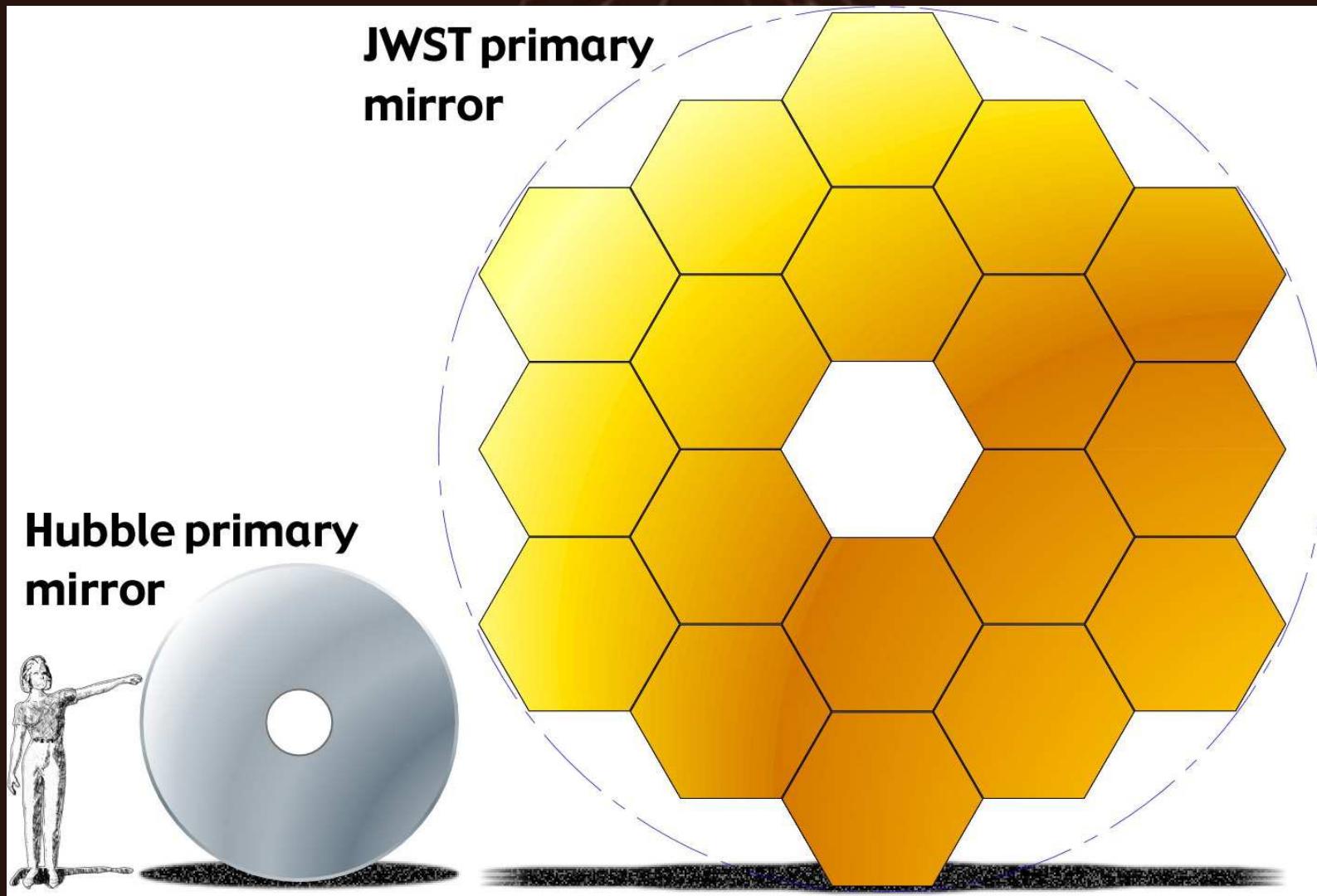
But ...

- The *Hubble Space Telescope* will not last much beyond 2015
- *HST* is **blind** at wavelengths further into the near- and mid-infrared (cannot see light emitted by the first stars and proto-galactic clumps, or peer into dense star forming regions)
- *HST* is **not big enough** to detect the faint light from the first stars (even if it could see at longer wavelengths), and not big enough to characterize the atmospheres of Earth-like exoplanets in Earth-like orbits around their parent star.

The James Webb Space Telescope

- Enter *Hubble's* successor: The *James Webb Space Telescope (JWST)*, to be launched in 2018.
- JWST (then called the *Next Generation Space Telescope*) was the top-priority recommendation of the NRC's 2000 *Decadal Survey in Astronomy & Astrophysics* (2010 *Decadal Survey* recommendations assume JWST)
 - designed to detect light from the first stars and to trace the evolution of galaxies from their formation to the present
 - designed to characterize the nearest Earth-like exoplanets and their atmospheres (presence of water vapor!)
 - designed as a multi-purpose observatory (NASA Flagship mission) for the entire astronomical community
 - ✓ allows rapid response to new discoveries, use for science not imagined in the design stages of the mission (*HST*'s biggest discoveries were not the science for which it was built; same will be true for JWST)

Comparison of *JWST* and *HST*



Sizes: 21.3 ft (6.5 m; *JWST*) versus 7.9 ft (2.4 m; *HST*)

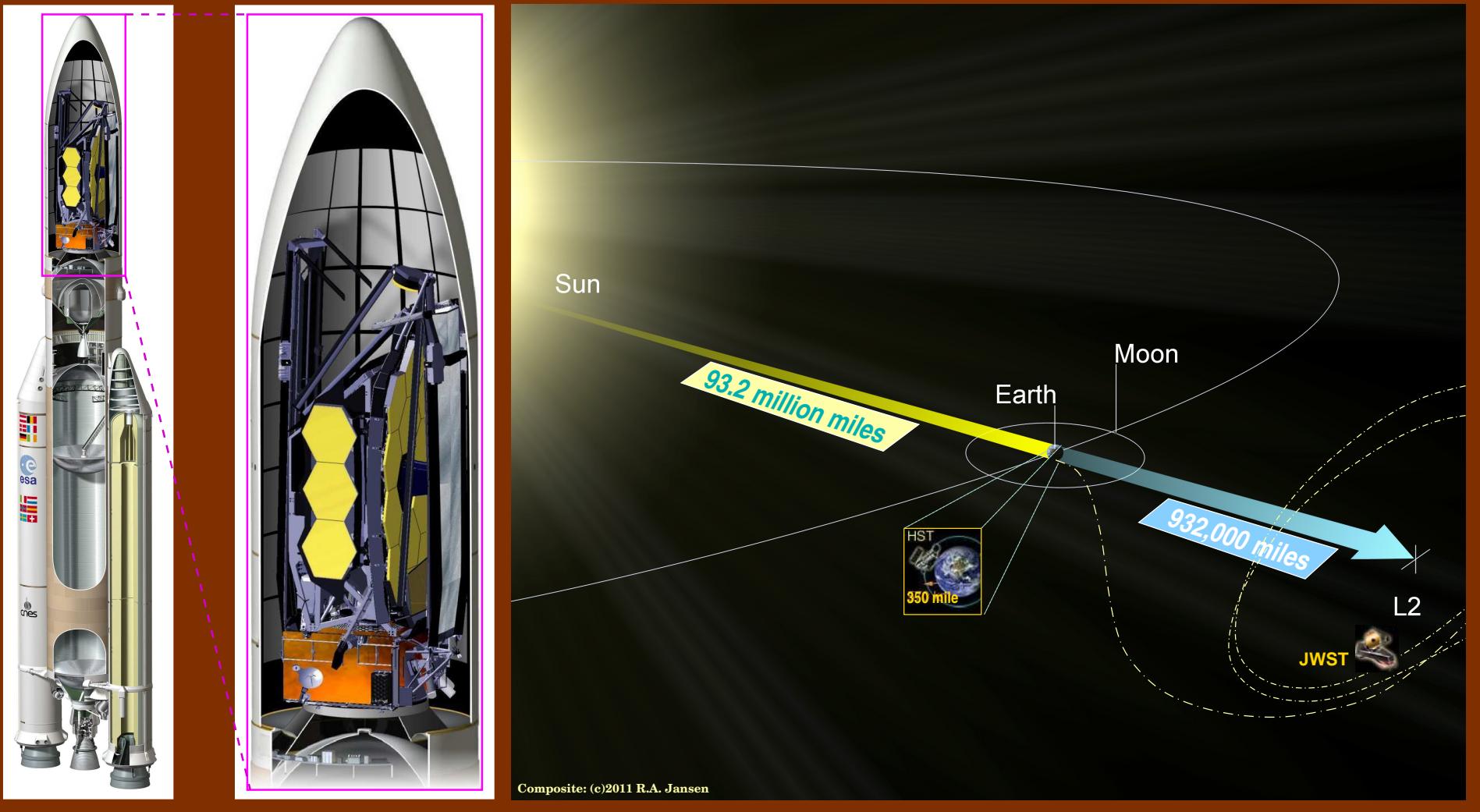
Comparison of *JWST* and *HST*



John Mather, JWST Q&A Session, Sep 21 2011

In the near-infrared, *JWST* will have higher angular resolution than *HST*

Comparison of *JWST* and *HST*



ESA, R.A. Jansen

Orbit: 932,000 miles (*JWST*) versus 350 miles (*HST*); launch to L2 by Ariane 5

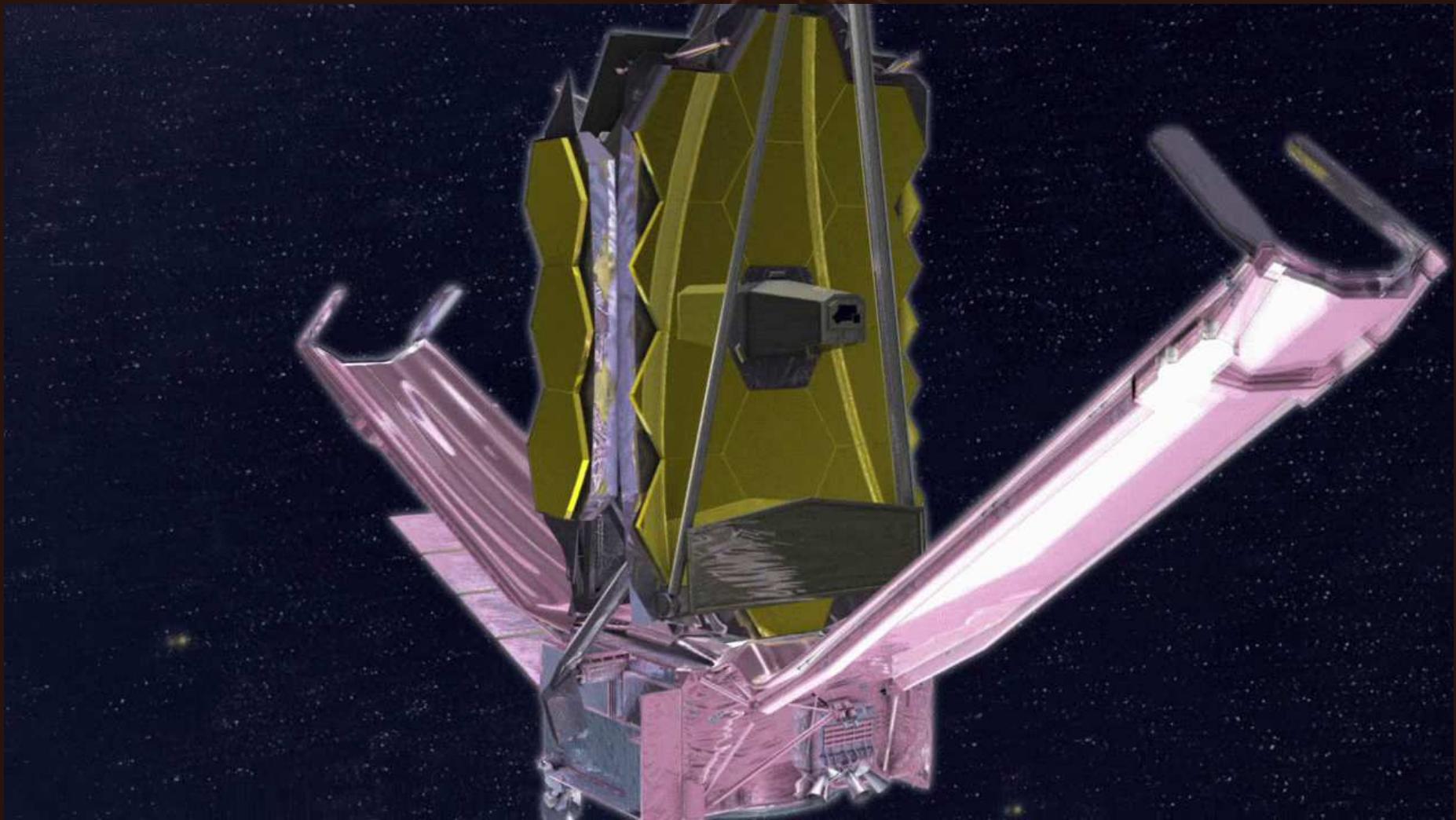
JWST deployment: advanced origami



Unfolding the *JWST* – 1

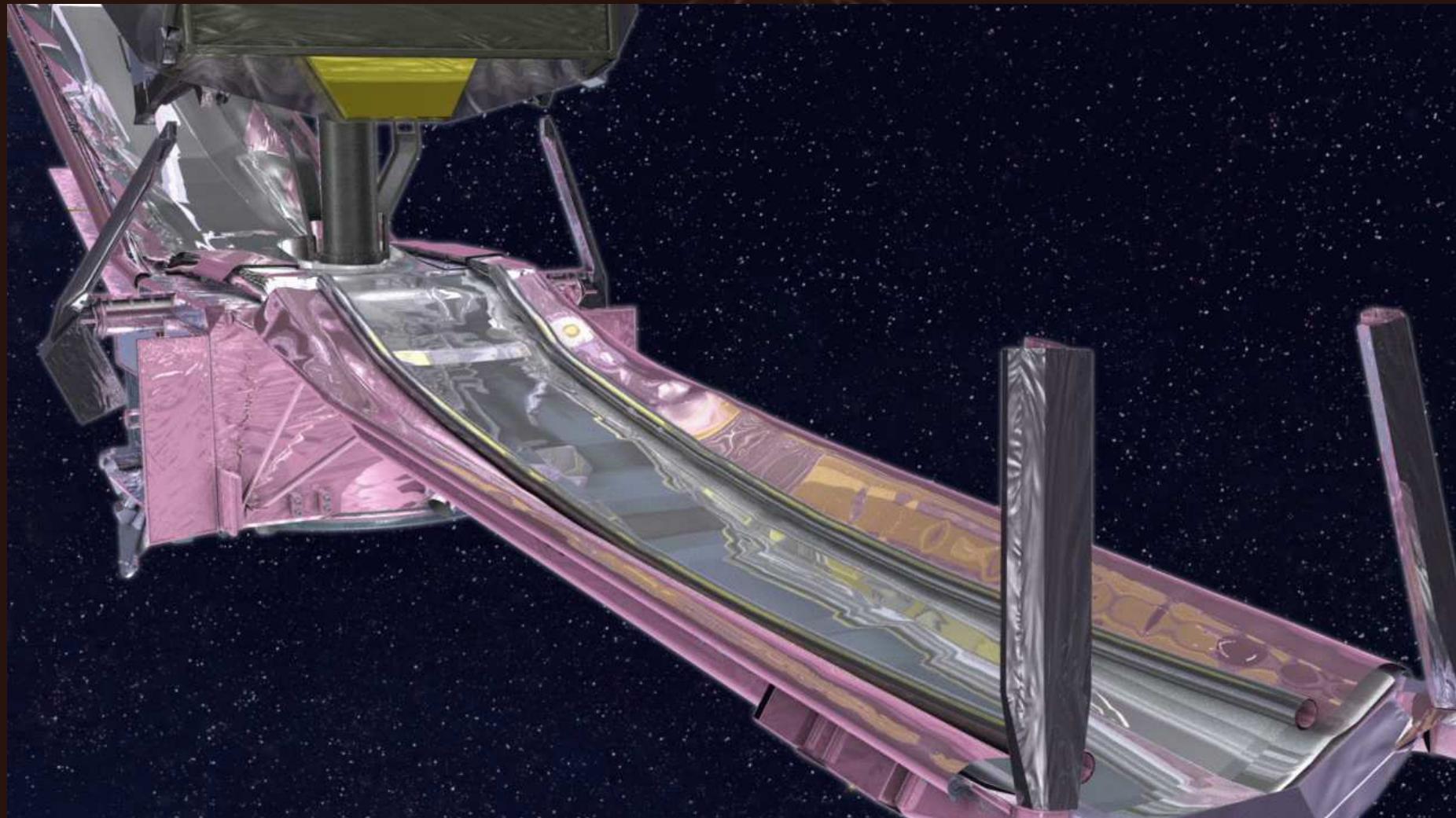
(or see movie: "JWST_DeployAnimation-longversion")

JWST deployment: advanced origami



Unfolding the *JWST* – 2

JWST deployment: advanced origami



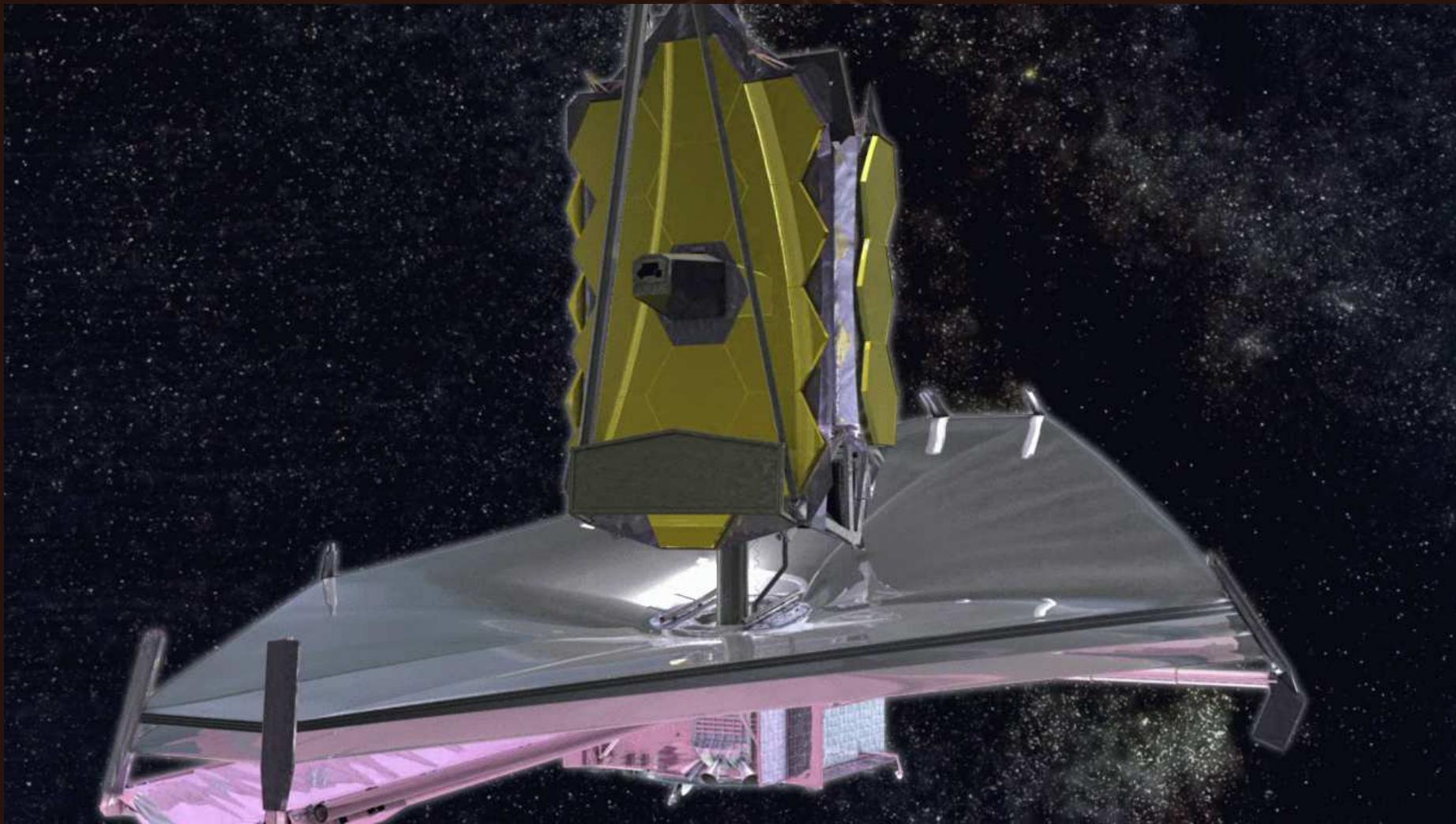
Unfolding the *JWST* – 3

JWST deployment: advanced origami



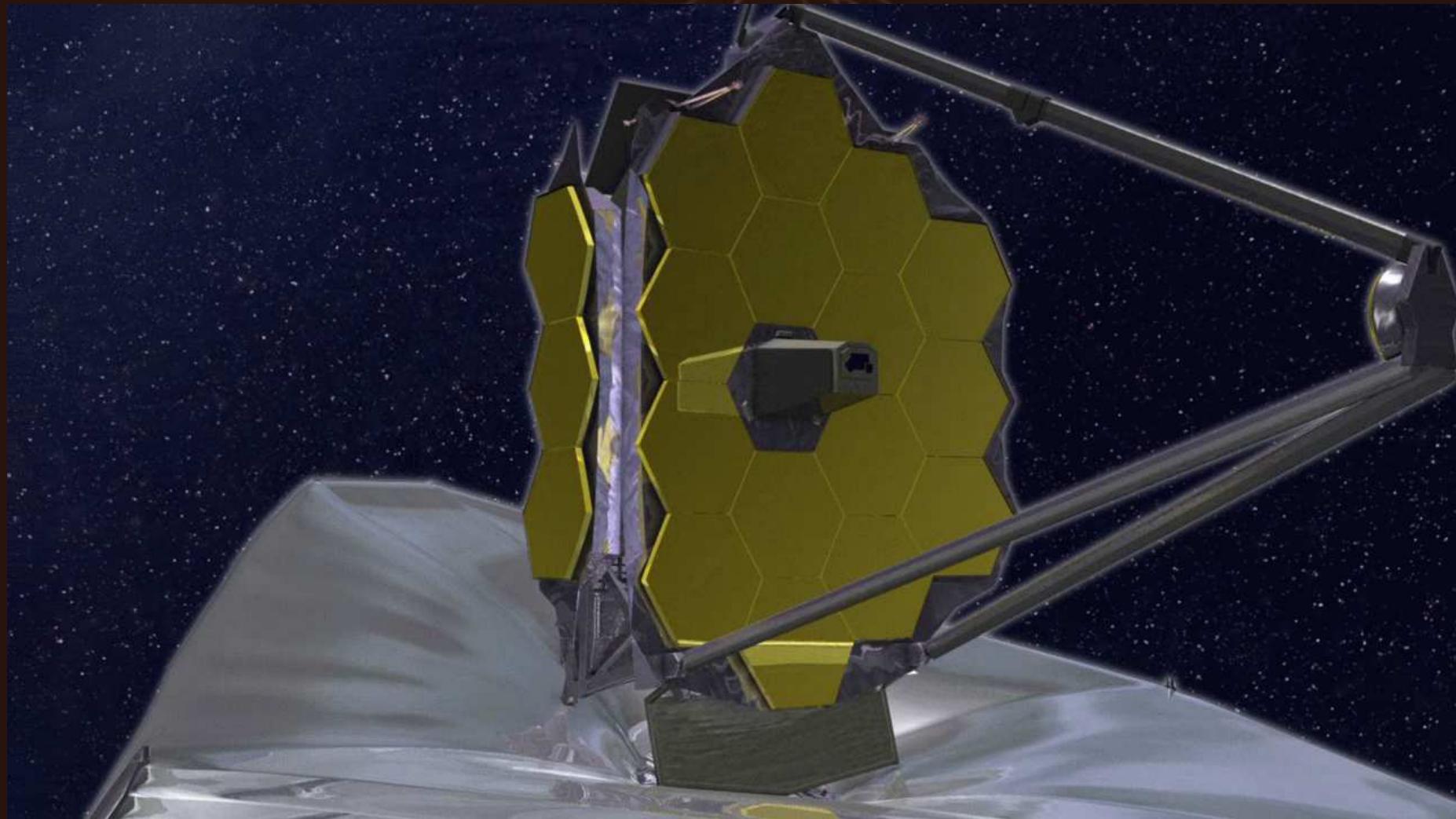
Unfolding the *JWST* – 4

JWST deployment: advanced origami



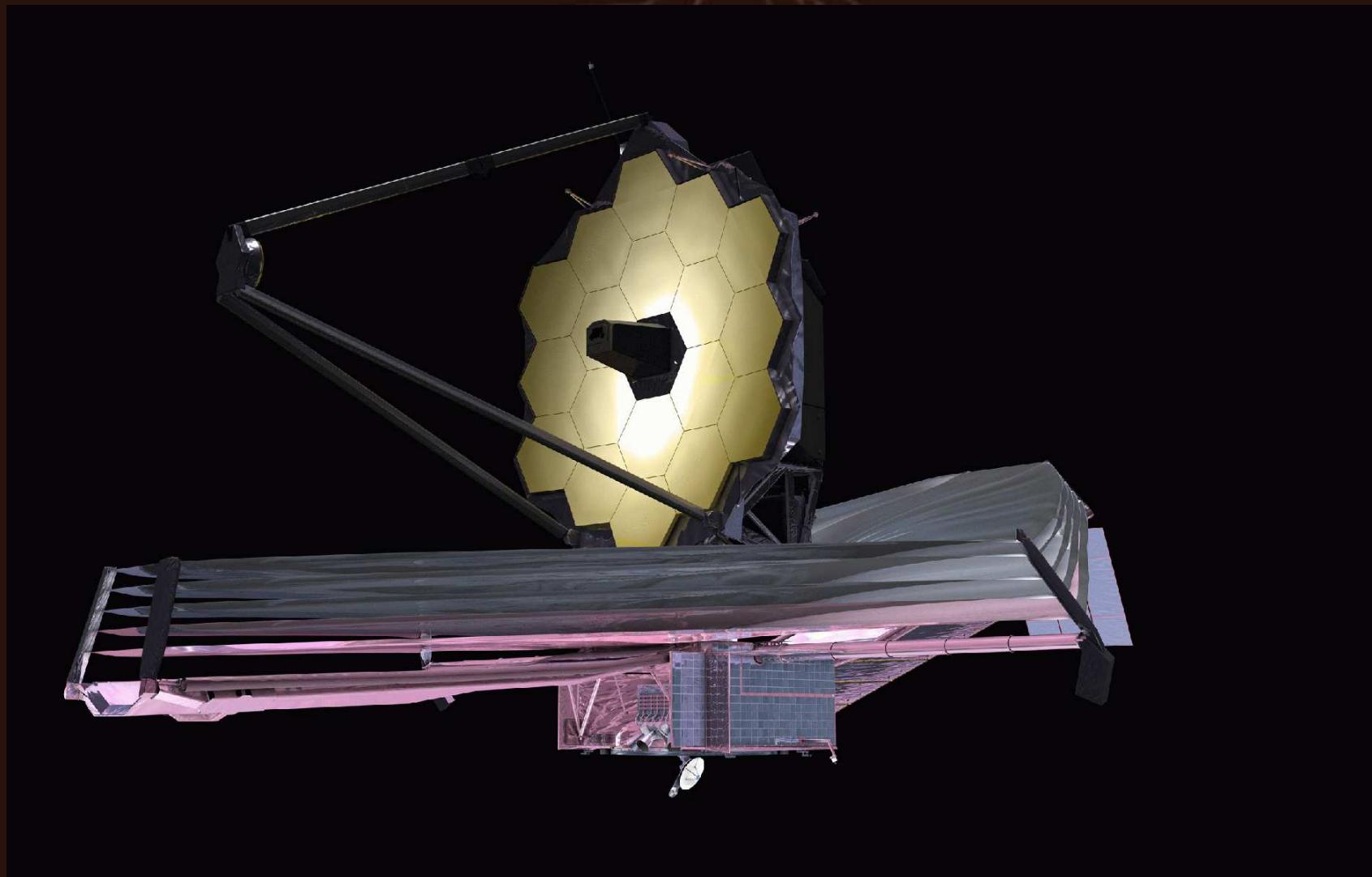
Unfolding the *JWST* – 5

JWST deployment: advanced origami



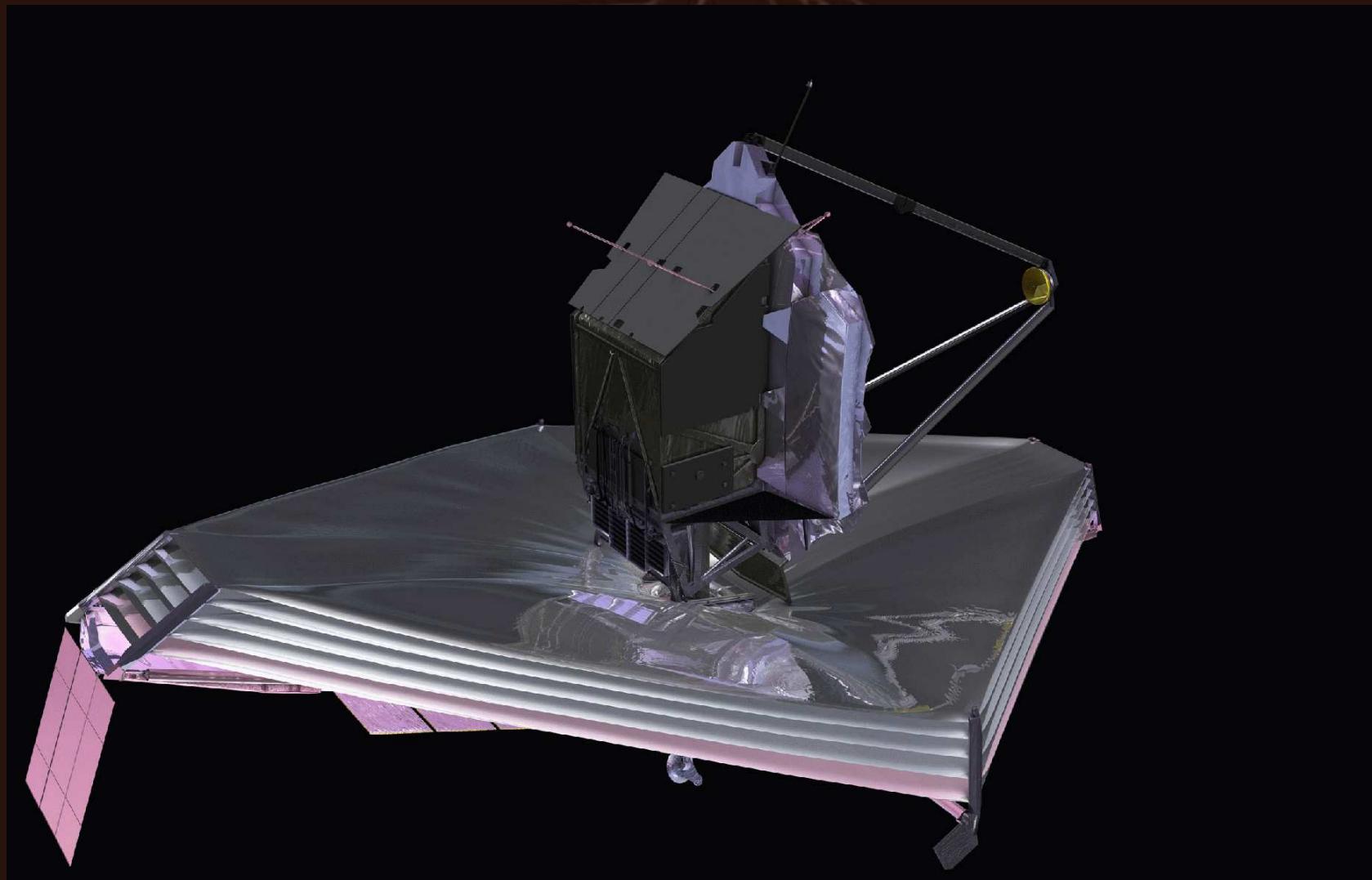
Unfolding the *JWST* – 6

What will *JWST* look like?



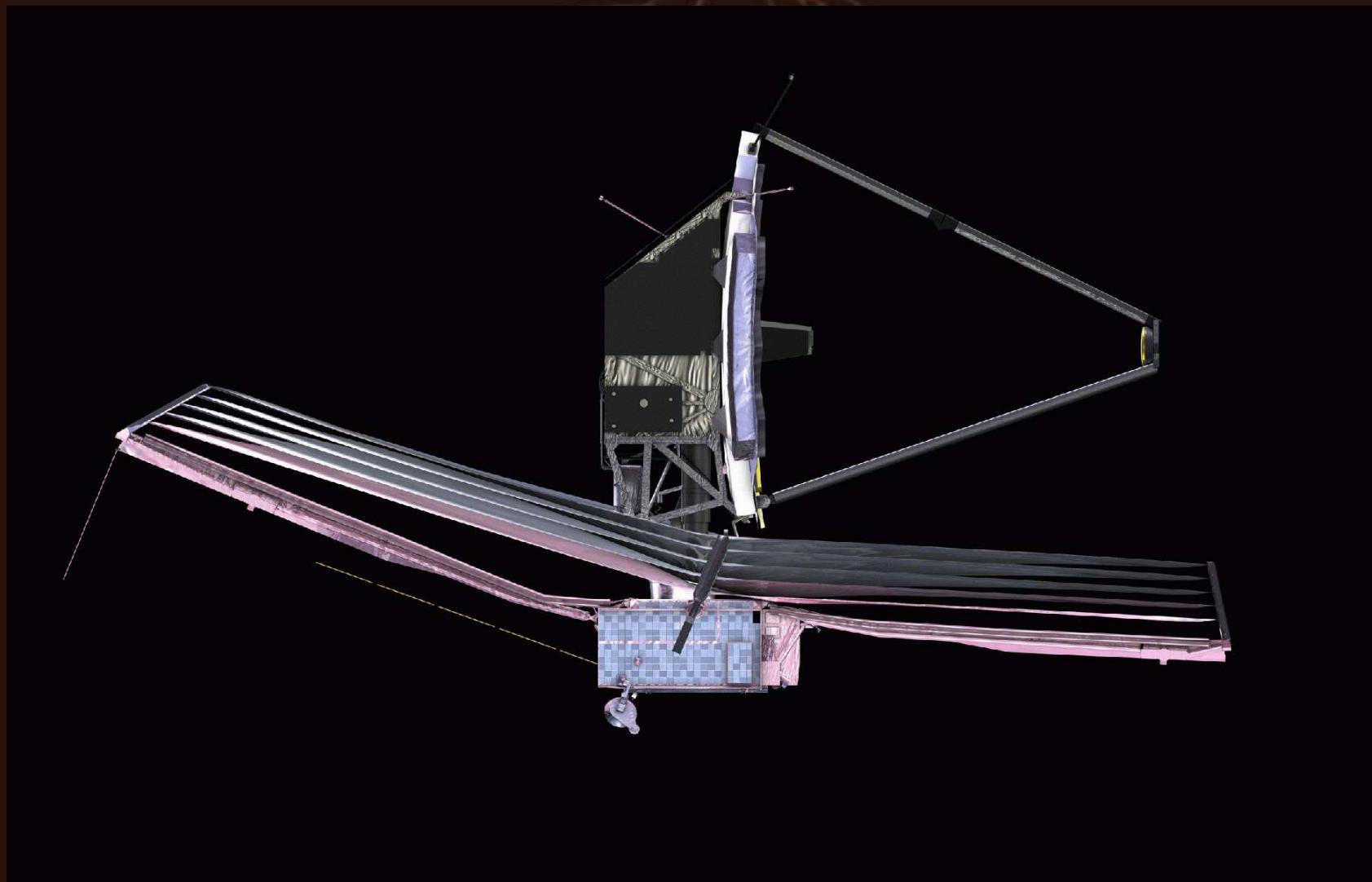
Rendering of the fully deployed *JWST*

What will *JWST* look like?



Perspective view from the rear of the fully deployed *JWST*

What will *JWST* look like?



View from the side of the fully deployed *JWST*

What will *JWST* look like?



Perspective view from below the fully deployed *JWST*

JWST's Scientific Instruments

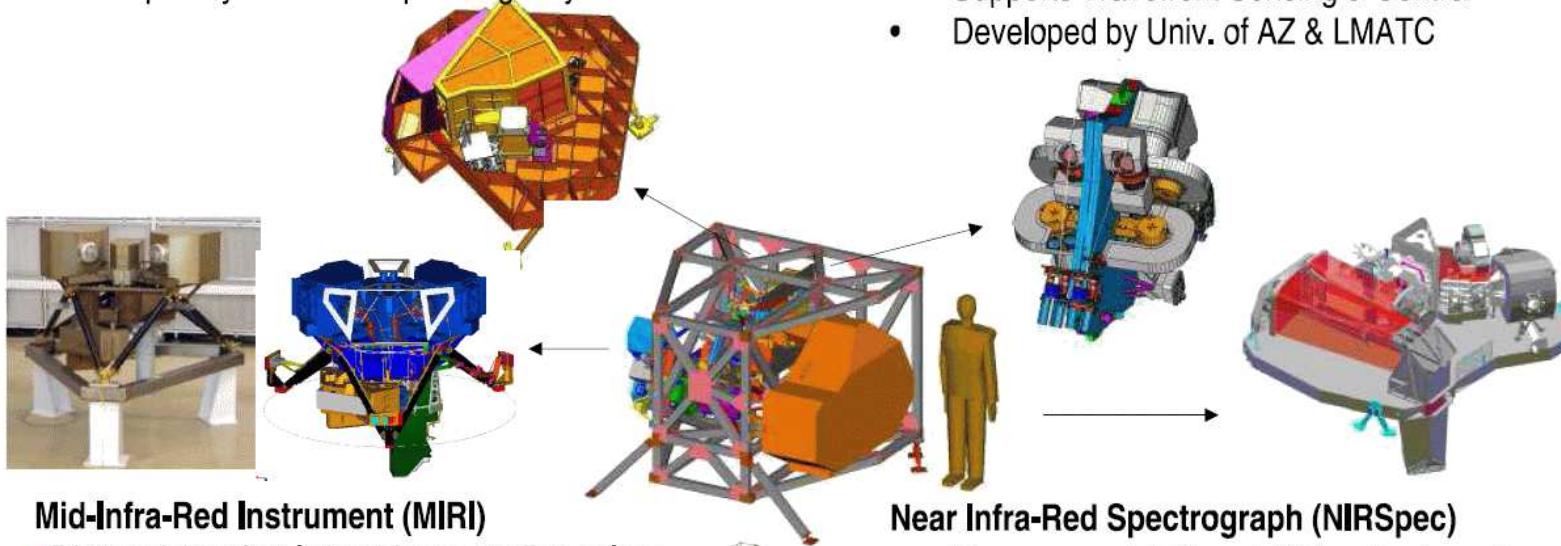


Instrument Overview



Fine Guidance Sensor (FGS)

- Ensures guide star availability with >95% probability at any point in the sky
- Includes Narrowband Imaging Tunable Filter
- Developed by Canadian Space Agency & COM DEV

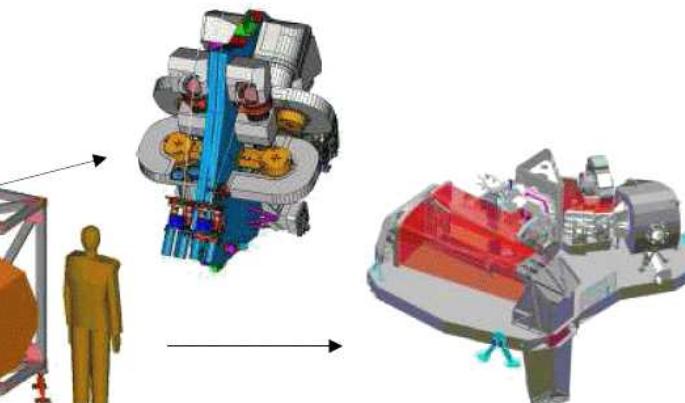


Mid-Infra-Red Instrument (MIRI)

- Distinguishes first light objects; studies galaxy evolution; explores protostars & their environs
- Imaging and spectroscopy capability
- 5 to 27 microns
- Cooled to 7K by Cyro-cooler
- Combined European Consortium/JPL development

Near Infra-Red Camera (NIRCam)

- Detects first light galaxies and observes galaxy assembly sequence
- 0.6 to 5 microns
- Supports Wavefront Sensing & Control
- Developed by Univ. of AZ & LMATC



Near Infra-Red Spectrograph (NIRSpec)

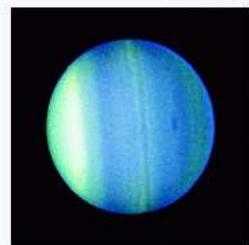
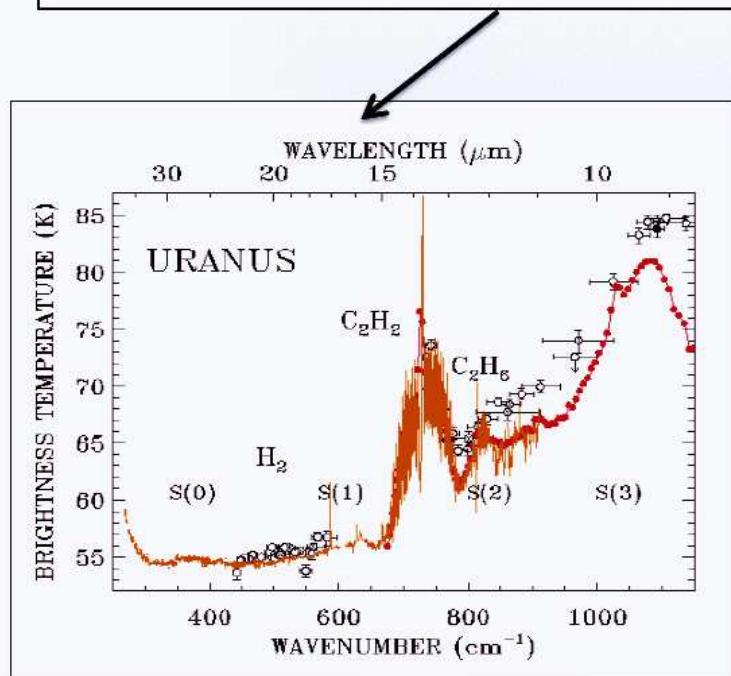
- Measures redshift, metallicity, star formation rate in first light galaxies
- 0.6 to 5 microns
- Simultaneous spectra of >100 objects
- Developed by ESA & EADS with NASA/GSFC Detector & Microshutter Subsystems

JWST Science Topics (for starters)

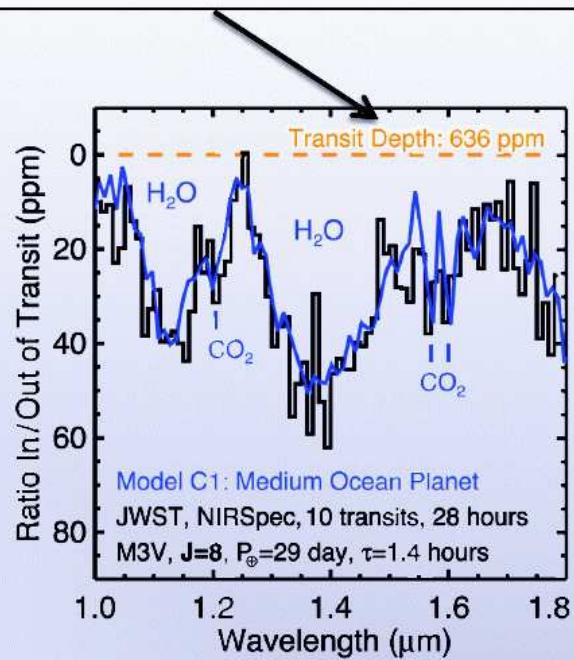
- Solar System:
 - ▶ JWST/MIRI: Spectra of gas giant planets, Kuiper Belt (Trans-Neptunian) Objects down to 25 magnitude; measure temperatures and dynamics; determine origins
- Debris Disks:
 - ▶ JWST/MIRI: resolve structure of the emission by circumstellar silicate dust grains
- Exoplanets:
 - ▶ JWST/NIRSpec: measure phase curves of exoplanets around nearby M-dwarf stars; detect/measure water features in atmospheres of '*ocean planets*'.

JWST Science Topics

JWST will Study Planets Both within our Solar System
and Around other Stars



Uranus over wavelength ranges and sensitivities in the IR unmatched from the ground.



First spectra of the atmospheres of super Earths around nearby stars, unachievable from the ground.



Jonathan Lunine, JWST Q&A Session, Sep 21 2011

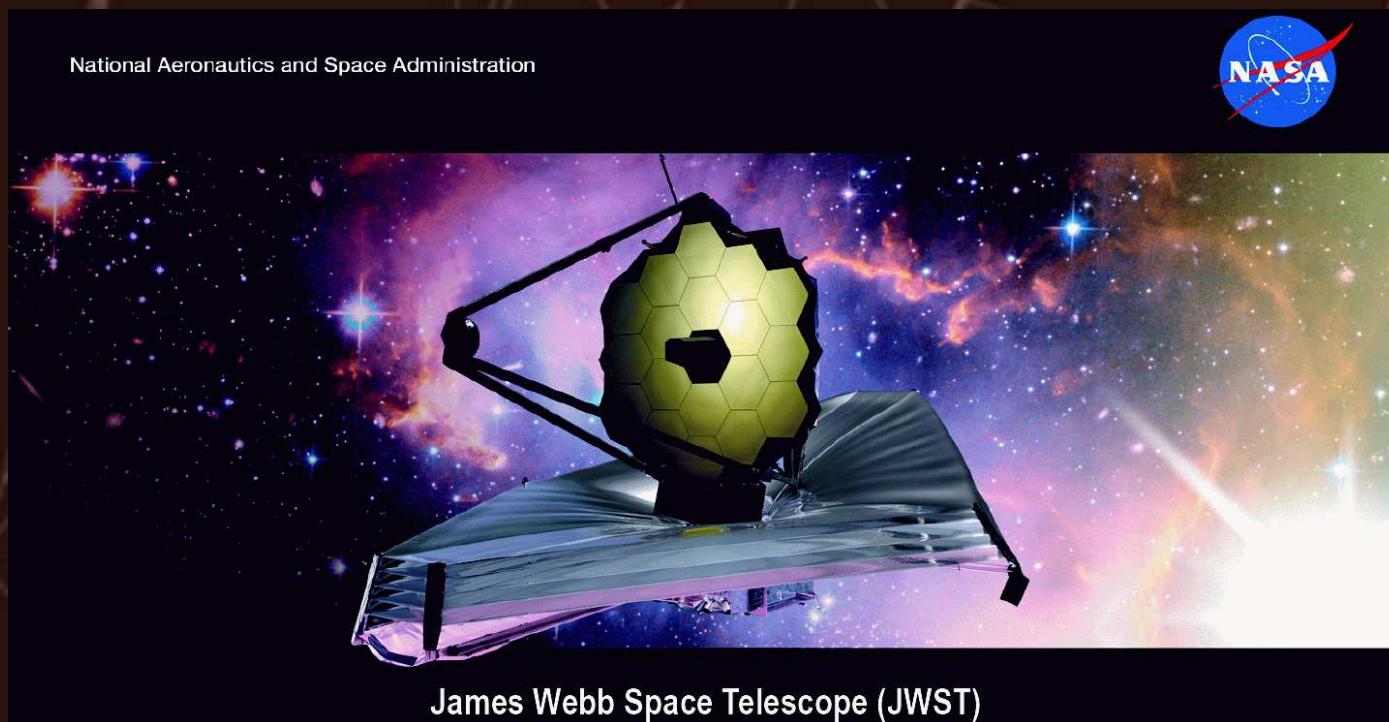
JWST Science Topics (for starters) (cont'd)

- Stars and Star Clusters:
 - *JWST/NIRCam*: measure stellar mass function down to the hydrogen burning limit (which separates true stars from ‘failed’ stars or brown dwarfs) throughout our Galaxy
- Galaxy Evolution:
 - *JWST/NIRSpec+MIRI*: measure escape fraction of ionizing light from star forming galaxies; importance for ionization budget of the Universe
- First Objects:
 - *JWST* will be able to see back in time to redshifts >7 (where the wavelengths of the light are stretched so far that *HST* can no longer detect it) and detect the first objects and explosions in the Universe

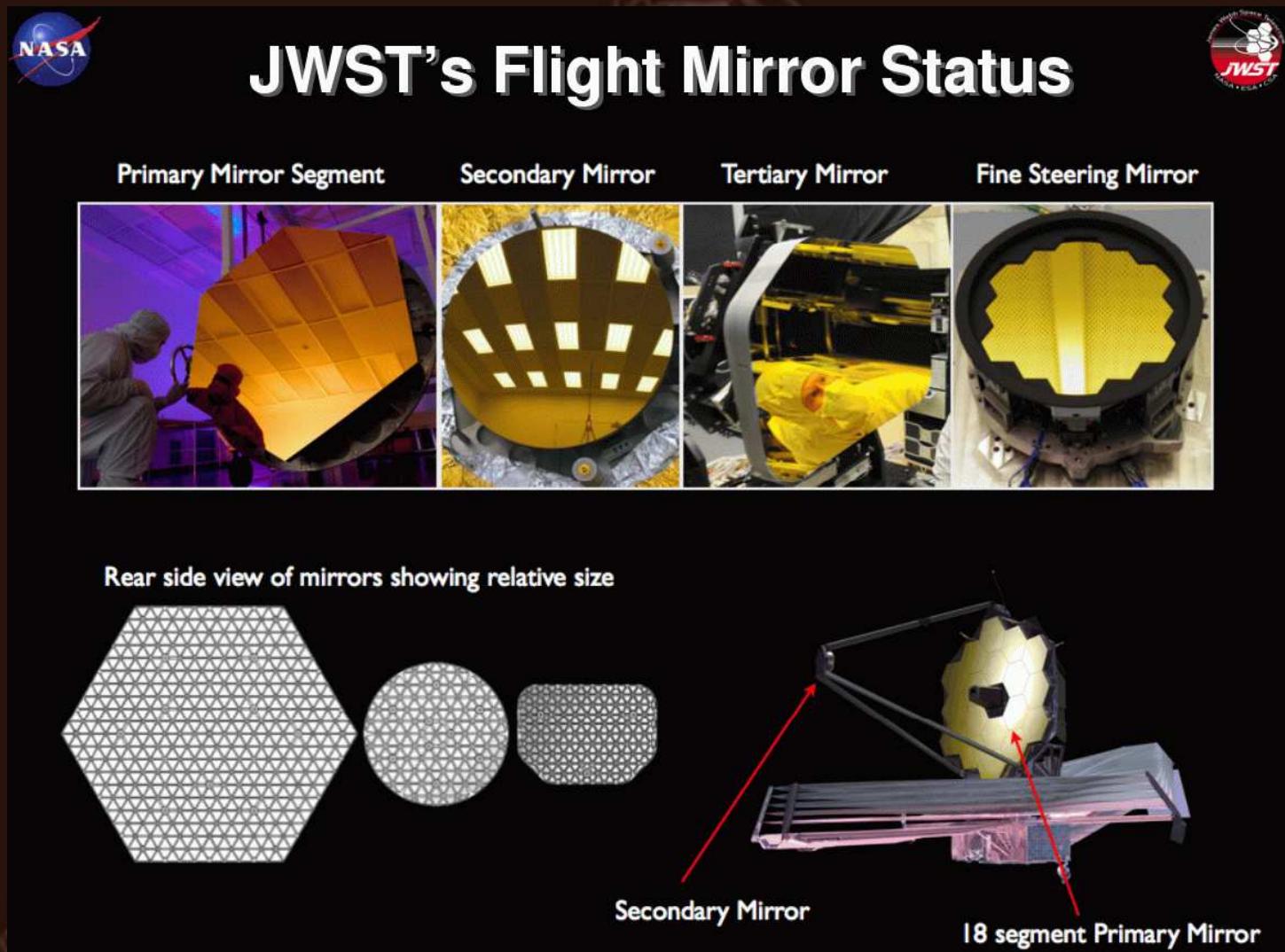
JWST Science Topics (for starters) (cont'd)

- Dark Energy:

- JWST/NIRCam will accurately measure the change in expansion rate of the Universe and so help determine the nature of the mysterious Dark Energy.

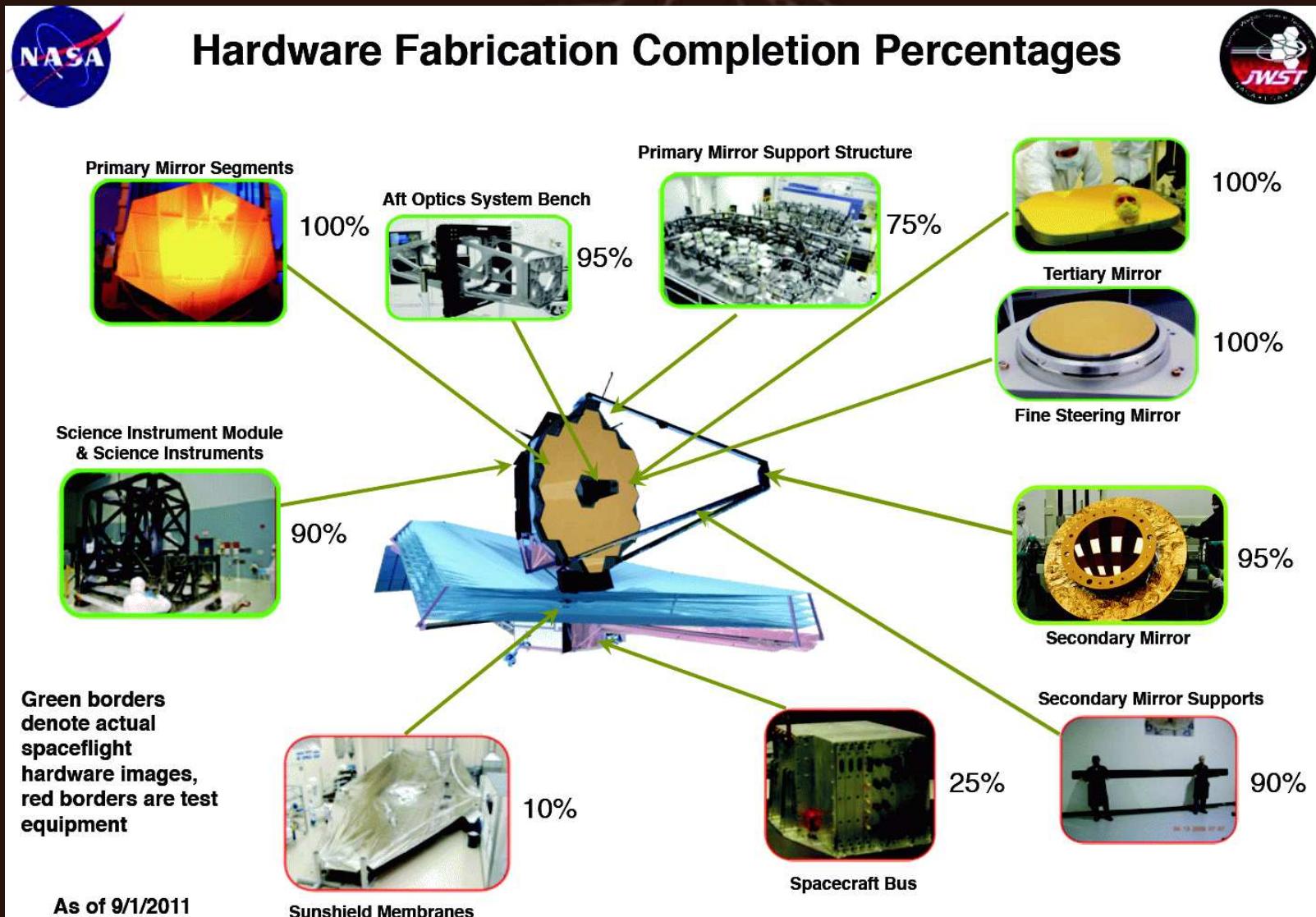


JWST Development Status



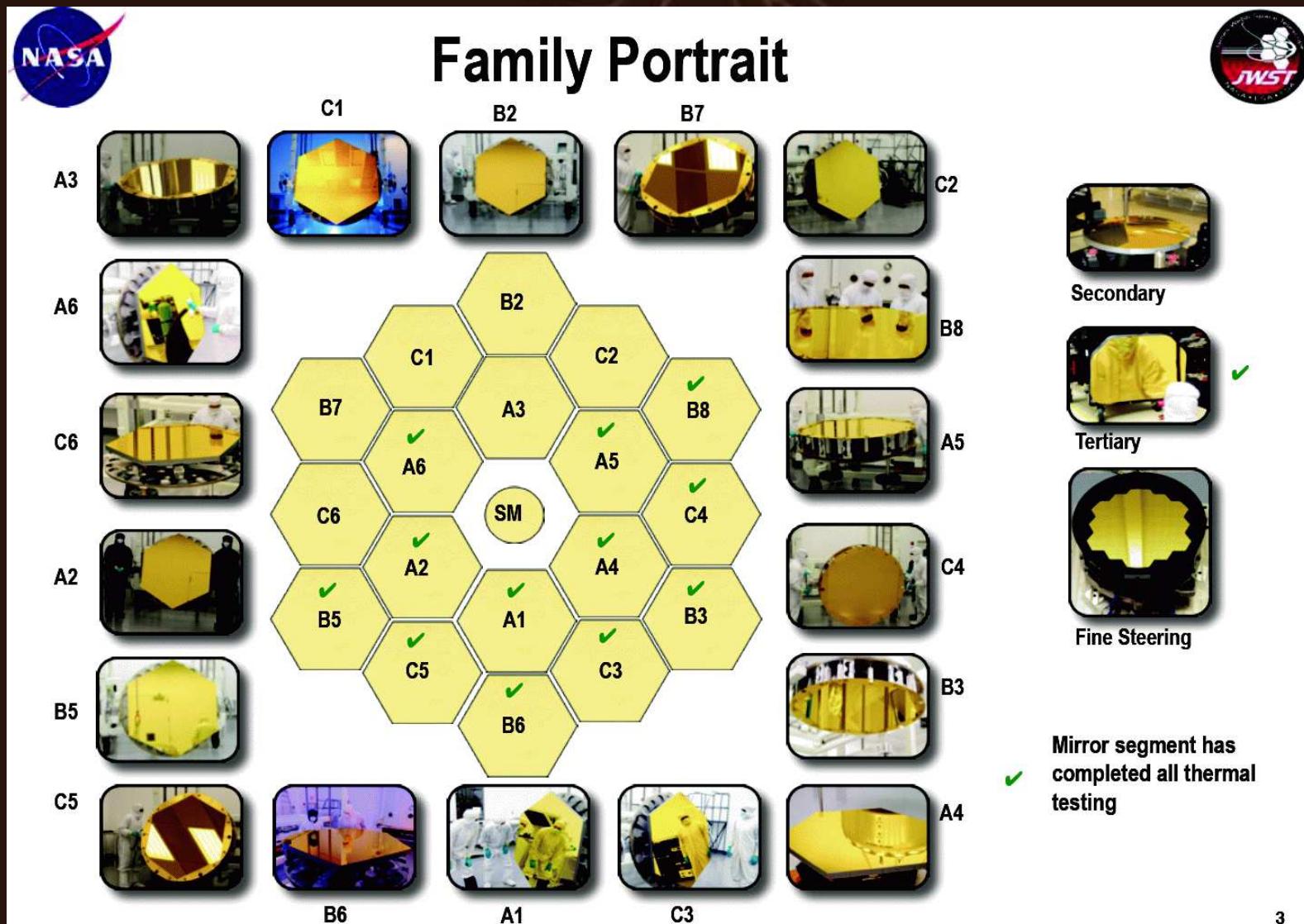
- Independent Comprehensive Review Panel (ICRP) report finds no technical hurdles

JWST Development Status



Eric P. Smith, JWST Q&A Session, Sep 21 2011

JWST Development Status



Eric P. Smith, JWST Q&A Session, Sep 21 2011

3

JWST Development Status

JWST Sunshield Membrane Engineering Model



Eric P. Smith, JWST Q&A Session, Sep 21 2011

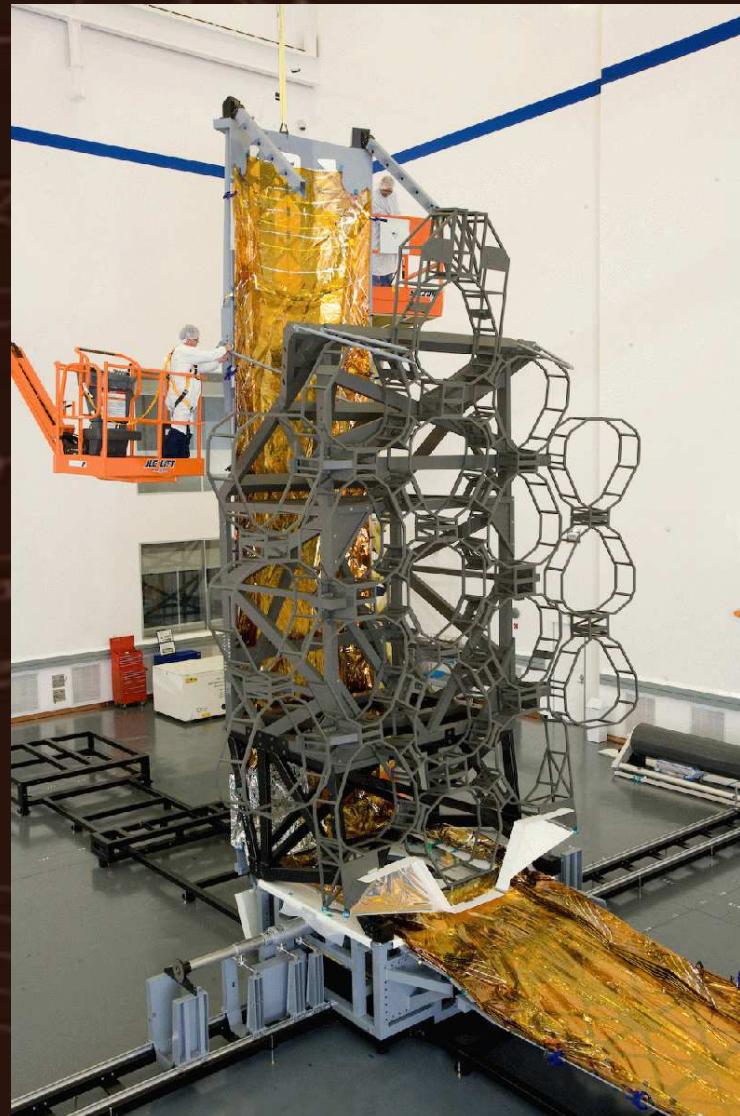
JWST Development Status

JWST mirror testing at NASA-MSFC



JWST Development Status

JWST mirror and support structure testing at NASA-MSFC and GSFC



JWST Development Status

- 11 new technologies invented from scratch early in *JWST*'s development process
 - >75% of real flight hardware procured, in production, under testing, or completed (incl. contributions by international partners)
 - Management/cost issues mitigated by elevating *JWST* to a division level (directly overseen by the NASA Associate Administrator)
- *JWST* continues to make great progress and is on track for a launch in 2018.

JWST Development Under Threat

- Jul 2011: House voted on Appropriations Bill to reduce NASA's 2012 Science budget (Earth Science, Planetary Science, Astrophysics, and Helio-physics) to \$4B, explicitly terminating all funding (\$ 431M) for *JWST*
 - *JWST* would not be finished and launched;
 - major threat to U.S. astronomy, loss of all its scientific opportunities and public excitement;
 - lost *JWST* funding would not be reallocated to other missions, but be permanently lost to astronomy;
 - damage to the international standing of NASA and the U.S. as an international partner: ESA (Europe) and CSA (Canada) contribute >\$1B to *JWST*.
- Sep 2011: Senate voted on its version of 2012 Appropriations Bill, proposing \$5B for Science and explicitly restoring funding to *JWST* at a level (\$530M) to allow launch in 2018.

JWST Development Under Threat (cont'd)

- Oct 2011? Final 2012 NASA budget to be determined in full conference of House and Senate
 - *JWST* could still be canceled in a comprise between House and Senate
 - Wide public support is needed to save *JWST*'s future.



What *you* can do to help save JWST: web links

- <http://www.savejwst.com/>
- <http://www.facebook.com/SaveJWST>
- <http://www.change.org/petitions/do-not-cancel-funding-for-the-james-webb-space-telescope>
- <http://capwiz.com/supportjwst/home/>
- <http://savethistelescope.blogspot.com/>
- <http://twitter.com/#!/saveJWST>
- <http://www.whitehouse.gov/contact>

Learn more about JWST at:

- <http://jwst.nasa.gov>
- <http://www.aura-astronomy.org/news/jwst.asp>
- <http://firstgalaxies.org/jwst/>

Write your senator ***Jon Kyl*** and reps. ***Jeff Flake*** or ***David Schweikert***