Science Synergy between ASU and the Netherlands: Hubble, Webb and other (Future) Telescopes

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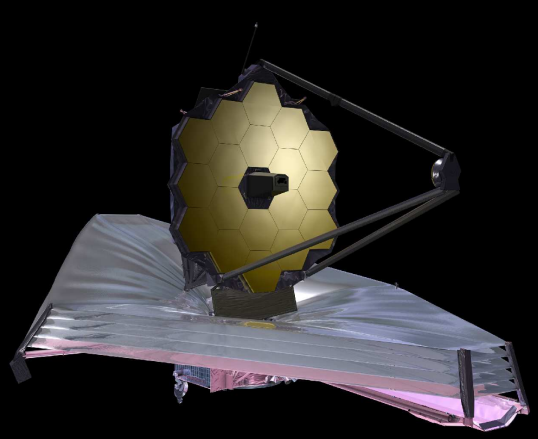
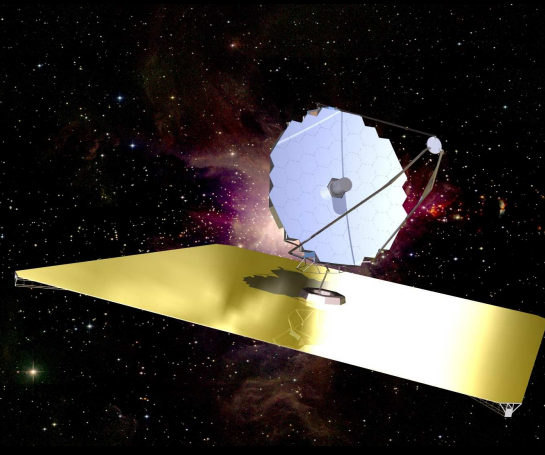
Prof. H. Röttgering, P. T. de Zeeuw (Leiden) & L. Koopmans (Groningen) + their students and postdocs.





1973∼2020^{+}; 1996∼2031; 2000∼2050^{+} 2020∼2050^{+}?

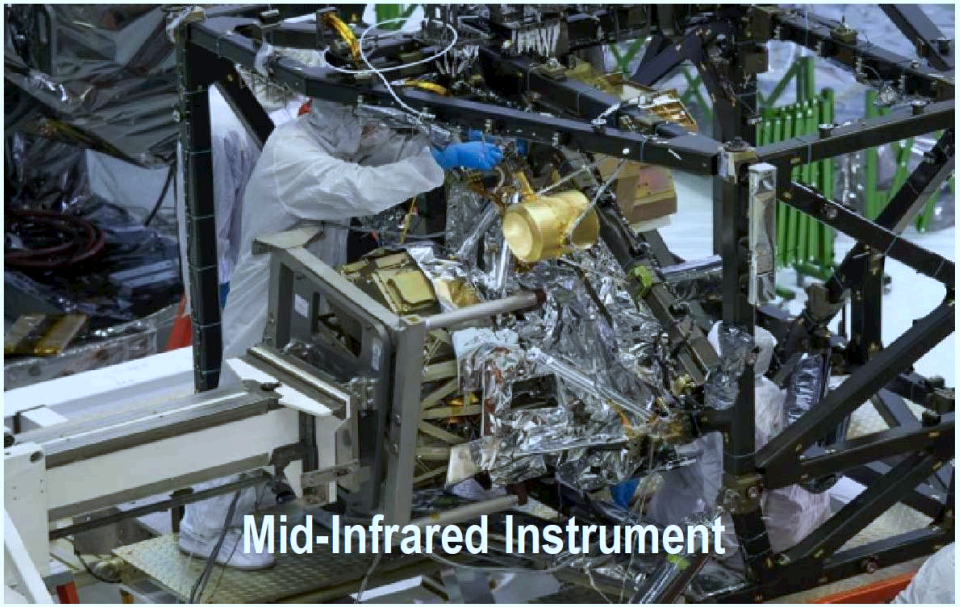
Focus charts for ASU meeting with Consulate of the Netherlands staff (ASU, Tempe, AZ);

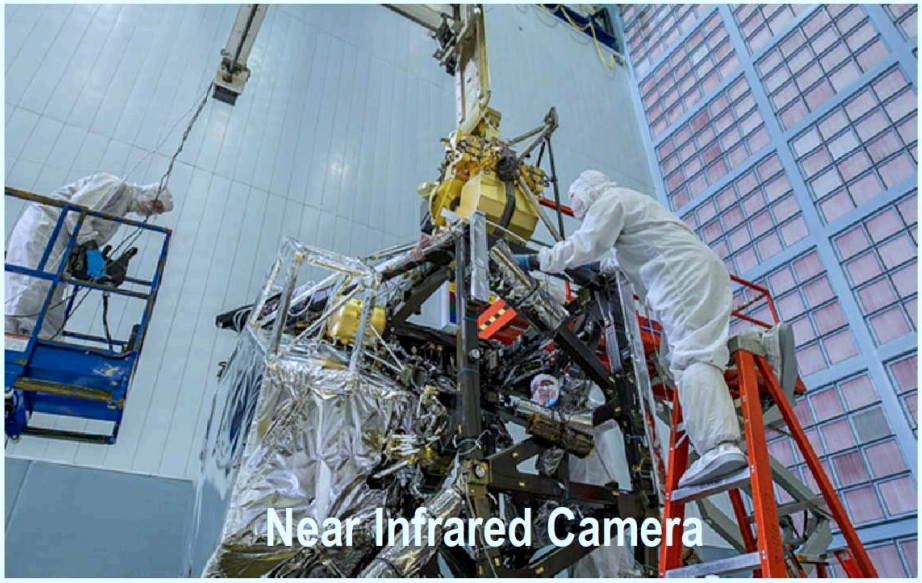
Wednesday Dec. 4, 2019. All presented materials are ITAR-cleared.

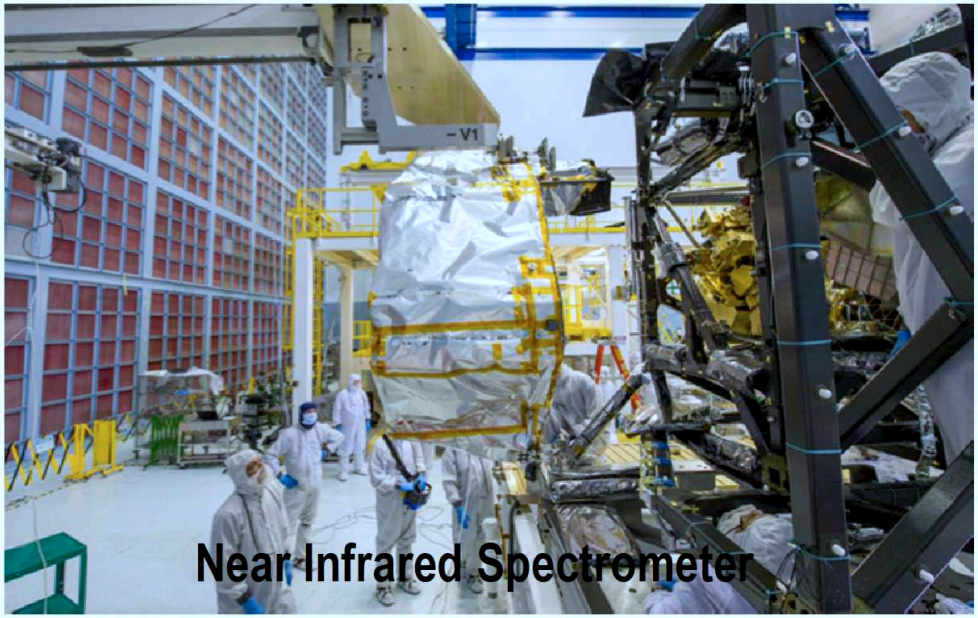
This talk: `http://www.asu.edu/clas/hst/www/jwst/jwsttalks/embassy19_ASU_NL_sciencesynergy.pdf`

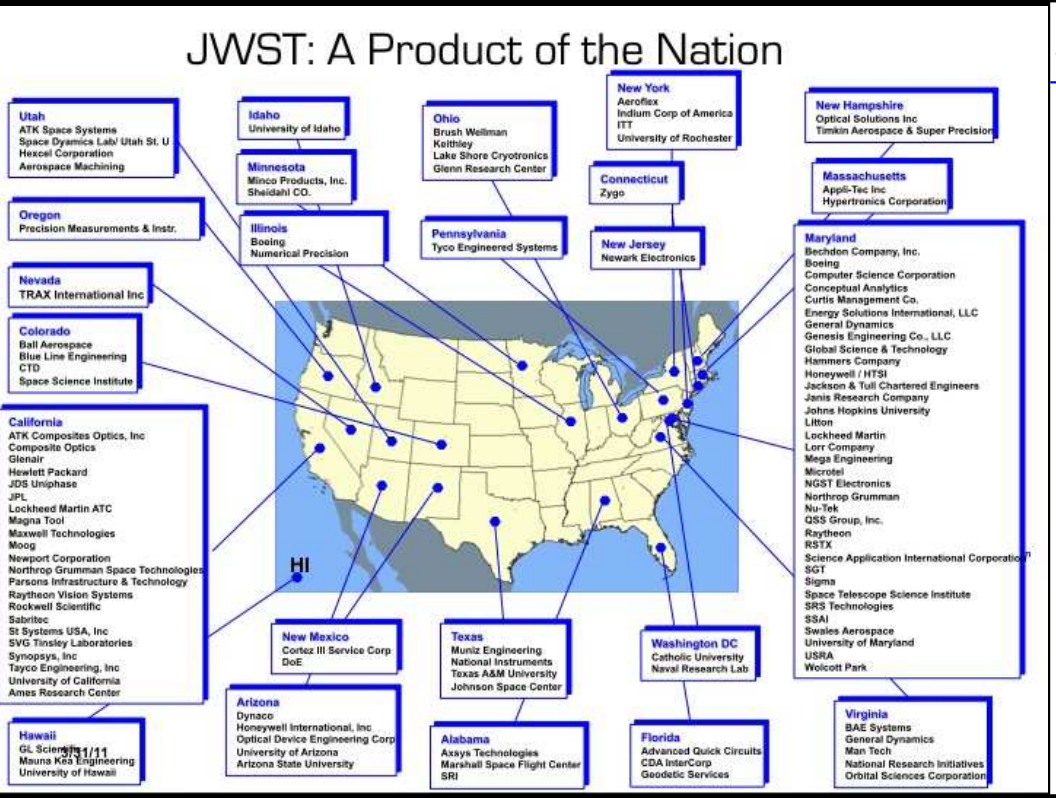
James Webb Space Telescope (JWST) tilted into the required position

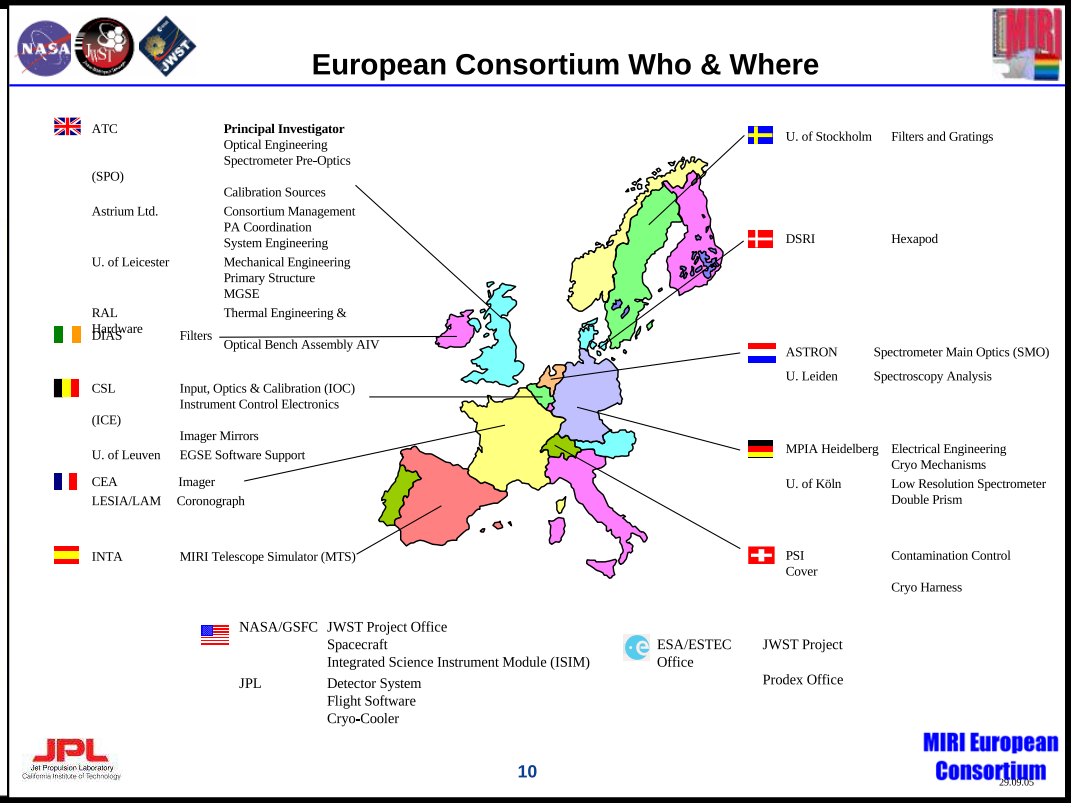
All Instruments Integrated







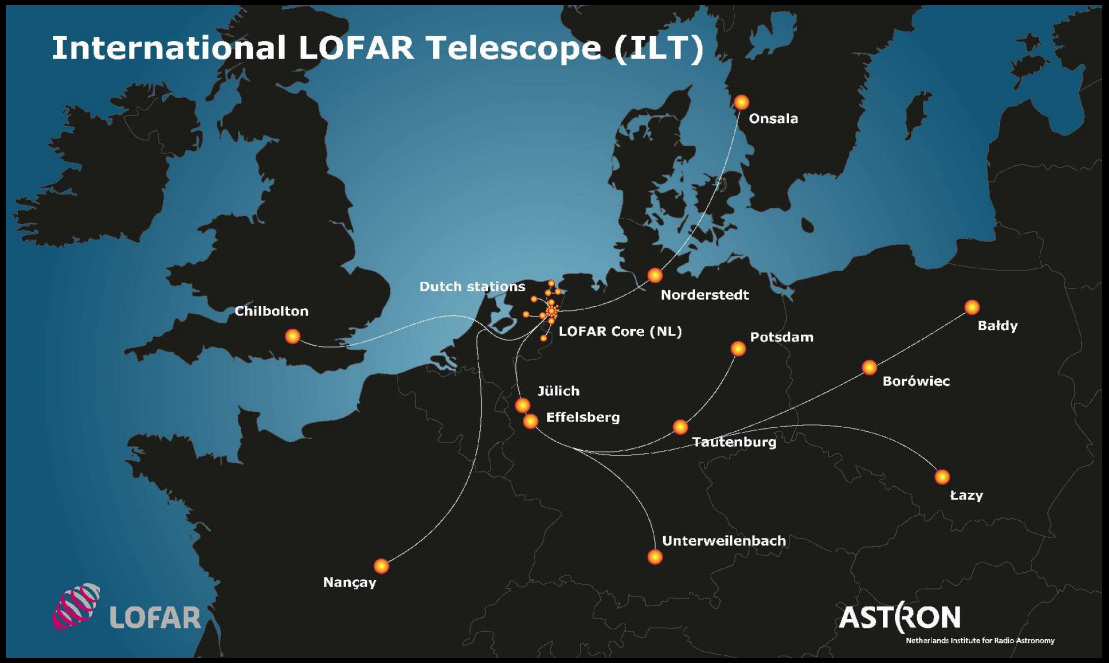


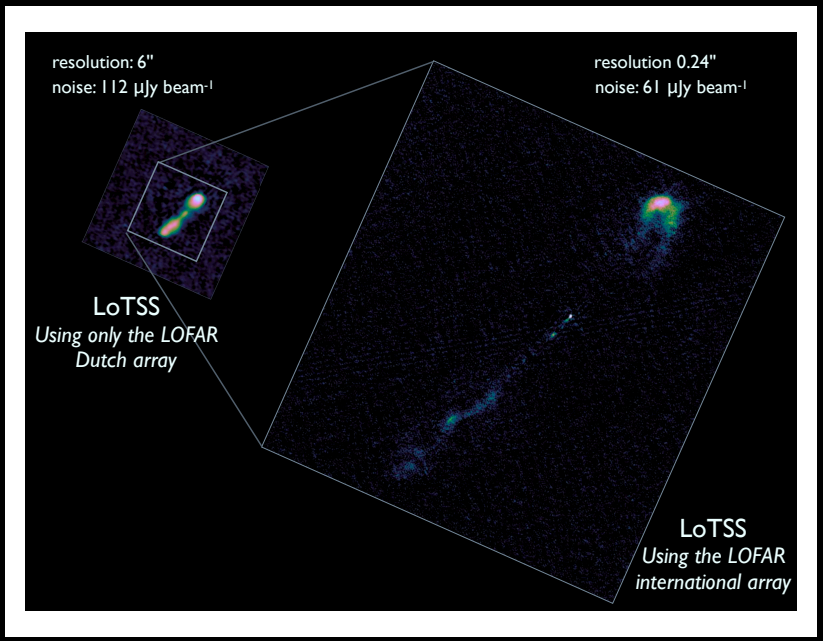


- JWST hardware made in 27 US States and 16 European countries.
- Ariane V Launch Vehicle provided by ESA.
- MIRI & NIRSpec by EU & ESA, major roles for ESTEC & ASTRON.
- JWST Fine Guider Sensor + NIRISS provided by Canadian Space Agency.
- JWST NIRCam by UofA and Lockheed. First Light science at ASU.

28 August 2019: JWST Telescope integrated with Sunshield & Spacecraft!

(2) Role of the Low-Frequency Array (LOFAR) in HST & JWST science





LOFAR = The Low Frequency Array:

Modern radio telescope built across NL and the EU. Designed to find:

- Hydrogen around the first stars (see Mahesh & Gehlot' charts).

[LEFT] • Magneto-hydrodynamics of jets around supermassive black holes, & in (gravitationally lensing) galaxy clusters.

- To operate, needs state-of-the-art software & supercomputers. Strong synergy with industry: Big-data, Petabyte data sets, & Petaflop computing.

- LOFAR has become a critical complement to HST & JWST.
- Foster stronger AZ (ASU, Intel+industry) / NL (LOFAR) connections.

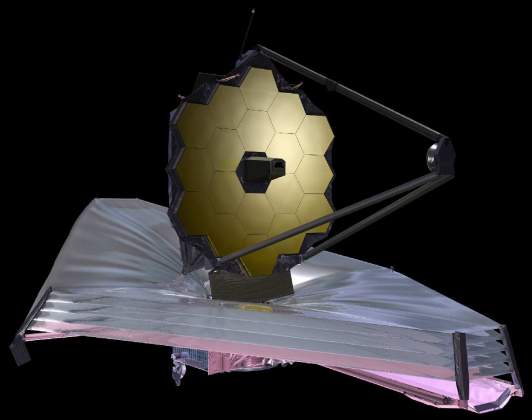
(3) Role of the EU Very Large Telescope in HST & JWST science

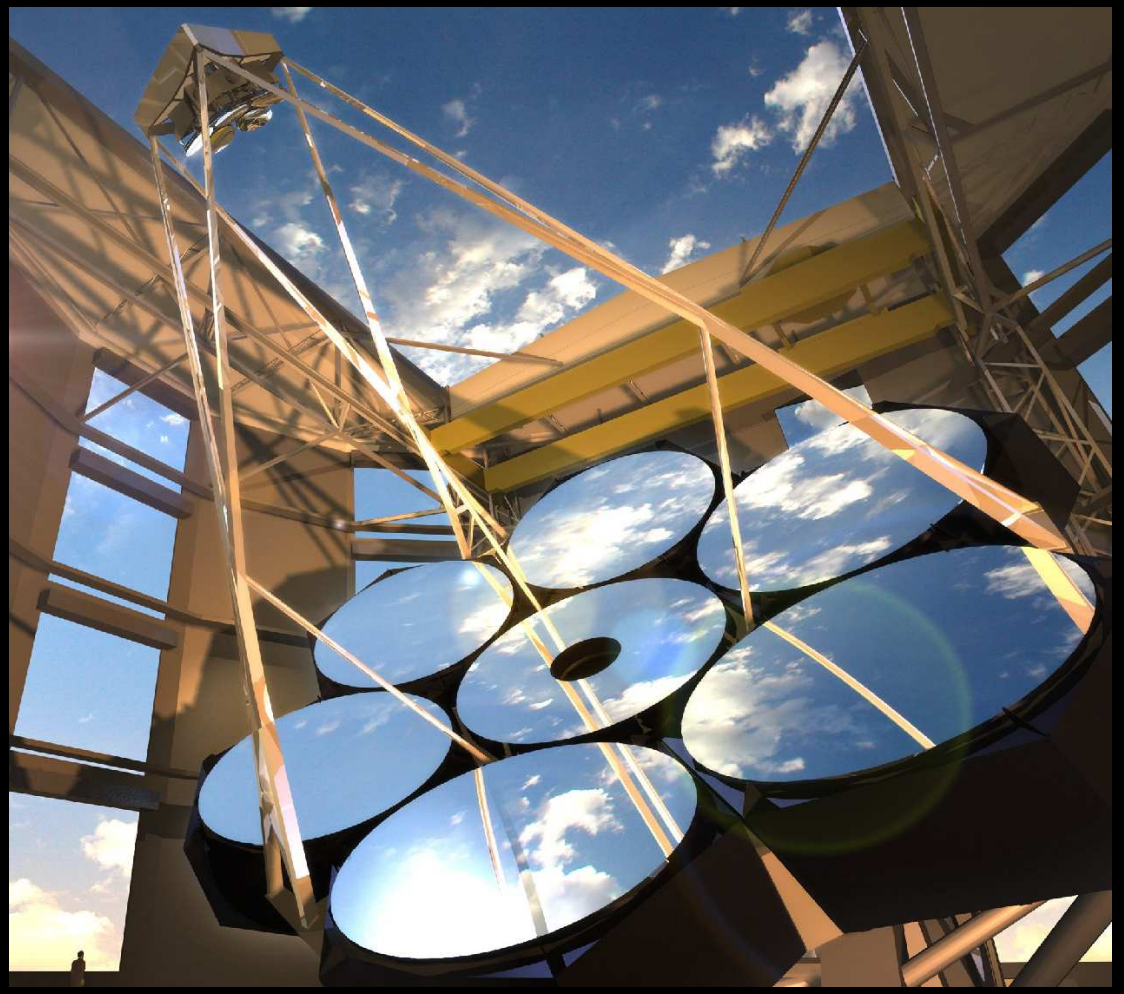
The Very Large Telescope in Chile a powerful complement to HST & JWST:

- Space-based telescopes provide very dark skies and stable images.
- Ground-based provides unique spectra for cosmic physics & chemistry.
- VLT and E-ELT instrumentation unprecedented and world-class.
- Has been a perfect marriage since the 1990's: this dream will continue!

(4) Future: Next generation 20–40 m ground-based telescopes and ATLAST

True relative size: Hubble, James Webb, & Giant Magellan Telescope



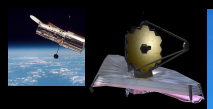


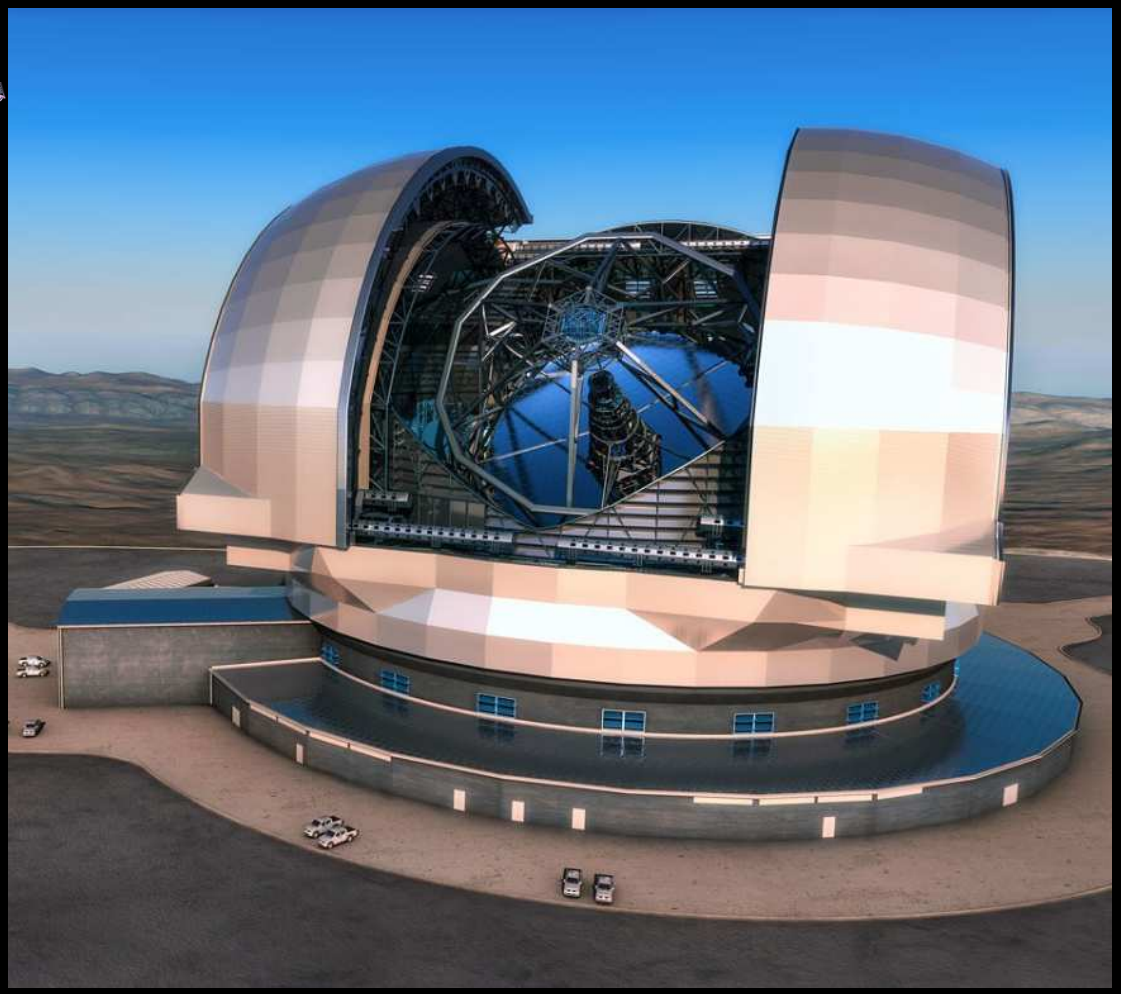
(1973∼2020^{+}); (1996∼2031); (2000∼2050^{+}).

- JWST will have superbly dark sky & sensitivity, and stable images.
- GMT provides 4×higher resolution images & and high-resolution spectra.

(4) Future: Next generation 20–40 m ground-based telescopes and ATLAST

True relative size: Hubble, James Webb, & EU Extremely Large Telescope

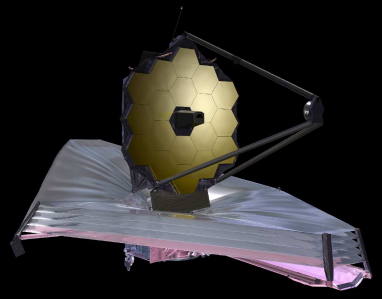


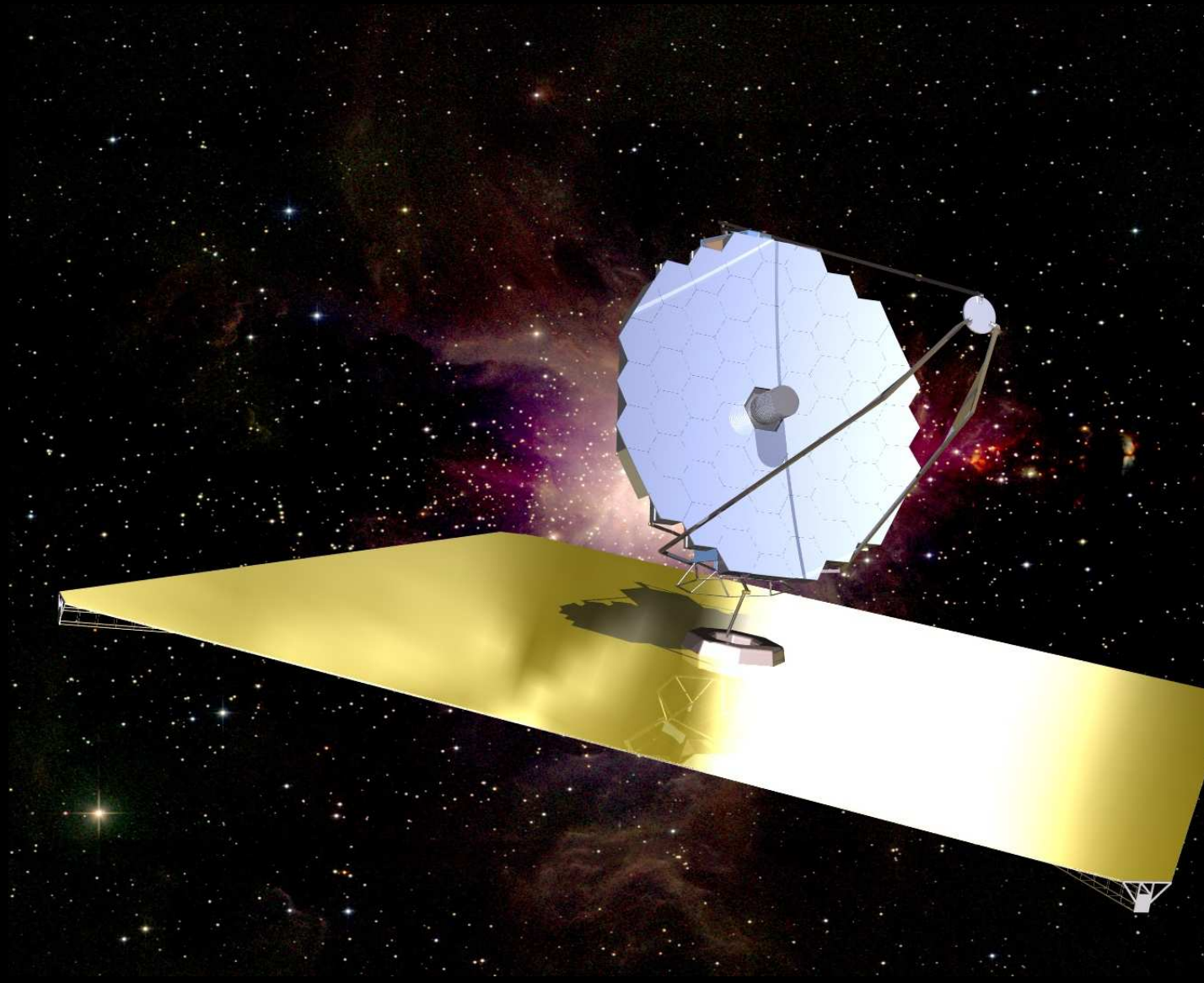


(1973∼2020^{+}); (1996∼2031); (2000∼2050^{+}).

- JWST will have superbly dark sky & sensitivity, and stable images.
- E-ELT provides 6×higher resolution images & high-resolution spectra.
- 39 m E-ELT will be a critical complement to JWST, and to ATLAST.

True relative size: Hubble, James Webb, and ATLAST ...





(1973∼2020^{+}); (1996∼2031); (2020∼2050^{+}?).

- Like HST will have done for ∼50 yrs, & JWST for ∼30 yrs, ATLAST can provide powerful US-EU/NL synergy for many decades to come.

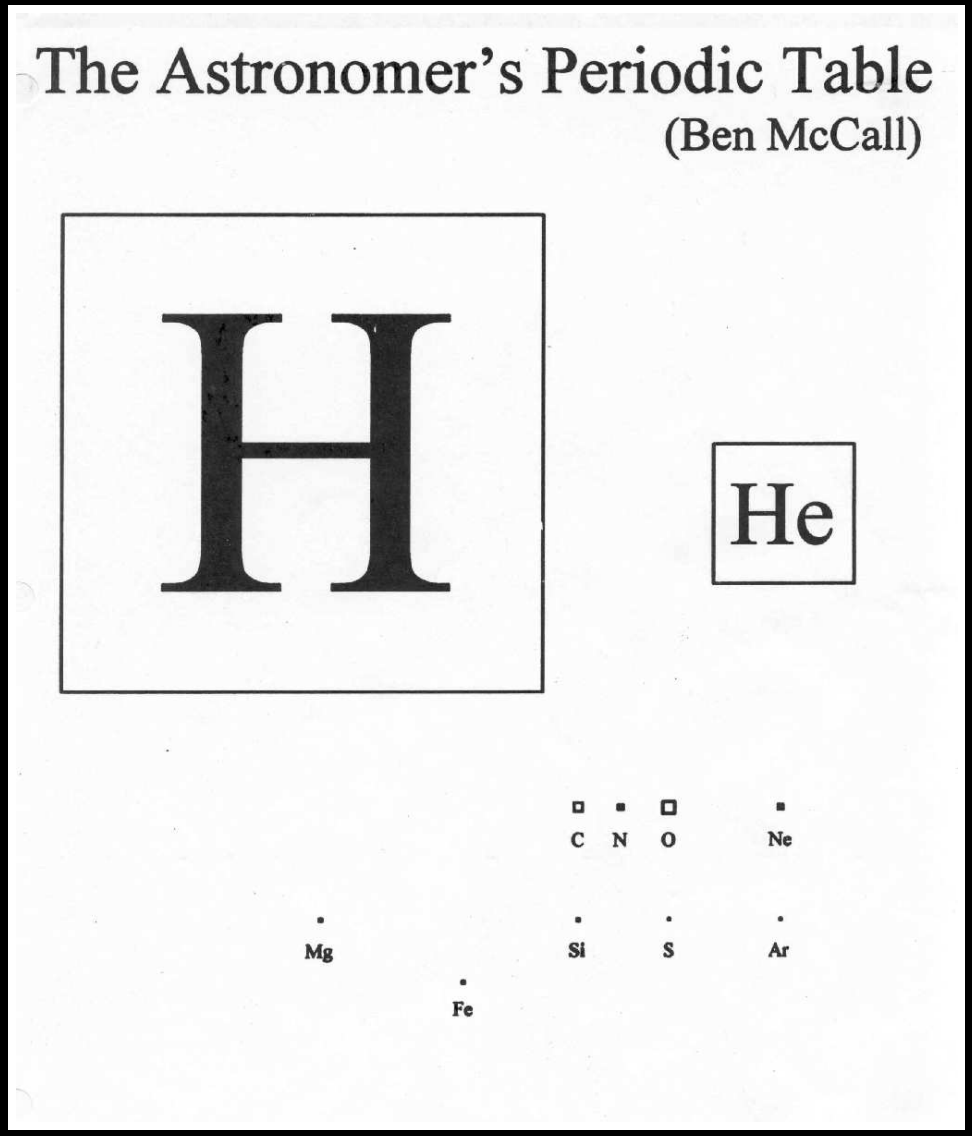
The real Periodic System

(1) Hydrogen & Helium only chemical elements made in the Big Bang.

(2) All heavier elements made inside (massive) stars.

(3) Late stages of stellar evolution and Supernova explosions distribute these throughout the universe.

(4) Planets and people literally made from stardust!



[The real Periodic Table with cosmic abundance included!]

- (5) Also requires the worlds largest supercomputers to model.
- (6) powerful potential synergy between AZ(Intel etc.)/ASU and NL/Univ. v. Amsterdam $\Longrightarrow$ More opportunities for exchange students & industry!

(5) Summary and Conclusions

(1) Hubble has revolutionized astronomy in the last few decades.

- The ESO VLT played a critical, complementary role in this.

(2) JWST will open the next frontier in 2021. JWST is designed to:

- Map the epoch of First Light and the first stars (first 0.2-0.4 Byrs).
- Galaxy Assembly and Supermassive Blackhole growth from the start.
- Characterize the atmospheres of Earth-like exoplanets.
- LOFAR and E-ELT (will) play a critical complementary role in this.

(3) JWST will have a major impact on astrophysics next decade:

- Infrared sequel to HST in 2021: Train our next generation researchers.
- Provide and outline technology for future space missions (ATLAST).
- Define the next frontier to explore: the Cosmic Dark Ages.

$\Longrightarrow$ Offers unique new opportunities for US/ASU–EU/NL collaborations.

SPARE CHARTS

- References and other sources of material shown:

http://www.asu.edu/clas/hst/www/jwst/ [Talk, Movie, Java-tool]

http://www.asu.edu/clas/hst/www/ahah/ [Hubble at Hyperspeed Java–tool]

http://www.asu.edu/clas/hst/www/jwst/clickonHUDF/ [Clickable HUDF map]

http://www.jwst.nasa.gov/ & http://www.stsci.edu/jwst/

http://ircamera.as.arizona.edu/nircam/

http://ircamera.as.arizona.edu/MIRI/

http://www.stsci.edu/jwst/instruments/nirspec/

http://www.stsci.edu/jwst/instruments/fgs

Gardner, J. P., et al. 2006, Space Science Reviews, 123, 485–606

Mather, J., & Stockman, H. 2000, Proc. SPIE Vol. 4013, 2

Windhorst, R., et al. 2008, Advances in Space Research, 41, 1965

Windhorst, R., et al., 2011, ApJS, 193, 27 (astro-ph/1005.2776).

Some of our ASU grad students do important outreach events:

Annual Girl Scout Stargazing at the White House South lawn (July 2015).

ASU student Amber Straughn (right; now at NASA GSFC working for Nobel Laureate Dr. John Mather) informs the Obama's about JWST.

• Need various in-roads with governments to advocate large international projects, and assure their completion.