Status of the JWST Science Instrument Payload

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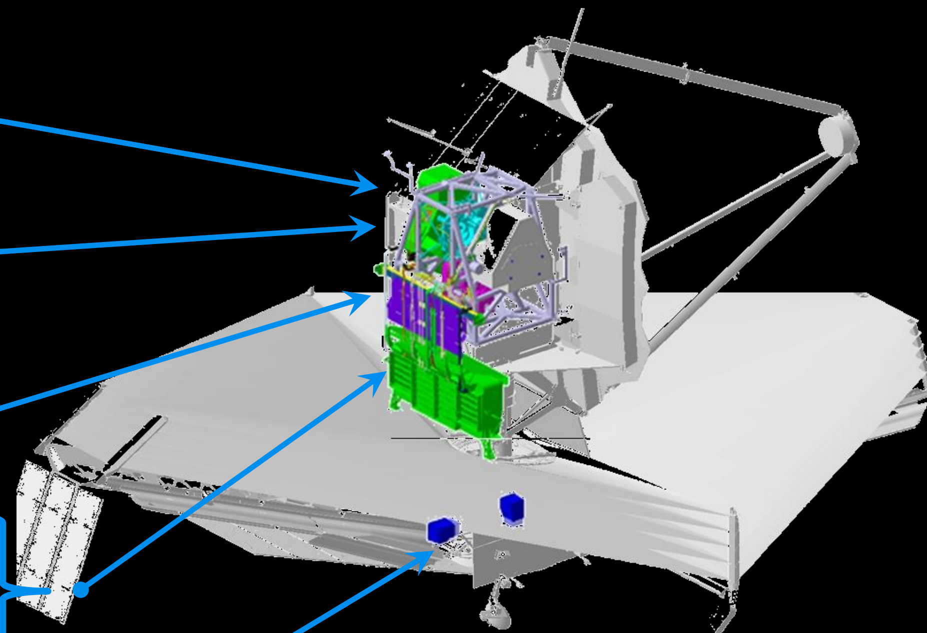
#JWST

The Integrated Science Instrument Module (ISIM) is the science instrument payload of the JWST

- ISIM is one of three elements that together make up the JWST space vehicle
  - Approximately 1.4 metric tons, ~20% of JWST by mass
  - Element-level I&T completed, ISIM was delivered to OTIS integration during March
- The ISIM system consists of:
  - Five sensors (4 science)
    - MIRI, NIRISS, FGS, NIRCam, NIRSpec
  - Nine instrument support systems:
    - Optical metering structure system
    - Electrical Harness System
    - Harness Radiator System
    - ISIM electronics compartment
    - ISIM Remote Services Unit
    - Cryogenic Thermal Control System
    - Command and Data Handling System
    - Flight Software System
    - Operations Scripts System



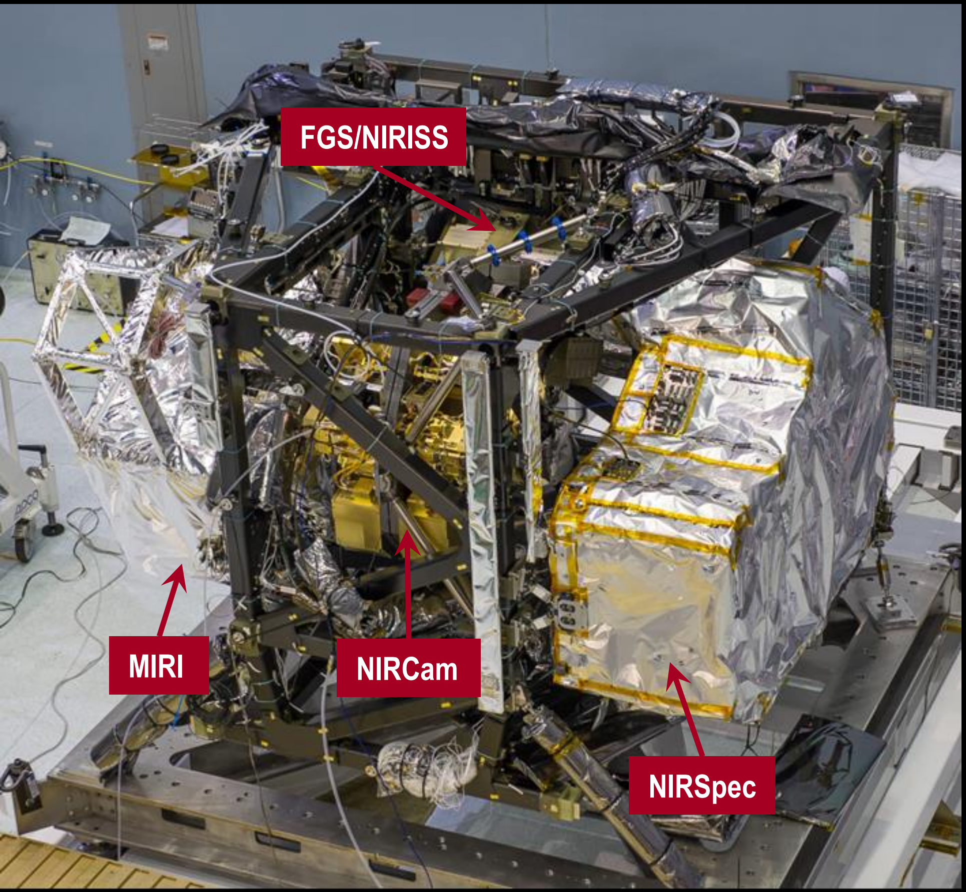
Three ISIM assemblies reside on the cryogenic side of the space vehicle

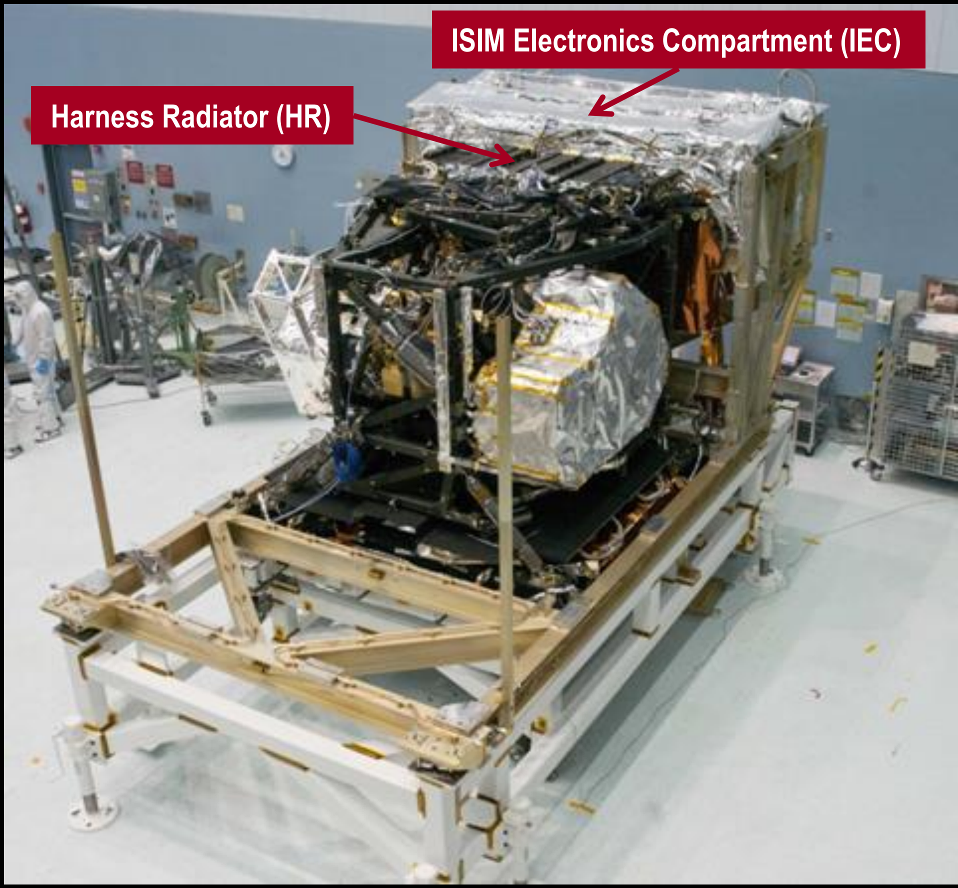
- Four science sensors:
  - NIRCam, NIRSpec, NIRISS, MIRI
- Fine guidance sensor (FGS)
  - Supports telescope pointing to ~ 10^{-6} deg
- Optical metering structure
  - Sensor launch loads
  - Sensor optical alignment over ~250 deg ΔT

- Harness Radiator (HR)
  - Passive cooling for ~2,700 electrical wires

- Electronics Compartment (IEC)
  - Houses 11 electronics boxes
  - Manages 220 W power on cryo side of space vehicle

Flight ISIM test configuration

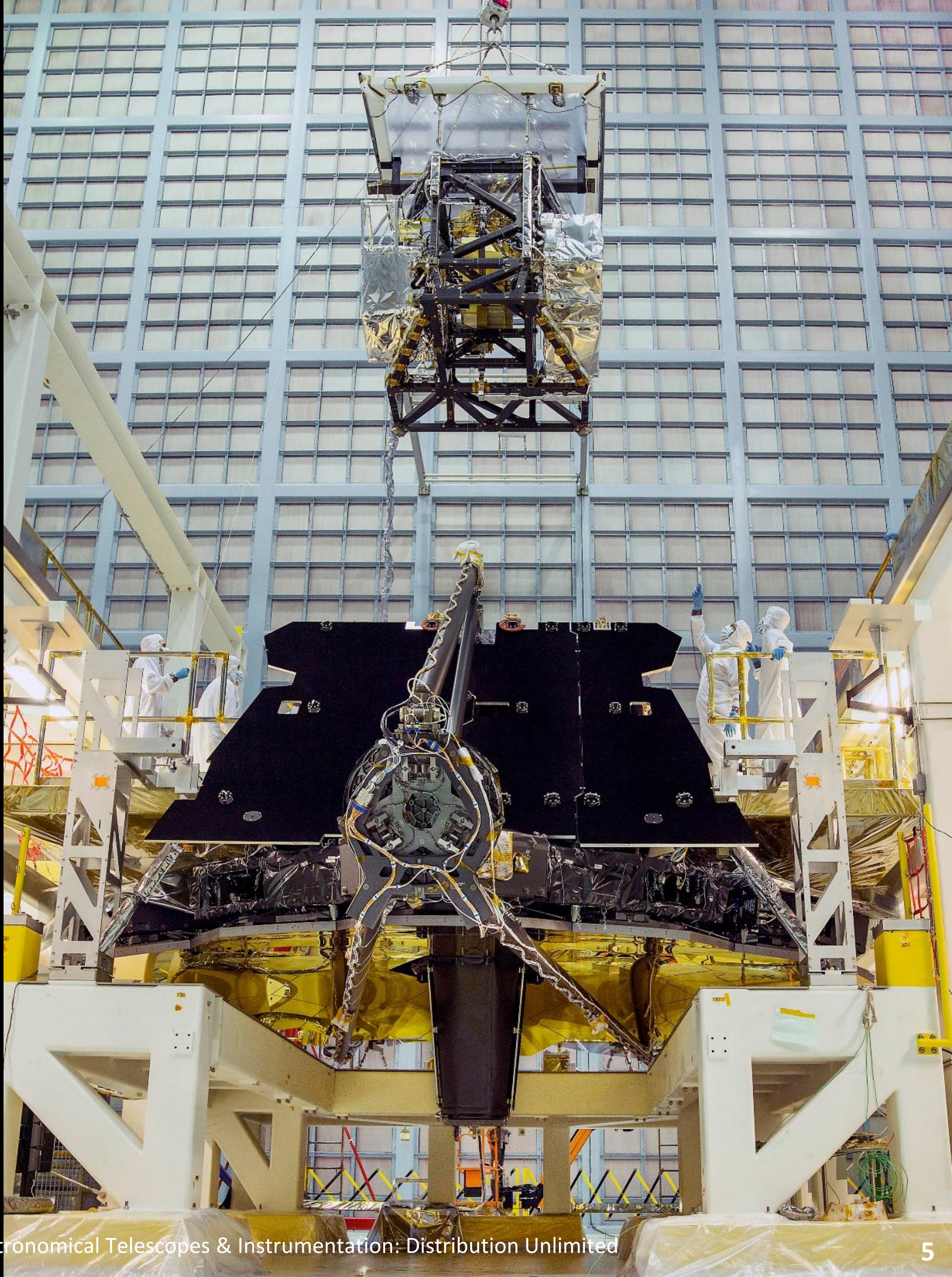




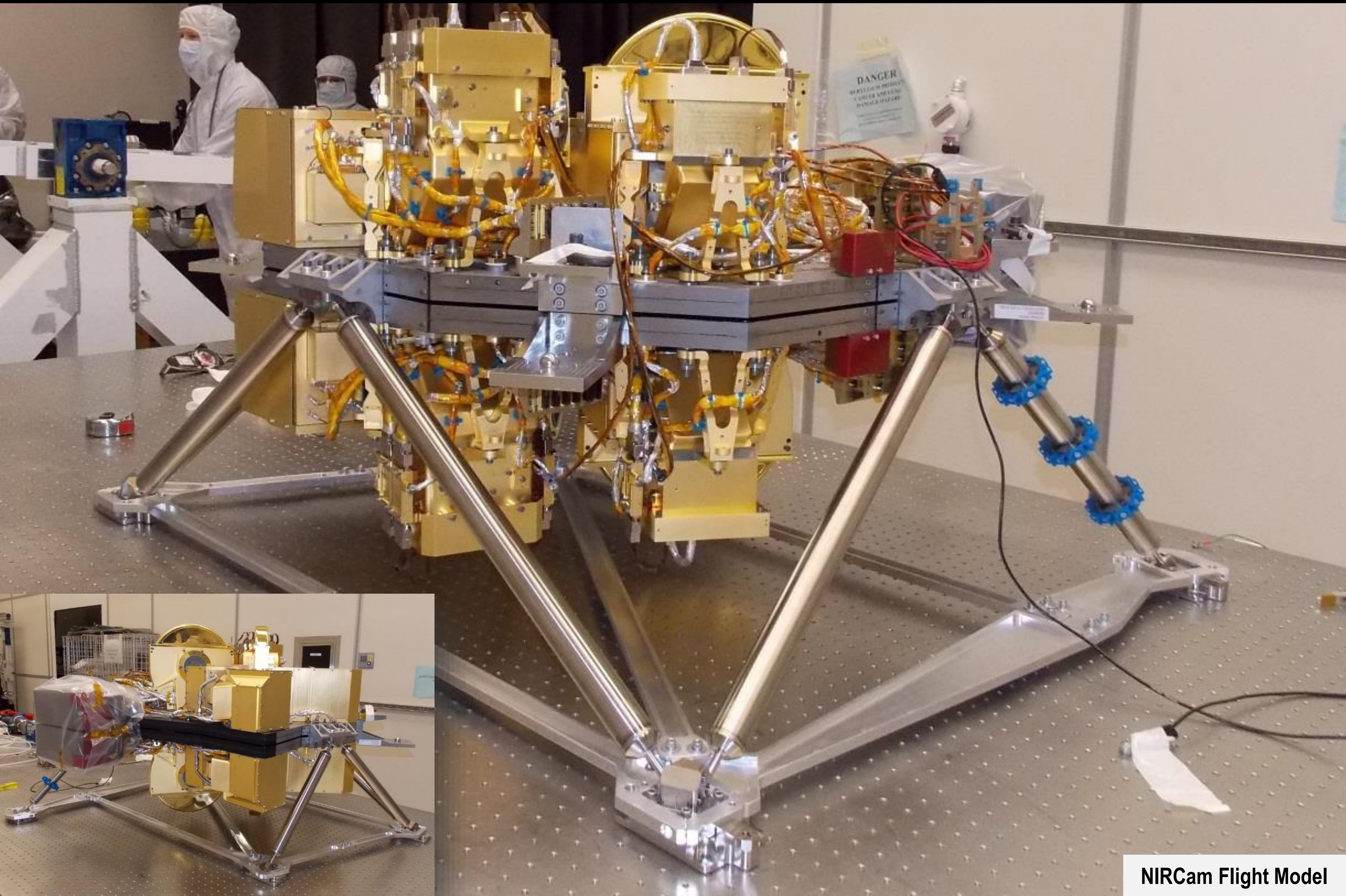
ISIM integration with OTE is on schedule for OTIS testing

Key 2016 integration milestones:

- ✓ ISIM Prime module integration w/ OTE: May
- ✓ MIRI FPE integration with IEC: Jun
  - FPE reworked after CV-3
- IEC integration w/ OTE: Aug
- Harness Radiator integration w/ OTE: Sep

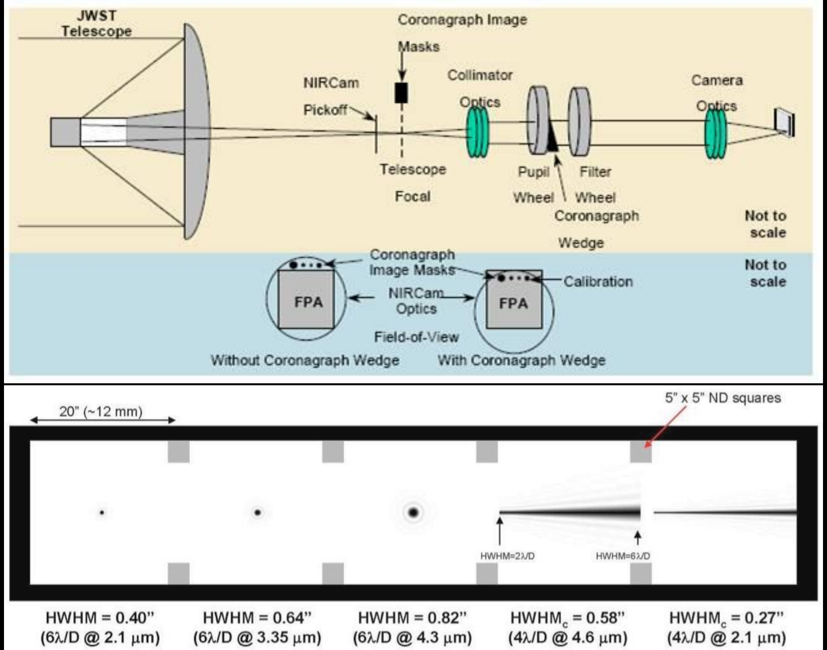


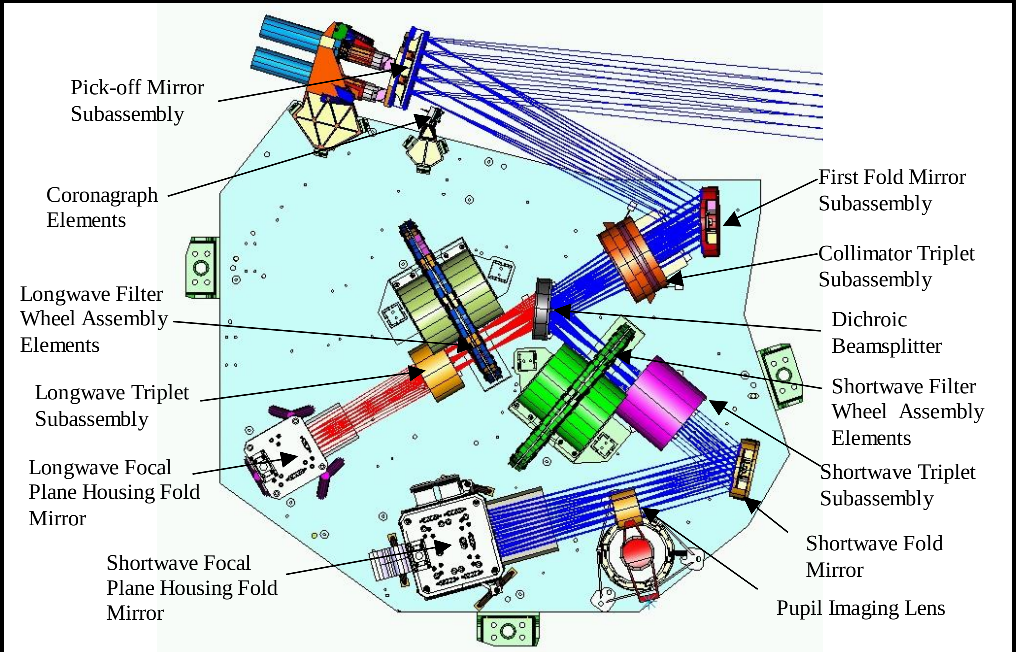
The NIRCam will image the earliest epoch of galaxy formation



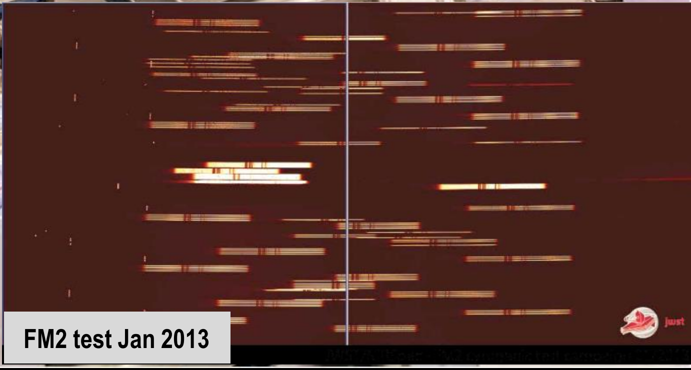
NIRCam will provide the deepest near-infrared images ever and will identify primeval galaxy targets for the NIRSpec

- Developed by the University of Arizona with Lockheed Martin
  - Operating wavelength: 0.6 – 5.0 microns
  - Field of view: 2.2 x 4.4 arc minutes
  - Angular resolution (1 pixel): 32 mas < 2.3 microns, 65 mas > 2.4 microns
  - Imagery: R= 4, 10, 100 filters
  - Spectroscopy: grisim (slit-less) R~2000 2.4 – 5 microns
  - Coronagraph

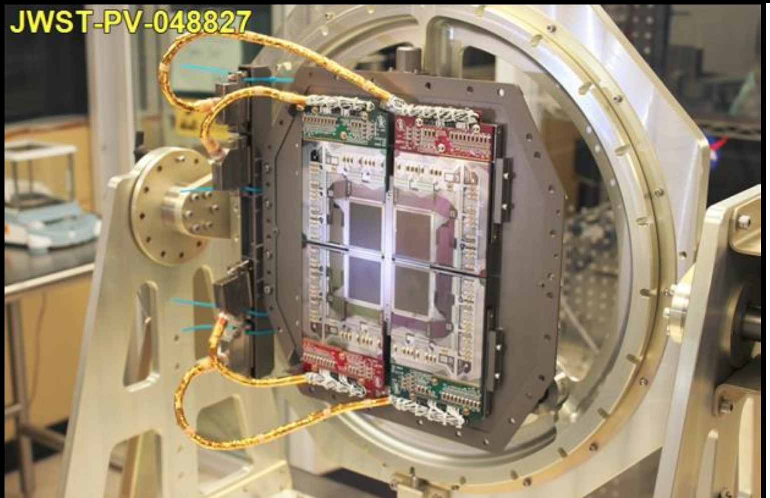


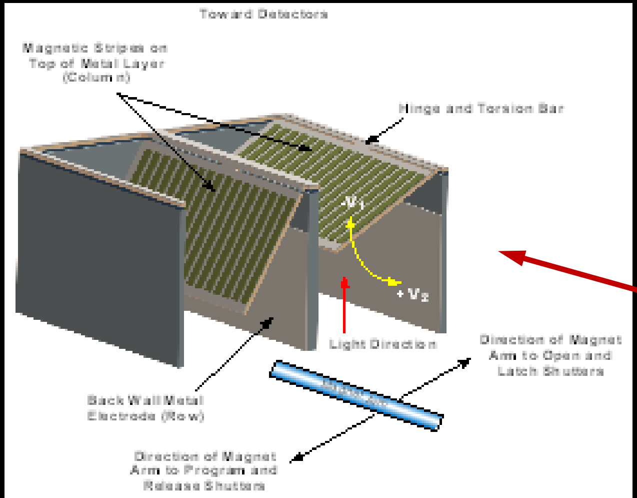


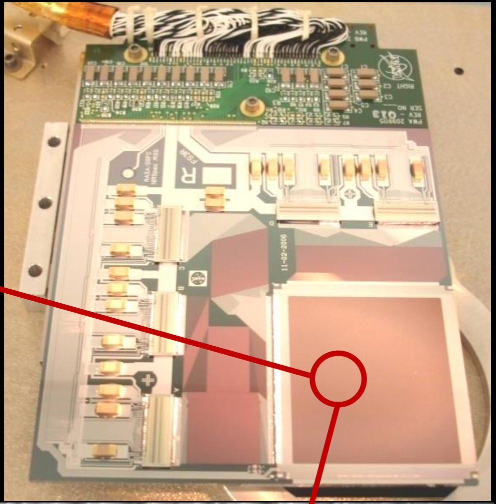
NIRSpec can obtain spectra of 100 compact galaxies simultaneously



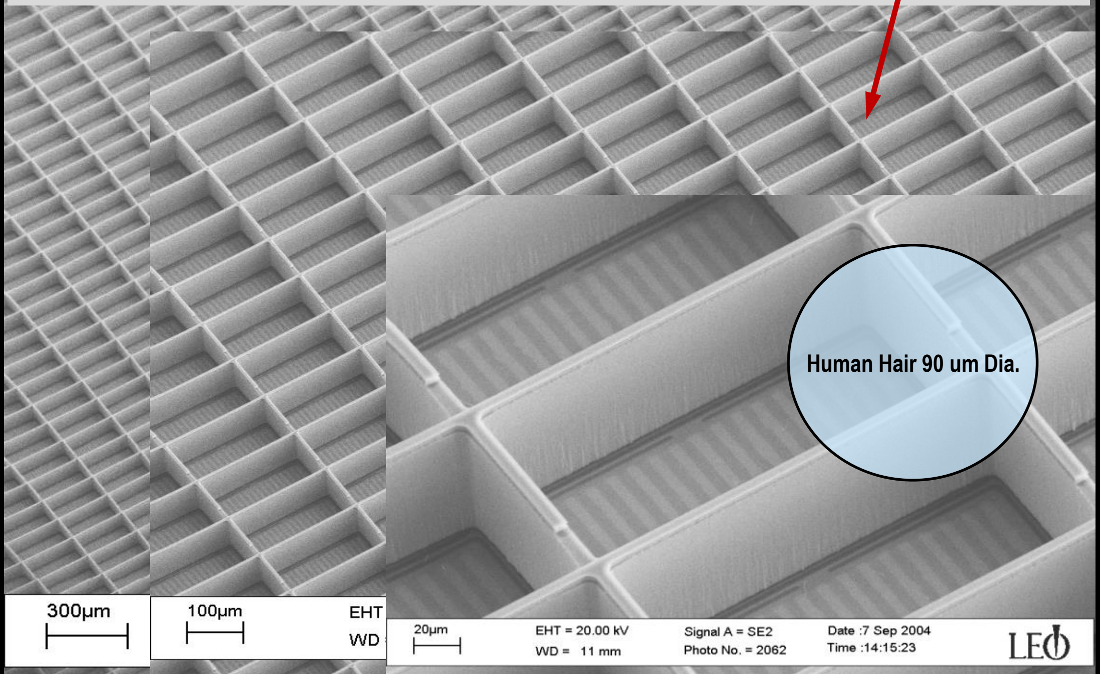
Aperture control: 250,000 programmable micro-shutters



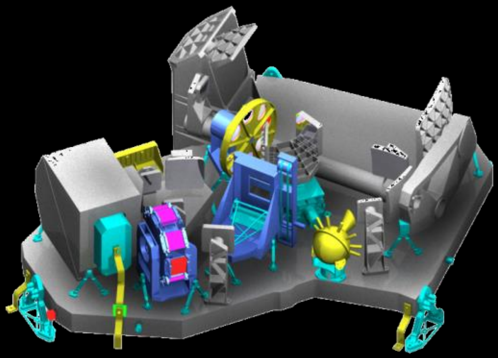


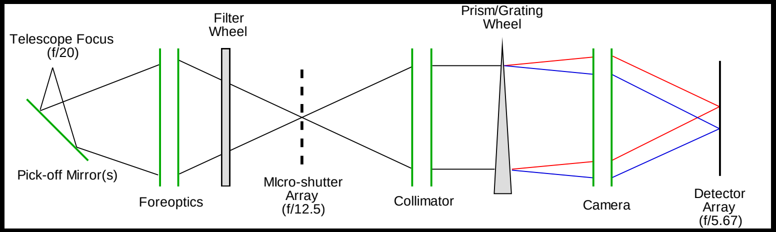


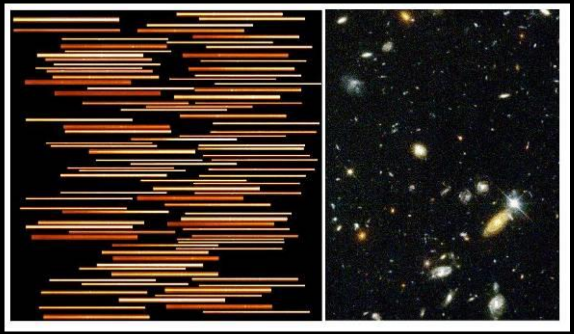
203 x 463 mas shutter pixel clear aperture, 267 x 528 mas pitch, 4 x 171 x 365 array



The NIRSpec will acquire near-infrared spectra of up to 100 objects in a single exposure



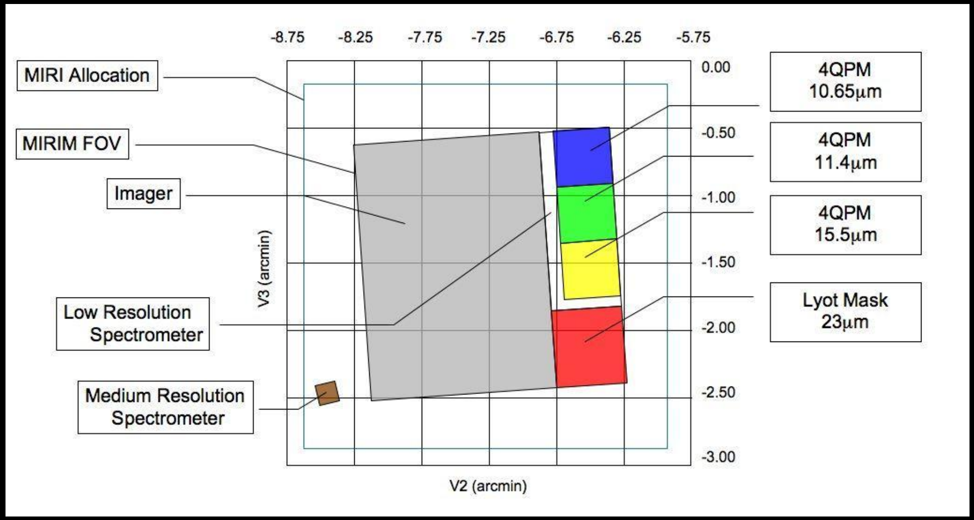


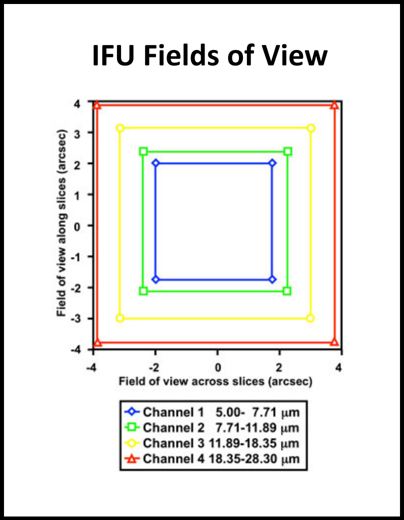


- Developed by the European Space Technology Center (ESTEC) with Astrium and Goddard Space Flight Center
  - Operating wavelength: 0.6 – 5.0 microns
  - Spectral resolution: 100, 1000, 3000
  - Field of view: 3.4 x 3.4 arc minutes
    - Aperture control:
      - Programmable micro-shutters, 250,000 pixels
        - 203 x 463 mas clear aperture (267 x 528 mas pitch)
      - Fixed long slits & transit spectroscopy aperture
        - 200, 400, 1600 mas slit width
      - Image slicer (IFU) 3x3 arc sec FOV (100 mas slice width)
  - All aperture control modes available with any spectral resolution mode

MIRI will provide the first high resolution imagery of the mid-infrared universe

The MIRI will characterize circumstellar debris disks, extra-solar planets, and the evolutionary state of high redshift galaxies

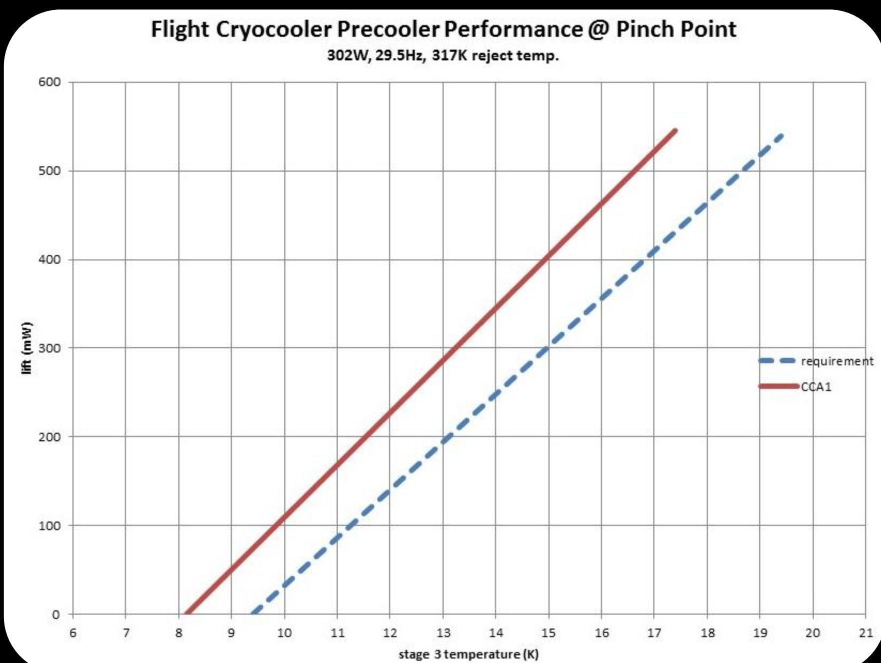


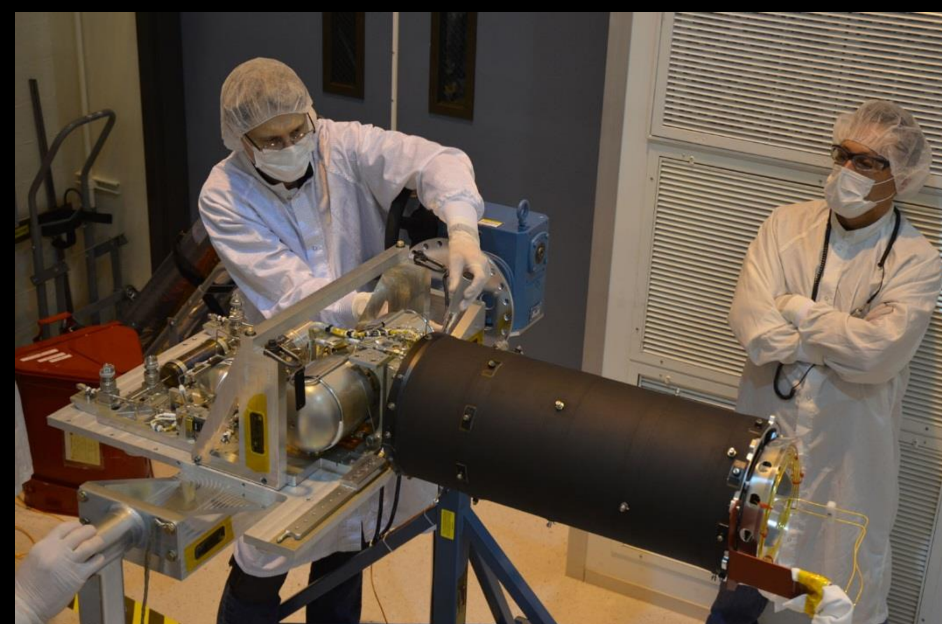


- Developed by a consortium of 10 European countries and NASA/JPL
  - Operating wavelength: 5 – 28.5 microns
  - Broad-band imagery: 1.9 x 1.4 arc minutes FOV, 110 mas/pixel, 9 filters (R~5)
  - Spectroscopy:
    - R~100 long slit spectroscopy 5 x 0.2 arc sec
    - R~3000 IFU spectroscopy (4 image slicers fed by dichroic beam splitters)
      - Slice width: 19, 19, 24, and 27 mas
  - Coronagraphic imagery: Three 4QPMs and 1 Lyot occulting mask, 110 mas/pixel

The MIRI cryo-cooler is complete and delivered to spacecraft I&T

- Pre-Ship review completed during May
- Flight spare cooler in final verification testing at JPL



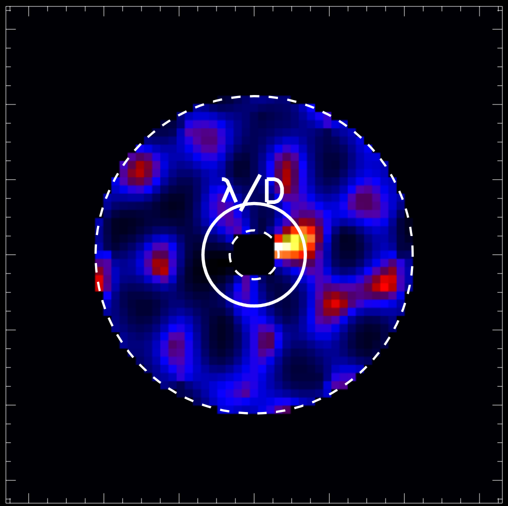


FGS can sense pointing to 1 millionth degree precision

NIRISS enables moderate contrast imagery at an inner working angle of 0.5λ/D

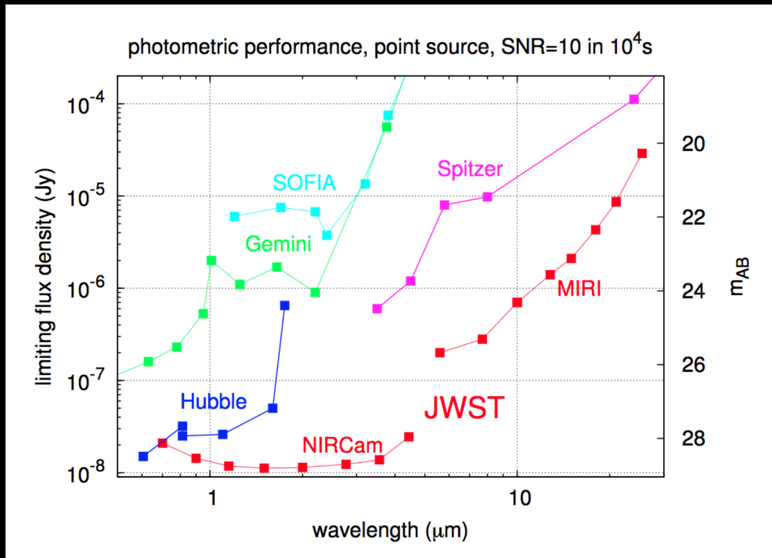
The FGS-Guider and NIRISS provide telescope pointing control imagery & slitless spectroscopy for Ly-a galaxy surveys and extra-solar planet transits

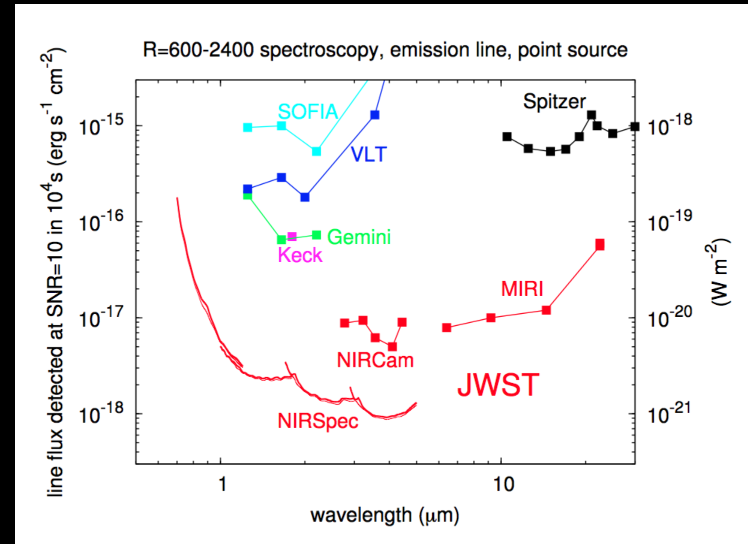
- Developed by the Canadian Space Agency with ComDev
- **FGS:** 4 mas noise equivalent angle (0.6 – 5 microns)
  - ~95% probability of guide star acquisition over whole sky
  - 7 mas LOS pointing stability
- **NIRISS:**
  - Wide-field slit-less spectroscopic imagery (grism)
    - R ~ 150, 0.8 – 2.25 microns optimized for Ly alpha galaxy surveys
  - Single object spectroscopic imagery (grism): 3 orders cross-dispersed
    - R ~ 700, 0.7 – 2.5 microns optimized for exoplanet transit spectroscopy
  - Aperture mask interferometric imaging (7 aperture NRM, 21 unique baselines) 3.8, 4.3, and 4.8 microns (IWA ~ $0.5\lambda/D$)
  - 68 mas/pixel all modes



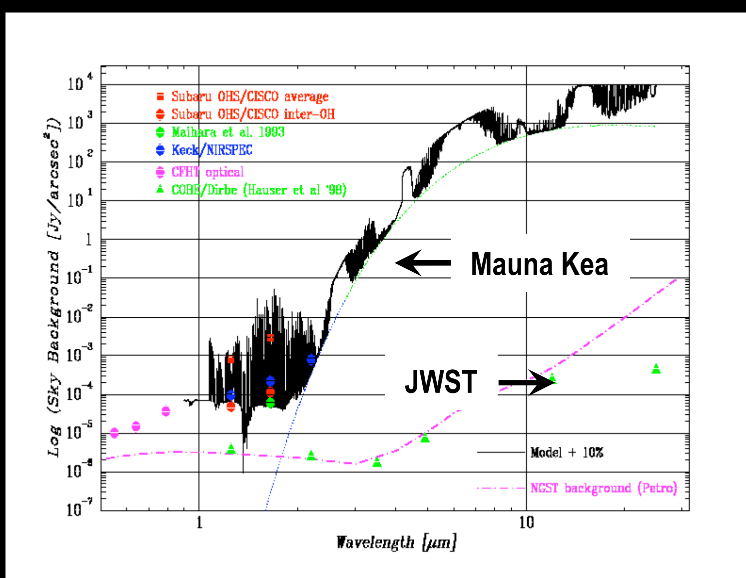
Simulated NIRISS aperture mask near-infrared image of a 1-2 M_{Jup} planet at ~1 AU of a M0V star 10 pc from the Sun.

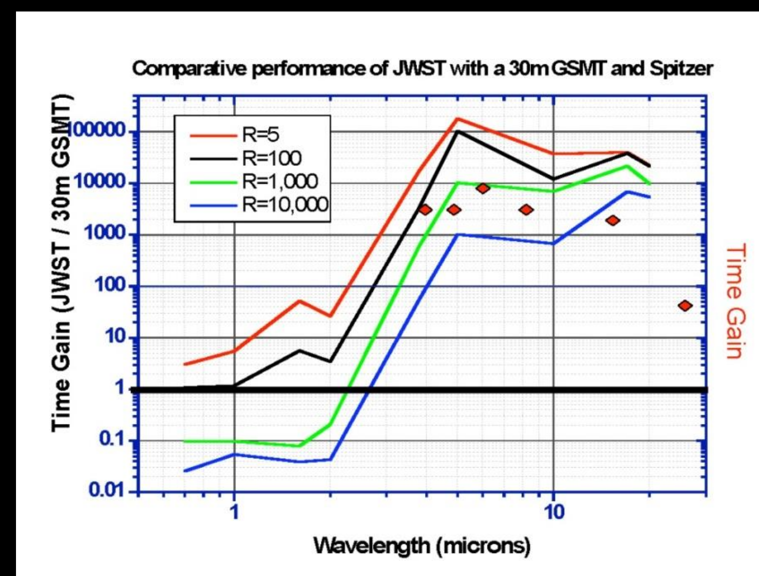
JWST will achieve unprecedented infrared sensitivity





However, 30 m ground-based facilities can challenge JWST performance for R > 1000 spectroscopy at wavelengths < 1.7 microns





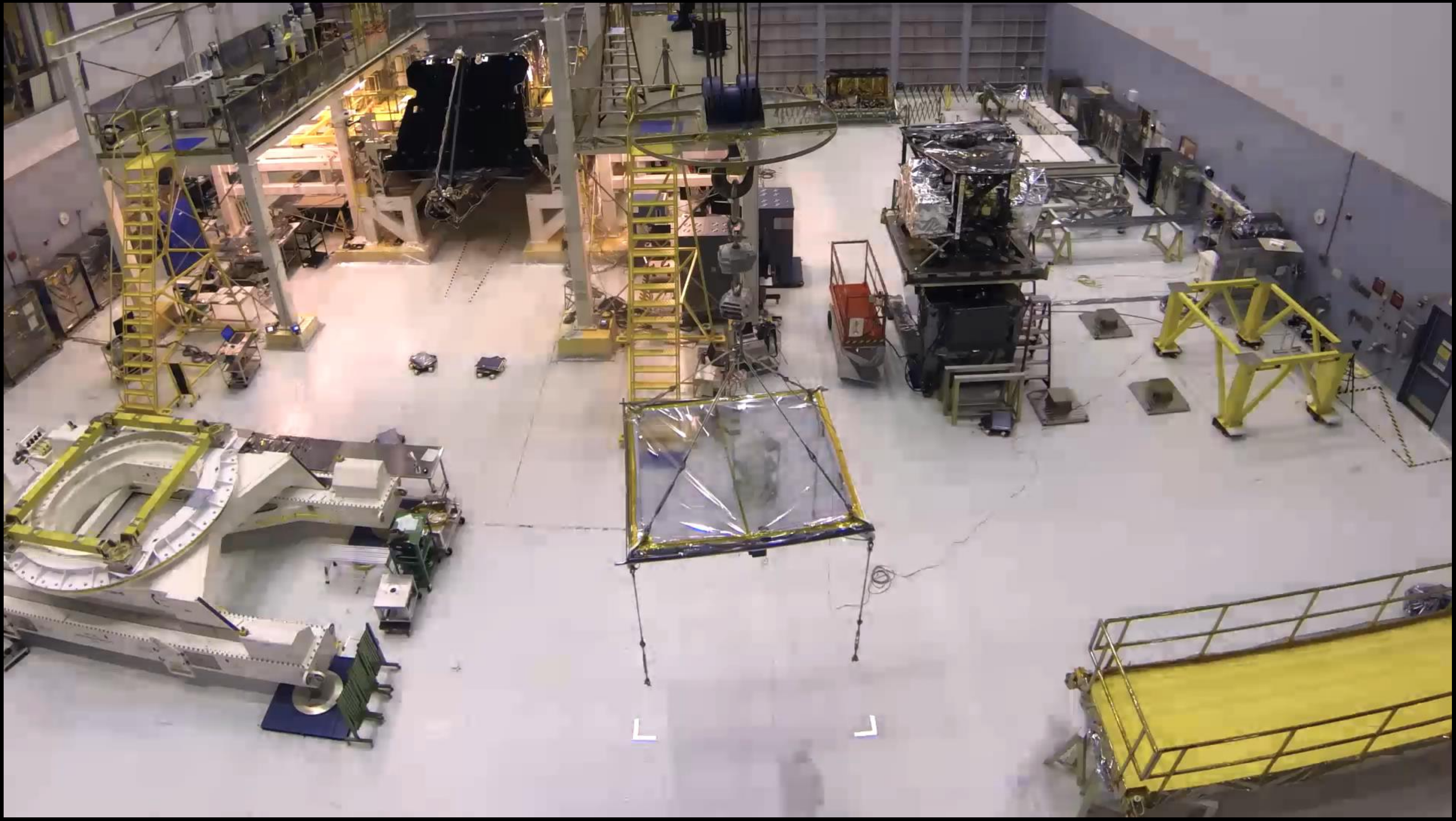
Observer take-aways

- The ISIM contains a Fine Guidance Sensor that enables the observatory to achieve 7 mas pointing stability
- The ISIM includes 4 science sensors that enable:
  - Nyquist sampled imagery in broad-band filters
  - Coronagraphic imagery with contrast ~10^4 - 10^5 over the whole JWST wavelength range
  - Slit-less, long slit, and multi-object spectroscopy with R ~ 10^2 - 10^3
  - IFU spectroscopy over the whole JWST wavelength range
  - Interferometric imagery over 4-5 microns with resolution 0.5λ/D

- All ISIM sensors have sub-array detector readout capability to enable observation of bright targets
- All ISIM sensors are designed for simultaneous and continuous operation

Instrument module integration with OTE

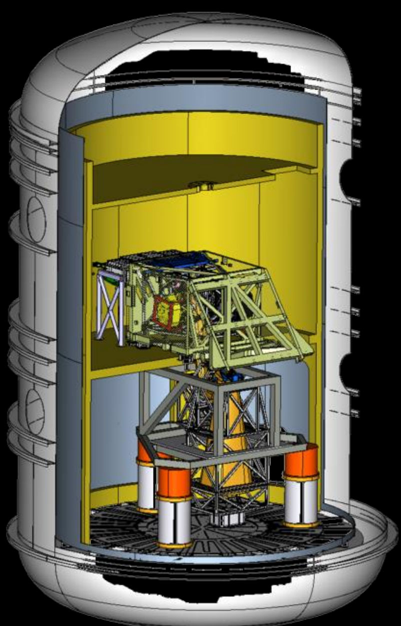
Click Video



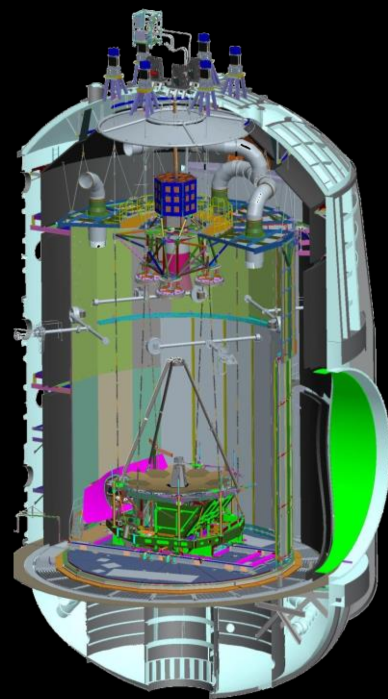
In Sum …

- ISIM is on track to support the OTIS end-to-end optical test at JSC during April 2017
- Integration of the ISIM system to the OTE is proceeding without issue

Last element-level ISIM test was completed during February 2016 in the GSFC SES chamber



Observatory end-to-end optical test begins during April 2017 in JSC Chamber-A



Launch 2018 from Kourou Launch Center (French Guiana)