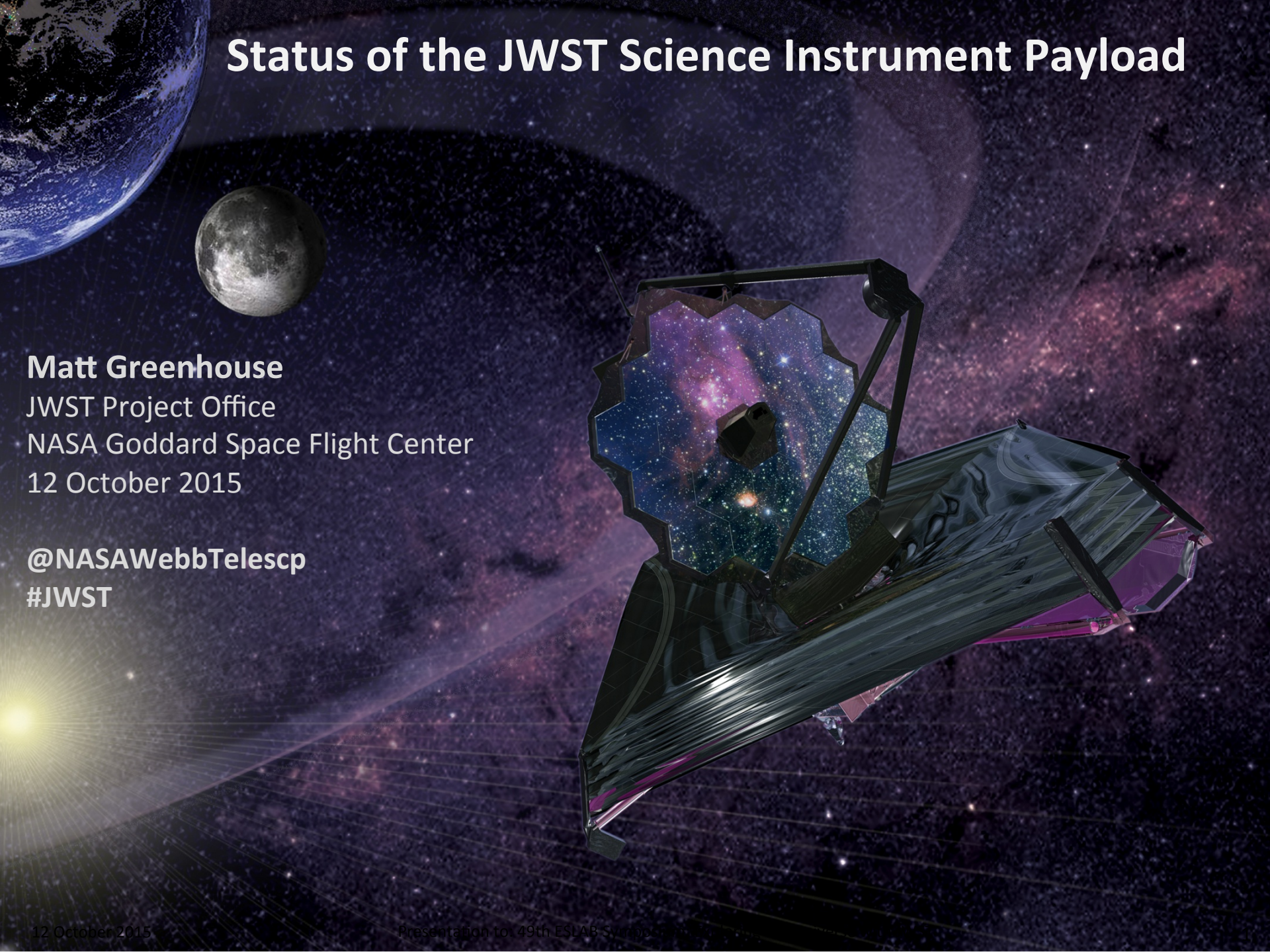
Status of the JWST Science Instrument Payload



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JWST Project Office
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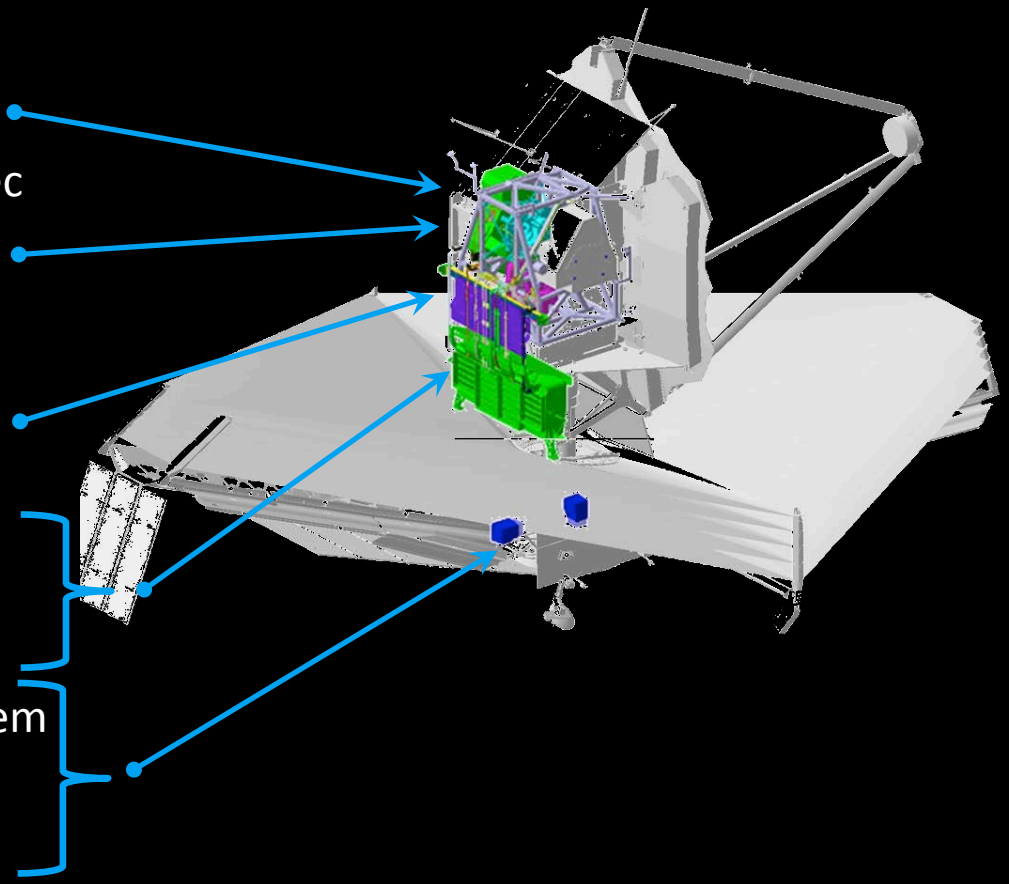
12 October 2015

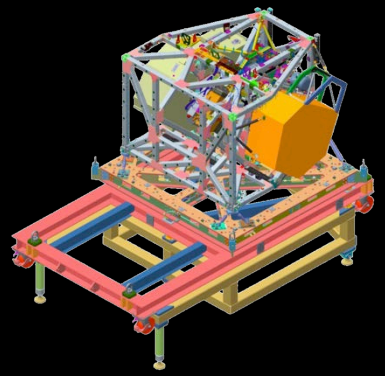
@NASAWebbTelescp
#JWST

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

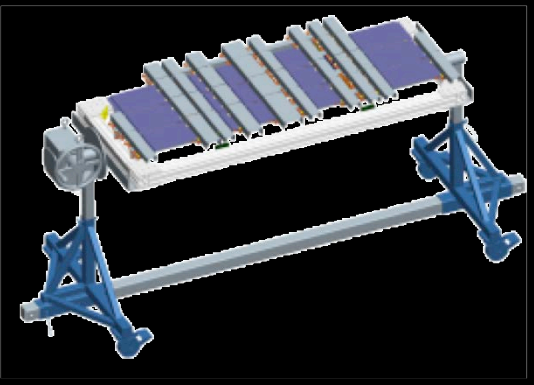
- **ISIM is one of three elements that together make up the JWST space vehicle**
  - Approximately 1.4 metric tons, ~20% of JWST by mass
  - Currently in integration and test and on schedule for delivery during Feb 2016
- **The ISIM system consists of:**
  - Five sensors (4 science)
    - MIRI, NIRISS, 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



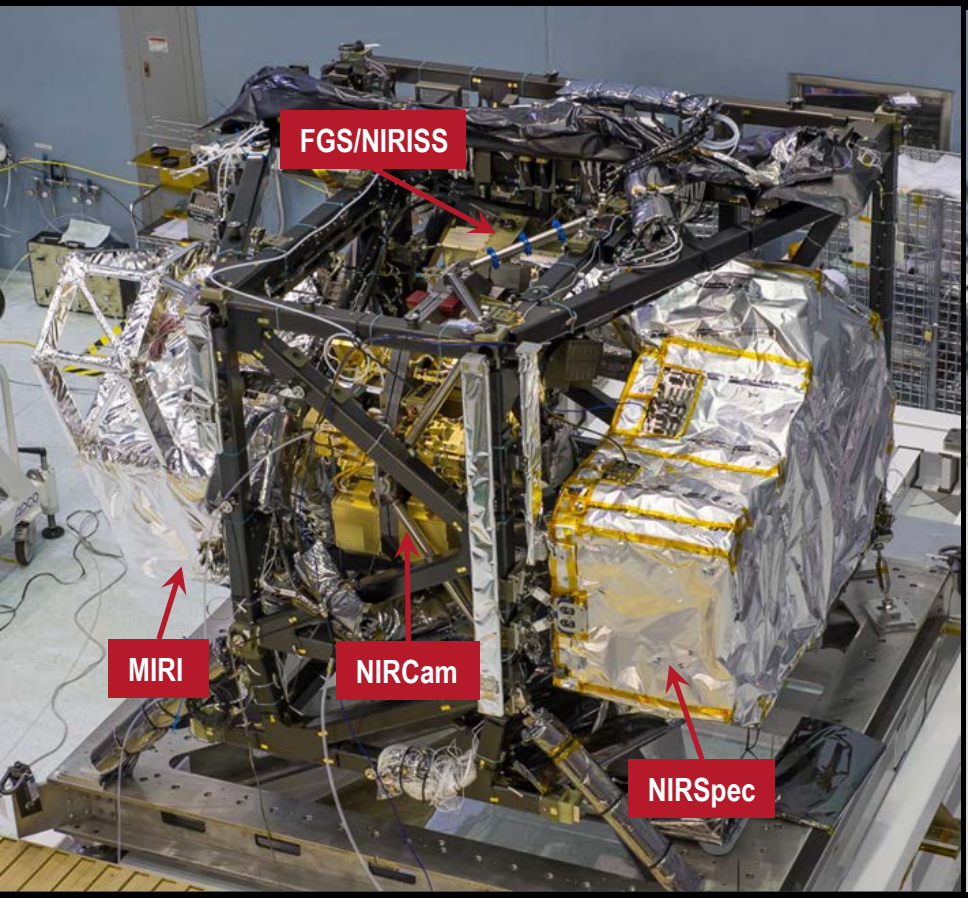
- Four science sensors:
  - NIRCam, NIRSpec, NIRISS, MIRI
- Fine guidance sensor (FGS)
  - Supports telescope pointing to ~ 10^{-6} deg
- Optical metering structure
  - Sensor launch loads
  - Sensor optical alignment over ~250 deg ΔT

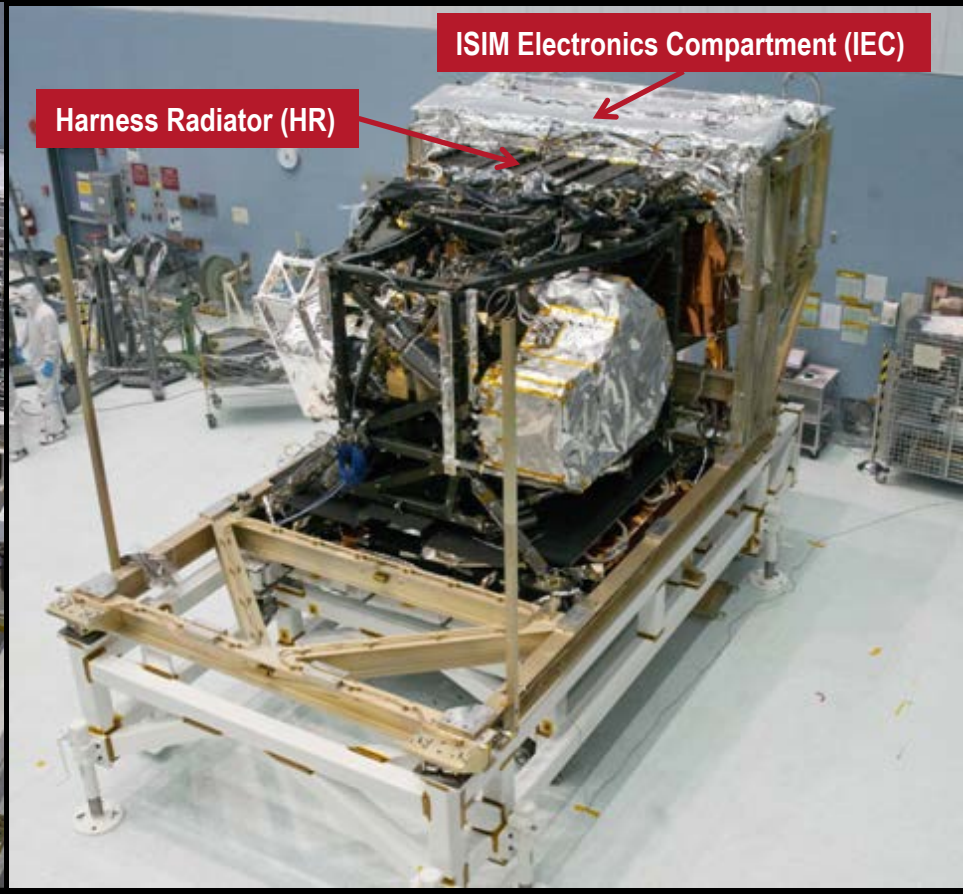


- Harness Radiator (HR)
  - Passive cooling for ~2,700 electrical wires

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

Flight ISIM test configuration





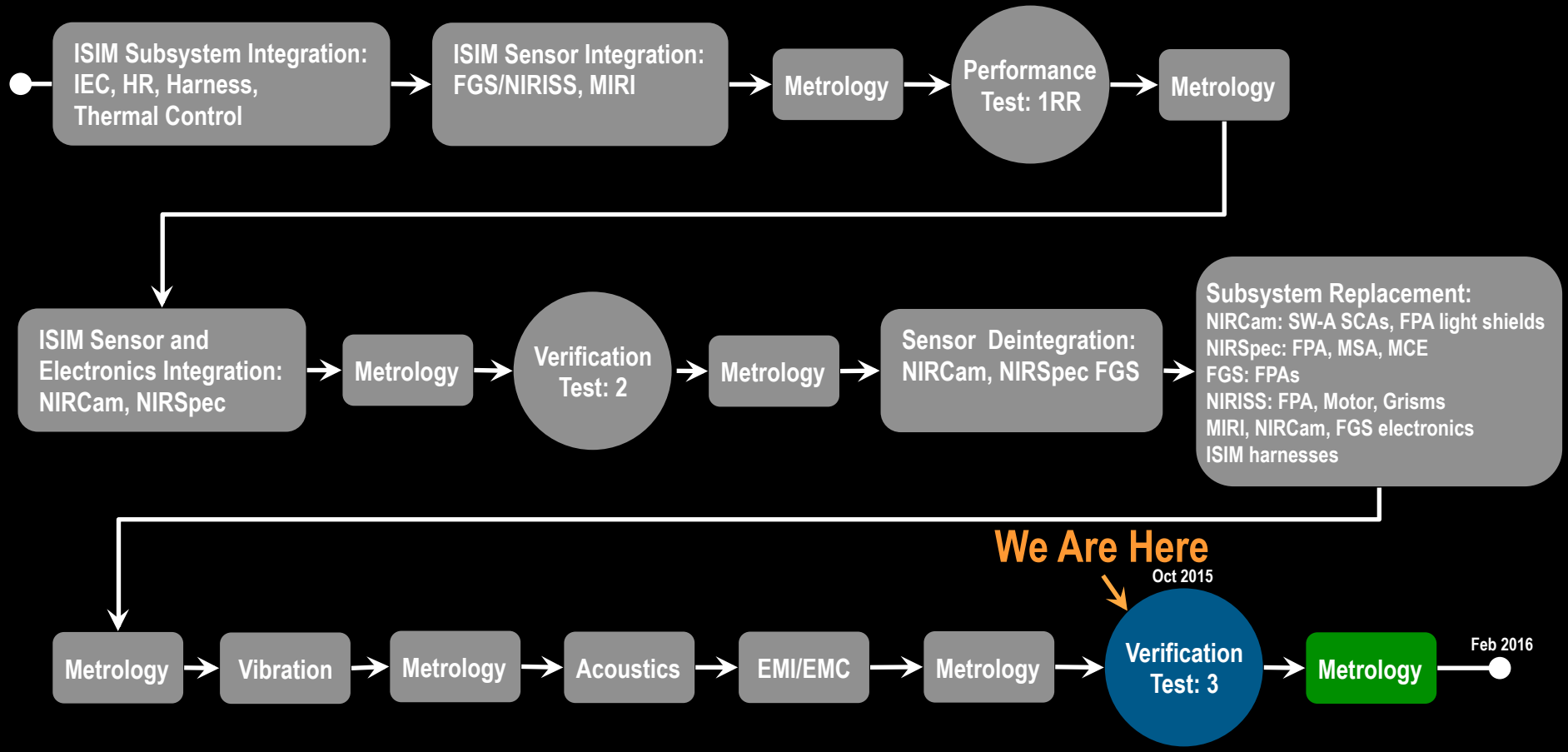
Making sure that it all works:

- **ISIM is on track for delivery to OTIS I&T during April 2016**
  - ~2 months slack to OTIS need date
  - Final element-level space simulation test begins this month

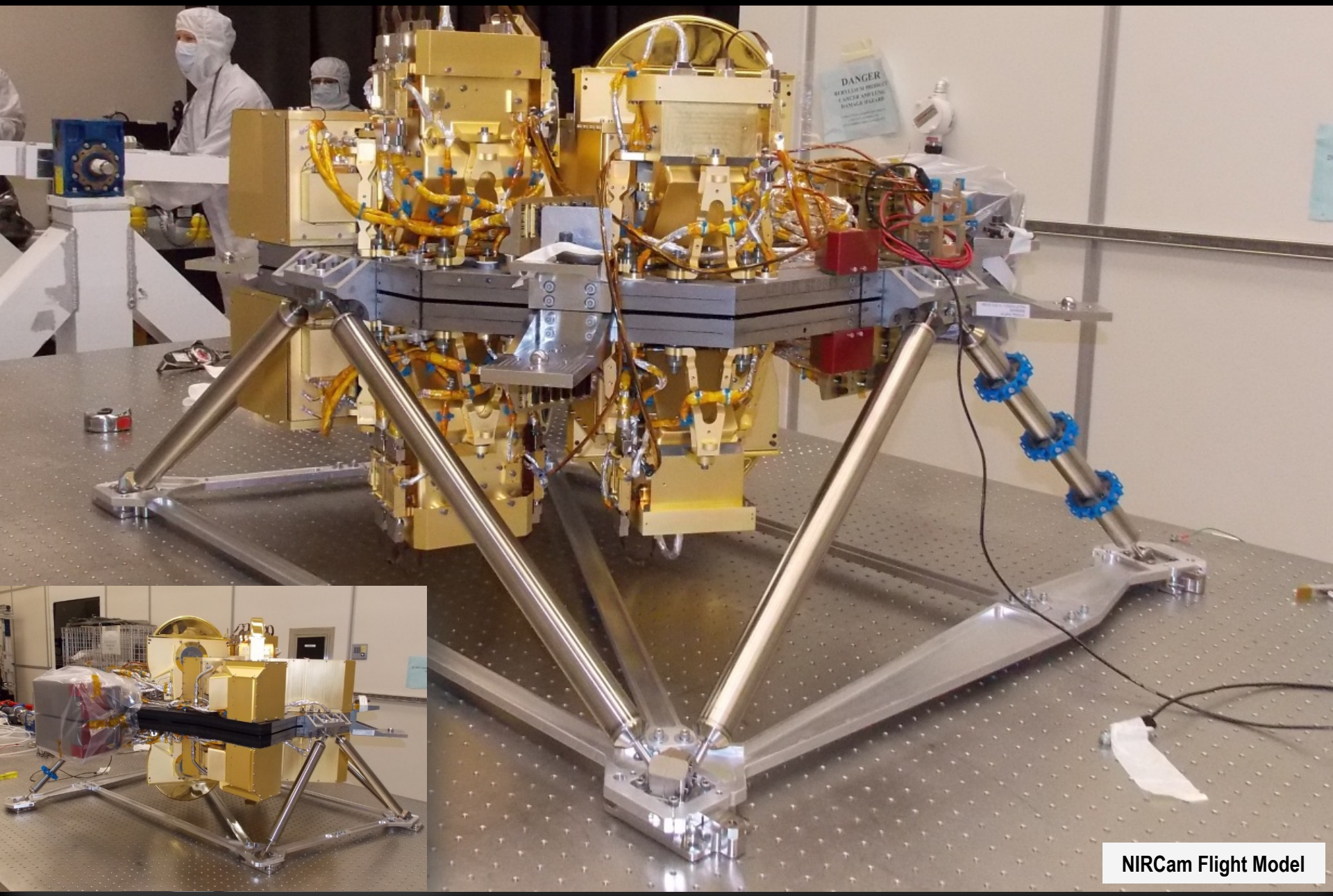
Ambient Temp Test Environment

Cryogenic Vacuum Test Environment

Completed Activity



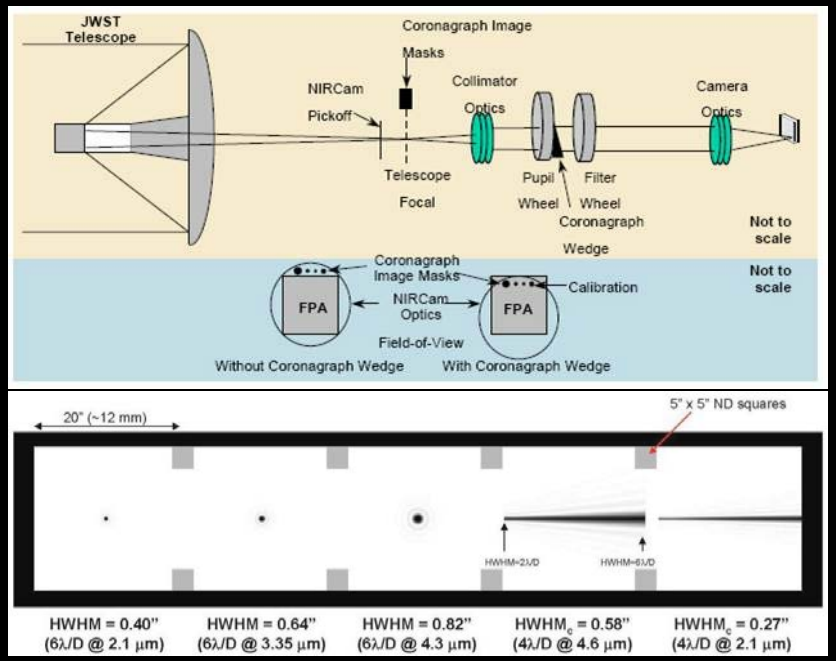
The NIRCam will image the earliest epoch of galaxy formation

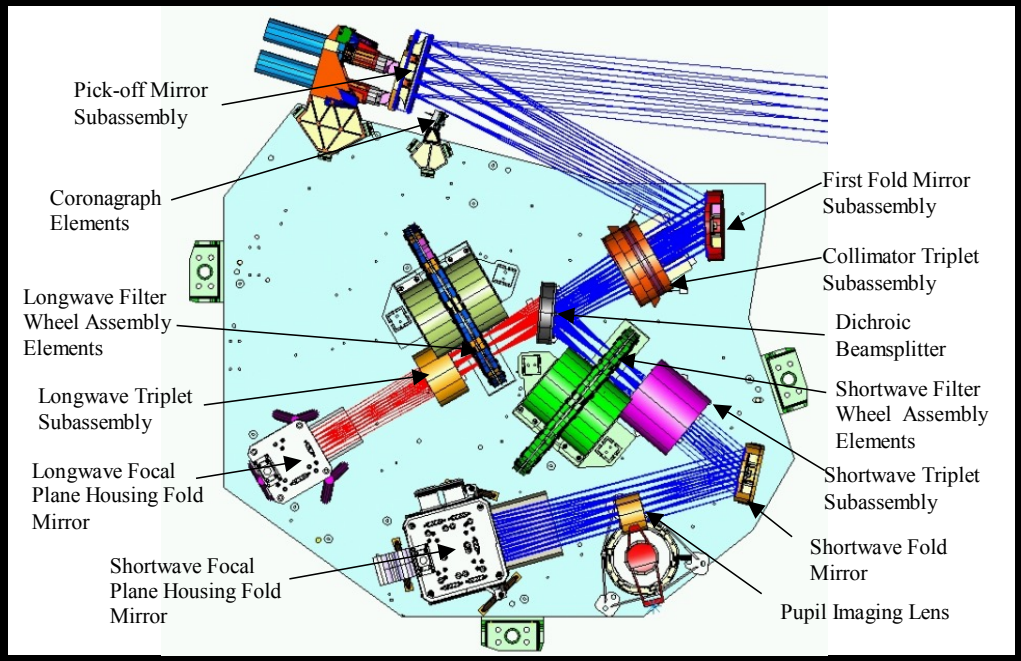


NIRCam Flight Model

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

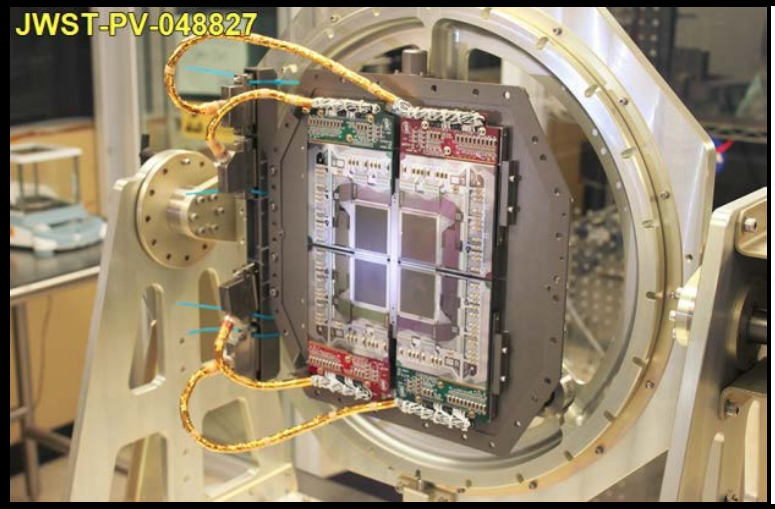
- Developed by the University of Arizona with Lockheed Martin STAR Labs
  - Operating wavelength: 0.6 – 5.0 microns
  - Field of view: 2.2 x 4.4 arc minutes
  - Angular resolution (1 pixel): 32 mas < 2.3 microns, 65 mas > 2.4 microns
  - Imagery: R= 4, 10, 100 filters
  - Spectroscopy: grisim (slit-less)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

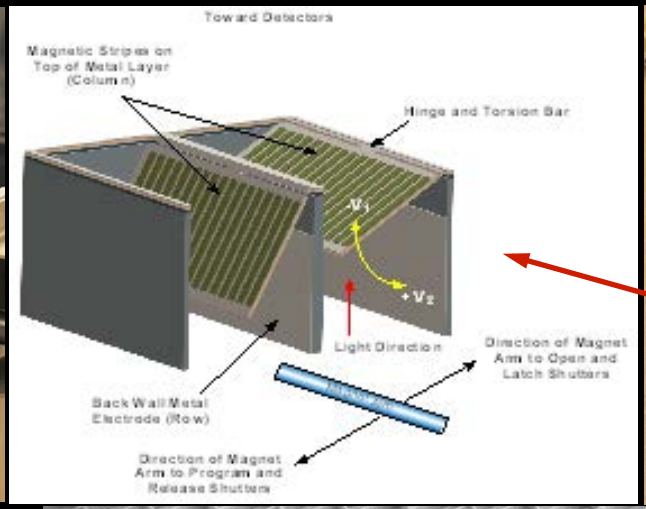


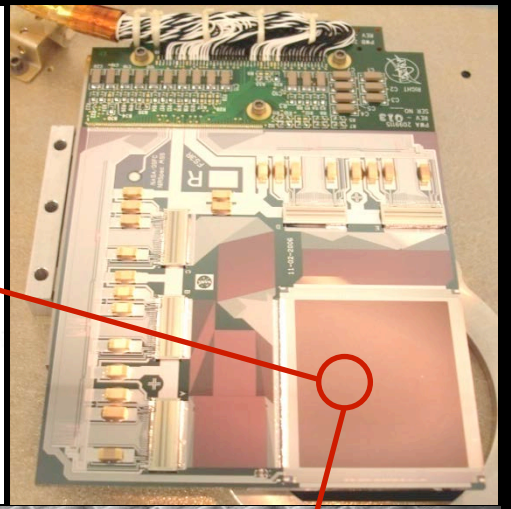


NIRSpec can obtain spectra of 100 compact galaxies simultaneously

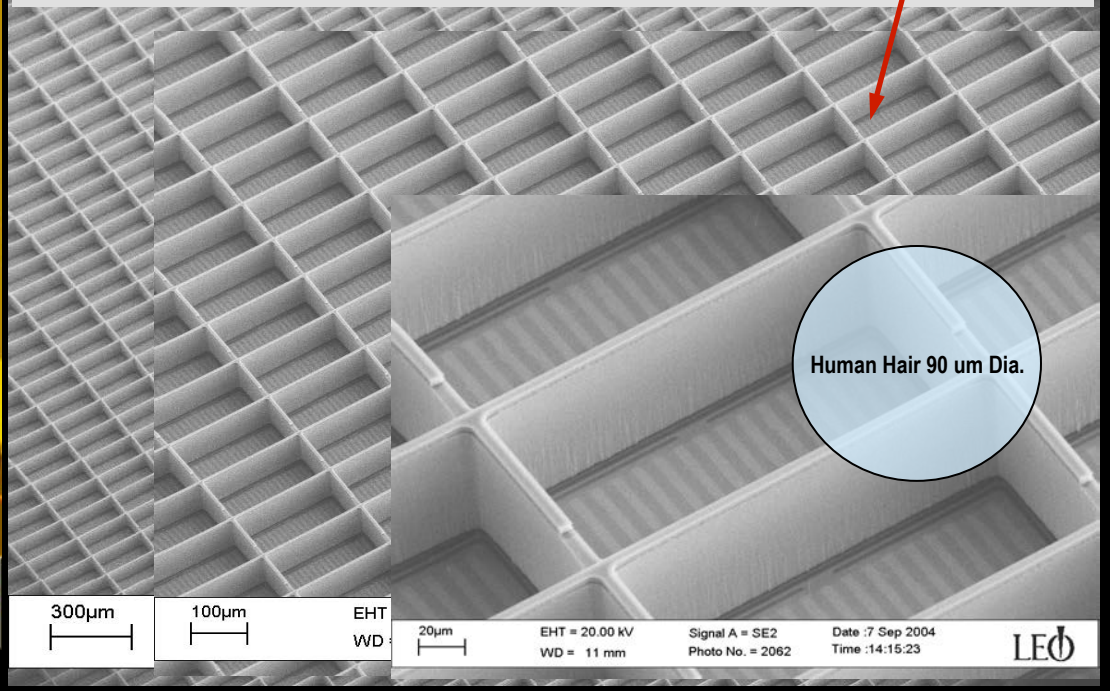
Aperture control: 250,000 programmable micro-shutters



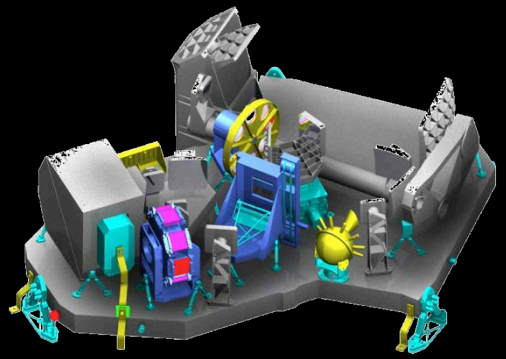


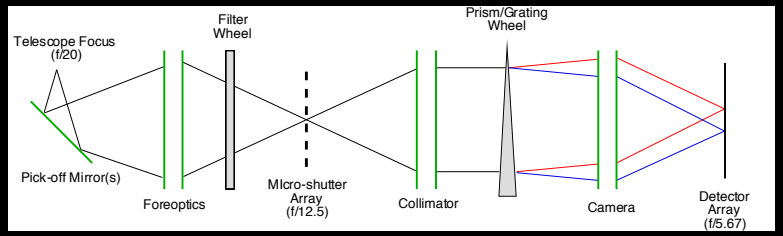


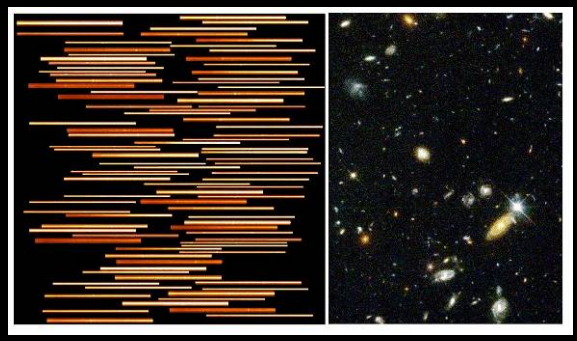
203 x 463 mas shutter pixel clear aperture, 267 x 528 mas pitch, 4 x 171 x 365 array



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





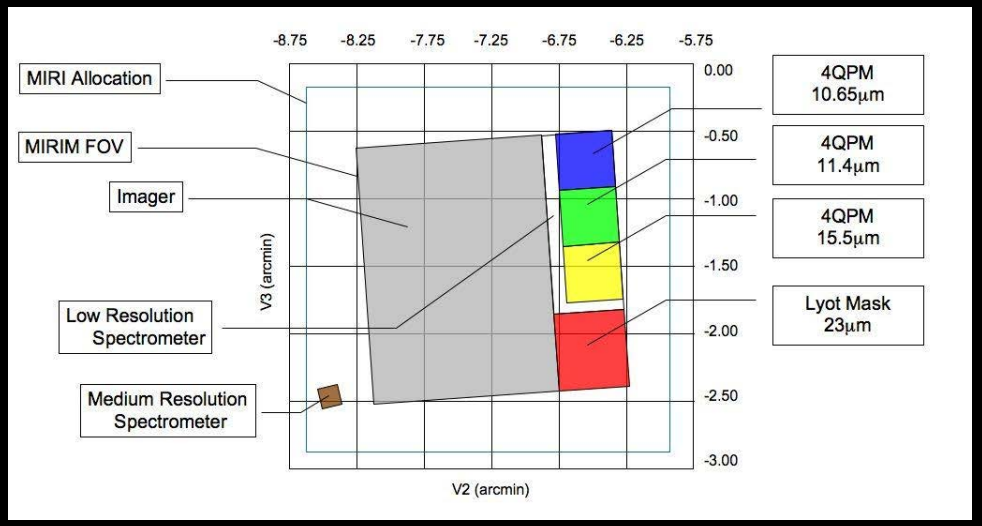


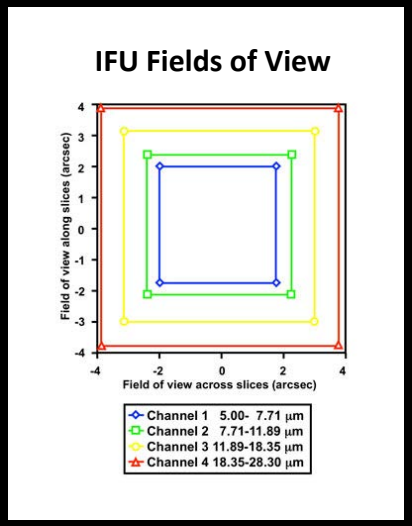
- Developed by the European Space Technology Center (ESTEC) with Astrium and Goddard Space Flight Center
  - Operating wavelength: 0.6 – 5.0 microns
  - Spectral resolution: 100, 1000, 3000
  - Field of view: 3.4 x 3.4 arc minutes
    - Aperture control:
      - Programmable micro-shutters, 250,000 pixels
        - 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

MIRI flight model

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



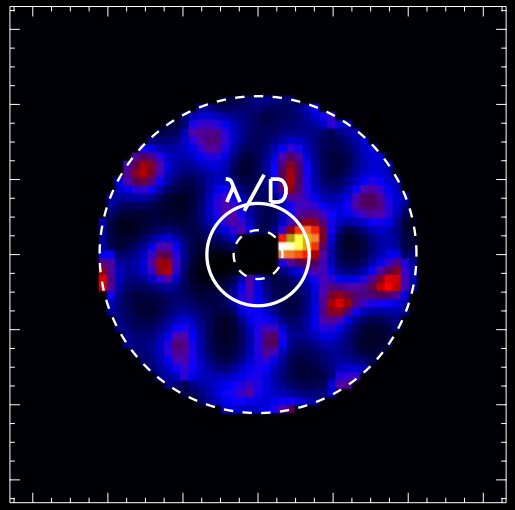


- Developed by a consortium of 10 European countries and NASA/JPL
  - Operating wavelength: 5 – 28.5 microns
  - Broad-band imagery: 1.9 x 1.4 arc minutes FOV, 110 mas/pixel, 9 filters (R~5)
  - Spectroscopy:
    - R~100 long slit spectroscopy 5 x 0.2 arc sec
    - R~3000 IFU spectroscopy (4 image slicers 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

FGS can sense pointing to 1 millionth degree precision
NIRISS enables moderate contrast imagery at an inner working angle of 0.5λ/D

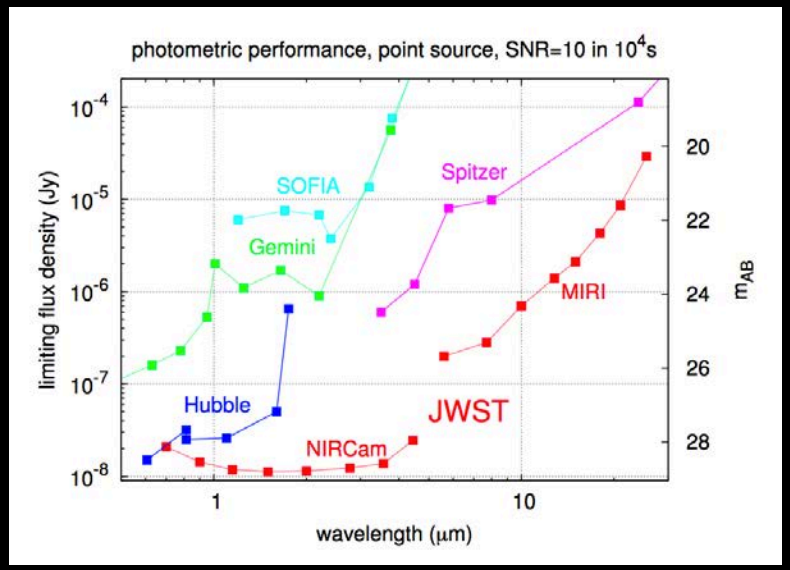
The FGS-Guider and NIRISS provide telescope pointing control imagery & slitless spectroscopy for Ly-a galaxy surveys and extra-solar planet transits

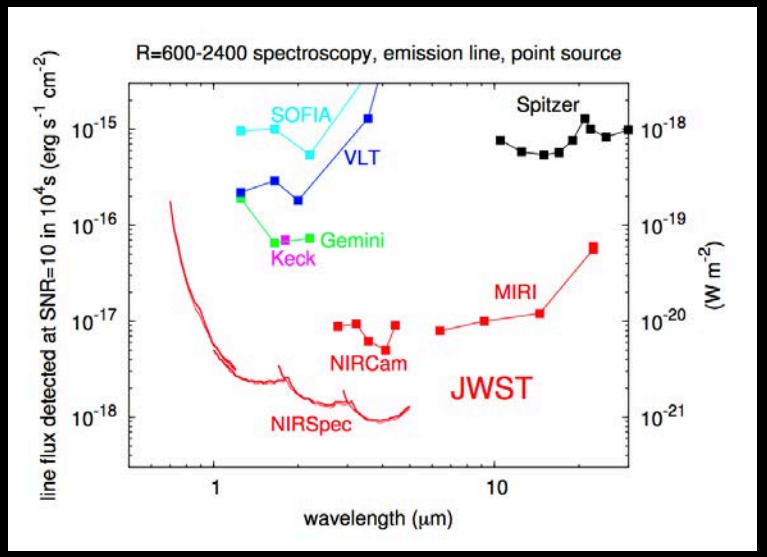
- Developed by the Canadian Space Agency with ComDev
- **FGS:** 4 mas noise equivalent angle (0.6 – 5 microns)
  - 95% probability of guide star acquisition over whole sky
  - 7 mas LOS pointing stability
- **NIRISS:**
  - Wide-field slit-less spectroscopic imagery (grism)
    - R ~ 150, 0.8 – 2.25 microns 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 ~ 0.5λ/D)
  - 68 mas/pixel all modes



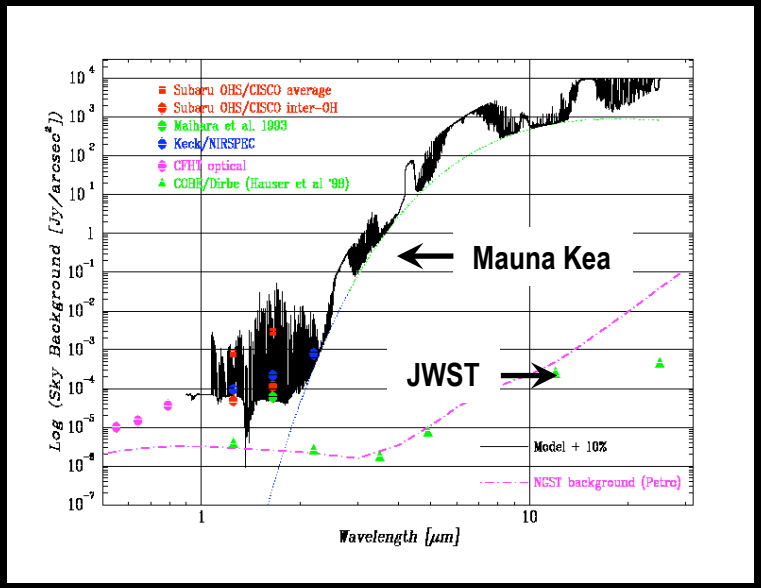
Simulated NIRISS aperture mask near-infrared image of a 1-2 M_{Jup} planet at ~1 AU of a M0V star 10 pc from the Sun.

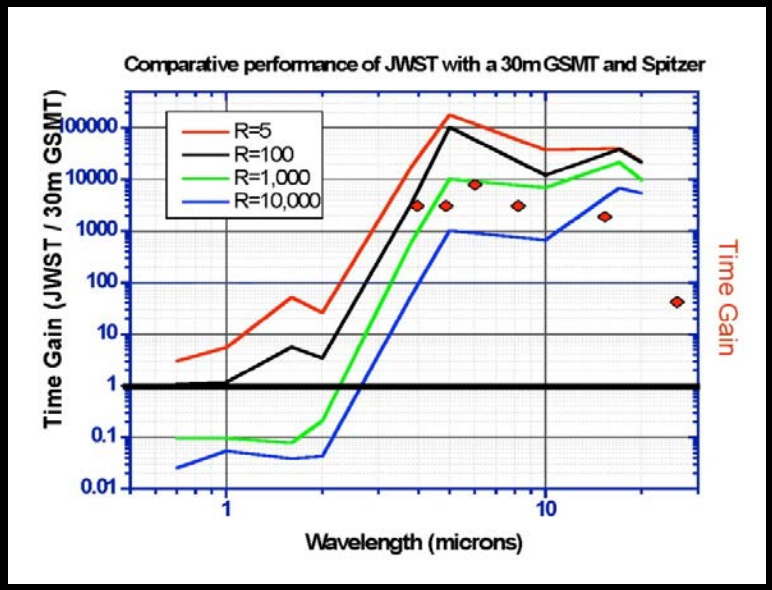
JWST will achieve unprecedented infrared sensitivity





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

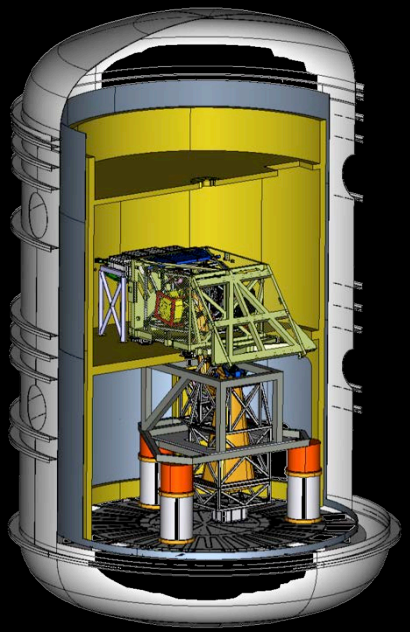
- All ISIM sensors have sub-array detector readout capability to enable observation of bright targets
- All ISIM sensors are designed for simultaneous and continuous operation

Instrument module at 100% integration in preparation for CV-3 test

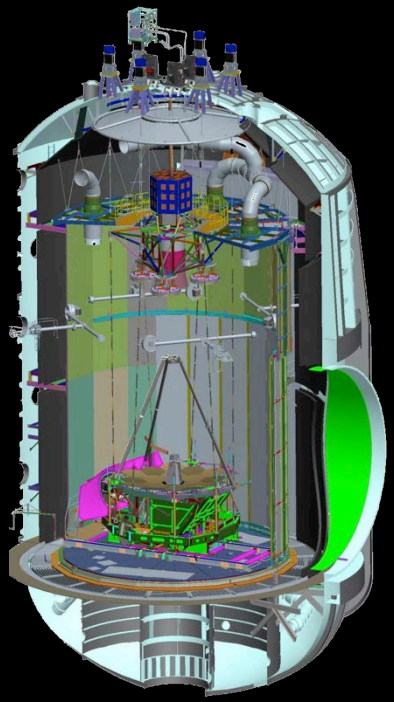
In Sum …

- **ISIM is on track for delivery to Observatory I&T during April 2016**
- **Challenging CV-3 test ahead**
  - Well understood facility and very experienced team to meet that challenge

Last element-level ISIM test begins during October 2015 in GSFC SES chamber



Observatory end-to-end optical test begins during December 2016 in JSC Chamber-A



Launch 2018 from Kourou Launch Center (French Guiana)