James Webb Space Telescope and its Instruments

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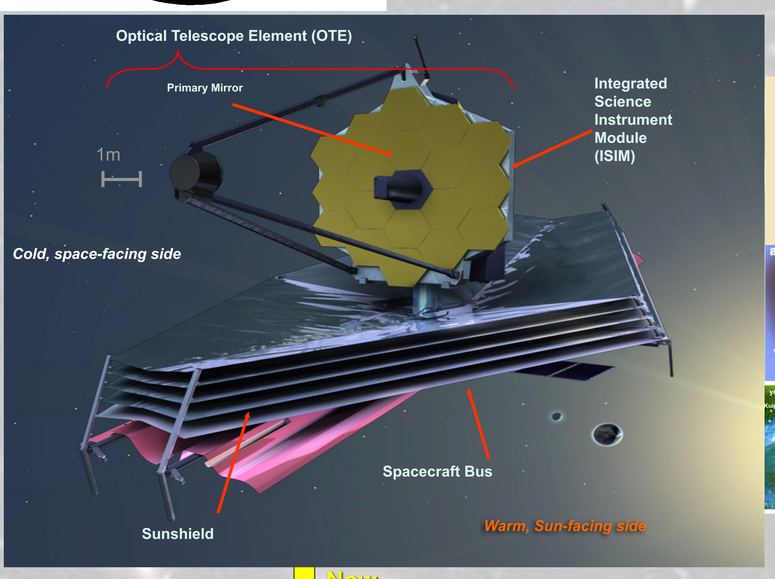
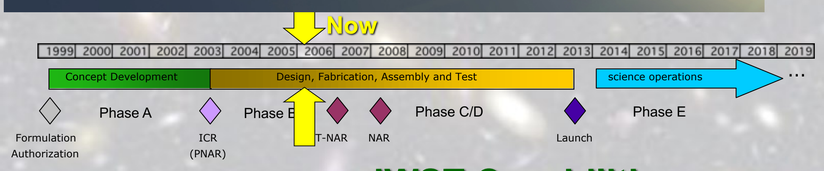




JWST Capabilities

25 m^2 collecting area using a segmented primary with 6.6-m tip-to-tip diameter

Low infrared background: L2 orbit enables passive cooling to ~45K for primary mirror, ~35K for instruments

Four instruments:

- NIRCam, 0.6 - 5 μm imaging
- NIRSpec, 0.6 - 5 μm, spectroscopy, R~100-3000 and multi-object
- MIRI, 5-29 μm, camera + R~2500 integral field spectrometer
- Tunable Filter, 1.7- 4.8 μm R~100

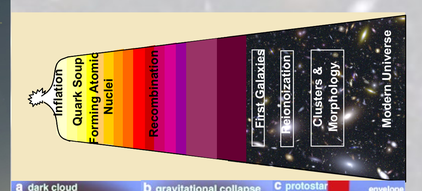
Key Design Features

- Large telescope optics
- JWST's telescope assembly is lightweight and deployable
  - Making its telescope lightweight and deployable makes JWST's large size feasible.
- Telescope assembly and scientific instruments are cold
  - The telescope and the instruments (cameras and spectrometers) attached to it need to be cold so that their own warmth does not overwhelm the faint infrared signals they are meant to detect.
- Sunshield allows the telescope and instruments to get cold
  - The cold telescope provides the phenomenal sensitivity in the IR.
  - The sunshield allows the telescope and instruments to radiate their heat to the extreme coldness of deep space.
- L2 is an ideal "Goldilocks" place for an infrared observatory
  - The Sun-Earth L2 point is far enough away from the warm Earth to provide a benign thermal environment and enable efficient operations, yet close enough for easy launch and communications.

All Be mirror blanks have been produced and are now being machined.

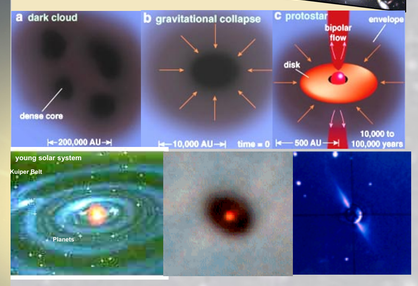
Testbed telescope has verified alignment algorithms.

JWST's Science Themes



The First Light in the Universe:
Discovering the first galaxies, Reionization

Period of Galaxy Assembly:
Establishing the Hubble sequence, Growth of galaxy clusters



Birth of Stars and Protoplanetary Systems: Physics of the IMF, Structure of pre-stellar cores, Emerging from the dust cocoon

Planetary Systems and the Origins of Life:
Disks from birth to maturity, Survey of KBOs, Planets around nearby stars

JWST has phenomenal capabilities for new astronomy!!

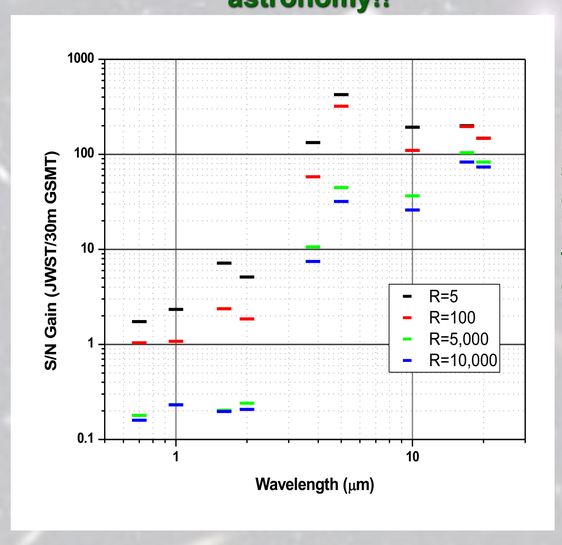


Figure to left shows sensitivity gains over a hypothetical 30-m telescope on the ground.

Instrument Design Features

NIRCam: images the 0.6 to 5μm (1.7 - 5μm prime) range
- –Dichroic used to split range into short (0.6-2.3μm) and long (2.4-5μm) sections
- –Nyquist sampling at 2 and 4μm
- –2.2 arc min x 4.4 arc min total field of view seen in two colors (40 MPixels)
- –Coronagraphic capability for both short and long wavelengths

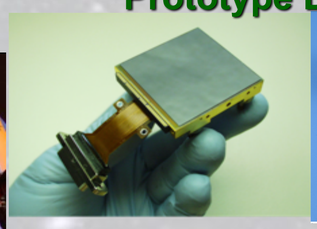
•NIRCam is the wavefront sensor
- –Must be fully redundant
- –Dual filter/pupil wheels to accommodate WFS hardware
- –Pupil imaging lens to check optical alignment

NIRSpec: Multi-object dispersive spectrograph (MOS) for 1-5 μm
- – R~1000 or R~100 for MOS
- – MOS pixels ~0.2", and cover a ~ ~3'x3' field
- – Capable of observing > 100 objects simultaneously.
- – Several fixed slits and an IFU (3"x3") are also available with R as high as 3000.
- – Being built by the European Space Agency

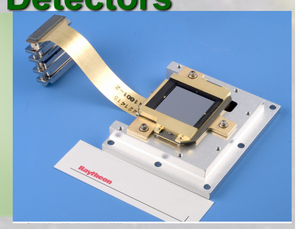
MIRI: JWST's Long Wavelength Instrument
- – 100x sensitivity over previous systems
- – Imaging and spectroscopy capability
- – Imager uses 1Kx1K detectors w/ 0.11"/pixel for a 1.9'x1.4' FOV with one edge dedicated to coronagraphy
- – Spectrometer comprised of 4 diffraction-limited IFUs
- – 5 to 29μm
- – Cooled to 7K by cryo-cooler
- – Combined ESA/NASA contributions

Tunable Filter/ Fine Guidance Sensor: R~100 imaging and facility guiding
- – All fields of view 2.3 x 2.3 arcmin, 68mas pixels
  - Matched to NIRCAM FOV
- –FGS guider passband 0.8 to 5.0 microns
  - No filters – may guide and do full field imaging
- –FGS-TF
  - -- ~1.7 – 4.8μm
  - -- R = 70 to 150
  - -- Wavelength continuously adjustable
  - -- Coronagraph capability

Prototype Detectors



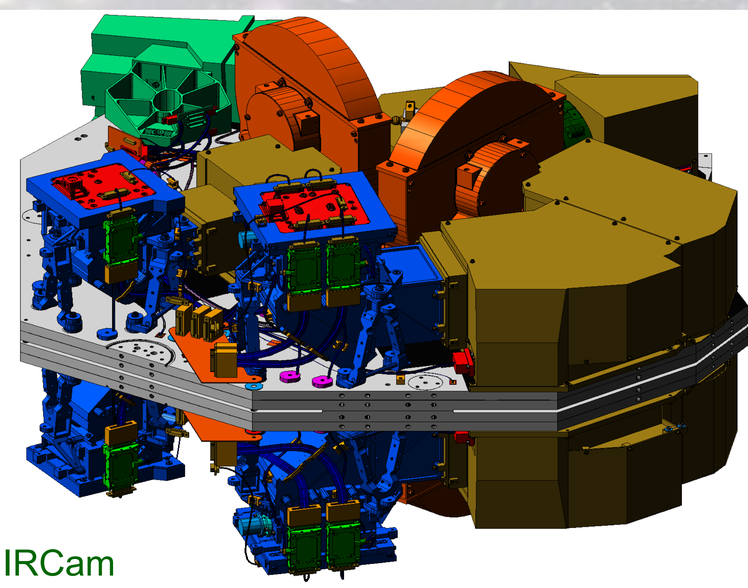
2Kx2K HgCdTe

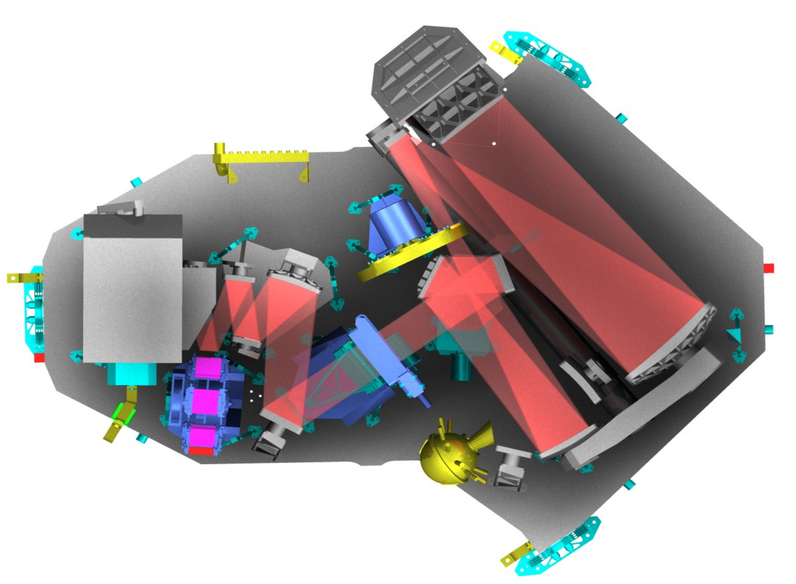


1Kx1K Si:As

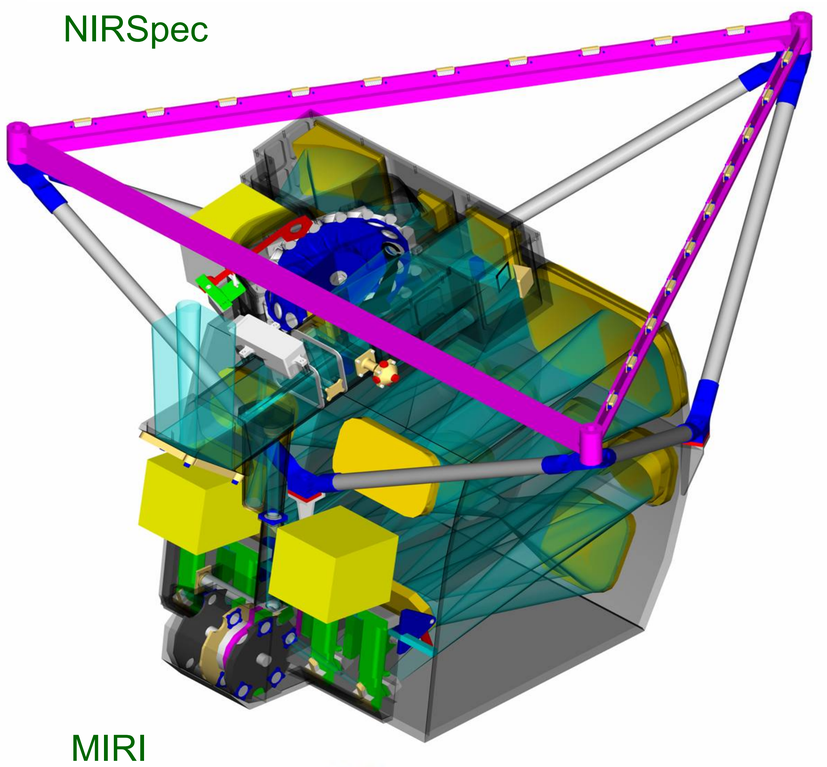
The three near-infrared instruments employ 2Kx2K HgCdTe detectors from Rockwell Scientific while MIRI employs 1Kx1K Si:As detectors from Raytheon.

NIRCam





NIRSpec



MIRI

Tunable Filter/FGS

Want to know more? Go to http://www.jwst.nasa.gov