MIRI
The Mid-InfraRed Instrument
for
JWST
The James Webb Space Telescope

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JWST MIRI European PI

UK SPACE AGENCY

Science & Technology Facilities Council
UK Astronomy Technology Centre

Science & Technology Facilities Council
Rutherford Appleton Laboratory

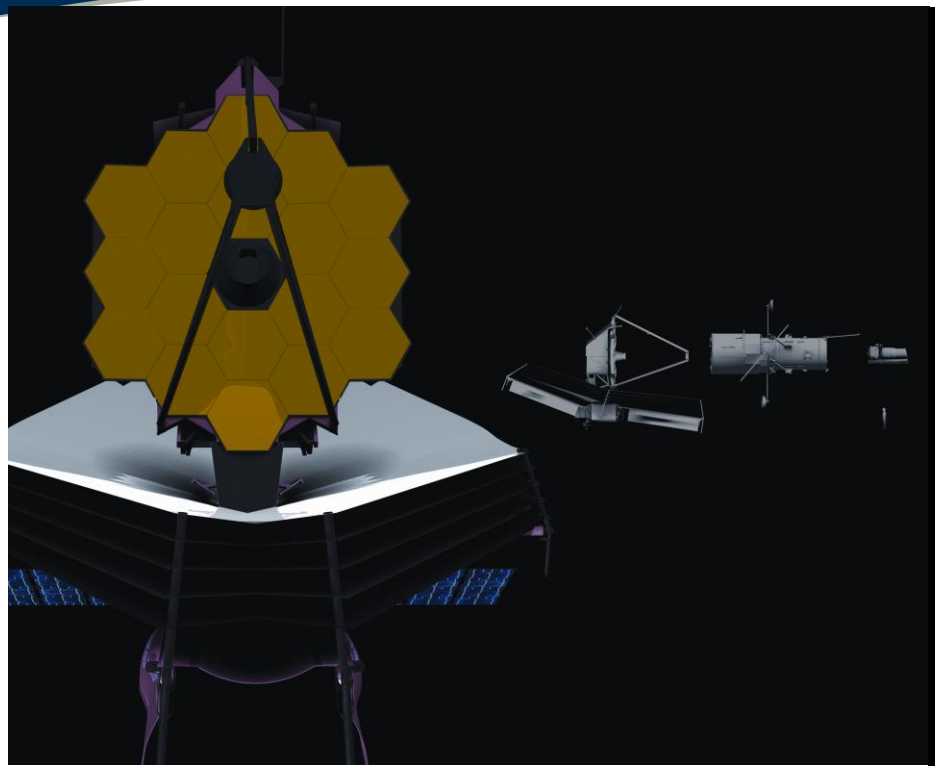
University of Leicester

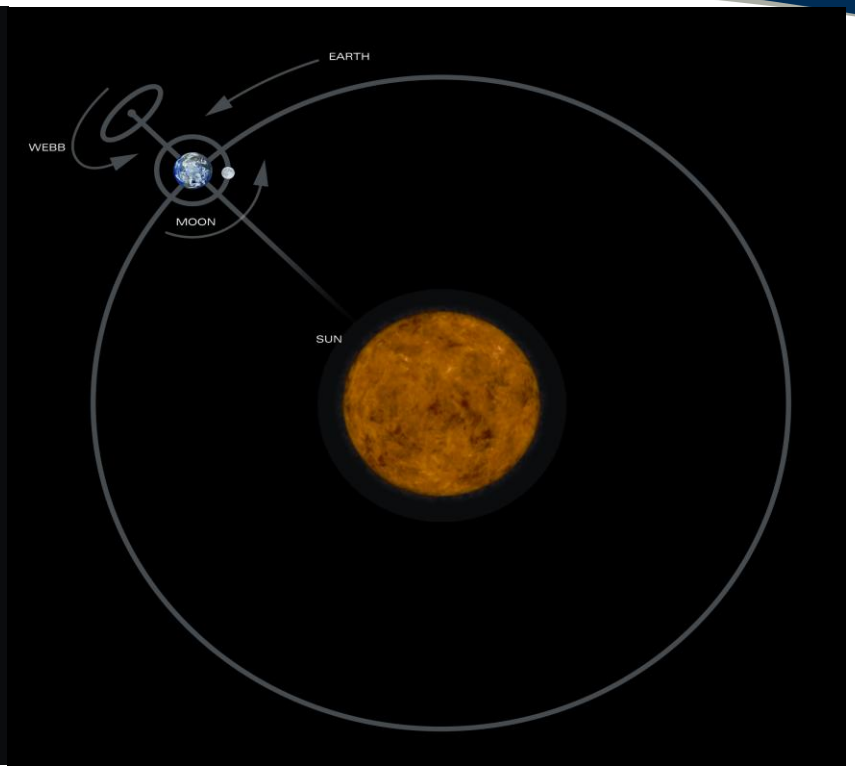
EADS ASTRIUM

Talk Overview

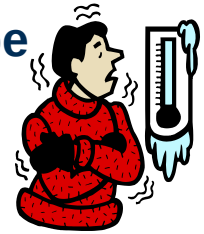
- Introduction to the JWST Mission and Instruments
- Science with JWST and MIRI
- Overview of the JWST MIRI Instrument and the UK role in JWST
- JWST and MIRI Status

James Webb Space Telescope





- 6.5m Diameter Primary Mirror
- Infrared Optimised Telescope
- Passively cooled to ~ 40K



- Launch June 2014 (under review)
- Placed in an L2 orbit
- Mission Lifetime 5-10 years

The JWST Mission

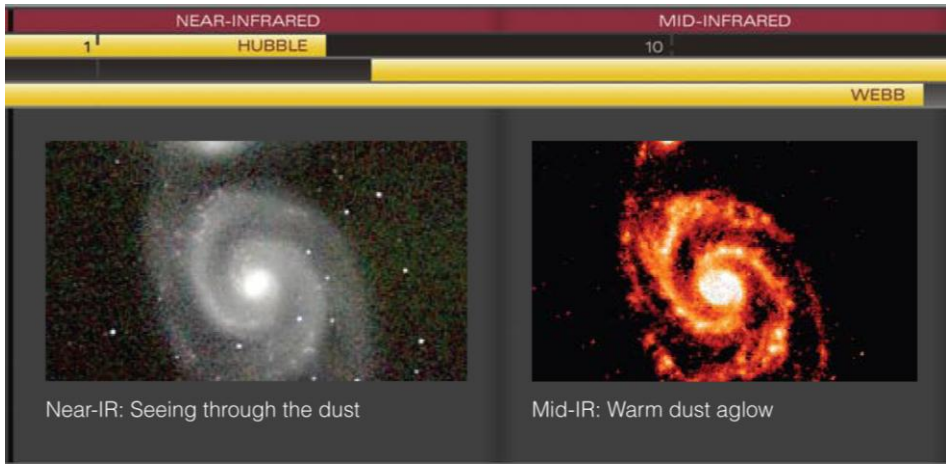
- JWST is being built by a collaboration between NASA, ESA and CSA
  - Europe has a guaranteed 15% share of the observing time
- It will be the largest space telescope and mission ever launched
- To place such a large telescope in a far away orbit and cool it sufficiently brings unique challenges

Why is JWST an Infrared Telescope ?

To help resolve key outstanding questions about the Universe we now need to:

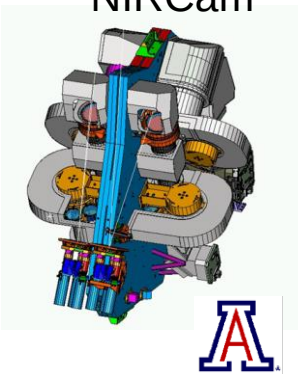
1. **Study further into the early universe than is possible with current telescopes and missions**
   - **the ultraviolet and visible light from distant sources is red-shifted into the infrared part of the spectrum**

2. **Look deep into regions where stars and planets are forming**
   - **Infrared light is less well absorbed by dust and we can see warm dust directly**

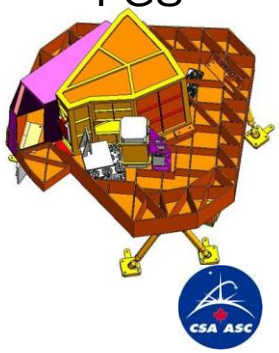


JWST Instruments

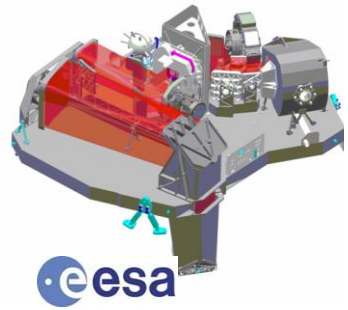
NIRCam



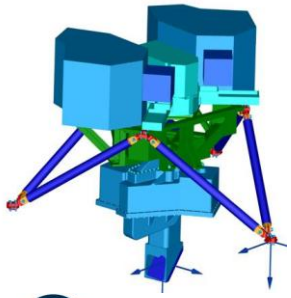
FGS



NIRSpec



MIRI



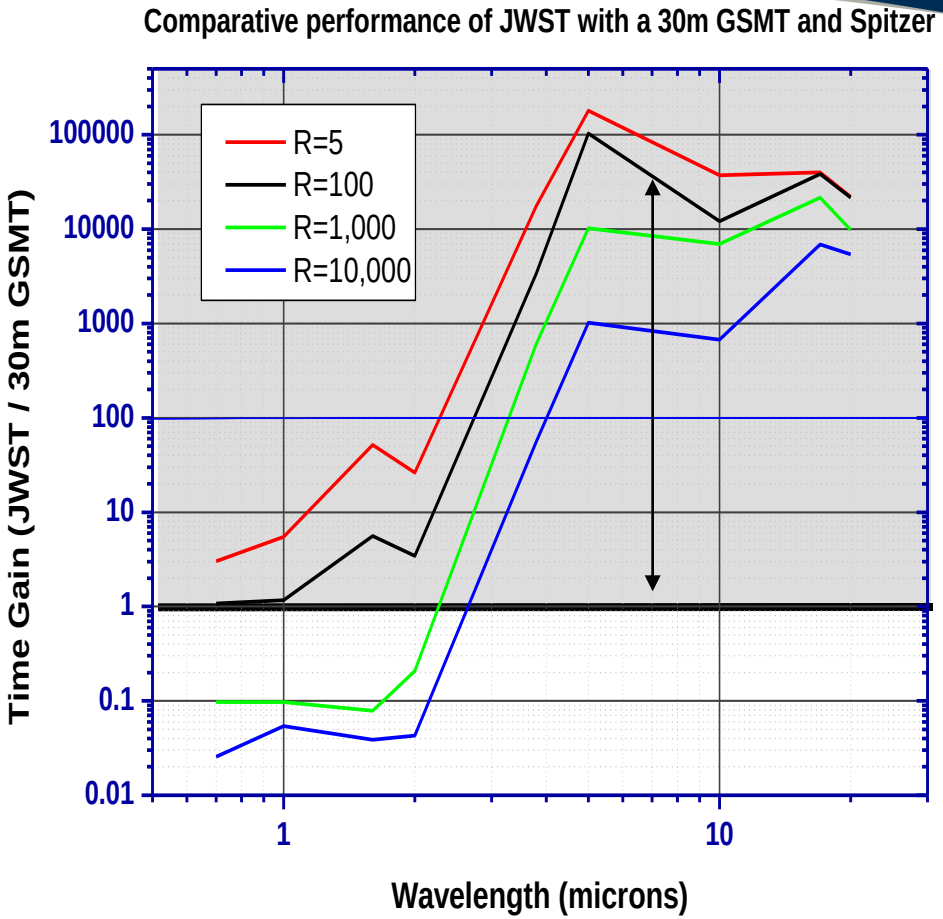
Science & Technology Facilities Council

JPL
Jet Propulsion Laboratory
California Institute of Technology

- **JWST is designed to enable broad science investigations by the world-wide astronomical community**
  - Broad- and narrow-band imagery: 0.6–29 μm
  - Low resolution spectroscopy: 0.6 – 11 μm
  - Medium resolution integral field spectroscopy: 5 - 29 μm
  - Multi-object spectroscopy : 1 – 5 μm and 9.7 sq arc-min FOV
  - Broad- and narrow band coronagraphic imagery: 2 – 23 μm
- **4 Instruments provide this capability**
  - Near Infra-Red Camera (NIRCam)
  - Near Infra-Red Spectrometer (NIRSpec)
  - Mid-Infra-Red Instrument (MIRI)
  - Fine Guidance Sensor (FGS)
- The UK has a major role in JWST

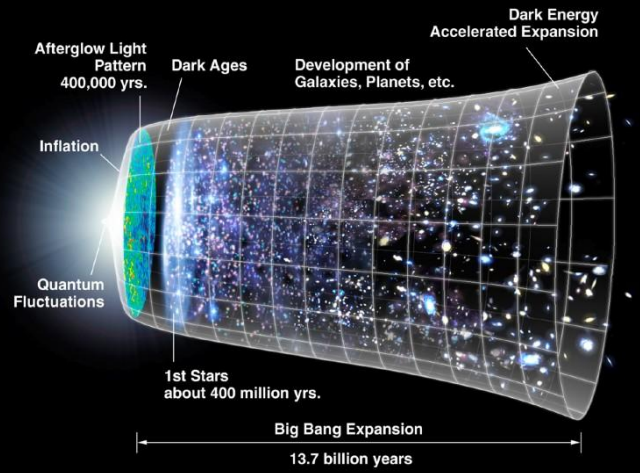
Stupendous JWST Performance

- **JWST offers enormous increase in observational capabilities.**
  - **1,000 x faster than Hubble in the near-IR, 5,000 to 100,000 x faster than *anything* in the mid-IR**
- **Whenever there is an increase by an order of magnitude or more in observational capability, new discoveries are made**
- **This gap in performance will never be matched from the ground**

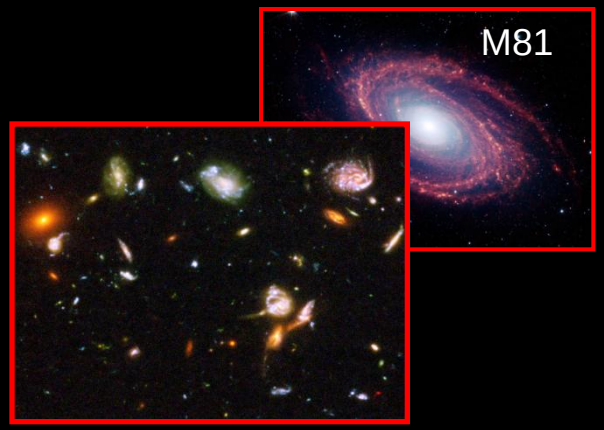


The plot shows the relative time gain of JWST compared to a GSMT. 1.0 means an observation with both JWST and GSMT (and Spitzer) will take the same time to reach the same S/N on a point source.(Mountian and Reike 2005)

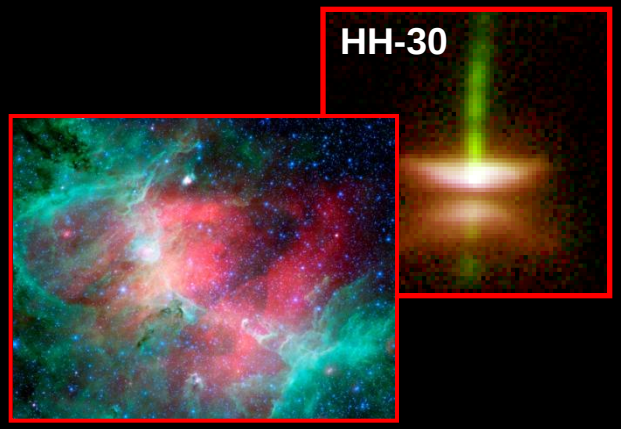
Science Overview



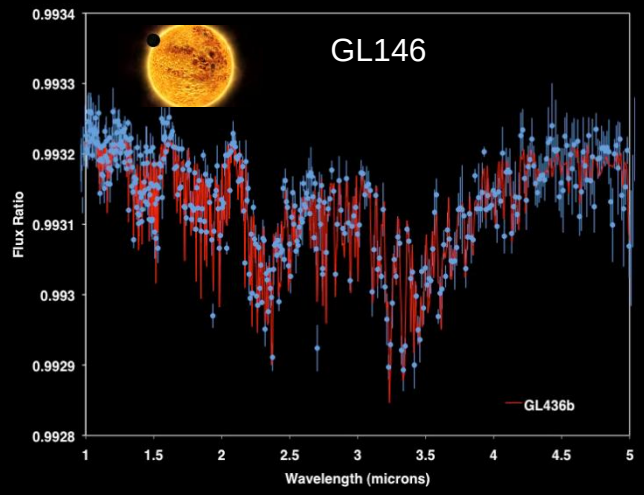
First Light and Re-Ionization



Galaxy Evolution



Birth of stars and
proto-planetary systems

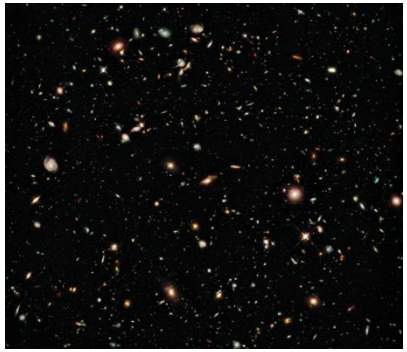


Planetary systems and the origin of life

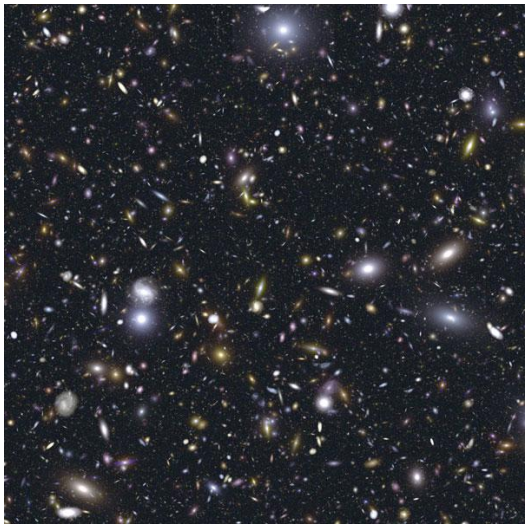
Searching for the first galaxies

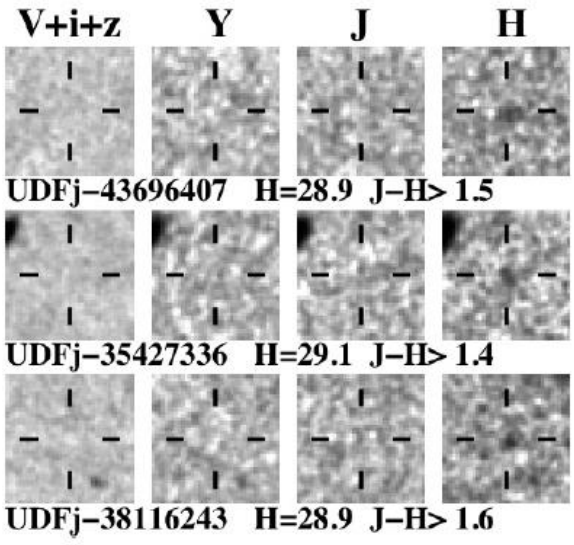
HST-ACS Ultra Deep Field
- Visible **z ≤ 6 - 7**

HST-WFC3 Deep Field Image
- near-IR **z ≤ ~8**



Simulated JWST image

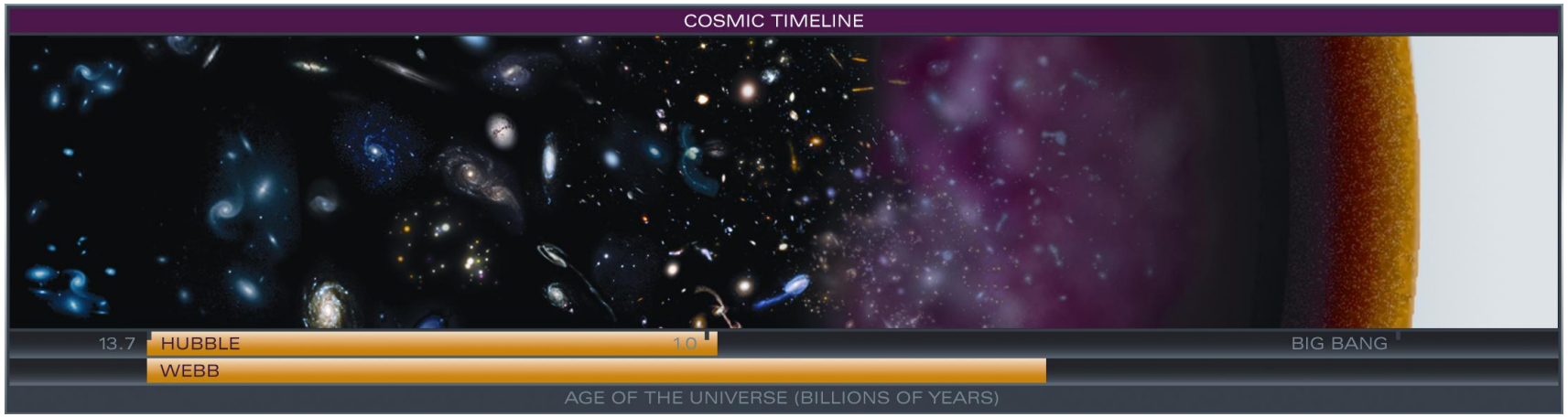




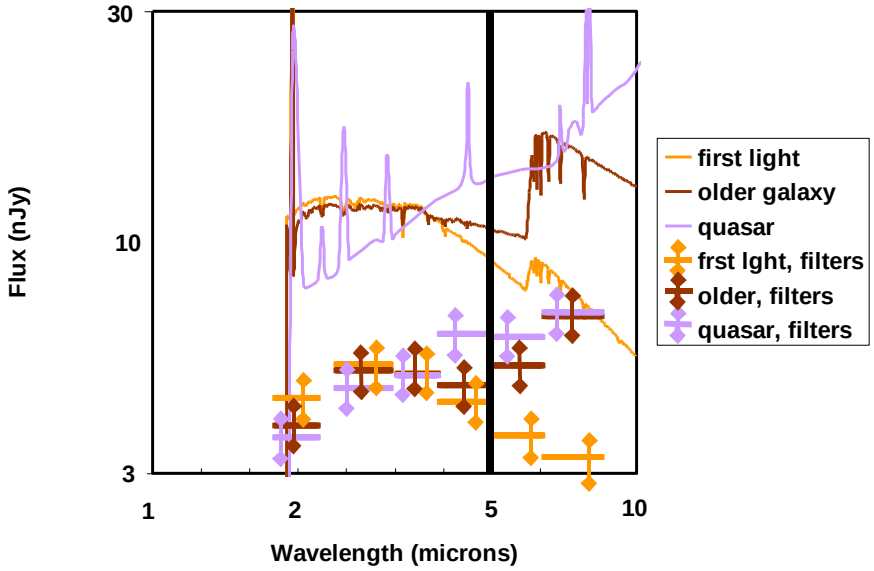
WFC3
J dropout candidates

Metallicity measurements and the detection by MIRI will be possible for bright Z >~ 10 sources and sources amplified by lensing.

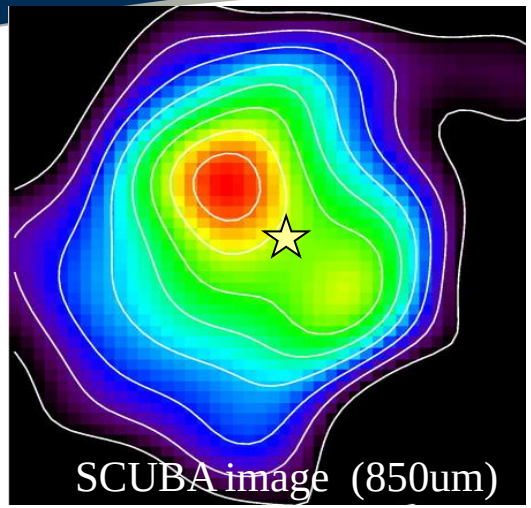
JWST Science :
Where are the 1st Stars and Galaxies ?

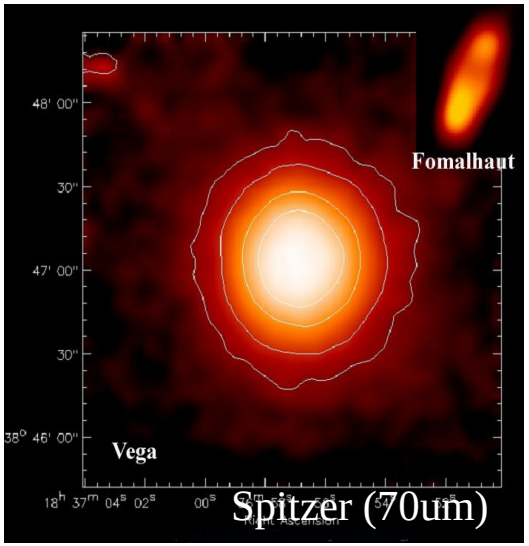


- **The host galaxies of luminous quasars at redshifts >6, and the first light objects will both be found in deep near-IR images**
- **Adding MIRI data for sources found in NIRCam surveys will provide a unique diagnostic for identifying first light sources and reddened ultraluminous galaxies forming quasars**



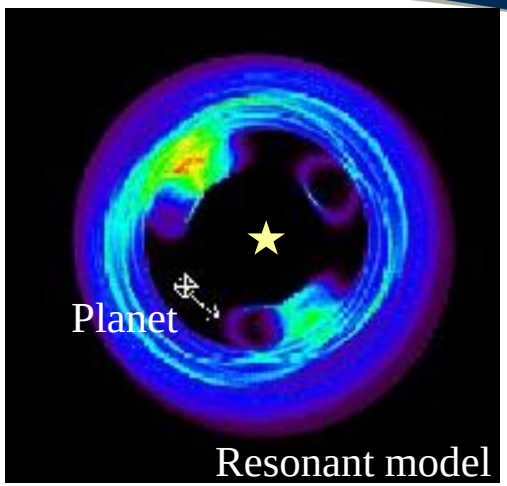
JWST Science: Planets and Debris disks


SCUBA image (850um)

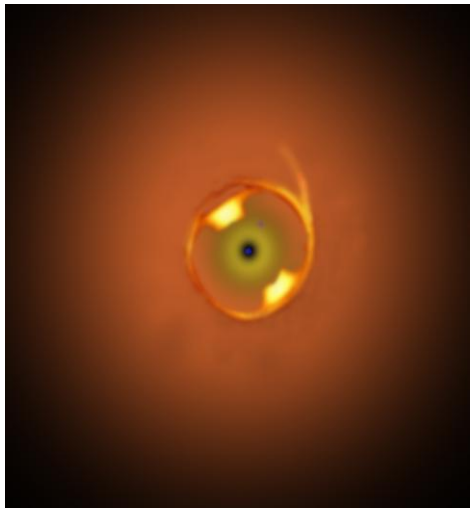


Spitzer (70um)

- **MIRI studies of debris disks will complement and add to work with Herschel, Scuba2 and Alma**
- **MIRI has unique ability to study structure of disks and chemistry of the material**
- **Warm dust (zodiacal light) ≥ 1% of disks are now known from Spitzer surveys to have warm dust component**

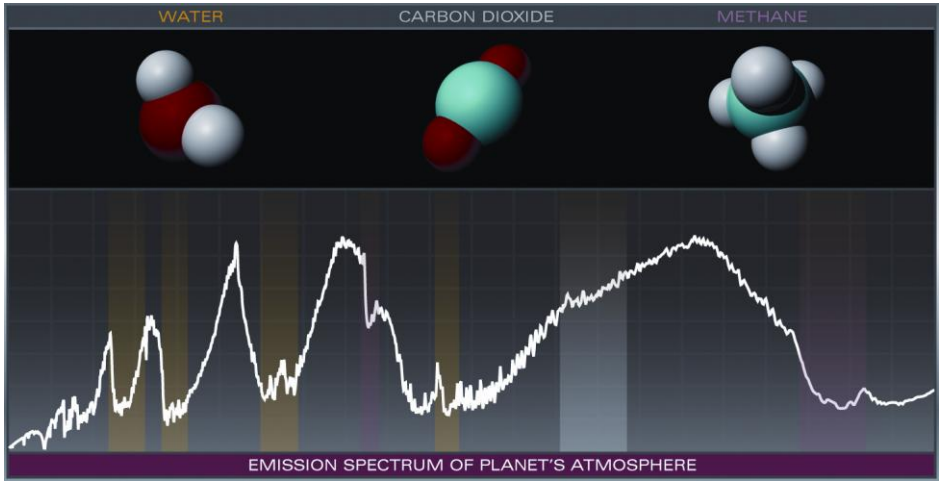


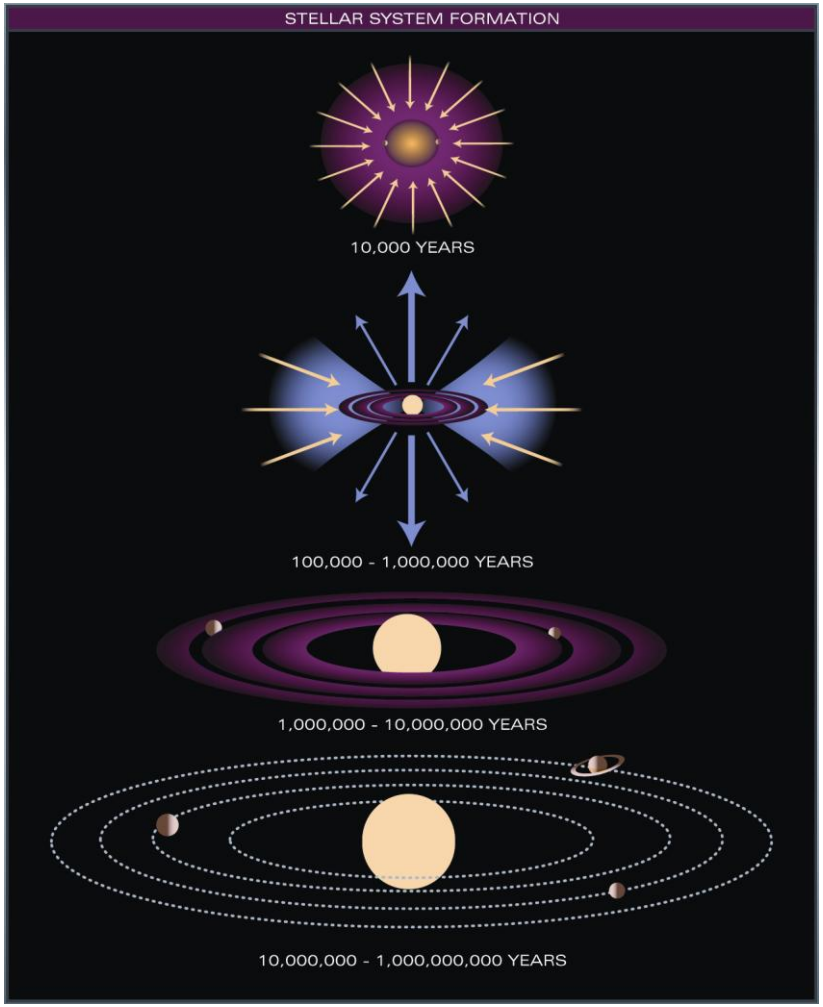
Resonant model


The JWST MIRI View at 24um

Pictures: Holland, Wyatt, Su, Rieke

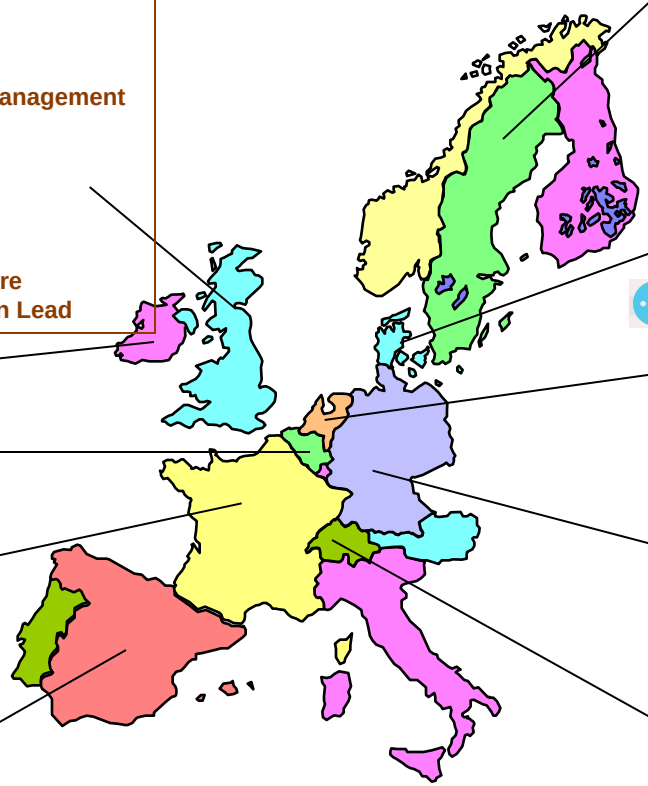
JWST Science : How do Planets Form ?





The MIRI Partnership

UK-ATC	**Principal Investigator** **Optical Engineering** **Spectrometer Pre-Optics (SPO)**
Cardiff	**Calibration Sources**
Astrium Ltd	**Project Office & Consortium Management** **PA Coordination** **System Engineering**
U. of Leicester	**Mechanical Engineering** **Primary Structure** **MGSE**
RAL	**Thermal Engineering & Hardware** **AIV Facility and Test/Calibration Lead**



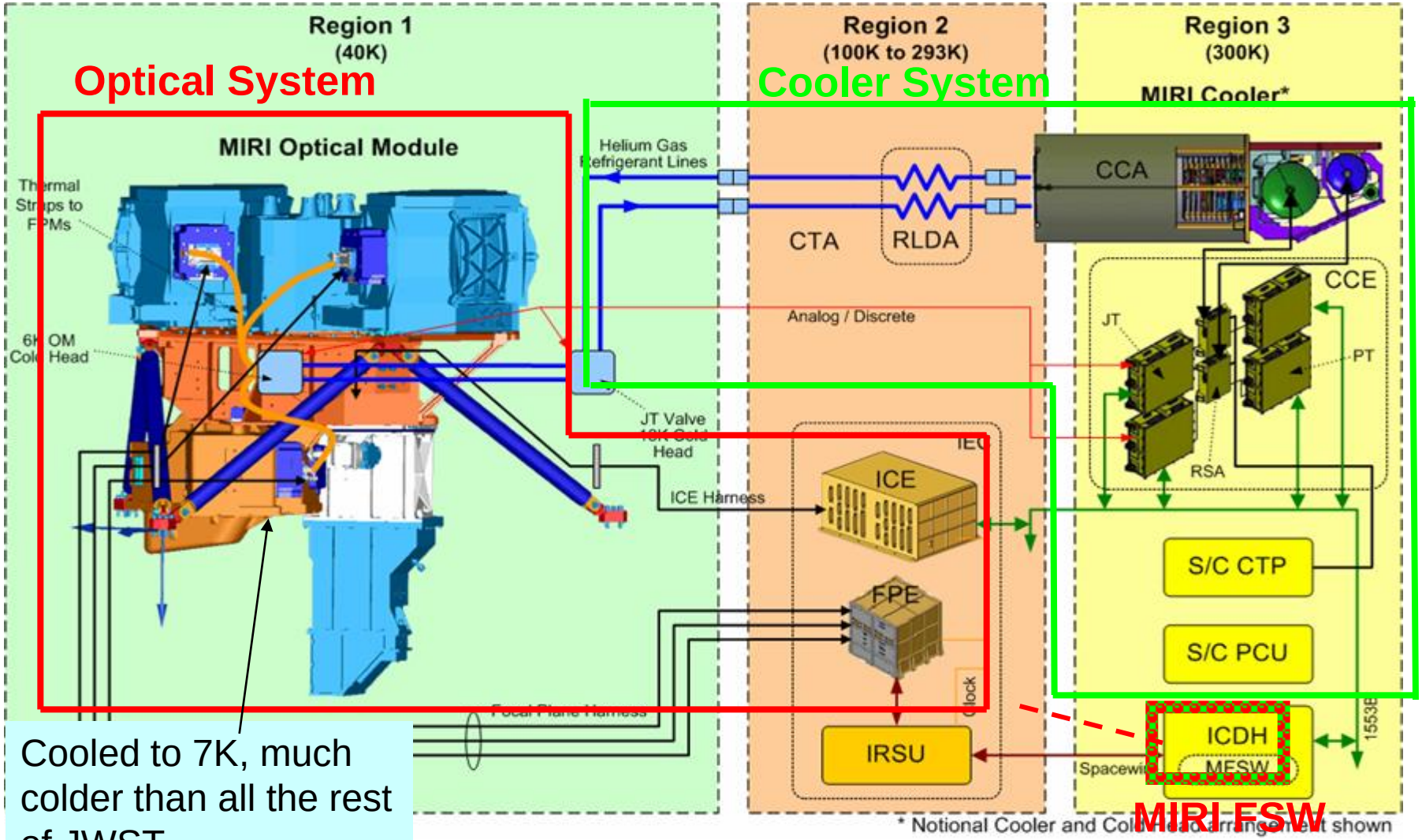
DIAS	Filters
CSL	Input, Optics & Calibration (IOC) Instrument Control Electronics
(ICE)	Imager Mirrors
U. of Leuven	EGSE Software Support
CEA	Imager Coronagraph Analysis
LESIA/LAM	Coronograph
INTA	MIRI Telescope Simulator (MTS)

U. of Stockholm	Filters and Gratings
DSRI	Hexapod
ESA/ESTEC	JWST Project Office Prodex Office
ASTRON (SMO)	Spectrometer Main Optics
U. Leiden	Spectroscopy Analysis
MPIA Heidelberg	Electrical Engineering Cryo Mechanisms
U. of Köln	Low Resolution Spectrometer
	Double Prism
PSI	Contamination Control Cover
	Cryo Harness

NASA/GSFC	JWST Project Office Spacecraft ISIM	STScI U. Arizona	Operations DHAS, US PI	JPL	Detector System Flight Software Cryo-Cooler

The MIRI Partnership was formed because of the enormous science potential of a Mid-IR instrument on JWST

Why is MIRI so challenging ?

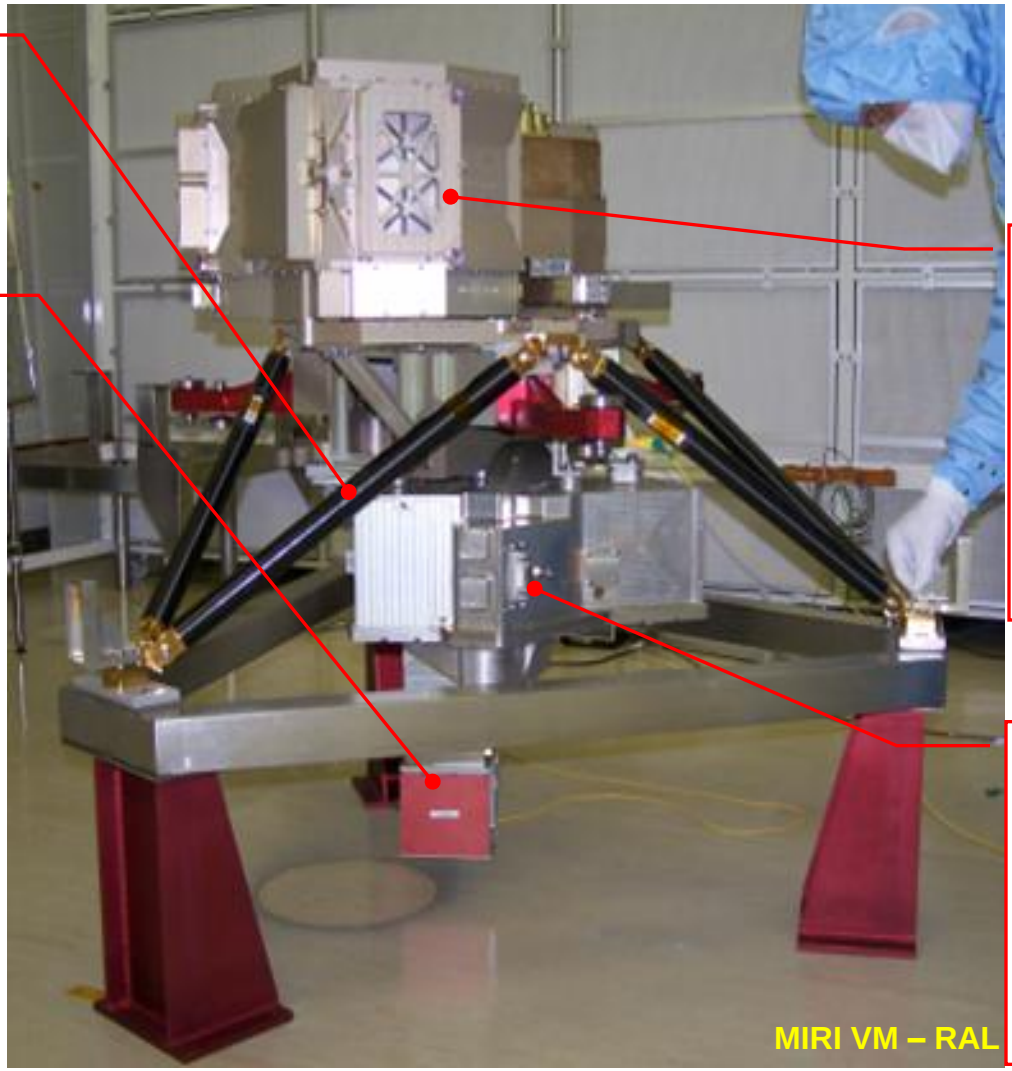


Cooled to 7K, much colder than all the rest of JWST

MIRI is an Imager and a Spectrometer

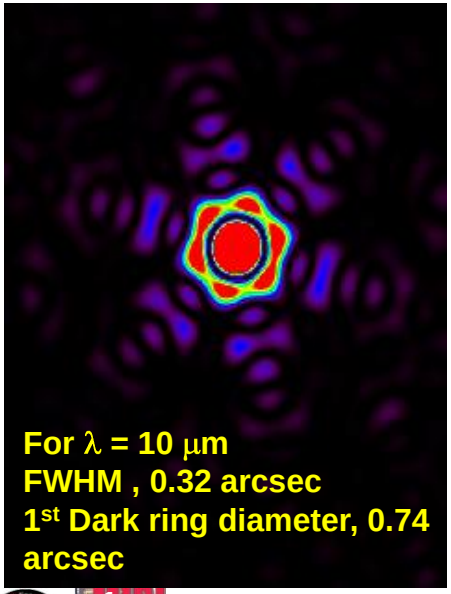
A carbon fibre truss isolates 7 K MIRI optics from the 40 K telescope

Light enters from the JWST telescope



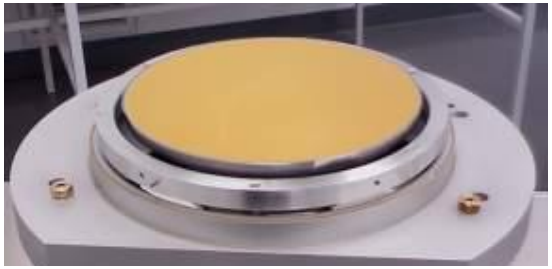
A 10 x 10 arcsec field passes through the deck into the R ~ 3000, 4 channel integral field spectrometer
2 detectors
2 channels per detector

A 115 x 115 arcsec region of the focal plane is directed into the imager
10 bandpass filters
4 coronagraphs
R ~ 100

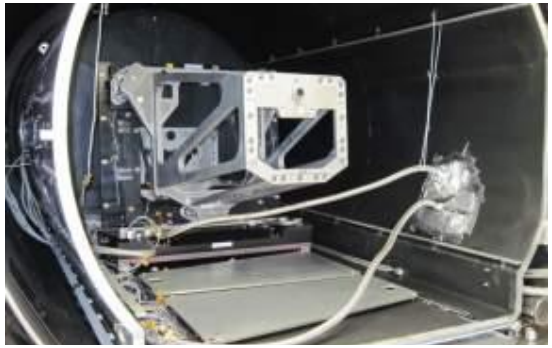


For λ = 10 μm
FWHM , 0.32 arcsec
1st Dark ring diameter, 0.74 arcsec

JWST Observatory is in construction

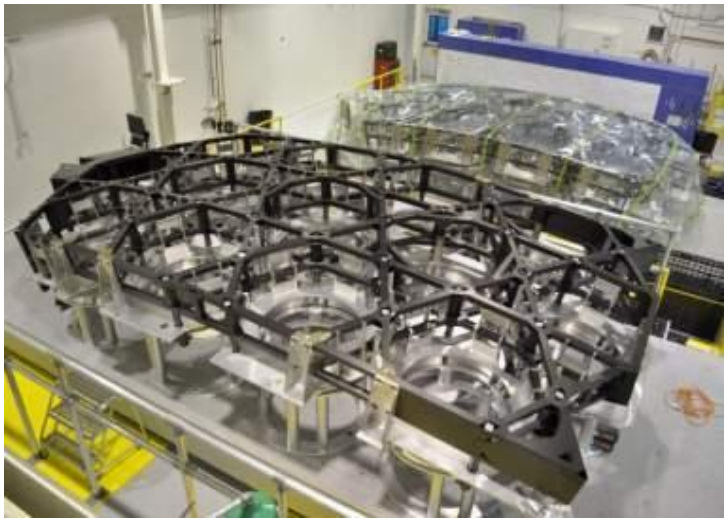


Fine Steering Mirror - Coated



Aft Optics Bench for Cryo Test

Primary Mirror EDU - Coated



Backplane Center Sections

12 containers store either an assembled PMSA, SMA EDU or TM

Backplane Support Frame – PF

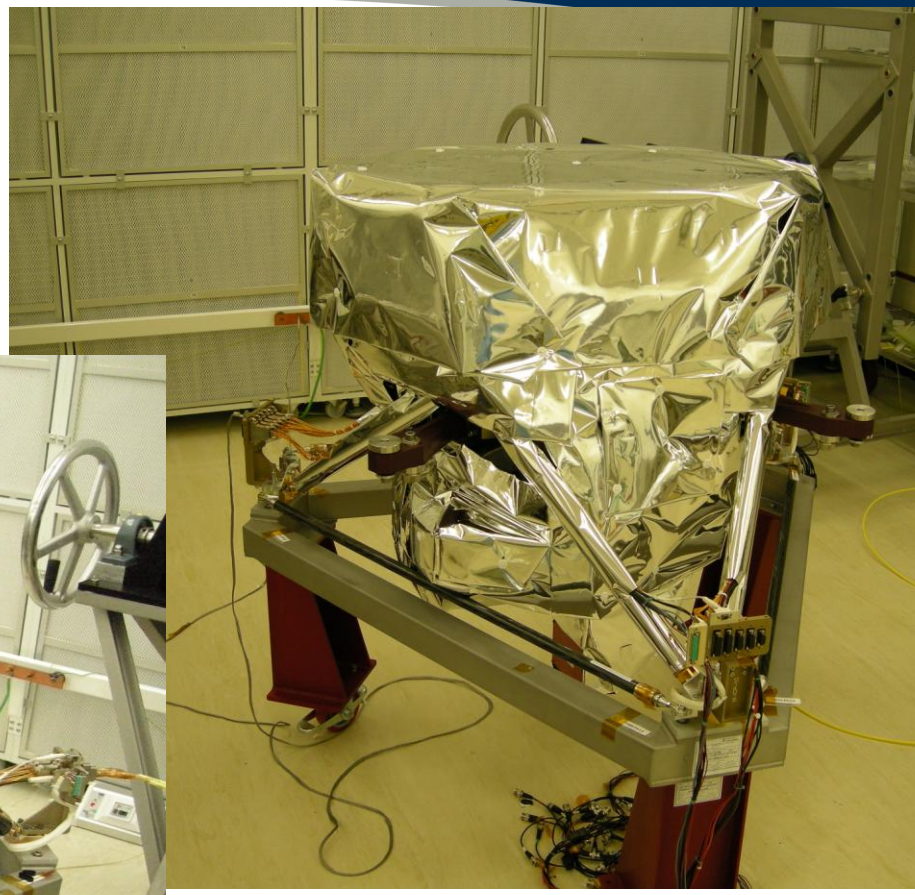
Tertiary Mirror - Coated

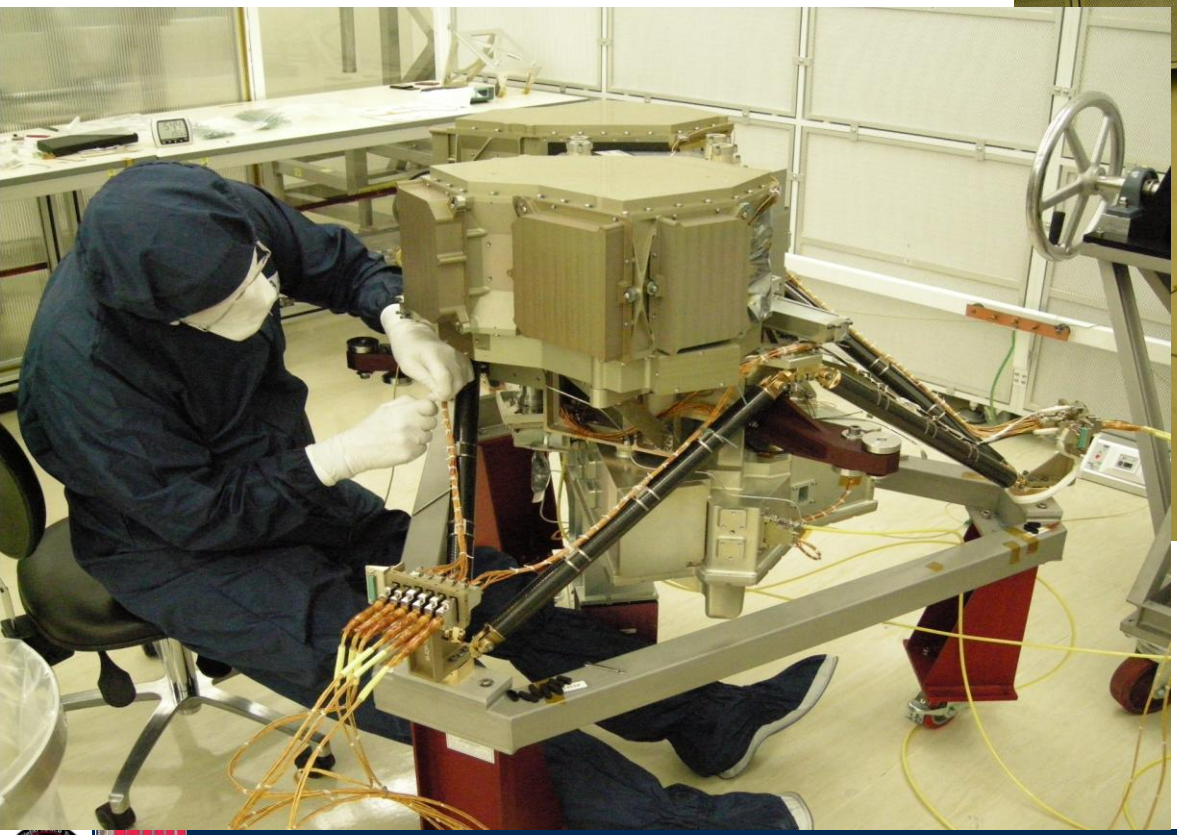
Primary Mirror Segment Tests

Engineering Models of the Instruments in Test

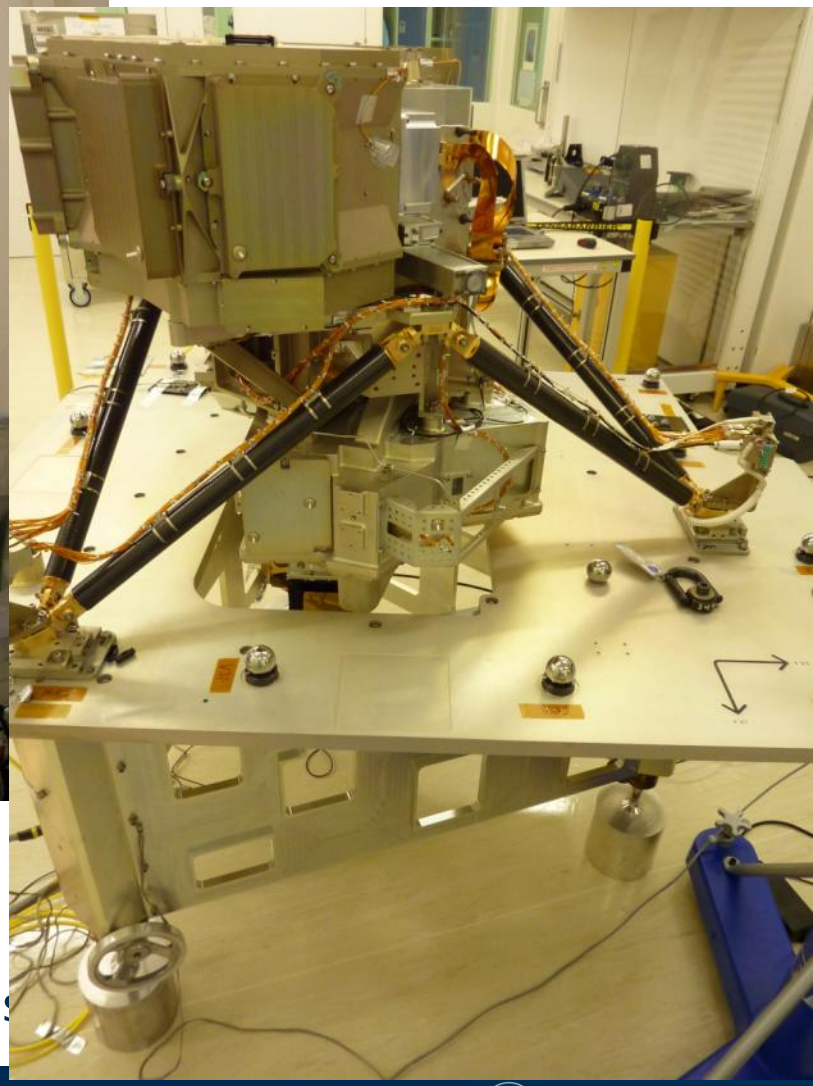
We delivered the MIRI Structure Thermal Model from RAL to Goddard Space Flight Centre in March

The Flight MIRI is now built





Final testing is in progress at RAL



- We have just successfully completed vibration test
- UK team is now preparing for full cryogenic performance and calibration tes

Conclusions

- JWST will become the dominant astronomical facility for a decade,
  - Vastly more sensitive and sharper images, coronagraphic images, spectral images and spectra enabling new and exciting astrophysics
- To build such a large and versatile space observatory is technically complex and challenging
  - The UK is playing a significant role
- The JWST technology development is on track and the mirror polishing is progressing to plan
- Testing of the flight MIRI instrument is making great progress
  - All the indications so far are that the expected performance will be met or exceeded
  - We expect to deliver the instrument to NASA in late 2011.