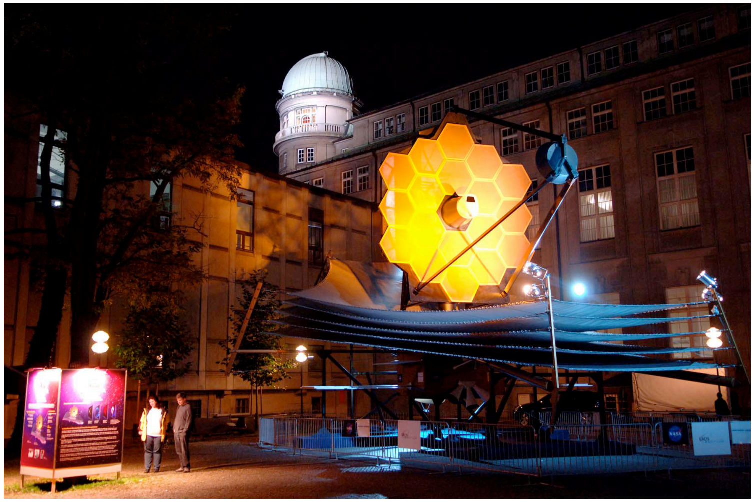
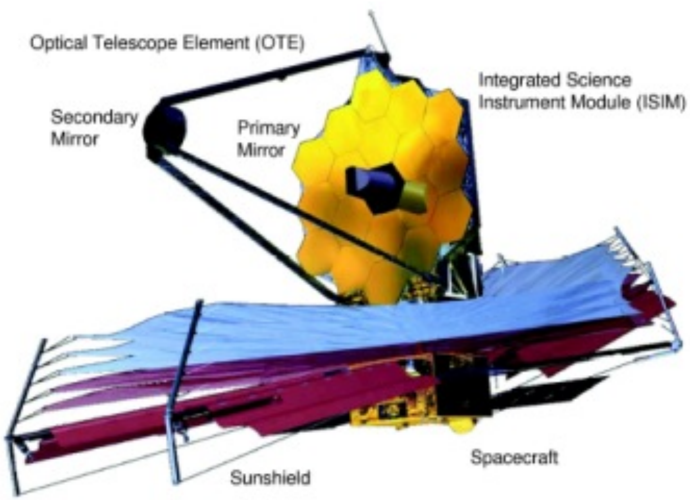
JWST IN A NUTSHELL





Largest optical/IR Telescope in Space
- 6.5m diameter
- Segmented telescope (18)
- IR spectral range (0.6 to 28 microns)
- No cryogenics. Passive cooling (L2)

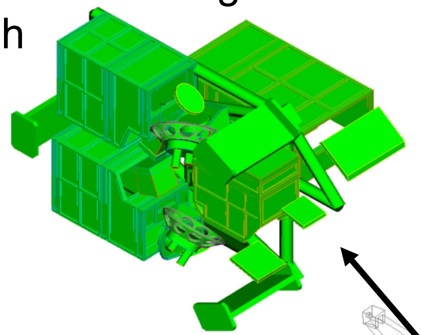
Science Themes
- First light
- Assembly of galaxies
- Birth of stars and protoplanetary systems
- Planetary systems and exoplanets

Schedule
- Launch by second half 2018
- Call for proposals: ~ Launch date – 1 year
- Life 5 years (requirement) / 10 years (goal)

JWST. SCIENCE INSTRUMENTS

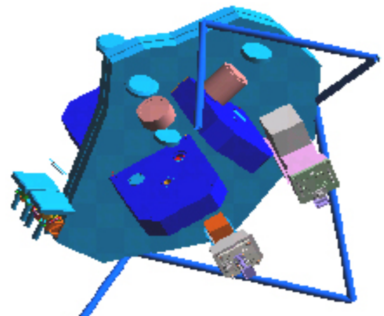
<u>Near-infrared Imager & Slitless spectrograph (NIRISS/FGS)</u>

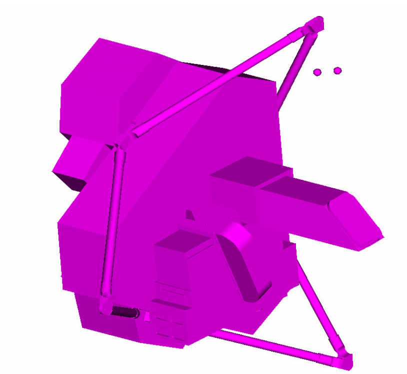
- 0.9 to 4.8 μm operation
- Guide star acquisition & tracking
- Slitless spectrograph
  2 (2048x2048)
  68mas pixels

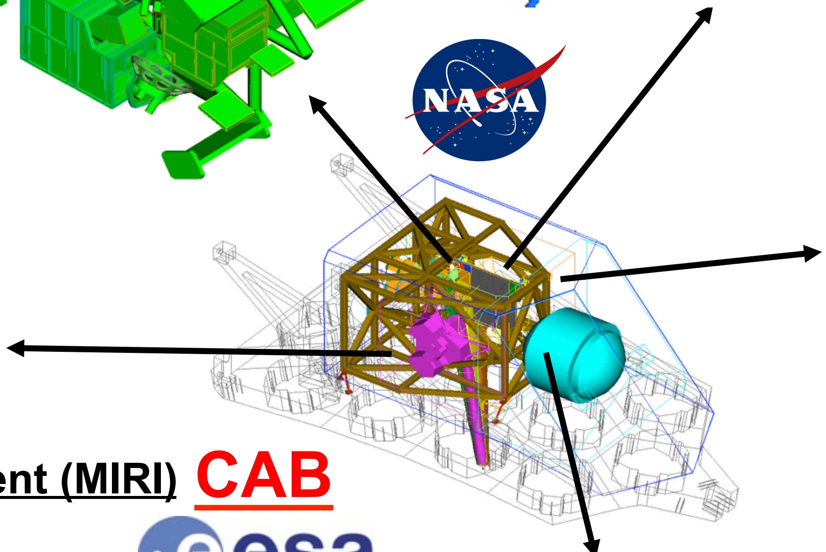


<u>Near Infrared Camera (NIRCam)</u>

- 0.6 to 5 μm operation
- Wide Field Imaging
- Coronagraph imaging capability
- Supports WFS&C
- 2 (4096x4096) 31mas pixels
- 2 (2048x2048) 62mas pixels







<u>Near Infrared Spectrometer (NIRSpec)</u> CAB

- 0.6 to 5 μm operation
- Simultaneous Spectra of >100 objects
- $\lambda/\Delta\lambda$ ~ 100 to 1000
- 2 (2048x2048) 100mas pixels

<u>Mid Infrared Instrument (MIRI)</u> CAB

- 5 to 28 μm operation
- Science Discovery Space
- Imaging
  1 (1024x1024) 110mas pixels
- Spectroscopy
  2 (1024x1024) 200-470mas pixels

Solid Hydrogen Dewar

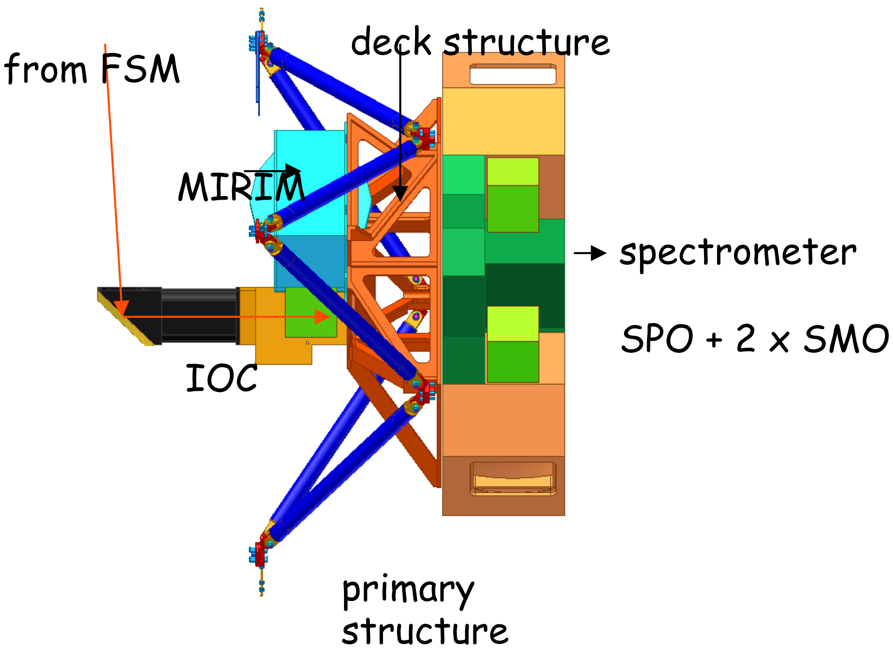
- Cools MIRI detectors to ~7K
- 5 year lifetime
- Studying Cryo-cooler

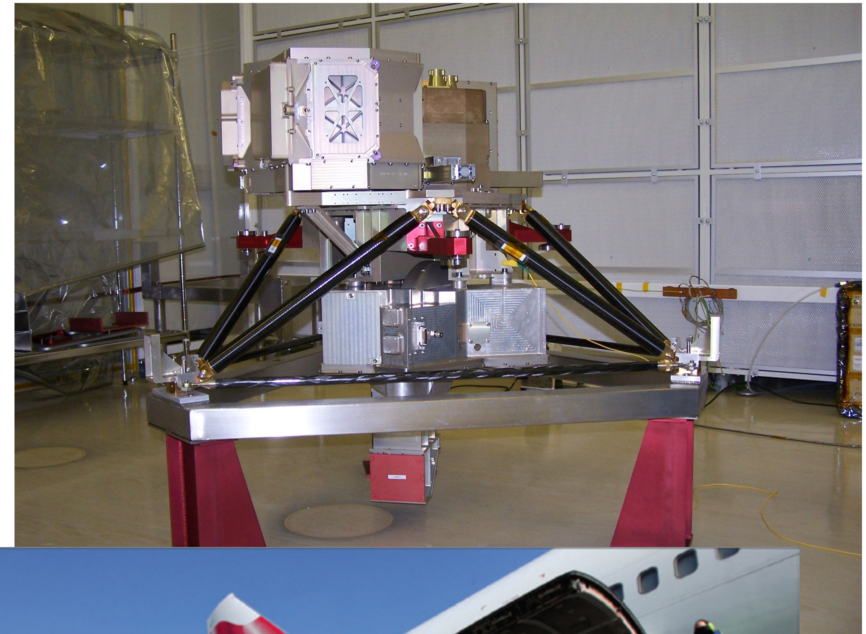
Jet Propulsion Laboratory
California Institute of Technology

MIRI. JWST MID-INFRARED INSTRUMENT

<u>TRULY UNIQUE</u>:

- Spectral range: 5 - 28 μm
- Modes: Imager, coronagraph and spectrograph
- Resolution: First sub-arcsec mid-IR instr. in space



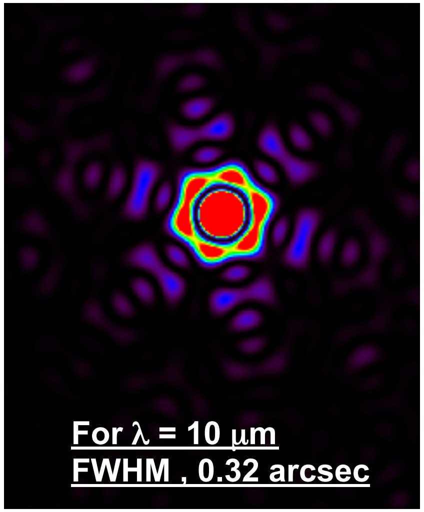


<u>First instrument delivered to NASA: May 2012</u>

Table 1: Observing Modes for the MIRI Instrument on *Webb*

Mode	Wavelength (microns)	Pixel Size/Resolving Power	Field of View
Imaging	5.0–28	0.11 arcsec	1.23 × 1.88 arcmin
Single Slit Spectroscopy	5.0–~14	$\lambda/\Delta\lambda$ = ~100 at 7.5 microns	0.6 × 5.5 arcsec slit
IFU Spectroscopy	5.0–7.7	$\lambda/\Delta\lambda$ = 3500	3.0 × 3.9 arcsec
	7.7–11.9	$\lambda/\Delta\lambda$ = 2800	3.5 × 4.4 arcsec
	11.9–18.3	$\lambda/\Delta\lambda$ = 2700	5.2 × 6.2 arcsec
	18.3–28.8	$\lambda/\Delta\lambda$ = 2200	6.2 × 7.7 arcsec
Coronagraphy	10.65	0.11 arcsec	24 × 24 arcsec
	11.4	0.11 arcsec	24 × 24 arcsec
	15.5	0.11 arcsec	24 × 24 arcsec
	23	0.11 arcsec	30 × 30 arcsec

MIRI IMAGER

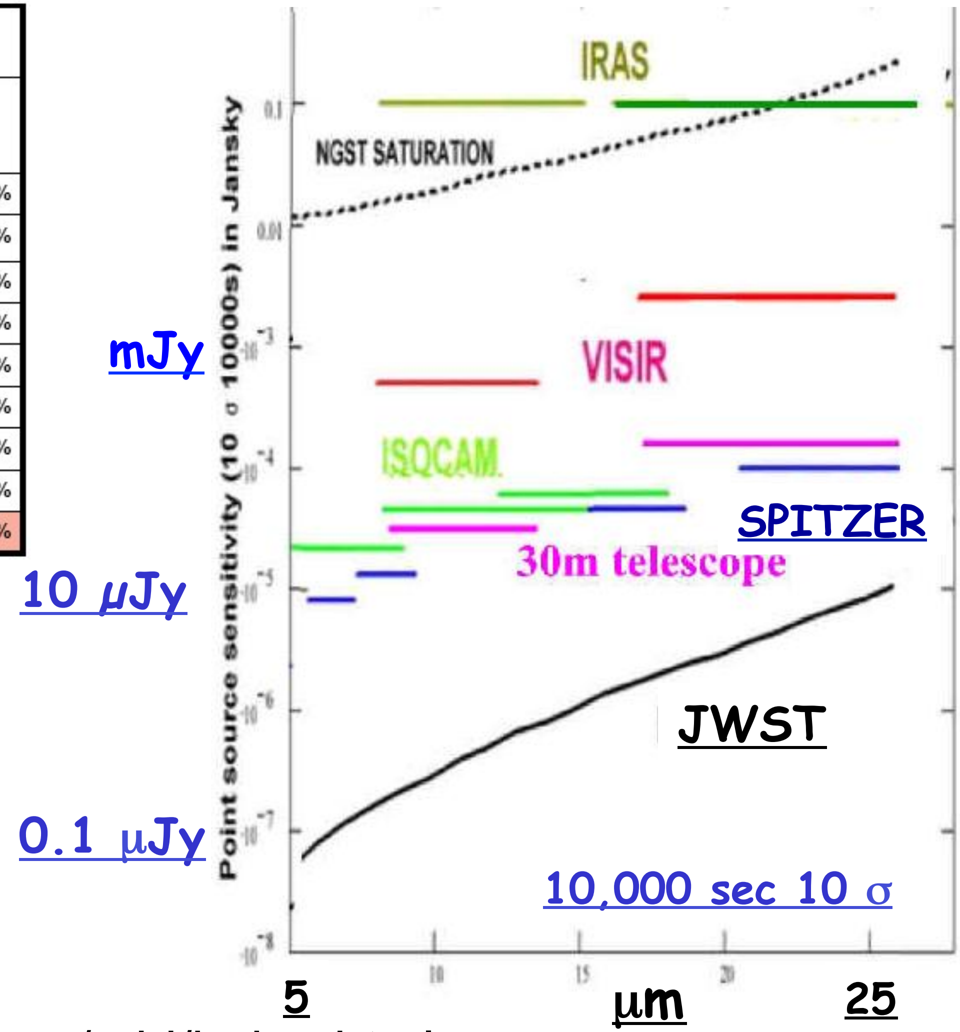


Filter name (and wavelength)	Pass band Δλ (µm)	Function
F560W	1.2	Imaging
F770W	2.2	
F1000W	2.0	
F1130W	0.7	
F1280W	2.4	
F1500W	3.0	
F1800W	3.0	
F2100W	5.0	
F2550W	4.0	
F2550WR	4.0	
P750L	5	R ~ 100 Spectroscopy
F1065C	0.53	Coronagraphy
F1140C	0.57	
F1550C	0.78	
F2300C	4.6	
FND	10	Target Acquisition
FLENS	N/A	Alignment
PAR+BLANK	N/A	Calibration

http://www.roe.ac.uk/ukatc/consortium/miri/index.html

MIRI IMAGING SENSITIVITY

Imager Filter		Point source sensitivity (10 sigma in 10,000 sec) [micro-Jansky]		
Wavelength [µm]	Passband [µm]	Requirement (FRD)	Design CBE	Margin
5.6	1.2	0.18	0.13	28%
7.7	2.2	0.27	0.22	19%
10.0	2.0	0.70	0.54	23%
11.3	0.7	1.66	1.33	20%
12.8	2.4	1.33	0.99	26%
15.0	3.0	1.77	1.28	28%
18.0	3.0	4.32	3.18	26%
21.0	5.0	8.63	7.13	17%
25.5	4.0	28.3	28.3	0%



MIRI

~ 10^4 deeper than VLT

~ 10-100 deeper than Spitzer

http://www.roe.ac.uk/ukatc/consortium/miri/index.html

MIRI 4QP CORONAGRAPH

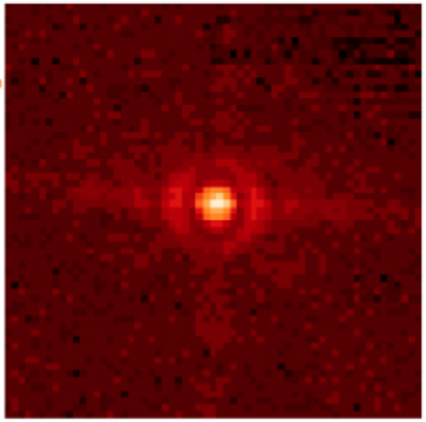


Figure 45: PSF at 11.4μm

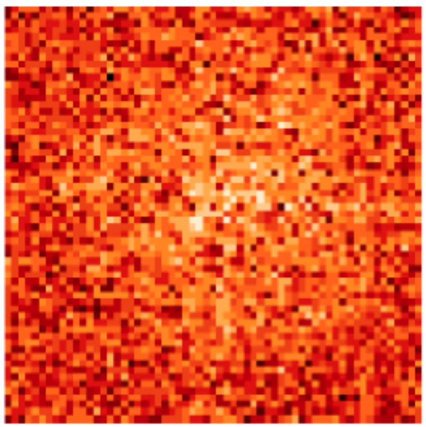


Figure 46: Coronagraphic image at 11.4μm

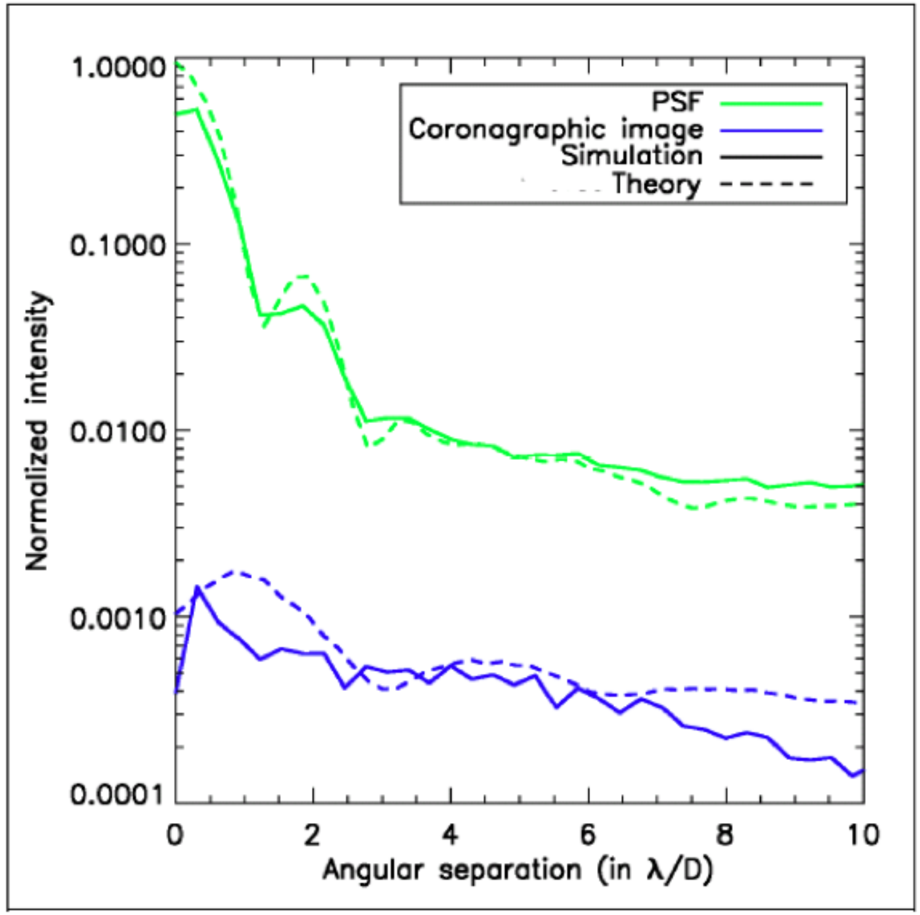
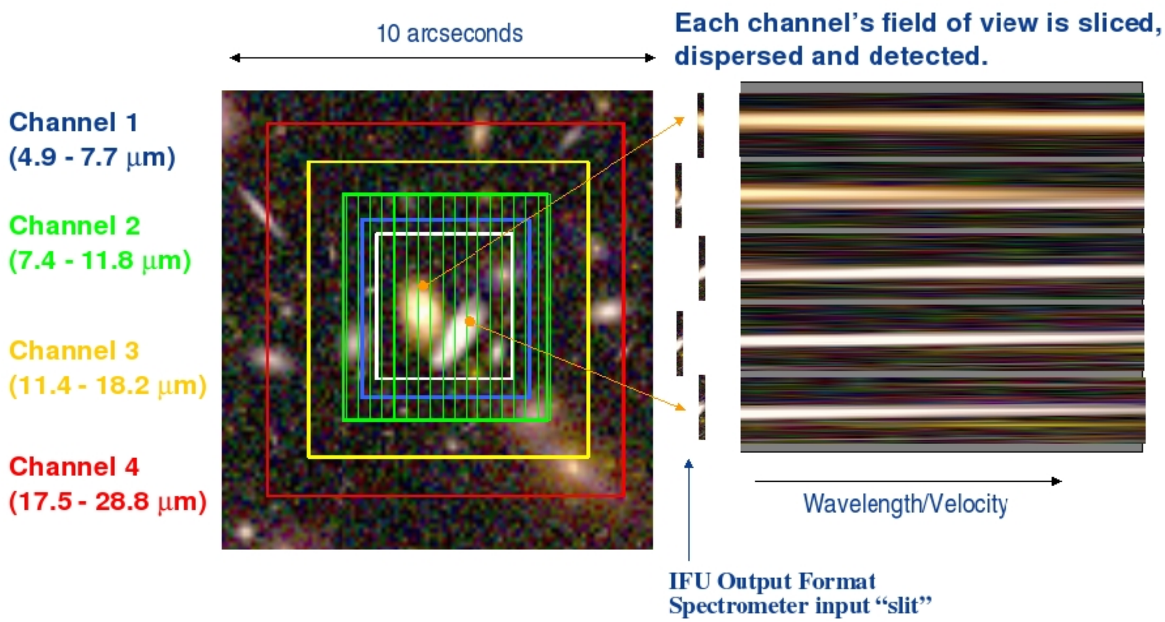


Figure 47: Normalized coronagraphic profile (blue line) and PSF (green line) compared to simulated profiles (doted lines) at 11.4μm

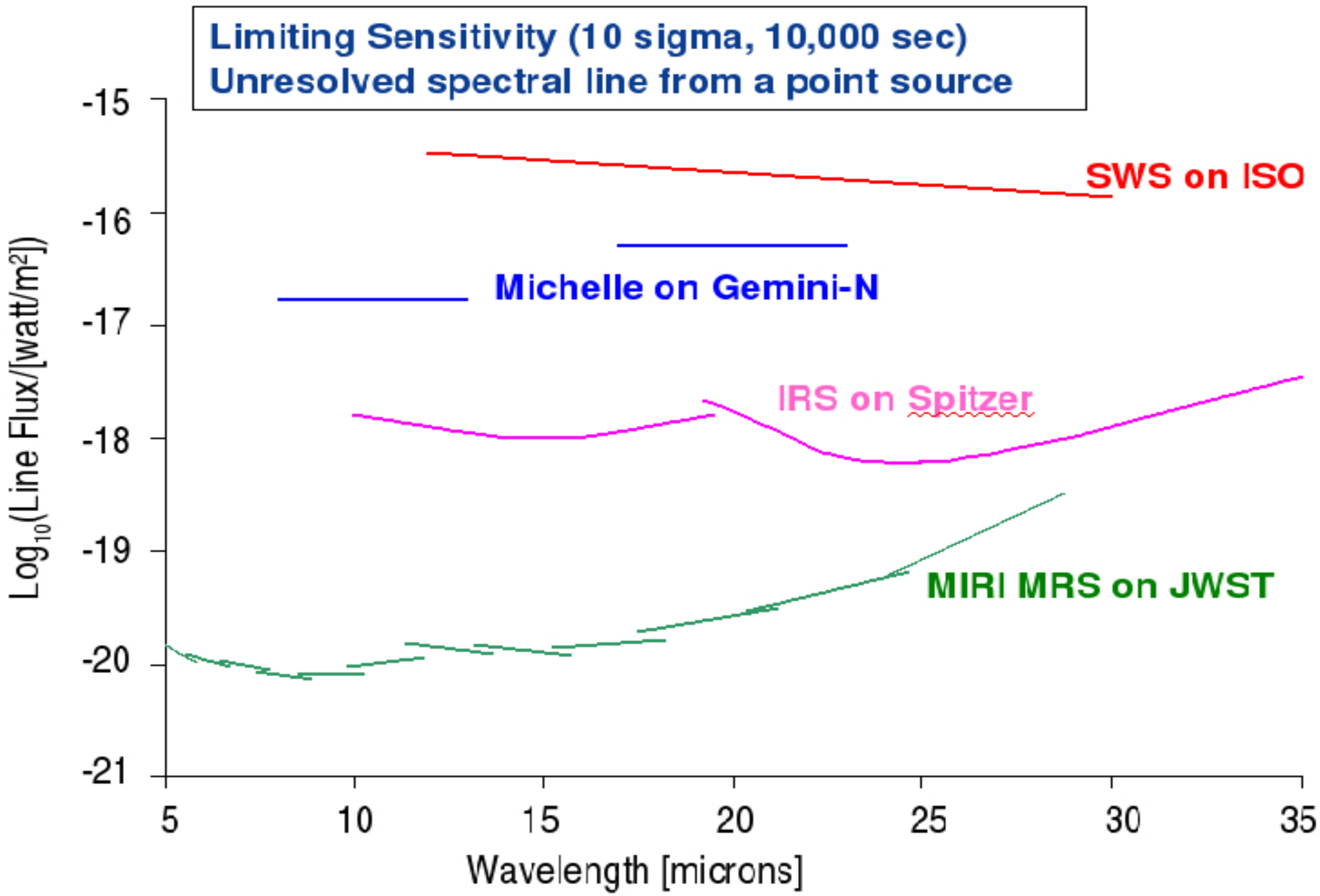
From S. Ronayette et al., MIRIM FM Optical Tests Results, MIRIM-RP-00919-CEA

MIRI IFS. CHARACTERISTICS



Channel	1	2	3	4
Number of Slices (N)	21	17	16	12
Wavelength range (µm)	5.5 – 7.7	7.7 – 11.9	11.9 – 18.3	18.3 – 28.3
Slice width Pixel size (arcsec)	0.176 0.196	0.277 0.196	0.387 0.245	0.645 0.273
FoV (arcsec)	3x 3.87	3.5x 4.42	5.2x 6.19	6.7x 7.73
Resolving Power	2400 - 3700	2400 - 3600	2400 - 3600	2000 - 2400

MIRI IFS SENSITIVITY



UK-ATC MIRI page

Science Example 1:
Spatially resolved protostellar envelopes, disks and outflows

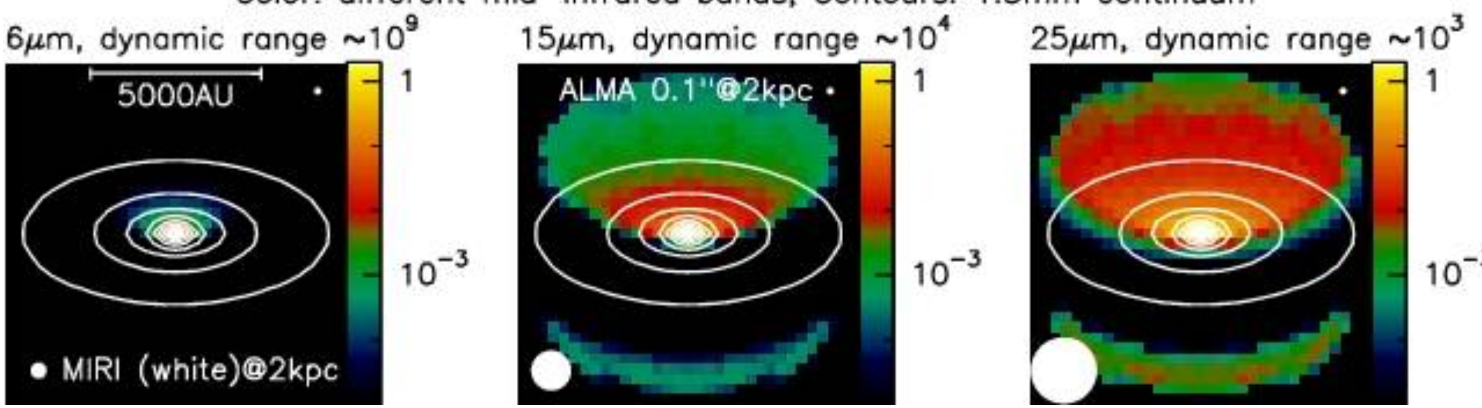
Biggest progress from ISO and Spitzer: Spatial resolution and sensitivity

		150pc	400pc	3kpc
5µm	0.19''	29AU	76AU	570AU
15µm	0.58''	87AU	232AU	1740AU
25µm	0.96''	144AU	384AU	2800AU

- Protostellar envelopes & disks have extensions between a few 100 and 1000AU (up to 10^4AU) for low- and high-mass protostars.

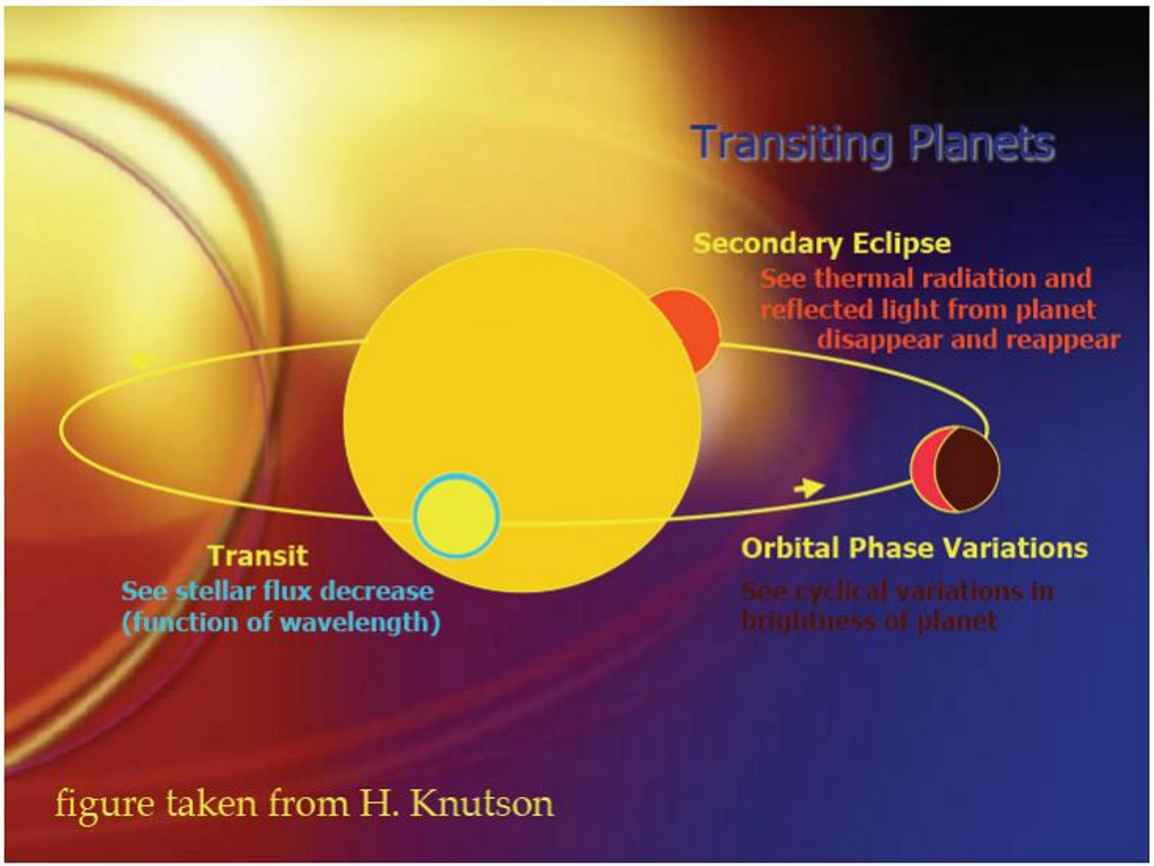
- Outflow launching area likely within inner few AU. However, launching signatures observable on much larger scales.

Color: different mid-infrared bands; Contours: 1.3mm continuum



Science Example 2: Exoplanet Characterisation and Detection

- **MIRI strengths are planet characterisation, not "planet hunting" – transit spectroscopy, and consequent requirements for stability**
  - MIRI "niche" - saturn-mass planets around young M dwarfs located in nearby moving groups and associations, a class of extrasolar planets that can only be accessed with JWST.



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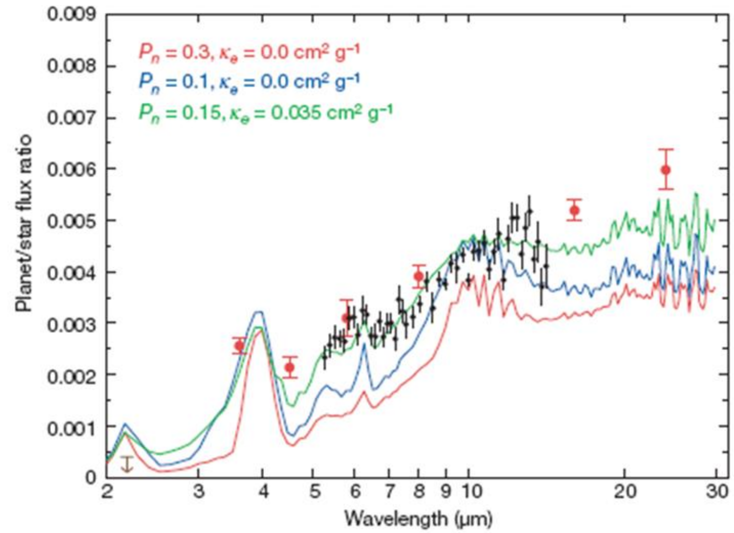

Figure 3 **Comparison of spectral observations with broadband photometry and theoretical models of the dayside atmosphere of HD 189733b.** The black points show the mean planet/star flux ratios for six second-order spectra (5–8 μm) and four first-order spectra (7.5–14 μm). The data have been binned by a factor of four after light-curve fitting (corresponding to two IRS resolution elements), and the plotted uncertainties reflect the standard error in the mean in each wavelength bin. The filled red circles show broadband measurements from ref. 5 at 3.6, 4.5, 5.8, 8.0, 16 and 24 μm (error bars on this data, s.e.). The upper limit at 2.2 μm is derived from Keck spectroscopy[16]. The red, blue and green traces are atmospheric model predictions for three values of a dayside–nightside heat redistribution parameter, P_n, and two values of the extra upper-atmosphere opacity, κ_e. The model predictions have not been scaled in any way.

From Grillmair et al., Nature 2008.

STAR & PLANET FORMATION & MIRI

ASTRONOMY FIRST HIGH SENSITIVE SUB-ARCSEC MID-IR INSTRUMENT

- Full mid-IR spectral range coverage
- Stable sub-arcsec PSF (≈GTC)
- Extreme sensitivity (x100 better than Spitzer)
- Imager + coronagraph + spectrograph capabilities combined

UNIQUE CAPABILITIES TO INVESTIGATE THE FORMATION OF STARS, PROTOPLANETARY DISKS AND EXOPLANETS

MIRI. JWST MID-INFRARED INSTRUMENT