# The JWST/MIRI Medium Resolution Spectrometer

*The Medium Resolution Spectrometer (MRS) for the JWST-MIRI instrument is designed to cover the wavelength range from 5 to 28.8 µm at a spectral resolving power of ~3000. This wavelength range is divided into four simultaneous spectral channels (each channel with its own IFU). A single MRS exposure provides a spectral sub-band, which covers one third of each channel. Two grating and dichroic wheels select these sub-bands. It covers a field of view of 4x4" up to 8x8"at a spectral resolution of 1500 to 4000. The expected on-orbit performance is presented, based on the latest commissioning plans and ground data.*

**Alvaro Labiano on behalf of the MRS team**

# James Webb Mid-IR Instrument (MIRI)

The **James Webb Space Telescope** (JWST) is the most ambitious and powerful space telescope ever built. It will fundamentally change our knowledge of the Universe. A joint NASA-ESA-CSA collaboration, it will be launched in 2021 on an Arianne 5 rocket to its operations orbit at L2.

Its scientific payload consists of four instruments: a multi-object and integral field near infrared spectrometer (NIRSpec), two wide-field near infrared cameras, NIRCam and NIRISS, the latter with slit-less spectroscopy capabilities, and a imager, coronagraph and spectrograph for the mid-infrared wavelengths (MIRI).

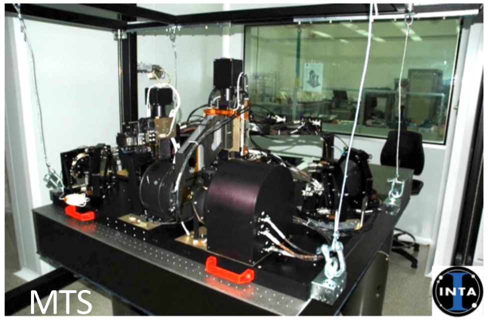
**MIRI** provides imaging, coronagraph, long-slit and integral field spectroscopic capabilities from 5 to 29 μm to the James Webb Space Telescope (JWST) in one single instrument. It was developed by a consortium of European and US institutes over a period of more than ten years.

The imaging can be performed in nine bands, with a field of view (FoV) up to 74” x 113”. The coronagraphy is performed by three four-quadrant phase masks plus a Lyot coronagraph with a FoV of up to 30”x30”. The Low Resolution Spectrometer provides both long-slit and slit-less capabilities from 5 to 14 μm. The **Medium Resolution Spectrometer** (MRS) is an integral field spectrograph that provides diffraction limited spectroscopy between 4.9 and 28.8 μm, within a FoV up to 8”x8”.

# MIRI development and testing

MIRI was developed by a consortium of 16 European and US institutes of 10 different countries, over a period of more than ten years. The Spanish contribution includes Co-I, instrument and calibration scientists, engineers, and the MIRI Telescope Simulator (MTS). The MTS is an optical bench to that reproduces the input light on MIRI coming from JWST. It was used to characterize and calibrate MIRI in flight conditions. CAB scientists have been involved in the development, testing and characterization of MIRI for the past two decades. They will play an important role during the on-orbit commissioning of the instrument, and the exploitation of MIRI guaranteed time programs including cosmological surveys, high-z and nearby Galaxies, as well as exoplanets and brown dwarfs.

MIRI's performance has been tested several times before its delivery to NASA, and after integration with the other JWST instruments. Three test campaigns were carried out at the UK Rutherford Appleton Laboratory to characterize all modes of operation, verification of photometric, spectral, and scientific performance, verification and calibration. Three campaigns were carried out after integration with the other JWST instruments, and one integrated with the optical elements of JWST, for functional and health checks, focus, alignment, simultaneous operations, as well as calibration updates.





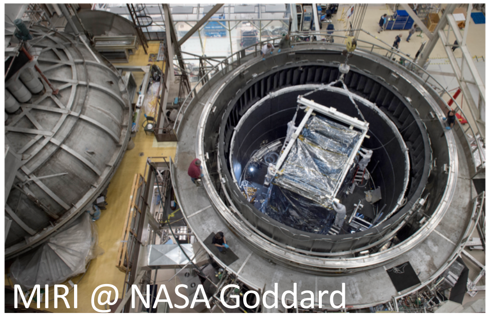


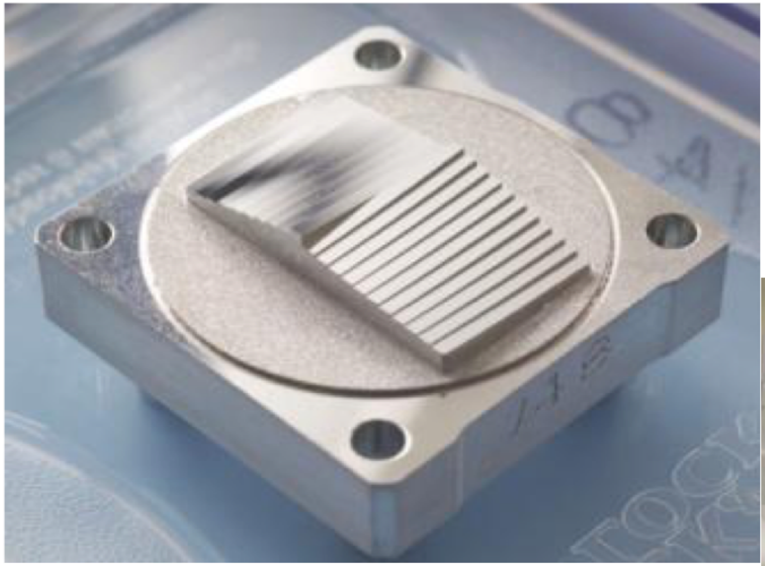




*Image credits: INTA, RAL, NASA*

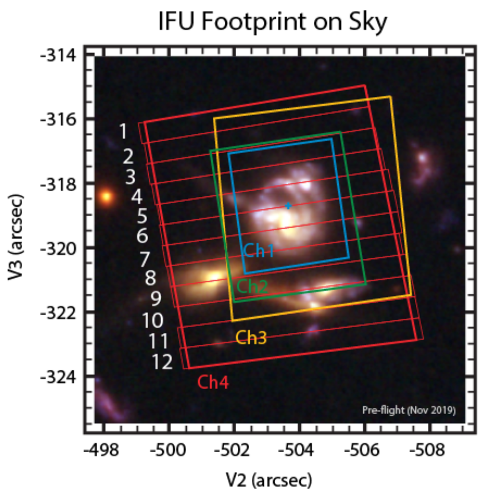
# The MIRI Medium Resolution Spectrometer

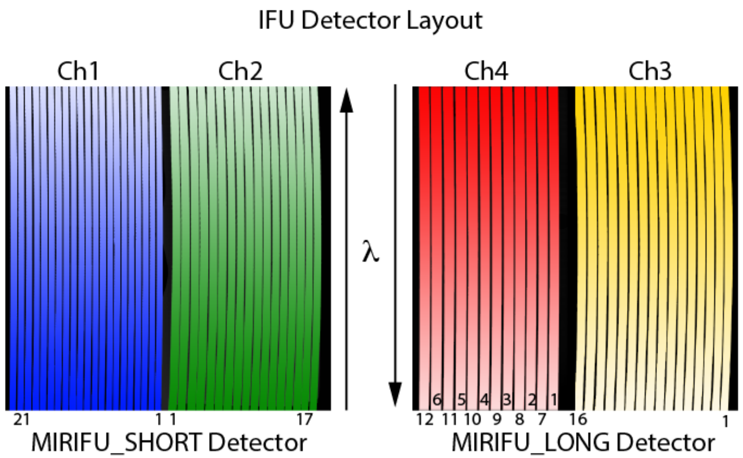
The MRS consists of two optical modules: Spectrometer Pre-Optics (SPO) and the Spectrometer Pre-Optics (SMO), plus the MRS internal calibration source. The SPO carries two dichroic and grating wheels (DGW) and a set of mirrors that split the input light of the MRS into 4 spectral channels, each one with a different optical path. The dichroics in the DGW divide also the light into three spectral sub-bands per channel. The SPO then feeds the light of the four channels into the SMO, where the MRS detectors lie. Each channel illuminates a dedicated integral field unit (IFU), which produce a 2D spectrum of the FOV.

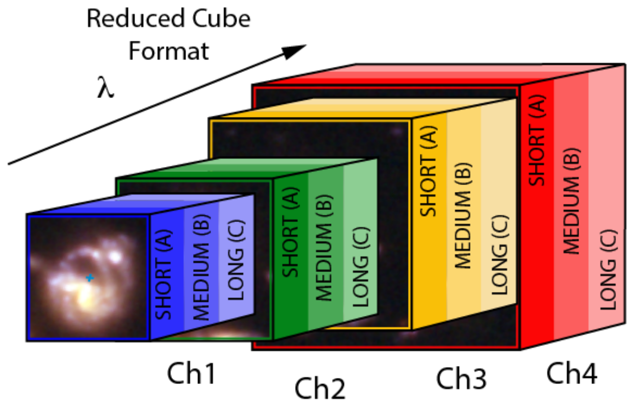


# The MIRI Medium Resolution Spectrometer

The MRS optical chain separates the light in 4 channels (1, 2, 3, 4), each with 3 bands (A,B,C) observed simultaneously in all 4 channels. To obtain a spectrum for the whole MRS wavelength range, the observer needs to stitch together 12 band spectra, obtained in three different exposures. One exposure for the 1A-2A-3A-4A bands, another one for 1B-2B-3B-4B, and a third one for 1C-2C-3C-4C. The 2D spectrum of the MRS FOV are recorded in two detectors: one for the short wavelength channels, one for the long wavelength channels. All four MRS IFUs have roughly concentric FoVs. However, each IFU divides its FoV in a different number of slices. These slices were built so their widths are similar to the expected PSF FWHM of each channel. Thus, Channel 1 IFU contains 21 slices (FOV = 3.5”x3.7”), Channel 2 (FOV = 4.1”x4.8”) has 17 slices, 16 slices for Channel 3 (FOV = 6.0”x6.2”), and 12 slices for Channel 4 (FOV = 7.0”x7.9”). All slices of a single IFU illuminate roughly one half of a detector.



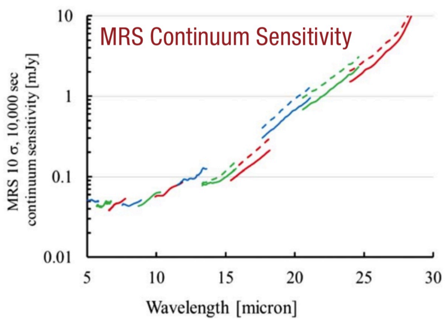



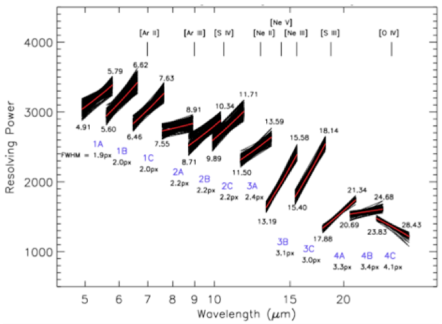

*Wells+15*

# On-orbit performance and commissioning

The final run of tests for MRS calibration and performance verification will be carried out on orbit, about 5 months after lunch, at the end of the JWST commissioning campaign. The main goal of the commissioning campaign will be to prepare the instrument for early science observations.  So, this includes verification of health and performance, (but not full calibration of all observing modes). MRS will undergo several activities combining all modes of observation and operation, to validate (and update where needed) the ground calibration results.

Based on the latest commissioning plans and ground data, the expected on-orbit performance will allow for efficient observations of unresolved, compact, and extended sources. The observer will have control over wavelength coverage in 4 channels simultaneously, several dither patterns optimized for unresolved and resolved sources, and detector read out modes to optimize noise in the data, cosmic rays, etc. The expected resolving power ranges from R ~ 3000 at 5 µm to R ~ 1500 at 28 µm. There will be also a capability of simultaneous imaging with the MIRI imager on an adjacent field to the MRS observation.



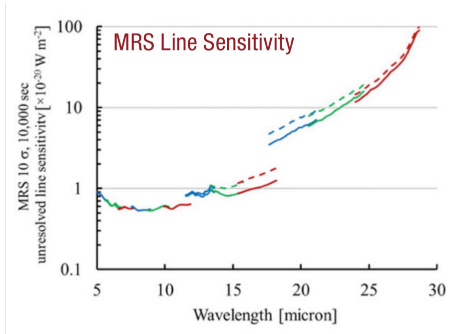






*Image credits: Wells+15, STScI, NASA*