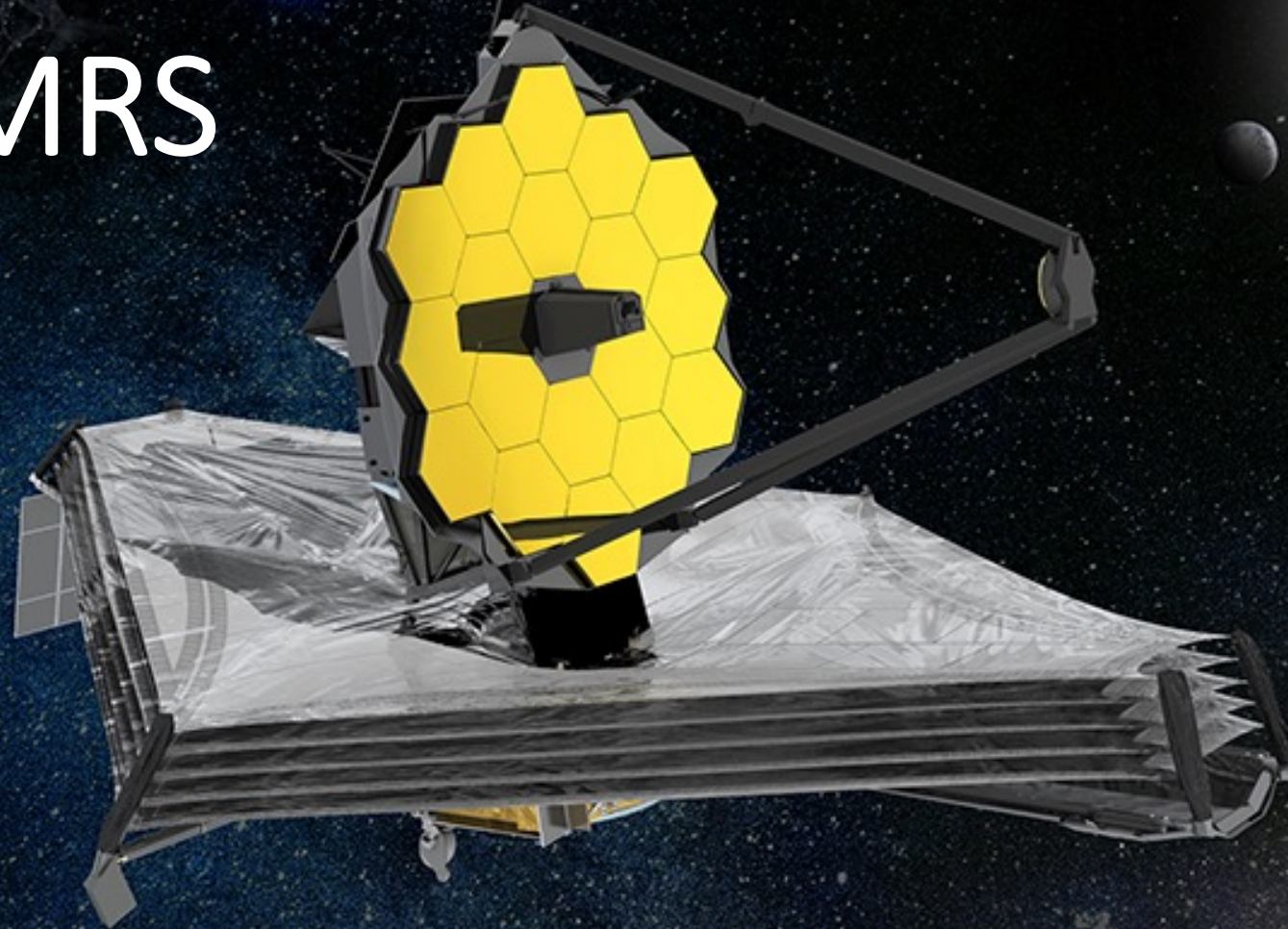


Data reduction for MIRI/MRS

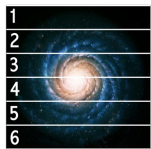


École de physique des Houches – Exo-atmosphères

Mathilde Mâlin

Integral field spectroscopy

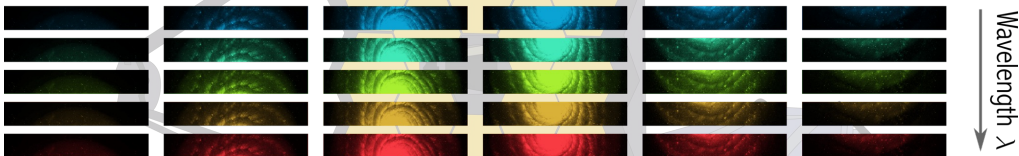
Original on-sky field of view



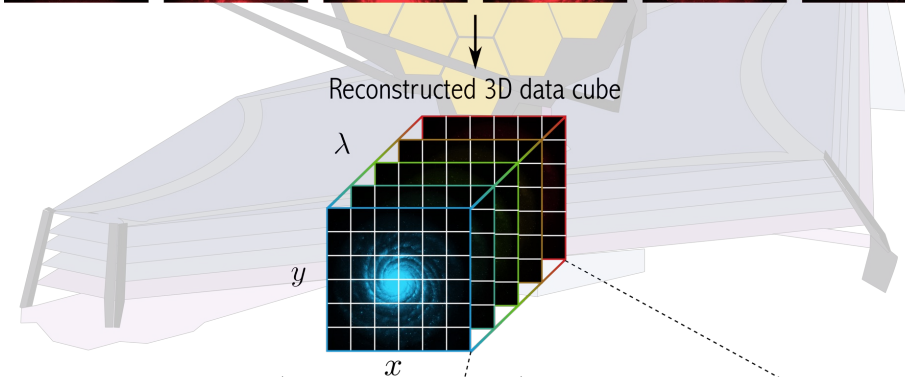
Optical slicing (mirrors) of the on-sky image



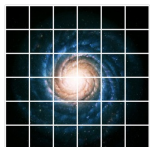
Spectral dispersion of the sliced image



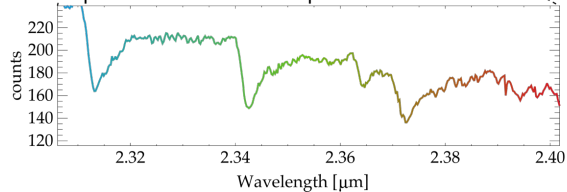
Reconstructed 3D data cube



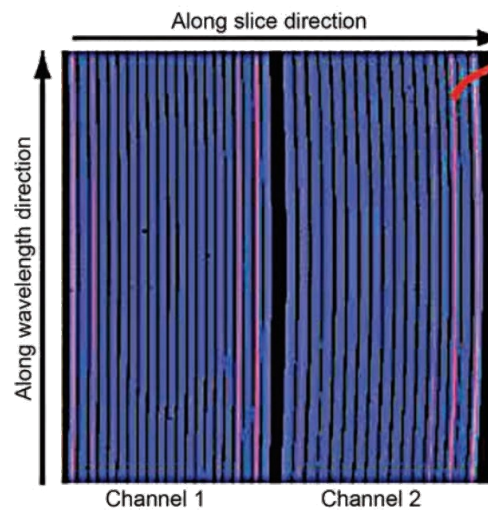
Reconstructed Image



Spectrum of each 2D spaxel

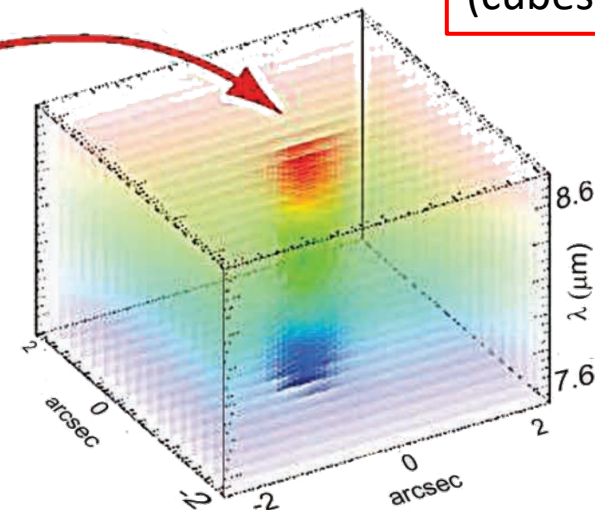


Detector



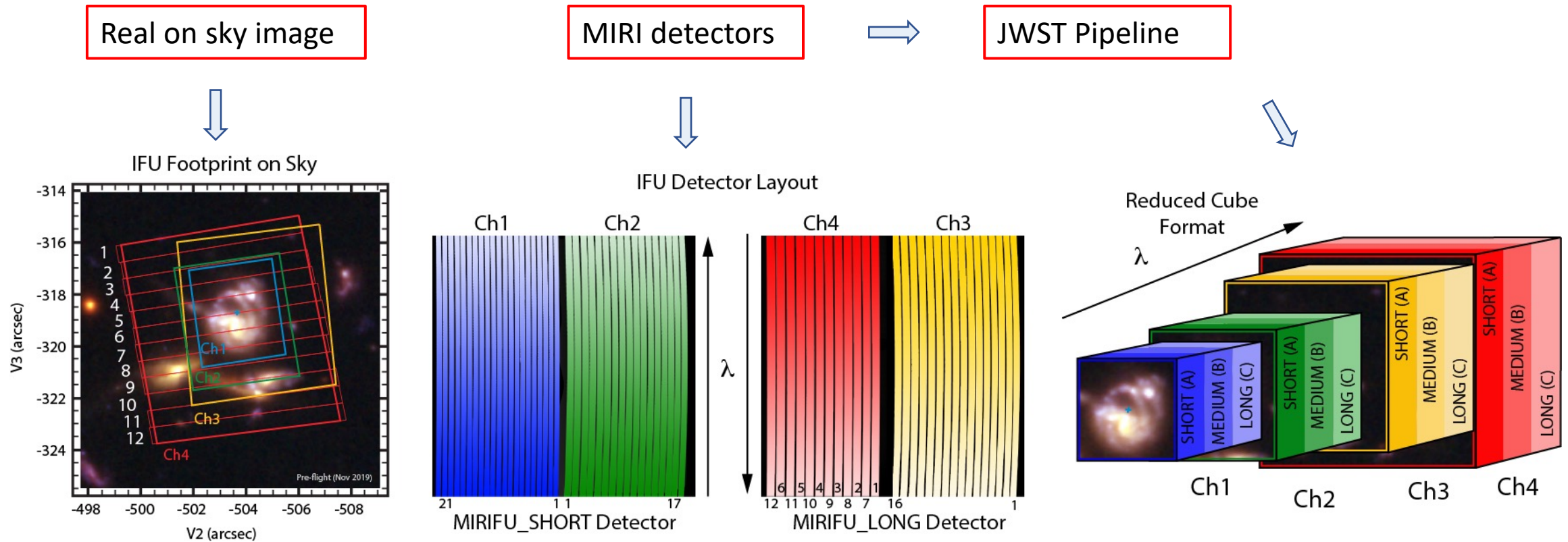
reduction pipeline

Reduced data (cubes)



Combining spectrographic and imaging capabilities

The Medium Resolution Spectrometer (MRS)

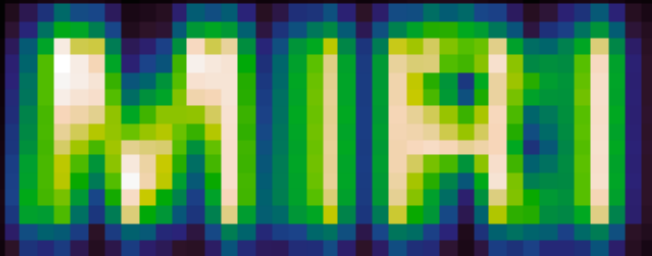


Wells et al. (2015)

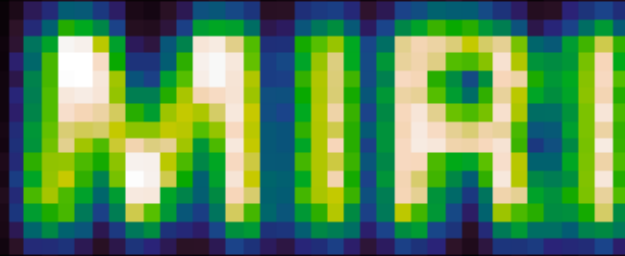
- Integral field spectroscopy from 4.9 μm and 28.3 μm
- 4 channels on 2 detectors
- 3 observations (using 3 sets of gratings : Short, Medium, Long)
- Full wavelength range = 12 cubes

Dithering

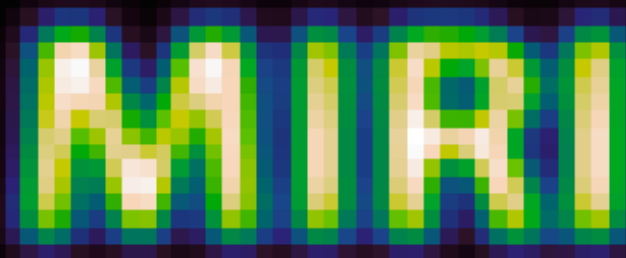
Undithered (POOR)



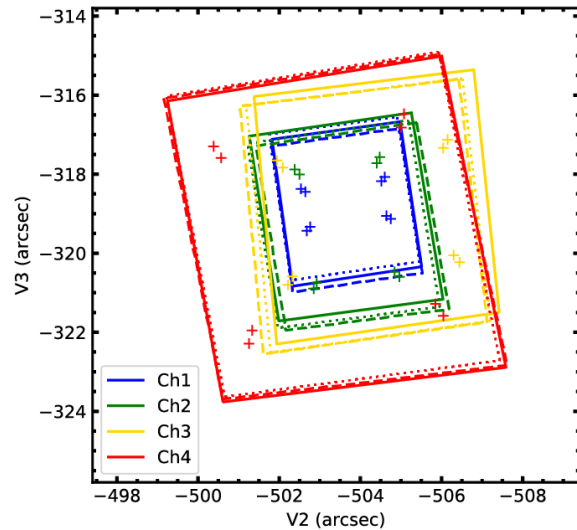
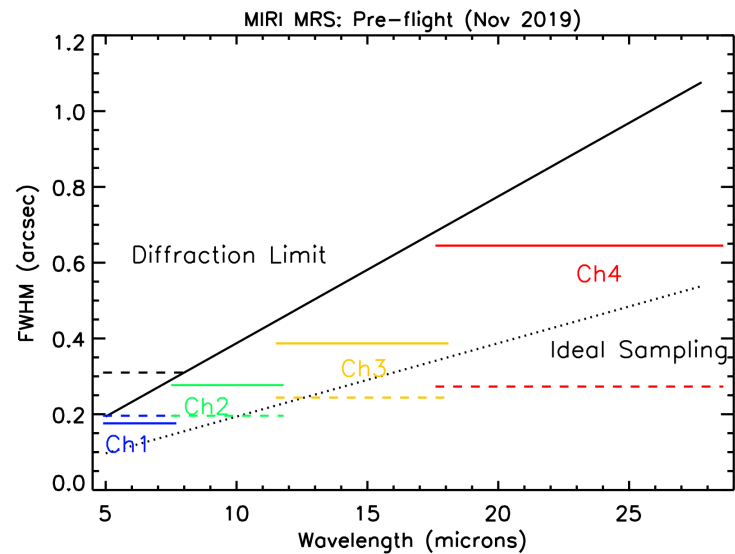
2pt dither (FAIR)



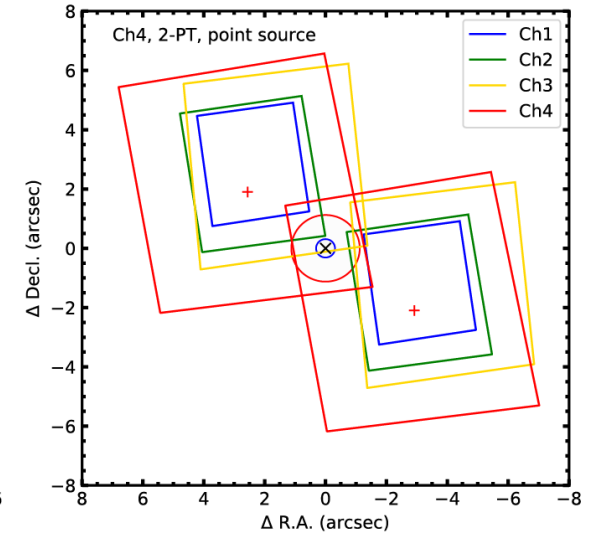
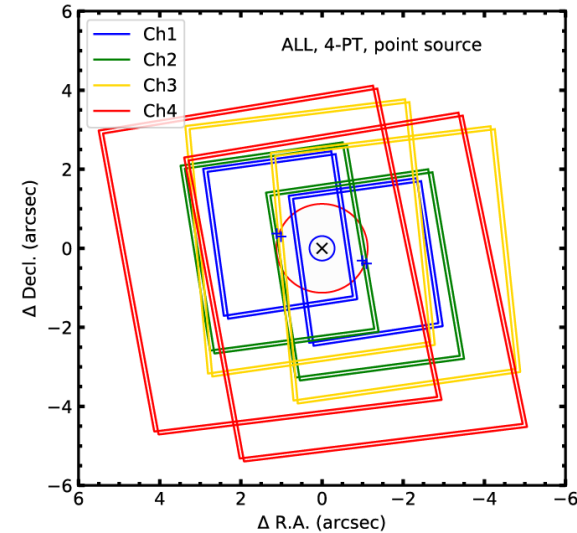
4pt dither (GOOD)



Dithering

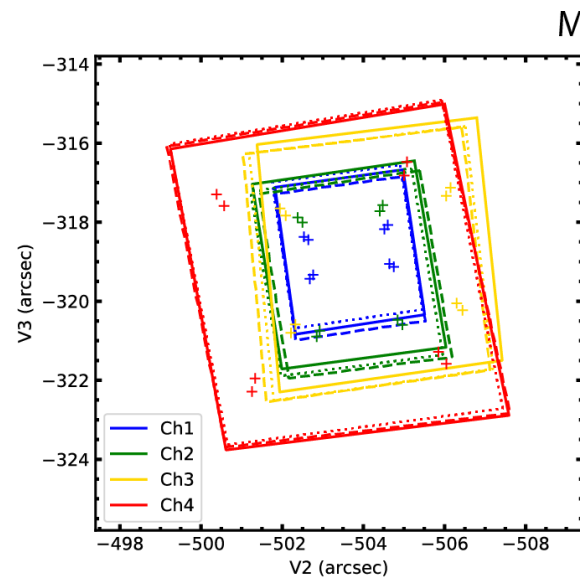
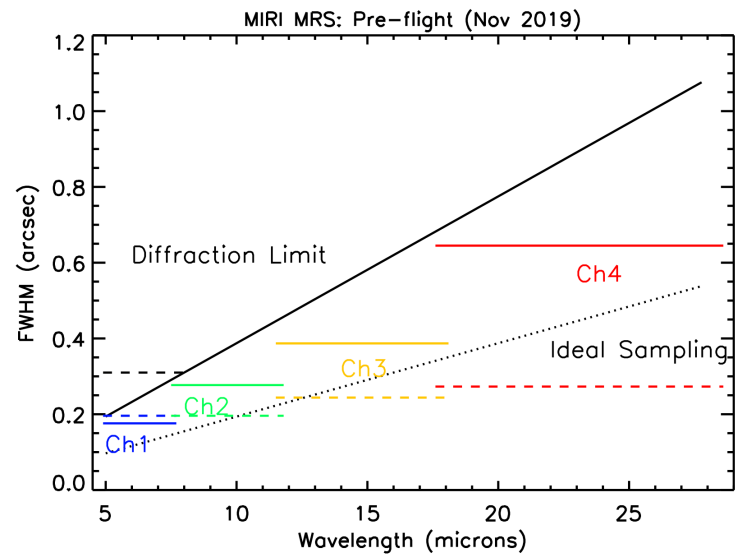


MRS Point Source Dithers: Pre-flight (Nov 2019)

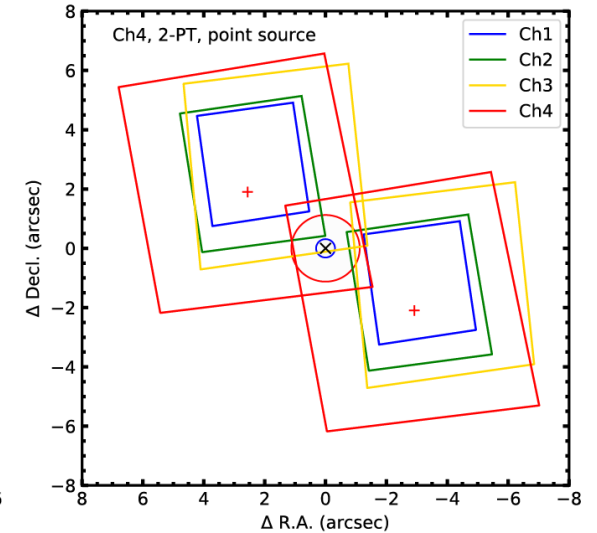
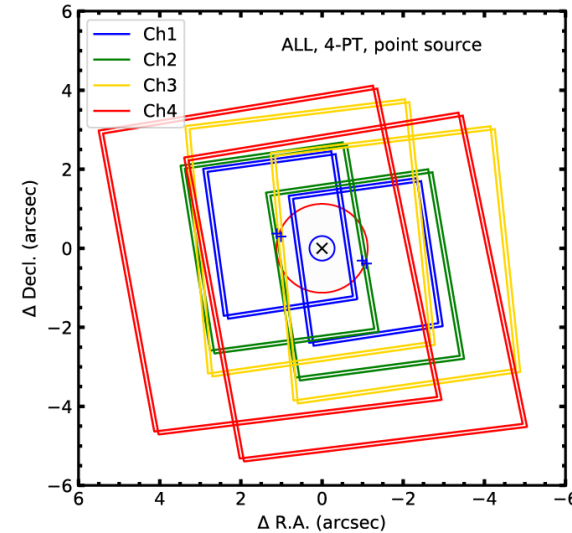


- Improves the spatial sampling
- Sequence of 4 observations with the target located at different positions in the field of view

Dithering



MRS Point Source Dithers: Pre-flight (Nov 2019)



- Improves the spatial sampling
- Sequence of 4 observations with the target located at different positions in the field of view

24 detector's images for the observation of one target with the MRS on the full wavelength range

Notebooks

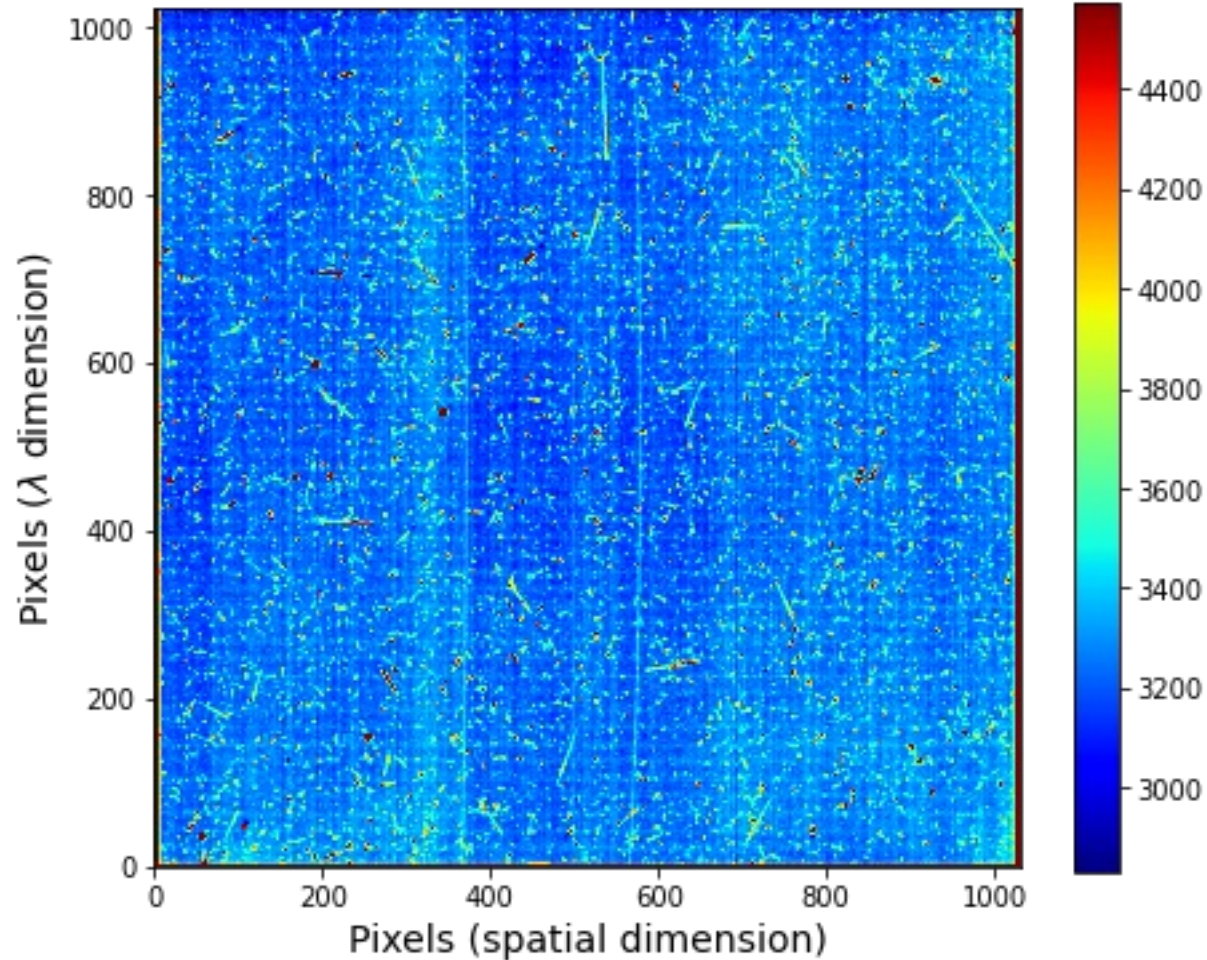
- **TP_MRS_pipeline** : learn about data reduction with ERS 1386 data of VHS 1256 b (using only one detector image)
VHS 1256 b is a <20 MJup widely separated ($\sim 8''$, $a = 150$ au), young, planetary-mass companion
- **TP_MRS_analysis** : application of molecular mapping based on simulated data with MIRISim
- Both notebooks are independent and can be done at the same time. Start with the **TP_MRS_pipeline** and since some stages of the pipeline take a bit of time, you can start **TP_MRS_analysis** while the pipeline is running.

Part 1. Data reduction

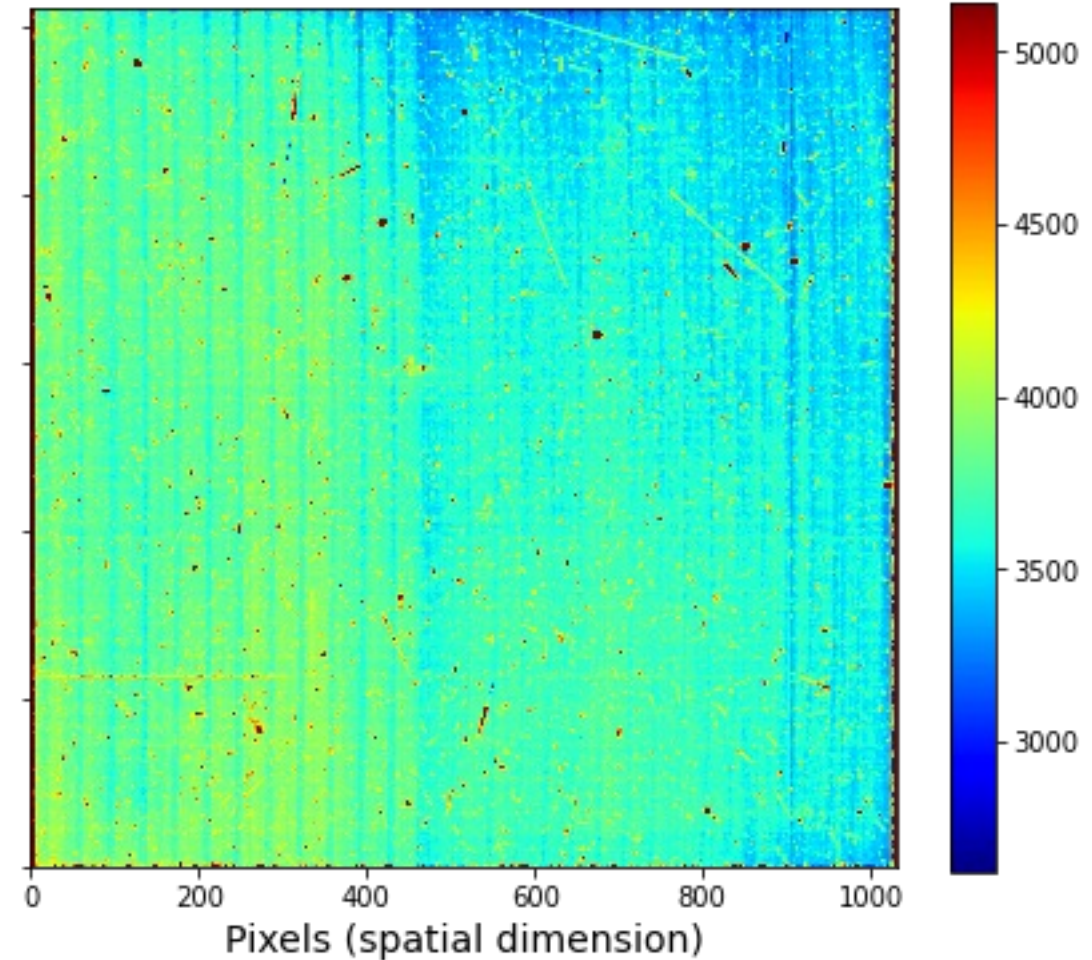
- Raw detectors images of VHS1256 b (ERS 1386)
- Stage 1 : Detector Processing
- Stage 2 : Spectroscopic Processing / Calibration
+ additional residual fringe step
- Stage 3 : Cube reconstruction

Raw detector images

Channels 1 & 2



Channels 4 & 3



Directories for part 1

- **MRS_ERS_1386** : Data from the observation 14 (VHS 1256 science exposure) : included SHORT, MEDIUM and LONG observations

`_uncal.fits` : uncalibrated data

`_rate.fits` : after stage 1

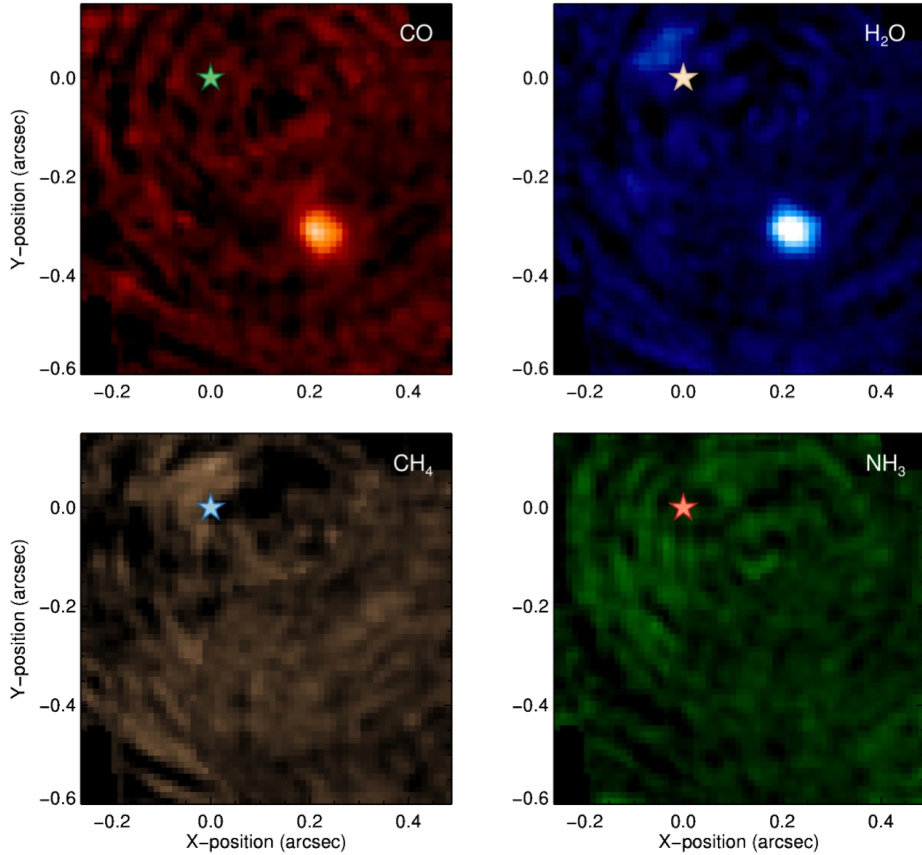
`_cal.fits` : after stage 2

`_x1d.fits` : after stage 3

`_s3d.fits` : after stage 3

- **pipeline_result** : where the results after each stage of the pipeline will be saved

Part 2. Analysis with molecular mapping

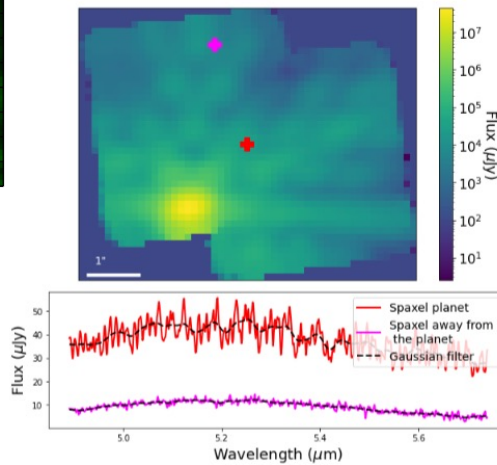


Introduce by Hoeijmakers et al. 2018 (Beta Pictoris)

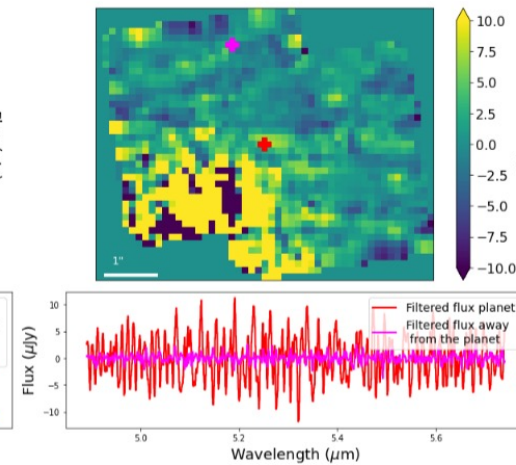
- Using IFS data
- Disentangle spectrally and spatially the star from the planet using correlation with models

Application on MRS data :

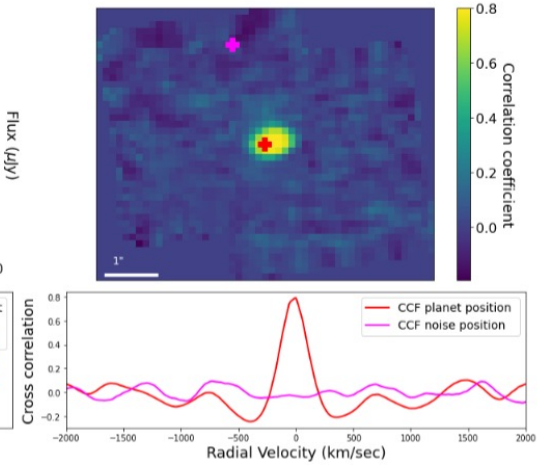
Simulation



Star subtraction



Correlation map



Part 2. Analysis with molecular mapping

Steps to run on the simulations with different planet's temperature :

- Observe the cubes
- Molecular mapping with the atmospheric model of the planet
- Molecular mapping with the molecules template spectra → identify the molecules detected in each planets.

Directories for part 2

- **simulations_data** : 5 directories with the level3 reduced data to be able to apply the molecular mapping
- **Spectra** : useful models spectra for correlation

Requirements

Use the same conda environment as last week but you need to install the jwst package

- conda activate eureka
- pip install jwst
- + indicate the path where you put the TP_MRS directory