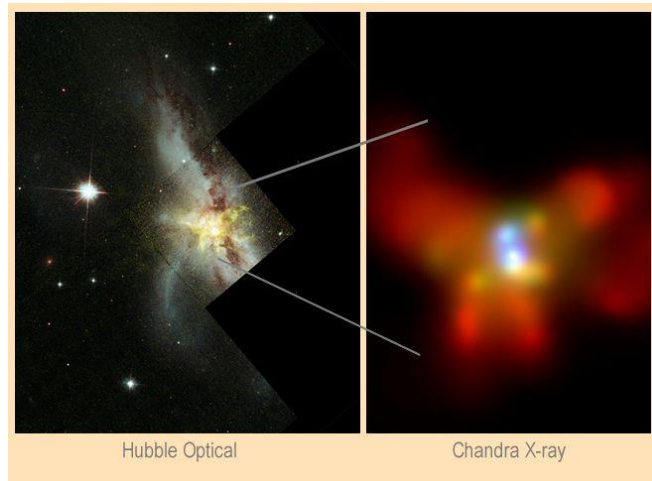


# JWST IFUs

## MIRI MRS and NIRSpec IFU for NGC 6240



### Science goals:

- A) Measure kinematics of the shock-excited extended  $H_2$  1-0 S(1)  $2.12 \mu m$  emission line.
- B) Map star formation in the 2 nuclei (point sources) using the  $7.7 \mu m$  PAH complex feature.

### NGC 6240 observational properties:

- 2 nuclei with a 1.6 arcsec separation.
- Redshift = 0.02448
- $H_2$  1-0 S(1)  $2.12 \mu m$  line:
  - $\lambda_{obs} = 2.1738 \mu m$
  - Line Flux =  $2E-13$  erg/cm<sup>2</sup>/s
  - FWHM = 400 km/s
  - Integrated continuum: 33.7 mJy at  $3.6 \mu m$
- PAH  $8 \mu m$  feature:
  - $F_v = 0.6$  Jy at  $8 \mu m$

# ETC scene construction and calculation notes

## A) H<sub>2</sub> 1-0 S(1) 2.12 $\mu$ m line measurement:

- 1) Create a new source, name it “NGC 6240 H2”
- 2) Create a new scene, name it “extended H2” and add them to “NGC 6240 H2” source
- 3) Define continuum and renormalization parameters.  
(Flat continuum in fnu, 33.7 mJy at 3.6  $\mu$ m)
- 4) Add the line of interest.  
(H2 1-0 at  $\lambda_{obs}$  = 2.1738  $\mu$ m, width 400 km/s, strength 2e13 erg/cm<sup>2</sup>/s)
- 5) Distribute line and continuum flux into ( $\sigma_x$ ,  $\sigma_y$ ) = 0.5” x 1” 2D Gaussian ellipse.
- 6) Create a NIRSpect IFU calculation.
- 7) Set the background to “medium” at RA= 16 52 58.8610 Dec = +02 24 3.55
- 8) Choose the appropriate Grating/Filter pair.
- 9) Use the “FULL” subarray and “NRSIRS2RAPID” readout pattern.
- 10) Set the aperture radius to 0.2” in the strategy panel.
- 11) We are going to use a 4-point dither so make sure there are 4 exposures per specification
- 12) Explore the exposure parameters in order to achieve a S/N > 180 at 2.5  $\mu$ m (hint set the required wavelength for S/N calculation in strategy panel).

## B) PAH 7.7 $\mu$ m feature:

- 1) Create a new scene “NGC 6240 PAH”
- 2) Create 2 new sources (point sources) representing the 2 nuclei and add them to “NGC 6240 PAH” source
- 3) Define continuum and renormalization parameters.  
(Flat continuum in fnu, 0.3 Jy at 8  $\mu$ m for each nuclei)
- 4) Separate the two sources by 1.6” (Y offset  $\pm$  0.8”)
- 5) Create a MIRI MRS calculation.
- 6) Set the background to “low” at RA= 16 52 58.8610 Dec = +02 24 3.55
- 7) Choose the appropriate channel and wavelength range.
- 8) Use the “FULL” subarray and “FAST” readout pattern.
- 9) Set a 0.5” radius aperture centered on the South nucleus.
- 10) Set the exposure parameters in order to achieve a S/N > 70 at 8  $\mu$ m.  
(hint set the required wavelength for S/N calculation in strategy panel).

# Parallel APT and ETC workflow for Target Acquisition

## A. NIRSpec IFU Target Acquisition:

1. Create a new fixed target for NGC 6240 in the APT.
2. Fill in the category (“Galaxy”) and Description (“Ultraluminous infrared galaxies”)
3. Create a new NIRSpec IFU observation.
4. Check the Visit Splitting Distance for NGC 6240.
5. Find an appropriate 2MASS star for TA.
  - i. Select the fixed target “NGC-6240” in the Form editor → Targets panel
  - ii. Click “View in Aladin” and “load DSS”
  - iii. load the 2MASS point source catalog in Aladin. (File → Load catalog → Surveys in Vizier → 2MASS-PSC → SUBMIT)
  - iv. Select a source and record its RAJ2000 DEJ2000 2MASS name and Jmag.  
Note make sure source is fainter than ~16 in Jmag  
Note TA must be within visit splitting distance for NGC 6240  
Hint can measure distances in Aladin (“dist” tool)
6. Go to ETC and calculate setup for selected 2MASS TA
  - i. Create new source “NGC 6240 TA”
  - ii. Create new scene (your 2MASS name set from Aladin)
  - iii. Flat Continuum in fnu, normalized to Johnson J vega mag set from Aladin
  - iv. Create NIRSpec target acq calculation
  - v. Set background to “medium” at 2MASS RA and Dec
  - vi. Find the appropriate exposure settings for the TA  
Hint: Acq Mode: WATA, Filter: Clear, Subarray: SUB32, Readout Pattern NRSRAPID works for an object of Jmag > 14
7. Define a new fixed target for the 2MASS star in APT
  - i. Search Databases: “2MASS Catalog”
  - ii. Search Method: “Near Position”
  - iii. Search Radius: 0.5 arcmin

## B. NIRSpec IFU APT parameters:

1. Go back to NIRSpec IFU observation for NGC 6240 (part A1)
2. Chose the 2MASS star as the Acquisition Target and fill in the Acq Subarray and
3. Enter the Dither (“4-POINT-DITHER”) and add the required gratings/filters and groups/integrations
4. Check the TA warning and consider a proper PA constraint to resolve it.
5. Based on the selected PA constraint, build a mosaic to align the observation along the vector between the two nuclei of NGC 6240.
6. Run the visibility planner to verify the schedulability of the observations.

## C. MIRI MRS APT parameters:

1. Create a MIRI MRS observation.
2. Go to the ETC and calculate setup for selected 2MASS TA (A part 5 and part 6)
  - i. Select MIRI → Target Acquisition
  - ii. Select correct source/scene (“NGC 6240 TA”)

- iii. Set the background to “low” at 2MASS RA and Dec  
Find the appropriate exposure settings for the TA Hint: Acq Mode: TA for MRS, Filter: 560W, Subarray: FULL, Readout Pattern: FAST
- iv. Set the PA requirements similarly as Part B4 and B5
- 3. Choose the *Primary Channel* to be “Channel 2” to map the 7.7  $\mu\text{m}$  PAH feature.
- 4. Select a 4-Point dither pattern optimized for extended sources, in order to optimize PSF sampling.
- 5. If the data volume constraints are not exceeded, we can choose simultaneous imaging, as this will improve astrometry.
- 6. Set exposures for each wavelength sub-band (IMAGER, MRSLONG, MRSSHORT).  
Choose the “F770W” filter for the imager.
- 7. Fill in the exposure parameters based on the ETC.
- 8. Build a mosaic to cover the 2 nuclei.
- 9. Use Aladin to define an *efficient* off-source location for a separate dedicated background exposure.
  - i. Right click “Copy the reticle location in the clipboard”
- 10. Create a new background fixed target based on the defined location.
  - i. Name: “NGC-6240-BCKGRD|
  - ii. Category: “Calibration”
  - iii. Description: “Telescope/sky background”
- 11. In the fixed target “NGC-6240” tick the box for a background observation and select “NGC-6240-BCKGRD”
- 12. Create a separate dedicated background exposure.
  - i. MIRI MRS
  - ii. No TA
  - iii. Primary Channel: Channel 2
  - iv. 4-point dither
  - v. Same exposure parameters as science observation
- 13. Set a special timing requirement for sequenced and non-interruptible for the two MIRI MRS observation (science and background).
- 14. Run the visibility planner to verify the schedulability of the observations.

# **Hints**

These are intended as possible solutions to the above problems, the ones that were found by the authors. Please use this as a guide to the correct procedure but not necessarily the only correct path to take.

## **ETC**

### **Hints for part A**

Grating/Filter:

- G235M/F170LP

Detector setup:

- Groups = 9
- integrations = 1
- exposures = 4
- SNR @ 2.5um = 185.29
- Total exposure time = 585.56 s (9 minutes 44 seconds)

### **Hints for part B**

Channel:

- Channel 2 (MRS\_Short)

Wavelength Range:

- Short (A)

Detector setup:

- Groups = 5
- Integrations = 1
- Exposures = 4
- SNR @ 8um = 74.41
- Total exposure time = 55.50 s

# **APT**

## **Hints for part A**

5iv:

- $\text{RAJ2000} = 253.245390 = 16\ 52\ 58.8936$
- $\text{DEJ2000} = +02.413331 = +02\ 24\ 47.99$
- $2\text{MASS} = 16525889+0224479$
- $\text{Jmag} = 15.897$

6vi:

- Acq Mode: WATA
- Filter: Clear
- Subarray: SUB32
- Readout pattern: NRSRAPID
- Groups = 3
- Integrations = 1
- Exposures = 1
- SNR @ 2.36  $\mu\text{m}$  = 49.37
- Total exposure time = 0.08 s

## **Hints for part B**

4:

- Warning reads that PA must be between 230.063 and 48.900 V3PA
- Set V3PA between 235 and 45

5:

- 1 row, 2 columns

## **Hints for part C**

2iii:

- Groups = 4
- Integrations = 1
- Exposures = 1
- Total exposure time = 11.10 s

2iv

- Warning reads that PA must be between 171.684 to 20.567
- Set V3PA to 175 to 20

9i

- Example: 16:52:58.85 +02:24:04.9