STScI | SPACE TELESCOPE SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

Wide Field Slitless Spectroscopy Level 2

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JWST Master Class

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Outline

- Overview of WFSS on NIRISS and NIRCam
- 3 proposed science cases
- Simulate the scene with the ETC
- Prepare the observations in APT

Overview

Wide Field Slitless Spectroscopy allows us to obtain spectra for all the objects in the field of view.

Specification	NIRISS	NIRCam
Field of view	2.2 x 2.2 arcmin	2 detectors of 2.15 x 2.15 arcmin
Wavelength range covered	0.8 to 2.2 µm	2.4 to 5 µm
List of filters	F090W, F115W, F140M, F150W, F158M, F200W	F250M, F277W, F300M, F322W2, F335M, F356W, F360M, F410M, F430M, F444W, F460M, F480M
Resolution	R = 150	R = 1120 - 1680

Science cases

Science cases

1. Detect the Lyα hydrogen line at redshift ~9.
   - Additional exercise: detect optical emission lines for the same source.

2. Measure the properties of quiescent and star-forming galaxies at redshift 3 to 4 in a random field.

3. Detect the Paα hydrogen line at redshift ~1 in an extended source.
   - Additional exercise: detect other emission lines for the same source.

Make an ETC workbook

ETC

https://jwst.etc.stsci.edu/

Read the Readme!!

Also: Help in JDox:

Exposure Time Calculator Overview

ETC for science case 1

Create the scene by

- Clicking on “Scenes and Sources”;
- Adding sources using the New button;
- Set the characteristics of the source in the “Source Editor”;
  - The goal is to observe a **redshift 9.2**,
  - **point source**,
  - using an **SED from a file** (hint: “Upload spectra”),
  - normalizing it to a certain **flux density** (e.g. 25.5 mag in WFC3/F160W),
  - and **adding** a strong Lyα **emission line** (e.g. 3E-17 erg/s/cm^2, width <=200 km/s).
- Add the source to the scene using the Add Source button;
- Repeat if you wish to add more sources.

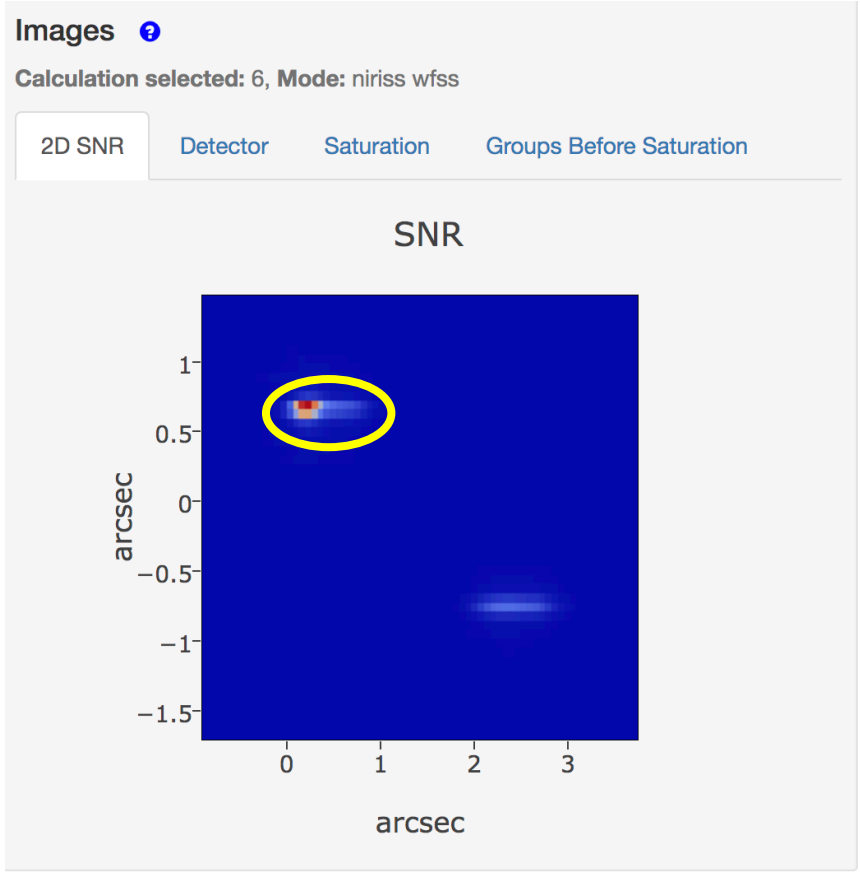
ETC for science case 1

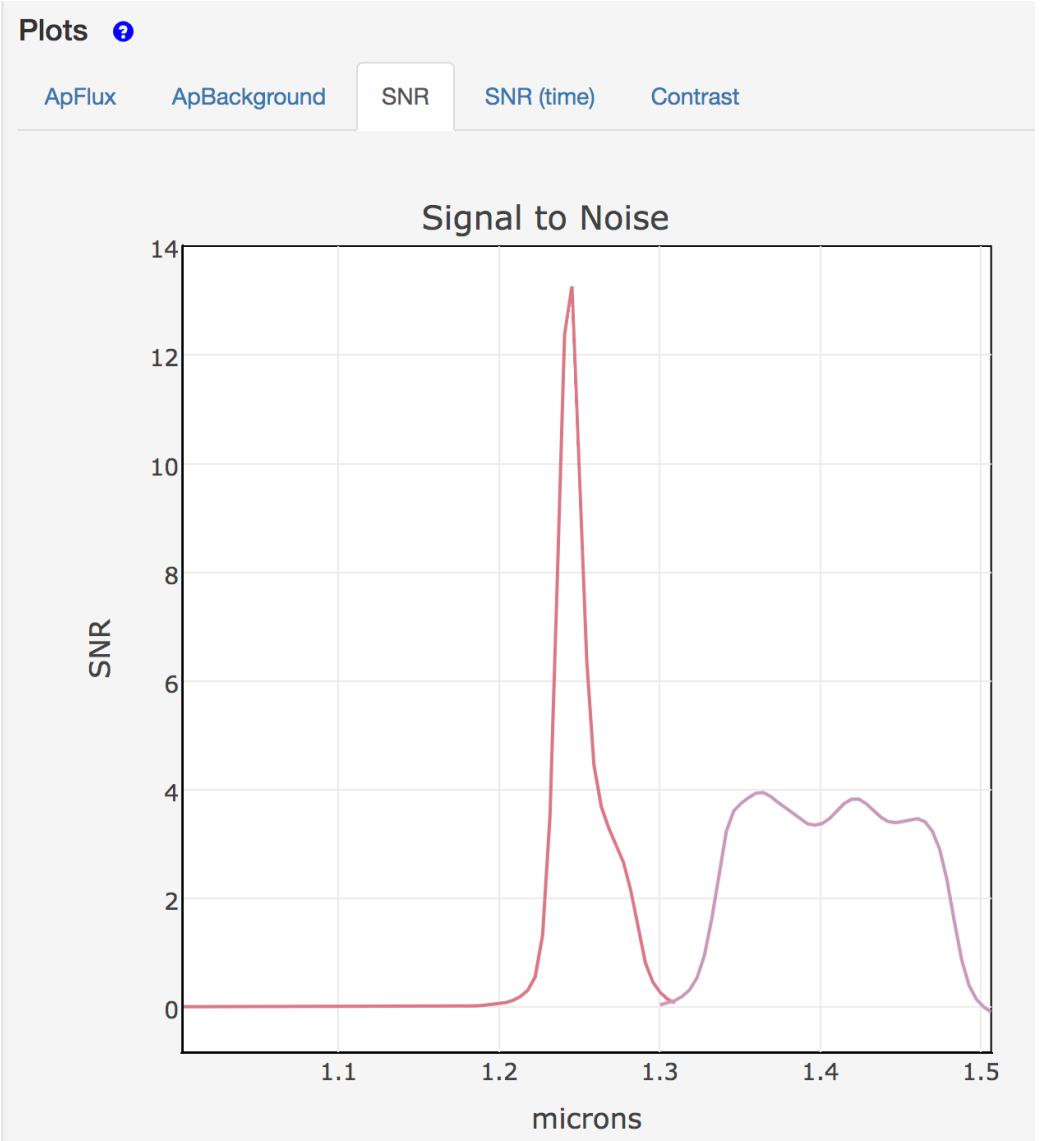
Now choose your instrument: WFSS NIRISS or NIRCam?

- Click on “Calculations” and choose the instrument and mode you want.
  - The calculation will start automatically.
- From the “Edit” menu above, you can delete or copy a selected calculation.
- On the right, you can change the characteristics of the observation:
  - Choose the **filter** where you expect Lyα to fall,
  - set a **background** of your choice,
  - adapt the **exposure time** to achieve the signal to noise ratio you desire (e.g. S/N~10 on Lyα),
    - account for the dithering pattern you wish to use (here),
  - center the **aperture** on the source.
- Do not forget to include some imaging along with WFSS!

ETC for science case 1

Possible output

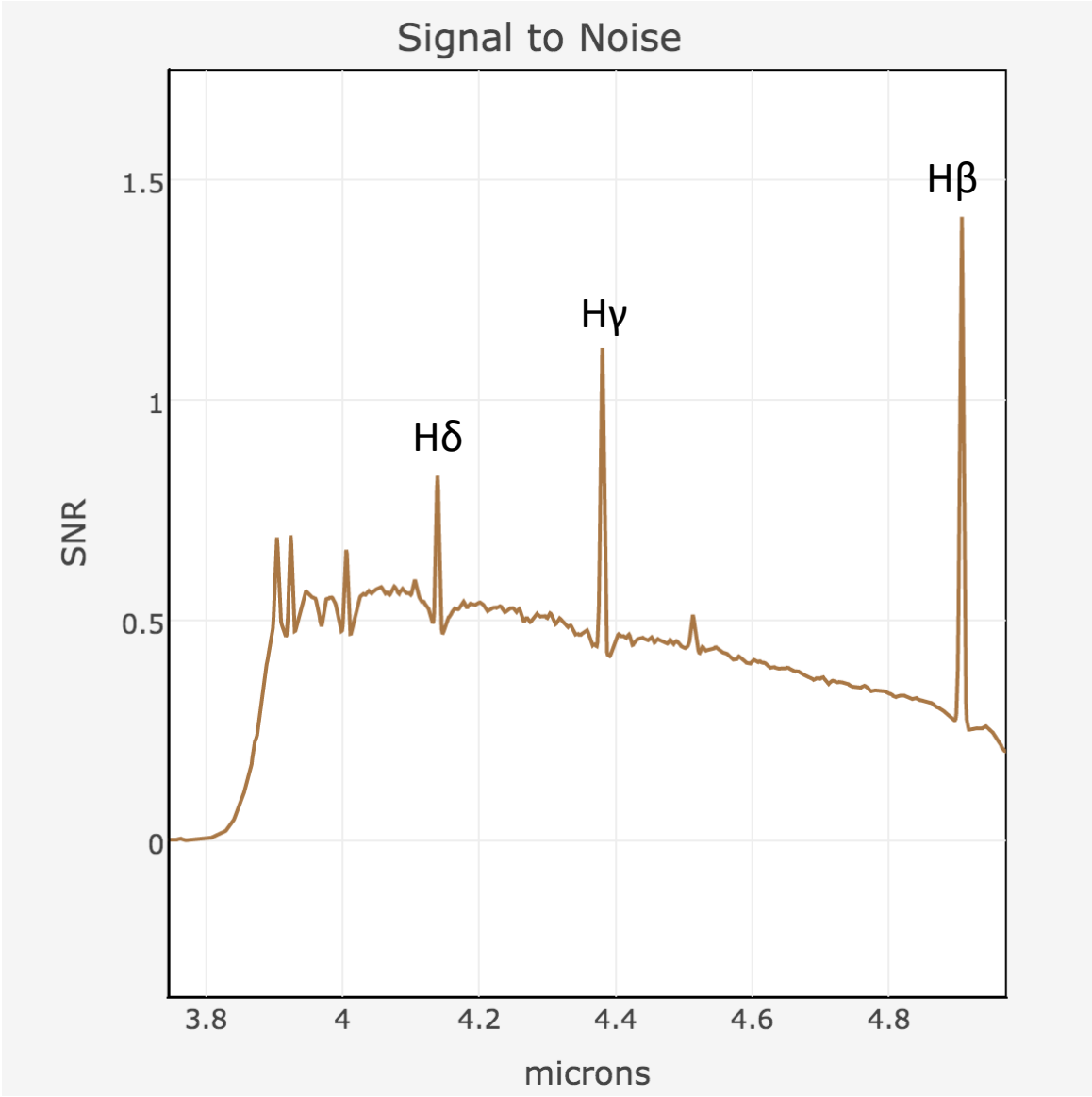




ETC for science case 1

Additional exercise

with NIRCam



ETC for science case 2

Create the scene by

- Clicking on “Scenes and Sources”;
- Adding sources using the New button;
- Set the characteristics of the sources in the “Source Editor”;
  - The goal is to observe various **redshift 3 to 4** galaxies,
  - **point sources**,
  - using the SEDs from the available **extragalactic spectra**,
  - normalizing them to a certain **flux density** (e.g. 24.5 mag in WFC3/F160W),
  - and to **offset** the sources to cover the entire field of view.
- Add the source to the scene using the Add Source button.

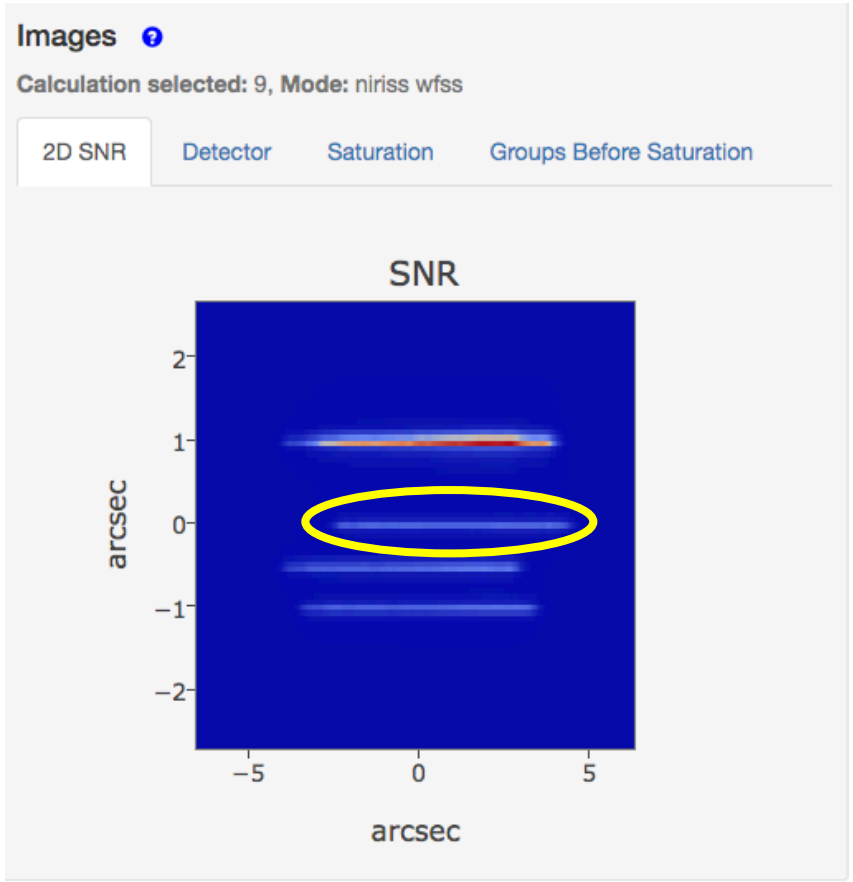
ETC for science case 2

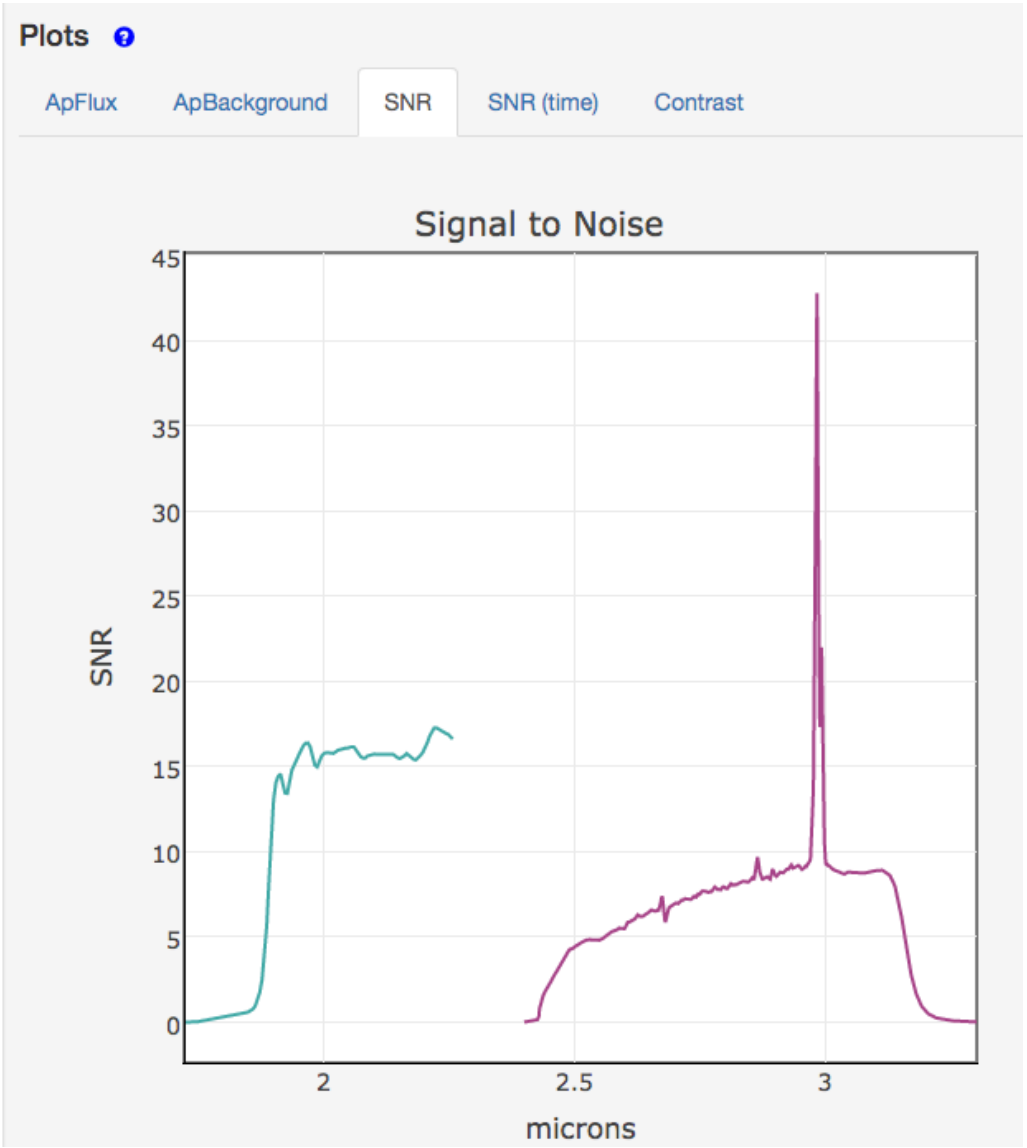
Now choose your instrument: NIRISS or NIRCam?

- Click on “Calculations” and choose the instrument and mode you want.
  - The calculation will start automatically.
- From the “Edit” menu above, you can delete or copy a selected calculation.
- On the right, you can change the characteristics of the observation:
  - Choose the **filter** where you expect some features to fall (e.g., D4000 A break, [OIII] and Hα lines),
  - set a **background** of your choice,
  - adapt the **exposure time** to achieve the signal to noise ratio you desire (e.g. S/N~15 or larger in the continuum),
  - center the **aperture** on the source and choose noiseless **sky background**.

ETC for science case 2

Possible output





ETC for science case 2

Things to think about:

- Overlapping sources. There could be contamination in the S/N calculations.
- Try with a different sky background, but careful where the sky is sampled.
- Remember that you need imaging too.

ETC for science case 3

Create the scene by

- Clicking on “Scenes and Sources”;
- Adding sources using the New button;
- Set the characteristics of the sources in the “Source Editor”;
  - The goal is to observe two **redshift 0.8**,
  - **extended sources with multiple components** (e.g. disk, bulge, clump),
  - setting the SEDs using the **available galaxy spectra** or a **flat continuum**,
  - normalizing them to a certain **flux density** (e.g. down to 23 mag in WFC3/F160W),
  - adding the Paα and a bonus Hα **emission lines**.
- Add the source to the scene using the Add Source button.

ETC for science case 3

Now choose your instrument: NIRISS or NIRCam?

- Click on “Calculations” and choose the instrument and mode you want.
  - The calculation will start automatically.
- From the “Edit” menu above, you can delete or copy a selected calculation.
- On the right, you can change the characteristics of the observation:
  - Choose the **filter** where you expect Paα to fall,
  - set a **background** of your choice,
  - adapt the **exposure time** to achieve the signal to noise ratio you desire (e.g. S/N~10 to 15 in the emission line),
  - center the **aperture** on the source and choose the **sky-background** region.

ETC for science case 3

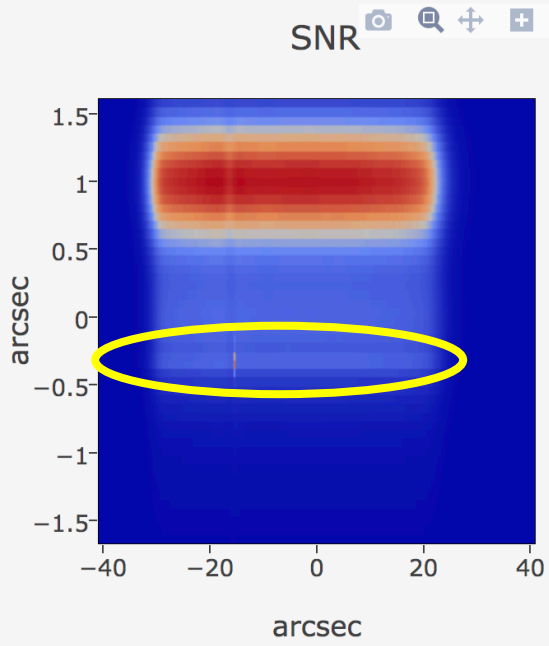
Possible output

Images

Calculation selected: 8, **Mode:** nircam wfgrism

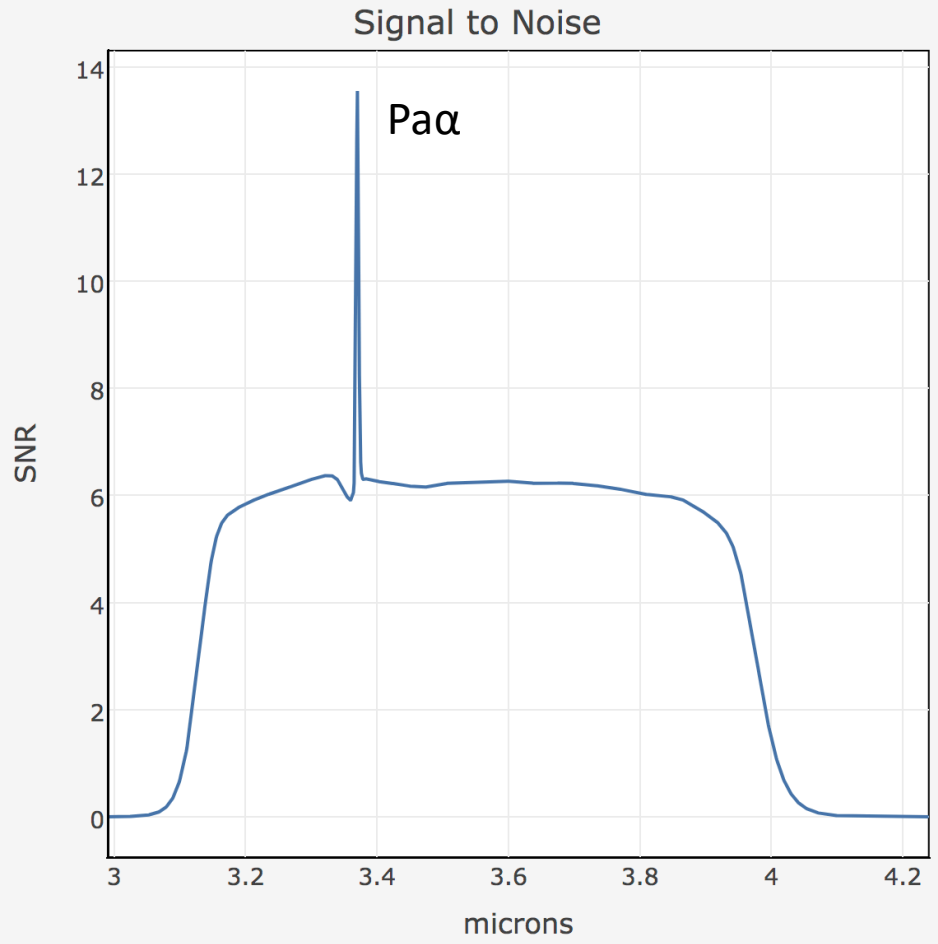
Note that in the NIRCam Wide Field Grism mode, the scene is correctly dispersed in the row or column direction. For GRISMC, the dispersed 2D plots are rotated 90 deg clockwise.

2D SNR | Detector | Saturation | Groups Before Saturation



Plots

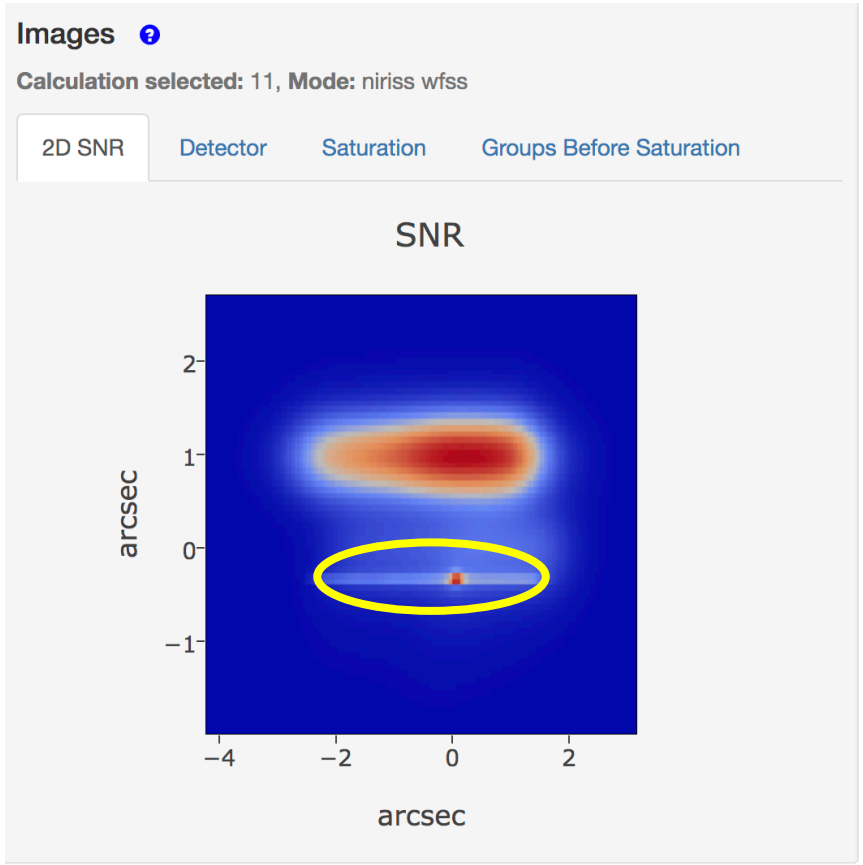
ApFlux | ApBackground | SNR | SNR (time) | Contrast

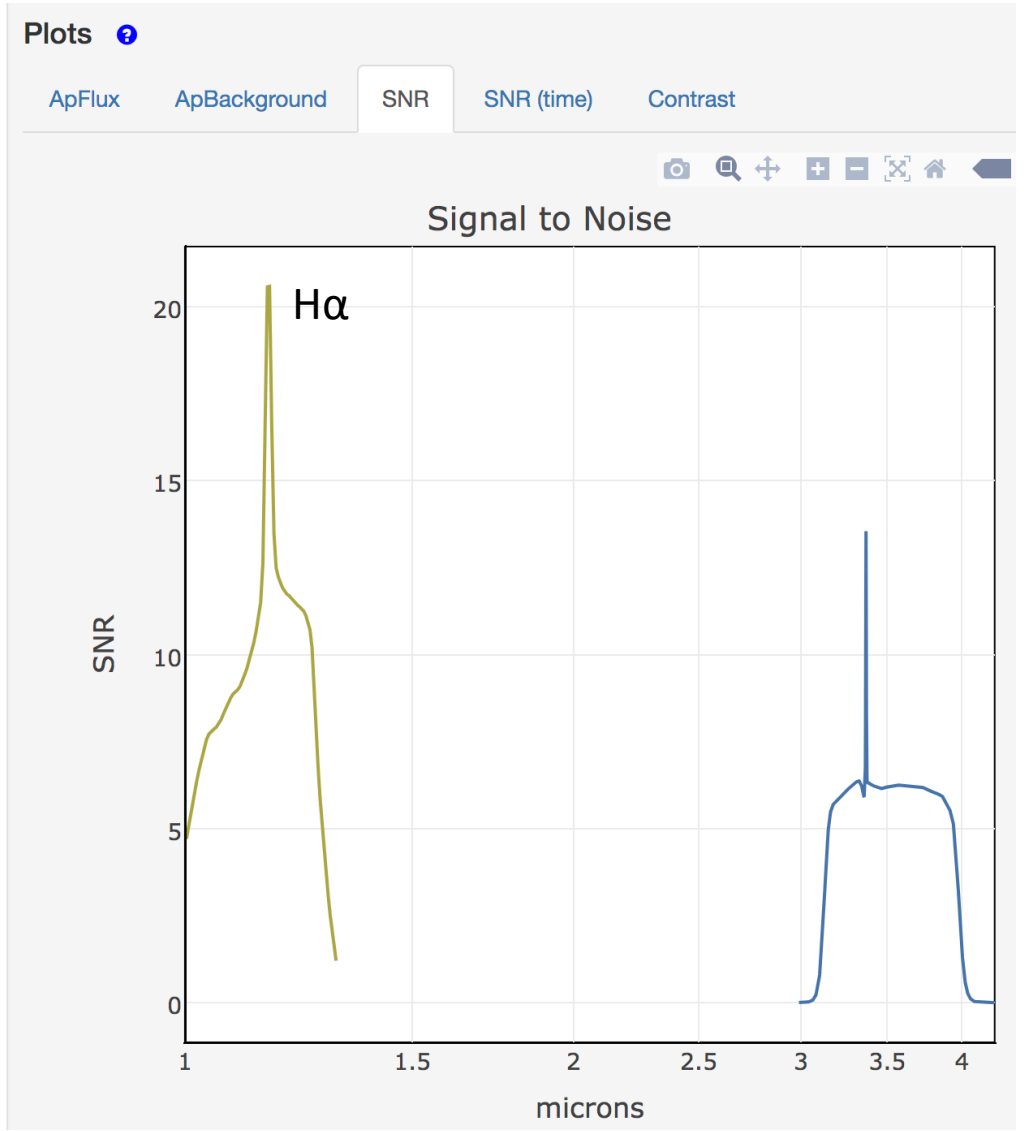


ETC for science case 3

Additional exercise

with NIRISS





Prepare the observations in APT

APT

JWST Astronomers Proposal Tool Overview

APT for the different science cases

Proposal information:

- general info that can be filled later.

Targets:

- “Fixed targets”
  - Science case 1: RA 11 49 33.5840 ; Dec +22 24 45.78
  - Science case 2: RA 03 32 18.8304 ; Dec -27 51 35.46
  - Science case 3: RA 03 32 22.5900 ; Dec -27 52 31.99

Observations:

- Create ”Observation folder” and 

observations.
- Go back to the ETC and copy all the relevant information.
  - When you select WFSS, you can add the direct images together, NOT as separate observations.

Astronomer's Proposal Tools Version 27.3 - JWST Draft Proposal (science_case_1.aptx)

Form Editor | Spreadsheet Editor | Orbit Planner | Visit Planner | Timeline | View in Aladin | BOT | Target Confirmation | PDF Preview | Submission | Errors and Warnings | Run All Tools | Stop

New Document | New | What's New | Roadmap | Feedback

- JWST Draft Proposal (science_case_1.a...
  - Proposal Information
  - Targets
  - Observations
    - Primary
      - Observation 2
    - Bonus
      - Observation 3
  - Observation Links
- JWST Draft Proposal (science_case_2.aptx)
- JWST Draft Proposal (science_case_3.aptx)

Observation 2 of JWST Draft Proposal (science_case_1.aptx)

	Science	Total Charged
Duration (secs)	44672	57242
Data Volume	9710 MB	

NIRISS Wide Field Slitless Spectroscopy | Mosaic Properties | Special Requirements | Comments

Science Observation

Dither: Image Dithers = 4, Pattern Size = MEDIUM

Sequences

#	Grism	Filter	Readout Pattern	Groups/Int	Integrations/Exp	ETC Wkbk.Calc ID	ETC
1	BOTH	F115W	NIS	20	3	26231	
2	BOTH	F140M	NIS	20	3	26231	

Add | Duplicate | Insert Above | Remove

Direct Image Exposure Parameters

Direct Images

#	Readout Pattern	Groups/Int	Integrations/Exp	ETC Wkbk.Calc ID	ETC
1	NIS	10	1	26231	
2	NIS	10	1	26231	

Use NIRISS Imaging mode in the JWST ETC to calculate exposure parameters for Direct Imaging.

All Exposures Display

Exposures

#	Exposure Type	Filter	Grism	Readout Pattern	Groups/Int	Integrations/Exp	Total Dithers	Total Integratio...	Total Exposure ...	ETC Wkbk.Calc ID
1	DIRECT	F115W		NIS	10	1	1	1	440.208	26231
1	GRISM	F115W	GR150R	NIS	20	3	4	12	10436.14	26231
1	DIRECT	F115W		NIS	10	1	2	2	880.415	26231
1	GRISM	F115W	GR150C	NIS	20	3	4	12	10436.14	26231
1	DIRECT	F115W		NIS	10	1	1	1	440.208	26231
2	DIRECT	F140M		NIS	10	1	1	1	440.208	26231

Edit Primary | New | Edit Visit 2:1

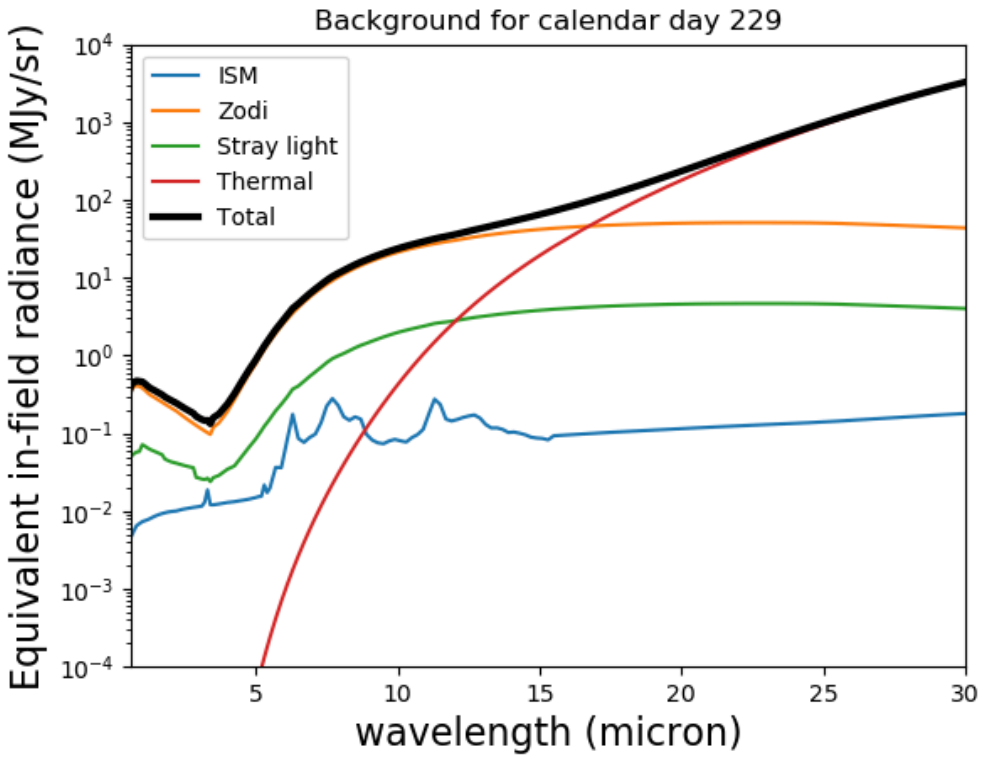
36 errors & warnings (Click for Details)

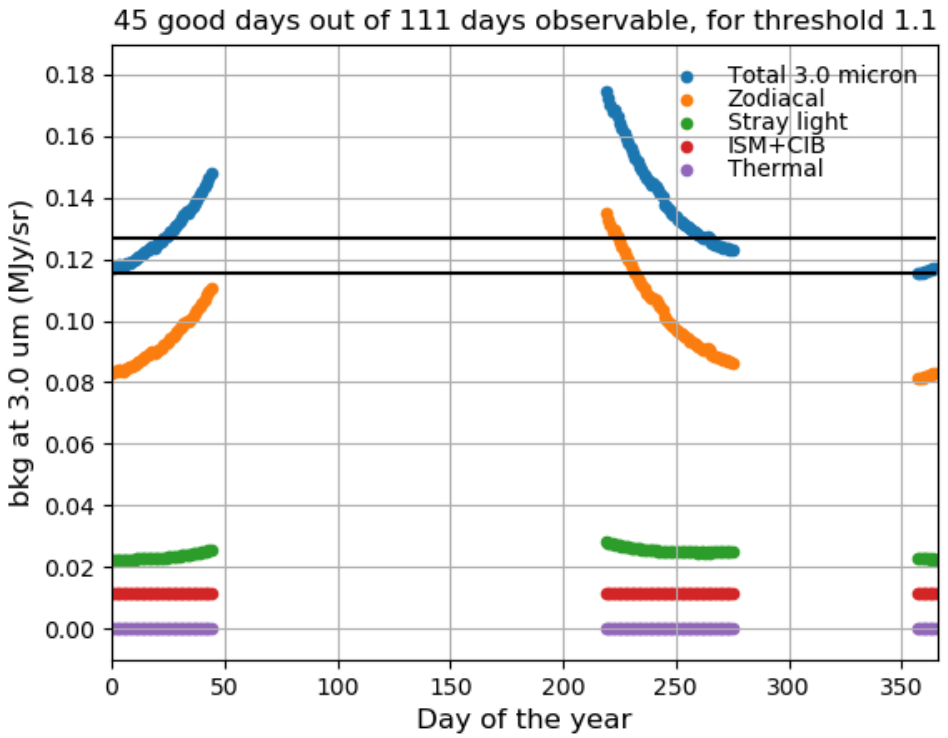
Additional exercises

Use the JWST Background Tool

JWST Backgrounds Tool

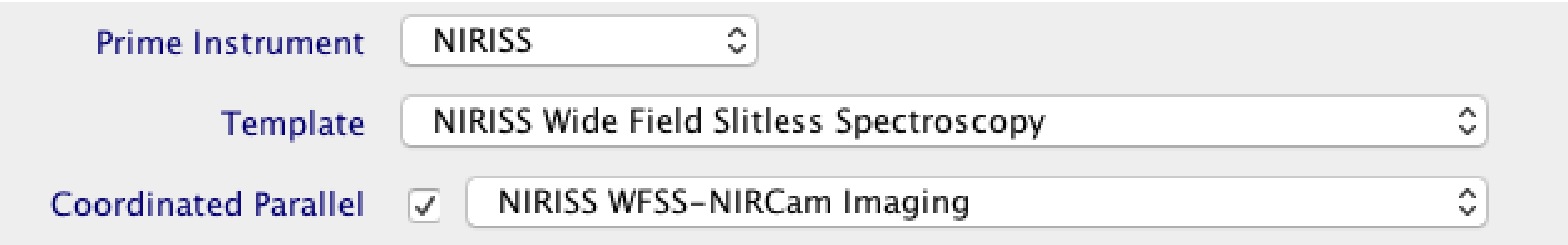
```
(jwstbackground) lunotta:/Users/cpacifici% jwst_backgrounds --day 100 --showsubbkgs 53.09412000 -2.7875570 3
These coordinates are observable by JWST 111 days per year.
For 45 of those days, the background is < 1.1 times the minimum, at wavelength 3.0 micron
Warning: The input calendar day 100 is not available, assuming the middle day: 229 instead
```





Add parallels

JWST Parallel Observations



- The number of exposures must be the same for the primary and the parallel instrument
- The total exposure time of the parallel has to match the total exposure time of the primary, per exposure.