JWST ETC Outputs Overview

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The JWST Exposure Time Calculator outputs 2D images, line plots, and scalar values for all the calculations it performs. All ETC output products, and some intermediate products can be downloaded as FITS files.

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Overview of output products

The JWST ETC outputs 2D images, line plots and scalar values for every calculation that is performed using scene and sources, background spectrum, instrument configuration, observing setup and extraction strategy selected by the user. The relevant extraction (and in some cases, observation) parameters and region used to determine the SNR are defined in the strategy.

ETC outputs are displayed in three panes on the "Calculations" page of the ETC user interface: the "Images" pane (left), "Plots" pane (center), and "Reports" pane (right) as shown in Figure 1 in the JWST ETC Calculations Overview page.

Images

The 2D images shown in the output "Images" pane are associated with the calculation selected by clicking a row in the calculations table. The selected calculation is highlighted in yellow in the calculations table. The ETC displays various 2D output images for a calculation and these can be selected using one of the 3 tabs: (1) **2D SNR**, (2) **Detector**, and (3) **Saturation**. The images contain the entire scene used in the calculation.

- **2D SNR** shows the signal-to-noise (SNR) per pixel over the 2D scene, with a color bar shows the SNR scaling.
- The **detector** image shows the count-rate (in e^-/s) for each detector pixel with a color bar indicating the count-rate scaling.
- The **saturation** map shows the 2D distribution of the saturated pixels, allowing the user to examine the exact locations of saturated pixels and decide whether the data would be useful even with saturation in a few pixels. When there are saturated pixels the status column of the calculations table shows a warning sign. In the "Reports" pane, the "warnings" tab will appear in red indicating that there is a warning message which will inform the user about partial saturation and full saturation. Partial saturation implies that partial ramps may still be used in some cases. Full saturation implies that some of the pixels are

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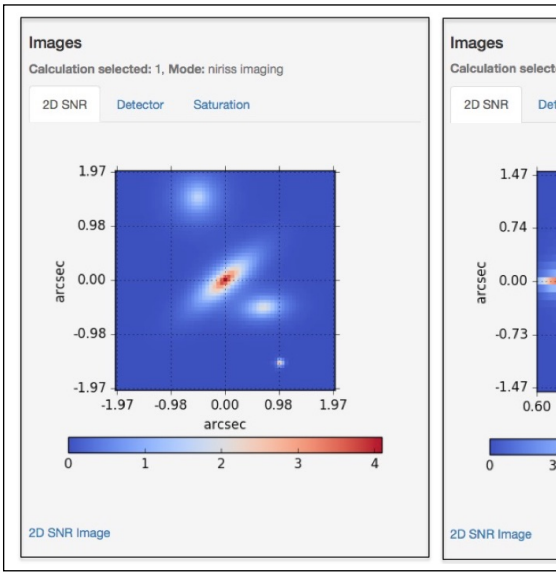
saturated at the end of the first group and cannot be recovered.

Note: The 2D images do not correspond to the displayed plots in the "Plots" pane unless the row containing that calculation is highlighted in the calculation table.

Figure 1. 2D SNR output images



The 2D SNR images from an imaging calculation using a scene with multiple sources (left) and from a fixed slit spectroscopy calculation using a single source (right).

Plots

The ETC Plots pane serves two purposes: (1) to visualize the output from a single calculation, and (2) to compare the results from multiple calculations within a workbook.

Visualizing the results from a calculation

The results shown in the "Plots" pane corresponds to the selected calculation that is checked using the checkbox in the calculations table. The color and linestyle in the plot corresponds to the color and linestyle of the checkbox.

Note: Plots do not always correspond to the displayed images unless the checkbox for that calculation is checked.

The desired output quantity to plot can be selected using one of the tabs within the "Plots" pane:

- **ApFlux** - shows the extracted flux (e^-/s) from the source in the aperture versus wavelength
- **ApBackground** - shows the extracted sky background flux (e^-/s) versus wavelength

- **SNR** - shows the signal-to-noise ratio (SNR) versus wavelength. The SNR in the extracted spectrum is per pixel and not per resolution element. For imaging calculations, the SNR value is shown at the wavelength of interest (usually, the effective wavelength of the filter) specified in the **strategy** tab.
- **SNR (time)** - shows the signal-to-noise ratio versus on-source time. For imaging calculations, the **SNR (time)** value is shown at the wavelength of interest (usually, the effective wavelength of the filter) specified in the extraction strategy.
- **Contrast** - shows the contrast versus separation, and is only for the coronagraphy mode.This shows the limiting contrast, that is the faintest possible point source that can be detected for the chosen observation strategy, as a function of angular separation from the host source. Under the "optimal strategy" the assumptions are that thermal and dynamical changes between science and reference exposures do not occur and the ETC quantifies the shot noise on both the host and reference sources occulted PSFs in order to asses the SNR of the faint source.

The "Plots" pane has widgets on the top that allow users to download plots, pan and zoom the plots, show or compare data that's closest to the location of the cursor.

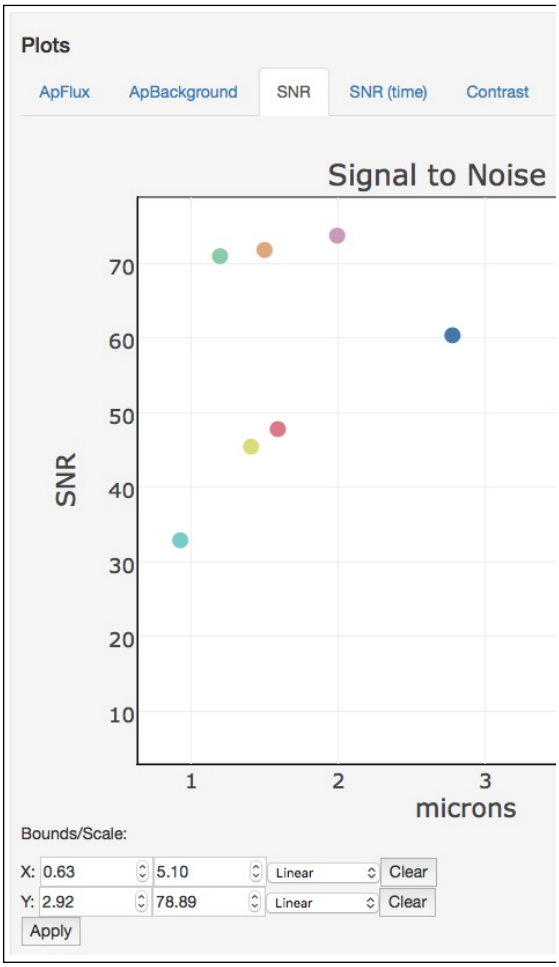
Comparing results from multiple calculations

The ETC allows users to easily compare the results from multiple calculations by overplotting them. The desired calculations can be selected from the calculations table by checking on the checkboxes, and the results from all of them will be displayed in the same plot. Different colors indicate the different calculations.

All calculations in a given workbook may be overplotted simultaneously by using the "all" option in the drop-down menu that is available on the Plot tab above the calculation table. This feature is useful for comparison of the calculated parameters for different filters/grisms of the same instrument, or for different instruments. This feature also makes it possible to compare the SNR vs wavelength for multiple filters and across instruments covering a broad spectral range, by selecting the calculations to be plotted simultaneously.

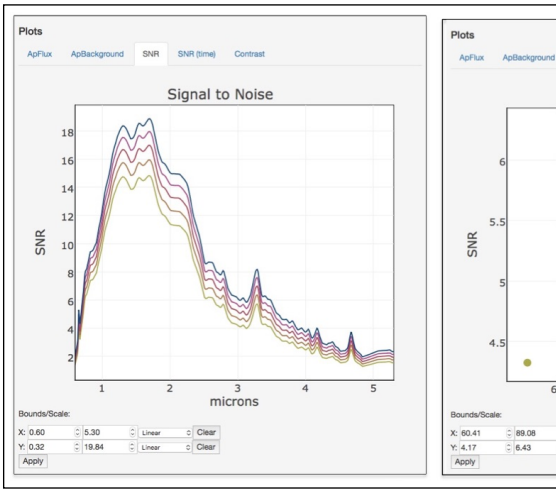
The ability to compare multiple calculations using the plot is especially useful to analyze the outputs from batch expansions (over filters, exposure times, etc). The SNR(Time) plot can be used to determine what is the exposure required to achieve a given SNR, by doing an expansion over groups or integrations. All the calculations done in batch expansion can be selected by using the checkbox and plotted simultaneously and the required exposure time for the desired SNR can be directly read off the graph.

Figure 2. The SNR versus wavelength from multiple imaging calculations.



The results shown are from multiple calculations performed using a batch expansion over all the broad-band and medium-band filters for NIRISS imaging mode. Each point corresponds to a different calculation that uses a different imaging filter.

Figure 3. The SNR versus wavelength from multiple spectroscopy calculations.



The SNR of extracted spectra from multiple calculations performed using a batch expansion over "Groups" for NIRSpec fixed slit spectroscopy of a single source (left panel). The batch calculation provides SNR for different exposure times resulting from the different number of groups, and the result has been plotted to show the SNR versus on-source time (right panel) for the wavelength of interest which was set to 3 microns.

Reports

The ETC "Reports" pane provides a summary of the calculation that is selected (indicated by the highlighted yellow) in the calculation table. The "Reports" pane includes a report on the scalar output values, warnings and errors, and a link to the downloads related to that calculation.

Report

The report provides a summary of the input parameters and output scalar values associated with the selected calculation. This includes:

- Input instrument configuration (e.g, filters, grisms), and the parameters used to define the extraction strategy (e.g., aperture position, size of extraction aperture).
- Wavelength of interest in the report corresponds to the desired wavelength specified by the user for the spectroscopy modes, and refers to the effective wavelength of the filter for the imaging modes.
- Total time is calculated based on the parameters specified by the user under the detector setup tab.
- Extracted flux corresponds to the measured count rate (e^-/sec) within the extraction aperture for the source after background subtraction.
- Variance includes various noise terms as described in Pontoppidan et al. (2016).
- Signal to noise is computed directly as the ratio of the extracted flux and standard deviation in the extracted flux.
- If background region was selected, the total background flux corresponds to the count-rate (e^-/sec) from the sky background and contamination from any signal that contributes counts to the background extraction aperture (e.g., from overlapping sources or extended wings of the source). If no background regions was specified, a noiseless sky background is reported.
- Count rate from the total sky background (for the configuration selected by the user) is reported as the total sky background flux. If no background region was specified in the strategy, the contamination from within the scene is not accounted for and the total background is equal to the total sky background.
- Fraction of the total background contributed by any other signal from within the scene that is contaminating the total background flux is also

reported. If no background region is specified, this fraction is zero.

- "Report" pane also provides the average number of cosmic rays per ramp computed by multiplying the assumed cosmic ray flux (in events/sec/pixel) by the ramp time.

Warnings

If there are warnings, this is indicated in the calculations table by the orange warning symbol in the status column of the calculation table. An explanation for the warnings issued are provided under the "warnings" tab of the reports pane. The warnings imply that there are problems that the user should be aware of that may not be showstoppers.

Errors

An error is indicated by the red cross in the status column of the calculation table. The errors indicate that the calculation did not complete. This may be due to problems with the input parameters. The message in the error tab will provide additional information.

Downloads

All the output products and intermediate products from the ETC calculations are available for download using the link under the download tab. The tarball contains FITS files of the 3D data cube for the IFU calculation, and 2D images that may be used for more detailed and specific analysis as desired by the ETC user. The extracted flux, backgrounds, contamination, and SNR used for the line plots are available as FITS tables.

The background.fits file is a FITS table of 5 columns representing the background data used in the ETC calculation, where the first column is wavelength (microns), the second column is the total combined background (MJy/str), and the last 3 columns are the thermal, straylight, and infield components, respectively.

Related links

JWST Exposure Time Calculator, ETC

JWST Exposure Time Calculator Overview

JWST Calculation page Overview

JWST Scenes and Sources Overview

JWST ETC User Supplied Spectra

References

go to the on-line JWST Exposure Time Calculator Tool

Pontoppidan, K. M., Pickering, T. E., Laidler, V. G. et al., 2016, *Proc. SPIE* 9910, Observatory Operations: Strategies, Processes, and Systems VI, 991016 , "Pandeia: a multi-mission exposure time calculator for JWST and WFIRST"