NIRISS WFSS and NIRCam Imaging of Galaxies Within Lensing Clusters

This article provides a walk-through of developing a JWST observing program using NIRISS Wide Field Slitless Spectroscopy (WFSS) as a prime observing mode with NIRCam Imaging as a parallel mode. The overarching science goals from the GTO Canadian NIRISS Unbiased Cluster Survey (CANUCS) program provide context for navigating the Exposure Time Calculator (ETC) and setting up the observation templates in the Astronomer's Proposal Tool (APT) GUI.

> *Main article: NIRISS Wide Field Slitless Spectroscopy, NIRISS WFSS Recommended Strategies*
> *See also: NIRISS WFSS Template APT Guide, JWST Parallel Observations*

The Canadian NIRISS Unbiased Cluster Survey (CANUCS) is a GTO program designed to study galaxies within and lensed behind galaxy cluster fields. The main science goals are to:

- measure physical properties (star formation rates, metallicities, abundances) of dwarf galaxies from $1 < z < 5$;
- spatially resolve emission lines, metallicities, and star formation rates of lensed galaxies at $z > 1$;
- detect extreme emission line galaxies from $1 < z < 8$ and determine their evolution in their number and their properties;
- discover and characterize galaxies in the era of reionization ($z > 7$) via spectral diagnostics (continuum breaks, Lyα emission lines; broad-band dropouts).

The NIRISS Wide Field Slitless Spectroscopy (WFSS) mode is designed to obtain spectra in the 0.8–2.2 μm wavelength range for every source within the 2.2' × 2.2' field of view (FOV) of the NIRISS detector. WFSS offers two grisms for this mode, GR150R, and GR150C, that are mounted orthogonally to each other in the filter wheel. A grism observation is performed with a blocking filter in the pupil wheel which limits the wavelength range of the observed spectra (which also reduces the spectral overlap between orders). Since the NIRSS WFSS point spread function (PSF) is undersampled, dithering of NIRISS grism exposures are required. A direct image is taken before and after each set of dithered grism exposures to determine object position, define the wavelength zeropoint of the dispersed spectra, and to facilitate modeling of spectral overlaps (i.e., "contamination").

NIRISS WFSS is the only JWST observing mode that permits slitless spectroscopy between 0.8–2.2 μm and is well-suited to measure emission lines from a large sample of galaxies over a range of redshifts. NIRISS has a high multiplexing factor and is thus optimal for a deep survey since it can obtain spectra for >1000 objects in one observation. The orthogonal mounting of the GR150R and GR150C grisms helps to mitigate contamination from overlapping sources.

NIRCam imaging, executed as a coordinated parallel observation in this program, is designed to detect galaxies with strong emission lines based on their narrow-band filter excesses in a region adjacent to the lensing clusters (here "adjacent" is defined by the relative locations of NIRISS and NIRCAM in the JWST focal plane and the spacecraft roll angle).

The CANUCS program will observe 5 strong-lensing galaxy cluster fields with the F115W, F150W, and F200W filters to optimize emission line and wavelength coverage. For illustrative purposes, we focus on one of the clusters from the *HST* Frontier Fields.

The Step-by-Step ETC Guide walks the user through navigating the JWST Exposure Time Calculator (ETC) to determine exposure parameters appropriate for the science goals for this program. Additional ETC calculations are shown to illustrate how the effects of background and spectral confusion can affect results, which are important caveats for a user to keep in mind when designing WFSS proposals.

The Astronomer Proposal Tool (APT) is used to submit JWST proposals. The Step-by-Step APT Guide provides instructions for filling out the APT observation templates, where NIRISS WFSS is the prime observing mode and NIRCam imaging is a coordinated parallel mode. The exposure parameters determined by the ETC are specified in the APT observation template.

Continue the tutorial:

Step-by-Step ETC Guide

Step-by-Step APT Guide