MIRI MRS Field

JWST MIRI's medium-resolution spectrometer (MRS) has four separate integral field units (IFUs), resulting in a non-unique and discontinuous mapping of the telescope focal plane to the two MRS detectors.

Introduction

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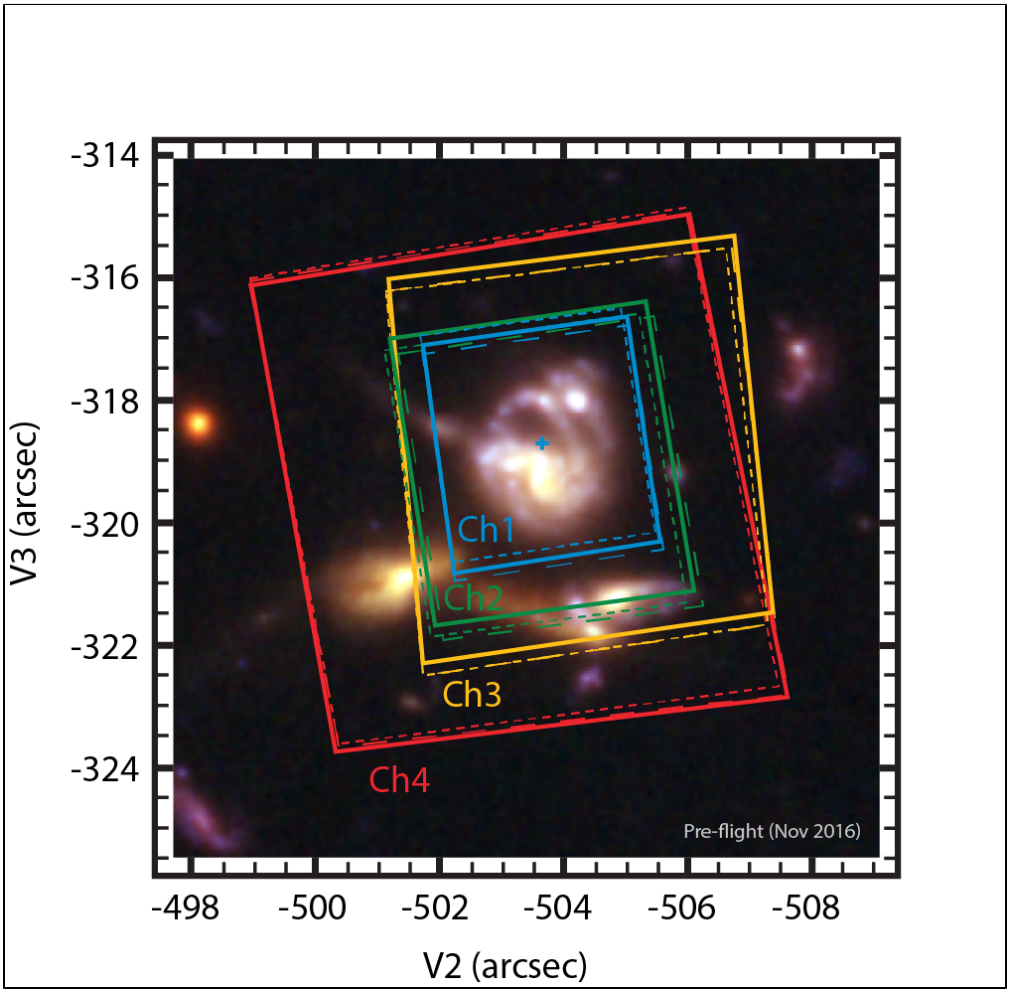
The MRS footprint on the sky is often depicted as nearly square for each channel, with slight differences for each sub-band (see Figure 1). However, this is only an approximation; the footprint at each wavelength is actually the combined collection of rectangular footprints from each individual optical slicer element of the integral field unit (IFU). These slices are not perfectly aligned with each other, and produce a staggered effective footprint on the sky (see Figure 2).

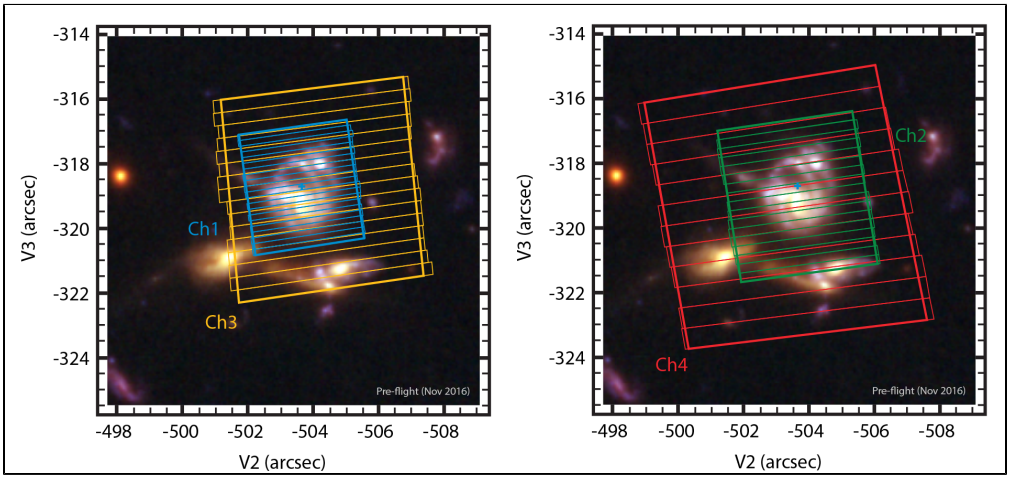
The simplified fields of view shown in Figure 1 (and displayed by APT) are calculated by inscribing a nominal rectangular field within the individual slice boundaries. Individual slices thus extend slightly beyond the simplified field boundary for a given MRS band, ensuring complete coverage within the nominal field. Table 1 in MIRI Medium-Resolution Spectroscopy gives the nominal field sizes calculated by averaging over the three sub-bands within each MRS channel.

Figure 1. MRS spatial footprint



This figure shows the MIRI MRS fields of view in the JWST coordinate frame (V2, V3); the field borders are drawn as solid lines (sub-band A), dashes (sub-band B), and dots (sub-band C) for channels 1 (blue), 2 (green), 3 (yellow), and 4 (red).

Figure 2. MRS individual slice footprints



Similar to Figure 1, but in this case the individual slices (of sub-band A) that make up the field of view are illustrated for channels 1 (blue), 2 (green), 3 (yellow), and 4 (red).

MRS coordinate frames

The MRS uses a variety of coordinate reference frames:

- The (V2, V3) coordinate frame is a spherical coordinate system tied to JWST that can be mapped to astronomical right ascension and declination by a series of Euler angle rotations. (V2, V3) is measured in units of arcseconds relative to the telescope boresight.
- The (α, β) coordinate frame is defined locally to each of the 12 MRS bands in which α and β correspond to the along-slice and across-slice directions respectively. (α, β) is measured in units of arcseconds relative to the center of the IFU field of view.
- The ideal coordinate frame is used to define the dither offsets applied by APT. For the MRS, it's defined such that $+X_{Ideal}$ lies along −V2, and $+Y_{Ideal}$ along +V3.

As illustrated in Figure 1, due to the differing optical paths, each of the 12 MRS bands is rotated by a slightly different amount with respect to the JWST V2,V3 coordinate system, and further distorted such that the along-slice (α) direction at the top and bottom of the IFU are not quite parallel to each other. On average, however, the along-slice direction of MRS is rotated by 8.4°, 8.1°, 7.7°, and 8.3° with respect to the V2,V3 coordinate system for channels 1, 2, 3, and 4 respectively. Since the MIRI imager is itself rotated by about 4.5° with respect to V2, V3, the MIRI imager and the MRS are therefore rotated with respect to each other by about 3.6°.

These angles between the different MRS fields of view and the ideal coordinate frame must be taken into account if specifying a particular position angle for observations. For instance, a position angle of −8.4° would orient the IFU such that the channel 1 across-slice direction is north-south on the sky, while a position angle of 90° − 7.7° = 82.3° would align the channel 3 across-slice direction east-west on the sky.

MRS pointing origins

Since each of the MRS channels have a slightly different field of view, they each have a different pointing origin with respect to which dither offsets are defined. For the four channels, these are defined as the pointing origin ((α, β) = (0,0)) locations in the Ch1A, Ch2A, Ch3A, and Ch4A coordinate frames, respectively, and given in Table 1 with their corresponding (V2, V3) locations. This defines the location at which an astronomical target would be placed in the field of view when observing with a given primary channel set in APT if no dither offset were applied.

Since all four channels are observed simultaneously, for purposes of the JWST pipeline and world coordinate system specifications, the channel 1 pointing origin is defined to be the reference point (V2_REF, V3_REF) for all MRS observations.

Table 1. MRS pre-flight pointing origins

Channel	V2 pointing origin value (arcsec)	V3 pointing origin value (arcsec)
1/ALL	-503.65447	-318.74246
2	-503.63609	-319.09146
3	-504.37241	-318.79844
4	-503.12848	-319.48786