Optimization of the Source Extraction Method for NIRCam Photometric Observations

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Overview

The methodology currently defined for photometric source extraction in the Time-series Observation (TSO) pipeline does not meet the precision requirements of time-series observations. Current methods to not account for any jitter in the source position, utilize a square aperture, and perform no background subtraction. Here we suggest a more optimal method for photometric source extraction that can achieve 100 ppm precision over the relevant timescales.

Proposed Strategy

We propose that following improvements to the current photometric source extraction methodologies for the TSO pipeline be implemented:

1. Perform a background subtraction at beginning of photometric extraction module. We have tried several different methods of background subtraction and have found that the following procedure best minimizes the scatter in the derived photometry:
   a. Mask a region 10 pixels in radius around the peak of the source flux distribution.
   b. Group the unmasked pixels by detector column and construct a histogram of their values.
   c. Iteratively (3 iterations) sigma-clip (6 sigma) the resulting distributions and derive a median background value to be subtracted from each detector column.
2. Employ a flux-weighted centroiding method to track changes in the location of the source on the detector as a function of time. We have tested several centroiding methods with the available test data and have found that the most robust method for tracking variations in the source position is simple flux weighting using the 11x11 pixel region centered on the peak of the flux distribution. Table/Figure XXX compares the scatter in the source centroid position as well as the extracted flux for each method (Gaussian fits, least asymmetry, PSF convolution, and flux-weighted).
3. Use a stand circular aperture with a radius of 5 pixels centered on the source centroid determined previously to extract the final photometric timeserises

As seen in Figure XXX, photometry extracted with the proposed method exhibits less scatter than photometry extracted with the current TSO method (2% scatter in current method, new method produces photometric scatter at the 500 ppm level). Since there may be further positionally dependent detector effects that the end user may wish to correct for using a variety of algorithms, the centroid information should be delivered to the end user, preferably as a table extension in the extracted photometric time-series data file.

Conclusions/Summary

The optimization of the photometric extraction method for NIRCam proposed here will yield significant improvements in the precision (and usability) the TSO pipeline data products. By robustly determining the stellar centroid position with our proposed method and storing that information the end user will be able to decorrelate any positional dependent effects. We have developed algorithms for the source extraction method proposed here in well-documented and commented python scripts that we will gladly deliver to STScI. It is our hope that this improved method can be slated for inclusion in the next pipeline build (7) six months from now.