# CCDLAB – Manual
Graphical UVIT Data Pipeline

Vikrant Jadhav,
Indian Institute of Astrophysics,
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- This is used for reducing Level 1 data from UVIT detector system onboard ASTROSAT to science ready images.

- **Installation**
    - Latest version is available in the github repository. (https://github.com/jikrant3/CCDLAB)
        - If not accessible, Download an older version CCDLAB from https://www.ucalgary.ca/uvit/
    - Install *CCDLABsetup.msi* in Windows 7/8/8.1/10
    - Keep *UVIT_CalDB* folder in *C:\ d*irectory*.
    - If needed, install *VC++ redistributable package (VC_redist.x64.exe).*

- Reference material:
    CCDLAB: A Graphical User Interface FITS Image Data Reducer, Viewer, and Canadian UVIT Data Pipeline
    Postma, Joseph E. and Leahy, Denis
    Publications of the Astronomical Society of the Pacific, vol 129, 115002, November 2017
    ADS bibliographic code: 2017PASP..129k5002P

Extracting and Digesting Level 1 data

- Check the Digestion settings so that one can use digestion automatically.

- Make sure to keep the *.gz/.zip* file in a separate folder. (If there are any files in the same folder, they might get corrupted)

- Unzip using **UVIT> Extract L1 gz or zip archives.**

- Select *yes* when asked to digest at the end of extraction.

- **In case of manual Extraction and Digestion:**
  - Copy all *level1, .lbt* and *.tct* files at some same folder.
  - If the observations were done before December 2018:
    - Digest using **UVIT > Digest L1.** Keep setting as shown in following image
    - Select all (FUV and NUV) "*level1*" files from the master folder and digest them.
  - If the observations were done after December 2018:
    - These is a clock issue in VIS filter.
    - Turn on **UVIT>Digest>TBC**.
    - Digest using **UVIT > Digest L1.** Keep setting as shown in following image
    - Select all (FUV and NUV) "*level1*" files from the master folder and digest them.

- After Digestion you will have files categorized based on Filters and Orbits.
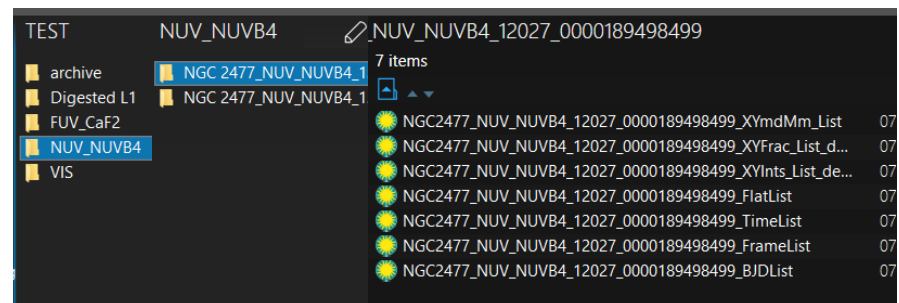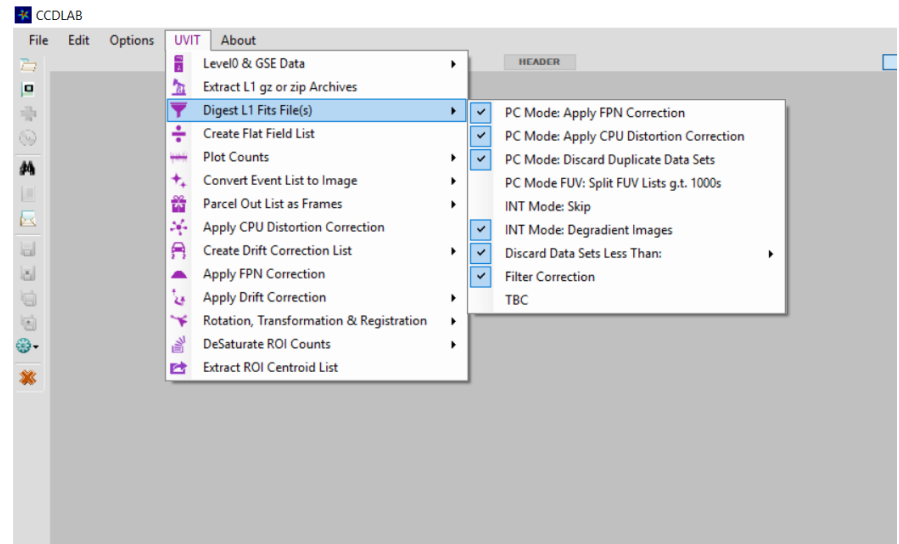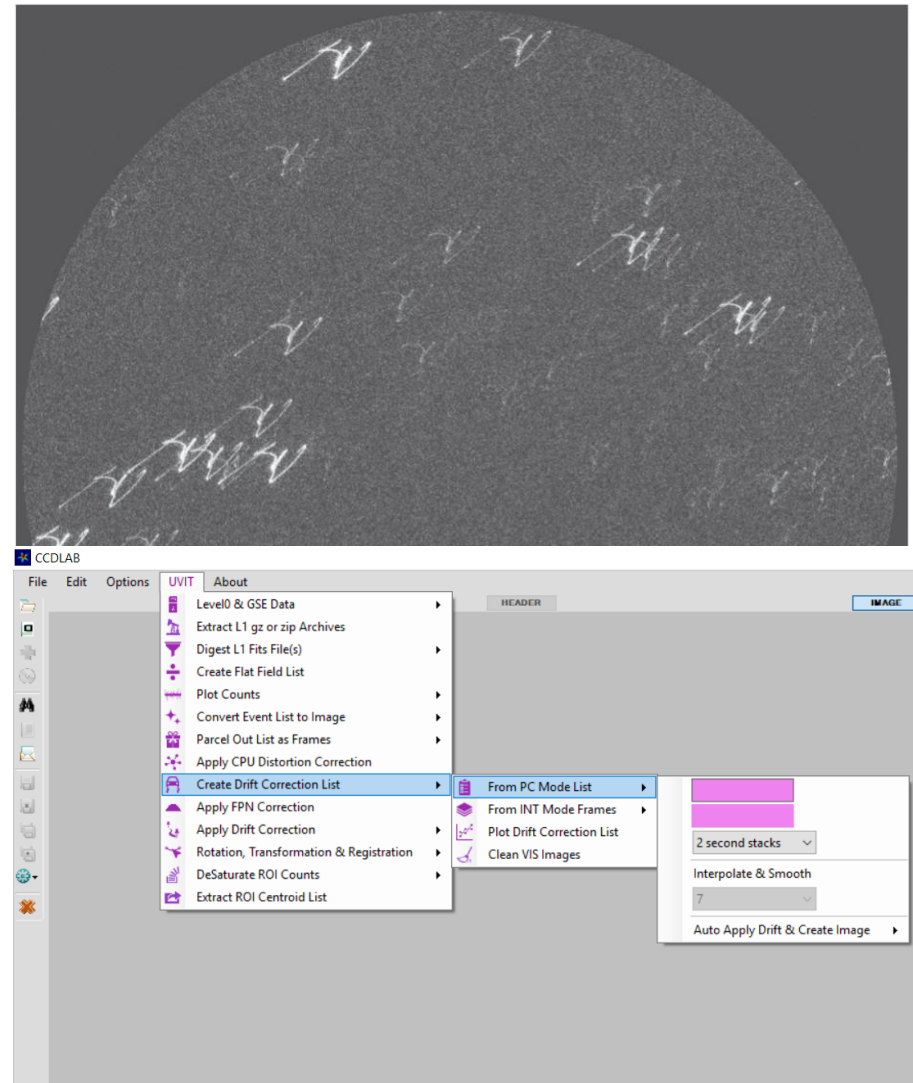
Drift Correction

UVIT images are distorted because of the drift of the satellite. There are two main ways of correcting the drift. Preferred method to Drift correct is using VIS channel.
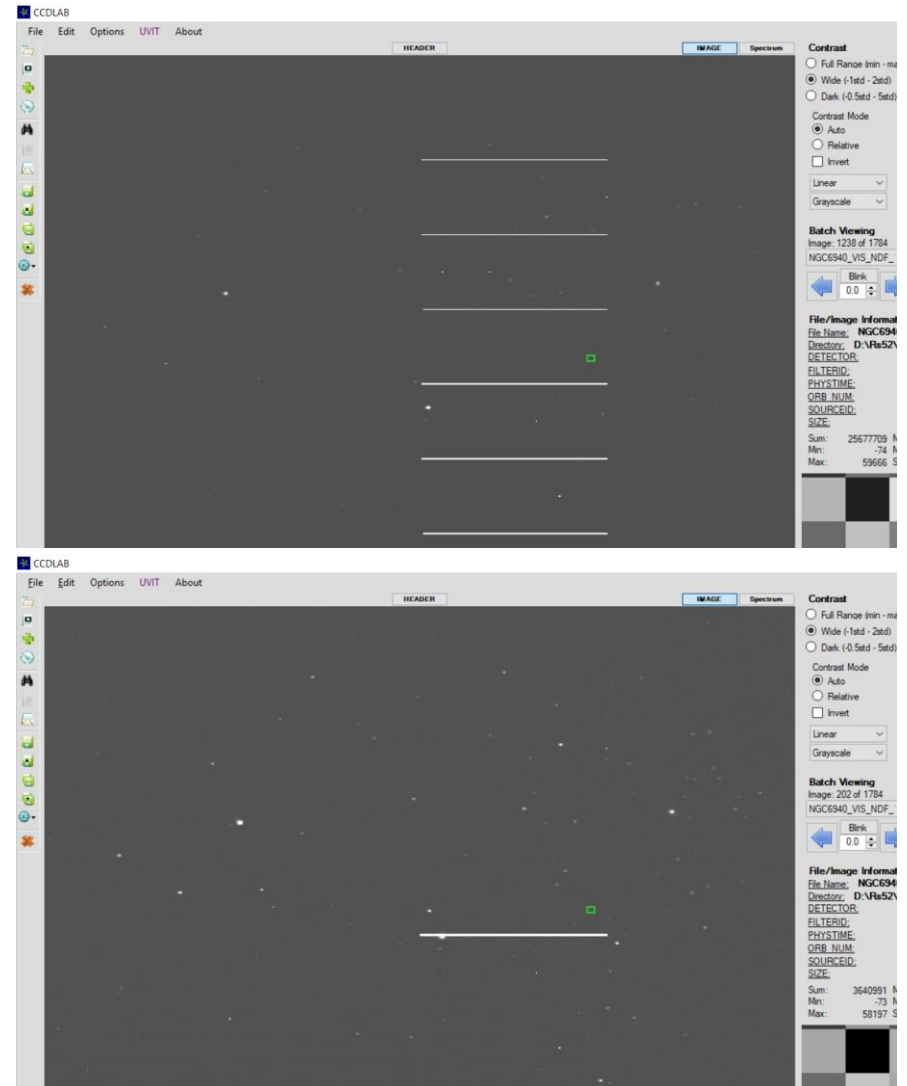
1. Self-Drift Correction

- The images will be drift corrected using bright stars in the respective filters.

- **UVIT>Create Drift Correction List>From PC mode List**

- Select _XYInts from all filters. Start with **Stacking Time = 2 sec**. (The final image will be better with lower stacking time. But depends upon the bright stars in the respective filter)

- It will creat _XYInts_deDrift files.

- If some images are not drift corrected:
    - Increase the stacking time gradually (3, 4, 5 ,7…) and try (ideally 5 sec should be the maximum stacking time, but you can increase the stacking time on your own discretion)
    - Repeat **UVIT>Create Drift Correction List>From PC mode List**.
    - Use original _XYints files here.

Drift Correction…

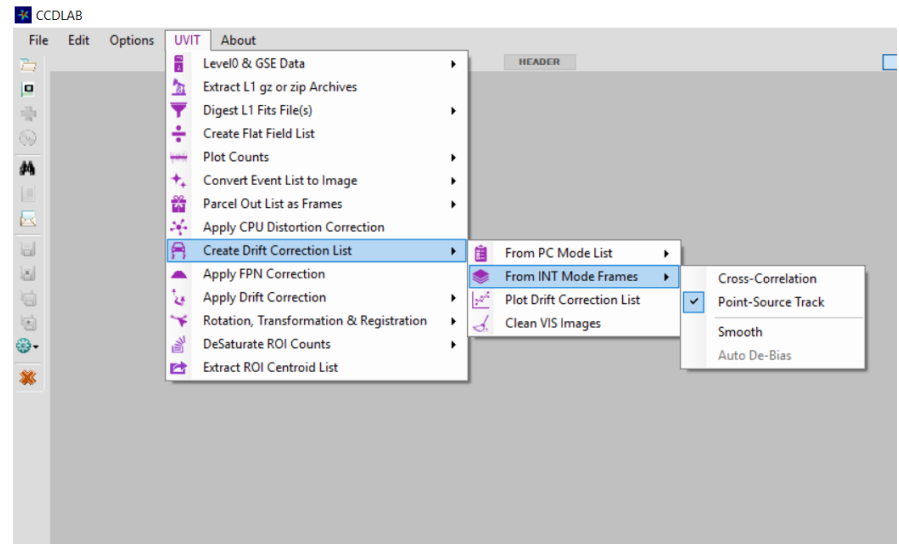**2. Drift Correction using VIS Images**

- **Look and clean VIS images**
    - The different folders in *VIS* signify different orbits.
    - Open all (In case if slow PC, some lower and random number of images can be opened) VIS images in one folder/orbit.
        - Check other folders. (Not entirely necessary but better to check all VIS folders).
    - Use 'scan' feature in CCDLAB (at time 0.0) to look for artefacts and overall drift.
    - If VIS images look ok, proceed to next step.
    - If there are artefacts as shown in 1st figure
        - Use **UVIT>Create Drift Correction List>Clean VIS Images** to clean VIS master folder.
        - Check *VIS* folder again for artefacts, it should be 'cleaner' now.
            - If there are still some small artefacts (2nd figure), you can go forward to next step.
            - If there are large artefacts after cleaning, do not use *VIS* for drift correction.
    - After this step, CCDLAB may require a restart.

Drift Correction...

2. Drift Correction using VIS Images...

- **Creating Drift Correction list**
  - **UVIT>Create Drift Correction List>From INT mode Frames.**
  - Select *VIS* master folder.
  - Select at least 2 bright sources (Even 'saturated looking' points can be selected)
    - You have to select these manually for each orbit.
    - Use LEFT-CLICK to select stars and RIGHT-CLICK to proceed to next orbit.
  - It will create *.drift* files in each VIS folder corresponding to their drift.
  - If the graphs of drift does not have discontinuities or sharp peaks, proceed to next step. In case of bad Drifts go to 'Finer Drift correction after VIS'

- **Applying Drift Correction**
  - Do this separately for NUV and FUV
  - **UVIT>Apply Drift Correction>Consolidate NUV or VIS drift series and Apply to NUV or FUV**.
  - Select all *.drift* files from *VIS* folder (search *drift in VIS folder)
  - Select *_timelist* files from NUV and FUV Separately (Search *NUV*time in Master folder)
  - It will creat *_deDrift* files.

Drift Correction...

2. Drift Correction using VIS Images...

- **Finer Drift correction after VIS**
    - This step is only recommended if VIS *.drift* is showing peaks or discontinuities. (Or sometimes if the stellar PSFs are not circularly symmetric.)
        - To recheck *.drift*: **UVIT>Create Drift Correction List>Plot Drift Correction List**
    - In case of graph like 1st figure recheck the observation date and turn on **TBC** while digesting
    - In case of graphs and deDrifted image like the 2nd figure use this method.
    - The orbit corresponds to some folders in different filters. Note the corresponding FUV/NUV folders with VIS folders by comparing observation times or from Astrosat Schedule viewer (https://issdc.gov.in/MCAP/)
    - **UVIT>Creat Drift Correction List**
        - Keep stacking time 30 or 20 or 10 sec.
        - Select *_XYInts_deDrift* in whichever filter and orbit had the problem
        - It will create *_Xyints_deDrift_deDtift* which will be used for final analysis

Orbit: 17447; Source: M67; Detector:VIS

Orbit: 8202; Source: NGC 2808; Detector:VIS
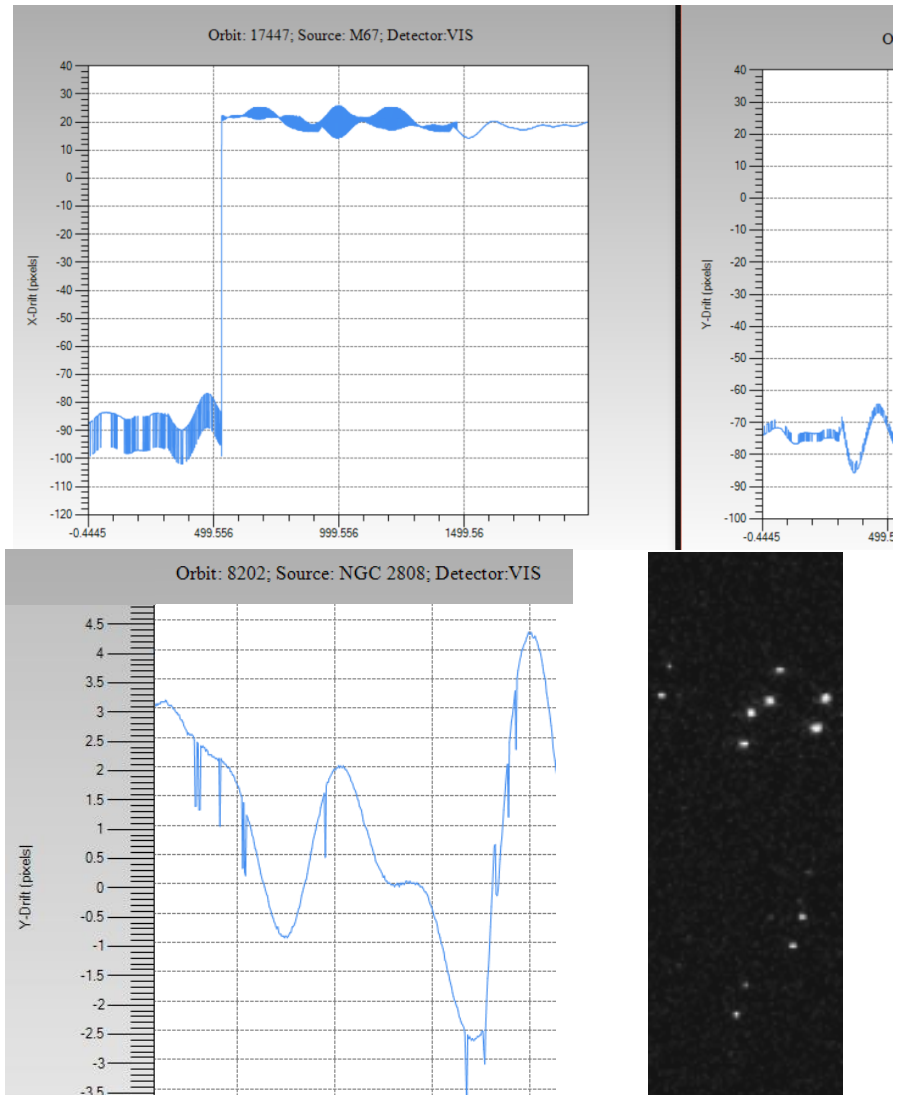
Drift Correction…

- After the drift correction you can check the profile of the stars using CCDLAB

- **Right click on a star in the smaller window>Radial Profile Plot**

- Use '**Fit**' in the Radial Profile Plot to get FWHM and overall intensity distribution.

- If the FWMH is good (<2.00) and radial symmetry is present, you can proceed to merge images.

- Otherwise tweak some settings in drift correction process like stacking time and redo the drift correction for problematic files/filters/orbits only. (It will replace previous _deDrift_ files so create a backup, if you want to compare with previous results)
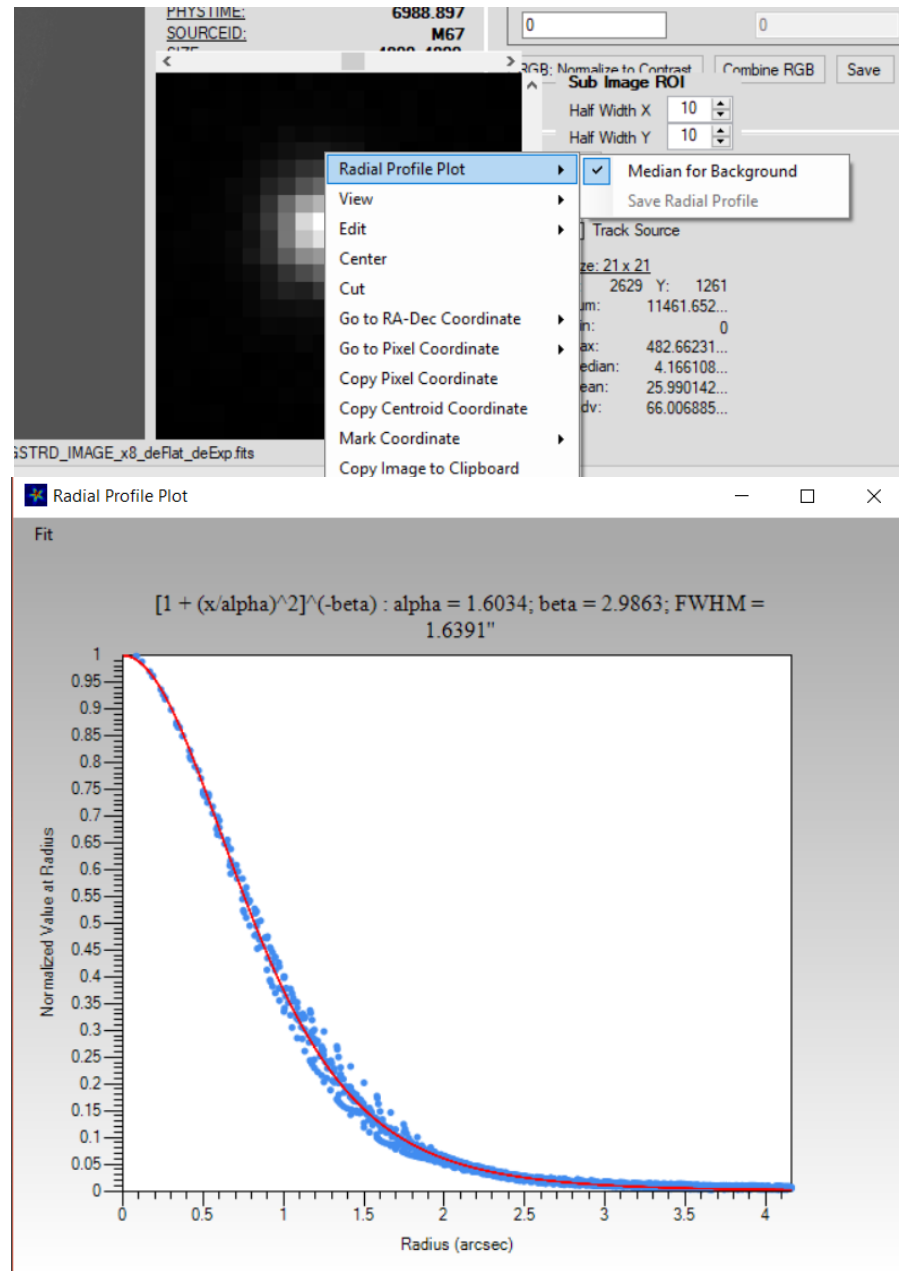
Creating and merging Images

- **Creating Images to view in the interim:**
  - **UVIT>Convert Event List to Image**
  - Select _XYInts_deDrift_ files in all (FUV and NUV) folders.
  - The images are created as _deDrift_IMAGE

- **Rotating NUV Images:**
  - NUV images are physically rotated and mirrored due to the sensor's physical placement.
  - **UVIT>Rotation, Transformation & Registration>Transform NUV to FUV Frame**
  - Select final _XYInts_deDrift_ (or _deDrift_deDrift_ if created) files in all NUV folders.
  - It will creat _XYInts_deDrift_FSRG_ files which will be used for further process

- **Selecting stars or registration/alignment**
  - Add FUV images along with transformed NUV images using **File>Add file(s)**
  - Visually select at least 3 bright & unsaturated stars common in FUV and NUV.

CCDLAB

File   Edit   Options   UVIT   About   HEADER

UVIT menu
Level0 & GSE Data ▶
Extract L1 gz or zip Archives
Digest L1 Fits File(s) ▶
Create Flat Field List
Plot Counts ▶
Convert Event List to Image ▶
Parcel Out List as Frames ▶
Apply CPU Distortion Correction
Create Drift Correction List ▶
Apply FPN Correction
Apply Drift Correction ▶
Rotation, Transformation & Registration ▶
DeSaturate ROI Counts ▶
Extract ROI Centroid List

Convert Event List to Image submenu
Filter Cosmic Ray Frames
Apply Max-Min Threshold
✓ Centroid Image Padding
✓ Apply Exposure Array Weighting
✓ Apply Flat Field Weighting
1 Pixel Resolution
1/2 Pixel Resolution
1/4 Pixel Resolution
✓ 1/8 Pixel Resolution
1/16 Pixel Resolution

Creating and merging Images...

- **Registering/aligning all images in XY coordinates:**
  - **UVIT>Rotation, Transformation & Registration>General registration** (Registration Image resolution = 4 = ¼ pixel)
  - Select final _*XYInts_deDrift* files from all FUV and NUV filters.
  - Select at least 3 bright and unsaturated stars using LEFT-CLICK and use RIGHT-CLICK to go to next image.
  - Slight adjustments in translation and rotation are needed in all subsequent images
    - Translation: Drag one of the green square
    - Rotation: First point you click will be set as origin. Use any other point to rotate the green squares
  - After all images are registered, _*XYInts_deDrift_RGSTRD* files are created.

- **Merging registers images**
  - **UVIT>Rotation, Transformation & Registration>Merge Centroid Lists**
    - Go to folder corresponding to a filter
    - Select _*XYInts_deDrift_RGSTRD* files in all subfolder in the same filter
  - Repeat the process for all filters

- The final science ready file will have name like: *NGC7789_NUV_NUVB13___MASTER___deFPN_deDIST_deDrift_FSRG_RGSTRD_IMAGE_x8_deFlat_deExp*