National Aeronautics and Space Administration

FLITECAM Data Process Validation

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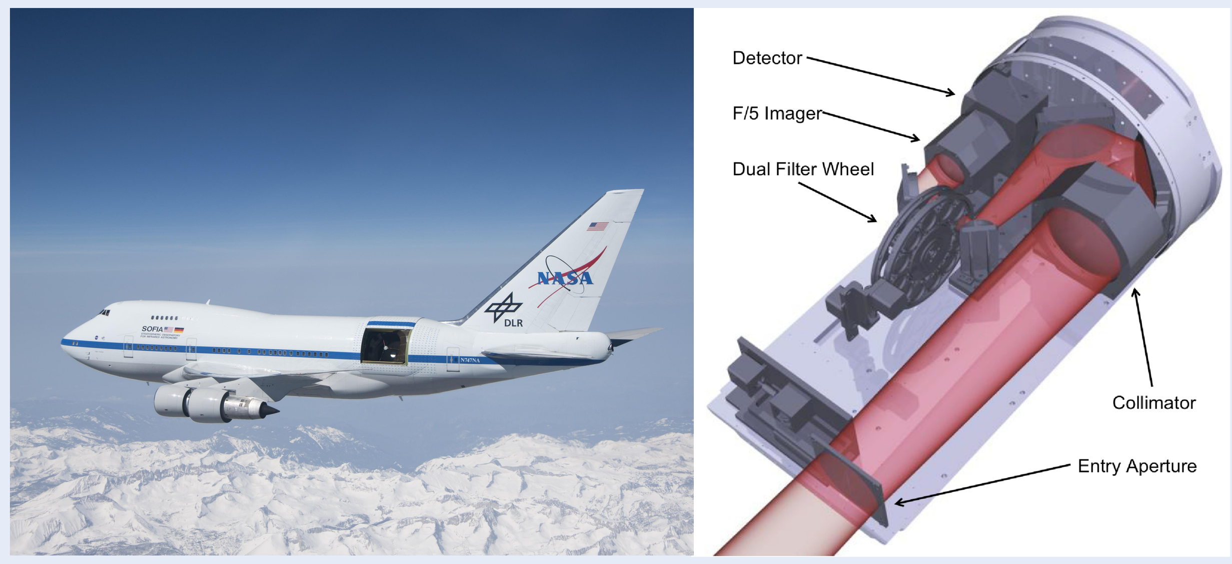
Introduction

This project contains two tasks centered on the data processing and validating FLITECAM images. The first task focuses on streamlining the data reduction process by separating the raw data into similar parameters, and running this input manifest through FDRP to produce a reduced set of data. The second task focuses on the validation of these results to ensure that the pipeline is producing a set of data that is an accurate and reliable source for future use and reference by astronomers.



Background

SOFIA and Infrared Astronomy

IR astronomy is an extremely useful bandwidth that can be used to detect astronomical information not visible to the naked eye. First Light Infrared Test CAMera (FLITECAM) is an infrared camera operating in the 1.0–5.5 µm wavelngth region onboard SOFIA (Stratospheric Observatory For Infrared Astronomy). NIR astronomy is particularly useful for peering through galactic dust and detecting cooler red stars. As wonderful as this may sound, IR astronomers often face two significant obstacles when observing the cosmos. Any object with a temperature emits IR radiation and would create significant noise for the detector. As a result, observations of celestial objects encounter infrared radiation from the atmosphere and the camera.

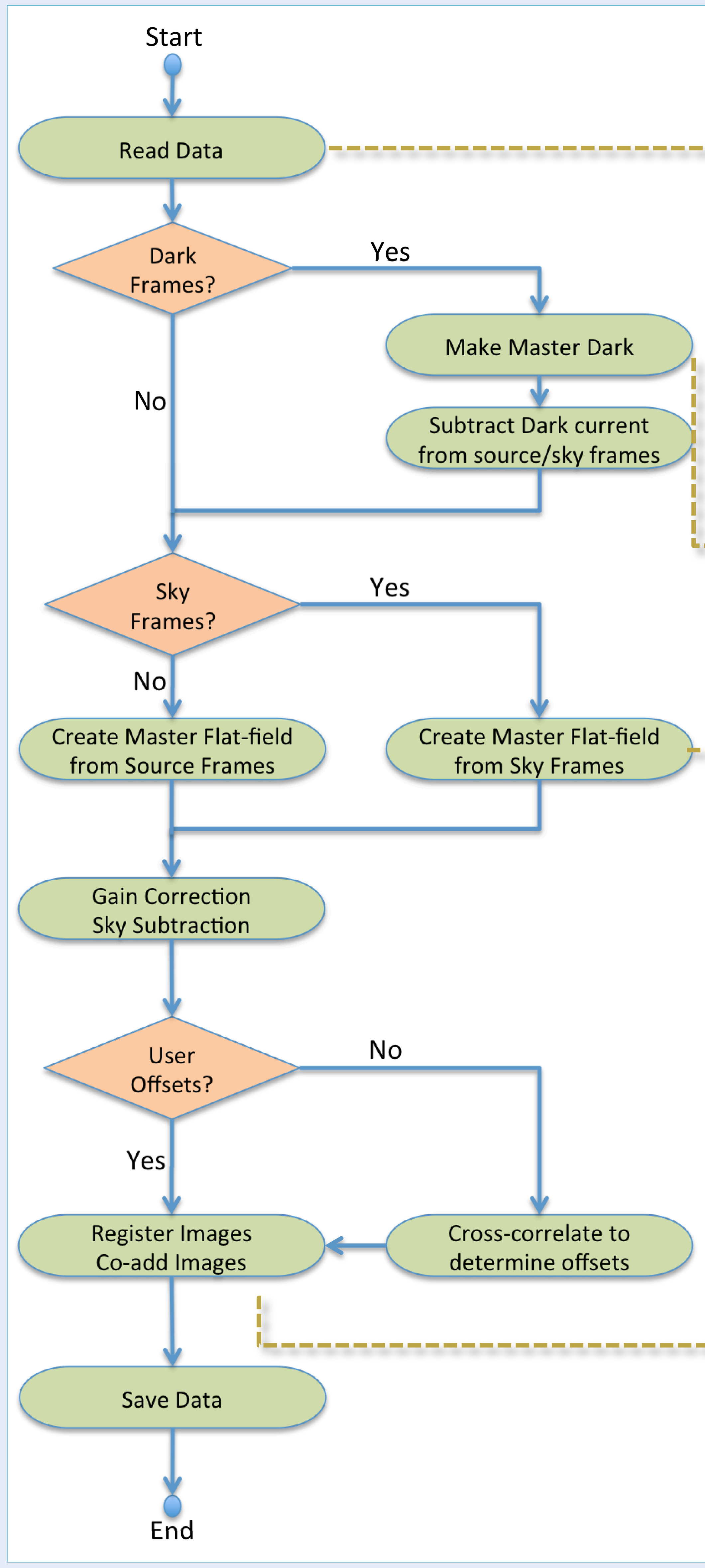
SOFIA is a modified Boeing 747SP designed to overcome these challenges of IR astronomy. SOFIA operates at altitudes of over 39,000 feet, well over 99% of the water vapor in the atmosphere, in order to reduce the amount of atmospheric radiation. SOFIA also cryogenically cools its instruments with a mixture of liquid helium and liquid nitrogen cryostat to minimize the noise from the camera itself. These advantages allow for the raw data to be significantly cleaner on board SOFIA in comparison to ground-based observations.

Data Reduction

Even after removing most of the radiation from the background, the raw data still suffers from noise. Data reduction is a method of removing as much noise as possible. The FLITECAM Data Reduction Pipeline (FDRP) is a program, developed at SOFIA Science Center, to subtracts darks, removes flats, and co-adds images. Even though the pipeline uses these processes to reduce the raw data, it is still up to the astronomers to verify the outputs as scientifically meaningful.

FLITECAM Data Reduction Pipeline

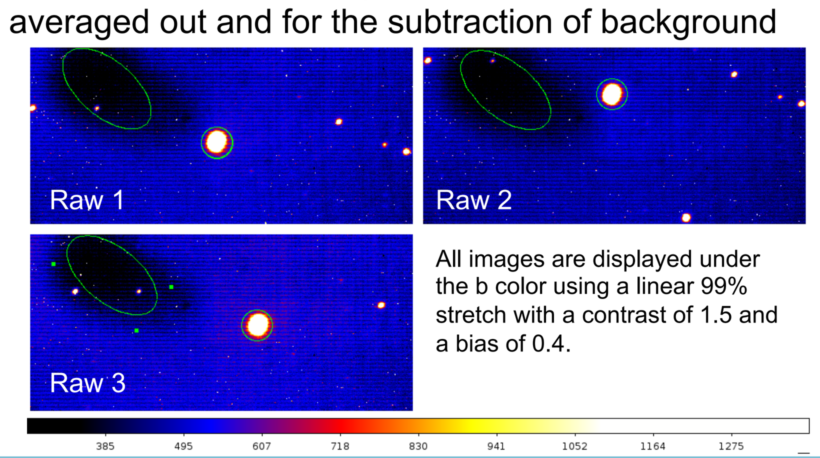
The FLITECAM Data Reduction Pipeline (FDRP) is a pipeline program designed to take a series of raw data files of similar parameters, reduce that raw data, and generate a co-added image by subtracting noise and artifacts that are found in the individual data files. Shown below is the flowchart of the pipeline consisting of three object files of NGC 7027 under filter Paschen-Alpha and four dark files, both with thirty seconds of exposure time.



Dithering

This process of offsetting a telescope between exposures is a crucial aspect of astronomy. The use of dithered exposures allows for both the image defects to be averaged out and for the subtraction of background noise.

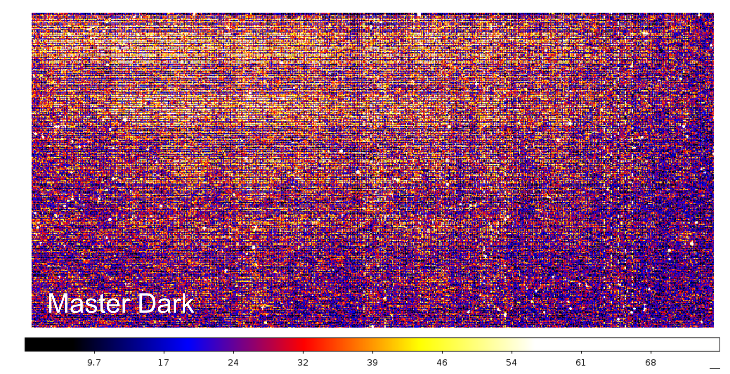
Note the slight displacement of the object of interest in each of the images and the dark region that is present in all captured images.



All images are displayed under the b color using a linear 99% stretch with a contrast of 1.5 and a bias of 0.4.

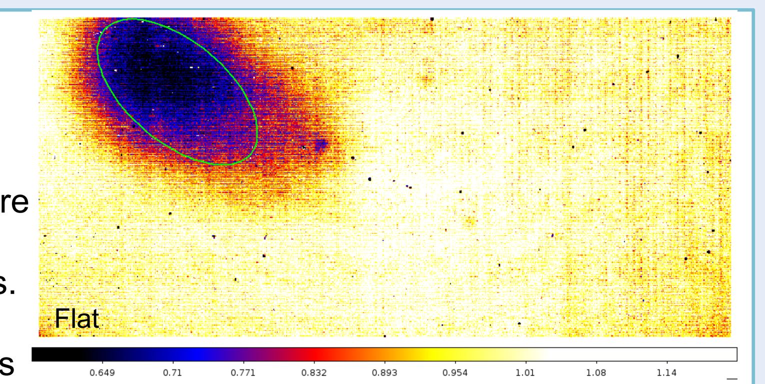
Darks

Since the camera is at a non-zero temperature, some photons will interact with the pixels on a camera creating 'light' in the image. This master dark is compiled from mean value of multiple dark files.



Flats

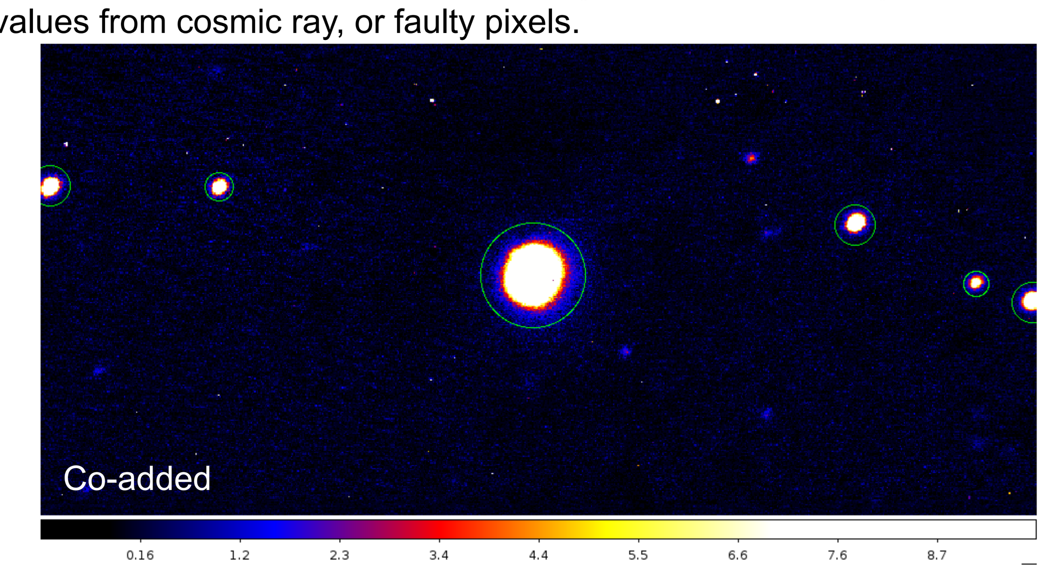
Most telescopes do not illuminate detectors homogeneously producing unevenly lit images. There are also obscurations of light in the optics producing artifacts.



Earlier, we noted that there is a dark portion of this image where there is low quantum efficiency, as well as the striping from the raw images.

Co-addition of Images

Before co-adding the images, the pipeline subtracts the master dark and divides out the flat from the images and produces a final image by stacking the dithered images based upon a point of reference and taking the average values. This end product has less background noise as it rejects extreme values from cosmic ray, or faulty pixels.



Validation of FDRP

Once a file is produced, it is up to the astronomer to validate the file by using a calibrated star from the catalogue of standard stars. Observing standard stars allows for the measured magnitudes from the objects in the data to be calibrated to the standard photometric system.

Aperture photometry is a technique for measures the instrumental magnitude of the object. This begins by choosing a circular region that encloses the image of the star and sums the flux inside the aperture, while another aperture is made in a region containing no stars to give the flux from the background. Subtracting the two yields the flux of the object.

Once the Instrumental Magnitude of the star (I_{ms}), has been determined astronomers use:

$$R_{ms} = I_{ms} - C * B - Z - k A$$

R_{ms} = catalogue magnitude of star
I_{ms} = instrumental magnitude of star
C = color transformation coefficient
B = mean catalogue color of star
Z = camera's zero point offset
K = atmospheric extinction coefficient
A = air mass of star

to calculate the "real" flux of the source.

The same calibration parameters will be used on other sources to calculate their "real" flux. Comparing these with the online, published values will validate the data.

References

[1] Images are used with permission from sofia.usra.edu
[2] S. Shenoy. FDRP Developer and User Manual.

Acknowledgements

Special thanks go to National Science Foundation and the STAR program for making this collaboration possible. Other individuals also recognized are Lawrence Horvath, Chris DeSouza, Jonathan Keller, Dimitri R. Dounas-Frazer, Chris McCarthy, Greg Soehr, Bryan Rebar, Samantha Grimaldo-Uribe, Gregory Punkar, Jamie Chan in their guidance through the STAR program at AMES.

And a special thank you to the other STAR members: Garret Holthaus, Hari Shetty, CJ Scott, Peter Sullivan, Melissa Siemer, and Sarah Bass.

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This material is based upon work supported by the S.D. Bechtel, Jr. Foundation, the National Marine Sanctuary Foundation, the Carnegie Corporation of New York, and/or the National Science Foundation under Grant Nos. 0952013 and 0833353. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the funders.

The STAR program is administered by the Cal Poly Center for Excellence in Science and Mathematics Education (CESaME) on behalf of th California State University.