Frontier Technology Inc.

Using the Integrated Sensor Analysis Tool for Remote Sensing Data Visualization and Calibration

Overview

1. Discuss, using examples, some of the challenges involved in performing analysis on large focal plane image data.

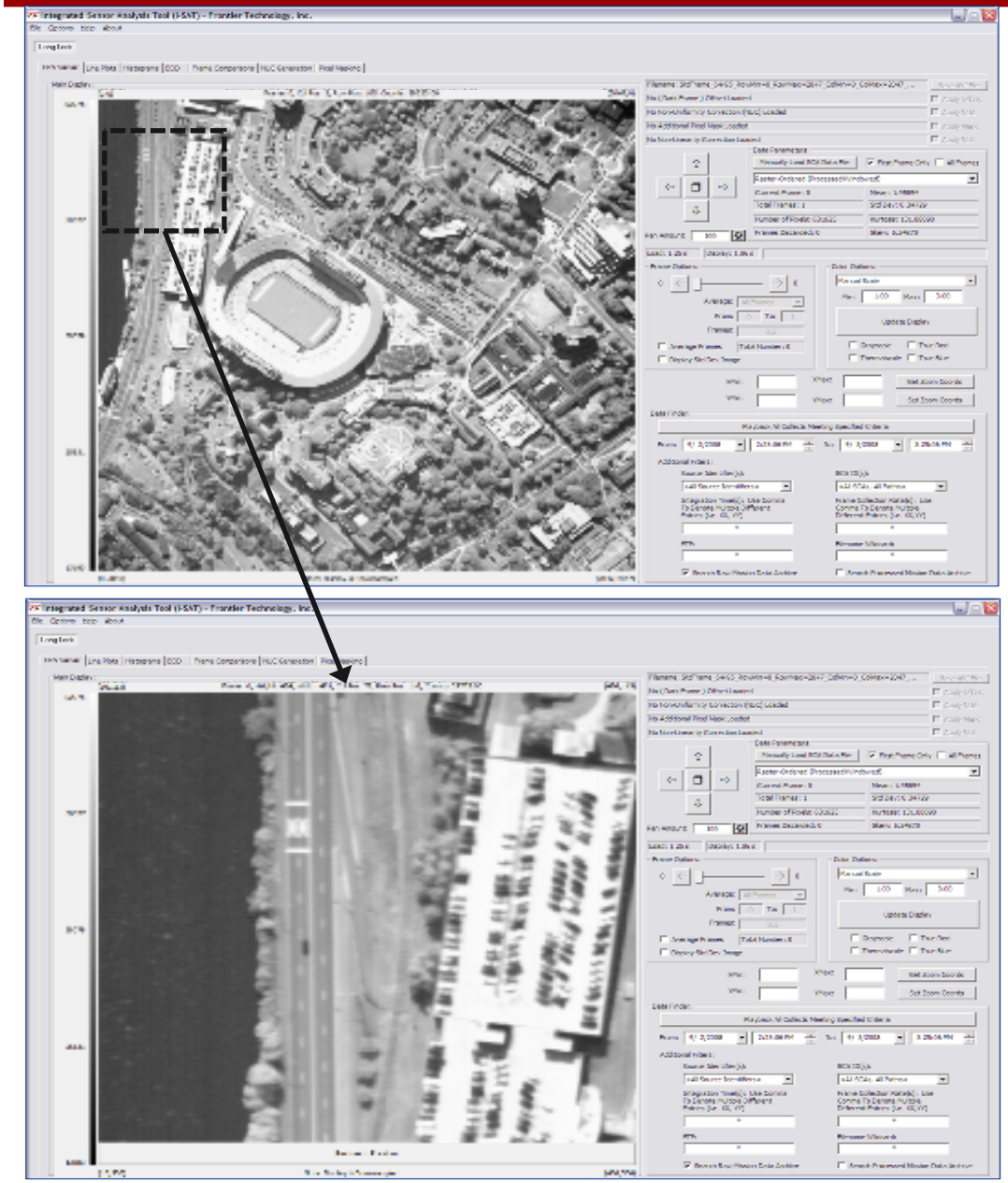
2. There are flaws in image data. What steps can we take to correct these flaws? Non-Uniformity Corrections and Pixel Masks.

3. Discuss one of the software tools we employ to help us rapidly analyze and correct image data.

4. Conclusions and questions.

Note: Data courtesy of Dave Pollock, Univ. of Alabama Huntsville: Large Format Giga-Pixel Camera

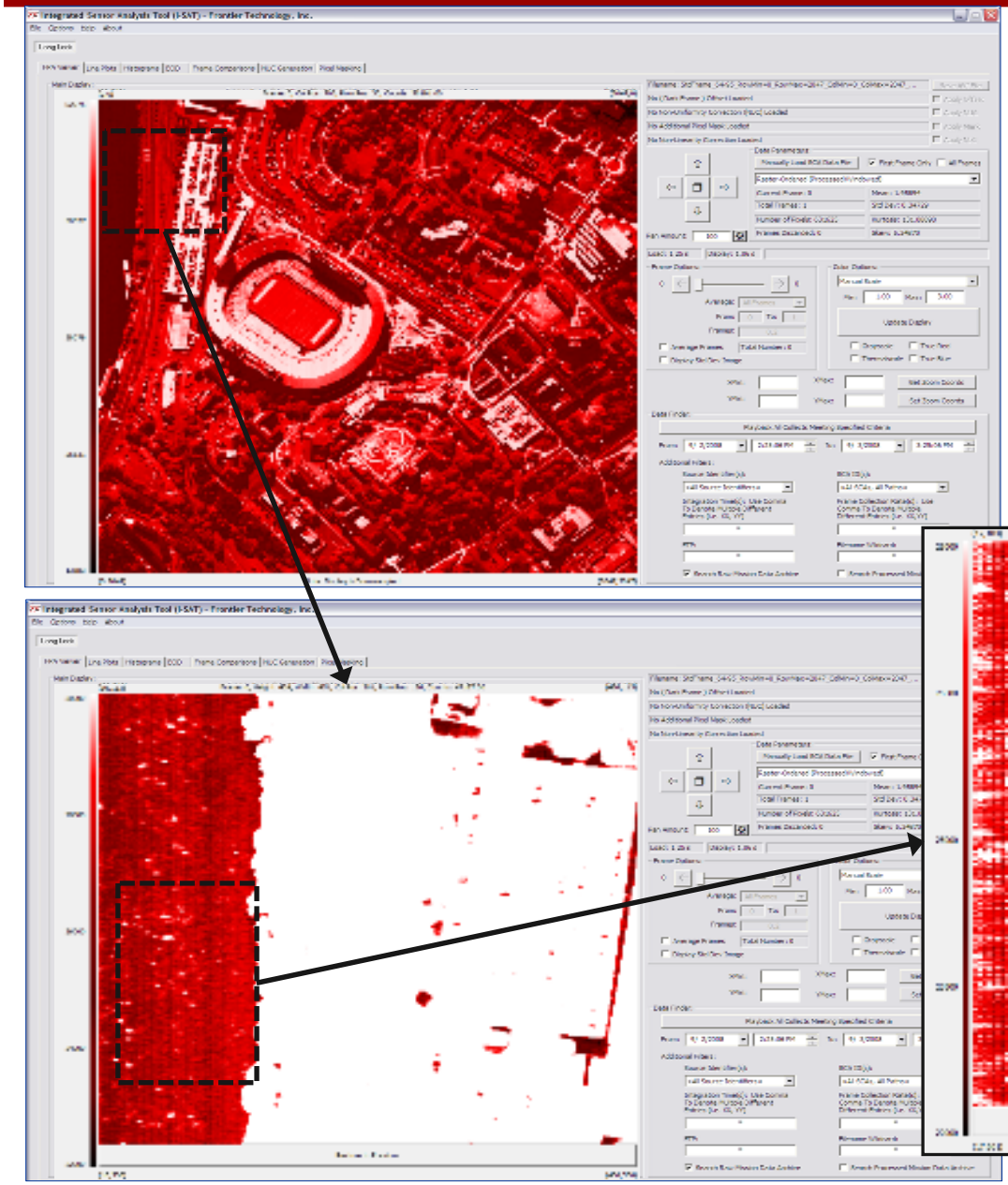
Common Tasks when Calibrating High-Resolution Imagery



Common issues with the data are:

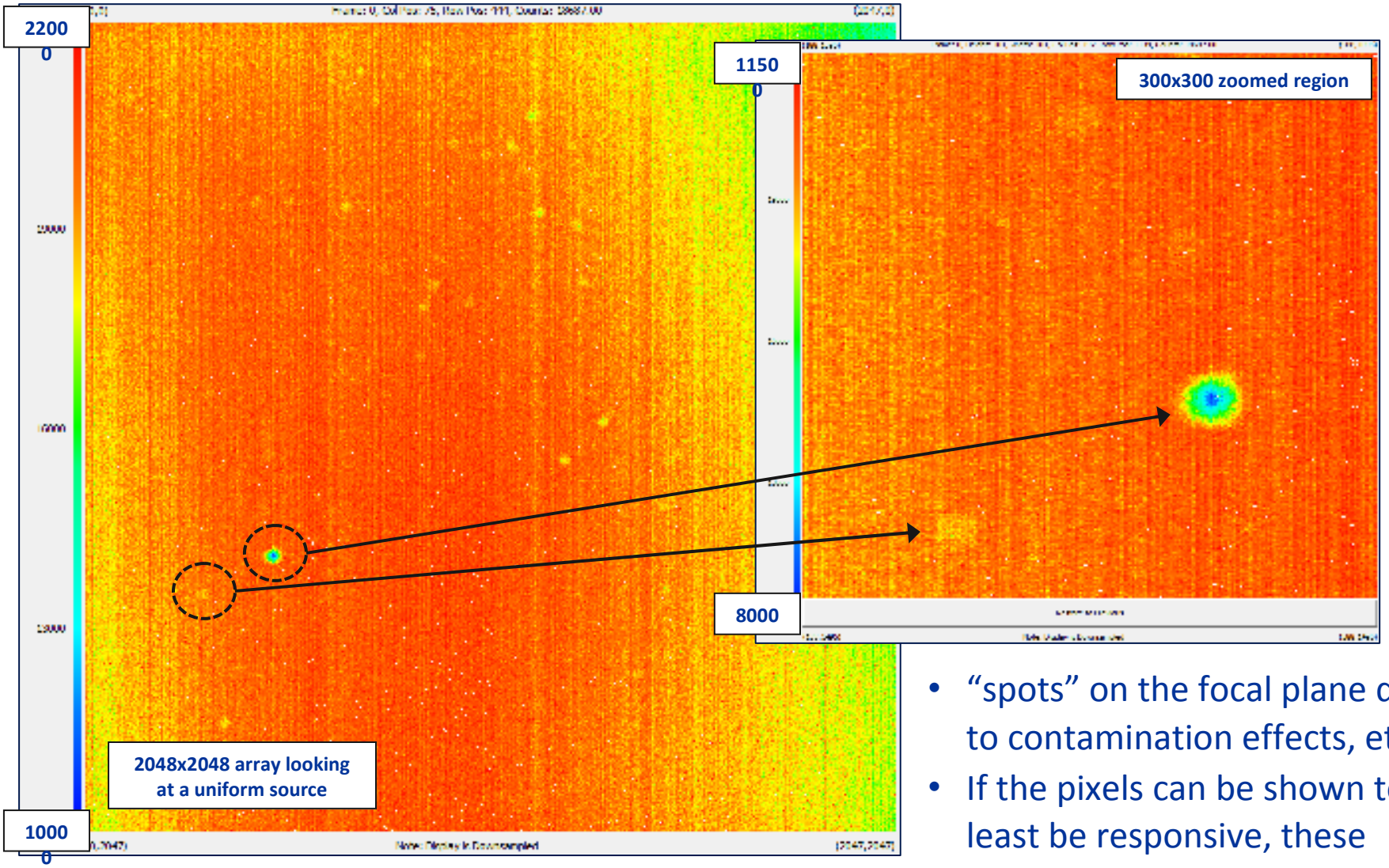
- Pixels or regions of pixels that possess out-of-family response characteristics.
- Pixels or regions of pixels that are just “bad”: they are dead or saturated, or exhibit overly noisy behavior.
- Special behavior near the edges of the focal plane, vignetting.
- Bad readout channels.
- Electrical or optical crosstalk between pixels or channels. “Ghosting”.

Examples of Image Imperfections in Scene Data



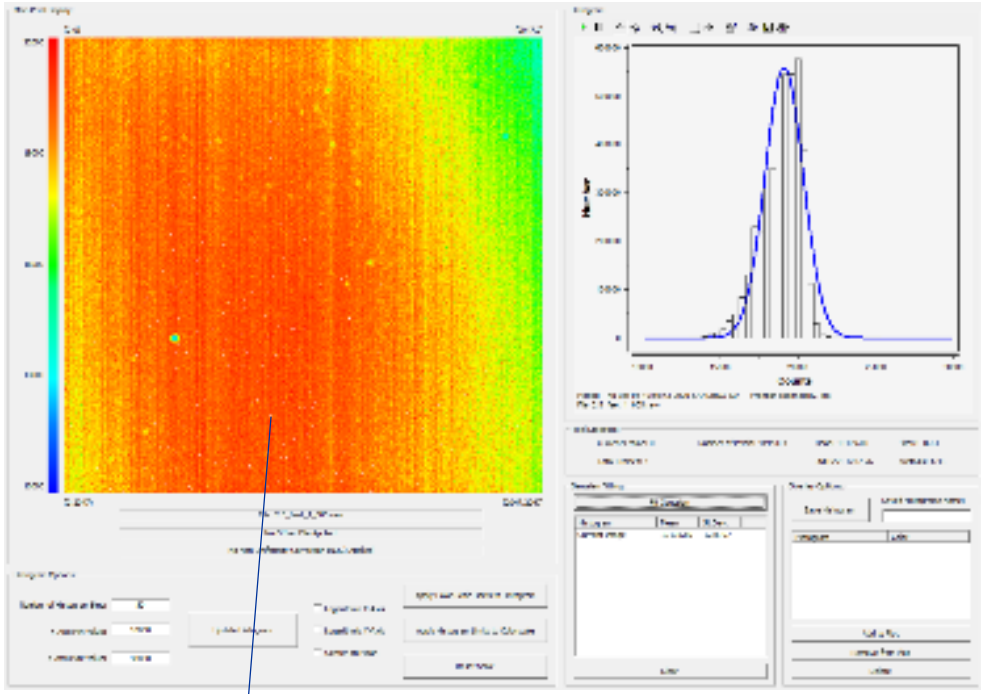
- Change the color scale (false color) and zoom in on a “flat” section of the image.
- Readout lines are visible as darker columns.
- Example of an imperfection data that is correctable.

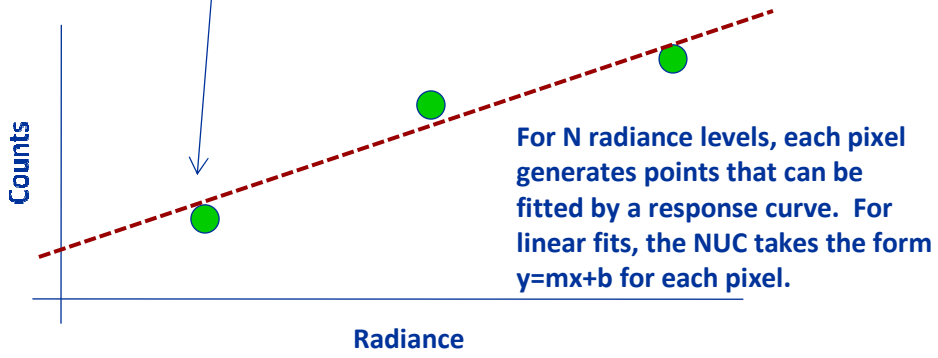
Focal Plane Imperfections Using a Uniform Source



- "spots" on the focal plane due to contamination effects, etc.
- If the pixels can be shown to at least be responsive, these effects are correctable.

Correcting Non-Uniformities in Pixel Gain



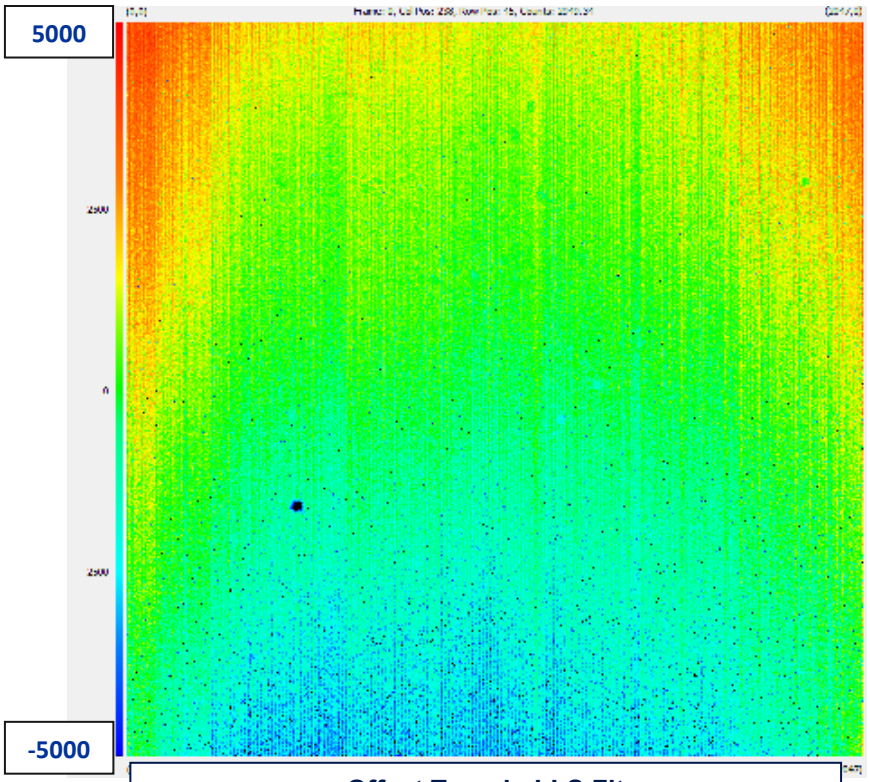


- A non-uniformity correction (NUC) accounts for pixel-to-pixel differences in gain characteristics.
- NUCs can be generated by fitting each pixel's counts-to-radiance (response) curve. The fit can be linear or non-linear.
- Fixed pattern noise, rolloff effects, and pixel-to-pixel response inconsistencies will be removed from NUC-ed images.
- The Gaussian noise distribution of a focal plane illuminated by a flat field source will have a smaller standard deviation after a NUC has been applied.

LLS NUC Results

LLS NUC fit frames.

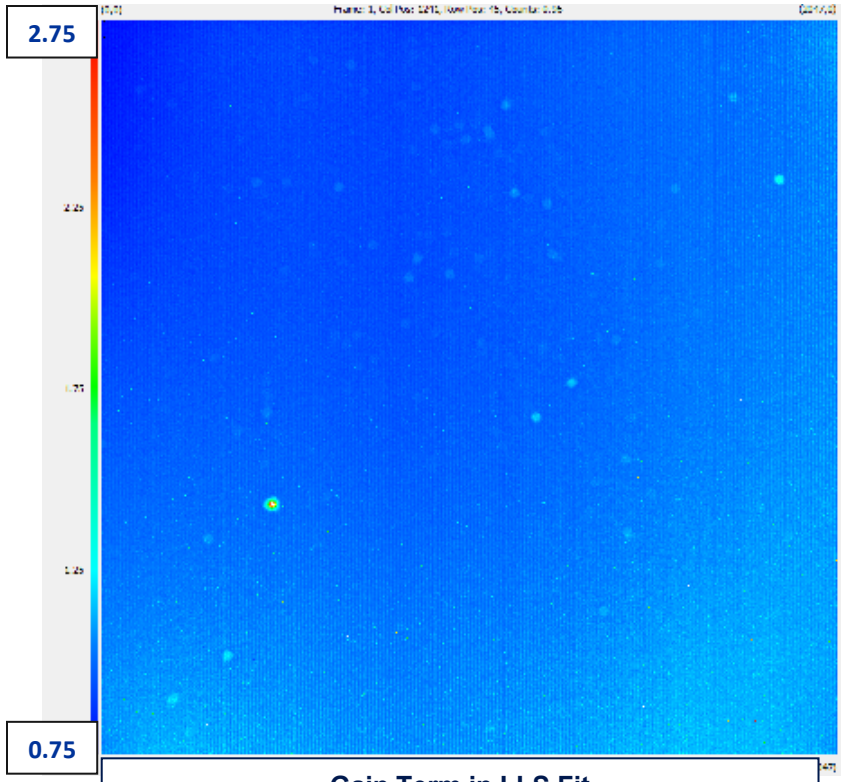
A_0 (offset) and A_1 (gain) terms shown for each pixel below



Offset Term in LLS Fit

Color scale -5000 to 5000 counts

Over Full Array - Mean: -74.48 Stdev: 1723.47

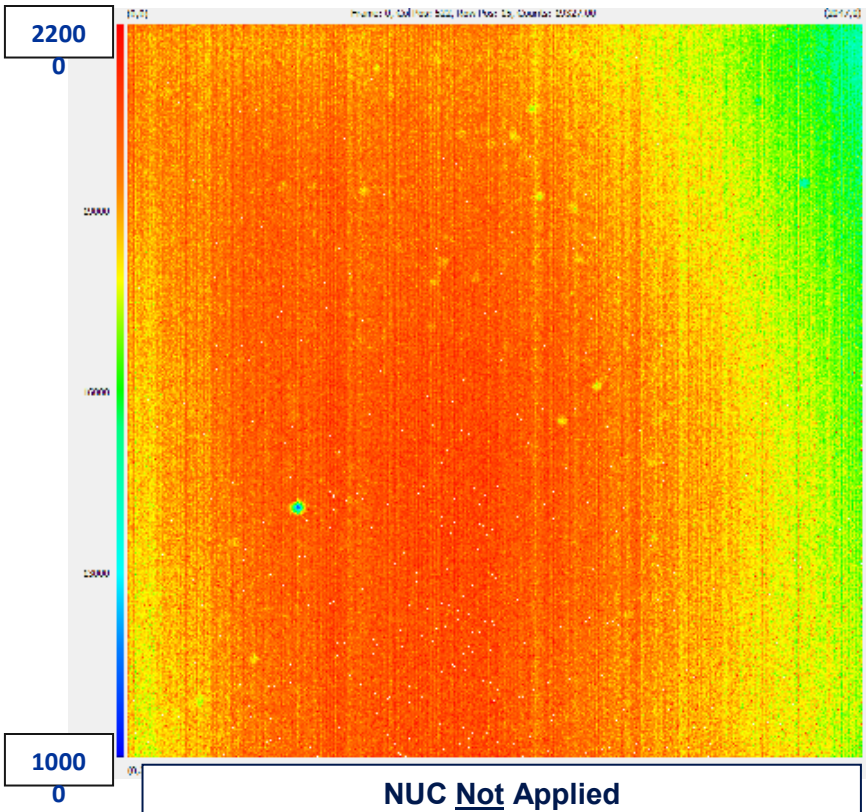


Gain Term in LLS Fit

Color scale 0.75 to 2.75 counts

Over Full Array - Mean: 1.01 Stdev: 0.08

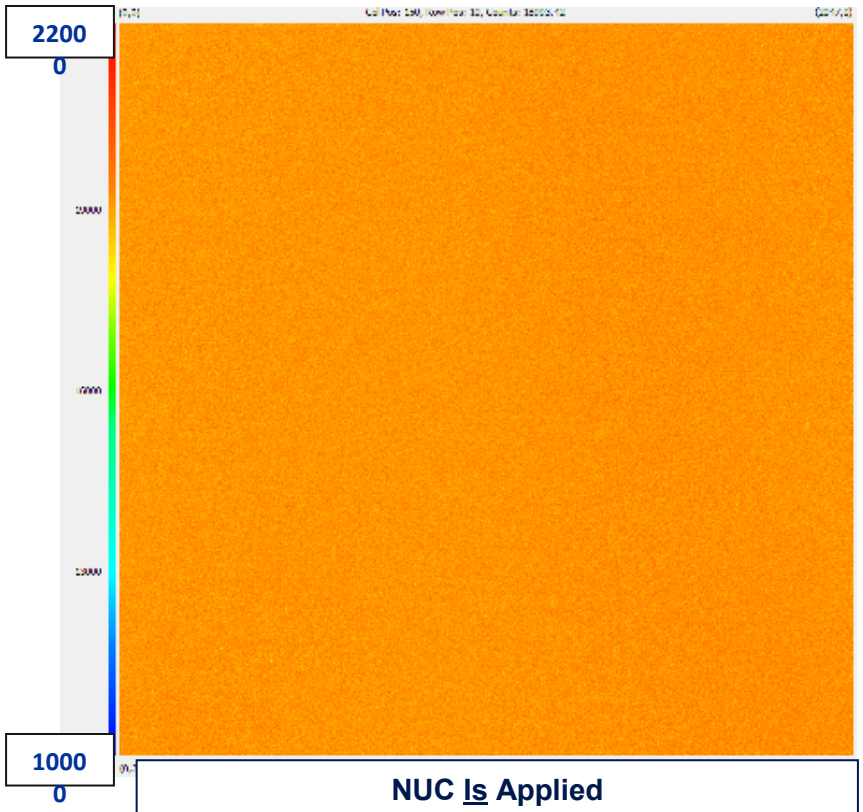
Application of NUC to Flat Field Data



NUC Not Applied

Scale: 10000-22000 counts

Over Full Array - Mean: 19109.00 Stdev: 1237.76



NUC Is Applied

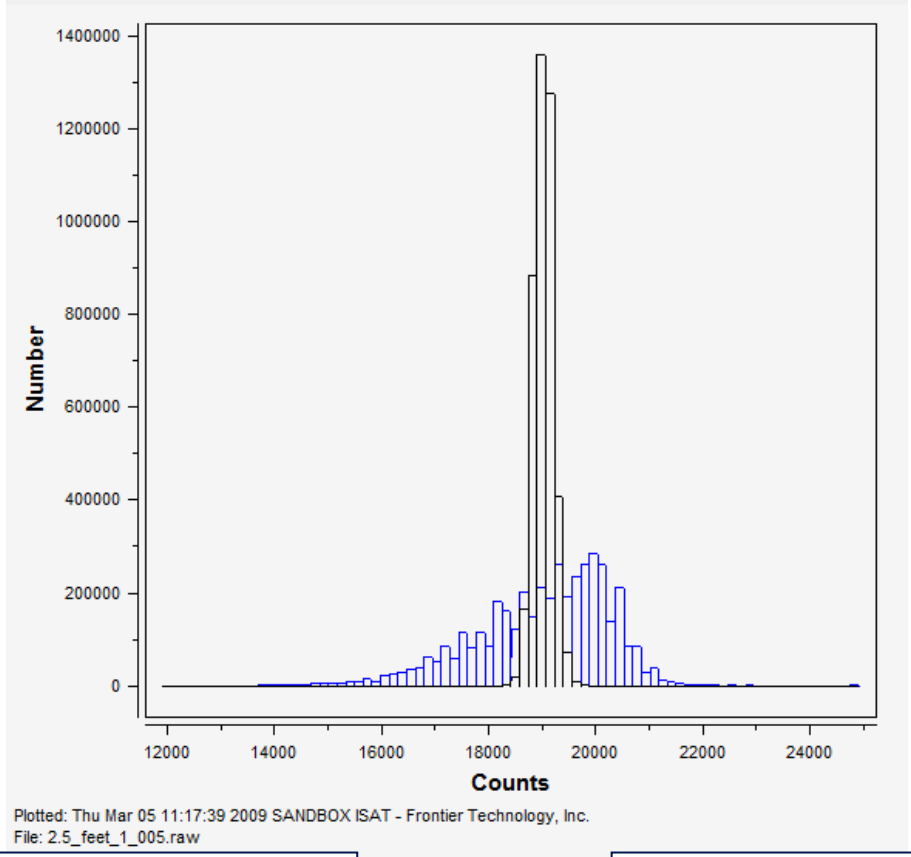
Scale: 10000-22000 counts

Over Full Array - Mean: 19111.68 Stdev: 171.54

Note the ~86% reduction in the standard deviation

“Before and After” Comparison (1/2)

Histograms using the full array. Blue: No NUC, Black: NUC Applied



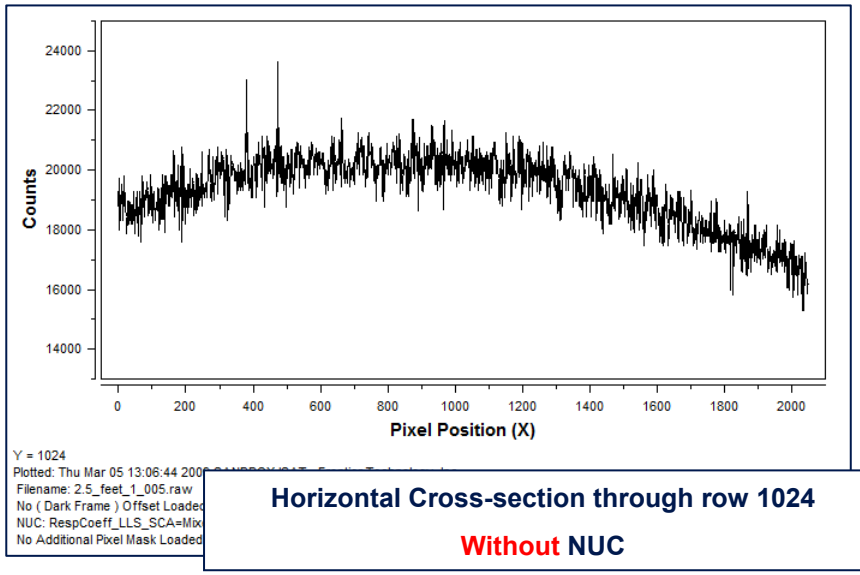
NUC Not Applied

Over Full Array - Mean: 19109.00 Stdev: 1237.76

NUC Is Applied

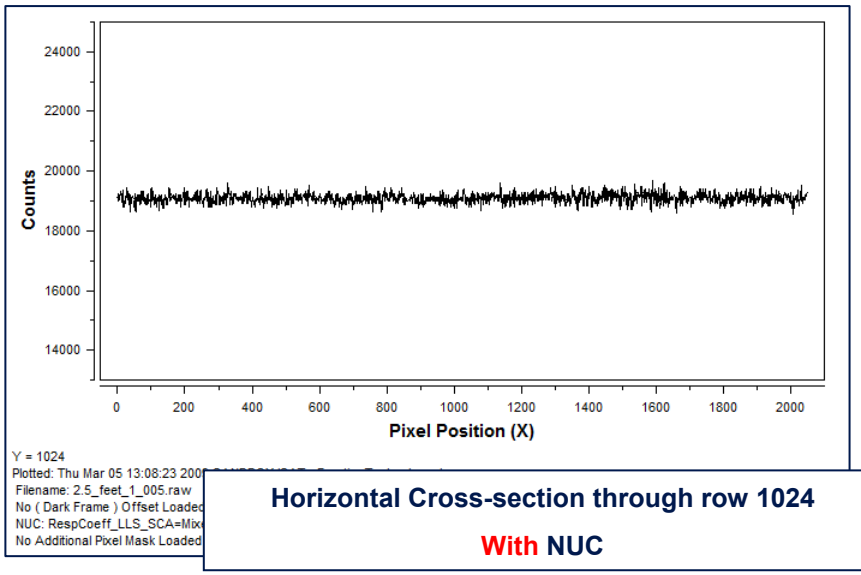
Over Full Array - Mean: 19111.68 Stdev: 171.54

“Before and After” Comparison (2/2)



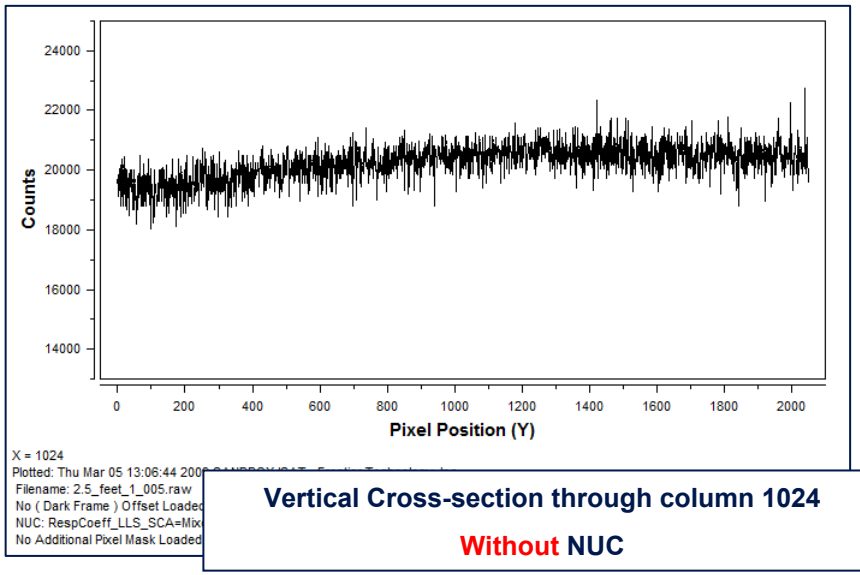
Horizontal Cross-section through row 1024

Without NUC



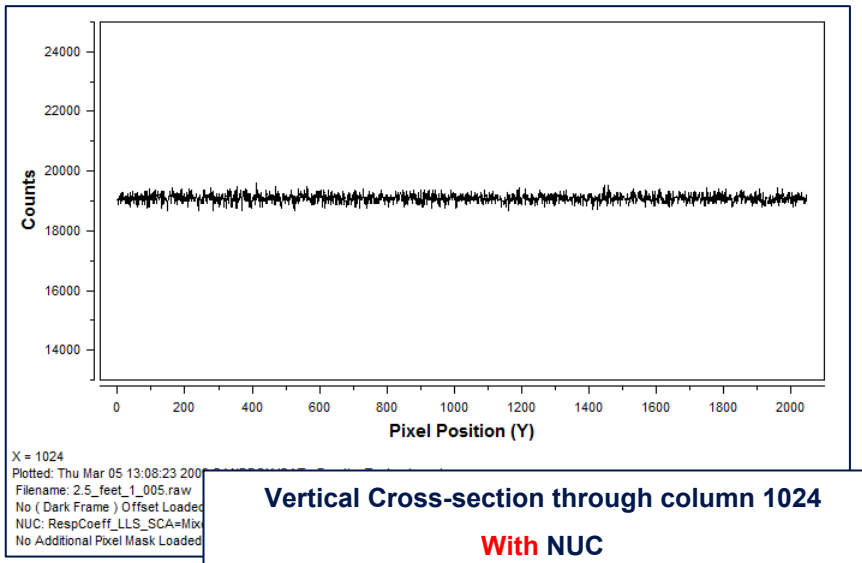
Horizontal Cross-section through row 1024

With NUC



Vertical Cross-section through column 1024

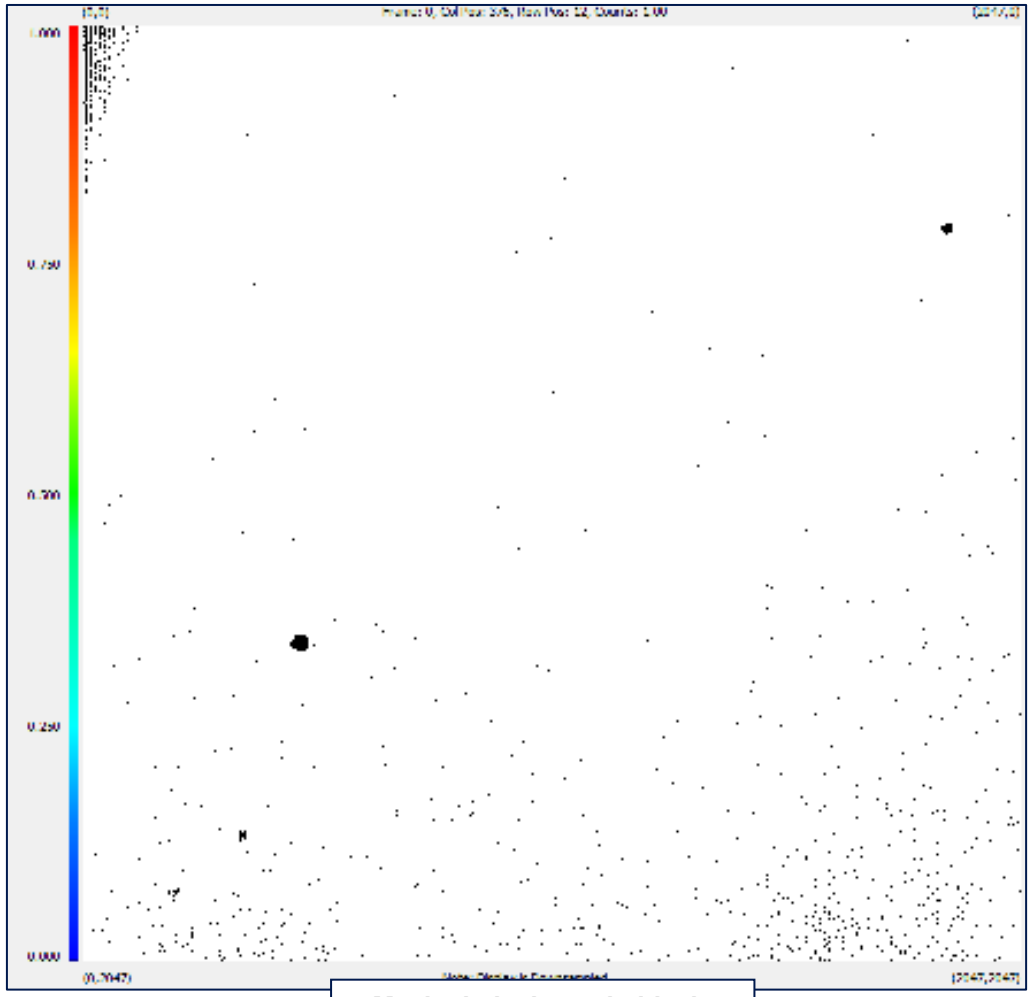
Without NUC



Vertical Cross-section through column 1024

With NUC

Bad Pixel Masking



Masked pixels are in black.

Bad pixel mask created by establishing thresholds on offset and gain.

- **Offset Min: -3500 counts**
- **Offset Max: 3500 counts**

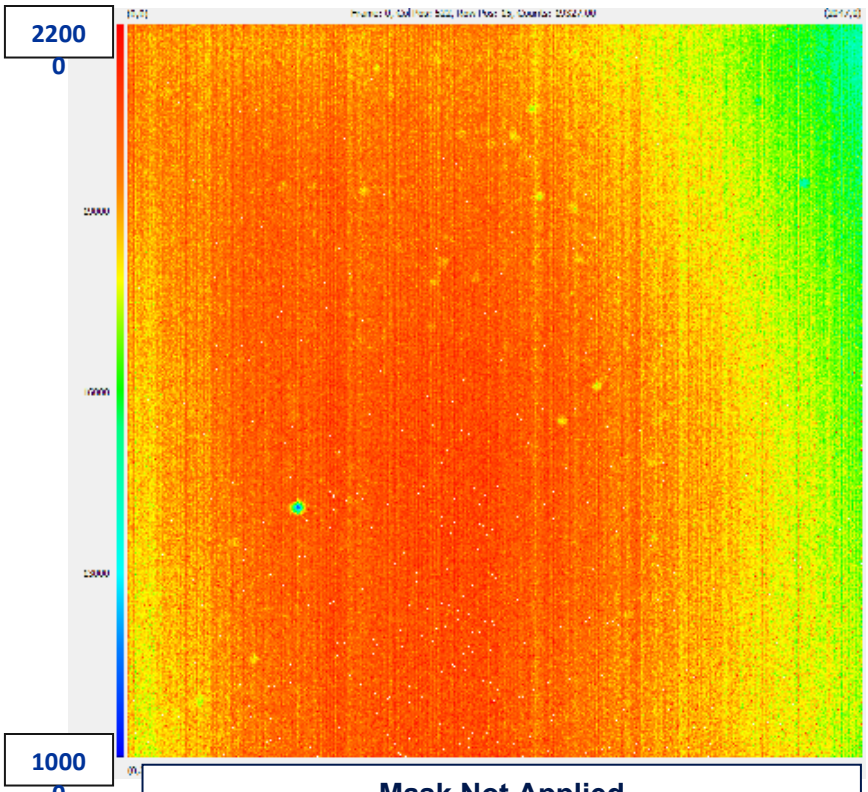
- **Gain Min: 0.8**
- **Gain Max: 1.2**

~21000 pixels masked out of over 4 million.

- **~5000 masked due to gain**
- **~20000 masked due to offset**

Note: total reflects the fact that some met some pixels were masked to due both gain and offset.

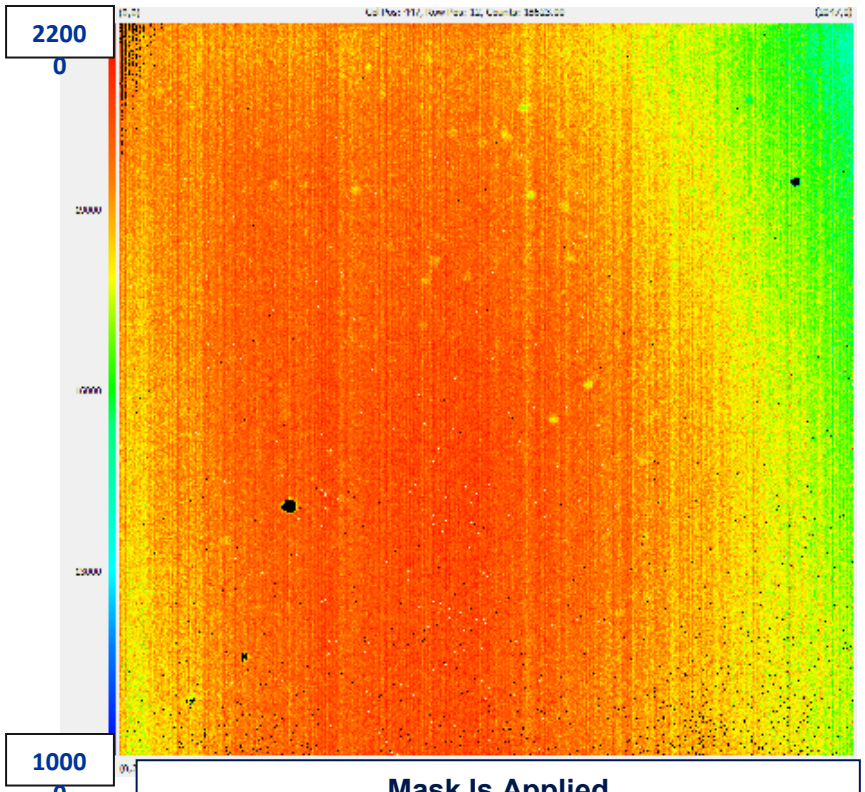
Application of Mask to Flat Field Data



Mask Not Applied

Scale: 10000-22000 counts

Over Full Array - Mean: 19109.00 Stdev: 1237.76



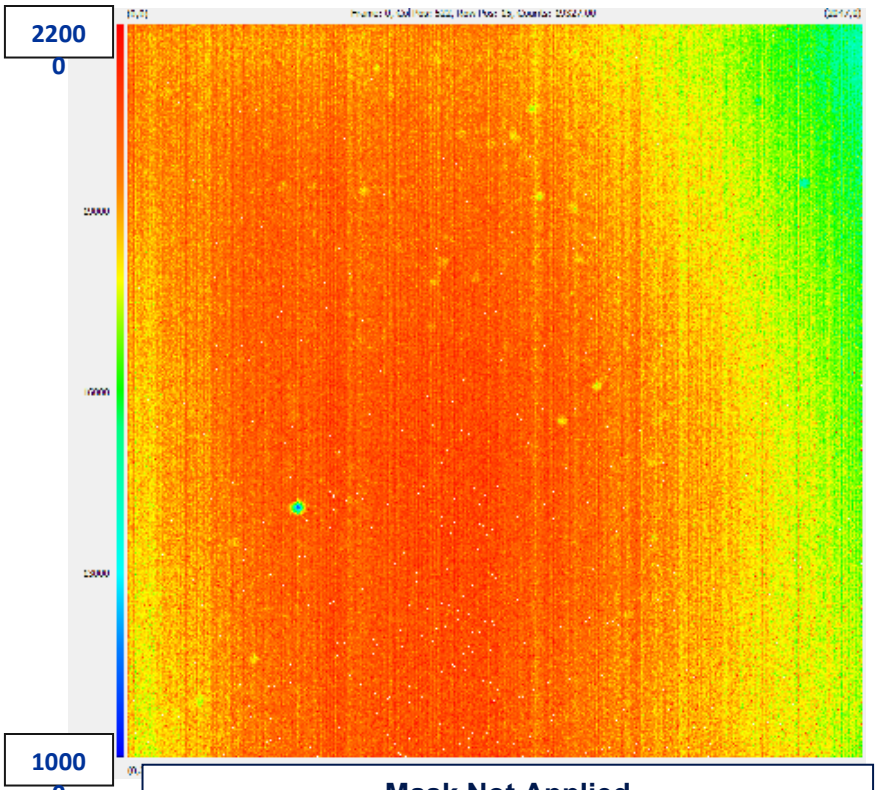
Mask Is Applied

Scale: 10000-22000 counts

Over Full Array - Mean: 19105.16 Stdev: 1225.31

By Choice, Eliminated Only Strong Imperfections

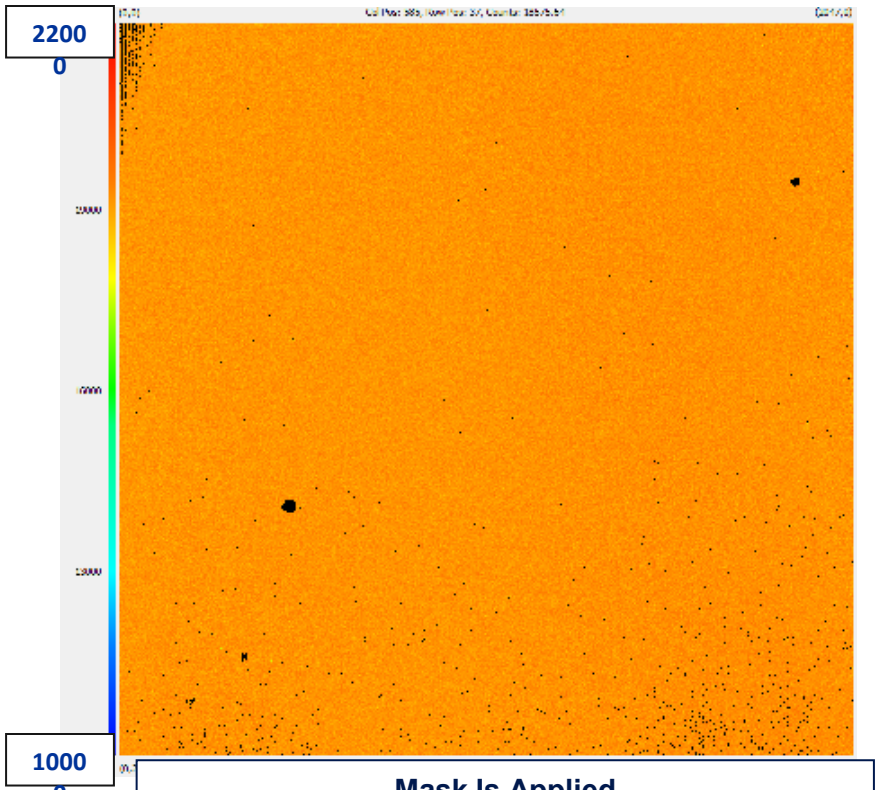
Application of NUC and Mask to Flat Field Data



Mask Not Applied

Scale: 10000-22000 counts

Over Full Array - Mean: 19109.00 Stdev: 1237.76



Mask Is Applied

Scale: 10000-22000 counts

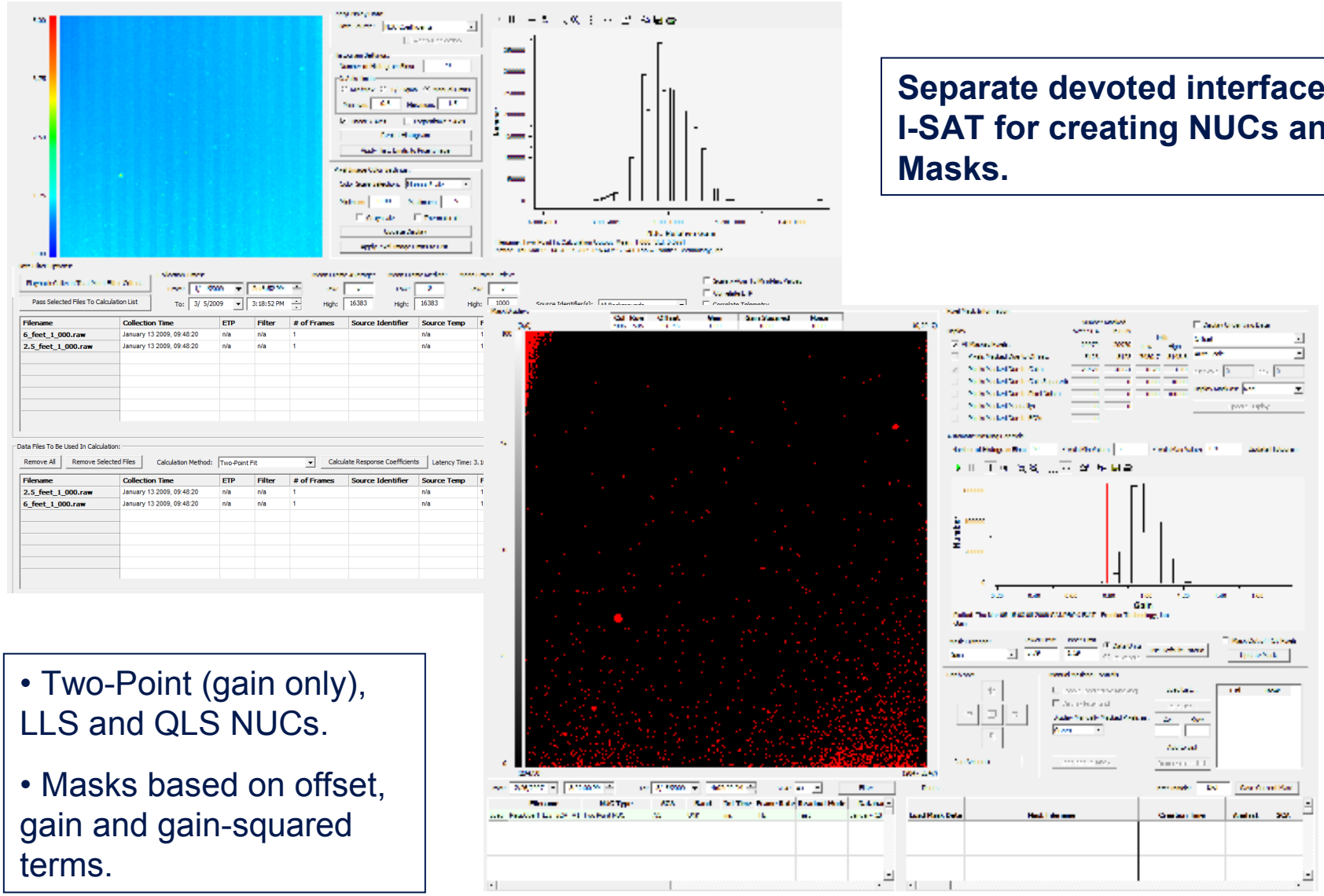
Over Full Array - Mean: 19105.16 Stdev: 169.72

Corrections/Mask Generated and Applied in I-SAT™

What is I-SAT™?

- I-SAT is a 4th generation software package designed and optimized for calibration, data reduction, and data analysis of large array focal planes.
- I-SAT incorporates a proprietary data visualization component that is capable of storing and displaying multiple frames of *NxM* data where the actual dimensions of the data array are dictated solely by hardware constraints.
- I-SAT utilizes parallelized algorithms to distribute CPU usage across multiple processing cores. It is also built in a modern code base and compatible with 64-bit Windows OS. As such, very large image sizes can be accommodated.
- I-SAT is mission-tested, having been used as the analysis software package on multiple large space-based sensor ground calibration programs.

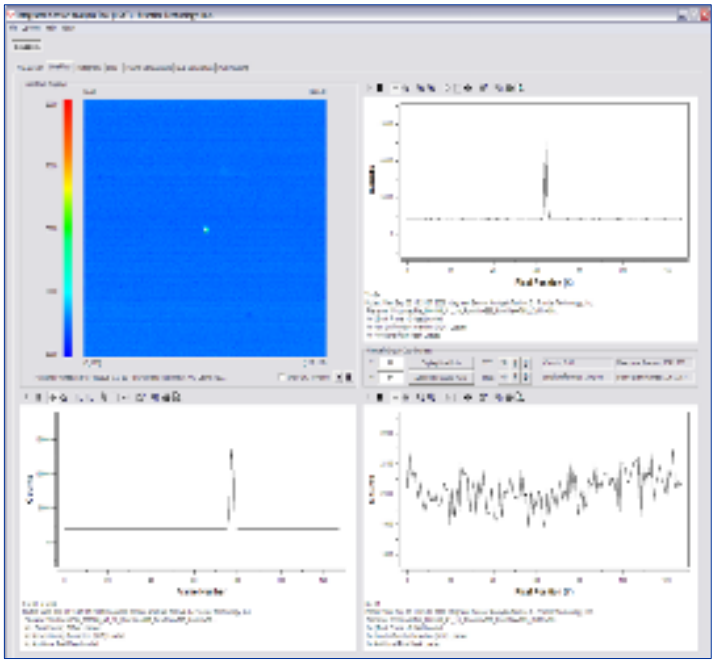
Generating Non-Uniformity Corrections and Pixel Masks

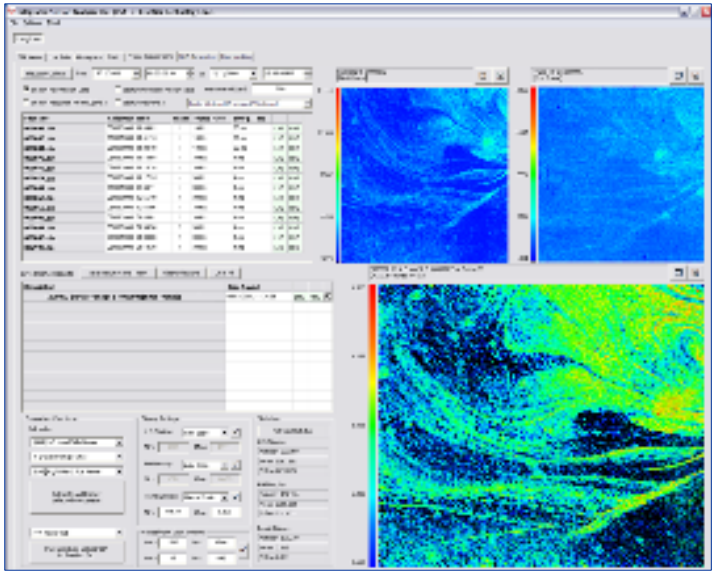


Separate devoted interfaces in I-SAT for creating NUCs and Masks.

- Two-Point (gain only), LLS and QLS NUCs.
- Masks based on offset, gain and gain-squared terms.

What Else Can I-SAT Do?





Sensor Calibration and Performance Evaluation Tools

Features

- Designed to enable rapid calibration and performance evaluation on multi Tb data sets
- Critical calculations embedded
- Changes in visualization of input data or output results with single click
- Simple data output to tables and images for presentation
- Integrated data base for input and output
- Transparent transfer of data from tab-to-tab

Benefits

- Perform critical calibration calculations quickly for multiple mega pixel arrays
- Shortens calibration and characterization timelines from days to minutes

Conclusions

- Focal plane image data contain many flaws and features that can be corrected using special analysis techniques.
- Non-uniformity corrections are used to reduce the effects of fixed pattern noise, vignetting and pixel-to-pixel response differences.
- Bad pixel masks are used to eliminate the effects of strong or uncorrectable imperfections. Masks can be generated based on offset, noise, gain, and gain-squared terms.
- I-SAT™ is a sensor calibration and analysis software product available for purchase to the community that can generate and apply these corrections. Website: http://www.fti-net.com

Thomas L. Murdock
tmurdock@fti-net.com
(978) 927-4774 x115

Daniel R. Taylor
dtaylor@fti-net.com
(978) 927-4774 x106

Chris Cooper
ccooper@fti-net.com
(978) 927-4774 x104

David B. Pollock
pollockd@email.uah.edu
(256) 824-2514