# A Robust Star Removal Algorithm for the Neutron Imaging System Diagnostic


George Labaria[1,2], Abbie Warrick[2], David Fittinghoff[2], and Petr Volegov[3]

University of California, Santa Cruz[1]; NIF, Lawrence Livermore National Laboratory[2]; Los Alamos National Laboratory[3]



***The Neutron Imaging System (NIS) diagnostic is an important tool for measuring the size and shape of the burning deuterium-tritium plasma during the ignition stage of inertial confinement fusion implosions. The NIS uses a pinhole neutron aperture array with penumbral apertures which is placed between the neutron source and a neutron detector. An iterative maximum likelihood algorithm reconstructs the neutron source from the observed image. However, during image collection, some neutrons scatter from the flight path and interact directly with the CCD elements, producing bright pixels called "stars," which could negatively impact the reconstruction. An automated algorithm has been developed to remove these stars and is in the process of being integrated in the NIF automated analysis framework.***


## Introduction

The National Ignition Facility (NIF) utilizes the Neutron Imaging System diagnostic to provide data on the size and shape of the fusion hotspot and surrounding cold fuel during the ignition stage of the inertial confinement fusion implosions.

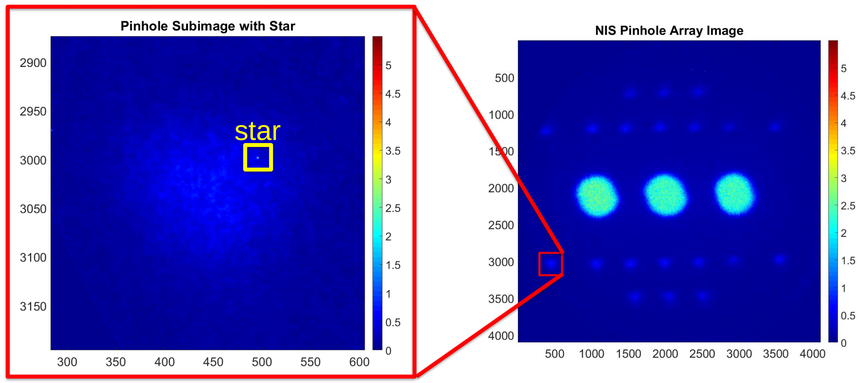
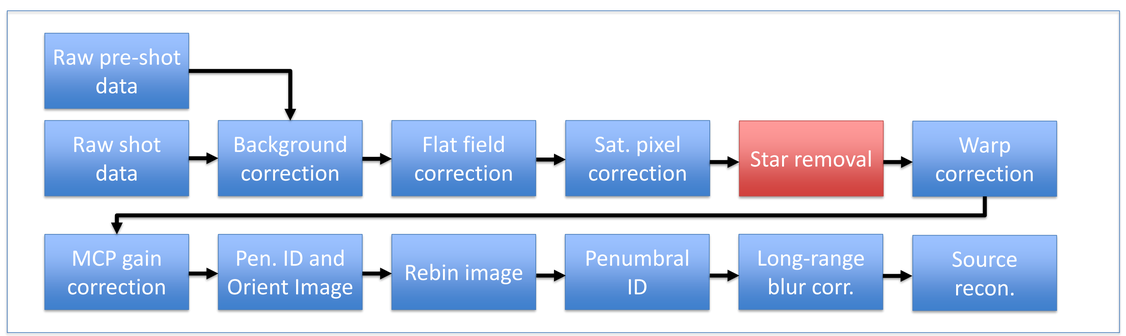



Figure 3. A typical example of a star in the pinhole region.

- Some neutrons scatter from the flight path and interact directly with the CCD, producing bright pixels called "stars" (figure 3).
- These stars negatively impact noise modeling and pinhole extraction algorithms.
- The star removal algorithm is a small but critical component in the NIS image pre-processing.
- The previous version of the star removal algorithm lacked the ability to correct stars that were greater than a pixel in size.
- Examination of the data suggests that stars greater than a pixel do exist.




## Star Removal Algorithm

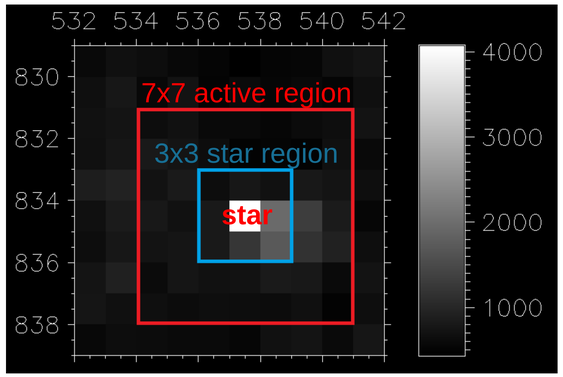



Figure 4. Active and star region pixels.

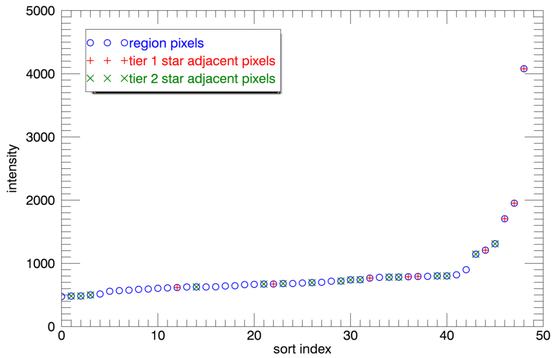



Figure 5. Active region pixel intensity profile.

- Let $N_{7x7}(i)$ be the 7x7 set of pixels centered around $i$ (figure 6).
- Let

$$reldiff(i) = \frac{i - med\left(N_{7x7}(i)\right)}{std\left(N_{7x7}(i)\right)}$$

- Pixel $i$ is flagged as a star if $reldiff(i) \geq 6$.
- If pixel $i$ is a star, then the eight adjacent pixels are considered and flagged as part of the star if $reldiff(j) \geq low\_thres$ where $j \in N_{3x3}(i) \backslash \{i\}$. The threshold $low\_thres$ is typically set to 3 or 1.5, determined by the data in $N_{7x7}(i)$.
- Flagged star pixels $i$ are replaced by the median $med\left(N_{7x7}(i)\right)$.

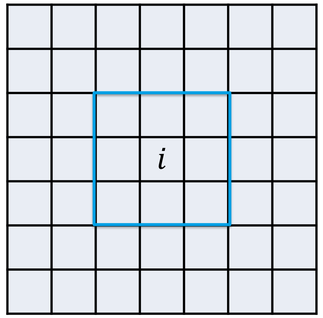
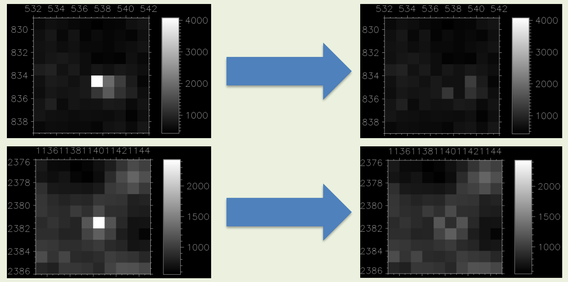



Figure 6. Schematic of $N_{7x7}(i)$.

## Results and Concluding Remarks



The star removal algorithm is a critical component to the image-preprocessing component for the NIS diagnostic. The algorithm provides a plausible replacement for the star pixels based on the surrounding data, which ultimately improves noise modeling and the centering of the pinhole extraction algorithm.


LLNL-POST-735383

National Ignition Facility • Lawrence Livermore National Laboratory • Operated by the US Department of Energy

This work performed under the auspices of the U.S. Department of Energy and an appointment to the Office of Science, Science Undergraduate Laboratory Internship (SULI) Program at the Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.


Lawrence Livermore National Laboratory

NIF&PS