NICMOS Closeout / Legacy Calibration

Overall context:

- NICMOS on-orbit for 10 yrs, post-NCS 5 yrs; >100,000 datasets in archive
- Continues as major science instrument in current Cycle
- Post-SM4 usage will be likely reduced, more science done with WFC3/IR
- Current Cycle - important to characterize instrument as fully as possible

Calibration:

- Expanded normal calibration program (additional flats, darks)
- Special close-out calibration programs (photometry, grism, distortion)

Software:

- Recently completed: SAAclean, Staypuft, count-rate non-linearity
- Currently in progress: improved CR rejection, temperature from bias
- Near-term: pedestal correction, amp glow persistence, electronic shading

Documentation:

- Write-ups providing full description of all the instrumental effects
- Complete revision of Instrument and Data Handbooks

NICMOS Legacy Calibration Programs

Motivation:

- Dominant effects in NICMOS data are related to:
  - temperature
  - persistence
- Inadequately correcting for effects often limits the achievable science
- Improve characterization through calibration /software to improve science

Expanded normal calibration programs

- Improved flatfields - all filters, all cameras
- Increased numbers of darks - repeated observations for all the most widely used read-out modes (spars + step sequences)

Special “legacy” calibration programs

- Improved photometric non-linearity calibration in all cameras
- Photometric cross-calibration
- Revised geometric distortion
- Improved grism calibration across entire detector

Expanded "normal" calibration programs

Improved flatfield programs

- Target all filters on all 3 cameras
- Last complete set of flats was obtained in Cycle 7
- Need to investigate time-dependent and temperature-dependent effects

Expanded dark calibration

- Darks provide a very direct measure of temperature-dependent effects:
  - amplifier glow
  - shading
  - etc
- However, depends on the exact read-out sequences and timing (SPARS, STEP, etc)
- Dark program to date has been fairly minimal (total ~36 orbits / cycle)
- Aim to expand dark / internal exposures by ~10x to cover more fully the variety of readout sequences, as well as covering a range of temperatures to enable construct more real darks and reduce reliance on synthetic darks

Special "legacy" calibration programs

Photometric non-linearity calibration

- current observations:
  - lamp-on/off measurements of standard target (NGC3606)
  - sufficient to show overall shape of the effect, but still large uncertainties on the measured coefficients
- need to characterize the effect for a wider range of count-rates and exposure times

Spectrophotometric standards

- Goal: update grism sensitivity curves, and provide cross-calibration data for other instruments
- grism spectroscopy:
  - 3 primary standards (GD71, G191B2b, GD153)
  - 9 secondary standards (P177D, P330E, C26202, SF1615+001A, SNAP-1, SNAP-2, 2M0559-14, 2M0036+18, VB8)
- imaging of grism standards to provide cross-calibration with WFC3, JWST, other future missions:
  - expand current program to include more spectrophotometric standards

"Legacy" calibration programs (cont'd)

Improved grism calibration

- Grism wavelength zeropoint and dispersion are only really well characterized at the nominal centre of the grating
- In order to improve legacy archival science value, need to characterize this across the entire detector:
  - evidence suggests that errors up to a few pixels exist
  - can be readily calibrated by placing targets at different locations on detector

Geometric distortion

- Evidence for changes of ~1-2 pixel since the last geometric distortion measurements (pre-2002)
- important to characterize for a wide range of filters, all 3 cameras
- observe astrometric standard field (NGC1850)
- aim to achieve ~1/4 NIC2 pixel accuracy

NICMOS Calibration Software

Recently completed:

- SAAclean
- Staypuft

Currently in progress:

- Count-rate-dependent non-linearity correction
- Temperature from bias
- Improved CR rejection and error array calculation

Near-term:

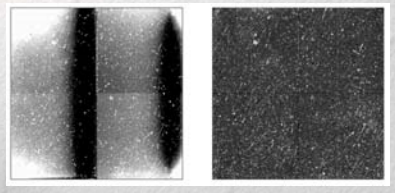
- Pedestal correction
- Amp glow persistence
- Supershading

Other:

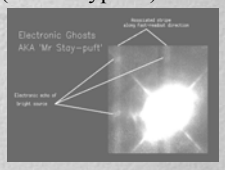
- Bias jump correction
- Vignetting

NICMOS Detector Effects - Correctable using Software

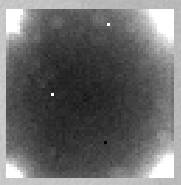
SAA-impacted CR persistence



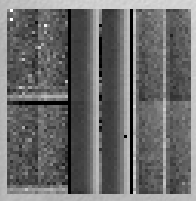
Electronic ghosts
("mr. Staypuft")



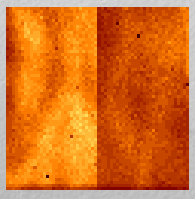
Amplifier glow



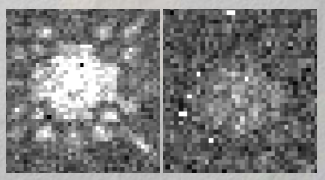
Electronic shading



"Supershading"



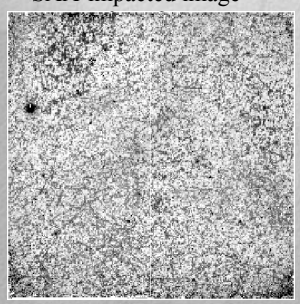
Bright object persistence



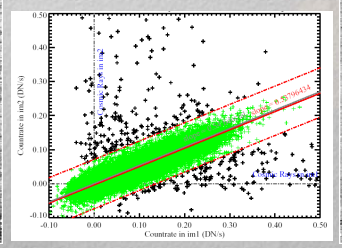
SAAclean - CR persistence removal

- SAA-persistent CRs impact large fraction of NICMOS data (~40 - 50%)
- Can be removed using darks obtained immediately prior to observations that begin after an SAA passage
- Script creates a model of the persistent CRs, scales and subtracts from the data (Bergeron ISR 2003-10; Barker et al. 2005 HST Cal. Workshop)
- "SAAclean" script has been implemented and delivered in Pyraf/STSDAS

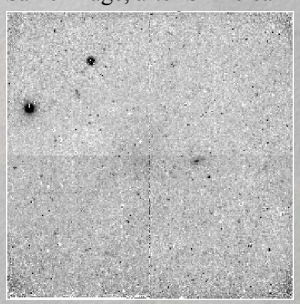
SAA-impacted image



Model of CR-persistent pixels created inside SAAclean

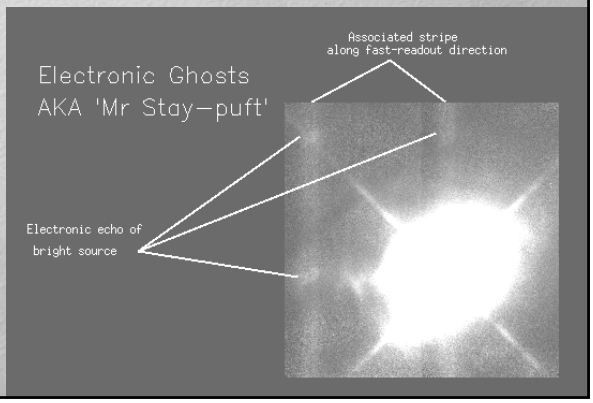


Same image, after SAAclean



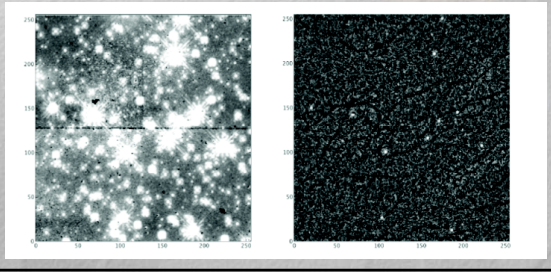
Electronic crosstalk ghosts ("mr. Staypuft")

- Occurs with very bright sources
- Essentially due to a pull-down of the power supply after reading high counts from one quadrant - hasn't completely recovered when reading out subsequent quadrants.
- Two principal effects:
  - mirror echoes of the source in the other quadrants
  - bright stripes along the fast read-out direction
- Can be corrected using the "puftcorr" software
- Currently completing testing, preliminary version in Pyraf



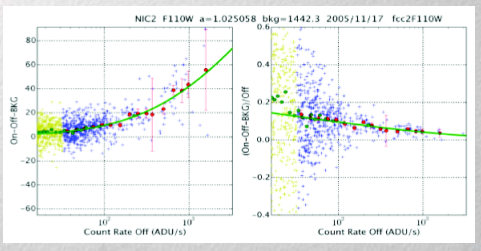
Count-rate Non-linearity

- Systematic offset in flux that depends on count-rate (Bohlin et al. ISR 2006-02, de Jong et al. ISR 2006-01,03)
- Different from the usual total-count linearity
- Appears to have wavelength dependence as well
- Does not appear to be accounted for by persistence
- Software currently being released in Pyraf: "rnlincor"
- Recent test: obtain images with the calibration lamp on and off:
  - subtract them to compare the difference
  - find residuals that depend on the count-rate (star + background)

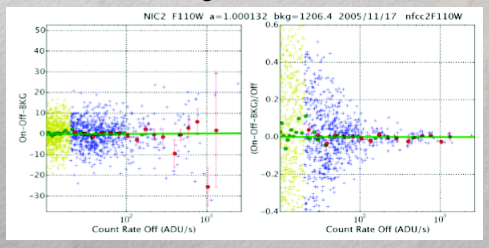


Count-rate non-linearity correction

Count differences before correction:



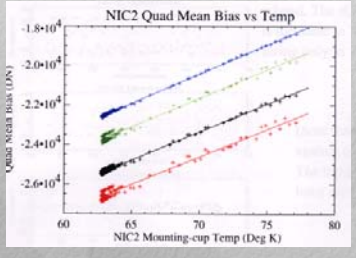
Count differences after running correction software:

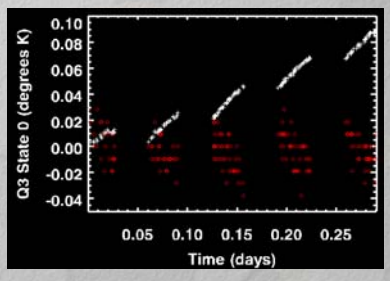


Measuring Temperature from bias level

- The problem:
  - many NICMOS electronic effects are extremely sensitive to temperature
  - the mounting cup temperatures do not measure the actual detector temperature
- Solution:
  - use detector as "diode" to measure temp (Bergeron 2005, HST Cal Workshop)
- The 0th-read bias correlates approximately with temperature
- Work currently in progress (Bergeron et al) shows it may be possible to measure temp to 5-10mK precision after accounting for voltage effects

(Bergeron 2005, HST Calibration Workshop)

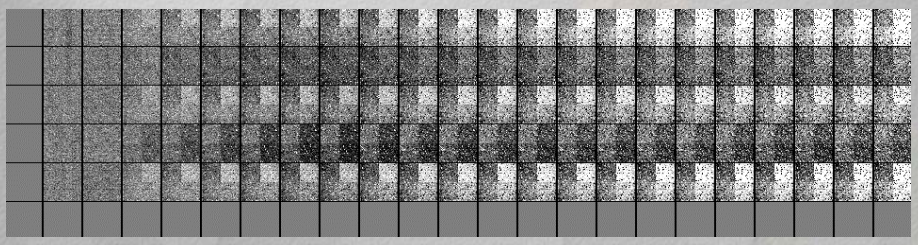




Pedestal Correction

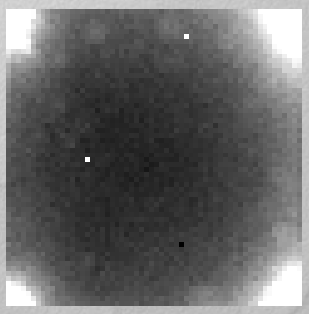
- Current pedestal correction is done empirically:
  - "pedsky" - assumed the image is mostly empty
  - "pedsub" - works well for crowded images
  - However, both have their limitations
- Experience suggests that pedestal offsets are very likely correlated with temperature and/or spacecraft bus voltage
- Thus, if the temperature and bus voltage are measured more accurately (using temp from bias), pedestal can be removed deterministically

(sequences of NICMOS multiaccums showing varying pedestal offsets - courtesy Bergeron)



Amplifier Glow Persistence

- Common problem affecting all NICMOS observations
- Whenever the detector is read out, the amplifiers are turned on
- Signal therefore correlates directly with the number of readouts since the last reset
- Currently there exists preliminary software to remove this using synthetic darks and empirical scaling to the observed signal
- Goal is to test this software, make it more robust, and incorporate into standard NICMOS calibration



Other planned calibration software work:

- Improved Cosmic Ray rejection in calnica 
- Electronic shading correction 
- Bias jumps 
- Linear dark current component removal 
- Supershading 
- Vignetting 
- Eventual goal: improve NICMOS calibration to be of the same quality as that automatically achieved for ACS/WFPC2...
- Open to additional suggestions...