InSb (3.6 & 4.5μm) Linearization

Frank Masci

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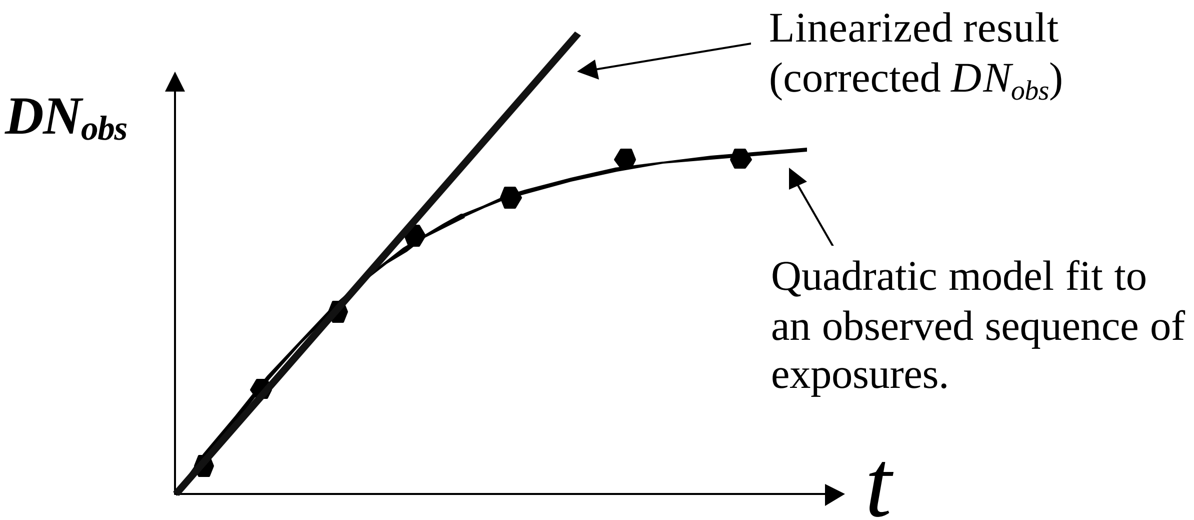
Preliminaries

- We have a new module ("Fowlinearize") that will correct InSb (Channels 1 and 2) array data for non-linearity using a model that is a quadratic in time:

$$DN_{obs} = mt + At^2$$

- A quadratic function meets the 1% requirement over entire data range for the InSb flight array only.
- The coefficients of the above model are computed by the LINCAL module (in the Linearity Calibration Thread), where *m* = linearized count rate and *A* = quadratic coefficient.



Processing in Pipeline

Input Science Data

SANITY_DATATYPE – FITS-header data check
QATOOL – Image-data quality-assurance characterization
SANITY_CHECK – Image-data check
TRANHEAD – Translation/derivation of required FITS keywords
INSBPOSDOM – Positive-domain transformation of InSb data
CVTI2R4 – Conversion from I*2 to R*4 & truncation correction
IMFLIPROT – Image re-orientation
IRACWRAPDET1 – Detection of negative image-data values
IRACWRAPDET2 – Spatial detection of negative values
IRACWRAPCORR – Correction of negative image-data values
IRACNORM – Barrel-shift correction & Fowler-*N* normalization
IRACEBWC – Electronic bandwidth correction of image data

SNESTIMATOR – Estimate noise image

DARKSUB – Dark-current subtraction
MUXBLEEDCORR – Mux-bleed correction
DARKDRIFT – Dark-current offset estimation & removal
FOWLINEARIZE – Linearity correction
FLATAP – Flat-field correction

Linearity correction

RHDETECT – Single-frame LMF rad-hit detection

DNTOFLUX – Conversion from DN to absolute flux-density units

QATOOL - Quality-assurance characterization

Output BCD ready for archiving

Inputs/Outputs to Linearization Module

- **INPUTS:**
  - Single plane science DCE (FITS image).
  - Non-linearity (quadratic) model coefficients for every pixel.
  - Noise model image to use in error propagation.
  - Mask images which specify: hot/dead pixels, saturated pixels, and pixels for which a non-linearity model could not be computed.

- **OUTPUTS:**
  - New science DCE with linearized counts.
  - Corresponding uncertainty image for the linearized DCE.
  - Updated “dce-mask” image indicating which pixels could and could not be linearized.
  - Output log file showing processing statistics and error messages.

Formalism

- Inversion of the above quadratic includes a correction due to “Fowler sampling error”.
- Fowler sampling is used to reduce the effective read read noise. This causes the actual number of photons in the well to exceed that returned by the read-out electronics. Difference could be as large as 8%.
- The final solution for “true” linearized counts (DN) is as follows:

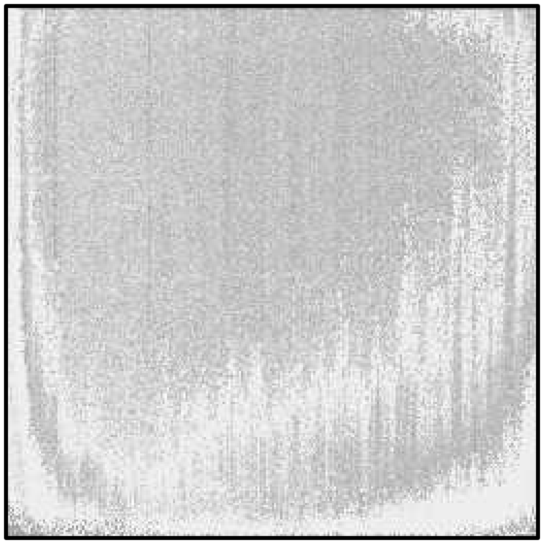
$$DN_{lin} = \frac{1 - \sqrt{1 - 4L_{cal} DN_{obs}}}{2L_{cal}}$$

- Where the constant L_{cal} depends on the quadratic model coefficients (A, m), number of “Fowler sample” read-out times (n) and number of “wait” periods (w) between pedestal and signal read-out times:

$$L_{cal} = \left(\frac{A}{m^2}\right)\left(\frac{1}{n(w+n)^2}\right)\left[\sum_{i=1}^{n} i^2 - \sum_{i=w+n}^{w+2n} i^2\right]$$

Image Input/Output Results

Testing on a transmission-calibrator flat in channel 1 (3.6μm) where all pixel counts are less than ≈ 1/4 the saturation value.



“Non-linearity model image” of A-coefficients

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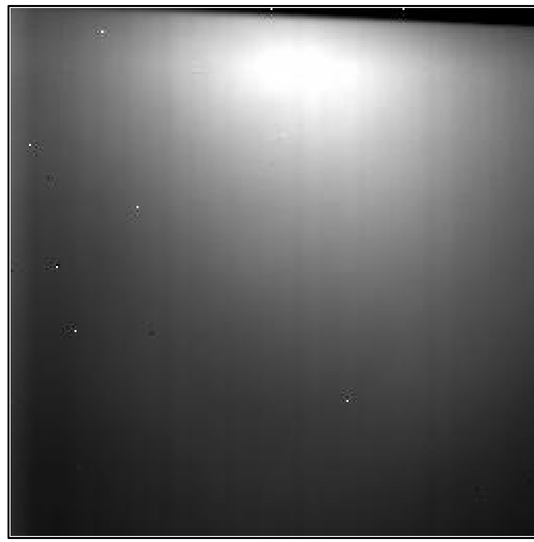
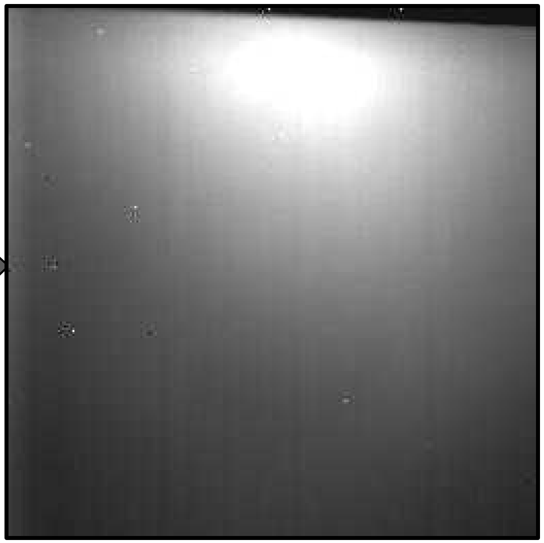


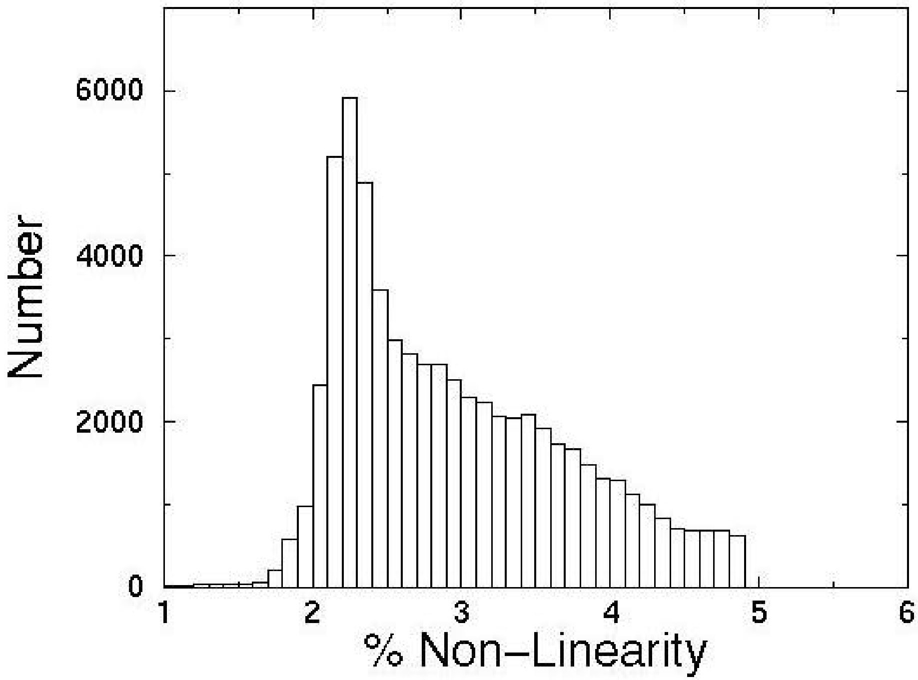
Raw (un-linearized)



Linearized image

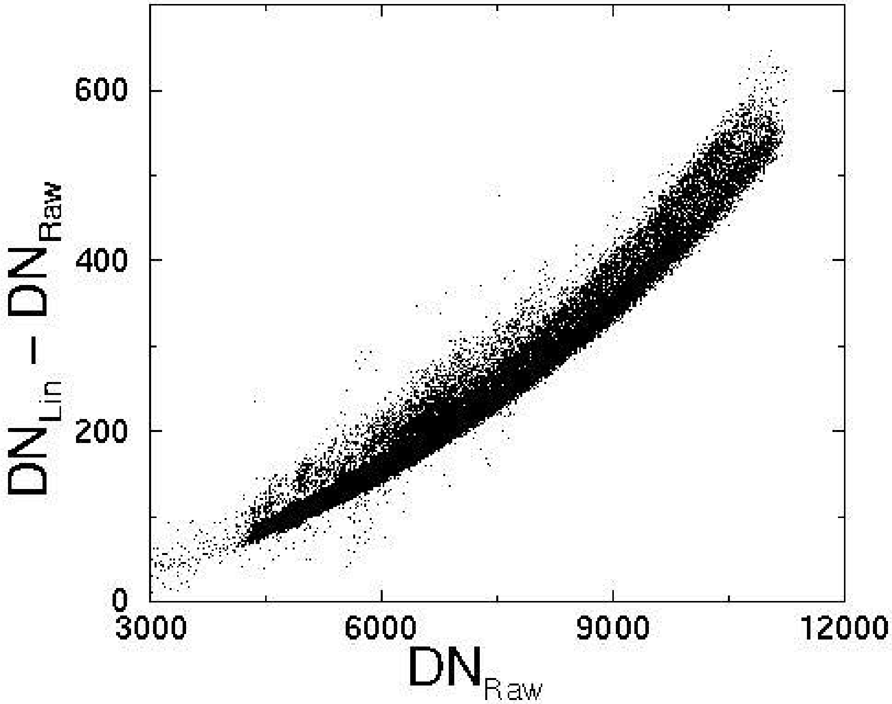
$$DN_{obs} = mt + At^2$$

Distribution of pixel non-linearities



$$\%NL = \frac{DN_{lin} - DN_{raw}}{DN_{raw}} \times 100$$

Linearized – Observed (raw) counts vs. observed counts.



SiAs Array Linearization

- SiAs arrays show considerable non-linearity below 90% full well compared to the InSb arrays which are essentially linear.

- We require a cubic function to meet the 1% requirement for fitting SiAs linearity data (5.8 and 8 μm bands) over the entire dynamic range (see presentation by J. Surace):

$$DN_{obs} = At + Bt^2 + Ct^3$$

- This must be inverted to solve for *t* and the linearized counts are given by $DN_{lin} = At$. Of the three possible roots, instrument team has shown that the appropriate physical solution is that which satisfies constraints from characterization of the non-linearity.

- This code upgrade will be completed by end of S6.