InSb (3.6 & 4.5\textmu m) Linearization

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Preliminaries

- We have a new module ("Fowllinearize") 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-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
- FOWLINERIZE – Linearity correction
- FLATAP – Flat-field 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

Linearity correction
**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.
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:

\[
L_{cal} = \left( \frac{A}{m^2} \right) \left( \frac{1}{n(w + n)^2} \right) \left[ \sum_{i=1}^{n} i^2 - \sum_{i=w+n}^{w+2n} i^2 \right]
\]
Testing on a transmission-calibrator flat in channel 1 (3.6μm) where all pixel counts are less than \( \approx 1/4 \) the saturation value.

\[
DN_{\text{obs}} = mt + At^2
\]
Results

Distribution of pixel non-linearities

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

\[
\%NL = \frac{DN_{lin} - DN_{raw}}{DN_{raw}} \times 100
\]
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.