24μm SUR-mode Linearization: SLOPECORR

Frank Masci

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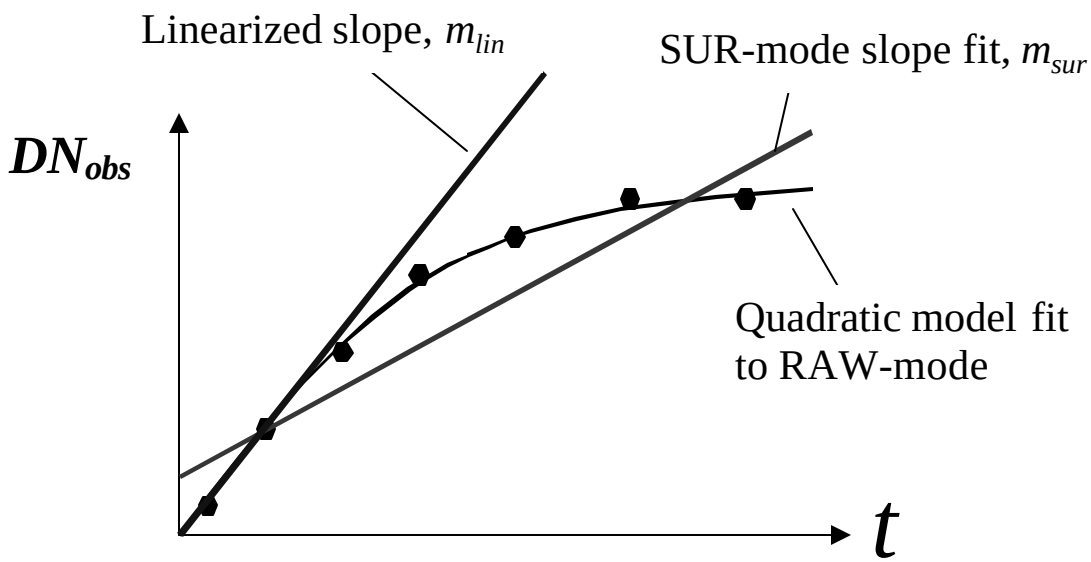
Aim

SLOPECORR corrects SUR-mode slope data for non-linearity in the“ramp” (or non-linearity in the RAW-mode).

Pictorial Representation



LINCAL: Computes non-linearity (quadratic) model from RAW-mode data:

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

SLOPECORR: Correct SUR-mode slopes for ramp Non-linearity

Processing in Pipeline

Input SUR-Mode Science Data

SANITY_CHECK– Header-data check
QATOOL – Image-data quality-assurance characterization
TRANHEAD – Translation/derivation of required FITS keywords
CVTI2R4 – Conversion from I*2 to R*4 & truncation correction

Saturated pixels are flagged here

SATMASK – Saturated-pixel detection
LATIMDETECT – Latent-image detection

CVTE - Convert to units of electrons

CUBESUB - Dark-current/offset subtraction

Linearity correction

SLOPECORR - Linearity correction (slope data only)

DROOPOP – Droop correction
DARKDRIFT – Jail-bar estimation & removal

FLATAP - Flat-field correction

RHDETECT – Single-frame rad-hit detection

DNTOFLUX – Conversion from DN to absolute flux-density units

QATOOL – Image-data quality-assurance characterization

Output BCD ready for archiving

Inputs/Outputs

- **INPUTS:**
  - SUR-mode FITS image (first plane contains the slope-values).
  - Non-linearity (quadratic) model from LINCAL module with coefficients from a FITS image.
  - Mask images which specify: hot/dead pixels, saturated pixels from the SATMASK module and pixels for which a non-linearity model could not be computed from LINCAL.

- **OUTPUTS:**
  - New SUR-mode FITS image with linearized slopes (in first plane).
  - Output log file showing processing statistics and error messages.
  - Updated “d-mask” image indicating which pixels were/were not linearized.

Method

• On board SIRTF, linear regression software will fit slopes m_{sur} to "sample-up-the-ramp" data:

$$y_i = m_{sur} t_i + c \quad \text{———} \quad m_{sur} = \sum_{i=1}^{N} [f_1 - f_2 t_i] y_i \qquad (1)$$

where $f_1 = \dfrac{\sum_i t_i}{\left(\sum_i t_i\right)^2 - N \sum_i t_i^2}$, $f_2 = \dfrac{N}{\left(\sum_i t_i\right)^2 - N \sum_i t_i^2}$, $y_i = DN_{obs}$

N = Number of sample "reads"

• LINCAL module provides quadratic model coefficients (m_{lab}, A_{lab}) from laboratory image data (with uniform illumination level):

$$y_i = m_{lab} t_{lab} - A_{lab} t_{lab}^2 \qquad (2)$$

Method continued...

• We can generalize the above quadratic to a source of arbitrary uniform illumination level, which is effectively the slope in the linear regime of a detector m_{lin} by equating the total accumulated counts to a predetermined laboratory value at different times:

$$m_{lab} t_{lab} = m_{lin} t_i$$

• This leads to a transformation in time: $t_{lab} \longrightarrow t_i = \left(\frac{m_{lab}}{m_{lin}} \right) t_{lab}$

• Generalized quadratic model for a source with constant photon rate m_{lin} (eqn. 2) becomes:

$$y_i = m_{lin} t_i - m_{lin}^2 \left(\frac{A_{lab}}{m_{lab}^2} \right) t_i^2 \qquad (3)$$

Method continued...

- Substituting eqn. (3) into the general SUR-mode slope equation (1):

$$L\, m_{lin}^2 - m_{lin} + m_{sur} = 0$$

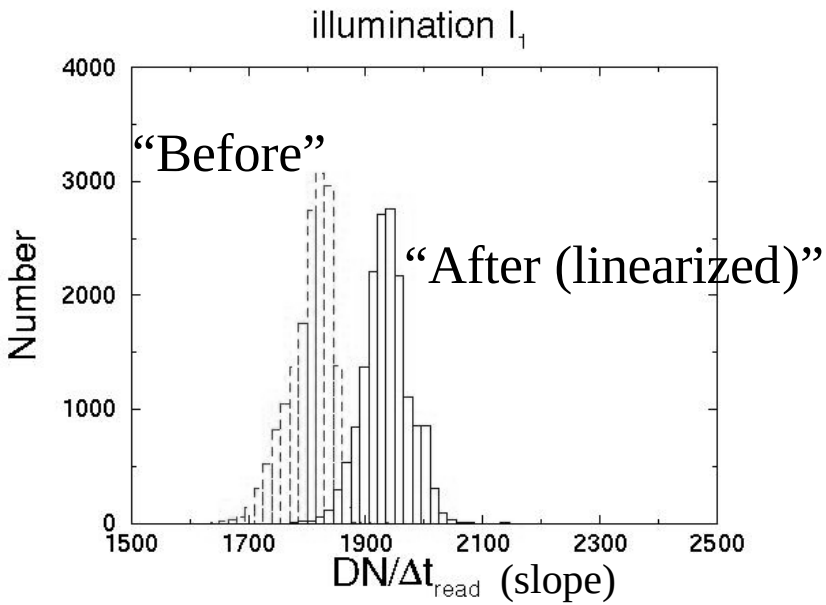
- Only physically acceptable solution to this is:

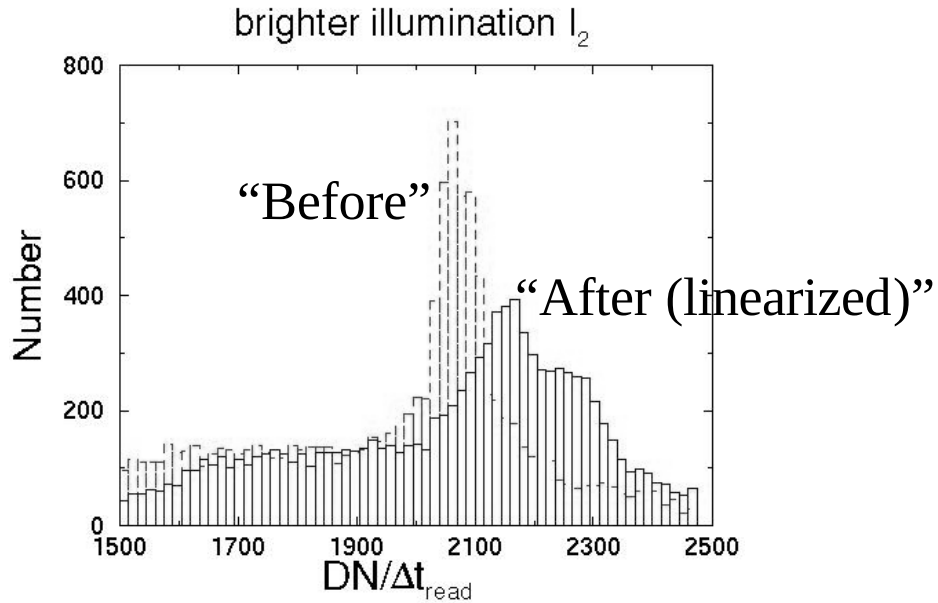
$$\boxed{m_{lin} = \frac{1 - \sqrt{1 - 4Lm_{sur}}}{2L}} \quad (4)$$

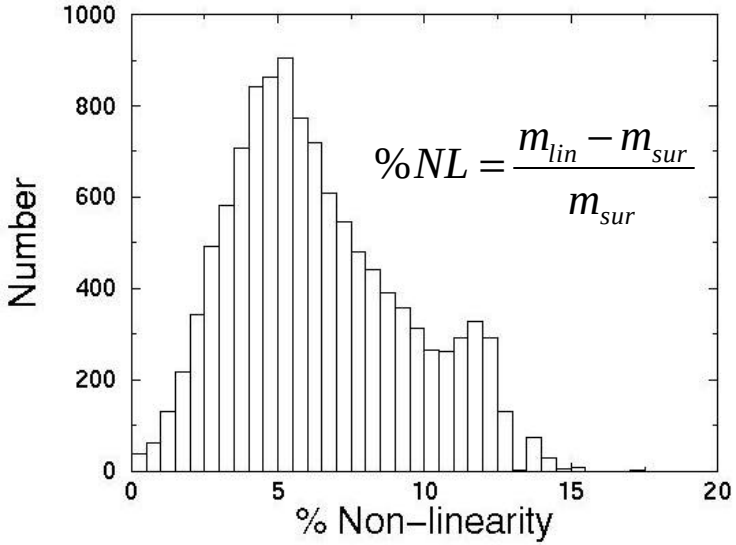
where: $$L = \left(\frac{A_{lab}}{m_{lab}^2} \right) \sum_{i=1}^{N} f_1 t_i^2 - f_2 t_i^3$$

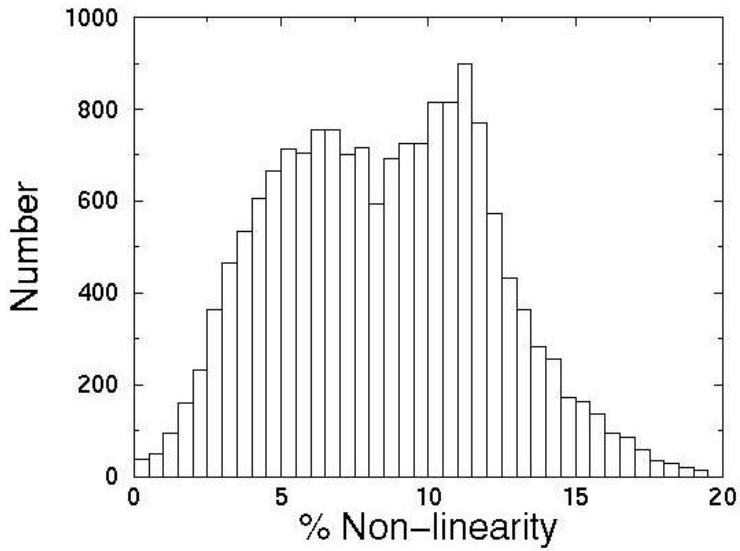
- Therefore, given a predetermined set of coefficients (m_{lab}, A_{lab}) from LINCAL and a knowledge of the number of samples in the ramp, equation (4) gives the "true" (linearized) slope.

Results


illumination I_1
"Before"
"After (linearized)"
Number
$DN/\Delta t_{read}$ (slope)

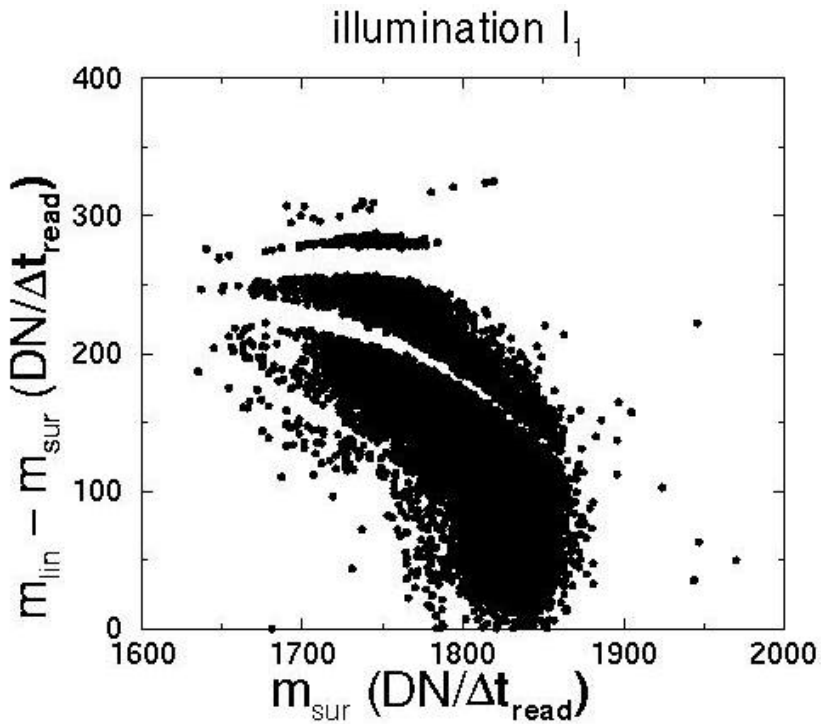

brighter illumination I_2
"Before"
"After (linearized)"
Number
$DN/\Delta t_{read}$


$\%NL = \frac{m_{lin} - m_{sur}}{m_{sur}}$
Number
% Non–linearity


Number
% Non–linearity

Results continued...

Linearity correction as a function of (input) SUR-mode slope



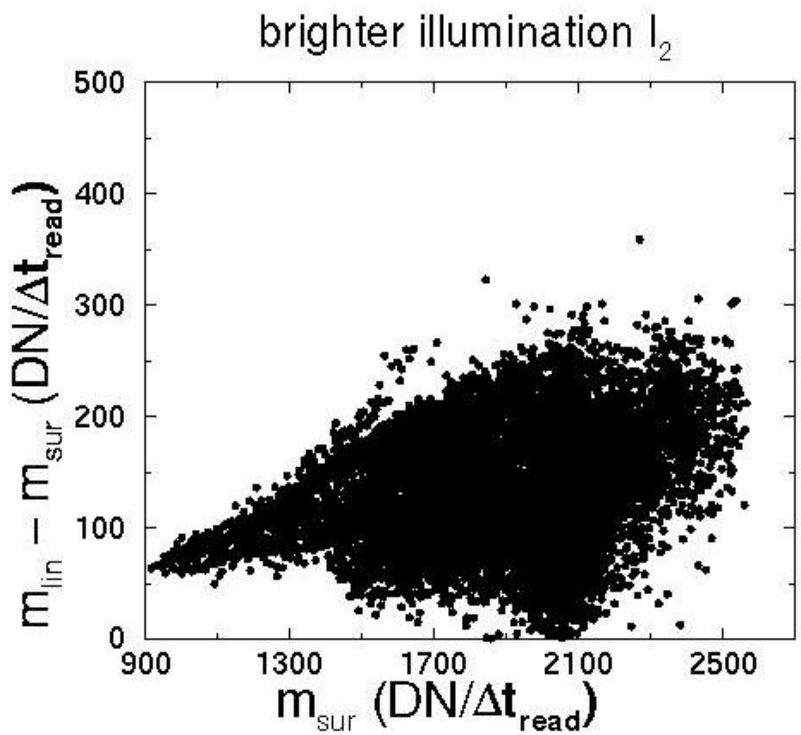
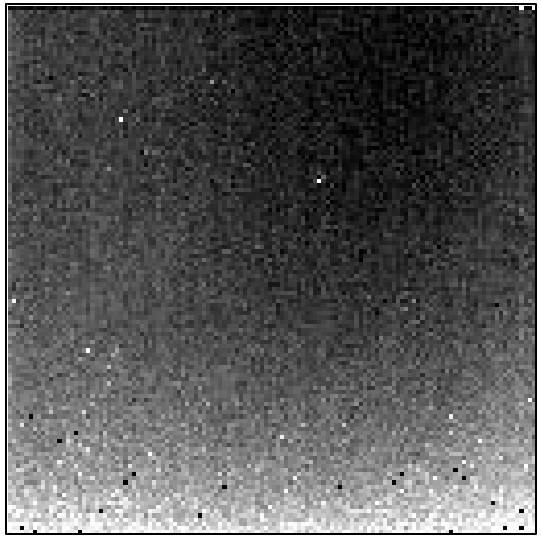
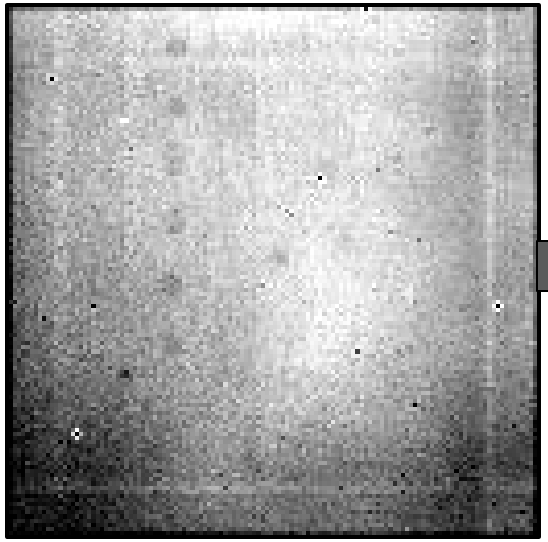
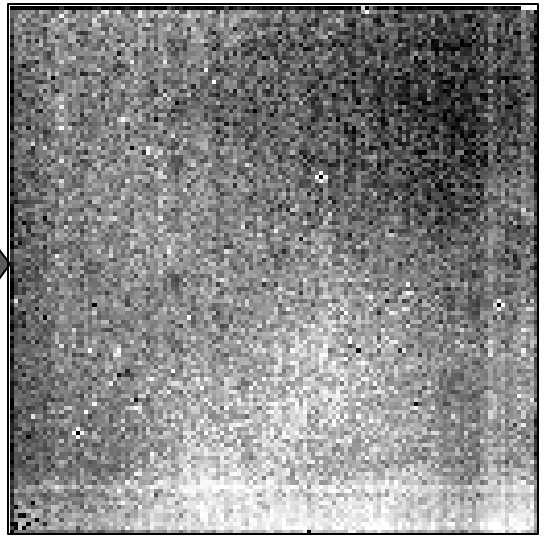


Image Input/Output Results

Testing on a RAW/SUR-mode stim. image:







"Non-linearity image" of A-coefficients:

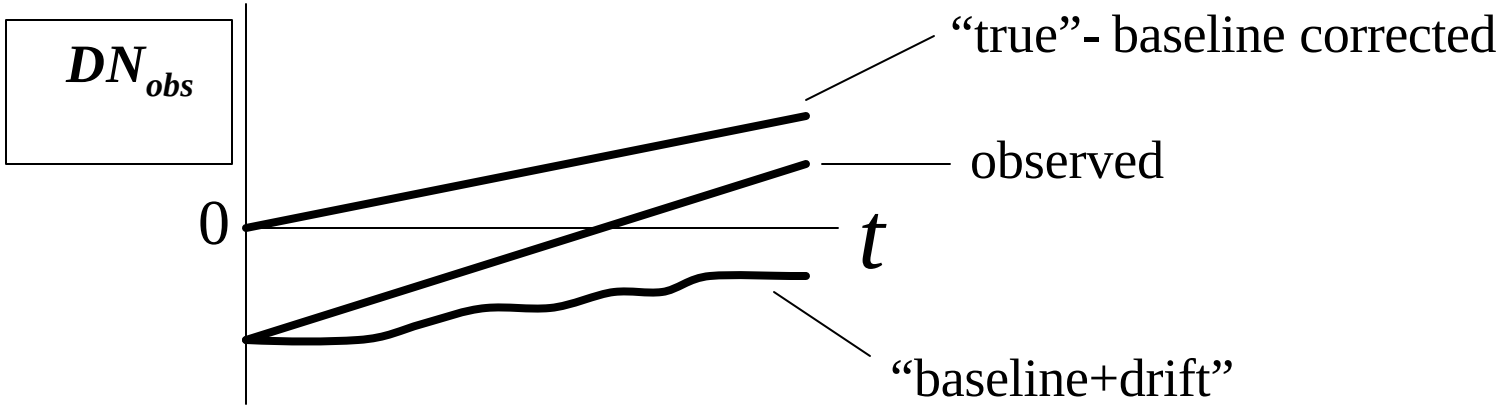
$$DN_{obs} = mt - At^2$$

SUR-mode slope image (un-linearized)

SUR-mode slope image (linearized)

Remaining Issue

- Uncertainties due to “baseline drift” or varying “dark offset” with time.
  - This includes the “cumulative dark current” up-the-ramp.
  - Need to characterize behavior: Predictable or Stochastic ?



- Affect will be greatest for the faintest (low ramp-slope) sources.
- Acquire darks at close enough intervals to account for baseline drifts.
- Will need to: Correct RAW-mode data prior to computing non-linearity model with <u>LINCAL</u> and SUR-mode data prior to <u>SLOPECORR.</u>

SLOPECORR

Back-up Slides

Inputs/Output: *Namelist parameter file*

INPUTS: "RED" *OUTPUTS: "BLUE"*

Ancillary_File_Path = './slopecorr',	
FITS_Image_Filename1 = 'unlinearized_sur.fits',	(Input SUR-mode image)
FITS_Image_Filename2 = 'lincal_model.fits',	(Input model coefficients image)
FITS_Image_PMask_Filename = 'pmask.fits',	(mask for hot/dead pixels)
FITS_Image_DMask_Filename = 'dmask.fits',	(mask for saturated pixels etc..)
FITS_Image_CMask_Filename = 'cmask.fits',	(mask with LINCAL anomalies)
FITS_Out_Filename = 'linearized_sur.fits',	(Output linearized image)
Log_Filename = 'stdout',	(for errors and processing stats)
CmdFrm_Keyword = 'CMD_FRMS',	(FITS keyword: total frame count)
Ignore_Frames = 2,	(Number of initial frames to ignore
PMaskFatal = 8192,	Fatal mask bit-words
DMaskFatal = 8192,	Fatal mask bit-words
CMaskFatal = 256,	Fatal mask bit-words
DMaskLin = 1024,	(bit for successful linearization)
DMaskNotLin = 4096,	(bit for un-successful linearization)