Characterization of Latent Images in MIPS 24μm Array

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I. Introduction

This document describes a method for determining the parameters of a latency model used to flag pixels suspected of containing a latent (residual) flux. The model is described in detail in a SDS (Subsystem Design Specification) document (sds-s5-latimflag.doc #674-S0-43, Frank Masci, Version 1.0, 9/11/2001).

Latents decay by the release of trapped charge during an integration. The total number of filled "latent traps" of a particular kind *i* (distinguished by a characteristic decay-time and trap-filling efficiency) at the end of an exposure of duration ΔT_{exp} is given by

$$N_F(\Delta T_{\exp})_i = N_{T_i}\left(\frac{f_i}{1+f_i}\right)\left[1-\exp\left\{-(1+f_i)\frac{\Delta T_{\exp}}{t_i}\right\}\right], \qquad (1)$$

where

$f_i = t_i c_i S_0$, where c_i = trap filling efficiency, t_i = e-folding decay timescale.
S_0 = Incident flux in *electrons* /sec (measured from non-linear detector read-out and gain).
N_{Ti} = Total number of available traps (in electron units).

Suppose, immediately following an exposure the lamp is turned off (so that S_0=0) and a series of *N* exposures each of duration ΔT are taken. The latent strength (in *electrons*) at the end of the n^{th} exposure is given by

$$N_n(\Delta T)_i = N_F(\Delta T_{\exp})_i \exp\left\{-\frac{(n-1)\Delta T}{t_i}\right\}\left[1-\exp\left\{-\frac{\Delta T}{t_i}\right\}\right], \qquad (2)$$

where *n = 1, 2, 3 ... N* is the image sequence number after the lamp is turned off.

The three model parameters for a particular trap type *i* are

$$\boxed{N_{T_i}\ ,\ c_i\ ,\ t_i}$$

Current latent characterization data shows that the decay curve can be represented as the sum of two exponentials with two different decay constants (or trap types *i*). Our aim is to determine the above three parameters from a sequence of illumination frames and following each illumination, a sequence of frames with the lamp turned off. A suggested procedure is outlined in the next section.

II. Suggested Test Procedure

The following outlines a CTA test procedure for inferring the three latent model parameters. It is recommended the test be carried out under optimal flight temperature (say 5K). Values quoted for integration times and number of latent frames needed are to be revised.

1. Acquire (3, 4, 10, 30..) x 0.524 sec RAW mode exposures with no illumination. These will represent the darks to be subtracted later.
2. Turn lamp on and acquire a 3 x 0.524 sec RAW exposure.
3. Immediately after this exposure, turn lamp off and acquire 8-10 RAW mode (3 x 0.524 sec) frames in succession. The shortest exposure time should be selected to provide good sampling.
4. Repeat step 2 for a “lamp-on” exposure time of 4 x 0.524 sec.
5. Repeat step 3 keeping the same exposure time of 3 x 0.524 sec or whatever was used in the first “lamp-off” exposure sequence.
6. Repeat steps 4 and 5 for different “lamp-on” exposure times and the same “lamp-off” sequence.

III. Fitting Procedure

1. Subtract the dark frames corresponding to each illumination frame of duration ΔT_{exp} and each “lamp-off” frame of duration ΔT.
2. From the last plane of each RAW-mode illumination image which effectively contains the total cumulative count for each pixel, measure and compute the incident fluxes (S_0 in above formalism) in electrons/sec by taking the mean within some pixel region.
3. Measure and compute the total electron (latency) count from the last plane of each “lamp-off” RAW-mode image. Each value represents “$N_n(DT)_i$” in equation (2) above where *n = image number 1, 2, 3...etc* in time-sequence since the lamp was turned off.
4. For each curve of $N_n(DT)_i$ versus n (i.e. from one sequence of lamp-off frames) we can fit for t_i and $N_F(DT_{exp})_i$ (the total number of available traps in electrons). These are fit to each “characteristic” decay curve “i”.
5. A new set of parameters can be fitted to another sequence of lamp-off exposures, i.e. corresponding to a different illumination exposure.
6. With a set of [t_i , $N_F(DT_{exp})_i$] values for one characteristic decay curve and for different illumination exposures (ΔT_{exp}), we can now fit for the parameters N_{Ti} and c_i from equation (1).