Limits to persistence suppression by global reset

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INTRODUCTION

Persistence with the HxRG infrared detectors is a well known issue by astronomers because it affects their measurement by correlating successive frames. R. Smith et al. suggested a theory [1] to explain the mechanism behind this phenomenon. This theory implies that some charges are captured by traps as the depletion region shrinks when accumulating signal. Slow release of those charges then creates a current seen as persistence. Thus, holding the diode array in reset during illumination should avoid this trapping mechanism by maintaining constant depletion region width. This was related to work by Smith et al and confirmed again by G. Finger[2]. Here we report limitations on effectiveness at high flux.

This work has been conducted for the IRIS instrument of the TMT to show how the global reset could be used as a persistence-free electronic shutter and quantify its effectiveness.

SETUP

A dark cryostat has been refurbished with new interface boards and a new set of LED and light bulb illuminators.
The Dark current is around 0.02e-/s

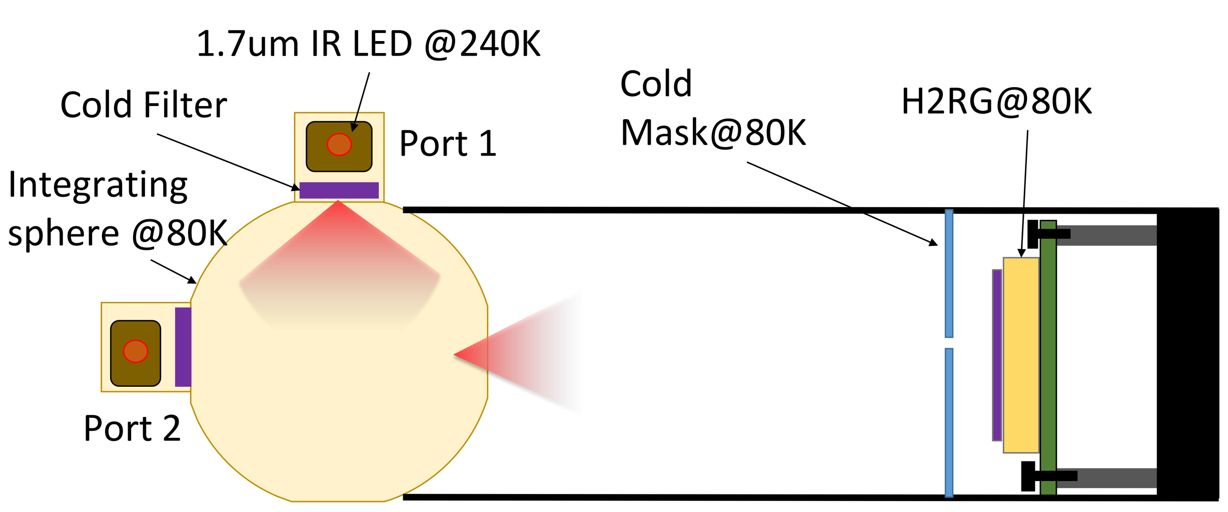


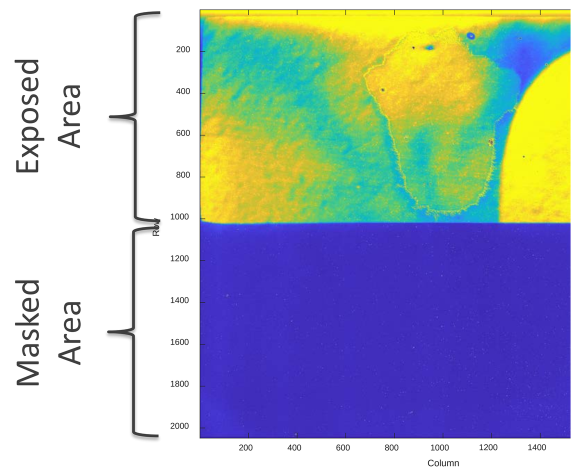
Fig. 1 : Illumination setup

READOUT MODE

The Global Reset mode consists of resetting the whole diode array to a constant voltage at once.
During a Sampling-Up-The-Ramp (SUTR) acquisition, frames are readout non-destructively and signal is accumulating on the integration capacitance.
The detector has a constant clocking scheme to keep thermal dissipation constant to avoid transients due to thermal drift [3].

PERSISTENCE

A cold mask blocks the light on half of the detector. The LED is pulsed for 1 second while the global reset is asserted.
Then a burst of non destructive readouts is acquired.



The integrated persistence seen after 200s of exposure in the dark is about 0.8% of the initial illumination intensity

Fig. 2 : Persistence Map remaining after a strong illumination

The decay of persistence level over time is extracted from the increasing signal during the SUTR exposure.

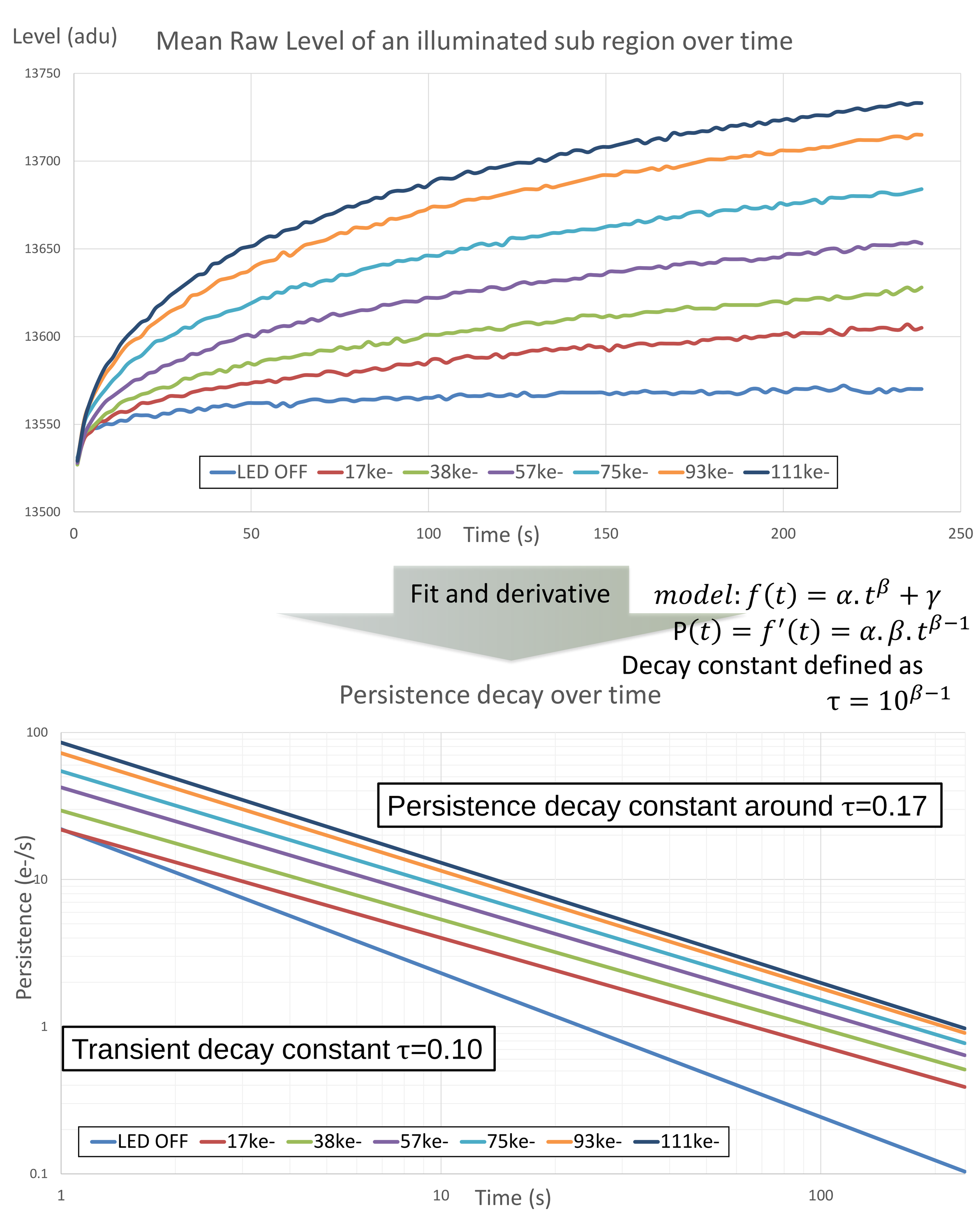


Fig. 3: Analysis of the persistence level for increasing illumination intensities

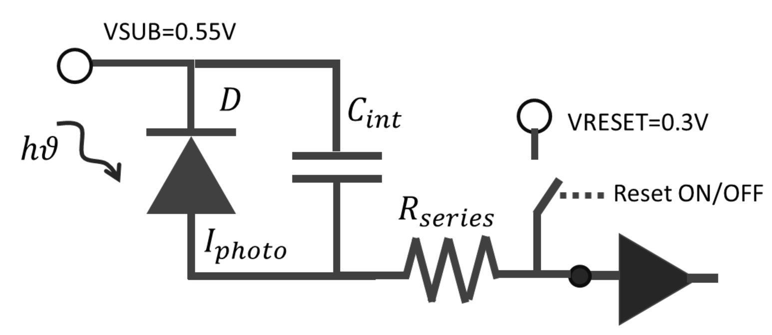
The intensity of the persistence is proportional to the intensity of the flash.
One can notice a transient even with no stimulus of light.
This transient [4] has a slightly faster time constant. It becomes negligible compared to high persistence levels.

Persistence is strong even when the detector is illuminated while Global reset is asserted. Those results were not expected and do not comport with the previously suggested theory.

DISCUSSION

Following points have been doubled checked:
- **Global Reset mode is properly set.**
- **Reset is held high during illumination.**
- **LED is not glowing.**

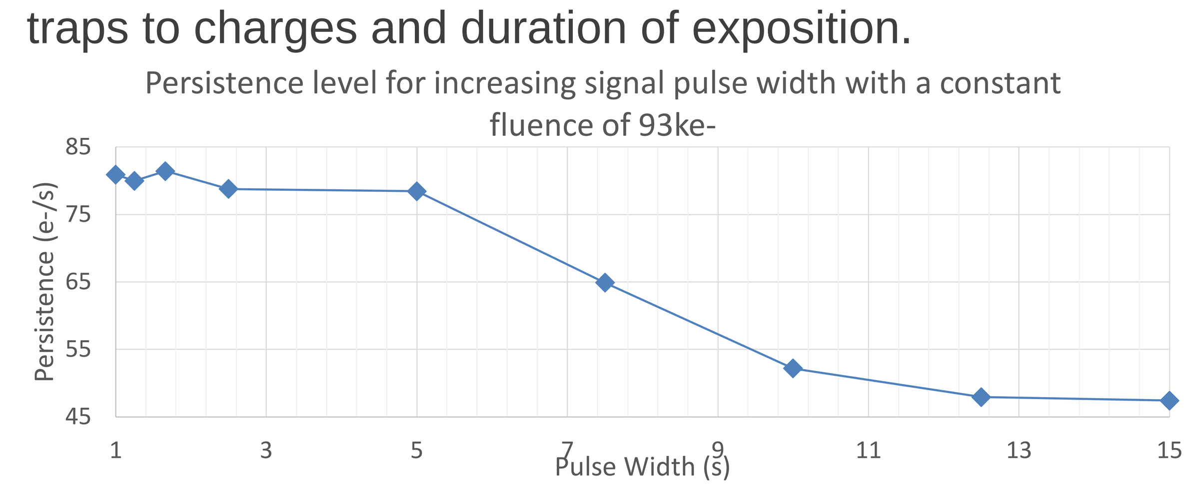
Introducing a parasitic resistor in series with the diode allows the voltage across the diode to increase and the depletion region to shrink and overlap with traps even with the reset switch clamped.
This depletion width is proportional to the intensity only and not to the total integrated charges over time.



Reset ON:
$\Delta V_D = R_{Series} I_{photo}$
Reset OFF:
$\Delta V_D = C_{int} \int I_{photo}.dt$

Fig. 4 : Simple electrical model of the diode including a parasitic resistor

For a given fluence, two effects are then competing to count for the persistence level: Volume of newly exposed traps to charges and duration of exposition.



This graph shows persistence decreases with a longer exposure of a smaller volume of traps.

The newly suggested model is compatible with observations previously made by peers and explains the persistence effect in the case of a strong illumination during Global Reset.

FUTURE WORK

- **Measure R_{series} and spatial variation. Infer ΔV_D**
- **Is this enough to explain persistence?**
- **Compare global-reset persistence with non-reset persistence.**
- **Reduce or mitigate effect.**

REFERENCES

1. A theory for image persistence in HgCdTe photodiodes, *R. Smith et al.*
2. Recent Performance Improvements, Calibration Techniques and Mitigation Strategies for Large-format HgCdTe Arrays, *Gert Finger et al.*
3. Noise and zero point drift in 1.7um cutoff detectors for SNAP, *R. Smith et al.*
4. Detectors for the JWST NIRSpec: Readout Mode, Noise Model, and Calibration Considerations, *B. J. Rausher and O. Fox*