Session Overview
Understanding Roman WFI Detectors and Calibration

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Introduction

- Bernie Rauscher: Overview (this talk)
- Stefano Casertano & Neil Zimmerman: Calibration working group activities
- Greg Mosby: Testing of the Nancy Grace Roman Space Telescope's H4RG-10s
- All: Q&A

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Importance of Systematics

- Some of the first ideas that became the Nancy Grace Roman Space Telescope sprang from the discovery of dark energy near the dawn of the millennium -a discovery that was enabled by understanding and properly accounting for systematic uncertainties
- Limiting and understanding systematic uncertainties remains central to Roman today
- Compared to HST and JWST, Roman requires about a factor of 10 reduction in systematic errors
  - Linearity of order ~0.1% over a range of 10^5 in brightness
  - Comparable improvement in point spread function (PSF) knowledge over a 0.28 square degree field of view
- From the very beginning, circa 2000, <u>it was widely understood that controlling near-IR detector systematics would be particularly important to Roman science</u>
- We look forward to sharing understanding with the Euclid team, for which controlling detector systematics is also very important

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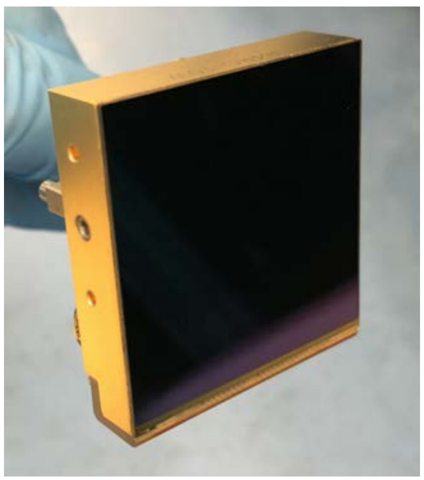
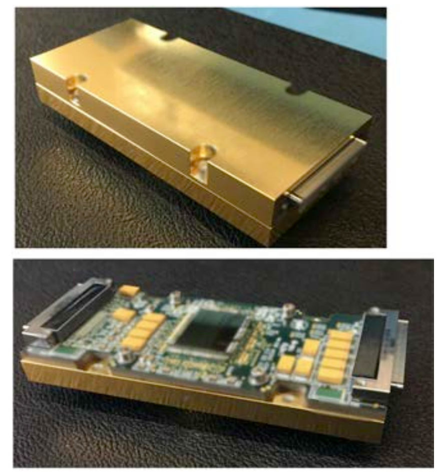
Roman's H4RG + ACADIA Near-IR Detector Systems

- Neil and Stefano will say more about the WFI focal plane, which contains 18 Teledyne H4RG-10 (H4RG) near-IR detectors paired with ACADIA readout electronics
- Greg will say more about measured detector performance
- Roman's H4RGs behave like an improved version of the familiar H1R (Hubble WFC3) and H2RG (JWST & Euclid) near-IR array detectors. But, because of the 10 μm vs 18 μm pixel size, Roman will have over 3x as many pixels as would have been possible using the previous generation detectors
- The ACADIA is a new development for Roman. We are optimistic that the read noise will be somewhat lower than JWST's and Euclid's SIDECAR ASICs (but more testing needed!)



Flight H4RG

Goddard Detector Characterization Laboratory (DCL)



ACADIA ASIC

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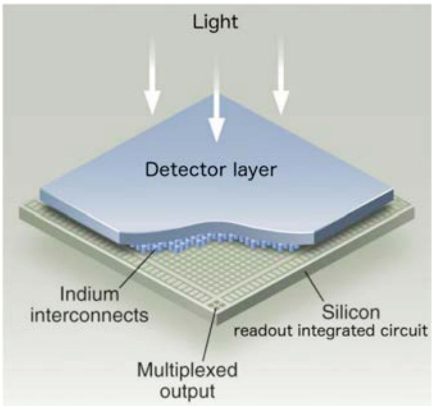
Physics of Light Detection in a Roman H4RG



Roman's H4RG-10s are hybrid near-IR detector arrays. The structure is like a sandwich. The light sensitive HgCdTe detector layer is cold soldered to the silicon readout integrated circuit (ROIC) using indium interconnects.

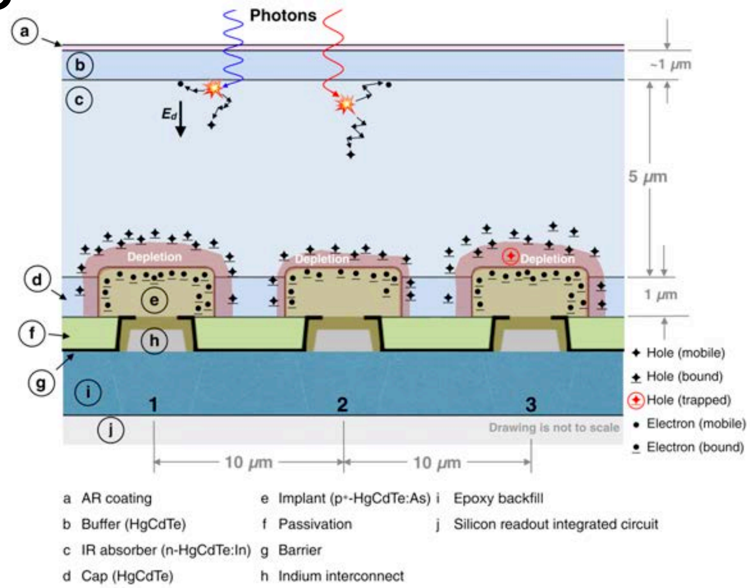
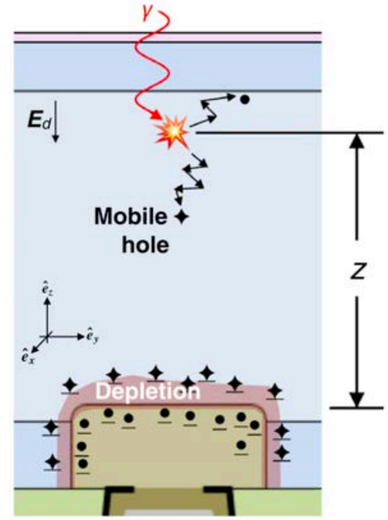


Fig. 2 Roman's H4RG-10s use a p-on-n $Hg_{1-x}Cd_xTe$ photodiode architecture. Photons pass through the AR coating and a transparent buffer before entering the IR absorber. The buffer is transparent because its HgCdTe has a wider bandgap than in the absorber. The buffer is needed to transition between the lattice spacing of the (now removed) CdZnTe substrate and the $Hg_{1-x}Cd_xTe$, which depends upon the x parameter. Once in the n-doped absorber, the photon excites an electron into conduction creating a mobile electron–hole pair. Following Beer's law, red light penetrates deeper than blue light on average. The absorber's bandgap is graded by varying the x parameter. This creates a built-in electric drift field, $\boldsymbol{E}_d$ (in this article, boldface italics denote vectors), that drives the electron up toward the "back side," from which light enters, and the hole down toward the pn-junctions. $\boldsymbol{E}_d$'s direction is indicated by a black arrow near the blue photon. Upon reaching depleted HgCdTe within about 1.5 to 2 μm of the junction (for a freshly reset pixel), the strong electric field there drives the hole into the p-doped implant where it recombines with a bound electron. We will return to this figure later to discuss the hole that is trapped in pixel #3, and the "BFE" that explains why comparatively full pixel #2 has a smaller collection area than pixels #1 and #3.



Zoomed in view of one pixel

Credit: Mosby, G. et al. Properties and characteristics of the Nancy Grace Roman Space Telescope H4RG-10 detectors. JATIS 6, 46001 (2020).

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What's happening now!

- Neil and Stefano will tell you more about plans for calibrating Roman
- Greg will tell you more about the flight detector characterization that is underway in the DCL now
- Chaz Shapiro (if available; he's recovering from a back injury) will tell you more about detector testing at the JPL Precision Projector Laboratory (PPL) that aims to emulate realistic astronomical scenes
- There should be time for questions

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