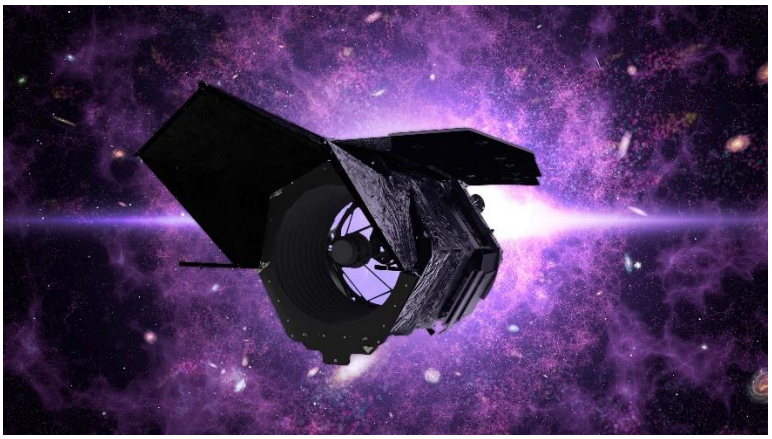
EMCCD detector development for space applications: from the Nancy Grace Roman Space Telescope to future mission opportunities

Project highlights:

- Work with the latest detector technology that is being used in the Nancy Grace Roman Space Telescope.
- "Best of both worlds" approach to a PhD studentship through the STFC CASE scheme - undertaking a PhD that is sponsored by our long-running industrial partner Teledyne e2v Space Imaging, with a dedicated industrial supervisor and an extended placement with the company during your PhD.
- Hands-on experiments with space technologies, both in the laboratories at the Open University, Teledyne e2v, and at a wide range of science facilities across Europe.
- Work on the calibration of detectors provided by the European Space Research and Technology Centre (ESTEC)
- Opportunity to discuss your research with scientists across Europe and at JPL NASA, as well as present at international conferences.



An artist's impression of the Nancy Grace Roman Space Telescope (NASA).

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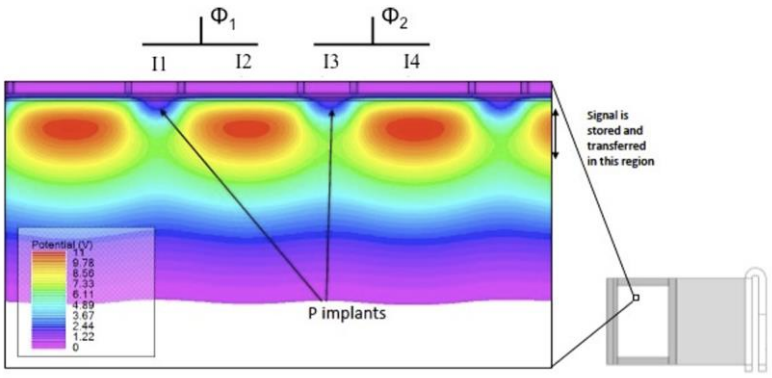
Project description:

The Electron-Multiplying (EM) CCD has formed the basis of a successful STFC-funded research programme in the CEI over the last decade. Following early successes, an STFC-funded CASE student studied the EMCCD gain register; this is the key to the technology, allowing electron signals to be multiplied before conversion to the digital domain, reducing the noise floor to near-zero regardless of the readout speed to enable observation of the faintest of objects in the sky. The student's research [1-3] led to contracts from NASA JPL to

further develop EMCCD technology for use in NASA's Nancy Grace Roman Space Telescope (formerly WFIRST) Coronagraph, using the photon-counting capabilities to directly image exoplanets. Teledyne e2v produced two test devices containing a selection of variants, designed by that student, with one now selected for use on the mission and the student now employed to work on the mission at NASA's Jet Propulsion Laboratory. Further CEI-developed test structures were also in development and require further tests and understanding; the risk-averse and time-pressured nature of space mission development left some of the most interesting design changes yet to be fully explored. With further detailed simulations and testing, there is potential to develop a new, fully optimised detector to dramatically expand the use of this exciting UK technology and provide a step-change for both space and ground-based applications.

Through a combination of device simulations and the laboratory study of the aforementioned test structures, as well as detectors from the flight development programme provided by the European Space Agency (ESA), in this studentship the student will develop a deeper understanding of the intricacies of the gain process and the generation of all noise sources in the detector currently limiting performance, and study their operation in the highly damaging space radiation environment. Armed with this new knowledge, the student will be able to better optimise current device performance and, most importantly, develop a new and improved design - an EMCCD for future space applications, allowing astronomers and space scientists to look deeper into the sky at objects fainter than ever seen before.



SILVACO TCAD model of an EMCCD [1].

With new test structures and devices from the flight development programme now freshly available the project is very timely. Indeed, there is potential for designs produced at the end of the studentship to provide dramatically improved performance just as the first-light from an EMCCD in space is received through the Nancy Grace Roman Coronagraph, capitalising on the increased interest in the technology for future missions. Previous STFC-funded CASE studentships with the CEI and Te2v related to novel device development have had great and proven success and provided exceptional scientific return, with major impacts on ESA's Euclid VIS, JUICE JANUS, Athena WFI and SMILE SXI, alongside new device development programmes at Teledyne e2v. **The student will undertake a placement at**

Teledyne e2v Space Imaging during their PhD studentship, giving a taste of both the academic and industrial environment and providing increased employment opportunities.

This studentship will be hosted by the Centre for Electronic Imaging (CEI) at the Open University. The group has successfully trained many STFC CASE students, all of whom have moved directly into employment following completion, be that with the space agencies (ESA/NASA), related industries, or continuing in academia. Through working closely with our industrial partner, Teledyne e2v (Te2v), the student will have access to key details and expertise on device design and the subtleties required to understand the complex issues presented. This information is only available through the OU and Te2v's close and long-running collaboration.

Teledyne e2v has been trusted to design and deliver CCD and CMOS imaging sensors and sub-systems for over 150 space missions by the world's largest space agencies, including NASA, ESA, JAXA, CNSA and most recently for the Russian-led World Space Observatory.

References:

1. http://oro.open.ac.uk/58189/
2. http://oro.open.ac.uk/47723/
3. http://oro.open.ac.uk/45133/