QUANTIX and INTRAPIX: test benches dedicated to quantum efficiency measurement and intrapixel response of detectors from VIS to LWIR

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Introduction

INTRAPIX and QUANTIX test benches are the tests means developed at CEA-IRFU for the evaluation of the scientific performances of large focal plane detectors for astronomy. If INTRAPIX is aimed to bring the knowledge of the spatial response inside the pixel, QUANTIX permits the evaluation of the absolute quantum efficiency of the detector in other words its overall capability to absorb light and collect/convert it into the electrical charges. QUANTIX passed the validation phase and we have demonstrated its operability in SWIR domain while INTRAPIX is under tests process. The preliminary results are quite promising.

INTRAPIX

Principle

The Intrapix test bench uses the **Talbot effect to measure the intra-pixel response of detectors.** The approach is based on the projection of highly resolved beams onto the whole surface of the detector using the self-imaging property of a grating (**C**ontinuous **S**elf-**I**maging **G**rating, **CSIG**).

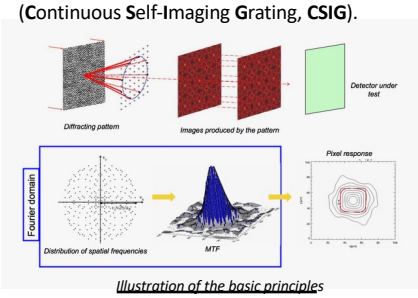
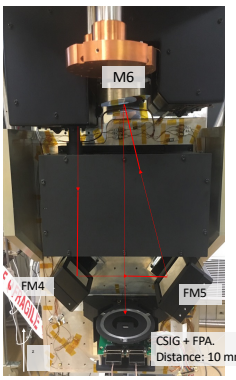


Illustration of the basic principles

The distribution of the spatial frequencies contained in the projected beams is sparse and predictable. The technique consists to measure Modulation Transfer Function and then estimate the intrapixel response.

The approach is **global** and **free of focusing optics** (no deconvolution from optics effects). The detailed description can be found in [1-2].

Test bench

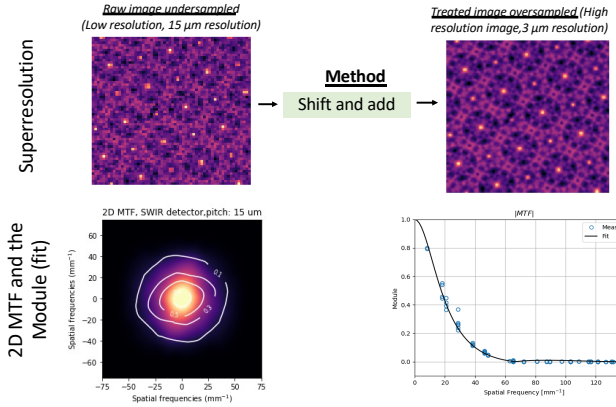


Picture of Intrapix test bench. Scheme of the beam path.

The bench can be seen as a cooled collimator which delivers a flat wavefront to a CSIG. The CSIG is mounted close to the Detector Under Test (DUT). The discrete spatial frequencies constitute the sparse data from which the pixel MTF is measured.

Currently, the validation phase is carried with a 24 orders CSIG designed to measure 2D MTF up to 145 mm^{-1}. The DUT is a 15 µm-pitch and the Nyquist frequency is 33.3 mm^{-1}. To overcome the aliasing effects, we oversample the image by a factor 5 by microscanning with a step of 3 µm. For this purpose the CSIG is mounted on cryogenic piezo actuators.

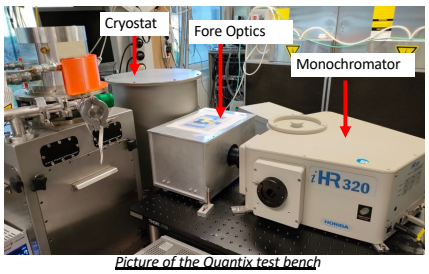
Experimental results: oversampled interferogram and MTF



QUANTIX

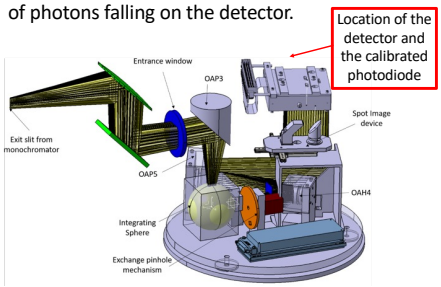
Description

Quantix has been built to measure the absolute quantum efficiency of detectors with cut off wavelength ranging from visible to LWIR domain.



Picture of the Quantix test bench

This test bench relies on the use of **calibrated avalanche photo-diode.** The calibrated photodiode is placed in the vicinity of the detector. The photodiode and the detector under test are operated simultaneously to know precisely the amount of photons falling on the detector.



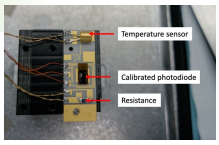
Inside the cryostat, the cryogenic optical bench relies on a integrating sphere with its output located at the focus of a collimator.
This configuration ensures **simultaneous uniform flat field illumination of the detector and the calibrated photodiode**.

Test bench validation in the SWIR domain

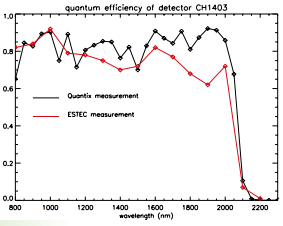
→ **A SWIR calibrated photodiode** has been manufactured and calibrated by CEA-LETI.

→ **Uniformity of illumination** has been demonstrated by a measurement of a relative standard deviation of 2% through the field.

→ **The QE of a detector** measured at ESA-ESTEC has been measured with Quantix test bench. The comparison shows a good agreement with the errors around 12% .



Picture of the SWIR calibrated photodiode



Ongoing activities

The ongoing activities consist mainly to evaluate the capability of the test bench to operate in the LWIR domain:

- A dedicated calibrated photodiode was delivered by CEA-LETI and used in a precedent activity[3].
- The first studies show that the Quantix bench suffers from leaks and spurious lights which are more dominant in the LWIR than in the SWIR domain.

Future work

- **Intrapix**: Apply the right interpolation procedure to reconstruct a continuous MTF and deduce the Pixel Response Function.
- **Intrapix**: Using a monochromator to estimate the dependency of intrapixel response with wavelength.
- **Quantix**: Improve the design of the optical bench (baffling,...) to be compatible with the operations in LWIR range.

References
(1) Pichon T. et al. In : *X-Ray, Optical, and Infrared Detectors for Astronomy IX*. SPIE, 2022. Paper number 12191-201.
(2) Huard, E. et al. Optics express 26(5) 5200–5211 (2018).
(3) Bounab A. et al. In : *X-Ray, Optical, and Infrared Detectors for Astronomy IX*. SPIE, 2020. Paper number 11454