

A Simulator for IR and CCD Detectors

Ole Möller-Nilsson and Markus Feldt,
Max-Planck-Institute for Astronomy, Heidelberg

Motivation

The main motivation derives from the **need** for **realistic IR data** for **pipeline development**.

Specifically, we develop the data reduction pipeline for SPHERE, a future planet finding and direct imaging instrument on the VLT.

More About SPHERE

SPHERE is a future planet finding instrument for the VLT, that will perform direct imaging of planets. SPHERE consists of three instruments, two of which use Hawaii 2RG infrared detectors. One of these, IRDIS, is a dual imaging instrument, projecting two 1024x1024 pixel images onto a 2k by 2k detector. The other, IFS, is an integral field spectrograph, projecting spectra from an array of 63551 lenslets onto a 2k by 2k detector.

References

M. Carillet, C. Verinaud, B. Femenia, A. Riccardi, L. Fini,

Modelling astronomical adaptive optics: I. The Software Package CAOS
MNRAS 356 (4), 1253 (2005).

M. Feldt, O. Möller-Nilsson, A. I. Pavlov, J.-L. Beuzit, D. Mouillet, R. Gratton, M. Langlois and F. Joos:
SPHERE baseline software for reducing calibration data. In: Advanced Software and Control for Astronomy II, (Eds.) Bridger, A., N. M. Radziwill. SPIE 7019, SPIE, 701930-701930-8 (2008)

Storrs 1999, NICMOS ISR-99-002: Color Dependence of NICMOS Flatfields
(<http://www.stsci.edu/hst/nicmos/performance/anomalies>)

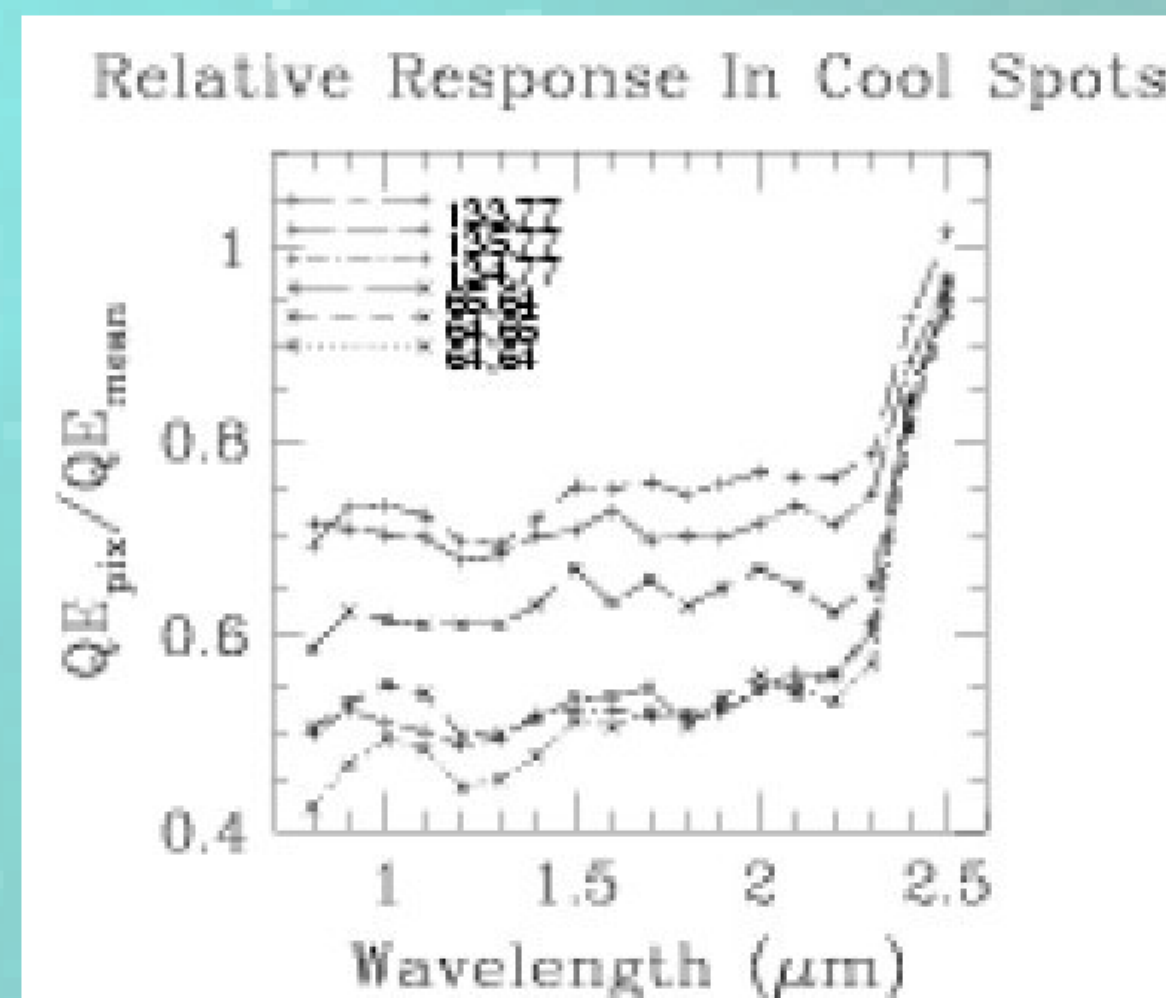
Features

- Simulation of detector effects for **both IR arrays and CCDs**.
- Separate detector characterisation simulation allows generation of **many consistent calibration products**
- Simulation of instrument properties for **standard imagers** (filters etc.) and **IFS instruments** (lenslet arrays) included.
- Effects such as **cosmic rays**, **wavelength dependent pixel response**, **persistence**, **bad**, **“crazy”** and **hot pixels** included.

More on simulating wavelength dependent response:

Two main ingredients:

1. a response to input signal that is linear at low input signal but becomes non-linear near the saturation point
2. a wavelength dependency of the quantum efficiency (QE) of the detector. This wavelength dependency is not the same for all pixels: hot and cold pixels behave differently.



We have tried to capture the qualitative behaviour of the NICMOS detector on HST, as described on <http://www.stsci.edu/hst/nicmos>. To do this, we fitted the behaviour described there qualitatively with a set of simple functions that model the pixel response. The figure above shows the wavelength response function from NICMOS we have tried to model.

First, the pixel response function $R_{\text{pix}}(f, w)$ is assumed to be separable into

$$R_{\text{pix}}(f, w) = R_{\text{pix}}(f) \cdot R_{\text{pix}}(w) \cdot QE_{\text{mean}}(w)$$

where $R_{\text{pix}}(f)$ gives the output response factor given an input count f and $R_{\text{pix}}(w)$ modifies this depending on the wavelength. The count that is read from a pixel in the detector is $f * R_{\text{pix}}(f)$. For ideal, linear, response $R_{\text{pix}}(f)$ is equal to unity. $R_{\text{pix}}(w)$ is normalized to the average pixel response of the detector at the wavelength w , i.e. the quantum efficiency at that wavelength, $QE(w)$, which means that $R_{\text{pix}}(w)$ can be > 1 . (Note: the detector bias and dark current are independent of wavelength and hence $R_{\text{pix}}(w)$ is not used for those.)

The functional forms for the two functions are:

$$R_{\text{pix}}(w) = R_0 + (1 - R_0) \cdot \left(L \cdot w + (1 - (L \cdot w_{\text{max}})) \cdot e^{-((w - w_{\text{max}})^2 / Q^2)} \right)$$

and

$$R_{\text{pix}}(f) = F_{\text{sat}} \cdot \left(1 - e^{-f / F_{\text{sat}}} \right)$$

In these equations, f is the input flux, w the wavelength, R_0 the average response at zero wavelength, L a linear factor, F_{sat} the saturation count, w_{max} the maximal wavelength and Q the width of the peak around the maximal wavelength.

More information: moeller@mpia-hd.mpg.de

Implementation

The implementation of the detector characteristics simulation is in C, external input is created with the IDL module CAOS (Carillet 2005).

