EMCCD calibration for astronomical imaging:

Wide FastCam at the Telescopio Carlos Sánchez

S. Velasco[1,2], A. Oscoz[1,2], R. L. López[1,2], M. Puga[1,2], A. Pérez-Garrido[3], E. Pallé[1,2], D. Ricci[1,2], I. Ayuso[1,2], M. Hernández-Sánchez[1,2], C. Protasio[1,2], S. Vázquez-Martín[4]. V. Béjar[1,2], N. Truant[1,2]

svelasco@iac.es

EXCELENCIA SEVERO OCHOA

INTRODUCTION

The evident benefits of Electron Multiplying CCDs (EMCCDs) –speed, high sensitivity, low noise and their capability of detecting single photon events whilst maintaining high quantum efficiency- are bringing these kinds of detectors to many state-of-the-art astronomical instruments. The EMCCDs are the perfect answer to the need for great sensitivity levels as they are not limited by the readout noise of the output amplifier, while conventional CCDs are, even when operated at high readout frame rates. Here we present a quantitative on-sky method to calibrate EMCCD detectors dedicated to astronomical imaging, developed during the commissioning process and first observations with Wide FastCam at Telescopio Carlos Sánchez (TCS) in the Observatorio del Teide.

INSTRUMENT

Wide-FastCam (WFC) is an adaptation of the FastCam platform (Oscoz et al. 2008) with the objective of obtaining wide field images (8'x8' FoV, 0.5"/px and a 1kx1k Andor Ixon 888 EMCCD) at a high temporal resolution (8 fps) with real time processing capacity. The large field of view guarantees the presence of a photometric calibration star in the majority of the pointings of the telescope. These features make WFC a unique instrument in the world for the observation of transient phenomena: no other instrument can process in real time the tens of thousands of images obtained each night with such a FOV in the optical range.

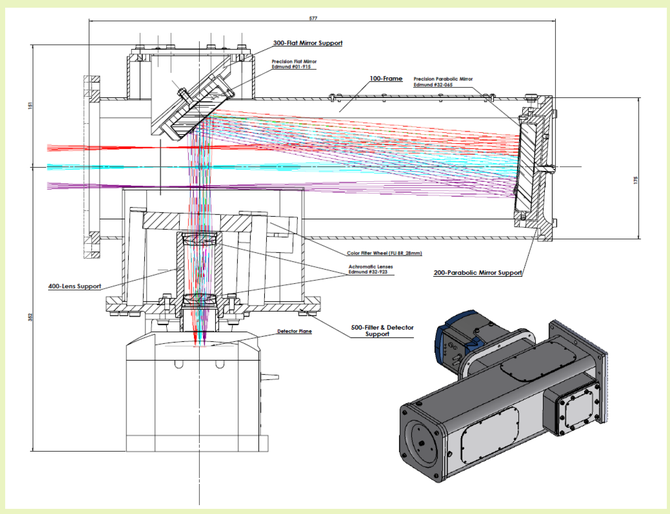

Fig. 1: Section view of the instrument with the ray tracing superimposed.

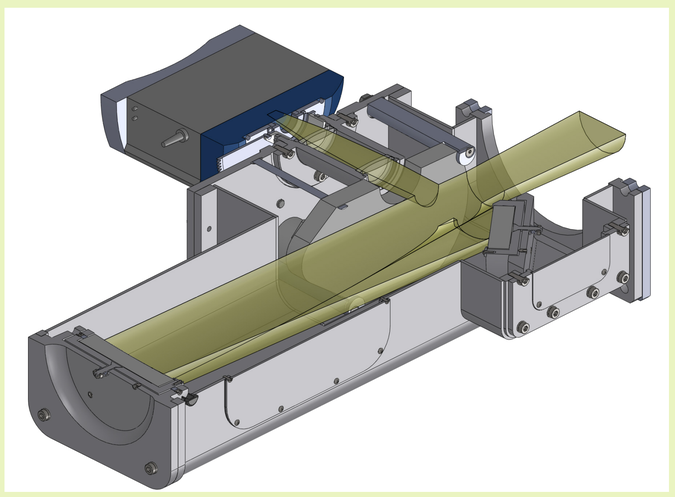

Fig. 2: Section view of the 3D model of the instrument.

METHOD

The scientific validation and commissioning tests were focused on characterizing the behaviour of the EMCCD on-sky performance. The possibility of having regular access to the Canarian telescopes has allowed us to develop this calibration method which measures:

- **Gain linearity**
- **Dynamic and photometric range**
- **Sensitivity**
- **Astrometric stability**

PERFORMANCE

WFC saw its first light at TCS in August 2014. Since then, 10 observing nights, apart from the research observations, have been devoted to EMCCD calibrations, obtaining thousands of sky and dome images.

Dome images have been used for illumination and noise tests as the variable gain of the cameras benefit from a stable light source.

We have selected five crowded regions containing stellar sources in a wide range of magnitudes to pursue photometric tests.

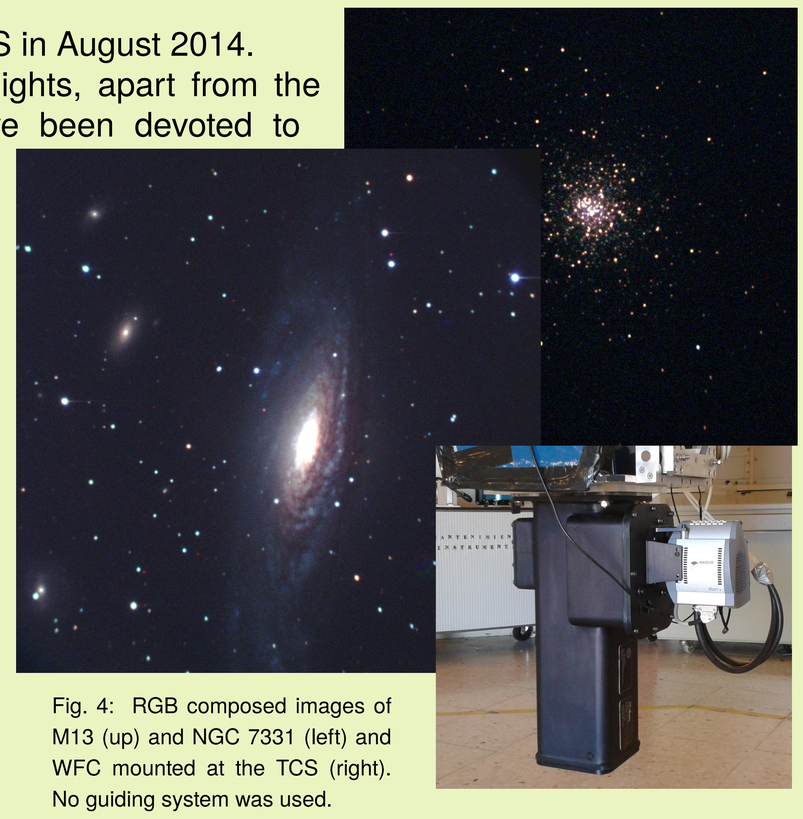

Fig. 4: RGB composed images of M13 (up) and NGC 7331 (left) and WFC mounted at the TCS (right). No guiding system was used.

SOME RESULTS

The results obtained will represent a referent to be taken into account for future instruments hosting EMCCD detectors. Here we present a small sample of them.

Among other interesting results, the linearity of EMCCDs has been found to be dependent on gain and exposure time.

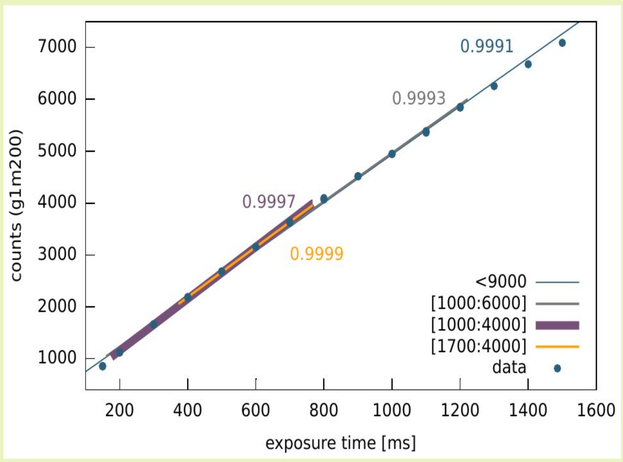

Fig. 5: Linearity for gain 200.

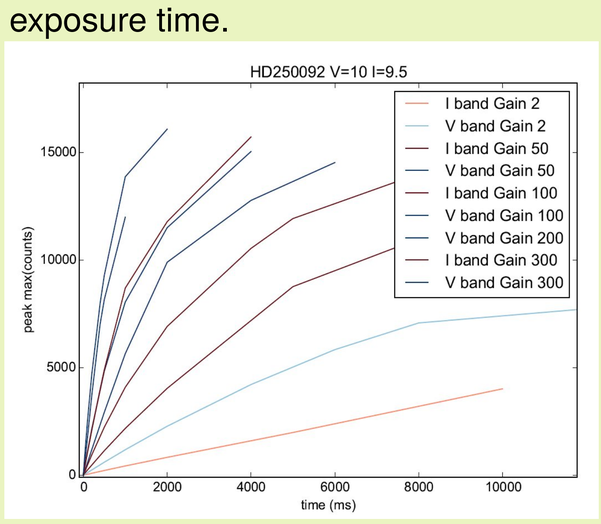

Fig. 6: On-sky linearity and sensitivity test.

GAIN	Filter	Range (counts)
2	I	200-6000
	V	200-5000
50	I	200-5000
	V	200-6000
100	I	200-5000
	V	300-4000
200	I	200-4000
	V	300-4500
300	I	200-4000
	V	300-3000

Table 1: Photometric linear range evaluated for I and V filters and different gains.

NEXT STEPS

We are optimizing and implementing our method in other EMCCD instruments, such as AOLI, with the aim of getting a simple and versatile method for EMCCD on-sky calibration.

Affiliations:

1 2 3 4

References:

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Oscoz et al., 2008, SPIE
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Velasco et al. 2016, MNRAS

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