# Integration of the Camera Backplane of the Gamma Cherenkov Telescope for the Cherenkov Telescope Array

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* Supported by the EU FP7-PEOPLE-2012-ITN project nr. 317446, INFIERI, "Intelligent Fast Interconnected and Efficient Devices for Frontier Exploitation in Research and Industry".

## 1. Introduction

The Gamma Cherenkov Telescope (GCT) is proposed to be part of the Small Sized Telescope array [1] of the Cherenkov Telescope Array (CTA) [2], the part of the array optimized for the highest gamma ray energy observable with CTA, aiming to see gamma ray up to 300 TeV.

GCT is based on an aplanatic, anastigmatic variation of Schwarzschild's optical system, developed by Andre Couder in the 1920s. The focal plane is located between two aspherical mirrors, close to the secondary. This design allows the implementation of a light-weight, compact camera, which will have reduced costs while still being able to deliver the required performance of a wide Field of View (FoV) and relatively fine pixellation.

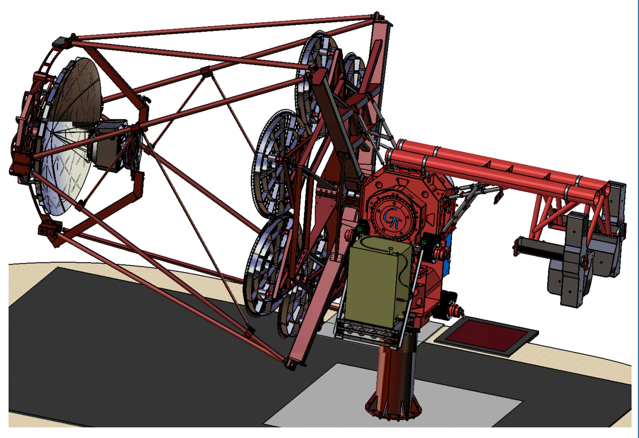

*Fig. 1 CAD of the GCT structure*

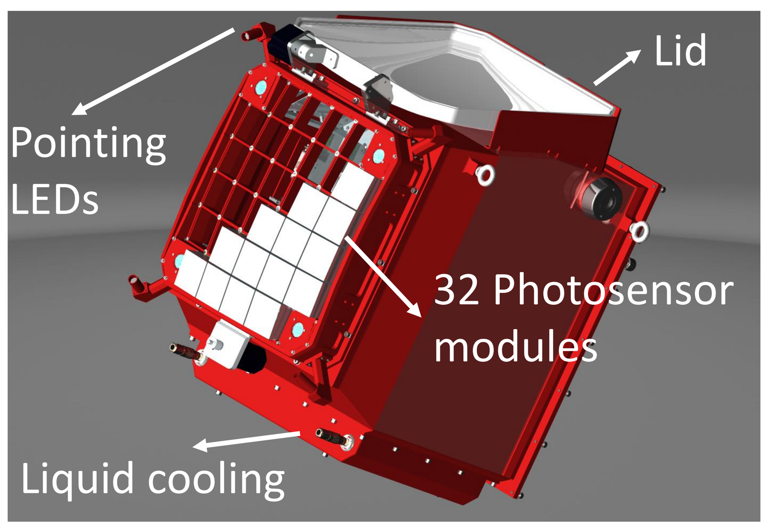


*Fig. 2 CAD of the GCT Camera prototype*

The camera [3] have a curved focal surface with radius of curvature 1m and diameter 35cm. When not observing the enclosure can be sealed by a lid operated by two motors providing protection from dust, heavy rain and improving longevity of the photosensors. The lid will be coated with reflecting material, the sky image on its surface will be seen by a CCD camera mounted at the centre of the secondary mirror for pointing and optical aberration calibration and correction.

The heat inside the camera is redistributed by a set of 4 fans and metal blades. A chiller installed at the base of the telescope cools a plate of the enclosure to remove up to 500W of heat.

## 2. Electronics

The analogue signal of the 64 channels of each of the 32 photosensor modules is shaped in a preamplifier board. This is fed to a TARGET module [4] to perform digitisation at 1Gs/s/channel and first level of trigger based on the discrimination of the sum of the signal in 4 neighbouring pixels (super-pixel). The data lines from all the 32 modules are routed trough a Backplane to the Data Acquisition Boards (DACQ). When 2 adjacent super-pixels are fired in the same coincidence window the Backplane generates a TACK message containing the nanosecond precision timestamp of the triggering event and sends it to all the TARGET modules. Upon receive of a TACK message the modules lookback in a buffer for the requested data based on difference from their actual time counter and the timestamp in the message and send data to the DACQ Boards. The DACQ handles communication to the outside world via 4 x 1Gbps links and provides clock synchronisation and timing via a *WhiteRabbit* [5] interface. A peripherals board, connected via SPI to the backplane, drives the thermal control unit, the lid motors and the LED flashers used for calibration.

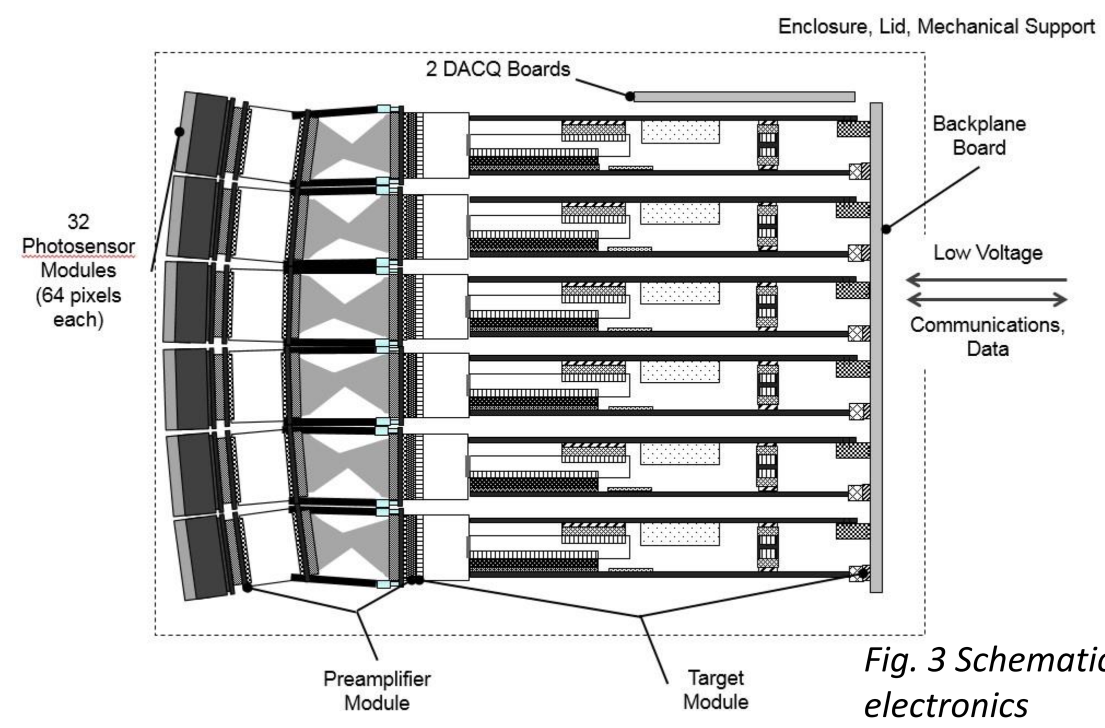


*Fig. 3 Schematics of the GCT camera electronics*

## 3. Backplane integration

The Backplane was recently integrated in the camera allowing for the first time self triggering on light pulses (See Fig. 4). Procedure to identify the optimal trigger parameters were addressed and tested in the lab. Two are the settable parameter: the threshold level at the comparator side after the analog sum of the 4 channel from the TARGET ASIC forming the super-pixel and the reference voltage add to the signals before the comparator (PMTRef4). The latter value obviously depends on the Pedestal Voltage applied to the waveforms (Vped). See Fig. 5 for a plot of the minimum PMTRef4 in function of Vped to avoid triggering on the level of the noise.

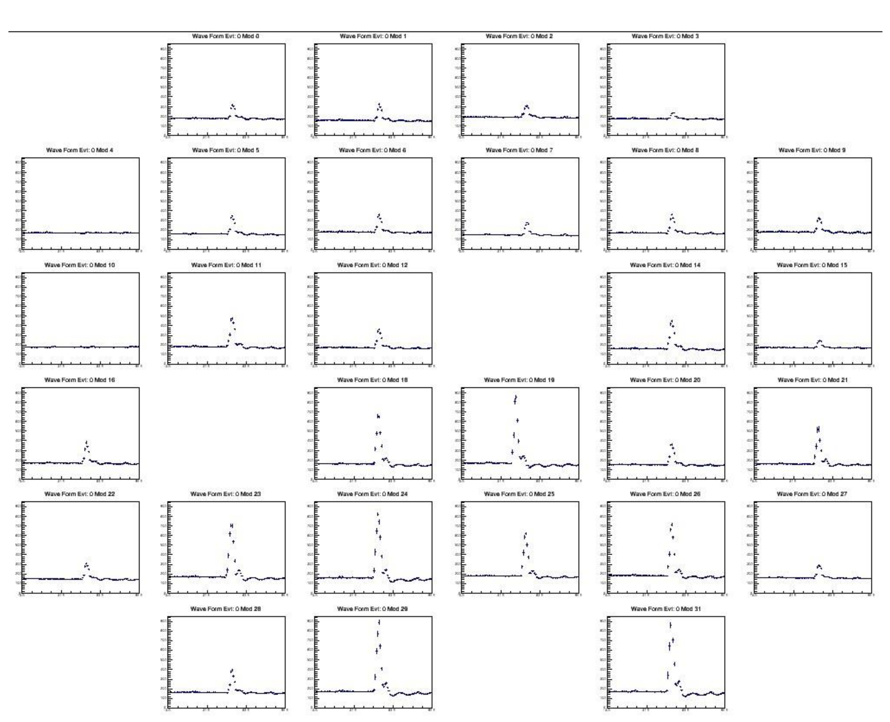

*Fig. 4 Uncalibrated waveforms from self triggered events on a diffused laser pulse. Laser clearly pointing towards the bottom of the camera. Few of the 32 modules missing in this preliminary test.*

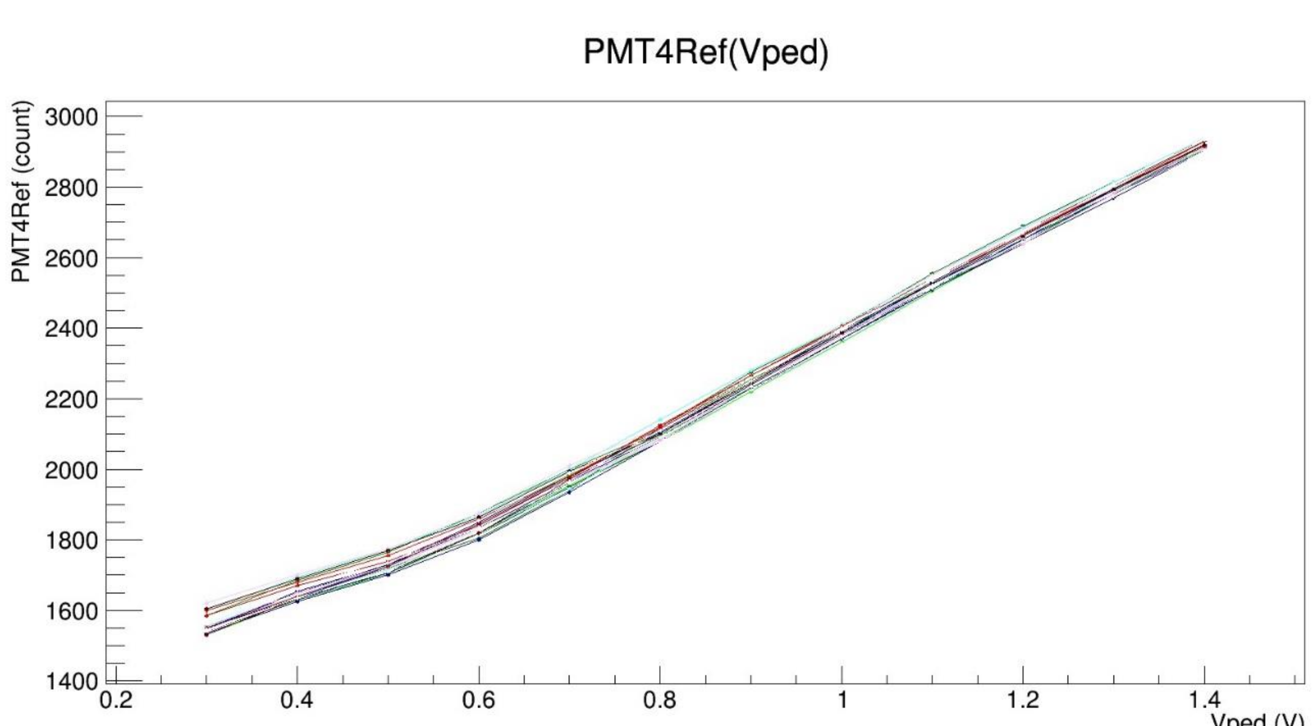


*Fig. 5 Dependencies of PMTRef4 on Vped for all the modules (different colours). The module by module data are fitted with a bi-linear function to fill optimal trigger settings tables.*

## 4. Planned test

The collaboration is now focused on identification of very robust, reliable bootup and camera running procedures. As well as systematic trigger efficiency verification on all camera patches with the use of laser mounted on a robot arm illuminating the desired subset of the camera.

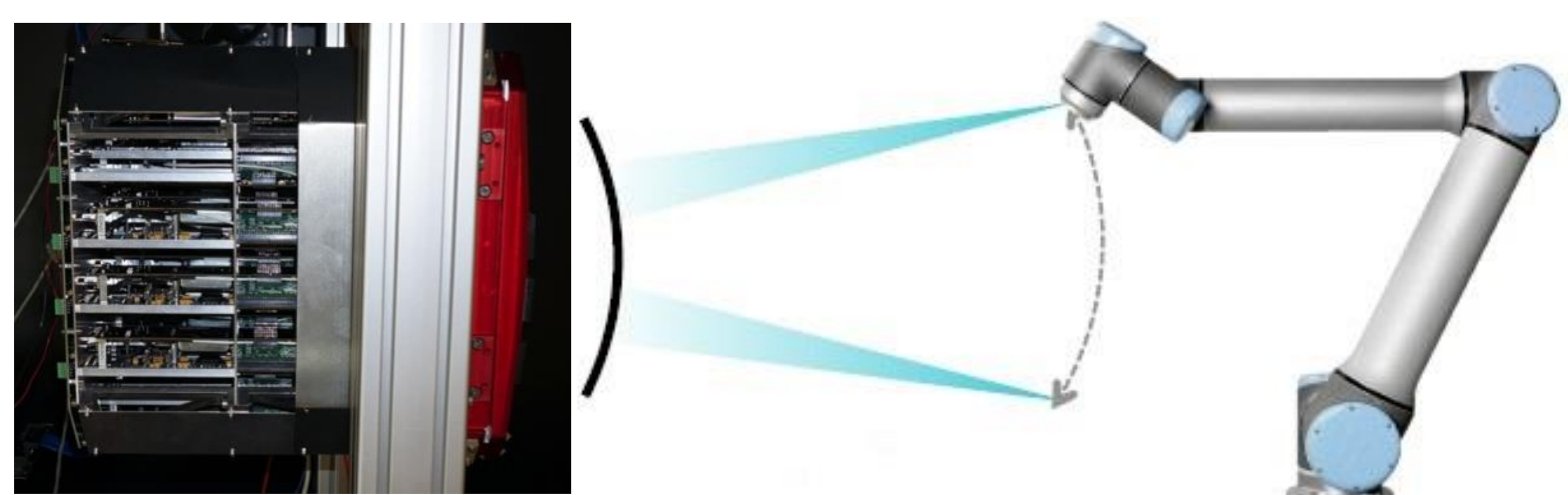

*Fig. 6 Schematics of the robot arm scanning trough the different patches of the camera for trigger efficiency test.*

## Reference & Acknowledgement

[1] CTA Consortium, Introducing the CTA concept, Astroparticle Physics 43 (Mar., 2013) 3-18
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[5] J. Serrano et al., The White Rabbit Project, Proceedings of the 2nd International Beam Instrumentation Conference, (2013)

The GCT Camera Collaboration include people at the following institutes: Max-Planck-Institut für Kernphysik; University of Durham; GRAPPA, Anton Pannekoek Institute for Astronomy, University of Amsterdam; University of Liverpool; Physikalisches Institut der Friedrich-Alexander, Universität Erlangen-Nürnberg; University of Leicester; Washington University at St Louis; Solar-Terrestrial Environment Laboratory, Nagoya University; School of Physics and Astronomy, Minneapolis); SLAC, KIPAC.
The research leading to these results has received funding from the People programme (Marie Curie Actions) of the European Unions Seventh Framework Programme FP7/2007-2013/ under REA grant agreement n [317446] INFIERI "INtelligent Fast Interconnected and Efficient Devices for Frontier Exploitation in Research and Industry". We would also like to acknowledge the support of the UK Science and Technology Facilities Council (grant ST/K501979/1) and the support from the agencies and organisations listed in this page: http://www.cta-observatory.org.