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The First G-APD Cherenkov Telescope (FACT) camera and its electronics - overview, operation experience and outlook

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Within the FACT project, we constructed the first full-scale Cherenkov telescope camera based on Geiger-mode avalanche photodiodes (G-APDs). Compared to photomultipliers, G-APDs are more robust, need lower operation voltage and promise higher efficiency and lower cost.
The FACT camera comprises 1440 pixels and readout channels, based on the DRS4 analog pipeline chip and features fully integrated electronics with commercial Ethernet components for data transfer.
Since October 2011, the FACT camera is operational in the harsh outdoor environment at the Roque de los Muchachos Observatory.

I will present the FACT camera electronics, results, operational experience and outlook.

Summary

Within the First G-APD Cherenkov Telescope (FACT) project, a camera based on Geiger-mode avalanche photodiodes (G-APD) for Imaging Atmospheric Cherenkov Telescopes (IACT) has been designed and constructed. In autumn 2011, this camera was installed on the refurbished HEGRA CT3 telescope at the Roque de los Muchachos Observatory on La Palma, Canary islands. Since October 2011, it is operational. The FACT camera is the first and only operational IACT camera based on G-APDs.
As by spring 2012, all the camera hardware is so far performing well under the harsh outdoor conditions IACTs are exposed to. Compared to the currently used photomultiplier tubes, G-APDs promise higher photon detection efficiency and have the potential for lower cost. They are smaller, more robust and operate at a much lower bias voltage. The FACT camera has 1440 pixels and the same number of readout channels. Preamplifiers, data acquisition, trigger electronics, slow control and low voltage power converters are integrated in the FACT camera.
The preamplifier- and trigger unit and digitizing boards of the FACT camera have 36 channels each. There are 40 boards of each type, mounted in four crates, ten boards of each type per crate. In a crate, there is a midplane board interconnecting the other boards. The digitizing boards are based on the DRS4 analog pipeline chip operated at a default sampling rate of 2 GHz.
Data readout is based on commercially available Ethernet components.
The trigger system uses analog sums over trigger patches of 9 pixels with the possibility to exclude individual pixels from trigger generation. Each trigger unit comprises four patches with a trigger threshold set per patch. The forty trigger units are controlled by a single trigger master. This trigger master collects the trigger primitive signals from the trigger units to generate one trigger signal. It provides slow control functions for the trigger units and in addition generates the sampling clock for the digitizing boards and a trigger-ID for every event. The trigger master is also controlled over an Ethernet interface.
The trigger signal and the sampling clock are distributed to the digitizing boards with a jitter of less than 100 ps. The trigger-ID is broadcasted to the digitizing boards over a dedicated RS-485 bus. There is one slow control board monitoring temperatures, humidities and supply voltages.
The necessary low voltage power supply is provided by power converters integrated into the housing of the FACT camera. These switching-mode power converters are themselves powered by a single external 48V supply. The total power consumption of the FACT camera is about 600W. The FACT camera is operated by a shift crew on site as well a semi-remote in preparation for a entirely remote peration.
Both "low-level"technical as well as "high-level"physics data analysis is currently ongoing. In my talk, I will present an overview of the FACT camera and its electronics as well a summary of the operational experience, first results and an outlook.

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