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FlashCam: A Novel Cherenkov Telescope Camera with Continuous Signal Digitization

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The Cherenkov Telescope Array (CTA) is the next generation ground-based observatory for cosmic gamma rays. The FlashCam camera for its mid-size telescope introduces a new concept, with a modest sampling rate of 250 MS/s, that enables a continuous digitization as well as event buffering and trigger processing using the same front-end FPGAs. The high performance Ethernet-based readout provides a dead-time free operation for event rates up to 36 kHz corresponding to a data rate of 2.4 GB/s sent to the camera server. We present the camera design and the current project status.

Summary

The Cherenkov Telescope Array (CTA) [1] is the next generation array of Imaging Atmospheric Cherenkov Telescopes (IACTs), and is the successor to the current generation of IACTs including MAGIC [2], H.E.S.S [3], and VERITAS [4]. These telescopes are used to detect gamma rays in the range of tens of GeV to tens of TeV, emitted from exotic (i.e. non-thermal) astrophysical sources such as quasars, supernovae and their remnants, gamma-ray bursts, and dark matter annihilations. When these gamma rays enter the Earth's upper atmosphere, they create an electromagnetic shower comprising many highly-energetic charged particles. Those particles traveling faster than light in the atmosphere produce Cherenkov photons that travel in a cone to the ground. The IACTs can detect these Cherenkov photons and reconstruct the electromagnetic shower by imaging it with multiple telescopes. The reconstructed shower can then be used to determine the direction and energy of the initial gamma ray. The goal of CTA is to build improved and larger versions of the current IACTs, based upon the lessons learned and exploiting new technologies. CTA is approaching the final R&D stage and first telescope prototypes already exist.

FlashCam [5] is a novel camera design for the mid-size telescope of CTA incorporating a fully digital data and trigger pathway. Its aim is to improve in performance compared to current generation IACT cameras while reducing costs per channel. The key point is a 250 MS/s readout system permitting a continuous digitization with data buffering and real-time processing in FPGAs. Trigger algorithms are implemented in the same FPGAs and use the full digitized information. This concept introduces flexibility in optimizing signal processing and trigger efficiency without the need of changing hardware. The Ethernet-based readout system sends the data of the 1764 camera pixels to a camera server using standard Ethernet switches and a tailor-made raw Ethernet protocol. Data rates of up to 2.4 GB/s corresponding to about 36 kHz trigger rate have already successfully been transmitted. Photon detectors, currently photomultipliers, high voltage generators and preamplifiers are embedded in discrete 12-pixel modules detached from the readout system. The analogue data are transmitted from the modules via CAT6 cables to the readout system. Detaching the two parts permits a simple change of detector types and pixel spacing.

The FlashCam concept has been studied extensively and has entered the prototyping phase. First results with a 144 pixel prototype show a significantly better performance than required for CTA.
We present the camera design as well as the project status.

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