# 7 Very High Energy Gamma Ray Astronomy with CTA

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**(CTA)**



The Cherenkov Telescope Array (CTA) is a planned next generation array of Imaging Atmospheric Cherenkov Telescopes (IACTs), and the successor to current IACT arrays including MAGIC [1], H.E.S.S [2], and VERITAS [3]. The goal is to build a larger and improved version of these current IACT arrays.

Various exotic (i.e. non-thermal) astrophysical sources such as quasars, supernovae and their remnants, gamma-ray bursts, and dark matter annihilations emit gamma rays in the energy range of tens of GeV to tens of TeV. When these gamma rays enter the earth's atmosphere they produce an $e^{+}e^{-}$ pair that initiates an electromagnetic shower comprising many highly-energetic charged particles. Many of these particles travel at speeds exceeding the speed of light in the atmosphere, and as a result produce Cherenkov photons that travel in a narrow cone to the ground. The IACTs may detect time and direction of individual Cherenkov photons and allow to reconstruct the electromagnetic shower by combining the signals from many telescopes. This information is used to determine the direction and energy of the initial gamma ray.

CTA is currently in a phase of heavy research and development. New technologies may be exploited that have arisen in the years since the current arrays were designed. Our own efforts include modular and distributed clock generation techniques, primary mirror alignment, optical components of a novel Geiger-mode Avalanche Photodiode IACT camera, and development of the first fully digital IACT camera.

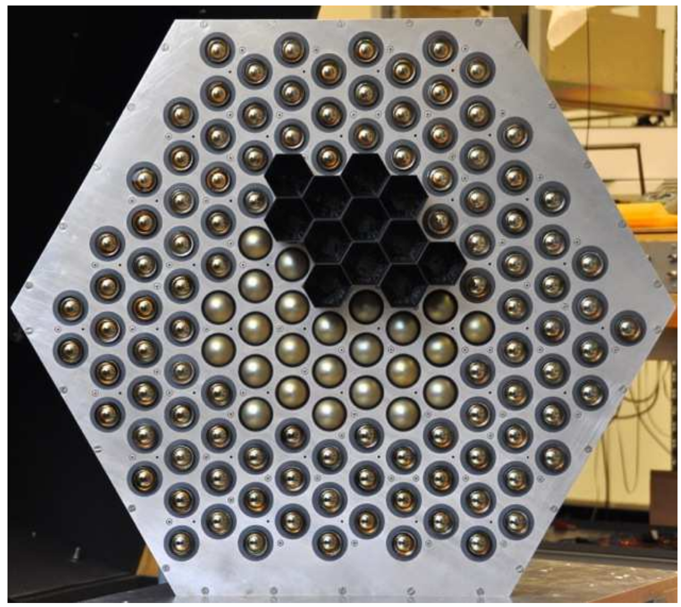

FIG. 7.1 – 144-pixel prototype for FlashCam. Note the two different types of PMT (see text). The hexagonal black structures are mechanical prototypes of the light concentrator.

## 7.1 FlashCam

FlashCam is a possible camera design for CTA that focuses on a fully digital data and trigger pathway: data is digitized continuously without the need of an analog trigger used to decide whether to digitize the stored analog data. Traditional techniques typically feature an effective sampling rate around 2 GS/s. Costs and power consumption of continuous digitization at 2 GS/s are, however, prohibitive for an array of hundreds of cameras with thousands of readout channels each. Interestingly, our collaborators at the Max Plank Institute for Nuclear Physics (MPI-K) in Heidelberg have shown that adequate instrumental and timing resolution can be achieved at a reduced sampling rate of 250 MS/s. This scheme looks feasible and is currently being prototyped.

The validation of the FlashCam concept, from the collection of photons at the detection plane up to the final data storage, is undertaken in several steps. The very front of the chain, the Photon Detection Plane (PDP), contains photomultiplier tubes (PMTs), their high-voltage supplies, preamplifiers, and slow control electronics. These electronic components are housed on two printed circuit boards to which the PMTs are soldered. The initial twelve-pixel FlashCam prototype, described in the previous Jahresbericht, was constructed to test this aspect of the FlashCam concept. It used Hamamatsu PMTs developed specifically for CTA. Meanwhile, we have built the 144-pixel prototype shown in Figs. 7.1 and 7.2.

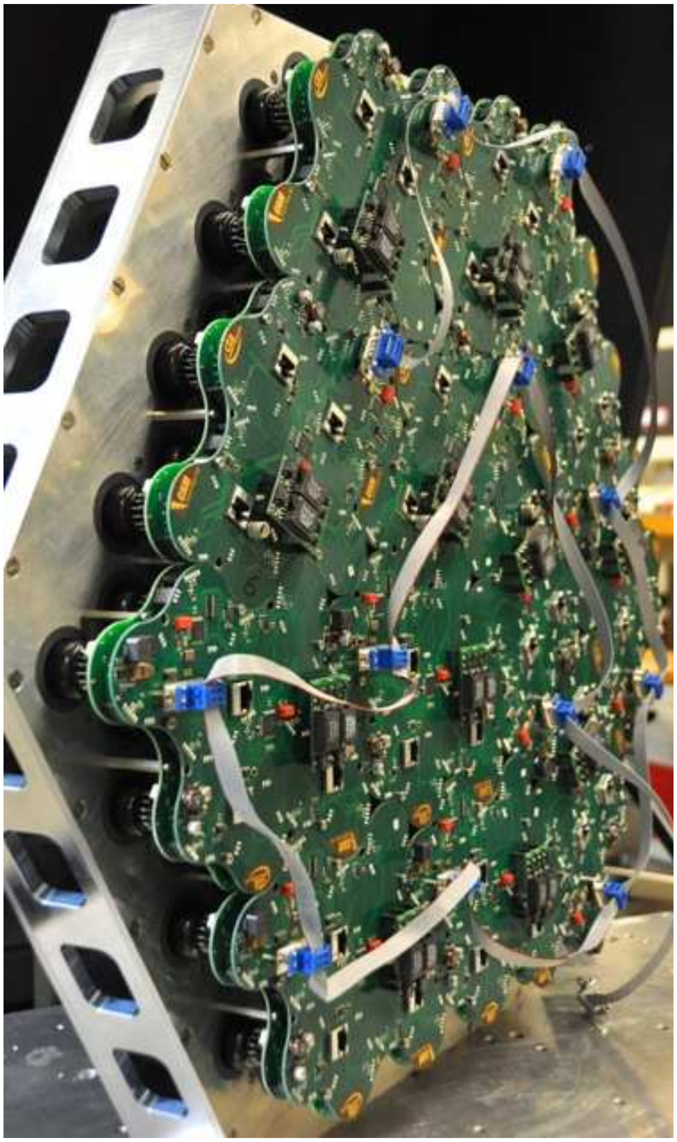

FIG. 7.2 – Rear view of the 144-pixel prototype showing the control boards.

The next step in validating the FlashCam concept is a full system test, including analog signal transmission, signal digitization on custom-made ADC boards, digital signal processing and transmission over custom backplanes, and real-time digital triggering. Due to the considerable cost of the PMTs, this 144-pixel prototype has been constructed with two types of PMTs. The inner 36 PMTs are the same Hamamatsu CTA PMTs, while for the remaining 108 positions Photonis PMTs (spare H.E.S.S. equipment) are used. The PDP electronics of this 144-pixel prototype has been tested and verified. The fully digital chain is due to arrive mid 2013 which will mark a milestone of FlashCam.


[1] J. A. Coarasa *et al.* (MAGIC Collaboration), J. Phys. Soc. Jap. Suppl. 77B (2008) 49.

[2] B. Opitz *et al.* (HESS Collaboration), AIP Conf. Proc. 1223 (2010) 140.

[3] D. Hanna *et al.* (VERITAS Collaboration), J. Phys. Conf. Ser. 203 (2010) 012118.