6 Very High Energy Gamma Ray Astronomy with CTA

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(CTA)

The Cherenkov Telescope Array (CTA) is currently the most promising candidate for the next generation of Imaging Atmospheric Cherenkov Telescopes (IACTs). IACTs, like the present H.E.S.S. [1], MAGIC [2], and VERITAS [3] are ground-based mirror telescopes used to detect gamma rays of energies from several 10 GeV up to hundreds of TeV. Sources of such very high energy (VHE) gamma rays are both galactic and extragalactic, including quasars, supernovae and their remnants, gamma-ray bursts, and possibly dark matter annihilations. The signal is a faint (100 photons/m^2 @ E_γ = 1 TeV) and very fast (few ns) Cherenkov light flash, produced in the shower developing in the Earth's atmosphere after an initial $\gamma \rightarrow e^+e^-$ pair production, allowing the reconstruction of the primary gamma ray's energy and direction. First CTA telescopes may be installed on site in 2017.

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

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

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

6.1 FlashCam camera body

Our group contributes two pre-series camera bodies (funding guaranteed) of the photomultiplier-based first fully digital IACT camera for the mid-sized telescope (MST) which has a 12 m dish diameter [4]. The production of additional fifteen camera bodies starts early 2017, if funding is secured by then. The FlashCam camera, as one of the two MST camera candidates, made an important step towards a fully functional prototype. The past years have been devoted to develop, test and build the enclosure. The main design goals were easy access to all parts for installation and maintenance, a good light and water tightness, low weight at low cost, and a design suitable for mass production. Combining proven techniques and materials used in industry with unconventional construction ideas lead to a 3x3x1.1 m^3 body of less than 1.7 tons, including the safety-, power- and filled cooling-systems and most of the cabling. The additional weight of the readout and detector electronics, to be installed in a next step, is estimated to be around 300 kg.

FIG. 6.1 – FlashCam body in Adlershof before installation. The lid has been opened to prevent accidental damage during transport and installation. The Plexiglas entrance window (here a non-UV transparent placeholder) was installed to study the system's mechanical stability under different elevation angles, as well as the cooling system under realistic conditions with a near-sealed body.

6.1.1 Test of the FlashCam body on a real telescope structure

End of June 2015 the body without the readout and detector electronics was transported to the MST prototype structure in Adlershof, Berlin for mechanical and electrical tests. Figure 6.1 shows the camera body with the transportation frame mounted on the sides and opened lid in Adlershof before being mounted into the camera frame of the MST prototype structure. The camera is installed with the help of a sledge system, which allows an easy and safe installation and removal of the camera (Fig. 6.2 left). The excellent teamwork of the two teams from the University of Zurich and from DESY Zeuthen permitted a quick and easy installation of the camera.

The communication with the in-house developed safety and slow control of FlashCam was tested with a dedicated Labview GUI as well as with a simple OPCUA framework. The piping, the flow and pressure of the cooling system was thoroughly tested under realistic coolant flow conditions. For this, the camera was connected to a simple

FIG. 6.2 – Rotating the telescope into the zenith position. The sledge, which can be moved with a winch, is visible below the camera body in the first picture. The camera lid is closed and the two installed detectors are read out for off-line study of possible light leaks and pick-up noise.

pump system (without heat exchanger) and was moved to different elevation angles (Fig. 6.2). Two photomultiplier modules with 12 PMTs each (see e.g. last year's report) and a readout crate was used to determine the light tightness of the camera at different elevation angles and also to investigate a possible noise pick-up from the drive system (Fig. 6.3).

The body was dismounted again in only two hours on July 30th and brought to the Max Planck Institut für Kernphysik (MPI-K) in Heidelberg for the subsequent integration of the readout and detector electronics for 800 pixels.

[4] G. Pühlhofer *et al.*, (FlashCam collaboration), arXiv 1211.3684 [astro-ph.IM] (2012).

FIG. 6.3 – Camera rear doors open. The safety and power cabinet at the left lower rack position is being inspected. The slow control drawer is installed in the middle of the right rack. Fan drawers and heat exchangers can be noticed at top and bottom of the two racks.

6.2 Photon-detector module

The photon-detector (PDP) module, equipped with 12 PMTs, preamplifiers, high-voltage generators and some other functionality has been developed at our institute during the past years, see e.g. reports 2012-2014.

Seventy such modules have been ordered and tested in-house before they were sent last autumn to the MPI-K for their integration into the camera body. A single camera contains 147 PDP modules. A total of 1764 pixels cover a field of view of 7.7°. The partially-equipped camera revealed some problems, which were solved by minor changes of the schematics and the layout of the modules (Fig. 6.4). The second half of the detector modules were ordered by the University of Erlangen. All components, including the readout electronics, will be installed in the prototype camera body during the second half of 2016 to allow testing the functionality of a complete camera.

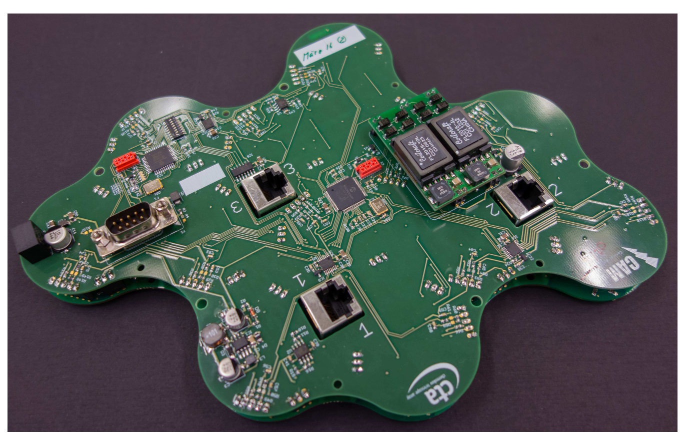

FIG. 6.4 – Improved electronics boards with reduced noise pick-up and reliable CAN-bus communication.