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Development of a SiPM camera module for the focal plane of the SCT telescope proposed for the Cherenkov Telescope Array

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Summary. — The Cherenkov Telescope Array (CTA) will be the new generation of ground observatories for the detection of very high energy γ-rays. The Italian Institute of Nuclear Physics (INFN) is developing a possible solution for the Cherenkov photon cameras based on Silicon Photomultiplier (SiPM) detectors sensitive to near ultraviolet energies. This contribution reviews the procedures for the assembly of 4×4 SiPM modules intended to equip a possible upgrade of the focal camera of the Schwarzschild-Couder optics Medium Size Telescope (SCT) proposed for CTA.

The Cherenkov Telescope Array is developing the project to build two arrays of Imaging Air Cherenkov Telescopes of different dimensions and mirror optics technologies for the detection of γ-rays in the 20 GeV–300 TeV range [1]. The possibility of a Schwarzschild–Couder (SC) dual mirror optics solution for the CTA Medium Size Telescopes is currently under investigation and a prototype telescope (pSCT) is being assembled [2]. The SC optics, designed to cancel aberrations and to de-magnify images with respect to single mirror solutions, allow to use Silicon Photomultipliers (SiPM) as imaging pixel of the compact camera for the Medium Size Telescope focal plane.

Near UltraViolet High-Density (NUV-HD) $6 \times 6\,\mathrm{mm}^2$ SiPMs with $30 \times 30\,\mu\mathrm{m}^2$ microcell area, produced by Fondazione Bruno Kessler in Collaboration with INFN, are

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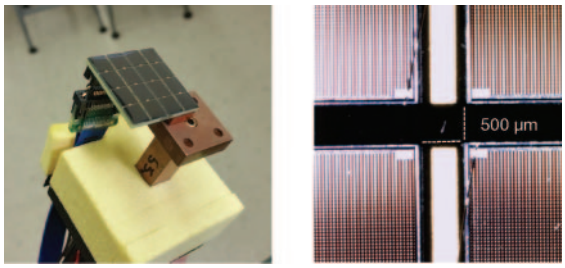

Fig. 1. – Left: a 16 SiPM module coupled with the pSCT telescope mechanical unit. Right: details of the module with the SiPM anode pads and the PCB readout pads visible.

being considered for a possible upgrade of the pSCT camera, currently equipped with Hamamatsu MPPC S12642 modules. The performances of the NUV-HD SiPM devices are described elsewhere, and they meet the minimum requirements for the equipment of the CTA telescope cameras [3].

The pSCT camera mechanics and readout electronics have been designed to host units with $54 \times 54\,\mathrm{mm}^2$ area, each divided in 4 modules composed of 16 SiPM sensors. INFN has designed custom PCBs of $27 \times 27\,\mathrm{mm}^2$ area with 0.5 mm sensor-to-sensor distance to obtain uniform pixel coverage of the modules and of the camera, and compatible with the current pSCT camera design (fig. 1). While single SiPM sensors are provided by the vendor, the procedures for the assembly and packaging of the modules have been completely developed by INFN.

A manual die-bonder machine is used to deposit the conductive glue on the PCB pads and to precisely place the SiPMs on the PCBs. The alignment of the sensors, checked with an optical metrology machine, is better than $40\,\mu$m. The flatness of the modules has been checked using a ruby-head touch probe machine, and the maximum deviation from planarity over the whole modules has been found to be $\sim 80\,\mu$m. The possibility to use semi-automatic die-bonder machines for future assemblies is under investigation.

Each SiPM anode is bonded using a $20\,\mu$m Al/Si wire to the signal readout pad of the PCB. Subsequently, the breakdown voltage of each sensor is measured analyzing its dark current dependence over the bias voltage to spot any defective sensor to replace. Fully working modules are finally covered with a UV-transparent epoxy for protection.

The pSCT digitization electronics, based on a TARGET7 ASIC, has been integrated with a DC-DC converter to optimize the bias voltage for the NUV-HD sensors. Currently the performances of the modules coupled with this readout electronics are being validated.

36 modules are planned to be installed on the pSCT camera for validation *in situ* by the end of 2017, while more recent technologies of SiPM sensors with similar size are being studied for a possible upgrade of the next mass production of modules.

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