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feasibility study of a 3-inch Vacuum Silicon Photo Multiplier Tube

The Vacuum Silicon PhotoMultiplier Tube (VSiPMT) is an innovative design that we proposed for the first time at the 11th Topical Seminar on Innovative Particle and Radiation Detectors (IPRD08) in Siena, triggering deep discussions on the feasibility of the device itself and on the convenience of such an idea. The basic idea is to replace the classical dynode chain of a PMT with a SiPM, which acts as an electron multiplying detector. Such a solution will match the goal of a large photocathode sensitive area with the performances of a SiPM. In this work we will present the feasibility study of a 3-inch VSiPMT. The work was based mainly on the electron beam focus on the SiPM surface. As will be shown, the linearity and the efficiency of the VSiPMT can be affected by poor electron focusing on the MPPC. For this reason, the focusing system requires special attention with the respect of classical PMTs. It will be presented COMSOL simulations of a possible solution for the electron beam focusing trying to keep the external dimensions of the device similar to those of a classical 3-inch PMT.

Summary

A feasibility study of a 3-inch Vacuum Silicon Photo Multiplier Tube Introduction
The Vacuum Silicon PhotoMultiplier Tube (VSiPMT) is an innovative design that we propose the first time at the 11th Topical Seminar on Innovative Particle and Radiation Detectors (IPRD08) in Siena, triggering deep discussions on the feasibility of the device itself and on the convenience of such an idea.
The basic idea is to replace the classical dynode chain of a PMT with a SiPM, which acts as an electron multiplying detector. Such a solution will match the goal of a large photocathode sensitive area with the performances of a SiPM. This will lead to many advantages such as lower power consumption, mild sensitivity to magnetic fields and high quantum efficiency. The feasibility of this idea has been thoroughly studied both from a theoretical and experimental point of view. As a first step we performed the full characterization of a special non-windowed Hamamatsu MPPC with a laser source. The response of the SiPM to an electron beam was studied as a function of the energy and of the incident angle by means of a Geant4-based simulation. After this firsts results Hamamatsu accepted to considered the idea and built, expressly for us, two prototypes for testing purposes. In this work, we present some results of the full characterization of the first two prototypes of VSiPMT.
Both devices exhibit very attractive features, such as low power consumption, weak sensitivity to magnetic fields, high resolution in the pulses height giving so excellent photon counting capability.
owever, the two prototypes made by Hamamatsu presents a photocathode of only 3 mm in diameter. In order, for these innovative devices, to be competitive, compared to traditional PMT (e.g. in areas such as underwater neutrino telescopes or dark matter search experiments), it was necessary to study the feasibility of a 3-inch VSiPMT. This study was based mainly on the electron beam focus on the SiPM surface.
As will be shown, the linearity and the efficiency of the VSiPMT can be affected by poor electron focusing on the MPPC. For this reason, the focusing system requires special attention with the respect of classical PMTs.
Will be present COMSOL simulations (figure 3) of a possible solution for the electron beam focusing trying to keep the external dimensions of the device similar to those of a classical 3-inch PMT.
We are confident that the realization of the VSiPMT will start a revolutionary generation of photo- detectors for near-future applications. Moreover, fields like medical equipment, physical checkup and diagnosis

(e.g. Radioimmunoassay and Enzyme immunoassay), biomedicine, environmental measurement equipment, oil well logging, all will require further improvements in photon detection performances, as linearity, gain, quantum efficiency improvement and single photon counting capability. We believe that the proposed device has the potential to fulfill these requirements.

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