Nowadays, there are two types of sensors to detect the low luminous flux, PMT (PhotoMultiplier Tube) and Geiger-APD (Geiger Avalanche Photodiode).
The Geiger-APD is composed of silicon that was developed in the early 90s to detect very low light flux, as is currently the PMT. The main advantages of these devices on the PMT are very high sensitivity to light (single photon), very high time resolution (<100ps), and integration into imaging, made possible by a great homogeneity. Unfortunately, these components have some drawbacks compared to PMT; where they have a very small sensitive area (<10µm) and a leakage current (Dark Count Rate) higher per unit area.
The work to be done includes the integration into Microsystems, with the aim , in the long run, to develop several applications in astrophysics, biology, optical detection, and most importantly, fast imaging systems. The manufacturing of imaging equipment through a new process must be defined by a detailed study on the imaging Geiger. Different applications in astrophysics are possible such as the detection of Cerenkov flash. But the most important application is a photonic solution for better health care. This work is included in the study of cancerous cells by using a mechanical system to reconstruct an image of the scanned area to identify the photons emitted by this cell and then locate the disease. The mechanical system is related also to another electronic system which controls the detector array and realizes a mechanism to be followed to obtain a better resolution and optimized results.
In this work, we will present the main characteristics of the proposed technology. A design of the proposed imager is shown with important ideas to measure a cancer cell.
Our design is principally based on a mix of two technological processes. The first part is the pixels that permit the detection of single photons and the second part is the read-out circuit of the APD based on transistors manufactured in CMOS standard process. Indeed, the entire ship is manufactured in CMOS 0.35µm Opto, designed by our team and achieved by AMS (Austria Micro-system) through the CMP (Circuit Multi-Projets).
To represent the system, the imaging device can be defined in the following figure (figure 1).

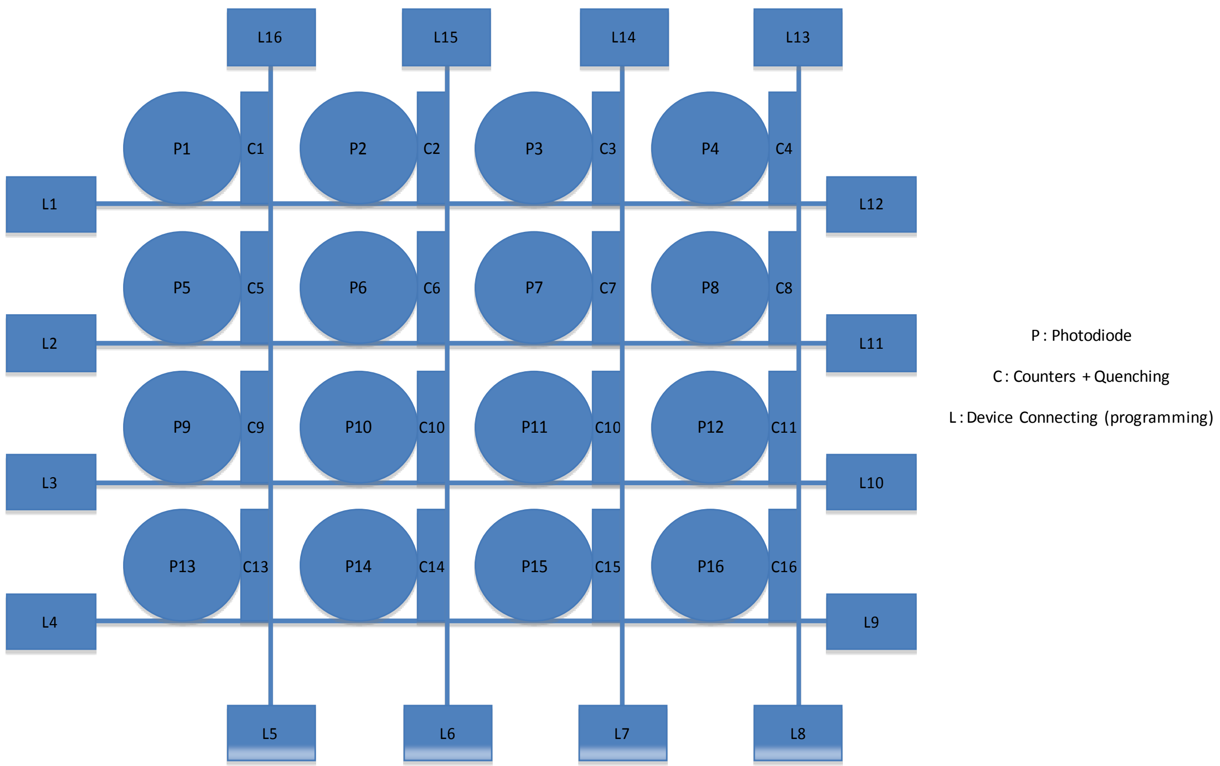

Figure 1: illustration of an imaging system in CMOS 0.35µm Opto.

Actually, this work is principally aimed to develop a multi-pixel detector for applications in nuclear medicine (detection of cancer cells). It did not begin from scratch; an interior work has been achieved during the PhD thesis of 2 of the team members (DP & KJ). For more details, see Pellion et al & Jradi et al (Ref: 1 & 2) which had the aim to develop imaging system for astrophysical applications (detection of Cerenkov flash).
Additionally, many works in this domain has reached important results and many experiences has demonstrated the advantages of using Silicone technologies, compared to PMT, for detection of single photons in the domain of biology for better health care.
For future improvement of the imaging system, a new structure also based on CMOS standard technology could be proposed. This structure is based on the 3D IC technology which is a very recent concept for imaging system. Many advantages could be achieved:

1- A reduced loss in the fill factor, due to the separation of the 2 principal parts (detectors and read-out circuits).
2- A better QE (Quantum Efficiency).
3- Possibility to design counter circuits with more transistors (no constraint surface).
4- Fewer electrical constraints between diodes and counters (separated and related via contacts).

Proposed structure is shown on figure below (figure 2).

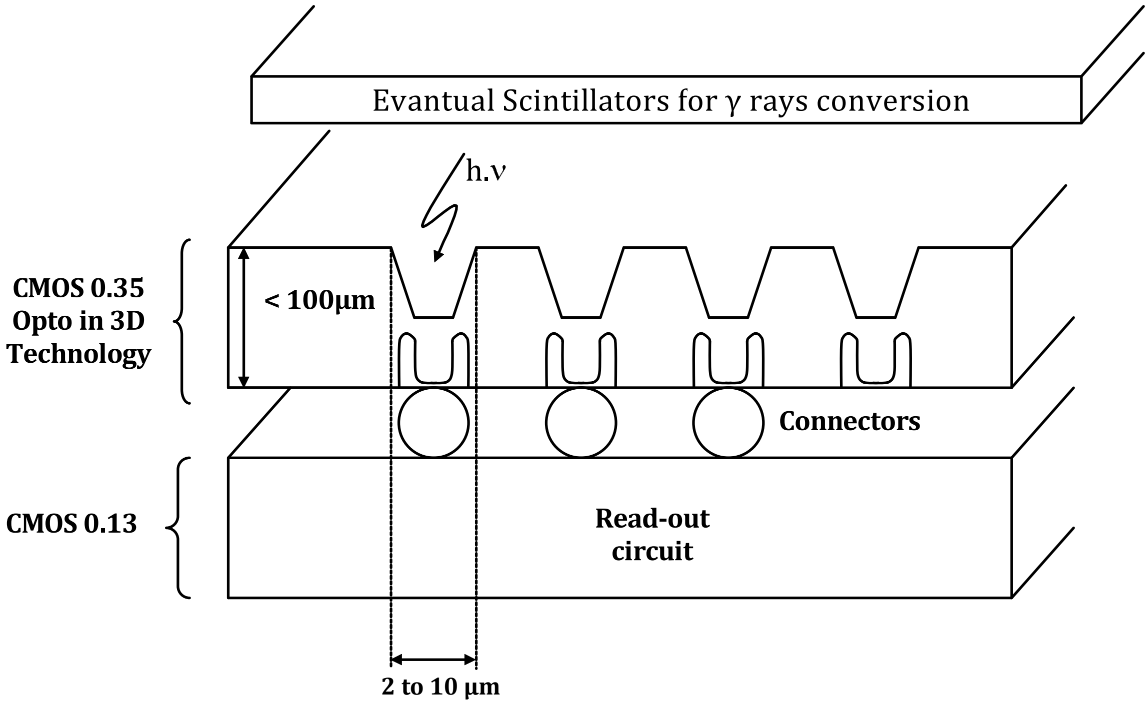

Figure 2: proposed structure in 3D technology.

In conclusion, the new structure is promoted to give important results in the domain of detection of low light intensity and new structures are included in this process for a new era of imaging in Geiger-mode.

[1]: K. Jradi et al, Nuclear Instruments and Methods in Physics Research A 626–627 (2011) 77–81.
[2]: D. Pellion et al, Nuclear Instruments and Methods in Physics Research A 610 (2009) 410.