Fabrication and Testing of a 1024-pixel SiPM Camera

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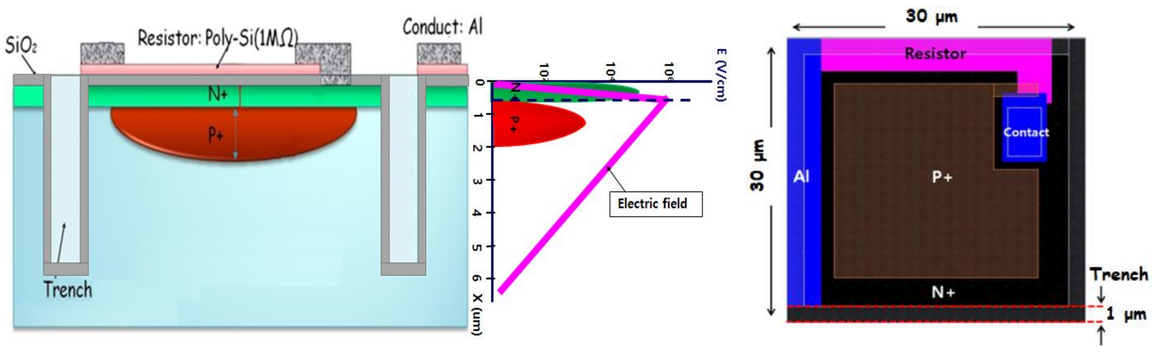
Abstract

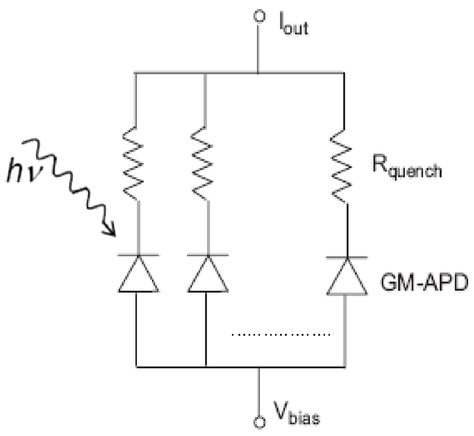
We have fabricated the 1024-pixel SiPM sensor and the associated electronics. We integrated the SiPM sensor and the electronics to build a pinhole camera. In this paper, we present the fabrication and assembly procedure of the SiPM sensor and the readout electronics, and the preliminary result of testing the pinhole camera. This camera can be readily used as an X-ray detector with an array of the scintillator pixels placed in front of the SiPM sensor. The application of such an X-ray detector includes the X-ray or gamma-ray imaging in the medical field and the detection of astronomical or astrophysical X-ray sources in space. This camera also can be used as a detector that counts photons in low light environment.

SiPM: an array of micro-pixels

Micro-pixel structure



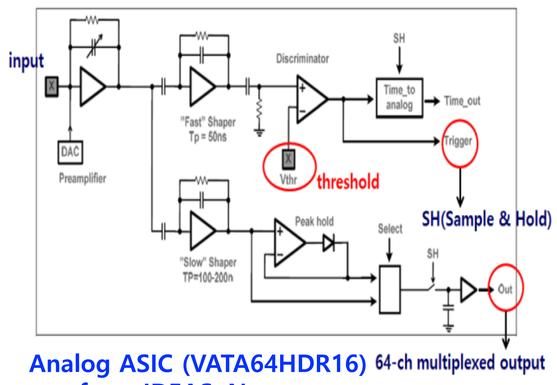
An array of micro-pixels



- Micro-pixel: Avalanche Photo Diode (APD) in Geiger mode
  - Size of micro-pixel = ~10 μm
  - Gain = 10^5 – 10^6
  - Distinctive binary single photo-electron signal
- SiPM: 1000 – 10000 micro-pixels / 1 mm^2
- Micro-pixels in a SiPM are connected through quenching resistors in parallel to a common output.
- SiPM output: Sum of binary signals --> counts the incident photons

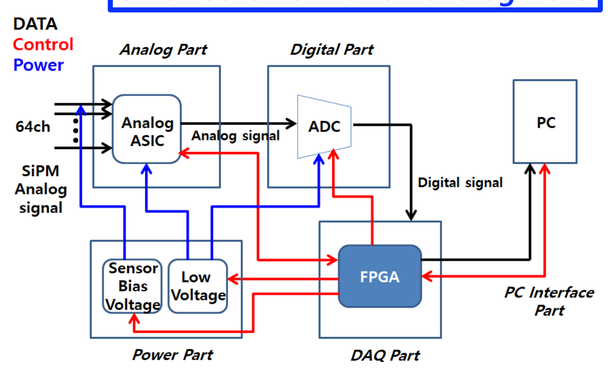
Readout Electronics

64-channel schematics



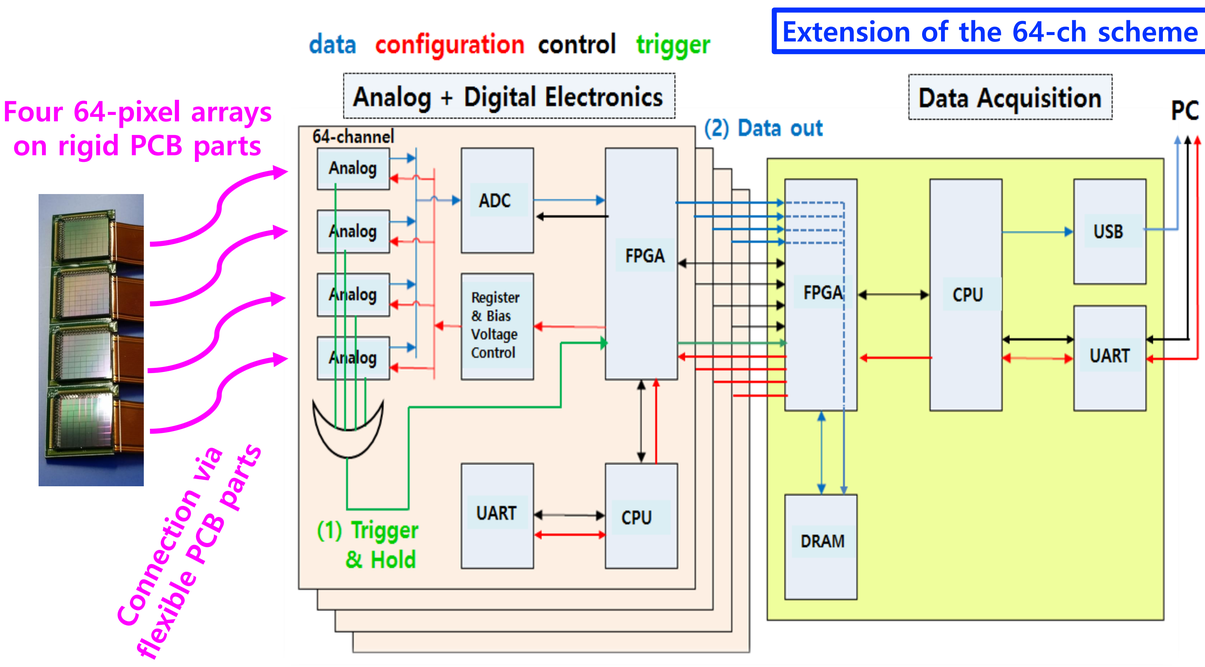
Analog ASIC (VATA64HDR16) from IDEAS, Norway — 64-ch multiplexed output

64-ch scheme with an analog ASIC



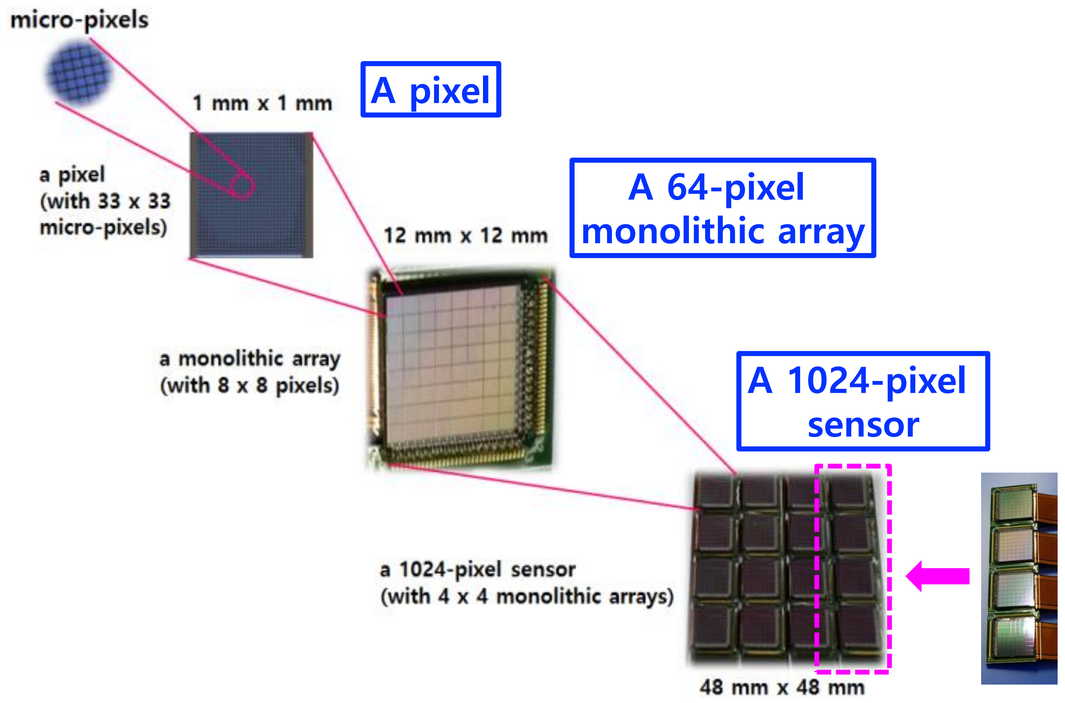
1024-channel schematics

Extension of the 64-ch scheme



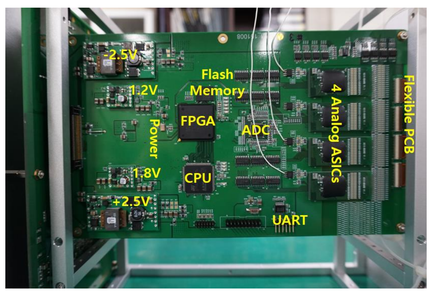
Sensor for the SIPM Camera

How to build the sensor

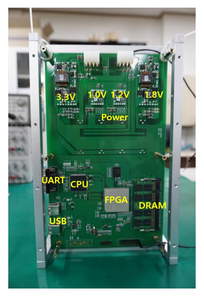


Manufactured 1024-channel electronics

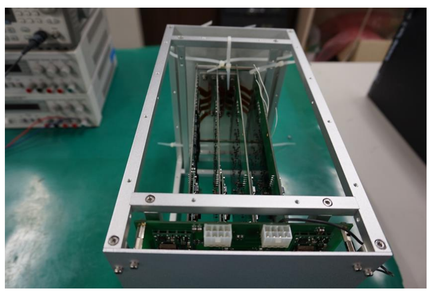
4 Analog boards on a Digital board



Data Acquisition board



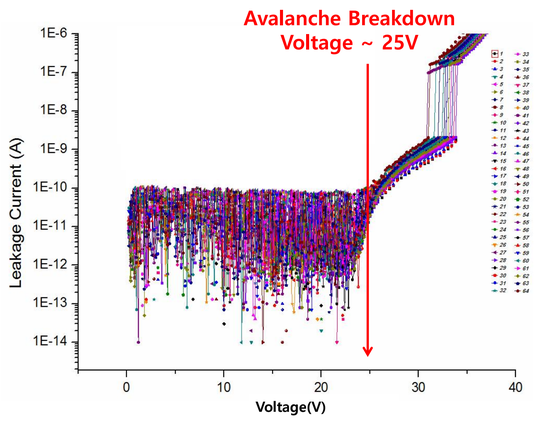
4 Digital boards + Data Acquisition board



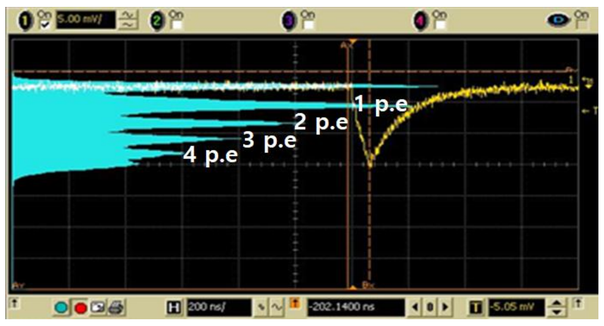
Result

Performance of pixels

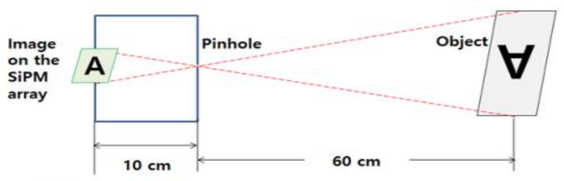
Uniform breakdown voltage

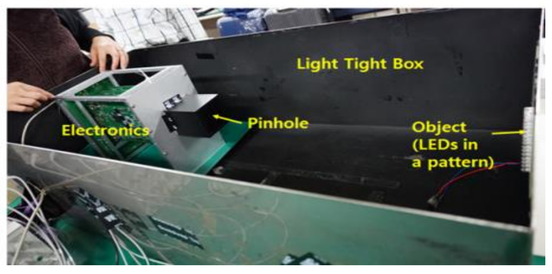


Single photon counting

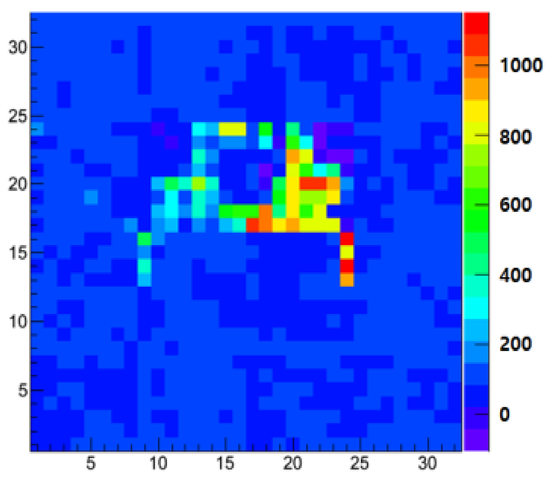


Experimental Setup





An example of SiPM camera images



- We have integrated a SiPM pinhole camera that consists of a 1024-pixel SiPM sensor, an associated readout electronics, and a pinhole.
- Images of pulsed lights from LED patterns have been obtained.
- Calibrations of SiPM pixels and electronics channels are underway.