Benchmarking Geant4 particle detection with CMOS technology

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ABSTRACT

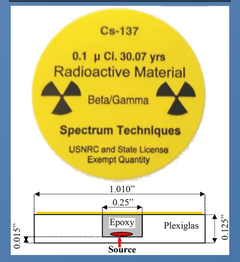
In this work we analyze the performance of an Omnivision OV5647 CMOS image sensor for particle detection. We use radioactive sources for electron and photon emission. Data collection is done using a Raspberry Pi 3 mini computer and the acquisition and processing are done with Python and OpenCV libraries. To reduce the noise we apply a correlated double sample (CDS) method for the fixed pattern and a 5 sigma threshold. The experimental results are compared with a detailed Geant4 simulation of the setup. The deposited energy in the active region of the sensor is converted into ADC levels via an electron-hole transformation. We present the correlation between the measured and simulated parameters based on the ADC values of the pixel sensors.

METHODS

An OV5647 (5Mp) CMOS camera was used. The sensitive part of a CMOS sensor is made of silicon that detects radiation. The lens was removed, exposing the pixel sensor. A radioactive source was placed at different distances from the sensor and source. One hundred 10-bit images were captured in the form of ADC arrays every 0.5 seconds, with the help of Raspberry Pi3, and Picamera libraries. Data are processed by applying the CDS and 5 sigma cut to reduce noise. Then pixel clusters are searched using OpenCV libraries. A simulation was made in Geant4 to compare different parameters obtained in the data, such as the number of ADC.

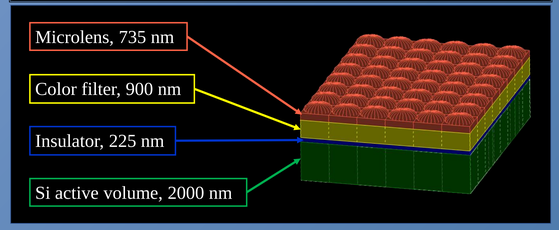
OV5647 CMOS sensor

Cs137 radioactive source

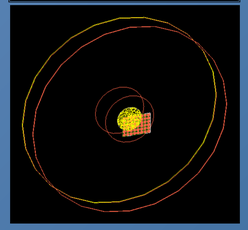


RESULTS

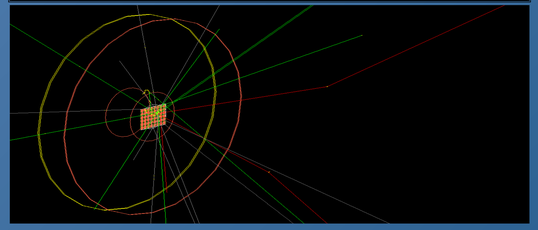
The simulation in Geant4 was performed using the measurements and the different materials of the camera.



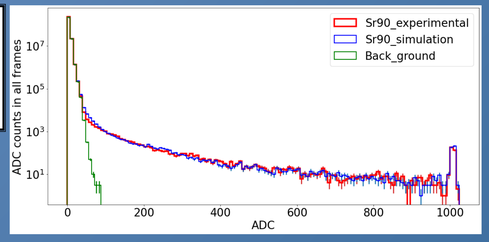
Source geometry and CMOS sensor in Geant4



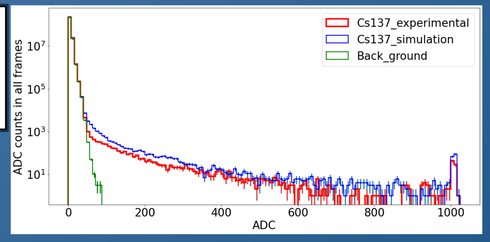
Geant4 simulation of the particles emitted by a radioactive source to the CMOS sensor. (e.g. 10 events)



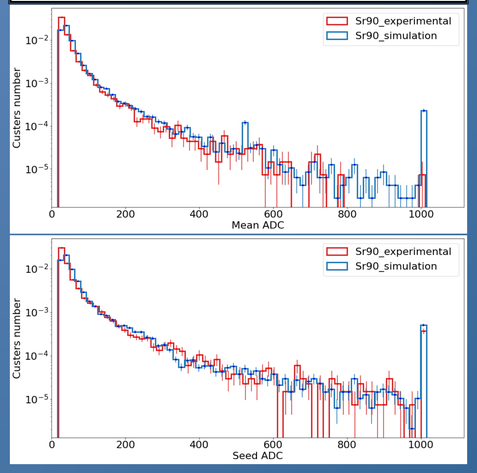
ADC number distribution for the experimental and simulated data from Sr90 applying CDS at 0mm between sensor and source.



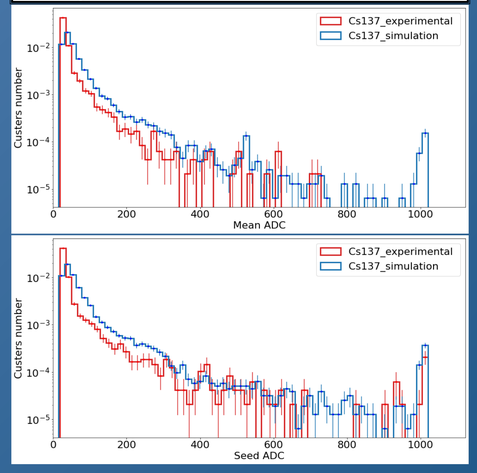
ADC number distribution for the experimental and simulated data from Cs137 applying CDS at 0mm between sensor and source.



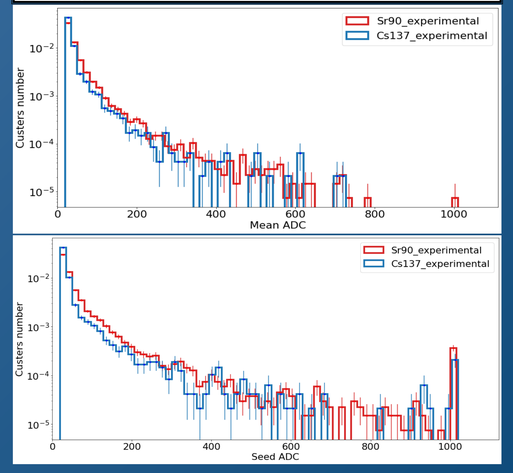
Cluster number vs Mean ADC and Seed ADC, for the experimental and simulated data of Sr90, applying CDS and 5 sigma threshold at 0mm between sensor and source.



Cluster number vs Mean ADC and Seed ADC, for the experimental and simulated data of Cs137, applying CDS and 5 sigma threshold at 0mm between sensor and source.



Comparison of experiment data for both radioactive sources, Cluster number vs Mean ADC and Seed ADC, applying CDS and 5 sigma threshold at 0mm between sensor and source.



CONCLUSIONS

- ADC counts, mean ADC and seed ADC for the simulation and the radioactive sources, when adding the real noise, show an acceptable agreement.
- When comparing experimental data for Sr90 and Cs137 in their different parameters, we conclude that they cannot be distinguished from each other.
- The results shown are preliminary, more tests have to be carried out.

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